

New Service Developments at IPS Radio and Space Services

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ABSTRACT: The focus of IPS Radio and Space Services (IPS) has shifted from long-term planning to real-time forecasting. On-line predictions are now possible via the Internet, utilising real-time ionospheric data instead of median models. IPS is developing software tools to assist frequency managers to produce frequency lists for the various major communications tasks; building a network of variometers, from which real-time data on the state of the geomagnetic field in the Australian region are obtained to assist aeromagnetic surveyors; and is collecting GPS/TEC/scintillation data to provide range error estimates for satellite navigation equipment. Also, IPS is in the final stage of becoming a World Data Centre for Solar-Terrestrial Science.

Introduction

For over 50 years, IPS Radio and Space Services (IPS) of the Australian Department of Industry Science and Resources (ISR) has been assisting radio communicators to optimise the probability of successfully transmitting radio messages via the ionosphere. Traditionally, IPS issued long-term planning predictions in many formats, which helped frequency managers to select the best usable frequency for any situation. During the last decade, the focus has shifted to real-time forecasting, based on data obtained in near real-time from an extensive network of ionospheric stations. On-line, do-it-yourself, skywave predictions are now possible via the Internet, using either median models or real-time ionospheric conditions.

For future services, the main area that IPS is working on is the development of software tools that will make it easier for frequency managers to produce frequency lists for the various major communications tasks, such as routine HF communications, direction finding, large area surveillance, and measures for protecting the secure transfer of messages.

IPS also provides timely geophysical and space weather advice. In cooperation with Antarctic Division and the Australian Geological Survey Organisation (AGSO), IPS is building a network of variometers, from which real-time data on the state of the geomagnetic field in the Australian region are obtained to assist aeromagnetic surveyors. In cooperation with AUSLIG (Australia's national mapping agency) and DSTO (Defence Science and Technology Organisation), IPS is collecting GPS/TEC/scintillation data to provide range error estimates for satellite navigation equipment. Most recently, IPS is in the final stage of becoming a World Data Centre for Solar-Terrestrial Science.

Traditional Services

The traditional services that IPS has been providing for several years include:

- ❖ *Services delivered over the Internet through our web site and e-mail subscription lists.* From the IPS homepage (www.ips.gov.au), there are many links to HF prediction services, including "Do-It-Yourself" predictions using real-time data. There are also links to routine daily propagation reports, ionospheric data, disturbance warnings and Short Wave Fadeout (SWF) information.
- ❖ *Routine monthly or quarterly HF predictions delivered by ordinary mail.* Several hundred customers subscribe to a range of monthly or quarterly HF long-term prediction services.

As more of these monthly services are becoming accessible via the IPS web site, more of our subscription customers are adopting these on-line services.

- ❖ *Frequency management software tools.* IPS offers three Commercial-Off-The-Shelf (COTS) software packages to help radio system operators and designers:
 - The IPS Advanced Stand Alone Prediction System (ASAPS) for skywave propagation at HF to low-VHF.
 - The IPS Ground Wave Prediction System (GWPS) for groundwave propagation at VLF to low-VHF.
 - The IPS Autoscale program automatically scales digital vertical incidence ionograms.
- ❖ *Training.* IPS presents courses on the theory of ionospheric propagation and how to make best use of our prediction services, including a tutorial on the use of ASAPS. These are conducted around Australia every one or two years.
- ❖ *Consultancy tasks in support of major communications projects.* IPS has been involved over many years in a range of consultancy tasks in support of major communications projects. Some of these relate to highly sensitive and expensive projects. By far the biggest consultancy task undertaken by IPS to date was a group of studies in connection with the DEFCOMSTA project, also known as Joint Project 2043, HFMOD or the Modernised HF Communication System (MHFCS).

New Software

ASAPS remains an important tool for skywave frequency management. The “ASAPS kernel” is also available as a callable pipeline function, in the form of a Dynamic Link Library, which can be linked to the user’s own software. The current version of ASAPS (Version 4.0) was developed for Microsoft Windows 3.11. The soon to be released ASAPS V5.0 will be a 32-bit version for Windows 95/98/2000 or NT. This will improve the execution speed by a factor of 2 or 3; be better able to handle very large 3D antenna files; and incorporate several new options.

A new version of GWPS was released in February. It now produces plots of electric field strength vs range and allows for batch mode processing.

Data from the IPSNET of ionospheric stations, and from many overseas stations, are used to generate a real-time ionospheric model (RTIM), which is used for our on-line real-time predictions. A modified version of ASAPS is being developed to access RTIM data from the IPS webpages.

New Service Developments

There are several new services under development.

- ❖ *Prediction software.* The ionospheric propagation model for ASAPS considers the ionosphere only at the sky-reflection points and assumes symmetrical paths, that is, the radiowaves follow undeviated ray paths between the earth and the ionosphere. However, the presence of electron density gradients at low latitudes can lead to non-symmetric paths.

To refine the ionospheric predictions, Dr. Didier Monselesan is developing a new computer program, called IPSRAY, based on the ray tracing technique. IPSRAY allows for refraction (or bending) of the rays due to gradients in the ionospheric profiles, as well as for variations in the profiles themselves along the path of the radiowave.

Figure 1 is a sample of HF radio paths predicted by IPSRAY through ionospheric gradients typically encountered over the south-north path between Sydney, Australia and Seoul, Korea. It shows the effect of gradients across the equatorial anomaly on radio waves of 15 MHz launched at elevations ranging from 2 to 30 degrees in 2-degree steps. The plotting projection is that of a flat earth. Note the two chordal trajectories (ricocheting rays) on the northern side of the anomaly at 3500-6000 km.

- ❖ *Geomagnetic micropulsations.* Geomagnetic micropulsations are ultra-low-frequency (ULF) electromagnetic waves, which originate in interplanetary space and the magnetosphere. Geophysical prospectors treat these pulsations as a nuisance when undertaking aeromagnetic surveys, since they can be mistaken as signatures of mineral or petroleum deposits.

Dr. Richard Marshall is establishing a network of variometers in the Australian region to provide a geomagnetic pulsation service that is aimed at supplying real-time and forecast information on geomagnetic micropulsations. Currently, the network consists of two IPS magnetometers at Townsville and Hobart, a Japanese STEL magnetometer at Canberra, an AGSO magnetometer at Learmonth and an Antarctic Division magnetometer at Davis. Later this year, two more IPS magnetometers will be installed at Darwin and Sydney. The Sydney one will send its data in real-time, whereas the others download data every hour (every half-hour from Learmonth).

Figure 2 is an example of a time series of filtered magnetometer data recorded in Canberra. It shows typical pc3 pulsation signals for the H and D geomagnetic components. The data are filtered over the pc3 pulsation frequency range of 10-45 seconds.

An RMS index is generated from 20-minute intervals of such data and used as an indicator of pc3 pulsation activity.

- ❖ *GPS/TEC/scintillations.* The Global Positioning System (GPS) is a radio navigation system, which uses a set of over 24 orbiting satellites that transmit radio timing signals. Suitable receivers can measure the time that the radio signals take to arrive from different satellites. Since the transmission times of the satellites are co-ordinated, the receiver can work out, with a small computer, its own position and speed. The system should be accurate in three dimensions to within a few metres, being limited by the uncertainty in the time delay due to the effects of the ionosphere. These time delays can be determined from observations of the Total Electron Content (TEC) of the ionosphere.

Dr. Junhu Du is developing a system for generating real-time maps of TEC, which can be used to correct the GPS time measurements for the extra ionospheric delay. TEC data are obtained:

- in real-time from an IPS dual-frequency GPS receiver at the IPS Culgoora solar observatory;
- hourly from the conversion of the foF2 regional maps into TEC maps through the IRI model;
- daily from Australian GPS stations operated by AUSLIG (another branch of ISR); and
- fortnightly from the IPS station at Vanimo in Papua New Guinea.

Figure 3 is an example of real-time TEC maps generated from the IRI model using observed regional foF2 data. The top map is for the current UT hour and the bottom map

is for the same hour on the previous day. Any major differences between these two maps would indicate the presence of an ionospheric disturbance.

Dr. Du is also investigating “scintillations” on satellite transmissions, which are rapid and large changes in the amplitude and phase of the satellite signals. Scintillations can cause a satellite receiver to “lose lock” on satellites. Scintillation data are obtained from an Ionospheric Scintillation Monitor (ISM), which belongs to the USAF but is on loan to DSTO and is maintained by IPS staff at Vanimo. An accompanying paper by Du et al. [1] describes a method of estimating the scintillation index S_4 from dual-frequency GPS measurements.

- ❖ *World Data Centre for Solar-Terrestrial Science.* During 1999, IPS applied to the Panel for World Data Centers to become a World Data Centre for Solar-Terrestrial Science. The application was very well received by the Panel at its meeting in Birmingham in July 1999. After a formal inspection of IPS facilities by the Panel representatives in February 2000, the application was approved and IPS became the first World Data Centre in the southern hemisphere. The IPS status as a World Data Centre formally recognises the fact that IPS already has a major role in the archiving of solar-terrestrial data. This activity is set to expand as the new centre develops.

As a World Data Centre, IPS will gain greater access to data, which is the lifeblood of its space weather services, and will make all these data available in Australia. The role is also important in that it enhances the already good reputation that IPS has in the international scientific community.

Summary

IPS is proud to help our customers overcome their technical problems through our services. We will continue to extend our existing services and to develop new services to better serve our customers. Our latest developments include a raytracing capability for predicting radio paths through a non-ideal ionosphere; a geomagnetic pulsation service for geophysical prospectors; TEC and scintillation measurements for users of satellite communications; and the creation of a World Data Centre for Solar-Terrestrial Science.

References

1. Du, J., J. Caruana, P. Wilkinson, R. Thomas, M. Cervera, Determination of equatorial ionospheric scintillation S_4 by dual frequency GPS, Workshop on Applications of Radio Science, Beechworth, 27-29 April 2000.

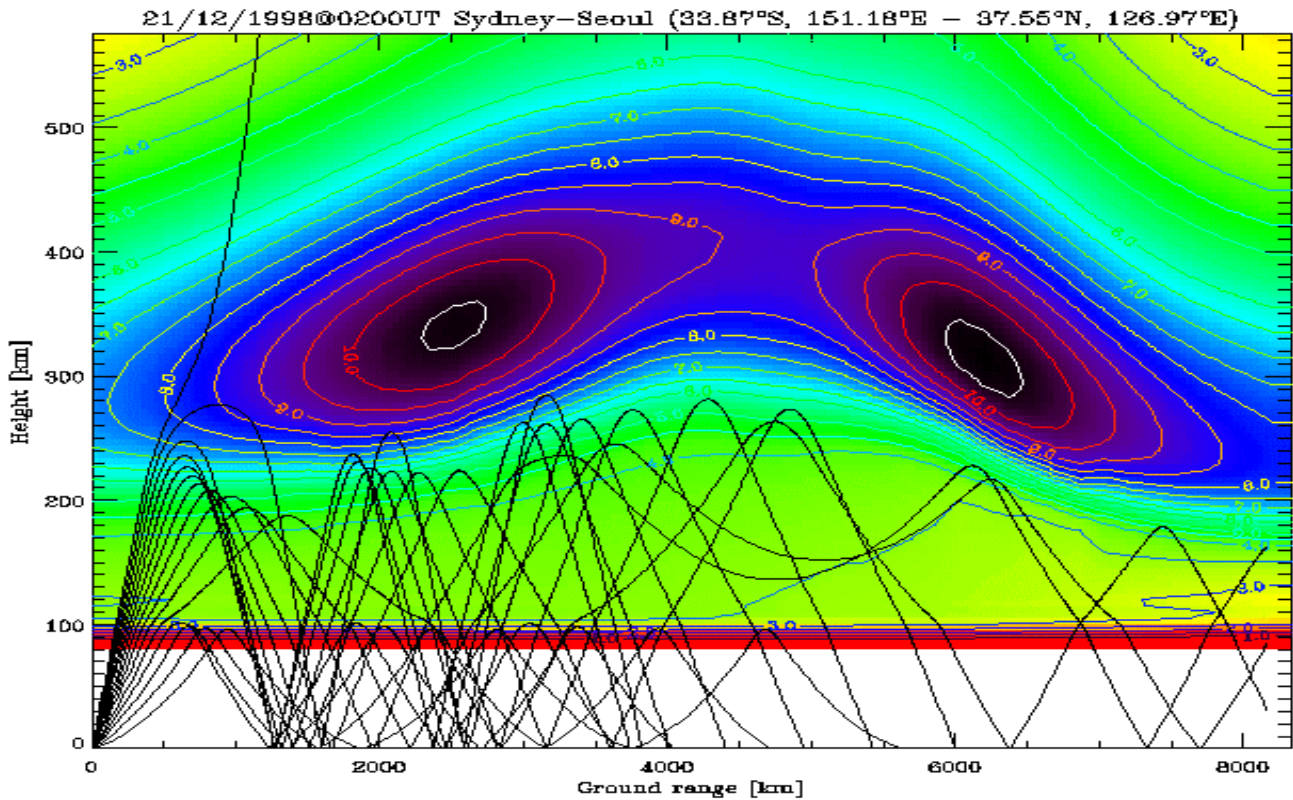


Figure 1. Sample of HF radio rays through ionospheric gradients typically encountered over the south-north path between Sydney, Australia and Seoul, Korea, as predicted by IPSRAY.

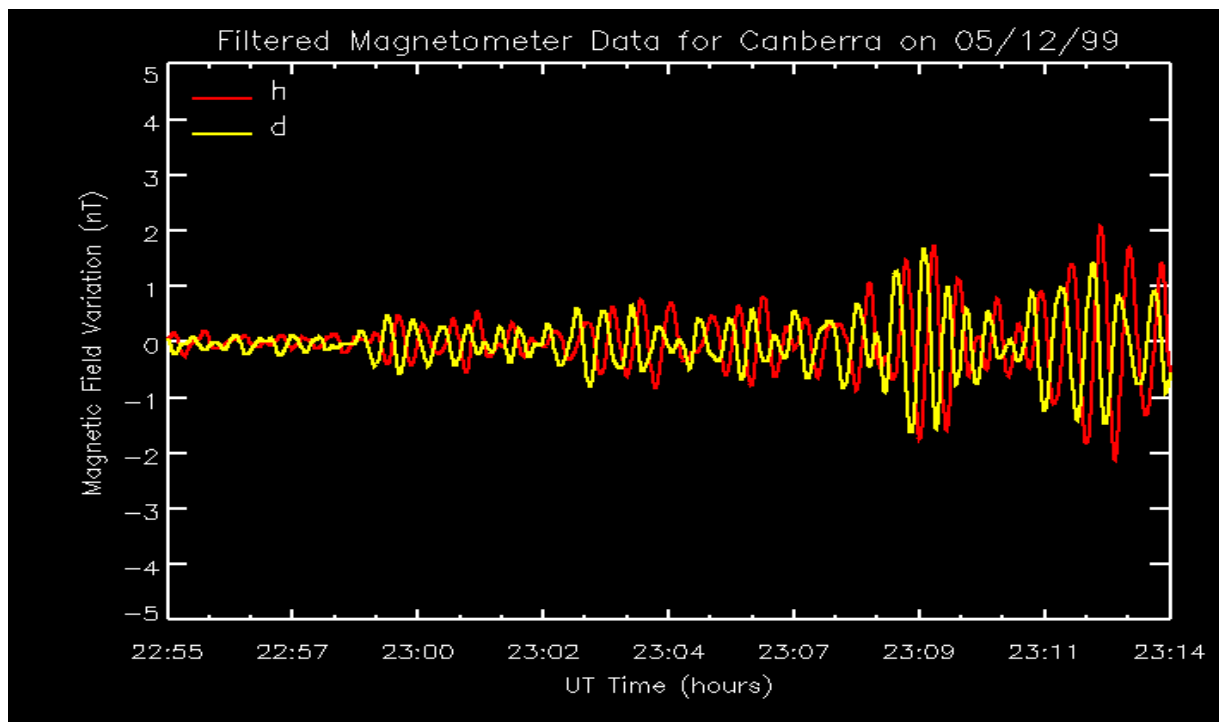


Figure 2. Time series of filtered magnetometer data recorded in Canberra at about 23UT on 5 December 1999, showing typical pc3 pulsation signals for the H and D geomagnetic components. The data are filtered over the pc3 pulsation frequency range of 10-45 seconds.

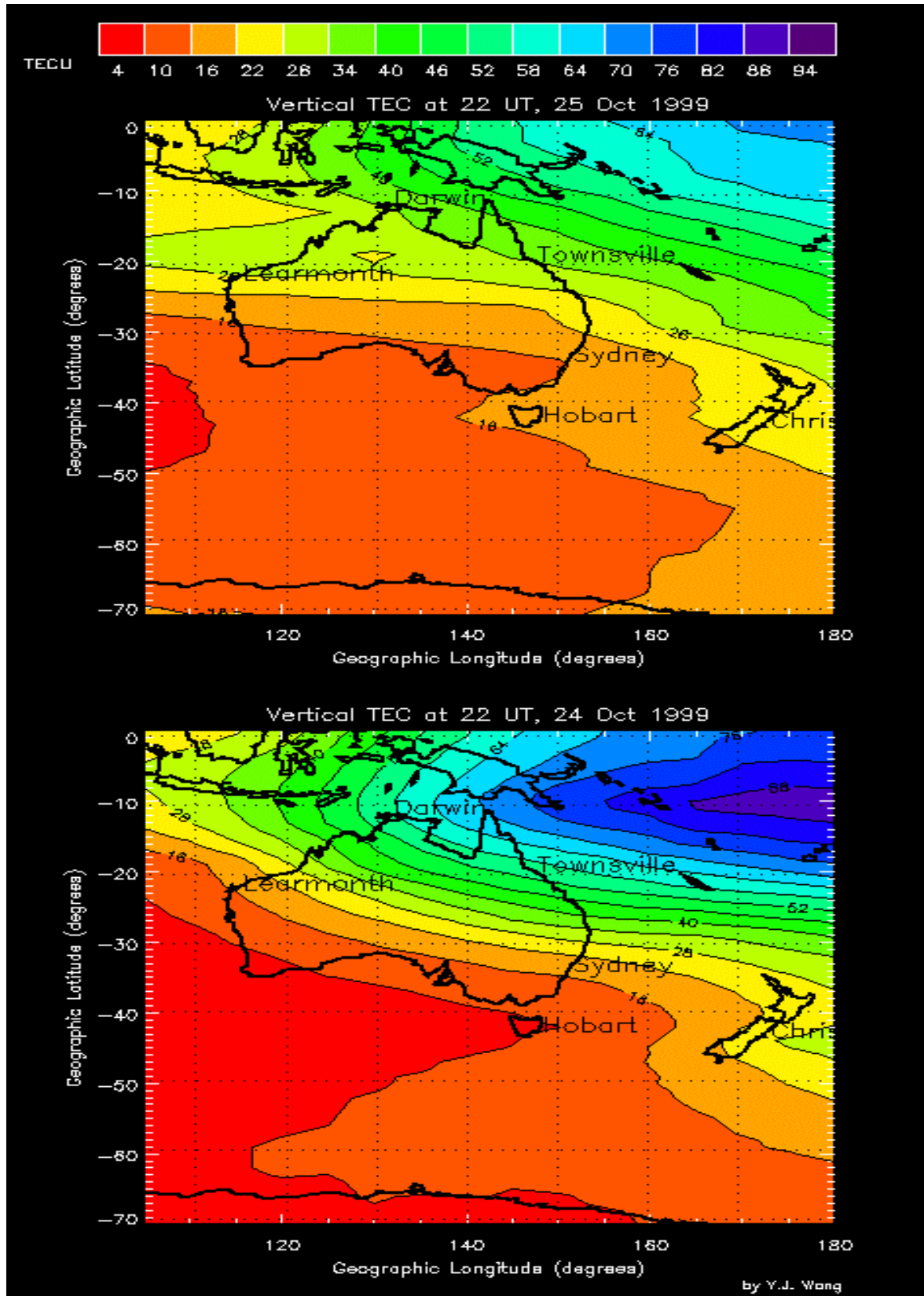


Figure 3. TEC maps generated from the IRI model using real-time observed regional foF2 data. The top map is for the current UT hour and the bottom map is for the same hour on the previous day. Any major differences between these two maps would indicate the presence of an ionospheric disturbance.