Longstanding Discrepancies in Stratospheric Water Vapor Measurements Revisited During the 2011 Mid-latitude Airborne Cirrus Properties Experiment (MACPEX)

Dale Hurst
Emrys Hall
Allen Jordan
Troy Thornberry
Drew Rollins
Ru-Shan Gao
Sean Davis
Karen Rosenlof
David Fahey
Jessica Smith
Maryann Sargent
David Sayres
Cornelius Schiller
Martina Krämer
Tim Klostermann
These differences are:

- Fairly consistent with altitude during each flight
- Quite variable from one flight/campaign to the next
- Typically 15-60% of the water vapor mixing ratio
Why are water vapor measurement differences a concern?

- Disparities of this magnitude infer sizeable uncertainties in water vapor measurements (inaccuracy)
- Biases that vary with time add significant uncertainties to long-term water vapor trends

Hurst et al. [2011]
Differences Also Exist Between Satellite-Borne Sensors

MLS - HALOE ≈ 0.5 ppmv during 16-month operational overlap

⇒ Good agreement between MLS and FPH suggests HALOE adjustment

⇒ Adjusted HALOE: +0.5 ppmv  (Davis and Rosenlof)
Frost Point - Satellite
  • HALOE (adjusted)
  • MLS

Boulder Overpasses
  No statistical biases
  Significant trends:
  FP-HALOE: 18-100 hPa
  FP-MLS: none

Lauder Overpasses
  No statistical biases
  No significant trends
    (MLS only)
Left Spear Pod
Harvard Water Vapor
(includes HHH)
SID3

Right Superpod (with spear pod forebody)
2DS
CPI
FCDP
HVPS
CIN

Right Hatches
ULH
DLH

Left Hatches
VIPS
JLH

Left Superpod
Harvard Halogen

Nose
PALMS
MMS
DLH Retroreflector

Payload Bay:
Forward transition – MMS electronics, O3
Pallet 1 (P305) – Harvard Total Water
Pallet 2 (P301) – FCAS, NMASS
Pallet 3 (P306) – CIMS, SP2, O3Lite
Pallet 4 (P303) – FISH

As of 24 Mar 11
Aircraft Instrument Differences - Summary Statistics

0.5 ± 0.2 ppmv (N=78)

-0.3 ± 0.2 ppmv (N=63)
Ideally...

Right Superpod (with spear pod forebody)
2DS
CPI
FCDP
HVPS
CIN

Payload Bay:
Forward transition – MMS electronics, O3
Pallet 1 (P305) – Harvard Total Water
Pallet 2 (P301) – FCAS, NMASS
Pallet 3 (P306) – CIMS, SP2, O3Lite
Pallet 4 (P303) – FISH

Left Superpod
Harvard Water Vapor
(includes HHH)
SID3

Left Superpod
Harvard Halogen

Left Hatches
VIPS
JLH

Right Hatches
ULH
DLH

Right Spear Pod
ALIAS
CLH
DLH Mirror

NOAA FPH or CFH

As of 24 Mar 11
A/C Instrument - Frost Point Differences: Summary Stats

FISH-FP
- 20110413
- 20110414
- 20110420
- 20110421
- 20110423

$0.0 \pm 0.2 \text{ ppmv} \quad (N=58)$

HW-FP
- 20110413
- 20110414
- 20110416
- 20110420
- 20110421
- 20110423

$0.4 \pm 0.1 \text{ ppmv} \quad (N=59)$

CIMS-FP
- 20110414
- 20110420
- 20110421
- 20110423

$0.7 \pm 0.2 \text{ ppmv} \quad (N=43)$
Conclusions

Since 1993: campaign-dependent biases of 15-60% between Harvard Lyman-α and NOAA Frost Point Hygrometers

Biases between HALOE & MLS/FPH in 2004-05 suggest HALOE adjustment
  • FP-adjusted HALOE: significant trends at 18-100 hPa (1991-2005)
  • FP-MLS: No biases or trends (2004-2012)

MACPEX: statistically significant biases between 3 aircraft instruments
  HW-FISH (0.5±0.2 ppmv) & HW-CIMS (-0.3±0.2 ppmv)

MACPEX: no statistically significant bias between FP and FISH (0.0±0.2 ppmv)

MACPEX: statistically significant biases between FP and HW and CIMS
  HW-FP (0.4±0.1 ppmv) & CIMS-FP (0.7±0.2 ppmv)
  (these are consistent with the biases between aircraft instruments)

Biases revealed during MACPEX are smaller than most historical differences between HW and the Frost Point Hygrometers
  This indicates progress in eliminating water vapor measurement biases
  but further efforts are clearly necessary
Thank you for your attention
Aircraft - Balloon Coincidences