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Unforced trends of surface solar radiation in CMIP5

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Surface solar radiation (SSR) is a key component of the surface energy balance. Changing anthropogenic aerosol emissions have been suggested to result in (forced) SSR changes and, in turn, changes in surface temperature or precipitation. Here we focus on unforced changes of annual mean all-sky SSR in 43 pre-industrial control (piControl) experiments of the Coupled Model Intercomparison Project Phase 5 (CMIP5). Unforced SSR trends over 10 to 50 years are found to be closely linked with internal SSR variability. An analytical relation is given that expresses the likelihood of occurrence of an unforced SSR trend of a specific length and strength as a function of SSR variability. The finding is not trivial as internal variability comprises a range of time scales (e.g., weather, El Nino, Atlantic Meridional Oscillation) that potentially leave an imprint on unforced SSR trends. The close link between variability and trends holds independent of whether quantification is done in absolute units or relative to the long term mean SSR. Absolute and relative SSR variability show, however, substantially different geographical patterns. Two corresponding maps are given. Depending on geographical region, we estimate that a positive unforced 30 year trend with at least a 25% chance of occurrence has a magnitude between 0.15 and 1.7 W/m2/decade or 0.11 and 1.4 percent of long term mean SSR per decade. Comparison with present-day observations and inter-model spread suggests for these estimates an average uncertainty of about 30%, and a regional uncertainty up to three times larger or smaller. Put differently, the geographical pattern of SSR variability shows a substantial model dependence despite comparable (to within 30%) variability in the global mean. Within each model and on the level of individual model grid boxes, correlation between all-sky SSR and cloud cover time series is typically larger than 0.5, in line with the expectation that cloud cover is a key factor for all-sky SSR changes. Finally, we illustrate how the above results may be used to get statistical estimates of how (un-)likely it is that observed SSR trends, or part thereof, are due to internal variability alone. Put differently, we use the above findings to put potentially forced SSR changes into perspective, especially for short (two or three decades) time series.

Reference: Folini, D. et al., "Trends of surface solar radiation in unforced CMIP5 simulations", JGR 2017, doi:10.1002/2016JD025869