Solar plume network investigation

using PROBA2/SWAP observations

Judith de Patoul & PROBA2/SWAP team

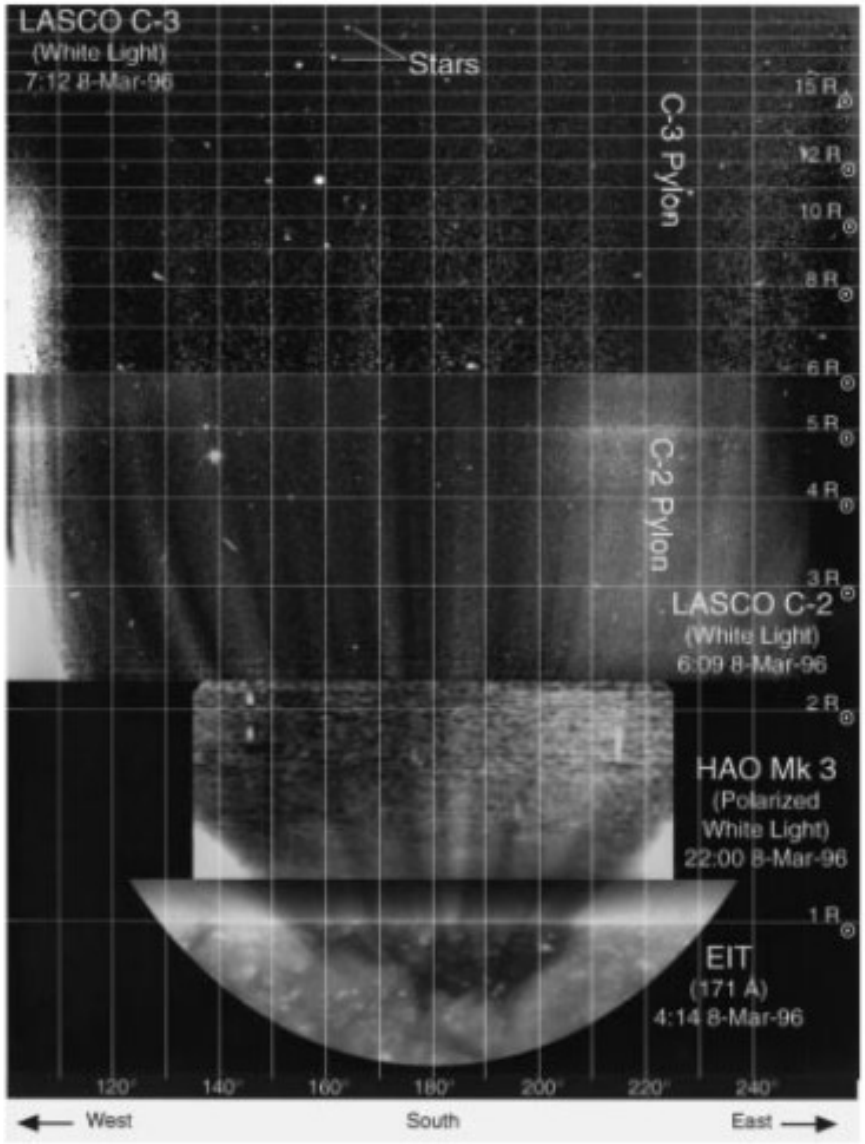
PROBA2 Guest Investigator Program

ESWW14, 2017

AXA Research Fund
Through Research, Protection

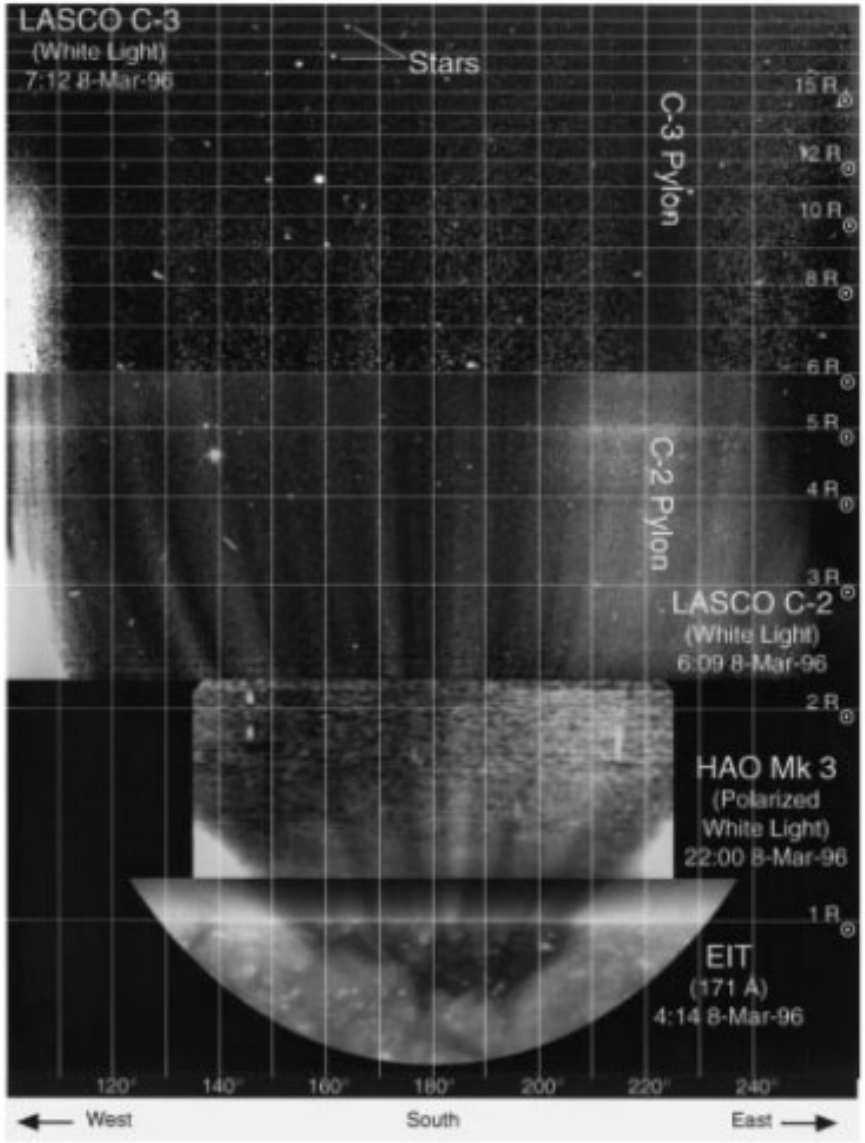
Royal Observatory *of* Belgium

Polar plumes

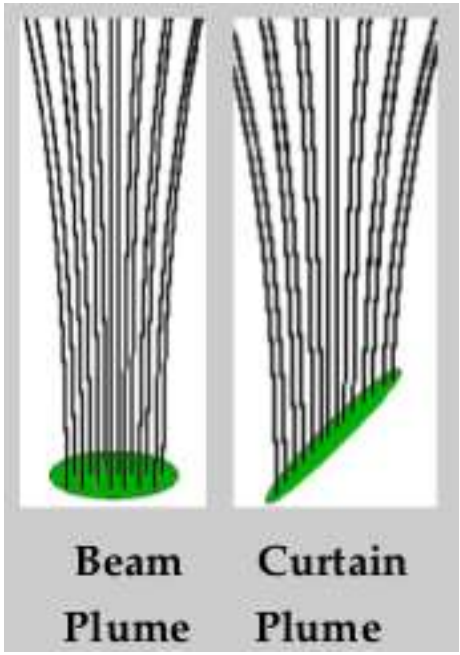


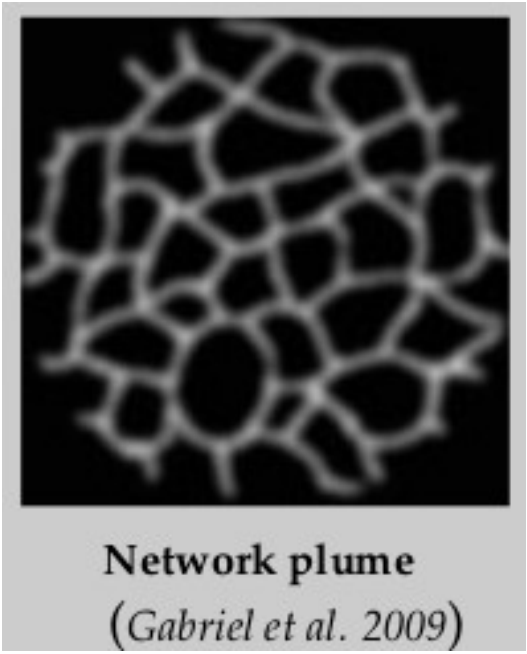
Deforest *et al.* **(1997)**

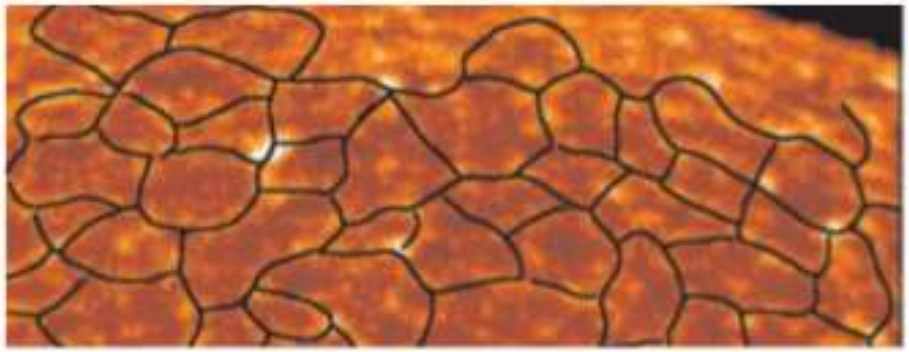
Polar plumes



Deforest *et al.* (1997)







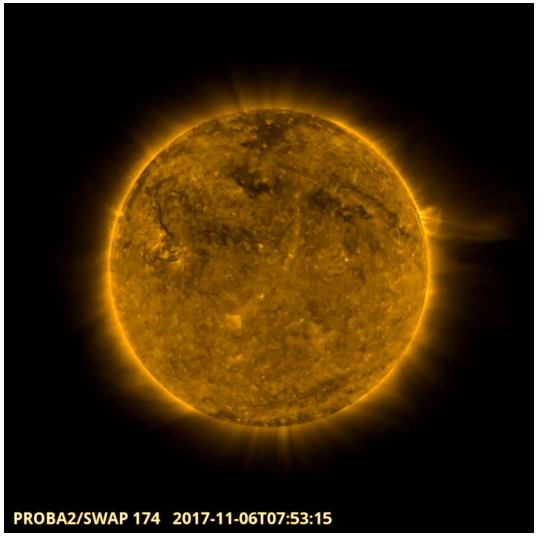
SOHO/SUMER Si II 1533Å. (Hassler *et al.*, 1999).

Questions:

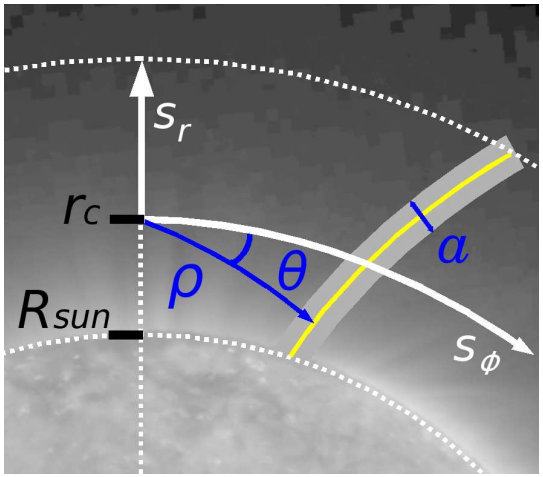
- How (inter-)plume regions are distributed over the pole?
- How is it related to the chromospheric network?
- How (inter-)plume structures evolve with height?

1. Polar plumes identification
2. Polar plumes 3D reconstruction

→ Plume network investigation



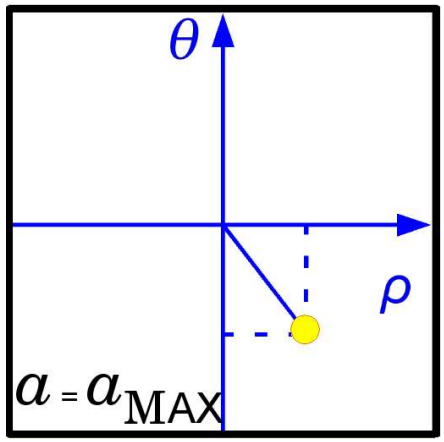
Polar plumes identification



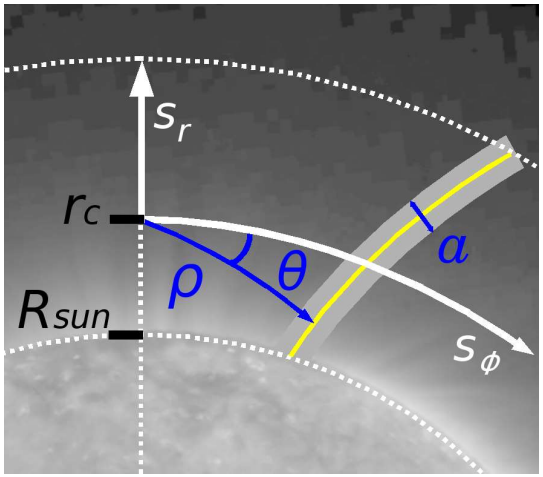
$$HW(\rho, a, \theta) = \int_{\mathbb{R}^2} I(\mathbf{x}) \quad \frac{1}{a} \psi^{MH}\left(\frac{\mathbf{u}_\theta \cdot \mathbf{x} - \rho}{a}\right) d\mathbf{x},$$

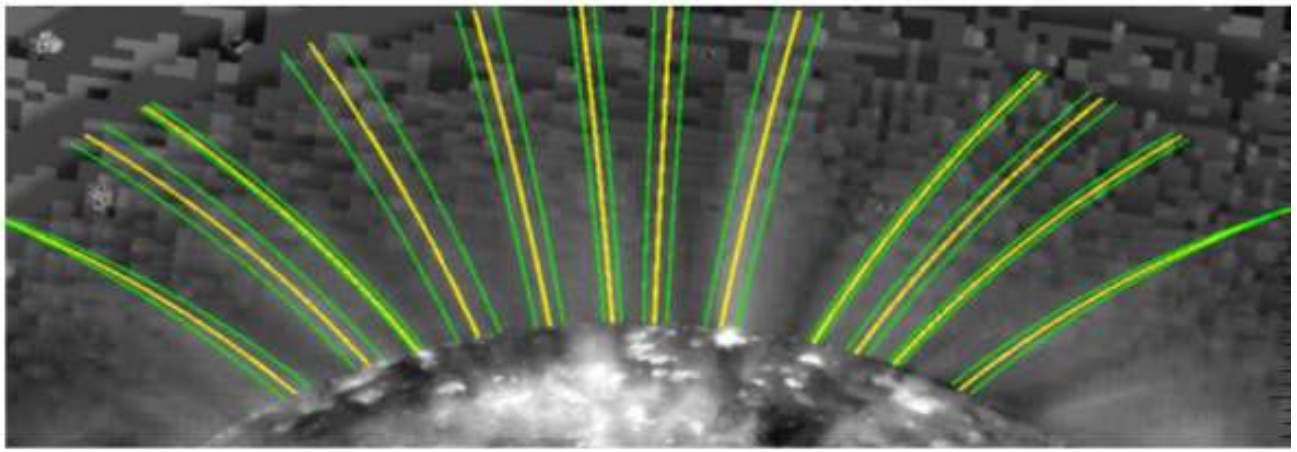
where $\theta \in [-\pi/2, \pi/2[$, $\mathbf{u}_\theta = (\cos\theta \quad \sin\theta)$,

$\rho \in [-\rho_{max}, \rho_{max}]$, and $a \in \mathbb{R}_0^+$



Polar plumes identification





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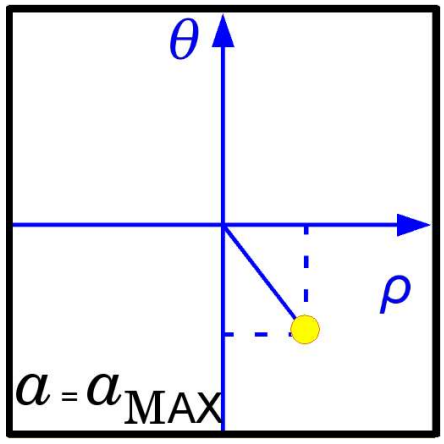
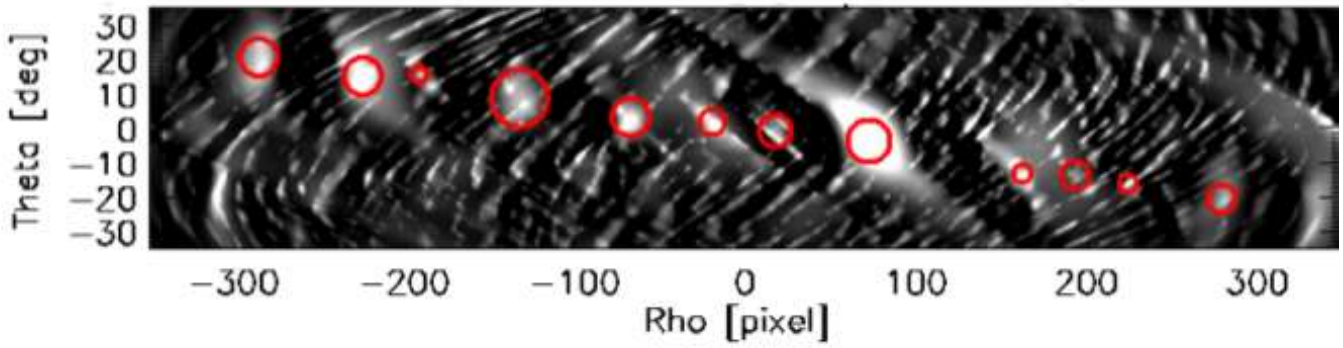
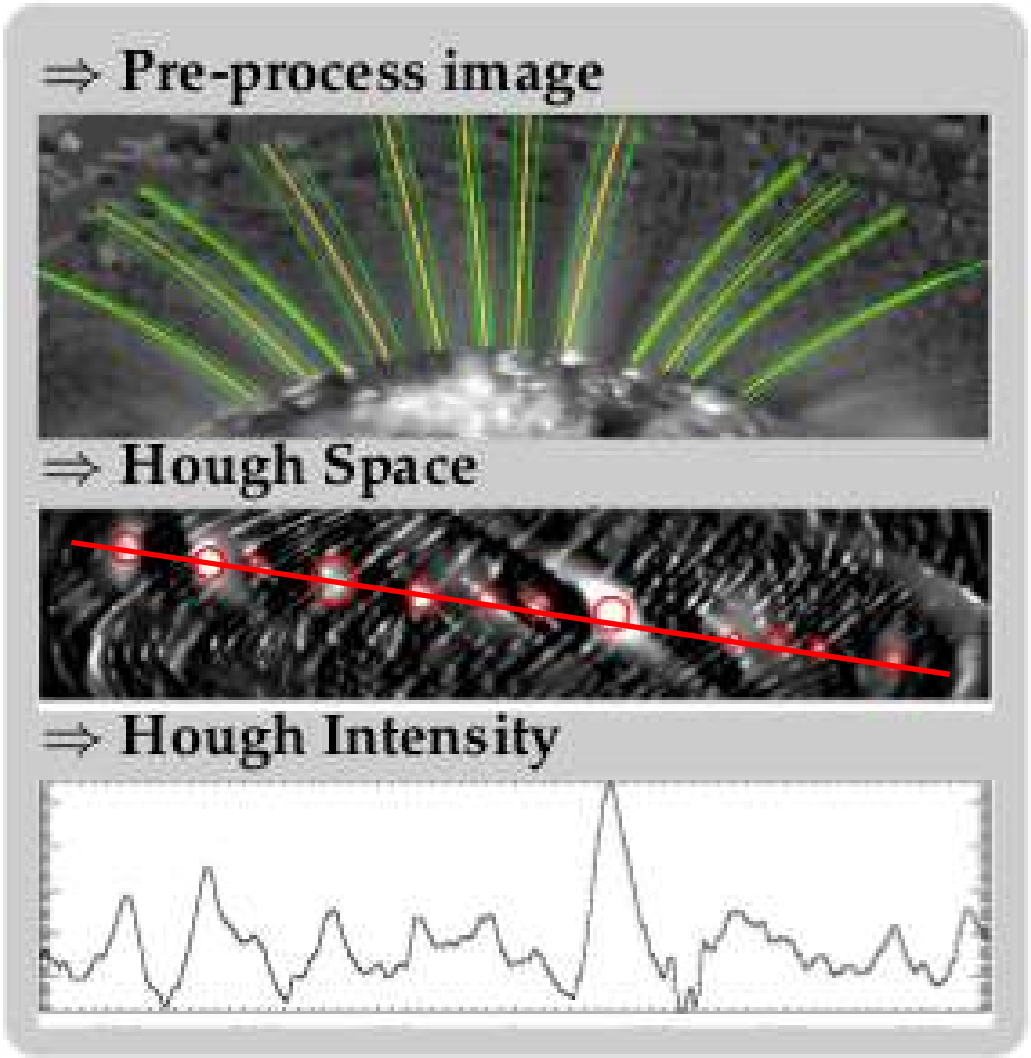


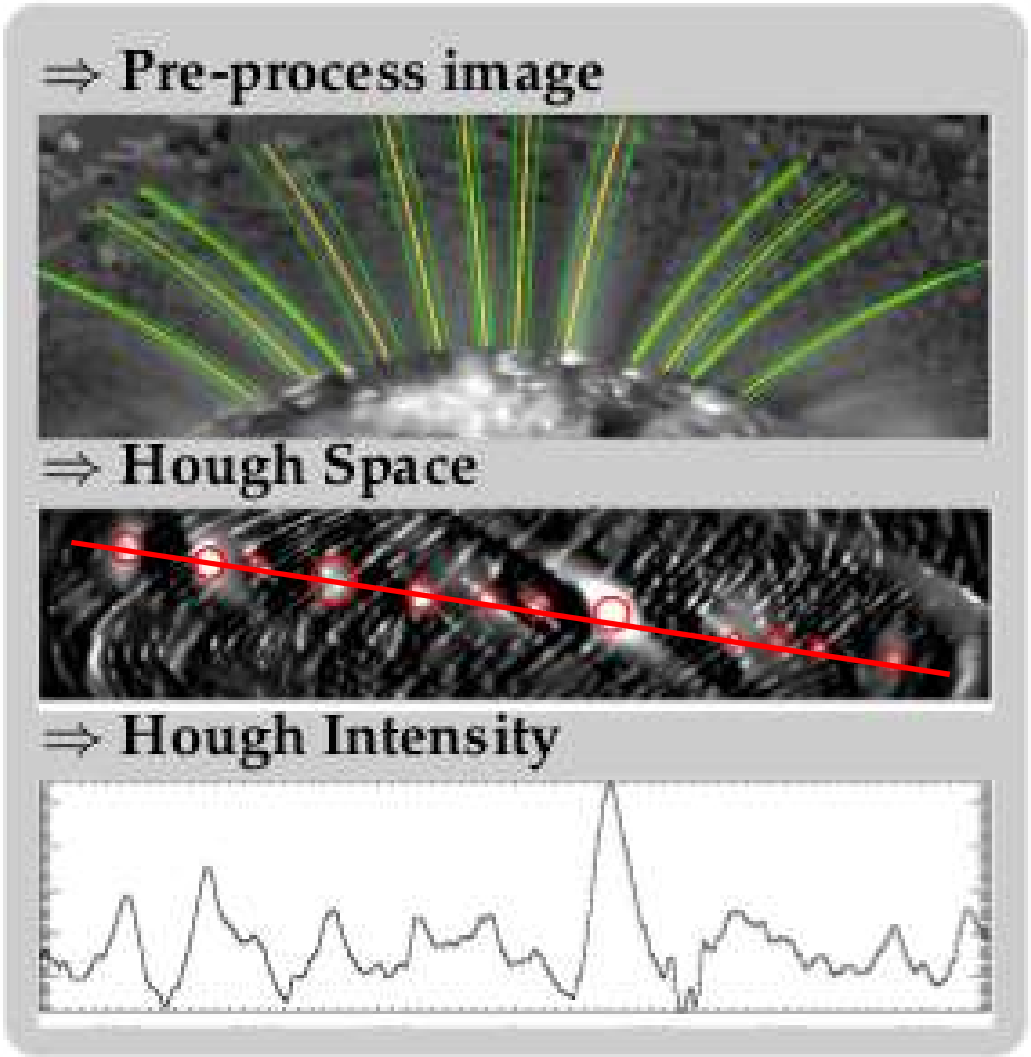


(*J. de Patoul et al., 2011*)

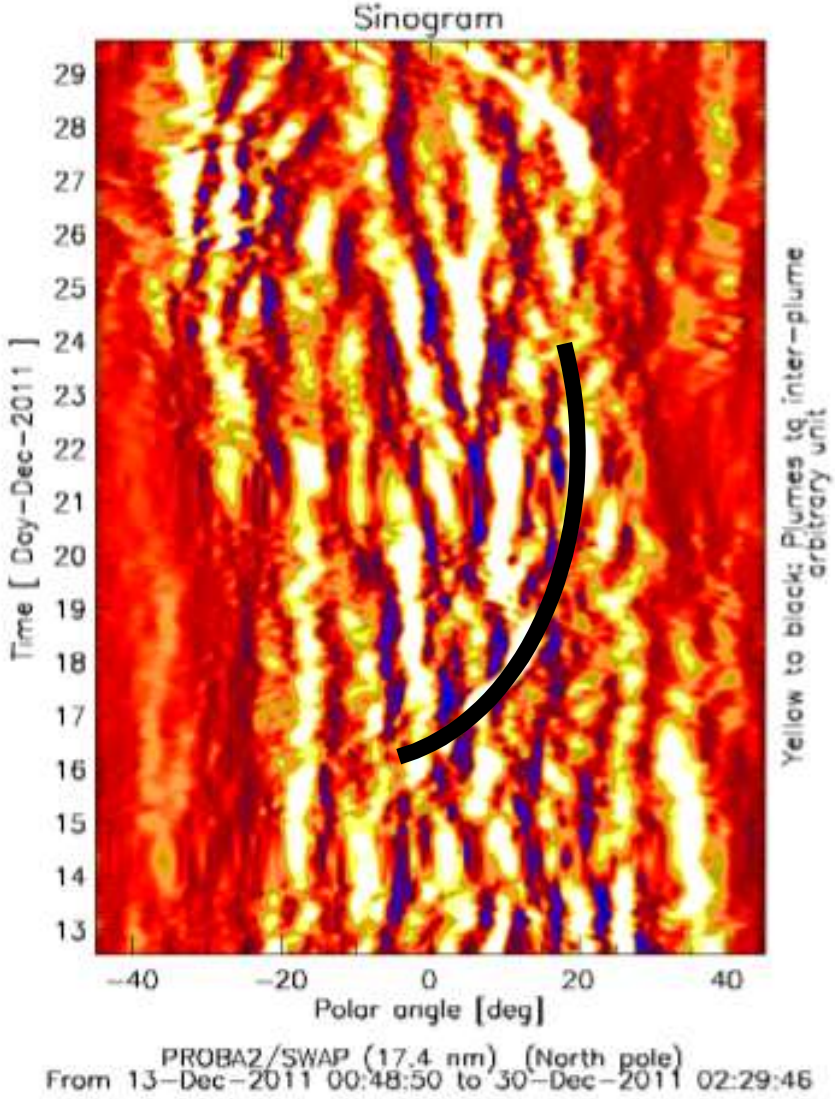
Temporal evolution | Sinogram



Temporal evolution | Sinogram



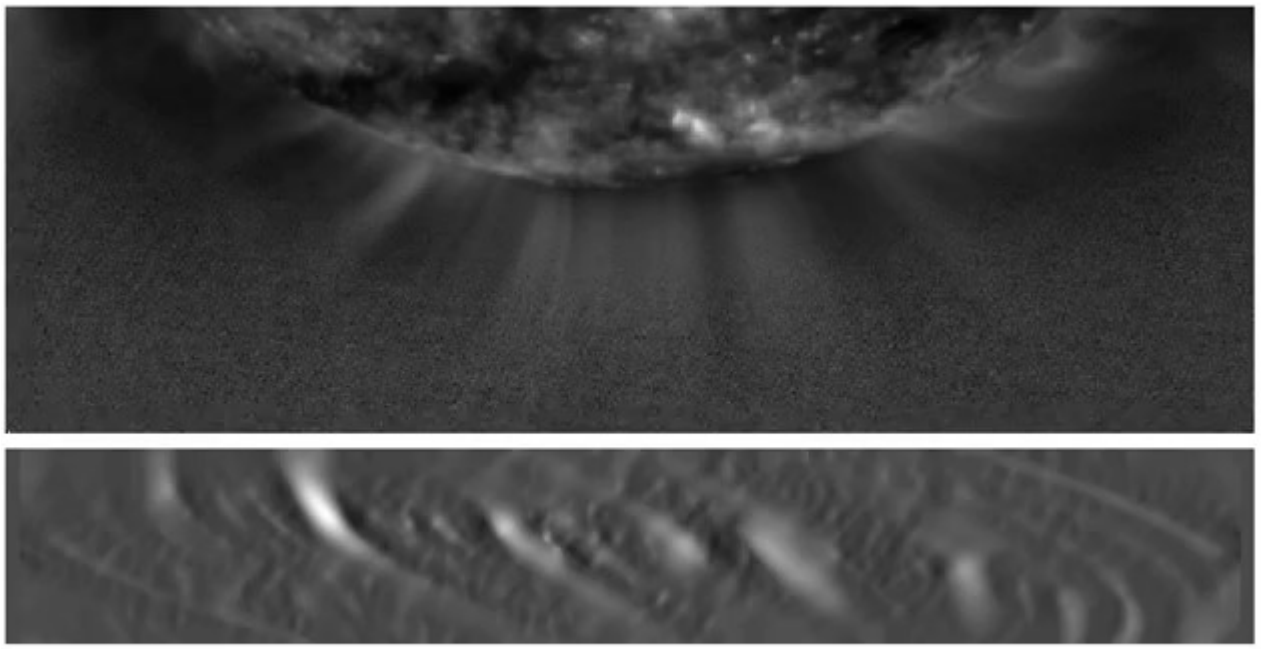
PROBA2/SWAP Sinogram



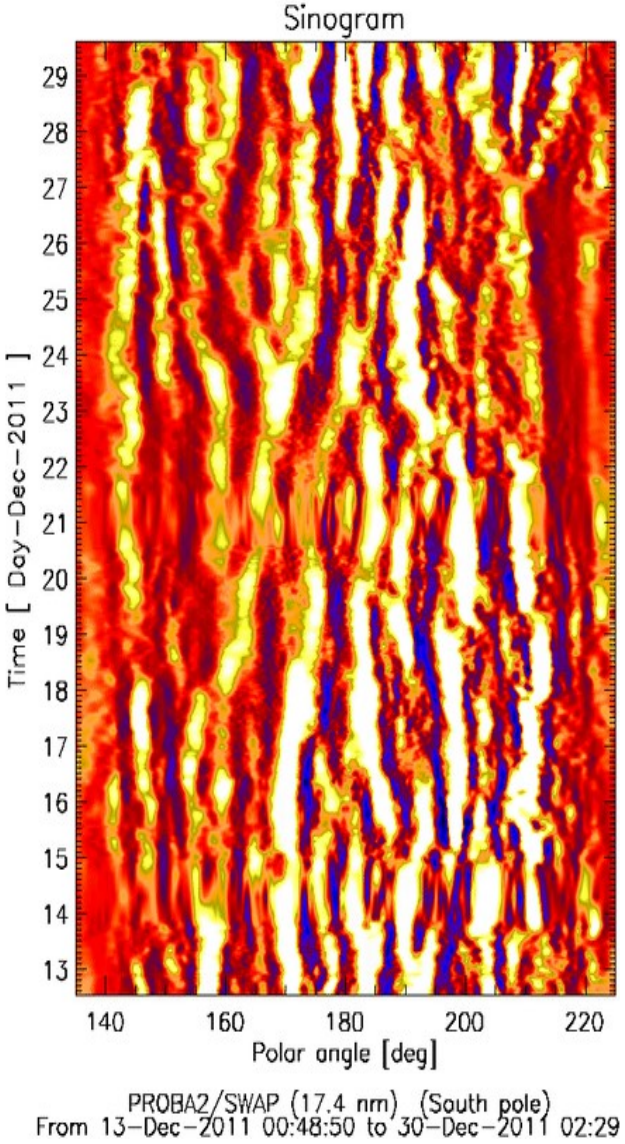
Temporal evolution | Sinogram

One month data set of PROBA2/SWAP observations

- from December 13, 2011 to January 09, 2012
- Image: contrast enhancement
- Hough space: Hough-wavelet transform
- Sinogram



(South) PROBA2/SWAP (17.4 n 2011-12-13 00:08:50



PROBA2/SWAP (17.4 nm) (South pole)
From 13-Dec-2011 00:48:50 to 30-Dec-2011 02:29

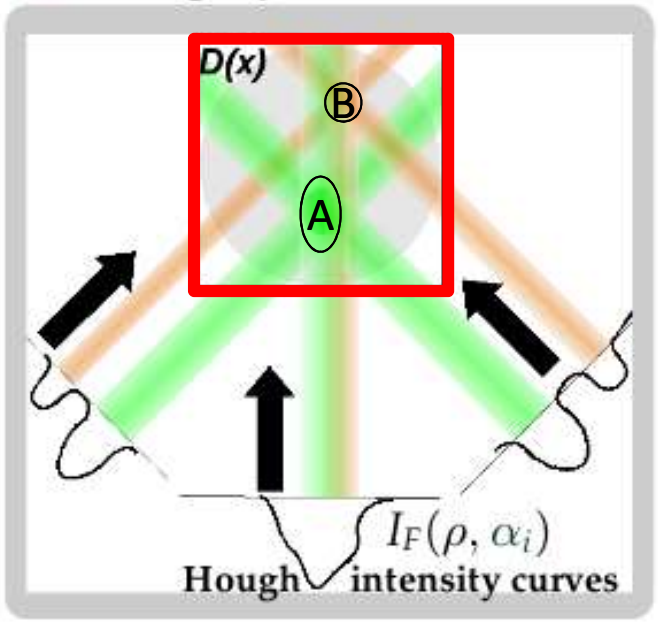
Plume network| Filter backprojection

The Hough-wavelet density plane D(**x**) is obtained by

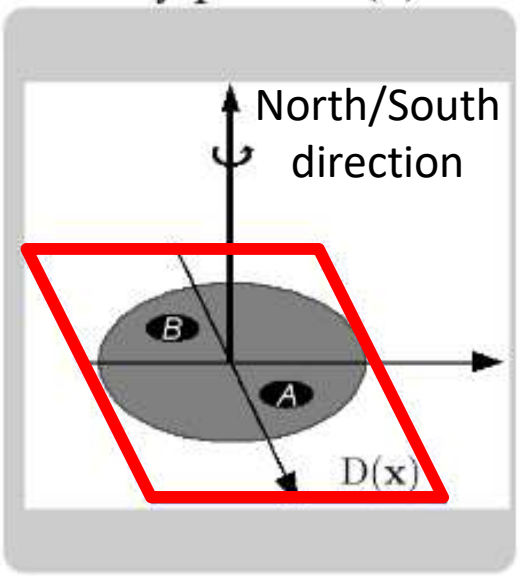
$$\mathrm{D}(\mathbf{x}) = \int_{\alpha_0}^{\alpha_1} \int_{\mathbb{R}} I_F(\rho, \alpha)\ \delta\left(\mathbf{e}_{\mathrm{LOS}}(\alpha) \cdot \mathbf{x} - \rho\right)\ d\rho\, d\alpha\ ,$$

where $I_F(\rho, \alpha)$ are the filtered Hough intensity curves.

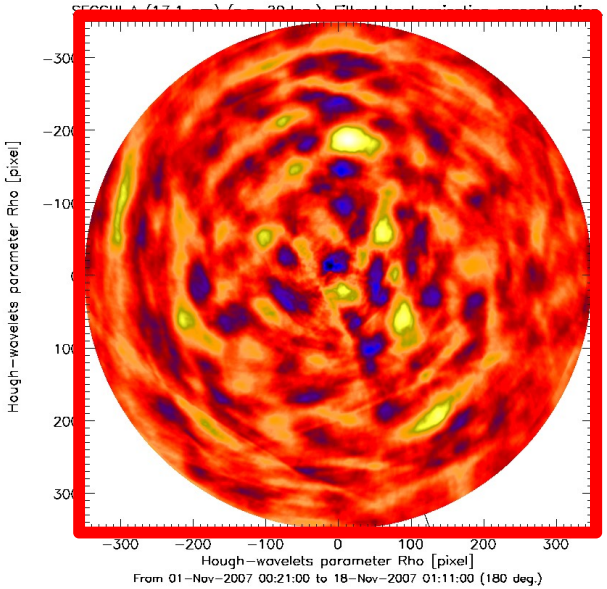
■ Backprojection:



■ Hough-wavelet density plane D(**x**):

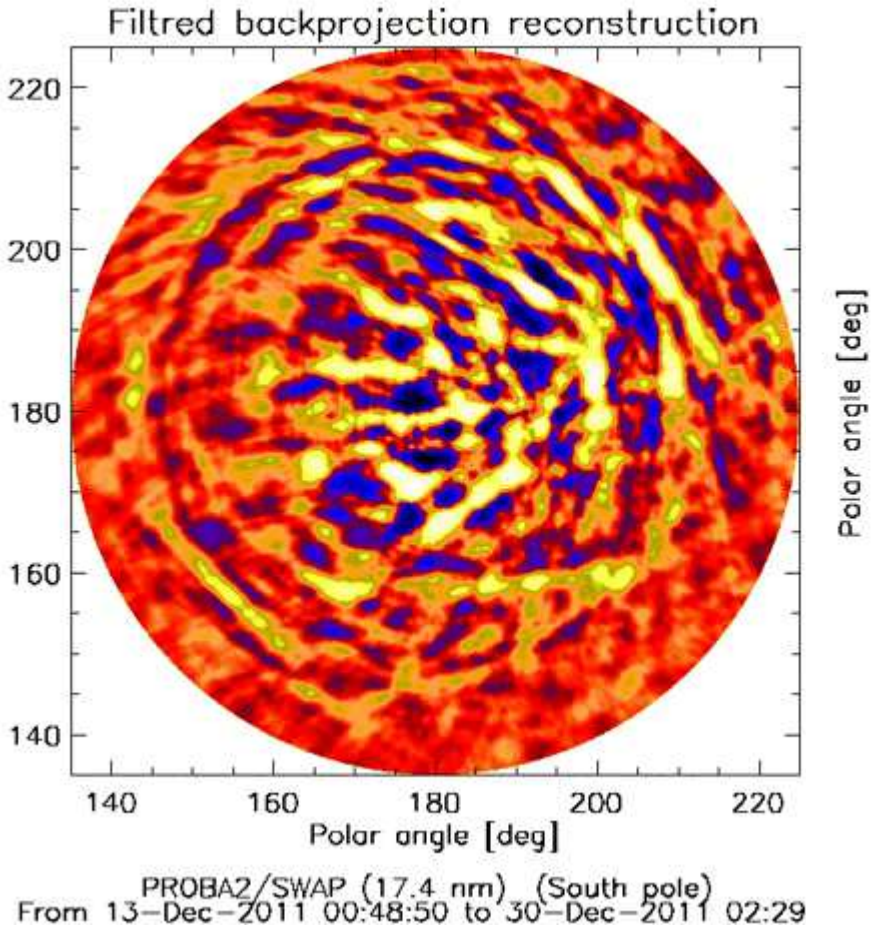


■ 3D reconstruction:

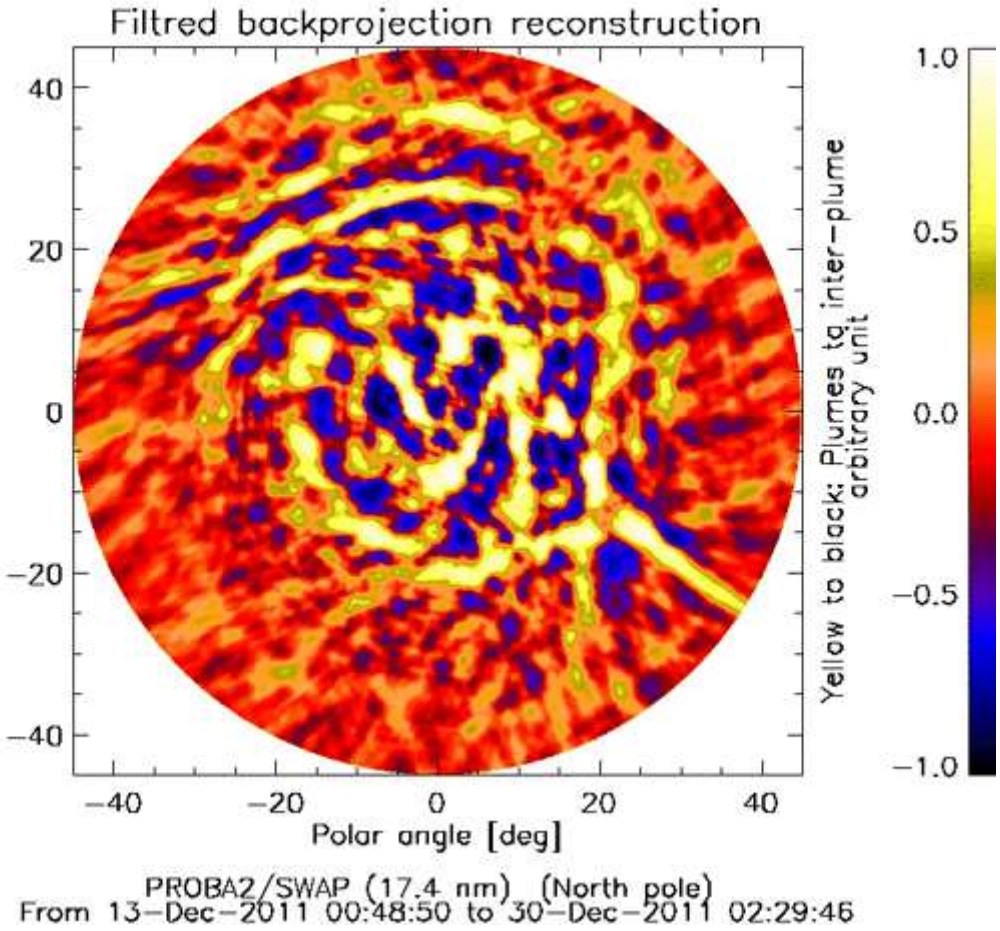


Polar plume network

South pole



North pole

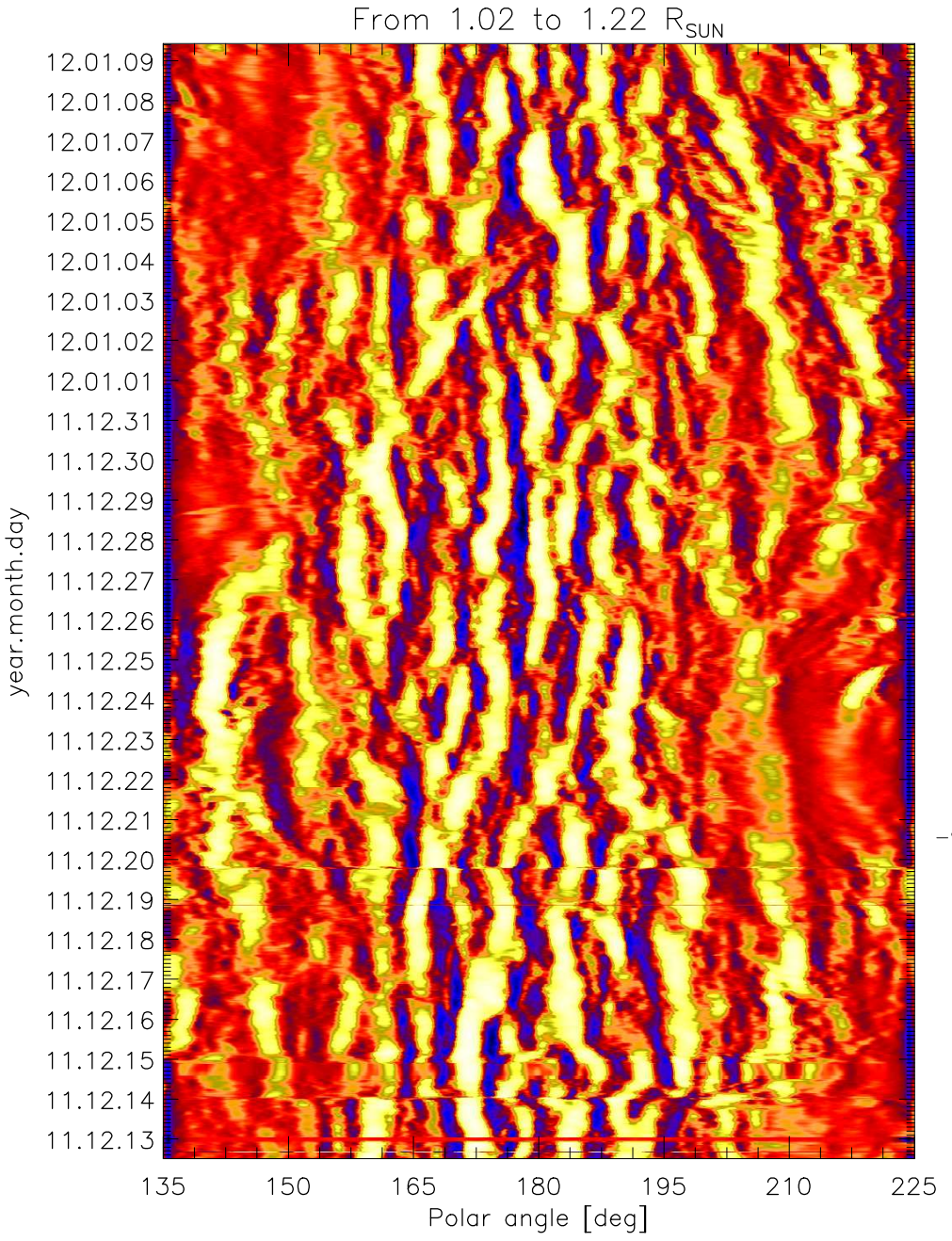


What about,

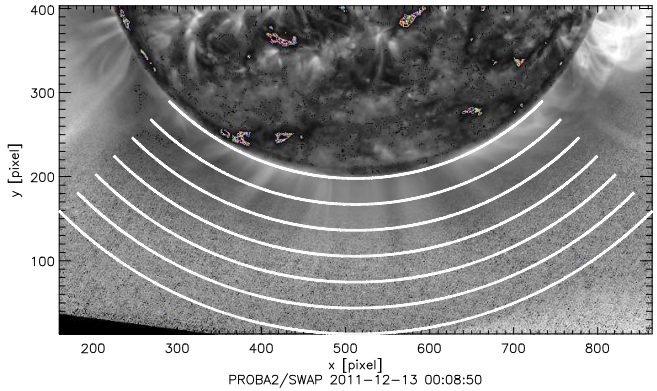
- Plume network vs. Chromospheric Network
- Expansion factor of plume (funnel shape)
- Magnetic inclination angle & pole opening

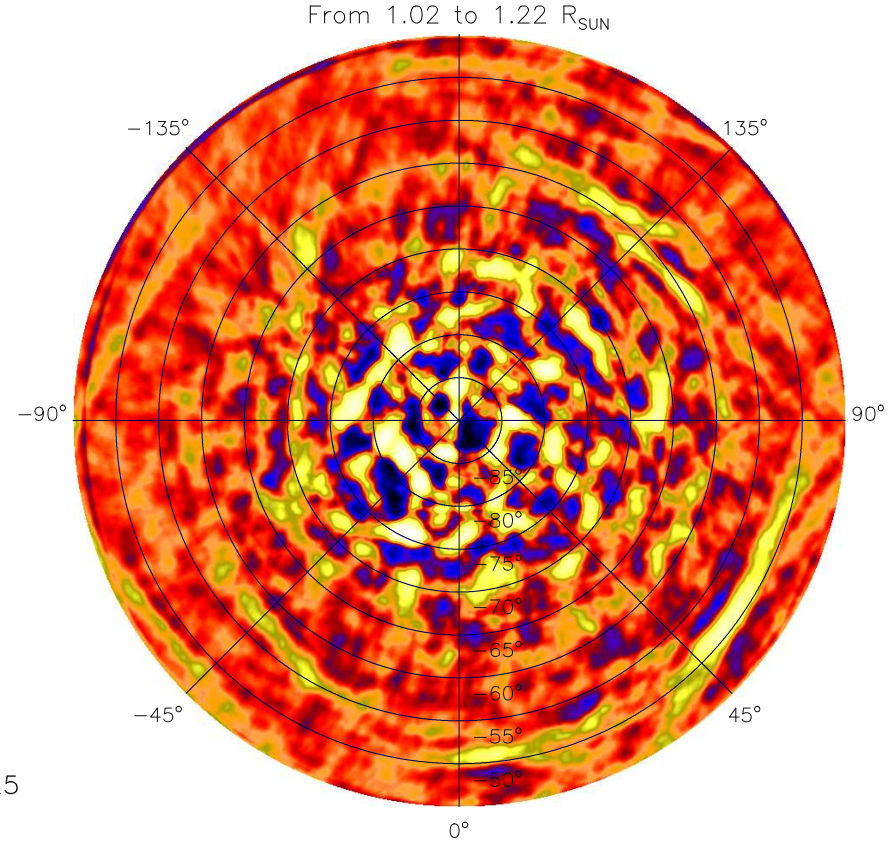
Further investigations,

- Plumes at multi heights
- Size of the network
- Inclination angle of the plumes

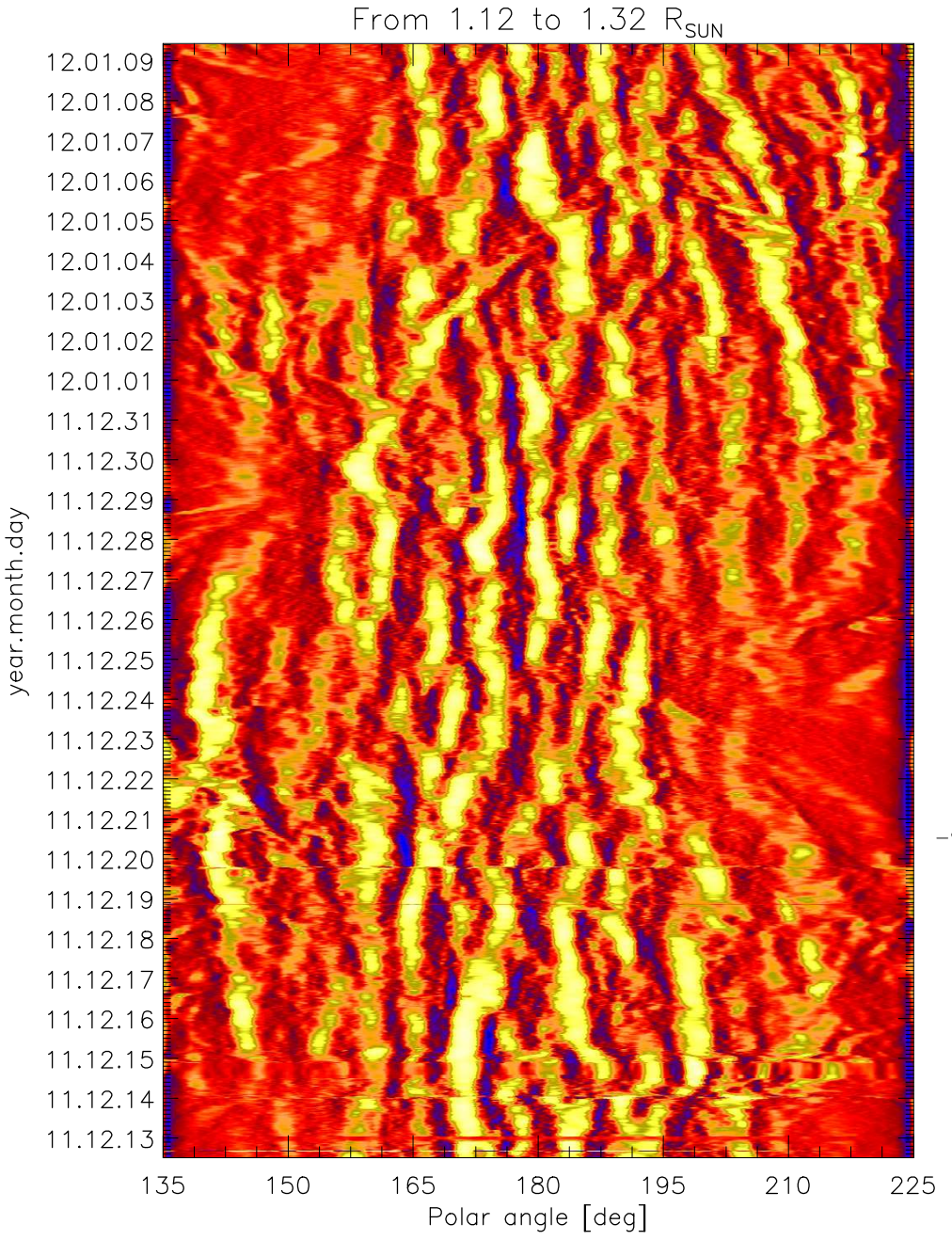


PROBA2/SWAP (17.4 nm) (South pole)
From 13−Dec−2011 00:08:50 to 09−Jan−2012 22:20:17





PROBA2/SWAP (17.4 nm) (South pole)
From 13−Dec−2011 00:08:50 to 30−Dec−2011 01:04:54



PROBA2/SWAP (17.4 nm) (South pole)
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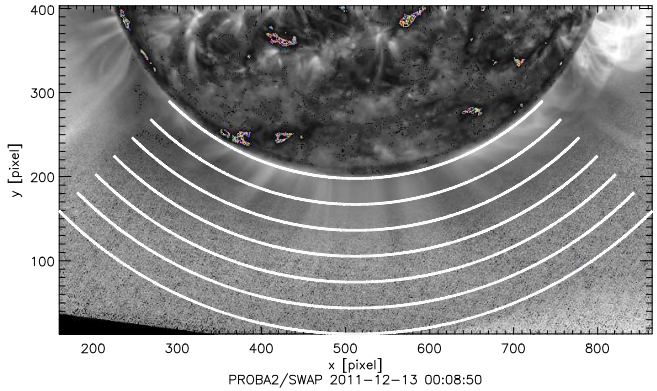

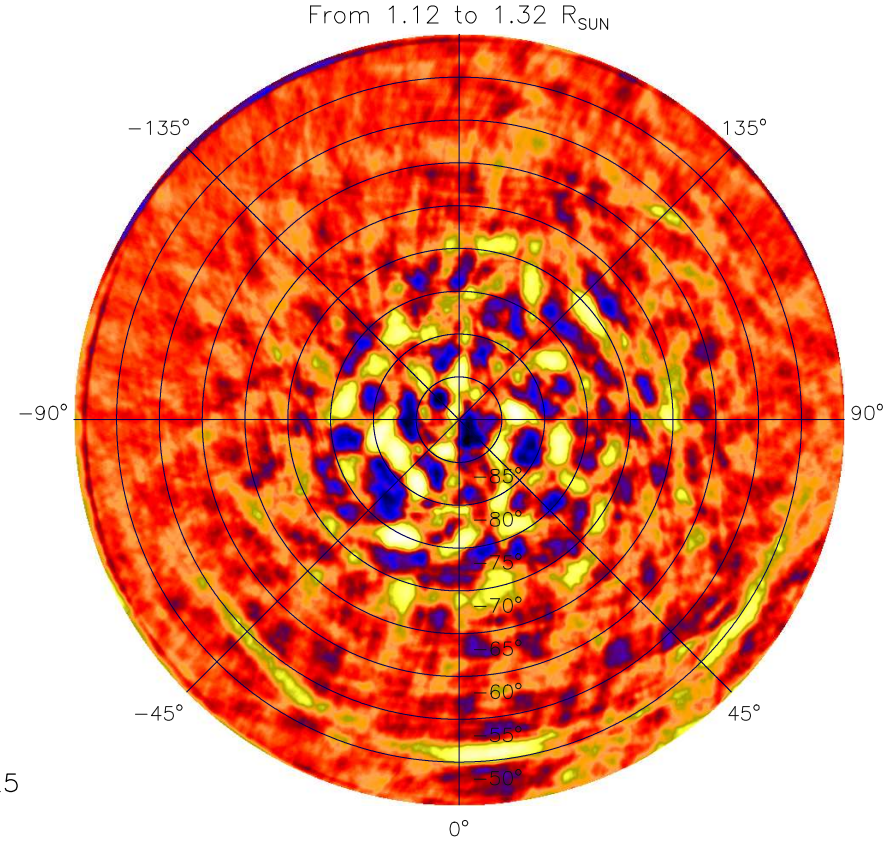

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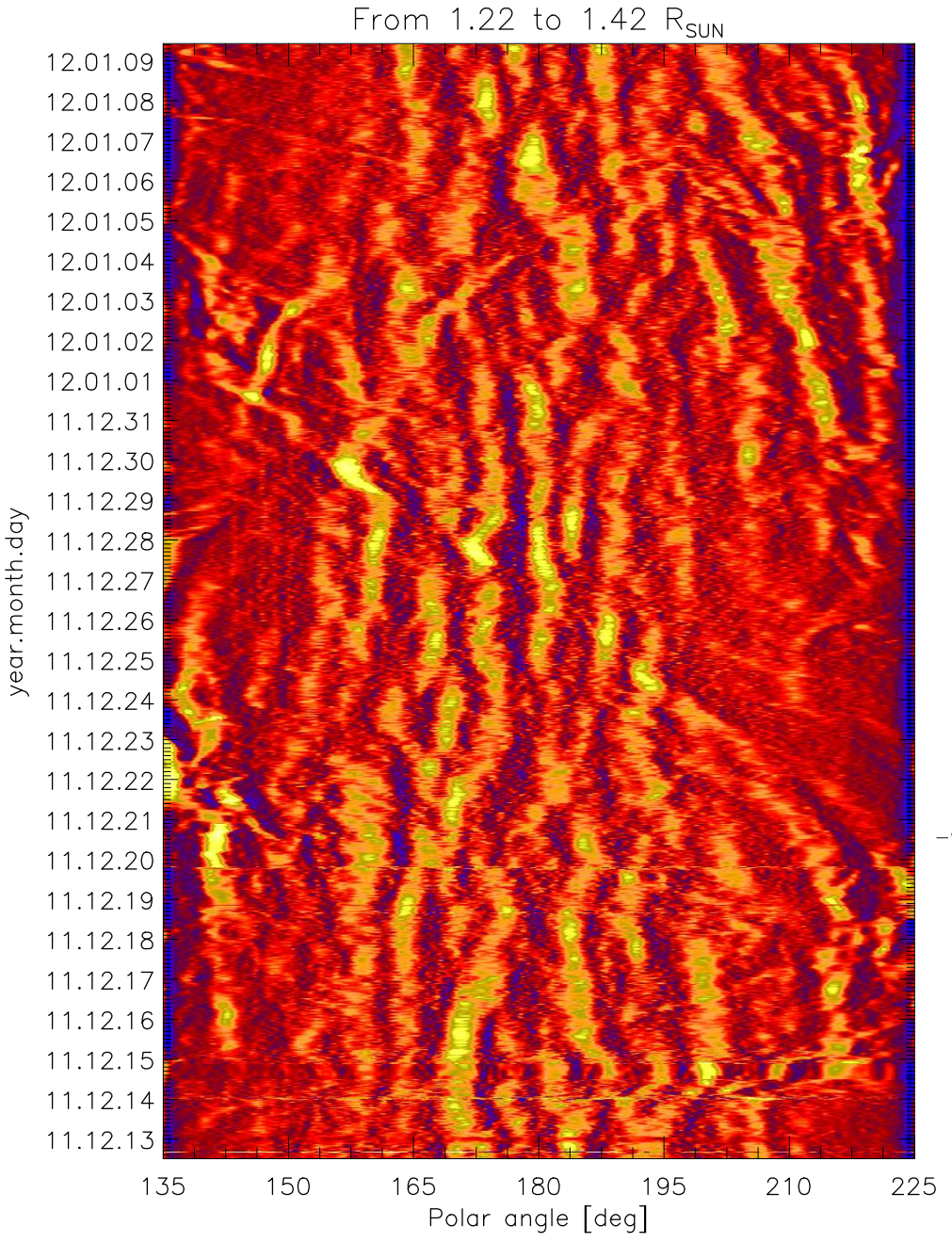

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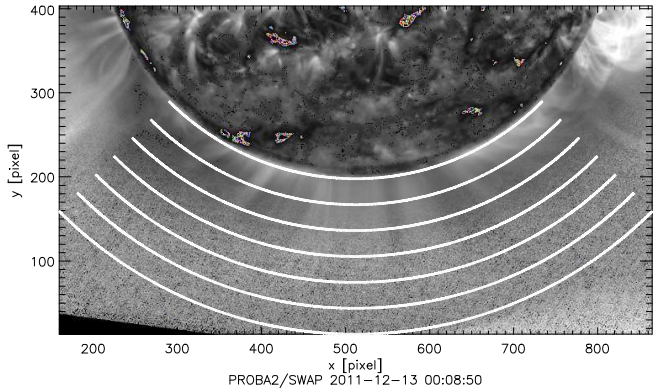

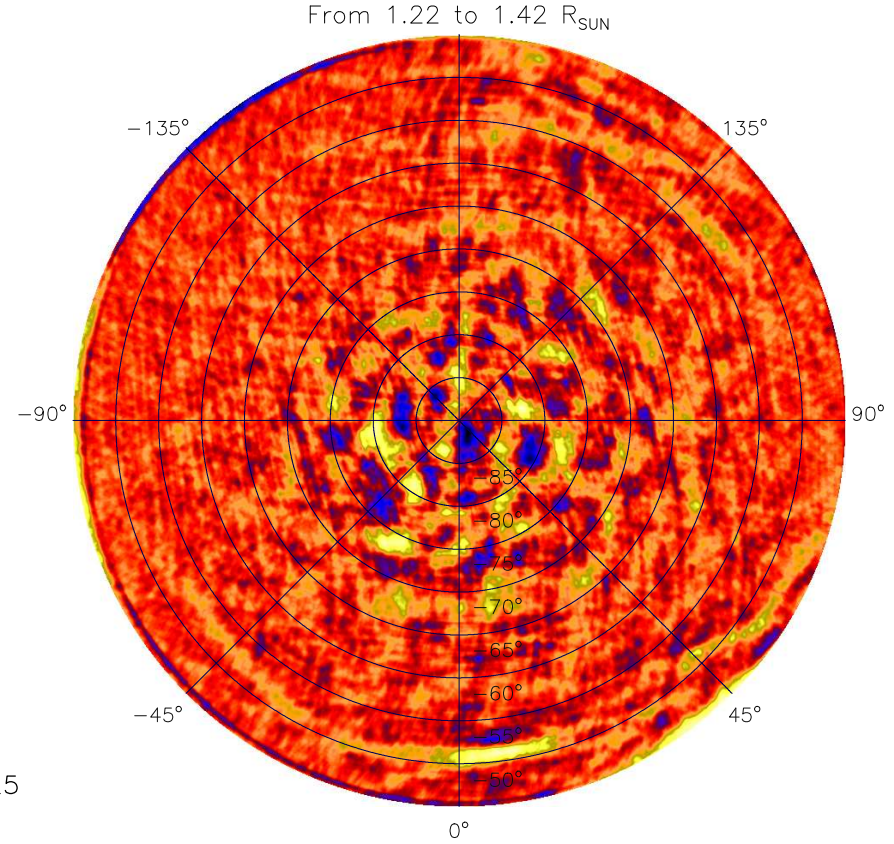

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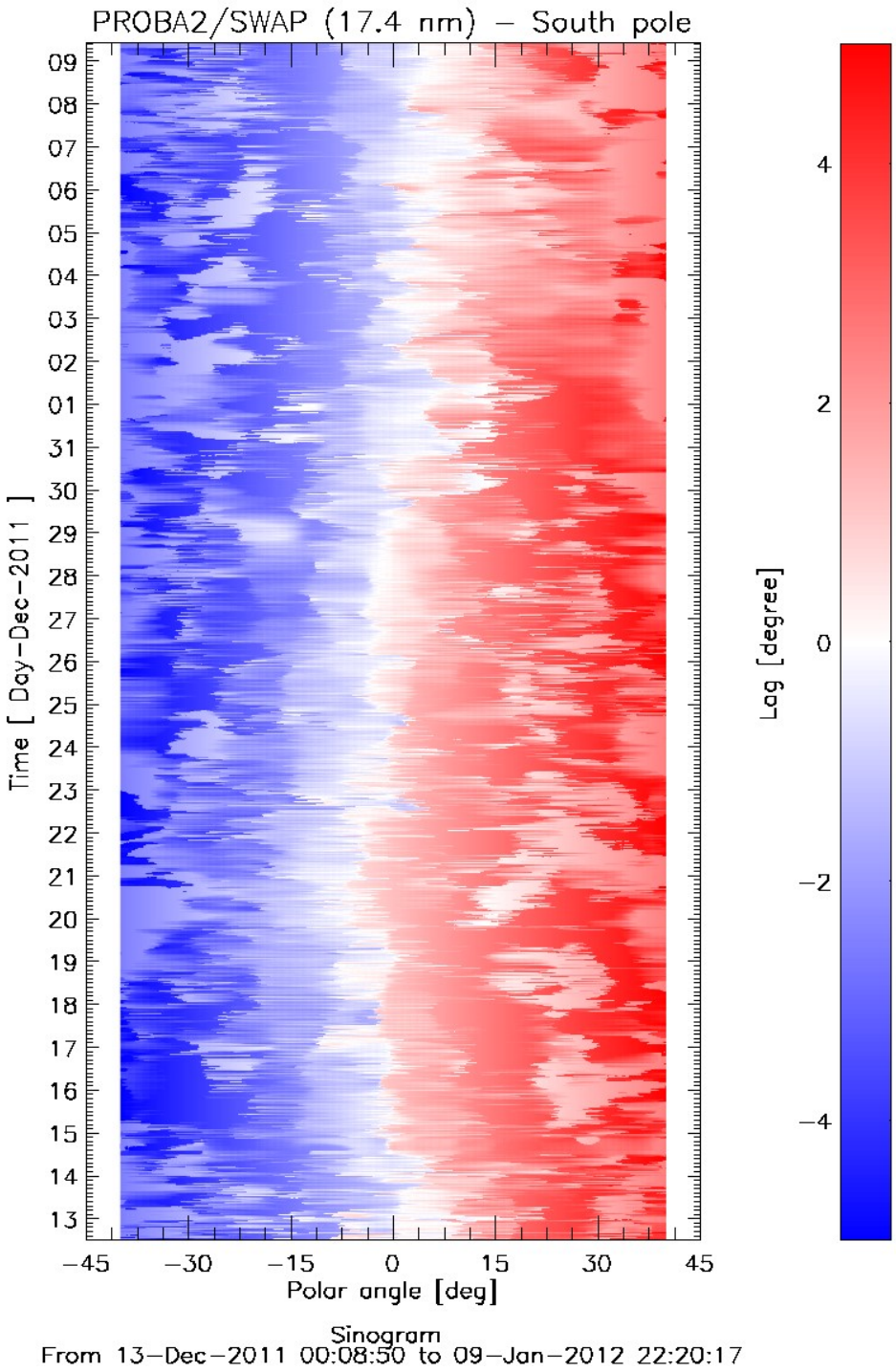
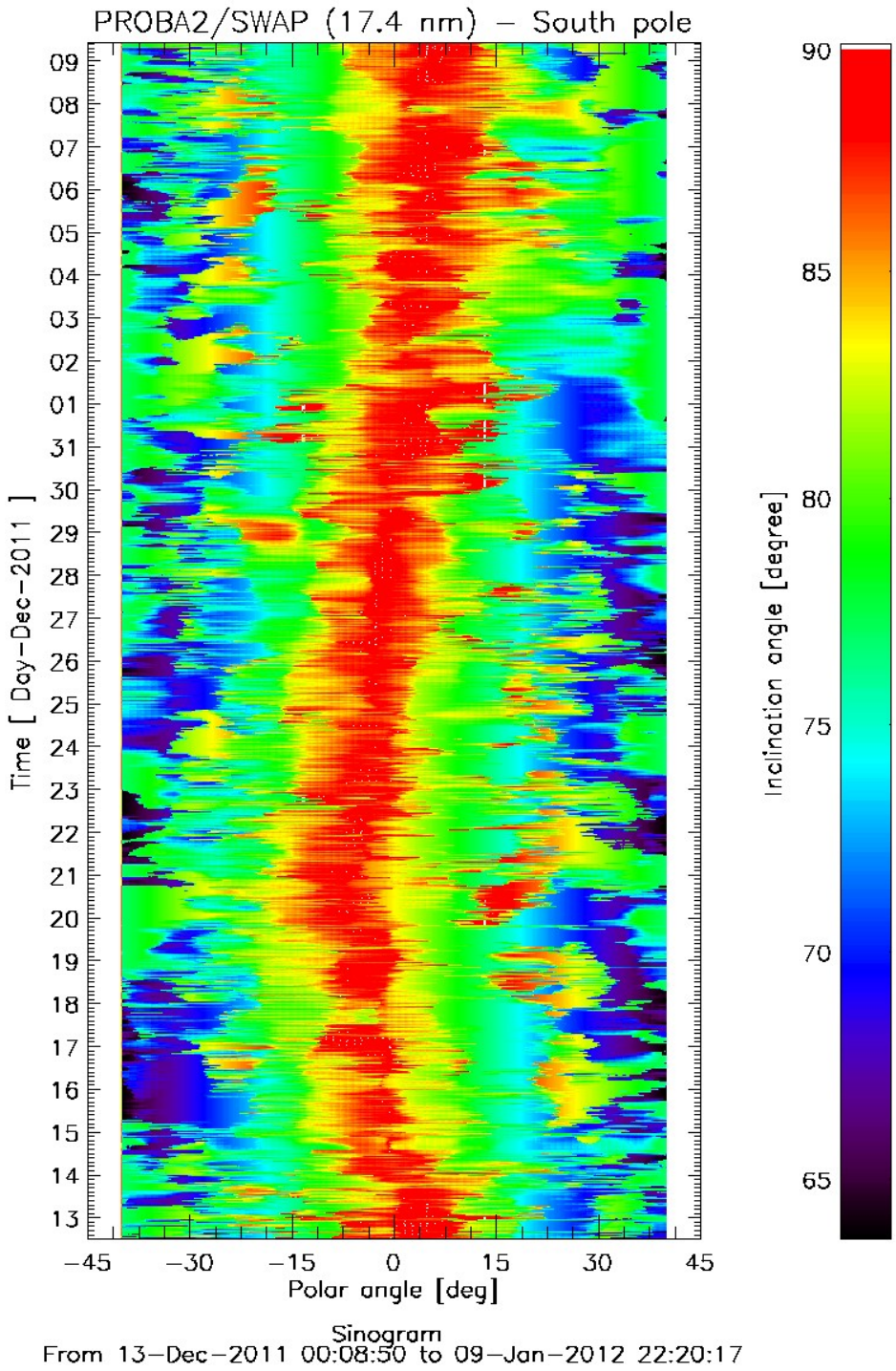
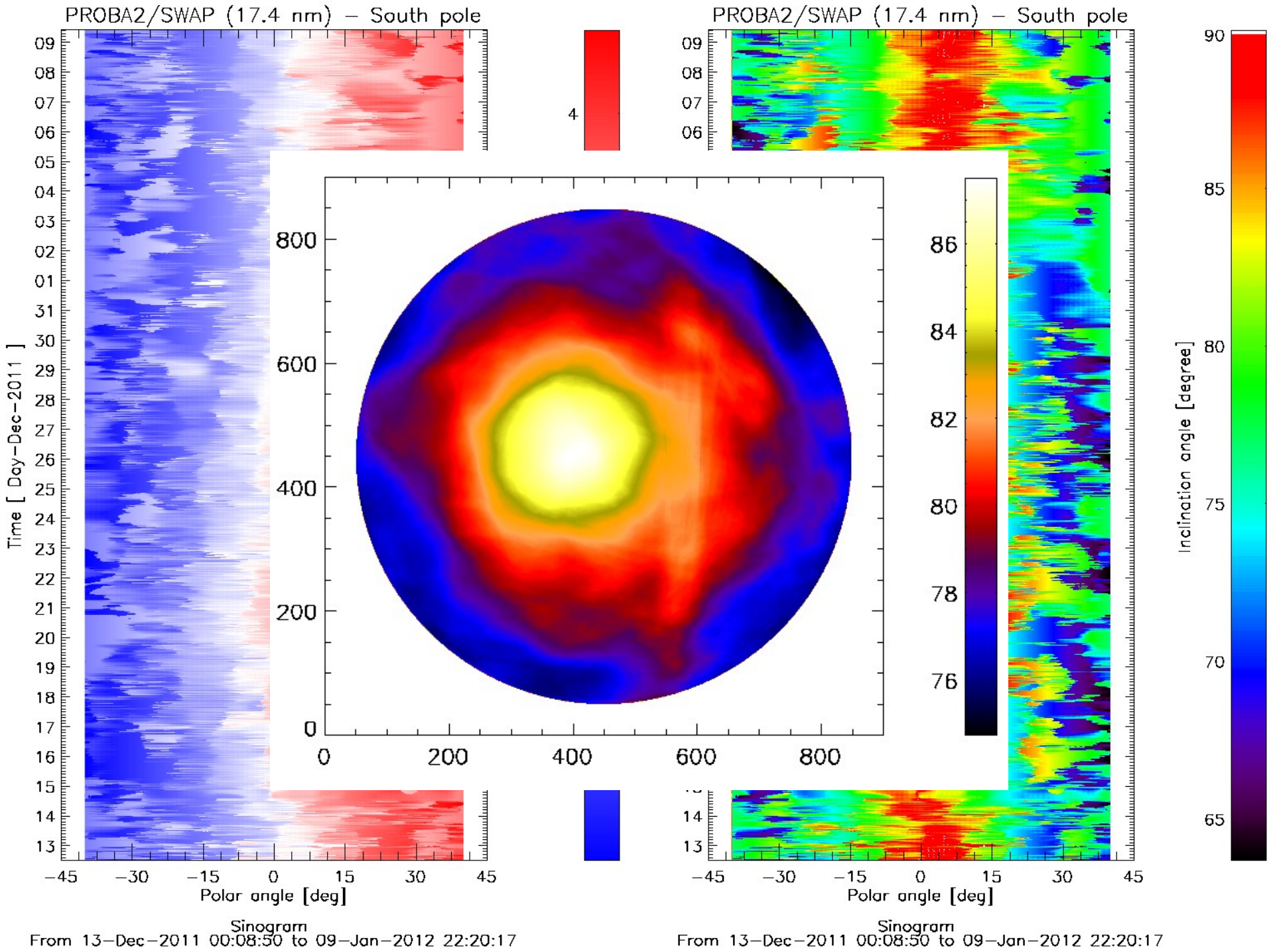
From 13-Dec-2011 00:08:50 to 30-Dec-2011 01:04:54


PROBA2/SWAP (17.4 nm) – South pole
Time [Day-Dec-2011]
09
08
07
06
05
04
03
02
01
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
−45
−30
−15
0
15
30
45
Polar angle [deg]
Log [degree]
4
2
0
−2
−4
Sinogram
From 13-Dec-2011 00:08:50 to 09-Jan-2012 22:20:17


PROBA2/SWAP (17.4 nm) – South pole
Time [Day-Dec-2011]
09
08
07
06
05
04
03
02
01
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
−45
−30
−15
0
15
30
45
Polar angle [deg]
Inclination angle [degree]
90
85
80
75
70
65
Sinogram
From 13-Dec-2011 00:08:50 to 09-Jan-2012 22:20:17


PROBA2/SWAP (17.4 nm) – South pole
PROBA2/SWAP (17.4 nm) – South pole
Time [Day-Dec-2011]
Polar angle [deg]
Polar angle [deg]
Inclination angle [degree]
Sinogram
From 13-Dec-2011 00:08:50 to 09-Jan-2012 22:20:17
Sinogram
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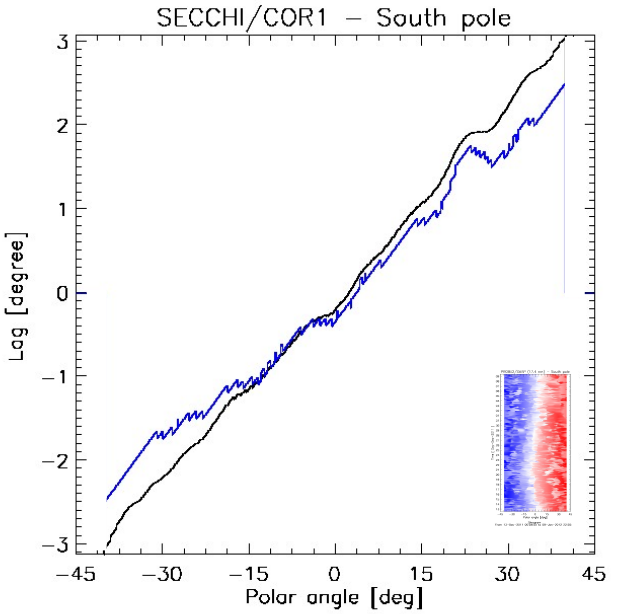
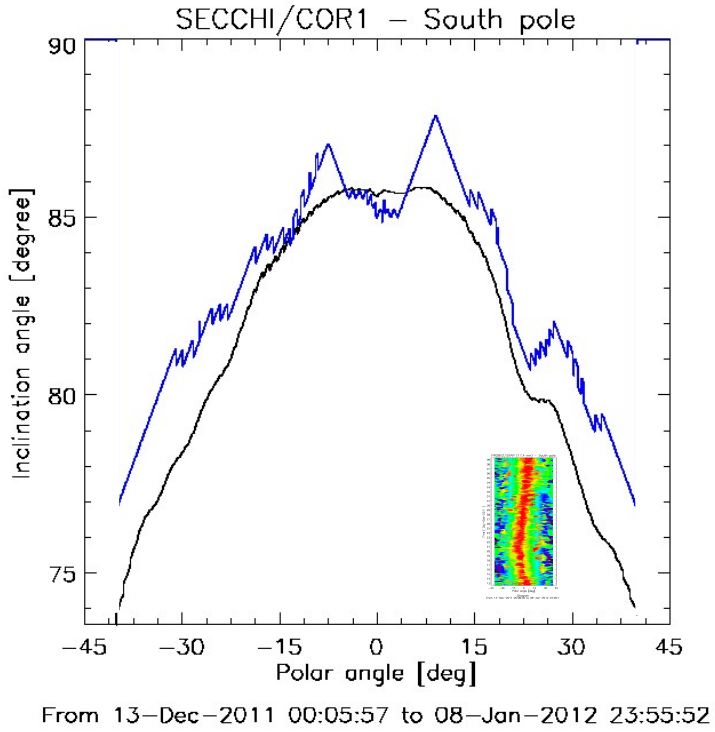
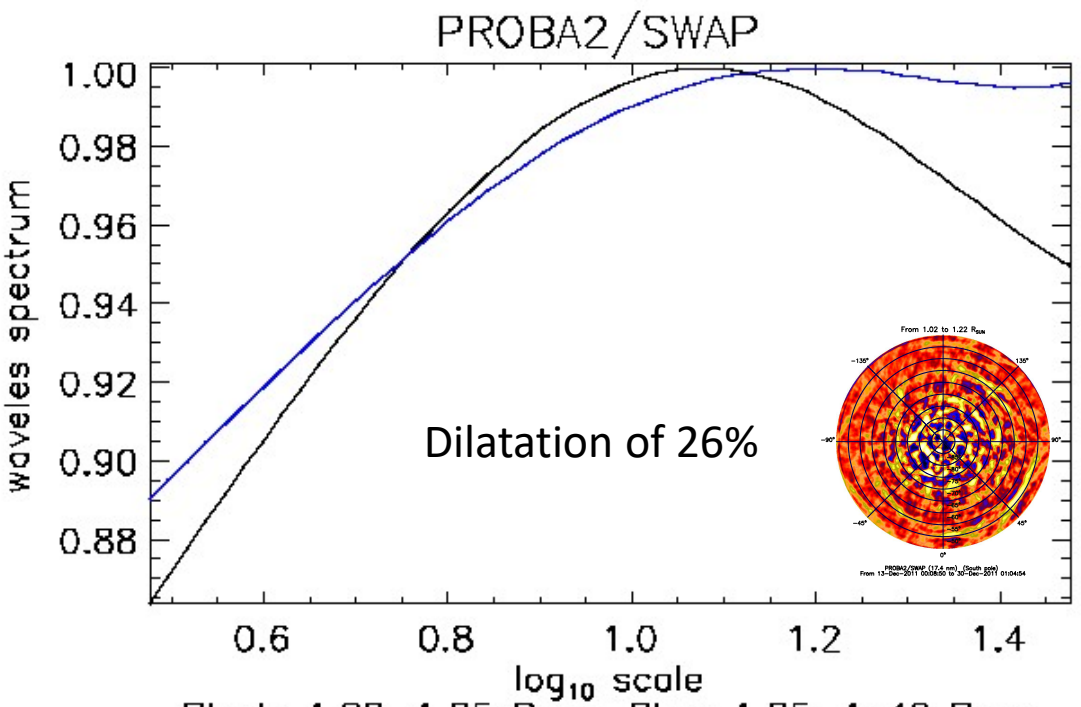
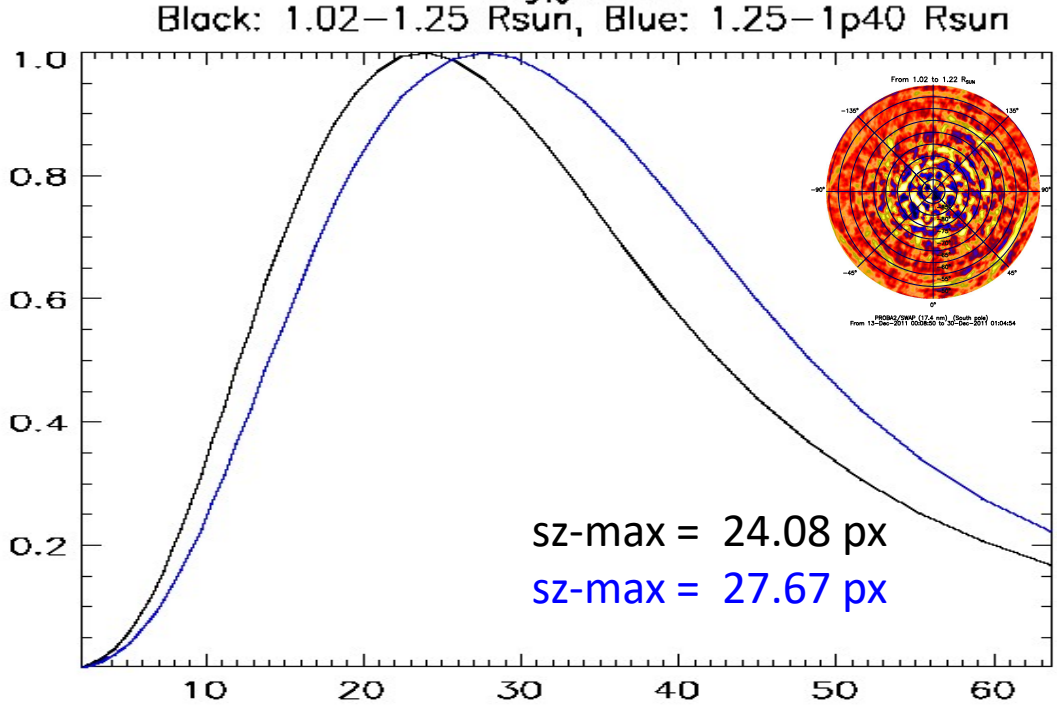

SECCHI/COR1 – South pole
Lag [degree]
Polar angle [deg]
From 13–Dec–2011 00:05:57 to 08–Jan–2012 23:55:52


SECCHI/COR1 – South pole
Inclination angle [degree]
Polar angle [deg]
From 13–Dec–2011 00:05:57 to 08–Jan–2012 23:55:52


PROBA2/SWAP
waveles spectrum
Dilatation of 26%
log10 scale


Black: 1.02–1.25 Rsun, Blue: 1.25–1p40 Rsun
sz-max = 24.08 px
sz-max = 27.67 px

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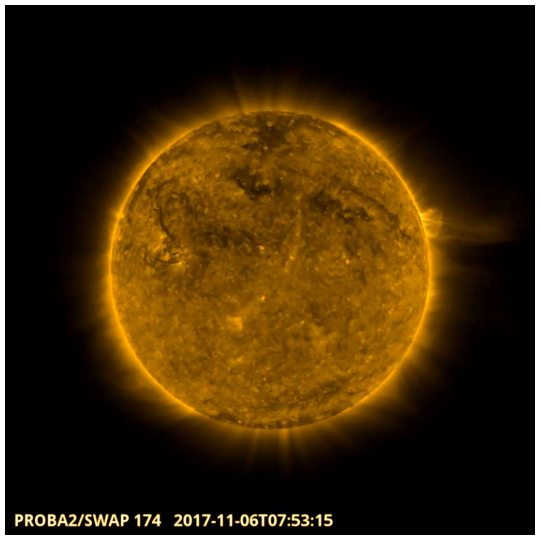
2. Polar plumes 3D reconstruction

Plume network investigation



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