NOAA/EPA UV Brewer Network

Effects of Clouds and Tropospheric Air Quality on Surface UV at 6 EPA UV Research sites

Kathleen Lantz, Peter Kiedron, Irina Petropavlovskikh

University of Colorado, Cooperative Institute for Research in Environmental Sciences

This research is funded by U.S. EPA - Science To Achieve Results (STAR) Program Grant # RD833224

UV and ozone profile

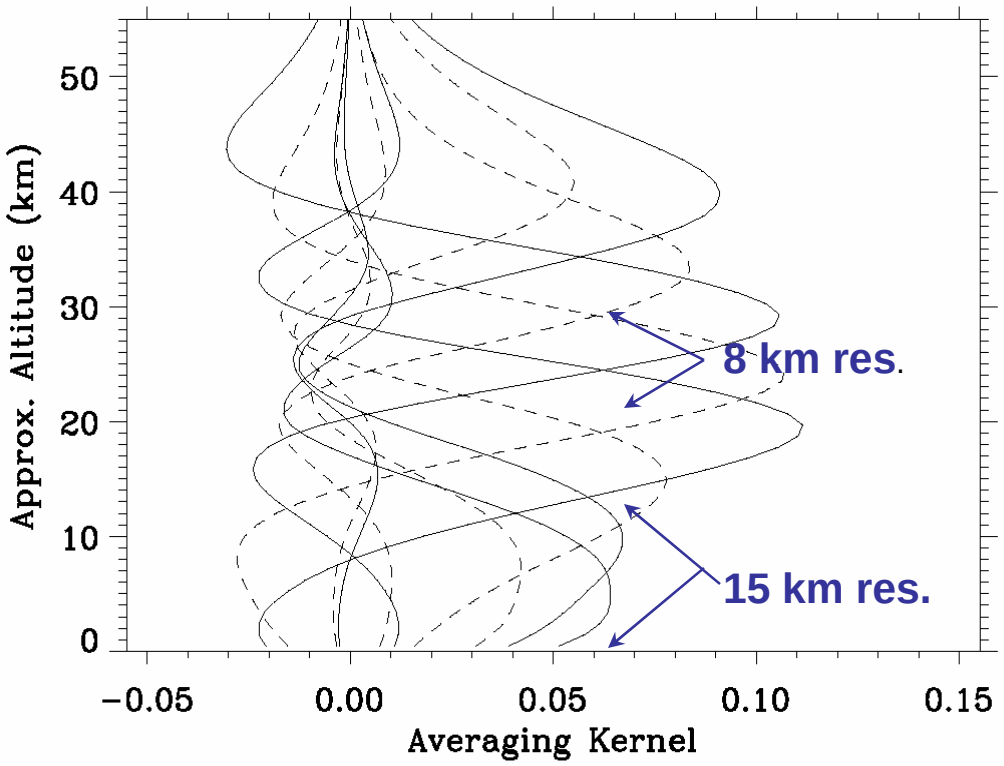
- UV flux is sensitive to the vertical distribution of ozone
- The knowledge of the location of the ozone maximum is important for UV modeling (Klenk et al, 1983; Wellemeyer et al, 1997)
- Ozone profile variability (Krotkov et al, 1998)
  - stratosphere- shows spectral dependence in UV response (up to a few percent), increased when sun is low
  - upper troposphere - has small effect on the UV flux.
  - low troposphere - more significant at high sun conditions – increased scattering in troposphere relative to stratosphere.
- We plan to account for effects of ozone profile (derived from Brewer Umkehr measurements) in analysis of the Brewer-measured UV fluxes.

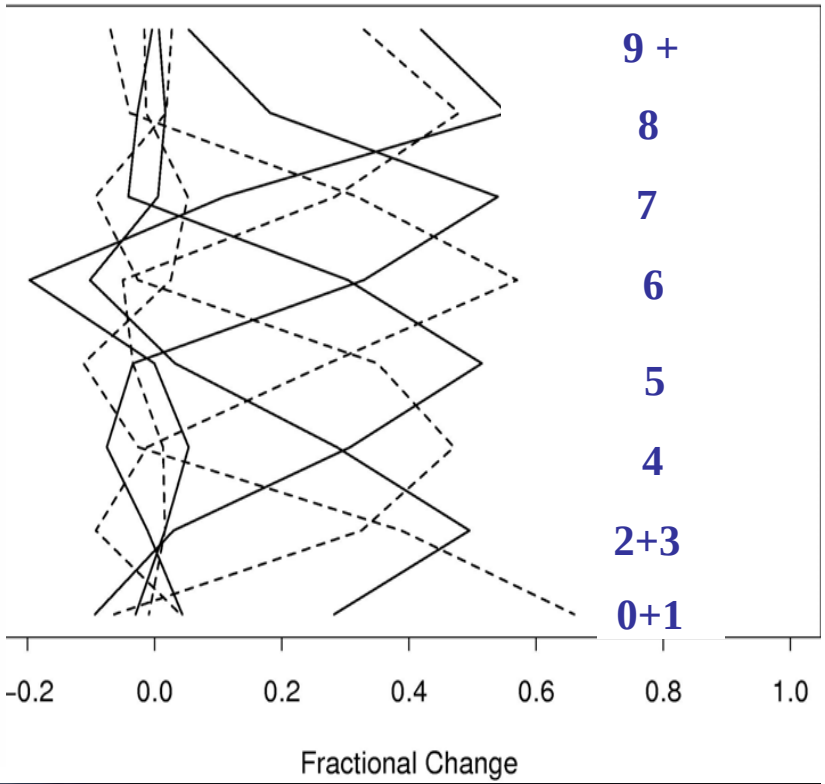
Umkehr background

- There are 4 types of operational Umkehr systems: traditional Dobson, automated Dobson and Brewer (single and double)
- Only single-pair data from the automated Dobson are used for ozone profile retrievals, even though they also take measurements at other wavelengths.
- Though a version of Dobson Umkehr retrieval has been revised for Brewer and used to process Arosa Brewer data, no Brewer data are available from the WOUDC archive.
- NOAA/EPA network will collect and archive Umkehr data from Brewers in the field. We will process and archive ozone profiles on regular network basis.

NOAA/EPA UV Brewer Network

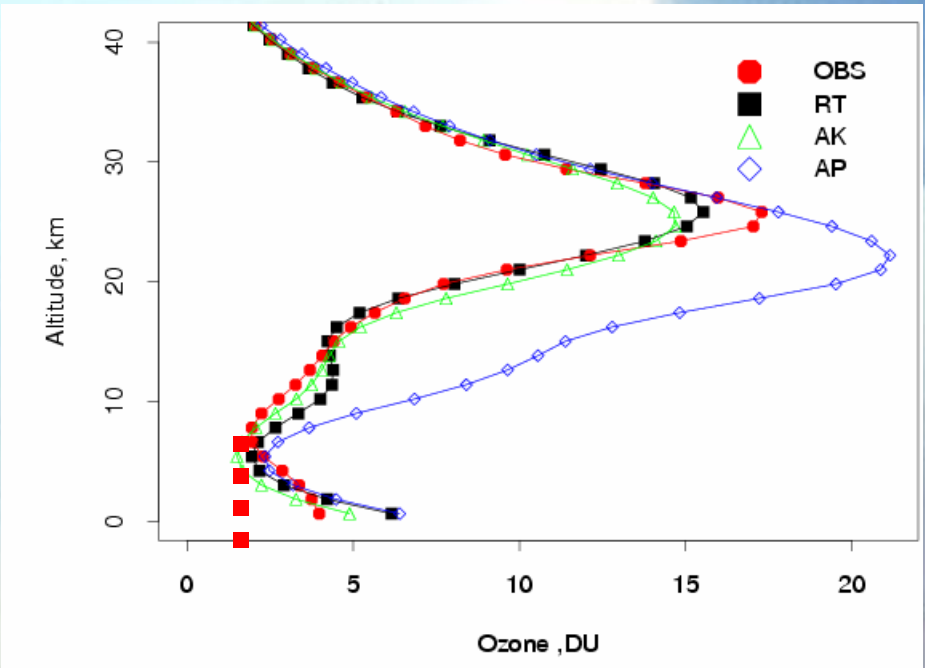
Umkehr C-pair Averaging Kernels and vertical resolution:
50 % from the layer and 50 % from adjacent layers
Layer 4 and 5 information is as good as in layers 6-8



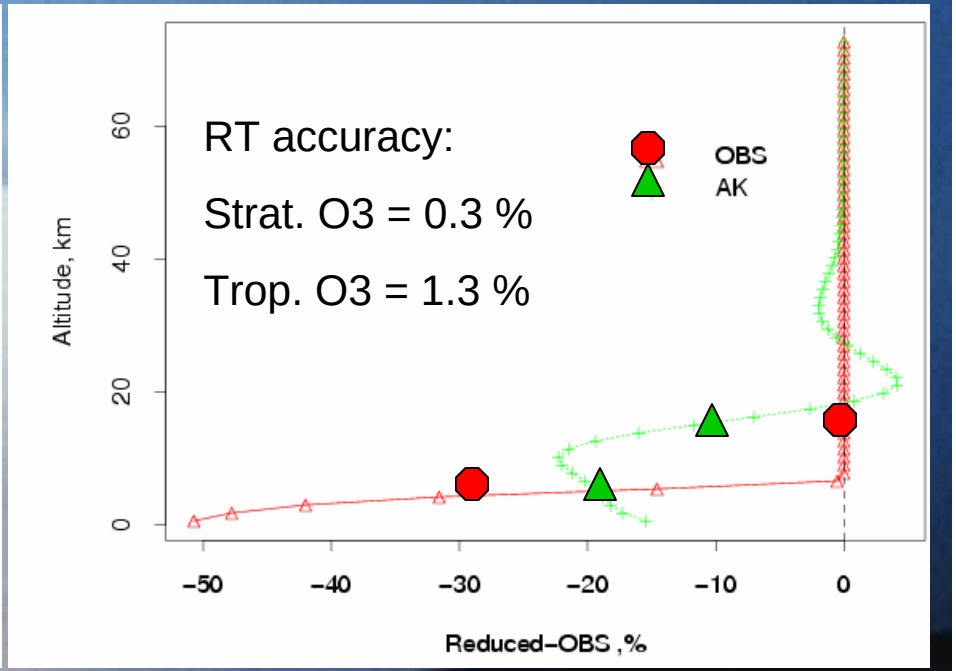


Effect of smoothing with single pair

Smooth profile – reduced trop. ozone



Smoothing errors – layer 0+1 and 2+3



Summary of algorithm

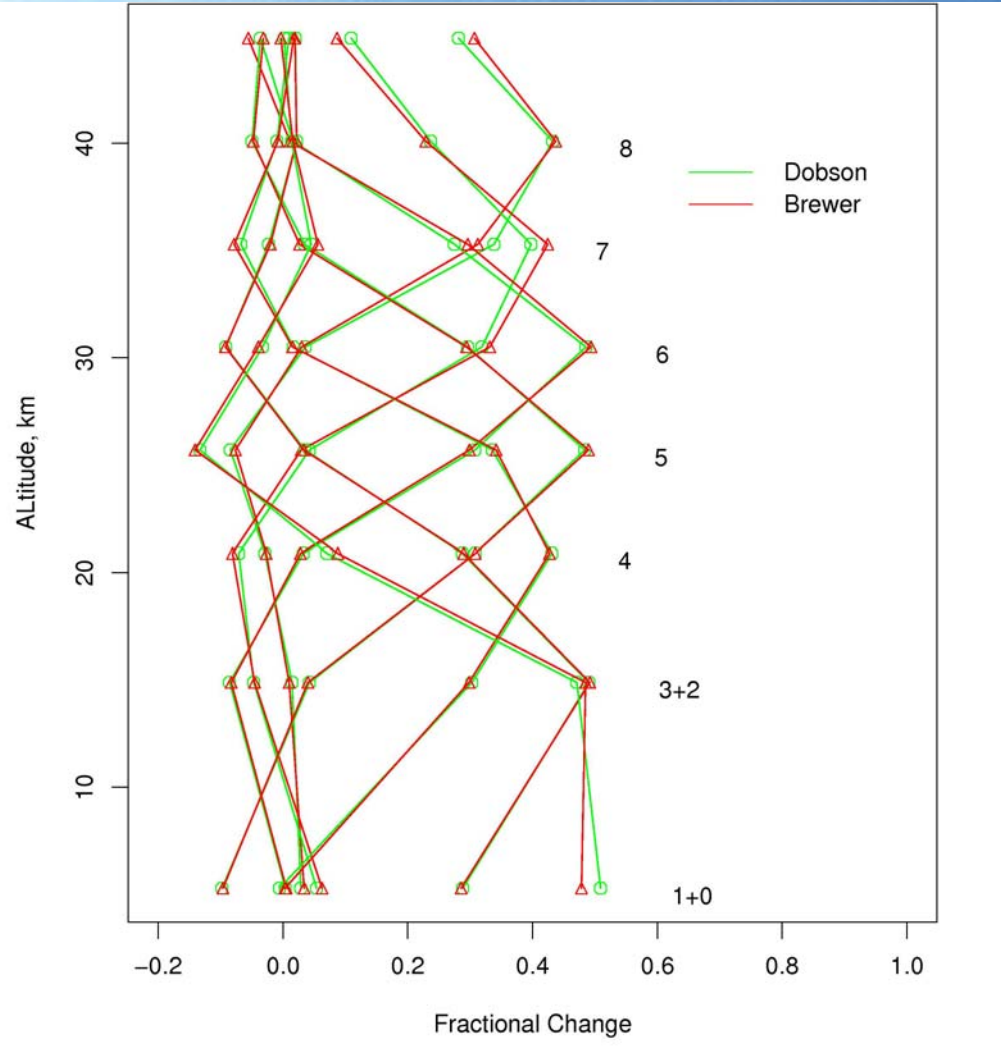
- Umkehr Dobson technique (Petropavlovskikh et al., 2005) may be too noisy to monitor short-term variability in atmospheric ozone.
- However, UMK04 is capable of monitoring long-term changes in MMA with less then 5 % uncertainty in the stratosphere, and less than 15 % in troposphere, and with no influence from a priori information.
- UMK04 is capable of measuring long-term changes in tropospheric O3

  http://www.srrb.noaa.gov/research/umkehr

Ozone algorithm modification for Brewer

- Dobson UMK04 algorithm is modified for Brewer single pair measurements (310 and 326 nm)
- Measurement noise is half of Dobson
- Still has no cloud detection capabilities – use co-incidence with Dobson data that are screened for clouds or will develop new screening procedures

Profile information: single wavelength



Synthetic dataset study

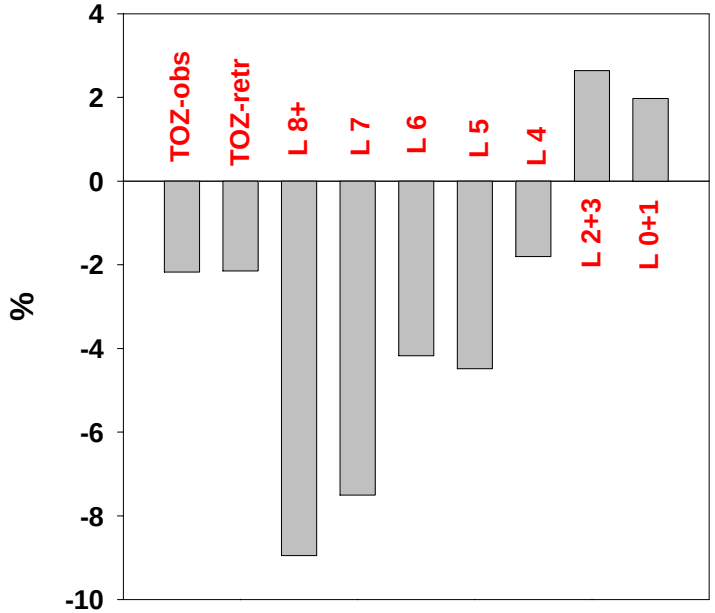
- Use synthetic ozone profiles to simulate Dobson and Brewer measurements
- Add statistical noise (0.25 N-value)
- Retrieve Dobson and Brewer profiles by using the same inverse model
- Difference between Brewer and Dobson RTs is minimal in the absence of instrumental effects.

Test Brewer RT: Arosa

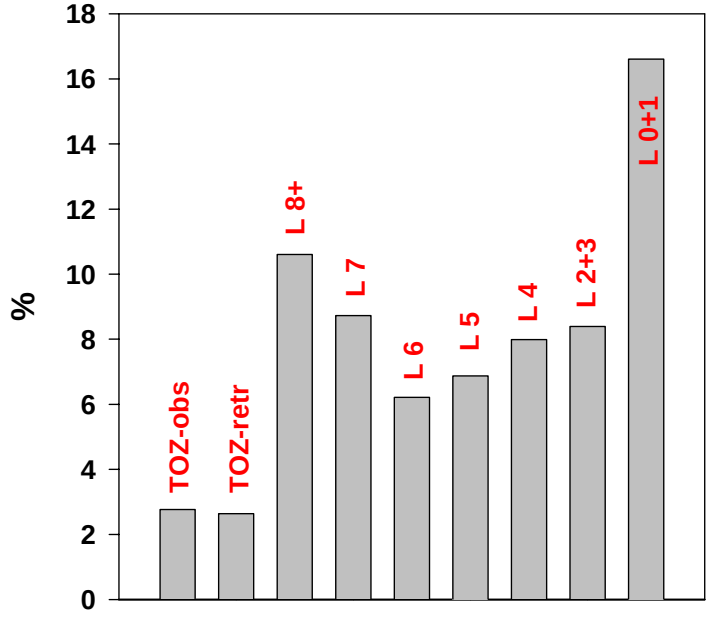
- Approach: use single wavelength pair Brewer data from 1988 to 2004
- Choose data co-incidental with Dobson measurements to assure elimination of clouds.
- Against Dobson (about 1500 measurements): ~8% higher at 35-45 km
- Against co-incidental SBUV: ~7 % lower
- Stray-light issue vs. ozone X-section issue

Dobson/Brewer, Bias and RMSD

Mean value for Dobson/Brewer difference

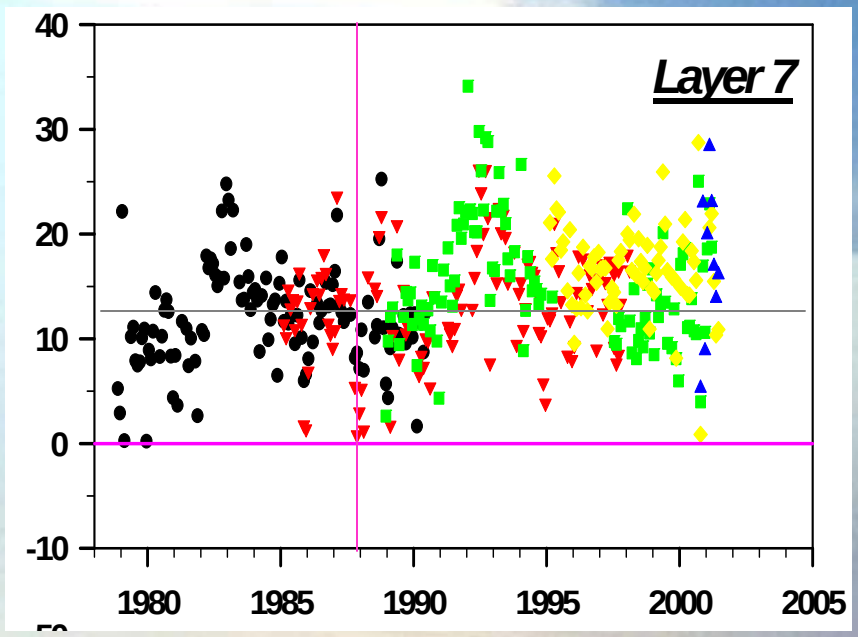


Std.Dev. for Dobson/Brewer difference

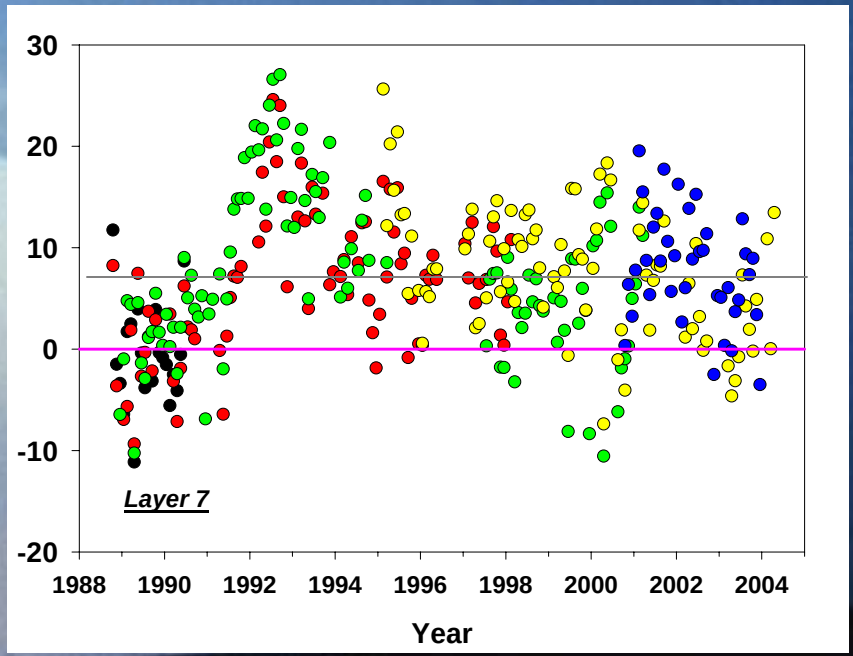


SBUV vs Dobson and Brewer for Arosa station, layer 7

Dobson, ~12 % offset



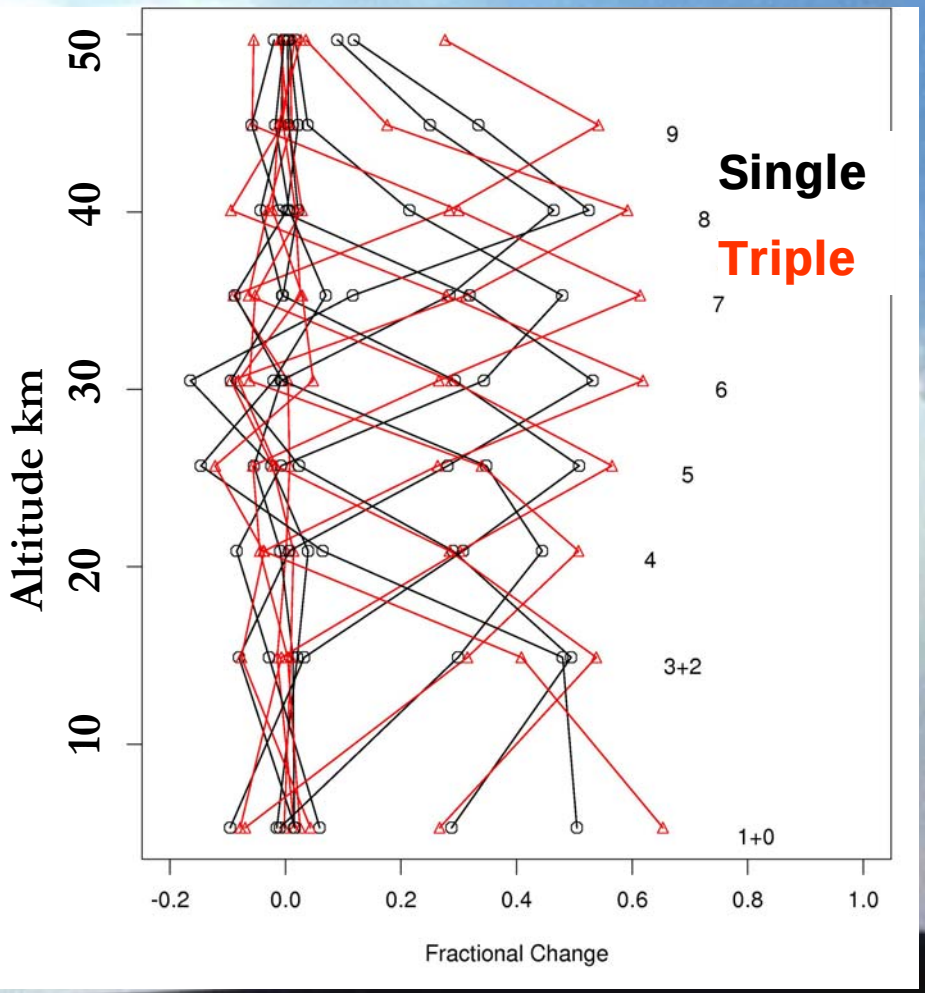
Brewer, ~7 % offset



Nimbus 7 NOAA-09 NOAA-11

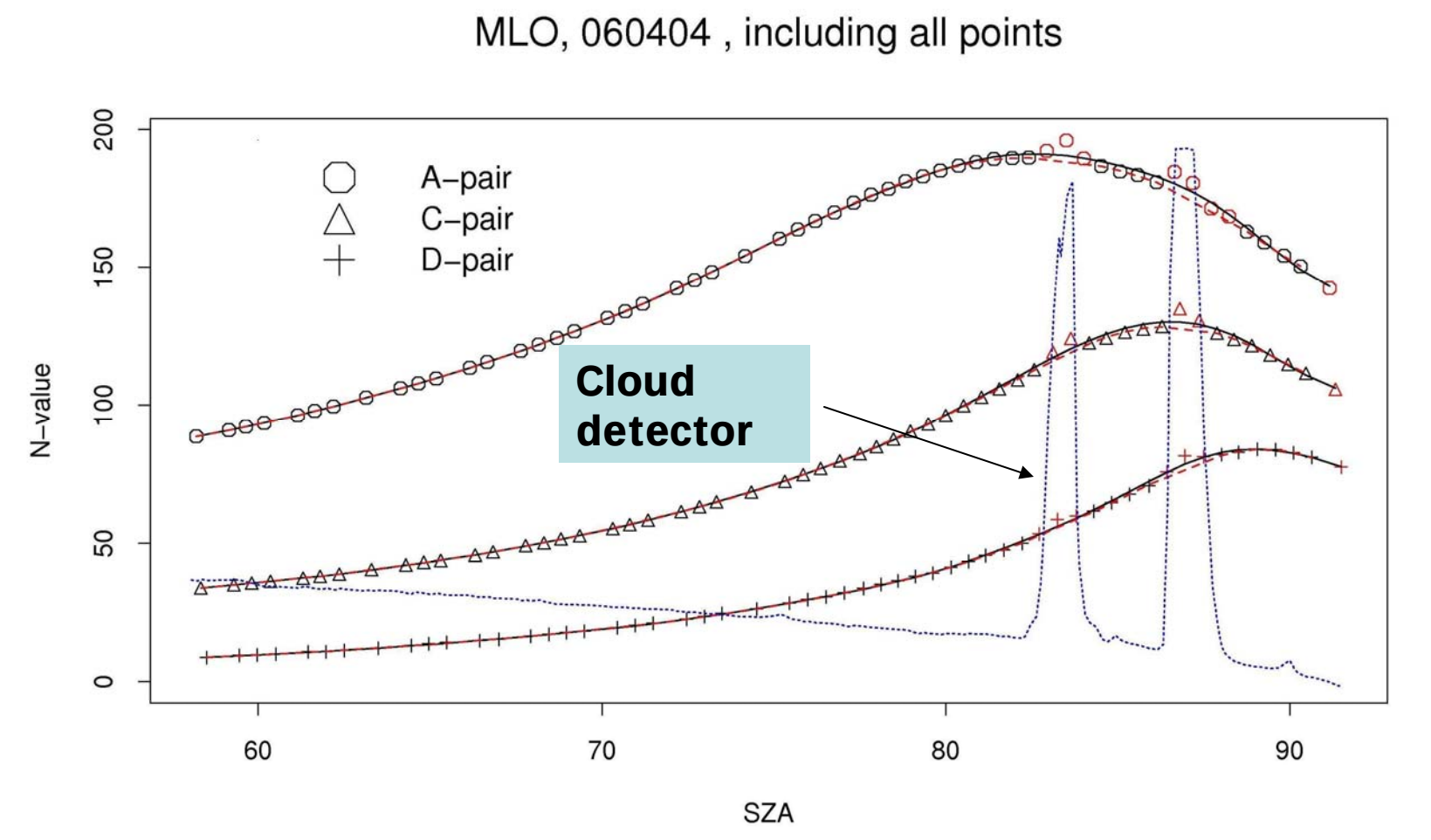
NOAA-14 NOAA-16 Zero level

Profile Information: single vs. multiple wavelengths

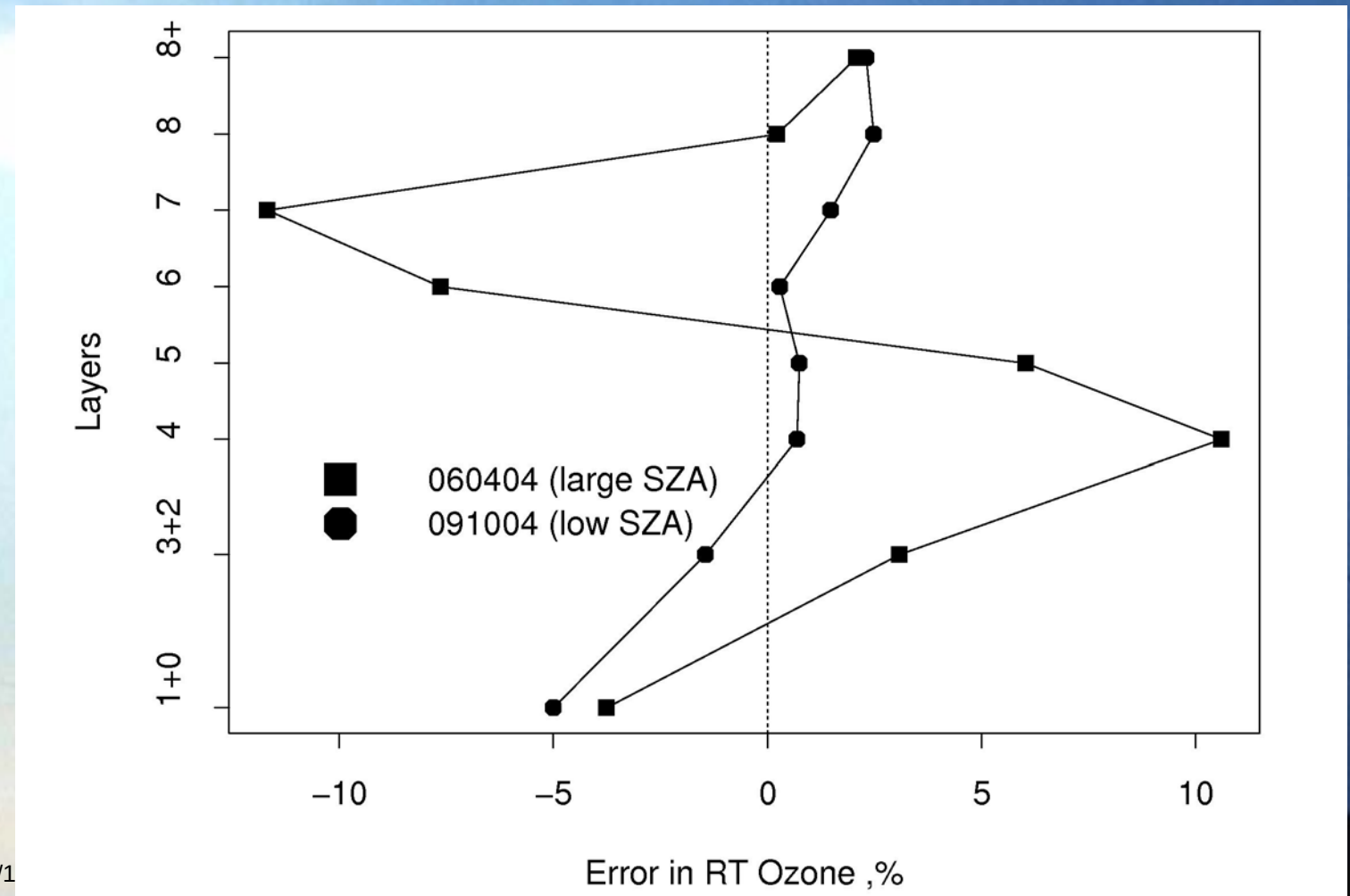


- The new algorithm uses only the C-pair wavelength.
- Averaging Kernel analysis shows that shorter wavelengths (A-pr) could provide information in layer 9, whereas C-pr doesn't.
- However, scattered light problem would get worse with A-pr, so this benefit may or may not be realized.
- The D-pair has very little profile information, but may be useful for cloud detection and increased sensitivity to tropospheric ozone

Cloud detection in MLO Dobson, clouds at high SZA

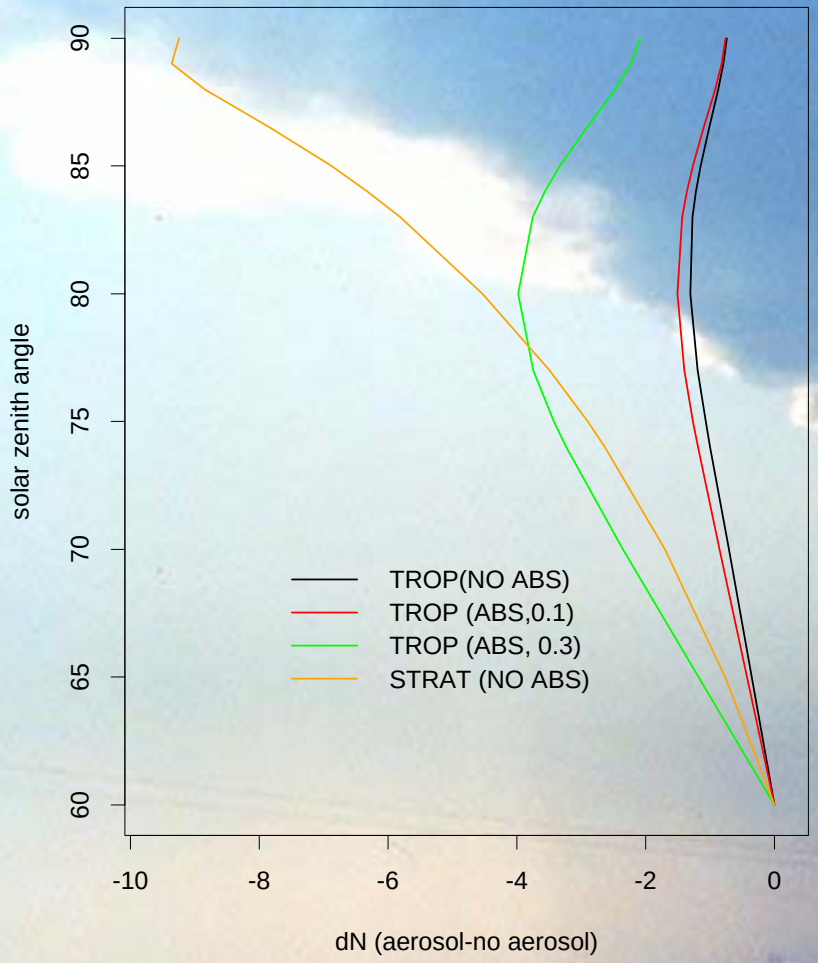


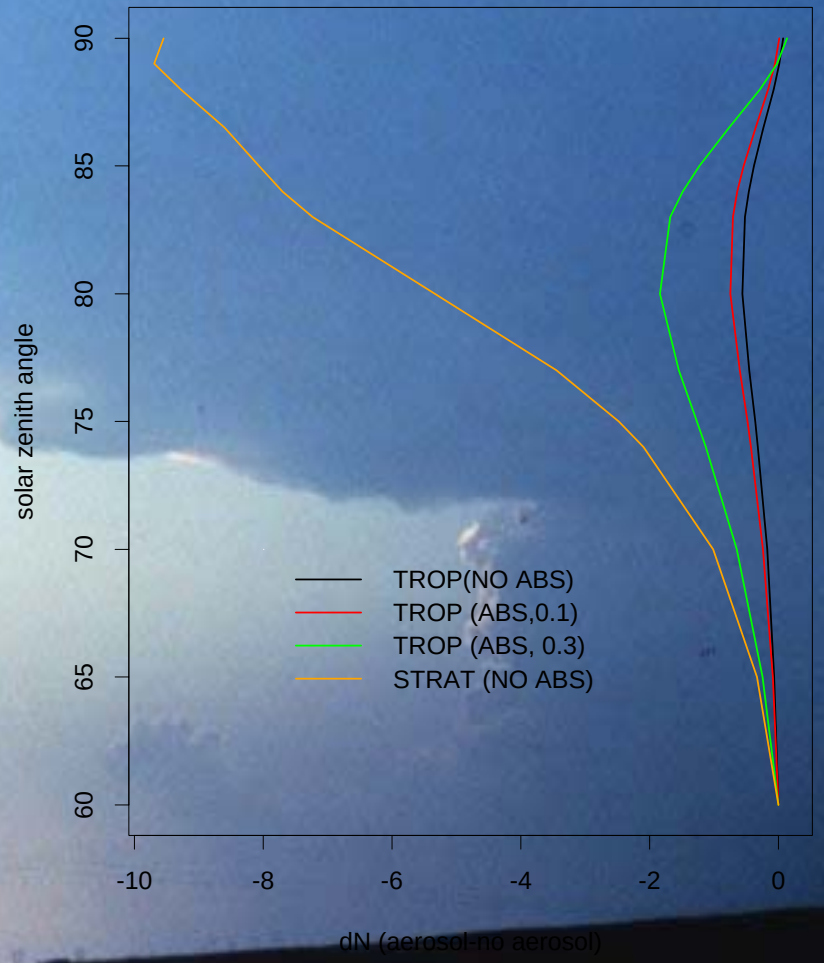
Errors in RT ozone due to unscreened clouds



NOAA/EPA UV Brewer Network

Aerosol effect on single wavelength (326) vs. a pair (326/310)





Outstanding Issues

- There is no common cloud clearing algorithm for Umkehr data in Brewer.
- Umkehr measurements are repeatedly taken at 319 nm channel within 30 sec, the variability at this channel could be used for cloud detection.
- Develop methods to screen for clouds in Brewer measurements – verify against cloud-sky detector or broad-band measurements
- Assess ozone profile information contained in other Brewer wavelengths (306, 313, 323, 329 nm)
- Assess aerosol impact on Brewer Umkehr measurements at Boulder site (aerosol OD, SSA, and profile)