

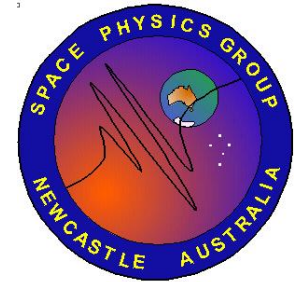
# Telluric currents induced in a North Queensland gas pipeline by geomagnetic variations

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The geomagnetic field varies with time, generating electric fields and currents in power transmission systems and pipelines (oil, gas, water). Geomagnetically induced currents (GIC) and their effects on technological systems have previously been studied at high latitudes where the effects of geomagnetic disturbances can be large. There have been few reports of GIC effects in pipelines at low latitudes. Australia has the majority of its population distributed along the coastal regions. Pipelines are essential for transporting resources to these centres.

Enertrade is responsible for the gas pipeline in north Queensland which runs from Townsville, south east to Moranbah which is located south west of Mackay. The pipeline has a cathode protection system that maintains the pipe to soil voltage in order to inhibit corrosion.

Pipeline voltage measurements have been compared with the magnetometer data located at Townsville. In this study the pipeline data were provided at a sample interval of 60 sec. Two data intervals are presented. The first is for geomagnetic quiet conditions while the second is for data recorded during a geomagnetic disturbed interval. Following a similar approach to high latitude data, we found a moderate correlation between the time varying magnetic field and the pipeline voltage (correlation coefficient  $\sim 0.4$ ). However, we also show that there is a diurnal variation in the pipeline voltage data which is in phase with the magnetometer signature of the Sq currents that are routinely detected at low latitudes.

The Australian Standard AS2885.1-1997 Section 5.6.5.3 states that the potential of structures subject to telluric variations shall not be less negative than -0.85 volts for more than 10% of the test period and the average potential over the test period must be more negative than -0.85 volts.



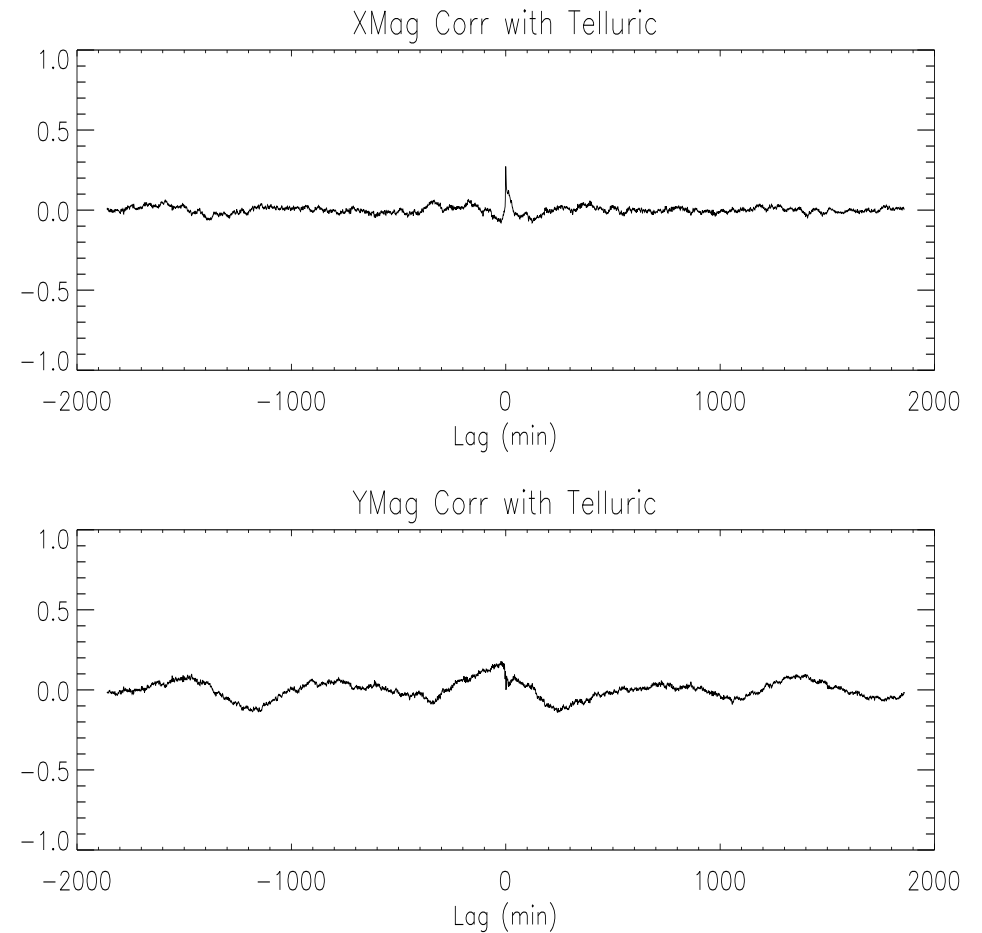
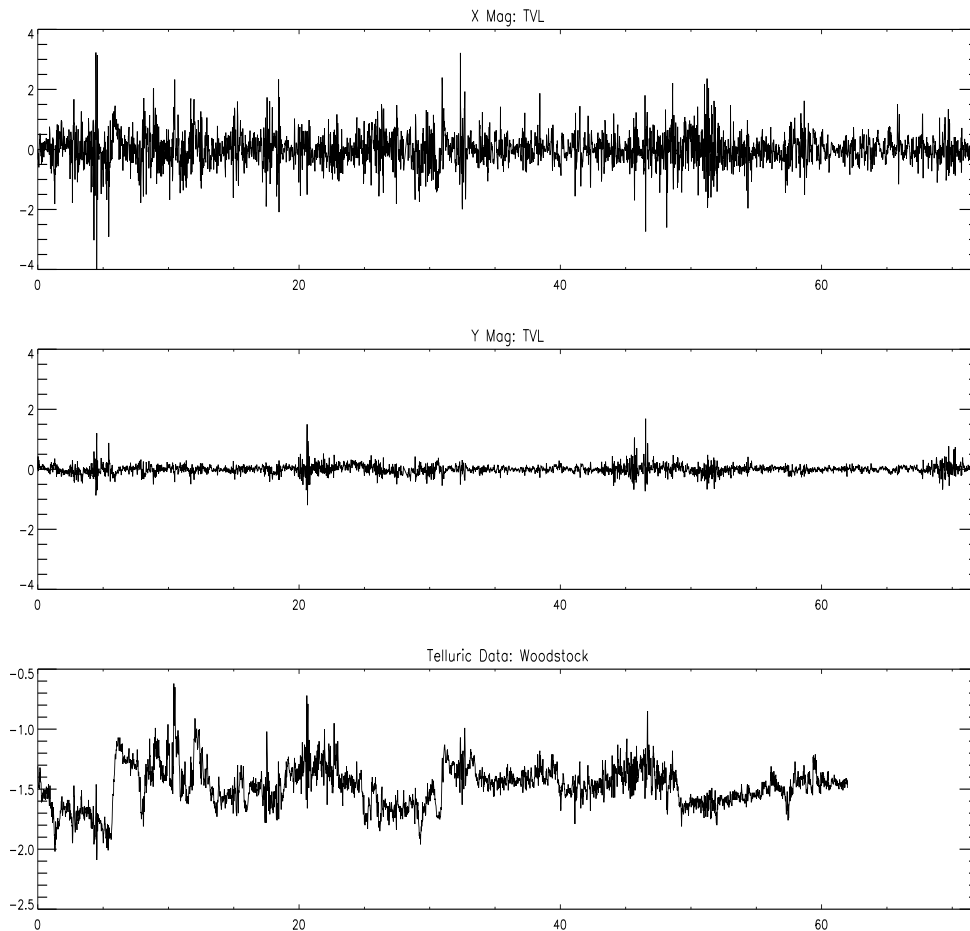
Location of the pipeline in north Queensland. Data from Woodstock are presented in this poster (from Enertrade).

Electromagnetic coupling between currents in space (the ionosphere) and pipelines cause currents and associated voltages in the pipeline.

Estimating the relationship between the space currents and pipeline voltage variations can be divided in to two parts (Pirjola, 2002)

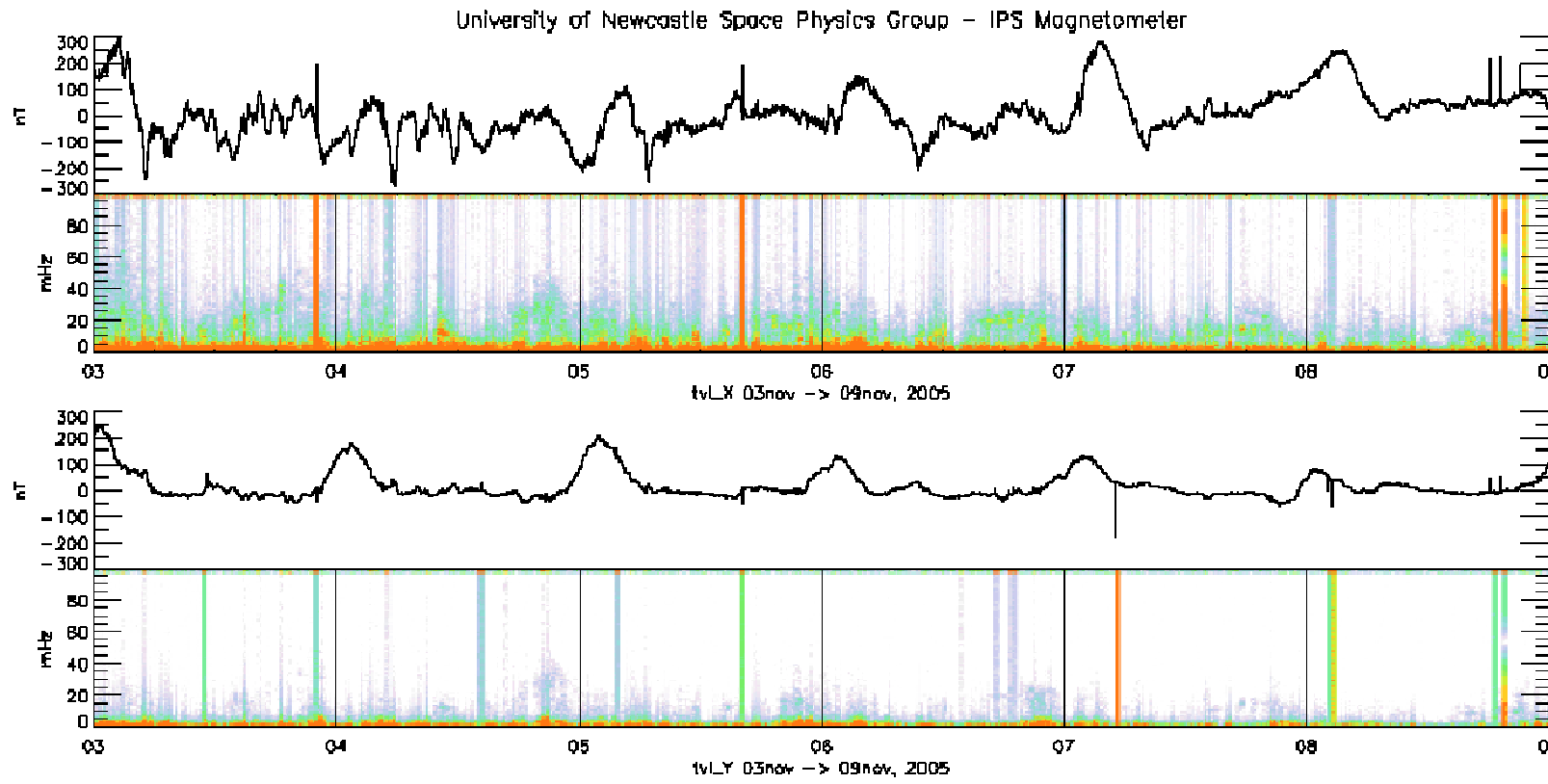
1. Determining the geoelectric field at the surface of the Earth,
2. Computing the associated currents and voltages (using Ohm and Kirchhoff Laws) in the pipeline.

## Pipeline and Magnetometer Data, 04-06 November, 2005



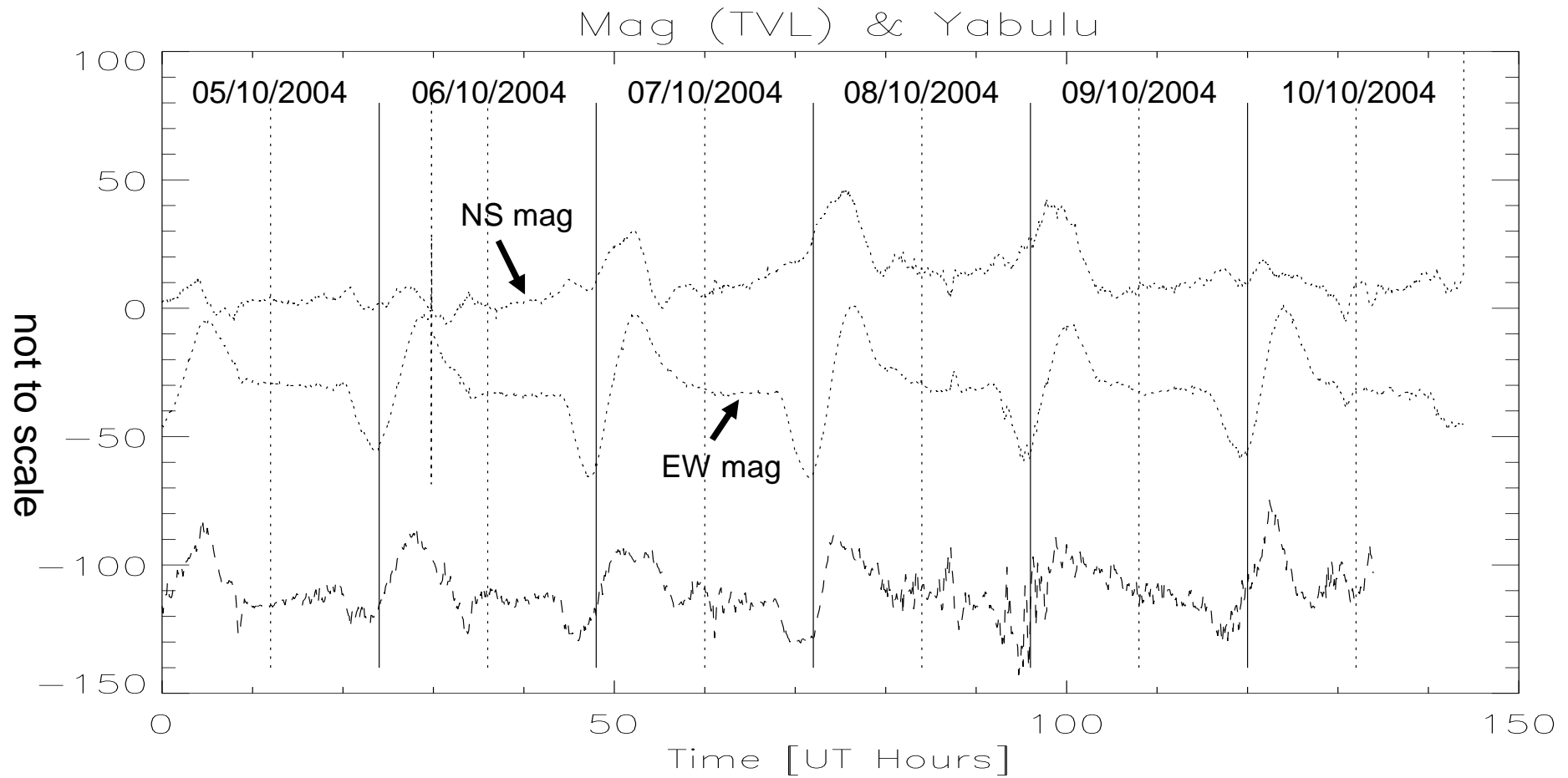
Magnetometer data (dB/dt) from Townsville and pipeline voltage (w.r.t  $\text{Cu}_2\text{SO}_4$  cell) from Woodstock, QLD.

Right hand panels show the cross correlation coefficient with lag. The data are correlated with the North-South component magnetometer channel.

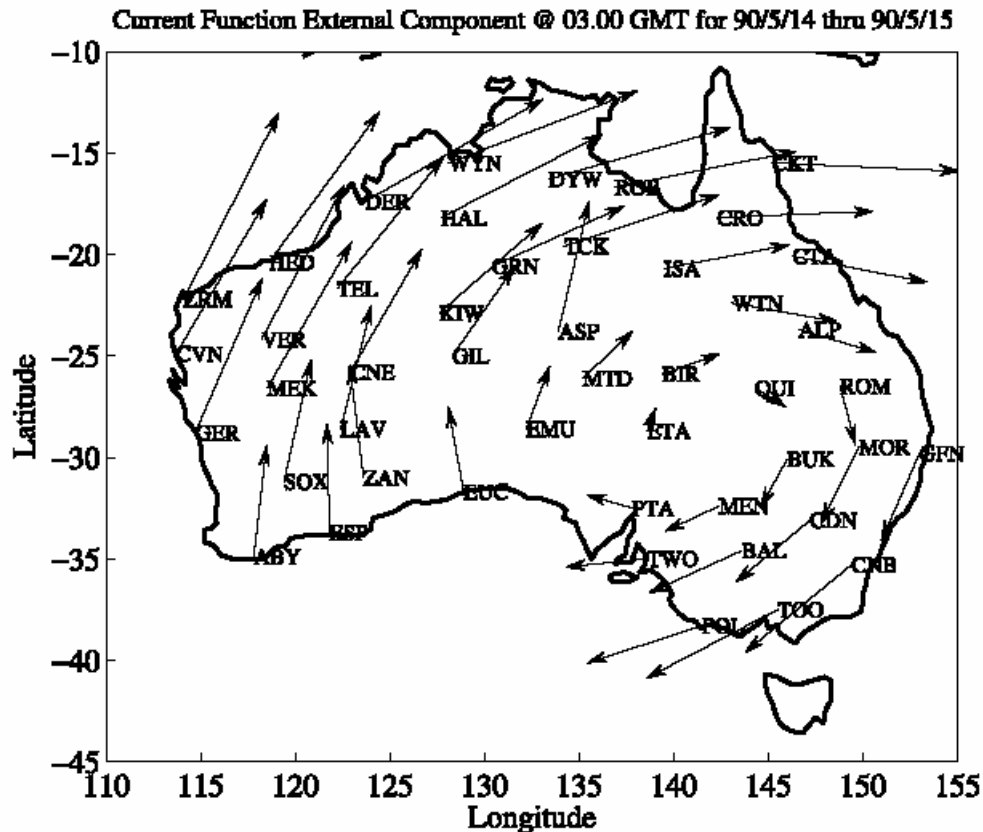


Time series and power spectra of magnetometer data from Townsville (TVL) QLD over 03-08 November, 2005. The time base is UT (Local Time + 10 Hrs).

The daytime Pc3,4 oscillations are evident in the top panel (North-South component). The east-west component data (bottom panel) show the diurnal signature of the Sq ionosphere currents.



Magnetometer and pipeline voltage at Yabulu for 05-10 October, 2004.

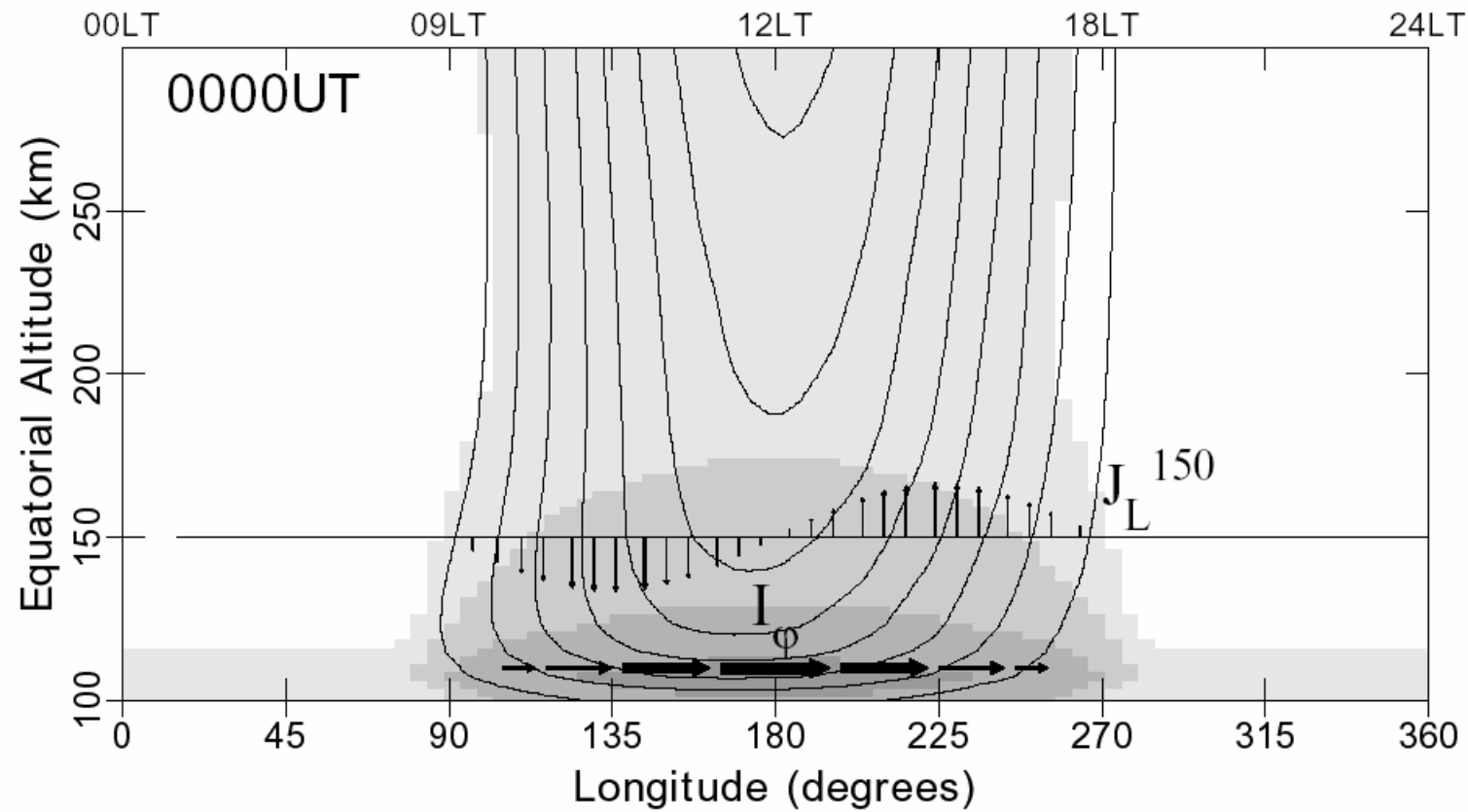


For low magnetic activity, the main ionosphere current system at equatorial (low) magnetic latitudes is the Solar Quiet (Sq) current.

The low-latitude electric fields result from neutral wind dynamo action of the coupled ionosphere-thermosphere system along with absorption of solar radiation in the ionosphere E region. (Rishbeth, 1971).

The northern and southern hemisphere systems combine near the equator to form an eastward flowing equatorial electrojet.

Sq Current over Australia, 03 UT, 5 May, 1990 (Stening et al., 2005)



Results from the simple modeling by Eccles (1998). The model describes the currents, electric fields and voltages in the ionosphere at the magnetic equator assuming an E region (1,-2) tidal mode (Sq) neutral wind model.

## What to do next

### ***1. More Data***

- (i) Sample pipeline voltage data at higher sample rates (at least 20 sec) to check any correlation with Pc3,4 geomagnetic variations. The present 1 min sample rate gives a 8 mHz Nyquist.
- (ii) Simultaneous data at various locations (eg. Moranbah, Yabulu, Woodstock) is required to determine which sections of the pipeline give the larger potentials and why (Yabulu larger than Woodstock).
- (iii) More data from different latitudes: Data from pipelines from Moomba (SA) and Ballera (QLD) would allow comparison of mid to very low latitude effects.
- (iv) What are the differences/similarities between voltage measurements of the pipeline with respect to (a) the ground beds (b) the  $\text{Cu}_2\text{SO}_4$  cell?

### ***2. What are the Causes?***

- (i) Previous work has focused on dB/dt and induction currents. There appears to be a correlation with these currents with the NS magnetometer data (see p3)
- (ii) There is also a relationship with the diurnal currents (see p5). These appear to be associated with the EW magnetometer component. A simple approach is to rotate the EW magnetic field values to estimate the overhead current (see p6).

### ***3. Modeling***

The simple model of Eccles (1998) may assist in explaining the diurnal variation in pipeline potential. These electric field models need to be extended to ground level and compared with pipeline data.

## References

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