GMD 2008 Annual Meeting

Increases in Stratospheric Aerosols

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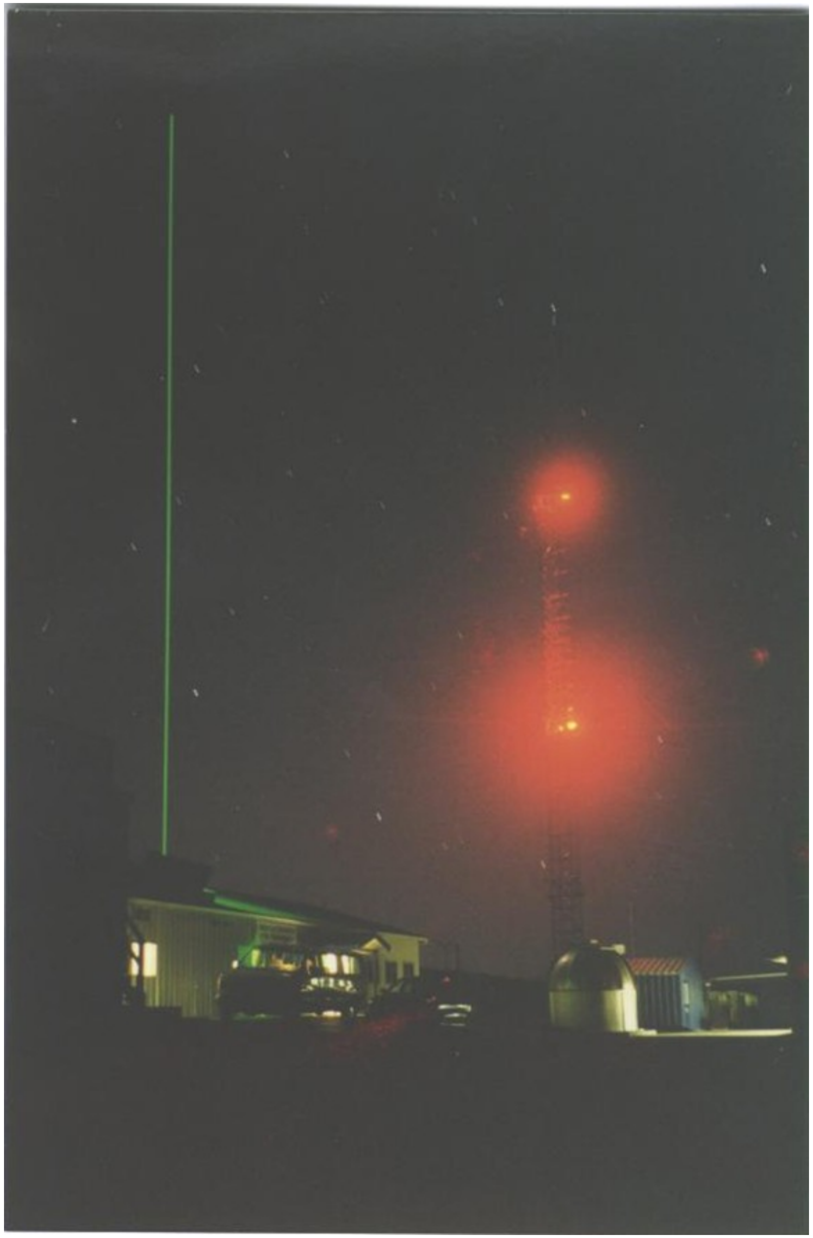
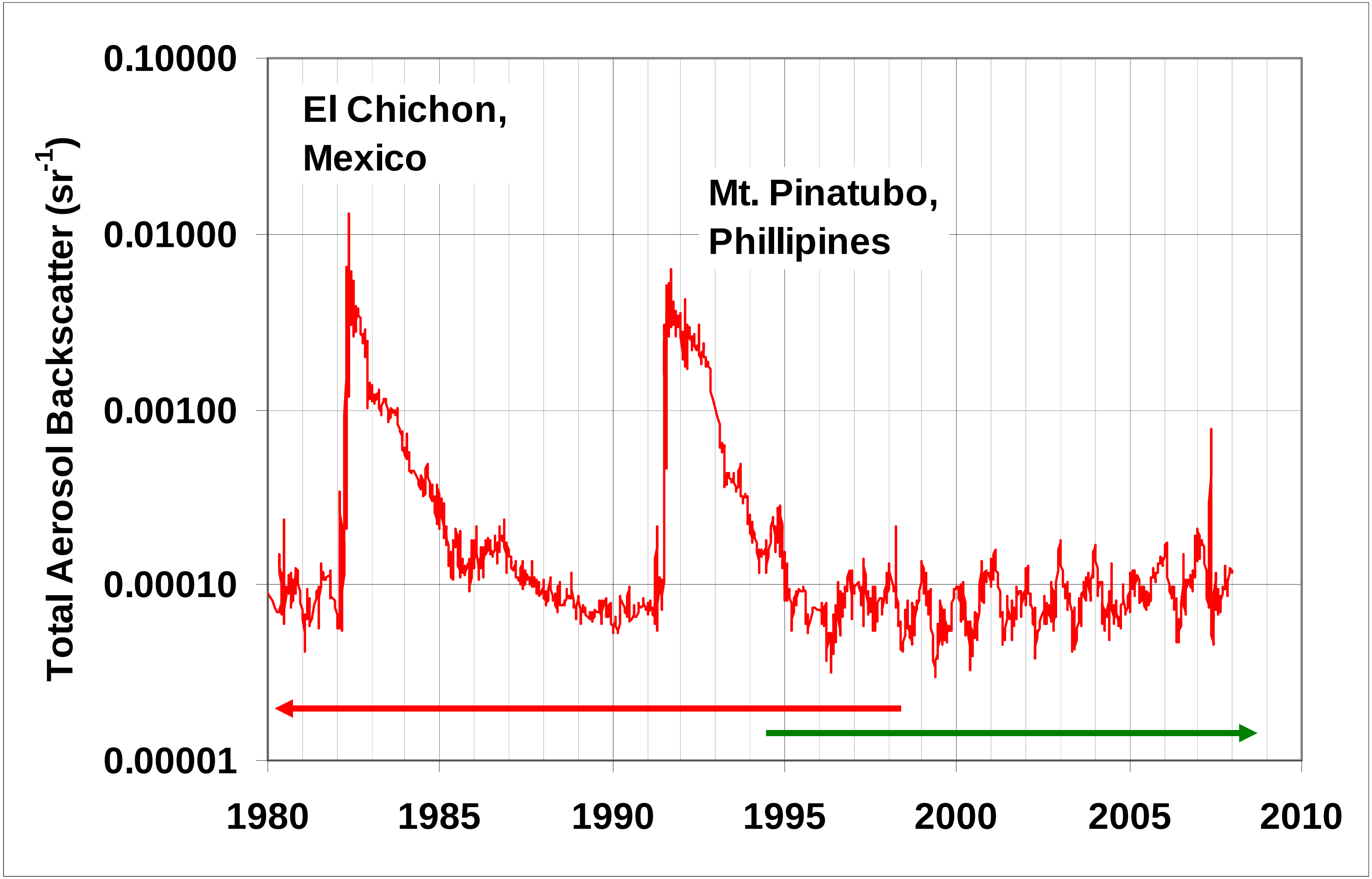
Thanks to:
Mike Trudeau
Trevor Kaplan

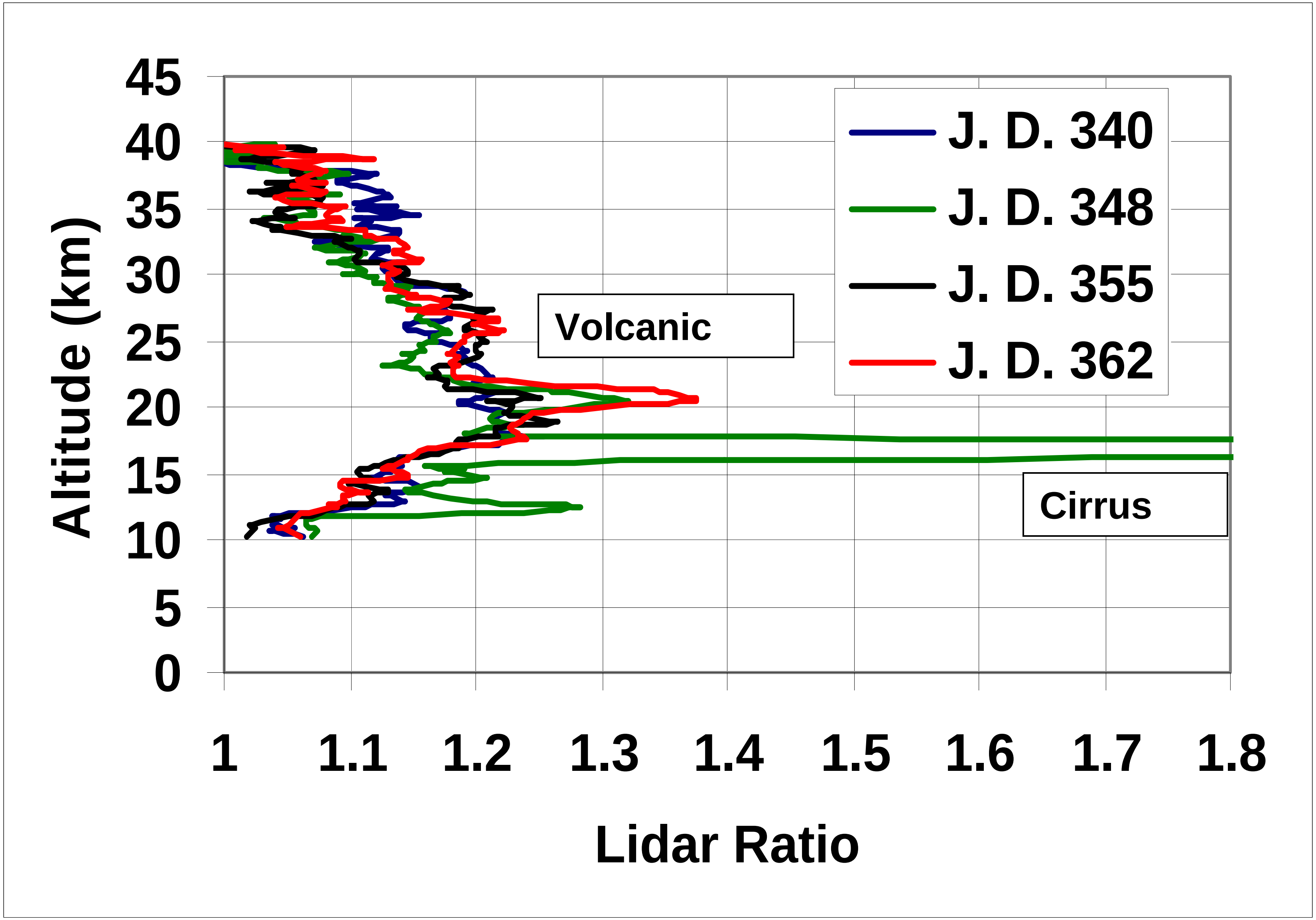


MLO Ruby and Nd:YAG Lidar Stratospheric Aerosol



Perturbations from Background Conditions

Eruption of Nyamuragira Volcano, November, 2006.



Perturbations from Background Conditions

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

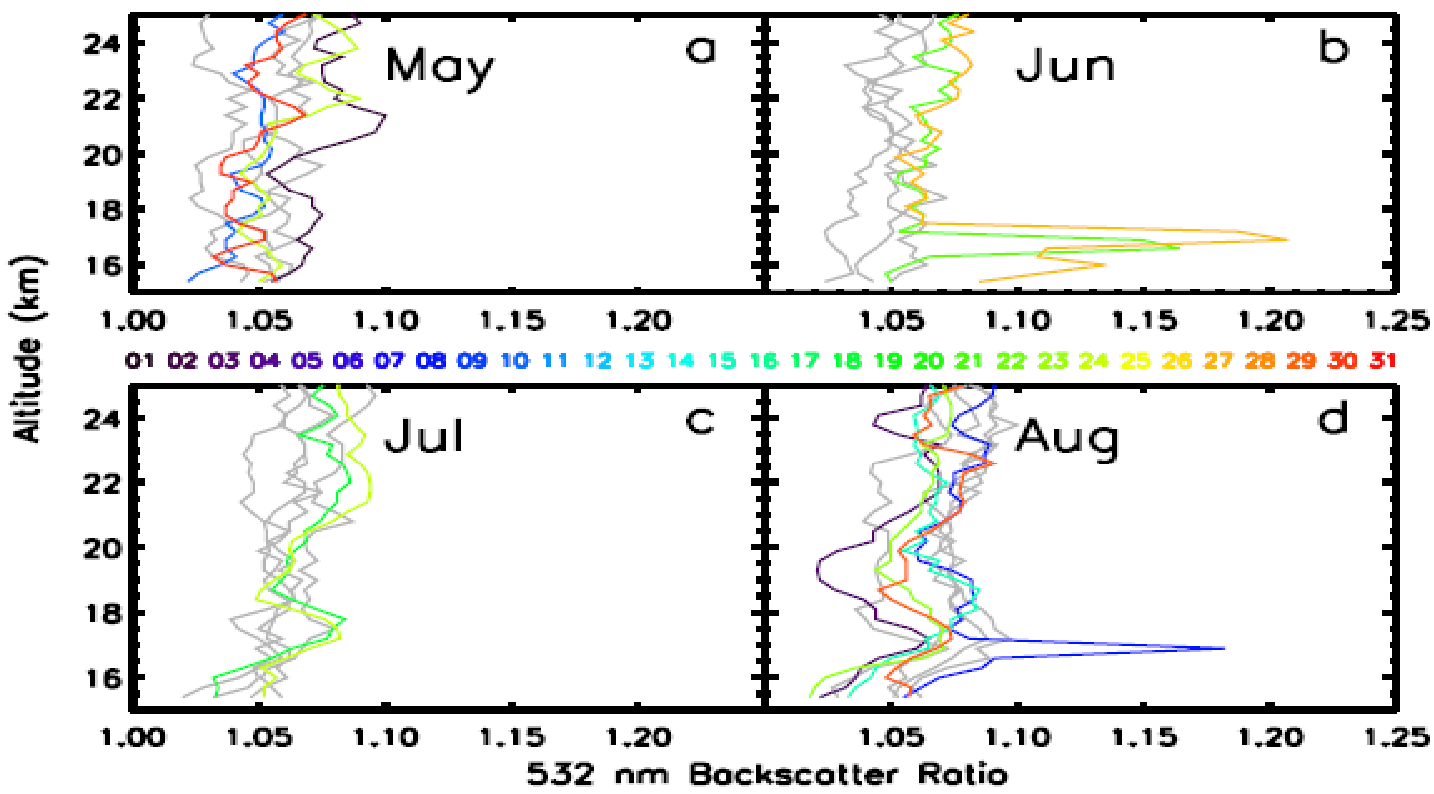


Figure 17. NOAA GMD lidar data from Mauna Loa. (a) May, (b) June, (c) July, and (d) August. Backscatter ratio profiles at 532 nm are color coded as described for Figure 16. Profiles for the same month of 2000 are plotted as gray lines. Vertical axis is altitude (km).

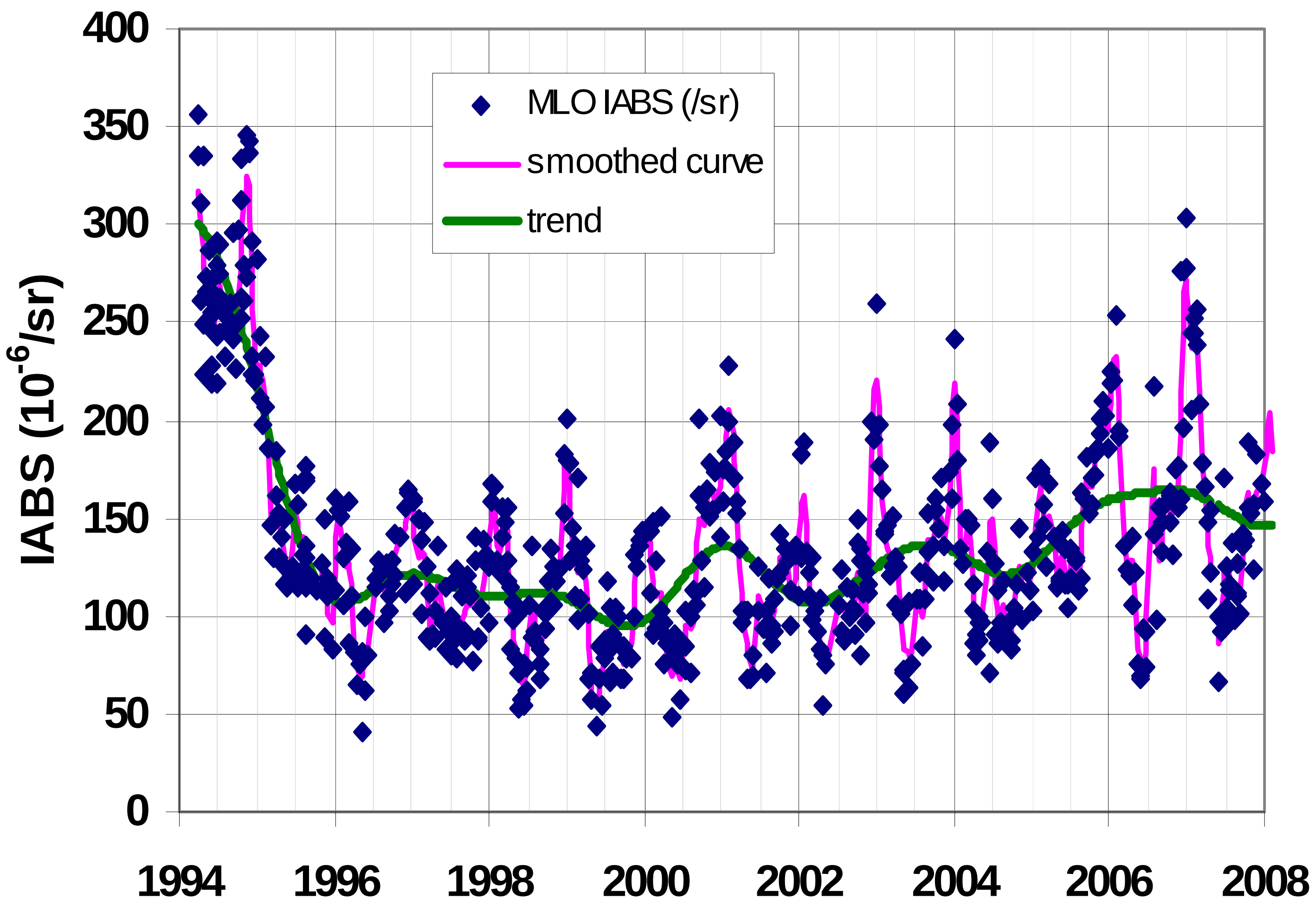
Conversion of Lidar Backscatter to more useful quantities such as Extinction, or Aerosol Mass

- Balloon/Lidar, (Jaeger and Hofmann, Applied Optics, 1991), (Jaeger and Deshler, GRL, 2002)
- Sage Satellite, (Thomason and Osborn, GRL, 1992)
- Raman Lidar, (Wandinger, Ansmann, Reichardt, and Deshler, Applied Optics, 1995)
- Thermodynamics/Mie Scatter Theory, (Steele and Hamill, J. Atmos. Sci., 1981)

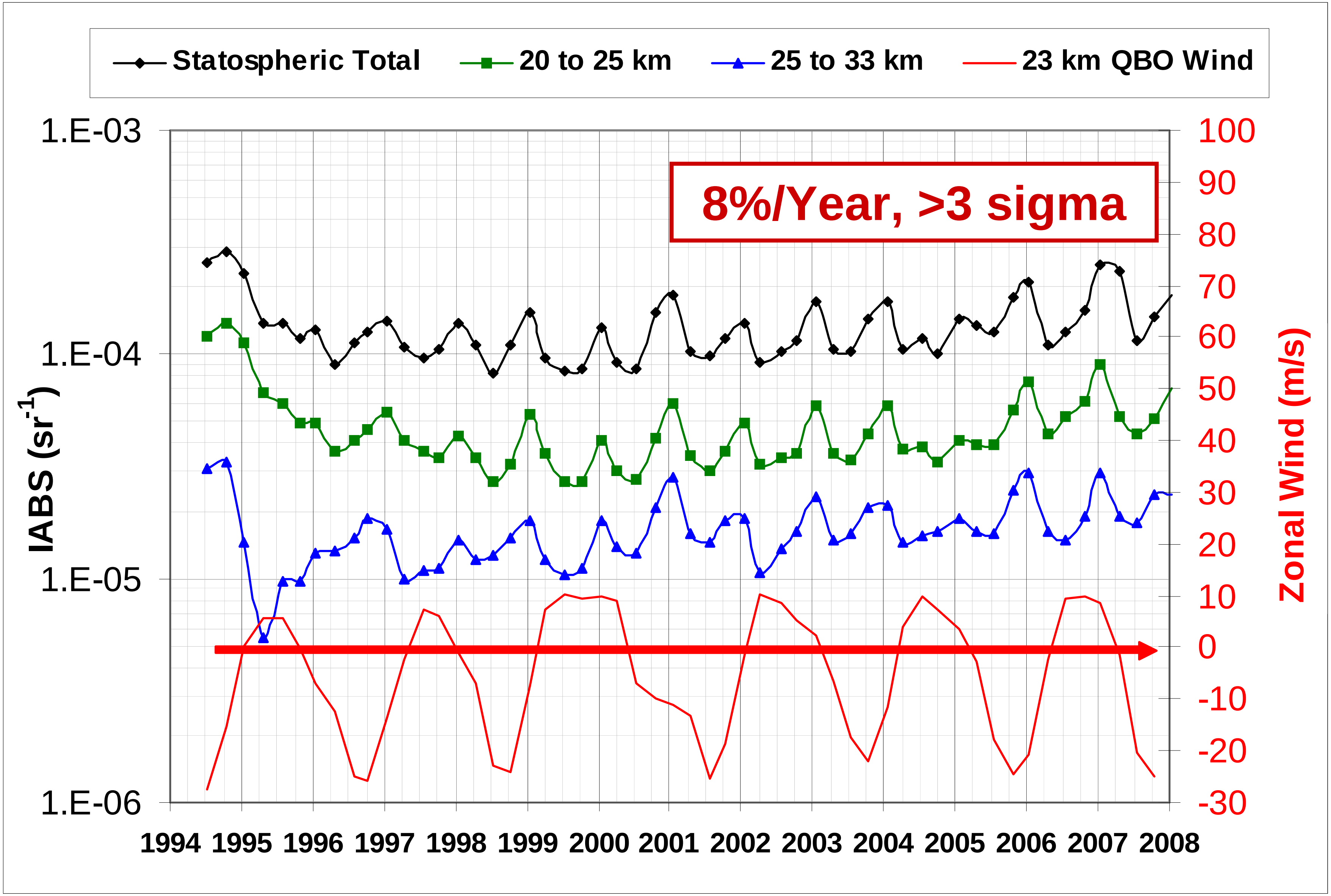
Trends in Background Stratospheric Aerosol

- Increase In The Stratospheric Background Sulfuric Acid Aerosol Mass In The Past 10 Years (Hofmann, Science, 1990)
- A comparison of the stratospheric aerosol background periods of 1979 and 1989-1991 (Thomason et. al, GRL, 1997)
- 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)
- Aircraft sulphur emissions (Hofmann, Nature, 1991)

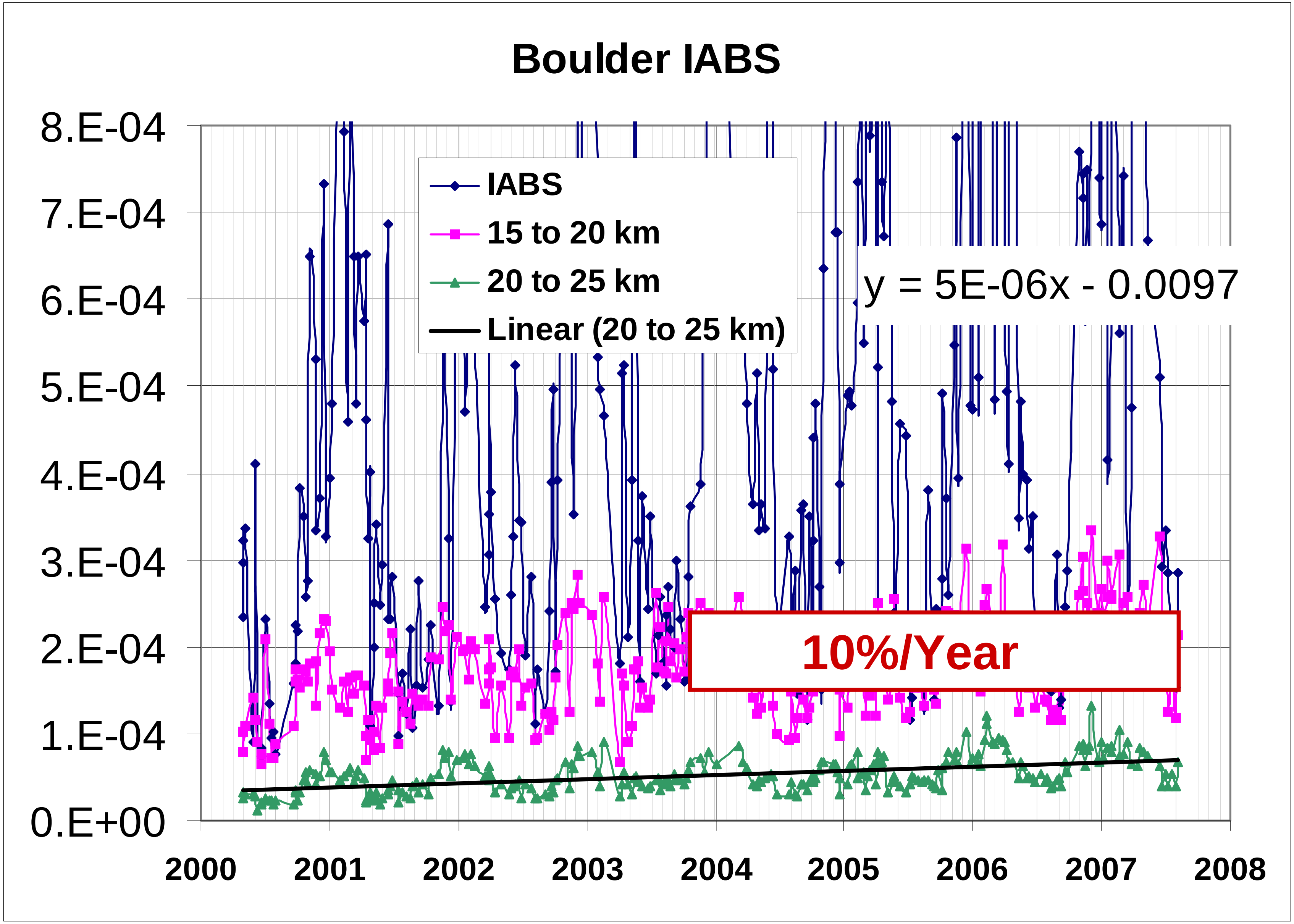
MLO Total Stratospheric Aerosol



MLO Stratospheric Aerosol Layers, Season Averages



Boulder Total Stratospheric Aerosol



SAGE II

Thomason et. al., Atmos. Chem. Phys., 8, 2008

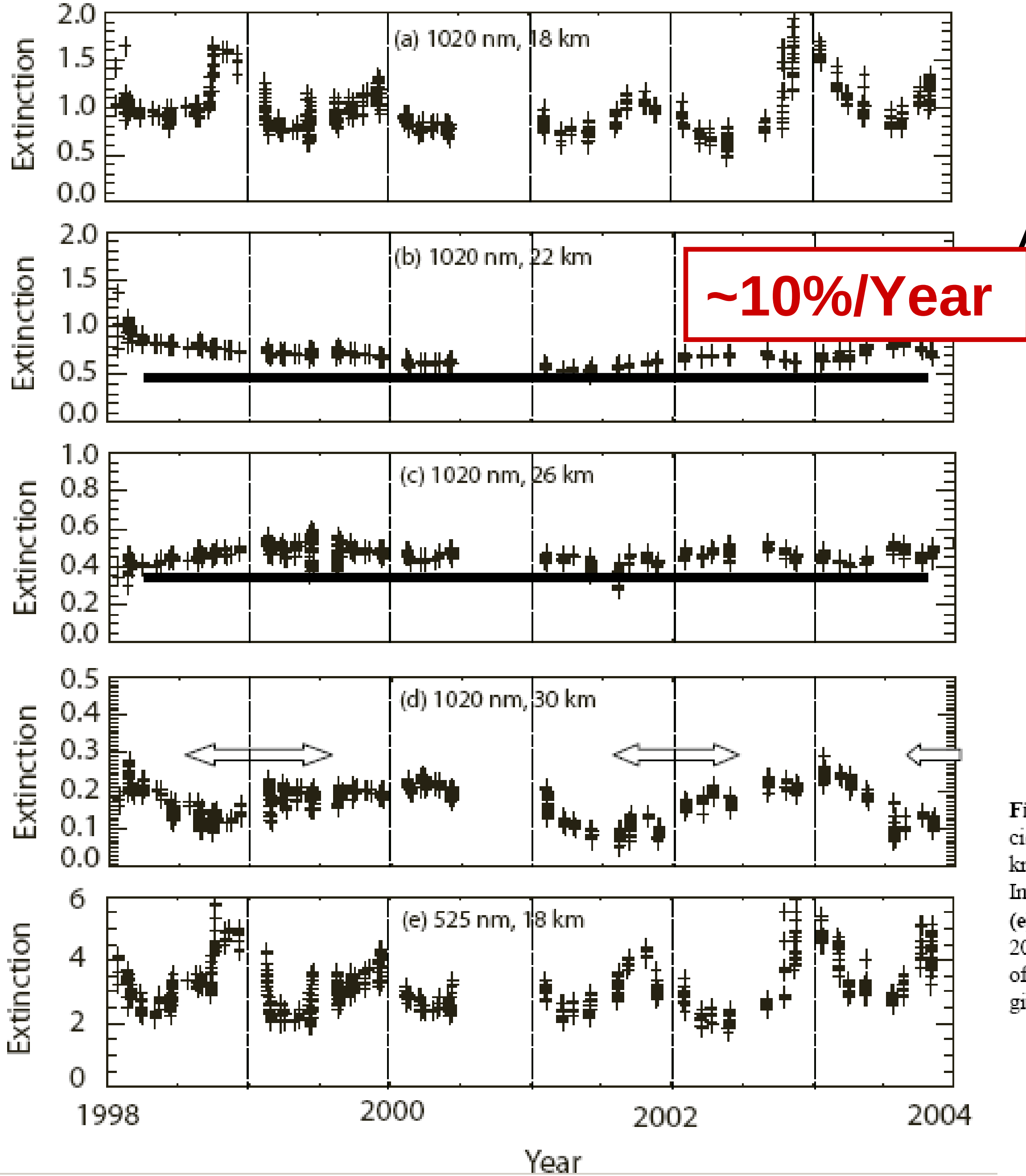
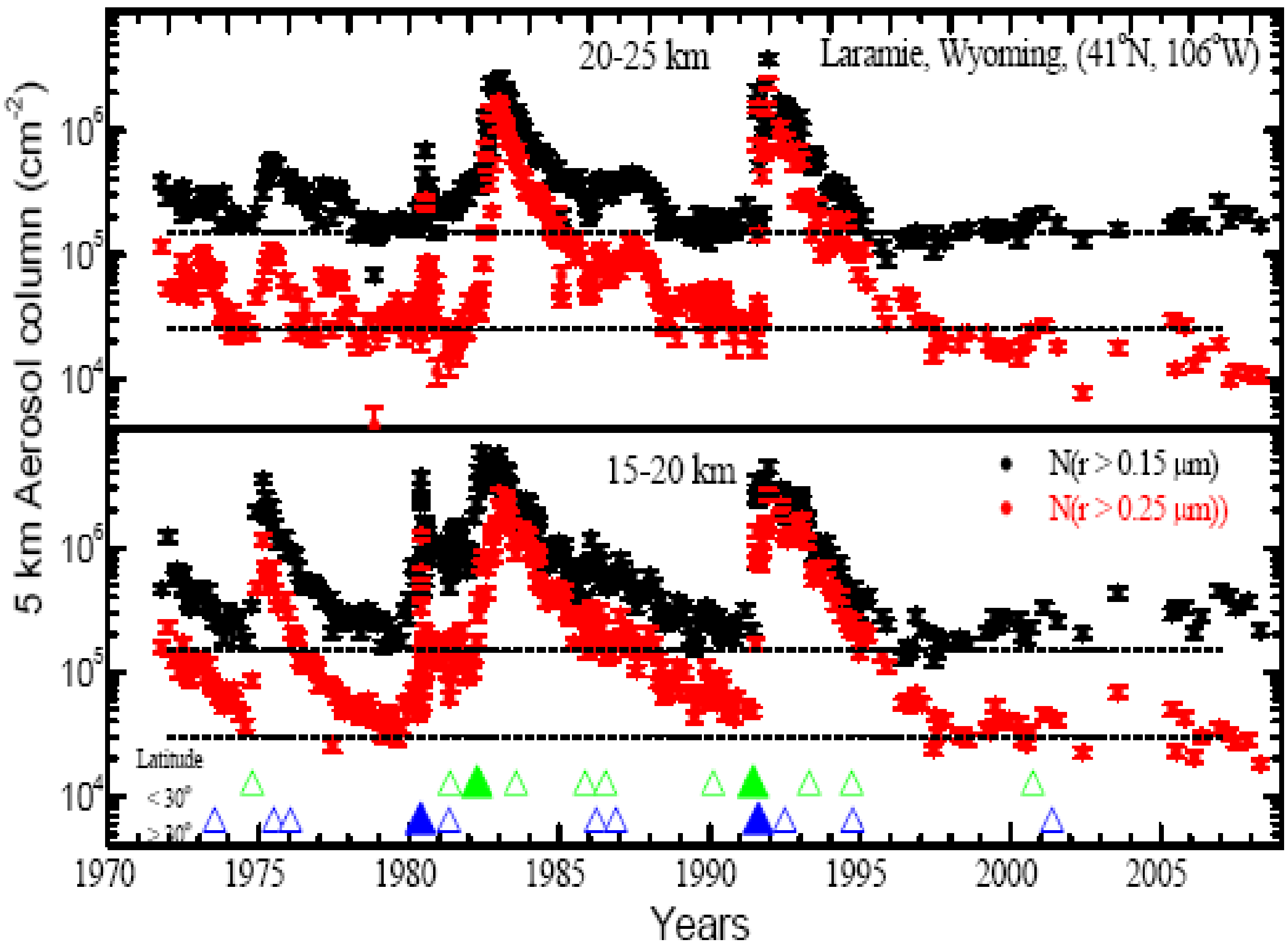


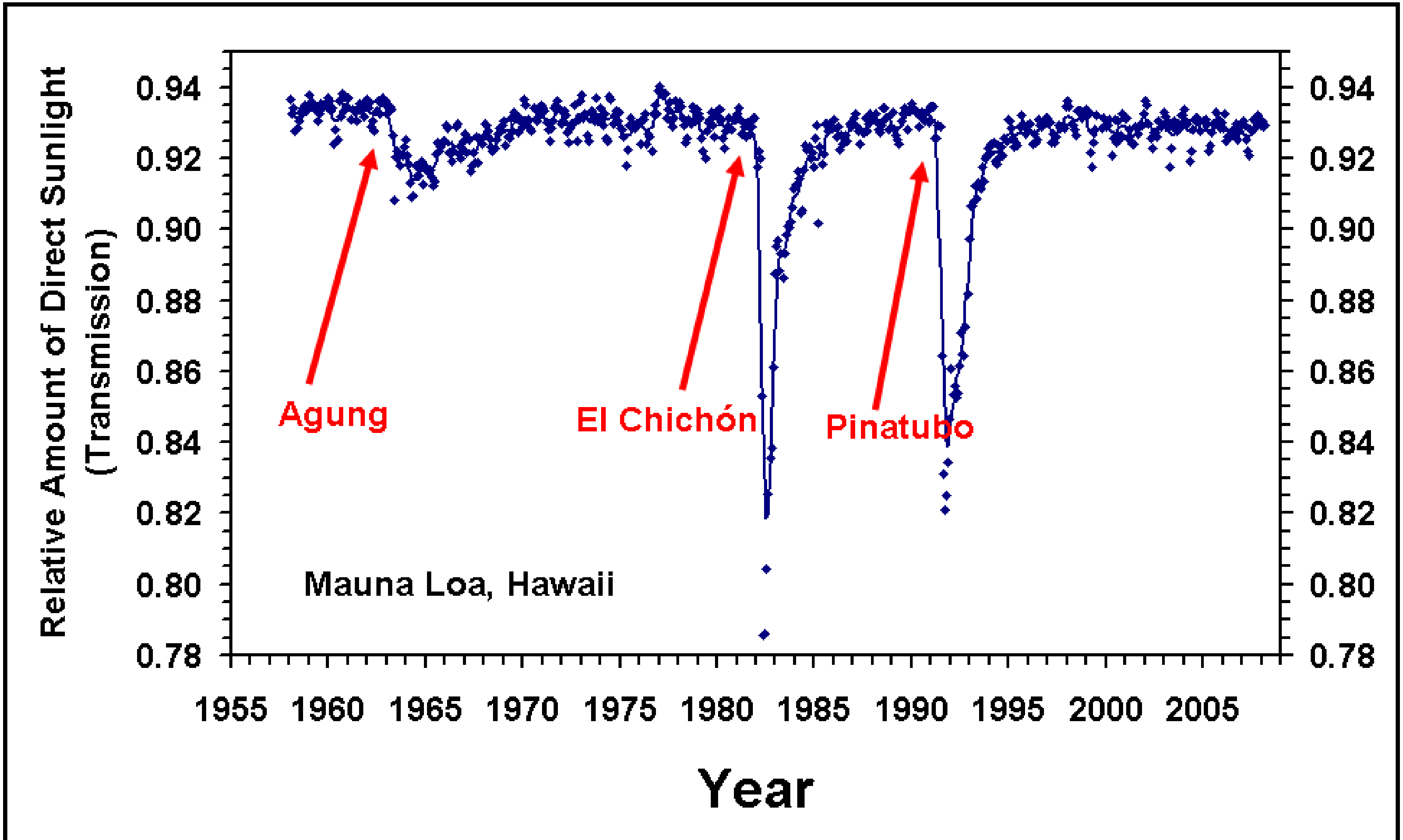
Fig. 2. SAGE II stratospheric 1020-nm aerosol extinction coefficient (in units of km^{-1}) for altitudes of 18 **(a)**, 22 **(b)**, 26 **(c)** and 30 km **(d)** between 10° N and 10° S for the years 1998 through 2003. In addition, 525-nm aerosol extinction variability is shown in frame **(e)**. The effects 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.

Wyoming particle counter, Deshler, 2008

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



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

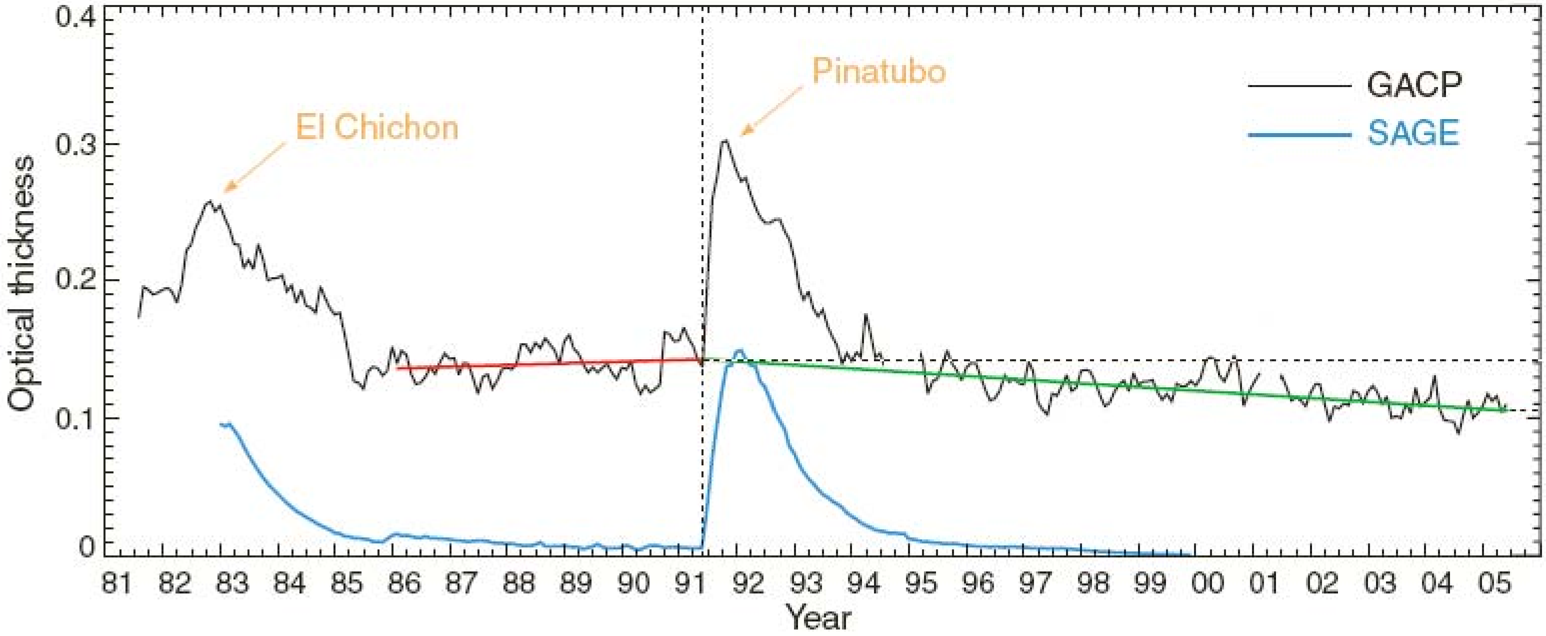


Fig. 1. GACP record of the globally averaged column AOT over the oceans and SAGE record of the globally averaged stratospheric AOT.

Trop. AOT 20 times higher than Strat. (0.005)

Possible effects of increasing stratospheric aerosol

- Increase in ozone depletion (**Hofmann, D. J., and S. Solomon, Ozone Destruction Through Heterogeneous Chemistry Following the Eruption of El Chichon, J. Geophys. Res., 94, 5029, 1989.**)
- 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)

Sulfur Cycle

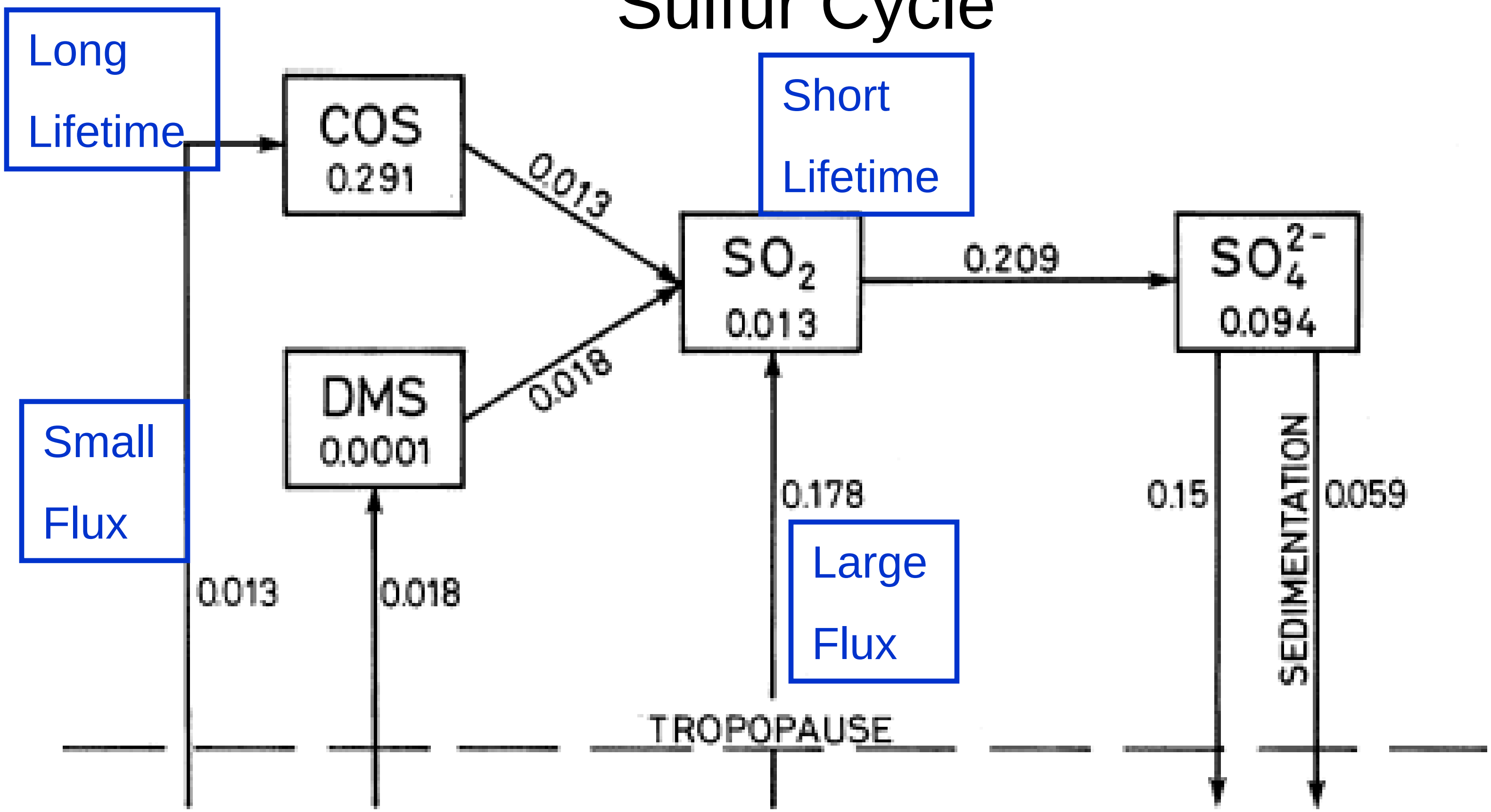
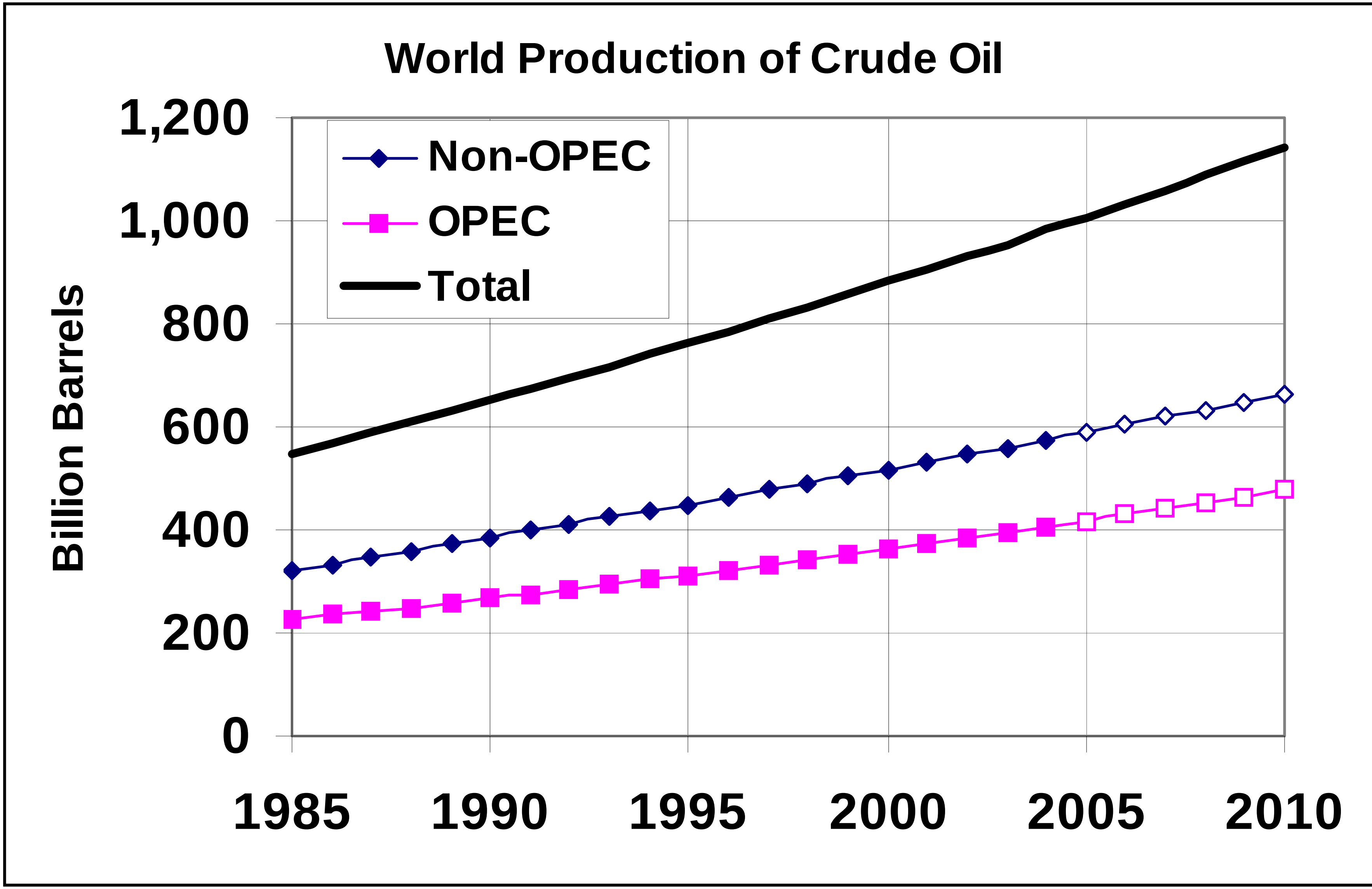
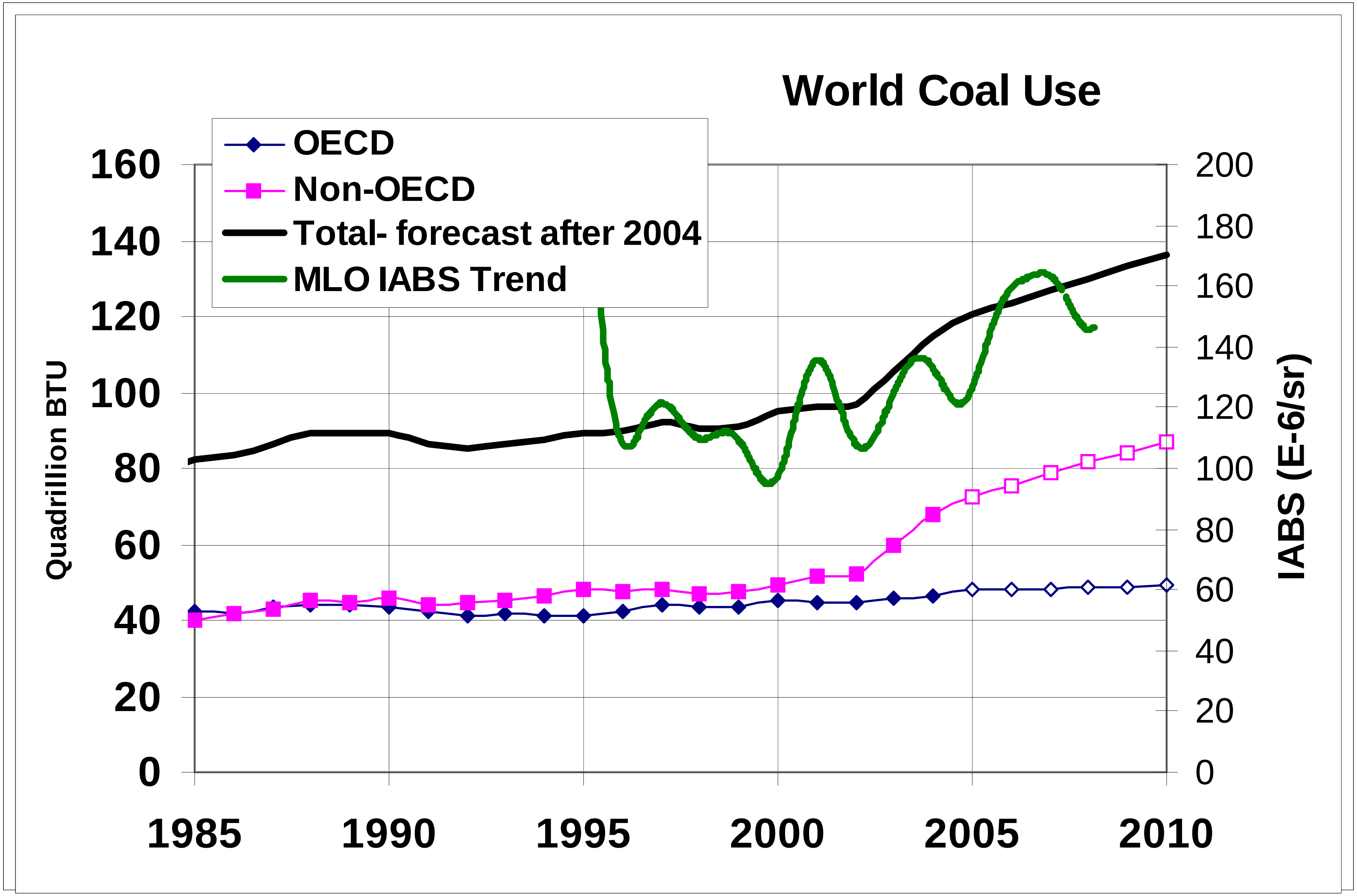


Figure 6. Calculated stratospheric sulfur budget. The fluxes to/from the troposphere are the net fluxes required to maintain the stratospheric sulfur balance. Units; content in TgS, fluxes in Tg S yr^{-1}.

- Kjellstrom, A Three Dimensional Global Model Study of Carbonyl Sulfide in the Troposphere and the Lower Stratosphere, J. Atmos. Chem., 1998



World Production of Crude Oil
Billion Barrels
1,200
1,000
800
600
400
200
0
1985
1990
1995
2000
2005
2010
Non-OPEC
OPEC
Total


World Coal Use
OECD
Non-OECD
Total- forecast after 2004
MLO IABS Trend
Quadrillion BTU
IABS (E-6/sr)
160
140
120
100
80
60
40
20
0
200
180
160
140
120
100
80
60
40
20
0
1985
1990
1995
2000
2005
2010

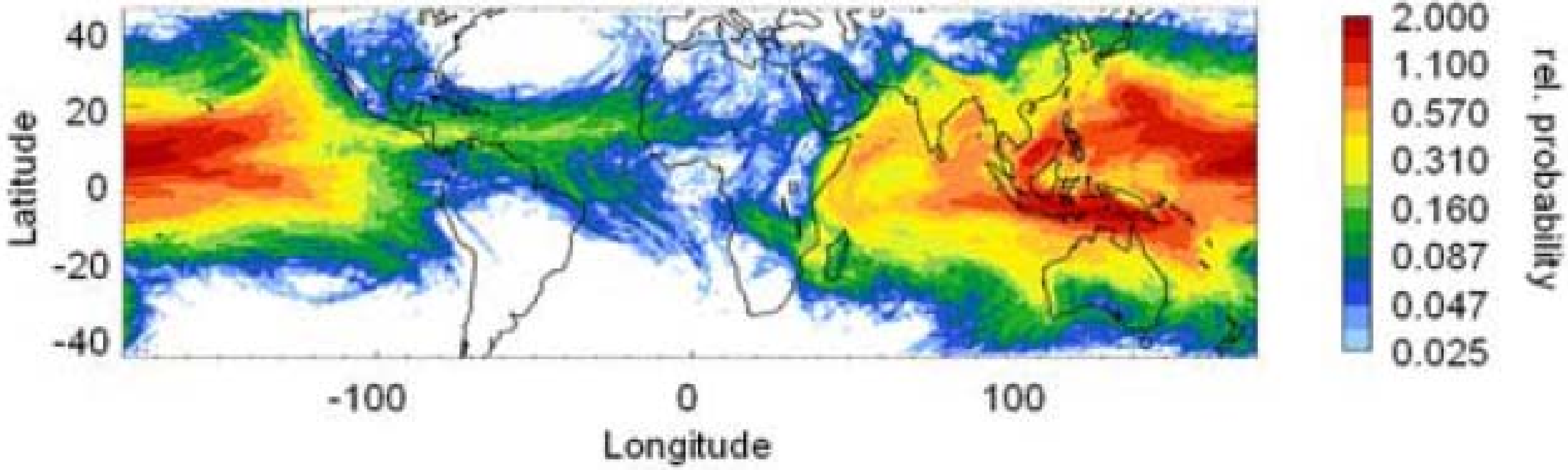


Figure 1. Spatial distribution of the probability that lower tropospheric air masses from a given location reach the 380 K isentropic surface.

Notholt et. al., Influence of tropospheric SO2 emissions… GRL, 2005

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