



LYRA

the Large-Yield Radiometer onboard PROBA2

Correlation between sunspot numbers and EUV irradiance as observed by LYRA on PROBA2

Ingolf. E. Dammasch & Laure Lefevre, ROB



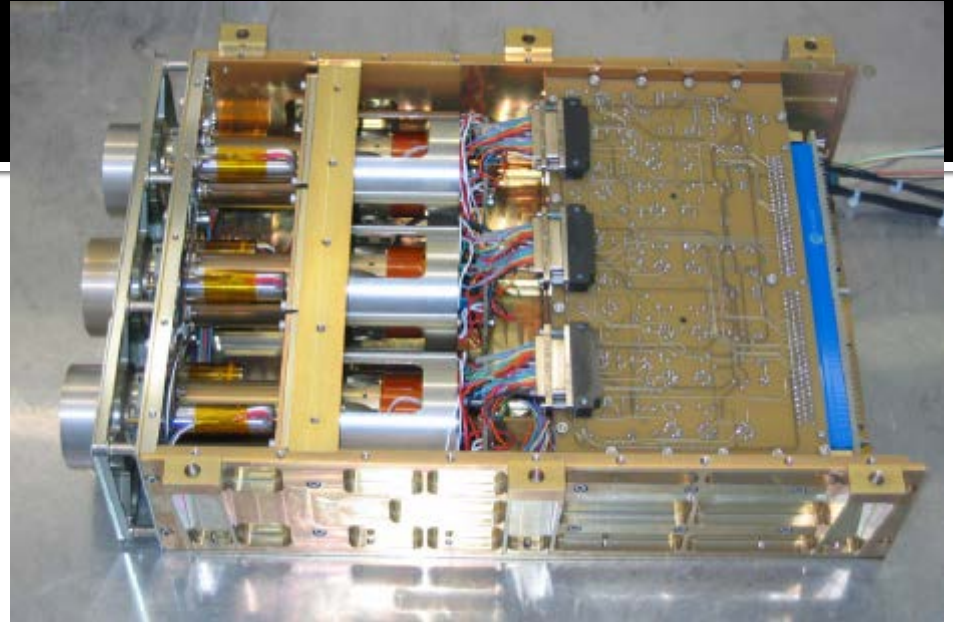
SIDC Seminar, Brussels, 10 Jul 2013

PROBA₂



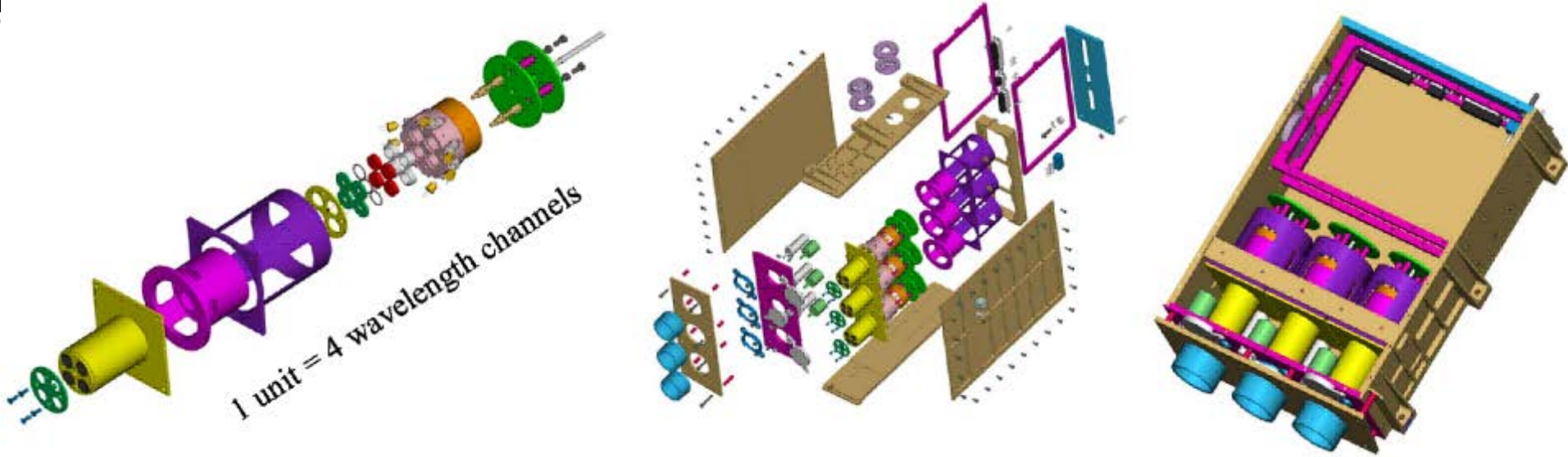
- ESA's "PRoject for On-Board Autonomy"
- Belgian microsatellite in Sun-synchronous orbit
- 725 km altitude
- Launched 02 Nov 2009
- Nominal operations since March 2010
- Technology *and* science mission
- 4 innovative instruments and 17 technological experiments for in-orbit demonstration
- Among them the EUV imager SWAP and the radiometer LYRA

LYRA



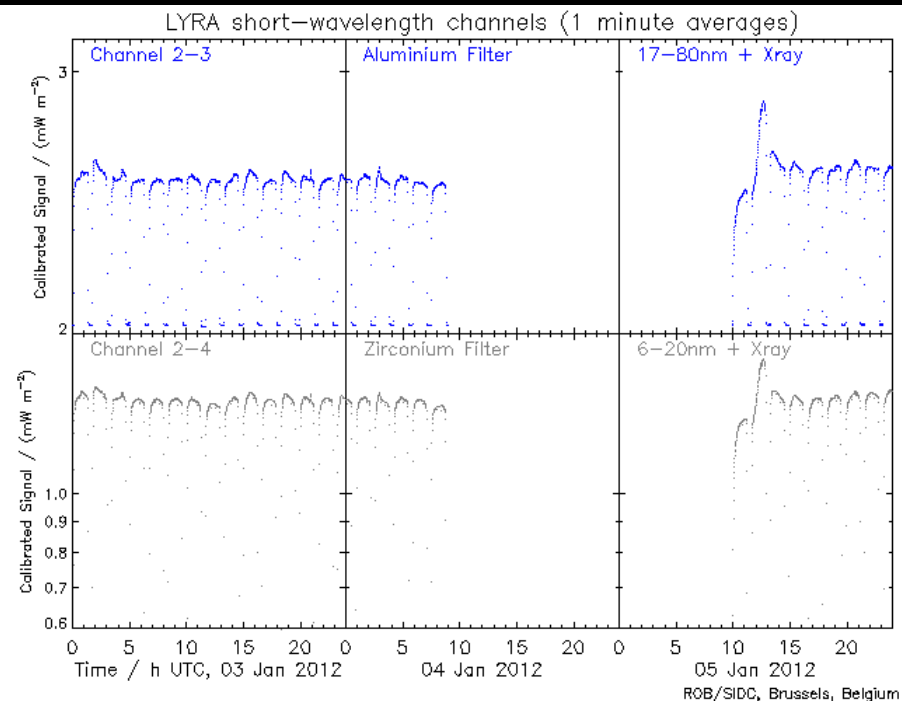
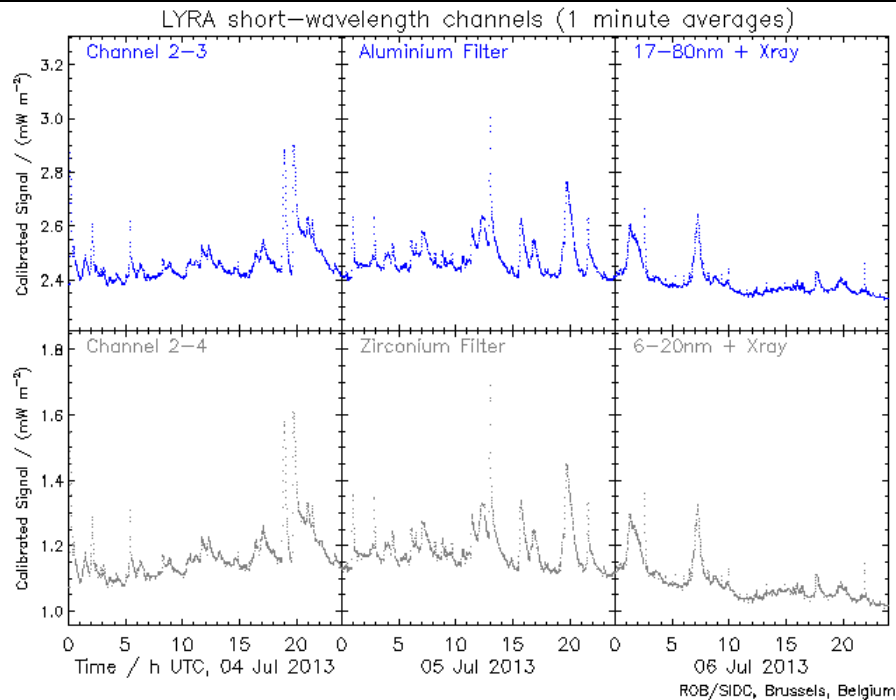
- “Large-Yield RAdiometer”
- 3 instrument units (redundancy)
- 4 spectral channels per head
- 3 types of detectors, Silicon + 2 types of diamond detectors (MSM, PIN): radiation resistant, insensitive to visible light as compared to Si detectors

LYRA Channels



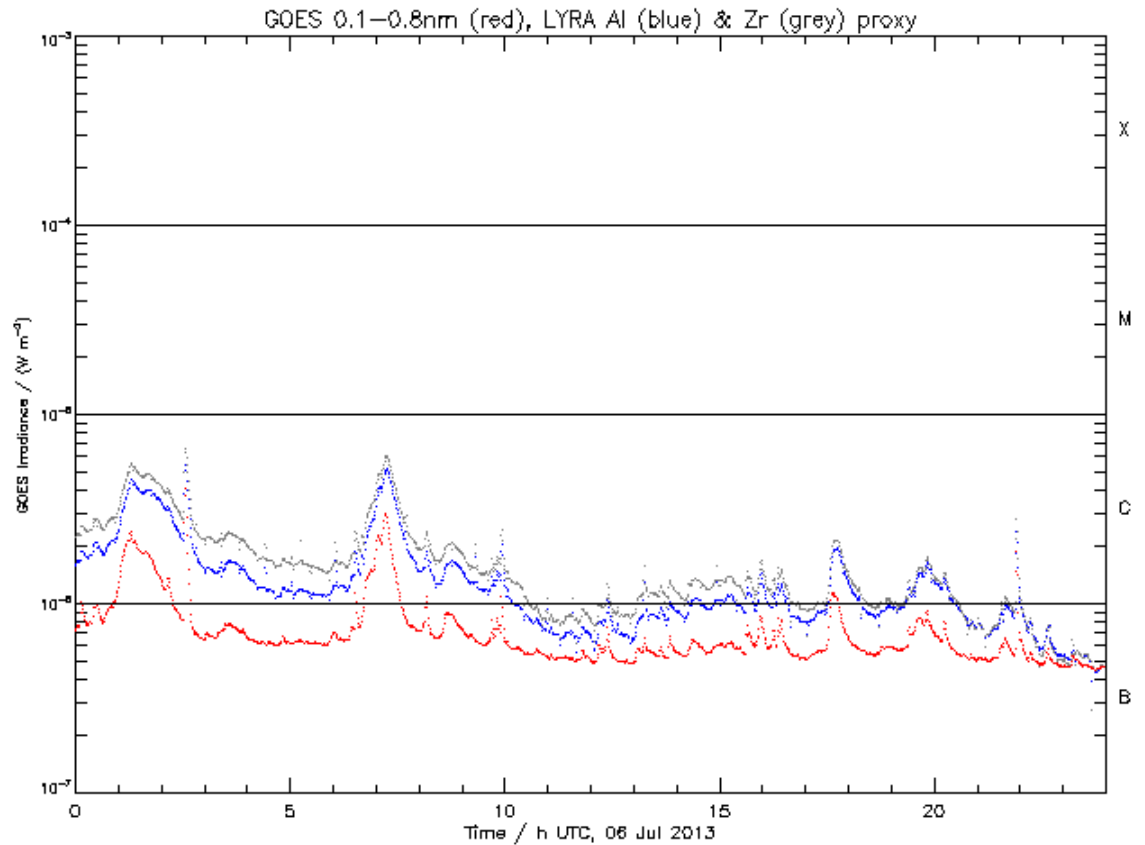
- Redundancy with different types of detectors:
- Channel 1 (Lyman-alpha) 120-123nm
- Channel 2 (Herzberg) 190-222nm
- Channel 3 (Aluminium) 17-80nm + <5nm
- Channel 4 (Zirconium) 6-20nm + <2nm

Instrument Artefacts



- Data gaps
- Satellite rotations
- Occultations by Earth atmosphere
- Off-pointings
- Temperature variations
- Switch on/off

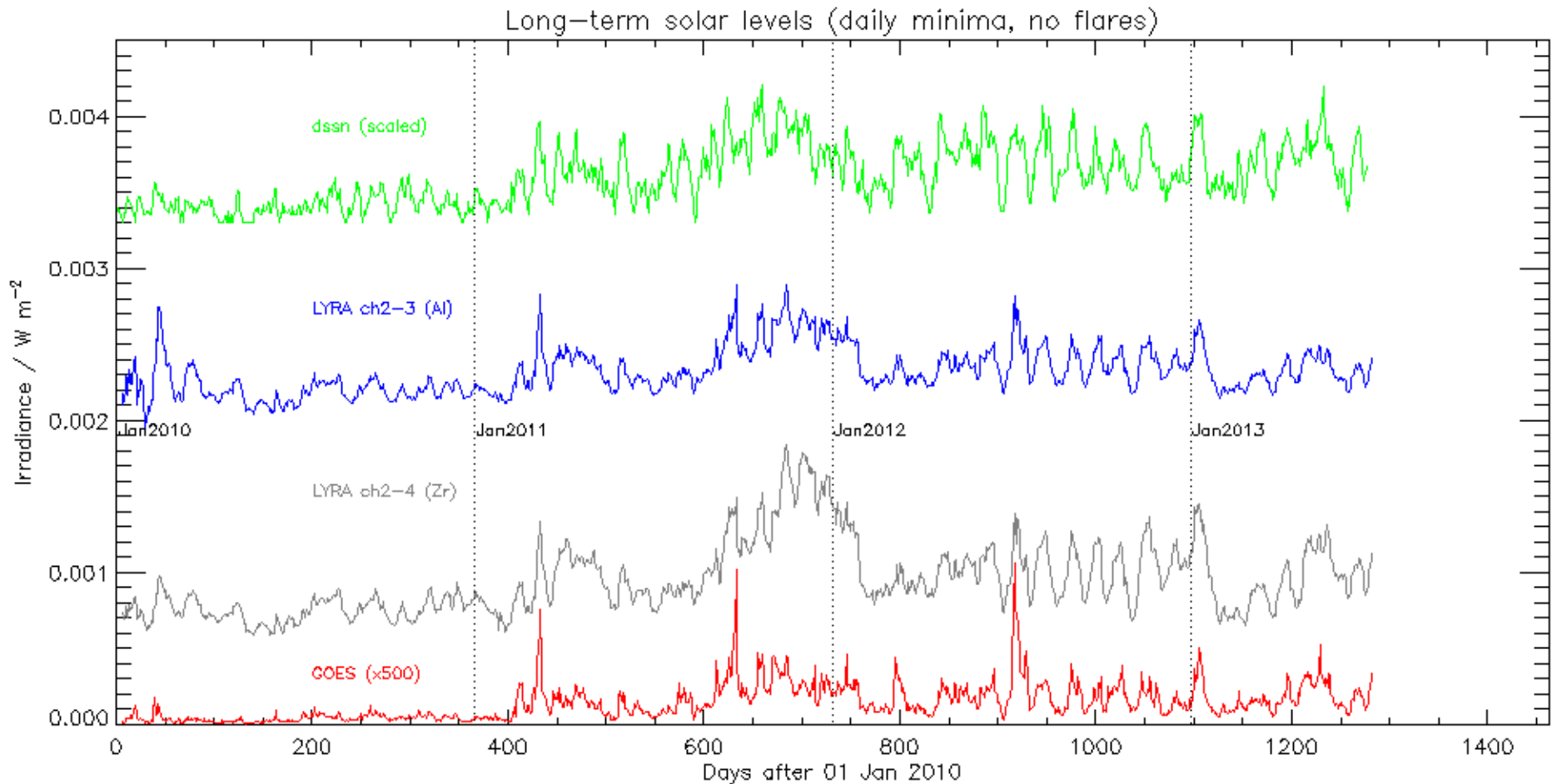
GOES vs. LYRA Proxies



ROB/SIDC, Brussels, Belgium

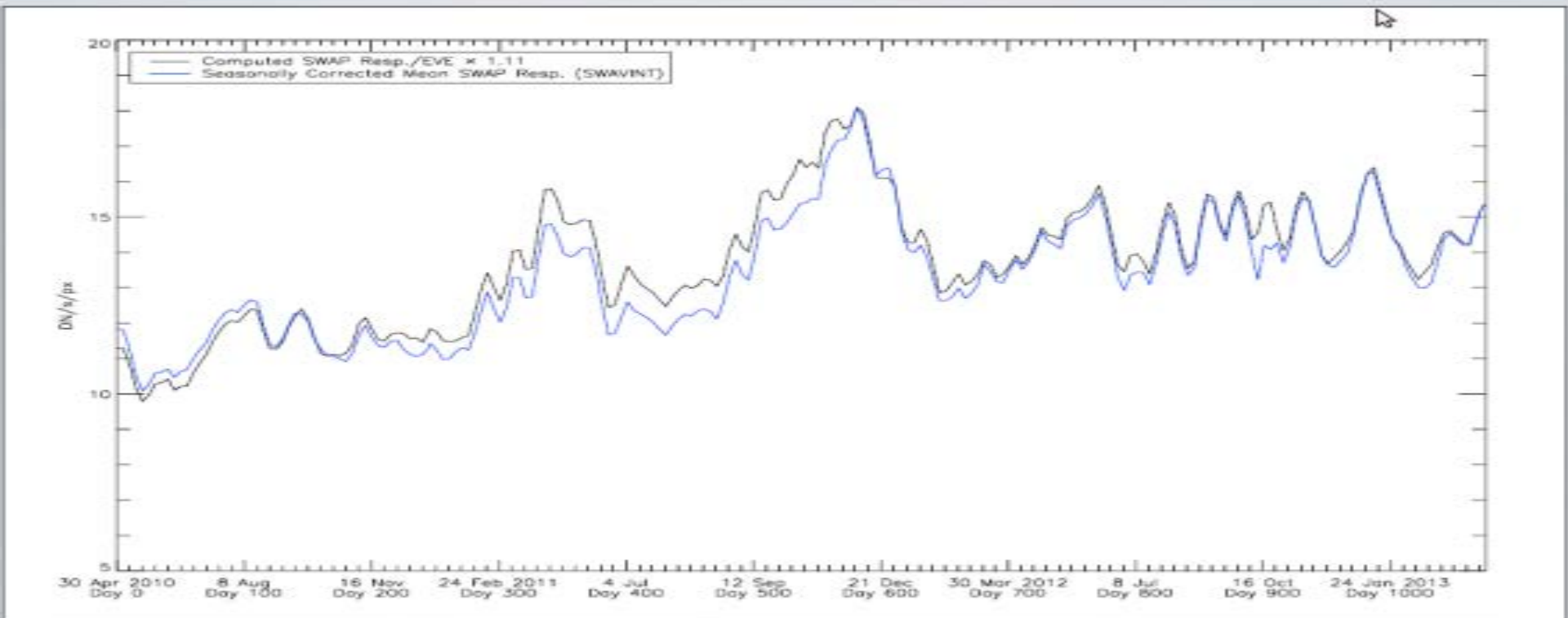
- Manually select significant minimum per day
- Calculate proxy with simple linear formula

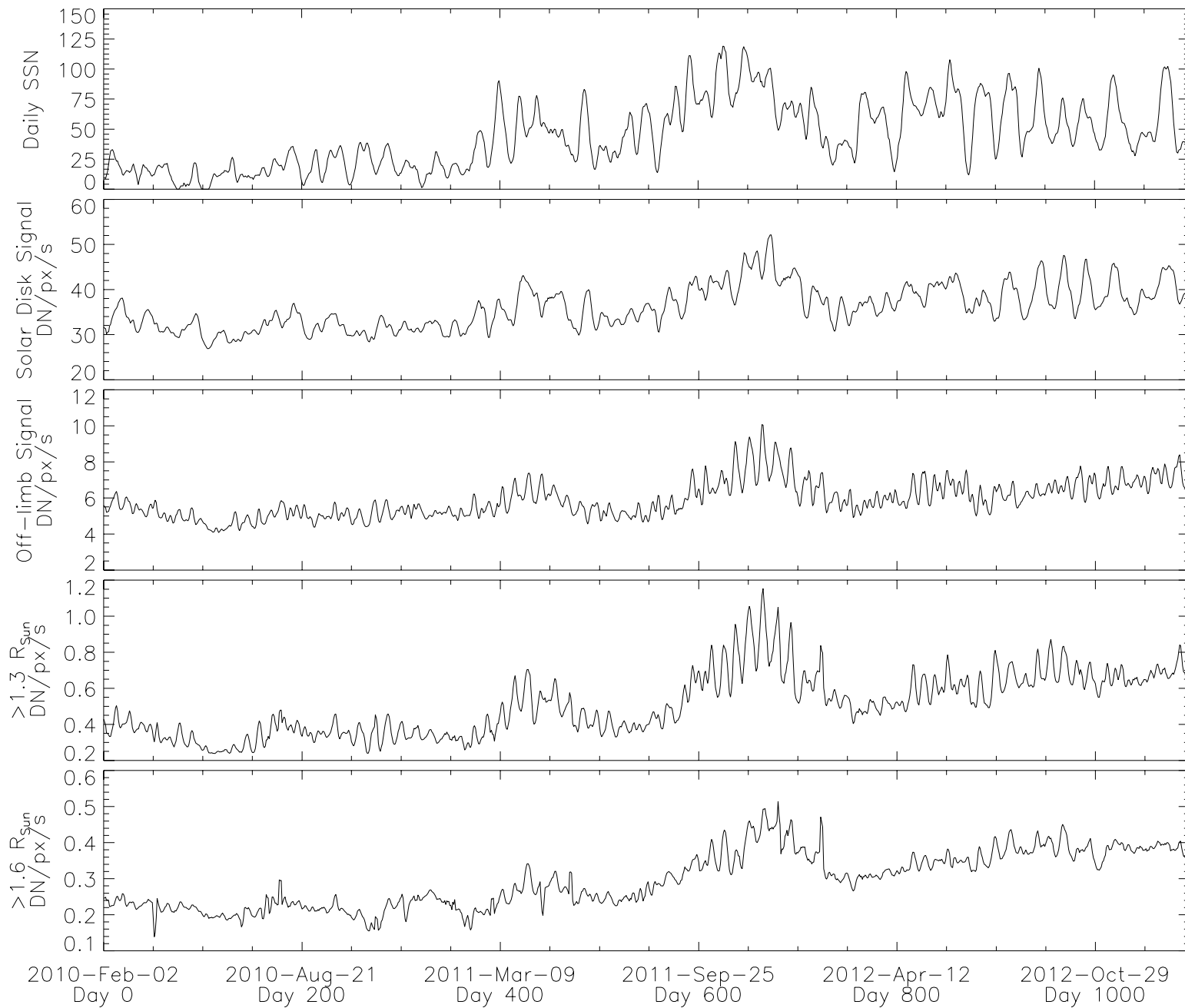
3 1/2 Years of Solar Development



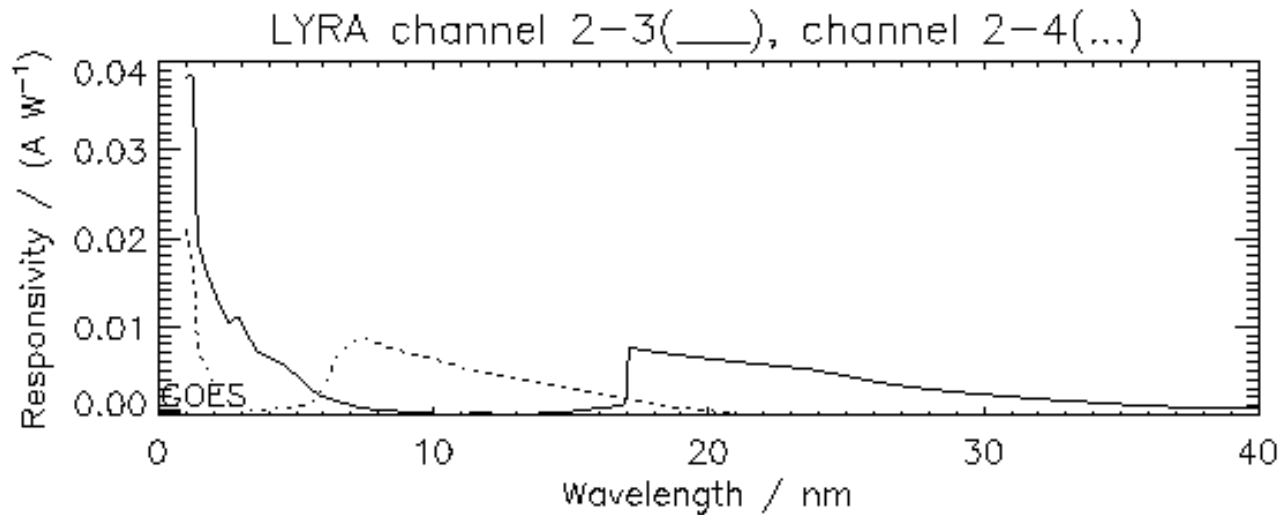
(initially a by-product of the daily significant minimum)

... also observed by SWAP and SDO/EVE



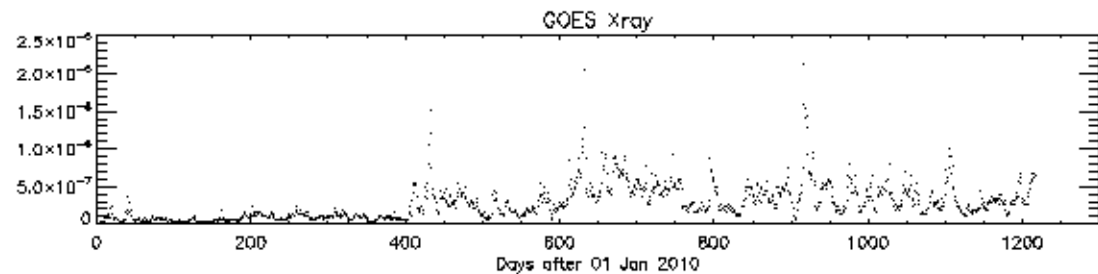
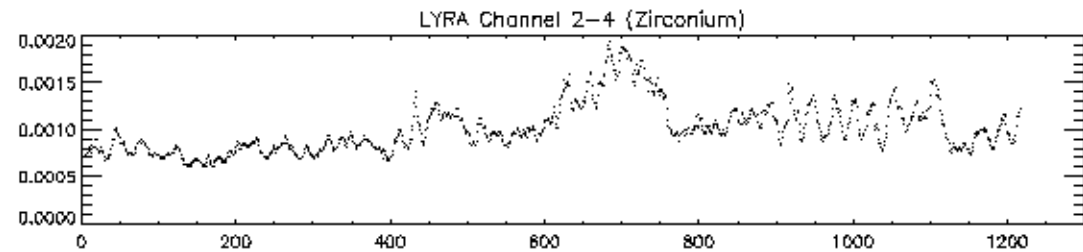
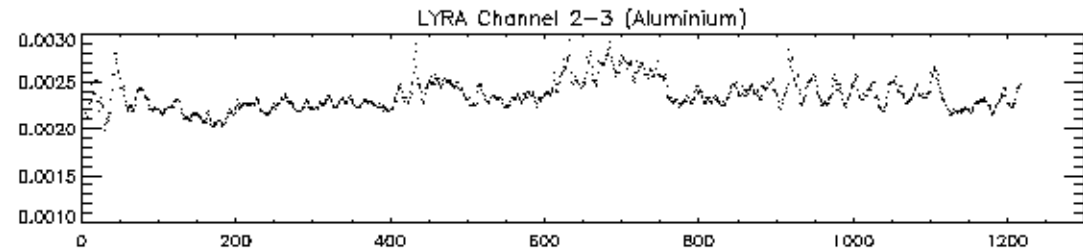
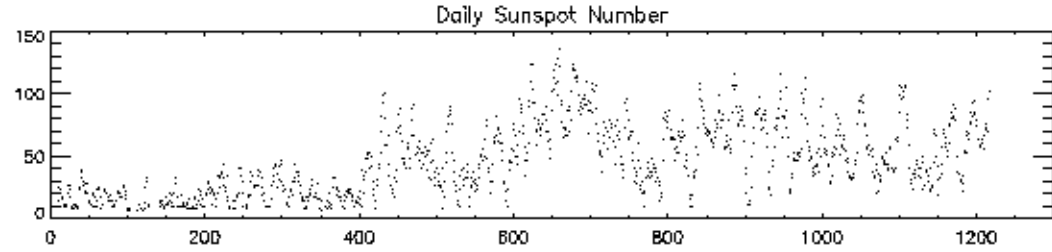


Another Instrument Artefact



- Spectral degradation (drastic above 19nm):
- Channel 2-3 lost 93% of its initial response
- Channel 2-4 lost 44% of its initial response

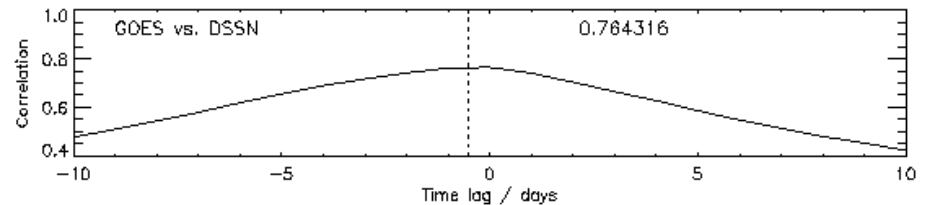
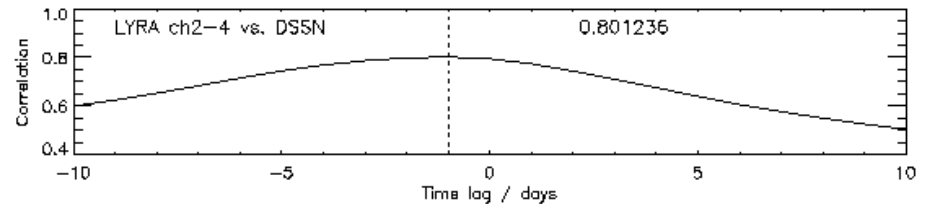
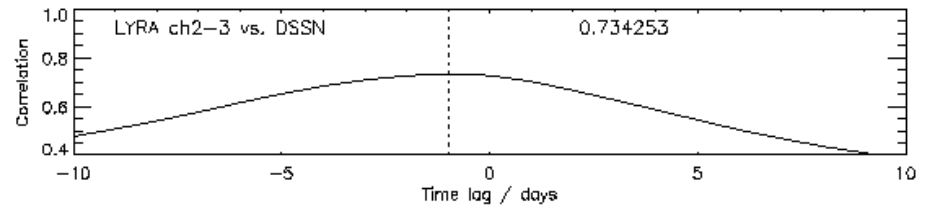
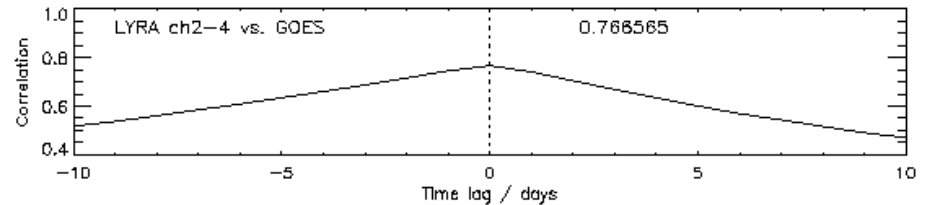
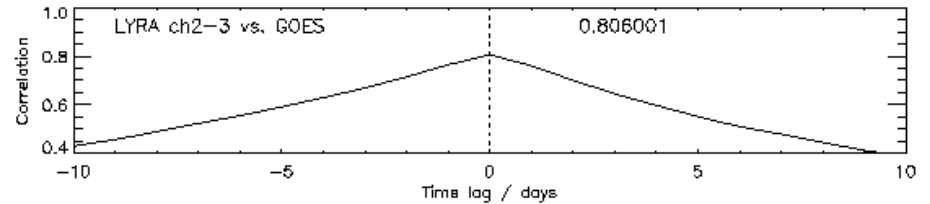
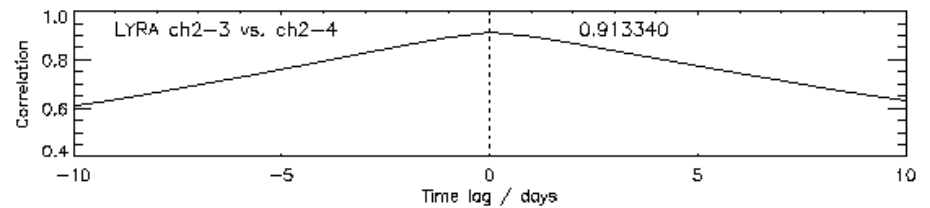
Comparing



- LYRA channel 2-3
- LYRA channel 2-4
- GOES 0.1-0.8nm
- Daily sunspot number

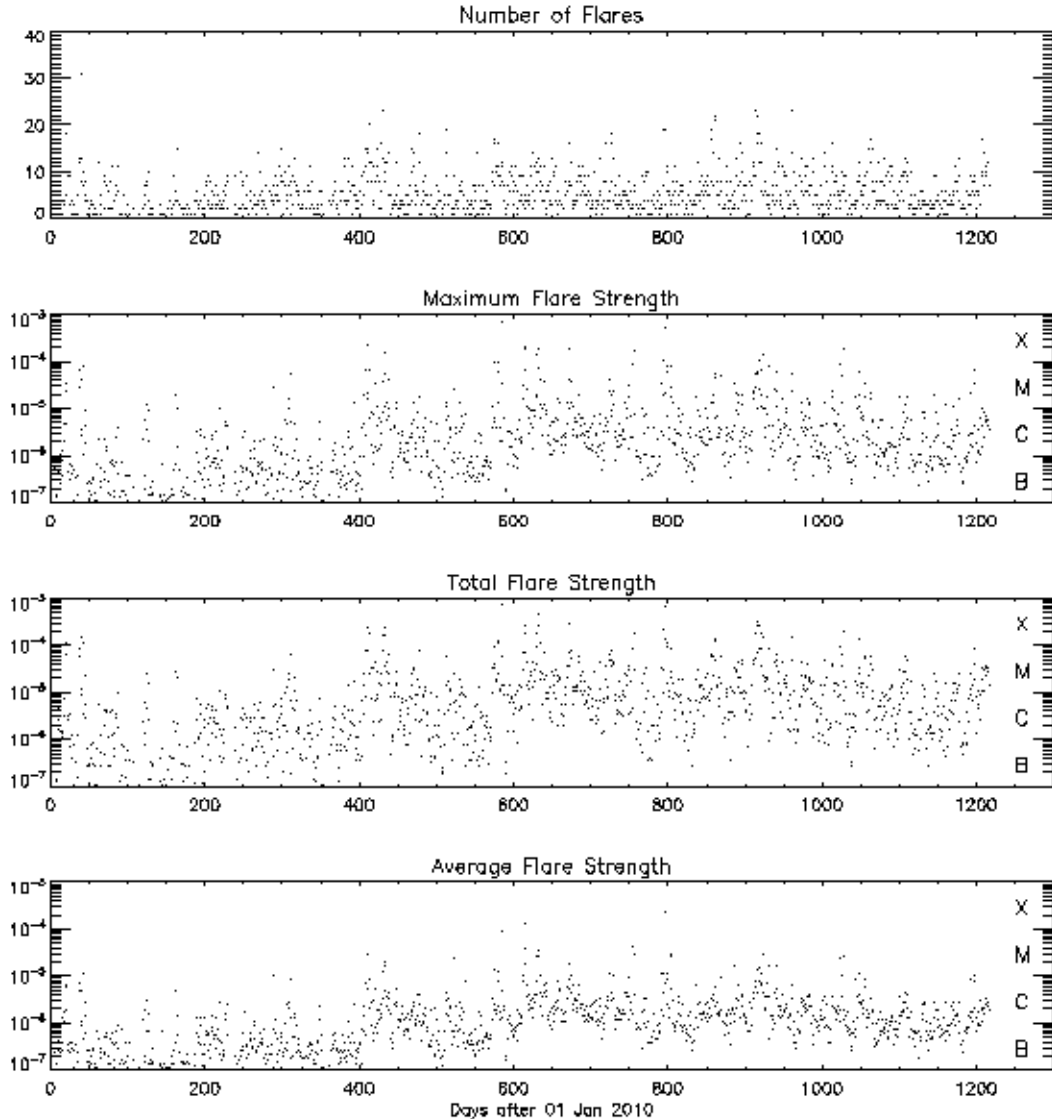
Comparing

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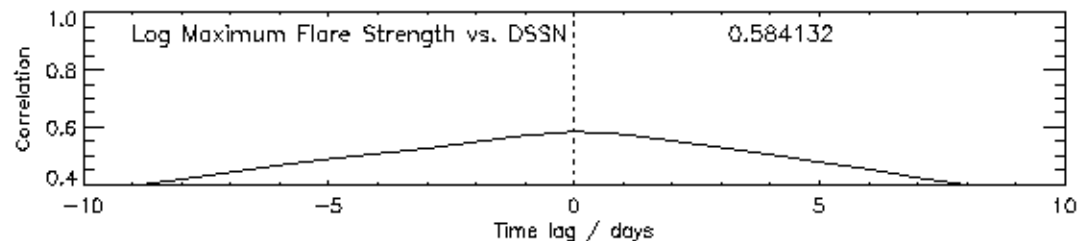
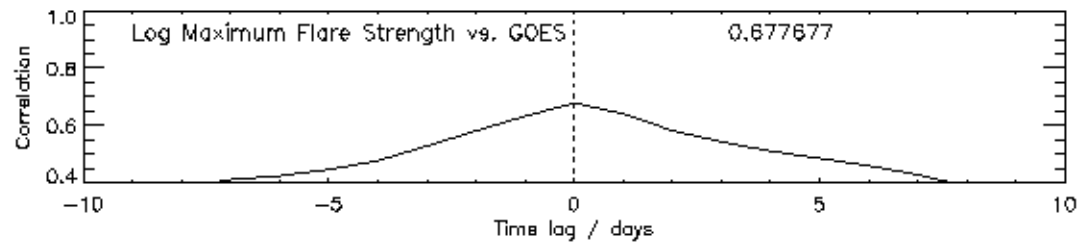
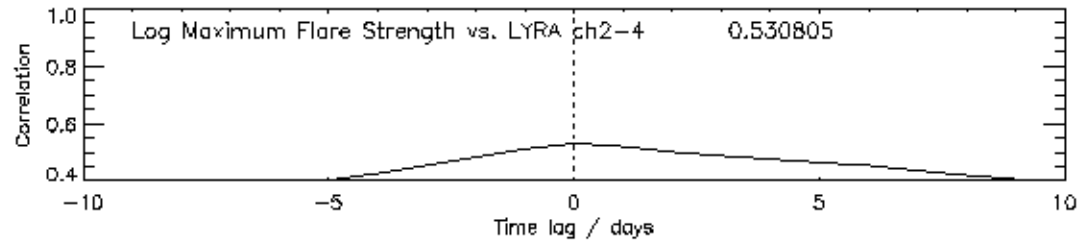
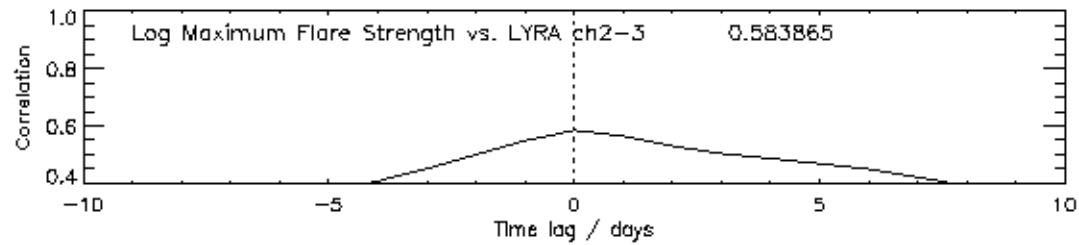
Comparing

- Another idea:
- *Compare these...*
- LYRA channel 2-3
- LYRA channel 2-4
- GOES 0.1-0.8nm
- Daily sunspot number
- ... to flare indices



Comparing

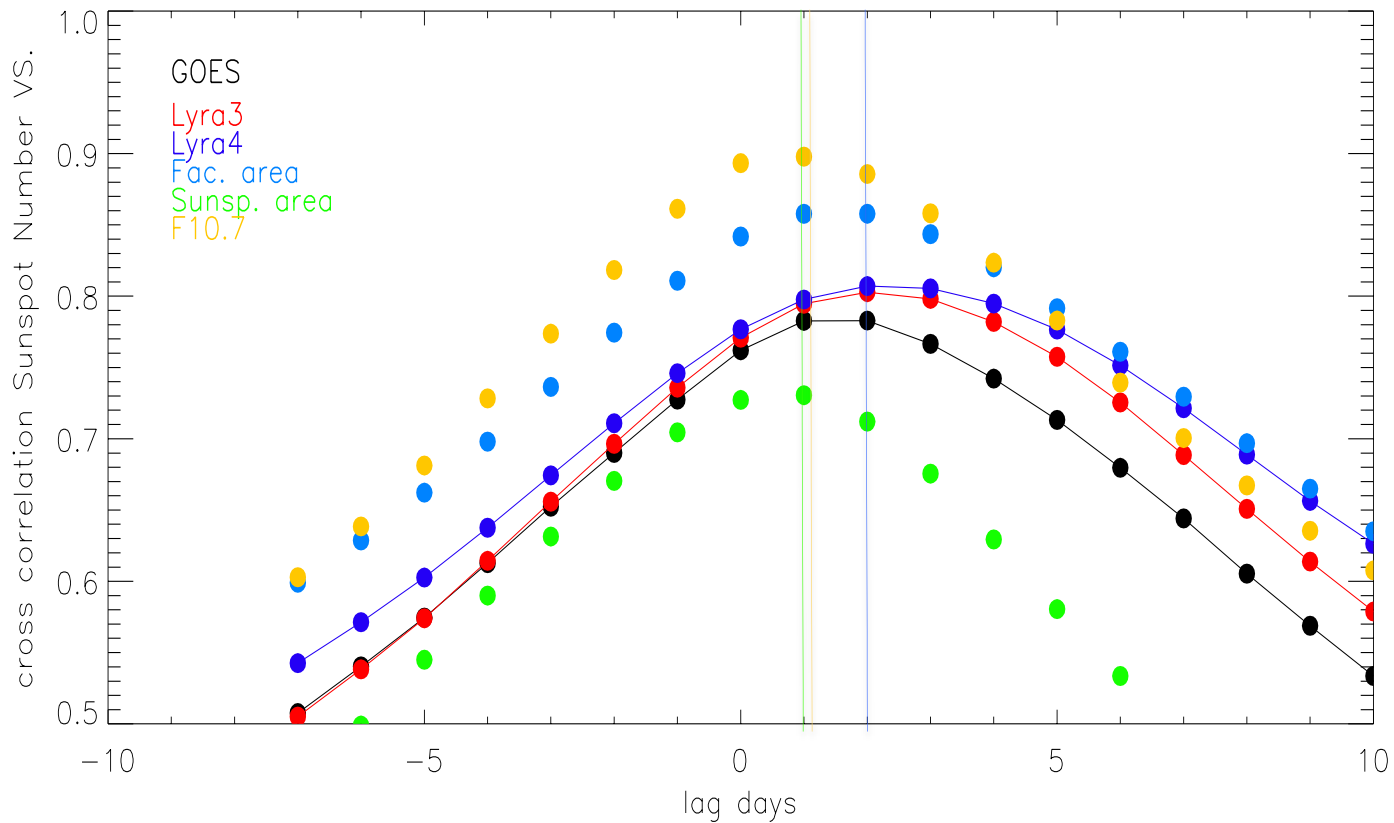
- Example:
- *Maximum flare strength and ...*
- LYRA channel 2-3
- LYRA channel 2-4
- GOES 0.1-0.8nm
- Daily sunspot number



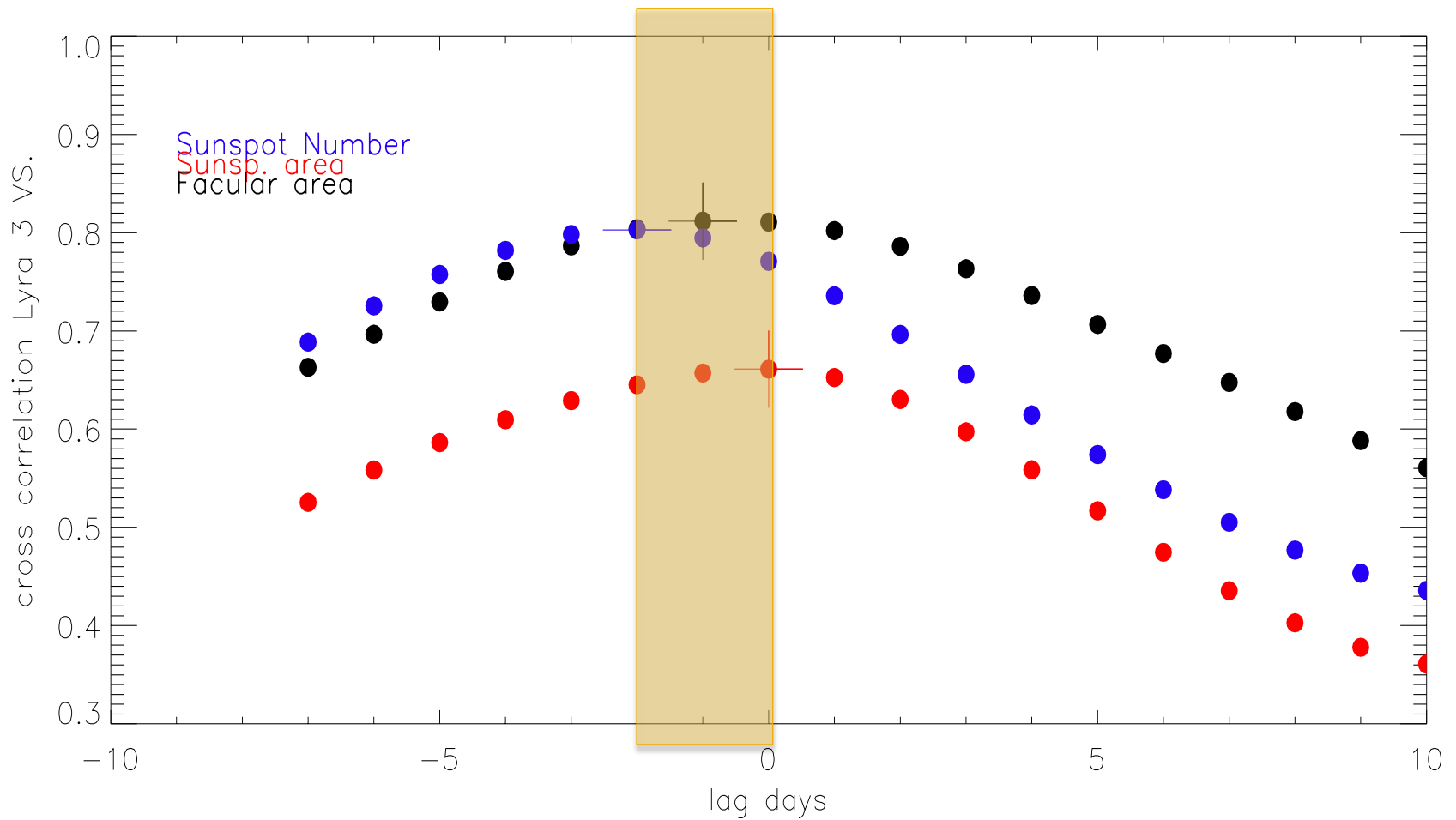
...now for Laure's part...

- GOES
- F10.7 (Penticton)
- CaIIK (SFO)
- Lyra4
- Lyra3
- TSI (Virgo / PMOD)
- Facular Area (SFO)
- Sunspot Area (SFO)
- Sunspot Numbers (from SIDC)

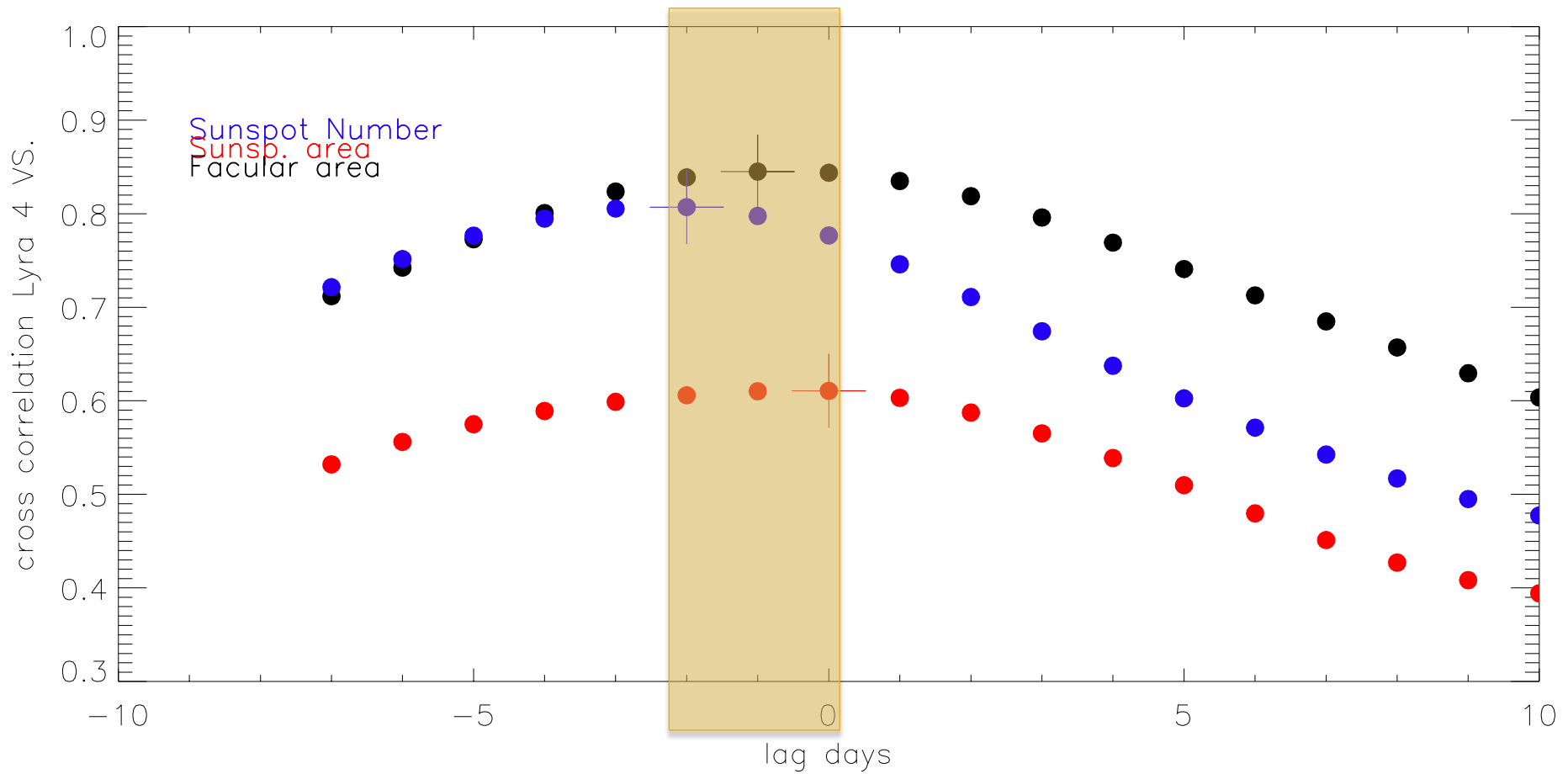
Cross Correlations ISSN VS. all

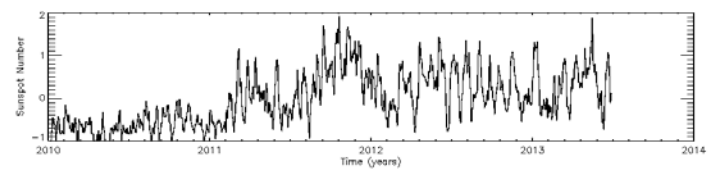
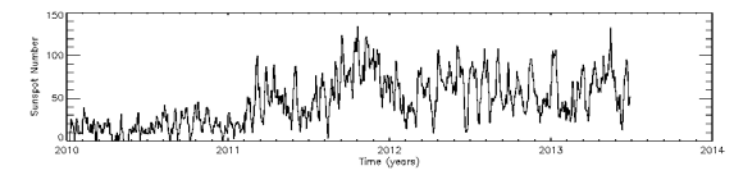
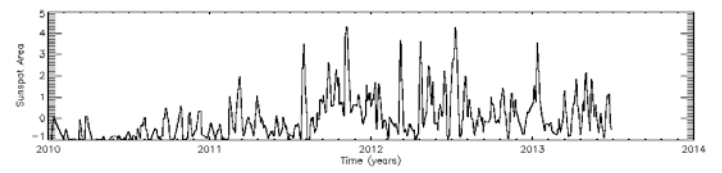
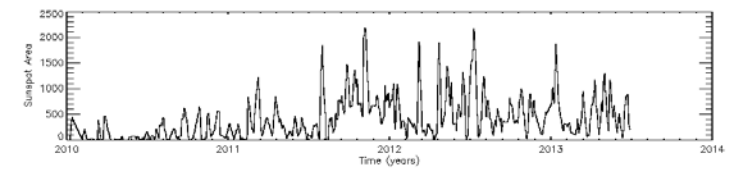
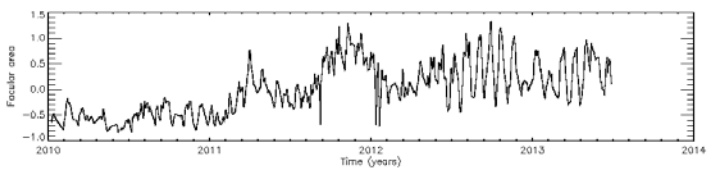
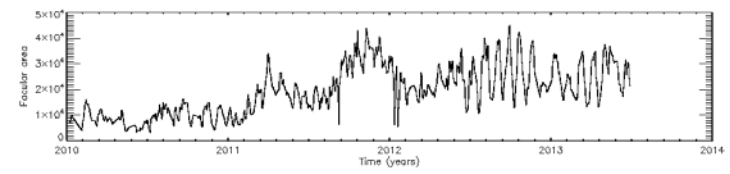
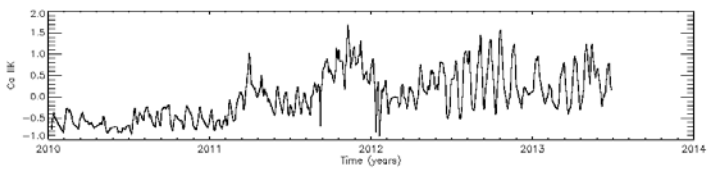
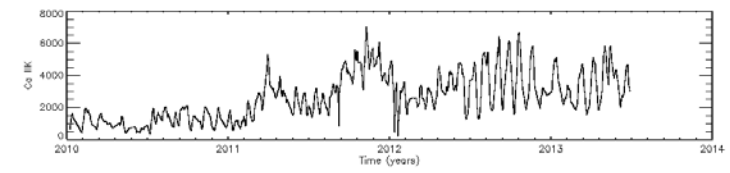
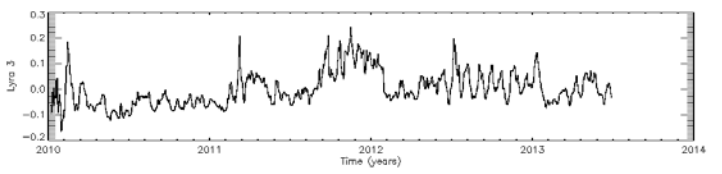
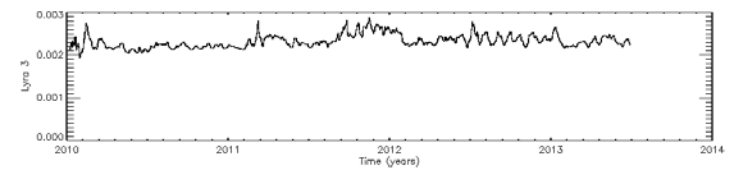
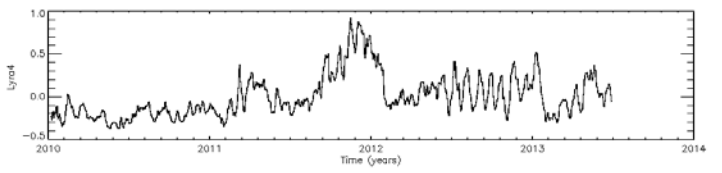
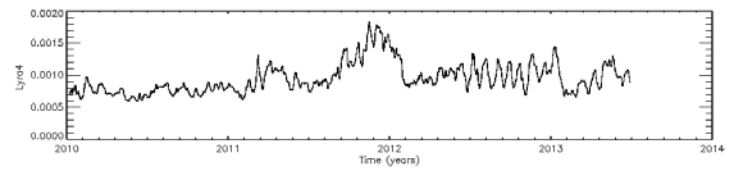
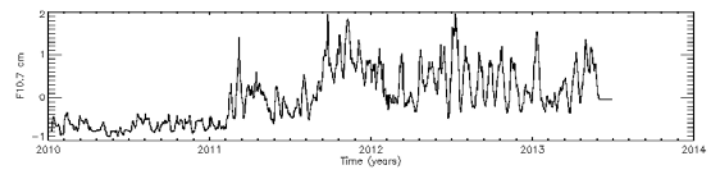
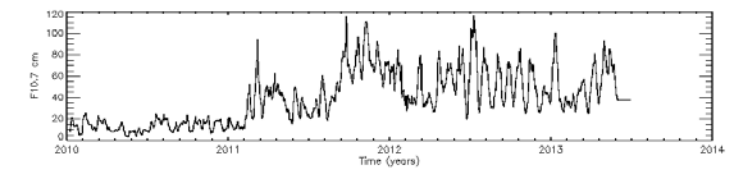
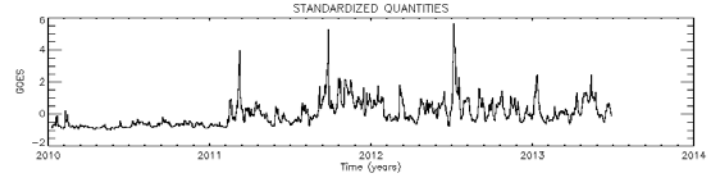
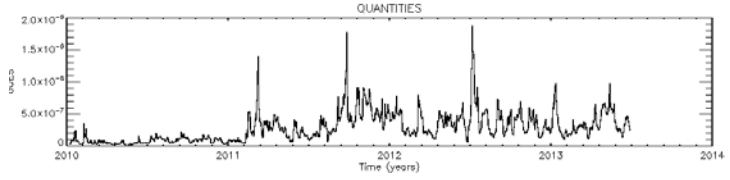


Cross correlation Lyra₃ vs. ISSN



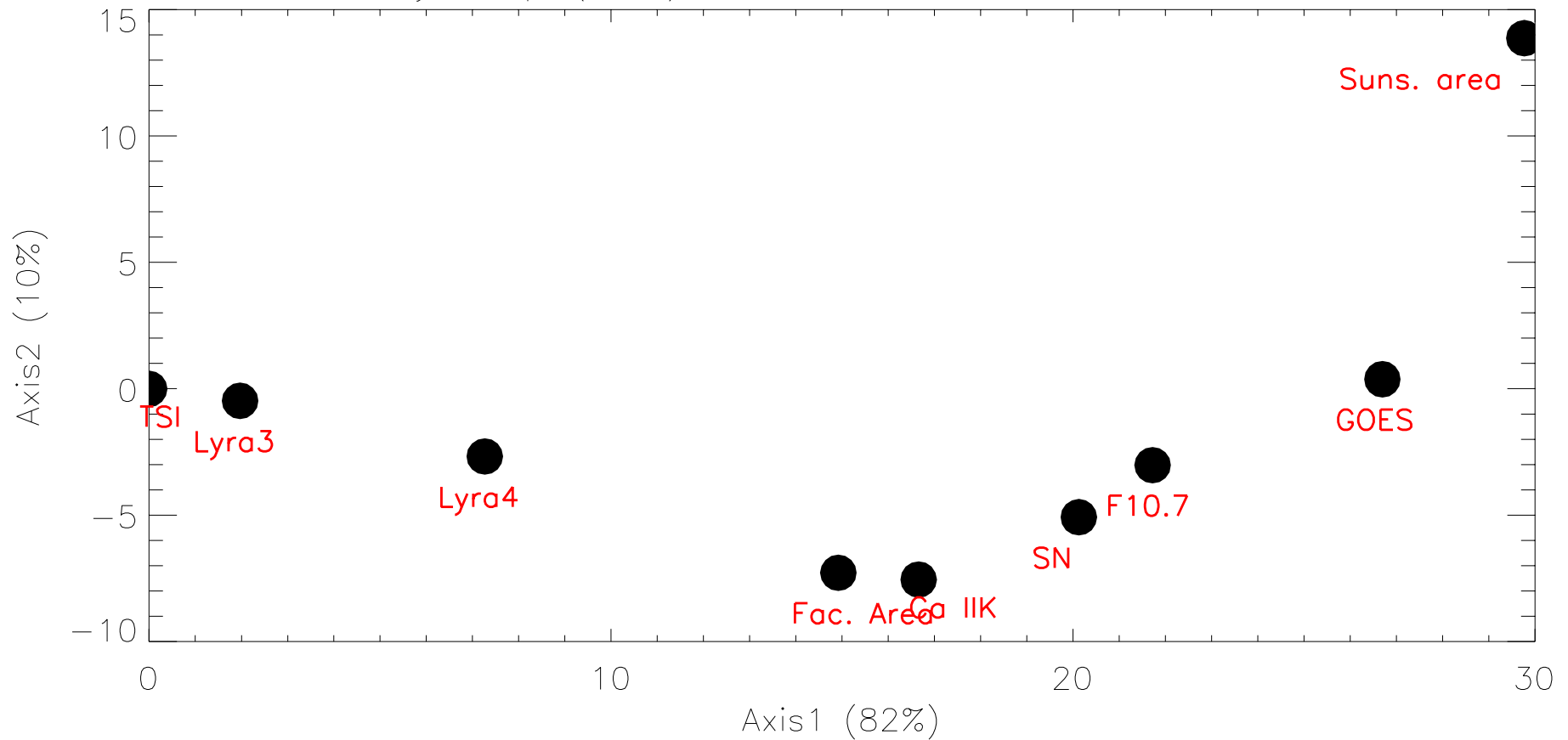
Cross correlation Lyra4 vs. ISSN



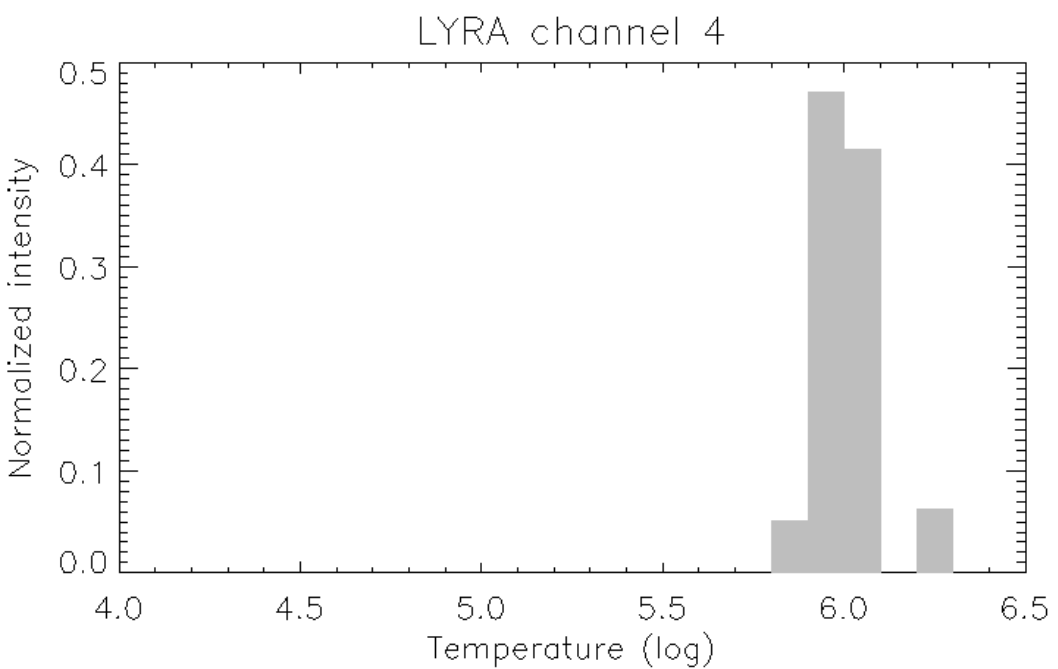
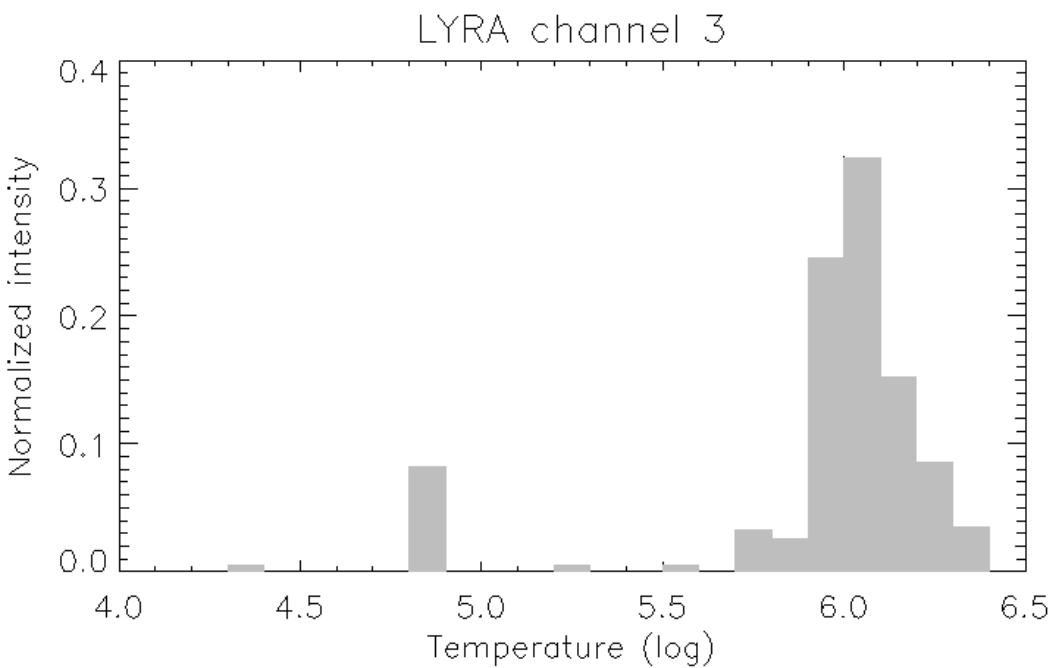


Similarity map

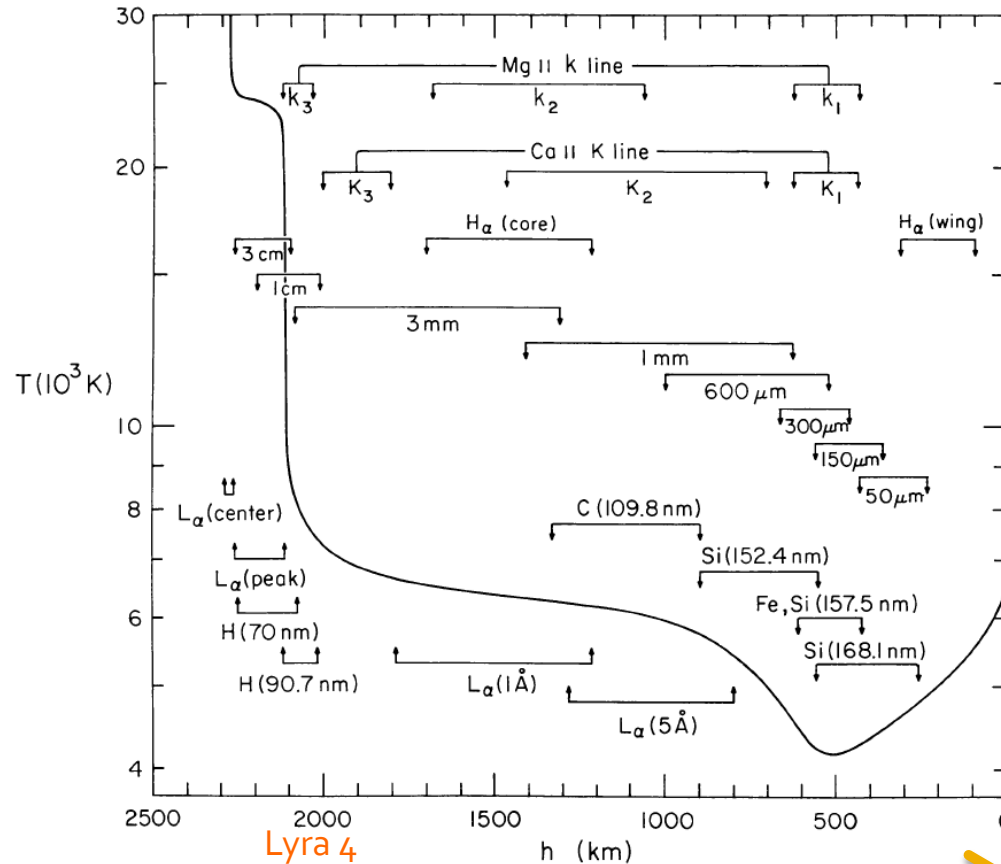
Similarity map (SVD) Period:2010-01-06_2013-03-05



Theoretical temperature components of Lyra channels 3 and 4



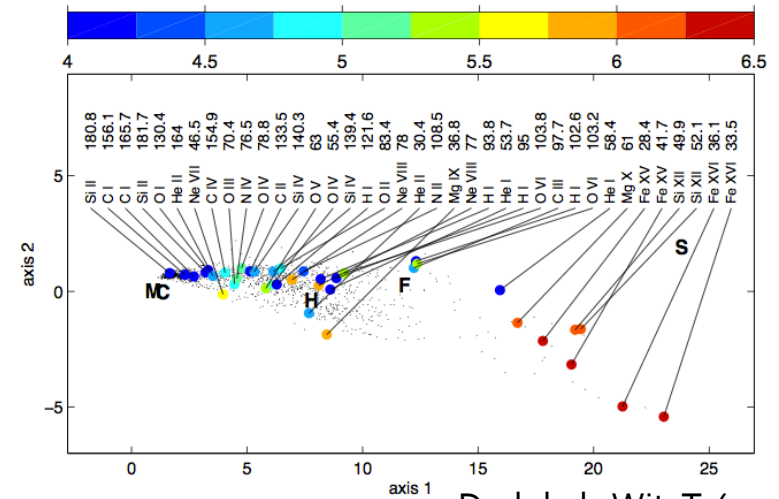
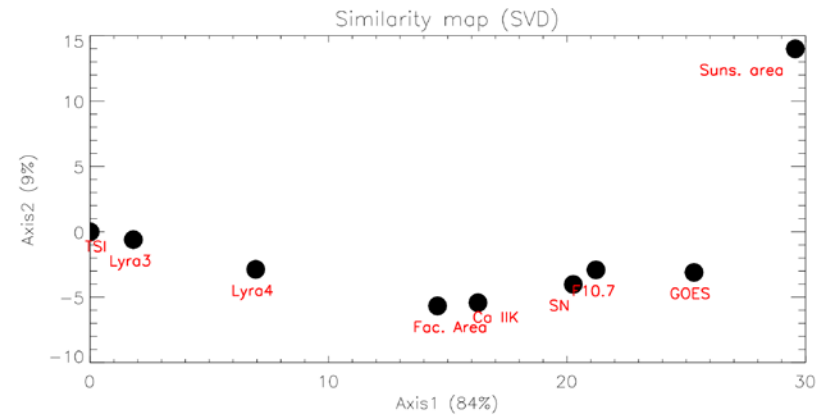
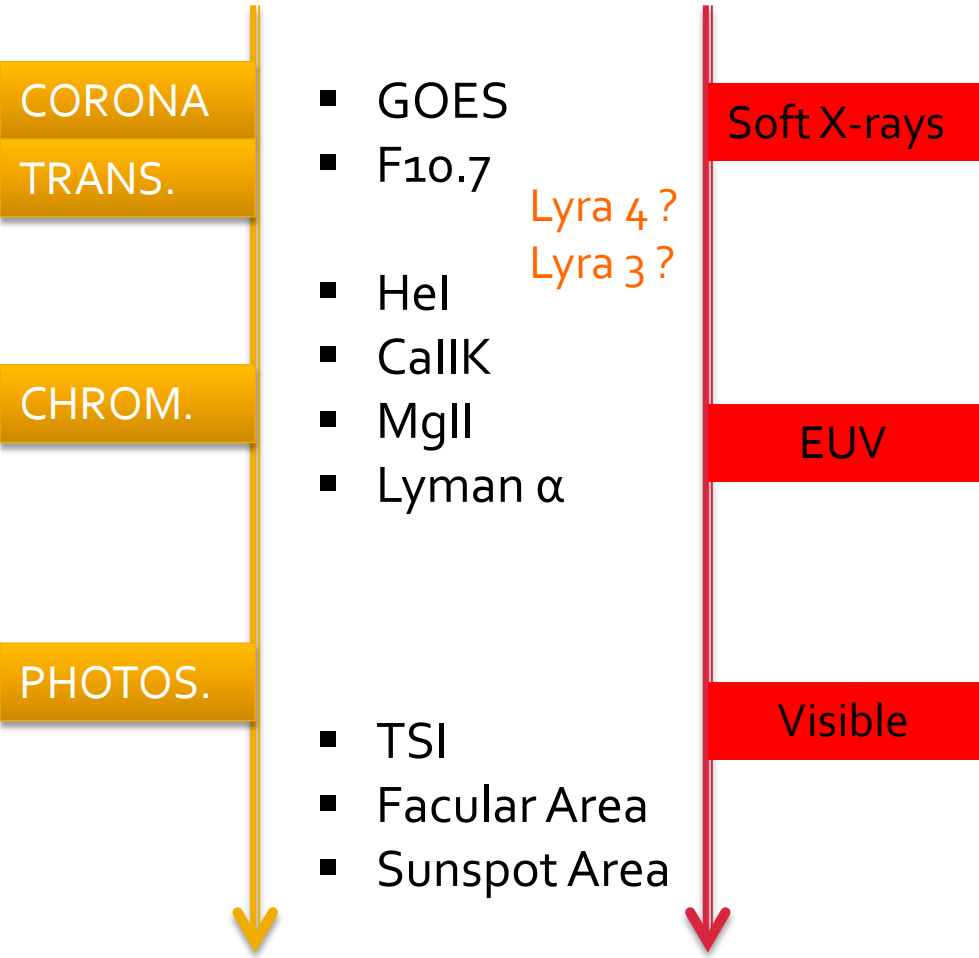
WHERE DOES WHAT COME FROM ?



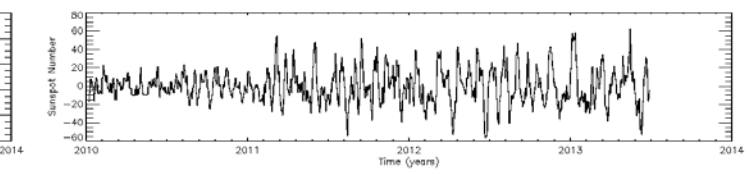
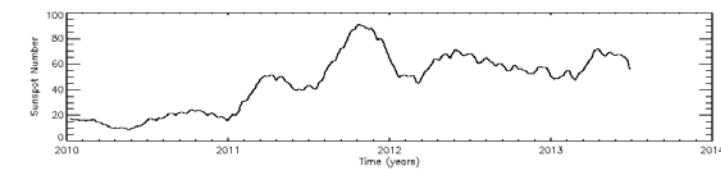
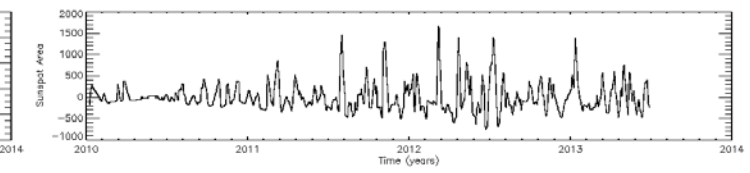
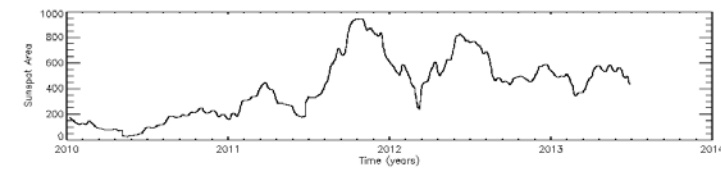
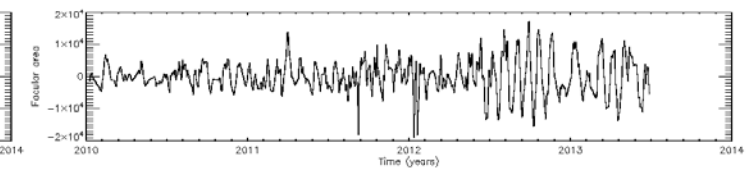
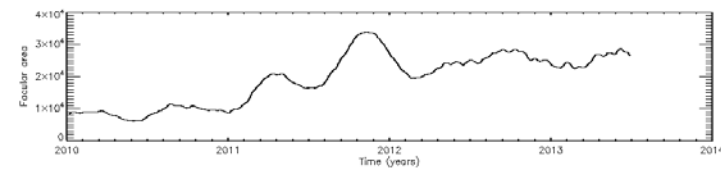
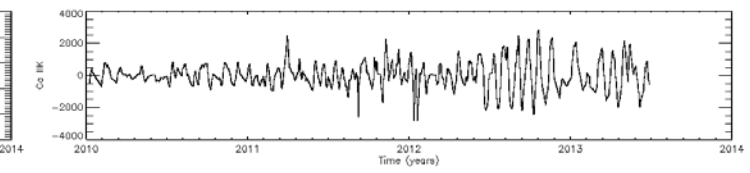
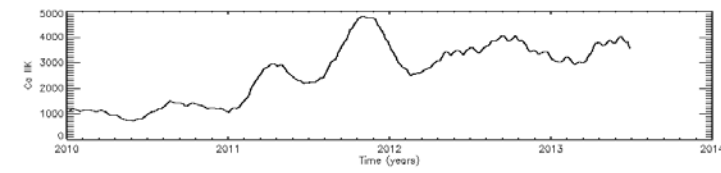
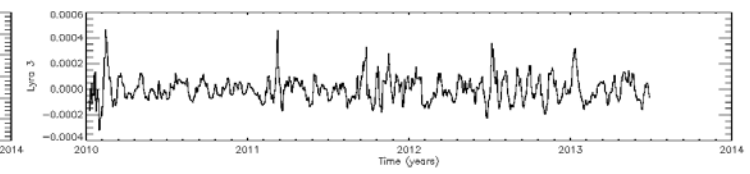
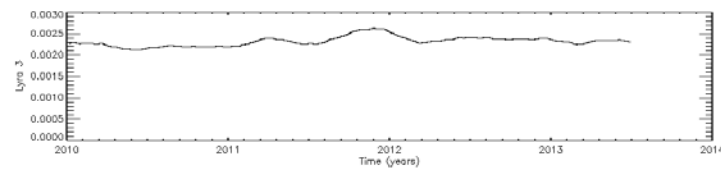
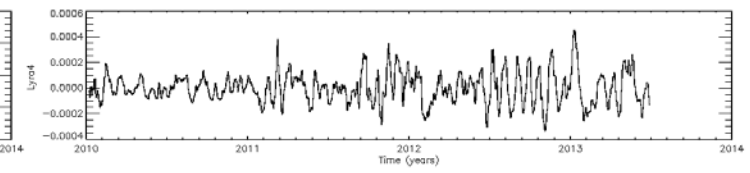
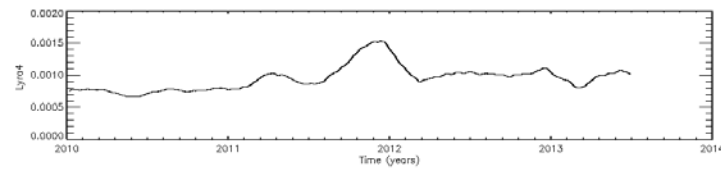
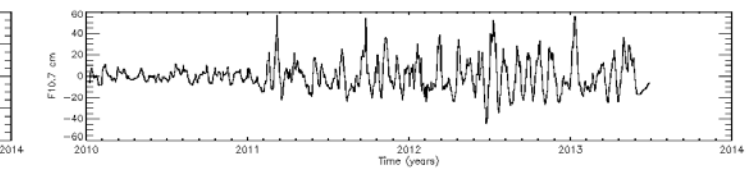
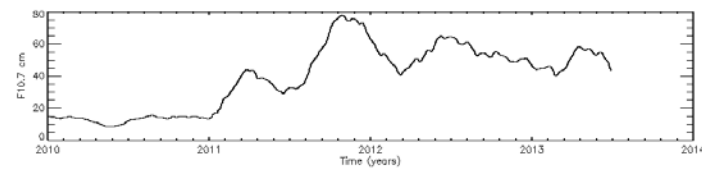
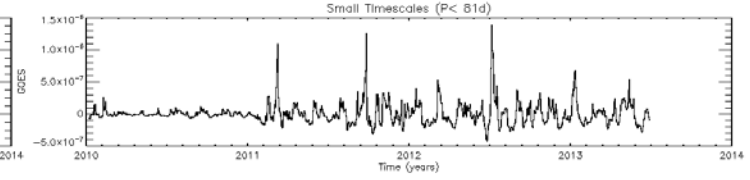
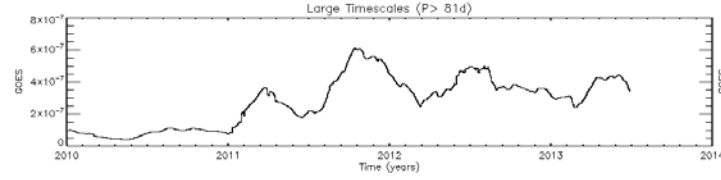
Lyra 4
CORONA Lyra 3 CHROMOSPHERE → PHOTOSPHERE

Vernazza et al., 1981

Now what does this mean ?

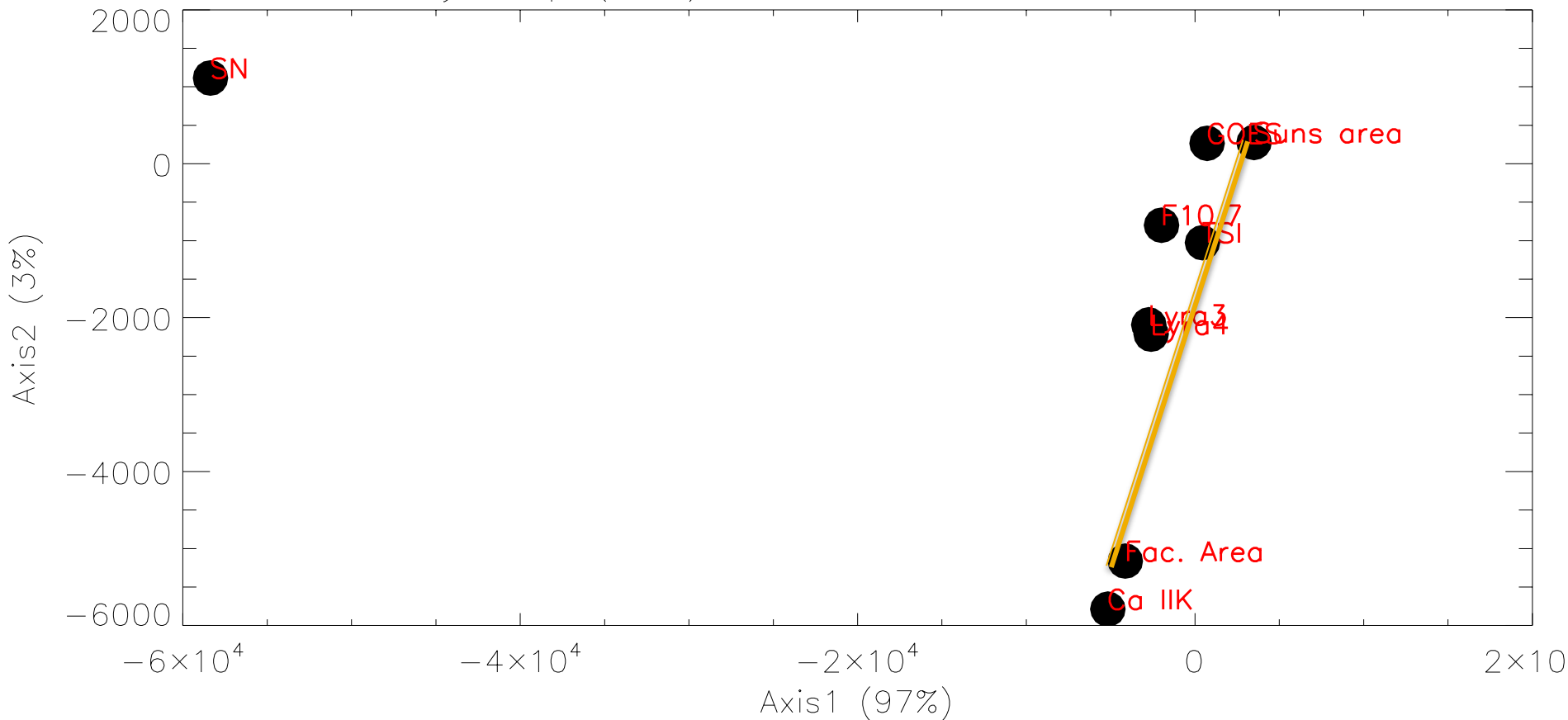


Dudok de Wit, T. (2007)



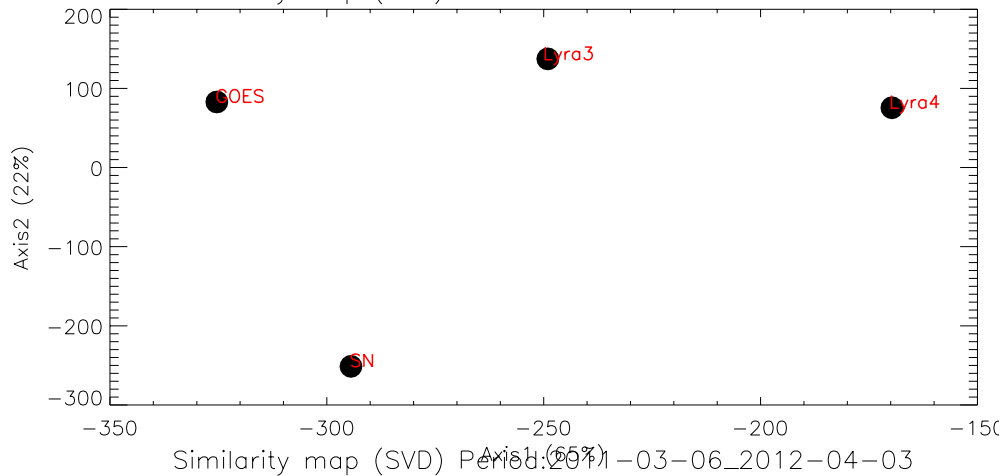
Shorter timescales (< 81 days)

Similarity map (SVD) Period:2010-01-06_2013-03-05

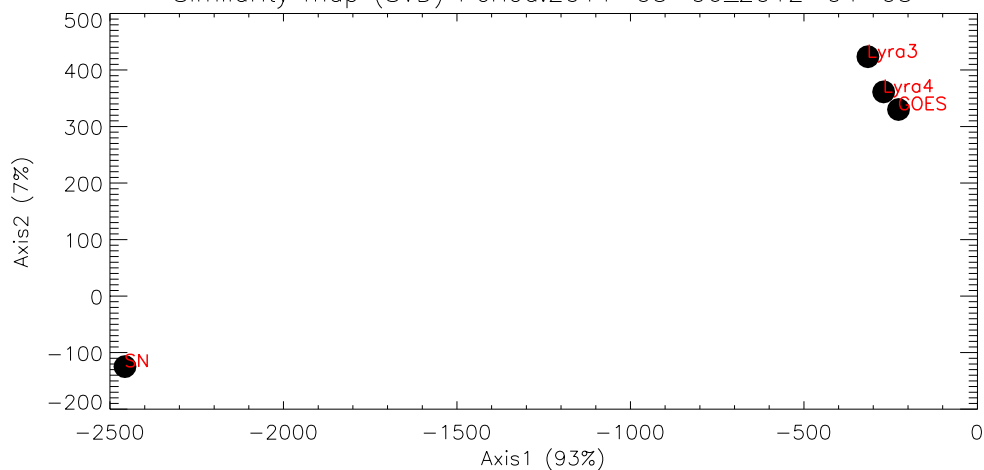


2010

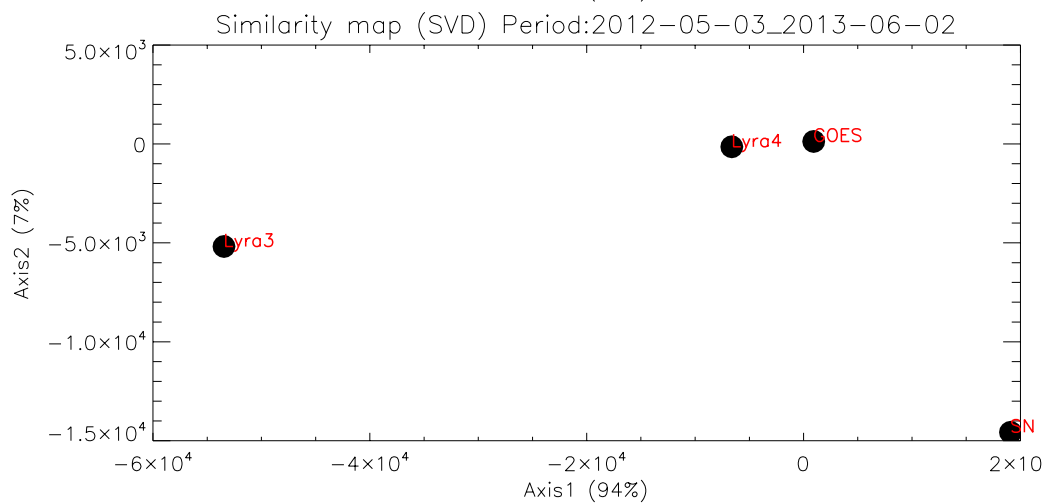
TIME



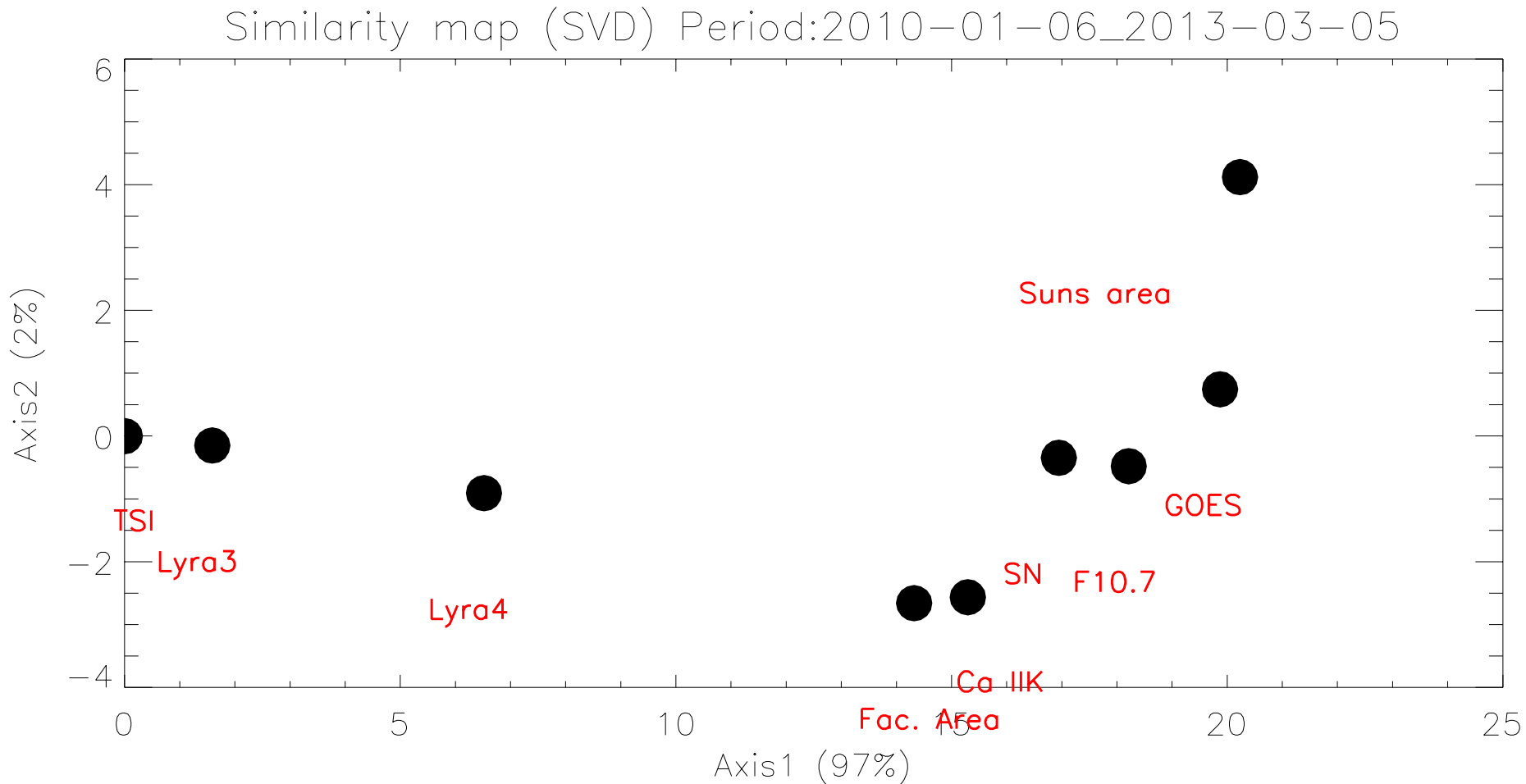
2011



2012-
2013



Longer timescales (> 81 days)

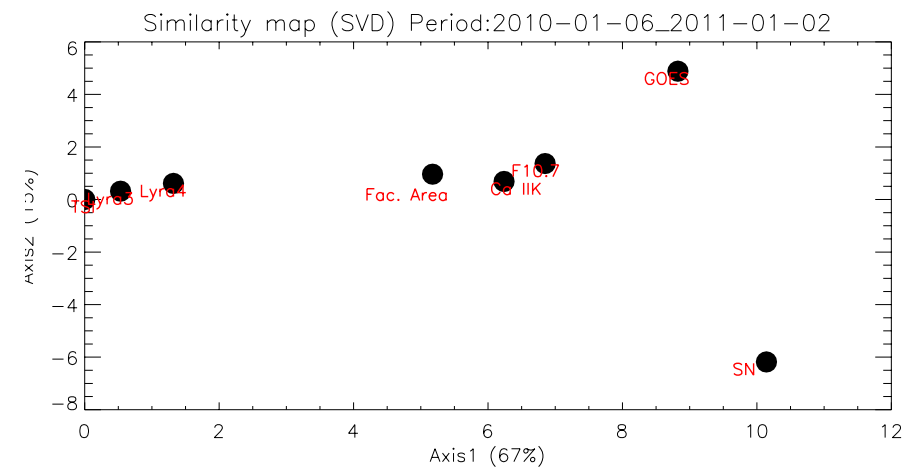


Now what about the long-term evolution of the instrument?

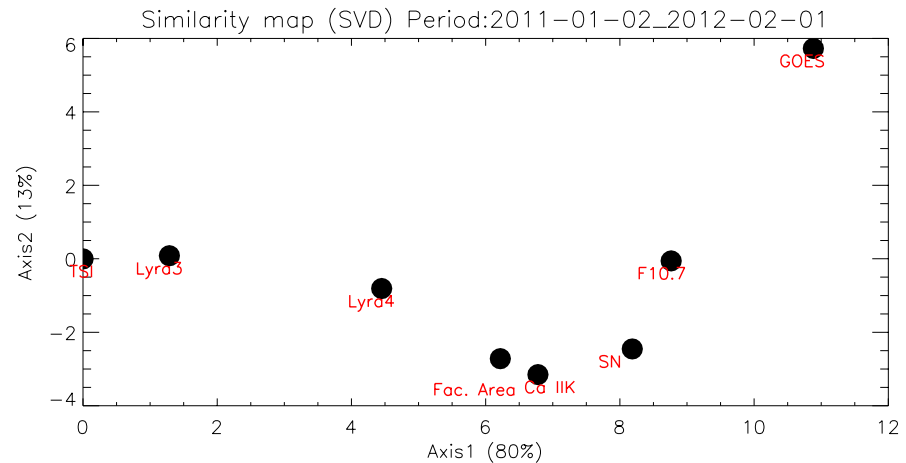
TIME



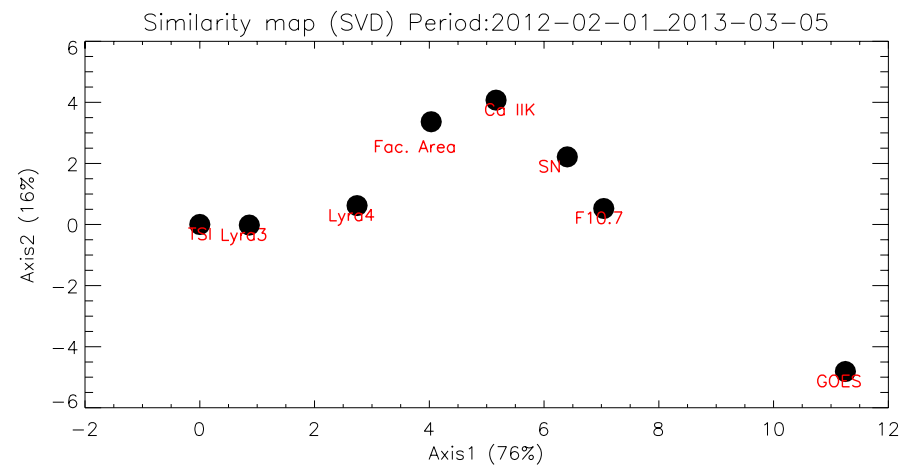
2010



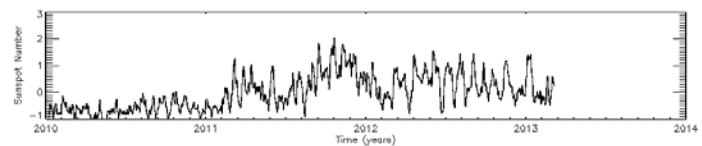
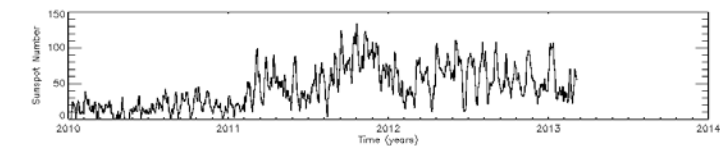
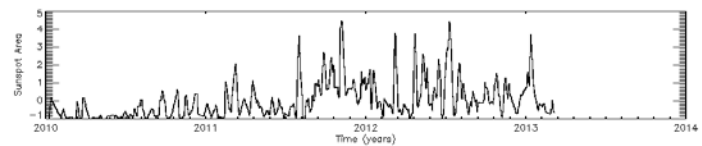
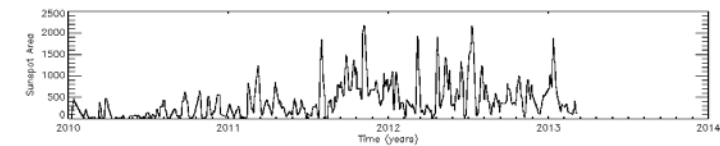
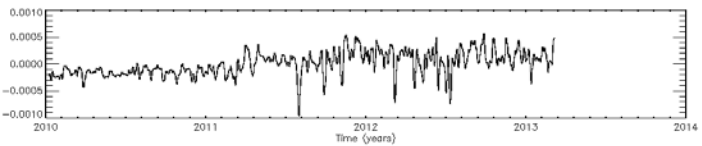
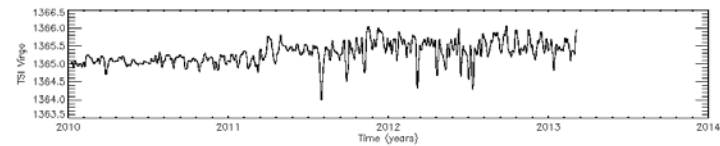
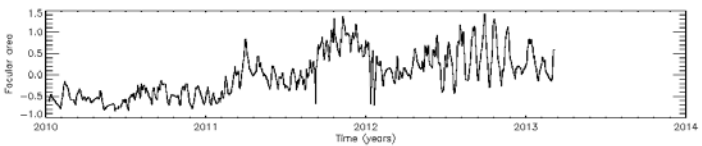
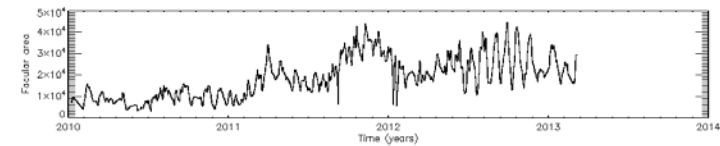
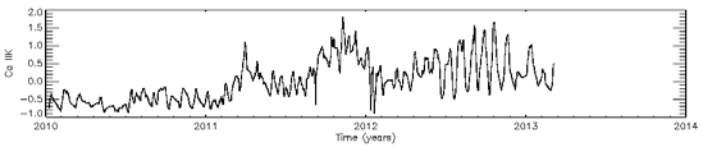
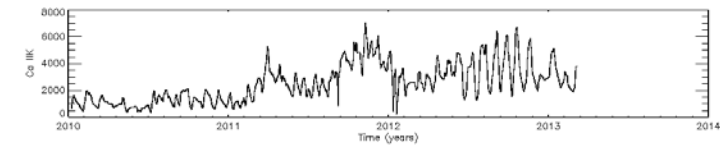
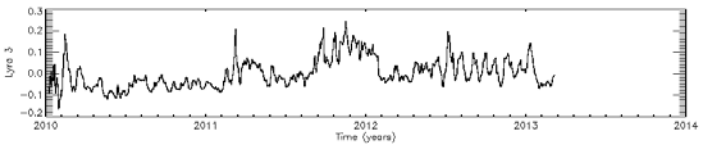
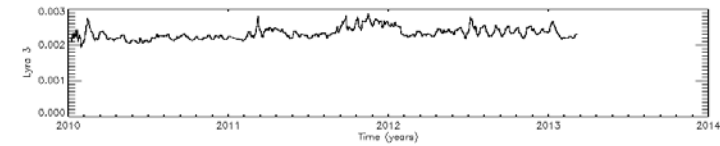
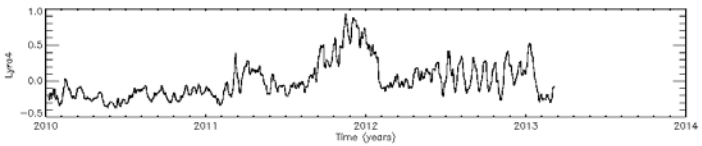
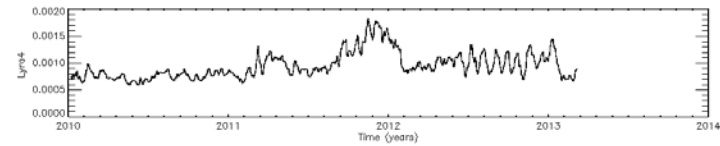
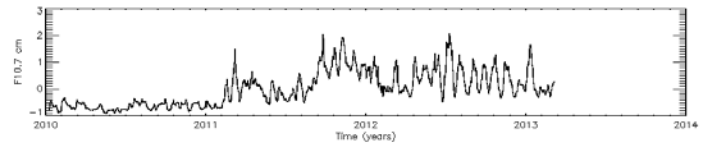
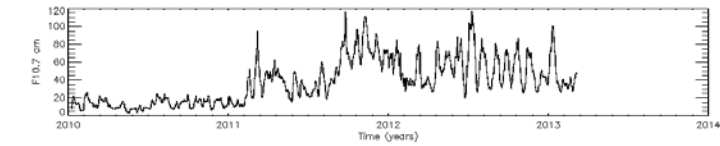
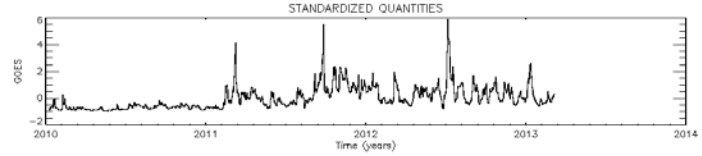
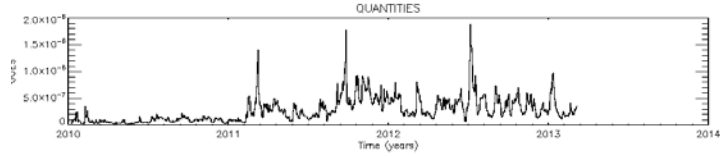
2011



2012-
2013

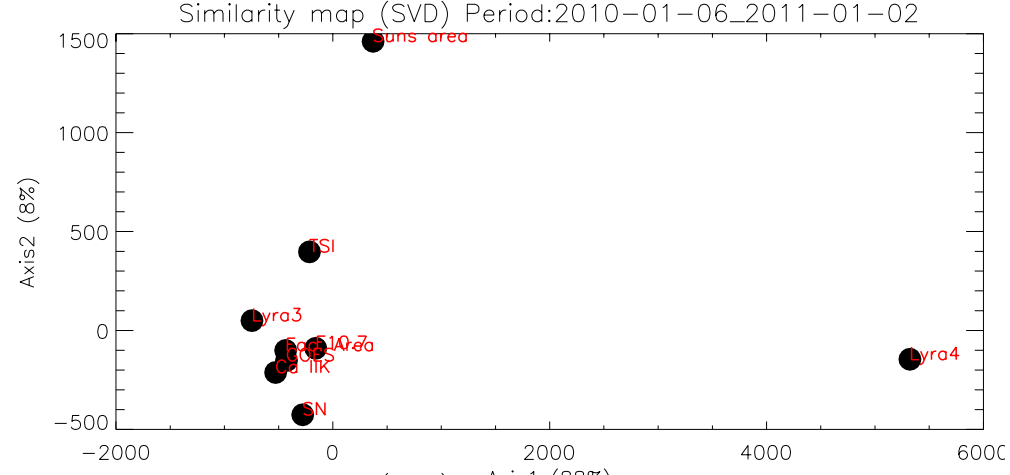


THE BEGINNING

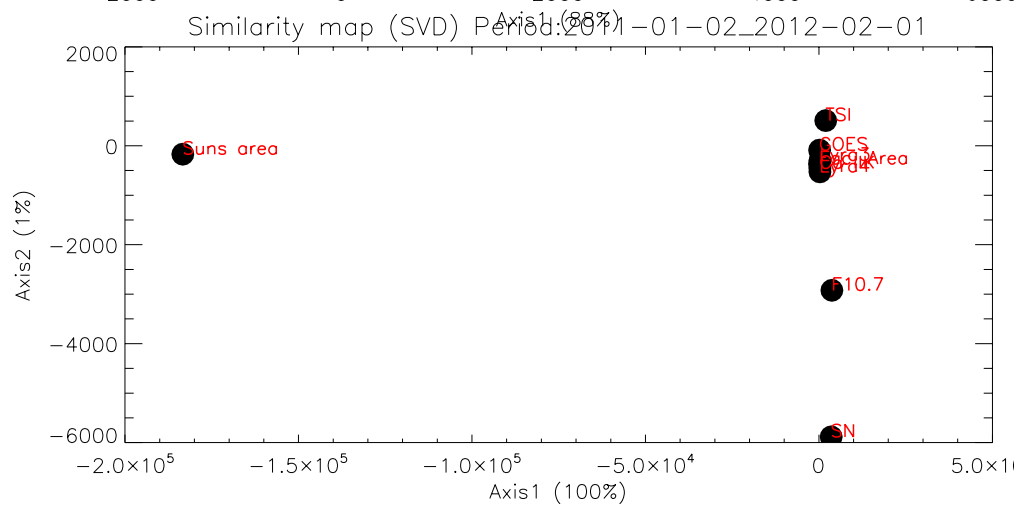


2010

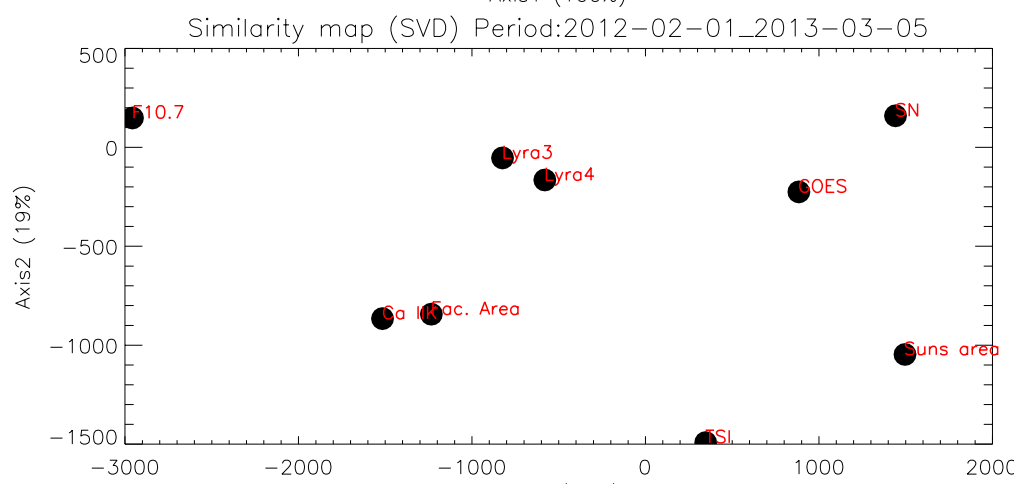
TIME



2011

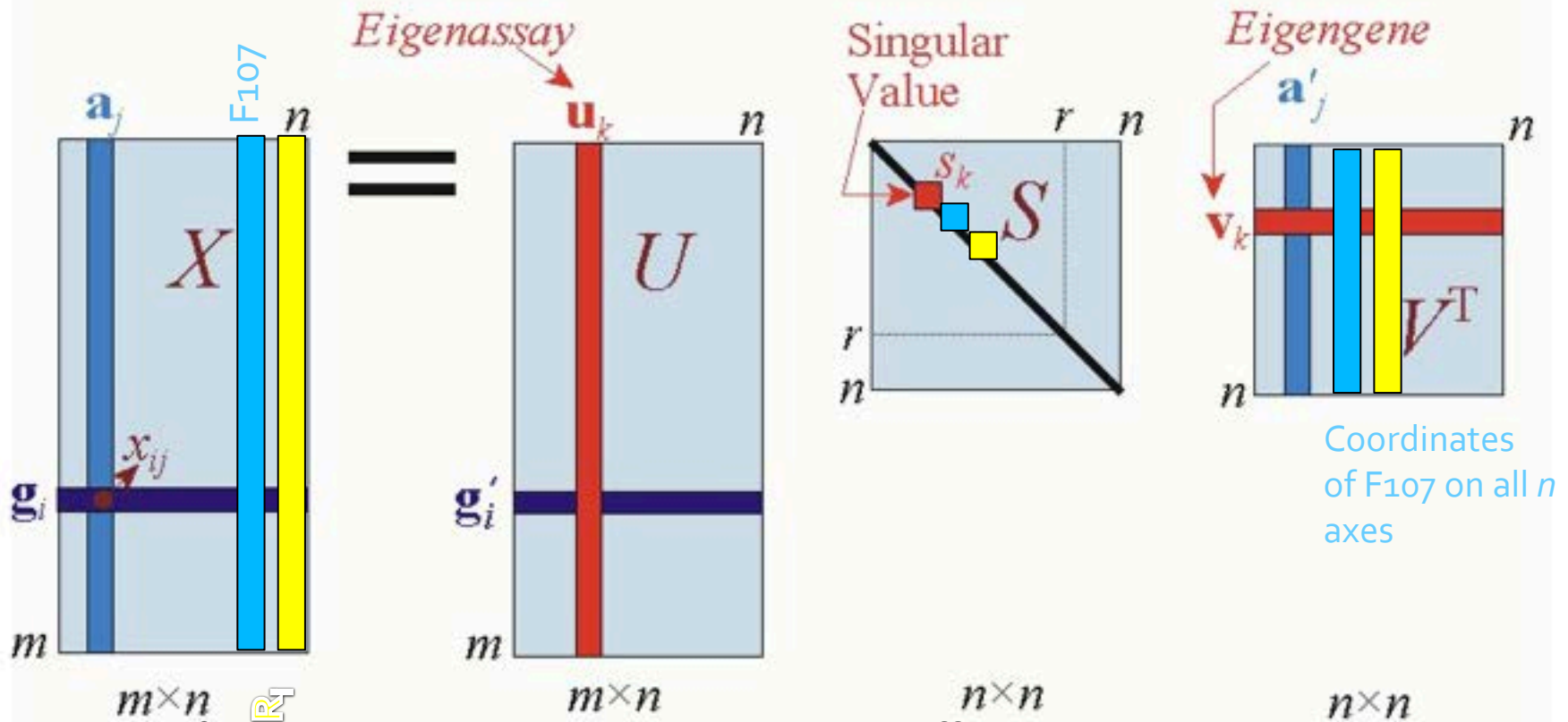


2012-
2013



Singular Value Decomposition : How does it work ?

$$X = USV^T$$



n : number of variables
 m : time length

gives n different axes
 S gives the amount of variance