

One Good Target

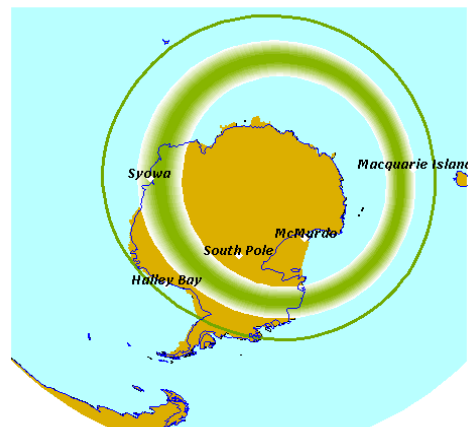
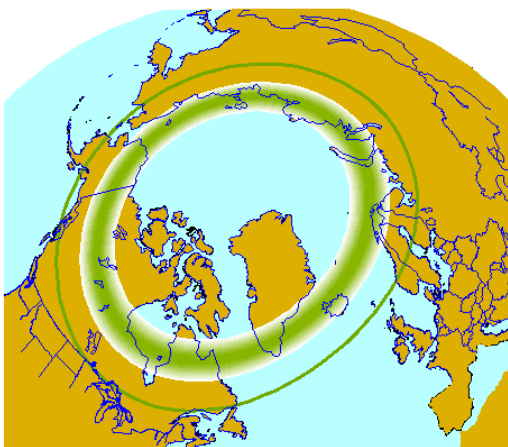
With Some Other Sights Worth Seeing
While You're in the Neighborhood

March

The Aurora Borealis

Ask any amateur astronomer what's on their bucket list, and a full-blown display of the aurora borealis will almost certainly be near the top of the pile. It's an experience that can be every bit as powerful as a total eclipse of the Sun, and just as visceral – especially when the aurora is breaking directly overhead. It's like solar totality in another way as well, since for the most part, the aurora's amazing displays of shimmering color are inconveniently confined to some of the most sparsely populated and relatively inaccessible places on the planet – and if that wasn't enough, the very best time and place to see the northern lights is during winter in the Arctic, when dangerously low temperatures are just one more inconvenience to be overcome. As a result, most of us will have to take a trip to the frozen North in order to observe the aurora at its best, unless heightened solar activity expands the area where auroras can be seen. Fortunately, such expansions sometimes occur.

The seeds of the aurora are found in the *solar wind*, a stream of ionized particles that flows constantly outward from the solar corona into the surrounding solar system. The intensity of the solar wind can be vastly increased by coronal mass ejections, whose effects reach Earth 1-3 days after they occur on the Sun. Most of the solar wind's particles are kept away from Earth by the *Van Allen belts*, groups of charged particles that flow along Earth's magnetic field lines and form a pair of protective structures, like a sideways figure-8 with Earth at its center. Solar wind particles that are not deflected by the Van Allen belts are shepherded along magnetic pathways at the center of the figure-8, flowing toward Earth's north and south geomagnetic poles, which are displaced by about 10° from the geographic poles. The particles thus enter our atmosphere along large ovals – the *auroral ovals* – centered near the poles.



The charged particles of the solar wind first encounter Earth's atmosphere in the *ionosphere*, which extends from 50 to 400 miles above ground. Their collisions with atoms of oxygen produce characteristic green and red emissions as excited electrons return to their rest state, while collisions with nitrogen atoms produce the aurora's less common blue and violet colors. Rare collisions with helium or neon atoms produce purple and orange emissions, respectively.

Auroras can be described by their color, shape, brightness, and activity. The classic fully-formed aurora displays a *band* or *curtain* shape, with a flat vertical face folded into a wavy structure. Auroras can also appear as one or more shorter segments known as *arcs*, individual vertical *pillars* or *rays*, extensive shimmering *veils*, or small unstructured *patches* of auroral light. A particularly dramatic (and sometimes overwhelming) effect occurs when the aurora is directly overhead, and the paths of the incoming particles trace out an *auroral corona* consisting of a series of lines converging in the far distance above you, that can seem to rush at you with unimaginable speed and intensity.

An aurora's brightness can range from a barely detectable ghostly image too faint to activate our eyes' color-sensing cones, all the way up to displays that are bright enough to cast definite shadows on the ground. Some auroras are *quiet*, without significant changes or apparent motion, but stronger ones generally *pulsate* with repeated changes in brightness or intensity, described as *flickering* if the changes occur more quickly (on the order of several times per second). If waves of color seem to climb up the aurora from bottom to top, it is said to be *flaming*.

Although the auroral oval usually hovers over the northern parts of Canada, Alaska, Scandinavia and Russia, strong solar activity can expand it far to the south. The current location of the auroral oval can be found on NOAA's Space Weather Prediction Center (swpc.noaa.gov), Spaceweatherlive.com, Spaceweather.com, or the University of Alaska's Geophysical Institute (gi.alaska.edu) – or you can try your hand at predicting when the aurora might be visible farther south by using a couple “space weather” data points available from any of those sites.

The first predictive tool is *the Bz Index*. It measures the strength of the north-south component of the interplanetary magnetic field, which is carried by the solar wind: southerly values (negative numbers) mean there is an attraction between the solar wind and Earth's magnetic field – a favorable condition for auroras – while northerly (positive) values indicate repulsion. The scale runs from 0 to 10 in each direction, and larger values indicate stronger attraction/repulsion. The second predictor is *the Kp Index*, which measures disturbances in the horizontal component of Earth's magnetic field on a 9-point scale. A larger Kp Index value indicates stronger auroral activity, and also means that the auroral oval may extend farther south, as indicated by the following table:

Kp	Activity may reach geomagnetic latitude	Representative Locations
0	66.5°	Tromsø Norway (67°) – Yellowknife NT Canada (68.6°)
1	64.5°	Fairbanks AK (65.5°)
2	62.4°	Reykjavik Iceland (63°)
3	60.4°	Sitka AK (60.2°) – Bergen Norway (61°)
4	58.3°	Winnipeg MB Canada (59.5°)
5	56.3°	Oslo Norway (56°)
6	54.2°	Toronto ON Canada (53.9°) – Minneapolis MN (55.1°)
7	52.2°	Chicago IL (52.2°) – Seattle WA (52.7°)
8	50.1°	New York NY (50.6°)
9	48.1°	Denver CO (48.3°) – St Louis MO (49.2°)

Note that these are *geomagnetic* latitudes, not geographical latitudes – and if you're below the 60° level, don't expect the auroral display to match what people in the Arctic are seeing: although your camera may show color and structure, your eyes are likely to see only a dim, muted, and relatively unstructured version of the aurora's splendor.