Australian Government
IPS Radio and Space Services

Space Weather and Radio Communications – Part Two

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Ionospheric Prediction and HF frequency management

In the previous section of this article, HF radio communications via the ionosphere were discussed and the connection between the sun and the ionosphere established. It was seen how the ionosphere is created by solar radiation and also how solar events can regularly disrupt radio communications which rely on the ionosphere.

One could be forgiven for thinking that with so many cataclysmic solar events going on and their effects on the ionosphere that HF is impractical. Fortunately, solar events that disrupt HF communications are not every day occurrences, happening on perhaps one hundred days per 11 year solar cycle. Events causing severe disruptions lasting for several hours that affect the entire HF spectrum are rarer still, occurring just a dozen or so times per cycle.

With constant observations of the sun-earth environment, disruptive solar events can be largely predicted and warnings and alerts issued in advance. The Australian government agency responsible for monitoring space-weather and issuing regular forecasts and warnings of imminent solar activity is IPS Radio and Space Services.

Predicting Solar Flares

The prediction of large solar flares has traditionally relied on observations of sunspot regions using ground-based telescopes such as at the IPS Solar Observatory located at Culgoora, NSW. At present, ground-based flare prediction is undergoing something of a revolution with new high resolution images of the magnetic field structures of sunspots becoming available. These new images, provided by the GONG project of which the IPS/USAF Learmonth Solar Observatory is a participant, provide new insights into the detailed magnetic behaviour of sunspots. Space-weather agencies such as IPS along with solar researchers expect that by analysing the solar flares of the coming cycle with these new insights, we will be able to even better predict the size and timing of major flare events.

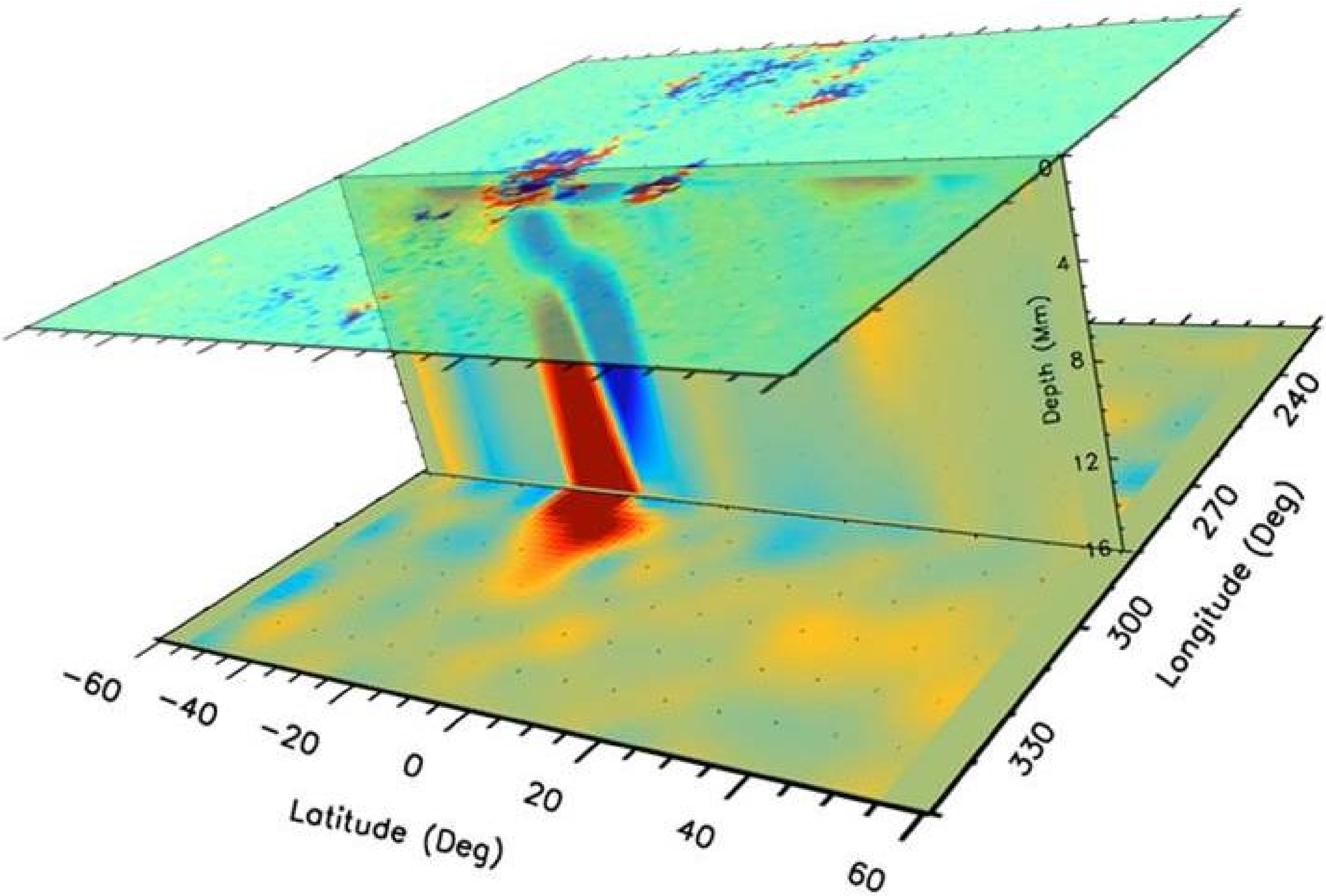

Figure Three: 3D image of plasma underlying 2 sunspots in close proximity showing tornado-like vorticity patterns with opposing senses. Such patterns are observed beneath every sunspot region which produces very large X-ray flares. Courtesy of the Global Oscillation Network Group (GONG).

Predicting Ionospheric Disturbances

The response of the ionosphere to a geomagnetic disturbance resulting from a CME or Coronal Hole (see Part One) is called an ionospheric storm. The effect on the ionosphere is complicated and depends on the time of day, the season and the latitude. However, severe geomagnetic storms invariably lead to severe ionospheric storms and depressed HF conditions.

During an ionospheric storm HF communication is likely to experience the greatest problems at higher latitudes (away from the equator). This is also where the well known ionospheric phenomena, the Aurora, is to be seen during an ionospheric storm. The greater the disturbance, the more equator-ward HF communication problems (and the Aurora) are experienced.

IPS Solar observatories located in outback NSW and WA monitor solar radio emissions to provide critical information such as the velocity of CMEs and the distribution of solar RF interference. IPS uses this information along with observations from ground based magnetic observing stations, NASA satellite-based solar wind data and many years of experience to predict the location, intensity and duration of ionospheric storms. With continual advances in satellite based observations of the sun-earth environment, such as the recent NASA STEREO program and the growing body of ionospheric data and models, ionospheric predictions for radio communicators have become very reliable and refined over the last 20 years.

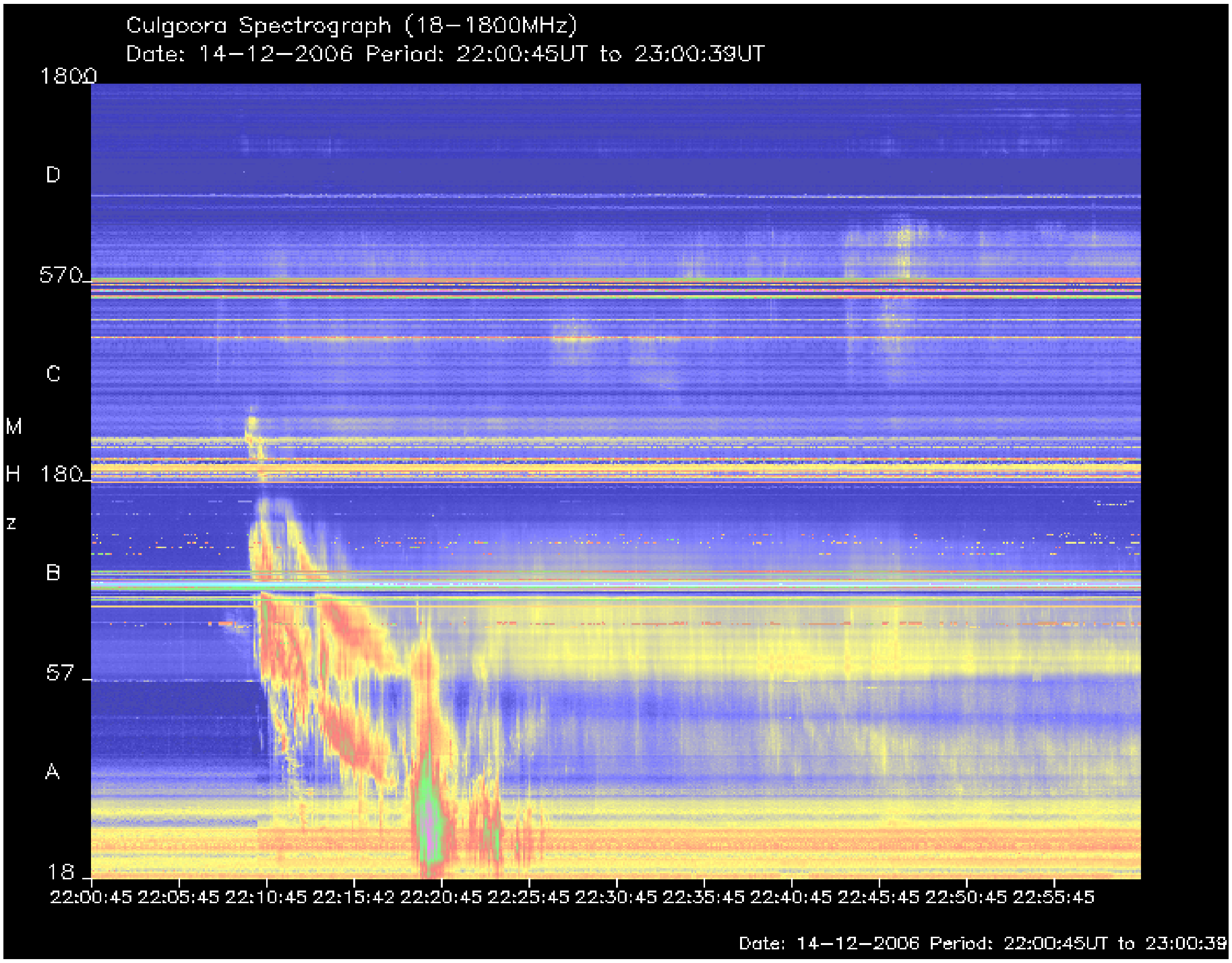

Figure Four: Radio emission burst highly characteristic of a CME moving through the solar atmosphere. The speed of the CME can be estimated from the slope of the radio burst. IPS Culgoora Solar Observatory, NSW.

Ionospheric monitoring and HF frequency management

Perhaps of greatest value, however, to the regular HF communicator is day-to-day frequency selection in response to the ever-changing conditions in the ionosphere. While the solar cycle and solar events are very important in determining the frequencies supported by the ionosphere, equally large variations are observed with latitude, with the seasons and throughout the day and night.

IPS operates a large network of ionosondes located throughout Australia, Antarctica, PNG and the Pacific which constantly ‘sound’ the ionosphere. Ionosondes produce an “ionogram” showing the range of frequencies reflected vertically by the ionosphere and the altitude they are reflected from.

Using real-time and historical ionospheric data in conjunction with sophisticated HF propagation models IPS is able to provide detailed HF frequency guides for any communication circuit at any time of the day or night. Predictions of optimum usable frequencies are offered in real-time or predicted in advance and are freely available online.

One of the most popular IPS frequency guides is the HAP chart (Hourly Area Prediction), which gives the best HF frequency to use from any location into any area of the globe specified. HAP charts are available in real-time based on current observed conditions, or in advance with conditions predicted days, months or (with declining confidence) even years in advance, for any hour of the day.

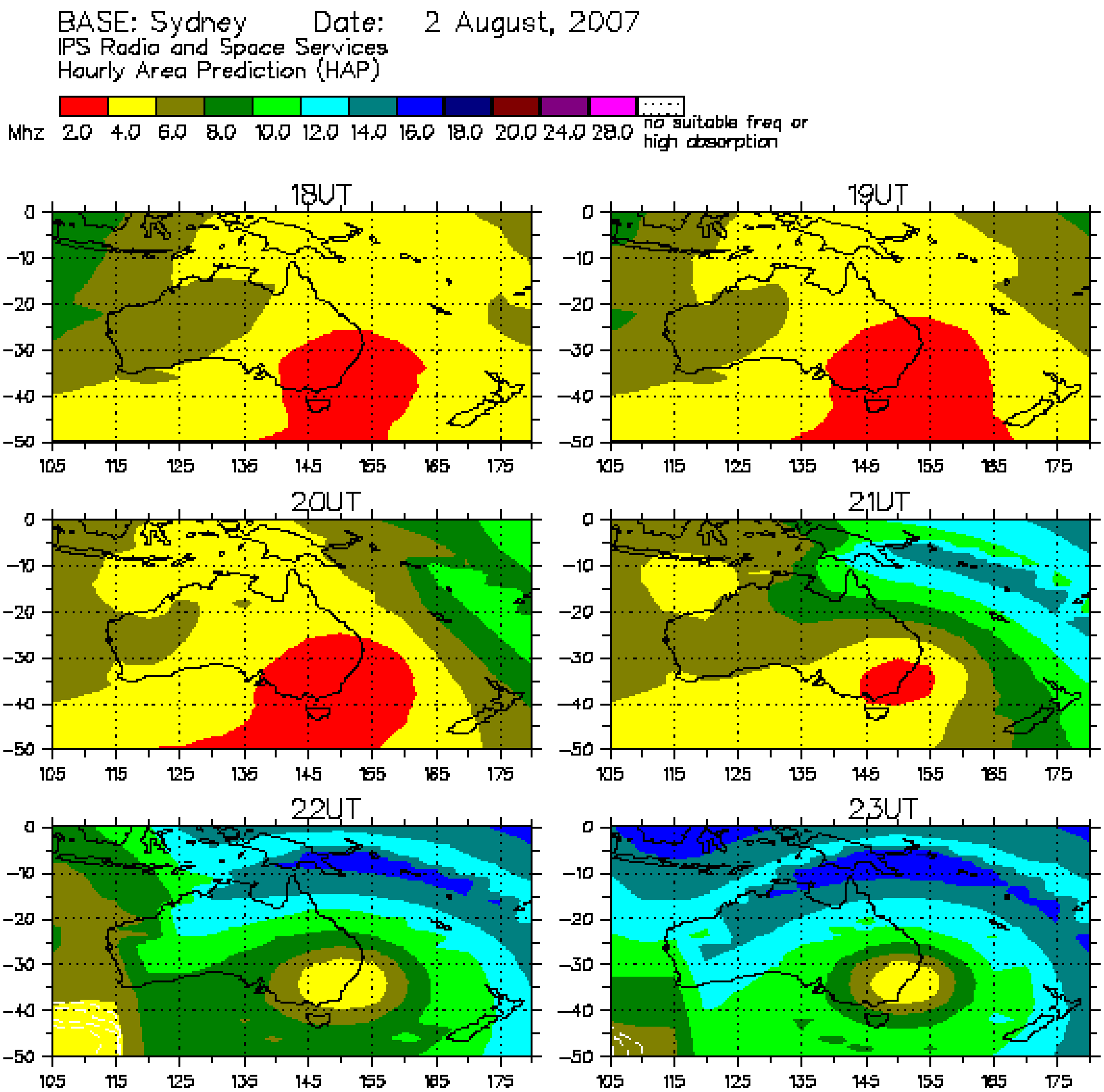

Figure Five: Daily HAP chart predictions showing optimum frequencies for HF communications between Sydney and anywhere in the Australasian region. For example, at 23 UT: for Sydney-Tasmania 8 MHz is recommended while for Sydney-Cape York, 14 or 16 MHz is recommended. Note the rapid change in the ionosphere around dawn (around 20 UT).

Other IPS on-line products can provide a more detailed frequency guide once a circuit is specified. URSL predictions are simple to use, giving upper (U), recommended (R), secondary (S) and lowest (L) frequencies for a given circuit. GRAFEX predictions provide much more detail. Frequencies for different propagation modes via E, F1 and F2 layers and lower limits due to D region absorption are given, for every hour of the day; sufficient information for a knowledgeable HF operator to communicate reliably and confidently at any hour of the day.

The products mentioned above are available online through the IPS website. IPS has also developed two commercial software packages for HF communications engineers; ASAPS and GWPS. ASAPS (Advanced Stand Alone Prediction System) incorporates all the features of the HF predictions described above while allowing inclusion of specific transmitting and receiving antenna specifications for field strength and SNR calculations. GWPS (Ground Wave Prediction System) is for predictions of HF propagation via *ground-wave* only. It includes transmitting and receiving antenna specification and transmitter power and makes detailed predictions of range and receiver field strength for different levels of man-made noise.

Space weather effects on GPS and Satellite Communications

While GHz signals such as those used in GPS systems pass straight through the ionosphere, they suffer a time delay as a result of the presence of so many free electrons. This typically results in positional errors of 5 to 10 metres, which can increase to many tens of meters under extreme ionospheric conditions.

IPS produces detailed world maps of Total Electron Count (TEC) which are indicative of the expected time delay and are able to be used by satellite operators and GPS receivers to make positional corrections for the ionosphere.

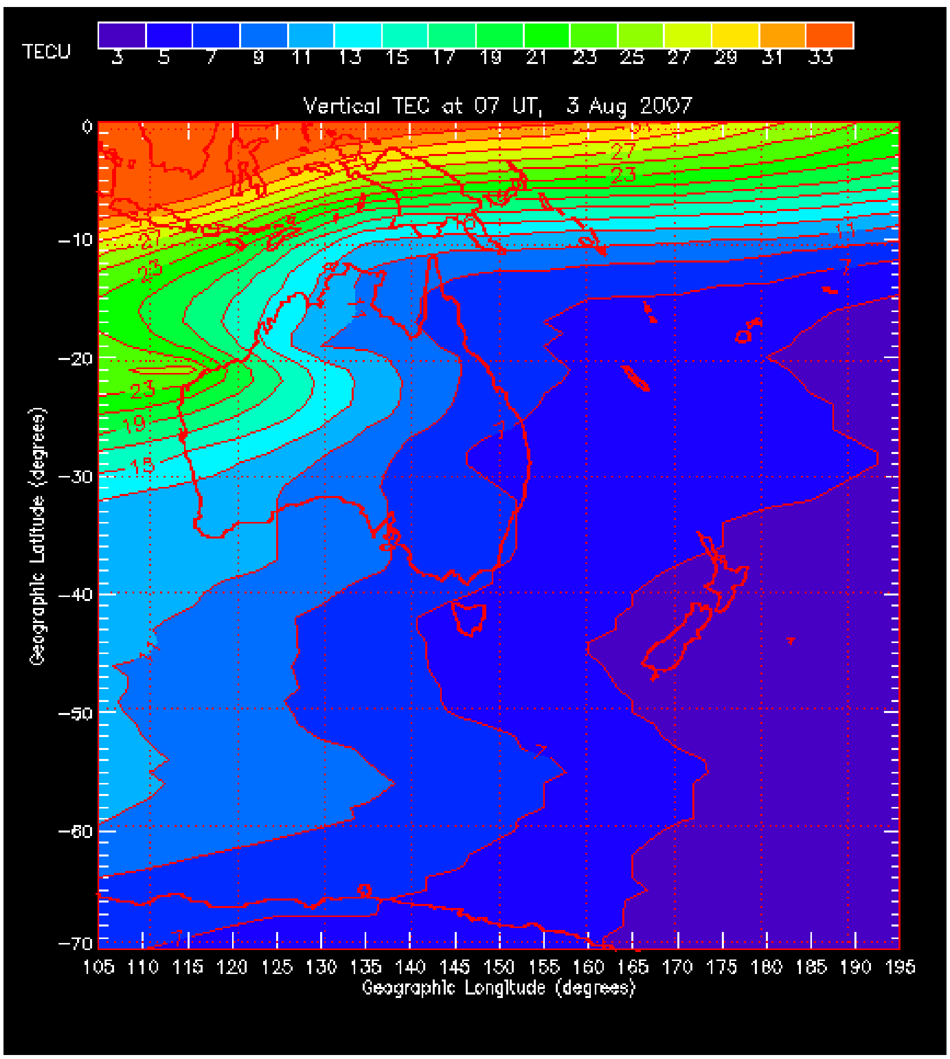

Figure Six: Australasian map of real-time Total Electron Count (TEC).

The Future of HF and Space-Weather Monitoring

With the development of digital HF mobiles able to provide email and internet connections, HF appears to be undergoing something of a resurgence. HF communication via the ionosphere is free and with proper frequency management, HF can provide reliable long distance communications 24 hours a day.

With the increasing dependence on satellite-based navigation systems such as GPS, which are vulnerable to large solar and ionospheric disturbances, space-weather alert systems will be increasingly important in the future.

IPS Radio and Space Services continues to develop space-weather and ionospheric forecasting and is committed to providing new services that meet the demands of the changing communications environment. IPS welcomes any enquiries about the sun and its effects on the earth and about the services we provide in support of HF communications and space-weather.

IPS Radio and Space Services
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