Optimal Estimation Method (OEM) retrievals of Temperature, Water Vapor and Ozone from Rayleigh, Raman and Differential Absorption Lidar Data

Presenters:

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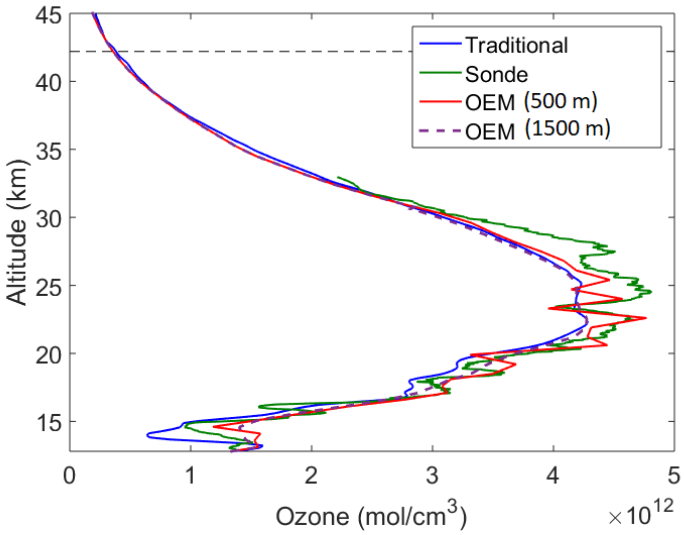
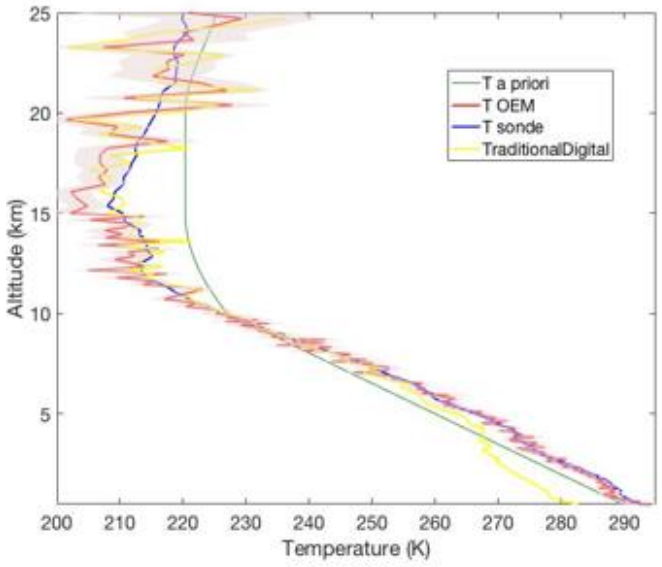
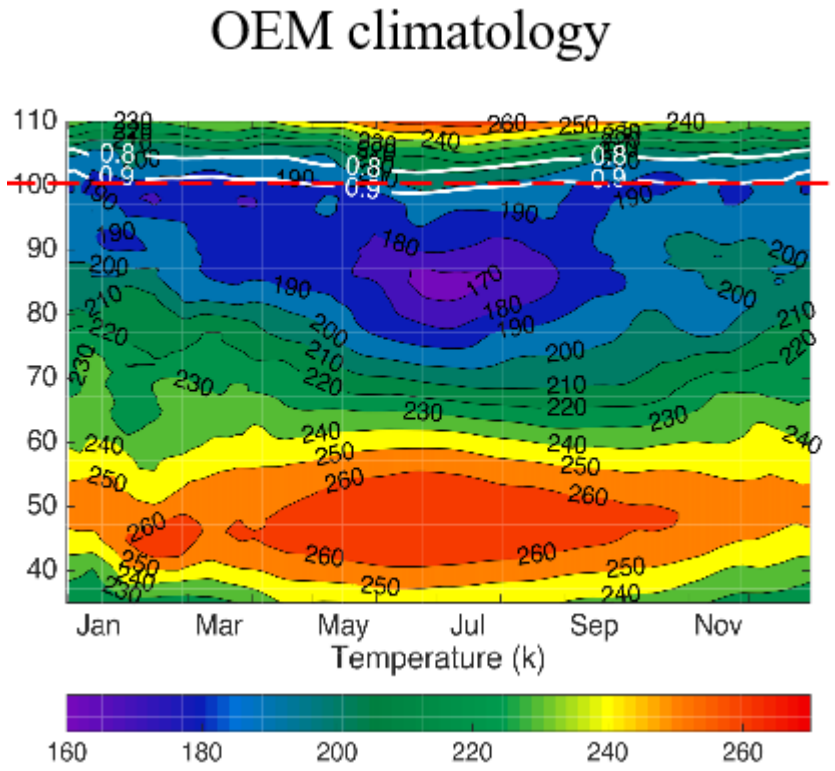
Outline:

- Ozone Retrievals (G. Farhani)
- Raman Temperature Retrievals (S. Gamage)
- Rayleigh Temperature Retrievals (A. Jalali)







Ozone retrievals: For the Forward model, we are using the lidar equation.

$$N_{obs}(z,\lambda_i) = \frac{C(\lambda_i)}{z^2}\beta(\lambda_i,z)\exp[-2\tau(z',\lambda_i)] + B(z)$$

$$\tau(z,\lambda) = \int_0^\infty [\sigma_{O_3}(\lambda,T(z))n_{O_3}(z) + \alpha(\lambda,z) + \sum_e \sigma_e(\lambda)n_e(z)]dz$$

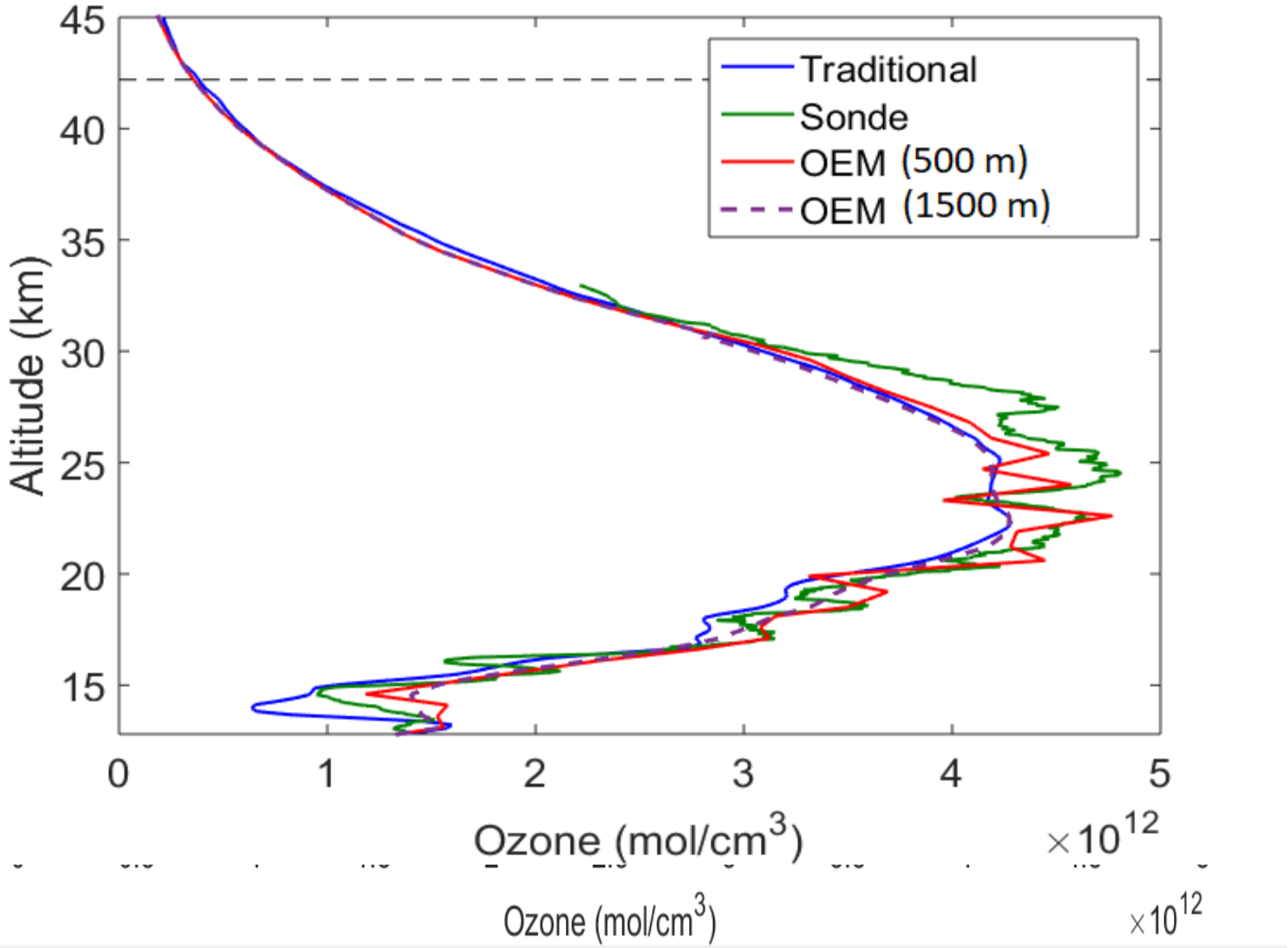
Optical depth

ozone absorption cross section

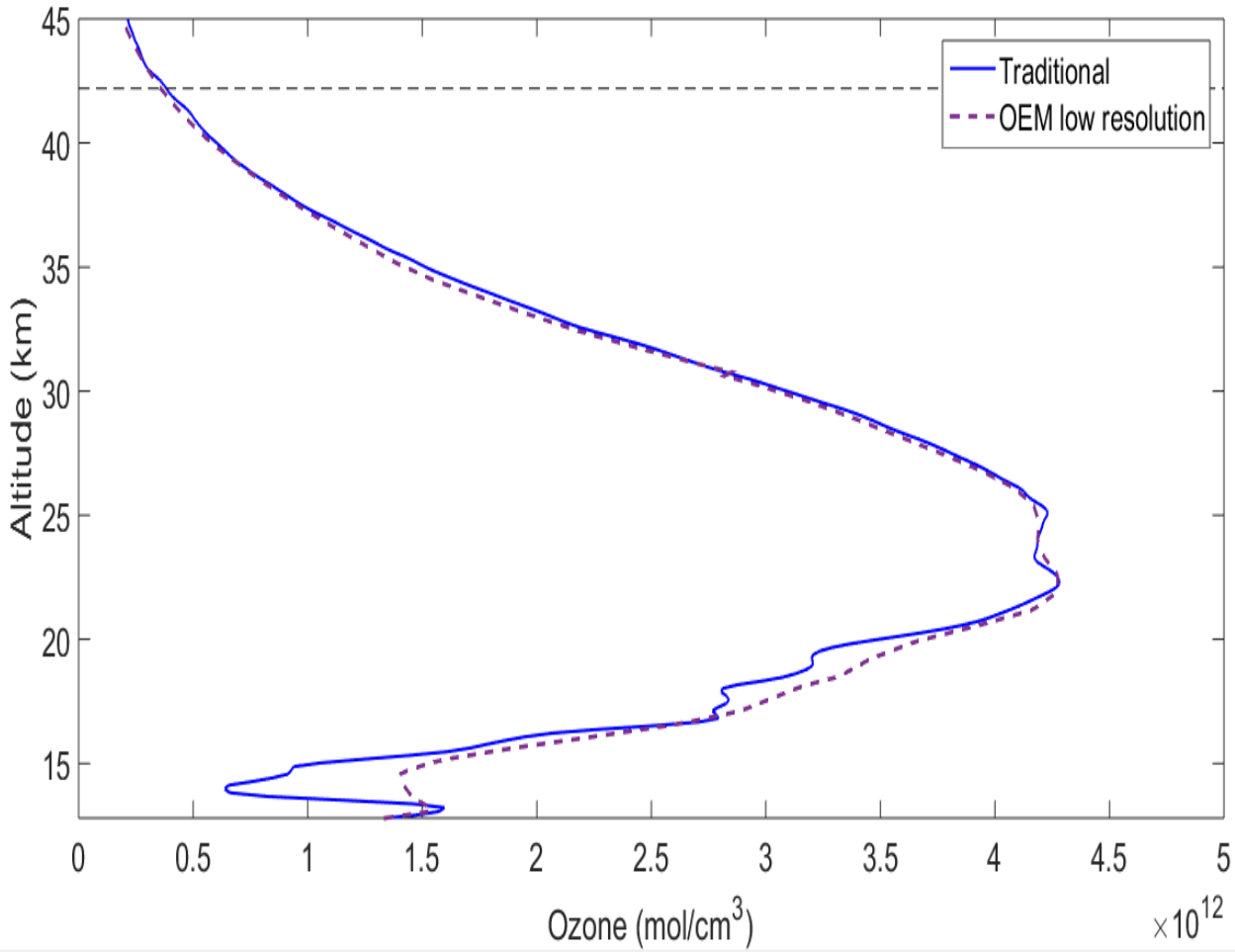
ozone density

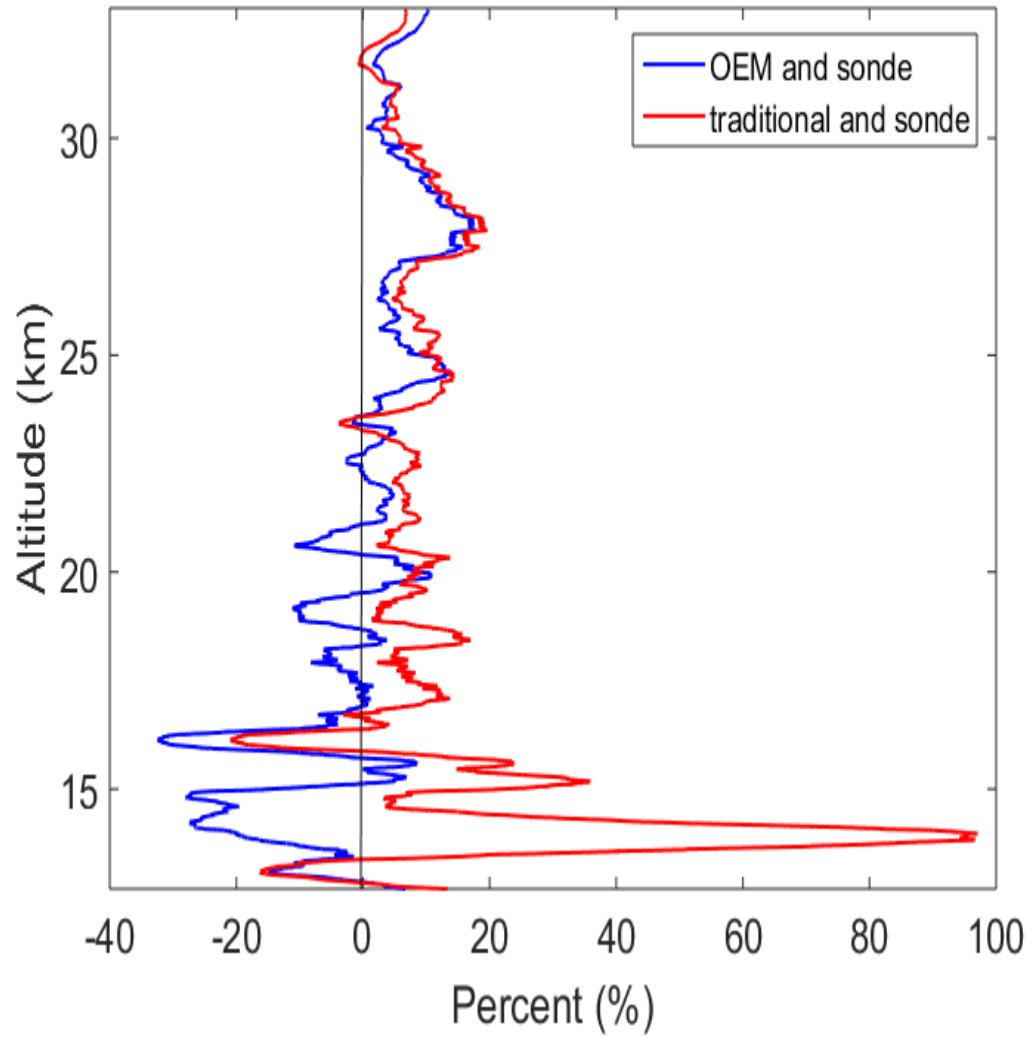
atmospheric extinction coefficient

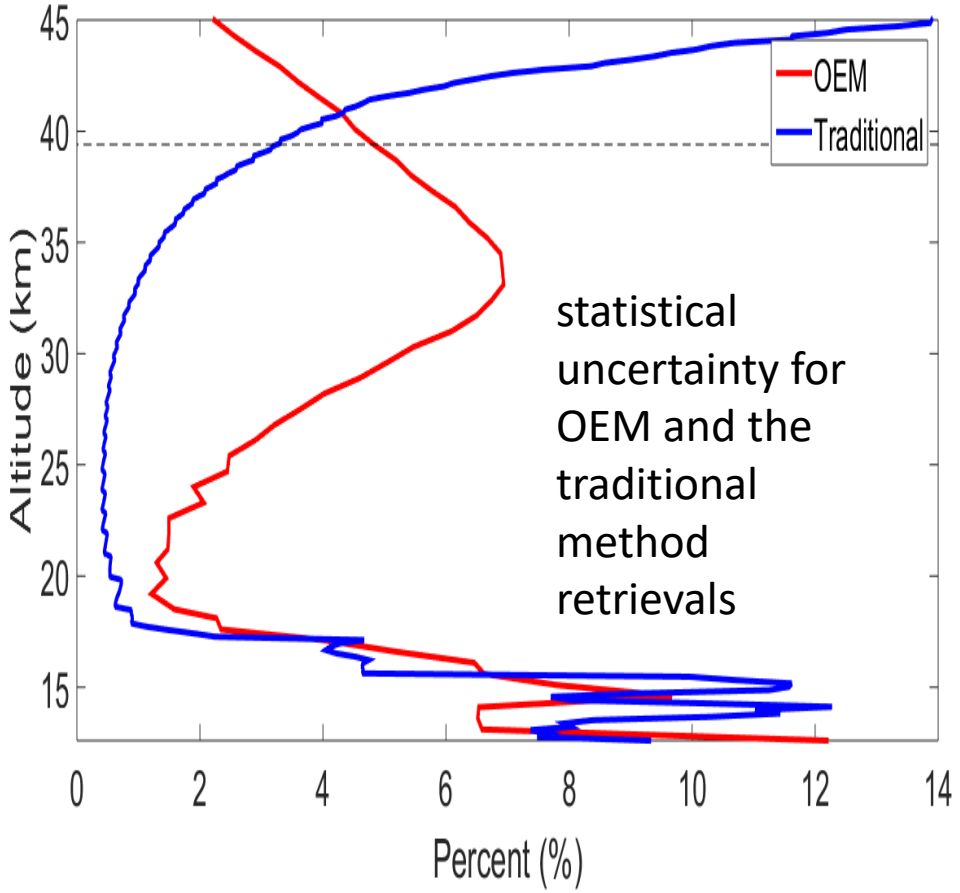
extinction due to other trace gases.



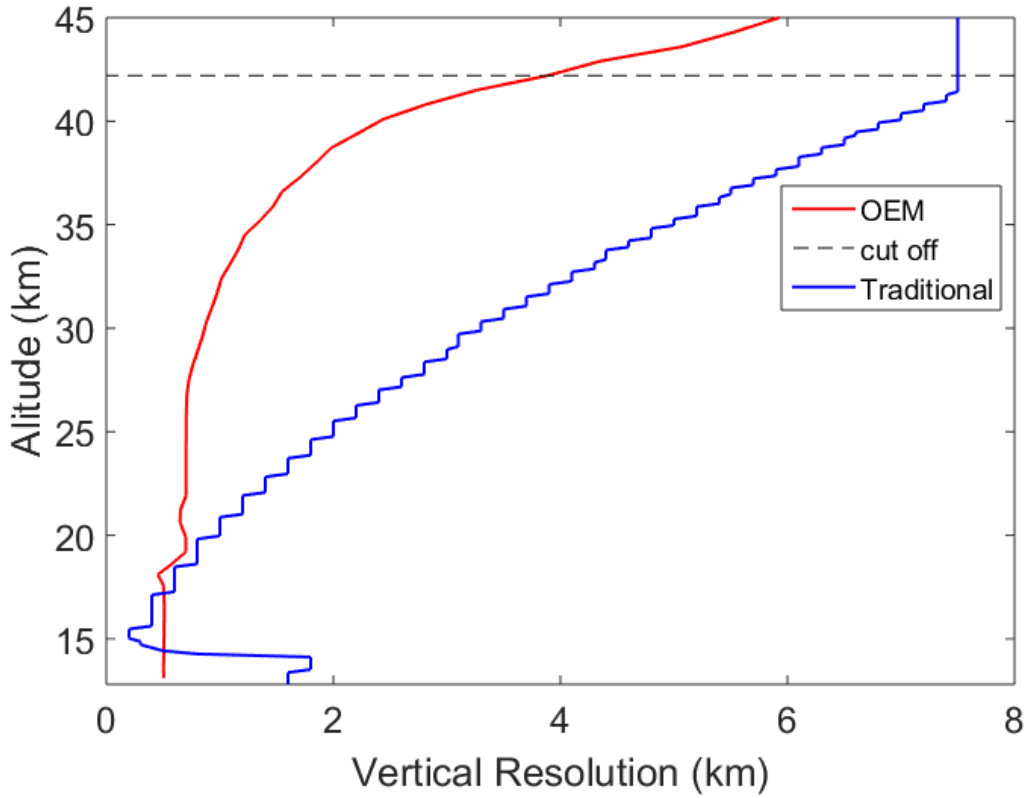
Using the OEM ozone density retrievals for Observatoire de Haute-Provence (OHP) observations for the night of July 26. 2017 is plotted against the sonde measurements and traditional analysis.


Traditional
OEM low resolution
Altitude (km)
Ozone (mol/cm^3)
$\times 10^{12}$


OEM and sonde
traditional and sonde
Altitude (km)
Percent (%)

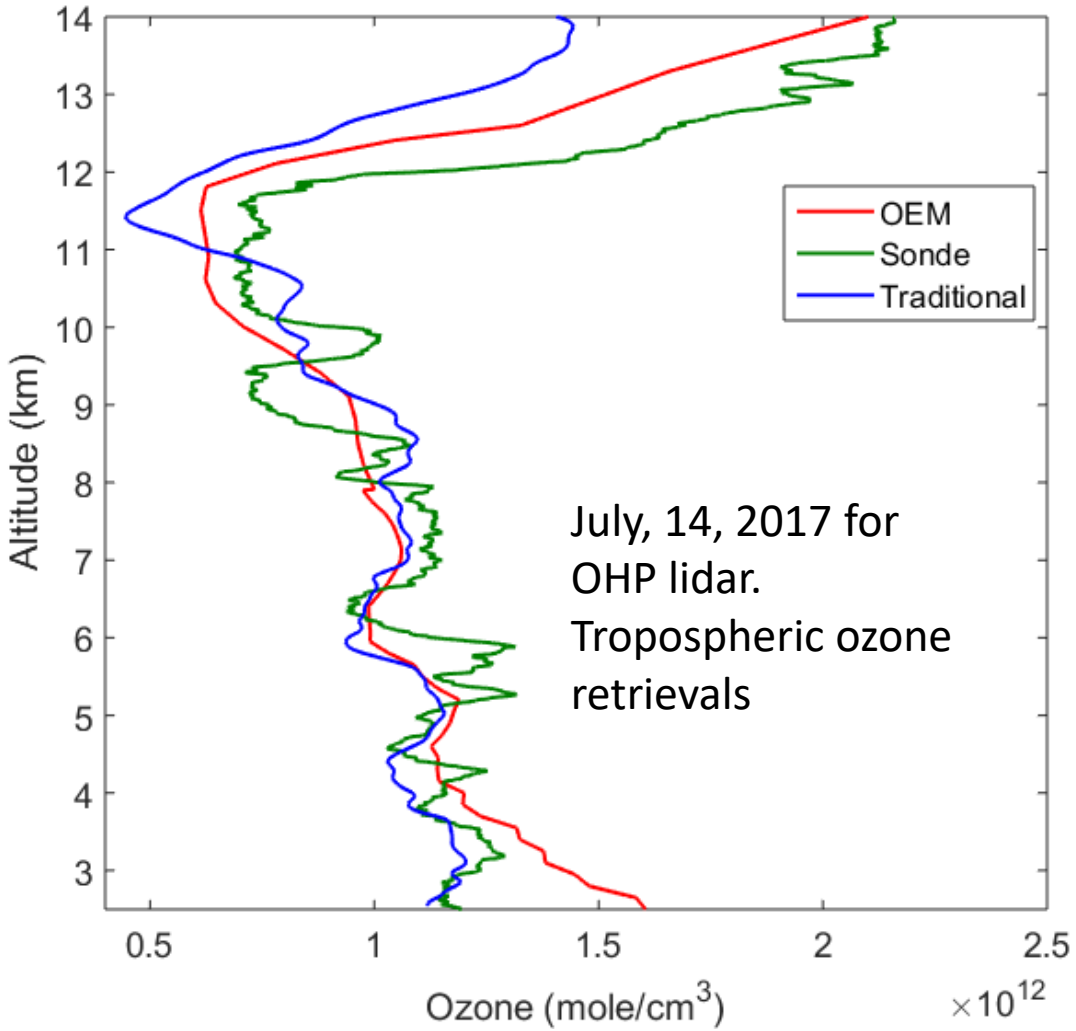


statistical uncertainty for OEM and the traditional method retrievals

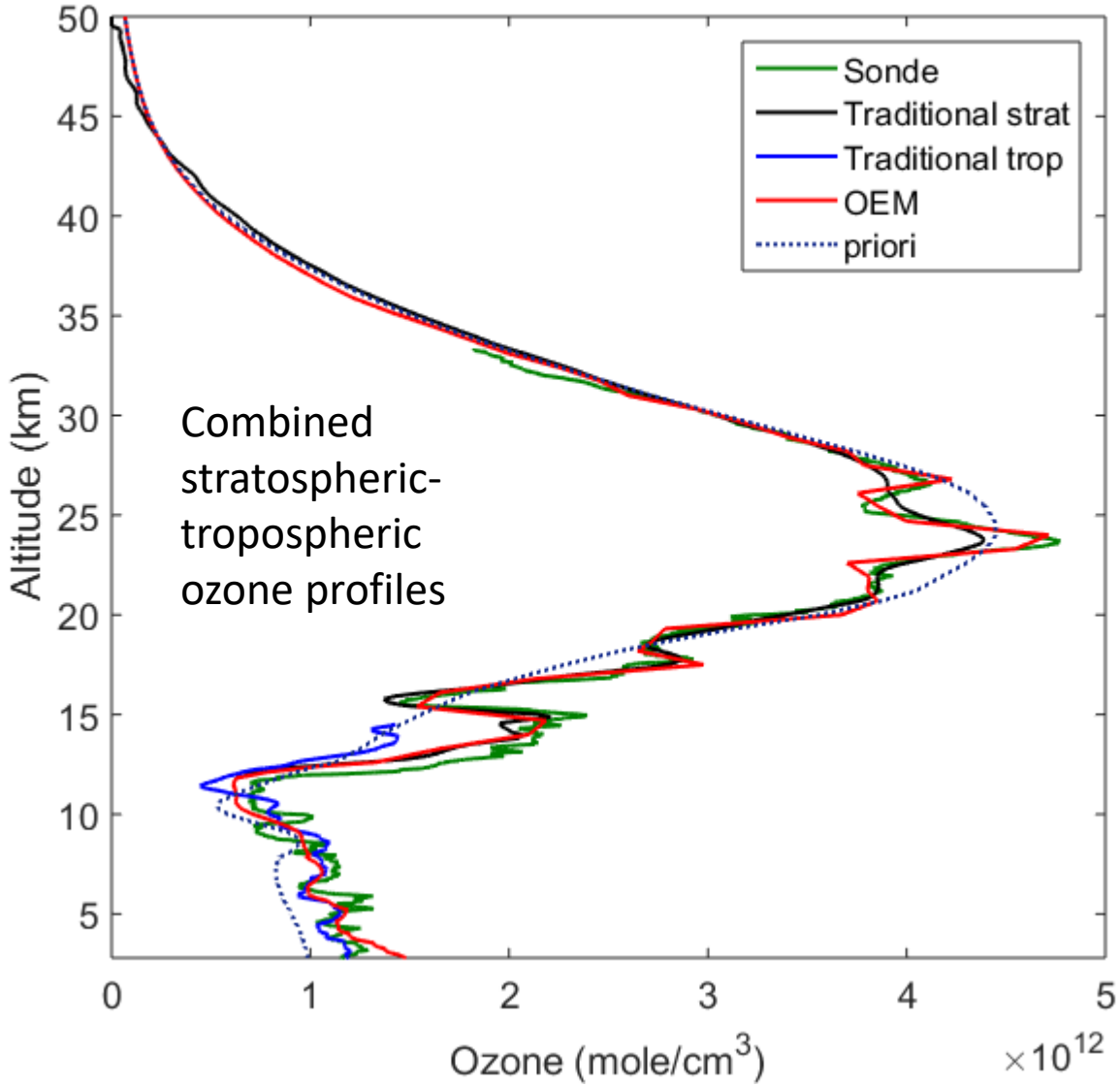


Trade-off between the vertical resolution and the uncertainty for the traditional method and the OEM.

Primary result :



July, 14, 2017 for OHP lidar. Tropospheric ozone retrievals

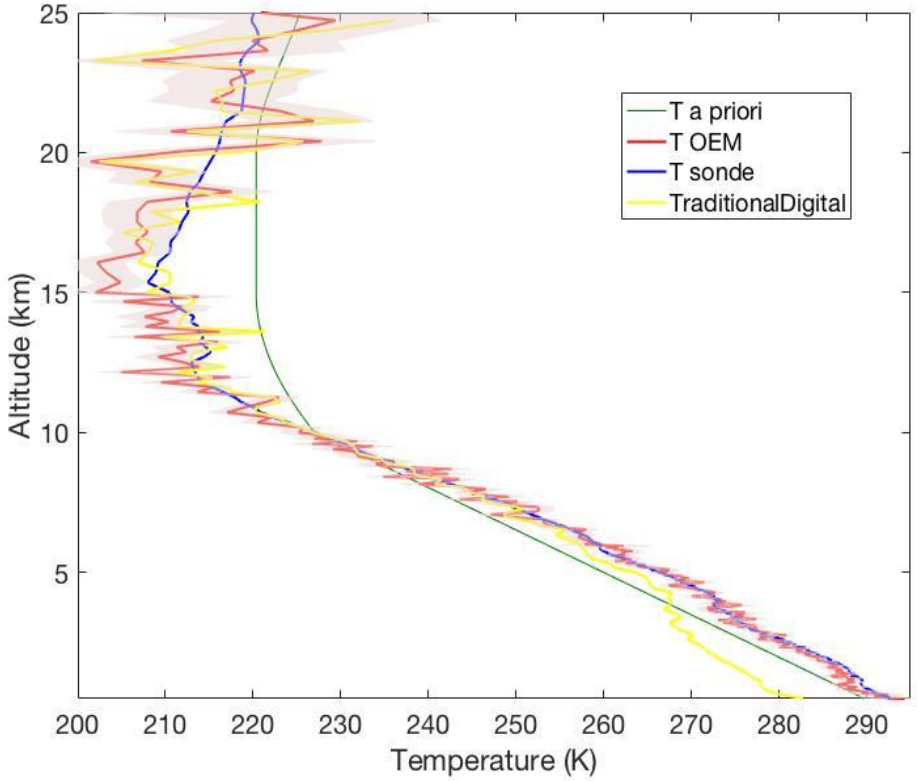


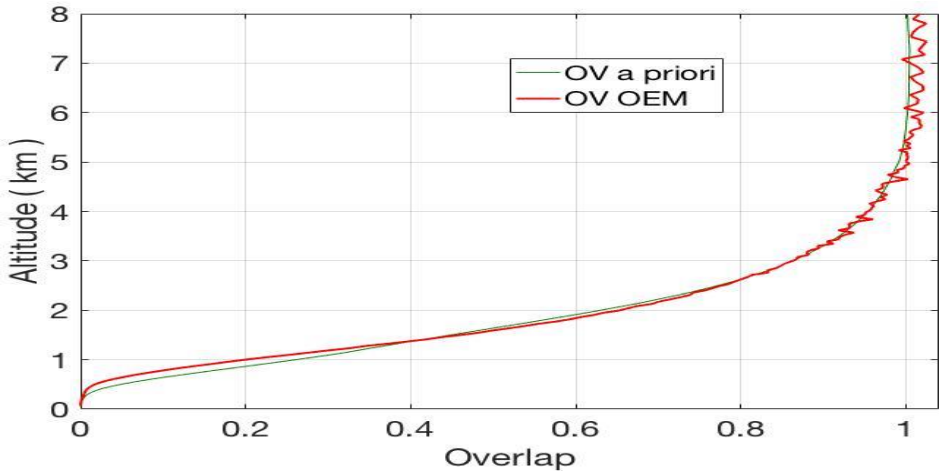
Combined stratospheric-tropospheric ozone profiles

OEM for PRR lidar temperature retrievals

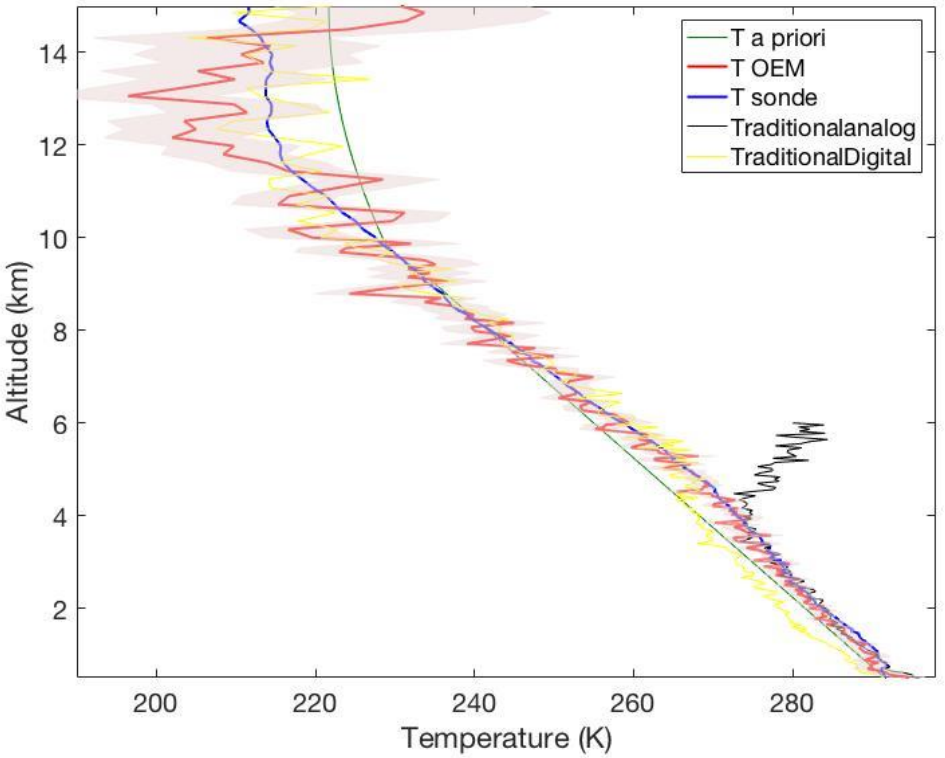
- Using RALMO PRR measurements for Clear Day and Night time retrievals are shown here.
- For clear night time OEM retrievals are good up to 25 km.
- For clear day time even with the high noise in the signal OEM retrievals are good up to 15 km.
- The retrieved overlap functions for clear conditions agree with in 10 % uncertainty.

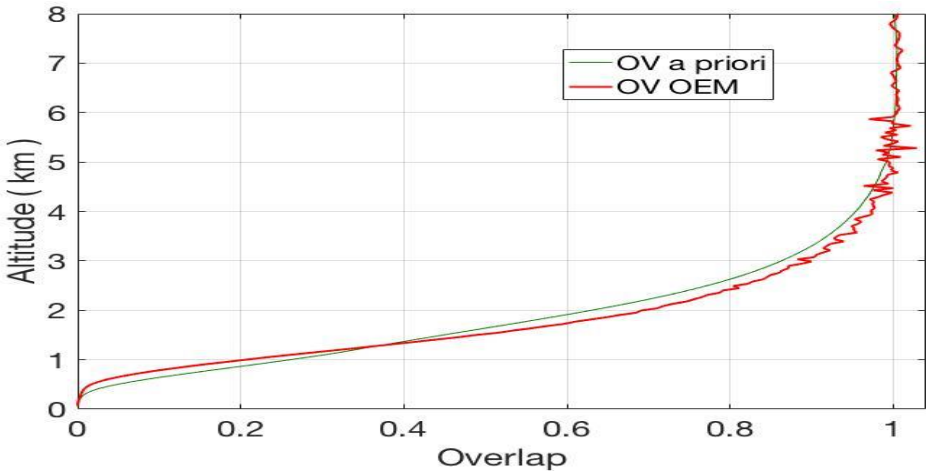
Case 1: 20110909 – Clear Night



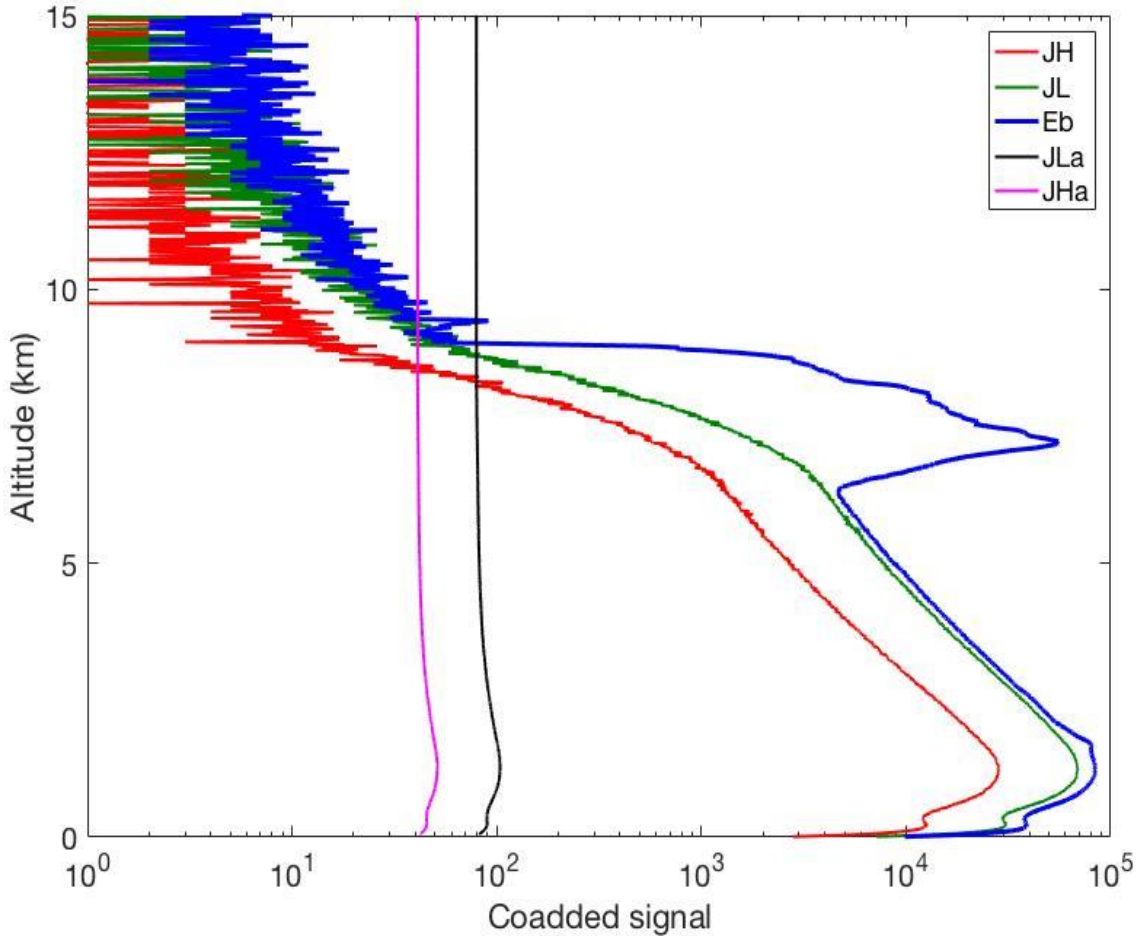


Case 2: 20110910 – Clear Day





Case 4: 20110705 Cirrus Clouds/ Heavy Clouds



Temperature retrieval above 5 km was not possible.

Why?

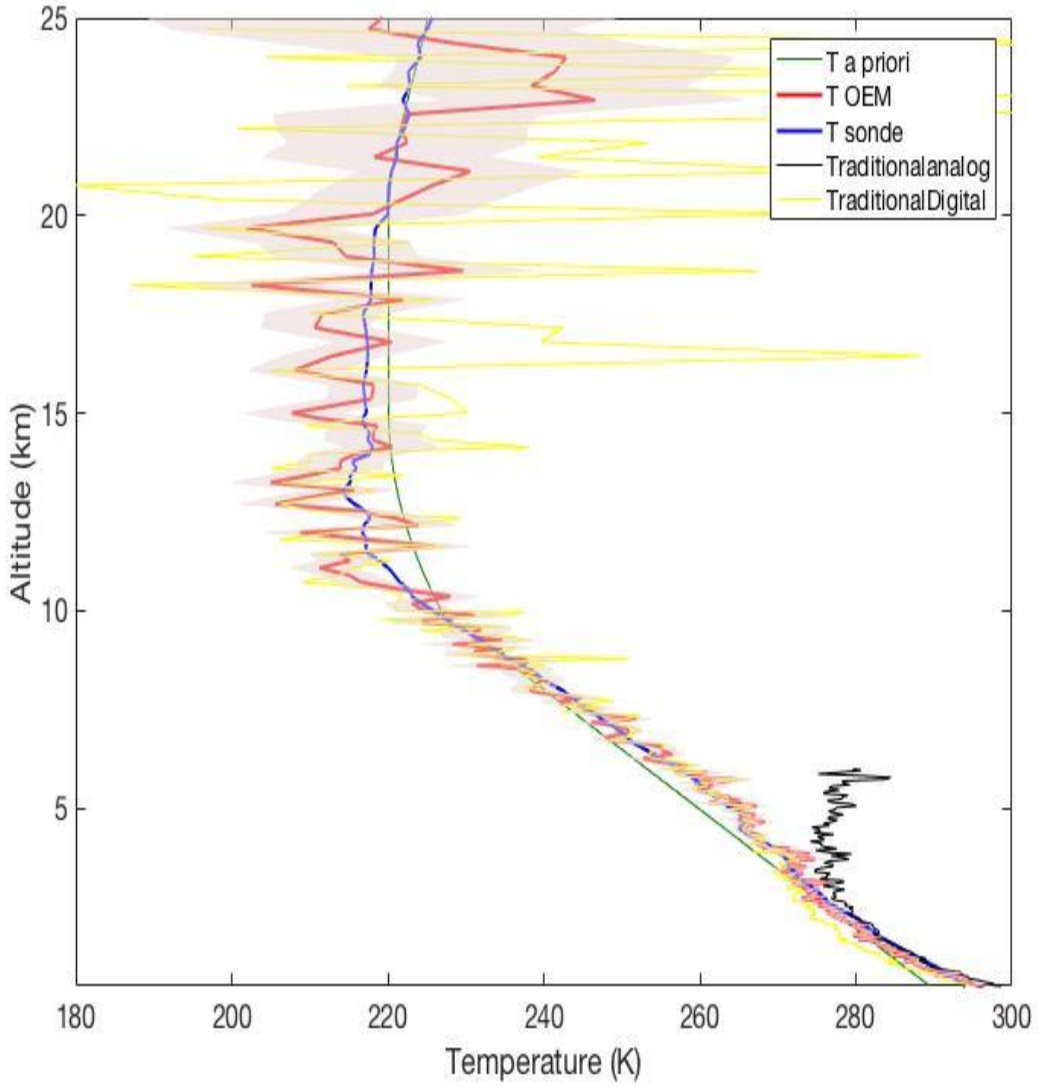
Aerosol extinction profile is calculated by assuming a Lidar Ratio. Estimation for **Lidar ratios** for clouds is tricky.

Solution?

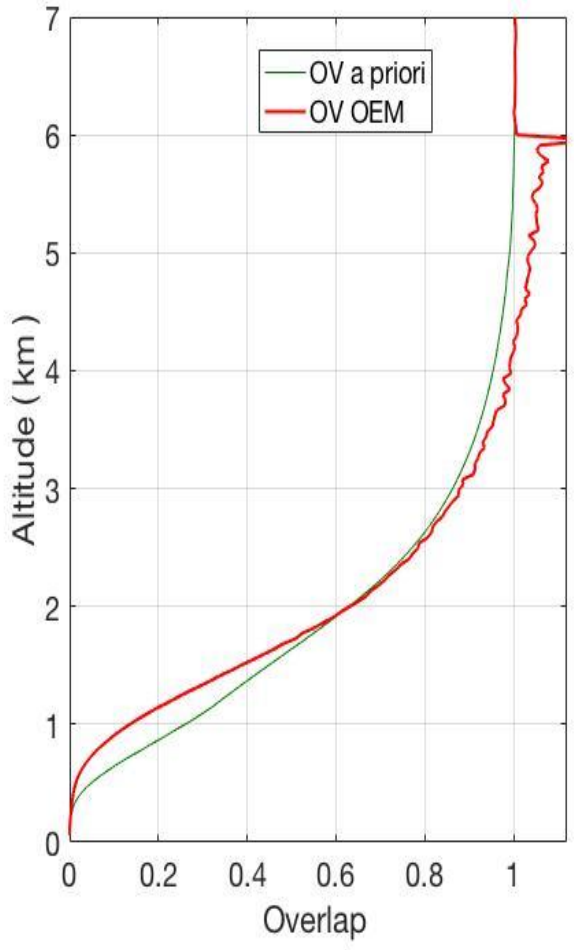
The OEM : Retrieve extinction above the cloud height.

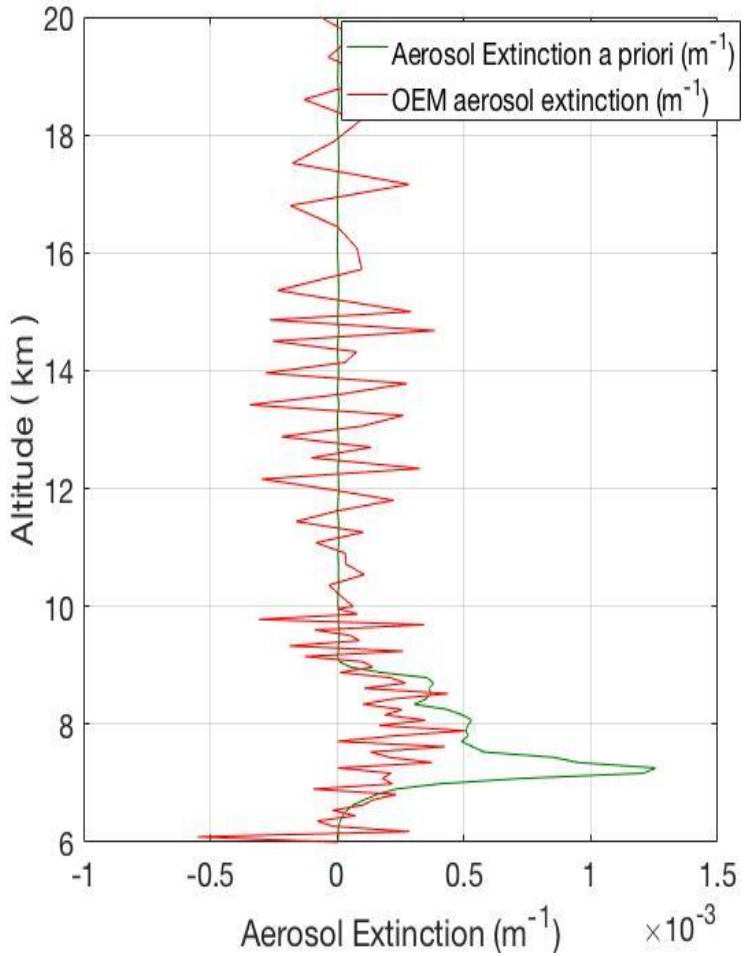
Does it work?

Yes, it does.



We can retrieve temperatures even inside the cloud.



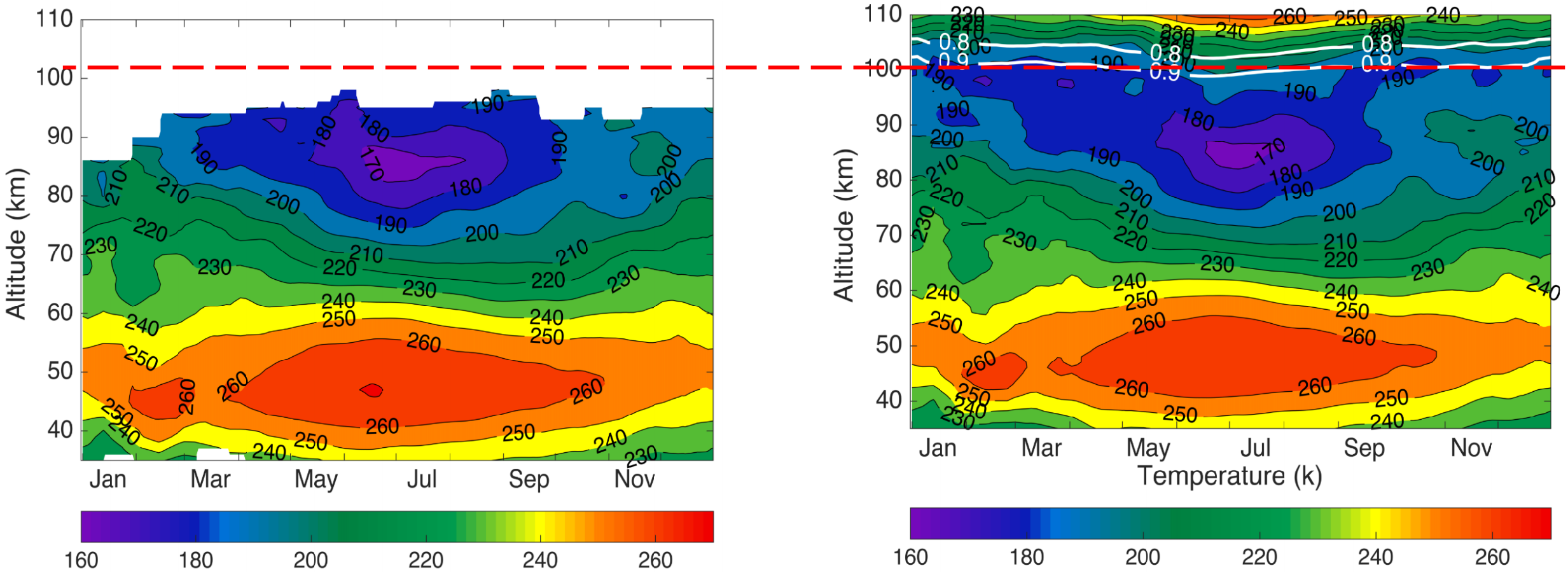


- Lidar ratio for cirrus cloud was assumed and using to determine the a priori aerosol extinction profile shown in the figure.
- The retrieved extinction is lower than what we assumed.

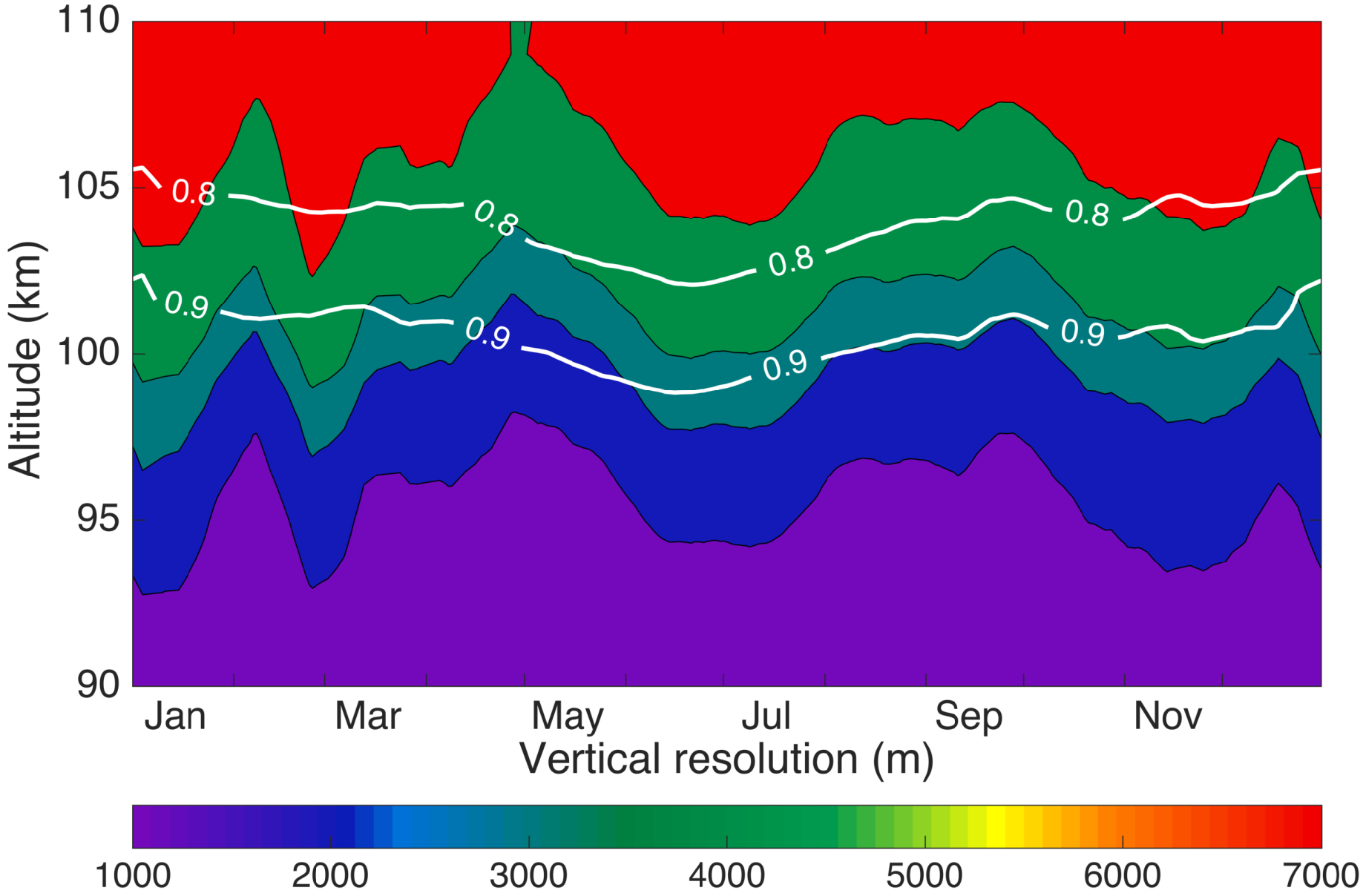
Temperature Climatology Composite Years (1994-2013)

HC climatology

OEM climatology

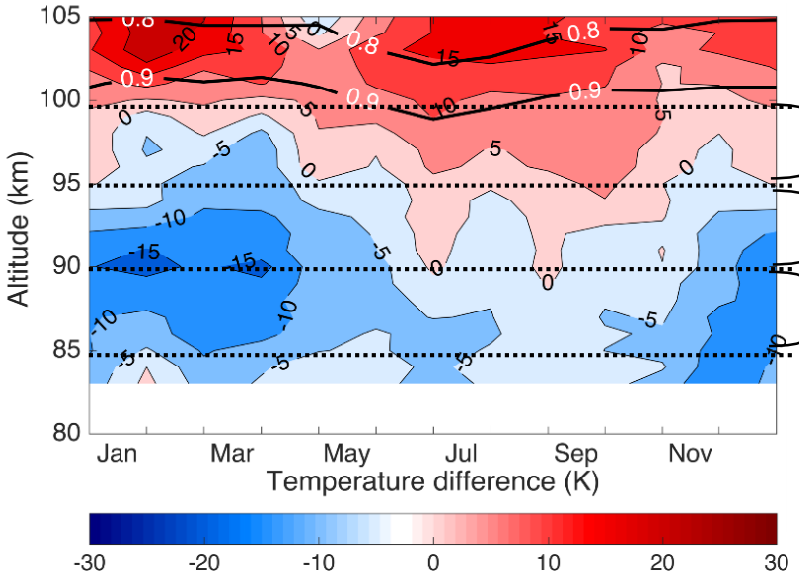


Vertical Resolution of PCL Temperature Climatology



Comparison between PCL and Sodium Temperature Lidar Climatology

PCL – CSU

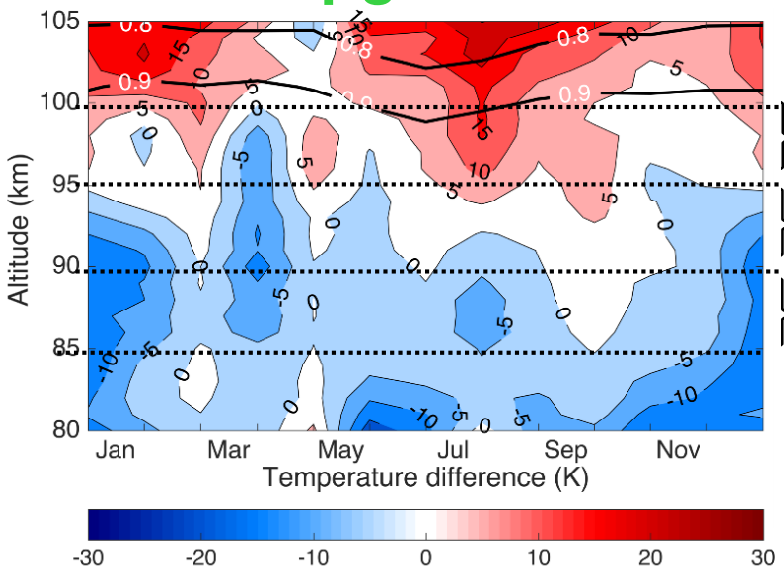


OEM: 6.6

OEM: 5.1 , HC: 6.2

OEM: 6.9 , HC: 8.4

PCL – upgraded CSU

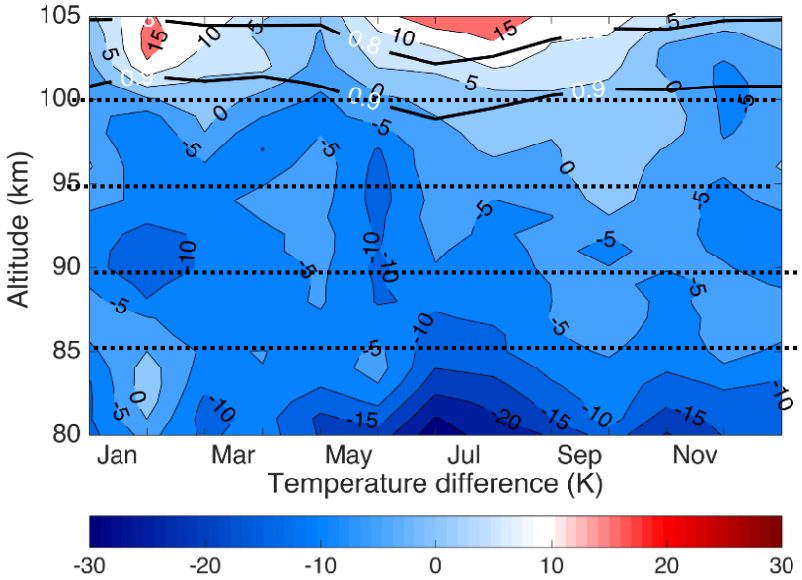


OEM: 7.8

OEM: 3.4, HC: 3.8

OEM: 4.1 , HC: 4.7

PCL – URB



OEM: 3.9

OEM: 4.4, HC: 6.7

OEM: 6.0 , HC: 8.1

T diff. between sodium lidars

Sodium lidars	85-90 km	90-95 km	95-100 km
CSU - URB	4.5	3.8	5.1
CSU-upgraded CSU	4.4	4.0	3.2
URB – upgraded CSU	4.6	5.7	7.1

Thanks for listening!

Questions?