Combining Remote and *In Situ* Observations with MHD models to Understand the Formation of the Slow Solar Wind

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Prediction for Parker Solar Probe and Solar Orbiter: There is no such thing as ‘the steady solar wind’

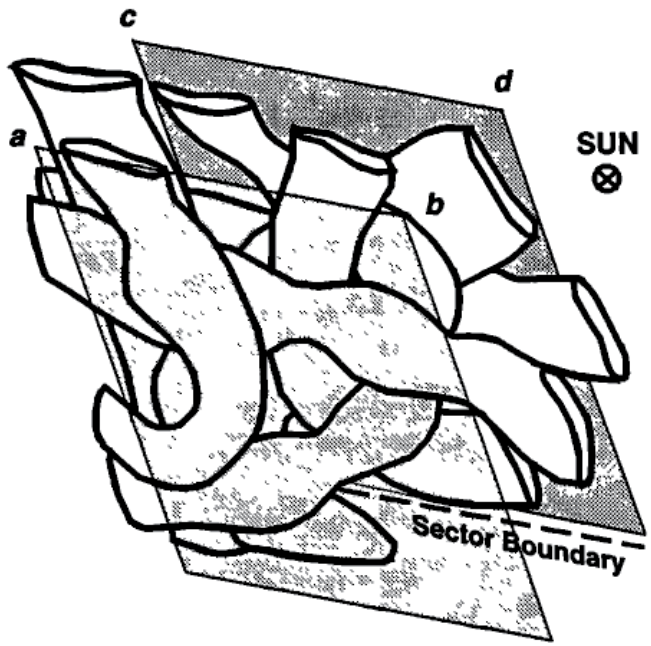

Figure 6. View toward the Sun of the plasma sheet region as distended, intertwined flux tubes forming planar magnetic structure at the sector boundary. Letters a-d reference the cross-sectional view in Figure 5.

- The observations at the HCS ‘preclude a single, wavey current sheet interpretation’. They interpreted the observations as ‘small-scale, intertwined flux ropes’
- Question: Are these transients injected into the HCS on top of an otherwise steady solar wind? Or are these the fundamental building blocks of the solar wind?

Crooker et al. 1996

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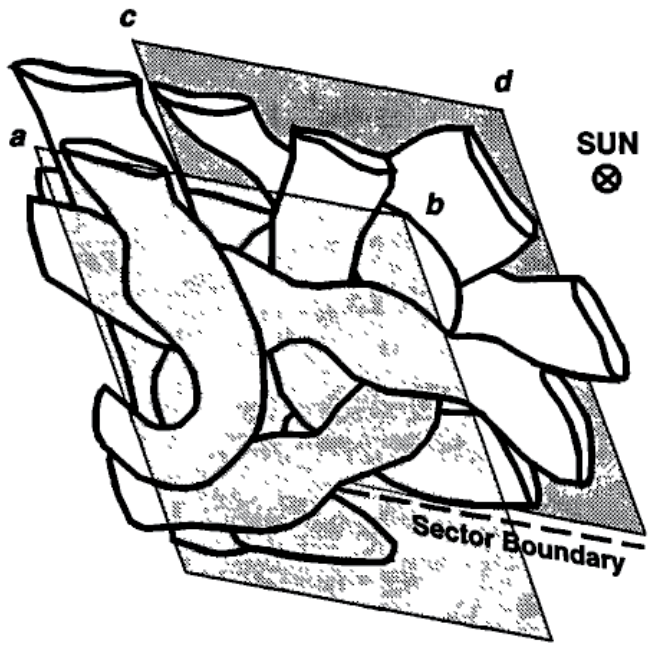

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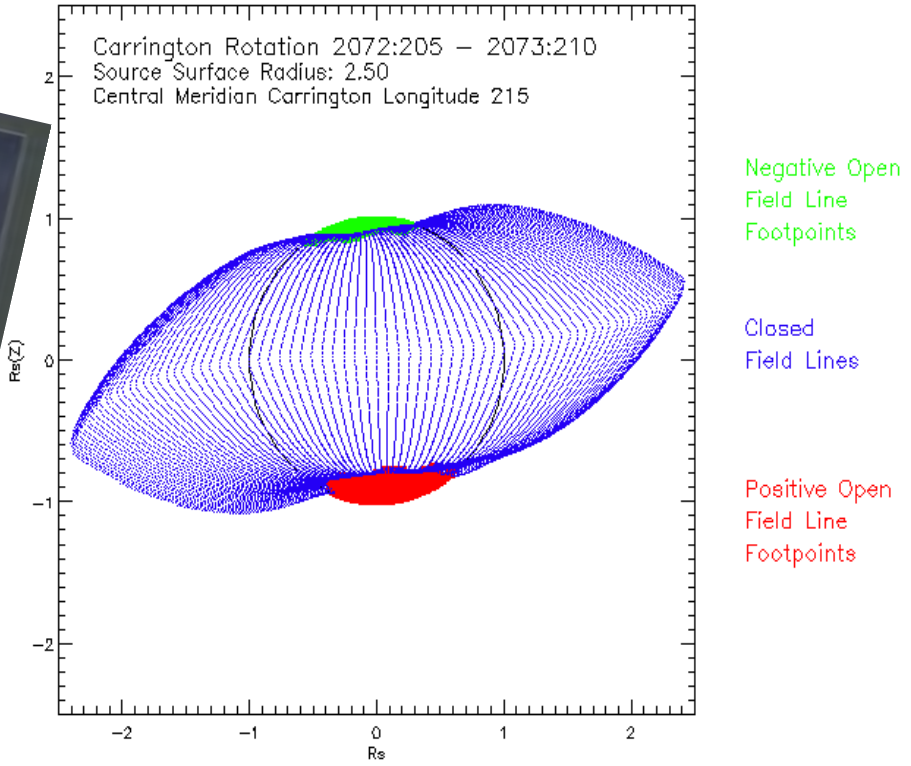
Crooker et al. 1996

- Starting to see evidence in data and modeling/theory that these may be a fundamental building block of the solar wind
- Observations are pushing the limits of current instrumentation

August 2008

Helmet streamer, pseudostreamer, and complex S-web structure => Universal process of transient plasma injection

PFSS as viewed by STEREO A



See Higginson, Next session

Yesterday, Ben Lynch SH12B-06

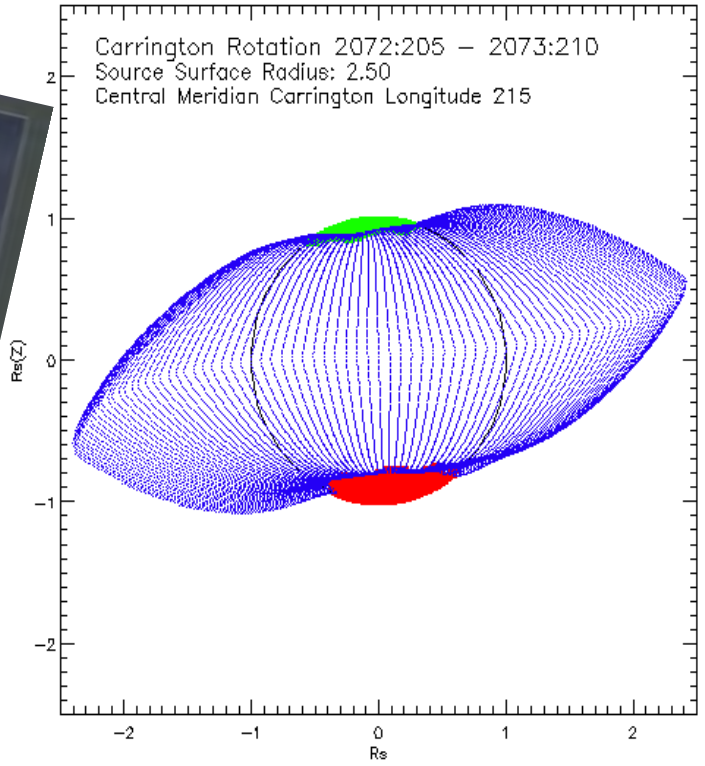
Success indirectly linking solar structures to heliosphere (*in situ*) with mesoscales

- ~tens of minutes up to a few hours/100s Mm up to a few thousand Mm radial length scale
- ‘small’ – compared to current heliospheric imager resolution and *in situ* composition measurements
- ‘large’ – compared to turbulence (‘mesoscale’-> generally larger than the inertial range) and Earth’s magnetosphere/space weather

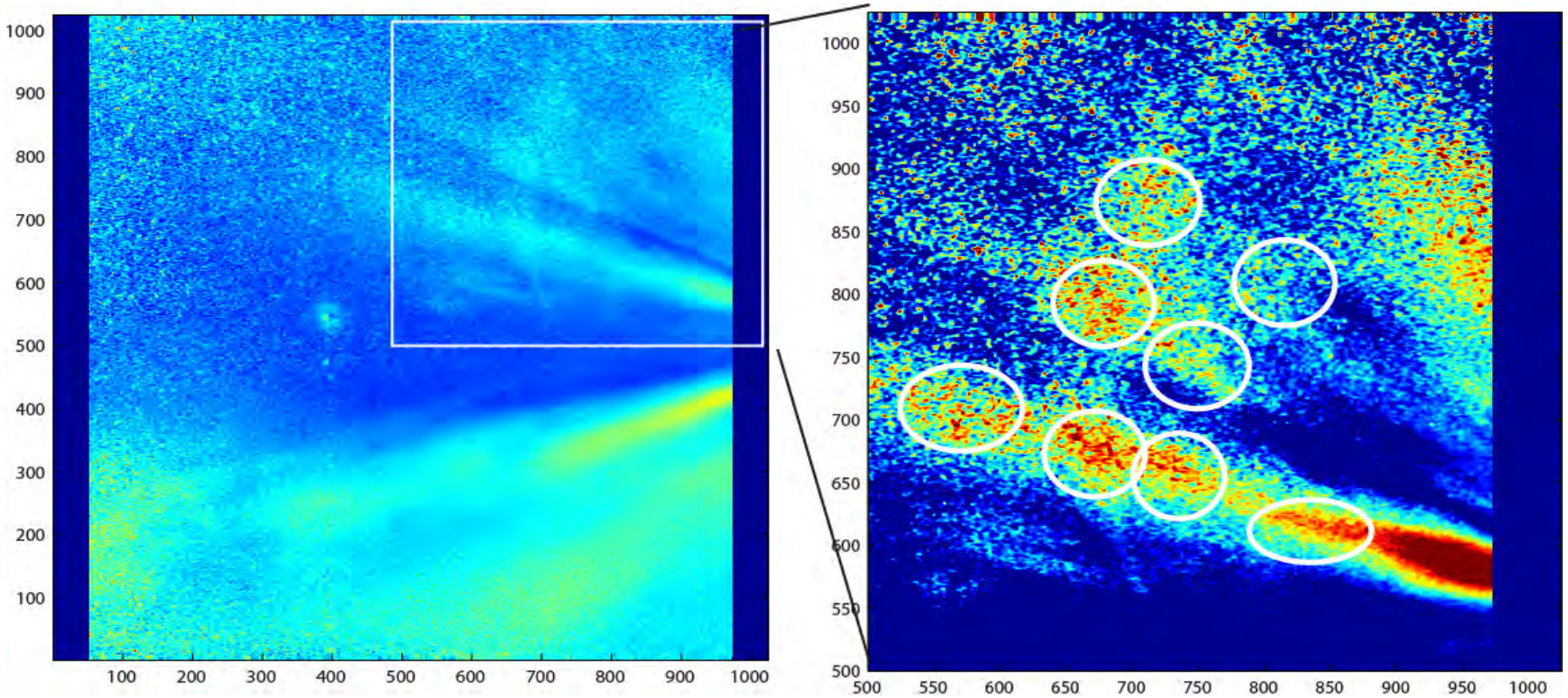
Parker Solar Probe and Solar Orbiter will finally give a DIRECT link of these mesoscale structures

August 2008
HCS is aimed south of Earth; pseudostreamer is aimed north

PFSS as viewed by STEREO A

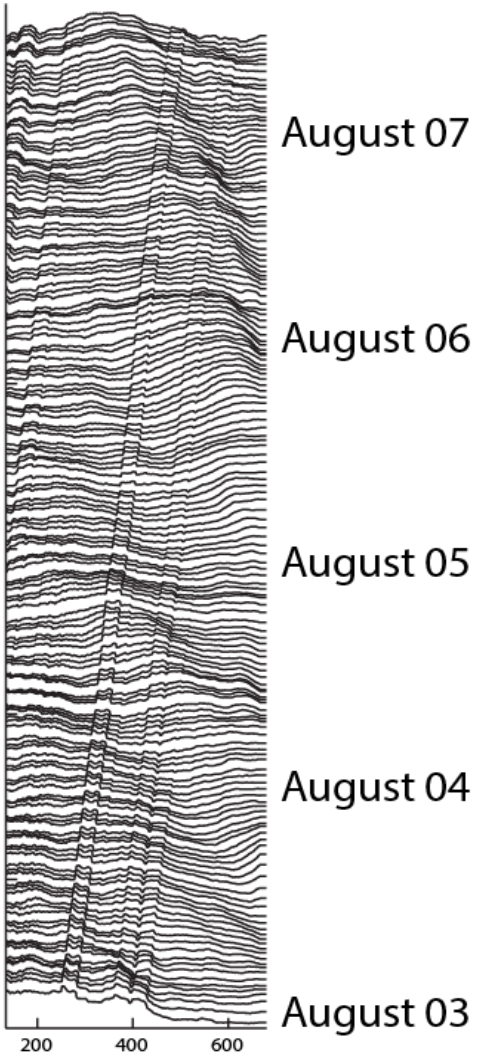


HI1 images show pseudostreamer continually releases ‘blobs’/‘puffs’/ solar wind structures

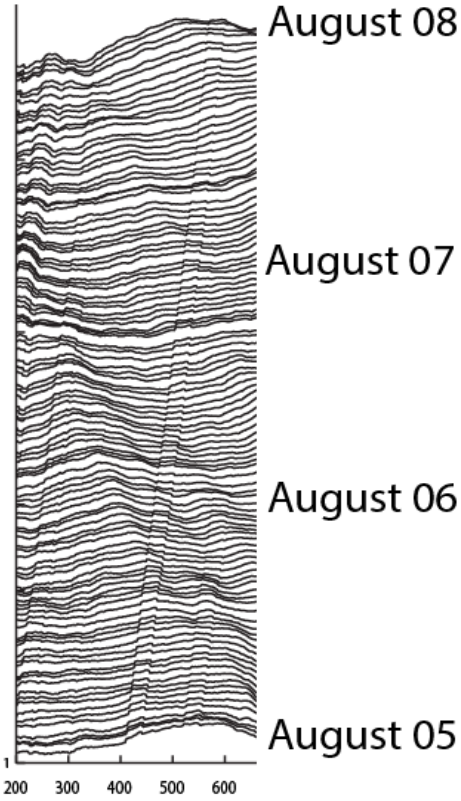


DeForest processed HI1 – on STEREO/SECCHI webpage

Time-distance plots show continuous release of transient structures from pseudostreamer



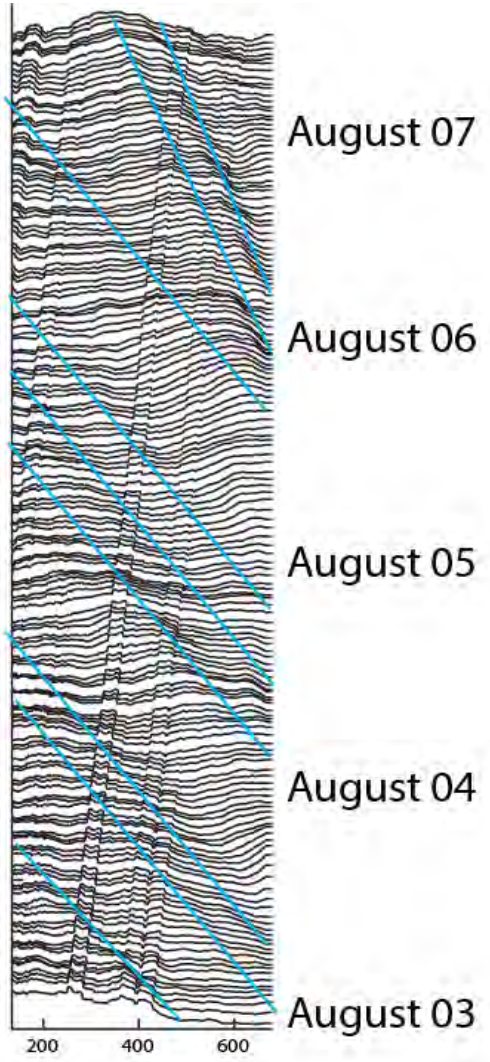
Horizontal Pixel (Distance from Sun)



Horizontal Pixel (Distance from Sun)

250 km/s
(Faster ones are
400 km/s)

Time-distance plots show continuous release of transient structures from pseudostreamer



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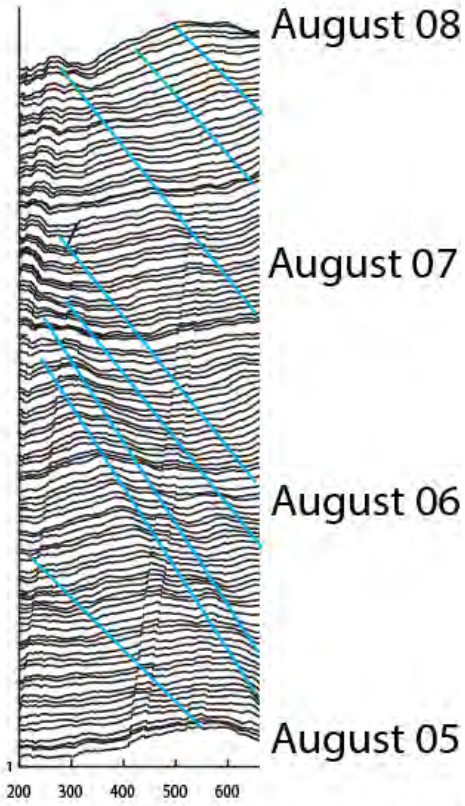

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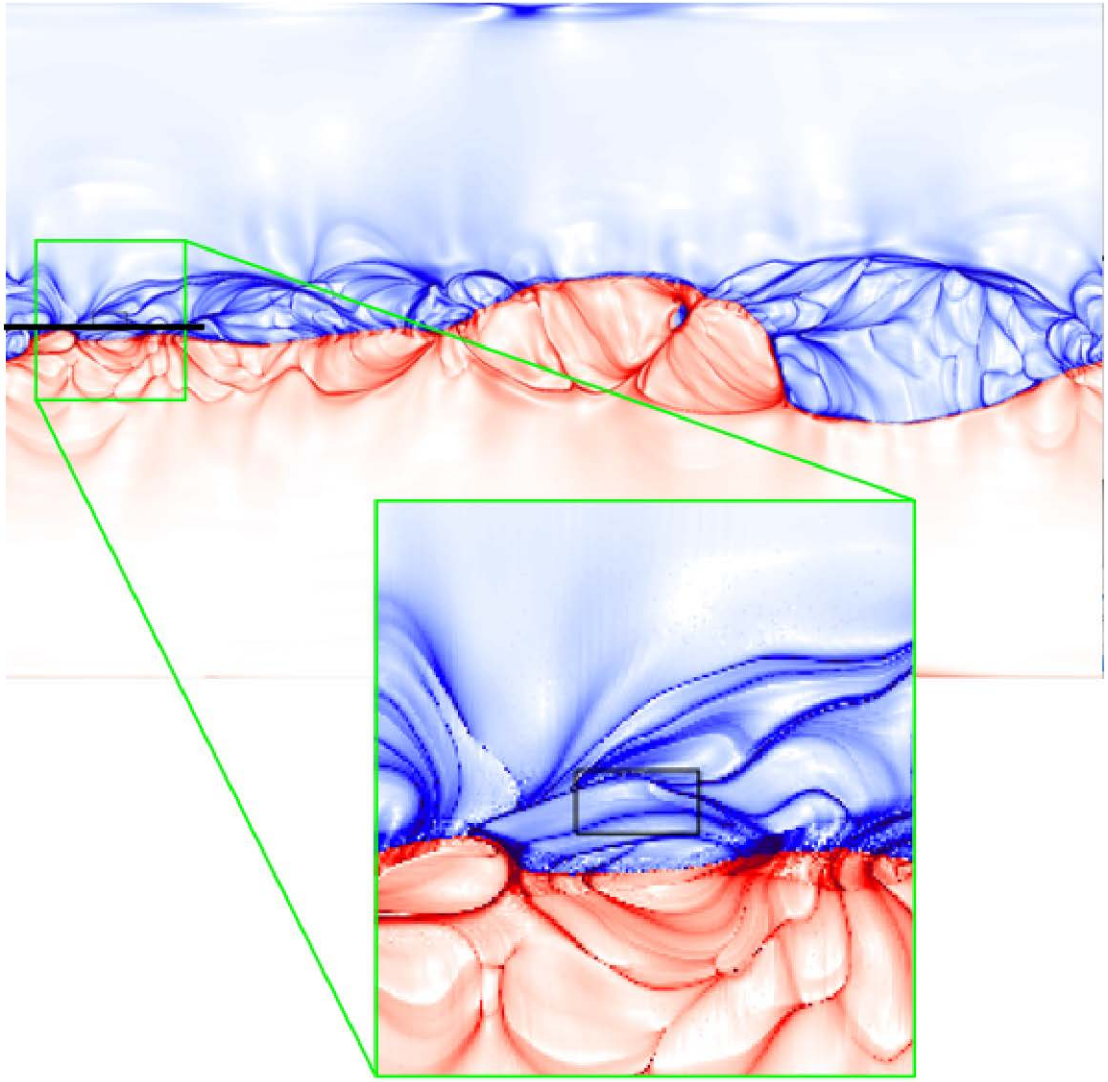
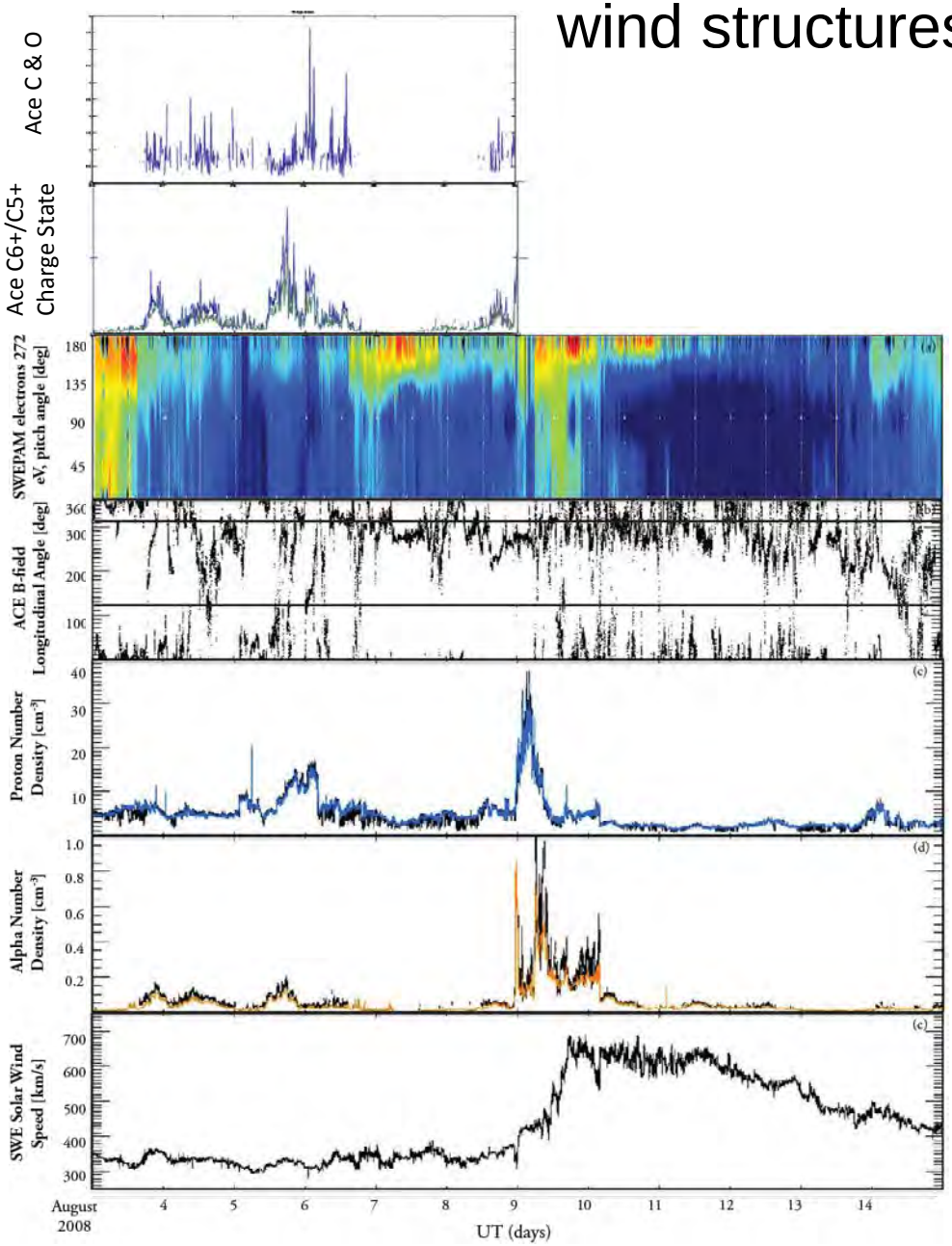
L1 maps to complex S-web arcs- not the streamer or pseudostreamer



Predictive
Science Inc

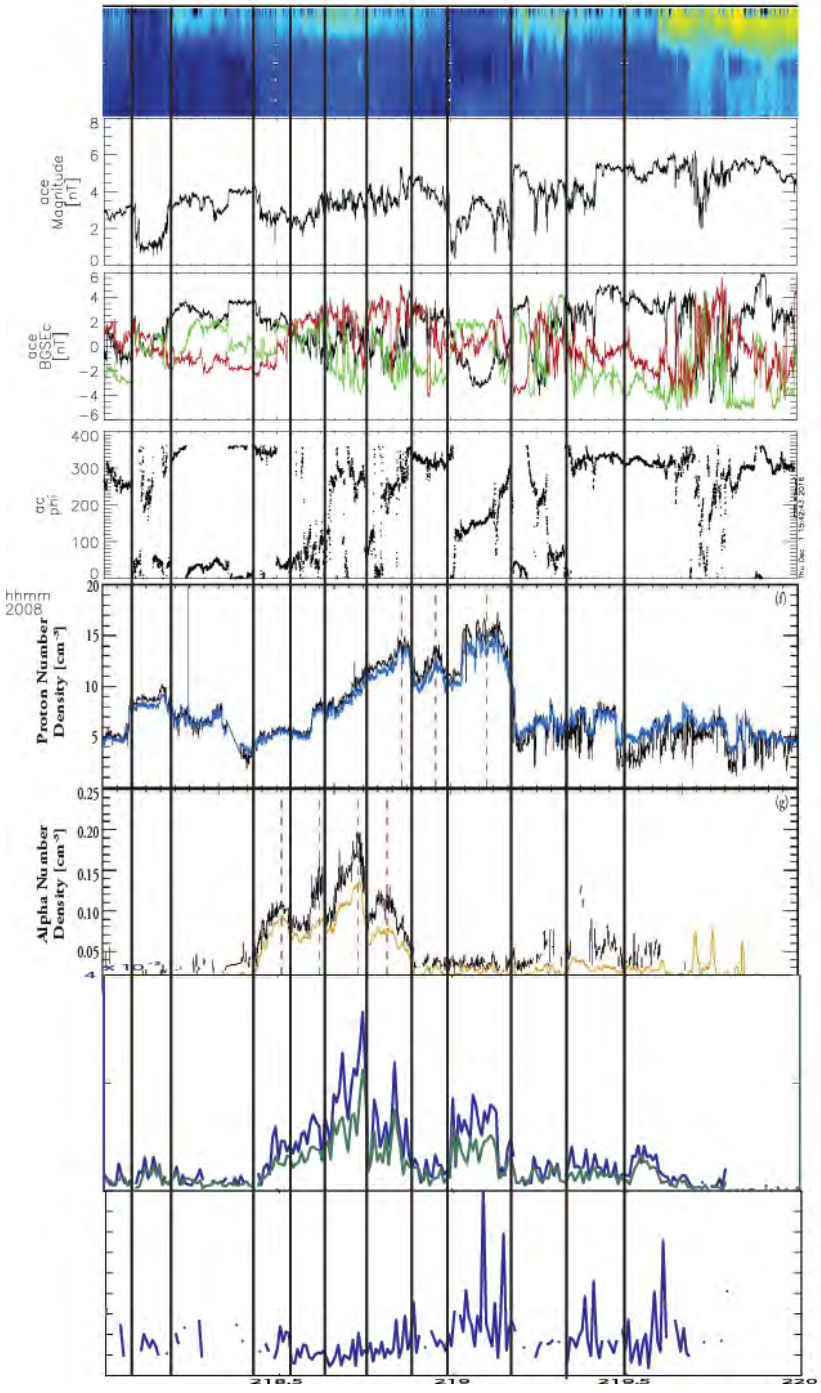
In situ, Wind/ACE observe a stream interface, many slow wind structures, and no HCS



T sector

A sector

- 14 days without a HCS
- Slow wind shows highly structured proton density, alpha, carbon, oxygen, charge state - solar source



Magnetic reconnection releases coronal loops with different heating histories

Composition boundaries generally correspond to B field tangential discontinuities and rotations, but not in a predictable orientation- i.e. not Alfven waves or waves between flux tube (see also Viall et al. 2009 alpha event)

Two heat flux drop outs in the train of periodic density structures are signs of connectivity changes (e.g. through interchange rxn; Chollet et al. Pagel et al)

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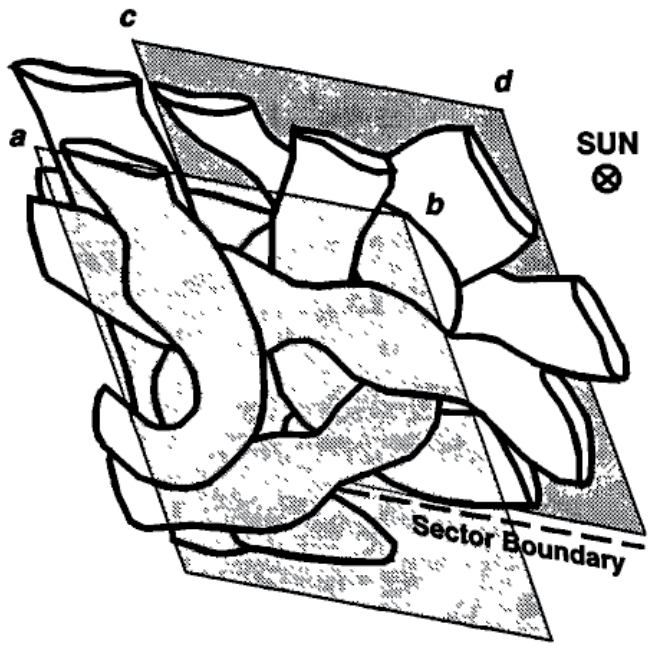
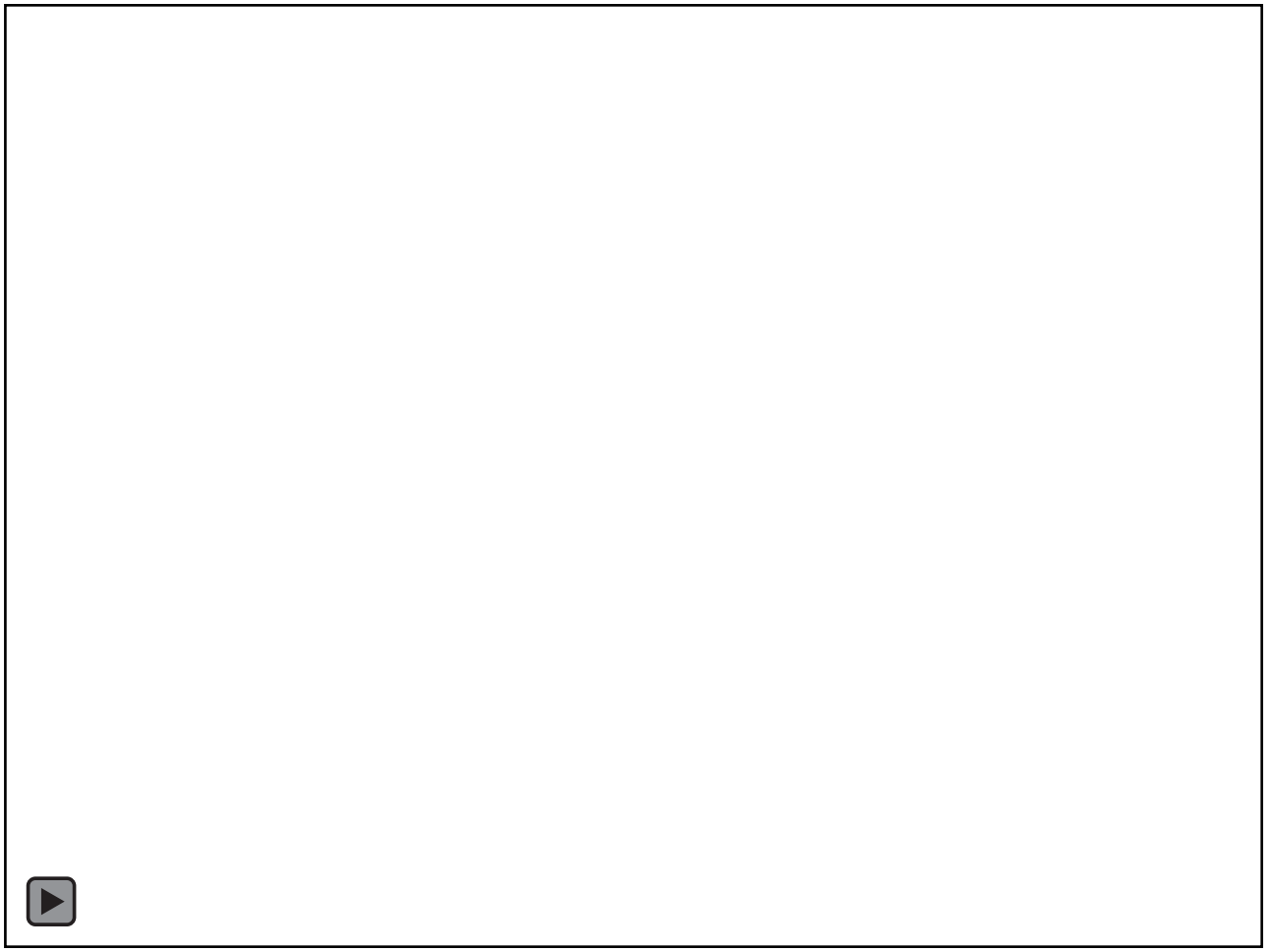


Figure 6. View toward the Sun of the plasma sheet region as distended, intertwined flux tubes forming planar magnetic structure at the sector boundary. Letters a-d reference the cross-sectional view in Figure 5.

Crooker et al. 1996

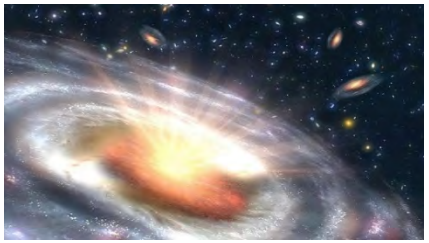
- No such thing as steady solar wind: Magnetic fields always store and then release energy.
- Key is to get high time resolution composition/alphas, high time and spatial resolution imaging, and modeling. This is really pushing imaging limits. We need PUNCH! See Craig's talk next

Solar wind structures drive dynamics in Earth's magnetic field.



‘Small Things Can do Big Damage’

Small Blackholes



Small Dogs

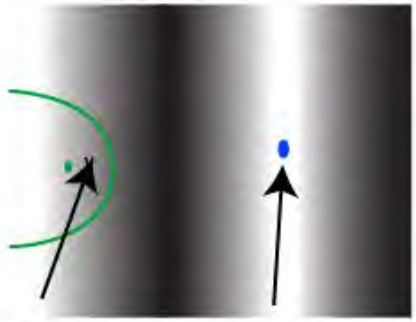
Small Kids

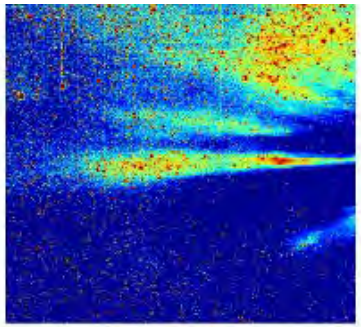
Small Carpenter Ants

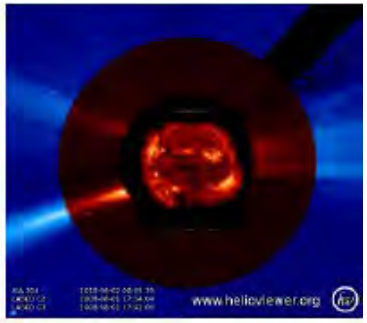
Small Hail

‘Small’ Structures from the Sun-
which are constantly emitted-
can have big, cumulative, impacts on
Earth (terrestrial planets in general)

Small leaks

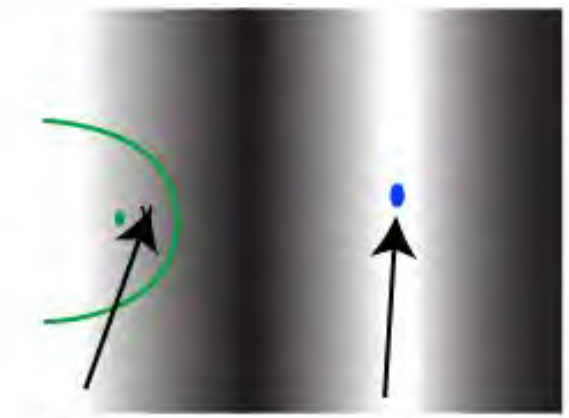






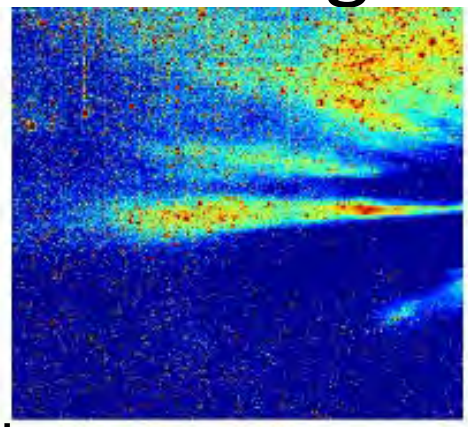
Extra

Indirect link solar structures with structures in solar wind hitting Earth.

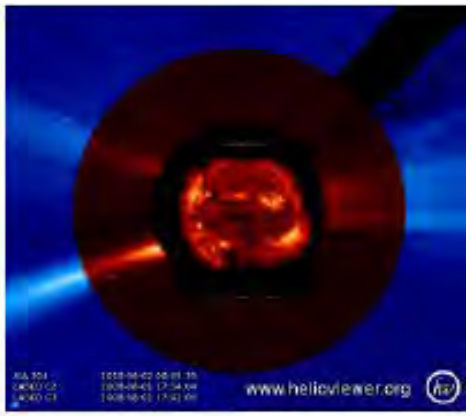


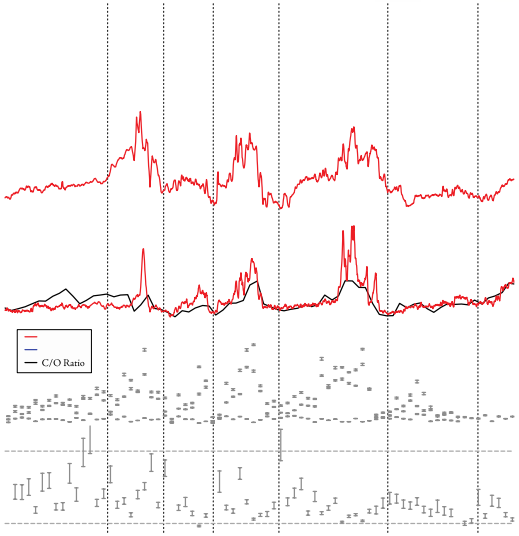
GOES Spacecraft

L1 Observatories

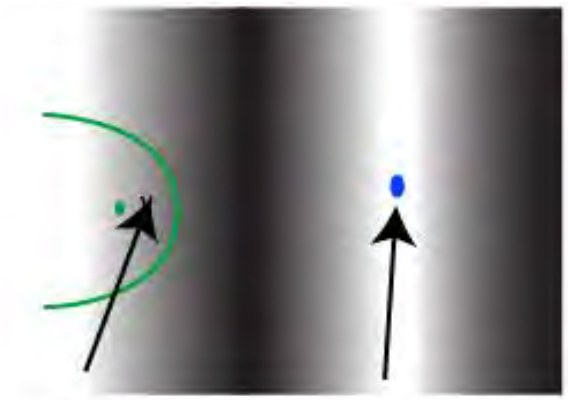


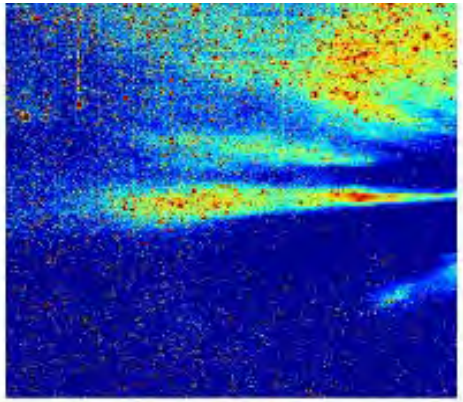
Current observational gap

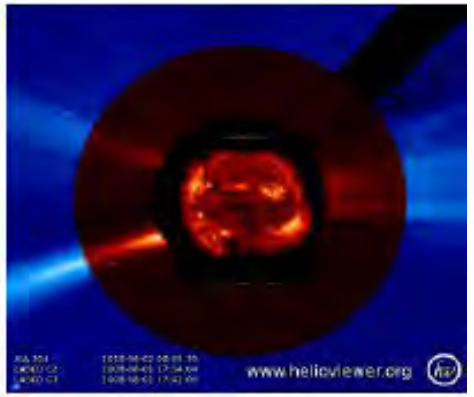


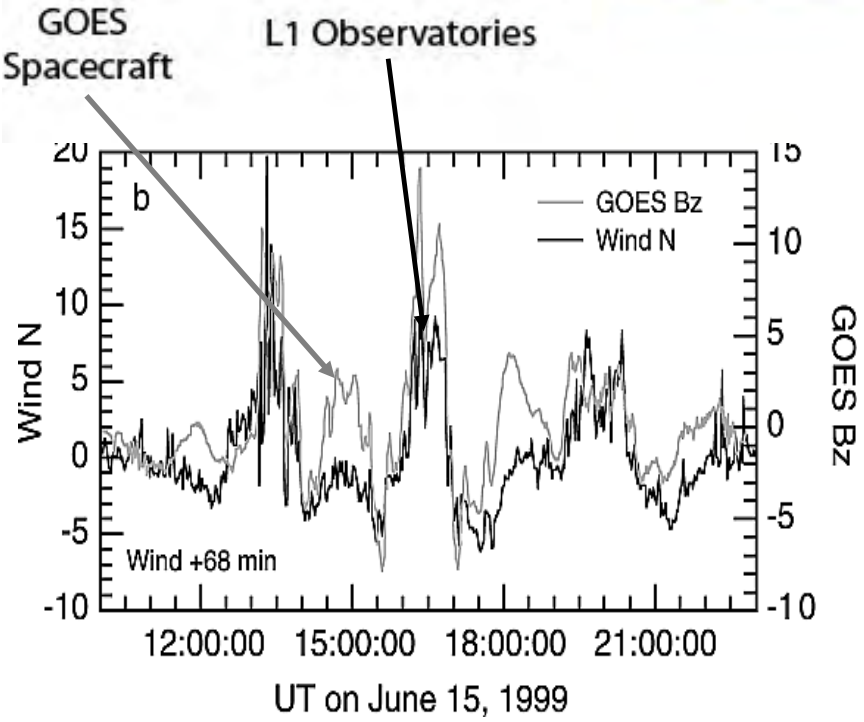


Structures from the Sun drive dynamics in Earth's magnetic field.









Quasi-periodic reconnection at the Sun directly drives oscillations in Earth's Magnetosphere (4 days later)