



Ionospheric Signatures of Magnetospheric Convection



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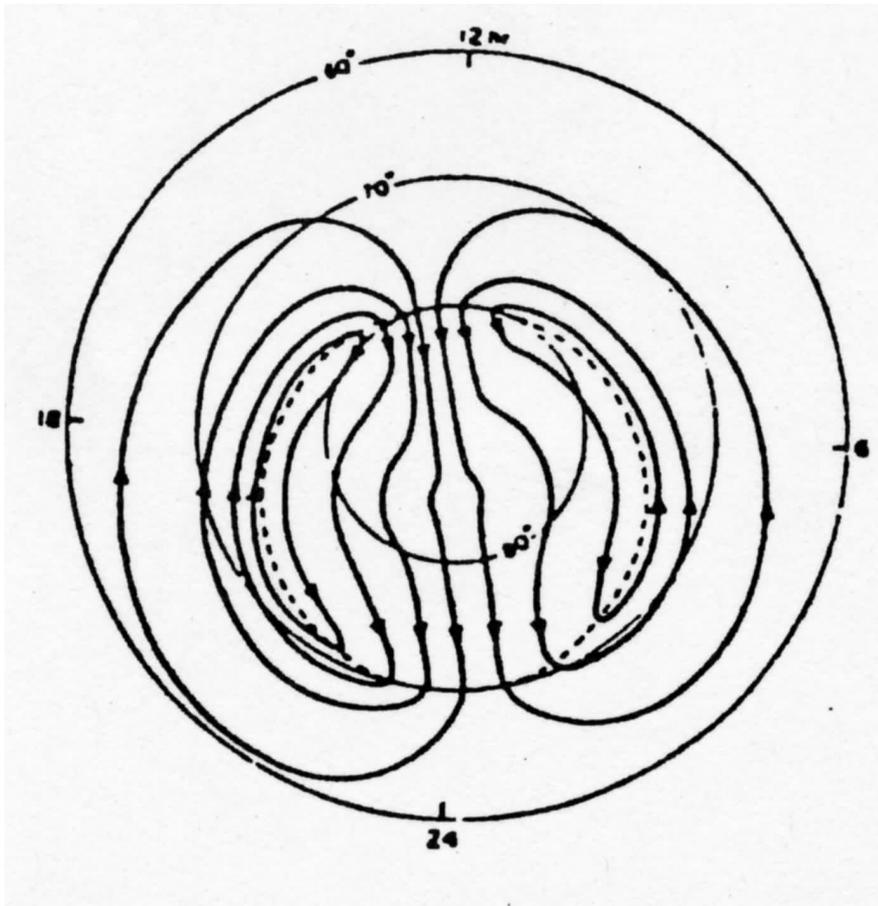
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Richardson, TX.

Unsolved Problems in Magnetospheric Physics
Scarborough, September, 2015.

Ionospheric Signatures of Magnetospheric Convection

- Features of the Convection Pattern
- Effects on the Plasma Distribution
- Present Deficiencies in Specification of the Pattern
 - Evolution in Time
 - Addition of Meso-Scales
- Capabilities of Expanding/Contracting Polar Cap Models

Ionospheric Signatures of Magnetospheric Convection



Polar cap potential drop about 60 Kv Typical
convection speed across the polar cap is $\sim 400\text{m/s}$

Polar cap traverse takes ~ 2 hours

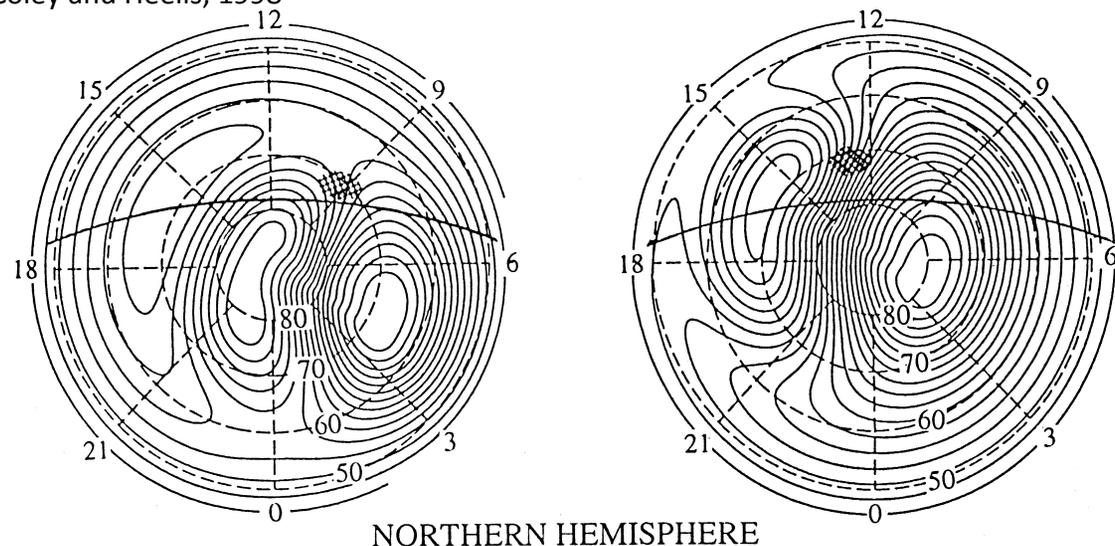
60 Kv distributed across 2hrs of local time produces
convection speeds of $\sim 1\text{ km/s}$

Auroral zone convection speeds $\sim 400\text{ m/s}$

Night to day traverse takes many hours

Effects of Convection on Ionospheric Plasma

Coley and Heelis, 1998

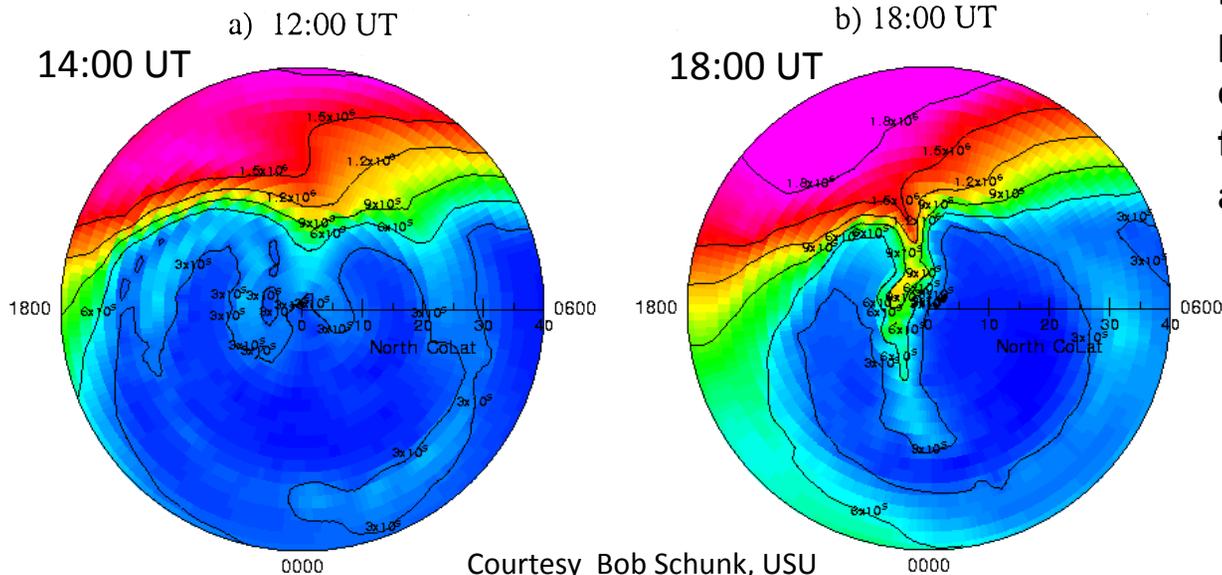


Plasma Density

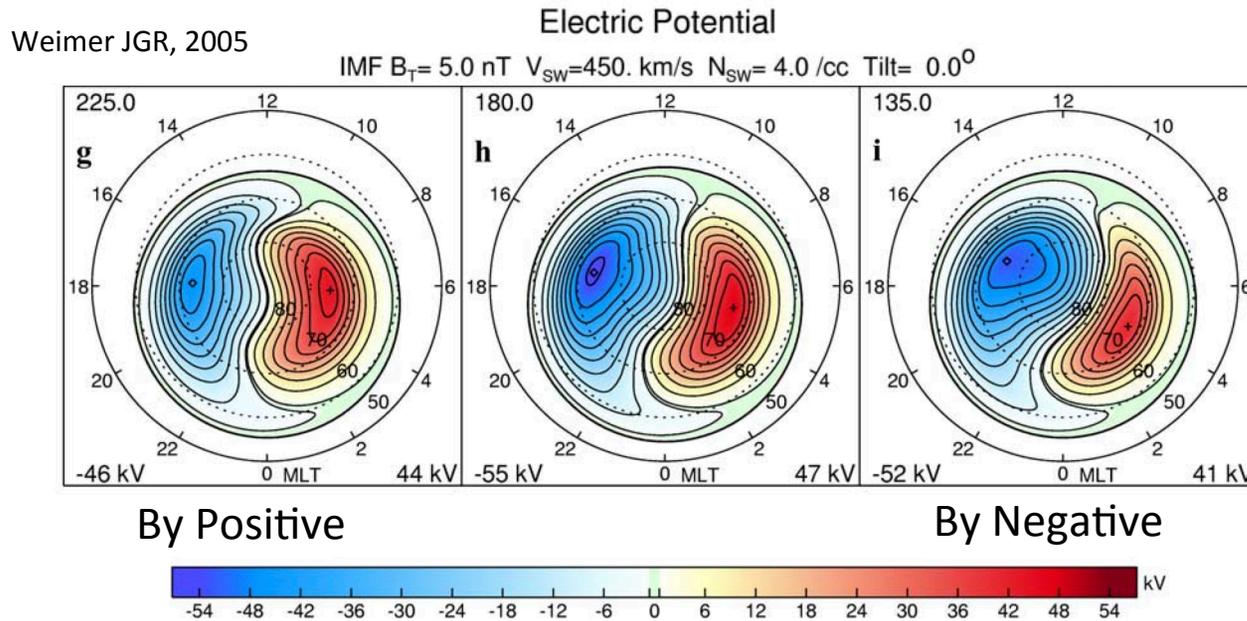
Poleward and upward motions in sunlight produce enhanced densities, that are preserved in darkness.

Density features are created locally in sunlight and transported in darkness.

Enhanced density features such as patches and ionization tongues are observed as enhanced airglow features hopefully not confused with arcs?



Model Ionospheric Convection Pattern



- Convection times around closed loops can be many hours
 - No plasma packet describes the loops shown.
- Modeling ionospheric plasma density gradients requires:
 - Specification of temporal evolution of pattern.
 - Specification of meso-scale convection features.
- How do we represent these convection features?

Ionospheric Convection Pattern

Must be consistent with particle precipitation pattern and conductance.

Must be known at temporal scales less than 30 minutes

Must be consistent with magnetospheric processes

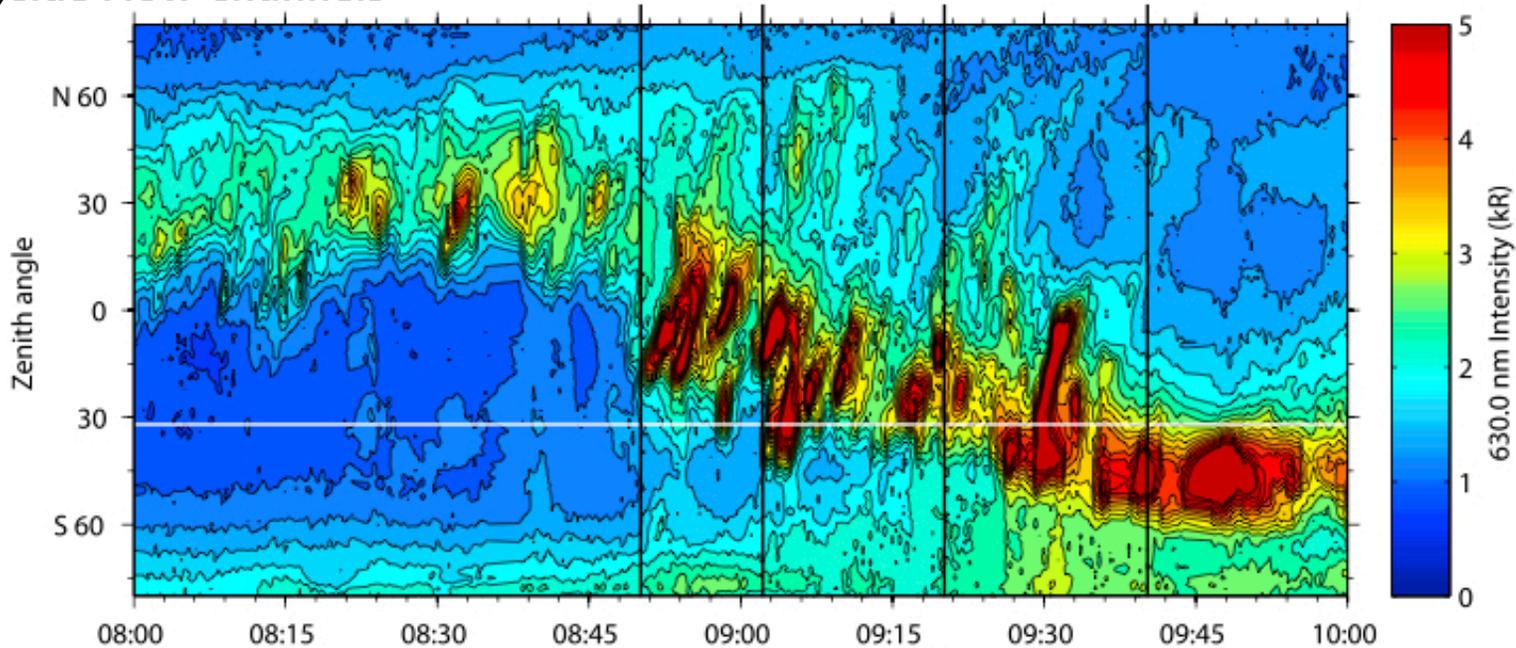
***Presently precipitation and potential distributions are specified independently
Electrodynamic consistency is not considered
Work on boundary alignments is on ongoing***

***Potential distributions are derived with no magnetospheric constraints.
Reconnection regions are not considered***

Time Varying Convection Pattern

Dayside Flow Channels

Skjaveland et al. JGR, 2001

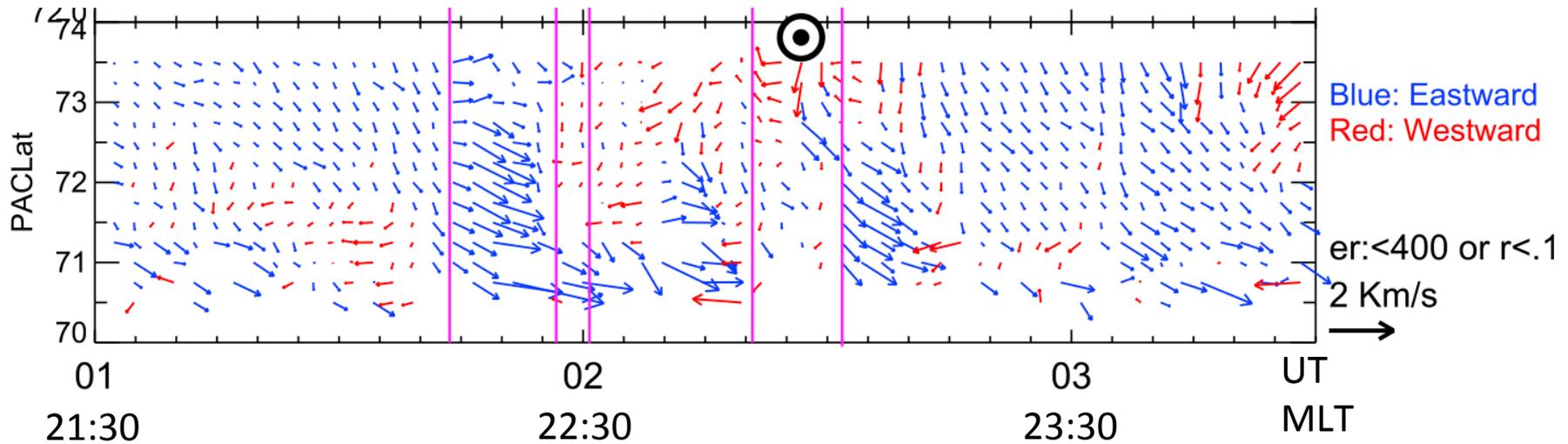


- Dayside merging events signified by poleward moving auroral emissions.
- Associated with equatorward motion of polar cap boundary.
- Interpreted as open flux added to polar cap.
- Entrain new plasma into convection pattern.
Representative width in local time?
Representative time duration?

Time Varying Convection Pattern

Nightside Flow Channels

Zesta et al. JGR 2011



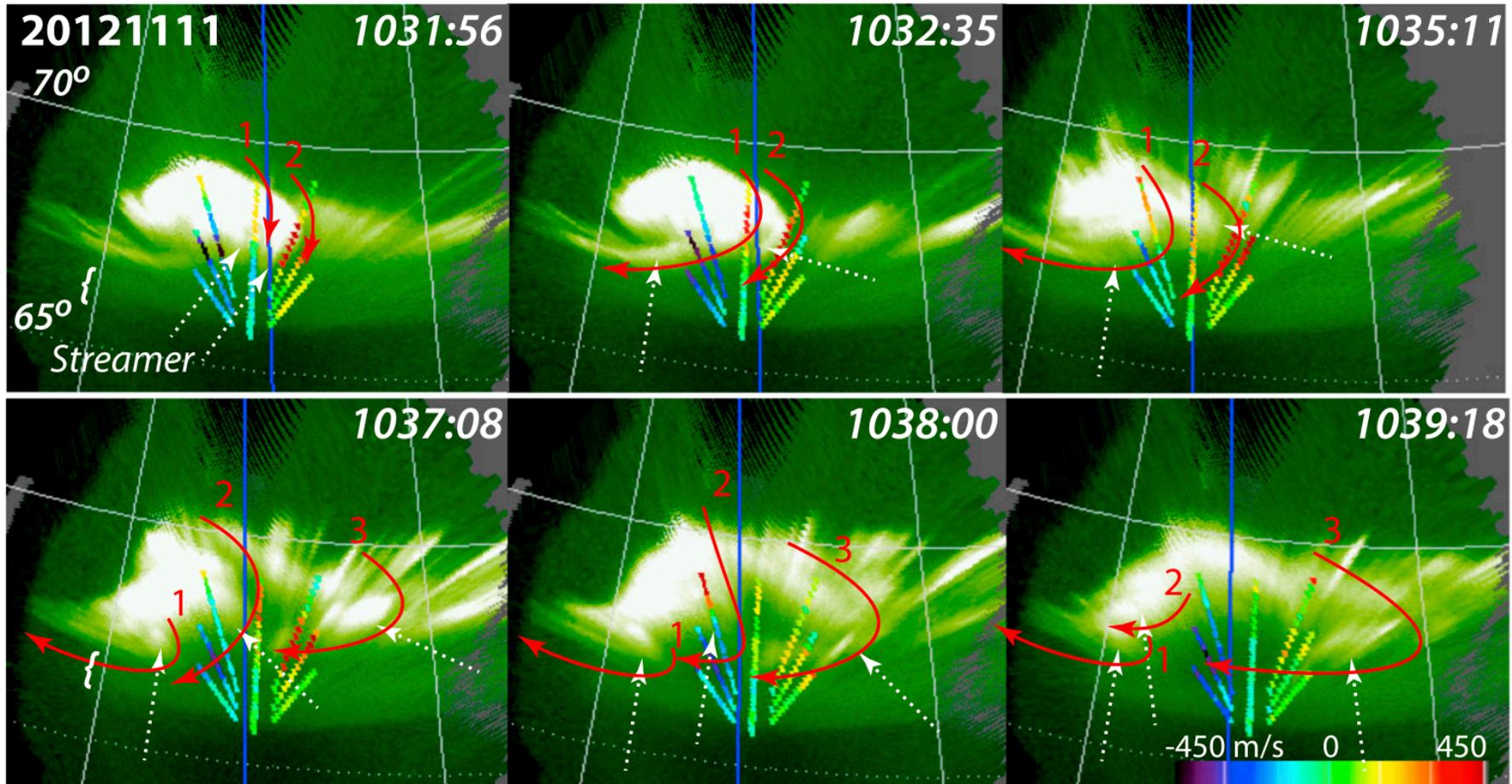
- Eastward Flow bursts with duration of about 10 minutes
- Flows originate from the polar cap
 - Not closed within the field of view of the measurement.

Time Varying Convection Pattern

Nightside Flow Channels

Near 0100 MLT

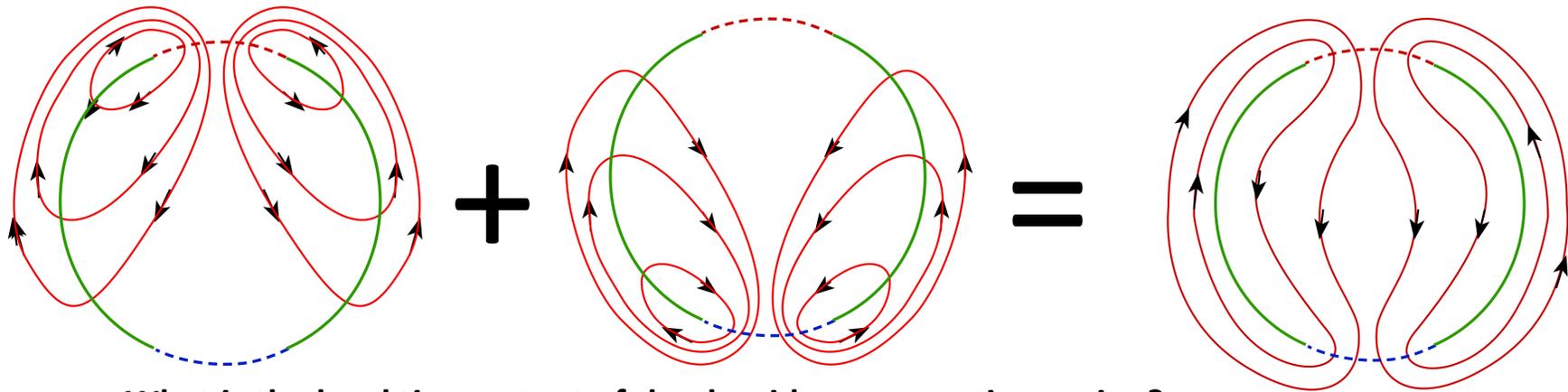
Lyons et al. JGR 2015



- Westward flow bursts expected to be connected to eastward flows from the polar cap

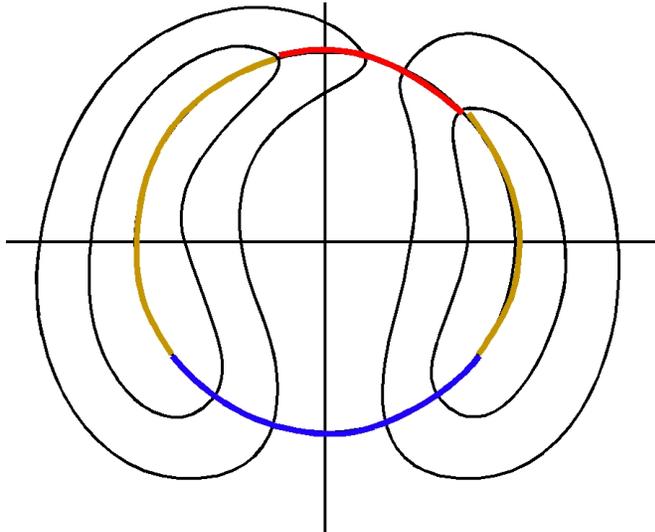
Dynamic Convection Pattern – Step 1

Dynamic Convection Pattern based on Expanding/Contracting Polar Cap Model
Siscoe and Huang (JGR, 1985) Cowley and Lockwood (Annales 1992)



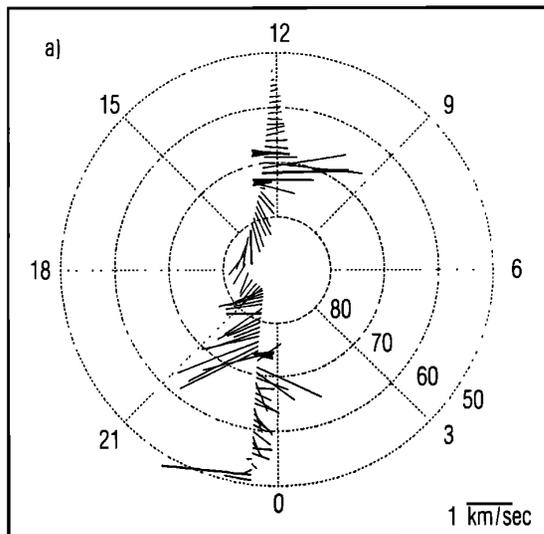
- What is the local time extent of the dayside reconnection region?
 - The potential across this region (red-dashed) = magnetic flux addition rate
- What is the local time extent of the nightside reconnection region?
 - The potential across this region (blue dashed) = magnetic flux removal rate
- Almost no flow across the boundary at the dawn and dusk flanks – OK?
- What part of the boundary expands/contracts in response to imbalances?
 - Boundary motion determined by potential distribution along it.
- When I have this figured out can I just add a contribution from viscous interaction?

Dynamic Convection Pattern – Step 2

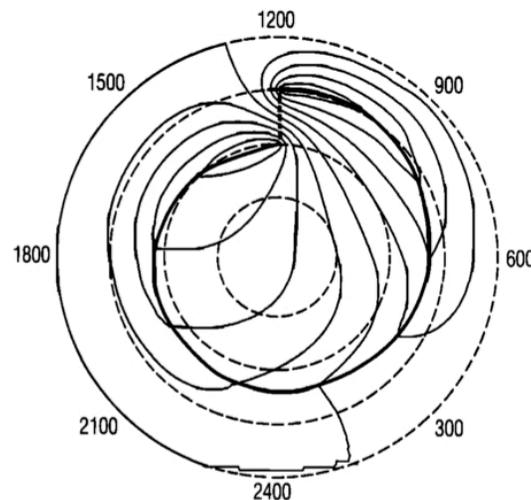


- Meso-scale structures added to background.
- Orientation of merging gap determines the direction of flows in the cusp.
- What is the initial spatial scale of the loop ?
How does it evolve in time ?
- Convection pattern evolves in time according to the specified potential around the boundary

DE-B ION DRIFT VELOCITIES
 MLT V ILAT NORTHERN HEMISPHERE
 DAY 82 61 UT 15:12 ORBIT 3140



Moses et al JGR, 1988



Ionospheric Signatures of Magnetospheric Convection

Message

- Initial considerations only for southward IMF
- Average large-scale convection pattern does not describe path of ionospheric plasma packets.
- Time variations in convection pattern have smaller spatial scales than large-scale circulation described in empirical potential models
- Spatial and temporal scales are poorly understood but essential to describing the effects of ion-neutral coupling.
- Need a new approach for specifying and evolving the convection pattern with rules enforced by magnetospheric physics.