

Driving of Strong Nightside Reconnection & Geomagnetic Activity by Polar Cap Flows: Application to CME Shocks and Possibly Other Situations

L. R. Lyons, Y. Zou, B. Gallardo-Lacourt,, Y. Nishimura, P. Anderson, V. Angelopoulos, E. F. Donovan, J. M. Ruohoniemi, L. Paxton, E. Mitchell, and N. Nishitani

Dynamic Pressure Impacts (e.g., shocks initiating CME storms) with southward IMF

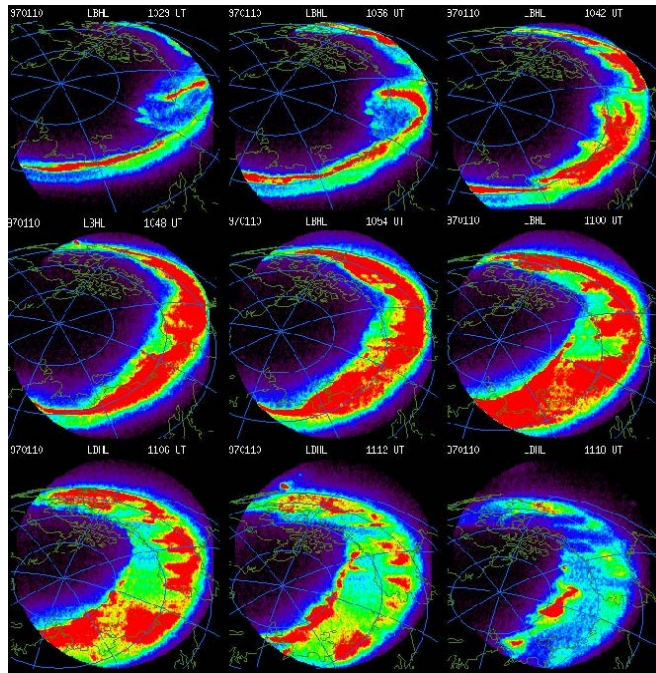
- **Strong responses:** nightside auroral activity, poleward expansion; global convection, currents [*Zesta et al., 2000; Boudouridis et al., 2003*]
 - ⇒ **Rapid nightside field line closing (reconnection)** despite strongly enhanced polar cap convection

Goal: Use THEMIS-era ASI and radar capabilities, low-alt spacecraft

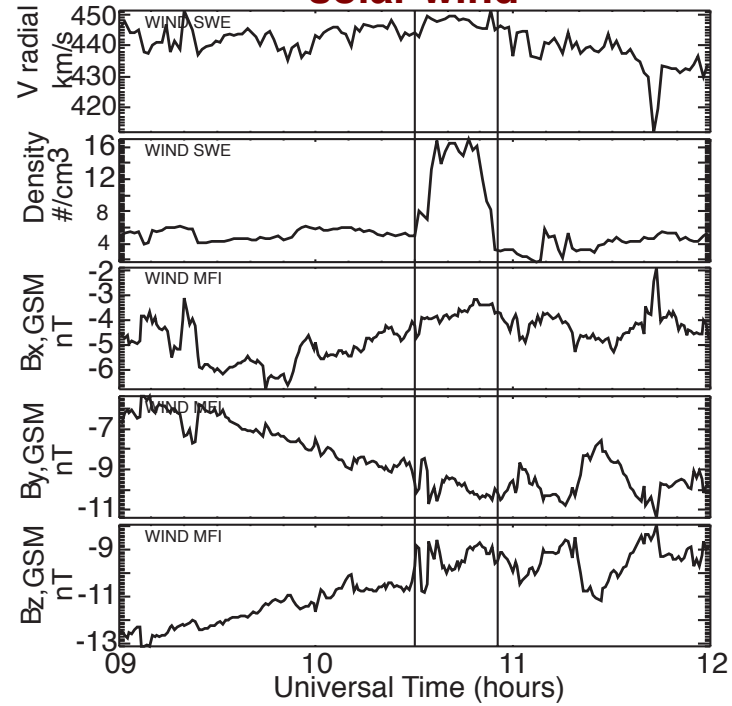
- **Describe dramatic nightside response**
- **What is driving the strong auroral, current, and reconnection activity?**
- **Provide evidence may be more common phenomena** than solely a dynamic pressure impact response.

Ideal Dynamic Pressure Pulse on 10 January 1997

Polar UVI



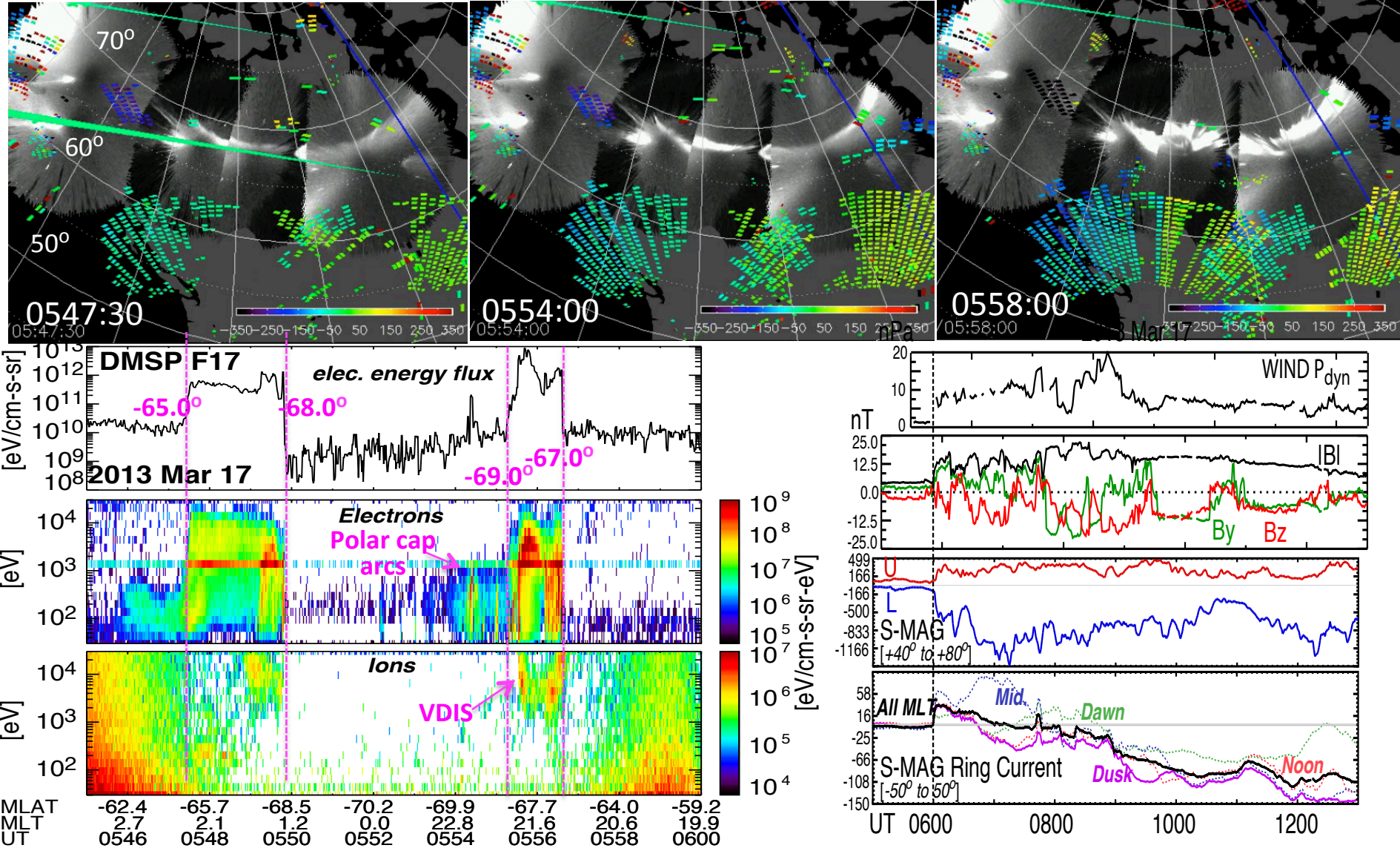
solar wind



Lyons et al., 2000

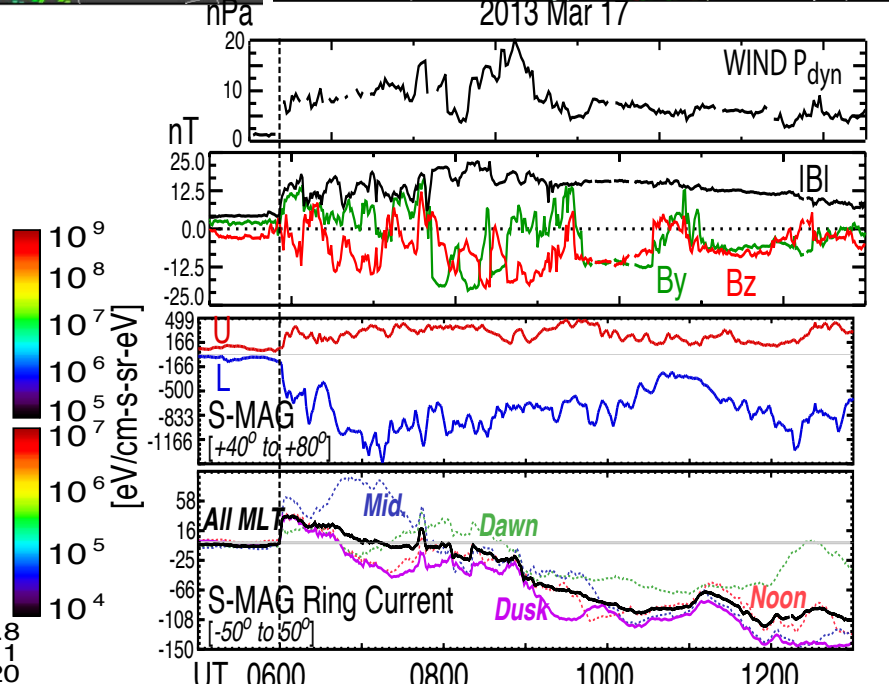
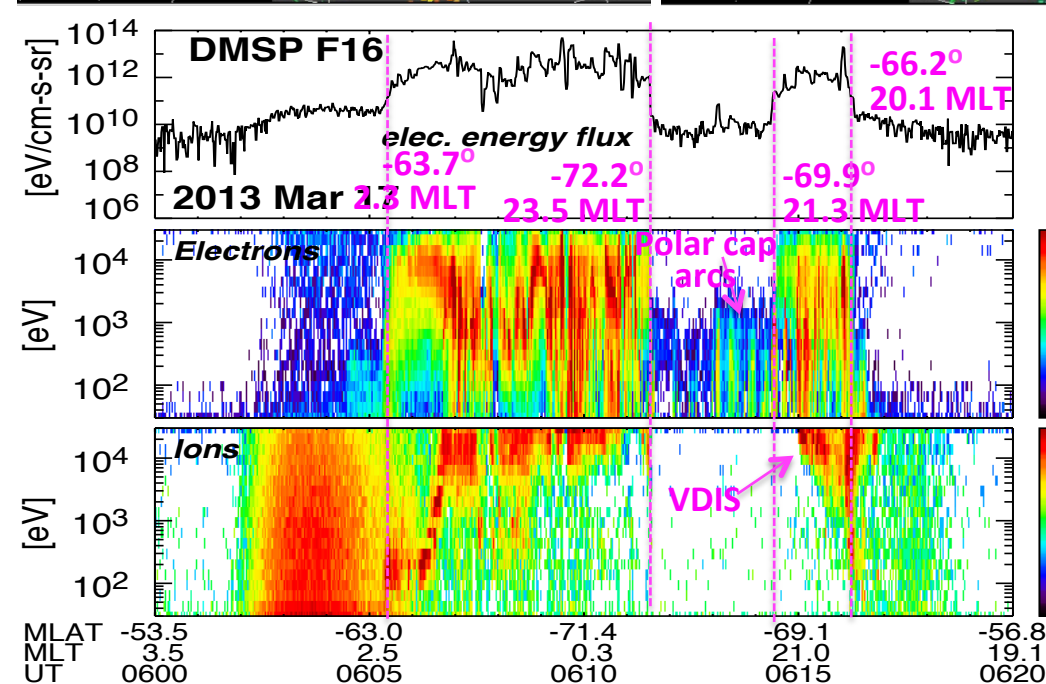
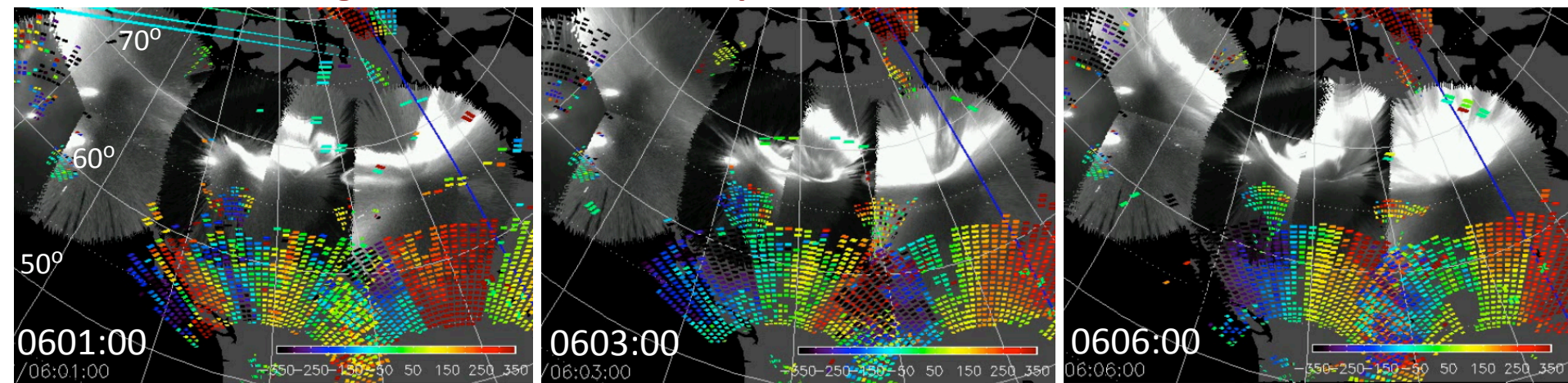
17 March 2013 Storm: pre-condition (before 0600 commencement):

- Expanded polar cap; thin oval with some poleward boundary activity
- Weak mid-lat convection

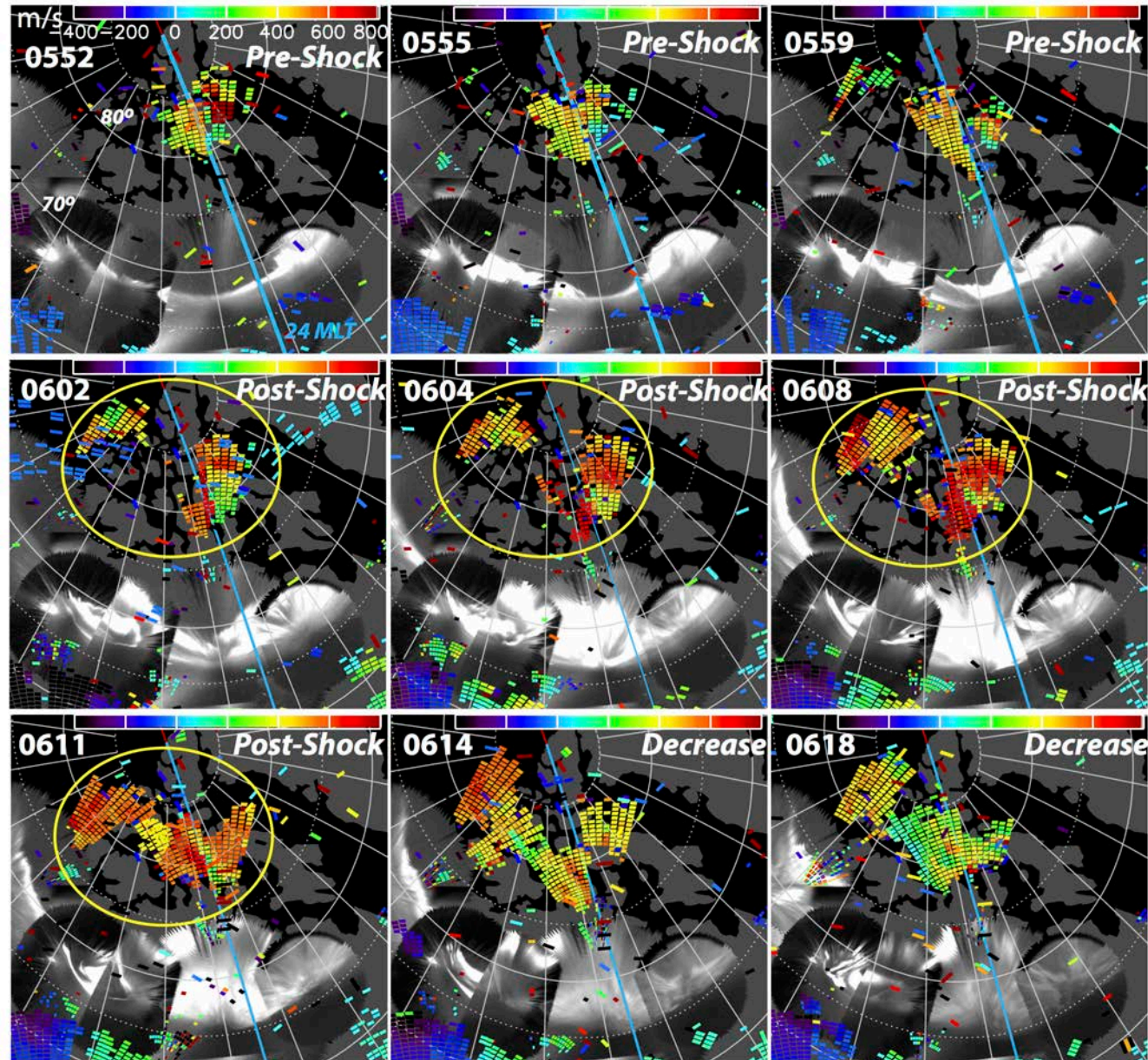


17 March 2013 Storm: Just after sudden commencement:

- Strong poleward **boundary activity**, broad poleward **expansion**
- Preliminary **impulse E**, maybe mixed with main **DP2 enhancement**
- Then large **DP2** enhancement, **penetration to $\Lambda < 52^\circ$**



After Shock: Immediate large enhancement of polar cap flows towards oval, including at meso-scale



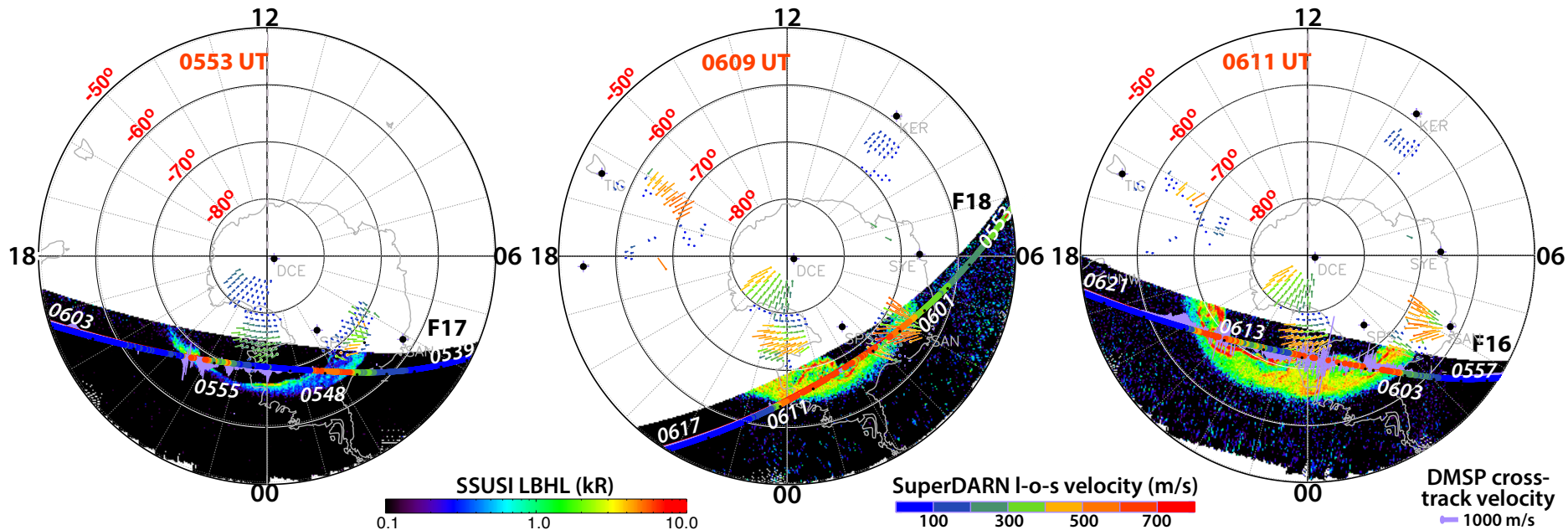
2013 Mar 17 storm: Before/after shock in southern hemisphere :

SuperDARN

- Enhancement of polar cap flows

DMSP SSUSI keograms along spacecraft orbits (also F17, F16 flows)

- Evidence for many enhanced polar cap flows impinging on poleward expanded oval

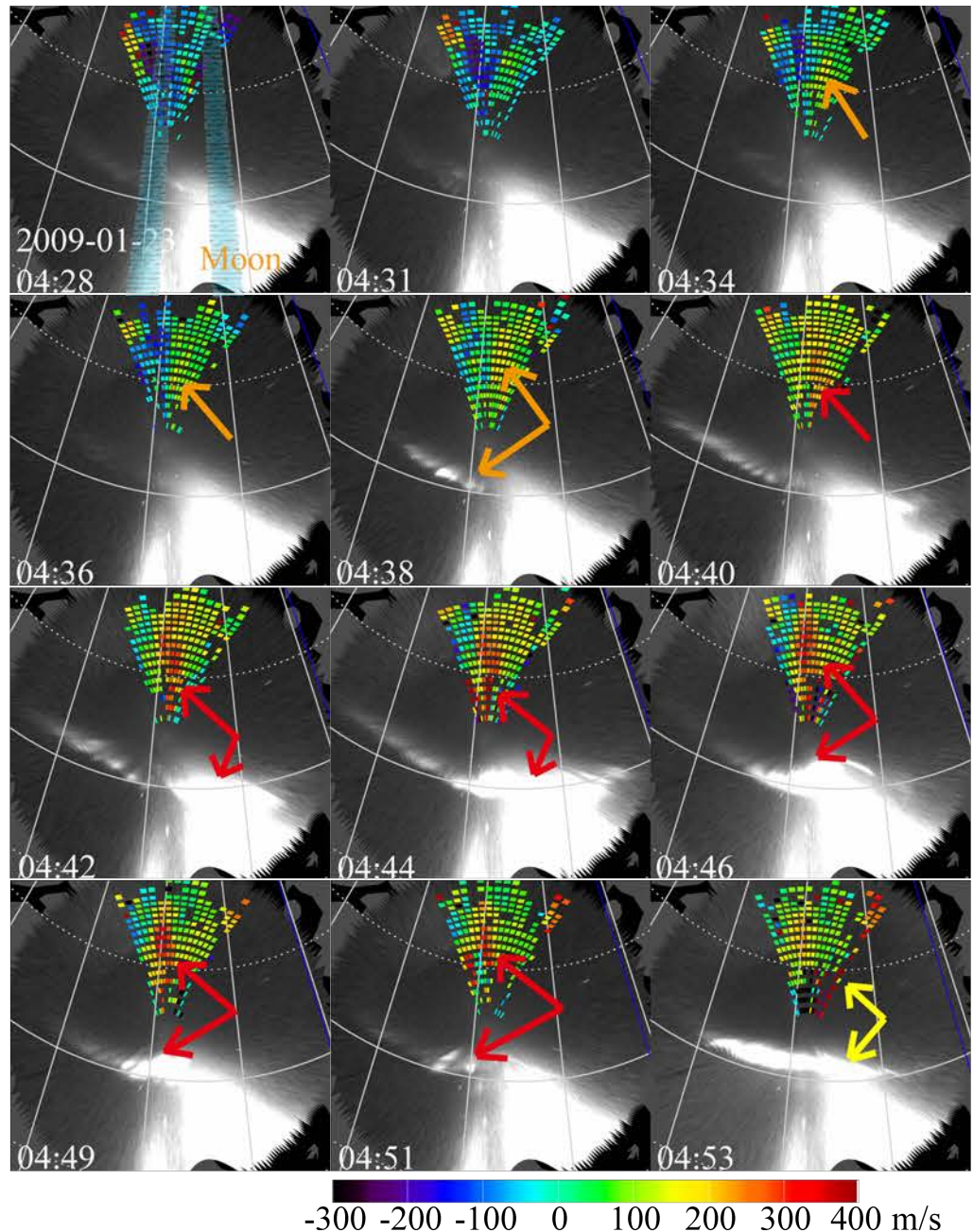


Meso-scale polar cap flows heading to nightside separatrix (localized)

- **Can cross separatrix** (externally driven localized reconnection)
 - **Lead to plasma sheet flow bursts, PBIs, and streamers**
[de la Beaujardière et al., 1994; Lyons et al., 2011; Nishimura et al., 2010; Pitkänen et al., 2013; Shi et al., 2012; Y. Zou et al., 2014]
- **Polar cap boundary can move poleward associated with such reconnection as seen in PBIs**
[Y. Zou et al., 2014, 2015]

To explain Pdym impact response

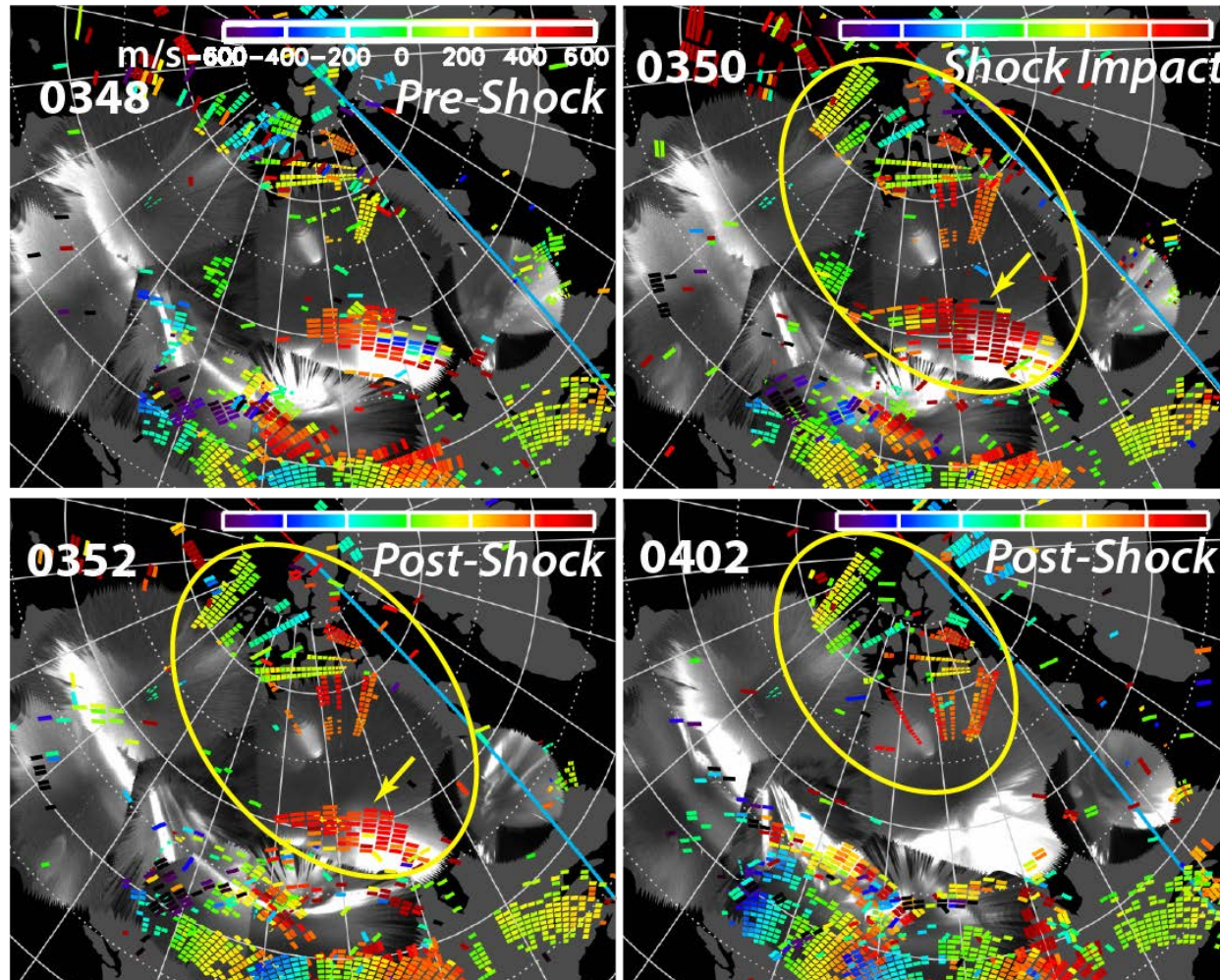
- **Meso-scale flows impact over MLT range of auroral activity/poleward expansion**
- **Persist during expansion**



Y. Zou et al. [2014]

19 Feb 2014, SuperDARN, ASI:

- Enhanced polar cap flows on impact
- Evidence that impinge on boundary (only a few min of echoes)



Abrupt P_{dyn} impacts, southward B_z drive almost immediately

- **Strong auroral activity, poleward expansion, convection, and currents** (externally driven localized reconnection)
- **Resembles substorm expansion, but onset much different**
 - Over much broader MLT range
 - **Not** from equatorward arc brightening

Enhancement of meso-scale polar cap flows heading to nightside separatrix seen after shock impact

- **Flows can cross separatrix** (reconnection), leads to activity
e.g., plasma sheet flow bursts, PBIs, and streamers
- **Polar cap boundary moves poleward** with such activity
- **Are attractive candidate for driving the strong auroral, current, and reconnection activity from shock impact**

Have evidence: enhanced meso-scale flows toward the nightside PC boundary:

- May be common for **driving auroral activity** that **extends into pre-existing polar cap**
- May start from **auroral poleward boundary**, unlike substorm auroral onset.

If suggestions true, would open new significant questions, e.g:

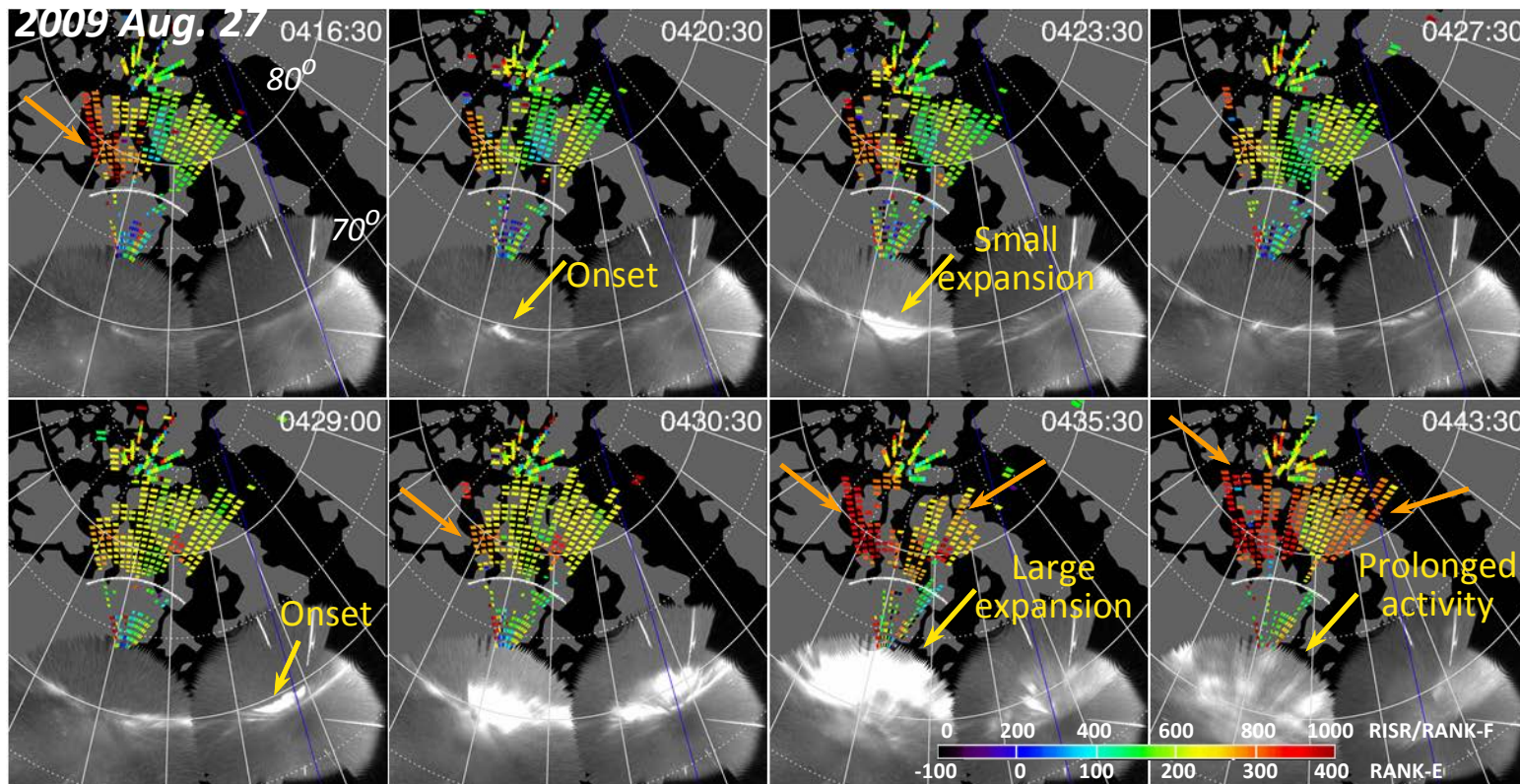
- **Under what conditions do enhancements in polar cap convection lead to**
 - **Substorm growth phase.**
 - **Versus directly to strong poleward expansion of, and strong activity**
- **What leads to and causes enhancements in meso-scale polar cap flows?**
 - **Clearly, enhancements in P_{dyn} do so, but how?**
 - **What drives flow enhancements without enhancements in P_{dyn} or southward IMF turning (have examples)?**

For Pdym impact, need enhanced meso-scale flows over MLT range, and during period of, poleward expansion

Evidence that enhanced meso-scale flows from deep within the polar cap may, in general, be important for auroral activity and its poleward expansion.

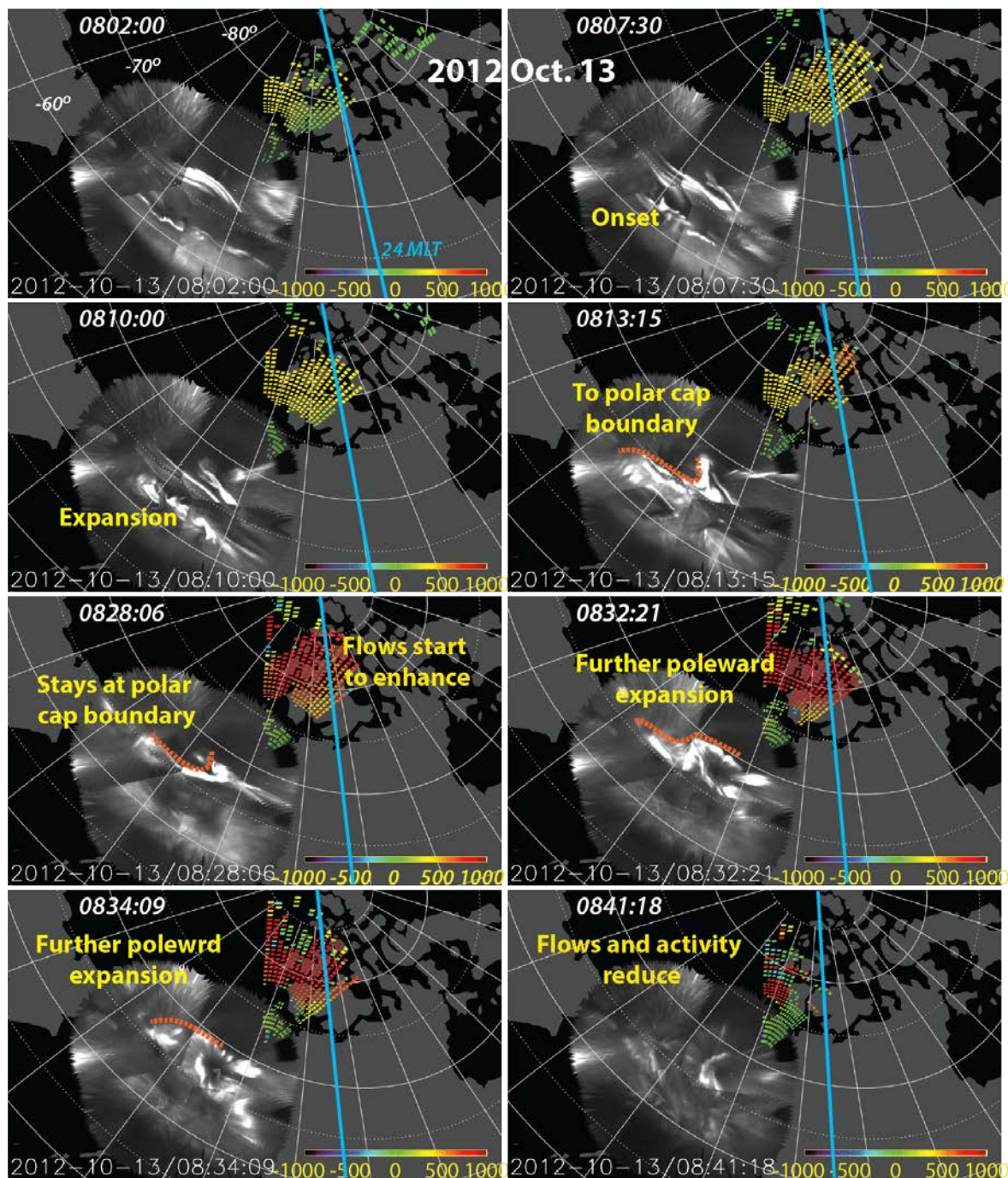
1. Such flows after substorm onset may be important in controlling poleward expansion and duration of post-onset auroral activity

[Lyons et al., 2011]: .



Evidence that enhanced meso-scale flows from deep within the polar cap may, in general, be important for auroral activity and its poleward expansion.

2. Enhancement of such flows may have led to further activity and poleward expansion after expansion phase activity apparently stopped.



Steady strong southward IMF: $B_z \sim -12$ nT

Meso-scale polar cap flows heading to nightside separatrix

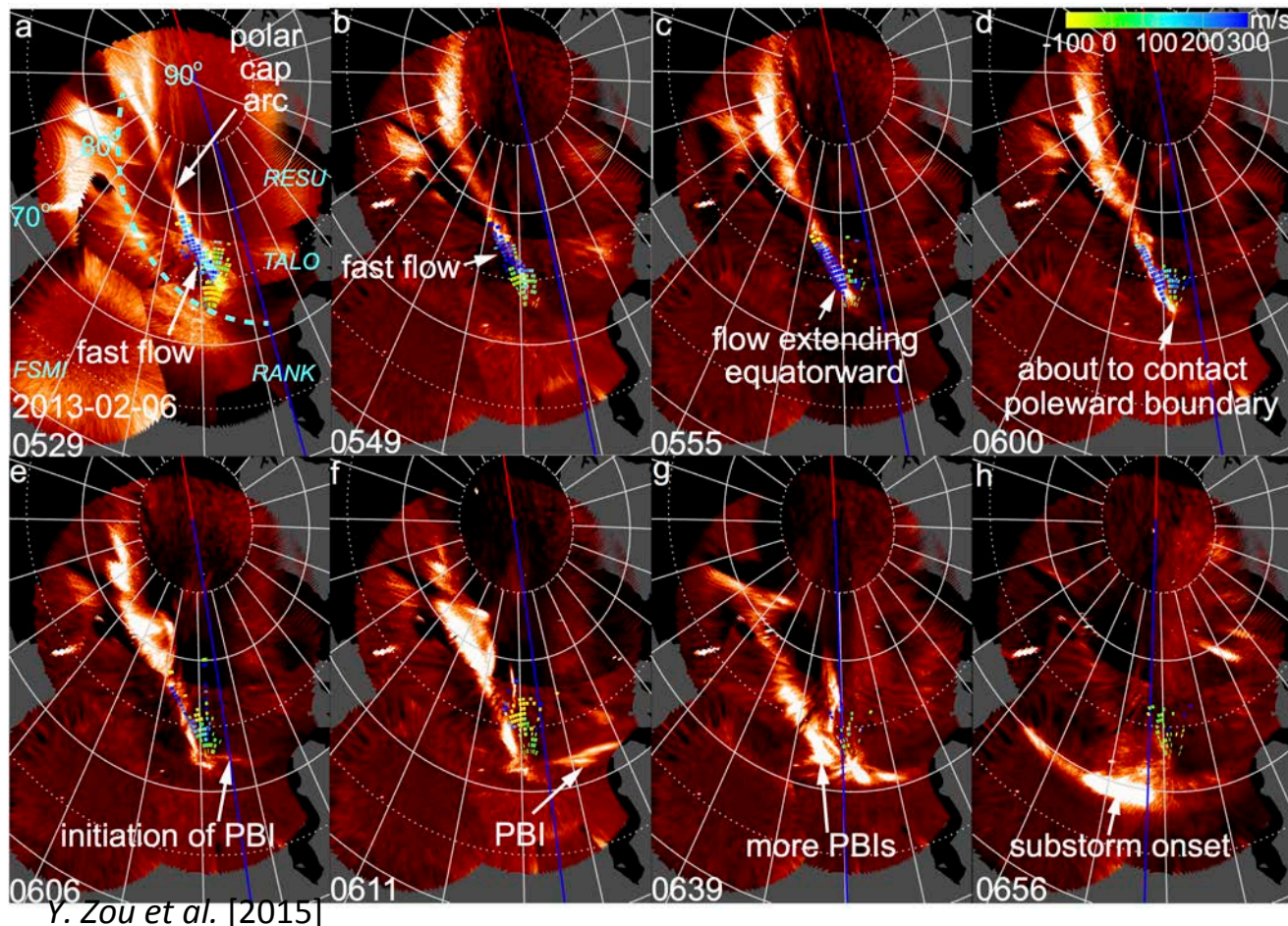
(localized)

- **Can cross separatrix (externally driven localized reconnection)**

- **Leads to plasma sheet flow bursts, PBIs, and streamers**

[de la Beaujardière et al., 1994; Lyons et al., 2011; Nishimura et al., 2010; Pitkänen et al., 2013; Shi et al., 2012; Y. Zou et al., 2014]

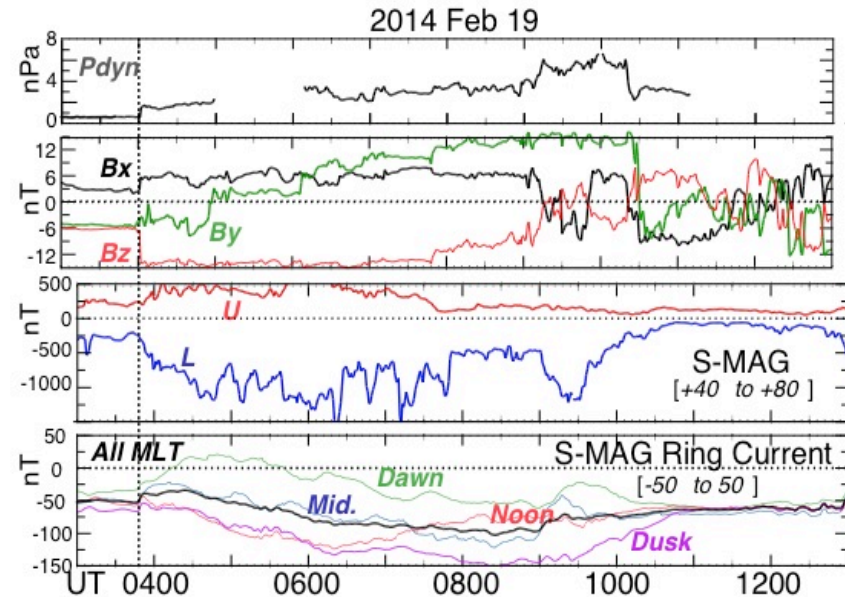
- **Polar cap boundary can move poleward associated with such reconnection as seen in PBIs** [Y. Zou et al., 2014, 2015]



Red-line auroral & SuperDARN I-o-s flows, shows connection to:

- **PBIs**
- **oval poleward expansion**
- **(then substorm onset a lower Δ)**

2nd Example of Auroral Brightening and Rapid Poleward Expansion from CME shock



2014 Feb. 19

