Modelling Study of Mt. Pinatubo Eruption and Applications to Geoengineering

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Introduction

So far suggested geoengineering measures are largely unexplored ideas that require careful inspections before they might become options. In order to evaluate the effectiveness and safety of geoengineering by injection of sulfur containing gases into the stratosphere, a particle-size resolving model is required to obtain reliable results. Here we study the Mt. Pinatubo eruption as an analogue for the geoengineering.

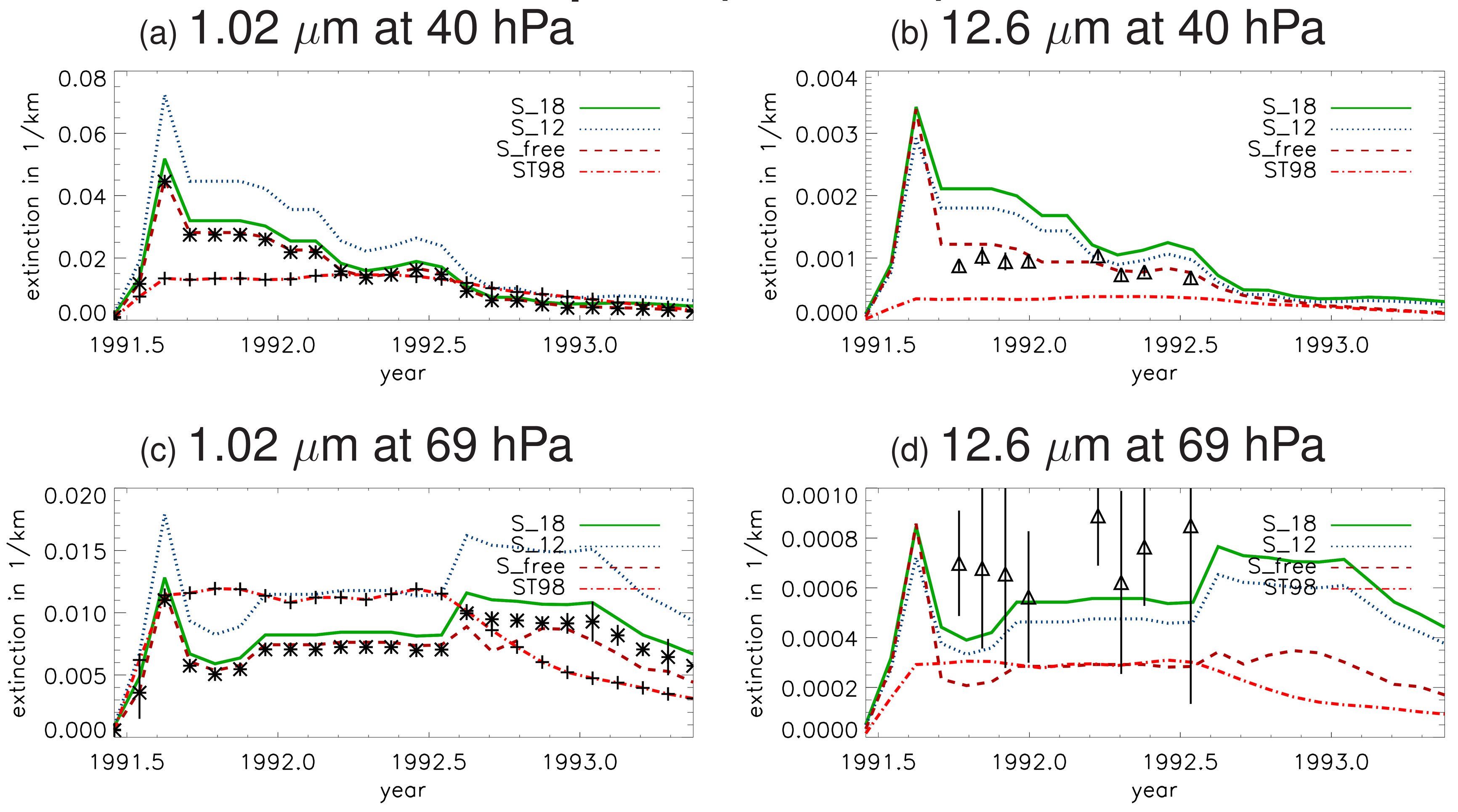
Methods to Retrieve Spectrally Resolved Optical Properties

The particle size distribution has to be known to retrieve extinctions in the whole spectral range. In this study we compare three methods to retrieve spectrally resolved optical properties. All these methods assume a unimodal lognormal distribution.

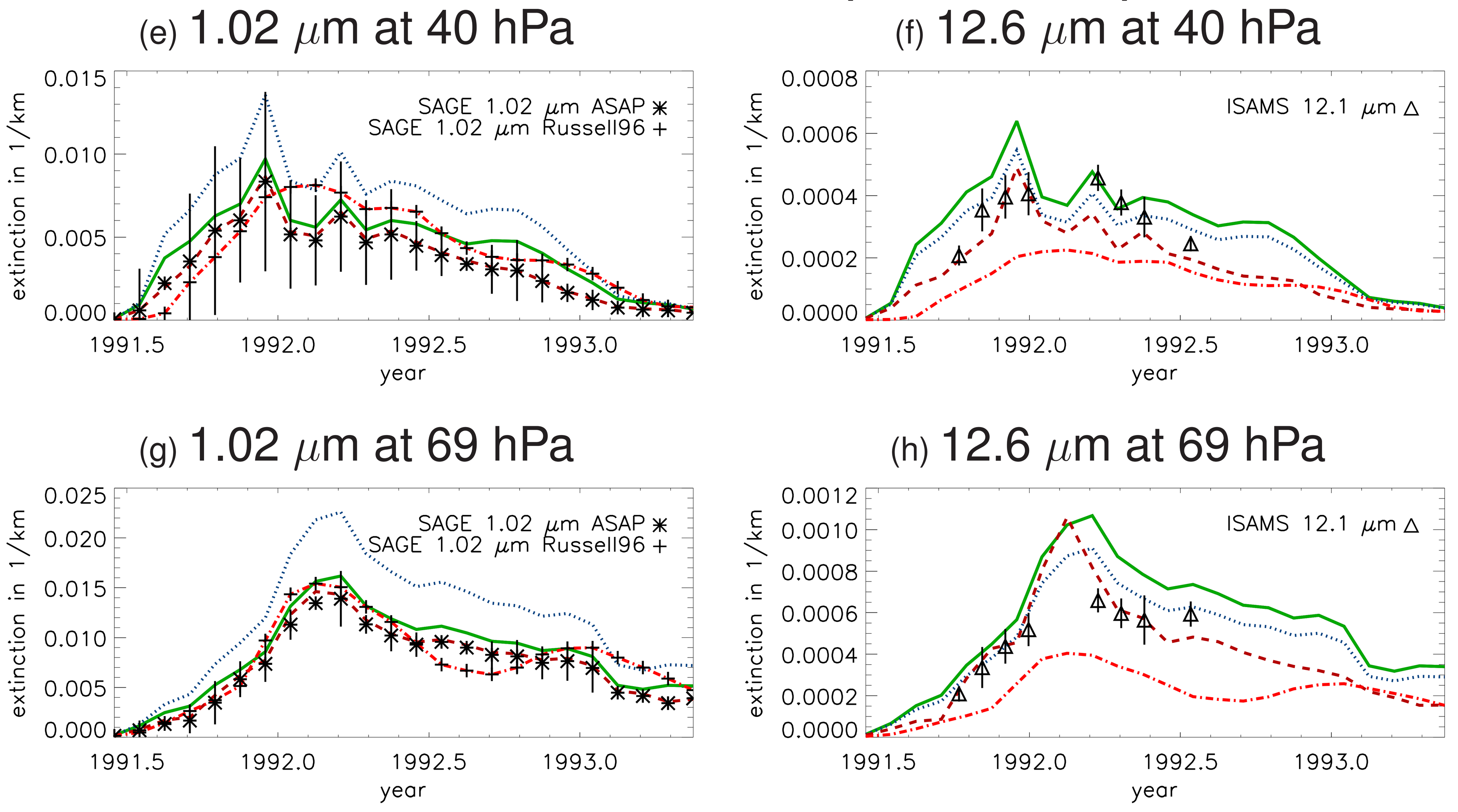
- **Previously Used (ST98):** Described by Stenchikov et al. (1998) using an older version of SAGE II data set and assuming σ=1.25.
- **New Method I (SA):** Described in Schraner et al. (2008) The gap-filled SAGE II data set (SPARC, 2006) is applied. The number density N is determined using surface area density (*SAD*) and effective radius r_{eff} data, and assuming a particle distribution width σ = 1.2, and 1.8 respectively. *SAD* and r_{eff} are based on a principal component analysis using four wavelengths (Thomason et al., 1997).
- **New Method II (SFree):** To find a best fit with the four wavelengths of the gap-filled SAGE II data set extinction measurements using varying freely effective radii and distribution widths σ from 1.2 to 2.6.

Extinction from June 1991 to 1993 for 1.02 μm and 12.6 μm.

At Equator (5°S – 5°N)



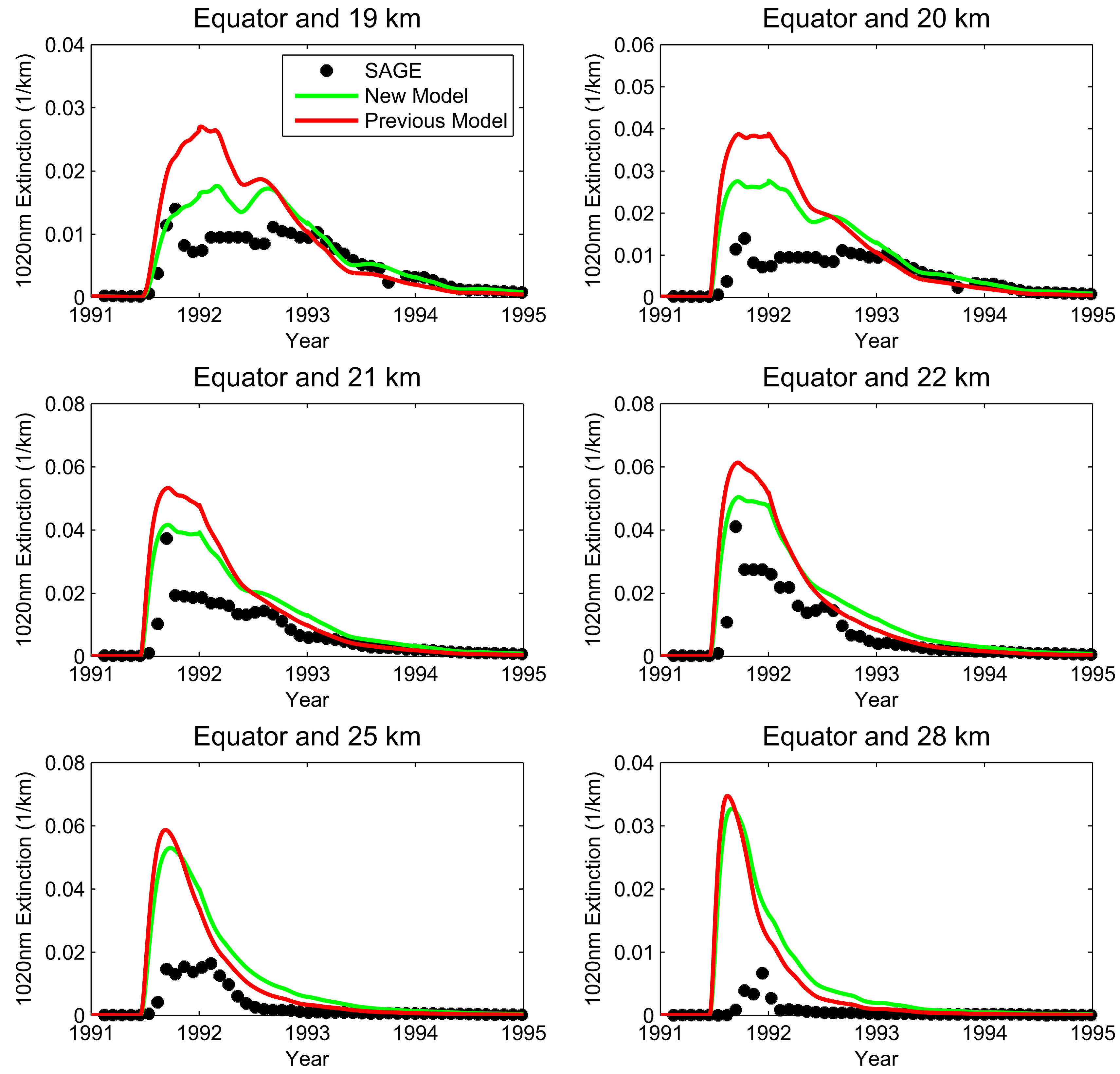
At Northern Midlatitudes (30°N – 40°N)



Modelling the Pinatubo Eruption with AER 2-D Aerosol Model (Weisenstein et al., 1997)

The AER model was one of the best models in the SPARC aerosol assessment (SPARC, 2006), but nevertheless overestimated the extinction with respect to satellite measurements in all wavelength regimes during the year of the Pinatubo eruption. The eruption is modelled assuming 9 Mt sulfur injected between 20 and 28 km. We also introduced an improved coagulation scheme and compared with the previous model. The results are shown below:

Extinction from 1991 to 1995 for 1020 nm at Equator for different levels.



Discussion and Conclusions

- The previously used method (ST98) massively underestimates longwave extinctions, which is largely due to using the outdated SAGE data set. This leads to much less heating of the stratosphere.
- The new methods (SA at σ = 1.8 and SFree) to retrieve the optical properties fit the vertical distribution of extinction at 1020 nm well, however there are strong discrepancies in the gap-filled regions, i.e. where the stratosphere was opaque for SAGE II and lidar measurements from ground stations had to be used as filling data. Moreover, the new methods present better agreement than ST98 with ISAMS data at long wavelength.
- A new coagulation scheme has been developed. For altitudes below 22 km it largely corrects the previous overestimation of extinctions, while for altitudes above 25 km there is no significant change.
- Further experiments are required to fully establish the aerosol optical and microphysical properties with a reasonable level of accuracy.

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