NASA LASE System:
Comparison of Water Vapor Measurements During AFWEX with LASE as a Reference

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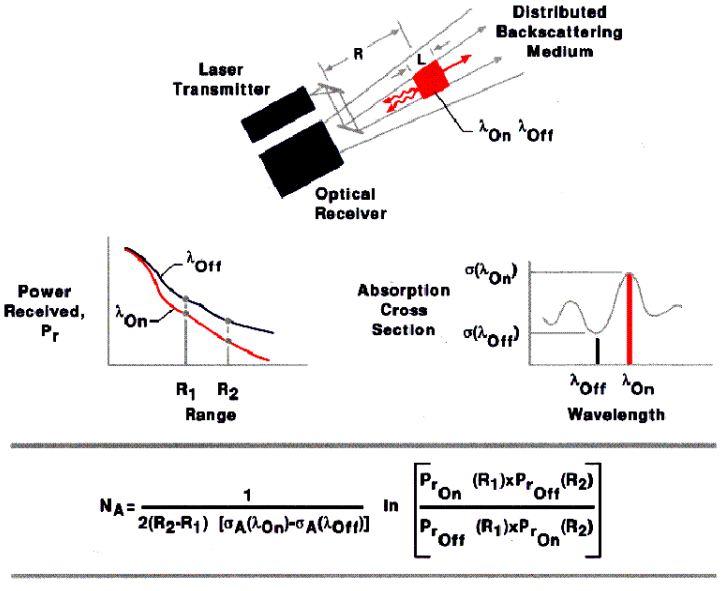
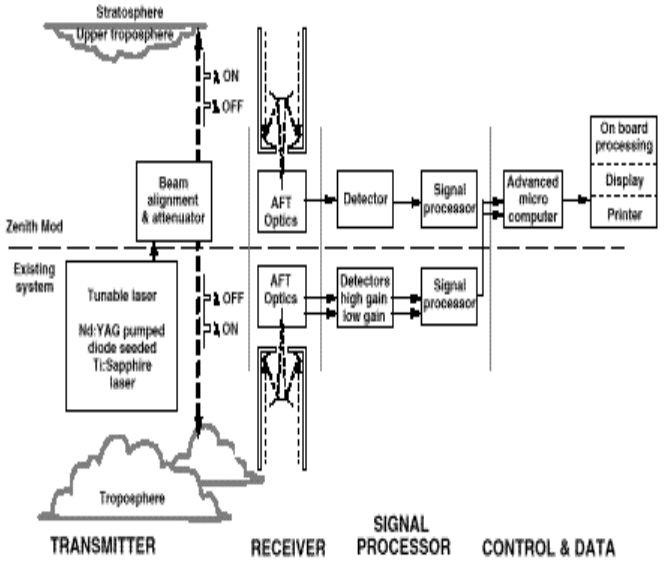
Lidar Atmospheric Sensing Experiment (LASE)



Airborne Water Vapor DIAL

- Laser
  - 5 Hz doubled-pulsed Ti:sapphire
  - 100 mj at λ_{on} and λ_{off}
- Wavelengths
  - 815 nm (λ_{on}- λ_{off} = 40-70 pm)
  - Two separate line pairs
- NASA ER-2, P-3, DC-8 aircraft
- Simultaneous nadir, zenith operations
- Real-time data analysis and display

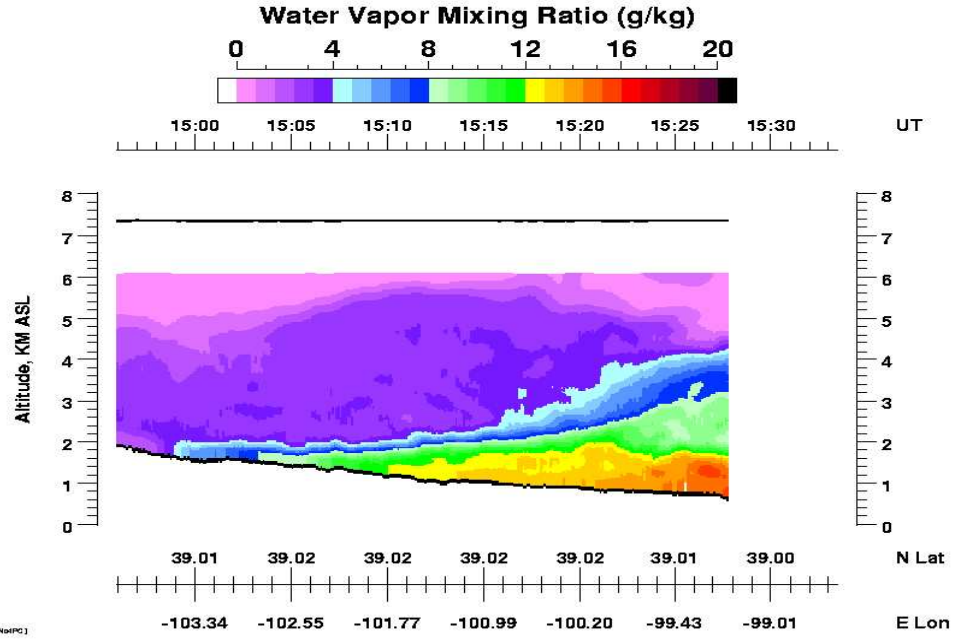


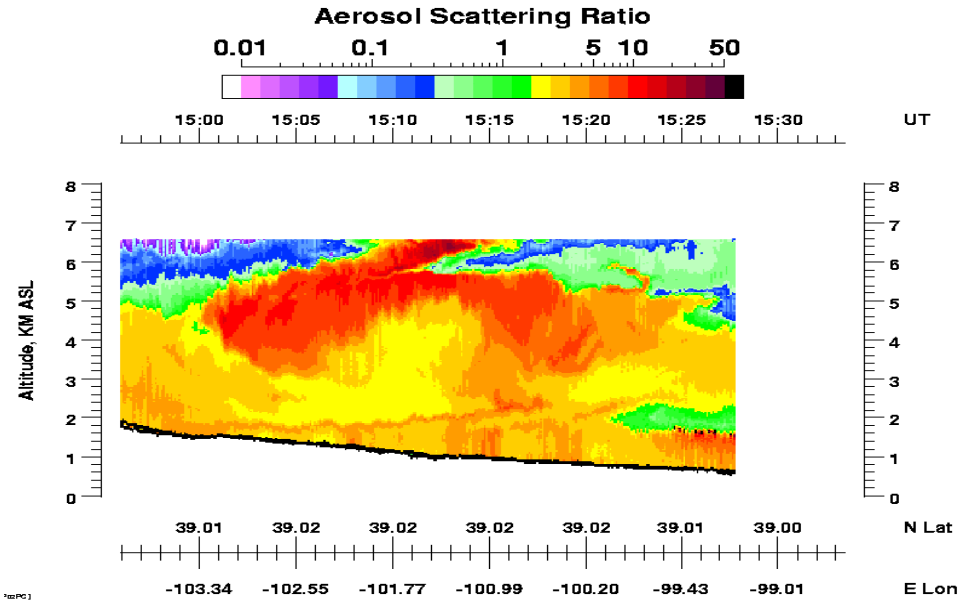
LASE Water Vapor, Aerosol, & Cloud Profiling on NASA DC-8

Water vapor profiles

- daytime and nighttime
- surface to upper trop.
- 0.01 to 25 g/kg
- accuracy: 6% or 0.01 g/kg
- resolution (variable)
  - vertical: 330 m
  - horizontal: 14 km (1 min)

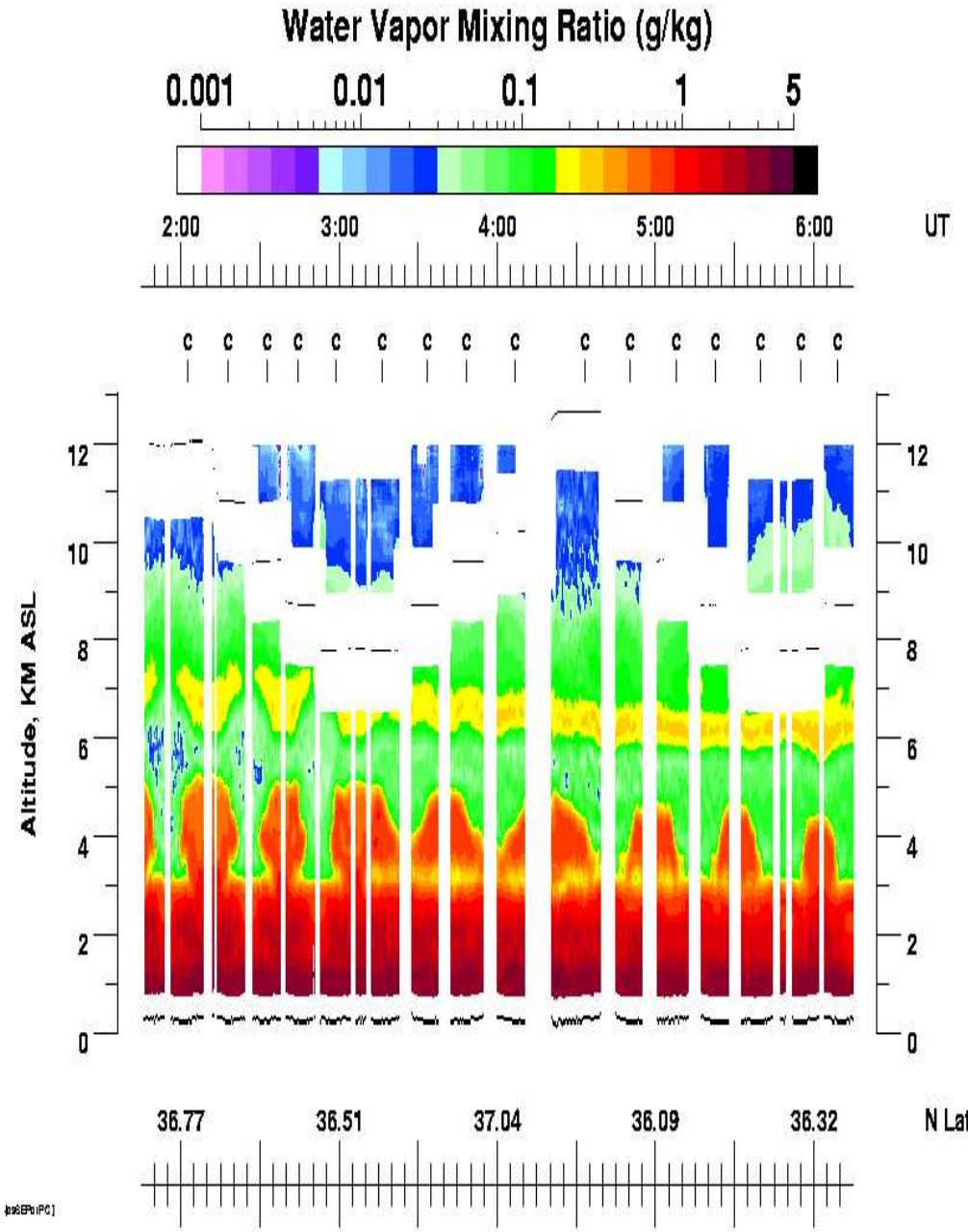
- **Aerosol/cloud profiles**
  - daytime and nighttime
  - 0.03 to 25 km
  - -resolution (variable)
    - vertical: 30 m
    - horizontal: 200 m

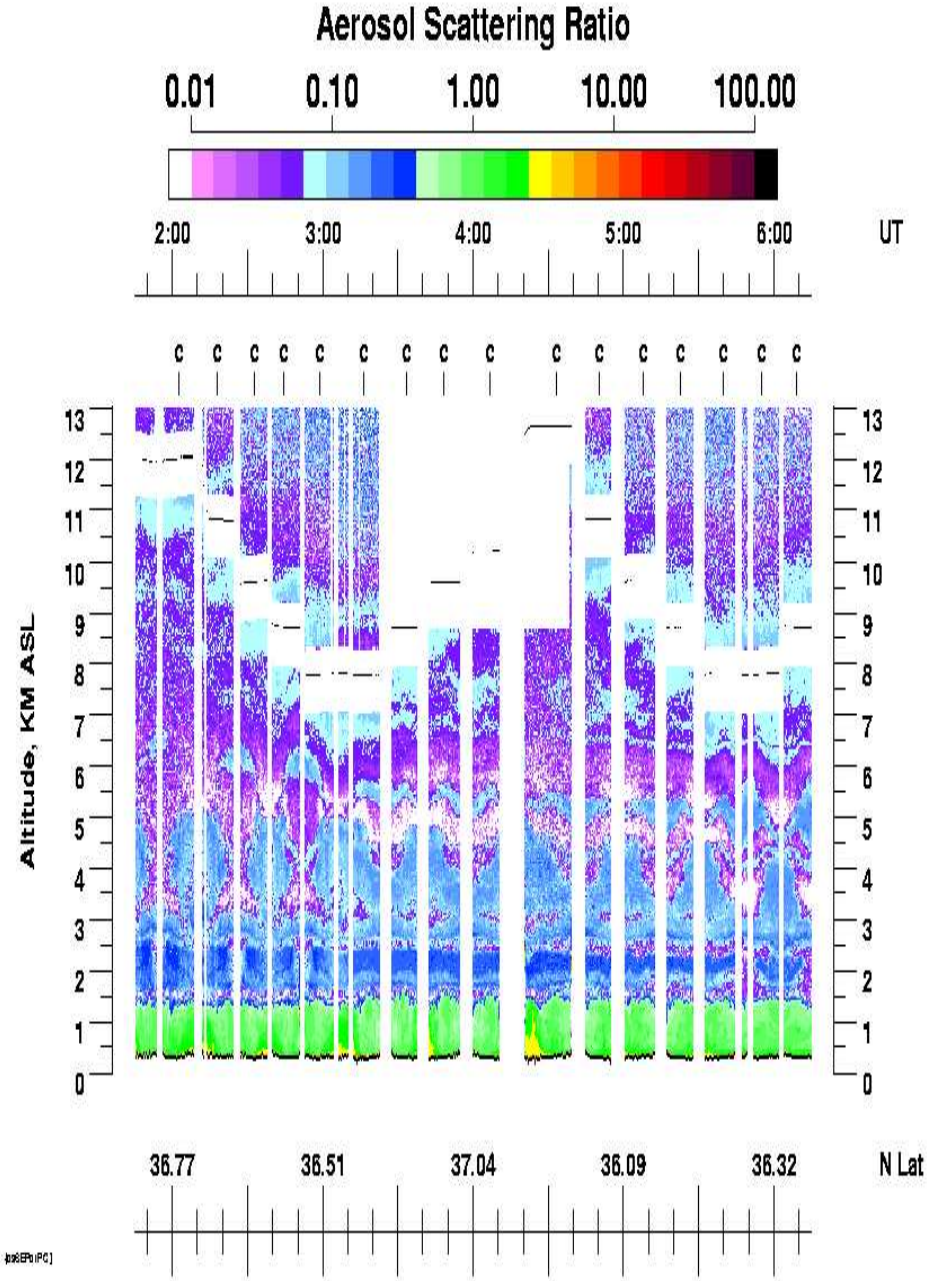




Examples of LASE profiles

DC-8 Flight 7 December 5, 2000





AFWEX data used for comparisons

Profiles

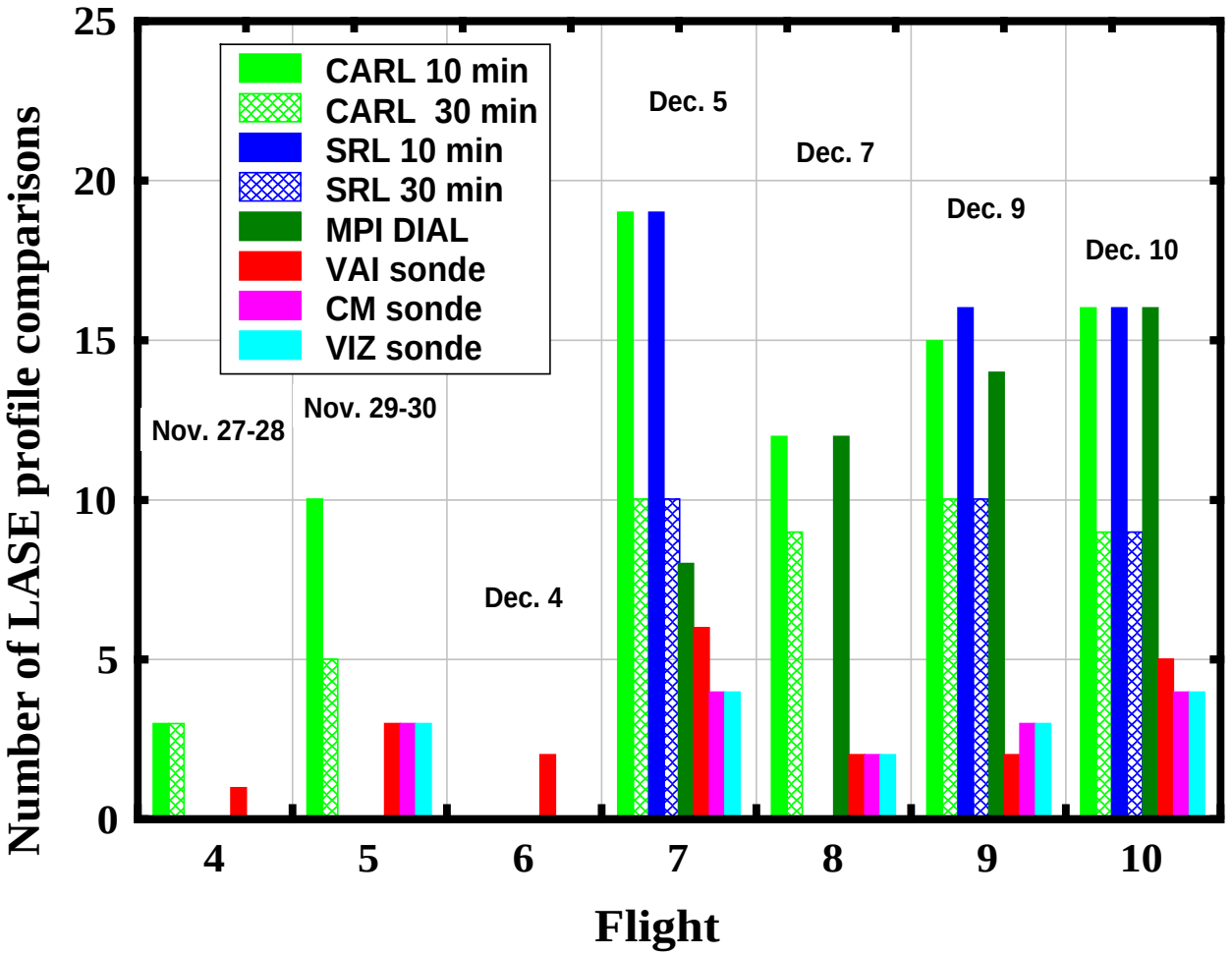
- LASE (Lidar Atmospheric Sensing Experiment)
- CART Raman Lidar (CARL)
    - Initial
    - Additional correction developed to correct for overlap function
- NASA GSFC Scanning Raman Lidar (SRL)
- Vaisala RS80H radiosonde data (VAI), (December, 2000) (Uncorrected)
    - Scaled to MWR, (Turner, January, 2002)
    - Corrected for calibration and calibration temperature dependence (Lesht, Jan. 2002)
    - Above corrections plus time lag correction (Miloshevich, March, 2002)
- Snow White Chilled Mirror radiosonde data (CM)
- Sippican radiosonde data (VIZ)

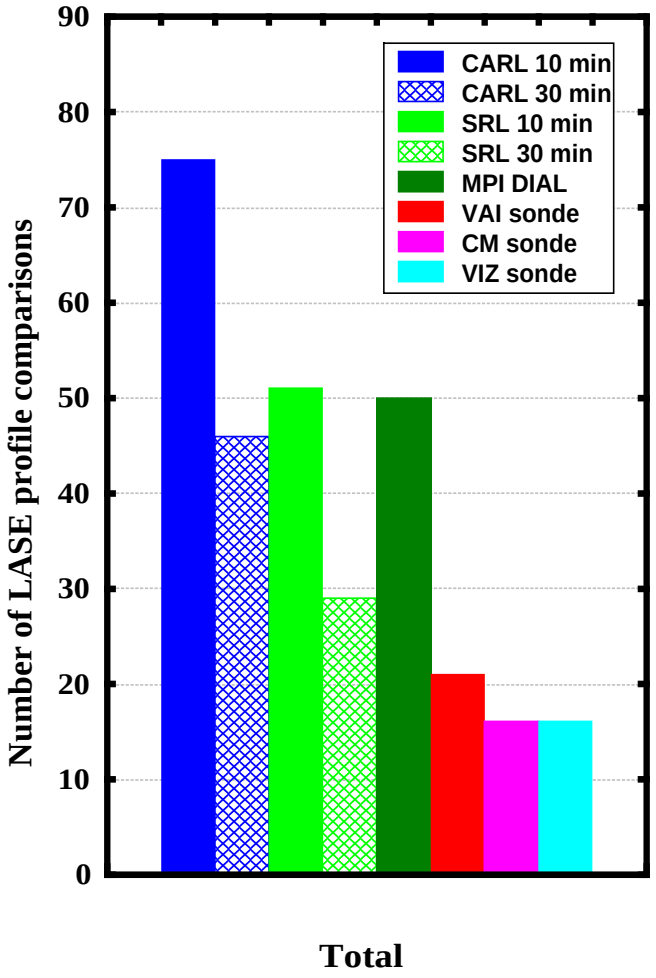
DC-8 In situ

- Cryogenic hygrometer (CRYO)
- Diode Laser Hygrometer (DLH)

Breakdown of LASE profile comparisons

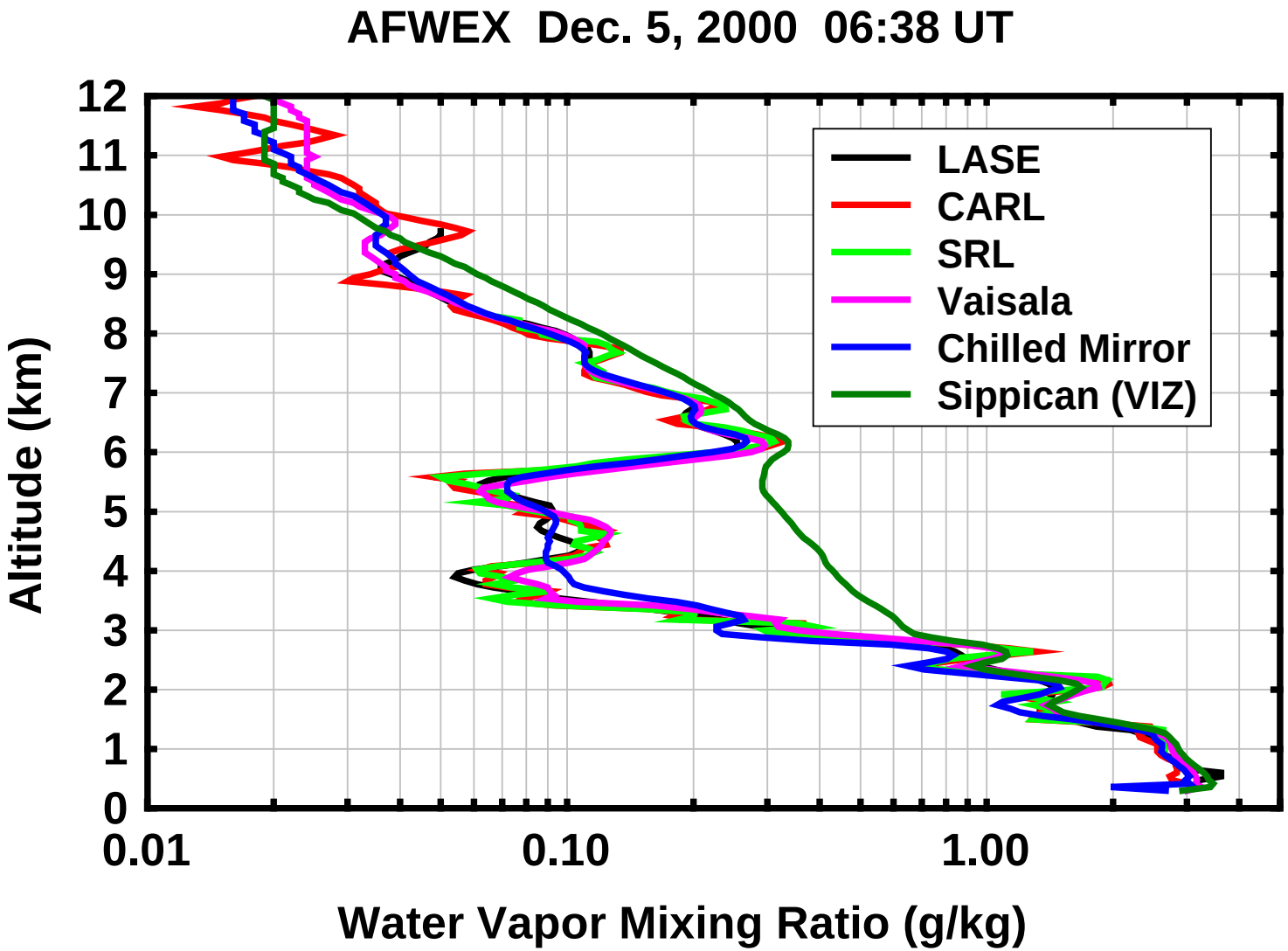
Number of LASE profile comparisons ranges from 75 (DOE ARM CART Raman lidar) to 16 (Chilled Mirror, Sippican) sondes





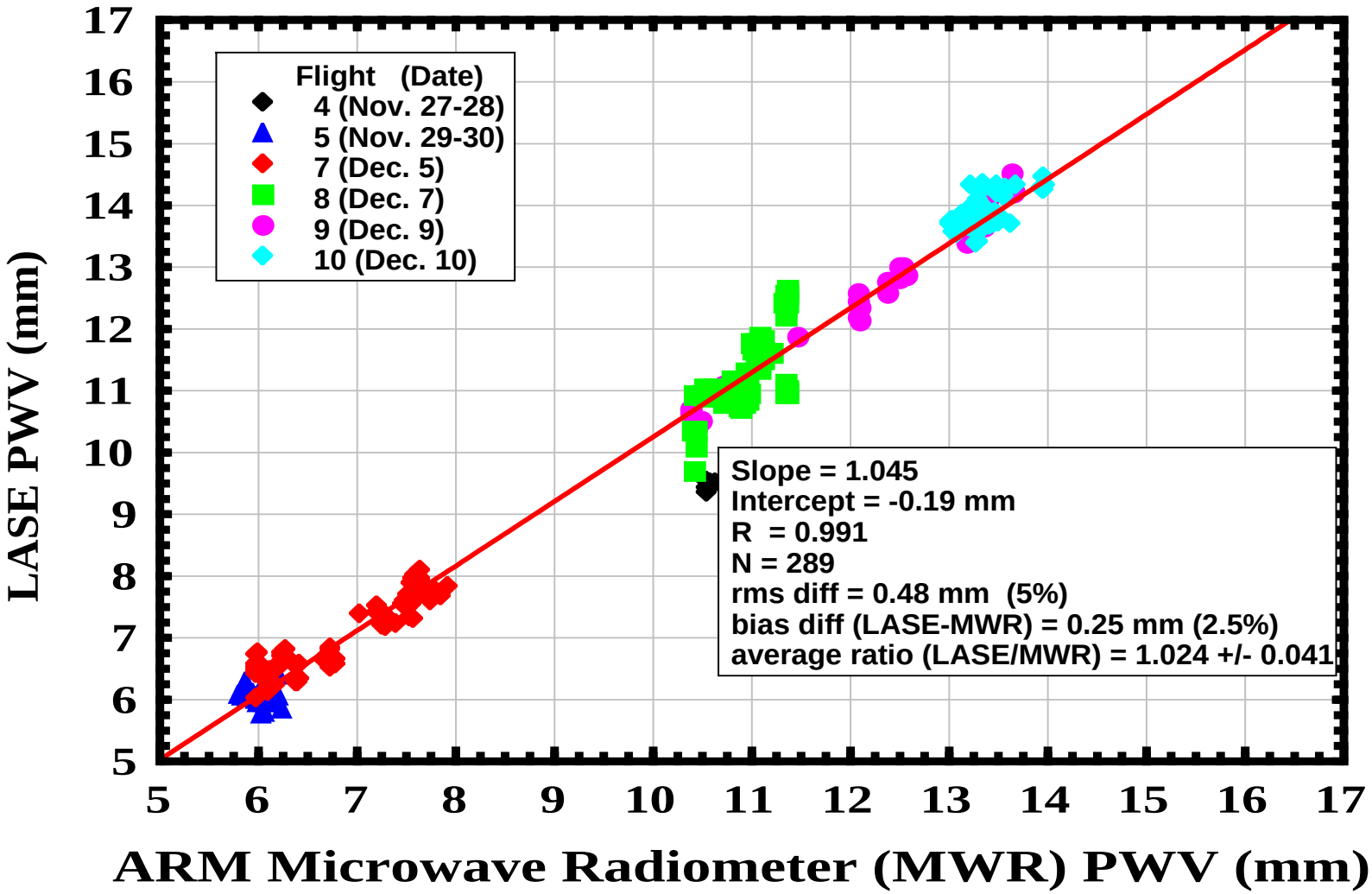
Example Water Vapor Profile Comparison

CART Raman (CARL) and Scanning Raman (SRL) Lidar profiles correspond to 10 minute averages
LASE profile corresponds to a 2 minute average centered over the SGP site.



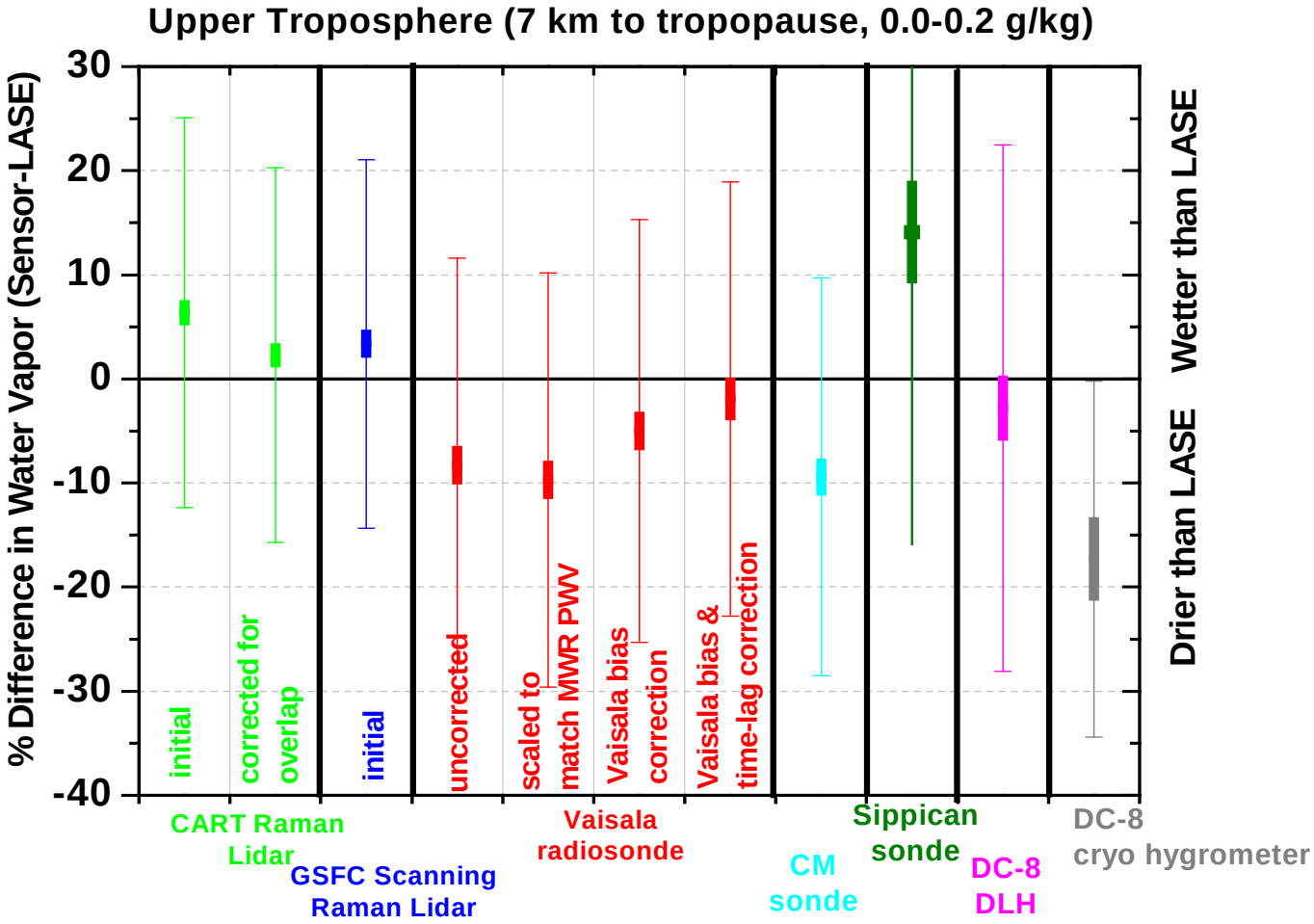
Precipitable Water Vapor (PWV) comparison (LASE vs. MWR)

Average bias differences showed MWR PWV drier than LASE by about 2.5%

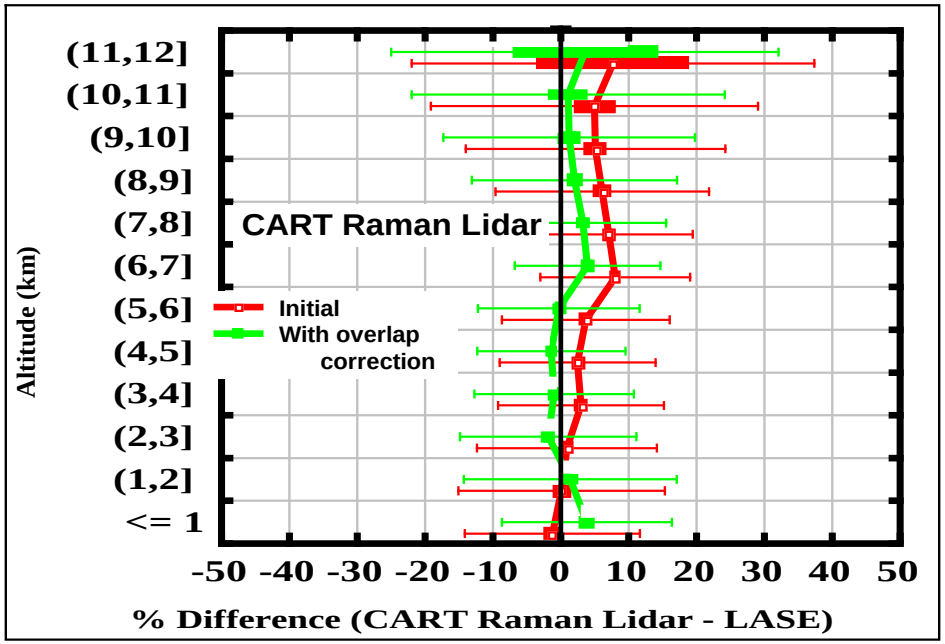


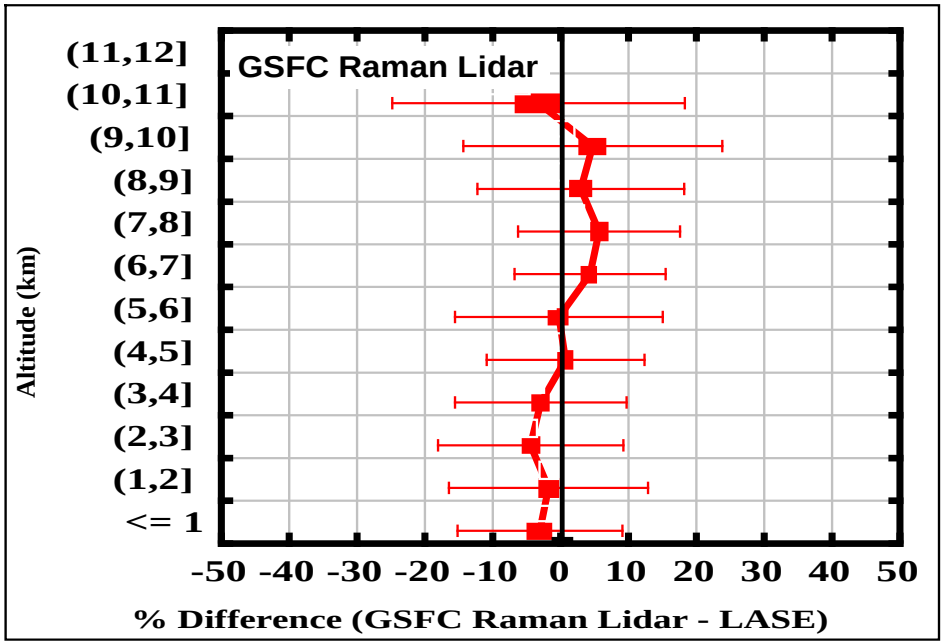
LASE Upper Troposphere Water Vapor Measurements as Reference

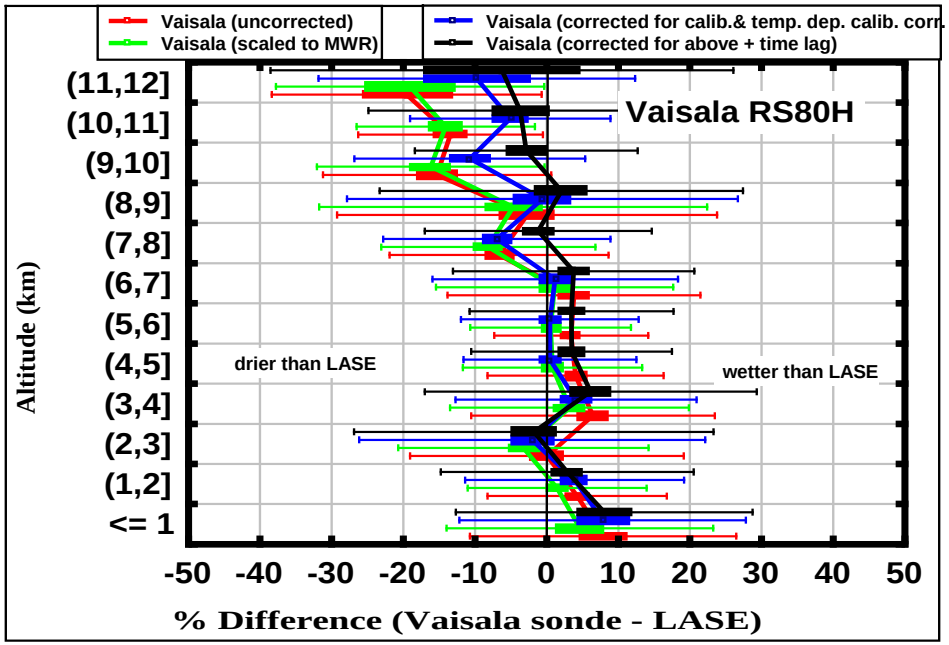
- LASE and Raman lidars in excellent average agreement (within ~2-3%)
- Corrections to Vaisala RS-80H radiosondes reduced sonde dry bias from 10% to less than 5%
- Chilled Mirror sondes about 8-10% drier than LASE and Raman lidars
- DC-8 diode laser hygrometer slightly (~3% drier) than LASE and Raman lidars
- DC-8 cryogenic frost point hygrometer 10-20% drier than LASE and Raman lidars

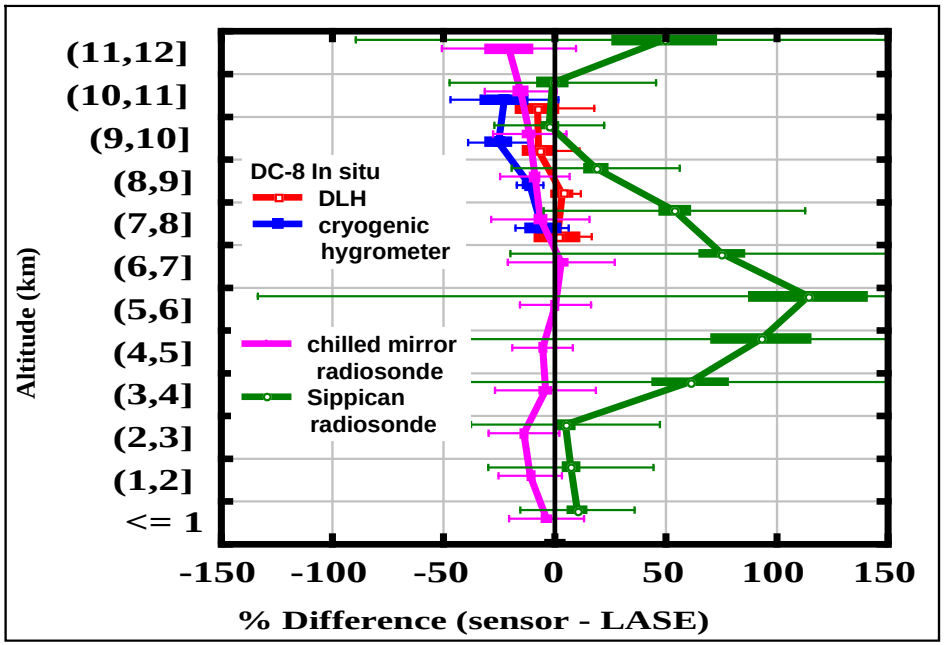


Summary of LASE Comparisons from AFWEX









Summary and Conclusions from AFWEX

- **LASE measurements from 6 DC-8 flights (4, 5, 7, 8, 9, 10) used to evaluate AFWEX upper tropospheric water vapor ($7 < z < 12$ km, $0 < w < 0.2$ g/kg) measurements**
  - **good agreement among LASE and CART, GSFC Raman lidars (<5% bias, 20% rms)**
  - **Vaisala RS-80H uncorrected sondes ~8-10% drier than LASE**
  - **Vaisala RS-80H corrected sondes ~3-4% drier than LASE**
  - **Sippican (VIZ) sonde had large variability, generally poor performance, wet bias**
  - **Good agreement among LASE and DC-8 DLH in situ sensors (<5% bias, 20% rms)**
  - **DC-8 cryogenic hygrometer 10-20% drier than LASE and DLH in situ sensors**
- **LASE and MWR precipitable water vapor (PWV) agree within about 3%**
- **Microwave radiometer (MWR) measurements at 22 GHz can accurately constrain the total water vapor amount**
- **Corrections to the Vaisala RS-80H humicap radiosonde data to account for calibration errors and time lag response were successful in reducing the radiosonde dry bias to about 5% or less.**