Climate responses to the 11-year solar cycle

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A growing body of evidence shows that the 11-year cycle of solar activity has a significant influence on the atmosphere.However, despite the potential importance of solar variability as a driver of natural climate variability, understanding and characterization of the solar influence is still poor compared to that of many other factors influencing climate. We here present results from analyses of 3D gridded climate data sets, which allow us to undertake rigorous multi-variate investigations of the Sun-Climate links. The tropospheric responses to solar variability must be evaluated against a background of intrinsic atmospheric variability and other forcing factors acting concurrently on similar time scales. We find that consistent patterns of statistically significant solar signals emerge in all major observables throughout the low- and mid-latitude troposphere, when El Ni\~no and volcanic signals are removed from the climate data. The solar signals are strongest in the tropics and at mid-latitudes, and the heating and moistening of the troposphere during solar maximum is accompanied by a modulation of the global-scale tropospheric circulation systems. These findings may have implications for the question of where and how the Sun exerts its influences in the climate system, and should be used to discriminate between e.g. direct solar irradiance forcing of the climate and indirect forcing of the climate via cloud modulation by cosmic rays.