Space Weather and Particle Effects on the Orbital Environment of PROBA2

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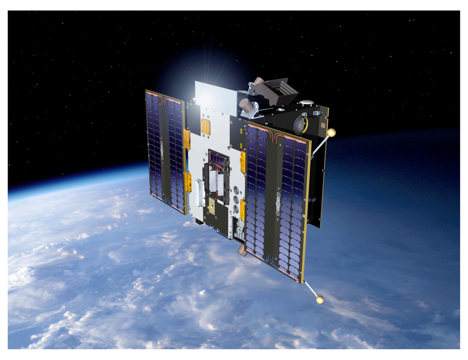
Abstract.

Data from the EUV imager *SWAP* and UV/EUV radiometer *LYRA* on board the *PROBA2* spacecraft are regularly affected by space weather conditions along the spacecraft's orbital path. While these effects are generally removed from calibrated data intended for scientific analysis, they provide an interesting opportunity to characterize the evolution near-Earth space environment as the result of changing space weather conditions. Here we present an analysis of these space weather effects on PROBA2 observations and some conclusions about both the long-term evolution of the inner magnetosphere and short-term events driven by the active sun.

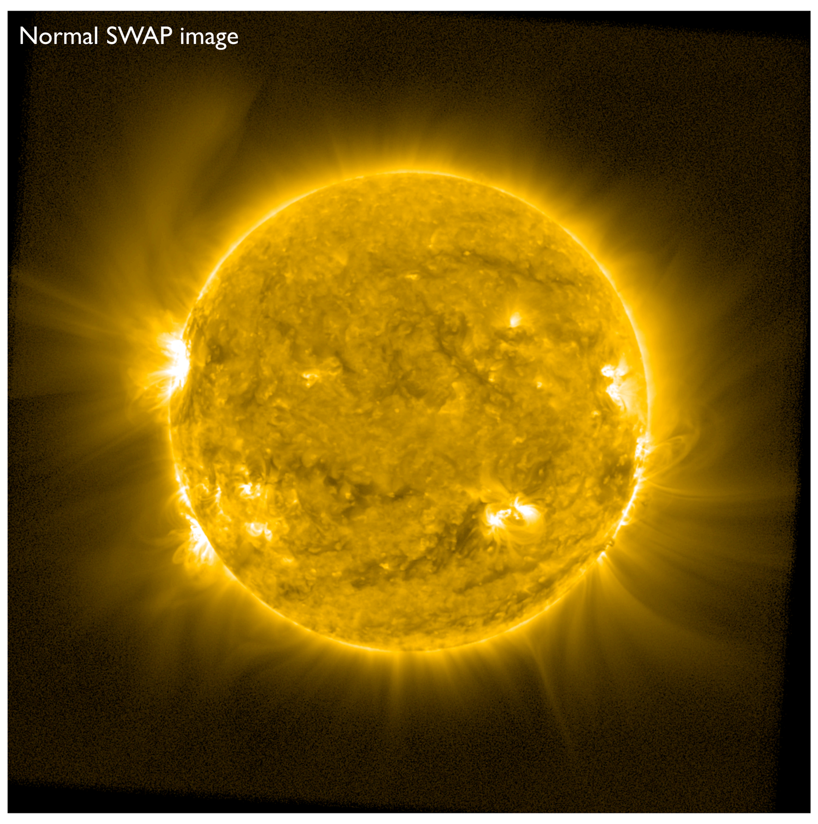
About PROBA2.

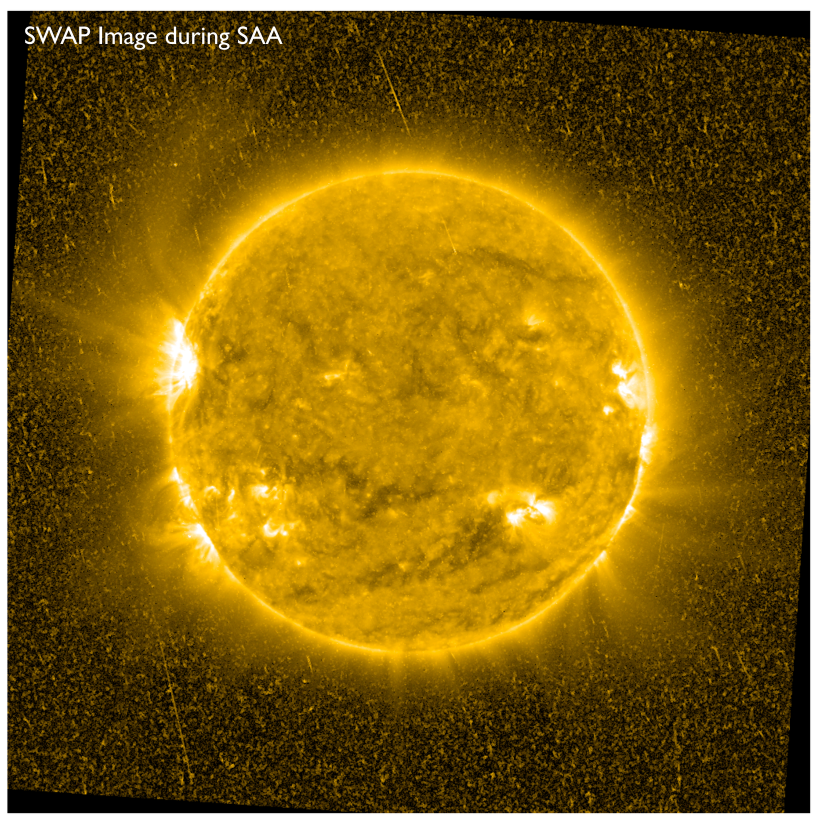
PROBA2 is a space-weather oriented microsatellite launched on 2009 November 2. Among its four scientific instruments are *SWAP*, an EUV solar imager, and *LYRA*, a four-channel UV/EUV radiometer. PROBA2 also hosts 17 technology demonstrations and two in-situ plasma instruments, *DSLP* and *TPMU*. Though SWAP and LYRA nominally observe the sun, a study of noise in the data they produce allows us to indirectly characterize radiation in low Earth orbit.

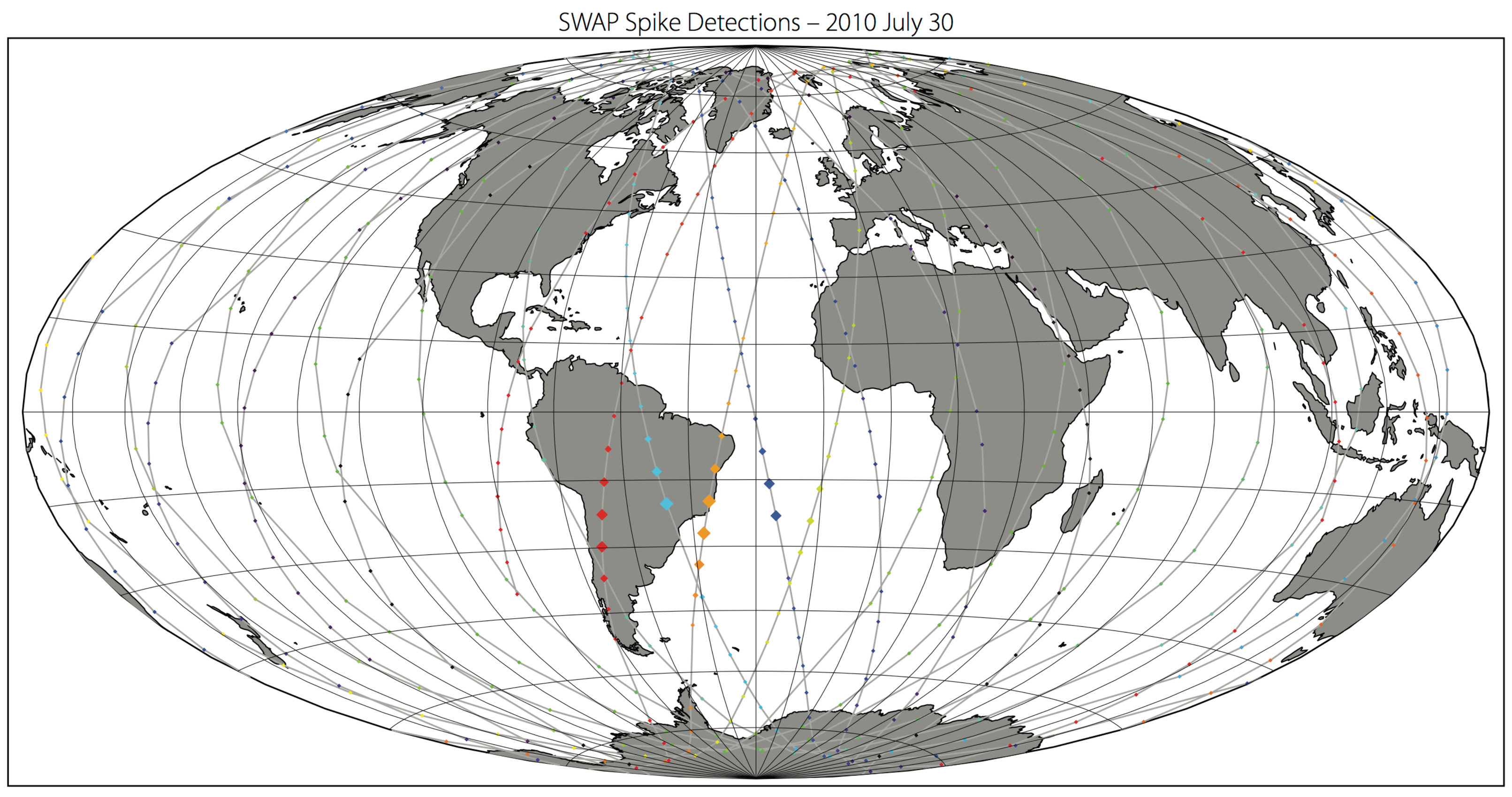


Space Weather Effects on SWAP.

Typical SWAP images reveal the structure of the high-temperature inner Solar Corona around 17.4 nm, the result of Fe IX/X emission lines that form at temperatures of about 8×10^5– 1×10^6 K (below, left). However, several times a day PROBA2's orbit carries the spacecraft through radiation belts at a height of about 725 km, resulting in noisy images (below, center). Counting the number of radiation-related spikes in each image yields an estimate of the variation of radiation intensity SWAP experiences as it orbits. By plotting the resulting spike counts as a function of location, we can map the intensity of radiation in the low Earth orbit environment (below right). The color of each point indicates the time of day of the observation (purple is early in the day, red late) while their size is proportional to the number of spikes. In such a map, the location of the South Atlantic Anomaly (SAA) over eastern South America becomes immediately apparent.

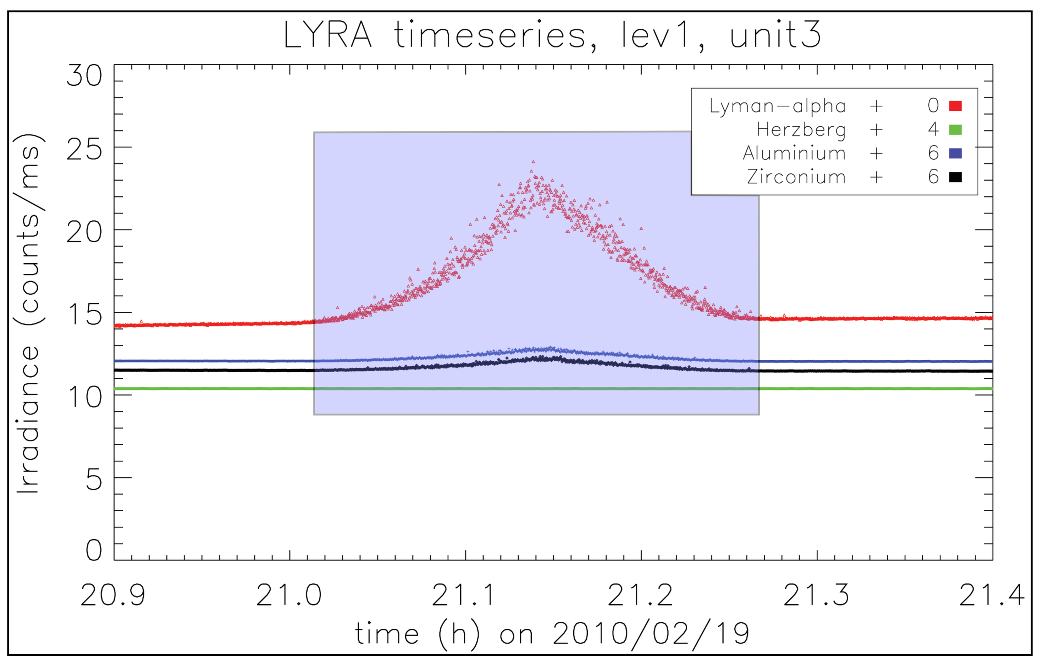


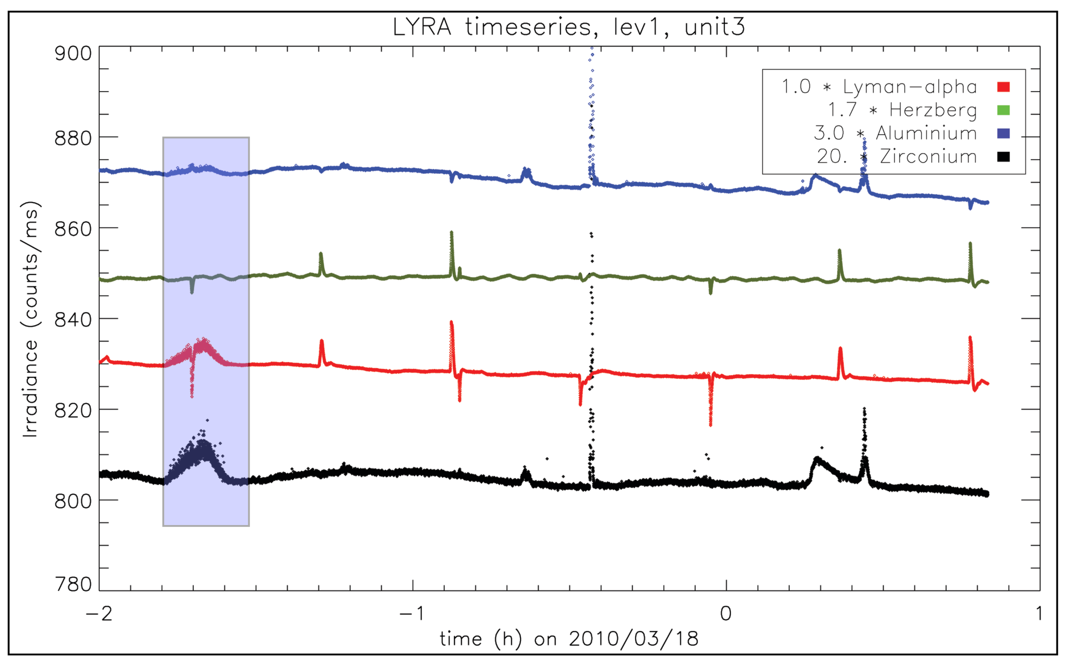




Space Weather Effects on LYRA.

LYRA is composed of three, four-channel irradiance detectors, only some of which are sensitive to the effects of space weather. This is easy to see in dark data—that is, data obtained with instrument covers closed (below, left). LYRA's silicon-based detectors are sensitive to radiation effects, and register the SAA (blue shaded areas), while its diamond-based detectors, like the Herzberg detector (green curve) on Unit 3, do not. With the covers open (below right), the effects of radiation are not as obvious, but can still be seen in the data; again the diamond-based detector's curve is flat.

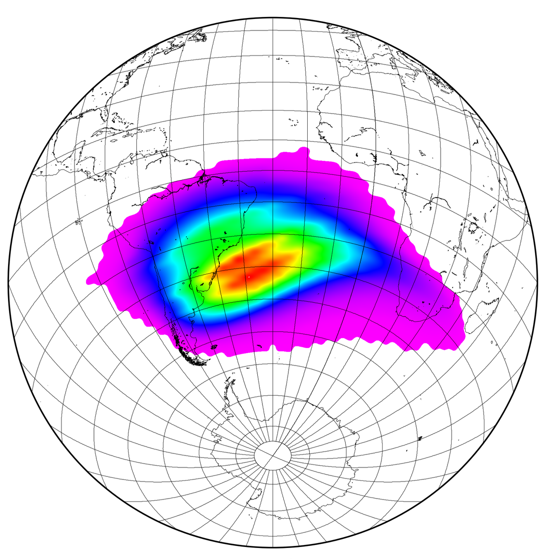


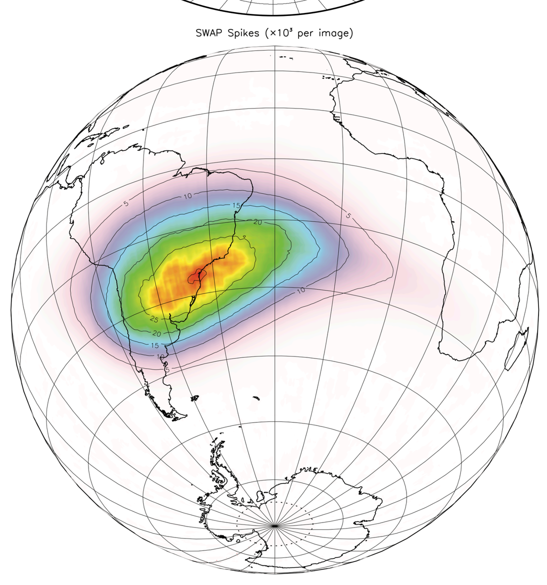


LYRA and the Auroral Ovals.

In addition to the SAA, LYRA observes increased signal when passing through the Auroral Ovals in the days following geomagnetic events with Kp ≥ 4. Interestingly, these effects are not present when the instrument covers are closed, and are seen only in EUV/X-ray channels. Possible explanations range from direct detection of aurora-related EUV photons to Bremsstrahlung caused by the interaction of energetic electrons and the instrument filters. Both SWAP and LYRA clearly observe energetic protons in the SAA, and SWAP does occasionally observe some signal in the auroral zones as well as LYRA, but not as frequently. Work on this topic is ongoing.

Characterizing the near-Earth Space Environment.





By combining multiple observations from throughout PROBA2's mission, we can construct a map of the particle environment through with the spacecraft's orbit travels. A comparison between maps from ESA's *Space Environment Information System* (SPENVIS; top left) and measured SWAP radiation intensity (bottom left) reveals that while the structure of the SAA is relatively unchanged, it has drifted west since the best-known recent measurements were made, now many years ago. The SAA is now largely centered over the southeastern quadrant of South America and has considerably weaker influence in the South Atlantic region.

Plotting these results on a monthly basis (right), we see the additional influence of radiation from the auroral ovals during periods of geomagnetic activity. The strongest example occurred during April 2010, during the same CME-related event that caused the Galaxy-15 spacecraft to fail.

Conclusions: Although the effects of trapped particles on data from PROBA2 are generally considered a nuisance to be removed during calibration, they can also be a useful diagnostic for local space weather conditions. With limited instrumentation dedicated to the observation of space weather effects in low Earth orbit, these serendipitous observations are highly useful in filling gaps in our understanding of the space environment.