

# Sensitivity of Dobson and Brewer Umkehr ozone profile retrievals to the choice of the ozone cross- section.

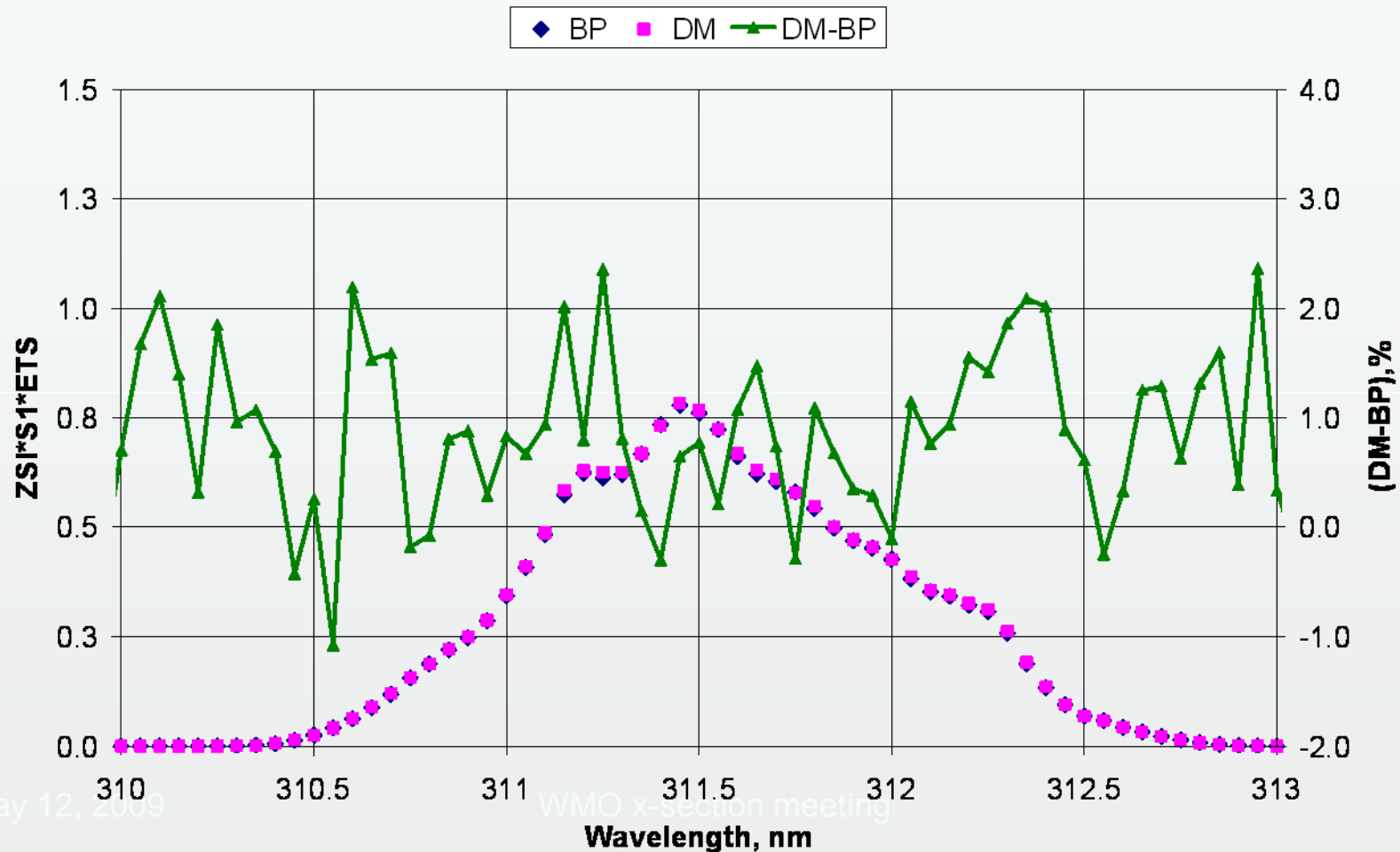
I. Petropavlovskikh,  
G. McConville, R. Evans, S. Oltmans,  
D. Quincy, K. Lantz, P. Disterhoft

# Umkehr ozone profile retrieval

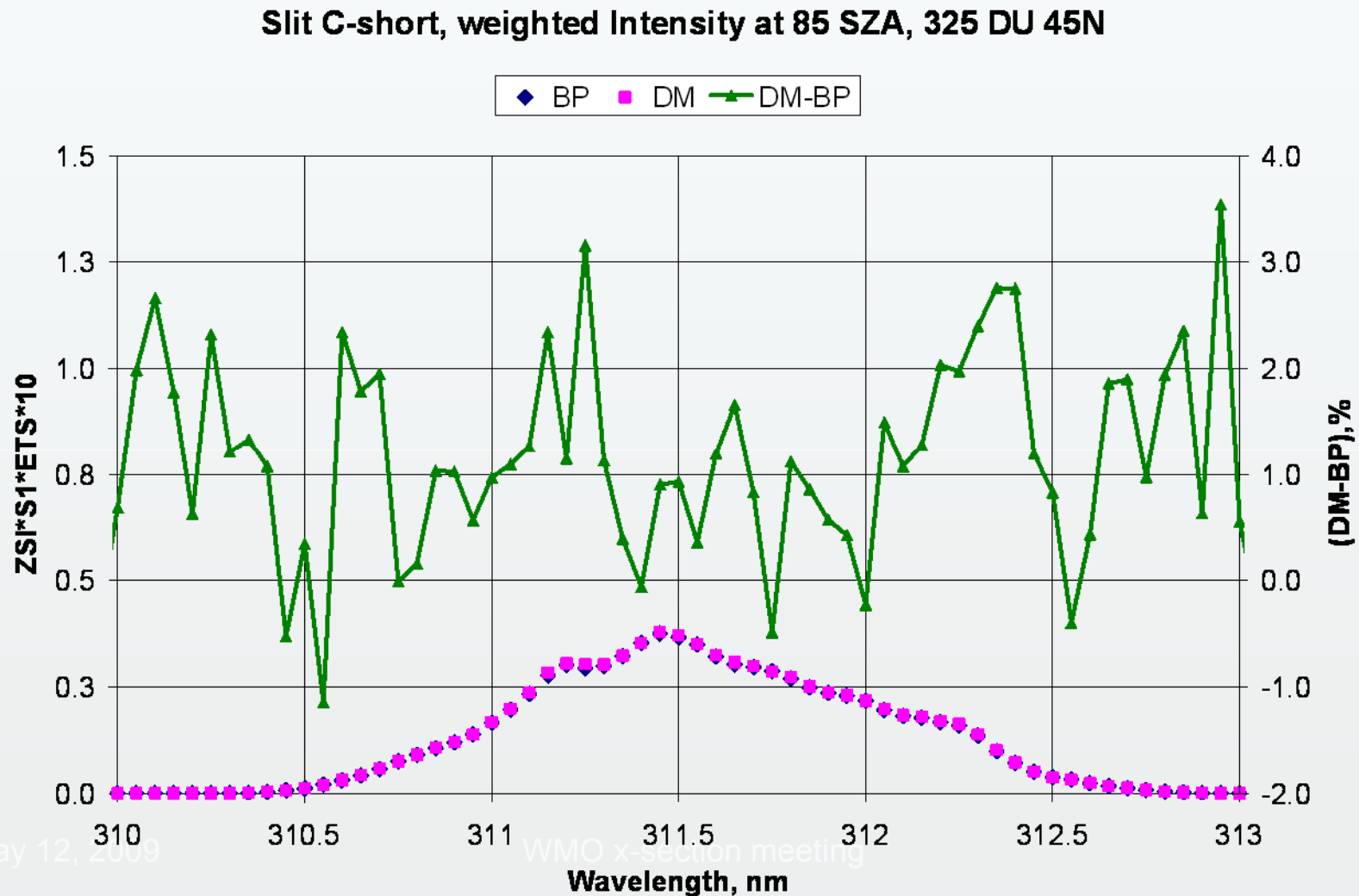
- Single pair zenith sky measurement or N-value= $100 \cdot \log_{10}(I)$ :  
UMK04 – Dobson C-pair, O3BUmkehr – 310/326 nm for Brewer
- Optimal statistical retrieval is used for solution – iterative process
- SZA between 70 and 90 degrees
- RT forward model for SS N-values
  - spectrally resolved line-by-line calculations across both band-passes
  - O<sub>3</sub> absorption and Rayleigh scattering database
  - Ozone profile climatology
  - Band-pass functions
- Multiple scattering correction (total ozone and latitude profile dependent, profile adjustment based on MS Jacobian)
- Refraction in air correction
- Temperature correction (seasonal climatology)
- Out-of-band stray light correction
- Spectral shift in band-pass center registration

# Slit and Solar Flux weighted intensity at 70 SZA, Dobson C-short, B&P and DMB x-sections similar at both short and long

Slit C-short, weighted Intensity at 70 SZA, 325 DU 45N

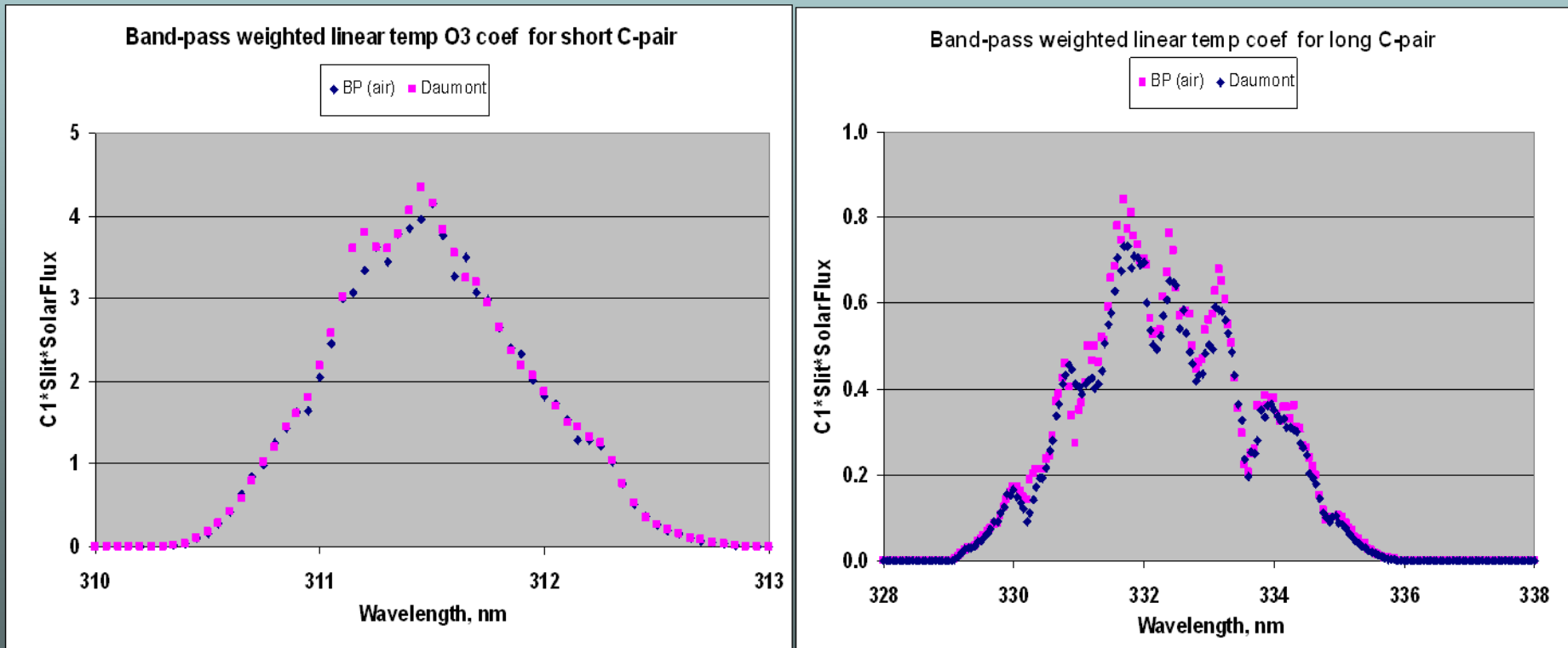


# Slit and Solar Flux weighted intensity at 85 SZA, Dobson C-short B&P and DMB x-sections similar at both short and long

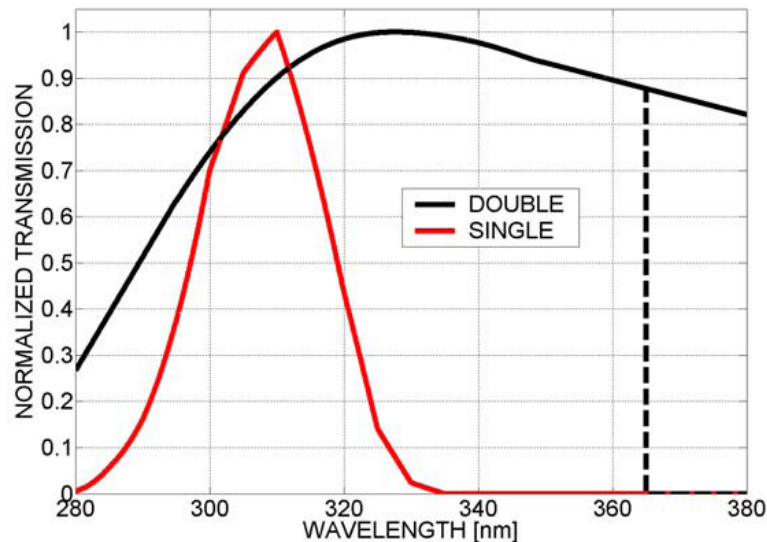




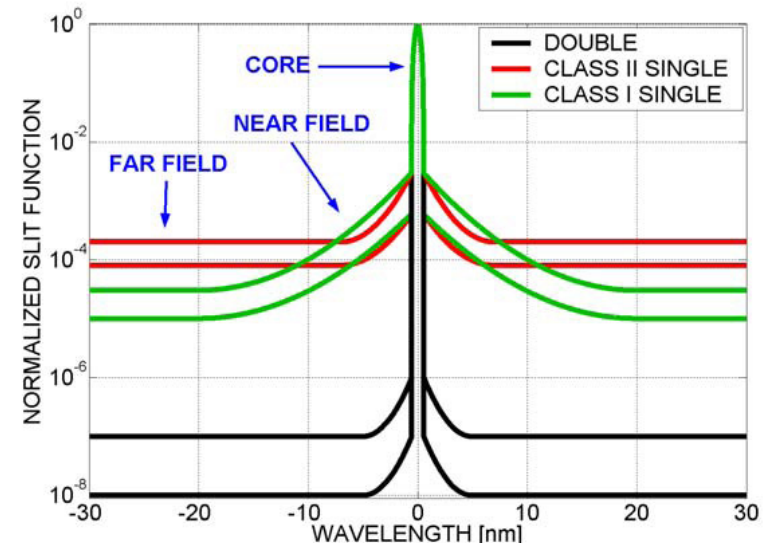
# Temperature dependence at Dobson C-pair short and long wavelengths for B&P and DMB x-sections similar at short and some difference at long



# Depiction of stray light by A. Cede (NASA/Goddard)

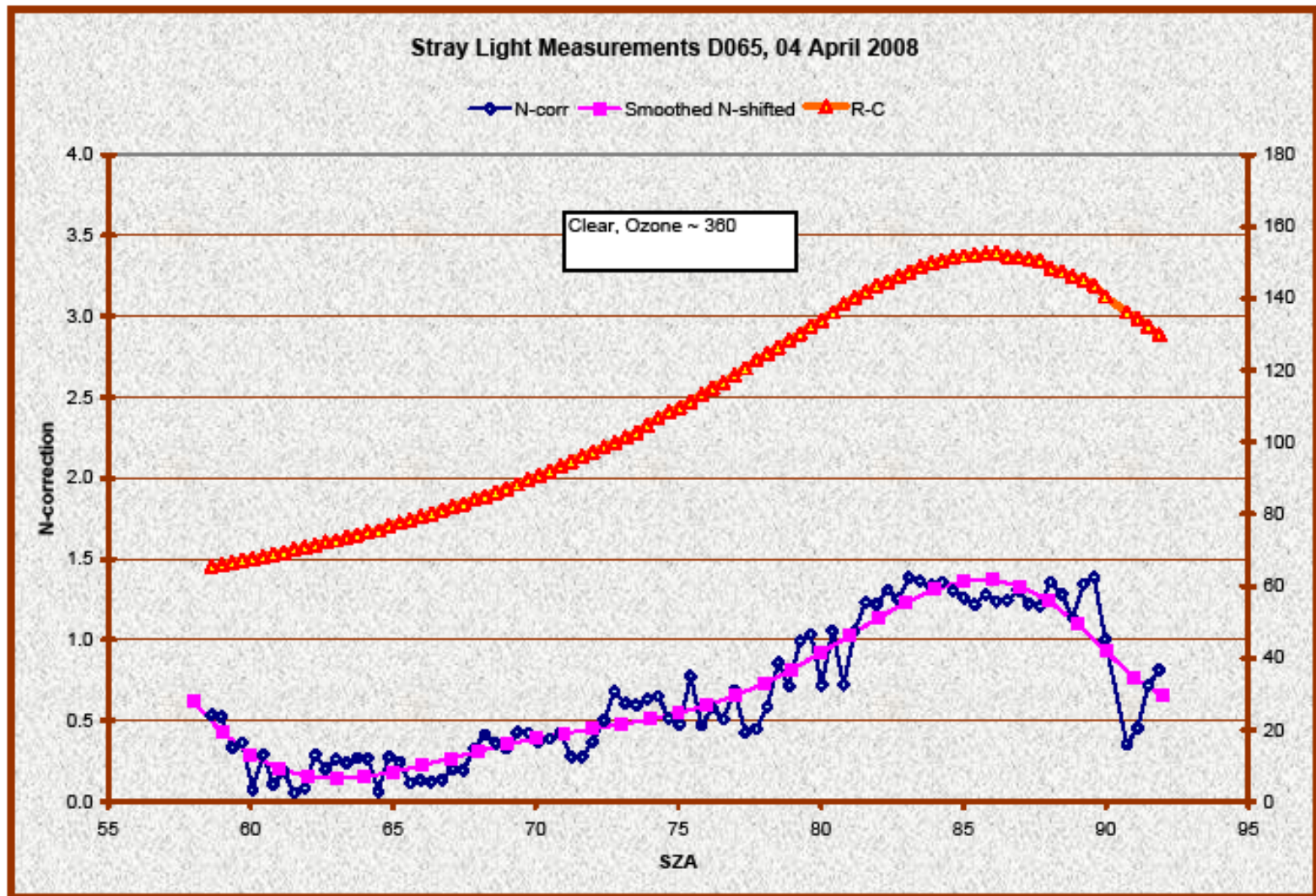


Example of the spectral transmittance for the double (MKIII) and single (MKIV) Brewer

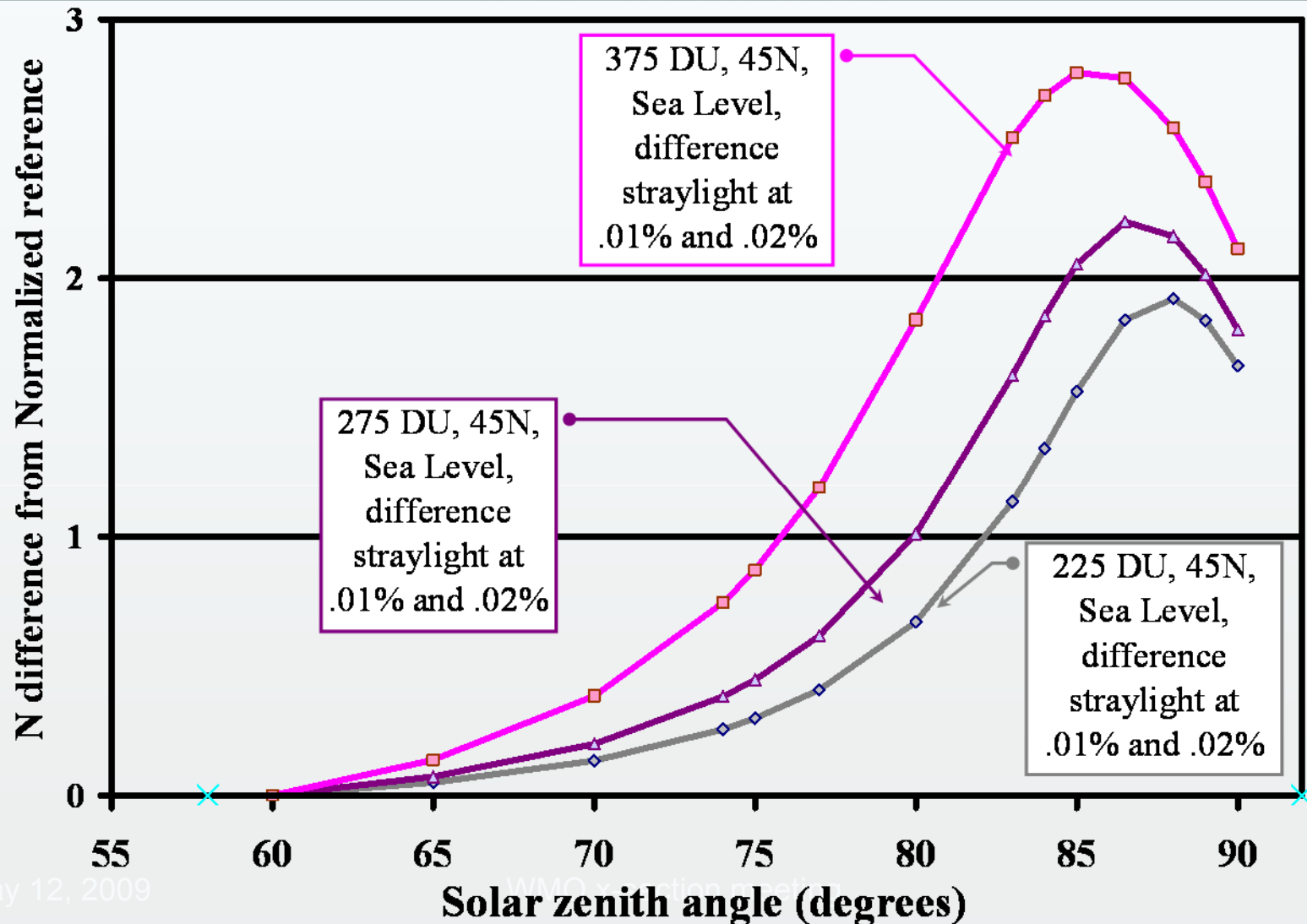


Examples of a Brewer slit functions for double and two single Brewers. The far, near fields and core are indicated, and the errors bars are provided

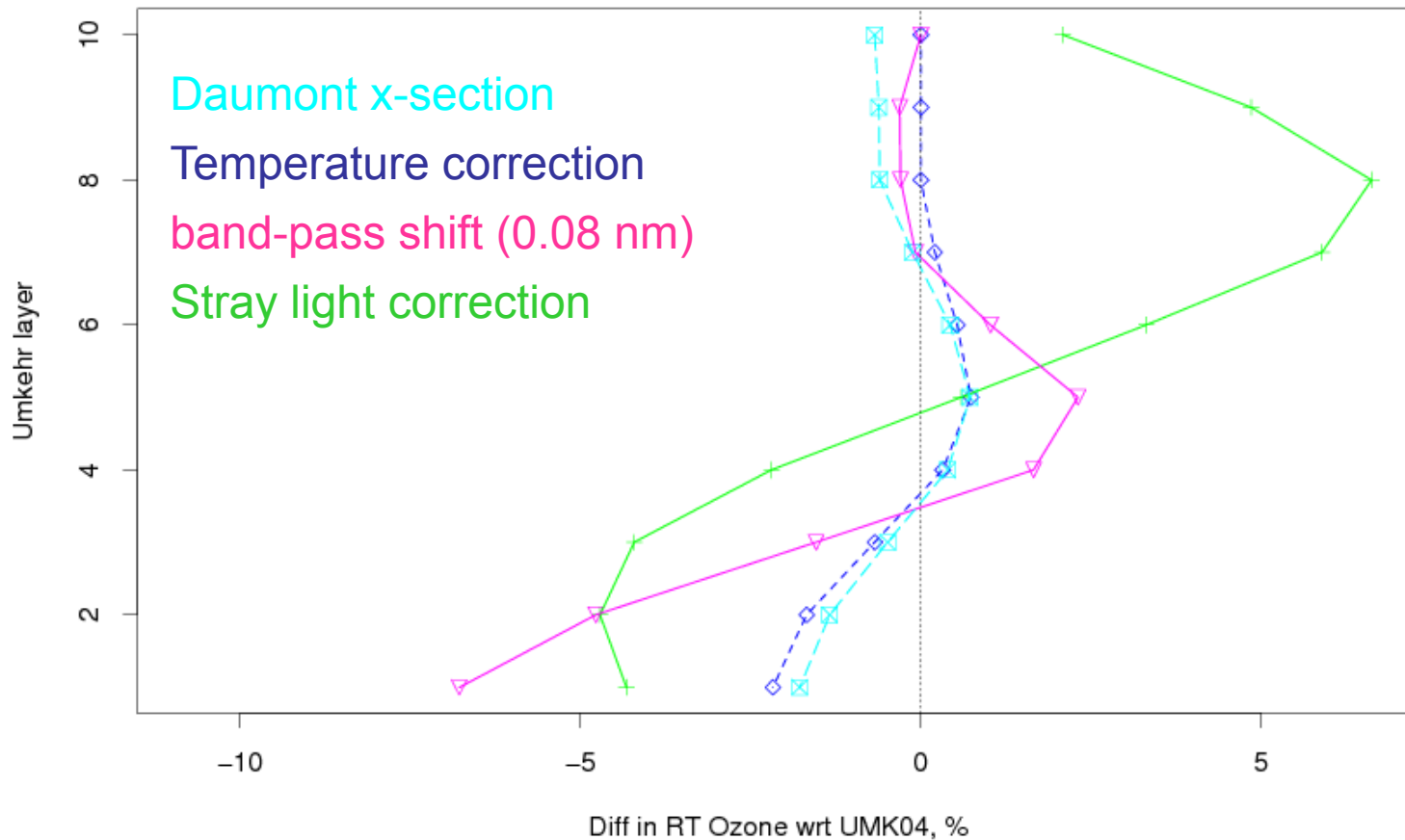
# Stray light measurements in Boulder ~ 1 N-value change



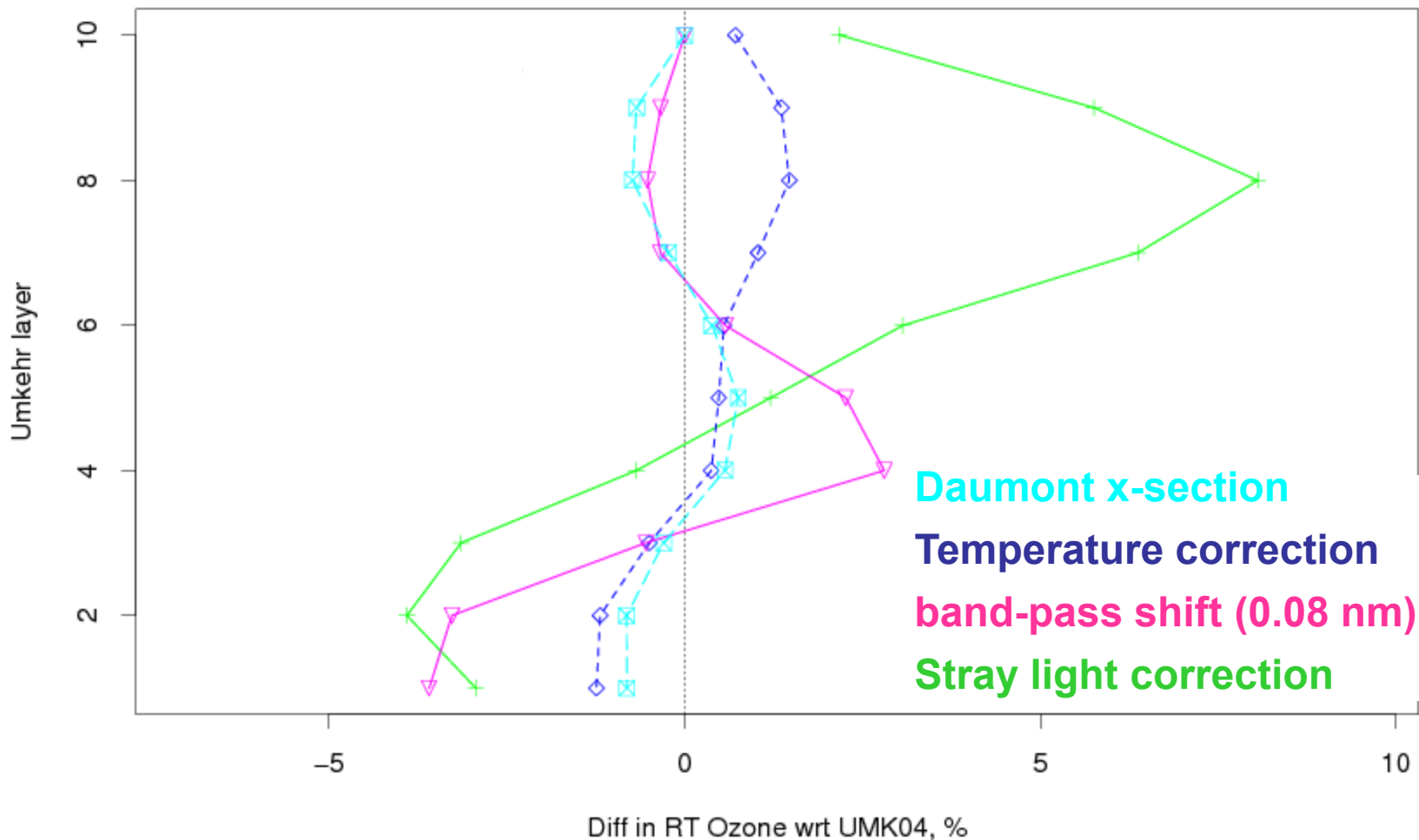
# Stray light estimates for different TO values



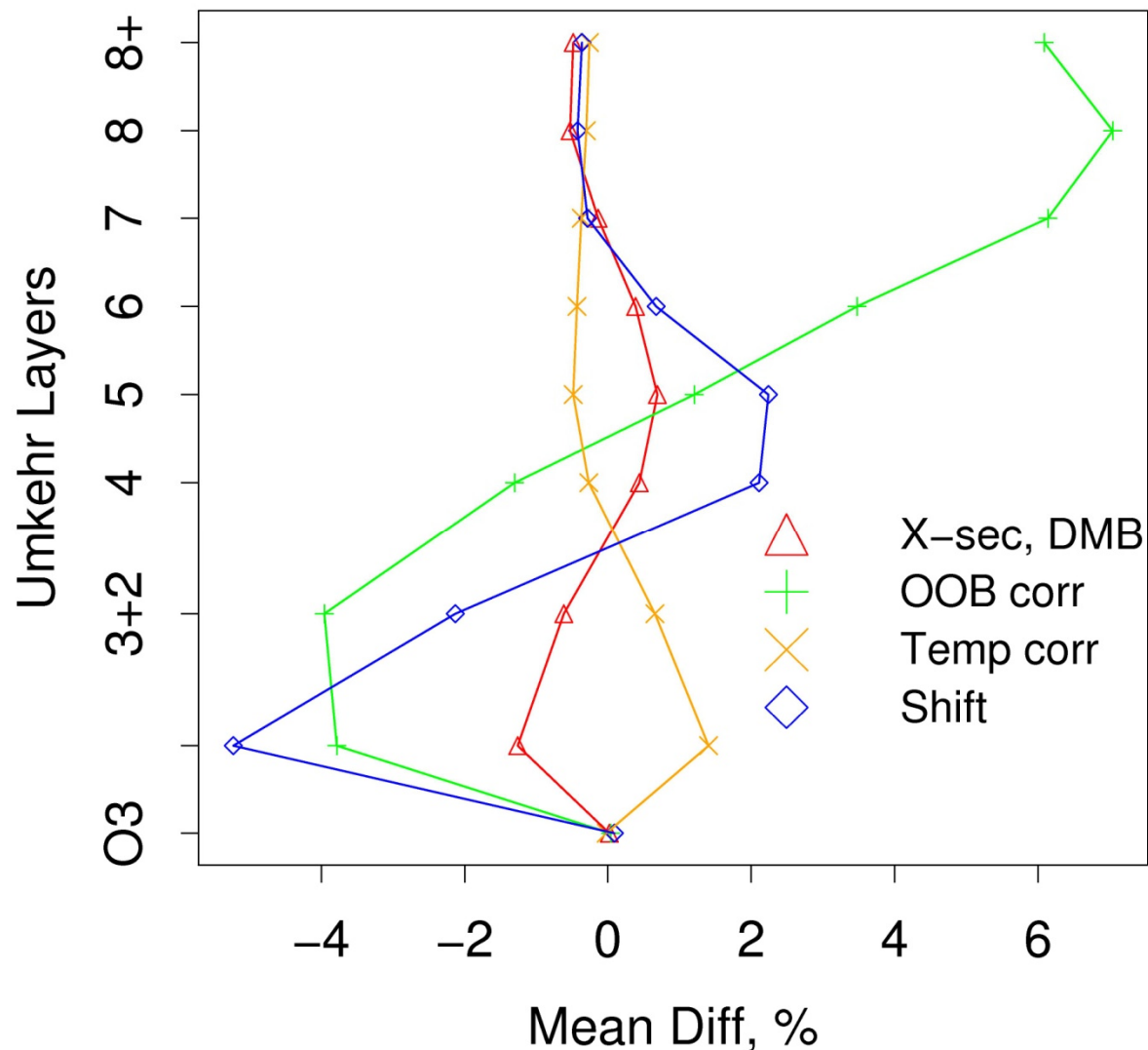
# Boulder, Fall (09/27/2007), TO 271 DU, D083, relative to UMK04 with B&P x-sec



# Boulder, **Spring** (04/07/2009), TO 330 DU, D083, relative to UMK04 with B&P x-sec



# Boulder, Dobson 061, 1979-2008, relative changes in layers



**X-section (DMB-BP)**  
**Band-pass spectral shift**  
**Stray light correction**  
**Temperature climatology correction**



# Conclusions for Dobson Umkehrs

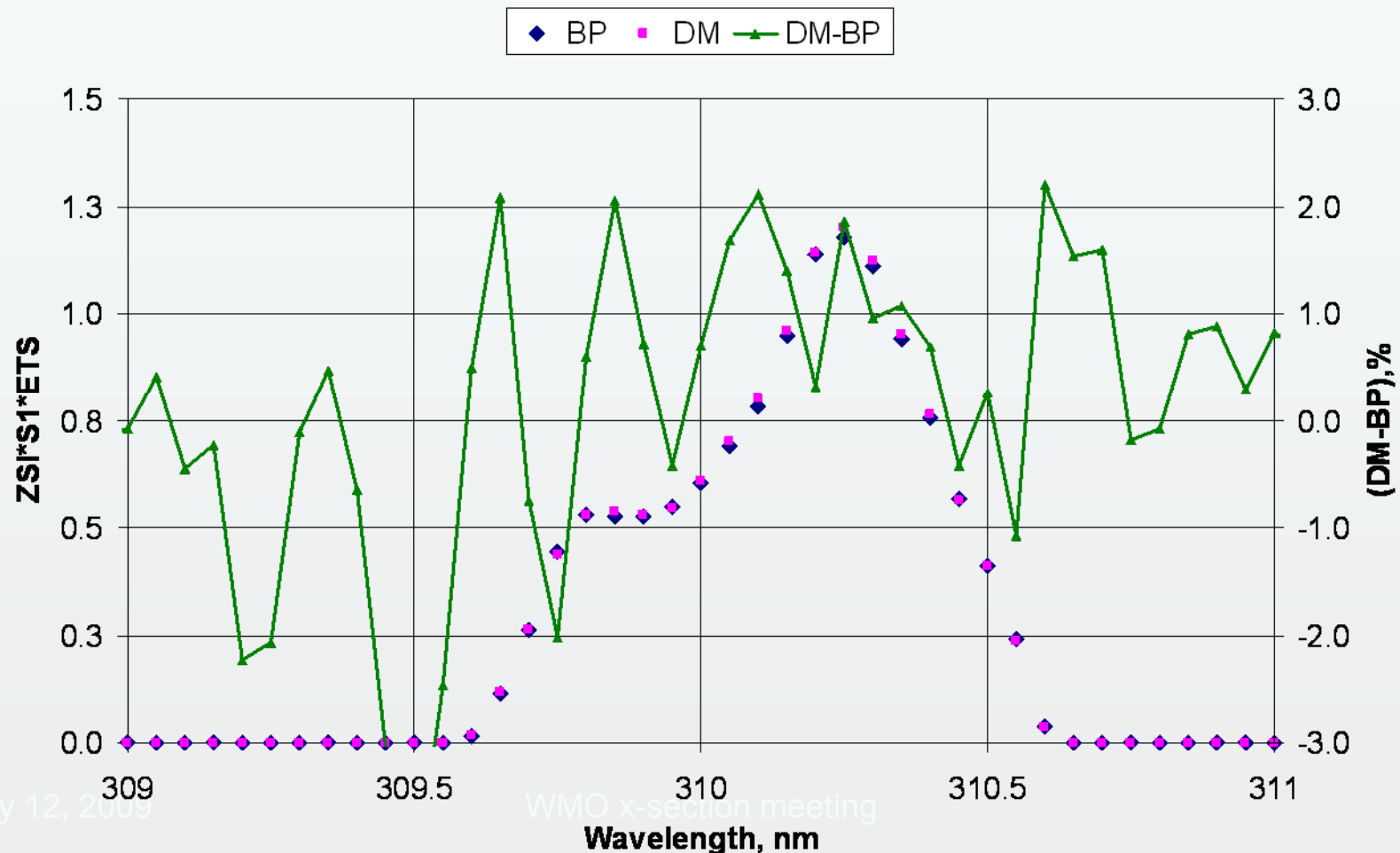
- Effect of X-section change – very small
- Effect of band-pass shift (0.1nm) is very small (wide band-passes)
- Effect of temperature corrections (climatology based) is small
- Stray light effect in Dobsons ( $10^{-5}$ ) is significant, but needs to be further evaluated for individual instruments
- Errors in Dobson Umkehr ozone profile retrievals related to the uncertainties in instrumental parameters are larger than due to X-section choice

# Dobson vs. Brewer

	Dobson	Brewer
Spectral channels (nm)	311.4/332.5	310.1/326.5
Spectral band-pass	Wide. Short channel: triangular 1.5 FWHM Long channel: trapezoid, about 3.8 nm at the base and 2 nm at the top	Narrow. Both channels have similar triangle shape, ~0.6 nm FWHM
Other filters	Cobalt filter (cuts off light above ~360 nm)	Double: Grating, PMT set zero below 250 nm and above 800 nm Single: UG-11 and NiSO <sub>4</sub> filters – zero below 280 and above 330 nm
Stray light (far field)	$\sim 2 \times 10^{-5}$ , 0.005 %	Single, class II: $\sim 10^{-4}$ for Mark IV at NEUBrew Double, Mark III: $\sim 10^{-7}$ for Double B171

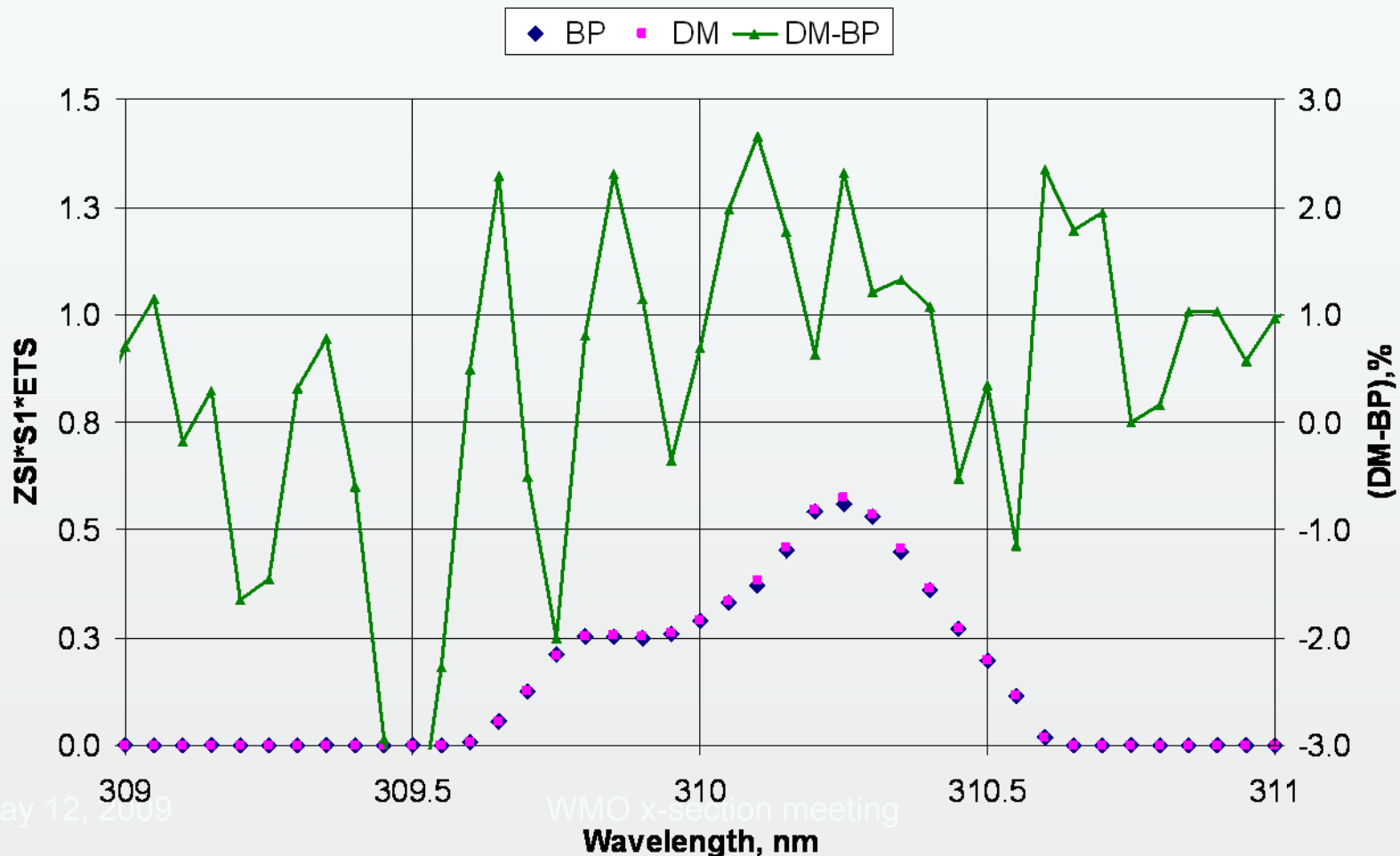
# Slit and Solar Flux weighted intensity at 70 SZA, Brewer C-short, B&P and DMB x-sections similar at both short and long

Slit C-short, weighted Intensity at 70 SZA, 325 DU 45N



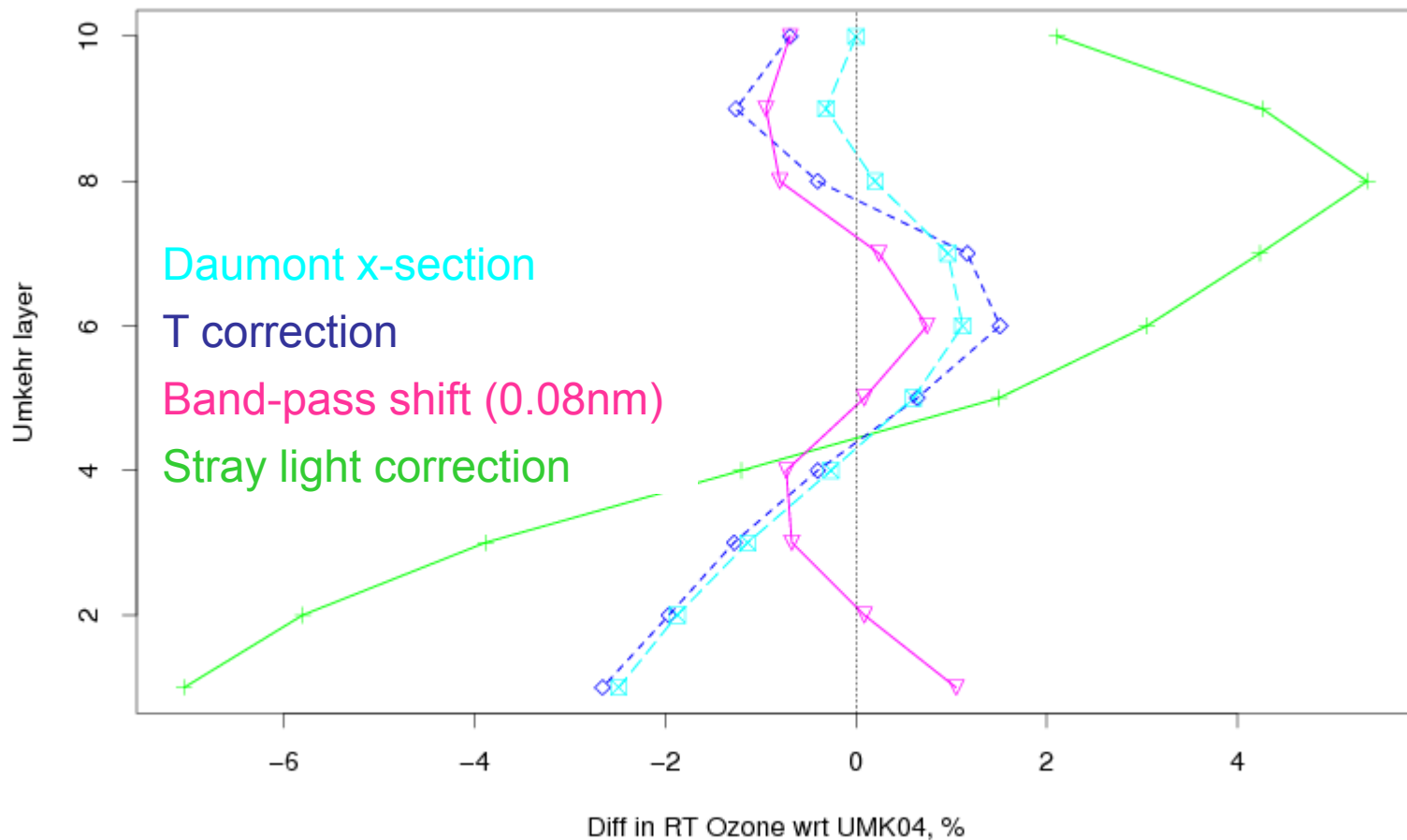
# Slit and Solar Flux weighted intensity at 85 SZA, Brewer C-short, B&P and DMB x-sections similar at both short and long

Slit C-short, weighted Intensity at 85 SZA, 325 DU 45N

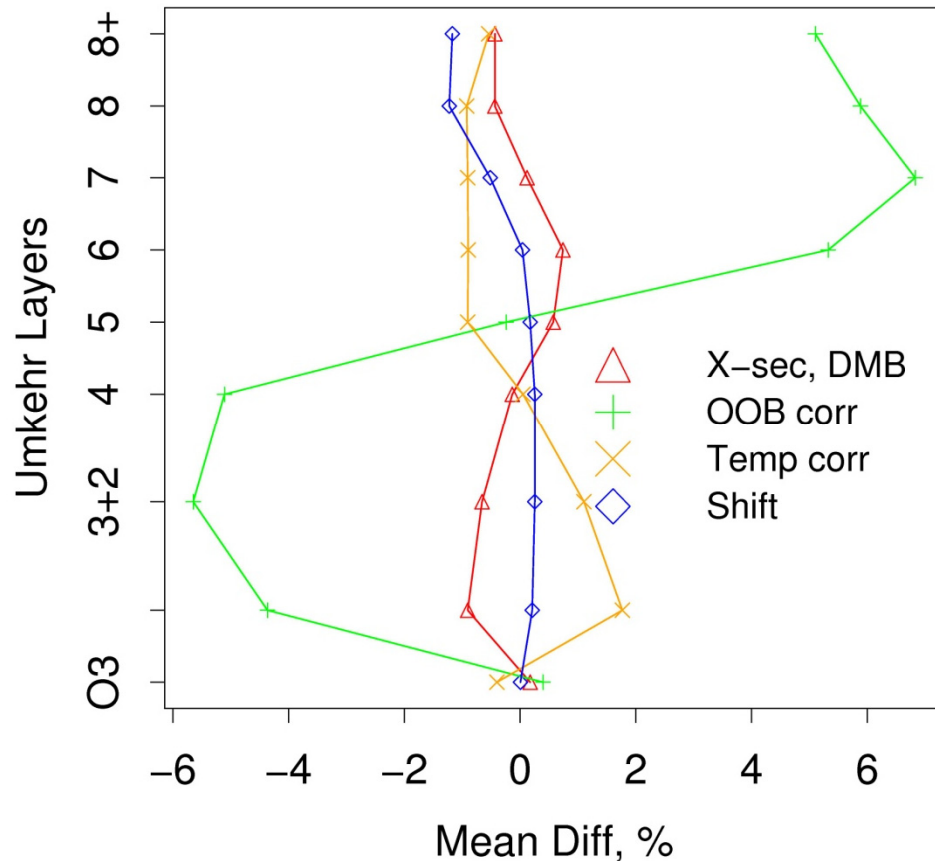


# Effects on Brewer Umkehr RT

## Boulder, 09/27/07



# MLO, Brewer 009 (Environment Canada), 1998-2005, relative changes in layers



X-section (DMB-BP)  
Band-pass spectral shift  
Stray light correction  
Temperature climatology correction

# Conclusion for Brewer Umkehrs

- Effect of X-section change – small
- Effect of band-pass shift is small
- Effect of temperature corrections (climatology based) is small
- Stray light effect in single Brewers ( $1 \times 10^{-4}$  level for Mark IV) is significant, but needs to be further evaluated
- Errors in Brewer Umkehr ozone profile retrievals related to the uncertainties in instrumental parameters are larger than errors due to X-section choice
- X-section sensitivity in Brewer Umkehr retrievals is similar to Dobson Umkehr retrievals (although Brewers have more narrow band-pass)



# Further work

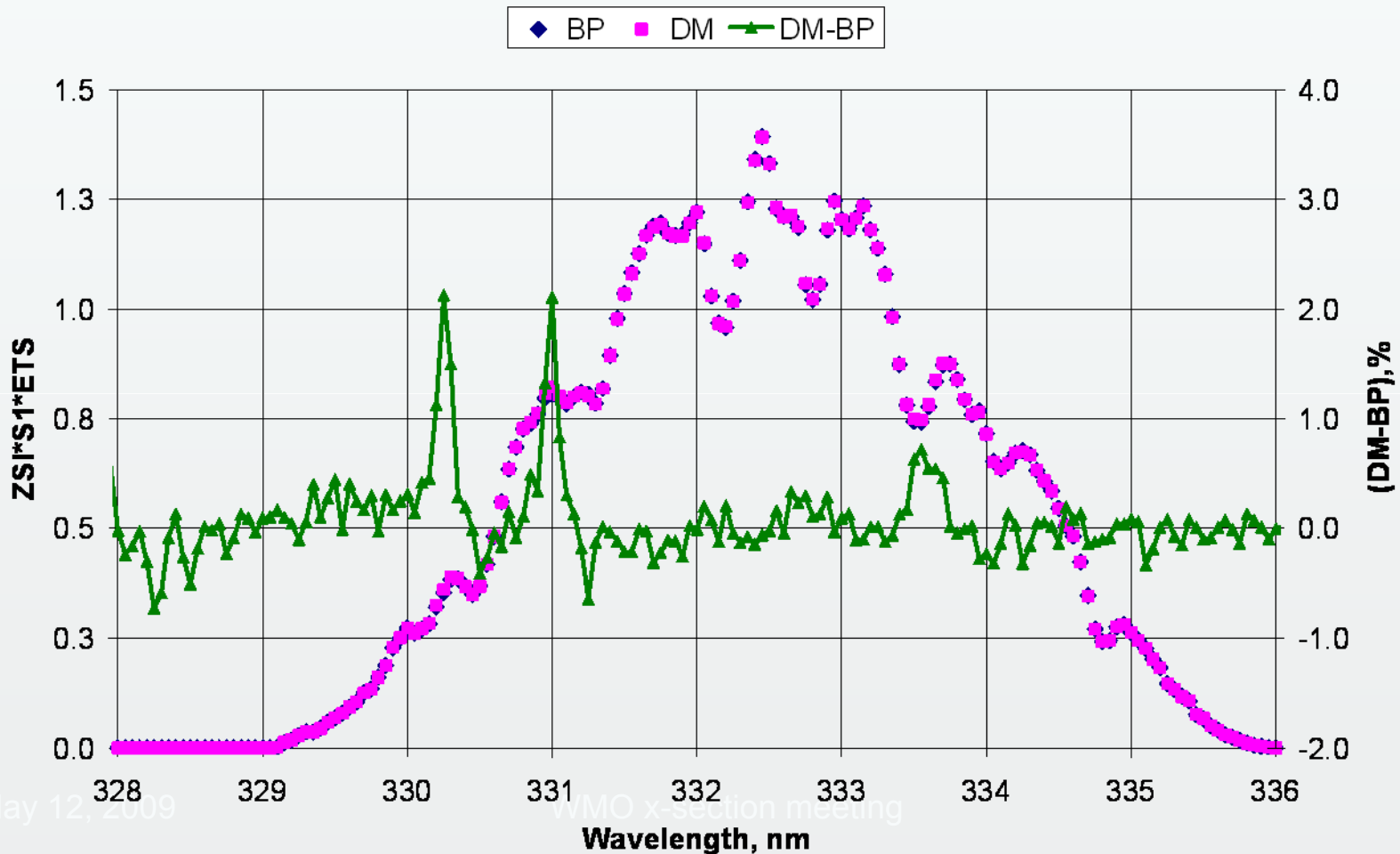
- Out-of-band contribution into Umkehr measurement (due to non-zero transmission in the far field of the slit band) needs to be evaluated for both Dobsons ( $2 \times 10^{-5}$ ?) and single Brewers ( $1 \times 10^{-4}$ ?)
- Band-pass centers (shift from nominal) and widths need to be carefully evaluated for all instruments
- $\text{NiSO}_4$  - UG11 filter transmission in single Brewers needs to be measured and utilized in Umkehr profile retrievals
- As we develop the Brewer Umkehr profile retrieval software for satellite validation activities – proper ozone x-sections would be of great importance.

**Thanks!**  
**I hope to learn more...**

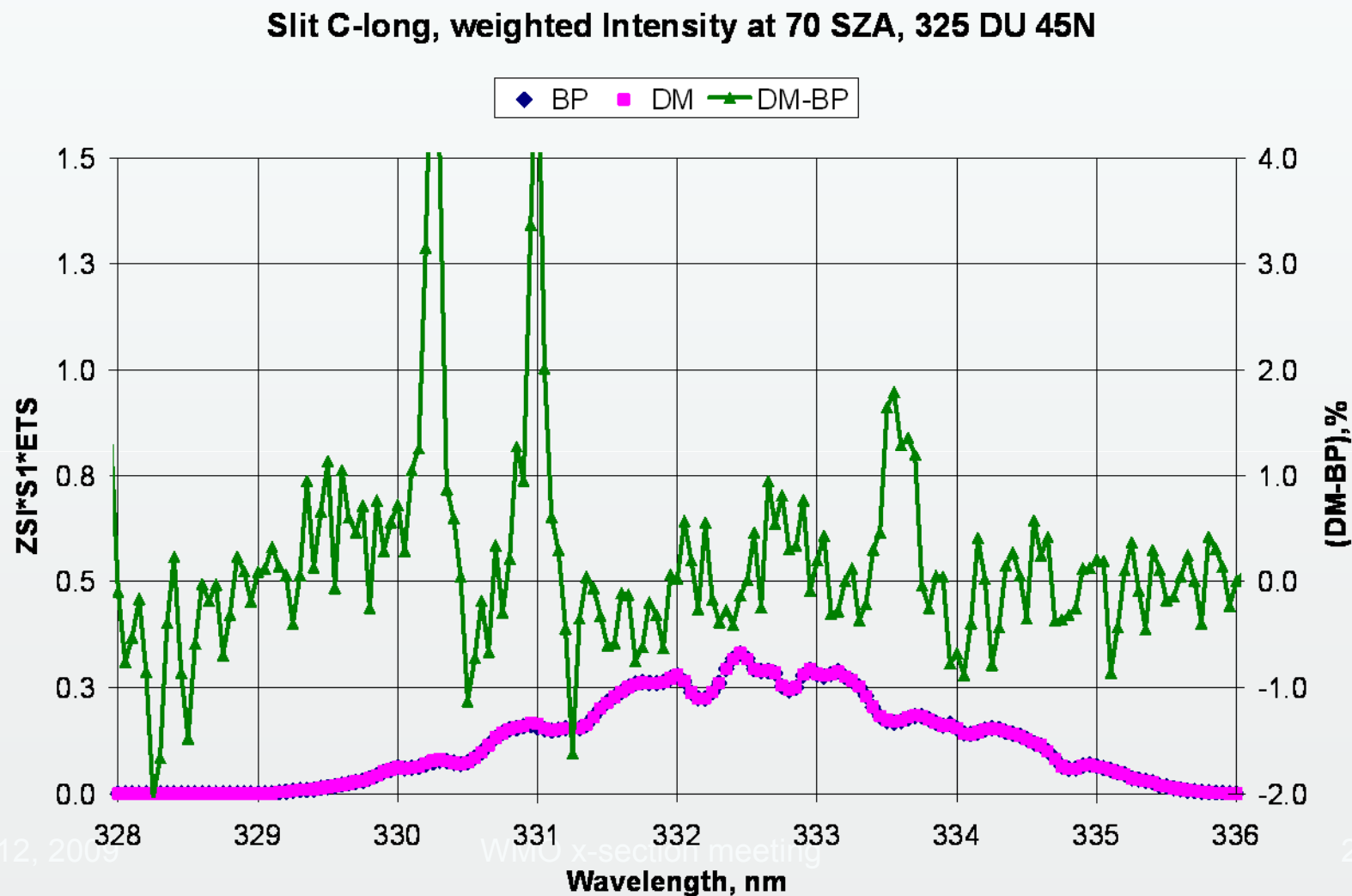
# Auxiliary slides

# Slit and Solar Flux weighted intensity at 70 SZA C-long, B&P and DMB x-sections – similar at both short and long

Slit C-long, weighted Intensity at 70 SZA, 325 DU 45N



# Slit and Solar Flux weighted intensity at 85 SZA C-long, B&P and DMB x-sections – similar at both short and long



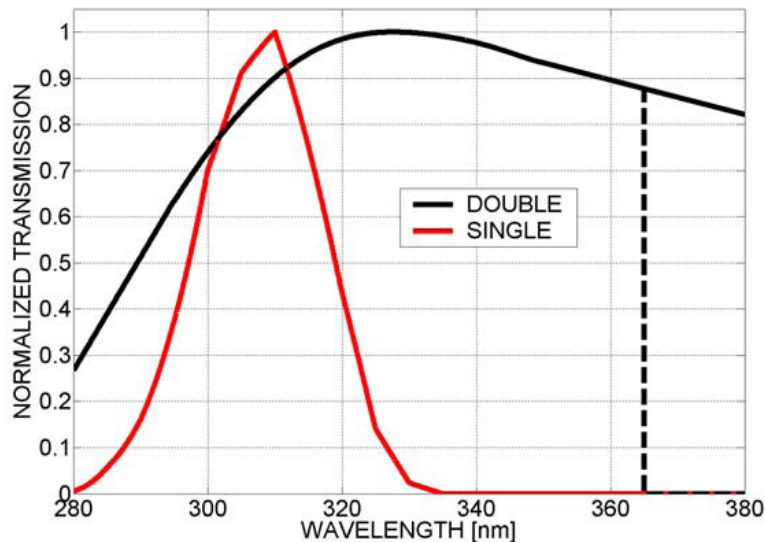
# Stray light treatment

- The Brewer intensities in zenith sky view can be represented by the following equation (A. Cede, private communications):

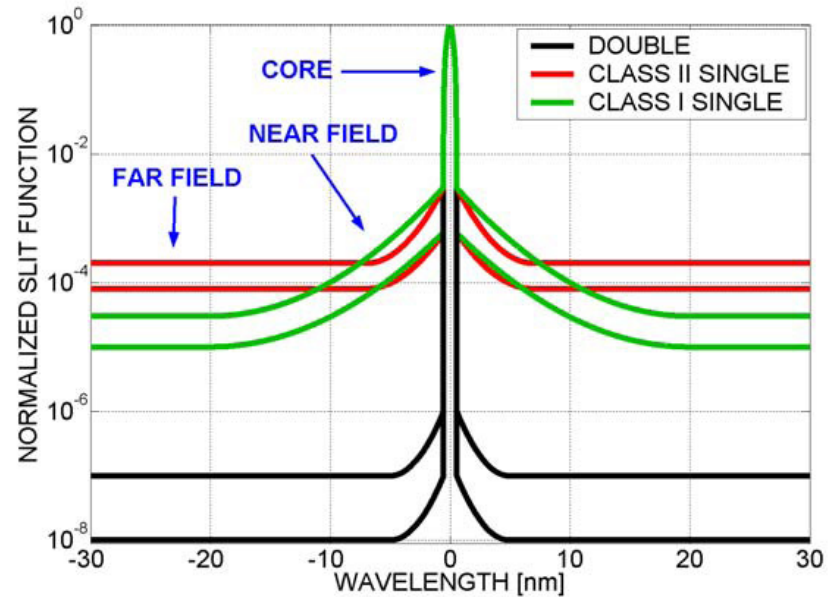
$$N(O_3, \lambda_i, \theta) = 100 * \log_{10} \left[ \int_0^{\infty} I(O_3, \lambda', \theta) * S(\lambda_i - \lambda') * T(\lambda') d\lambda' \right]$$

- $\lambda_i$  Center wavelength at slit i and fixed grating position
- $O_3$  Total ozone column
- $\Theta$  Solar zenith angle
- $N(O_3, \lambda_i, \theta)$  Umkehr N-value
- $I(O_3, \lambda', \theta)$  Zenith intensity at wavelength  $\lambda'$ , depends on other atmospheric parameters as well (e.g. aerosols)
- $T(\lambda')$  Spectral sensitivity
- $S(\lambda_i - \lambda')$  Slit function.

# A. Cede depiction of stray light



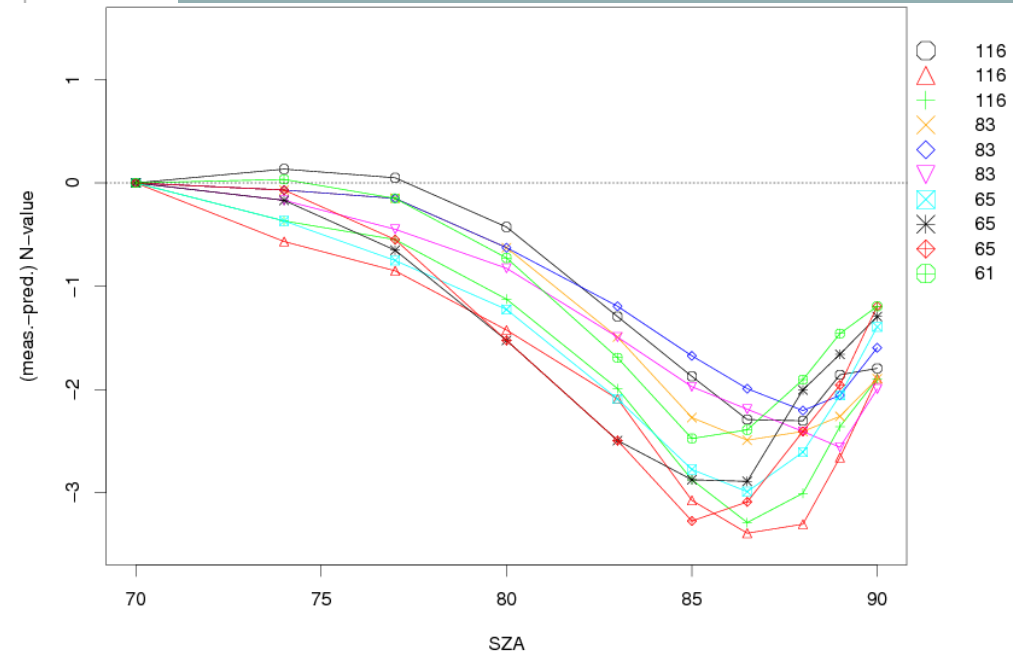
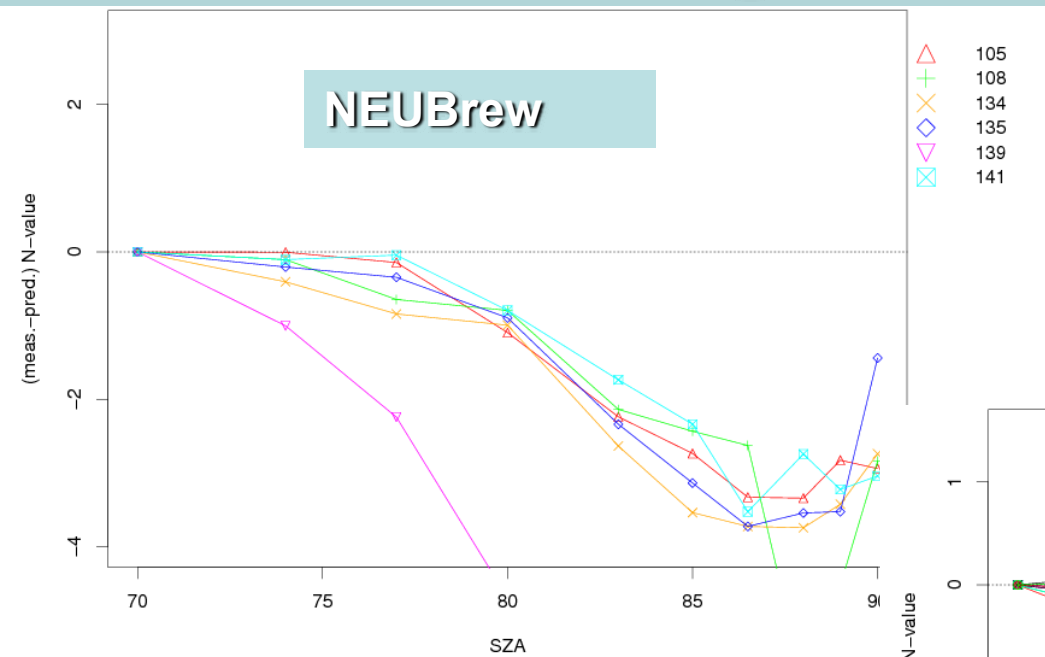
Example of the spectral transmittance for the double (MKIII) and single (MKIV) Brewer



Examples of a Brewer slit functions for double and two single Brewers. The far, near fields and core are indicated, and the errors bars are provided

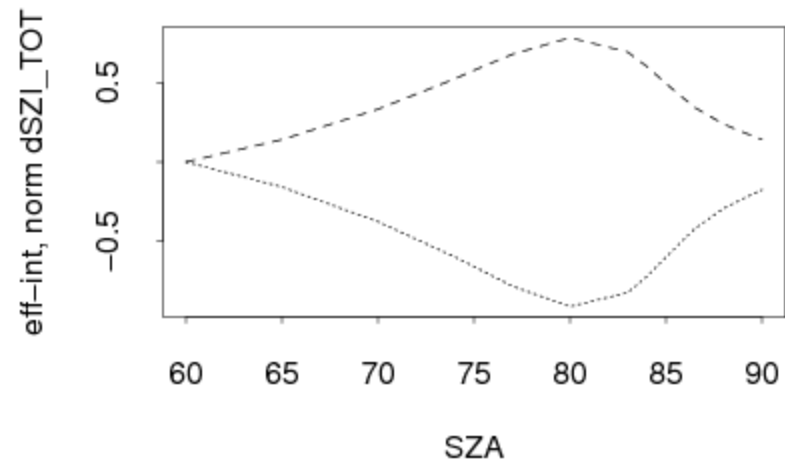
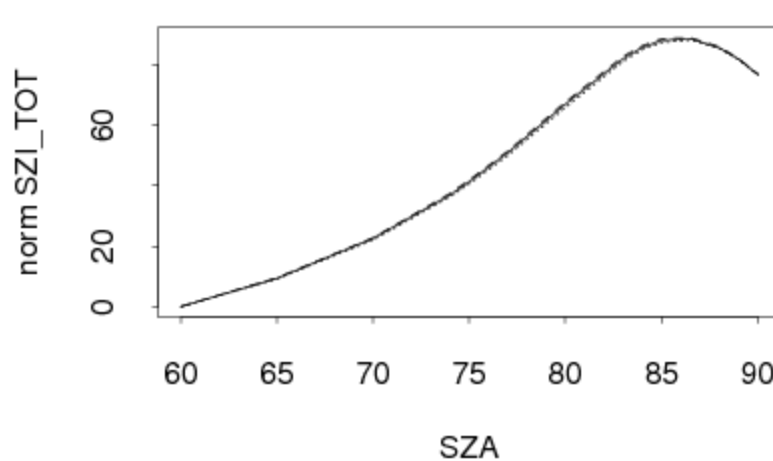


# OOB in Umkehrs as compared to reference (MLS+sond synthetic on 09/27/07) – similar effect in single Brewer and Dobson

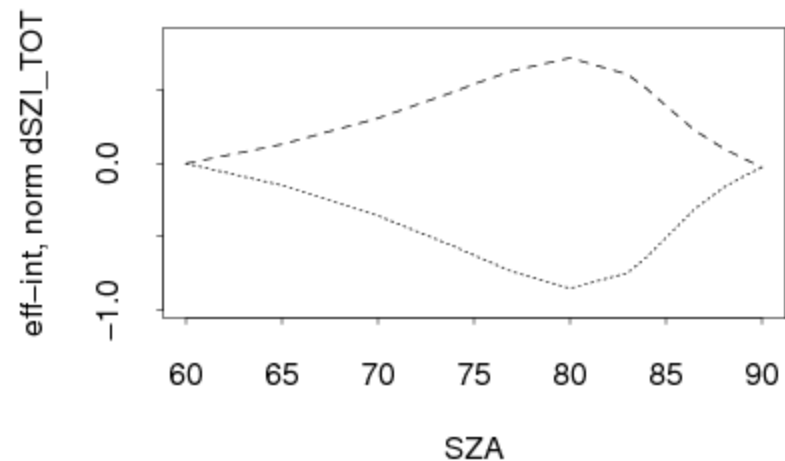
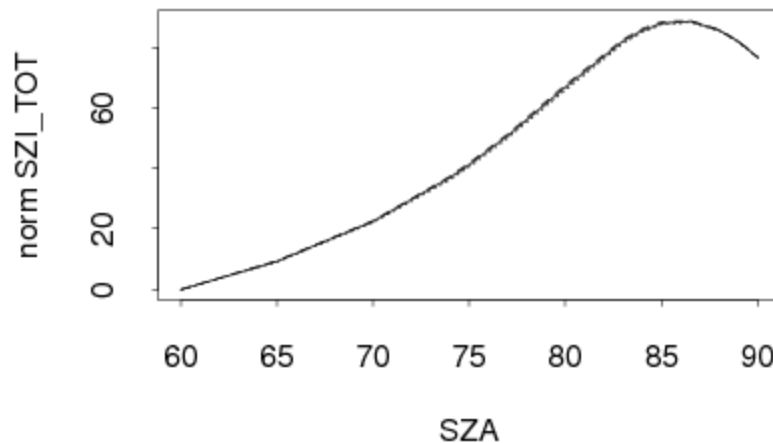


# Change of the band-pass center – results in maximum 1 N-value Umkehr change

Only short is shifted by 0.15 nm

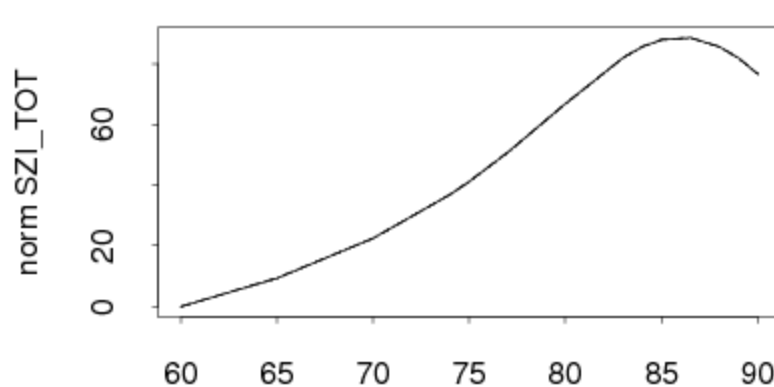


Both short and long shifted by +/- 0.15 nm

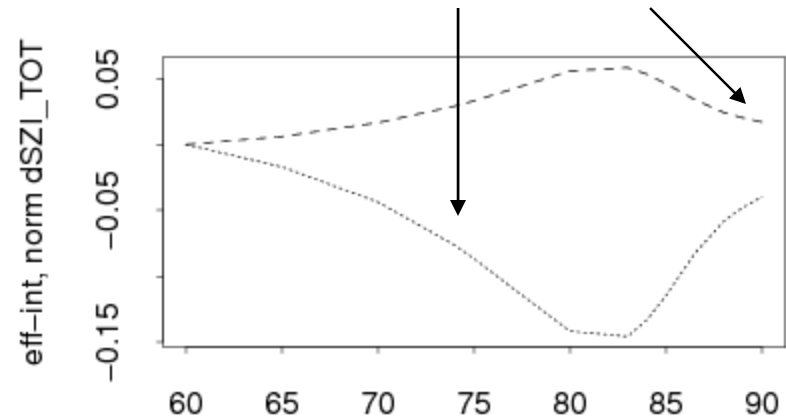


# Change of the band-pass width –small change in Umkehr curve

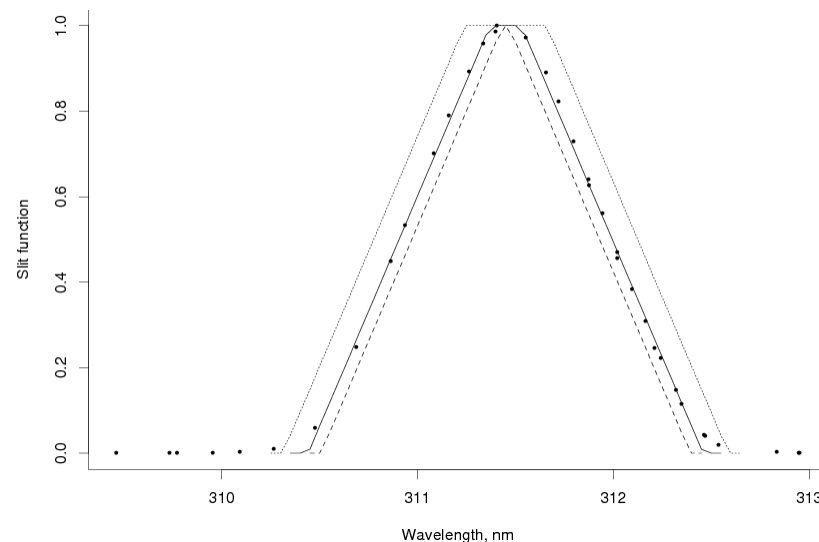
Only short is changed by 0.15 nm to make it wider/narrower



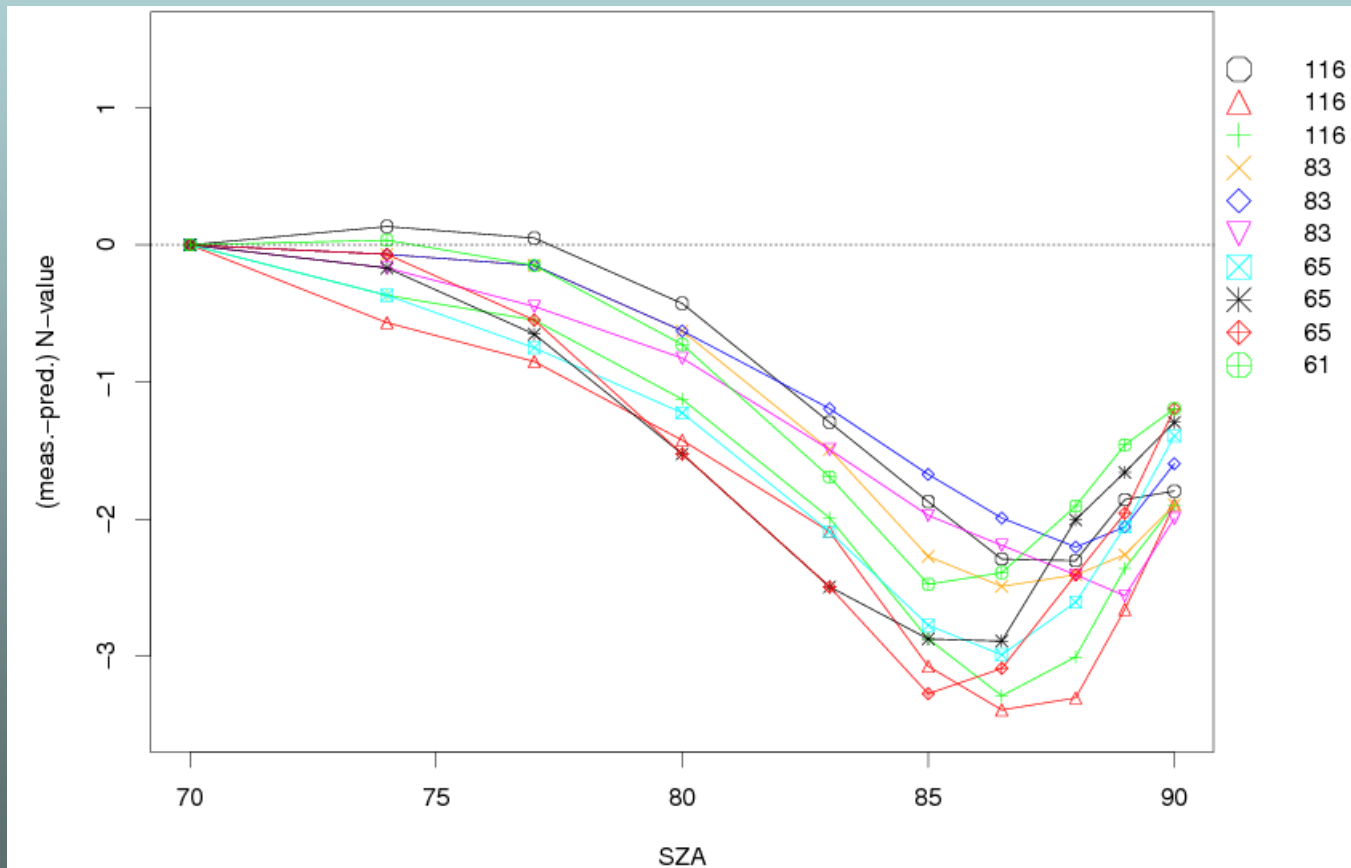
SZA



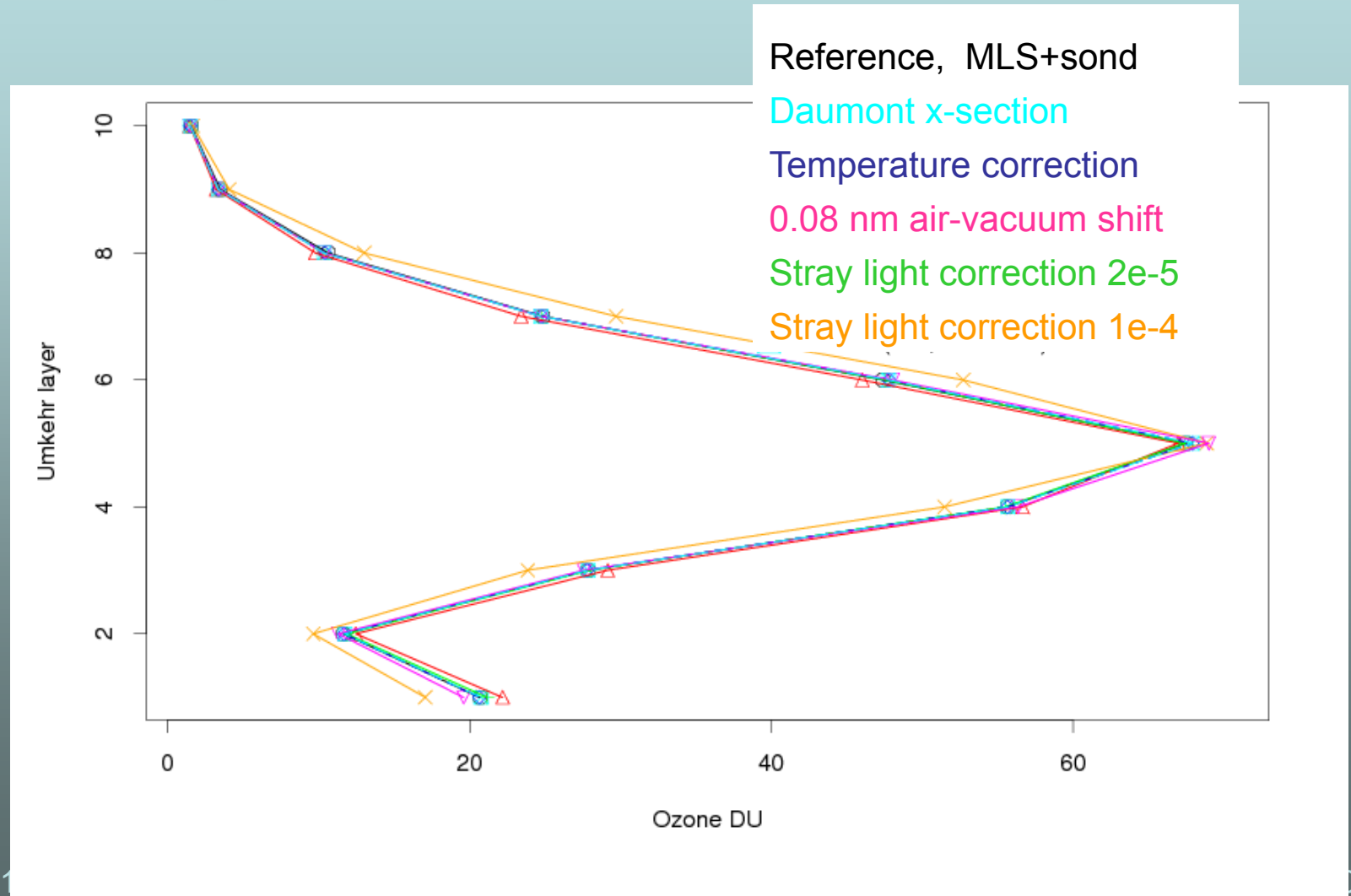
SZA



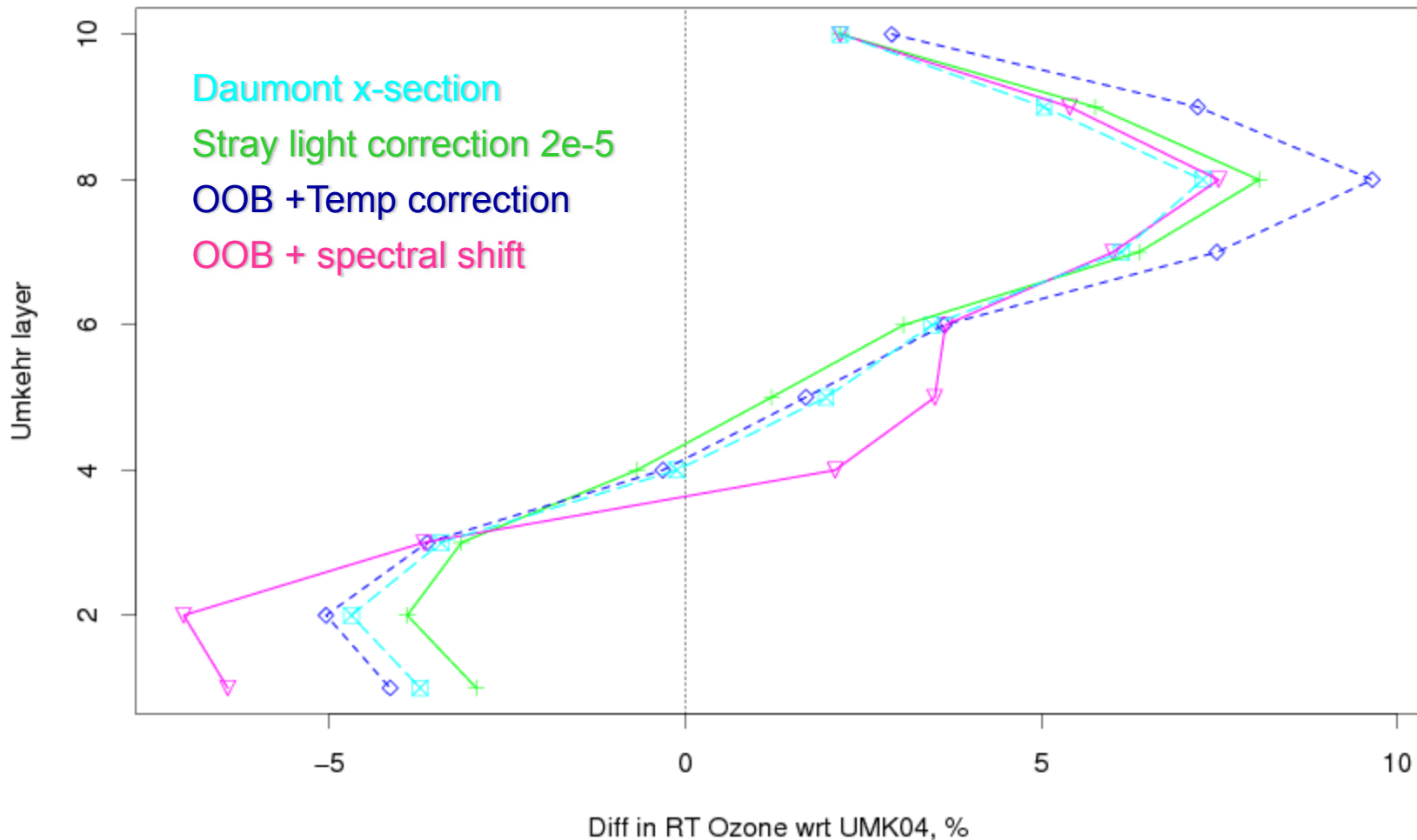
# OOB in measured Dobson Umkehrs as compared to the reference (MLS+sond synthetic on 09/27/07)



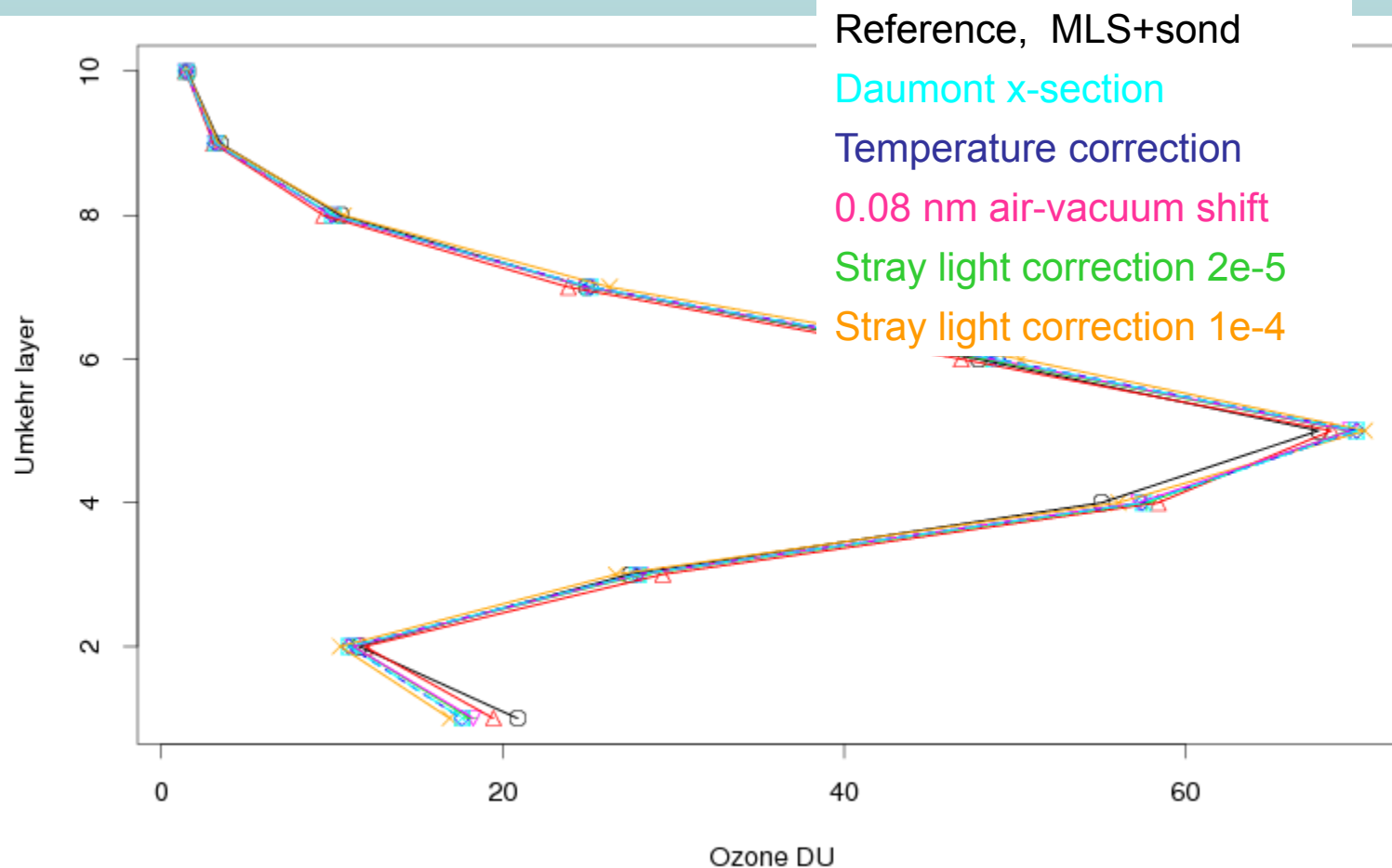
# Comparisons of Dobsons in Boulder, September 20 and 27, 2007



# Effects of x-section and other changes on Dobson Umkehr retrievals, September 20, 2007, Boulder

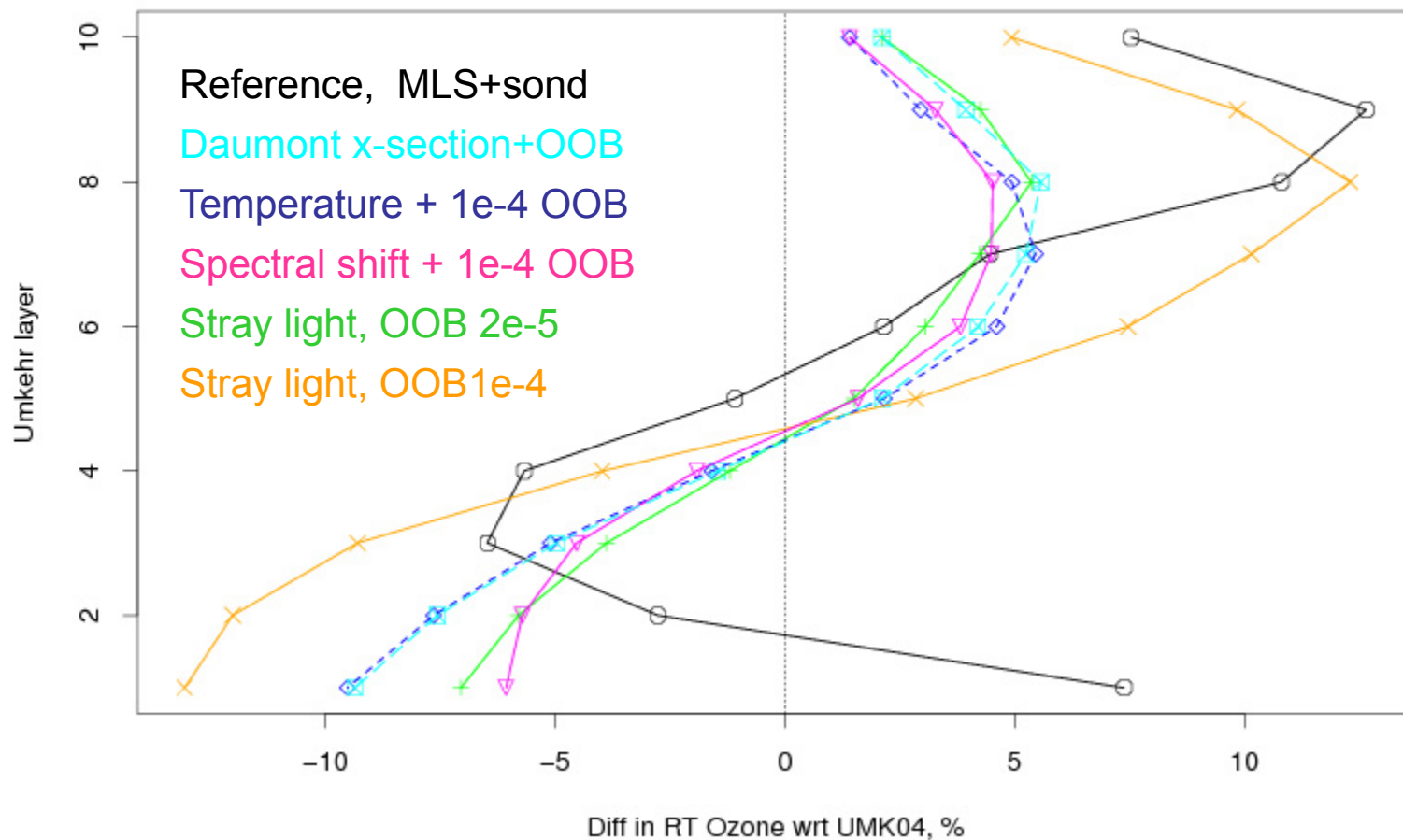


# Brewer 134, Boulder, Sept 20 2007

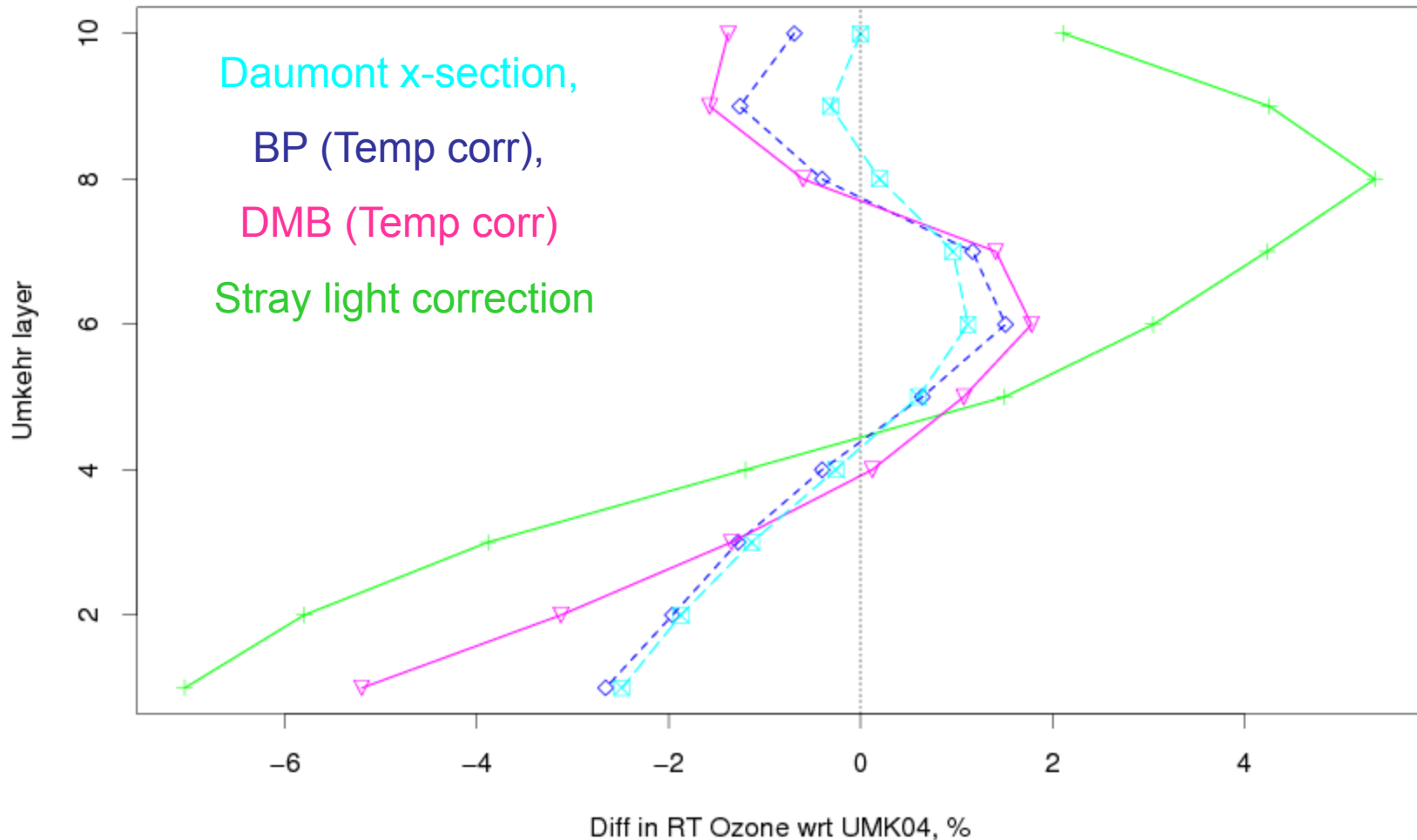




BOULDER 20070920 ,BR 134 , 271 DU,MLS(040709)+sond(040709)

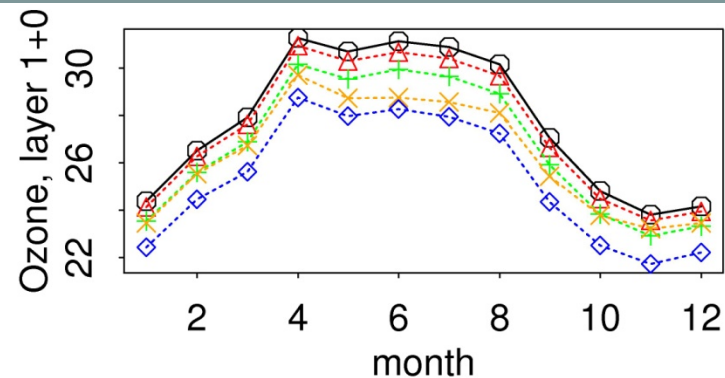
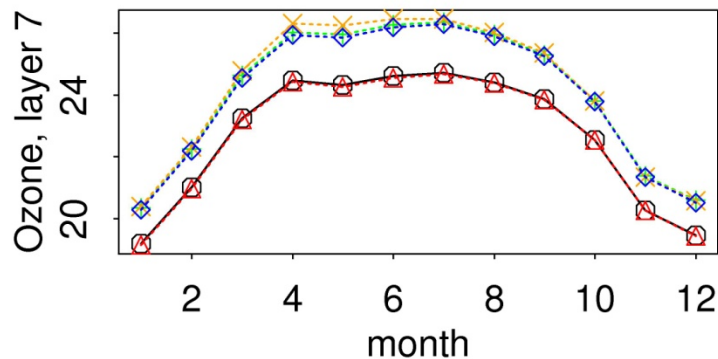
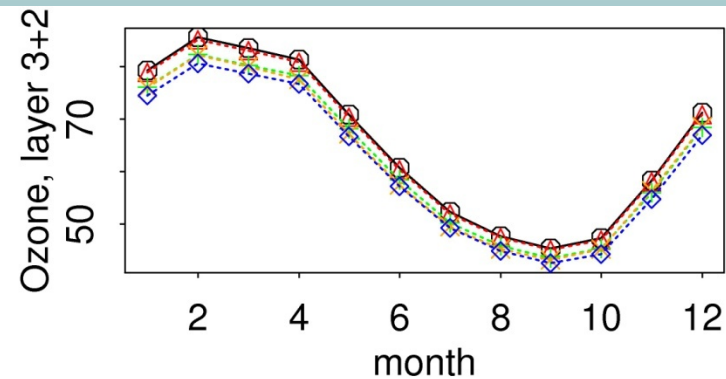
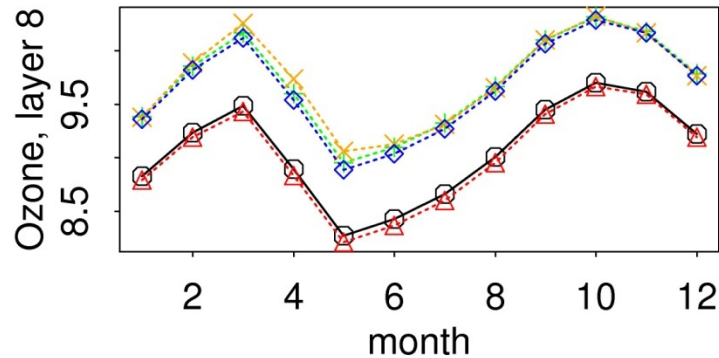


# Temp Effects on Brewer Umkehr RT with BP and Daumont x-sec

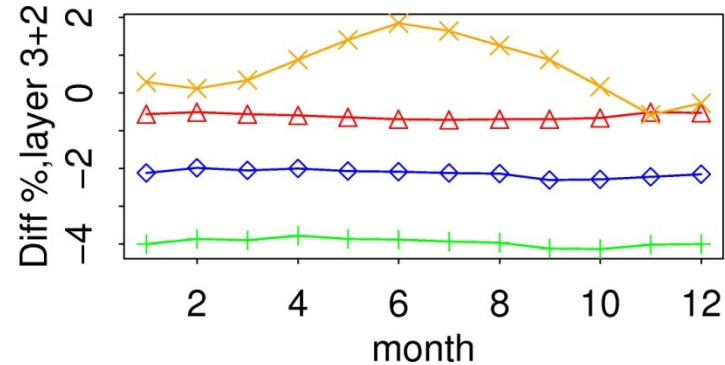
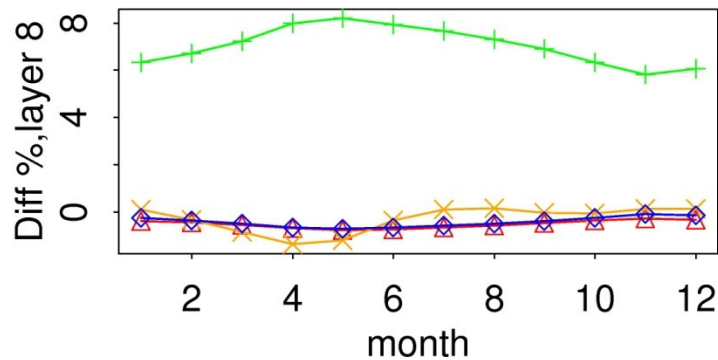


# Boulder, Dobson 061, 1979-2008

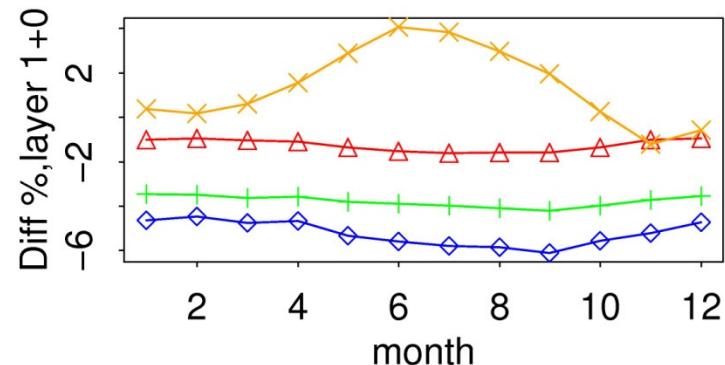
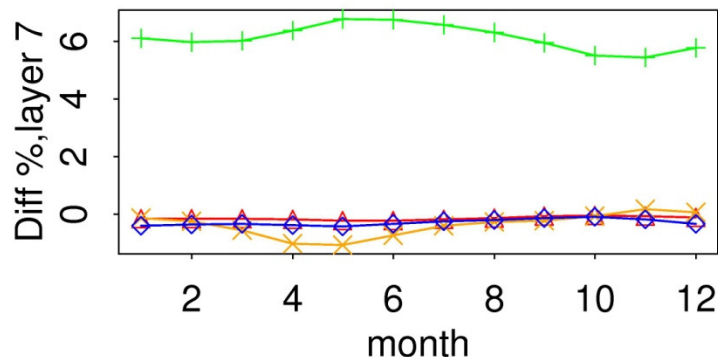
UMK04, X-section (DMB), Stray light, Stray light and band-pass shift,  
Stray light and w/o Temperature climatology



# Boulder, Dobson 061, 1979-2008, annual cycle changes in layers

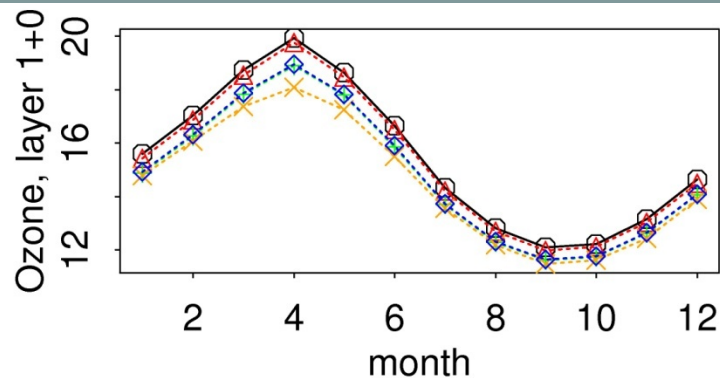
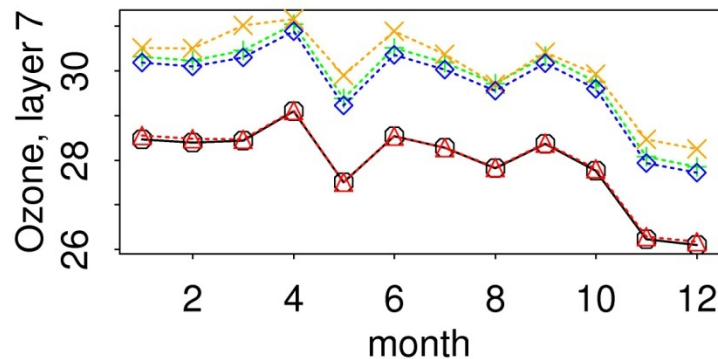
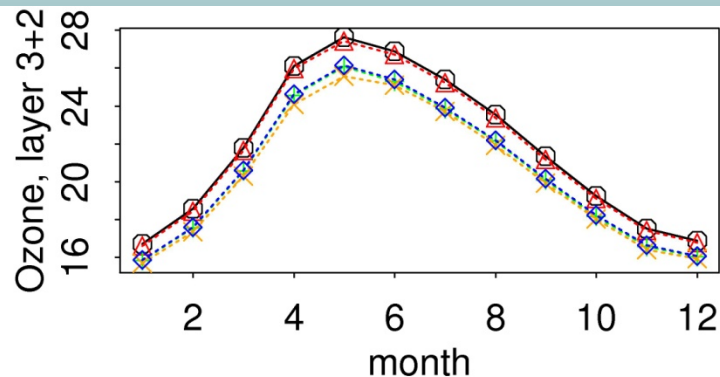
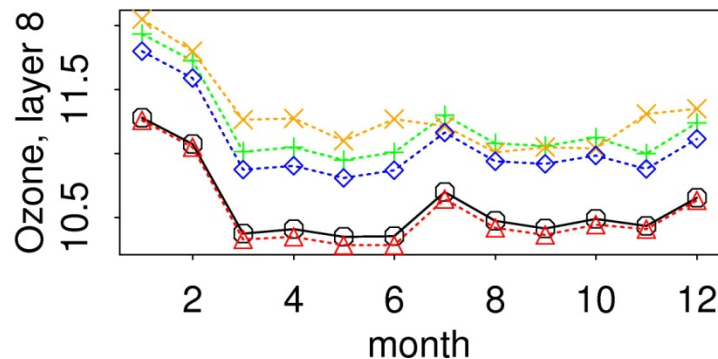


**X-section (DMB-BP), Band-pass spectral shift, Stray light correction, Temperature climatology correction**

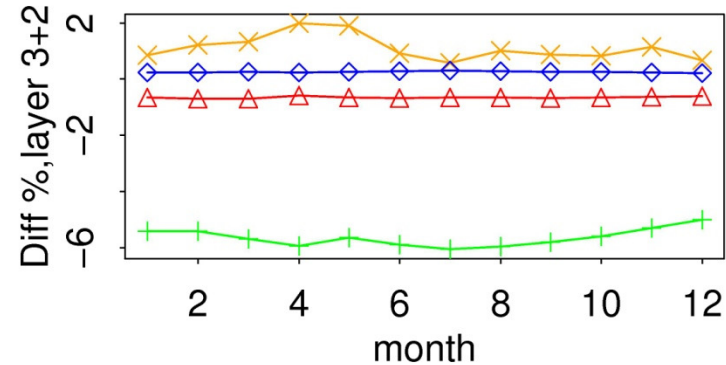
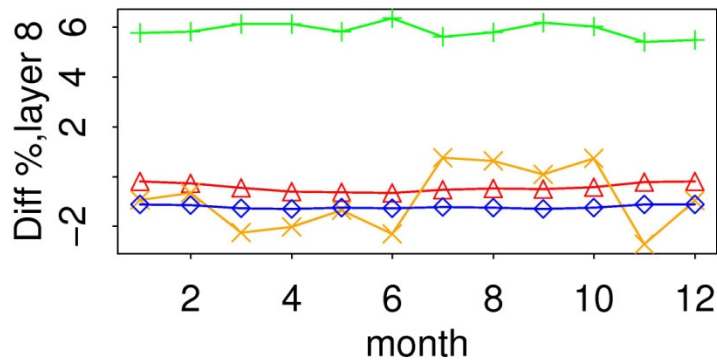


# MLO, Brewer 009, 1998-2005

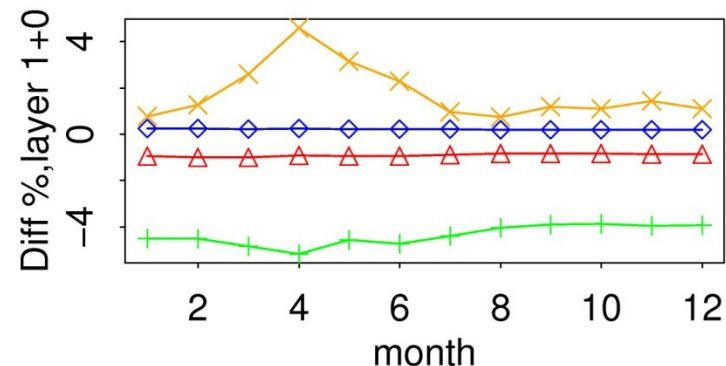
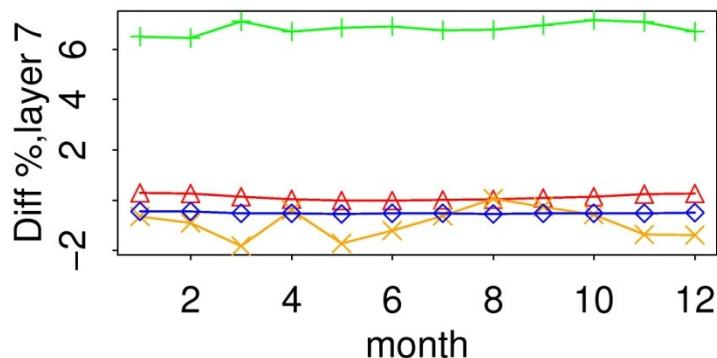
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Stray light and w/o Temperature climatology



# MLO, Brewer 009, 1998-2005, annual cycle changes in layers



**X-section (DMB-BP), Band-pass spectral shift, Stray light correction, Temperature climatology correction**



# Ozone x-section coefficient C0, A long

