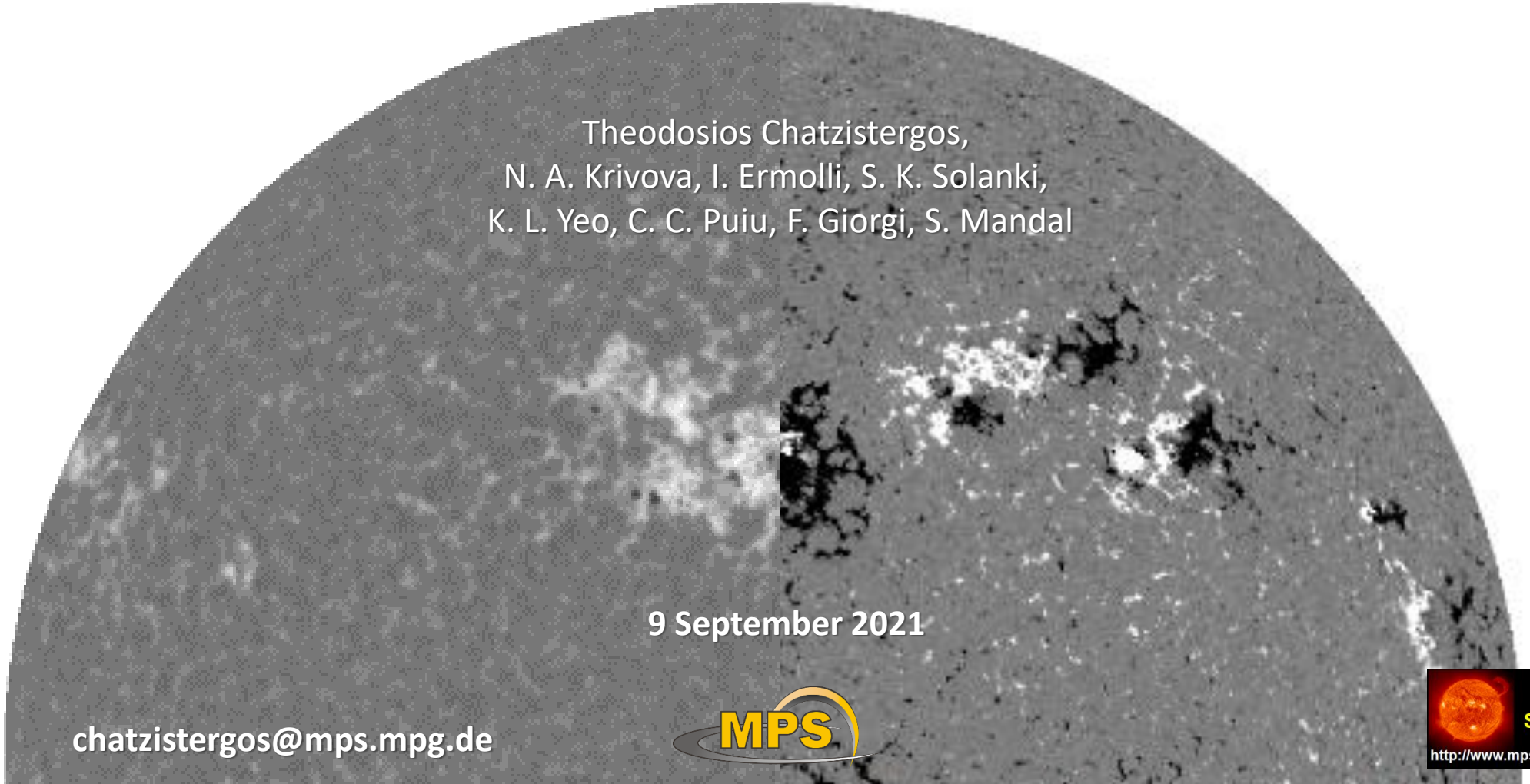
Reconstructing past solar irradiance variations with Ca II K observations



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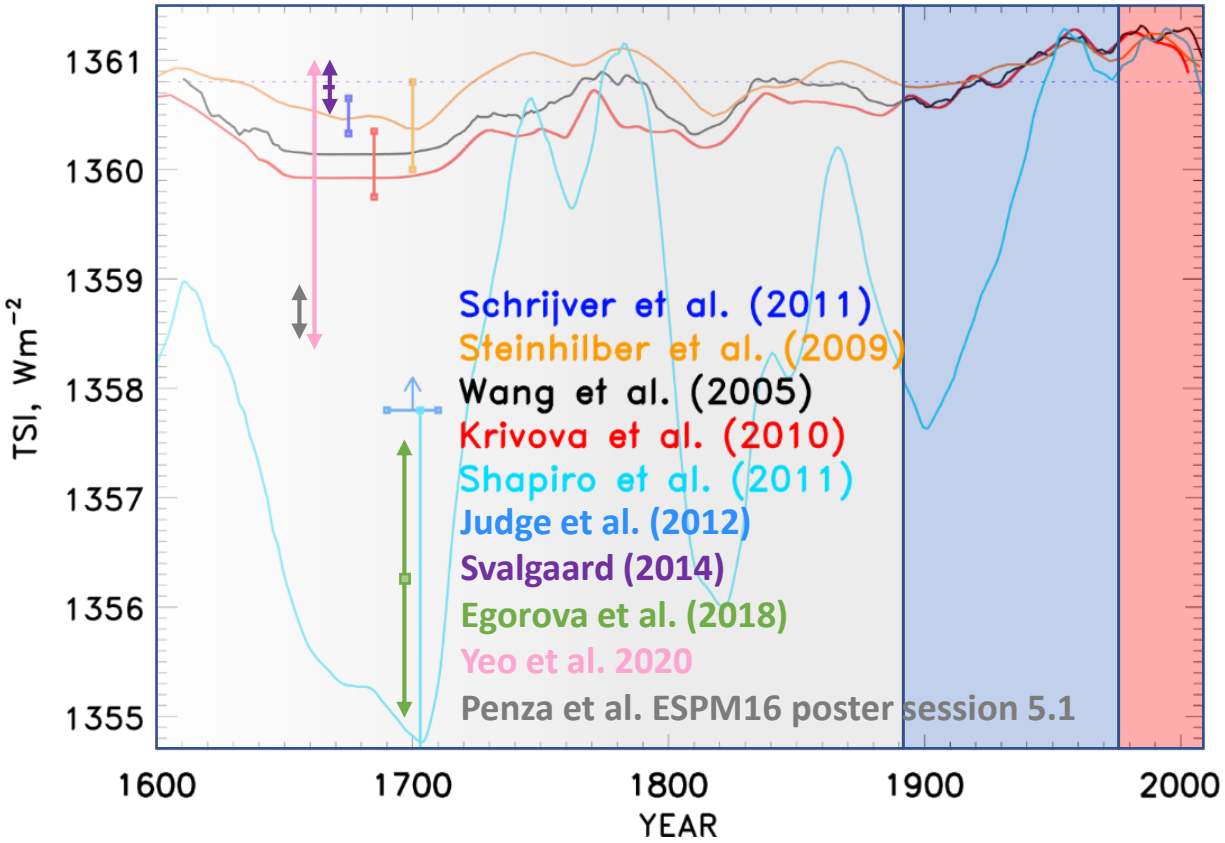
SUN – CLIMATE
http://www.mps.mpg.de/projects/sun-climate/

Motivation

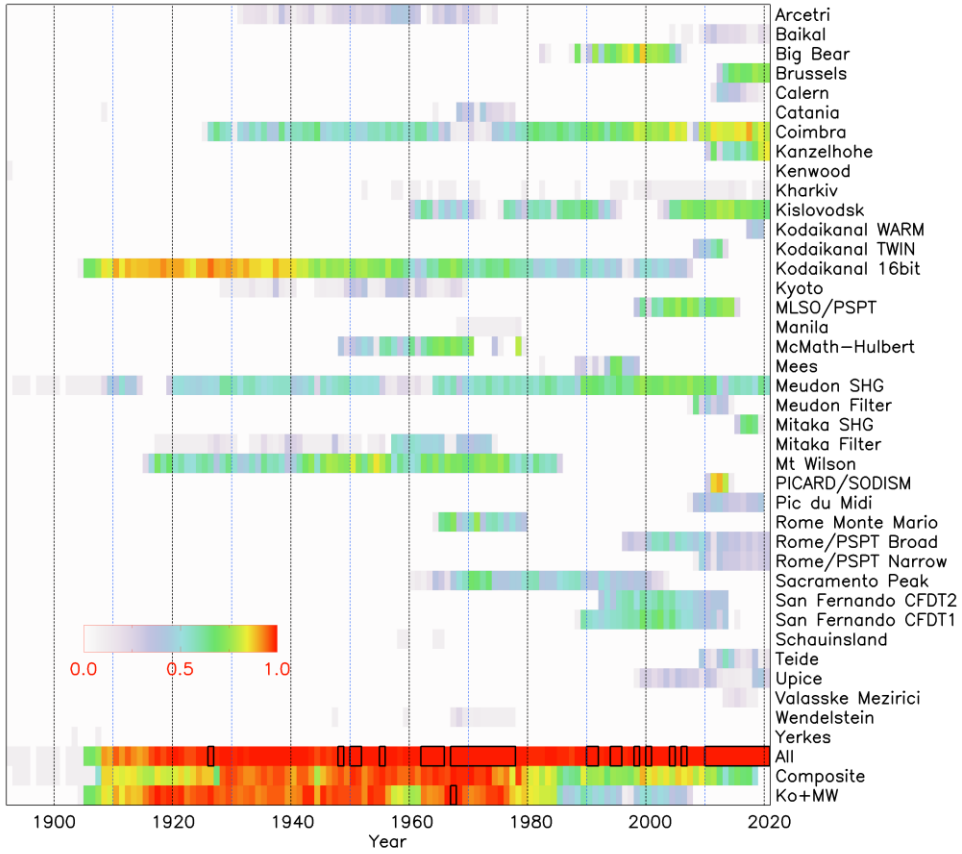
Employment of Ca II K observations → More accurate reconstructions back to 1892

→ Constraints on other reconstructions

Irradiance variations ~0.7 – 6 Wm^{-2} since 1600's



Solanki et al., 2013, ARA&A 51 1



Chatzistergos et al., 2020, A&A 639 A88

Spectral And Total Irradiance Reconstructions

Intensity spectra computed from corresponding model atmospheres (Unruh et al. 1999, A&A 345 635)

$$S(t) = \int \left(\sum_{i,j} a_s(i,j,t) I_s(i,j,\lambda) + a_f(i,j,t) I_f(i,j,\lambda) + a_{QS}(i,j,t) I_{QS}(i,j,\lambda) \right) d\lambda$$

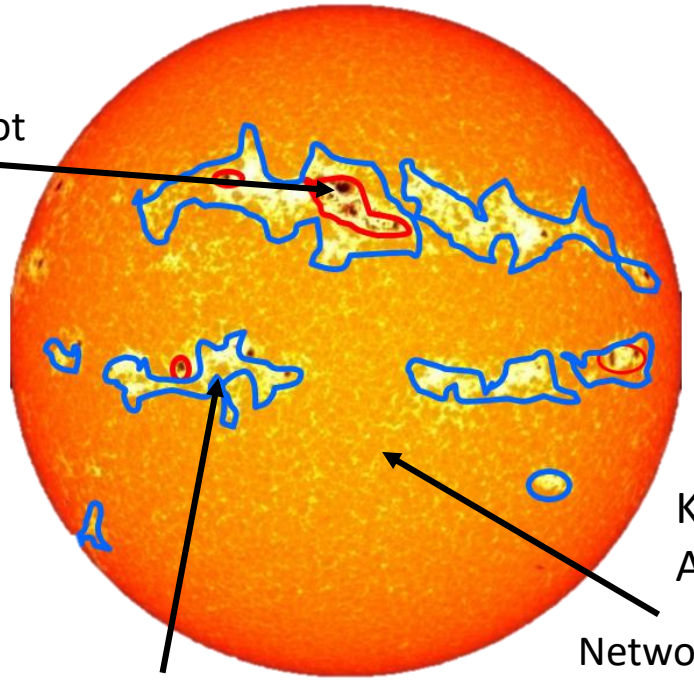
Filling factors

Faculae: Reconstructed magnetograms from Ca II K (Chatzistergos et al. 2019a, A&A 626 A114)

Sunspots: Sunspot areas and positions database from Kislovodsk and Pulkovo observatories (Mandal et al. 2020, A&A 640 A78)

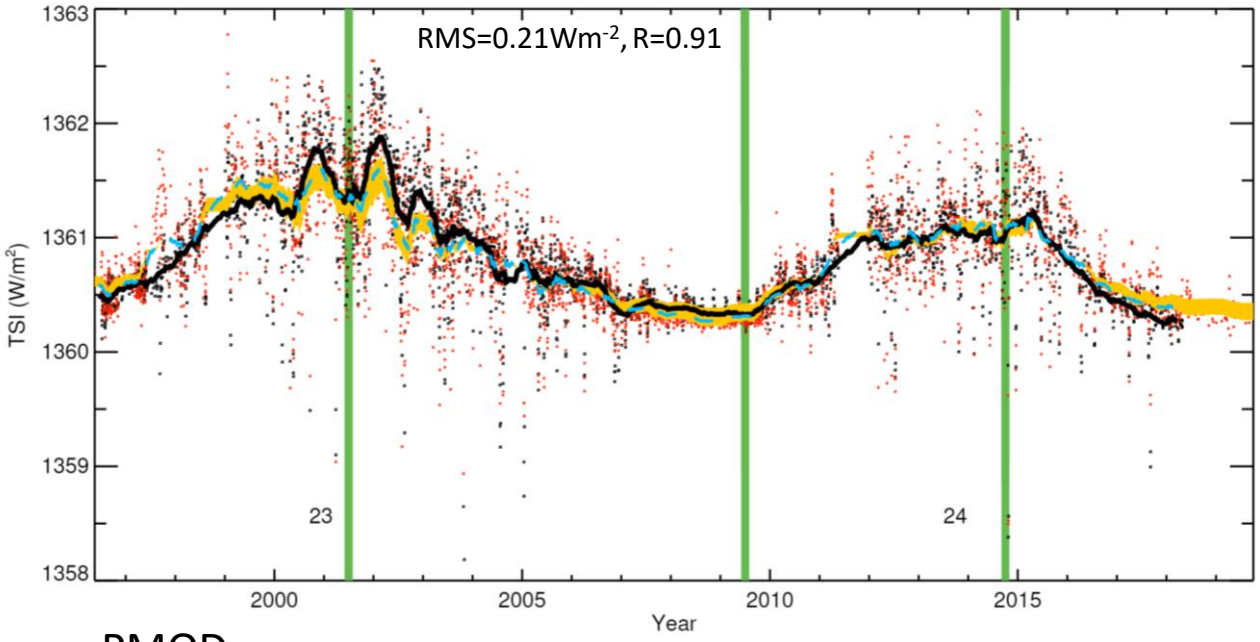
Only one free parameter: B_{sat} such that

$$a_f(i,j) = \begin{cases} \dfrac{|B|}{|B_{sat}|}, & |B| < |B_{sat}| \\ 1, & |B| \geq |B_{sat}| \end{cases}$$



Krivova et al. 2003 A&A 399

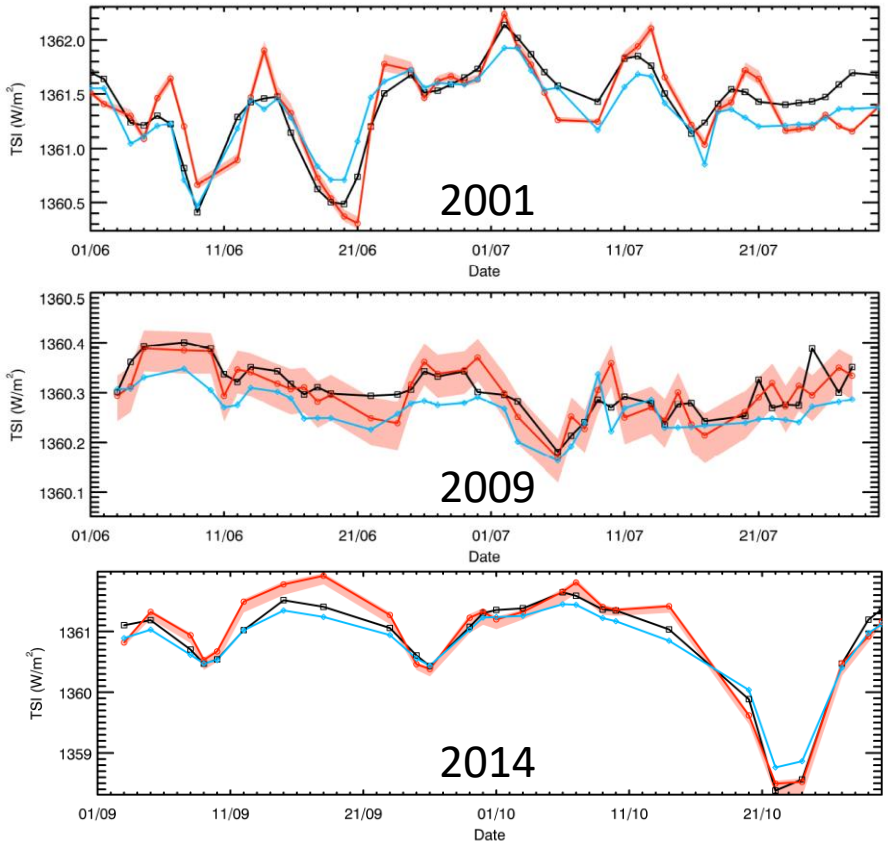
SATIRE reconstruction with Rome/PSPT Ca II K



PMOD

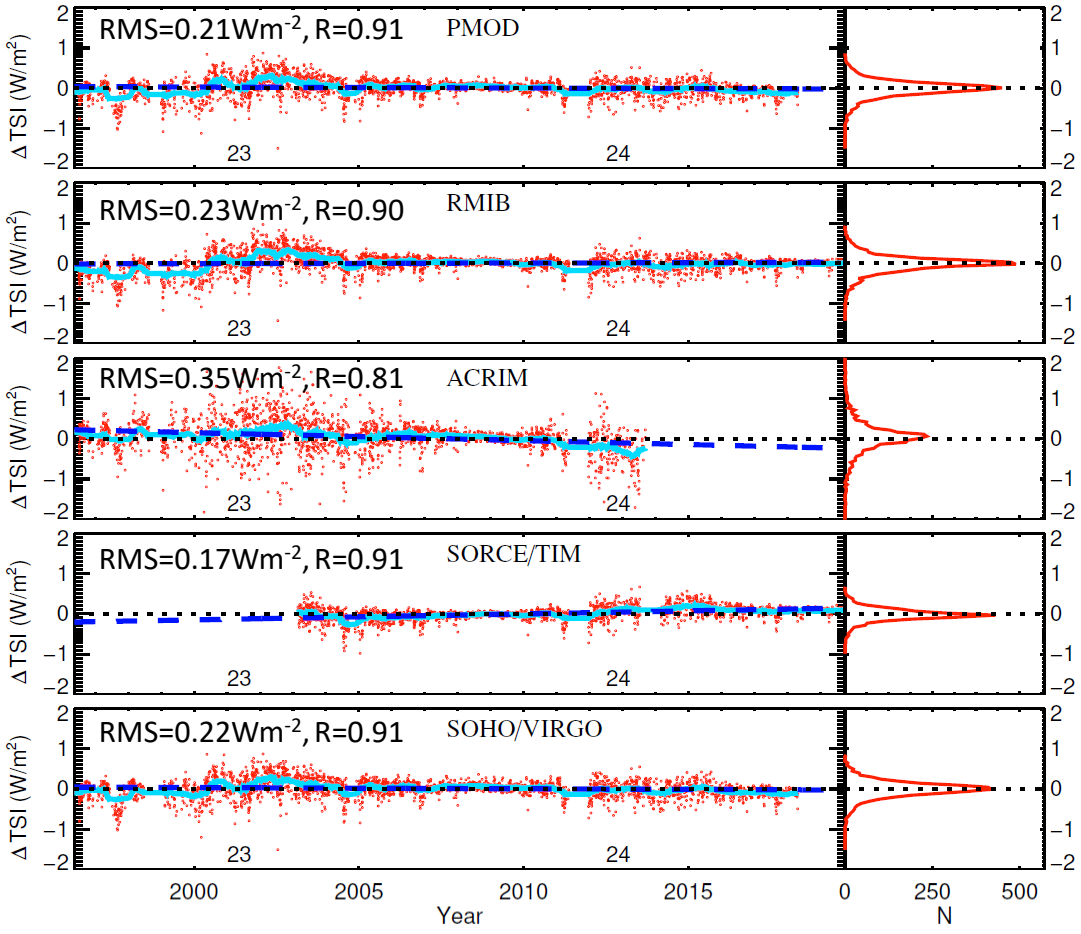
Ours (daily, 81-day running mean)

PMOD SATIRE-S Ours



Chatzistergos et al. submitted

Agreement to different TSI series



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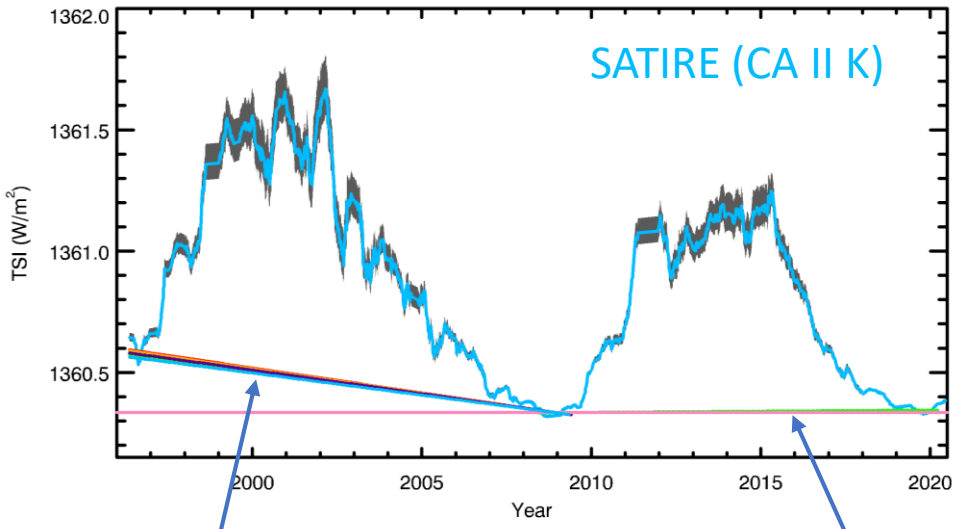
Trends of our reconstructed TSI series
Using different reference TSI series



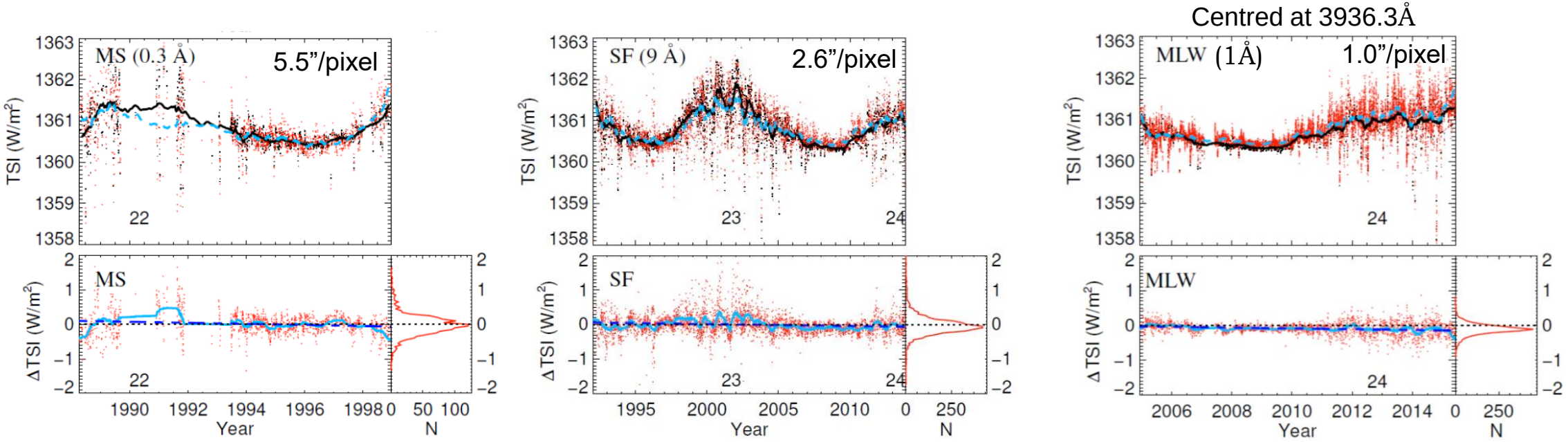
ACRIM
PMOD
RMIB
SORCE/TIM
SOHO/VIRGO
EMPIRE
NRLTSI
SATIRE-S

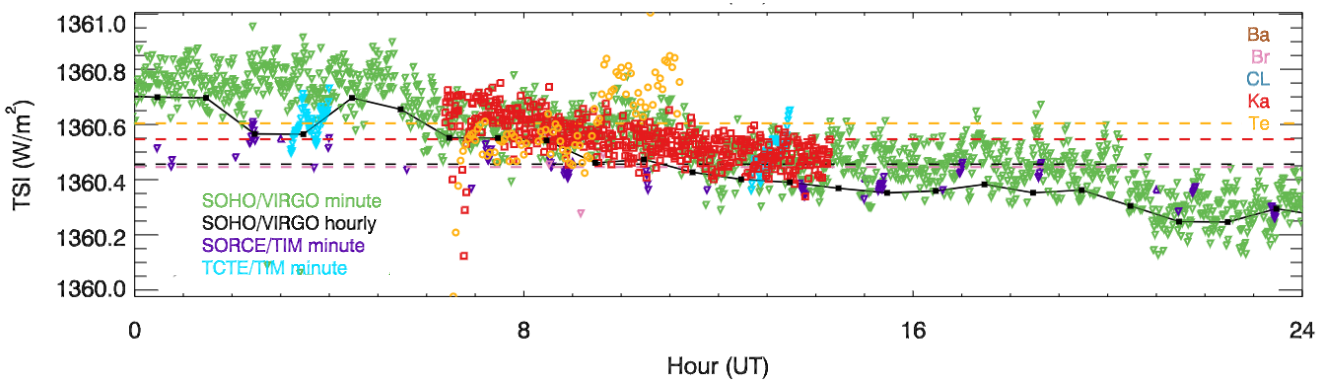
no-trend line

-2×10^{-2} Wm^{-2} y^{-1} 9×10^{-4} Wm^{-2} y^{-1}

Chatzistergos et al. 2021 ESSOAr

Reconstructions for diverse Ca II K archives





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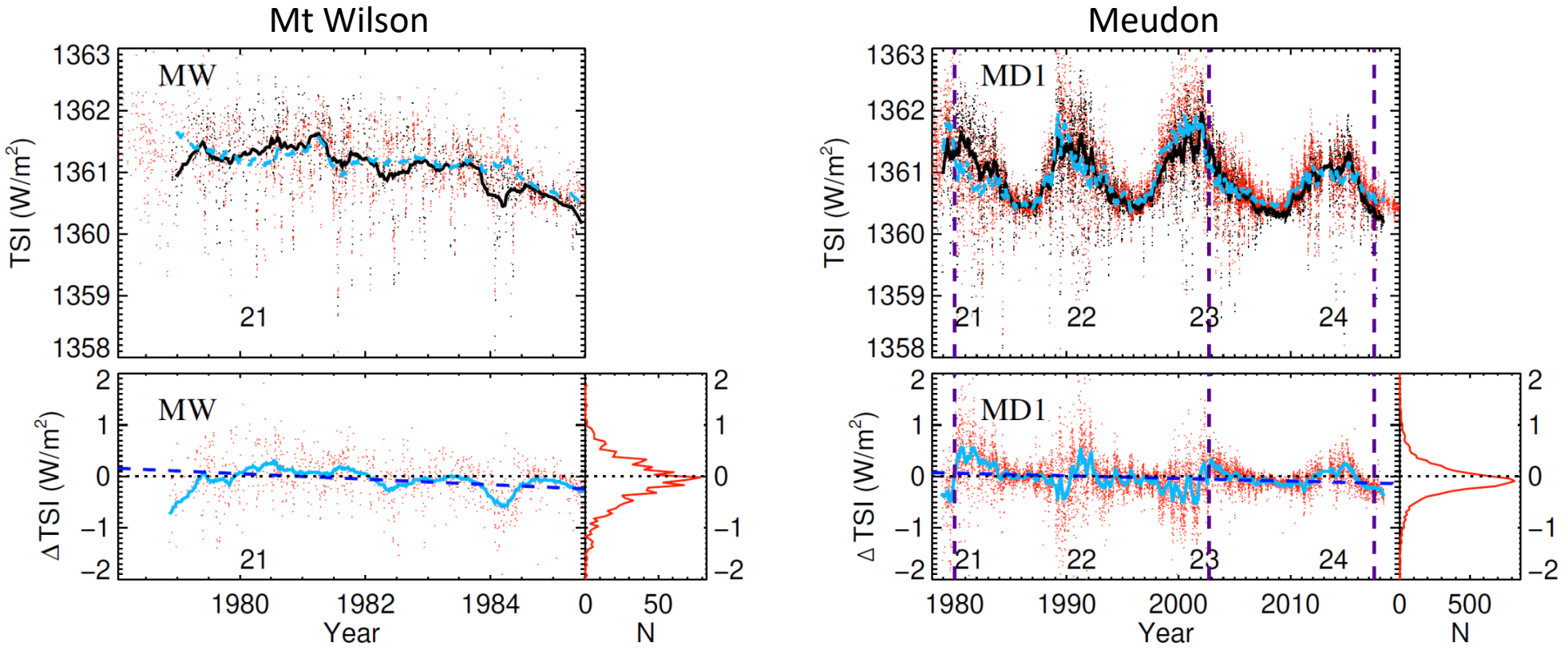
Results for photographic Ca II K data



Chatzistergos et al. submitted

Summary

- Ca II K observations are a valuable, but largely unexplored, resource for irradiance studies
- We used high-quality and carefully calibrated solar Ca II K observations to reconstruct solar irradiance with the semi-empirical SATIRE model
  - The reconstruction shows excellent agreement with PMOD & RMIB TSI composites, not with ACRIM
  - Selection of reference TSI series does not significantly affect the determined trend
  - We acquire accurate reconstructions with quite diverse Ca II K archives including photographic ones
- Inconsistencies of the photographic archives need to be addressed

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