ISES Report

IPS and the Bureau of Meteorology (BoM) Realignment

In order to improve service delivery to our stakeholders the BoM has decided to realign the Bureau Structure.

Objectives include:

- Enhance the capabilities in specific areas
- Match accountability with authority
- Even out the management load
- Focus on information and infrastructure

As a part of this realignment IPS has been divided and place into two divisions. Two thirds of the staff have been placed in the Hazards, Warnings and Forecasts Division and one third (10 staff) are being moved to the Observations and Infrastructure Division along with the network assets such as the solar observatories, magnetometers, ionosondes and TEC equipment. Moreover, a new position is being established to oversee the IPS staff in this division. The realignment should not affect the Culgoora Solar Observatory (CSO) upgrades of both the optical and radio telescopes due to a lightning strike on 8 January 2012 and antiquated equipment. In addition, the near real-time magnetometer, ionosonde, and TEC networks should continue to be maintained and upgraded as planned.

Space Weather Services Review of IPS

A Review of IPS Space Weather Services is underway and undertaken by independent reviewers, appointed by the Director of Meteorology. The driver for the review was the Bureau of Meteorology's Munro Review which identified (Option 20) for ceasing, reducing or commercialising IPS Radio and Space Services as a potential savings measure. The reviewers will deliver their report in August 2014. The review terms of reference are:

- Review the policy basis for the Bureau's Space Weather services;
- Provide an analysis and international benchmarking comparison of the Bureau's Space Weather services, and use of observations and infrastructure, including:
    - their current status;
    - performance and impact;
    - scope;
    - manner of delivery; and
    - adequacy of capabilities and resourcing to deliver the service;
- Evaluate the extent to which the Bureau's Space Weather services meet user needs, especially those of significant user groups and high-impact users;

- Assess the strategic outlook (over 5-10 years) for Space Weather services in Australian, regional and global settings and, in light of 1 to 3 above, provide advice on the capabilities required to meet the future challenges;
- Comment on the potential for cost-recovery of Space Weather services;
- Provide recommendations based on the above analyses, assessments and evaluations.

The review process is lead by Dr. Paul Cannon and assistant reviewer is Dr. Terry Onsager

- Dr. Paul Cannon, University of Birmingham, UK. Professor Cannon serves on the UK Cabinet Office, Space Weather Project Board, is an expert witness to the House of Commons Science and Technology Select Committee and has supported the Prime Minister's Committee on Science and Technology. He is Professor of Radio Science and Systems at the University of Birmingham.

- Dr. Terry Onsager of the U.S. Space Weather Prediction Centre (SWPC) in the National Oceanic and Atmospheric Administration (NOAA). Dr Onsager is Director of the International Space Environment Service (ISES) which coordinates the approved Regional Warning Centres, and co-chair of the World Meteorological Organization (WMO) Inter-Programme Coordination Team on Space Weather (ICTSW). He is also a member of the Space Weather Expert Team for the UN Committee on the Peaceful Use of Outer Space Working Group on the Long-Term Sustainability of Outer Space.

Caveat, the ASFC future plans will be influenced by the Space Weather Services Review recommendations and the Bureau of Meteorology's response.

Australian Space Forecast Centre (ASFC) Activities and Plans

ASFC Sydney

The ASFC continues to retire antiquated computers with obsolete operating systems and upgrading to newer systems to boost the capability to run new models and software. During 2013/2014 the low resolution WSA-Enlil model was put into

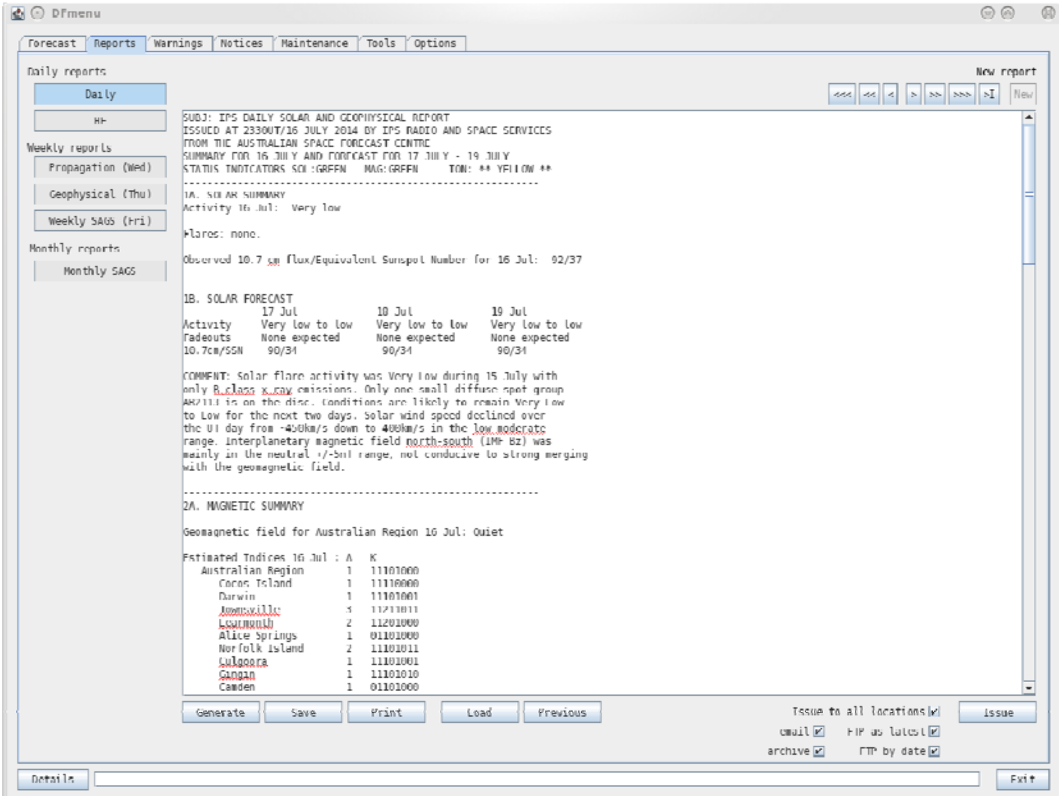
operation along with output displays. In addition, the Severe Space Weather Service (SSWS) warning has been fully implemented. Note SSWS covers only very large events and gives warning indicating probable impact on specific technologies.
Also, IPS has been trialling for some time the automatic identification and characterisation of ionospheric scintillation events as observed in our network of ionspheric scintillation monitors (ISMs). The details of the most recent 5 events are shown on our website at http://www.ips.gov.au/Satellite/1/3. We have recently made available an email notification service allowing customers to be notified in near real time when scintillation is first observed and what geographic areas are likely to be affected.

Ongoing work continues on ASFC DFmenu, the forecast centre user interface which aids the duty forecaster with writing, compiling, editing and issuing warnings, as well as daily, weekly and monthly reports, in addition to facilitating model runs. Moreover, the ASFC is now working on a new data management system, the Data Infrastructure Project (DIP), which is meant to replace our ASCII based file system. DIP was born out of a desire to make the storing and accessing of data standardised, simpler and quicker than the current IPS file-system. The ASFC intends to move to DIP as the main source of data access over the coming years. Also a prototype mobile space weather application has been developed, but will need to go through the BoM assessment before implementation.

An automatic flare patrol program will be run in the ASFC in the near future, analysing GONG H-alpha images. What's more, preliminary work has commenced on improving the Flarecast flare prediction capabilities and moving to a probability type flare forecast. There is also an initiative to improve the T-index forecasts as well. Additional work will begin on improving the Automated Radio Burst Identification System (ARBIS-2), which currently automatically analyses Learmonth Solar Observatory (LSO) and Culgoora Solar Observatory (CSO) solar radio spectrograph data for type II and type III sweeps. The planned improvements include adding San Vito, Sagamore Hill and Kiana Point Solar Observatory data for near 24/7 coverage and to decrease the false alarm rate. Lastly, yet high on the list of priorities is to establish verification procedures in the coming years monitor the accuracies of daily, weekly and monthly forecasts. Recently the IPS forecast verification software has been migrated to use the DIP database. Also one of the old forecaster tools, used to compare Ap and T index forecasts with observations, has been reimplanted as a web-based tool. The following is a more detailed description of work being done in and around the ASFC.

Menu Driven Forecasting Software

The main forecast entry tool, which used to be a text-based combination of bash scripts and C programs, has recently been migrated to a GUI-based Java application called DFmenu (duty forecaster menu). The new tool provides improved presentation of forecast data, easier navigation between forecast elements, WYSIWYG editing of forecaster comments, easy viewing of past forecasts, and a log of activity and problems.



Reports Tab of DFmenu

Over the last year the program has had features added as well as required bug fixes. Some of the more significant features are included below:

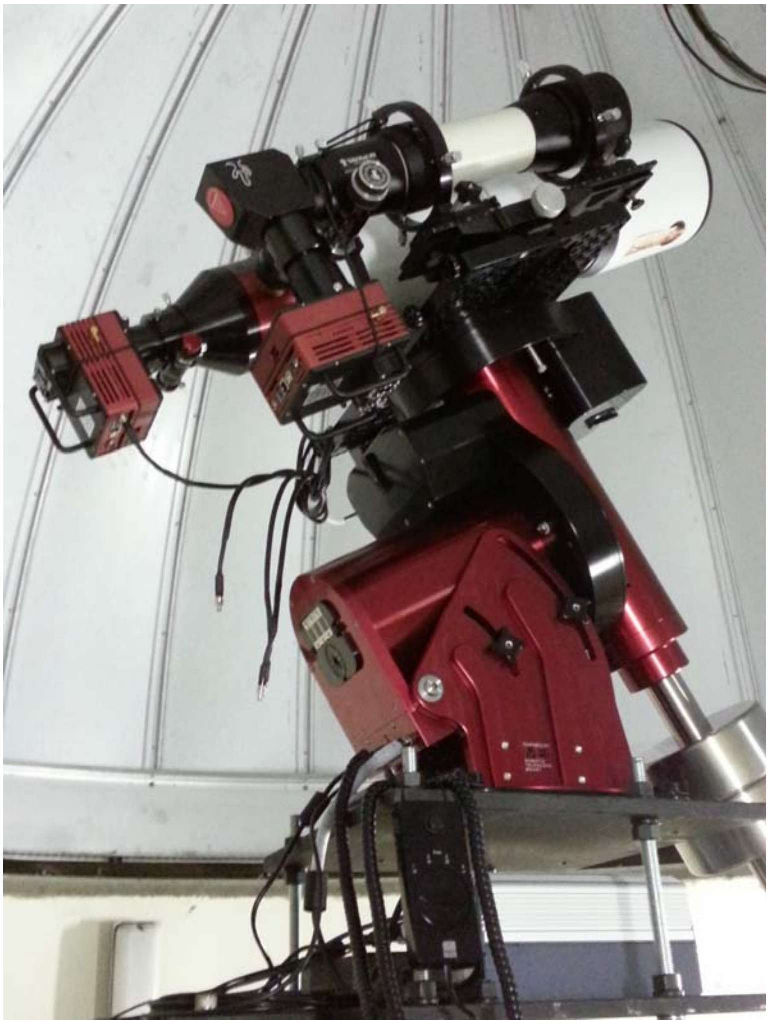
- Added menu driven capability to run the Severe Space Weather Service model and issue warnings.
- Added menu driven capability to run the WSA-Enlil CME prediction model.
- Added 1-day max Kaus forecast support.
- Updated configuration to use Gingin rather than Gnangara magnetometer data.
- Added support for monthly Solar and Geophysical Report writing, compiling, editing and issuing capabilities.
- Added the ability to generate and issue Type II PRESTO (URASP) messages.
- Modified to access the new database (DIP) for delivering and retrieving data.
- Added the ability to suppress auto-issued warnings.
- Updated to provide details of field validation failures.

Learmonth Solar Observatory

Learmonth Solar Observatory

Learmonth Solar Observatory is located in Western Australia and is a jointly operated by United States Air Force (USAF) and Observation & Infrastructure Division of Bureau of Meteorology. Presently the USAF is continuing to upgrade the RSTN systems for remote operation by 2016. This plan includes the solar radio spectrograph (SRS) and the Radio Interference Monitoring Sets (RIMS) to be remotely operated with a power and environmental monitoring system. A broadband data link has been upgraded by the USAF to accommodate remote operation. Radio and optical data is now available on the Non-classified Internet Protocol Router Network (NIPRNet). These upgrades are a large task that depends on continuing funding and support by USAF. IPS has also upgraded its broadband data link to 2Mb/s, which may increase to 10 Mb/s in the coming year to enable the automatic flare patrol and video conferencing, as well as improve general data flow.

Culgoora Solar Observatory



The Culgoora Solar Observatory is now operated by the Observation & Infrastructure Division of Bureau of Meteorology out of Narrabri, New South Wales (due to the Bureau realignment). A major upgrade of the radio and optical telescopes is underway. Components of the Culgoora solar radio spectrograph control system are also being upgraded to improve the protection of the system from its harsh operating environment. Cladding was applied to the A-band antenna to provide water-proofing and enhance its structural integrity. A combination of damage from a lightning strike and long term wear prompted a complete replacement of the optical telescope systems at Culgoora. The old system has been decommissioned and removed. A new Paramount ME II telescope mount has been installed and is being commissioned. Three new telescopes are being fitted: a Lunt with H-alpha filter; a Lunt with CaK filter; and a Televue with a white light filter. Each telescope will be equipped with an 8 Megapixel SBIG camera. The picture above shows the partial installation of the new system. In addition, a new SERC MAGDAS-9 (Magnetic data Acquisition) unit was installed on site. To accommodate the higher resolution data, CSO received a bandwidth increases to 2Mb/s, which may increase to 10 Mb/s in the coming year.

Ionosonde Network

Receive antenna at Cocos Island

IPS operates an extensive ionosonde network currently consisting of three high latitude stations and eleven low to mid latitude stations extending from the western Pacific Ocean to eastern Indian Ocean and from Northern Australia to East Antarctica. The high latitude stations operate CADI 4-receiver systems while the low to mid latitude stations operate the in-house designed and built IPS 5d system. Production of the 5d ionosondes is now complete to the point where IPS has sufficient instruments and spares for the foreseeable future.

In the past year IPS has commenced an upgrade of the high-latitude CADI systems to a Linux-based operating system. This upgrade simplifies the installation and should enhance system stability. It is hoped to complete the upgrade program during the coming Antarctic summer shipping season.

The University of Canterbury has operated an ionosonde system near Christchurch, NZ for many years, providing IPS access to the data. As this system was ageing, it was replaced by an IPS 5d system a few years ago. However, the data flow proved unreliable for a number of reasons and the 5d was replaced by an IPS owned CADI in 2013. Shortly thereafter, the site was forced to close due to alternative land-use requirements. UoC is now exploring possible new ionosonde sites in the Canterbury region of New Zealand.

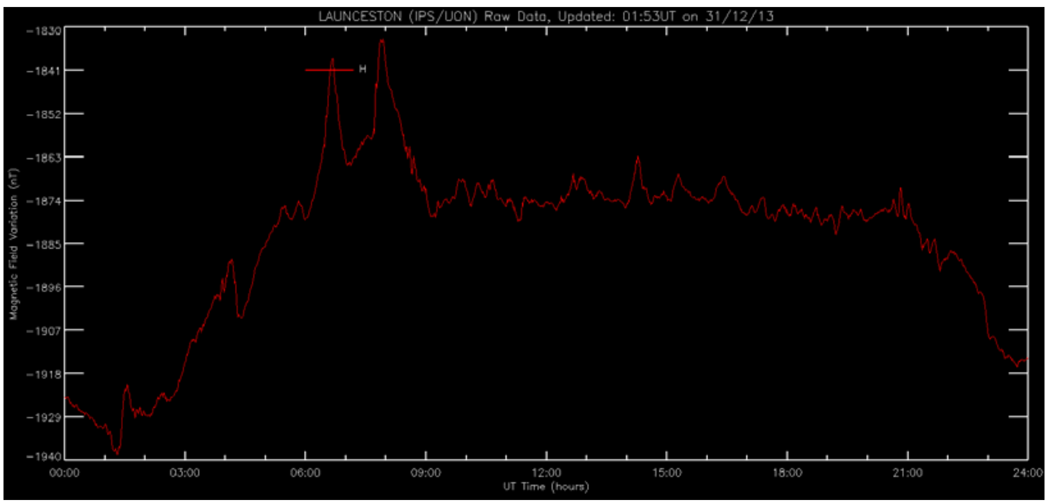
Where coverage is available, IPS has over the past few years upgraded communications to its Australian ionosonde sites to a 4G wireless link, using equipment common to many Australian Bureau of Meteorology remote weather stations. This has considerably improved near-real time data delivery. Connection to local ADSL networks has also improved the data delivery from Niue Island and

Norfolk Island stations. Ionosonde data from most sites is now available in the Australian Space Forecasting Centre within a few minutes of collection on site.

A temporary ionosonde site was established at Learmonth Meteorological Office in NW Australia in 2011. It is likely this will become a permanent installation in the near future. Further expansion of the network is unlikely, although an additional central-Australian location has been discussed.

Magnetometer Network and Services

A large real-time network continues to be maintained and upgraded. A new magnetometer installation was created at an existing BOM field site at Launceston, in northern Tasmania. The installation was a collaborative effort between the Bureau of Meteorology's (BOM's) IPS, and the University of Newcastle, NSW. Geomagnetic data is arriving into the ASFC in near real-time via the BOM's communication network infrastructure and is being used in IPS services.



Launceston raw data plot

The MAGDAS network is a global magnetometer network and the initiative of ICSWSE, Japan, and provides data for both scientific and space weather applications. The BOM's IPS manages six Australian installations, the largest sub-array of the global MAGDAS network and receives data from these installations to assist in delivery of space weather services. During 2013-14, the MAGDAS unit at Culgoora was upgraded to a MAGDAS-9 and has been providing data in near real-time to the ASFC for service support. Two further MAGDAS-9 upgrades planned for 2013-14 (Melbourne and Sydney) have been postponed until 2014-15.

BOM/IPS has been involved with a study into the impacts of space weather on the Australian power network. This involves collaboration with state power transmission network service providers (TNSPs) and is coordinated by the Australian Energy Market Operator (AEMO). This study has involved installing GIC monitoring devices at strategic locations within the network and the reconciliation of this data with data derived from the IPS magnetometer network. The results stimulated the desire to develop and implement procedures for the management of geomagnetic storms at the "severe event" level. The first iteration of such operating procedures for the National Energy Market (NEM) was developed in collaboration with the BOM, AEMO, and the TNSPs and published in 2013 under the AEMO website. The core of these procedures is the table shown below with full details available in Section 12 of the Power System Security Guidelines (http://www.aemo.com.au/Electricity/Policies-and-Procedures/System-Operating-Procedures/Power-System-Security-Guidelines-SO_OP3715). These procedures will be refined as new modelling and observations become available.

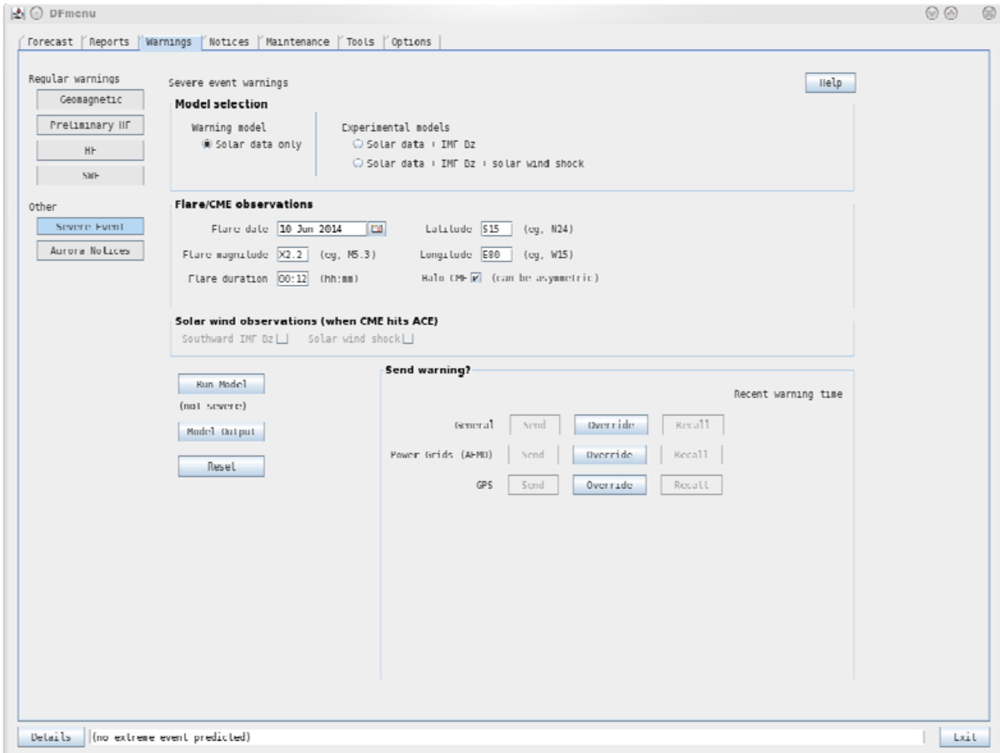
Table 6: SSWS Notifications - Summary of Notifications, timeframes and AEMO Actions

NOTIFICATION from SSWS	ETA (Forecast lead time)	ETD (Warning lead time)	AEMO Actions
Severe Space Weather Watch	12hrs+	TBA	1. Issue a market notice; 2. Increased awareness for next 48 hours 3. Maintain increased awareness of GIC monitored equipment
Short Duration GIC Warning	NOW	30-60 mins.	1. Issue a market notice; 2. Maximise dynamic reactive reserves across the power system; 3. AEMO instruct restoration of transmission outages; 4. Maintain increased awareness for more warnings 24hrs 5. Maintain increased awareness of GIC monitoring equipment
Sustained GIC activity Warning	30-60 mins	6-12 hrs	1. Issue a market notice; 2. Maximise reactive reserves across the power system; 3. Instruct the restoration of transmission outages 4. TNSP may re-rate transformers (possibility of instructing for load shedding) 5. TNSP may advise with the intent to take transformer OOS due high impact of GIC. May have to instruct load shedding to maintain security 6. Maintain increased awareness of GIC monitoring equipment levels 7. Maintain increased awareness & monitor for "Event End"
Severe Space Weather Event End	NOW	NOW	1. Issue market notice; 2. Return power system to normal operations; 3. Maintain increased awareness of GIC monitoring equipment levels 4. Maintain increased awareness and monitor for any further "Warnings" and/or "Cancellations" notices.
Severe Space Weather Cancellation	NOW	NOW	1. Issue market notice; 2. Anticipate event summary from IPS.

(from AEMO Power System Security Guidelines for the management of Geomagnetic Storms, Section 12).

A pivotal part of these procedures is the issuing of the "Severe Space Weather" (SSW) Watch and Warnings by BOM. A study by Terkildsen et al. (2014) investigated the statistical relationship between severe geomagnetic storms (defined by Dst < -250nT) and parameters of the solar region of origin to develop a Generalised Linear Model (GLM) for severe geomagnetic storms. This model has been integrated into the operational procedures of the Australian Space Forecast Centre at BOM and forms the basis of mitigating procedures (refer to next section). Since implementing the operating procedures, the SSW model has successfully predicted "true negatives" only and therefore no mitigating actions have been taken since the inception of the procedures.

Terkildsen, M.B., R.A. Marshall, G. Steward, D. Neudegg, A. Kelly, and G. Heller (2014), Development and implementation of a data-based storm model and alert service for severe space weather, Space Weather, (to be submitted).



DFmenu Severe Space Weather Service user interface

```
-----------------------------------------------------------------
Model prediction

  (no event)

Inputs

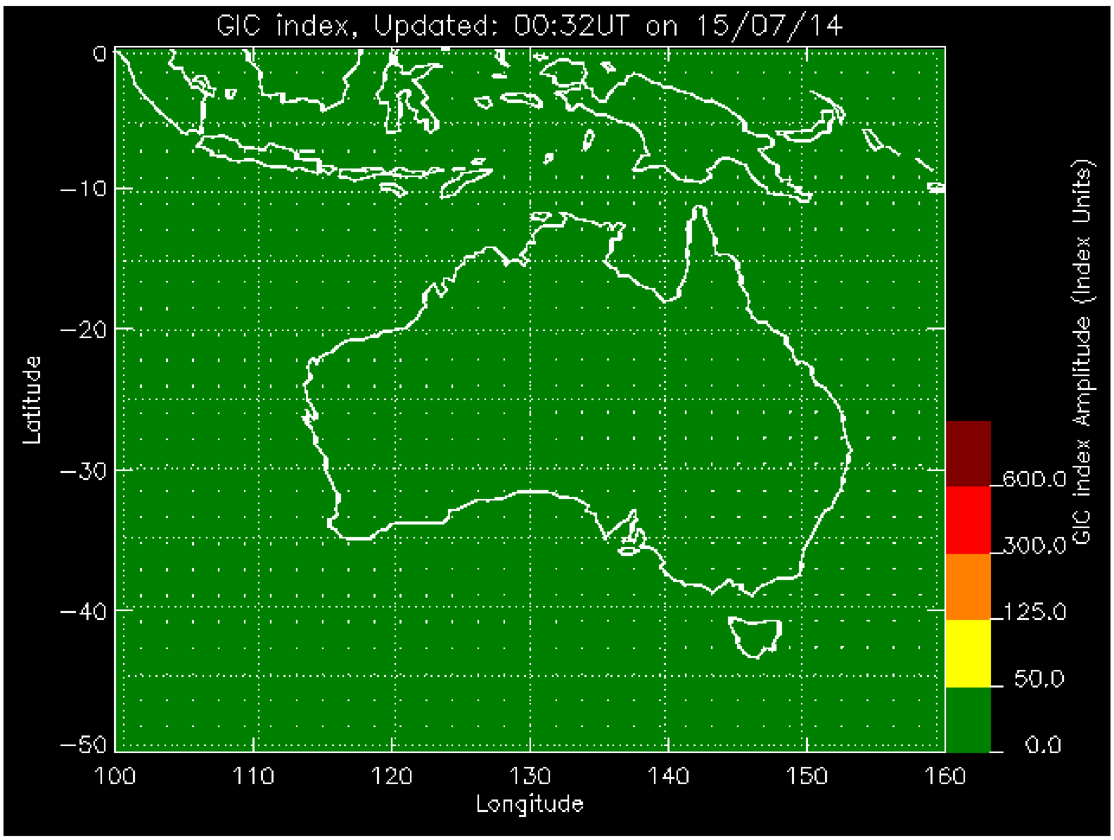
      Model type: Solar Imf Shock
      Flare date: 10-Jun-2014
      Duration:   0.2 hours
      Magnitude:  X2.2
      Latitude:   -15.0
      Longitude:  -80.0
      Halo CME:   true

      IMF Bz south: true
      Solar wind shock: true
-----------------------------------------------------------------
```

Model output message

A new webpage service (http://www.ips.gov.au/Geophysical/1/2/5) aimed at providing information on space weather activity specifically related to the impacts caused by Geomagnetically Induced Currents (GICs) was developed and implemented. Maps such as the one below are contoured "GIC-index" which is a proxy for the "geoelectric" field in addition to a vector indicating the direction of this field which scales with field amplitude. For low levels of GIC-index activity the vectors appear as dots and increase in size to be visible as directional arrows when activity increases. The index thresholds for these maps were calibrated from reports of GIC impacts from power networks around the world as described in the reference [Marshall et al. 2011] below.

Marshall, R. A., E. A. Smith, M. J. Francis, C. L. Waters, and M. D. Sciffer (2011), A preliminary risk assessment of the Australian region power network to space weather, Space Weather, 9, S10004, doi:10.1029/2011SW000685



GIC index map

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WSA-Enlil Solar Wind Model

Over the past year the low resolution WSA-Enlil model was put into operation along with output displays. One output display shows arrival times of CMEs similar to the SWPC version (Figure 1). The other display creates WSA-Enlil forecast summary plots of both density and velocity (last 48 runs) to assist in predicting the CME/coronal hole arrival time based on an adjusted median measure rather than just one run (Figure 2.). SOHO LASCO and STEREO images are automatically downloaded for the SWPC CME Analysis Tool (CAT) and our coronagraph difference display to speed up examination of CME activity. Plans over the coming year are to try and optimise boundary condition parameters (closer to true background) for CME forecasts and comparing the results with the standard WSA background input. There is also an initiative to move to a medium resolution run (need access to Bureau high performance computers for this to happen).

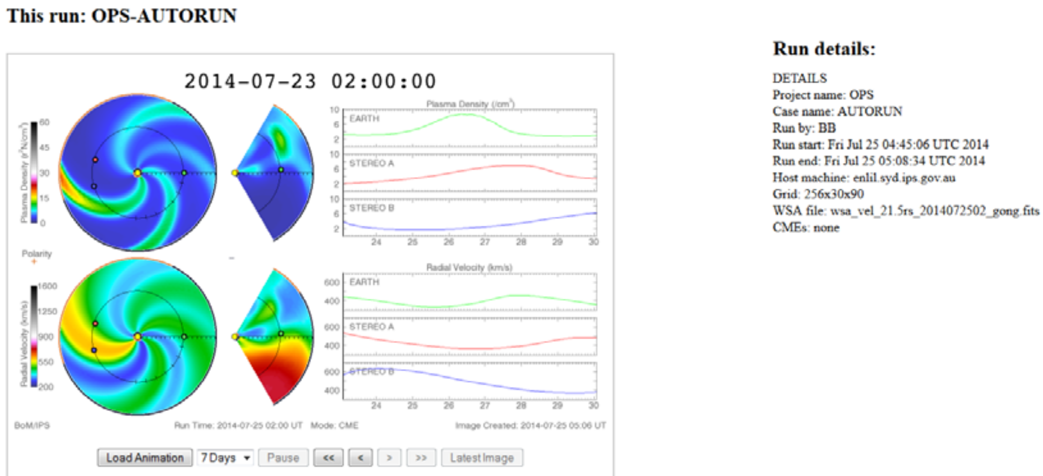

Figure 1. WSA-Enlil model display provided to IPS courtesy of SWPC/NOAA

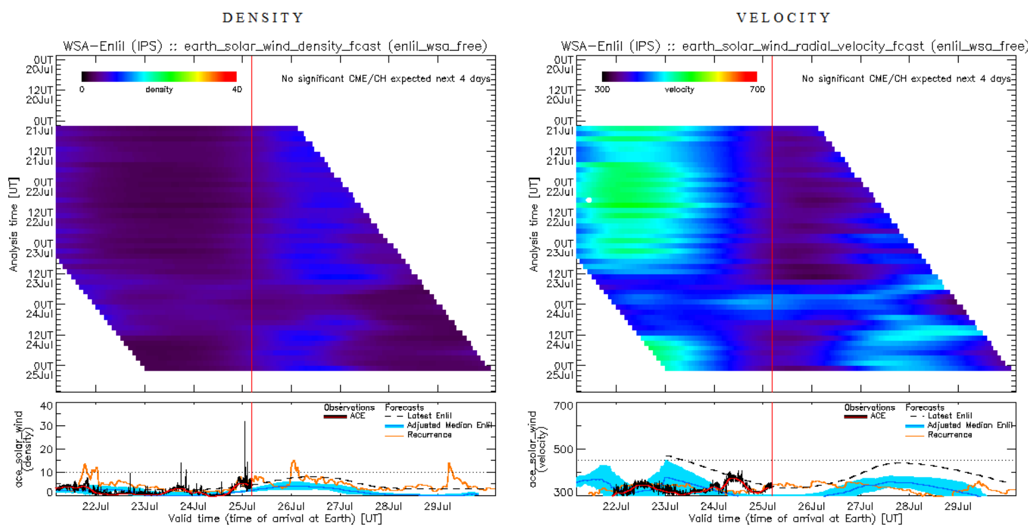

Figure 2. WSA-Enlil Forecast Summary

Automatic Flare analysis from GONG H-alpha images

Automated flare analysis program has been tested on data from all of the GONG (Global Oscillation Network Group) sites. Figures 1 through 4 shows a flare analysed with the system. No human interaction is required as the computer automatically adjust the image to produce good histograms.

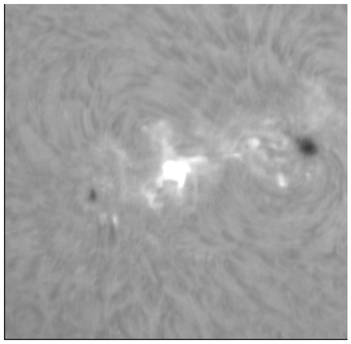

Figure 1. Sample flare image from GONG Big Bear obtained on 2012/07/30 at 15:45:54 UT (location S21.6E28.1).

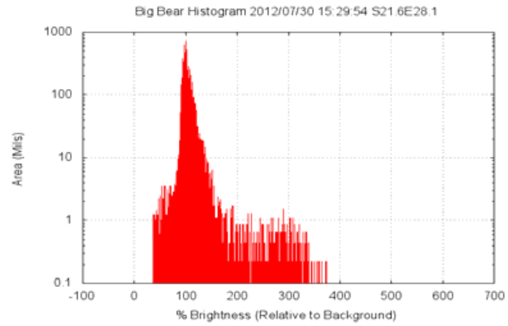

Figure 2. Sample flare histogram from GONG Big Bear.

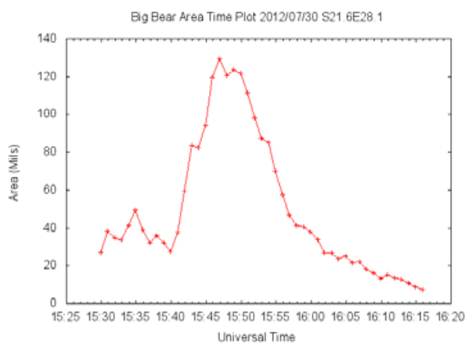

Figure 3. Sample Area vs Time Plot from GONG Big Bear.

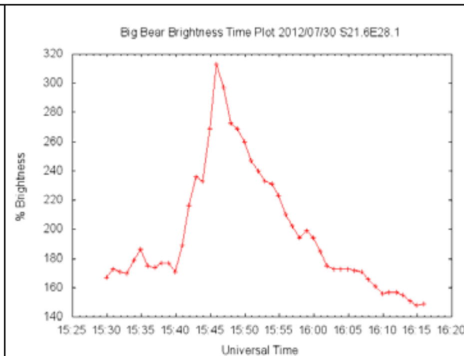

Figure 4. Sample Brightness vs Time Plot from GONG Big Bear.

The flare analysis program has 7 components:

1. Image Centring and Limb Find: A simple algorithm is used to find the image centre and radius of the disk. This process also determines if the image is affected by cloud or poor calibration.
2. Normalisation: This adjusts the image brightness. A full disk histogram is produced and image is scaled so that the peak of the histogram occurs at bin 100.
3. Limb Darkening Correction. This corrects the image brightness as a function of disk radius.
4. Flare Pixel Search and Grouping: Bright pixels are found on the disk. Any bright pixels that are within 5 degrees of each other are grouped together.
5. Histogram Analysis: A box containing the flaring pixels along with at least double the area of quiet sun is processed and a histogram is produced to determine if the flaring region meets any of the flare criteria.
6. Classification: The flare brightness and area categories are determined from the histogram and the flare centre determined by further analysis of the region.
7. Archiving: The flare plots, images and statistics are archived for later viewing if needed.

This Method has been successfully tested on archived data and is currently being tested at Learmonth Solar Observatory on real time data.

ARBIS 3: A Software Package for Automated Radio Burst Identification

The automatic solar flare radio sweep warning project, ARBIS, is a venture done in partnership with IPS and the University of Sydney, School of Physics, via an ARC Linkage grant. This program is automatically detects type II and type III solar radio bursts in real-time data provided by LSO and CSO. There are 2 main ARBIS modes: (1) real-time mode and (2) survey mode. In the both modes, ARBIS processes available data (near-real-time or daily) and creates a pictorial summary showing the data availability and events detected. If there are detections, it creates the corresponding text files (separate files for different kinds of events) which are copied to the ARBIS online folder and emailed to subscribers (refer to Figure 1.). In addition, for type II and III bursts, their “portraits” are created. In real-time mode, the portraits are copied to the online folder for recent detections. In the survey mode, the portraits, event lists and pictorial summaries are copied to an archive available online at ftp://www.ips.gov.au/data/Solar/Learmonth%20Observatory/ARBIS/arbis_public/archive/ . A typical pictorial summary for daily data is shown in Figure 2. Note that in addition to solar radio bursts, ARBIS shows solar X-ray fluxes measured by the GOES spacecraft and has a capability to show CMEs if such data are available. Fragments of radio event listings produced by ARBIS look as follows:

```
 --------------------------------------------------------------------
        Learmonth – Type II bursts
                 Daily summary
   from 20101111 2143 to 20101112 1038  (YYYYMMDD hhmm UT)
  date    start-end time   shock speeds    arrival dates & times
(YYYYMMDD)   (hhmm UT)     (km/s  km/s)   (YYYYMMDD hh  YYYYMMDD hh)
 20101112    0138 – 0146     543  858      20101115 23   20101114 19
    The results are preliminary. The Newkirk model is used to
estimate the shock speeds and arrival times.  The 2 values are
obtained under the assumption that the emission is fundamental and
harmonic, respectively. The actual detections are shown in pictures
with dynamic spectra.
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Figure 1. Example of emailed text file for Type II event

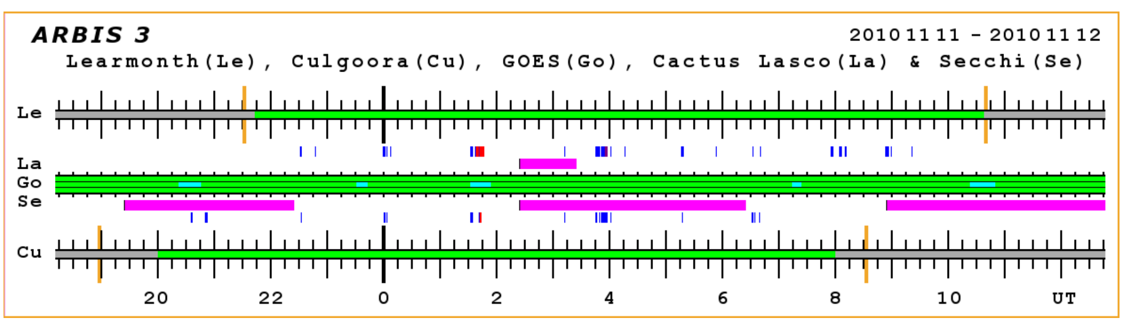


Figure 2. A typical pictorial summary. Orange vertical dashes show sunrise/sunset times. Green color shows available data. For X-rays, green is replaced by aqua, blue and red if peak flux corresponds to C, M and X classes of flares, respectively. Type II and III burst are shown by red and blue vertical dashes between the axes. Purple bands with black left edges correspond to CMEs detected by CACTUS. Note, real-

time CACTUS detections were not available; they were added later. Planned improvements over the coming year include adding San Vito, Kaena Point, and Sagamore Hill Solar Observatory data to give near 24/7 coverage and to decrease false alarm rates.

Two papers describing ARBIS techniques were published:

Lobzin, V. V., I. H. Cairns, P. A. Robinson, G. Steward, and G. Patterson (2009), Automatic recognition of type III solar radio bursts: Automated Radio Burst Identification System method and first observations, *Space Weather*, *7*, S04002, doi:10.1029/2008SW000425 (available at http://onlinelibrary.wiley.com/doi/10.1029/2008SW000425/abstract).

Lobzin, V. V., I. H. Cairns, P. A. Robinson, G. Steward, and G. Patterson (2010), Automatic recognition of coronal type II radio bursts: the Automated Radio Burst Identification System method and first observations, *Astrophys. J. Lett.*, 710, L58–L62, doi:10.1088/2041-8205/710/1/L58 (available at http://iopscience.iop.org/2041-8205/710/1/L58/).

Data Infrastructure Project

A small group at IPS has undertaken a large project to migrate all (or most) of IPS data from 1970s-style ASCII text files to a modern database system. Motivations for this project are several:

- Existing file-based data is in various non-standard formats and is spread over several directories in the file system, so is often difficult to locate or parse.
- A planned redevelopment of the IPS website would benefit from the data being more easily accessible.
- Old forecaster tools on near-obsolete hardware platforms need to be replaced soon. New web-based tools will be easier to develop using database-sourced data.

The project is still underway with the following progress to date:

- More than 80 datasets (including some 3rd-party data) are now stored in the database.
- Simple APIs have been developed for fetching and/or updating data from Java, IDL and Unix shell scripts.
- A web-based tool for browsing, charting and exporting the data has been developed.
- Forecast verification software has been migrated to use the database.
- A few old forecaster tools have been redeveloped to use a web-browser UI and data from the database.
- A new web-based animation tool allows easy generation of movies from images stored in the database (from IPS as well as SDO, SOHO, STEREO and GONG).

Examples of the user interface can be found in figures 1, 2, and 3.

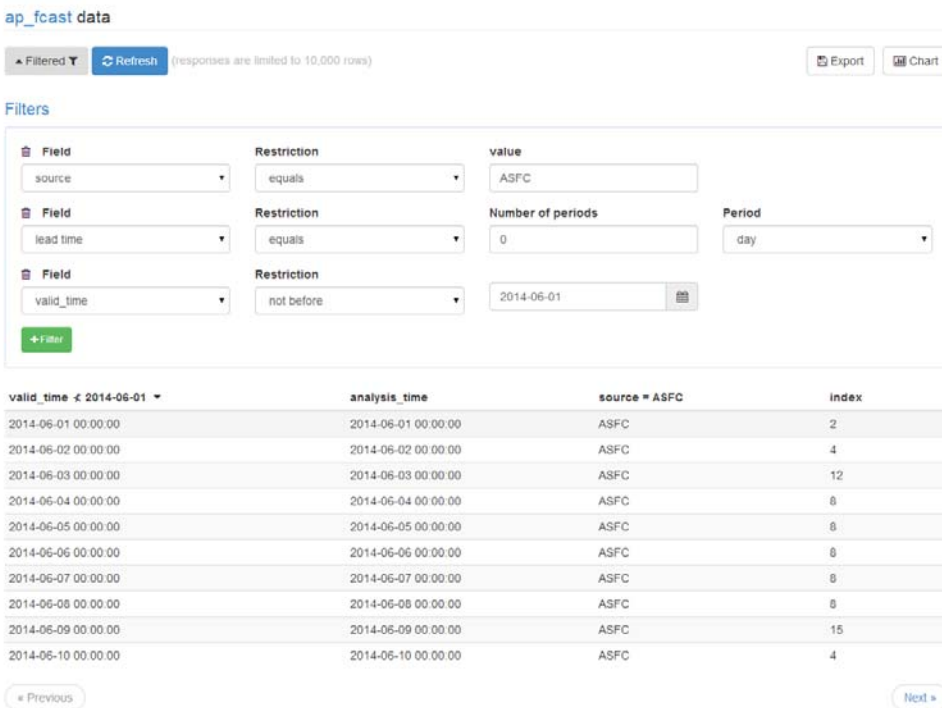


Figure 1. DIP data browsing interface

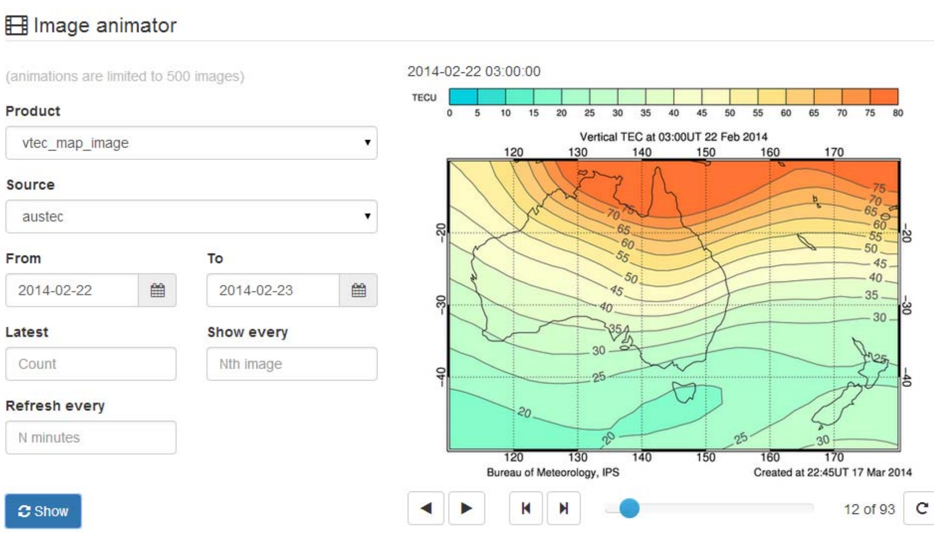


Figure 2. DIP animation viewing interface

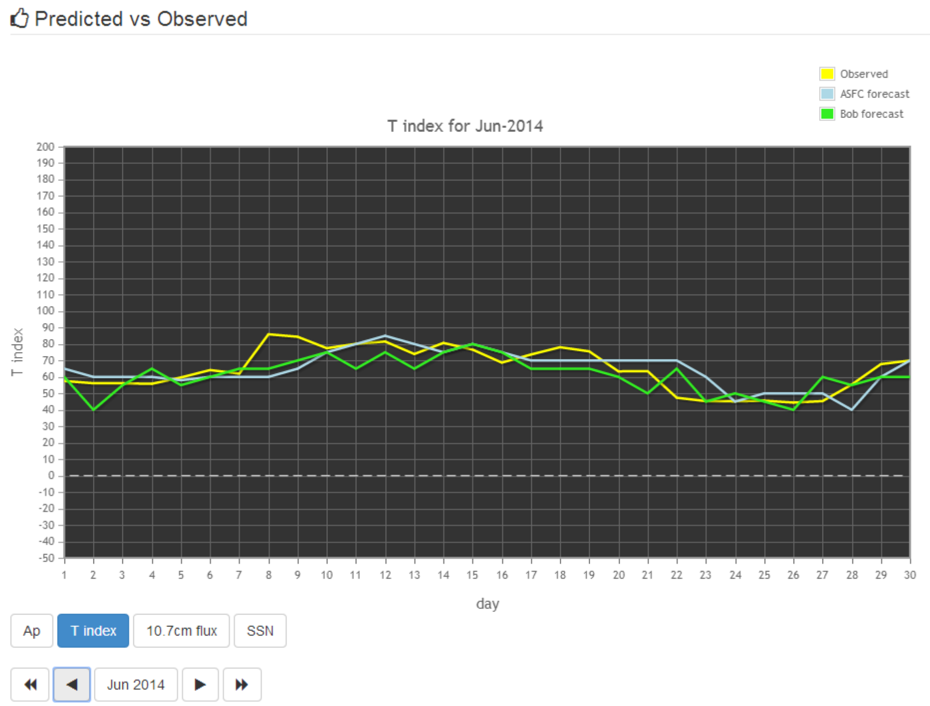
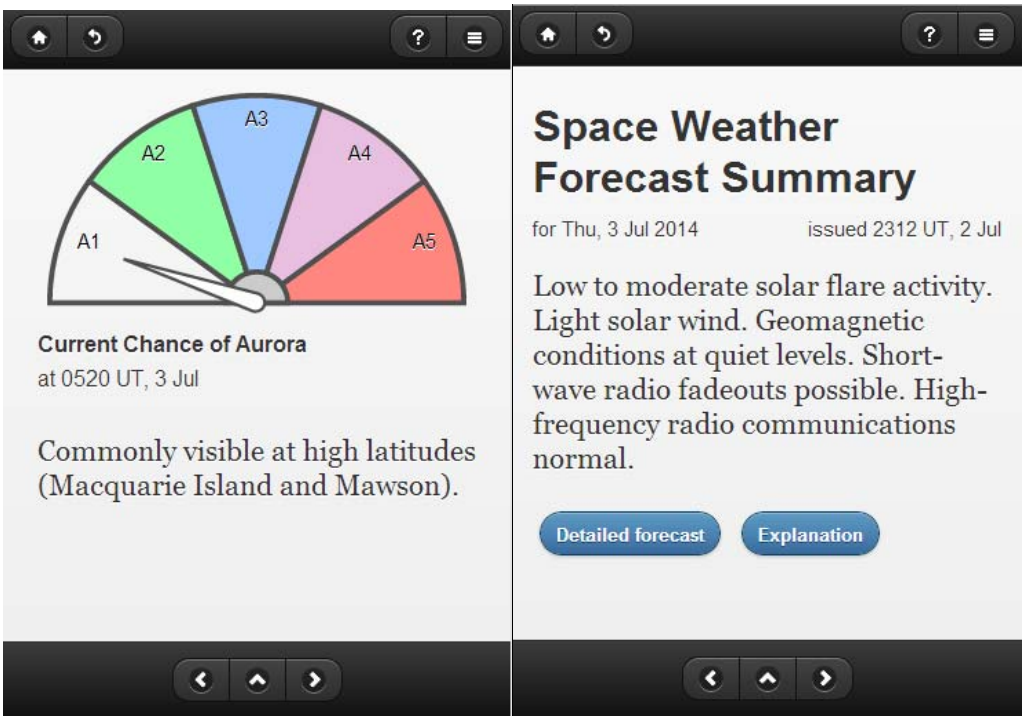


Figure 3. Redeveloped verification forecaster tool

Space weather mobile app

A prototype mobile space weather application has been developed, which includes the following features.

- Current conditions – NOAA G, S and R scales, as well as ionospheric depressions/enhancements.
- Recent (last 24 hours) conditions, as above.
- Summary space weather forecast (as per IPS website home page).
- Chance of an aurora.
- Ability to subscribe to IPS services (via email or mobile device notification).
- View recent messages from subscribed services.



Examples user interface

New T-index Forecast Model

IPS has for many years issued monthly smoothed sunspot number and global T index predictions that extend out to the end of the current solar cycle and are updated monthly using the observed sunspot number and monthly median T indices. On a much shorter timescale, we also issue 1-3 day Australian region T index forecasts on a daily basis in the ASFC daily reports. In these reports, the observed and predicted maximum useable frequencies (MUFs) are described as 'enhanced', 'depressed' or 'near predicted' using the global forecast monthly T as the baseline. HF communication warnings are issued when the observed or forecast MUF falls too far below the monthly predicted values. It has been noted that the observed regional T index can depart significantly from the monthly predicted value for extended periods due to regional differences and shorter term changes in the solar output than is modelled by a smooth solar cycle. Work has been done to produce a more accurate regional monthly T forecast in order to provide a more appropriate baseline for defining depressed and enhanced conditions and allow more accurate forward planning for customers in the Australian region. Time series models including Kalman filters, auto-regressive and exponential smoothing have been applied to determine the technique most suited to this problem.

Figure 1 'Monthly Comparison' gives an overview of the observed Australian region monthly T values compared with the existing global T index monthly forecast and an example of the predictions from a new model under development. The image 'Monthly Accuracy' shows the accuracy of these two sets of predictions in terms of the fraction of days in which the observed daily T index was within 20 points of the monthly prediction (an error which is considered to be acceptable). The first plot shows that the new model is much more responsive to recent changes in observed T index, however at times is too responsive and can over-extrapolate short term changes in the time series. Work is now underway on an ensemble model combining the existing global T index prediction software using Australian region data (previous 27 days) with the new models.

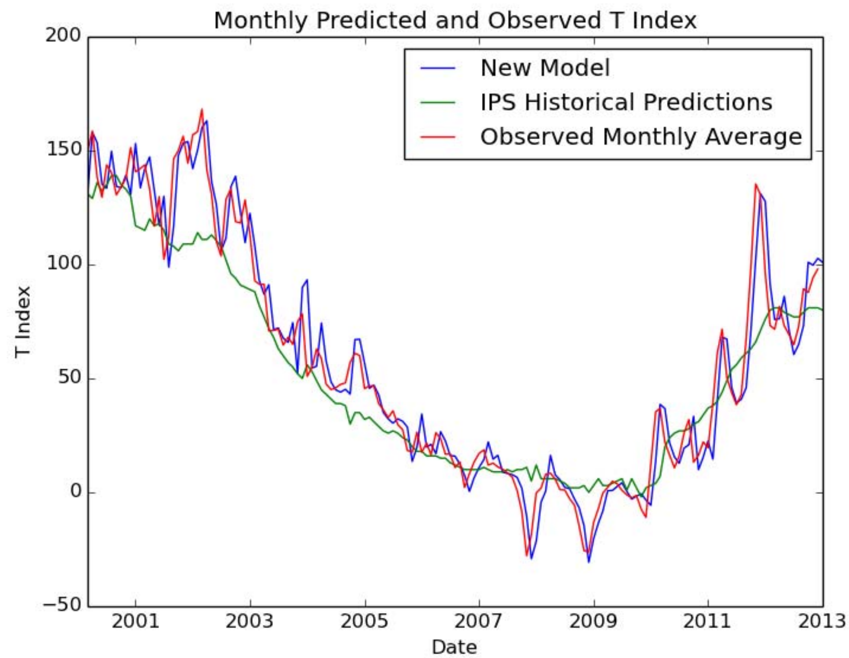


Figure 1. Monthly Comparison

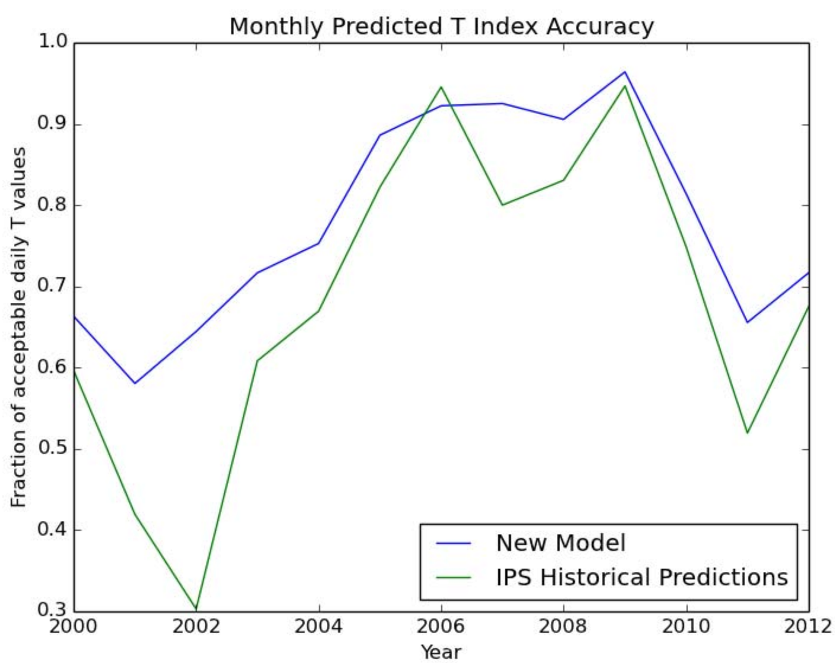


Figure 2 Monthly Accuracy

Automatic Flare Warning Program

The automatic flare warning project, Flarecast, is an undertaking done in partnership with BoM and the University of Sydney, School of Physics, via an ARC Linkage grant. This program automatically analyses complex regions based on characteristics of the neutral line using near real-time GONG magnetogram images. The analysis includes estimating the flare potential as well as class of flare to expect (C, M, or X). Below is an example of the main window of the Flarecast program now running in the ASFC. A paper has been published on this work in the AGU Space Weather Journal.

Steward, G. A., V.V. Lobzin, P. J. Wilkinson, I. H. Cairns, and P. A. Robinson. 2011. Automatic recognition of complex magnetic regions on the Sun in GONG magnetogram images and prediction of flares: Techniques for the flare warning program Flarecast, Space Weather, 9, S11004, doi:10.1029/2011SW000703

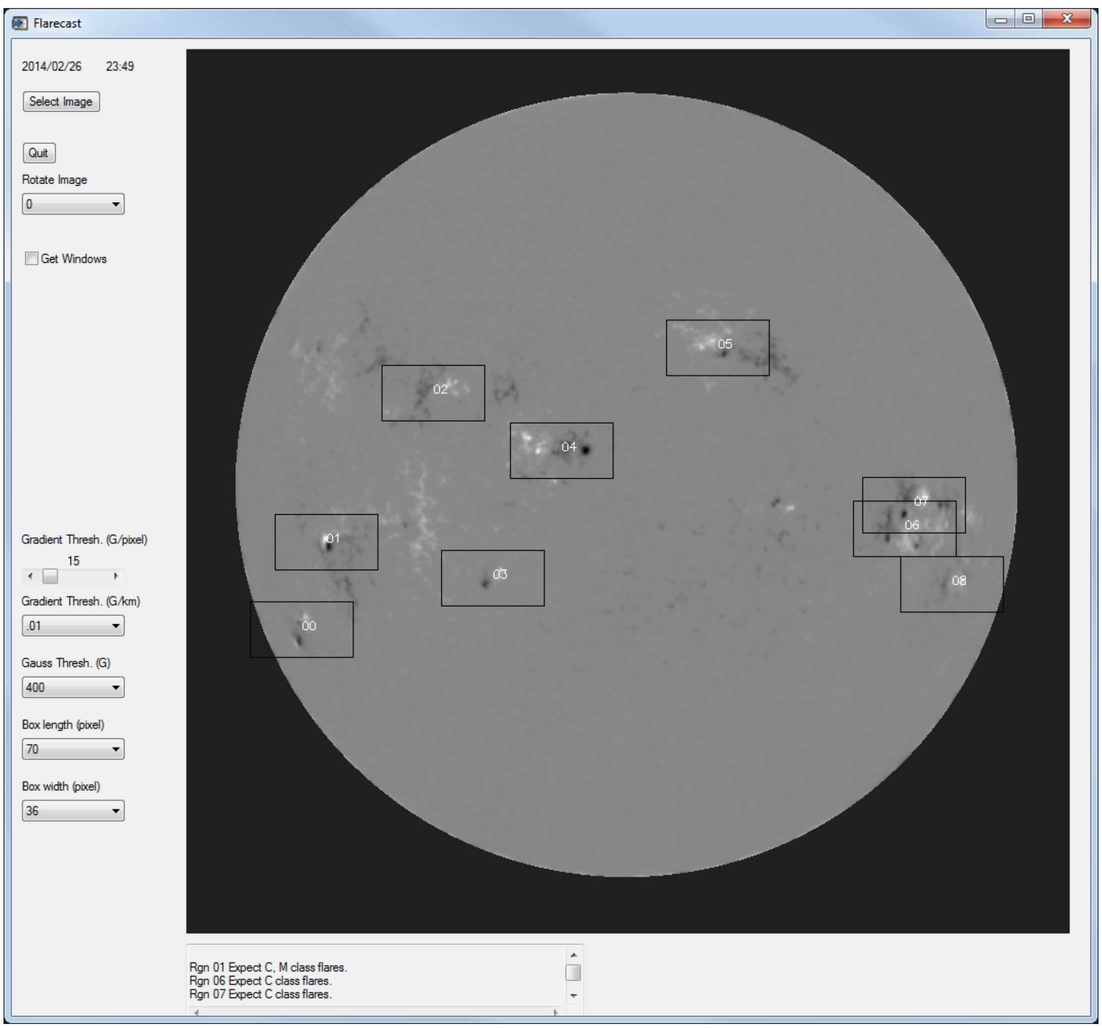


Figure 1. The 26 February 2014 magnetogram image shown was obtained from the GONG archives and analysed by Flarecast.

Once complex regions are identified the program provides three additional windows related to each complex region as shown below. The information window provides the latitude, CMD, radial extent, maximum positive and negative field strength, steepest north-south and east-west gradients, a poxy for curvature, length of longest neutral line, summation of gradient along the neutral line, and flare probablilty based on 2003 data. Contour and Neutral line windows are also displayed for each region.

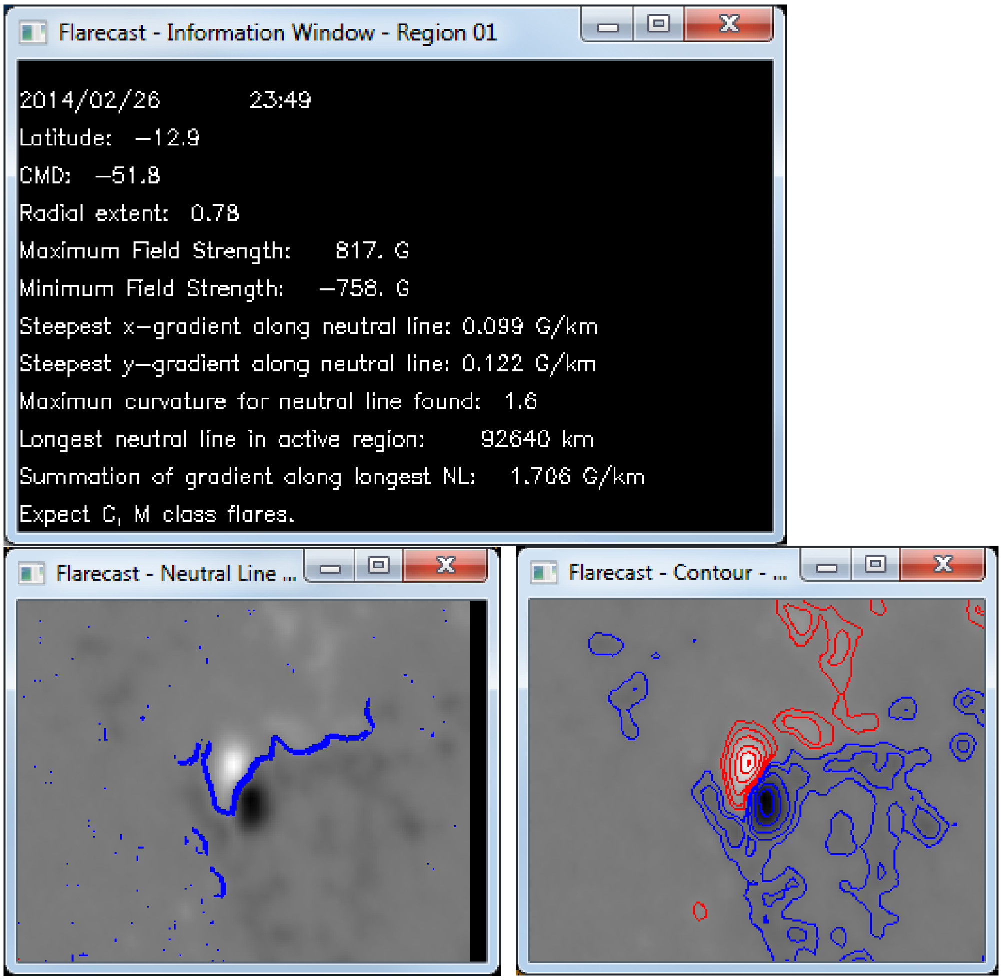


Figure 2. Example information, contour, and neutral line windows. In the contour window, red and blue colors correspond to north and south polarities, respectively. In the neutral line window, the strong-gradient polarity inversion lines (SPILs) are composed of blue pixels.

There is now an initiative to improve the forecasting capability of this project. Presently we use three parameters to predict flares: curvature of the neutral line, length of the neutral line, and the north-south gradient of the neutral line. The plan is to include additional parameters and to estimate probabilities for M and X class flares, using data ranging from 01/2011 to 06/2014. Also we will be examining regions before and after events for changes in the above parameter characteristics along the neutral line. As well as following specific regions through several rotations from emerging to fading to verify flare prediction capabilities. The project is ongoing and may change depending on data analysis results.