Solar flux from SMOS mission: an introduction

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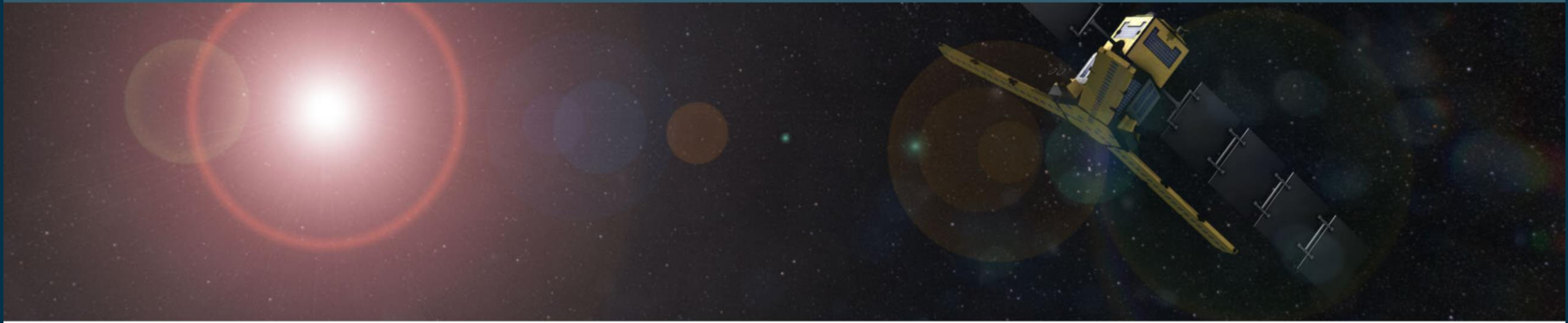
ESA ESRIN

27/10/2023



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Validation of the SMOS Mission for Space Weather Operations: The Potential of Near Real-Time Solar Observation at 1.4 GHz

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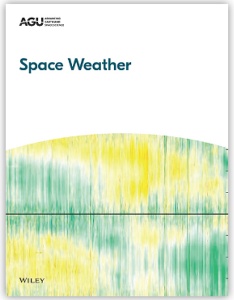
Abstract



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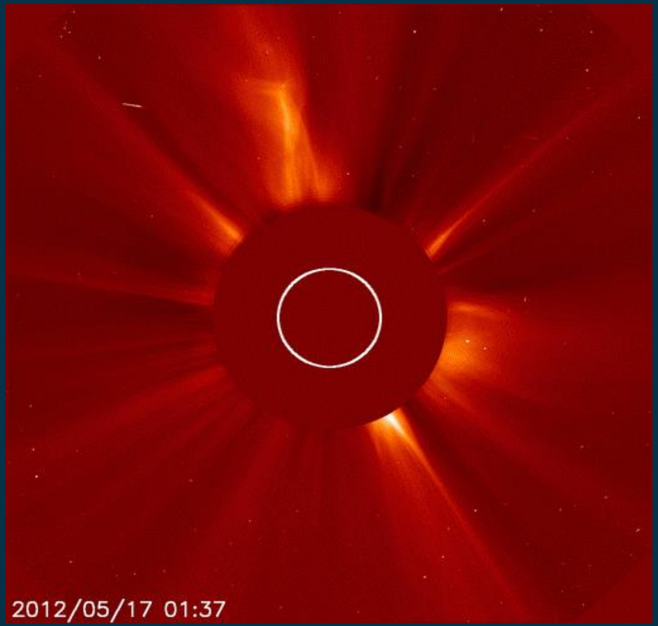
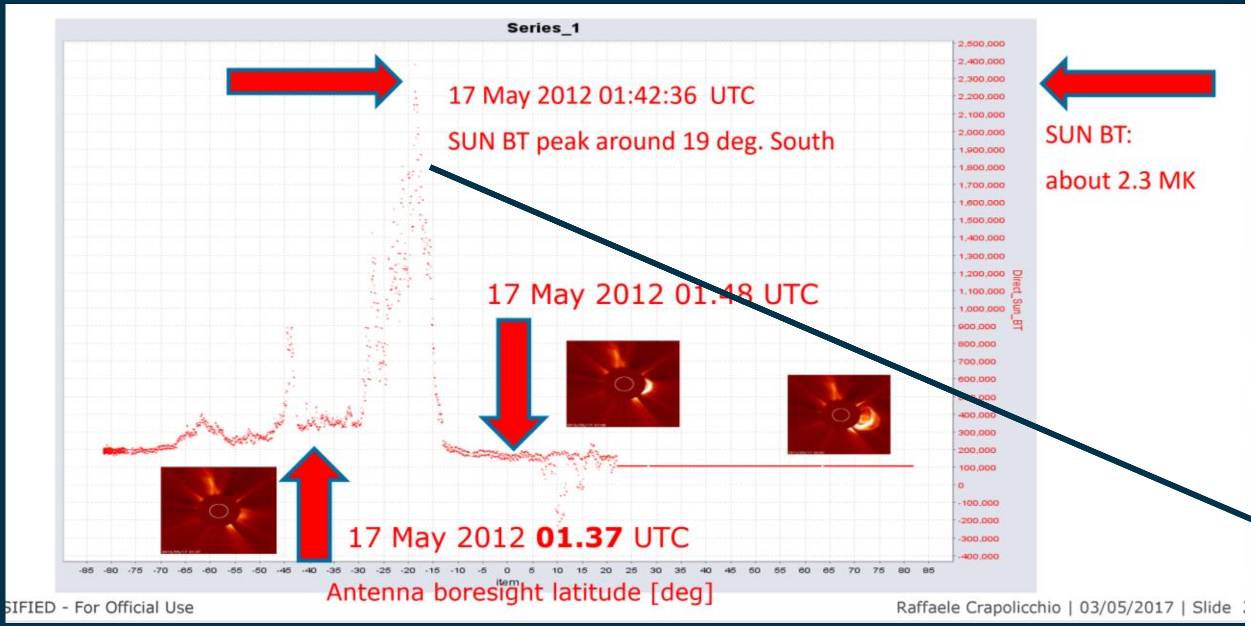
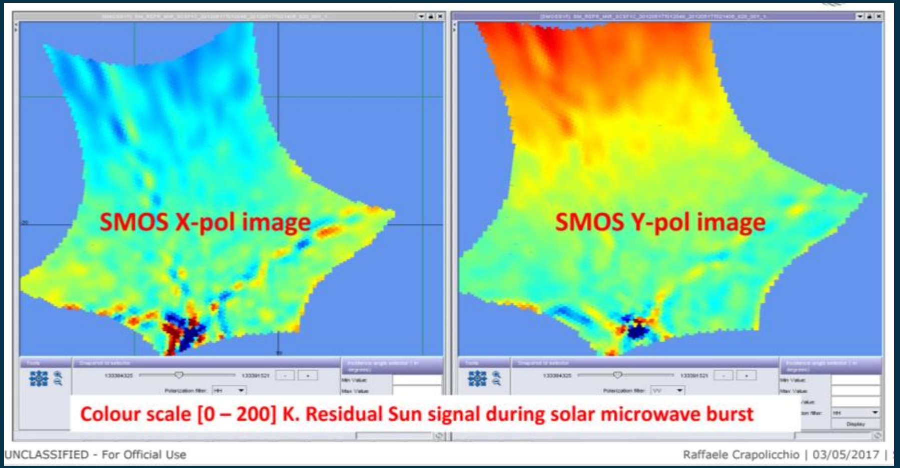
Highlight

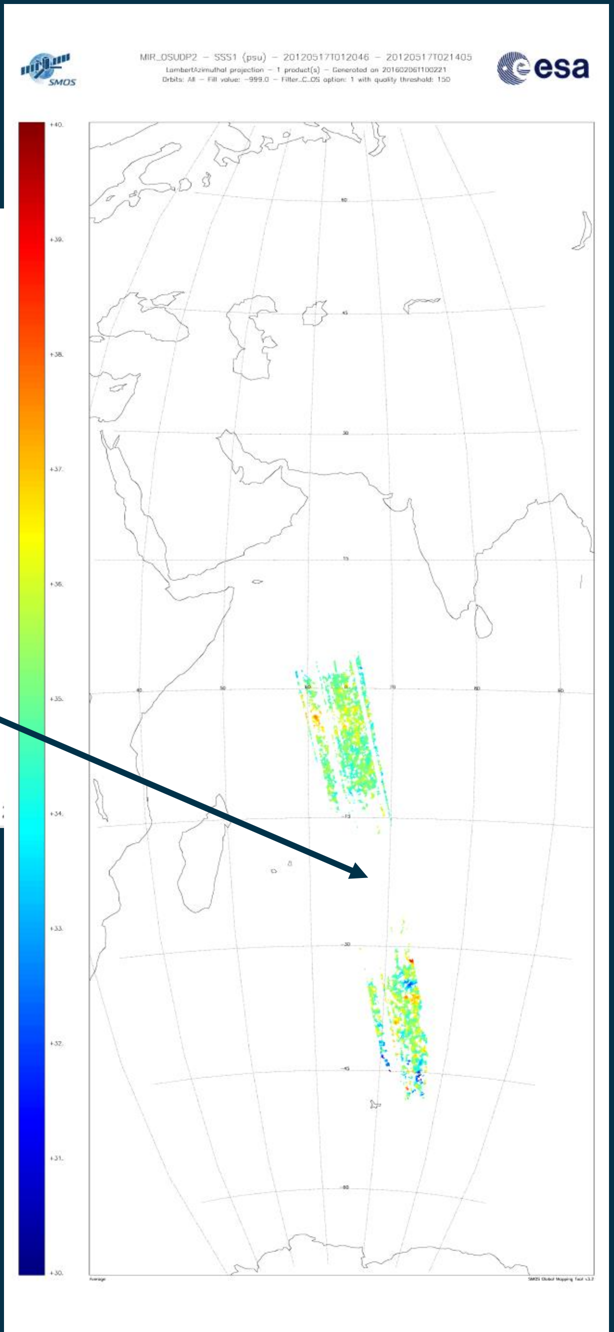
Editor Highlight—Observing the Sun via Soil Moisture Measurements

Sun Activity impacts on sea surface salinity retrieval



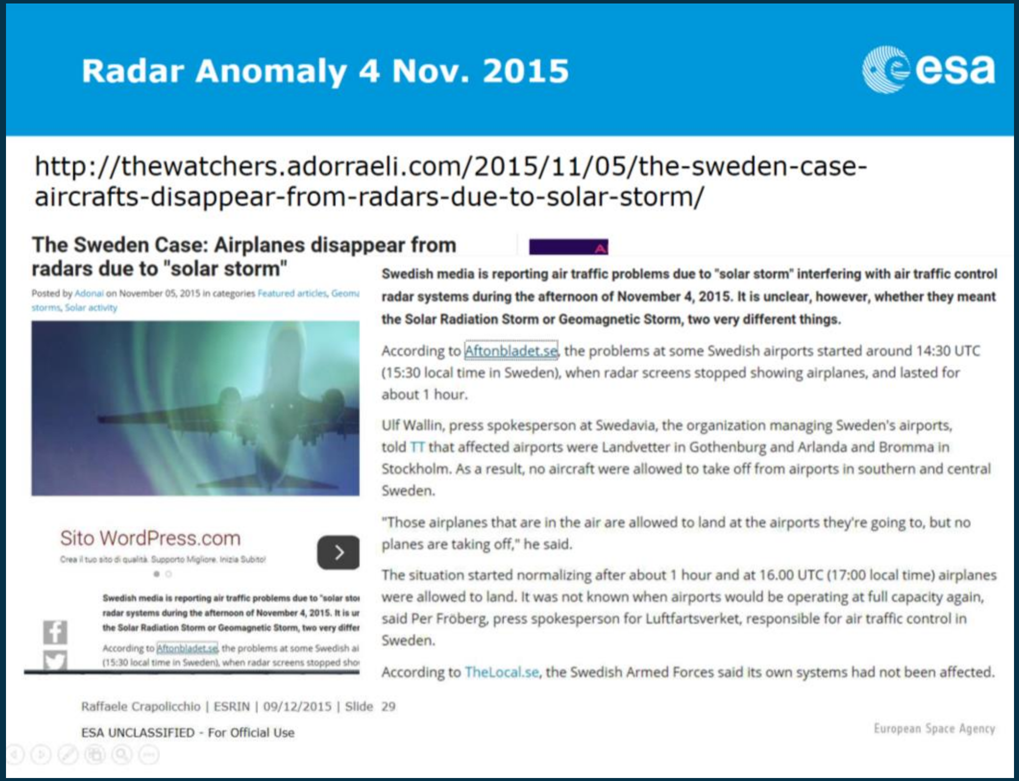


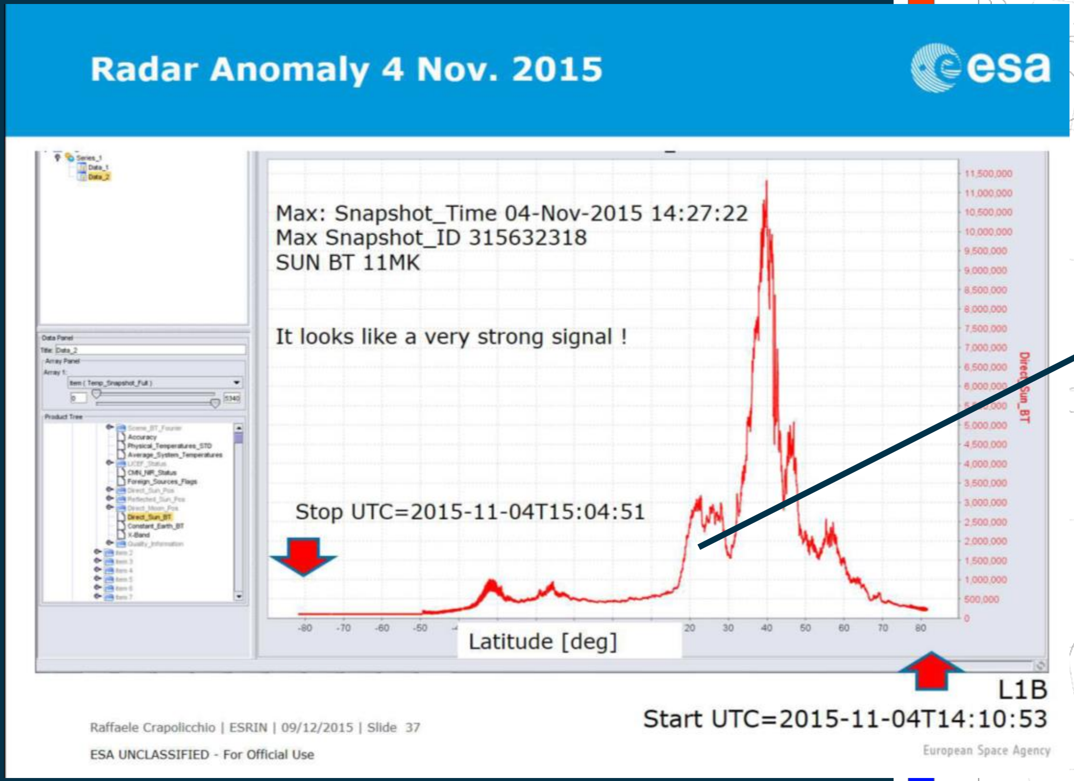


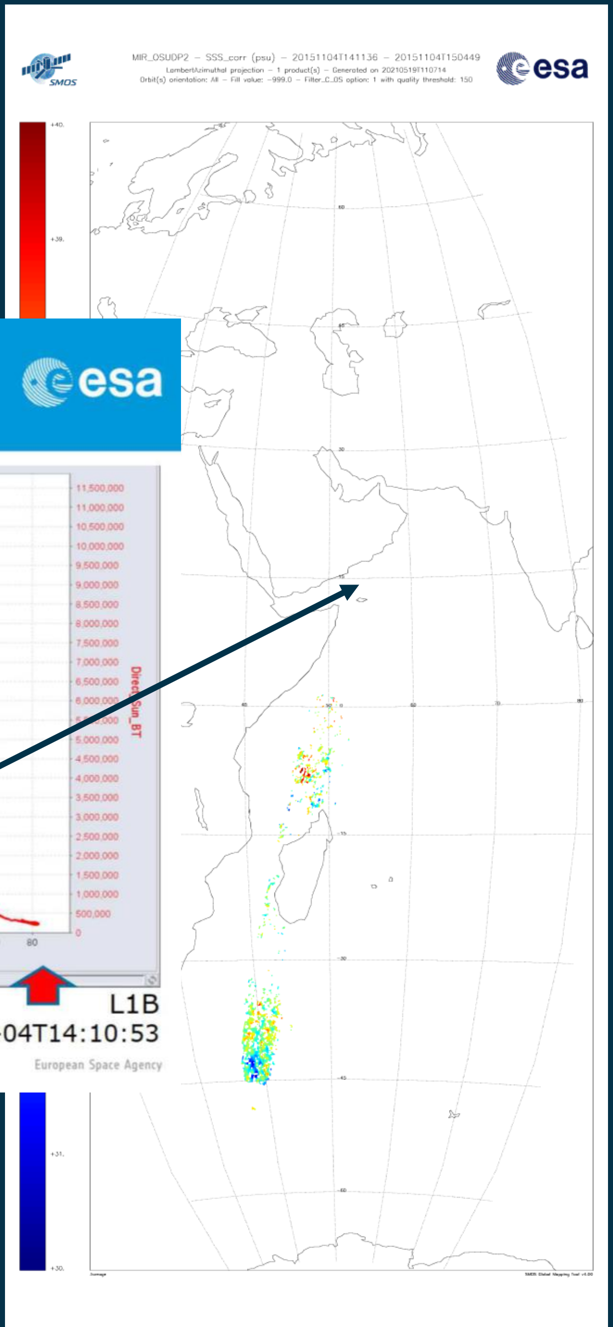


A moderate solar flare (M-class) on May 17 2012 lit up ground stations all over the world with an unexpected and puzzling pulse of high-energy particles. The Coronal Mass Ejections (CME) occurred between 17-05-2012 **01.37 – 02.12** utc. Full developed flare at about 02:00 utc

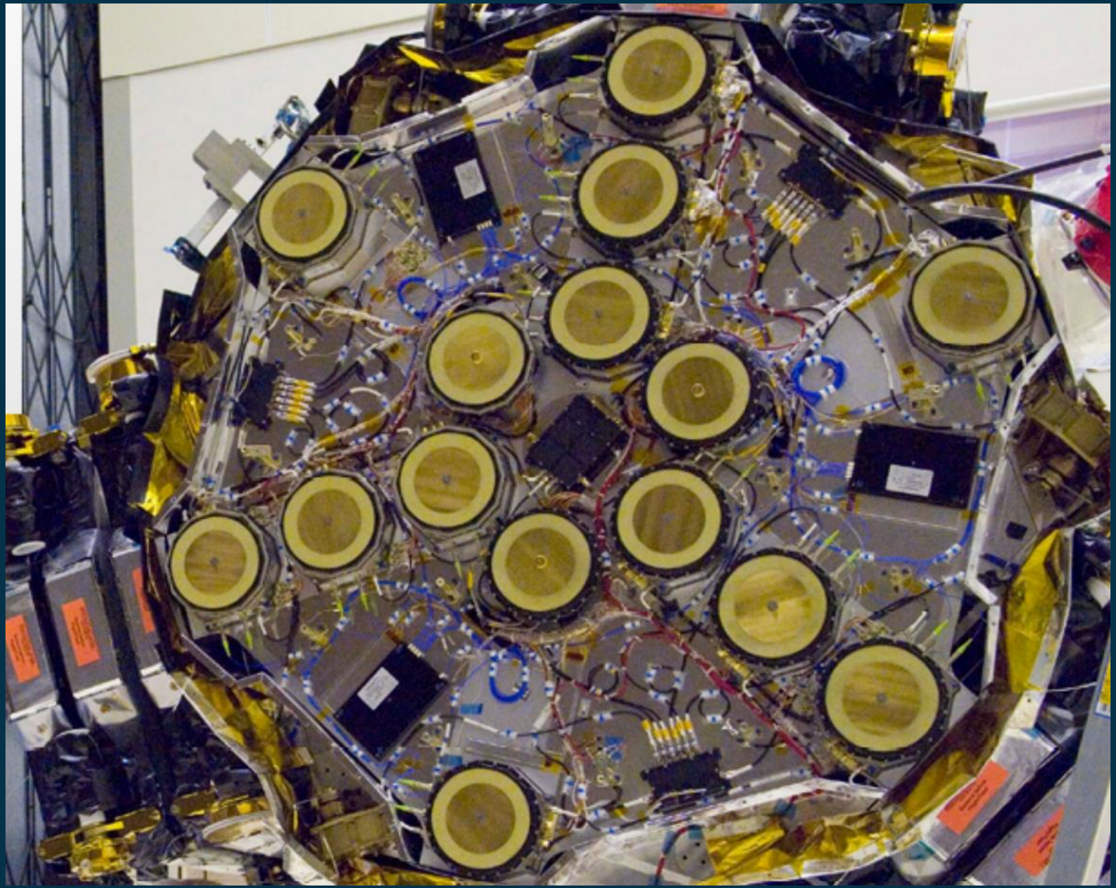
Sun Activity impacts on sea surface salinity retrieval





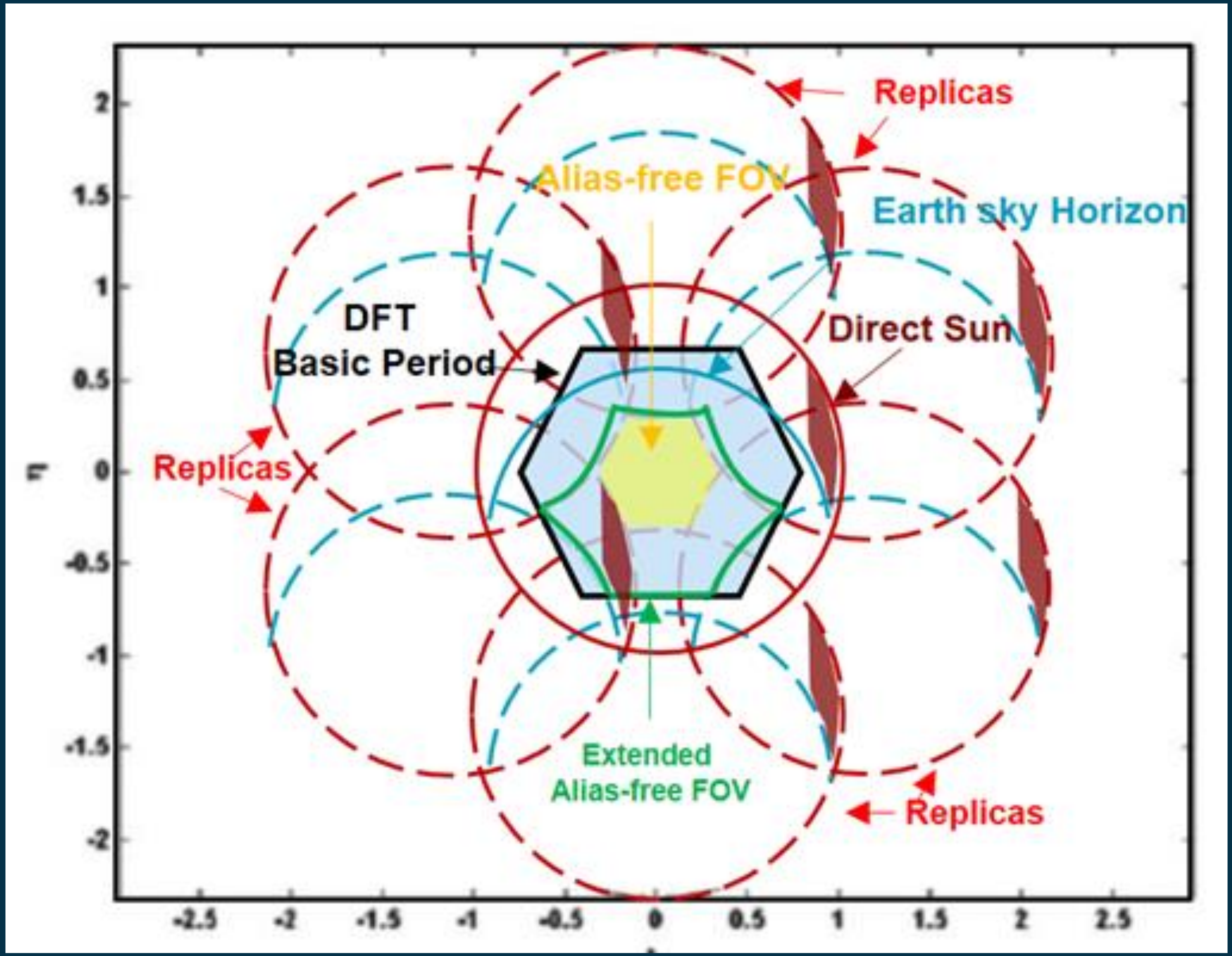


How MIRAS instrument is sensing the Sun



Due to antenna size (diameter equal to 16.5 cm) and frequency wavelength (21 cm at L-band) the instrument's field of view (FoV) is large and includes full **Earth-disk** and part of the surrounding **Sky including the Sun**.

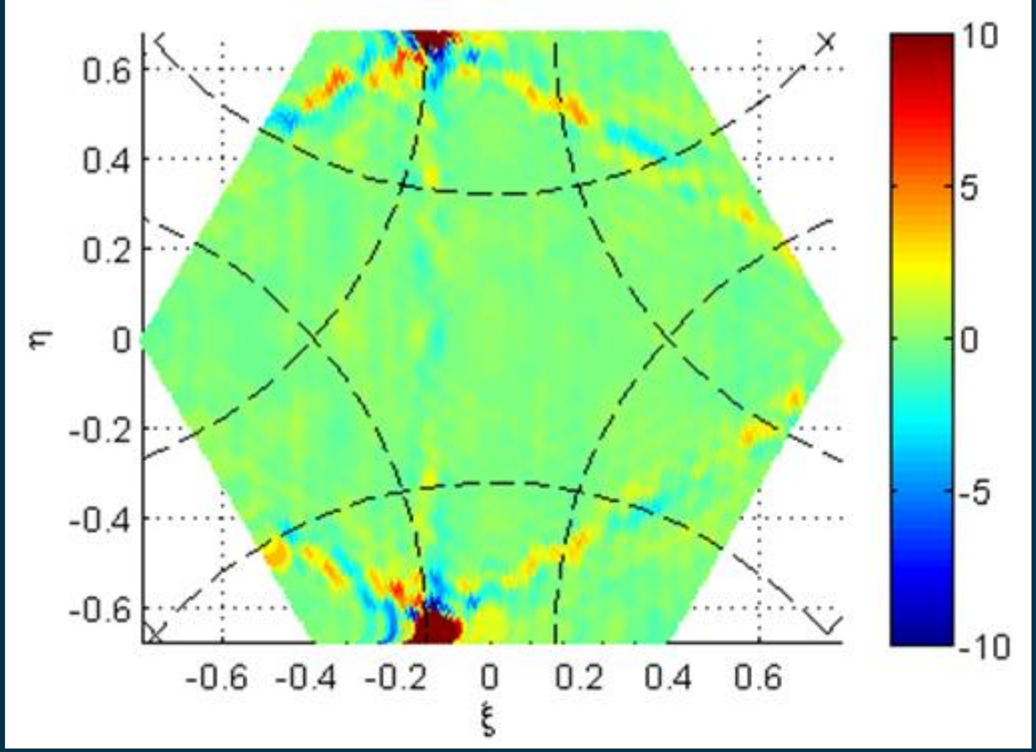
How MIRAS instrument is sensing the Sun



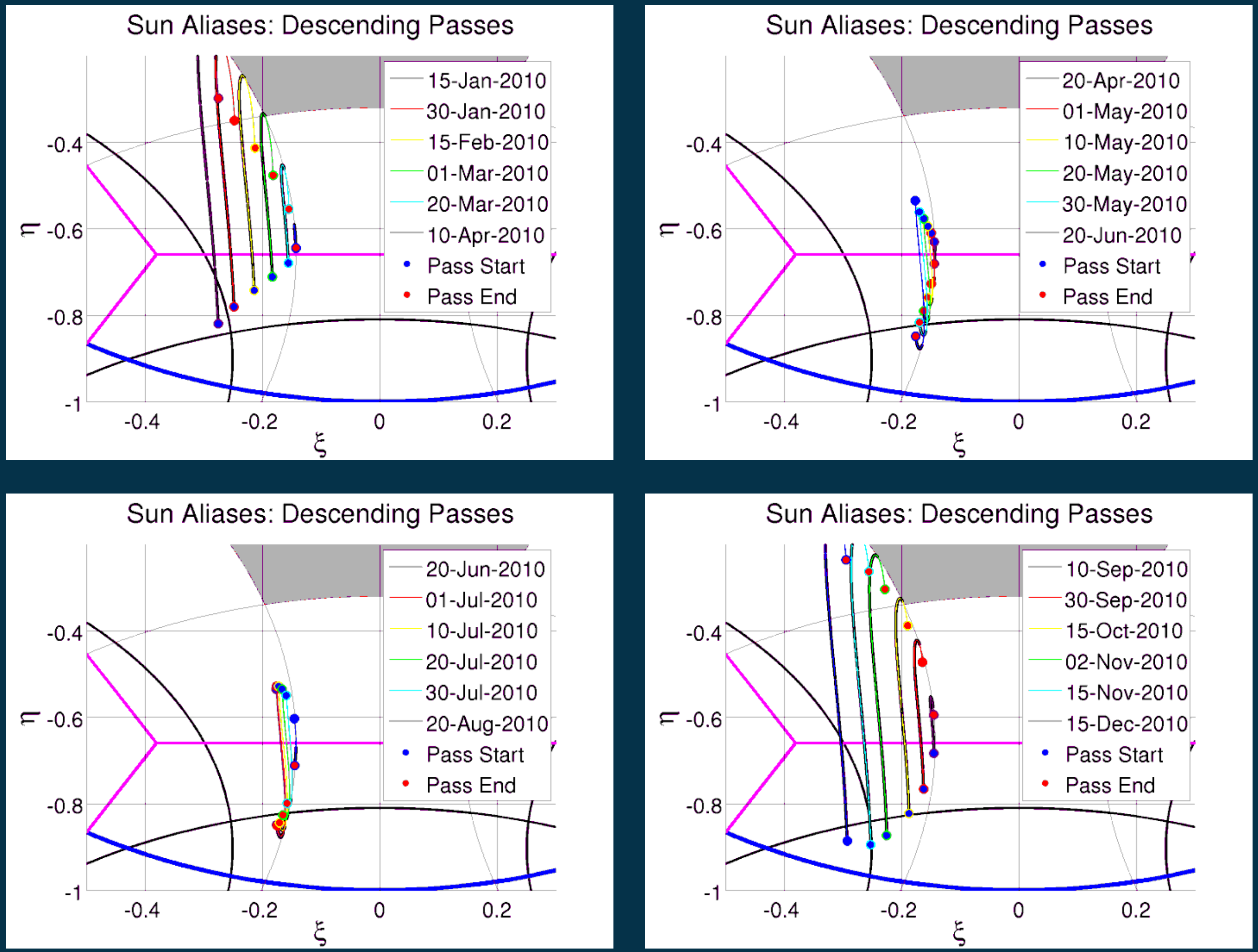
MIRAS DFT basic period and 6 replica in the direction of the 3-armsAliasing in 2-D aperture synthesis Y-shaped interferometry radiometers like MIRAS case. Representation of the earth–sky horizon, unit circle, Discrete Fourier Transformation (DFT) basic period, geometric place of the sun positions (direct and reflected images), and their six closest replicas to the main DFT period. The extended alias-free FOV is the largest region where the brightness temperature images can be formed. The direct Sun signal alias is present in the bottom left area of the alias-free FOV (credits A. Camps, et Al. "Sun Effects in 2-D Aperture Synthesis Radiometry Imaging and Their Cancelation", IEEE TGRS, vol. 42, no. 6, June 2004)

MIRAS performs, as first approximation, a Discrete Fourier Transformation (DFT) of the entire scene. The sampling performed by the antenna with a spacing of 0.875 wavelengths does not fulfil Nyquist requirements. Part of the FoV is affected by **aliasing**.

How MIRAS instrument is sensing the Sun



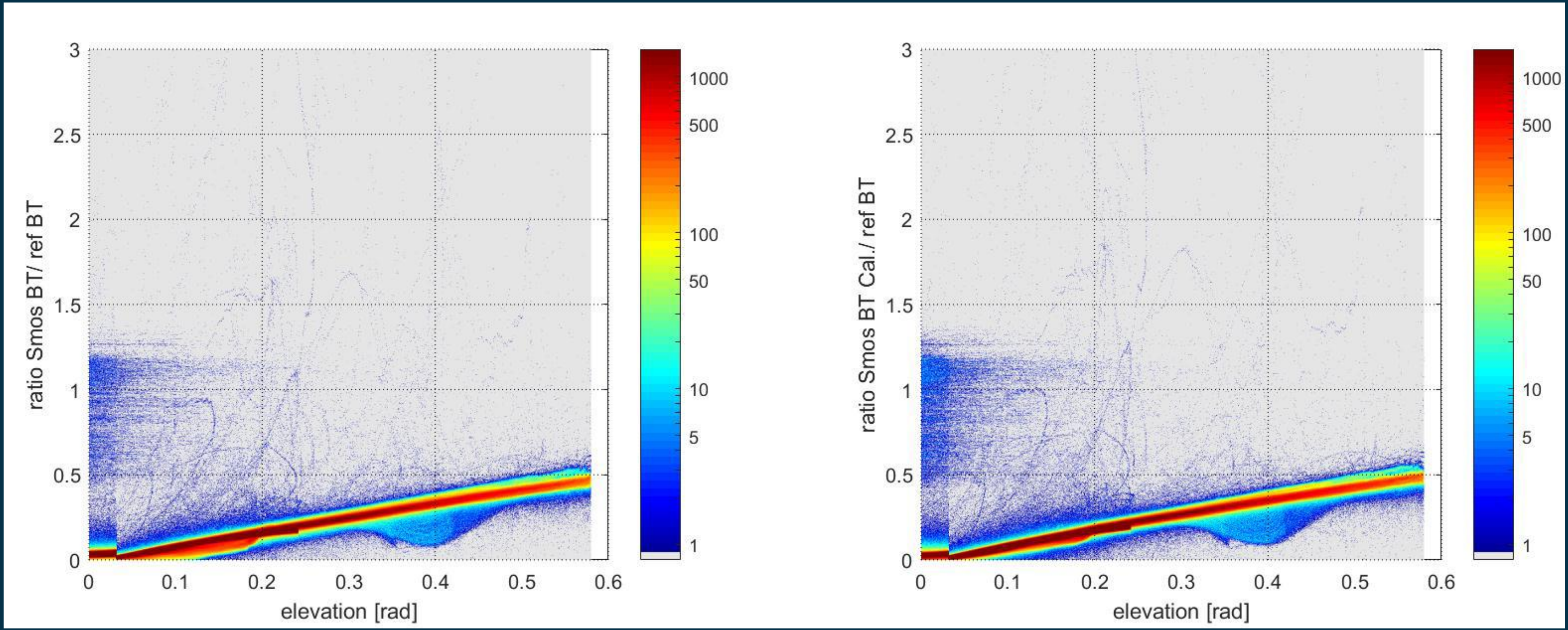
Direct Sun signal appears as a replica in the SMOS image disturbing the sensing of Earth surface emission. This signal is “removed” by the L1 processor, the result of this removal is annotated in L1B product.



(credits: J. Tenerelli, OceanDataLab)

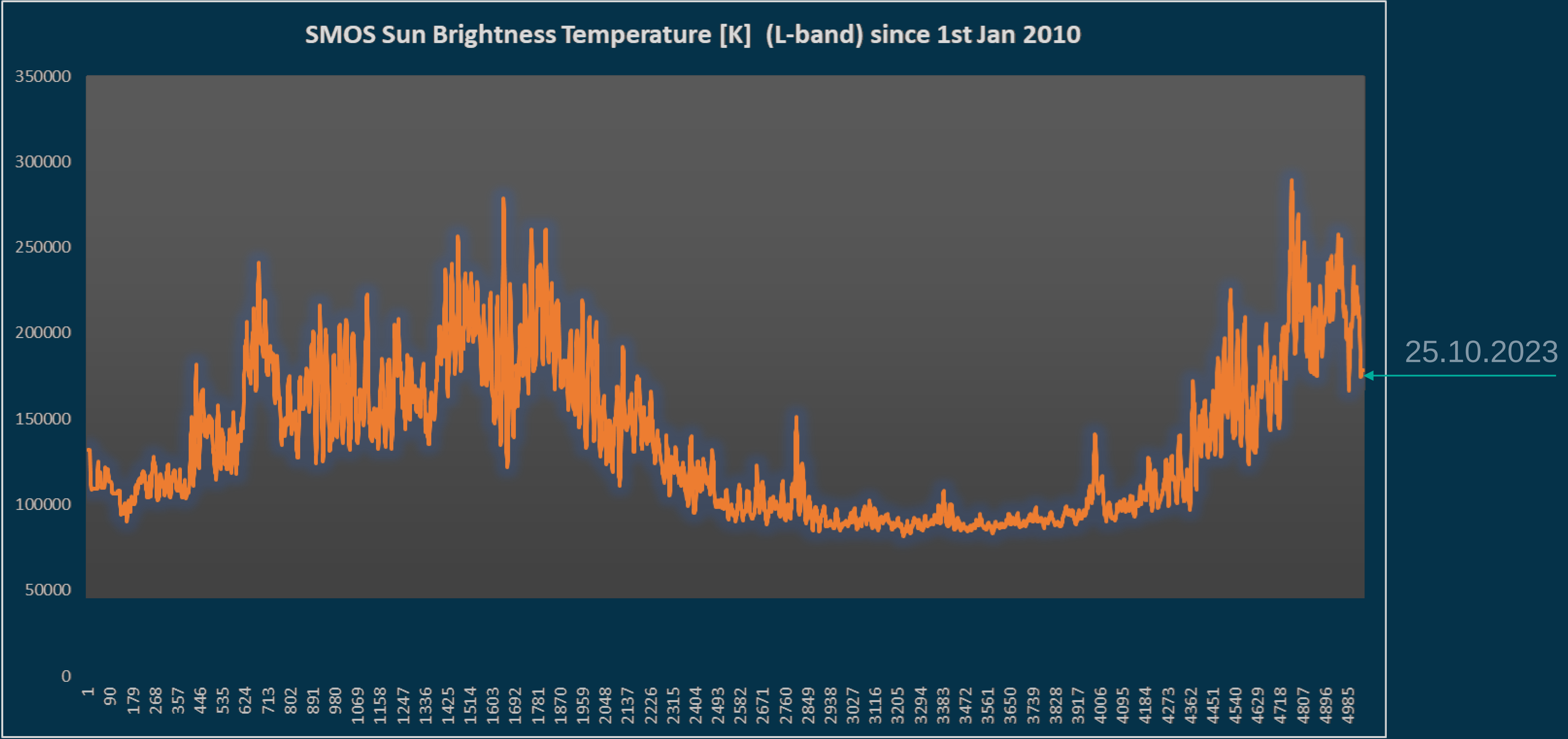
How MIRAS instrument is sensing the Sun

Ancillary information derived by the Sun removal algorithm annotated inside L1B (BT^{sun}_{Unc})

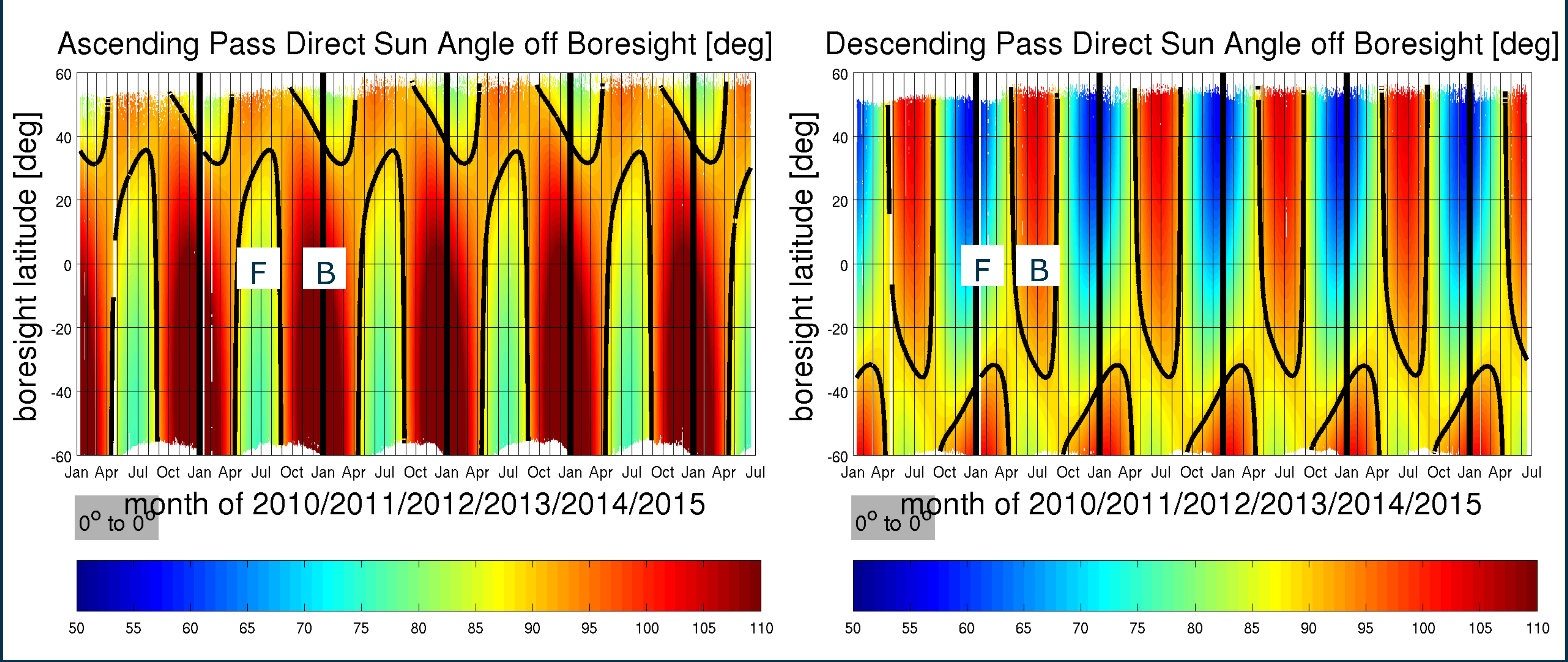


Ratio between the SMOS Sun BT v724 for Sun position in the Front divided by the ground-based reference Shimojo dataset as function of the Sun elevation angle ($e = \arccos(\sqrt{xi^2 + eta^2})$) , colours represent the population in logarithmic scale for both polarization (X-pol on the left, Y-pol on the right).

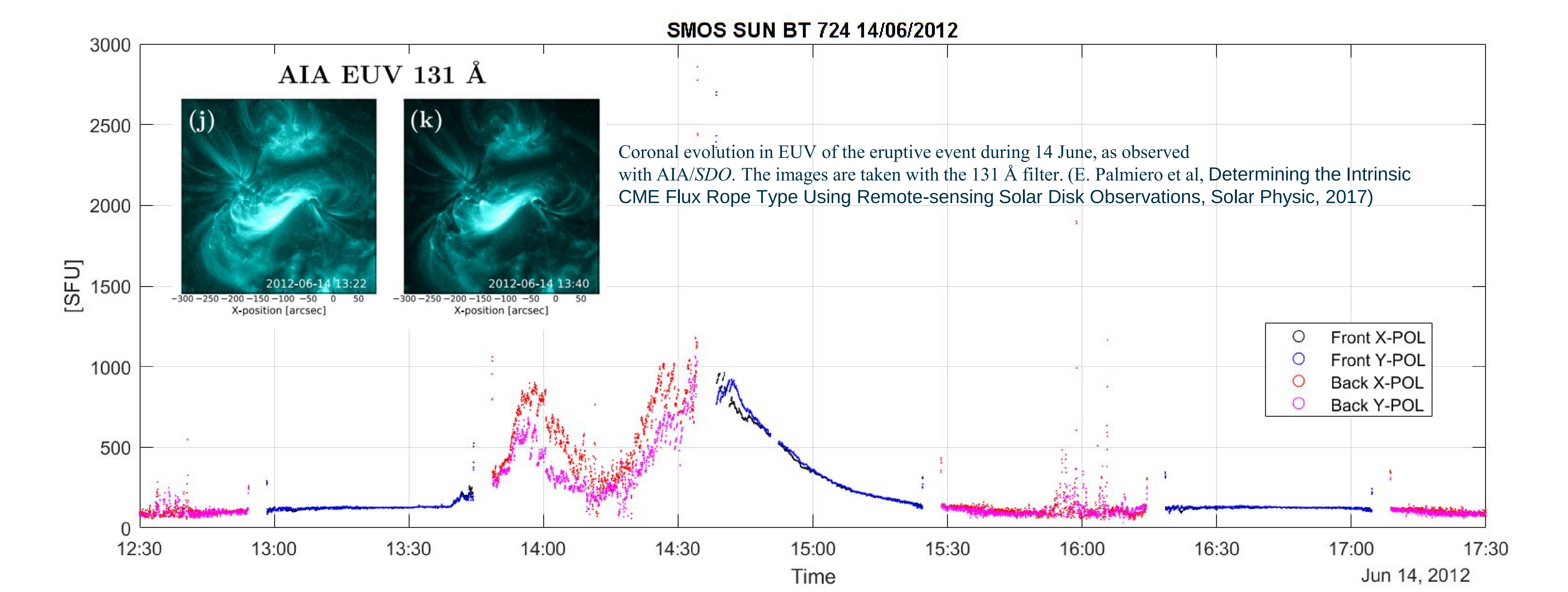
How MIRAS instrument is sensing the Sun (results)



How MIRAS instrument is sensing the Sun

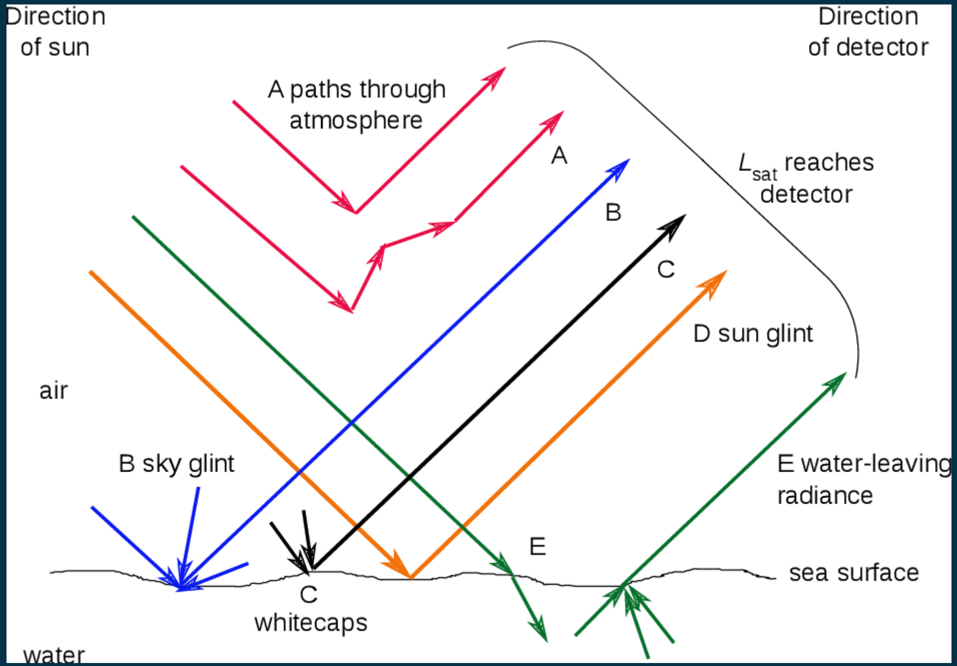


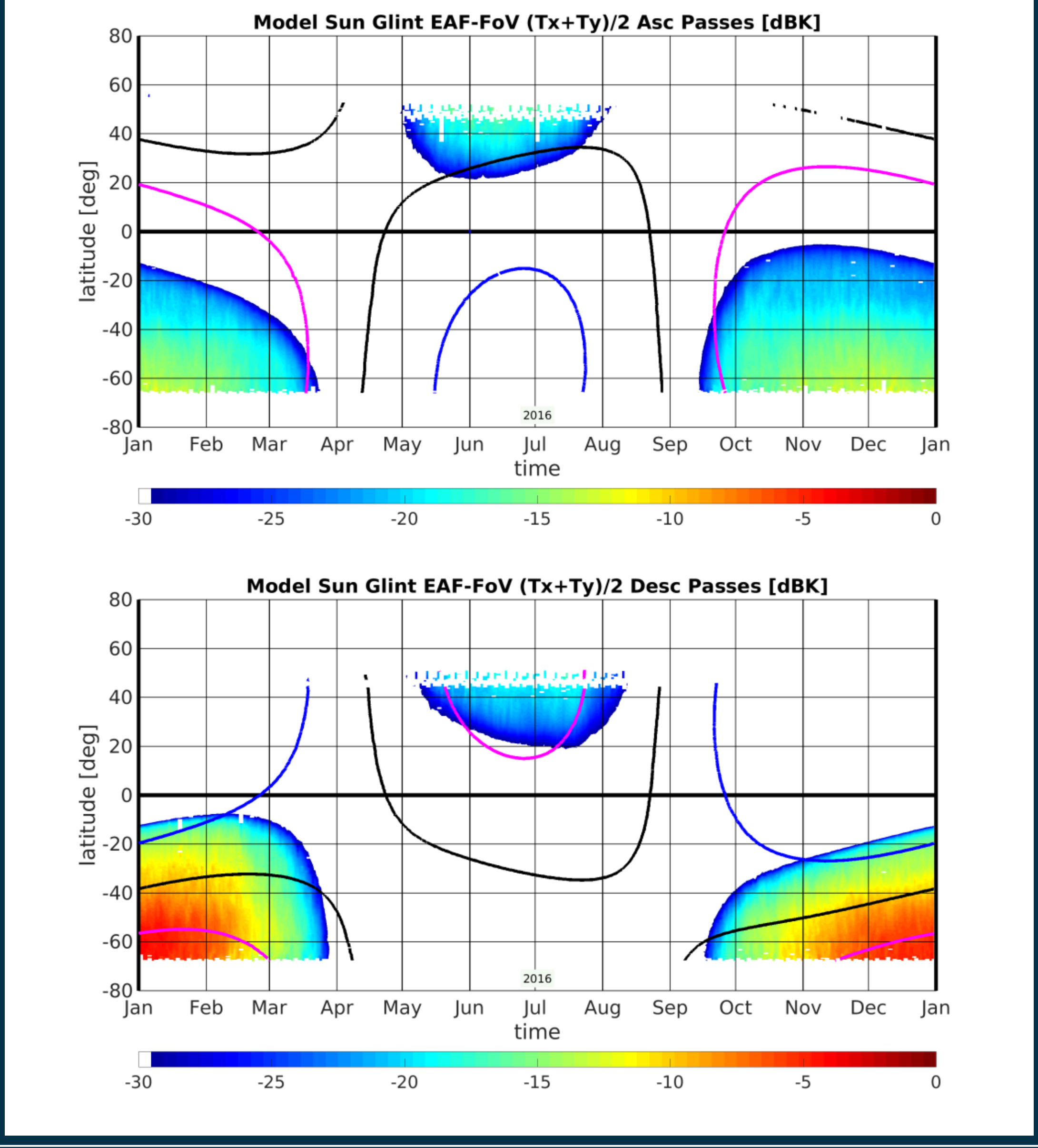
How MIRAS instrument is sensing the Sun



Direct Sun signal appears also when Sun position is in the **back** of the antenna's array

How MIRAS instrument is sensing the Sun (glint)

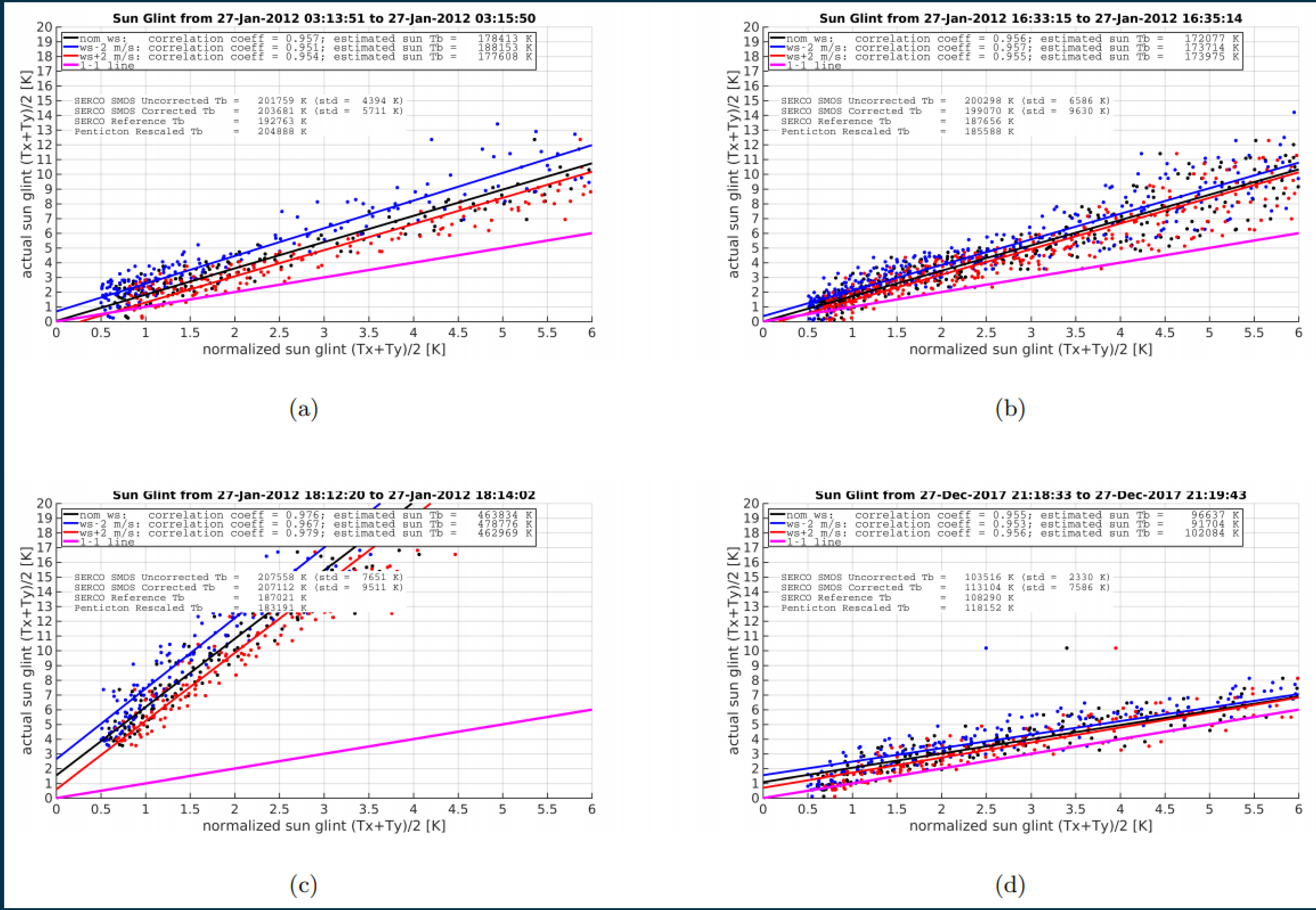




$$T_{ss}(\bar{n}_s, t, \alpha) \approx \frac{T_{Sun}(t)\Omega_{Sun}}{4\pi \cos\theta_s}\left[\sigma^0_{\alpha\alpha}(\bar{n}_s, \bar{n}_i) + \sigma^0_{\alpha\alpha_0}(\bar{n}_s, \bar{n}_i)\right]$$

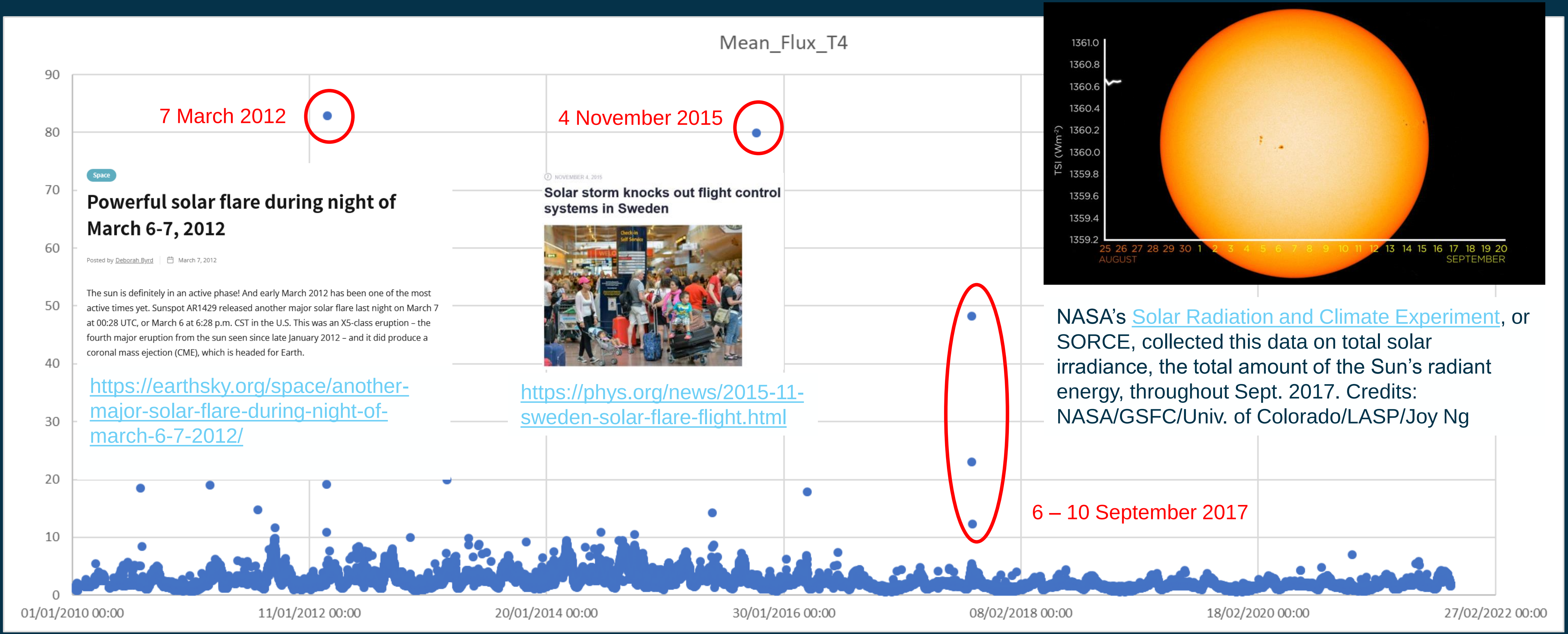
Where $\bar{n}_s$ and $\bar{n}_i$ are the local MIRAS observation and sun illumination directions at target T, respectively. Ω_{Sun} is the solid angle intercepting the sun as seen from the earth, and with $\frac{\beta_{Sun}}{2} \approx 0.293°$ at 1.4 GHz:

How MIRAS instrument is sensing the Sun (glint)



Scatterplots of actual versus nominal sun glint (first Stokes divided by two, as discussed in the text) for four distinct 2-min time intervals during which sun glint strongly affects the measured brightness. (a)-(c) are three-time intervals on 27 Jan 2012, and (c) corresponds to a solar flare during which there is a large increase in the solar flux lasting just a few minutes. (d) is a two-min interval on 27 Dec 2017 which corresponds to a quiet sun period (and low sun brightness temperature). The black lines correspond the linear fits at the wind speed provided by the CCMP product, while the red and blue lines are linear fits for CCMP wind speed +/- 2 m/s, respectively. (credits, J. Tenerelli, OceanDataLab

How MIRAS instrument is sensing the Sun (polarization)



NASA's Solar Radiation and Climate Experiment, or SORCE, collected this data on total solar irradiance, the total amount of the Sun's radiant energy, throughout Sept. 2017. Credits: NASA/GSFC/Univ. of Colorado/LASP/Joy Ng

Conclusion

1. SMOS: **S**olar **M**easurement **O**bservation **S**ystem at L-band
2. SMOS payload MIRAS can observe Solar activity **continuously (24H)** when Sun position is in front and in the back of the antenna array
3. Sun Observations include the full Stokes vector, this is a **unique** asset of SMOS
4. Ocean observations at L-band under Sun glint conditions can be further explored for current (SMOS/SMAP) and future mission (CIMR, EE12?) to continue polarimetric L-band Solar long-term monitoring.

Thank you for your attention