



Declining aerosols - solar brightening - and the rapid temperature rise in Europe since the 1980s

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The rapid temperature increase of 1 °C over mainland Europe since 1980 is considerably larger than expected from anthropogenic greenhouse warming. Solar brightening observed during this time period, which followed several decades of solar dimming, has apparently added to the temperature rise. Here we present evidence of a substantial decline in aerosol concentrations over Europe, which has led to a significant increase of solar radiation reaching the ground. Aerosol optical depth (AOD) observations at six remote locations from the Baltic Sea to the Central Alps show a decrease in AOD by up to 60 percent from 1986 to 2005. However, the rate of decline has recently decreased and AOD appears to be stabilizing at low values since about 2000. Solar radiation, concurrently measured under cloud-free skies and averaged over eight German and twenty-five Swiss radiation stations below 1000 m a.s.l., shows a statistically significant increase of $+1.13 (\pm 0.30) \text{ Wm}^{-2} \text{ dec}^{-1}$ between 1981 and 2005. Climate sensitivity inferred from radiation and temperature changes during Pinatubo indicates that this aerosol-induced solar brightening since the 1980s is responsible for 30 to 50 percent of the rapid temperature rise over mainland Europe. However, the observed current stabilization in AOD now brings solar brightening to an end, and will probably reduce future temperature rise to levels congruent with greenhouse warming.