Propagation Planning for DXpeditions

6 Steps for a More Successful Trip

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Planning a DXpedition involves many tasks – choosing operators, securing equipment, arranging transportation, and a heck of a lot more. In the propagation arena, usually propagation predictions are run after all else is settled to identify when the bands are open to target areas.

Instead of doing propagation work *after* everything is settled, this article explains how propagation is affected by a variety of issues and encourages you to do propagation work *before* you go. Sure, you can't *change* propagation, but at least you can better understand the variables in order to help make the most important decision - when to go to best meet the goals of your DXpedition.

This is not a cookbook - you don't put in your goals and out pops the dates you should go. But the information is here – all you have to do is read it and apply it as best as possible. The decision when to go is still yours.

Step 1: Get the Big Picture

Using a great circle map (also called an azimuthal equidistant map), print out a copy centered on your DX location with the auroral ovals shown at a low K index. Since great circle paths are straight lines on this map projection, draw straight lines from your DX location to your target areas. Figure 1 (from DXAID by Oldfield) shows an example of this for the January 2005 3YØ Peter I Island DXpedition.

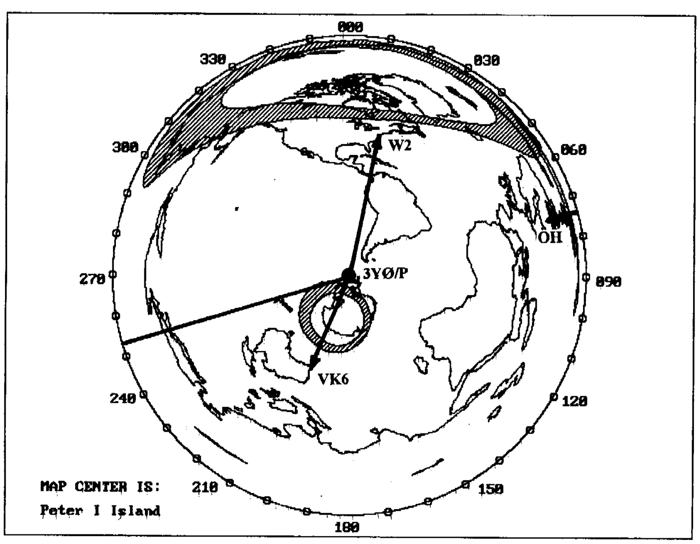

Figure 1 Great circle map

Three important pieces of knowledge come out of this map.

First, the straight lines give you headings for your directive antennas – both short path and long path. The outer perimeter of a great circle map is halfway around the world – 20,000km. Any line that ends before the outer perimeter is short path (e.g., 3YØ to W2 on a north heading at about 12,000km). Any line that goes to the outer perimeter and comes back onto the map from the opposite direction is long path (e.g., 3YØ to OH on a southwest heading at about 23,000km). A comment – with this map projection, the most distortion occurs at the outer perimeter of the map. That's why features near the outer perimeter (for the 3YØ example, the land masses halfway around the world and the northern auroral oval) look funny.

Second, the straight lines give you distances since the outer perimeter of the map is 20,000km and the distance is linearly scaled from the center. In general, the shorter paths provide stronger signals. Checking long path will be discussed in the **Run Predictions** step.

Third, the straight lines tell you if they are high latitude paths – the ones that go through or get near either of the auroral ovals (e.g., 3YØ to VK6). This is discussed in the next step.

Step 2: Understand the Impact of Geomagnetic Field Activity

For many years I've been plotting the number of days in the month that Ap (the planetary A index) is less than 7 (indicating quiet conditions) versus the smoothed sunspot number. Figure 2 is this plot.

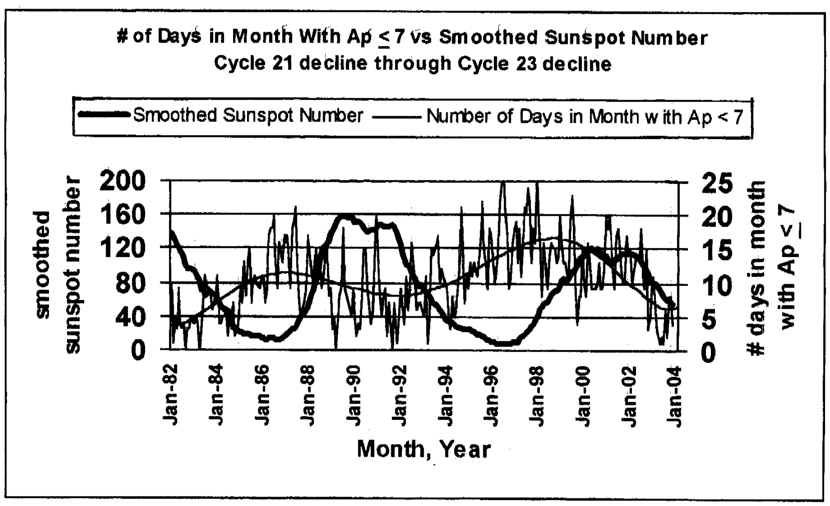

Figure 2 Ap vs SSN

What this shows is the quietest period in a solar cycle (with respect to geomagnetic field activity) is just after solar minimum – where the Ap trendline (to smooth out the spiky Ap data) maximizes. Turning that statement around, the most disturbed period is just after solar maximum – during the declining phase of a solar cycle when the Ap trendline minimizes.

Now let's tie Ap to propagation conditions. In general, an elevated Ap index (which is the daily average of the eight 3-hour Kp indices) means propagation on paths going through or near an auroral oval could be disturbed for up to several days. If any path goes through or near either auroral oval, your DXpedition could have a problem with that path during the declining phase of a solar cycle. Does this mean you shouldn't go on a DXpedition just after solar maximum? Of course not. All it says is the probability of a disturbed path is higher just after solar maximum if the path goes to high latitudes – it doesn't say that a disturbance is a sure thing.

If you do go just after solar maximum, there is something you can do to lessen the probability of disturbed high latitude paths. And that is to go during the quietest months. Figure 3 plots the number of days in the month that Ap is less than 7 versus the months of the year (averaged from 17 years of data).

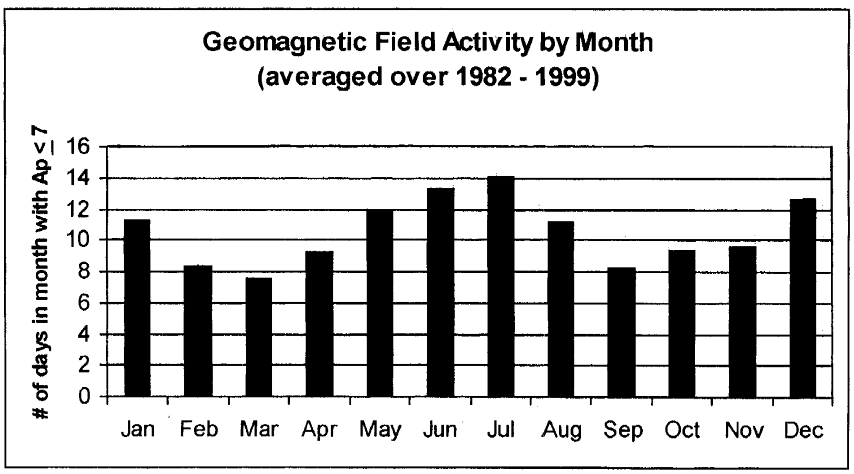

Figure 3 Ap vs Month

It's obvious that the winter months (December and January) and the summer months (June and July) are the quietest. A good example of some forethought in this area is the 1998 8Q7AA DXpedition. Originally it was scheduled for April 1998, but data similar to Figure 3 resulted in moving it up to January.

And here's some more good news in relation to minimizing the impact of geomagnetic field activity. If the paths to your target areas stay at low latitudes (in other words, they don't get near or go through either auroral oval), then the probability of disturbed paths is lessened considerably.

Before leaving this topic, a good question to ask is "what about big solar flares – the ones that can cause radio blackouts (from radiation at wavelengths in the 1-10Å range) and polar cap absorption events (PCAs – from energetic protons)." Should these be factored in? Solar flares are more in step with a solar cycle than geomagnetic field activity, so the probability of radio blackouts and PCAs is highest at solar maximum. But radio blackouts are short-term events (up to several hours) and PCAs only occur on average at the rate of 6 per year. Thus for all intents and purposes the probability of a long-term disruption due to big solar flares is quite low, and will be ignored.

Step 3: Know Basic MUF Trends

If your primary mission is the higher bands (15m, 12m, 10m, and even 6m), then the F2 region maximum usable frequency (MUF) is your major concern. This means you should go at or near solar maximum, and you'll just have to accept the fact that you may have some propagation disturbances due to geomagnetic field activity.

Are there months that have higher F2 region MUFs? Yes there are, and it's due to a composition change in the atmosphere at F2 region altitudes. A higher ratio of atoms to molecules gives more ionization targets, and this ratio is highest during the winter months. So daytime MUFs are highest during the winter months. A plot comparing daytime summer MUFs to daytime winter MUFs is pretty standard in books on the ionosphere.

But ionization targets isn't the only issue here – the amount of solar illumination along the entire path (especially the very long distance paths) also factors in and can modify the daytime MUFs so that the equinox months have the highest MUFs. In essence there are two processes competing here – the change in composition of the atmosphere during the year and how the entire path is illuminated by the Sun during the year.

The easiest way to sort this out is to run predictions to your target areas for different months and choose the month that best meets your goal.

Step 4: Run Predictions

There are many propagation prediction software packages available You can buy software to run your predictions, you can use free-download software to run your predictions (VOACAP and W6ELProp), or you can use the predictions in the ARRL Antenna Book CD.

For some background information on propagation predictions and prediction software, check out the Propagation Software Review presentation on the Dayton Antenna Summary 2004 link at www.k3lr.com.

VOACAP is the Voice of America version of the well-respected IONCAP. W6ELProp is the Windows version of the discontinued MiniProp DOS series. For more information about downloading, setting options, running a prediction, and interpreting the results for these two programs, see www.arrl.org/tis/info/pdf/Voacap.pdf and www.arrl.org/tis/info/pdf/W6elprop.pdf, respectively.

The Antenna Book CD predictions use VOACAP. The data is in two formats: a Summary Table and a Detailed Table. The Summary Table gives predictions for 80m, 40m, 20m, 15m, and 10m versus UTC and for seven general areas of the world, all on one sheet of paper. The Detailed Table is for 160m, 80m, 40m, 20m, 15m, or 10m, each with predictions to all 40 CQ zones by UTC. If you don't want to bother with running predictions yourself, then use the Antenna Book CD predictions. Note that the Antenna Book CD doesn't have predictions for the WARC bands – the WARC band predictions can easily be derived by interpolation from the bands on either side.

Which software prediction program you use is, in my opinion, a matter of personal preference. They all start with a monthly median model of the ionosphere, so all of them are statistical in nature over a month's time frame. For all intents and purposes, the differences are in the output data format and the bells and whistles.

Earlier I mentioned checking long path. A good rule of thumb to use is that if the short path distance is close to 20,000km, then it would be worthwhile to run long path predictions. For example, the short path from 3YØ to OH is just over 17,000km – that's close enough to warrant a look at long path (which is what is shown in Figure 1).

Since predictions (MUF and signal strength) are statistical in nature, you essentially have two ways to present the data. You can either list all the times a given band is expected to be open, even though some times may be at a low probability (this is the format of the Antenna Book CD predictions). Or you can list 'best' times, with a probability threshold criteria defined for MUF and signal strength (e.g., at a 50% probability - the band should be open on at least half the days of the month and the signal strength should exceed your selected value on half the days of the month).

Once you're done running your predictions, you might find it helpful to put them into an easily readable (tabular) and readily accessible (one page) format for quick reference. Figure 4 shows partially completed predictions for the January 2005 3YØ DXpedition, including 160m (which will be discussed in the next step).

Best times from 3YØ, Jan 2005, all times UTC

Target	hdg	160m	80m	40m	30m	20m	17m	15m	12m	10m
NA east	13°	0515-0708	0130-1000	00-11	00-11	13-23	14-22	20-21	nil	nil
NA mid										
NA west										
S Amer north										
S Amer south										
EU west										
EU north - sp	73°	0515-0732	0000-0630	23-07	23-07	07-10	10-15	14-15	nil	nil
EU north - lp	253°	not likely	1030-1200	09-14	08-13	06-12	06-09	07	nil	nil
EU south										
EU east										
N Afr										
S Afr										
Mideast										
SE Asia										
Far East										
VK4										
VK6										
ZL										

Notes: 160m based on sunrise/sunset times, 80m rounded to nearest half hour, all other bands rounded to nearest hour
band open on at least 15 days of the month and signal strength greater than S5 on at least 15 days of the month
1000w to vertical/dipole on lower bands, small Yagi on higher bands

Figure 4 Sample predictions

Note that the title says ‘best times’, with the assumptions in the notes. Also note that long path predictions are given for northern EU (OH as in Figure 1). And finally note that the headings are from 3YØ to each target area – this format would be useful for the 3YØ team for planning their antennas and which bands to be on at a given time. You could change the title from ‘Best times from 3YØ’ to ‘Best times to 3YØ’ and give the heading from each target area to 3YØ – this would be useful for DXers worldwide and could be put on the DXpedition website.

Step 5: Identify 160m Issues

Most of the propagation prediction programs do not include 160m. The reason is because 1.8MHz is close enough to the electron gyro-frequency to cause absorption, refraction, and polarization on Topband to be affected by the Earth’s magnetic field. That gets very complicated very quickly. So how do we predict propagation on 160m?

Not having enough ionization to refract energy back to Earth (i.e., a high enough MUF) is not an issue on 160m, so it all boils down to signal strength – of which absorption is a big player. This means we need to be in darkness or near darkness for 160m to be ‘open’.

The easiest way to determine 160m paths in relation to darkness is with a map that shows both the great circle paths and the terminator. Figure 5 shows such a map, and this one comes from W6ELProp. A comment about the Geochron clock – it only shows the terminator – it does not necessarily show the great circle path between your DX location and the target area.

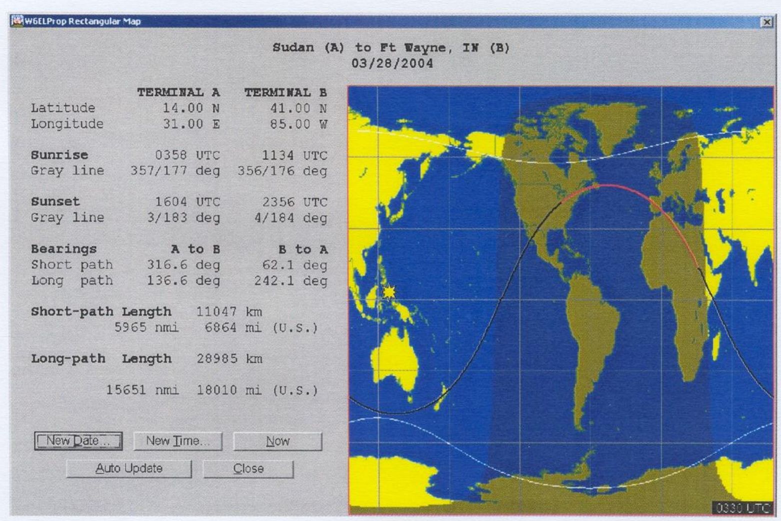

Figure 5 Great circle paths and terminator

Of special importance on 160m is sunrise and sunset times at both ends of a path. Not only do these times tell when the path is in darkness, they also tell when to look for sunrise and sunset signal strength enhancements. Enhancements around sunrise are generally the most spectacular. Knowing these times will also help with skewed path propagation – the common adage being ‘southwest at sunrise’ and ‘southeast at sunset’.

Earlier I mentioned that the predictions in the Detailed Tables in the Antenna Book CD include 160m. The 160m predictions are derived by subtracting 3 S-units from the 80m predictions (this is based on an analysis of East Coast data). Since these predictions only give on-the-hour values, the predictions are too coarse and need to be used in conjunction with sunrise and sunset times to address sunrise and sunset enhancements.

Be aware that certain times of the year may preclude 160m propagation (and 80m and even 40m propagation to a certain extent) to certain areas of the world. This is due to the path never being totally in darkness to certain locations. The best example of this is the 1997 VKØIR DXpedition, and their path to the North America Plains states. Figure 6 shows how many minutes the short path between VKØIR and North America was in darkness.

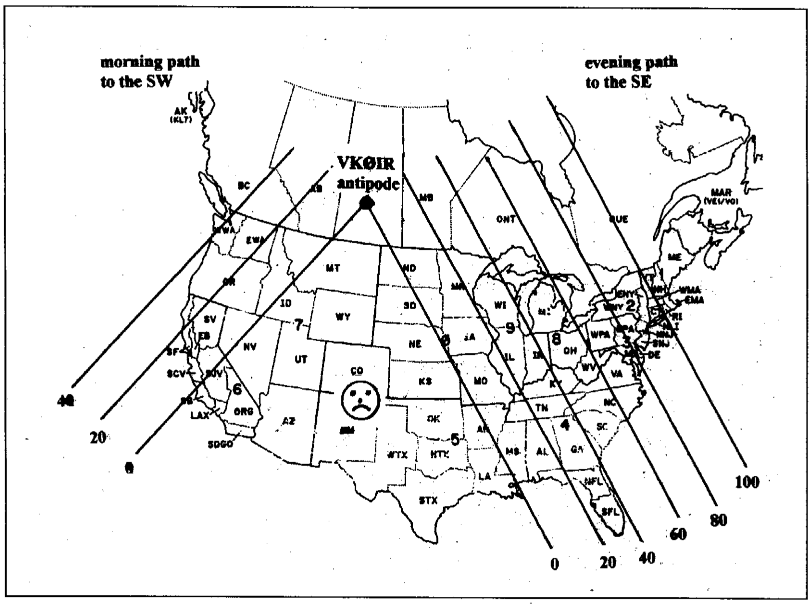

Figure 6 Amount of Minutes that the VK0IR-to-NA short path is in darkness

Note that a wedge of ‘no darkness along the entire path’ existed (the sad face area between the two ‘0 minutes’ lines). No one in this wedge worked VKØIR on 160m. And it was tough on 80m, too, but some got in through the back door – via long path. Working with sunrise and sunset times for the various months will highlight which paths may have this problem.

Finally, if you’re near the magnetic equator and a main target area is pretty much directly East or West, magneto-ionic theory says horizontal polarization will couple the most energy in and out of the ionosphere. Since the major amateur radio population areas are at mid to high latitudes in the northern hemisphere, more than likely this won't be too big of an issue even if you are near the magnetic equator. Additionally, when angle of radiation issues are factored in (it's hard to get low angle radiation from a horizontal dipole on 160m due to low electrical heights above ground), the benefit of adhering to this issue may be lost in the real world.

So for 160m predictions, know sunrise and sunset times for your DX location and the target areas. Be on every night if possible, as propagation on 160m can be highly variable from night to night (and if you've been on 160m for a while, you'll realize it's highly variable from hour to hour!). Finally, realizing that long distance propagation on 160m is probably via a duct mechanism in the electron density valley above the nighttime E region peak, try to go when the ionosphere is most stable – around solar minimum.

Step 6: Check for Thunderstorms

If a big part of your DXpedition mission is the low bands and you'll be near the equator, then you might want to check for thunderstorm activity. There's nothing like S9-plus QRN from nearby lightning discharges making 160m and 80m very difficult (if not impossible).

Figure 7, from the Handbook of Geophysics (the 1960 version, edited by the United States Air Force), is a worldwide map of thunderstorm activity for an entire year.

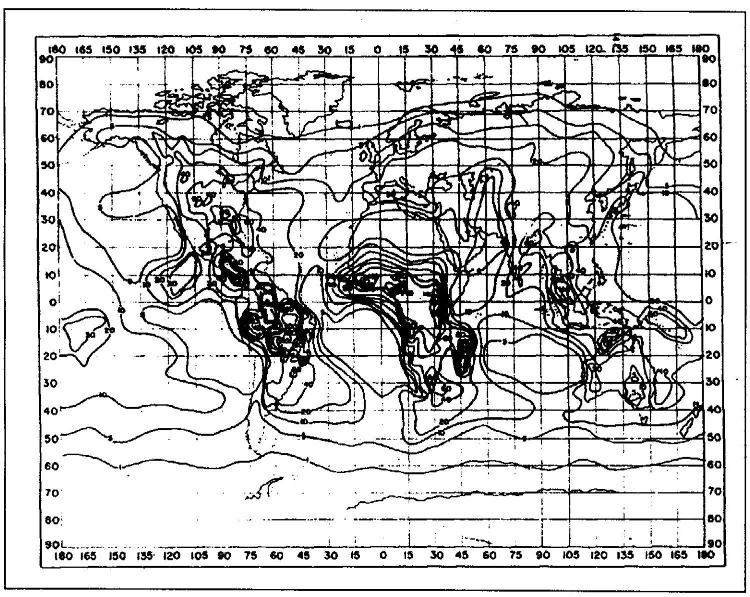

Figure 7 Thunderstorm days for an entire year

Although the actual number of days is tough to read, it's easy to see that the problem areas (the dark areas with very close-spaced contour lines) are those locations near the equator. In these areas, there are up to 180 days per year with thunderstorms.

Are there any patterns to thunderstorm activity that would allow selection of a best month? In general, most thunderstorm activity in December, January, and February is 10 to 20 degrees below (south of) the geographic equator. Most thunderstorm activity in June, July, and August is 10 to 20 degrees above (north of) the geographic equator. Thunderstorm activity in the other months tends to straddle the geographic equator.

A technique to help combat QRN is to plan on directional receiving antennas. For example, if your DX location is close to but north of the geographic equator, going during December, January, or February generally puts the thunderstorm activity off the back of your directional receiving antenna for the major ham population areas (NA, EU, JA). If your DX location is close to but south of the geographic equator, going in June, July, or August puts the thunderstorm activity farthest away and, coupled with good front-to-side rejection of your receiving antennas, may improve the low band QSO count to certain areas of the world.

Summary

Based on the information presented in this article, it would be nice to end with a tried and true set of rules dictating when you should go on a DXpedition. As stated in the opening paragraphs, that's not going to happen here. There's a good reason for this - in reality it's next to impossible because most of the time out-of-phase issues exist. For example, a major DXpedition covering all the bands would ideally want to go at solar maximum for the higher bands due to MUF issues but would ideally want to go at solar minimum for the lower bands due to a quieter geomagnetic field for the high latitude paths.

If you do have the luxury of such long term planning, then by all means pick the years in the solar cycle that best meet your DXpedition goals. If you can't do this, then try to pick the best season or at least the best month.

Of course many DXpedition dates are set by factors other than propagation. For example, the 3YØ DXpedition is going in the month of January because of weather factors at extreme southern latitudes. The original 3YØ plan was to go in January 2004 so as not to be too far down Cycle 23, but a transportation problem surfaced and postponed the DXpedition until January 2005. Undoubtedly the lower sunspot numbers in January 2005 compared to January 2004 will reduce their QSO totals on the higher bands. Another example would be going on a dual-purpose trip – a DXpedition that also coincides with operation in a specific contest (like the FP/VE7SV operation for CQ WW PH at the end of October 2004). These are great examples of going when you have to and taking what you get.

Realizing that compromises are inevitable, in my opinion the best time for an all-band DXpedition is on the ascending phase of a solar cycle in a winter month (December or January). This scenario says sunspots are getting high enough for good propagation on the higher bands but geomagnetic field activity is still low. The next opportunity for this will be in the 2008-2010 time frame as Cycle 24 increases.