Global Maps with Contoured Ionosphere Properties

Some F-Layer Anomalies Revealed

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In this column, I shall handle some possibilities given by PROPLAB-PRO to have information about different ionospheric properties as projected on a global map. These maps can be generated at any time or date and use other input data, such as sun activity and geomagnetic disturbances. There is also a wide choice of global map types in the software packet, such as cylindrical, polar azimuthal, and oblique azimuthal equidistant. Some other propagation prediction programs have the power to generate similar kinds of global maps showing ionosphere properties too. I plan a mutual comparison in forthcoming prediction software reviews.

By means of global maps with the foF2 data and by plasma transverse frequencies maps, I shall visualize some F2-layer anomalies, in particular the ***Polar Anomaly,*** the ***Earth Magnetic Anomaly*** and partly the ***Season Anomaly.*** For background, please re-read the information on F-layer anomalies in **Column-4.**

In this column again, and also in the future ones, you can download wizards to bring animation to the pictures.

E – Layer Critical Frequencies Maps

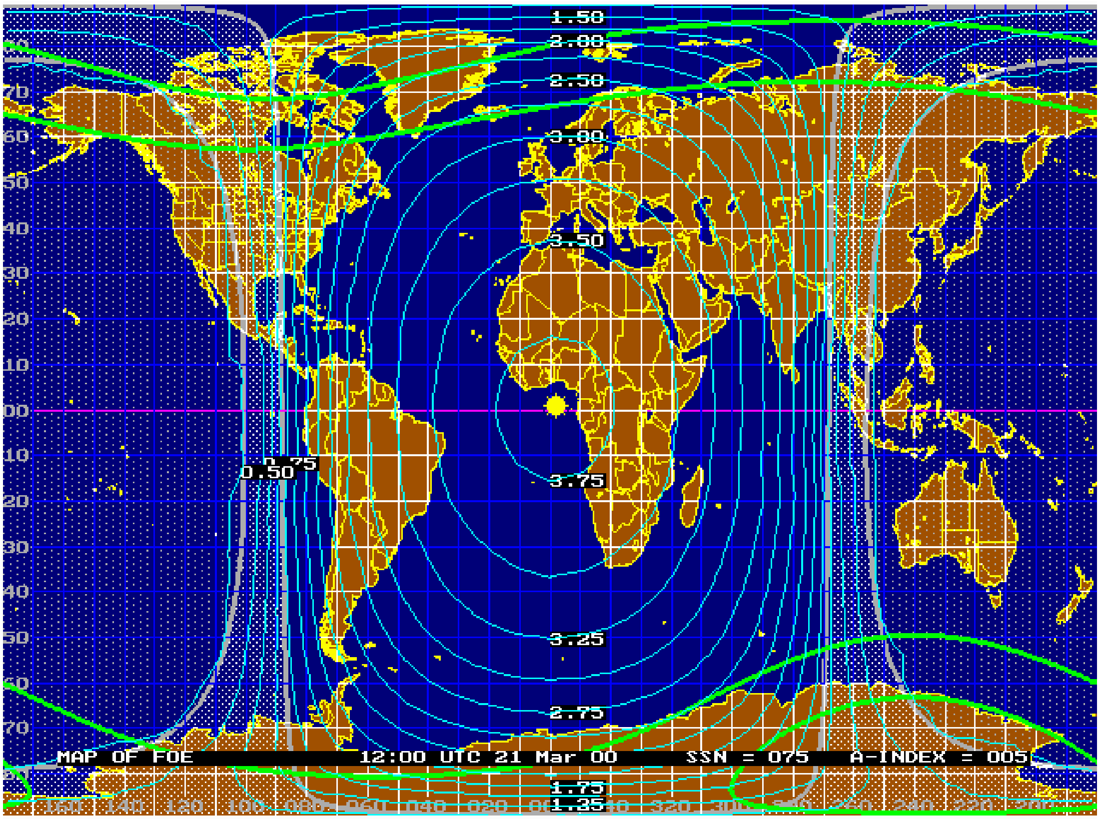
The E-layer critical frequency corresponds to the highest frequency signal that can be refracted back to earth by that layer, when transmitted straight upwards (vertically incident). Signals exceeding the E-layer critical frequency (at vertical incidence) will penetrate the E-region and propagate toward the F-regions. Signals with frequencies lower than the foE will always be refracted towards earth, no matter the propagating angle.

The E region is the second lowest primary ionospheric region. It is located at a height of ±105 km (65 miles) and situated a small distance above the D region. Together with the D region, the E region is a location in the ionosphere where the greatest signal attenuation can occur. It is a daytime region only and nearly vanishes during the nighttime. Radio communicators most often do not want their signals to spend very much time in this region. Signals refracted within the E region spend the greatest time in the E layer and are accordingly attenuated the most. Our low frequency bands (160m, 80m and 40m) are affected the most by the E-regions. Higher HF band are influenced much less.

When considering long distance contacts made by means of E-region refractions, the critical frequency at the area where the oblique-angled signals enter into the E-layer is significant. The furthest single hop reaches from 700 to 1000 km (435 to 620 miles) away from your transmitting location.

The E-layer critical frequency map is helpful to inform you where the E-region is strongly enough ionized to influence your communications. Unless you want to use the E-region as the refracting downward medium, your transmission frequency must exceed the greatest contoured value along your desired path.

In **Map 7.1,** from the sun symbol towards the “grayline” (see below), the critical frequency decreases and almost totally disappears during the nighttime. Normal foE values are from 2.5MHz to 3.75 MHz. Higher SSN (higher sun activity) gives higher critical frequency values, occasionally climbing to 5 MHz in the solar zenith region. In the same region at certain seasons, we frequently have another ionization phenomenon, sporadic-E (Es). The ionization density or the critical frequency of this Es, can be much higher than the normal E-layer values. The foEs can climb to values exceeding even 10 MHz and cause strange propagation conditions. Later, we shall present an entire column handling the sporadic E phenomenon, along with its behaviors and effects on propagation.



Map 7.1 *foE March 21 at 12:00 UTC. Contoured in steps of 0.25 MHz.*

In the above **Map 7.1** is also shown the grayline zone and the auroral zones: these zones need some brief description.

GRAYLINE

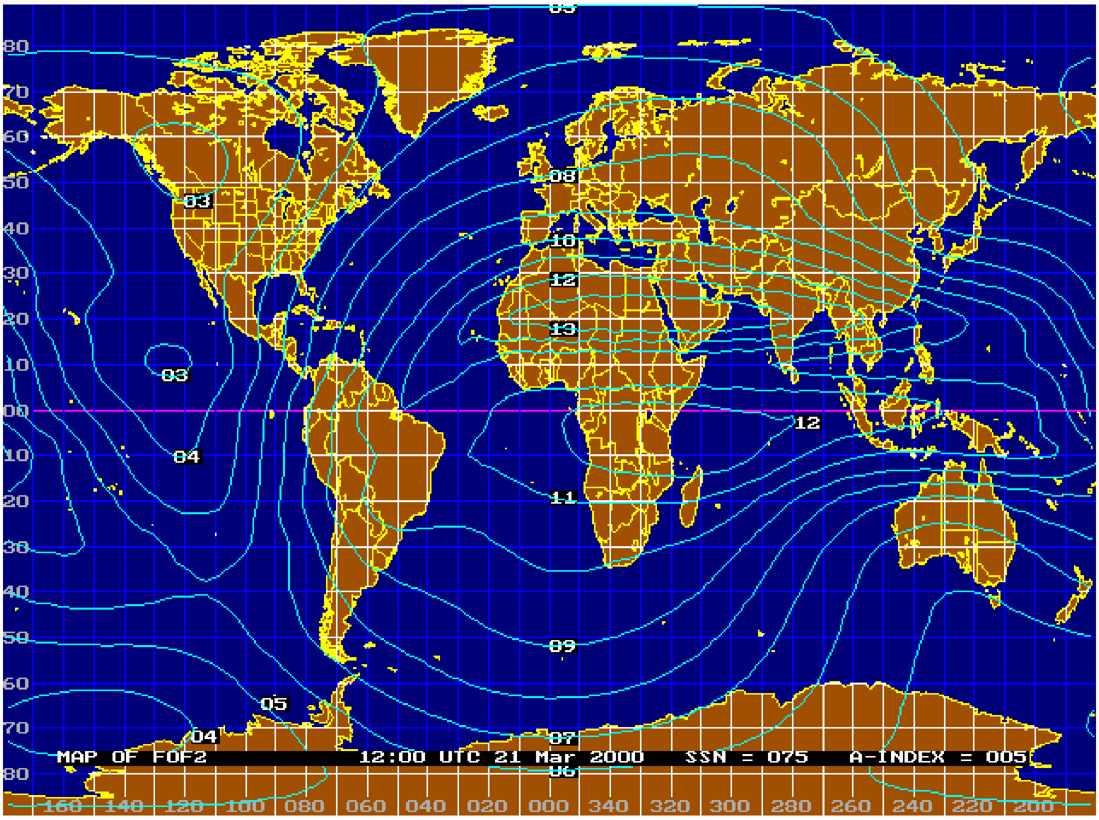
The solid gray-colored line closest to the sun symbol is known as the **grayline** or **terminator**. This is the region where the sun is exactly **rising** or **setting.** The second solid gray-colored line defines the region of the world where the sun is exactly **12 degrees below the horizon**. This line defines the **end of evening twilight**. The heavy shaded area between these two lines is known as the **twilight zone or grayline zone**. This zone has special significance to radio communicators. Signals traveling inside the grayline zone often experience improvements in propagation, because the D-layer ionization disappears as the sun sets. Therefore, D-layer absorption ends, and the attenuation of the E-layer are also strongly decreased. However, the F-regions of the ionosphere remain strongly ionized for longer periods of time. Low frequencies can now propagate via F-layer refractions and lengthen drastically the distance they reach. Higher frequency signals are able to travel to greater distances with less attenuation when they travel within the grayline zone.

Radio Auroral Zones

Near the northern and southern poles, the map shows the radio auroral zones as green-colored bands. The area within these green bands can strongly influence radio signals passing through them. Signal degradation in the form of fading, multi paths, scattering, and absorption are some of the effects.

The grayline and auroral zones can be superimposed on any cylindrical map, but we shall not do this on the forthcoming maps.

F2 – Layer Critical Frequencies Maps



Map 7.2 *foF2 March 21at 12:00 UTC.*

foF2 maps correspond to the maximum radio frequency that can be refracted back downward by the F2 region at vertical upwards incidence. Maps showing the contour lines of the F2-layer critical frequencies (foF2) can be used to determine the frequencies that always will return to the earth, no matter the propagating angle.

Frequencies higher than the foF2 may penetrate the ionosphere, depending of how much higher the frequency and how much lower the oblique angle of incidence.

When considering long distance communications contacts made by means of the F2-region refractions, the critical frequency at the area where the oblique-angled signals enter into the F2-layer is significant. Single hops may reach 1000 to 2000 km (620 to 1240 miles) away and around your transmitting location.

Low foF2 values indicate a weaker ionized ionosphere and correspond to regions with lower Maximum Usable Frequencies (MUFs). High foF2 values indicate a stronger ionized ionosphere and correspond to regions with higher MUFs.

Maps with F2-layer critical frequencies contour lines are helpful to illustrate regions of the ionosphere that are weak or strong in supporting communications. F2 critical frequencies in excess of about 8 MHz correspond to regions that are strongly ionized and capable of refracting higher frequency signals over long distances. F2 critical frequencies below about 4 MHz correspond to weaker regions and result in greater signal loss into space and only support our lower frequency bands. Zones with low foF2 values give lower MUFs and therefore with greater signal instability at some frequencies.

Some F2 layer Anomalies Visualized

Polar anomaly - Earth magnetic anomaly - Seasonal anomaly

With the help of the maps below, try first to study and discover for yourself the anomalies. Thereafter, you can compare your findings with the summary I give at the end.

The time used in the maps is 10:00 UTC: this is midday at 30 degrees East longitude and midnight at the opposite 150 degrees West. The SSN = 075 and the A-index 005.

Northern hemisphere maps with foF2 contours (critical frequencies F2-layer).
Map 7.3 March 21
Map 7.7 June 21
Map 7.11 September 21
Map 7.15 December 21

Southern hemisphere maps with foF2 contours (critical frequencies F2-layer).
Map 7.5 March 21
Map 7.9 June 21
Map 7.13 September 21
Map 7.17 December 21

North pole zone transverse frequencies maps.
Slice from location 60 N – 30 E to 60 N – 150 W.
In the maps are on the horizontal distance axis:
0 kilometers = 60 N – 30 E.
3 333 kilometers = North pole;
6 666 kilometers = 60 S – 150 W.
Map 7.3 shows where the North Pole slice for the transverse plasma frequencies is situated.

Map 7.4 March 21
Map 7.8 June 21
Map 7.12 September 21
Map 7.16 December 21

Equator zone transverse frequencies maps.
Slices from location 30 N – 30 E to 30 S – 30 E.
In the maps are on the horizontal distance axis:
0 kilometers = 30 N – 30 E.
3 333 kilometers = geographic equator.
6 666 kilometers = 30 S – 30 E.

Map 7.6 March 21
Map 7.10 June 21
Map 7.14 September 21
Map 7.18 December 21

Fig 7.1 shows where the equator slice for the transverse plasma frequencies is situated.

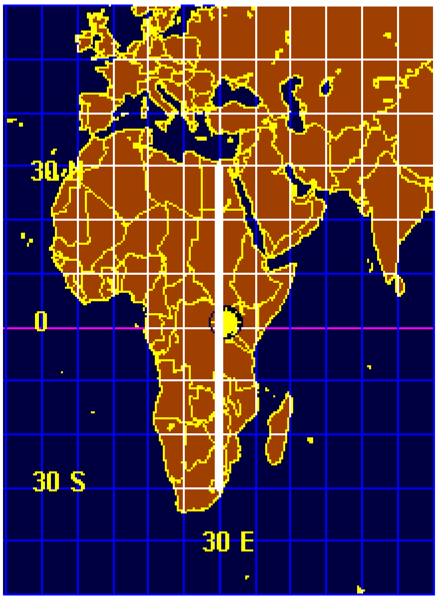
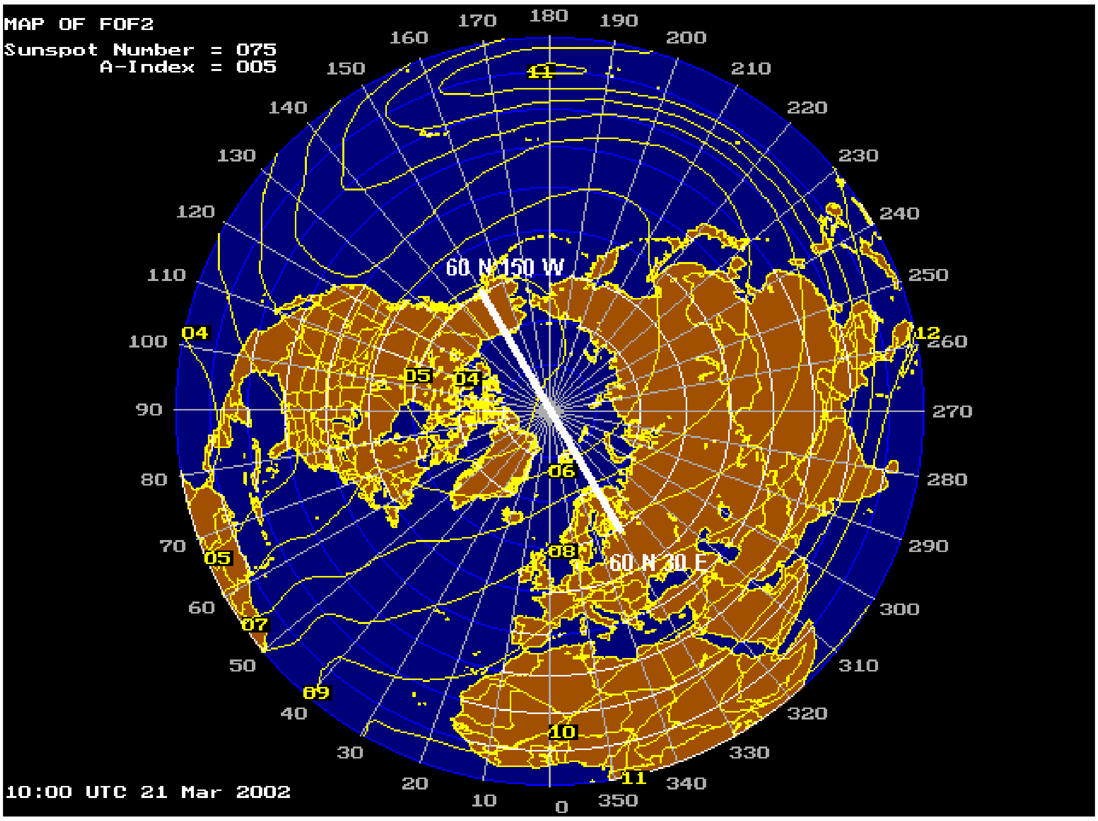
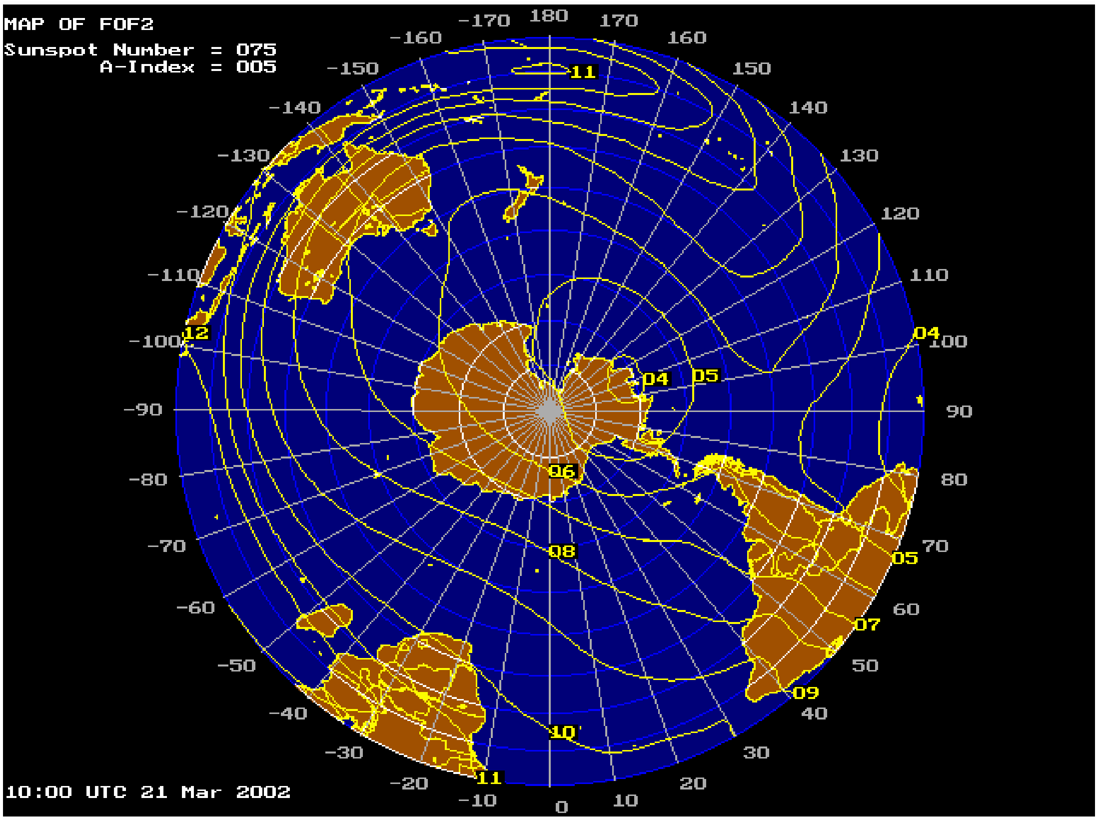


Fig 7.1 *Equator zone slice location.*

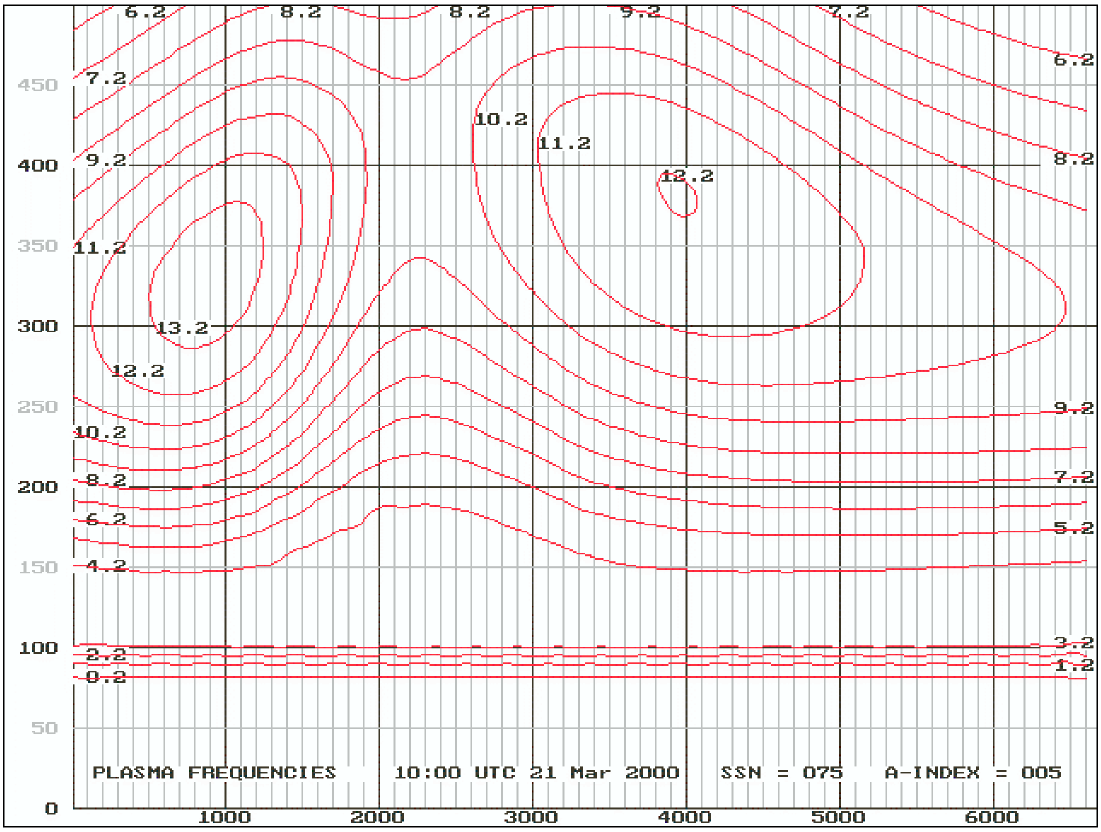


Map 7.3 *Northern hemisphere foF2, March 21 at 10:00 UTC.*
The magenta colored line is where the North Pole transverse plasma frequency slice line is situated.

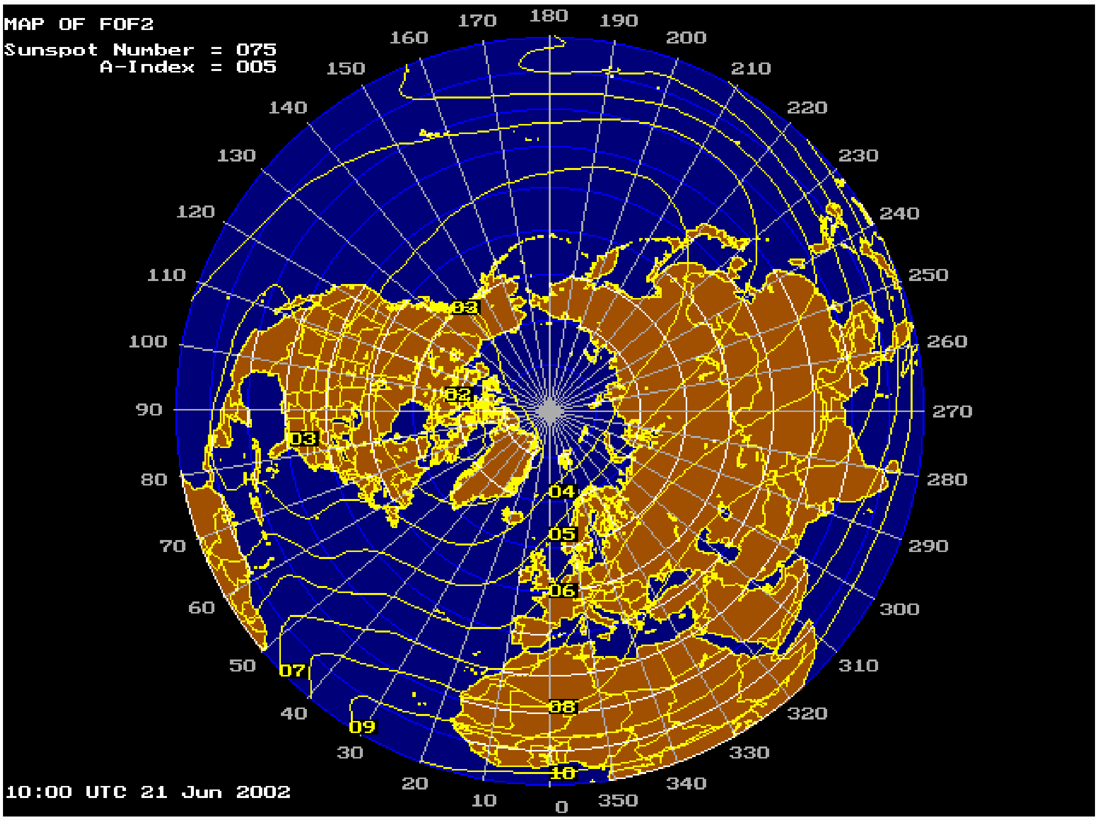
Map 7.4 *Transverse frequencies map, March 21 at 10:00 UTC.*
Slice from location 30 N – 30 E to 30 N – 150 W.



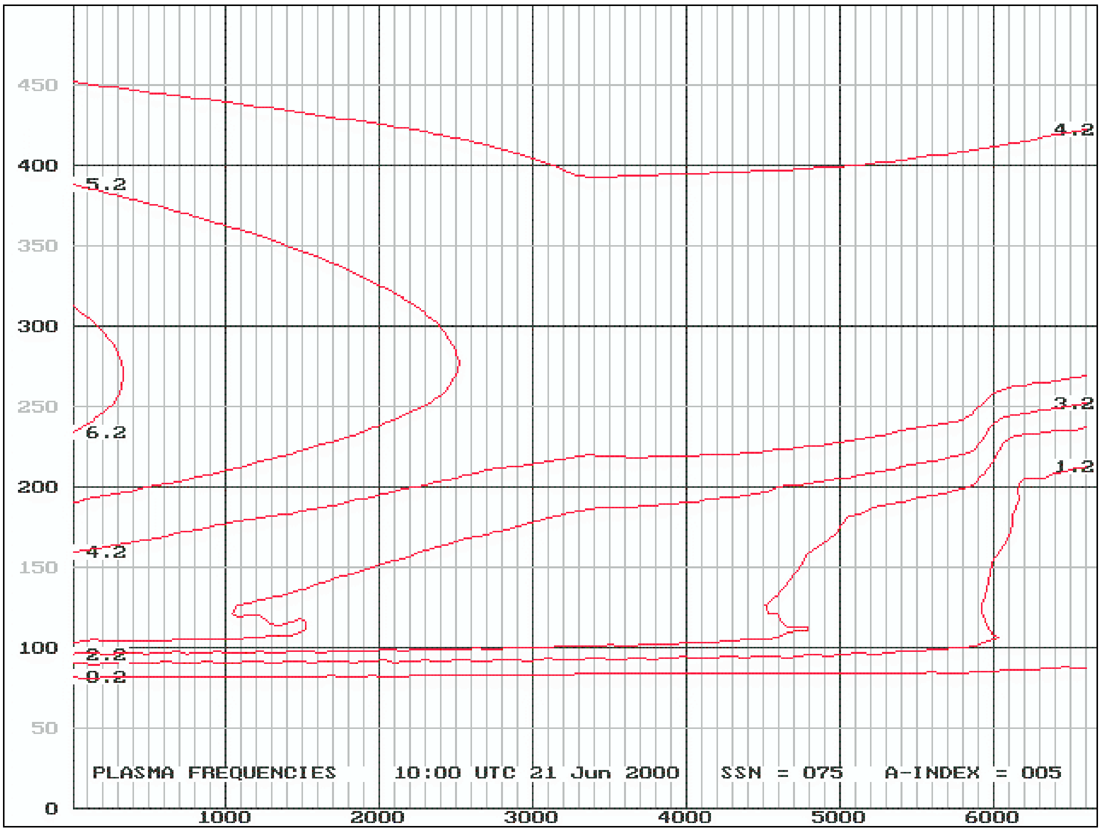
Map 7.5 *Southern hemisphere foF2, March 21 at 10:00 UTC.*



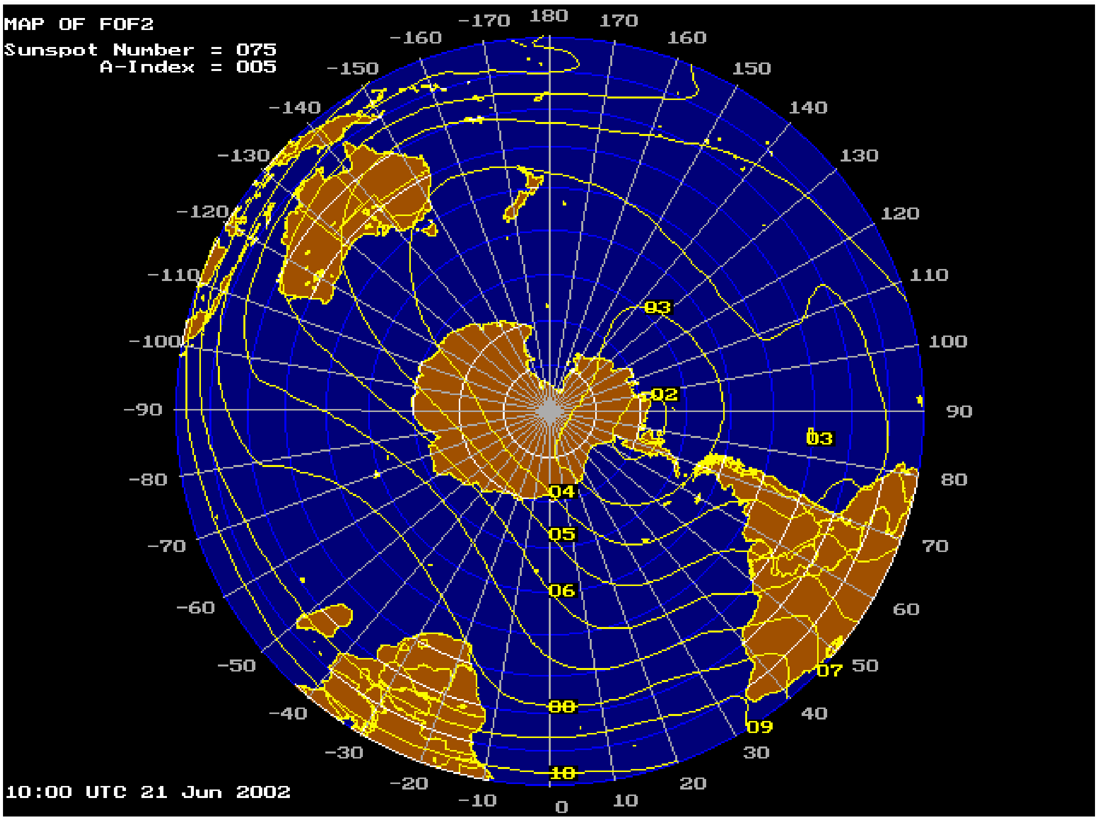
Map 7.6 *Transverse frequencies map, March 21 at 10:00 UTC.*
Slice from location 30 N – 30 E to 30 S – 30 E.



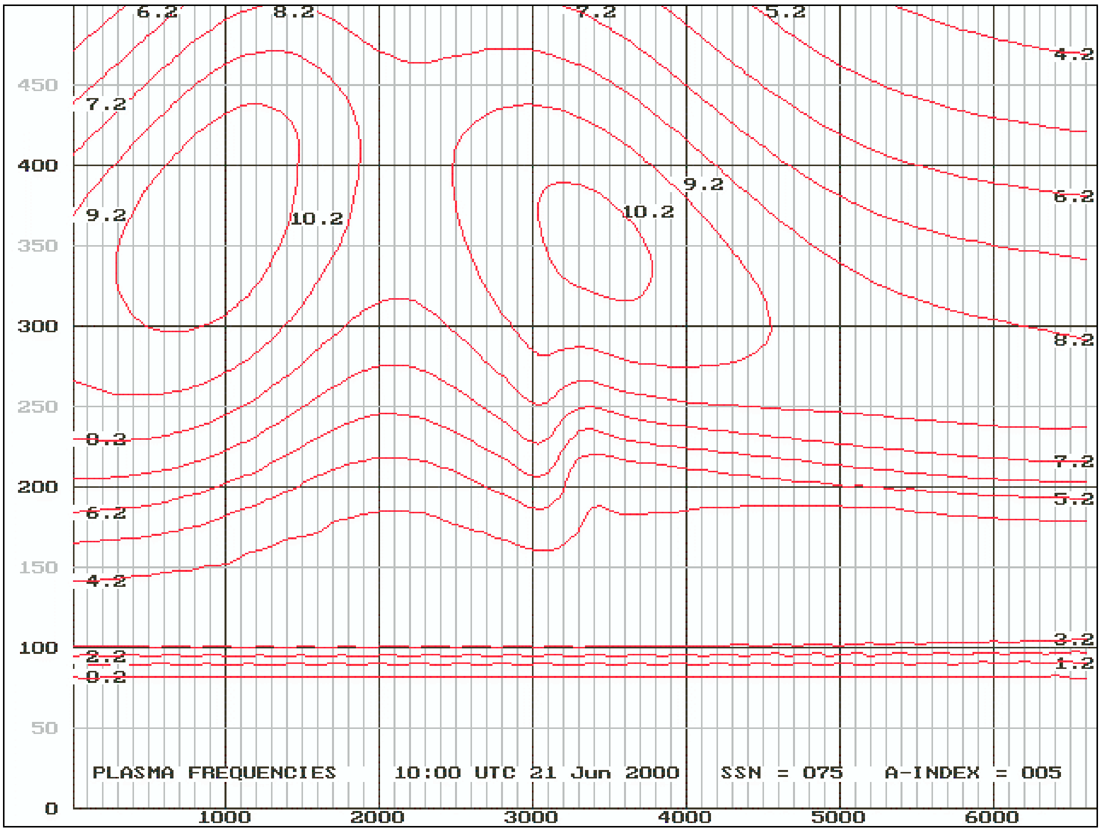
Map 7.7 *Northern hemisphere foF2, June 21 at 10:00 UTC.*



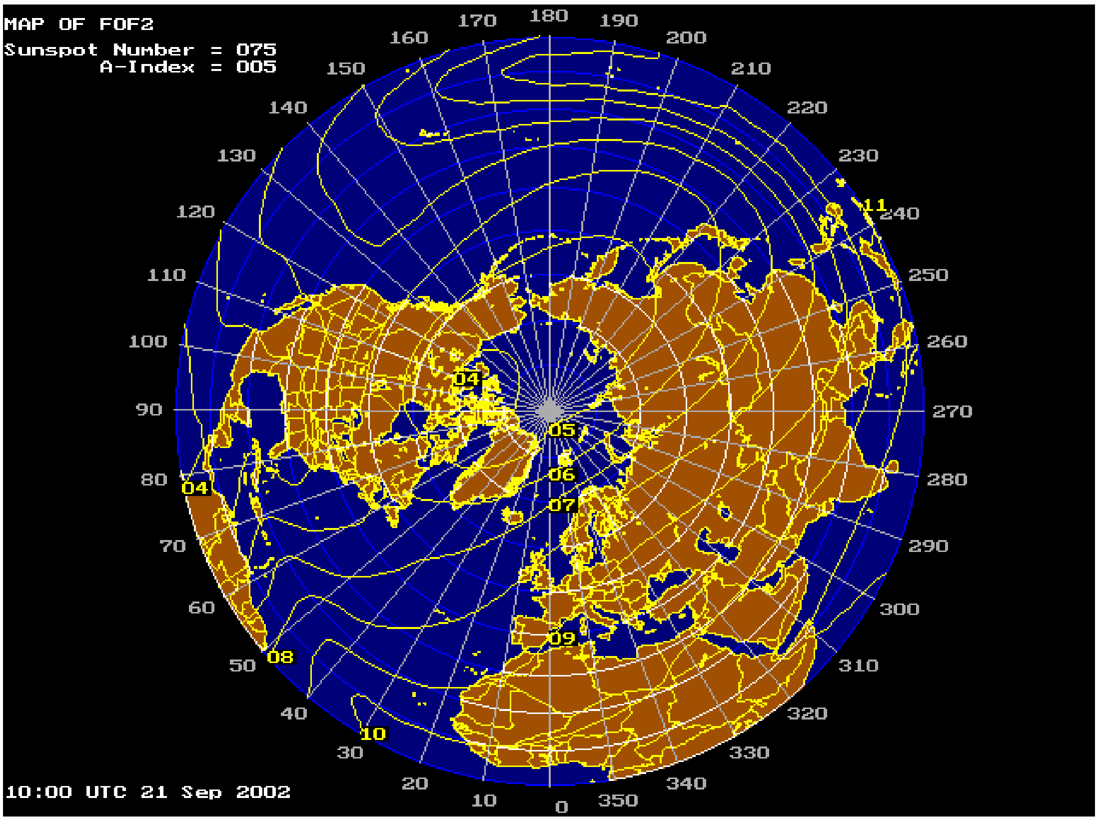
Map 7.8 *Transverse frequencies map, June 21 at 10:00 UTC.*
Slice from location 30 N – 30 E to 30 N – 150 W.



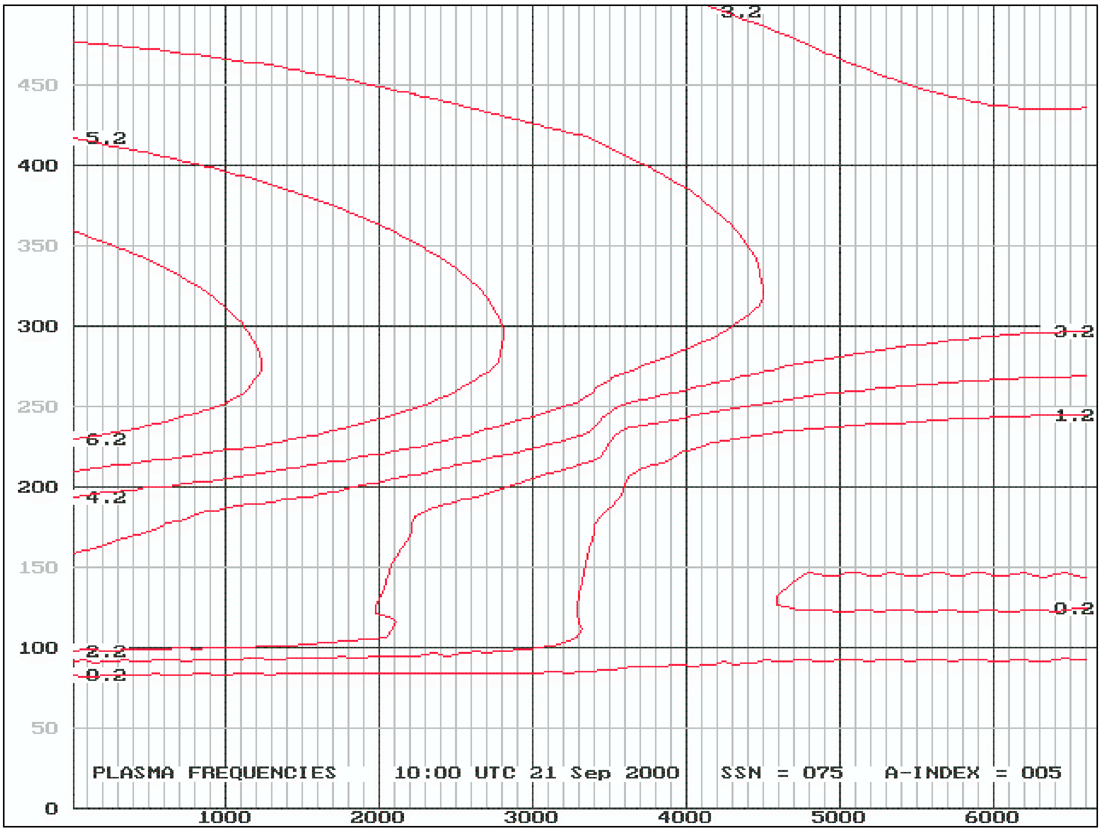
Map 7.9 *Southern hemisphere foF2, June 21 at 10:00 UTC.*



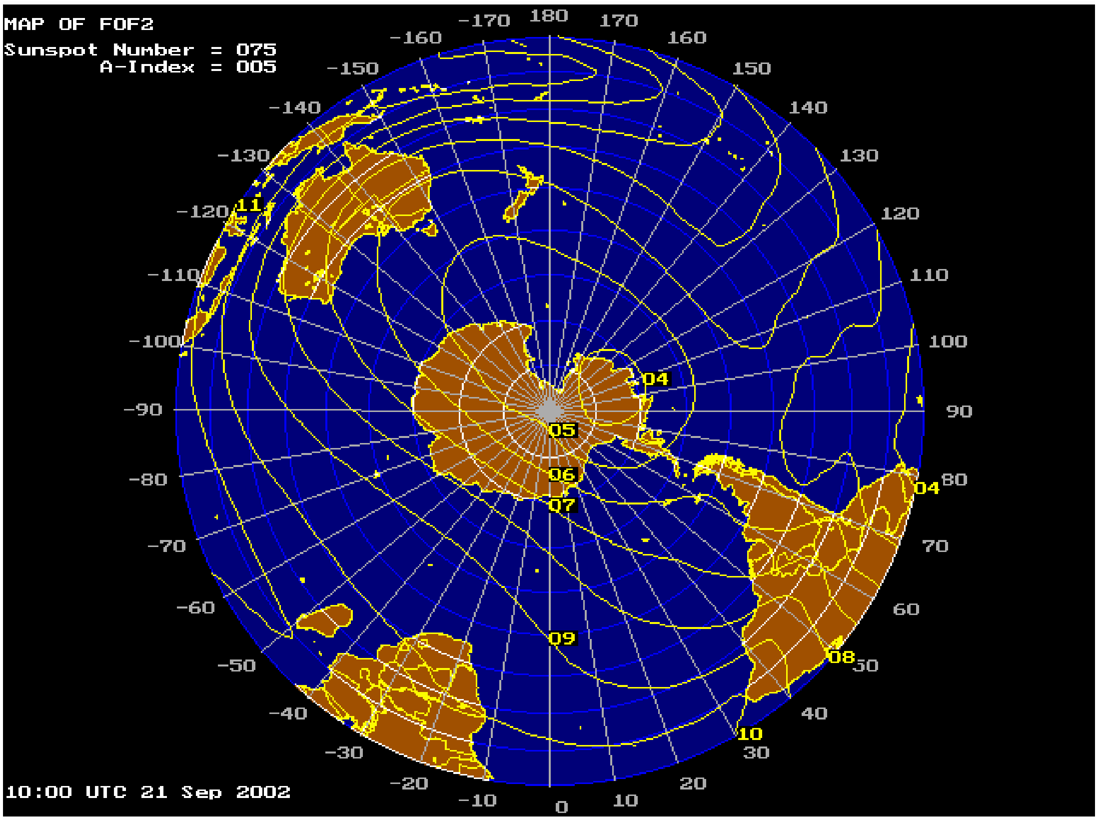
Map 7.10 *Transverse frequencies map, June 21 at 10:00 UTC.*
Slice from location 30 N – 30 E to 30 S – 30 E.



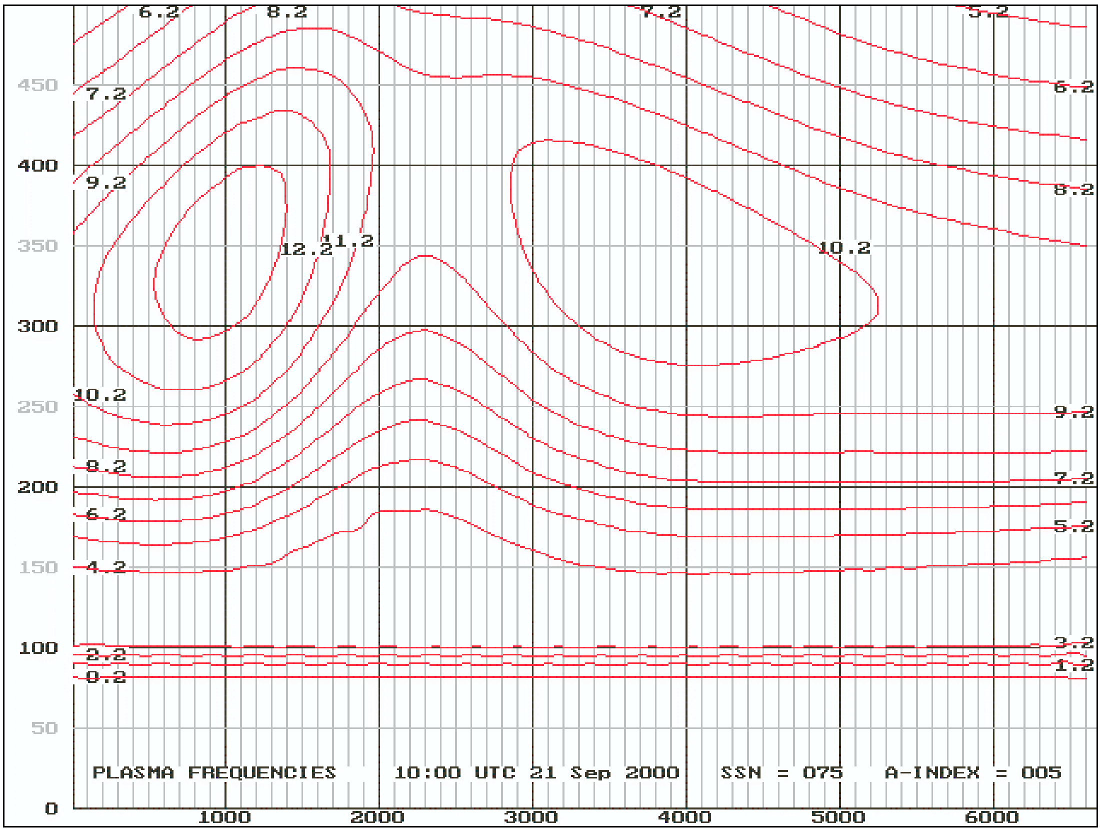
Map 7.11 *Northern hemisphere foF2, September 21 at 10:00 UTC.*



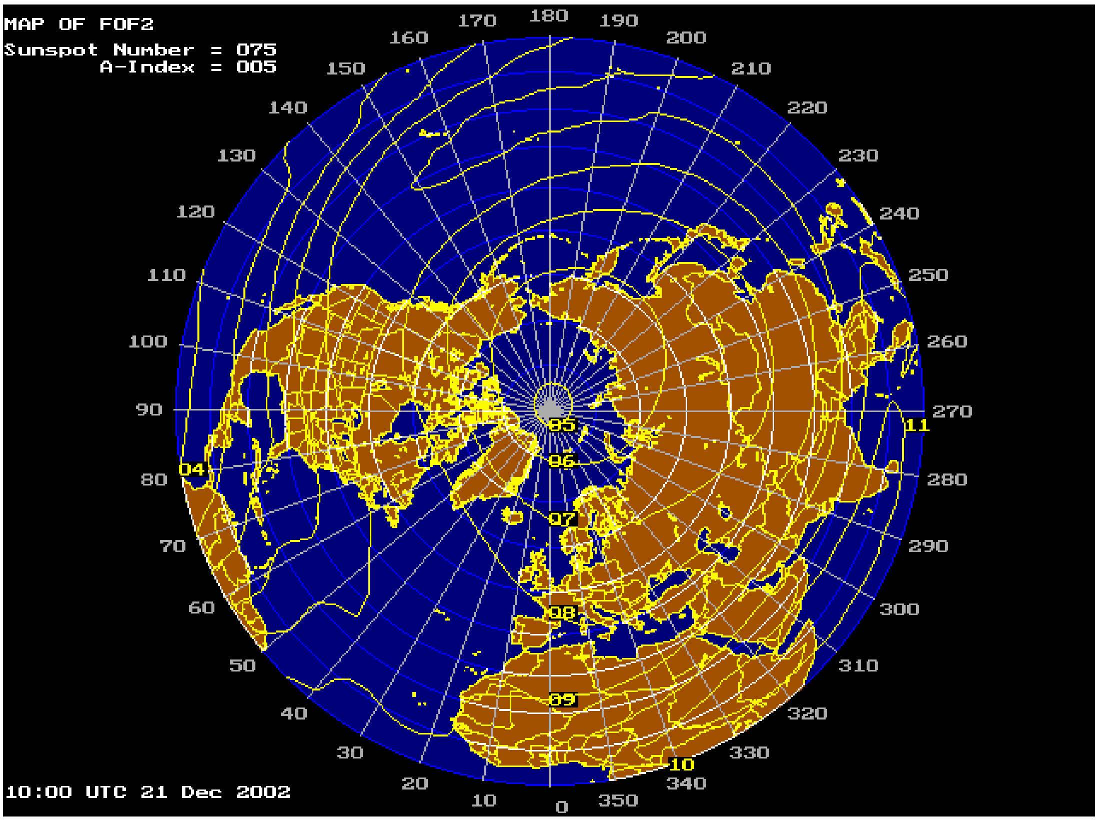
Map 7.12 *Transverse frequencies map, September 21 at 10:00 UTC.*
Slice from location 30 N – 30 E to 30 N – 150 W.



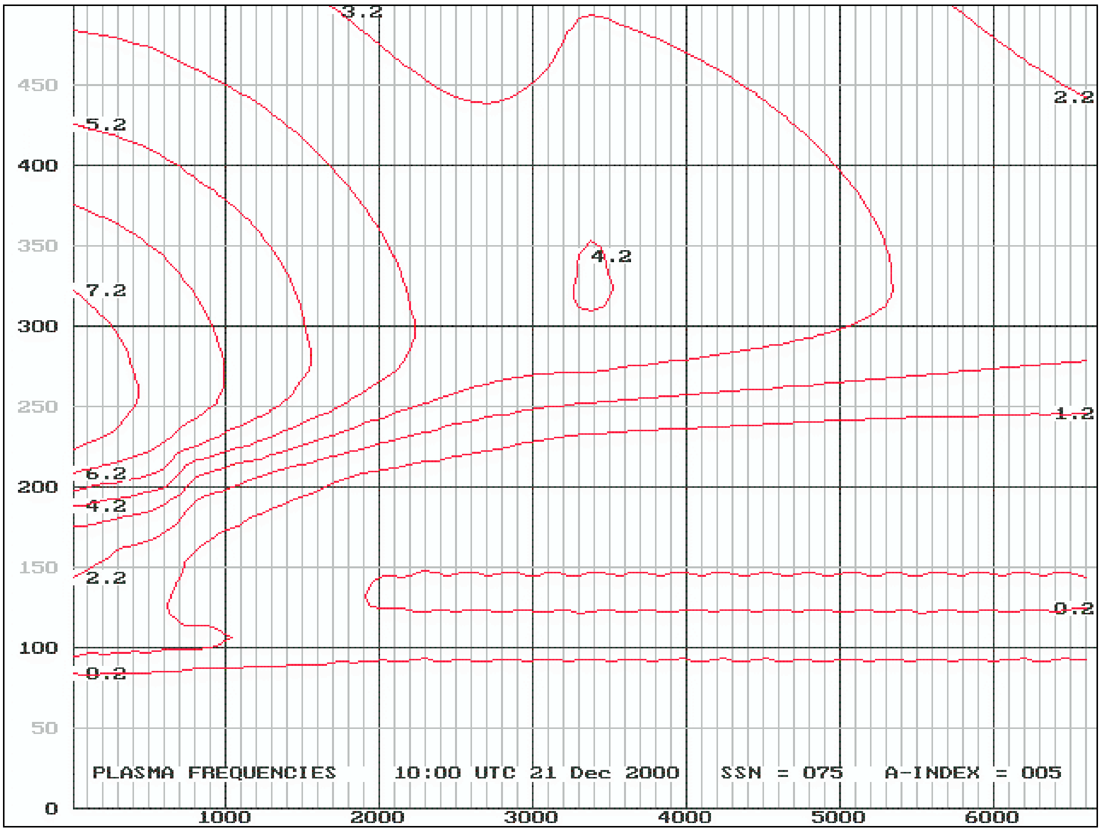
Map 7.13 *Southern hemisphere foF2, September 21 at 10:00 UTC.*



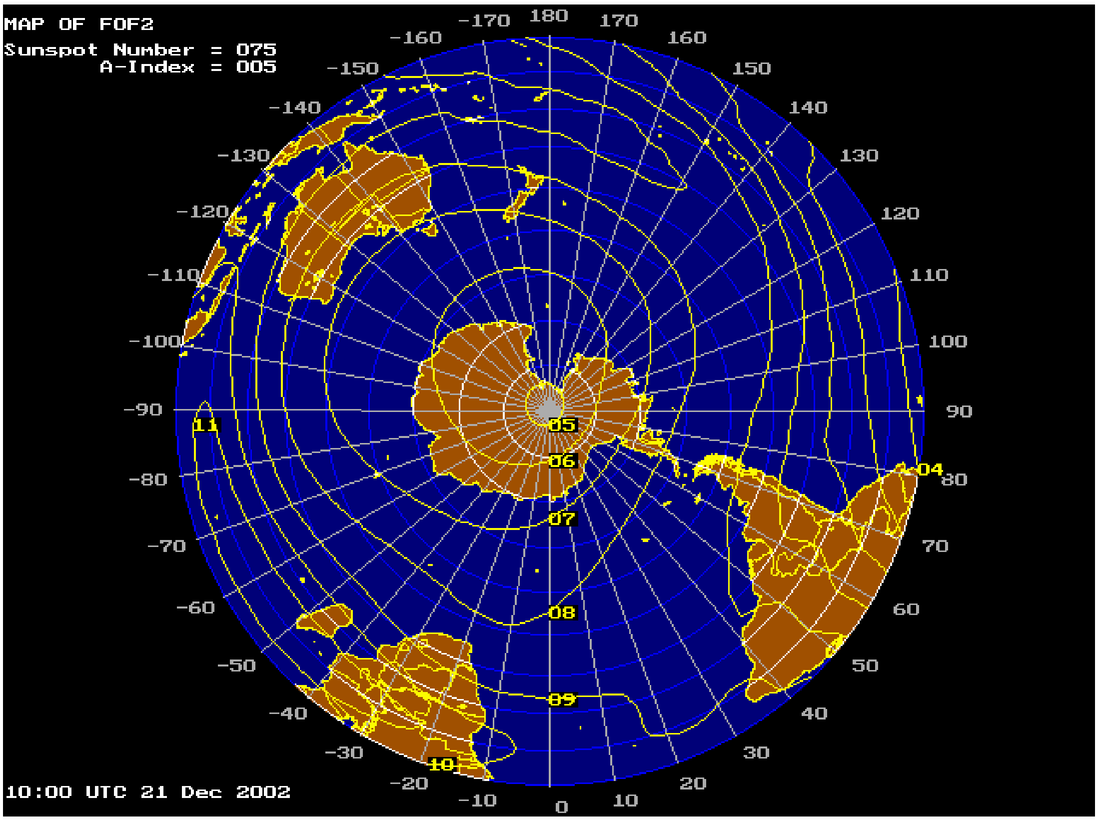
Map 7.14 *Transverse frequencies map, September 21 at 10:00 UTC.*
Slice from location 30 N – 30 E to 30 S – 30 E.



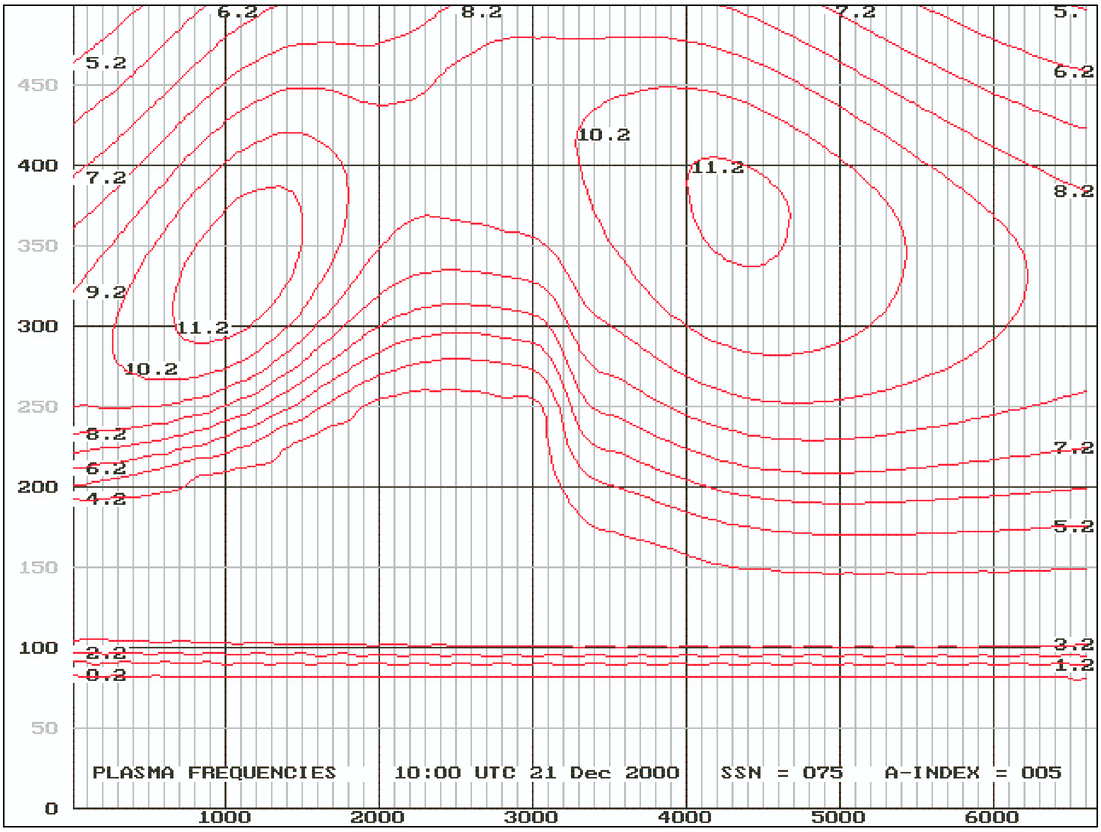
Map 7.15 *Northern hemisphere foF2, December 21 at 10:00 UTC.*



***Map 7.16** Transverse frequencies map, December 21 at 10:00 UTC.*
Slice from location 30 N – 30 E to 30 N – 150 W.



Map 7.17 *Southern hemisphere foF2, December 21 at 10:00 UTC.*



Map 7.18 *Transverse frequencies map, December 21 at 10:00 UTC.*
Slice from location 30 N – 30 E to 30 S – 30 E.

SUMMARY about Anomalies findings

Polar Anomaly and (Partly) Seasonal Anomaly

North Pole critical frequencies F2-layer (foF2). Time 10:00 UTC, Midday.

March	night zone = 4 MHz	day zone = 6 to 7 MHz
June	low sun zenith = 2 MHz	highest sun zenith = 4 to 5 MHz
September	night zone = 4 MHz	day zone = 6 to 7 MHz
December	Polar night = 5 to 7 MHz	

South Pole critical frequencies F2-layer (foF2). Time 10:00 UTC, Midday.

March	night zone = 4 MHz	day zone 6 to 7 MHz
June	Polar night = 2 to 5 MHz	
September	night zone = 4 MHz	day zone 6 to 7 MHz
December	low sun zenith = 5 MHz	high sun zenith = 6 to 7 MHz

In the equinox periods, March and September, we find a minimum foF2 of 4 MHz on the night-side and 6 to 7 MHz on the dayside of the globe. These values are similar at both North and South polar zones. **Note:** the March equinox is sometimes named the **Vernal equinox** and the September one the **Autumnal equinox.**

During the solstice on 21 June period (the Northern hemisphere Summer and the Southern hemisphere Winter), you notice a foF2 of 2 MHz to 5 MHz. Even in the South Pole zone, with its polar night at this period, we have an unexpectedly high foF2 value.

During the solstice on 21 December period (the Northern hemisphere Winter and the Southern hemisphere Summer), you notice a foF2 of 5 MHz to 7 MHz. Even in the North Pole zone, with its polar night at this period, we have an unexpectedly high foF2 value. Another eye catcher is this one: a much higher foF2 at the December solstice period, about 2 MHz higher compared to the June solstice period. This phenomenon is noticeable at both poles. It might look strange and unexpected, but even with no direct sunlight or rays during Polar nights, we have a rather high ionization level.

Earth Magnetic Anomaly and (Partly) Seasonal Anomaly

You might expect the highest ionized levels at the highest sun zenith region. (These regions are located right above the equator at the equinoxes and, respectively, 23° 27’ north or south from the equator at the solstices.) ***But this is not the case.*** Instead you find two distinctly higher ionized zones (belts). One is north and one is south of the equator, no matter the date. Only a slightly ionized belt migration is noticed at the different dates.

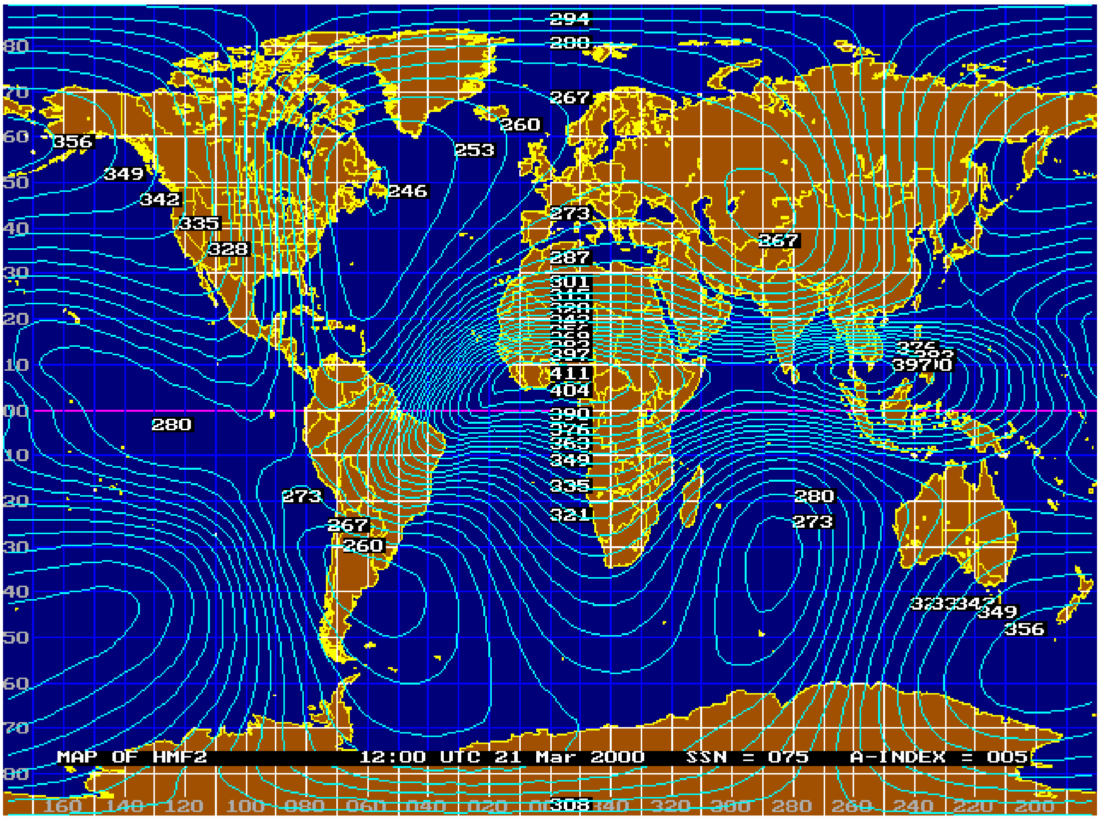
Equator zone critical frequencies F2-layer (foF2). Time 10:00 UTC, Midday

March	North belt ±13 MHz	South belt ±12 MHz
June	North belt ±10 MHz	South belt ±10 MHz
September	North belt ±12 MHz	South belt ±10 MHz
December	North belt ±11 MHz	South belt ±11 MHz

The highest ionization levels of the distinct belts north and south of the equator occur around the equinox periods. This phenomenon sounds normal, because the sun zenith is then equally right above both belt zones. Strange is the nearly equal ionization of both belts at the two solstice periods. We would expect that, at the June solstice, the belt situated north of the equator should be much more highly ionized and, at the December solstice, the belt situated south of the equator, because the sun zenith is then respectively right above them.

At the December solstice period, again you notice a higher ionization than at the June solstice period. If you didn’t re-read the F-layer anomalies description in column 4, it is to do so now.

F2 – Layer Height Maximum Maps



Map 7.19 *hmF2 21 March at 12:00 UTC.*

hmF2 maps indicate the altitude above the earth's surface where the ionosphere electron density reaches a maximum. This region is known as the height maximum of the F2-layer. It is given in kilometers above the earth surface.

The higher the altitude of the F2 layer maximum density, the further the distance our signal can propagate if the ionization density level qualifies to refract our used frequency. These maps can be used as a guide to help determine the region that will permit propagation to the greatest distances. For example, signals that pass through the equatorial regions, where the hmF2 is rather high, may easily travel much further than in lower height regions elsewhere. These maps are also very useful in searching for where the ionosphere is tilted. Tilted ionosphere regions exit wherever the gradient (spacing between the contour lines) is the greatest (contours lines closer together). When signals pass through these tilted regions, they certainly experience non-great-circle propagation and may end up at locations that are a great distance away from the intended target point.

Signals traveling parallel to the hmF2 contours will experience non-great-circle propagation. The crooked path will intensify as the gradient increases. Signals that travel perpendicular to the hmF2 contours will not suffer much non-great-circle deviation, but may enter into “chordal” hops or inter-layer ducting propagation modes. These strange propagation modes depend on the tilt gradient, the signal frequency and the angle of incidence. The ordinary and the extraordinary waves will follow completely different paths and cause the mentioned chordal hops and inter-layer ducting. These propagating possibilities can give amazing and odd DX openings. To ensure the greatest probability of conventional great circle propagation, one should seek the path where the hmF2 contours gradients are the farthest apart and do not curve or turn very much.

Again some technical jargon has sneaked into the discussion. We have encountered terms such as *terminator*, *grayline*, *twilight zone* or *grayline zone, radio auroral zones*, *MUF, chordal hop, interlayer ducting, path deviations, great* and *non-great-circle paths, ordinary* and *extraordinary waves,* etc. All this will be handled in the forthcoming columns. Stay tuned.

This monthly column downloadable Wizards and PDF documents.

Transverse Plasma Frequency Map's during 24 hours. N60 E30 – N60 W150 North Pole zone circuit. March 21	**Size: 1.328 Mb 573 kb**	**CLICK. Wiz07a Doc07a**
Transverse Plasma Frequency Map's during 24 hours. N30 E30 – S30 E30 Equator zone circuit. March 21	**1.500 Mb 631 kb**	**Wiz07b Doc07b**

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