Toward a more accurate estimate of global stratospheric aerosol surface area density. Is it important?

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- History of stratospheric aerosol
- Present climatology – SAGE II+ and times of concern
  - 1971 - 1984
  - Post Pinatubo – low aerosol loading

Why we care
- Comparison with in situ measurements and fixing the climatology
  - Comparisons over Laramie
  - Broadcasting
- Using the new climatology – results from Chem-CAM (3D) – 1970s
  - NOx, ClOx, Ozone
Satellite Record

Current Surface area density used in Atmospheric models

Periods of concern
Why we care

\[ \text{N}_2\text{O}_5 + \text{H}_2\text{O}_{\text{aer}} \rightarrow 2\text{HNO}_3 \]

• Results of this conversion
  – Less \( \text{N}_2\text{O}_5 \) for: \( \text{N}_2\text{O}_5 + \text{hv} \rightarrow \text{NO}_2 + \text{NO}_3 \)
  – Less \( \text{NO}_2 \) for
    • \( \text{NO}_2 + \text{ClO} + \text{M} \rightarrow \text{ClONO}_2 \)
    • \( \text{NO}_2 + \text{OH} + \text{M} \rightarrow \text{HNO}_3 \)
  – More \( \text{ClO} \) for
    • \( \text{HO}_2 + \text{ClO} \rightarrow \text{HOCl} + \text{O}_2 \), \( \text{HOCl} + \text{hv} \rightarrow \text{OH} + \text{Cl} \)
    • \( \text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2 \)
  – More \( \text{OH} \) for
    • \( \text{OH} + \text{O}_3 \rightarrow \text{H}_2\text{O}_2 + \text{O}_2 \)
    • \( \text{HO}_2 + \text{O}_3 \rightarrow \text{OH} + \text{O}_2 + \text{O}_2 \)

• Net result
  – Less ozone from reactions with \( \text{ClO} \) and \( \text{OH} \)
  – More ozone from reduction in loss from \( \text{NOx} \)
Revising the climatology using In Situ Aerosol Profiles

University of Wyoming –
with particular thanks to Jim Rosen and Dave Hofmann

- http://www-das.uwyo.edu/~deshler/
- AU_Mildura_34S_142W (1972 - 1980)
- Miscellaneous
  - Brazil, Niamey, France
Aerosol concentration for particles > 0.01, 0.15, 0.25 µm
Aerosol concentration for particles > 0.01, 0.15, 0.25, ... 2.0/10.0 µm
Fixing the climatology

- Comparisons over Laramie
- Resultant ratios
- Broadcasting
  - Comparison with far flung measurements
    - Mildura Australia (1972-1980)
    - Lauder New Zealand (1991-2001)
  - Led to determining rate of latitudinal spread and weighting functions for dispersal from eruptions
Fuego
Low aerosol load
Extinction measurements
Can’t see the small particles
Controlling surface area
1988 – 1991 Pre Pinatubo
Aerosol load high enough for extinction meas. to obtain good estimates of surface area

Decay of Pinatubo aerosol in good range for extinction measurements

Peak of Pinatubo
SAGE blinded

Post Pinatubo low aerosol load
Comparison of revised climatology with measurements

In situ measurements at 72 hPa above Laramie, Wyoming 41N

- In Situ
- Satellite Climatology
- Satellite In Situ Climatology

Reasonably Homogeneous Aerosol Periods

SAGE I and SAGE II Operational periods
Comparison of revised climatology with measurements

In situ measurements at 51 hPa above Mildura_Australia:

In situ measurements at 72 hPa above Mildura_Australia_34S

Reasonably Homogeneous Aerosol Periods

SAGE I and SAGE II Operational periods
Periods of concern

In situ measurements at 51 hPa

Satellite Climatology Laramie 41N
Satellite Climatology Lauder 45S
Satellite In Situ Climatology Laramie 41N
Satellite In Situ Climatology Lauder_NZ 45S

Aerosol Surface Area (μm² cm⁻³)

Time (1960-2010)

Period investigated
With CAM - chem
NOx New / Old Climatology

Results CAM – chem run through 1970s

NOX [mol/mol], 01Mar1975 00:00, ca. 53.114604 hPa
NOX [mol/mol], 01Mar1975 00:00, ca. 53.114604 hPa
NOx Profiles 40 N
New / Old Climatology

NOX [mol/mol], lon 180.000000, lat 40.736842

Results CAM – chem run through 1970s

NOX [mol/mol], lon 180.000000, lat 40.736842
Revised Climatology
NOx profiles 40 S
New / Old Climatology

Results CAM – chem run through 1970s

$\text{NOX [mol/mol]}$, lon 180.00000, lat -40.736842

$\text{NOX [mol/mol]}$, lon 180.00000, lat -40.736842
CLO [mol/mol], 01Mar1975 00:00, ca. 53.114604 hPa

CLO [mol/mol], 01Mar1975 00:00, ca. 53.114604 hPa
Revised Climatology

CLO [mol/mol], lon 180.00000, lat 40.736842

CLO [mol/mol], lon 180.00000, lat 40.736842

Results CAM – chem run through 1970s

CLO 40 N
New / Old Climatology

Pressure (mb)

Altitude (km)


Revised Climatology

Fuego

1.65
1.60
1.55
1.50
1.45
1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.950
0.900

/Volumes/Data/jpl/ldi/lcl_aer/un_00/lcl_aer_00.cam1.1970-91.nc

idesher 01.05.2000 13:14
Revised Climatology

CIO 40 S
New / Old Climatology

CLO [mol/mol], lon 180.00000, lat -40.736842
CLO [mol/mol], lon 180.00000, lat -40.736842

Results CAM – chem run through 1970s
Ozone 40 N New / Old Climatology 40 S is similar

Results CAM – chem run through 1970s

O$_3$ [mol/mol], lon 180.00000, lat 40.736842
O$_3$ [mol/mol], lon 180.00000, lat 40.736842
Total ozone global average
New / Old Climatology

Results CAM – chem run through 1970s

O3 Col Dens [DU], global average

Graph showing the total ozone global average over the years 1971 to 1979, with a peak in 1974 and a significant decrease in 1978.
Summary

• Present aerosol surface area density climatology has some deficiencies, < 1970, 1981-1984, > 2000
• A new climatology corrected with in situ measurements is available along with the in situ measurements used to develop it. See: http://www-das.uwyo.edu/~deshler/
• First results with the new climatology show differences in NOx, ClOx and OH leading to ± 0.5% for global average ozone in the 1970s when stratospheric chlorine was 1500 – 2000 ppt.
• Future work
  – Fix blanks at pressures > 100 hPa in El Chichon period
  – Smooth climatology at pressures < 20 hPa, where signal is very weak
  – Use the new climatology in model runs, 1980-1985, and 1991-2010
• There are many people and agencies to thank for these results
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