



Australian Government
Bureau of Meteorology

The Australian region space weather network

Richard Marshall

**IPS Radio and Space Services
Bureau of Meteorology**



IPSNET - space weather sensor network

Cocos Island



Solar Observatory

Ionosonde

Magnetometer

Riometer

TEC

Scintillation

Pulsation

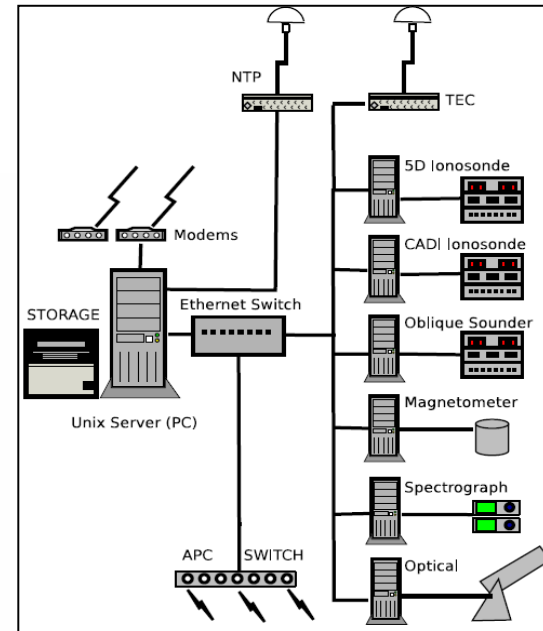
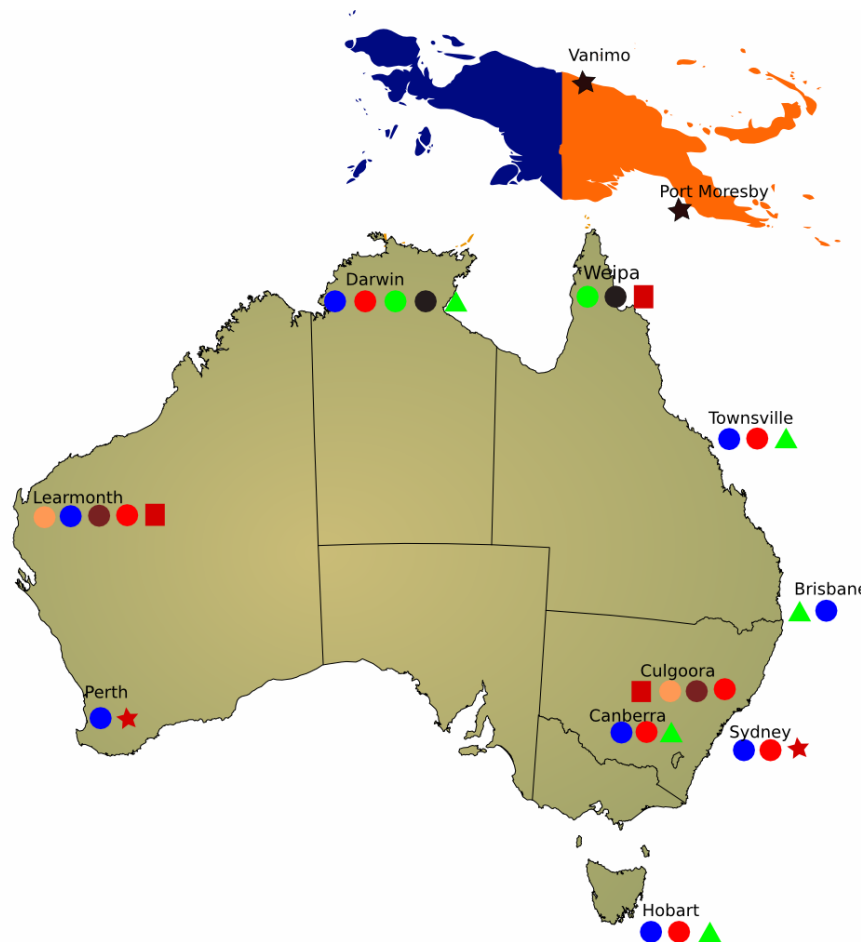
Spectrograph

Internet Access

Dialup

Direct link

Station Closed



Niue Is



Norfolk Is



Lord Howe Is



Mawson



Davis



Casey



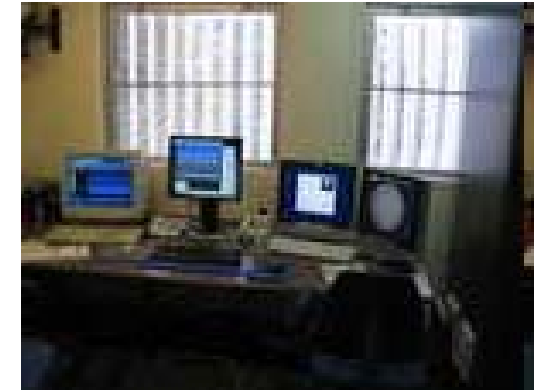
Macquarie Island



Scott Base



Culgoora Solar Observatory

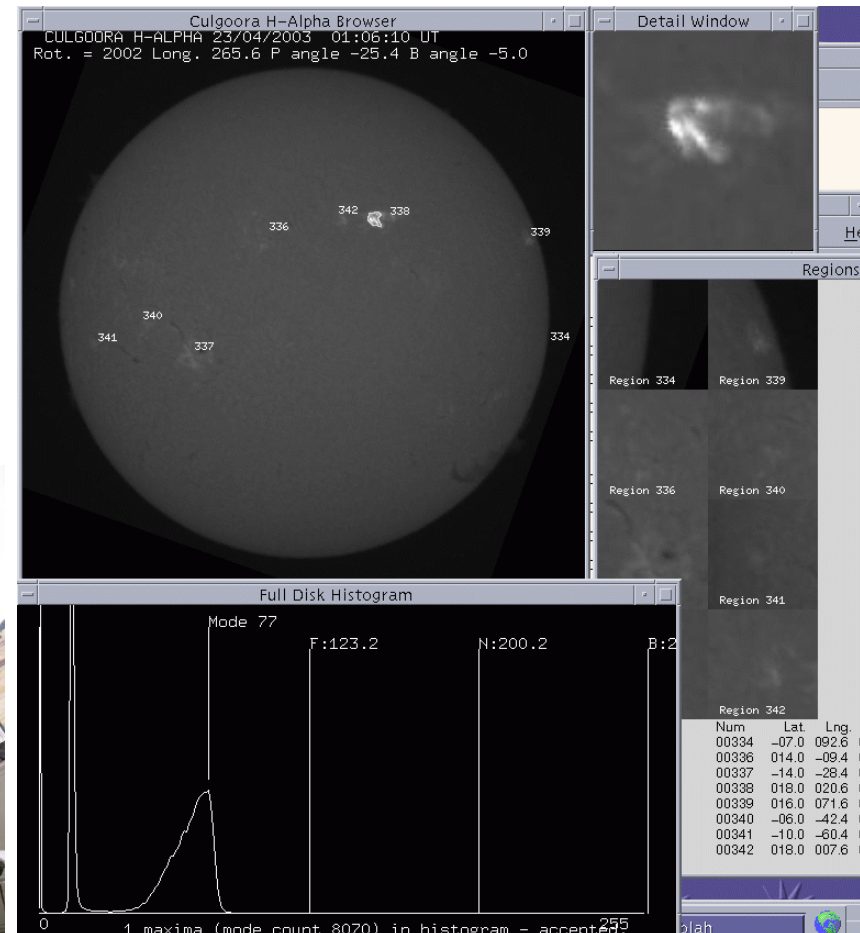
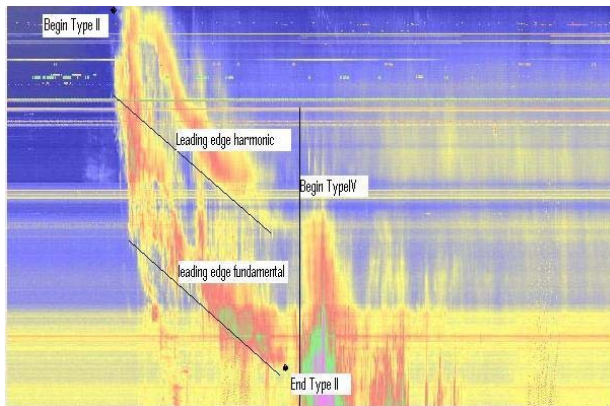


Culgoora

Radio quiet zone Next to CSIRO ATNF.
No transmissions. Excellent radio reception site.

Solar radio and optical
Magnetometers (IPS & MAGDAS)
Oblique HF radio Rx from NZ and TVL

Spectrograph 18-1800MHz



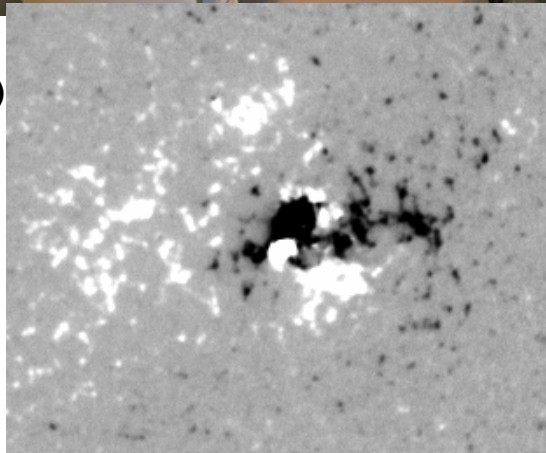
Learmonth Solar Observatory



8m antenna

Learmonth

RSTN – Radio Solar Telescope Network



Cover from 25 MHz to 15.4 GHz
3 parabolic antennae
8 fixed frequencies (245, 410, 610,
1415, 2695, 4995, 8800, 15400 MHz)

Solar Radio Spectrograph (designed by IPS)
sweeps from 25 to 180 MHz – fed by semi-
bicone (low band) and tracking log periodic
(high band) antennae.

Operation from sunrise to sunset



IPSNET Observatories



Flare Forecast

SOLAR DAILY FLARE FORECAST (\geq M class) from
LEARMONTH SPOTS SUMMARY 0120 UT ON 22/06/04

RGN#	Class	Rate	Prob
0632	HAX	0.11	10.0%
0634	FAO	1.48	77.3%
0635	FAI	1.56	78.9%
0636	BXO	0.01	1.0%
0637	AXX	0.02	1.8%

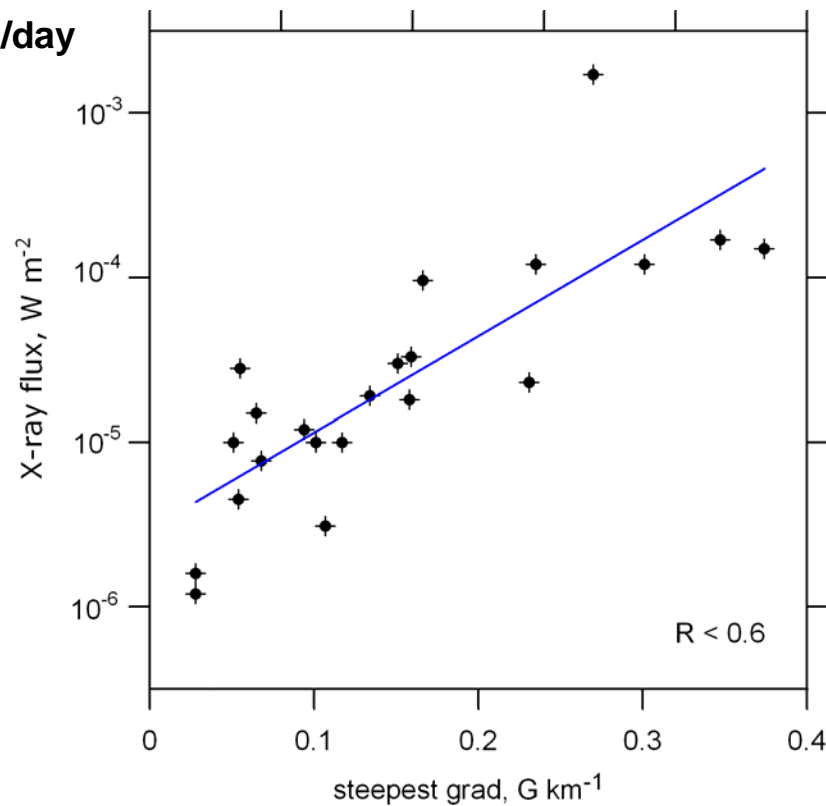
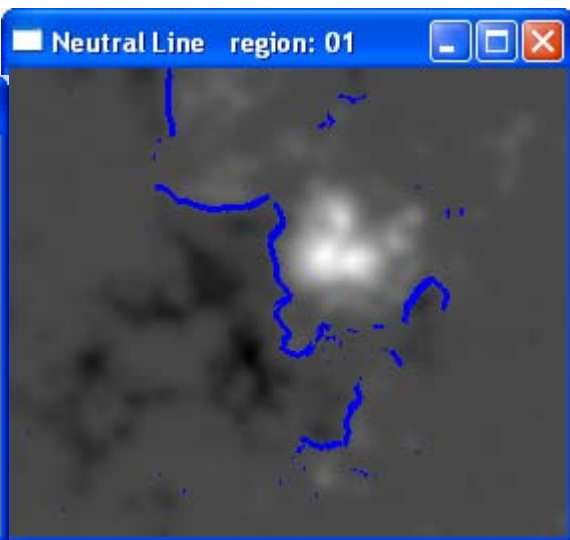
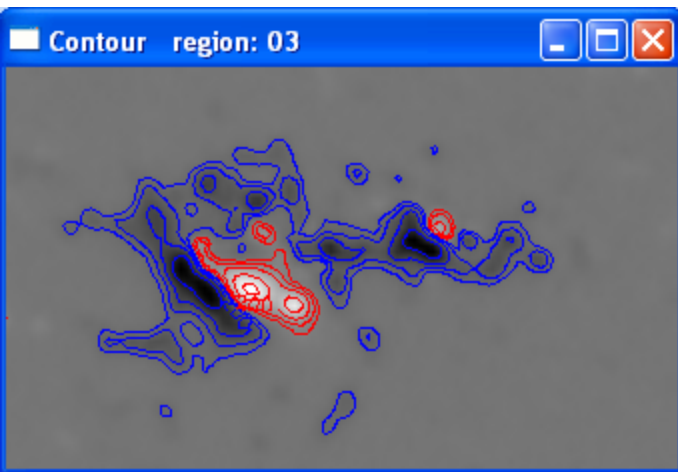
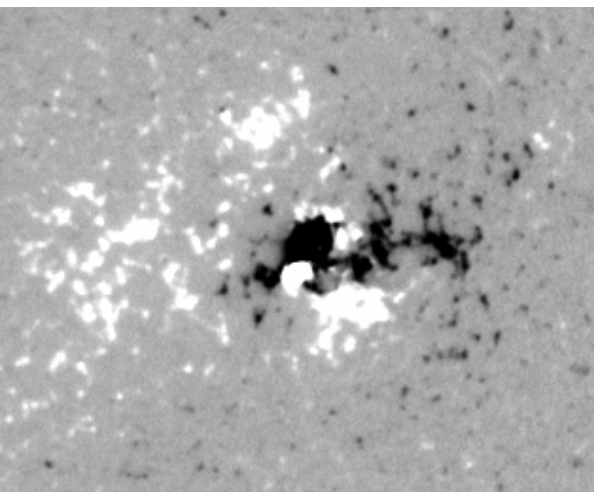
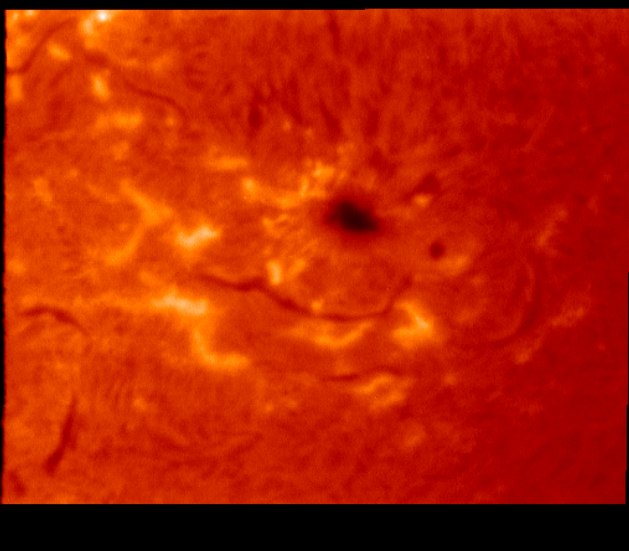
(McIntosh, P.S. 1990, Sol Phys., 125,251)

Total regions = 5, Flare Rate = 3.2/day

Daily flare probability = 95.8%

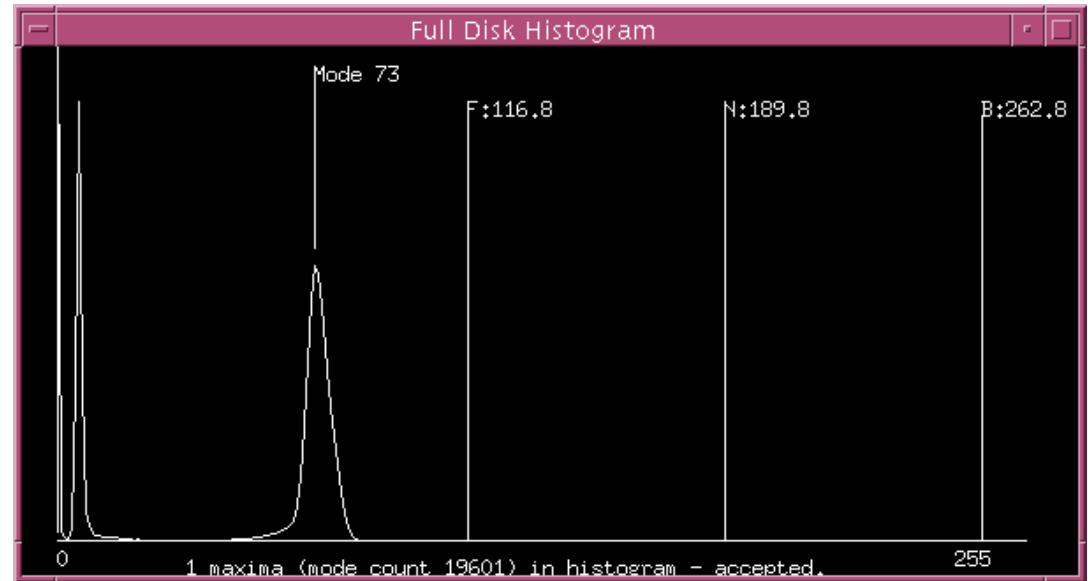
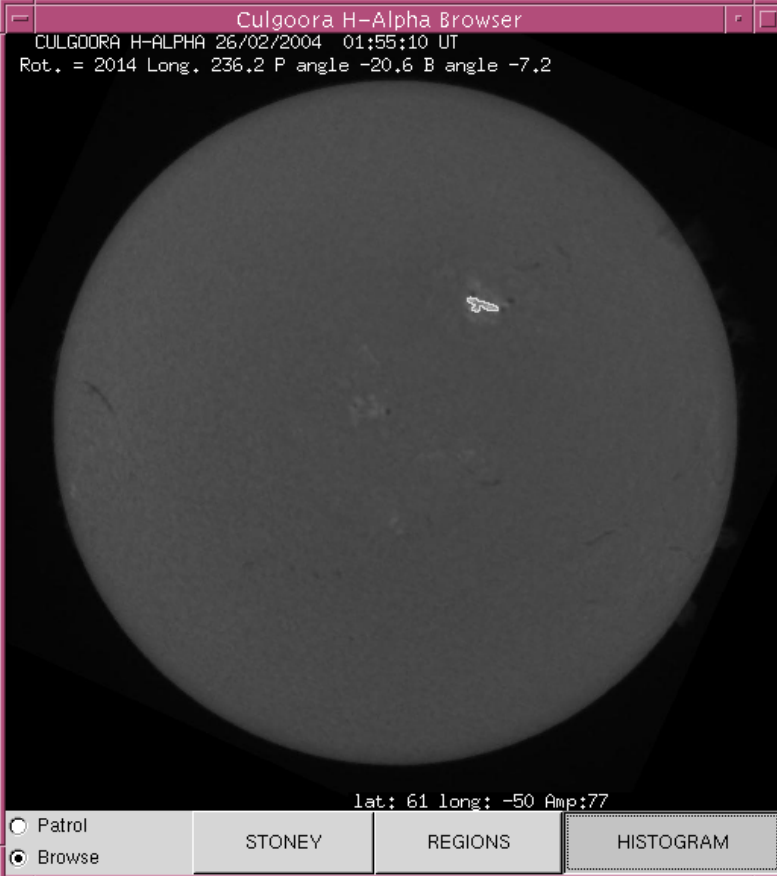
Max Gradient

- 0.025 - 0.09 – possible C-flares
- 0.09 - 0.25 – possible C and M-flares
- > 0.25 – possible C, M, and X-flares

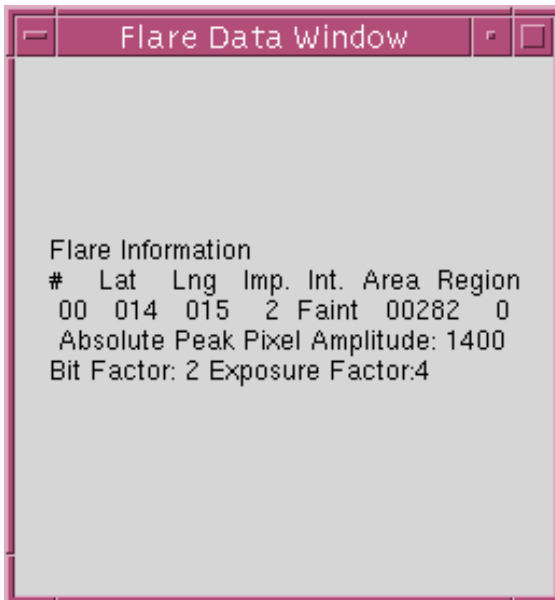


Steward et al., (to be published)

Flare Alert



(G.Patterson)



IPS XRAY AND OPTICAL FLARE CORRELATION –PART D ISSUED AT 0245 UT on 26 Feb 2004 BY IPS RADIO AND SPACE SERVICES FROM THE AUSTRALIAN SPACE FORECAST CENTRE

Optical flares with maximum within 10 minutes of X-ray maximum are correlated.

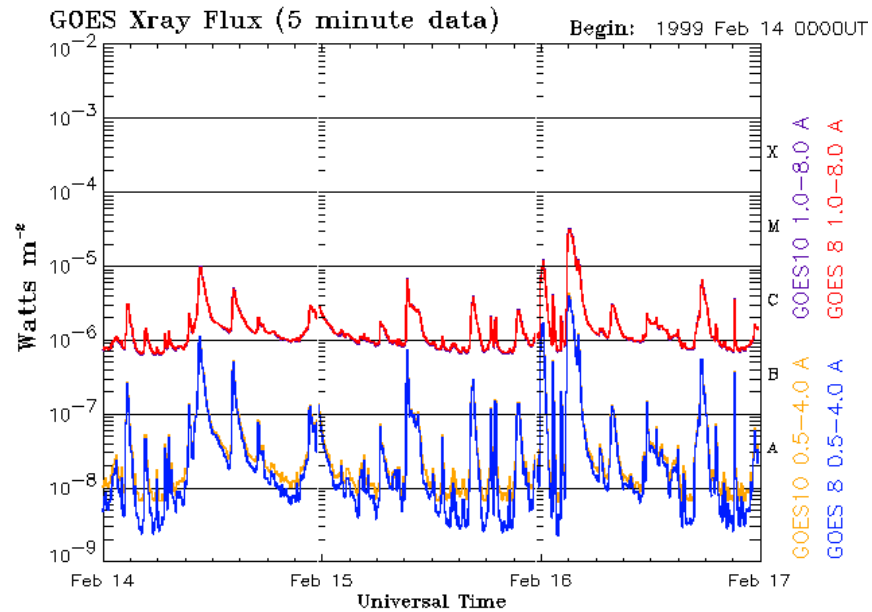
Approximate xray flare maximum 26 2 2004 0204 UT at Flux X1.1

Xray flare possibly optically correlated with the following H-alpha flare auto-detected at IPS Culgoora Solar Observatory:

Start date/time	Max date/time	End date/time
26 02 2004 01:55UT	26 02 2004 01:59UT	26 02 2004 02:41UT

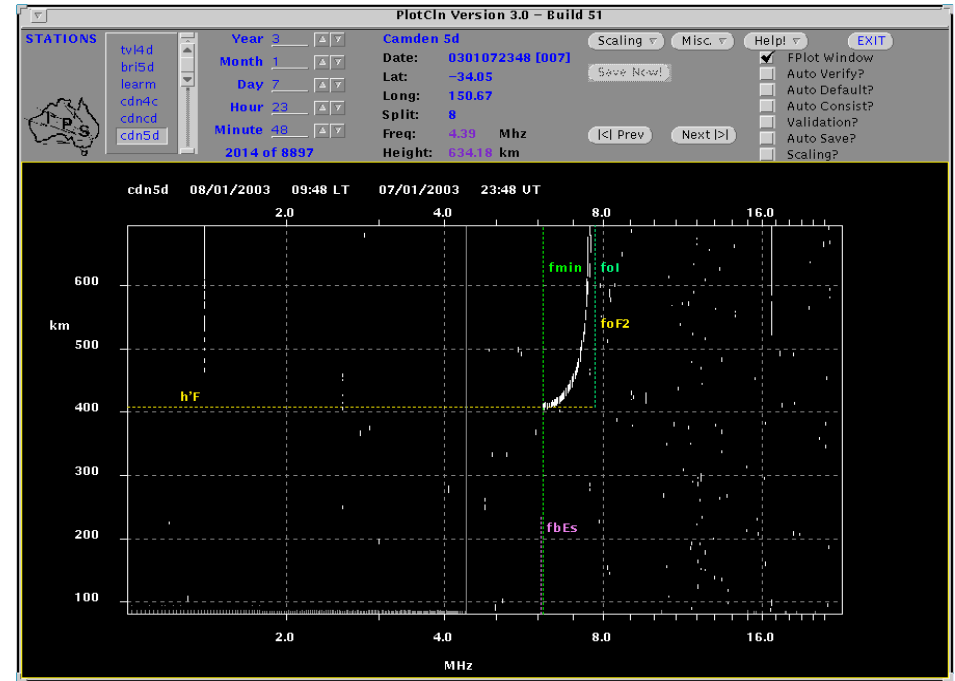
Lat	Long	Imp.	Bright.	Area	SEC	Region Num
014	014	2	Bright	00485		564

HF SWF Alert



Updated 1999 Feb 16 23:59:10

NOAA/SEC Boulder, CO USA

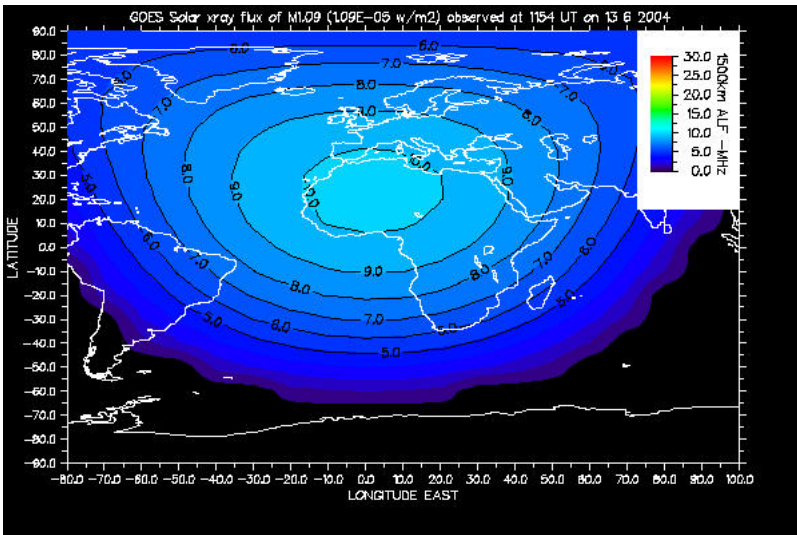


IPS FADEOUT ALERT - PART A FOR HF FADEOUTS AFFECTING THE AUSTRALIAN REGION
ISSUE TIME: Thu Feb 26 13:00:24 EST 2004

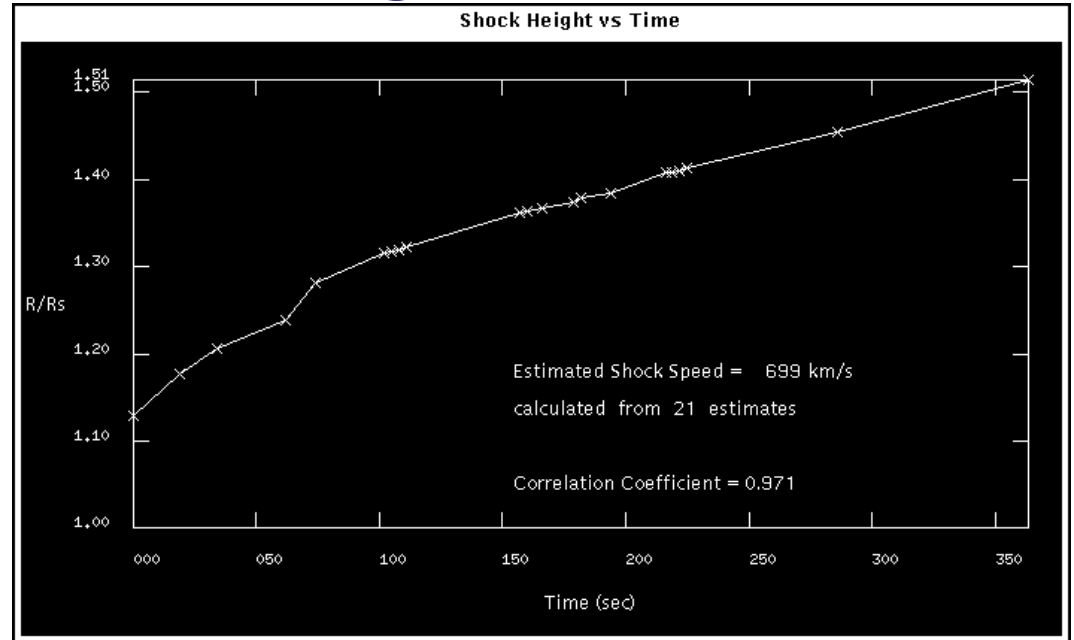
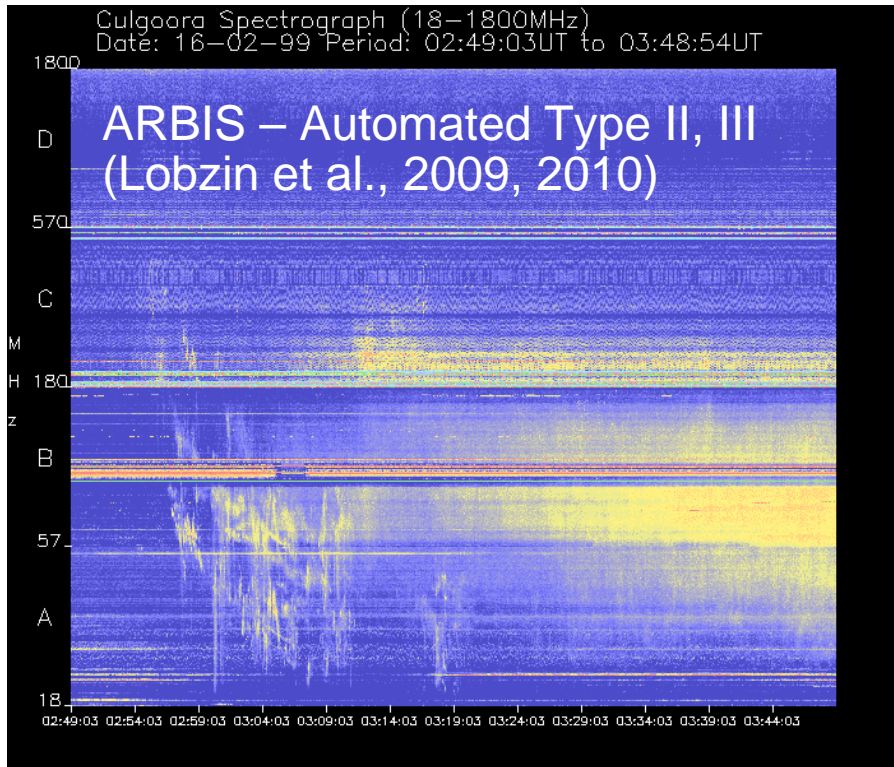
A HF FADEOUT IS NOW UNDERWAY IN PART OF THE AUSTRALIAN REGION. MORE DETAILS OF THE TIMING AND EXTENT OF THIS EVENT WILL BE ISSUED JUST AFTER IT ENDS.

Follow the progress of this event on the IPS Web site
<http://www.ips.gov.au> Click "Space Weather" Click "X-Ray Flux"

Australian Space Forecast Centre IPS Radio and Space Services
 (61)(2)9213 8010 (phone) (61)(2)9213 8061 (fax) asfc@ips.gov.au



CME Warning



PLAIN PRESTO CULGOORA 03/0131UT NOV 2003

SOLAR RADIO EVENT 1: DRIFTING: 200 - 30 MHZ

START TIME: 0124 UT

END TIME: 0129 UT

SPECTRAL TYPE: TYPE II BURST

IMPORTANCE: STRONG

FUNDAMENTAL AND HARMONIC VISIBLE

ESTIMATED SHOCK SPEED 699 KM/S

FLARE OBSERVED IN REGION 10488 SHORTWAVE

FADEOUT OBSERVED

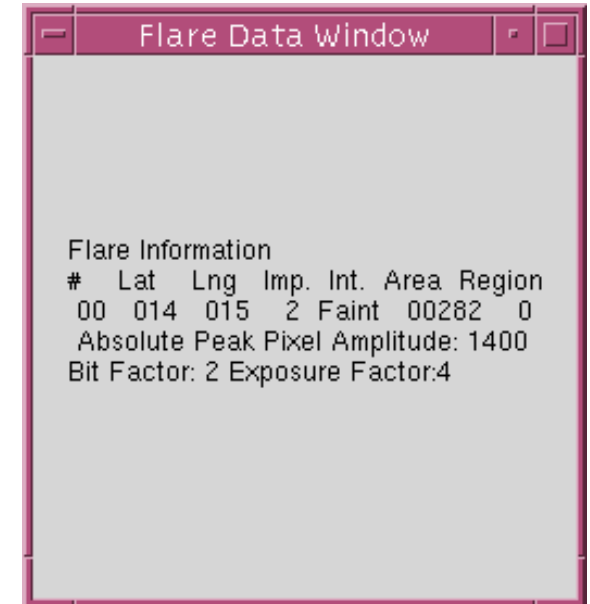
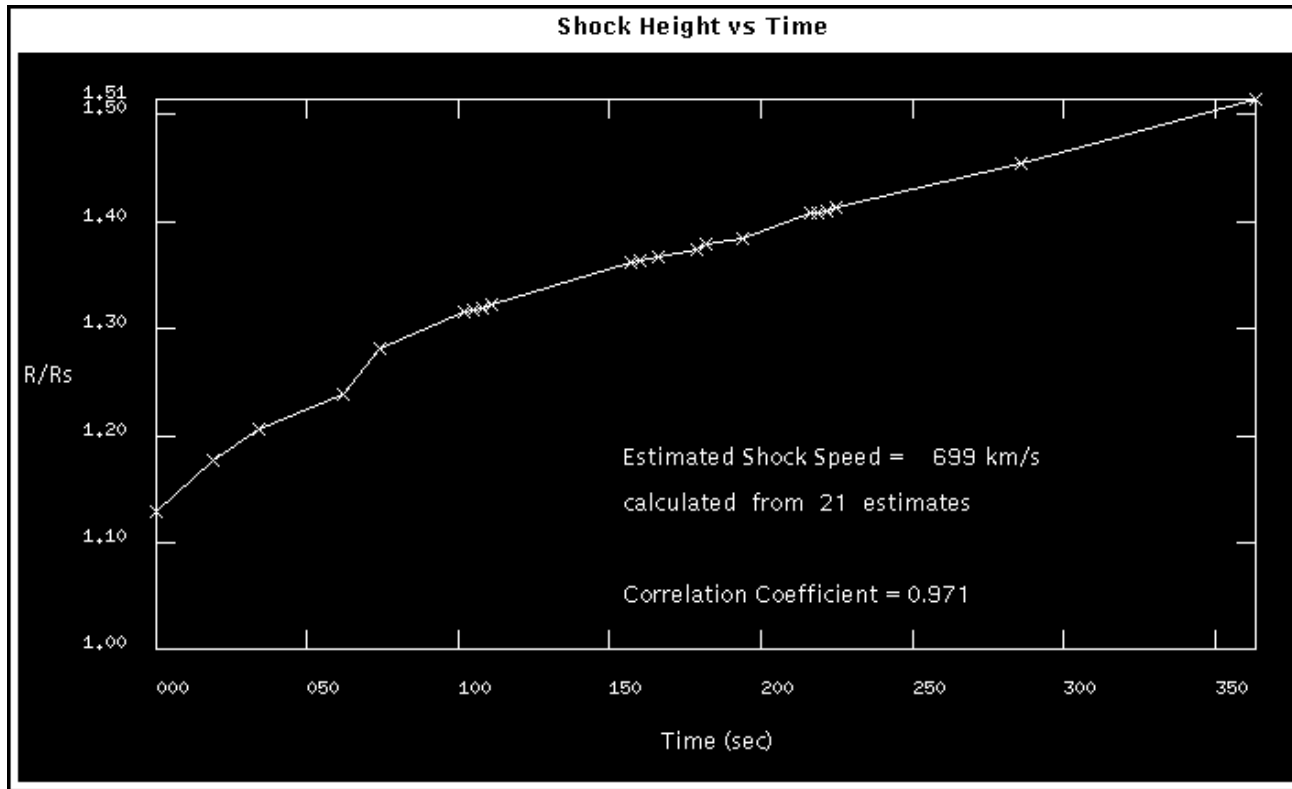
Shock Details

#####

Type II Radio Burst Type
Fundamental

#	Time sec	Freq MHz	Ne	Height Rsun
0	0	159	2.820	1.13
1	19	133	1.964	1.18
2	34	120	1.604	1.21
3	62	108	1.298	1.24
4	74	94	0.993	1.28
5	102	85	0.811	1.32
6	105	85	0.801	1.32
7	108	85	0.797	1.32
8	111	84	0.778	1.32
9	157	75	0.626	1.36
10	160	74	0.618	1.36
11	166	74	0.610	1.37
12	179	72	0.586	1.37
13	182	72	0.574	1.38
14	194	71	0.554	1.38

Geomagnetic Storm Warning



**SUBJ: IPS GEOMAGNETIC DISTURBANCE WARNING 02/46
ISSUED AT 23/0107Z DECEMBER 2002 BY THE AUSTRALIAN
SPACE FORECAST CENTRE.**

**INCREASED GEOMAGNETIC ACTIVITY EXPECTED DUE TO
CORONAL MASS EJECTION FROM 23-24 DECEMBER 2002**

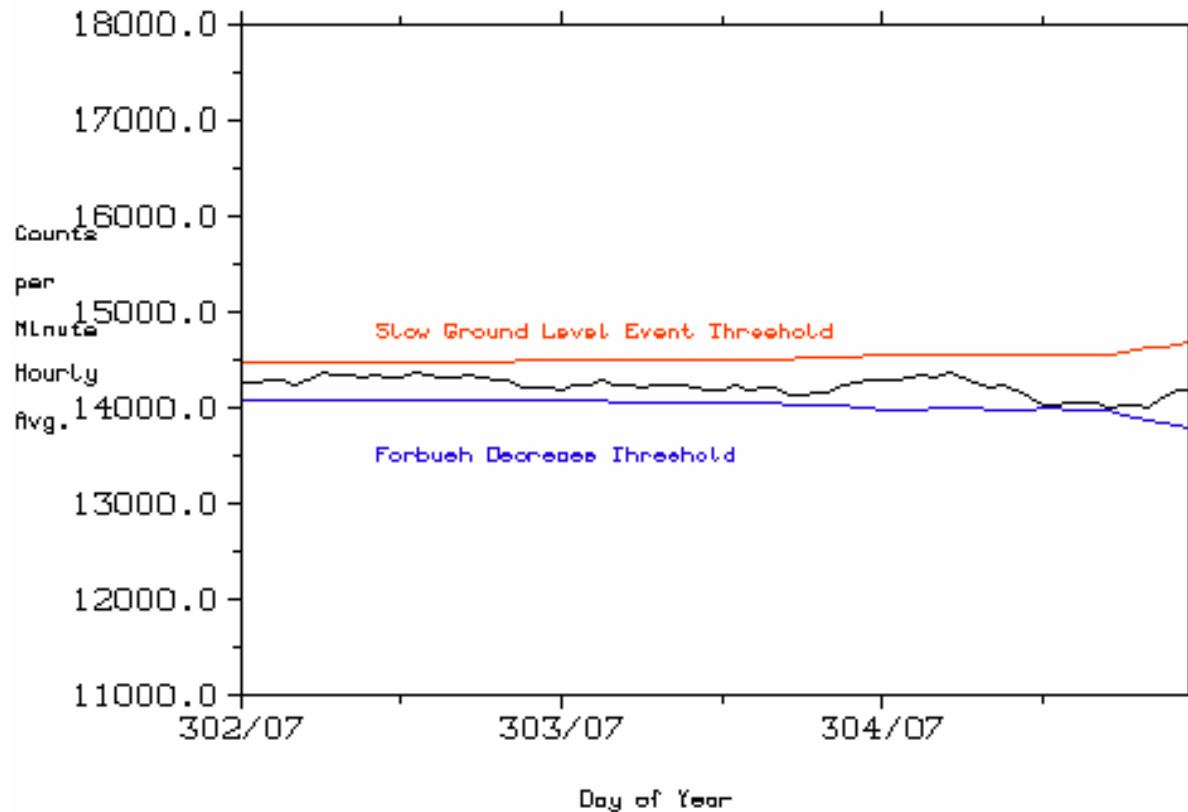
GEOMAGNETIC ACTIVITY FORECAST

23 Dec: Active to minor storm periods.

24 Dec: Active

CME Alert

RAD/IPS Mawson Cosmic Ray Data 2010/302 0700 to 2010/305 0600 UT

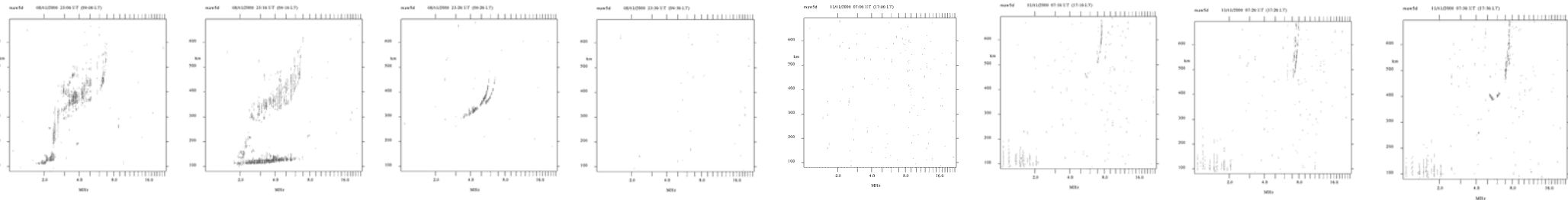
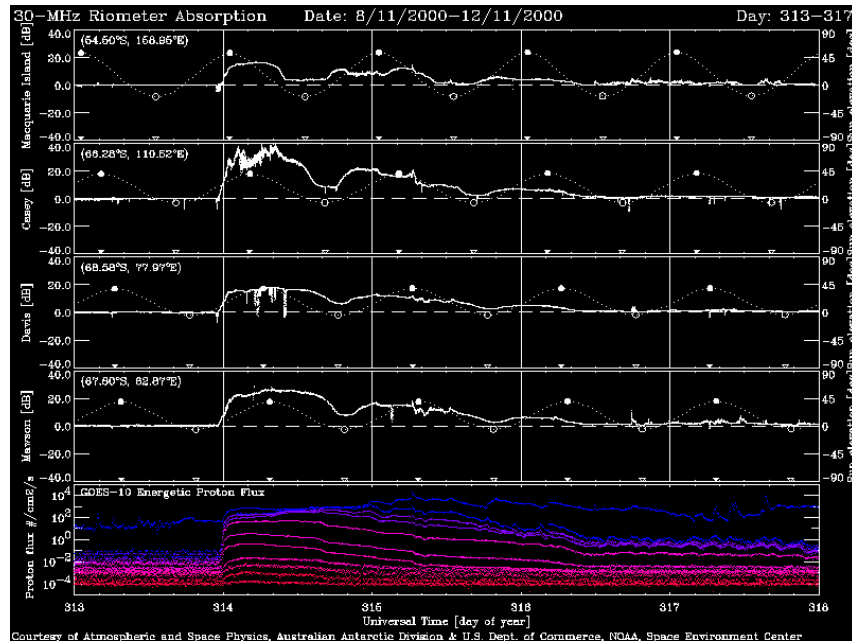


Last updated 01 Nov 2010 07:30 UT

Forbush Decrease Observed (3%) at MAW 05/04/2010 DOY: 95 Hour: 17UT
Forbush Decrease Observed (3%) at MAW 04/08/2010 DOY: 216 Hour: 04UT

PCA Alert

$$A(\text{dB}) = 10 \log_{10}(A_{\text{qdc}}/A_{\text{day}})$$



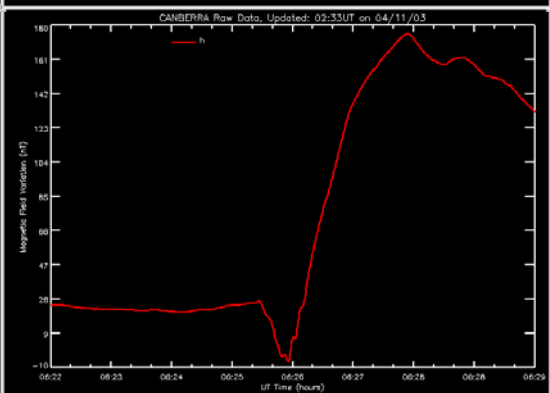
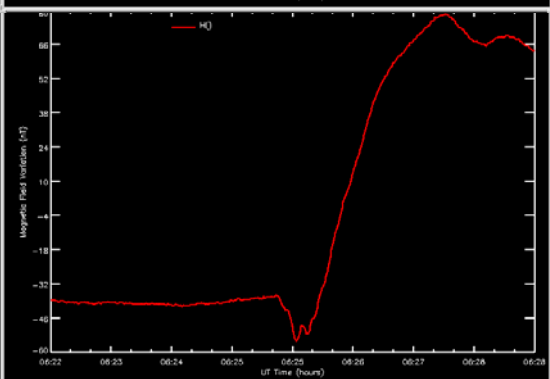
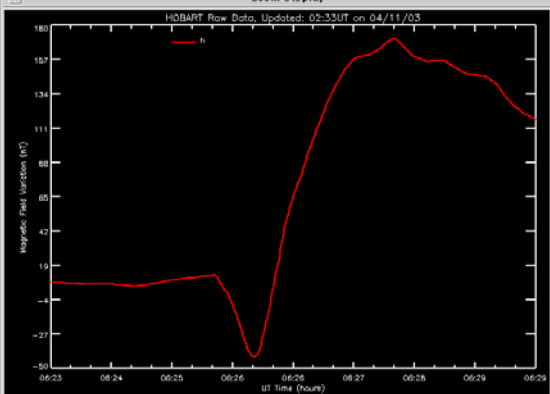
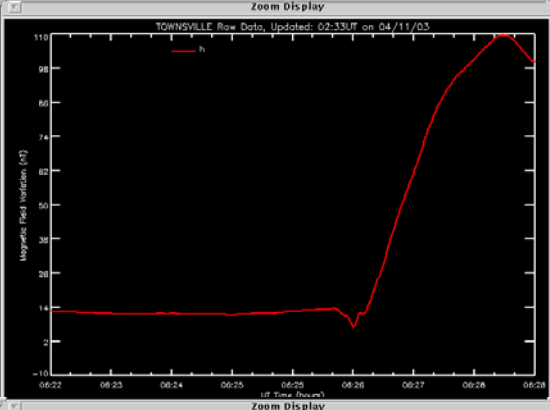
10Mev Proton/PCA Event Began 31 05 2003 0505UT and is in progress

Casey 30Mhz Riometer Data at time of Issue: Casey 1.9 dB

**IPS Radio and Space Services
PO Box 1386
Haymarket NSW 1240 AUSTRALIA
tel: +61 2 9213 8010**

**| email: asfc@ips.gov.au
| WWW: <http://www.ips.gov.au>
| FTP: <ftp://ftp.ips.gov.au>
| fax: +61 2 9213 8060**

SSC/SI Alert

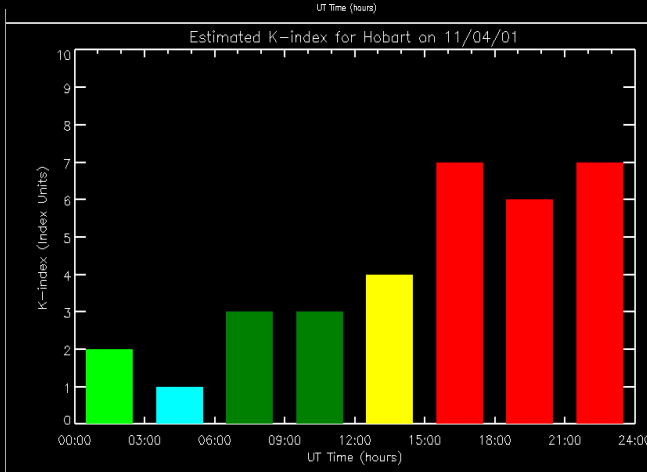
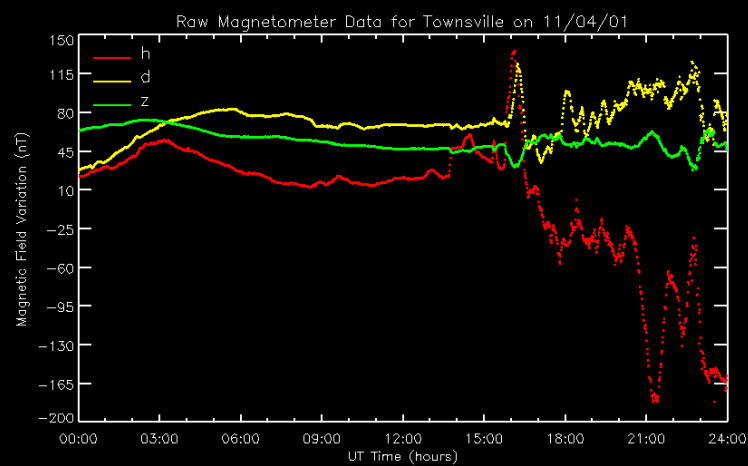
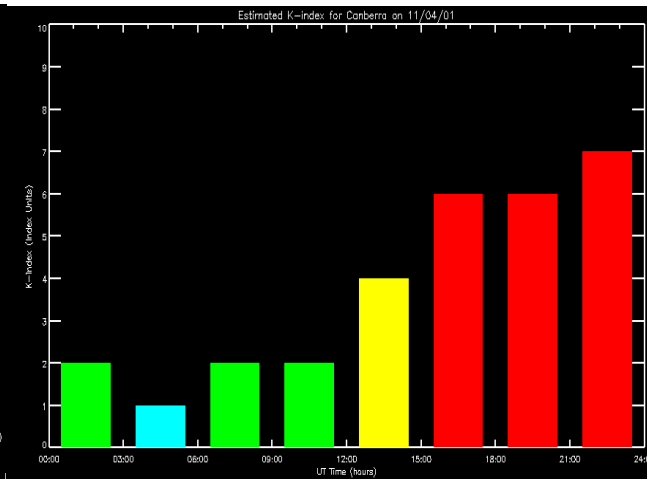
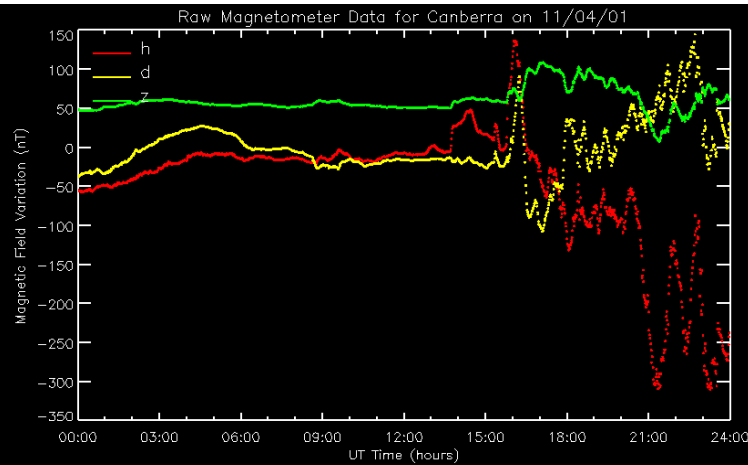


**MODERATE SUDDEN IMPULSE DETECTED (87nT)
IN IPS MAG DATA 04 11 03 0626UT**

Mean Mag Parameters Pre/Post Impulse:

	Pre	Post	
Stn Unit	Impulse	Impulse	Change
Hbt nT	15.0	118.9	103.9
cbr nT	29.1	131.7	102.5
tvI nT	17.0	69.6	52.6
lem nT	43.2	130.4	87.2
clg nT	-34.4	54.7	89.1

Geomagnetic Storm Alert



Estimated Indices 05 Jun :

Darwin	2222	1222
Townsville	1222	2222
Learmonth	1212	2332
Culgoora	2211	2222
Canberra	-311	2223
Hobart	1211	2222

Australian Region 2212 2222

SUBJ: IPS GEOMAGNETIC DISTURBANCE ALERT

ISSUED AT 1716 UT ON 11 APR 2001 BY IPS RADIO AND SPACE SERVICES FROM THE AUSTRALIAN SPACE FORECAST CENTRE

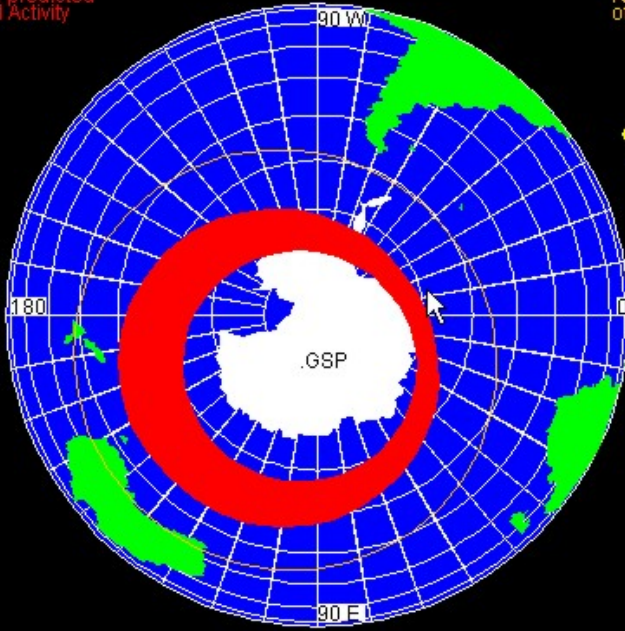
**SEVERE GEOMAGNETIC DISTURBANCE IN PROGRESS (K OF 7 REACHED)
PRELIMINARY AUSTRALIAN REGION K INDICES FOR 11 04 01: 2122 47--**

jun Kaus 9 UT HOUR 14

SOUTHERN TERRESTRIAL HEMISPHERE

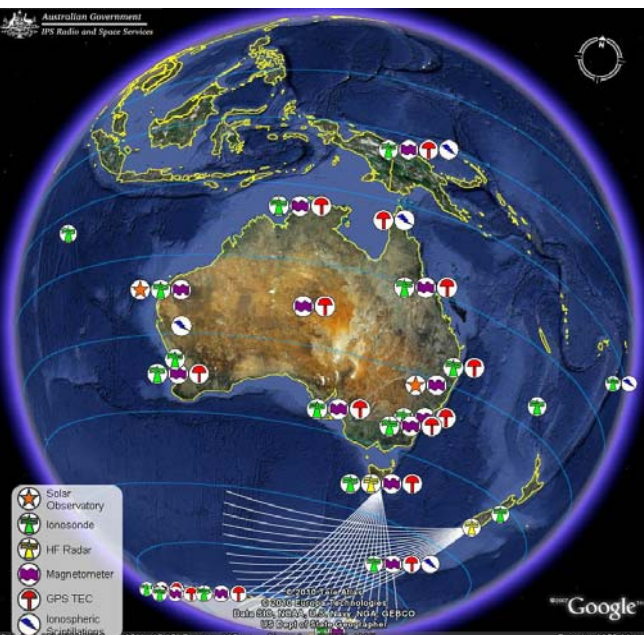
Area of predicted Auroral Activity

Predicted Northern Limit of Auroral Visibility



GSP - GEOMAGNETIC SOUTH POLE

Aurora Alert

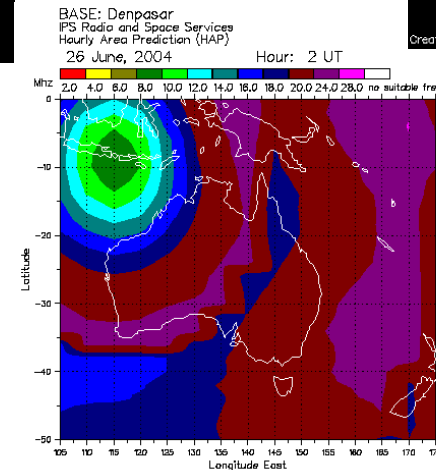
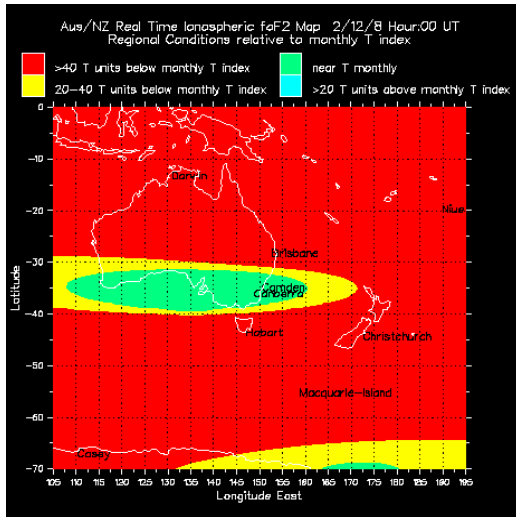
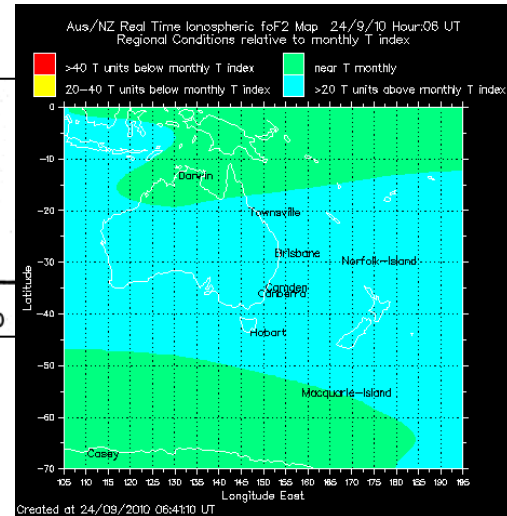
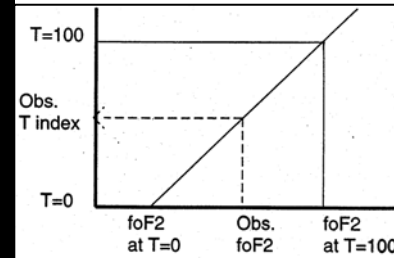
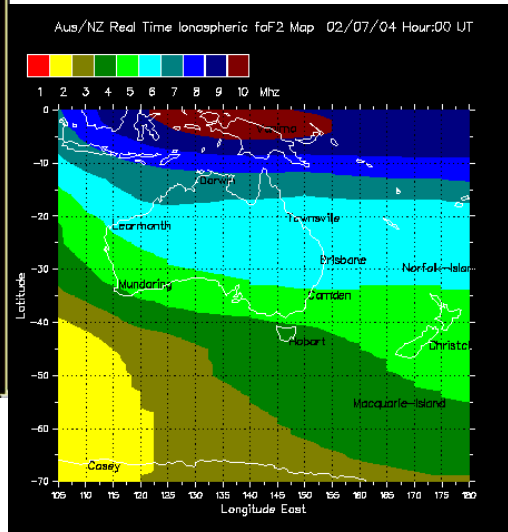
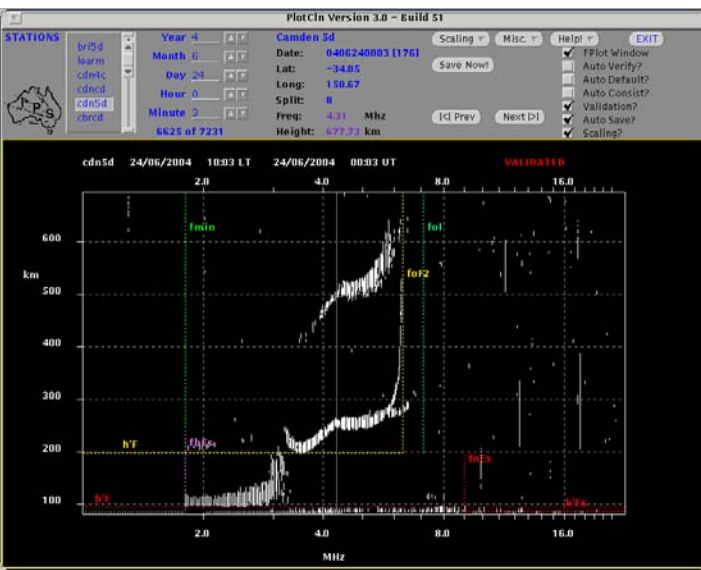


SUBJ: IPS AURORA ALERT ISSUED AT 1818 UT on 31 Mar 2001 BY IPS RADIO AND SPACE SERVICES FROM THE AUSTRALIAN SPACE FORECAST CENTRE

SEVERE GEOMAGNETIC STORM IN PROGRESS.

AURORA MAY BE OBSERVED DURING LOCAL NIGHT TIME HOURS IN GOOD OBSERVING CONDITIONS AT REGIONS AS FAR EQUATORWARD AS MIDDLE LATITUDES.

HF COMMS Warning

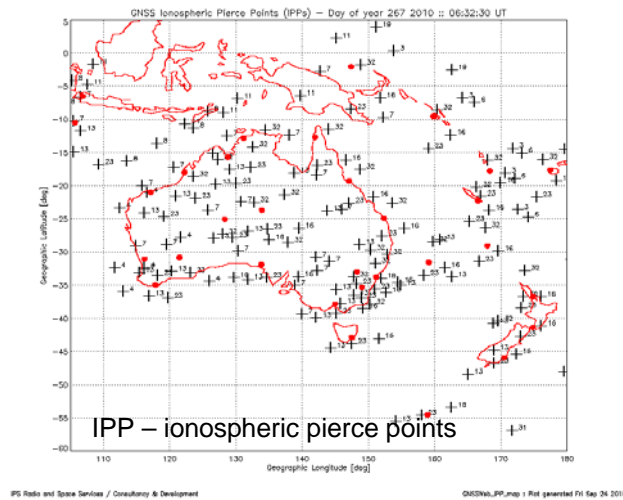


**SUBJ: IPS HF RADIO COMMUNICATIONS WARNING 10/21 ISSUED AT 23/2354Z OCTOBER 2010 BY THE AUSTRALIAN SPACE FORECAST CENTRE. DEGRADED HF PROPAGATION CONDITIONS EXPECTED FOR 24 OCTOBER 2010
IF COMMS DIFFICULTIES EXPERIENCED TRY A LOWER FREQUENCY BAND**

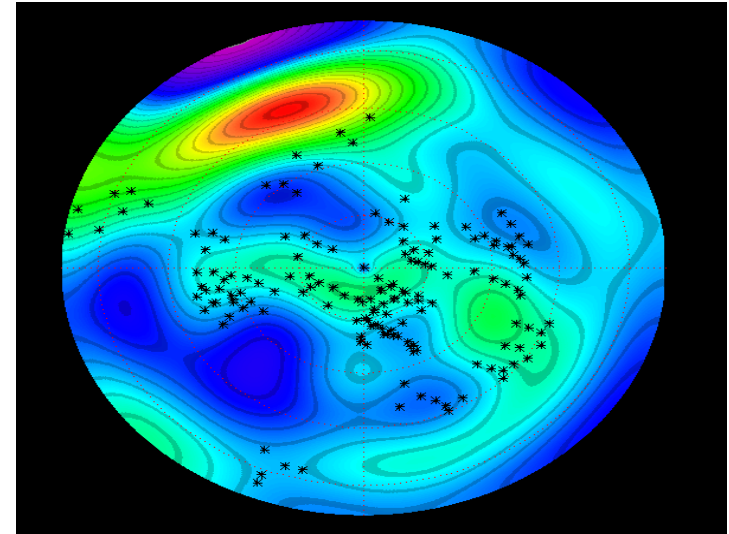
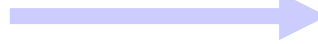
HF COMMUNICATIONS FORECAST (AUSTRALIAN/NEW ZEALAND REGION) FREQUENCY BANDS

T-index	MUFs	2	4	6	8	12	16	22	26
-10	-22%	2	4	6	8	8	12	16	16

TEC Ionospheric Model



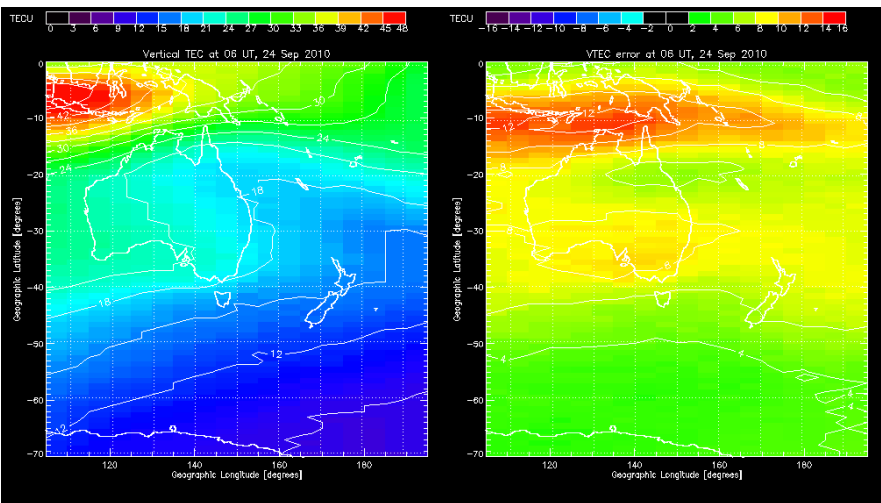
Input data QC
Kalman filtering



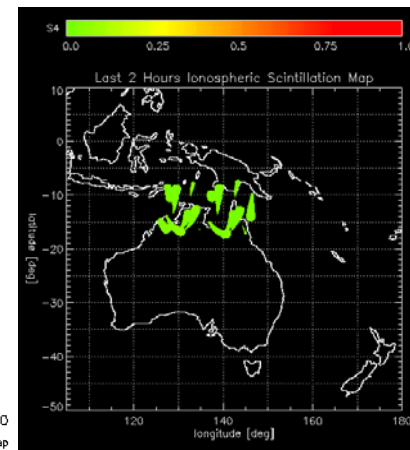
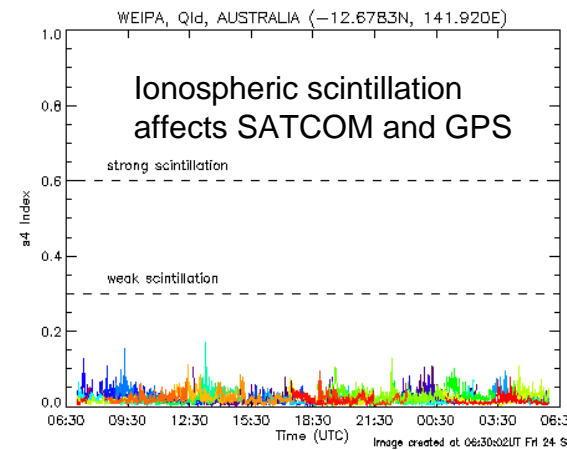
(M.Terkildsen, Z.Bouya and M.Francis)

SCHA – spherical cap harmonic analysis of TEC
Legendre polynomial basis functions

$$TEC(\vartheta, \varphi) = \sum_{k=0}^{K \max} \sum_{m=0}^k P_{nk(m)}^m(\cos(\vartheta)) [g_k^m \cos(m\varphi) + h_k^m \sin(m\varphi)]$$



Plasmasphere model
Klobuchar model



GICs in Pipelines

Australia's Major Pipeline System as at 2009

Compiled and published by:
 Pipeline Publications Australia
 GPO Box 4967, Melbourne Vic 3001
 Tel: +61 3 9248 5100 Fax: +61 3 9602 2708
 E-mail: query@pipeliner.com.au
 Website: <http://www.pipeliner.com.au>

[Note: This map is a schematic representation only and shows approximate location of major pipelines. It does not show exact pipeline routes.]



LEGEND

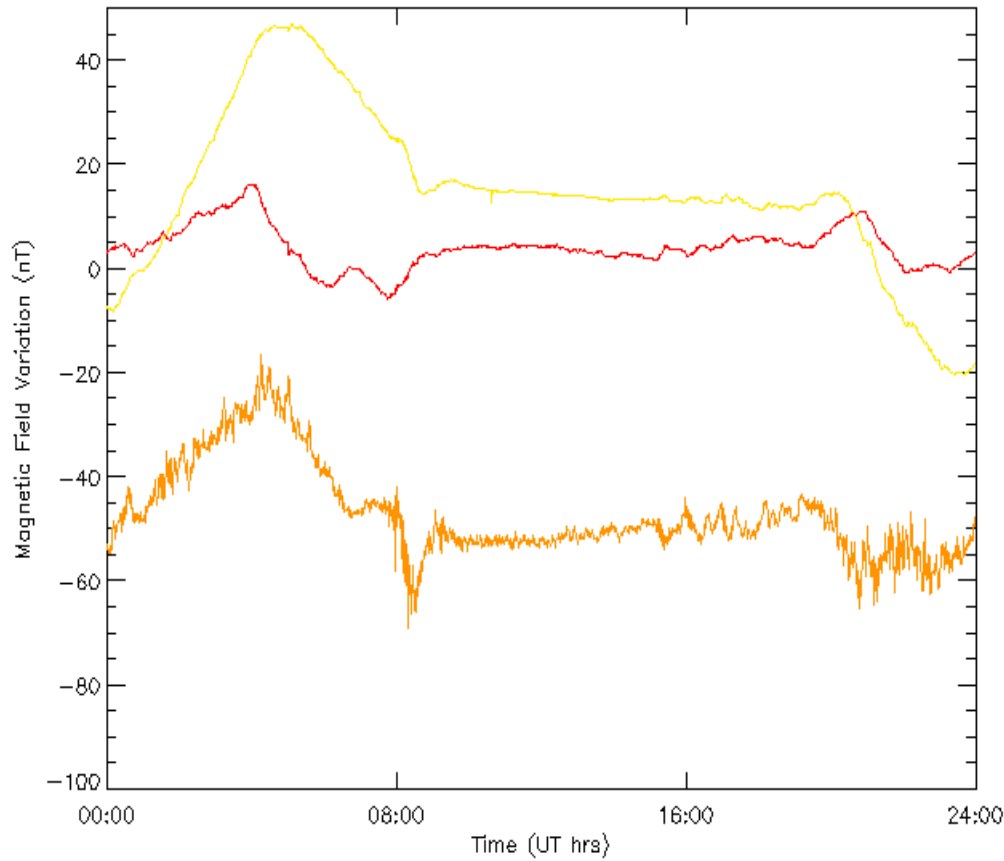
- Gas Pipeline
- Oil Pipeline
- Ethane Pipeline
- Slurry Pipeline
- - - Proposed Pipeline

SCALE

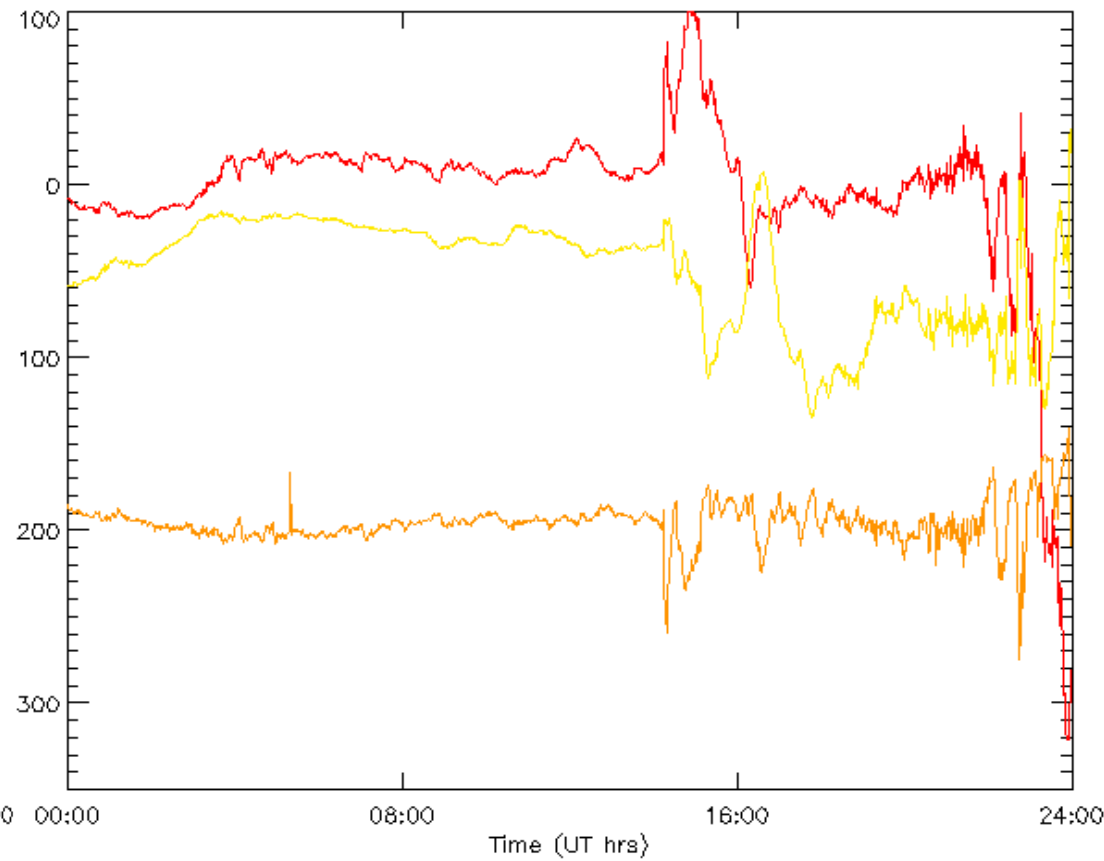
0 250 500 750 1000 kms

GICs in Pipelines

Geomagnetic Quiet Day

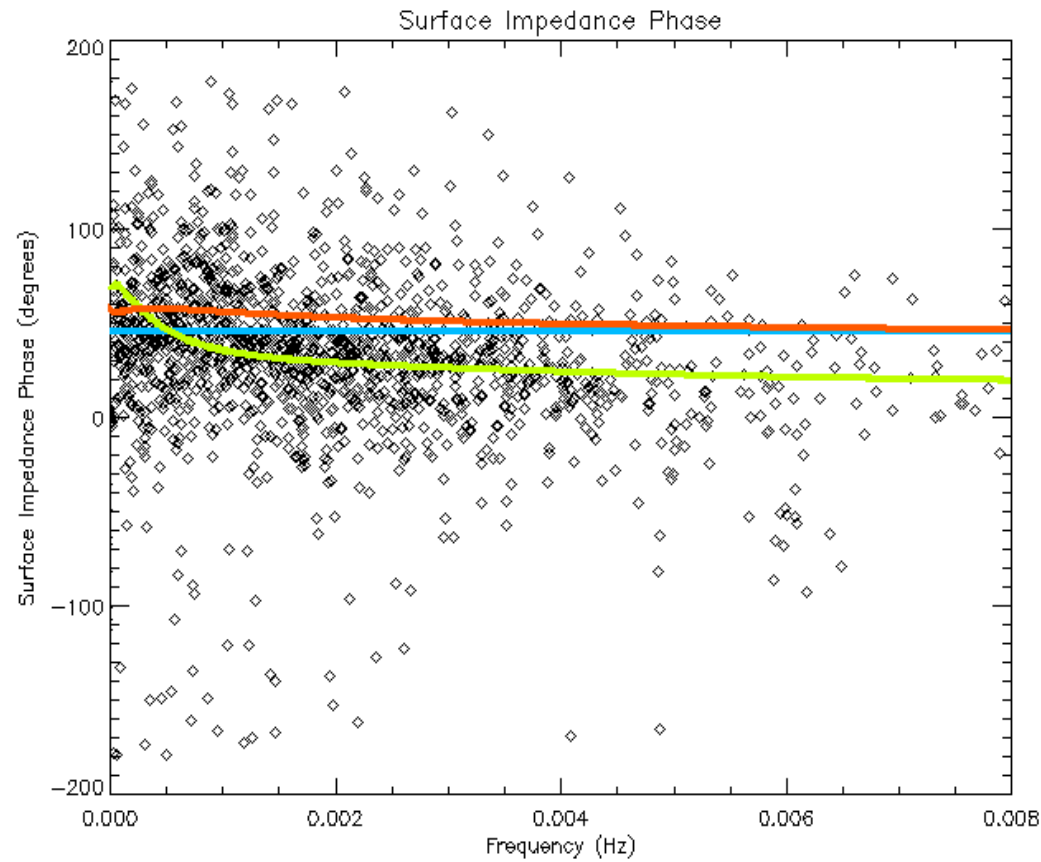
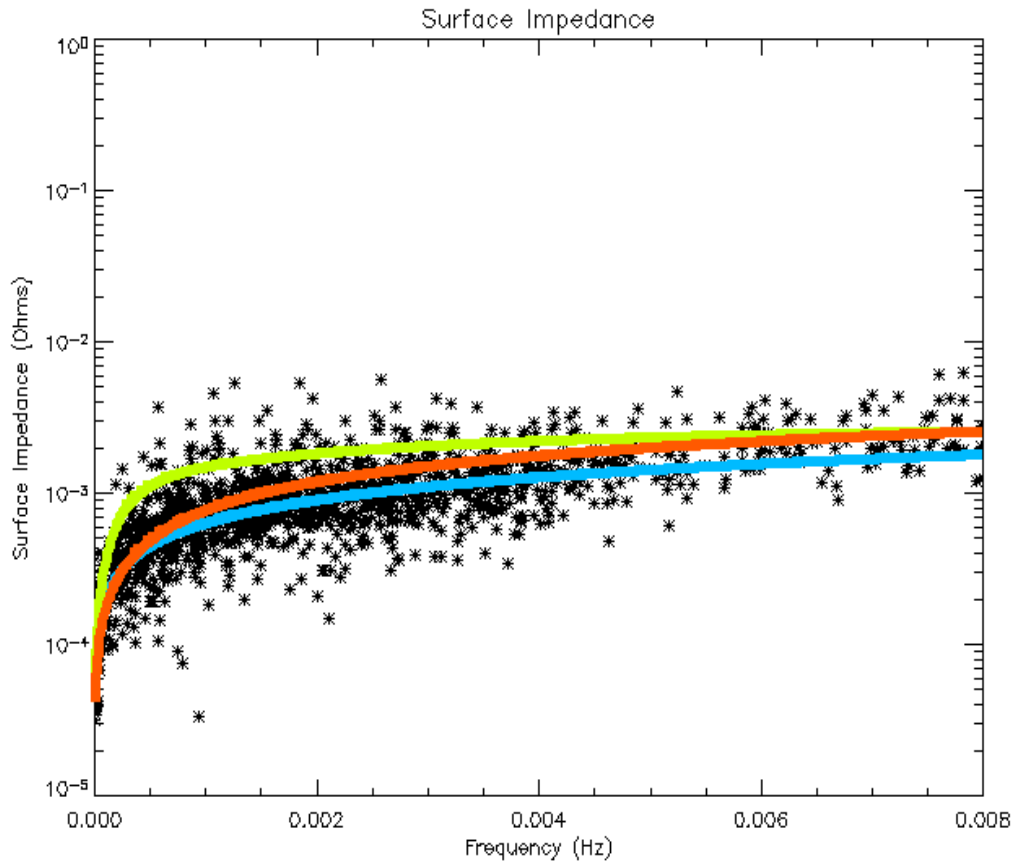


Geomagnetic Storm



GICs in Pipelines

Spectral Analysis: B vs PSP

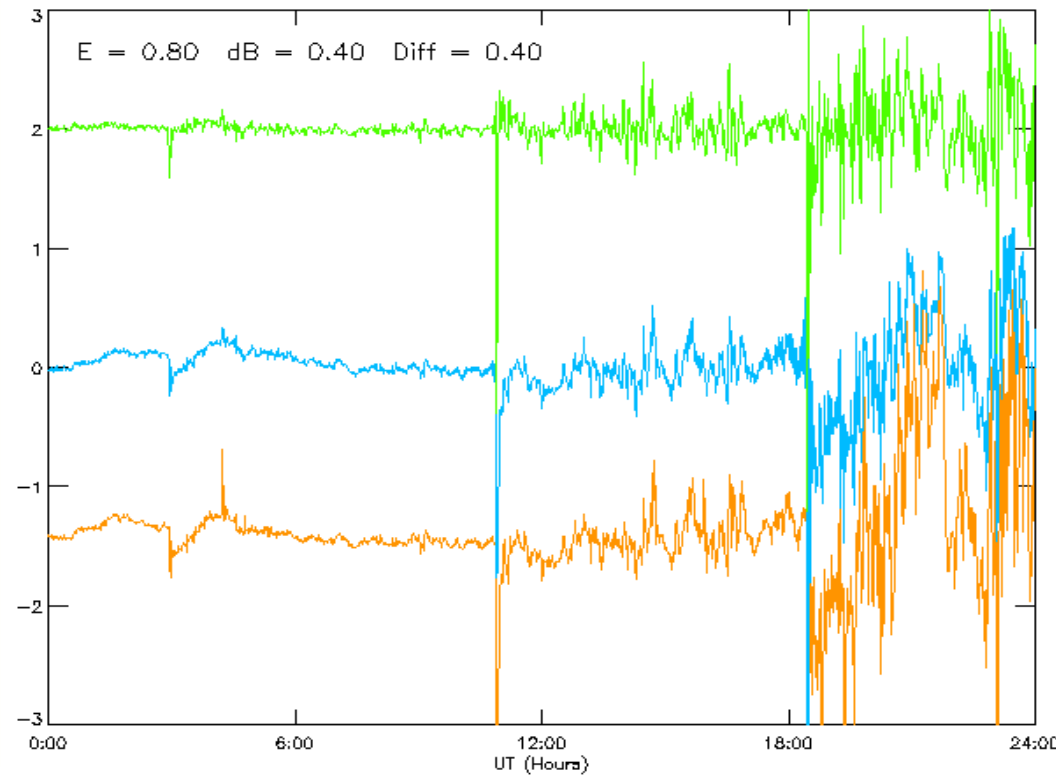
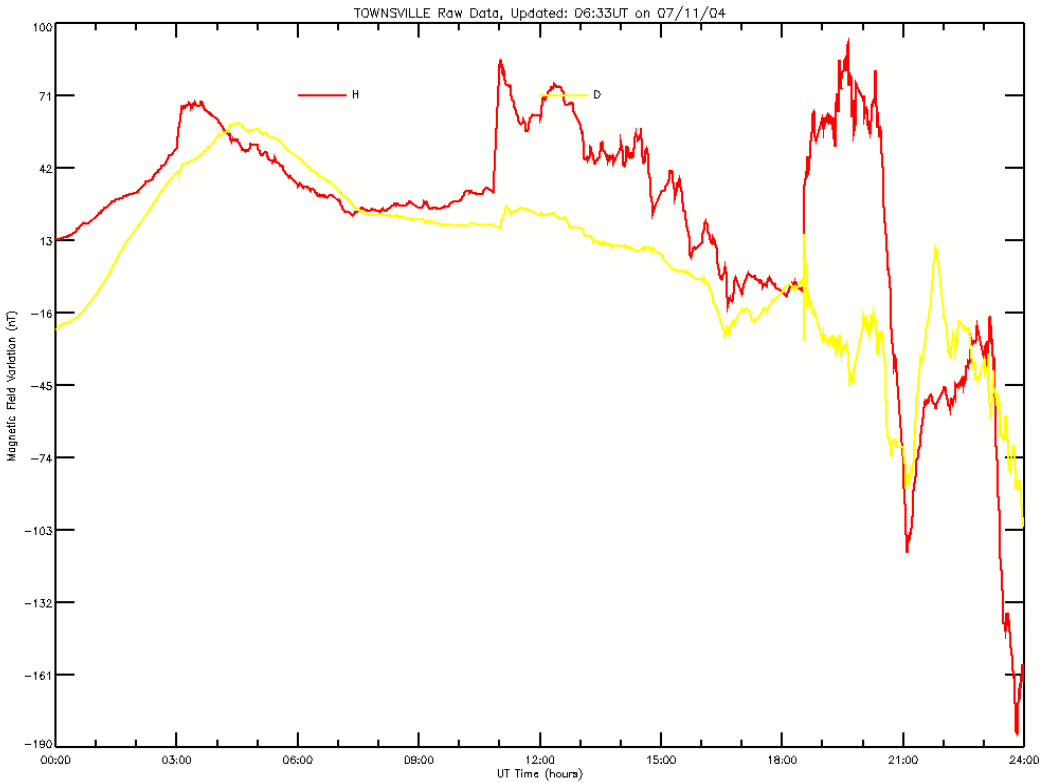


GIC- Index: $Z(f) = \sqrt{\frac{f}{f_N}} e^{i\frac{\pi}{4}}$

(Marshall et al., 2010)

GICs in Pipelines

GIC Index: 7th November 2004



Red – H Comp

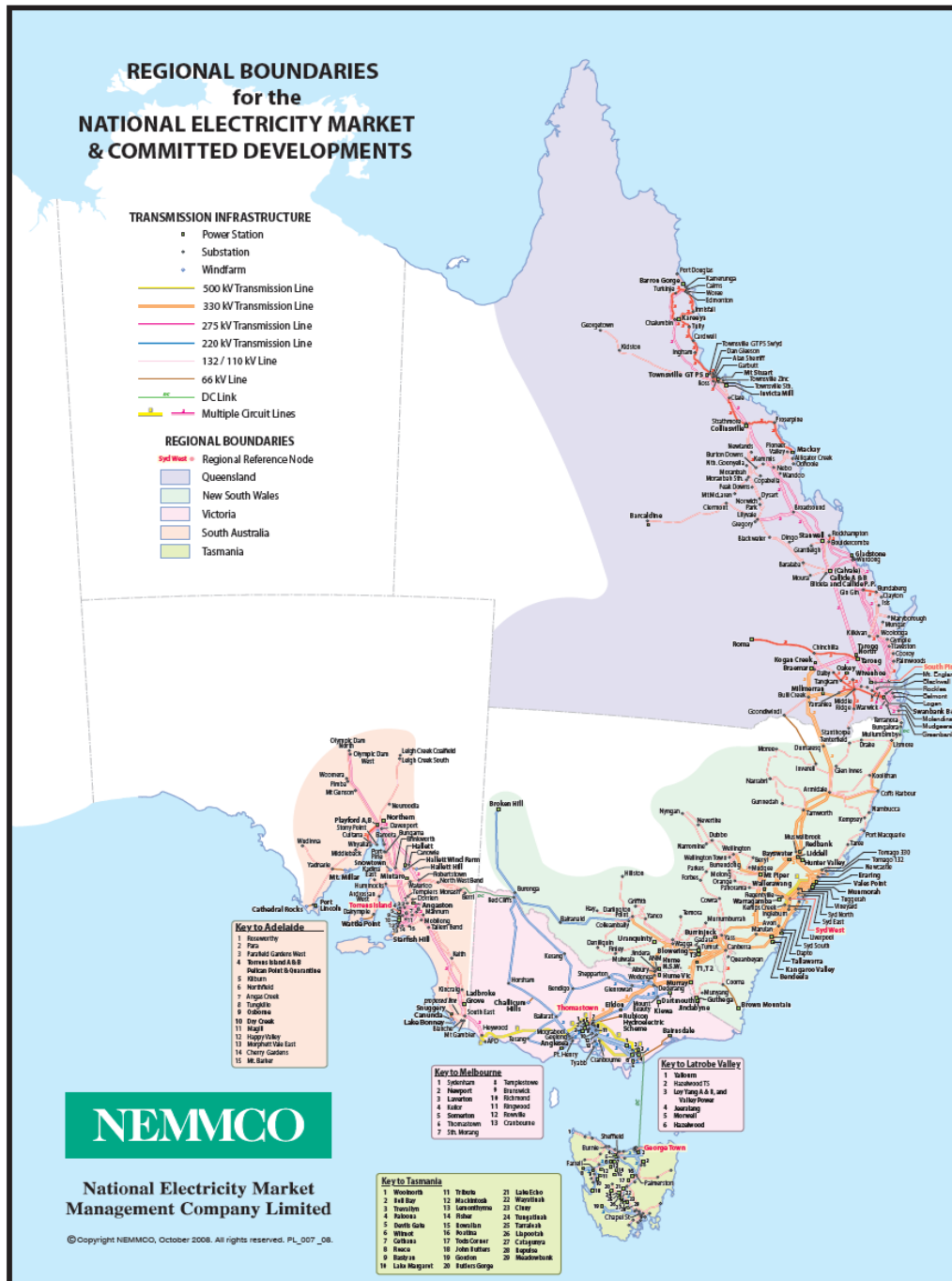
Yellow – D Comp

Green – dB/dt

Blue – GIC-index

Orange - PSP

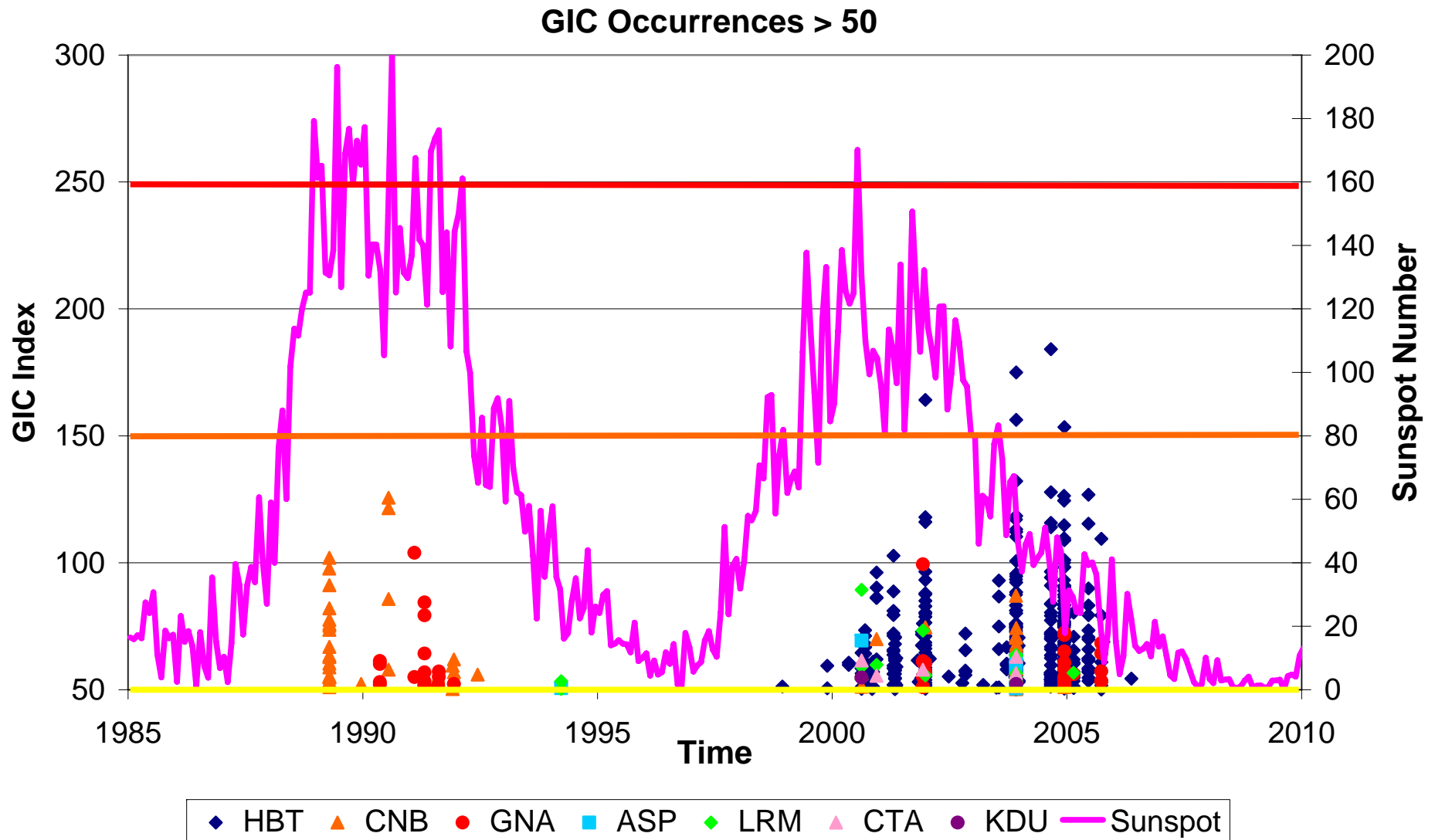
GICs in Power Networks



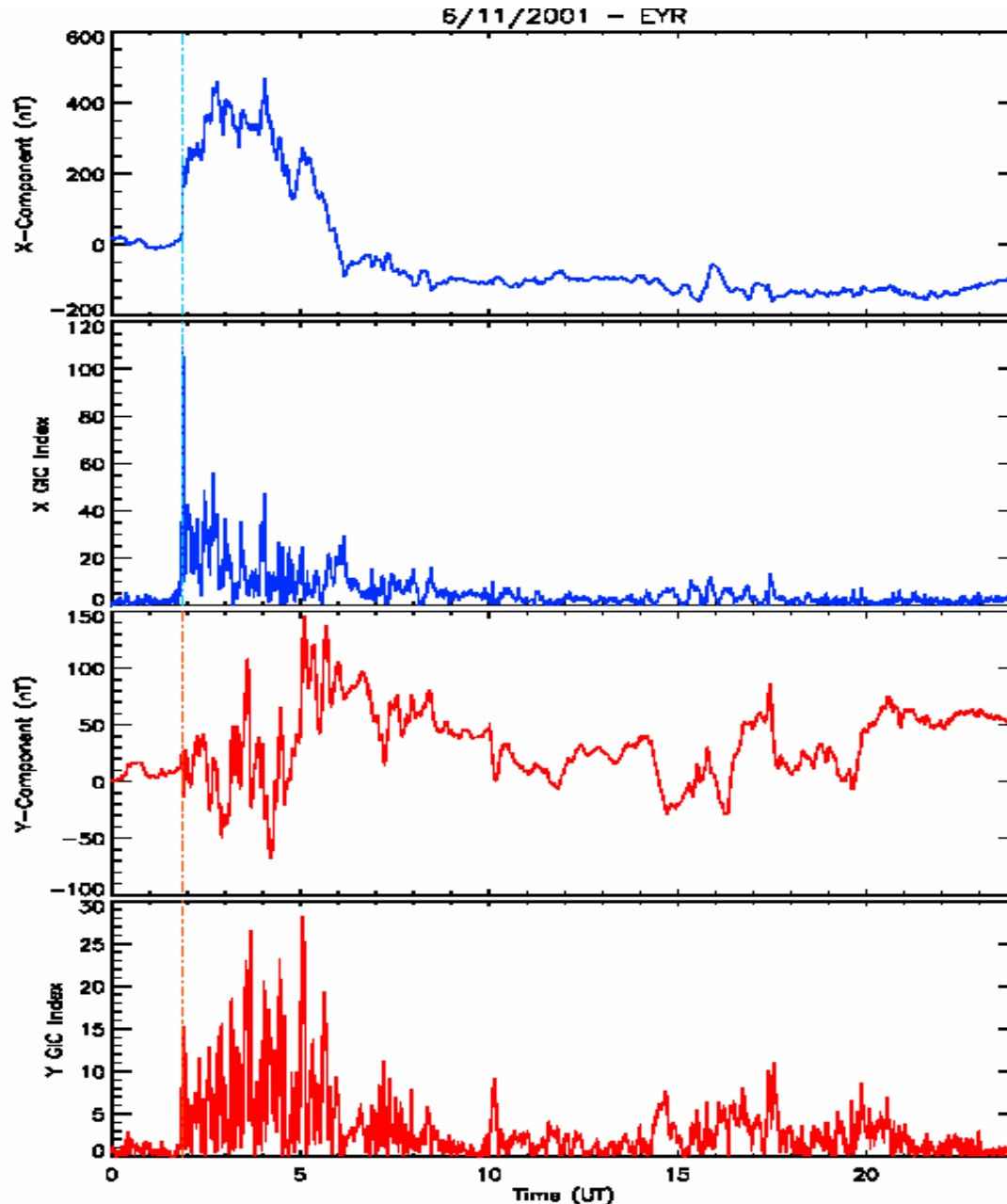
Increased Connectivity eg., HVDC link TAS

- Market Competition
- Robustness to demand
- Increased susceptibility to Space weather

GICs in Power Networks

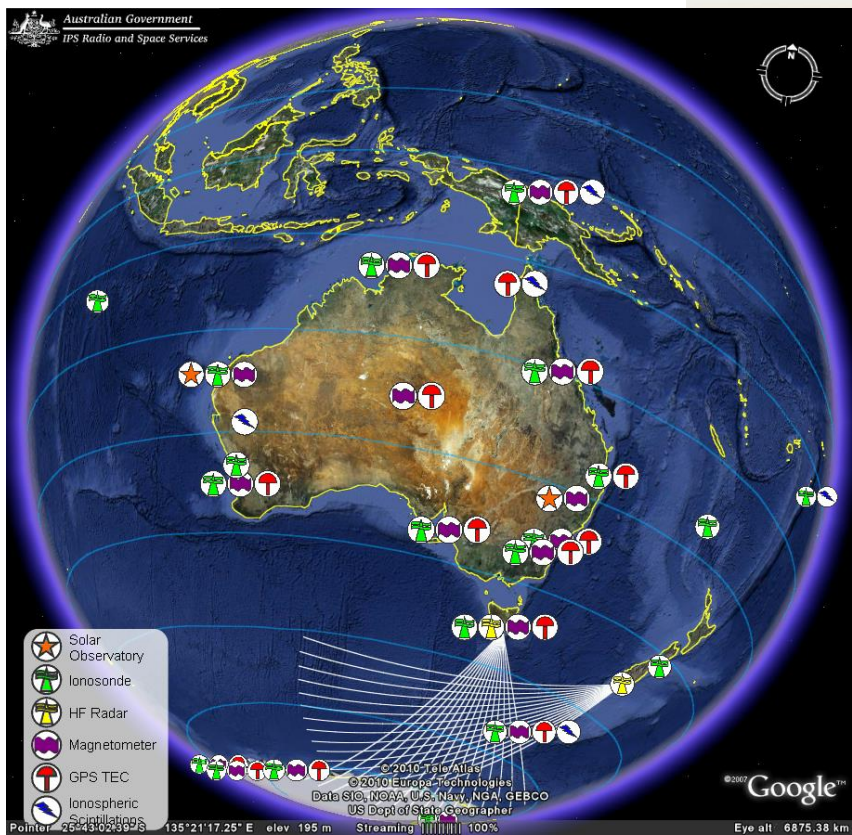


GICs in Power Networks



- NZ Previously considered safe due to mid-latitude location
- Prior to 2001 no GIC related faults recorded
- Fault attributed to premature ageing
- Analogous situation between NZ south Island and TAS

www.ips.gov.au/Space_Weather



IPS - Space Weather - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://www.ips.gov.au/Space_Weather

Australian Government
Radio and Space Services

The Australian Space Weather Agency

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Friday, Dec 15 2006 06:39 UT

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Solar Conditions	Geophysical Conditions	HF Propagation Conditions	Ionospheric Conditions	TEC Conditions
Solar Wind Speed [Color scale]	Geomagnetic Warning Warning	HF Comm. Warning Warning	Australasia [Map]	Australasia [Map]
X-Ray Flux B1.1	K-Index 5	Current HF Fadeout No Event	North America [Map]	North America [Map]
X-Ray Flares [Image]	p3 Index 4	HF Fadeout Warning Warning	Europe [Map]	Europe [Map]
Latest Culgoora Spectrograph [Image]	GEOSTAT Alert 0	Polar Cap Absorption 2.5dB AT 08:11 UT	World [Map]	World [Map]
Latest Culgoora H-Alpha Image [Image]	Geomagnetic Alert Alert			
	Aurora Alert No Alert			

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