Characterizing the Purple Crow Lidar to investigate potential sources of wet bias

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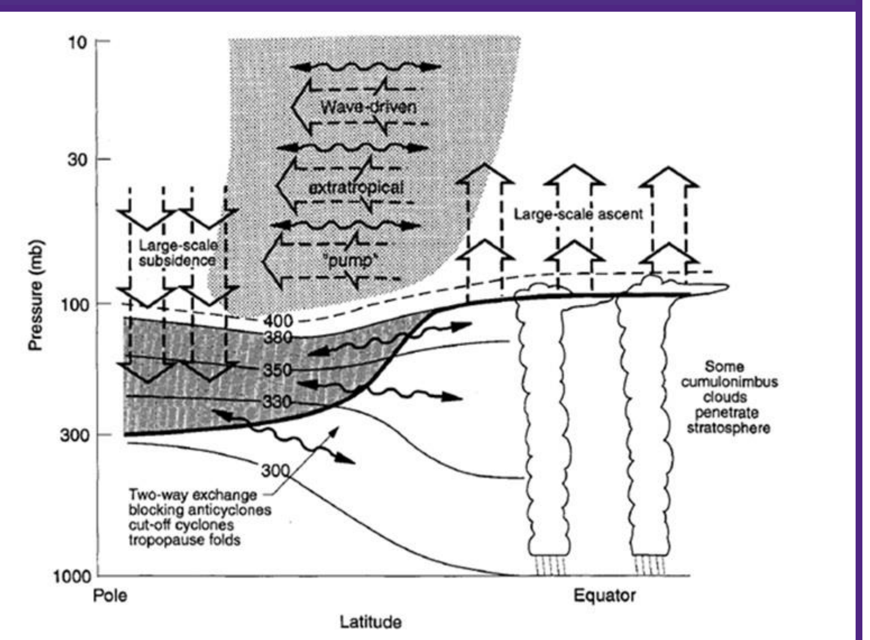
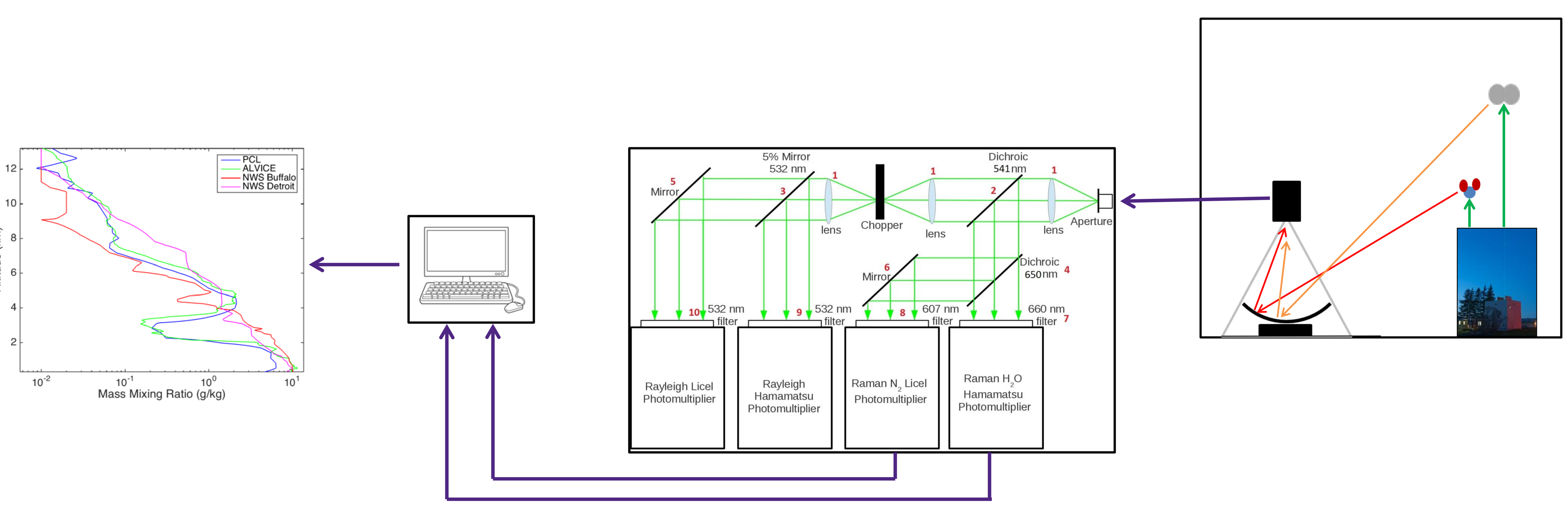
Importance of atmospheric water vapor

- Primary component of hydrological cycle
- Free radicals involved in ozone destruction
- Major role in radiation budget:
  - Absorbs infrared radiation (most abundant greenhouse gas)
  - Forms clouds (reflect incoming solar radiation)
- Increases in stratospheric water vapor causes an increase in surface temperatures
- Facilitates energy/material transfer over large scales (UTLS exchange)



UTLS (Upper Troposphere-Lower Stratosphere) exchange [3]

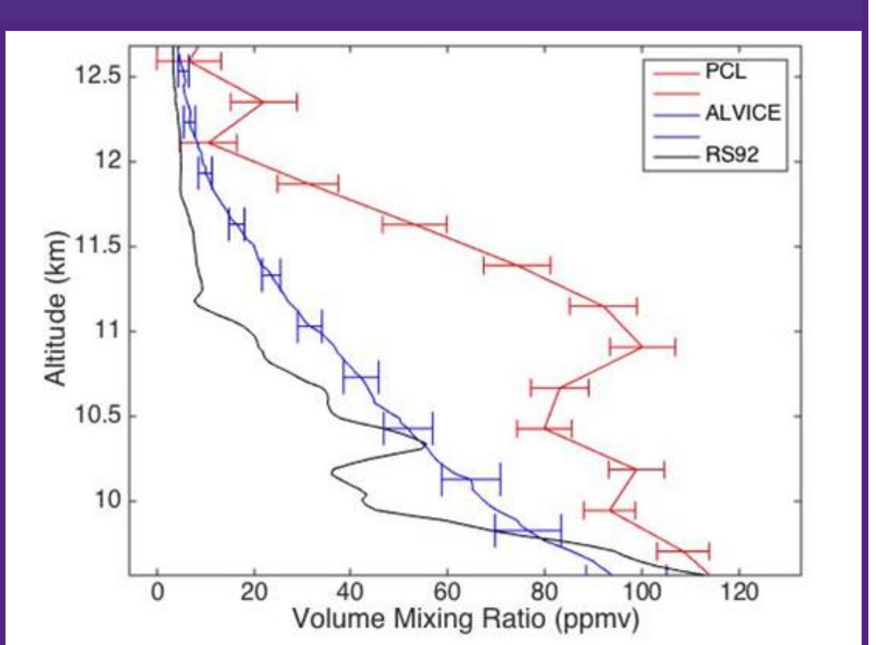
Purple Crow Lidar



ALVICE comparison

In Spring 2012, the Purple Crow Lidar (PCL) participated in a water vapor comparison with the NASA/GSFC ALVICE (Atmospheric Laboratory for Validation, Interagency Collaboration, and Education) lidar. Analysis showed that the PCL water vapor mixing ratio measurements were consistently higher than ALVICE (wet biased) [8].

Water vapor mixing ratio: $w \propto \frac{N_{\text{water vapor}}}{N_{\text{nitrogen}}}$



Wing 2012 [8]

Dead time Correction

At high photocount rates, the detectors cannot distinguish overlapping pulses, causing the measured count rate to be lower than the actual count rate (see right figures). This is corrected by identifying the *dead time*, the time required for the system to resolve individual pulses. The correction for a paralyzable system (where the counting extended by the next arriving pulse) is:

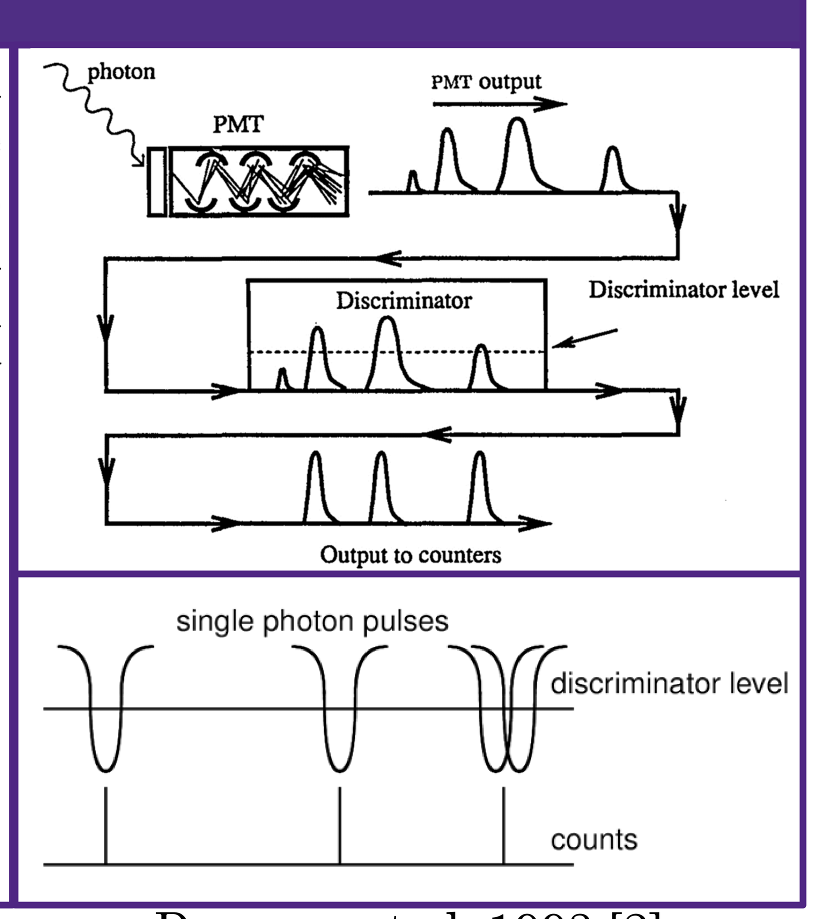
$$N = S\exp(-S\tau_d)$$

where:

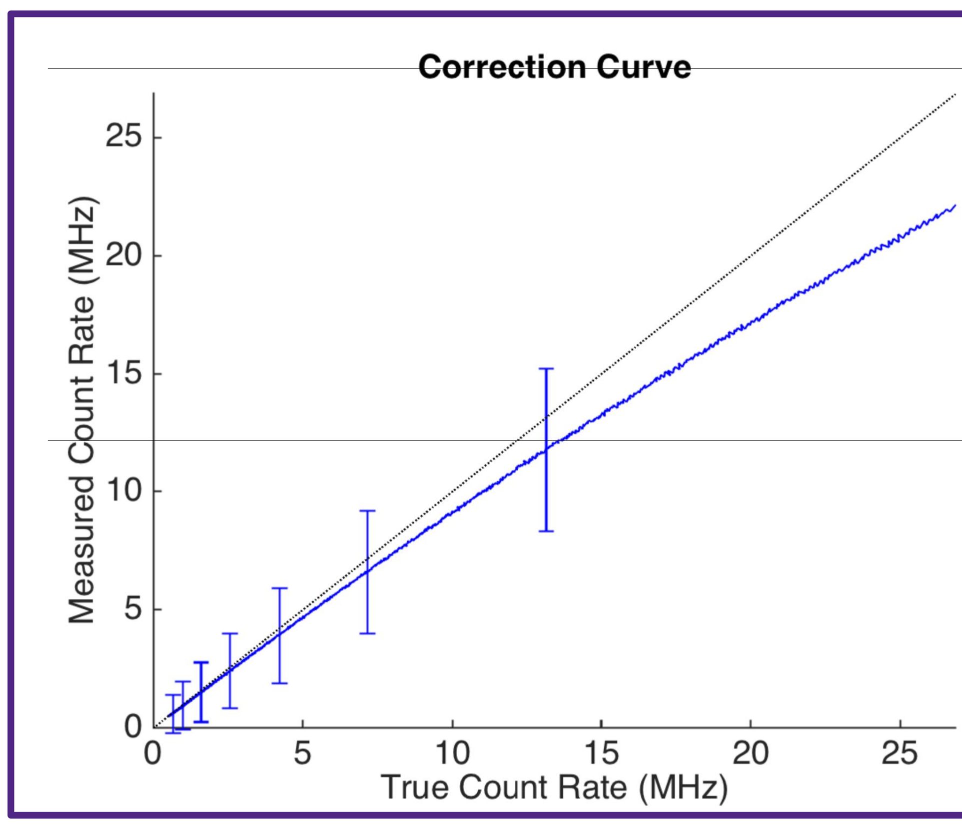
N = Observed count rate

S = True count rate

τ_d = Deadtime



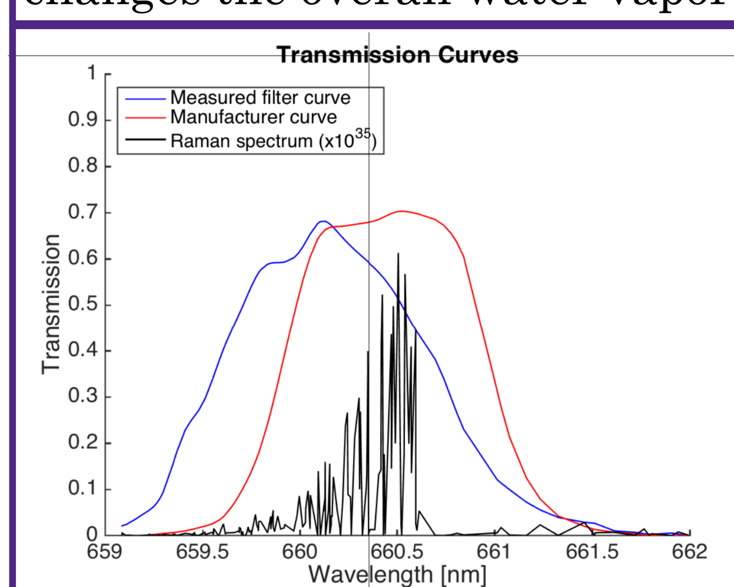
Donovan et al. 1993 [2]



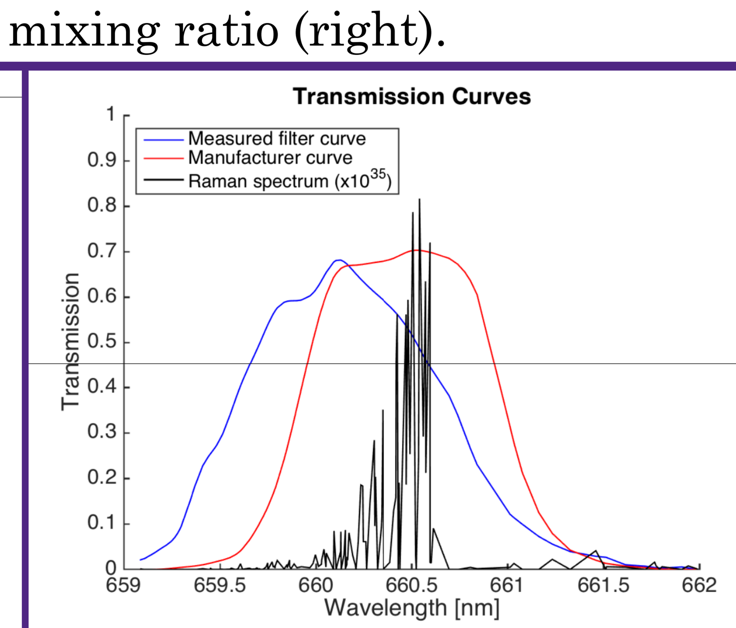
Finding deadtime:
By comparing the actual count rate (assumed to be analog or neutral density filter-attenuated signal) to the measured count rate (digital or attenuated signal), the dead time can be calculated (see left figure).

Temperature Dependence Correction

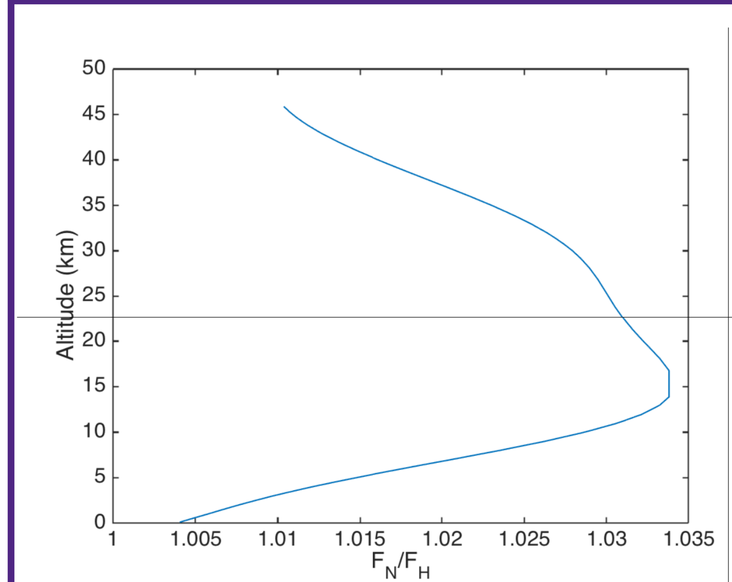
As atmospheric temperature changes, the Raman backscattering cross-section changes. If the interference filter used has a narrow passband, it might be sensitive to changes in the cross-section, resulting in a loss of signal. The top figures show how the cross-section spectrum changes from 30°C to -60°C. The lower figures show the temperature sensitivity correction (left) and how much it changes the overall water vapor mixing ratio (right).

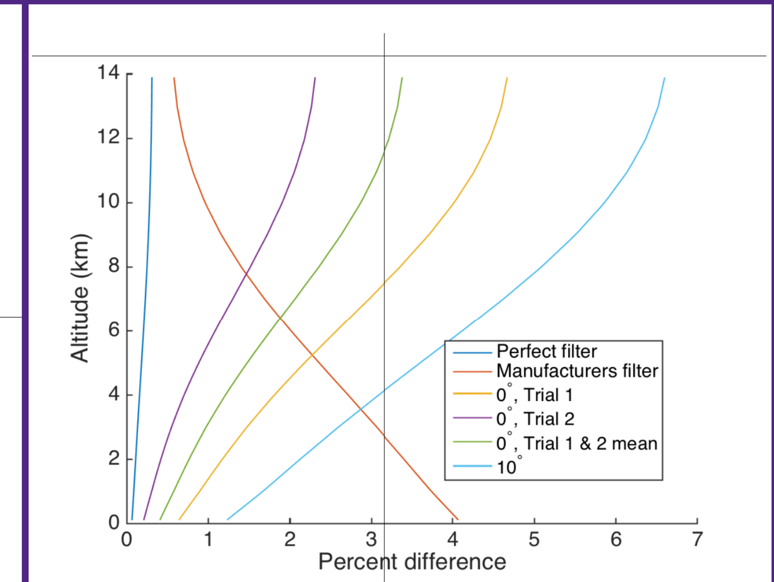


T = 30°C (ground)



T = -60°C (Tropopause)





Discussion

A summary of the corrections considered is shown below:

Correction	Affected Altitude	Maximum change affected altitude (%)
AC offset	All heights	0.001
Warm-up	All	0.08
Linear background	Middle, upper	>200
Deadtime	Lower	Small
Temperature dependence	Middle, upper	4
Overlap	Lower	6
Fluorescence	???	???

Future Work

- Use OEM to retrieve background, deadtime, and mixing ratio, along with a full uncertainty budget
- Examine possible system fluorescence

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