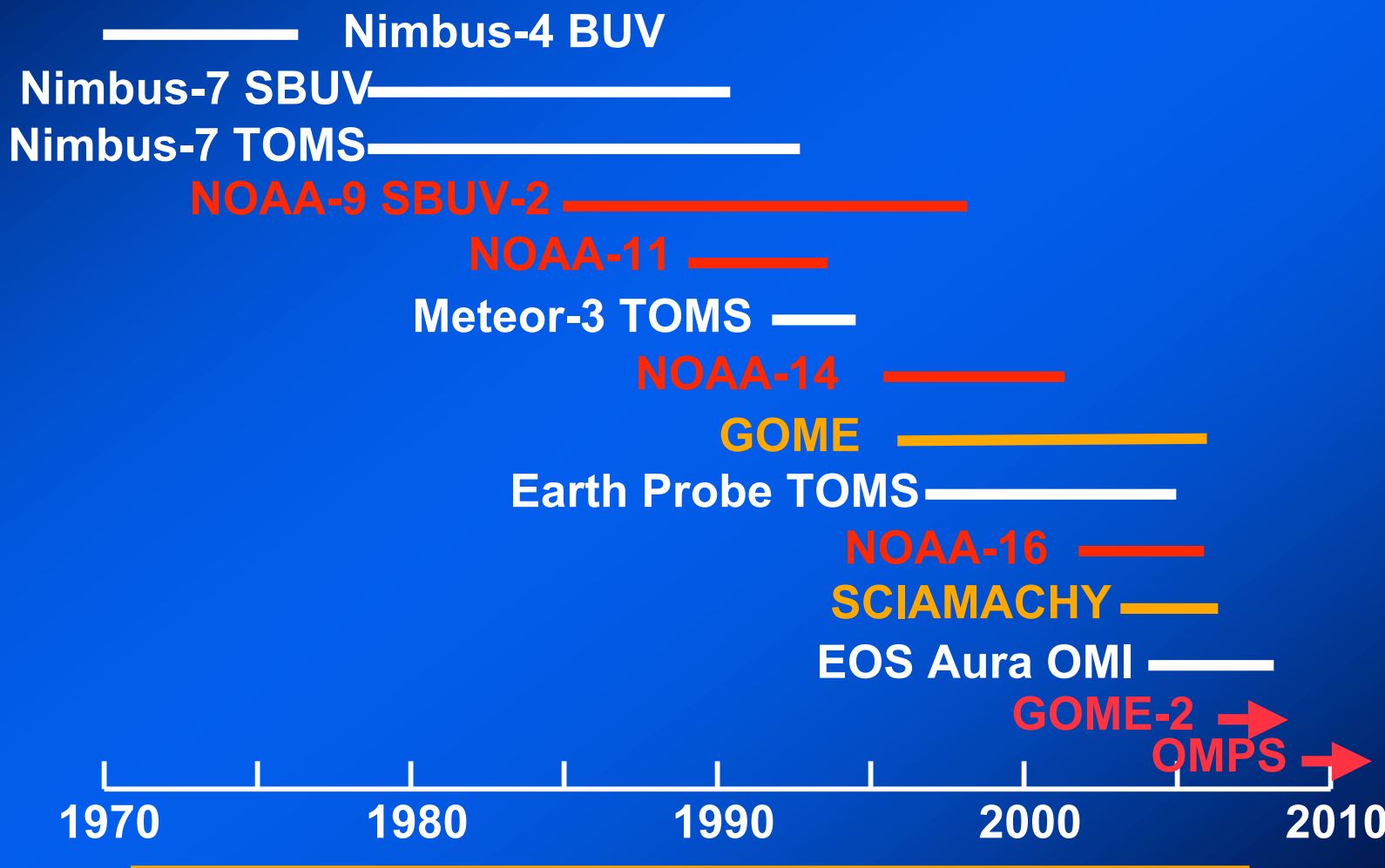
Study of Tropospheric Trace Gases and Aerosols by Backscatter Ultraviolet Remote Sensing

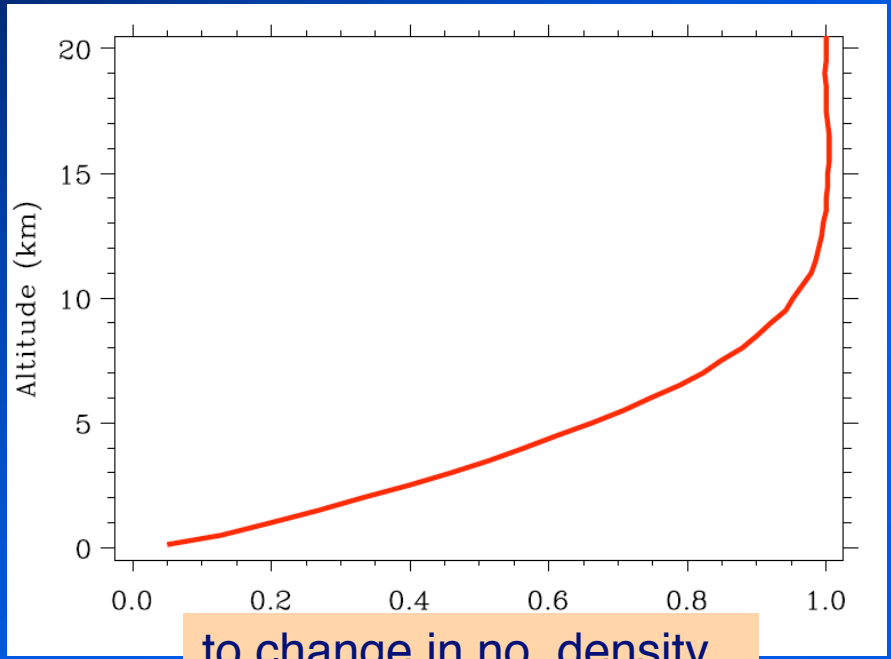
Pawan K. Bhartia
NASA Goddard Space Flight Center
Greenbelt, Maryland, USA

40 Years of BUV Observations from LEO

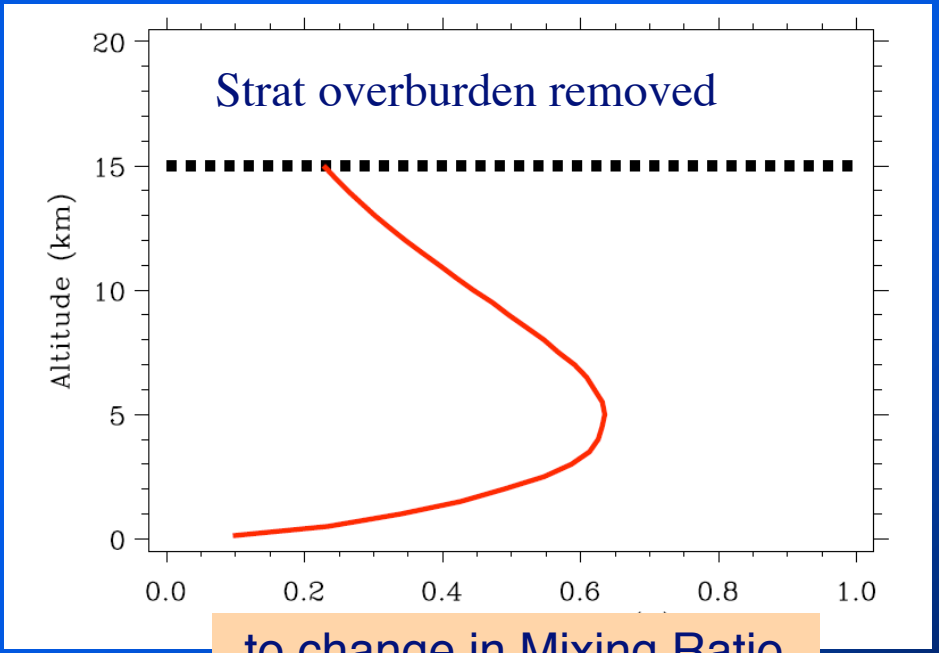


Variation with ht of Sensitivity to Absorbers

CLEAR SKY



to change in no. density



to change in Mixing Ratio

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

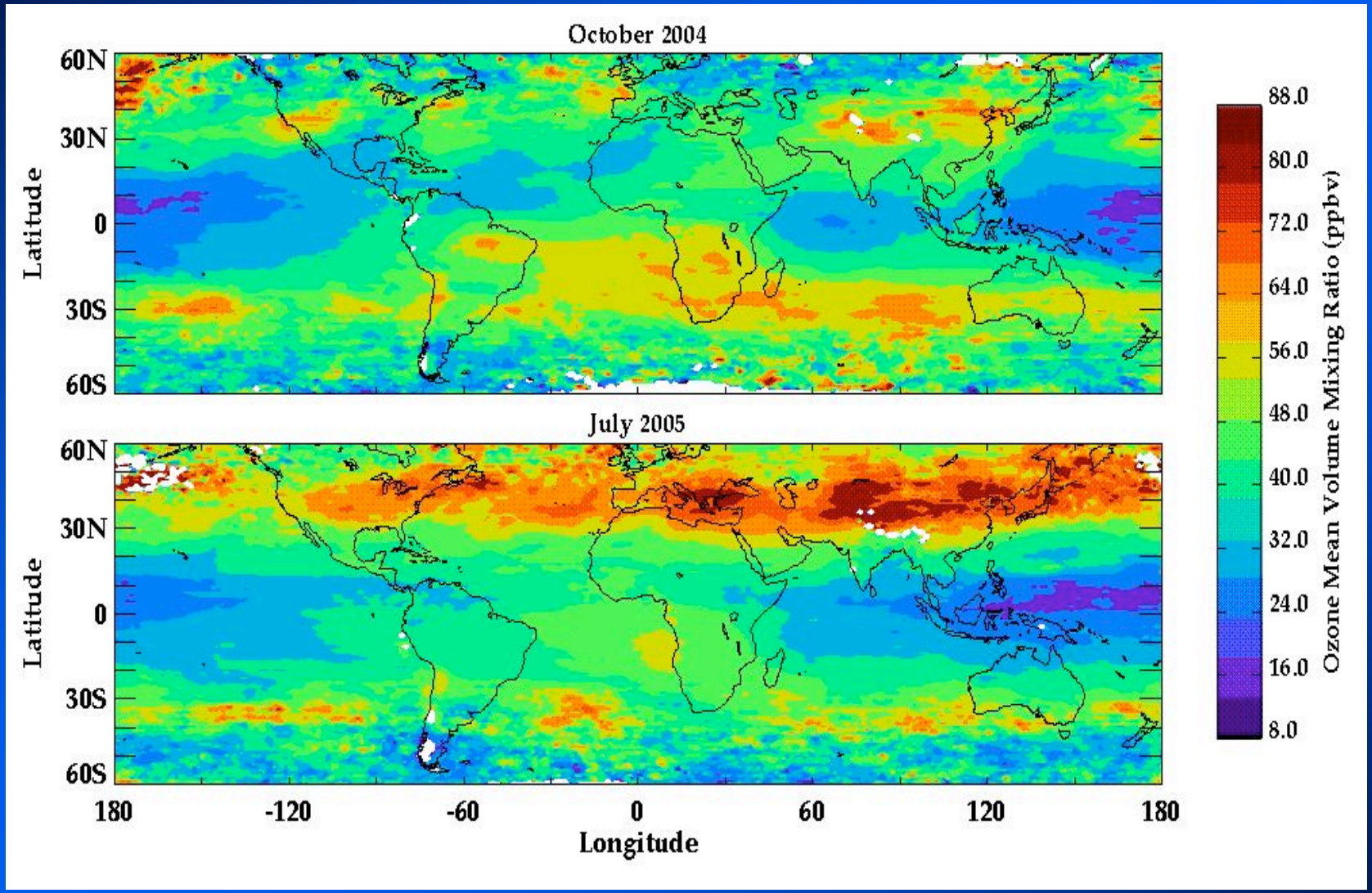
- Limited or no vertical information
- Peak sensitivity (to m.r.) near 5 km
- Reduced, strongly ht dependent, sensitivity in PBL, greatly affected by clouds- *common to all passive remote sensing techniques*.

Tropospheric Ozone

Techniques

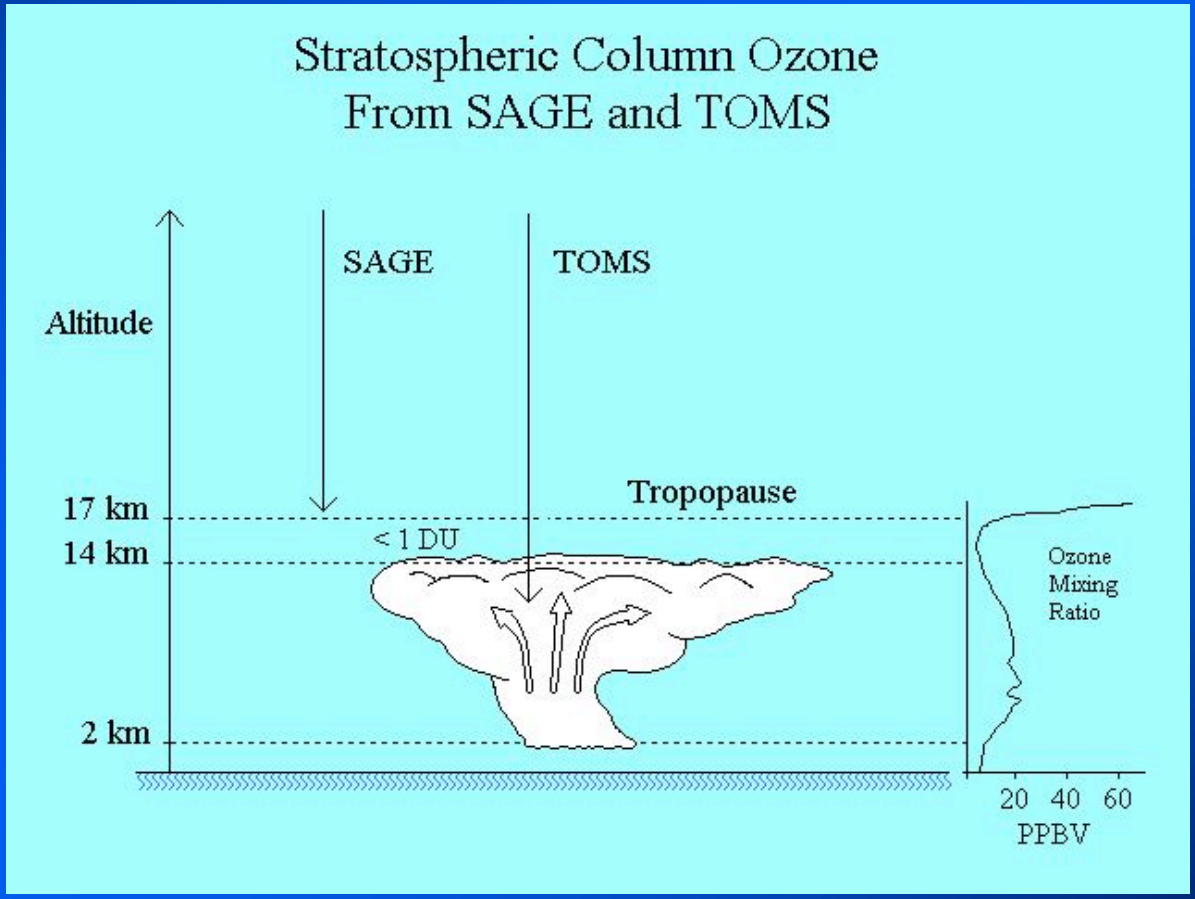
- Multi-instrument (nadir + limb)
  - **Advantage**: good separation of trop & strat
  - **Disadvantage:** only one piece of information
- Cloud Slicing
  - **Advantage:** good separation of upper and lower trop
  - **Disadvantage**: poor sampling, particularly from LEO
- Multi-spectral (UV, UV+IR, UV+VIS)
  - **Advantage:** some profile information
  - **Disadvantage**: broad weighting fn near tropopause

OMI + MLS (Weighted-Mean MR in ppmv)

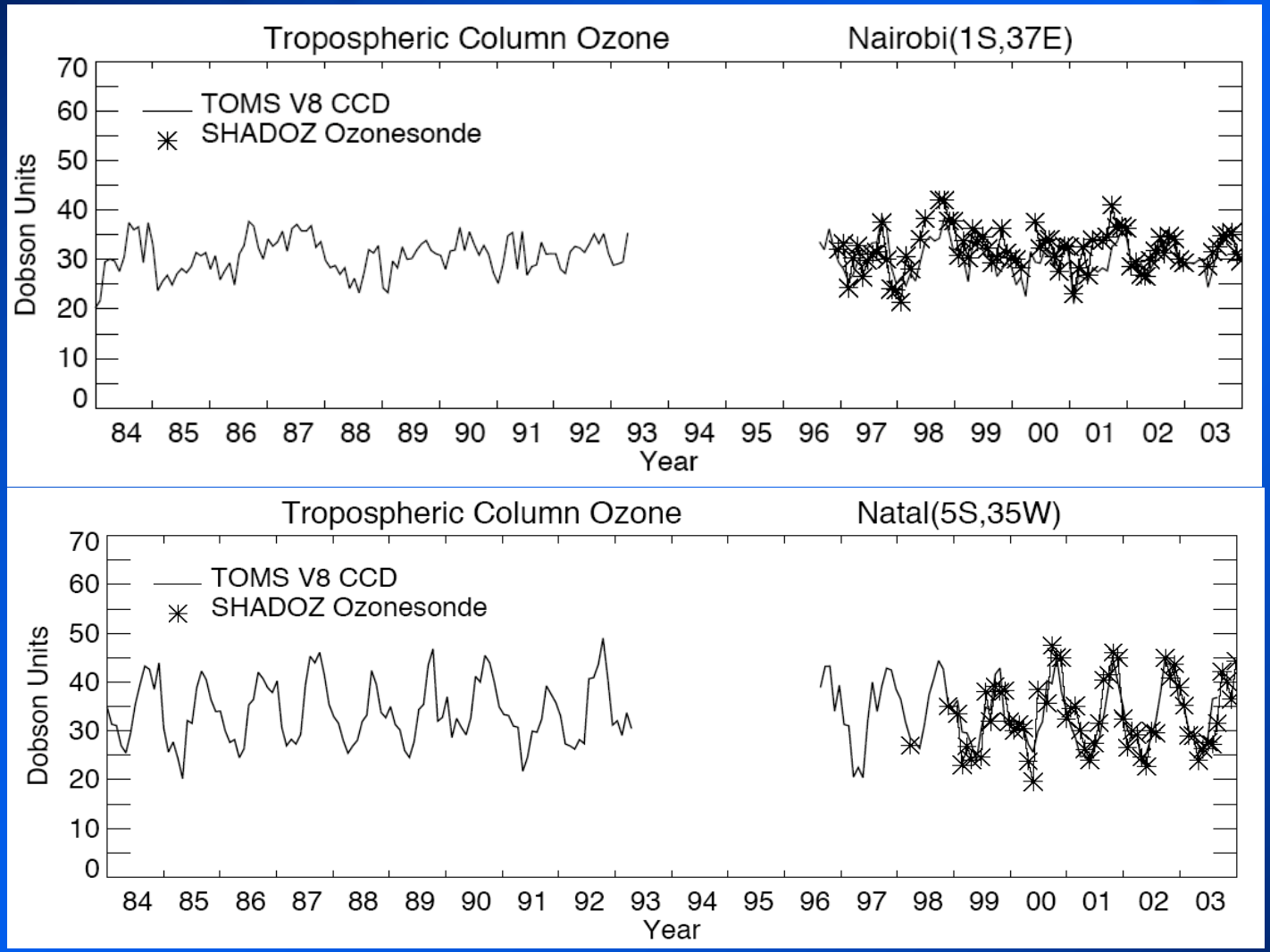


O_3 Above Deep Convective Clouds in Pacific

From: Observation of near-zero O_3 concentrations over the convective Pacific: Effects on air chemistry, Kley et al., Science, Oct 1996.



Trop O_3 Column from Cloud Slicing

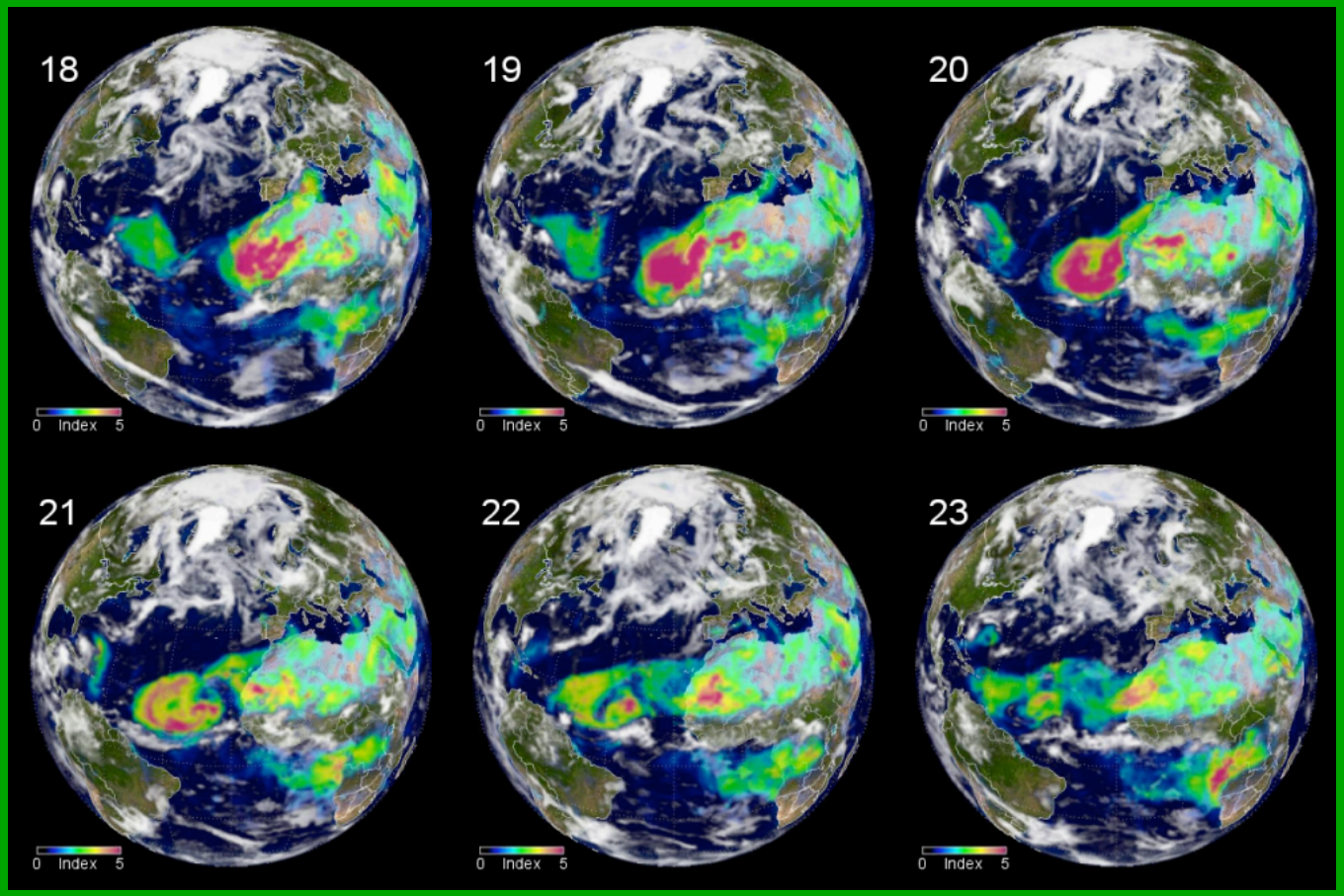


Tropospheric Aerosols

Why Ultraviolet?

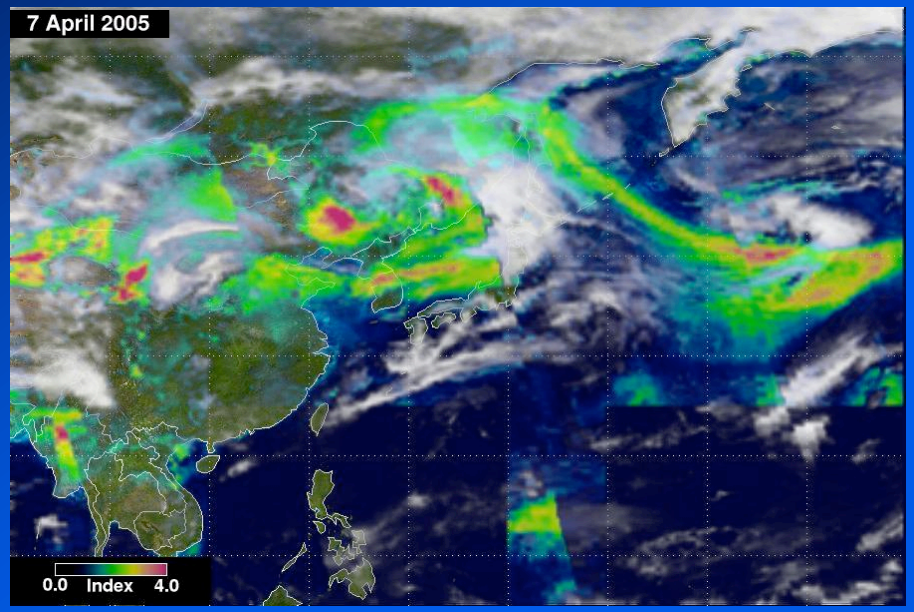
- One can reliably track transport of UV-absorbing aerosols (smoke, desert dust, volcanic ash) in the free troposphere- even over clouds & snow/ice
- If aerosol height information is available (from LIDAR or models) aerosol absorption OT can be derived with accuracy approaching that of AERONET.

OMI Aerosol Index

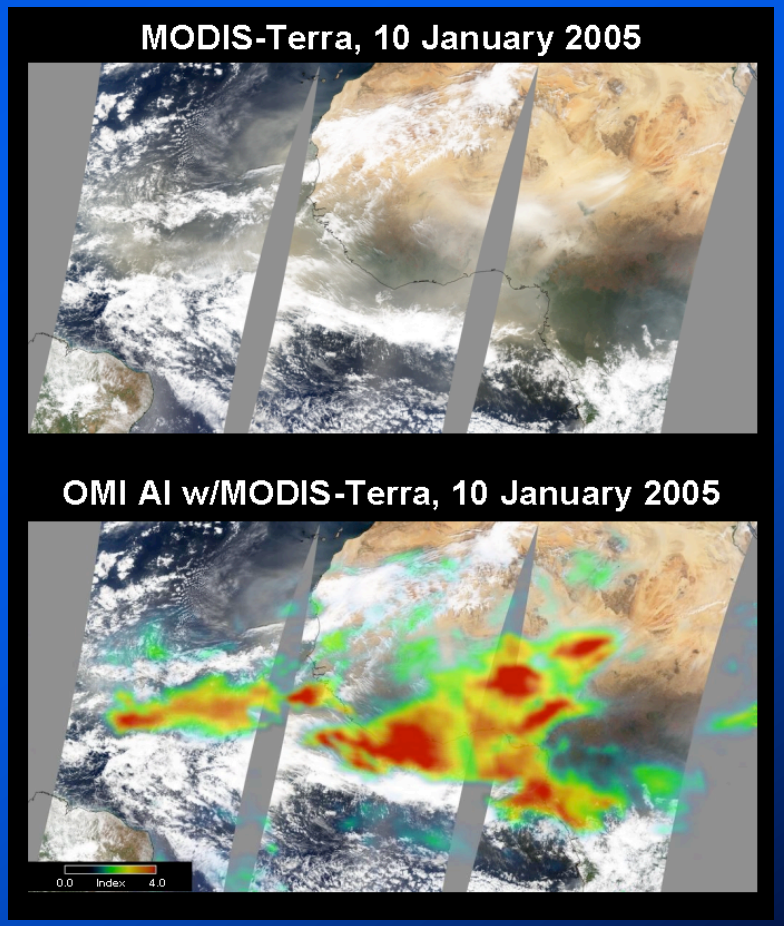


July 2005 Saharan Dust Storm as seen by OMI

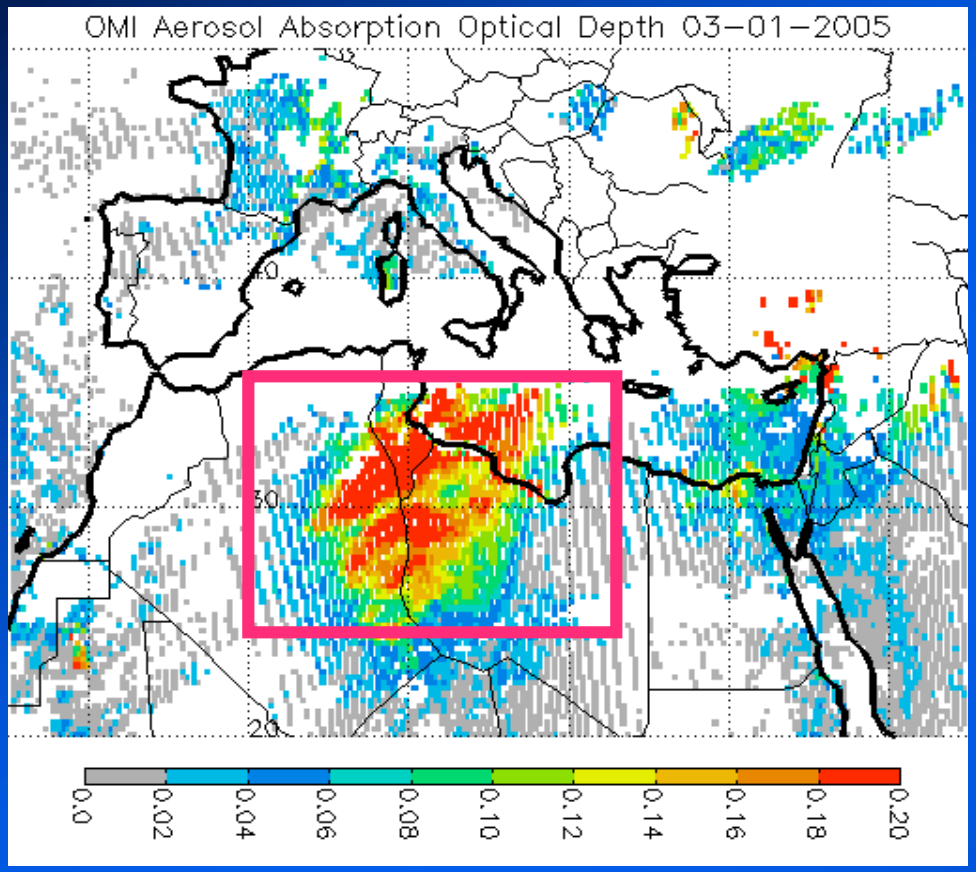
Aerosol Detection in Presence of Clouds: A Unique Capability of the BUV technique



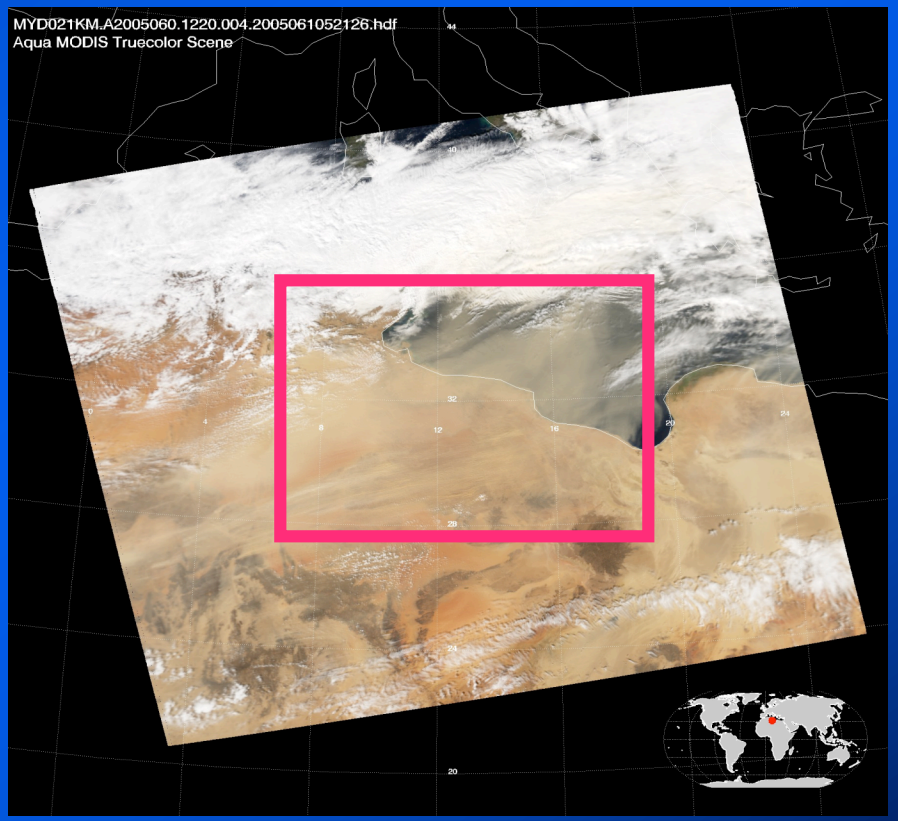
Aerosol Index (color scale)
Reflectivity (gray scale)



Dust Storm over Libya (Mar 1, 2005)



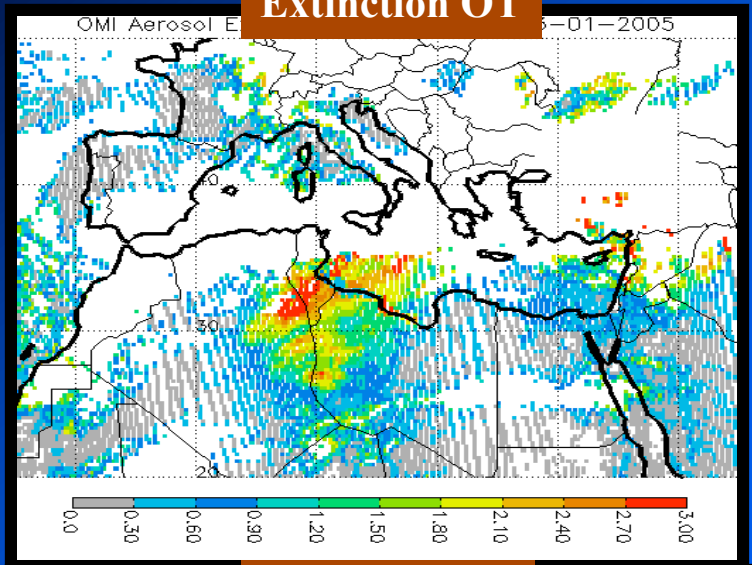
OMI



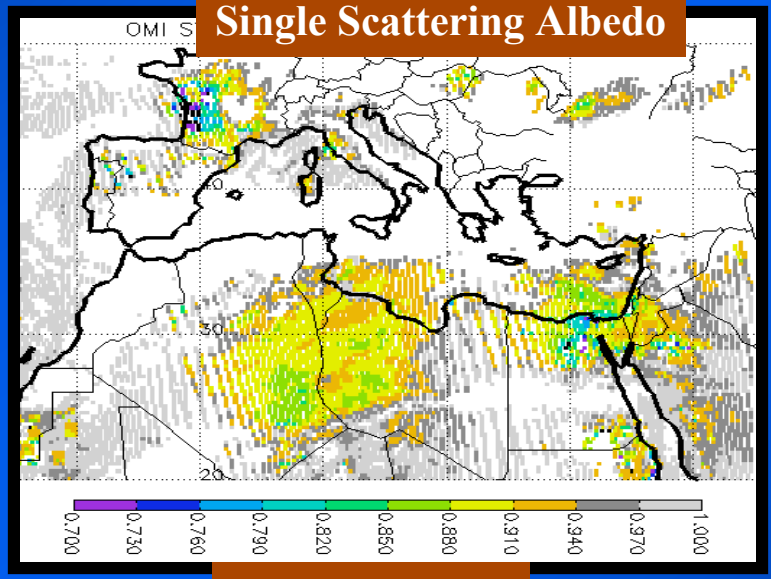
Aqua-MODIS

Dust Over Africa (March 1, 2005)

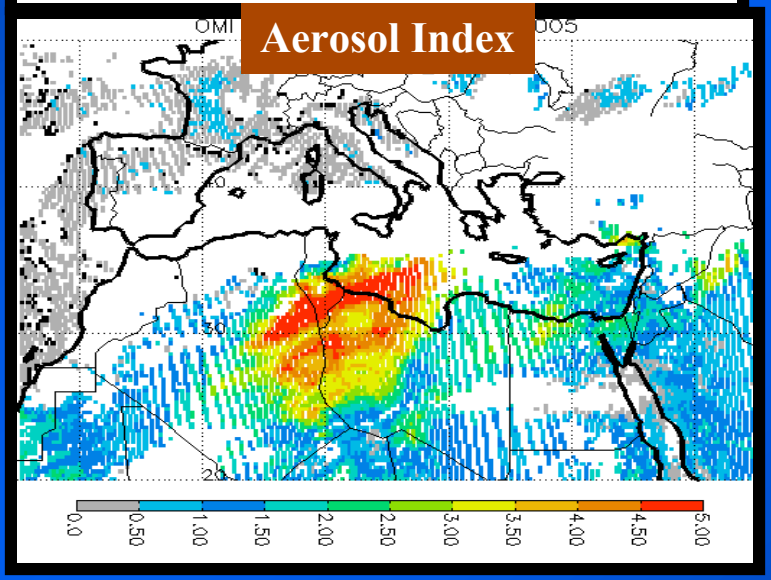
Extinction OT



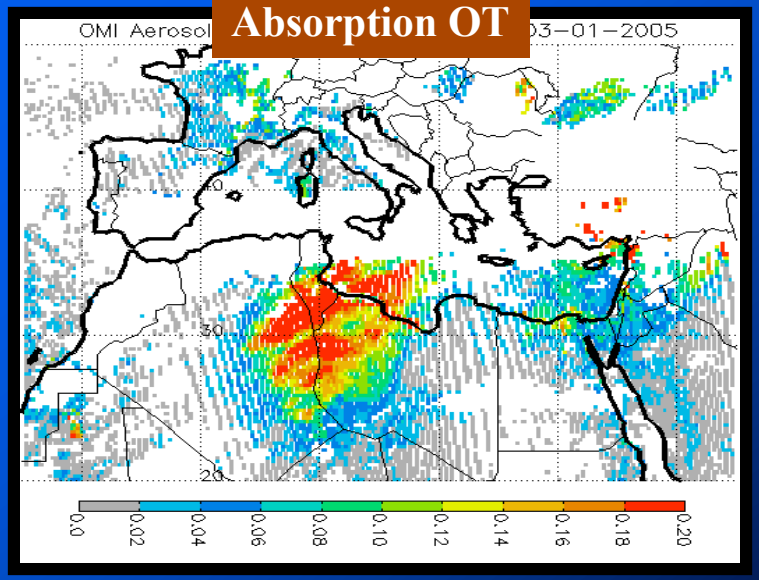
Single Scattering Albedo



Aerosol Index

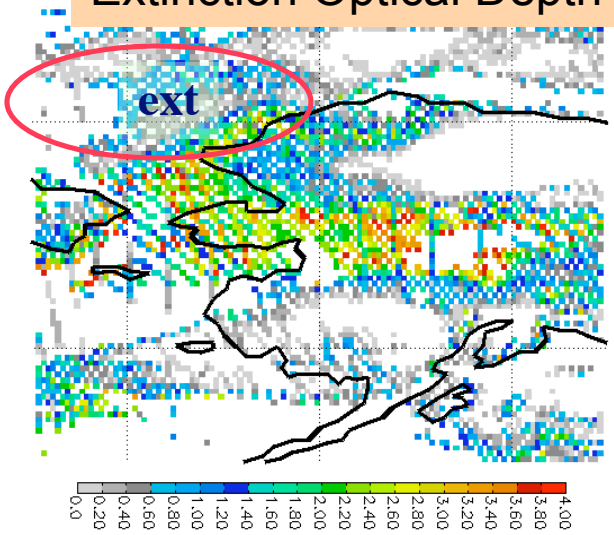


Absorption OT

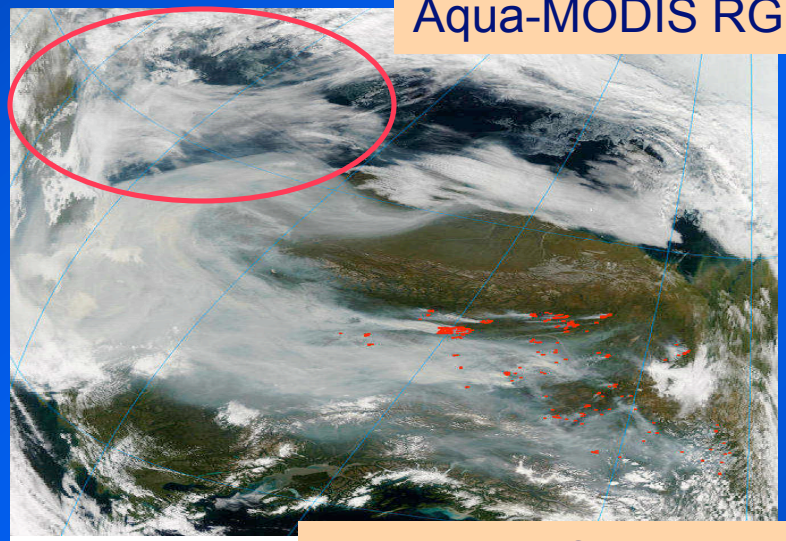


Smoke over Alaska (Aug 21, 2004)

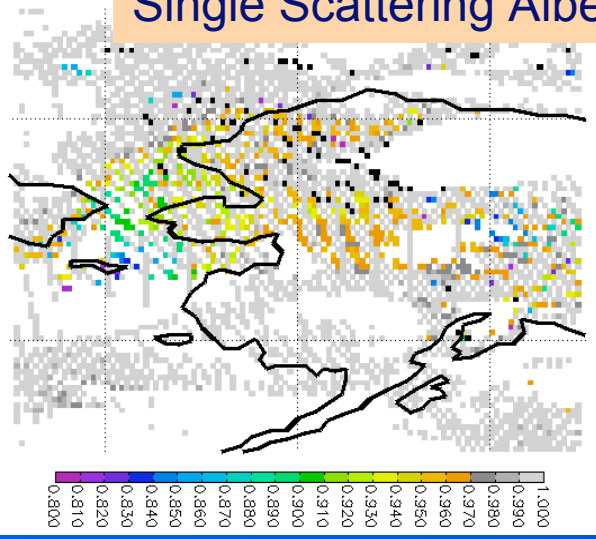
Extinction Optical Depth



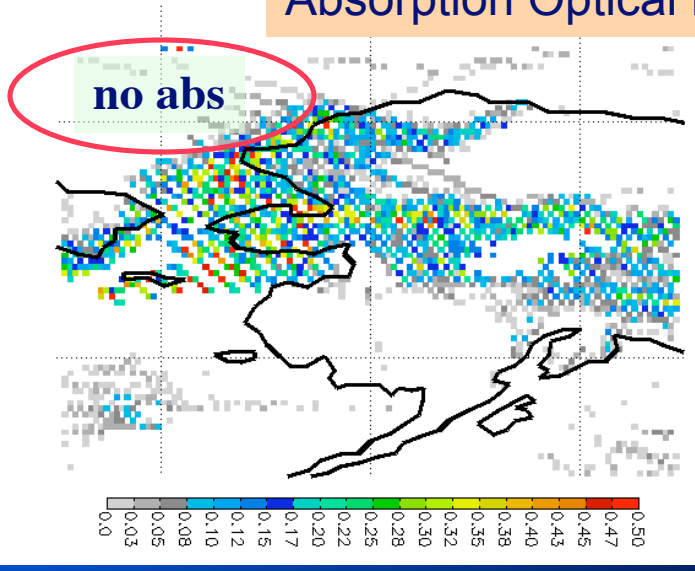
Aqua-MODIS RGB



Single Scattering Albedo



Absorption Optical Depth



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.