NOAA/EPA UV Brewer Network

The short-term and long-term tropospheric ozone variability available from zenith sky measurements.

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CIRES

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Purpose – Study the effects of tropospheric air quality and clouds on surface UV radiation.

What's new: As in the previous EPA Network, the NEUBREW network will provide calibrated UV solar irradiance from 290 -363 nm from Mark IV Brewer Spectrophotometers. The NEUBREW network will provide calibrated total ozone measurements and ozone altitude profiles will be produced. The NEUBREW network was designed to be collocated with several existing radiation and aerosol networks. (The Mark IV Brewer spectrophotometer has the potential of measuring NO2 and SO2.)

Applications:

- UV Forecast
- Satellite Estimates of UV
- UV climatology
- Health and epidemiological studies
- Plants, agricultural products, and ecosystems
- Photolysis rates
- Photochemistry
- Material degradation

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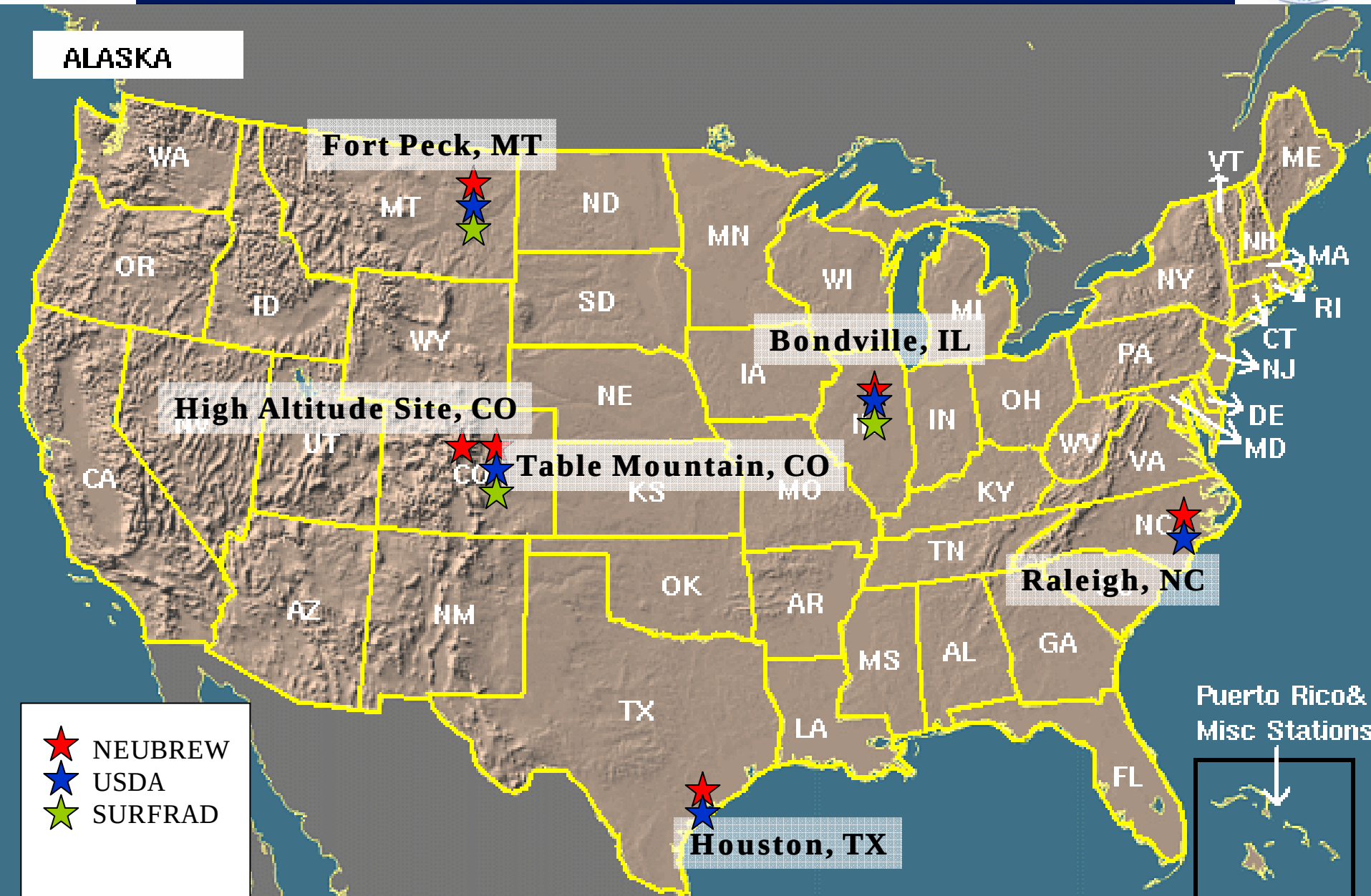

UV and ozone profile

- UV flux is sensitive to the vertical distribution of ozone
- 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 the effects of ozone profile (derived from Brewer Umkehr measurements) in the analysis of the Brewer-measured UV fluxes.
- An ozone sounding is not always available at the UV sites, except for Boulder, CO (once a week) and Houston, TX (during the pollution season)

Objectives of this presentation

- Evaluate the quality of tropospheric ozone information derived from the ground-based Dobson and Brewer measurements.
- Validate Umkehr-derived tropospheric ozone data through comparisons against co-incident ozonesonde measurements of high vertical resolution.
- Concentrate on the short-term and long-term tropospheric ozone variability in data available from Boulder, CO (middle latitude) and Mauna Loa Observatory in Hawaii (subtropical station).

Umkehr systems 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.
- The Dobson UMK04 algorithm was modified for Brewer single pair measurements (310 and 326 nm) and tested on the Arosa, Switzerland dataset.
- Brewer measurement noise is half of Dobson or comparable
- Still, Brewer has no cloud detection capabilities – use co-incidence with Dobson data that are screened for clouds or will develop new screening procedures

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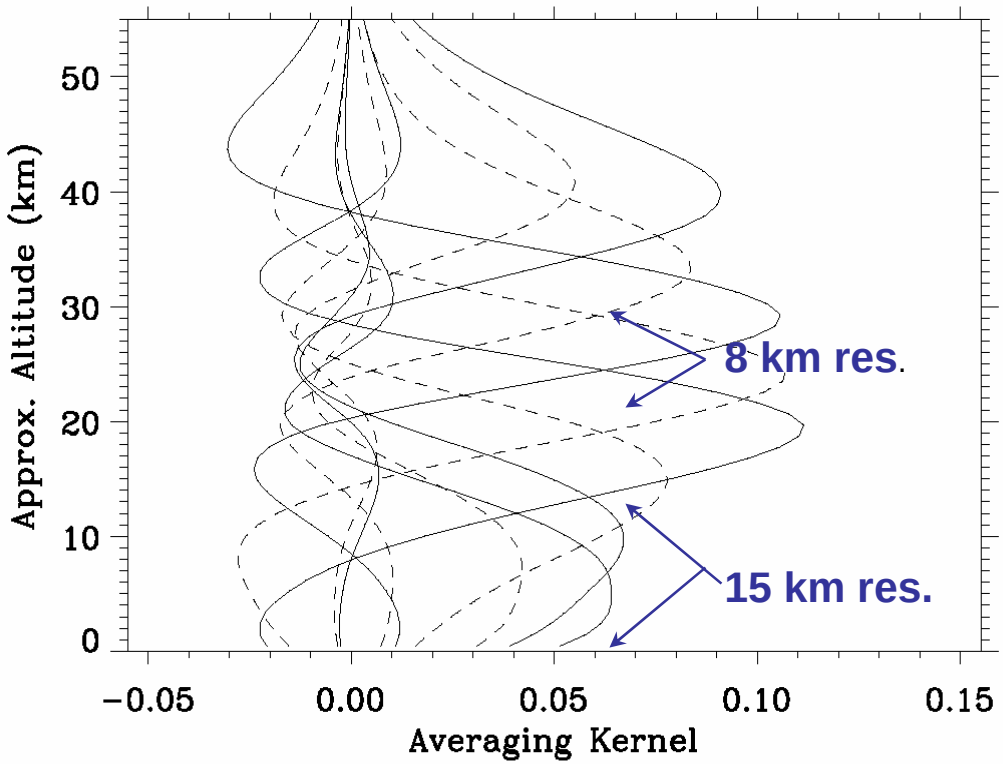
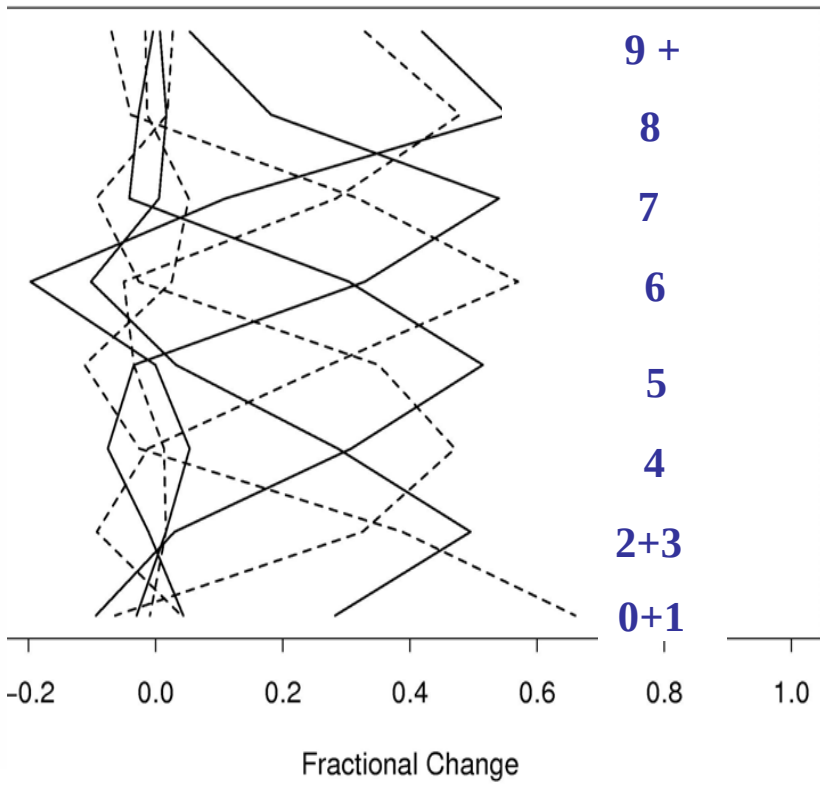
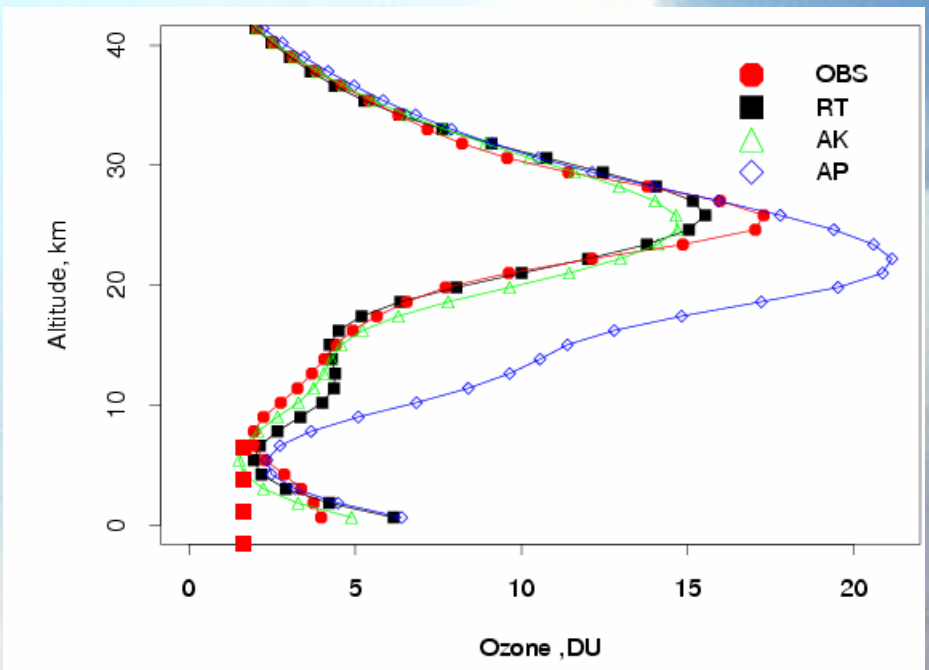
Umkehr C-pair Averaging Kernels and vertical resolution: 50 % from the layer and 50 % from adjacent layers



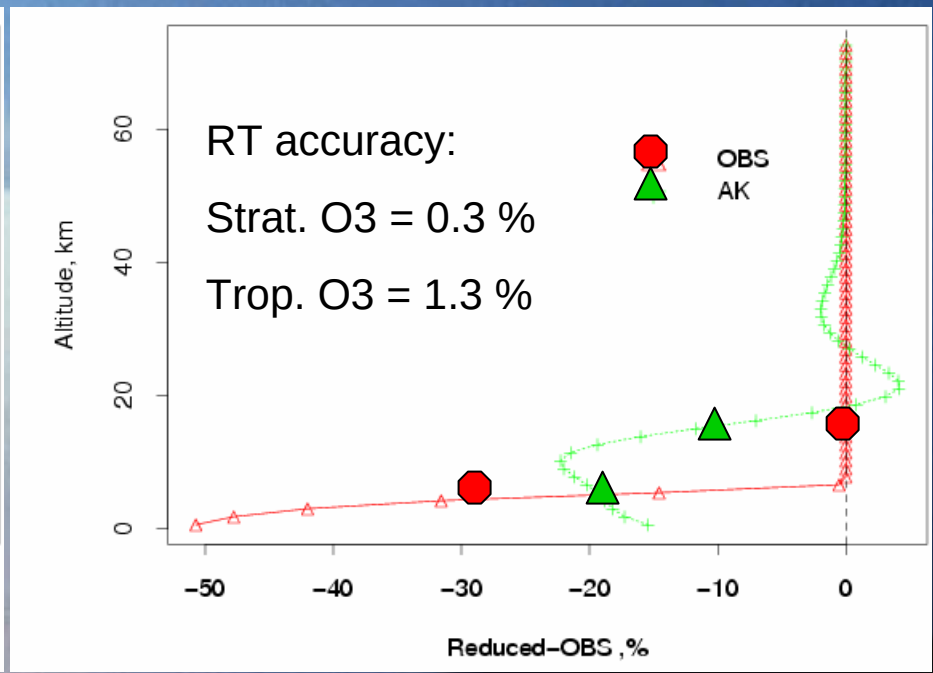


Effect of smoothing with single pair

Smooth profile – reduced trop. ozone



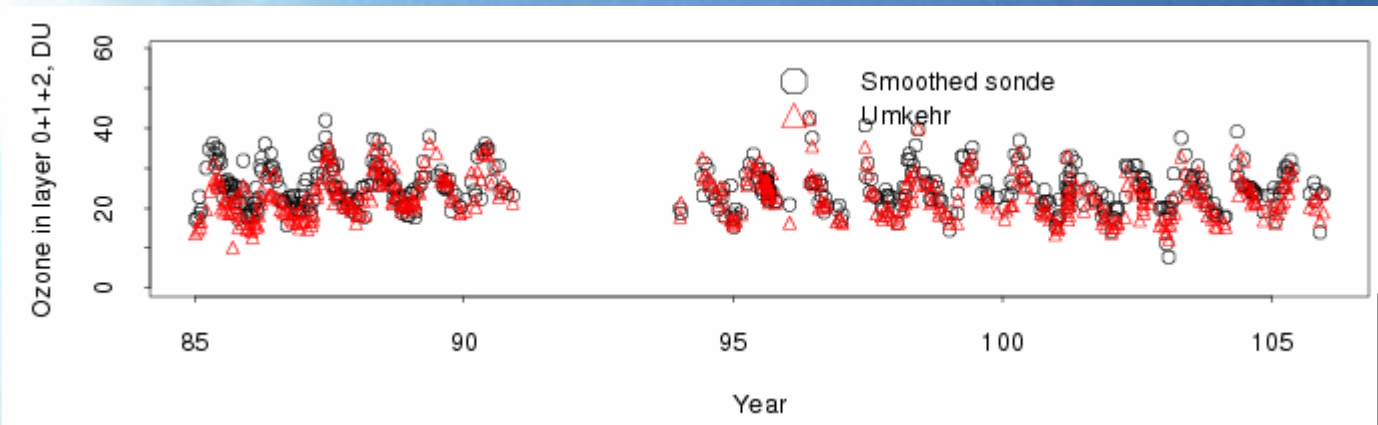
Smoothing errors – layer 0+1 and 2+3

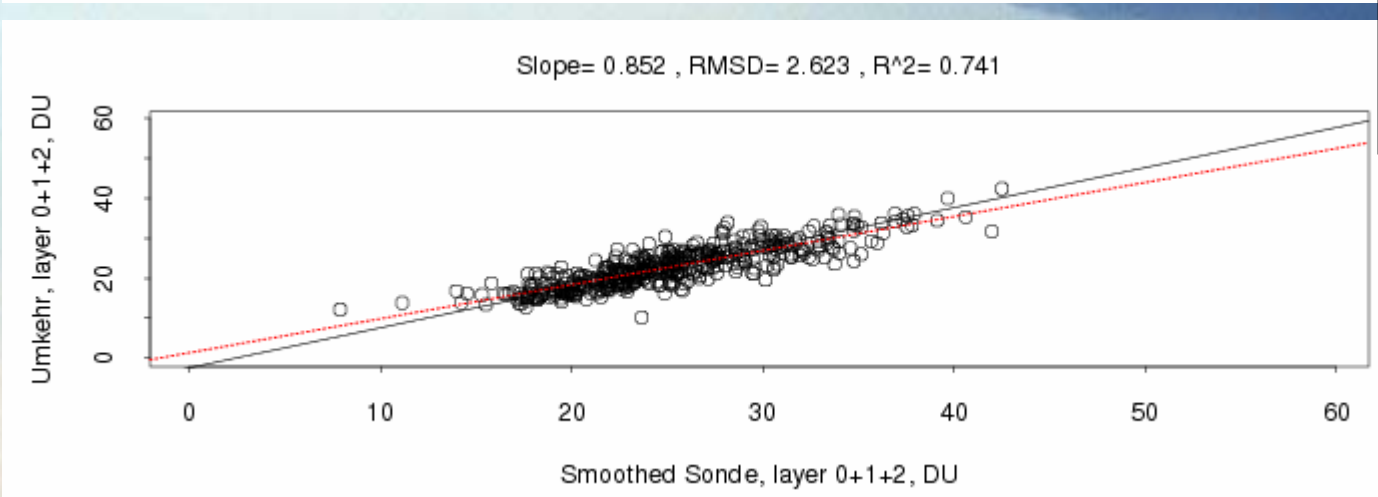


Comparisons of sonde and Umkehr

- Long-term ozone-sonde measurements in Boulder, CO (since 1979) and Mauna Loa (MLO), HI (since 1982)
- Sounding is in close vicinity to Dobson and Brewer measurements
- Sounding is done about once a week
- Dobson/Brewer measurements are done daily with the exception of overcast conditions (Dobson: ~272/year in MLO, ~146/year in Boulder)

MLO Time Series - Dobson/sonde

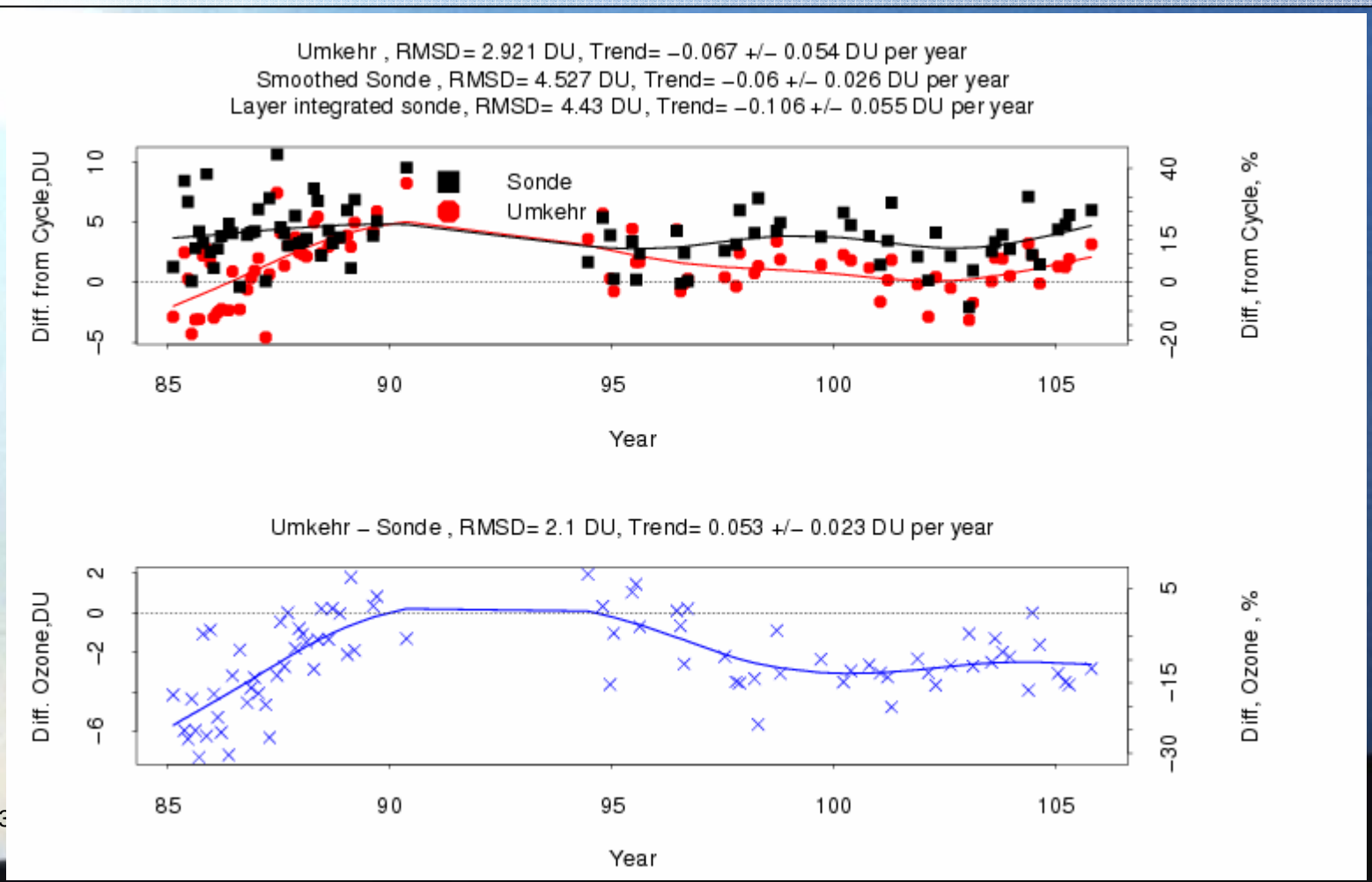




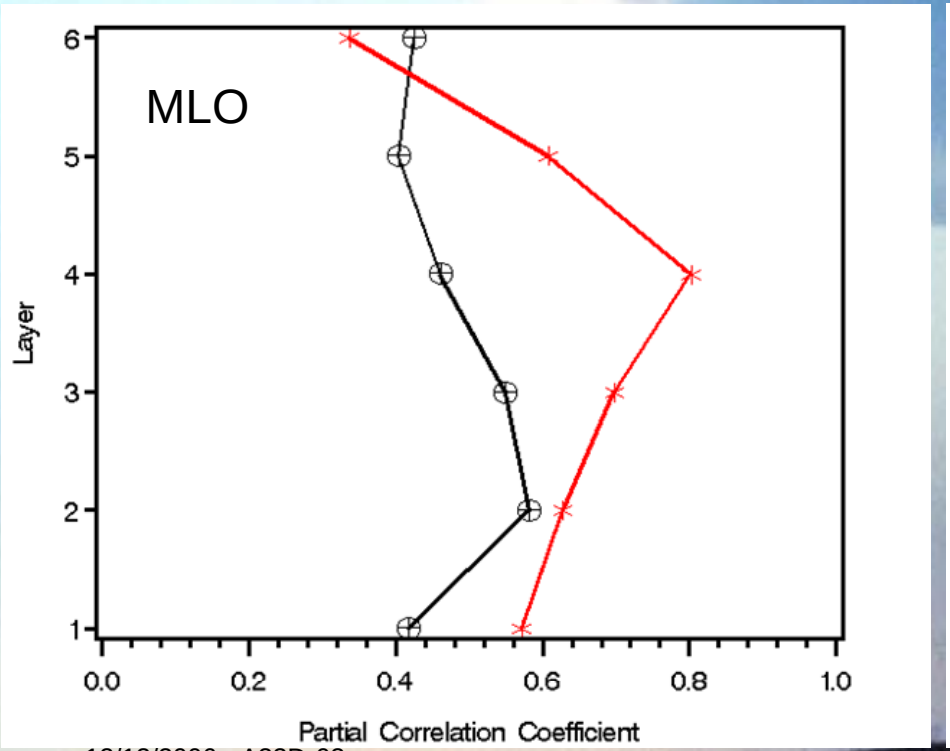
Layer below 125 mb

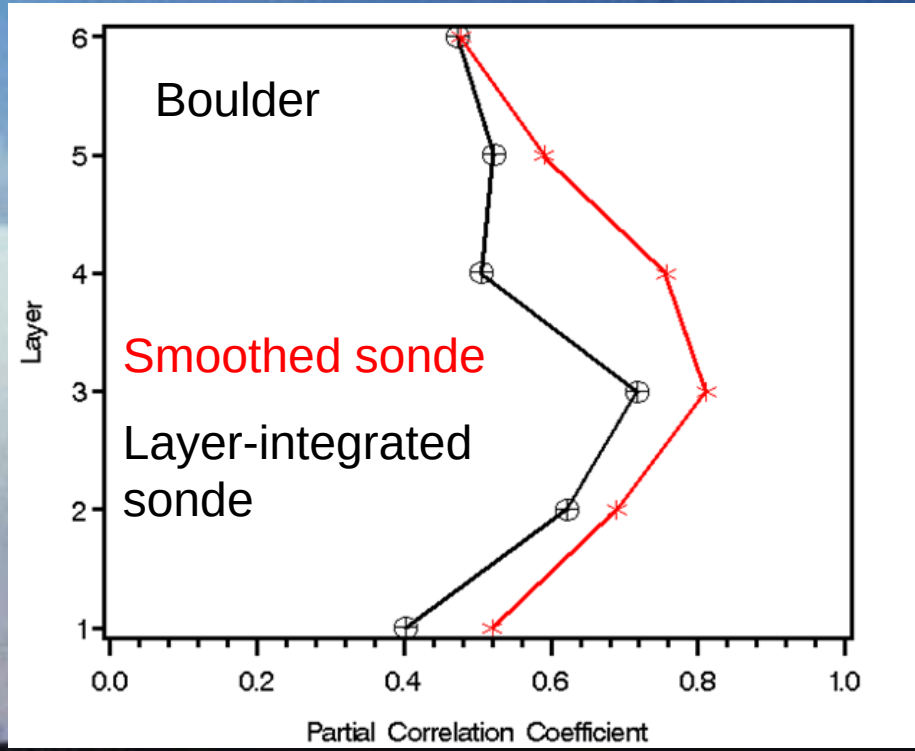
1 day coincidence

MLO deseasonalized time series of coincident Dobson and sonde data



Correlation between sonde and Dobson (in excess of a priori), MLO (1985-2005) and Boulder (1985-2005)

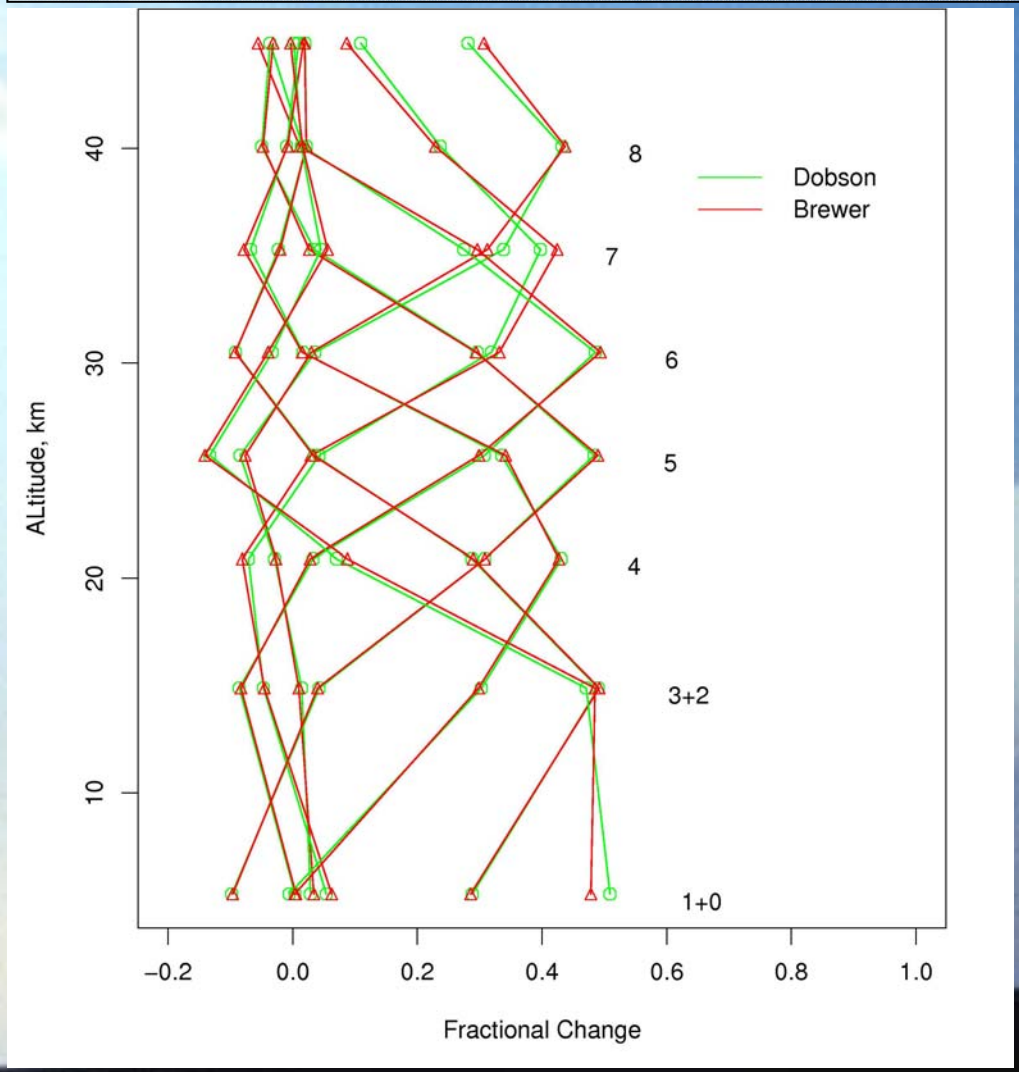




Summary of Results

- Dobson Umkehr technique is capable of monitoring short-term variability in tropospheric ozone. It can explain about 50 % of the variability measured by sonde.
- The 1-day co-incident data have higher correlation coefficients than the 2-day window for Boulder, but not for Mauna Loa.
- Correlation coefficients in the troposphere are relatively large and statistically significant, although the best correlations are in the lower stratosphere.
- Smoothed sondes show larger correlation coefficients than layer-integrated ones.
- Based on correlation analysis Dobson data can capture tropospheric ozone variability.
- Umkehrs are capable of measuring long-term changes in tropospheric ozone.

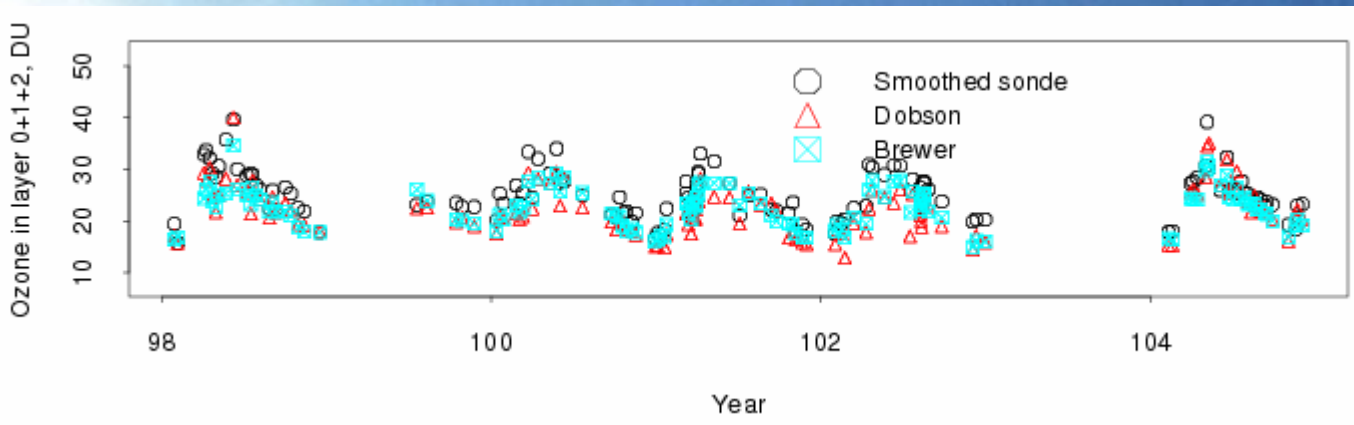
Profile information: single wavelength

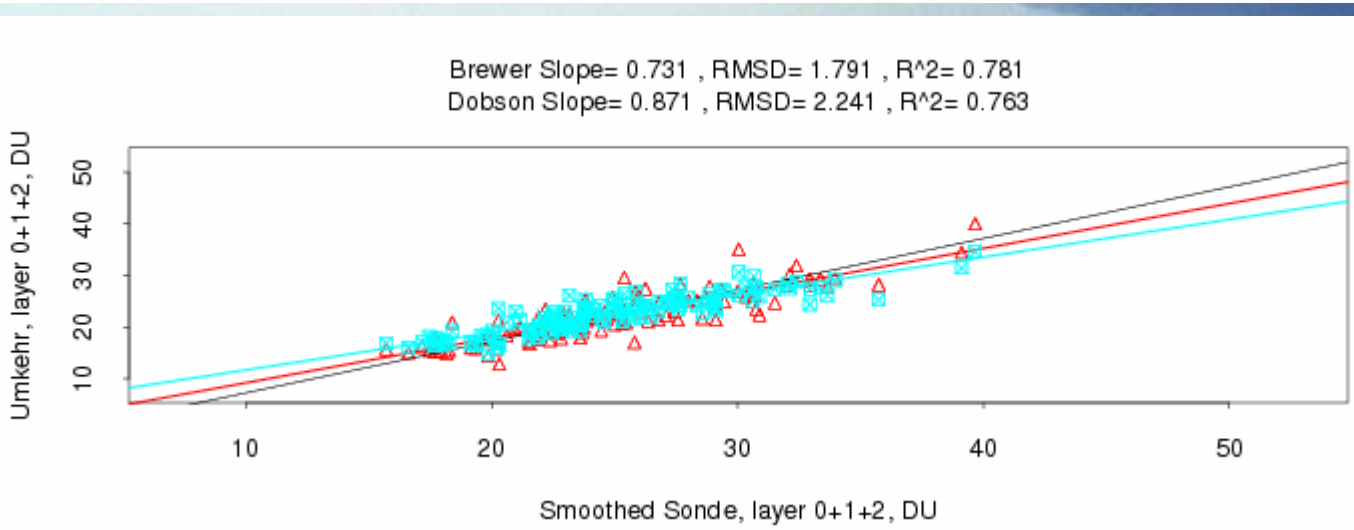


Synthetic dataset study

- 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.

MLO time series - Brewer/Dobson/sonde



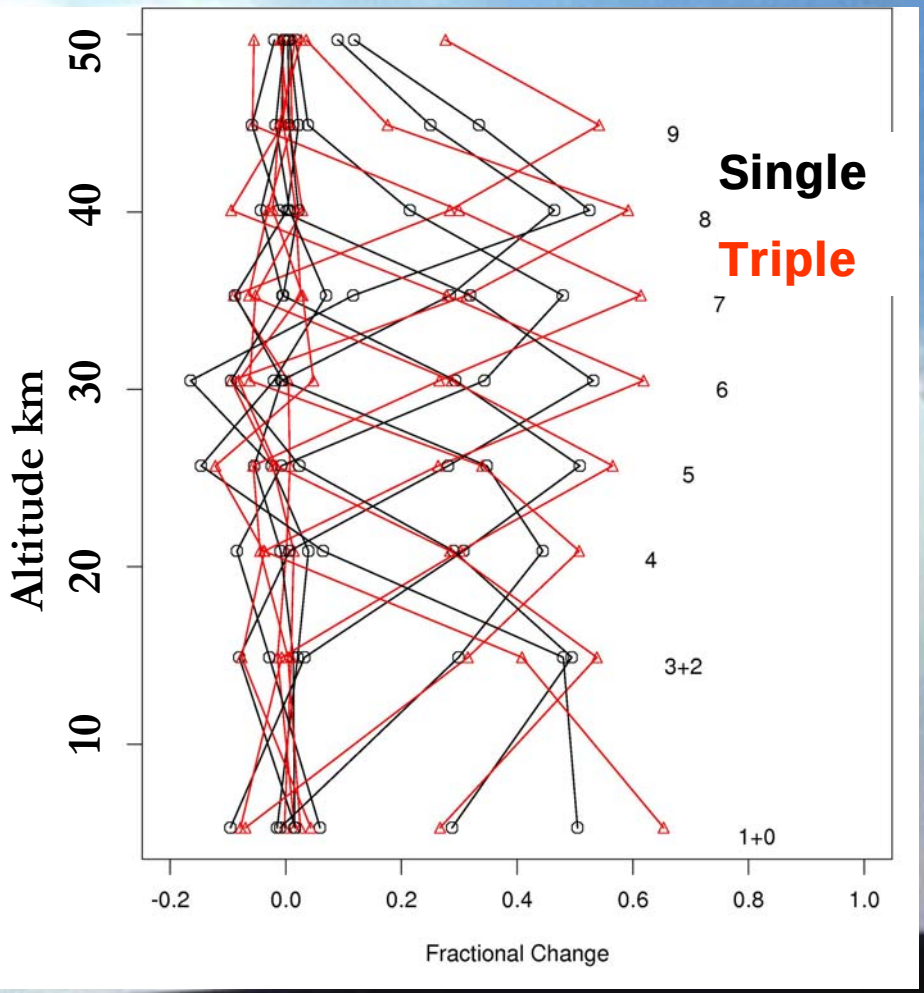


Layer below 125 mb

2 days coincidence

Brewer data are courtesy of the Meteorological Services of Canada

Profile Information: single vs. multiple wavelengths



- The UMK04 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

Outstanding Issues

- There is no common cloud clearing algorithm for Umkehr data in Brewer. 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)
- Continue analysis of sounding measurements as validation of Umkehr technique

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Thank You!