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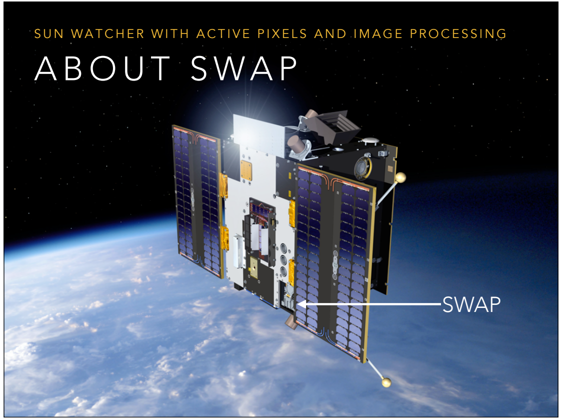
ROYAL OBSERVATORY OF BELGIUM / ESAC
EUROPEAN SOLAR PHYSICS MEETING 14 ☀ TCD ☀ 8 SEPTEMBER 2014

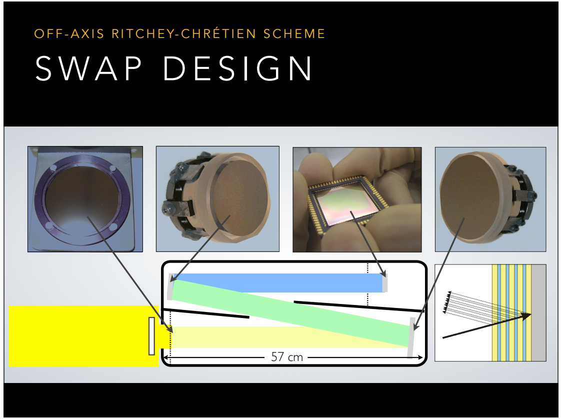
SOLAR CYCLE 24 AND THE LARGE-SCALE EVOLUTION OF THE EUV CORONA

PROBA2/SWAP

A BRIEF INTRODUCTION



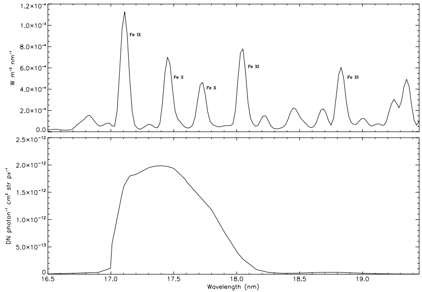
PROBA2 is the second of ESA's Project for On-Board Autonomy missions. It hosts SWAP, and three other science instruments: LYRA, a radiometer, and two plasma instruments. It also hosts 17 technology demonstrations.



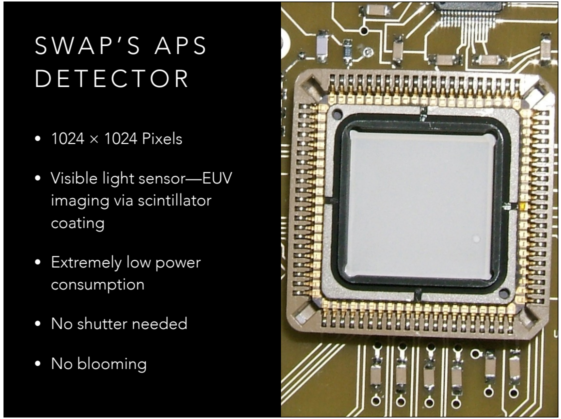
SWAP is a small, internally baffled Ritchey-Chrétien telescope. It has two aluminum filters at the entrance pupil and focal plane. Spectral selection comes from multilayer coatings on the mirrors.

BANDPASS PEAK AT 17.4 NM

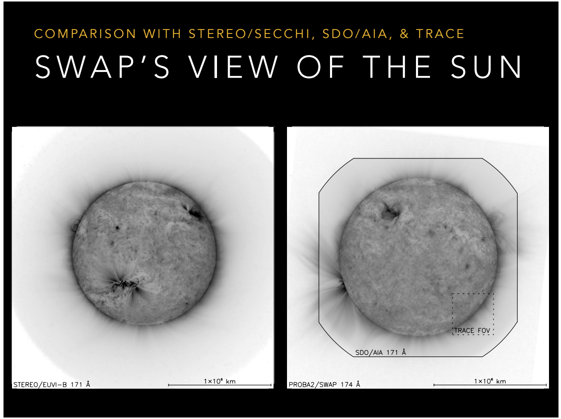
RESPONSE FUNCTION



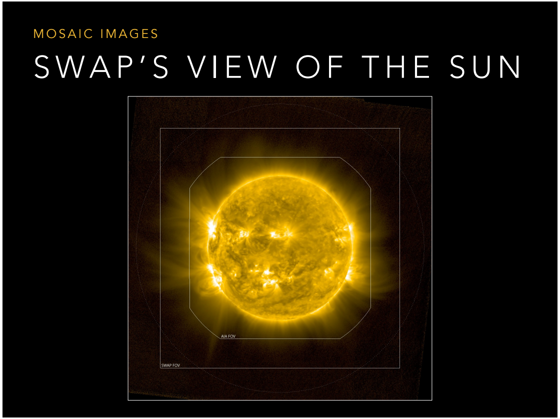
SWAP’s passband peak is about 17.4 nm, so it sees a few Fe lines that form around 0.8 MK. During flares, it has a bit of sensitivity to hotter lines as well.



SWAP uses a CMOS-Active Pixel Sensor for its camera, which has many advantages over traditional CCD cameras.

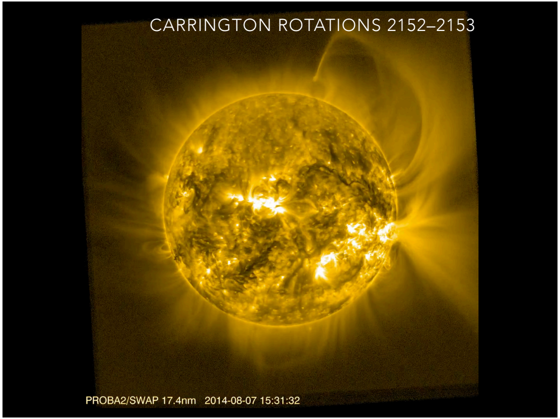


SWAP's field-of-view is comparable to the FOVs of the EUVI imagers on STEREO. Early in the solar cycle we saw only a few structures extending to large heights in the FOV.



SWAP can be commanded to do mosaic imaging to obtain an even larger FOV for special campaigns.

The genesis of this project came from trying to find interesting ways to exploit SWAP's unique capabilities, so we started making movies of Carrington rotations.

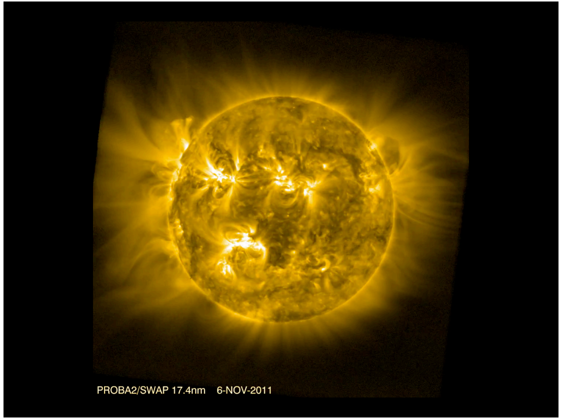


This movie shows the last two Carrington Rotations, which show many large, dynamic structures, especially near the north pole.

SOLAR CYCLE 24

THE LARGE-SCALE EUV CORONA

So we extended this analysis to the whole solar cycle…

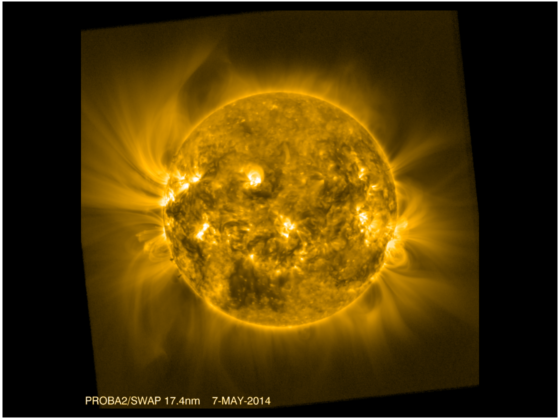


We carefully prepare one frame/day from full orbit of data (30–40 images). This approach controls anisotropy in the frame due to orientation from because the spacecraft rotates every 25 minutes. We took care to remove stray light, thermal noise, etc. The movie shows the growth over the whole solar cycle to date.

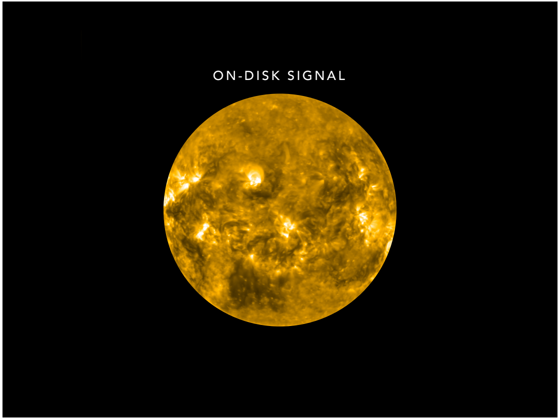
SOLAR CYCLE 24

CORONAL BRIGHTNESS

We looked at various ways to track the growth and structure of the corona over the long term. Tracking brightness alone reveals many interesting features.



We tracked the brightness of the disk and at various heights above the solar surface as well.



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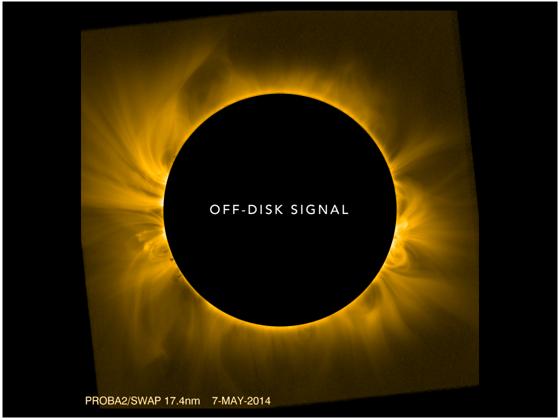

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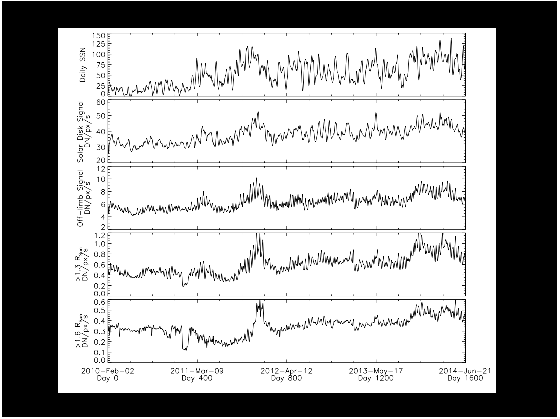
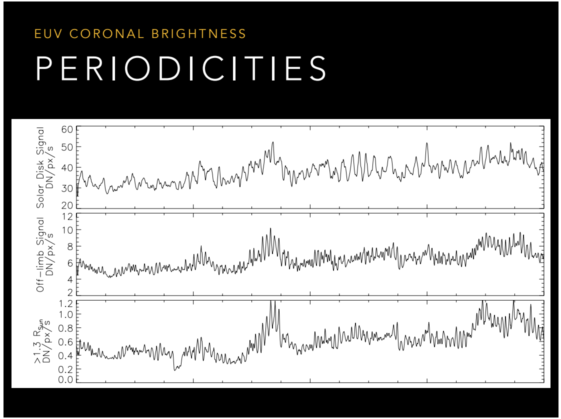
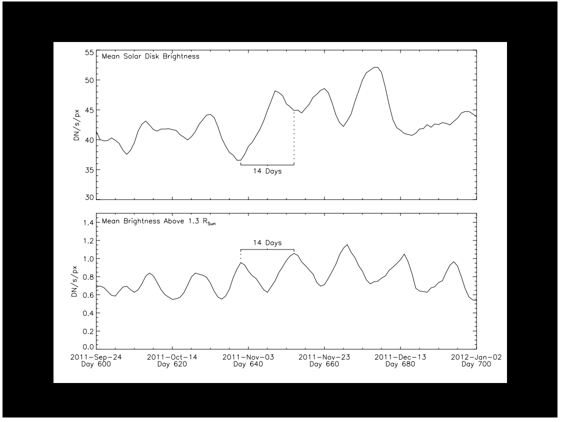


We compare the International Sunspot Number to our various measurements of SWAP brightness. There were clear outbursts of activity in late 2011 and mid-2014. The dip in off-limb signal in early 2011 is (apparently) a calibration artifact.

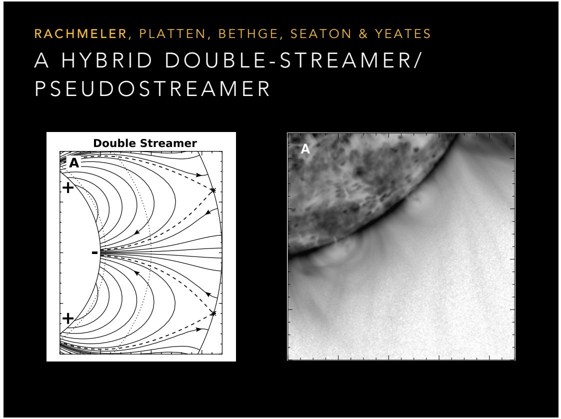


The off-limb signal in particular is very sensitive to changes in activity. When there is not much activity it is quite dark, but rapidly brightens during active periods. In many cases is shows interesting periodicities. We can explore these further…

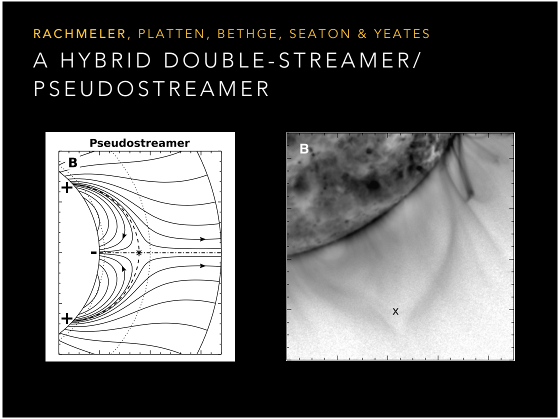


A close look shows the oscillations have (often) a 14-day period, in anti-phase on- and off-disk. This is due to the rotation of bright, active-region-associated fans, to the limb, across the disk, and back at (roughly) the Carrington rotation rate.

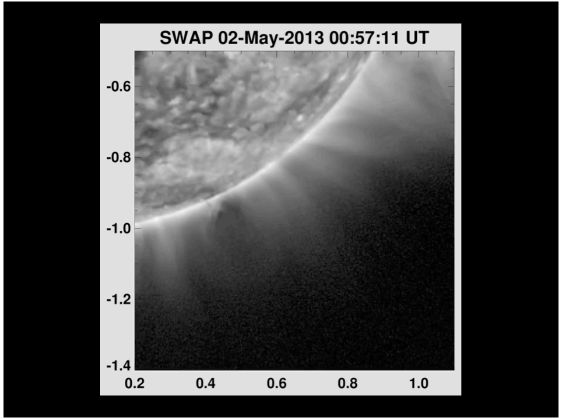
These fan structures are usually near active regions with open field that overlies prominence cavities. They appear to be related to streamers and/or pseudostreamers.



Laurel Rachmeler studied these structures, comparing SWAP and COMP (Coronal Multichannel Polarimeter) observations and models. She finds some structures are hybrid in nature, side-by-side streamers in some places along two parallel polarity inversion lines…



…while in other places along the same inversion lines they are pseudo streamers. These structures appear to be ubiquitous and long lived in SWAP observations.



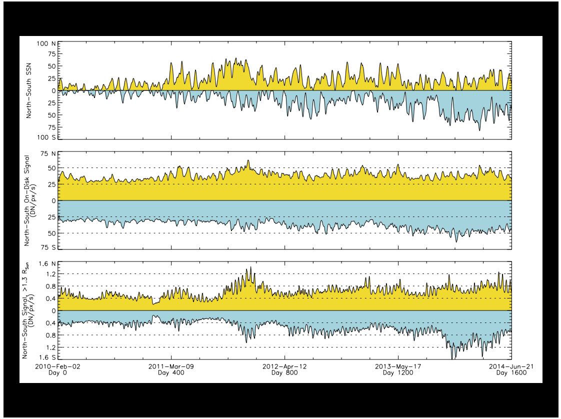
This movie illustrates how one such structure changes along its length, which we can see as it rotates to the limb over several days. More on this in the poster, session 2.

So we have some understanding of how these relate to streamers and pseudostreamers, but what about the fans? Why are they bright? Why do they extend so far into the corona? How far do they really extend? Research still ongoing.

SOLAR CYCLE 24

THE PRESENT CYCLE

We would like to make a few remarks about the nature of the present solar cycle. It is useful to break the brightness up by hemisphere. (For optically thin, three-dimensional structures the division is a bit ambiguous, but it's still a useful exercise.)

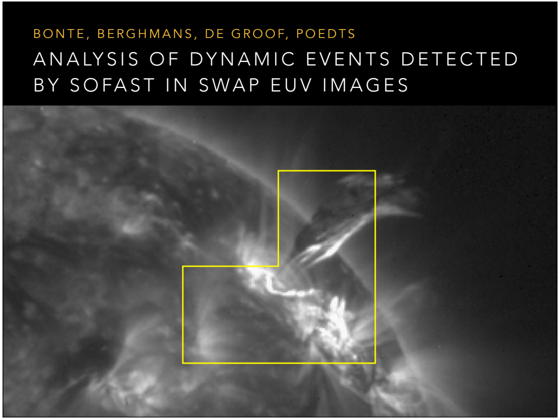


We compared the hemispheric sunspot number to on- and off-disk brightness by hemisphere. It's pretty clear here, especially from the SSN and off-disk curves, that the Northern Hemisphere peaked in late 2011, while the south is peaking more or less now.

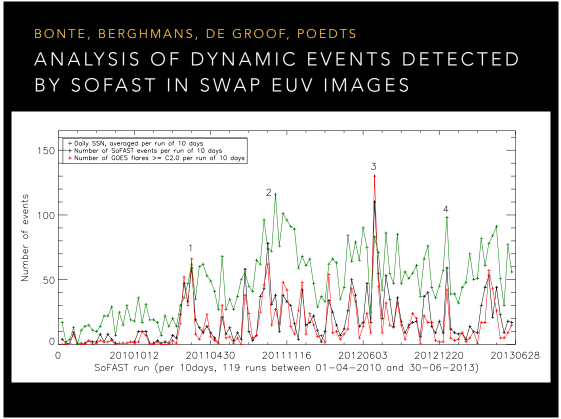
SOLAR CYCLE 24

GOING FARTHER

What else can SWAP tell us about the solar activity cycle?



Katrien Bonte has developed an algorithm that can automatically detect brightenings in SWAP data, and tracks flares and other events. SOFAST. This is an example of one such detection.



Events detected by GOES & SWAP are well correlated and sort of track solar activity.

This is really a wholly different way of evaluating activity, events in a sense encode a measure of real energy storage and release in the corona. (Poster, session 6.)

CONCLUSIONS

- SWAP reveals surprising structure & brightness in the corona at large scales
- 17.1 nm observations are dominated by fans related to interface between streamers, pseudostreamers, and active regions
- Solar activity in the north peaked in late 2011, south appears to be at peak now

For movies:

http://proba2.oma.be/Presentations/20140908_Seaton_ESPM14/

See also: Seaton et al., 2013, *ApJ*, **777**, 72. (DOI: 10.1088/0004-637X/777/1/72)