

New Model of Solar Irradiance

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Supervision of PhD Thesis

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Background and Motivation

■ New model of TSI and SSI:

Code for Solar Irradiance *Reconstructions* – COSIR

▶ reconstructions of past and forecasts of future irradiance
 **improved 11-year + long-term trend,**

▶ **predecessor:**

COSI's irradiance modelling after **Shapiro et al. (2011)**,

▶ **radiative transfer within COSI:**

improved by R. Tagirov et al. (2015), *in prep.*; allows calculation of synthetic spectra for each active feature.

Background and Motivation

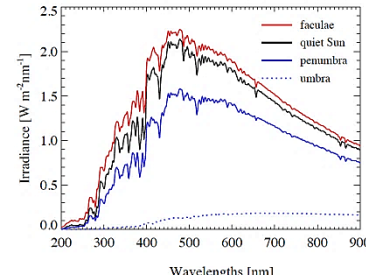
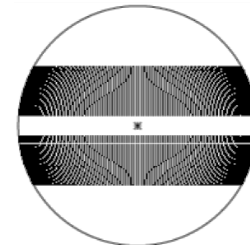
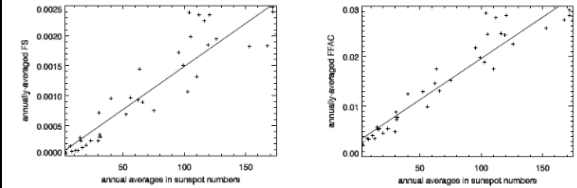
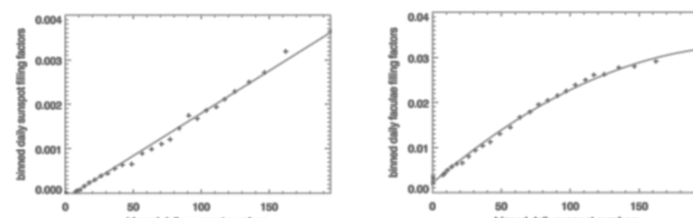
■ Shapiro et al. (2011) results:

- ▶ TSI and SSI with annual resolution for 1610–present and 22-year resolution over the Holocene,
- ▶ “*Shapiro forcing*” :
6 W/m² peak-to-peak difference in TSI since the Maunder Minimum; other long-term reconstructions converge to values of ≤ 1.5 W/m² .

■ Judge et al. (2012):

- ▶ re-examines Shapiro forcing; makes recommendations for improvement in COSI’s long-term trend in irradiance.

11-year irradiance variability: TSI

features	COSI	COSIR
spectra of active photospheric features	sunspots = umbrae	sunspots = umbrae + penumbrae 
distribution of sunspots and faculae	homogeneous + full-disk	homogeneous + activity belts 
weighted spectral contributions to TSI: empirical relations between SSN and filling factor	linear regression coefficients 	linear + parabolic regression coefficients 

11-year irradiance variability: SSI

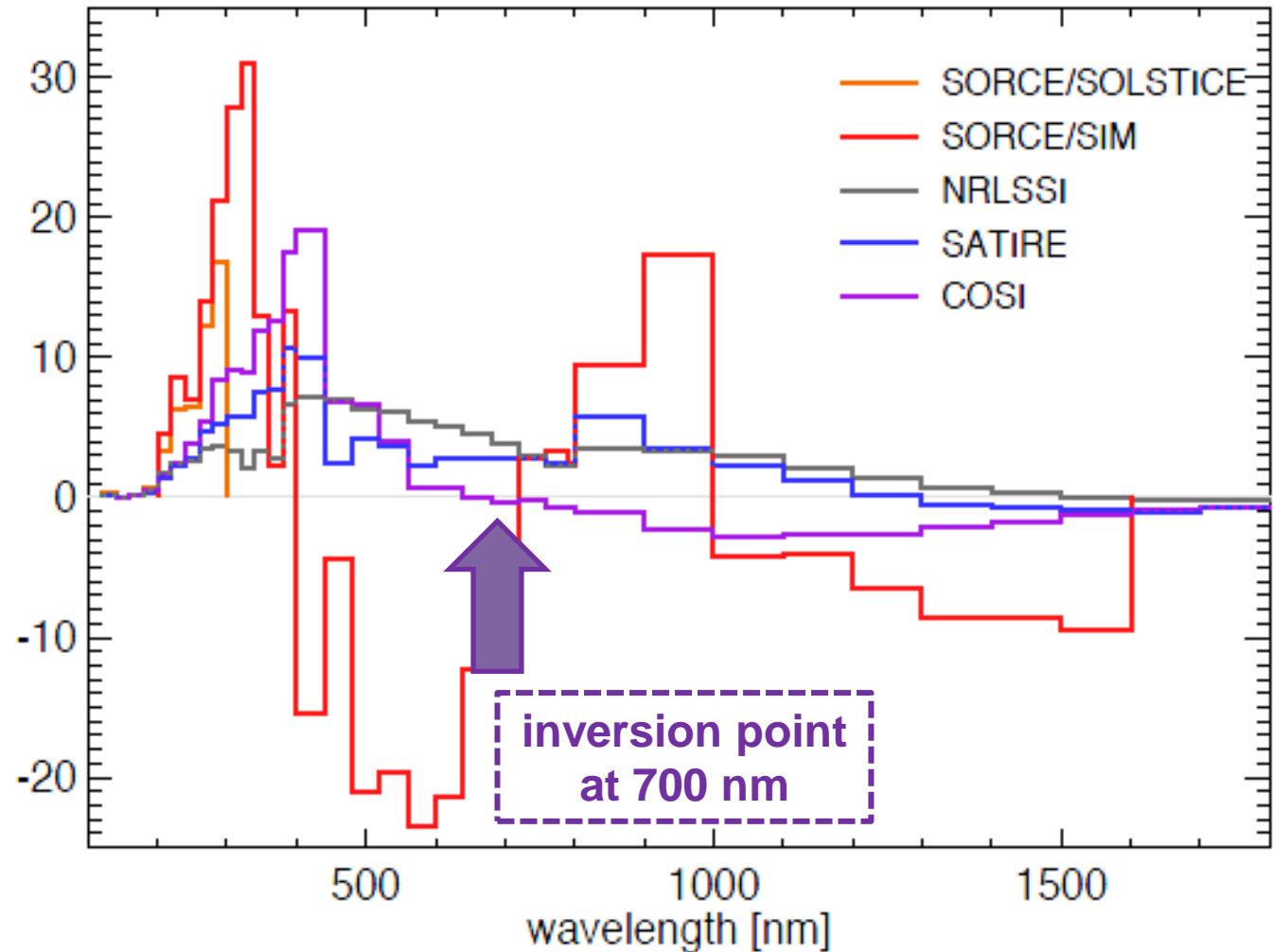
features

$\Delta \text{SSI} / \Delta \text{TSI}$ [%]

= relative contribution of spectral regimes to overall TSI changes between solar maximum in 2004 and solar minimum in 2008 of solar cycle 23 (weak)

Ermolli et al. (2013)

COSI



11-year irradiance variability: SSI

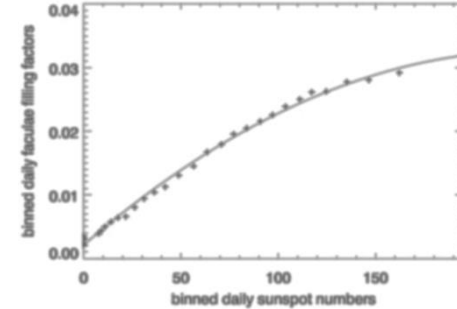
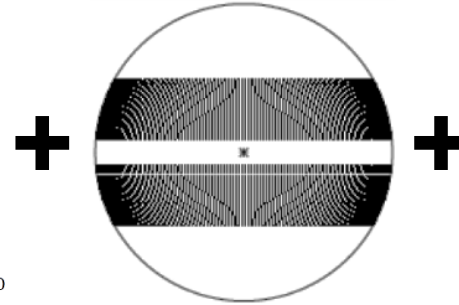
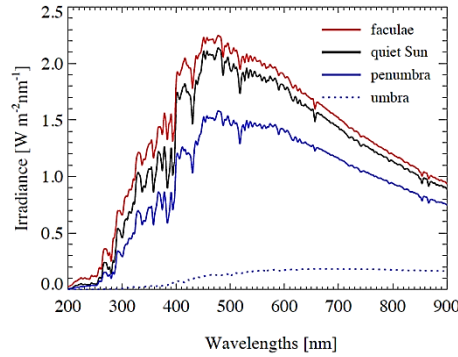
features

$\Delta \text{SSI} / \Delta \text{TSI} [\%]$

= relative contribution of spectral regimes to overall TSI changes between solar maximum and solar minimum of solar cycle 23 (weak) and, respectively, solar cycle 21 (strong)

COSIR

Once we've implemented:

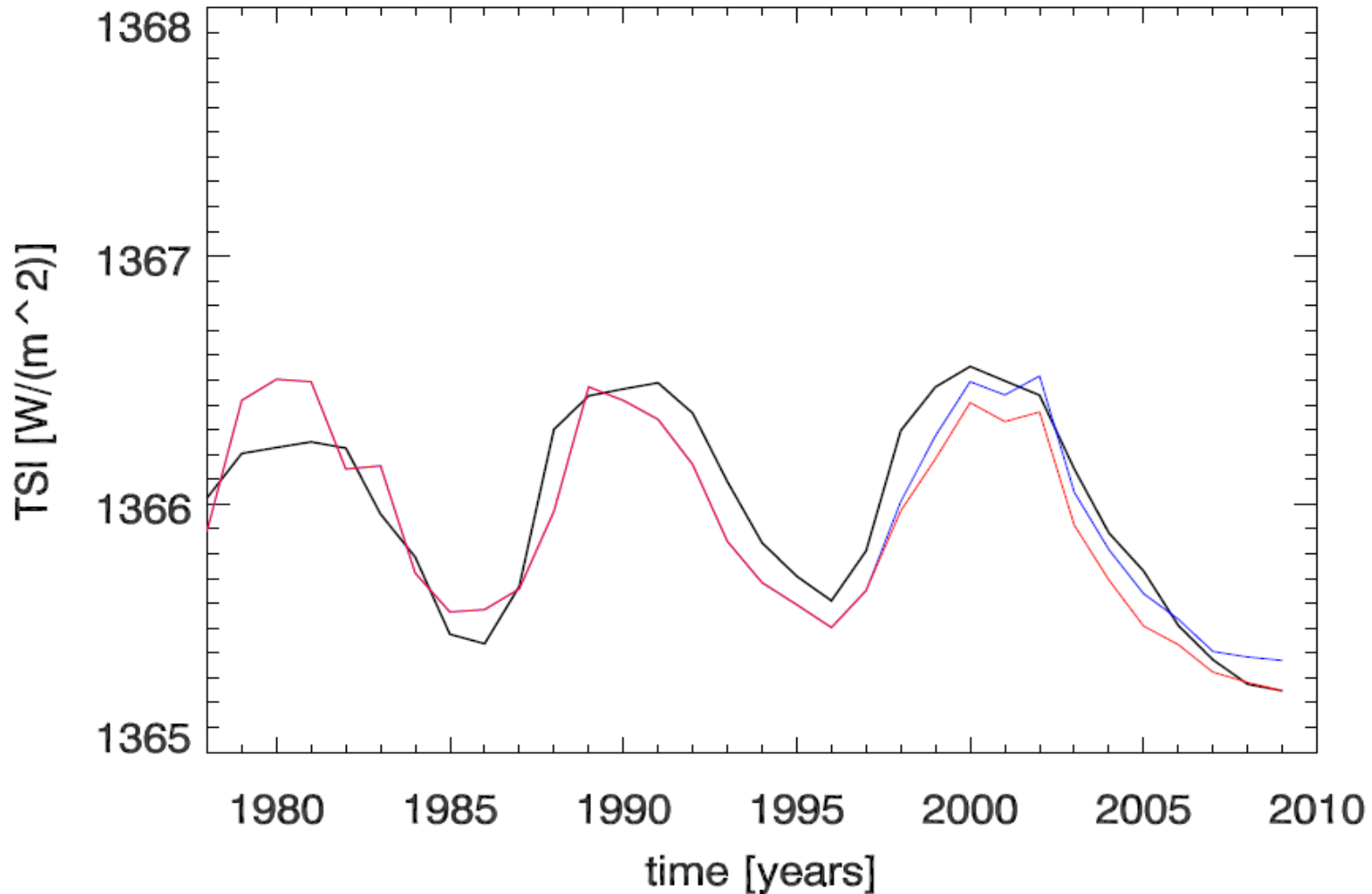


=

histograms of two different inversion points

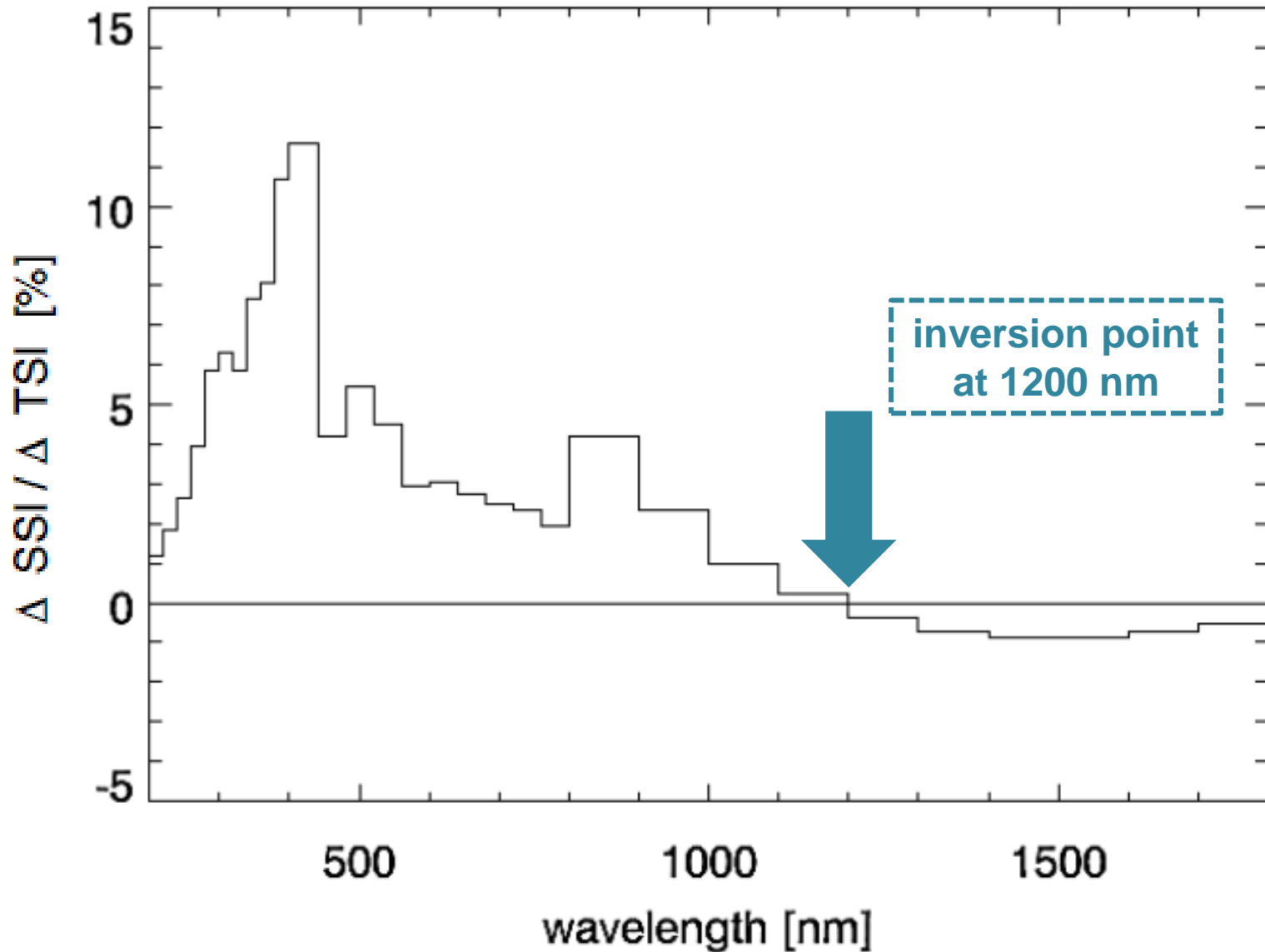


Results with COSIR: TSI over the satellite era

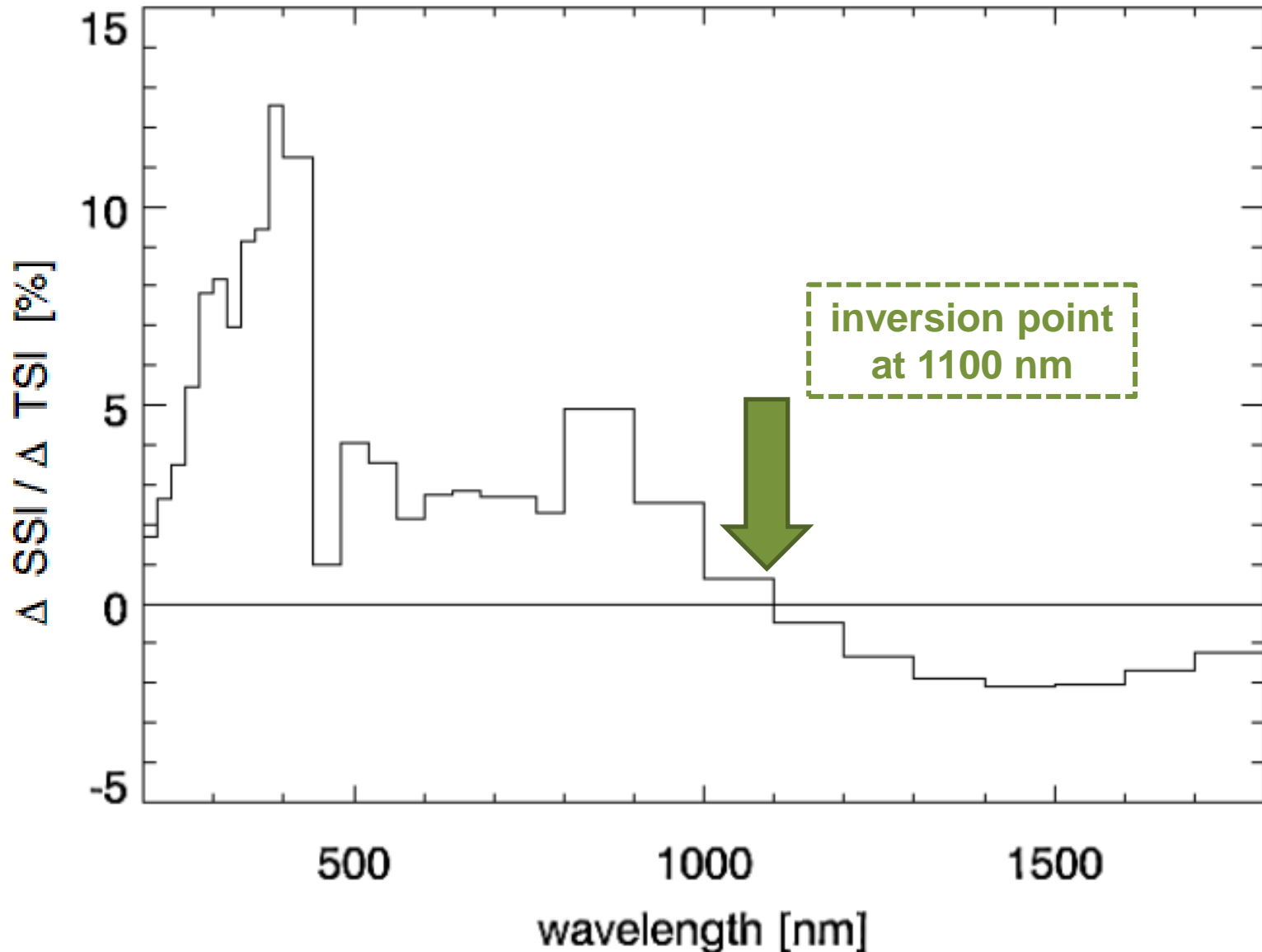


TSI modelled with **COSIR** (black) overplotted with two TSI composites.
Red – old PMOD composite. Blue – updated PMOD composite.

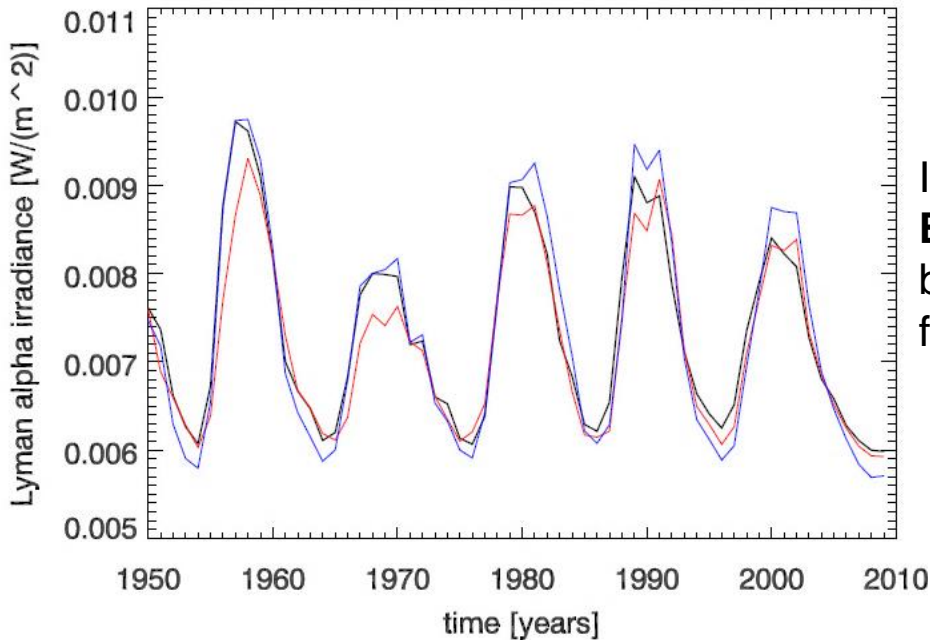
Results with COSIR: SSI / TSI for solar cycle 23 (weak)



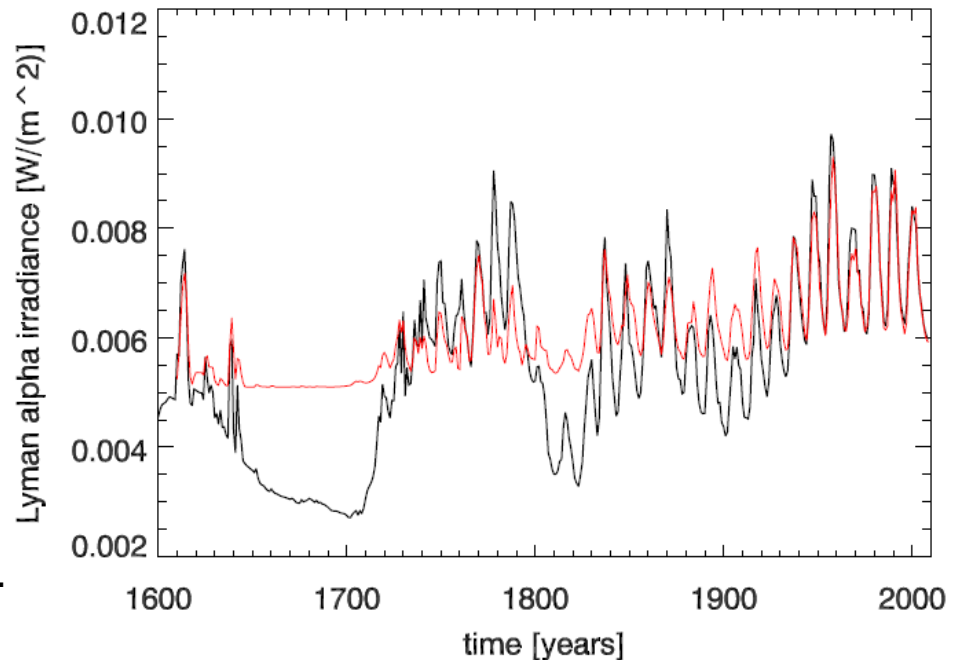
Results with COSIR: SSI / TSI for solar cycle 21 (strong)



Results with COSIR: Lyman-alpha time series



Integrated flux of Lyman-alpha, 1950–2010.
Black – COSIR; red – SATIRE;
blue – measurements and semi-empirical models
following Woods et al. (2000).



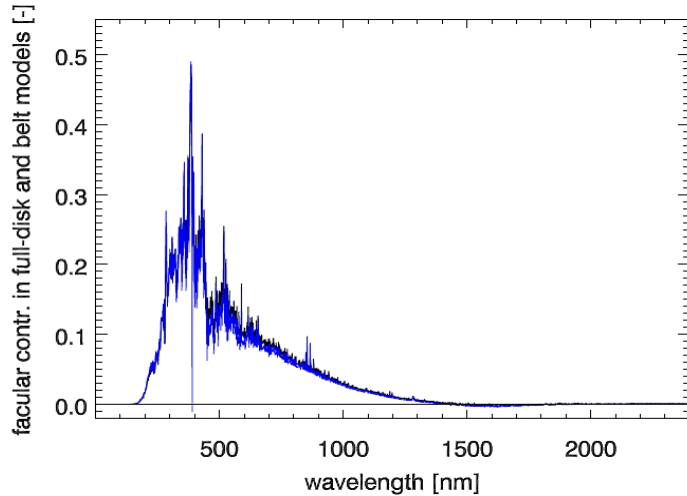
Integrated flux of Lyman-alpha, 1600–2010.
Black – COSIR, red – SATIRE.

New Model of Solar Irradiance

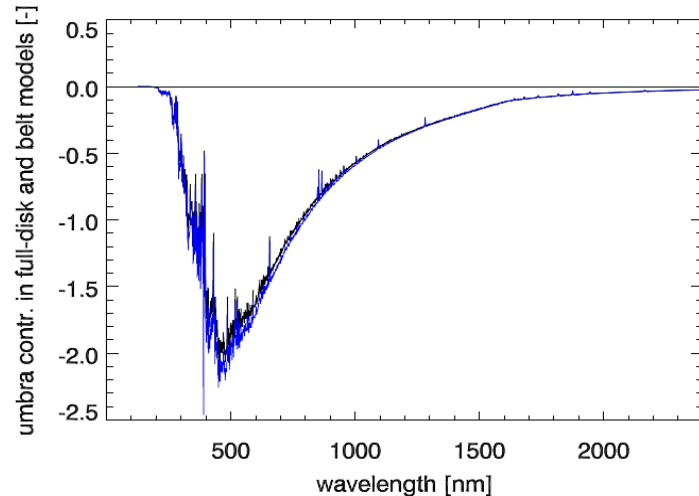
Additional slides

Results with COSIR:

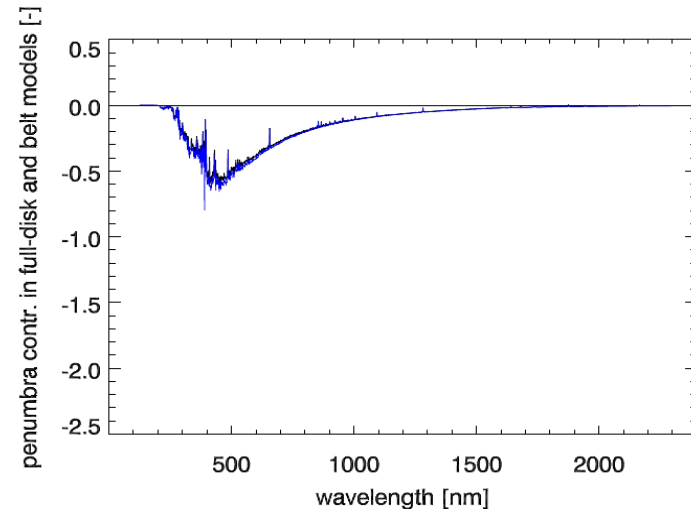
Full-disk model versus activity belt



Faculae in the full-disk model of COSI (black) and the **belt model** of **COSIR** (blue).



Umbrae in the full-disk model of COSI (black) and the **belt model** of **COSIR** (blue).



Penumbrae in the full-disk model of COSI (black) and the **belt model** of **COSIR** (blue).

Shapiro et al. (2011)

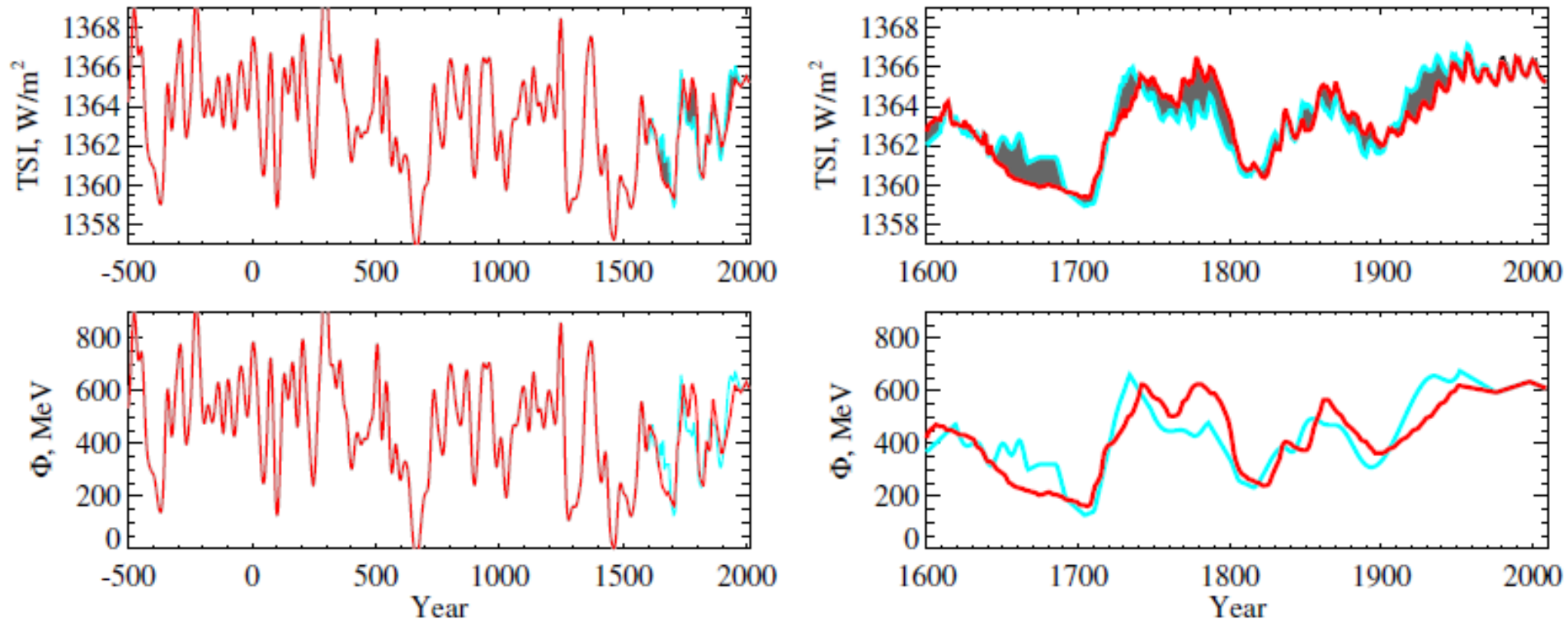
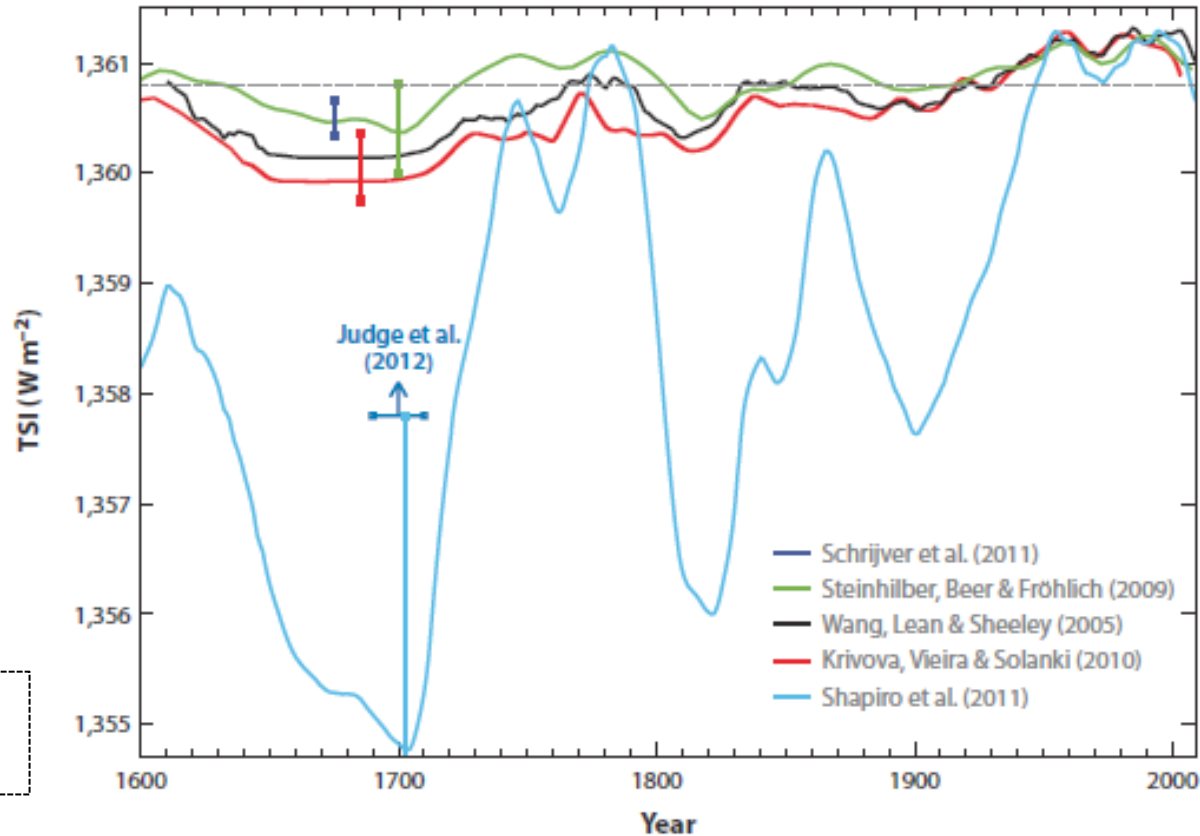


Fig. 2. Modulation potential (*lower panel*) and TSI reconstructions (*upper panel*) for the last 2500 years. Data before 1600 AD are based on the modulation potential derived from ^{10}Be records from the Greenland Ice core Project (red curves). Data since 1600 AD are based on the two composites shown in Fig. 1 (red and cyan curves). The gray-shaded area indicates the intrinsic uncertainty.

Implications of Judge et al. (2012)



Solanki, Krivova
and Haigh (2013)

Figure 10

Various total solar irradiance (TSI) reconstructions since 1600 identified in the plot. The dark blue vertical bar shows the possible range of the TSI change following Schrijver et al. (2011; no reconstruction available). Other vertical bars denote uncertainties of the models, plotted in same colors. Note that the uncertainty in the Shapiro et al. (2011) model, $\pm 3 \text{ W m}^{-2}$, extends downward outside the plot, and the blue horizontal bar and arrow mark the reduced value of this model as argued by Judge et al. (2012). The black dotted line shows the TSI value representing solar minimum conditions following *Solar Radiation and Climate Experiment* (SORCE)/Total Irradiance Monitor (TIM) measurements.