CMIP Climate Forcings | WCRP | IAA Instituto de Astrofísica de Andalucía | Excelencia Severo Ochoa | APARC Atmospheric Processes And their Role in Climate | SOLARISHEPPA Solar influences for SPARC

Solar forcing

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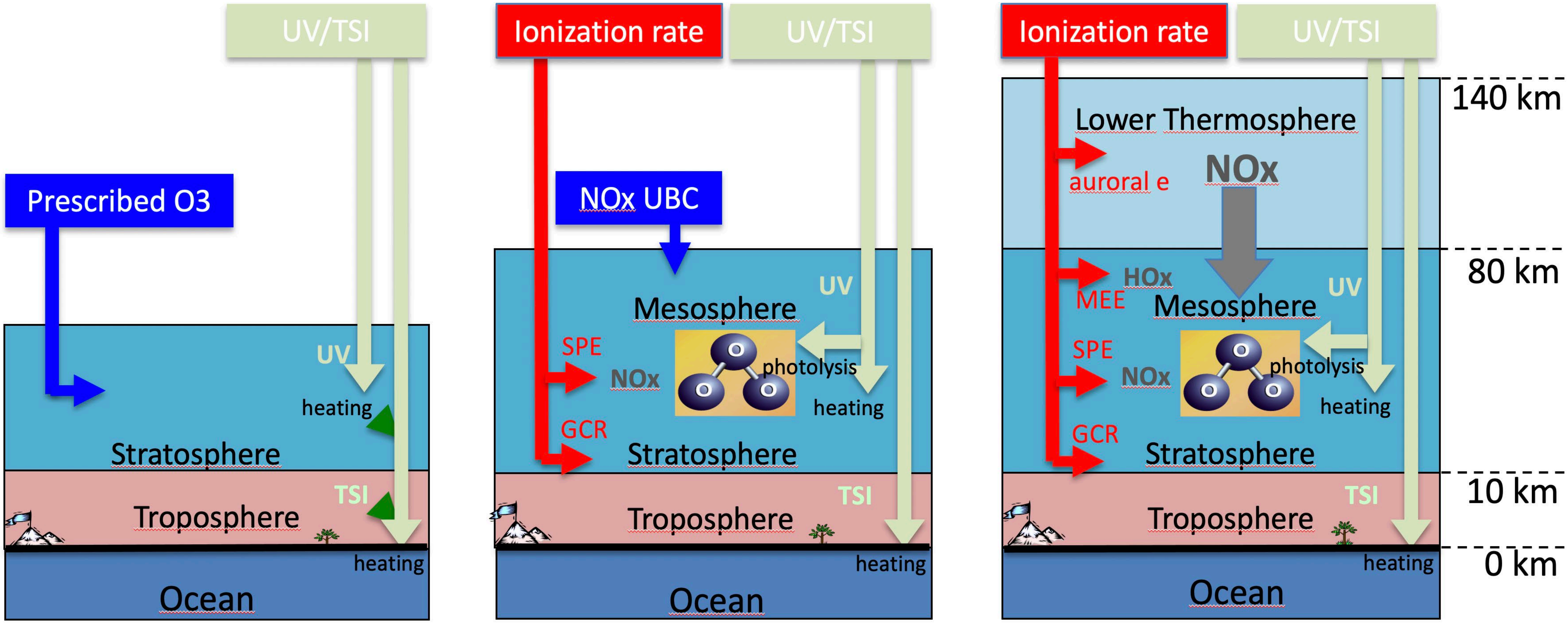
Solar forcing in climate models



"Low-top" model without interactive chemistry

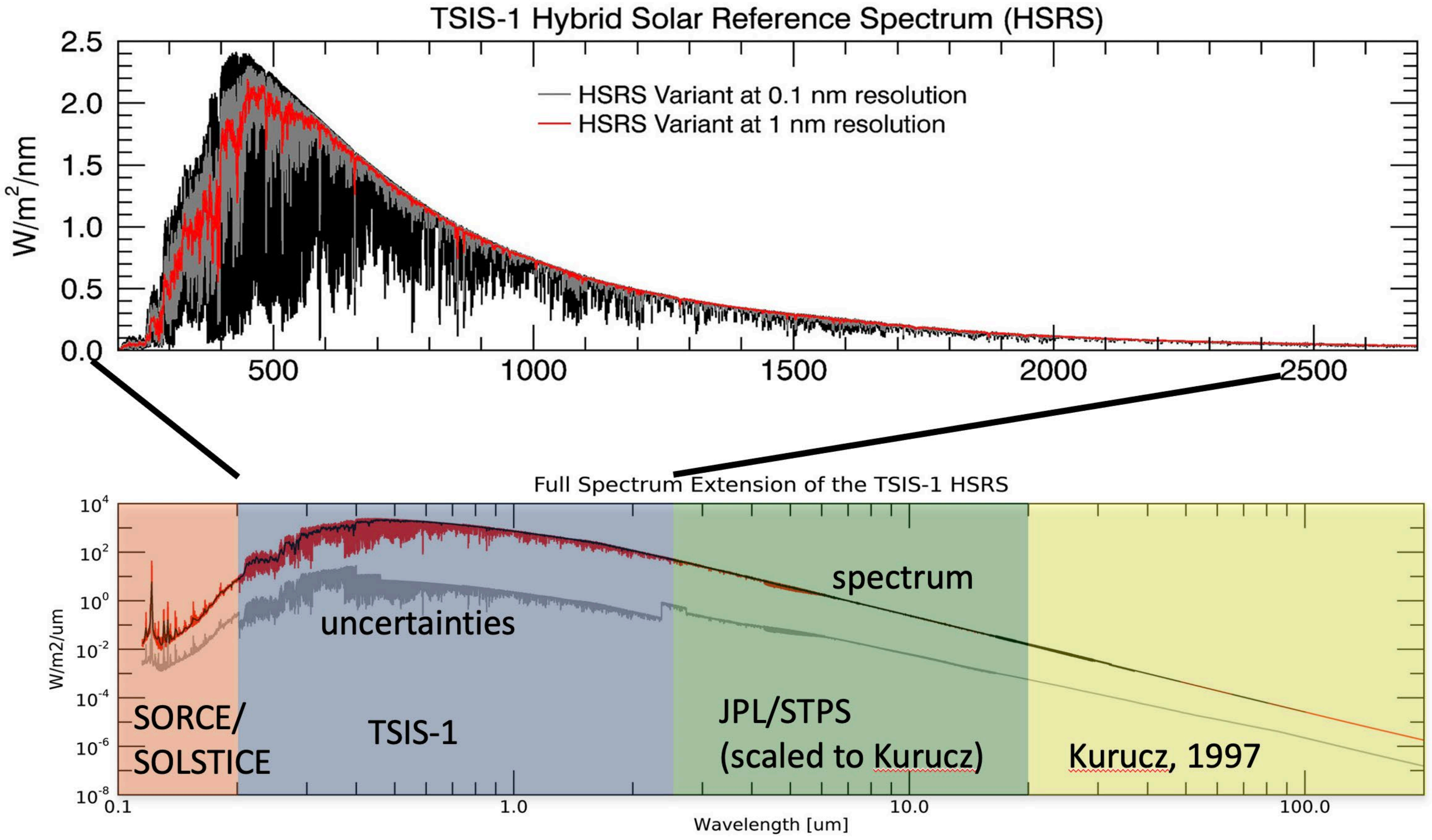
"Medium-top" model with interactive chemistry

"High-top" model with interactive chemistry

Radiative forcing for CMIP7

	CMIP5	CMIP6	CMIP7
TSI reference	1365.4 Wm^{-2}	1360.6 Wm^{-2}	**1361.2 Wm^{-2}**
SSI	NRLSSI1	(NRLSSI2+SATIRE)/2	**Reference: NNL1/CDR3** **alternative dataset: SATIRE-CMIP7**
QS spectrum	< 400 nm: UARS/SOLSTICE 401-874 nm: ATLAS-1 > 875 nm: Kurucz, 1991	NRL: 115 - 300 nm: LASP WHI 300 – 1000 nm: ATLAS-1, constrained to LASP WHI SATIRE: 1000-2400 nm: LASP WHI > 2400 nm: Kurucz, 1991 115 - 2400 nm: LASP WHI > 2400 nm: Kurucz, 1991	**Version 2 HSRS (Coddington et al. 2023)** **TSIS-1 + STPS + Kurucz**
EUV	Only > 1882	EUV extension (10-115 nm) obtained by regression from the UV band, trained with TIMED/SEE.	**from NNL1/CDR3**

Version 2 HSRS solar reference spectrum

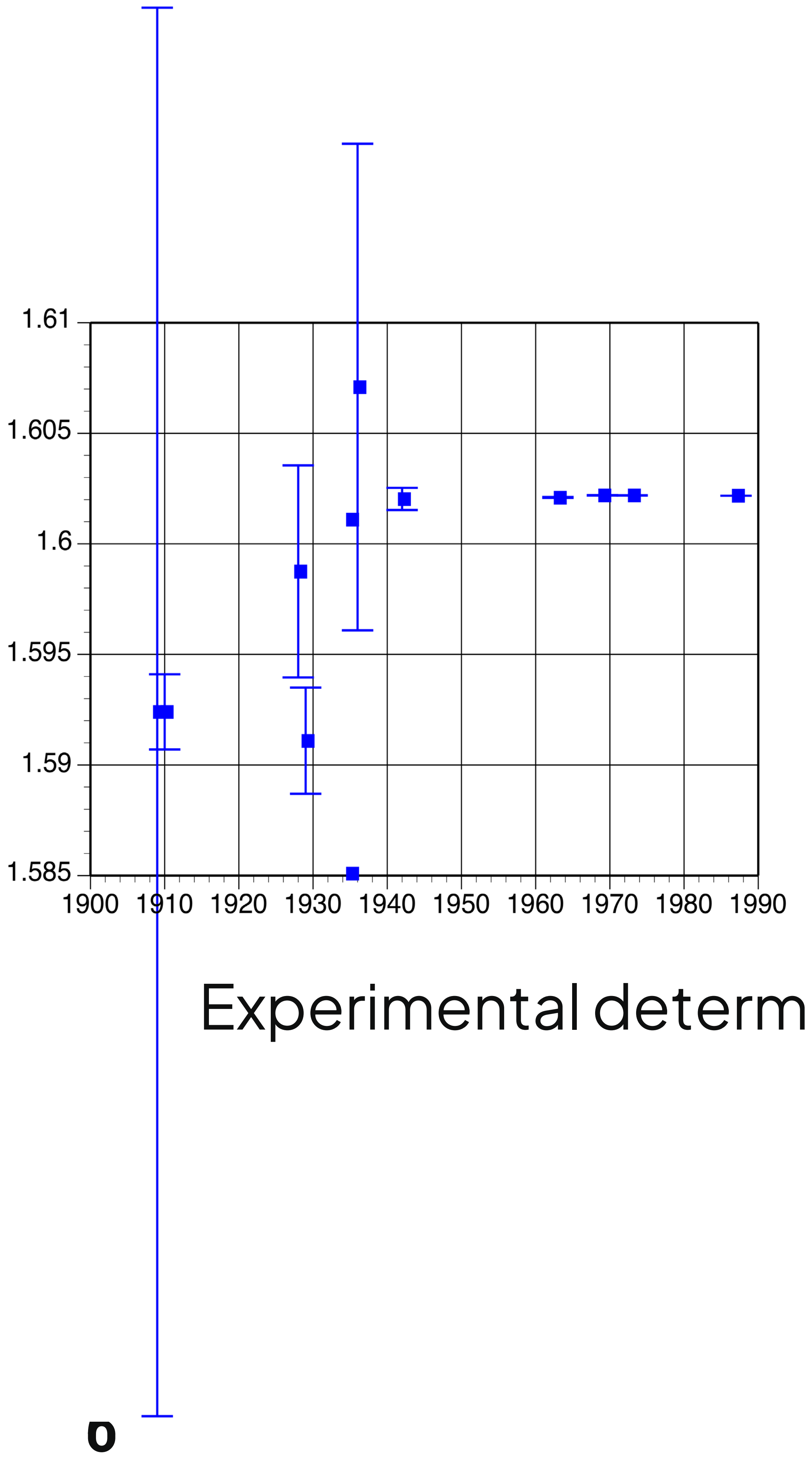


Coddington et al., GRL, 2021

Recommended as new solar irradiance reference spectrum standard by CEOS Working Group on Calibration and Validation (WGCV)

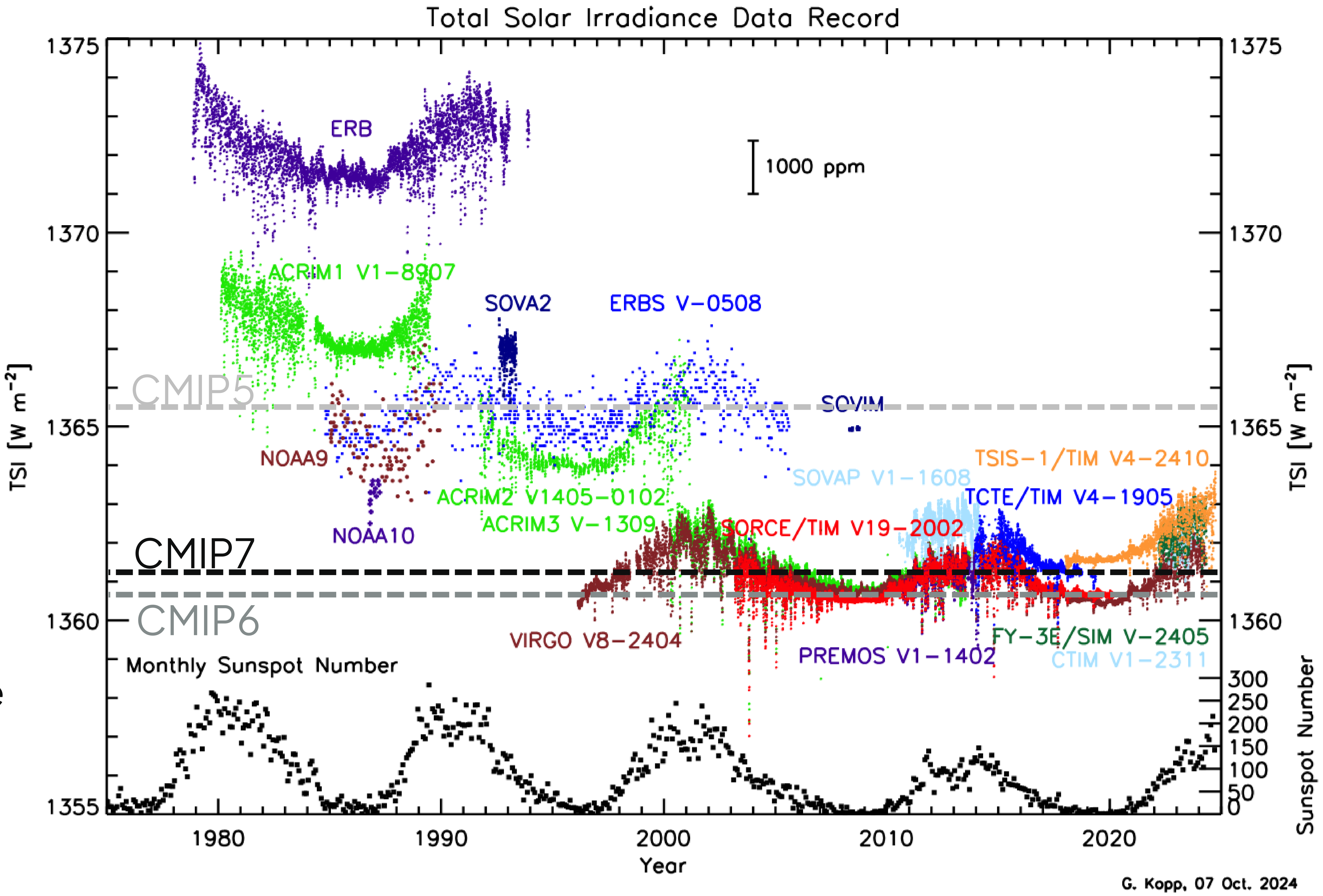
UV: 1–5% > CMIP6
VIS: 1–2% < CMIP6
Direct implications on the climate response: albedo of sea ice is higher in the visible and lower in the Near-IR. Relevant for climate model tuning (prior to simulations)

How “final” is the CMIP7 TSI reference?

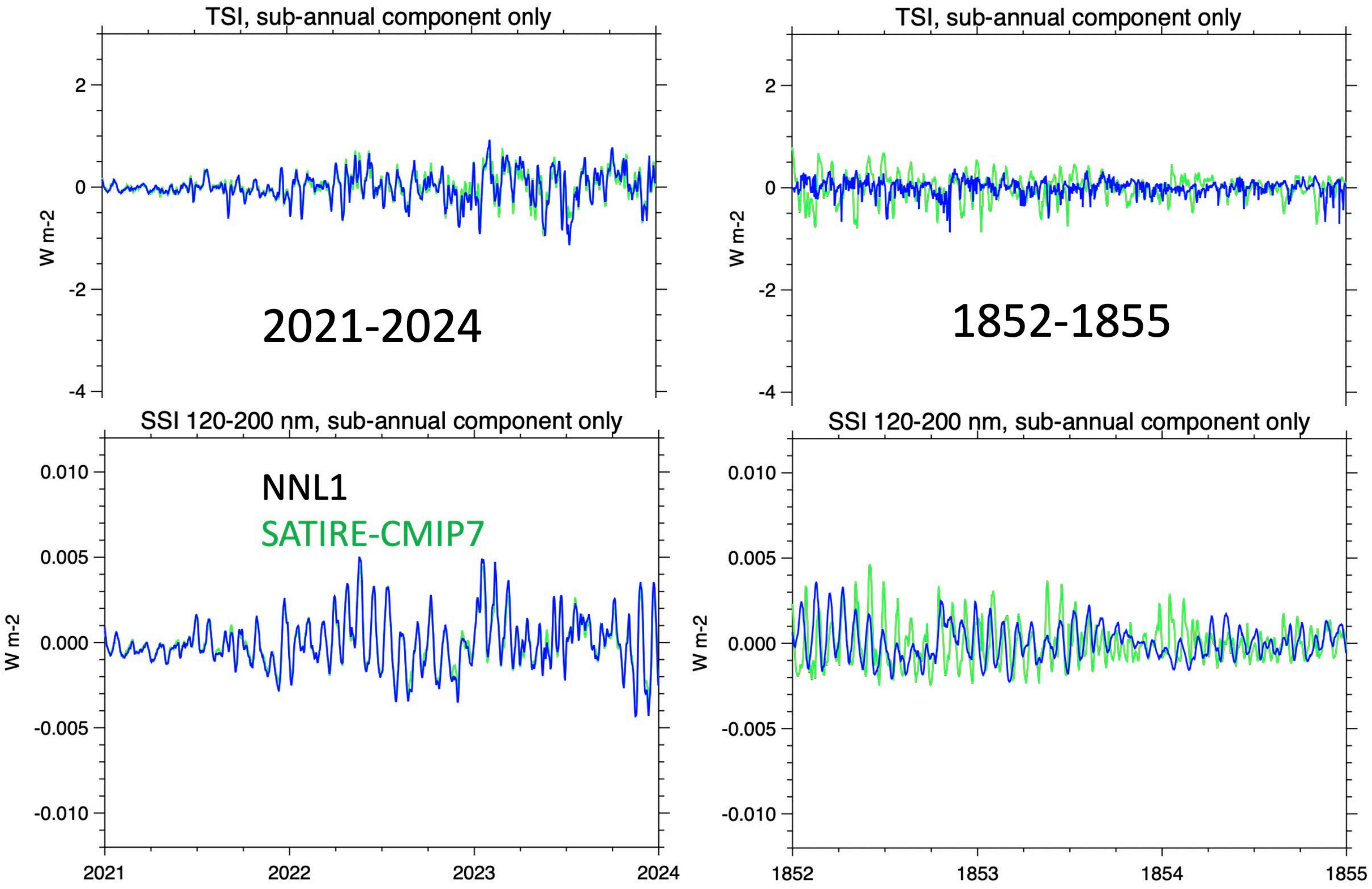


Millikan (notebooks)
Millikan (published)
Erik Backlin, Nature 1929
[Birge, 1929]
Backlin and Flemberg, Nature 1936
Backlin and Flemberg, cited in HR Robinson RPP 1937
Gunnar Kellström PR 1936
[Birge, 1942]
[Dummond and Cohen, 1963]
[Taylor et al, 1969]
[Cohen and Taylor, 1973]
[Cohen and Taylor, 1987]

Experimental determination of electron charge



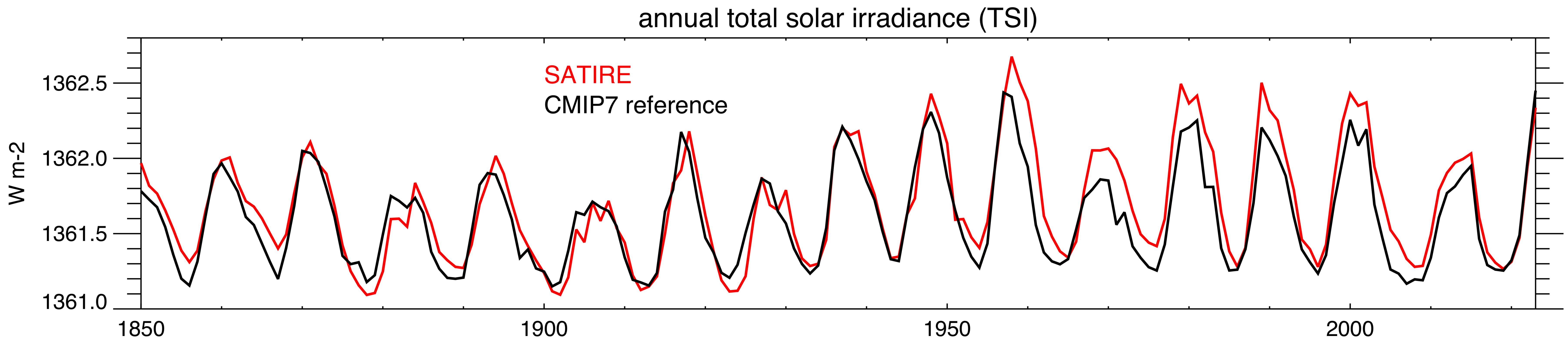
Why not merging again NNL1 and SATIRE?

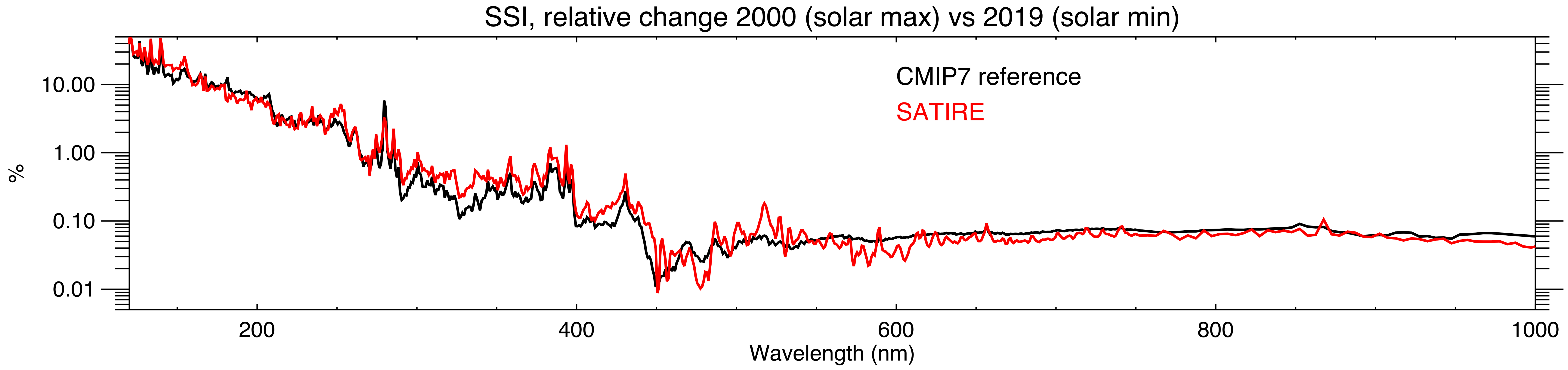


Out-of-phase short-term variability in the early phase of the CMIP period.

Merging would lead to dampening of variability magnitude and unrealistic variability patterns

Reference (NNL1-CDR3) vs. sensitivity (SATIRE) dataset

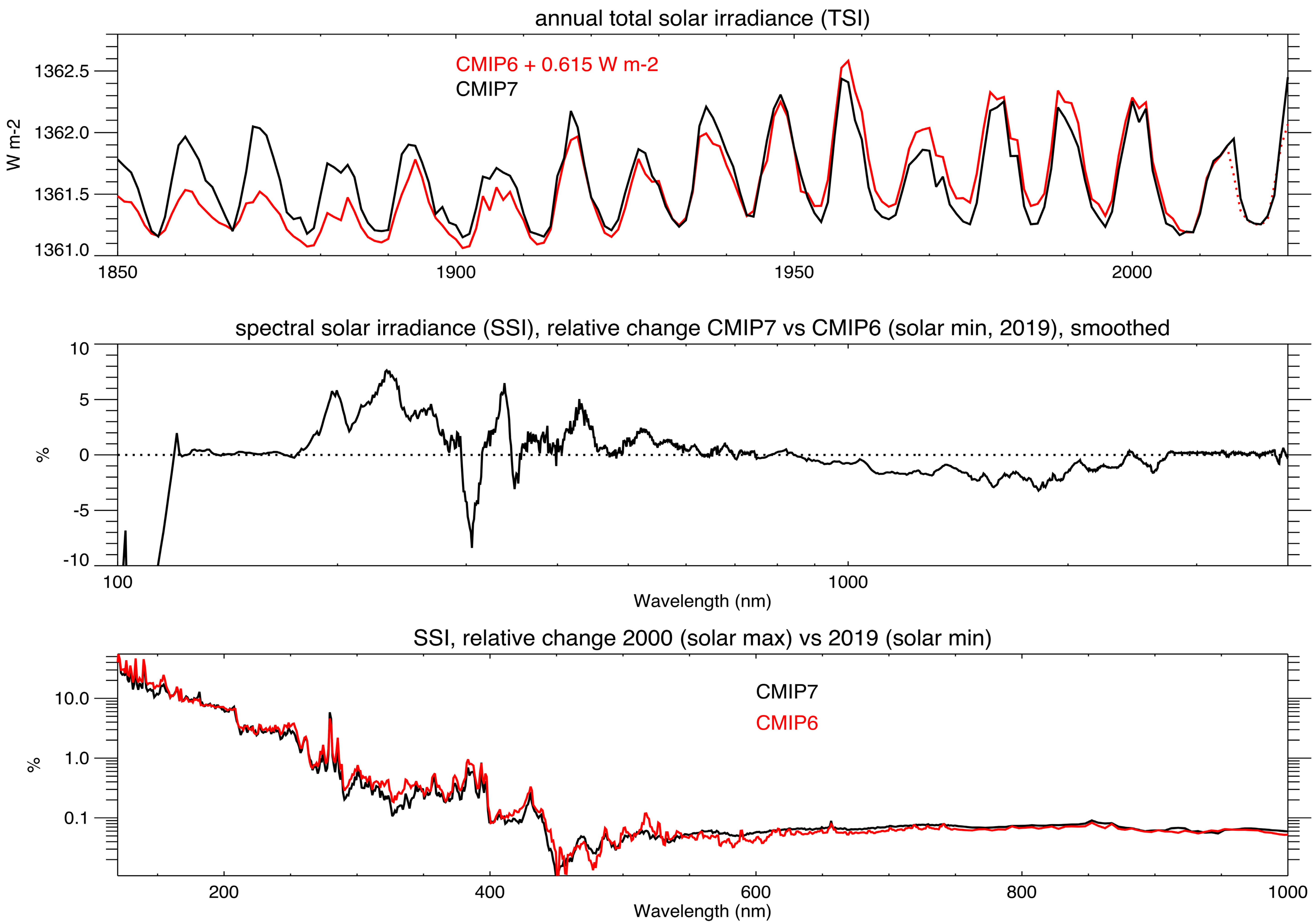




TSI differences (annual scale): < 0.2 W m^{-2}

Slightly larger UV variability in SATIRE-CMIP7

Solar radiative forcing: CMIP7 vs. CMIP6



- TSI reference slightly larger: $+0.615\ Wm^{-2}$
- slightly smaller secular trend
- enhanced (reduced) irradiance in the UV (NIR)
- slightly smaller (larger) decadal variability in the UV (NIR)

Energetic particle forcing (most relevant for generation of O3 dataset)

	CMIP 5	CMIP6	CMIP7
Geomagnetic proxies	none	Ap, kp	As CMIP6
EEP (MEE)	none	MEPED/POES 0 deg telescope, Ap-based reconstruction (van der Kamp et al., 2016)	Consideration of both (0 and 90 deg) telescopes, improved energy spectrum, refined reconstruction with lagged Ap response
SEP (solar protons)	none	GOES/IMP (<300MeV), SC-aligned random projection prior 1963 (Jackman et al.)	Inclusion of 400 MeV fluxes (Rakunen et al., 2022), MC-based modeling of nucleonic cascade
GCR	none	CRAC:CRII, based on solar modulation potential (Usoskin et al., 2010)	Use of NM data after 1951
NOy UBC for medium-top models	none	observation-based (MIPAS), driven by Ap (Funke et al, 2016)	Improved version (based on MIPAS-V8)

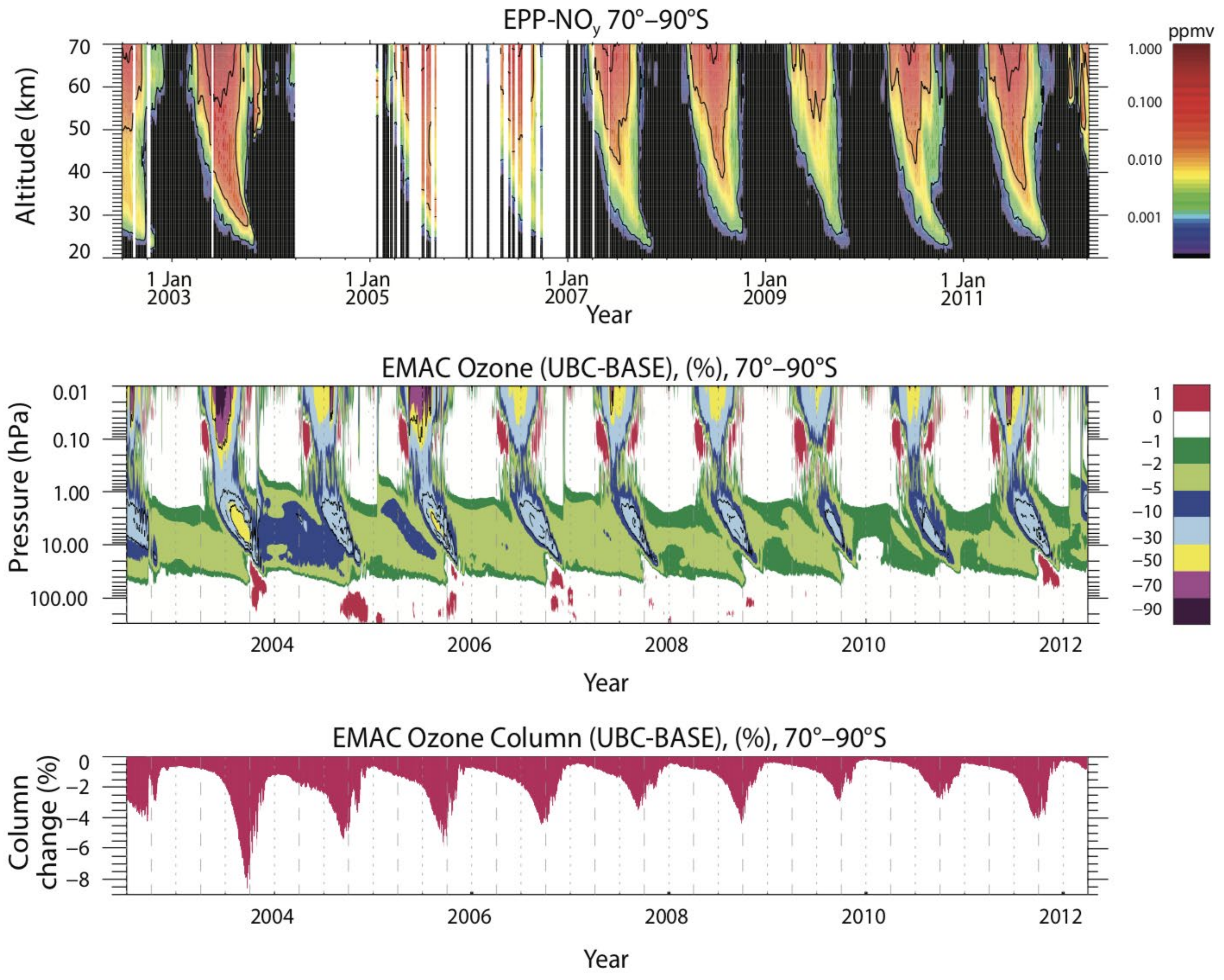
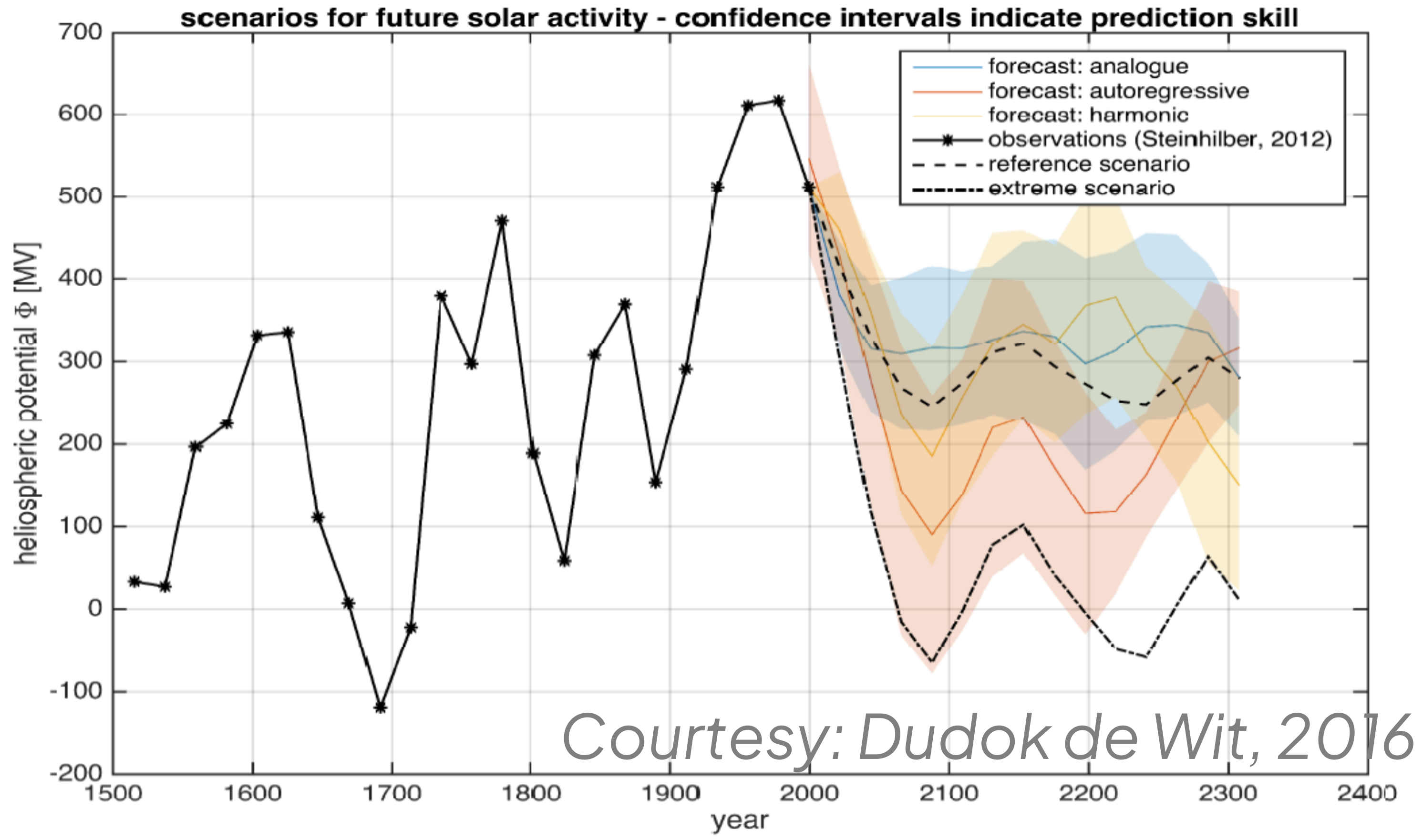


Figure 4-13. (*top*) Temporal evolution of the NO_y contribution produced by energetic particle precipitation (EPP-NO_y) (in ppmv) at 70°–90°S taken by the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) on board the Envisat satellite during 2002–2012. The contribution of EPP-NO_y has been discriminated from that produced by N_2O oxidation using a tracer correlation method based on MIPAS CH_4 and CO observations. (Adapted from Funke et al., 2014). (*middle and bottom*) Ozone loss due to EPP as a function of pressure level (*middle*) and for the total ozone column (*bottom*) at southern high latitudes (70°–90°S). Shown is the percentage difference between EMAC model simulations with and without EPP impact. The EPP effect is prescribed as an upper boundary condition of NO_y based on MIPAS observations; solar proton events (e.g., in October/November 2003 or January 2005) are prescribed by modeled ionization rates. Adapted from Sinnhuber et al. (2018).

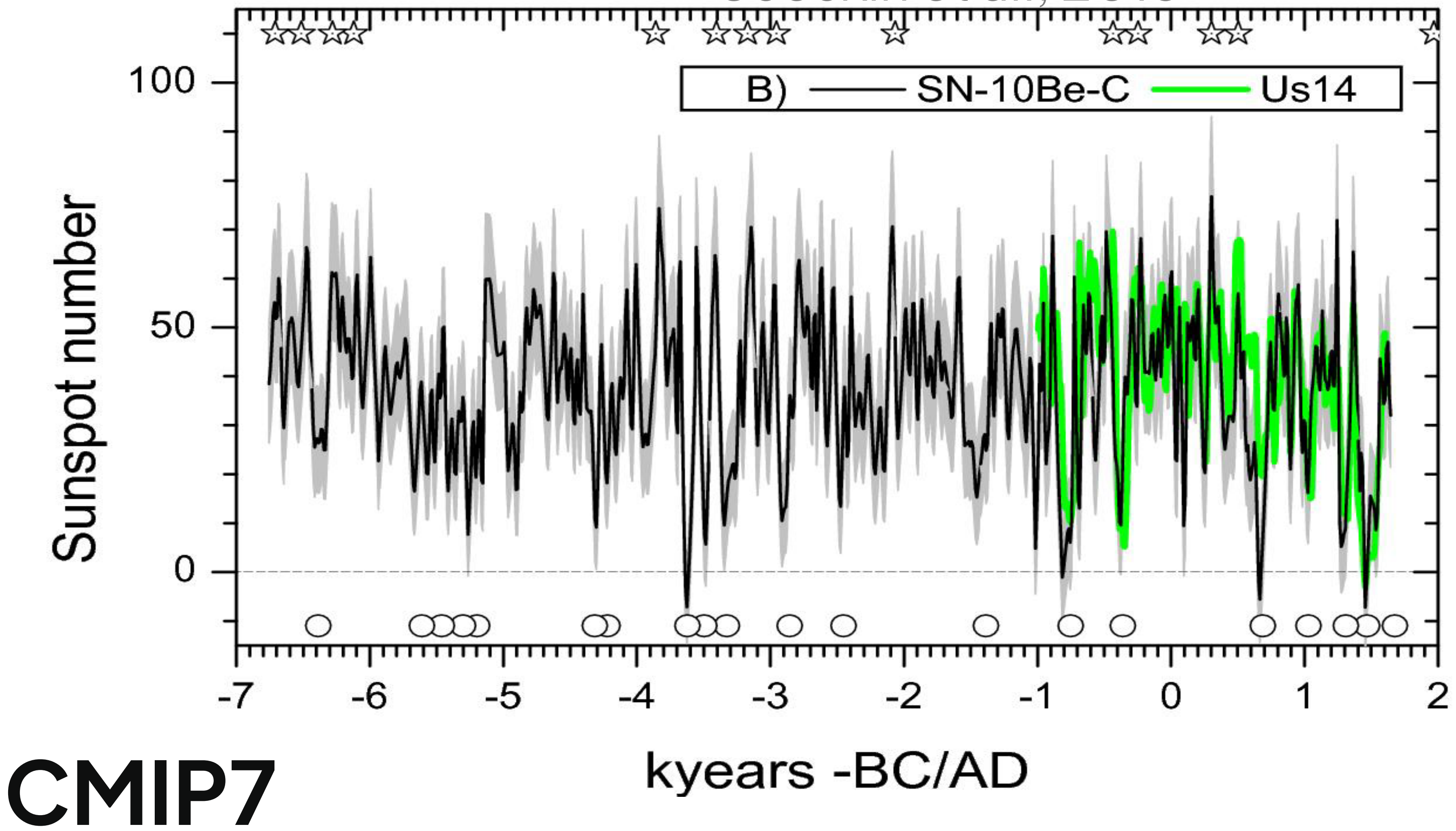
WMO-UNEP Ozone Assessment 2018, Chapter 4

Future solar activity scenario(s)



Courtesy: Dudok de Wit, 2016

Usoskin et al., 2015



CMIP5

- stationary-Sun scenario (i.e., repetition of solar cycle 23)

CMIP6

- plausible scenario for future solar activity, exhibiting variability at all timescales (daily to centennial) in accordance with the Sun's past behavior (from cosmogenic isotope records)
- One reference + one extreme scenario

CMIP7

- Ensemble of solar activity evolutions from surrogate analysis of cosmogenic isotope records
- Generation of corresponding SSN and Ap records to feed reconstruction models
- One reference scenario (for climate model simulations) + ensemble forcing for DA analysis

Solar forcing: Status and timeline

- First preliminary (CMIP6plus) historical dataset released in June, current version 4-4 (accessible on input4MIPs and solarisheppa.geomar.de)
- Status Version 4-4:
  - Radiative forcing (TSI, SSI) stable
  - Particle forcing: Ongoing refinements of MEE reconstruction (to be solved within next weeks)
  - Still missing: uncertainty estimates
- Final historical dataset (for CMIP7 DECK) to be delivered until Jan 2025
- Future solar forcing (to be finalized until end of 2025)

Thank You