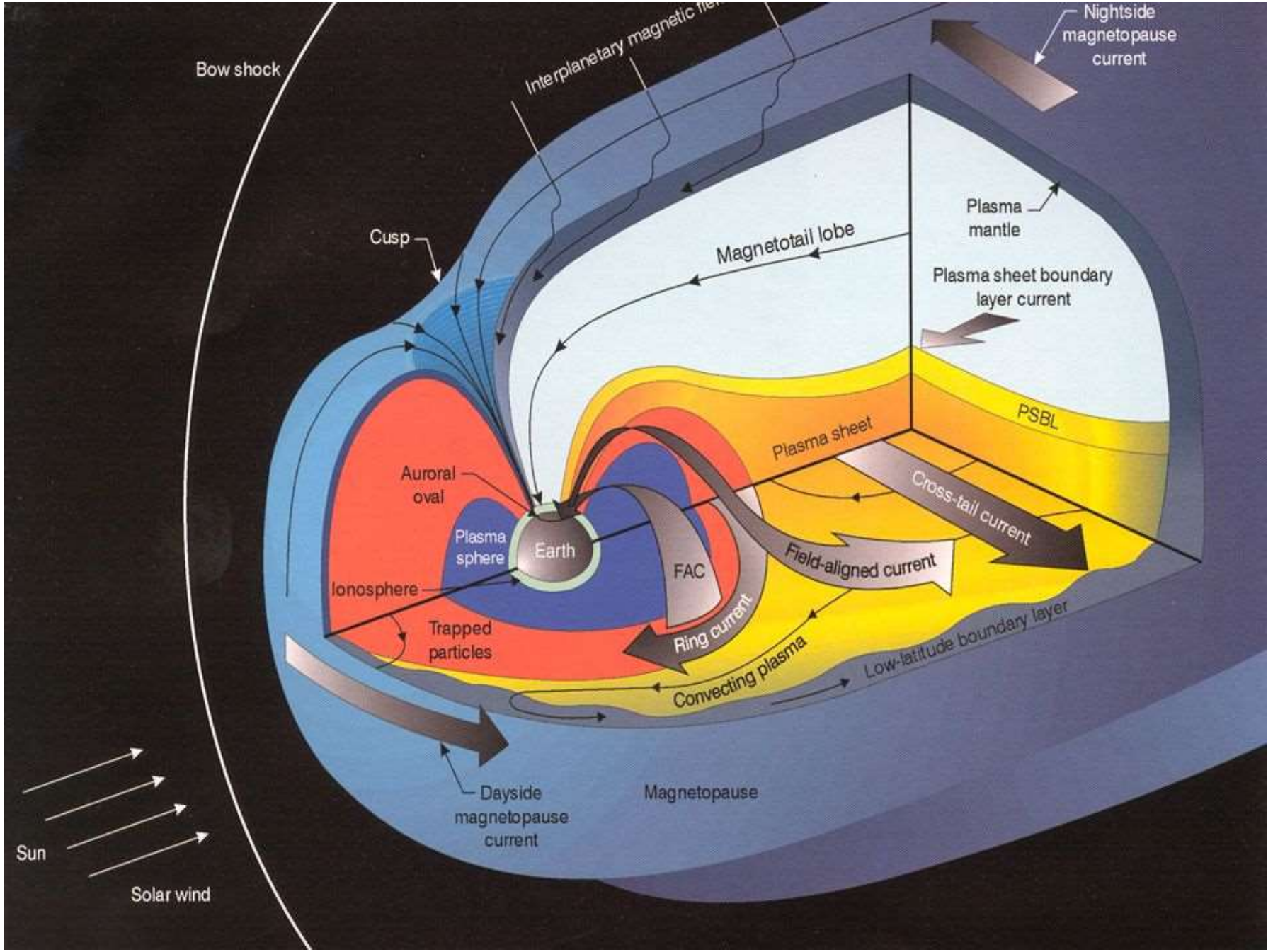
Ionospheric currents: electrojets and auroral oval

Additional reading:
Baumjohann & Treumann, Ch. 4


Bow shock
Interplanetary magnetic field
Nightside magnetopause current
Cusp
Magnetotail lobe
Plasma mantle
Plasma sheet boundary layer current
PSBL
Plasma sheet
Auroral oval
Plasma sphere
Earth
Ionosphere
FAC
Field-aligned current
Cross-tail current
Trapped particles
Ring current
Convecting plasma
Low-latitude boundary layer
Dayside magnetopause current
Magnetopause
Sun
Solar wind

Conductivity tensor and Ohm's law

Generalised Ohm's law

$$\mathbf{j} = \sigma_\parallel \mathbf{E}_\parallel + \sigma_P \mathbf{E}_\perp - \sigma_H (\mathbf{E} \times \mathbf{B})/B$$

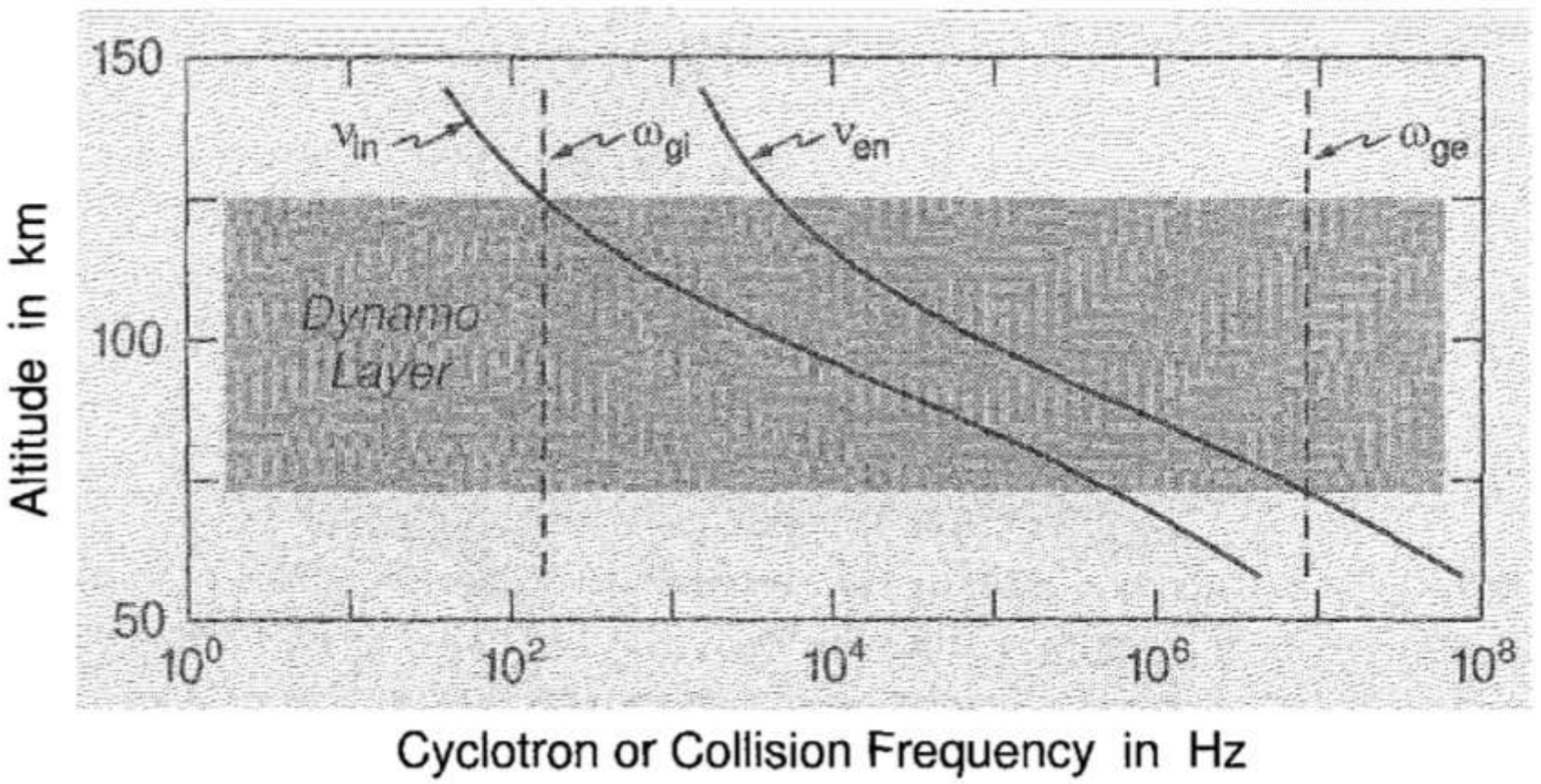
Pedersen, Hall, and parallel conductivities

$$\sigma_P = \left(\frac{\nu_{en}}{\nu_{en}^2 + \omega_{ge}^2} + \frac{m_e}{m_i} \frac{\nu_{in}}{\nu_{in}^2 + \omega_{gi}^2} \right) \frac{n_e e^2}{m_e}$$

$$\sigma_H = -\left(\frac{\omega_{ge}}{\nu_{en}^2 + \omega_{ge}^2} + \frac{m_e}{m_i} \frac{\omega_{gi}}{\nu_{in}^2 + \omega_{gi}^2} \right) \frac{n_e e^2}{m_e}$$

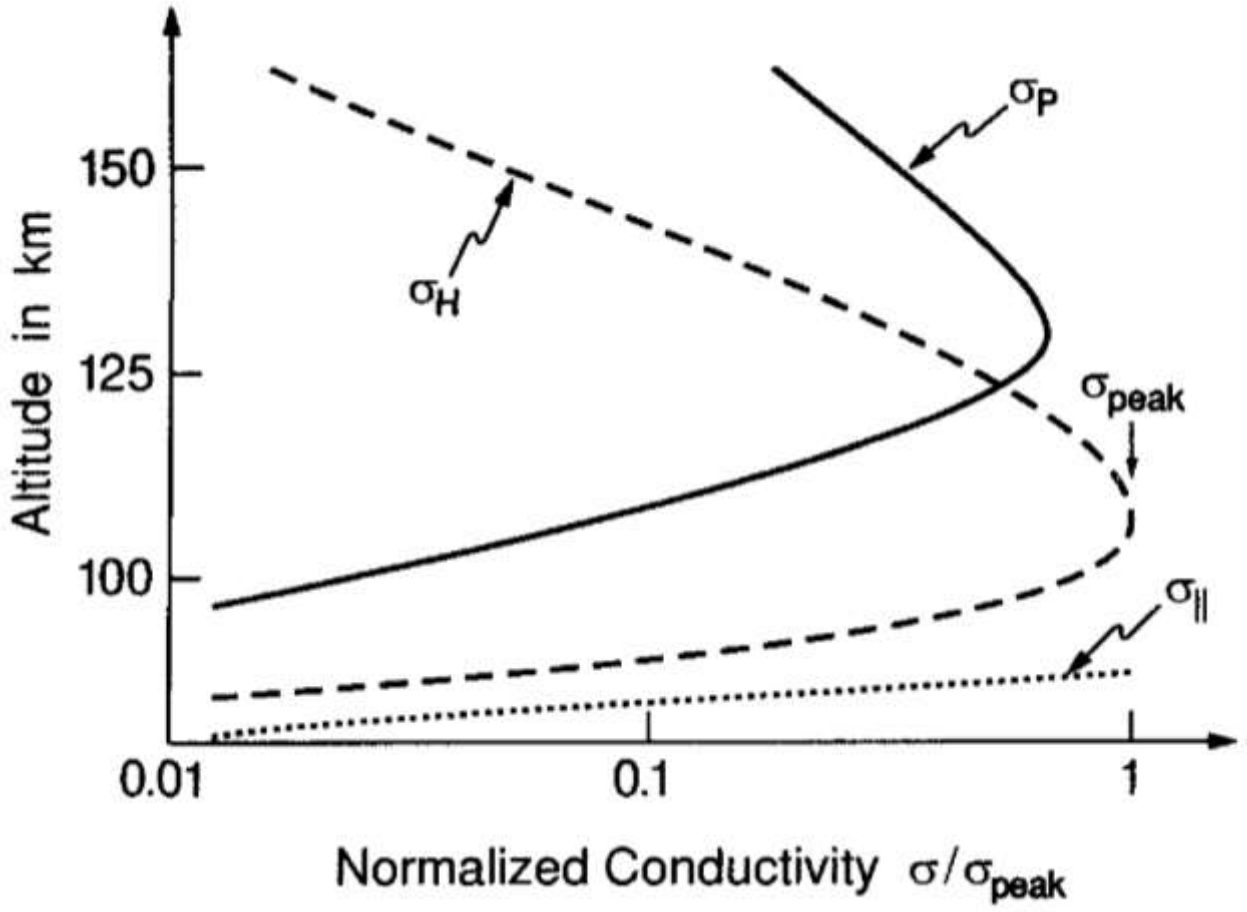
$$\sigma_\parallel = \left(\frac{1}{\nu_{en}} + \frac{m_e}{m_i} \frac{1}{\nu_{in}} \right) \frac{n_e e^2}{m_e}$$

Ionospheric transition region



While gyro frequencies are relatively constant, collision frequencies drop exponentially with altitude.

Pedersen and Hall conductivity profiles

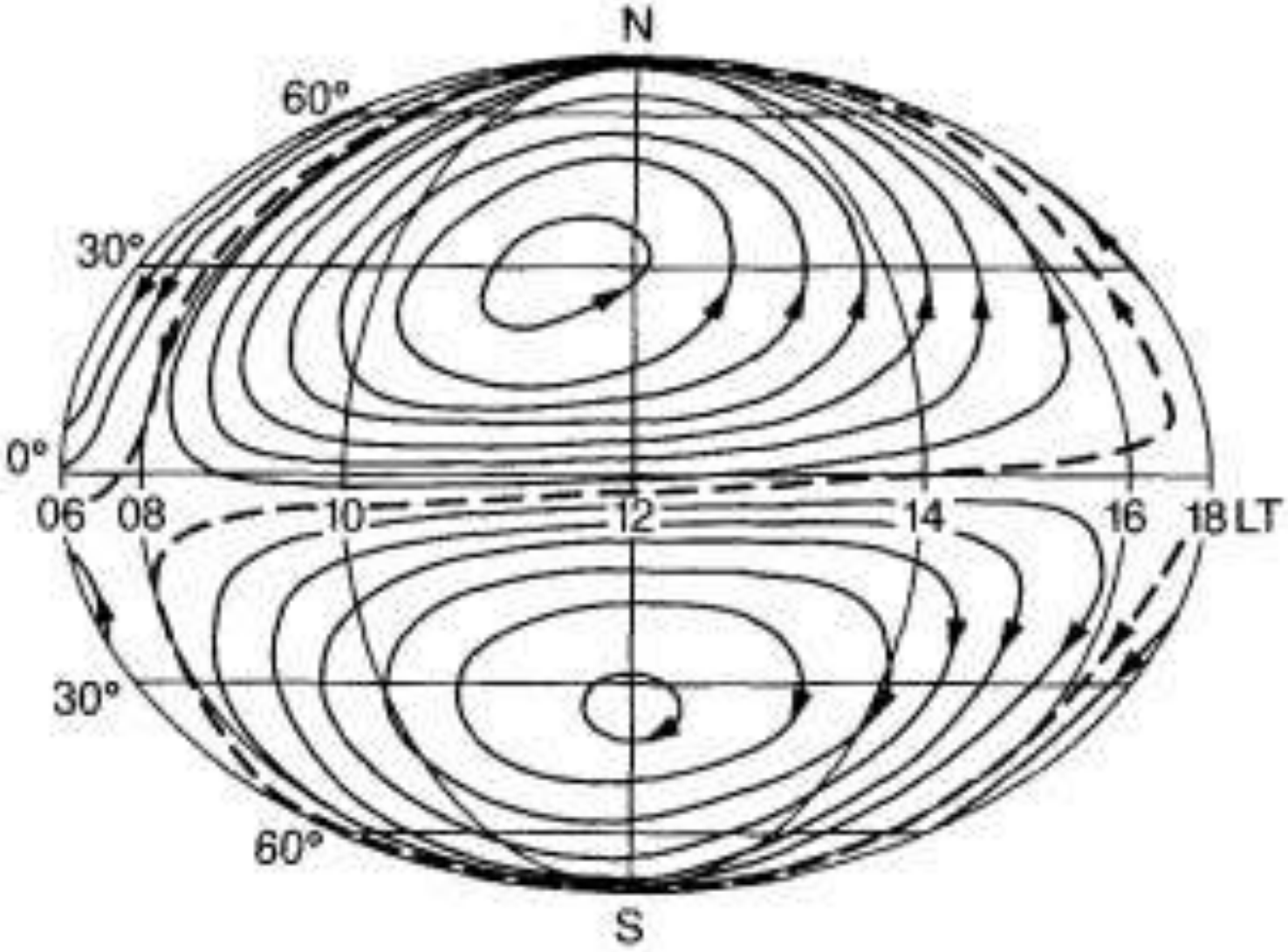


Pedersen current is carried by ions

Hall current is carried by electrons

Read B&T, Sect. 4.4

Sq currents

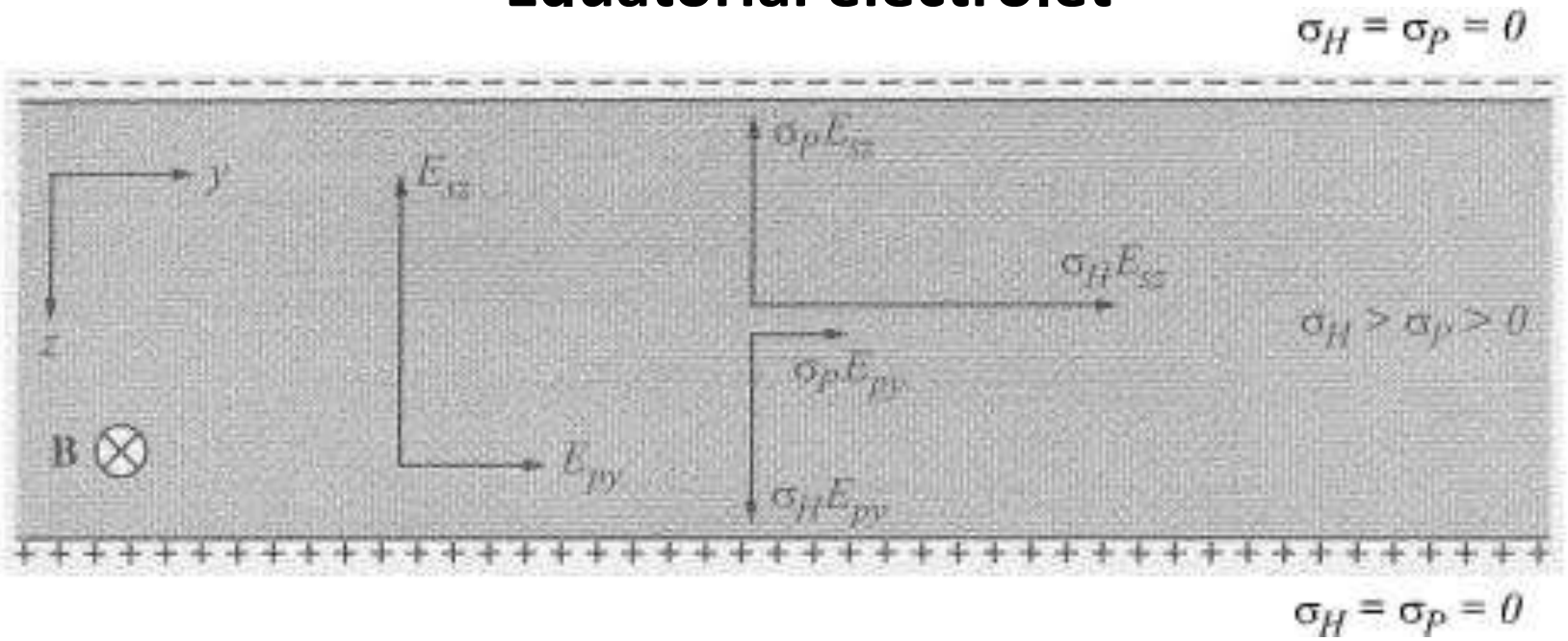


Mid-latitude tidal-like current system

$$\mathbf{j} = \sigma \cdot (\mathbf{E} + \mathbf{v}_n \times \mathbf{B})$$

Geomagnetic forcing and neutral atmosphere forcing may balance each other, under specific conditions.

Equatorial electroiet

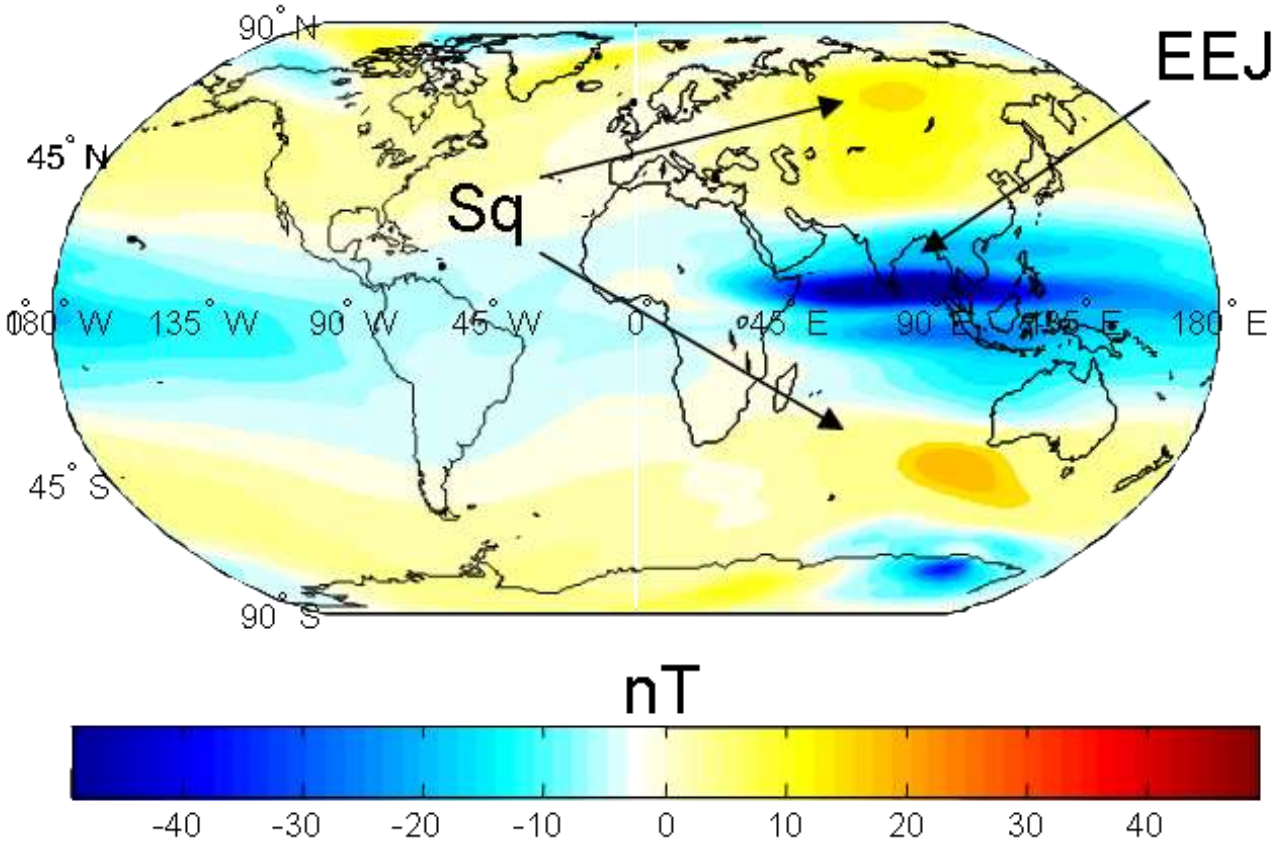


Enhancement of Pedersen and Hall currents within limited range of latitudes around the geomagnetic equator.

Few factors lead to the equatorial electrojet being strong:

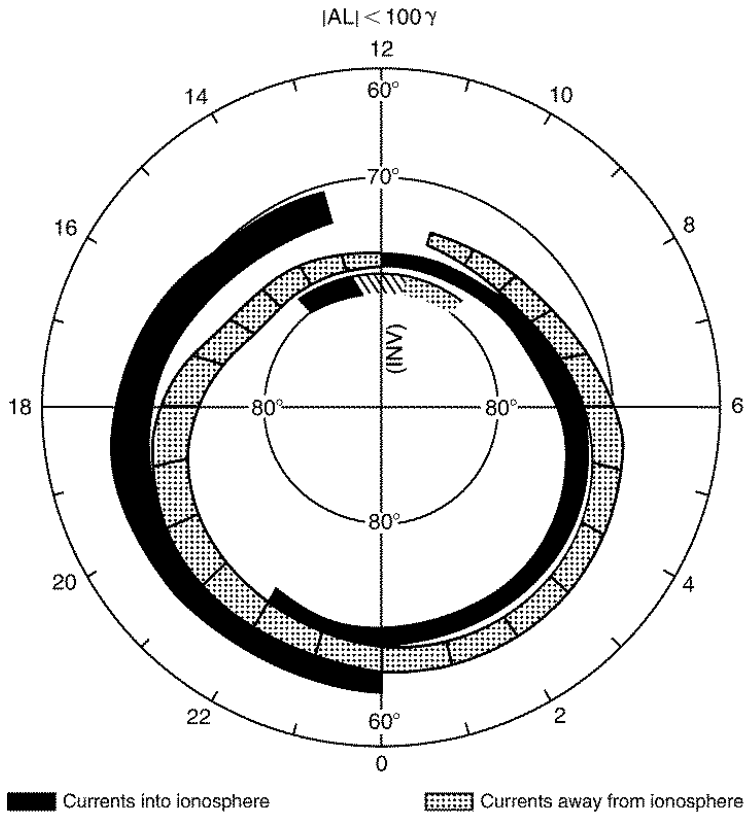
- geometry of Sq currents;
- solar zenith geometry;
- Cowling effect, etc.

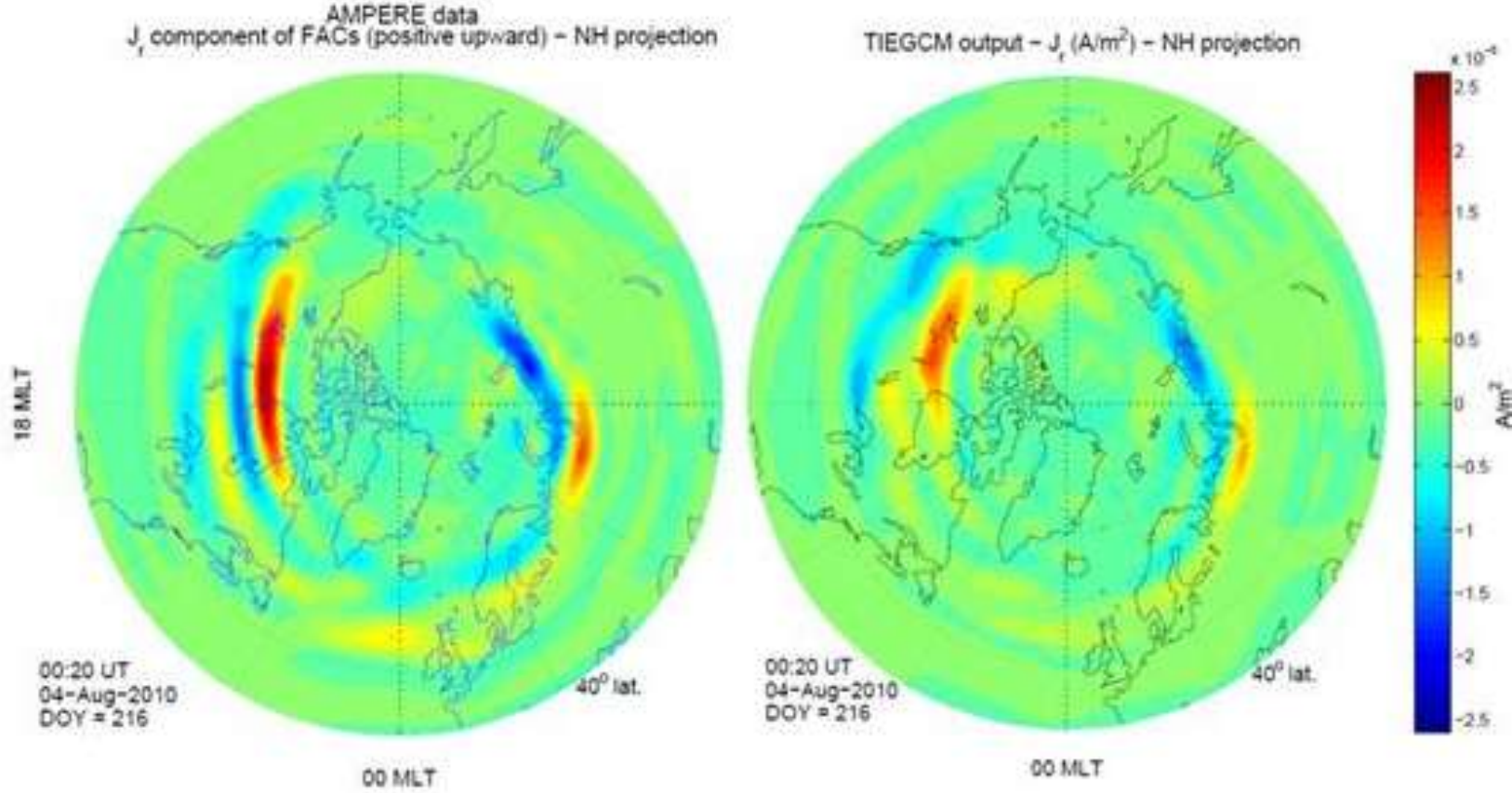
Mid- and low-latitude magnetic perturbations



Source: https://en.wikipedia.org/wiki/Equatorial_electrojet

Satellite observations of FACs

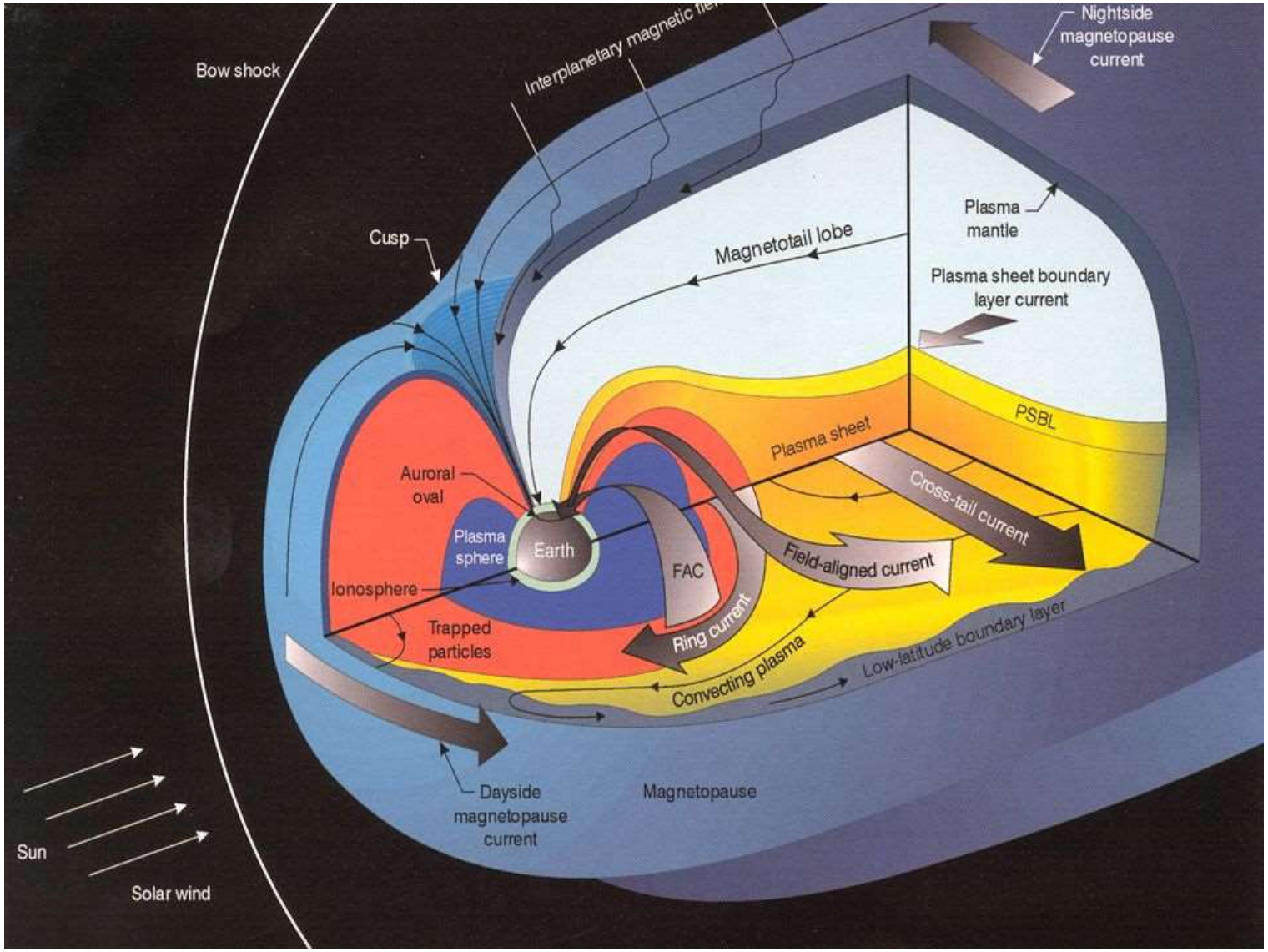


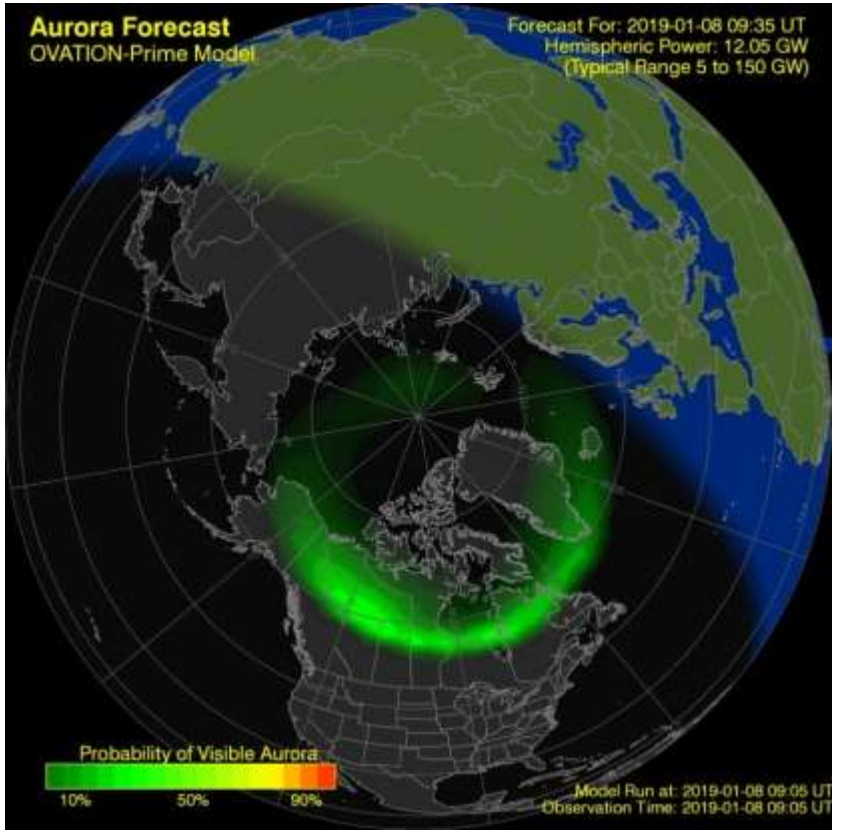


Credit: AGU

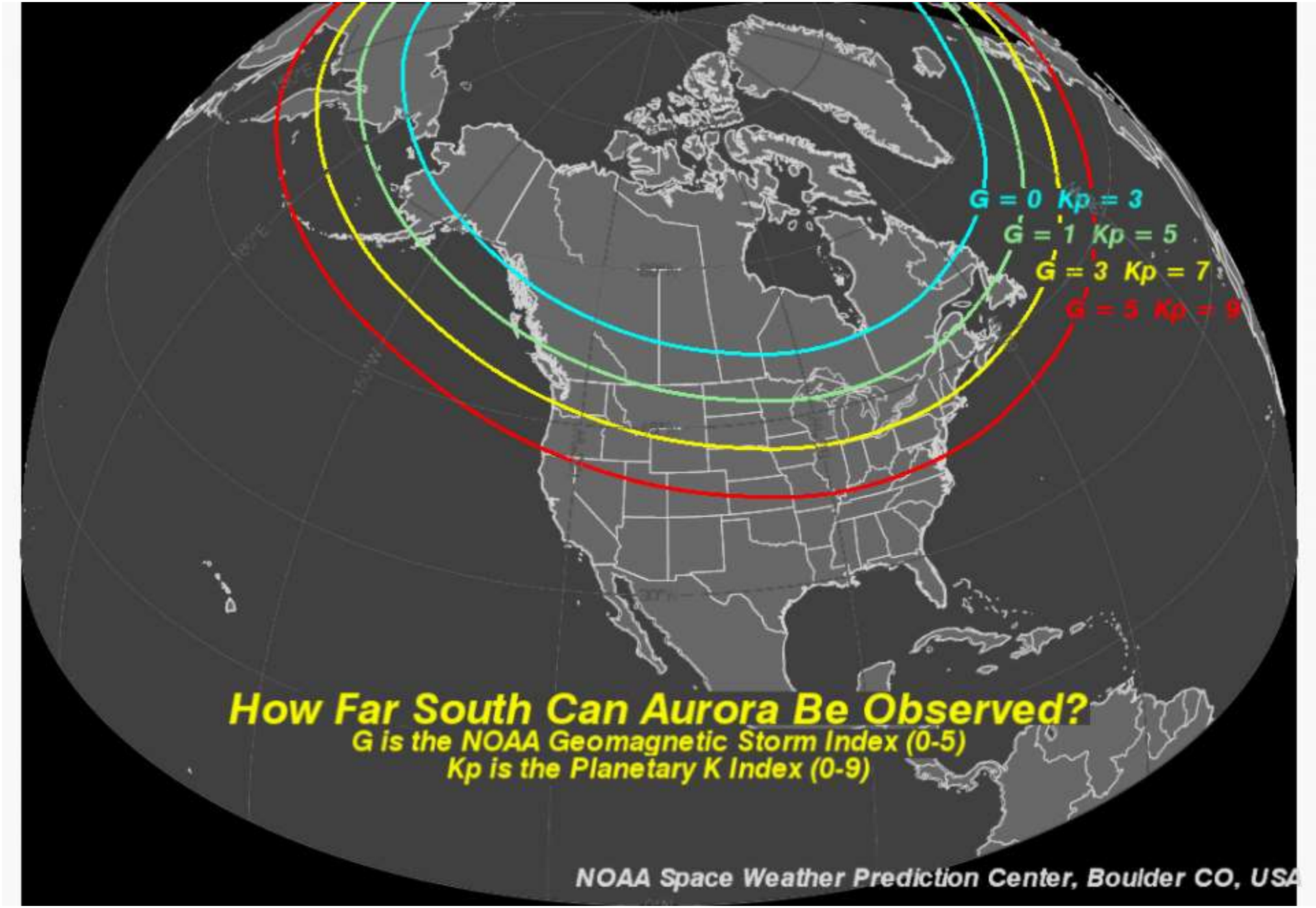
First satellite observations by *Ijima and Potemra* (1976).

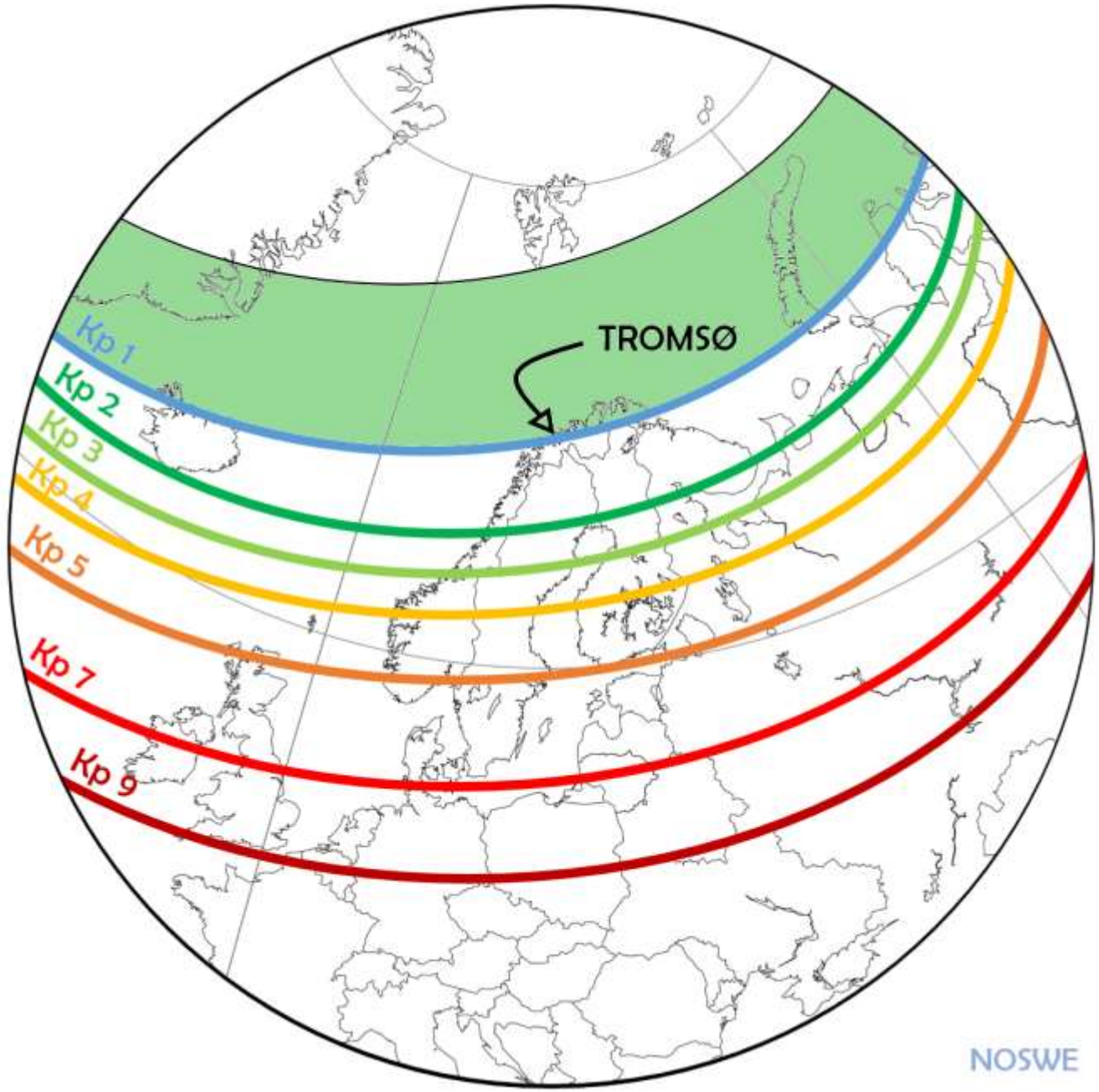
Field aligned currents and auroral electrojets





Credit: NOAA


G = 0 Kp = 3
G = 1 Kp = 5
G = 3 Kp = 7
G = 5 Kp = 9
How Far South Can Aurora Be Observed?
G is the NOAA Geomagnetic Storm Index (0-5)
Kp is the Planetary K Index (0-9)
NOAA Space Weather Prediction Center, Boulder CO, USA


TROMSØ
Kp 1
Kp 2
Kp 3
Kp 4
Kp 5
Kp 7
Kp 9
NOSWE