Long-Term Satellite Record Reveals Likely Aerosol Trend

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Recent observations of downward solar radiation fluxes at Earth's surface have shown a recovery from the previous decline known as global "dimming" *(1)* with the "brightening" beginning around 1990 *(2)*. The increasing amount of sunlight at the surface profoundly affects climate and may represent diminished effects of certain counter-balances of the greenhouse warming, thereby making it more evident during the past decade.

It has been suggested that tropospheric aerosols have contributed significantly to the switch from solar dimming to brightening via both direct and indirect aerosol effects *(1,2)*. It has further been argued *(3)* that the solar radiation trend mirrors the estimated trend in primary anthropogenic emissions of SO_2 and black carbon, which contribute significantly to the global aerosol optical thickness (AOT). A similar increase of net solar flux at the top of the atmosphere (TOA) over the same period appears to be explained by corresponding changes in lower latitude cloudiness *(4)*, which confounds the interpretation of the surface radiation record. Therefore, it is very important to provide a direct and independent assessment of the actual global long-term behavior of the AOT. In this Brevium, we do this by using the longest uninterrupted record of global satellite estimates of the column AOT, the Global Aerosol Climatology Project (GACP) record (http://gacp.giss.nasa.gov).

The GACP record is derived from the International Satellite Cloud Climatology Project (ISCCP) radiance dataset composed of calibrated and sampled Advanced Very High Resolution Radiometer (AVHRR) radiances (http://isccp.giss.nasa.gov). The solid black curve in Fig. 1 depicts global monthly averages of the column AOT for the period August 1981 – June 2005. The two major maxima are caused by the stratospheric aerosols generated by the El Chichon (March 1982) and Mt Pinatubo (June 1991) eruptions, also captured in the Stratospheric Aerosol and Gas Experiment (SAGE)

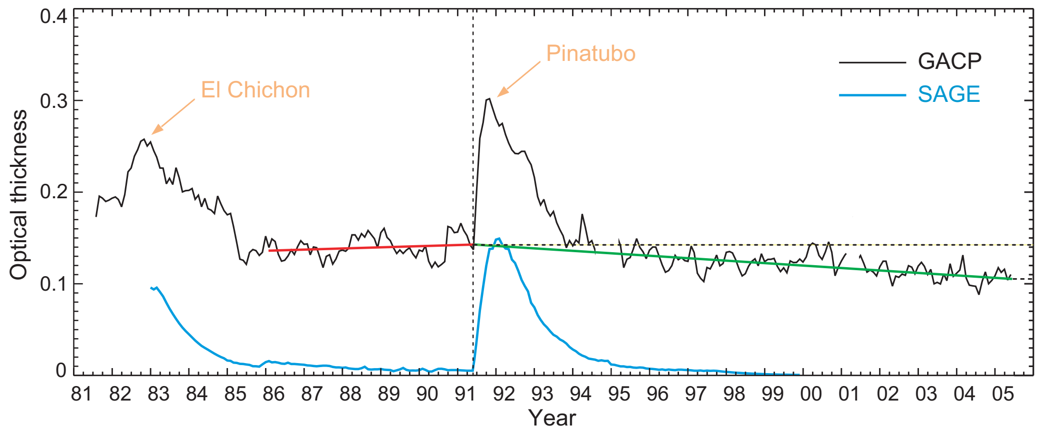

Fig. 1. GACP record of the globally averaged column AOT and SAGE record of the globally averaged stratospheric AOT.

stratospheric AOT record *(5)*. The quasi-periodic oscillations in the black curve are the result of short-time aerosol variability.

The red line traces the overall behavior of the column AOT during the eruption-free period from January 1986 to June 1991. It shows only a hint of a statistically significant trend and indicates that the average column AOT value just before the Mt Pinatubo eruption was close to 0.142. After the eruption, the GACP curve is a superposition of the complex volcanic and tropospheric AOT temporal variations. However, the green line reveals a clear long-term trend in the tropospheric AOT. Indeed, even if we assume that the stratospheric AOT just before the eruption was as large as 0.007 and that by June 2005 the stratospheric AOT became essentially zero (*cf.* the blue curve), still the resulting change in the tropospheric AOT during the 14-year period comes out to be 0.03. This trend is significant at the 99% confidence level.

Admittedly, AVHRR is not an instrument designed for accurate aerosol retrievals from space. Among the remaining uncertainties is radiance calibration which, if inaccurate, can result in spurious aerosol trends. However, the successful validation of GACP retrievals using precise sun-photometer data taken from 1983 through 2004 *(6,7)* indicates that the ISCCP radiance calibration is likely to be reliable. This conclusion is reinforced by the close correspondence of the calculated and observed TOA solar fluxes *(4)*. The unique advantage of the AVHRR dataset is its duration, which makes possible the detection of statistically significant trends like the substantial decrease of the tropospheric AOT between 1991 and 2005. With all the uncertainties, the tropospheric AOT decrease over the 14-year period is estimated to be at least 0.02.

Our results suggest that the downward AOT trend may have contributed significantly to the concurrent upward trend in the surface solar fluxes. Neither AVHRR nor other existing satellite instruments can be used to determine whether the tropospheric AOT trend is due to long-term global changes in the natural or anthropogenic aerosols. This discrimination would only be possible with an instrument like the Aerosol Polarimetry Sensor (APS) scheduled for launch in December 2008 as part of the NASA Glory Mission *(8)*. It is thus imperative to provide uninterrupted multidecadal monitoring of aerosols from space with dedicated instruments like APS in order to detect long-term anthropogenic trends potentially having a strong impact on climate.

References and Notes

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