Study of Tropospheric Trace Gases and Aerosols by Backscatter Ultraviolet Remote Sensing

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40 Years of BUV Observations from LEO

- Nimbus-4 BUV
- Nimbus-7 SBUV
- Nimbus-7 TOMS
- NOAA-9 SBUV-2
- NOAA-11
- NOAA-14
- GOME
- Earth Probe TOMS
- NOAA-16
- SCIAMACHY
- EOS Aura OMI
- GOME-2
- OMPS

Variation with ht of Sensitivity to Absorbers

CLEAR SKY

to change in no. density

to change in Mixing Ratio

Strat overburden removed
Features of the BUV Technique

**Strengths**

- Measurement of $O_3$, $SO_2$, $NO_2$, $HCHO$, $CHOCHO(?)$, plus smoke and dust absorption.
- Clouds & snow/ice enhance the sensitivity (to the column above), *rather than reduce it, as in TIR*.
- Thin clouds, aerosols, and surface albedo have relatively small effect on sensitivity (*compared to NIR)*

**Weaknesses**

- Limited or no vertical information
- Peak sensitivity (to m.r.) near 5 km
- Reduced, strongly ht dependent, sensitivity in PBL, greatly affected by clouds- common to all passive remote sensing techniques.
Tropospheric Ozone
Techniques

• Multi-instrument (nadir + limb)
  – **Advantage**: good separation of trop & strat
  – **Disadvantage**: only one piece of information

• Cloud Slicing
  – **Advantage**: good separation of upper and lower trop
  – **Disadvantage**: poor sampling, particularly from LEO

• Multi-spectral (UV, UV+IR, UV+VIS)
  – **Advantage**: some profile information
  – **Disadvantage**: broad weighting fn near tropopause
OMI + MLS (Weighted-Mean MR in ppmv)

October 2004

July 2005

NCAR AQ Remote Sensing Workshop    Feb 21-23, 2006
O$_3$ Above Deep Convective Clouds in Pacific

Trop O$_3$ Column from Cloud Slicing
Tropospheric Aerosols
Why Ultraviolet?

• One can reliably track transport of UV-absorbing aerosols (smoke, desert dust, volcanic ash) in the free troposphere— even over clouds & snow/ice

• If aerosol height information is available (from LIDAR or models) aerosol absorption OT can be derived with accuracy approaching that of AERONET.
OMI Aerosol Index

July 2005 Saharan Dust Storm as seen by OMI

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Aerosol Detection in Presence of Clouds: A Unique Capability of the BUV technique

Aerosol Index (color scale)
Reflectivity (gray scale)
Dust Storm over Libya (Mar 1, 2005)

OMI Aerosol Absorption Optical Depth 03-01-2005

OMI

Aqua-MODIS

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Dust Over Africa (March 1, 2005)

Extinction OT

Single Scattering Albedo

Aerosol Index

Absorption OT

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Smoke over Alaska (Aug 21, 2004)

Extinction Optical Depth

Aqua-MODIS RGB

Absorption Optical Depth

Single Scattering Albedo

no abs
**BUV Experience Summary**

- 35+ years of experience.
- 50+ years of measurement from LEO is assured.
- Can measure all criteria pollutants except CO.
  - The only proven technique for measuring aerosol absorption from space.
  - The only passive remote sensing technique that can track smoke and dust plumes above clouds & snow/ice.
- Performs best for trace gases and aerosols in the free troposphere.
- UV Absorbers in the PBL can be seen, but only if there is nothing above (incl. clouds). Retrieval is very sensitive to vertical distribution of the absorber.