The effect of change of BP to DBM ozone absorption cross-sections on lidar measurements

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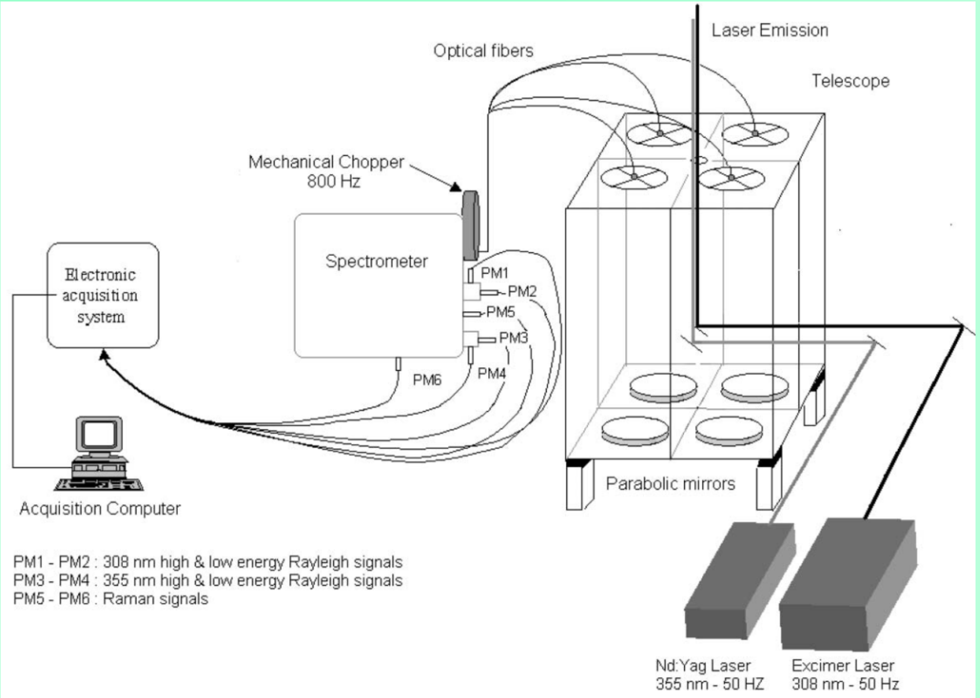
Principle of lidar ozone measurement

DIAL Method : DIfferential Absorption Lidar



Common wavelengths pairs used:
stratospheric systems: 308, 351-355 nm
Tropospheric: 266, 289, 299, 316 nm

- ✓ Emission of 2 laser beams in the UV range ($\lambda_{on,}$, λ_{off})
- ✓ Different ozone absorption cross-section
- ✓ Pulsed laser sources: range resolved measurement
- ✓ Large dynamic of the lidar signals: several acquisition channels
- ✓ N_2 Raman wavelengths: volcanic aerosols
- ✓ Self calibrated measurement

Retrieval of ozone number density: Rayleigh

DIAL Method : DIfferential Absorption Lidar

$$n_{O_3}(z) = -\frac{1}{2\,\Delta\sigma_{O_3}(z)}\frac{d}{dz}Ln\left(\frac{S(\lambda_{on},z)-S_b(\lambda_{on},z)}{S(\lambda_{off},z)-S_b(\lambda_{off},z)}\right)+\delta n_{O_3}(z)$$

- $\Delta\sigma_{O_3}(z)$: **Differential ozone absorption cross-section** $\sigma_{O_3}(\lambda_{on},z)-\sigma_{O_3}(\lambda_{off},z)$
- $S(\lambda,z)$: **lidar signal**
- $S_b(\lambda,z)$: **background**
- $\delta n_{O_3}(z)$: **correction term**

Laser wavelengths chosen so that the correction term is less than 10% of main term

$$\delta n_{O_3}(z) = \frac{1}{\Delta\sigma_{O_3}(z)}\left[\frac{1}{2}\frac{d}{dz}Ln\left(\frac{\beta(\lambda_{on},z)}{\beta(\lambda_{off},z)}\right)-\Delta\alpha(z)-\sum_i \Delta\sigma_i n_i(z)\right]$$

- β: **backscatter Rayleigh & Mie**
- $\Delta\alpha(z)$: **extinction Rayleigh & Mie**
- $\sum_i \Delta\sigma_i n_i(z)$: **Extinction by other species**

Retrieval of ozone number density: Raman

Use of Raman signals in the presence of volcanic aerosols

$$n_{O_3}(z) = -\frac{1}{\Delta\sigma^R_{O_3}(z)}\frac{d}{dz} Ln\left(\frac{S(\lambda^R_{on}, z) - S_b(\lambda^R_{on}, z)}{S(\lambda^R_{off}, z) - S_b(\lambda^R_{off}, z)}\right) + \delta n^R_{O_3}(z)$$

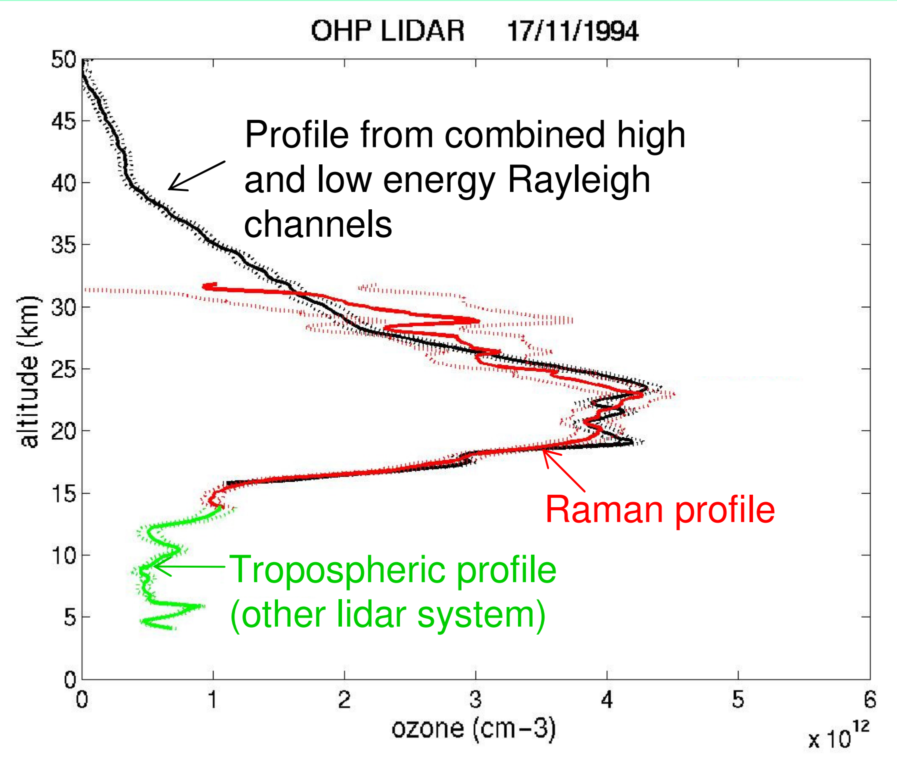
Differential ozone absorption cross-section — lidar signal — background — correction term

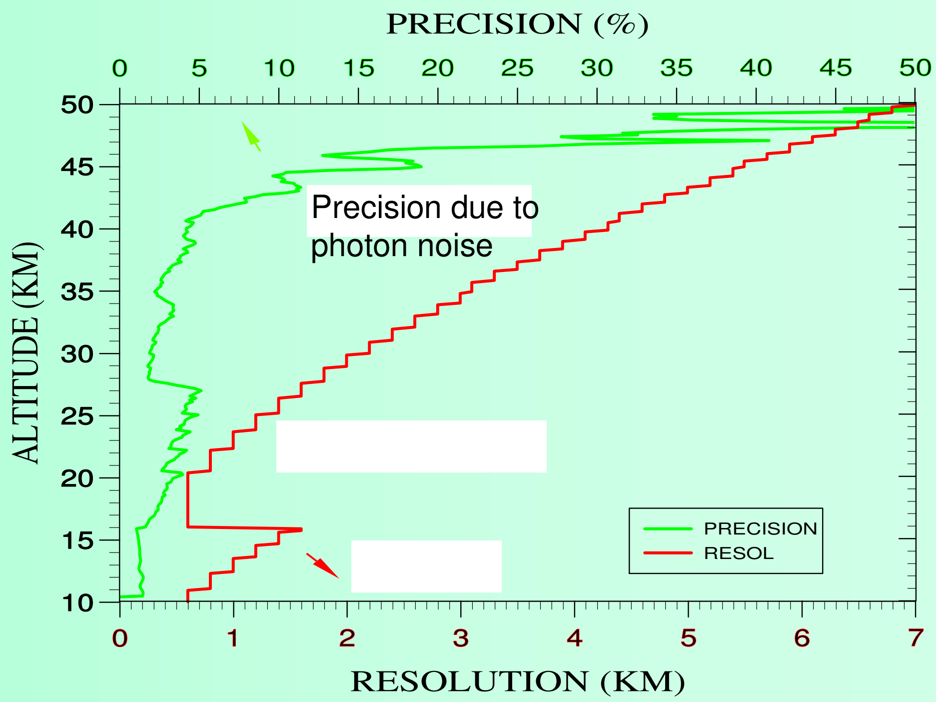
$$\Delta\sigma^R_{O_3} = \sigma_{O_3}(\lambda_{on}, z) - \sigma_{O_3}(\lambda_{off}, z) + \sigma_{O_3}(\lambda^R_{on}, z) - \sigma_{O_3}(\lambda^R_{off}, z)$$

$$\delta n^R_{O_3}(z) = \frac{1}{\Delta\sigma^R_{O_3}(z)}\left[-\Delta\alpha^R(z) - \sum_i \Delta\sigma^R{}_i n_i(z)\right]$$

extinction Rayleigh & Mie — extinction by other species

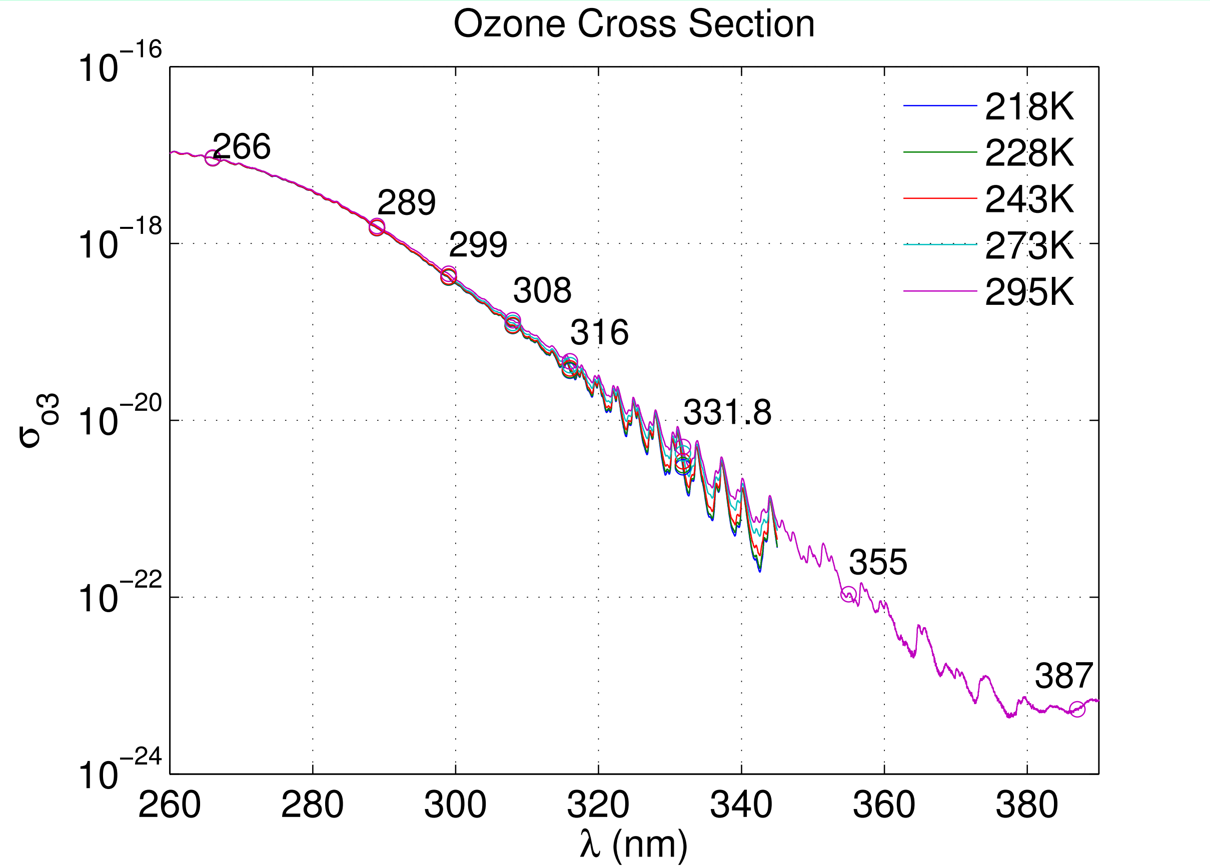
Example of DIAL ozone profile





- Ozone measurements performed during the night
- Temporal resolution 3 – 4 hours, depending on laser power and repetition rate
- Require clear skies

Wavelengths used in lidar measurements

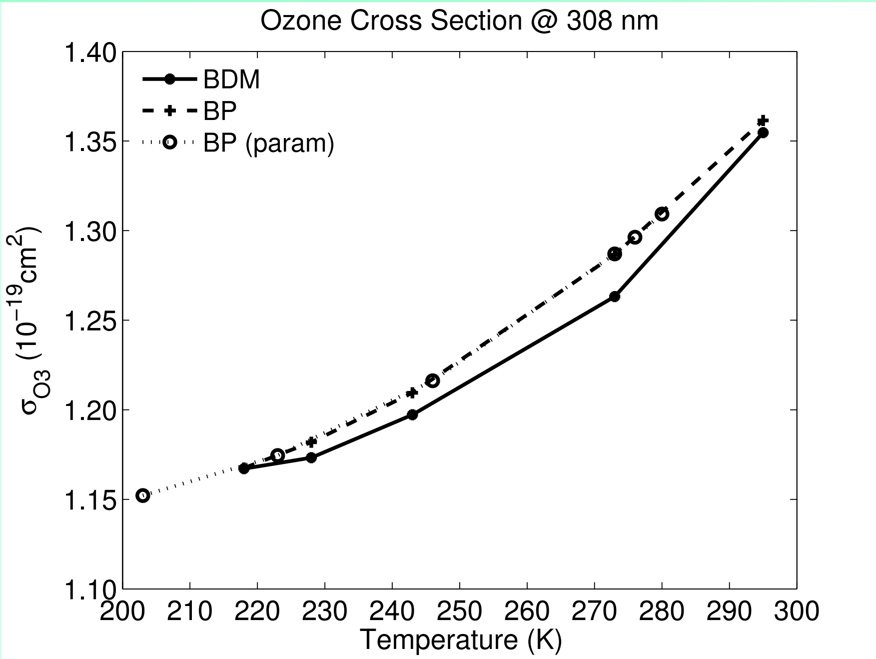


Spectral variation of ozone cross-section between 260 nm and 390 nm (Malicet et al., 1995; Brion et al., 1998).

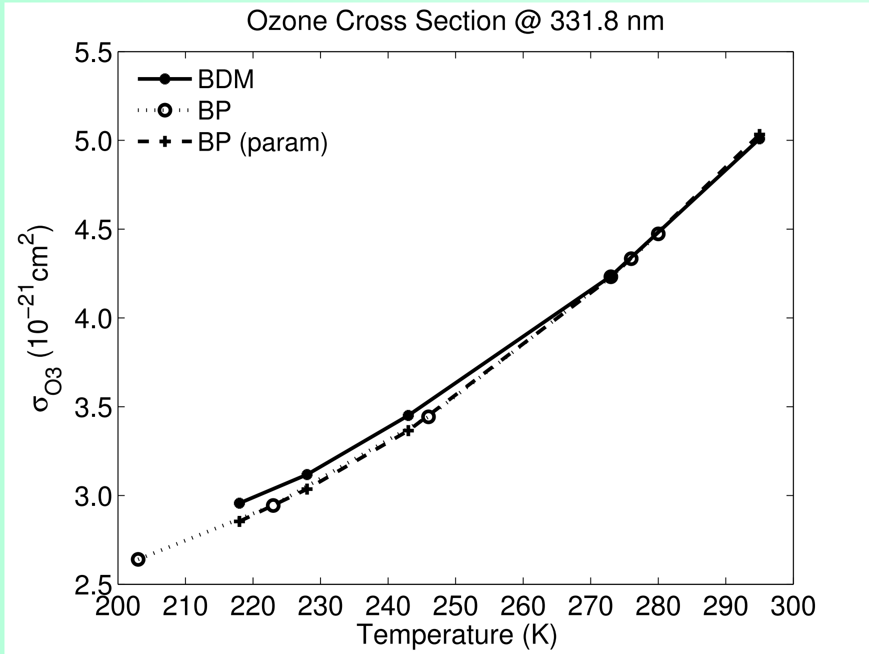
Wavelengths used for ozone measurements in the troposphere and stratosphere.

Variation of ozone X-section with temperature

Rayleigh absorbed wavelength: 308 nm

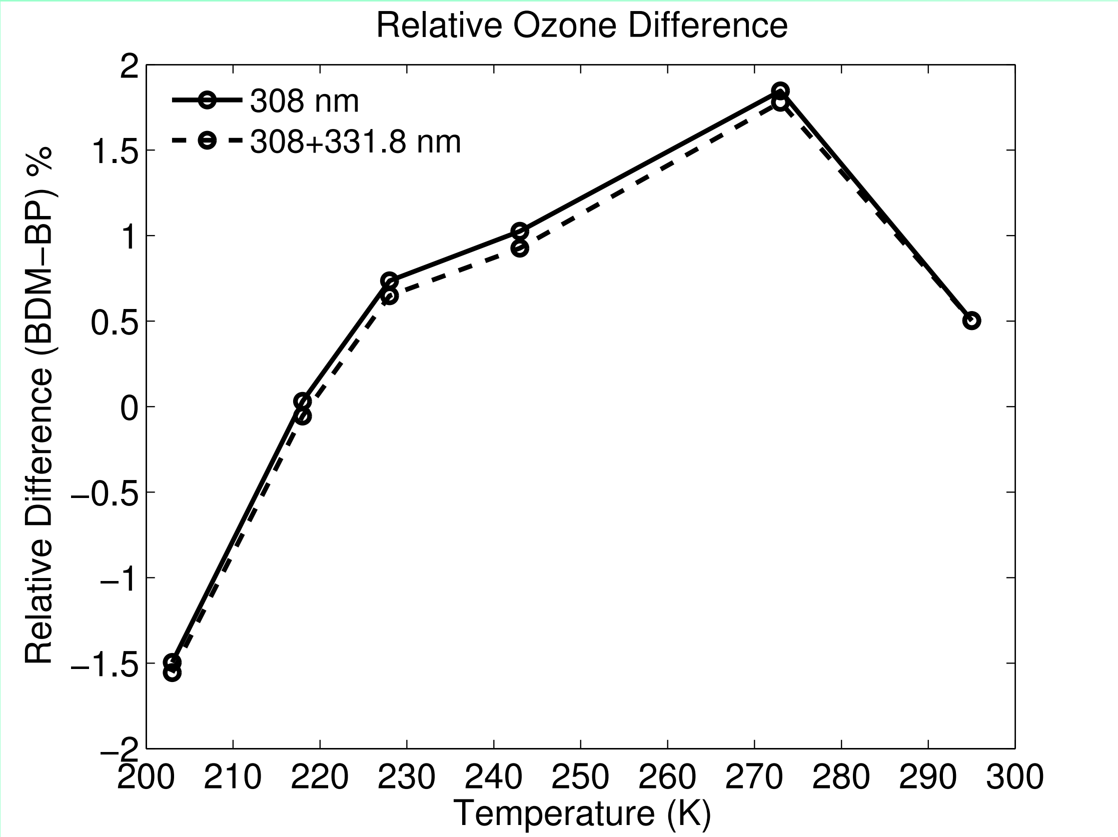


Raman absorbed wavelength: 331.8 nm



Ozone cross-sections as a function of temperature for Malicet et al. (1995, BDM) and Bass and Paur (1984, BP) data sets.

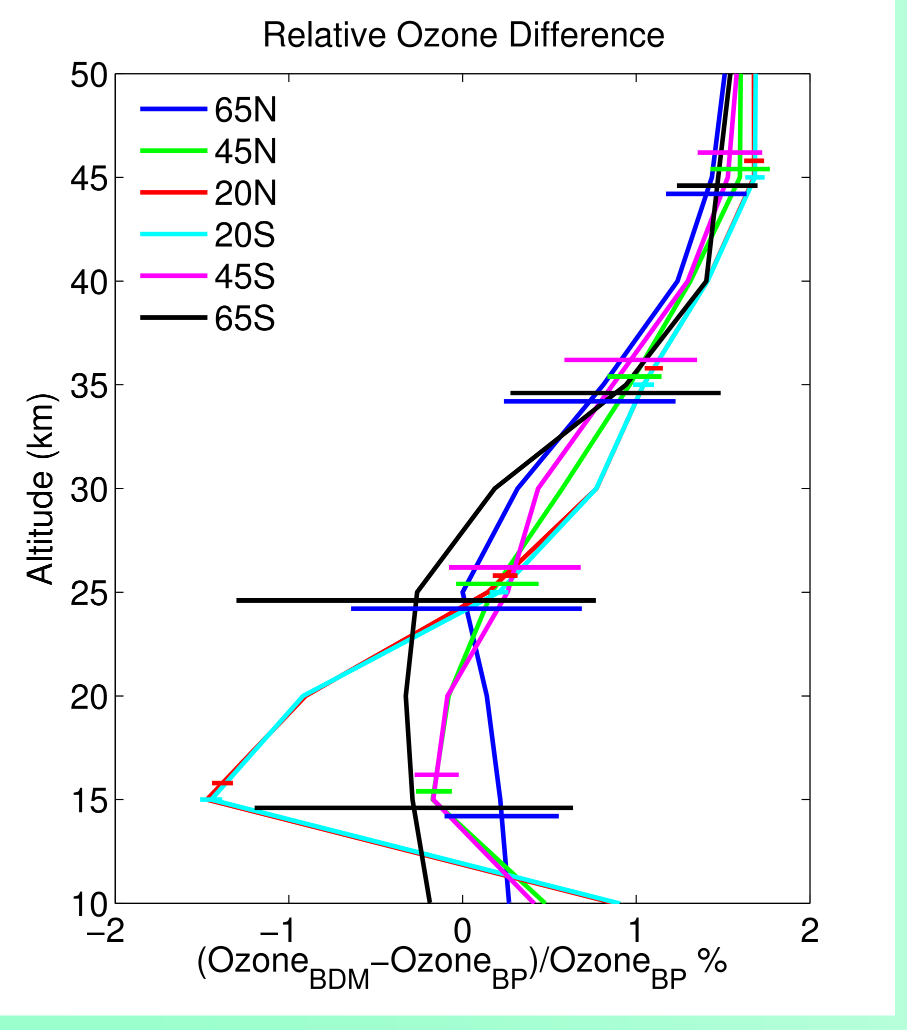
Effect of a change of X-sections on ozone



$$\Delta n_{O_3}(z) = \frac{\Delta\sigma_{o3}^{BP}(z)}{\Delta\sigma_{o3}^{BDM}(z)} - 1$$

Relative difference in ozone (BDM-BP)

Ozone change as a function of latitude



Relative difference in ozone (BDM-BP) using the CIRA model, for various latitude bands

Annual average

$$\overline{\Delta n_{O_3}(z)} = \sum_{m=1}^{12} \frac{n_{o3}^{BDM}(z,m) - n_{o3}^{BP}(z,m)}{n_{o3}^{BP}(z,m)}$$

Conclusions

- The difference on ozone in both the classical DIAL retrieval based on elastic scattering and the retrieval based on Raman scattering is **below 1.5 %** in absolute value **from 10 to 30 km**.
- **Above 30 km**, the difference, estimated for the classical DIAL retrieval only, **are maximum around 45 km**. Largest differences are found **in the tropics** and reach about **1.8 %.**
- Correct evaluation of ozone cross-section temperature dependence is important for ozone trends evaluation from lidar measurements, due to temperature trends in the stratosphere.
- At present, most lidar groups within NDACC use Bass & Paur ozone cross-sections but DIAL ozone measurements can easily be re-computed from archived raw data in case of change in recommended ozone cross-section.

Initiative from the NDACC lidar group

Proposal in Response to the 2010 Call for the Formation of an ISSI International Team in Space Science on:

Critical Assessment and Standardized Reporting of Vertical Filtering and Error Propagation in the Data Processing Algorithms of the NDACC Lidars

Submitted by T. Leblanc, JPL

Ozone cross-section issue included.