

Determining the equatorward and poleward boundaries of the auroral oval from CHAMP field-aligned currents signatures

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Outline

- **Motivation**
- **CHAMP FAC observation**
- **Statistics of Auroral Oval Boundaries**

Motivation

The newest version of the IRI model, **IRI-2012**, includes significant improvements not only for the representations of the electron density, but also for the description of electron temperature and ion composition.

Need to be improved :

➤ **Low latitude:** the **amplitude** and **width** of the **equatorial ionization anomaly** (EIA).

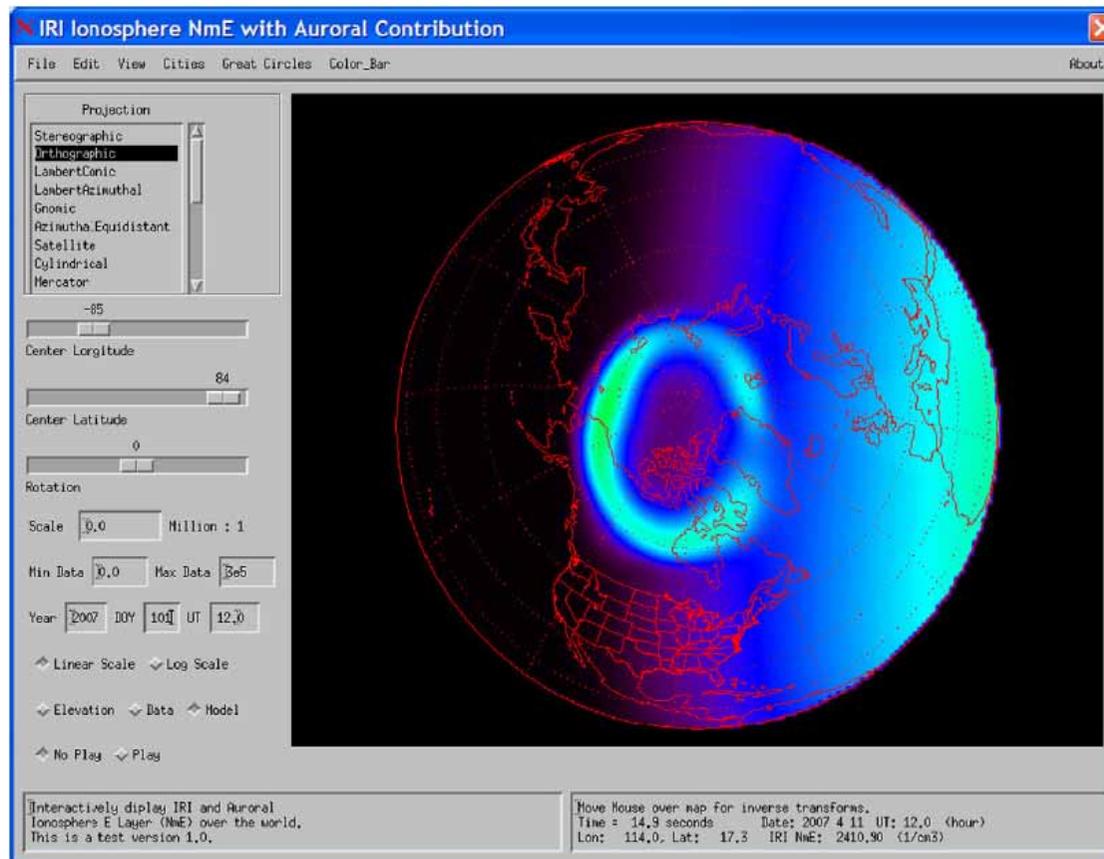
➤ **High latitude:** the **auroral boundaries** and the **subauroral density trough** and **temperature peak**.

[D. Bilitza et al., 2008; 2010]

Motivation-Auroral model

Using a threshold flux value to define the poleward and equatorward boundaries of the oval and the movement with magnetic activity.

IRI peak E-region electron density with assimilated auroral NmE from GUVI auroral model.

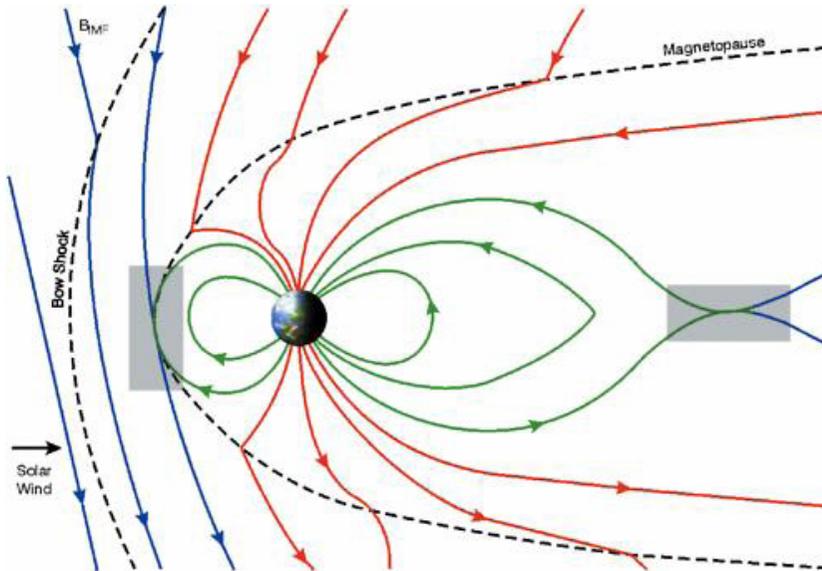


← Kp

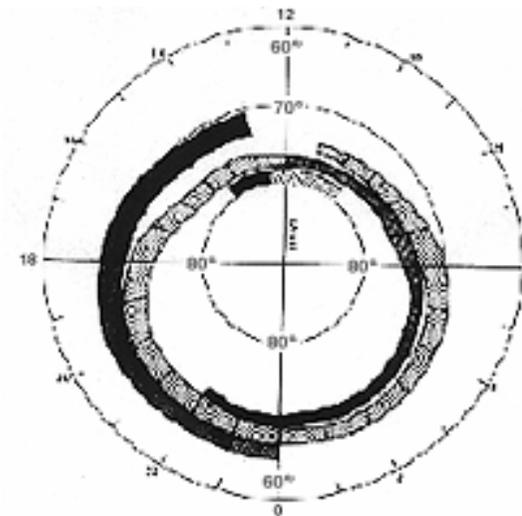
[zhang et al., 2010]

Motivation

- **Auroral Oval / Polar Cap: decreased energetic particle precipitation rates conductivity drop**
- **Polar Cap Boundary (PCB) is a projection of OCB**
- **Reconnection processes in the magnetotail: closure of open field lines Plasma flow between the regions of open and closed field lines (OCB)**

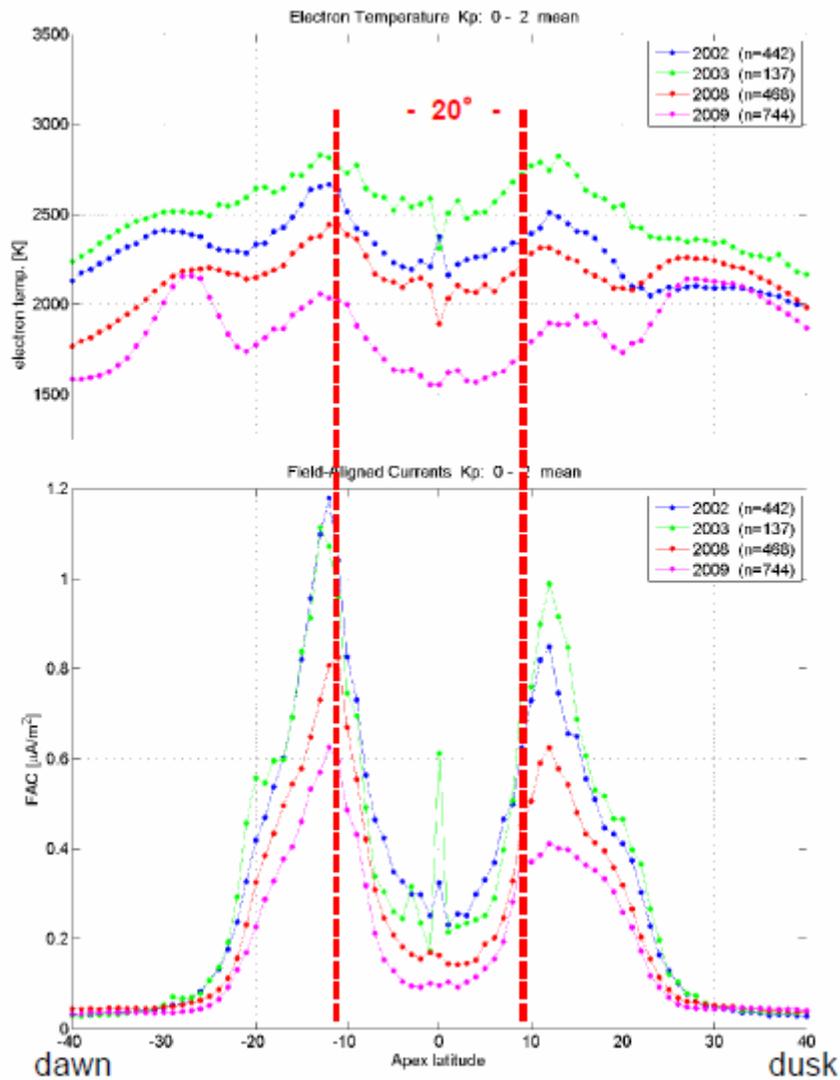


Charles Day, Physics Today

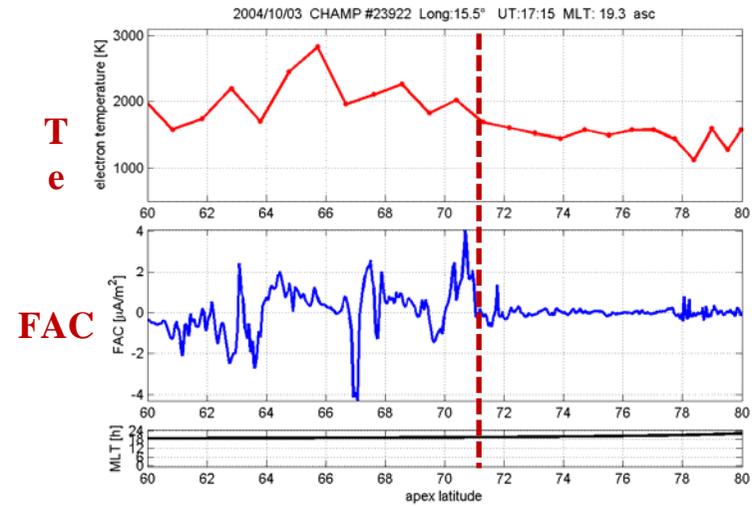


Iijima and Potemra (1976)

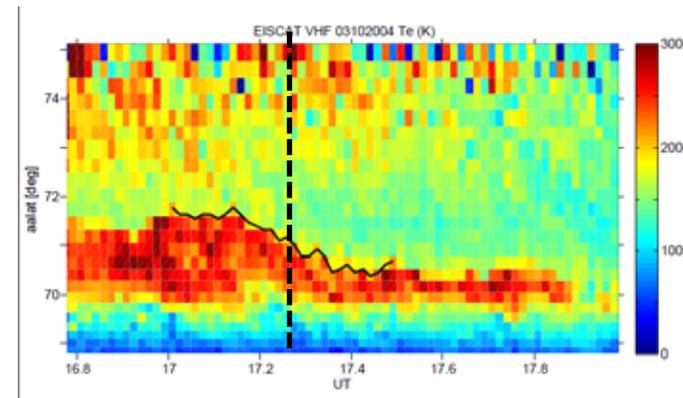
CHAMP FAC and Te observations



CHAMP

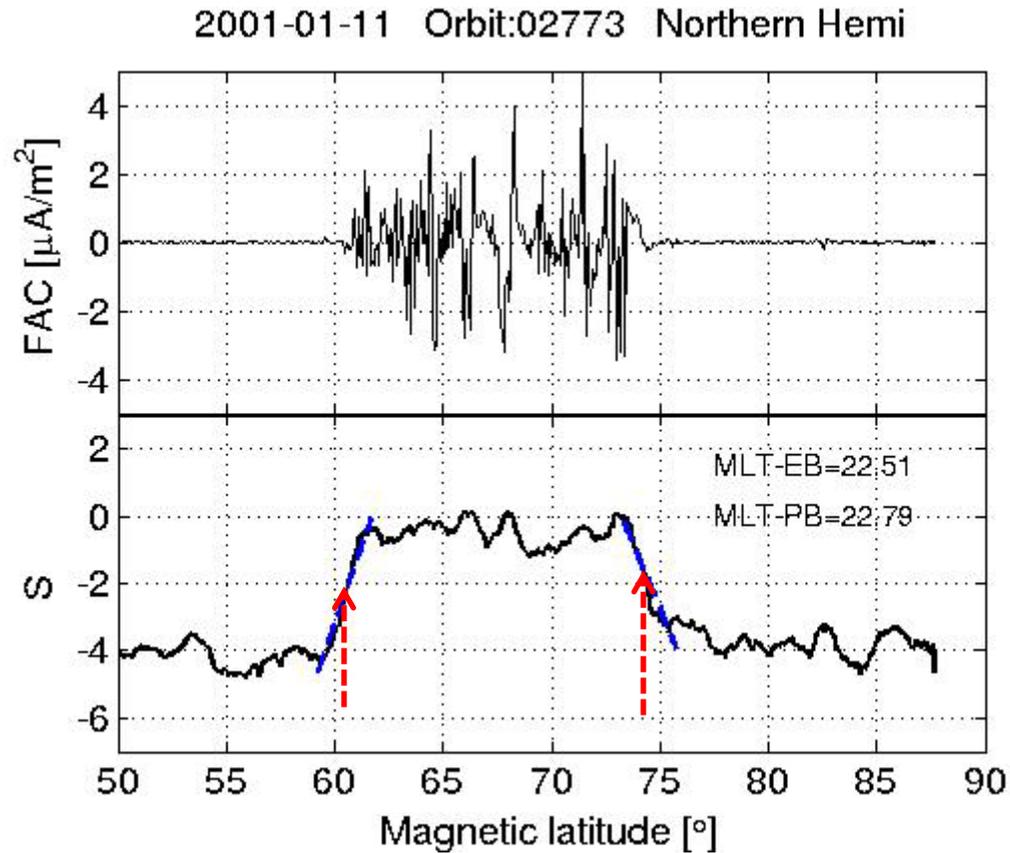


EISCAT



[Ritter et al., 2010]

Using FAC to determine the auroral oval boundaries

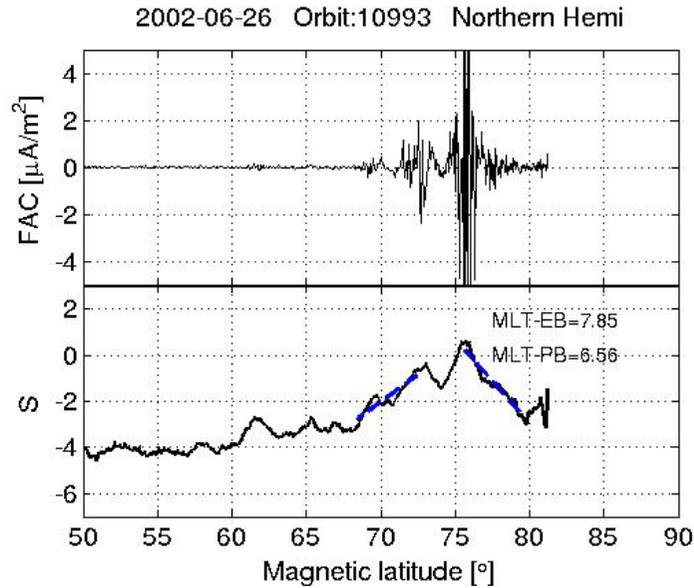


$$j_{\parallel} = -\frac{1}{\mu_0 v_x} \frac{dB_{\Phi}}{dt}$$

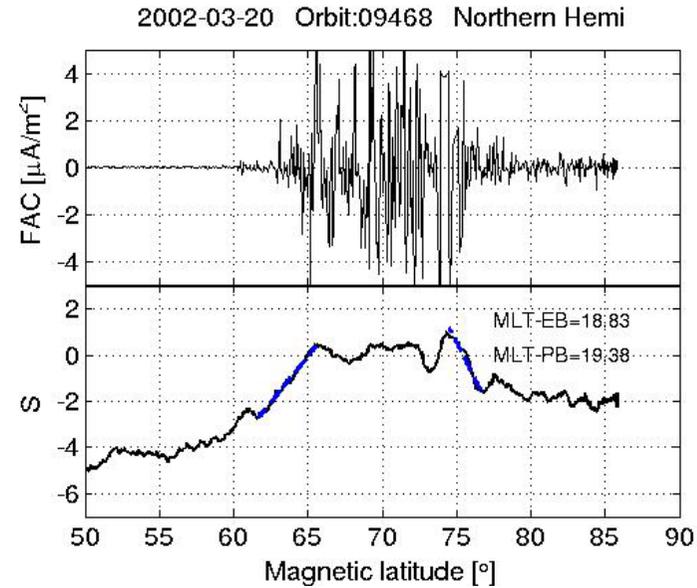
$$S = \left\langle \log_{10} j_{\parallel}^2 \right\rangle_{20s}$$

Using FAC to determine the auroral oval boundaries

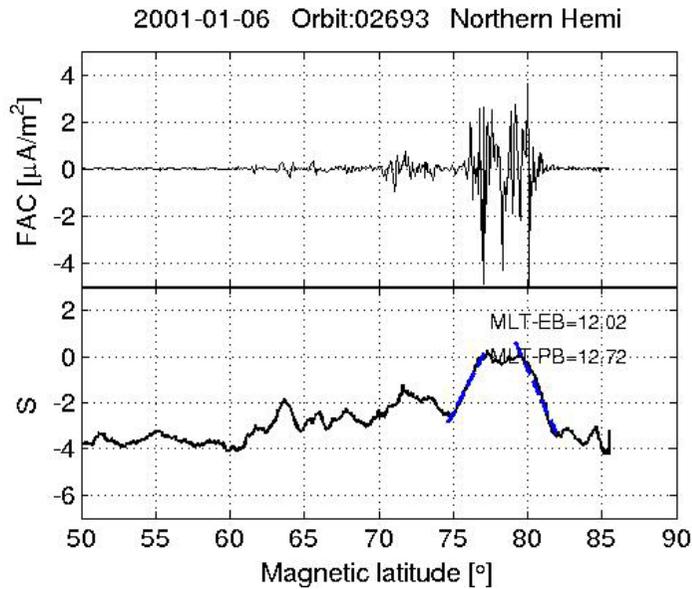
Dawn



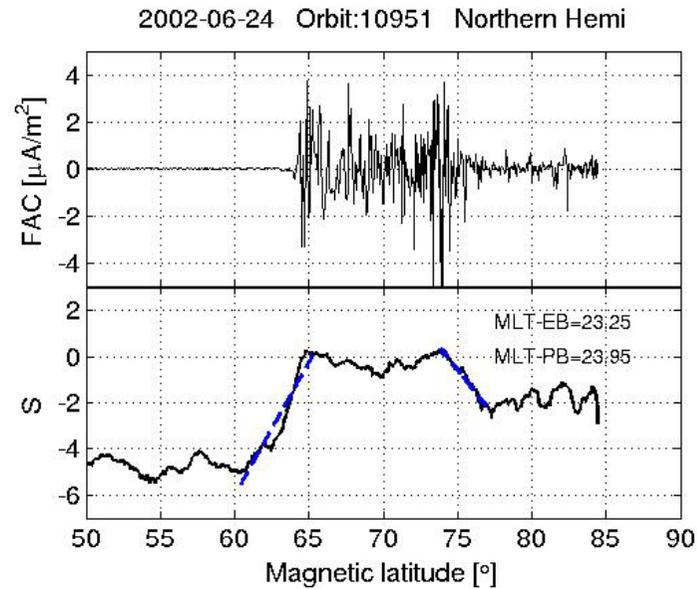
Dusk



Noon



Midnight



Events of auroral oval boundaries

Northern hemisphere

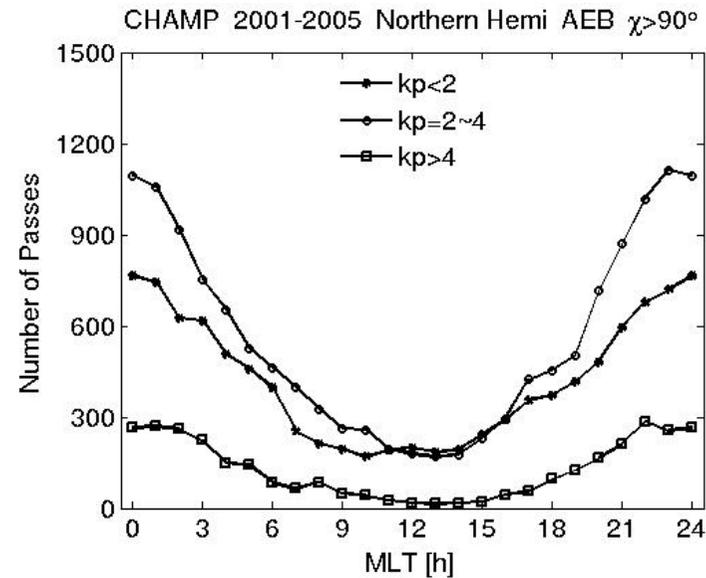
Time interval: **2001-2005**

Solar zenith angle: $\lambda > 90^\circ$

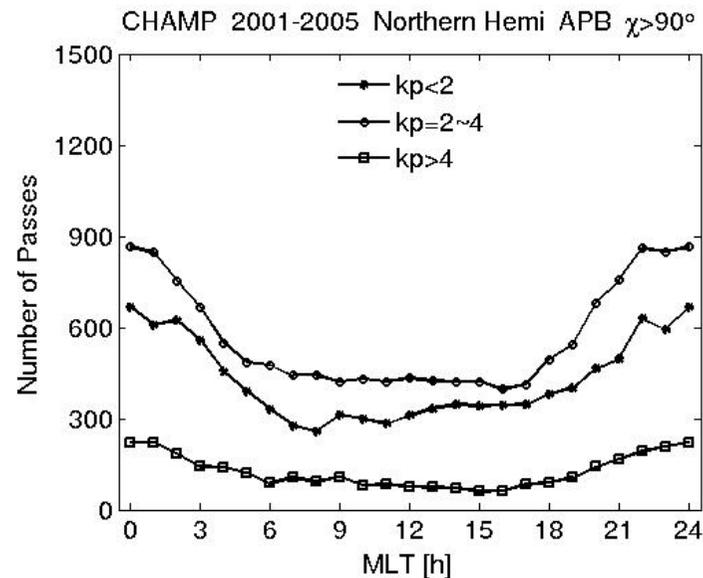
Magnetic activity:

- Quiet: $kp < 2$
- Moderate: $kp = 2 \sim 4$
- Disturbed: $kp > 4$

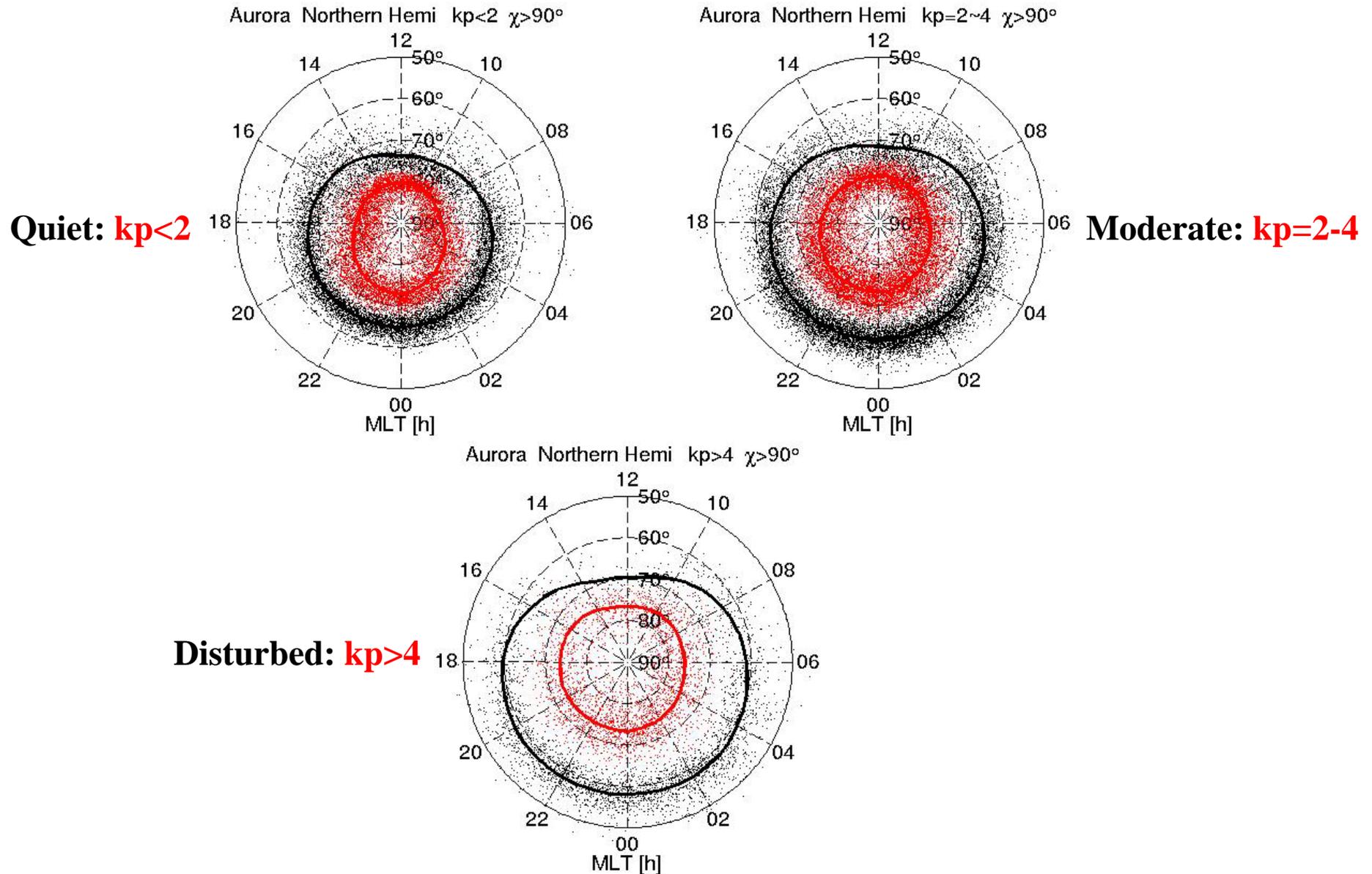
Equatorial boundary



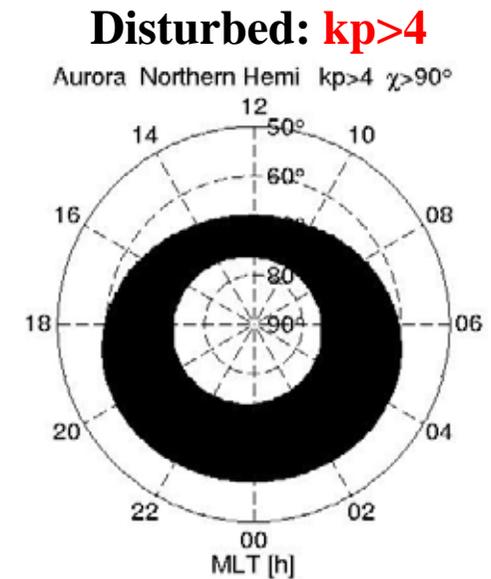
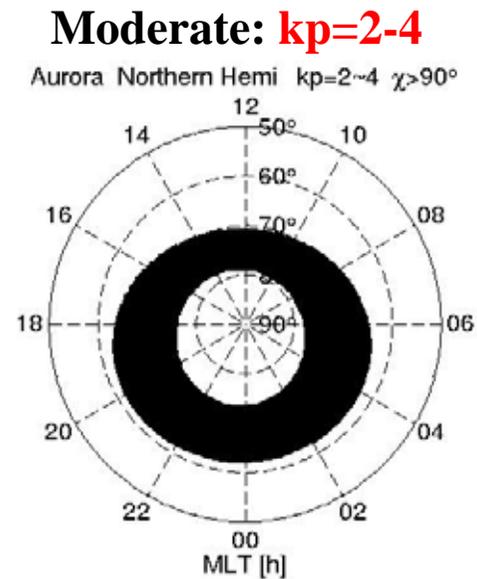
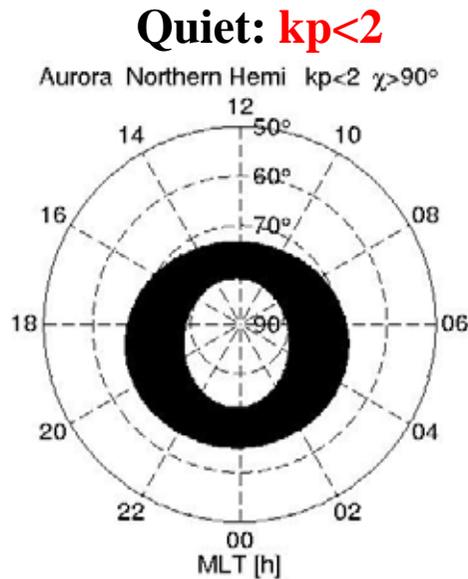
Polar boundary



Events of auroral oval boundaries



Ellipse fit of auroral oval boundaries

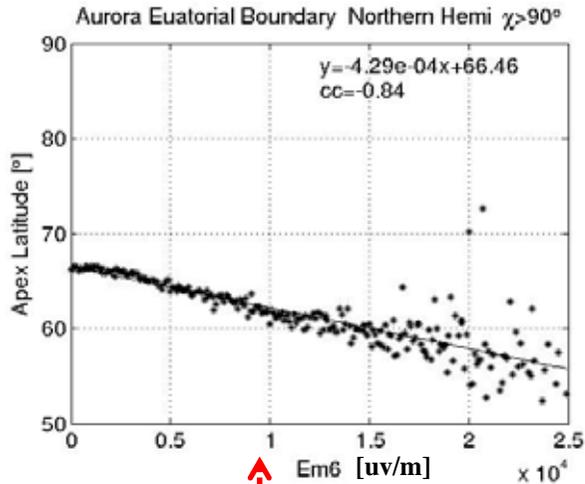


Auroral oval		$kp < 2$	$kp = 2-4$	$kp > 4$
Equatorial Boundary ($^\circ$)	a	22.53	26.03	30.34
	b	20.58	23.35	26.56
	φ	-9.04	-3.59	2.69
	x0	-0.58	-0.67	-0.37
	y0	-4.13	-4.30	-4.99
Polar Boundary ($^\circ$)	a	11.17	13.53	15.59
	b	13.44	14.16	15.31
	φ	-1.67	-8.69	-16.90
	x0	-0.54	-0.94	-1.28
	y0	-3.80	-2.69	-1.21

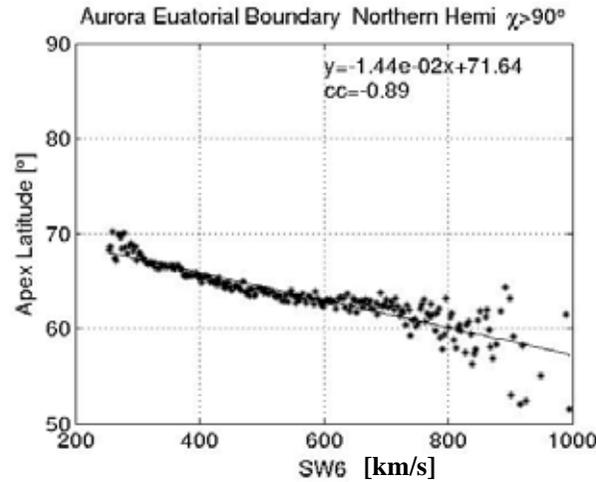
Equatorward auroral oval boundaries with magnetic index

All local time: 0000-2400MLT

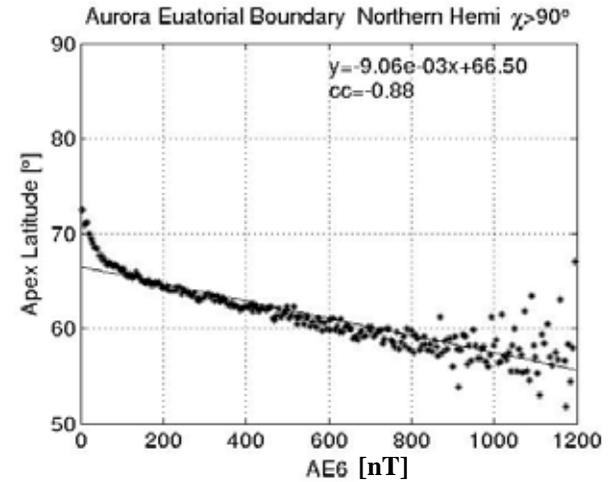
Merging E-field



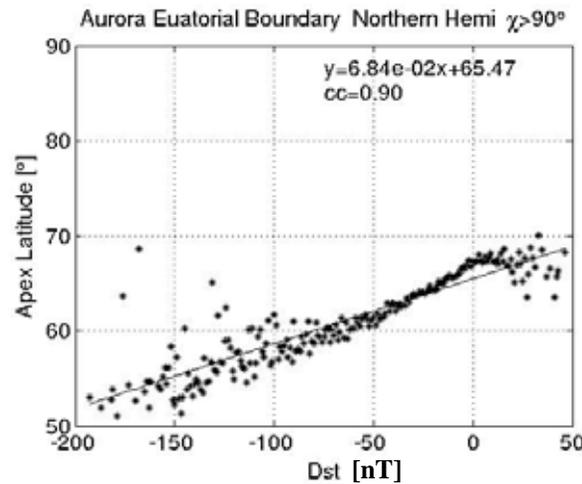
Solar Wind



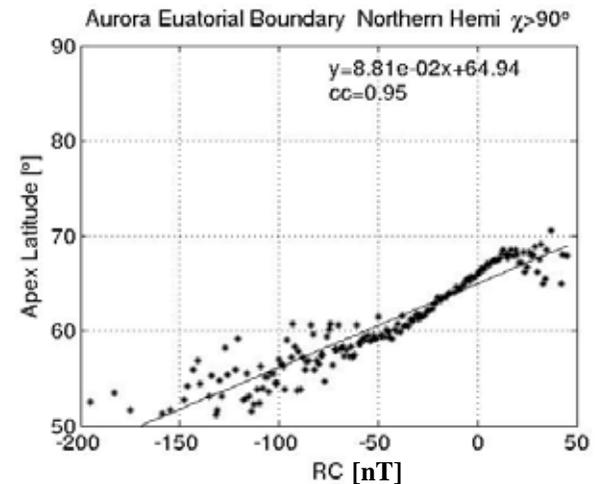
AE6



Dst



Ring Current index



Newell coupling function :

$$E_m = v_{sw}^{\frac{4}{3}} B_T^{\frac{2}{3}} \sin^{\frac{8}{3}}\left(\frac{\theta}{2}\right)$$

$$B_T = \sqrt{B_y^2 + B_x^2} \quad [\text{Newell et al., 2007}]$$

Memory effect:

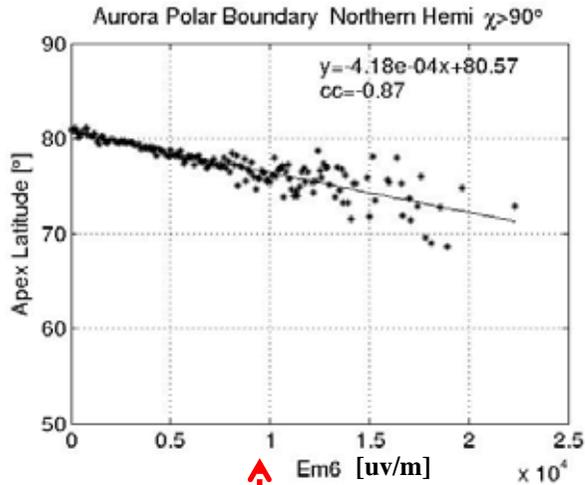
$$AE_6 = \frac{\sum_{i=0}^{i=6} AE(UT - i[h])e^{-i}}{\sum_{i=0}^{i=6} e^{-i}}$$

[Werner and Pröls, 1997]

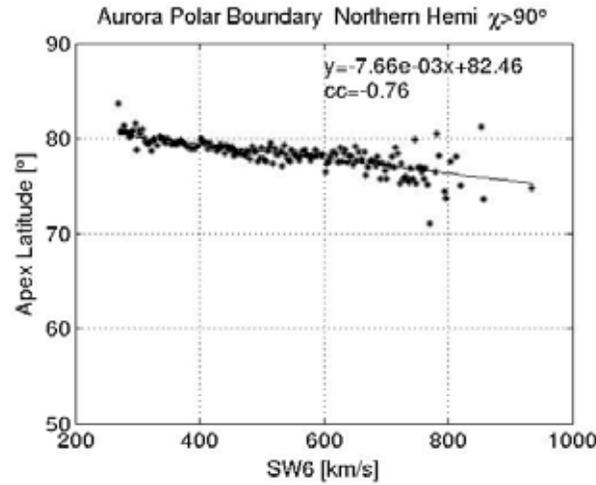
Poleward auroral oval boundaries with magnetic index

Daytime: 0800-1600MLT

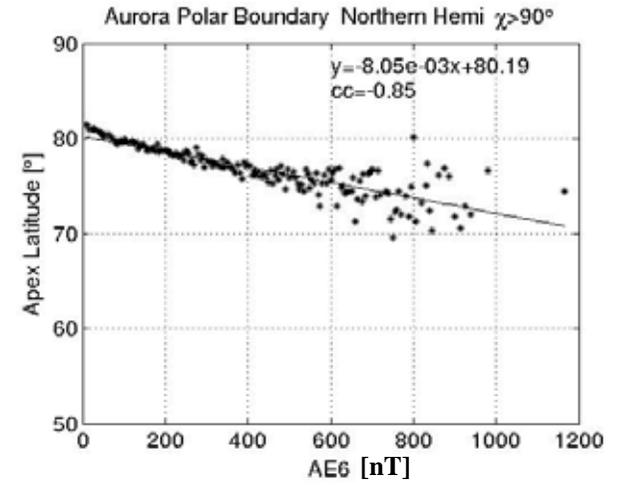
Merging E-field



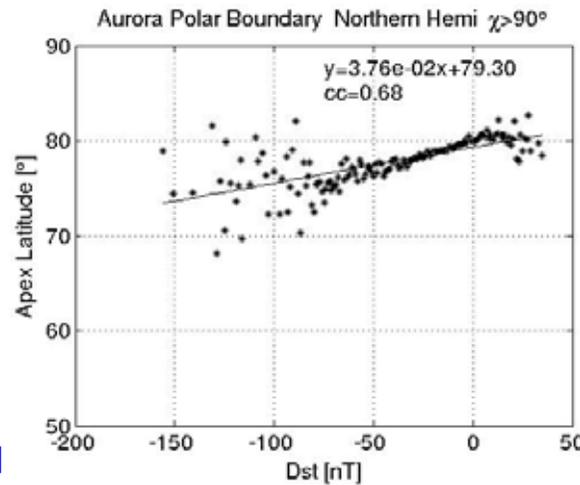
Solar Wind



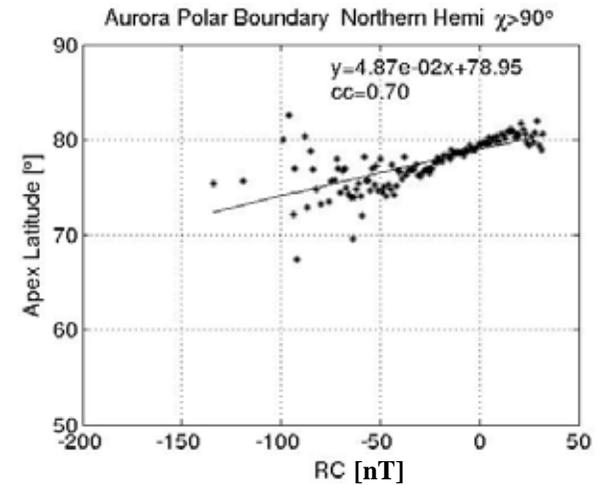
AE6



Dst



Ring Current index



Newell coupling function :

$$E_m = v_{sw} \frac{4}{3} B_T^2 \sin^3\left(\frac{\theta}{2}\right)$$

[Newell et al., 2007]

$$B_T = \sqrt{B_y^2 + B_x^2}$$

Memory effect:

$$AE_6 = \frac{\sum_{i=0}^{i=6} AE(UT - i[h])e^{-i}}{\sum_{i=0}^{i=6} e^{-i}}$$

[Werner and Pröls, 1997]

Summary

- The **medium-scale field-aligned currents (10-100km)** is closely related to the location of the auroral oval at all levels of activity and can be used to determine the boundaries of auroral oval.
- The latitudes of the boundaries are closely controlled by magnetic activity:
 - ❖ The **equatorward boundary moves equatorward** with increasing magnetic activity, and the **ring current index (RC)** shows best correlation with a value of 0.95 during **all local time**
 - ❖ The **poleward boundary moves poleward** with increasing magnetic activity, and the **merging electric field (Em)** shows best correlation with a value of 0.87. during **0800-1600MLT**.
 - ❖ **During midnight** the poleward boundary of auroral oval seems to **stay on average at latitudes of about 73° (Mlat)**.

Acknowledgement and References

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References

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Thanks for your attention!