FP7 Project – HELCATS – WP 6

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WP6: Initialising advanced numerical models based on the kinetic properties of STEREO/HI CMEs and CIRs

The primary goal of WP6 is to transform the catalogues of CMEs and CIRs observed by HI, accomplished in WP2/3 and WP5, into more advanced catalogues of simulations results of CIRs and CMEs. This advanced database will provide to the space community a set of simulation results optimised by assimilating direct images of the solar wind into ENLIL simulations. The delivery of these advanced catalogues will enhance forefront research on the 'background' solar wind (fast and slow solar wind) and on the spatial and temporal evolution of CIRs and CME shocks, and will provide unique material to study and interpret particle radiation measurements in the inner heliosphere. This resource will also be useful to assess the potential role of HI images for space-weather predictions and to prepare future missions (e.g. ESA's Solar Orbiter).

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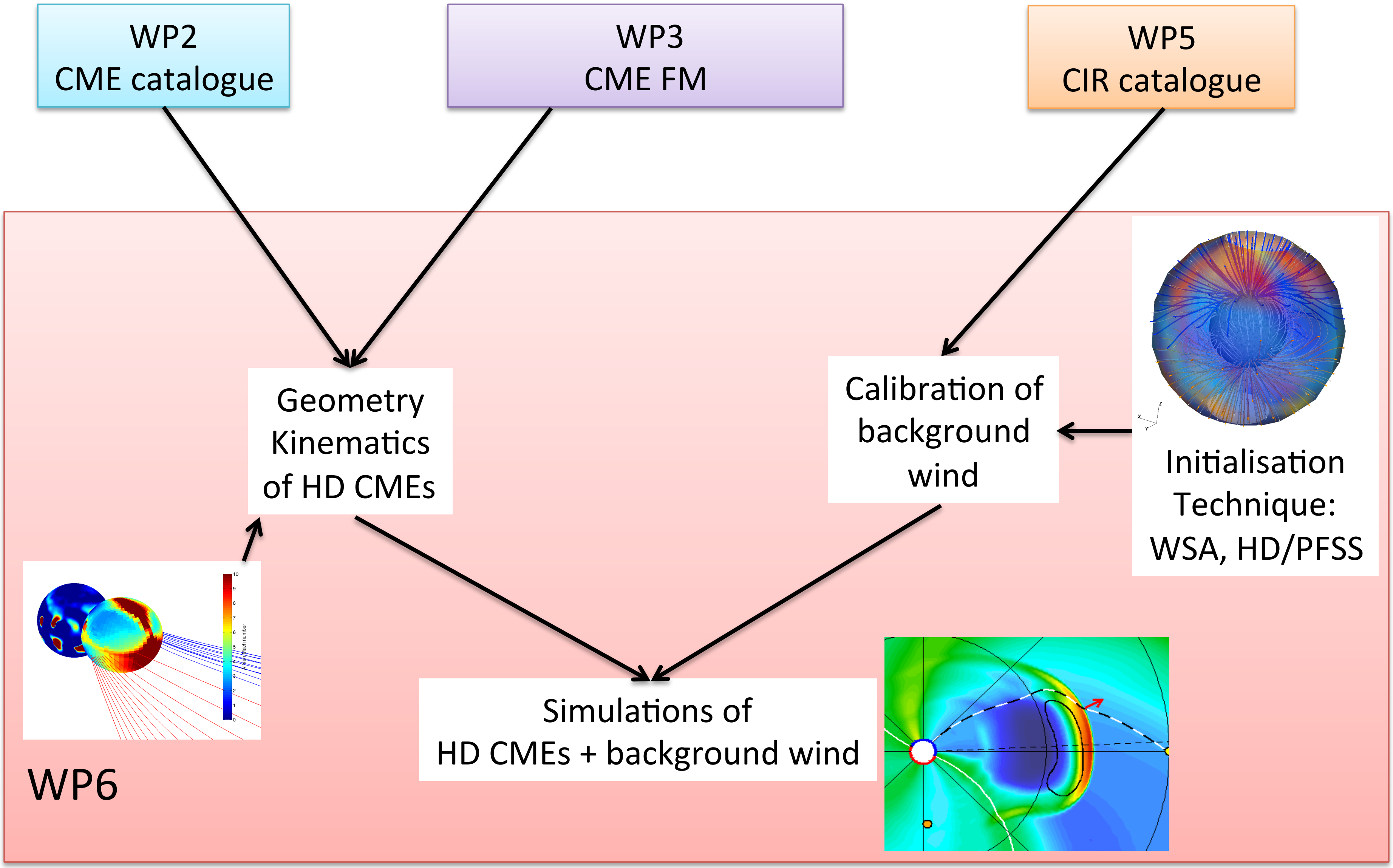
WP6: Simulating CIRs/CMEs



T6.1 - Assimilating HI images to model the background solar wind [Months: 7-36]
UPS

D6.1: J-maps derived from HI images and movies will be compared with synthetic J-maps and movies of CIRs derived from numerical simulations of the background solar wind (ENLIL). We will divide events in two classes: Class 1 for which a good correspondence is immediately obtained between simulated and observed height-time maps and Class 2 for which J-maps differ significantly. We will compare how well ENLIL predicts the in-situ measurements of CIRs for these two classes of events separately. We will then modify the coronal input of ENLIL of the second class of events until synthetic and observed J-maps are in good agreement. [month 24] (WIP).

J-map integrated in the propagation tool, currently comparing predicted and observed J-maps, we can now use Illya's CIR catalogue. > Illya's paper started doing that.

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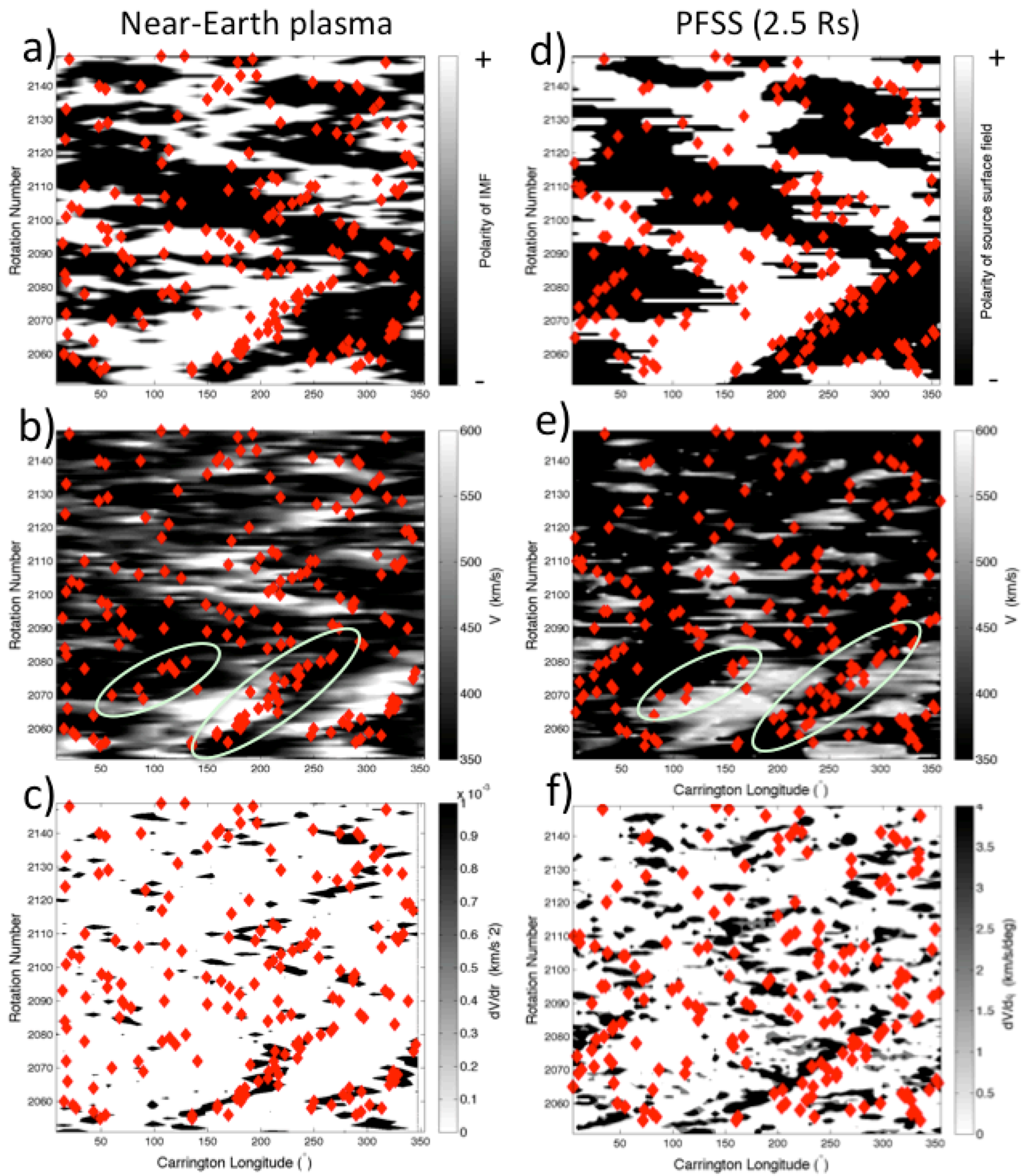

Near-Earth plasma
PFSS (2.5 Rs)
a)
b)
c)
d)
e)
f)
Rotation Number
Carrington Longitude (°)
Polarity of IMF
Polarity of source surface field
V (km/s)
dV/dr (km/s^2)
x 10^-3
dV/dθ (km/s/deg)
+
-

T6.2 - Assessing the use of HI to initialize ENLIL [Months: 7-36]
UPS

D6.2 : A catalogue of the most accurate set of simulations of the background solar wind will then be established. This catalogue will be very useful for further simulations or for scientific users to obtain a more accurate estimate of the magnetic connectivity of spacecraft with solar events. [month 24]

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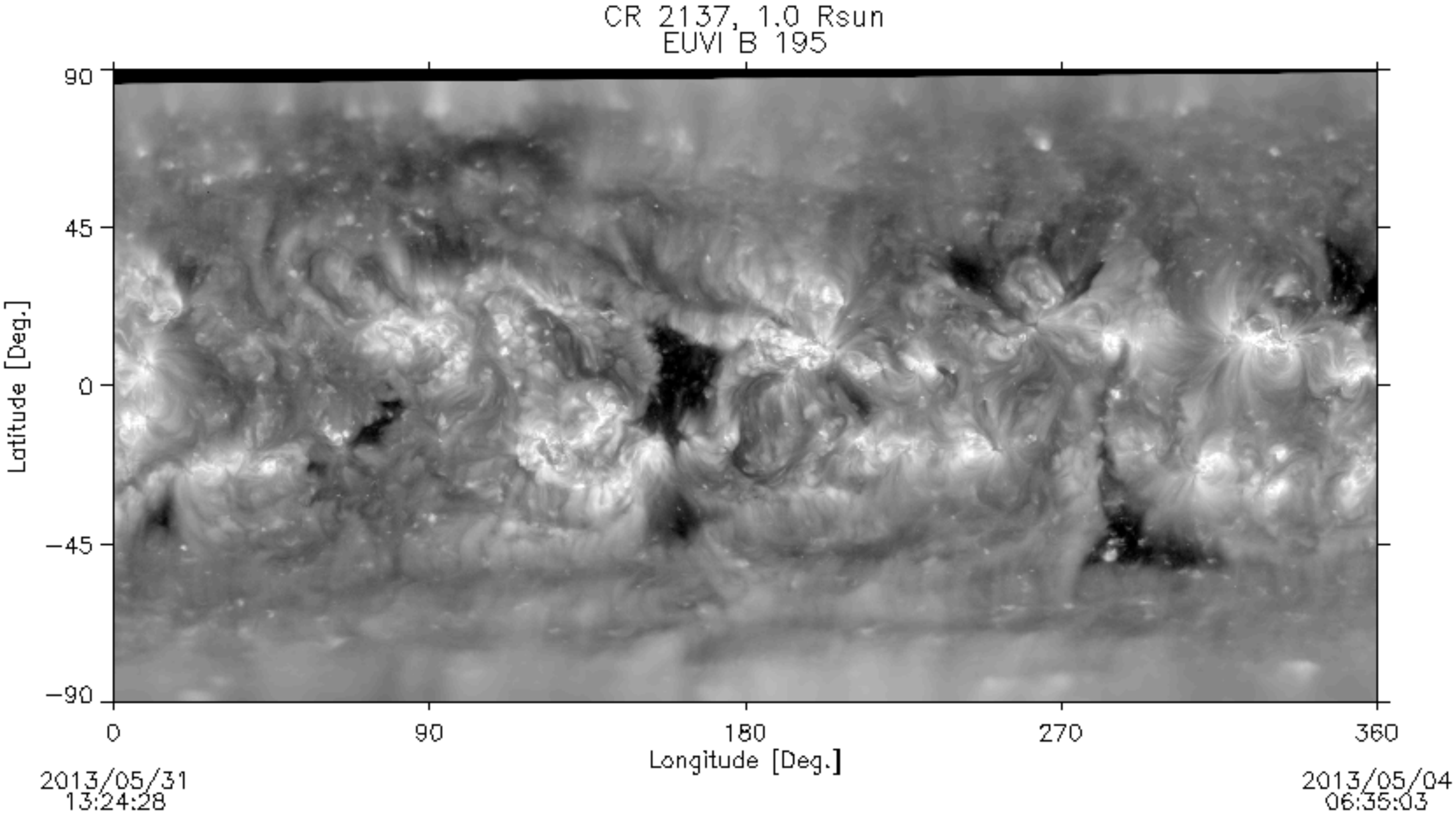
- We have put in place an automated modelling of the solar wind output computed using a hydrodynamic model run along magnetic field lines derived from PFSS. In principle, this could be applied to NLFF or MHD.

- The model is run between the chromosphere to 21.5Rs

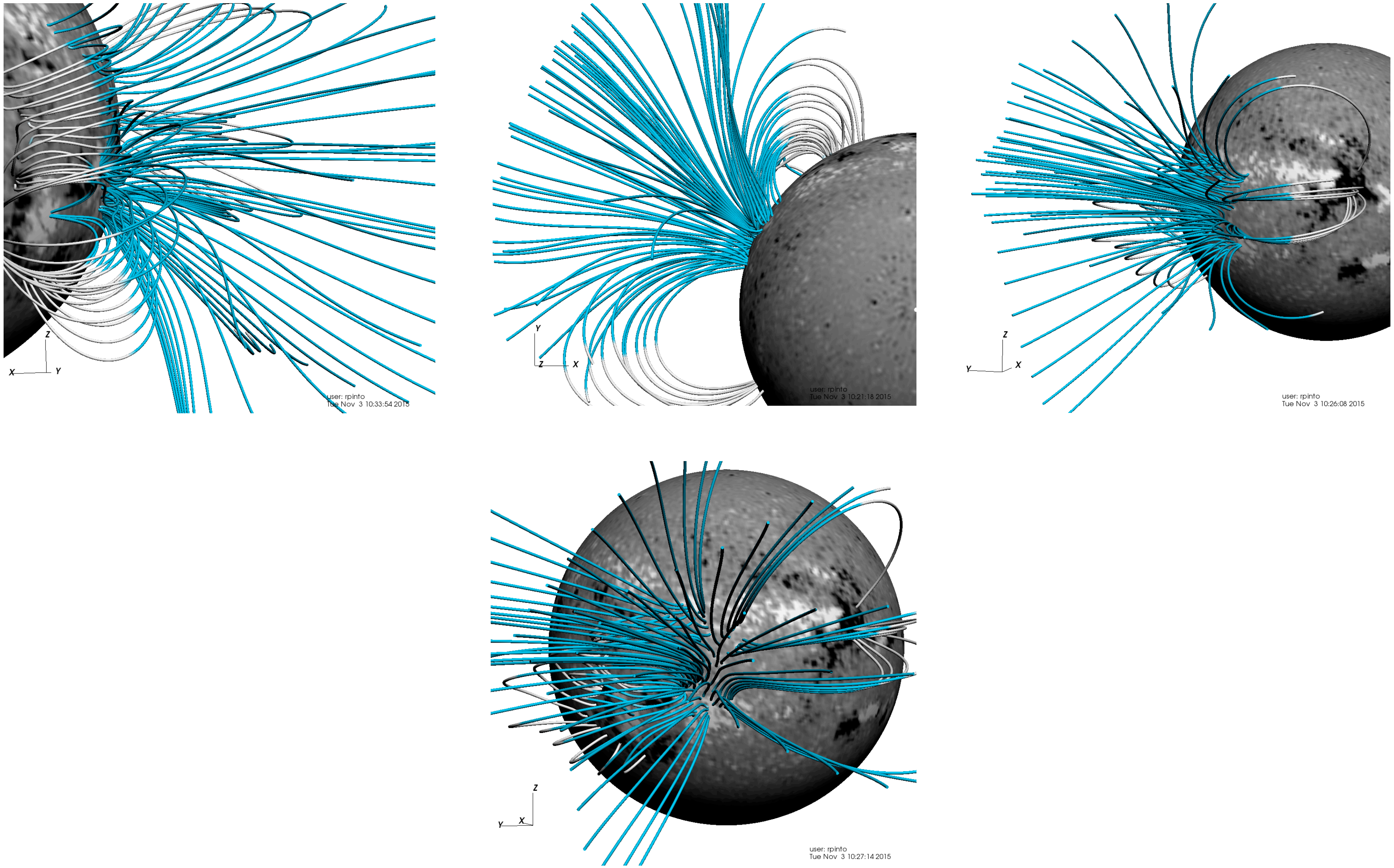
- The method is automatically tested against OMNI data, we are testing modelling of a spectacular coronal hole that occurred at CR2137,

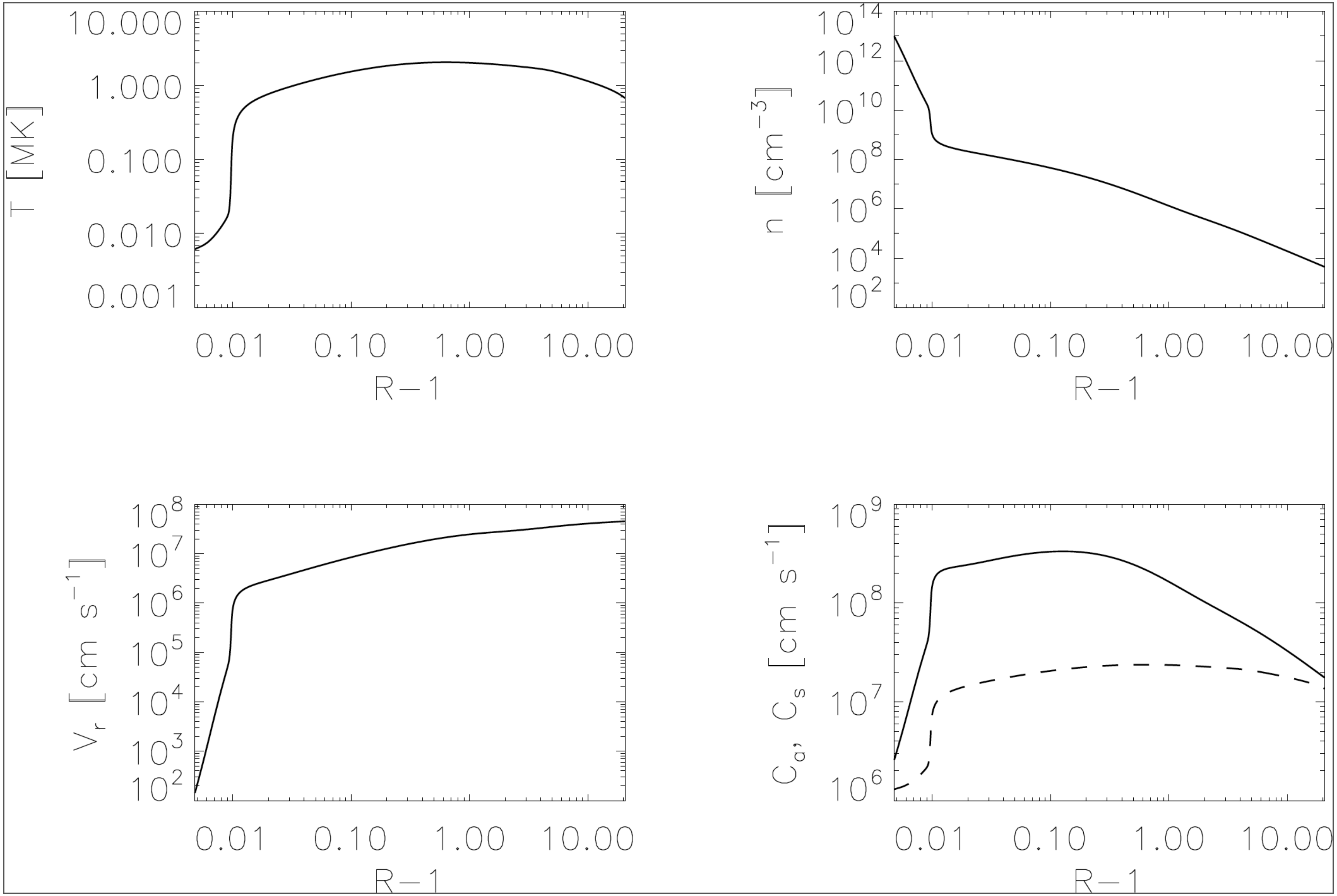
- Likely providing the first explanation for meso-scale structures in the fast solar wind.

- Speed and temperature are well simulated however density is currently a problem. We could parametrise density predictions but wish to derive a self-consistent computation, > Suzuki's heating formulation, or a varying scale-height of heating rate.

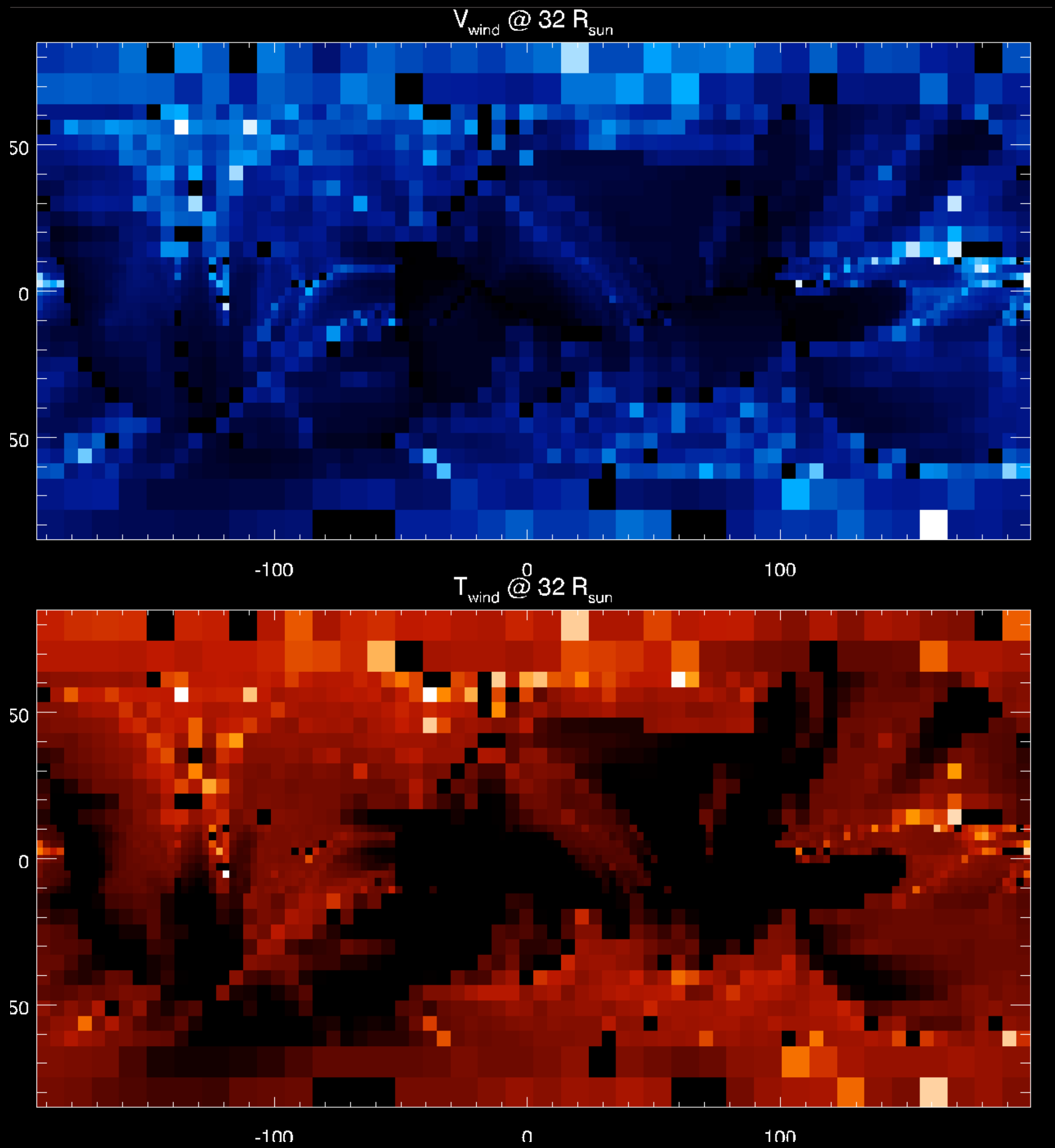


CR 2137, 1.0 Rsun
EUVI B 195
90
45
0
-45
-90
Latitude [Deg.]
0
90
180
270
360
Longitude [Deg.]
2013/05/31
13:24:28
2013/05/04
06:35:03

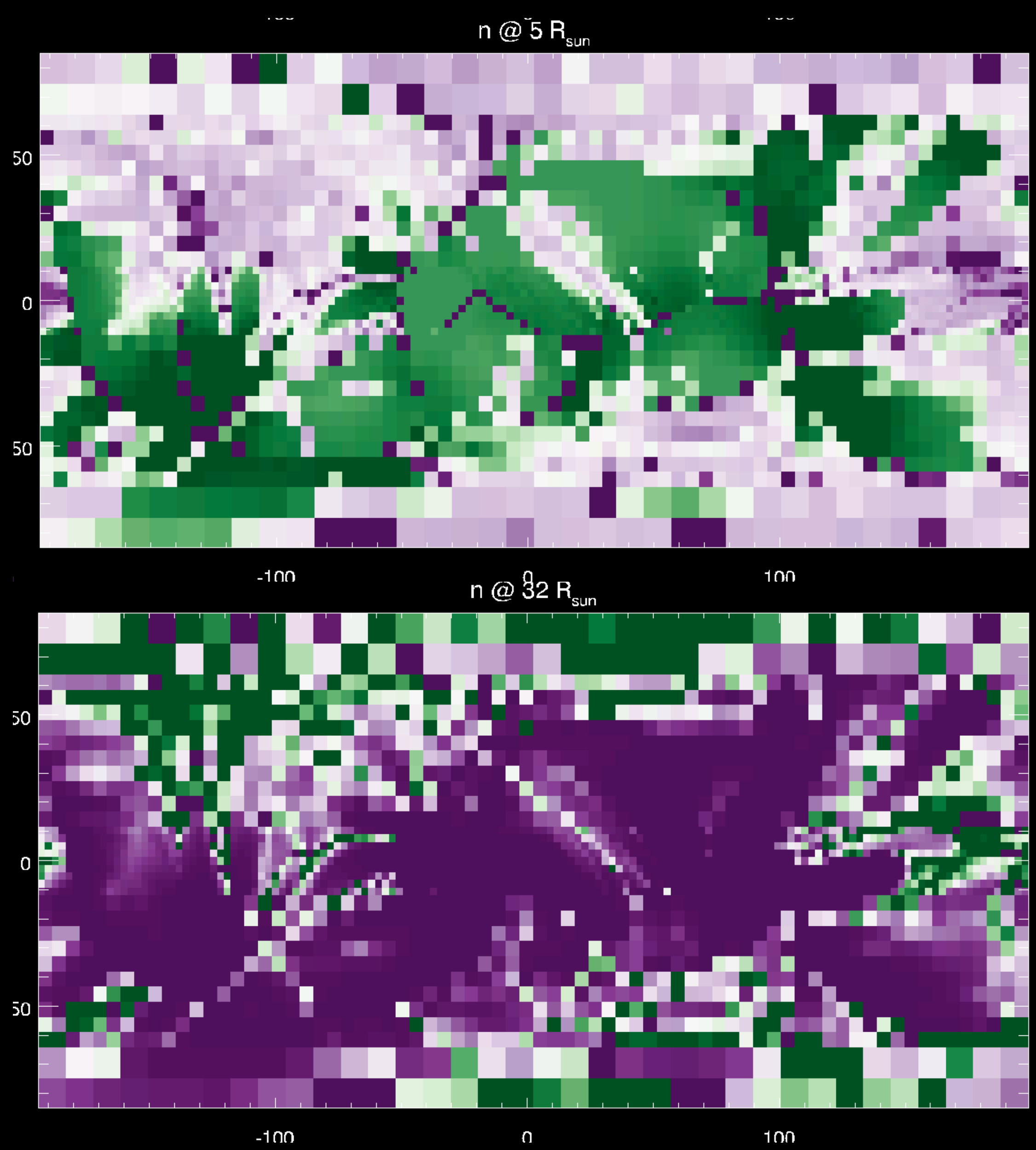

Z
X
Y
user: rpinto
Tue Nov 3 10:33:54 2015
Y
Z
X
user: rpinto
Tue Nov 3 10:21:18 2015
Z
Y
X
user: rpinto
Tue Nov 3 10:26:08 2015
Z
Y
X
user: rpinto
Tue Nov 3 10:27:14 2015



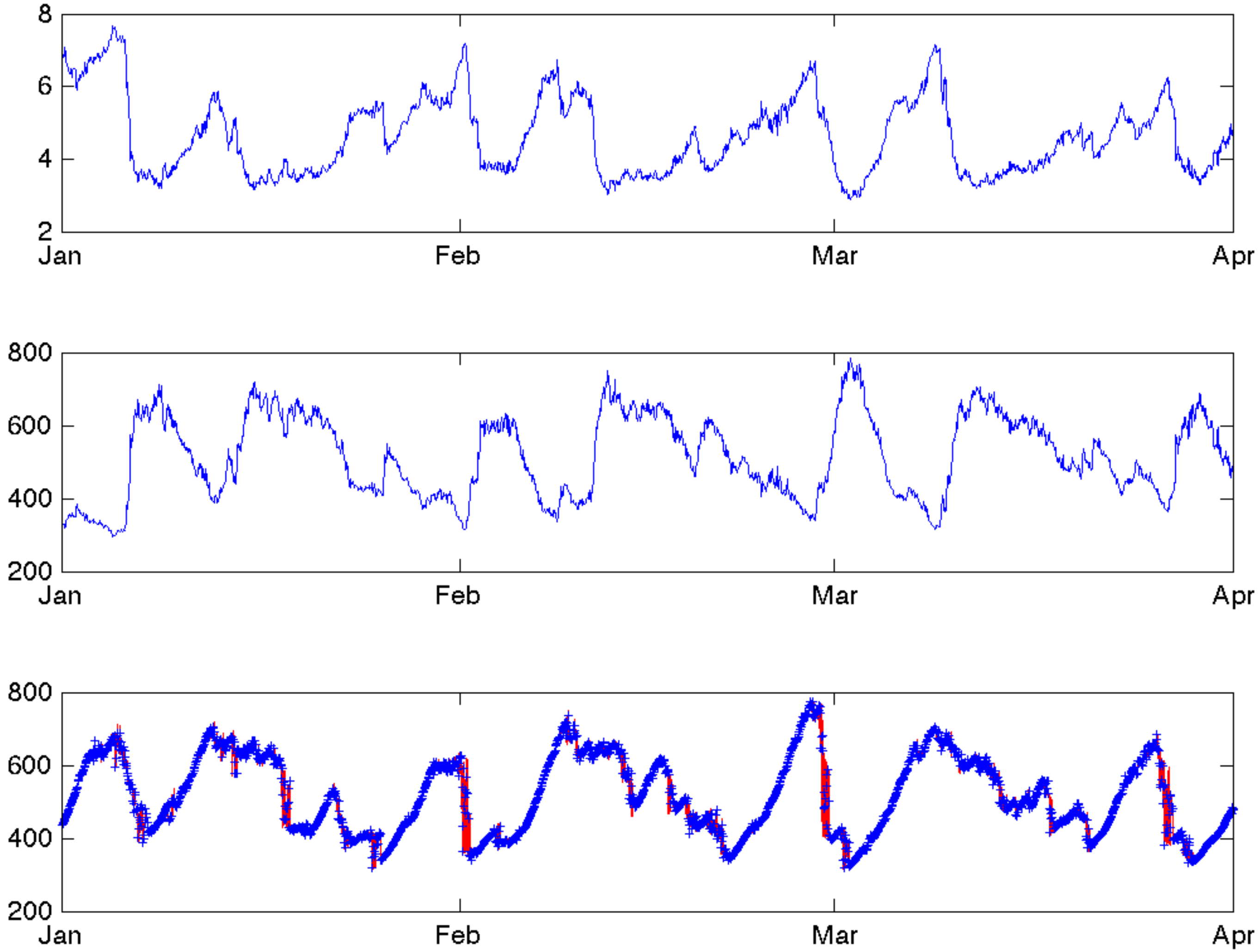
10.000
1.000
0.100
0.010
0.001
T [MK]
0.01
0.10
1.00
10.00
R−1
10^14
10^12
10^10
10^8
10^6
10^4
10^2
n [cm^-3]
0.01
0.10
1.00
10.00
R−1
10^8
10^7
10^6
10^5
10^4
10^3
10^2
V_r [cm s^-1]
0.01
0.10
1.00
10.00
R−1
10^9
10^8
10^7
10^6
C_a, C_s [cm s^-1]
0.01
0.10
1.00
10.00
R−1

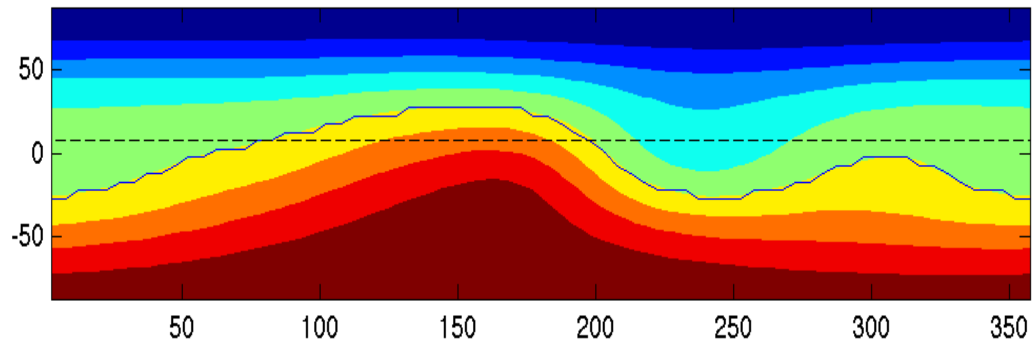


V_{wind} @ 32 R_{sun}
50
0
50
-100
0
100
T_{wind} @ 32 R_{sun}
50
0
50
-100
0
100

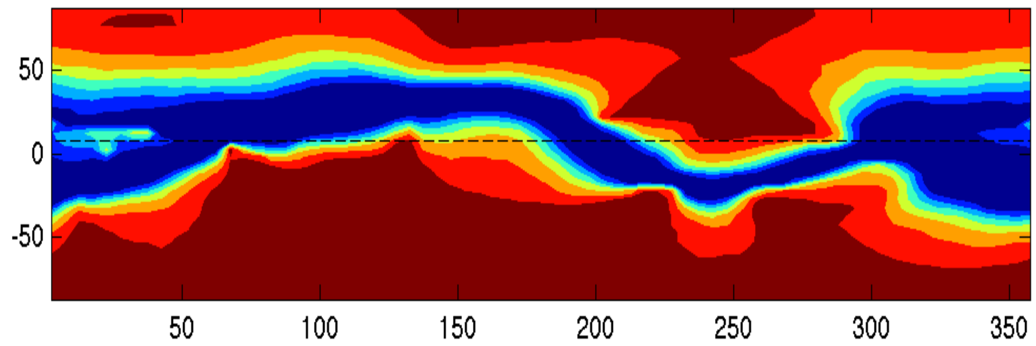


n @ 5 R sun
50
0
50
-100
0
100
n @ 32 R sun
50
0
50
-100
0
100

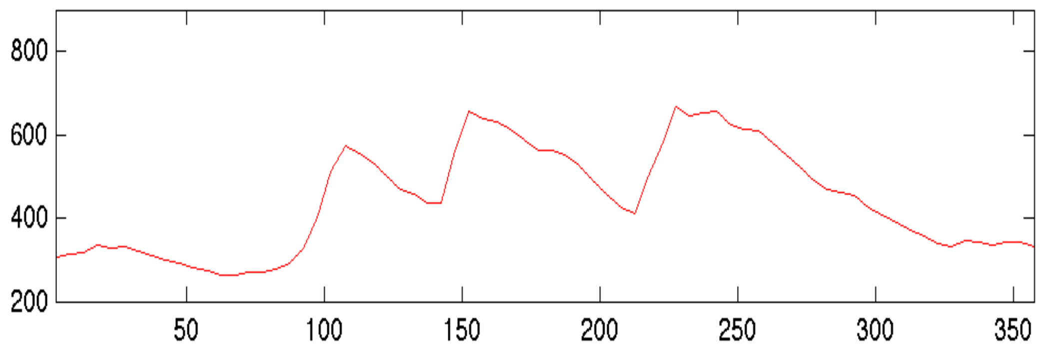

8
6
4
2
Jan
Feb
Mar
Apr
800
600
400
200
Jan
Feb
Mar
Apr
800
600
400
200
Jan
Feb
Mar
Apr



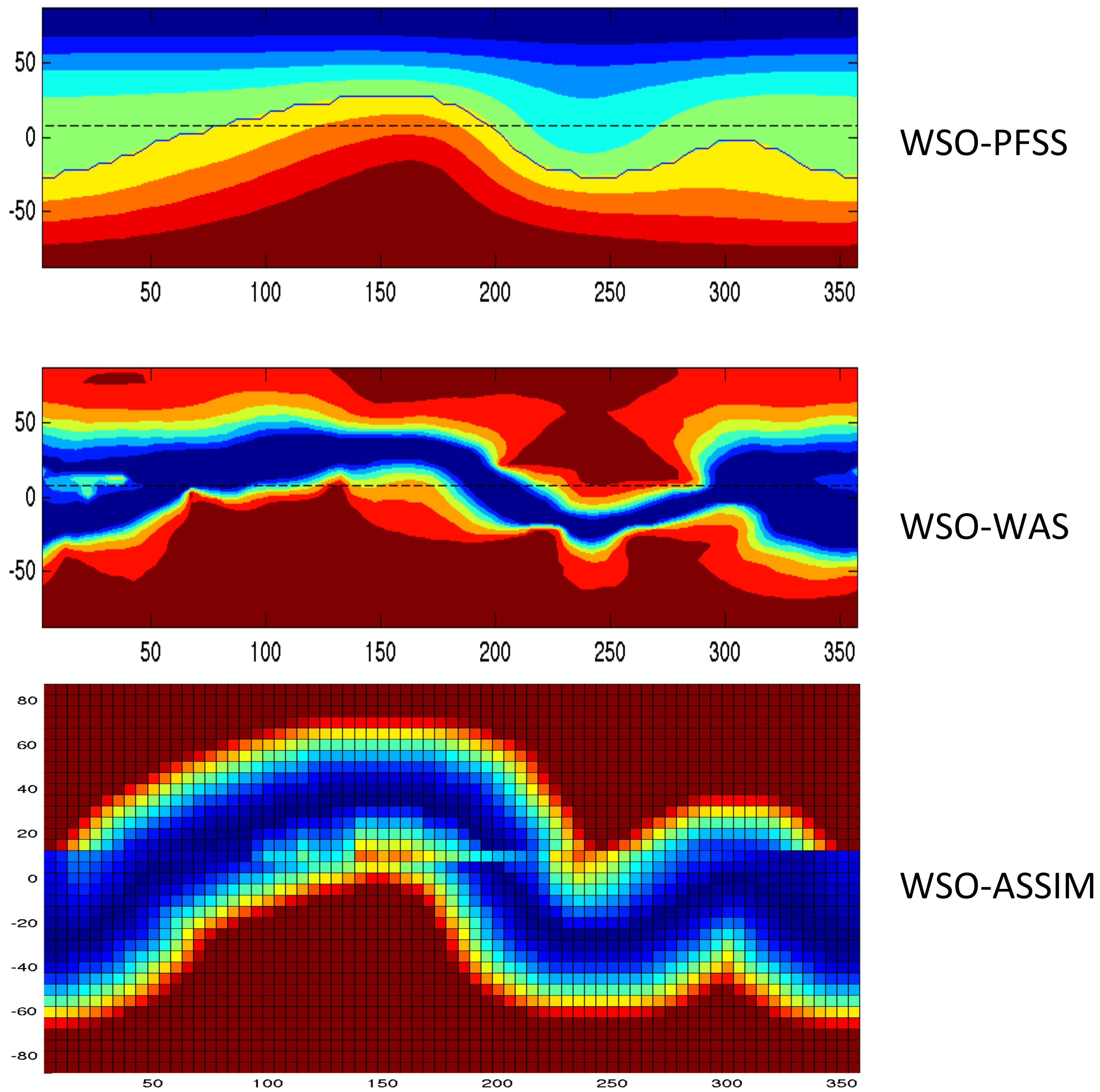
WSO-PFSS

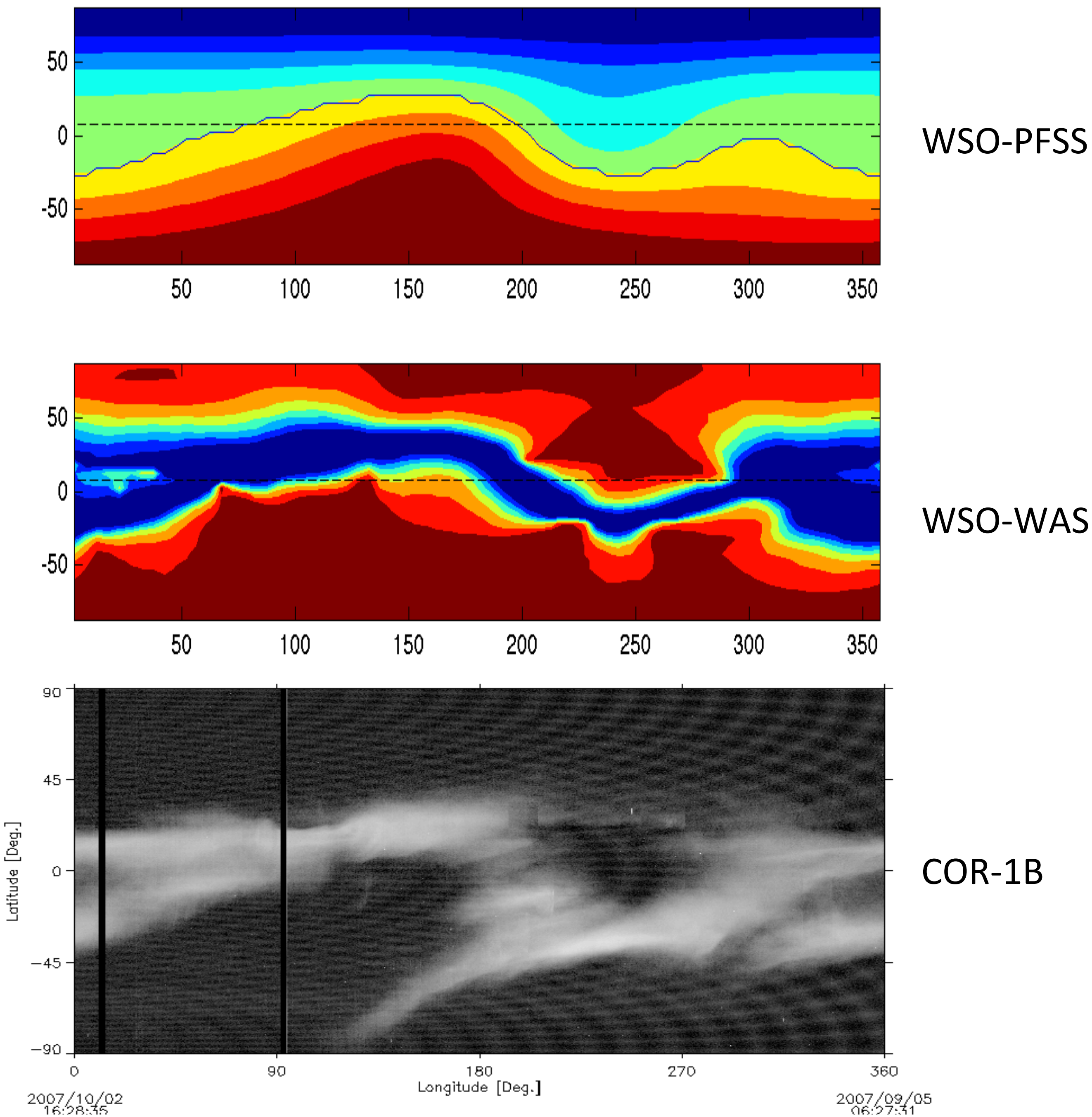


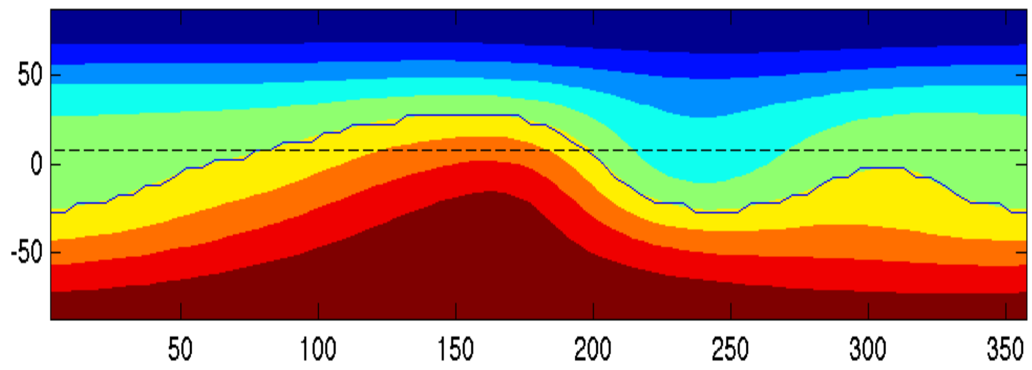
WSO-WAS



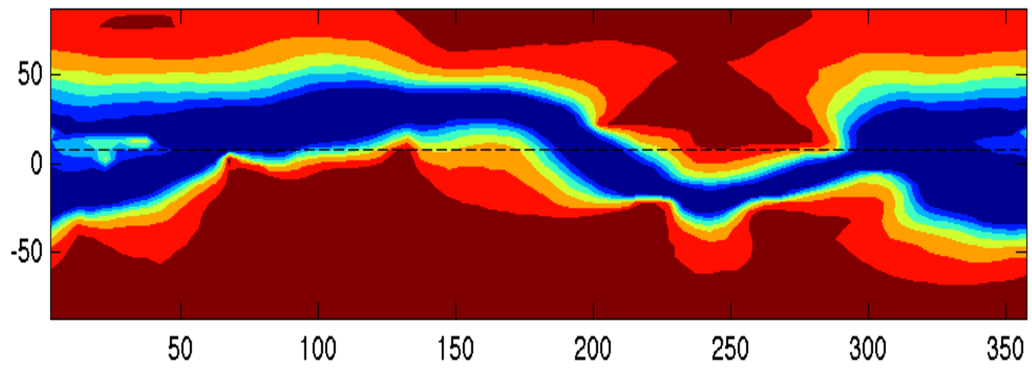
In-situ traced back


WSO-PFSS
WSO-WAS
WSO-ASSIM

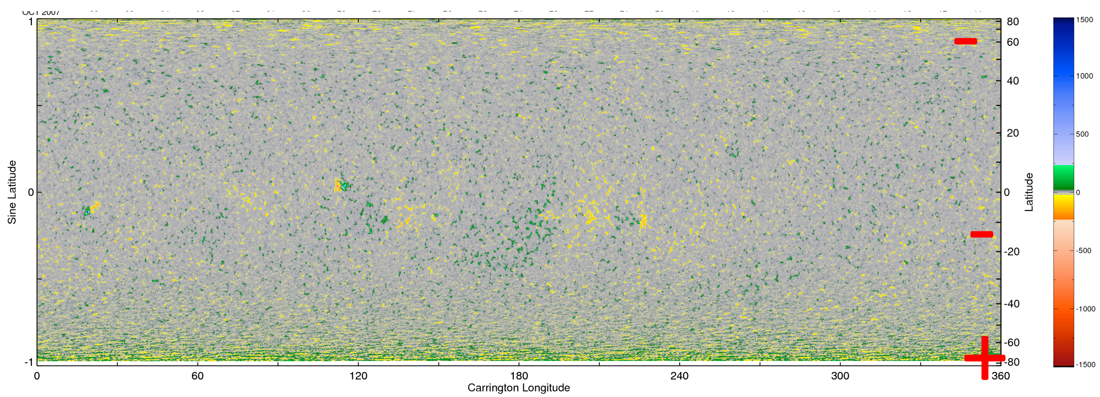

WSO-PFSS
50
0
-50
50
100
150
200
250
300
350
WSO-WAS
50
0
-50
50
100
150
200
250
300
350
COR-1B
90
45
0
−45
−90
Latitude [Deg.]
0
90
180
270
360
Longitude [Deg.]
2007/10/02
16:28:35
2007/09/05
06:27:31

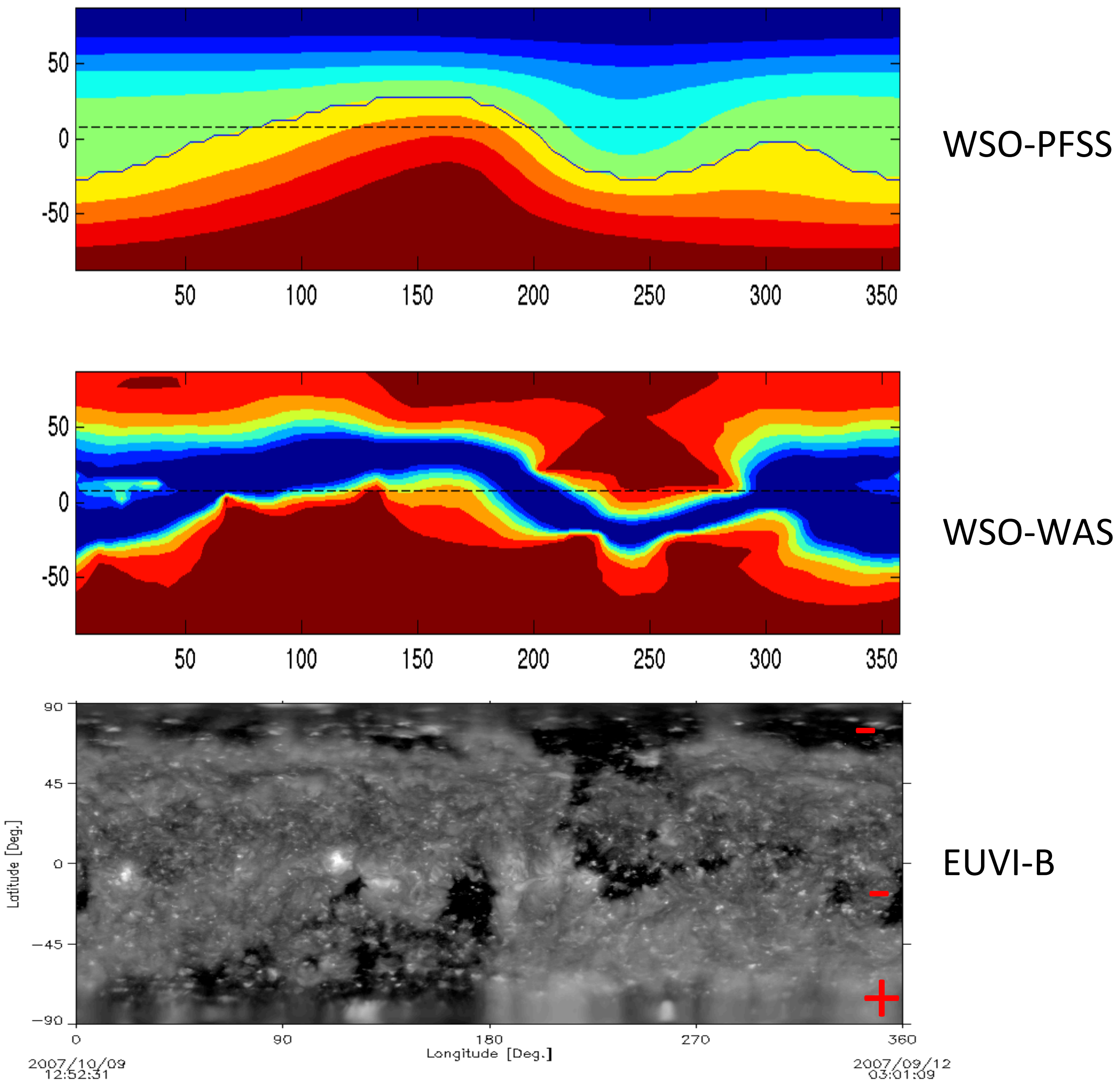


WSO-PFSS

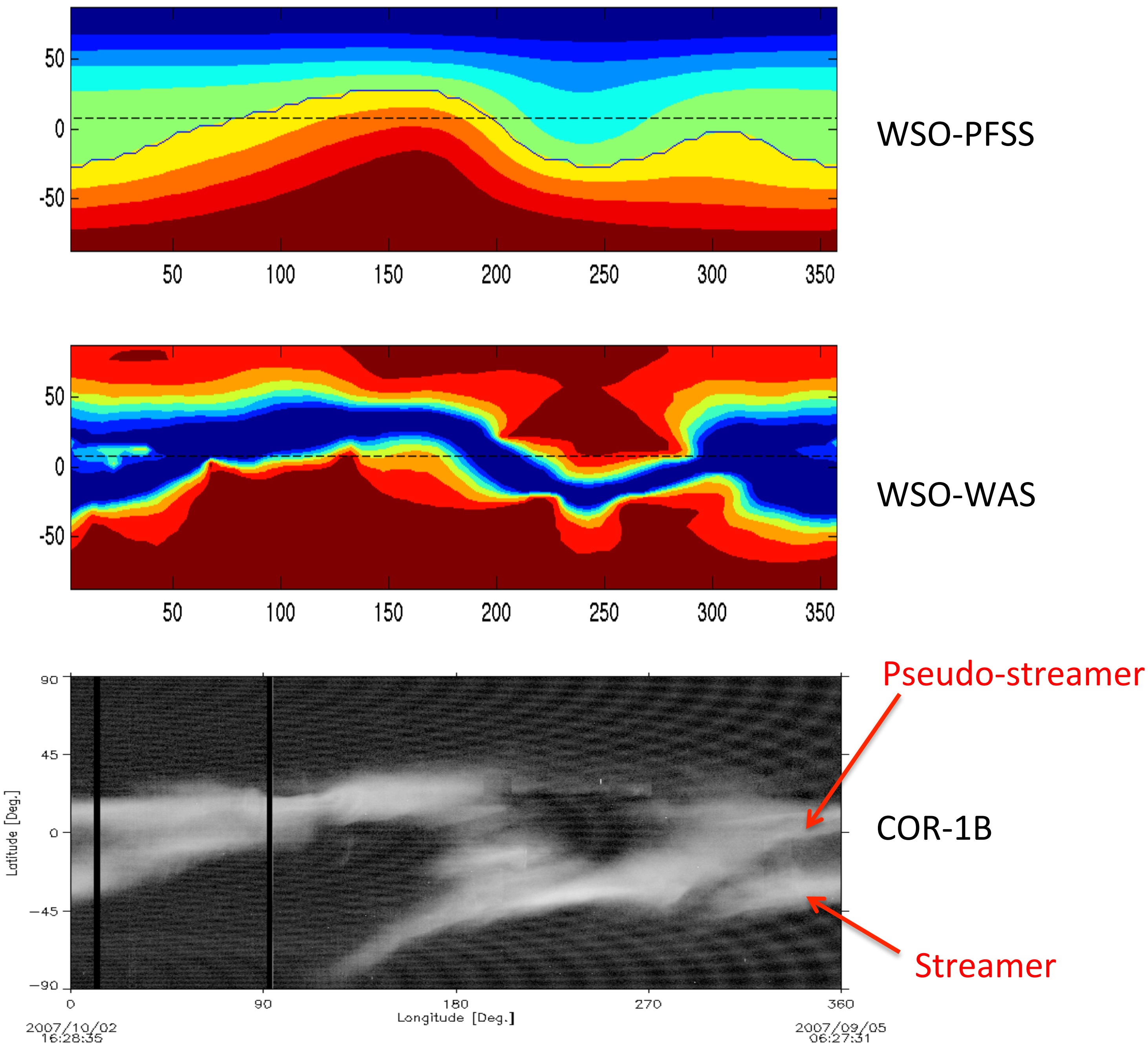


WSO-WAS





WSO-PFSS
WSO-WAS
EUVI-B
Latitude [Deg.]
Longitude [Deg.]
2007/10/09
12:52:31
2007/09/12
03:01:09



50
0
-50
50
100
150
200
250
300
350
WSO-PFSS
WSO-WAS
90
45
0
−45
−90
Latitude [Deg.]
0
90
180
270
360
Longitude [Deg.]
2007/10/02
16:28:35
2007/09/05
06:27:31
Pseudo-streamer
Streamer
COR-1B

Our Goal: to provide the most accurate set of background solar wind simulations

- We are developing a new technique exploiting to the full extent the STEREO imagery and in situ data:

- In situ data from STEREO-A, STEREO-B, OMNI will be used to remove the effect of CMEs

- Using the neutral line alone is not sufficient as pseudo-streamers can also be associated with the slow dense solar wind > we use imagery during calm conditions to infer location of streamers and pseudo-streamers.

T6.3 - Continual assimilation of HI data in ENLIL and comparison with standard implementation techniques

D6.3 : The results of WP3 and 4 will provide the central axis, volume and speed of CMEs between 10 and 20 solar radii (range of inner boundary for ENLIL). These CMEs will then be injected as hydrodynamic spheres into the most accurate simulations of the background solar wind derived from WP6.1. The arrival time of the leading edge of the CMEs and the properties of the potential shocks driven ahead of them will be compared with in-situ measurements (exploiting the results of WP4.2). A catalogue of these optimised ENLIL simulations of CMEs and their shocks will then be stored for the ecliptic plane. This advanced catalogue will help studies of the origin of solar energetic particle events. [month 36]

D6.4 : In Task 6.2, the CME properties are specified once at the inner boundary. The CME position, volume and speed can be updated every 40 minutes for HI-1 and 2 hours for HI-2. Medium resolution ENLIL simulations will be re-launched
at every time step such that the CME position and speed remains in agreement with HI images. The results of this set of assimilated simulations will be compared with results of Task 5.2 and in-situ measurements; we will determine whether a continual assimilation of HI images provides a better forecast of CME arrival times at 1 AU. [month 36]

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WP6: Simulating CIRs/CMEs

Steps to follow:

October-December 2015:

- Initialisation of ENLIL using the HD/PFSS model on 14 rotations (maps are ready)

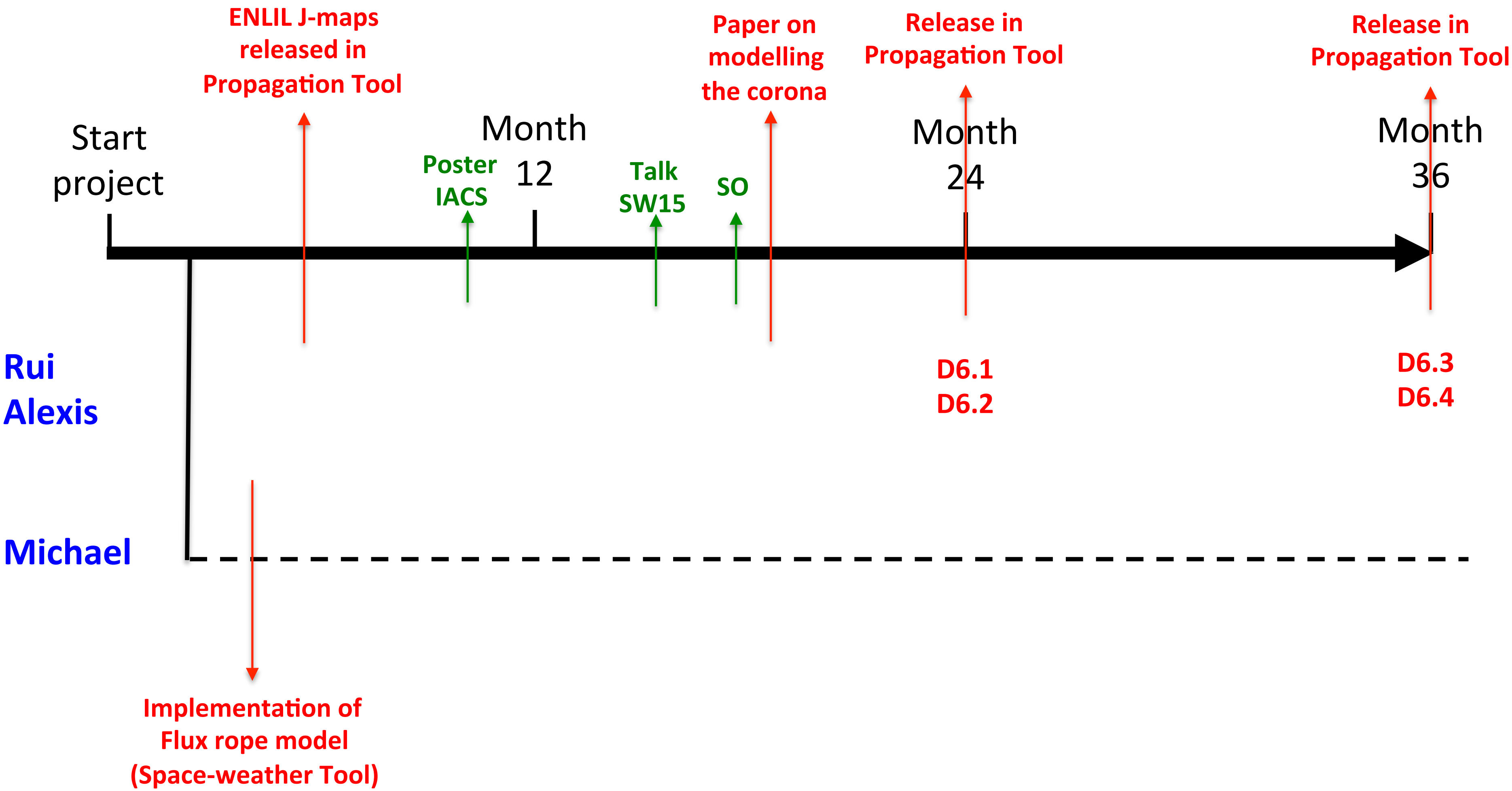
- Validation of background solar wind on one year of data (14 Carrington rotations) via Jmaps maps (comparison real/synthetic in propagation tool) (WIP)

January-Apr 2015:

- Initialisation of ENLIL combining better background initialisation + HD CMEs.

- Validation of new solar wind/ CME simulations (14 Carrington rotations) via Jmaps maps (comparison real/synthetic in propagation tool).

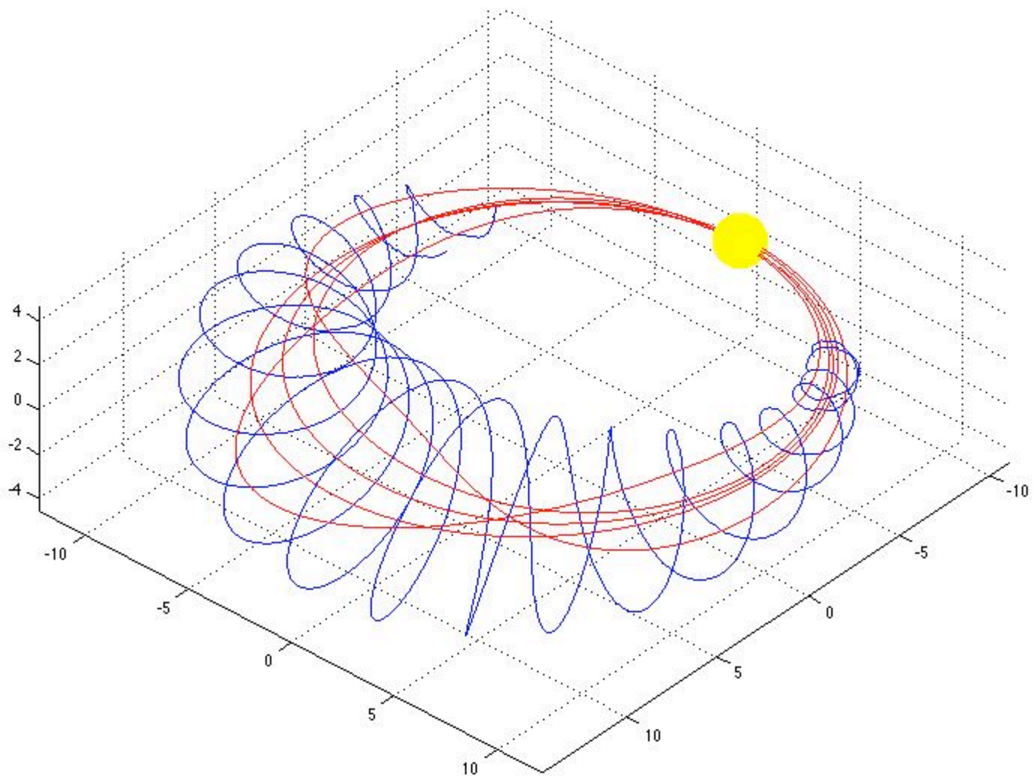
WP5: Catalogue of CIRs



Work outside HELCATS:
Preliminary work using HELCATS/AFFECTS catalogues:

Including forces acting acting on flux rope (Lorentz, gravity, drag):
->3-D topology inferred along a cylindrical current channel:
- using conservation of helicity,
- using asymmetric flux surfaces,

->Inclusion of variable mass
->Much faster derivation of 3-D topology at 21.5Rs for ENLIL



Conserves

Kinematics in the low corona (EUV, COR-1, COR2: 3-D fitting: Rouillard).
Orientation given by HELCATS (WP3)
Direction of propagation in corona (WP3)
In situ identification (WP4)