AquaVIT

The AQUAVIT formal intercomparison of atmospheric water measurement methods

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Harald Saathoff, Cornelius Schiller, Volker Ebert
Tom Peter, Martina Krämer
and the AquaVIT participants

Background and Objectives

AquaVIT

Observation of very large ice supersaturations
in upper troposphere

↓

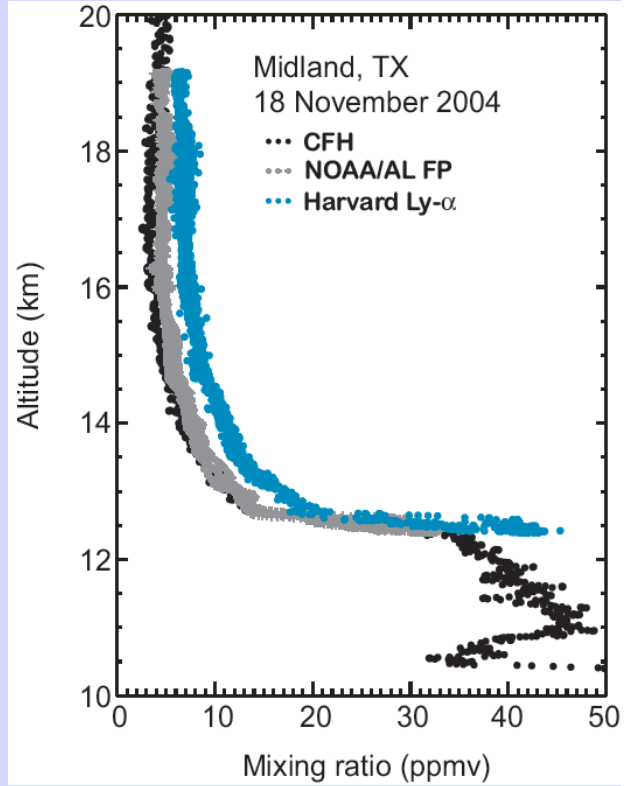
Matter of incomplete understanding of UT processes
→ see SPARC lecture by Thomas Koop
or
an artefact of measurement uncertainty?

↓

Organise lab activity to compare major field instruments
for humidity measurements

↓

AquaVIT = Water Vapour Instrument Test
held at AIDA simulation chamber in Karlsruhe



Vömel et al., JGR, 2007

See also
Peter, Krämer, Möhler
SPARC, 2008

Participating Instruments (22 different types)

AquaVIT

Instrument name	Type	Operators	Institute
CFH	mirror	Holger Vömel	University of Colorado
JPL Laser Hygrometer	TDL	Robert L. Herman, Robert F. Troy	JPL, Caltech
Harvard water vapour HWV	Ly-α	Elliot Weinstock, Jessica Smith	Harvard University
FISH (2 instruments)	Ly-α	Cornelius Schiller	Forschunszentrum Jülich (ICG-1)
FLASH (2 instruments)	Ly-α	Sergey Khaykin, Leonid Korshunov	Central Aerological Observatory
AIDA in situ TDL APicT	TDL	Volker Ebert	University of Heidelberg
AIDA MBW-373LX	mirror	Harald Saathoff	Forschungszentrum Karlsruhe (IMK-AAF)
Snow-White	mirror	Frank Wienhold, Ulrich Krieger, Martin Brabec	ETH Zürich
CLH TDL	TDL	Linnea Avallone, Sean Davis	University of Colorado
HIAPER VCSEL TDL	TDL	Mark Zondlo	Southwest Science, Inc.
Ojster TDL	TDL	Martina Krämer	Forschunszentrum Jülich (ICG-1)
PicoSDLA (TDL)	TDL	George Durry	University of Reims & INSU/CNRS
Water Isotope Composition	TDL	Andreas Zahn, Julia Keller, Christoff Dyroff	Forschungszentrum Karlsruhe (IMK-ASF)
AIDA extractive TDL APeT	TDL	Volker Ebert	University of Heidelberg
Vaisala Sensor DM 500	DM500	Theo Brauers, Rolf Häseler	Forschungszentrum Jülich (ICG-2)
WaSul-Hygro (2 instruments)	PA	Zoltán Bozóki, Arpad Mohacsi	University of Szeged
Met Office	Ly-α	Debbie O'Sullivan	UK Met Office
NCAR-BUCK	mirror	Frank Flocke, Dennis Krämer	NCAR Boulder
NCAR-OPLH	TDL	Teresa Campos,	NCAR Boulder
CARIBIC Buck	mirror	Andreas Zahn, Julia Keller, Christoff Dyroff	Forschungszentrum Karlsruhe (IMK-ASF)
CARIBIC Photoacoustic	PA	Andreas Zahn, Julia Keller, Christoff Dyroff	Forschungszentrum Karlsruhe (IMK-ASF)
PADDY	surface	Ulrich Bundke	University of Frankfurt

Host Facility AIDA

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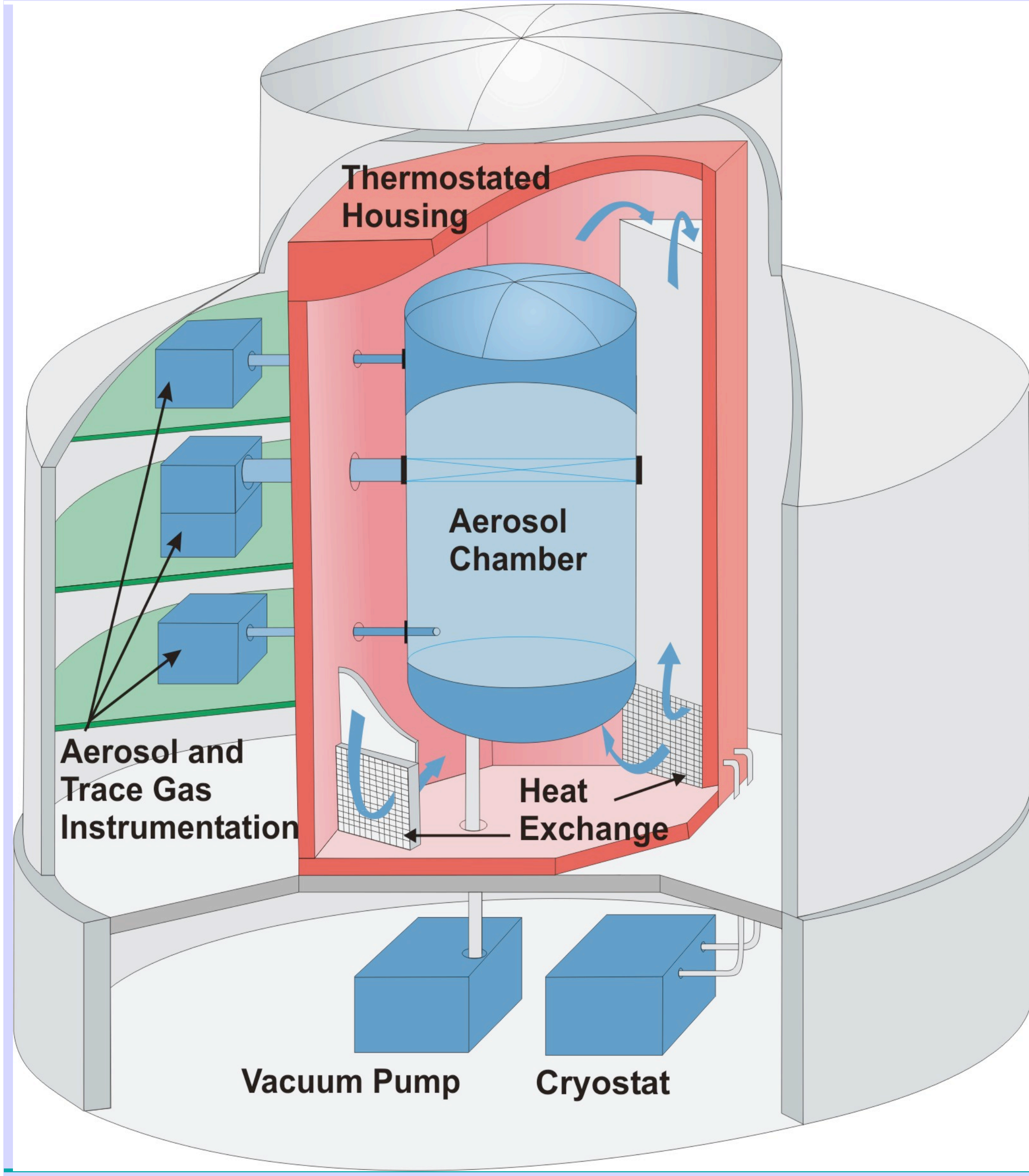
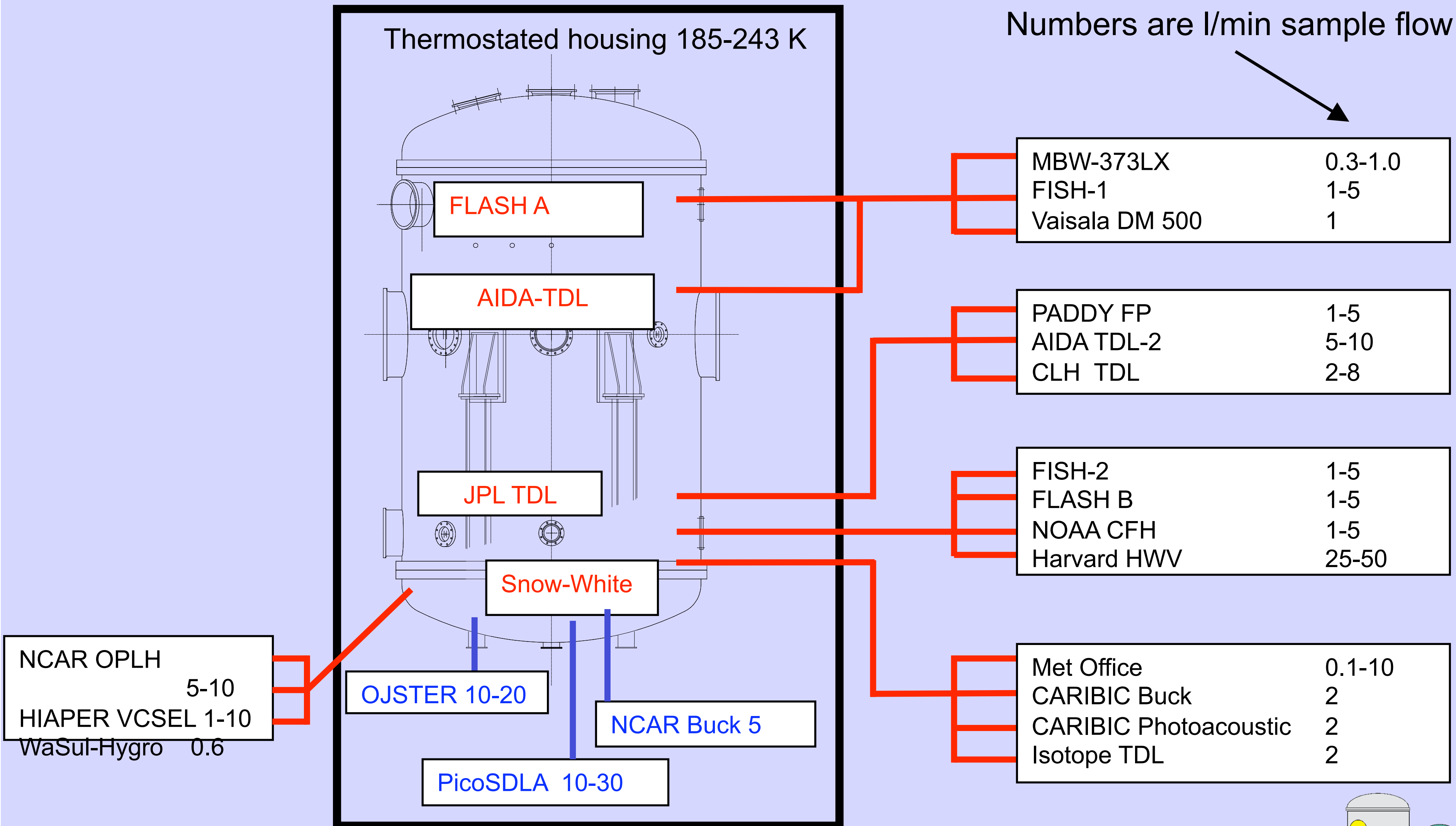


Instrument Setup



Collection of instrument installations

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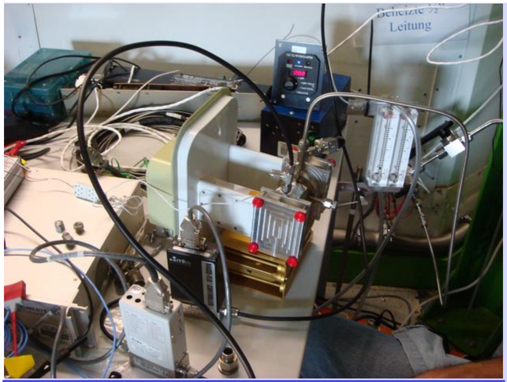
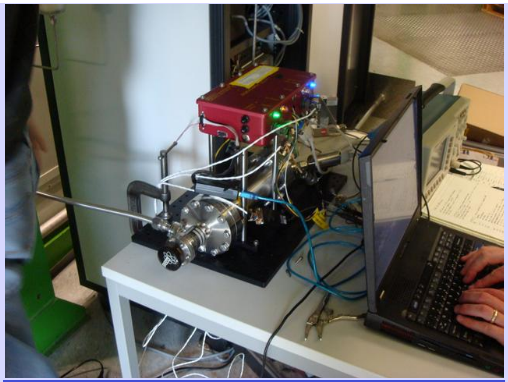
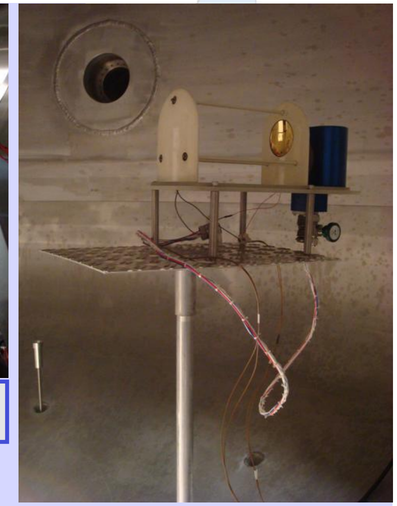


NCAR OPLH



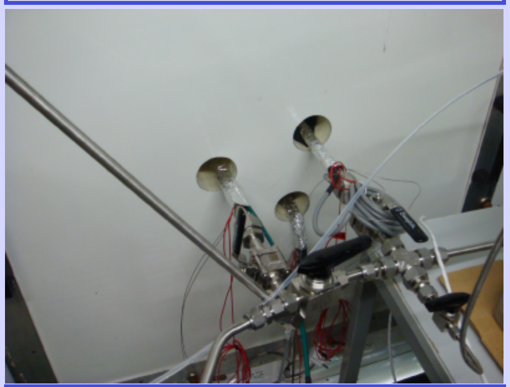
HIAPER TDL

Pico SDLA



JPL Laser Hygrometer

AIDA sampling lines

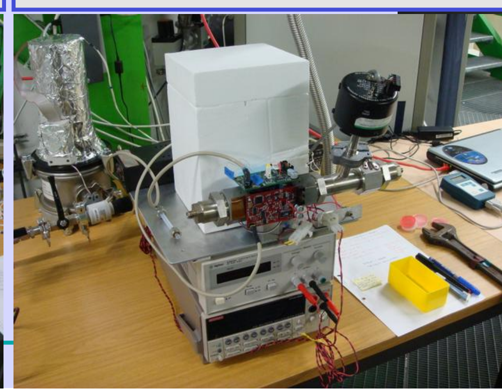


Snow-White

Harvard Water Vapour HWV

Jülich FISH

FLASH and CFH



List of AquaVIT experiments October 2007

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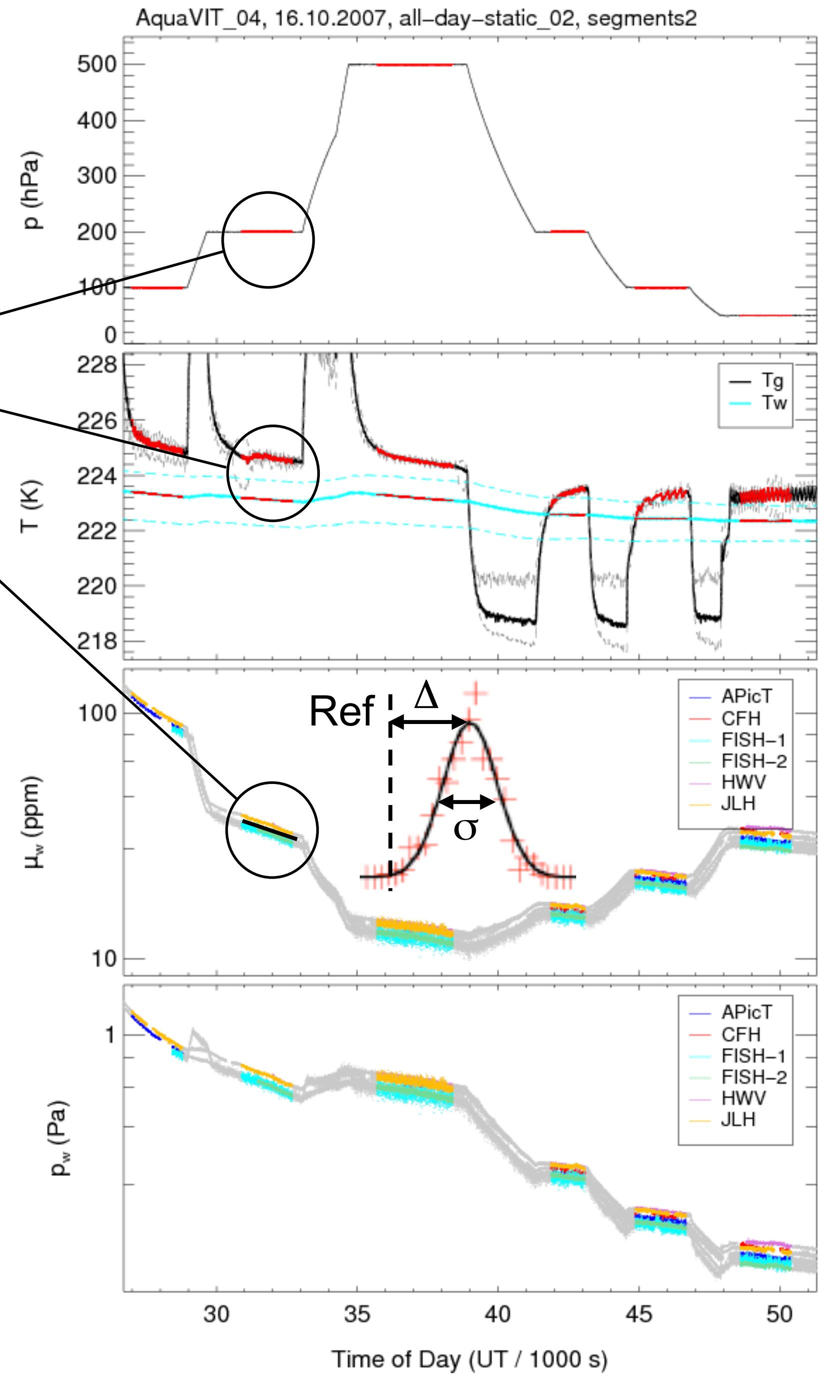
Day	Exp. No.	Experiment type	T (K)	P (hPa)	H_2O (ppm)
15	3	Constant p,T	243	50-500-50	30 - 300
16	4, 5	Constant p,T	223	100-500-50	3 - 20
17	6	Constant p,T	213	100-300-50	3 - 20
18	7	Constant p,T	196	80-300-50	3 - 17
19	8	Constant p,T	185	80-500-50	0.5 - 3
22	9	Dynamic p,T	243	200 - 140	1800 - 3800
23	10	Dynamic p,T	223	200 - 140	190 - 400
24	11	Dynamic p,T	213	300 - 50	35 - 210
25	12	Dynamic p,T	200	300 - 50	5 - 30
26	13	Dynamic p,T	185	300 - 50	0.5 - 3

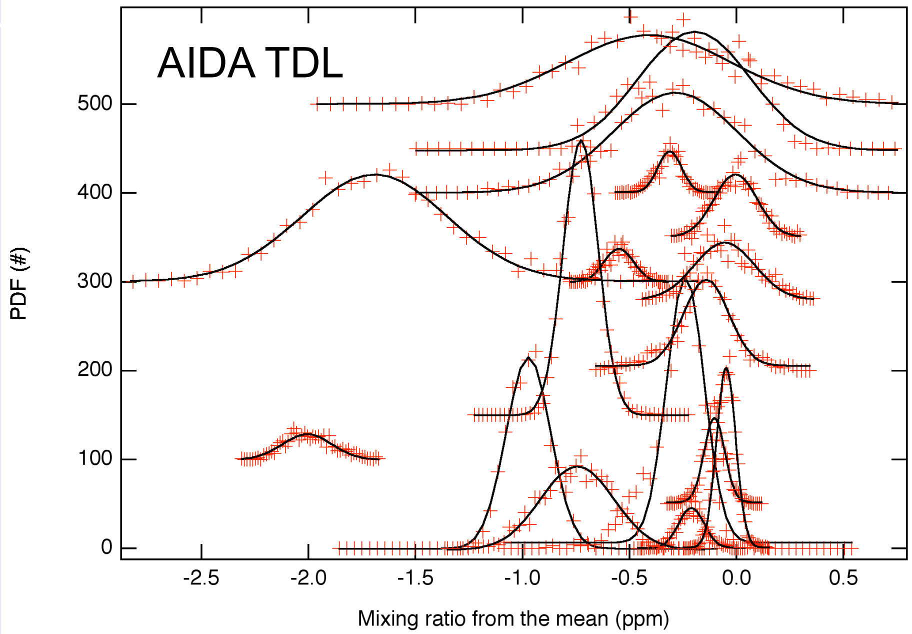
Example of static experiment

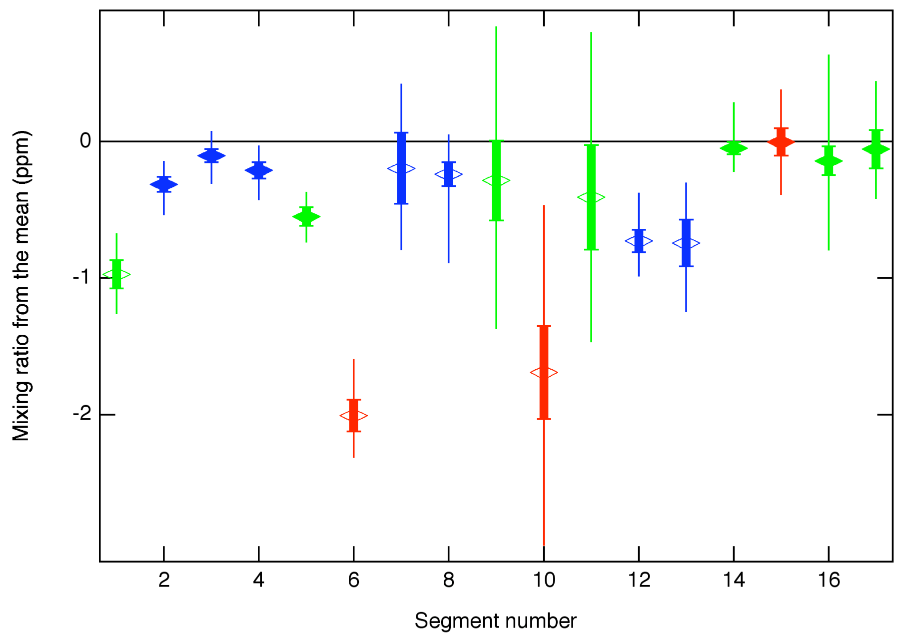
Steps of data analysis:

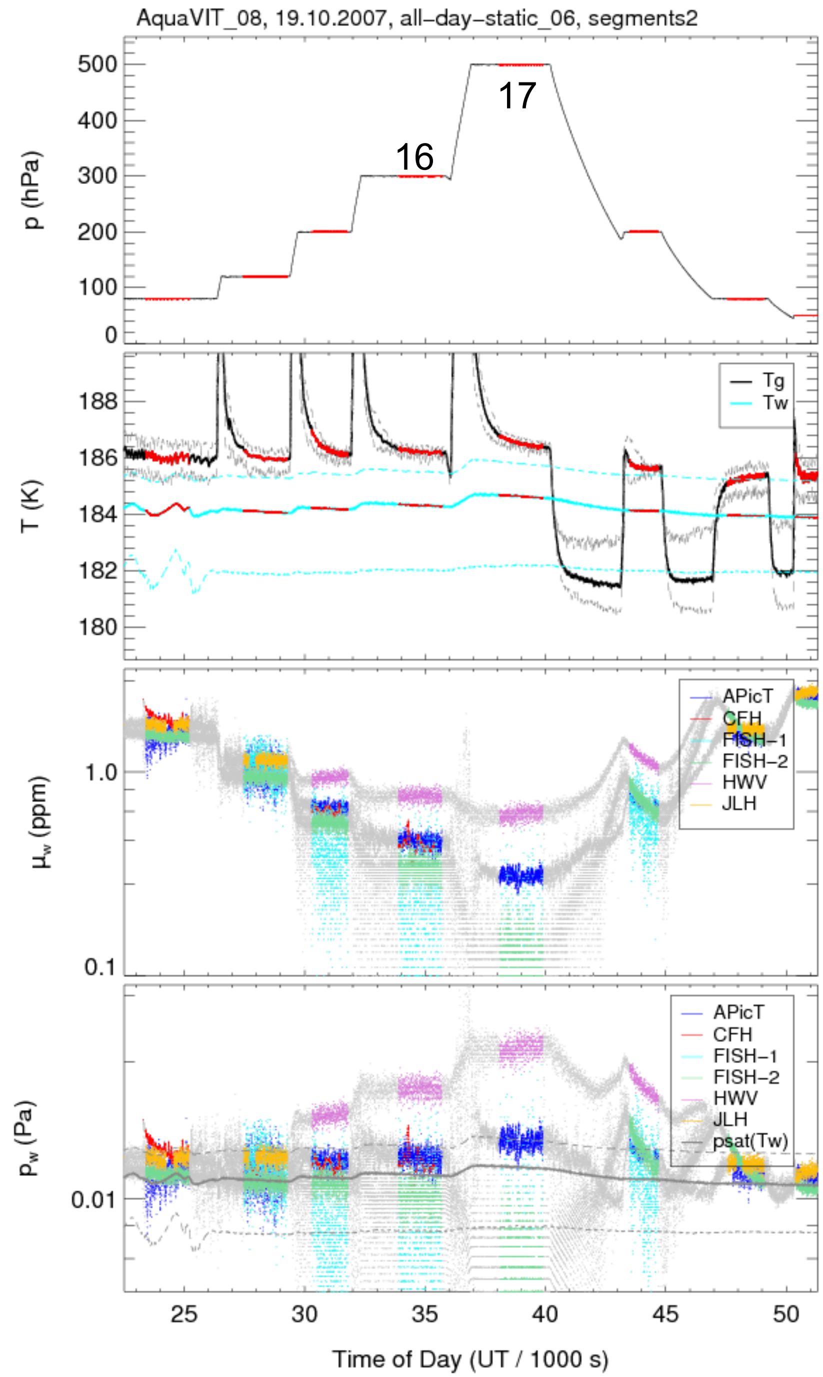
1. Define 31 segments of constant p,T.
2. Linear fit to core instrument average as reference value.
3. Calculate probability distribution function for difference of 1-s instrument data to reference
4. Calculate Gaussian fit to pdf and define sigma as instrument precision and median as deviation from reference.
5. Create master plot for instrument deviation from reference.



Example of pdf analysis







Core instrument results

JPL Laser hygrometer (JLH)
• no data below 1 ppm
• tends to be high at larger pressure

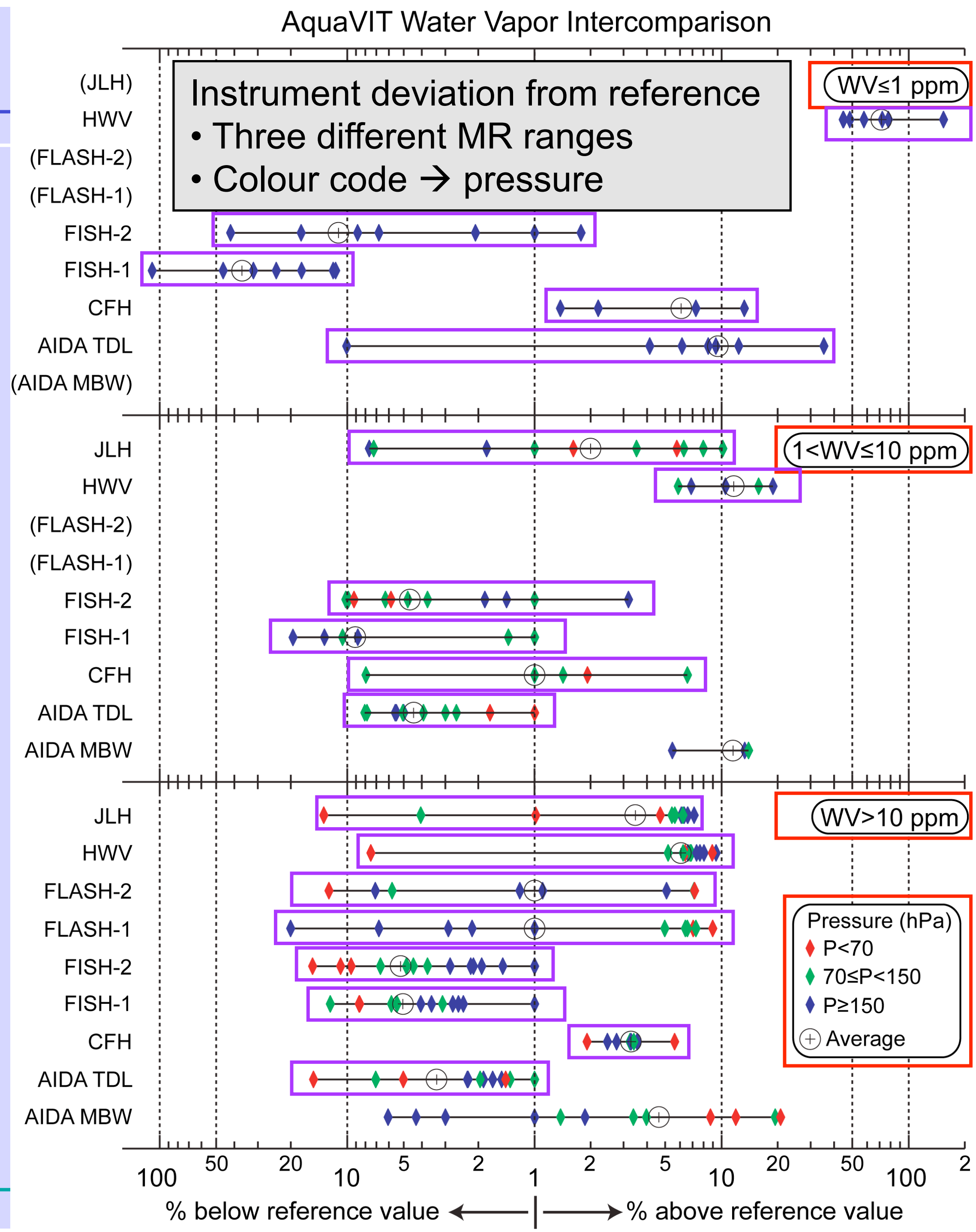
Harvard Ly-α instrument (HWV)
• little scatter
• high bias, in particular at low MR

FLASH
• no data below 10 ppm
• above 10 ppm scatter of ±10 %

FISH
• slightly lower than reference
• larger bias below 1 ppm

Cryogenic frost point hygrometer (CFH)
• slightly higher than reference
• larger scatter at 1 to 10 ppm range

AIDA in situ TDL system (APicT)
• above 1 ppm slightly lower than reference
• below 1 ppm more scatter, high bias



Summary and Conclusions

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AquaVIT first blind lab comparison of major aircraft and balloon instruments

Still preliminary conclusions for core instruments (JLH, HWV, CFH, FISH, FLASH, AIDA in situ TDL)

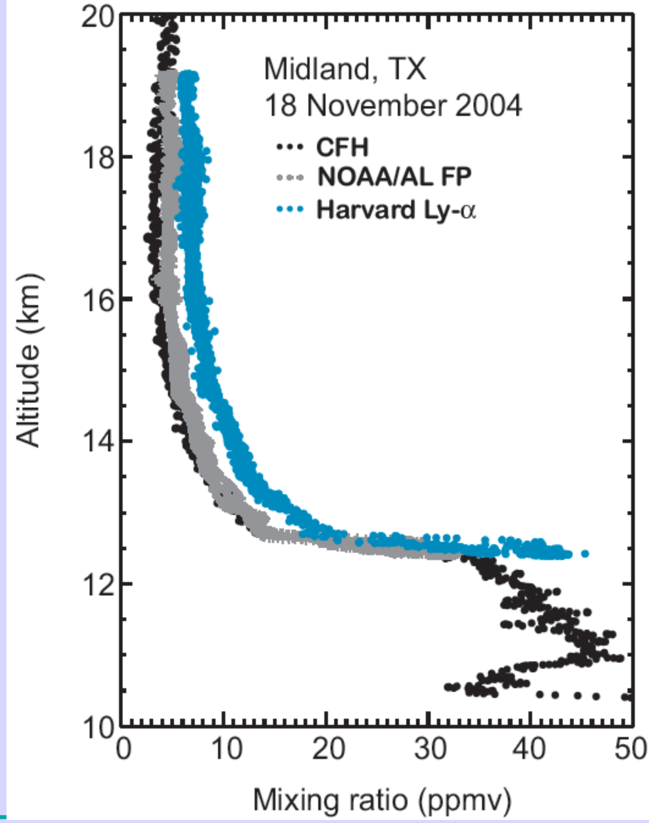
- At MR < 1 ppm deviations from reference up to ± 100 % or more
  → poor instrument performance
- At MR > 1 ppm deviations from reference within ± 10 %
- Observed bias can partly be due to lab configuration.

Implications for field employment

AquaVIT is milestone for instrument improvement

Uncertainties observed during AquaVIT are not sufficient to explain those observed in field

→ Additional sources of uncertainties which can only be quantified in field studies



Perspectives

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More accurate in situ measurements (below 5 % uncertainty) require more efforts:

- Better standards for lab calibrations
- More blind instrument comparison in the lab at relevant sampling conditions
- More comparison of instruments in field applications
- Need for improved and better characterised instruments

AquaVIT Sponsors

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Stratospheric Processes and their Role in Climate – SPARC (a core project of the World Climate Research Program WCRP)

EUROCHAMP – A European Union FP6 project.

SCOUT-O3 – A European Union FP6 project.

Swiss Federal Institute of Technology Zurich (ETH)
Institute for Atmospheric and Climate Science.

Forschungszentrum Jülich
Institute of Chemistry and Dynamics of the Geosphere (ICG-1).

Forschungszentrum Karlsruhe
Institute of Meteorology and Climate Research (IMK-AAF)