GMD 2008 Annual Meeting

Increases in Stratospheric Aerosols

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Thanks to:
Mike Trudeau
Trevor Kaplan
MLO Ruby and Nd:YAG Lidar Stratospheric Aerosol

El Chichon, Mexico
Mt. Pinatubo, Philippines
Perturbations from Background Conditions
Perturbations from Background Conditions

Stratospheric impact of the Chisholm pyrocumulonimbus eruption,
Fromm et. al., JGR, 2008.

Figure 17. NOAA GMD lidar data from Mauna Loa. (a) May, (b) June, (c) July, and (d) August. Backscatter ratio profiles at 532 nm are color coded as described for Figure 16. Profiles for the same month of 2000 are plotted as gray lines. Vertical axis is altitude (km).
Conversion of Lidar Backscatter to more useful quantities such as Extinction, or Aerosol Mass

- **Balloon/Lidar**, (Jaeger and Hofmann, Applied Optics, 1991), (Jaeger and Deshler, GRL, 2002)
- **Sage Satellite**, (Thomason and Osborn, GRL, 1992)
- **Thermodynamics/Mie Scatter Theory**, (Steele and Hamill, J. Atmos. Sci., 1981)
Trends in Background Stratospheric Aerosol

- Increase in the stratospheric background sulfuric acid aerosol mass in the past 10 years (Hofmann, Science, 1990)
- Lidar measurements of stratospheric aerosol over Mauna Loa Observatory (Barnes and Hofmann, GRL, 1997)
- Trends in the nonvolcanic component of stratospheric aerosol over the period 1971-2004 (Deshler et. al., JGR, 2006)
MLO Total Stratospheric Aerosol

MLO IABS (/sr)
smoothed curve
trend
MLO Stratospheric Aerosol Layers, Season Averages

8%/Year, >3 sigma
Boulder Total Stratospheric Aerosol

Boulder IABS

\[ y = 5E-06x - 0.0097 \]

10% / Year

IABS

15 to 20 km

20 to 25 km

Linear (20 to 25 km)

Fig. 2. SAGE II stratospheric 1020-nm aerosol extinction coefficient (in units of km$^{-1}$) for altitudes of 18 (a), 22 (b), 26 (c) and 30 km (d) between 10° N and 10° S for the years 1998 through 2003. In addition, 525-nm aerosol extinction variability is shown in frame (e). The effects of the eruptions of Ruang and Reventador in late 2002 can be seen at 18 km. Dashed vertical lines show 1 January of each year. Horizontal block arrows in (d) show easterly QBO as given by zonal winds at 50 mb over Singapore.
Figure 1. History of stratospheric aerosol above Laramie at 0.15 and 0.25 μm for altitude columns between 15-20 and 20-25 km. Volcanic eruptions in the low latitudes are shown in the green and high latitudes in blue. Solid symbols are eruptions with VEI > 4.
Transmission at Mauna Loa Observatory

Year

Relative Amount of Direct Sunlight (Transmission)

Mauna Loa, Hawaii

Agung

El Chichón

Pinatubo
Changes in Tropospheric Aerosol
Mishchenko et. al., Science, 16 March, 2007

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

Trop. AOT 20 times higher than Strat. (0.005)
Possible effects of increasing stratospheric aerosol


- Direct increase in backscattered light (cooling effect)

- Increase in condensation nuclei, which would create smaller water aerosols, which would have lower settling velocities...more water into stratosphere (Notholt et. al., GRL, 2005)

- Modification of cirrus cloud optical properties, more condensation nuclei (Indirect effect)
Figure 6. Calculated stratospheric sulfur budget. The fluxes to/from the troposphere are the net fluxes required to maintain the stratospheric sulfur balance. Units: content in Tg S yr$^{-1}$.  

World Production of Crude Oil

- Non-OPEC
- OPEC
- Total

Billion Barrels

Figure 1. Spatial distribution of the probability that lower tropospheric air masses from a given location reach the 380 K isentropic surface.
Stratospheric Increase Summary

• Lidars at 20 and 40 deg North latitude show an increase in backscatter of 8%/year since 2000

• SAGE II tropical extinction has increased ~10%/year from 2000 to 2004

• Increases cannot be due simply to changes in particle size.
SAGE Extinction

(b) \( \text{lat}=0, 24 \text{ km} \)

- Extinction \((\text{km}^{-1})\)
- Angstrom Parameter
- Effective Radius (\(\mu\text{m}\))

Year:
- 1985
- 1990
- 1995
- 2000
- 2005