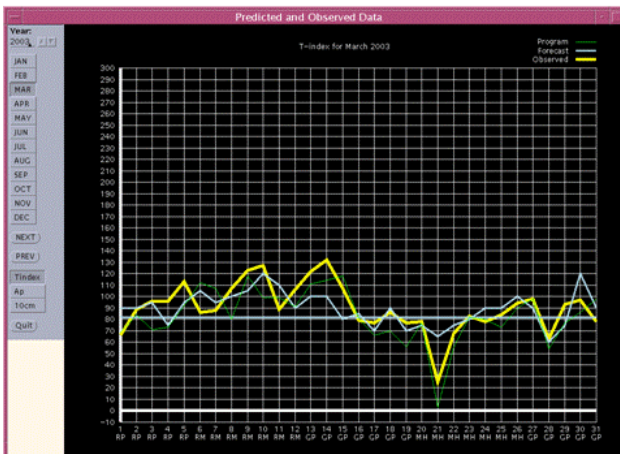


Why do we want to map foF2 in near real time?

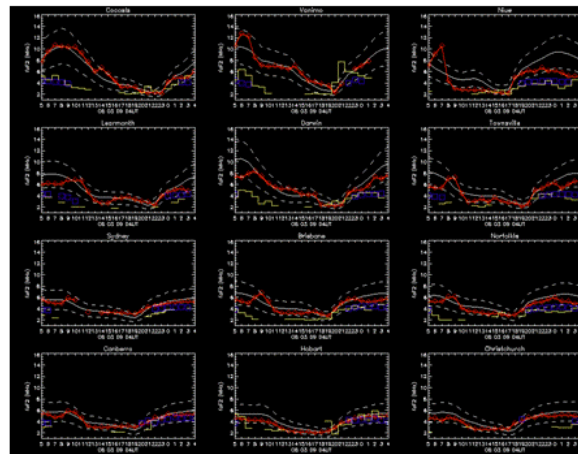
Ionospheric storms

One of the benefits of real time measurement and mapping of the ionosphere is to increase the availability of HF communication to IPS customers, particularly during storm conditions, when the frequency of support for HF communication can be very different (both depressions and enhancements) from what is normally used.

The amount of ionospheric departure is usually measured relative to some average or median value, using either an ionospheric index or foF2 values.



IPS ionospheric T-index for March 2003. Note the low index value on March 21.



foF2 values from IPSNET stations for March 08, 2009, showing enhancements and depressions.

At mid latitudes ionospheric storms tend to follow geomagnetic storms, and usually have a depression response. Frequency depressions are of more significance than enhancements to the HF operator. Low latitude ionospheric conditions are extremely hard to predict.

IPS Quiet World Maps

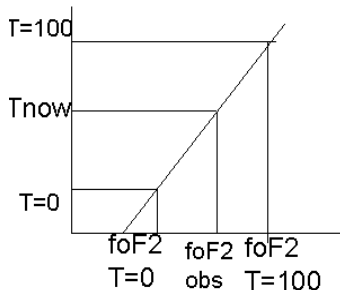
- IPS has monthly “quiet” world maps of foF2. A world map of foF2 exists for each UT hour (24) and month (12), and for two levels of ionospheric effective sunspot number (the IPS T index, Turner 1968) $T = 0$ and $T = 100$, giving $24 \times 12 \times 2 = 576$ maps. These maps were constructed from over 30 years of ionospheric data. By interpolation or extrapolation these maps provide a relationship between foF2 and T index at any location in the world. By using a T index that indicates the current level of ionospheric support, a world map of foF2 for the current UT hour can be produced. However, this map will not contain storm gradients.
- IPS uses the “quiet” maps and a monthly forecast T-index (for a solar cycle) as a reference for real time foF2 variation.



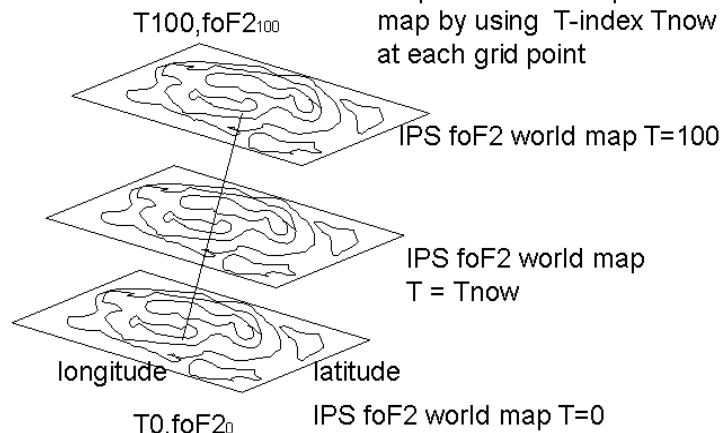
Constructing an IPS “quiet” world map for a given UT hour using the ionospheric T-index derived from an observed foF2 value at some location

Step 1. Extract $(T_0, foF2_0)$ and $(T_{100}, foF2_{100})$ from the IPS world maps at the ionosonde station location

Step 2. Convert observed foF2 to T index (T_{now}) at the ionosonde station location



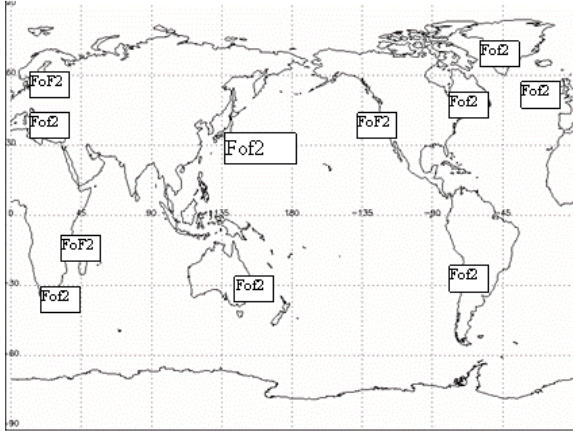
Step 3. Create interpolated map by using T-index T_{now} at each grid point



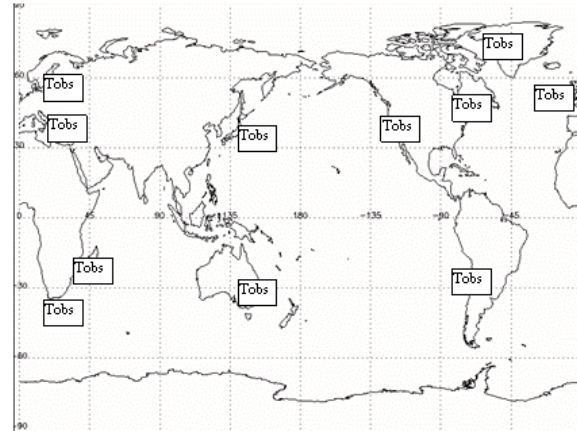
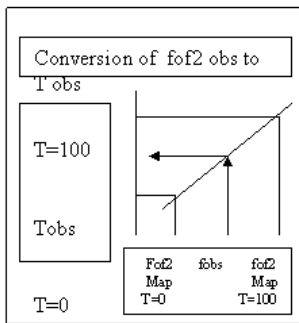
Constructing a real time ionospheric map for a given UT hour

- **IPS Real Time World maps**
- To attempt to follow storm gradients a different T index is used for each grid point. This allows distortion of the IPS “quiet” map.
- The real time mapping process is as follows:
 1. Using the IPS quiet world maps each contributing station foF2 is converted to its equivalent station T-index value for the UT hour, date and location.
 2. The individual station T-indices form an irregularly gridded array over the world. The programming language IDL “krig2D” routine is used to turn the irregular gridded T-indices into a regular grid of T-indices.
 3. This regular grid of T-indices and the IPS quiet world maps are used to produce a regular grid of foF2 values.
 4. These foF2 values are then contoured.
- **Gradient controls in the real time map production**
- To control gradients the following rules were imposed on the output:
- For middle latitudes, the world is divided into sectors. For each sector a median T index is produced from the contributing station T index values. If a station T-index is more than 80 T-index units above this median it is rejected. (foEs contamination)
- Interpolated T-index values were not allowed to be greater/less than the contributing maximum/minimum of the station T-indices.
- For the daylight sector, foF2 was not allowed to be less than the calculated foF1 at that grid point location.

IPS Real Time World Maps



For each station convert the observed station foF2 into an observed effective sunspot number . This gives an irregular grid of T-index values.



Equivalent observed T index values at each station location for a given UT hour

Why perform gridding in T-index?

- By using the T-index the underlying structure of the IPS “quiet” world maps is included. For example if gridding was performed with just one stations contributing foF2 value, the resulting gridded data will contain all the same foF2 value, which is unrealistic. If the equivalent station T-index is used, the T-index is the same everywhere, but by using the IPS “quiet” maps and the T-index at each grid point location, a different foF2 is produced at each grid point location, which is a more realistic result. This map is effectively a “quiet” world map of foF2. The more stations that contribute to the mapping process the more you are able to track storm gradients, as contributing station T-indices can become very different during ionospheric storms. This approach provides robustness with a varying number of contributing stations which is a likely situation with real time operation. However, the fewer the number of stations the more the real time map will resemble a “quiet” map.