CMIP6 solar and volcanic forcing for ESM 1.5

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Solar

CMIP6 solar data is described by Matthes et al. (2017) and is quite different to CMIP5. In particular the present day solar cycle average of the total solar irradiance is now 1361.0 Wm^{-2}, compared to ~1366 in CMIP5.
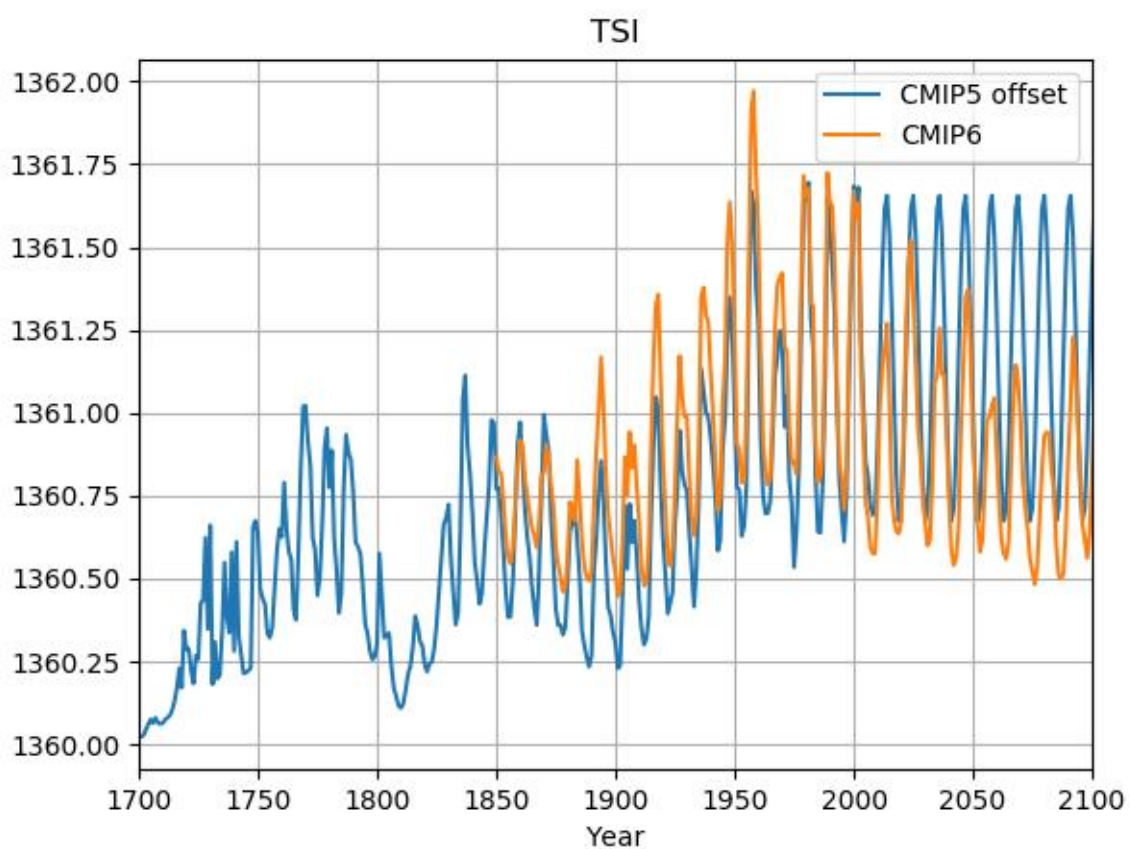

Figure 1. CMIP5 and CMIP6 TSI. The CMIP5 value has been reduced by 5 Wm^{-2} as in Matthes et al Figure 1.

The ESM PI control has been using 1365.65 which is the 1850-1860 solar cycle mean in the CMIP5 data. The CMIP6 recommendation is to use the mean of two solar cycles 1850-1872 = 1360.75 Wm^{-2}. Therefore for ESM we use the CMIP6 series with a 4.9 Wm^{-2} offset.
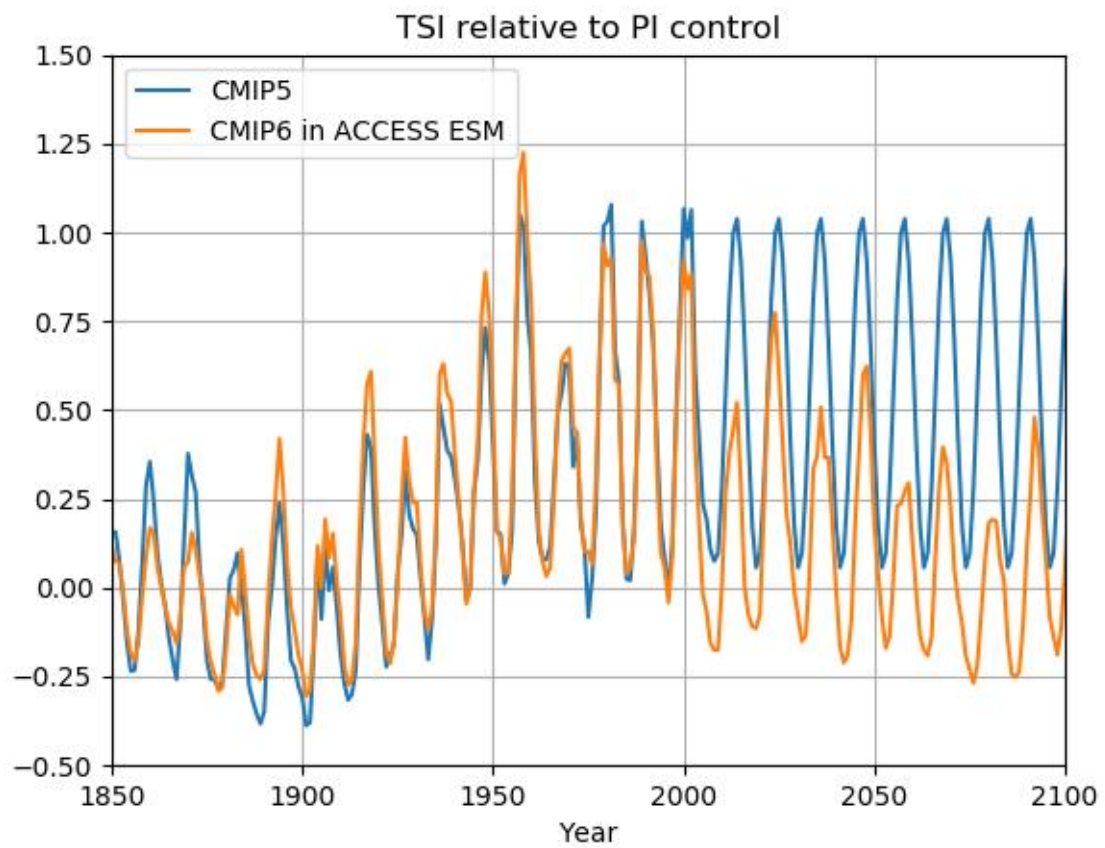
Figure 2. TSI relative to control value for CMIP5 and CMIP6. Values calculated from the TSI_WLS_ann_1700_2300 and TSI_CMIP6_ESM data files, using a python equivalent of the UM solvar routine. Note that the radiative forcing is approximately 0.18 times the TSI change (factor of 0.25 for average over diurnal cycle and latitude and ~ 0.7 for planetary albedo).

Volcanic forcing

CMIP5 used an extended version of the Sato et al. (1993) data. This simply specifies monthly optical depths in 4 equal area latitude bands (90N-30N, 30N-0, 0-30S, 30S-90S). For CMIP6, full aerosol optical properties are available as a function of latitude, height and wavelength. ESM 1.5 can't actually use these but fortunately a simple optical depth at 550 nm is also available, ftp://iacftp.ethz.ch/pub_read/luo/CMIP6/CMIP_1850_2014_extinction_550nm_strat_only_v3.nc. I integrated this as a function of height and averaged over the 4 bands.
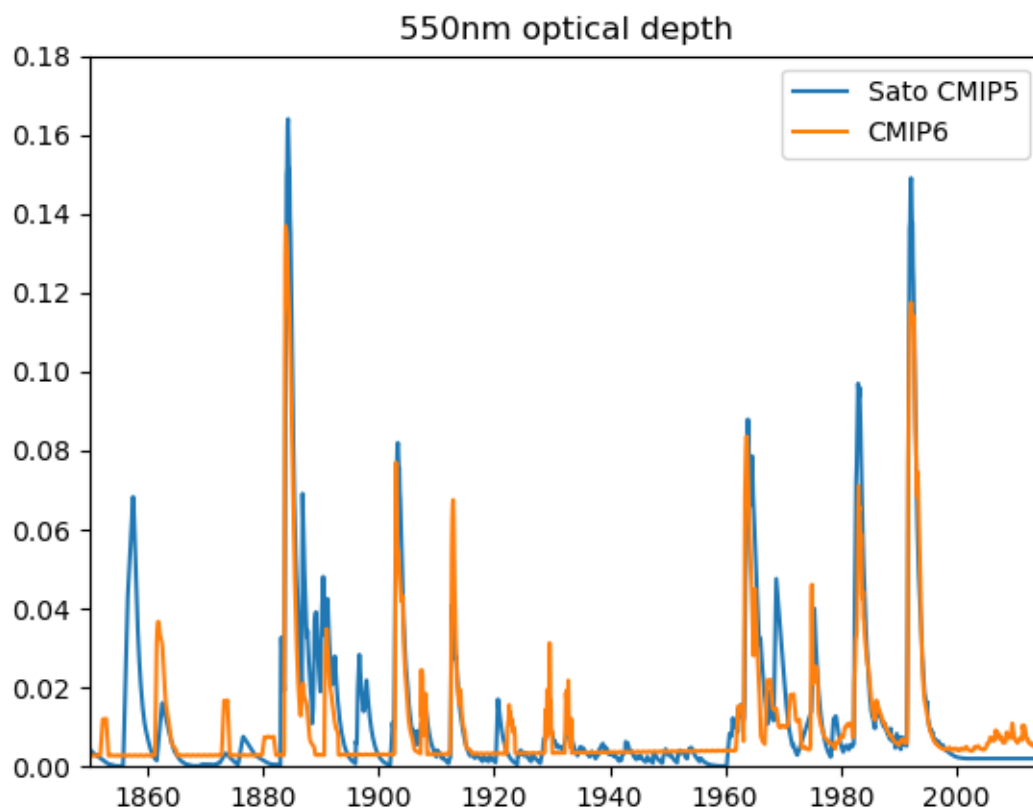

Figure 3. Comparison of CMIP5 and CMIP6 global mean stratospheric optical depths from volcanic aerosol.

For comparison I also calculated the band 3 (500-690 nm) optical depth from the Met Office CMIP6 forcing files used by CM2, `/g/data/access/TIDS/CMIP6_ANCIL/data/ancils/n96e/timeseries_1850-2014/VolcanicAod/v3/volc_aer_extinction_sw.nc`. See https://code.metoffice.gov.uk/trac/ancil/attachment/wiki/ticket/422 for a description of the Met Office processing.
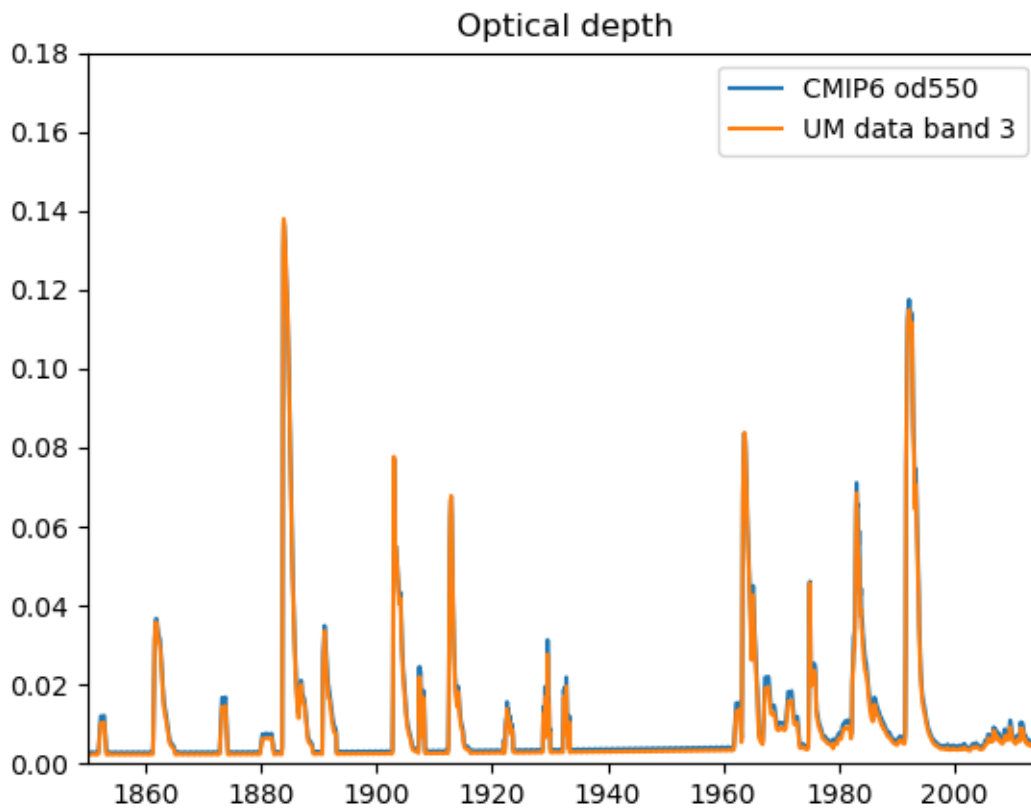
Figure 4. Comparison of CMIP6 optical depth derived here with the vertical integral of the band 3 optical depth used in ACCESS-CM2.

The CMIP6 recommendation is for the PI control to use the historical period (1850-2014) mean volcanic forcing. For future forcing the SCENARIOMIP instruction is to use the historical mean from 2025 onwards and to linearly interpolate from 2015 to 2025 (O'Neill et al. 2016, Sect. 4). In the CMIP5 Sato data the 1850-2000 mean is 0.01338. The ESM PI control is using this value from `/projects/data/access/ancil/CMIP5/volcts_18502000ave` (note that values in the file are scaled by 10^4). The CMIP6 mean is 0.01067, so to match the ESM PI control the CMIP6 values were uniformly increased by 0.00271 (uniform in time and across the 4 latitude bands).
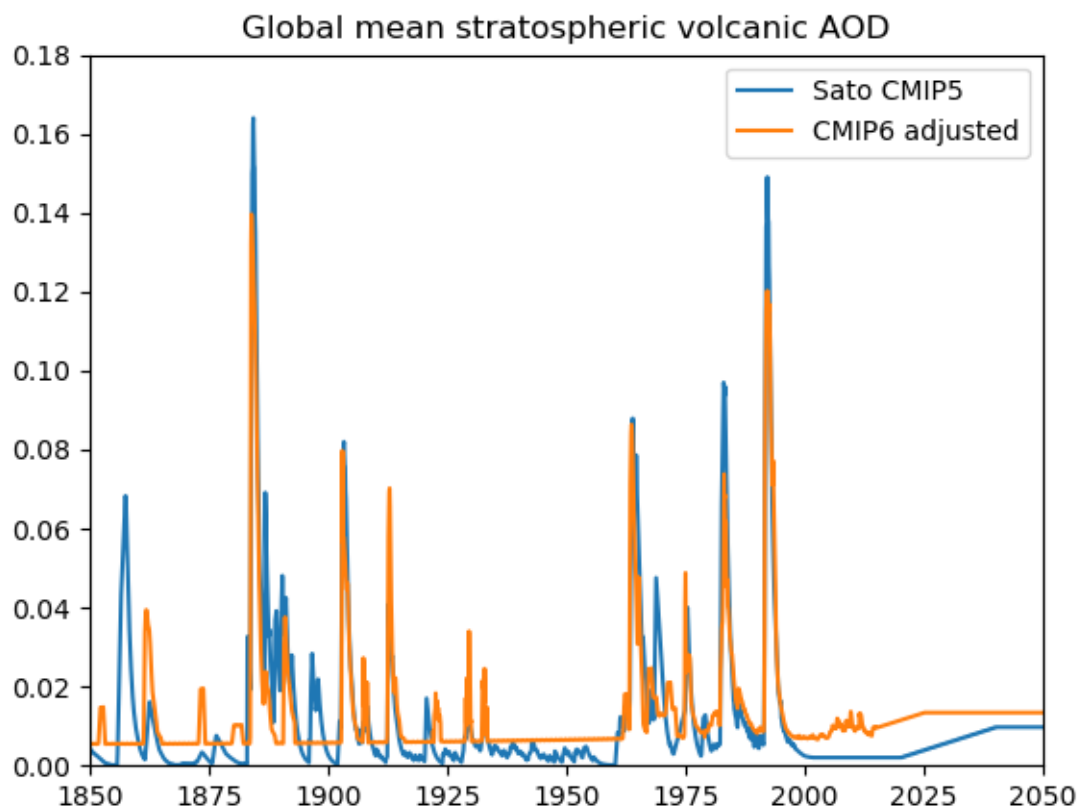
Figure 5. Comparison of the CMIP5 stratospheric volcanic AOD with the extended CMIP6 version, including the offset so that the means over 1850-2000 match.

References

Matthes, K., and Coauthors, 2017: Solar forcing for CMIP6 (v3.2). *Geosci. Model Dev.*, **10**, 2247–2302, doi:10.5194/gmd-10-2247-2017.

O'Neill, B. C., and Coauthors, 2016: The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6. *Geosci. Model Dev.*, **9**, 3461–3482, doi:10.5194/gmd-9-3461-2016.

Sato, M., J. E. Hansen, M. P. McCormick, and J. B. Pollack, 1993: Stratospheric Aerosol Optical Depths, 1850–1990. *J. Geophys. Res.*, **98**, 22987–22994, doi:10.1029/93JD02553.