Solar UV & EUV Variability and Activity Monitoring of Flares & CMEs: EUV, Lyman- and H-Alpha Indicators

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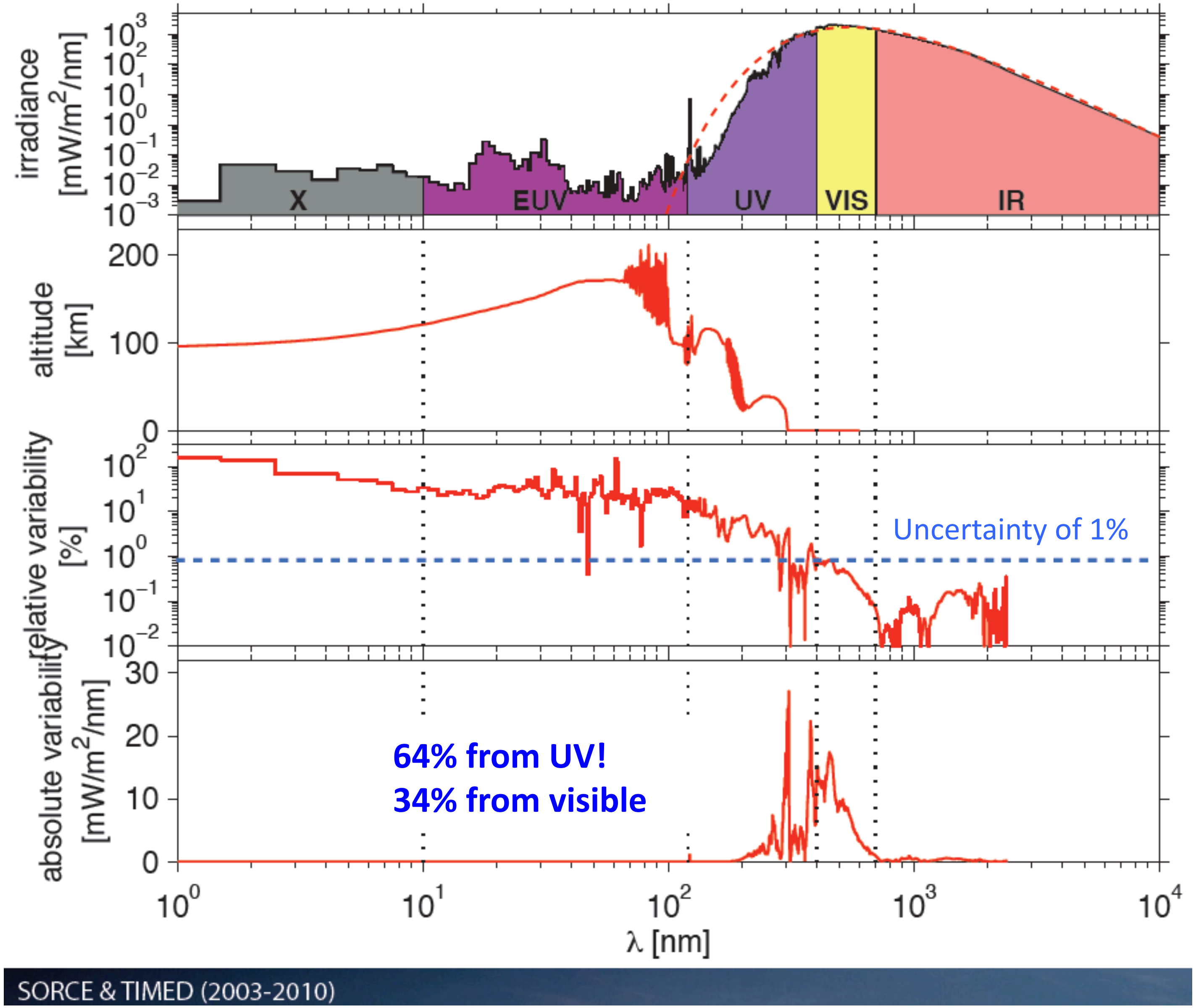
Solar UV affects stratospheric dynamics and temperatures, altering weather patterns

- UV radiation, on the contrary to visible and IR, interacts strongly with the ozone layer and the upper atmosphere. So, though UV solar radiation makes up a much smaller portion of the TSI than infrared or visible radiation, UV solar radiation tends to change much more dramatically over the course of solar cycles.
- The impacts of undulating UV solar radiation may be substantial. Since UV radiation creates ozone in the stratosphere, the oscillation in UV levels can affect the size of the ozone hole. Absorption of UV radiation by the ozone also heats up the stratosphere. Many studies suspect that changes in stratospheric temperatures may alter weather patterns in the troposphere.

...and variability



Solar spectrum

Absorption altitude

Relative variability

ABSOLUTE VARIABILITY over solar cycle

Monitoring Flares: from H-Alpha to Lyman-Alpha

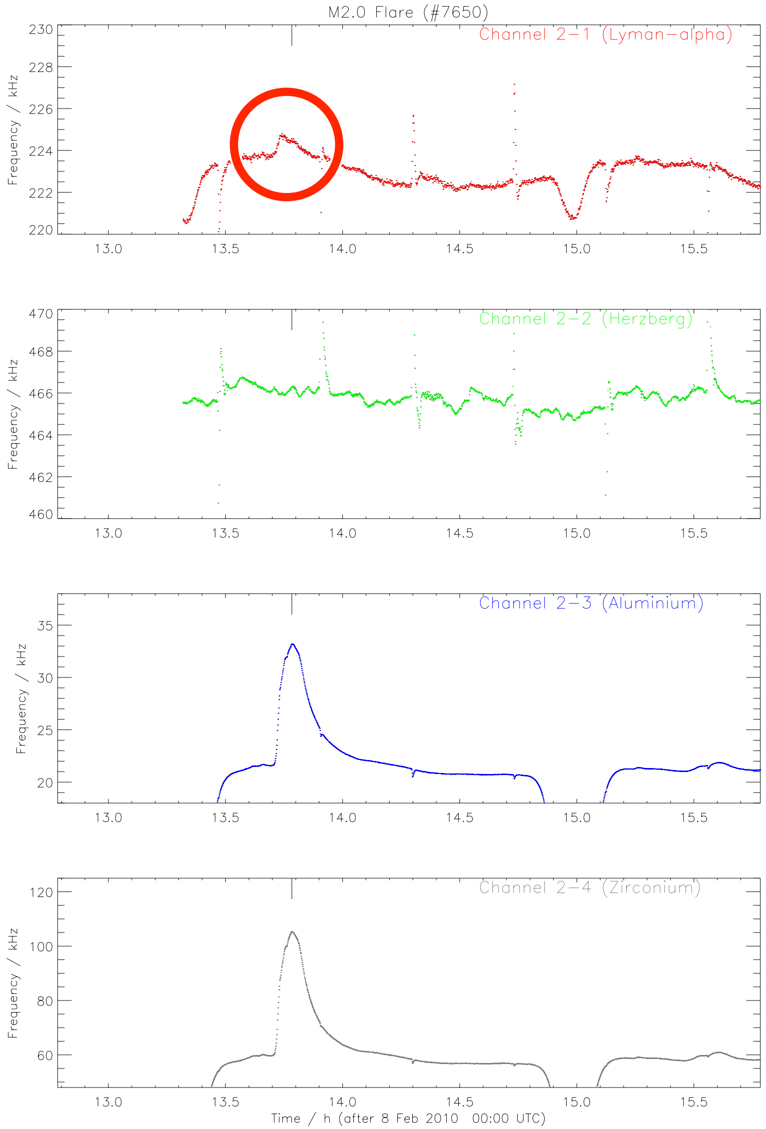
Objective is to monitor Flares in Lyman-Alpha and to compare sensitivity difference with H-Alpha (space application) and precursor indicators on the flaring region, compared with classical EUV – X-ray indicators (GOES 1-8 Å but also LYRA channels 2-3, Aluminum 17–80 nm, and 2-4, Zirconium 6–20 nm)

Lyman-Alpha Flare data available

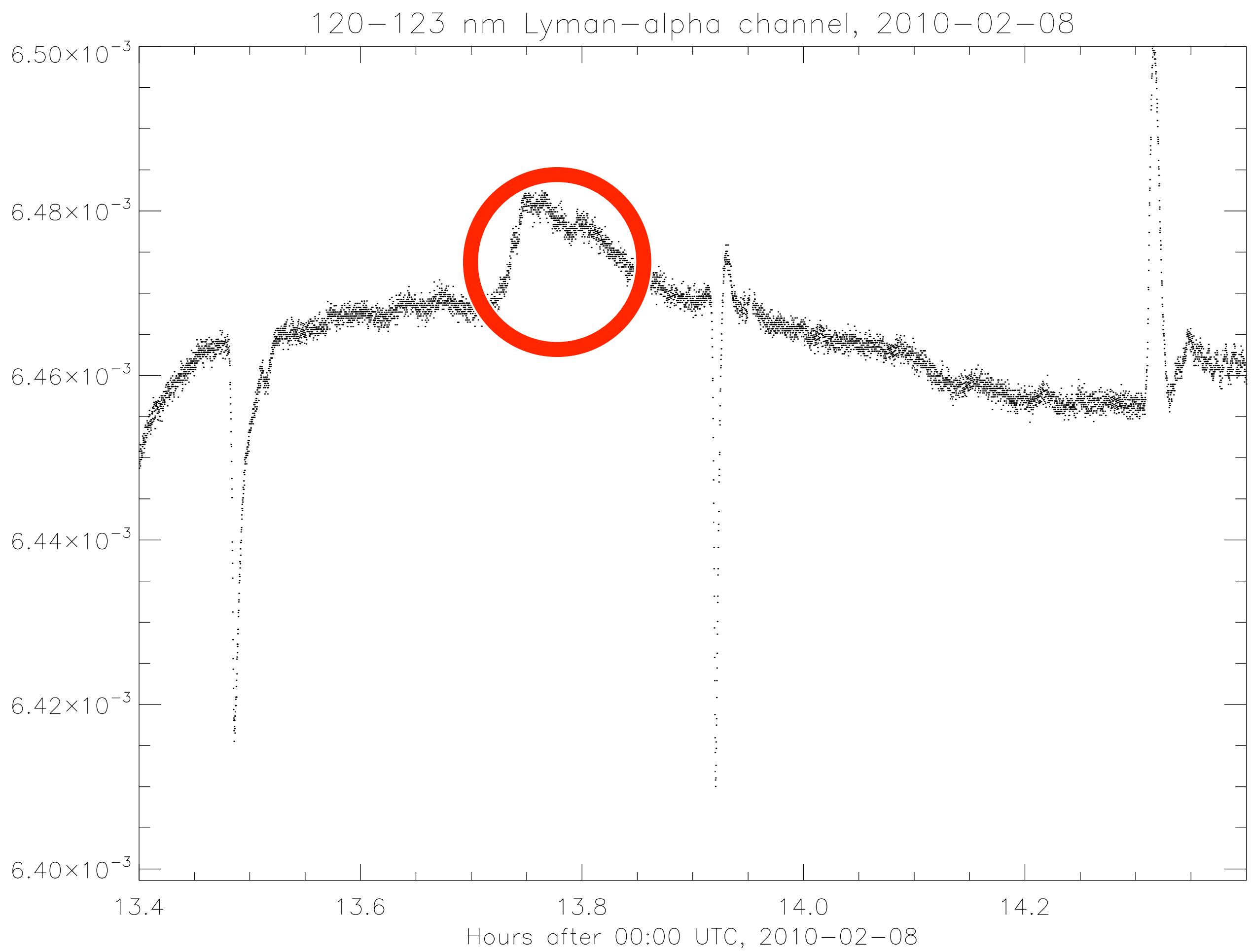
The list of potential candidates is very limited due to degradation of sensitivity: all from very early 2010 where channel 2-1 was still strong:

- event 5800 (M1.8) 20 Jan 2010
- event 6590 (C4.0) 06 Feb 2010
- event 6880 (C9.9) 07 Feb 2010
- event 7080 (C4.2) 07 Feb 2010
- event 7510 (C6.8) 08 Feb 2010
- event 7650 (M2.0) 08 Feb 2010
- event 7790 (M1.0) 08 Feb 2010

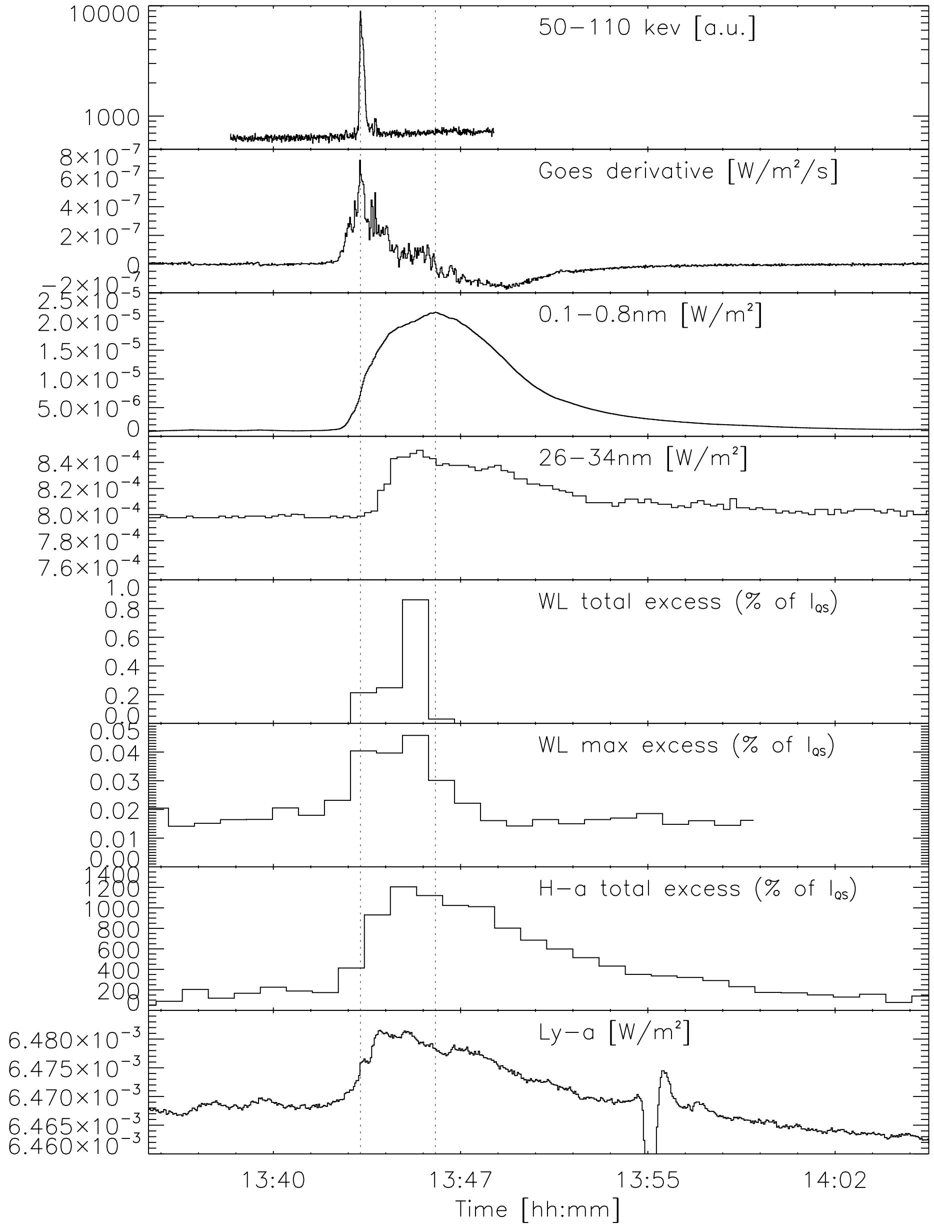
Event 7650 (M2.0) 08 Feb 2010



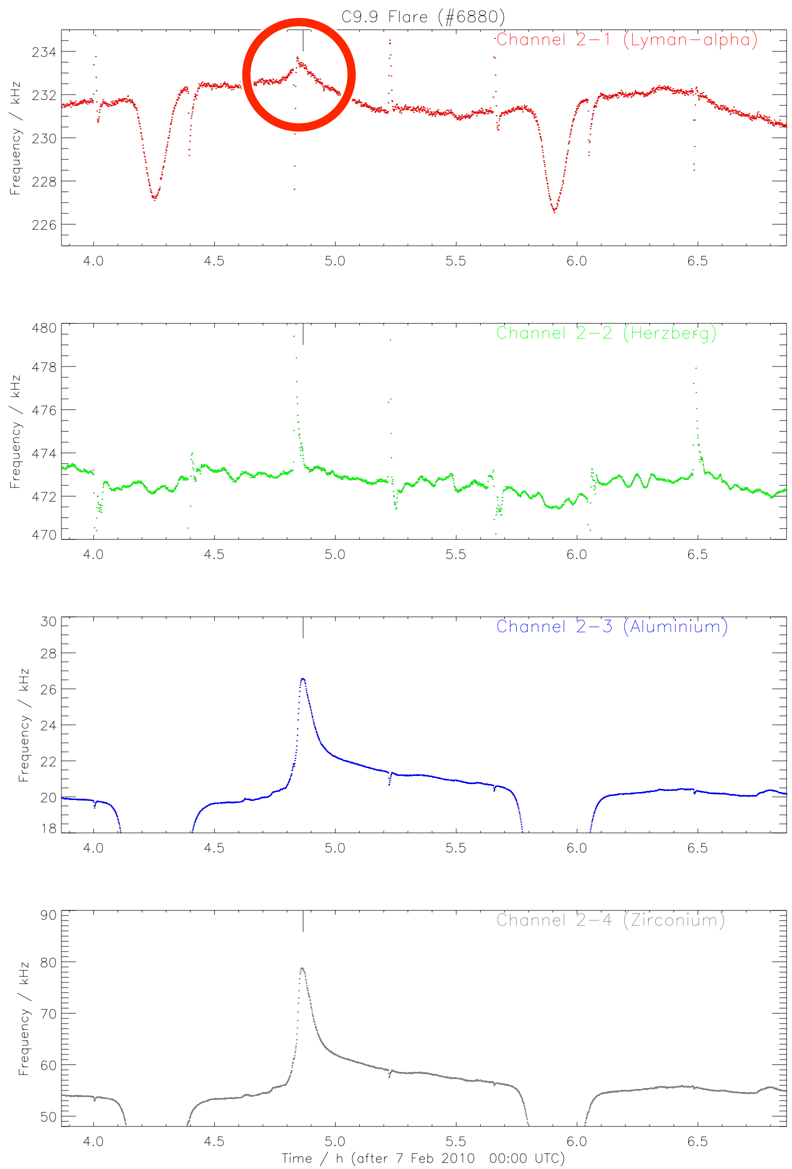
Lyman-Alpha excess



Flare 7650 M2.0 Feb 8 2010
(Matthieu Kretzschmar et al., 2011)

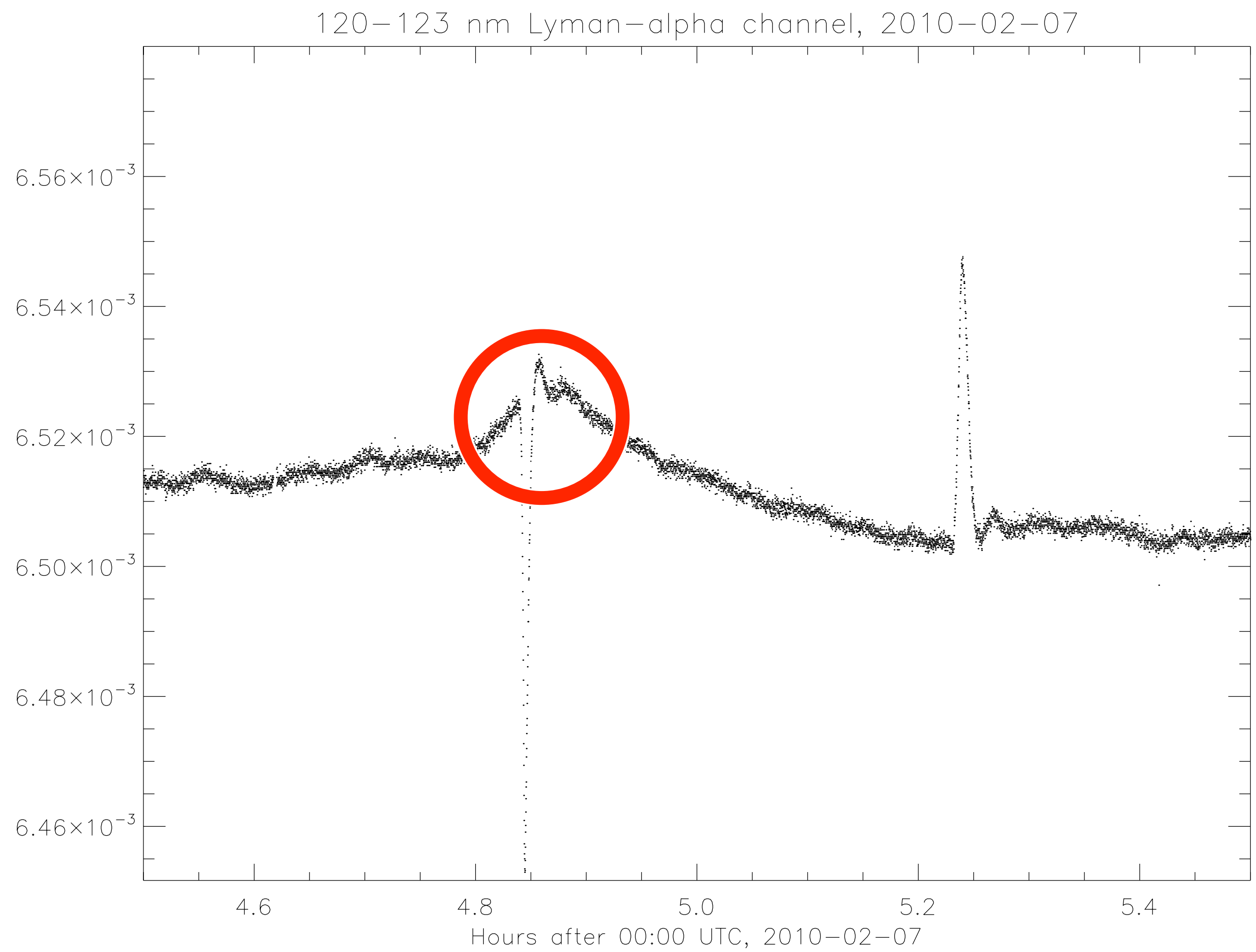


Event 6880 (C9.9) 07 Feb 2010



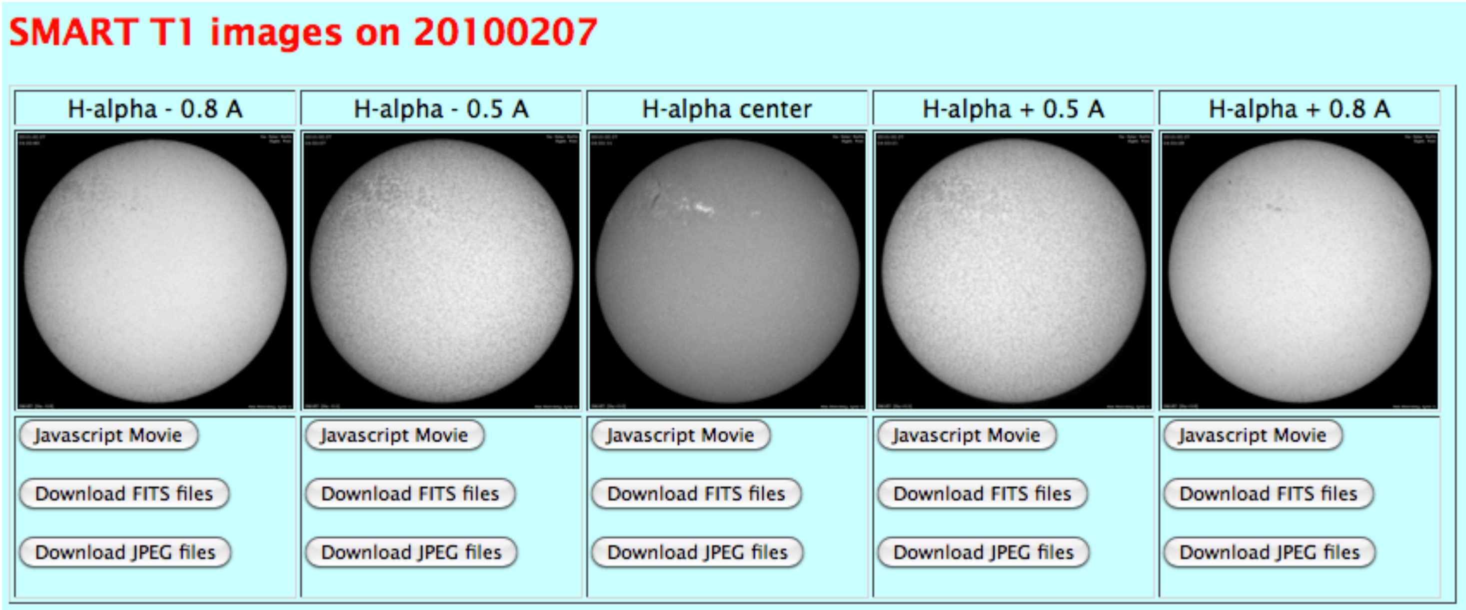
L. Damé — ESWW8, Namur, November 29, 2011

Lyman-Alpha excess



Ground support observations

There are Mauna Loa, Peru, Big Bear, Pic-du-Midi, and Hida Observatory data available depending of the time of the day (and cloud coverage). We prefer Peru or Hida Observatory data when available since providing velocities (spectroheliograms) also (Flare Monitoring Telescope at Hida and Peru; SMART at Hida)



Hida Observatory Data

In January and February 2010 the FMT Peru was not active yet but the SMART Telescope of Hida Japan was. They have data for:

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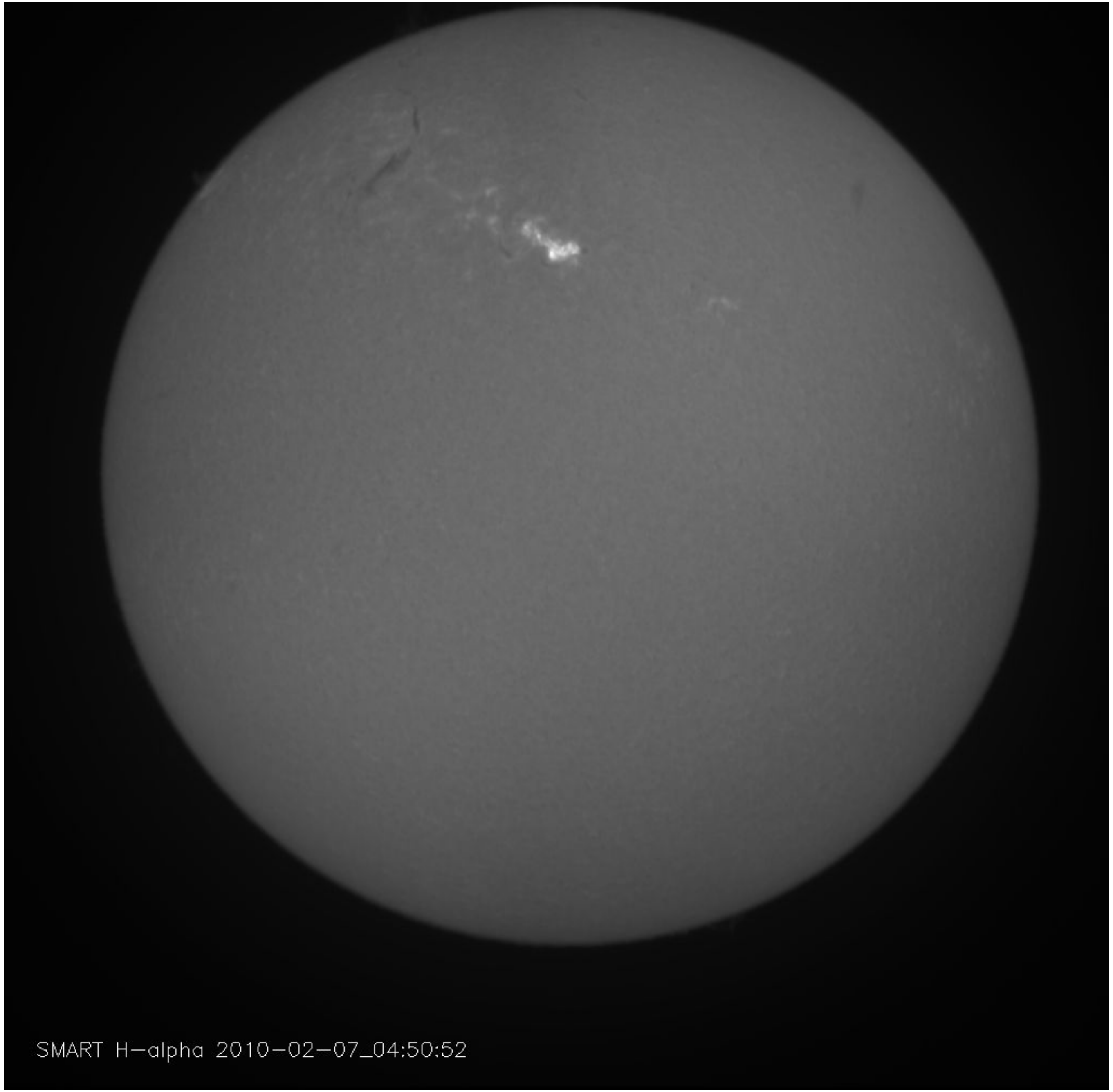
- 2010 01 17 5450 22:12 22:33 22:41 C2.1 1040 (*)
- 2010 01 19 5710 23:17 23:26 23:38 C2.2 1041 (+)
- 2010 01 20 5720 00:10 00:22 00:30 C4.0 1041 (+)
- 2010 01 20 5730 02:47 02:53 03:02 C1.7 1041 (+)

- 2010 02 07 6810 02:20 02:34 02:39 M6.4 1045 (#)
- 2010 02 07 6870 03:25 03:29 03:33 C1.1 1045 (#)
- 2010 02 07 6880 04:42 04:52 04:54 C9.9 1045 (#) <= Best
- 2010 02 12 8750 07:18 07:25 07:28 C7.9 1046 ($)


SMART H-alpha 2010-02-07_04:50:52

Perspectives

- Excellent news for Lyman-Alpha Flares is that LYRA/PROBA-2 made recent observations campaigns with the spare Lyman detectors (opening reserved unit3 - not calibrated though - in parallel to unit2 for a limited duration to regain sensitivity!)
- More information on that possibility will be given this afternoon by Marie Dominique knowing that a compromise is to be found between long openings to "watch for Flares" from a promising region and limited openings after a first Flare to limit filter's exposition (and, thus, degradation…). This second strategy was used up to now but with limited success.
- A follow-up of LYRA/PROBA-2 is proposed with more FUV-MUV-UV bands (and also a full Sun Lyman-Alpha and 200-220 nm telescope): the Space Weather Ultraviolet Solar Variability Microsatellite Mission (more on proposal at the end of the day)

EUV Solar Irradiance Variability from PROBA2/LYRA/SWAP

- Objective is to understand the physical origin of UV-EUV irradiance changes
- If, indeed, of magnetic origin (contribution of various magnetic features), then is there a suitable "proxy" for that variability?
- Irradiance models are based on full-disk surrogates, such as 10.7 cm radio flux, Ca II K index or the HeI line equivalent width at 1083 nm. Plages, network and intranetwork contribute to variability, so that spatially resolved data are important.

Observations and analysis

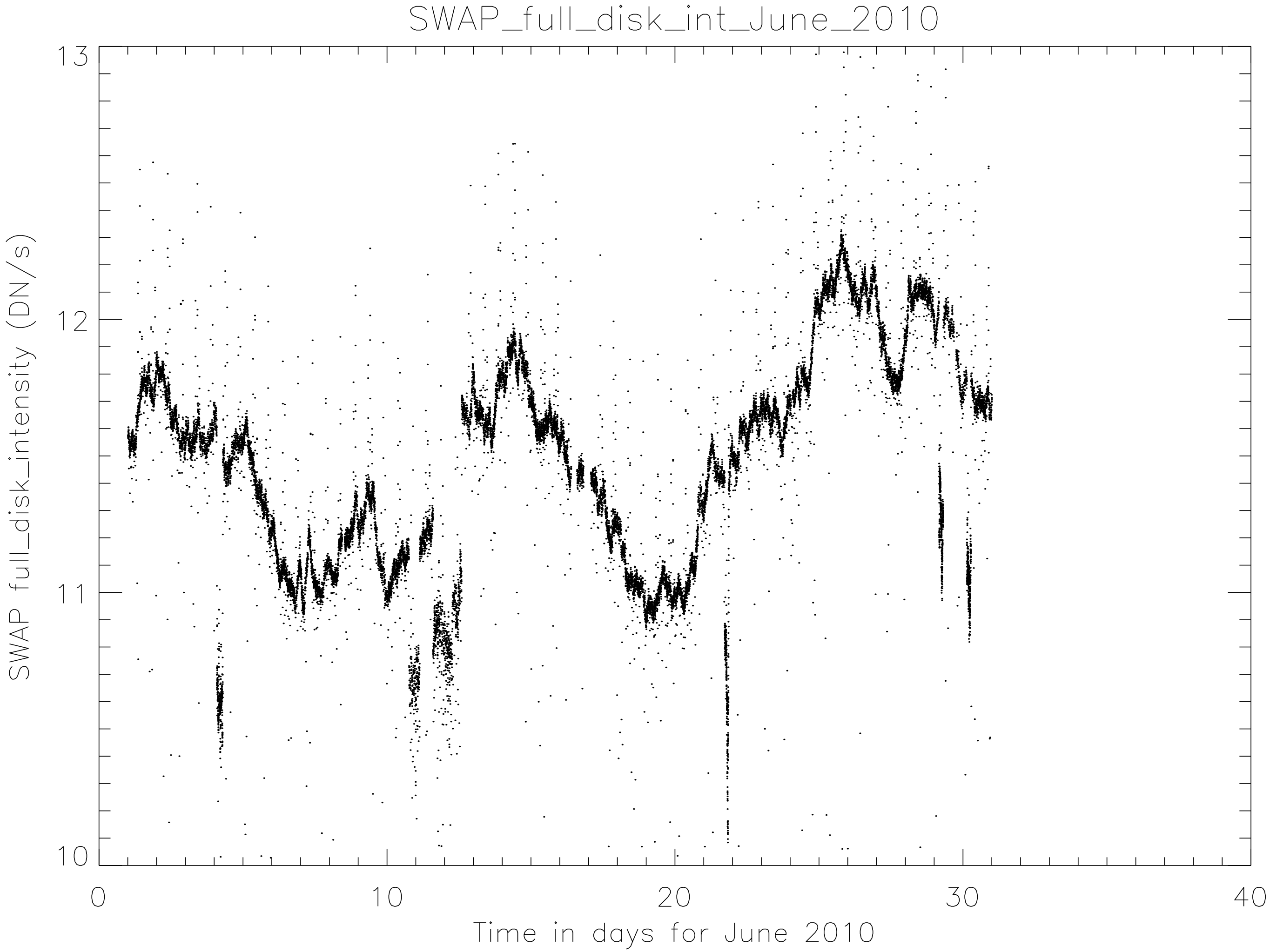
For day to day variations:

- LYRA irradiance observations for June 2010 measured in Channel 3 (Aluminium Filter Channel: 170 – 800 Å, including strong HeII 304 Å) are used;
- Full disk SWAP (174 Å) integrated intensity values for June 2010;
- Compared LYRA irradiance values with full-disk integrated intensity values determined from spatially resolved images of SWAP in 174 Å and with CaII K 1 Å Index values observed from NSO/Sac Peak.

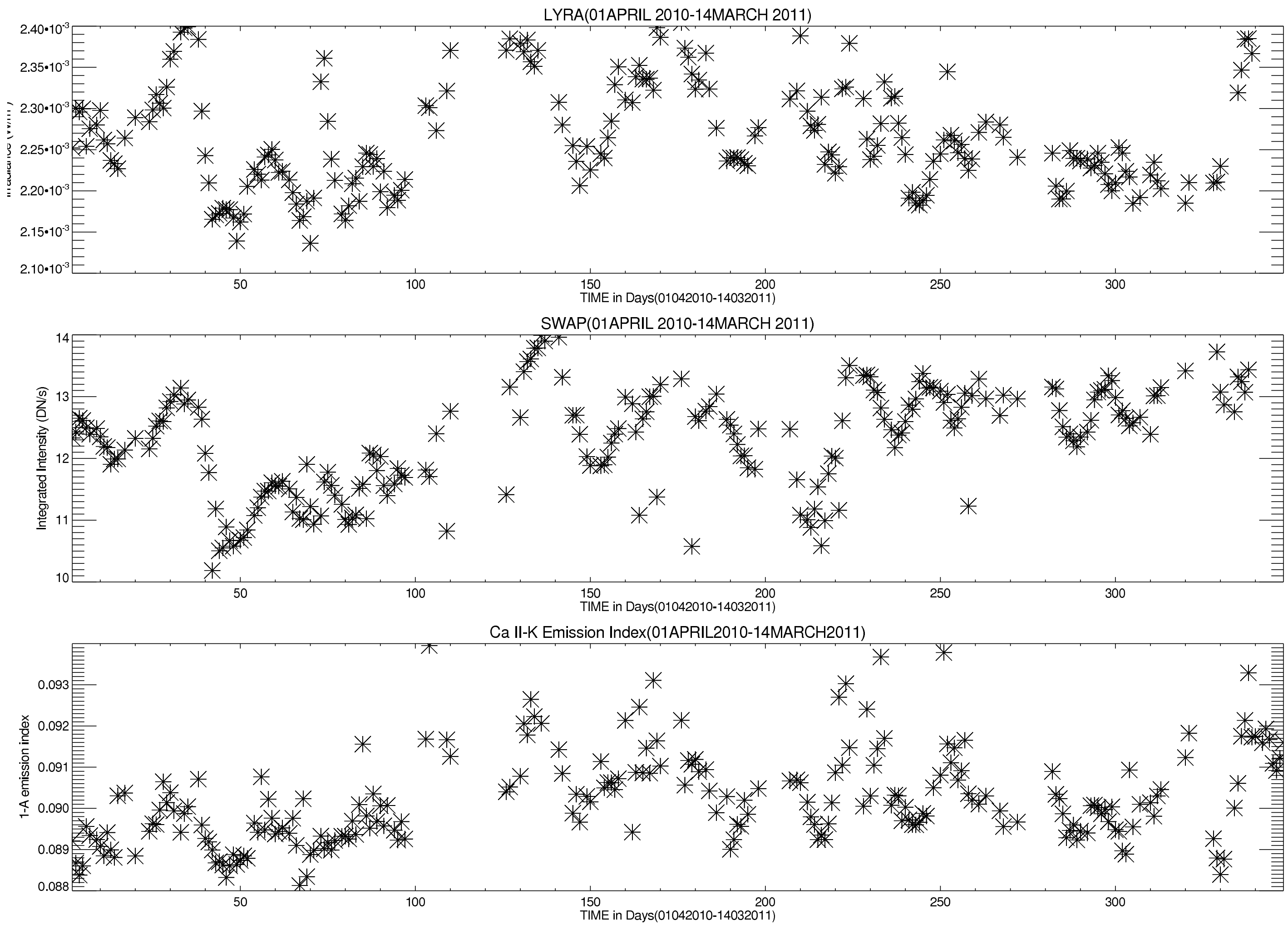
For short term variations:

We have used LYRA irradiance and SWAP full-disk integrated intensity values for June 10, 2010 from 00.00 hours to 12.00 hours.

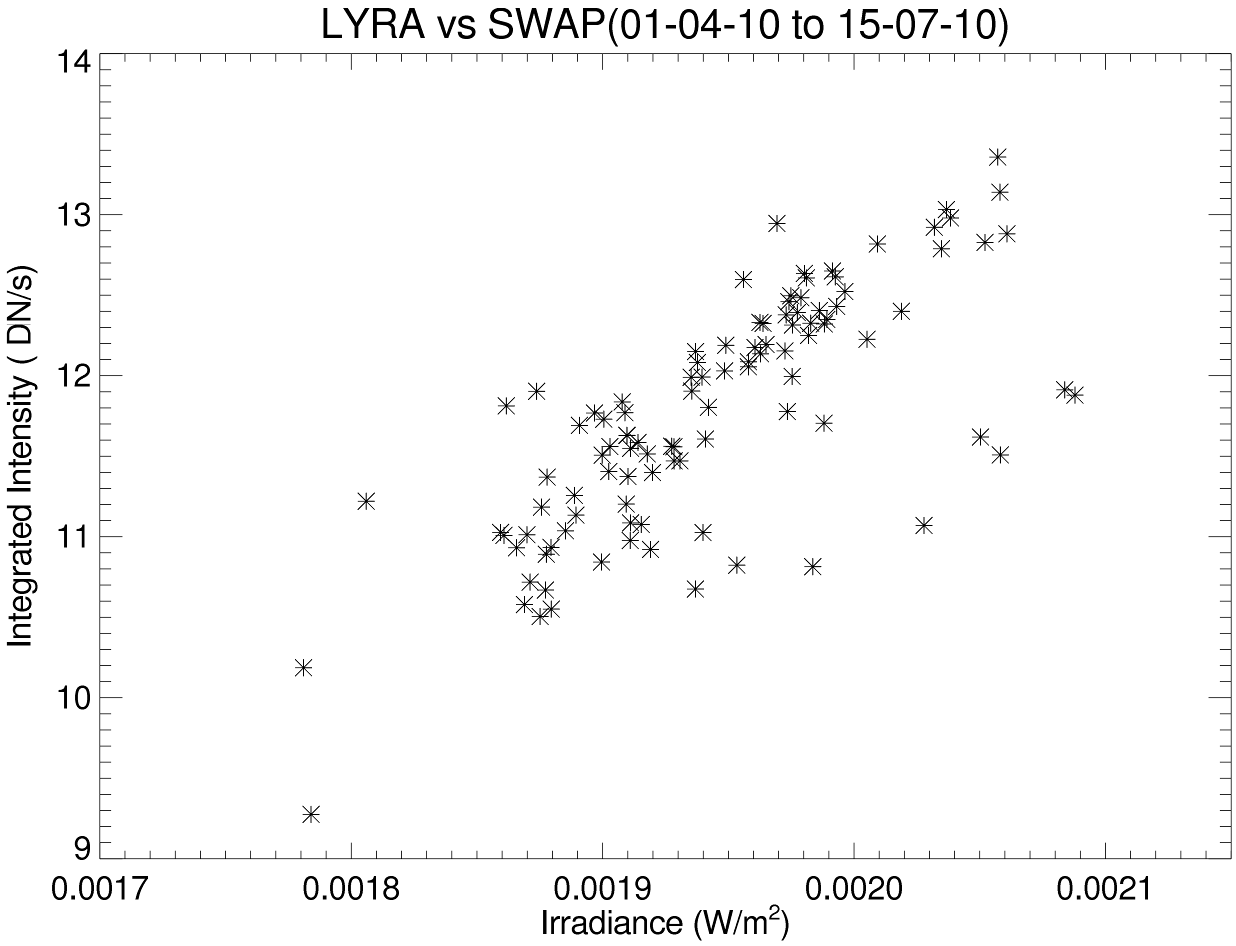
Integrating SWAP for total flux
(June 2010)



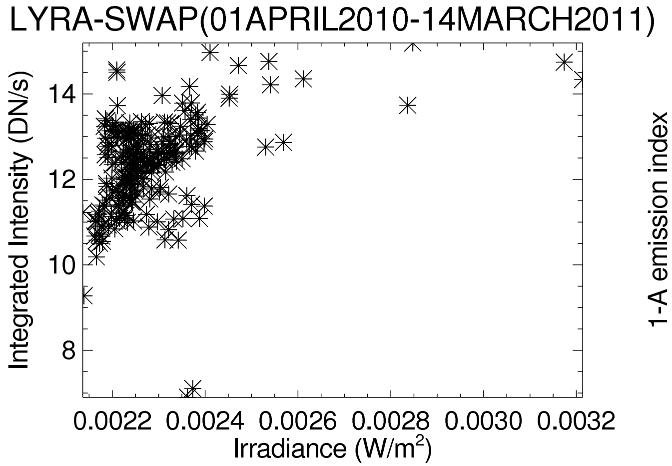
LYRA/SWAP/Ca II K
(March 2010 to April 2011)

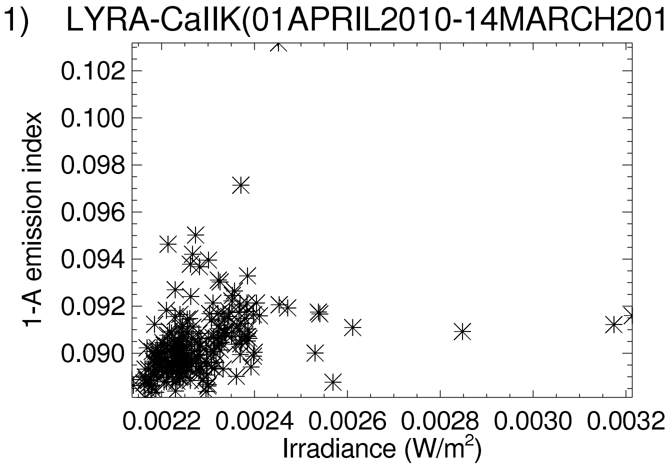


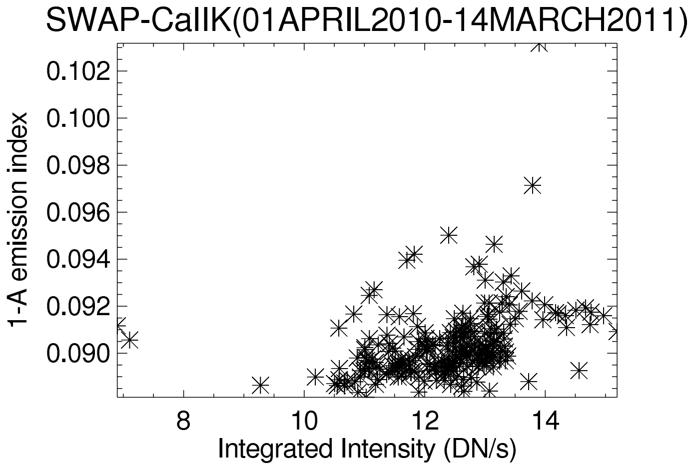
LYRA (2-3) — SWAP Correlation
(April–July 2010)



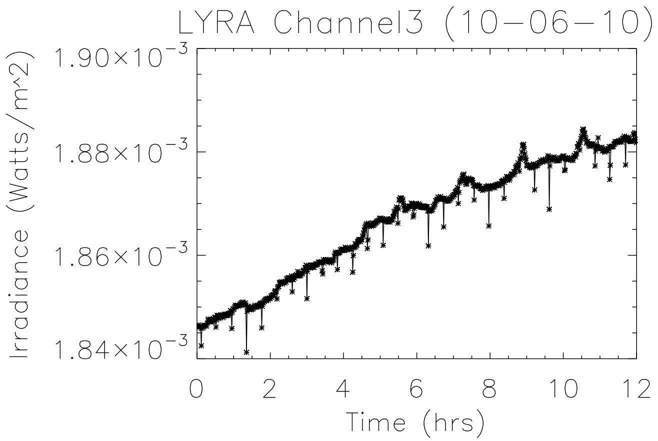
LYRA — SWAP — Ca II K
(April 01 2010 – March 14 2011)

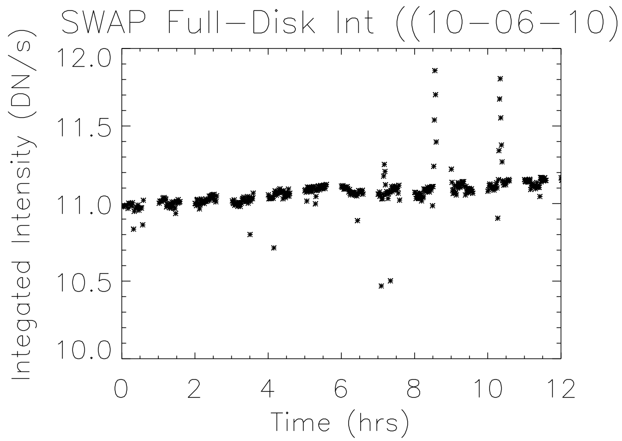


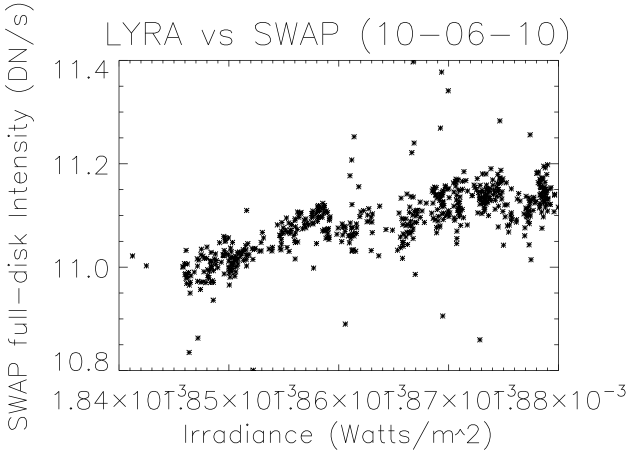




Short term: 12 hours correlation LYRA(2-3 Alu) — SWAP







June 10 2010; 0 to 12:00.

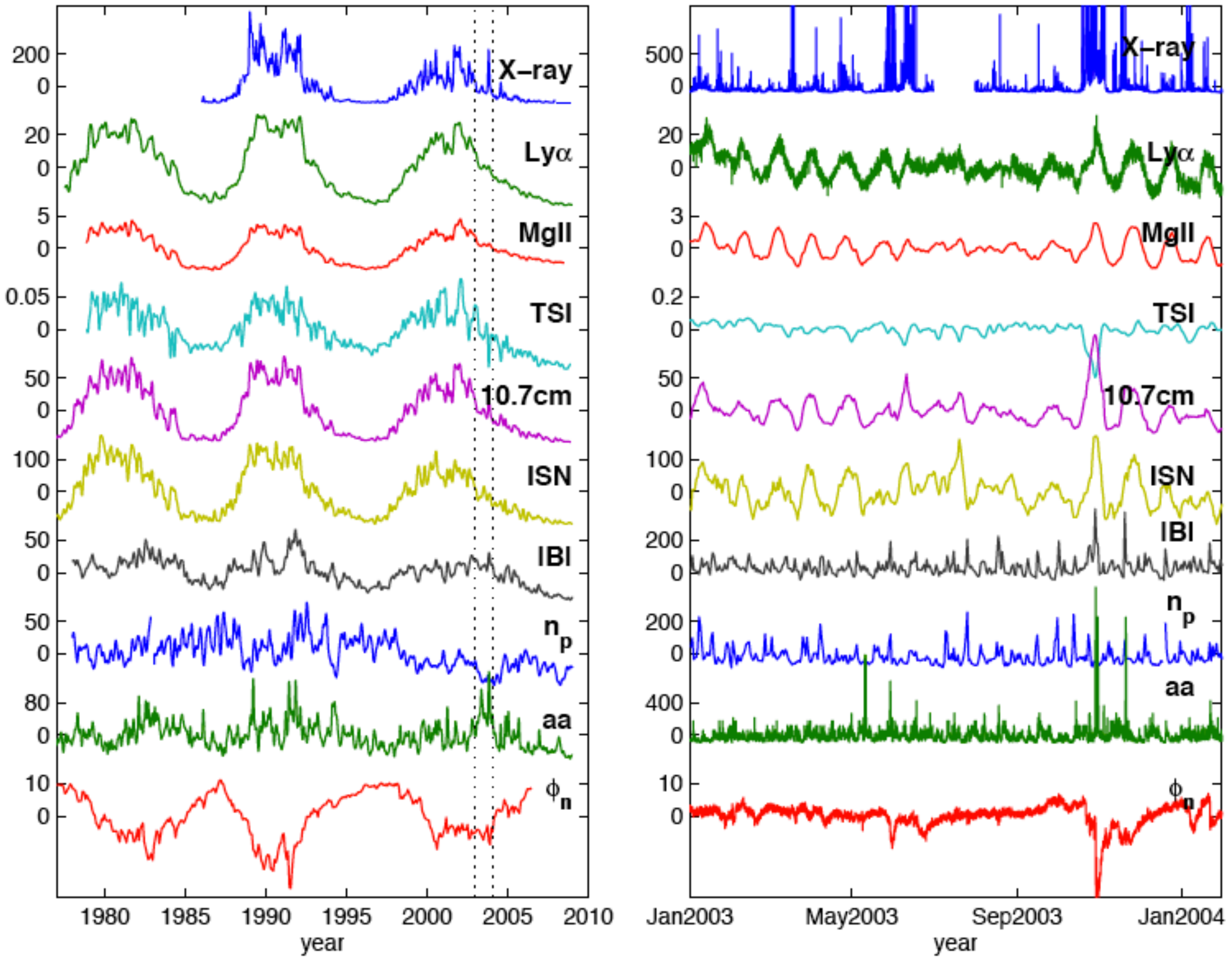
Conclusions

We compared LYRA irradiance values with SWAP 174 Å full-disk integrated intensity and with CaII k 1 Å index values to study the day-to-day variations and within a day variations:

- we observed from the time series plots that there is a good correlation between the LYRA irradiance, SWAP full-disk intensity and CaII K 1 Å index values;
- it suggests that the variations in LYRA irradiance are due to the variations of solar magnetic features observed in SWAP 174 Å. The SWAP (174 Å) full-disk integrated & CaII K 1 Å index measurements can be used to understand and explain the LYRA irradiance variations. **???**

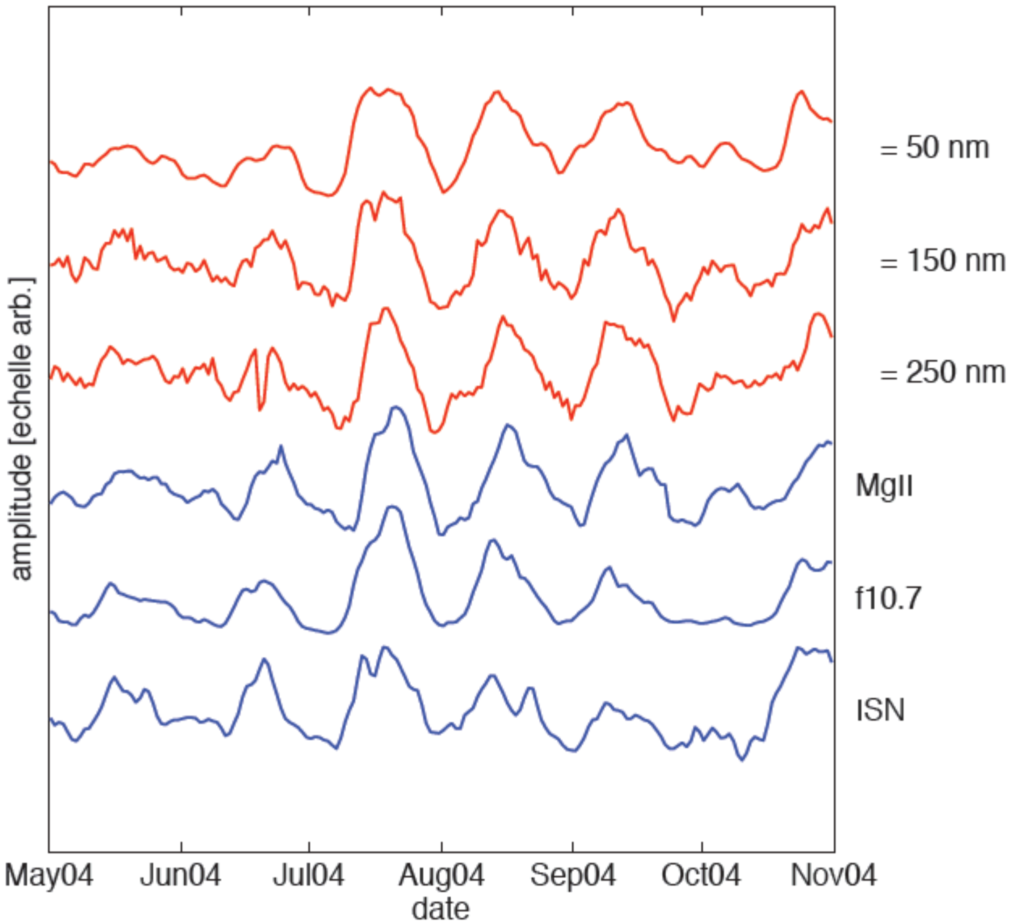
Separating out the different solar magnetic features from full-disk spatially resolved images obtained from PROBA2/SWAP (174 Å) and SDO/AIA (304 Å) is in progress.

Indices are useful but not responding to exact same time scales



Relative variations in % are "globally" in agreement on a long term scale but not when it comes to shorter times (days or weeks)

Measurements and images to address the physics of phenomena



Again, variations are correlated but only on long term trends, and not perfectly whatever indices are used. Direct flux measures in the FUV, MUV and UV are required, and IMAGING to identify the source(s) of the variations (what physics behind them?).

Thank you!!

SWAP full
Carrington Rotation
Movie
(September-
October 2011)