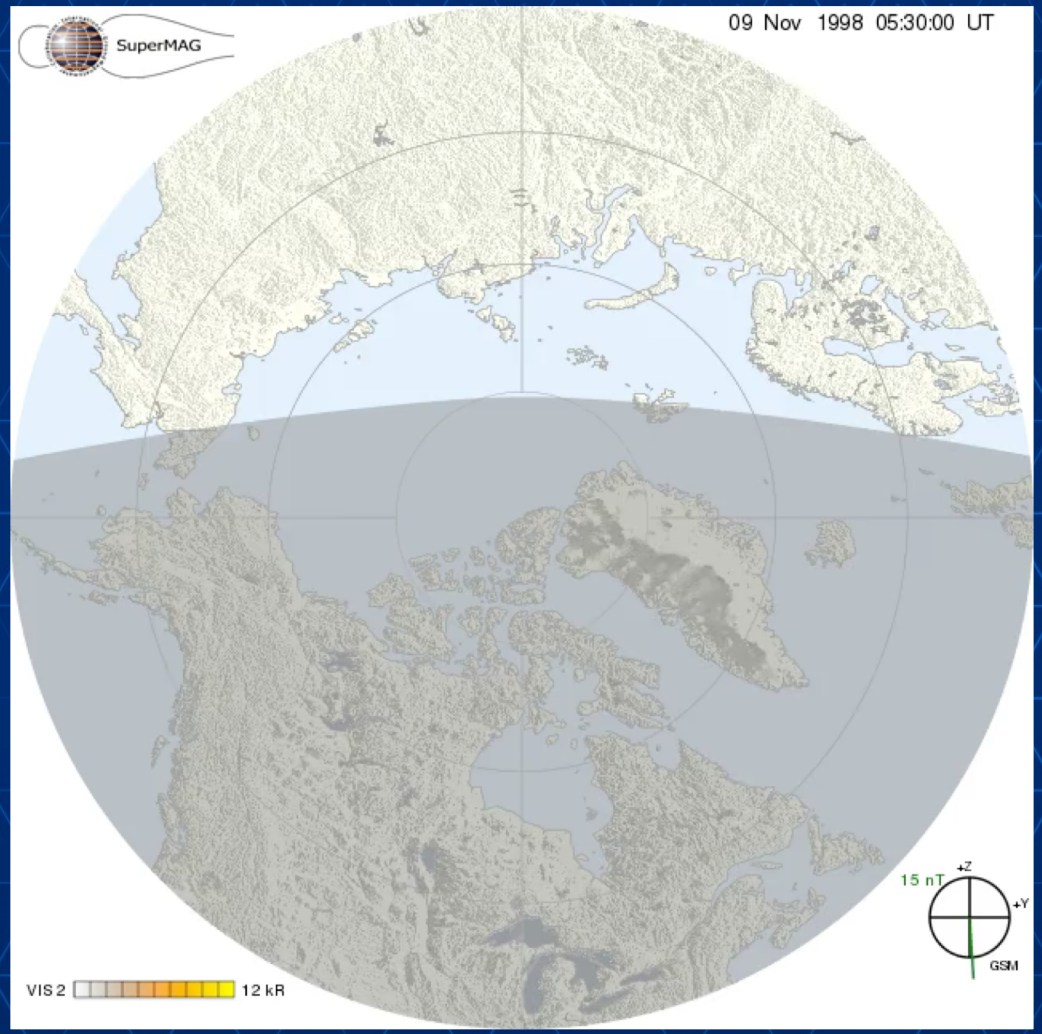
JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

Three Issues To Keep In Mind For GDC:

- Dynamics
- Spatial hierarchy
- Reference frame



J. Gjerloev and S. Ohtani

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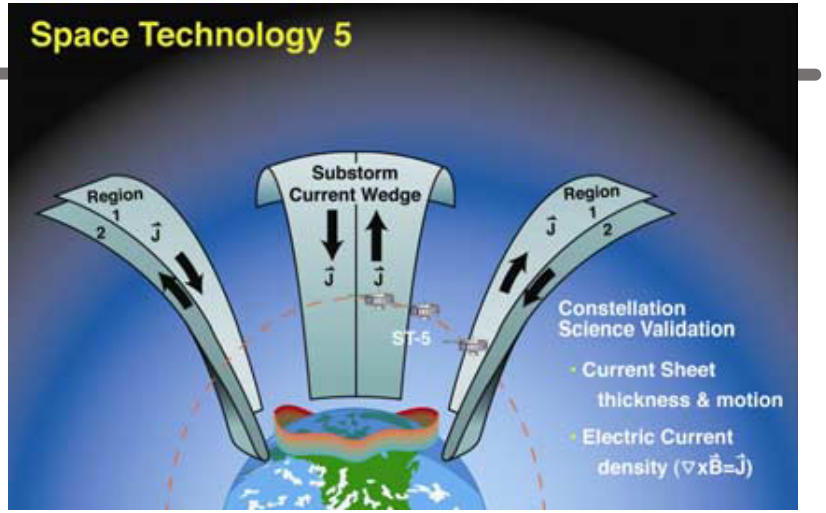
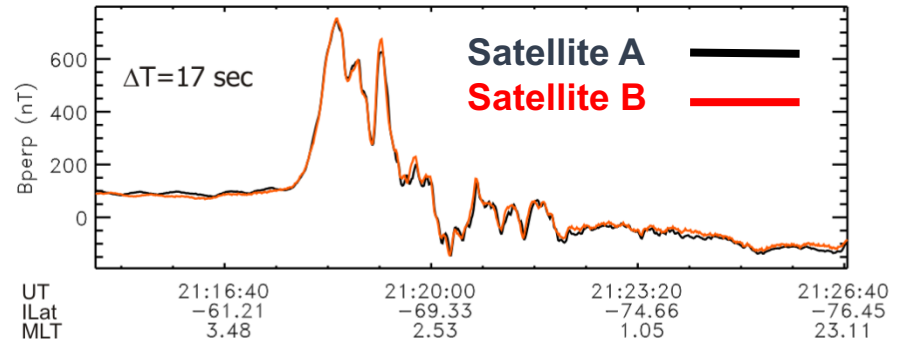
Dynamics – The Variable Magnetosphere-Ionosphere-Thermosphere System

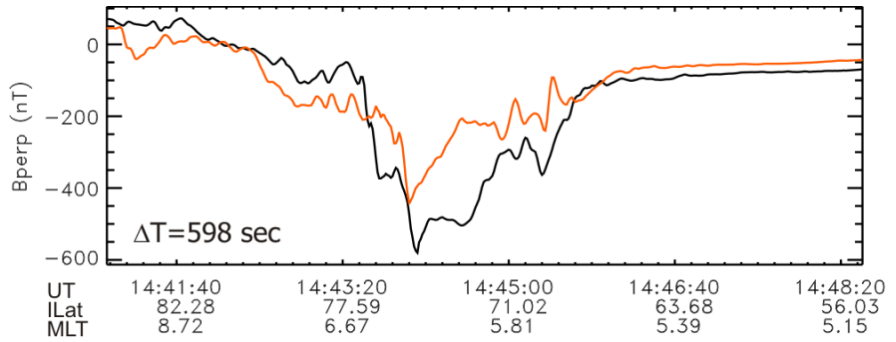
- **Physical Parameter.** Time derivative of basic electrodynamic parameters.
- **Observational Challenge.** Single satellite measurements can typically not distinguish between spatial and temporal variations.
- **Solution.** Multi-point measurements either separated in time (e.g. co-orbital or pearls-on-a-string) or space (e.g. separated in local-time).

Slavin et al. [2007]





Gjerloev et al. [2011]



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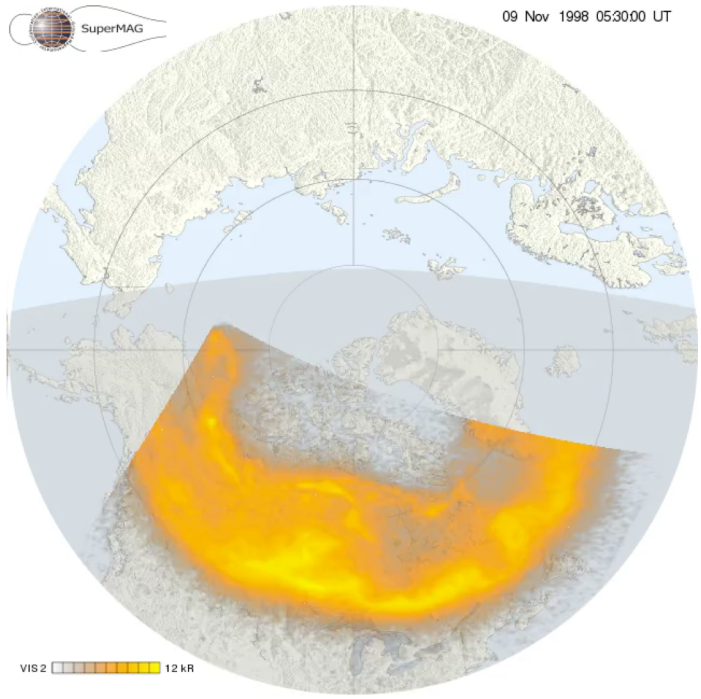
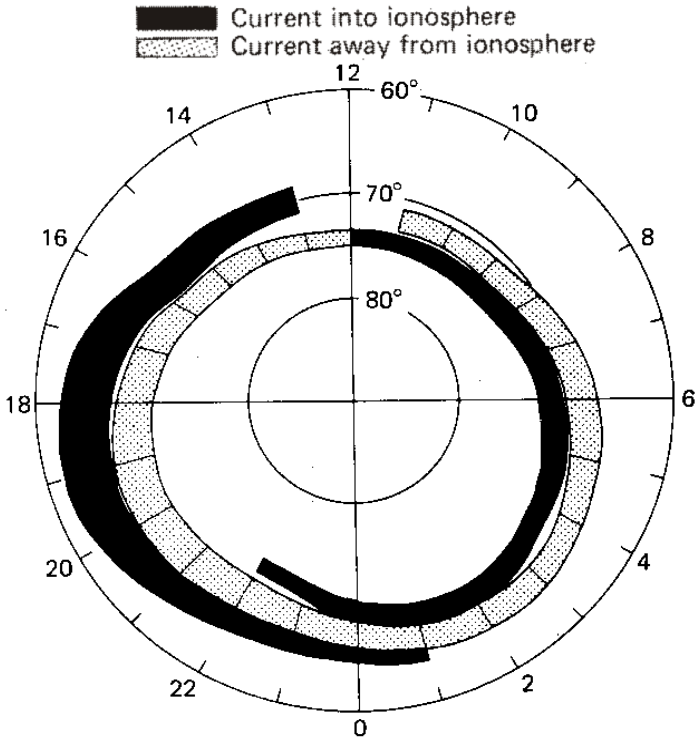
Questions:

- To what extent do large-scale static empirical models predict the actual distribution?



Iijima and Potemra, 1978



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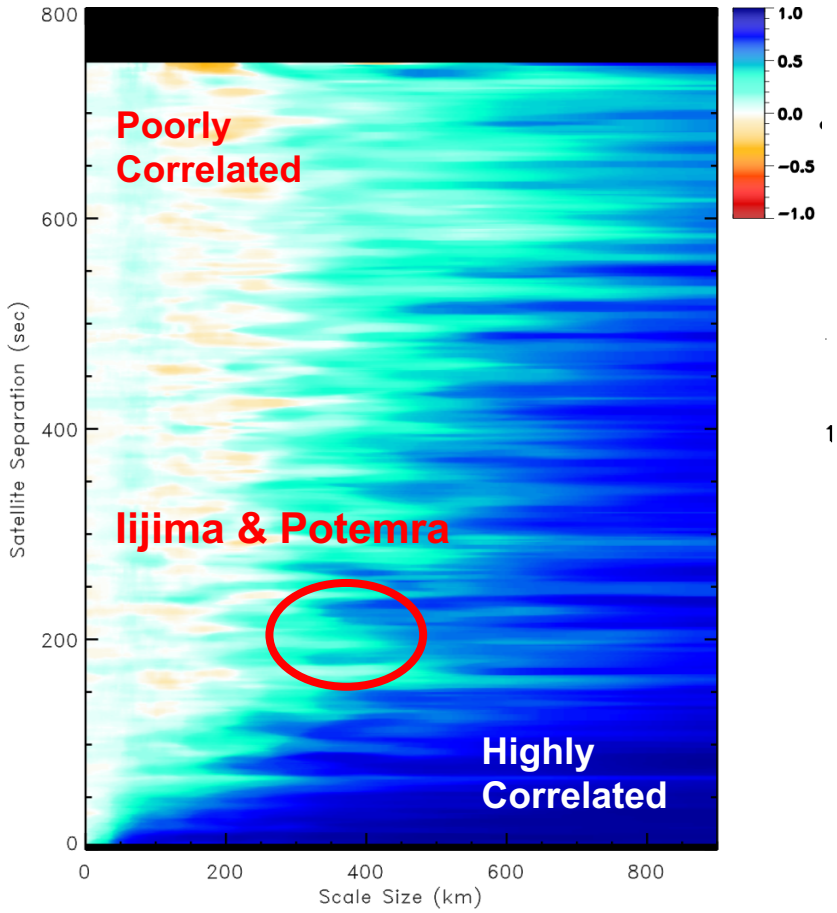
Question:

- How does energy and momentum transport depend on temporal and spatial scales of the M-I system?

Gjerloev et al. [2011]



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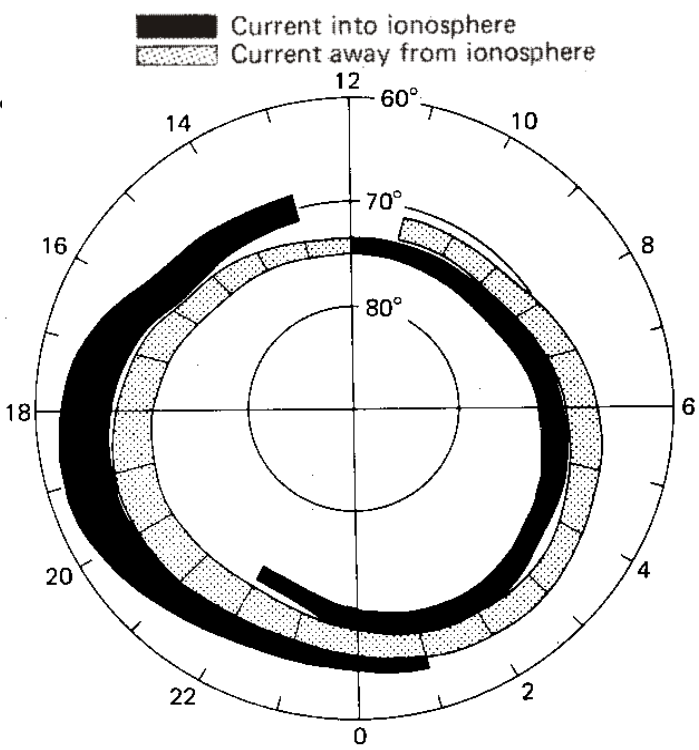

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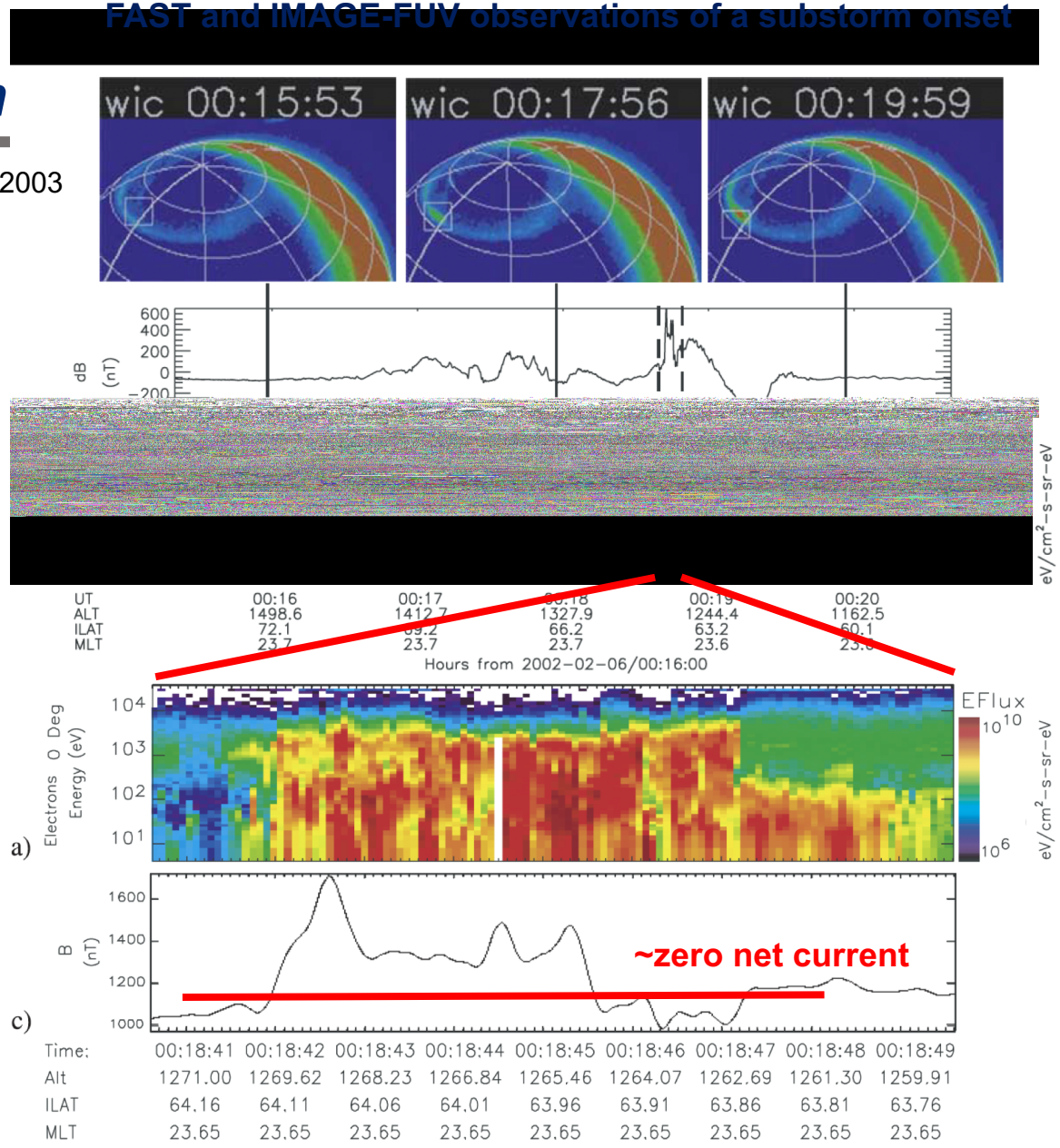
Mende et al., 2003

Questions:

- What is the relationship between broadband precipitation and FAC's?
- What is the evolution of broadband precipitation?



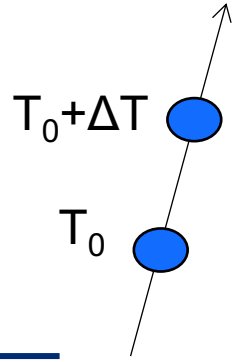
Spatial hierarchy – energy and momentum transfer

- **Physical Parameter**. Field-aligned currents (FAC's) is the dominant mechanism transport of energy and momentum in the M-I system.
- **Observational Challenge**. FAC's are dynamic and structured. Single satellite measurements have been used to estimate the FAC density but are subject to a some crude assumptions (static and simple geometry).
- **Solution**. Multi-point measurements of magnetic field perturbations allowing first-principle instantaneous measurements of FAC density (curlometer technique).

Measurements separated in space and time:

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{J} \Rightarrow J_Z = \left[\partial B_y/\partial x - \partial B_x/\partial y\right]/\mu_0$$

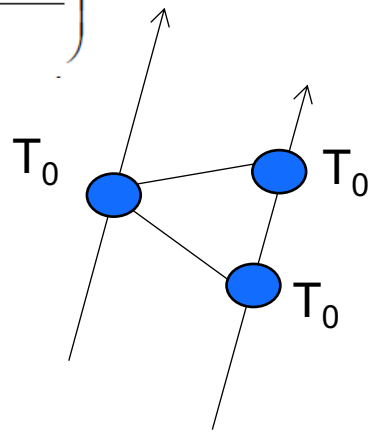
Assumptions:
- Static
- Simplistic current configuration (e.g. infinite sheet)



Measurements separated in space:

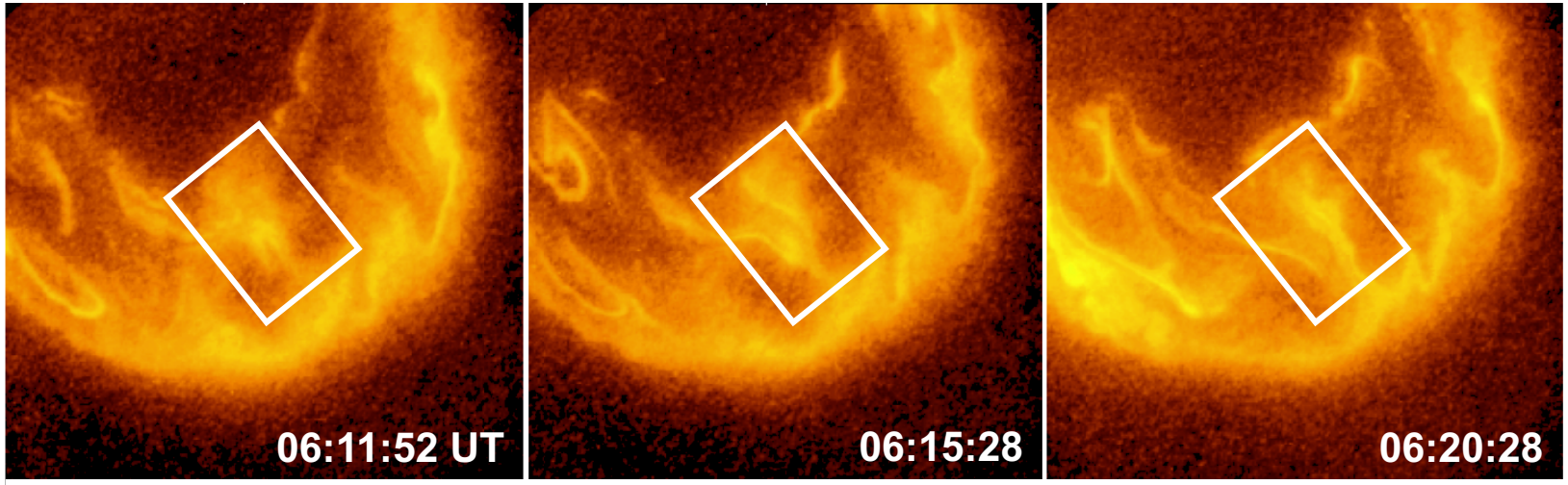
$$j = \frac{1}{\mu_0 A}\oint \boldsymbol{B}\cdot d\ell \Rightarrow J_z \approx \frac{1}{\mu_0}\left(\frac{\mathbf{r}_{13}\cdot\Delta\mathbf{B}_{12} - \mathbf{r}_{12}\cdot\Delta\mathbf{B}_{13}}{\left|\mathbf{r}_{13}\times\mathbf{r}_{12}\right|}\right)$$

Assumption:
- Average current over area is meaningful



Reference Frame – needed to interpret local detailed measurements

- **Physical Parameter**. Global large-scale distribution of physical parameters.
- **Observational Challenge**.
  A) Satellites typically provide local high precision measurements but these should be interpreted in the context of global conditions.
  B) Electrodynamic parameters are organized by processes not, for example, magnetic coordinates.
- **Solution**. SuperMAG, SuperDARN, AMPERE provide context, near-global continuous solutions that allow satellite measurements to be organized spatially and temporally.



Question:

- What are the flows associated with north-south structures?

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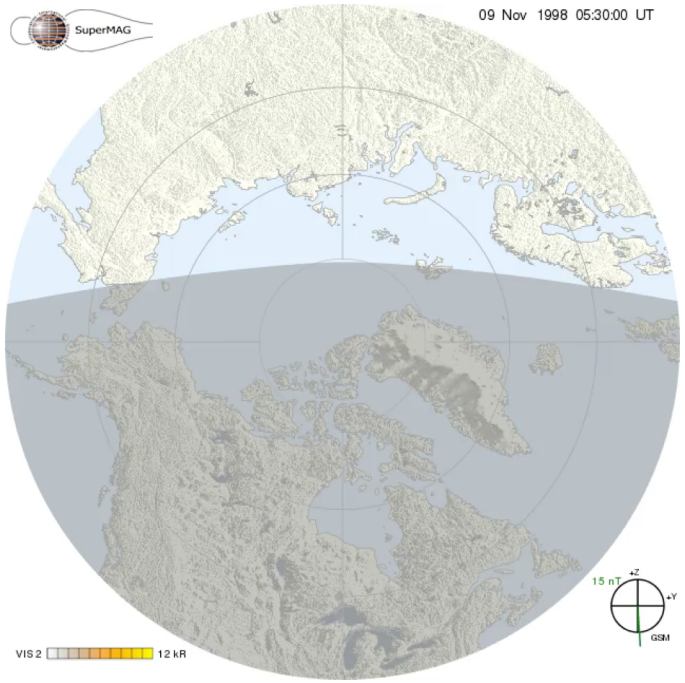

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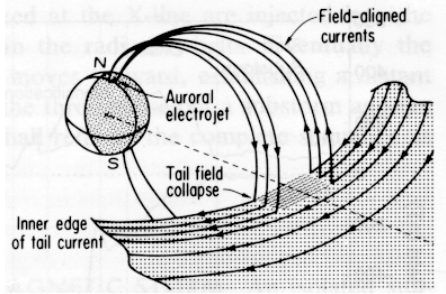
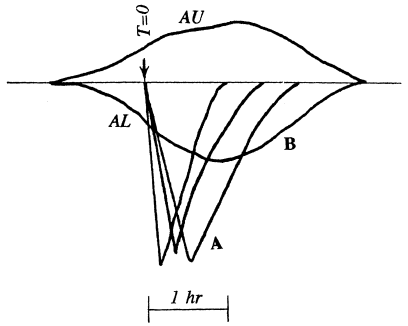
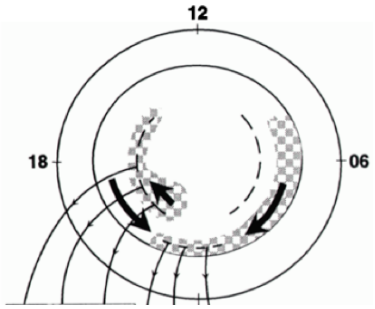
Substorm current wedge, McPherron et al.



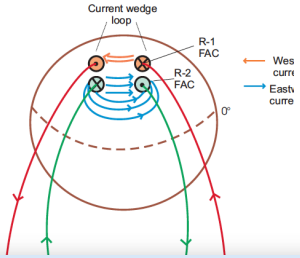
Two component model , Kamide et al.



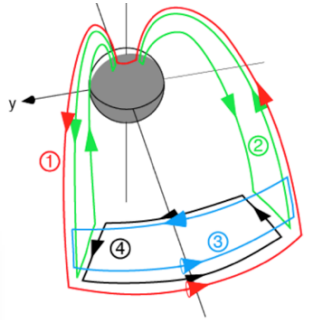
Boundary layer model, Rostoker



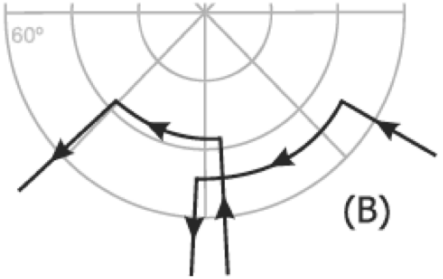
Improved Substorm model, Ritter and Lühr



Two loop model, Sergeev et al.



Double wedge model, Gjerloev and Hoffman



Question:

- Auroral electrojet feeding and drainage – when and where?

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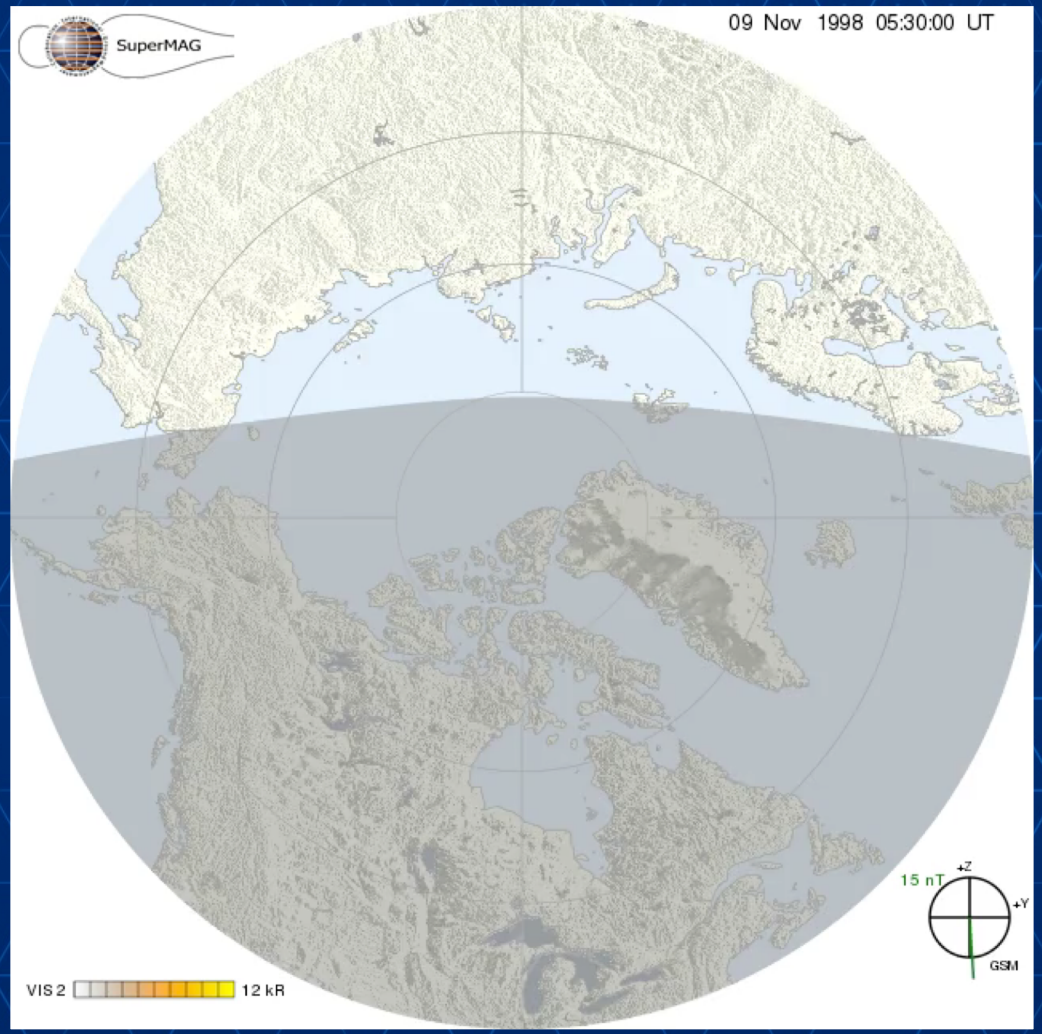

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