Detection of downflows with Metis and ASPIICS observations

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10th Metis Workshop, February 11-13, 2026

Metis observations @perihelion

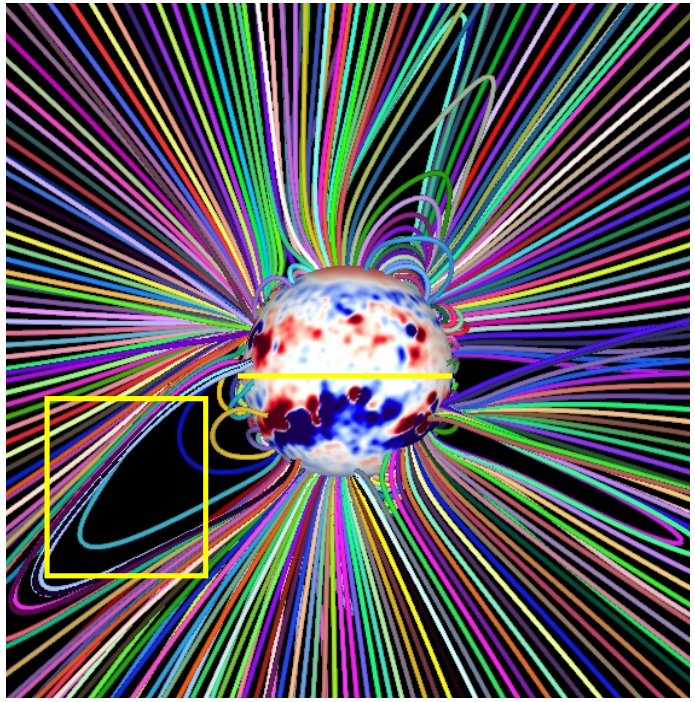
Date	Start obs.	End obs.	Type of obs.	texp	Duration
12/10/2022	09:30:31	10:12:02	tB	20 s	41 m 31 s
12/10/2022	10:15:01	20:18:45	tB	120 s	10 h 3 m 44 s
13/10/2022	01:15:01	10:04:13	pB	60 s	8 h 49 m 12 s

Date	Start obs.	End obs.	Type of obs.	texp	Duration
13/04/2023	01:18:00	02:40:43	tB	20 s	1h 22 m 43 s
13/04/2023	03:30:00	09:04:03	tB	60 s	5h 34 m 03 s
13/04/2023	09:07:00	14:41:03	tB	60 s	5h 34 m 03 s

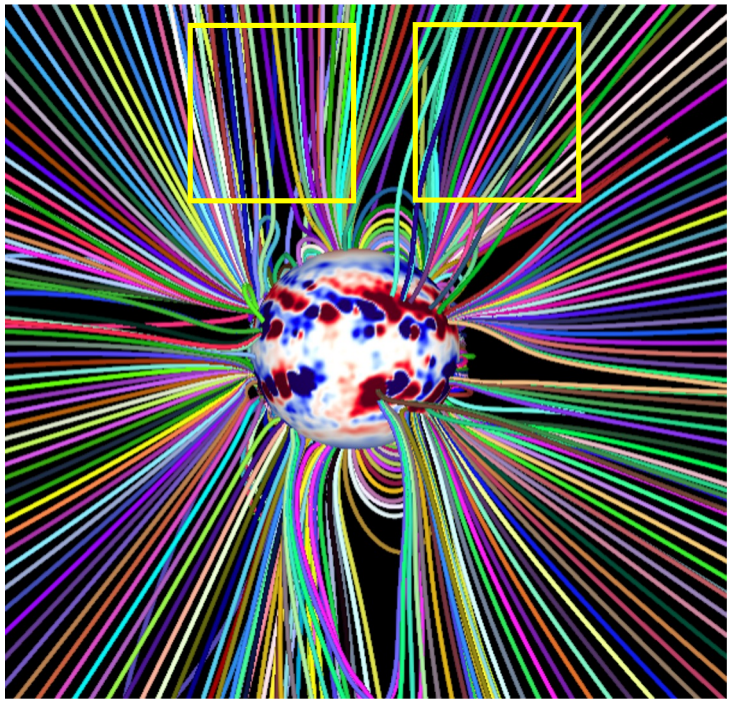
Date	Start obs.	End obs.	Type of obs.	texp	Duration28
28/09/2024			tB	20 s	4 days

The FOV of all observations ranges from 1.7 to 3.5 Rsun

MHD extrapolation maps (PSI)



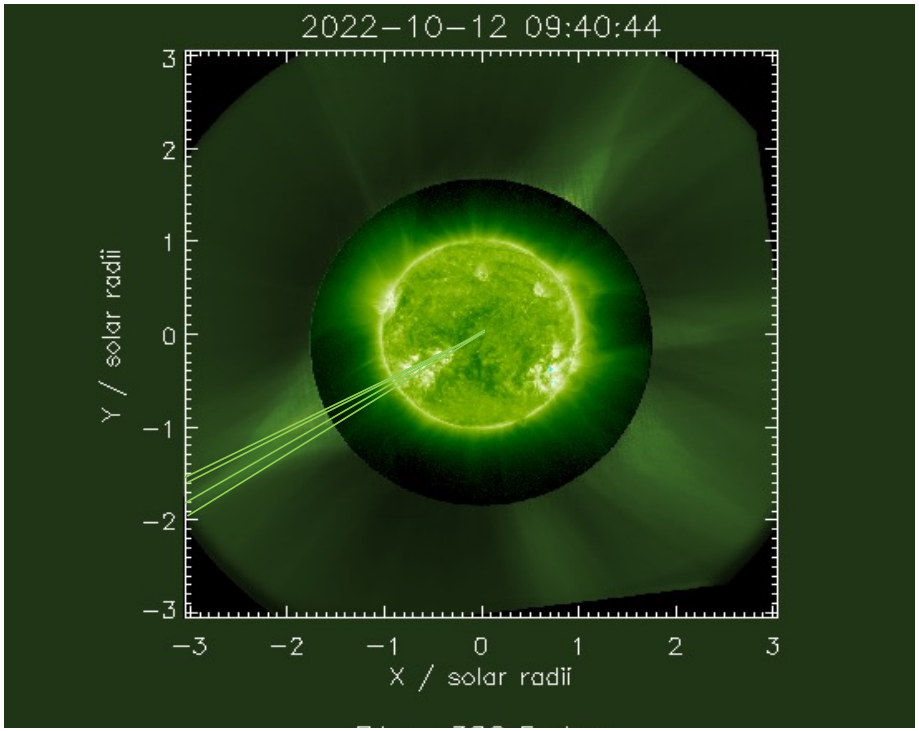
12-13 Oct 2022

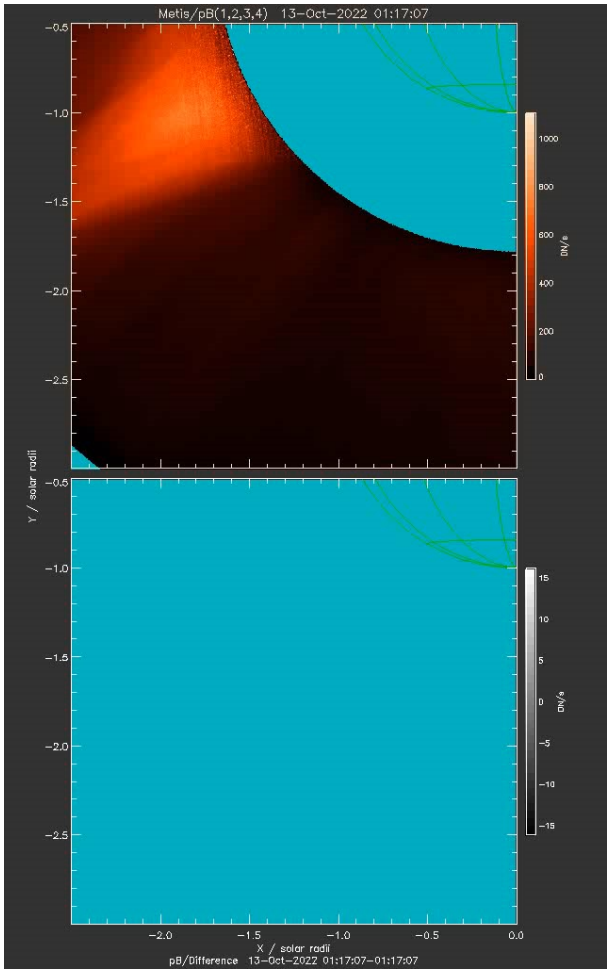


13 Apr 2023

Inflows and collapsing loops observations

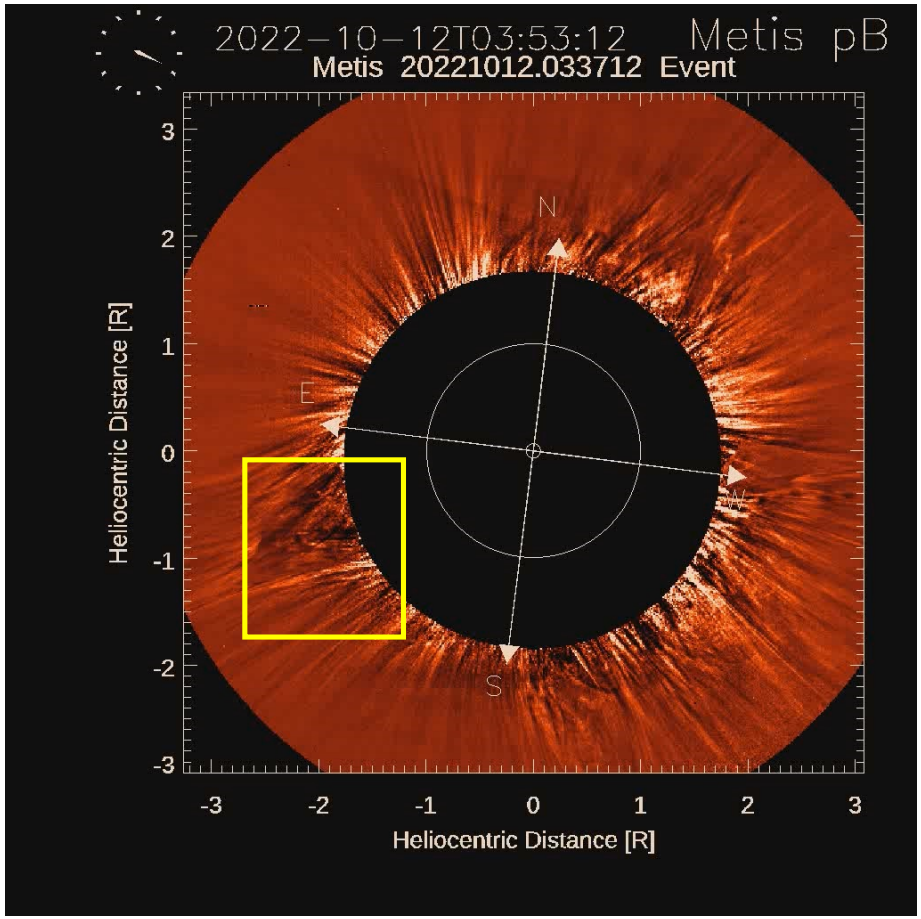
13 Oct 2022 – pB running difference images

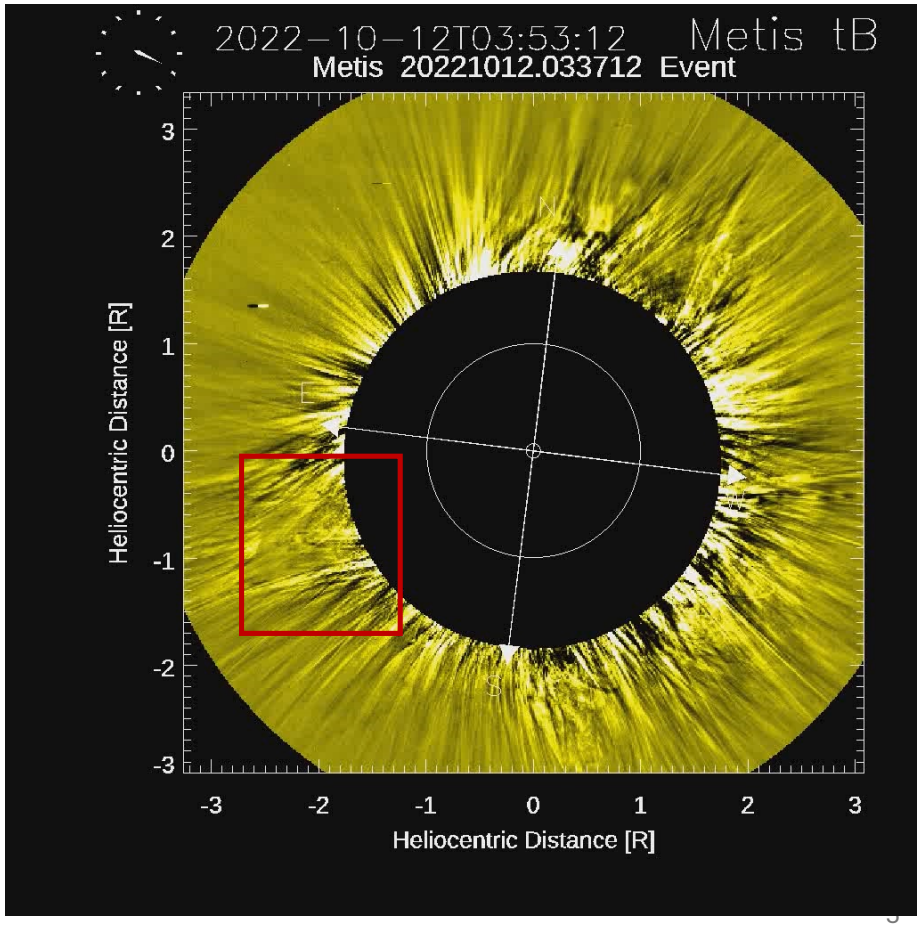




Inflows and collapsing loops observations

12 Oct 2022 – pB and tB running difference images





High cadence observations in VL

Metis high cadence observations provide a new window on the dynamics of the solar corona in a range of physical parameters never explored before.

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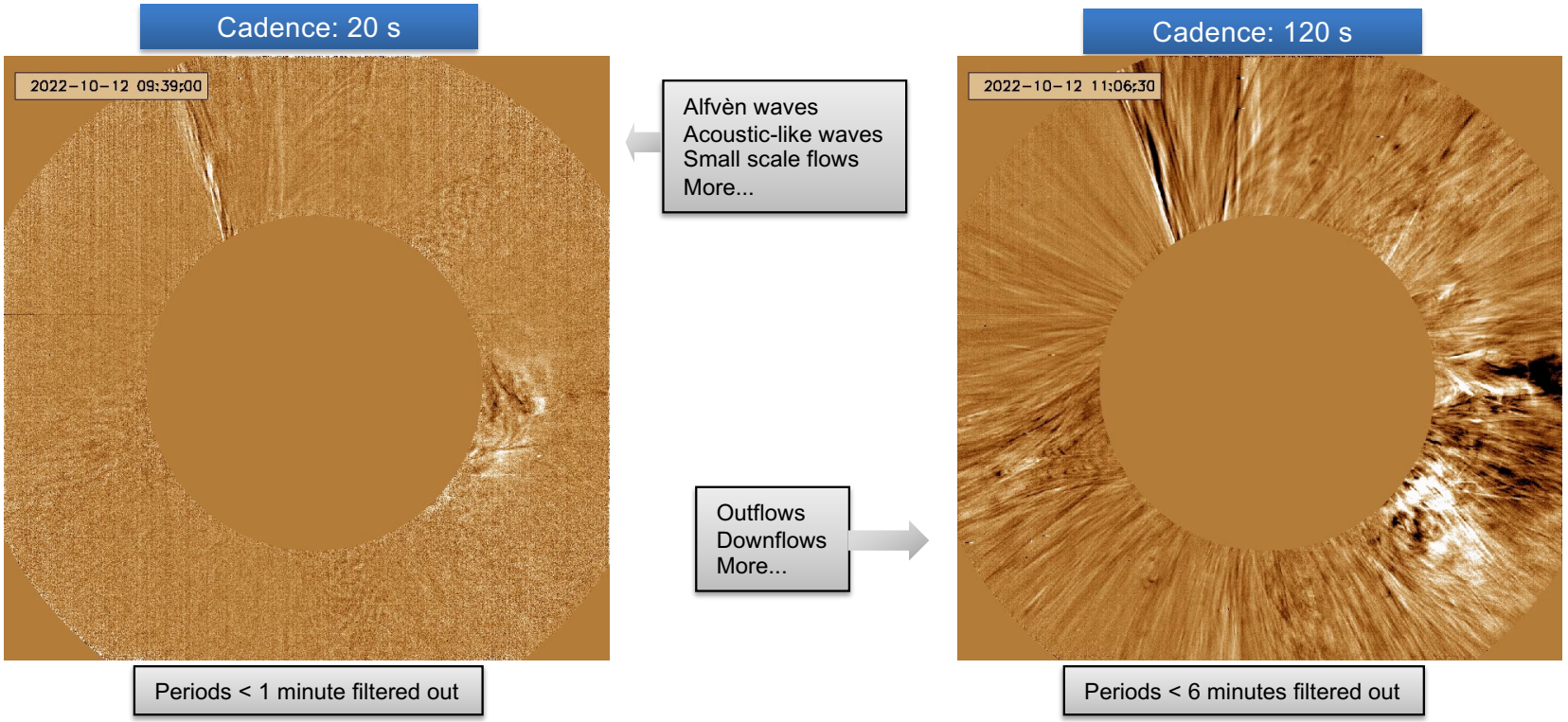
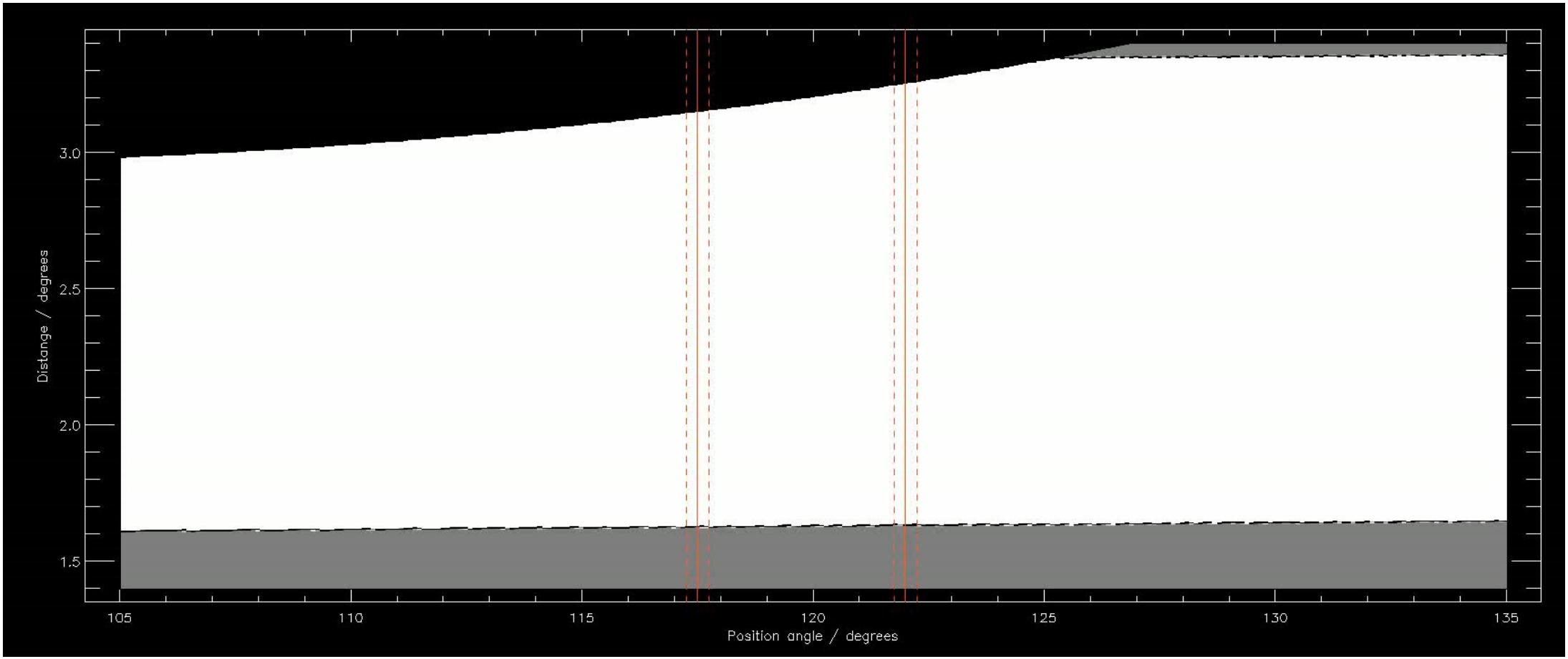


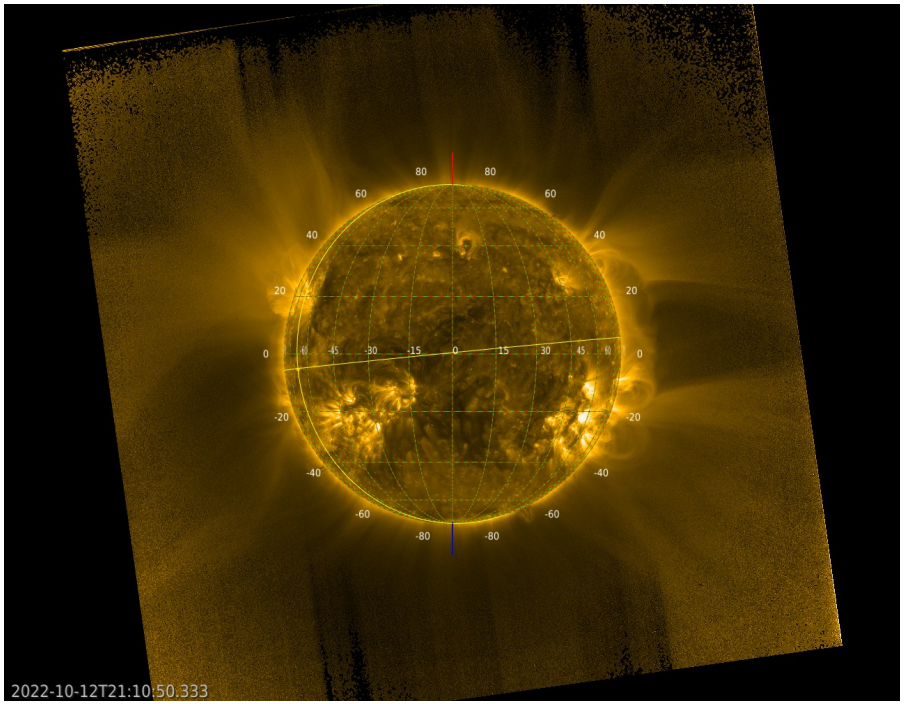
Inflows (collapsing loops observations) and downflows



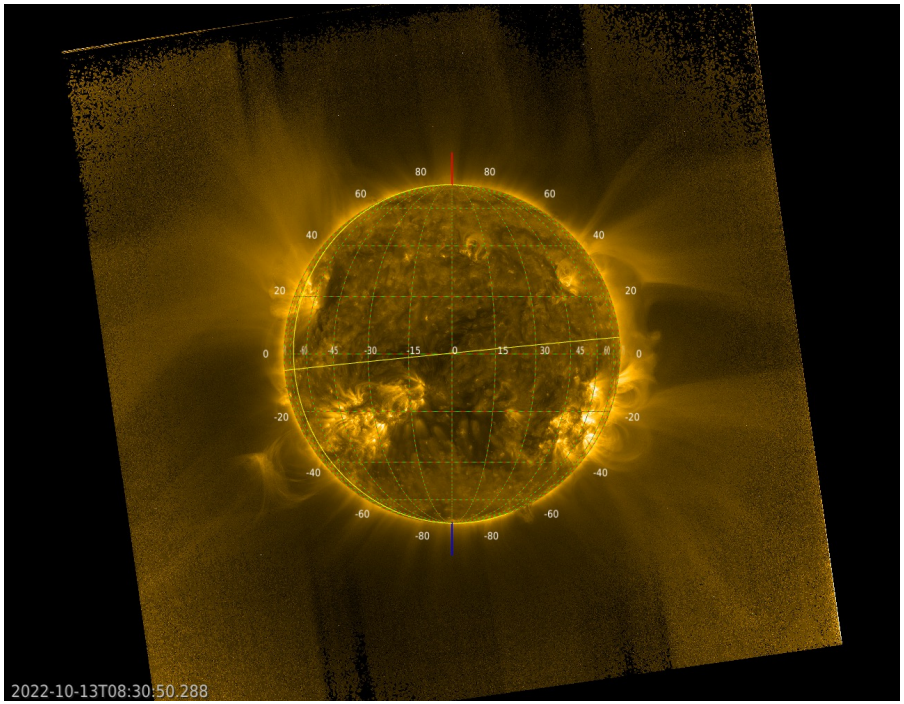
12 Oct 2022 – tB running difference – images in polar coordinates

Cadence 120s, Duration 10 h 3 m 44 s = 604 m

EUI observations



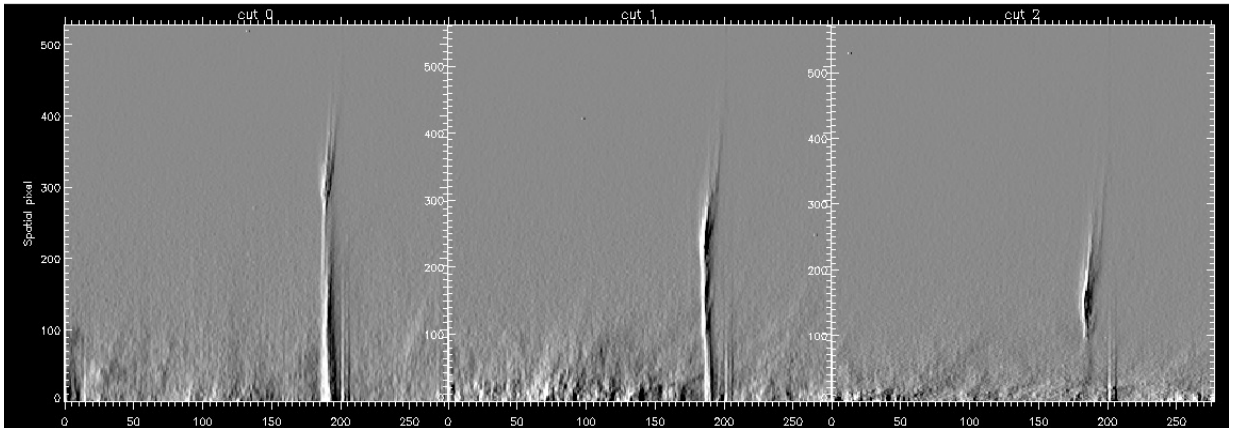
FSI 174



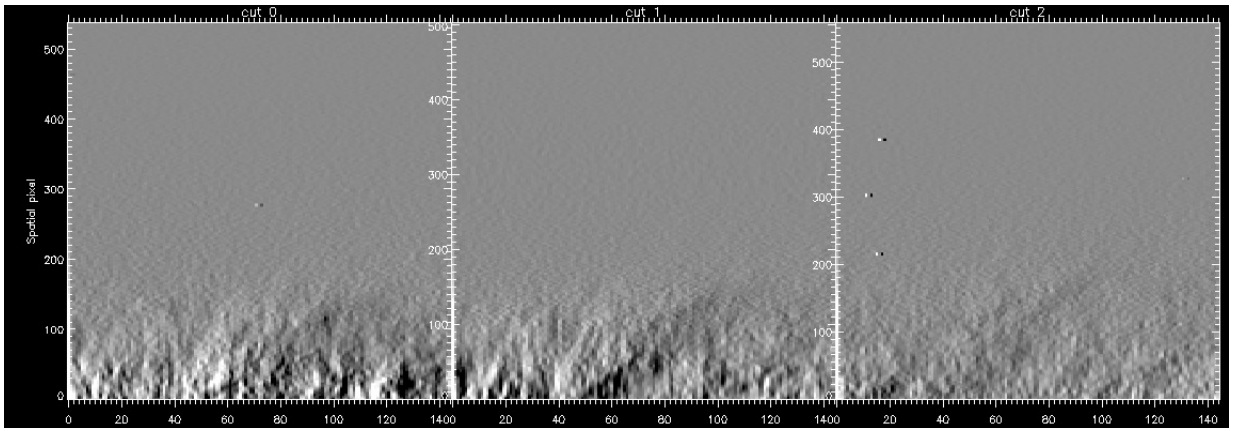
Region at SE, eruption starting at around 05:30, Oct13

12-13 Oct 2022

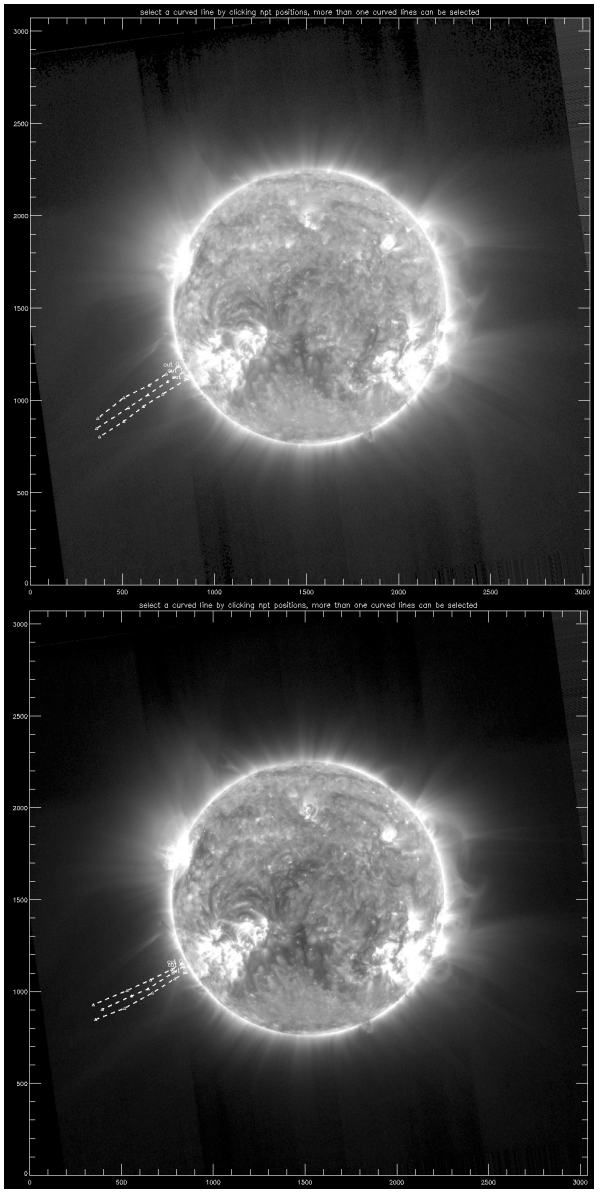
EUI observations



Lower cut Middle cut Upper cut



Lower cut Middle cut Upper cut



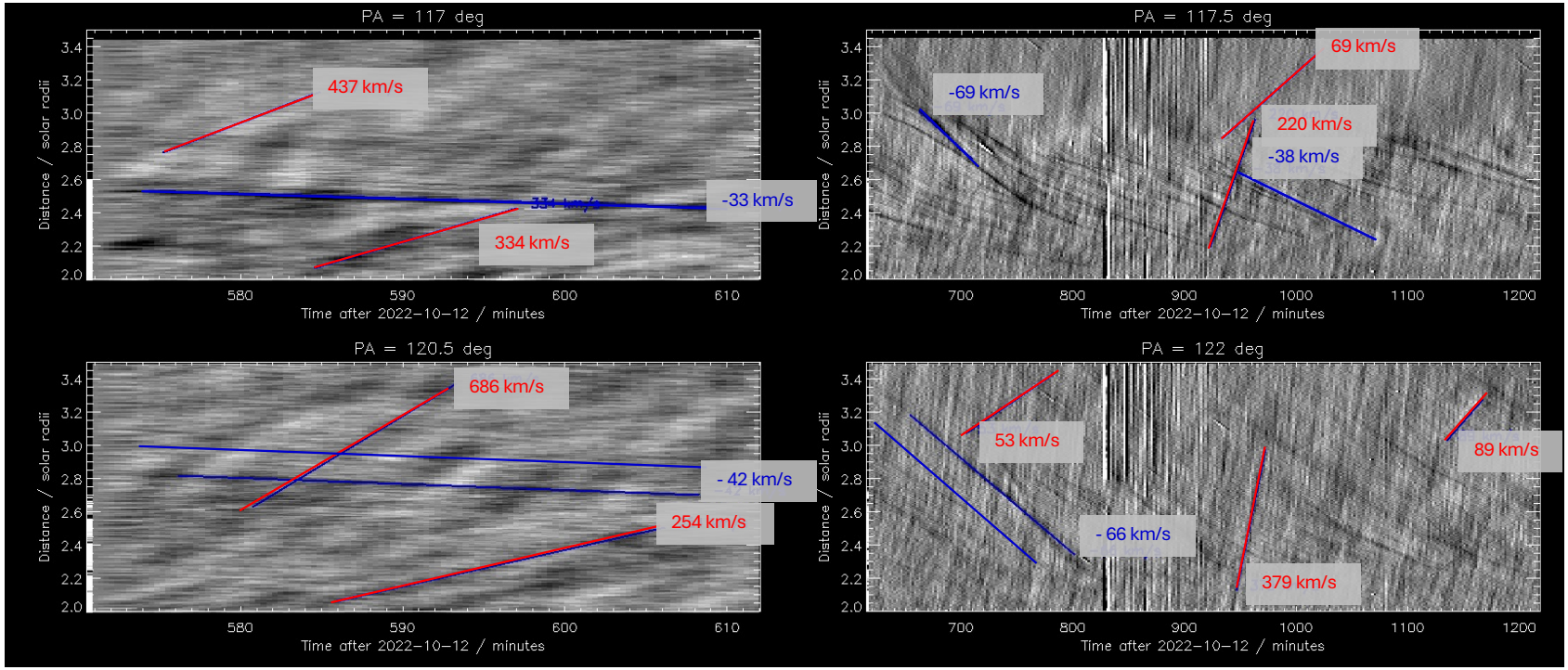
12-13 Oct 2022

Inflows (collapsing loops observations) and downflows

On Oct-12-13, studying the streamer structure at south east (PA 117°-122°), we observe several downflows with velocities from -30 to -70 km/s (obtained from J-maps at different PA) corresponding to collapsing loops as detected in the pB running difference images.

We detect also outflows with different ranges in velocity: between 50-90 km/s, 220-380 km/s, but also few cases with much higher velocities of 437 and 686 km/s at a height range 2.6-3.4 Rsun.

12 Oct 2022 – tB running difference, J-map (plot time-distance along a PA)

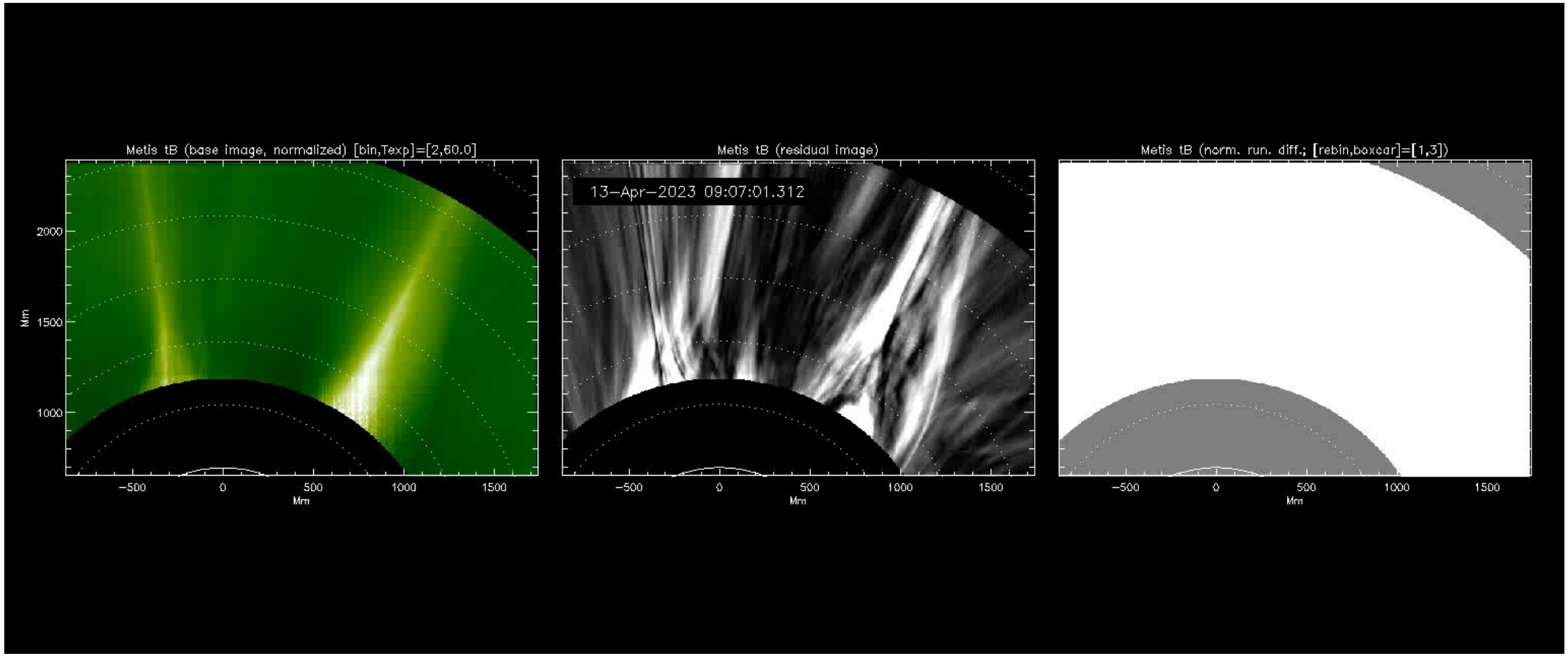


Cadence 20 s, Duration 41 m 31 s

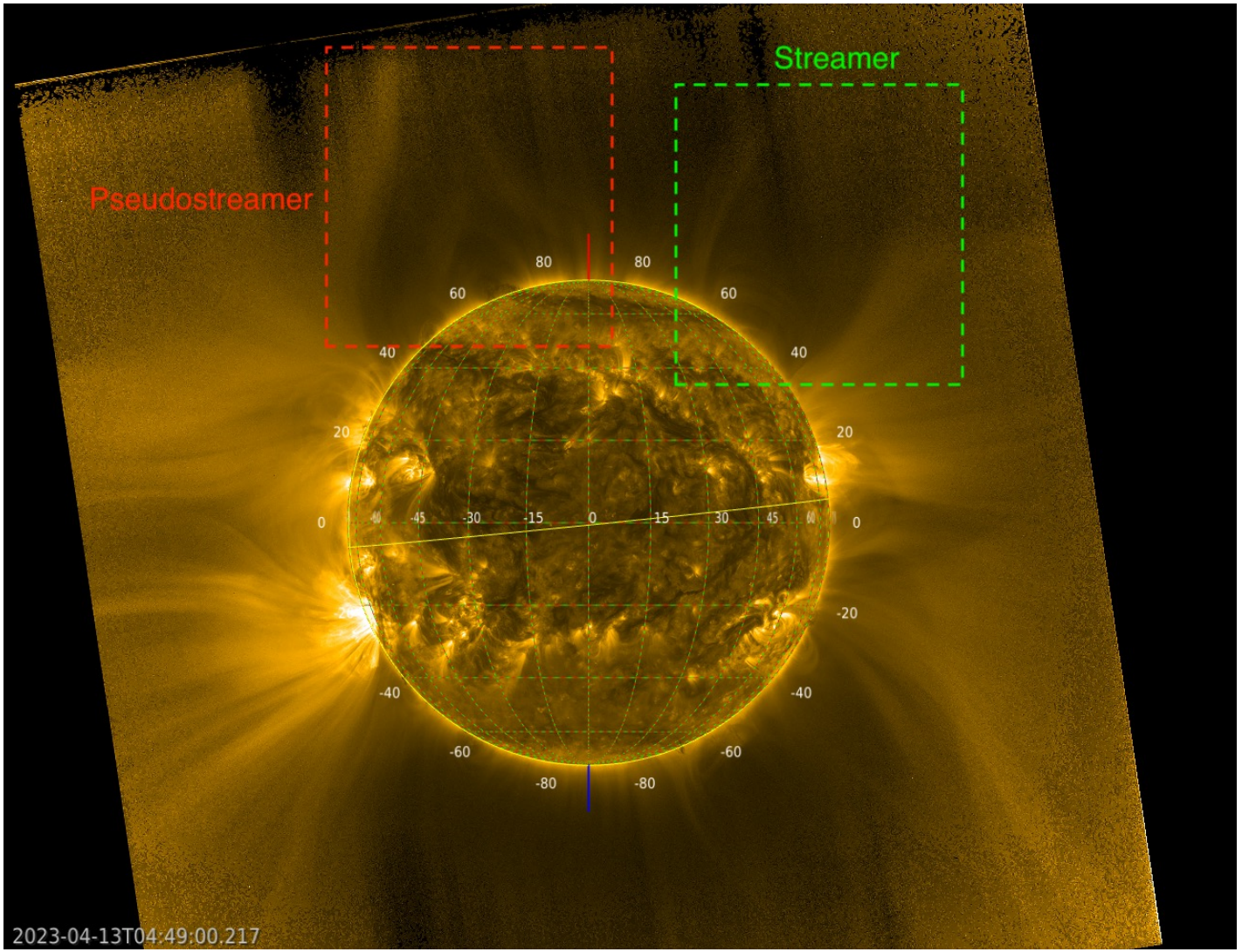
Cadence 120s, Duration 10 h 3 m 44 s = 604 m

Inflows on perihelion #3

13 Apr 2023 – tB running difference



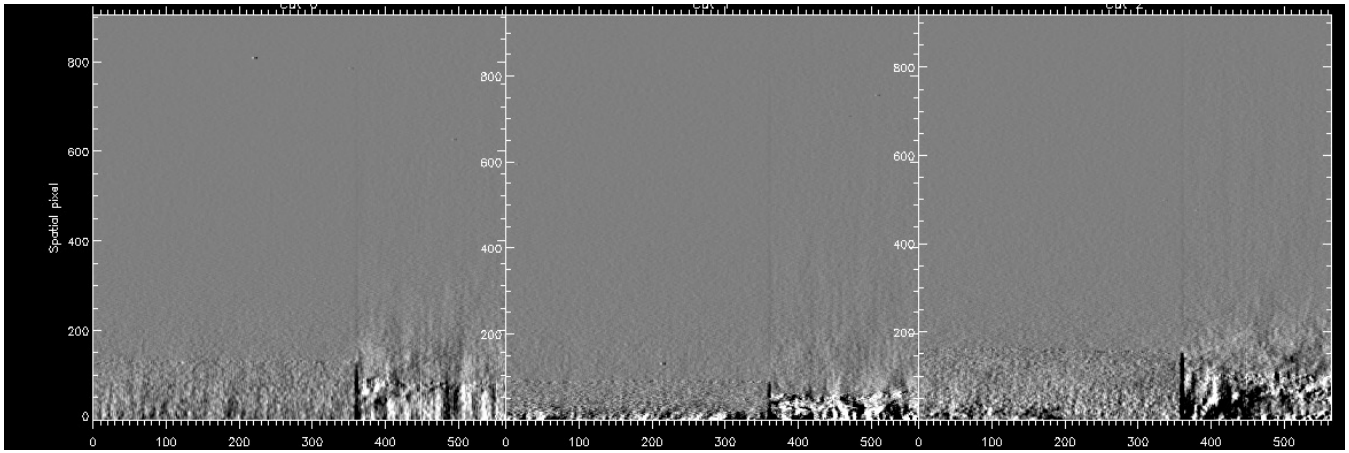
EUI observations



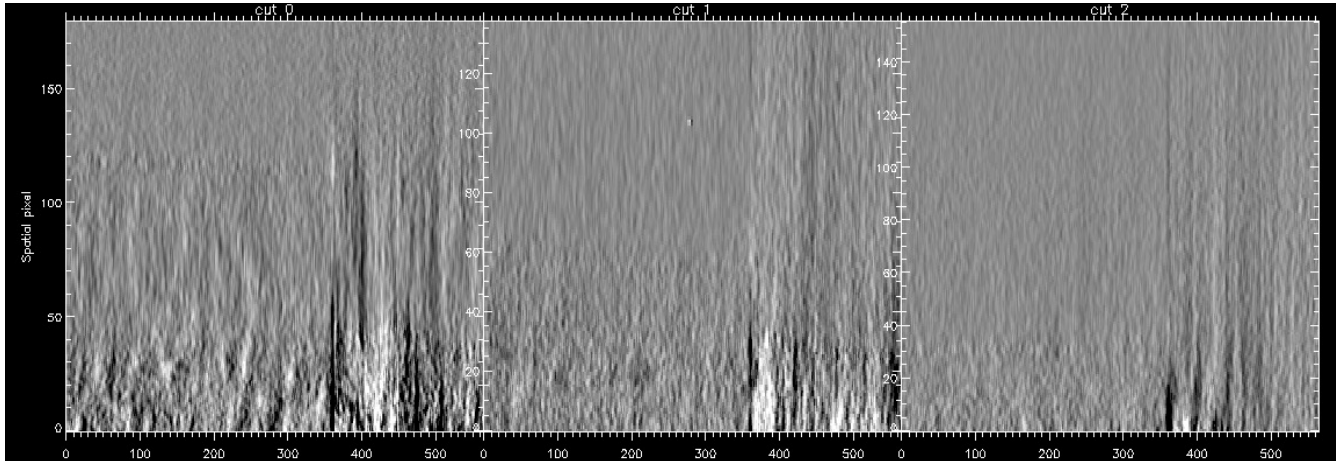
FSI 174

13 Apr 2023

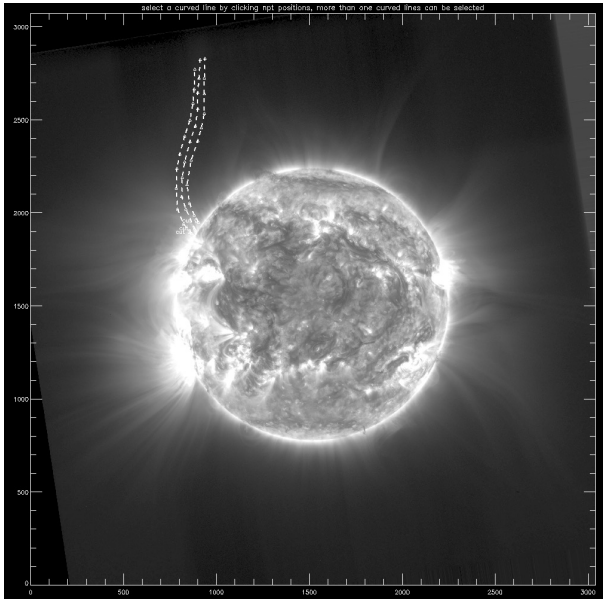
EUI observations

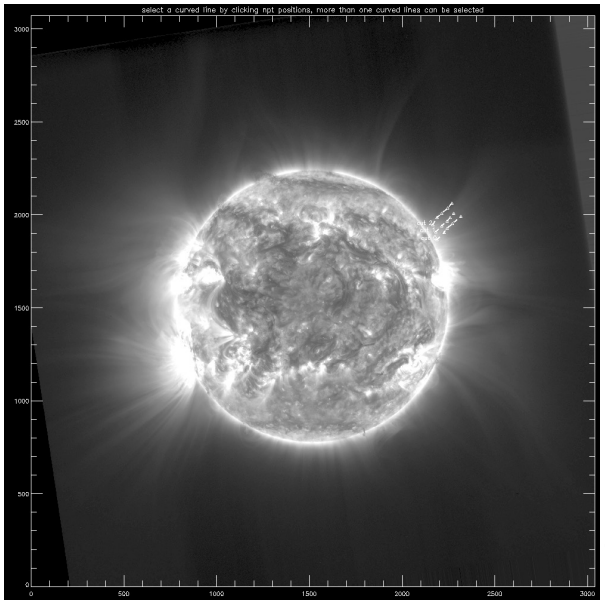


Left cut Middle cut Right cut



Lower cut Middle cut Upper cut

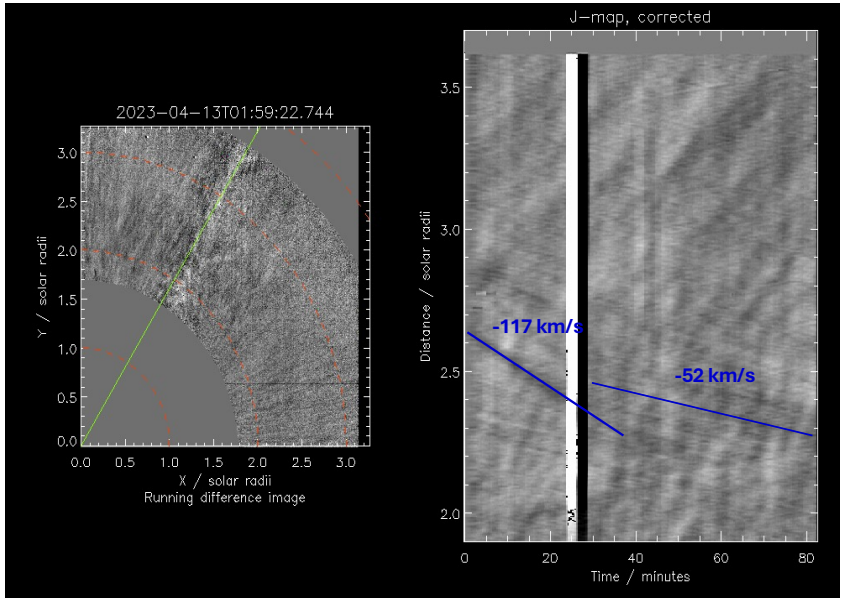




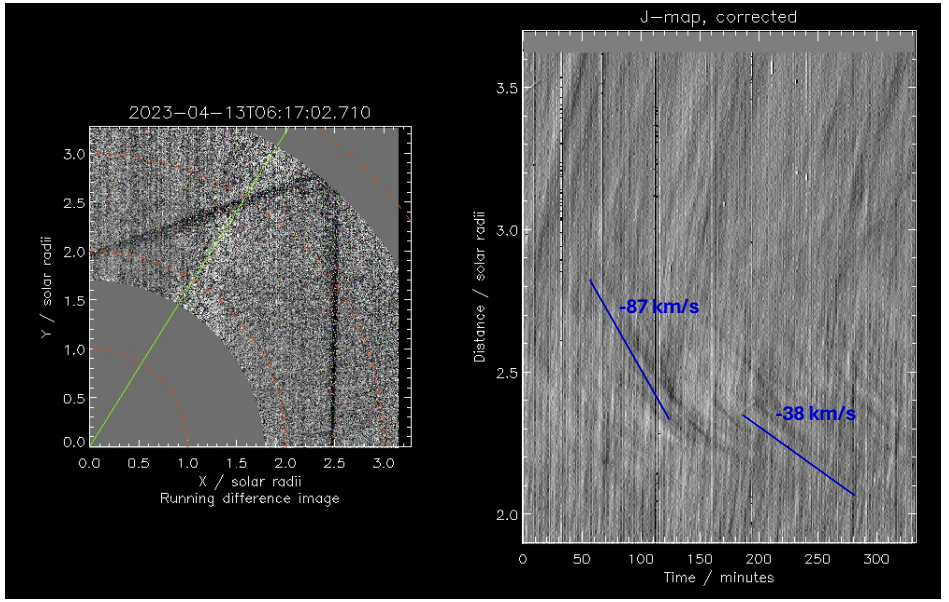
13 Apr 2023

Inflows on perihelion #3

13 Apr 2023 – tB running difference, J-map (plot time-distance along a PA)



82 m 43 s

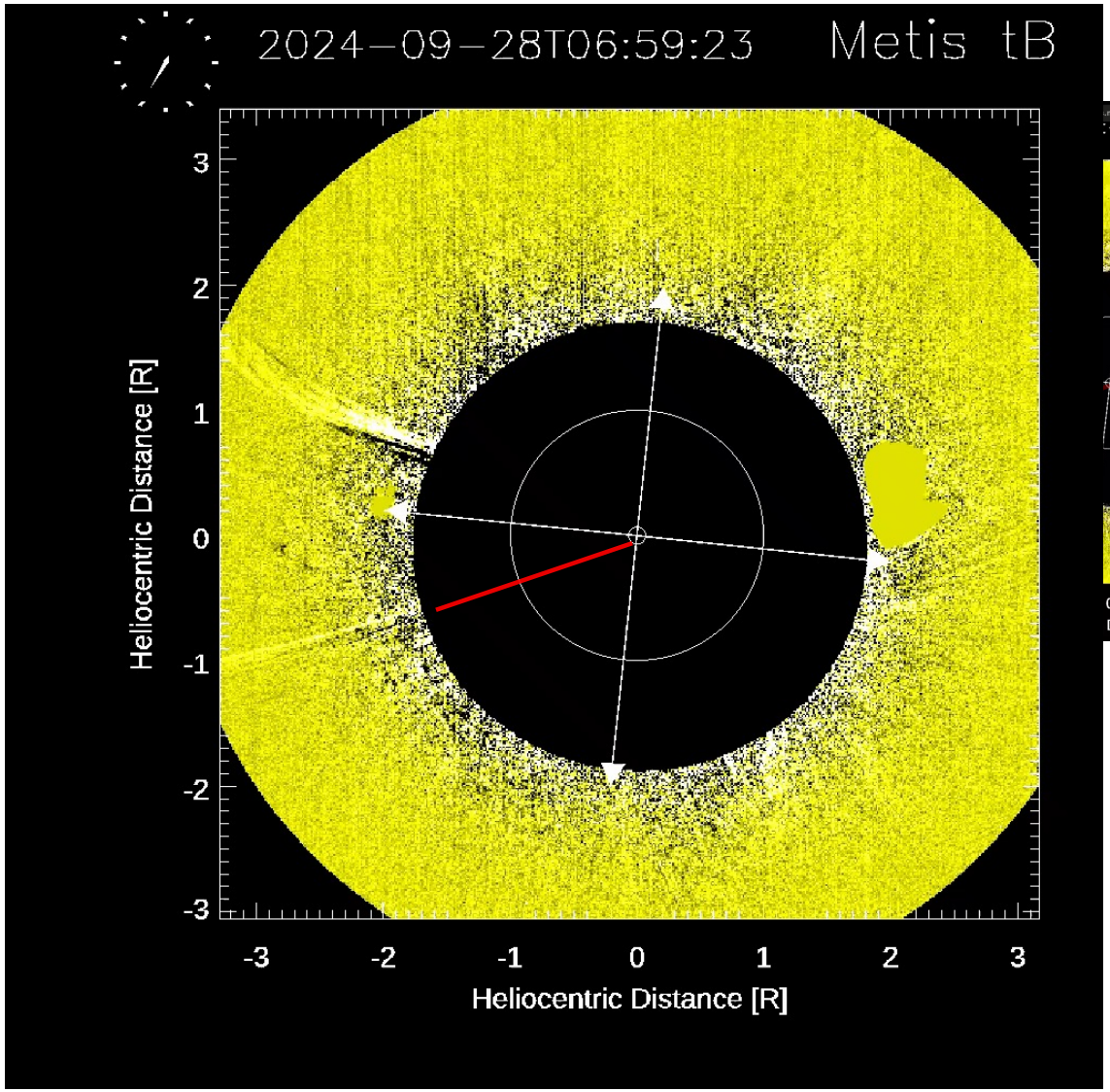


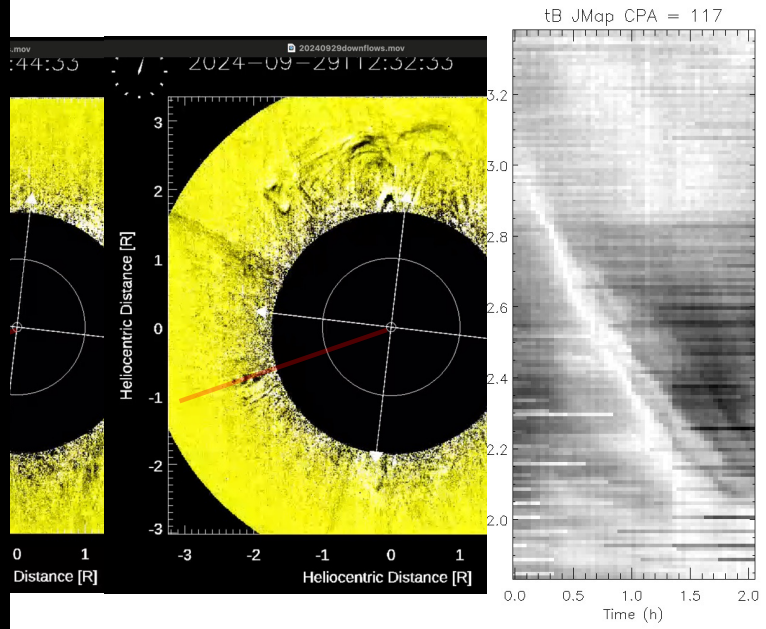
334 m 3 s

Studying the streamer structure on north west (PA=328°, along the streamer axis), we obtain from J-maps analysis, several downflows with velocities from -38 to -117 km/s between 2 and 3 Rsun. They present two different regimes in velocities: 90-120 km/s between 2.3 and 3 Rsun ans 40-50 km/s in the height range 2-2.5 Rsun.

The features are wide about **14 Mm (0.02 Rsun).** We have noticed that this kind of features are observed mainly along the streamer axis and they are not observed in pseudo-streamers

28 September -1 October 2024– tB running difference, J-map (plot time-distance along a PA)

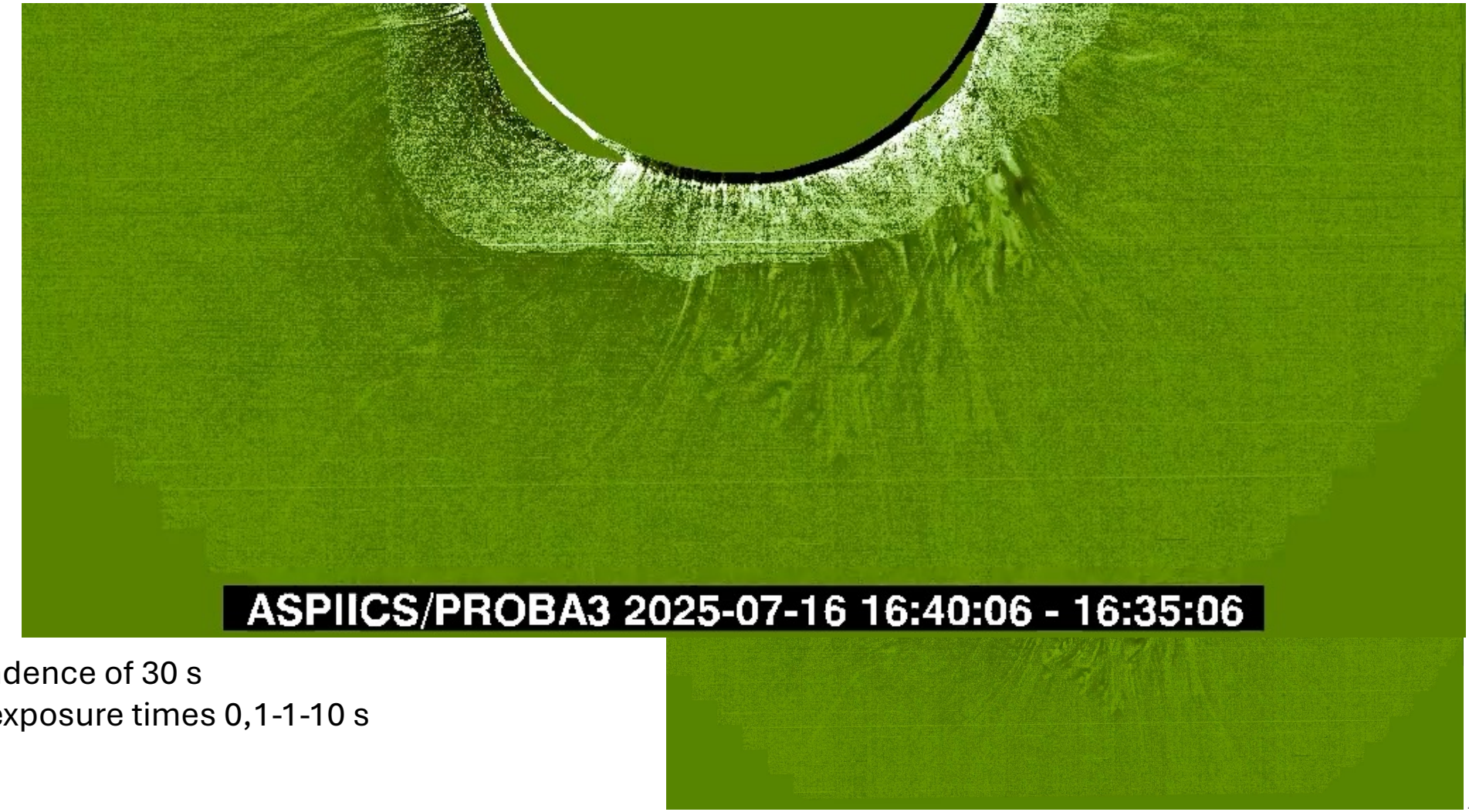




Several downflows are evident with higher constrast and dimensions, lasting for 2 days.

A first estimate of the velocity is about of 110 km/s from 2.6 and 2.2 Rsun.

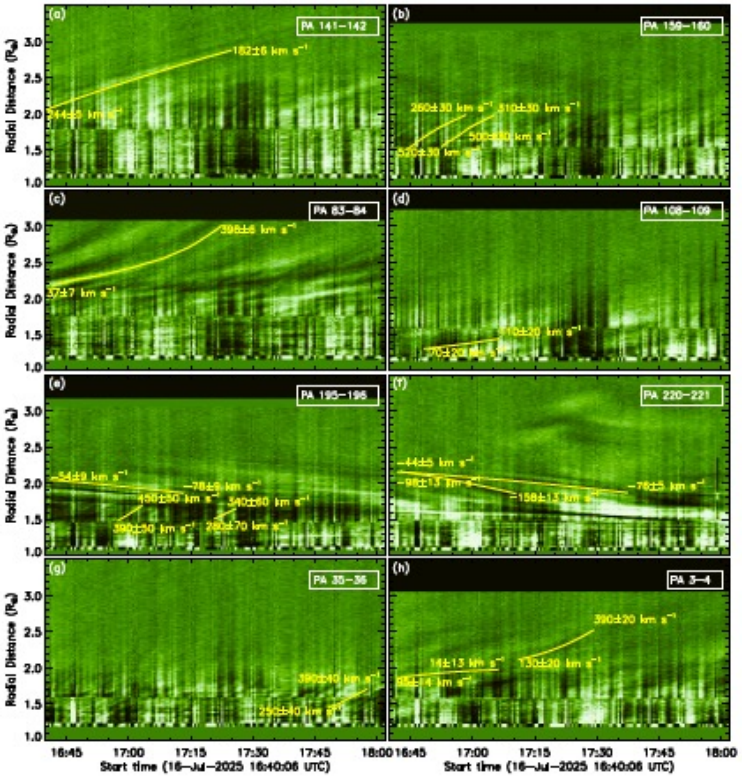
Inflows with ASPIICS



Cadence of 30 s
3 exposure times 0,1-1-10 s

Zhukov +, under review, 2026

Inflows with ASPIICS

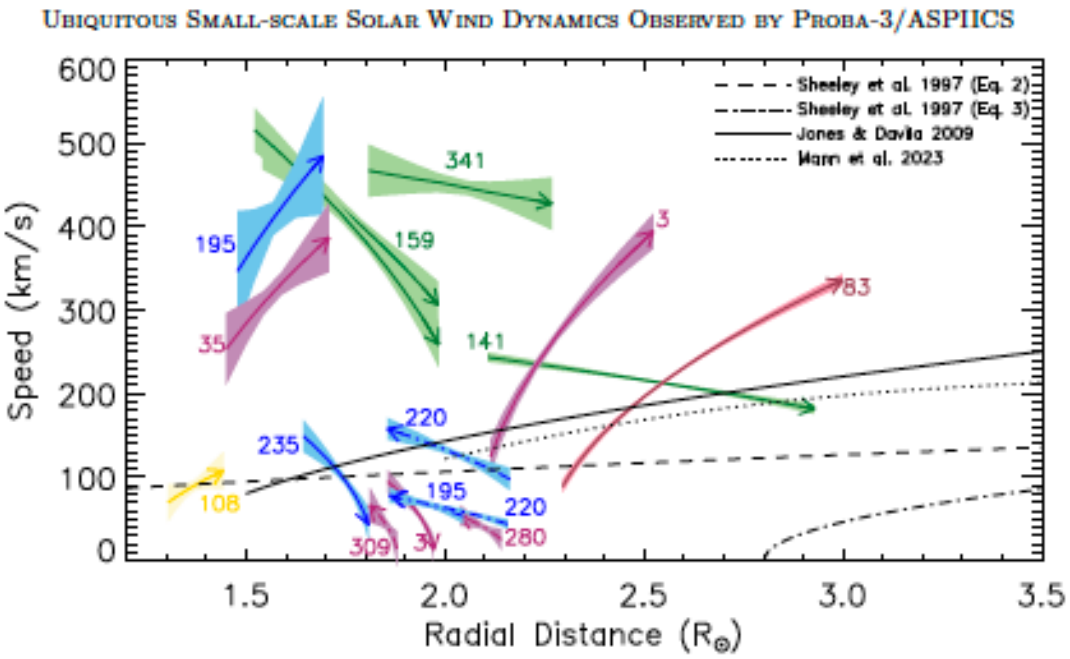


Difference image of the corona taken by Proba-3/ASPIICS in wide white-light passband (5510 Å) on 16 July 2025 at 16:55:06 UTC. A previous image taken at 16:50:06 UTC was subtracted.

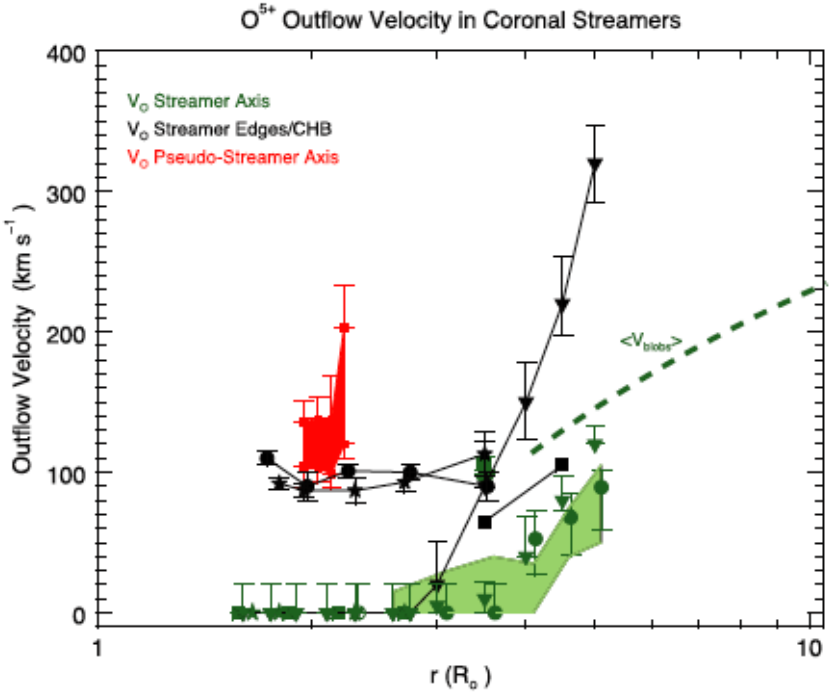
The inflows usually propagate at speeds around 100 km/s, although two inflows most prominent decelerate from 350 km/s to around 100 km/s, descending from around 3 R to less than 2 R in around an hour.

Zhukov +, under review, 2026

Inflows and outflows with ASPIICS

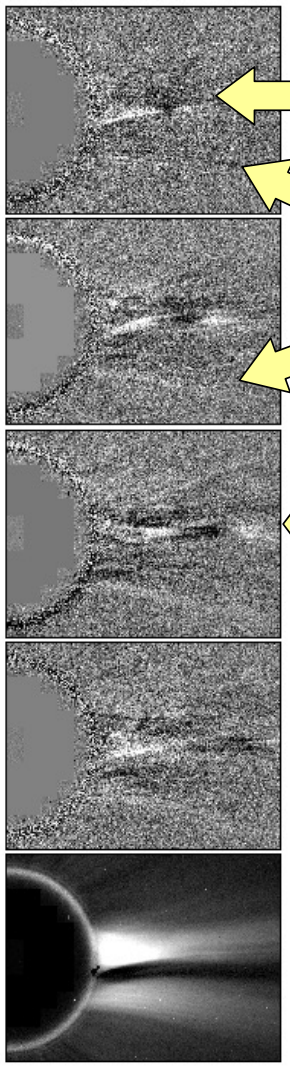


Zhukov +, under review, 2026



Abbo+, 2016

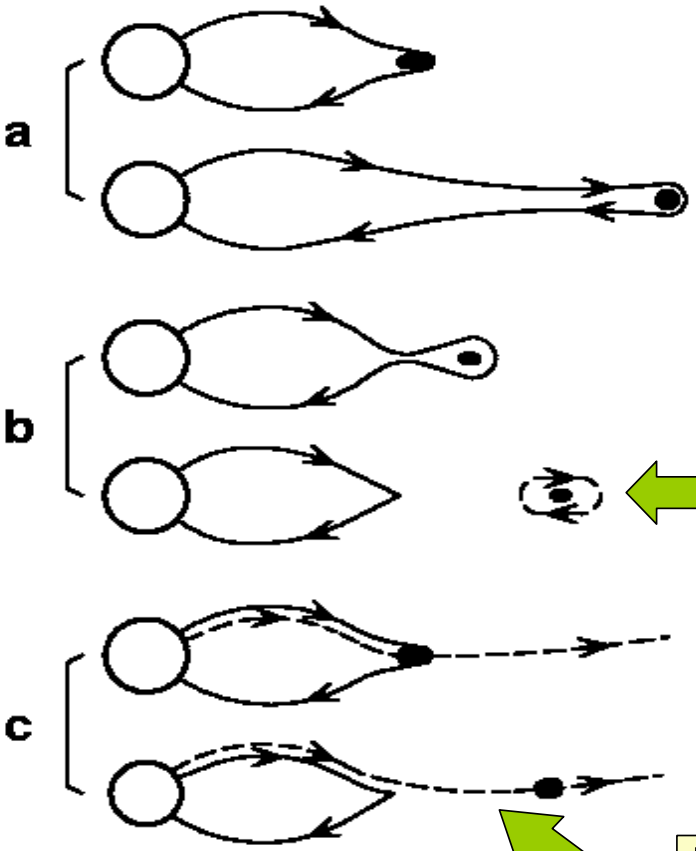
Discussion

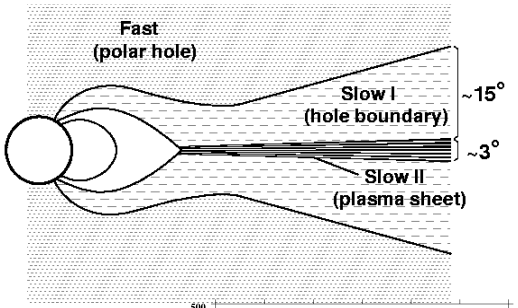


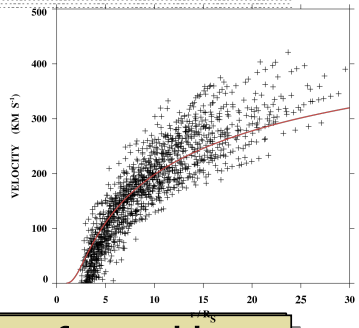
streamer cusp

streamer rays

streamer blob







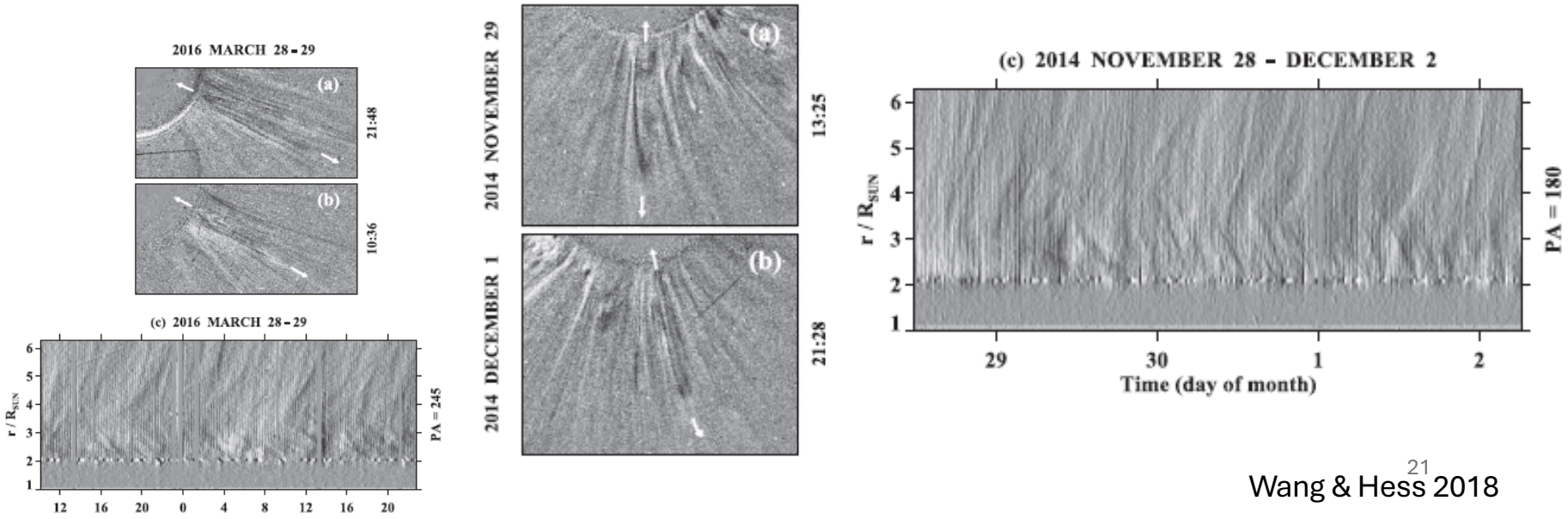
mini flux rope formed by 3D pinchoff : blob

interchange reconnection: streamer ray

Wang + 2000
Sheeley + 2009

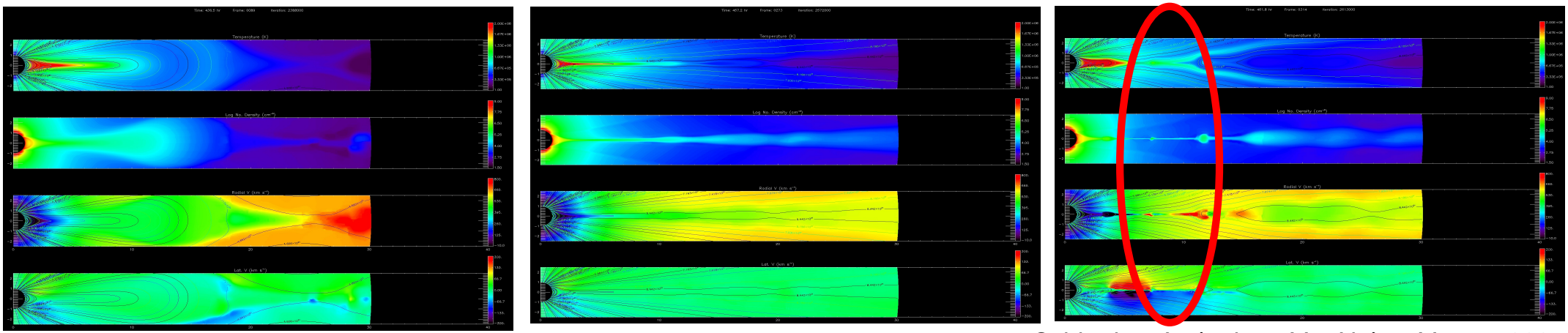
Discussion

- From Wang & Hess 2018: “Gradual Streamer Expansions and the Relationship between Blobs and Inflows”. Coronal helmet streamers show a continual tendency to expand outward and pinch off, giving rise to flux ropes (“blobs” propagating outward along the heliospheric current/plasma sheet). The blobs form within the range 2–6 Rsun (e.g. Sheeley+,1997, 2009; Wang&Sheeley,1998; Wang+, 2007). Sometimes the expanding helmet-streamer loops pinch off beyond about 4 Rsun, triggering strong inflow streams whose outgoing counterparts are usually very faint. They found that the visibility of the blobs and inflows depends on the amount of material that the diverging components sweep up within the 2–6 Rsun field of view. Is the same scenario observed by Metis as collapsing loops and inflows?



Wang & Hess 2018

MHD simulations of inflows and outflows



Schlenker, Antiochos, MacNeice, Mason, 2021

The 2.5D MHD code includes the full magnetic field dynamics as well as the detailed plasma thermodynamics. Thermal nonequilibrium (TNE) occurs in coronal loops with sufficiently large length (helmet streamer), and it is found that the process also drives substantial magnetic dynamics, especially near the top of the streamer where the plasma beta becomes of order unity.

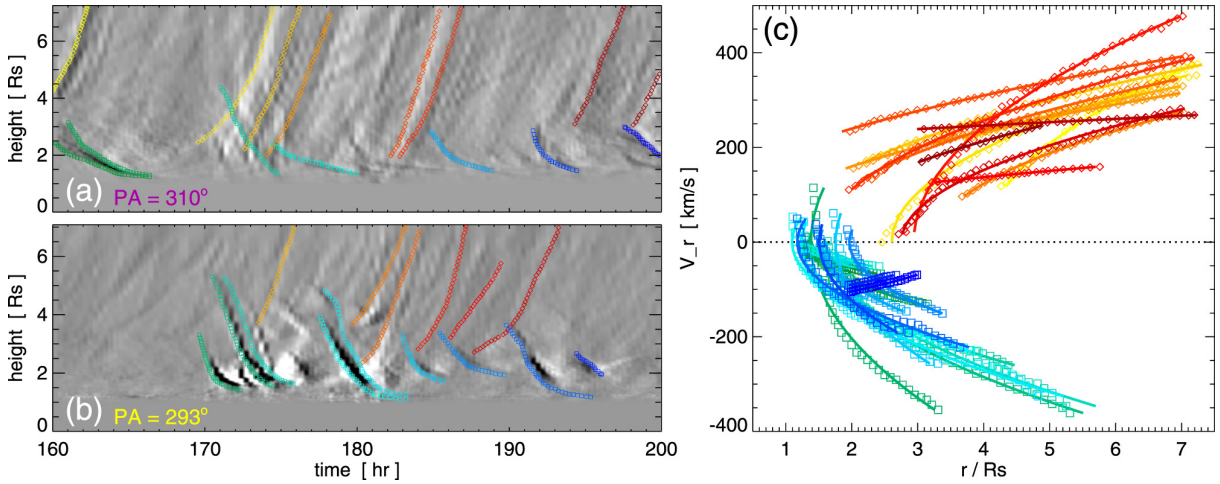
The frames show the initial dipole field stretching open to form a solar wind, and two frames from later in the evolution showing the **formation of plasmoids** in the heliospheric current sheet via reconnection. As a result of the reconnection the closed field, especially near the top of the streamer, moves up and down and there is **production of inflows**.

The model is described in Schlenker, Antiochos, MacNeice, Mason, 2021 “The effect of thermal non-equilibrium on helmet streamers” and Peter MacNeice is working on an improvement of the MHD model.

Discussion

- From Lynch 2020: “A Model for Coronal Inflows and In/Out Pairs”. Coronal inflows in the LASCO/C2 field of view (approximately 2–6 Rsun) seem to arise from the dynamic and intermittent release of solar wind plasma associated with the helmet streamer belt as the counterpart to outward-propagating streamer blobs, formed by magnetic reconnection.

  To detect outflows, is it necessary to observe by Metis above 3 Rsun?



Lynch 2020

MHD simulation results

Figure 4 from Lynch 2020. Height–time plots and their resulting velocity profiles. Panel (a): samples an edge-on portion of the helmet streamer belt. Panel (b): samples a face-on portion of the helmet streamer belt. In panel c) the inflow (outflow) tracks are shown in the green–cyan–blue (yellow–orange–red) color gradient.

Next steps

- Study the velocity and the structure dimensions of inflows and outflows from the base to the extended corona.
- Are they due to a density and/or a temperature effect (difference in WBF and FeXIV observations)?
- Do we observe pairs and in particular outflows before downflows with ASPIICS and Metis?

Concluding remarks

- Metis high-cadence observations, from pb at 120 s cadence down to B ('tB') at 20 s reveal many apparently downflowing features. These are most evident in running-difference images, but they can also be seen in base-difference images or even in normalized brightness images.
- Coronal inflows have been observed in the past (LASCO C2, STEREO) and have been interpreted as due dynamic and intermittent release of solar wind plasma associated with the helmet streamer belt as the counterpart to outward propagating streamer blobs formed by magnetic reconnection (e.g. Lynch 2020).
- The features observed by Metis seem much more frequent than observed in the past. However, inflows seem to outnumber the observed outflows by a large factor, indicating perhaps reconnection events beyond the edge of the Metis FoV.
- Note that examples of apparent downflows can be found even in open field regions both in Metis and EUI FoVs (Andretta et al., in preparation).