The Share Astronomy Guide to Observatory Site Selection

By

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Observatory Site Selection

Introduction

The year 2018 *may* be very big for astronomy...literally. The Thirty Meter Telescope, the Giant Magellan Telescope (24 meter) and the European Extremely Large Telescope (42 meter) are all scheduled for completion in 2018 (assuming funding is approved). Various cost estimates for these telescopes range from 987M to 1.3B USD.

If you're going to build an observatory that costs that much, it's extremely important to ensure it's built in the best possible location. Site selection for all of these telescopes involved in-depth investigation and years of evaluation and study. Interestingly, each of these telescopes will be built in a different place. The Thirty Meter Telescope will be built on Mauna Kea, Hawaii in the U.S. The Giant Magellan Telescope will be built at the Las Campanas Observatory about 115 km from La Serena, Chile. The European Extremely Large Telescope will be located on Cerro Armazones near Paranal in Chile.

Obviously, site selection for an amateur observatory is much simpler than it is for a professional observatory. However, in both cases, before you start construction you must choose a site. For some amateurs, this may be as simple as picking a spot in your backyard (or garden) that's as far as possible from your neighbor's trees, but for others, there's a more complex choice involved. In either case, the site you choose will affect the quality and quantity of viewing, imaging, and science that can be performed.

This article provides some key evaluation criteria and guidelines for choosing an observatory site that addresses your needs and requirements.

This article is aimed at amateurs, not professionals…but how do you define an "amateur" in 2010? Many of today's amateurs use complex equipment, produce stunning images that would have rivaled those from professional observatories not so many years ago, and assist professional astronomers in "real" science in areas like photometry, spectroscopy, and astrometry.

The increased sophistication of today's amateurs has resulted in the desire to build observatories in optimal locations that advance the astronomer's goals. In fact, more and more astronomers are willing to locate their observatories hundreds or even thousands of miles from home and operate their equipment remotely.

Amateurs who choose to build a local observatory may still have numerous options to consider when evaluating potential sites. For example, astronomers living in San Diego County, California, can build on the coast (at sea level), in the mountains (potentially over 6,000 feet) or in the desert and still remain in the county. San Diego County residents can even build observatories in a different country—Mexico—and still be within a few hours of home.

Regardless of how far you're willing to travel, choosing the best possible site for your observatory will result in more viewing nights, increased productivity, better images, better science and more fun. How do we evaluate potential sites? We review 11 key factors.

Key Evaluation Criteria

The 11 primary factors to examine and evaluate when considering potential sites for an observatory are:

- Northern Hemisphere versus Southern Hemisphere
- Percentage of clear nights
- Darkness of the sky
- Astronomical seeing
- Sky transparency
- Weather conditions
- Legal/environmental restrictions and requirements
- Proximity to other astronomers
- Access to infrastructure
- Cost
- Future risk factors

Northern Hemisphere versus Southern Hemisphere

For many people, this will be the easiest factor to evaluate. After all, how many amateurs seriously consider locating their observatory in the opposite hemisphere from where they live? The answer is probably not a lot, but there may be more amateur astronomers doing this than you think. As we pointed out above, amateurs are more sophisticated than they used to be. In addition, increasing numbers of people have vacation homes in far away places.

Basically, this decision boils down to what objects you want to observe or study and how much money you have. It's really a personal decision, but one you should carefully consider.

Percentage of Clear Nights

For astronomers—amateur or professional—the percentage of photometric nights is a key factor when deciding where to build an observatory. (Photometric nights are often defined as completely cloud-free, but they're sometimes defined as nights with six or more photometric hours.) The number of usable nights is also an important measurement. (Usable nights are nights with partial cloud cover but some observing is still possible.)

The best way to evaluate the percentage of clear nights at a site is to examine historical weather reports. This can be a tricky process and you shouldn't rely on quantitative data for short periods like three or four years. It's best to look for averages over longer periods of time.

One potential good source of information for people in the U.S. is the NOAA Regional Climate Centers page, which you can access directly at http://www.ncdc.noaa.gov/oa/climate/regionalclimatecenters.html or by clicking on the Regional Climate Centers link on the left side of the National Climate Data Center (NCDC) home page (http://www.ncdc.noaa.gov/oa/ncdc.html). Click on a region on the map and then look for links like "Historical Climate Information" or "Historical Climate Data Summaries," or simply "Climate Data."

Unfortunately, each region has a different look and feel to its web page. On the positive side, there's a lot of detailed data available. The information in this area is free, but some information on the NCDC web site must be purchased.

Another source of valuable information for people in the U.S. and North America is the California Regional Weather Server web site (http://squall.sfsu.edu/), which has satellite images for the Eastern Pacific and North America and weather radar maps for the U.S. It has archived satellite images going back to 2008.

If you live in a rural area of the U.S., you may be able to get historical weather information from local university-run agricultural research facilities.

Astronomers evaluating sites outside the U.S. have a couple options. First, you should try searching for official government web sites for the country in question. Some countries have a large amount of information available. Second, you can access individual country information from the World Meteorological Organization web page (http://www.wmo.int/pages/members/index_en.html).

Regardless of the country you're considering, anecdotal information from people who live or work in the area you're evaluating can be very valuable. For example, people who live in the coastal areas of Southern California often refer to "May grey" and "June gloom"…a strong indication that May and June probably have few photometric nights. Amateur astronomers will probably provide reliable information. Try contacting the local astronomy association or club. Astronomers are always happy to assist their peers.

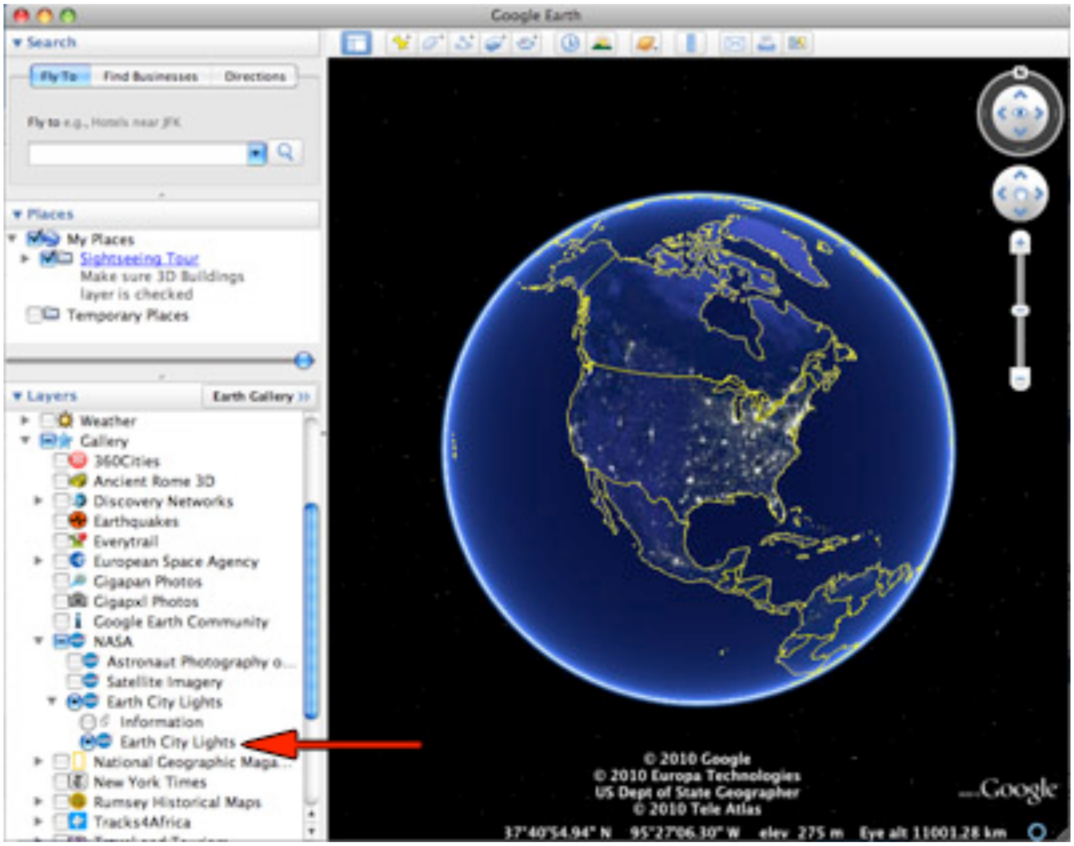
Darkness of the Sky

Astronomers love clear *dark* skies. The negative consequences of light pollution for astronomy have been well documented over the years.

You can get some idea of the brightness at a site under consideration by reviewing satellite images for the area in question. One source of data is The Light Pollution Science and Technology Institute (ISTIL - Istituto di Scienza e Tecnologia dell'Inquinamento Luminoso), a non-profit Italian organization. You can find a large map showing artificial night sky brightness for the entire world or maps for individual regions of the world on its web site (http://www.lightpollution.it/worldatlas/pages/fig1.htm). These maps are color-coded using the Bortle Dark-Sky Scale. (We'll talk more about the Bortle Dark-Sky Scale below.)

The ISTIL maps are useful if you just want to get an approximation of the situation at the site you're considering. However, it can be very difficult to find an exact location on these maps. It is possible to overlay Google Earth with the maps from the ISTIL, but this procedure is beyond the scope of this article. If you're interested in this procedure, you can do a Google keyword search for "Google Earth dark sky" and you should get some useful results.

An easier alternative is to start Google Earth (downloadable at http://www.google.com/earth/index.html) and then follow the Layers > Gallery > Nasa > Earth City Lights menu items and choose the "Earth City Lights" radio button. (Please see the screen capture below.) This will overlay a "city lights" map on your Google Earth map. It won't be as detailed as the ISTIL maps, but it's easier to pinpoint a specific location.



The ISTIL maps are a good source of information, but a better choice would be to estimate the darkness of the sky in person at the candidate site. The Bortle Dark-Sky Scale is a good tool to use when estimating sky darkness. John E. Bortle first proposed it in a February 2001 article in Sky and Telescope magazine. You can find the article in PDF format at http://media.skyandtelescope.com/documents/BortleDarkSkyScale.pdf.

The Bortle Dark-Sky Scale is used to rate a location on a numeric scale ranging from Class 1 (excellent dark-sky site) to Class 9 (inner-city sky). The article referenced above provides detailed guidance on how to rate a location and can be used to compare candidate observatory locations with each other. The classes and titles are listed below along with the color-coding commonly associated with the Bortle Dark-Sky Scale and used on many maps:

- Class 1 - excellent dark-sky site - black
- Class 2 - typical truly dark site - gray
- Class 3 - rural sky - blue
- Class 4 - rural/suburban transition - green and yellow
- Class 5 - suburban sky - orange
- Class 6 - bright suburban sky - red
- Class 7 - suburban/urban transition - red
- Class 8 - city sky - white
- Class 9 - inner-city sky - white

The best way to assess the impact of light pollution is to actually *measure* the sky brightness from the ground at a candidate site. One method of measuring sky brightness is to use a Sky Quality Meter (SQM) from Unihedron (http://www.unihedron.com/). These instruments range in price from about 120 to 250 USD, depending on functionality, and they measure the brightness of the sky in magnitudes per arcsecond. Unihedron makes some units that are handheld and others that are connected to a computer and provide the ability to perform continual measurements throughout the night or compare measurements year-over-year, day-to-day, etc.

In our opinion, you should not rely *solely* on the SQMs described above to evaluate sky brightness at a particular site. We believe SQMs *may* be fooled by a relatively dark location and really dirty, dusty, pollen-filled skies. If the transparency is bad, the SQM may say the skies are really dark because less starlight can get through. On the other hand, if the transparency is really great, you can see your shadow from the light of the Milky Way and the SQM may say the sky is brighter than it is. If you do use one, your best bet is to point the instrument straight up and use one of the SQMs that allow you to log data to a computer, so you can take measurements over an extended period of time.

When looking for a nice dark sky site, keep in mind that some communities, like Flagstaff, Arizona, U.S.; Borrego Springs, California, U.S.; Cloudcroft, New Mexico, U.S.; and Coonabarabran, NSW, Australia, have strict light pollution regulations. (Flagstaff was designated the world's first "International Dark-Sky Community" by the International Dark-Sky Association in 2001. Borrego Springs is the second and only other International Dark-Sky Community at this time.) Some U.S. states, like Arizona, Connecticut, Maine, Texas and New Mexico, have laws regulating light pollution. In 2007, Slovenia became the first country to pass a *national* law aimed at reducing light pollution. (The Czech Republic passed a law earlier—in 2002—but it didn't contain any enforcement mechanisms; it was a declaration only.)

Astronomical Seeing

Astronomical seeing—or just seeing—is a term that describes atmospheric turbulence. A highly turbulent atmosphere can cause astronomical objects to be blurred or "wavy," like the view you'd have of the bottom of a clear lake on a windy day. Atmospheric stability results in the best seeing.

When considering candidate observatory sites, astronomical seeing is one of the most important factors to consider. Seeing is a complex topic and it's important to keep the following points in mind:

1. Seeing conditions are determined by wind patterns in the atmosphere as well as the impact of different temperature layers in the atmosphere.
2. Wind can vary by season.
3. Wind can vary by time of day. (You only need to worry about nighttime unless you're doing solar observing.)
4. Wind at all altitudes affects seeing; you can't just consider the conditions where you're standing. You also have to consider the conditions at 9,000m (~30,000 ft.) as well as altitudes in between.

It's useful to divide the atmosphere into three "layers" when evaluating the seeing situation at a candidate site:

1. The first 100m (~330 ft.)
2. The zone between 100m (~330 ft.) and the 300mb level (300 millibars)
3. The 300mb level—the jet stream level (~9,000m or ~30,000 ft.)

(It's interesting to note that all three of these layers fall in the troposphere. The word troposphere was derived from the Greek word tropos, meaning "to turn" or "turning," which pretty much summarizes the turbulent nature of this part of our atmosphere.)

Let's take a look at each of these "layers" and see what part each plays with regard to astronomical seeing.

The first layer starts at your feet and ascends up to around 100m (~330 ft.). The primary problem here is convection currents, which are caused when air near the ground heats up, causing it to rise. The rising air causes turbulence and has a negative impact on seeing conditions. Obviously, locating your observatory in the middle of an asphalt parking lot would be a recipe for disaster. Ideally, you'd want to locate your observatory away from materials that will store heat during the day and then radiate it away at night. Gravel or dirt roads are better than asphalt roads, for example. Grassy fields are better than highways. You get the picture.

Evaluating the wind patterns in the mid layer between 100m (~330 ft.) and the 300mb level (~9,000m or ~30,000 ft.) requires knowledge of meteorology and a careful evaluation of historical weather patterns and the local terrain. Any location on earth can experience extreme weather systems that can dramatically impact seeing conditions at any point in time. What's important, in the context of this article, is that you gain an understanding of the "normal" conditions at the site you're evaluating.

Let's look at an example. Let's say you're considering an observatory site located on the leeward (i.e., downwind) side of a mountain range. One thing you should investigate is the possibility of mountain waves, which are standing atmospheric waves that are formed when wind blows over a mountain range. Mountain waves can form over a mountain or on its leeward side. At the point where lee waves come in contact with normal air, an area of extreme turbulence (called a rotor) can form. Locating your observatory directly under or downwind from a rotor would not be a good idea. If there's enough moisture in the air to form clouds, you may be able to recognize areas with mountain waves and rotors by looking at them. Mountain waves will often result in lenticular clouds (clouds in the shape of a lens) above the wave crests and rotors will often generate cumulus clouds.

So, where should you put your observatory? If you want to stay in the same geographic area described above, a good choice may be to relocate to the top of the mountain facing the prevailing winds. This is especially true if the wind has crossed a large area of flat land or ocean, since that condition will provide a smooth laminar airflow and excellent astronomical seeing. (A laminar flow, in which air flows in a regular path, is the opposite of a turbulent flow.)

Finally, we need to consider our upper layer (the 300mb level). Depending on the location of a candidate observatory site, one potential way of evaluating air turbulence in the upper layer (~9,000m or ~30,000 ft.) is to spend some time doing jet stream analysis. (Jet streams are areas of fast moving air currents that can be 1,000 - 3,000 miles long and 1 -3 miles thick.) A very helpful tool in this endeavor is the Jet Stream Analyses and Forecasts portion of the California Regional Weather Server (http://squall.sfsu.edu/crws/jetstream.html). This web page has links to jet stream analysis maps for the Northern Hemisphere and Southern Hemisphere and more detailed maps for the Eastern Pacific and Western North America, North America, and the North Atlantic. Archived maps are available going back to 2006. As we mentioned above, wind can vary by season and time of day. Fortunately, the archived maps on this site were produced several times a day and cover all seasons. There are many other sites that provide weather forecast information and jet stream forecasts, but many look forward in time and don't really provide the historical data that's necessary when evaluating observatory site locations.

Careful analysis of past weather and wind patterns will be required to make an informed decision regarding the suitability of a potential site for an observatory. However, you're also going to want to visit candidate sites and make your own assessment of the seeing conditions.

Amateur astronomers can assess seeing conditions at candidate observatory sites in at least three ways. One approach is to use the 10-point Pickering Scale developed by William H. Pickering (1858 - 1938) of Harvard University. A value ranging from P1 (very poor) to P10 (excellent) is assigned to the seeing conditions at a given point in time. The value is determined by observing a star at high magnification in a telescope. Under perfect seeing conditions, the star will look like a bull's eye with a central light disc surrounded by one or more concentric circles. Under the worst seeing conditions, the star will look like a blob. An excellent resource to help you understand the Pickering Scale can be found on Damian Peach's Courses in Astrophotography web site (http://www.damianpeach.com/pickering.htm). The referenced page has a very nice set of animations that clearly illustrate each of the steps on the Pickering Scale.

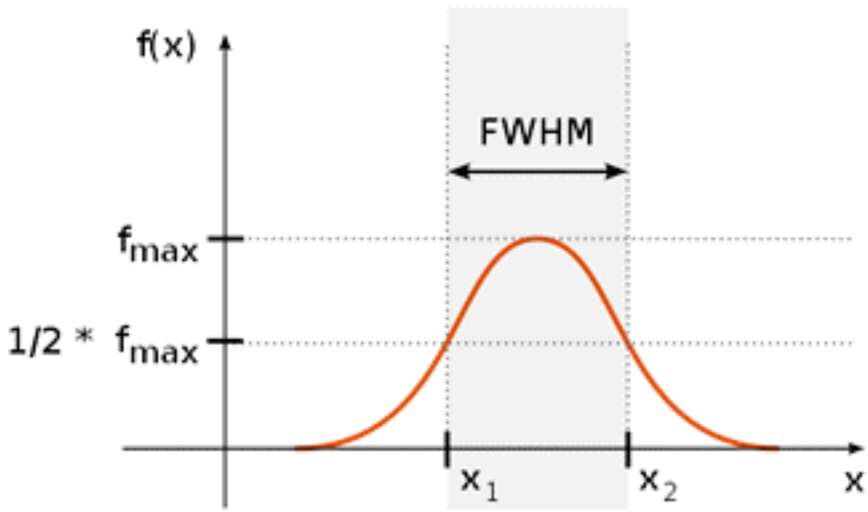
Since the Pickering Scale provides a subjective evaluation—not a true measurement—it's less valuable than some of the other techniques for assessing astronomical seeing, in our opinion. The eye/brain system can be fooled very easily. All too often, we see what we want to see, rather than reality. Optical illusions are a good example of this phenomenon, proving that subjective evaluation can be nothing more than a "guesstimate."

By the way, while Pickering did make some valuable contributions to astronomy, he also claimed to have discovered vegetation on the Moon, two crops a day. We think this just proves the point that no one's perfect. You can find an article from the New York Times detailing Pickering's "discovery" by choosing the "NYT Archive 1851-1980" dropdown on the New York Times Search Page and searching for "William H Pickering." (The article was published on October 9, 1921.)

A second approach for assessing astronomical seeing is to measure the diameter of something called "the seeing disc" in arcseconds. Wikipedia defines "seeing disc" as "the point spread function for imaging through the atmosphere." Some of you may be wondering, "What the heck is a point spread function"? Good question. If you took an image of a star with a telescope located in space (i.e., above our atmosphere) and that telescope had perfect optics, you'd end up with an image of a point of light identical to the star's point of light (leaving aside camera "issues"). If you could take an image of a star with an optically perfect telescope located on earth, you would *not* end up with an image of a point of light identical to the star's point of light, because the earth's atmosphere would distort the image. You'd end up with an irregular disc of light, not a point of light. The disc would be brighter in the center and unevenly dimmer on the edges. Basically, the point spread function is the irregular disc of light.

The size of the seeing disc provides a measurement of astronomical seeing. The smaller the seeing disc, the better the seeing. The larger the seeing disc, the worse the seeing. As we said before, the seeing disc is measured in arcseconds. The best seeing conditions on earth (typically where you'll find the biggest professional telescopes) will yield a seeing disc diameter of about 0.4 arcseconds.

Measuring the width of the seeing disc is tricky because it doesn't have sharp edges; the light is bright in the center and then dims unevenly on the edges. To solve this problem, the width of the seeing disc is measured using a technique called Full-Width Half-Maximum or FWHM. FWHM is useful for measuring the diameter of an object that doesn't have sharp edges, like our seeing disc. In this case, the diameter of the seeing disc is equal to the width at the points where the light drops to half its maximum value. The curve below illustrates FWHM:



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Some of the software used by amateurs to determine FWHM is actually pretty sophisticated. For example, it's our understanding that at least one product will compute FWHM around the circumference of a star in multiple steps and then pick the median value. (We haven't been able to verify this.) Be sure to measure the size of the seeing disc for multiple stars in an image and then use the mean value to obtain an accurate assessment for current seeing conditions.

Finally, amateurs can also use differential image motion monitors (DIMMs) to measure astronomical seeing. DIMMs are instruments that have two sub-apertures positioned in front of a CCD or webcam. If seeing conditions were perfect (i.e., there was no atmospheric turbulence or distortion), you'd have two identical images of a given star. However, when there's turbulence in the atmosphere, the light arriving at one aperture will differ slightly in direction from the light arriving at the other aperture. This will cause the two image spots on the camera chip to shift with regard to each other. The coordinates of each image spot can be determined and the differences can be used to compute the current seeing value.

Differential image motion monitors are commonly used at professional observatories. However, at least one company—Alcor System (http://www.alcor-system.com/us/index.html)—markets DIMM software at a price within reach of amateurs (150 Euros). In addition to the software, you'll need a two-hole mask (which you may be able to make yourself), a telescope and a camera (which can be a webcam). There's a lot of valuable information on the Alcor System web site if you're interested in this technology.

Sky Transparency

Sky transparency—or just transparency—provides an assessment of how clear the sky is. If the sky is clear, you'll be able to see fainter stars (and other objects) than if the sky is less clear.

The scattering of light in the atmosphere causes poor transparency. Air molecules scatter some light, but the real culprit is the presence of aerosols in the atmosphere. Aerosols are small, solid particles or liquid droplets suspended in the air. Examples of aerosols include smoke, dust, pollen, industrial pollution, smog and most importantly, precipitable water vapor (PWV). The more aerosols present in the atmosphere, the more light is scattered. More scattered light means less transparency.

Sky transparency is also affected negatively by sky brightness. Light pollution reduces transparency and makes it difficult or impossible to see dim objects.

As part of your site selection activities, be sure to evaluate the proximity of industrial plants, dusty areas (like some desert regions), major airports (jet exhaust), etc. Any source of aerosols that can reach the atmosphere should be avoided.

Generally speaking, altitude is your friend when considering candidate observatory sites. At higher altitudes, you may be above many of the aerosols that cause poor transparency.

If you're interested in researching aerosols in the atmosphere and their impact on your candidate observing sites, there's a web site you should know about: the MACC Project (http://www.gmes-atmosphere.eu/). MACC, which stands for "Monitoring Atmospheric Composition and Climate," is funded by the European Union. You can find maps of the world or Europe that show:

- Forecast of Aerosols Optical Depth - Natural (sea-salt and dust)
- Forecast of Aerosols Optical Depth - Anthropogenic (generated as a result of human activity: organic, black carbon and sulphate)
- Forecast of Aerosols Optical Depth - Total
- Observed Daily Fire Activity
- And a lot more

You can get to a lot of this information by clicking on the Services menu tab and then selecting the "Global Atmospheric Composition" image. Most of the information on the MACC site is forecast information, but in some cases you can get data from any day within the past year.

Sky transparency at a candidate site can be measured by determining the magnitude of the faintest star visible to the unaided eye. The best approach is to go to each candidate site and select a constellation that has stars of varying magnitudes. Find as many stars as you can in the constellation you've selected. The sky's transparency will equal the faintest star you can see. Good candidate constellations include Ursa Minor, Corona Borealis, Orion, and Pegasus, depending on your location and the season.

This would probably be a good place to mention Clear Sky Charts (http://cleardarksky.com/csk/), which are graphical forecasts of the cloud cover, transparency, seeing, wind, humidity and temperature for a specified site. Clear Sky Charts exist for thousands of sites in Canada, parts of Mexico and the U.S. (Unfortunately, they don't exist for other locations.) The forecast data used to produce these charts comes from the Canadian Meteorological Centre. Please keep in mind that the data represented in a Clear Sky Chart is a *forecast*. Forecast information isn't normally useful when evaluating a potential site for an observatory; we usually prefer historical information for that task. However, if you're undertaking a long-term study of potential sites and don't plan on making a decision for months or years, the Clear Sky Charts could provide you with useful information. Just monitor the charts for candidate sites for an extended period of time and maintain your own historical record of forecast information to evaluate when it's time to make a decision. Finally, you should be aware that, in our experience, forecasts for some areas aren't very accurate due to local microclimate conditions.

Weather Conditions

As we've seen, weather has a big impact on other evaluation criteria like percentage of clear nights, seeing and transparency. However, weather can impact your astronomy activities in other significant ways. For example:

- Windy conditions on the ground may require the dome or the roll-off roof of your observatory to be closed, effectively halting all activity.
- Extremely low temperatures may limit the amount of available imaging or viewing time.
- High temperatures may impact imaging equipment sensitivity and choice. (Very high temperatures could preclude the use of DSLRs, since they normally aren't cooled and high temperatures can lead to increased noise in the CMOS.)
- Humidity causes dewing and can reduce viewing or imaging time.

The weather sites previously mentioned in this article can be used to provide valuable historical information regarding weather patterns and weather-related issues.

Legal/Environmental Restrictions and Requirements

There are three important points that can be made when examining the legal and environmental issues related to a candidate observatory site:

1. This is one of the most important areas you'll investigate. It doesn't matter how good the site is if you won't be allowed to build your observatory.
2. Governmental laws and restrictions vary widely from country to country and, at least in the U.S., from city to city. For example, some zoning laws in the U.S. require that a home exists on a piece of property prior to building an observatory. Some laws require an architect to design the observatory building. Still others restrict the size of an observatory. Public hearings may even be required in some cases.
3. In some countries, like the U.S., additional rules and restrictions may be imposed by your homeowners' association (HOA) or the bylaws in certain types of communities. These restrictions may dictate whether you may or may not build an observatory, what area the observatory can occupy, how high it can be, and even if you're allowed a roll-off roof or a dome.

What should you do? Our best advice is to start investigating the legal and environmental issues early, not late. As soon as you find a candidate site with potential, start your investigation. If you're considering a site in a foreign country, make sure you thoroughly understand that country's laws regarding property ownership by non-citizens.

Proximity to Other Astronomers

Early in your planning process, you should ask yourself if you'd like to be part of an astronomical community or if you'd prefer to be on your own. Communities can be planned or unplanned, formal or informal. Sometimes areas with above-average conditions for astronomy act like magnets and draw astronomers from all over the world. In other cases, land developers have created communities specifically for astronomers.

Astronomical communities can have many advantages:

- You'll be close to people who share your interests and the opportunity exists to make life-long friends.
- You'll probably be able to try out different equipment.
- You'll have access to people who can teach you new things.
- You may have access to shared facilities like machine shops and workshops.
- Knowledgeable help is nearby.

There are some planned astronomy communities in the U.S. that provide many of the advantages of living in proximity to other astronomers. Examples include:

- New Mexico Southern Skies (http://www.nmsouthernskies.com/) next to New Mexico Skies and near Mayhill, New Mexico
- Chiefland Astronomy Village and the surrounding area (http://www.chiefland.com/chieflandastronomyvillage.php) in Florida
- Deerlick Astronomy Village (http://www.deerlickgroup.com/) in Sharon, Georgia
- Arizona Sky Village (http://www.arizonaskyvillage.com/) in Portal, Arizona

We're unaware of similar communities in other countries. If they do exist, we'd be happy to add them to the list above.

One example of an unplanned or informal astronomical community outside the U.S. would be Coonabarabran, NSW, Australia. Coonabarabran is often described as the astronomy capital of Australia, primarily due to its proximity to the Siding Spring Observatory and other professional observatories in the area. Because of the beautiful dark skies, light pollution restrictions and excellent seeing, amateur astronomers have built observatories along the road between the town of Coonabarabran and Siding Spring.

Access to Infrastructure

Once you've decided on a location for your observatory, you're going to have to build it and operate it. It's a smart idea to analyze the infrastructure at the candidate site to determine if the site is appropriate for an observatory. For example, does the site have roads, underground utilities (e.g., electricity and phone service), water, and Internet connectivity? Is healthcare near? Are firefighters close? Do you have ready access to construction materials (e.g., concrete, lumber, etc.)? Is skilled labor available?

It may be technically possible to build and operate an observatory without some or all of the resources listed above, but it probably wouldn't be desirable. We suggest making a list of your own infrastructure "must haves" and evaluating all candidate sites with regard to the items on your list.

Cost

For most people, this is one of the most important factors to consider when evaluating competing sites for an observatory. For some people, this is the single most important consideration. It's also the area where we have the least to say. Bottom line: it's a personal decision and you have to make it based on what you feel you can afford.

Risk Factors

Finally, you should evaluate the impact of future changes on your candidate site. Of course, it's hard predicting the future. However, most people will have their observatory for a considerable amount of time, so it's worth the effort to try and understand how change will impact your investment.

Areas to evaluate include:

- Changing weather patterns. Weather patterns are changing worldwide, but the nature of the changes is often unpredictable. On the other hand, weather is probably the single most important factor affecting the viability of a site for an observatory. What is a poor astronomer supposed to do? Good question. We're afraid we don't have any crystal balls lying about, so we're unsure, too. There are some factors you can predict. For example, if the water for your observatory (and perhaps home) comes from a well, you can determine how long the well water will last at current annual rainfall amounts and how long it will last at half that amount. Will you have enough for 5 years? 15 years? Your expected lifetime?
- The likelihood of a natural disaster. Observatories are often built in rural areas that are often prone to fires…at least in some parts of the world. Forest fires will happen, but they're something you can prepare for. For example, you can make sure you have properly cleared the area around your observatory and do your best to use fire-resistant materials for its construction. You can work with the forest service or firefighting authorities in your area to make sure you have adequate fire access roads and sufficient supplies of dedicated firefighting water on hand. In many parts of the world, earthquakes, tornados and hurricanes are potential threats. You can mitigate the risk from these disasters somewhat by ensuring that your observatory is located in a relatively safe place and is built in compliance with local building codes.
- Light pollution. How long until urban crawl results in significant light pollution at your candidate site? To evaluate this risk factor, you can take a look at the growth patterns of nearby urban areas and make an assessment of the rate and direction of growth. Locating your observatory near national forests or state parks will help mitigate the risk because these areas are typically off limits to development.

Conclusion

Many of today's amateur astronomers bear little resemblance to those of only 20 or 30 years ago. Today's amateurs have access to tremendous amounts of information via the Internet, the ability to communicate instantly with amateurs and professionals all over the world, the use of better telescopes and mounts, and the availability of sophisticated instruments (e.g., cooled CCD cameras, spectrographs, etc.) and software. Amateurs increasingly demand and expect the best; it's little wonder that they're interested in building their own observatories and are willing to go well beyond their backyards in search of the ideal location.

Any observatory will make an amateur astronomer more productive, because more time is spent on observing, imaging or science and less is spent setting up and taking down equipment. A first-class observatory location will not only increase productivity; it will also pay dividends in terms of better images, higher quality science and more fun observing.