Validation of SSI datasets

On the long term

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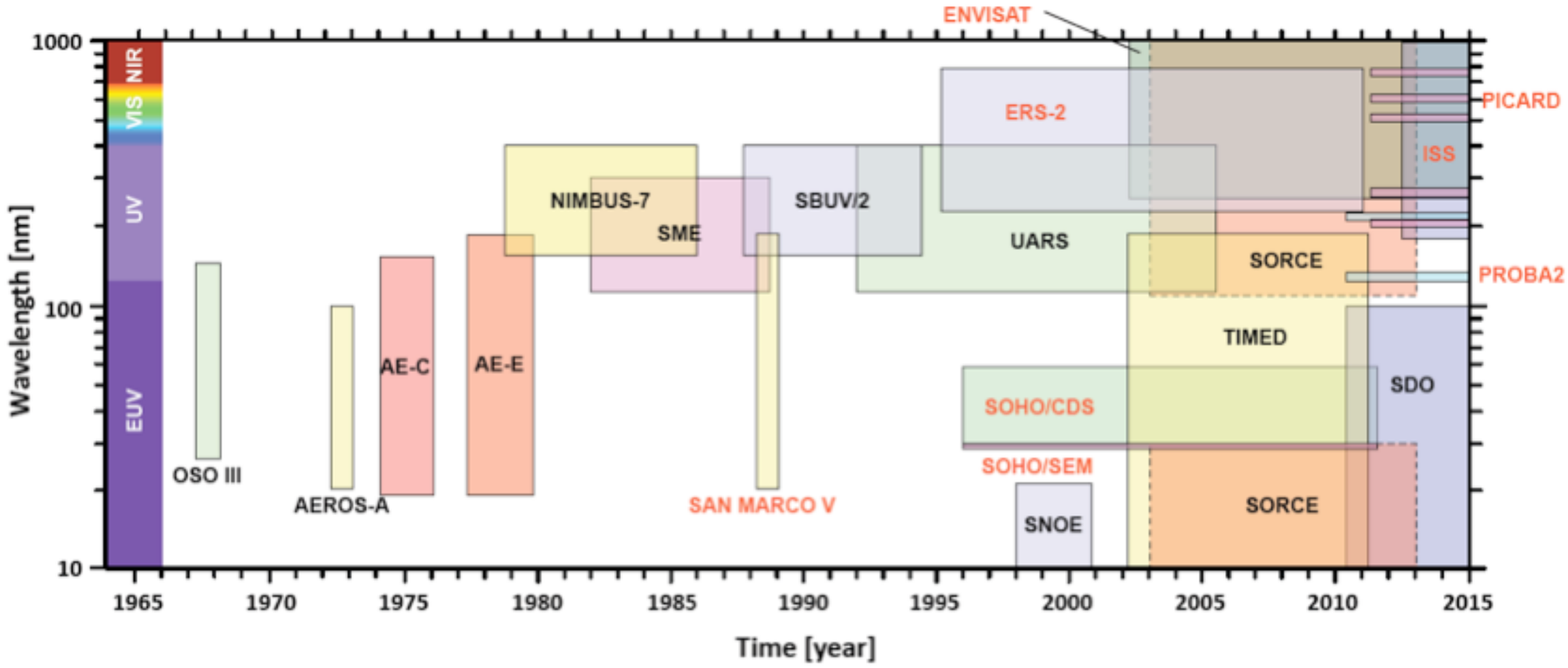
SSI Measurements



- What are the uncertainties on these time series ?

Measuring SSI

True irradiance

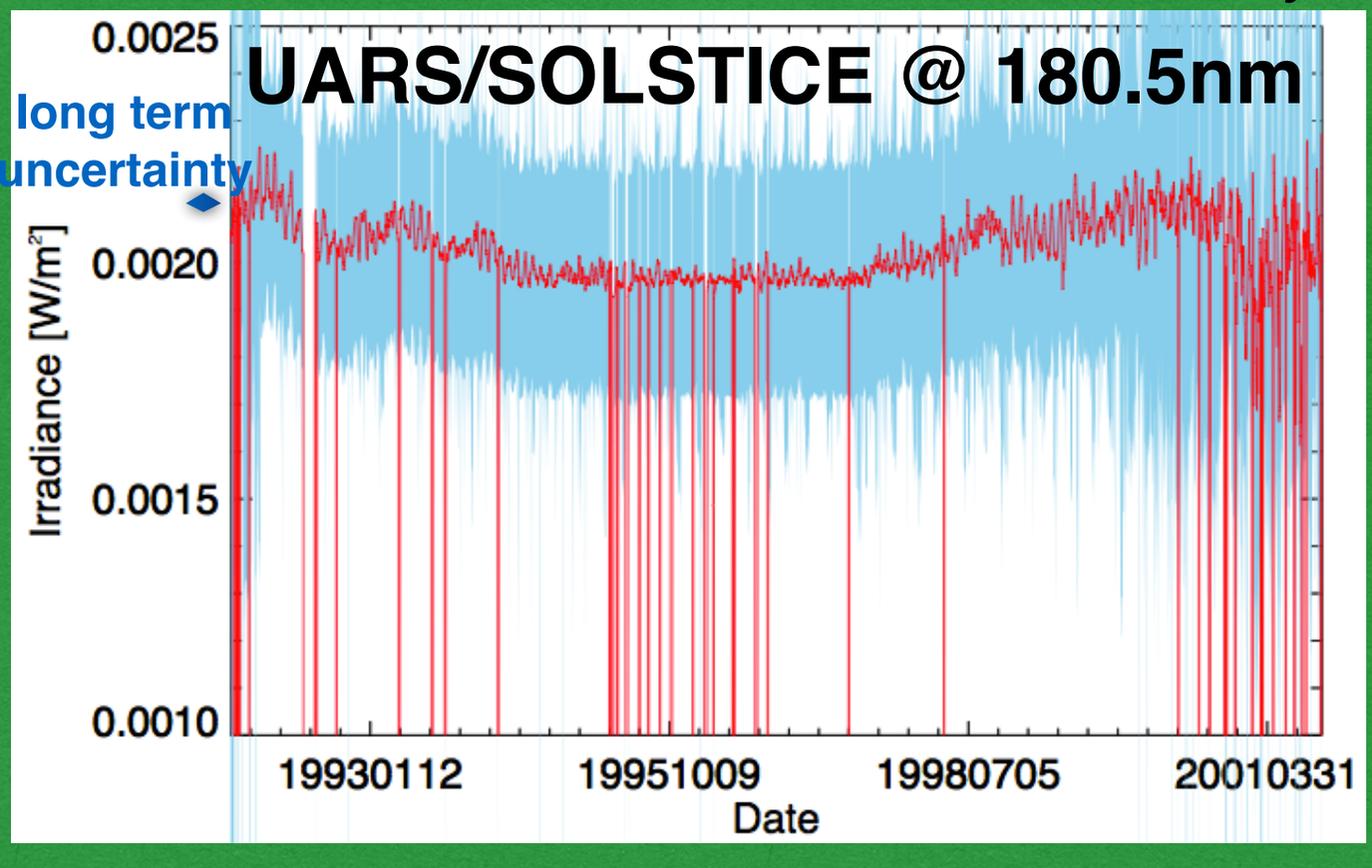
$h\nu$

INSTRUMENT

On board monitoring system: degradation + others

Ground calibration & processing

Measured irradiance *+ Uncertainty*



NB: accuracy or long term uncertainty

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Ground calibration & processing

Instrument team

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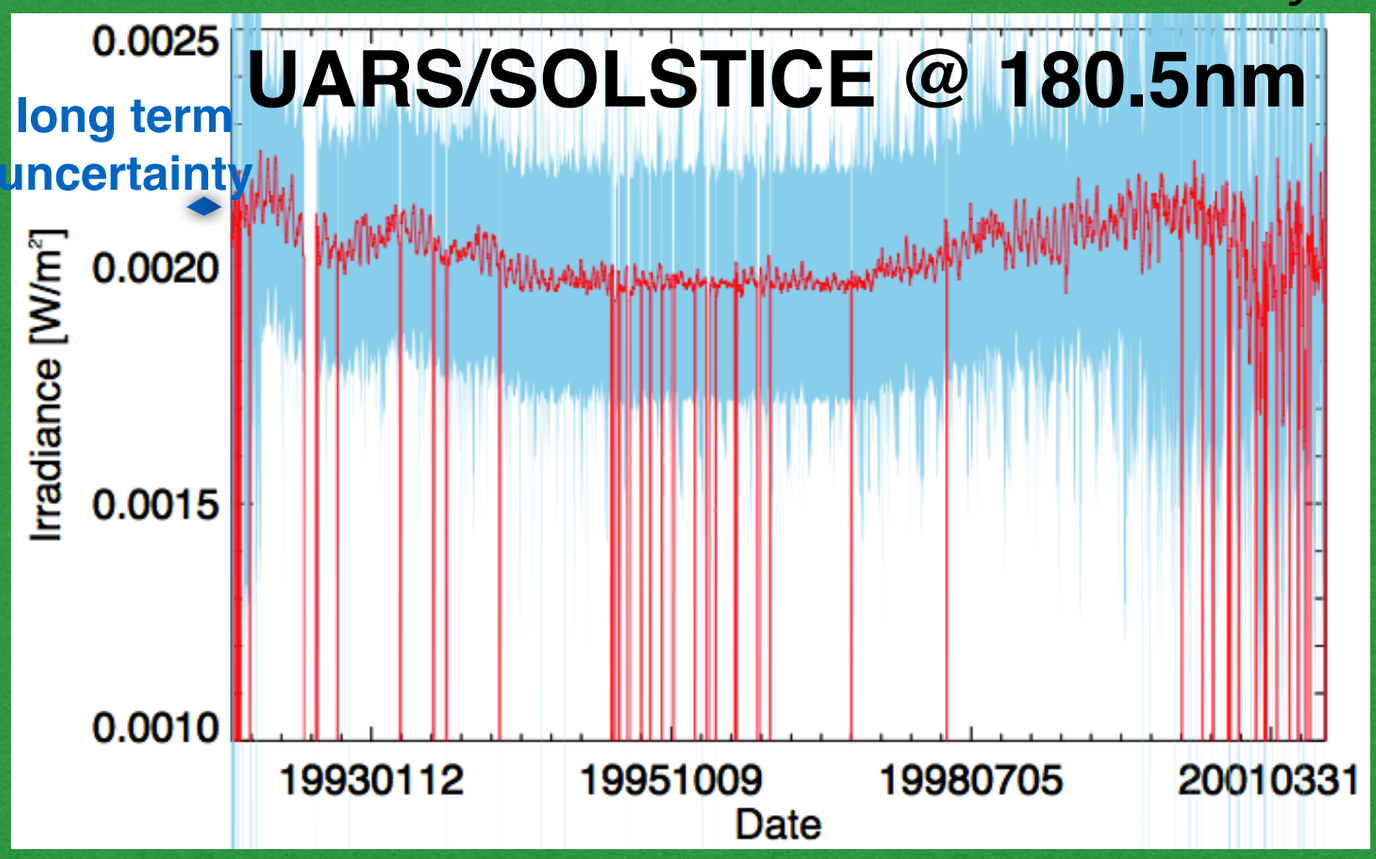

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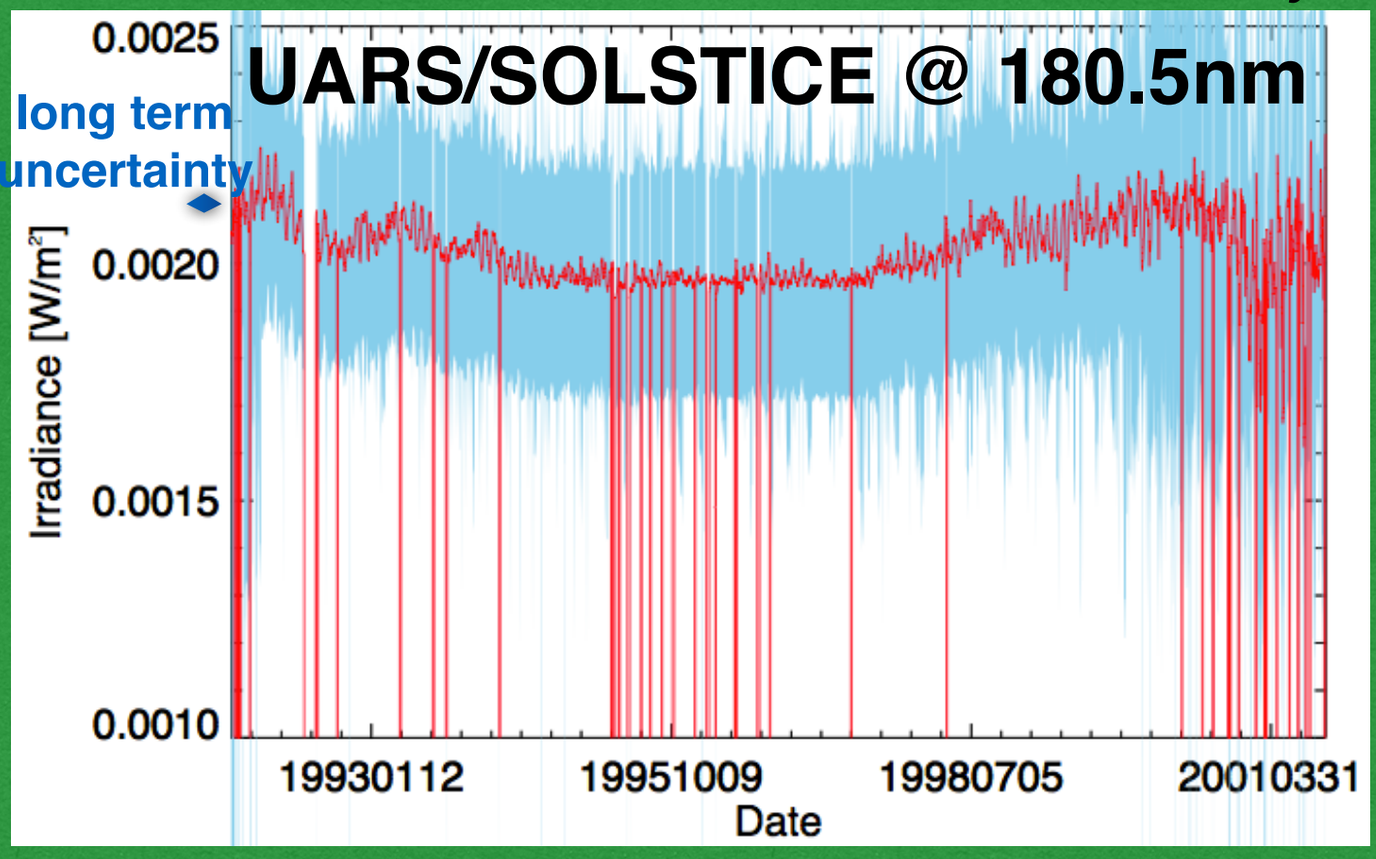

NB: accuracy or long term uncertainty

COMMUNITY

Analysis/Comparison with other instruments, models, solar proxies, and all (almost) you can imagine

Measuring SSI

True irradiance

$h\nu$

INSTRUMENT

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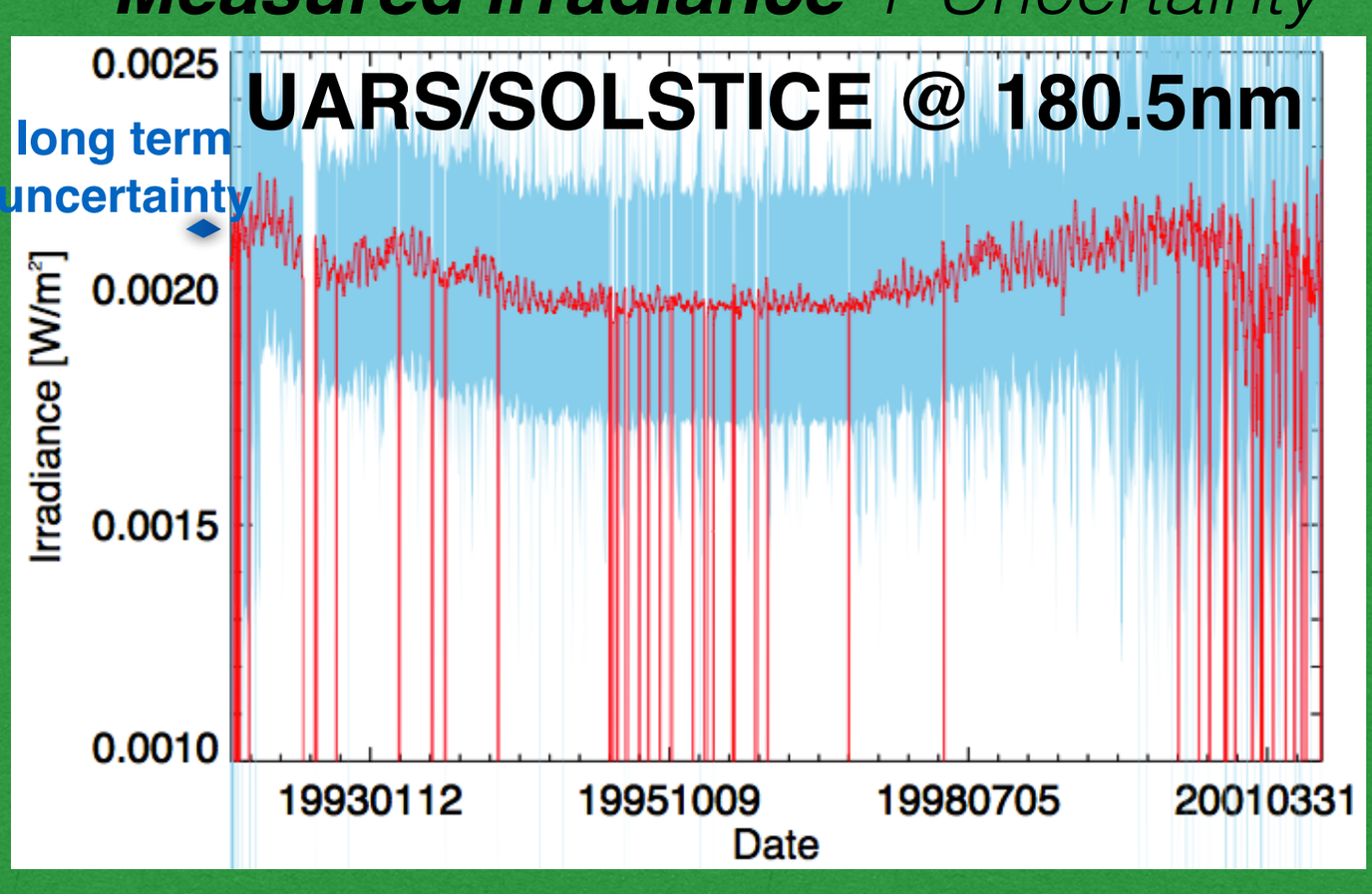
$$R(t_1, t_2) = \frac{I(t_2)}{I(t_1)} \qquad U(R)?$$

Measured irradiance *+ Uncertainty*



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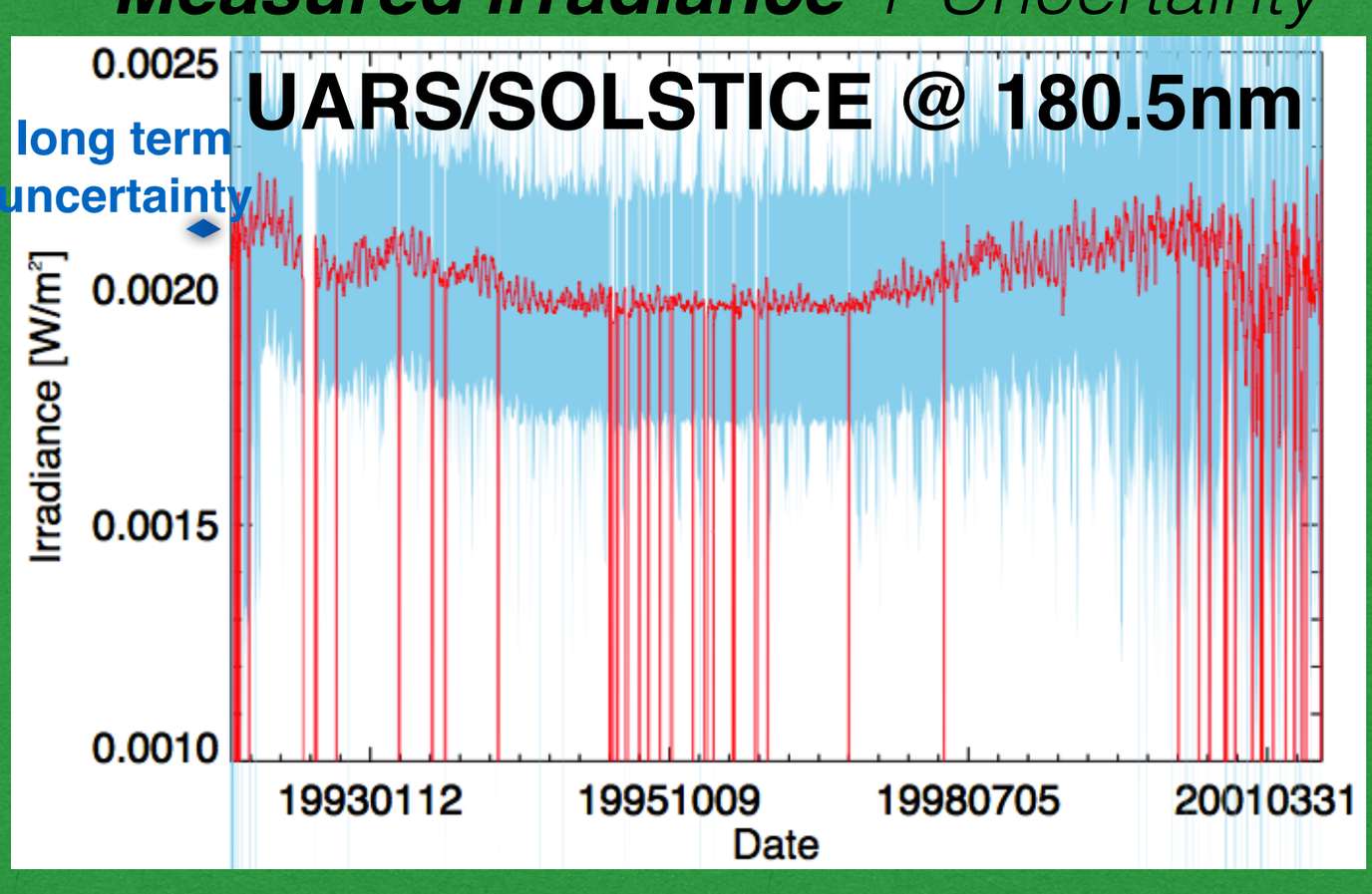

NB: accuracy or long term uncertainty

$$R(t_1, t_2) = \frac{I(t_2)}{I(t_1)} \qquad U(R)?$$

$$\frac{U(R)}{R} = \sqrt{\left(\frac{U(I(t_1)}{I(t_1)}\right)^2 + \left(\frac{U(I(t_1)}{I(t_1)}\right)^2}$$

Measuring SSI

True irradiance

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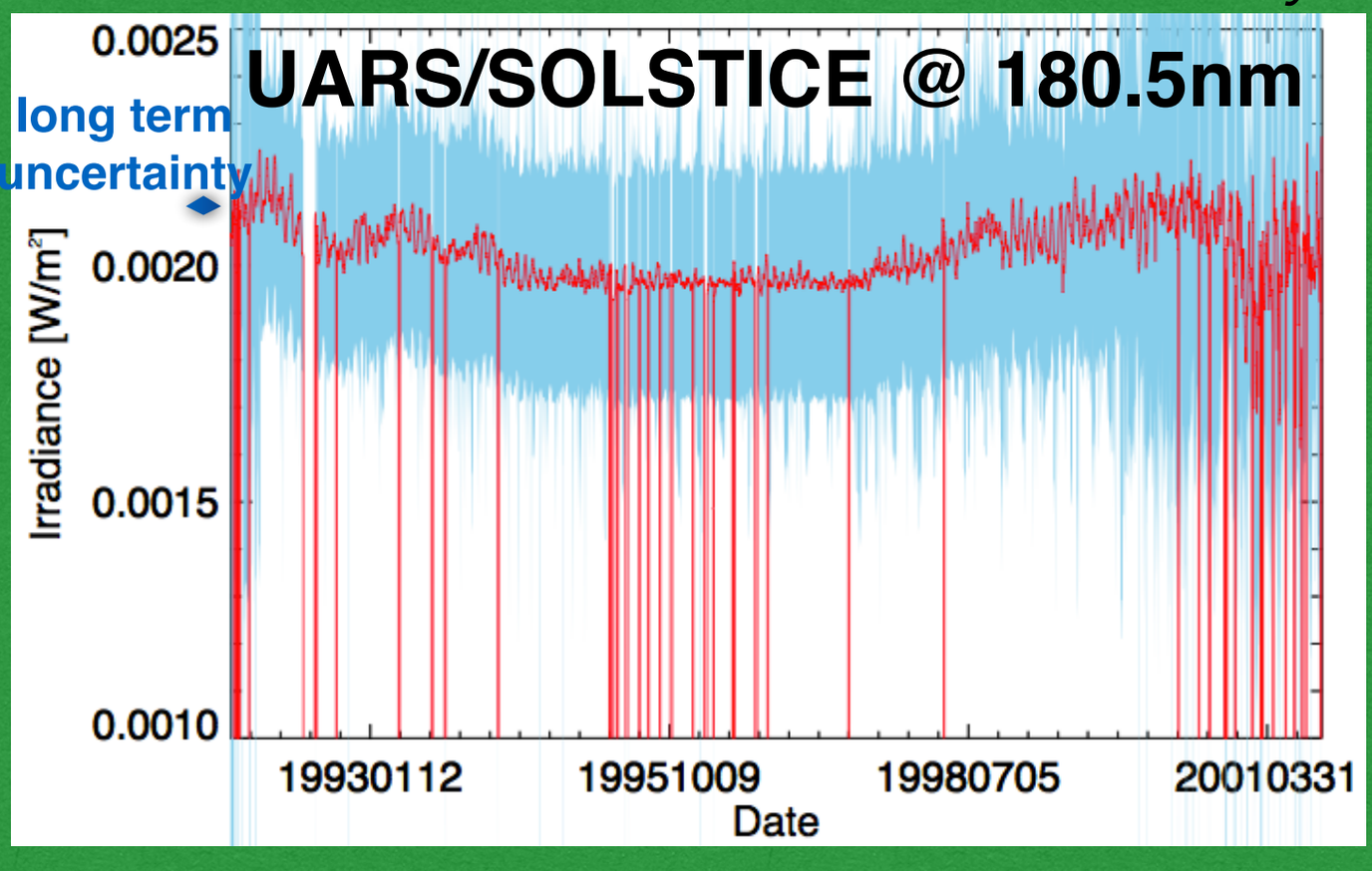

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$$\frac{U(R)}{R} = \sqrt{\left(\frac{U(I(t_1)}{I(t_1)}\right)^2 + \left(\frac{U(I(t_1)}{I(t_1)}\right)^2}$$

$$\frac{U(R(t_1,t_2))}{R(t_1,t_2)} = \int_{t_1}^{t_2} LTU(t)dt$$

$$\approx LTU \times (t_2 - t_1)$$

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True irradiance

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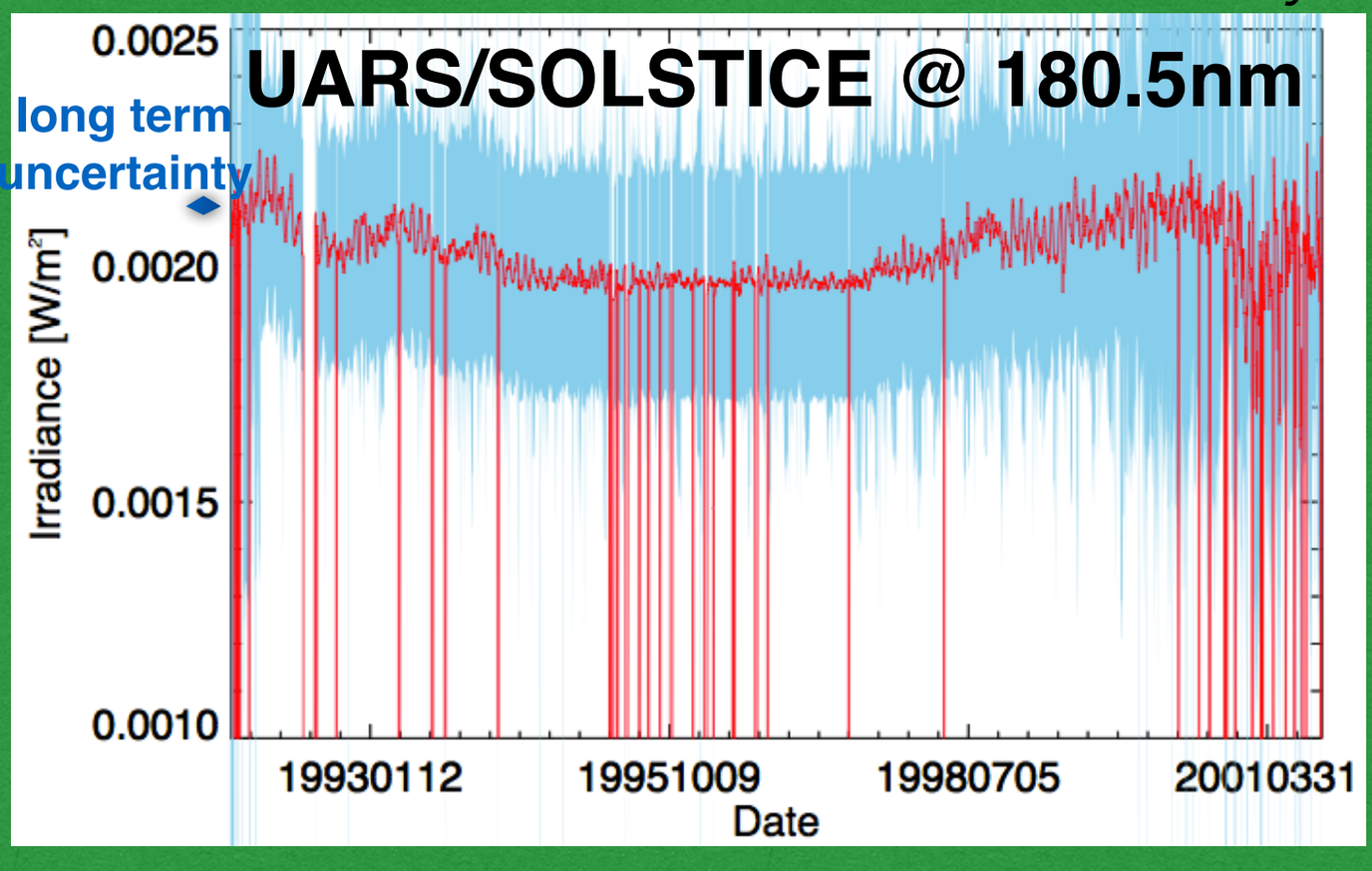

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$$\frac{U(R(t_1,t_2))}{R(t_1,t_2)} = \int_{t_1}^{t_2} LTU(t)dt \approx LTU \times (t_2 - t_1)$$

Ideally,

LTU is in % (or ppm) / year

LTU is time dependent

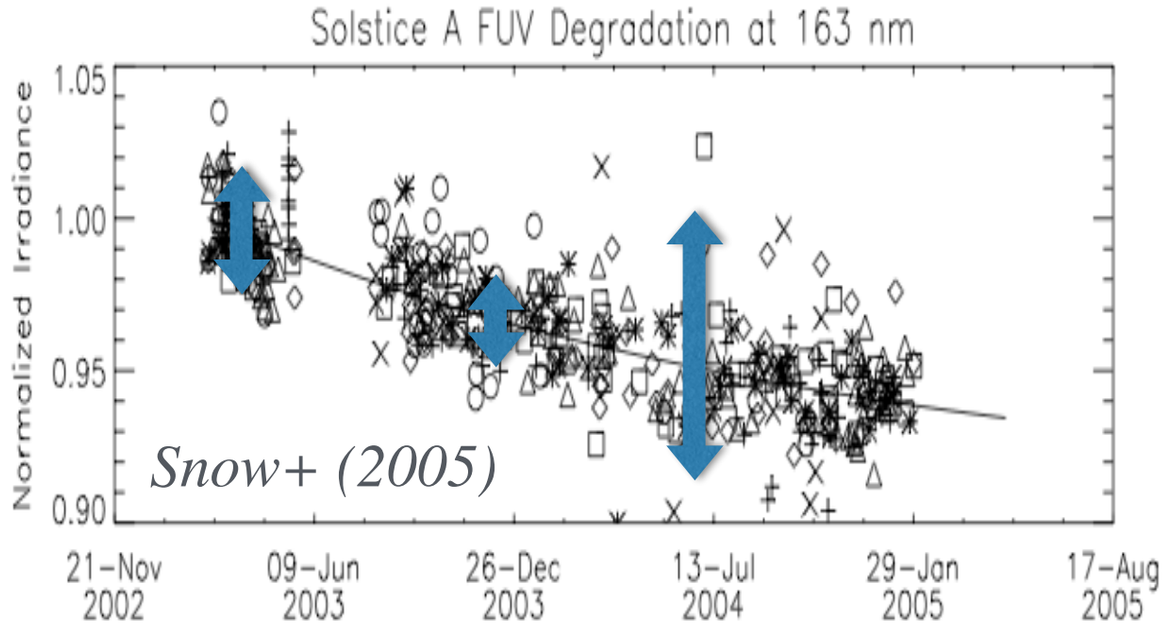
Long term uncertainty

$$I^{meas}(t) = I^{true}(t)g(t) \qquad LTU \approx U(g(t)) \qquad \text{(but not only)}$$

- It is usually difficult from the instrument to give time-dependent long term accuracy.

- Old datasets (SME ?) has no LTU.

- Some have no independent LTU (SBUV)



➡ **<u>Aim</u>: homogeneous assessment of long term uncertainties of all datasets**

Validation / Comparison

- What to compare with ?

➡ Other data
➡ Existing models (proxy based or semi empirical)
➡ proxies

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➡ Existing models (proxy based or semi empirical)

➡ **proxies**

➡ **Hyp. 1: proxies can reproduce ssi variations to a certain degree**

Validation / Comparison

- What to compare with ?

➡ Other data

➡ Existing models (proxy based or semi empirical)

➡ **proxies**

Hyp. 1: proxies can reproduce ssi variations to a certain degree

Hyp. 2: assumed relationships between proxies and SSI

Method1

Method2

The less restrictive
The more permissive

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

SSI time series — LF (>108 days) proxies — HF (<108 days) proxies

$$I(\lambda,t) = a_0 + \sum_i a_{i,lf}(\lambda)P_{i,lf}(t) + a_{i,hf}(\lambda)P_{i,hf}(t) \; + \; \varepsilon$$

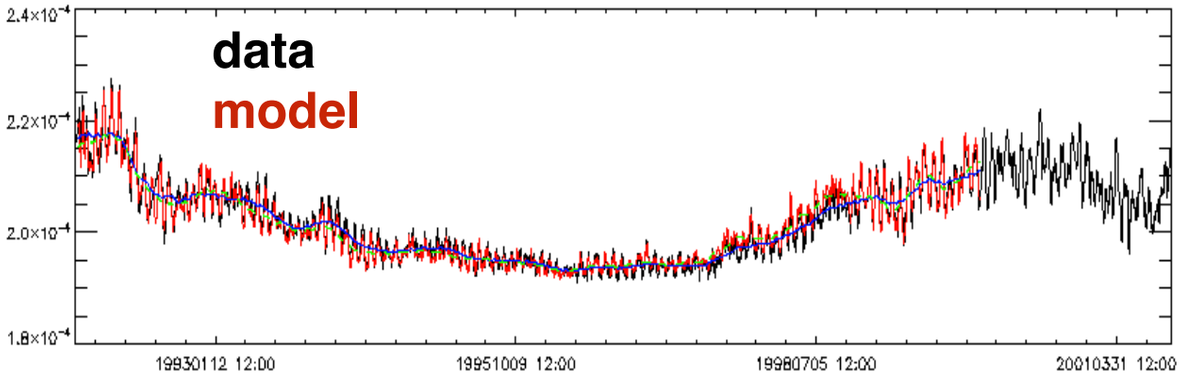
best model coefficients (lsq sense) determined for each λ

- Used proxies:

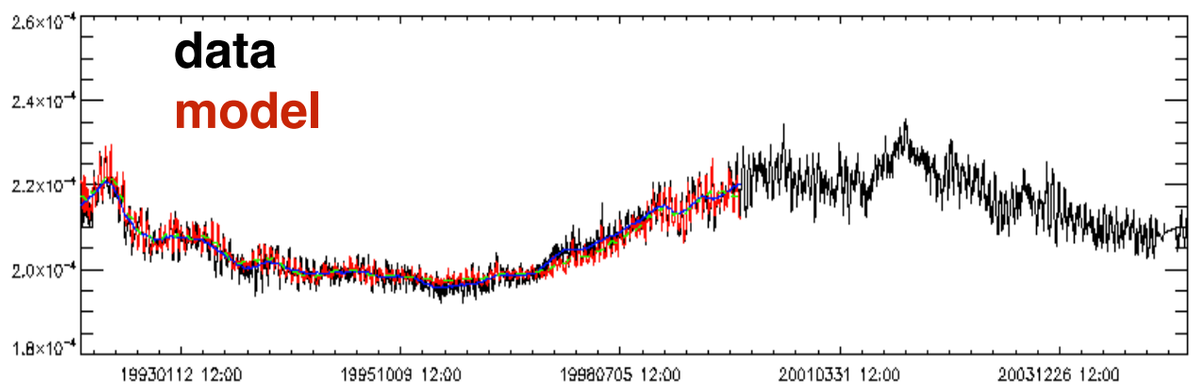
  DSA, Mg II, and radio fluxes at 3.2cm, 10.7cm, 15cm, 30cm.

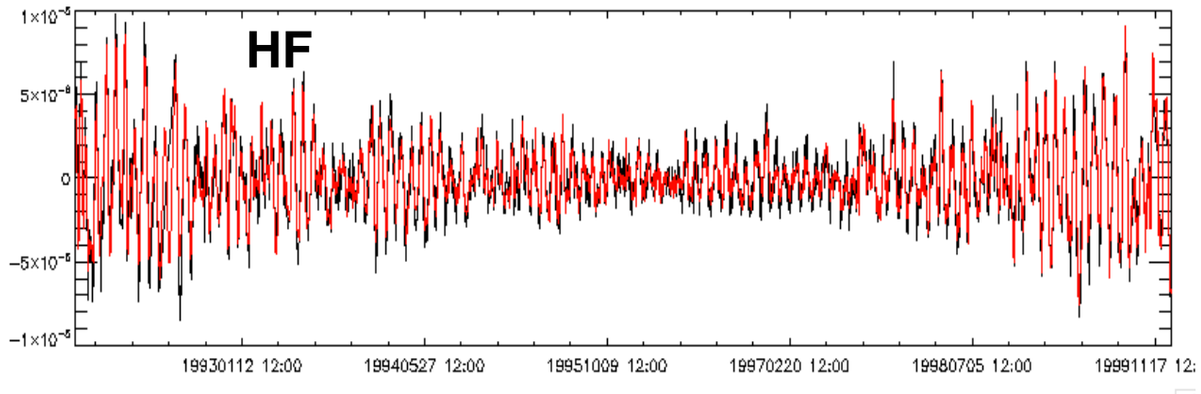
Why two time-scales ?

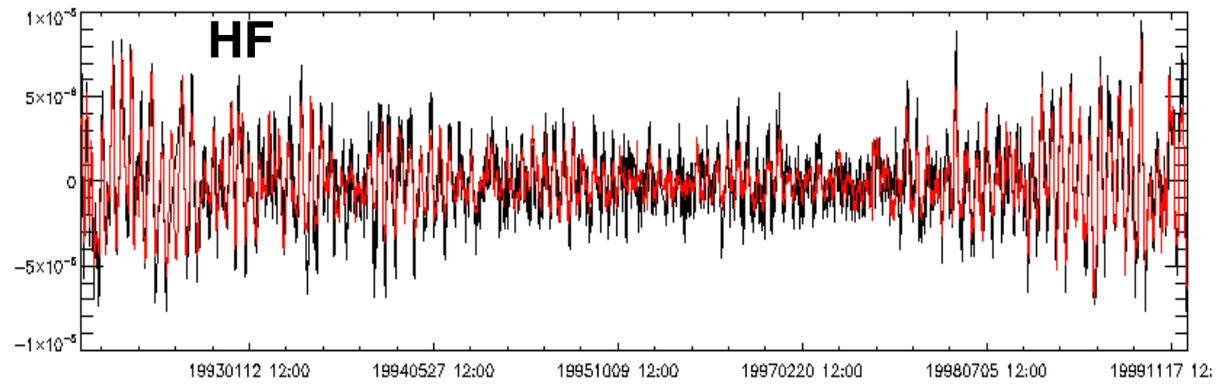
U/SOLSTICE@160nm

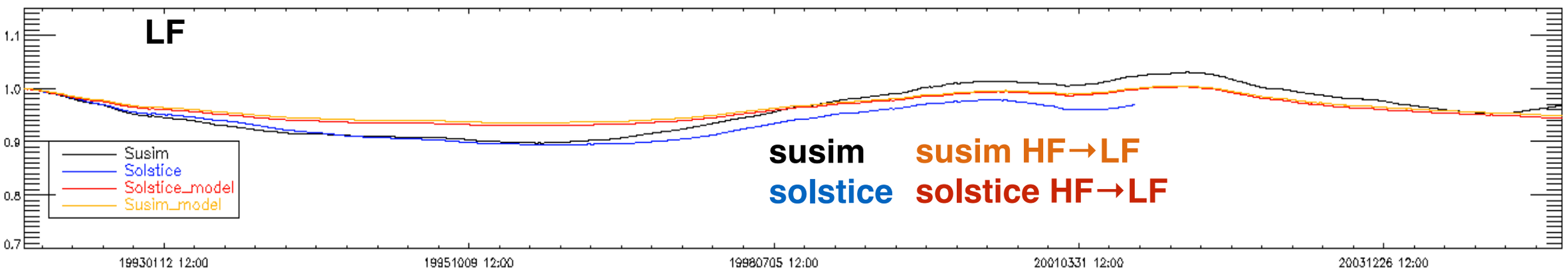


U/SUSIM@160nm





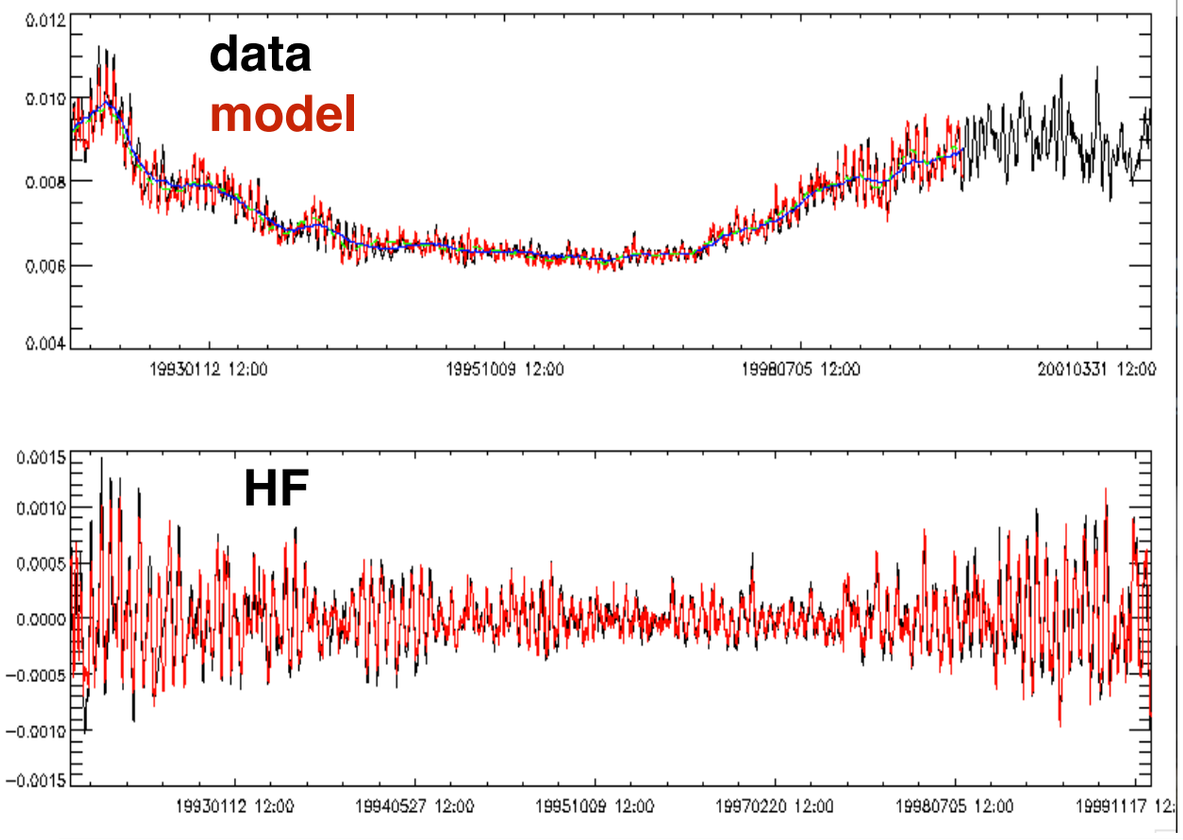




- Rotation amplitudes underestimates the cycle variations

Why two time-scales ?

U/SOLSTICE@Ly-α



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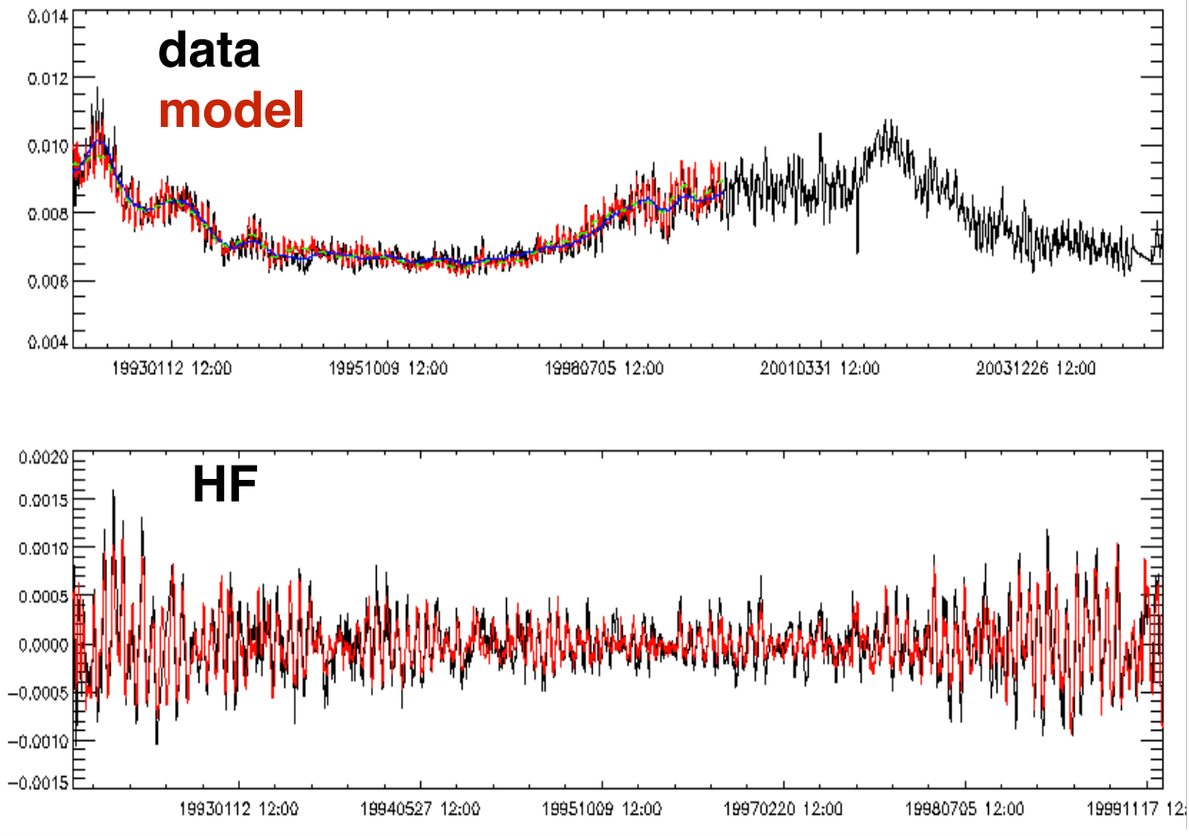
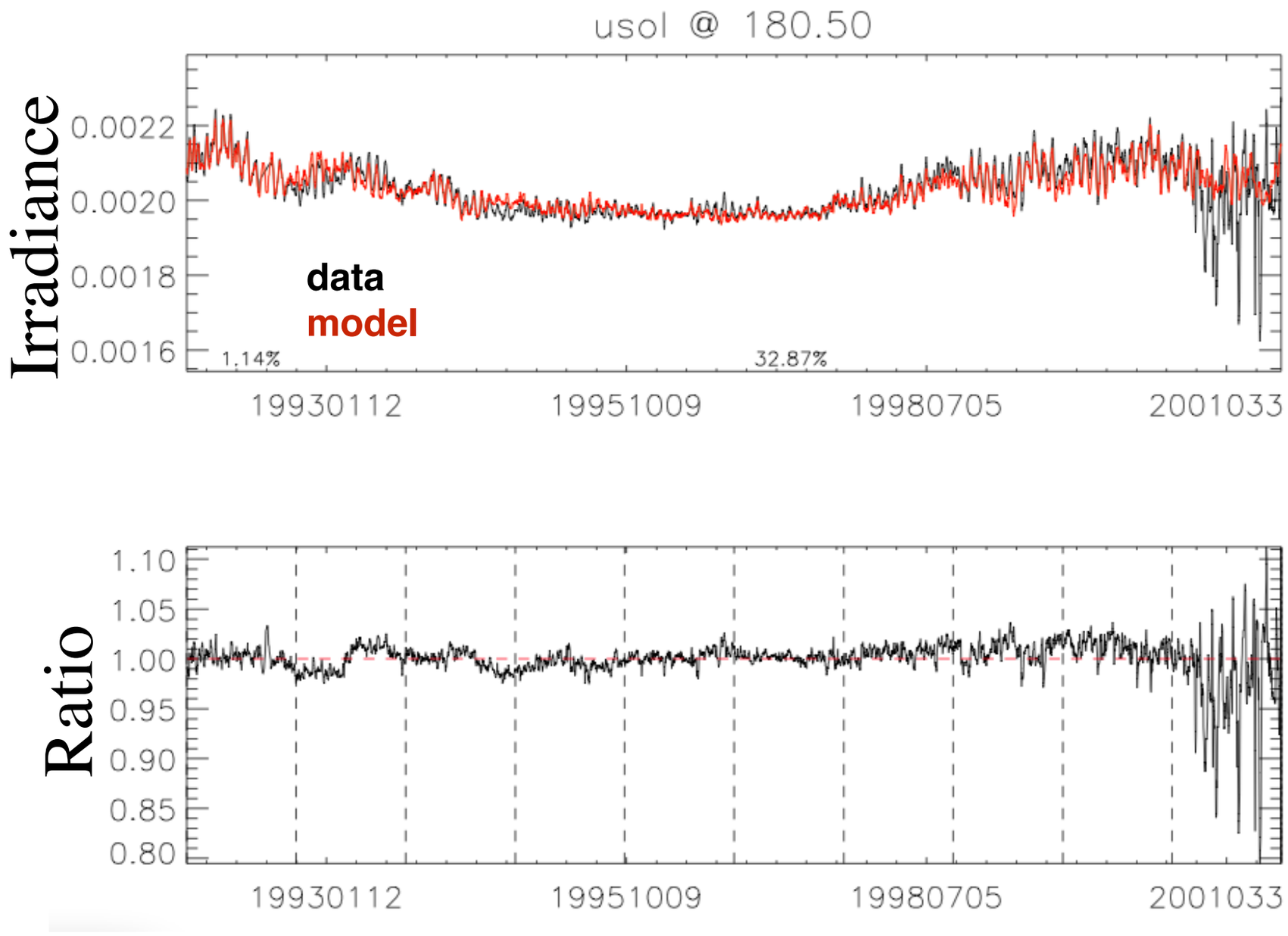


- Rotation amplitudes underestimates the cycle variations

LTU: How does it work ?

Example: UARS/Solstice @180.5nm

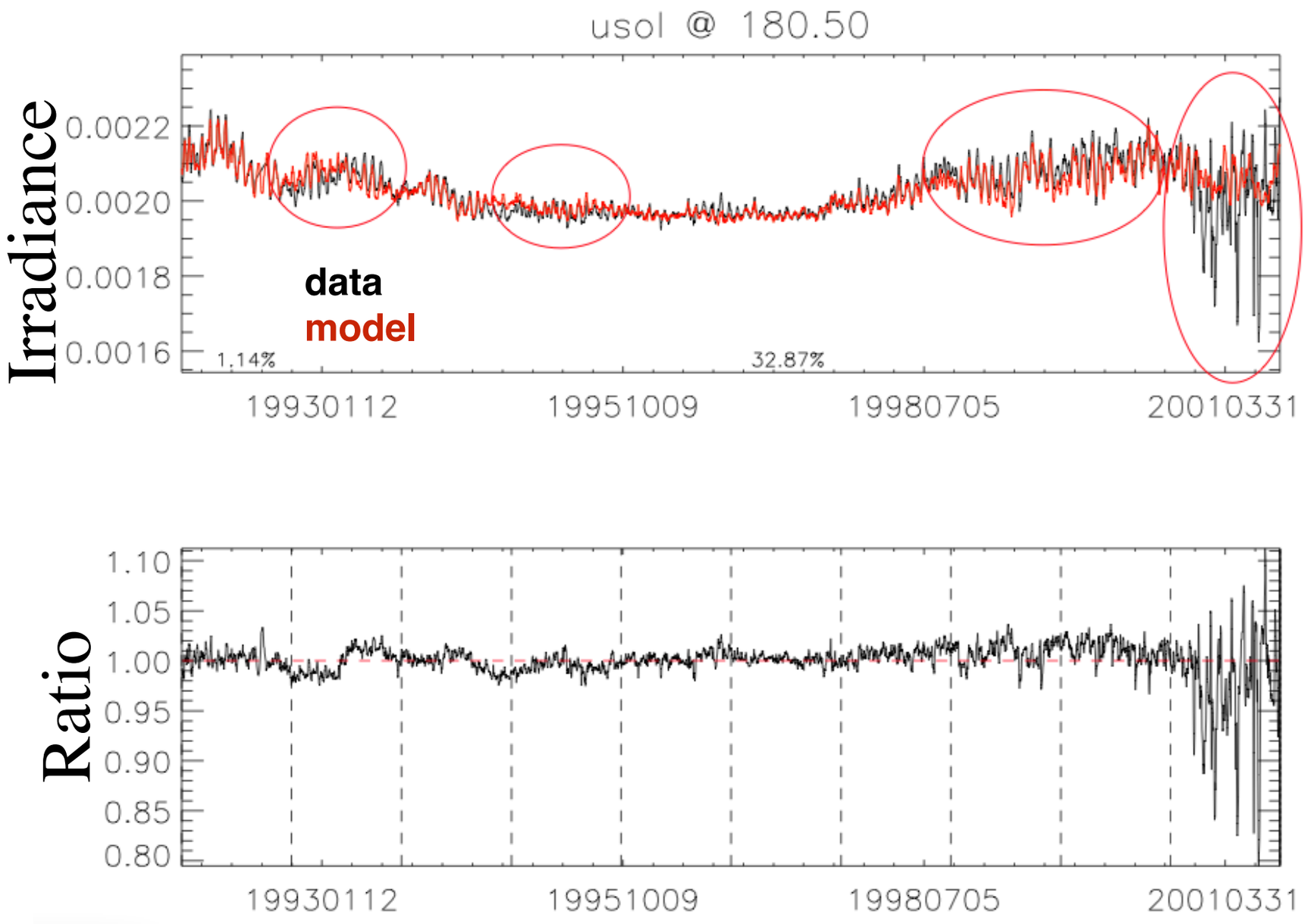
- Very good agreement



How does it work ?

Example: UARS/Solstice @180.5nm

- Very good agreement
- Except at some time of the mission



Long term uncertainty ?

How does it work ?

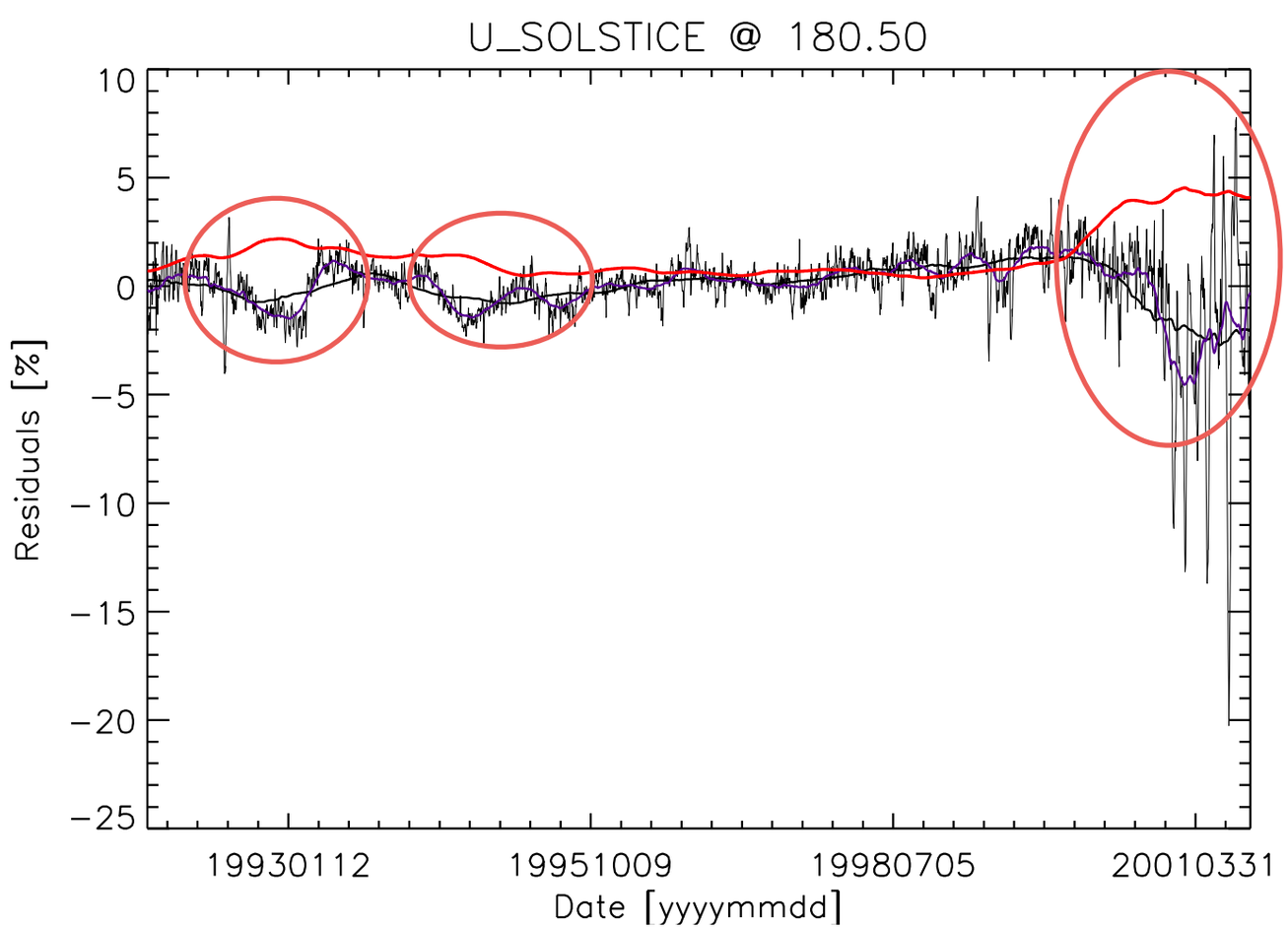
Example: UARS/Solstice @180.5nm

U(λ,t): average disagreement in the yearly slope of the observed and modeled SSI

$$U(\lambda,t) = \mathrm{smooth}_{1\text{-}yr}\left(\left\|a_{obs}(\lambda,t) - a_{model}(\lambda,t)\right\|\right)$$

with a(λ,t): normalized slope of the time series computed over one year

- Uncertainty is about 0.5%/yr except where disagreement improves
- Snow+ (2010) estimated 0.5% / yr



How does it work ?

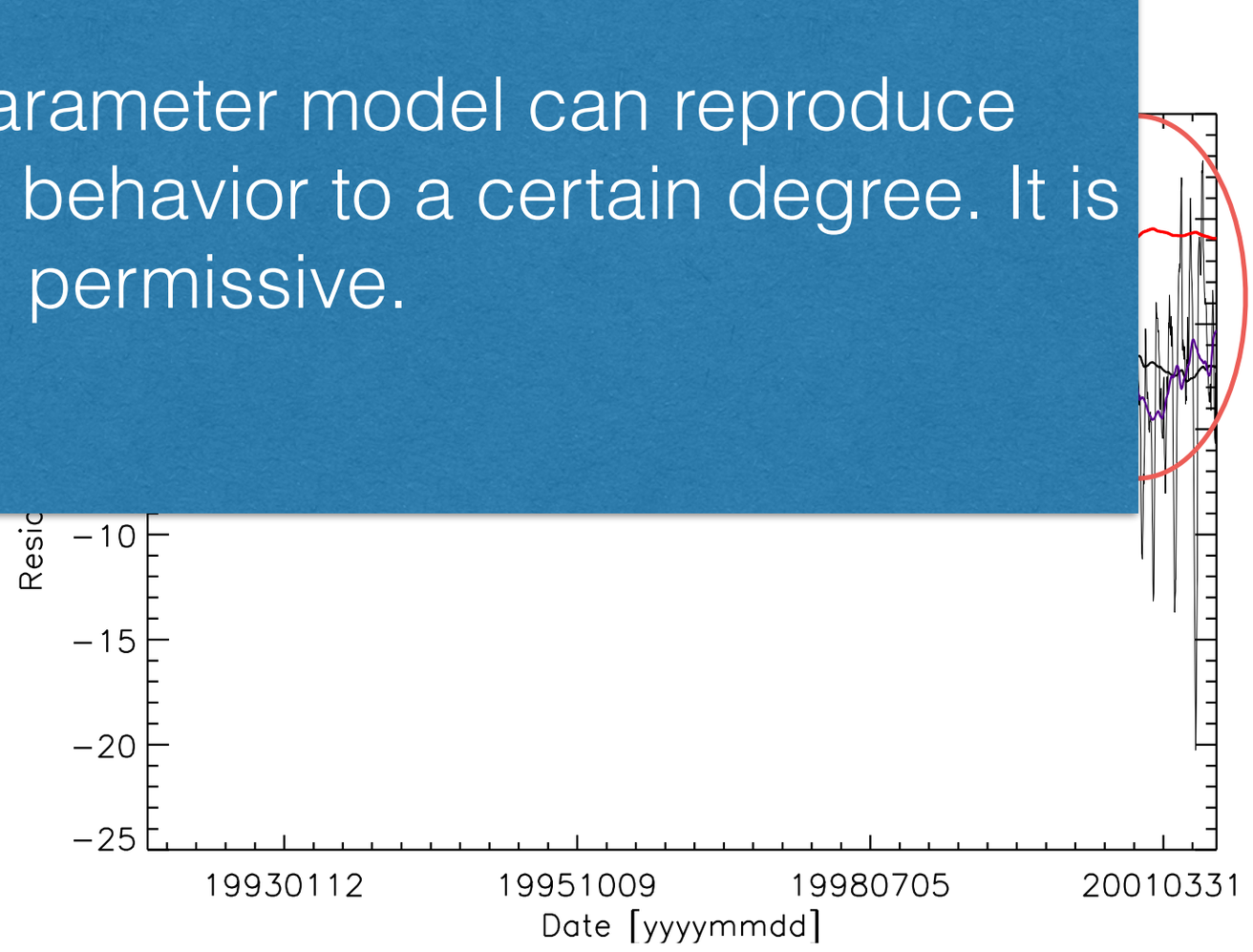
Hyp. 2:

What can not be reproduced by the two time scales proxy-model is more uncertain.

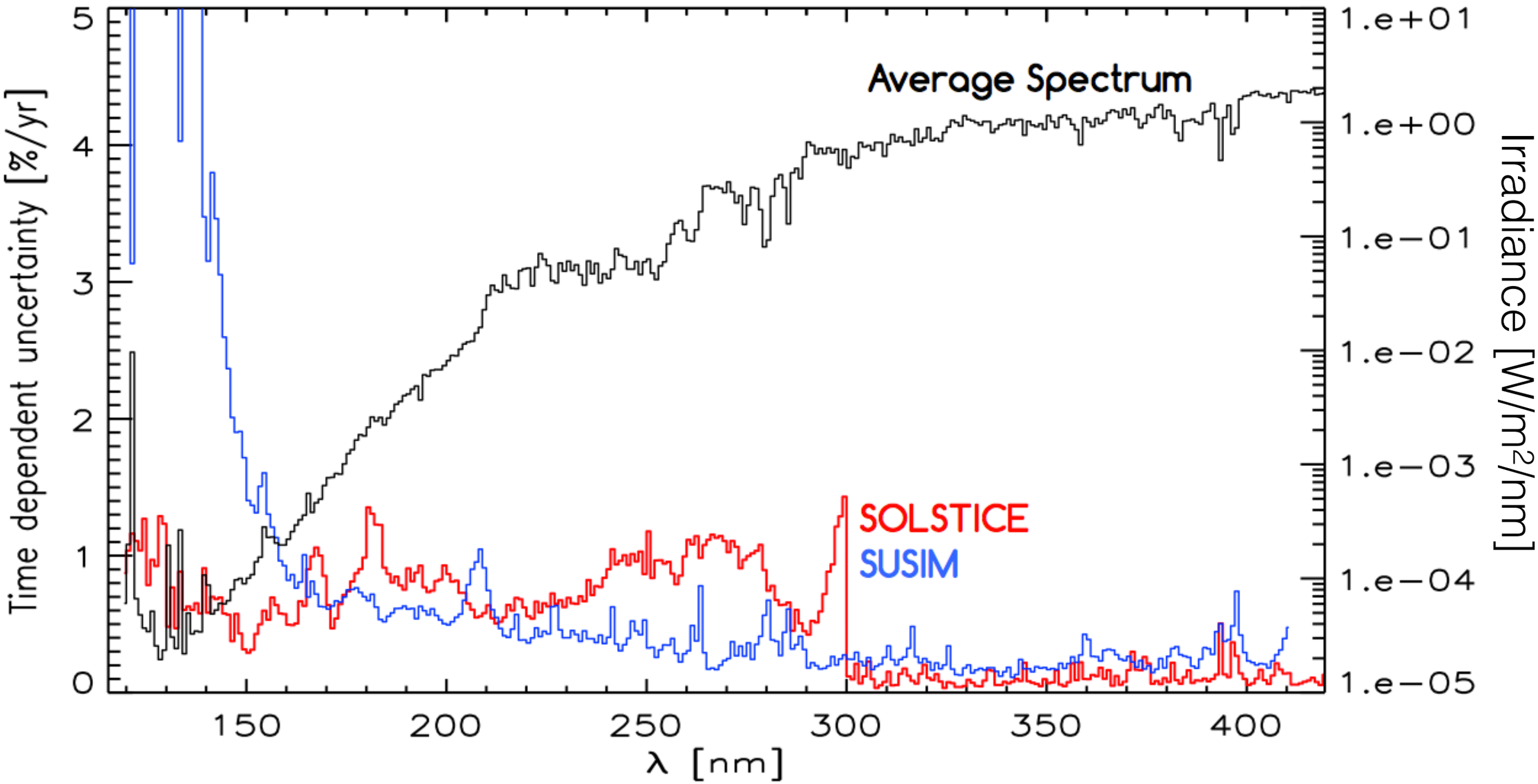
cons: this multi parameter model can reproduce trends and non solar behavior to a certain degree. It is permissive.

- Unce
  0.5%
  wher
  improves

- Snow+ 2010 estimated 0.5% / yr



UARS Overview



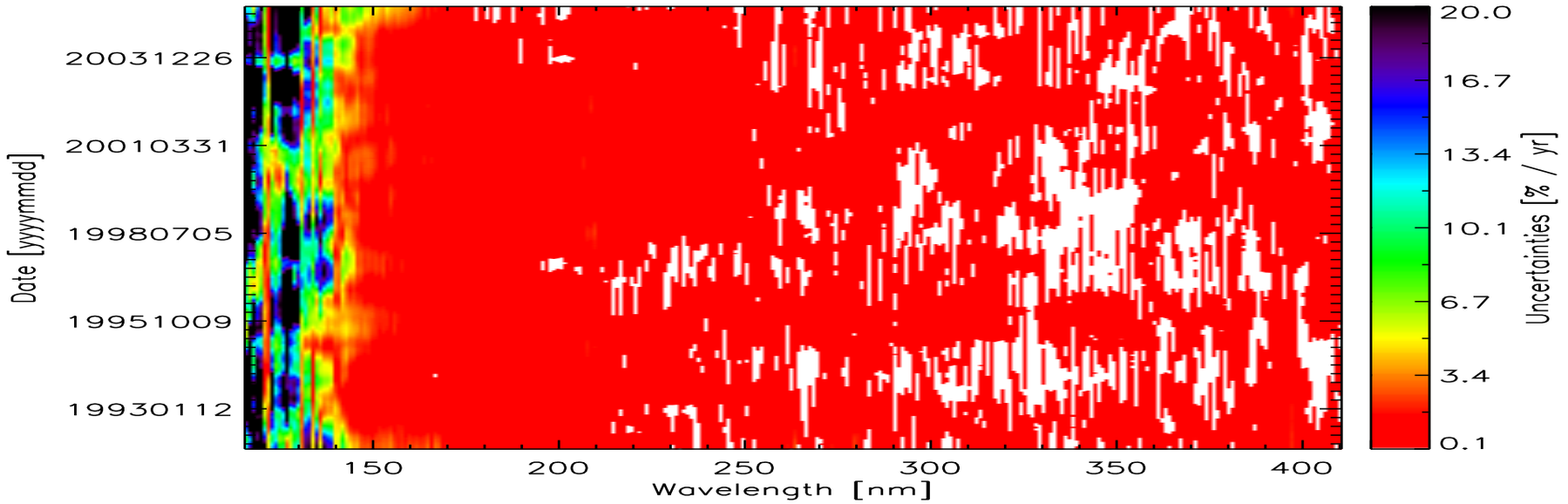
- The time dependent LTU are averaged over the mission lifetime

UARS / SOLSTICE

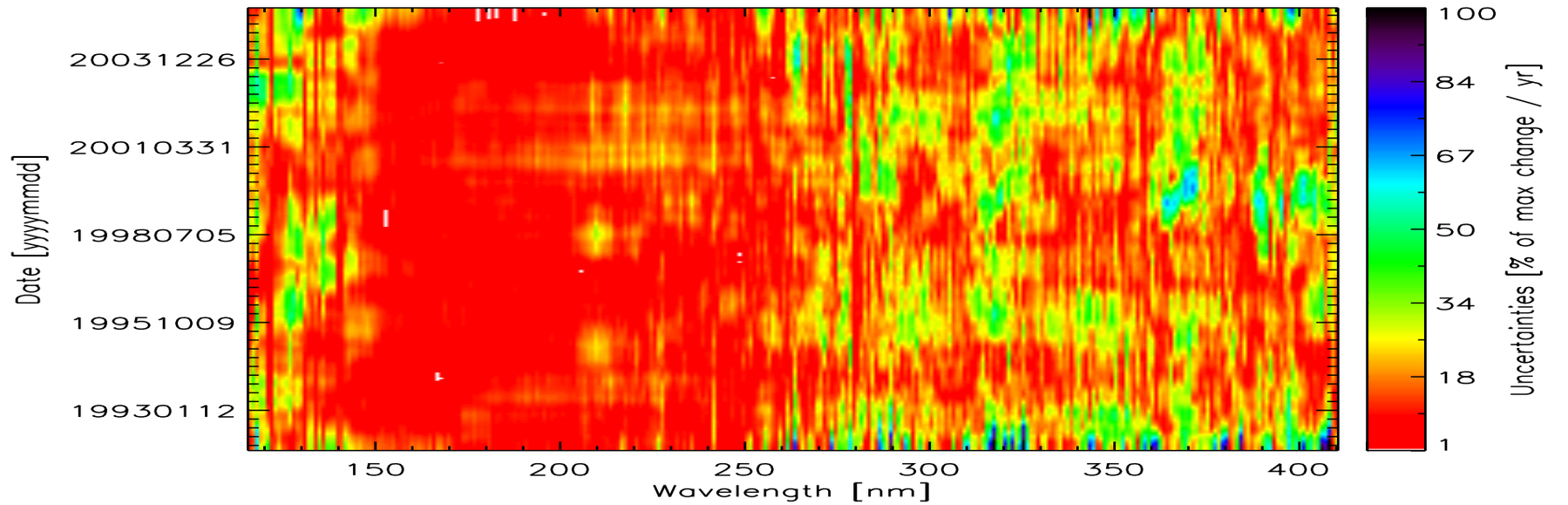
- LTU in % / yr
- LTU in % of maximum variation / yr
- LTU in % of solar cycle variation / yr

UARS / SUSIM

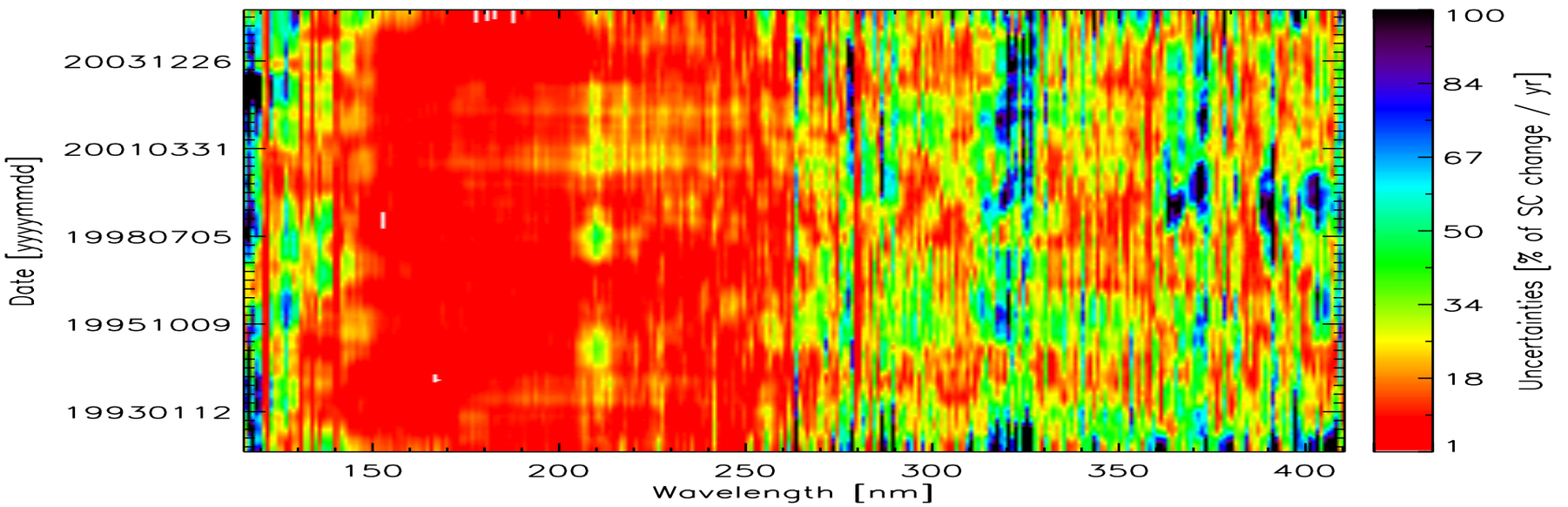
- LTU in % / yr



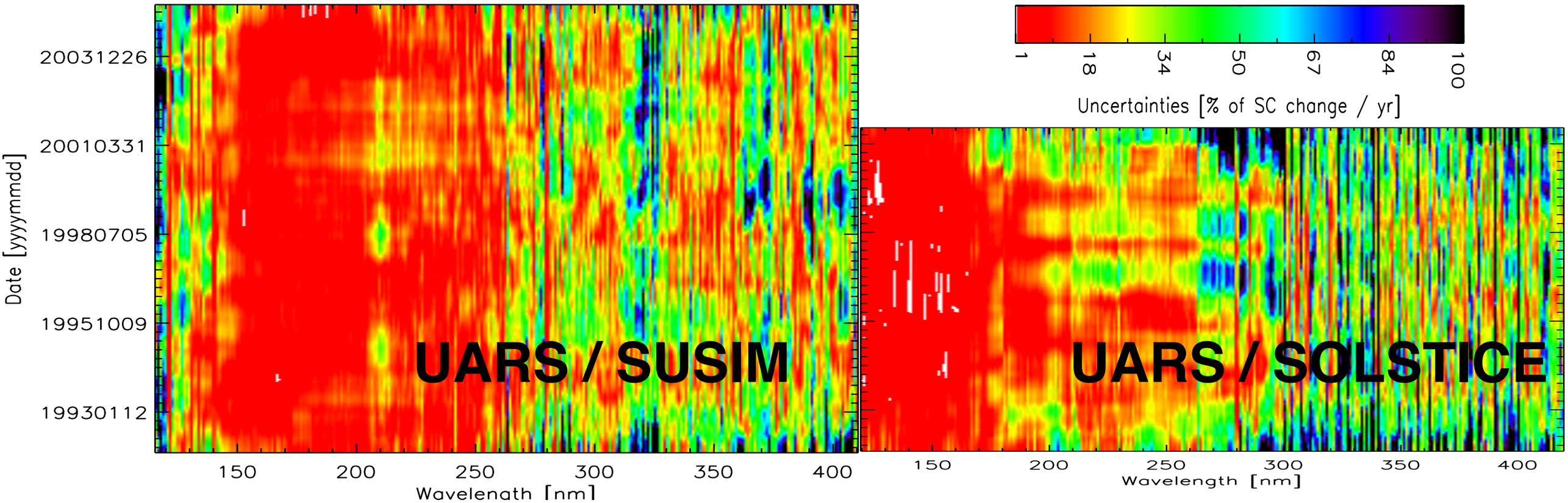
- LTU in % of maximum variation / yr

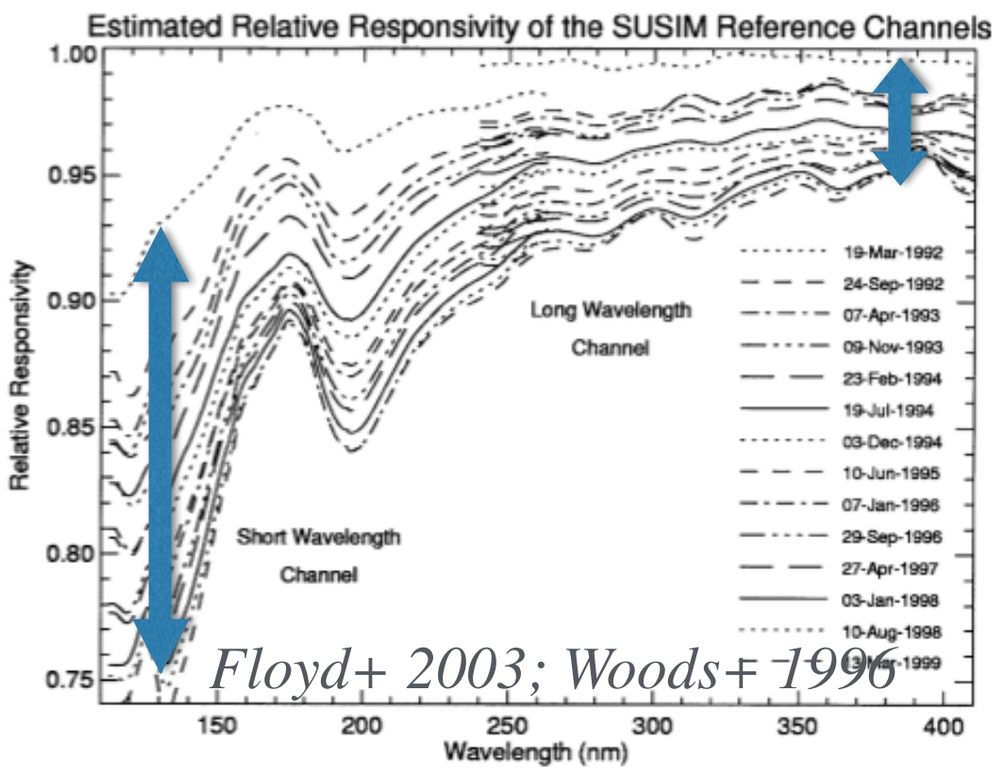


- LTU in % of solar cycle variation / yr



U_SUSIM vs U_SOSLTICE





Floyd+ 2003; Woods+ 1996

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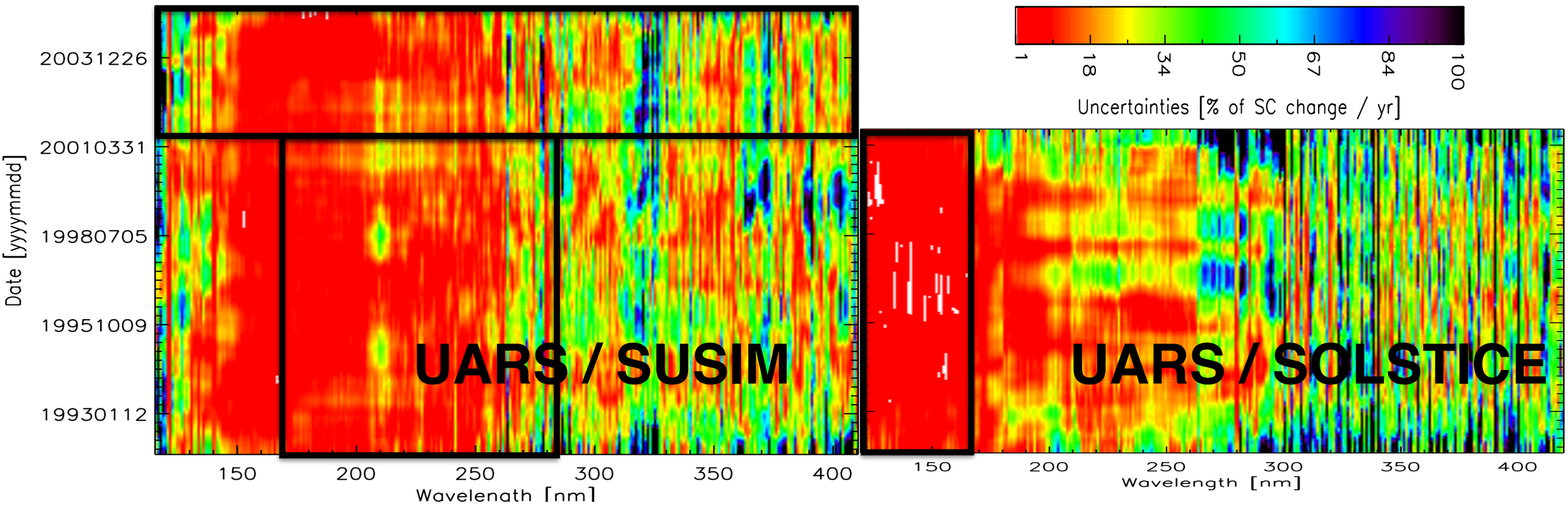

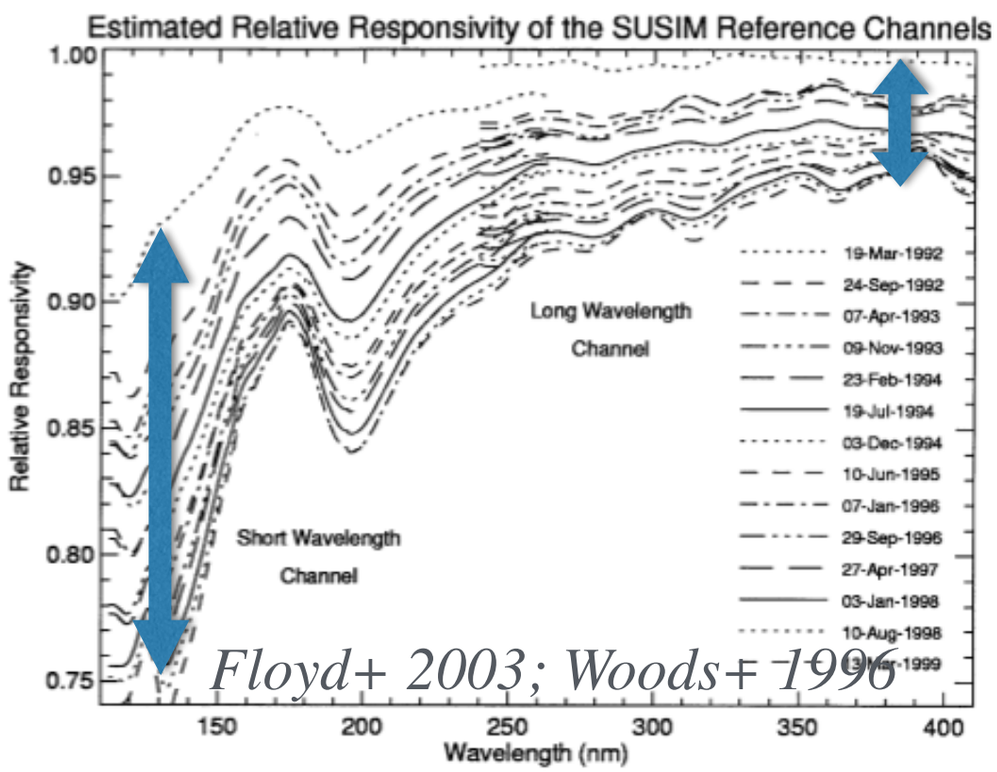

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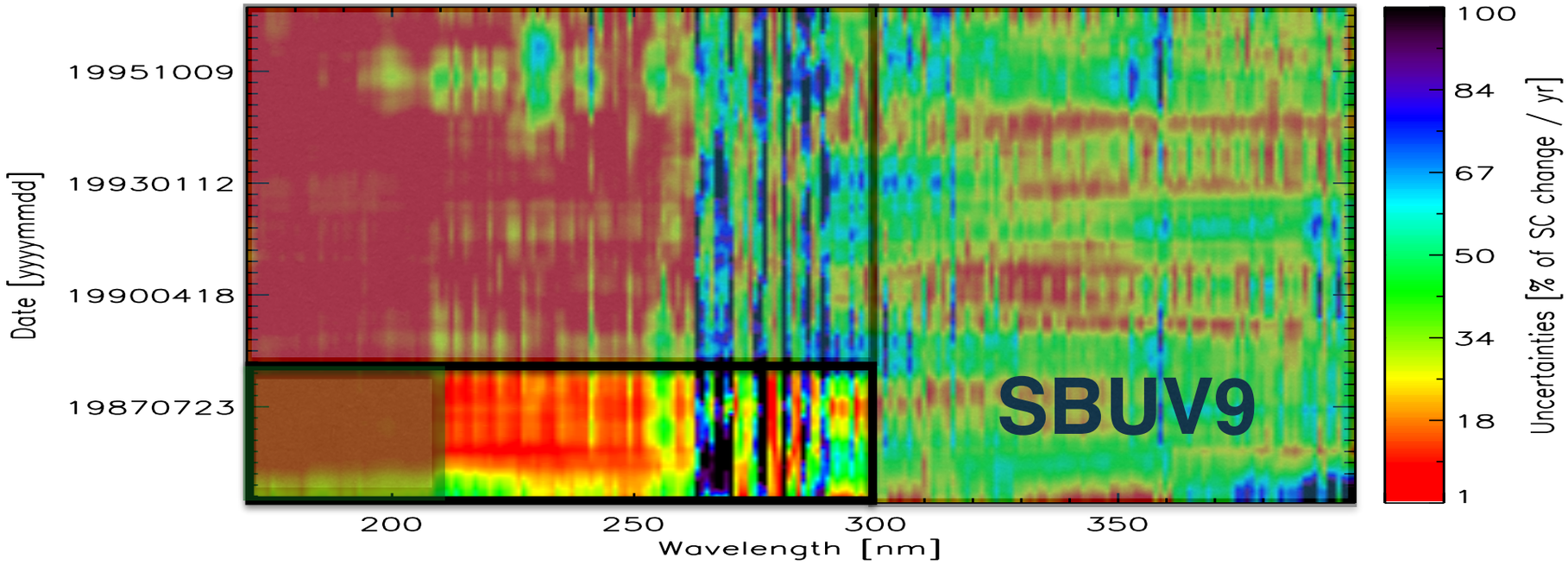
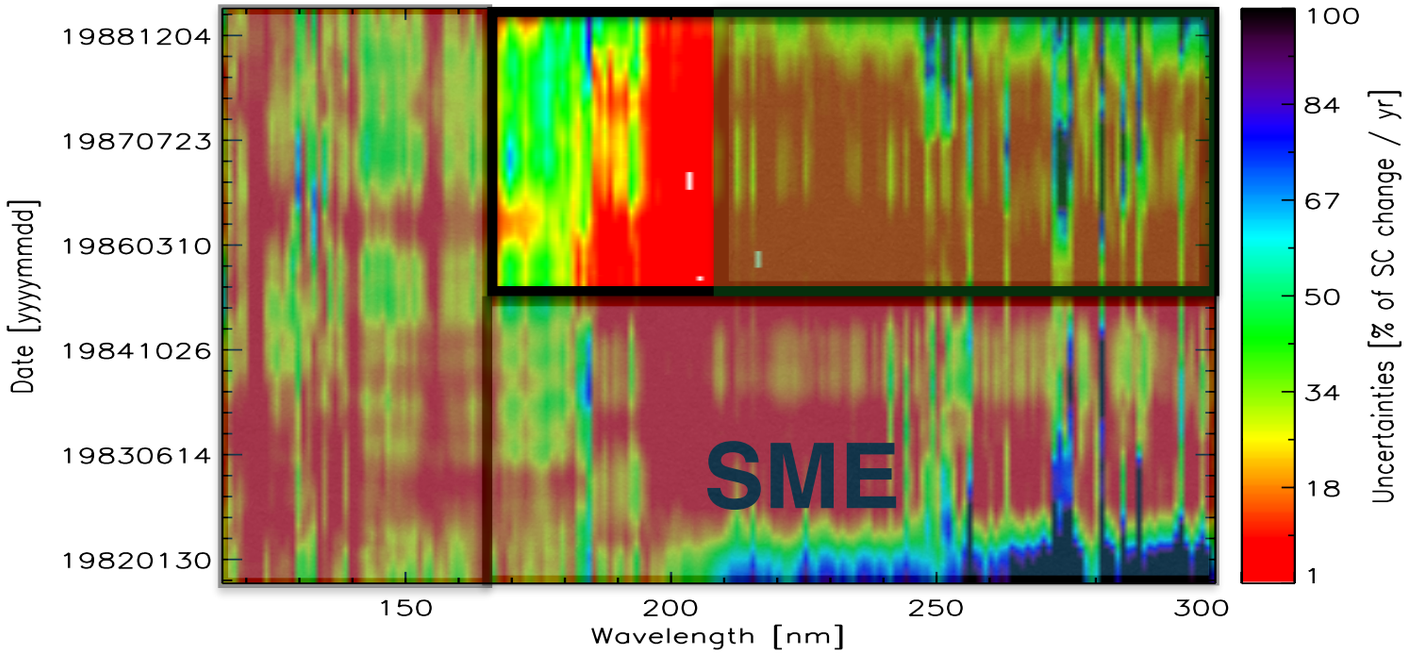
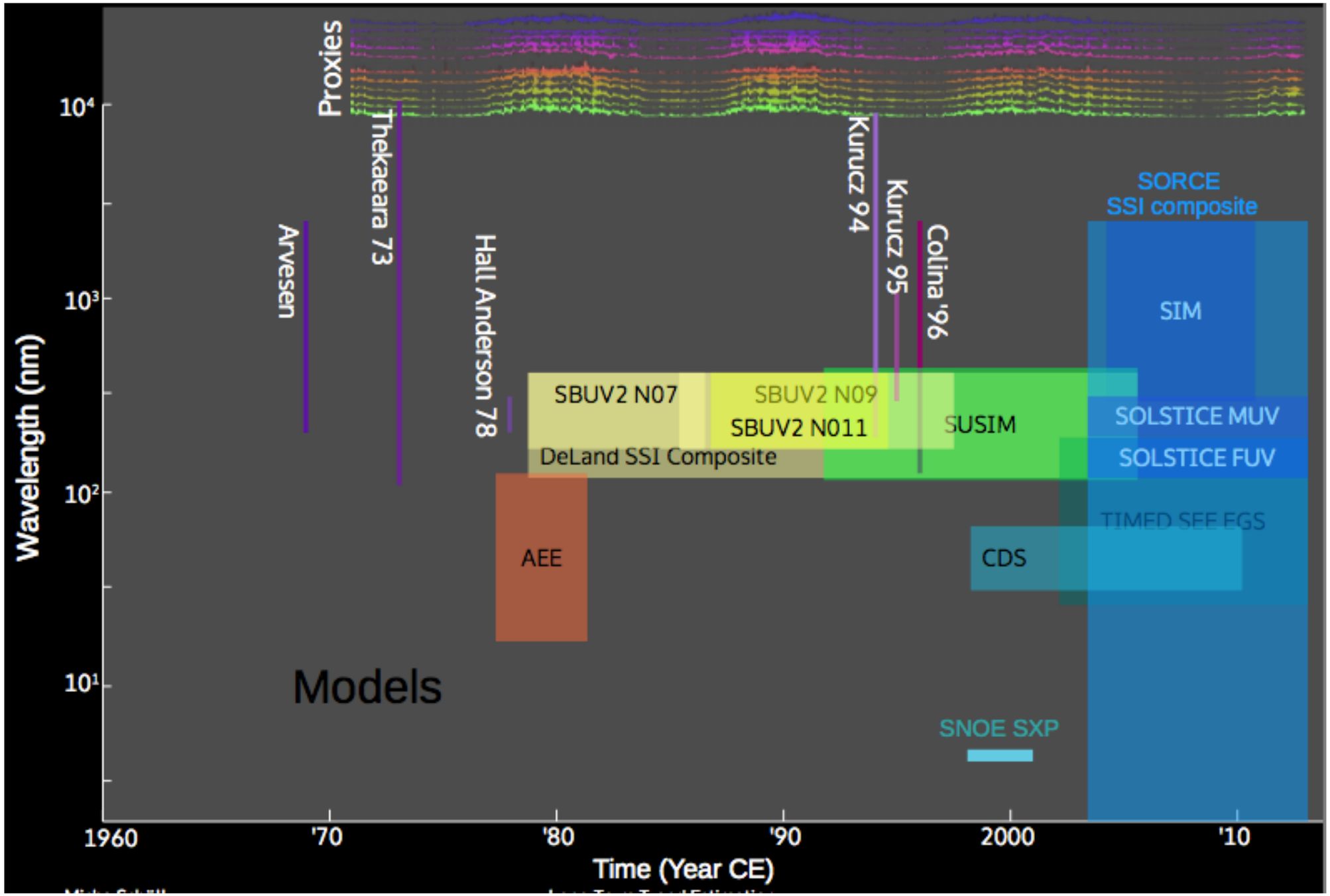
SME & SBUV9





- **Not definitive:**
  - ➡ Other SBUV data available.
  - ➡ Degradation of SBUV's response corrected using proxies…

General Overview



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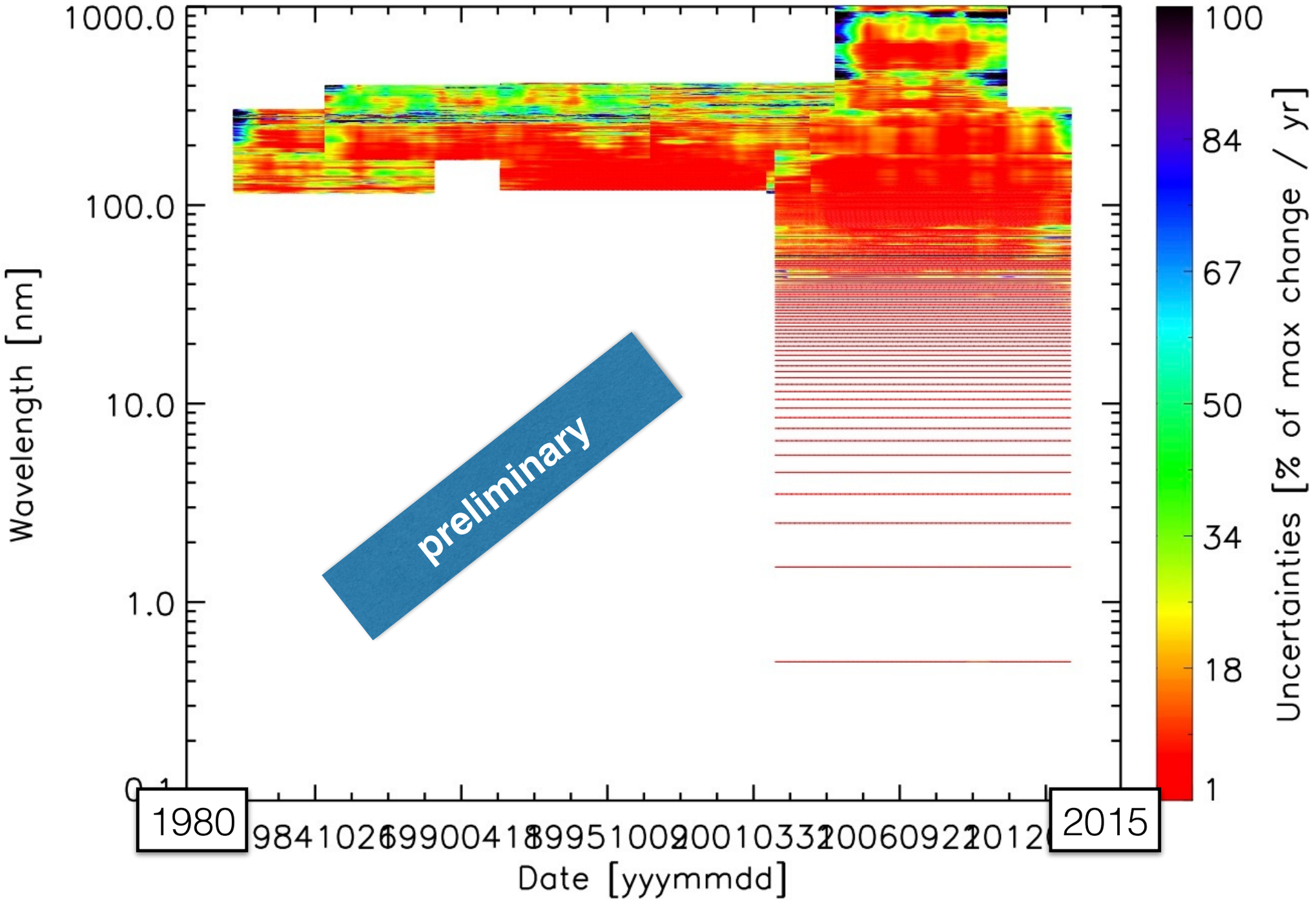

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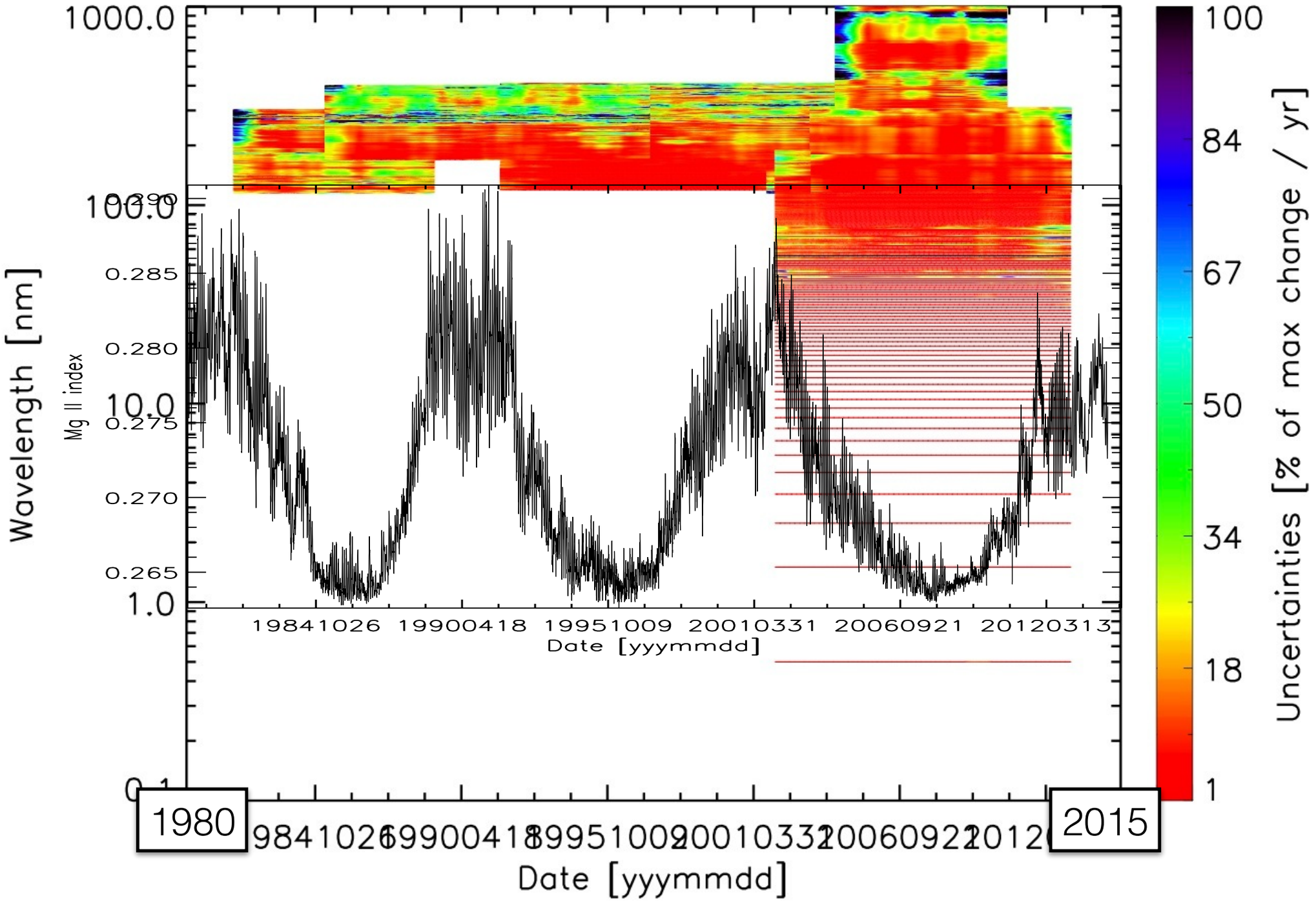


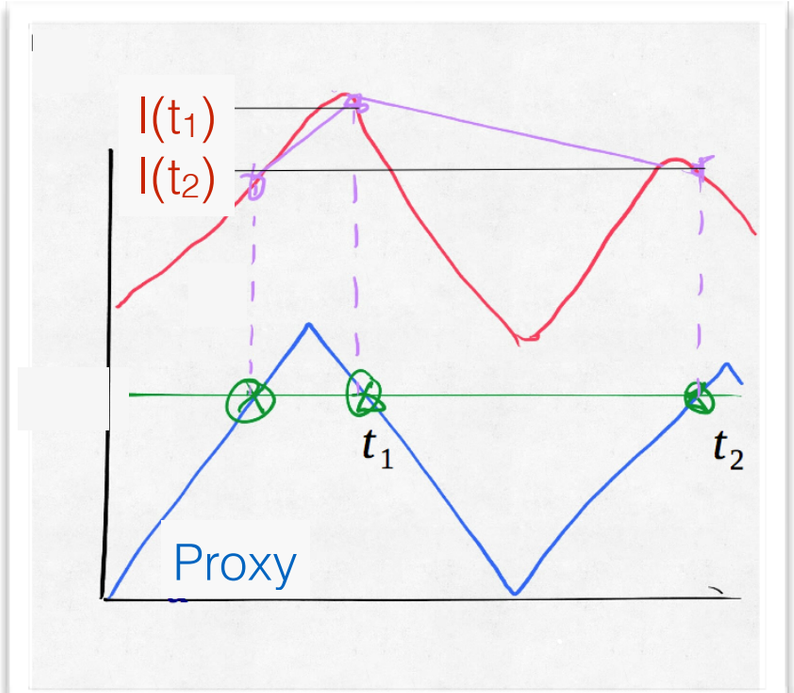
The less permissive

- Unfortunately there is residual degradation in the observed values $$I^{meas}(t) = I^{true}(t)g(t)$$

- Assume an unknown but exact proxy model:

$$I^{true}(t) = f(p(t)) + \epsilon$$

$$p(t_1) = p(t_2) \rightarrow I^{true}(t1) = I^{true}(t2) + \epsilon$$



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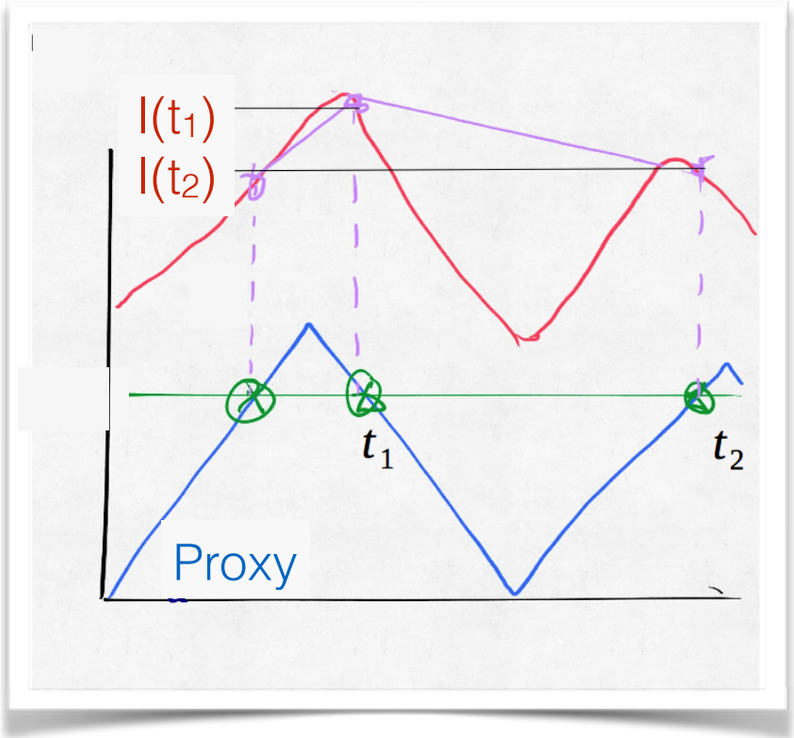
$$\frac{I^{meas}(t_1)}{I^{meas}(t_2)} = \frac{I^{true}(t_1)g(t_1)}{I^{true}(t_2)g(t_2)} \approx \frac{g(t_1)}{g(t_2)} + \epsilon$$

$$g(t) = a_0 + a_1 t + a_2 t^2 + ...$$
$$g(t = 0) = 1$$



The less permissive

- Unfo… erved valu…
- Ass…

$$I^{true}(t$$

$$p(t_1) =$$

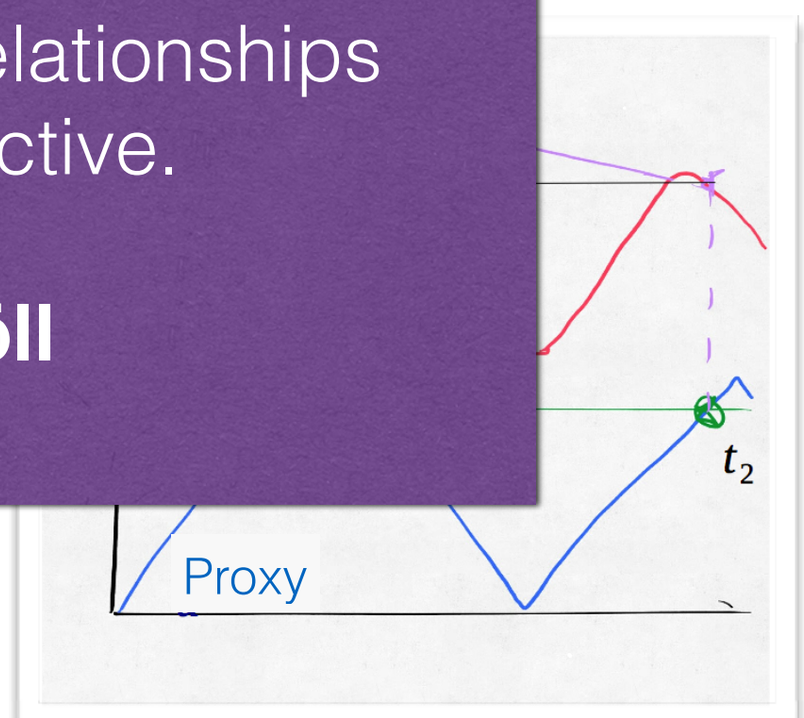
$$\frac{I^{meas}(t_1)}{I^{meas}(t_2)} = \frac{I^{true}(t_1)g(t_1)}{I^{true}(t_2)g(t_2)} \approx \frac{g(t_1)}{g(t_2)} + \epsilon$$

Hyp. 2:

if $p(t_1) = p(t_2)$ then $I(t_1)=I(t_2)$

cons: no phase shift, no change in relationships between proxy and I. It is restrictive.

See poster by Micha Schöll



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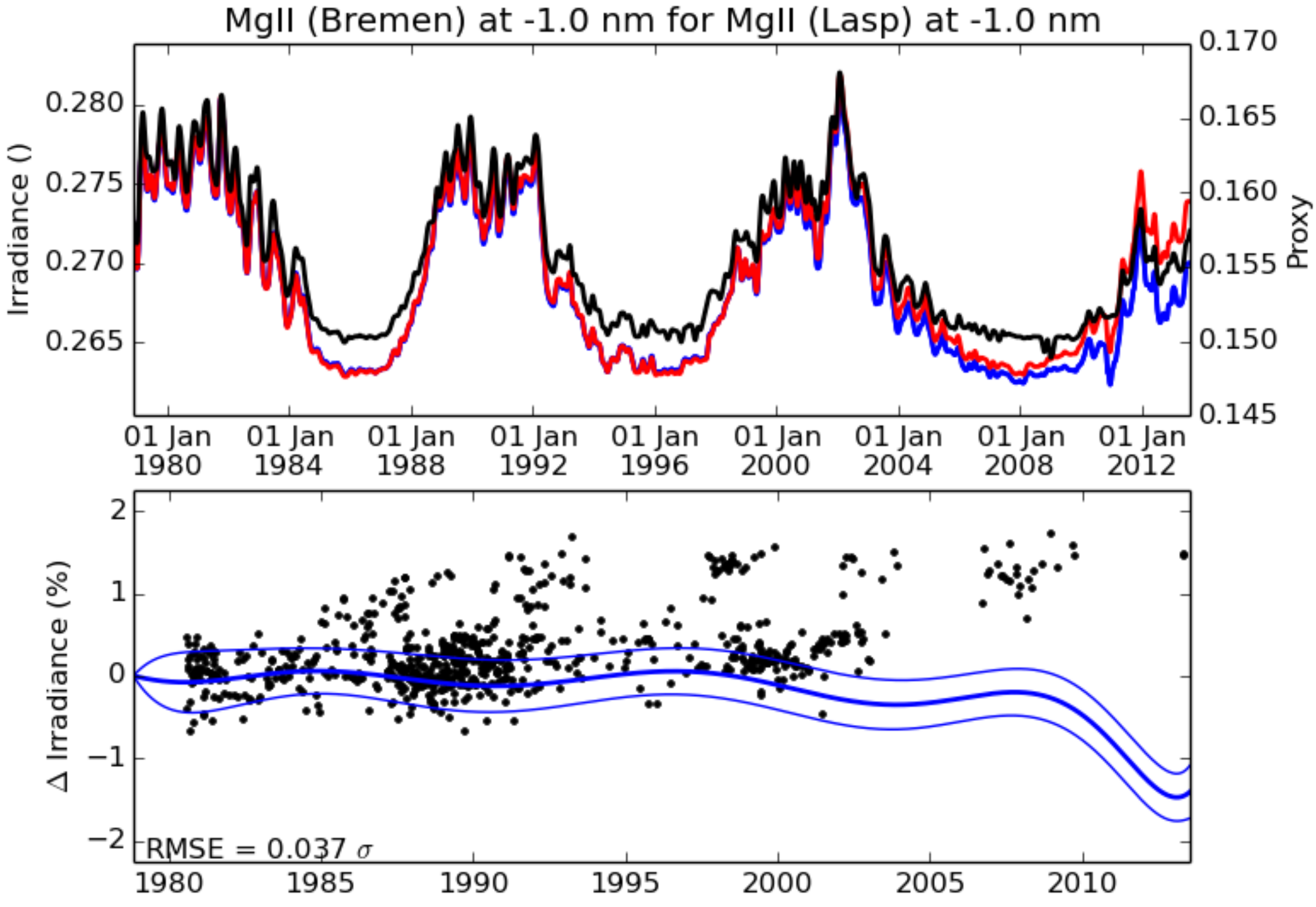
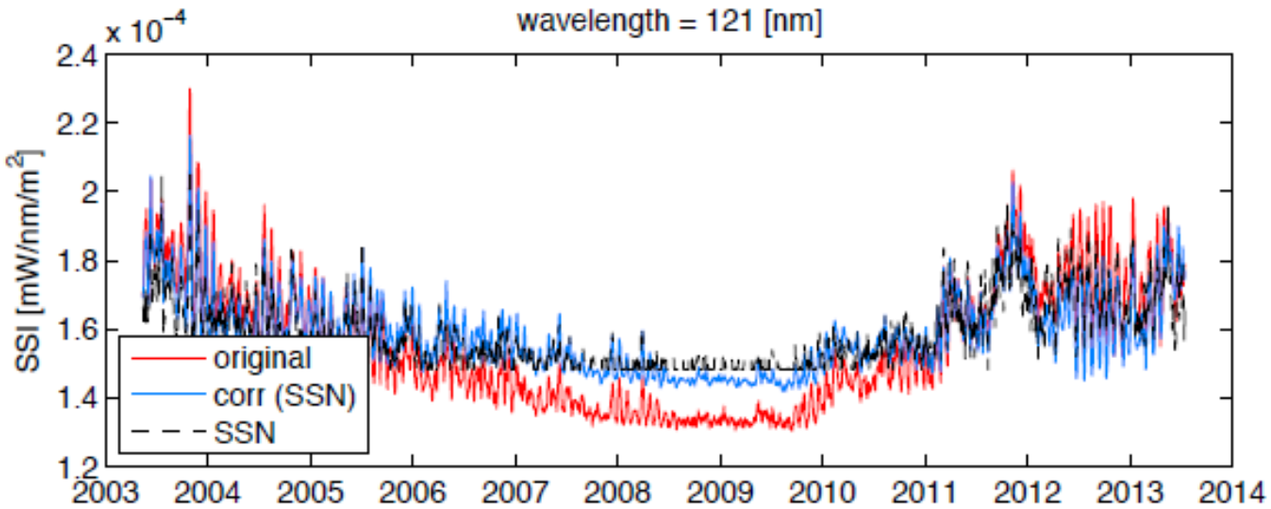
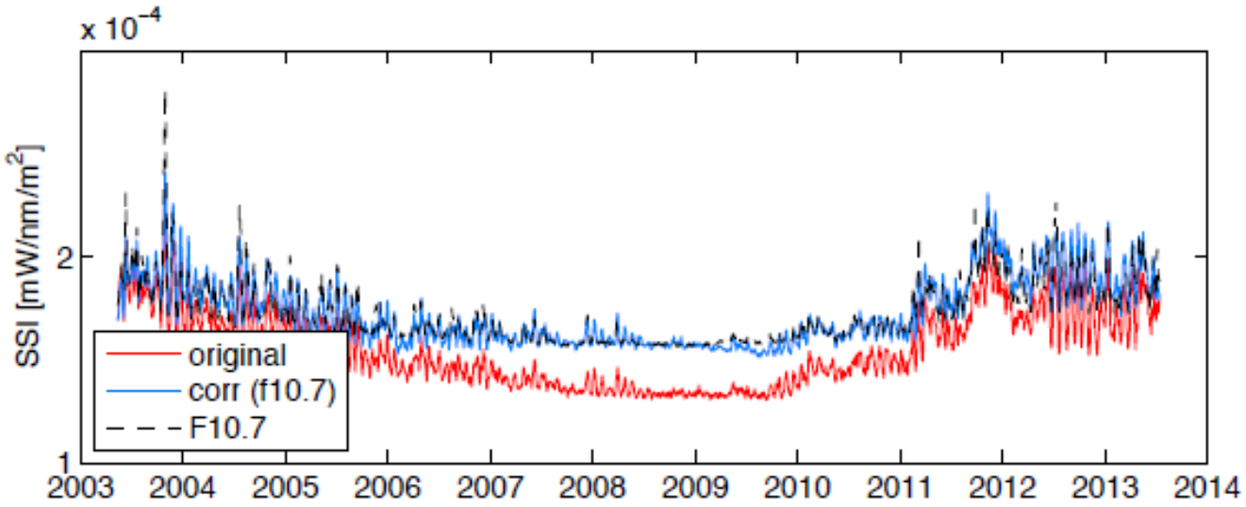
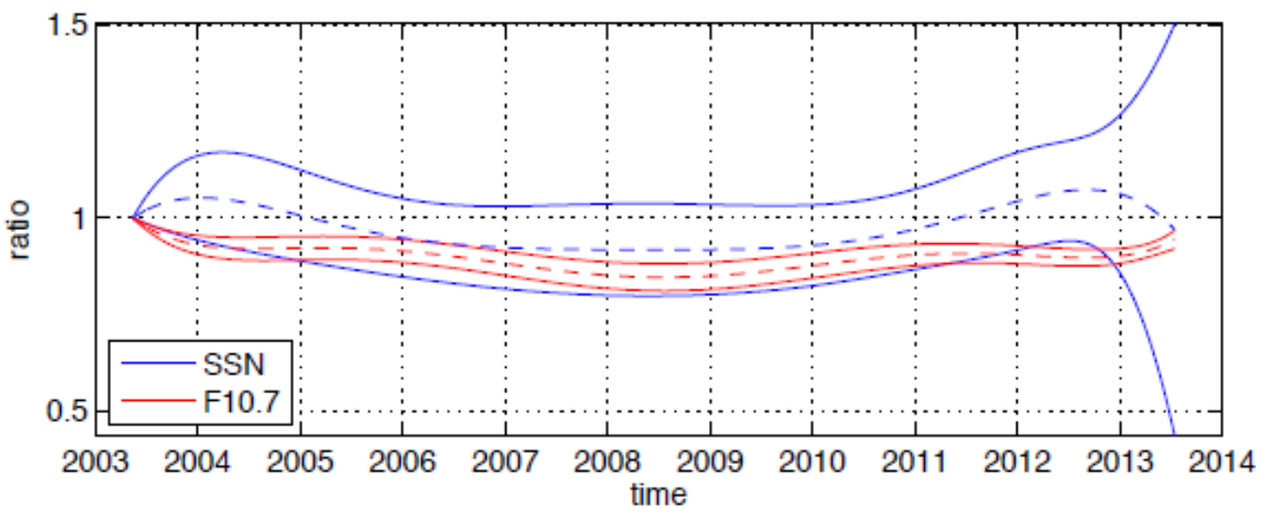

MgII (Bremen) at -1.0 nm for MgII (Lasp) at -1.0 nm
Irradiance ()
0.280
0.275
0.270
0.265
0.170
0.165
0.160
0.155
0.150
0.145
Proxy
01 Jan 1980
01 Jan 1984
01 Jan 1988
01 Jan 1992
01 Jan 1996
01 Jan 2000
01 Jan 2004
01 Jan 2008
01 Jan 2012
Δ Irradiance (%)
2
1
0
−1
−2
RMSE = 0.037 σ
1980
1985
1990
1995
2000
2005
2010

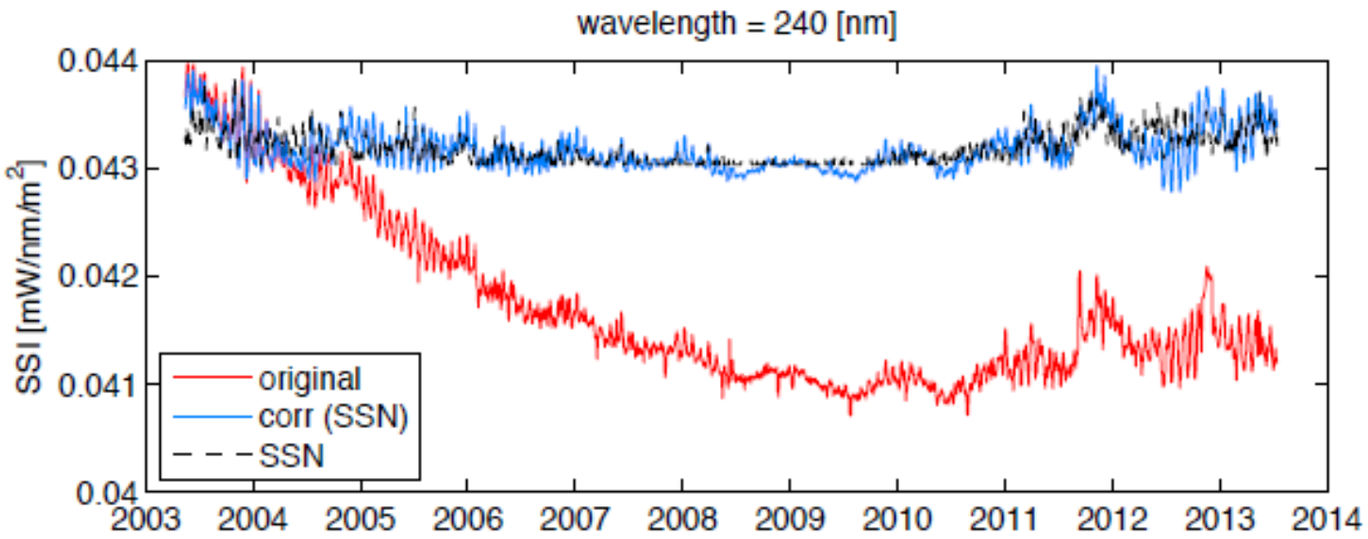


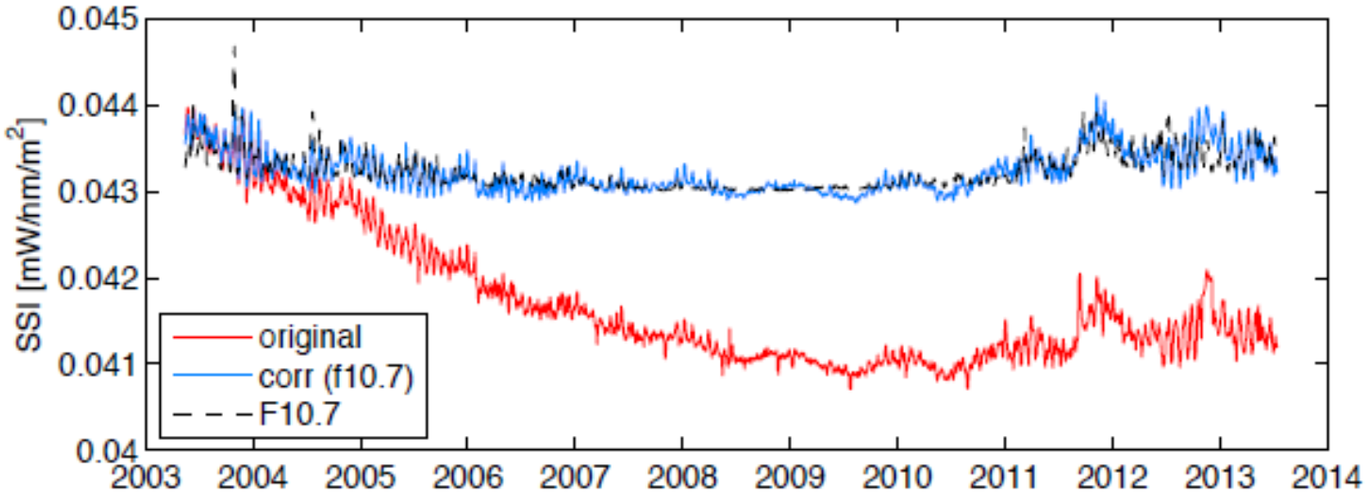


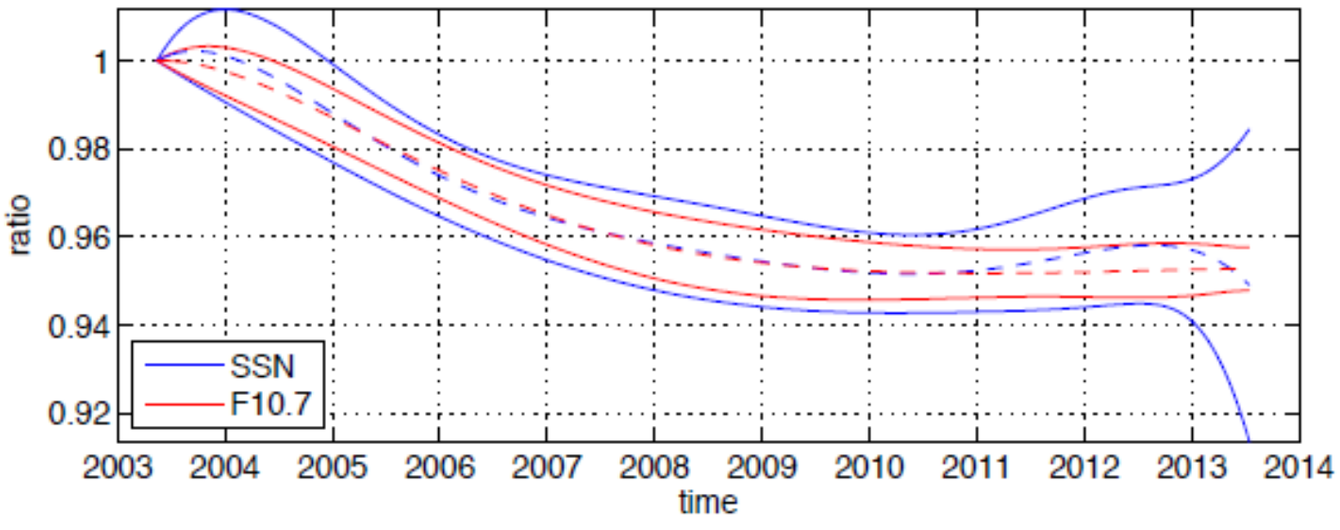


SOLSTICE Trend correction for Ly-a (121 nm)

Using SSN and F10.7 as equal activity indicators (EQA)







SOLSTICE Trend correction for 240 nm

Using SSN and F10.7 as equal activity indicators (EQA)

Conclusions

- Long term uncertainties is essential. Should be time dependent

- Two time-scale proxy model:
  - ➡ simple and robust. Time dependent.
  - ➡ give value in agreement with instrumental value.
  - ➡ permissive

- « if $p(t_1) = p(t_2)$ then $I(t_1)=I(t_2)$ » method
  - ➡ strong assumptions
  - ➡ give results in agreement to « what is expected »

THANK

YOU