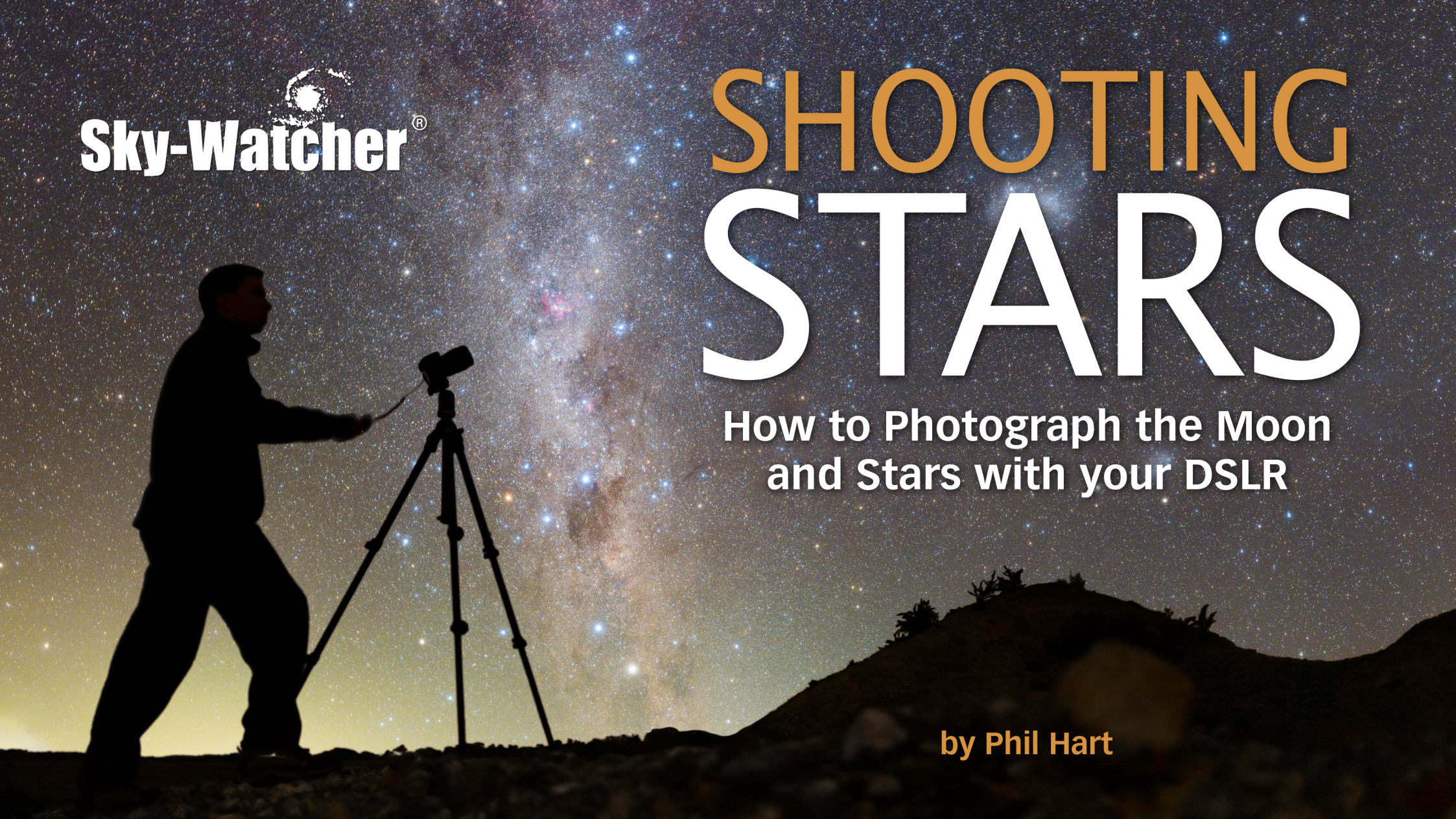


Sky-Watcher®

SHOOTING STARS

How to Photograph the Moon and Stars with your DSLR

by Phil Hart

Written and Published By: Phil Hart www.philhart.com
Graphic Design/Layout: Naomi Creek naomi@naomicreek.com

All photos by the author unless otherwise stated.

Credits:

Additional photo contributions by my friend and colleague Neil Creek and workshop participants Shona Dutton and Luke Haag as noted.

Light Pollution Map: Credit: P. Cinzano, F. Falchi (University of Padova), C. D. Elvidge (NOAA National Geophysical Data Center, Boulder). Copyright Royal Astronomical Society. Used with permission of John Wiley and Sons.

Illustrations by Carlyn Iverson (Absolute Science at www.guru.com) and Mark A. Garlick (www.space-art.co.uk) as noted.

Moon Comic: The Doghouse Diaries (with thanks) www.thedoghousediaries.com

Contents

Acknowledgments and Thanks

My greatest thanks are to my partner Karen Goodwin. Astronomy may not be the most sociable of hobbies, particularly if you don't like the cold, but Karen has always been supportive despite my regular weekend trips away and hours of image processing time at home.

Thanks also to my colleagues Neil Creek and Naomi Creek who I have known since my earliest days in astronomy and who helped me get the workshops up and running in 2011. Without Neil's enthusiasm and support and Naomi's stellar graphic design skills (pardon the pun), this eBook would not exist.

Thanks also to my many friends in the **Astronomical Society of Victoria (Australia)** and the **Aberdeen Astronomical Society (Scotland)** for the many skills you have taught me and your company under the stars.

About the Author

Phil Hart's tagline these days is 'engineer by day, astronomer by night'.

Growing up in Melbourne, Australia, he developed a strong interest in astronomy and photography. On a student budget through school and university, he built his own telescope which remains one of his more successful DIY projects. As an engineer now, he naturally has a strong technical approach to night sky photography but enjoys exploring the artistic side of the hobby as well.

After five years in Scotland enjoying the northern skies and an occasional aurora, Phil returned to Melbourne and continued to dive deeper into the hobby, just as the age of affordable and high performing digital SLRs really began to bloom.

Phil started running Night Sky Photography Workshops in Melbourne, to share his love of photography and the night sky with others. When you combine these workshops with his twenty five years' experience, it is safe to say that the information in this book has been well road-tested.

Phil now lives with his partner Karen under the dark skies of central Victoria.

www.philhart.com

Canon EOS Ra and Sigma 35mm lens.
Panorama of 28 frames, each 30 secs, F2, ISO3200

About this Book

Modern DSLRs perform incredibly well at night – a far cry from the difficulties of working with film in my early years in this hobby. So this book is for all those people who want to learn how to capture images or videos of the night sky and either own or have access to a DSLR and a tripod. That is all you need to get started tonight! I assume you understand just the basic controls on your camera for daytime photography, but do not assume you know anything about astronomy.

This book is divided into six parts:

Part 1, The Sky at Night, introduces some basic astronomy concepts, to help you understand what you can expect to see at night from different places on Earth and at different times of the year.

Part 2, Night Sky Photography, is the heart of the book. It begins by discussing your camera and lenses and how to use them to turn the faint light of the night sky into stunning images. I also cover other equipment and accessories that will enable you to do more with your camera at night and help make the experience more enjoyable.

Building on that background, I introduce you to five key 'styles' of night sky photography and the camera settings required for each. I refer to these styles throughout the book as Twilight Landscapes, Night Sky Scenes, Star Trails, the Moon and Timelapse Video.

Part 3 covers **Image Processing.** I assume you know the basics for processing daytime images and instead concentrate on the particular techniques and steps you will need to get the most out of your night sky images.

Part 4, Wonders of the Night Sky, will inspire you to get outside with your camera more often. This part covers interesting events, features and phenomena that you can see at night and how to apply night sky photography techniques to capture them.

The **Field Guide** included as part of this PDF includes a 'Cheat Sheet' summarising the settings for the different styles of Night Sky Photography and some hints about finding the key settings required on the most popular DSLRs from Canon, Nikon, Sony, Pentax and Olympus.

New in this edition is **Tracking the Stars**, which steps you through setting up and using a Sky-Watcher Star Adventurer portable tracking mount for long exposures of the stars and provides an introduction to astrophotography image processing. The advice is relevant to any equatorial tracking mount.

So charge your batteries, rug up and get ready to enjoy being out under the stars with your camera!

Images in this Book

While almost all of the images in this book were taken with Canon equipment, since that is what I own and use, the instructions are relevant to any brand of camera and I know from the workshops that I have run that you can expect to take similar images with any modern digital SLR. I've even included a few examples from participants in my workshops as proof.

Spelling & Conventions

Australian spelling and metric units are used throughout this book. In most cases, the imperial equivalent is also given.

Full Screen Mode

Enjoy reading this PDF in full-screen mode by using the Acrobat Reader shortcut **Ctrl-L** if you are using a PC or **Command-L** if using a Mac.

Monitor Callibration

To get the best out of this book, and when viewing and editing your own night sky images, you should be able to see all the steps in the chart below, particularly differences between A, B and C. If not, it's time to ***calibrate your monitor***.

THE SKY AT NIGHT

The Celestial Sphere

It is easy to stand outside at night, away from the lights of the city, and enjoy the sight of thousands of stars and our Milky Way galaxy without knowing very much about what you are looking at. And you can learn to photograph the night sky without learning the names of any of those stars or the shapes and patterns (constellations) that they form. But it is helpful, and hopefully interesting, to learn at least a little about the night sky and how it changes from hour to hour, night to night and month to month.

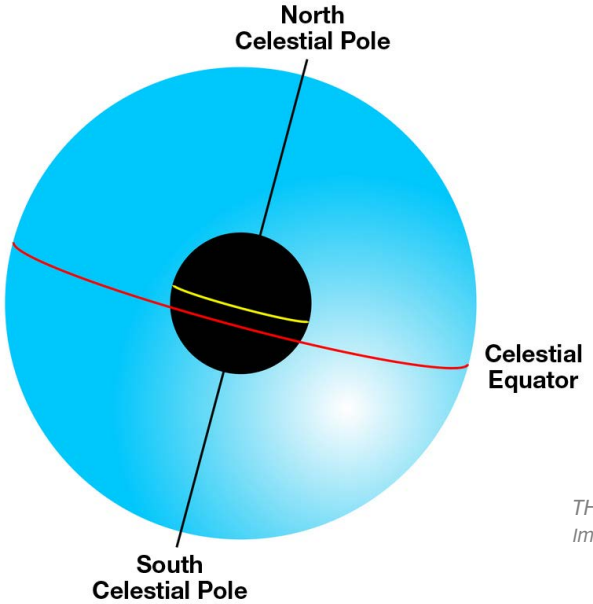
Imagine that the Earth sits in the middle of a giant sphere. Astronomers call this the **celestial sphere**. Just like using a globe to define the position of cities and countries on Earth, the celestial sphere allows us to define the position of things in the sky. So what we call the North Pole, South Pole and the equator on Earth we can also project onto this celestial sphere.

Each day, Earth rotates once on its axis, inside this imaginary celestial sphere.

If you were standing in the Arctic at the North Pole you would see 'Polaris', the famous pole star, directly overhead and conveniently marking what astronomers call the north celestial pole. All the stars in the sky would appear to rotate around Polaris overhead, while stars low in the sky would move from left to right all the way around the horizon at the same height, never rising or setting. It would be like standing inside a giant clear spinning top, looking straight up and seeing everything rotate around the spinning axis.

From the South Pole, the movement would be similar with the stars rotating around the point directly over your head (in the opposite direction to that of the Northern Hemisphere). However, there is no bright 'pole star' in the southern sky to conveniently mark this south celestial pole.

Standing on the equator, the movement of the stars looks very different. Imagine instead that you are inside a rolling barrel. The Pole Star near the north celestial pole is sitting on your northern horizon, while the south celestial pole sits on the southern horizon. The entire sky rotates around these two points, appearing to 'roll' over you through the night.



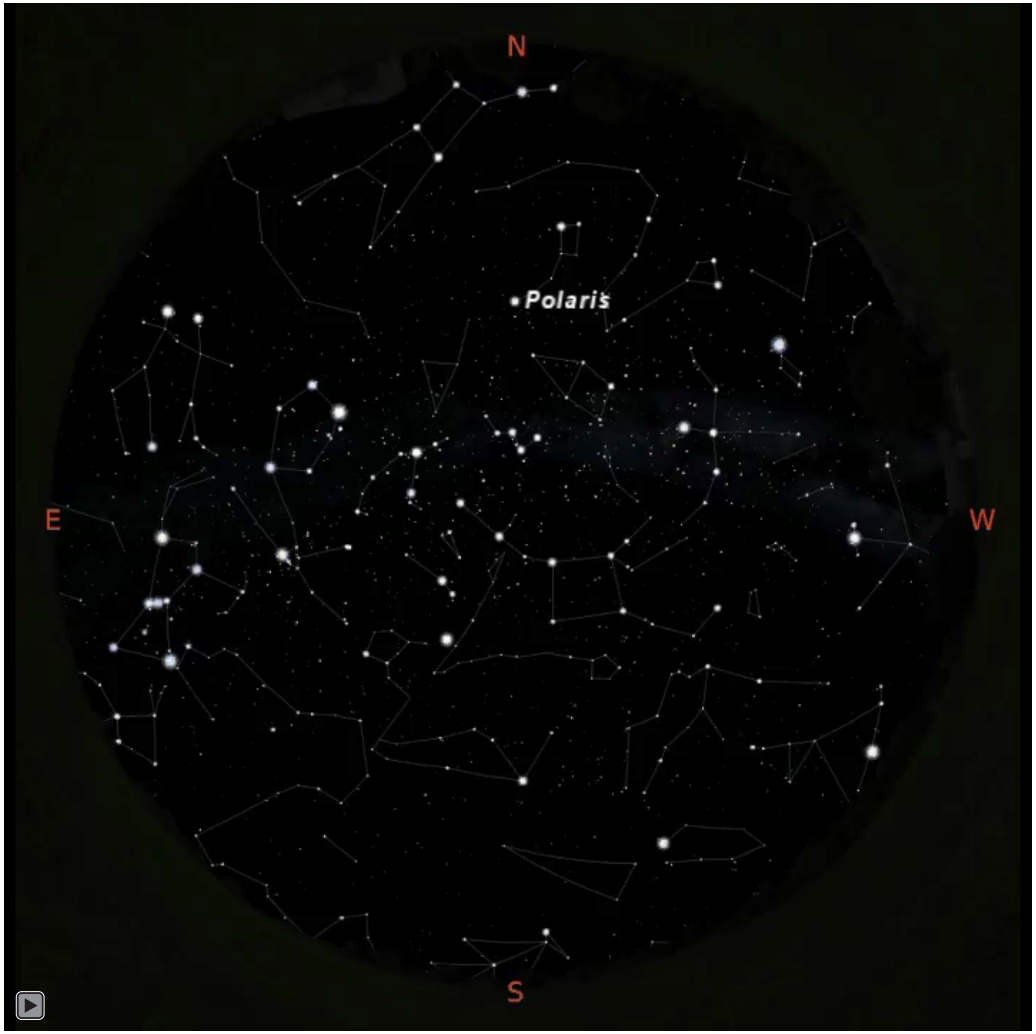
THE CELESTIAL SPHERE
Image: Fcn (Wikipedia)

As you travel north away from the equator, the north celestial pole rises above the horizon. At 40 degrees north, roughly the latitude of New York or Rome, Polaris and the north celestial pole will be the same 40 degrees above your northern horizon. The animation on this page shows the motion of stars across the sky from a location such as this. Stars close to the north celestial pole rotate around that point almost halfway up in the northern sky. Other stars closer to the celestial equator rise in the east, travel from left to right high up into the southern half of the sky and then down to set in the west. Stars close to the south celestial pole remain out of view below your southern horizon.

South of the equator, the geometry is reversed. At 35 degrees south, roughly the latitude of Sydney or Cape Town, stars appear to rotate around the south celestial pole the same 35 degrees above your southern horizon. Near the celestial equator, stars will rise in the east travelling from right to left high up in the northern half of the sky before setting in the west. Polaris and other stars close to the north celestial pole are permanently hidden from view below your northern horizon.

Click here to watch it at higher quality on Vimeo or if it does not play (eg. on an iPad).

ANIMATION OF NORTHERN HEMISPHERE NIGHT SKY (Stellarium)



The Sky through the Seasons

The seasons are governed by the tilt of Earth's axis and how much sunlight each hemisphere of the Earth receives each day. With the North Pole tilted towards the sun in July, the Northern Hemisphere has long summer days with the sun high in the sky and short nights, while the Southern Hemisphere has short days with the sun low in the sky and long winter nights.

In December with the North Pole tilted away from the sun, the Northern Hemisphere has its short days with the sun low in the sky and long winter nights while the Southern Hemisphere has long days with the sun high in the sky and short summer nights.

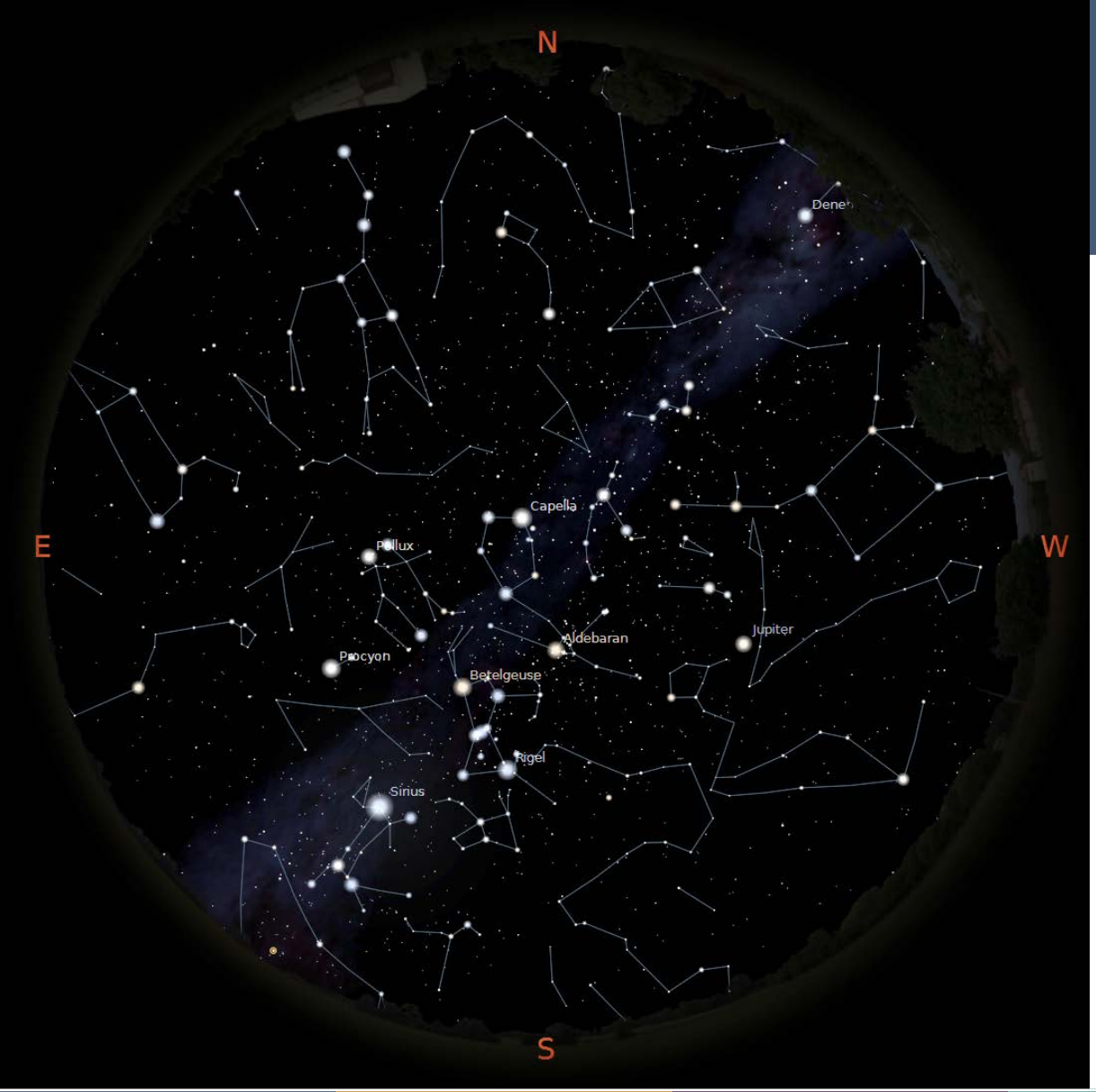
As the Earth moves in orbit around the sun, the sky reveals a different part of the celestial sphere each night, with the sun and daytime sky hiding our view of the other half. So the seasons are also characterised by which particular constellations (groups or patterns of stars) are prominent in the night sky at that time of year.

As they move around in their own orbits, the planets are not fixed on the celestial sphere (the name planets means 'wandering star'). So when they will be visible changes from month to month and year to year.

To see exactly what will be up in the sky each year, astronomers use 'planetarium' software. ***Stellarium*** is a great free open source planetarium program for Windows and Mac users with excellent visualisation of the night sky. You can select the town where you live and explore what's up at any time of year.

Monthly "Evening Sky Maps" from ***skymaps.com*** are great if you want a PDF that you can print to paper and take with you.

WINTER'S NORTHERN LIGHTS OVER SPRUCE TREES, CANADA
Canon 5DMKII, 24mm lens, 8 sec, f1.4, ISO800



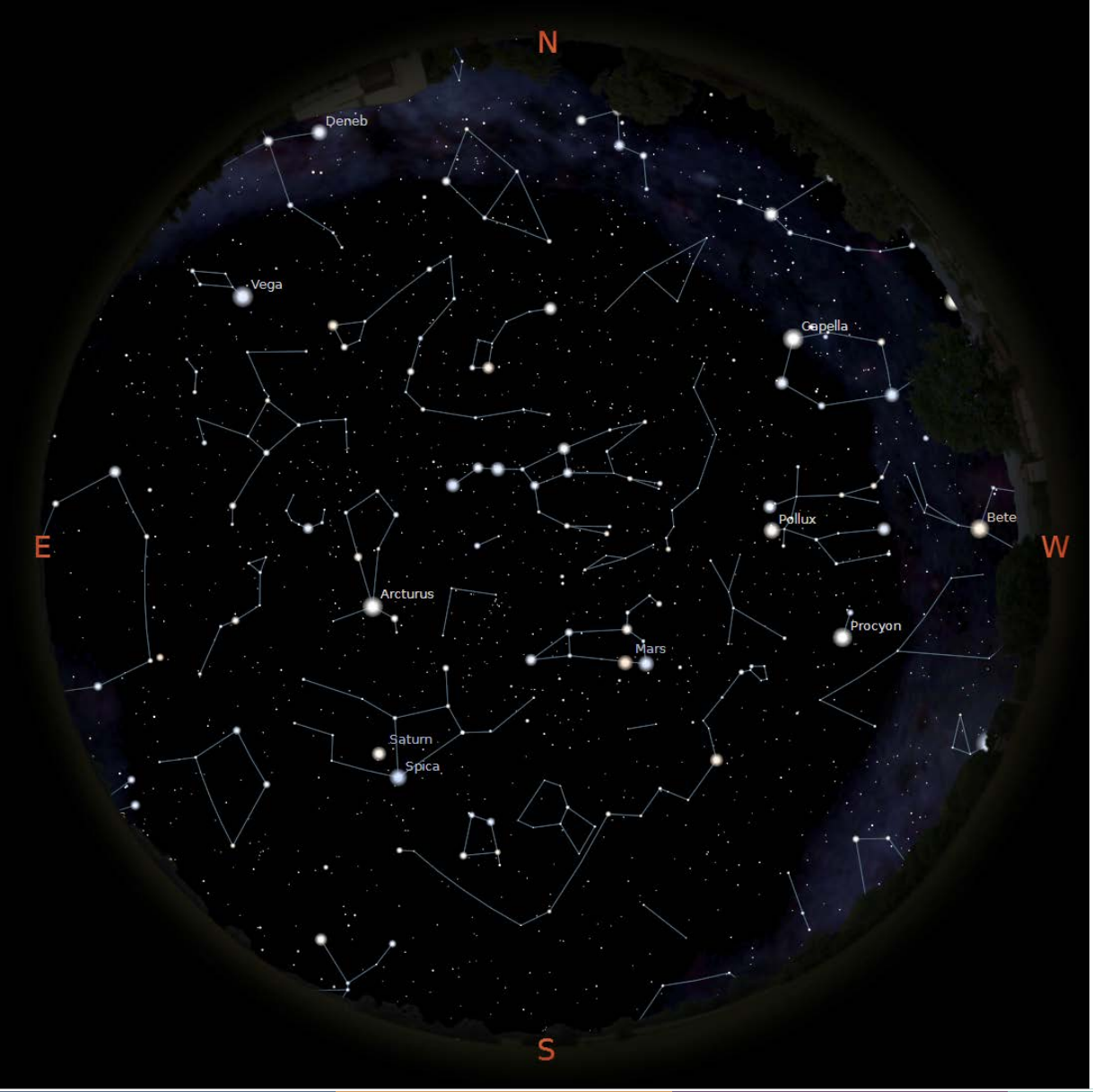
The Northern Hemisphere

These Northern Hemisphere charts have been prepared for a latitude of 40 degrees north, but will give a good indication of the sky from anywhere in North America, Europe and central Asia.

Winter

January 10pm

Perhaps the most famous constellation, Orion the Hunter and its bright stars Betelgeuse and Rigel rise high in the sky on winter nights in the Northern Hemisphere. Nearby are the bright stars Capella in the constellation Auriga and Aldebaran in the constellation Taurus the Bull. Surrounding them all is the faint outer arm of our Milky Way visible under a dark sky away from the city.

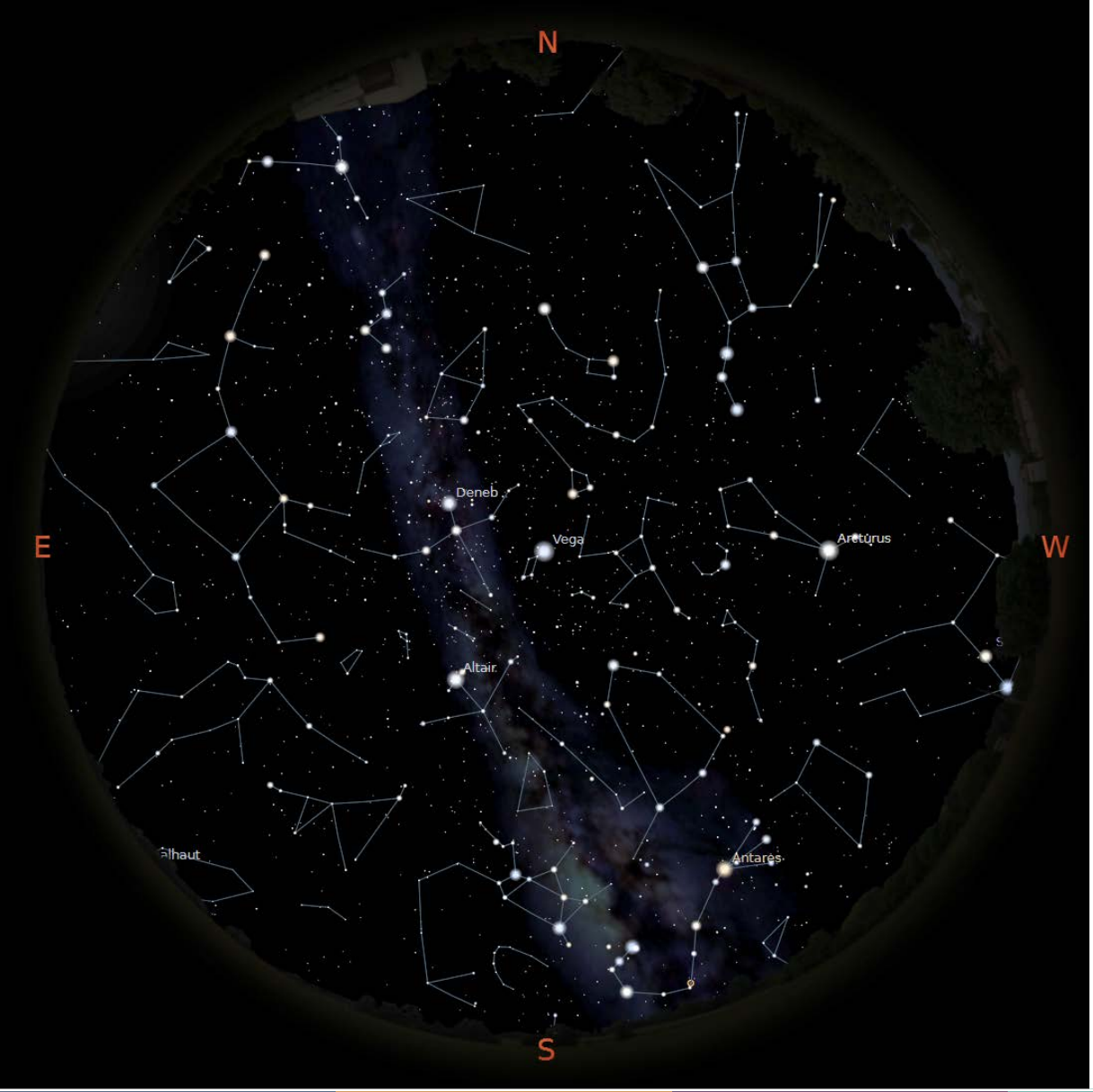


Spring

April 10pm

Ursa Major, the Great Bear, more commonly known as 'The Big Dipper', is high overhead at this time of year.

Arcturus is the brightest star in the sky at this time of year, almost overhead, but the Milky Way is not so well placed, setting in the west early in the night.

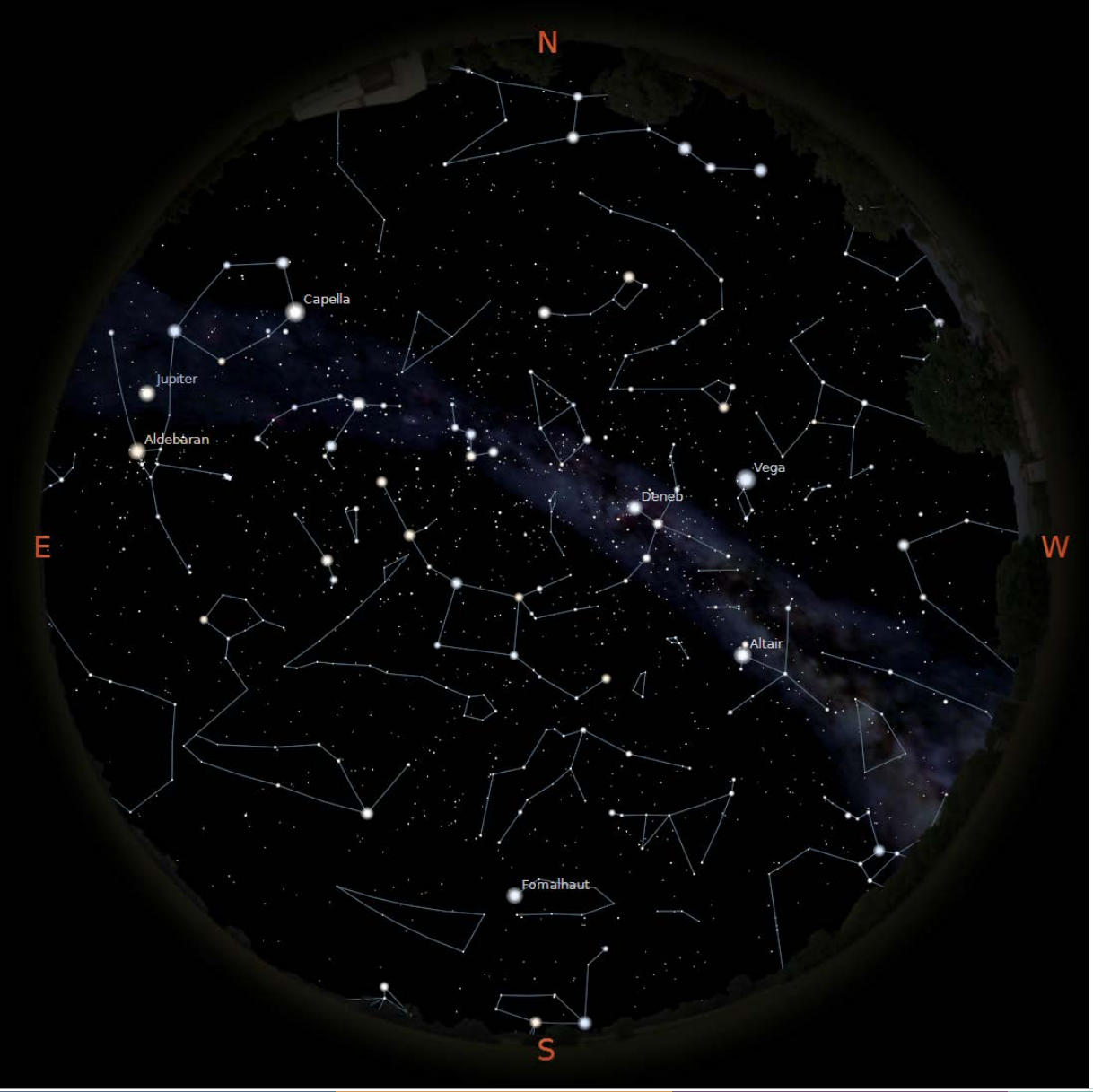


Summer

July 11pm

Summer nights also bring the most impressive parts of the night sky in the Northern Hemisphere.

The 'Summer Triangle' made up of the three bright stars Vega, Deneb and Altair is overhead marking the respective constellations of Lyra, Cygnus the Swan and Aquila the Eagle. They are set amongst the Milky Way, with the very brightest sections of our galaxy lower in the south near Antares in the constellation Scorpius.

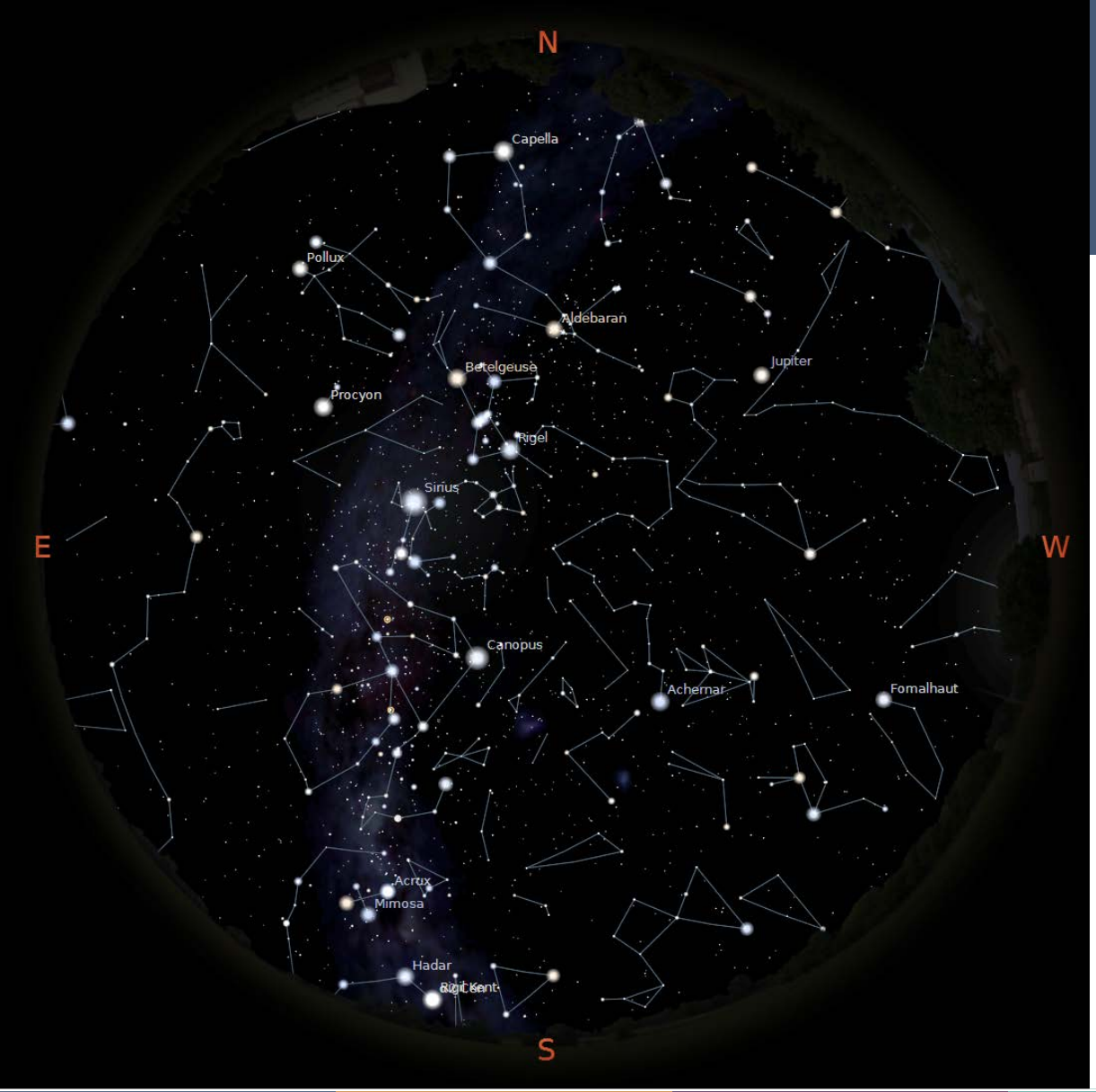


Fall/Autumn

October 10pm

As the nights get colder, the brightest parts of the Milky Way set early but the 'Summer Triangle' of Vega, Deneb and Altair is still high above the western horizon.

The fainter outer arm of the Milky Way rises in the north-east, around the bright star Capella.



The Southern Hemisphere

These Southern Hemisphere charts have been prepared for a latitude of 30 degrees south and will give a good indication of the night sky from anywhere in southern Australia and southern parts of Africa and South America.

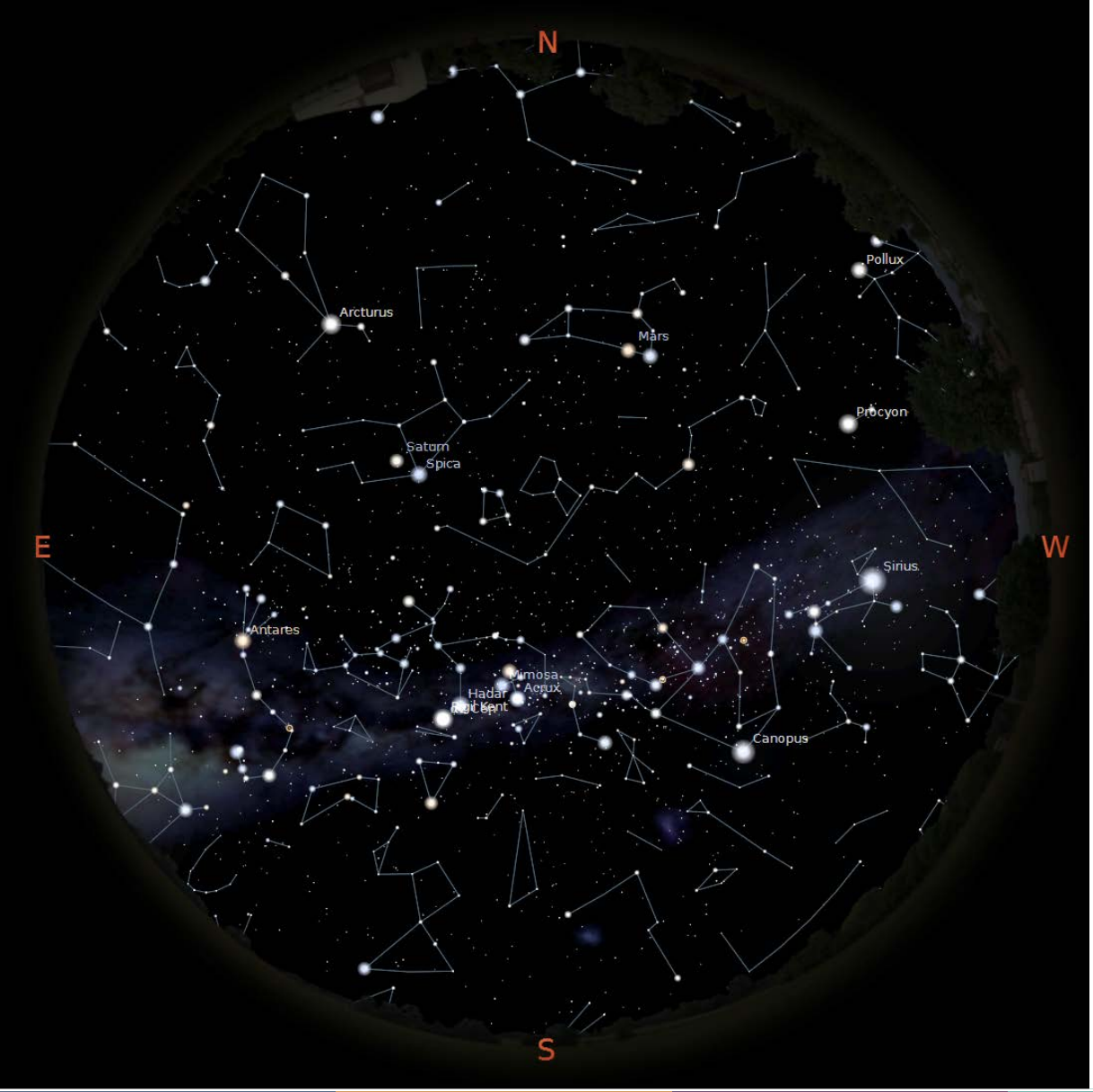
Summer

January 11pm

Summer skies are dominated by the constellation Orion (the Hunter) rising in the east and getting progressively higher as the night and the season move on. The belt and sword of the Hunter are commonly known in the Southern Hemisphere as the Saucepan.

Orion is accompanied by two hunting dogs, Canis Major and Canis Minor, with their bright stars Sirius and Procyon. Sirius is the brightest star in the sky – if you can see anything brighter it must be a planet (or a plane!). The bright southern stars Canopus and Achernar are also high up in the south (almost overhead).

The outer arm of the Milky Way passes overhead on summer nights, a faint broad river of light from millions of distant stars. Low in the south-east, the Southern Cross and the Pointers are rising and will be higher later in the night.

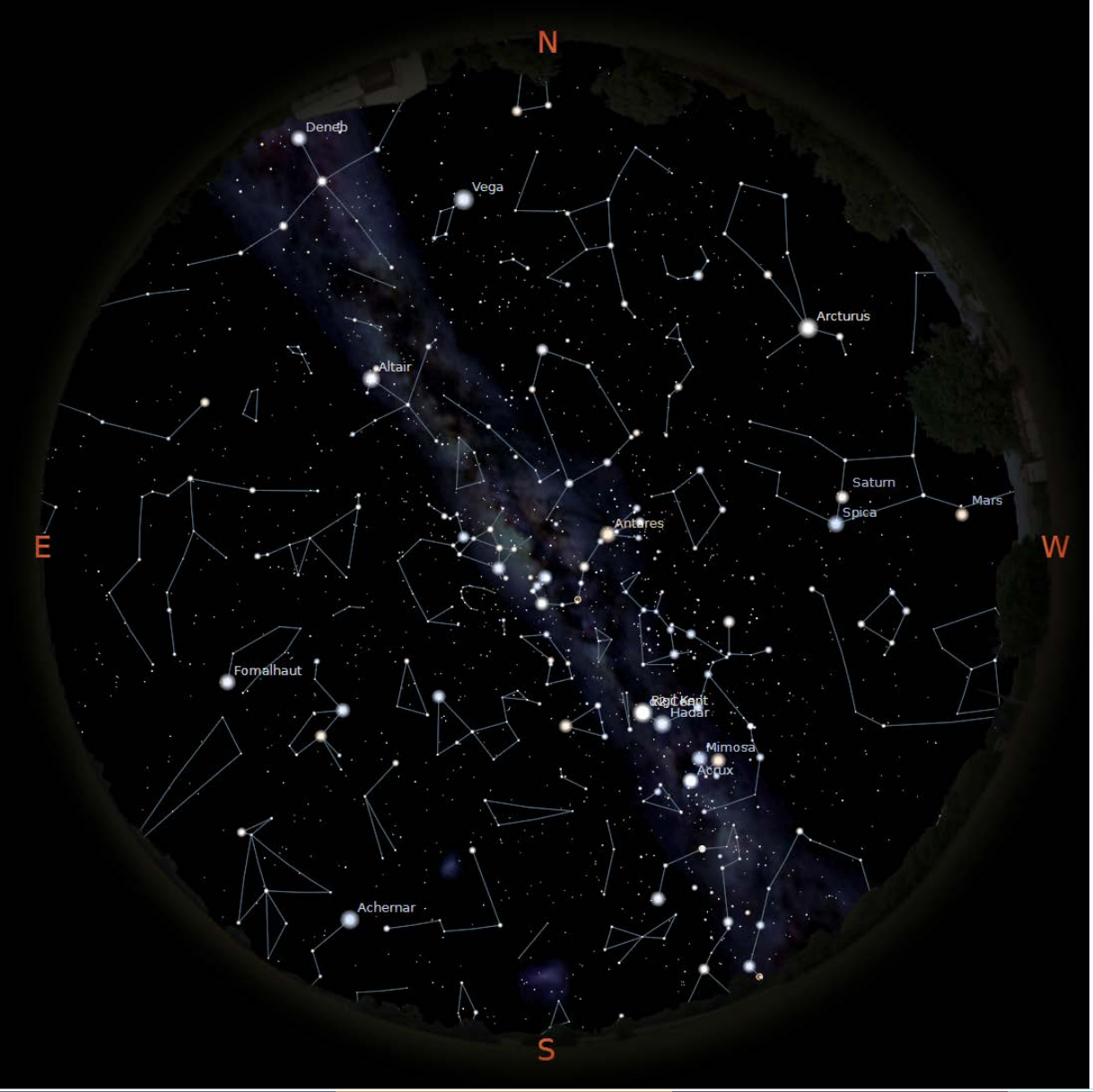


Fall/Autumn

April 10pm

As Sirius the brightest star in the sky sets in the west, the Southern Cross and the Pointers rise higher each night through autumn. These are the jewels of the southern sky and the constellations that many people will be easily able to identify.

Rising in the east later is Antares in the constellation Scorpius and the brightest parts of the Milky Way.



Winter

July 10pm

Winter nights may be cold, but it gets dark early and the full glory of the southern sky is on display. With the Pointers and Southern Cross still high in the sky, the constellations Scorpius and Sagittarius are moving high ahead, bringing the brightest central areas of our Milky Way galaxy overhead later in the night.

From a dark site away from the cities, the Milky Way arching all the way across the sky on a winter night is a most impressive night sky sight.

Spring

October 10pm

If you are lucky, spring nights can start to warm up a little, but if you get out early you can still catch the bright Milky Way before it sets in the west. The bright northern stars Altair and Deneb are lower in the northern parts of the Milky Way.

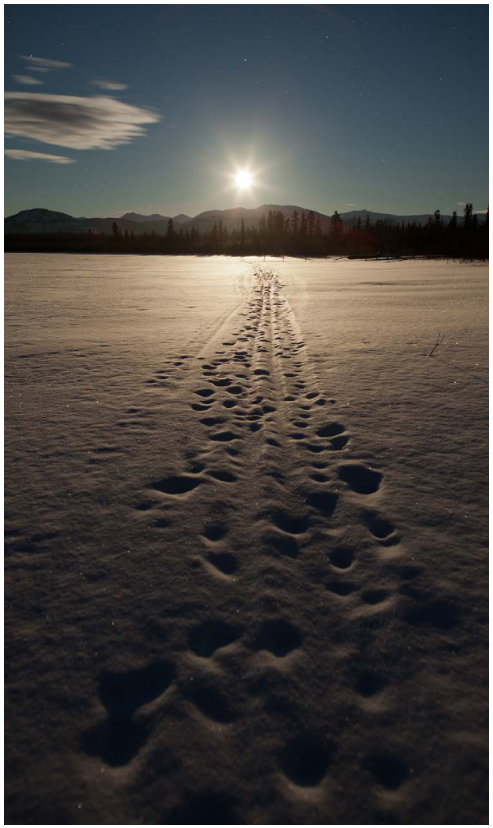
The bright star Achernar at the end of Eridanus 'the River' is high in the south, with the lonely star Fomalhaut high overhead. The Large and Small Magellanic Clouds are satellite galaxies of our Milky Way, and these 'clouds' rise higher throughout spring, but you will need a dark sky to see them.

The Moon

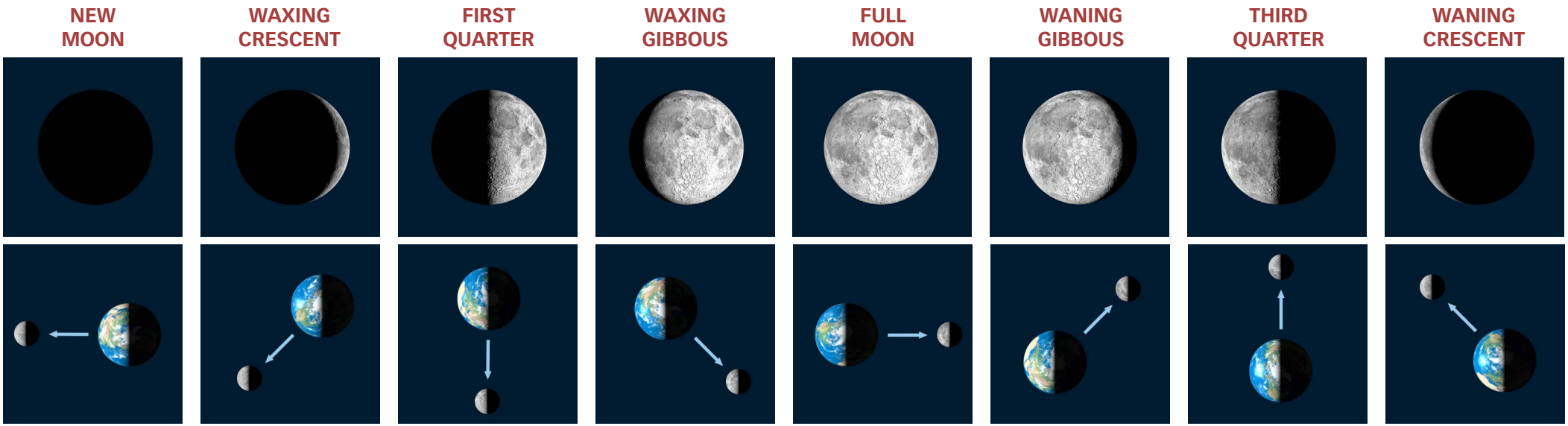
If nothing else in the sky, everyone at least knows the moon.

The moon travels in an orbit around the Earth each month. While one half of the moon is always in bright sunlight, how much of that sunlit side we can see from Earth depends on the relative positions of the Earth, sun and moon. This determines the 'phase' or shape of the moon that we see in the sky and at which time of the day or night it will be up in the sky.

Click here to watch it at higher quality on Vimeo or if it does not play (eg. on an iPad).



MOONRISE OVER SHALLOW BAY, YUKON TERRITORY
Canon 5DMKII, 24mm lens, 25 sec, f4, ISO400



At 'new moon', the moon is in between the Earth and the sun so it is not visible – with only the dark, unlit side of the moon facing us. On rare occasions when the alignment is perfect, the moon actually passes directly in front of the sun and we see a solar eclipse. Generally though, the moon is invisible to us around each new moon and very close to the sun in the sky.

A few days after new moon, the moon moves slightly away from the sun in the sky and we can see a slender crescent moon in the evening for just an hour or so until it sets shortly after the sun. We see a crescent because just a thin sliver of the sunlit half of the moon is visible to us. The rest of the moon is not completely dark though – light reflected back from Earth ('earthshine') weakly illuminates the rest of the lunar disc facing Earth.

With each subsequent day after new moon, the moon moves further away from the sun. It starts each night higher in the sky and the crescent grows larger ('waxing') as we see more of the sunlit side of the moon.

One week after new moon, the moon is at right angles to the sun and so the moon is split down the middle – bright sunlight on one side and dark on the other. This phase is called 'first quarter'. At sunset, the first quarter moon will be high in the sky and will set halfway through the night.

On following nights the moon becomes 'gibbous', with more and more of the sunlit side visible to us. Then two weeks after new moon, the moon is opposite the sun and we see all of the sunlit side (and none of the dark side). At this phase, the moon rises as the sun sets and the moon is visible all night. The bright illumination of a full moon through the night may be great for those interested in other outdoor night activities, but for astronomers the full moon washes out much of the sky with its bright light and only the brighter stars and planets are visible.

CRESCENT MOON WITH EARTHSHINE

After full moon, the cycle continues. The moon becomes gibbous again, rising well after sunset. By last quarter, when the moon is again split down the middle between light and dark, the moon only rises halfway through the night and so many people never see it at this phase. If you look carefully in the morning, you should be able to find the last quarter moon in the western daytime sky while the sun is in the east.

As the moon moves back closer to the sun, we see a crescent rising in the morning sky just before the sun, becoming smaller ('waning') until we get back to new moon again.

You can view the phases of the Moon for the current month, or any month ahead, at ***https://www.spaceweatherlive.com/en/moon-phases-calendar.*** In the example to the right:

- the week of 8th–14th around New Moon would suit photographing the Milky Way under a dark sky
- on the 15th and 16th you could capture a slender crescent Moon in the evening
- on the 27th you can capture the Full Moon rising in the east at the time of sunset, or a little later in the day or two after Full Moon.

Table of lunar phases

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2	3	4	5	6	7
Waning Gibbous	Waning Gibbous	Waning Gibbous	Waning Gibbous	Last Quarter	Last Quarter	Waning Crescent
8	9	10	11	12	13	14
Waning Crescent	Waning Crescent	Waning Crescent	New Moon	New Moon	New Moon	Waxing Crescent
15	16	17	18	19	20	21
Waxing Crescent	Waxing Crescent	Waxing Crescent	Waxing Crescent	Waxing Crescent	First Quarter	Waxing Gibbous
22	23	24	25	26	27	28
Waxing Gibbous	Waxing Gibbous	Waxing Gibbous	Waxing Gibbous	Waxing Gibbous	Full Moon	Waning Gibbous

THERE ARE MANY OTHER ONLINE RESOURCES FOR PHASES OF THE MOON AND TIMES FOR SUNRISE/SUNSET AND TWILIGHT, SUCH AS ***www.timeanddate.com/moon/phases/***

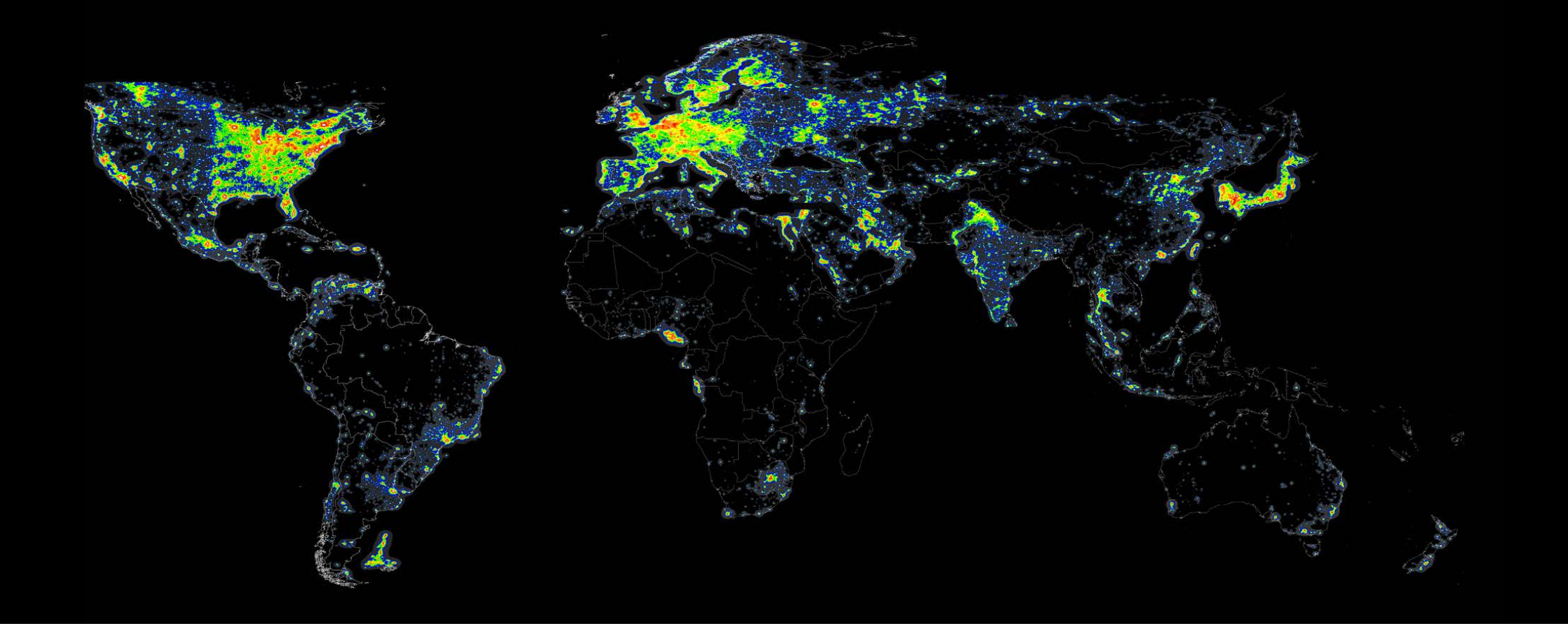
A SCALE REPRESENTATION OF THE DISTANCE BETWEEN THE EARTH AND MOON – Image: Cantus (Wikipedia)

Light Pollution

Unfortunately, it is not only the moon that interferes with the brightness of the sky at night. The bright lights of the cities are often poorly designed so that much of their light shines up in the sky rather than down on the ground where it is needed. This 'light pollution', much of it unnecessary, spoils our view of the night sky for a very large area around major cities and towns.

The maps on the following page were produced from satellite data by the Light Pollution Science and Technology Institute in Italy. They show the worst light pollution as white/red/orange, fading through yellow to green to blue and then dark skies as grey or black. For much of Europe and the eastern United States light pollution is hard to escape so get as close as you can to the blue zones. Coastal areas may offer slightly more accessible locations with somewhat darker skies looking out over the ocean, so your best bet may be to head to the beach!

Images: istockphoto



WORLD ATLAS OF ARTIFICIAL NIGHT SKY BRIGHTNESS
Image: Royal Astronomical Society

For those in the western United States and less populated areas of Europe and in Australia/New Zealand you should seek out truly dark skies away from the coloured zones on these maps. This can still require a long drive out of the big cities so make sure it's a moonless night too!

www.lightpollutionmap.info has light pollution overlay maps for the entire world so you can study the area where you live in detail.

Read More:

Visit the International ***Dark Sky Association*** online to learn more about light pollution and join the campaign to reduce it.

Weather

istockphoto

Cloud forecasts

Clouds are the enemy of astronomy and night sky photography, but they are notoriously difficult to forecast accurately, especially within a hundred miles or so of the coast. Although there are scores of websites and Apps offering cloud forecasts, most of them rely on the same freely available data from the United States GFS global weather model. While one of these may be good enough, if you are planning an observing night or weekend several days in advance, then comparing forecasts from more than one of the global weather models can be helpful to gain an understanding of the 'confidence' in the forecast.

And if you want the most accurate forecast for just the night or two ahead, it pays to look at a higher resolution regional model for your part of the world. I have listed a few key regions with some of the Apps and websites that cover them in the table on the next page. Forecasts from your own meteorological agency in other areas will always be worth a look.

- ***Astrospheric:*** Website and App using data from the Canadian Meteorological Centre for all North America. ***Clear Sky Charts*** is an older and simpler website providing the same forecasts.
- ***MeteoBlue:*** A full featured but complex website and App which provides a 'multi-model' view of several cloud forecasts which provides an indication of the confidence of the predictions.
- ***MetOffice:*** Website provides "Cloud and Rain" or just "Cloud Cover" maps for United Kingdom and Ireland. The App has worldwide coverage but includes only basic cloud forecasts.
- **ScopeNights App:** Makes use of data from several weather models including the European Centre model but is only available for iPhone.
- ***WeatherWatch MetCentre:*** The only site I know that provides forecasts from the high-resolution ACCESS-C regional models for Australian locations.

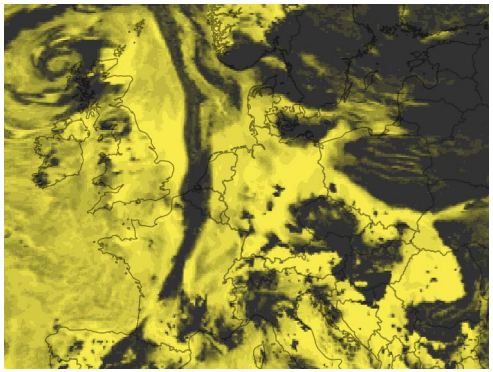
MOONLIT NIGHT AT GIBSONS STEPS, AUSTRALIA
Canon 5DMKII, 24mm lens 4 min, f4, ISO400

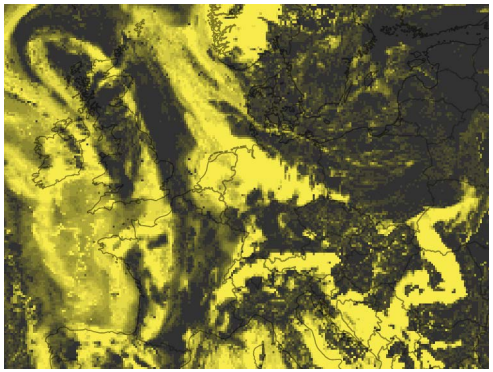
- ***YR.NO:*** This Norwegian site is the only free and easily available source I know with worldwide data from the highly regarded European Centre weather model. Worth checking out particularly for long-range forecasts. Select the 'English' version from the menu and search for your nearest town. Then choose the 'hourly' forecast and 'Expand Table' to get a full breakdown of the forecast for high, medium and low cloud.

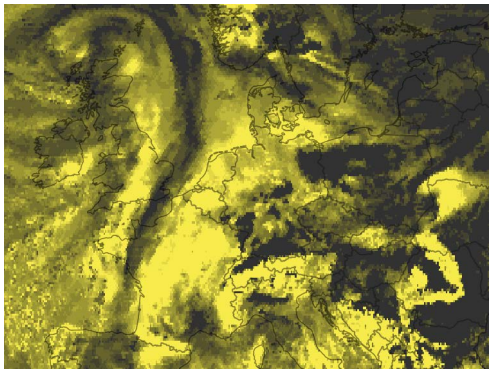
			Global Weather Models					Regional Models (high-resolution)				
	Web	App	GFS	ECMWF	GEM15	UKMO	ACCESS-G	NAM North America	GEM2 Canada	UKMET UK	ICON7 Europe	ACCESS-C Australia
Clear Outside	Y	Y	F									
DarkSky.net	Y	iOS	F									
yr.no	Y	Y		F								
Pivotal Weather USA/Europe only	Y		F	F	F	F		F	F			
Astrospheric	Y	Y	F						F			
Clear Sky Charts	Y			P					F			
Meteoblue (multimodel)	Y		F		F	F			F		F	
Meteologix (also ***Weather.us***)	Y		F	F	F		F	F			F	
ScopeNights		iOS	F	F		F		F		F		
MetOffice	Y	Y				F				F		
Weatherwatch MetCentre	Y		F									P

Y = Android and iPhone App iOS = iPhone App only F = Free or low-cost app purchase only P= Paid (subscription service)

To illustrate the benefit of comparing more than one weather model, here are example forecast charts for the European region from three different models issued four days ahead. Although there are similar large-scale weather patterns displayed, the locations that are forecast to be clear or cloudy change considerably. It is better to be aware of that variability rather than having false confidence in just one forecast. When the forecasts align then you can plan your night under the stars with greater confidence.







MeteoLogix

NIGHT SKY PHOTOGRAPHY

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STAR TRAILS AT GIBSONS BEACH, AUSTRALIA
Canon 5DMKII, 24mm lens, stack of 8 x 10 min, f4, ISO200

Your Camera at Night

While not always the case, photographing the night sky can certainly push your camera and lenses to their limits. There can be no more demanding optical test for a lens than trying to reproduce pinpoint stars of light across the frame and out to the corners of the field of view, especially when you need to work with the aperture wide open to capture what little light is available.

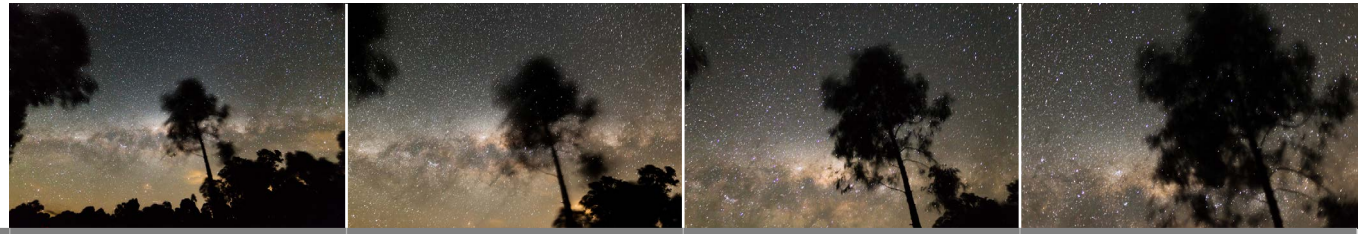
The sensor has to work hard too. When night sky photography gets serious, we are almost counting individual photons of light as they arrive at the sensor. Daytime photography is more like measuring flood levels by comparison. The ability of your camera's sensor to capture and record very weak levels of light accurately while minimising other sources of noise governs the quality of night sky images you can produce.

Thankfully, the sensors in modern DSLRs have reached outstanding levels in this regard and are now operating near theoretical limits. Compared to what was available in the early era of digital cameras ten years ago and certainly compared to film, the sensor in your camera is an amazing device. As a result, digital SLRs now open up photographic possibilities unheard of 15-20 years ago.

LENSES

Focal Length & Field of View

As is often the case, it is the type and quality of lens on your camera that will make most difference to your photographs of the night sky, rather than which particular camera you choose to use. You will probably find that the widest lens you have is the one you will use most often for night sky photography.



Lens	Super Wide Angle	Extra Wide Angle	Wide Angle	Standard
Cropped Sensor	10mm	15mm	18mm	32mm
Full Frame	16mm	24mm	28mm	50mm
Field of View	100° x 75°	75° x 50°	65° x 45°	40° x 25°

The field of view of your image is determined by the focal length of your lens and the size of the sensor in your camera. A typical 'cropped sensor' camera has a sensor 1.6 times smaller than a 'full frame' camera, so lenses need to have a focal length 1.6 times shorter to give the same field of view.

The images above of the Milky Way setting behind foreground trees give a sense of how much sky you can fit in with lenses of varying focal lengths for both types of camera. To understand the field of view figures, from the horizon to overhead is 90 degrees while a hand span held at arm's length is about 20 degrees. The moon is barely half a degree in diameter, which is tiny at this image scale.

Typical zoom lenses for cropped sensor cameras have a focal length of 18mm at their wide end, which is short enough to capture a good view of the sky. For full frame cameras, the equivalent standard zoom lens has a focal length at the wide end of 28mm.

Some wider zoom lenses extend this range down to 15mm on cropped sensor cameras or 24mm on full frame cameras. The difference might not seem like much on paper but that increased view often makes for a more aesthetically pleasing result.

Super wide angle lenses, down to 10mm on cropped sensor cameras and 16mm for full frame cameras, offer extremely wide fields of view but they can require a little more thought to produce a pleasing composition.

A 50mm lens was often considered a 'standard' lens for an old film SLR. But for night sky photography even 50mm on a full frame camera (or 32mm on a cropped sensor camera) is a relatively long focal length with quite a restricted field of view. The longer focal length also makes the movement of the stars more apparent, although the availability of very fast lenses in this range makes shorter exposures possible which compensates a little. However, it's a rare night when I use anything longer than a wide angle lens.

Fisheye lenses, both circular and diagonal, also offer interesting options. While distortion of the horizon is prominent, the effect hardly matters on the sky overhead since there will rarely be straight lines in your images.

Aperture

At night, we are severely limited by available light and so it is very common to work with the aperture of the lens wide open. Making matters worse, stars are small, sharp and demanding subjects. While you can easily hide a little softness in your daytime images, stars will clearly show the true quality of your lens.

The sequence below shows the stars of the Southern Cross from near the corner of a frame taken at various aperture settings with a 24mm f1.4 lens.

As expected from such a fast lens, wide open at f1.4 it produces bloated stars in the corners of the frame. But the sharpness improves quickly as the lens is stopped down to f2.8. Very few lenses can produce stars this sharp at f2.8, so we see for example that this is a good setting for this lens when sharp stars are important. Just as often though, I use the lens wide open at f1.4, choosing more light over sharper stars. Stopping down further to f4 produces little further improvement and in fact the bright stars are now so sharp and small that they are getting 'lost' among the background fainter stars. So a small amount of blurring from the lens is not such a bad thing.

For most people using a zoom lens with a maximum aperture of f3.5, you will generally have little choice but to use it wide open and accept whatever image quality it provides at that setting. Only when you are shooting with bright moonlight or a long exposure star trail will you reduce the aperture from its widest setting.

What lens should I use?

For many people, the standard 18mm zoom lens often purchased with a cropped sensor camera will be your best bet, especially while you are getting started. The following notes will give you something to think about when you're ready to upgrade.

Zoom lenses are popular multi-purpose tools, but their slower focal ratios are not ideal at night. Prime lenses (fixed focal length) are generally faster and offer better optical performance than a zoom lens at a similar price, or even any price.

28mm f1.8 lenses are readily available for full frame cameras from several manufacturers and provide an affordable starting point for night sky imaging. Faster, wider and more expensive 24mm f1.4 lenses are my personal favourite, available for most camera mounts. At the wider but slower end, my 14mm f2.8 gets plenty of use as well. The Canon 16-35mm f2.8 and expensive but highly regarded Nikkor 14-24mm are nice alternative options to have in your kit bag. The Sigma ART series of fast prime lenses are all excellent for night sky photography.

Ideally, there would be a budget prime 18mm f1.8 lens available for cropped sensor cameras, to match the 28mm field of view on a full frame camera. But such a lens does not seem to exist yet, so the choices are more limited. The Samyang 10mm f2.8 is a solid and affordable ultra-wide prime lens option and a good place to start. The Sigma 18-35mm f1.8 is an expensive zoom but performs very well even wide open at f1.8. This fast aperture is helpful in night sky photography if you are willing to accept 18mm as the wide end of the range. The slower Canon 10-22mm lens is a good option I have used regularly, which offers a super wide field of view. The Sigma 10-20mm appears similar. The best value extra wide zoom lens I have come across for cropped sensor cameras is the Tokina 11-16mm f2.8. Many participants on my workshops have used this very successfully and it is available for most camera mounts. It is also worth considering some of the faster fisheye lenses which offer interesting possibilities in a fixed focal length lens, particularly if you already have one in your kit.

Perhaps the best option for cropped sensor cameras is to use some of the ultra-wide full frame lenses. If you invest in one of these, you will be well positioned if you later make the upgrade to a full frame camera. The Samyang (aka Rokinon) 14mm f2.4 is good value, while the Sigma ART 14mm f1.8 offers a faster option with a higher price tag (and is a very heavy lens). On a budget, you can pick up an older Samyang 14mm f2.8; heavy vignetting and distortion with this lens can be corrected with Lightroom lens profiles available online.

TIP: Because you can't see easily through the viewfinder at night, keep checking that your zoom lens is at the setting you want it on (often the widest end of the range). It's easy to accidentally move the zoom ring when you are working in the dark and not realise. Also watch out for zoom lenses with loose mechanisms where the weight of the lens barrel may cause the focal length to shift while you leave the camera pointing up at the sky.

Some short, fast lenses worth considering:

Cropped Sensor Cameras

Fixed Focal Length

- Samyang 10mm f2.8
- Sigma 10mm f2.8 and other diagonal fisheye lenses to suit your camera
- Canon/Nikkor 20mm f2.8

Zoom

- Tokina 11-16mm or 11-20mm f2.8
- Canon 10-22mm f3.5-5.6
- Nikkor 16-85mm f3.5-5.6
- Sigma 10-20mm f3.5
- Sigma 18-35mm f1.8

Full Frame Cameras

Fixed Focal Length

- Canon/Nikkor/Pentax/Samyang 14mm f2.8
- Samyang (Rokinon) 14mm f2.4
- Canon/Nikkor 24mm f1.4
- Sigma 20/24mm f1.8
- Sigma ART series 14mm, 20mm, 24mm, 35mm
- Various 28mm prime lenses (f1.8 and faster) to suit your camera

Zoom

- Canon 16-35mm f2.8
- Nikkor/Sigma 14-24mm f2.8
- Tokina 16-28mm f2.8

One of the most important skills to learn in night sky photography is how to get the focus right. With the aperture often wide open at night, focus must be precise and stars are demanding subjects which will easily show if it is not 'spot on'. With autofocus as standard, most people rarely use anything else, but at night there is not enough light and contrast for your camera to be able to autofocus on the stars.

Here are three different methods that I recommend for getting your focus right at night. Try them all and see which one works best for you.

FOCUS

Method 1: Autofocus on a Flashlight

Most lenses will be able to autofocus on the moon or a distant bright light if you can see one, but wide angle lenses for night sky photography will not generally be able to autofocus on even the brightest stars.

You can also autofocus before the sun sets; switch the lens to manual and hope that the focus ring does not get bumped in the meantime. You may be able to mark this position in some way or tape the focus ring down so that it can't move, but none of these are ideal options.

Instead, my recommendation is to place a flashlight about 15-20 metres (50 feet) away, pointing back at the camera. Autofocus on the flashlight using the central focus point, then switch the camera back to manual focus and you're ready to go.

This is one of the simplest and easiest ways to get your camera focused at night and should work with any SLR and lens. Note that this technique only works with wide angle lenses where 20 metres away is the same as infinity focus as far as the camera is concerned. You should not use this technique if you are photographing the moon with a telephoto lens.

Image: Carlyn Iverson

Method 2: Liveview on the Stars

Most recent digital SLRs include a **'Liveview'** option, allowing you to see the view live on the LCD screen of your camera. Point the camera at a bright star and try to find the star near the middle of your Liveview screen. Zoom in on the Liveview screen and make tiny adjustments to the focus until the star is as small as you can get it. The animation below shows what you can expect to see as you do this.

Click here to watch it at higher quality on Vimeo or if it does not play (eg. on an iPad).

Liveview focus on the stars is great if you can make it work, but the tricky bit is that the lens needs to be roughly in focus before you start otherwise no stars will be visible at all. Even then, with slower lenses it can be very difficult to see any stars, bearing in mind that it is just a video mode. One trick is to try to centre the camera on a bright star, then zoom in a little in the middle of the Liveview screen as that makes the stars a little easier to see (so long as you are looking in the right spot).

Despite the difficulties, Liveview can be very convenient. You can also combine these first two options, by using Liveview to focus on a flashlight you place well away from the camera. The flashlight is bright and easy to find in Liveview and it saves you having to centre the autofocus spot over it.

Sharp focus

Soft focus

Method 3: Step-through Manual Focus

I routinely perform a focus test, where I manually step the focus through a series of small changes and then playback and review the images on camera to decide which setting represents best focus.

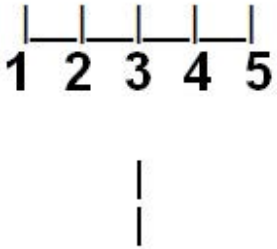
The instructions for this technique depend on whether you focus by rotating the front of the lens (external focusing) or whether your lens has an internal focusing element, in which case the front of the lens does not rotate when you adjust the focus ring.

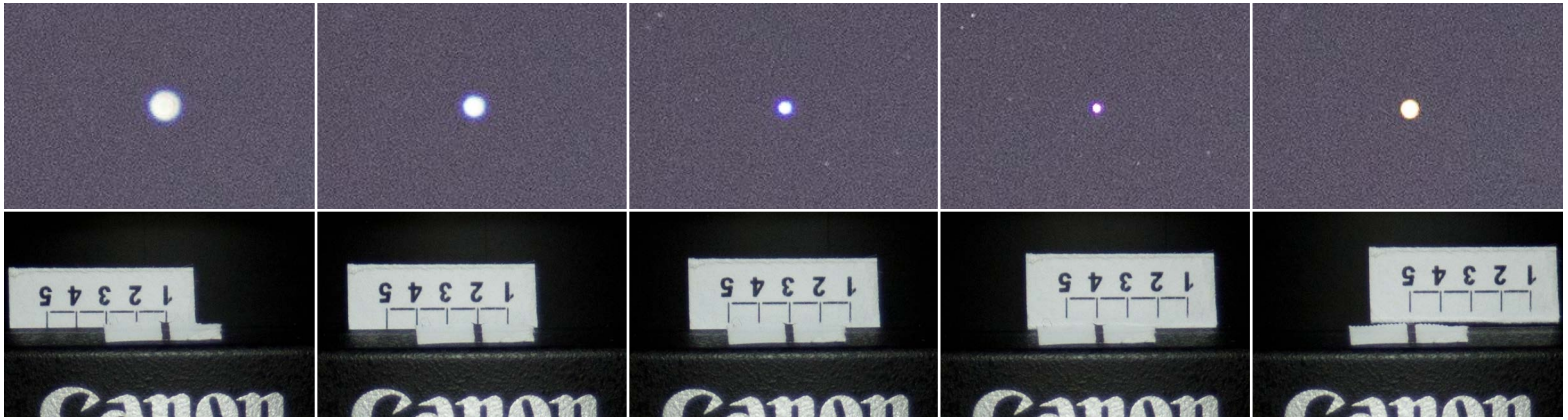
External Focusing

With these lenses, you manually focus the lens by turning the front of the lens (the same part that moves when you autofocus). Typically there are no markings on such lenses to indicate focus distance, so I place a small sticker of my own on the front of the lens. I usually place a numbered scale on the rotating element and a single mark on the non-moving part of the lens barrel, as shown in the image. Make sure the lens is roughly focused at infinity (e.g. during the day) when you position the numbered scale relative to the fixed marker on the lens.

This scale allows me to take a series of exposures as I step the focus through each of the positions marked. I typically use a 5 second exposure with the lens wide open and ISO set to 1600. After taking the sequence of images, changing focus with each frame, I then study the results by magnifying the image and reviewing the same star in each image as I flick between them. It is easy to see the focus getting sharper from one image to the next, till you get to the sharpest image and then they start getting worse again. In the example below, the fourth image was sharpest, so I simply rotate the front element of the lens until the #4 mark is lined up and then I'm ready to shoot.

Here's a copy of the scale and marker that I stick on my lenses which you can copy and print, or you can even draw something up by hand. If you find there is a large change in focus between each step, then try to make the scale smaller.





Internal Focusing

More expensive autofocus lenses have internal focus mechanisms (often referred to as 'ultrasonic'). In this case, you can see the focus scale inside the camera move as the autofocus operates, but the external focus ring does not. You can manually move this ring around at any time independent of the autofocus mechanism.

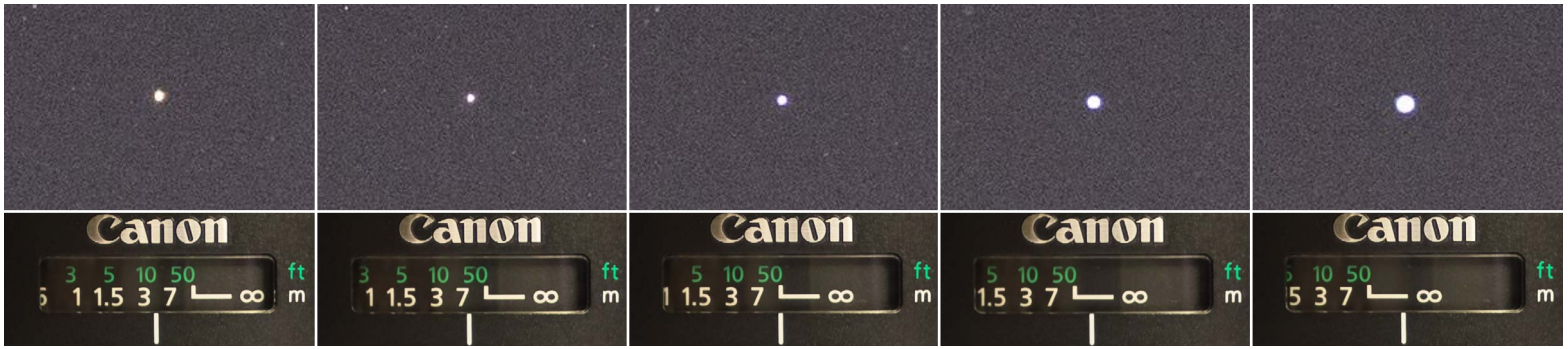
While you can use the focus marks shown inside the lens, with most lenses you cannot simply line up the infinity focus mark and expect the stars to be sharpest at that setting.

To establish exactly where the correct focus point is, set the camera on a tripod pointed at a distant object and switch it to **manual focus**. Take a series of photos with the aperture wide open as you move this focus ring through say five small steps around the infinity mark, looking carefully at the scale each time (see example below). After magnifying zooming the image in and reviewing the sequence of images on screen, it should be easy to determine which position represents 'best focus'. Remember that setting or even sketch it in a notebook if you can.

The example below is typical of what this test shows at night, also using 5 second exposures of the stars with the lens wide open at ISO1600. In this case, the second image is sharpest which is slightly closer to the 7m and 50ft marks on the scale than the infinity position (third image below). Having noted that position down for that 15mm zoom setting, I can simply dial the focus ring to that position anytime I am outside at night and be ready to shoot straight away.

While a little time consuming, testing your lenses in this way can be very educational (and saves time in the long run). And if you watch what happens as you autofocus on a distant object during the day, you may find that even though you are pointing at the same object, the focus position selected by the camera varies considerably. If you are shooting in bright conditions with the aperture stopped down, the difference will not be noticed, but with the aperture wide open even a small change in focus position can be important. Being able to manually (and quickly) select the right infinity focus position can be very helpful in a number of photographic settings, not just at night.

TIP: As you move the camera around during the night, try to avoid bumping the focus ring as it's easy to accidentally move it. To be sure, refocus often during the night – it gets easier with practice! **And if you alter the zoom setting on your lens, you will generally need to refocus then as well.**



SHUTTER SPEED

30 seconds (30”) is my typical exposure length for a night sky scene with a wide-angle lens. It offers about the right compromise between getting as much exposure as possible while keeping the trailing of the stars down to an acceptable level. Conveniently, it is also the maximum exposure that most cameras can do without needing to use the bulb setting.

If the stars didn’t move, night sky photography would be a whole lot easier. You could stop down the aperture on the lens to get nice and tight stars and stick the camera on a tripod with a very long exposure to build up a decent exposure.

UnfortunatelyUnfortunately, the world turns and so the stars move (remarkably quickly, as you may discover once you start pointing a camera at the sky). Consequently everything is a compromise. You need the aperture open wide to get the bare minimum amount of exposure before the stars have noticeably trailed across your image.

18MM LENS, 60 SECOND EXPOSURE
LOOKING EAST/WEST

18MM LENS, 60 SECOND EXPOSURE
LOOKING NORTH/SOUTH

How quickly the stars appear to move and trail across the image depends on the focal length of the lens and also to some extent on which direction you point the camera.

Stars near the celestial poles travel in small circles while near the celestial equator they travel all the way across the sky. So star trails in a short exposure will be significantly longer shooting east or west compared to shooting towards the celestial poles (north in the Northern Hemisphere, south in the Southern Hemisphere).

While 30 seconds is what I recommend for most night sky scenes, the table suggests some slightly higher maximum exposure times when you're trying to capture as much detail as possible and can tolerate some trailing of the stars. Of course, with digital cameras you can simply experiment to find your own balance between capturing more detail and keeping star trails to a minimum.

As you increase the focal length of the lens, the star trails naturally increase as well. A 50mm lens is about the practical limit for producing sharp stars in short exposures on a tripod. With telephoto lenses, some form of motorized mount to track the stars becomes necessary.

Suggested Maximum Exposures		
Focal Length	Facing North or South	Facing East or West
<15mm	90″	45″
15-30mm	60″	30″
30-50mm	30″	15″

TIP: When your camera displays the shutter speed, a number like 4, 60 or 250 means that number as a fraction of a second (i.e. 1/4, 1/60 or 1/250 of a second, which are typical daytime shutter speeds).When you want an exposure of several seconds, you need to turn your exposure dial until you see 1″, 4″ or 30″. The ″ symbol indicates seconds rather than just fractions of a second exposure. It may seem obvious, but if you're not used to programming long exposures in Manual mode it might not be something you've had to consider before.

NORTHERN HEMISPHERE STAR TRAILS
Canon 5DMKII, 14mm lens, 15 min, f5.6, ISO400

ISO AND NOISE REDUCTION

I recommend using quite high ISO settings, around ISO1600-3200, for night sky scenes on a dark night. Over the next few pages, I discuss the reasons why I make this recommendation and also the types of noise that affect long exposure images in low light conditions.

What does the ISO setting do?

The sensor in your digital SLR is a remarkable device. Each pixel in the sensor reacts to incoming photons, ideally converting them into electrons and generating a charge that can be measured. At the end of each exposure, the camera 'reads out' the amount of charge at each pixel.

Before converting the charge levels to a digital value and writing them to an image file, your camera amplifies the levels recorded in each pixel. The higher the ISO setting on the camera, the more amplification is applied. But in the world of digital sensors there is no such thing as a free lunch. Amplifying the signal from the sensor, or 'stretching' the image, also amplifies the various types of noise present as well. It's important to note that high ISO settings are not 'adding' noise to the image, they are merely stretching the noise that is inherent to low-light images. Very high ISO settings also reduce the dynamic range that it is possible to capture in your image.

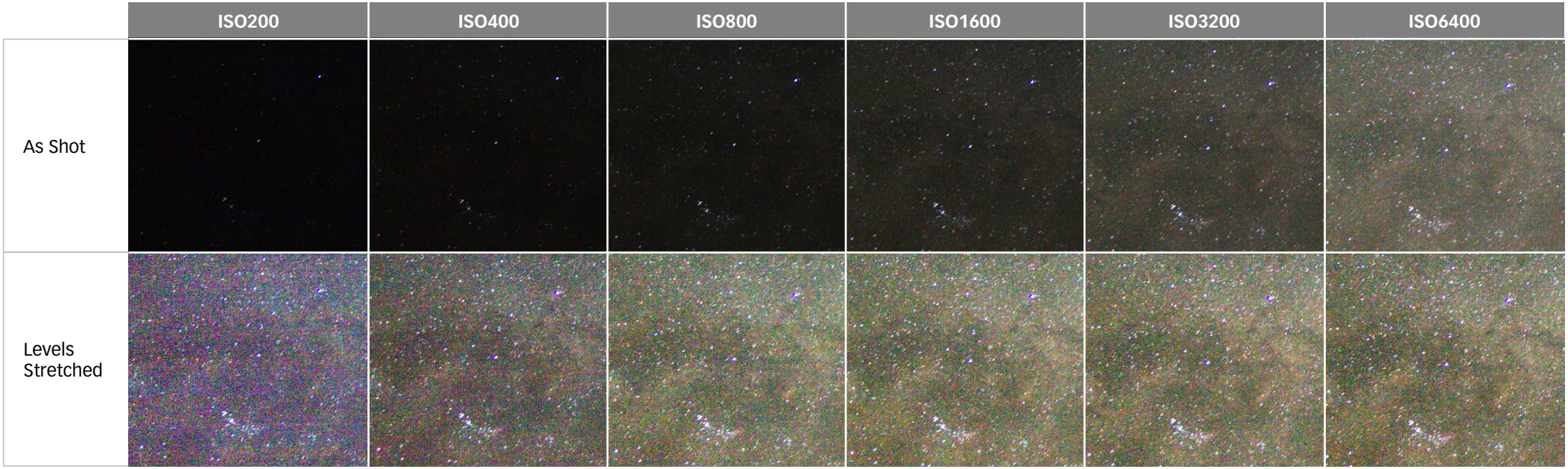
So the question then is how much ISO amplification is the right amount? The surprising answer to this, at least with recent digital SLRs working in the top half of their ISO range, is that it actually does not make all that much difference. Whether you increase the amount of amplification in the camera or stretch the image further in software later, the final image can look surprisingly similar.

Consider the test sequence shown on the following page, taken with a Canon 1100D (Rebel T3). The top row shows a series of images each with the same 30 second exposure time and f3.5 aperture. Only the ISO setting varies between images. The bottom row shows the same images after the levels have been adjusted in Lightroom so that they are all of about the same brightness.

In the images 'as shot', not until at least ISO3200 do we appear to have a properly exposed image as we would like to see on the back of the camera. However, after digitally stretching the images with software we can see that much of the same information is present in each image. The images at ISO200 and 400 still look visibly worse than the others, but at ISO1600 and above the images all look very similar. In other words, it would not have mattered whether you shot this image at ISO1600 or ISO6400, the end result is very much the same.

Once you have reached a sufficient level of ISO amplification, it makes little difference whether you apply more amplification with a higher ISO in the camera, or whether you apply a greater amount of digital stretching in post-processing.

TIP: Some cameras will display very high ISO settings as H1, H2 or Hi1, etc., rather than an ISO figure. Refer to the manual if it's not clear what ISO speed these relate to. In some cases these high settings are only enabled through Custom Settings. Generally there is little benefit in using these very high settings, at least when shooting RAW.



What ISO setting should I use?

For night sky scenes, select a high ISO setting that gives you a well-exposed image on the back of the camera. This is typically ISO3200 with most zoom lenses and ISO800 or 1600 if you have a fast prime lens. Although you can shoot at a slightly lower ISO setting and post-process it later for a similar result, it's more important that you can see your image clearly on your camera screen as you shoot, so that you can assess the composition and also get excited about what you are photographing!

Because the dynamic range is greatly reduced at higher ISO settings, review your images as you take them and wind back the ISO setting if any part of your image is getting over-exposed (this is rarely a problem, at least on a dark night).

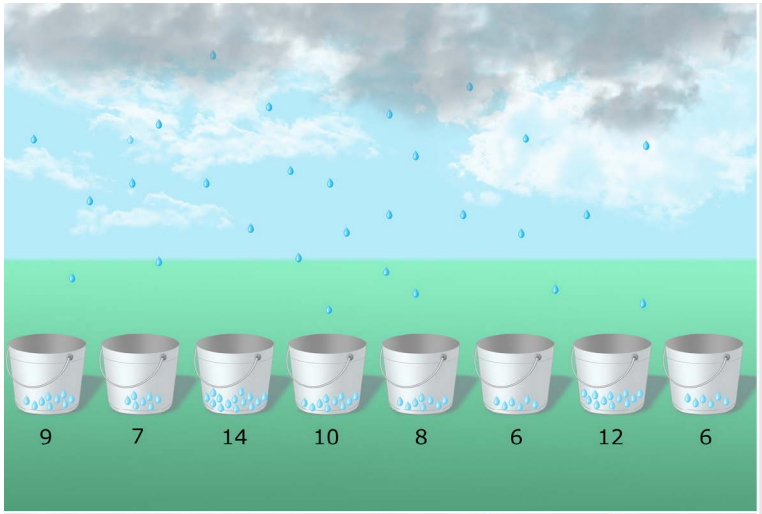
While it may be obvious, the most important thing to remember about the ISO setting is that it does not affect how much light you capture during your exposure. The best way to reduce noise in your image is to increase the amount of light the camera actually receives by extending the exposure time or opening up the aperture as much as possible. So if you are shooting in twilight, bright moonlight or are capturing long exposure star trails and you can achieve a fully exposed image at a lower ISO setting, then that should always be your aim. An image that receives more light and does not need to be 'stretched' either with ISO amplification or during post-processing will always show less noise.

NOISE

Types of Noise in Digital Images

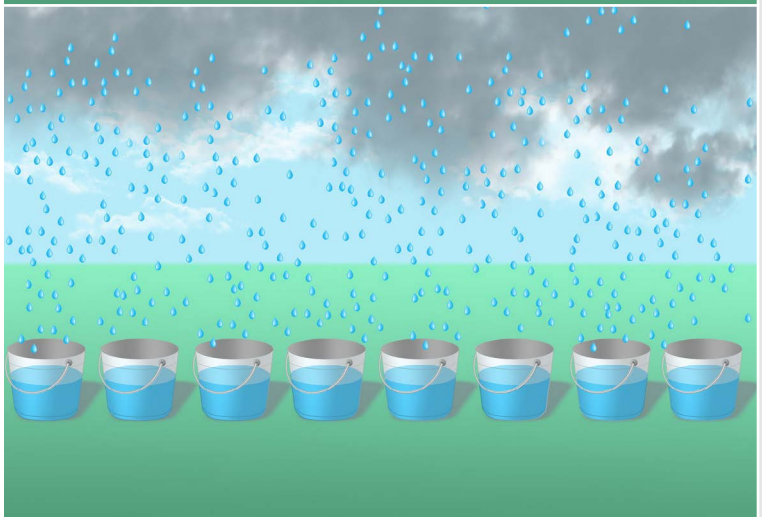
Shot Noise – A Rainfall Analogy

Picture a day when it is just starting to rain lightly, and you can see individual drops of rain as they leave a wet spot on the ground. Despite the grey cloud above seeming perfectly uniform, some raindrops land on top of earlier ones while other bits of ground stay dry for longer.



Now imagine that you have placed a row of eight small buckets outside to catch the rain. In the first minute with just a few rain drops falling, you count the number of drops that land in each bucket. What you find is shown in the image here.

While the average number of drops in each bucket is 9, there is a large variation between the buckets. Most of the buckets have between 6 and 12 drops, which is 9 +/- 3. So we can say that the 'noise' among our bucket values is very high, around 30% of the average value.



Later the rain becomes quite heavy and after half an hour the buckets are three-quarters full.

Tens of thousands of raindrops have now fallen into each bucket and the level in each bucket appears almost identical, so we could say the variation or noise is now very low.

Statistical theory tells us that the difference between each bucket would indeed be less than 1%.

Images: Carlyn Iverson

Taking photos of the sky during the daytime is like measuring the level of water in the buckets that have been well filled. The pixels in your sensor receive so much light that you can expect the brightness values in your image to be quite consistent with very little noise or random variation from one pixel to the next.

Capturing images at night is more like counting the first few raindrops that fall into our buckets, except we are counting photons of light rather than raindrops. The pixels in your sensor receive very little light and so the effect of random variation in how many arrive at each pixel is quite high. The technical term for this random variation is **shot noise**. The important thing to understand about shot noise is that it is no fault of your camera – it is a natural statistical result of trying to record the very faint light of the night sky.

Shot Noise and Pixel Size

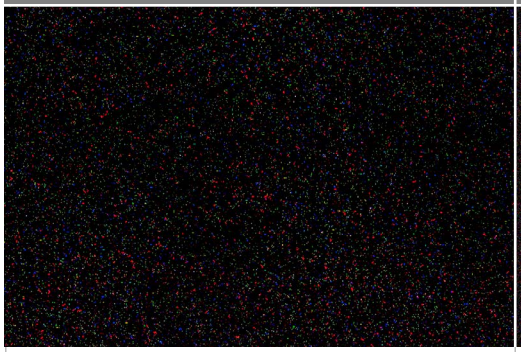
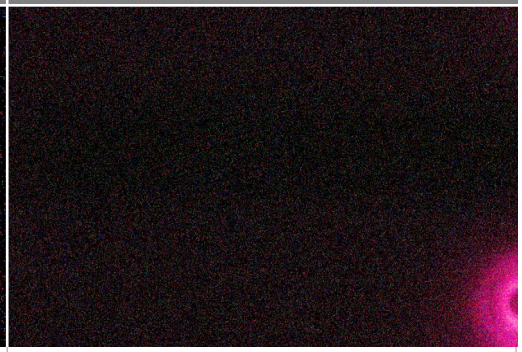
The one main aspect of your camera that does affect this random shot noise is the pixel size. Smaller pixels are like having smaller buckets, so they collect less light and therefore shot noise is more significant. While you may prefer a camera with more 'megapixels' for increased resolution, it is a trade-off and a camera with larger pixels (less megapixels) will perform better in low light.

This is the main reason that full frame cameras generally perform better in low light, because they have larger pixels. It is also the reason why compact cameras cannot match DSLRs for performance in low light. The tiny sensors in compact cameras have pixels that are much smaller than those in DSLRs and they simply cannot collect as many photons, so shot noise and other sources of noise have a more significant effect.

Thermal Noise

As well as responding to incoming photons of light, the pixels in your camera randomly generate what is called 'thermal noise' during long exposures. The amount of thermal noise increases with the length of the exposure, and is also significantly worse in warmer temperatures. If you take a very long exposure image in summer and in winter with the same settings, you should be able to see that the summer image has more noise. Because thermal noise is also random, there is very little you can do about it.

Hot Pixels & Amp Glow

Hot Pixels	Amp Glow in older DSLRs
	
There are some types of sensor 'noise' that are not random. In long exposure images at night, you may notice 'hot' pixels scattered across your image – bright pixels which may be red, green, blue or even white where they should be dark. These are caused by defective or badly behaving pixels in your camera's sensor, which spontaneously generate a charge during a long exposure.	Older DSLRs often suffer from a whole region of hot pixels in the corners or along the sides of the image, often called 'amp glow'. This is caused by the circuitry in the camera that amplifies the data from your sensor emitting infrared radiation that is unintentionally detected by pixels in the sensor. More recent DSLRs have eliminated the cause of amp glow.

The good news is that because hot pixels and amp glow are generally quite repeatable from one frame to the next, we can do something to reduce their effects, which leads us to the topic of Noise Reduction.

Most DSLRs offer two different settings for noise reduction. Long Exposure Noise Reduction effectively removes 'hot pixels' and other repeatable defects from your image and is therefore quite useful. High ISO Noise Reduction is simply a smoothing algorithm that reduces the appearance of random noise but also smooths out detail in your image and so is less useful.

TIP: See the 'Shooting Stars Field Guide' for details of how to access and set these options for your particular camera.

Noise Reduction

Long Exposure Noise Reduction

It is possible to reduce the effect of repeatable (non-random) sources of noise like hot pixels (and amp glow in older cameras) by subtracting a 'dark frame' from your image.

For a 'dark frame', the sensor is activated for the same exposure duration but the shutter is closed so that it is not actually exposed to any light. In this way your camera records the hot pixels during the dark frame, and can subtract them from the image.

This is a very useful tool and you can see the difference in the two images above right, with most of the hot pixels removed, but the effects of other random sources of noise still visible.

Canon, Nikon and Sony cameras refer to this technique as **'Long Exposure Noise Reduction'**, while Pentax camera menus list it as **'Slow Shutter Speed NR'**. In Olympus cameras it is simply **'Noise Reduct'**.

Long Exposure Noise Reduction Off

Long Exposure Noise Reduction On

Dark frame subtraction works very well at removing hot pixels. It will also reduce the effects of amp glow but will not completely eliminate it. Most DSLRs since around 2008 do not suffer from 'amp glow' and the number of other hot pixels are generally lower on newer cameras as well.

The only problem with 'Long Exposure Noise Reduction' is that it costs you valuable time (and battery power) in the field. For a 1 minute exposure, the camera is frozen for another minute afterwards while the camera captures and then subtracts the dark frame. If you take a 1 hour star trail image, the camera will be frozen for another hour to capture and then subtract the dark frame.

I suggest that at first you turn off this 'Long Exposure Noise Reduction', so that you can concentrate on framing your shots and getting the focus and exposure settings correct. Then when you have an image composed and you are happy with the result on the camera, turn this setting on and take just that image again. Then you will have a version with fewer hot pixels.

With older cameras (more than say three years old), the effect of Long Exposure Noise Reduction is often visible even in exposures less than 30 seconds. But with many newer cameras, hot pixels only really become a problem for exposures longer than around five or ten minutes. Experiment with your camera to find out how much difference it makes to your images.

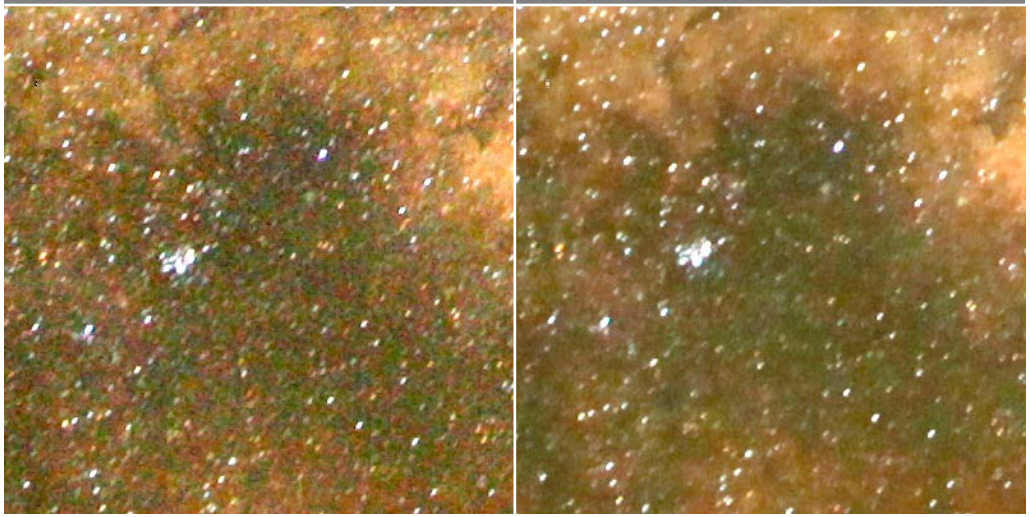
Noise Smoothing

Dark frame subtraction can only fix repeatable (non-random) sources of noise, but much of the noise in night sky images is random, especially for short exposures less than a few minutes long. In this case, the other option we have is to artificially smooth out the noise, but this inevitably sacrifices detail in the image at the same time.

You can see the effect of High ISO Noise Reduction in the images at right taken at ISO3200. The noise smoothing function in the camera does a reasonable job of reducing the speckled colour typical of high ISO images, but it is also smooths out some of the fainter stars and other fine details in the image.

In Canon and Pentax cameras, Noise Smoothing is called **'High ISO Noise Reduction'** which Nikon and Sony abbreviate to **'High ISO NR'**. In Olympus cameras it is called a **'Noise Filter'**.

High ISO Noise Reduction Off	High ISO Noise Reduction On



RAW and JPG

A RAW file captures a much greater depth of information than it is possible to record in a JPG file. For this reason alone, it is worth shooting in RAW wherever possible.

When 'Long Exposure Noise Reduction' is set and the camera subtracts a 'dark frame' from your image, the beneficial effect is the same whether the camera saves a RAW or a JPG file.

However, the noise smoothing applied by the 'High ISO Noise Reduction' setting only applies to the JPG image. In this case, you are better off shooting in RAW and controlling the amount of smoothing yourself during post-processing. Lightroom 3 and other applications offer very impressive noise smoothing algorithms, so it is safe to leave the 'High ISO Noise Reduction' setting on the camera turned off and forget about it.

OTHER CAMERA SETTINGS

Image Stabiliser

It is best to turn off all forms of image stabilization – whether they are built into the camera or the lens. If you're desperate, you could try some early twilight shots with image stabilisation. For everything else, you will need a sturdy tripod.

Self-Timer

If you are triggering the exposures by hand, even on a tripod you may find it useful to use the self-timer so that any vibration from pressing the shutter has died out before the exposure starts. A two second delay is usually enough on a sturdy tripod.

Mirror Lockup

Most DSLRs offer a 'Mirror Lockup' setting where the mirror can be locked up in position before the shutter is activated to take the photo. Most of the mechanical vibration moving the camera is caused by the movement of the mirror so locking this up before the exposure helps to reduce 'camera shake'. This is useful when using telephoto lenses on a tripod, say for images of the moon. It is usually not required for wide angle images of the night sky.

If 'Mirror Lockup' is turned on, when you push the shutter the first time the mirror will lockup. You then need to press it again to fire the shutter. If you have selected the self-timer on the camera and have 'Mirror Lockup' on, most cameras will move the mirror when you push the shutter button, and the shutter will activate after the delay you have set. In this case there is no need to press the shutter a second time.

White Balance

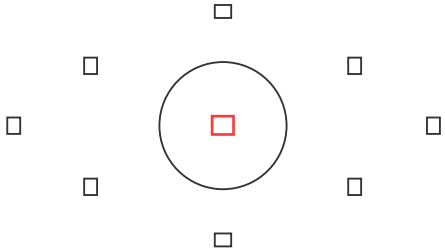
The most accurate white balance is generally achieved with a 'Daylight/ Sunlight' setting, although you may develop a personal preference for other settings. Generally it is preferable to shoot in RAW mode so that you can make decisions about colour balance (and more) during post-processing.

Image Size

If possible, you will want to shoot in RAW mode at maximum resolution to be able to get the most out of your images during post-processing. If you are shooting timelapse sequences, available memory card space may limit your options. If so, you can choose to capture small JPGs (or small RAW) files, which are still more than sufficient for creating Full HD resolution video files.

Auto-focus Points

While your camera probably offers multiple autofocus points across the frame, the central spot is usually the most sensitive and accurate. So for those times when you are trying to autofocus at night, select just the centre focus point. Then make sure you line up the star, moon or other bright light that you are focusing on under this spot before you attempt to autofocus.



NOTE: STOCK IMAGES HERE AND ON FOLLOWING PAGES FROM ISTOCKPHOTO

Equipment & Accessories

TRIPOD

A tripod is the first essential item of equipment to add to your kit for night sky photography. A sturdy tripod and one that is easy to operate in the dark (with gloves on) will make composing your images a lot easier too. On a cold winter night your hands may appreciate having some foam or rubber wrapped around the legs, or you can upgrade to a carbon-fibre tripod. But the most important thing is that your tripod is solid and well made.

Get the most out of your tripod

Look after your tripod and it will look after you! For starters, make sure your camera is firmly attached to the head of the tripod. Whether you use a base plate adapter or connect direct to the tripod, make sure the connection is done up well so that the camera will not move around the point of attachment.

Before moving the camera around the sky, be sure to loosen the tilt and pan clamps on the tripod – you shouldn't need force to move the camera around. Then when the camera is pointing where you want it, firmly tighten all the clamps again so the camera will not move or slip during a long exposure. But do not over-tighten the clamps or you may damage the threads. If you have everything right, the camera should feel solid and secure, not loose and wobbly.

The classic tripod design has a long arm for the tilt adjustment which won't allow you to point the camera straight up because it won't pass the central pillar of the tripod. In this case, put your camera on the tripod backwards and when the camera points up the arm will also be pointing up, out of the way of the central pillar of the tripod.

If your tripod is sturdy enough, it's certainly convenient to have the legs fully extended so that you don't have to bend down or kneel in the dirt at night. However, if your tripod is anything less than rock solid or it is a windy night; you may still need to reduce the height to get the best results. It's generally best not to extend the centre column up very much.

CAMERA REVERSED ON TRIPOD HEAD TO AID POINTING HIGH OVERHEAD

REMOTE RELEASES & INTERVALOMETERS

REMOTE RELEASE (INTERVALOMETER)
MMorpheus (BEPIXELUNG)

With digital SLRs, you can generally select shutter speeds up to a maximum of 30 seconds. If you want longer than that, you could choose bulb mode and sit still with your finger on the shutter for minutes or even hours, but this quickly gets tedious. The better option is to get a remote release.

Simple models have a switch that can be locked down for as long as necessary. Programmable models, also called 'intervalometers', allow you to set a number of exposures, the length of the exposure and a delay in between.

Some DSLRs have an intervalometer built in, although not usually with all the capabilities of an external one.

DEW CAPS & DEW HEATERS

There are several problems that arise when doing photography at night that are not usually encountered during the day. One of these is dew. The dew and frost that form on the ground or your car windows at night will also form on your camera lens – and often there before anywhere else.

Simply wrapping a sock or other insulating material around the outside of a lens will stop it cooling down so quickly which is what causes the dew to form. This may extend the time before dew forms, and may be enough on mild nights. As you switch lenses, if you keep one somewhere warm (e.g. in a jacket pocket) then that will also help to prevent dew forming.

On nights where dew forms early, you will need an external source of heat. One way of achieving this is to wrap chemical heat packs around the lens. They are often available from chemists and drug stores under many different brand names. One example is ***Hotteeze Heat Pads***.

Alternatively, there are a number of commercial products called 'dew heaters' which you strap around a lens and power from a 12 volt battery (e.g. ***Kendrick*** and ***Dew-Not***). The need for a power supply makes it more awkward to walk around with a tripod but they are very useful if you plan to shoot for an extended period of time. I have a ***page on my website*** describing a simple adaptor that makes a more portable solution using 12V Lithium batteries possible.

DEW HEATER CONTROLLER
Kendrick Astro Instruments

DEW HEATER STRAP
Kendrick Astro Instruments

BUBBLE LEVEL

It can be difficult to see the horizon in the viewfinder of the camera at night. A bubble level that fits in the flash hot-shoe of your camera can be useful. Recent DSLRs have a very handy 'digital horizon' feature built in.

FILTERS

I generally use UV filters for protection on the front of my lenses at night. It's much easier to bump into things or knock them over in the dark so the protection occasionally comes in handy. It also means that if I do get dew on the front of the lens, I can wipe it off with anything that comes to hand and not worry about damaging the lens itself.

One exception to this is when photographing aurora. Remove all filters from the front of your lens in this case otherwise it is possible to get strange rings in your images, caused by optical 'interference' between the filter coatings and the light of the aurora.

Soft or diffusion filters can be held over the lens for part of an exposure to help enlarge and accentuate bright stars.

BATTERIES AND POWER SUPPLIES

DSLRs perform better than compact cameras regarding battery life, but shooting long exposures on cold nights does place high demands on batteries.

Older cameras typically only last for one hour of continuous shooting at night, while newer ones may last four hours or more. Having spare batteries close to hand, or using a battery grip, will keep you going with less interruptions.

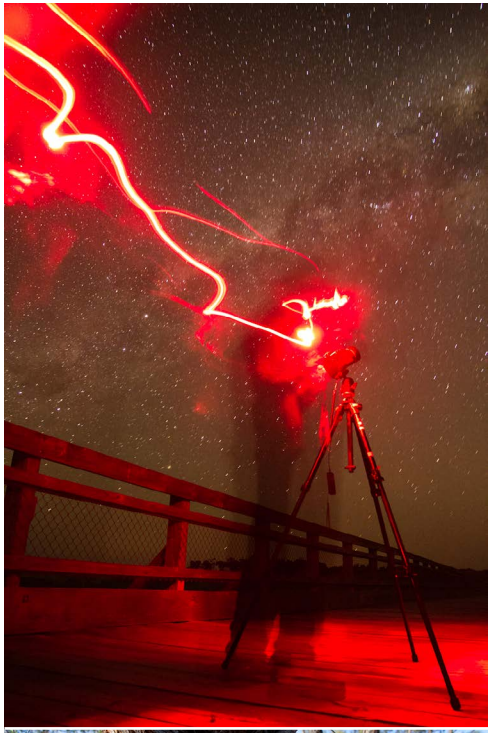
If you start shooting very long exposure star trail images or timelapse sequences, then you may need an external AC or 12V DC power supply which you can plug directly into the camera.

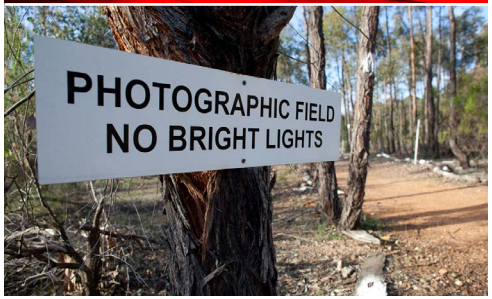
FLASHLIGHTS

While a flashlight is an obvious accessory for working at night, there is more to it than you might think. As you spend time under a dark sky away from other lights, the rod cells in your eye's retina chemically adapt, helping your eyes to see more. This process is called ***'dark adaptation'*** or simply 'night vision'. Every time you turn on a bright white flashlight, you disrupt this 'night vision' and it takes time afterwards for it to recover.

Astronomers often use a faint red light to work by at night as this does not disrupt your night vision and provides just enough illumination to work by. You can cover one of your existing flashlights with several layers of red cellophane, or buy a red LED flashlight which will run for hours on even small batteries.

If you do use a bright flashlight, you are also more likely to interfere with your own exposures. An image can easily be ruined by the glow from a light outside the frame as you look for something to eat or drink.





FOOD & DRINK

Having some food and drink close to hand is important for keeping warm and providing energy as you work on capturing images late into the night. It also gives you something to do while you wait for long exposures to finish!

CLOTHING

Winter

Even on a mild day, it can be surprising how cold it can be at night. Bring plenty of extra gear and dress as though you are going to the snow – you won't regret it! Try to dress with multiple layers on your legs as well as your upper body. Waterproof trousers and thermals keep out the wind and trap warm air around your legs.

The right footwear is important too. The ground can get quite wet with dew at night so your shoes should be at least moderately waterproof. You might even like to have a spare pair for the drive home. Hard-soled shoes can conduct the heat away from your feet so something with softer, more insulating soles can be better.

Handling your camera and tripod at night can also give you cold hands very quickly. Thin or finger-less gloves that allow you to operate the camera can be good, otherwise try to find a pair of gloves that you can quickly remove and put back on as you need to.

Summer

On a balmy summer night, in many parts of the world you can expect plenty of mosquitoes or other annoying insects so cover up as much as you can and remember the repellent. Mosquitoes will easily bite through socks so add some repellent to your socks as well as your hands and neck. I find wearing solid jeans and a lightweight rain jacket good for keeping out the mosquitoes, even if it is a little more clothing than necessary.

You may often be surprised how cold it can feel to stand around late at night even during summer. So, bring plenty of warm clothes for later in the night just in case.

Twilight can be a rich time for night sky photography. Strong and beautiful colour variations low on the horizon can be captured just as the brighter stars are becoming visible. Depending on the time of year, the planet Venus may also be visible as the bright evening star in the west or the morning star in the east before sunrise. You can also capture the dusky colours of Earth's shadow looking opposite the sun, east after sunset or west before sunrise.

Twilight Landscapes

Shortly after sunset, photography can still be conducted in a fairly conventional manner. This is typically when sunset colours are most impressive to the eye. Autofocus will still work on most cameras (especially using high contrast features like dark trees against the bright sky background). Shooting into the bright sky can be managed (barely) without a tripod but for other purposes a tripod soon becomes a necessity.

The second half hour after sunset is where the transition from light to dark really takes place. The bright stars become visible and the moon and Venus if they are present become obvious twilight photo targets. A tripod is no longer optional, autofocus will rarely work (except on the moon) and it becomes hard to even see the settings on the camera. While the remaining brightness and colour fades from the sky as far as the eye is concerned, the camera will still pick up strong colour and brightness gradients close to the western horizon (or east in the morning).

By an hour after sunset the sky is already very dark, and in the following half hour whatever remaining twilight there is in the sky fades away leaving just the feeble natural glow of the night sky itself or illumination from the moon.

Light levels change rapidly from about half an hour before sunset to an hour afterwards, so you'll need to use your camera's light meter or just experiment to work out the right exposure as you take the shots. Unless there is movement in your field of view that you are trying to 'freeze' or you need your aperture stopped down to gain 'depth of field', it is better to keep your ISO low for as long as you can.

You can also experiment with 'light painting' to illuminate foreground objects, although it can take a bit of practice to get the right balance between twilight and artificial illumination. In the snow camping picture, although the sky looks bright it was quite dark to the eye. The stars of the small constellation Grus (the Crane) are visible through a gap in the clouds.

Camera Settings for Twilight Landscapes

	Shutter Speed	Aperture	ISO
Around sunset	1/60	f5.6	100
30 minutes after sunset	2″	f4	400
1 hour after sunset	30″	f3.5	1600

Image Quality	RAW (Full Size)
White Balance	Daylight/Shade (Experiment in post-processing)
Drive Mode	Single Shot (or Auto Exposure Bracketing)
Long Exposure Noise Reduction	Off
Focus	Auto (in bright early twilight) or Manual

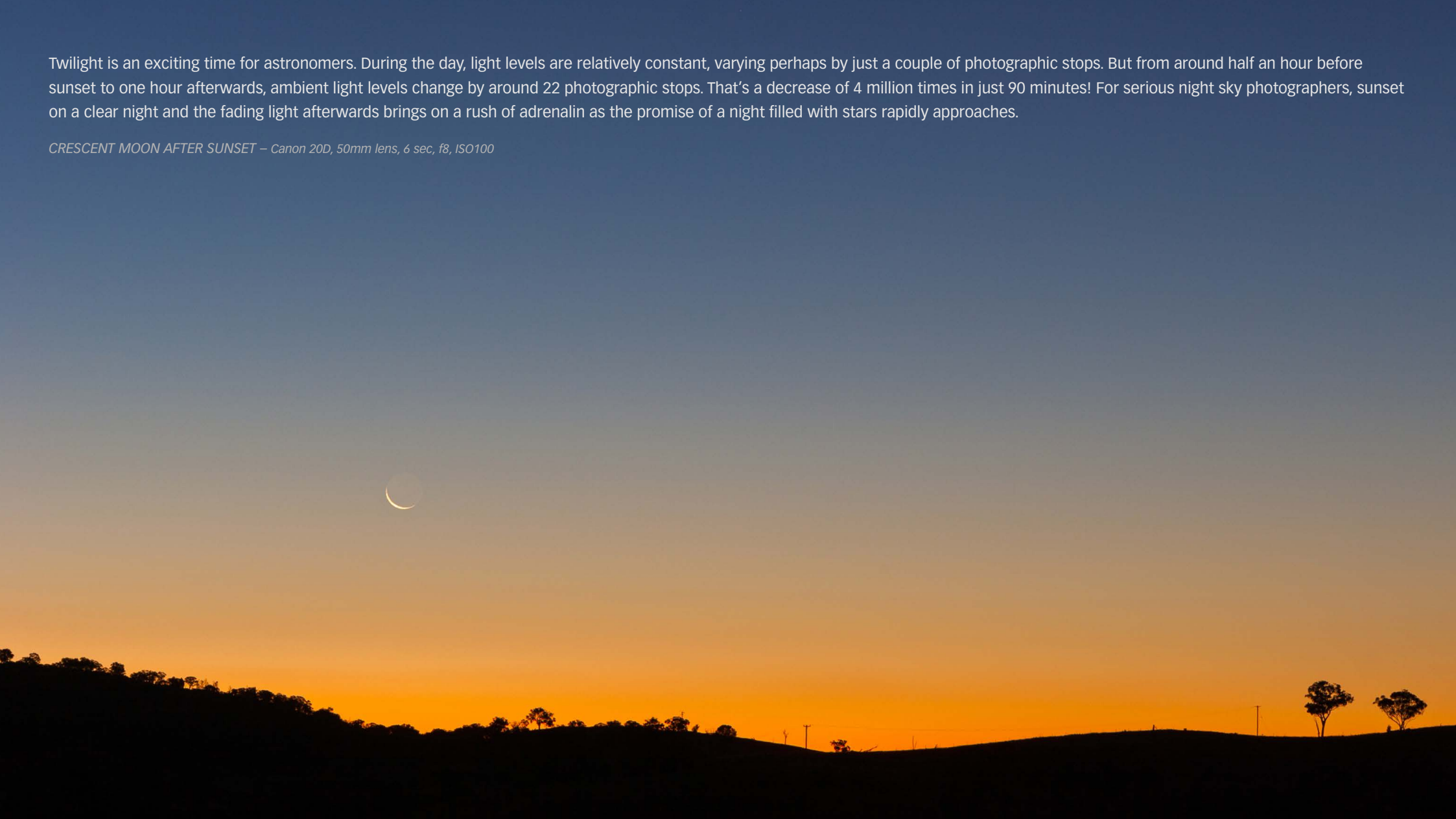
SNOW CAMPING UNDER THE STARS – Canon 5DMKII, 24mm f1.4 lens, 30 sec, f3.5, ISO400

LEFT: EVENING CONJUNCTION OF THE MOON, VENUS AND JUPITER
Canon 1100D (Rebel T3), 18-55mm lens @45mm, 30 sec, f4.5, ISO100

TIP: Use Automatic Exposure Bracketing to capture a series of images through the changing twilight with a wide range of exposure settings. The slightly under-exposed images may look better on camera, with richer colours but the slightly over-exposed images often come up well in post-processing too. As long as the highlights are not burnt out, you can compress the levels, which brings the colour and saturation back. On the other hand, if you have to stretch the under-exposed images they will start to look more noisy.

Twilight is an exciting time for astronomers. During the day, light levels are relatively constant, varying perhaps by just a couple of photographic stops. But from around half an hour before sunset to one hour afterwards, ambient light levels change by around 22 photographic stops. That's a decrease of 4 million times in just 90 minutes! For serious night sky photographers, sunset on a clear night and the fading light afterwards brings on a rush of adrenalin as the promise of a night filled with stars rapidly approaches.

CRESCENT MOON AFTER SUNSET – Canon 20D, 50mm lens, 6 sec, f8, ISO100



HIGH DYNAMIC RANGE IMAGES

The strong contrast between the relatively bright twilight sky and the foreground can make for great silhouettes. Alternatively, it can be a useful time to apply High Dynamic Range (HDR) techniques if they suit your tastes.

Use Auto-Exposure Bracketing to capture a base image and others of the same scene under- and over-exposed by 1-2 stops. Photoshop or dedicated HDR software packages like ***PhotoMatix*** make short work of combining the images. You can also try the ***LR Enfuse plug-in*** for Lightroom.

Base Exposure 1/4 SEC, F3.5, ISO200	-2 stops	+2 stops
		

CSIRO PARKES RADIO TELESCOPE – Canon 5DMKII, 24mm lens

HDR Composite →

SELF-PORTRAIT UNDER THE MILKY WAY
Canon 5DMKII, 24mm lens, 30 sec, f1.4, ISO800

While the lighting environment around you changes quickly during twilight, once that fades you have plenty of time to get used to working with your camera in the dark. Then you can carefully frame and capture images of the night sky with more stars than your eyes can see. Stay warm, and remember that your DSLR is an amazing device because it was almost impossible to capture images like these just ten years ago!

Night Sky Scenes
SHORT EXPOSURES

Camera Settings for Night Sky Scenes

	Shutter Speed	Aperture	ISO
Zoom Lens	30″ or bulb (up to 60″)	Wide open (f2.8-f4)	3200
Prime Lens	30″	f1.4-f2	1600

On nights with strong moonlight or light pollution, start by reducing the ISO first. Review your images and the histogram on the camera and adjust as necessary.

Image Quality	RAW (Full Size)
White Balance	Daylight
Drive Mode	Single Shot
Long Exposure Noise Reduction	Off or On*
Focus	Manual

Leave Long Exposure Noise Reduction Off while you are experimenting with settings and composition to save time. If you have an older camera and notice a lot of hot pixels even in short exposures, turn it On to capture a cleaner version once you have everything else right.

Steps

1. Set your lens to its widest zoom setting

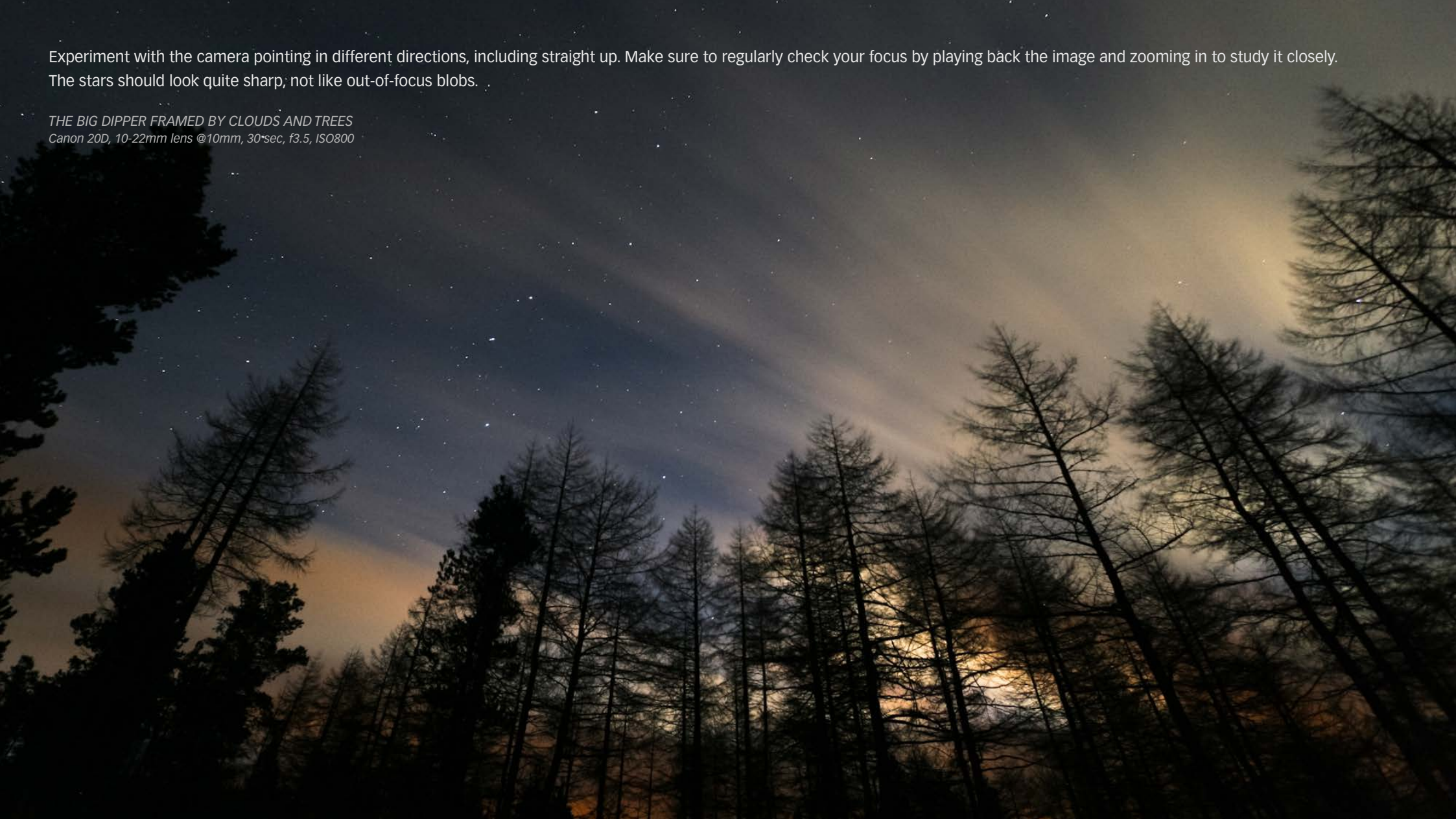
2. Focus your camera using one of the three manual focus techniques described earlier

3. Frame your image and make sure the tripod is secure

4. Open the aperture up wide, select a 30″ shutter speed and high ISO

5. Release the shutter

Experiment with the camera pointing in different directions, including straight up. Make sure to regularly check your focus by playing back the image and zooming in to study it closely. The stars should look quite sharp, not like out-of-focus blobs.



THE BIG DIPPER FRAMED BY CLOUDS AND TREES
Canon 20D, 10-22mm lens @10mm, 30 sec, f3.5, ISO800

See the Big Picture and Get Excited

More so than many other types of photography, imaging at night is a compromise, and so 'pixel peeping' will not be rewarded. The night sky is faint so we don't have the luxury of stopping the aperture down and using low ISO settings. If you zoom in to 100% and study every pixel in the image, you will see a lot of noise, the stars will have trailed a little during the exposure and the corners of the image particularly may show aberrations from the lens. But if you stand back and view your image as a whole, most of those issues will not be obvious and instead you can marvel at an image that likely shows thousands of stars in a single shot, many times more than you could see with your own eyes.

It's easy to forget how remarkable modern DSLRs are, but people like me who started in the days of film may have spent ten years photographing the sky and never produced an image as good as you might capture on your first night out. So don't get distracted by the imperfect details. Admire your image as a whole and get excited about what you captured with your camera!

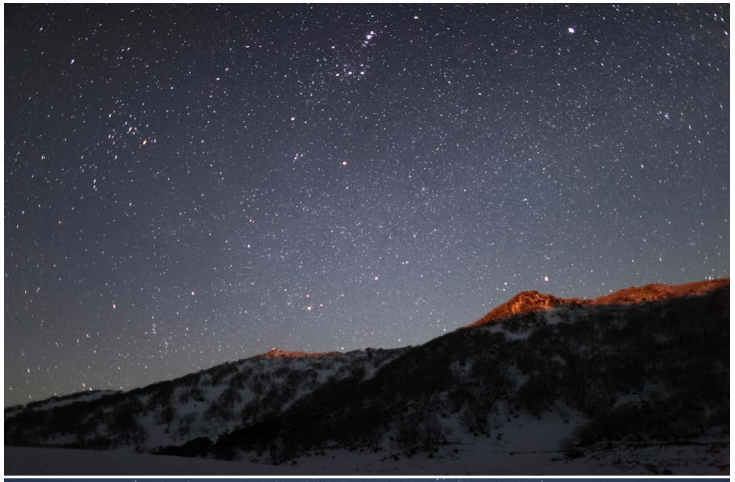
SIGNS AT NIMONS BRIDGE, AUSTRALIA
Canon 1100D (Rebel T3), 15-85mm lens @15mm, 90 sec, f3.5, ISO3200

CHURCH OF THE GOOD SHEPHERD, NEW ZEALAND – Photo by Neil Creek
Canon 350D (Rebel XT), 8mm fisheye lens, 2 min, f4, ISO1600

MOONLIT LANDSCAPES

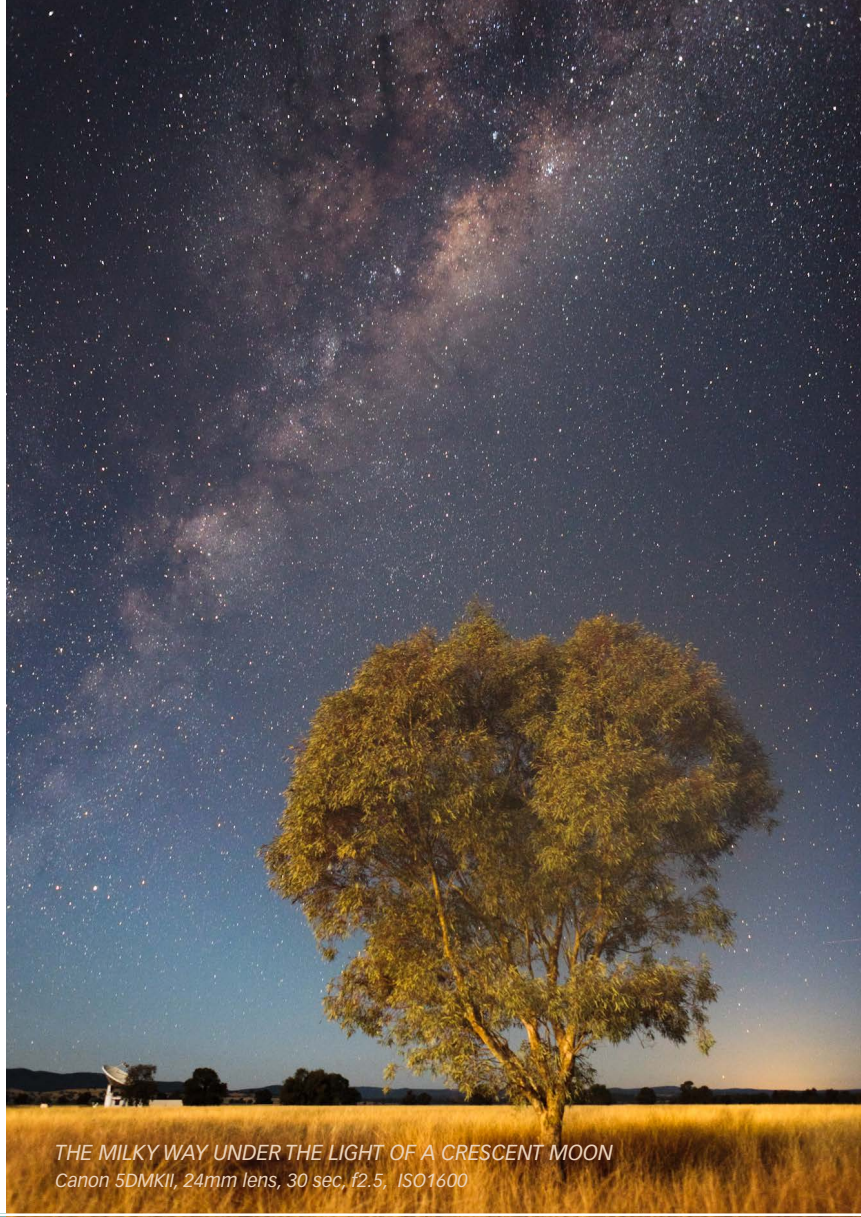
Your camera can easily make moonlight look like daylight. Your exposures will be several seconds rather than say 1/250 second, but the colours, shadows and saturation will be just like shooting during the day. For example, the moon overhead will lead to images with stronger contrast and lower saturation than when it is lower in the sky.

While the bright full moon will wash out the Milky Way and all but the brightest stars, the feeble light from a crescent moon in the evening (or a few days before new moon in the morning sky) is perfect for illuminating the landscape well after twilight, without washing out the sky. The first time you try it you may get a shock to see everything in full colour, like daylight on your camera screen, while you can barely see where you are walking in the dark. A long exposure on a camera sees the world in very different ways to your eyes at night.



TOP RIGHT:
RED LIGHT OF THE SETTING MOON, AUSTRALIAN ALPS
Canon 5DMKII, 24mm lens, 10 sec, f1.4, ISO1600

BOTTOM RIGHT:
MOONLIGHT OVER THE HIMALAYAS, NEPAL
Image: Luke Haag. Canon 550D (Rebel T2I), 10-22mm lens @10mm, 30 sec, f3.5, ISO3200



THE MILKY WAY UNDER THE LIGHT OF A CRESCENT MOON
Canon 5DMKII, 24mm lens, 30 sec, f2.5, ISO1600

If you are brave enough, you can also visit your favourite tourist spots at night to capture them in a different light. Places that are swarming with people during the day might be yours to enjoy alone at night.

Longer exposures will blur the natural motion of clouds and waves or trees moving in the wind so consider this effect as you compose your shots.

TWELVE APOSTLES, AUSTRALIA
Canon 5DMKII, 24mm lens, 30 sec, f1.8, ISO 800

SILHOUETTES & REFLECTIONS

While the night sky is dark, it is not quite black. That natural brightness means that foreground scenery can be used in profile against the sky on even the darkest, moonless nights. Flat, calm water at night also provides for reflections. Small ripples in the water will blur out the stars a little, making them appear larger and therefore brighter than their counterparts in the sky.

LEFT:
THE GROTTO BY MOONLIGHT, AUSTRALIA
Canon 5DMKII, 24mm lens, 60 sec, f2.5, ISO400

TOP RIGHT:
REFLECTIONS OF THE MILKY WAY
Canon 5DMKII, 24mm lens, 20 sec, f1.6, ISO1600

BOTTOM RIGHT:
REFLECTIONS AT DAWN OVER LAKE EPPALOCK, AUSTRALIA, VENUS IN THE MORNING TWILIGHT
Canon 5DMKII, 24mm lens, 30 sec, f2.8, ISO800

PANORAMAS

As at any time of day, panoramas at night can also produce impressive results. If you are shooting during twilight, it helps to keep your exposure time as short as possible, otherwise the sky brightness can vary too much between frames as you shoot the sequence making it harder to blend the images together.

VENUS AND OBSERVATORY DOMES IN LATE TWILIGHT
Canon EOS RA, Sigma 35mm lens plus Lee soft filter.
Panorama of 4 frames each 25 sec, F2.2, ISO800

You can shoot panoramas even in the middle of the night, despite the stars moving quite a bit by the time you take a series of 30 second exposures. Use plenty of overlap (around 20%) to make it easier for software to Many match up the stars between frames and minimise the effect of vignetting. Single row panoramas can be done easily enough with the camera in portrait orientation on a standard tripod head, while a panorama head such as the Nodal Ninja makes multi-row panoramas much easier.

WINTER MILKY WAY PANORAMA
Canon 6D, 14mm lens, Panorama of 4 images, each 30 secs, f2.8, ISO3200

LIGHTING AT NIGHT

It takes some practice to visualise how your images will look at night before you take them, but it's worth thinking about the lighting around you and the type of image that it will help create.

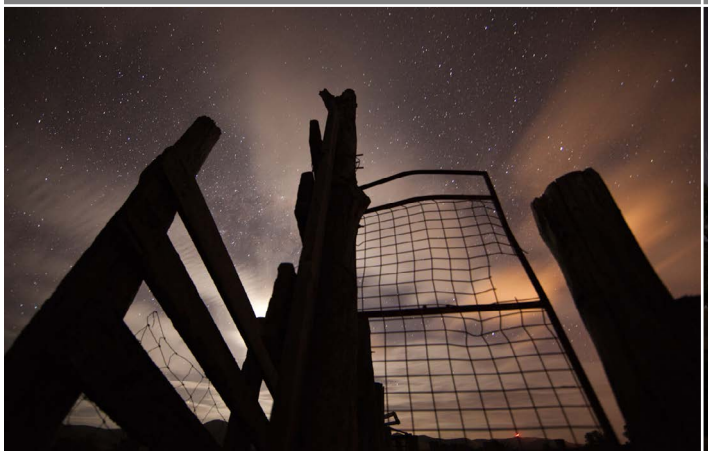
Below left: For this cattle ramp in outback NSW, when I arrived the scene was backlit by the moon, with additional colour in the clouds from the lights of the nearby town of Mudgee.

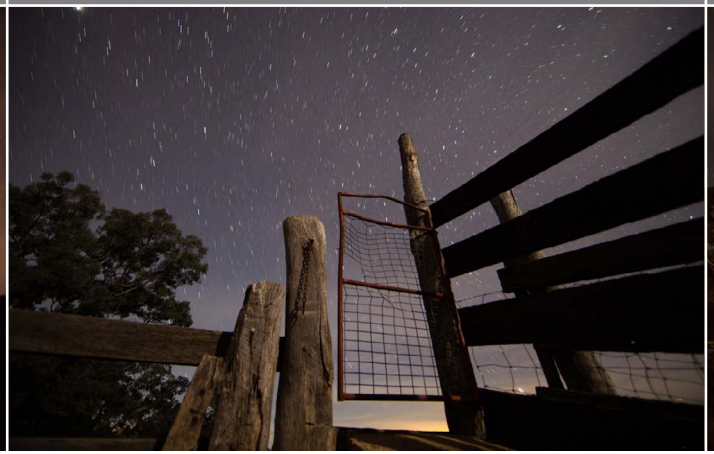
Below middle: Capturing the scene from the other direction, the moon as the light source is now behind the camera and the surface details and texture of the timber and rusty iron gate are now visible.

Below right: Later on, the moon had set so the sky was darker, but in this last image the scene is strongly backlit by a passing car.

NORWEGIAN NIGHTS
Canon 20D, 18-55 @18mm lens, 30 sec, f3.5, ISO1600

1 MIN, F2.8, ISO1000	4 MIN, F2.8, ISO 400	3 MIN, F4, ISO 800





In the days of less sensitive film cameras, star trails were one of the most rewarding areas of night sky photography. While digital cameras open up many other possibilities, star trails still make for striking images, dramatically presenting a scene in a way your eyes can never see it.

Star Trails
LONG EXPOSURES

WATCH THE WORLD TURN

If you were to stand at the North Pole in winter, the stars would complete a circle around the sky in 24 hours, or a quarter of the way around in 6 hours. But even a 15 minute exposure clearly shows the movement of the stars due to Earth's rotation. While exposures up to 6-10 hours are possible from most locations in a single night, 1 hour is enough to create a striking image with long overlapping trails, as in the examples below.

15 minutes	1 hour	4 hours

If you want big circular star trails, you need to point your camera towards the celestial poles. This means facing north in the Northern Hemisphere or south in the Southern Hemisphere. If you shoot looking east or west, you will have stars near the celestial equator travelling in straight lines, although tilted at an angle to the horizon.

In this example, the camera is facing due north (from the Northern Hemisphere) with the bright pole star 'Polaris' very close to the north celestial pole, which the stars are turning around. In the foreground are the red lights of astronomers working around their telescopes through the night.

Camera Settings for Star Trails (Single Shot)

	Shutter Speed	Aperture	ISO
Short	15 minutes	f4	200
	30 minutes	f4	100
Medium	1 hour	f5.6	100
	2 hours	f8	100
Long	4 hours	f11	100

Image Quality	RAW (Full Size)
White Balance	Daylight (Sunny)
Drive Mode	Single Shot
Long Exposure Noise Reduction	Off or On (if your battery will last)
Focus	Manual

Decide which direction you want to face and seek out some foreground to add interest to the scene, then follow these steps:

Steps

1. Set up the camera and tripod

2. If necessary, wrap a chemical heat pack or dew heater around the lens

3. Focus using your preferred manual technique

4. Take a 30 second test exposure with aperture wide open and high ISO

5. Check focus and composition

6. Dial in the aperture and ISO settings for your chosen exposure time

7. Set the camera to bulb mode and open the shutter with a remote release

8. Come back after your desired exposure time and release the shutter

NORTHERN HEMISPHERE STAR TRAILS
Minolta MXE1 SLR, 16mm fisheye lens, 2 hrs, f4, Fuji Provia 100F film

STAR COLOURS

If you study the star trails in your images, you should be able to see variation in their colours. This colour is a direct indication of the temperature of the star, but counter-intuitively hot stars are blue while cooler stars are yellow and even red.

Star trail images tend to look a little de-saturated 'as-shot' so don't be disheartened by how the image appears on your camera screen. The colour information should be there ready to bring out during post-processing.

COLOURS OF THE STARS
Canon 5DMKII, 24mm lens, 1 hr, f4, ISO100

COLOURFUL CONJUNCTION OF SPICA (BLUE), MARS (ORANGE/RED) AND SATURN (YELLOW)
Canon 5D MKII, Pentax 300mm lens, 20 minute exposure, f5.6, ISO100

STAR TRAILS OVER LAKE EPPALOCK, AUSTRALIA
Canon 5D MKII, 24mm lens, 30 mins, F5.6, ISO100

STAR TRAIL IMAGE STACKING

Rather than capturing star trails in a long single image, it is also possible to stack a sequence of much shorter exposures. If you capture a sequence of say 12 five minute exposures and then stack them together, you will end up with something similar to a one-hour star trail. The exposure length you choose for each 'sub' image can be quite varied; anything from 30 seconds up to several minutes.

Which technique you prefer is a personal choice. One downside to stacking is that it is very difficult not to end up with little gaps in the star trails between each exposure. I also find that the star colours are less saturated when you stack shorter exposures with the lens wide open. However, managing noise in a single very long exposure can be a bit tricky, especially with older cameras, so the stacking method is worth experimenting with.

The image below left was taken as a series of six minute exposures over two hours which were combined into this single image.

Using a Cable Release:

A programmable release (intervalometer) can make capturing star trails a lot easier, as it can get tedious trying to remember when you started a star trail and then manually stopping it after the desired exposure has been reached. With a programmable cable release, you can set the desired exposure time and then head off and do something else without needing to keep an eye on your watch.

You can even set the camera to record several one hour star trails through the night while you sleep, or just capture one very long one.

STAR TRAILS OVER LAKE ST CLAIR, AUSTRALIA
*Canon 20D, 10-22mm lens @ 22mm, Stack of 40 * 6 mins, f8, ISO100,*

Camera Settings for Star Trails (Stacking Sequences)

Shutter Speed	Aperture	ISO*
30 seconds	f3.5	1600
2 minutes	f5.6	400
5 minutes	f8	400

* If there is bright moonlight, reduce the ISO setting. Take a test image and adjust down until no part of the image is over-exposed.

Image Quality	RAW or JPG*(Full Size)
White Balance	Daylight (Sunny)**
Drive Mode	Continuous Shooting (Sports Mode)
Long Exposure Noise Reduction	Off
Focus	Manual
Mirror Lockup	N/A
Exposure Bracketing	N/A

* If you are planning a long sequence over several hours of short 30 second exposures, you could easily generate several hundred files for a star trail sequence like this. In this case, as long as each frame is well exposed, it is OK to compromise and shoot JPG files for star trail sequences.

** Any fixed White Balance setting is OK, but do not use Auto White Balance as this is likely to result in the colour balance varying between exposures.

BATTERY POWER AND DEW

Most camera batteries are capable of powering the camera through a star trail exposure for up to an hour. More recent cameras can go considerably longer, even up to four hours. But especially if you have Long Exposure Noise Reduction turned on, you may need either a battery grip or an external power supply to power the camera through a long star trail and the subsequent dark frame.

Depending on the climate and the time of year, you will also need to think about protecting your lens from dew. For starters you can try wrapping a chemical heat pack around your lens. But if you are going to make a habit of long star trail images, I suggest you get hold of a small 12-volt battery and a dew heater system.

TIP: If you are going to leave your camera outside for all-night star trails while you sleep, consider protecting it with a rain cover in case the weather changes. The rain cover leaves the front of the lens clear but protects the rest of the camera – well worth the investment of a few dollars.

STAR TRAILS ON FILM

Film cameras cannot compete with the sensitivity of digital SLRs when it comes to capturing night sky scenes with short exposures. But for long star trail exposures, film cameras have several advantages. It doesn't take any battery power to hold the shutter open, so the camera will happily run all night no matter how cold it is. Old manual focus lenses are also easy to set to infinity focus, since it is usually exactly at one end of the range. And star colours on film are naturally rich and well saturated, so star trails are one area of night sky photography where film makes life easy and performs very well.

The image below is shot facing due south (from the Southern Hemisphere). The stars are rotating around the south celestial pole with the red light of an astronomer moving around in the foreground.

SOUTHERN SKY STAR TRAILS
Minolta MXE1 SLR, 16mm fisheye lens, 2.5 hours, f4, Kodak E100 slide film

MUDGEE STAR TRAILS
Canon 5DMKII, 14mm lens, 20 min, f4, ISO320

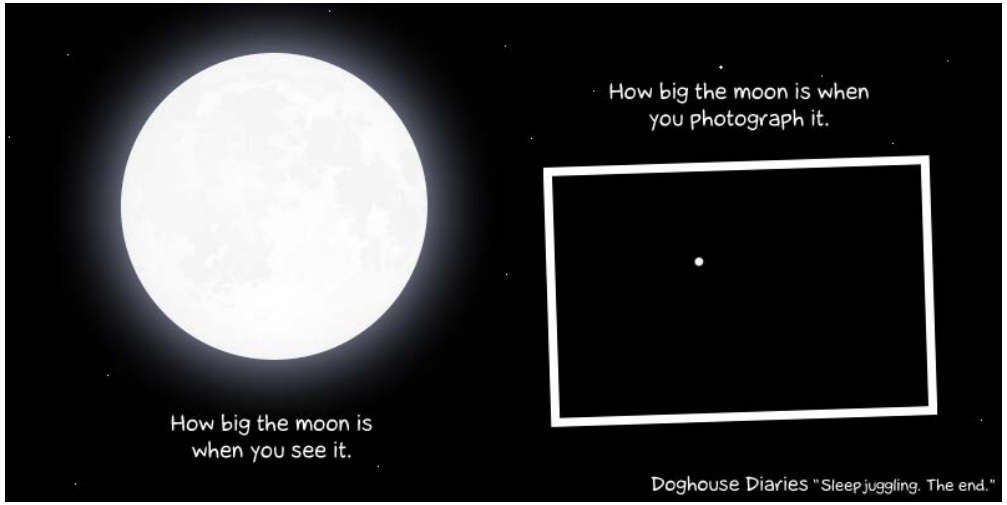
The Moon

The first thing you'll discover when you try to photograph the moon is how small it is. To completely fill the field of view of even a cropped sensor camera requires a focal length of 1500mm – more than most people can carry in their backpack!

Fortunately, the moon is a bright object so rewarding shots can be taken with telephoto lenses and teleconverters using a fixed tripod.

The examples on the following page show the field of view of a cropped sensor camera working at focal lengths of 24, 105 and 420mm. While the heavily cropped image taken at 105mm is enough to show surface markings and a hint of craters, it takes a focal length of 300mm and above to record them with a reasonable amount of detail.

IMAGE: thedoghousediaries.com



Canon 1100D (Rebel T3), 300mm lens + 1.4X Teleconverter (420mm), 1/640, f5.6, ISO400

Camera Settings for the Moon

With long telephoto lenses, the vibration caused by movement of the mirror and the shutter inside the camera is enough to cause slight blurring of the image. Using the mirror lock-up setting can help, but I still recommend using moderately high ISO settings and very fast shutter speeds (even on a sturdy tripod).

At such long focal lengths, the blurring effect of the Earth's atmosphere will also affect your images. Photos of the moon low in the sky near the horizon will generally be affected most. For the sharpest images of craters and other surface details on the moon, shoot it when it is higher in the sky.

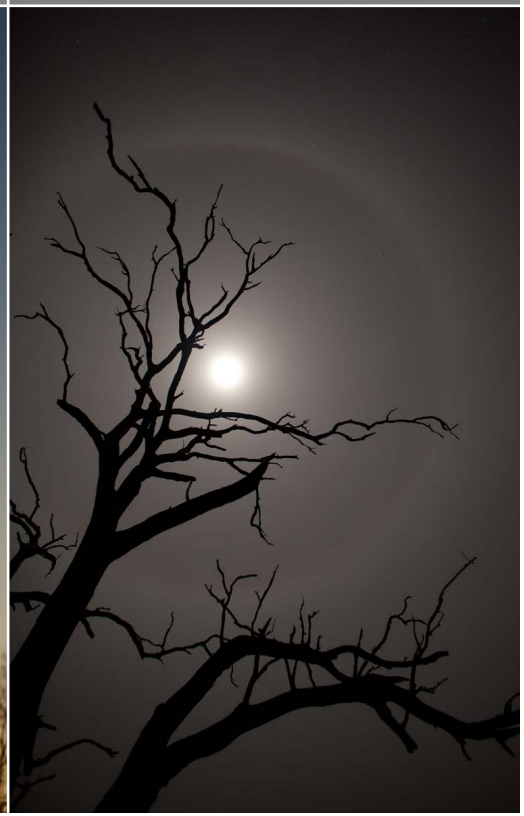
	Shutter Speed	Aperture	ISO
Bright moon	1/500 sec	f5.6	~400-800
Crescent moon with earthshine	1 sec	f5.6	~400-800

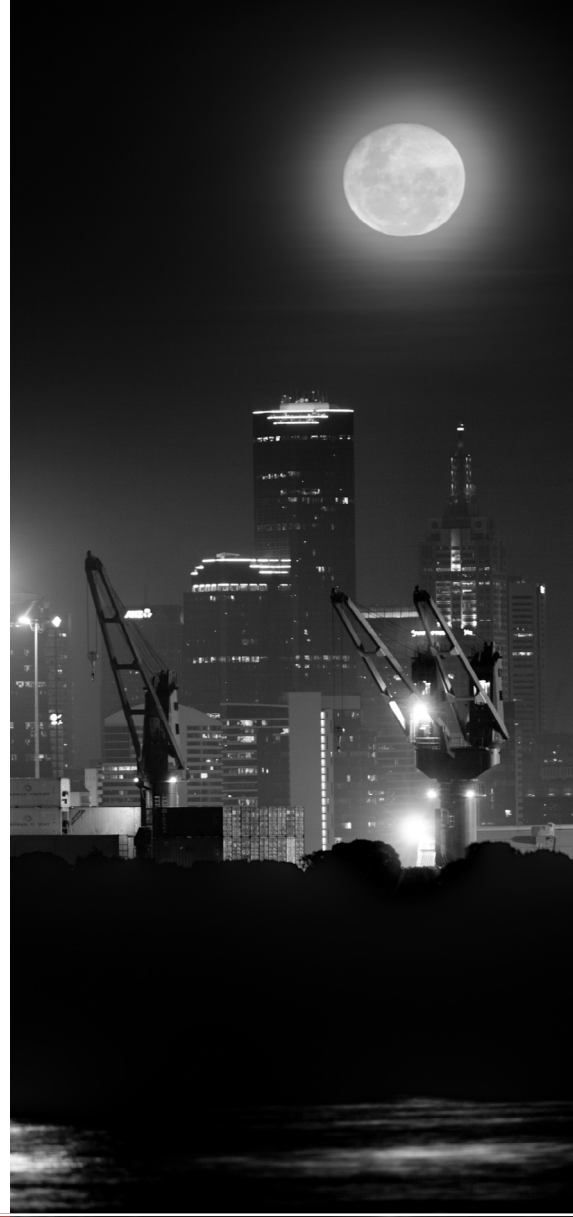
Image Quality	RAW
White Balance	Daylight (Sunny)
Drive Mode	Self-timer with 2 second delay or use remote release
Long Exposure Noise Reduction	Off
Focus	Autofocus or use Liveview
Mirror Lockup	On (optional) to reduce vibration

An alternative to trying to image the moon at very long focal lengths is to capture the moon with other objects to fill the frame. Sometimes this can be other bright stars or planets nearby, foreground objects or simply the colours of the twilight sky. And in the same way that haloes and rainbows form during the day, these same optical phenomena can be seen and photographed on nights with a bright moon.

CRESCENT MOON WITH EARTHSHINE
CANON 5DMKII, 200MM LENS
+ 1.4X TELECONVERTER, 1 SEC, F5, ISO400

CANON 5DMKII, 24MM LENS
30 SEC, F2.5, ISO200





HDR Stack (1/8 & 1 sec), f8, ISO100

MOONRISE OVER MELBOURNE, AUSTRALIA
Canon 5DMKII, 300mm lens + 1.4X Teleconverter, HDR Stack (1/4, 0.8 & 2.5 sec), f8, ISO100

One of the emerging trends of recent years has been the use of digital SLRs to capture high quality timelapse video sequences. This capability has been especially impressive when applied to the night sky. Timelapse sequences with DSLRs and fast lenses capture and animate the night sky in ways that audiences find truly stunning.

Timelapse Video

ANIMATE THE NIGHT SKY

Creating a timelapse video is just a simple extension of the settings described earlier for Night Sky Scenes. But instead of taking just one 30 second image of the night sky, we now take hundreds or even thousands in a sequence over the course of a few hours and then compile them into a video.

The number of images or 'frames' captured determines how long the video sequence will be. For example, ten seconds of video at 24 frames per second requires 240 frames. If your exposures are 30 seconds long, then it will take two hours to capture enough frames for just that ten second clip.

For this reason, if you have fast lenses, it can be worth reducing the exposure time to the bare minimum. Noise is less apparent in video than in a single image, so using high ISO settings can be tolerated more readily.

Click here to watch it at higher quality on Vimeo or if it does not play (eg. on an iPad).

Camera Settings for Timelapse

	Shutter Speed	Aperture	ISO*
Zoom Lens	30″	f3.5	3200
Prime Lens	10-15″	f1.4-f2	1600-3200

* If there is bright moonlight or light pollution, reduce the ISO setting. Take a test image and adjust the ISO down until the image is correctly exposed.

Image Quality	small/medium JPG (or sRAW)
White Balance	Daylight (Sunny)
Drive Mode	Continuous Shooting (Sports Mode)
Long Exposure Noise Reduction	Off
Focus	Manual

Steps

1. Compose and focus the image as you would for a night sky scene

2. Set as short an exposure as you can get away with by opening the aperture up wide and setting the ISO quite high (typically ISO3200)

3. Set the drive mode on the camera to continuous shooting

4. Use a cable release to lock the shutter down. The camera will shoot a continuous sequence of exposures until you release the remote switch

Aside from your DSLR and a tripod, the only other accessory you need is a remote release.

This continuous shooting mode is the same setting that you would use to take a rapid sequence of images of a fast-moving subject during the daytime, where you might shoot several frames per second. But now because the exposure time is up to 30 seconds, it has a very different feel to it compared to the rapid clicking of shutters you hear at a sporting event. But with the remote release locked down, when the camera finishes one 30 second exposure, it will start the next one and so on until you release the remote.

Since you are going to generate hundreds or even thousands of image files in the process, you may find handling and processing full size RAW files challenging. If your camera offers an sRAW (small RAW) option that can reduce the burden significantly while still providing the depth and post-processing capability of RAW files. Small JPG files that are well exposed can easily be used to render Full HD resolution (1920 x1080) video files. Or you could shoot medium JPG files to suit 4K video formats.

Depending on your batteries the camera may be able to continue this sequence for anything from 30 minutes to several hours. Consider a battery grip or external power supply if you want to extend the possibilities. For longer sequences, especially in winter, you will also need to consider protection against dew.

TIP: If you want your camera to record a timelapse sequence but stop at a certain time (e.g. before sunrise), you can use a programmable cable release or intervalometer. Rather than trying to program in 400 exposures of 30 seconds, simply enter one exposure say two hours long and leave your camera in continuous shooting mode. The remote release is effectively 'On' for those two hours, so your camera will keep taking exposures for that period of time.

Read More:

The forums at ***timescapes.org*** provide an extensive resource for those wishing to dive deeper into the world of day and night timelapse.

See More:

View more of my ***portfolio of timelapse movies on Vimeo.***

Planning

There's no escaping the fact that most people's brains don't work at their best late at night. Just the simple act of thinking things through beforehand and writing down a plan of the images you want to capture and the settings you plan to try makes a big difference. And if you have that plan with you and can refer to it in the dark, it's much more likely that you'll keep thinking straight and taking good images.

Planning for night sky photography involves thinking about the location around you and what's up in the sky above you. Here are some things to consider:

Your Location

- Which directions give good views?
- Which directions have the darkest skies (looking away from distant cities)?
- Will nearby traffic or street lights affect the shot?
- Where can I park? How far will I have to carry gear in the dark?

The Sky

- What time is sunset and sunrise? When does it get dark?
- What time is the moon up and where in the sky will it be?
- Is the Milky Way visible tonight? Which direction?

After you've taken the shots, writing a few quick notes before you head to bed is also helpful. Although your camera captures all the exposure details of each image, it doesn't record what you had in mind as you were taking them. Notes that describe whether a sequence of images was intended for star trails or timelapse help you to organise and process your images.

Location Scouting

Exploring and visiting new locations during the daytime can make your life much easier when you get a chance to take photos there at night. Finding the easiest way to get access and exploring different angles beforehand can save you a lot of precious time at night. And just finding out where the ground is dry can save you a wet pair of boots and an unpleasant drive home!

Software and Apps

- ***Stellarium*** is a great free open source planetarium program for Windows and Mac users with excellent visualisation of the night sky. **Stellarium** is also available as an App on yourfor iPhone or Android phones. Another very popular alternative is **SkySafari**, the basic version of which is sufficient for night sky photographers.
- ***The Photographers Ephemeris*** is an App for iPhone and Android that will allow you study the rise and set direction of both the Sun and the Moon from anywhere on Earth.
- The unique ***Photo Pills App*** allows you to plan the position of not just of the Sun and Moon but also the Milky Way. You may enjoy using it to plan your photos.

GRAIN SILOS
Canon 5DMKII, 24mm lens, 30 sec, f1.4, ISO1600,

- For those who like a hardcopy, each month you can also download and print ***The Evening Sky Map***. This is a nicely produced PDF map of the evening sky available in Northern and Southern Hemisphere editions, plus one for Equatorial Regions. It includes a list of celestial events for the month.

IMAGE PROCESSING

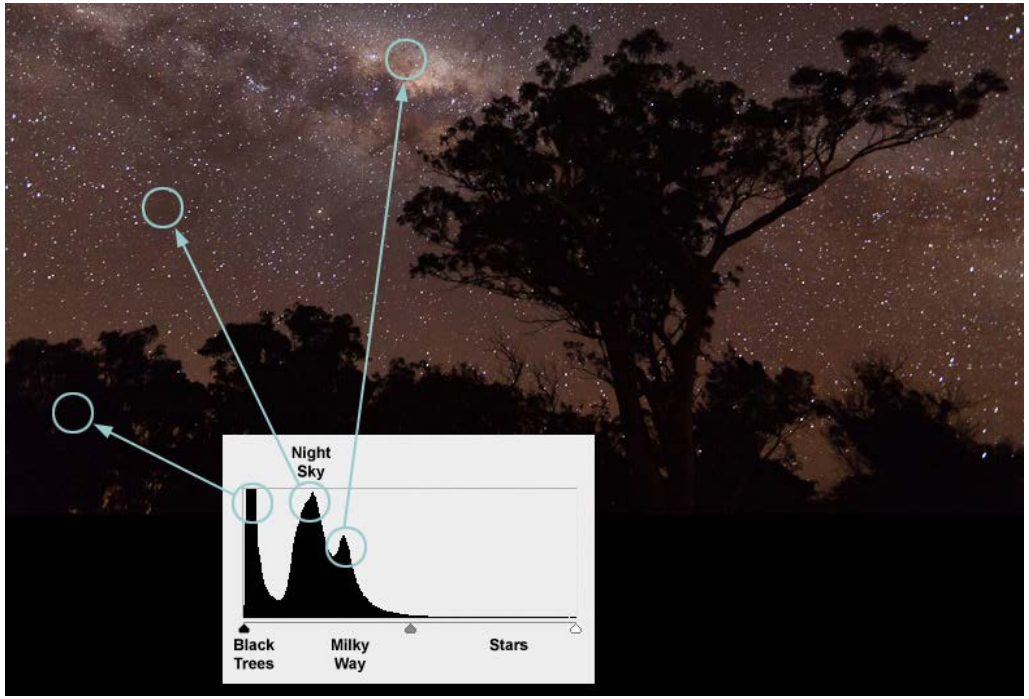
BRIGHTNESS LEVELS AND THE HISTOGRAM

The first thing to consider as you start processing an image is what it should look like. There is always room for artistic interpretation but it helps to understand some of the basic principles as they apply to night sky images first.

While you can shoot and process night sky images without looking at a histogram, it is a very useful tool. The histogram is a graph that shows the distribution of brightness values across an image. The horizontal axis on the histogram has black at the left and white on the right. The vertical scale shows quantity, or how many pixels in the image have each corresponding brightness value.

This histogram shows the distribution of brightness values before any processing of the image is done. The tall narrow peak at the left-hand side of the histogram shows all the pixels in the silhouette of the trees in the foreground. They have a very similar value and are almost completely black.

The second broader peak covers the larger number of pixels across the rest of the image. While this is still in the darker half of the histogram, it is clearly separated in brightness from the very dark trees and you can see this in the image, looking at where the sky meets the trees. This is important as the night sky is not completely black and if your sky background is too dark you will not be able to see the faint details and structures that you have captured in your image.



On the right-hand side of the broad peak for the night sky, there is a smaller peak that represents the brighter pixels of the Milky Way. The Milky Way is certainly a brighter feature of the night sky but not compared to the bright white of a cloud in a daytime image, for example. The stars themselves are very bright, but they are so small that the number of pixels they cover barely shows up in the histogram and so the right-hand side of the histogram in this case is almost flat.

ABOVE RIGHT:
Canon 5DMKII, 14mm lens, 30 sec, f2.8, ISO3200

COLOUR AND SATURATION

Several factors affect the colour of the night sky and it varies considerably from one location to another and one night to the next.

For many people living in large cities, it will be hard to escape the effects of light pollution. Even an hour's drive out of town, the sky is still likely to be affected by the distant lights. This will generally give the sky a murky orange/yellow cast, particularly looking back in the direction of the city.

On a night when the moon is out, the sky will appear blue in your images, just like the daytime sky. This is because the molecules in the atmosphere scatter more blue light from the sun and less of the red light. The same process causes the sun itself to turn even deeper yellow or red at sunset as the light has to travel through a greater thickness of the atmosphere and almost all the blue light from the sun is scattered rather than transmitted.

BLUE SKY AT NIGHT WITH A FULL MOON
Canon 5DMKII, 24mm lens, 2 min, f2, ISO200

LIGHT POLLUTION
Canon 5DMKII, 24mm lens, 30 sec, f2.8, ISO1600

No matter how far you travel, even from the middle of the ocean or the desert, the night sky still has some natural brightness and colour. In the absence of any light pollution or moonlight, the main contribution to the brightness of the night sky is ***airglow***. Nearly 100km (60 miles) up in the Earth's atmosphere, molecules that were formed with energy from the sun during the day spontaneously decay during the night, emitting light as they do. In the NASA image on the following page, taken from the International Space Station, you can see a faint band of green and red airglow in the atmosphere high above Earth.

Various chemical reactions and other processes contribute to airglow, but they primarily emit red and green coloured light. The actual colour of the sky on any given (moonless) night is impossible to predict as it can be any possible mix of the two, often yellow/brown but occasionally you will see distinct bands of red or green airglow in your images from very dark sites.

If you set the white balance for your image to 'Daylight', then the colours in your image will be about as realistic as you can hope to achieve, given that it will show the image recorded relative to the sun being defined as 'white'. Whether you choose to preserve that real colour of the night sky in your images, tone the saturation up or down or alter its colour entirely is of course up to you.

For most people shooting under light polluted skies, you may need to be a little more aggressive with the white balance and colour settings to achieve a more pleasing image.

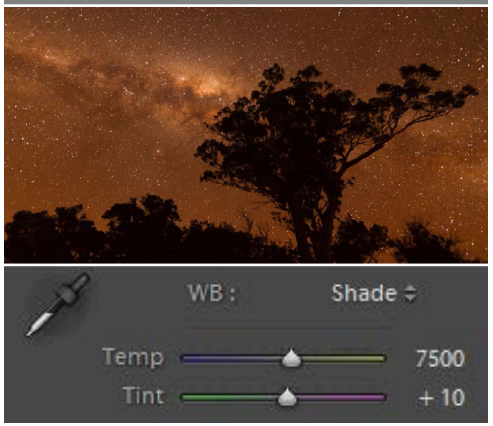
AIRGLOW AND A METEOR
AS SEEN FROM THE INTERNATIONAL SPACE STATION
NASA

White Balance Examples

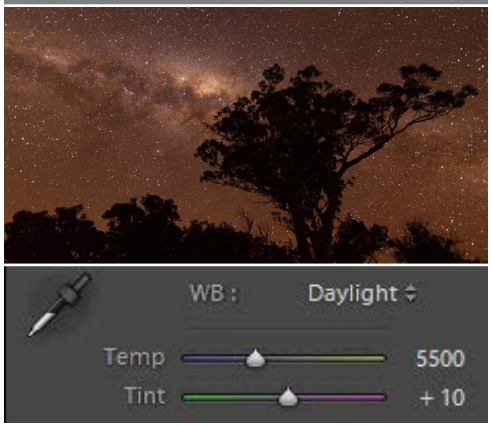
The examples below show how the colour and appearance of a night sky image is affected by the white balance setting, in this case using Lightroom.

Applying the Shade setting (7500K) leaves the sky with a strong orange cast, while the Tungsten setting (2850K) has a strong blue cast. The Daylight setting could be considered the most 'accurate'; however, you may prefer a more neutral sky in your images, perhaps like Lightroom's Auto setting has chosen for this image using a colour temperature of 3750K.

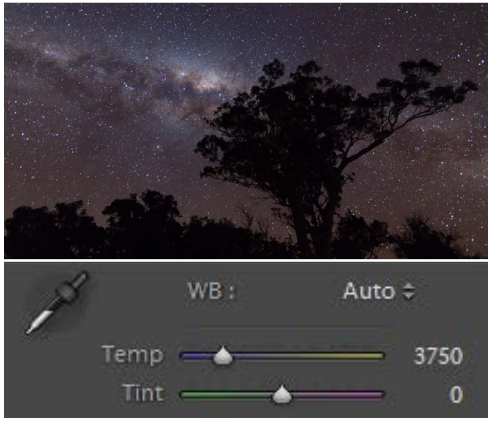
Shade



Daylight



Auto



Tungsten

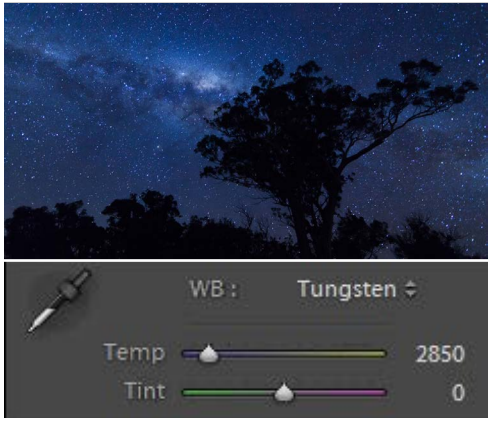


IMAGE PROCESSING STEPS

The basic steps needed for most night sky images include:

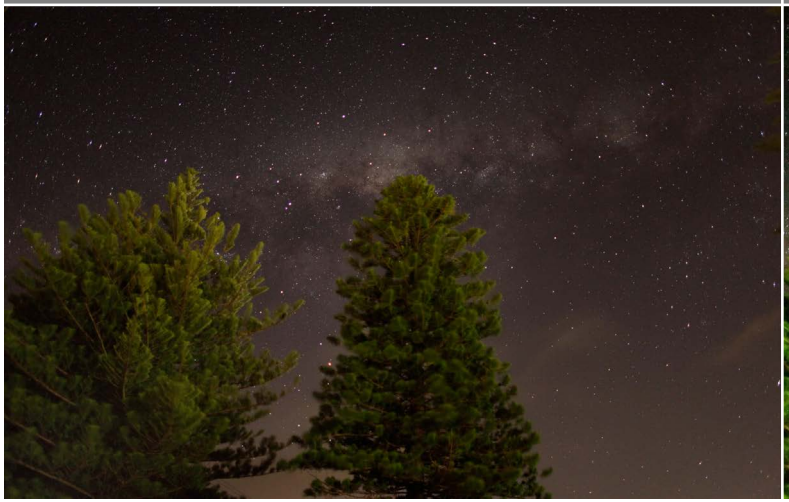
- Adjust Levels: Brightness and contrast
- Adjust Colour: White balance and saturation
- Reduce noise
- Reduce vignetting

The following pages contain several examples that show how each of these steps can be achieved in Photoshop and Lightroom, with other examples using Aperture and ACDSee Pro. Many other programs offer similar settings to achieve the same outcome.

Photoshop Example

Photoshop Adjustment Layers

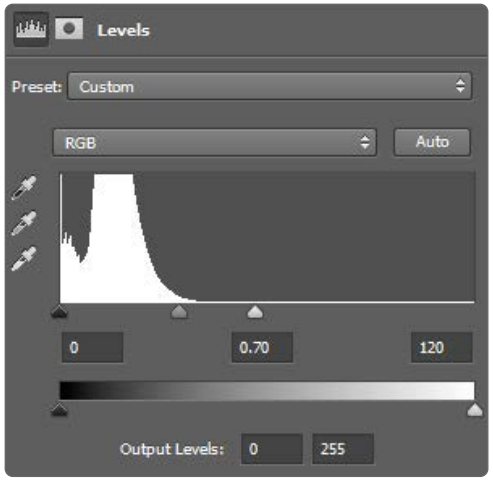
In Photoshop, the ideal way to apply levels, curves, colour balance, saturation and other adjustments is with 'Adjustment Layers'. These do not alter the underlying image and you can keep changing the settings as often as you want. It also makes it easy to turn the adjustment layer on and off so that you can see what effect it is having on your image.

AS SHOT	PROCESSED WITH PHOTOSHOP
	

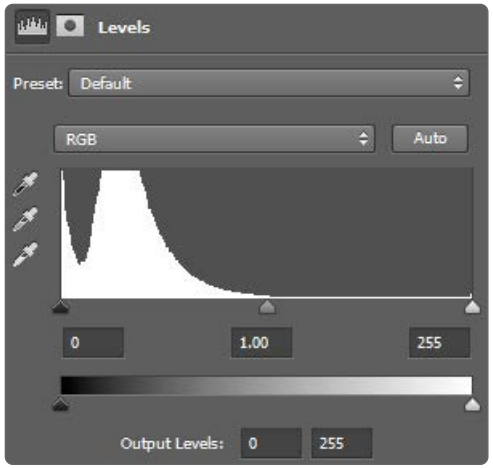
Canon 5DMKII, 24mm lens, 8 sec, f1.4, ISO1600

Step 1: Brightness Levels

Select Layer:
New Adjustment Layer: Levels
As is often the case, because there is very little information in the bright right half of the histogram, I have chosen to move the white point slider a long way to the left, dramatically brightening the image.
I then move the mid-point slider back to the right to darken the image and restore a 'night sky' appearance, but one with much more contrast as the dark left half of the histogram has now been heavily stretched.

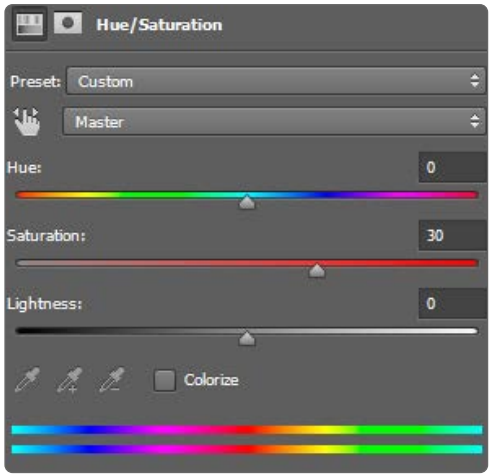


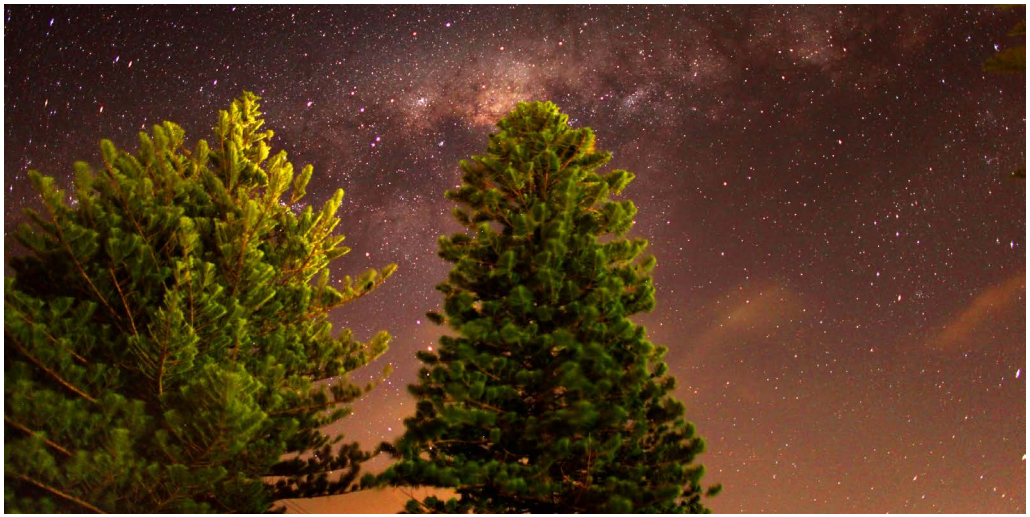
The stretched image and the new corresponding histogram are shown below. Pixel values are now spread further across the histogram, but still predominantly in the dark half as we would expect for a 'night' image.



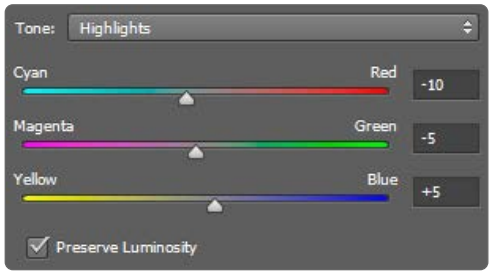
Step 2: Saturation

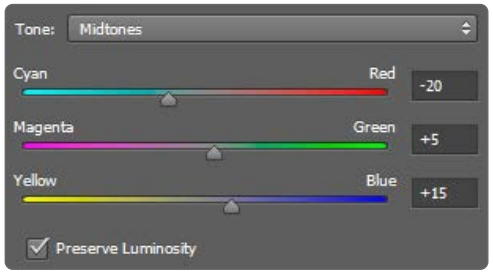
Select Layer:
New Adjustment Layer: Hue/Saturation
Whether you want more saturation in your image is a personal decision. I often set a high saturation adjustment initially which makes it easier to see what you are doing while using the Colour Balance tool. After adjusting the colour, I may then tone down the saturation a little to restore a more natural appearance.

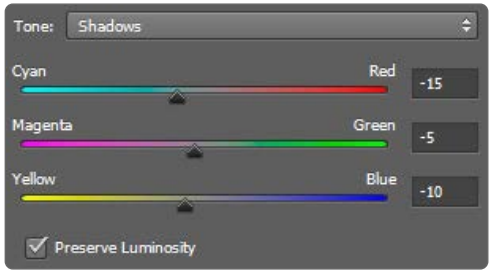




Step 3: Colour Balance







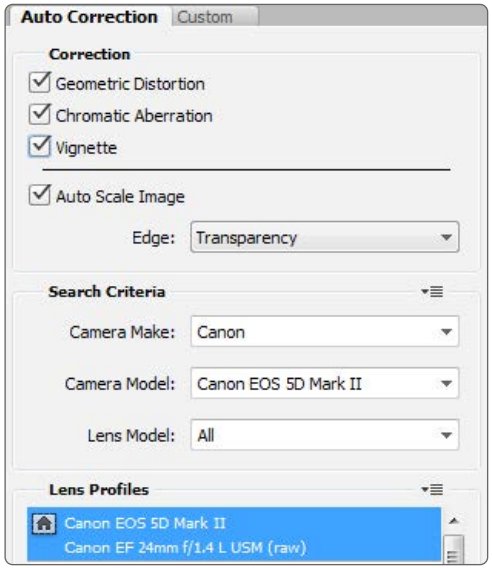
Select Layer:
New Adjustment Layer:
Colour Balance
The Colour Balance tool allows you to separately adjust colour for the shadows, mid-tones and highlights of an image.

This image is strongly affected by light pollution, so I have reduced the red and yellow (increased cyan and blue). In the mid-tones I have also reduced magenta (increased green). Preview the effect of these settings as you move the sliders and make your judgment about what looks best.

Step 4: Lens Corrections

Select Filter: Lens corrections
Lens corrections must be applied to your image layer (or a copy of it). They cannot be applied as an Adjustment Layer.

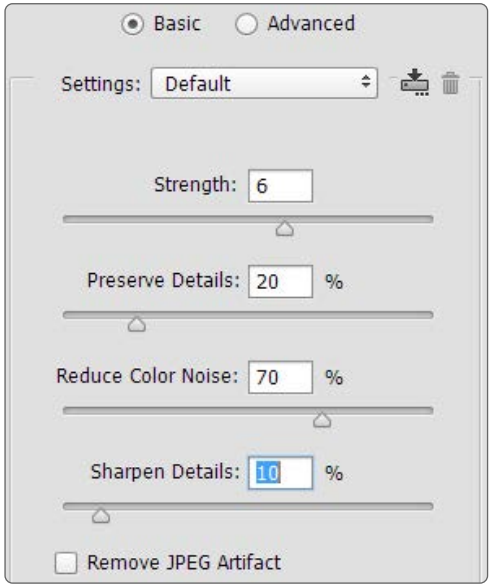
In most cases, Photoshop will automatically identify the camera and lens combination and auto-correct the image. Otherwise you can make your adjustment with the Custom tab.



Step 5: Noise Reduction

Select Filter: Noise: Reduce Noise
Noise reduction must also be applied directly to your image layer or a copy of it (it cannot be applied as an Adjustment Layer).

These settings require a bit more experimentation to find what works best for your image. Typically it is colour noise that you want to reduce most so keep that setting high. Then adjust the strength setting to your own taste.



Lightroom Example 1: *Twilight Landscape*

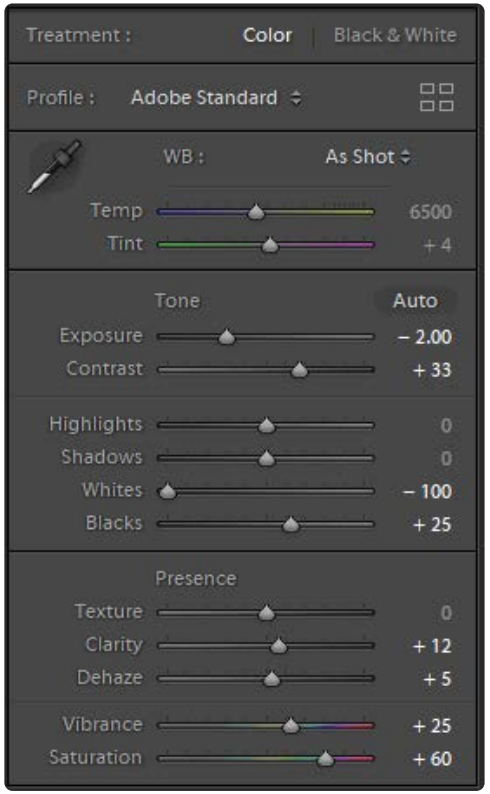
Twilight images are in many cases processed in the same way as you would a normal daytime image. The challenge is managing the large range of brightness levels across the image.

An image that is exposed for the brightest part of the sky will tend to be under-exposed in the darker areas. Using software to stretch these dark parts of the image increases the appearance of noise. I prefer to work with an image that is slightly over-exposed as compressing the levels in the brighter parts of the image actually reduces the appearance of noise and makes for a smoother final result.

In this case I have decreased the Exposure slider to -2.00 and used the Whites slider at -100 to further compress the highlights in the image. The Saturation slider has been used to enhance the twilight colours. This processed result is much closer to how the eye perceived this scene than the original image.

AS SHOT

PROCESSED WITH LIGHTROOM



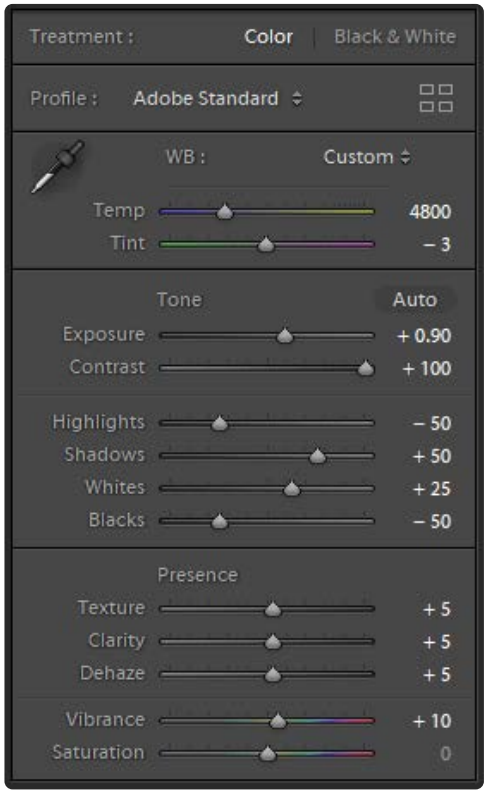
Canon 5DMKII, 50mm lens, 8 sec, f4, ISO200

Lightroom Example 2: *Night Sky Scene*

AS SHOT	PROCESSED WITH LIGHTROOM

Canon 5DMKII, 24mm Lens, 30 sec, f2.5, ISO1600

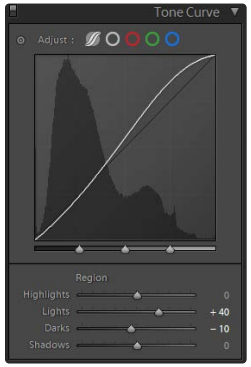
Step 1: Brightness Levels and Contrast



Working down the panels in the Develop mode of Lightroom provides a fairly logical sequence of steps to work through. The first is the 'Basic' settings, where you adjust the white balance (colour), brightness and contrast of the image.

In this case the Auto white balance settings have done a good job and are very similar to the Daylight white balance that was set on the camera.

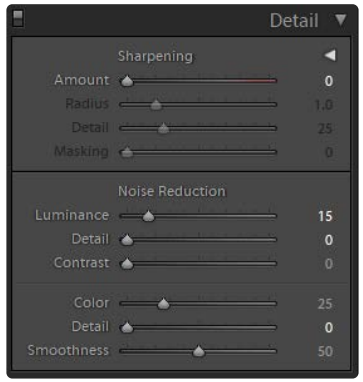
The main adjustment I have made is to increase the contrast slider all the way up to +100 and then increase the exposure. I've also added a little more punch to the image using the clarity, vibrance and saturation settings.



You can also experiment with the Tone Curve settings to further increase the brightness and contrast of the image.

Step 2: Detail

Photographers typically use these settings in Lightroom to sharpen up detail in their daytime images, but there is an inevitable compromise between sharpening and noise reduction. So for night sky images I use these Detail settings primarily to reduce the visibility of noise. Lightroom's ability to smooth out noise in night sky images without blurring the stars and other details is one of its most impressive capabilities.



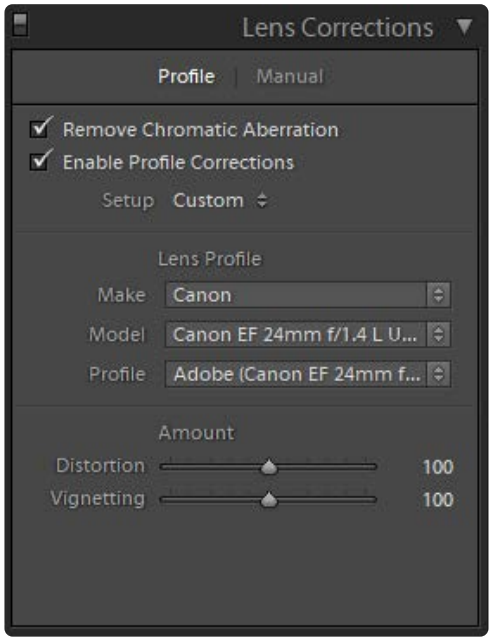
Much of the unpleasant noise in night sky images is colour noise, a natural characteristic of the RGB matrix in your camera's sensor. Lightroom's default value of 25 for Colour noise reduction is often the optimum for reducing this without overdoing it. If the image is very noisy, sometimes I will use Luminance noise reduction as well.

If you increase the detail sliders, Lightroom will place greater priority on maintaining detail in the image and the noise reduction effect will be reduced. Consequently, I tend to also reduce all the detail sliders to zero.

BEFORE NOISE REDUCTION

AFTER NOISE REDUCTION

Step 3: Lens Corrections



Most lenses do not produce an evenly illuminated field. The corners receive less light than the centre of the frame leading to vignetting. Lightroom offers a very quick and easy way to fix vignetting and other lens artefacts. In most cases, you can select 'Enable Profile Corrections' and Lightroom will automatically identify the lens and camera you were using and correct distortion, chromatic aberration and vignetting with just that one click. You can further adjust the amount of each correction with the sliders if you want.

Or you can select 'Manual' rather than 'Profile' lens corrections and make your own manual adjustments.

The default lens corrections for the built-in profile of the 24mm lens on the Canon 5DmkII have worked very well in this case to reduce the vignetting in the corners of the image.

BEFORE DEFRINGING

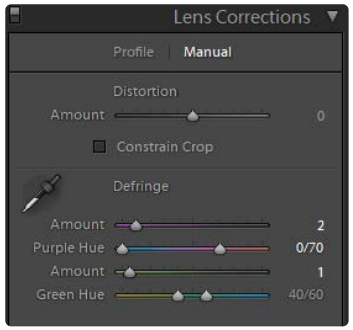
AFTER DEFRINGING

You can also use the Lens Corrections panel to correct some colour issues introduced by the lens. Ticking the 'Remove Chromatic Aberration' option should help reduce the colour fringing that is most obvious near the corners and edges of an image.

Stars across the frame, especially when captured with the aperture wide open, will often have purple or occasionally orange/yellow halos. This can be reduced by selecting the *Defringe* amount. First increase the Amount of the purple slider to a low value and then increase the Hue range that defringing applies to if needed. If you have green/orange/yellow halos as well you can set a low Amount for the slider and adjust the Hue that it applies to.

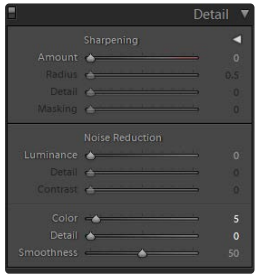
While the halos are small, having them around every star can result in a colour cast across the image. Defringing these halos can help remove that colour cast but don't overdo it or you'll end up with processing artefacts around the stars instead.

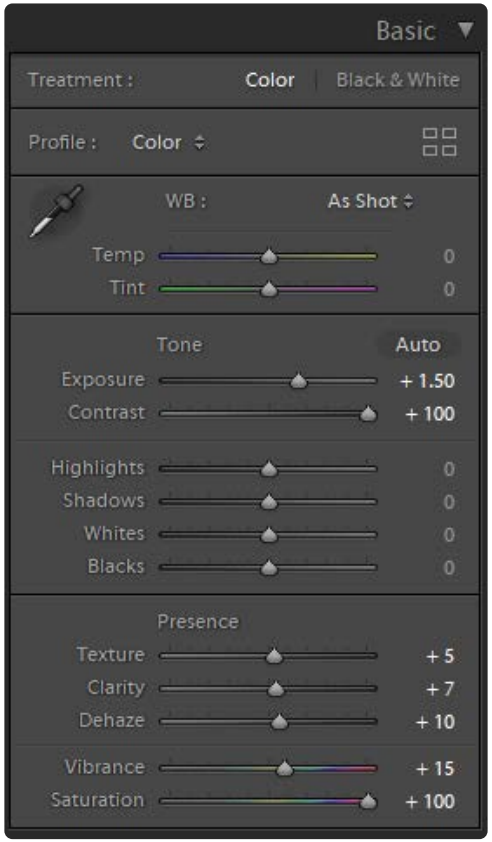
Compare the final result to the 'as shot' low contrast and heavily vignetted image. With Lightroom it takes only a few clicks to apply all these settings to each image.



Lightroom Example 3: *Star Trail*

AS SHOT	PROCESSED WITH LIGHTROOM





Star trail images will often look flat and de-saturated at first, both on the back of the camera and when you download them to a computer. But there is plenty of information in the image that can be brought out.

In this case, the Auto white balance setting worked well, as it often does. I have then pulled the contrast slider to maximum at +100 and also increased the exposure to +1.50.

With star trail images, I find I can be much heavier handed with the saturation slider than I would with any other image, here bringing it all the way to +100. For most images this would be way too much but the colours it accentuates in this image are real.

Hotter stars are blue which contrast with the yellow of stars with lower surface temperatures. And the yellow and brown tones of the Milky Way are caused by absorption and scattering from dust and gas in the spiral arms of our galaxy. So if you capture your images under dark skies and process them carefully, they can reveal information about real physical processes occurring among the stars.

Even though this image was taken at a very low ISO setting of 50, in the long one hour exposure quite a lot of thermal noise is generated inside the camera. With 'Long Exposure Noise Reduction' turned on, the camera has taken a dark frame which removed most of these hot pixels from the image. The residual noise remaining has been cleaned up very nicely by a very minor tweak of the colour noise slider under the Detail tab.

TOP LEFT:
Canon 5DMKII, 24mm lens, 60 min, f4.5, ISO50

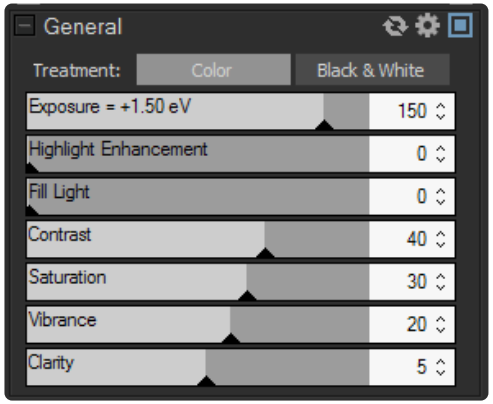
ACDSee Pro Example

AS SHOT	PROCESSED WITH ACDSee

Canon 6D, 14mm lens, 30 secs, f2.8, ISO3200

Develop

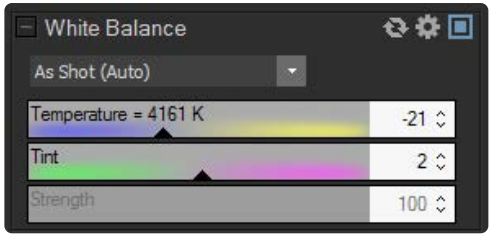
Tools in the Develop mode apply to the whole image. The Develop mode consists of three tabs: Tune, Detail and Geometry.



BRIGHTNESS LEVELS AND CONTRAST

Tune

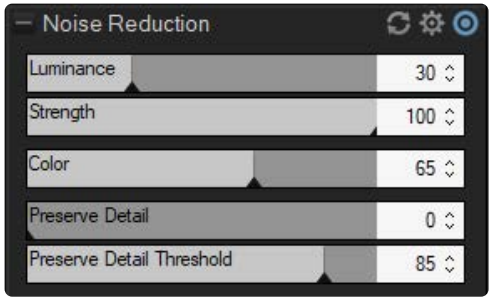
1. **Tune-General:** The first step for night sky images is typically to increase the exposure and adjust other settings to get the overall brightness levels and contrast of the image right. You can make further adjustments with the Lighting or Tone Curves tools.
2. **Tune-White Balance:** Experiment with various white balance settings and choose what works best for each image.
3. **Tune-Saturation:** A little extra saturation often helps, as long as colour noise and light pollution in the image are not too strong already.



SATURATION

Detail

The Detail tab provides the Sharpening and Noise Reduction tools. Typical Luminance Noise settings would be in the range 5-50, but more like 20-60 for Colour Noise. Noise generally limits the application of Sharpening to night sky images so this would typically be set quite low or even left at zero.



BEFORE NOISE REDUCTION

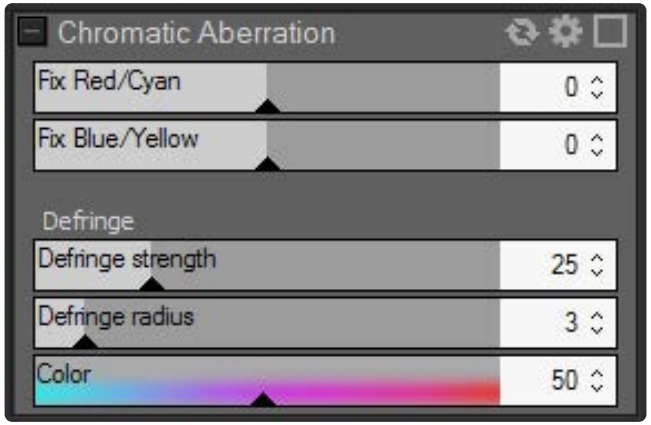
AFTER NOISE REDUCTION

BEFORE CHROMATIC ABERRATION CORRECTION

AFTER CHROMATIC ABERRATION CORRECTION

Chromatic Aberration

You can use the Defringe options in particular to reduce purple halos which are common around stars shot with the aperture wide open. See examples on this page. The Red/Cyan and Blue/Yellow sliders can also reduce chromatic aberration in the corners of the image if it is present in your images.

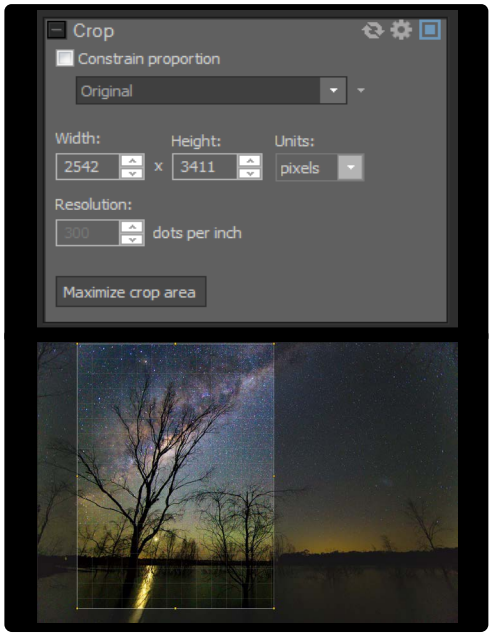


Geometry

The Geometry tab has tools for cropping, rotating and straightening your image, as well as for fixing lens distortion and vignetting.

Edit

The Edit mode is used to make selective or pixel level changes to your image. For night sky images, this could mean using the Repair Tool to touch up some hot pixels or stray light in your image.

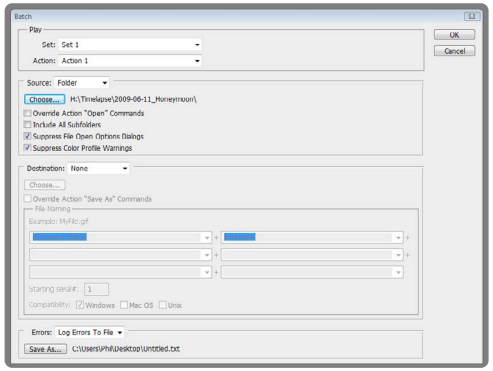


Star Trail Stacking

Chris Schur's Photoshop Action

Chris Schur's Photoshop Action is a popular little action file, which will stack a directory of images (not RAW), adding them all together to produce a composite similar to one long exposure.

It's a very simple action which takes each image in turn, adds it as a layer on top of the previous result, sets the Blending Mode of the new layer to 'Lighten', flattens the image and then moves on to the next image in the sequence.



Step 1: Load the action into the Action Palette.

Step 2: Create a blank all black image, the same size as the images you wish to stack and leave it open.

Step 3: From the menu, select File --> Automate --> Batch.

Step 4: Select directory of files as source, and NONE for output directory. Hit OK, and the images will open, stack and close in succession.

Step 5: When the action is finished, the flattened image can be saved as you wish.

I recommend testing it with a short sequence first. You should see the star trail image being built up as the Action runs. The image to the right was produced from a sequence of images captured during my honeymoon, sailing around the Whitsunday Islands in Queensland. You can see the effect of the boats moving around at anchor as well as the stars trailing.

Canon 5DMKII, 28-135@28mm, stack of 70 x 30 seconds, f3.5, ISO1600

StarStaX

StarStaX is a fast and simple piece of software developed by Markus Enzweiler primarily for stacking Star Trail Photos. StarStaX is available as Freeware for Mac OS X, Windows and Linux. Of course if you like it, you can donate to support Markus.

StarStax does not process raw files, so before you begin you will need to export a sequence of jpg or tif files from your developed raw files.

The four main buttons in StarStaX

Step 1: Click the "OPEN IMAGES" button (top Left) and select all the images you want to stack. You can also drag and drop into the left pane or select File:Open Images from the menu.

Step 2: Select the 'Lighten' Blending mode (right hand side).

Step 3: (Optional) If you are having trouble with hot pixels, you can use the "OPEN DARK FRAMES" button to select some dark frames you captured manually. These should have been recorded with the lens cap on for the same duration and with the same ISO as your image files. Then select the option to "Subtract Dark Images" (right hand side). I rarely use this option as processing the RAW files in Lightroom with Noise Reduction is usually all that is required and gives a better result.

Step 4: Click the "Start Processing" button. The star trail image will build up in front of you.

Step 5: When the whole sequence has been processed, Click the "Save As" button and choose where to save the resulting image.

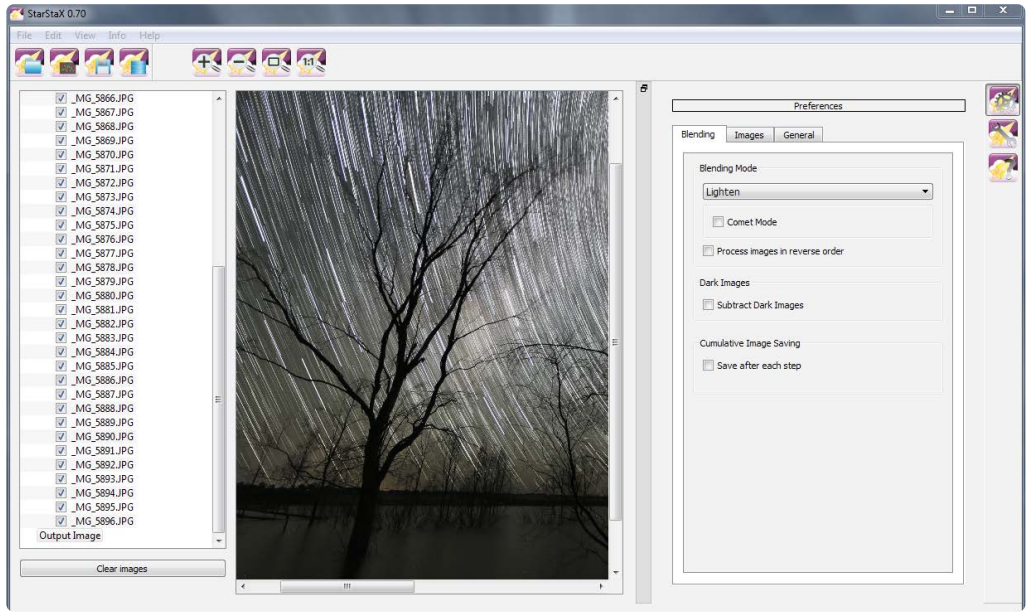


IMAGE: SHONA DUTTON & PHIL HART
Nikon D7000, Sigma 10-20@10mm, stack OF 44 x 5 min, f4, ISO400

Timelapse Video

Once you have downloaded your long sequence of night sky images to a folder on your computer, it is simply a case of rendering them to video. Most video editing software applications will offer this capability, but they often don't come cheap.However, the free PC application ***VirtualDub*** can render a video for you in just a few steps. For the Mac, I recommend the more straightforward ***Timelapse Assembler***.

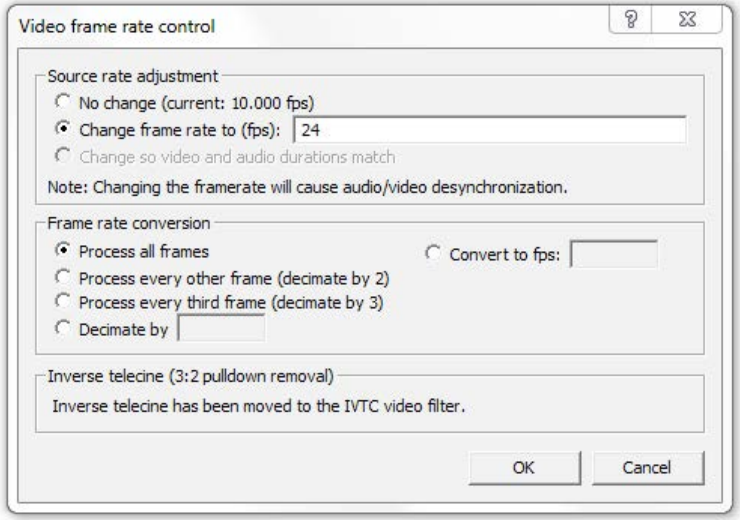
Before you start using VirtualDub, you should download and install the ***H264 video codec*** so that you can save your video files with an effective compression algorithm.

Step 1:

Drag and drop the first image in a sequence of named files into the VirtualDub window. It will recognise and load the full sequence, provided the files are numbered sequentially.

Step 2:

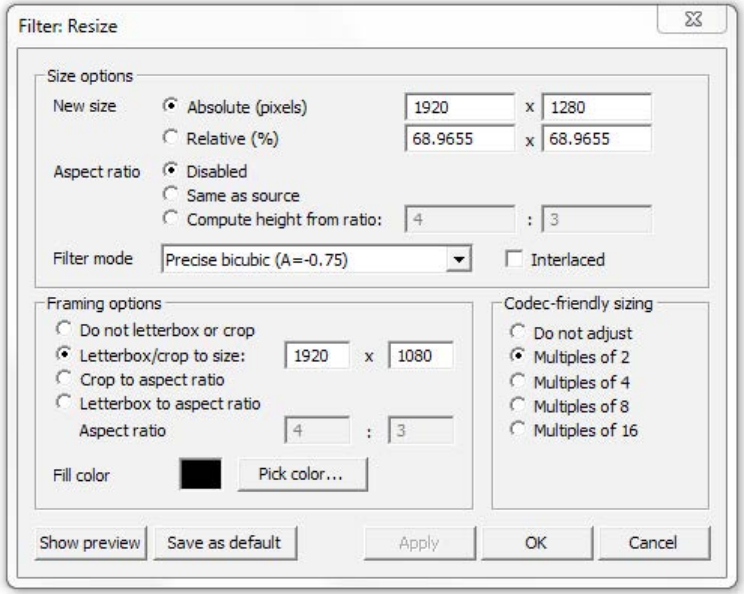
Set the desired frame rate, e.g. 24fps (Video Menu --> Frame Rate)



Step 3:

Set the desired output size (Video Menu --> Video Filters --> Resize).

- I usually resize to a width of 1920 pixels and then crop to Full HD format, 1920 wide by 1080 pixels high.
- It is helpful to tick the Codec-friendly sizing option 'Multiples of 2' to ensure that the video does not end up with odd dimensions.



TIP: If you have tried shooting timelapse sequences in RAW format, ***LR Timelapse software by Gunther Wegner*** allows you to alter white balance and other settings over time in the animation using key-frames and also offers a powerful 'deflicker' tool to correct for step changes in brightness.

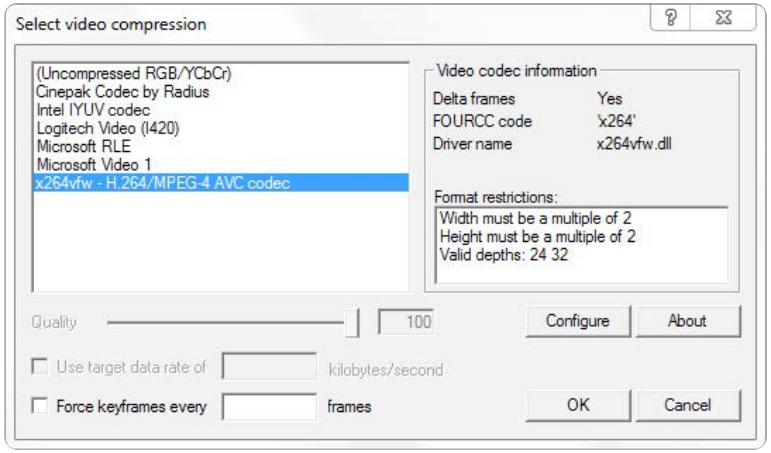
Step 4:

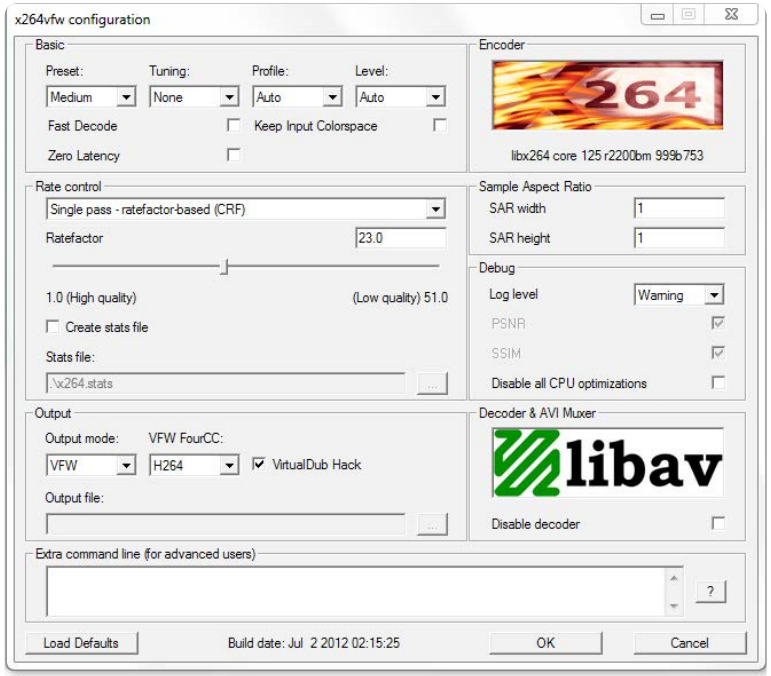
Choose a compression option to reduce the size of the video file (Video Menu --> Compression).

- Having installed the H264 Codec before you started, you should be able to select that option. Otherwise the only one of the default options I can recommend is Intel IYUV compression.
- With H264 selected, click the Configure button and then tick the little box that says 'Virtual Dub Hack'. Don't ask why but it won't work if you don't tick this.
- Select OK and OK again on the Video Compression box as well.

Step 5:

Choose File: Save as AVI from the menu and VirtualDub will render the sequence to an AVI file.





Night Sky Panoramas with PTGui

Processing night-sky panoramas is much the same as for source images shot in daylight. However, finding matches between frames filled with only stars and dark foregrounds can be challenging and I find that Photoshop and Lightroom still struggle.

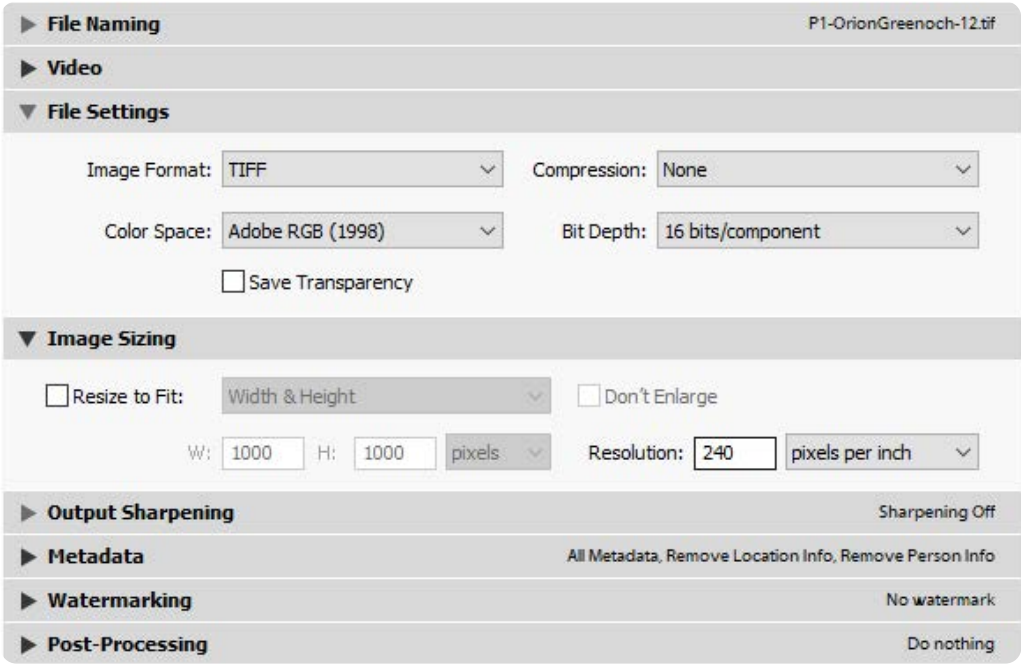
Instead, I recommend PTGui for night sky panorama editing. PTGui has developed to the point where it reliably and easily stitches night-sky panoramas. If I have substantial overlap between frames (around 20%), I rarely need to add to manual control points, which can be a tedious step otherwise.

Although PTGui can process RAW images, I find it helpful to brighten the source images before importing them as TIF files to PTGui so that both the sky and foreground have enough detail for the pattern matching algorithms to work with.

Be careful with this initial editing of the individual frames as the Blacks, Whites, Shadows, Highlights and Texture, Clarity and Dehaze sliders are all to some extent 'intelligent' or 'context-sensitive'. This means their effect on the pixel values in an image can vary based on the overall content of the image, which can vary between frames and then introduce artefacts when blending them together.

It is therefore best to achieve the bulk of your initial editing before stitching the panorama primarily through the Exposure and Contrast sliders and the Tone Curve panel, with only mild adjustment of the context-sensitive sliders. While it is also possible to use the Lens Corrections panel to adjust for vignetting, I typically have more success with complex panoramas by allowing PTGui to measure and correct for vignetting.

Here is the sequence I follow to create a night-sky panorama:



Step 1:

Apply basic adjustments in Lightroom to brighten your images and export a series of TIFF files with 16-bit depth.

Step 2:

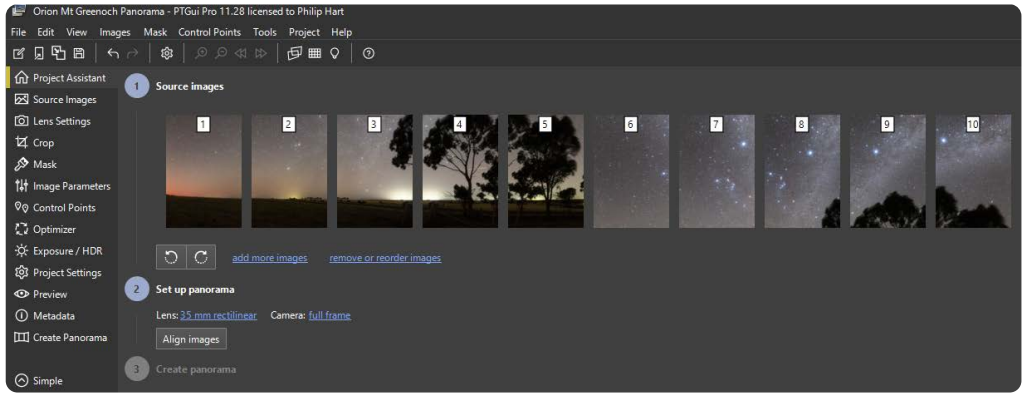
From the Project Assistant home screen in PTGui, load the TIFF images and confirm the lens settings if required.

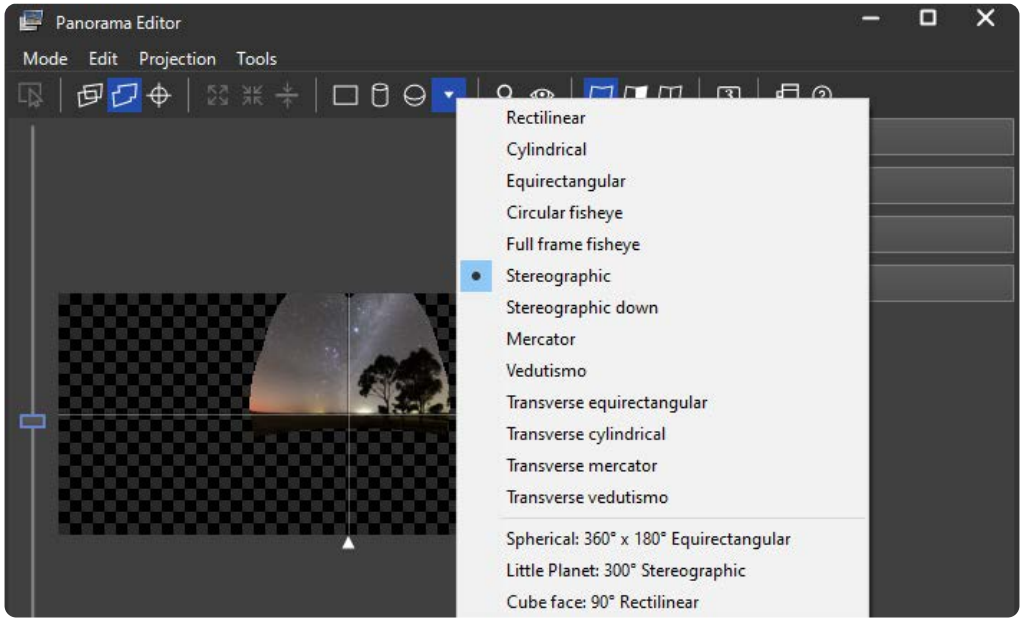
Step 3:

Click “Align Images”.

Step 4:

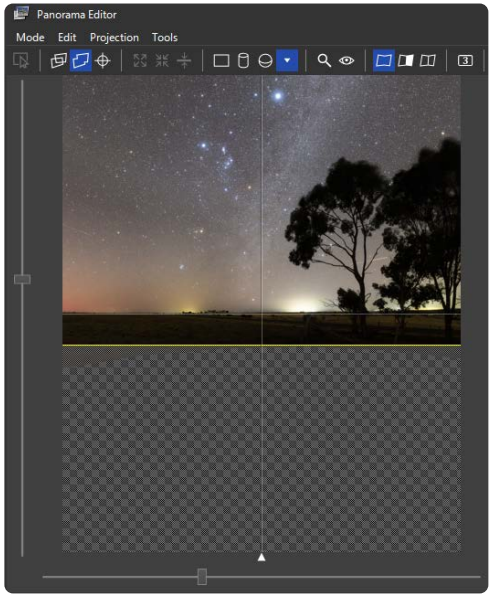
From the Panorama Editor (shortcut ‘Ctrl-E’), change the Projection to “Stereographic” or experiment with other projections to suit your panorama, then adjust the vertical and horizontal field of view sliders.





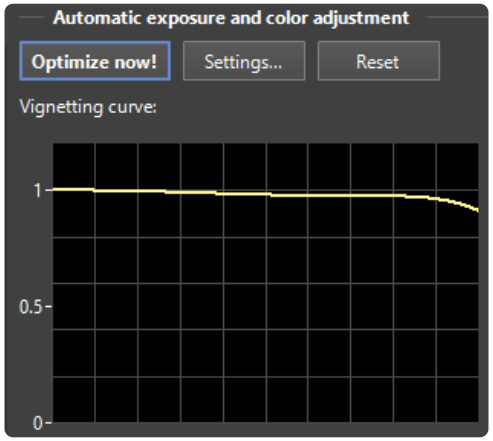
Step 5:

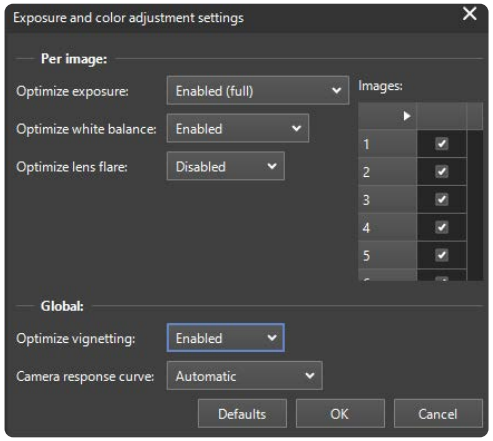
As the field of view sliders act symmetrically, you will often end up with a large blank area below the horizon. This can be cropped out with yellow crop lines which are enabled by dragging in from one corner or side of the image.



Step 6:

From the 'Exposure/HDR' panel click "Optimise Now". Unless vignetting was fully corrected in Lightroom, you will see a vignetting curve that is lower on the right side which represents the corner of the source frames. If the image needs additional correction, click "Settings" and you can choose the "Enabled" rather than automatic options for Exposure and Vignetting correction.





Step 7:

Create the Panorama. I export 16-bit TIFF files for maximum further editing in Lightroom or Photoshop. The resolution can be reduced from 100% as you will be creating very large files here which can tax your processing power.

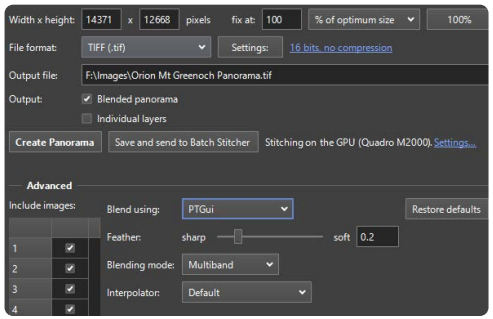


IMAGE: ORION AND MILKY WAY
10 frame panorama, Canon EOS Ra, Sigma 35mm lens and Nodal Ninja Pano Head. Each frame 25 secs, f2.5, ISO3200

Step 8:

Once you have the merged panorama, you can further process the image with the full suite of Lightroom adjustments available.

Astute observers may notice the emphasis the stars have in this image. This effect was achieved by holding a Lee soft filter in front of the lens for 1/3 of each exposure in the field. The Canon EOS Ra astrophotography camera has also picked up the red emission from hydrogen nebula in Barnards Loop and the North Orion Bubble in the centre of the panorama.

WONDERS OF THE NIGHT SKY

LAKE EPPALOCK WITH MILKY WAY, VENUS, ZODIACAL LIGHT AND THE FIRST HINT OF TWILIGHT

Canon 6D, 14mm, 30 sec, f.8, ISO3200

Having now described how to photograph the night sky, in this part I discuss some of the interesting events, features and phenomena that you can see at night and how to apply the techniques explained earlier to photograph them. The topics covered are:

- **Earth's Shadow and the Belt of Venus**
- **Zodiacal Light**
- **Planetary Conjunctions**
- **Noctilucent Clouds**
- **The Milky Way**
- **Lunar Eclipse**
- **Meteors**
- **Comets**
- **Satellite Flares**
- **The Aurora Borealis**
- **Bioluminescence**

All of these can be captured with nothing more than a digital SLR, a tripod and perhaps a remote release. Some, like Earth's shadow and satellite flares, can be photographed on just about any clear night even from a city environment. Others like the Milky Way and zodiacal light are regular features of the night sky but require a dark sky location well away from the city lights.

The orbit and arrival of some bright comets is well known, but others can arrive with barely a few weeks' notice. Noctilucent clouds and the aurora are also unpredictable, but require a high latitude location for them to be regular rather than rare phenomena. Some events you can plan for, like a lunar eclipse, while meteors might be seen anywhere, anytime but require perseverance and more than a little luck to catch a bright one on camera.

If you find yourself heading outside at night regularly, anticipating the enjoyment of these celestial 'wonders', then it becomes time to call yourself a true astronomer and 'star gazer'. I hope you enjoy observing and photographing them as much as I do!

LEFT: AURORA STORM IN SCOTLAND
Canon 10D, 20mm lens, 4 sec, f1.8, ISO800

Earth's Shadow and the Belt of Venus

What is it?

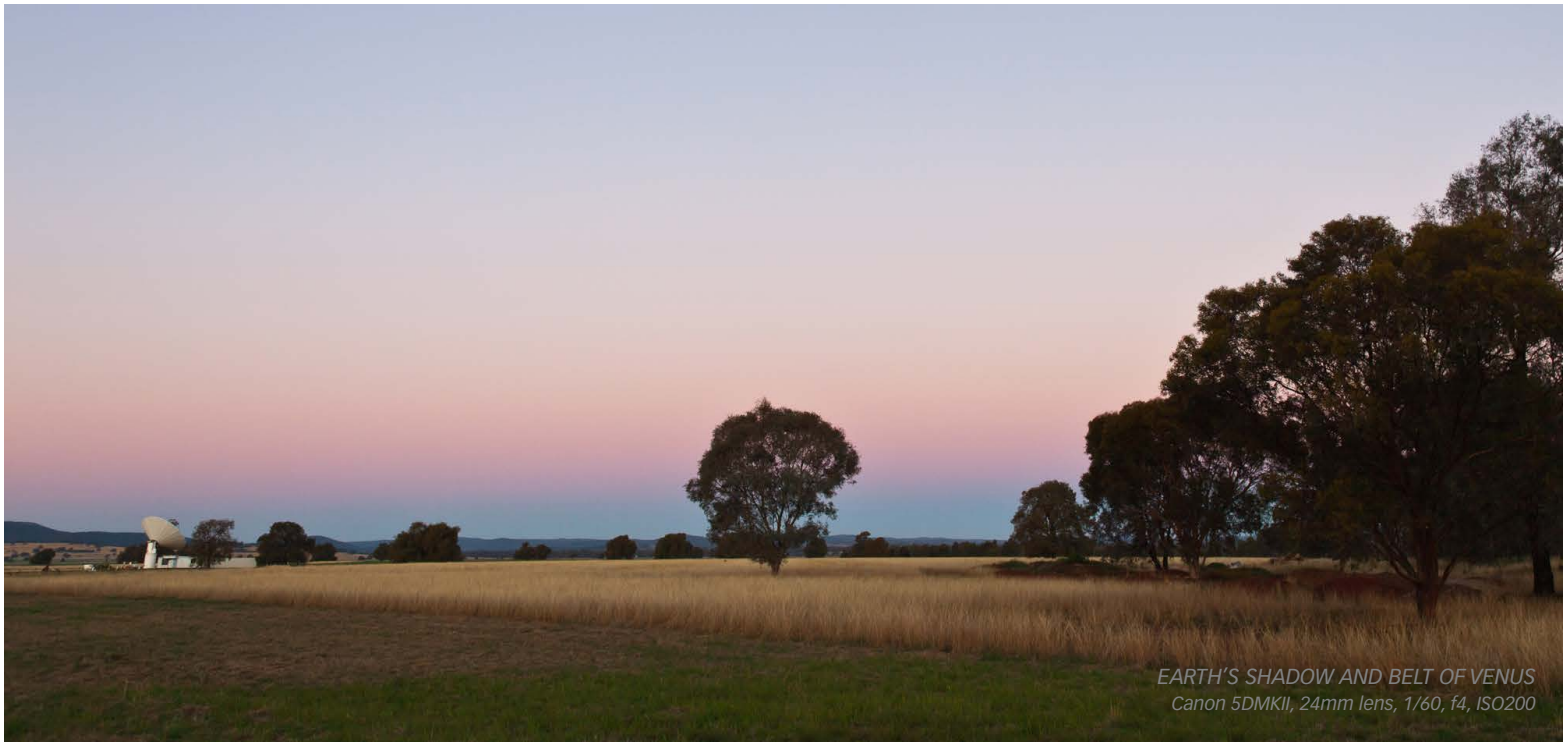
The Belt of Venus is a red or pink coloured glow, caused by backscattering of red light from the setting sun in the atmosphere. As the sun sets in the west, Earth's shadow rises above the opposite horizon. The Belt of Venus separates this darker band of Earth's shadow from the brighter twilight sky above it.

When can you see it?

The dark band of Earth's shadow and the more colourful Belt of Venus above it are visible opposite the sun shortly after sunset or before sunrise, so look east 5-15 minutes after sunset or west before sunrise. At the time of full moon each month, the moon will rise amidst these dusky twilight colours.

How to photograph it?

Because the Belt of Venus is visible in bright twilight, you can use your camera as you would during the day. Try to keep your ISO setting low and use a tripod to enable longer exposure times and give the sensor plenty of light.



EARTH'S SHADOW AND BELT OF VENUS
Canon 5DMKII, 24mm lens, 1/60, f4, ISO200

About these images

The image above was taken while I was setting up gear for a timelapse video near the Parkes radiotelescope in New South Wales in July 2010. While 'The Dish' was the main focus for the night, the flat horizons afforded a great view of the Belt of Venus as I was setting up gear with my talented friend ***Alex Cherney***.

This image was taken as the full moon was rising above Greens Lake in north-east Victoria, just a few hours before the start of a total lunar eclipse on 28th August, 2007. Twilight often gets my adrenalin pumping, but the full moon rising just hours before the start of an eclipse is even more exciting!

FULL MOON RISING WITH EARTH'S SHADOW AND THE BELT OF VENUS
Canon 20D, 18-55mm lens @55mm, 1/8, f8, ISO100

Zodiacal Light

What is it?

The zodiacal light is a band of light that runs along the ecliptic, the path through the sky that all the planets follow as they orbit the sun. As well as planets and asteroids, the solar system also contains a lot of dust and smaller particles. Because they tend to be confined to the same orbital plane as the planets, the sunlight they reflect is also visible along the ecliptic.

When can you see it?

The zodiacal light is strongest looking close to the sun. So in the west after it is dark or in the east before morning twilight begins. The angle of the zodiacal light up from the horizon is steepest in the evening during spring and in the morning during autumn (fall), so those are the best times of year to catch it.

VENUS AND ZODIACAL LIGHT, ST GEORGE, QUEENSLAND
Canon 5DMKII, 14mm lens, 30 sec, f2.8, ISO3200

Canon 5DMKII, 14mm lens, 15 min, f4, ISO200

How to photograph it?

You can capture the zodiacal light using the settings for a short exposure night sky scene or with a longer star trail type image. In the first case, try with your aperture wide open, ISO set quite high (1600 or higher) and exposure time at least 30 seconds and up to 2 minutes.

For a star trail type image of the zodiacal light, try 15 minutes at an aperture of f4 and an ISO setting around 200-400.

Note in the image to the left how the stars are trailing around both the south celestial pole (outside the top right corner of the frame) and the north celestial pole (to the bottom left of the frame but well below the horizon). This effect requires a very wide-angle lens with a field of view approaching 180 degrees, to be able to capture the view looking close to north and south in a single image.

ZODIACAL LIGHT (BOTTOM RIGHT) AND MILKY WAY WITH STRONG GREEN AND RED AIRGLOW

Canon 6D, 14mm lens, Full 360 degree panorama of 18 images (3 rows of 6). Each frame 30 secs, f2.8, ISO3200. Combined with PtGui.

Planetary Conjunctions

What are they?

A conjunction occurs when two or more celestial bodies appear close together in the sky. The most common type of conjunction is when the moon passes close to another planet as it moves through the sky each month. Occasionally two or three bright planets and the moon will be close together at the same time.

When can you see them?

The position of the moon and planets in the sky can be predicted with great precision for centuries in advance, using planetarium software like Stellarium. However, astronomy magazines and calendars (and ***my email newsletter***) will also give you a heads up of bright conjunctions in the month or two ahead.

Conjunctions occur most often in the west after sunset or in the east before sunrise, as the bright planet Venus and smaller Mercury only ever appear in that part of the sky. So conjunctions are often at their best during twilight before it is completely dark.

1ST DECEMBER 2008, MOSAIC OF THREE EXPOSURES – Canon 20D, 200mm lens, 3 sec, f5.6, ISO200

How to photograph them?

For twilight conjunctions, use the camera light meter to determine exposure settings but try to maintain a lower ISO setting. If the conjunction is visible later in the evening, then use a setting for a typical night sky scene, with aperture wide open, exposure at least 30 seconds and ISO1600 or even higher if necessary.

Either way, experiment with both wide angle and telephoto lenses for very different views of each conjunction and look for an interesting foreground.

About these images

The 'Smiley Face' conjunction of December 2008 (previous page) was one of the most well publicised conjunctions that I can remember. The crescent moon and the two brightest planets Venus and Jupiter combined to form a 'smiling face' in the evening sky.

A telephoto lens allows you to get in a little closer to these planetary bodies, but it means that your foreground elements also need to be relatively distant from the camera. For the image on the previous page I used Google Street View to check out the regional town of Sale in eastern Victoria, a 1 hour drive from where I was staying that week. I was particularly trying to determine if there was a good view to the west behind the clock tower. With that confirmed I packed up the car and headed out for the evening to capture this 'timely conjunction' image. Some people would say that it was a lot of effort for a timestamp on an image!

PLANETS ALIGN OVER SNOWY MOUNTAINS UNDER MOONLIGHT – 16TH AUGUST 2016 (FROM BOTTOM VENUS, MERCURY, JUPITER), Canon Powershot G1X MARKII, Panorama 2 X 10 Secs, f3.5, ISO400

The image above of the conjunction between Venus, Mercury and Jupiter in August 2016 was taken while I was on a snow camping trip in New South Wales. I had carried my Canon G1X Mark II, rather than a heavy DSLR, and I certainly didn't have a tripod so had to fashion a support for the camera out of snow, skis and whatever else I had to hand.

Noctilucent Clouds

What are they?

Noctilucent clouds are tenuous, extremely high altitude clouds, visible in the middle of the night from high latitude locations, where the light of the sun comes over the poles and illuminates these somewhat mysterious clouds 50 miles (80km) up in the atmosphere. They are much higher than any other clouds visible during the daytime but can only be seen at night when there is no sunlight in the lower atmosphere.

When can you see them?

Noctilucent clouds are visible in summer months from latitudes 50 to 70 degrees north, so anywhere in Canada and in Europe north of London, Brussels and Prague. Look low on the northern horizon during the middle of the night. Very few people live far enough south to see them in the Southern Hemisphere.

Canon 10D, 20mm lens, 4 sec, f4, ISO100

How to photograph them?

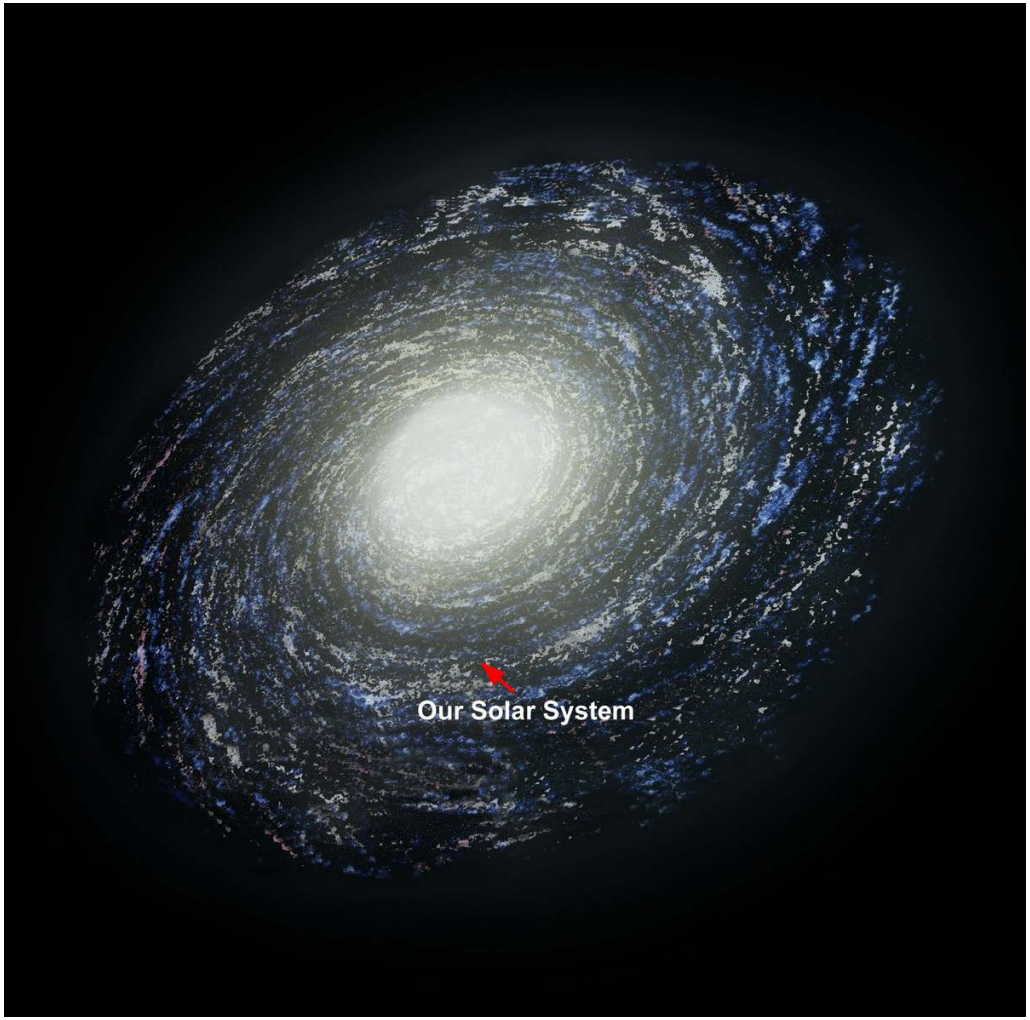
Noctilucent clouds occur in deep twilight. Although it is the middle of the night there is still a faint twilight glow at this time of year in locations this far north. The camera light meter should be able to determine correct exposure as for other twilight images but these are certainly the darker end of what could be considered 'twilight' images.

About these images

These images were taken while I was living in Aberdeen in north-east Scotland. I had spent the day at the T-in-the-Park music festival near Edinburgh and I noticed them while driving north late that night. Once I got home, I rushed up to the park at the end of my street with my camera and tripod to snap these pictures before finally crashing in bed.

TIP: Visit spaceweather.com for reported sightings of noctilucent clouds and other 'space weather updates'.

Canon 10D, 28mm lens, ¼ sec, f1.8, ISO1600



The Milky Way

What is it?

The Milky Way is our home in the Universe, a spiral galaxy, containing more than 200 billion stars. Our solar system sits in one of the outer arms of the Milky Way, and the light of all those distant stars creates a diffuse band of light across the sky showing the plane of the galaxy. Dust and gas between the stars absorb light, forming a web of dark dust lanes and clouds against the brightness of the Milky Way.

Perhaps the most impressive target for night sky photographers, the Milky Way when it is visible is the prime target to capture in your images.

LEFT: ILLUSTRATION OF OUR POSITION IN THE MILKY WAY GALAXY.
Adapted from illustration by Azcolvin429 (Wikipedia)

When can you see it?

The brightest central parts of the Milky Way, through the constellations Scorpius and Sagittarius, are visible in the evenings from June through to September. The fainter outer arms of the Milky Way which run between Orion and Gemini are high in the evening sky from December through to February.

In the Northern Hemisphere, the Milky Way through Cygnus and Cassiopeia is high in the sky around October/November. For the Southern Hemisphere, the bright Milky Way around the Southern Cross and the Pointers is up high during April/May evenings.

Canon 1100D (Rebel T3), 18-55 lens @18mm, 60 sec, f3.5, ISO3200

How to photograph it?

The Milky Way spoils you for choice of lenses – anything from the widest fisheye to a standard lens can provide a pleasing view. Foregrounds are optional too as the Milky Way has enough structure and variation to carry a photo on its own. The image on the previous page was taken with an entry level 1100D (Rebel T3) and kit lens, so you don't need expensive gear to take great night sky shots!

Use the settings for a night sky scene, with the aperture wide open, exposures of 30 seconds or more and a high ISO setting (1600-3200).

The Milky Way also adds a strong compositional element to star trail images. The longer the exposure the more the detail of the Milky Way becomes blurred out, but even up to an hour it is still easily recognisable amongst the trailed stars.

MILKY WAY OVER NIMONS BRIDGE WITH ZODIACAL LIGHT BELOW
Canon 5DMKII, 14mm lens, 60 sec, f2.8, ISO3200

MILKY WAY & STAR TRAILS, LAKE NAGAMBIE, AUSTRALIA
Canon 5DMKII, 14mm lens, 15 min, f3.2, ISO200

Lunar Eclipse

What is it?

A lunar eclipse occurs when the alignment of the full moon (when the moon is opposite the sun) is just right, taking it inside Earth's shadow. While there is a full moon once each month, usually it passes just above or below Earth's shadow as it moves through its orbit. Only rarely is the alignment perfect such that we get a partial or total eclipse of the moon. Inside Earth's shadow, the only light reaching the moon is a small amount that is refracted and scattered by Earth's atmosphere, so the eclipsed moon is about 17 photographic 'stops' (or about 100,000 times) fainter than normal.

Experiencing a total lunar eclipse makes this change in brightness much more obvious. At full moon, everything is brightly lit around you (it even looks like daylight in long exposure photographs). As the moon enters Earth's shadow, that illumination quickly fades away. The night becomes dark and the fainter stars and Milky Way are visible for an hour or so, before the moon moves out the opposite side of the shadow.

4TH MAY 2004, PARTIAL LUNAR ECLIPSE, ABERDEEN, SCOTLAND – Canon 10D, 200mm lens, 0.7 sec, f4.5, ISO100

When can you see them?

On average, there is a lunar eclipse visible from a given location every couple of years.The table below shows dates of partial and total lunar eclipses until 2026.

Date	Type of Eclipse	Region of Visibility
26th May 2021	Total	eastern Asia, Australia, Pacific, Americas
19th Nov 2021	Partial	Americas, northern Europe, Asia, Australia, Pacific
16th May 2022	Total	Americas, Europe, Africa
8th Nov 2022	Total	Asia, Australia, Pacific, Americas
28th Oct 2023	Partial	eastern Americas, Europe, Africa, Asia, Australia
18th Sep 2024	Partial	Americas, Europe, Africa
14th Mar 2025	Total	Pacific, Americas, western Europe and Africa
7th Sep 2025	Total	Europe, Africa, Asia, Australia
3rd Mar 2026	Total	eastern Asia, Australia, Pacific, Americas
28th Aug 2026	Partial	eastern Pacific, Americas, Europe, Africa

Read More: Visit the ***NASA Lunar Eclipse page*** for more information

How to photograph it?

You can capture a sequence of images of the partial phases of a lunar eclipse with a telephoto lens on a sturdy tripod. Some suggested exposures are given in the table below but you'll need to experiment with whatever gear you have. Look closely at the moon in your images as you take them to see how well exposed it is.

Eclipse Stage	Shutter Speed	Aperture	ISO
Partial Phases	1/500 – 1/125	F5.6	200
Totality	1/4 -5"	F5.6	1600

The long exposures of several seconds during totality will cause the moon to 'trail' significantly during the exposure if you try to use a telephoto lens (without some form of 'tracking' mount). However, experiment with the aperture wide open and short shutter speeds and if you don't look too closely you may still be able to capture pleasing images even during totality. For better results, try capturing the eclipsed moon and foreground with a standard lens.

About these images

The image on the previous page shows the moon just starting to move into Earth's shadow. The image is over-exposed for the part of the moon still receiving direct sunlight, but shows some details inside the shadow area.

The image on this page with a standard 50mm lens was taken from Mt Buffalo in north-east Victoria during the June 2011 eclipse. The moon was still totally eclipsed as it was setting low in the western sky just before sunrise.

16TH JUNE 2011, LUNAR ECLIPSE IN MORNING TWILIGHT, MT BUFFALO, AUSTRALIA
Canon 350D, 200mm lens, 0.7 sec, f4.5, ISO100

This square image shows the kind of composite that can be achieved with very simple equipment, in this case a medium format film camera. This eclipse in August 2007 started soon after moonrise in the evening. With an image taken every six minutes, you can see the moon getting dimmer as it moves deeper into the shadow, all the while rising higher in the sky, and then turning a deeper red colour during totality. The exposure time during the partial phases is much shorter than during totality, so the equivalent brightness at each stage in this image is deceptive.

28TH AUGUST 2007, MOONRISE & LUNAR ECLIPSE COMPOSITE – Mamiya C330 twin lens reflex camera, Kodak E200 film

TIMELAPSE OF THE JUNE 2011 TOTAL LUNAR ECLIPSE FROM MT BUFFALO
Canon 5DMKII, 24mm lens, each frame 5 sec, f1.4, ISO3200

Click here to watch it at higher quality on Vimeo or if it does not play (eg. on an iPad).

RIGHT: 28TH JULY 2018. LUNAR ECLIPSE COMPOSITE ABOVE WAUBRA WIND FARM Canon 6D MKII, 50mm Lens, f4, ISO200.
Exposures of 1/45 sec for partial phases up to 10 secs for totality and foreground during twiliglight. www.philhart.com/waubra-lunar-eclipse

PARTIAL PHASES OF LUNAR ECLIPSE OVER MARYBOROUGH STATION
Canon 5D Mark II, 24-105mm lens at 82mm.
Nine exposures of the Moon, 1/90 sec, f/8, ISO200 stacked
(lighten blending mode) with one 2 second exposure of foreground.

Visit blog post on philhart.com for more info.

Meteors

What are they?

A meteor is the 'shooting star' that you see in the sky when a small particle not much bigger than a grain of sand and travelling at something like 30 miles per second (45km/sec) burns up in just a few seconds as it runs into Earth's atmosphere.

When can you see them?

You can see 'sporadic' meteors any time of the night and any night of the year; however, activity is generally highest in the hours just before dawn. On a few special nights, as the Earth moves around in its orbit, it passes through streams of particles left behind by comets. Because the particles are all travelling in roughly the same direction, when we see them burn up as meteors they all appear to be coming from the same part of the sky. This produces a 'shower' of meteors named after the constellation they appear to be coming from. However, only very rarely is the rate of meteors high enough to make this effect apparent. Even on nights of the most active meteor showers, you'd be lucky to see a meteor every minute, but that's a lot better than average!

While you may see activity from any of these showers for several days either side of the peak date, the hourly rate is usually much less than on the peak date.

Meteor showers also have a strong Northern Hemisphere bias, and observers in the Northern Hemisphere are fortunate to get a good view of all the meteor showers listed in the table. Observers in the Southern Hemisphere are well placed to catch Eta Aquarid meteors, but hourly rates for the other streams will be reduced and the Quadrantids, Perseids and Draconids will not be visible at all to observers at latitudes greater than 40 degrees south.

GEMINID METEOR, 14TH DECEMBER 2009 – Canon 5DMKII, 24mm lens, 8 sec, f1.4, ISO3200

Meteor Shower Name	Peak Dates	Hourly Rate
Quadrantid	January 4	60-120
Lyrid	April 22	10-20
Eta Aquarid	May 6	20-80
Perseid	August 13	60-100
Draconid	October 8	10-100
Orionid	October 21	10-30
Leonid	November 18	10-20
Geminid	December 14	80-120

How to photograph them?

Catching an image of a meteor requires a great deal of persistence, and a little luck. Luckily, you can burn a lot of exposures over several hours in one night with a digital SLR and not have to pay a cent.

The best approach is to treat it as though you were taking a timelapse sequence. Set your camera up somewhere with a good view of the sky, using the widest and fastest lens that you can get your hands on. Keep the aperture wide open and the ISO set to at least 1600, preferably 3200. Expose each image for up to 30 seconds, less if there is moonlight or light pollution increasing the brightness of the sky. The trick is to set the drive mode on your camera to 'sports' mode or 'continuous shooting' so that the camera takes one image after another as long as the shutter is pressed. Then lock the shutter down with a cable release and walk away for a few hours while your camera takes a continuous sequence of images. You may need to shoot straight to JPG files (or smaller RAW resolutions) unless you have big memory cards.

Scan carefully through the images on a computer later to see if you got lucky. Did I mention that you'll need to be persistent? You may need to try this a few times on different meteor shower nights before you 'catch a falling star'!

About these images

The image on the previous page of a bright Geminid Meteor was one of over a thousand short 8 second exposures I took on 14th December 2009. I captured dozens of faint meteors in that sequence but this was the best.

The image at right dates back to my early days in night sky photography. The Leonid Meteor Shower in 1998 did not produce large numbers of meteors, but it did produce several very bright 'fireballs'. In this case, I was doubly lucky as the path of the meteor had it diving in towards the south celestial pole, around which all the stars were rotating during the 30 minute exposure. Persistence pays off!

LEONID METEOR SHOWER NOVEMBER 1998 – Minolta XE1, 16mm fisheye lens, 30 min, f2.8, Kodak multi-speed PJM film

My colleague Neil Creek took this composite image from his home in the light-polluted suburbs of Melbourne. Neil kept shooting
18 second long exposures continuously for half an hour and then stacked the ten frames that had captured meteors. In the image at right, the meteors have been circled to help you identify them. This image clearly shows the effect of the meteors streaming out from the radiant in the constellation of Gemini.

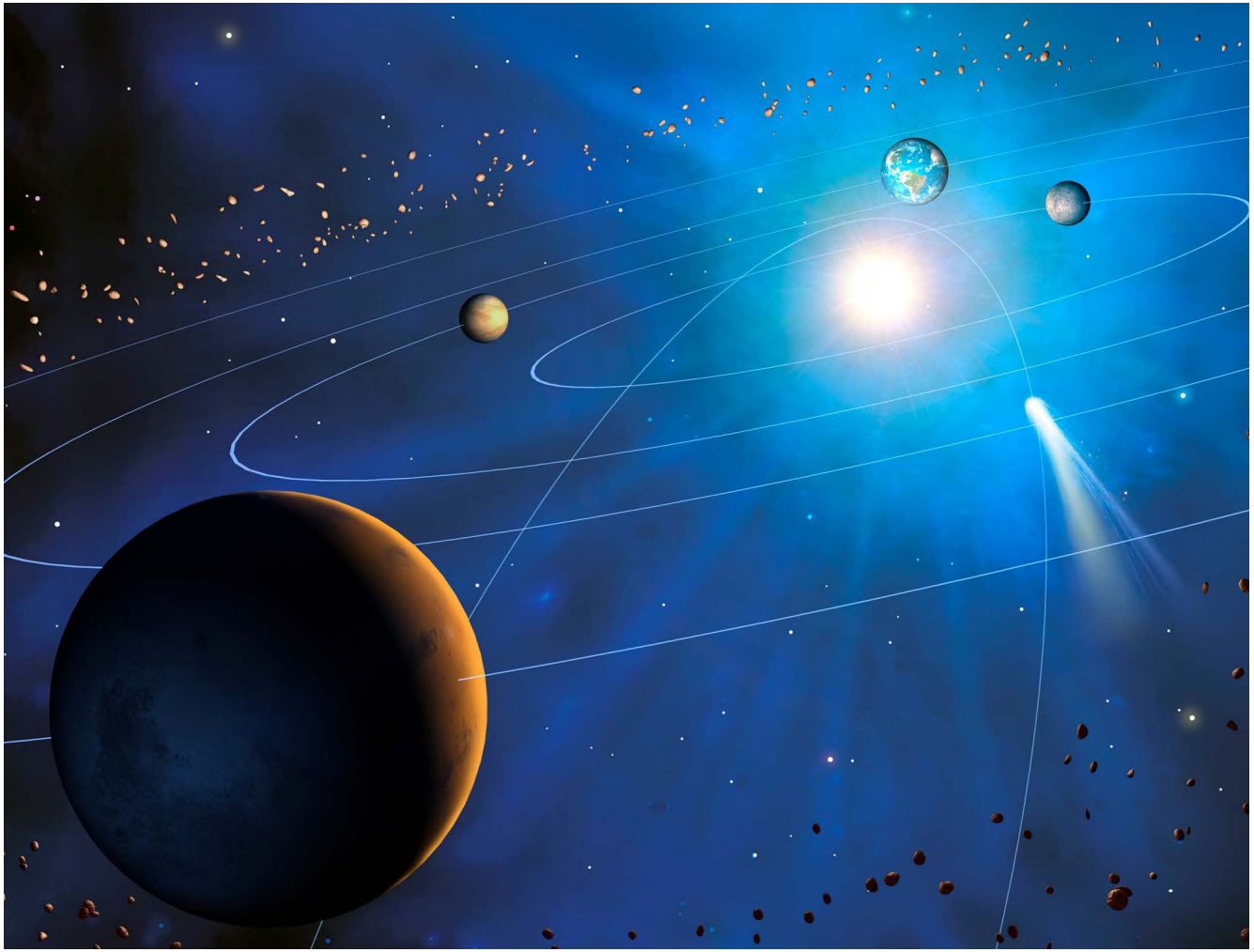
Neil also associates this image with the need to remember insect repellent when taking night sky photos. Capturing this image cost him at least forty mosquito bites!

GEMINID METEORS, 15TH DECEMBER 2010 – BY NEIL CREEK
Canon 5DMKII, 24-70 lens @24mm, stack of ten images captured over 30 min, 18 sec, f2.8, ISO800

BRIGHT SPORADIC METEOR
Canon 6D, 24mm lens, 20 sec, f2.8, ISO3200

Read More:

Visit ***www.philhart.com/content/geminid-meteor-shower*** for a composite image of the Geminid Meteor Shower in 2009, captured using a tracking equatorial mount which also shows the effect of meteors streaming out from the 'radiant'.



Comets

What are they?

A comet is a loose mixture of ice, dust and rocky particles. They range in size from a few hundred metres to tens of kilometres across. The outer parts of their orbits can take them way out in the distant reaches of the solar system, at which point they are all but invisible. But as their orbit brings them closer to the centre of the solar system, the radiation from the sun heats them up and they develop a bright coma of gas around the nucleus and possibly also a tail of gas and dust.

People often confuse comets and 'shooting stars'. A shooting star as we've seen is a tiny rock, perhaps the size of a pea, that burns up in our atmosphere in the space of a few seconds. A comet is a much larger body with a long orbit through the solar system. The nucleus may measure many kilometres in diameter, but the gaseous and dusty coma around it might be as large as a small planet, and the tail even larger. As it moves around in its orbit, it appears in roughly the same part of the sky for several nights in a row and you would not generally be able to notice any movement while observing one.

MARK A. GARLICK
Artist's illustration of a comet in orbit around the sun – not to scale!

COMET C/2006 P1 MCNAUGHT. 22ND JANUARY 2007. COMET MCNAUGHT FROM MT MACEDON, AUSTRALIA
Canon 20D, 18-55 lens @18mm, 15 sec, f4, ISO1600

When can you see them?

Experienced astronomers relish the announcement of a bright new comet on the way. The stars are firmly fixed in their place in the sky, and the position and brightness of the planets following their wandering path along the ecliptic can be predicted well in advance. Comets are much less predictable, but much more exciting when they do arrive. How bright a comet appears depends not only on how big the comet is but also how close it comes to Earth during its passage through the inner solar system.

While some comets make regular visits on long timescales, like the famous Halley's Comet which returns every 76 years, newly discovered comets might be on their first journey into the solar system. They might be visible in the sky for a few days, weeks or even months and then disappear perhaps never to return again. Every few years a new comet is discovered that is bright enough to see in the sky with just your eyes. Some of the greatest recent examples are Comet Hale-Bopp in 1997 and Comet McNaught in 2007. Comet Lovejoy surprised amateur and professional astronomers alike by surviving a close encounter with the sun in December 2011 and put on a spectacular show for Southern Hemisphere observers afterwards, albeit at the anti-social hour of 4am in the days before Christmas!

How to photograph them?

Comets need just the same settings as most other night sky scenes (unless they are only visible during twilight). With your camera on a tripod, keep the aperture open wide, shutter duration 30 seconds or anything up to 2 minutes and at least ISO1600. Bright comets don't come around too often, so make the effort to travel out to dark skies when the next one makes an appearance. A pair of binoculars will help you enjoy the view as well.

About these images

I took this image of Comet McNaught in January 2007. For several evenings in a row, I travelled an hour north-west of Melbourne to Mt Macedon where I had a clear western horizon looking away from the lights of the city. Dozens of other people had chosen the same spot so there was quite an excited group of us as the sun set and we waited for the comet to become visible. Comet McNaught's orbit took it away from the sun quickly and the moon began to interfere on the following evenings as well so it was at its best for only a few nights. But it was a truly spectacular comet and very impressive to observe as well as photograph.

While I also used telescopes and tracking mounts to capture other images of Comet McNaught in 2007, the images on these pages were all taken on a tripod with simple short exposures.

From Mt Dandenong on the other side of the city, my friend and colleague Neil Creek took the opportunity for some light painting to express what he thought of the comet in this single image!

COMET MCNAUGHT, 22ND JANUARY 2007
BY NEIL CREEK
Canon 350D (Rebel XT), 50mm lens, 10 sec, f2.8, ISO400

COMET LOVEJOY, BALNARRING BEACH, AUSTRALIA, 24TH DECEMBER, 2012 – Canon 5DMKII, 24mm lens, 60 sec, f2.2, ISO400

Comet Lovejoy appeared in the morning skies before Christmas 2011 with very little notice. The very early hours of Christmas Eve were hardly convenient for night sky photography, but this was a truly great comet so I had to make the most of the occasion. I also captured timelapse footage of the comet in the days after Christmas which you can ***view on my website***.

The northern hemisphere finally got lucky with a bright comet during the coronavirus pandemic. A google image search for '***Comet NEOWISE 2020***' will return many examples of perhaps the most photographed comet of all time.

COMET C/2011 L4 PANSTARRS. 3RD MARCH 2013
Canon 5D Mark II, 24-105mm lens at 82mm.
Five frame panorama with Canon 6D and 300mm lens,
each frame 3 secs, f4, ISO800

The Aurora Borealis

What is it?

For our cave dwelling ancestors, the night sky held many wonders. But the dancing lights of the aurora must have been amongst the most spellbinding and inexplicable.

When storms erupt on the surface of the sun, they can send streams of charged particles hurtling through the solar system. When they arrive at Earth, they interact with magnetic fields, particularly near the magnetic poles, emitting light 50km or more up in the outer edge of the atmosphere. Because they are related to the magnetic poles, the 'Aurora Borealis' or 'Northern Lights' are most common for people living in far northern parts of North America, Europe and Russia than elsewhere.

In the Southern Hemisphere, there are not so many people living in areas where the 'Aurora Australis' can be seen regularly although strong aurora 'storms' can be seen from southern parts of Australia and New Zealand.

AURORA BOREALIS OVER LAKE LABERGE, YUKON TERRITORY, CANADA – Canon 5DMKIV, 14mm lens, 30 sec, f2, ISO400

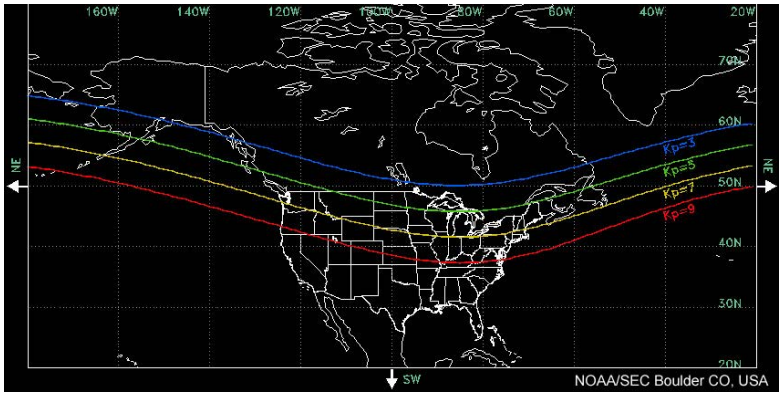
When can you see it?

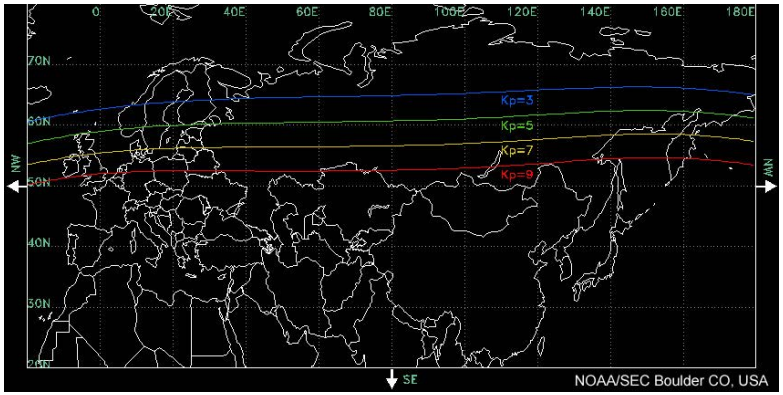
Like a category rating for hurricanes (cyclones), astronomers have defined what they call the 'Planetary K-index' to describe the intensity of aurora storms. The more intense an aurora storm, the higher the 'K-index' and the greater the area over which the aurora can be seen.

The maps to the right show how the visibility of an aurora storm moves further away from the poles as the intensity of the storm increases. If you live anywhere in the Northern Hemisphere north of the red line (Kp=9), then it would be worth signing up to aurora alert services for the chance to catch these rare high intensity storms when they occur.

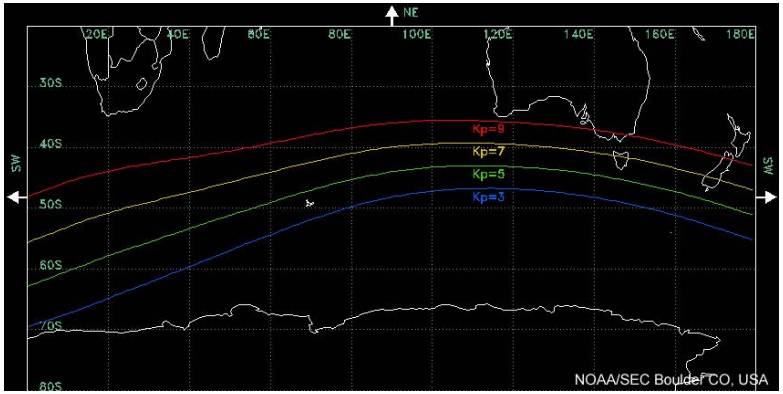
If you live or even take holidays north of the green line (Kp=5) then aurora should be visible on a fairly regular basis from your location and it is well worth monitoring aurora forecasts.

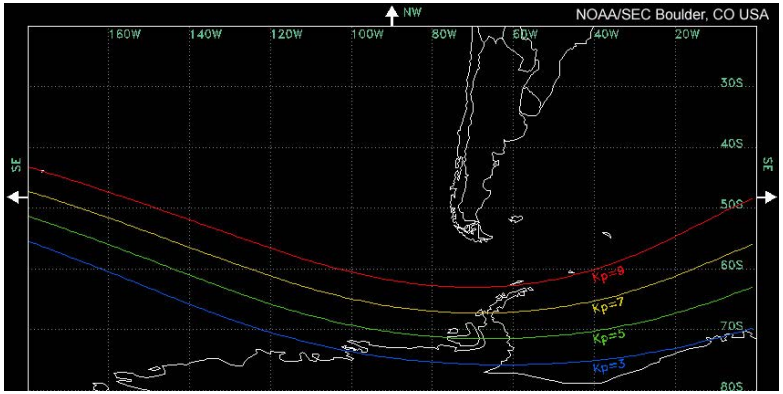
In the Southern Hemisphere, few people live in locations where aurora is frequent, but those in the far south of Australia and New Zealand can catch the more extreme aurora storms when they occur.





NORTHERN HEMISPHERE





SOUTHERN HEMISPHERE

TIP: Visit ***www.spaceweather.com*** for more information about aurora and other 'space weather' and sign up for alerts when they occur.

How to photograph it?

Generally you can photograph the aurora as you would other night sky scenes, with aperture wide open, shutter speeds of up to 30 seconds and high ISO settings. If you are lucky and the aurora is bright, you will be able to reduce these settings.

Like many things at night, the aurora appears completely different to the eye compared to the way the camera sees it. Your eye is not sensitive to colour at night, so your eye does not see the brilliant colours visible in aurora images. But the movement of the aurora is what can be striking to a visual observer. The longer your exposure, the more the movement blurs rays and other structure within the aurora, so if the aurora is bright, experiment with short exposures of just a few seconds to capture as much detail as possible.

About these images

I have seen aurora twice in my lifetime from near Melbourne in southern Australia, close to the red line in the map above. But it was only while I lived in north-east Scotland for five years that I could get serious about chasing aurora. While Aberdeen is close to the green (Kp=5) line, Scotland has a very cloudy climate so catching aurora was still quite a challenge. However, in October/November 2003 we got very lucky with two of the biggest solar storms ever recorded generating huge aurora storms around the time of new moon and with clear skies in Scotland. They were some of the most memorable nights of my five years living in Scotland.

2003 was in the early days of digital SLRs and I was still using film cameras as well. Modern digital SLRs are much better suited to aurora photography.

Minolta XE1, 16mm lens, 30 sec, f2.8, Fuji Provia 400F film

SOUTHERN HEMIPSHERE AURORA FROM CENTRAL VICTORIA, AUSTRALIA
Canon 6D and 35mm lens, 10 secs, f2, ISO3200

CORONA - THE AURORA OVERHEAD – Canon 5DMKII, 24mm lens, 6 sec, f1.4, ISO800

In early 2012, I spent nine weeks living in the Yukon Territory in Canada on an astronomy adventure to capture images and timelapse footage of the Aurora Borealis. The temperature was a lot colder than anywhere else I've tried night sky photography but my gear and I generally held up OK. I fell in love with the Yukon and returned in the fall of 2017, after the 'Great American Eclipse', for more aurora photography.

Read More:

Read more about my adventures chasing aurora in the Yukon in Canada and enjoy lots more images on my website ***philhart.com/tag/yukon-aurora***.

AURORA OVER ANNIE LAKE ROAD: YUKON TERRITORY, CANADA –Canon 1100D (Rebel T3), 10-22mm lens @10mm, 25 sec, f3.5, ISO800

TWILIGHT AURORA STORM OVER LAKE LABERGE, YUKON TERRITORY, CANADA
Canon 6D and Sigma 50mm lens,6 secs, f2, ISO800

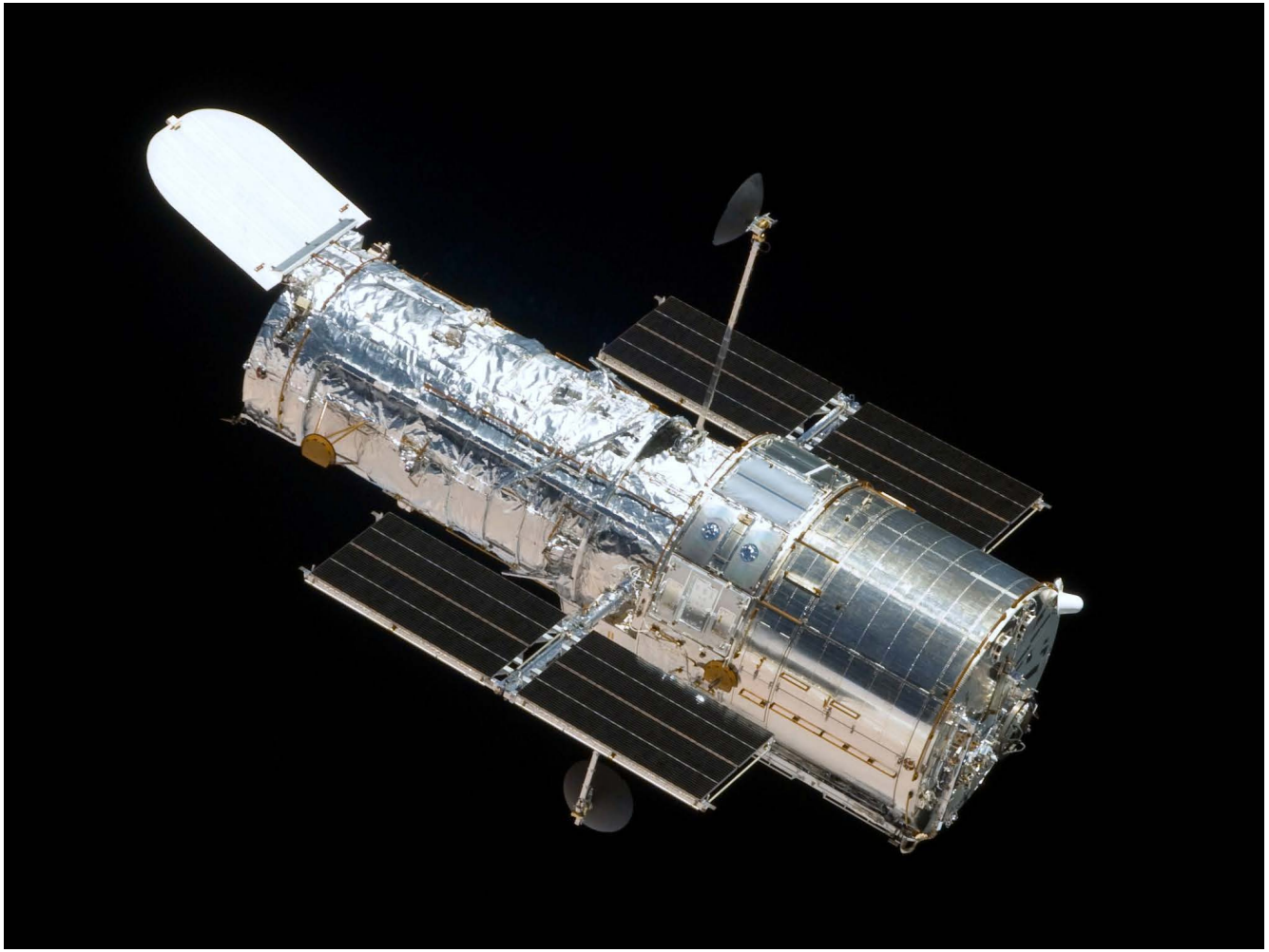


IMAGE: NASA

Satellite Flares

What are they?

Since Sputnik 1 was launched by the Soviet Union in 1957, humans have launched thousands of satellites into orbit around the Earth. They are used for navigation, communication and observation of the weather and changes on the ground.

The Hubble Space Telescope shown here is a famous example of a large artificial 'satellite'.

Some satellites have large reflective surfaces, and when the alignment of the sun and the observer on the ground is just right, you can see a bright 'flare' from a satellite as the sunlight glints off the solar panels or other reflective components.

Although these are not a 'natural' wonder of the night sky, they can be impressive, especially when you surprise your friends by predicting the arrival of a bright 'star' just a few moments beforehand!

What are they?

The Iridium communication satellites are well known for producing bright flares and websites such as ***heavens-above.com*** and ***spaceweather.com*** provide predictions for your location, telling you exactly when you can expect to see one and in which direction to look. You need to enter your location reasonably accurately, as a flare that is bright in one location may be barely visible 30 kilometres (20 miles) away.

How to photograph them?

Iridium flares last about 40-50 seconds, although they are only bright for part of that time. Try to choose flares that occur when the sky is dark (not during twilight).

If you have an accurate watch, you can start a bulb exposure ~20 seconds before the listed time for the flare. Alternatively keep a series of 30" exposures rolling continuously from well beforehand.

You can also capture the International Space Station as it passes over your location, which creates a longer but not quite as bright trail in your images. Check the links on the previous page for details.

Canon 1100D (Rebel T3), 15-85mm lens @45mm, 30 sec, f5, ISO200

Canon 5DMKII, 50mm lens, 50 sec, f2, ISO100

Bioluminescence

What is it?

While bioluminescence is a relatively common phenomenon, with a number of different micro-organisms in the sea known to emit light when the water around them moves, the light they give off is generally quite faint and hard to photograph. On rare occasions or in special conditions, the concentration of the micro-organisms can be so high as to cause very bright bioluminescence.

Where can you see it?

Bioluminescence is a relatively common phenomenon in the ocean, but it is usually relatively faint. Keep your eye out for it at night in salt water environments and one day you might get lucky. Also try a search for bioluminescence and the name of your state or country; e.g. Wikipedia has ***an image*** of bioluminescence on the coast between Philadelphia and New York.

How to photograph it?

Typical settings for night sky scenes are going to be your best bet for any kind of faint night phenomenon like this. Keep the aperture wide open, expose for as long as you can until movement becomes excessive and keep the ISO up high (e.g. ISO800 to ISO3200).

Canon 20D, 10-22mm lens @10mm, 2 min, f3.5, ISO1600

About these images

These images of 'bioluminescence' in the Gippsland Lakes area are among the most remarkable night images I have ever taken and have proved incredibly popular online. While not a 'sky' phenomenon, it only occurs at night and the combination with the night sky has made for some striking images. Besides, it would be a shame to rule them out of this book on a technicality.

Widespread bushfires in alpine areas of Victoria in summer 2006/07 were followed by heavy rainfall and floods the following winter. This washed a lot of ash, debris and nutrients from the burnt mountain areas into the Gippsland Lakes. That eventually resulted in this outbreak of 'Noctiluca Scintillans' and the vivid bioluminescence in 2008/09.

While the bioluminescence was obvious to the naked eye, like other faint lights at night the colour was only barely perceptible. But to the camera, the colour was striking. I have not significantly enhanced the colour or saturation in the images shown here; they look very much like they did on the back of the camera on the night.

The bioluminescence returned in January 2013. Although not as bright on that occasion, with a better camera and faster lenses I was actually able to record equally stunning images.

Note the green 'airglow' in the bottom half of the sky and the distant red light close to the horizon from the flares of offshore oil and gas platforms in Bass Strait. You can also see variation in the star colours. Although the eye cannot detect these striking colours at night, they are all 'true' even though some people have a hard time believing it.

Read More:

Visit ***www.philhart.com*** for more images and the full story of the fires and floods that caused this outbreak of bioluminescence in the Gippsland Lakes.

BIOLUMINESCENCE IN LAKE VICTORIA, JANUARY 2013
Canon 5DMKII and 24mm lens, 'Star trail stack' of 105 exposures, 30 secs, f2, ISO1600

BIOLUMINESCENCE IN LAKE VICTORIA, JANUARY 2013
Canon 5DMKII and 24mm lens.
Composite of 15 min, f4, ISO200 for stars
and 20 X 4 sec, f1.4, ISO6400 for bioluminescence in waves

FIELD GUIDE

Checklist

Here's a quick checklist of things to pack before heading out on a night sky photography expedition:

- **Tripod, plus any quick release plates needed**
- **Camera Body**
- **Camera Battery, plus spares**
- **Memory Card, plus spares**
- **Wide Angle Lenses**
- **Remote Release/Intervalometer**
- **Red Head Torch, plus spare batteries**
- **Dew Prevention: Heat Packs or Dew Heater, Cables and 12V Battery**
- **Warm clothing (gloves, beanie, jacket)**
- **Sturdy footwear (and a dry change of shoes for the drive home)**
- **Insect Repellent**
- **Snacks and drinks to keep you going through the night**

Read More:

I have a page on my website with links to some of my favourite and most useful night sky photography accessories:

http://philhart.com/content/accessories-night-sky-photography

It is also helpful to review SkySafari, Stellarium or your favourite planetarium software or app to plan for the night ahead (refer to the Planning Section).

Cheat Sheet
PART 1

These are starting points only – review as you take the images and adjust up/down as necessary.

These are starting points only. Review as you take the images and adjust up/down as necessary.

1. Set camera to 'Manual' or 'bulb'

2. Turn off Autofocus and Image Stabilisation

Night Sky Scenes
SHORT EXPOSURES ON A FIXED TRIPOD

	Shutter Speed	Aperture	ISO
Zoom Lens	30" or bulb (up to 60")	Wide open (f2.8-f4)	3200
Prime Lens	30"	f1.4-f2	1600

On nights with strong moonlight or light pollution, start by reducing the ISO first. Review your images and the histogram on the camera and adjust as necessary.

Image Quality	RAW (Full Size)
White Balance	Daylight (Sunny)
Drive Mode	Single Shot
Long Exposure Noise Reduction	Off or On*
Focus	Manual

Leave Long Exposure Noise Reduction Off while you are experimenting with settings and composition to save time. If you have an older camera and notice a lot of hot pixels even in short exposures, turn it On to capture a cleaner version once you have everything else right.

Steps

1. Set your lens to its widest zoom setting
2. Focus your camera using one of the three manual focus techniques described earlier
3. Frame your image and make sure the tripod is secure
4. Open the aperture up wide, select a 30" shutter speed and high ISO
5. Fire the shutter

Star Trails
LONG EXPOSURES ON A FIXED TRIPOD

	Shutter Speed	Aperture	ISO
Short	15 minutes	f4	200
	30 minutes	f4	100
Medium	1 hour	f5.6	100
	2 hours	f8	100
Long	4 hours	f11	100

Image Quality	RAW (Full Size)
White Balance	Daylight (Sunny)
Drive Mode	Single Shot
Long Exposure Noise Reduction	Off or On (if your battery will last)
Focus	Manual

Decide which direction you want to face and seek out some foreground to add interest to the scene, then follow these steps:

Steps

1. Set up the camera and tripod
2. If necessary, wrap a chemical heat pack or dew heater around the lens
3. Focus using your preferred manual technique
4. Take a 30 second test exposure with aperture wide open and high ISO
5. Check focus and composition
6. Dial in the aperture and ISO settings for your chosen exposure time
7. Set the camera to bulb mode and open the shutter with a remote release
8. Come back after your desired exposure time and release the shutter

Cheat Sheet
PART 2

The Moon
TELEPHOTO LENSES ON A FIXED TRIPOD

	Shutter Speed	Aperture	ISO*
Bright moon	1/500 sec	f5.6	~400-800
Crescent moon with earthshine	1 sec	f5.6	~400-800

Image Quality	RAW
White Balance	Daylight (Sunny)
Drive Mode	Self-timer with 2 second delay or use remote release
Long Exposure Noise Reduction	Off
Focus	Autofocus or use Liveview
Mirror Lockup	On (optional) to reduce vibration

Steps

1. Make sure camera and tripod are stable and well secured
2. Focus on the Moon using Autofocus or a magnified Liveview
3. Compose the Shot without touching the focus or zoom rings
4. Enable Mirror Lockup, 2 second Self Timer and then trigger the image
5. Experiment with lower/higher shutter speeds and ISO to see which gives the sharpest result

LAKE BOGA MOONRISE
Canon 1100D (Rebel T3), 300mm lens with 1.4x teleconverter (420mm), 1/20 sec, f5.6, ISO100

Timelapse Animation
IMAGE SEQUENCE TO RENDER TO VIDEO

	Shutter Speed	Aperture	ISO*
Zoom Lens	30″	f3.5	3200
Prime Lens	10-15″	f1.4-f2	1600-3200

* If there is bright moonlight or light pollution, reduce the ISO setting. Take a test image and adjust the ISO down until the image is correctly exposed.

Image Quality	small/medium JPG (or sRAW)
White Balance	Daylight (Sunny)
Drive Mode	Continuous Shooting (Sports Mode)
Long Exposure Noise Reduction	Off
Focus	Manual

Steps

1. Compose and focus the image as you would for a night sky scene
2. Set as short an exposure as you can get away with by opening the aperture up wide and setting the ISO quite high (typically ISO3200)
3. Set the drive mode on the camera to continuous shooting
4. Use a cable release to lock the shutter down. The camera will shoot a continuous sequence of exposures until you release the remote switch

Using Your Timer Remote (Intervalometer)

Timer remotes come in all shapes and sizes, but they generally have four settings that can be programmed:

- **Self-timer/Delay**
- **Interval**
- **Long/Exposure Length**
- **N/Number of Frames**

The time for the delay, interval and exposure length is displayed as 00:00:00 which is HH:MM:SS (hours/minutes/seconds).

In general the process is to use the Mode button to cycle between the four settings, then press the Set button to allow it to be changed (the number will then flash). Use the left and right buttons to move between setting Hours/Minutes/Seconds and the up and down arrows to increase or decrease each number in turn. Press the Set button again to lock in the value. When you are ready, press the Start or Play button to begin the sequence.

1) **Self-timer/Delay:** This is often zero or very short but a delay of 5-10 seconds allows you to hang the timer remote on the tripod and get yourself and your flash light out of the way before the exposure starts.

2) **Interval:** If you are setting a single long frame (for a star trail or timelapse sequence) an exposure interval is not needed. If you are setting a large number of frames, an interval of ~4 seconds allows time for the camera to write each image to the memory card in between exposures and prevents the buffer filling up.

3) **Exposure Length:** This might be anything from 45 seconds for a slightly longer than normal Night Sky Scene, 1 hour for a Star Trail or 4 hours for a long Timelapse Sequence.

4) **Number of Frames:** This is often just 1 but can be as high as you like. When setting the number of frames, if you press the down button to go one setting below 1, the display will show 00 or --. This indicates that the timer remote will cycle through the sequence indefinitely using the programmed exposure length and interval (until your camera battery runs flat or memory card is full).

Here are some examples that get progressively more complex. You might only use Example 1 & 2 but the last two examples show how sophisticated you can get, using your timer remote to make interesting things possible (and allowing you to sleep while your camera works).

Example 1:

15 minute star trail

Self-timer/Delay	Interval	Length	No. of Frames
00:00:10 (10 seconds)	N/A	00:15:00 (15 minutes)	1

Example 2:

1 hour timelapse sequence

Self-timer/Delay	Interval	Length	No. of Frames
00:00:10 (10 seconds)	N/A	01:00:00 (1 hour)	1

For a timelapse sequence, the drive mode on the camera must be set to 'continuous shooting' and the desired manual exposure time set (e.g. 30 seconds). While the timer remote counts down through the 1 hour, the camera will continue to take a series of 30 second exposures just as if the shutter button was being held down for that duration.

Example 3:

Two one hour star trails with time for automatic dark frames in between

Self-timer/Delay	Interval	Length	No. of Frames
00:00:10 (10 seconds)	01:00:15 (1 hour, 15 seconds)	01:00:00 (1 hour)	2

For star trails, you can turn Long Exposure Noise Reduction on in the camera settings. Then allow an interval between the two shots that is slightly longer than the exposure time. When the first exposure stops, the camera will automatically commence the 'dark frame' of the same duration and then subtract that from the image. After the few extra seconds you allowed for the interval, the next star trail exposure will start.

Example 4:

Two hour timelapse sequences with four hour delay and three hour interval

Self-timer/Delay	Interval	Length	No. of Frames
04:00:00 (four hours)	03:00:00 (three hours)	02:00:00 (two hours)	2

I often setup and then leave my camera in fairly remote places during the late afternoon while the sun is still shining, but I want to set a long exposure on the camera for night sky timelapse and not use up any battery during daylight. Using the same camera settings as in Example 2, these settings mean I could start the timer remote sequence running in the afternoon but the camera won't start recording images until it gets dark (e.g. four hours later). I typically keep a single sequence running all night with external power to the camera, but in this example there would be a break of three hours and then a second two hour timelapse sequence would start late in the night. (I can get four hours total shooting out of good quality batteries in modern cameras – your mileage may vary).

This way you could potentially get two nice sequences at different times of the night out of the one battery in the camera and without having to lose any sleep or be beside the camera at all during the night. You'll probably need a dew heater for the lens and might want to put a rain cover over the camera in case the weather changes while you're away from the camera, but this is a productive way to get nice sequences on a camping holiday while still being sociable during the day!

Using your camera in Manual Mode

Many people who only use their camera during the daytime may not be familiar with some of the manual settings needed for Night Sky Photography. Here are tips to accessing these key settings on most recent and popular digital SLRs, Refer to the relevant section of the book to find advice on which setting to use for different situations.

The headings on the following page list the key current models that the instructions apply to. Sub-headings list previous or similar models that are also covered by the instructions.

Canon 850D/Rebel T8i

Also 450D, 500D, 550D, 600D/Rebel T3i, 650D/Rebel T4i, 700D/Rebel T5i, 750D/Rebel T6i, 800D/Rebel T7i

- **Manual Exposure:** Set Mode Dial to M for Manual.
- **Drive/Release Mode:** Press the Drive Mode (Left) button. Press left/right keys to select Single Shot, Self-timer or Continuous shooting.
- **Shutter Speed:** Turn the main control dial (front of camera). Bulb mode is set by increasing the shutter speed one step above 30".
- **Aperture:** Turn the main control dial while holding down the Av+/- button.
- **ISO:** Select using the ISO button, which is on top of the camera in front of Mode Dial, and use the left/right keys to change.
- **White Balance:** Select using the WB button (back of camera – Up arrow) and use the left/right keys to change.
- **Touch Screen (recent models):** All of the above settings can also be accessed by pressing the Q (Quick Control) button on the back of the camera and using the Touch Screen.
- **Image Playback:** During image playback, rotate the main control dial to view the same location in other images at the current zoom ratio (e.g. for comparing focus on a star between frames).
- **Dark Frame Subtraction (Long Exposure Noise Reduction):**
  - Recent Models: Set with Shooting Menu 4 (Red) or Menu 3 for earlier models. Set to On, Auto or Disable. Camera will display "BUSY" while dark frame is being taken.
  - Older Models (1200D/Rebel T5, 600D/T3i and earlier): This function is set using *Custom Functions>Image>Long Exposure Noise Reduction*.
- **Noise Smoothing (High ISO Noise Reduction):**
  - Recent Models: Set with Shooting Menu 4 (Red) or Menu 3 for earlier models. Set to Disable, Low, Standard, High or Multi-Shot.
  - Older Models (1200D/Rebel T5, 600D/T3i and earlier): This function is set using *Custom Functions>Image>High ISO Speed Noise Reduction*.

Canon 90D, 6D Mark II and 5D Mark IV

Also 20D, 30D, 40D, 50D, 60D, 70D, 80D, 5D Mark II and III, 6D, 7D, 7D Mark II

- **Manual Exposure:** Set Mode Dial to M for Manual.
- **Drive/Release Mode:** Select with the Drive Mode button (top of camera). Change by turning the main dial (front of camera) to select Single Shot, Self-timer or Continuous shooting.
- **Shutter Speed:** Change by turning the main control dial (top of camera, near shutter). Recent models have a Bulb setting on the Mode Dial. Earlier models set Bulb by increasing the shutter speed one step above 30".
- **Aperture:** Change by turning the Quick Control Dial (back of camera).
- **ISO:** Select with the ISO button (top of camera) and change using the Quick Control Dial (back of camera)
- **White Balance:** Select with the WB button (top of camera) and change using the Quick Control Dial (back of camera).
- **Touch Screen (recent models):** All the above settings can also be accessed by pressing the Q (Quick Control) button on the back of the camera and using the Touch Screen.
- **Image Playback:** During image playback, rotate the Quick Control Dial (back of camera) to view the same location in other images at the current zoom ratio.
- **Dark Frame Subtraction (Long Exposure Noise Reduction):**
  - Recent Models: Set with Red Shooting Menu 4 (Menu 3 for some earlier models). Set to On, Auto (>1 sec exposures) or Disable. Camera will display "BUSY" while dark frame is being taken.
  - Older Models: *Custom Functions>Image>Long Exposure Noise Reduction*. Set to On, Auto or Off. Camera will display "BUSY" while dark frame is being taken.
- **Noise Smoothing (High ISO Noise Reduction):**
  - Recent Models: Set with Red Shooting Menu 4 (Menu 3 for some earlier models).
  - Older Models: *Custom Functions>Image>High ISO Speed Noise Reduction*. Set to Low, Standard, High or Disable.
- **Electronic Level (recent models only):** Press the INFO button (back of camera) to cycle through display options.

Canon 1DX Mark III

Also 1DX Mark II, 1DC, 1Ds Mark III

- **Manual/Bulb Exposure:** Press the Mode button (top of camera, left side) and turn either dial to select M for Manual or B for Bulb.
- **Drive/Release Mode:** Press the Drive Mode button (top of camera, left side). Turn main control to select Single Shot, Self-timer or Continuous shooting.
- **Shutter Speed:** Turn the main control dial (front of camera). For older models, Bulb mode is set by increasing the shutter speed one step above 30".
- **Aperture:** Turn the Quick Control Dial.
- **ISO:** Press the ISO button (top of camera, right hand side). Turn either dial to change.
- **White Balance:** Select with the WB button (top of camera, right side) and change using the Quick Control Dial (back of camera).
- **Image Playback:** During image playback, rotate the Quick Control Dial to view the same location in other images at the current zoom ratio.
- **Dark Frame Subtraction:**
  - *Recent Models:* Set with Red Shooting Menu 2. Set to On, Auto (>1 sec exposures)
    or Disable. Camera will display "BUSY" while dark frame is being taken.
  - *Older Models:* Custom Functions>Image>Long Exposure Noise Reduction.
- **Noise Smoothing:**
  - Recent Models: Set with Red Shooting Menu 2. Set to Low, Standard, High or Disable.
  - Older Models: *Custom Functions>Image>High ISO Speed Noise Reduction*.
- **Electronic Level:** Press the INFO button (back of camera) to cycle through display options.

Canon Mirrorless EOS R and Ra *(astrophotography camera)*

Also R5, R6

- **Manual Exposure:** Press Mode button and use quick control dial to select M for Manual or B for Bulb.
- **Shutter Speed:** Turn the main control dial (front of camera).
- **Aperture:** Turn the quick control dial (around Mode button).
- **Drive/Release Mode:**
  - R/Ra: Press the Multi-function button (top of camera), use the quick control dial (around Mode button) to select which option you want to change, and adjust using the main dial (top of camera, near shutter) to select Single Shot, Self-timer or Continuous shooting.
  - R5/R6: Press the Multi-function button (top of camera), use the quick control dial (rear of camera) to select which option you want to change, and adjust using the main dial (top of camera, near shutter) to select Single Shot, Self-timer or Continuous shooting.
- **ISO, White Balance:**
  - *R/Ra:* Can be selected with the Multi-function button (top of camera), use the quick control dial (around Mode button) to select which option you want to change, and adjust using the main dial (top of camera, near shutter).
  - *R5/R6:* With an image displayed on screen, ISO can be set directly with the rear control dial (top of camera).
- **White Balance:**
  - *R/Ra:* Can be selected with the Multi-function button (top of camera), use the quick control dial (around Mode button) to select which option you want to change, and adjust using the main dial (top of camera, near shutter).
  - *R5/R6:* Press the Multi-function button (top of camera), use the rear dial (back of camera) to select WB, then adjust using main dial (top of camera, near shutter).
- **Touch Screen:** All the above settings can also be accessed by pressing the Q (Quick Control) button on the back of the camera and using the Touch Screen. This is the easier option for ISO, White Balance and Drive Mode on these Canon mirrorless cameras.
- **Image Playback:** During image playback, rotate the main dial to view the same location in other images at the current magnification (e.g. for comparing focus on a star between frames).
- **Dark Frame Subtraction (Long Exposure Noise Reduction):**
  - *R/Ra:* Set with Red Shooting Menu 5. Set to On, Auto or Disable. Camera will display "BUSY" while dark frame is being taken.
  - *R5/R6:* Menu 4.
- **Noise Smoothing (High ISO Noise Reduction):**
  - *R/Ra:* Set with Red Shooting Menu 5. Set to Disable, Low, Standard, High or Multi-Shot.
  - *R5/R6:* Menu 4.

Nikon D3500

Also D3000, D3100, D3200, D3300, D3400

- **Manual Exposure:** Set Mode Dial (top right of camera) to 'M' for 'Manual'.
- **Drive/Release Mode:** Use the Release Mode button which is on the back of the camera, below the multi selector (or top right of camera for D3100 & D3000). Choose Single Shot (S), Continuous or Self-timer. The length of the Self-timer delay can be adjusted using the Self-timer delay option in the Setup Menu.
- **Shutter Speed:** Use Command Dial (top right on back of camera) to change shutter speed. Bulb mode is set by increasing the shutter speed above 30".
- **Aperture:** Press +/- button (top of camera near shutter) and use the Command Dial to change aperture.
- **ISO:** Press the *i* (INFO) button (bottom left) and select the current value with the multi-selector. Change ISO by highlighting the current ISO setting on the information display, press OK and then use the arrow keys to change it.
- **Auto ISO:** *Shooting Menu>Auto ISO Sensitivity Control.* You may like to set Auto ISO Sensitivity to OFF, otherwise you may not get the ISO setting you expect even in Manual mode.
- **White Balance:** Press the *i* (INFO) button (bottom left) and select the current value with the multi-selector. Change by highlighting the current white balance setting on the information display, press OK and then use the arrow keys to change it.
- **Image Playback:** During image playback, rotate the Command Dial to view the same location in other images at the current zoom ratio.
- **Dark frame subtraction and Noise Smoothing:** *Shooting Menu>Noise Reduction*. Set this to ON if you want the camera to subtract a dark frame after your image. The camera will display "Job nr" while taking the dark frame. Whether this is set to ON or OFF, D3000 series cameras will apply some additional noise smoothing to high ISO images.

Nikon D5600

Also D5000, D5200, D5300, D5500

- **Manual Exposure:** Set Mode Dial (top right of camera) to 'M' for 'Manual'.
- **Drive/Release Mode:** Use the Release Mode selector with the symbol shown. Choose Single Shot (S), Continuous or Self-timer. The length of the Self-timer delay can be adjusted using the Self-timer delay option in the Setup Menu.
  - On D5600, D5500 and D5300 this button is front right of camera below the lens release lock.
  - On D5200 this button is top right of camera, to the right of the mode dial.
  - On D5100 this is a selector switch on top right of the camera.
  - On D5000 release mode is set through the Information Screen.
- **Shutter Speed:** Use Command Dial (top right of camera) to change shutter speed. Bulb mode is set by increasing the shutter speed above 30".
- **Aperture:** Press +/- button (top of camera near shutter) and use the Command Dial to change aperture.
- **ISO:** Press the *i* (INFO) button. Change ISO by highlighting the current ISO setting on the information display, press OK and then use the arrow keys to change it.
- **Auto ISO:** Shooting Menu>Auto ISO Sensitivity Control. You may like to set Auto ISO Sensitivity to OFF, otherwise you may not get the ISO setting you expect even in Manual mode.
- **White Balance:** Press the *i* (INFO) button. Change by highlighting the current white balance setting on the information display, press OK and then use the arrow keys to change it.
- **Image Playback:** During image playback, rotate the Command Dial to view the same location in other images at the current zoom ratio.
- **Dark Frame Subtraction:** *Shooting Menu>Long Exposure Noise Reduction*. Set this to ON if you want the camera to subtract a dark frame after your image to remove hot pixels. The camera will display "Job nr" while taking the dark frame.
- **Noise Smoothing:** *Shooting Menu>High ISO NR*. Can be set to High, Normal, Low or Off. I recommend 'Normal' or set to 'OFF' and apply your own noise smoothing later.
- **Built-in Interval Timer:** *Shooting Menu>Interval timer shooting*. Choose starting time (e.g. 'Now'), interval, number of intervals and number of shots per interval. Then highlight ON and press OK and the sequence will start. Select OFF to stop interval shooting.

Nikon D7500

Also D7000, D7100, D7200

- **Manual Exposure:** Set Mode Dial (top left of camera) to 'M' for 'Manual'.
- **Drive/Release Mode:** Press the release mode dial lock release and turn the release mode dial (top left of camera under Mode Dial) to Single Shot (S), Continuous (CL) or Self-timer. If you are using the Self-timer, change the self-timer delay in the Custom Settings menu (Option c3) or the *Remote control mode in the Shooting Menu (D7000)* and select the 2 second delay option.
- **Shutter Speed:** Use Main Command Dial (top right on back of camera) to change shutter speed. Bulb mode is set by increasing the shutter speed above 30".
- **Aperture:** Use the Sub-command Dial (front of camera below shutter) to change aperture.
- **ISO:** Change by pressing the ISO button on top of the camera (or back of camera, left side for earlier models) and adjust using the Main Command Dial.
- **Auto ISO:** *Shooting Menu>Auto ISO Sensitivity Control.* You may like to set Auto ISO Sensitivity to OFF, otherwise you may not get the ISO setting you expect even in Manual mode.
- **White Balance:** Change by pressing the WB button (back of camera, left side) and using the Main Command Dial.
- **Image Playback:** During image playback, rotate the Command Dial to view the same location in other images at the current zoom ratio.
- **Dark Frame Subtraction:** *Shooting Menu>Long Exposure NR (Noise Reduction)*. Set this to ON if you want the camera to subtract a dark frame after your image to remove hot pixels. The camera will display "Job nr" while taking the dark frame.
- **Noise Smoothing:** *Shooting Menu>High ISO NR (Noise Reduction*). Can be set to High, Normal, Low or Off. I recommend 'Normal' or set to 'OFF' and apply your own noise smoothing later.
- **Built-in Interval Timer:** *Shooting Menu>Interval timer shooting*. Choose starting time (e.g. 'Now'), interval, number of intervals and number of shots per interval. Then highlight ON and press OK and the sequence will start. Select OFF to stop interval shooting.
- **Virtual Horizon:** *Setup Menu>Virtual horizon*. Displays a virtual horizon based on the camera's tilt sensor. Especially useful for getting the camera level in the dark! The Virtual Horizon can also be shown in Live View mode by pressing the INFO button and cycling through the five display options to one with the Virtual Horizon.

Nikon D6, D850

Also D3, D3s, D4, D4s, D5, D800, D810, D810a, D700, D750, D780, D300, D300s, D500

- **Manual Exposure:** Press Mode Button (top right near shutter) and rotate Main command dial (back of camera, top right) to select 'M' for 'Manual'.
- **Drive/Release Mode:** Press the Release Mode Dial Lock Release and turn the Release Mode Dial (top left of camera) to Single Shot (S), Continuous (CL) or Self-timer. If you are using the Self-timer, access the Self timer settings in the Custom Settings menu (c3) to choose the length of the delay (2 seconds is generally fine).
- **Shutter Speed:** Use Main Command Dial (top right on back of camera) to change shutter speed. Bulb mode is set by increasing the shutter speed above 30".
- **Aperture:** Use the Sub-command Dial (front of camera below shutter) to change aperture.
- **ISO:** Select by pressing the ISO button and change using the Main Command Dial.
  - D6, D5, D850, D780: ISO button is on top of the camera, right side
  - D810, D800, D700, D300s, D300: ISO button is on top of the camera, left side
  - D4s, D4, D3s, D3: ISO button is on the back of the camera, near bottom
- **Auto ISO:** *Shooting Menu>Auto ISO Sensitivity Control*. You may like to set Auto ISO Sensitivity to OFF, otherwise you may not get the ISO setting you expect even in Manual mode.
- **White Balance:** Select by pressing the WB button and change using the Main Command Dial.
  - D6, D4s, D4, D3s, D3: WB button is on back of the camera, near bottom.
  - D850, D810, D800, D700, D300s, D300: WB button is on top of the camera, left side.
  - D780: WB button is on back of the camera, left hand side.
- **Image Playback:** During image playback, rotate the Main Command Dial to view the same location in other images at the current zoom ratio.
- **Dark Frame Subtraction:** *Shooting Menu>Long Exposure NR (Noise Reduction)*. Set this to ON if you want the camera to subtract a dark frame after your image to remove hot pixels. The camera will display "Job nr" while taking the dark frame.
- **Noise Smoothing:** *Shooting Menu>High ISO NR (Noise Reduction)*. Can be set to High, Normal, Low or Off. I recommend 'Normal' or set to 'OFF' and apply your own noise smoothing later.
- **Built-in Interval Timer:** *Shooting Menu>Interval timer shooting*. Choose starting time (e.g. 'Now'), interval, number of intervals and number of shots per interval. Then highlight ON and press OK and the sequence will start. Select OFF to stop interval shooting.
- **Virtual Horizon:** *Setup Menu>Virtual horizon*. Displays a virtual horizon based on the camera's tilt sensor. Especially useful for getting the camera level in the dark! The Virtual Horizon can also be shown in Live View mode by pressing the INFO button and cycling through the five display options to one with the Virtual Horizon.

Pentax K-1 Mark II, K-3 Mark II

Also K-1, K-3, K-5, K-5 Mark II, K-7, K-70, KP, K-500

- **Manual Exposure:** Set the Mode Dial (top left of camera) to M for Manual or B for bulb.
- **Drive/Release Mode:** Press the up arrow on the four-way controller to set Single Shot, Self-timer or Continuous shooting mode.
  - K-30, K-50, K-500, K-70, KP: Select using Right arrow.
- **Shutter Speed:** Front e-dial (front of camera, below shutter).
- **Aperture:** Rear e-dial (top right, back of camera).
- **ISO:**
  - Select using the ISO button (top of camera, near shutter) and adjust with the rear e-dial (top right, back of camera).
  - K-30, K-50, K-500, K-70, KP: Select using Up arrow.
- **White Balance:**
  - Select using the WB button (left arrow on four-way controller, back of camera) and adjust with the rear e-dial (top right, back of camera).
  - K-30, K-50, K-500, K-70, KP: Select using Down arrow.
- **Image Playback:** During image playback, rotate the front e-dial to view the same location in other images at the current zoom ratio.
- **Dark Frame Subtraction:**
  - Record Mode Menu 2 - Slow Shutter Speed NR (Noise Reduction).
  - K-5/K5-II, K-30, K-50, K-500: Menu 3.
  - K-7: Custom Setting Menu 3>#18. Slow Shutter Speed NR.
- **Noise Smoothing:**
  - Record Mode Menu 2 - High ISO NR (Noise Reduction). Choose between High, Medium, Low or Off You can also set the ISO at which High ISO NR starts.
  - K-5/K5-II, K-30, K-50, K-500: Menu 3.
  - K-7: Custom Setting Menu 3>#19. High ISO Noise Reduction. You can set the ISO at which noise reduction/ smoothing starts in menu item 20.
- **Electronic Level:**
  - Image Capture Menu 3 - Electronic Level. Press the INFO button to cycle through display options. This is turned off by default but is especially useful for getting the camera level in the dark.
  - K5/K5-II: Menu 4.
  - K-70, KP: Menu 5.
  - Not available on K-500.

Pentax K-r, K-m

- **Manual Exposure:** Set the Mode Dial to M for Manual.
- **Drive/Release Mode:** Press the Up key on the four-way controller to set Single Shot, Self-timer or Continuous shooting mode.
- **Shutter Speed:** Turn Rear e-dial. Bulb mode is set by increasing shutter speed one more step above 30".
- **Aperture:** Turn Rear e-dial while pressing +/- button (top of camera near mode dial).
- **ISO:** Press the Right button on the four-way controller (back of camera) and use Up/Down buttons to change ISO. Settings range from ISO100 to ISO12800.
- **Image Playback:** During image playback, turn rear e-dial to view the same location in other images at the current zoom ratio (only when comparing two images side-by-side).
- **Dark Frame Subtraction:** Rec. Mode 2>Slow Shutter Speed NR.
- **Noise Smoothing:** Rec. Mode 2>High ISO Noise Reduction. Choose between High, Medium, Low, Off or Auto. You can set a different option for each ISO setting.
- **Built-in Interval Timer:** Rec. Mode 2>Interval Shooting. Use the four-way controller to enter interval, number of shots and start time.
- **Virtual Horizon:** Electronic Level in Viewfinder is Off by default. Set to ON in Rec. Mode 3 menu.

Olympus OM-D EM-1 Mark III, E-M5 Mark III

Also EM-1 Mark II, EM-5 Mark II, EM-10 Mark IV

- **Manual Exposure:** Set Mode Dial to M for Manual or B for Bulb.
- **Drive/Release Mode:**
  – Recent models: Top of camera, left side, front button. Adjust with front or rear dial.
  – Earlier models: Press the OK button (back of camera) and use arrows to select Drive Mode. Change to Self-timer or Sequential (Continuous) shooting using the Front Dial and press OK again to select.
- **Shutter Speed:** Turn the Rear Dial on the top of the camera. For older cameras and EM-10 Mark IV, Bulb mode is set by increasing the shutter speed one more step above 60".
- **Aperture:** Turn the Front Dial on top of the camera.
- **ISO:**
  – Recent models: Press the ISO button (top right of camera) and use front or rear dials to adjust.
  – Earlier models: Press the OK button (back of camera) and select ISO. Change with the front dial and press OK again to select.
  – EM-10 Mark IV: Press the up arrow and adjust with the front dial.
- **White Balance:** Press the OK button (rear of camera), use arrows to select WB from screen and front dial to adjust, then OK again to select.
- **Image Playback:** Use Rear Dial (top of camera) to magnify image or zoom back out. Use Front Dial to step forward/back between images, which allows you to view the same location in other images at the current zoom ratio also (useful for comparing focus on a star between frames)
- **Dark Frame Subtraction:** *Custom Menu>Exp/ISO (E1)>Noise Reduct.* Set to On, Auto or Off.
- **Noise Smoothing:** *Custom Menu>Exp/ISO (E1)>Noise Filter*. Set to Standard or High.
- **Level Display:** Press INFO button to cycle through options to show the Level Gauge. Especially useful for getting the camera level in the dark.

Olympus E-620

- **Manual Exposure:** Set Mode Dial to M for Manual.
- **Drive/Release Mode:** Press Drive mode button (top of camera, left side) to select Single Frame, Self-timer or Sequential (Continuous) shooting.
- **Shutter Speed:** Turn the control dial. Bulb mode is set by increasing the shutter speed one more step above 60".
- **Aperture:** Turn the control dial while holding down the +/- button.
- **ISO:** Press the ISO button (back of camera) and turn the control dial.
- **Image Playback:** Use Control dial (top of camera) to enlarge image. Use left/right arrow keys to view the same location in other images at the current zoom ratio.
- **Dark Frame Subtraction:** *Custom Menu>Custom>Noise Reduct.* Set to On, Auto or Off.
- **Noise Smoothing:** *Custom Menu>Custom>Noise Filter.* Set to Standard or High.

Sony a7 III, a7R IV, a7S III, a 6600

Also a7, a7 II, a7R, a7R II, III, a7S, a7S II, a77, a77 II, a6000, a6100, a6300, a6400, a6500

- **Manual Exposure:** Set Mode Dial to M for Manual.
- **Drive/Release Mode:** Press the Drive button (left arrow on rear control wheel) and select Single Shot, Self-timer or Continuous Shooting. You can also use the Quick Navi Screen.
- **Shutter Speed:**
  – Turn the front control dial. Bulb mode is set by increasing shutter speed one more step above 30".
  – a6000 series: Turn the rear control wheel (back of camera).
- **Aperture:** Turn the rear control dial (top of camera).
- **ISO:**
  – Select by pressing right side of control wheel (back of camera).
  – a7S, a7, aA7r, a77 II: Rotate the control wheel (before pressing any of the arrow buttons).
  – a77: Select by pressing the ISO button on top of the camera.
- **White Balance:**
  – Camera Settings Menu 1
  – a7S: right side of control wheel
- **Image Playback:**
  – Use rear control dial (top of camera) to magnify image or zoom back out. Use front control dial to view the same location in other images at the same magnification, which is useful for checking focus on a star between frames.
  – a6000 series: Press + (enlarge) button (top right, rear of camera). Use control wheel (back of camera) to step between images at the same magnification.
- **Dark Frame Subtraction:** Camera Settings *Menu 1>Long Exposure NR (Noise Reduction)*. Set to On or Off.
- **Noise Smoothing:** Camera Settings *Menu 1>High ISO NR (Noise Reduction)*. Set to Normal, Low or Off.
- **Digital Level:** Cycle through the display options (top of control wheel) to show the digital level gauge in Viewfinder Mode.

Sony a5100

- **Manual Exposure:** Set Mode Dial to M for Manual.
- **Drive/Release Mode:** Press the Drive Mode button (left arrow on rear control wheel) and select Single Shot, Self-timer or Continuous Shooting.
- **Shutter Speed/Aperture:** Press the bottom side of the control wheel to select the shutter speed or aperture value, then turn the control wheel to select a value.
- **ISO:** *Menu>Camera Settings>ISO*.
- **Image Playback:** Use the W/T (wide/tele) zoom level to enlarge an image or zoom back out. Use control wheel (rear of camera) to view the same location in other images at the same magnification.
- **Dark Frame Subtraction:** *Menu>Camera Settings>Long Exposure NR (Noise Reduction)*. Set to On or Off.
- **Noise Smoothing:** *Menu>Camera Settings>High ISO NR (Noise Reduction).* Set to Normal, Low or Off.

Sony a560/a580

- **Manual Exposure:** Set Mode Dial to M for Manual.
- **Drive/Release Mode:** Press the Drive button (near shutter) and select Single Shot, Self-timer or Continuous Shooting.
- **Shutter Speed:** Rotate the control dial (front of camera). Bulb mode is set by increasing shutter speed one more step above 30".
- **Aperture:** Rotate the control dial while pressing +/- button (back of camera, top right).
- **ISO:** Press the Fn (Function) button on back of camera and select ISO. Use Up and Down buttons to adjust. Settings extend up to ISO1600.
- **Dark Frame Subtraction:** *Menu 3>Long Exposure NR*. Set to On or Off.
- **Noise Smoothing:** *Menu 3>High ISO NR*. Not applied to RAW images.
- **Multi Frame Noise Reduction:** The camera automatically shoots multiple images continuously, combines the images, reduces the noise, and records one image. In Multi Frame NR, you can select ISO numbers up to ISO 25600.

TRACKING THE STARS

THE MILKY WAY
CANON 5D MARK IV, 50MM SIGMA ART LENS, TRACKING ON STAR ADVENTURER, 10 MINS, F2.8, ISO400.

Portable equatorial tracking mounts allow us to move beyond night sky photography on a tripod to long-exposure astrophotography. The first thing to learn when using these mounts is how to 'polar align' them. Secondly, the 'Track and Stack' approach to gathering photographic data requires entirely new image processing techniques. This section will help you with these two important astrophotography skills.

What is Polar Alignment?

As we saw when discussing shutter speed for night sky photography (Page 35), because of the motion of the stars, even with wide-angle lenses we are limited to exposures of around 30 seconds duration. With longer focal lengths this exposure limit becomes much shorter. Shooting at 200mm, our exposures can be barely 2-3 seconds long before the trailing of the stars becomes unacceptable. But to capture faint astronomical objects we need exposures ideally measured in hours.

It is possible to have a mount that moves simply up and down and side-to-side (called an alt-azimuth mount) and this can indeed follow the stars for visual observing. But when used for photography, the mount may follow the star in the centre of the frame, but the rest of the field appears to rotate around it, introducing trailing of a different kind.

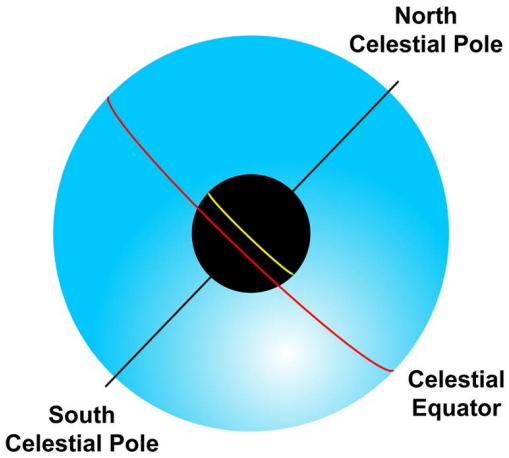
To properly follow the stars and achieve long exposures, we need an 'equatorial tracking mount'. The primary axis of the mount must be aligned parallel with Earth's axis and move at a matching speed of one rotation each 24 hours to 'track' the stars.

We describe positions or coordinates on Earth using longitude and latitude. In the night sky, we use the equivalent terms 'right-ascension' and 'declination' to describe positions on the celestial sphere. For this reason, the primary axis of an equatorial mount is called the 'right-ascension' axis.

We need to align the right-ascension axis to be parallel to Earth's, and we achieve this by pointing the mount due north in azimuth (or south in the southern hemisphere) and up at an angle of altitude matching your latitude (degrees north or south of the equator).

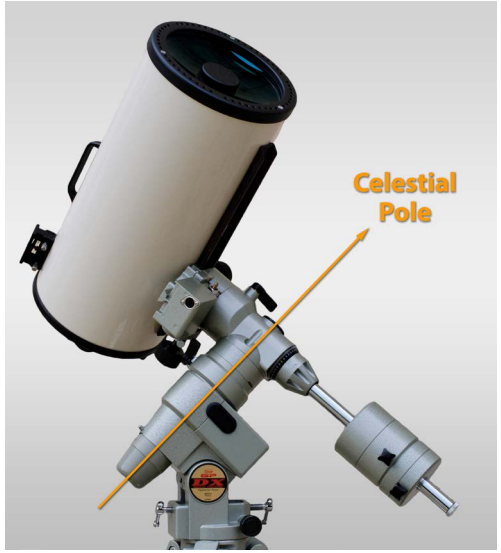
With the bright star 'Polaris' conveniently located close to the north celestial pole, this process is considerably easier in the northern hemisphere.

Refer to Page 8 for further explanation of the 'Celestial Sphere' and how the stars move around the night sky.



THE CELESTIAL SPHERE

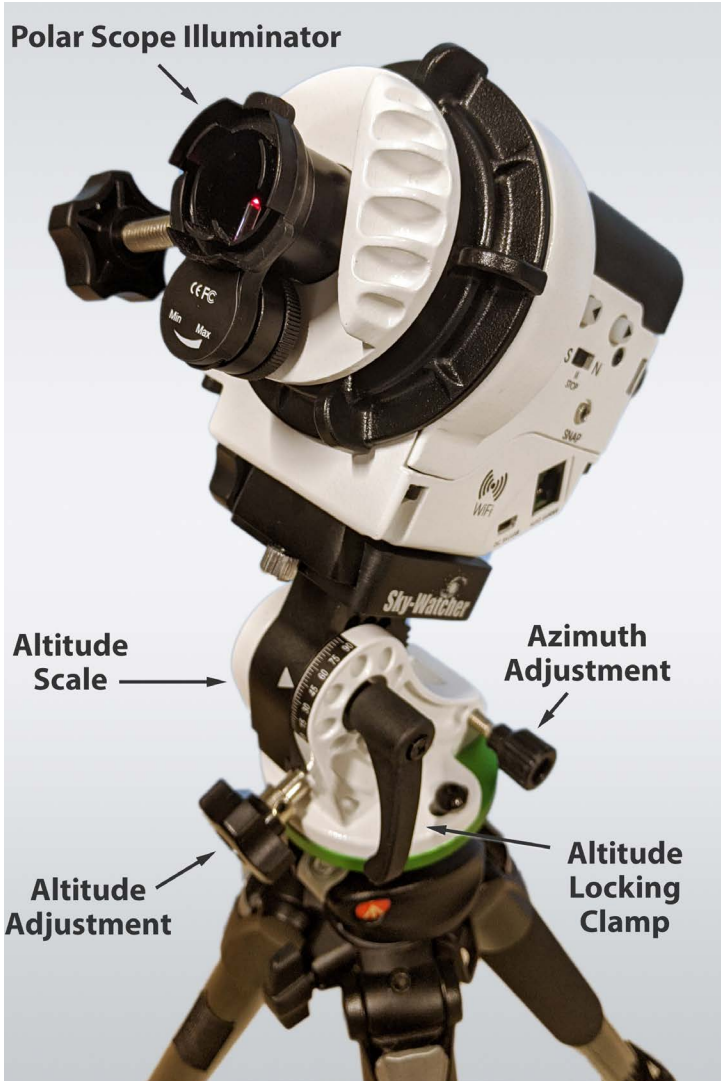
Image: Fcn (Wikipedia)



A SIMPLE EQUATORIAL MOUNT SHOWING THE RIGHT-ASCENSION AXIS

Image: Marie-Lan Nguyen (Wikipedia)

The following instructions are for a Sky-Watcher Star Adventurer 2i tracking mount but will be similar and relevant to any equatorial mount, no matter how large or small, although these portable tracking mounts are simpler having only one motorised axis.

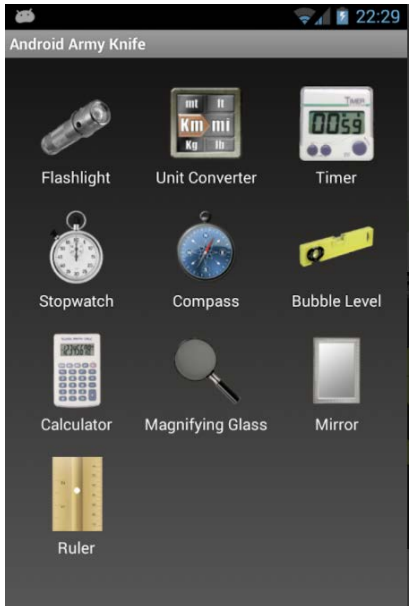


ADJUSTING POLAR ALIGNMENT WITH THE SKY-WATCHER STAR ADVENTURER 2i

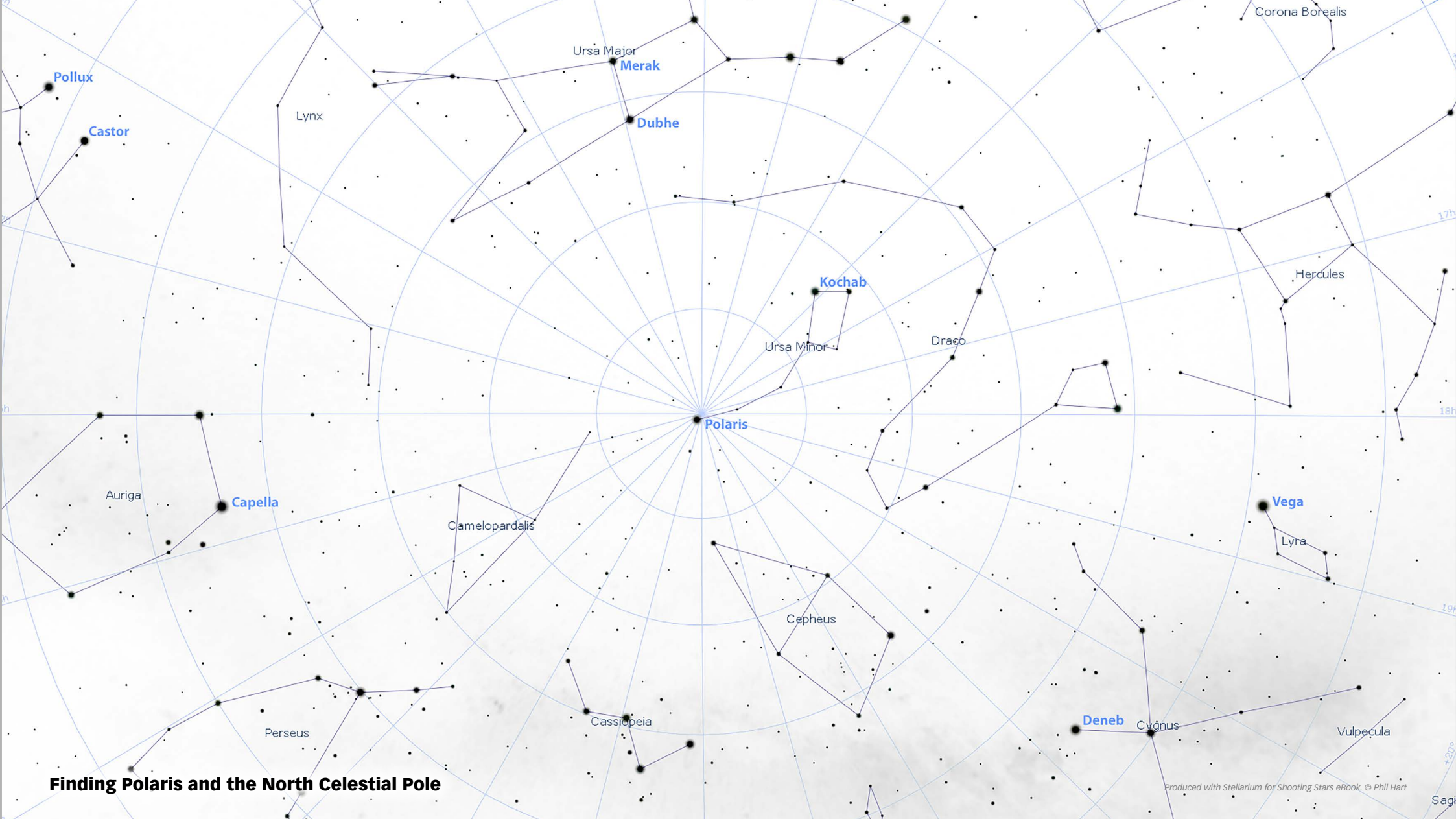
Step 1: Rough Polar Alignment

The first step is to become familiar with the bright stars and constellations around your north or south celestial pole. Choose the chart for your hemisphere from the following two pages - these are designed to be printed and used in the field to learn your way round these 'polar' regions of the sky.

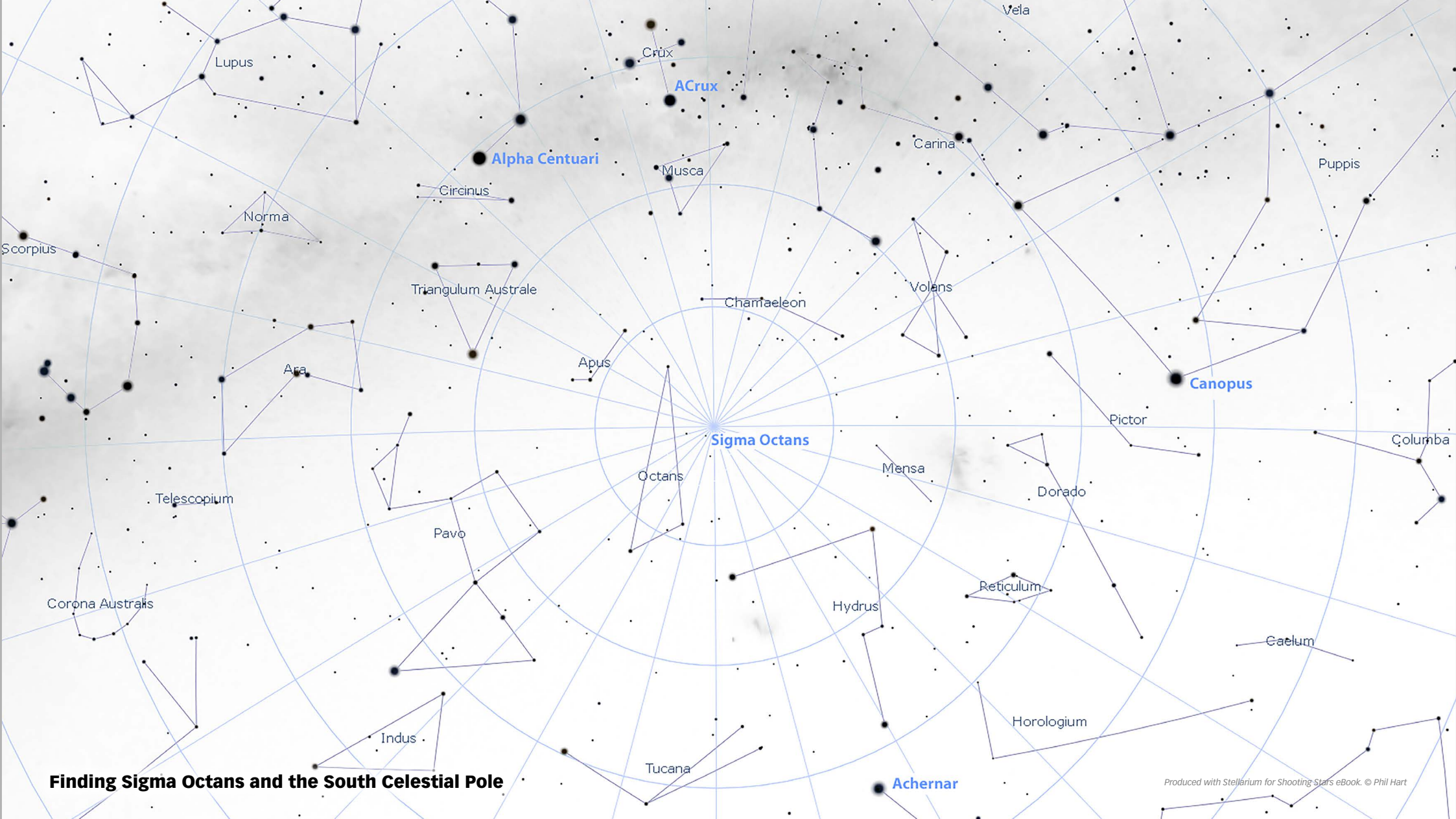
An app such as "Army Knife" is also helpful for polar alignment providing both a compass and a bubble level.



TOOLS AVAILABLE IN THE ARMY KNIFE APP



Finding Polaris and the North Celestial Pole



Finding Sigma Octans and the South Celestial Pole

Setting the Azimuth

Azimuth is the horizontal or left/right alignment of your mount, which needs to be pointing due north in the northern hemisphere or due south in the southern hemisphere.

Start by moving the whole tripod or rotating its centre column until it is roughly lined up. Then use the azimuth adjustment knobs on the mount to refine it.

To help find north or south, you can use a compass, after correcting for magnetic declination at your location. The compass on your phone should be automatically corrected for declination but accuracy varies considerably.

Unless you need to align during daylight, the most accurate way to align the azimuth is to eye-ball align the mount with the stars. In the northern hemisphere, this is easy. Simply find the moderately bright star Polaris based on the charts on the previous page, or an app such as Stellarium, and visually line the mount up with it.

In the southern hemisphere, unless you have dark skies and particularly good eyesight, you will often not be able to see 'Sigma Octans' or the trapezium of stars around it with the naked eye. In this case, Stellarium provides a good alternative. From the app settings menu choose 'Advanced' and tick the option to 'Show meridian line'.

SETTTINGS TO ENABLE THE 'MERIDIAN LINE' IN STELLARIUM

FINDING DUE SOUTH WITH STELLARIUM AND THE MERIDIAN LINE

The green meridian line, as shown in image above is a line drawn across the sky from due north to south through the zenith (overhead). Any star near that line at that moment in time can be used to 'eye-ball' align the mount. In the example above, you could align the mount with the bright star Canopus just visible through the trees. Or without being able to see Canopus or even the entire region around the south celestial pole, you could align the mount with the triangle of stars in the constellation Pavo, representing the head of the peacock, near the top of this chart.

Setting the Altitude

Set the altitude of the mount to roughly the right level using the altitude scale on your mount, if it has one. This step is more accurate if your tripod is set level to begin with, but this is not essential.

The 'Army Knife' or similar apps have a bubble level that allow you to measure angles with your smartphone. If you're finding it difficult with your phone, a digital inclinometer such as the ***Tilt Box II from Beall Tools*** is a more accurate and reliable way of doing this. Either way, set the angle of the mount above horizontal to match your latitude north or south of the equator, for example 37 degrees up as shown in the photos.

With a little care, this combination of eye-ball azimuth alignment and measured altitude can be quite accurate, within one or two degrees. This is good enough for short exposures with wide-angle lenses. It should also be accurate enough to bring the stars near the pole within the field of view of the polar scope for more accurate alignment as shown on the following pages.

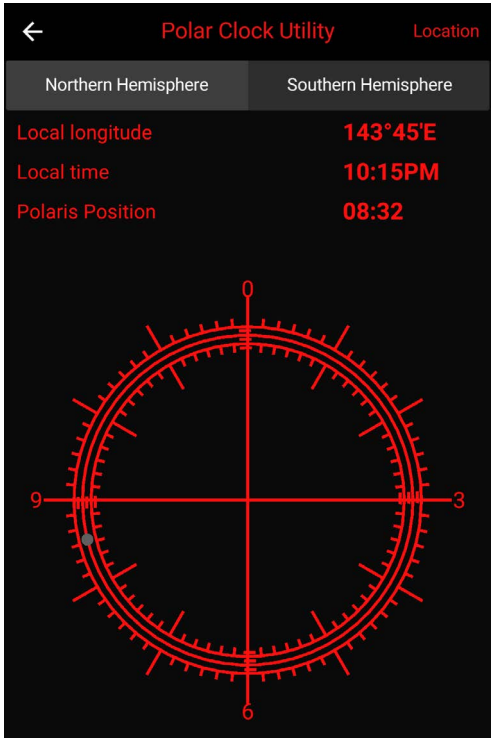
Step 2: Accurate Polar Alignment

To achieve accurate polar alignment for imaging with telephoto lenses or longer exposure times requires using the polar scope built-in to mounts such as the Star Adventurer, in combination with the Polar Clock Utility in the Star Adventurer Console app.

Using the Polar Scope – Northern Hemisphere

If you have successfully set the azimuth and altitude of the mount, you should be able to see the bright north star Polaris in the field of view. To correctly position Polaris relative to the true north celestial pole, Polaris needs to be placed within the middle of the ring around the clock face inscribed in the polar scope. Use the polar scope Illuminator to backlight the markings and the Polar Clock Utility to show at which clock position Polaris should be placed based on the date and time when you are setting up.

In the example below, Polaris (represented by the grey dot) needs to be placed at the 8:32 clock position. Use the azimuth and altitude adjustment knobs to achieve this position as accurately as you can. From this point on, be careful not to bump the tripod or the mount, which is easier said than done in the dark.



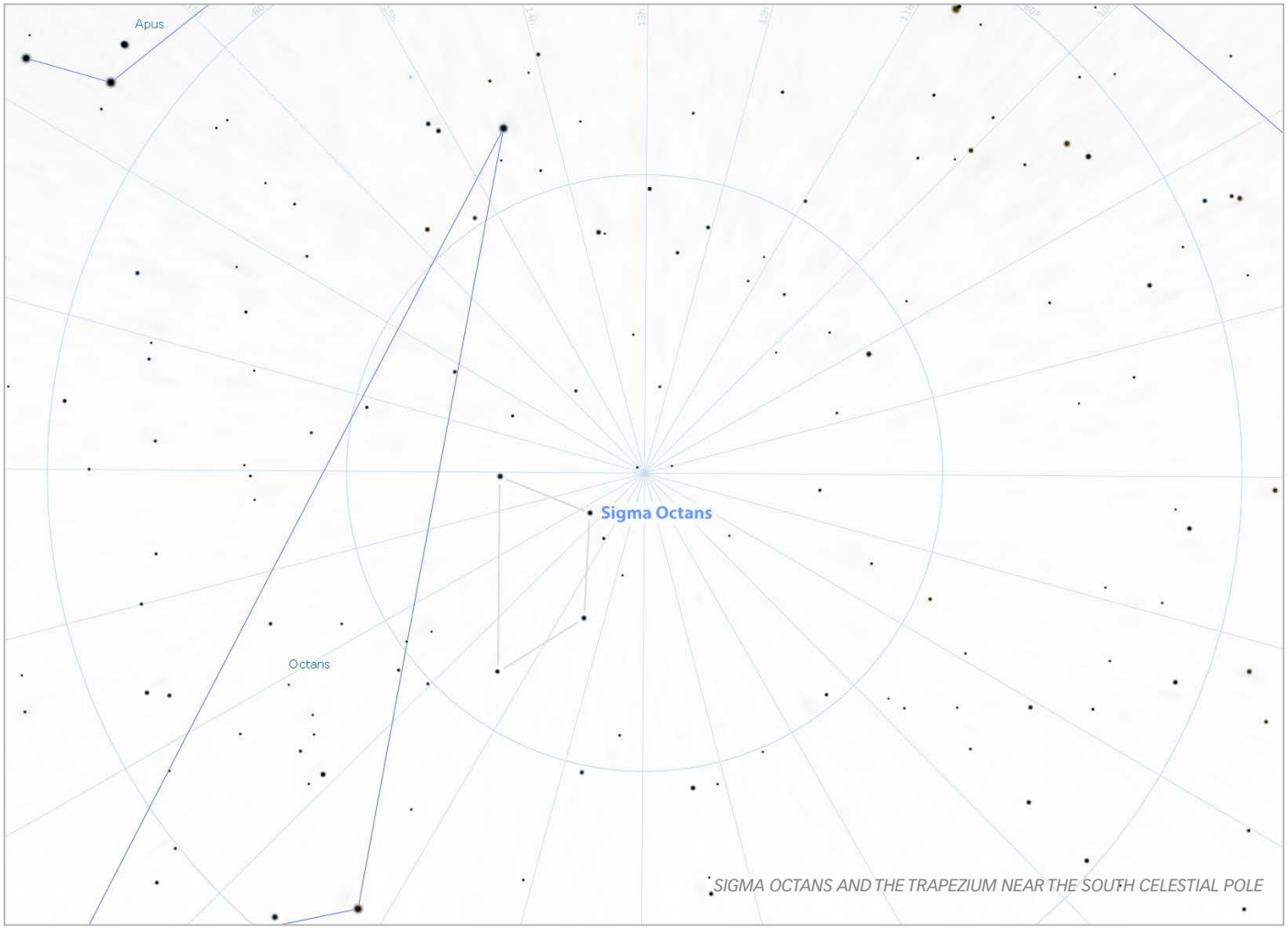
POLAR CLOCK UTILITY SHOWING REQUIRED POSITION OF POLARIS (GREY DOT) IN THE POLAR SCOPE

Using the Polar Scope – Southern Hemisphere

Using a polar alignment scope is considerably harder in the southern hemisphere. Crouching down to look up at an awkward angle is hard enough, but with only faint stars to align with near the pole, for us southerners this takes some practice.

Browse this area with a pair of binoculars first, starting with the wide view chart earlier then learning to recognise what the asterism of stars around Sigma Octans looks like first before trying to find this in the polar scope of your mount. Note that the view will be inverted in the polar scope compared to what you see in binoculars.

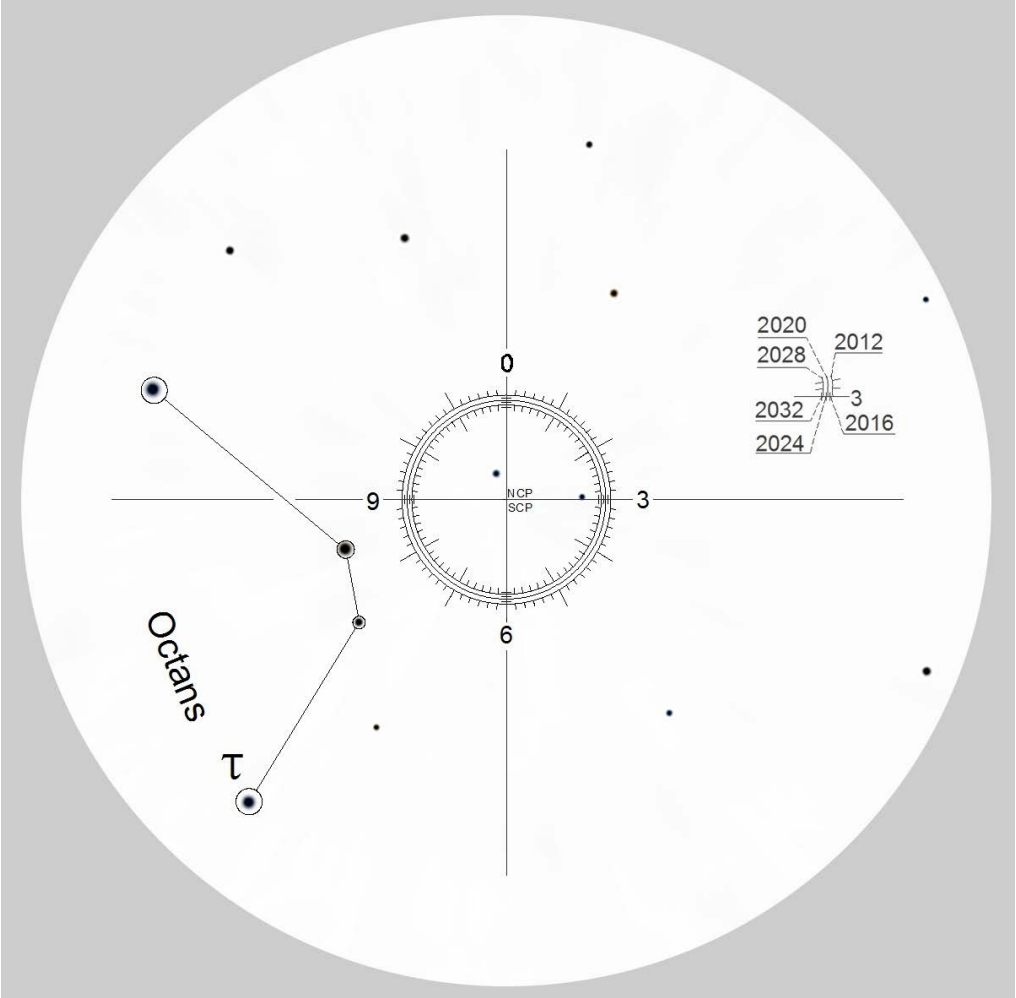
Next to the faint constellation Octans, astronomers look for a small and faint trapezium of stars with Sigma Octans at one corner closest to the south celestial pole. Sigma Octans also forms a distinctive line with two other even fainter stars outside the trapezium. This pattern is helpful to look for when trying to find Sigma Octans. The view through the polar scope is not wide enough to show the fourth corner of the trapezium.

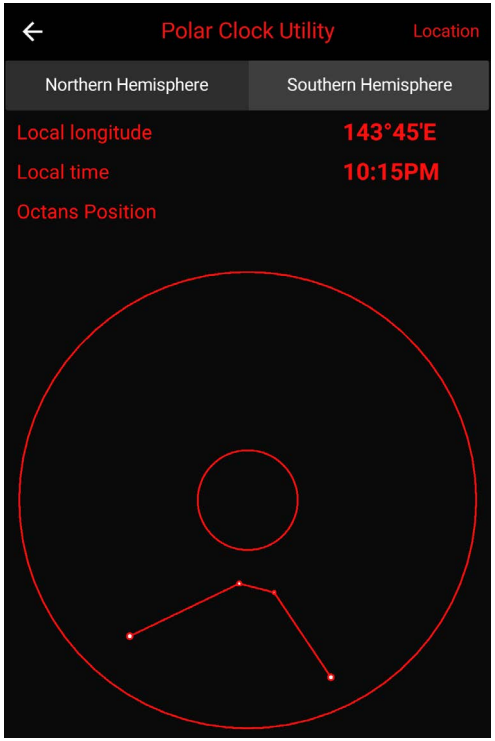


SIGMA OCTANS AND THE TRAPEZIUM NEAR THE SOUTH CELESTIAL POLE

THE VIEW THROUGH THE POLAR SCOPE WITH STARS

- Attach the Polar Scope Illuminator at the dimmest setting that allows you to see the reticle markings. You may need to turn it on and off as you line up the mount.
- Use the Polar Clock Utility in the Star Adventurer Console app and rotate the right-ascension axis of the mount so that the orientation of the markings matches that shown in the app. To rotate the mount, release the clutch knob, which is the large black ring on the front of the mount, by turning it anti-clockwise.
- If azimuth and altitude have been correctly set, you should be able to see Sigma Octans and the matching stars around it inside the field of view. Now use the fine adjustment knobs for azimuth and altitude to line the stars up as shown.
- If you cannot see Sigma Octans in the field of view, try to pan the mount left and right a small amount, possibly by gently rotating the centre column of your tripod. You can also move the mount up and down by around half the field of view. If you still can't find Sigma Octans, go back and repeat the rough alignment steps. This can be quite difficult the first time you try but does get a lot easier with practice.





POLAR CLOCK UTILITY SHOWING CURRENT ORIENTATION OF SIGMA OCTANS

Long Exposure Astrophotography

The Sky-Watcher Star Adventurer mount can be used in two configurations, with the ball-head adapter or with the fine-tuning mounting assembly and counterweight.

Mounting the camera directly on a sturdy ball-head makes it relatively easy to point a wide lens anywhere in the sky. The camera should be positioned so that its weight is roughly in line with the mount.

With longer and heavier lenses, the mounting assembly with the counterweight is the better option. Now you point the camera by rotating in right-ascension, after releasing the large black clutch ring on the front of the mount, and in declination by releasing the clutch under the camera. If your lens has a collar mount then you will still be able to rotate the camera, otherwise if the camera body is attached directly then the orientation of the camera will be fixed.

With the mounting assembly, the polar scope can still be used to check polar alignment which often changes a little once the weight of the imaging gear is added to the mount. To illuminate the reticle markings, you may need to modify the polar scope illuminator or shine a red flashlight in from the side.

Once you have the camera mounted and pointing at your target, there are two different approaches to capturing images:

- **Single long exposure**
- **Multiple short sub-exposures ('Track and Stack')**

With a wide lens and accurate polar alignment, you may be able to achieve single exposures of 10-20 minutes with sharp stars. In this case, you can stop the aperture down a little to improve image quality and reduce the ISO setting considerably compared to typical night sky photography settings. The image at the start of this section is a good example, which has an exposure of 10 mins with aperture f2.8 and ISO400.

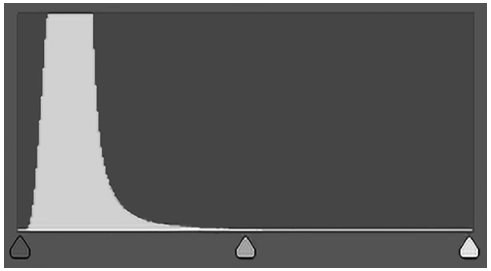
STAR ADVENTURER WITH BALL-HEAD (LEFT) OR FINE-TUNING MOUNTING ASSEMBLY AND COUNTERWEIGHT (RIGHT)

Track and Stack Settings

Once you start moving to longer lenses, your maximum exposure times will start to reduce. In this case, the Track and Stack approach is what astrophotographers use to capture multiple short sub-exposures and then combine (stack) them in software.

There is a lot of flexibility with the exposure settings for this Track and Stack approach. The first step is to determine your maximum sub-exposure length before trailing of the stars becomes noticeable. The ISO setting can then be adjusted to suit.

The ISO should be high enough that the peak of the histogram representing the large area of sky across your image is up around 10-20% and clearly separated from the black end of the histogram. Don't push the ISO much higher than needed though, which will prevent the stars and small bright objects in the image from being over-exposed and heavily clipped. The table shows typical recommended settings assuming an aperture around f2.8-f4.



TYPICAL HISTOGRAM PEAK FOR TRACK AND STACK EXPOSURES

TRACK AND STACK EXPOSURE SETTINGS

Sub-Exposure Length	Suggested ISO
60 secs or less	ISO3200
2 minutes	ISO1600
5 minutes	ISO800
10 minutes	ISO400

Once you have your sub-exposure settings worked out, it is time to start capturing many of them in Bulb mode. A programmable timer release makes this much easier, or internal camera timer if you have one. Refer to the instructions in the Field Guide on Page 139.

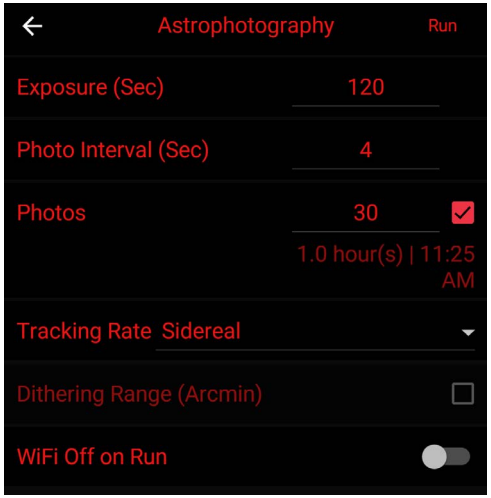
Start by aiming for 10-15 minutes of total exposure time, then progress to 30 minutes and you will see the benefits in your final images. Doubling that to one or even two hours total exposure becomes time consuming but can be the key to producing high quality deep sky images.

Mirror Lock-Up

When using a telephoto lens on a small tracking platform, vibration from the reflex mirror movement can lead to a wobble in the stars at the start of your exposure. To avoid this, set mirror lock-up to 'On' and use the two-second delay drive mode on your camera. On most cameras, the mirror should flip up first, then the exposure starts two seconds later after the mirror vibration has settled.

Star Adventurer Control

The Sky-Watcher Star Adventurer 2i and Star Adventurer Mini include camera control as part of the Star Adventurer Console app with a matching camera cable. Example settings to capture one hour of total exposure with 30 two-minute sub-exposures are shown below.



Astrophotography Image Processing

For single long exposures, astrophotography images can be processed following the same Lightroom principles as described for night sky photography on Page 85.

Once you start capturing multiple images, the Track and Stack technique requires a completely new approach to image processing. There are many astrophotography image processing applications to choose from and on the following pages I present instructions for three options:

1. **Photoshop**
2. **Deep Sky Stacker**
3. **Astro Pixel Processor**

At this point, it becomes helpful to think of the sequence of sub-exposures you capture as 'data' and astrophotography software as providing the mathematical tools to calibrate and combine this data.

When you take multiple images of the same object, you are gathering a lot of data, in hundreds of gigabytes of files. The 'signal' or image of the object is present in each image, while the noise varies between them (refer also to the Light Buckets analogy on Page 39). By adding the data from many sub-exposures, we increase the signal to noise ratio, improving the quality of the image and revealing things that were not visible in a single short exposure.

The example below is a very faint cloud of dust in the constellation Corona Australis. In a single 45 second exposure with a 200mm lens, the dust cloud can barely be perceived through the noise in the image. By combining 480 sub-exposures together, we acquire data for a total exposure of 6 hours. Now we can see the full extent of the dust cloud and varying colour and texture within it. This is the power of long-exposure astrophotography. It becomes addictive teasing out the faint details of the universe in this way.

SINGLE 45 SECOND EXPOSURE OF THE CORONA AUSTRALIS DUST CLOUD CANON 5D MARK IV, 200MM LENS, F2.8, ISO3200

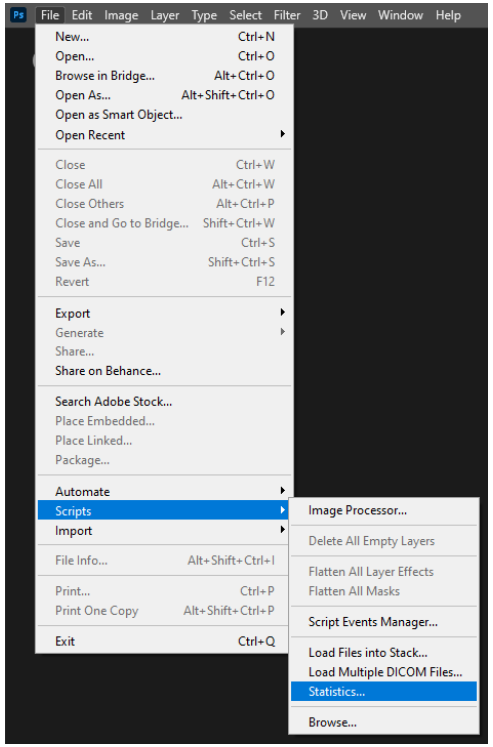
STACK OF 480 SUB-EXPOSURES (6 HOURS OF DATA) REVEALING THE CORONA AUSTRALIS DUST CLOUD

Stacking Images in Photoshop

If you have a modest number of reasonably well exposed images, there is a simple Script technique in Photoshop that allows you to combine them into one image with an exposure time equivalent to the sum of them all.

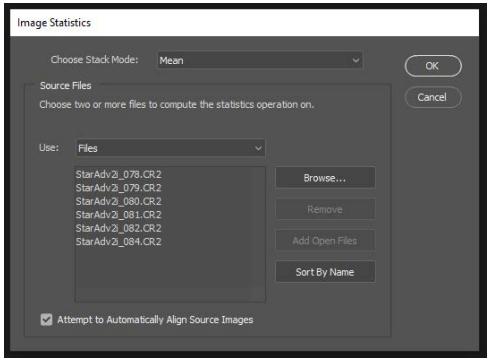
Step 1

From the File Menu, choose Scripts and then Statistics.



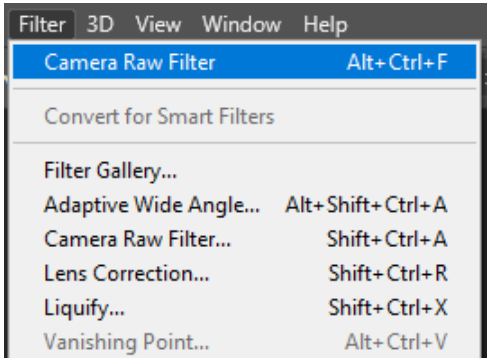
Step 2

For the Stack Mode, choose Mean or Median. Browse to select all the files that you want to stack together. These should all be similar in framing and exposure details. Select the option to Automatically Align Source Images.



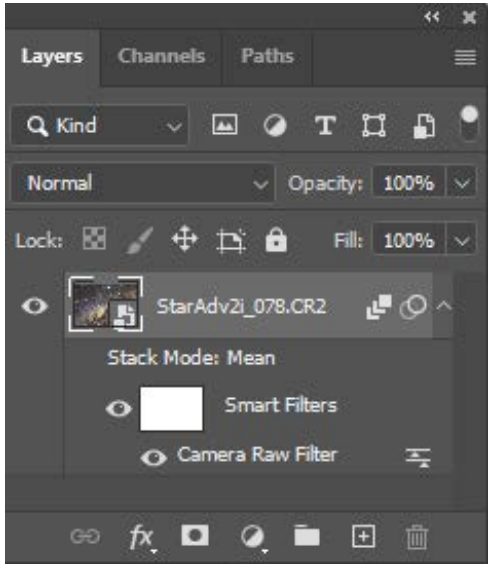
Step 3

The complete stack will be created as a Smart Object layer in Photoshop. A good next step is to use the Camera Raw Filter for non-destructive image processing which maintains the integrity of the stack, while providing all the same options as developing camera RAW files in Lightroom (refer to Page 85), including the Optics panel to correct for vignetting.



Step 4

Your Layers panel in Photoshop should then show the image stack with the Camera Raw Filter applied to it. You can double click this filter layer to adjust any of the camera RAW settings at any time.



The example below uses a stack of seven frames, each with the same exposure. A small crop from this image shows the subtle but important benefit of stacking even a small number of images. Stacking a larger number of exposures will yield greater improvements.

A SINGLE FIVE-MINUTE EXPOSURE (LEFT) AND A STACK OF SEVEN EXPOSURES (RIGHT)

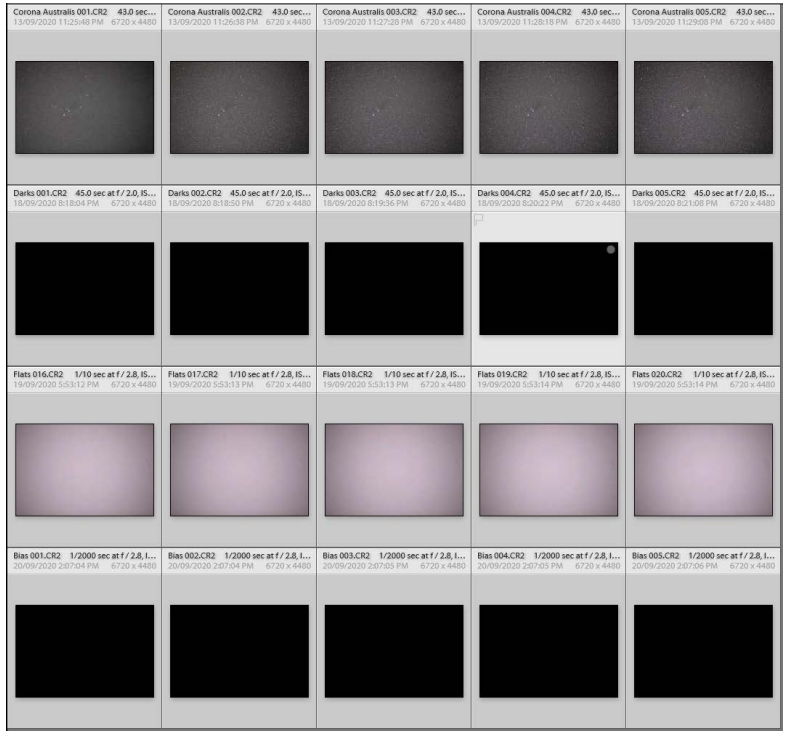
Calibration Frames

To take the step beyond Photoshop to dedicated astro-image processing software requires learning about calibration frames. These calibration frames are part of the mathematical process of working with your image data and allow software to correct for uneven illumination and substantially remove 'hot pixels' and other artefacts from your images. The calibration frames are applied to your 'Light Frames', which are your actual images of the astronomical object.

For the software to correctly calibrate and combine the data captured, at least three out of the following four types of calibration frames are required:

1. **Dark Frames:** As described on Page 40, during a long exposure your sensor generates charge in the pixels and a Dark Frame records what this looks like for your camera. This 'dark signal' increases with time, ISO and ambient temperature, therefore your Dark Frames should be captured with the lens cap on but in otherwise similar conditions. Use the same exposure length and ISO and ideally capture them at a similar temperature. Keep the camera in a dark location as well as keeping the lens cap on as it is quite easy for light leaks through the viewfinder to affect your Dark Frames if they are captured in bright outdoor conditions.
2. **Flat Frames:** Flat Frames are photographs of an evenly illuminated subject used to correct for uneven illumination primarily due to vignetting and dust spots. See notes on the next page on how to capture them.
3. **Dark Flat Frames:** The same concept as Dark Frames, but instead of using the exposure length of your Light Frames, these have a short duration with ISO and exposure that matches your Flat Frames.
4. **Bias Frames:** Bias frames are very short exposures which aim to record any pattern noise associated with 'reading' the image data from the sensor. With a DSLR, Bias Frames should be captured with the lens cap on and no light reaching the camera. Use a very short exposure such as 1/1000 sec exposure and the same ISO as your Light Frames.

The calibration frames have their own noise, therefore, we need to capture many calibration frames to average that out, otherwise we introduce that noise into our images while aiming to calibrate and improve them. A good starting point is to capture 25 of each. Using 50-100 of each will achieve a slightly better result, although you would have to inspect the images very closely to notice the difference.



A SELECTION OF LIGHT FRAMES READY FOR CALIBRATION WITH DARK, FLAT AND BIAS FRAMES

Calibration Flat Frames

There is an art to capturing accurate Flat Frames, so some experimentation may be required. An easy and generally reliable option is to photograph your laptop/PC screen filled with a blank white or grey canvas image in Photoshop.

Keep the lens roughly focussed on infinity and with lens hood on if you have one, hold the lens right up close to the screen so there are no reflections on the screen or light coming in from the side. You can also try using a clean sheet of paper in between.

Adjust the exposure so that the histogram is up around 60-75% or use aperture priority mode with +1-2 stops exposure compensation. Make sure that the histogram is not clipped at either the dark or light end.

If your exposures are very short and becoming affected by the 50-60Hz refresh rate of the screen, create a dark grey rather than white image on screen to photograph which will result in a longer exposure time (e.g. ¼ sec or slower).

FLAT FRAME, WITH CONTRAST ENHANCED, WHICH CAPTURES THE EFFECTS OF VIGNETTING AND DUST SPOTS

Calibration Option 1: Dark, Flat and Dark Flat Frames

With both Deep Sky Stacker and Astro Pixel Processor, I recommend capturing Dark Frames, Flat Frames and Dark Flat Frames. In this case, capture the Flat Frames and Dark Flat Frames with a low ISO setting (and longer exposure) as they will be 'cleaner' with less noise this way. The Dark Frames must still have the same exposure and ISO as your Light Frames.

Calibration Option 2: Bias, Dark and Flat Frames

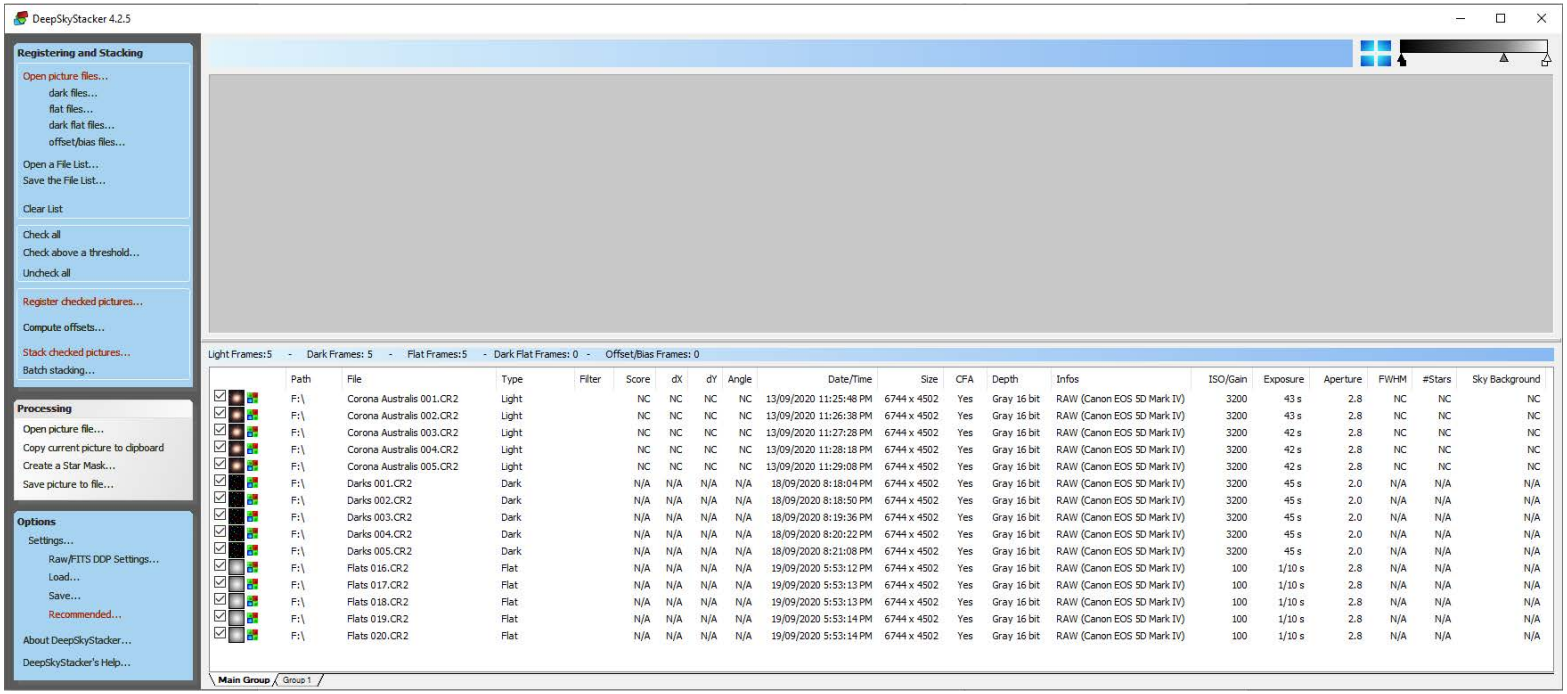
Bias Frames allow software to 'scale' your long-exposure Dark Frame to match the short exposure of your Flat Frame. In this case, you do not need Dark Flat Frames, but the Bias and Flat Frames should be captured at the same ISO as your Light and Dark Frames. It would be helpful in this case to capture a larger number of Flat Frames to counter the noisier image produced at higher ISO with shorter exposures.

Stacking Images with Deep Sky Stacker

Deep Sky Stacker is freeware created in 2006 by Luc Coiffier and widely used for the pre-processing step of calibrating and registering astrophotography images. Deep Sky Stacker will register and stack your Light Frames alone if you prefer to start that way but providing calibration frames will yield superior results.

Step 1: Open Files

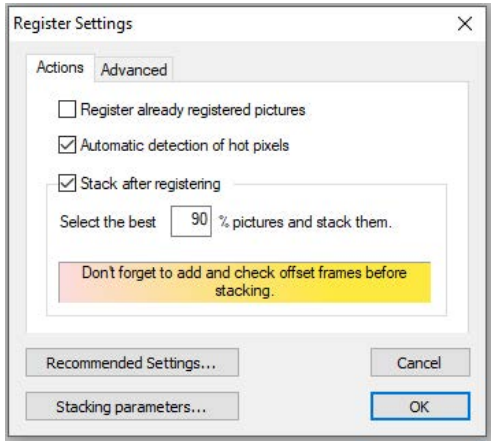
Click the top menu item to 'Open picture files' and browse and select your batch of Light Frames. Then click the subsequent items to open your Dark, Flat and Dark Flat calibration frames (if using Calibration Option 1 described earlier). The files you have selected will be summarised with various parameters in a list below the main screen area.



	Path	File	Type	Filter	Score	dX	dY	Angle	Date/Time	Size	CFA	Depth	Infos	ISO/Gain	Exposure	Aperture	FWHM	#Stars	Sky Background
	F:\	Corona Australis 001.CR2	Light		NC	NC	NC	NC	13/09/2020 11:25:48 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	3200	43 s	2.8	NC	NC	NC
	F:\	Corona Australis 002.CR2	Light		NC	NC	NC	NC	13/09/2020 11:26:38 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	3200	43 s	2.8	NC	NC	NC
	F:\	Corona Australis 003.CR2	Light		NC	NC	NC	NC	13/09/2020 11:27:28 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	3200	42 s	2.8	NC	NC	NC
	F:\	Corona Australis 004.CR2	Light		NC	NC	NC	NC	13/09/2020 11:28:18 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	3200	42 s	2.8	NC	NC	NC
	F:\	Corona Australis 005.CR2	Light		NC	NC	NC	NC	13/09/2020 11:29:08 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	3200	42 s	2.8	NC	NC	NC
	F:\	Darks 001.CR2	Dark		N/A	N/A	N/A	N/A	18/09/2020 8:18:04 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	3200	45 s	2.0	N/A	N/A	N/A
	F:\	Darks 002.CR2	Dark		N/A	N/A	N/A	N/A	18/09/2020 8:18:50 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	3200	45 s	2.0	N/A	N/A	N/A
	F:\	Darks 003.CR2	Dark		N/A	N/A	N/A	N/A	18/09/2020 8:19:36 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	3200	45 s	2.0	N/A	N/A	N/A
	F:\	Darks 004.CR2	Dark		N/A	N/A	N/A	N/A	18/09/2020 8:20:22 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	3200	45 s	2.0	N/A	N/A	N/A
	F:\	Darks 005.CR2	Dark		N/A	N/A	N/A	N/A	18/09/2020 8:21:08 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	3200	45 s	2.0	N/A	N/A	N/A
	F:\	Flats 016.CR2	Flat		N/A	N/A	N/A	N/A	19/09/2020 5:53:12 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	100	1/10 s	2.8	N/A	N/A	N/A
	F:\	Flats 017.CR2	Flat		N/A	N/A	N/A	N/A	19/09/2020 5:53:13 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	100	1/10 s	2.8	N/A	N/A	N/A
	F:\	Flats 018.CR2	Flat		N/A	N/A	N/A	N/A	19/09/2020 5:53:13 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	100	1/10 s	2.8	N/A	N/A	N/A
	F:\	Flats 019.CR2	Flat		N/A	N/A	N/A	N/A	19/09/2020 5:53:14 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	100	1/10 s	2.8	N/A	N/A	N/A
	F:\	Flats 020.CR2	Flat		N/A	N/A	N/A	N/A	19/09/2020 5:53:14 PM	6744 x 4502	Yes	Gray 16 bit	RAW (Canon EOS 5D Mark IV)	100	1/10 s	2.8	N/A	N/A	N/A

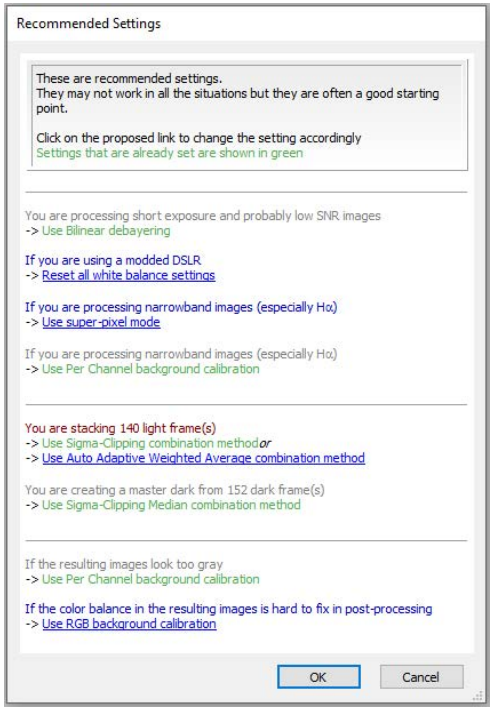
Step 2: Open Register Pictures Dialog

Click the menu item to “Check All” to make sure that all files will be processed. Then click “Register Checked Pictures”. If some of your images have trailed stars, you can set a percentage here and Deep Sky Stacker will reject the lowest quality images before combining them. You can safely ignore the message about adding offset (bias) frames if you are following Calibration Option 1.



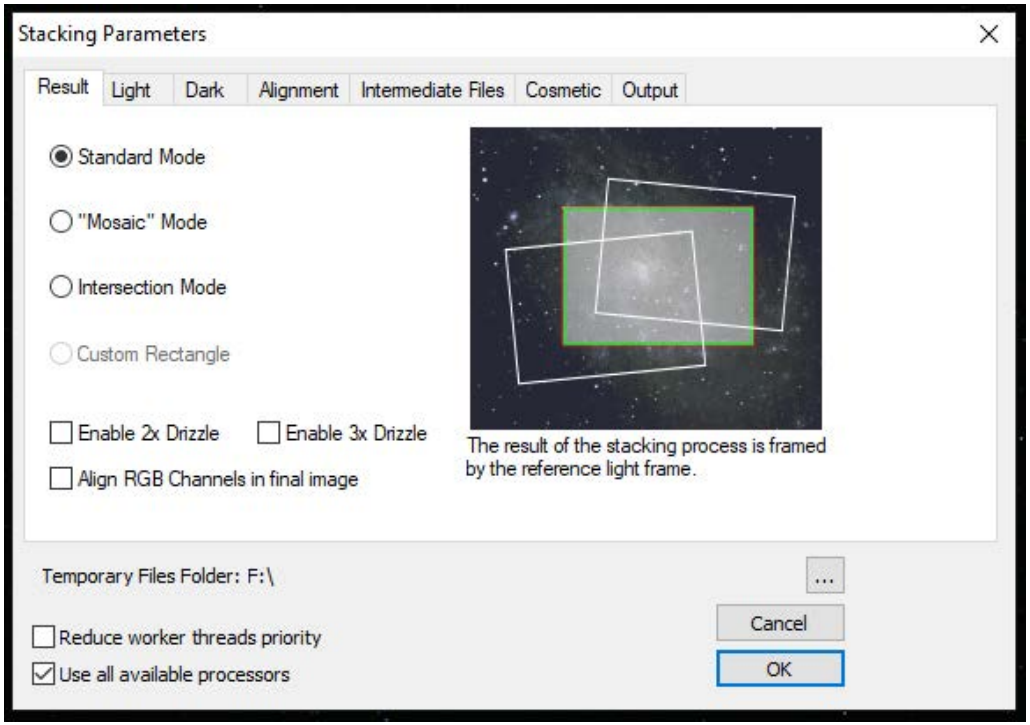
Step 3: Review Recommended Settings

Before clicking OK at Step 2, you can click the “Recommended Settings” button and review Deep Sky Stacker advice and prompts for alternative processing options.

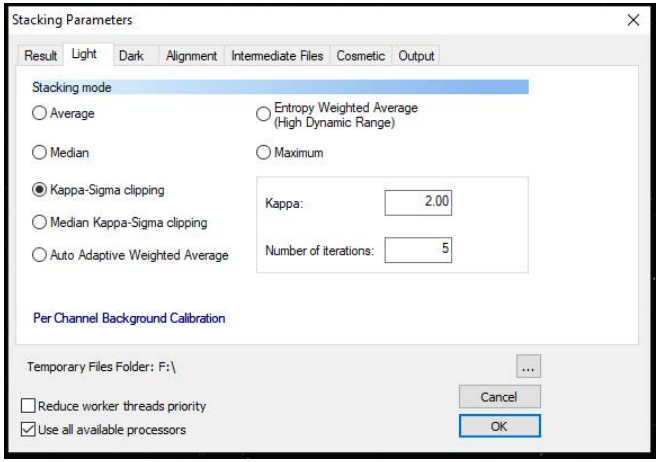


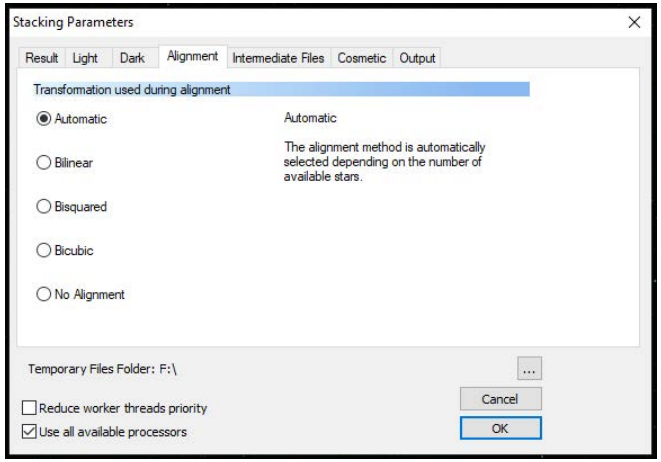
Step 4: Review StackingParameters

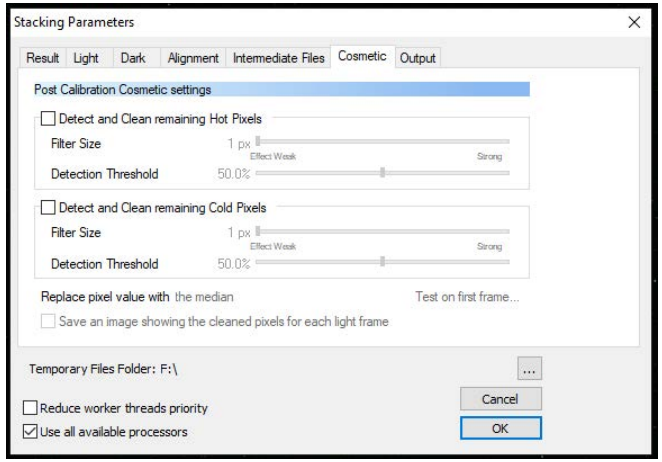
At Step 2, you can also click “Stacking Parameters” and review all the Deep Sky Stacker parameters across seven different tabs. The first “Result” tab is shown below. Standard stacking mode will create an image with the same dimensions as one reference frame in the stack. Intersection mode can be useful to crop the result down to just that section that is common to all of the frames in the stack.

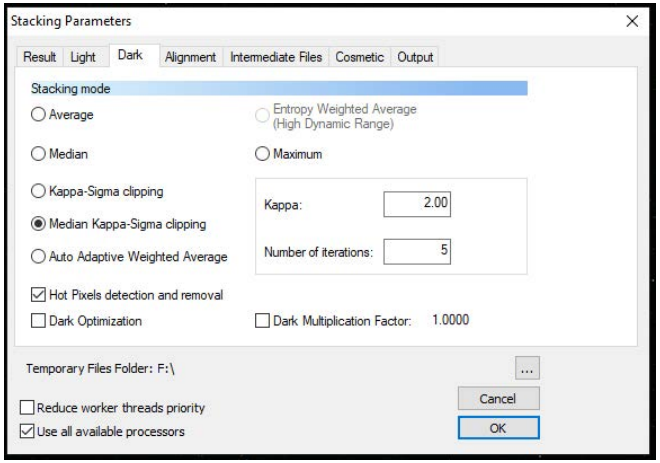


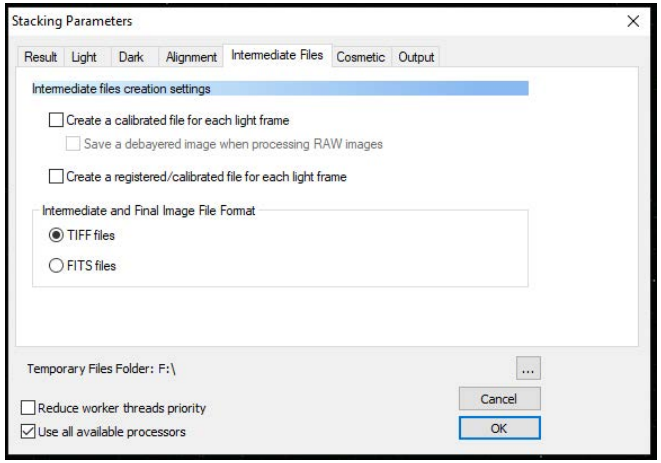
The default settings for six other Stacking Parameter tabs are shown below. The preferred statistical stacking mode for each frame type depends on the number of frames. The Recommended settings dialog above will suggest the best option for the number of frames you have, but differences between the options will be minor. The default settings should all be fine for this type of wide-field astrophotography.

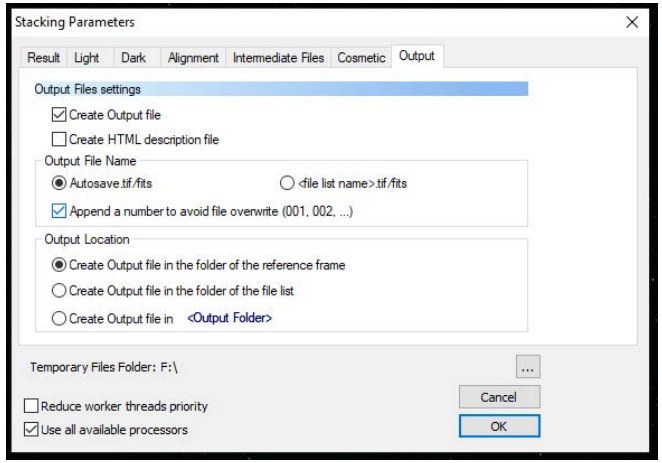










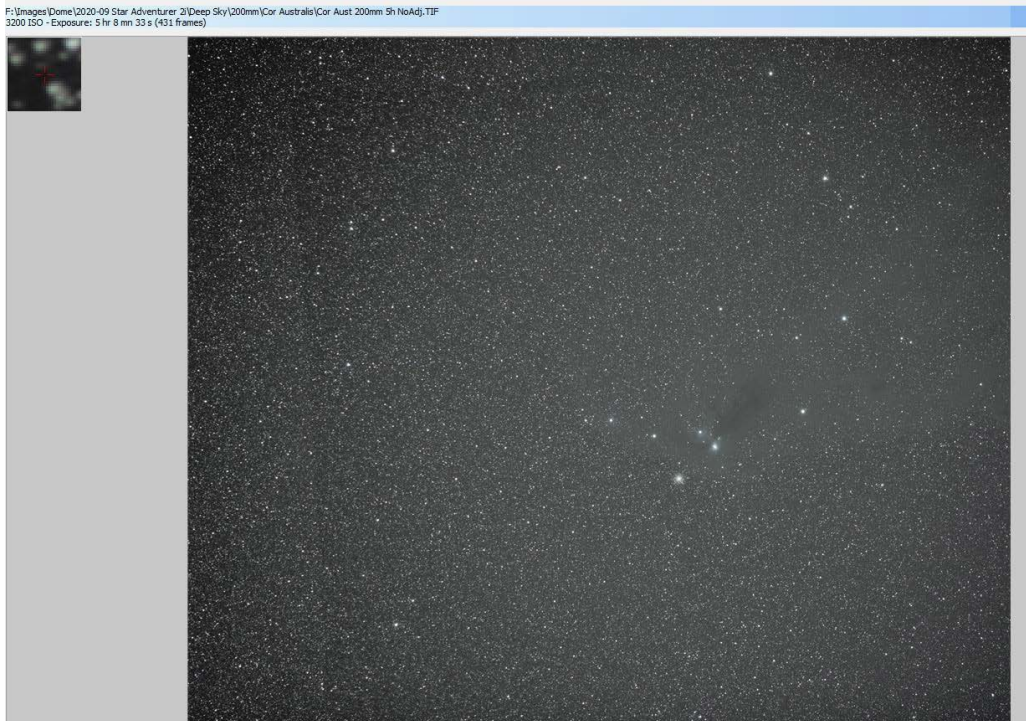


Step 5: Register Checked Pictures

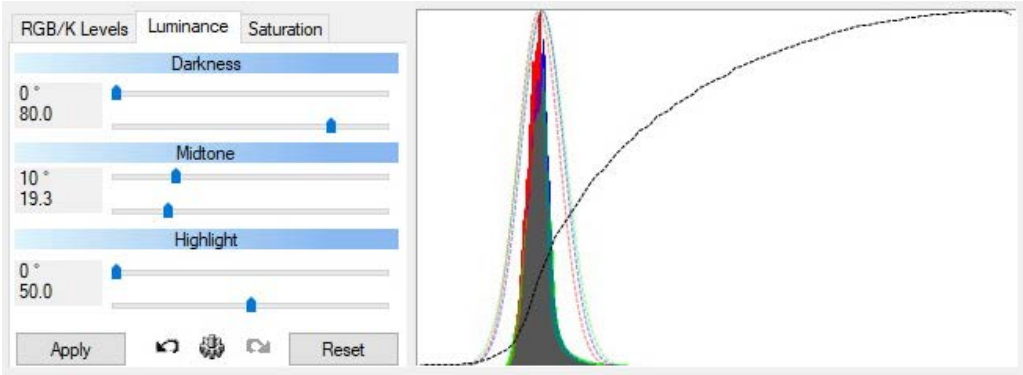
On the Register Pictures dialog box shown in Step 2, click OK. Depending on the number of files, this process may take quite some time for Deep Sky Stacker to calibrate, register and combine all the files.

Step 6: Stretch and Adjust the Combined Image

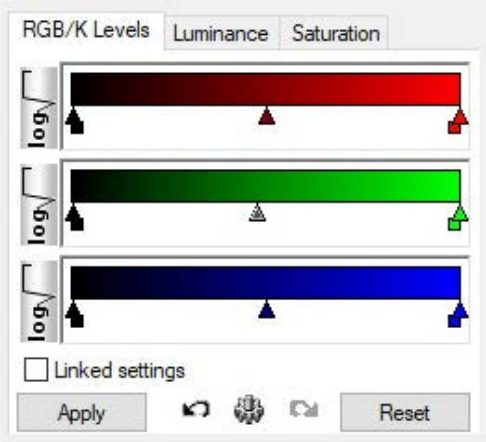
Once the calibrated, registered and combined image is shown on screen, it is likely to have very low contrast and may also be quite dark. A histogram for the image and some basic options to adjust it are shown below the image.



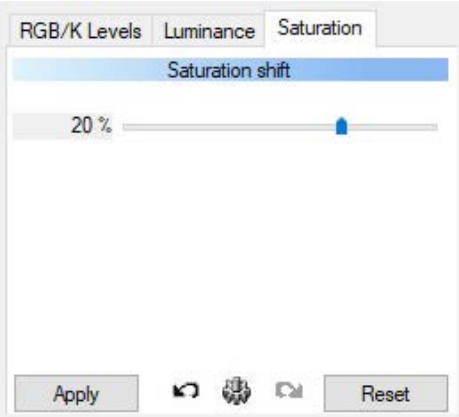
1. On the Luminance tab, use the mid-tone sliders to place the steep part of the brightness adjustment curve near where the RGB histograms peak.



2. Use the mid-tone sliders for each channel under the RGB tab to shift the individual channel histograms so that they are roughly lined up, reducing any overall colour cast to the image.



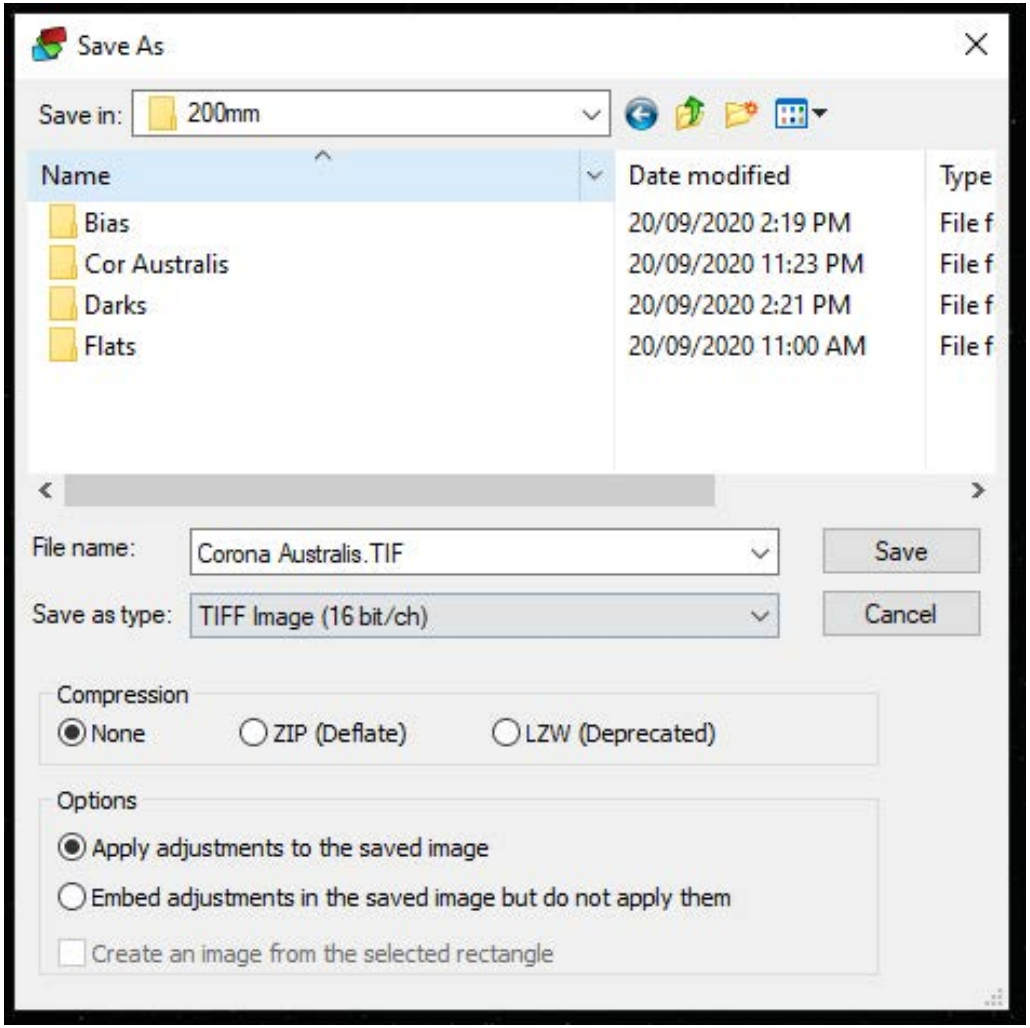
3. Boost the saturation on the third tab.

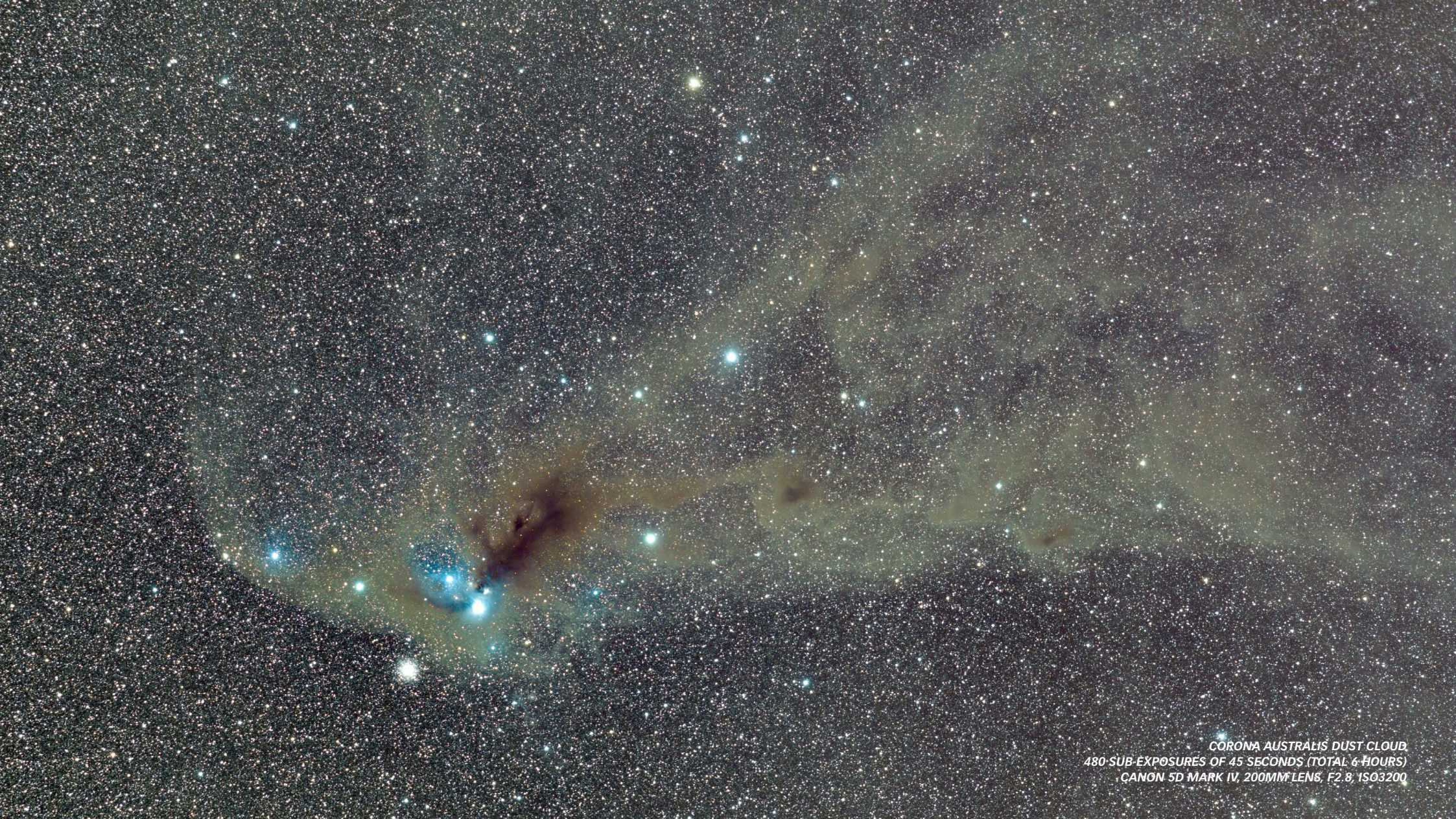


Step 7: Save Image

Save the image as a TIFF file with 16 bits per channel, ensuring that the "Apply adjustments" option is selected. Now you can open the file in Lightroom or Photoshop for further and often more aggressive processing using familiar tools. A completed result using Deep Sky Stacker to combine 480 sub-exposures of less than a minute each is shown on the following page. This is a rather faint region of dust in the constellation Corona Australis which has been revealed with clear depth and detail through these astrophotography techniques.

While the calibration, registration and stacking are straightforward and work reliably, the final image processing step can be a little awkward in Deep Sky Stacker. If it works for you then it is a great freeware option to have. If you have trouble producing an acceptable image in Deep Sky Stacker then it may be worth pursuing other options, such as Astro Pixel Processor discussed next.





CORONA AUSTRALIS DUST CLOUD
480 SUB-EXPOSURES OF 45 SECONDS (TOTAL 6 HOURS)
CANON 5D MARK IV, 200MM LENS, F2.8, ISO3200

Image Processing with Astro Pixel Processor

There are many astrophotography image processing applications, used primarily for producing deep sky and planetary images with telescopes of all shapes and sizes. ***Astro Pixel Processor*** (APP) by Dutch astronomer Mabula Haverkamp and Aries Productions is a relatively new application, quite affordable and among the options better suited to beginners working with DSLRs and lenses. A 30-day trial version is available.

Software for astronomy often have unique, even quirky, and sometimes dated looking interfaces and APP is no exception in this regard. But as well as effective calibration and stacking, APP offers highly effective post-processing tools to enhance your images before finishing them off in Photoshop/Lightroom. APP is also effective at combining mosaic images.

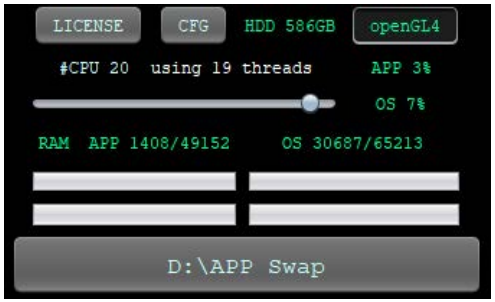
Before you Start

After purchasing and installing APP, click the button to "Set a Working Directory", shown here on the D: drive.

Also click the CFG (configuration) button at the top and increase the amount of memory allocated if possible.

The process of calibrating, registering and combining images is set out in numbered tabs on the left panel in APP and the instructions below use corresponding numbering.

There is a loud 'gong' when each step completes, helpful if you have stepped away from your PC and want to know when a task is complete but can otherwise be distracting.



Step 0: RAW file settings

Set Bayer colour filter array type for your camera. In almost all cases, the automatic "supported" setting should be fine.

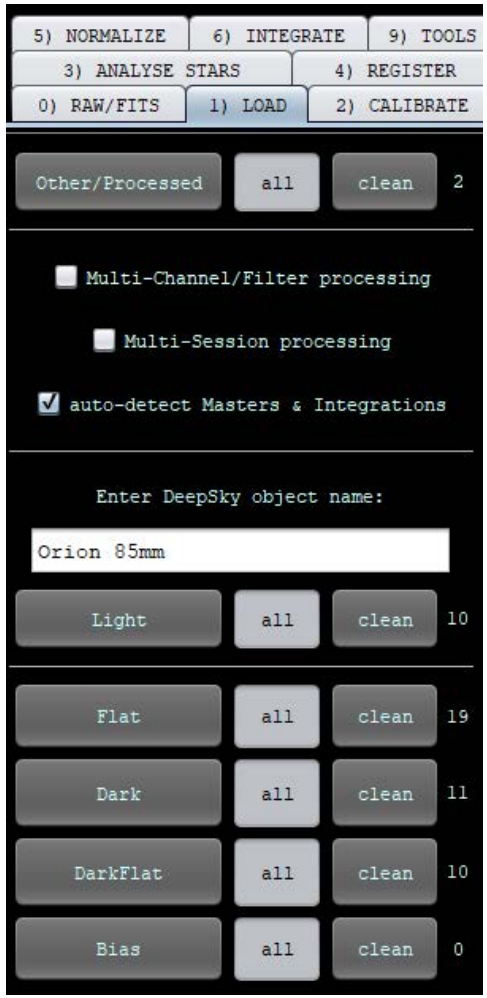
If you have a regular DSLR (unmodified), you can experiment with the Camera White Balance setting enabled.

Step 1: Load Images

Deselect the Channels and Sessions options. These are used for advanced imaging through multiple colour filters over several nights.

Click the Light button to select and load your pictures and the Flat, Dark and Dark Flat buttons to load your calibration frames (if following Calibration Option 1 described earlier).

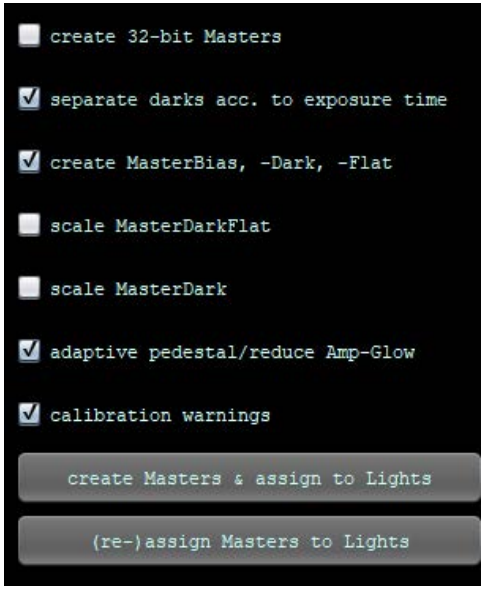
The Master buttons are used if you have in a previous processing session already combined your calibration frames into a master version.



Step 2 – Calibrate

Stick with automatic settings for how to combine each set of calibration frames.

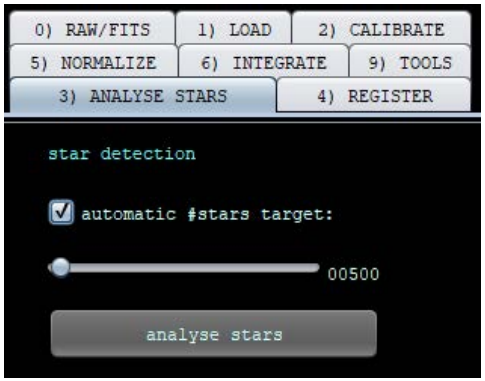
Scroll to the bottom of this panel and click "create Masters and assign to Lights"on.



Step 3: Analyse Stars

Default settings are fine.

Click "analyse stars".

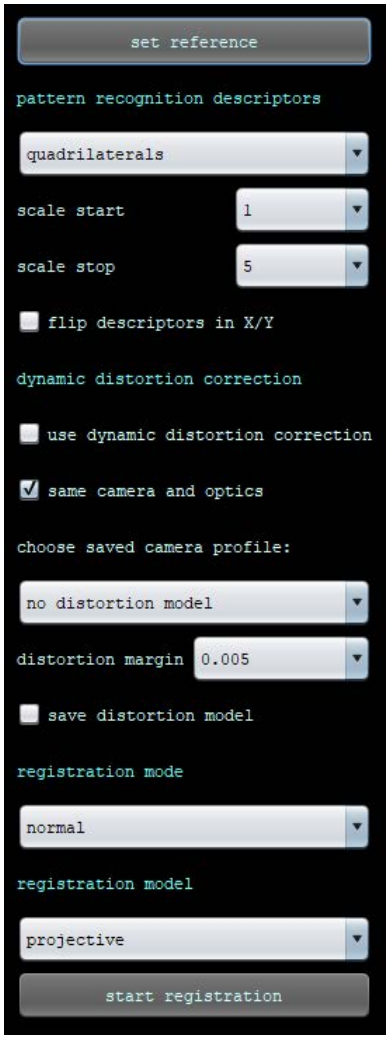


Step 4: Register

You can choose a file to set as the reference for your stack, otherwise the highest quality frame will be chosen automatically.

Change the registration mode from “normal” to “mosaic” if you want to build a mosaic from photos of overlapping regions of the sky.

Click “start registration”.

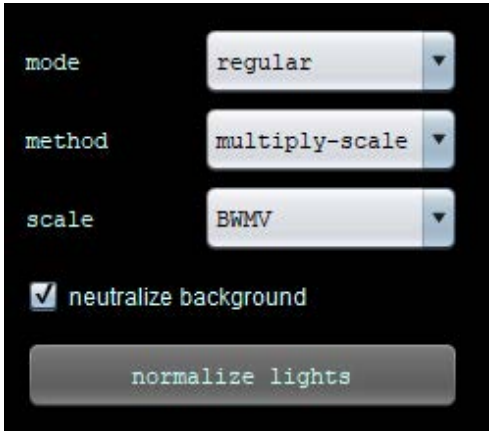


Step 5: Normalise

Default settings are fine.

Click “normalise lights”.

You do not need to “save normalised frames” unless you want a copy of each image after this step.



Step 6: Integrate

Default settings are fine.

Click “integrate”.

Rather than completing all the Steps from 2-6 one after the other, you can just review the settings under each of the tabs and click the "integrate" button and APP will complete all of the processing in one single but time-consuming task.

After Step 6 is complete, the File List at the bottom of the screen will show the new files that have been created in the working directory:

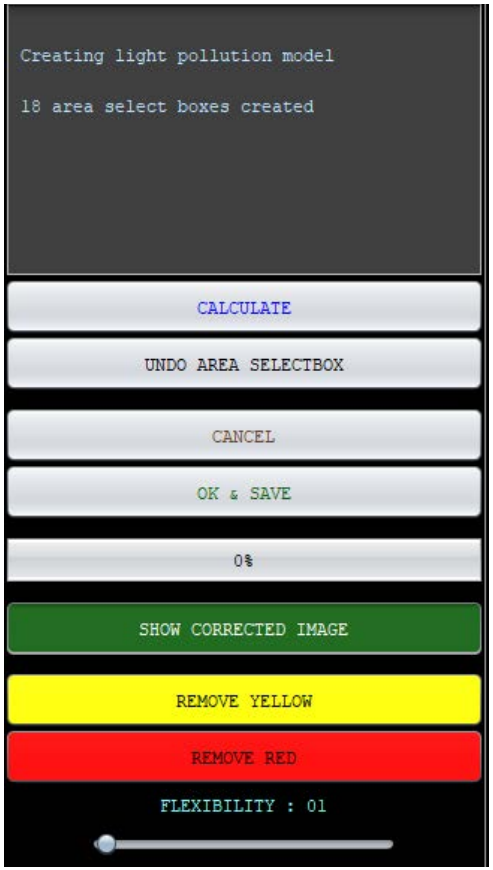
- Master Flat with prefix MF
- Master Dark with prefix MD
- Master Dark Flat with prefix MDF
- A 'Bad Pixel Map' with prefix BPM

The completed integration of all the calibrated and registered images will be at the bottom of the file list and open in the main screen.

Post-Processing Tools

The single most valuable post-processing tool available under the Tools tab is "Remove Light Pollution". Almost all astrophotography images are affected by light pollution or other sources of sky glow and removing these gradients will allow more aggressive processing of your image to reveal the faint details captured.

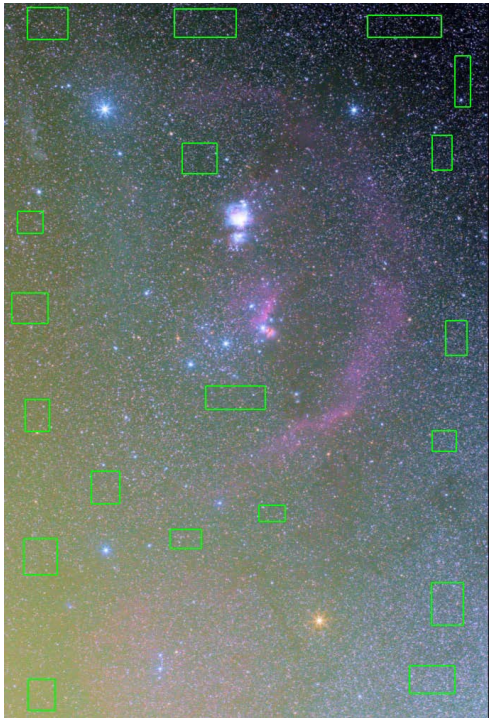
Select this tool and then click and drag the cursor to draw boxes across your image in areas that reflect the background of your image, avoiding areas of nebulosity or other features of the image that should be preserved. Click the "Calculate" button and APP will remove the background determined by the boxes drawn.



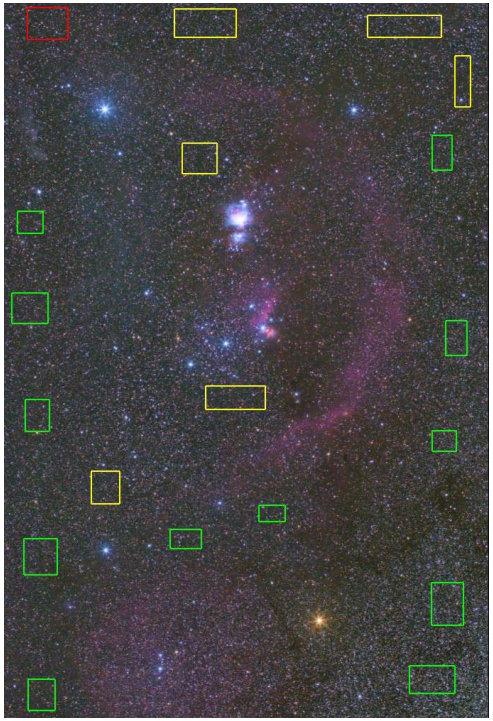
APP will also now change the colour of some of the boxes to yellow or red to indicate that they may contain objects or data of interest but apply your own judgement before changing them. You can click the button to remove the yellow or the red and boxes, or draw more new boxes, and click "Calculate" again.

There is also a button to "Show Corrected Image". The gradient shown should be smooth without any hint of the objects in your image that you want to reveal. Keeping the Flexibility setting low will help ensure this.

Once you are happy with the result, click "OK and Save". A new file will appear in the file list with the suffix LPC (light pollution correction). From the file format options, you will generally want to choose 16-bit TIFF so the file can be opened in Photoshop/ Lightroom rather than FITS which is only recognised by astronomy applications.



ORION IMAGE WITH SAMPLE BOXES DRAWN BEFORE LIGHT POLLUTION GRADIENT REMOVAL



ORION IMAGE AFTER LIGHT POLLUTION REMOVAL WITH COLOURED ASSESSMENT OF SAMPLE BOXES

Other post-processing tools included in APP are:

1. Batch Modify: Basic image adjustment tools including crop.
2. Batch Rotate/Resize: Other image geometry functions.
3. Correct Vignetting: If your Flat Frames did not correctly calibrate vignetting, this tool may be able improve it.
4. Remove Light Pollution: The most valuable APP tool as described above.
5. Calibrate Background: Adjusts colour balance of image background.
6. Calibrate Star Colors: Adjusts colour balance of stars.
7. Combine RGB: Advanced image processing when shooting through individual Red, Green, Blue filters.
8. HSL Selective Colour: Hue, Saturation and Luminosity adjustments.

Numbers 1, 2 and 8 above are easier to perform in Photoshop/Lightroom, while numbers 3 and 7 should not be required.

Remove Light Pollution (4) is the powerful technique described above and will in many cases make a substantial improvement to your image. APP implements this process very effectively and this tool alone is worth the effort to learn how to use APP before final processing in Photoshop/Lightroom.

Calibrate Background (5) is applied in much the same way as Remove Light Pollution, although the Calibrate Background step is effectively included when removing light pollution gradients.

Stars captured with DSLRs and lenses often have coloured halos or fringes around the stars due to aberrations in the lens or the micro-lenses above each pixel on the sensor. These halos will confuse the Calibrate Star Colors algorithm, so this tool is best avoided for wide-field images. Refer to Page 87 for Lightroom de-fringing adjustments to apply to remove these halos, which will improve the overall appearance of the image.

Stretching and Saving Images

The right side of the screen in APP is a panel of settings that affect how the linear data in the image is 'stretched' or 'developed' for display on screen.

The settings here are not very intuitive but clicking the red 'question mark' button will display a detailed on-screen explanation. Note that the labels are shown below their corresponding slider. The numbered boxes beside each slider adjust the sensitivity of the slider.

Below the histogram is the option to "save" your image. Be sure to tick the "stretch" box to save the stretched image as shown rather than the underlying linear data only.

There is an option to neutralize the background but it is better to achieve this with the Light Pollution Removal and Calibrate Background tools earlier.

Below that are settings for the black (B) and white (W) clipping points and gamma (G). The auto settings for black should be fine but leave white and gamma at 1.0 (no clipping).

Tick the option for "DDP" (Digital Development and Processing stretch) to be applied and enable the "auto" settings. Enable saturation sliders by ticking that box also.

Parameters for the DDP stretch are a combination of strength (ST), base (BA) and black point (B) above.

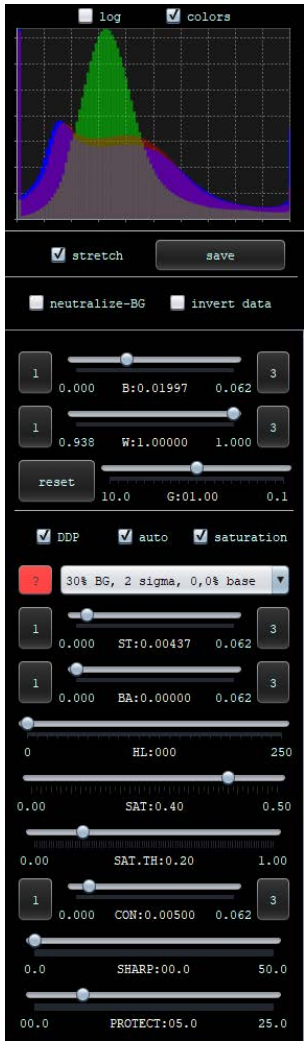
Next to the red question mark is a drop-down box with several pre-sets for the strength of the digital development stretch – selecting one of these will automatically calculate the strength, base and black point settings for your image. Note that decimals for the base setting are indicated with a comma (European notation).

- 10% BG, 5 sigma, 2.5% base is a mild stretch
- 30% BG, 3 sigma, 0.0% base is an aggressive stretch

Increasing the HL slider protects highlights from being clipped due to the stretch.

Increase saturation with the SAT slider. Increasing the saturation threshold SAT.TH slider restricts the saturation boost to only the bright parts of the image.

Contrast can be strengthened with the CON slider and sharpness with the SHARP slider. The PROTECT slider prevents the sharpening from introducing artefacts around the stars.



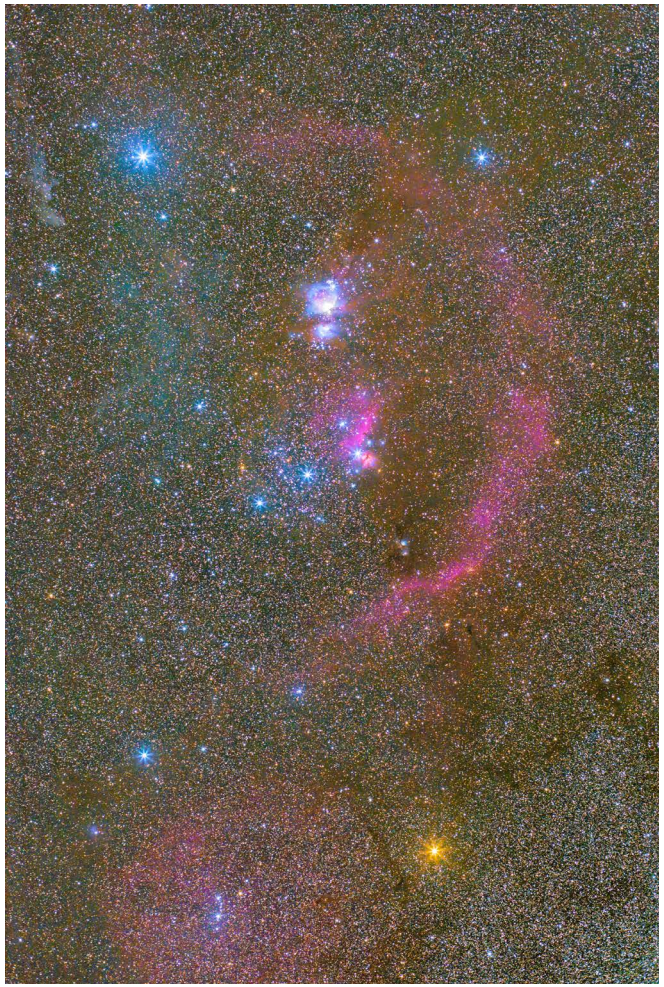
The Final Image

Here is a comparison of a single six-minute image with a Canon 6D and a stack of ten images calibrated, combined and processed with Astro Pixel Processor. The famous extended nebula of the Orion region are clearly revealed in impressive colour, contrast and detail for a standard (unmodified) DSLR.

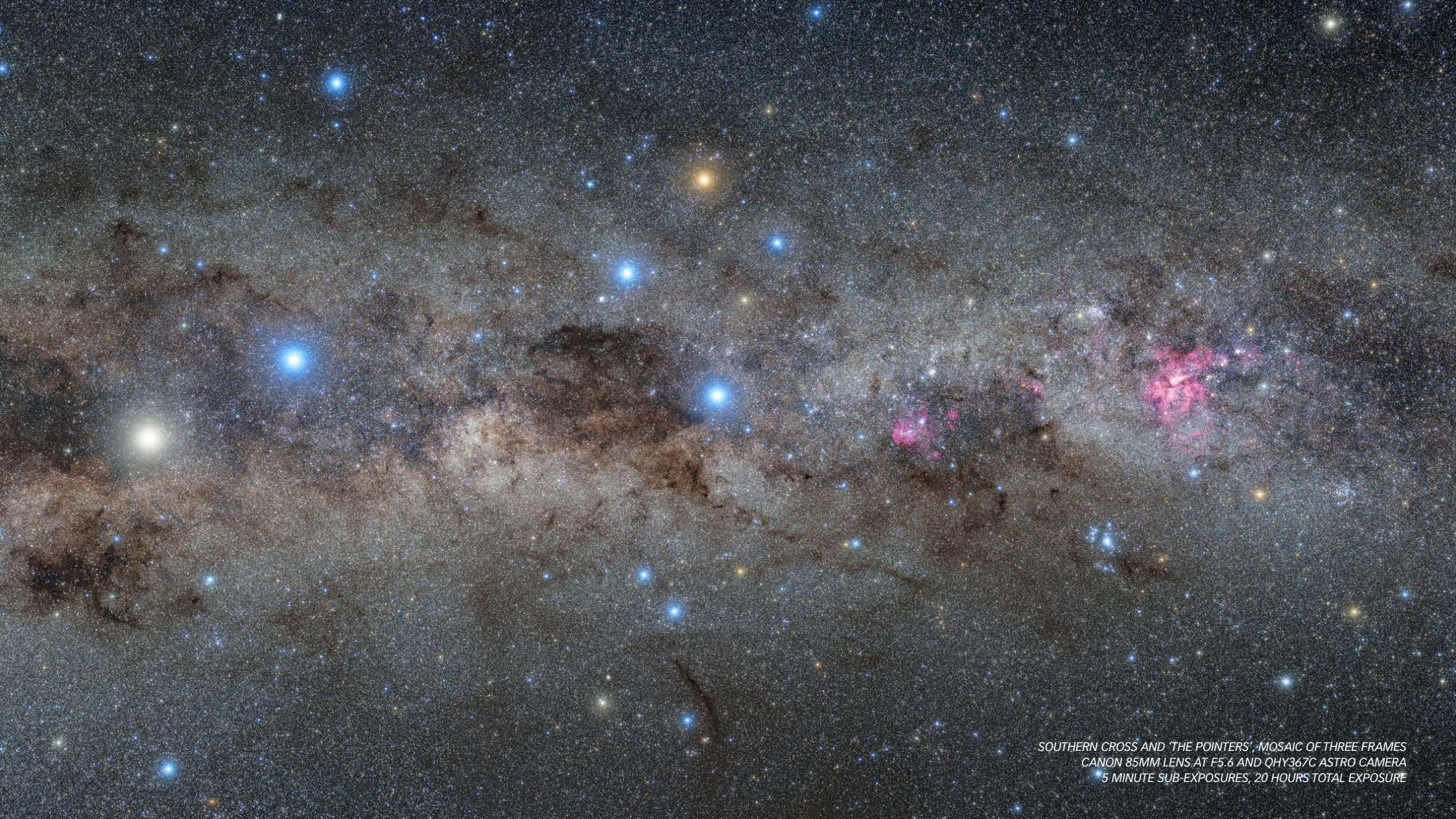
Using the Track and Stack approach to capture hours of exposure, combined with the power of software such as Astro Pixel Processor yields dramatic results. The tools in your hands now are capable of amazing astronomy images.

Clear skies and enjoy your imaging and editing!

SINGLE IMAGE OF ORION
CANON 6D WITH 85MM LENS, 6 MINUTES, F4, ISO800



STACK OF 10 IMAGES COMBINED AND PROCESSED IN ASTRO PIXEL PROCESSOR
TOTAL EXPOSURE 1 HOUR



SOUTHERN CROSS AND 'THE POINTERS', MOSAIC OF THREE FRAMES
CANON 85MM LENS AT F5.6 AND QHY367C ASTRO CAMERA
5 MINUTE SUB-EXPOSURES, 20 HOURS TOTAL EXPOSURE

Learn more

Once you are familiar with the settings for night sky photography and are comfortable working with your camera in the dark, you will be ready and able to capture whatever happens in the sky at night. It's a great skill to learn and allows you to take images of much more than just what the eye can see.

Below are some ways you can keep learning more about photographing the sky at night and places to share your images with others who have a passion for 'Shooting Stars'.

Night Sky Photography Newsletter

philhart.com/newsletter

This short occasional update provides a brief description of 'what's up' in the night sky for the month ahead, particularly noting astronomical events that are easy to photograph with the equipment and techniques described in this book.

Be social

Facebook Page

Follow the Night Sky Photography Page on Facebook where my colleague Neil Creek and I post tips and tricks, notes about upcoming night sky events and our own photos.You can share your own images and ask for advice as well. **facebook.com/nightskyphotography**

Sharing the Love

Email a Friend

If this book has helped you photograph the moon and stars, I'd love if you could tell a friend about it too by sending them this link: **philhart.com/shooting-stars**

Find an Astronomical Society near you

If you find yourself falling in love with the night sky and want to learn more about it, including the use of telescopes for visual observing and 'astrophotography', search for an astronomical society in your home city or state. Most places have one and you'll find like-minded people ready to share their love and experience of the night sky.

Contact Phil

You can contact me via my website **www.philhart.com/contact** or email **hello@philhart.com**.