

# **SOLSPEC DATA ANALYSIS**

Presentation prepared by:

J-M. Perrin, OHP

W. Schmutz, PMODWRC

A. Shapiro, MPG

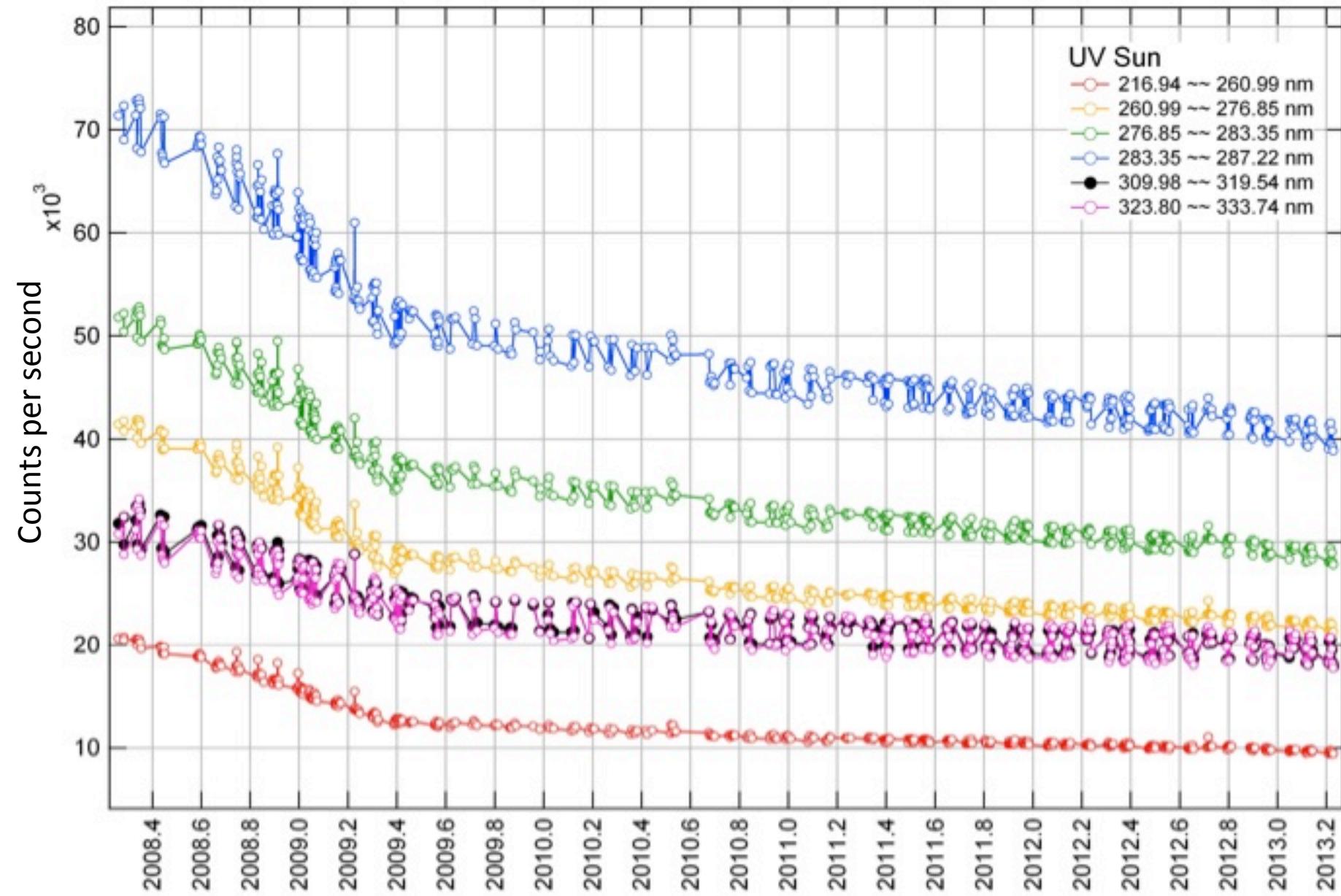
T. Sukhodolov, PMODWRC

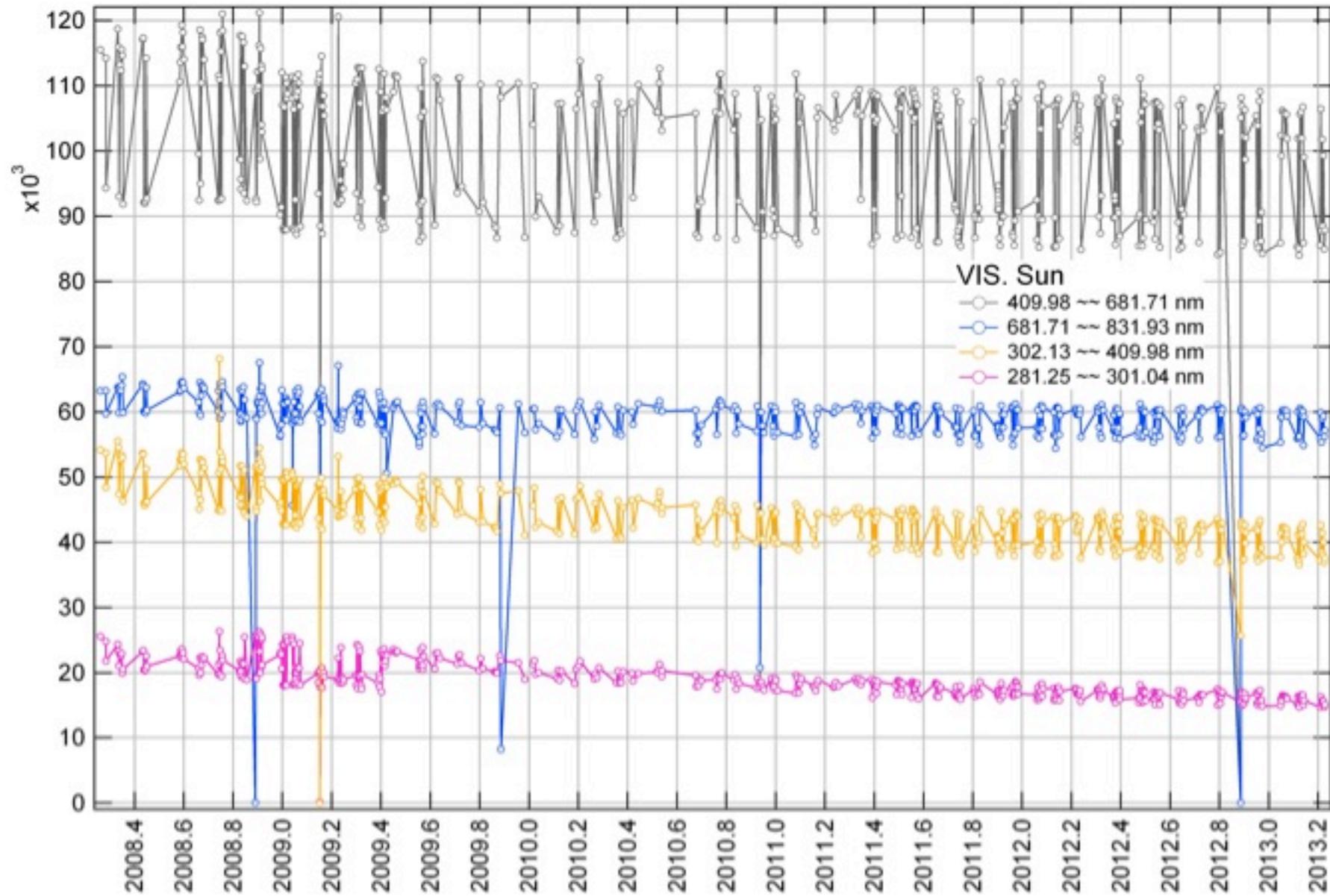
G. Thuillier, LATMOS

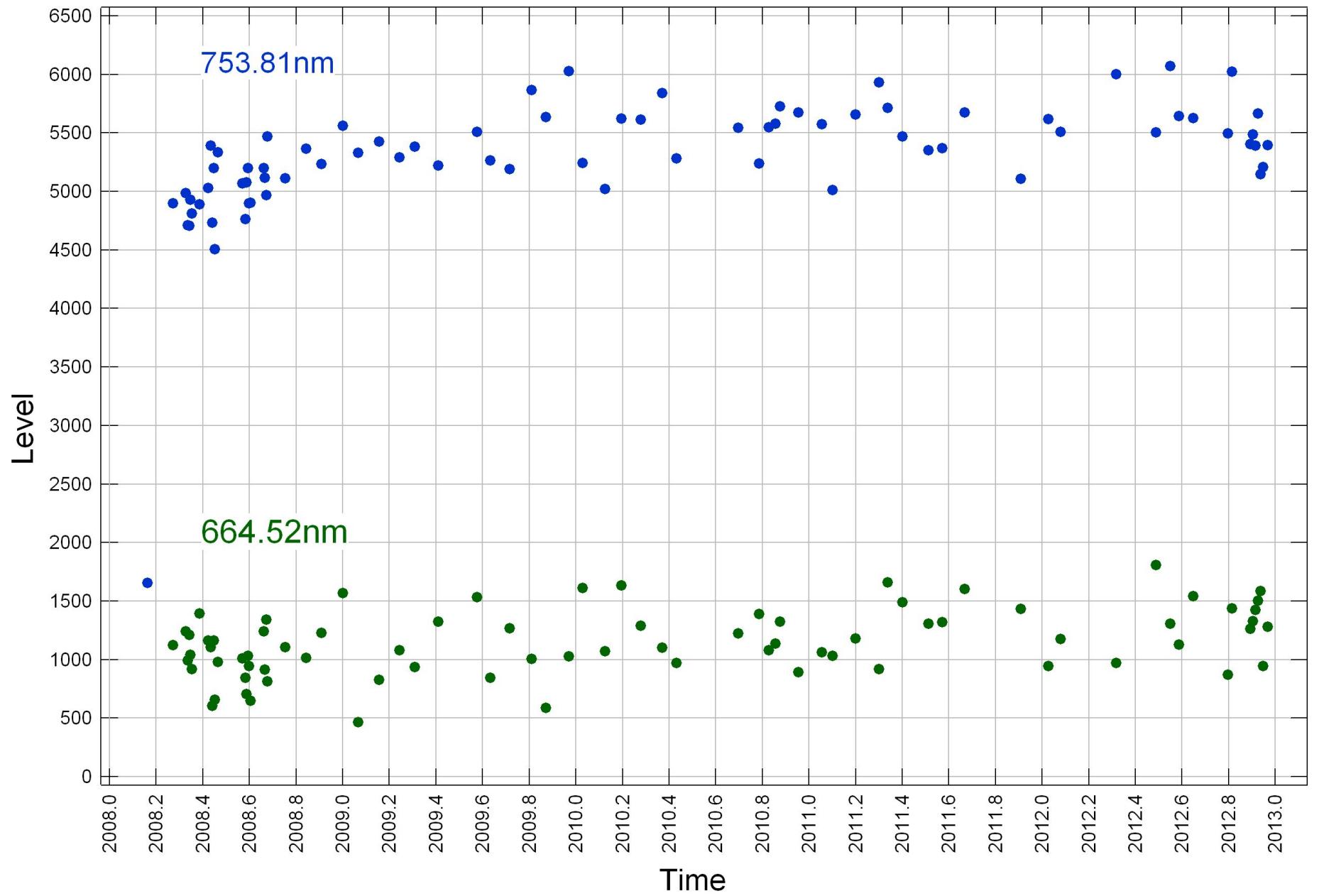
# OUTLINE

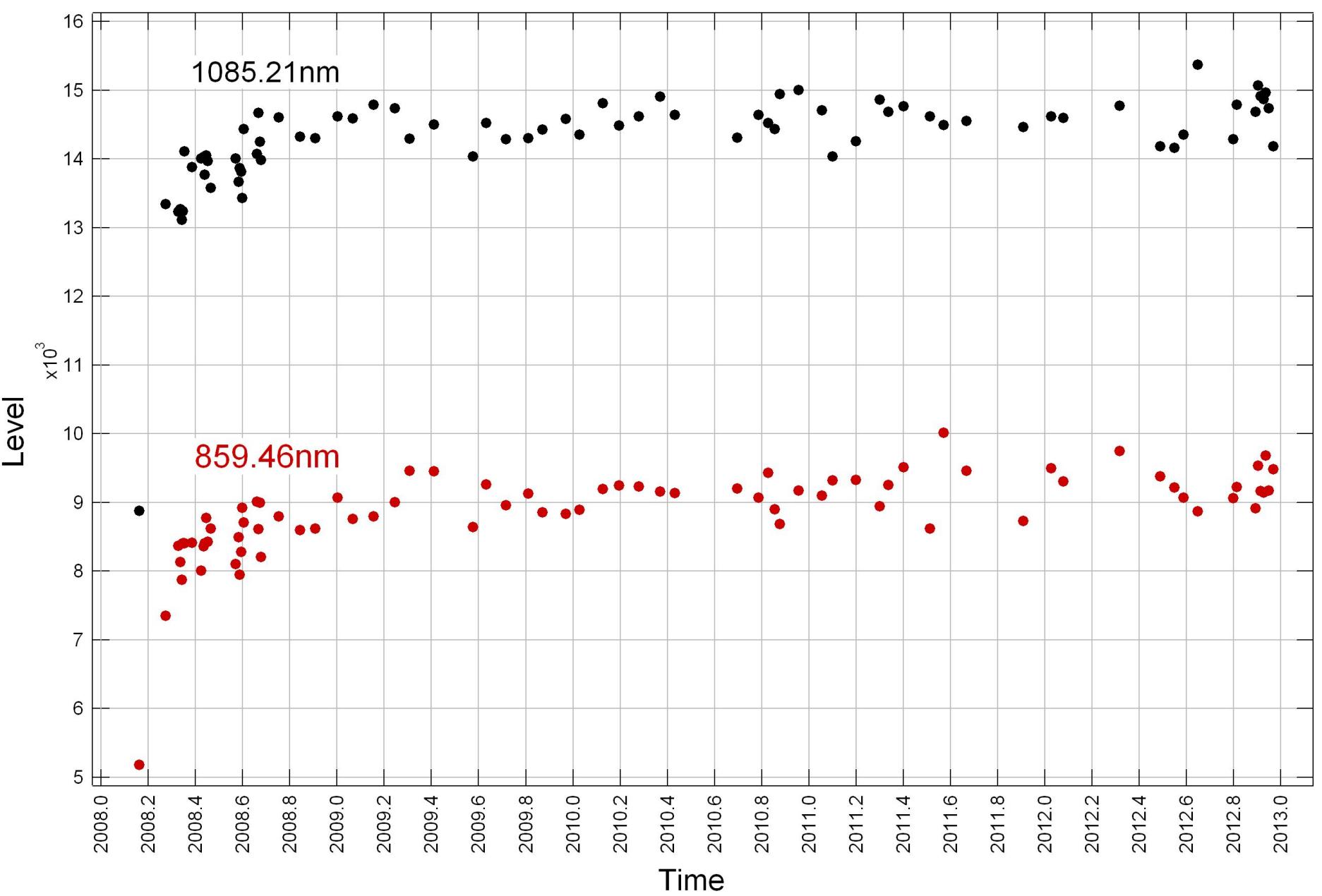
- UNSTABILITIES
- AGING
- 20 MARCH 2015 ECLIPSE DATA
- AGING CORRECTION
- TIME SERIES

# **UNSTABILITIES**

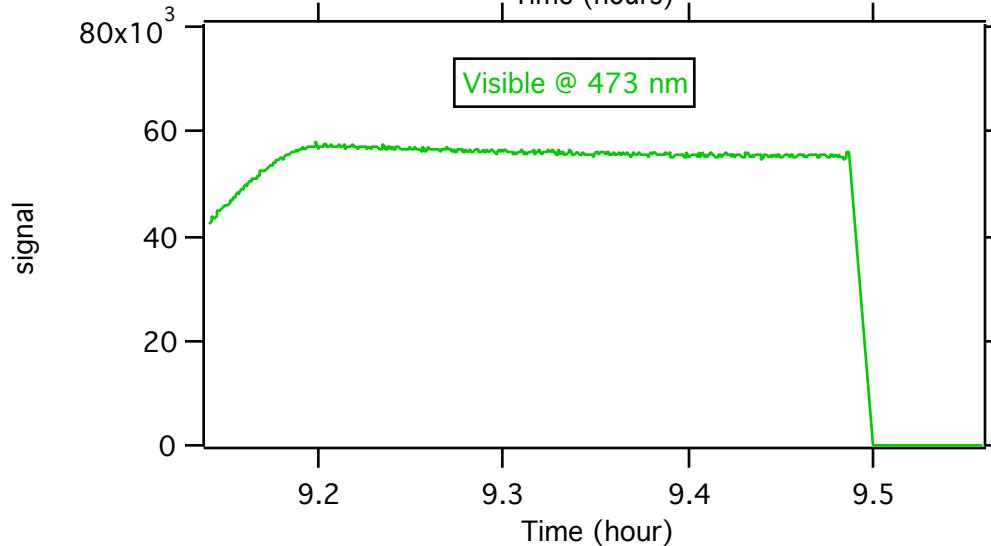
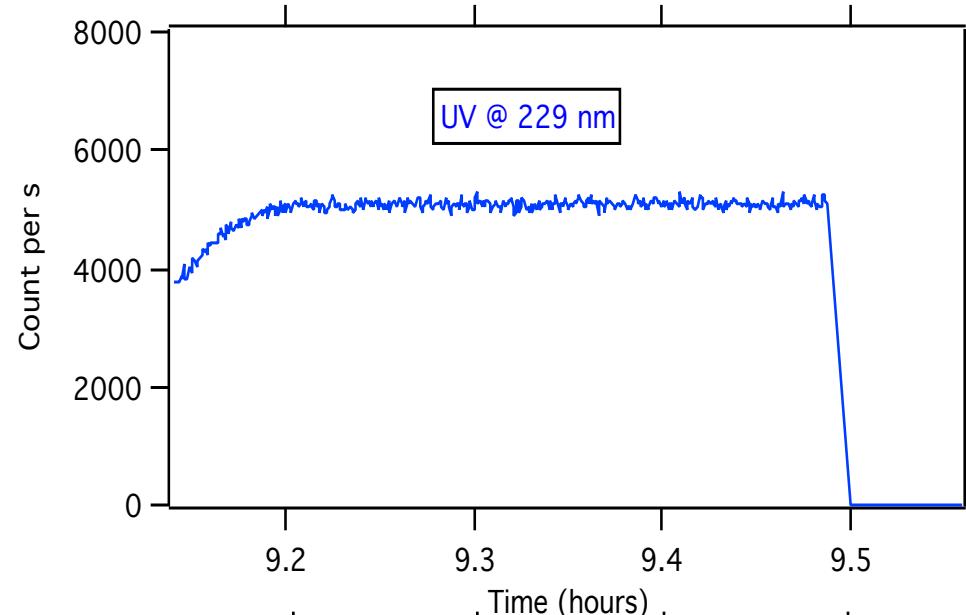


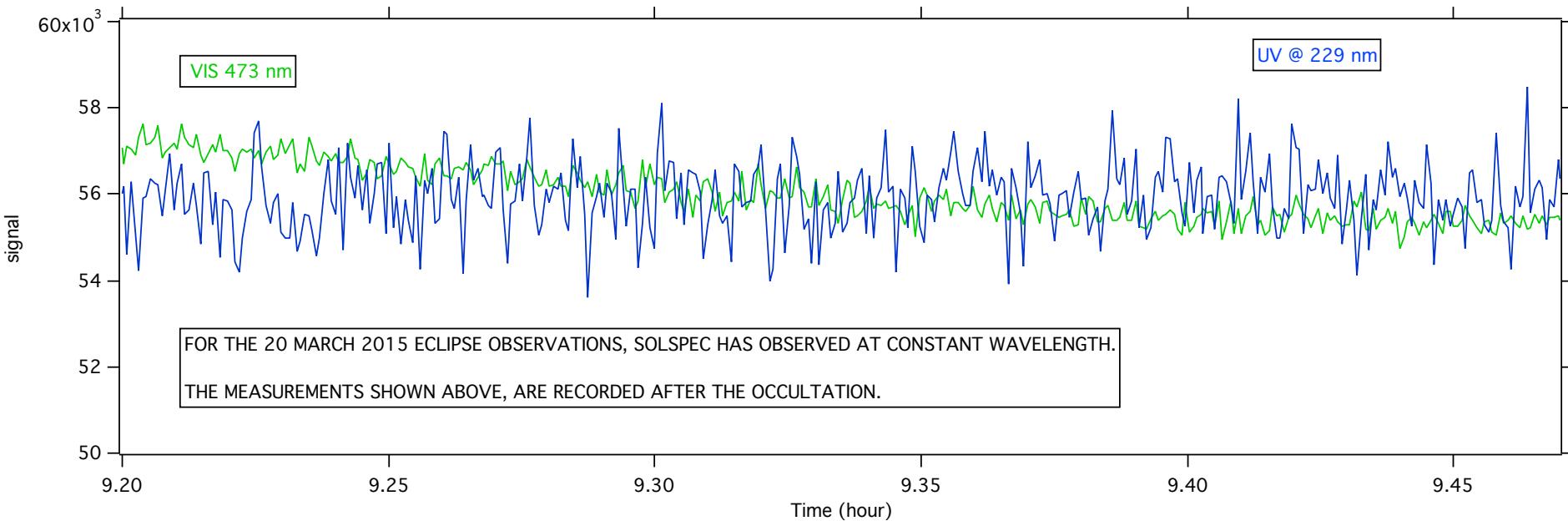






# 20 MARCH 2015 ECLIPSE DATA





### Notes:

- The UV and visible channels are simultaneously sampled.
- quasi no trend with time in UV, and a linear decrease in visible.
- UV and visible detector are photomultipliers
- IR detector is PbS cell with synchronous detection
- Nber of points = 360

UV , using raw data

| Measured Mean | Measured Variance | Derived RMS from Mean | Calculated RMS from Measured Variance |
|---------------|-------------------|-----------------------|---------------------------------------|
| 5084.2        | 5204.3            | 71.3                  | 72.2                                  |

After making a (minor) trend correction: no significant change in results

=> The noise process is gaussian.

Visible, using raw data

| Measured Mean | Measured Variance | Derived RMS from mean | Calculated RMS from measured variance |
|---------------|-------------------|-----------------------|---------------------------------------|
| 56037.41      | 397869.6          | 236.72                | 630.76                                |

Visible, using corrected data from trend

| Measured Mean | Measured Variance | Derived RMS from mean | Calculated RMS from measured variance |
|---------------|-------------------|-----------------------|---------------------------------------|
| 56037.66      | 55555.30          | 236.7                 | 235.7                                 |

=> The noise process is gaussian

IR

| Measured Mean | Measured Variance | Derived RMS from mean | Calculated RMS from measured variance |
|---------------|-------------------|-----------------------|---------------------------------------|
| 3325.7        | 67.6              | 57.7                  | 8.22                                  |

The noise is very small, but likely not gaussian due to the way of detection

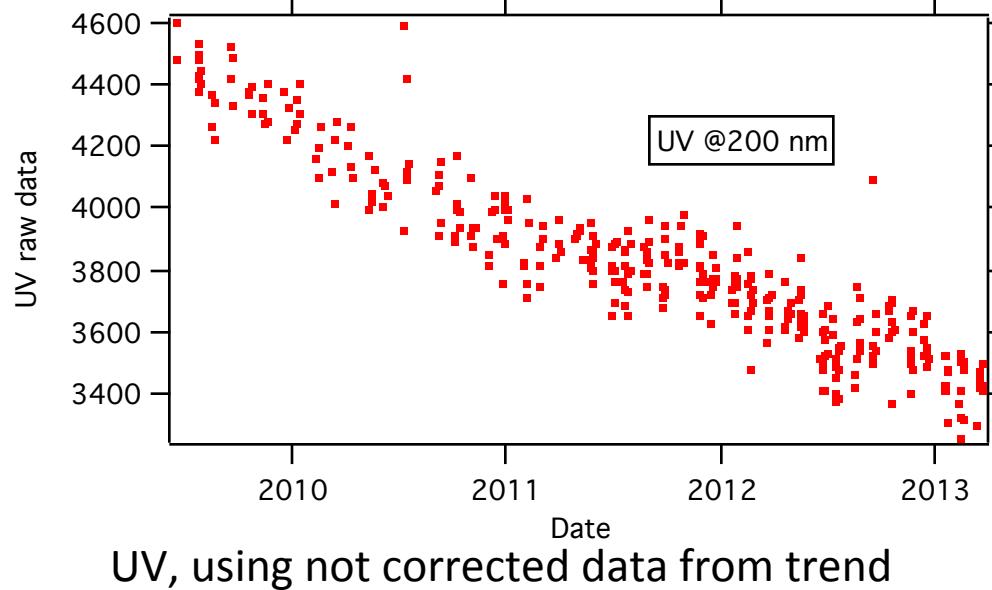
# UV CHANNEL BEHAVIOUR FROM MEASURED SPECTRA

We note: Eclipse data used here are obtained with an instrument always **ON**.

To study the behaviour of the UV channel, the irradiance at a chosen wavelength is extracted from spectra obtained on a more or less daily operation, with an **OFF** instrument between two consecutive spectra.

The period, which is analysed uses the same number of points as in the eclipse data.

The wavelength is chosen to provide the same signal level as in the eclipse data.



| Measured Mean | Measured Variance | Derived RMS from Mean | Calculated RMS from Measured Variance |
|---------------|-------------------|-----------------------|---------------------------------------|
| 3810.4        | 74920.2           | 273.7                 | 61.7                                  |

UV, using corrected data from trend

| Measured Mean | Measured Variance | Derived RMS from Mean | Calculated RMS from Measured Variance |
|---------------|-------------------|-----------------------|---------------------------------------|
| 3810.4        | 5383.1            | 61.7                  | 73.4                                  |

=> The noise process is not gaussian

## PROPERTIES:

- When there is no on/off in the analysed time series, no instability appears,
- When an off is separating two consecutive measurements, instabilities appear.

## QUESTIONS:

- What is the origin of the instabilities? Likely the TM format processing
- How they were taken into account in the L1 processing?

## ACTION:

It is necessary to justify the way of correcting this effect. Otherwise, a systematic bias will be generated. Consequently, analysis of the phenomenon needs a specific data.

For that, special measurements at constant wavelength using internal lamps/Sun, and providing different levels of signal. This operation can be run when the ISS does not allow solar viewing. During solar viewing, solar data at fixed wavelength may be also obtained.

If the **on/off effect** is confirmed, SOLSPEC should stay in stand-by (e. g. always on) between two consecutive operations. Analysis of the results will allow to define the best strategy.

# **AGING CORRECTION**

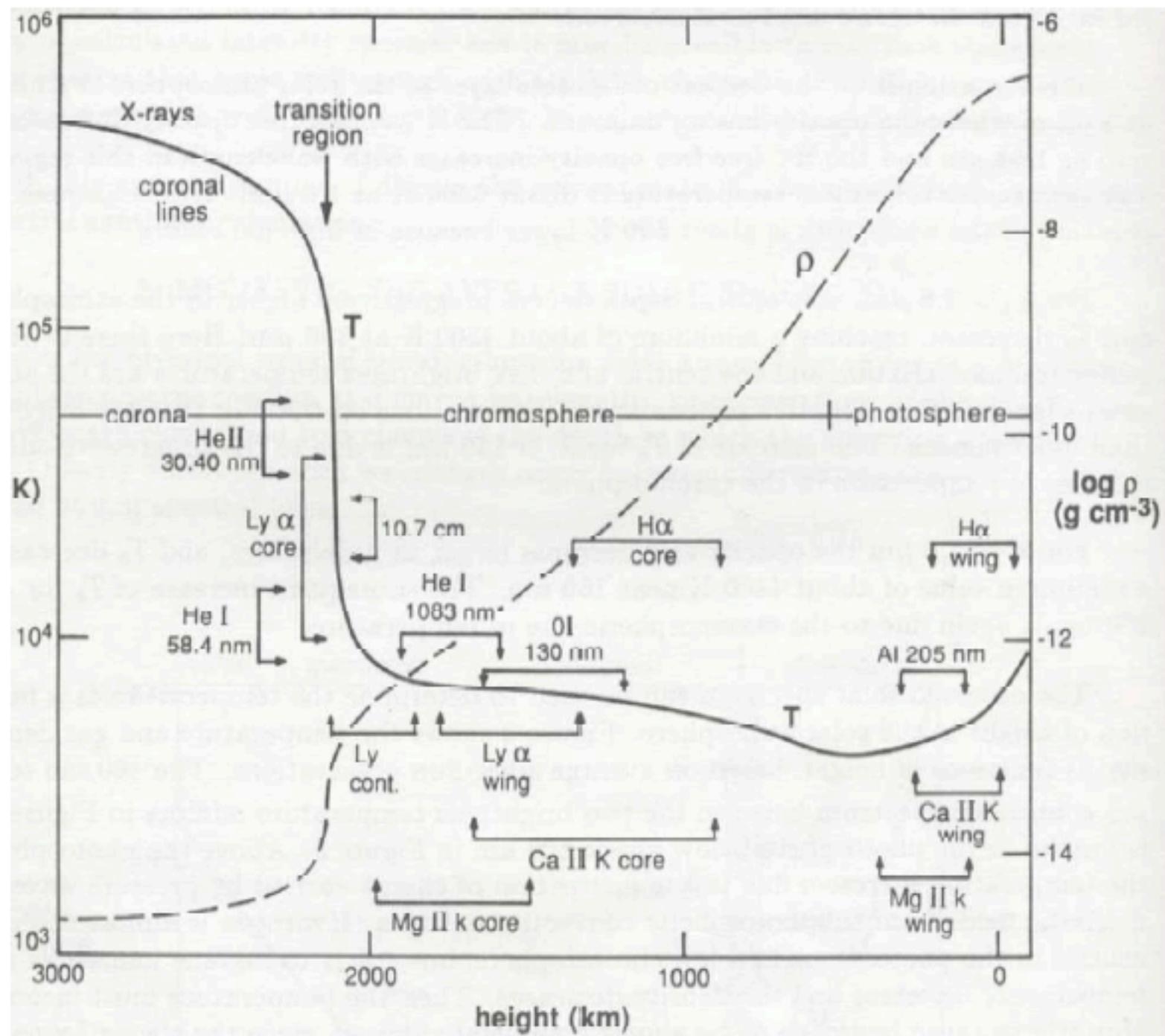
# DATA AGING CORRECTION BY MODELING

Proposed proxies:

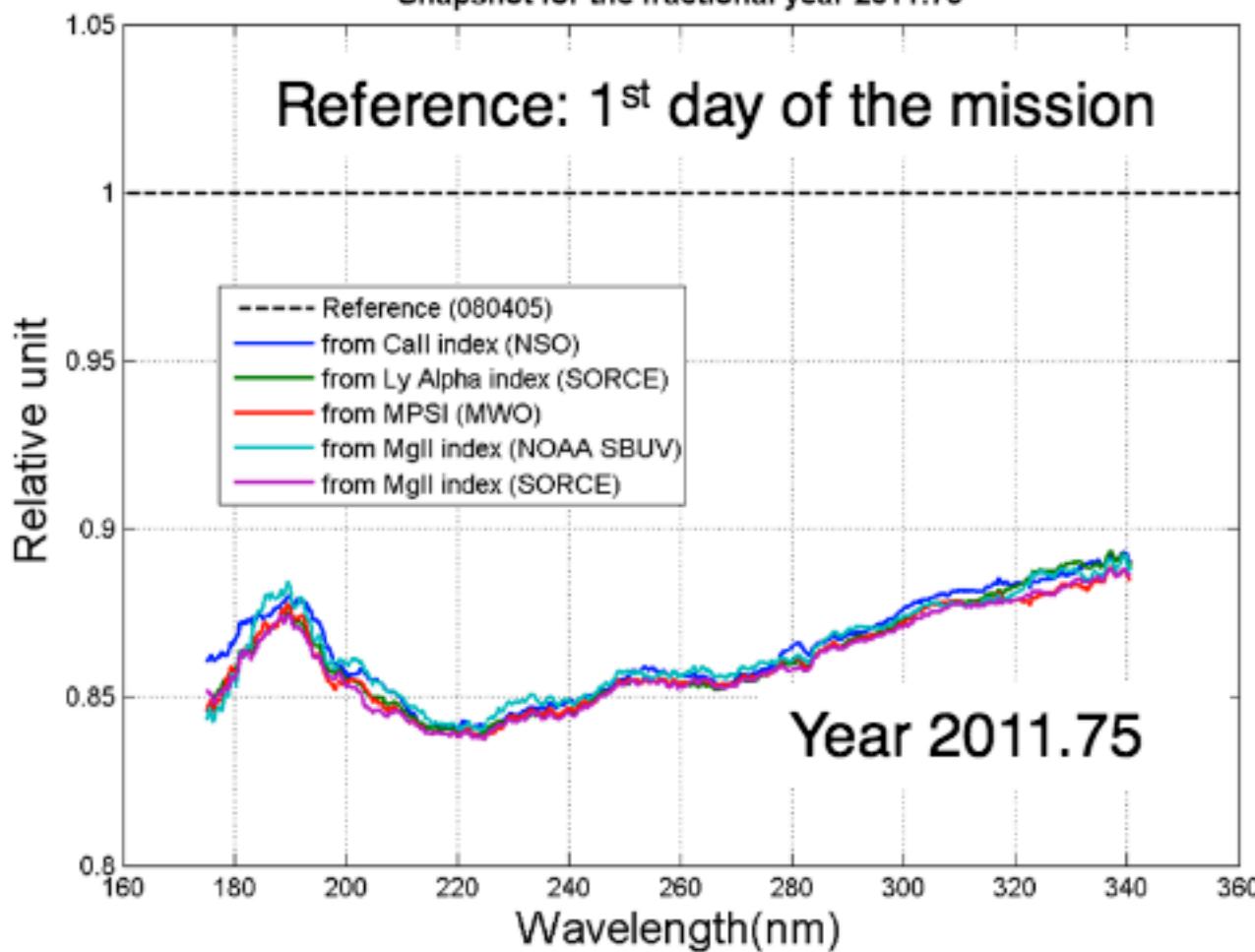
- Mg II index (data from the NOAA SBUV and the SORCE/SOLSTICE experiments),
  - Ca II index (data from the National Solar Observatory, Sacramento Peak)
  - Ly  $\alpha$  index (data from SORCE/SOLSTICE, SDO/EVE and TIMED/SEE)
  - Magnetograms (Magnetic Plage Strength Index from the Mount Wilson Observatory)
- 
- It exists several SSI semi-empirical / empirical models: NRLSSI, SATIRE, .... very well documented and with scientific justification.
  - It exists several SSI theoretical models: COSI, SRPM, ...

It is unclear why the above set of proxies would be scientificaly better.

As a general consideration in data aging correction, HK data are used, special measurements, comparison with other data from similar measurements, ..... But a modeling-correction not using any data from the instrument to be corrected cannot be considered as a correction, but another model.

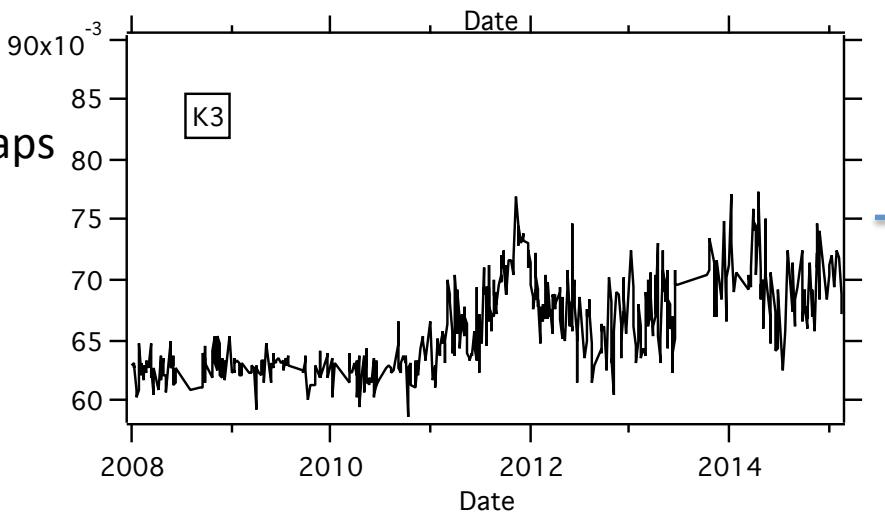
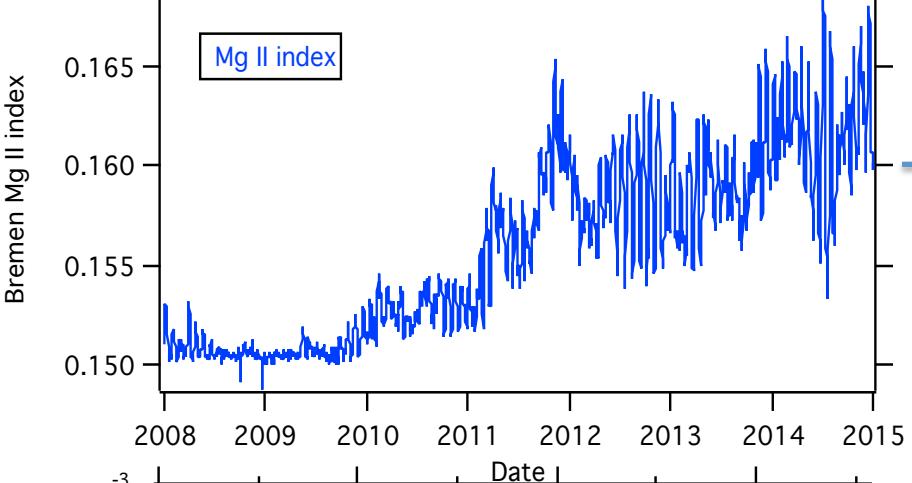
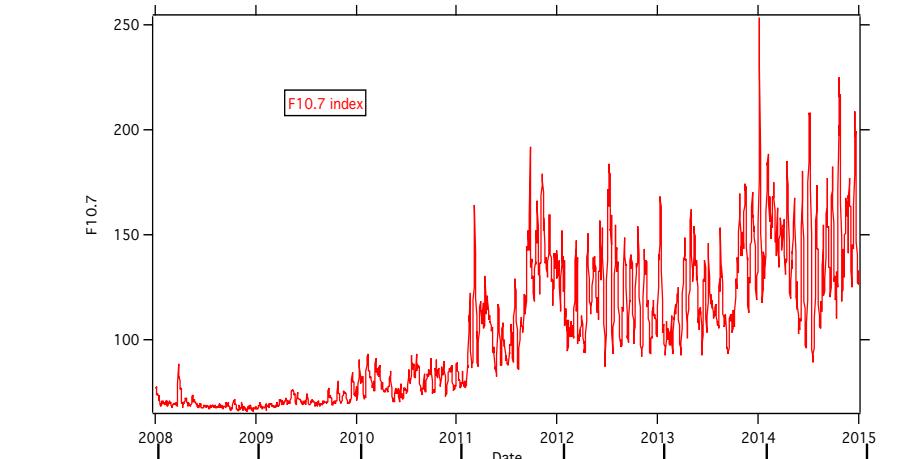


SOLAR/SOLSPEC - UV Channel - Responsivity change  
Results obtained from All Solar proxies  
Snapshot for the fractional year 2011.75



From D. Bolsée's presentation at the 5 June Estec meeting

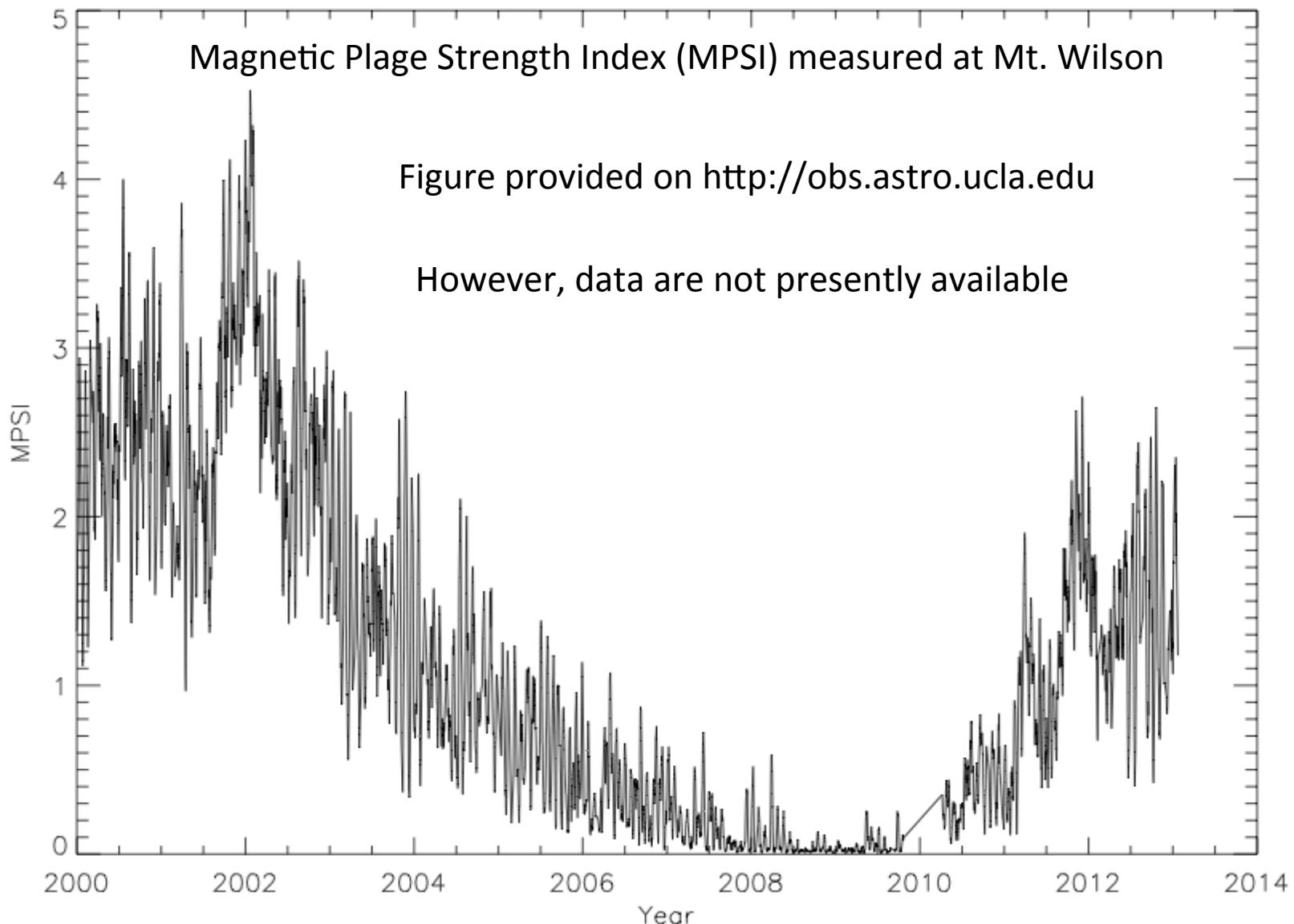
We note the absence of uncertainties bars. This figure as a function of wavelength gathers 3 years of data. It is known that solar proxies correlate when data from a large time interval are used. The next slides will show that with some details.



P = 0.93

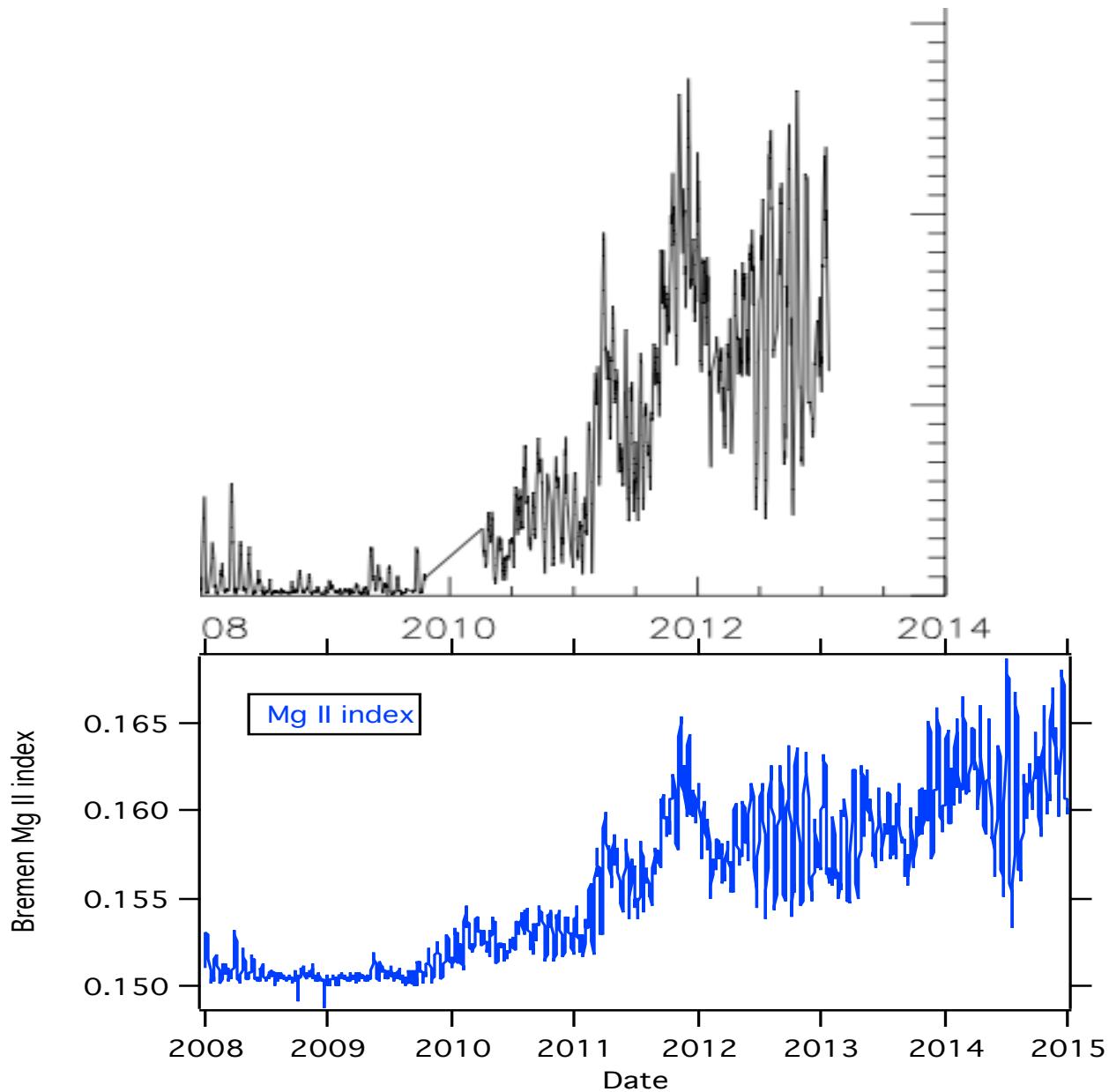
Note the Ca II data gaps  
and noise as these  
measurements are  
made from ground.  
<sup>K3</sup>

Magnetic Plage Strength Index (MPSI) since 2000 -- most recent data: 1/22/13

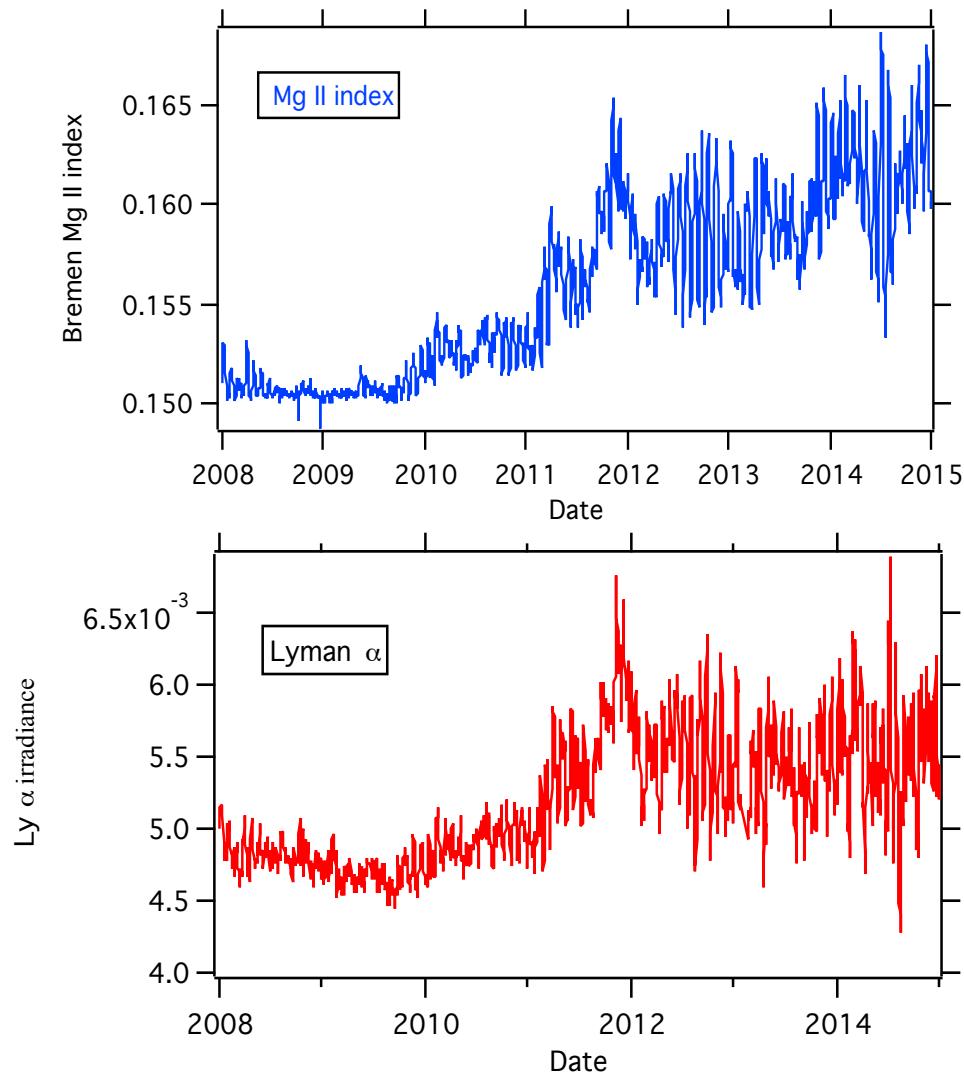


MPSI is obtained by calculating the mean of the absolute values of the magnetic field strengths for all pixels where the absolute value of the magnetic field strength is between 10 and 100 Gauss.

Consequently, the period 2008-2014 is extracted for comparison with Mg II



# Mg II versus Ly $\alpha$



Mg II and Ca II core lines are emitted at the same altitude, and both are in relation with UV

Ca II is redundant with respect to Mg II. Nevertheless, being measured from ground, there are interruptions and noise, likely from atmosphere origin.

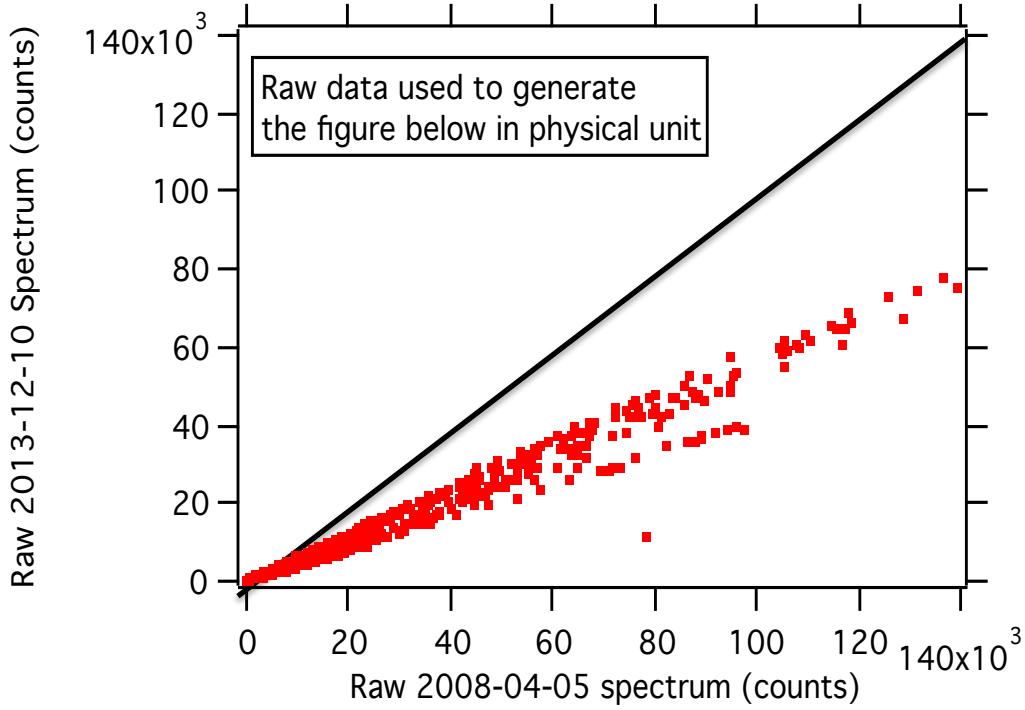
MPSI is correlated with Mg II.

Consequently, Mg II, Ca II, and MPSI are correlated. Ly  $\alpha$  is also correlated with Mg II , However, to a lesser extend.

As for Ly  $\alpha$  use, its use is irrelevant in UV modeling:

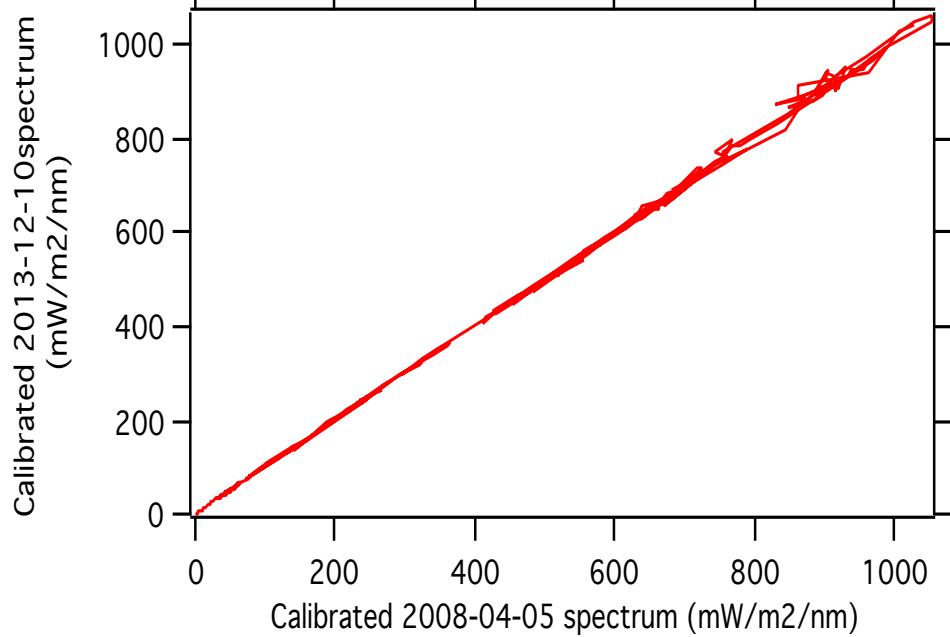
Ly  $\alpha$  is emitted in the transition region. The sunspots have a contribution to its irradiance.

However, in UV the sunspots have a very small role. Mg II and Ly  $\alpha$  show some similar variations, but differ in details. Likely, it introduces some noise.



## AGING CORRECTION

The black line is the bisector.



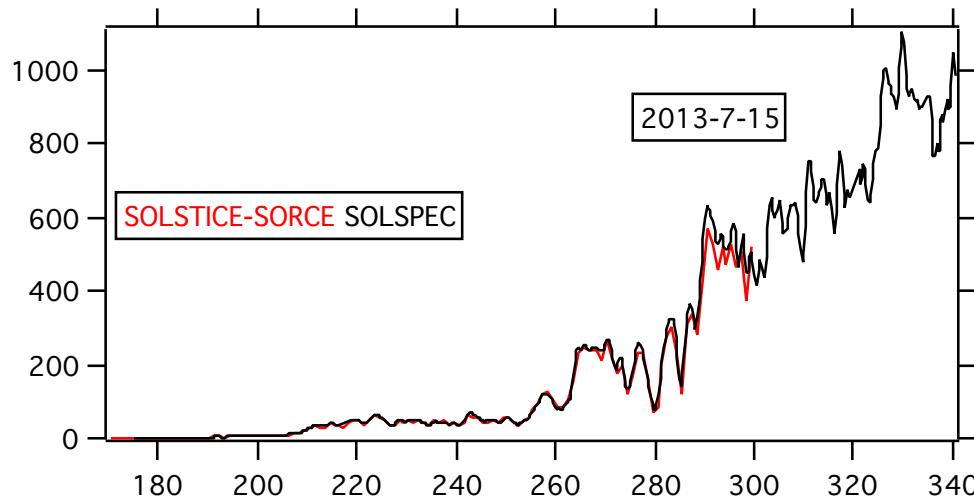
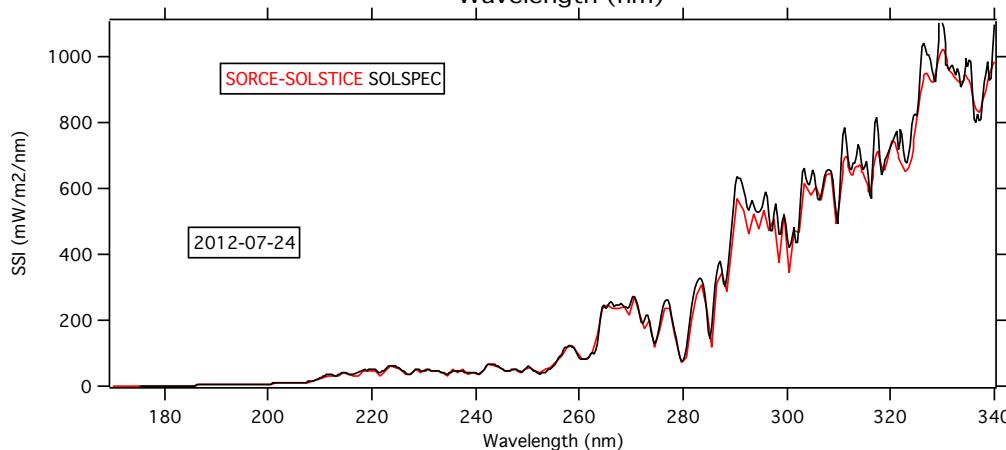
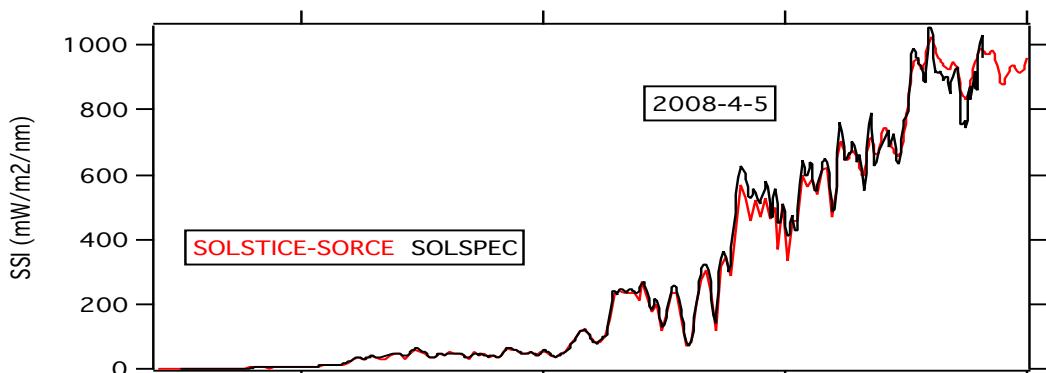
A linear fitting provided a slope corresponding to the bisector

# **TIME SERIES COMPARISON BETWEEN EXISTING SSI MODELS, SORCE DATA, AND SOLSPEC MODEL-CORRECTION**

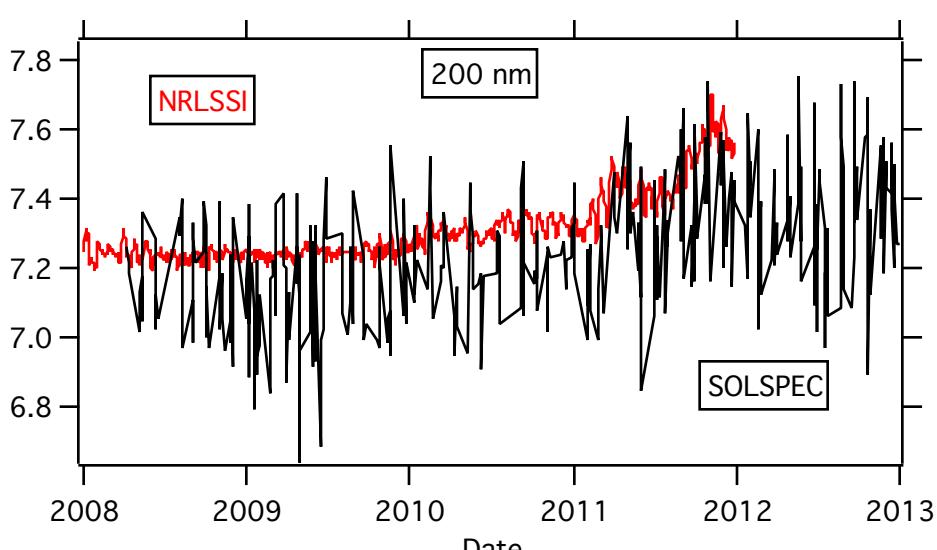
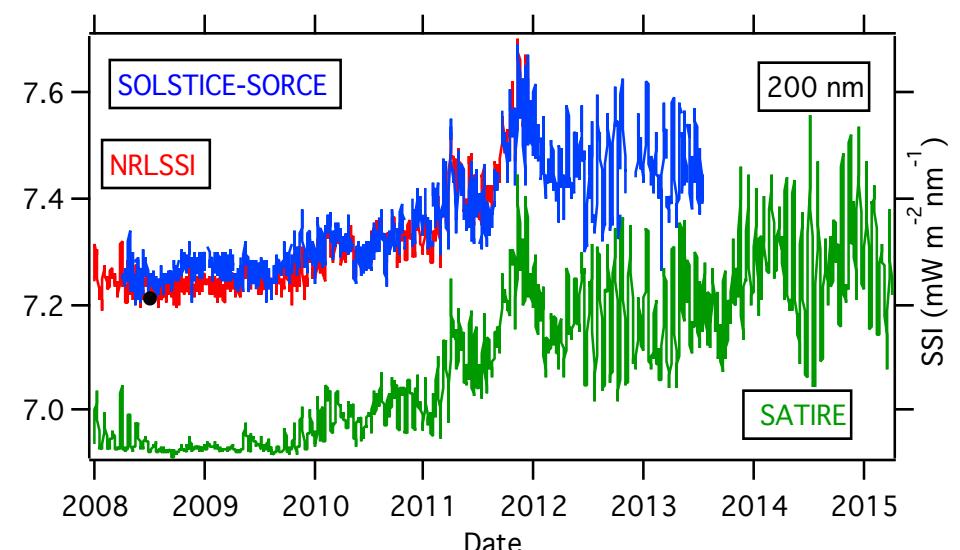
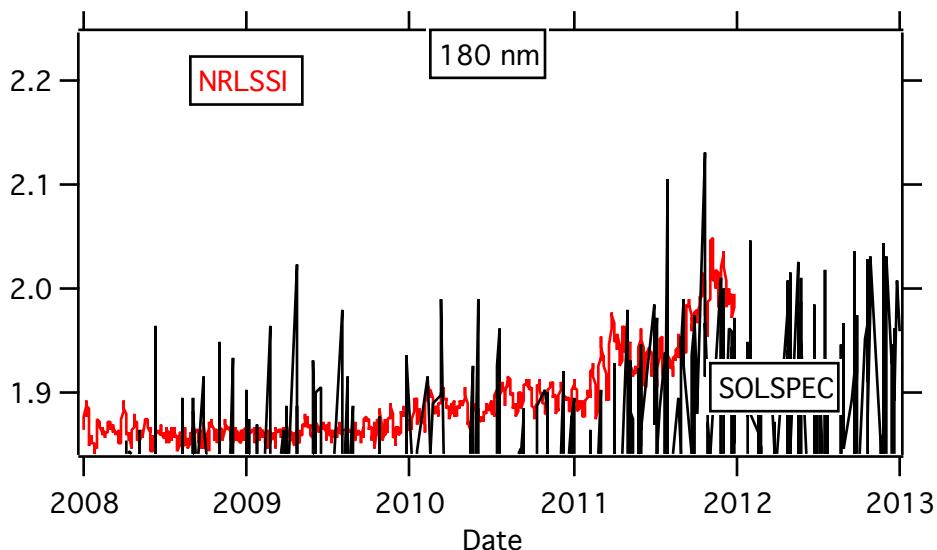
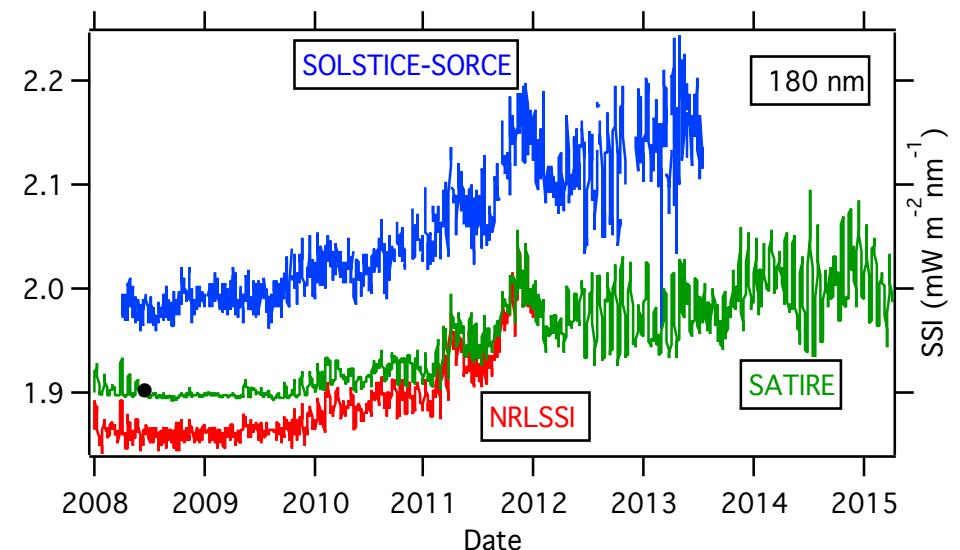
We use:

- NRLSSI
- SATIRE

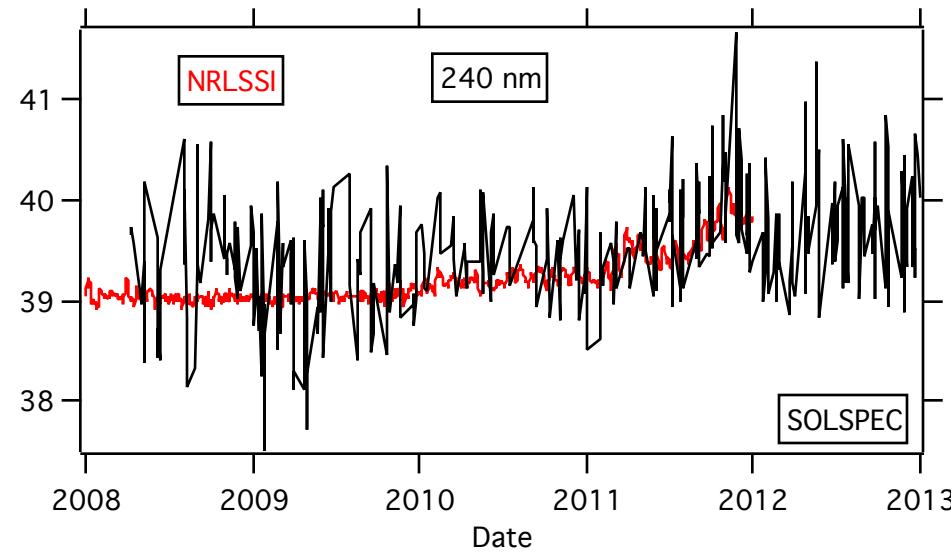
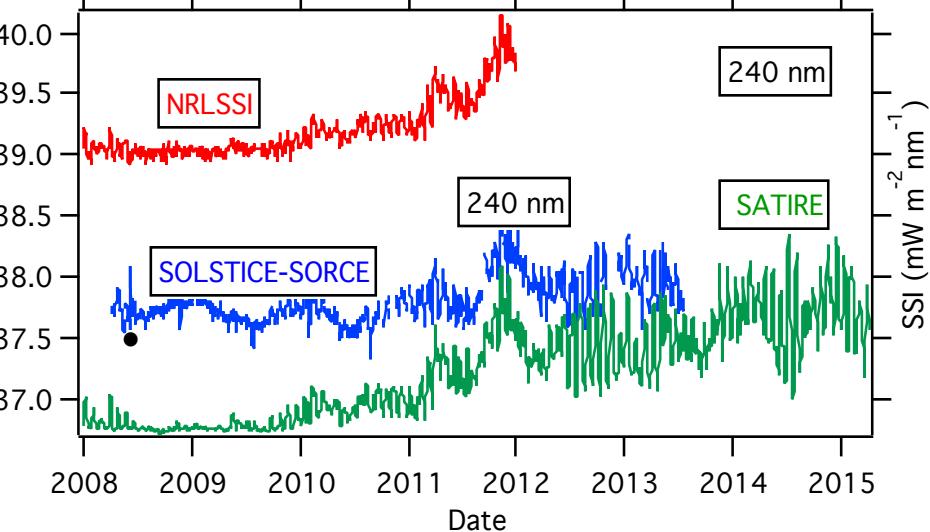
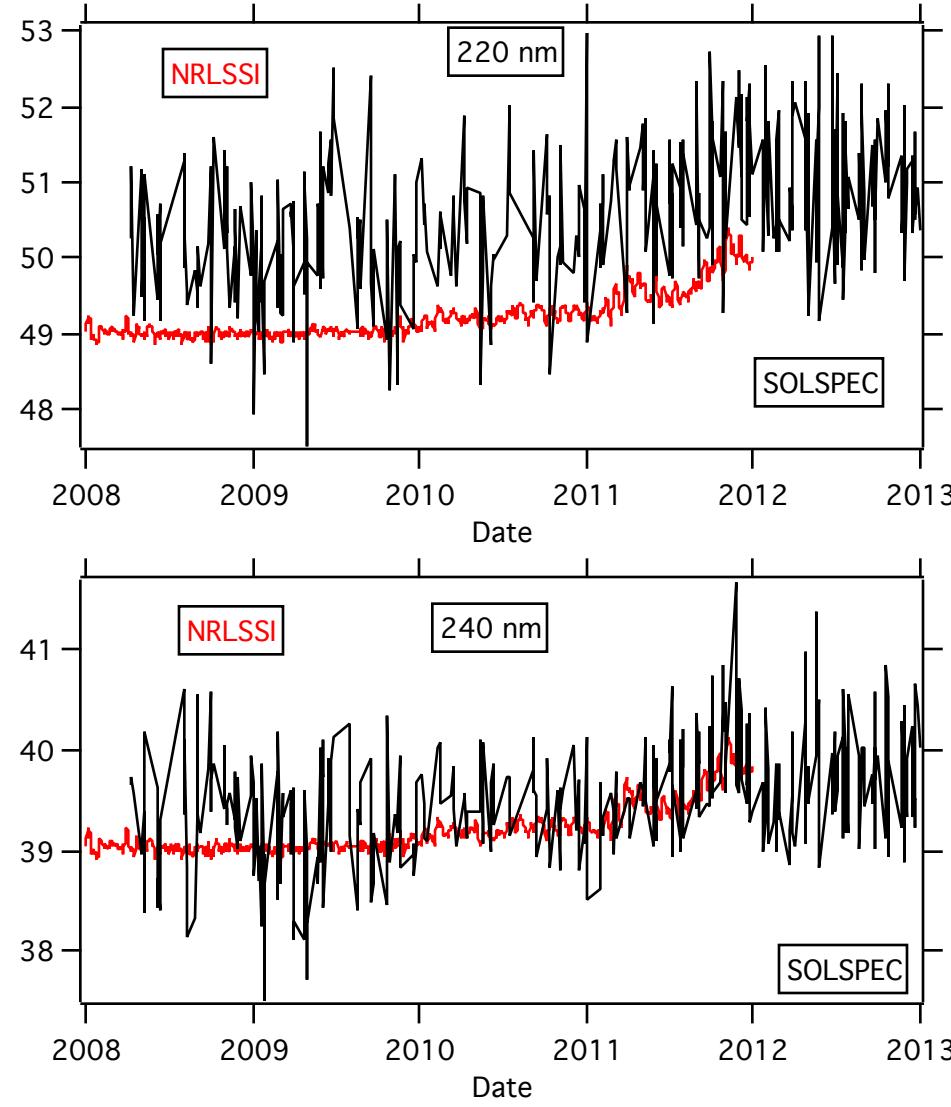
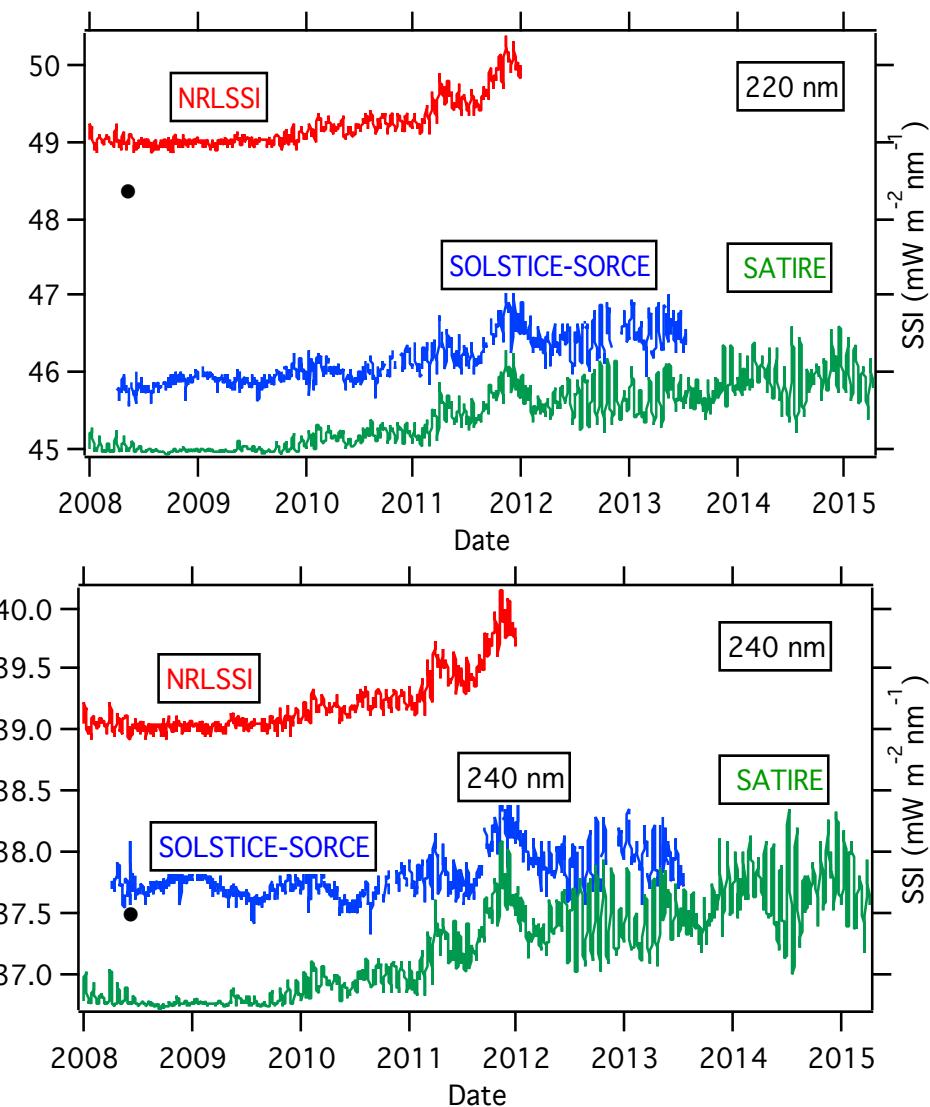
and **SORCE**



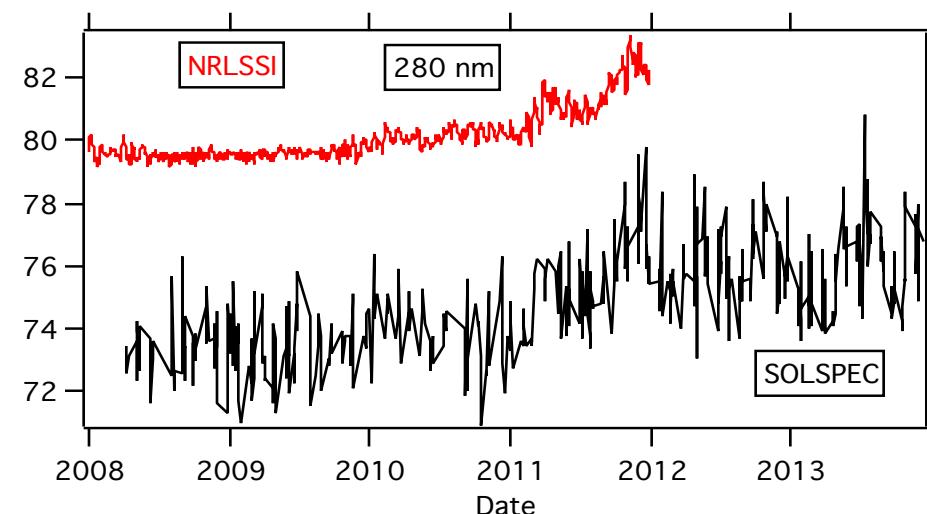
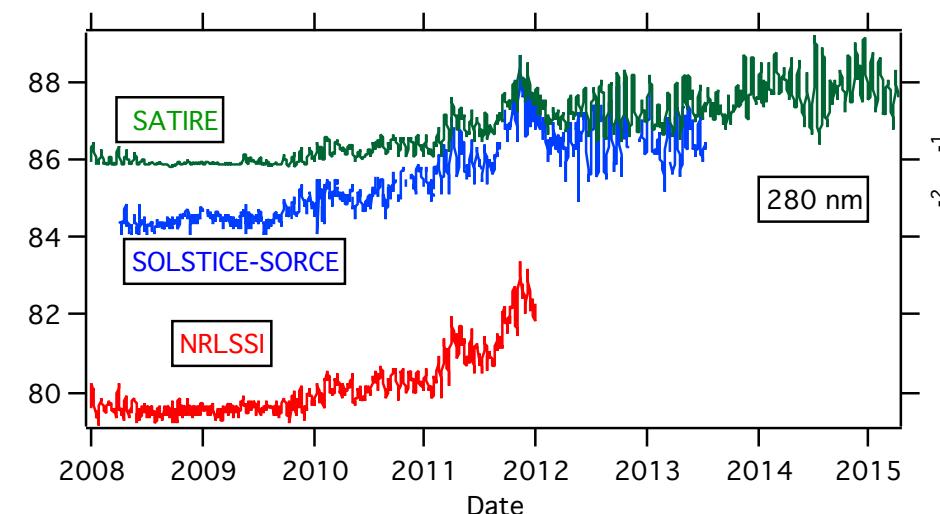
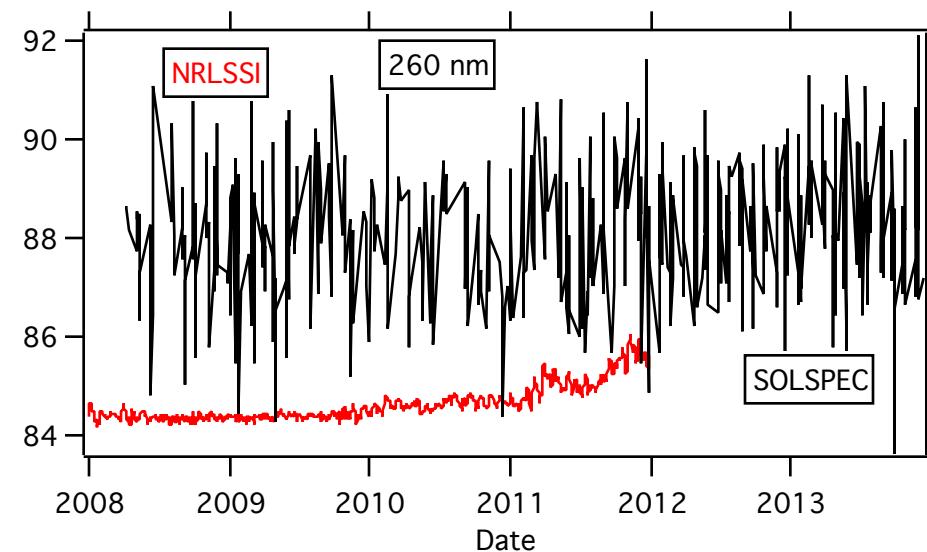
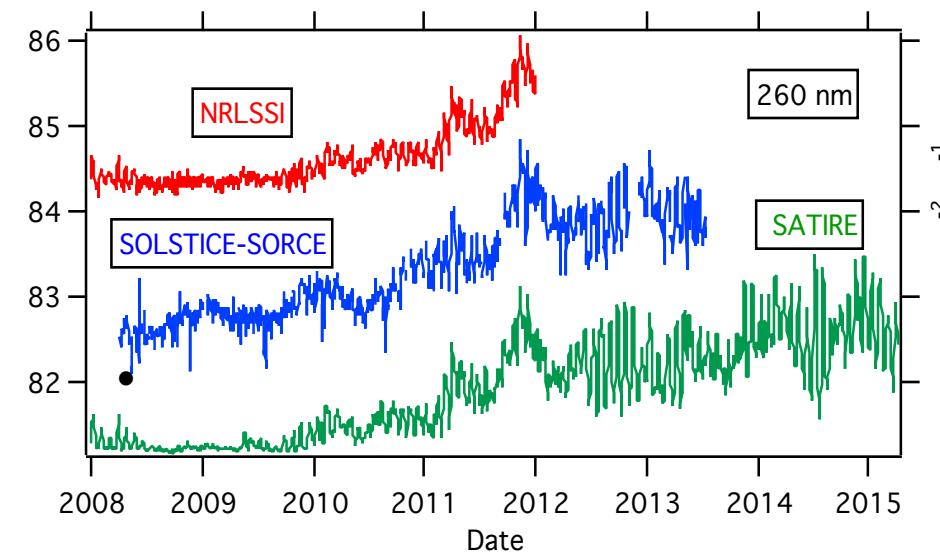
# TIME SERIES:COMPARISON BETWEEN NRLSSI, SOLSTICE AND SOLSPEC



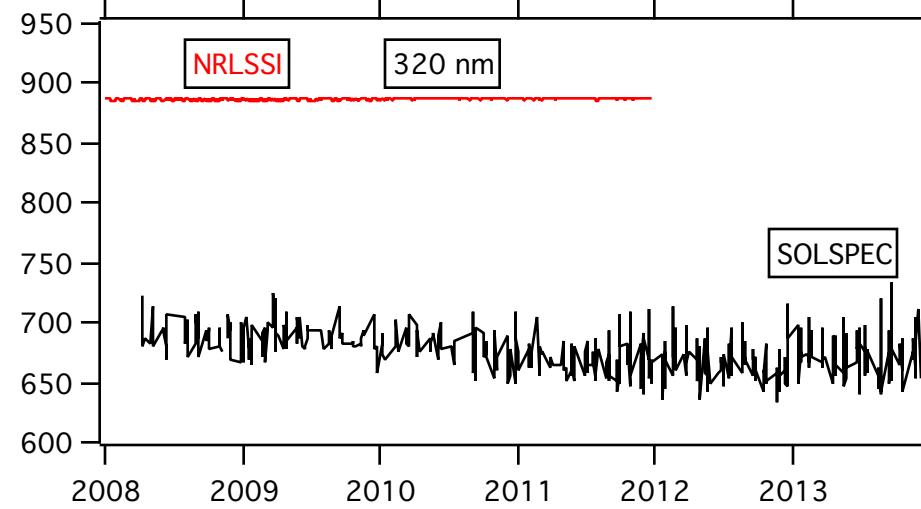
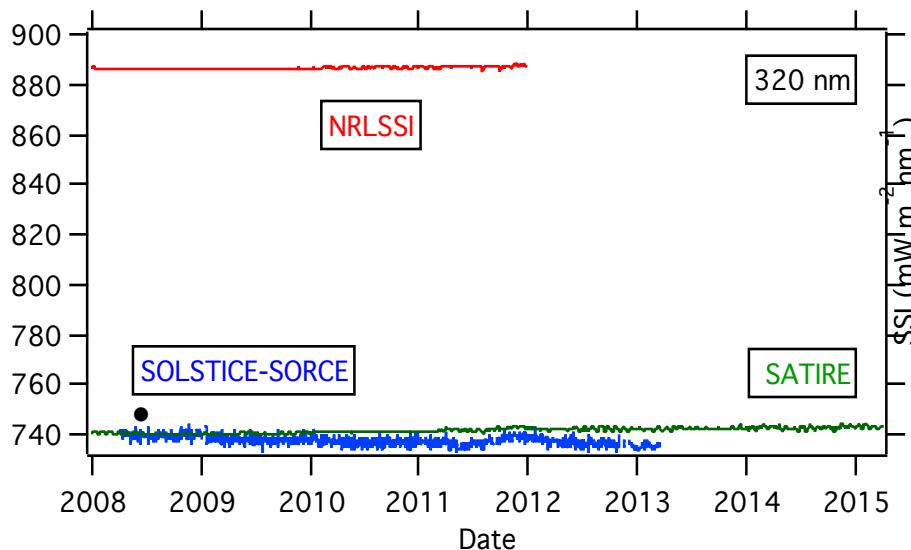
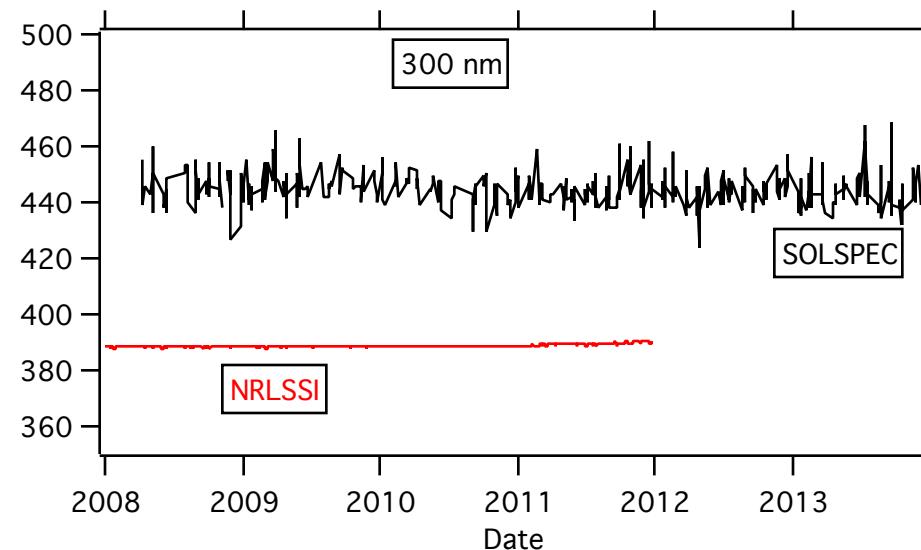
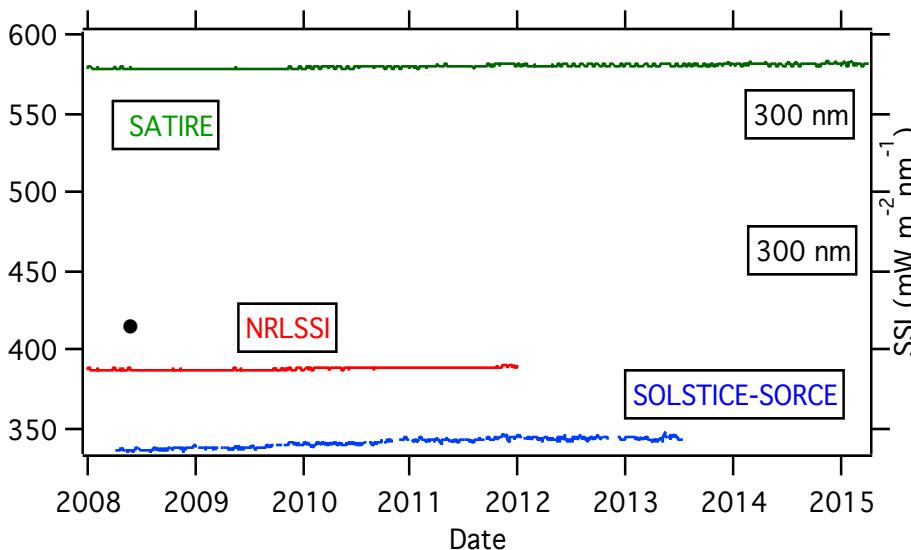
# TIME SERIES:COMPARISON BETWEEN NRLSSI, SOLSTICE AND SOLSPEC



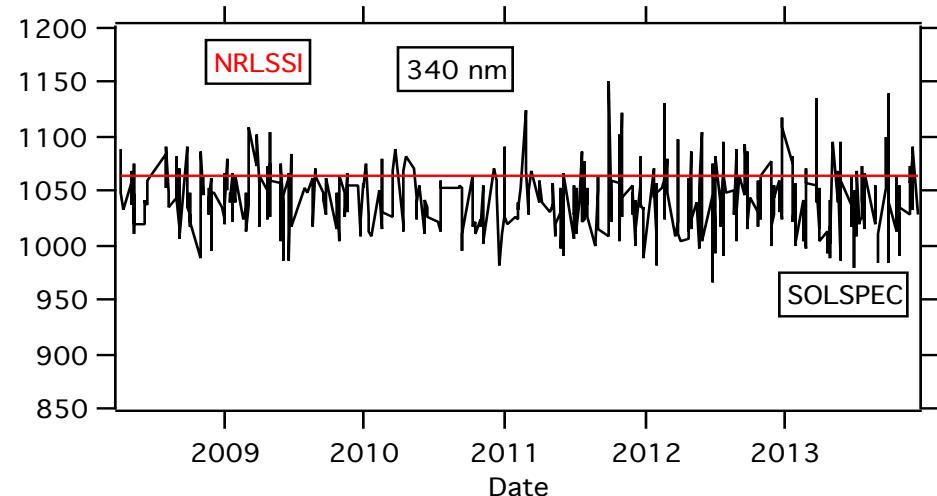
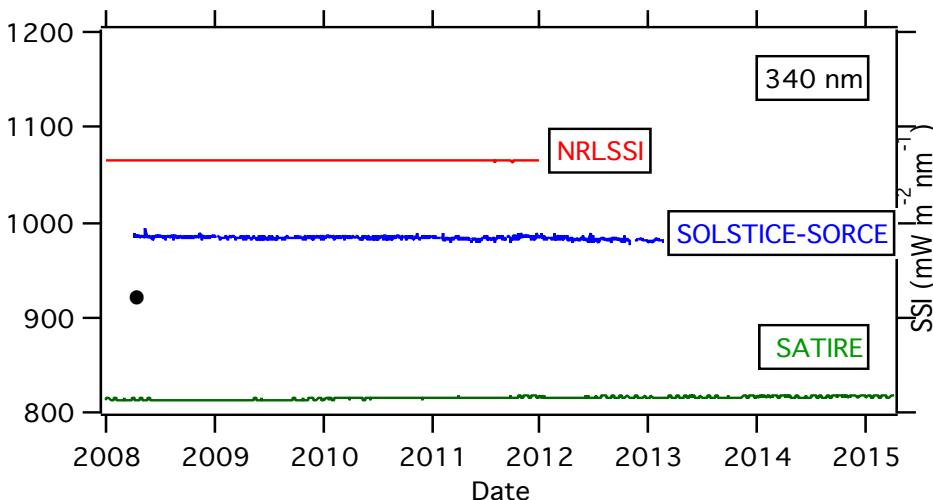
# TIME SERIES:COMPARISON BETWEEN NRLSSI, SOLSTICE AND SOLSPEC



# TIME SERIES:COMPARISON BETWEEN NRLSSI, SOLSTICE AND SOLSPEC



# TIME SERIES:COMPARISON BETWEEN NRLSSI, SOLSTICE AND SOLSPEC



- SOLSPEC corrected data by modeling is the closest to NRLSSI at short wavelength, likely due to the use of Mg II index
- SOLSPEC corrected data by modeling is noisy
- Absolute irradiance values predicted by models may differ as depending of their choice
  - for irradiance normalisation
- Models short term variations are in agreement as well as with SORCE
- SOLSPEC corrected data by modeling do not represent the short variations, likely due to
  - the noise despite the use of Mg II index.



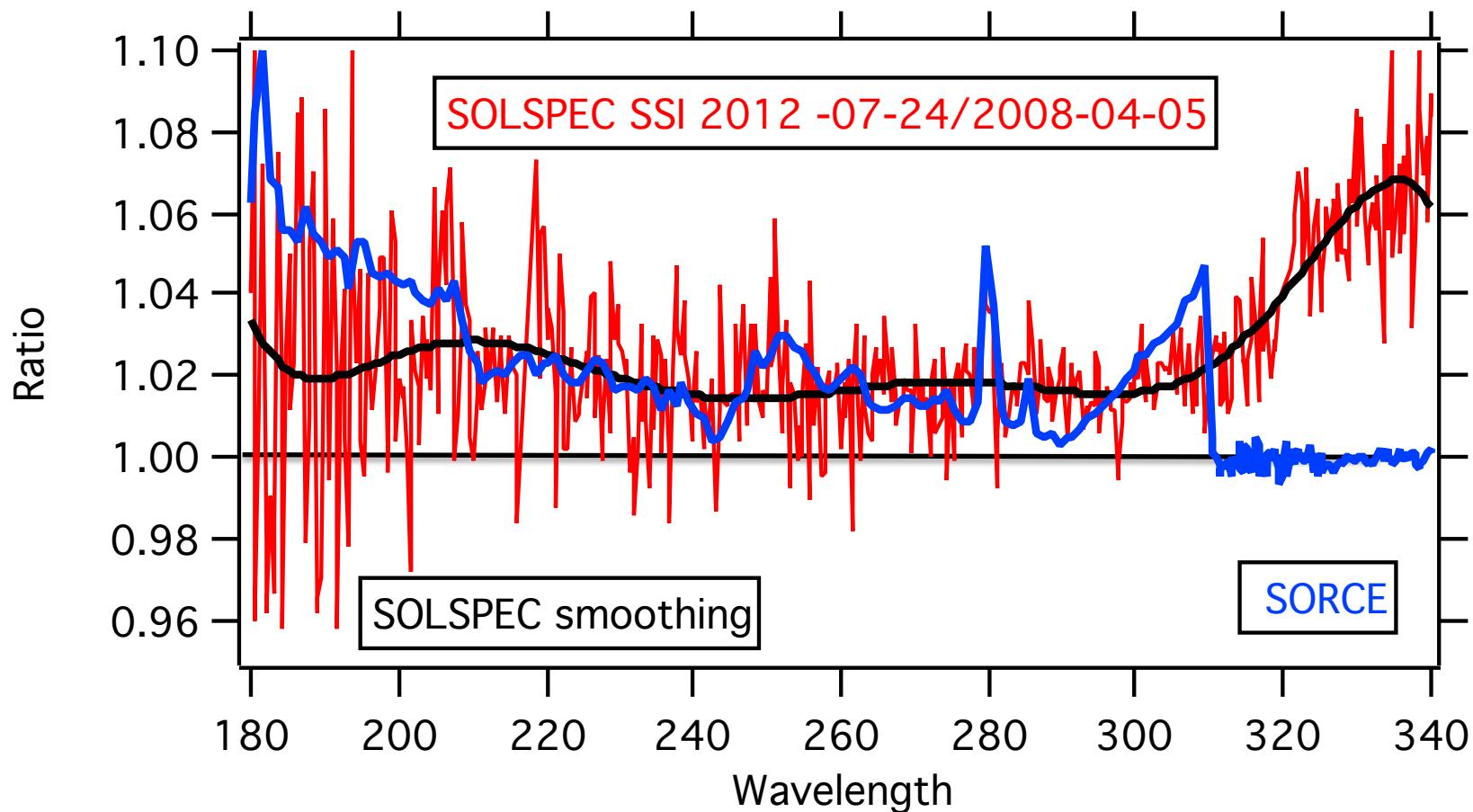
Ajouter satire

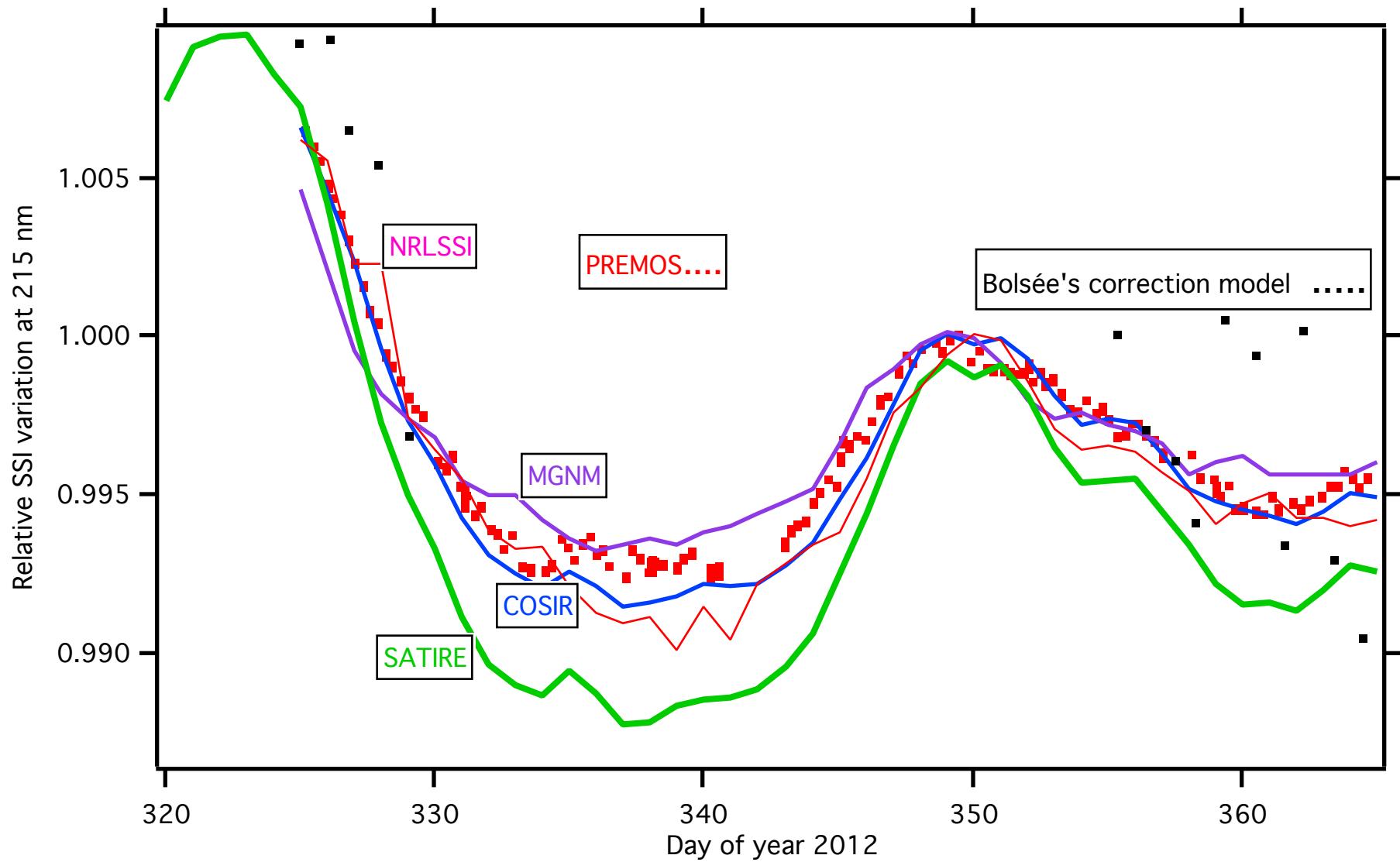
# TIME SERIES COMPARISON: SUMMARY

| Wavelength (nm) | SOLSPEC / NRLSSI | SOLSPEC / SOLSTICE-SORCE |
|-----------------|------------------|--------------------------|
| 180             | ≈                | <                        |
| 200             | ≈                | ≈                        |
| 220             | ≈                | >>                       |
| 240             | ≈                | >                        |
| 260             | >                | >                        |
| 280             | <<               | <<                       |
| 300             | >>               | >>                       |
| 320             | <<               | <                        |
| 340             | ≈                | ≈                        |

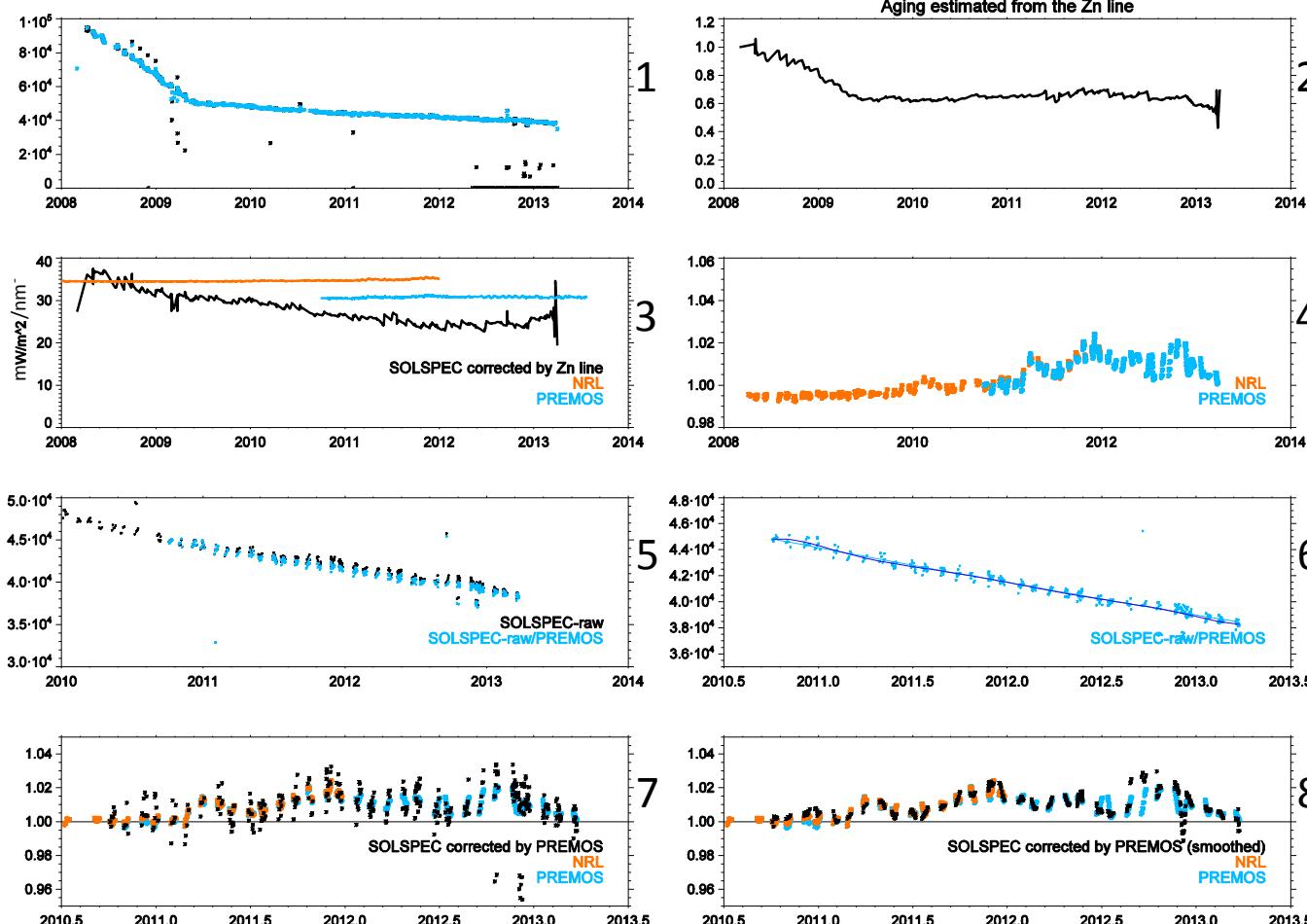
- Differences are wavelength dependent. They partially originate from absolute calibration difference, from psf, from wavelength (e.g. NRLSSI providing data at XXX.5), and Fraunhofer lines.
- Unstabilities make noisier results than SOLSTICE-SORCE.
- Differences with respect to NRLSSI and SOLSTICE range from 5 to 10 %
- Agreement with respect to NRLSSI is likely per construction below 260 nm.

# VARIABILITY



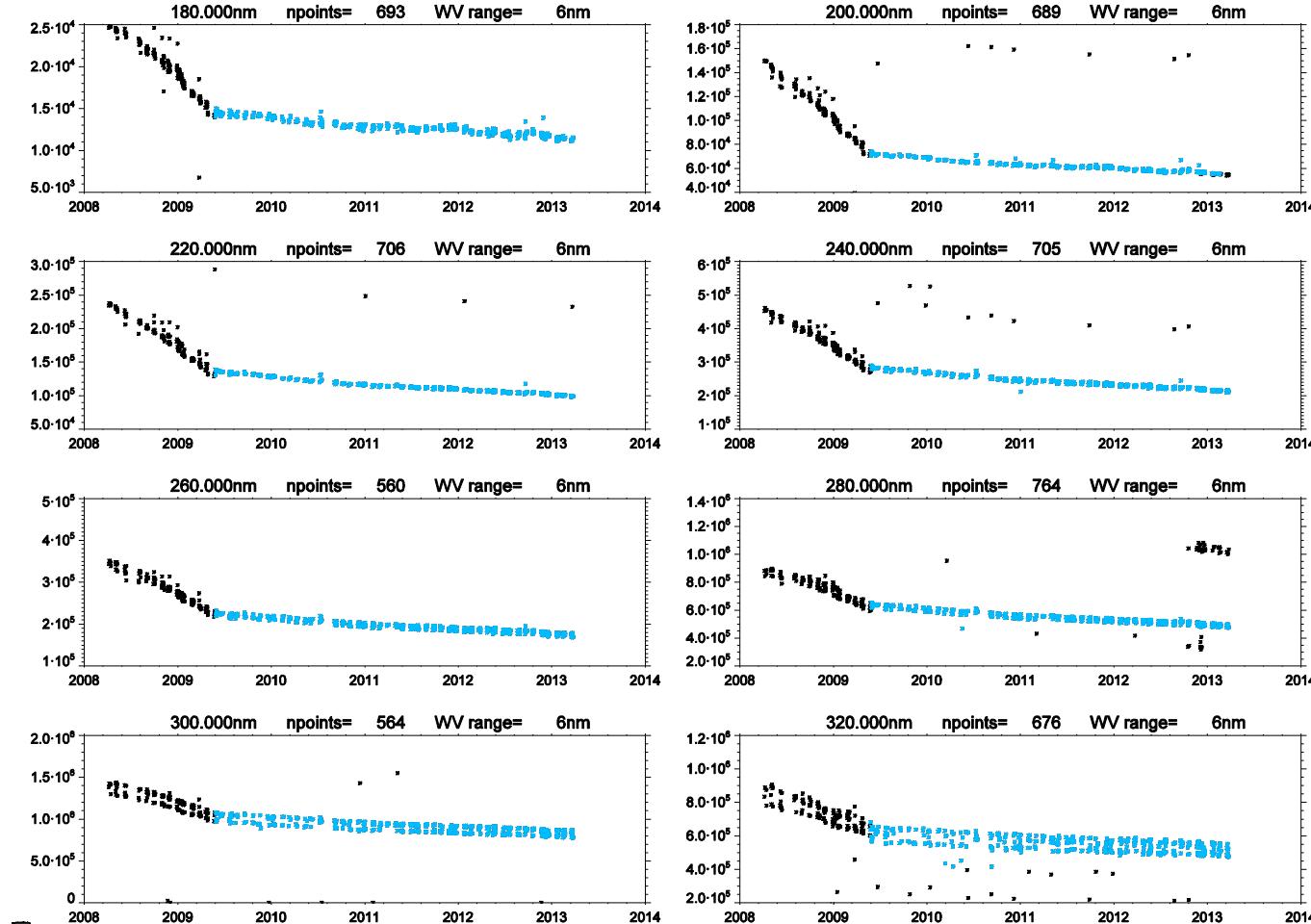


1. Solar measurements at 215 nm are cleaned from outliers
2. Aging estimated from the pressure term and Zn213 line
3. This is what we get if we use HCL lamp.
4. Normalized NRL and PREMOS data
5. We divide raw solar data by PREMOS. What left is aging.
6. The aging estimated from PREMOS is quasi-linear
7. If we apply new quasi-linear aging to raw SOLSPEC we get nice result. But still instability effect is pronounced
8. Same but smoothed by a running mean



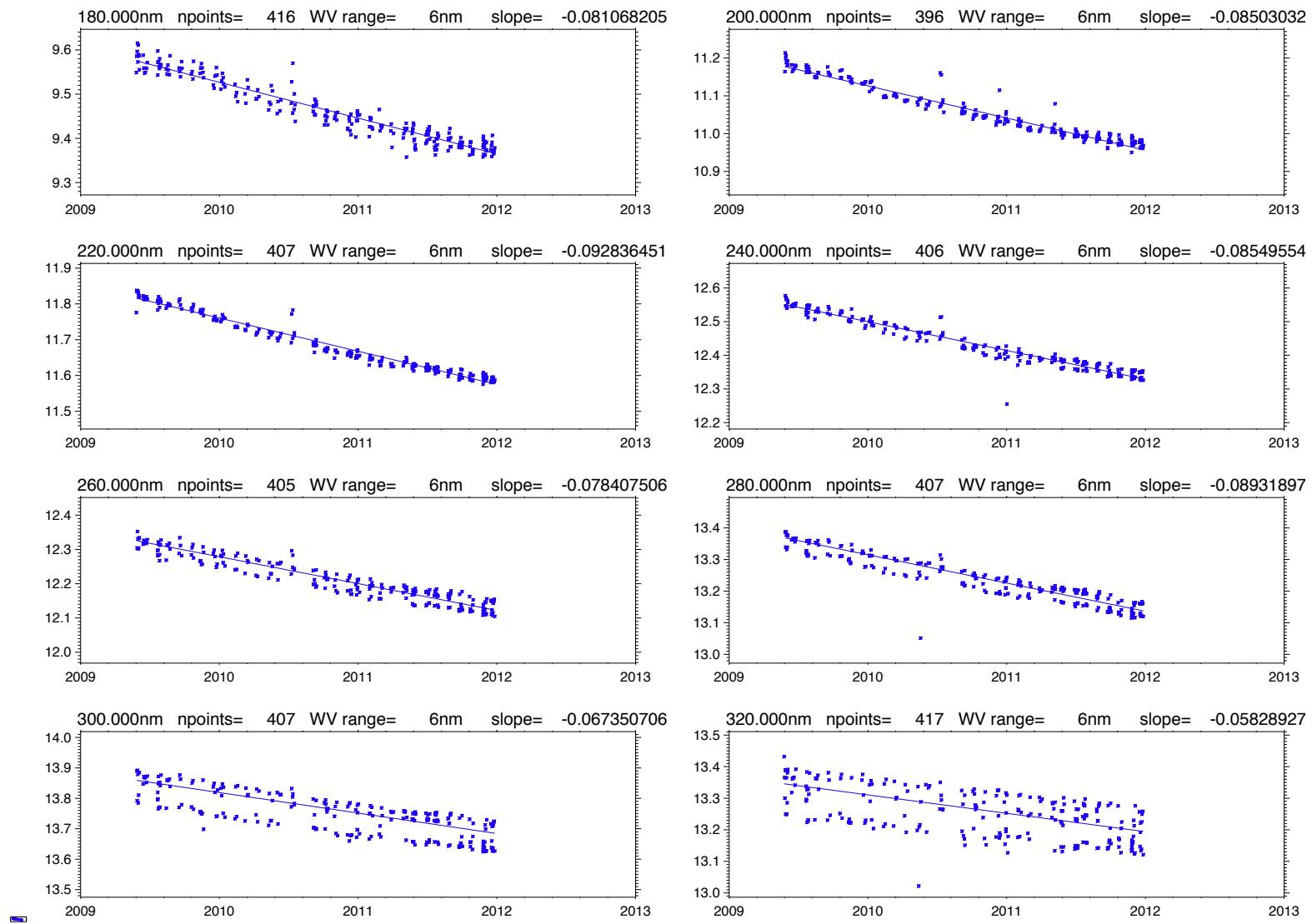
We do the same aging estimation but using NRL data at different UV wavelengths

Here we remove outliers. Note the instability increase with wavelength



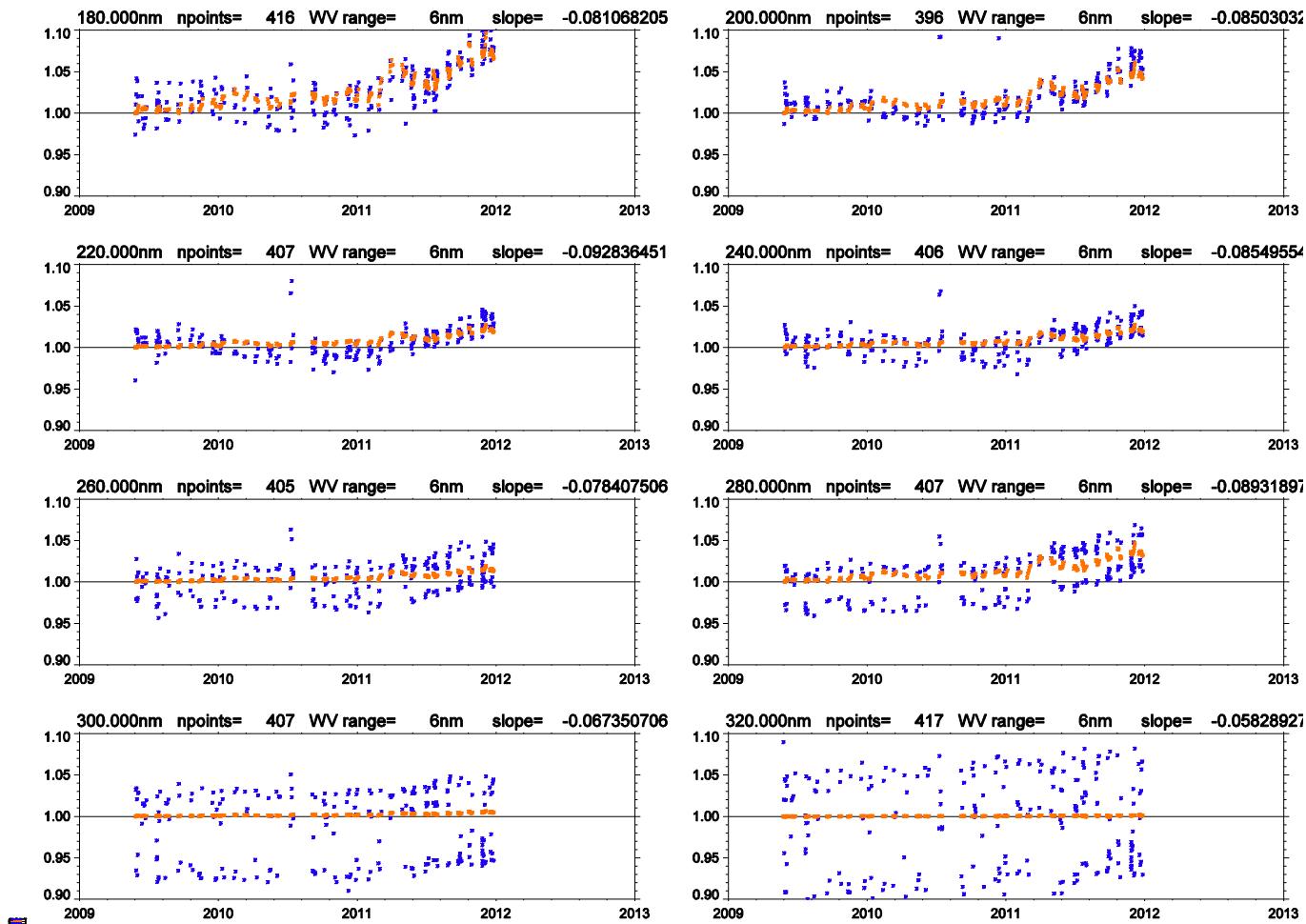
**Log (SOLSPECraw/NRL) is fitted linearly.**

**Note that non-linear behavior (upward shift during the active Sun) of what we see can be caused also by the fact that SOLSPEC can have higher variability than NRL**



SOLSPEC is corrected using aging estimated from NRL

Problem of instability for wavelength above 240 nm. Yellow dots is the mean



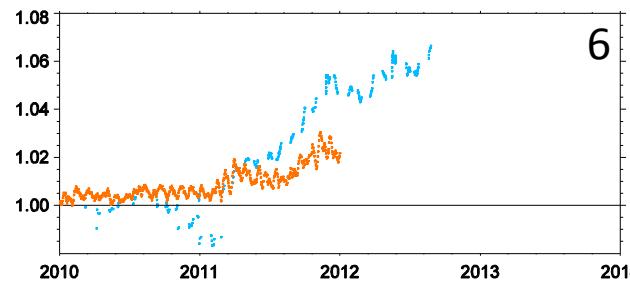
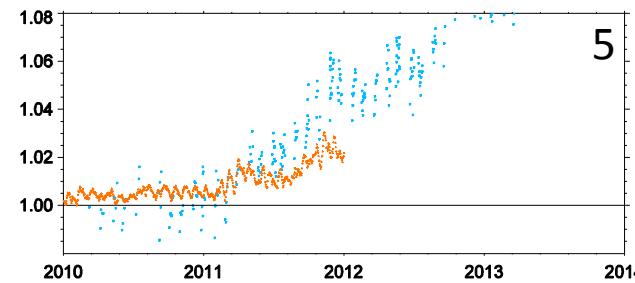
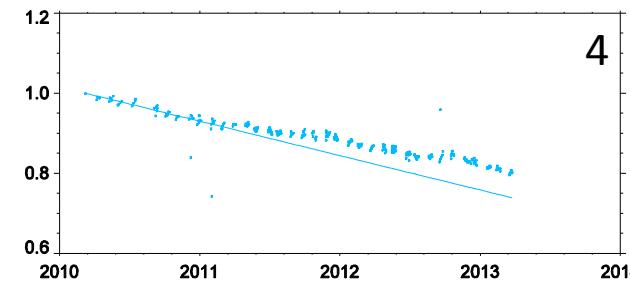
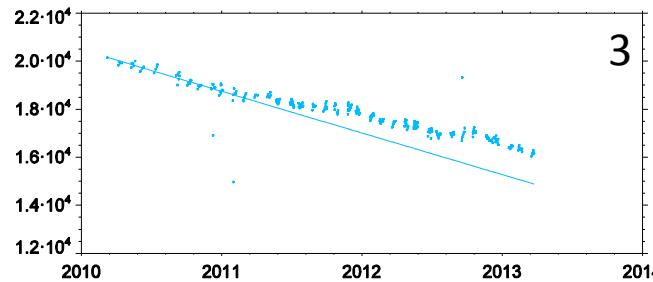
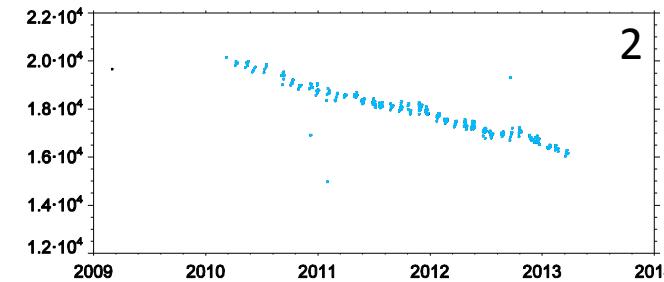
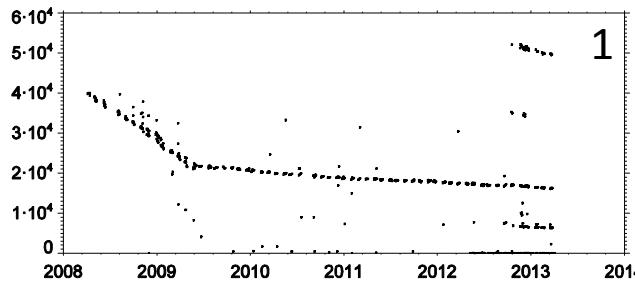
Variability is calculated with respect to the Sun quiet episod after the D-period

From previous tests with PREMOS and NRL we assume that aging is quasi-linear and try to use SOLSPEC data itself to correct the aging

1. Raw data at 213 nm
2. We take period after D-death and remove outliers
3. We estimate the trend from the period 2010-2011
4. Same but normalized
5. Using the estimated trend we correct raw data (red is NRL)
6. Same but smoothed (red is NRL)

Problem is that 2010-2011 period is not actually a quiet period. But we can try to apply the same approach if will get the SOLSPEC observation during the declining phase of the solar cycle. Then we would be able to estimate the linear trend from the periods with the same MgII index. Data after end of 2012 is required to continue the aging study.

However, the problem of instability correction should be solved first.



## **CONCLUSIONS and ACTIONS**

- 1) Make available all the SOLSPEC raw data including the HK data to the science team up to now by an easy access (e.g. PICARD, LISERD), and the calibration coefficients obtained with the PTB blackbody.
- 2) Unstabilities to be investigated in depth by running special lamps/Sun operations or using existing data if appropriate. Using the eclipse data (instrument always on), the insabilities disappear. Special operations are requested to confirm this finding.
- 3) The agreement SOLSPEC corrected data by modeling with NRLSSI below 260 nm is likely per construction
- 5) During peiod where, the solar activity is the lowest and constant. Sun can be used for aging studies.

SOLSPEC detects the solar variability using NRLSSI, however given the unstabilities, and the aging, its extraction Is not presently precise.