ULH Water Vapor Measurements during ATTREX Autumn 2011 Deployment

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ATTREX Science Team Meeting
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Overview

Why is water important?

TTL water has disproportionate impact on climate (e.g. Solomon et al., Science, 2010).

Water vapor and clouds are key measurements during ATTREX.

Schematic of the Tropical Tropopause Layer (TTL) from 13-18 km.
Overview

• ATTREX EV-1 mission on the NASA Global Hawk (right).
• ULH measures in-situ stratospheric water.
• Scientific Goals for Oct-Nov 2011 flights:
  1. Intercept the tropical Cold-Point Tropopause (CPT)
  2. Measure the relation between cirrus, water, temperature.
  3. Evaluate atmospheric model predictions.

Left: sample flight plan to probe the CPT in a series of dips by the NASA Global Hawk.
Instrument Description

- **UAS Laser Hygrometer (ULH)** is a single-channel open-path laser spectrometer.
- **Measurement**: in-situ water vapor (1 Hz).
- **Technique**: tunable diode laser.
- **Optical cell**: Herriott folded-path (left). Nominal solution is 54 multipasses, yielding 11.37-meter total optical pathlength.
- **Internal path**: < 4 cm.
- **Accuracy**: 10% expected
- **Precision**: 0.15 ppmv on 9 Nov flight.

Electronics package inside Zone 13:
Fit observed spectrum with a Voigt lineshape. Use Beer’s Law and MMS P,T to calculate water volume mixing ratio.
Instrument Issues

- Data archived for Oct 28 and Nov 9 science flights.
- Loose laser cable on Nov 5, repaired for Nov 9 flight.
- Continued loss of optical alignment at T<205 K.
- Through data analysis, we conclude that on significant portions of the flights, the optical signal was a mixture of the nominal path (54 passes) and the adjacent optical solution (100 passes). Stratospheric data from 9 Nov are from the 100-pass pathlength.
- Plan to mitigate this issue: athermalized mirror holders (next page). It is being tested at low temperature in our lab this month, and will fly during SEAC4RS in Aug-Sept 2012.
Athermalized Mirror Holders

MACPEX optical bench (flexure mounts) plus new Invar mirror holders
Our focus has been on the Oct 28 and Nov 9 flights
10/28 vertical profile
11/09 second dive

November 9, 2011

- DLH
- ULH

Water Vapor (ppm)

Time (seconds UT)
November 9, 2011
- DLH
- ULH

Water Vapor (ppm)

Time (seconds UT)
ULH vs DLH, Nov 9

\[ ULH = a + b \times DLH \]

\[ a = 0.2852 \pm 0.0192 \]

\[ b = 0.93437 \pm 0.000951 \]
ULH vs UCATS, Nov 9

ULH = a + b * UCATS
a = 0.47997 ± 0.023
b = 0.97853 ± 0.00118
• More stable optical mounting (already implemented for SEAC4RS).
• We plan to fly JLH in SEAC4RS (direct comparison with Harvard H$_2$O) and then in ATTREX.
• Narrow-band optical filter installed on detector.
• Expectation: 10% accuracy and 0.05 ppmv precision.
Acknowledgments

- ATTREX and UARP for financial support.
- Eric Hintsa for providing intercomparison plots.