Comparative Magnetospheric Dynamics of Earth and Saturn

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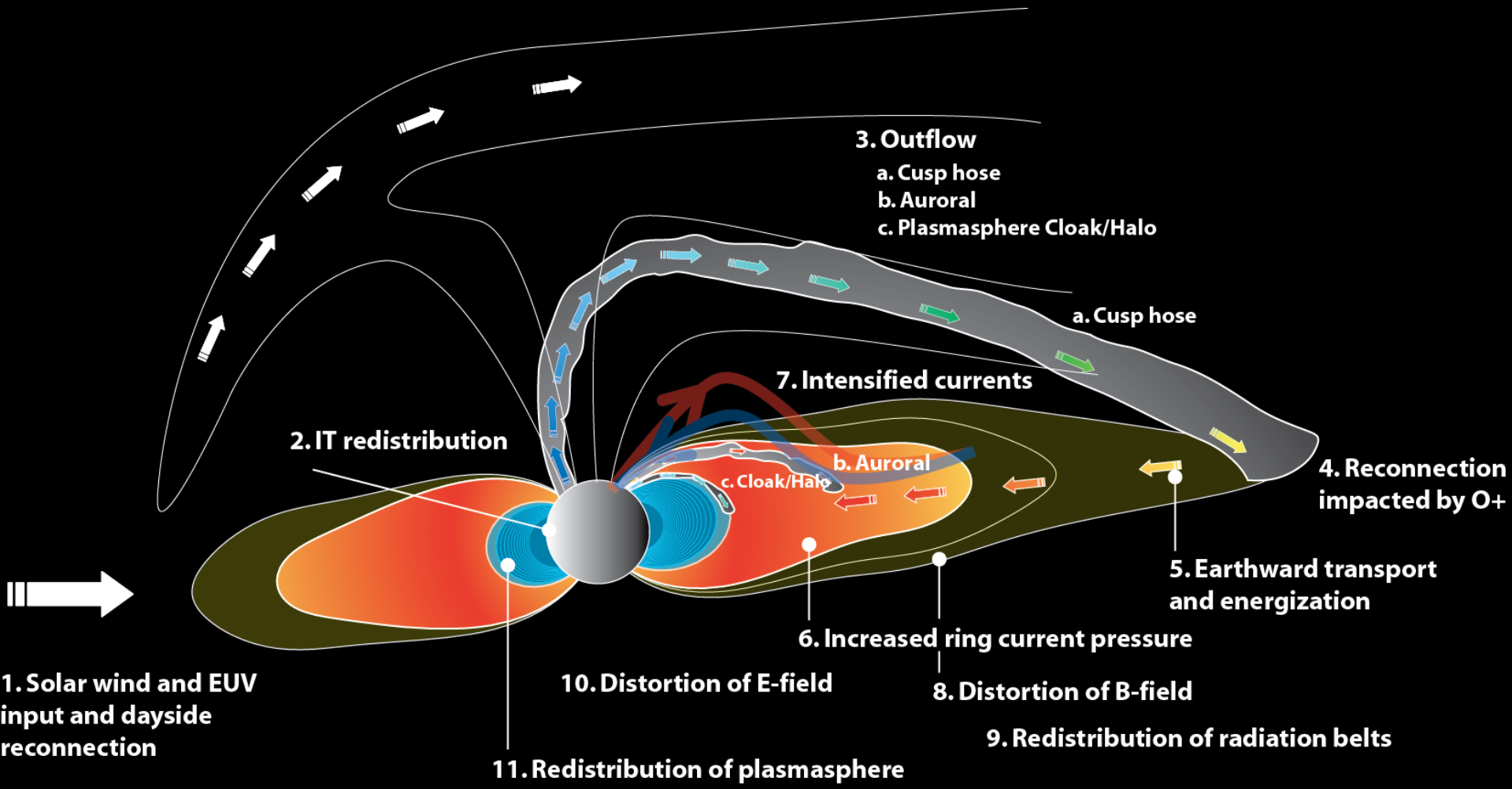
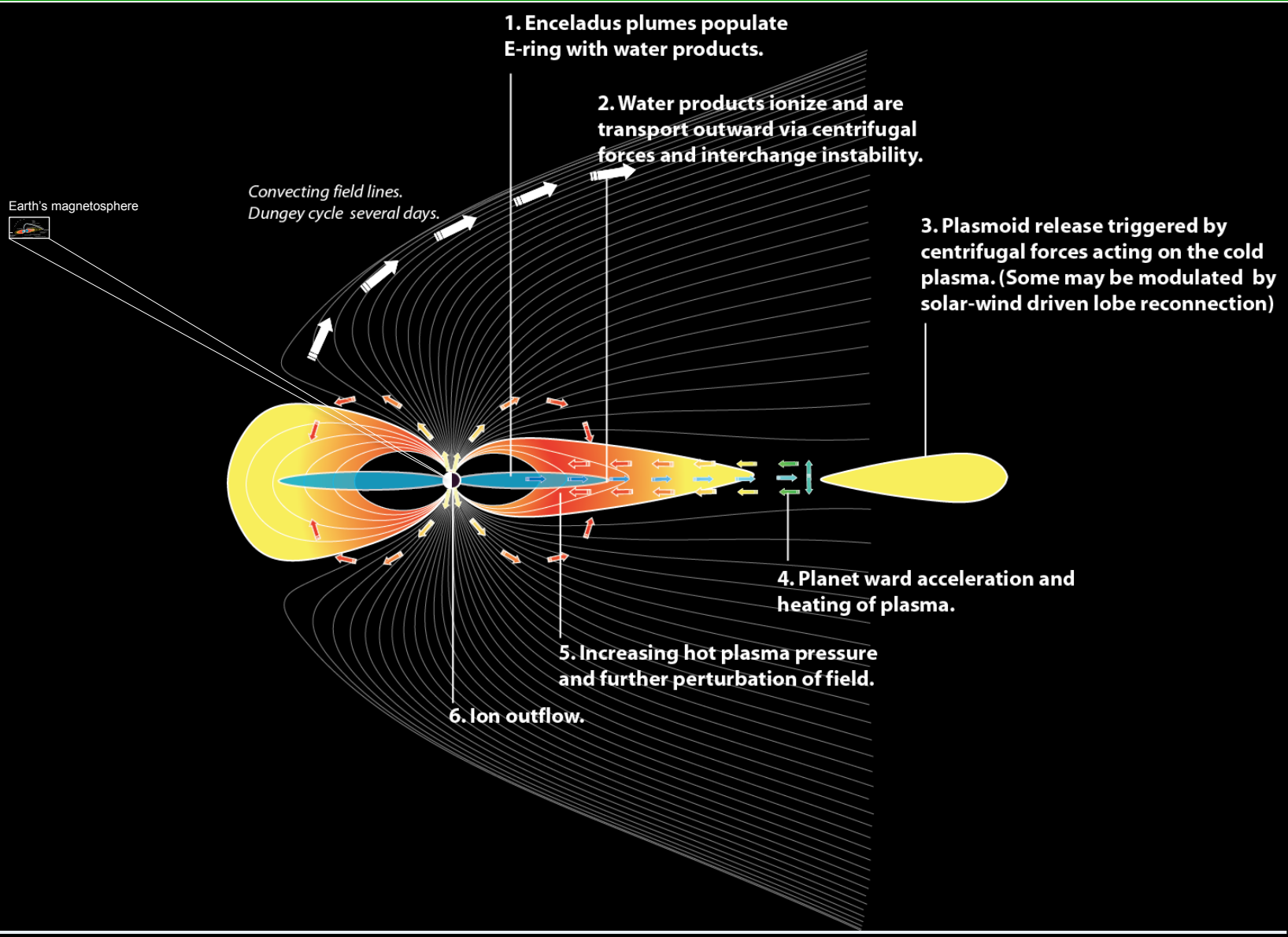
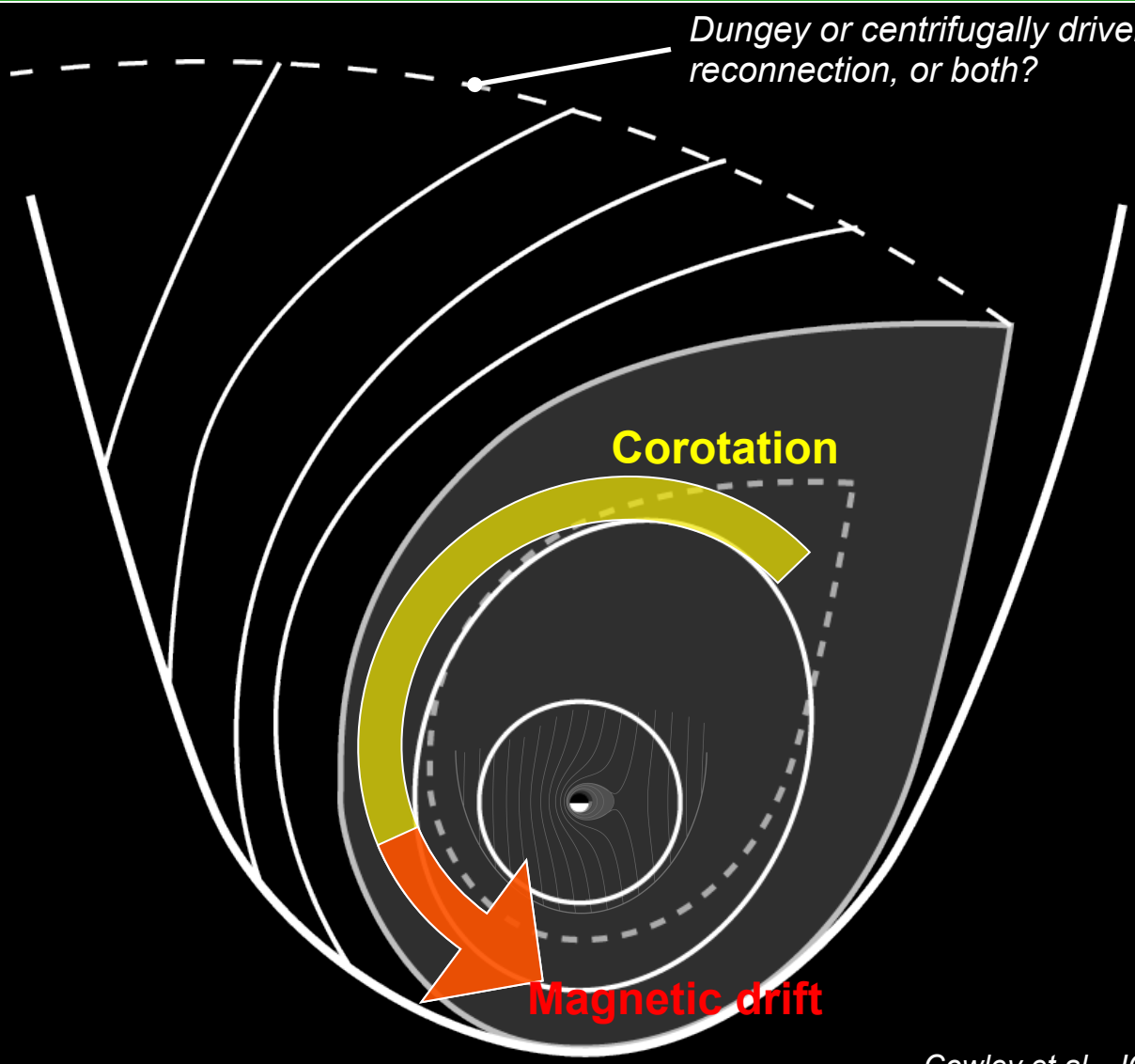
Storm circulation: Earth



Storm circulation: Saturn

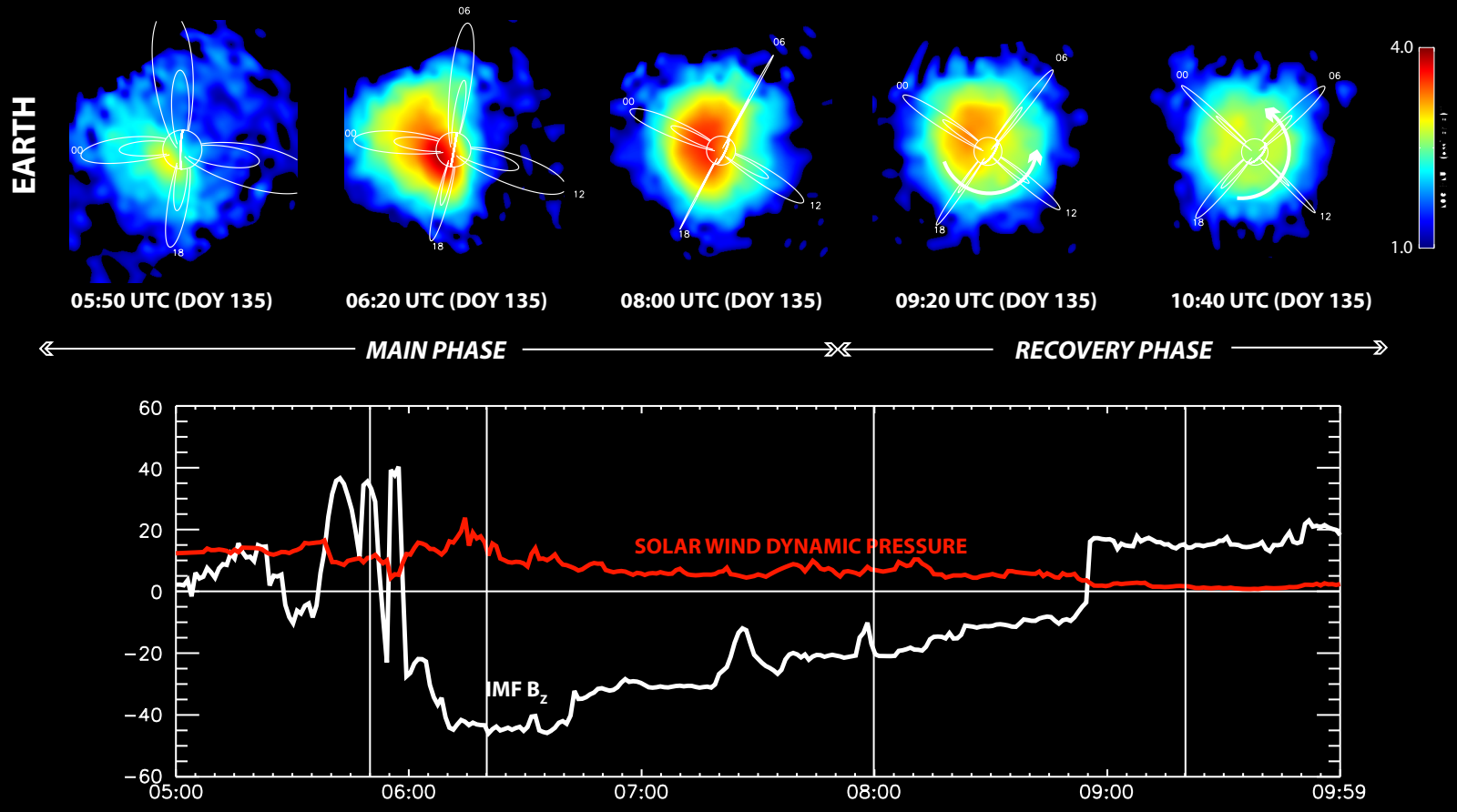


Convection: Saturn



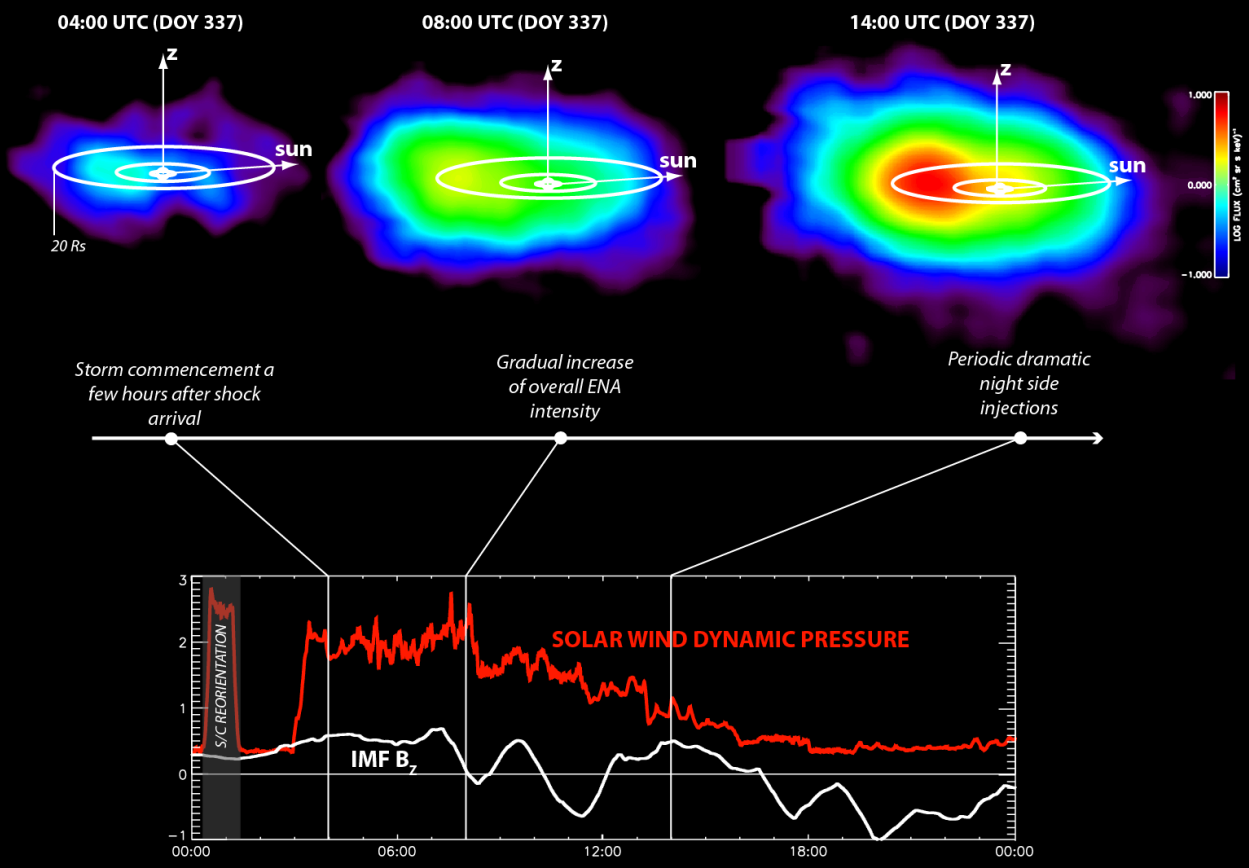
Cowley et al., JGR, 2004.

Storms: Earth



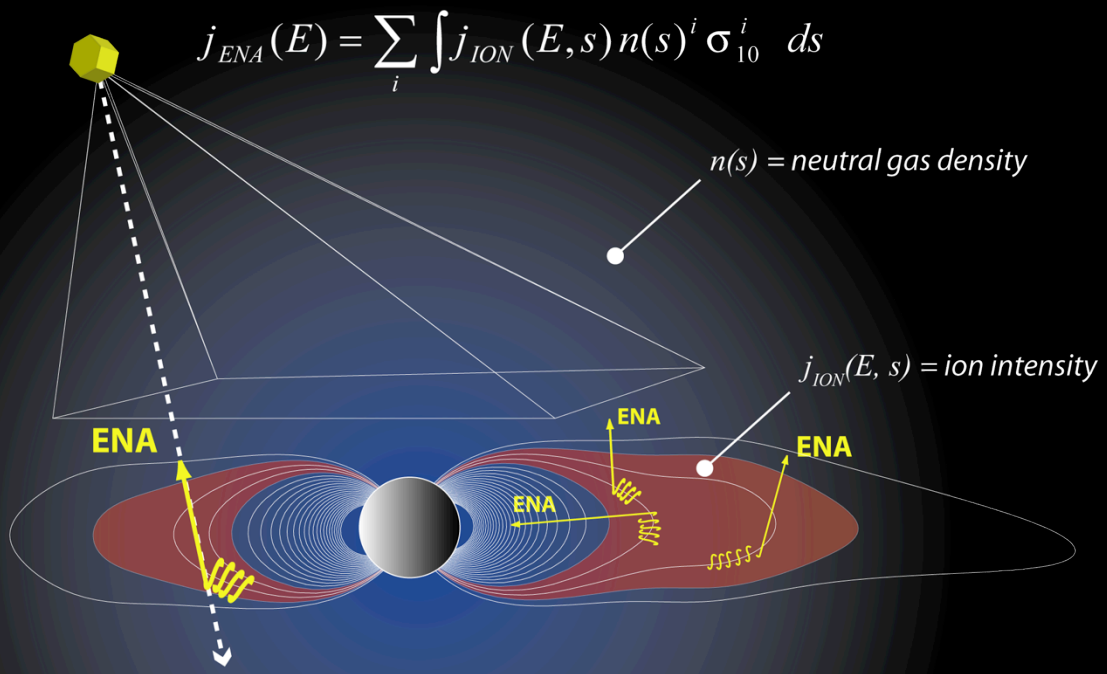
Magnetospheric storms at Earth are mainly driven by the IMF, resulting in an enhanced plasma pressure in the inner magnetosphere (the “ring current”). Solar wind dynamic pressure alone has a weak effect on the pressure of the inner magnetosphere [*Lee et al., 2007*].

Storms: Saturn

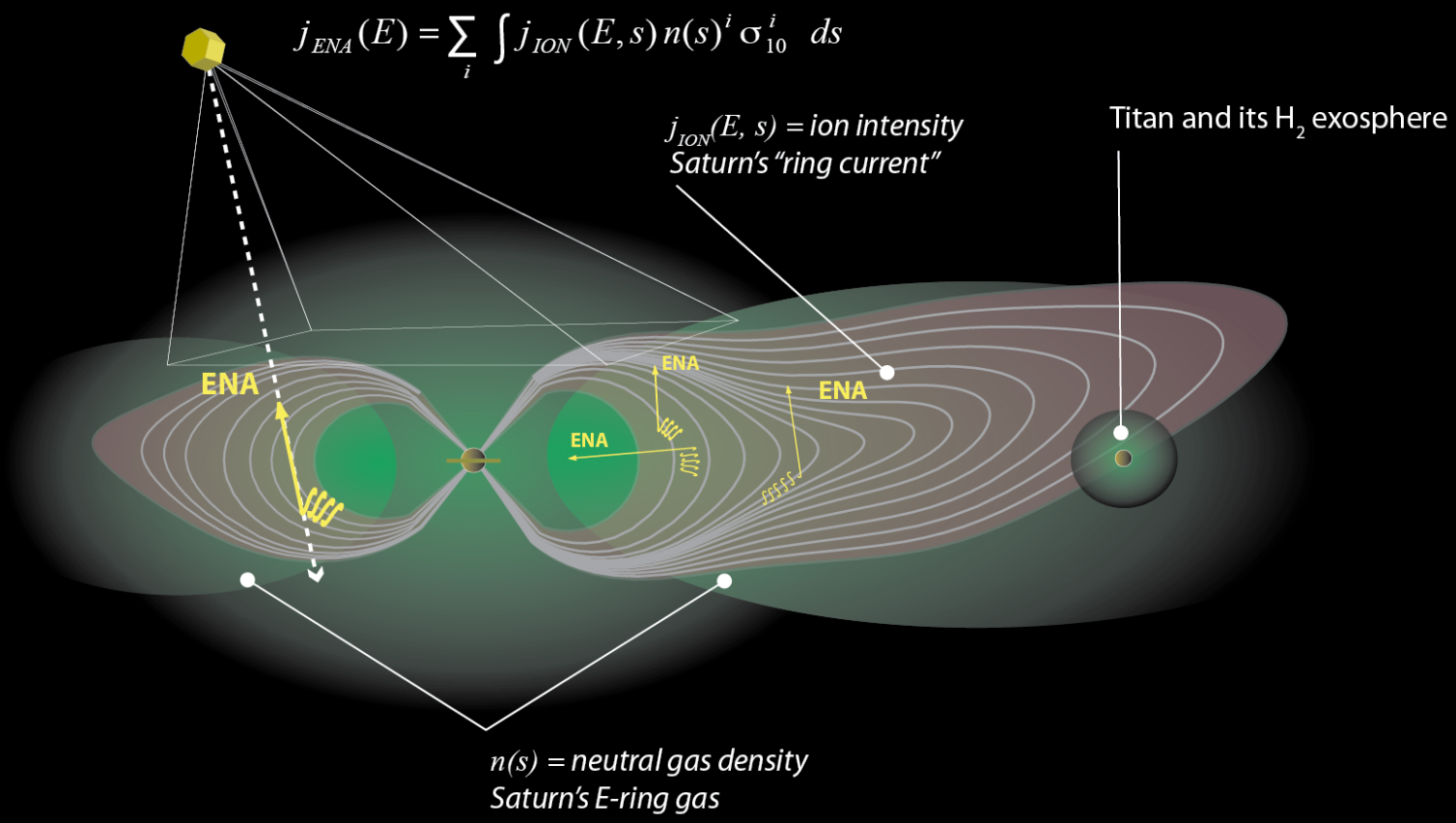


Solar wind speed drives magnetospheric activity at Saturn [*Brandt et al., 2005; Zarka et al., 2007*].

Energetic Neutral Atom (ENA) Imaging: Earth

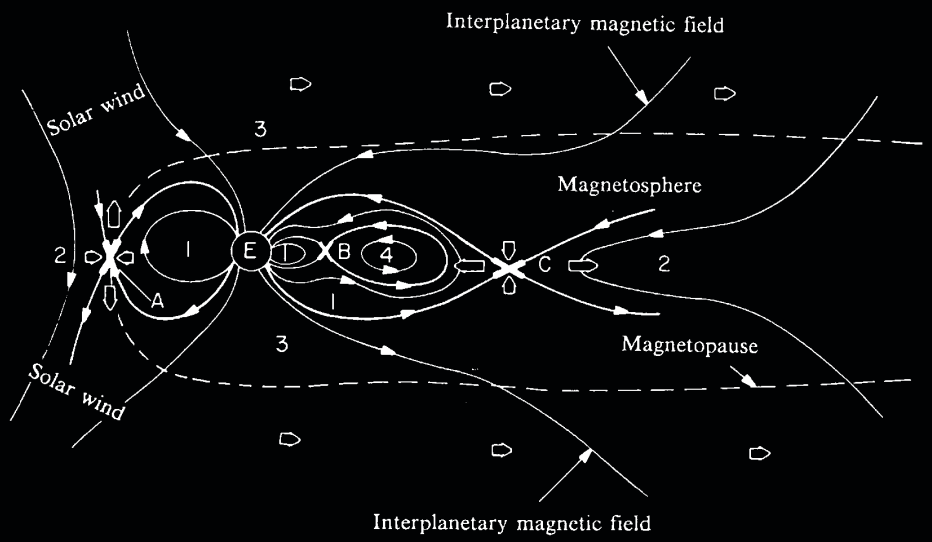


Energetic Neutral Atom (ENA) Imaging: Saturn

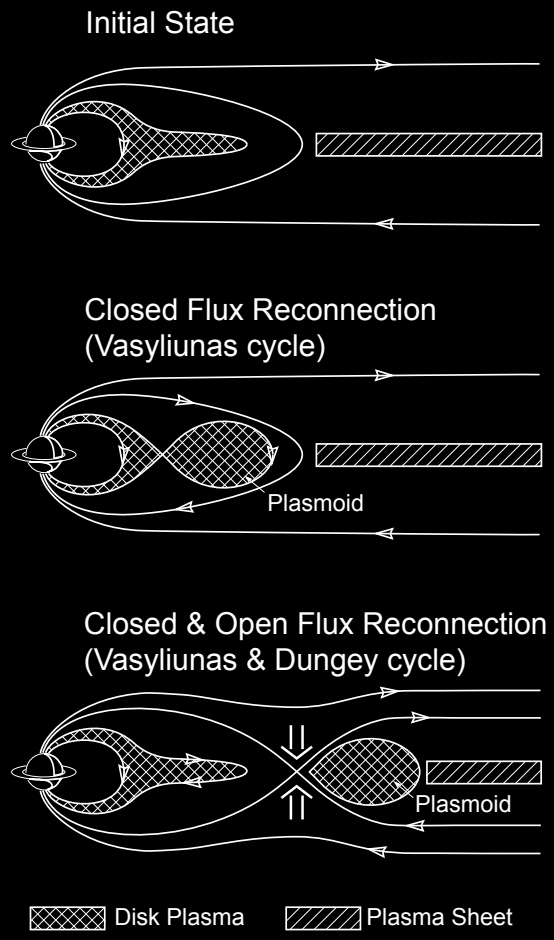


Substorms: Global dynamics

Earth
[Hones, 1977]



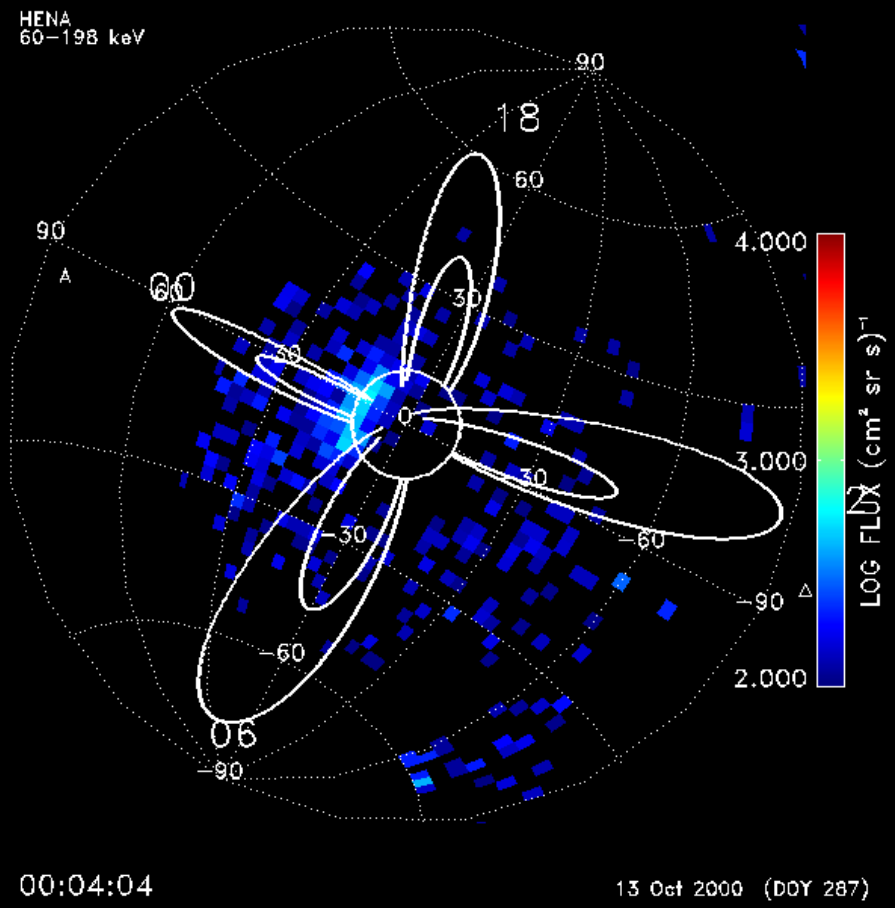
Saturn
[Jackman et al., 2011]



Substorms: Global dynamics

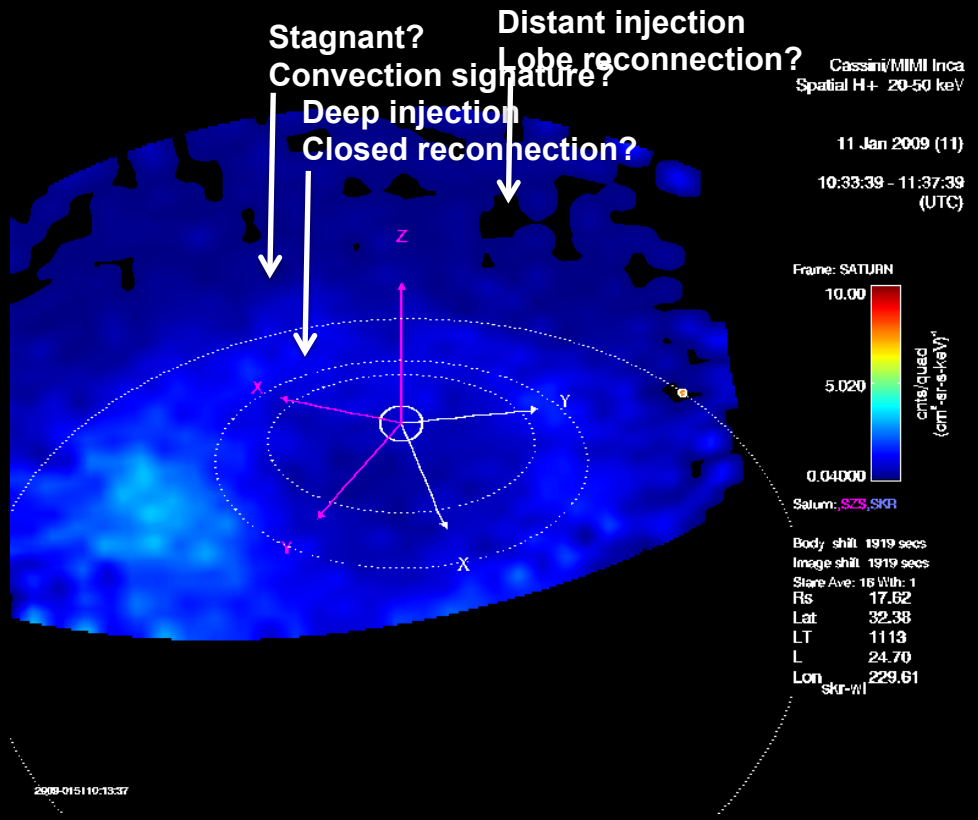
Earth

IMAGE/HENA Hydrogen 60-198 keV

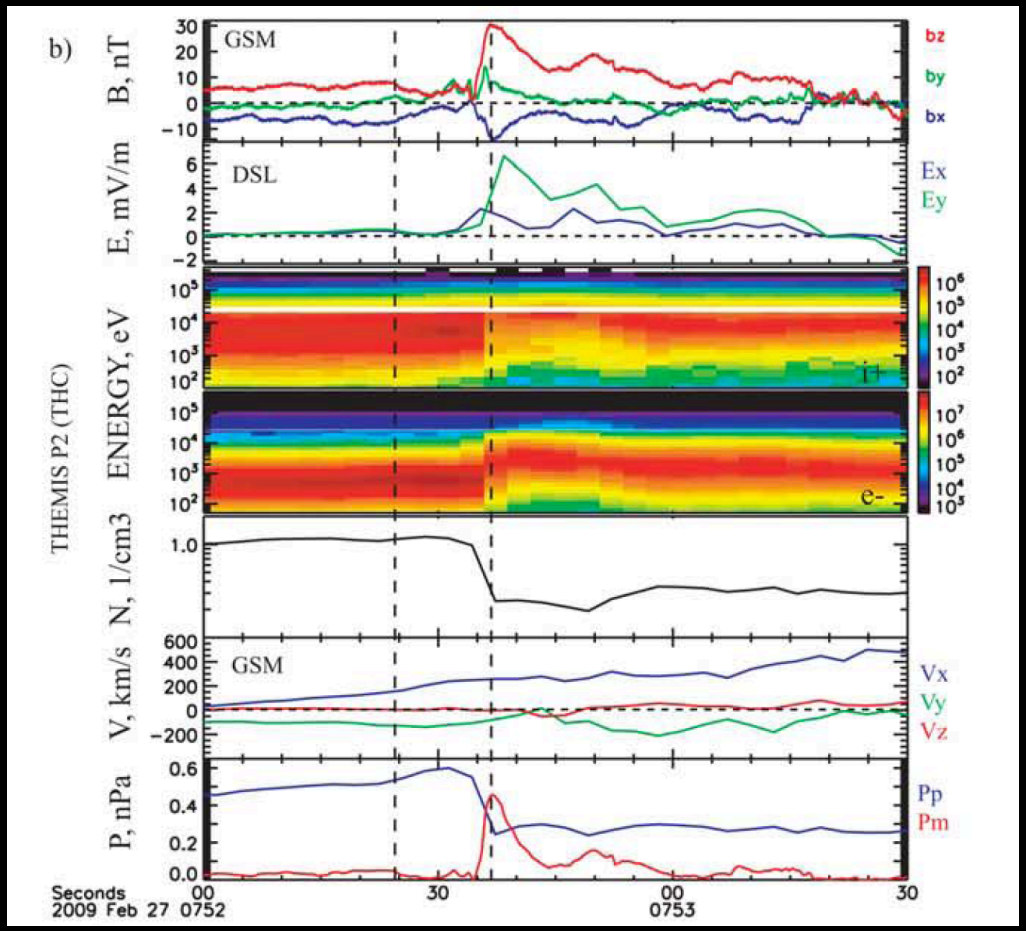


Saturn

Cassini/INCA Hydrogen 27-39 keV

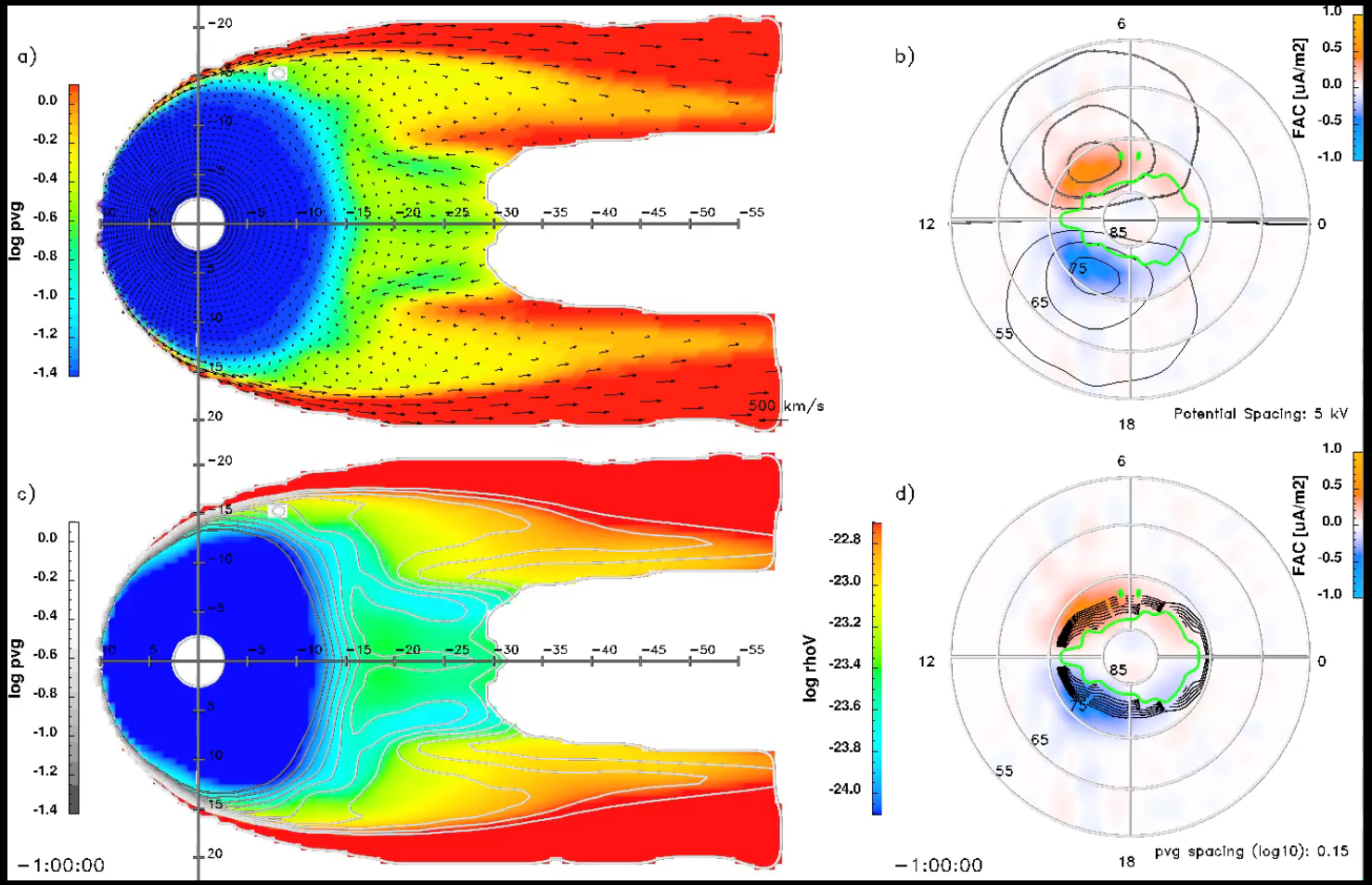


Earth: Injections, bubbles, dipolarization fronts etc.



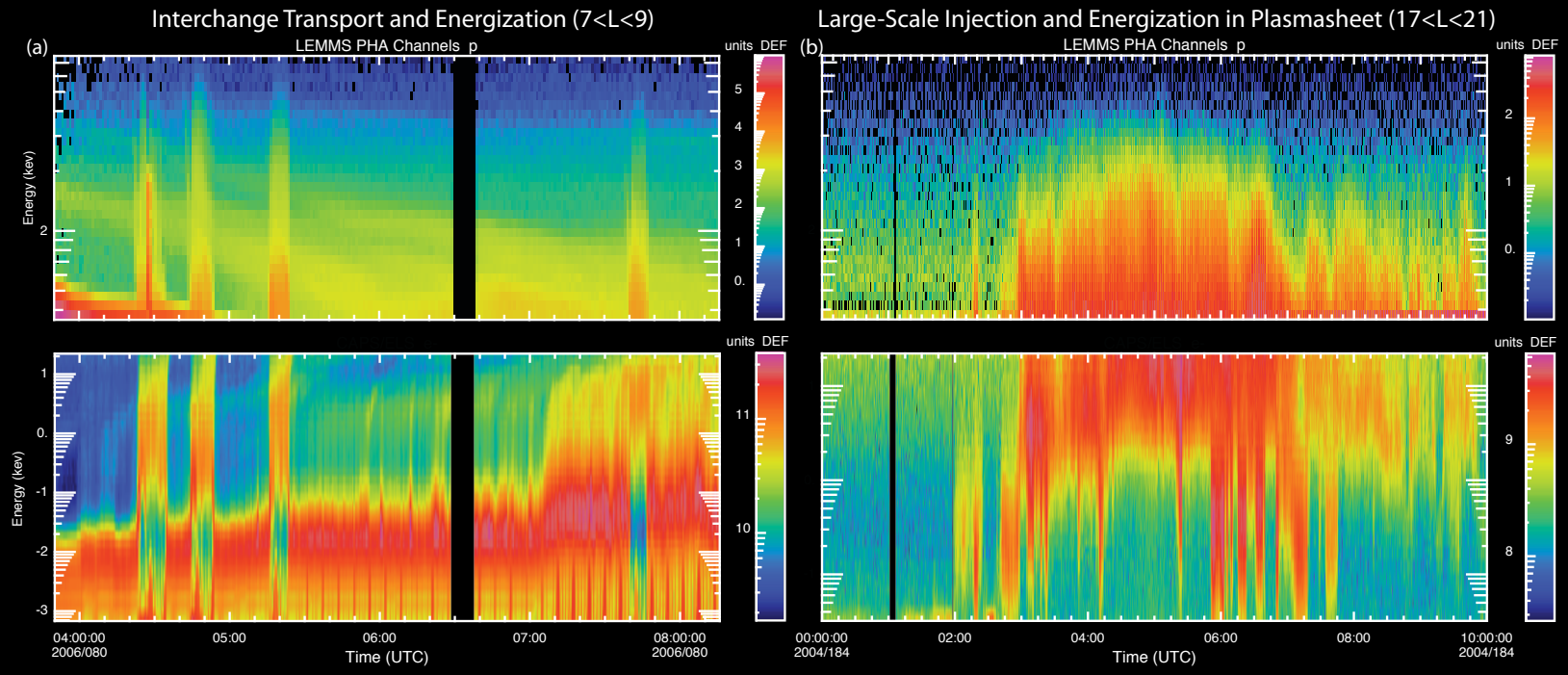
Are "plasma bubbles" the mode by which hot plasma populates the inner magnetosphere? THEMIS observes "bubbles" of hot tenuous plasma with gyro-radius thin dipolarization fronts [Runov et al., 2011].

Earth: Injections, bubbles, dipolarization fronts etc.



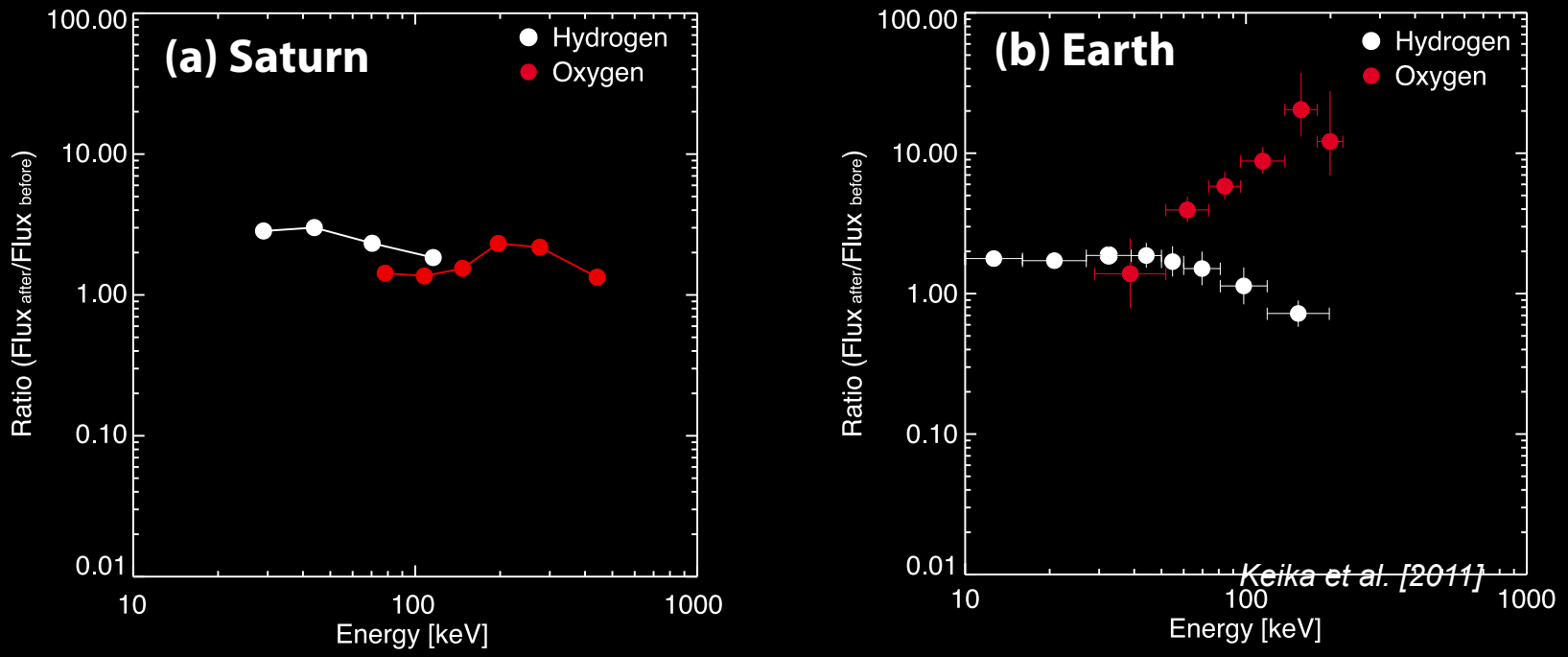
Bubbles are a consistent feature of the coupled RCM-LFM model of Earth's magnetosphere [Pembroke et al., 2011].

Saturn: Injections, bubbles, dipolarization fronts etc.



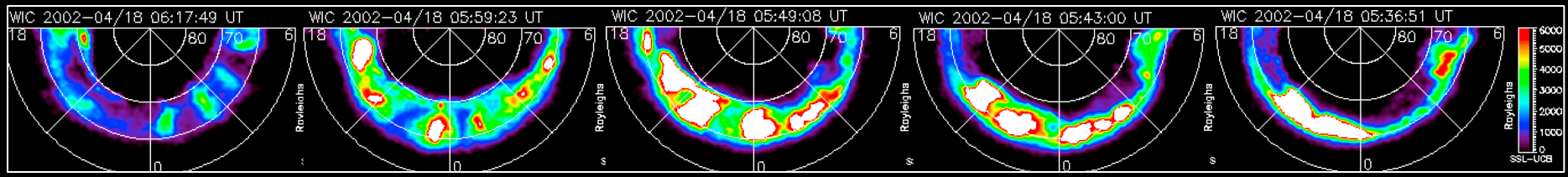
Small-scale interchange-like fingers or bubbles transport hot tenuous plasma in to Saturn's inner magnetosphere. Dipolarization front signatures not determined yet. Large-scale injections appear at L>9. Their relation is still under investigation.

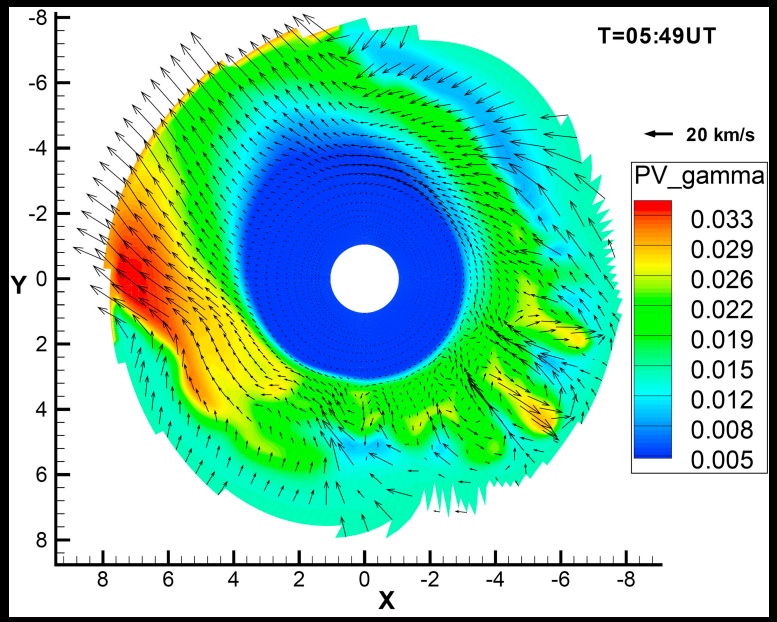
Acceleration: Earth versus Saturn



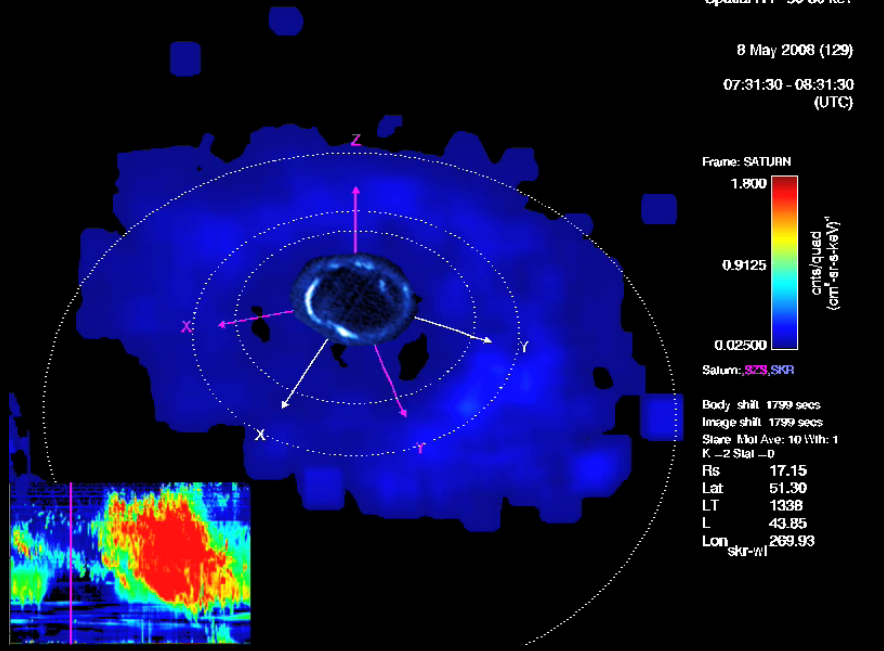
At both Earth and Saturn, O^+ appears to be more dramatically energized during injections compared to protons, pointing to non-adiabatic acceleration processes such as the proposed surfatron and wall-effect mechanisms [Delcourt, 2002; Drake et al., 2009; Ashour-Abdalla et al., 1992].

Auroral connection at Earth and Saturn



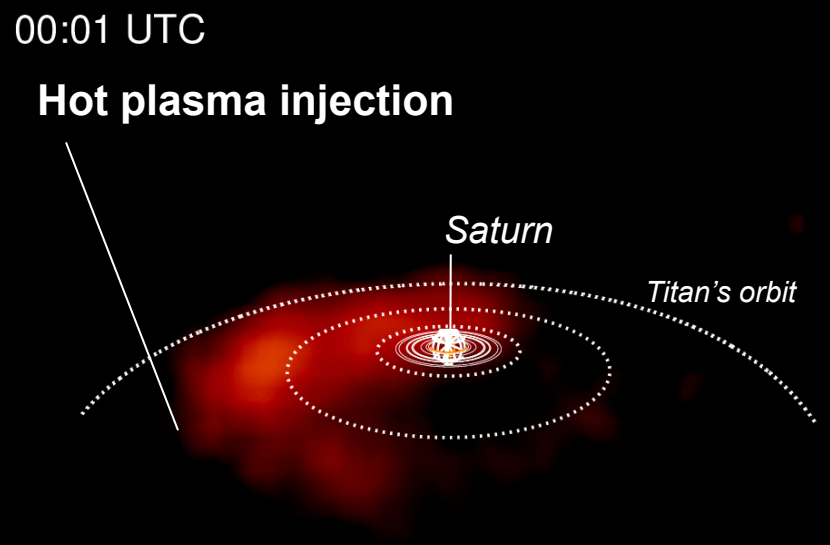


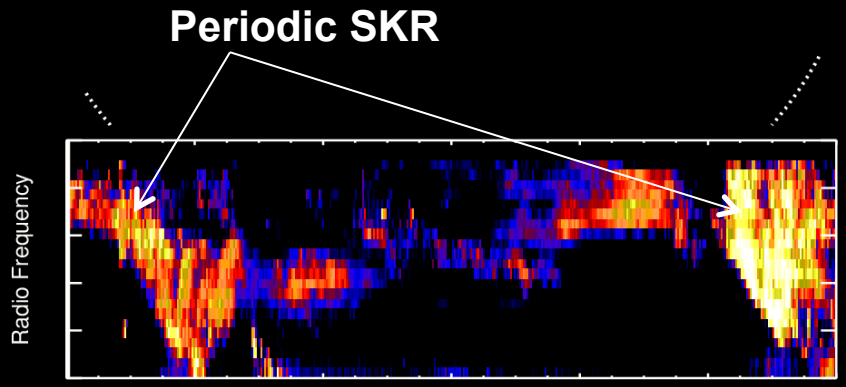
At Earth, substorms cause azimuthal structure in the aurora and the E-field of the inner magnetosphere consistent with interchange "fingers" seen in RCM-LFM simulations [*Ohtani et al., 2008; Yang et al., 2008*].

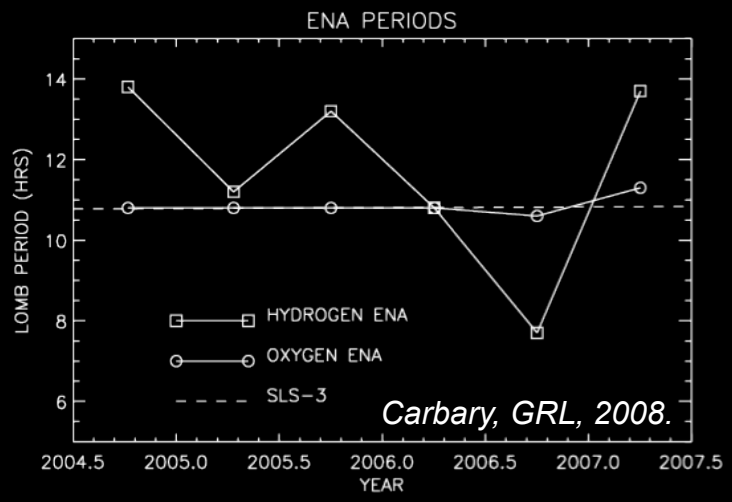


At Saturn, large-scale injections are clearly correlated with auroral intensifications. Looking closely you will see structuring in both the aurora and injection. Are these interchange fingers, just like we think at Earth?

Saturn: Saturn Kilometric Radiation (SKR)

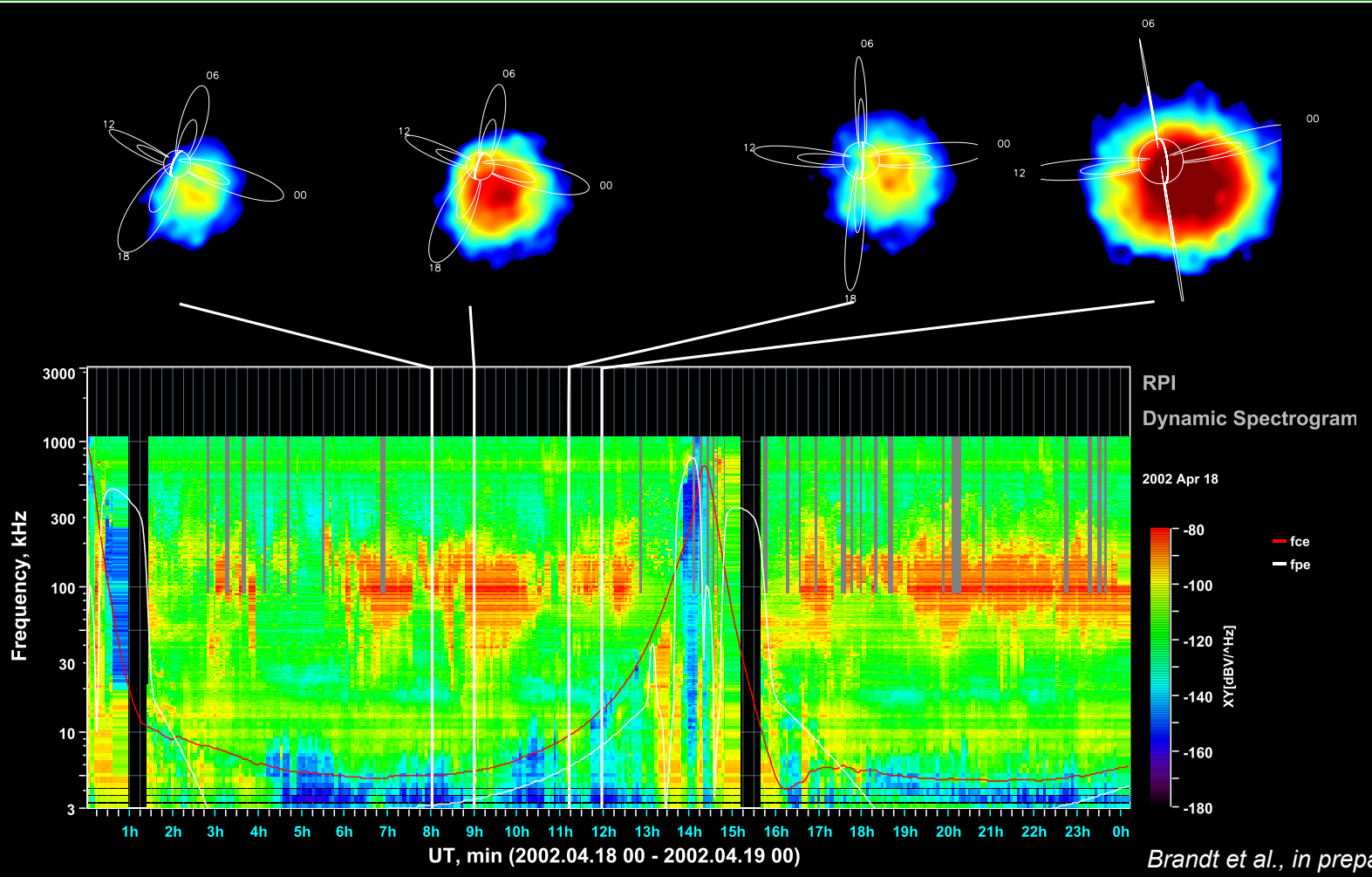






Injections are on average periodic at Saturn with the same rate as the period SKR bursts that have been used to "define" Saturn's rotation rate.

Earth: Auroral Kilometric Radiation (AKR)

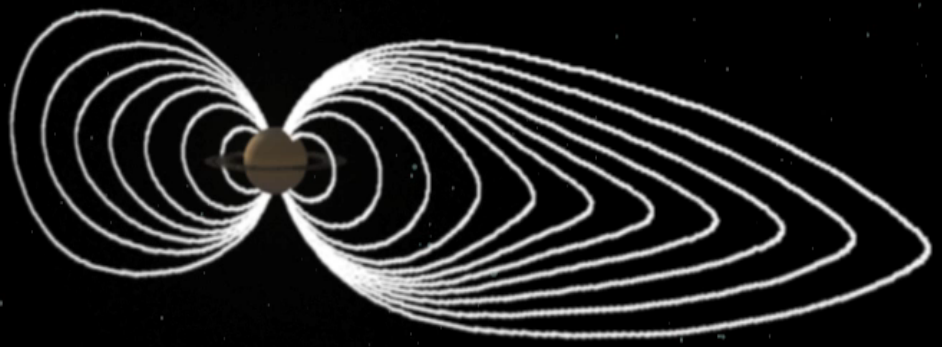


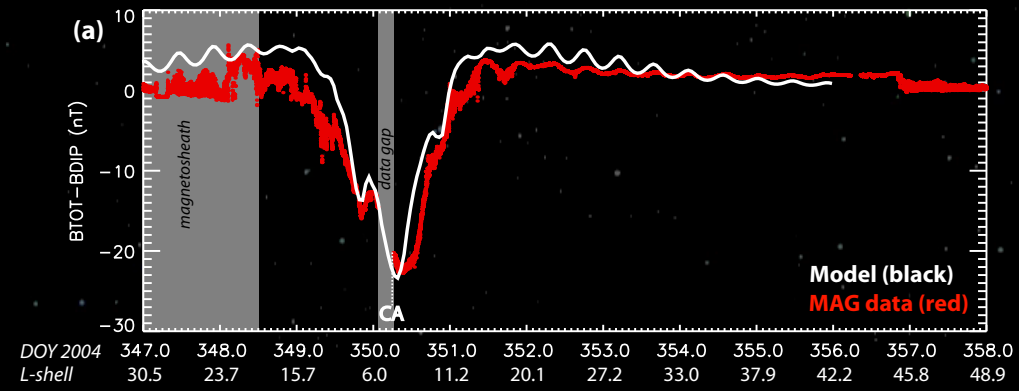
Brandt et al., in preparation.

At Earth, substorms are not periodic but can appear quasi-regular intervals during steady convection. There is a well-known 0.99 correlation with AKR, but magnetospheric engine is still under debate.

Saturn: Impact on the inner magnetosphere

- ***At Saturn, the heated plasma also leads to an increased pressure that drives a 3D current system – a rotating partial ring current (PRC)***
- ***The rotating and recurrent PRC severely distort the magnetic field***
- ***Leads to magnetic field periodicities [Provan et al., 2009; Brandt et al., 2010; Kivelson et al., 2011]***





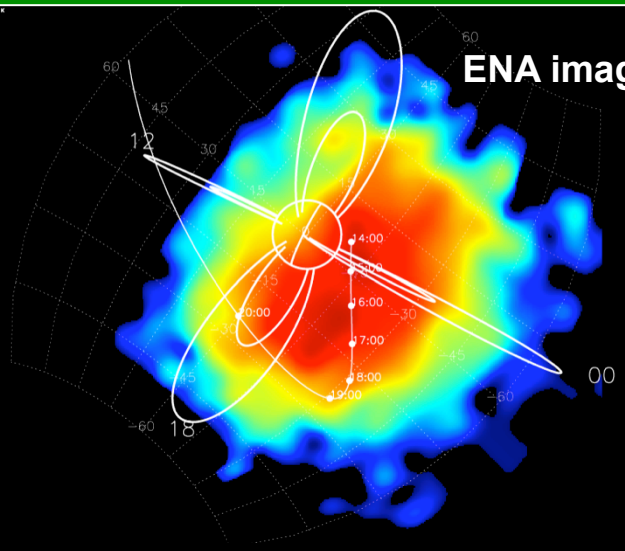
Brandt et al., GRL, 2010.

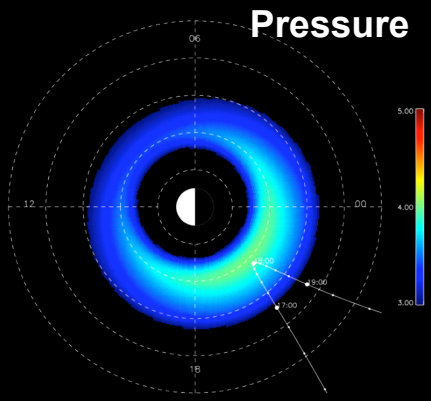
Summary

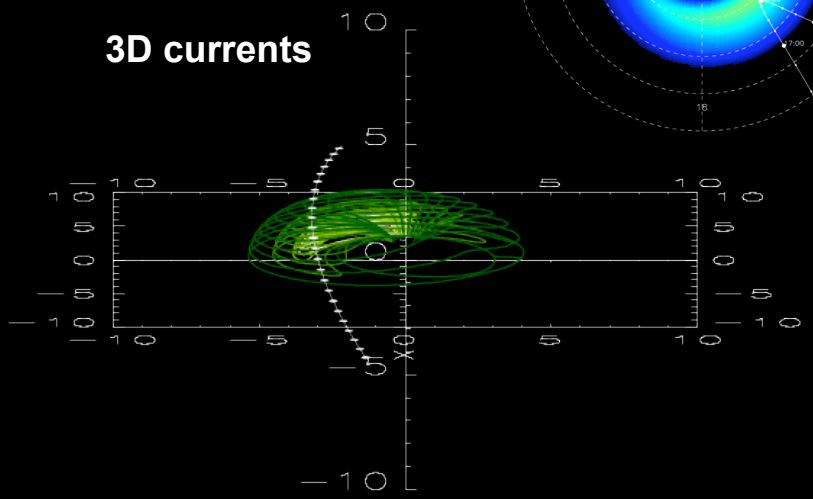
Features	Earth	Saturn
Solar-wind driven storms?	▪ Yes, driven mostly by IMF	▪ Yes, driven mostly by speed
Substorms/large-scale injections?	▪ Yes, on the night side ▪ Plasma instability unknown ▪ Imbalance of day- and night side reconnection	▪ Yes, on the night side ▪ Plasma instability unknown ▪ Centrifugally triggered reconnection, but modulated strongly by solar wind
Modes of plasma transport?	▪ Dungey cycle ▪ Interchange bubbles with hot tenuous plasma in to inner magnetosphere	▪ Dungey and Vasyliunas cycles ▪ Interchange bubbles with hot tenuous plasma in to inner magnetosphere
Sources?	▪ Solar wind and ionosphere	▪ Enceladus (water)
Radio emissions?	▪ AKR correlated with substorm injections ▪ Flow-shear or pressure-driven?	▪ SKR correlated with large-scale injections ▪ Flow-shear or pressure-driven?
Field depression during "storms"?	▪ Yes, due to partial ring current fixed around midnight	▪ Yes, due to corotating PRC

Collaborations

- **Cluster-IMAGE-TS07d**
  - *Ring current injections and energization*
  - *3D current system*
- **THEMIS-RBSP** (Aug 2012)-**Cluster-TWINS**
  - *Plasma transport and energization in to the inner magnetosphere*
- **IMAGE-Cluster-LANL-GPS-Ground based-…**
  - *Plasmasphere behavior*







Plasmasphere behavior and its influence on the ionosphere and magnetosphere

- **Five NASA/LWS funded teams work together on one topic**
- **Objective: Plasmasphere behavior and its influence on the ionosphere and magnetosphere**
  1. *How is the plasmasphere created and maintained from below?*
  2. *How is plasmasphere dynamics controlled?*
  3. *How does the plasmasphere affect the magnetosphere?*
  4. *How does the plasmasphere affect the ionosphere?*
- **We are using multiple models and a wide range of observations of the inner magnetosphere system**
- **Invite and encourage collaboration**
  - *Now we collaborate with NSF/GEM and European funded projects, but we want more international collaboration.*
- **Collaboration through regular tele conferences, web conferences and meetings**
- **Sign up on email list: pontus.brandt@jhuapl.edu**