# Thermospheric preconditioning of the ionosphere

**Anasuya L. Aruliah, E. M. Griffin, E. A. K. Ford,**
**A. Dobbin, A. D. Aylward,**
**Atmospheric Physics Laboratory**
**University College London**
**C. J. Davis**
**Rutherford Appleton Laboratory**

**Three themes:**

a) Geomagnetic history

b) Composition change

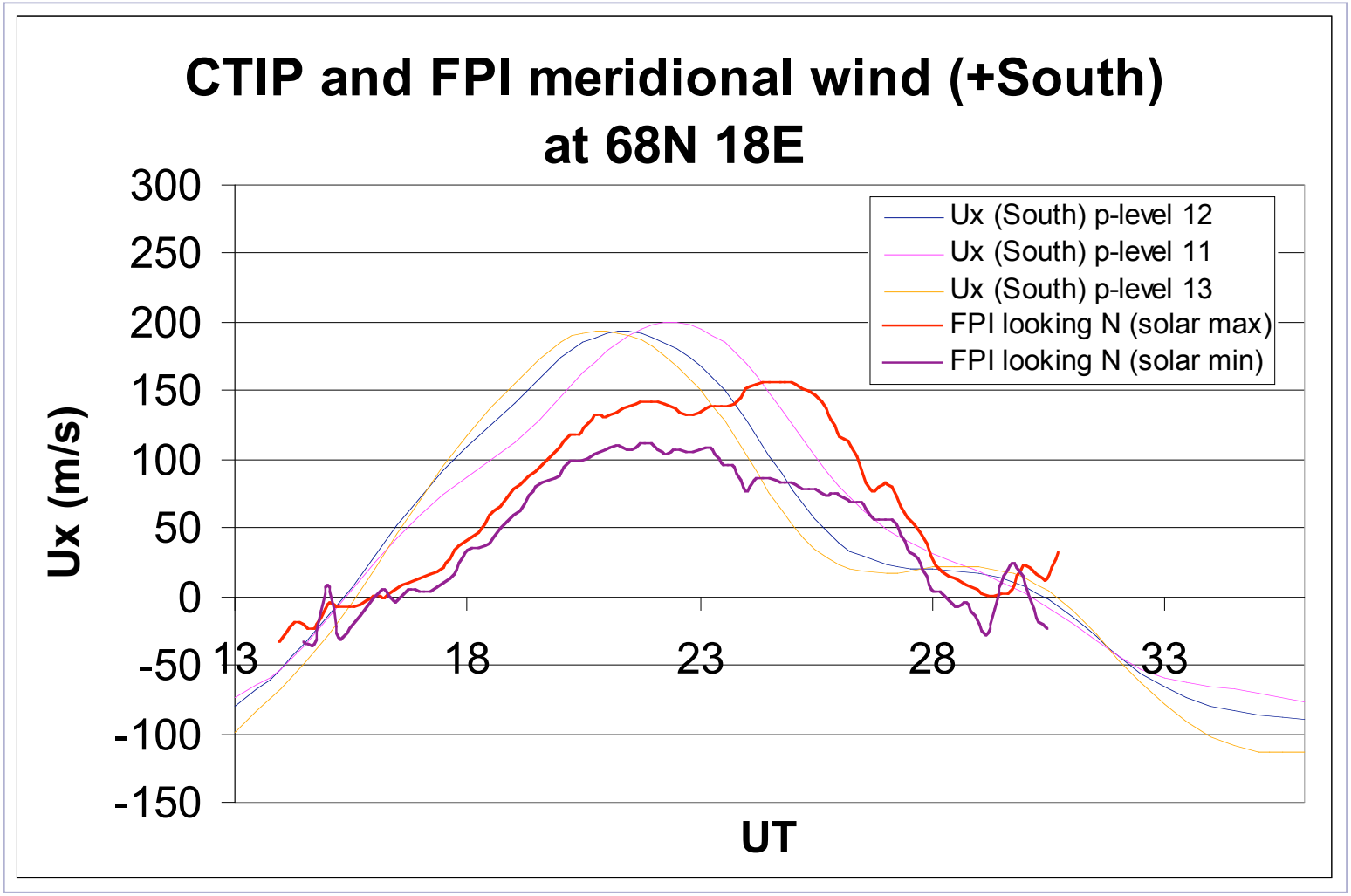
c) Neutral wind dynamo and feedback

# The problem is the potentially wrong allocation of energy

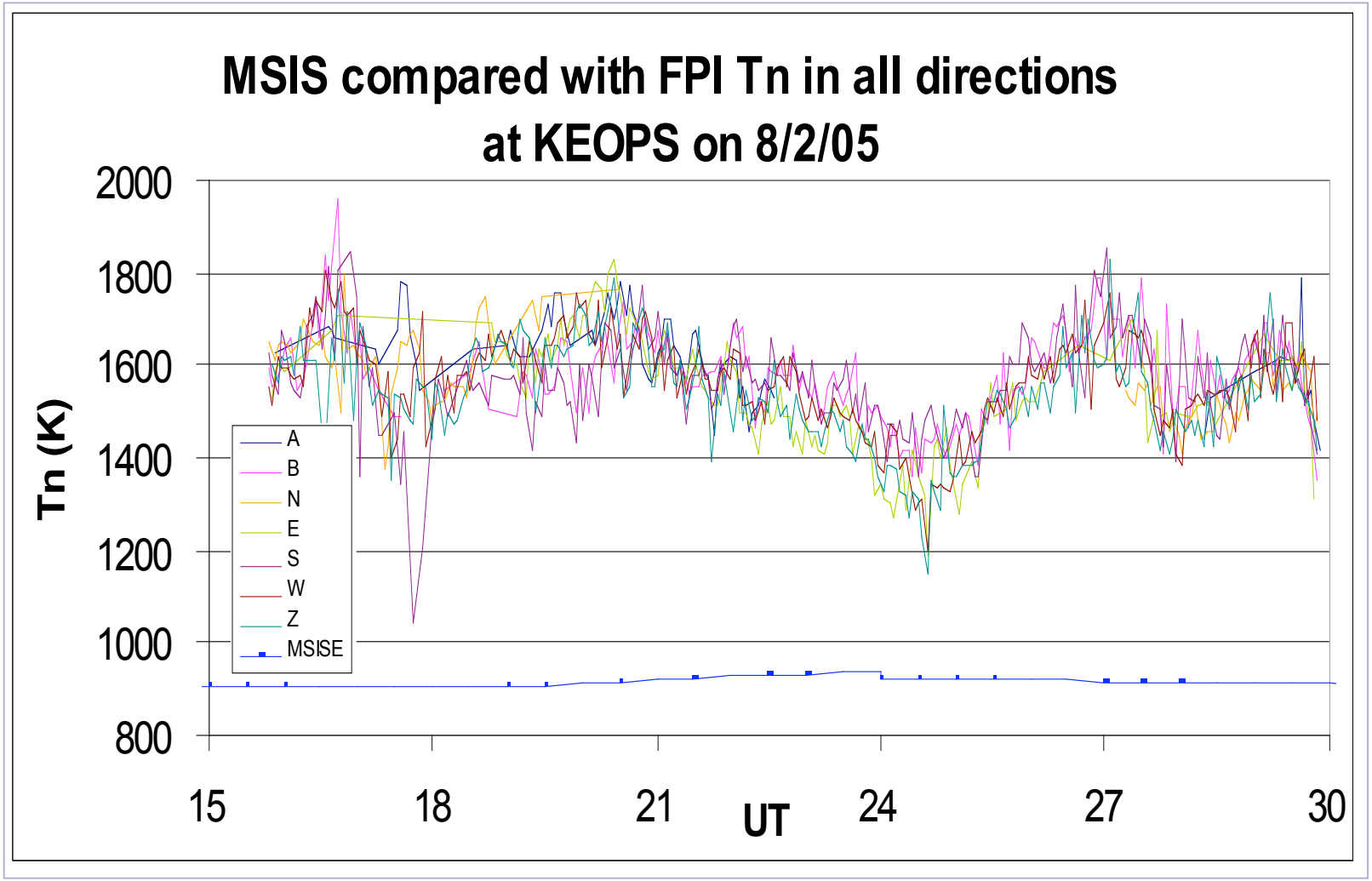
E-M energy from magnetosphere = Joule heating in thermosphere/ionosphere + acceleration of the neutrals

# The source of the problem is the limitation of observations and consequent assumptions

No direct observations of all parameters-hence derivation required; limited height determination; limited spatial and time resolution; poor use of models




GCM models such as CTIP systematically overestimate the magnitude of neutral winds by up to a factor of 2

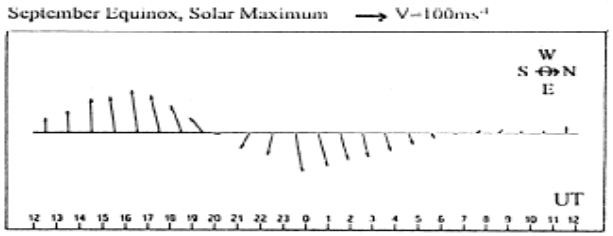



MSIS and GCM models underestimate high-latitude thermospheric temperatures by a few hundred Kelvin

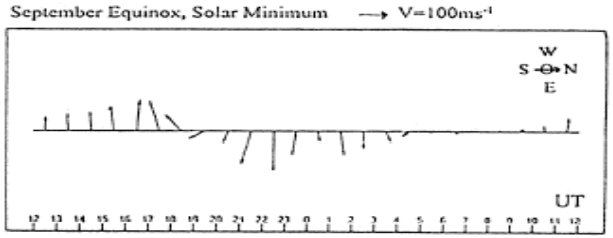
# Seasonal and Solar Cycle Variation of Ion Velocities from the EISCAT radar

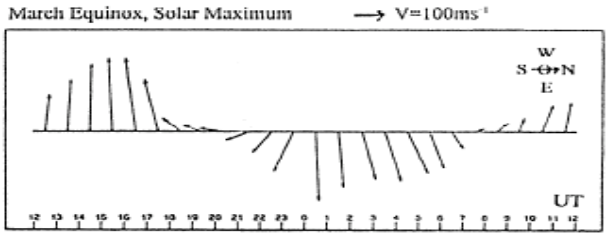
Solar max

Solar min




September equinox




March equinox

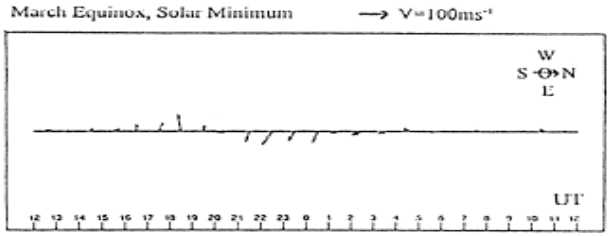



**Figure 7.** Seasonal variation in ion velocities at Tromsø at solar maximum. Positive north is towards the right, therefore positive east is pointing to the bottom of the page and positive west to the top. The scale is given by the arrow marked $V=100$ m s$^{-1}$.

**Figure 8.** Seasonal variation in ion velocities at Tromsø at solar minimum. Positive north is towards the right, therefore positive east is pointing to the bottom of the page and positive west to the top. The scale is given by the arrow marked $V=100$ m s$^{-1}$.

# What do we do with these measurements?

Magnetospheric electromagnetic energy (Poynting's vector $ExB/\mu_o$)

Frictional heating/Joule heating in the thermosphere

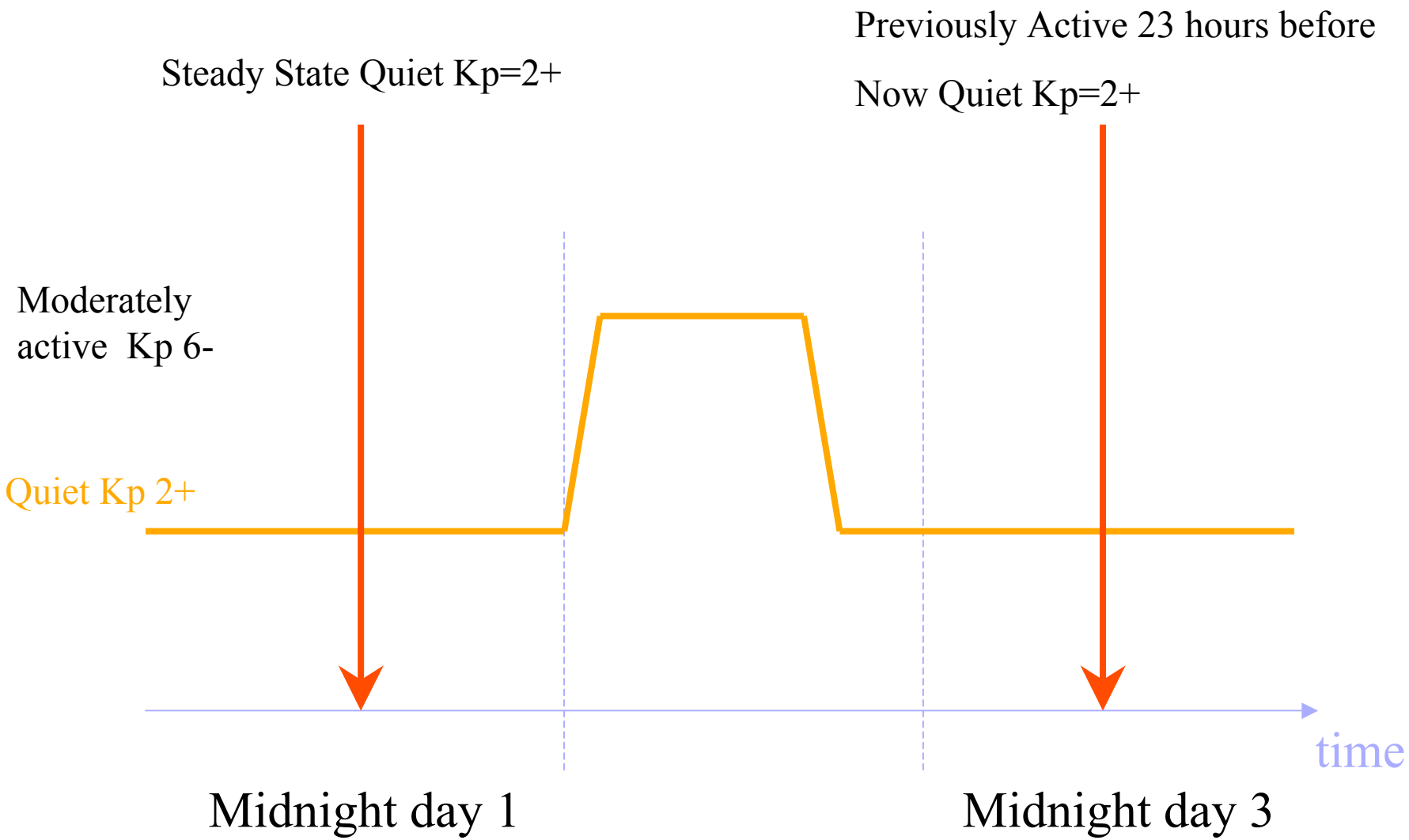
Acceleration of the particles in the thermosphere

Height integrated $JH = \Sigma_P E^2$

Assumes $U_n = 0$

$$JH = \int \sigma_P(z)\, E(z)\, dz$$

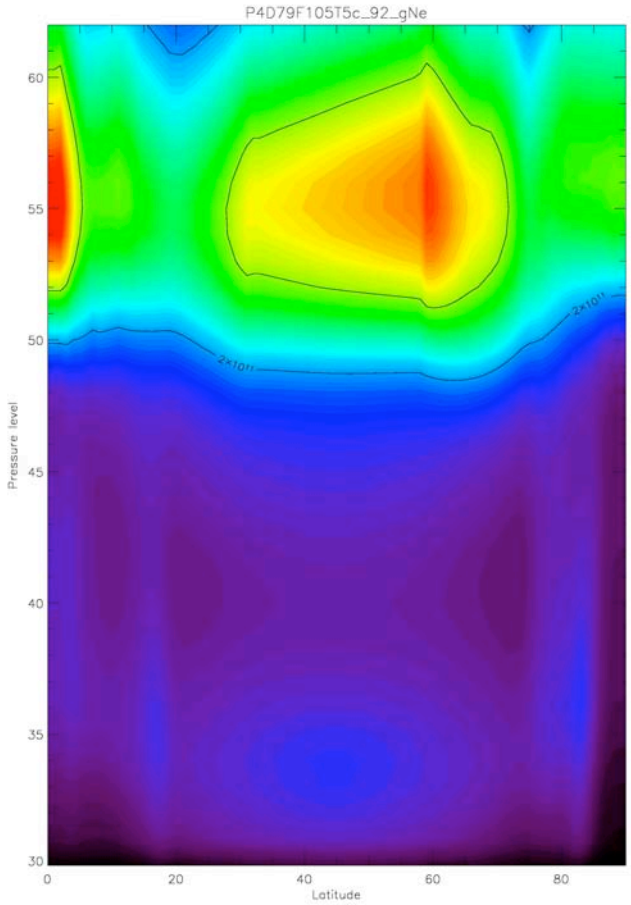
# Geomagnetic history effect on CMAT model zonally averaged data



# Geomagnetic history effect on CMAT model zonally averaged Ne

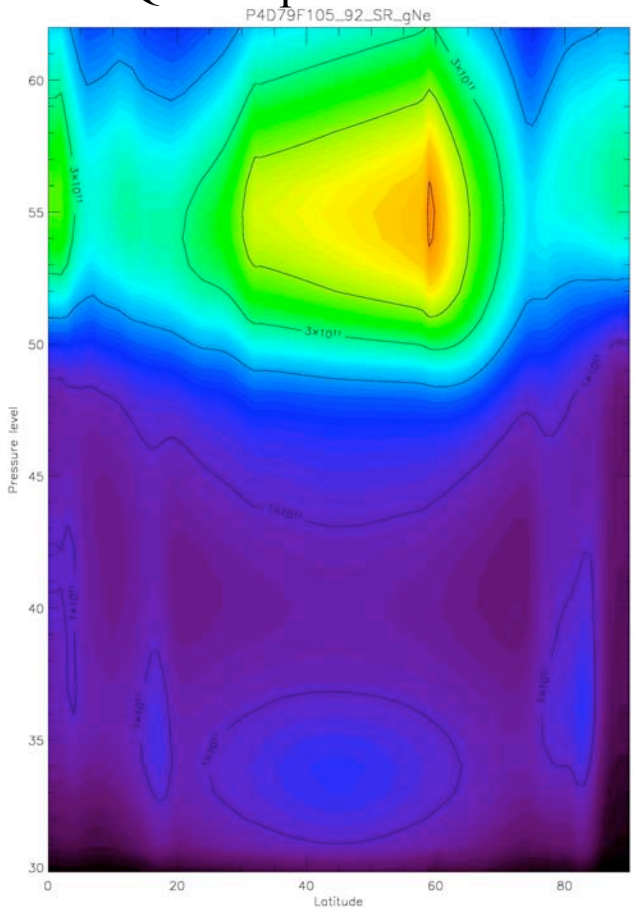
(plotted for heights 100-400km and all latitudes)

Steady State Quiet Kp=2+



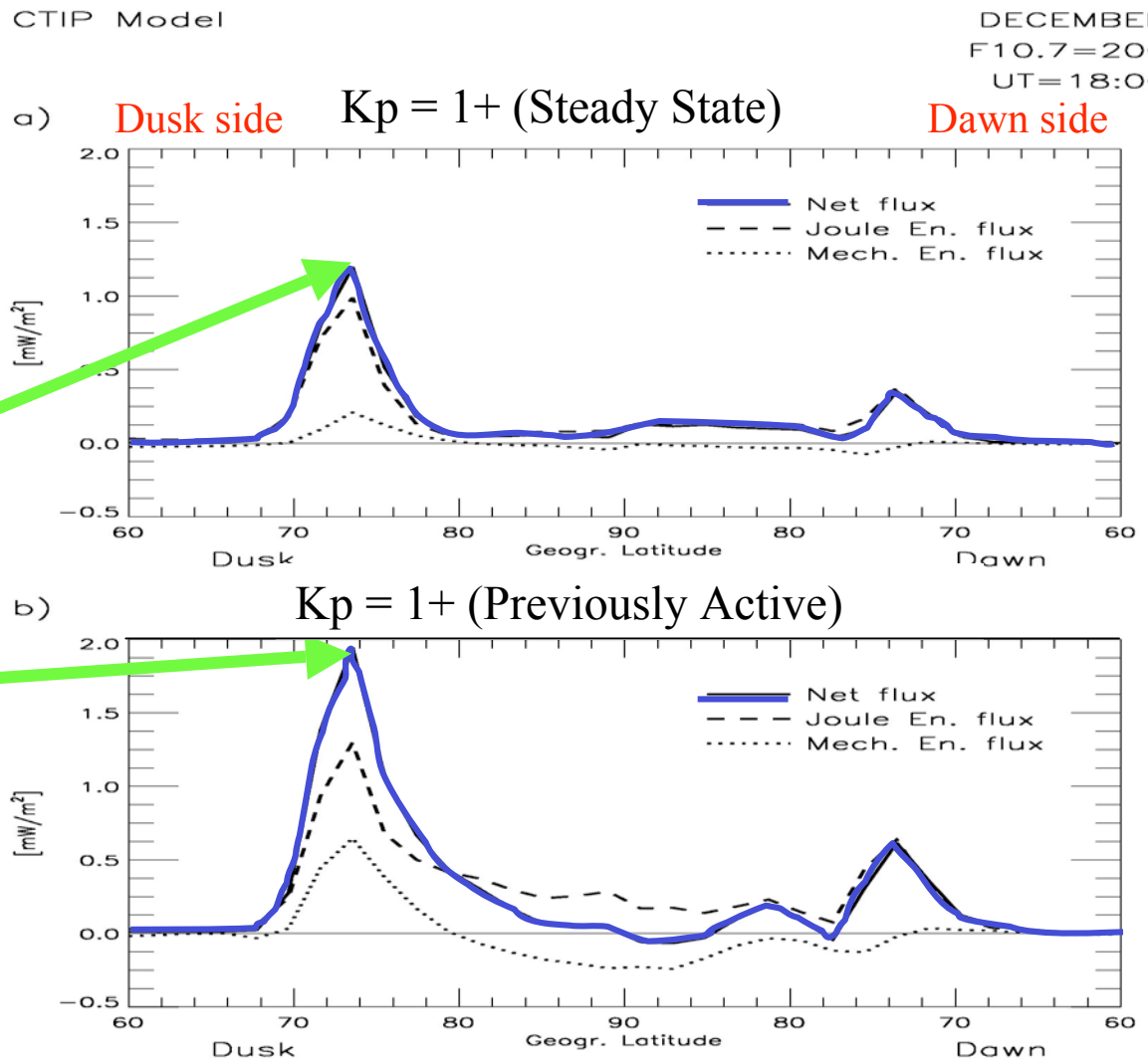

Previously Active 23 hours before

Now Quiet Kp=2+



# Why is this important? - Geomagnetic history effect

More energy drawn from the magnetosphere for “previously active” conditions

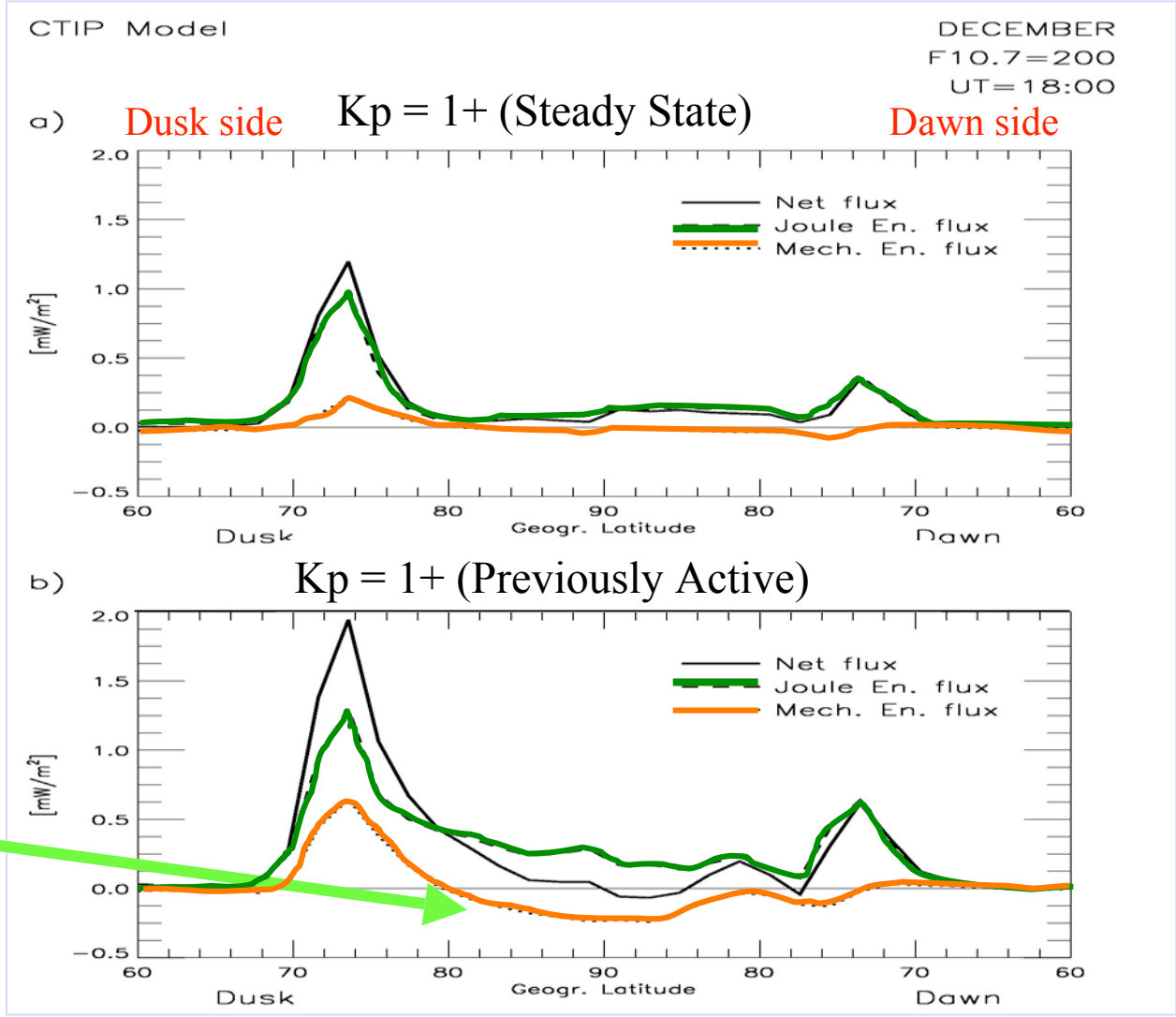


# Why is this important? - Geomagnetic history effect

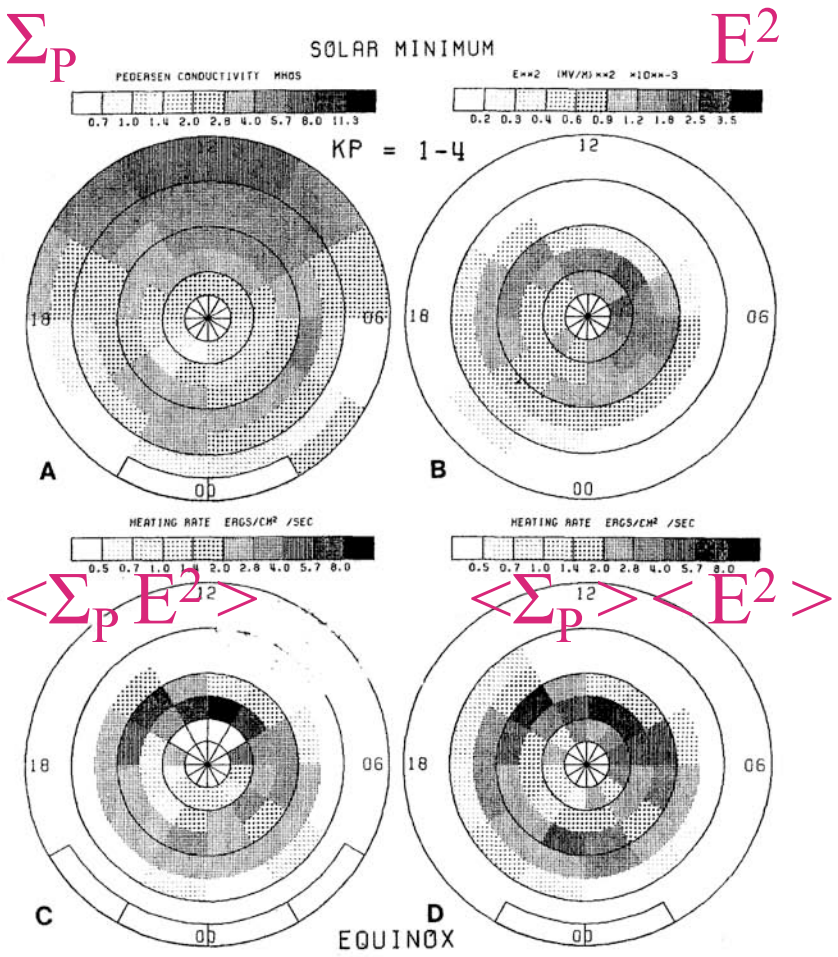
Redistribution of energy into heating and acceleration of the neutral gas

Most interestingly:

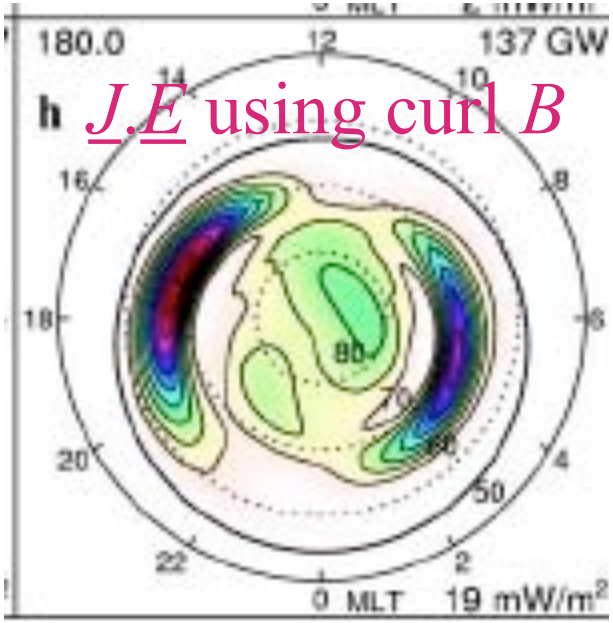
Energy storage → feedback to magnetosphere (negative net flux)



# The problem is *also* the wrong allocation of energy to the wrong places




AE-satellite (Foster et al., 1983)

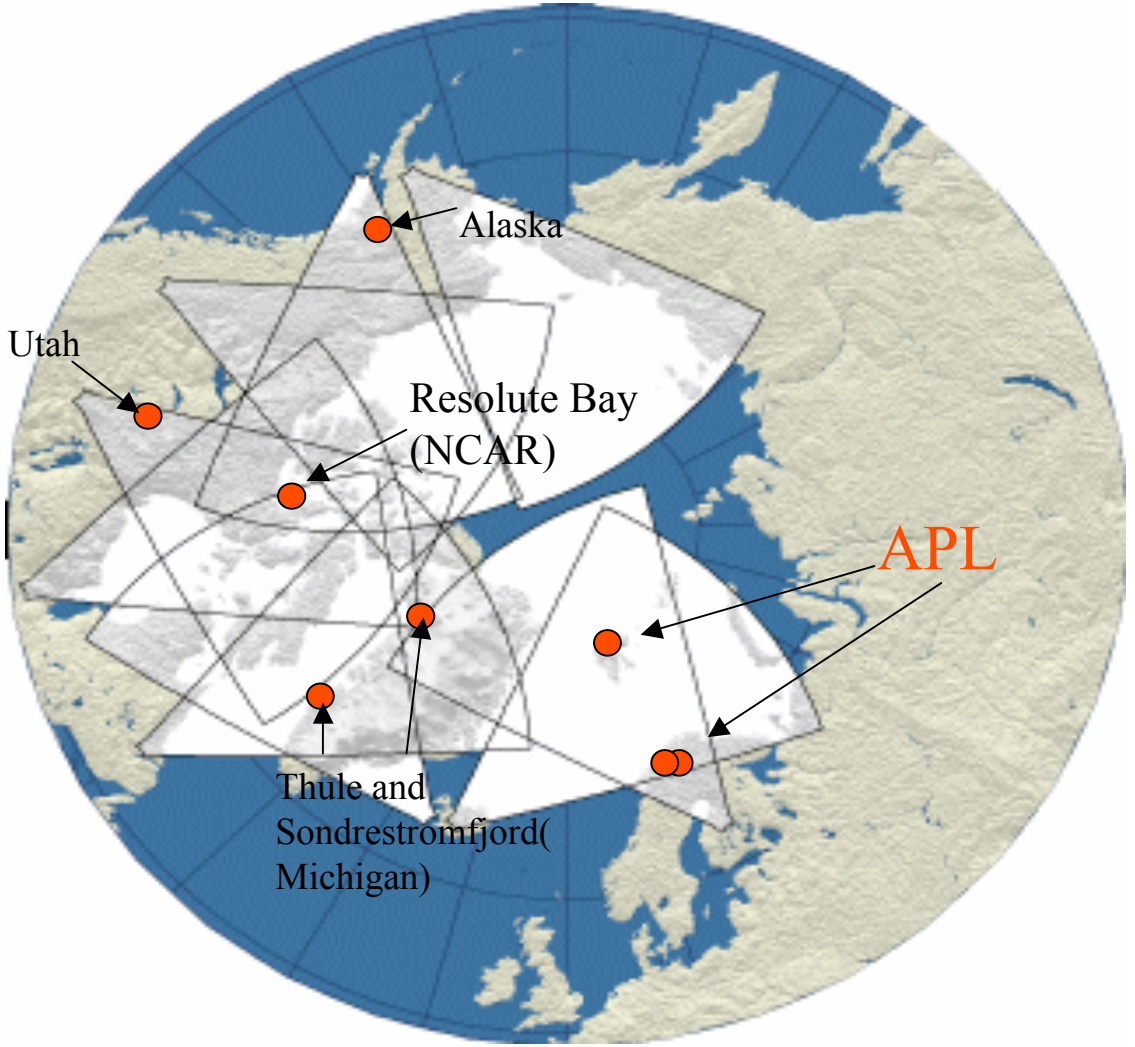



DE-2 satellite (Weimer, 2005)

Implicitly including conductivity.

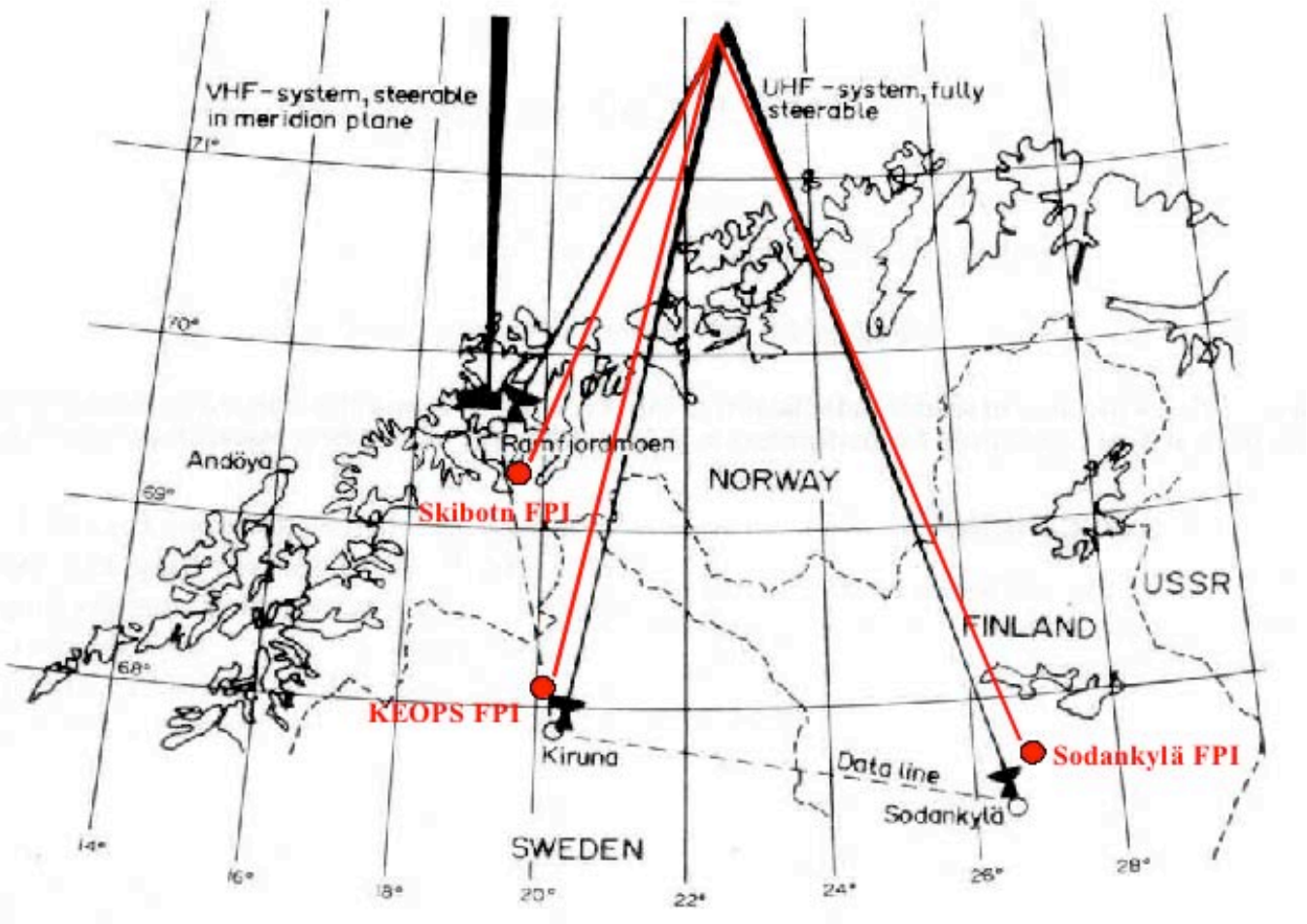
# Global high-latitude thermosphere

## FPI/SCANDI coverage and the SuperDARN network

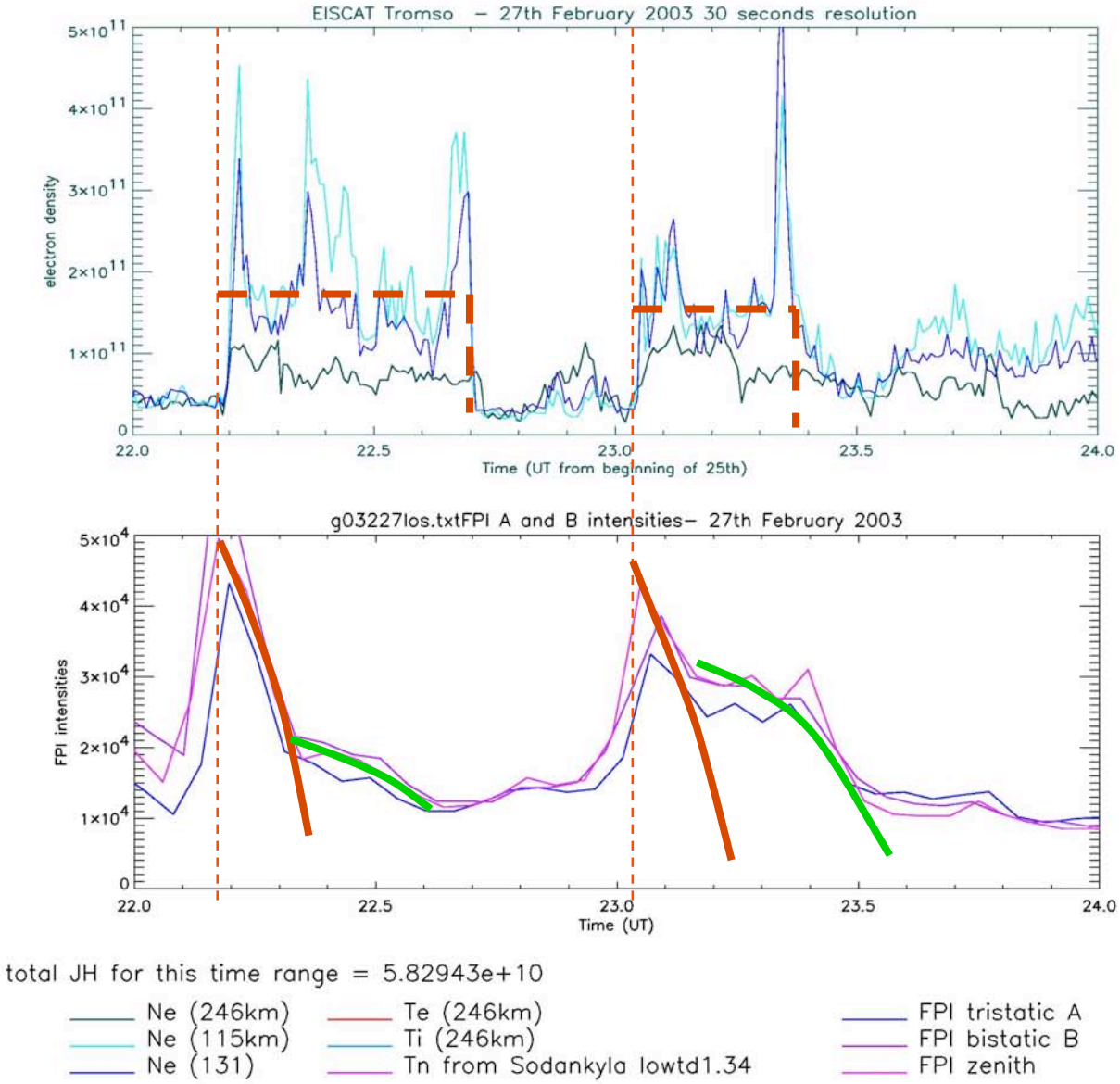


# SP-UK-TRISTATIC

## Unique tristatic measurements of ion-neutral coupling in a common volume using FPIs and EISCAT



# Meso-scale structure

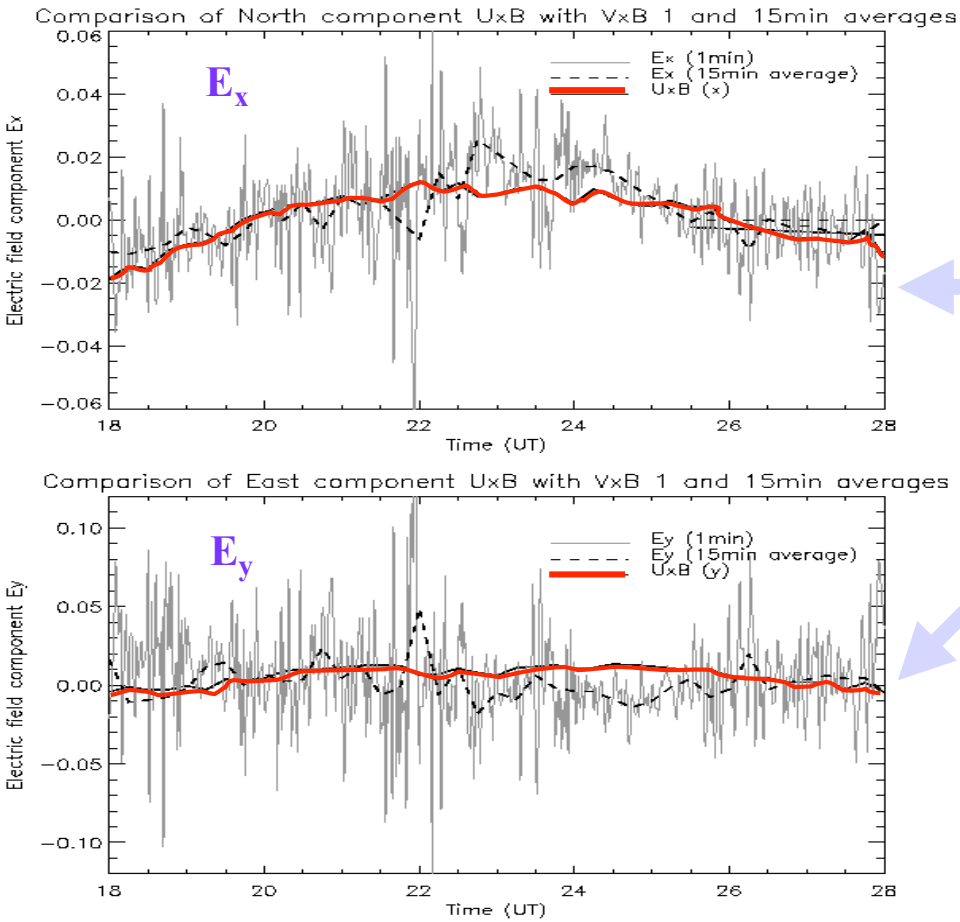



Comparison of EISCAT Ne (E and F-region) with FPI 630nm intensity over period 22-24UT

Decay of 630nm emission despite near constant particle precipitation.

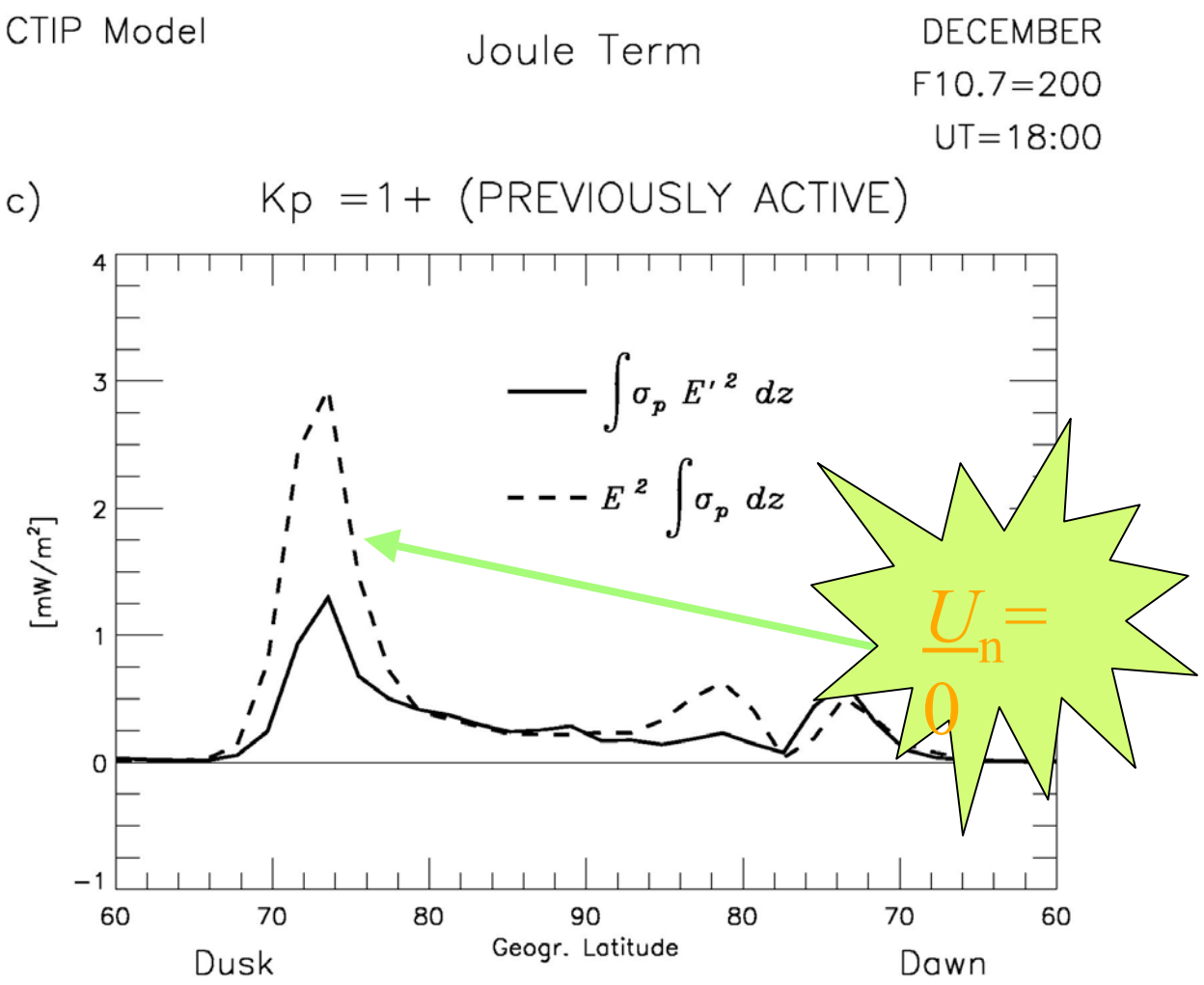
Decay times of between 14-40 mins

# F-region Neutral Wind Dynamo is up to 50% of the Magnetospheric Dynamo




x- and y-components of magnetospheric (1min and 15min averages) and neutral wind dynamo electric fields

# What is Joule Heating?

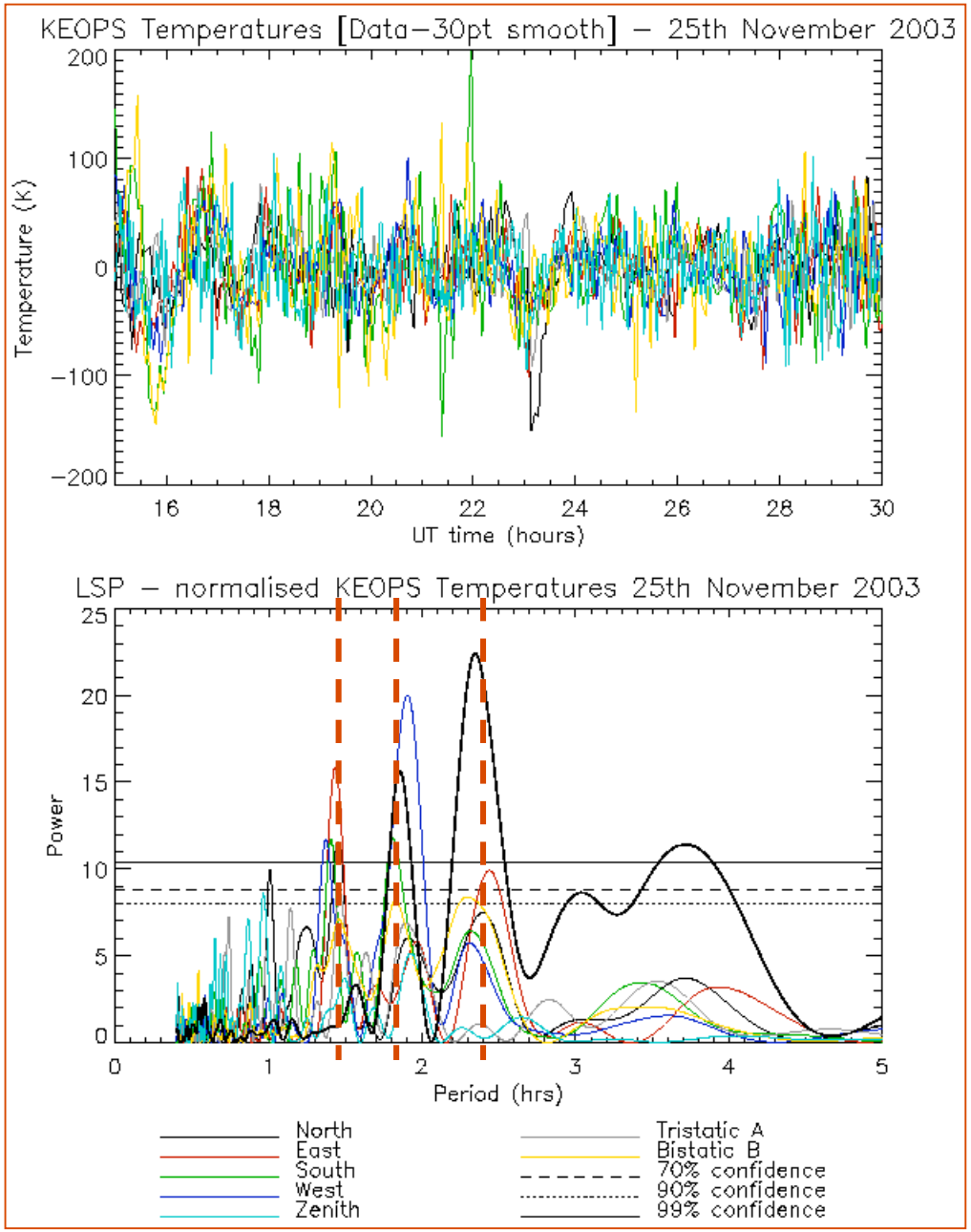



$U_n = 0$

Neutral wind contribution to Joule heating

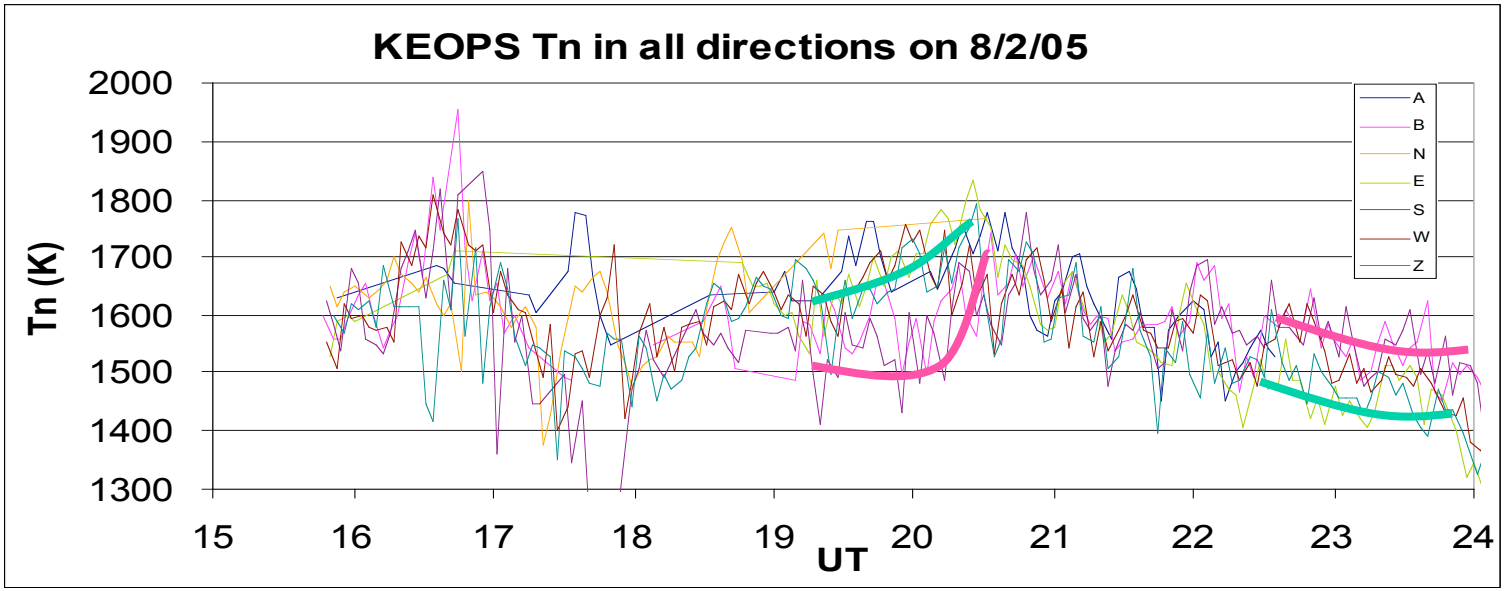
# Meso-scale structure

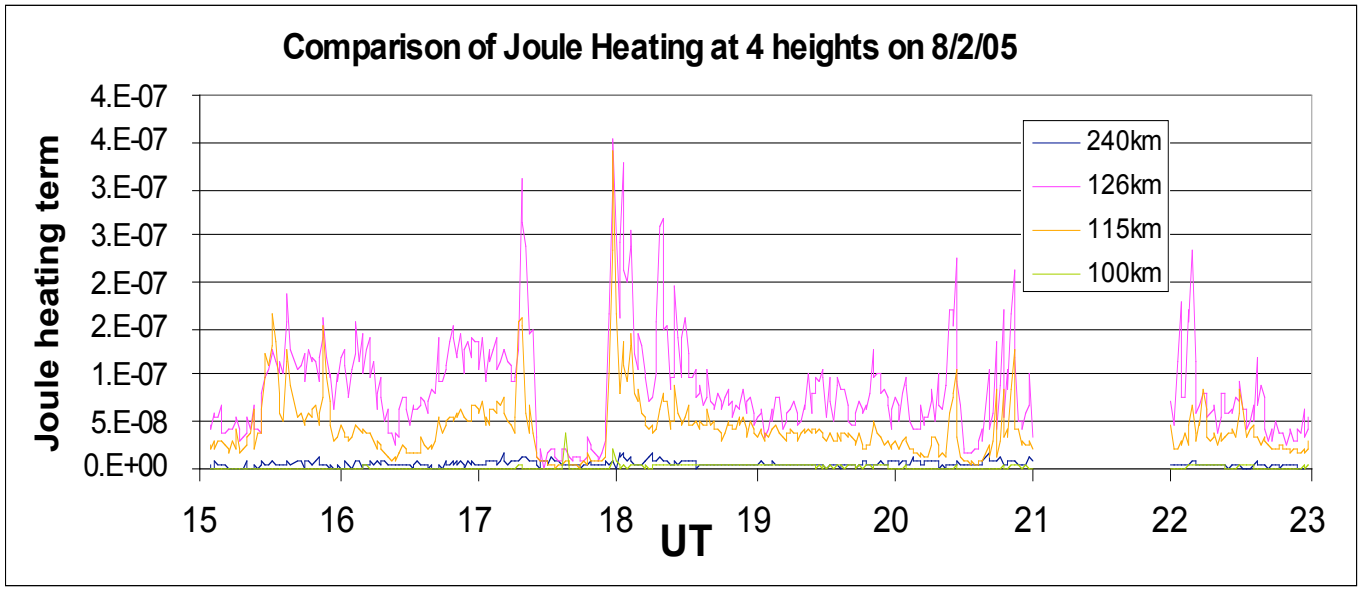
Anasuya Aruliah




Clear wave structure in neutral temperature

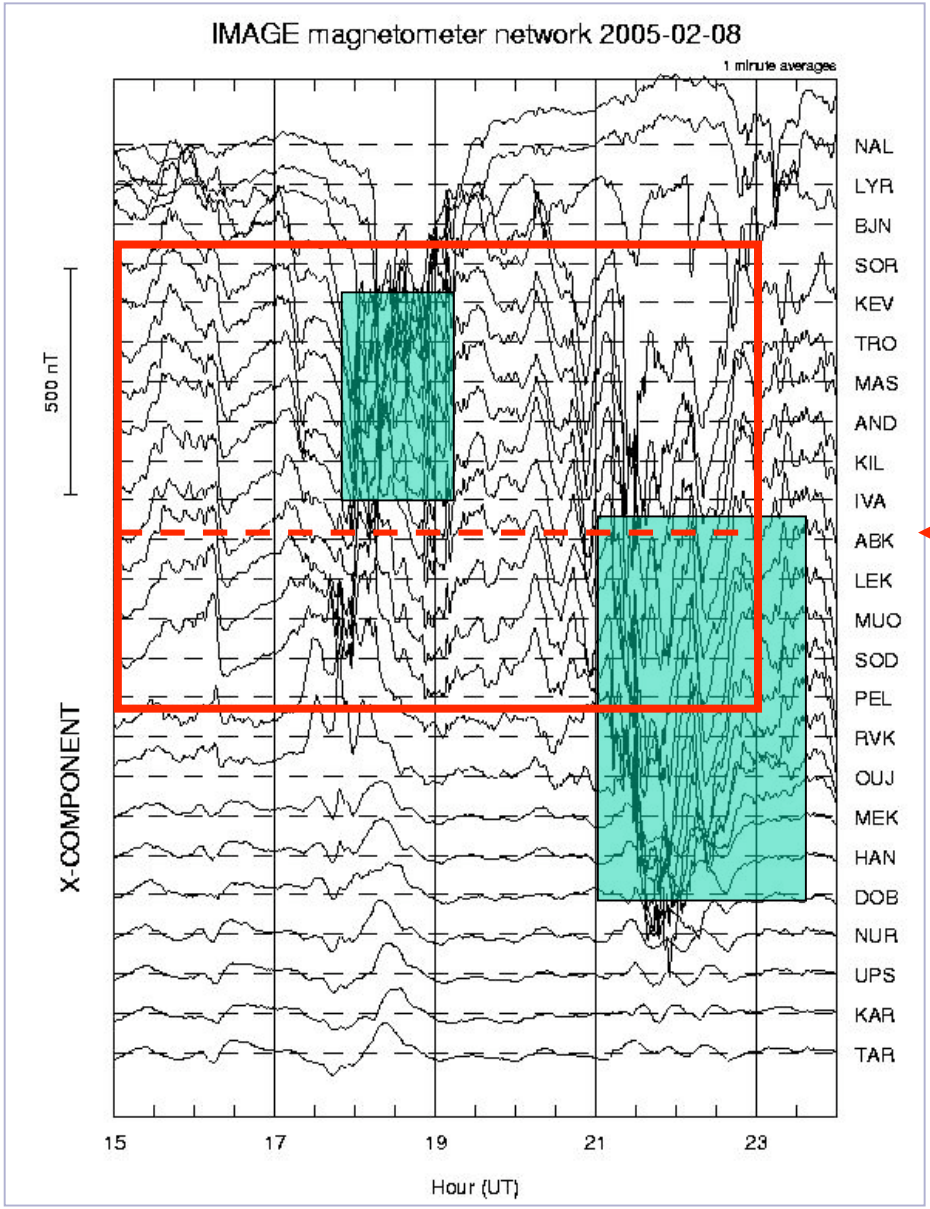
Lomb-Scargle analysis shows periods at > 99% confidence at 1.4, 1.8, 2.4 hours in both Tn and in equivalent current densities from IMAGE magnetometers




Large latitudinal temperature gradients

# Meso-scale structure




Location of electrojets determine temperature gradients

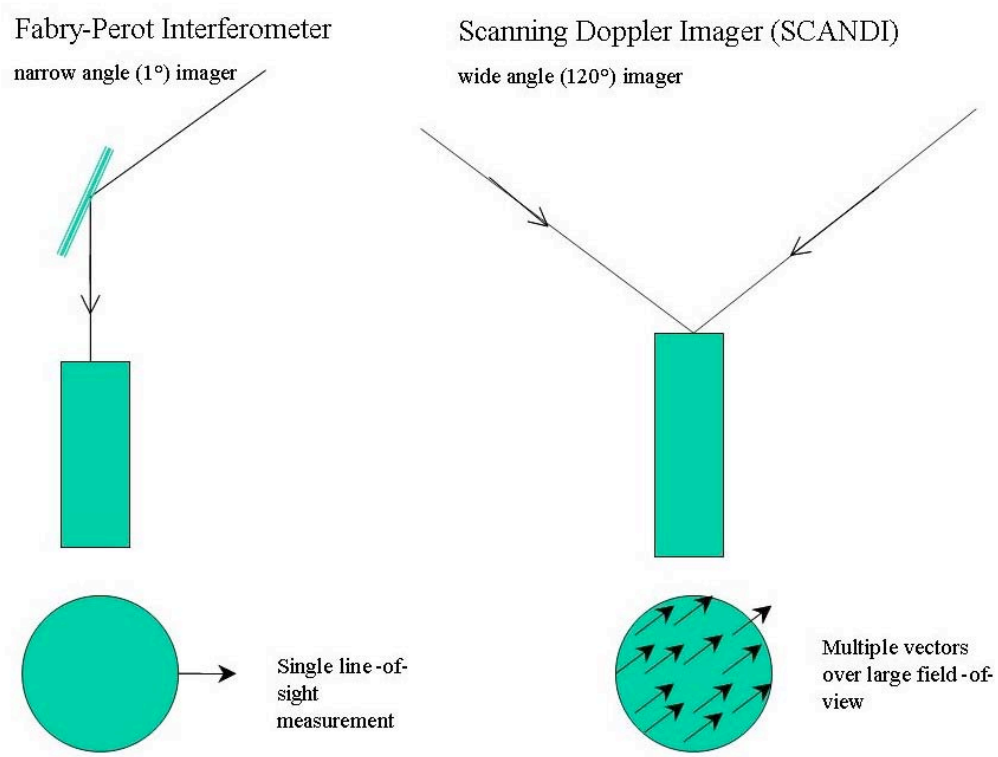
KEOPS latitude 67.8ºN

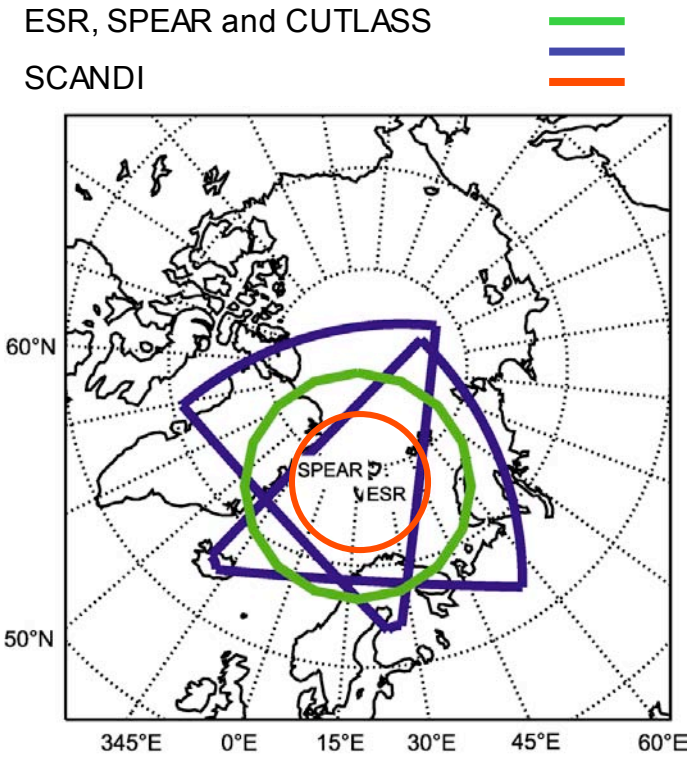
**EISCAT sp-uk-tri-4 experiment** radar operated between 15-23UT on 8th February 2005

FPIs observing overnight between 16-06 UT over the latitude range 65º-71ºN

| Kp: | 4+ | 5o | 4+ |
|---|---|---|---|

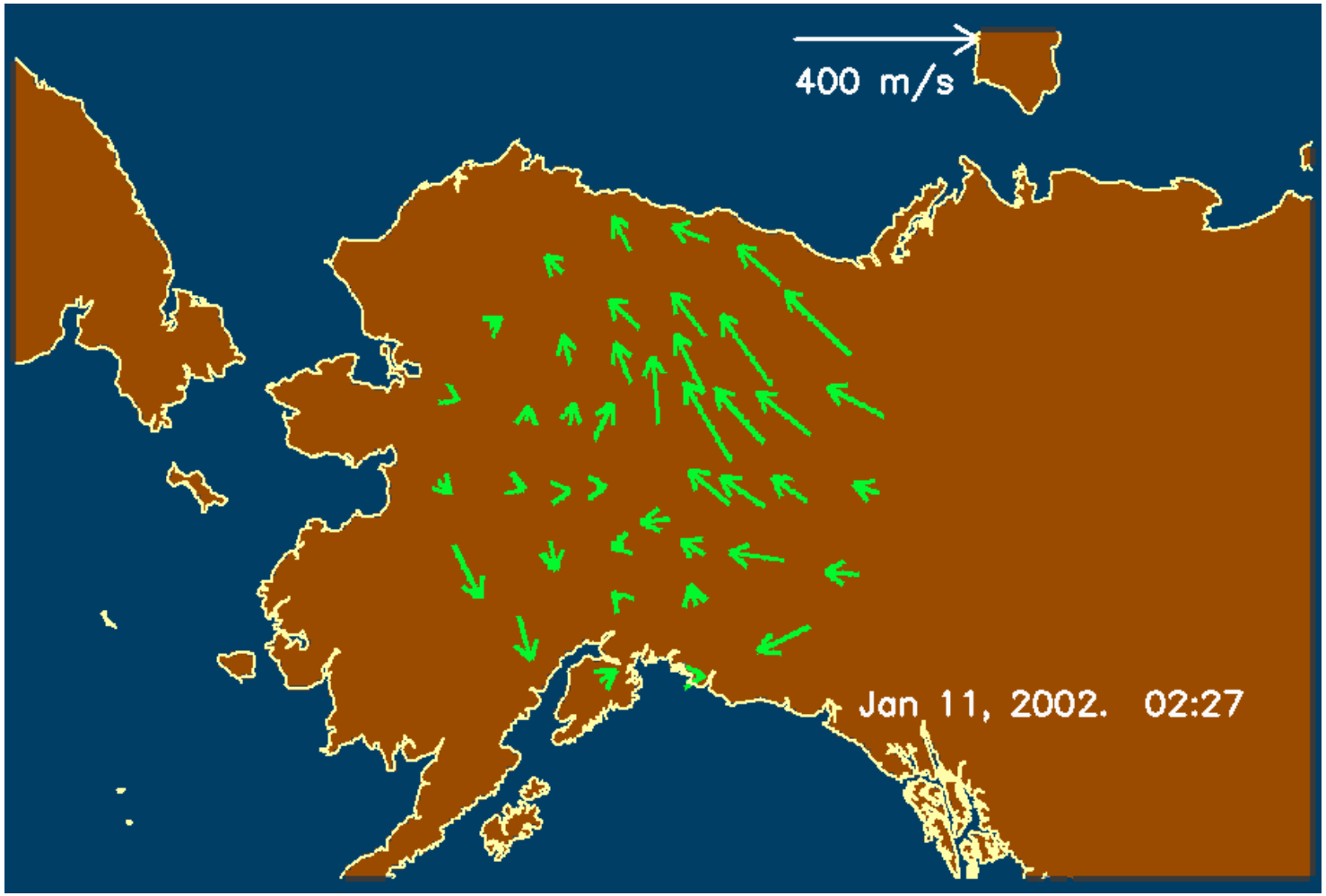
# SCANDI: new instrument providing all-sky imaging of wind and temperature fields using state-of-the-art CCD technology



# Scanning Doppler Imager at Alaska

## Mark Conde



# Thermospheric preconditioning of the ionosphere through:

a) Geomagnetic history

b) Composition change

c) Neutral wind dynamo and feedback

Acknowledgements: E.Griffin, E.Ford, I.McWhirter, A.Charalambous (FPIs) + ESRANGE and SGO institutions

A.Dobbin, I.Mueller-Wodarg, A.Aylward (CMAT/CTIP model)

C.Davis (EISCAT)