Measurements of condensed water concentration from NCAR GV during DC3

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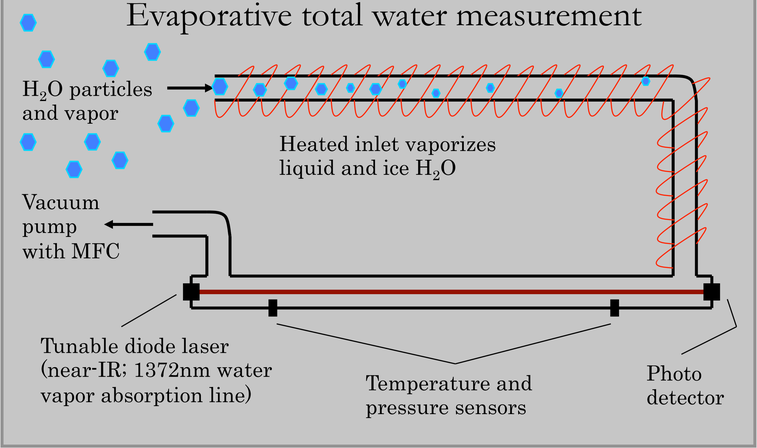
Deep Convective Clouds and Chemistry (DC3)

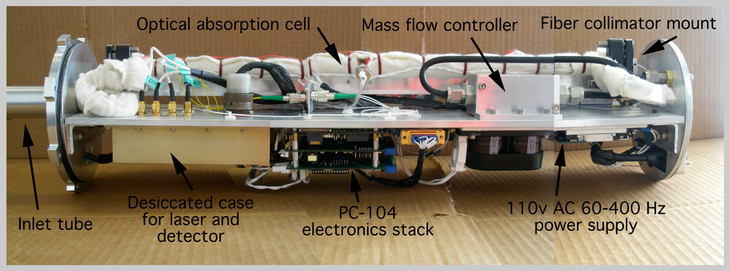
May 15, 2012 – June 30, 2012

- Flights targeting convective storms over Great Plains
- Coordinated with radar sites, soundings and lightning mapping arrays
- 85% CLH2 instrument uptime during 22 research flights

Closed-path Laser Hygrometer (CLH-2)

Evaporative total water measurement





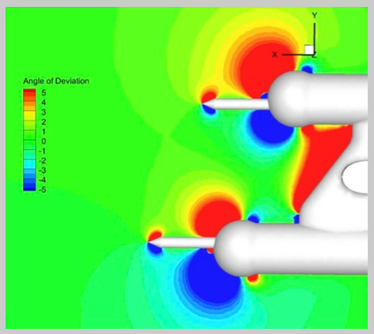
Mounted on left outboard wing pylon of GV

Instrument description

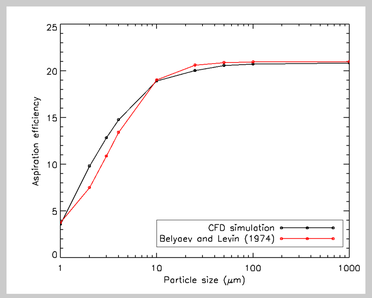
The **CU Closed-path Laser Hygrometer (CLH-2)** was deployed on the NCAR GV during DC3 to measure the in situ mass concentration of **condensed water** (liquid + ice).

TDL spectroscopy is used to measure **the total water concentration** that results from the vaporization of water particles in a heated inlet. In post-processing, the background water vapor concentration is subtracted and the resulting **condensed water concentration** is corrected for the inlet particle sampling efficiency.

Particle sampling efficiency



For the GV wing pylon installation, the airflow around the CLH-2 was evaluated with a CFD simulation **(upper left)**.

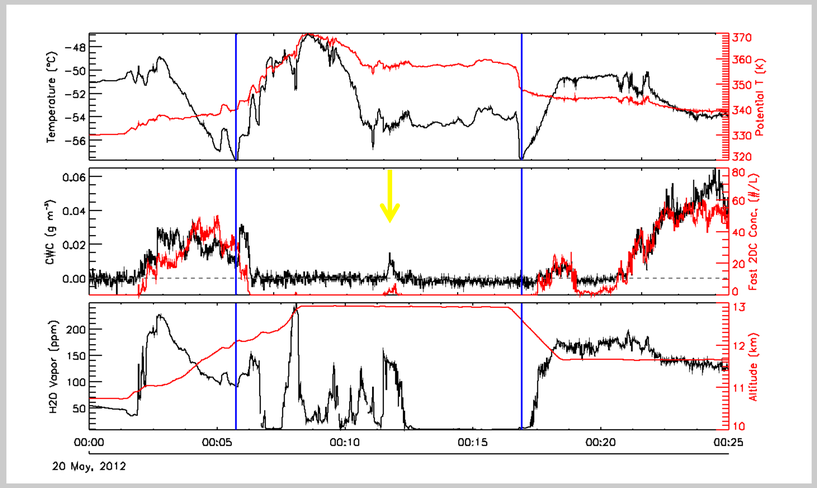


The CFD simulation is used to calculate particle aspiration efficiency for use in sampling efficiency correction. The simulation agrees with the Belyaev and Levin (1974) parameterization to within 10% for particles with D > 4 μm in DC3 conditions **(lower left)**.

Ice water in lower stratosphere convective injection

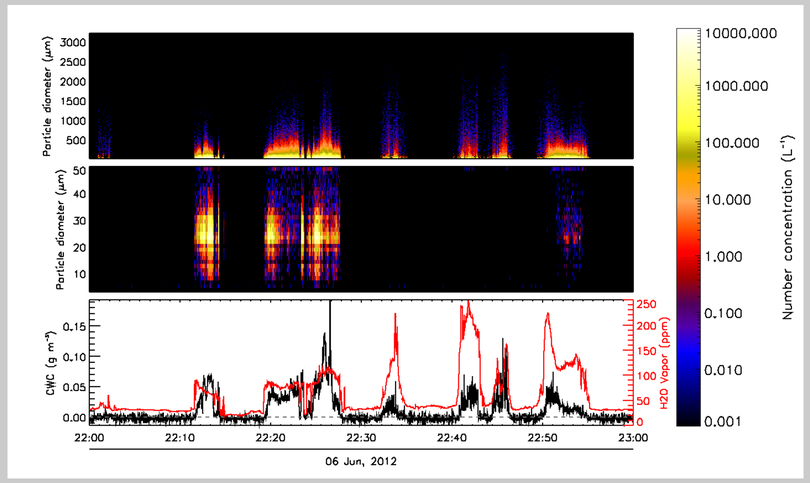
(presented by Cameron Homeyer in Oct. DC3 telecon; we're not pursuing this research but just highlighting the condensed water observations)

- Within cloud, condensed phase water is 10-38% total mass
- Ice particles (150 μm < D < 350 μm), also small particles (6 μm < D < 40 μm) that may be shattering products



Flight segment from May 19, 2012 showing microphysical measurements during tropopause crossings (blue bars) and in overshooting cloud top (arrow).

Water concentration and particle size observations in convective anvil



Flight segment from June 6, 2012 showing microphysical measurements from 2D-C (top), CDP (middle) and CLH-2 and VCSEL (bottom) during cloud anvil intersections.

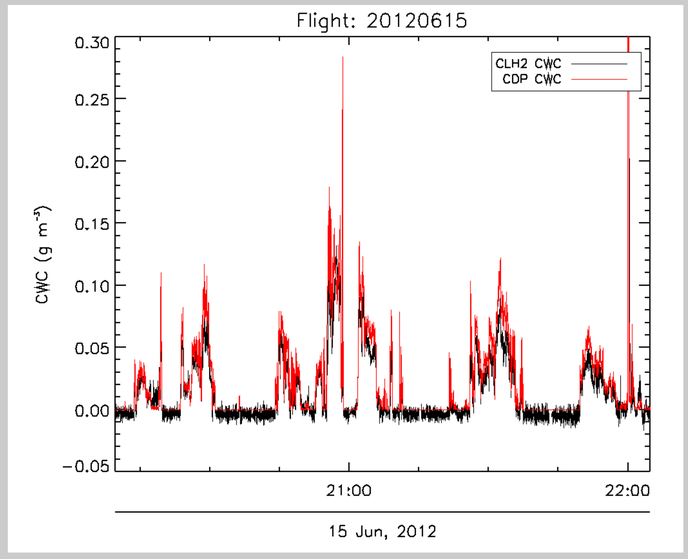
Observations aloft of small convective anvil over Colorado's Front Range show both mixed-phase and ice-only regions. Of these observations, the highest CWCs (~0.15 g m^{-3}) are found in a mixed-phase region which includes particles D > 1.5 mm.

Phase-specific terminology

(eg. Baumgardner et al., 2011)

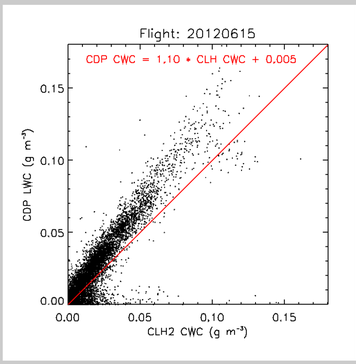
Water vapor + Liquid water + Ice water =	Liquid water + Ice water =
Total Water Conc. (TWC)	**Condensed Water Conc. (CWC)**

Condensed-water concentration measured with CLH-2 and CDP in liquid-only clouds



Flight segment from June 15, 2012 showing CLH-2 CWC and CDP CWC during liquid-cloud interceptions.

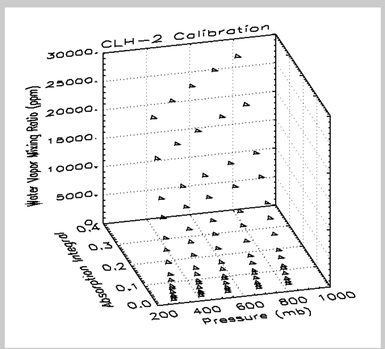
In liquid-only clouds of June 15th flight (in which 2D-C observes no large particles), the CDP and CLH-2 exhibit a similar qualitative response during cloud intersections **(above)**, but the CDP reports water concentrations roughly 10% larger than those measured by the CLH-2 **(lower right)**.



CLH-2 calibration and uncertainty

The CLH-2 was calibrated using a Li-Cor 610 dewpoint generator over a range of water vapor mixing ratios from 750 to 27240 ppmv and over pressures spanning 275 mb to 820 mb.

Uncertainty in the reported CWC is estimated to be ± 22 % (2-σ). This includes error due to calibration uncertainties, measurement variability, removal of the ambient water vapor concentration and the correction for cloud particle sampling efficiency.



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