On the stability of SSI records

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Content

Surface magnetic field

SORCE/ Sim

NRLSSI2

ISN

UARS/ Susim

NLTE below 300nm

faculae, sunspot

Mg II

UARS/ Solstice

NOAA/ SBUV

f10.7

Ca K

SORCE/ Solstice

1D model atmosphere

SATIRE

network, ER

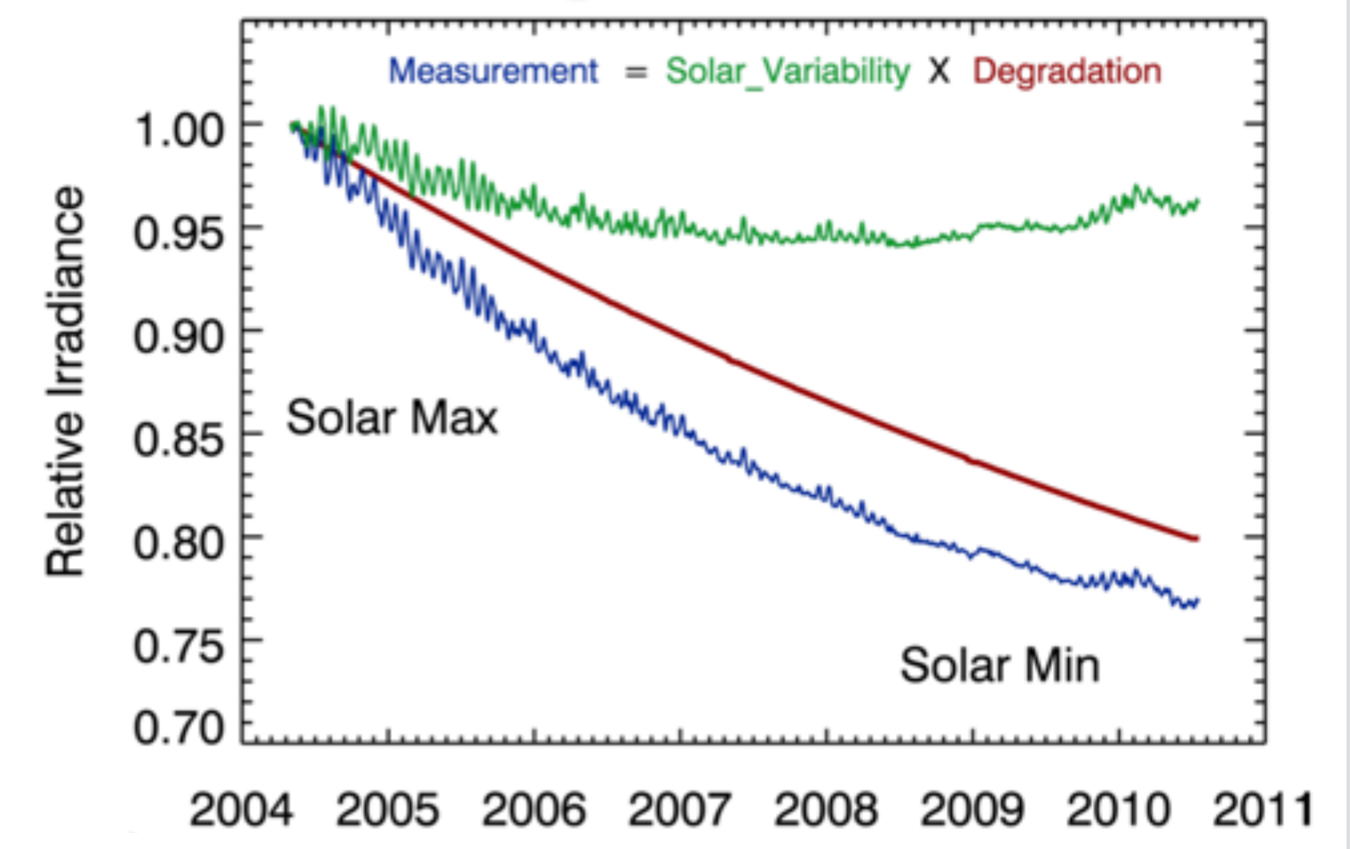
What about modeling the Mg II profile?

Outline

❖What Solar rotational variability can tell us about longer trend variations in SSI records ?

❖Can we provide a common measure of the stability of SSI records ?

$$I(\lambda, t) = I_0(\lambda) + I_{st}(\lambda, t) + I_{lt}(\lambda, t)$$



court. T. Woods

Solar rotational variability

✓ **Well measured !!**

$$I(\lambda,t) = I_0(\lambda) + I_{st}(\lambda,t) + I_{lt}(\lambda,t)$$

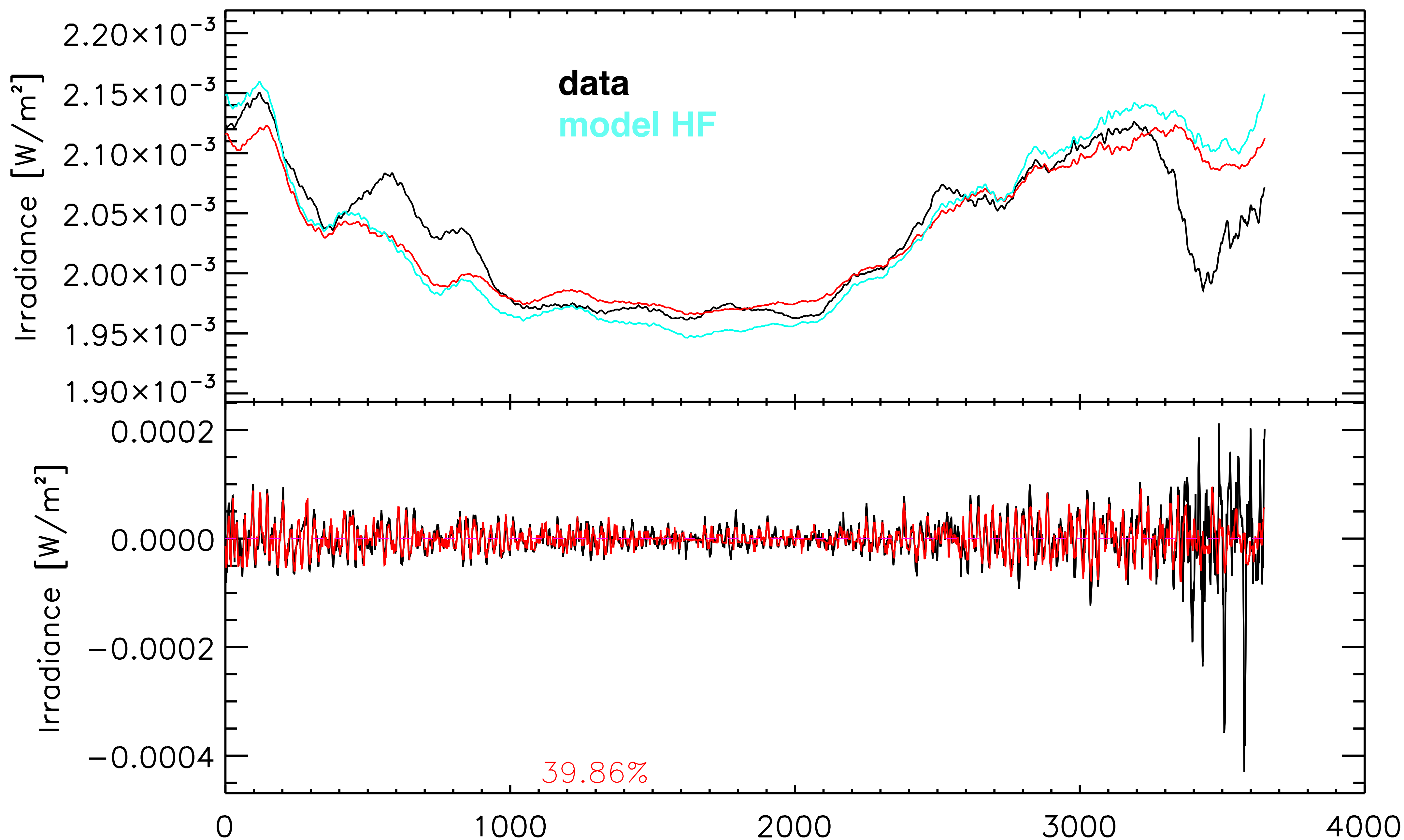
$$I(\lambda,t) = a_0 + \sum_i a_i(P_i(t) - < P_i(t) >_\tau) + \sum_i b_i < P_i(t) >_\tau$$

➡ $$I(\lambda,t) - < I(\lambda,t) >_\tau = \sum_i a_i(P_i(t) - < P_i(t) >_\tau)$$

NB:IF scaling does not change between rotational and « slow » change, then

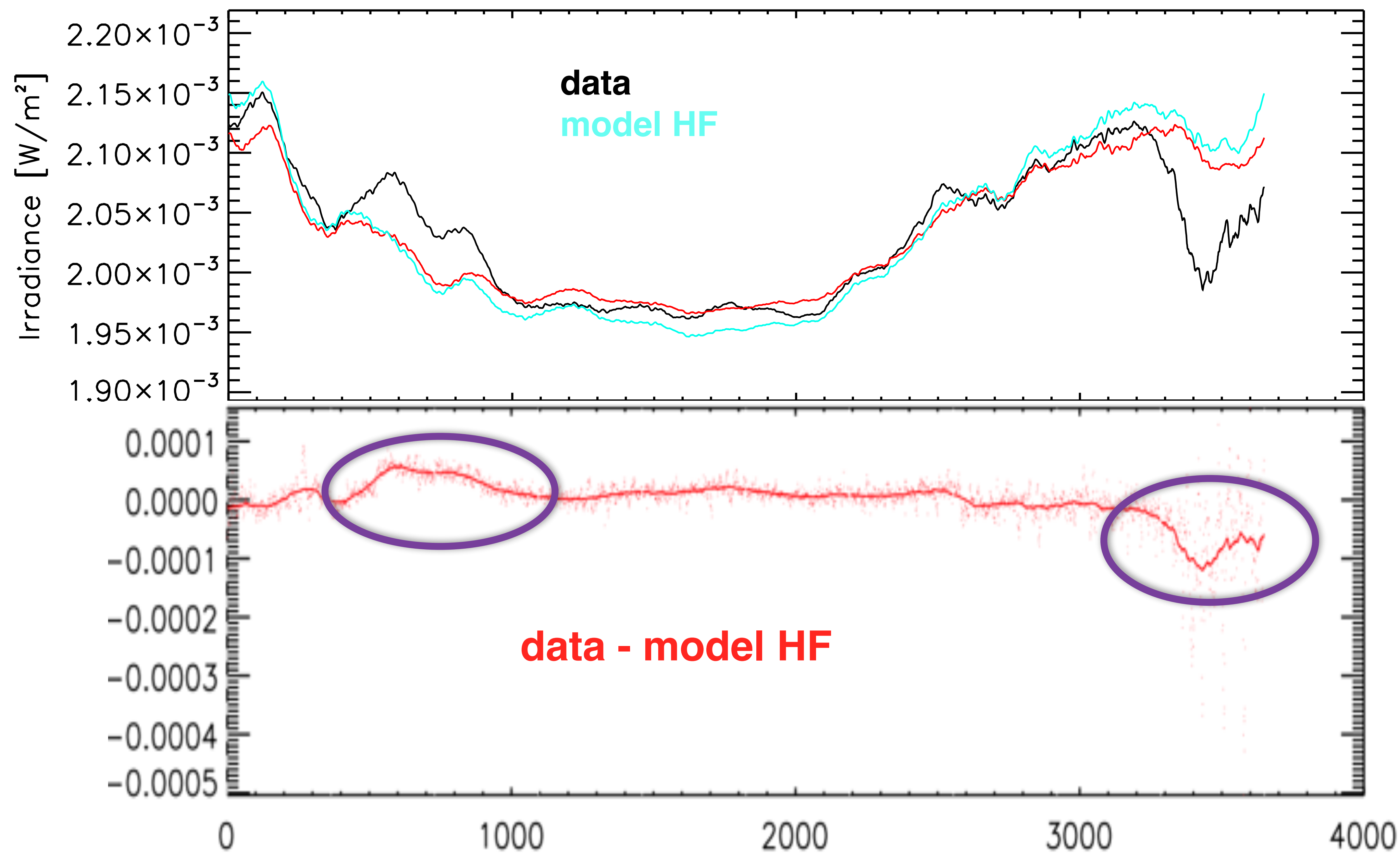
$$I(\lambda,t) = a_0 + \sum_i a_i P_i(t)$$

Ex: UARS/Solstice @ 180nm



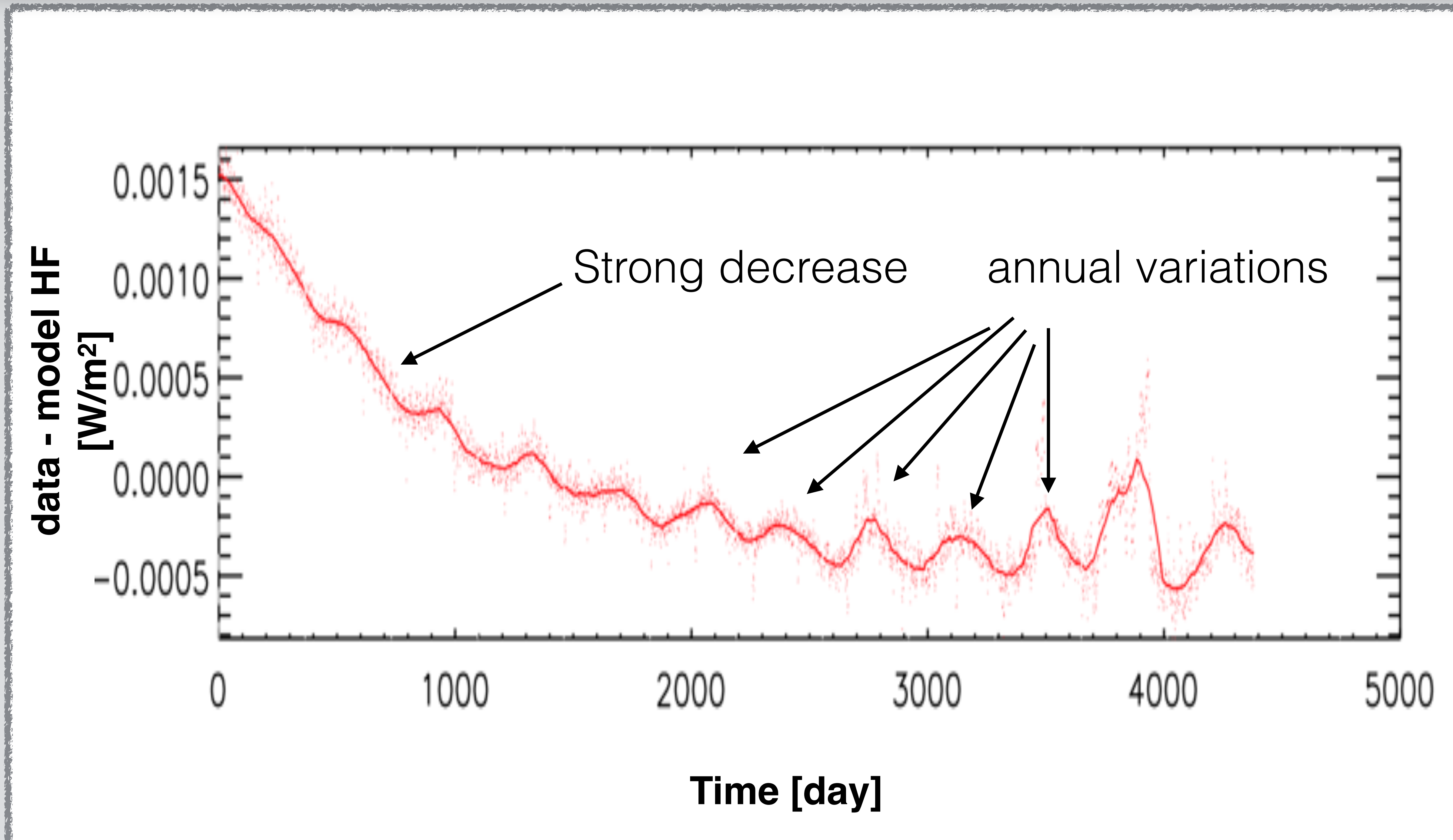
fitted with DSA & MgII

Ex: UARS/Solstice @ 180nm



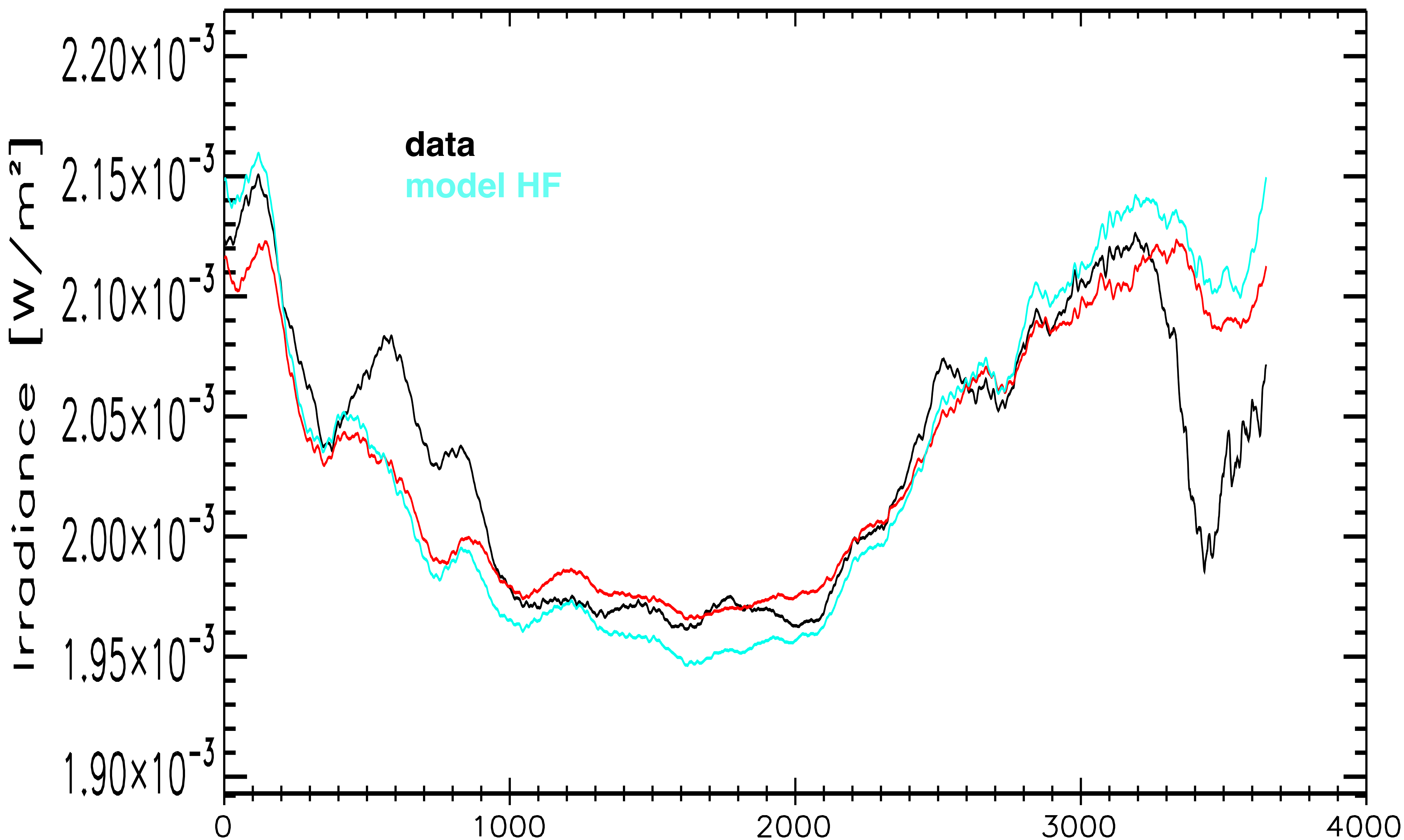
fitted with DSA & MgII

Ex: SORCE/Solstice @ 245nm



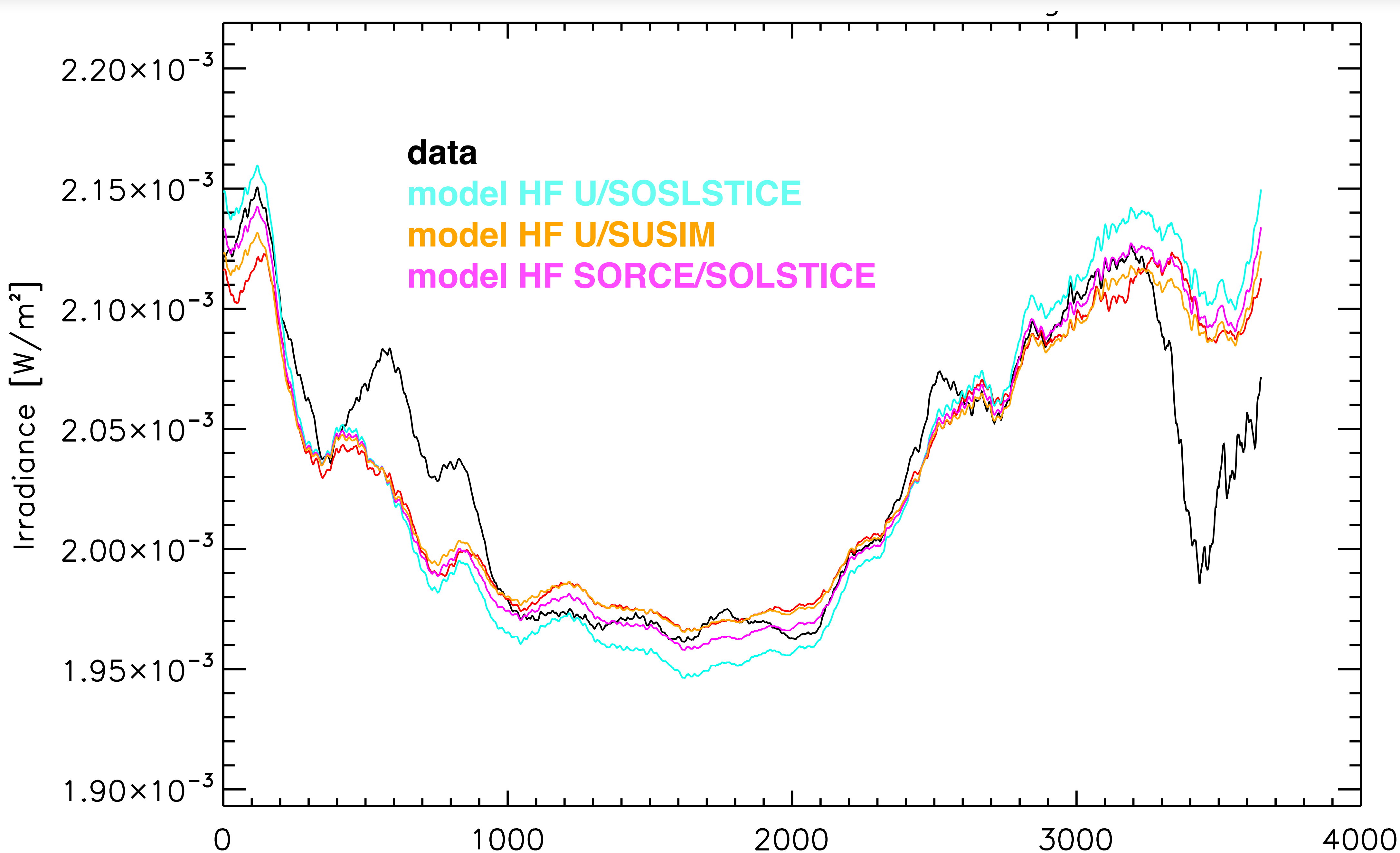
fitted with DSA & MgII

Solar rotation viewed by different instrument

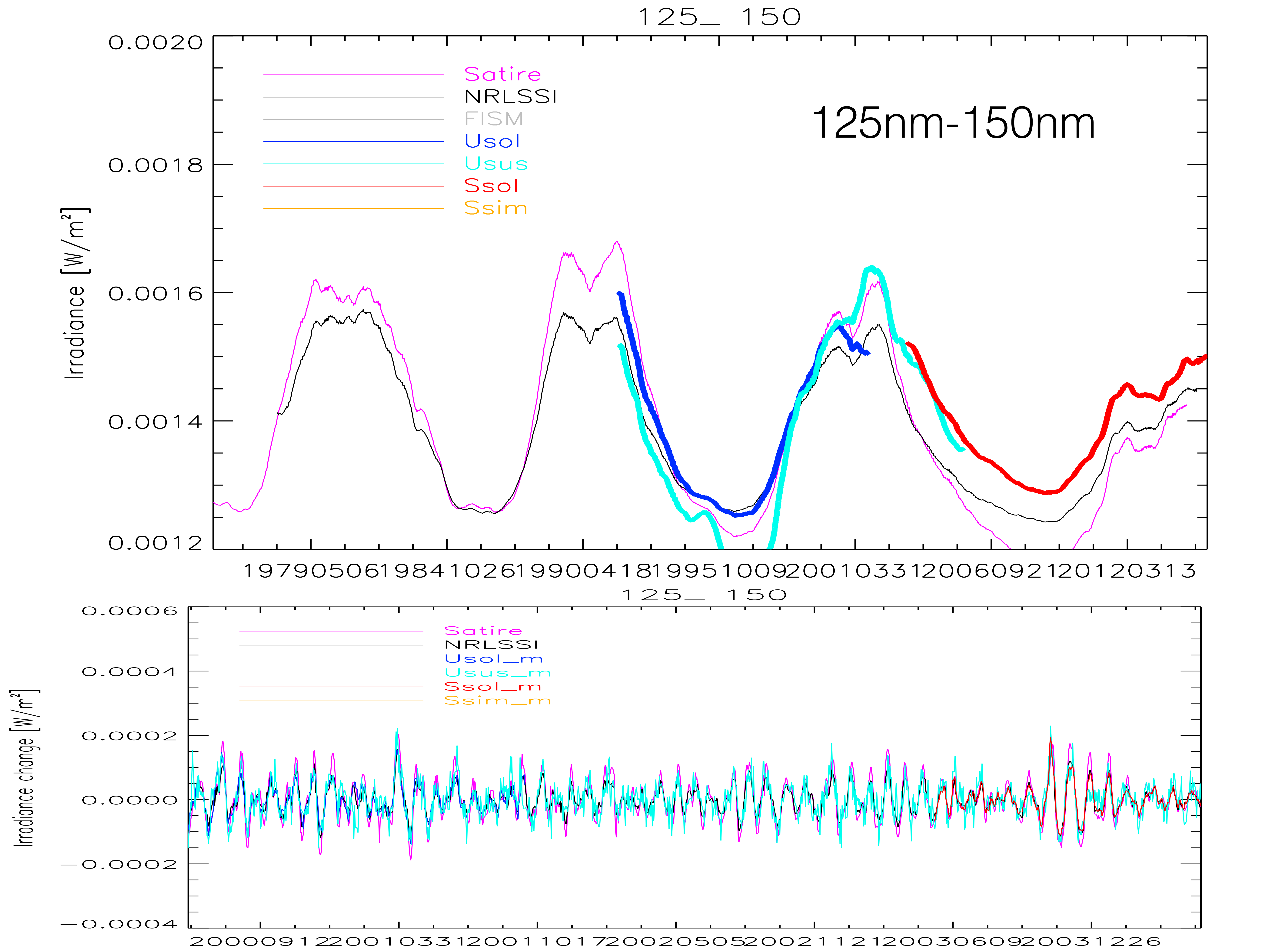


fitted with DSA & MgII

Solar rotation viewed by different instrument



fitted with DSA & MgII


125_ 150
0.0020
0.0018
0.0016
0.0014
0.0012
Satire
NRLSSI
FISM
Usol
Usus
Ssol
Ssim
125nm-150nm
Irradiance [W/m2]
19790506
19841026
19900418
19951009
20010331
20060921
20120313
125_ 150
0.0006
0.0004
0.0002
0.0000
−0.0002
−0.0004
Satire
NRLSSI
Usol_m
Usus_m
Ssol_m
Ssim_m
Irradiance change [W/m2]
20000912
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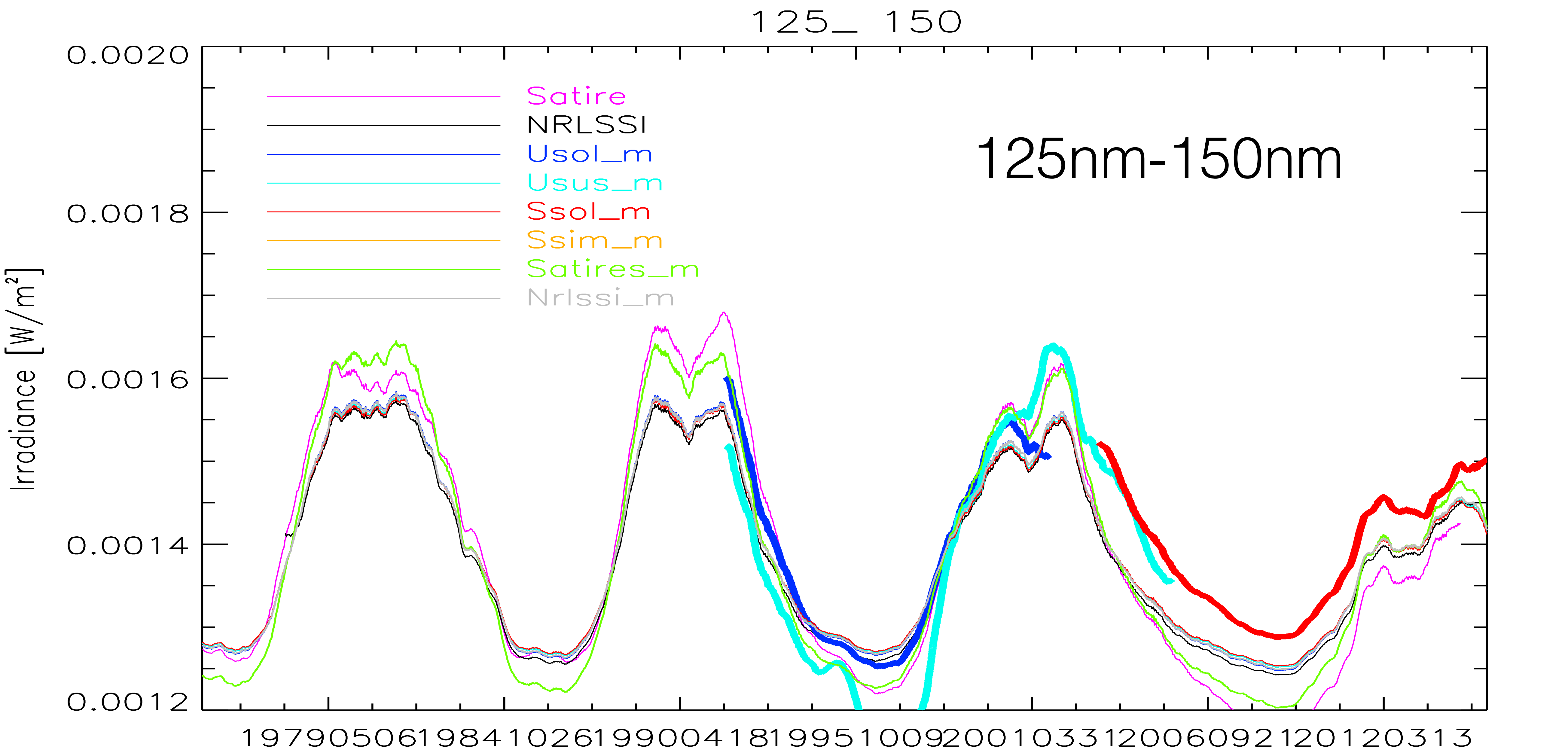
20011017
20020505
20021121
20030609
20031226


125_ 150
125nm-150nm
Satire
NRLSSI
Usol_m
Usus_m
Ssol_m
Ssim_m
Satires_m
Nrlssi_m
Irradiance [W/m²]
0.0020
0.0018
0.0016
0.0014
0.0012
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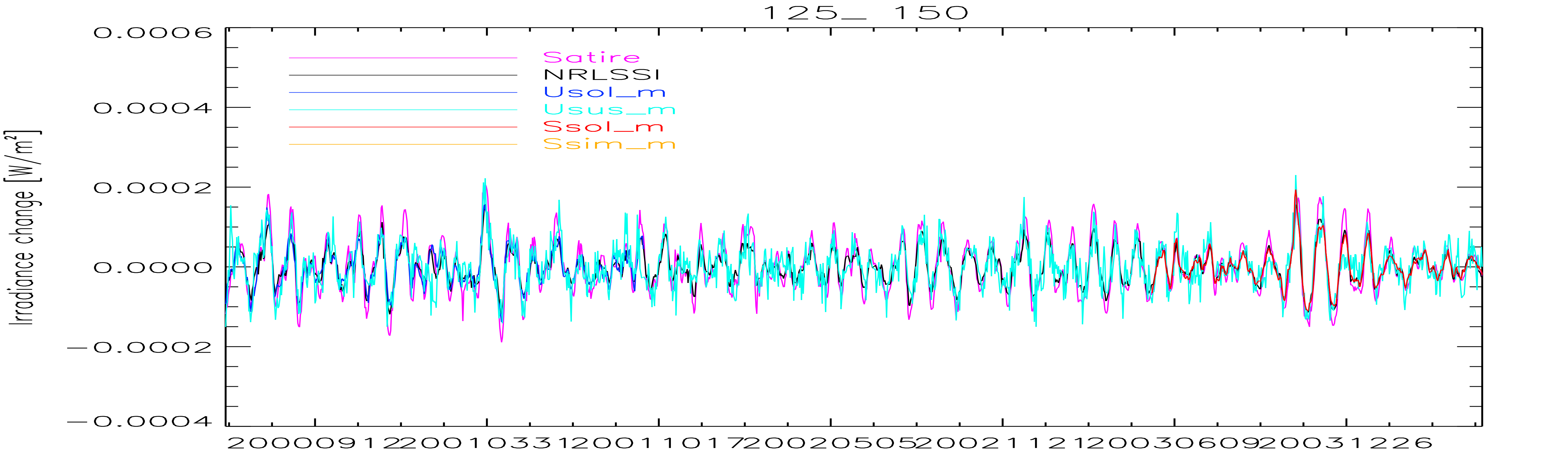
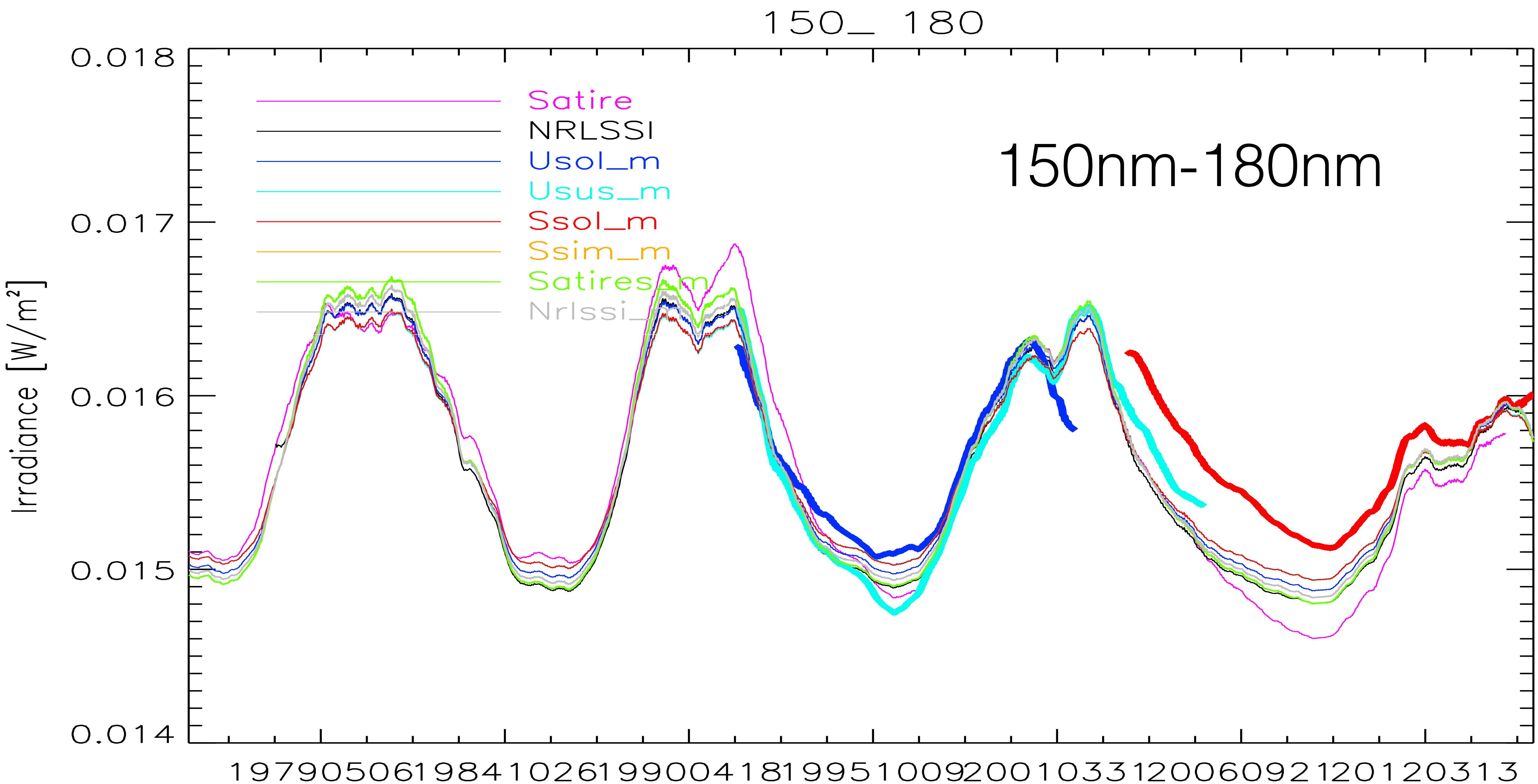
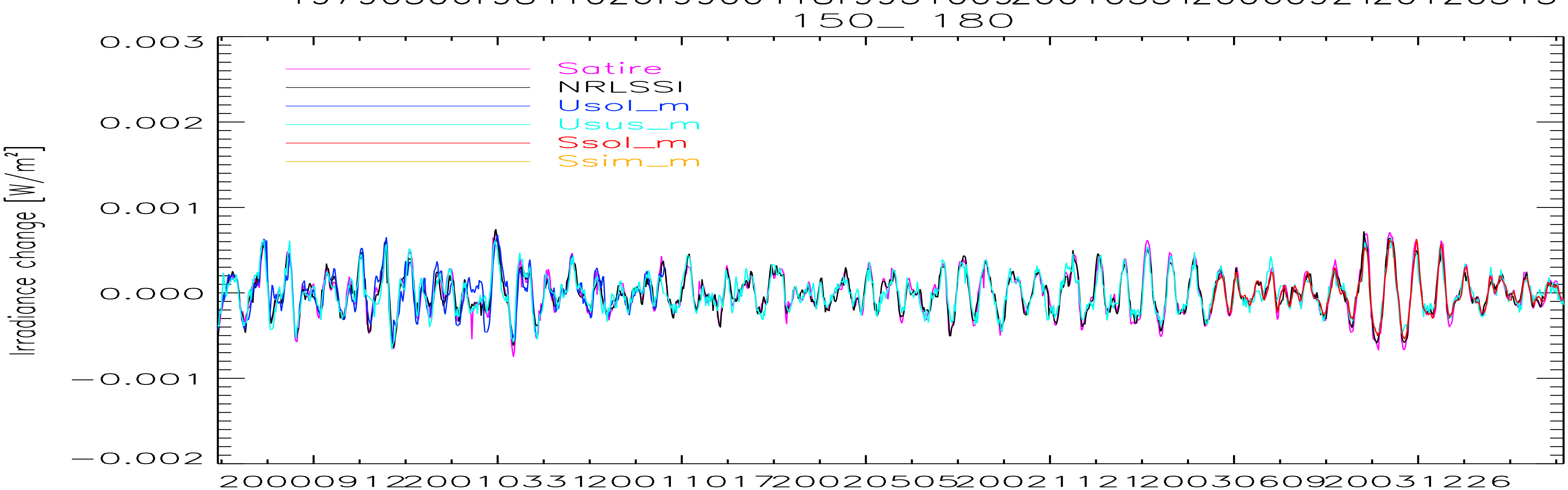
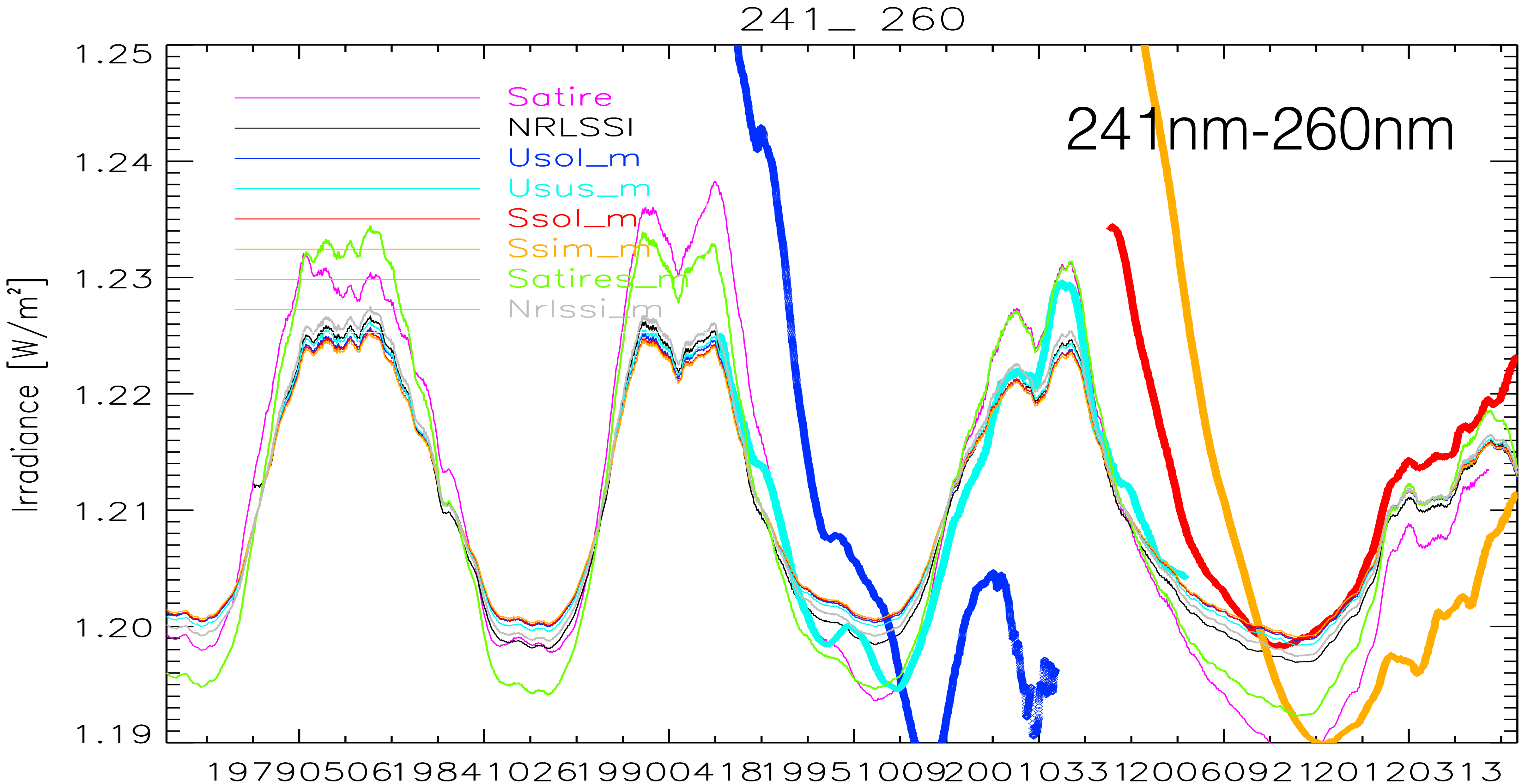
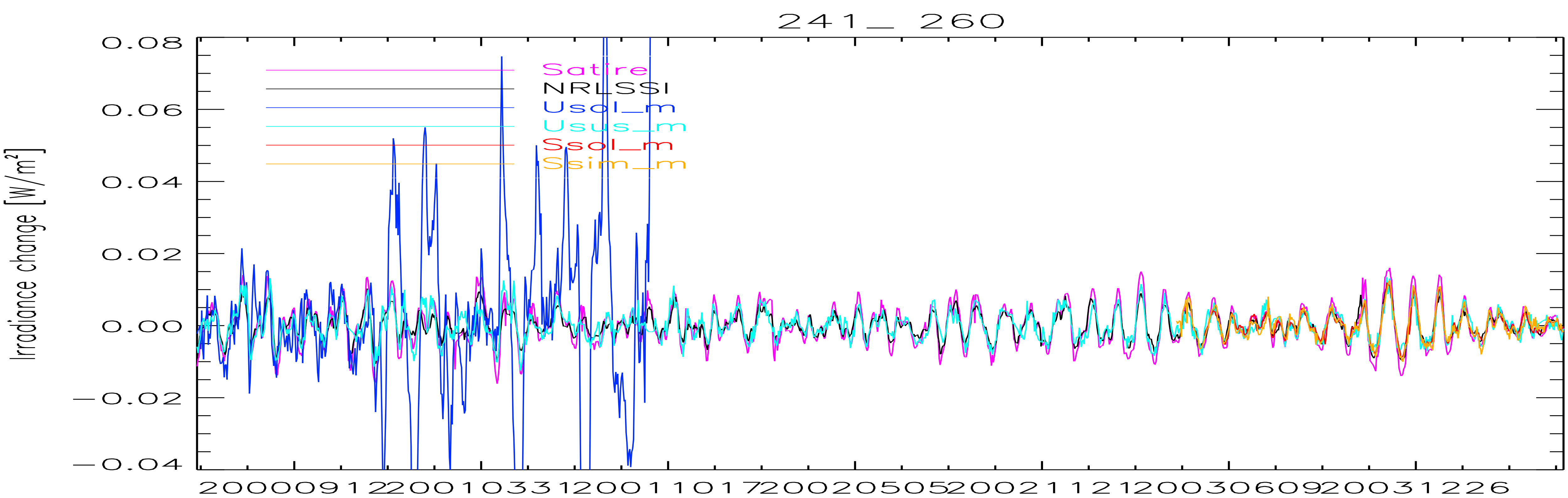

125_ 150
Satire
NRLSSI
Usol_m
Usus_m
Ssol_m
Ssim_m
Irradiance change [W/m²]
0.0006
0.0004
0.0002
0.0000
−0.0002
−0.0004
20000912200103312001101720020505200211212003060920031226


150_ 180
0.018
0.017
0.016
0.015
0.014
Satire
NRLSSI
Usol_m
Usus_m
Ssol_m
Ssim_m
Satires_m
Nrlssi_
150nm-180nm
Irradiance [W/m²]
19790506
19841026
19900418
19951009
20010331
20060921
20120313


150_ 180
0.003
0.002
0.001
0.000
−0.001
−0.002
Satire
NRLSSI
Usol_m
Usus_m
Ssol_m
Ssim_m
Irradiance change [W/m²]
20000912
20010331
20011017
20020505
20021121
20030609
20031226


241_ 260
241nm-260nm
Satire
NRLSSI
Usol_m
Usus_m
Ssol_m
Ssim_m
Satires_m
Nrlssi_m
Irradiance [W/m²]
1.25
1.24
1.23
1.22
1.21
1.20
1.19
19790506
19841026
19900418
19951009
20010331
20060921
20120313


241_ 260
Satire
NRLSSI
Usol_m
Usus_m
Ssol_m
Ssim_m
Irradiance change [W/m²]
0.08
0.06
0.04
0.02
0.00
−0.02
−0.04
20000912
20010331
20011017
20020505
20021121
20030609
20031226

1st part conclusion

- ✓ What is the reason when observed/model SSIs variations differ significantly from their solar rotation prediction ?

- ✓ Solar rotational signals are consistent between instruments and give the same SC variability.

- ✓ SATIRES larger cycle variability (in particular, SC 22 min and max and SC 24 min) wrt others looks partly caused by larger rotation modulation. Depends on wavelengths.

ok.

Other effects might exist.

Go for a 3 components model

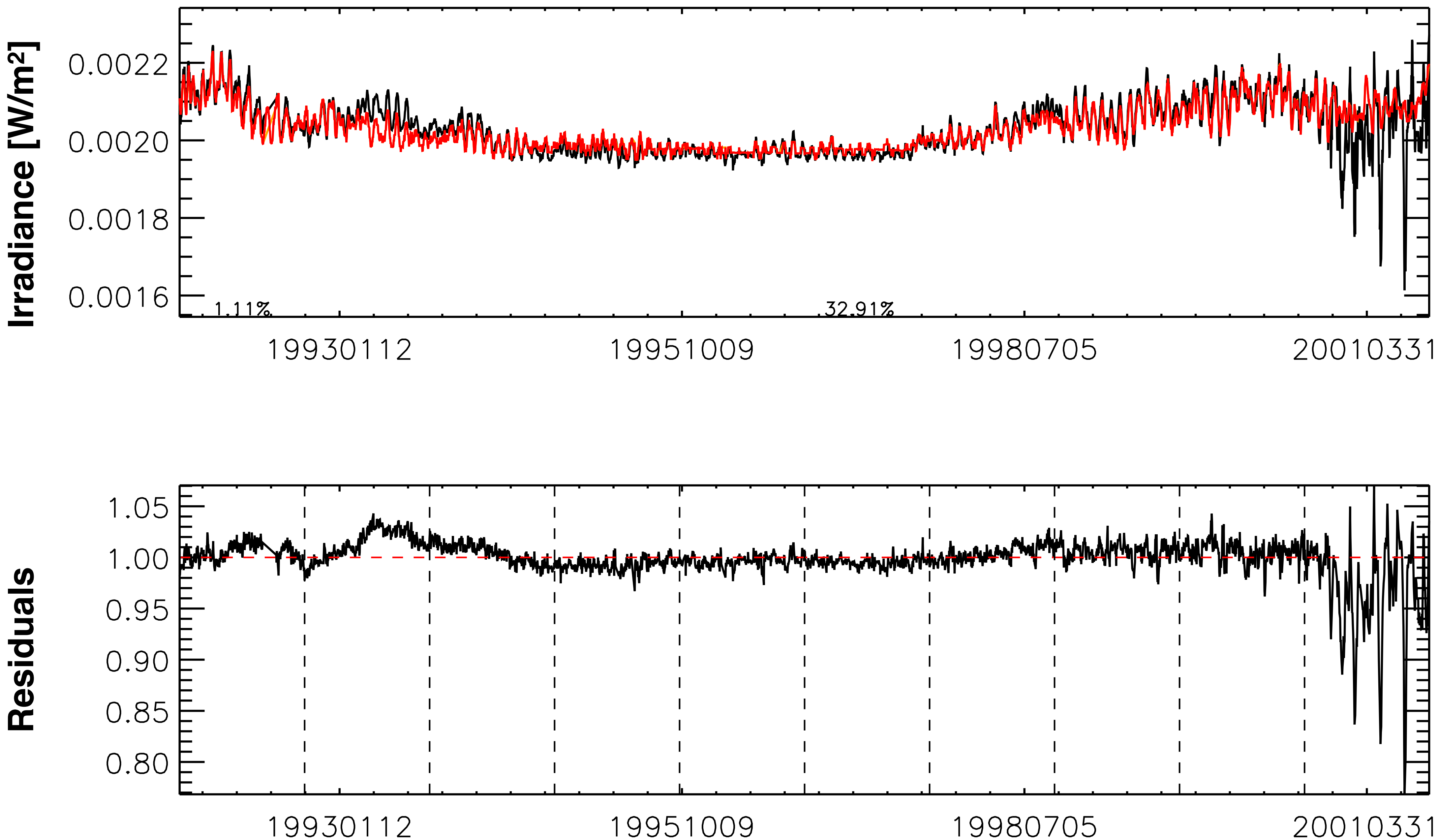
$$\overbrace{I(\lambda,t)}^{\text{SSI time series}} = a_0 + \overbrace{\sum_i a_{i,lf}(\lambda)P_{i,lf}(t)}^{\text{LF (>108 days) proxies}} + \overbrace{a_{i,hf}(\lambda)P_{i,hf}(t)}^{\text{HF (<108 days) proxies}} + \varepsilon$$

best model coefficients (lsq sense) determined for each λ

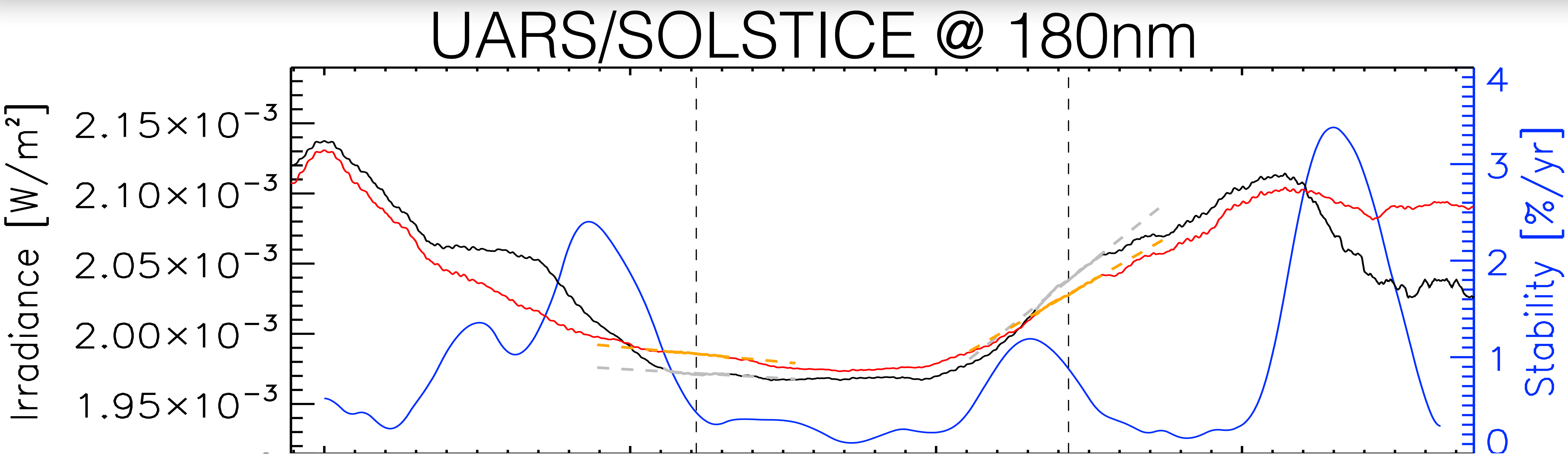
Each spectral time series of each datasets is fitted with a two time scale linear component model

Estimating stability

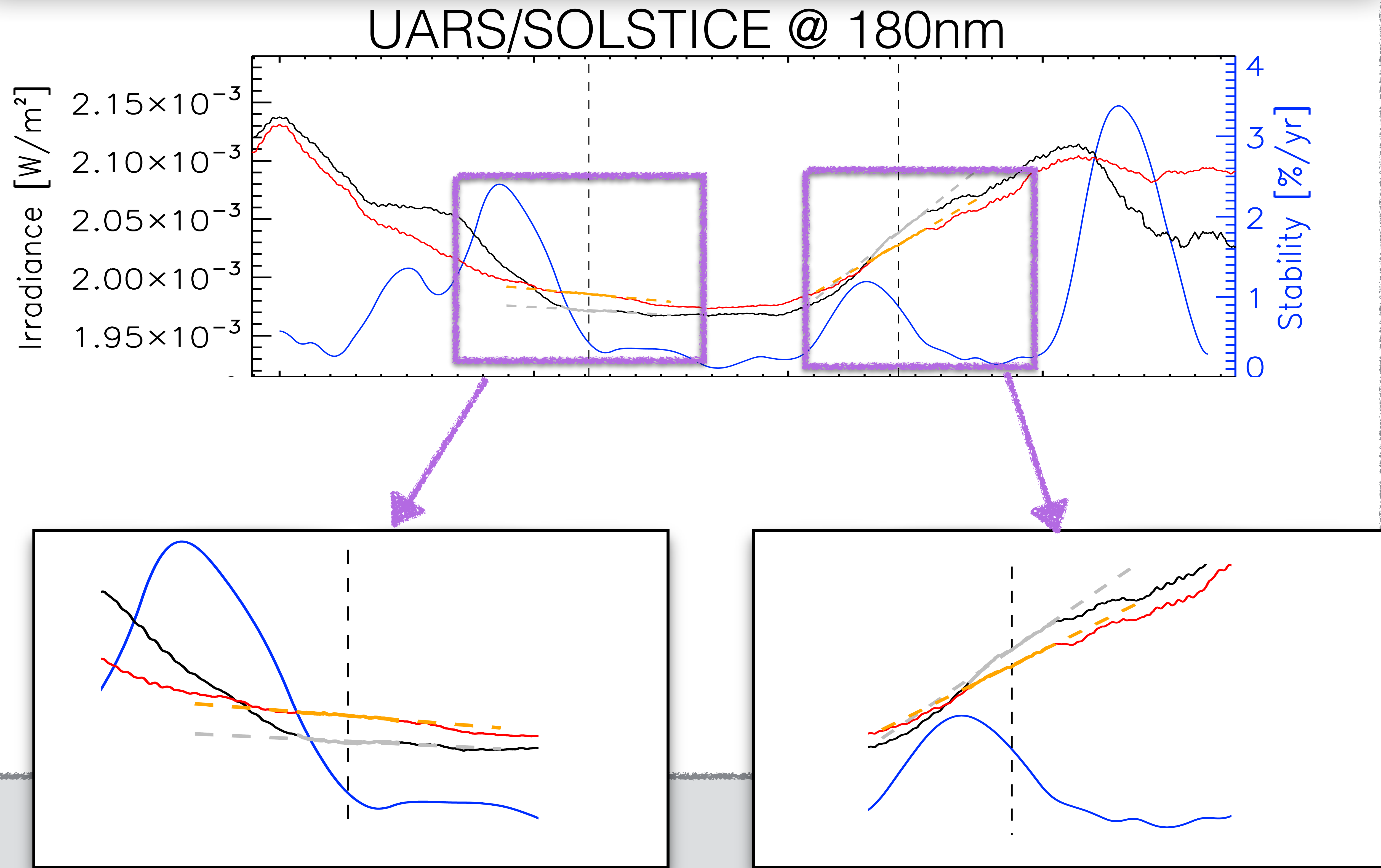
UARS/SOLSTICE @ 180nm



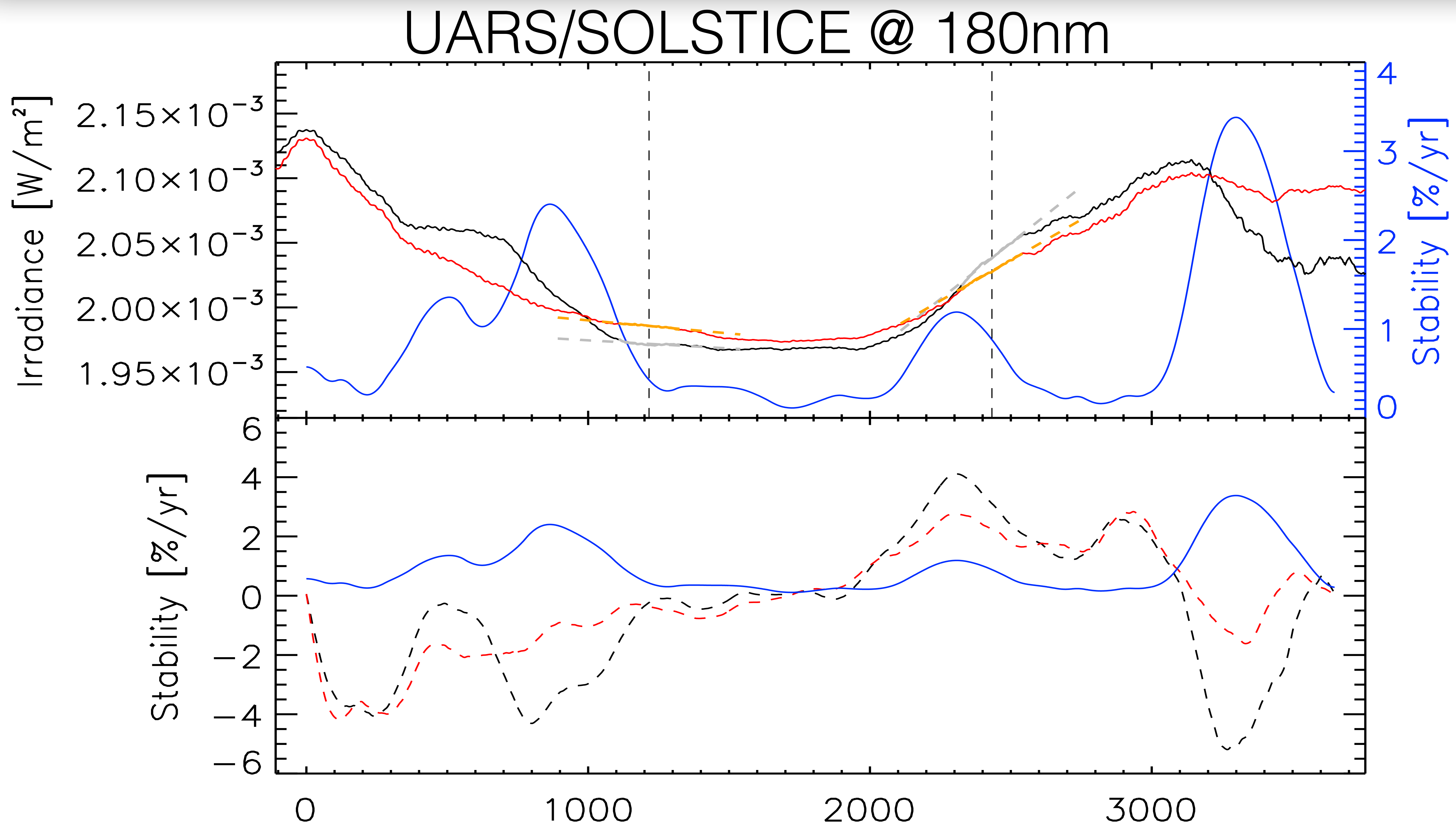
Estimating stability



Estimating stability

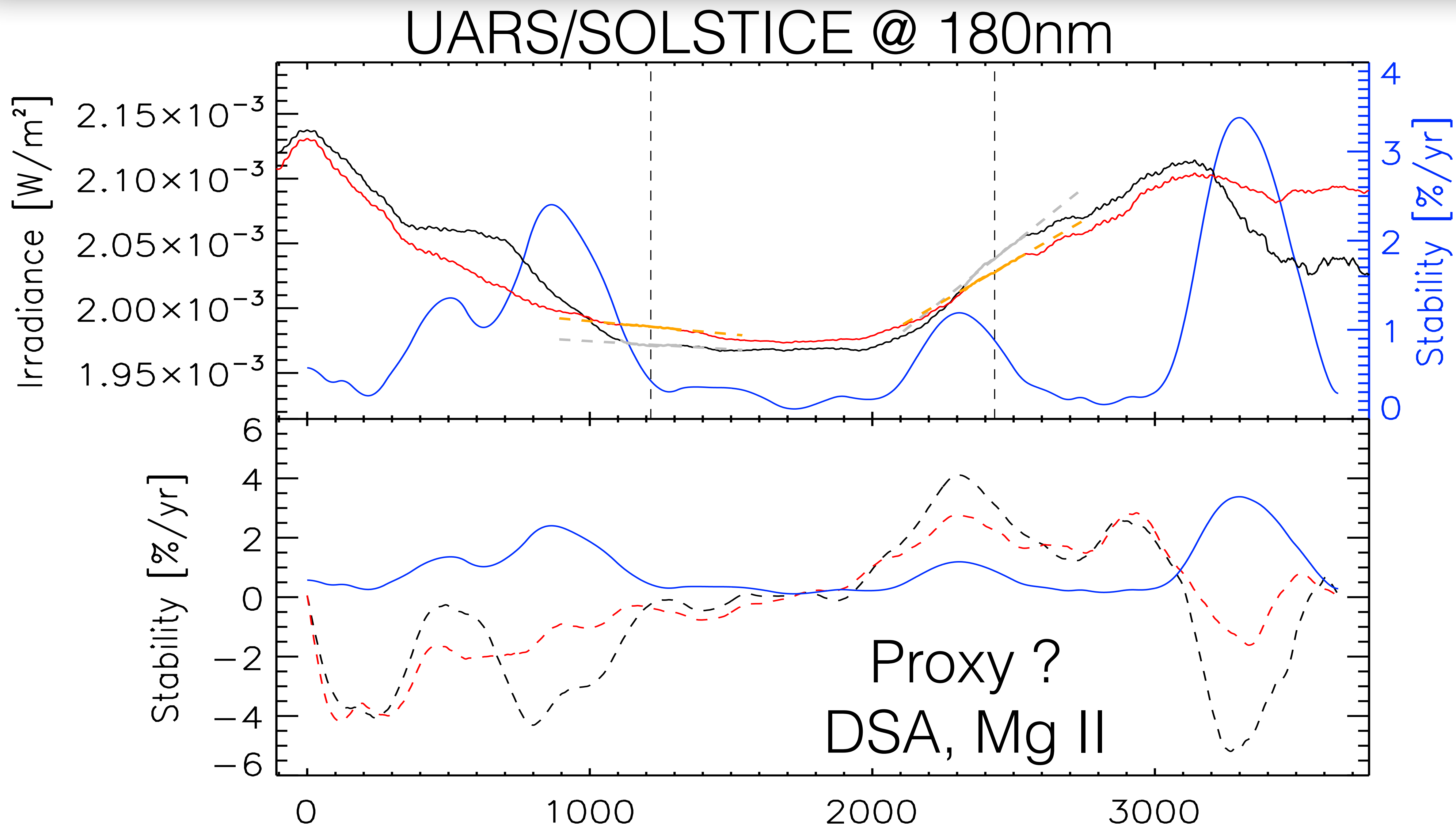


Estimating stability



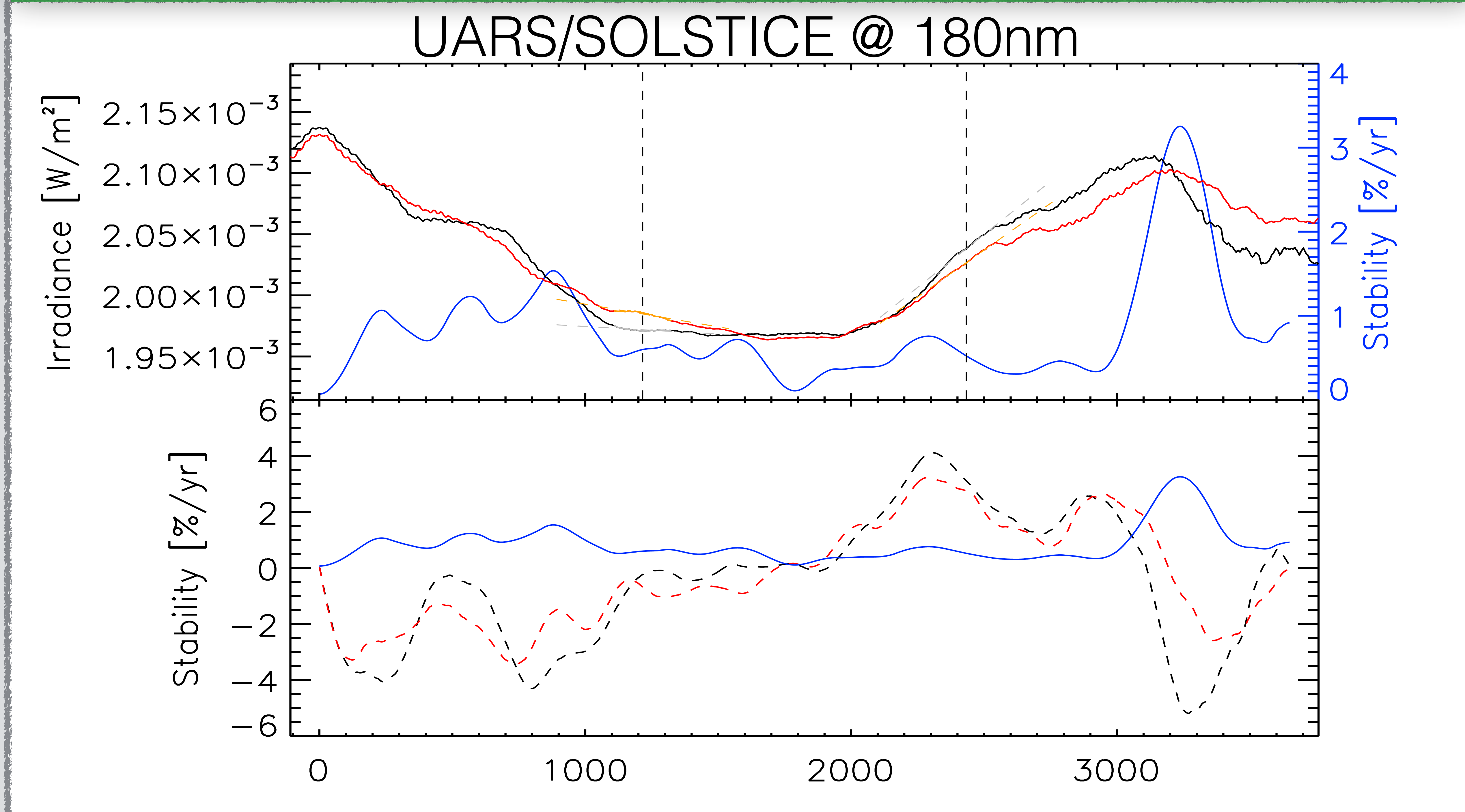
The stability is defined as $s(\lambda, t) = \mid a_{obs}(\lambda, t) - a_{bestfit}(\lambda, t) \mid$

Estimating stability



The stability is defined as $\boxed{s(\lambda, t) = | a_{obs}(\lambda, t) - a_{bestfit}(\lambda, t) |}$

Estimating stability



Proxy ?

DSA, Mg II, radio flux at 3.2cm, 10.7cm, 15cm, and 30cm

Hypothesis behind

What can not be reproduced by a two time scales and six proxies model is more uncertain !

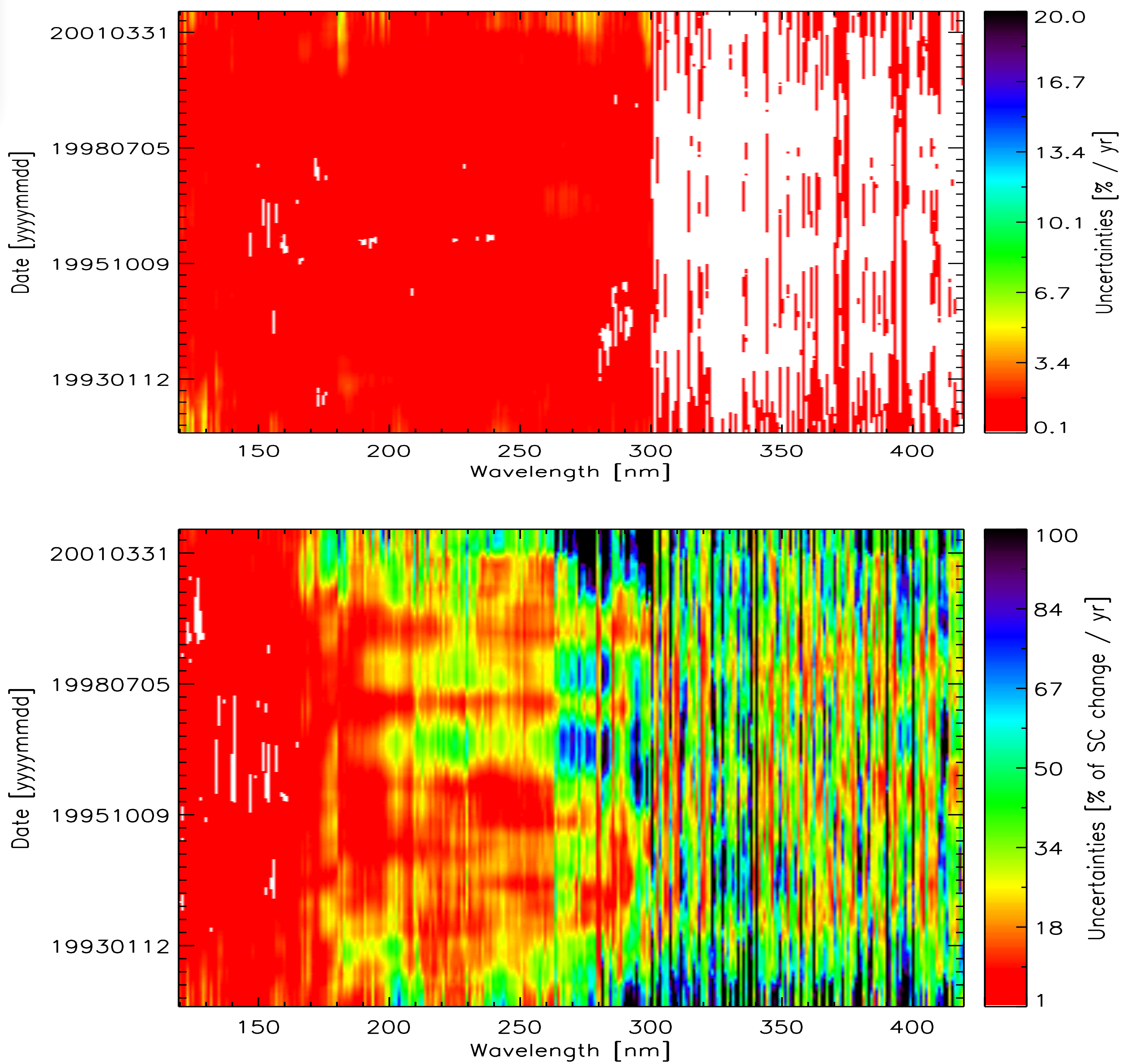
Cons: this multi parameters model can reproduce trends and non solar behavior to a certain degree. It is permissive.

Results

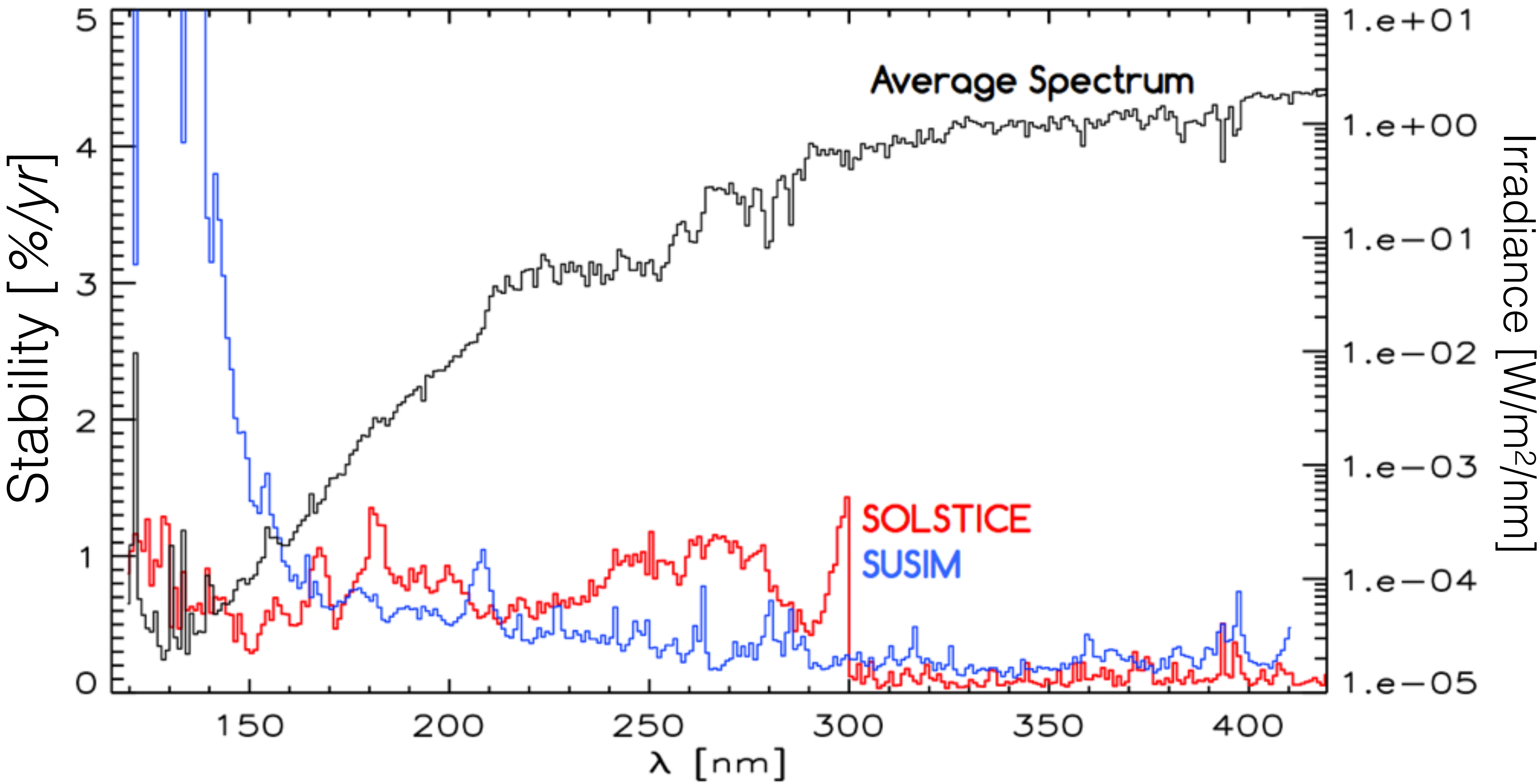
UARS/ SOLSTICE

- In % / yr

- In % of solar cycle variation / yr

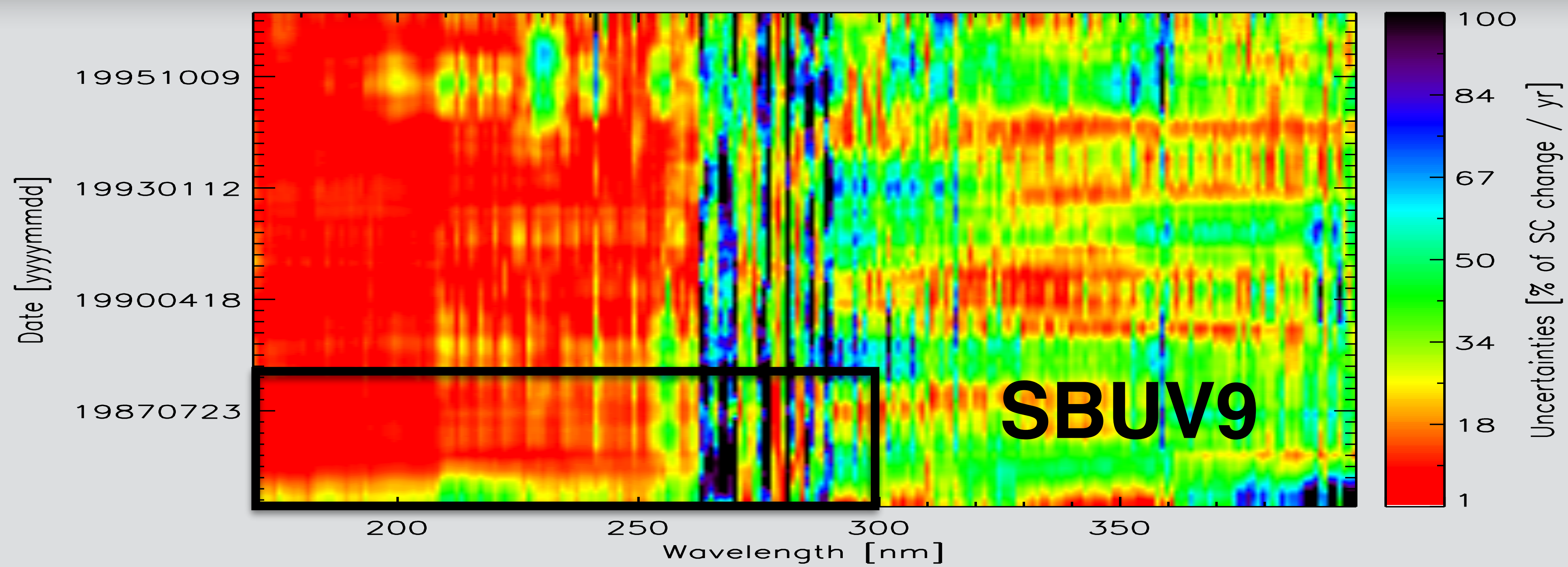


UARS Overview

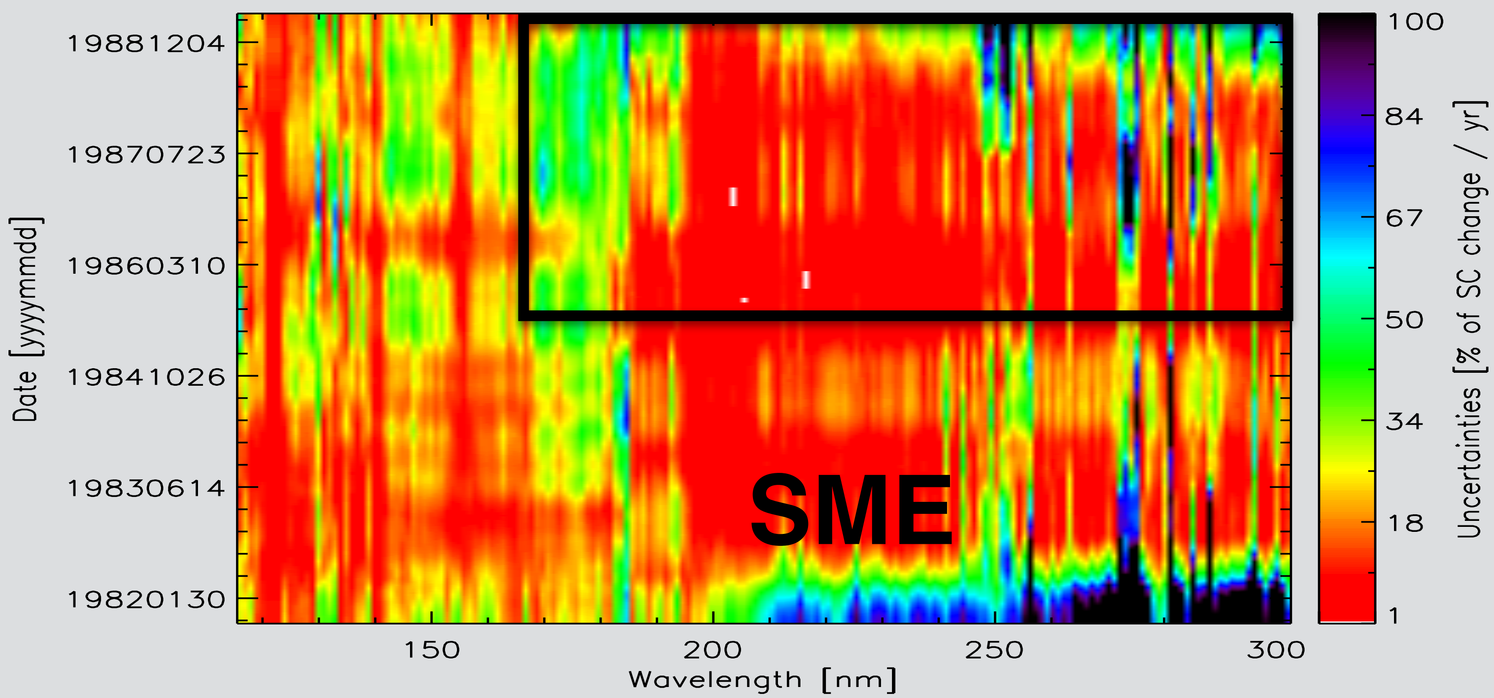


- Stabilities are averaged over the mission lifetime

SME & SBUV 9

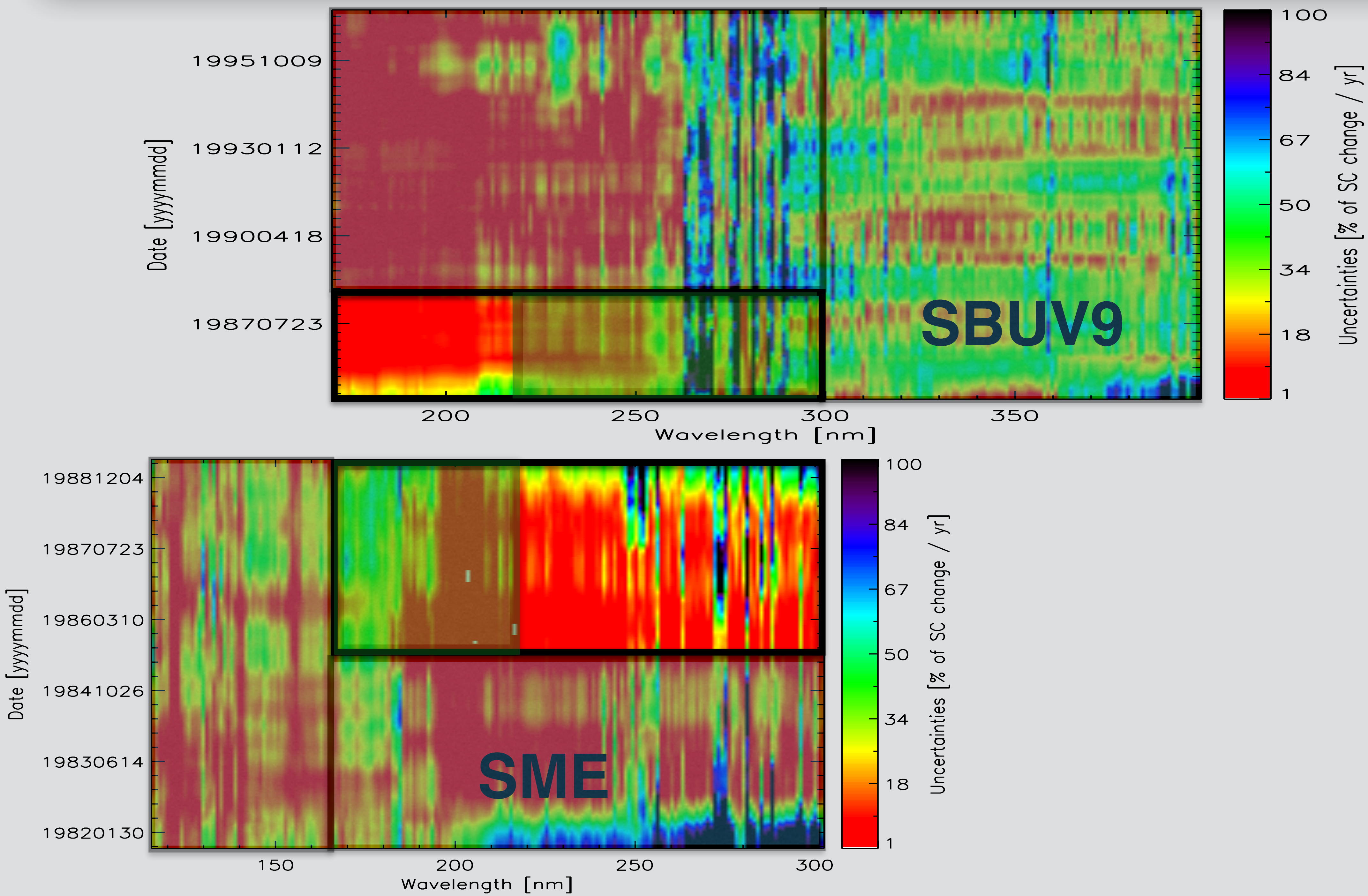


19951009
19930112
19900418
19870723
Date [yyyymmdd]
SBUV9
200
250
300
350
Wavelength [nm]
100
84
67
50
34
18
1
Uncertainties [% of SC change / yr]



19881204
19870723
19860310
19841026
19830614
19820130
Date [yyyymmdd]
SME
150
200
250
300
Wavelength [nm]
100
84
67
50
34
18
1
Uncertainties [% of SC change / yr]

SME & SBUV 9



19951009
19930112
19900418
19870723
Date [yyyymmdd]
SBUV9
200
250
300
350
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Uncertainties [% of SC change / yr]
19881204
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SME
150
200
250
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Wavelength [nm]
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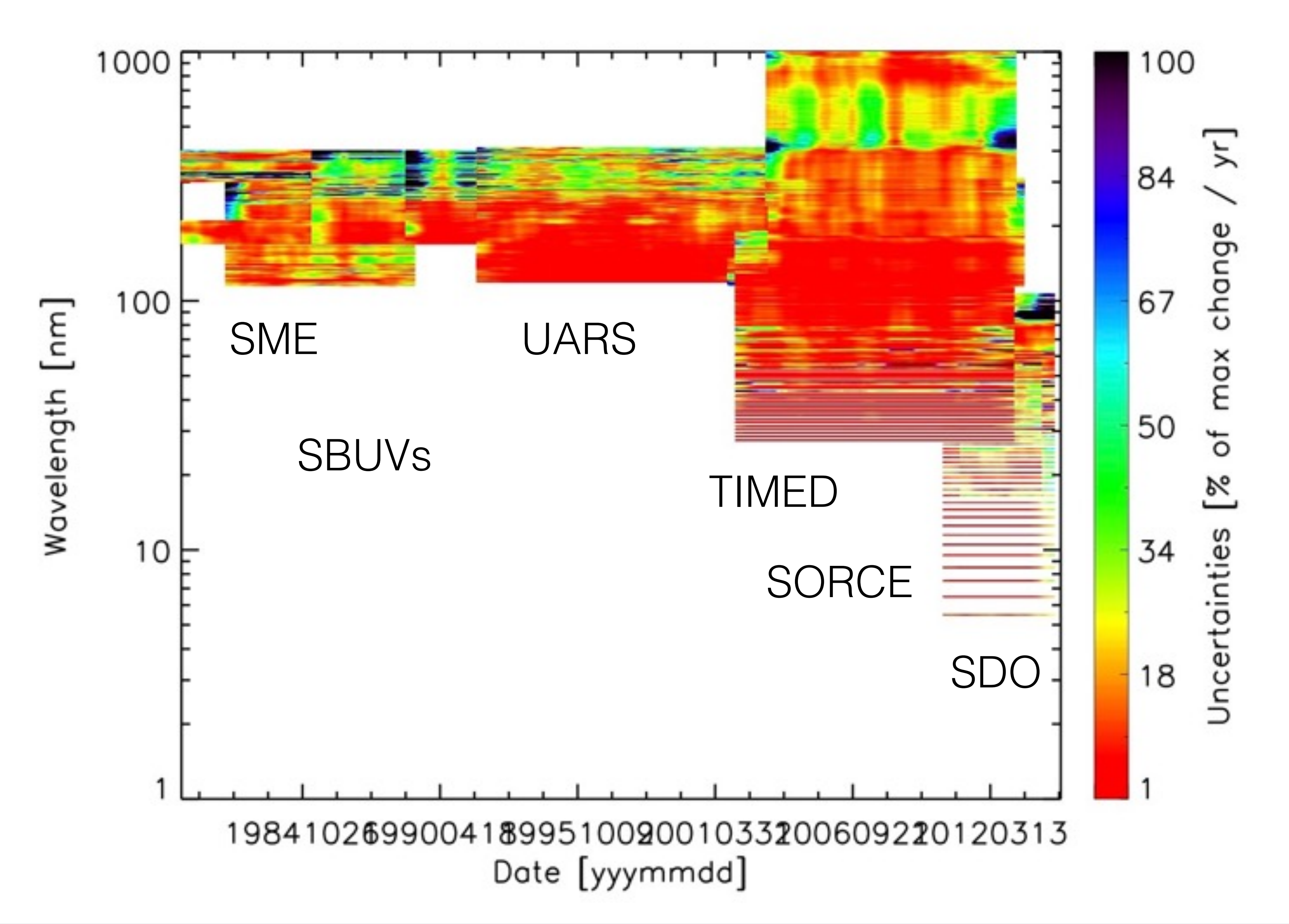
84
67
50
34
18
1
Uncertainties [% of SC change / yr]

SSI datasets Overview



➡ Best range is in the UV below 220nm: no surprise !

CONCLUSION

- ✓ Strength of stability as computed here:
  - ✓ Determine the SSI/proxy relationships for each time series, in a permissive way
  - ✓ Allows to quantify (weight) in the same way most of the doubts on all instrument time series
- ✓ Weakness of stability as computed here:
  - ✓ depending on number of proxies used, can reproduce instrumental features)
- ✓ Stability can be used as weights for composite.
- ✓ SSI variations trustable up to about 220-240nm
- ✓ SORCE trend in the visible canNOT be reproduced by combination of proxies

Used in this work: SSI datasets corrected for outliers and gaps, see Scholl et al., 2015