Solar Wind Structure and Source Mapping Efforts

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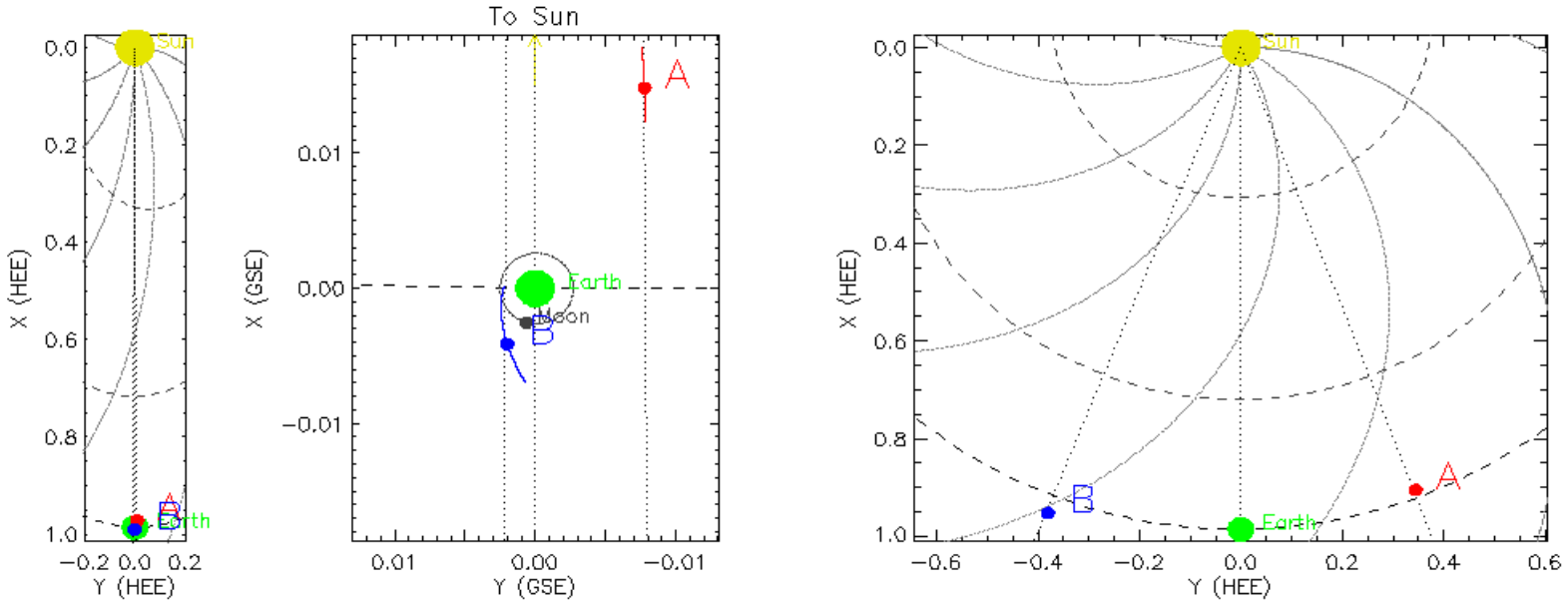
April 2008 SWG, Meudon

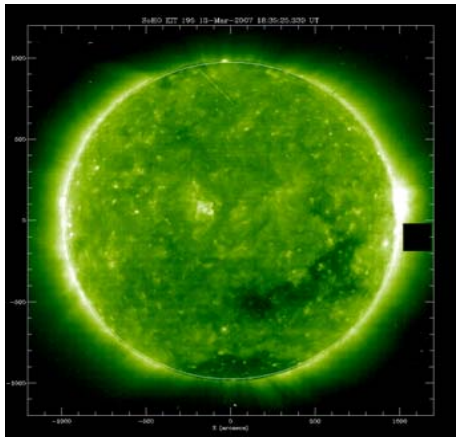
Fast Solar Wind

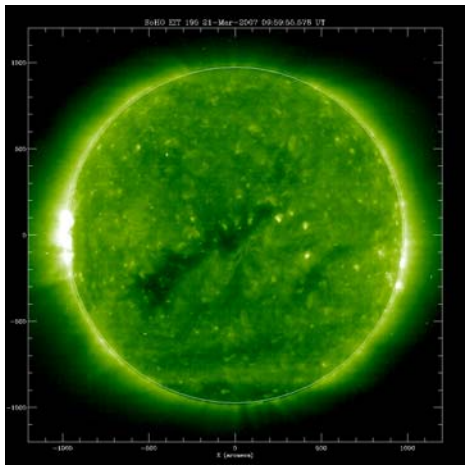
STEREO separation was significant by late 2007 (right panel)

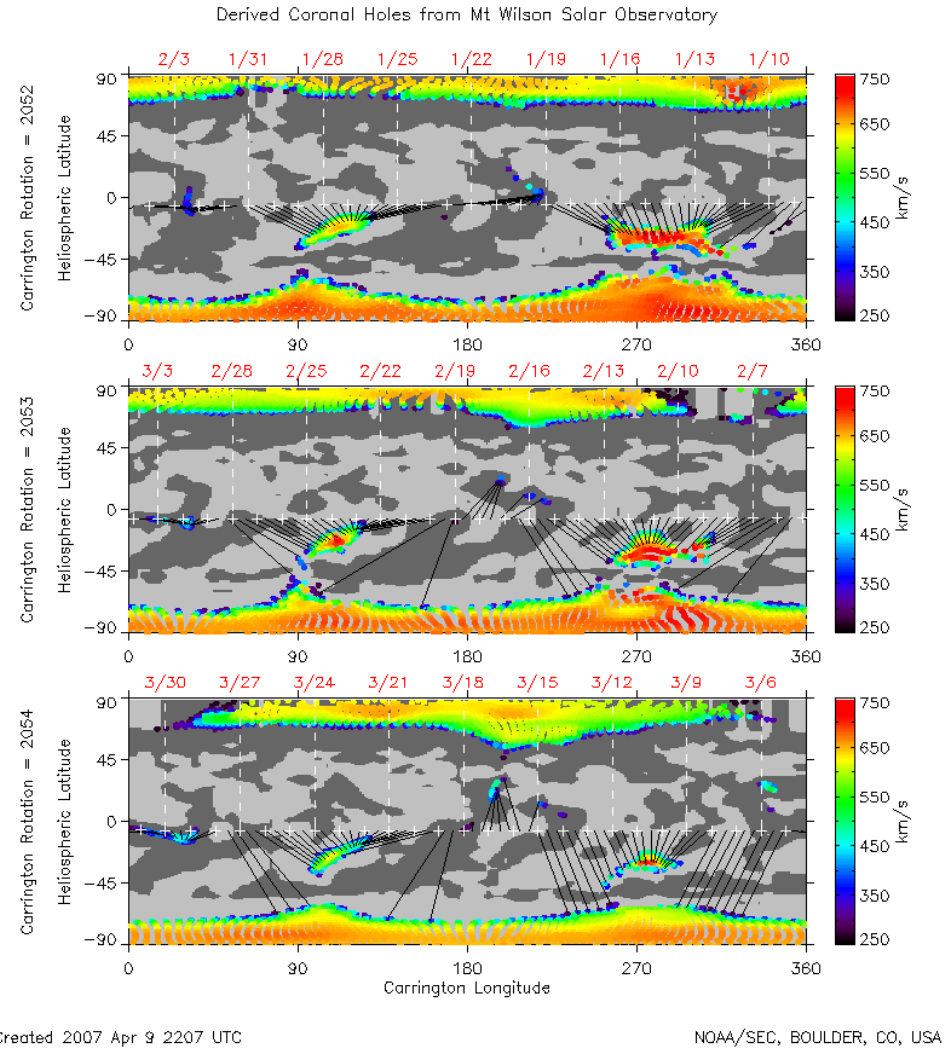


(from SSC ‘where is STEREO’)

In early 2007 the midlatitude southern hemisphere coronal were the clear high speed wind sources



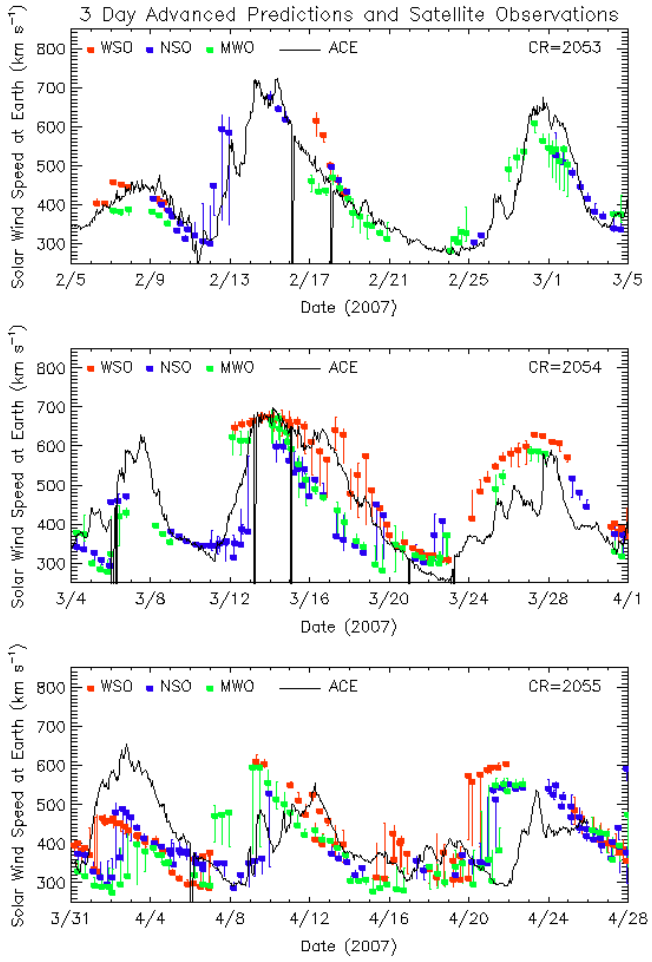


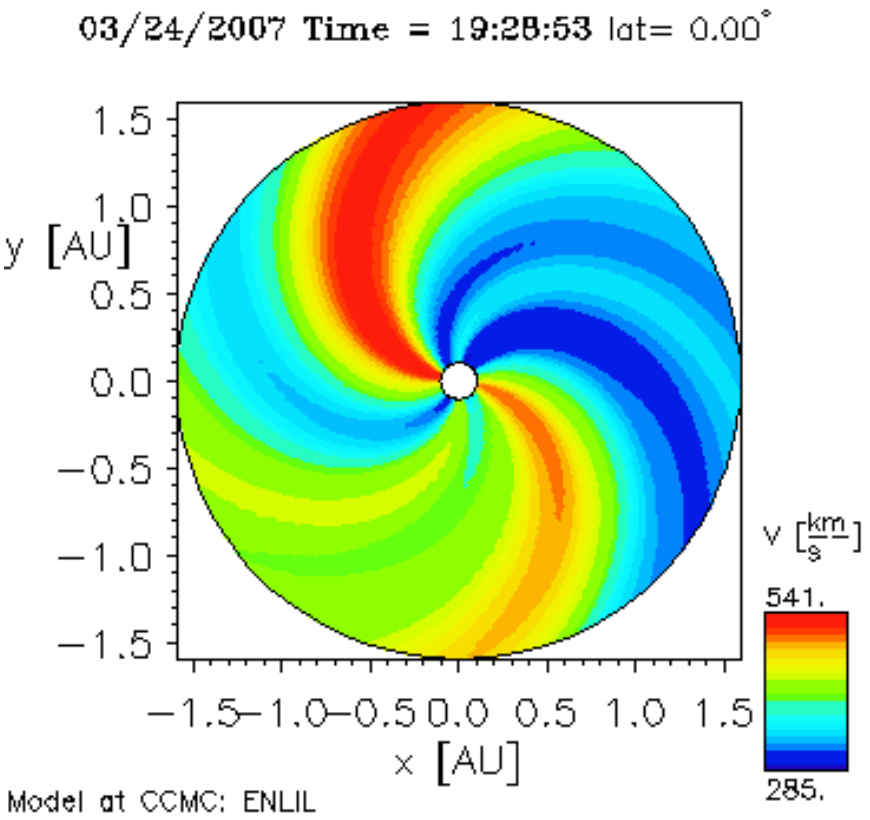


SOHO EIT images

WSA model plot from NSWPC website

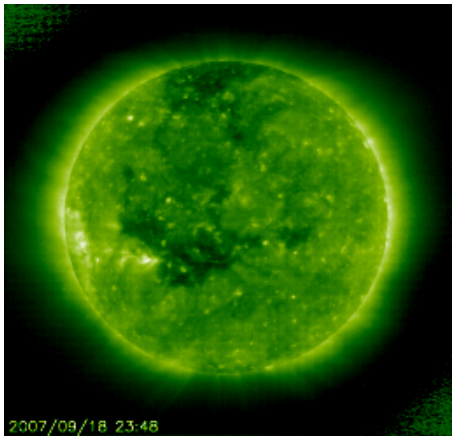
These early sources were well-modeled with the magnetogram-based WSA model for L1

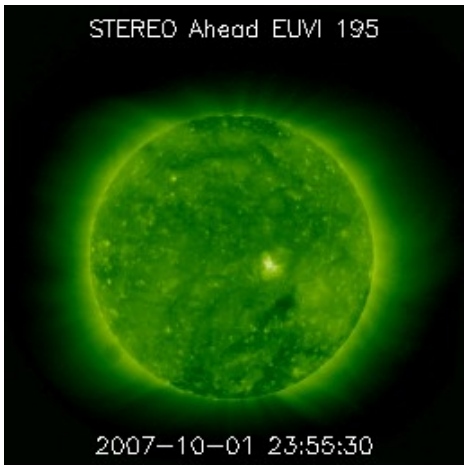


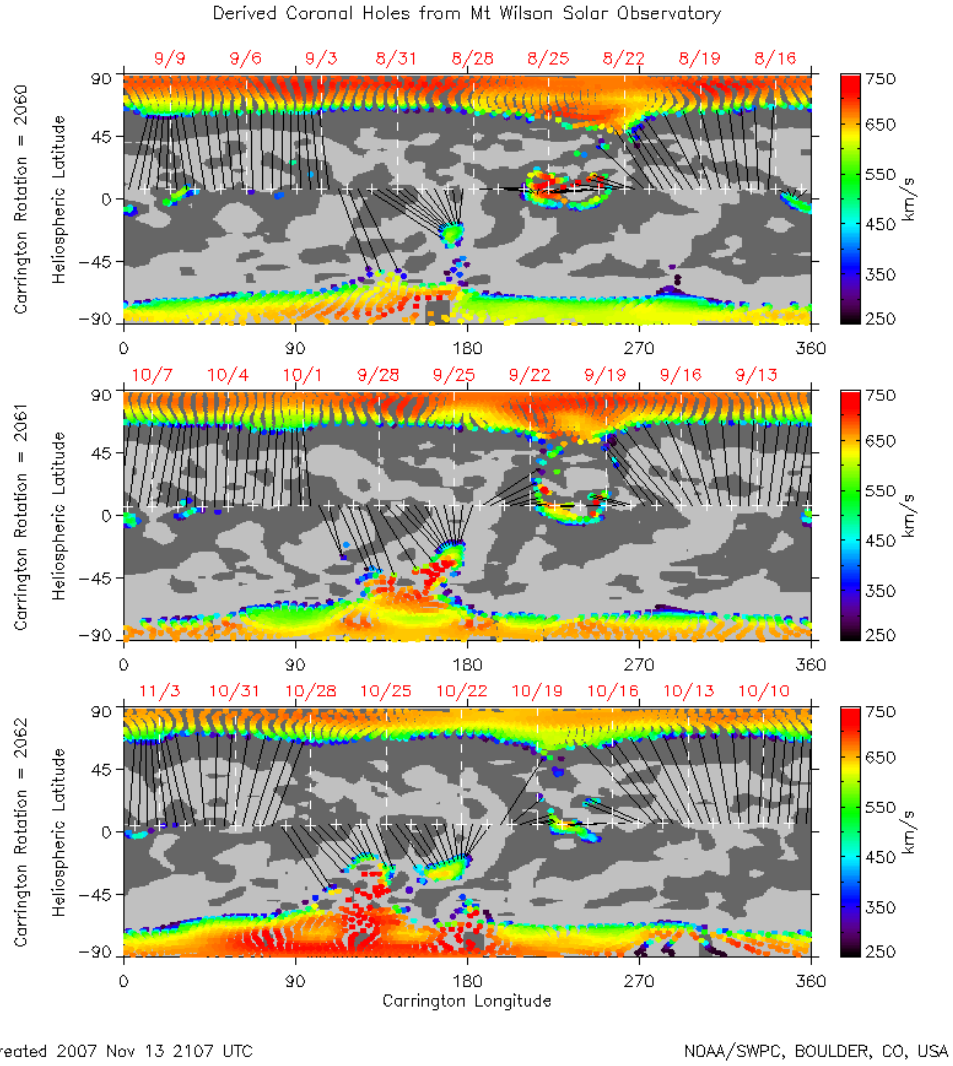


ACE/WSA model comparisons from NSWPC website, color plot from CCMC website

The later 2007 source mappings show a mixture of connections to mid-latitude open field regions, and to polar holes and their midlatitude extensions

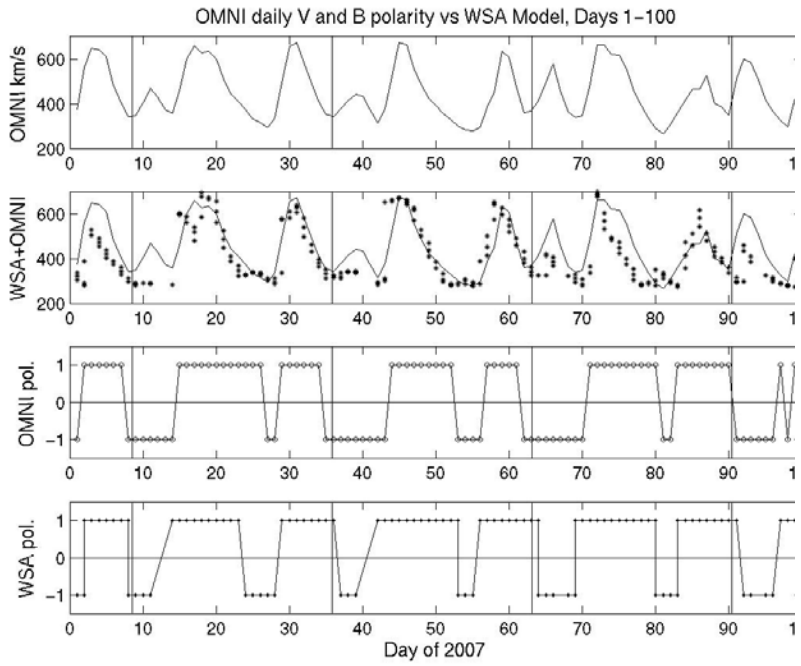




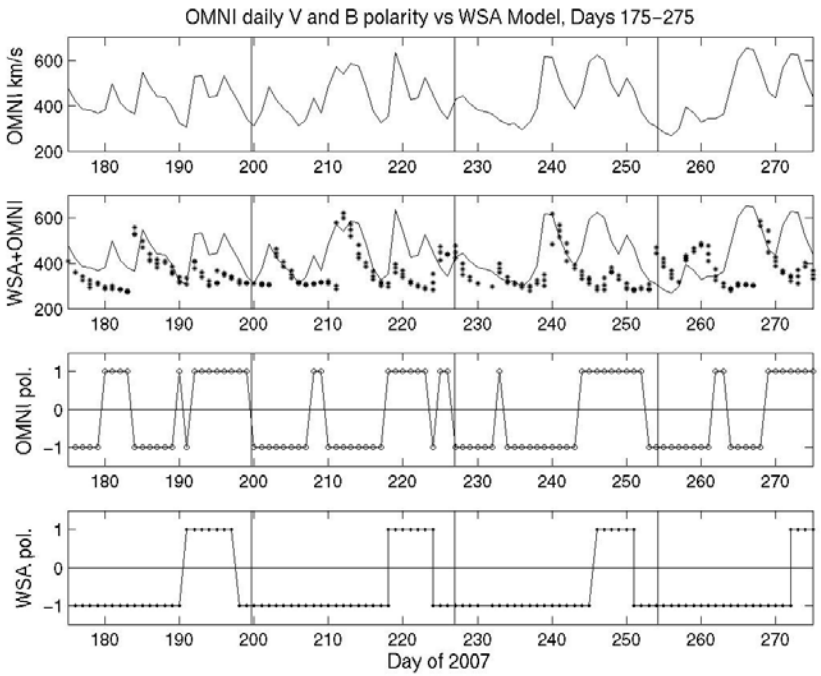


SOHO EIT images

WSA model plot from NSWPC website



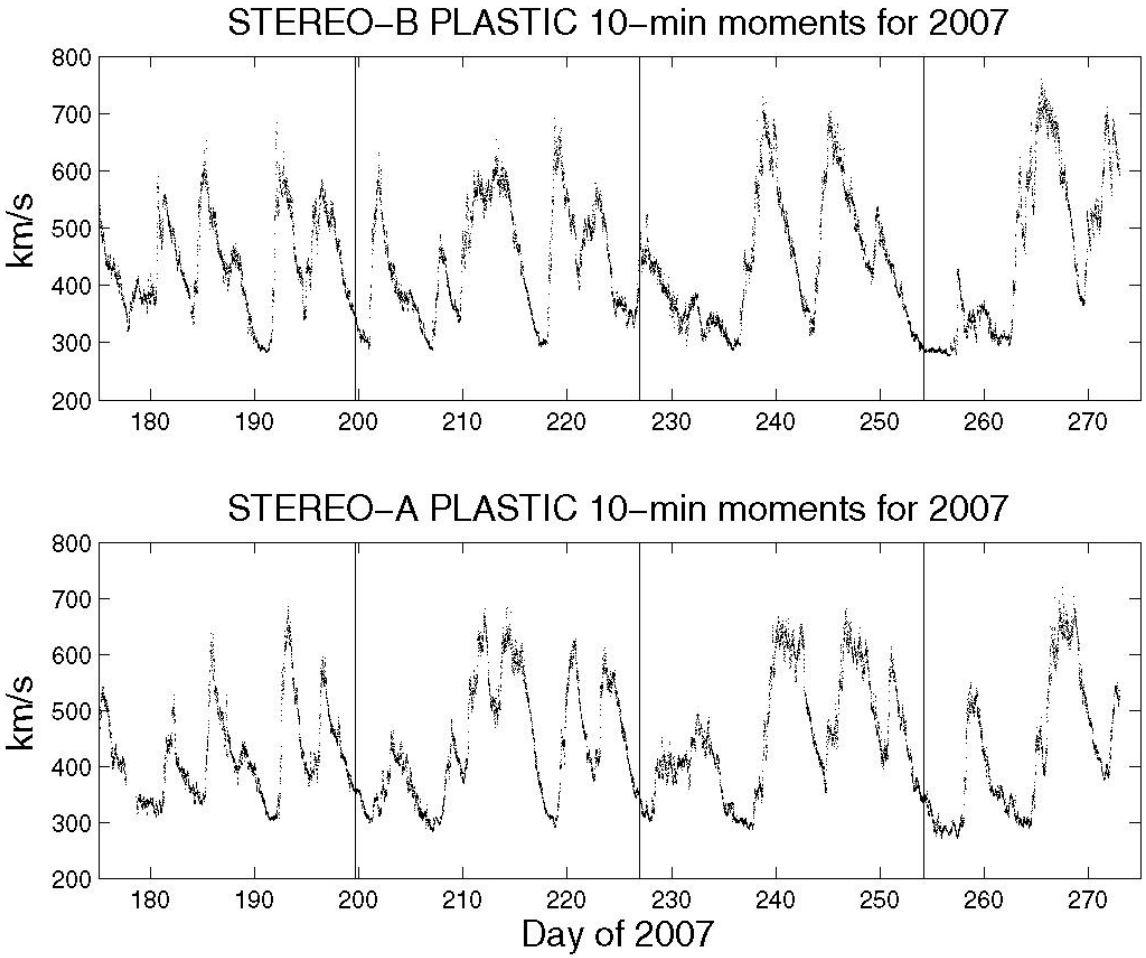
(a)



(b)

The late 2007 L1 sources were not as well modeled. (Compare early 2007 at left (a) and later 2007 at right (b).) One possible explanation is that the real solar wind stream structure is not steady on a 27-day timescale as assumed.

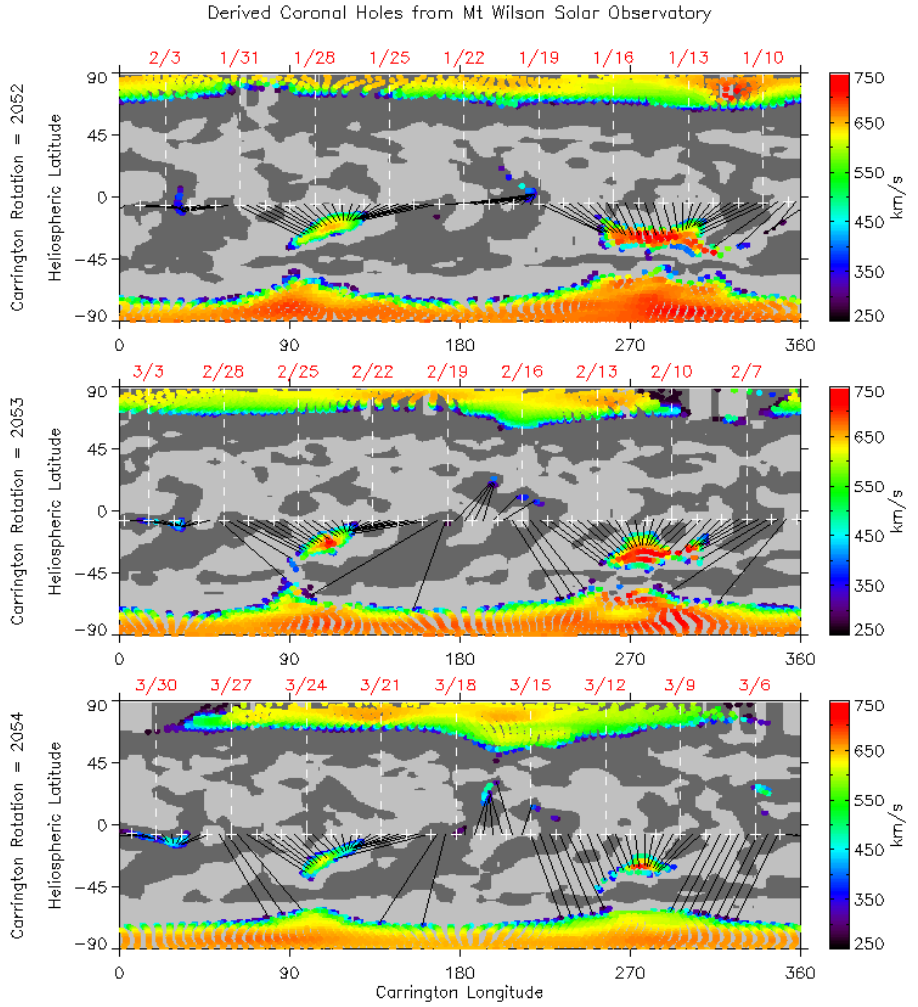
Comparison of separated STEREO A and B data (PLASTIC and MAG) tested stream structure steadiness

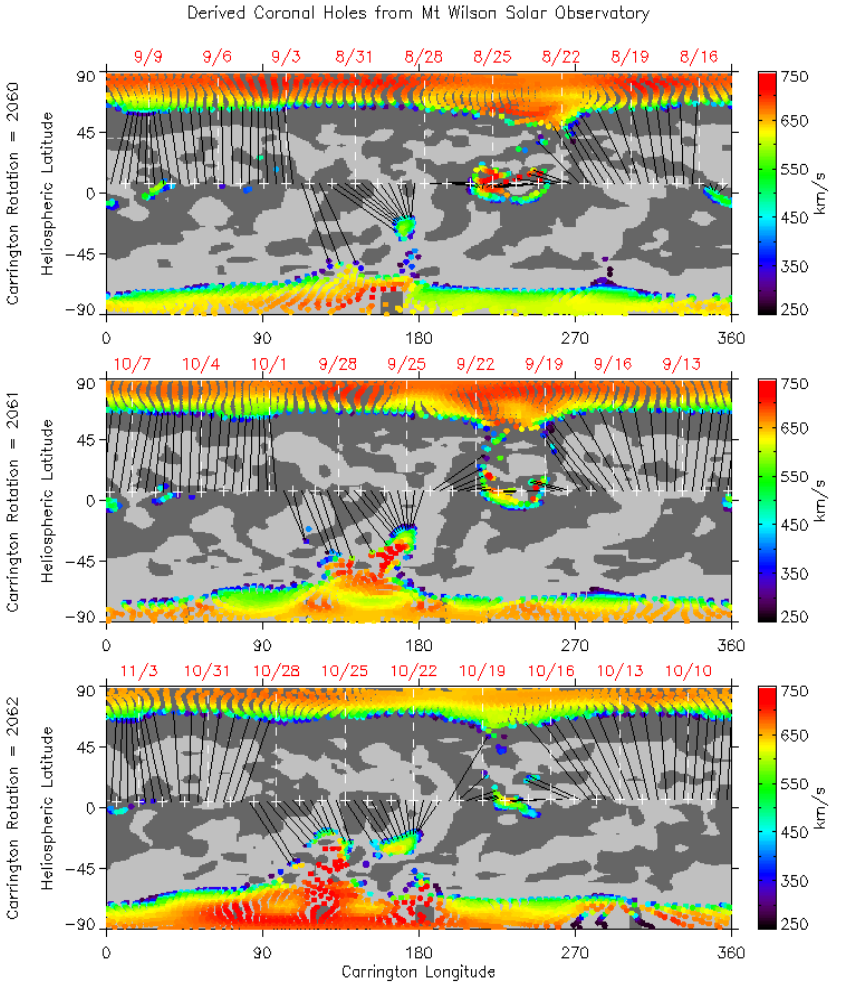


Conclude unsteadiness is not the cause of model disagreement.

Must be the source mapping at this time.

We are exploring why the early 2007 model source mapping (left) was better than for late 2007 (right).





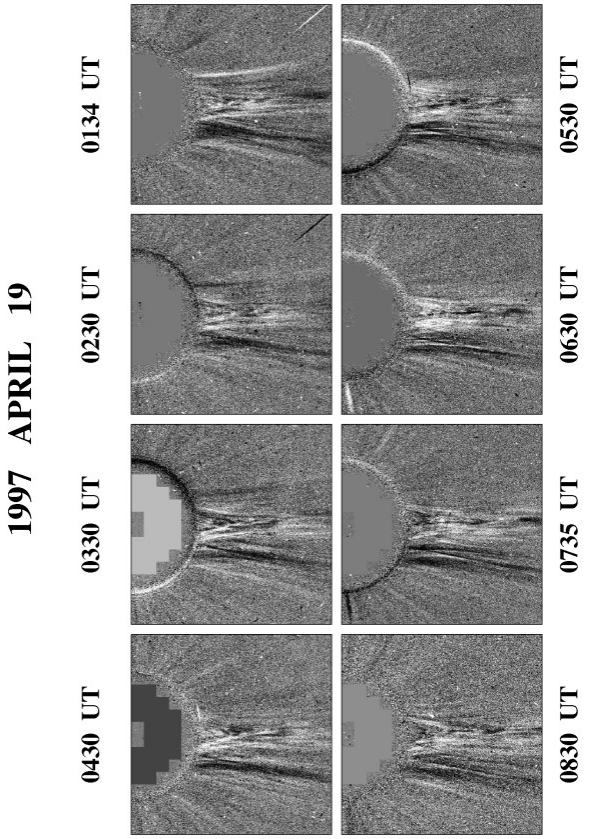
WSA model plot from NOAA NSWPC website

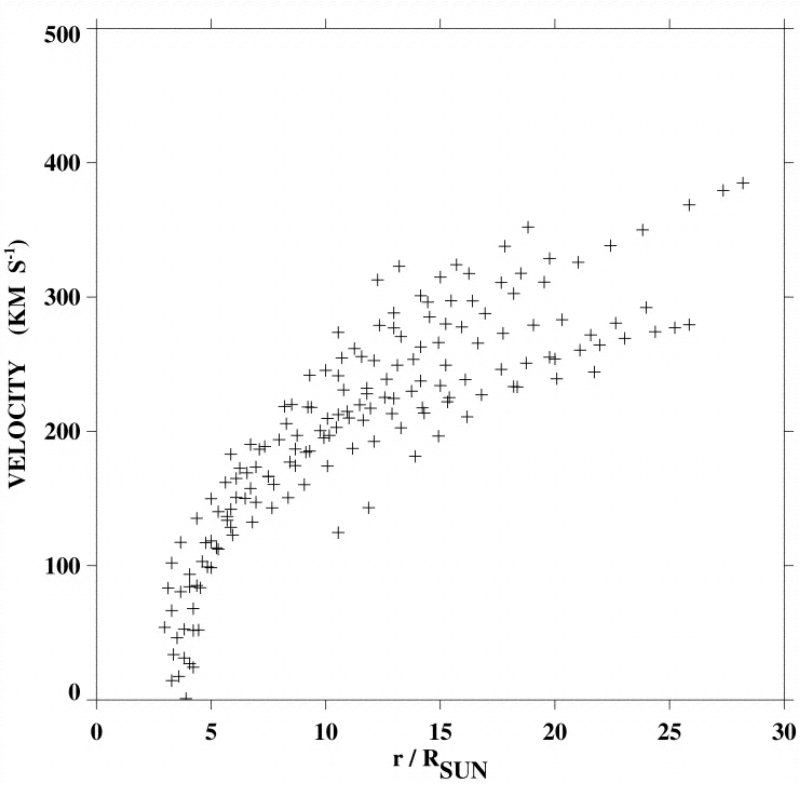
Conclusions so far

- Fast solar wind stream structure observed on STEREO looks fairly steady in 2007 (near solar minimum) over ~45 deg separations
- 3D, magnetogram-based solar wind models describe the early 2007 period very well but the late 2007 period much less well. Separated STEREO data suggest the reason lies in the model source mapping rather than stream structure evolution. We are finding this may be related to the current weak solar polar field.

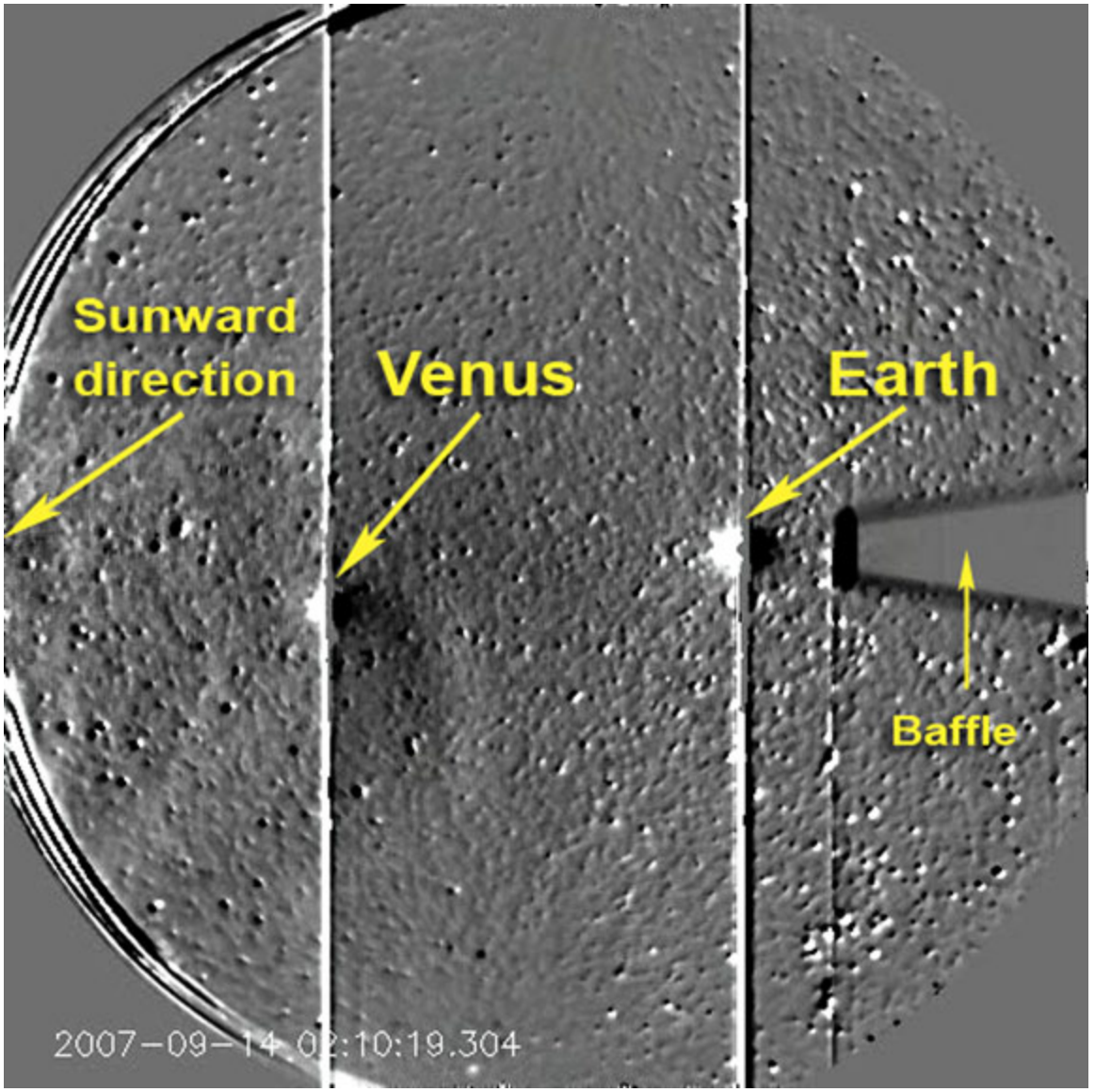
Slow Solar Wind

It has been recognized for some time that the slow solar wind includes a transient component. Wang et al. (ApJ 1998) used LASCO blobs as tracers of slow solar wind from apparent streamer belt source(s)



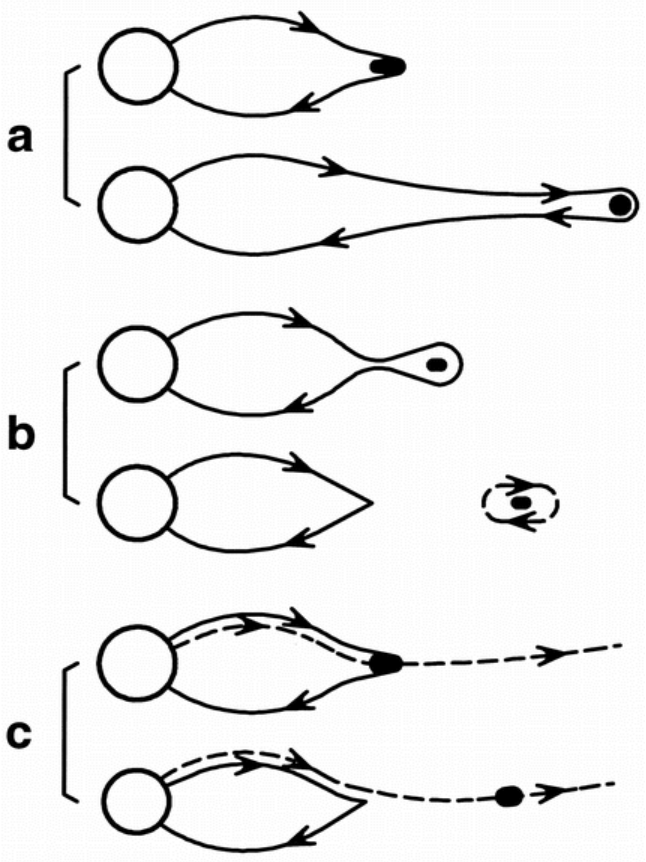


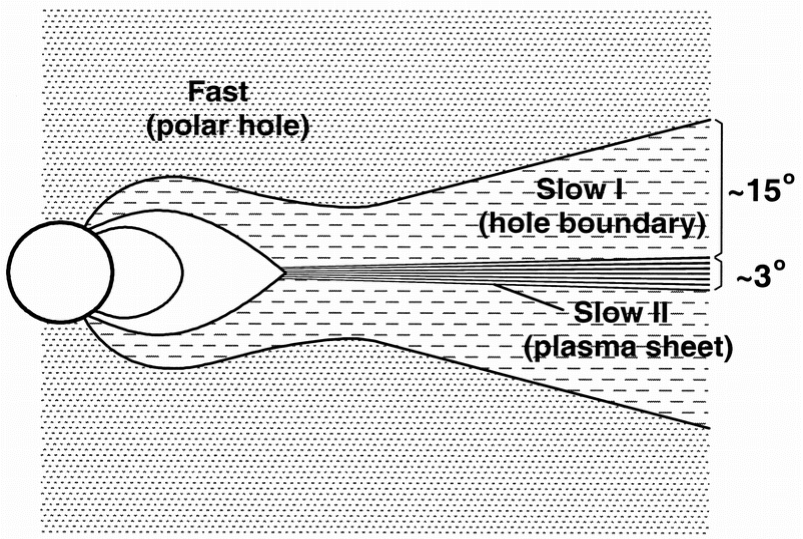
(SECCHI website Image)



SECCHI HI observations of structures on many scales moving to and beyond 1 AU reinforce this picture.

One expects to observe the in-situ signatures of this transient component at the interplanetary boundaries of solar wind streams





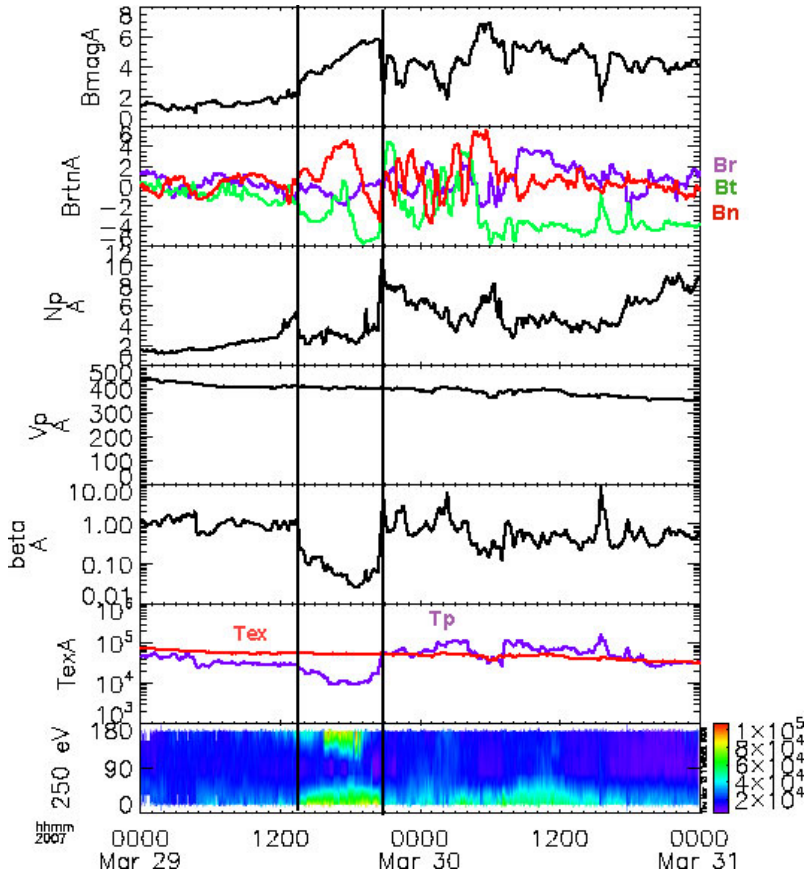
(Cartoons from Wang et al., ApJ paper)

In-situ signatures of small scale transients may include one or more of:

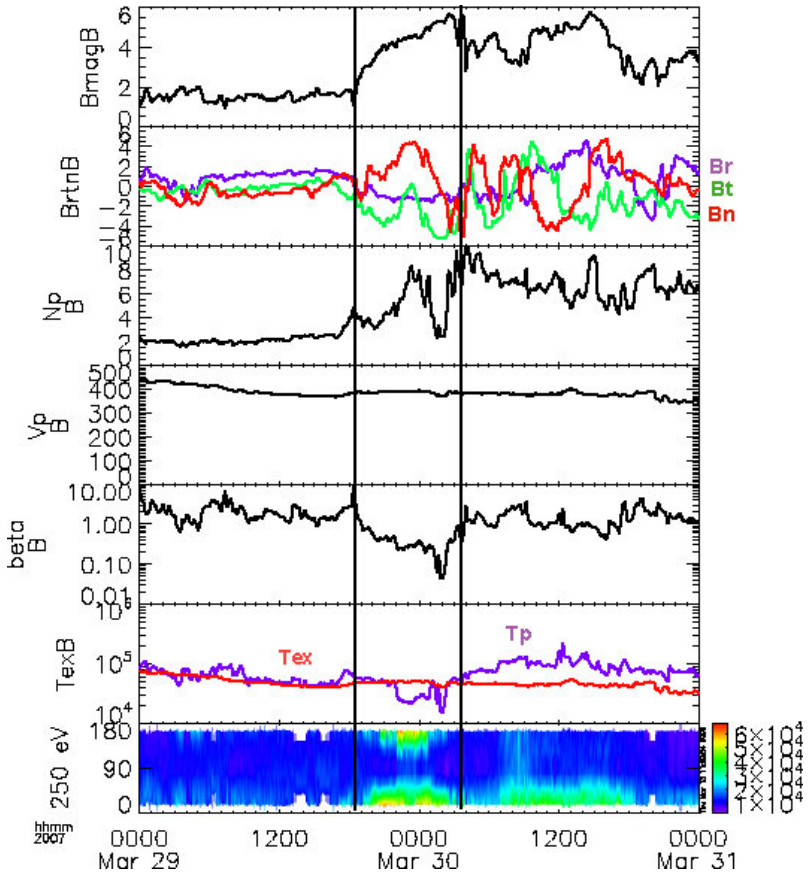
- Birectional electron heat fluxes
- False magnetic polarity reversals (periods of heat flux beams or strahl traveling toward the Sun)
- Heat flux ‘dropouts’
- Periods of low ion temperature (like ICMEs)
- Magnetic field signatures suggesting twisted structures, loops, plasmoids, U’s, and/or multiple current sheets

-These have been investigated with single spacecraft observations by Crooker et al. and Kahler et al. since the early 90s. STEREO and models make mapping to the solar sources a new possibility.

Example of a small transient using combined IMPACT MAG and SWEA and PLASTIC data (E. Huttunen)

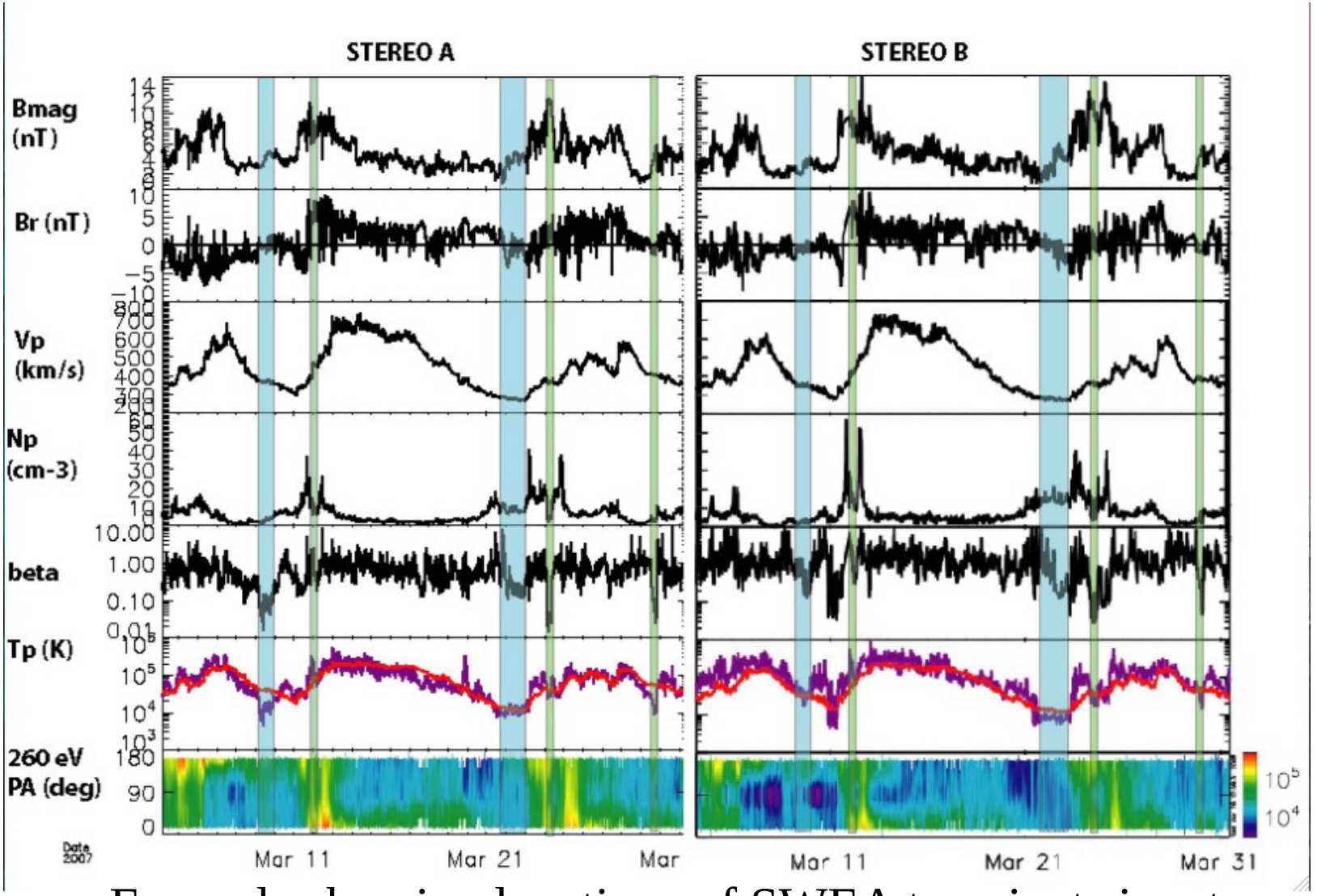


STEREO A



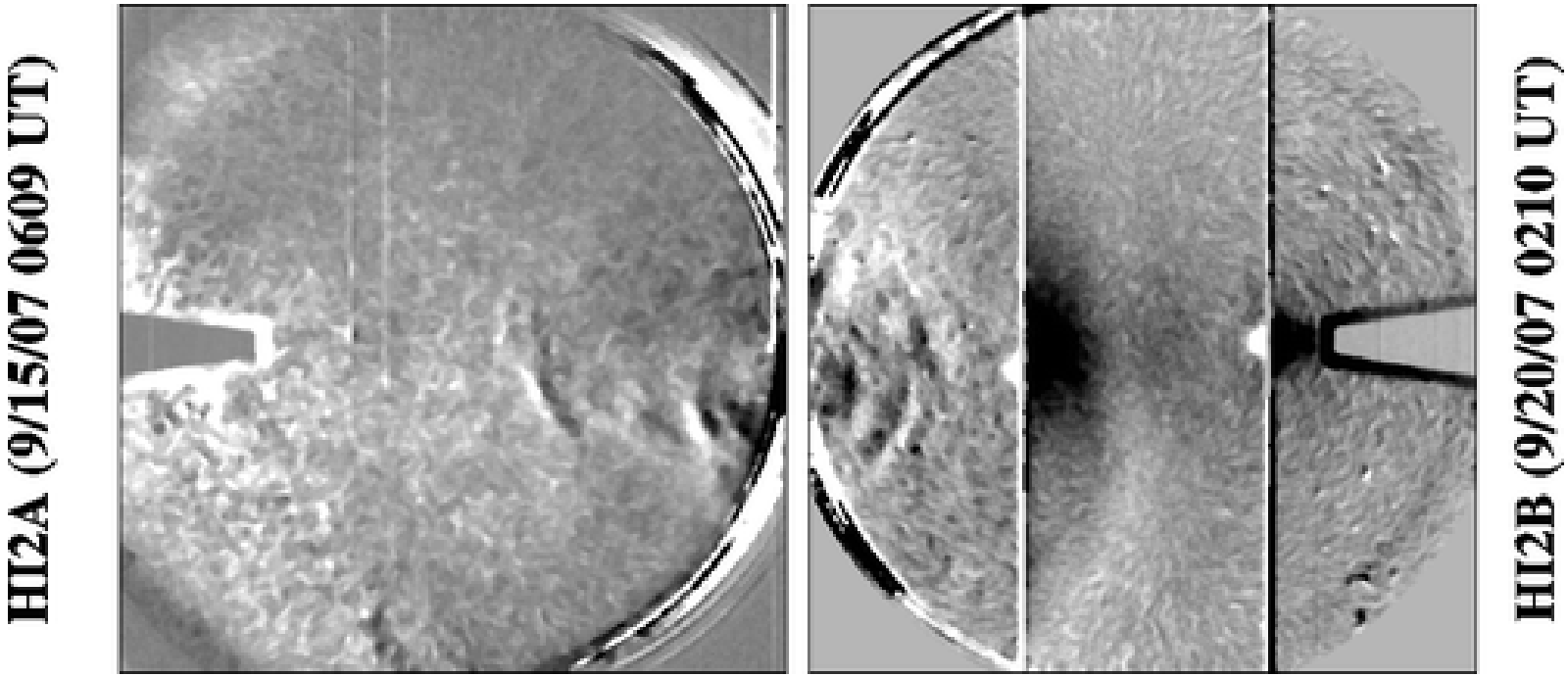
STEREO B

CR2054 IMPACT MAG and SWEA and PLASTIC data

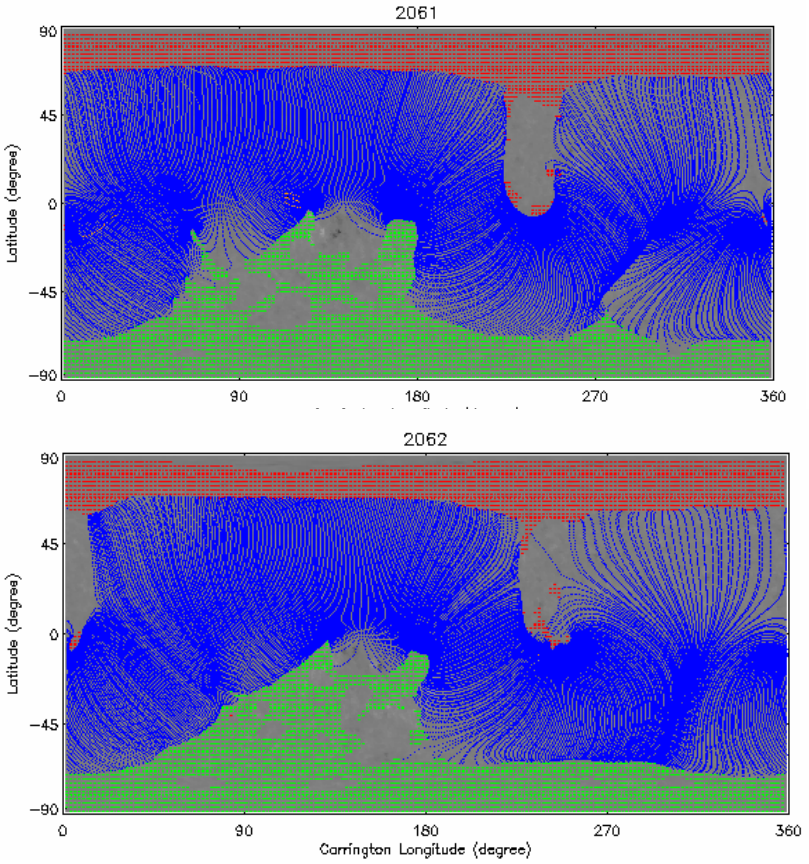


Example showing locations of SWEA transient signatures in slow wind for CR 2054 (E. Huttunen)

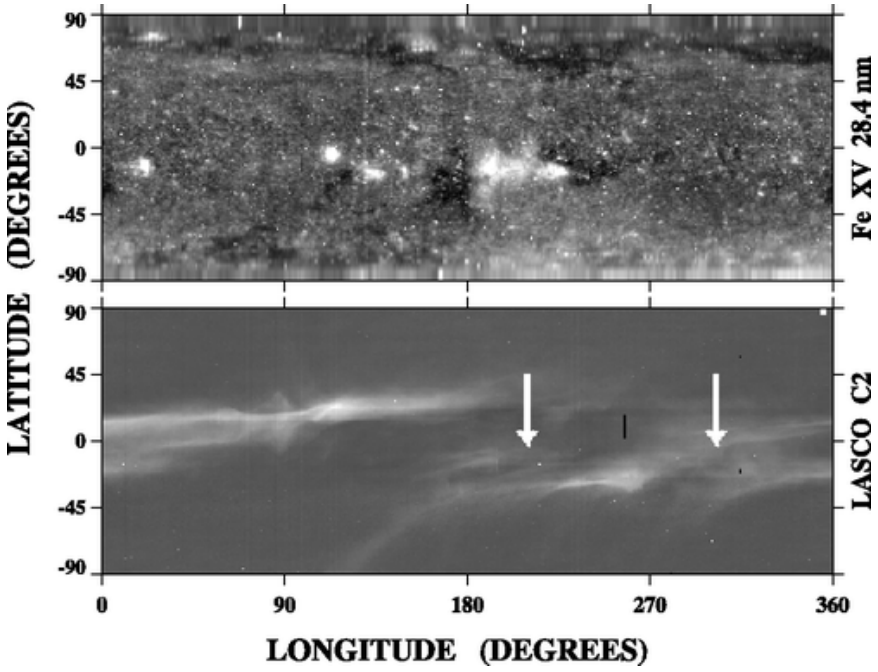
Sheeley et al., ApJ 2008 recently reported small scale transients originating in the STREAMER belt as seen with SECCHI HI



GONG magnetogram-based PFSS models provide approximate updated coronal field geometry several times an hour, showing changes in response to evolving photospheric fields

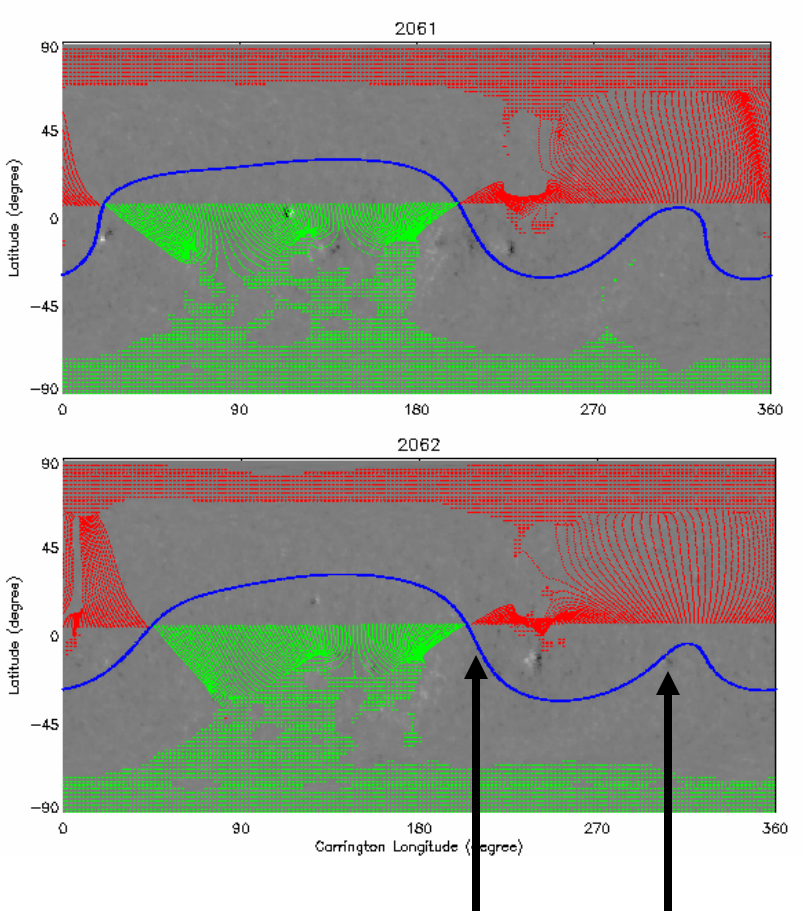


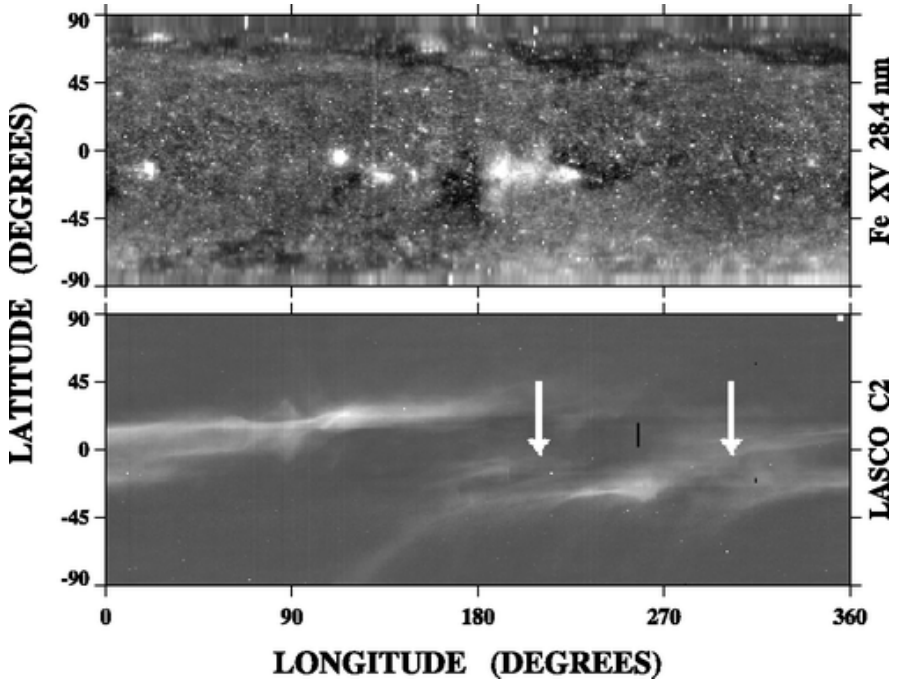
(G. Petrie-GONG website)



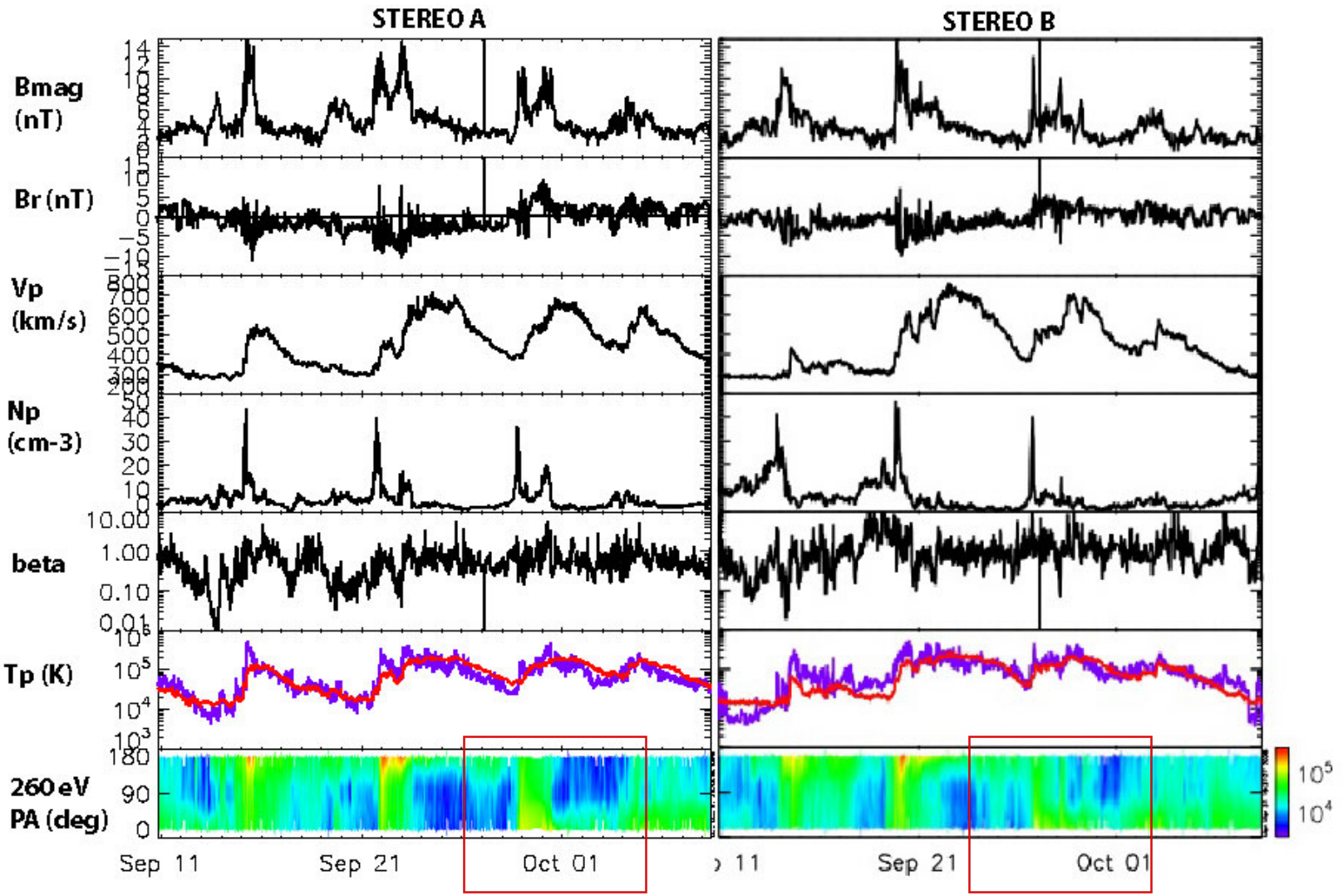
(N. Sheeley et al., ApJ 2008, showing probable blob origins in streamers during CR2061)

GONG PFSS-based ecliptic mappings (left) imply related solar wind sources (here, change between CRs)





CR2061 IMPACT MAG and SWEA and PLASTIC data



We are using the STEREO data and the models to see if we can relate these portions of the streamer belt to in-situ transients.

Conclusions so far

- The contribution of the transient component to the slow solar wind remains an outstanding and important question
- SWEA suprathermal electrons are now available to investigate transients in the solar wind on all scales at multiple locations
- Specific comparisons with SECCHI images may be possible as the spacecraft continue to separate
- Modeling with time-dependent solar wind source models may help us to identify locations where transient solar wind should be observed, and some of its expected characteristics