Automated Dobson & Brewer ZS Algorithm

Irina Petropavlovskikh (NOAA/CIRES)

P. K. Bhartia (NASA/GSFC)

Sources of Noise in C-pair Algorithms

- Normalization reduces effects of tropospheric aerosols and clouds but only partially.
- Change in TO during observation.
- Sources of instrument noise
  - Stray/scattered light
  - Measurement noise at large SZAs due to low signal

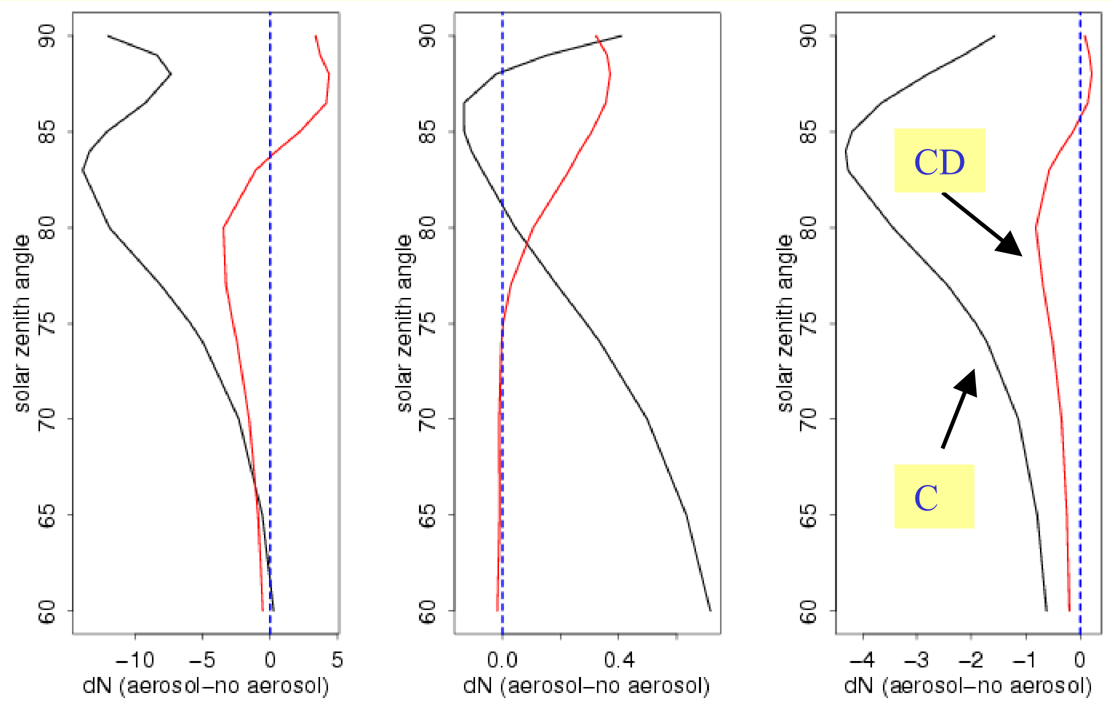
Proposal: Use Double Pair Retrieval Algorithm without normalization

- Use AD or CD double pair (or Brewer eqv.) to derive TO and Profile.
  - Dbl pr N-values are much less sensitive to aerosols- both trop & stratospheric.
  - TO is determined from ZS radiances.
- Calibrate double pair ZS N-values by comparing with DS total O_3 at smaller SZAs (<72˚) where ZS is profile insensitive.

Effect of Aerosols on C and CD

Plots are for τ=0.1 (clean site)
At Boulder: μ ≈0.2; σ ≈ factor of 2

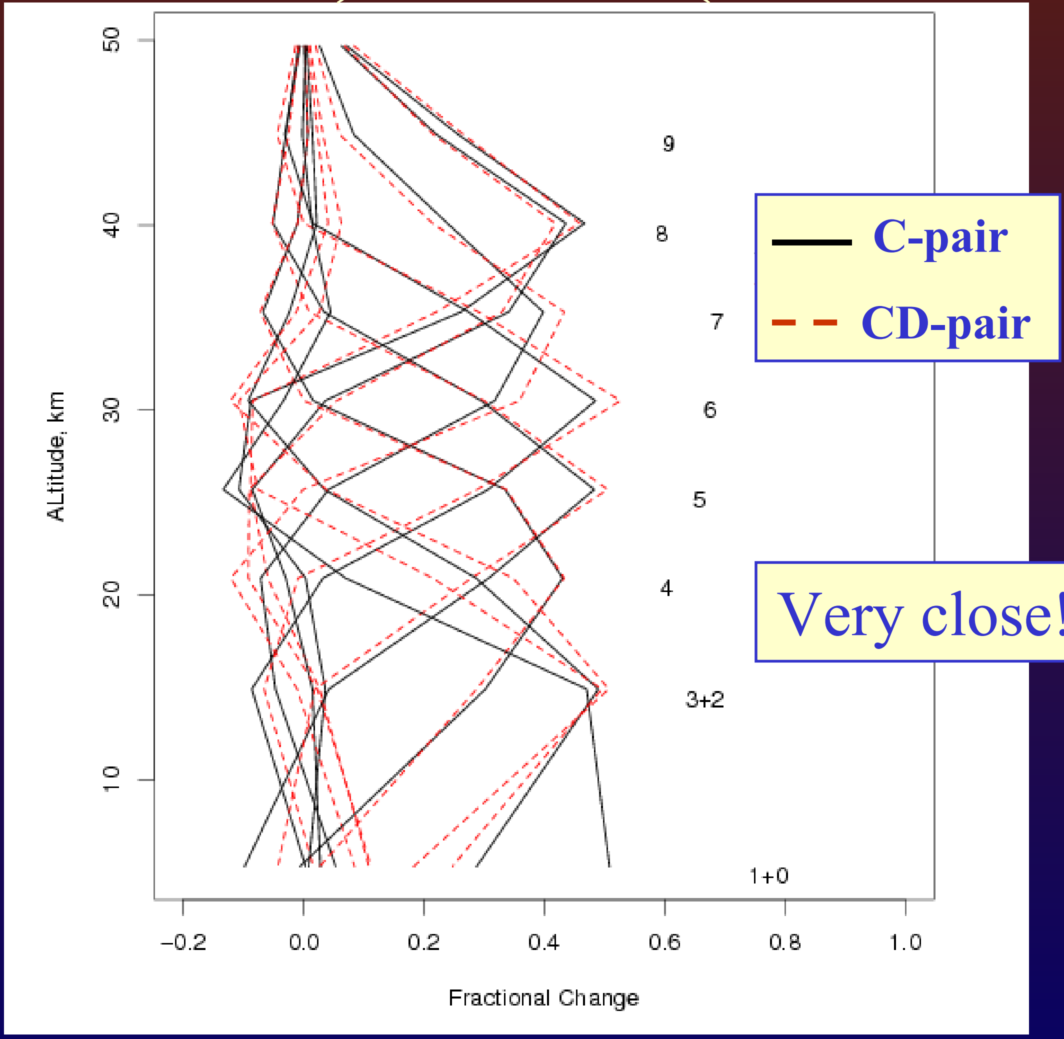
Stratospheric aerosol	Tropospheric aerosol	
	Non-abs	Abs



Aerosol/Cloud effects on RT O_3

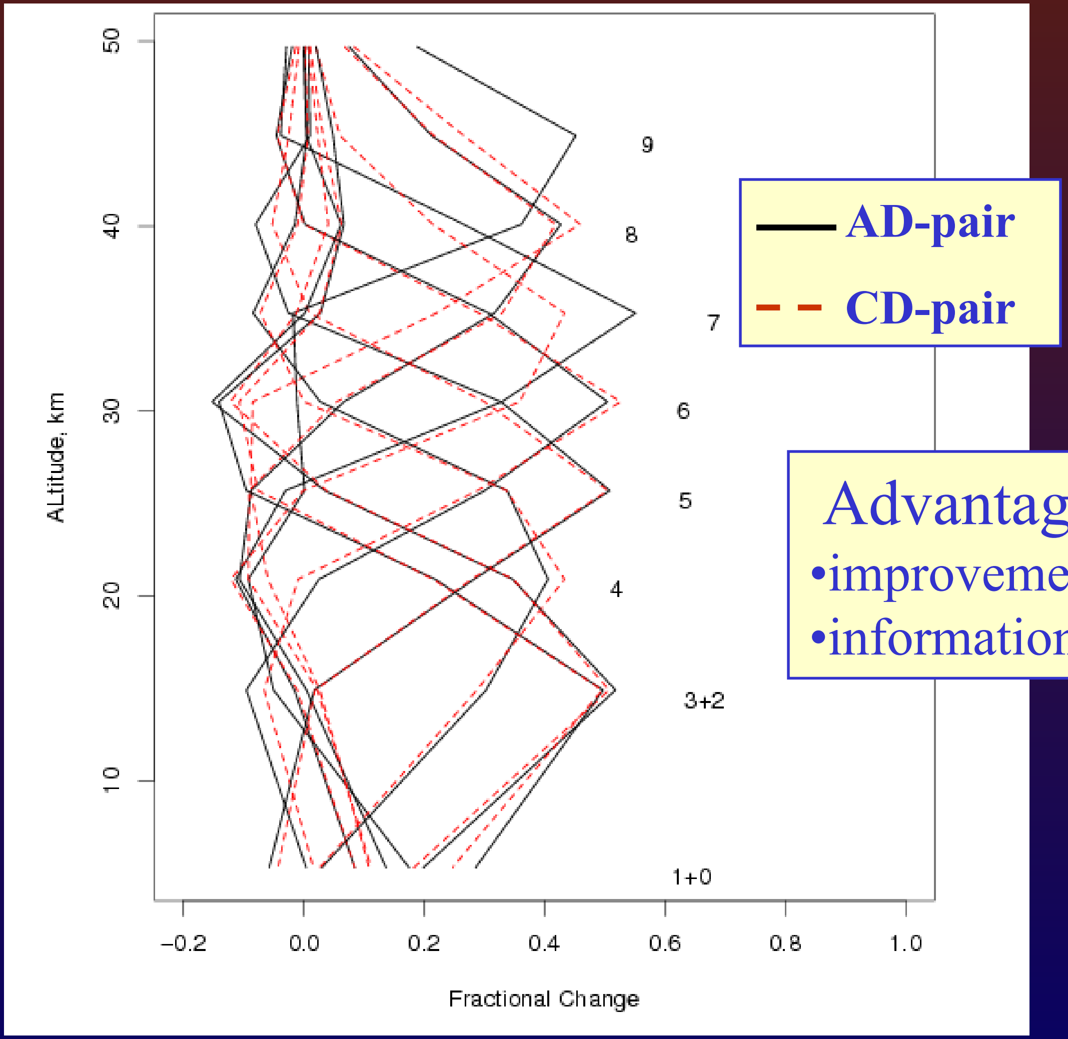
- Normalized C-pair is affected by aerosols- possible reason for increased noise at large SZAs.
- CD pair removes most of the aerosol interference.
- CD is more sensitive to clouds because the two pairs are not measured simultaneously.
- Solutions to reduce cloud noise (McElroy):
  - use raw data, rather than interpolated data
  - for Brewer, compare data from two grating positions at the same wavelengths

CD (no norm) vs. C (norm to 70 SZA)



Very close!

CD vs AD, no normalization



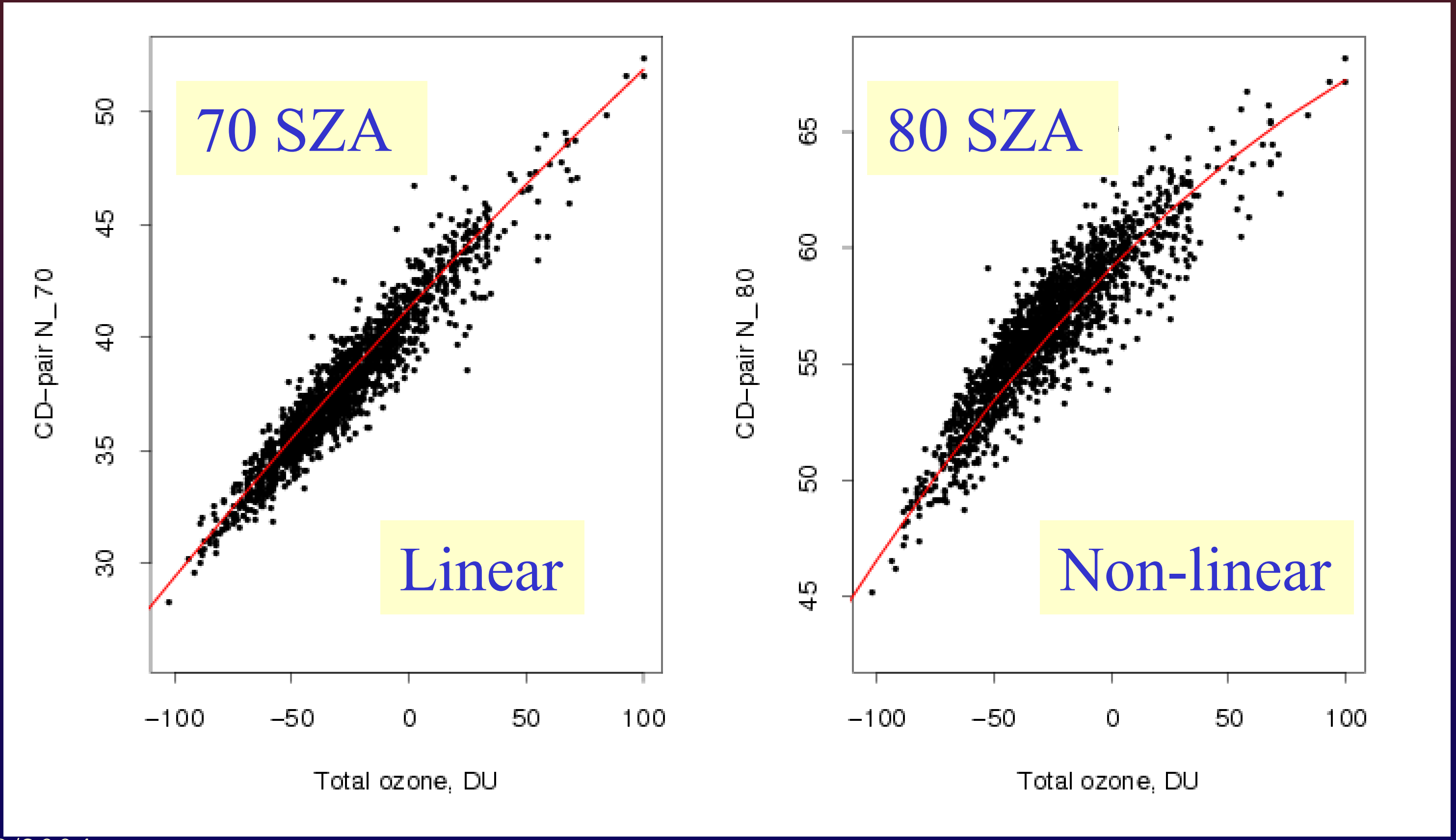
Advantage of AD

- improvement in layer 7
- information in layer 9

TO info in ZS measurement

- Goal: replace the empirical tables currently used by the stations.
- Benefits of using standard radiative-transfer tables:
  - account for non-linear relationship between N-value and TO at large SZAs
  - allow correction for profiles using seasonally and zonally varying standard tables.

TO dependence in Boulder CD pair



Correction of ZS TO for profile effects

- Method 1:
  - Use two set of tables, select one that gives smaller AD/CD difference.
  - Works only at moderate SZAs (70˚-80˚)
- Method 2:
  - Estimate TO and profile from Umkehr data.
  - Better at large SZAs (>80˚)

CD/ZS-DS TO retrieval at Boulder

Method 1. Results at nominal SZA

SZA	RMSD %
60	3.0
65	2.8
70	2.7
74	2.7
77	3.0
80	3.7

Method 2 RMSD: 2.5 %

Other Issues

- Can one use all measurements rather than meas interpolated to 12 fixed SZAs?
  - Need a cloud detection algorithm
- Can one correct the Brewer N-values for clouds by comparing measurements from two grating positions?

Summary

- One can obtain reliable TO data from ZS measurements, to at least 80˚ SZA, by using CD data and radiative-transfer tables.
- CD Umkehr is less sensitive to aerosols than the C-pr Umkehr, plus it can give accurate TO.
- AD Umkehr can provide layer 9 O_3 and may improve layer 7 O_3.