ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Radiosonde and Hygrometer humitidy measurements at Sodankylä

NDACC-H2O workshop, IAP, University of Bern
July 5-7, 2006

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Finnish Meterological Institute –Arctic Research Centre

RS13/15 : 1967-1975
RS13 : 1976-1981
RS80: 1982-1999
RS90: 2000-2004
RS92: 2005->

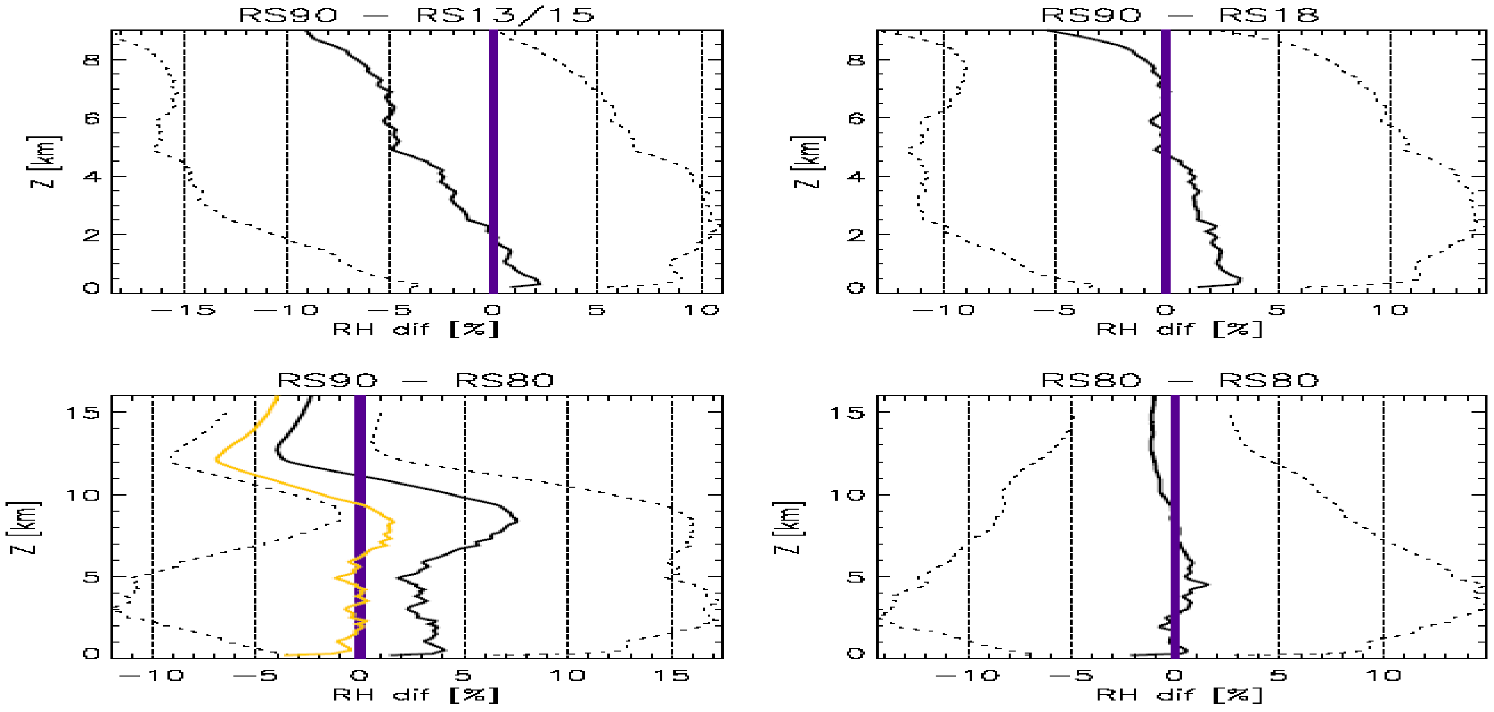


Figure 2 *Sonde generation comparison showing differences from the RS90 era mean profile for each sonde generation (excluding the RS21). Plots are based on the Sodankylä radiosonde record. Dashed lines represent one standard deviation from the mean. The yellow line corresponds to the corrected RS80-A (Leiterer correction). The bottom RHS window shows the internal comparison for the RS80 era, i.e., years 1999 to 1996 minus 1985 to 1988.*

Sonde sensor evolution creates discontinuities in the timeseries

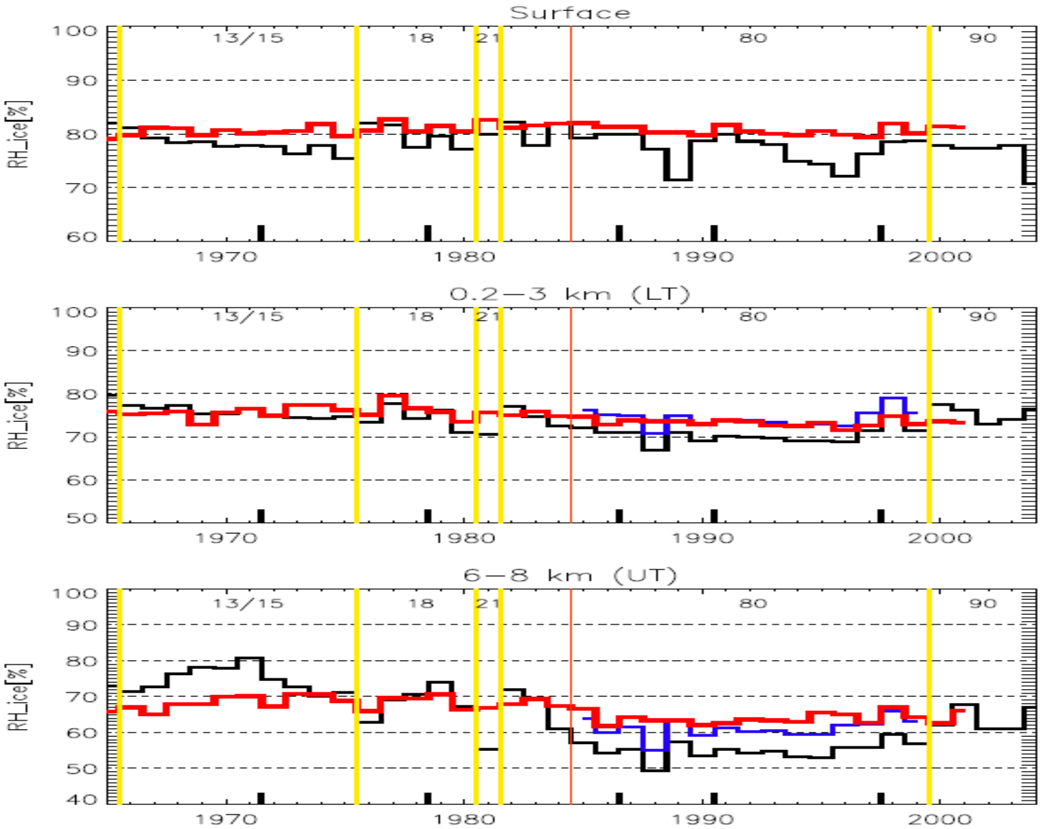


Figure 4 *Annual averages of radiosonde time-series of RH with respect to ice at three different altitudes above Sodankylä (troposphere). ERA-40 data are shown in red, radiosonde data from Sodankylä (black). Corrected RS80-A data are shown as a blue line. In this example, the worst cases of iced RS80-A soundings are filtered out. Sub-periods of ERA-40 are shown with black markers above the x-axis.*

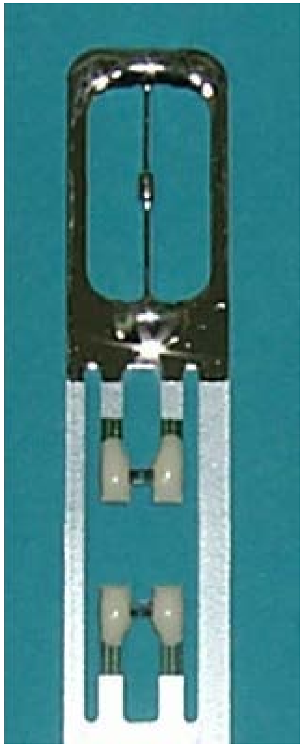
Hygrometer Intercomparison Campaign at Sodankylä, LAUTLOS Jan 26-Feb 28 2004

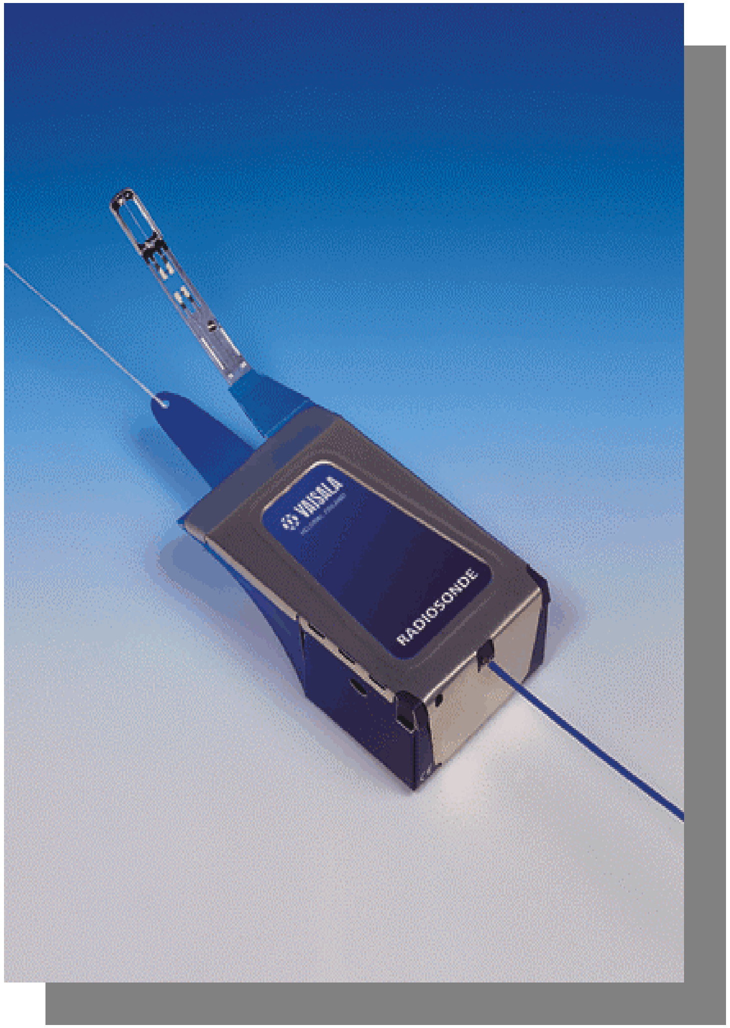
1. Finnish Met. Institute-Arctic Research Centre , Sodankylä, Finland
2. Vaisala Oyj, Helsinki, Finland
3. Meteolabor AG, Zürich, Switzerland
4. German Weather Service, Meteorological Observatory Lindenberg, Germany
5. Central Aerological Observatory, Moscow, Russia
6. University of Colorado, Boulder, USA
7. Alfred Wegener Institute for Polar and Marine Research, Potsdam, Germany
8. University of Bern , Switzerland

Vaisala radiosonde RS-92 (2004-), sensorboom and Sonde packages

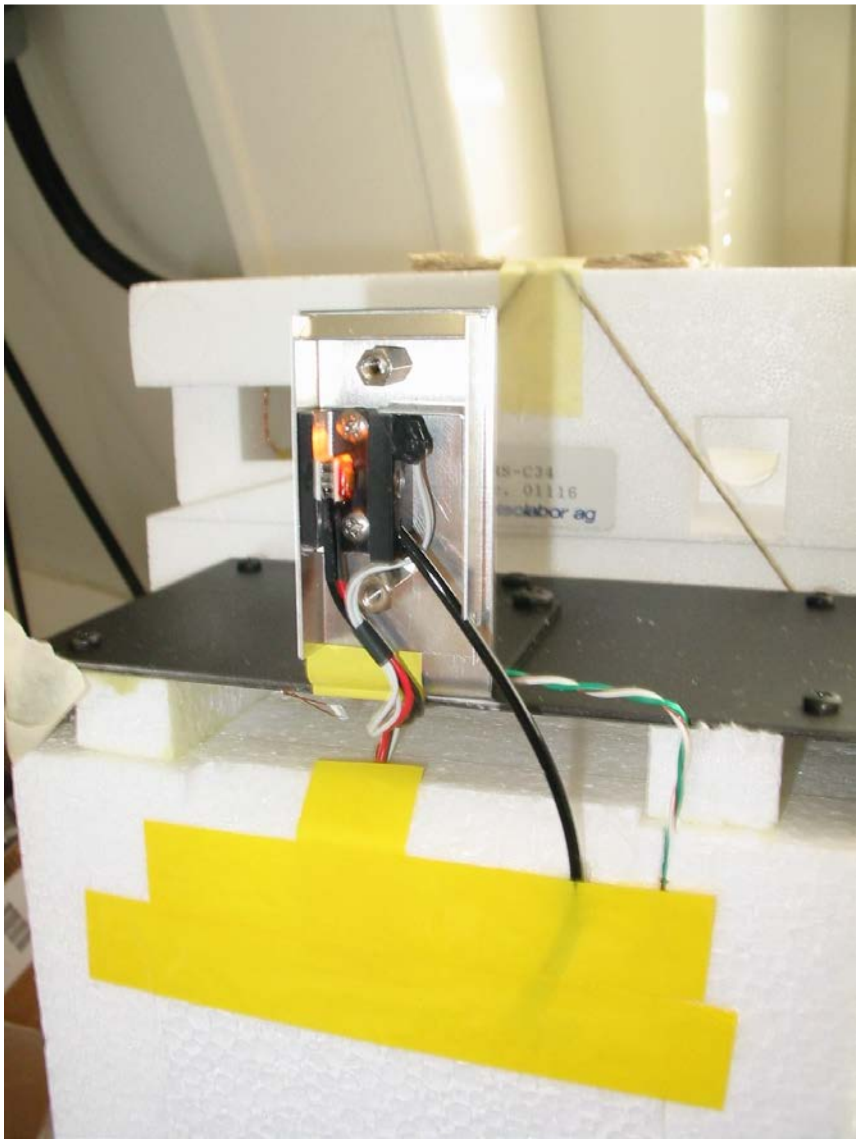
Vaisala radiosonde RS-80 (1982-1999 at FMI)

FN-sonde of Lindenberg Observatory, Germany, uses slightly modified Vaisala RS-90 and Lindenberg's own calibration/calculation method

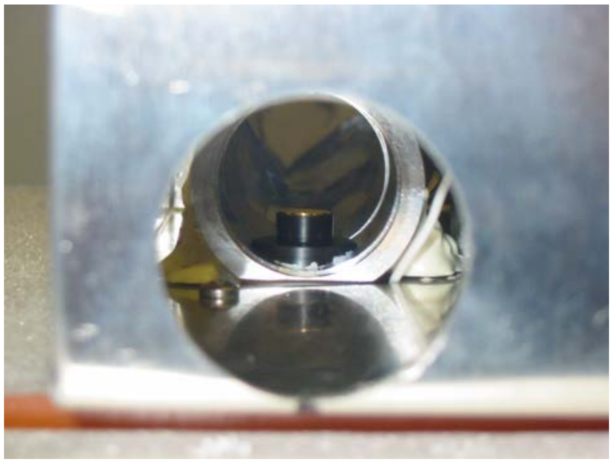


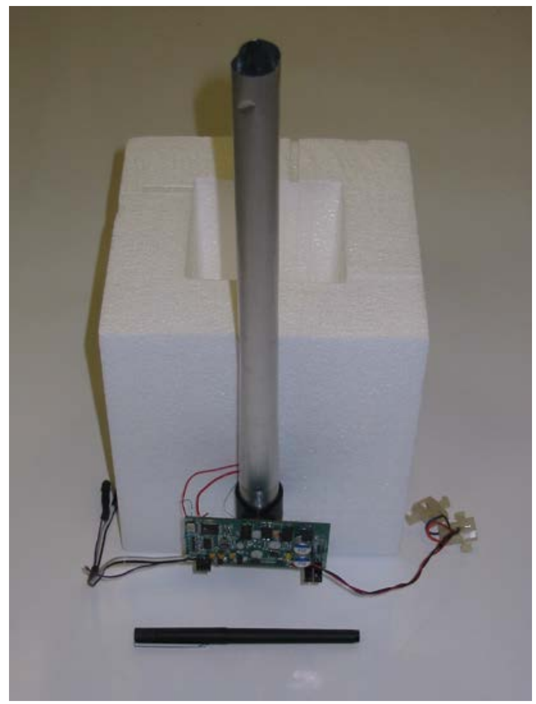


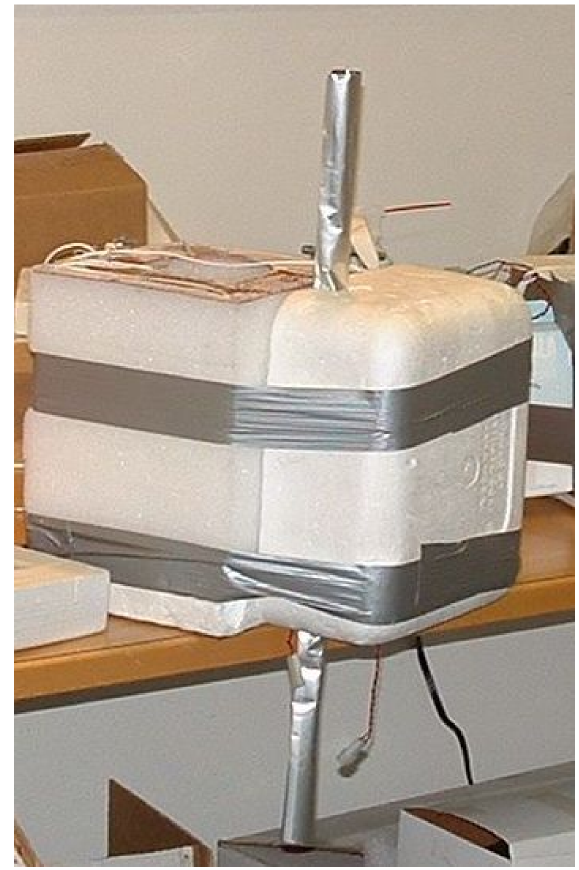
Snow White Hygrometer, Meteolabor, Switzerland



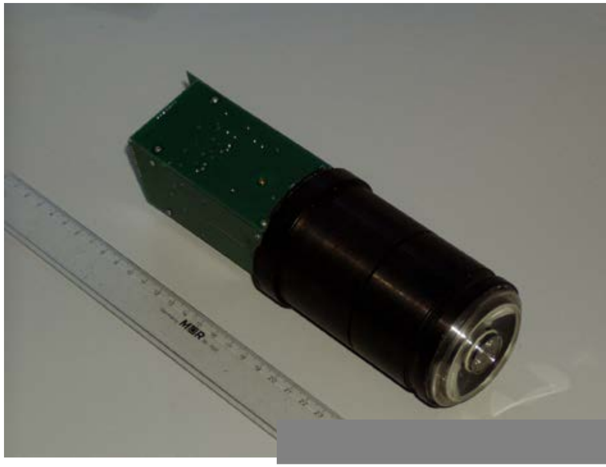
Cryogenic Frostpoint Hygrometer (CFH) of Colorado University:
Cryogen coolled frostpoint mirror, control board and sonde package

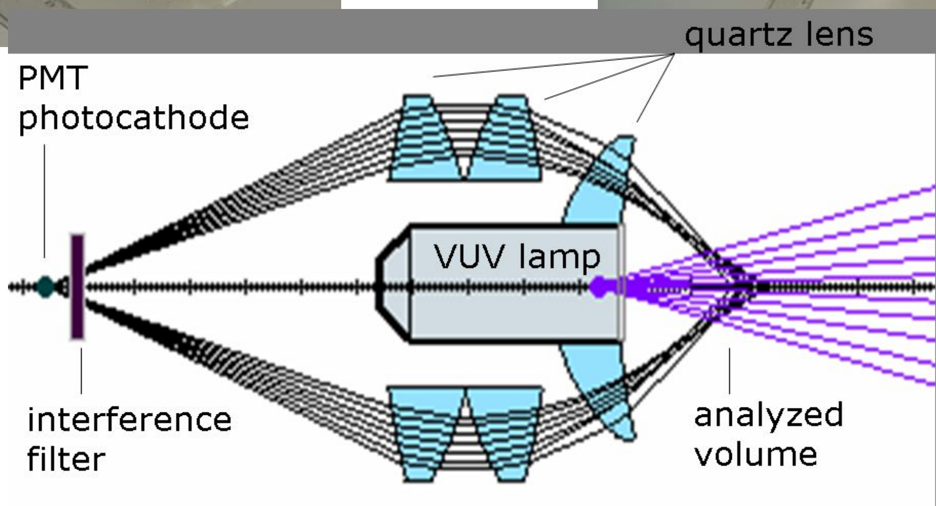






Lyman Alpha hygrometer from Central Aerological Observatory, FLASH





Optical layout of the fluorescent hygrometer (FLASH) for balloon

22 Ghz Microwave radiometer of University of Bern

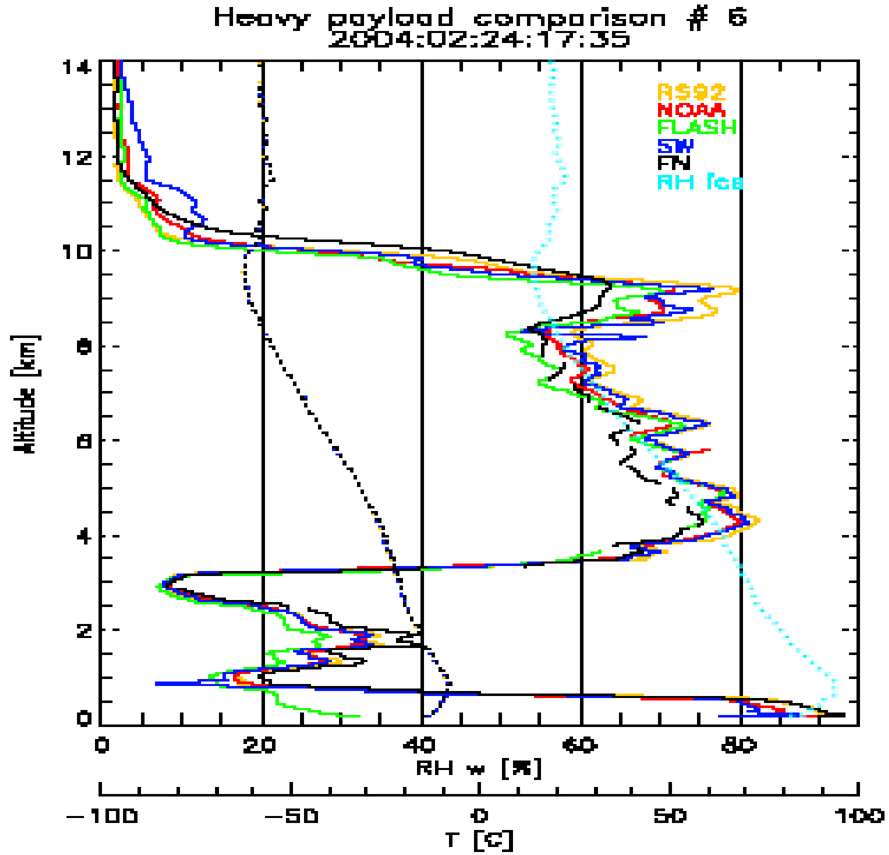


Figure 8: Example of the reference-class instrument performance in the troposphere inside a thick cloud. Plotted parameter is relative humidity (RH%). Sondes: NOAA (thick red), RS92 (orange), Snow White (blue) and FN (black). RH with respect to water at ice-saturation is shown in turquoise. For RH profiles, a 10 s wide (i.e., 50 m) smoothing operator is applied to make visual inspection easier. The left-hand side set of profiles is for temperature (broken lines).

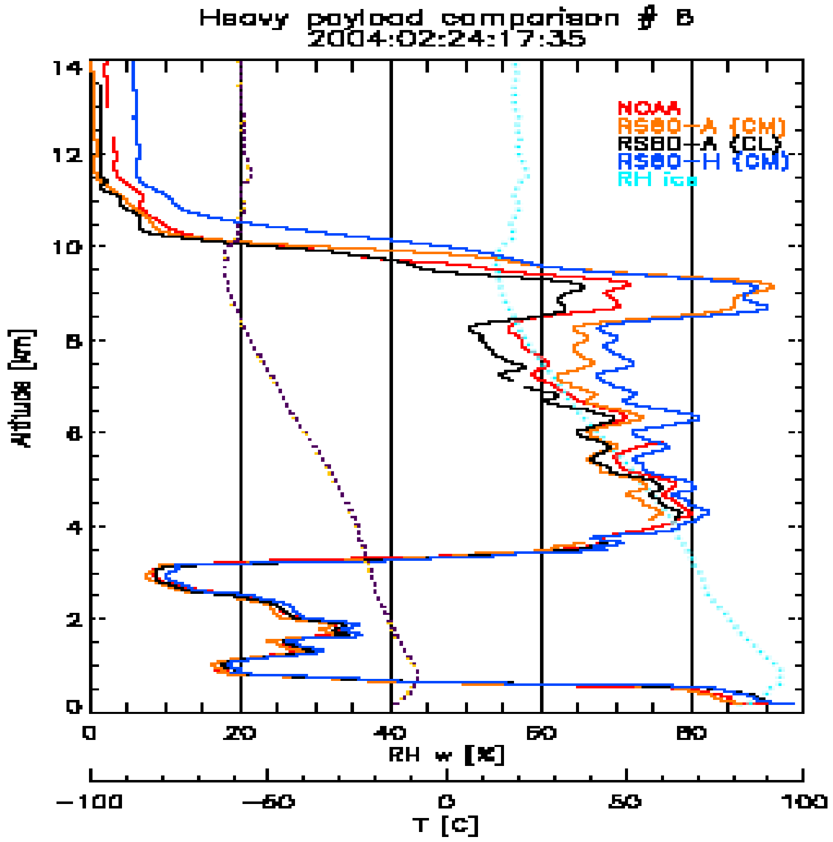


Figure 10: Example of the RS80 performance in the troposphere inside a thick cloud. Plotted parameter is relative humidity (RH%). Sondes: NOAA (thick red), RS80-A with Leiterer correction (black), RS80-A with Miloshevich correction (orange), and RS80-H with Miloshevich correction (dashed violet). Otherwise same as the previous Figure.

Various temperature dependent -, Time lag -, and Bias corrections have been developed for radiosondes and they correct to some extent (at least in statistical sense) the sensor biases up to upper troposphere. In the stratosphere the data from the current commercial radiosondes are not usable.

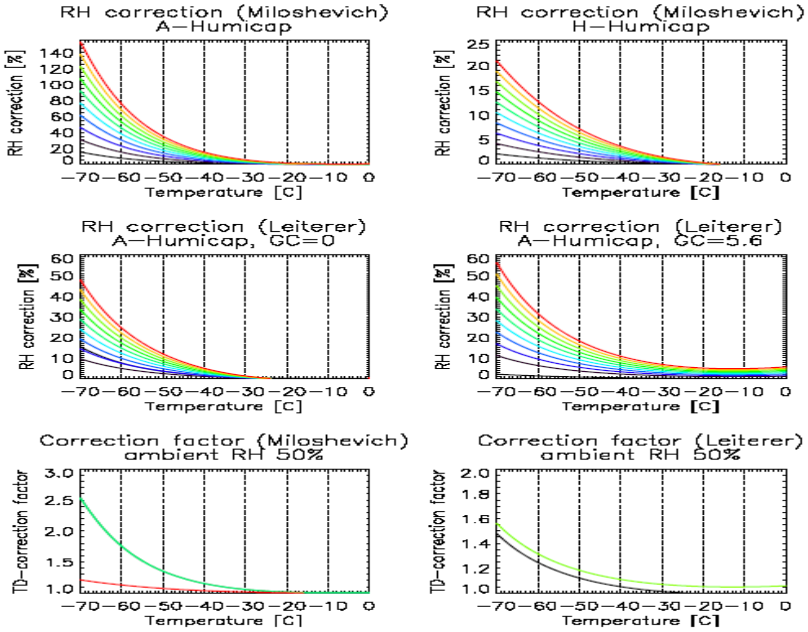


Figure 2: The four top panels show the amount of temperature-dependence (TD) correction at various RHs as a function of T for A Humicap, according to Leiterer and Miloshevich corrections. For the H-Humicap, the correction was only available by Miloshevich. The RH interval between RH-correction curves is 10%, the red being equal to 100%. The two lower panels show the magnitudes of the correction factors at 50% RH. The key for lower panels: A-Humicap (green), H-Humicap (red). Please, notice the effect of different y-scales in the plots.

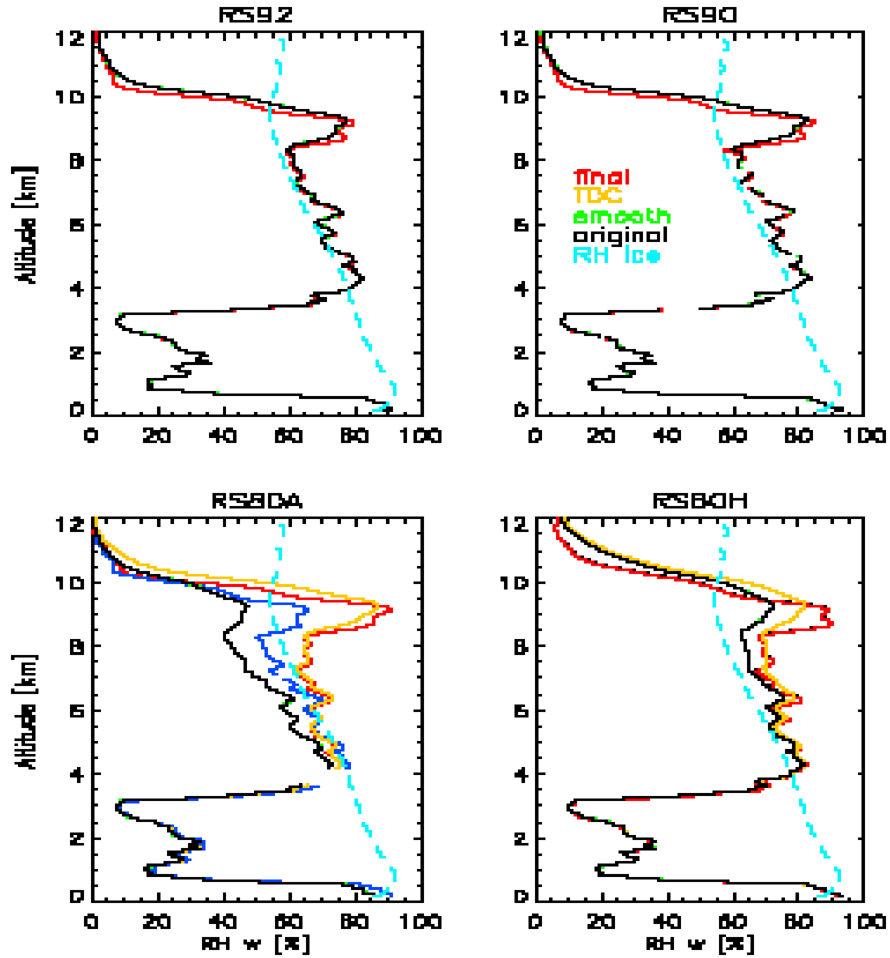


Figure 3: The applied corrections for an example RH profile on 24.2.2004. The original raw data is shown with black. The Miloshevich corrections as follows: final data (thick red), bias correction TDC (orange) and smoothed data (green). Final data includes TLC for all instruments, in addition to that, TDC is applied for the both types of RS80. In case of the RS80-A, the Leiterer correction including TLC and TDC is shown too (thick blue). As a reference, RH with respect to water at ice-saturation (dashed turquoise).

LAUTLOS: Tropospheric results

Tuomo Suortti

Finnish Meteorological Institute

Hygrometer inter-comparisons:

- **Radiosondes**: RS80-A, RS80-H, RS90, RS92 and FN
- **Frost point hygrometers:** NOAA/CMDL, CFH and Snow White
- **Ly-alpha**: FLASH-B

PLOT KEY:

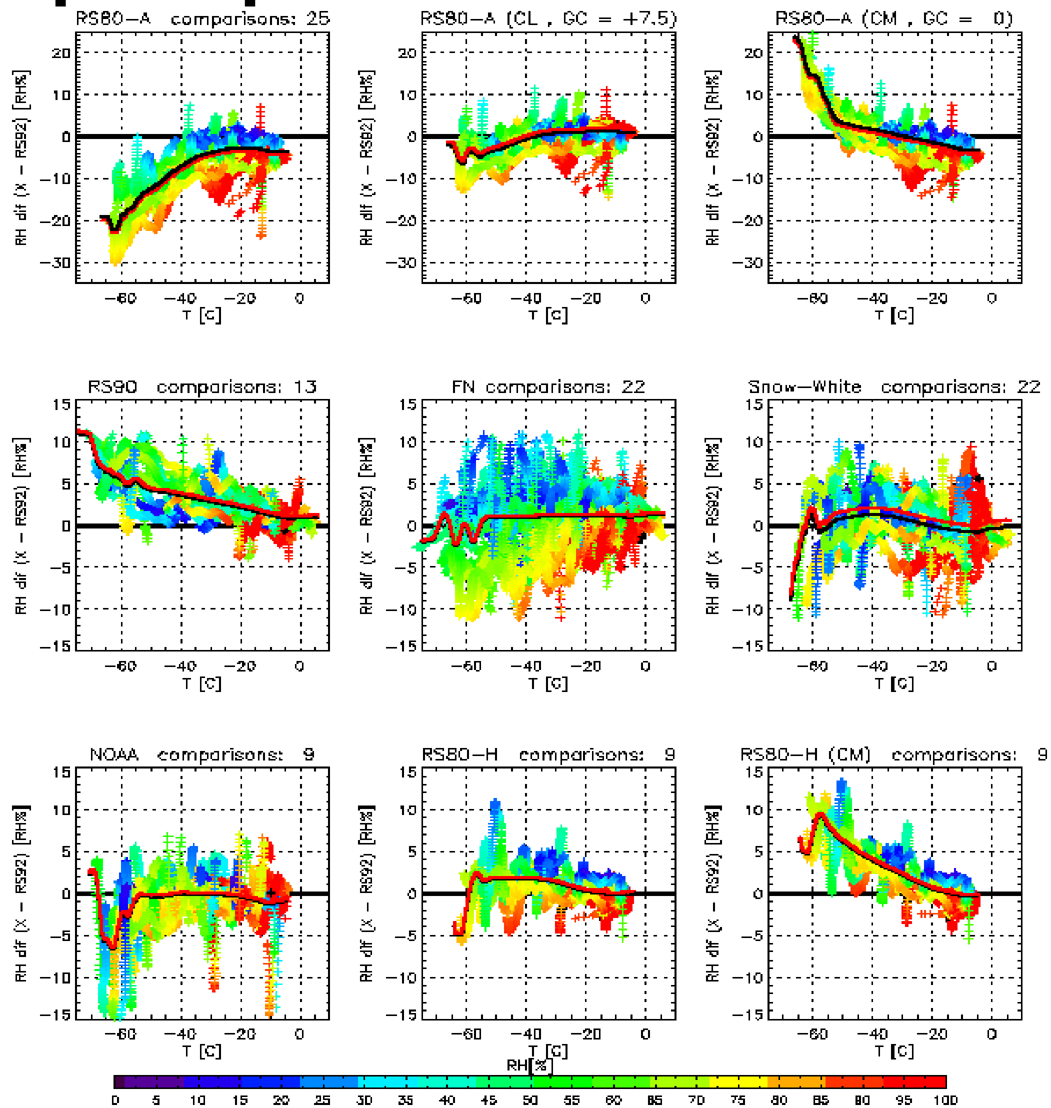
- Plot shows RH differences as a function of temperature (i.e. temperature dependence, TD)

- RS92 as used as a reference

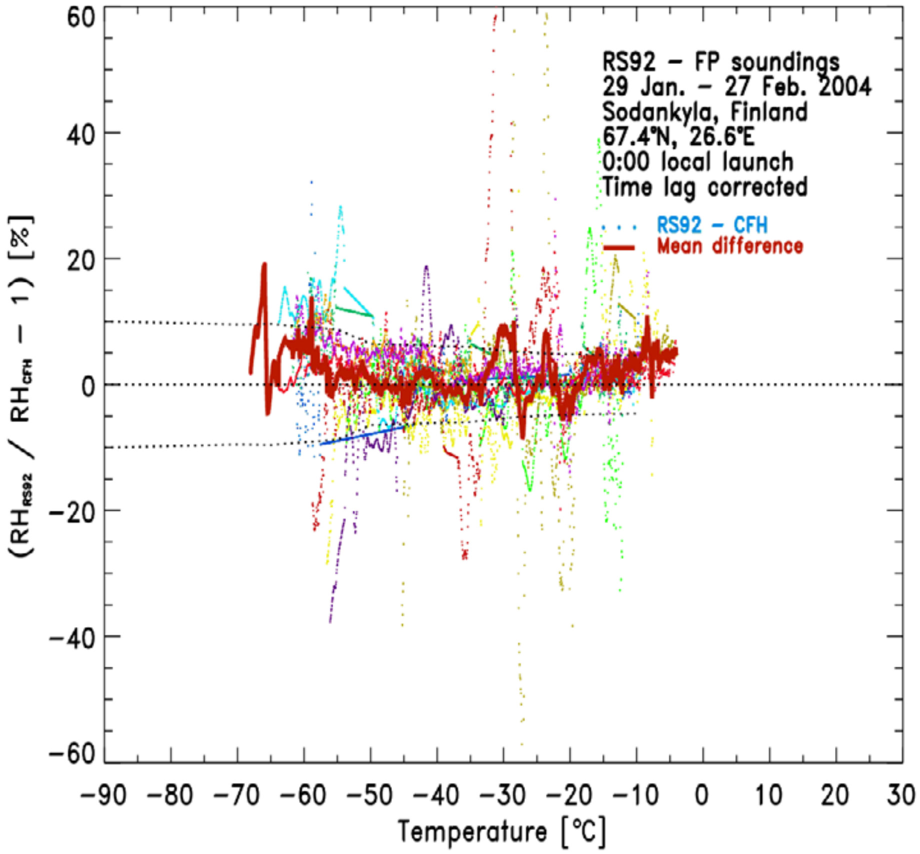
- Ambient RH is shown by the color scale.

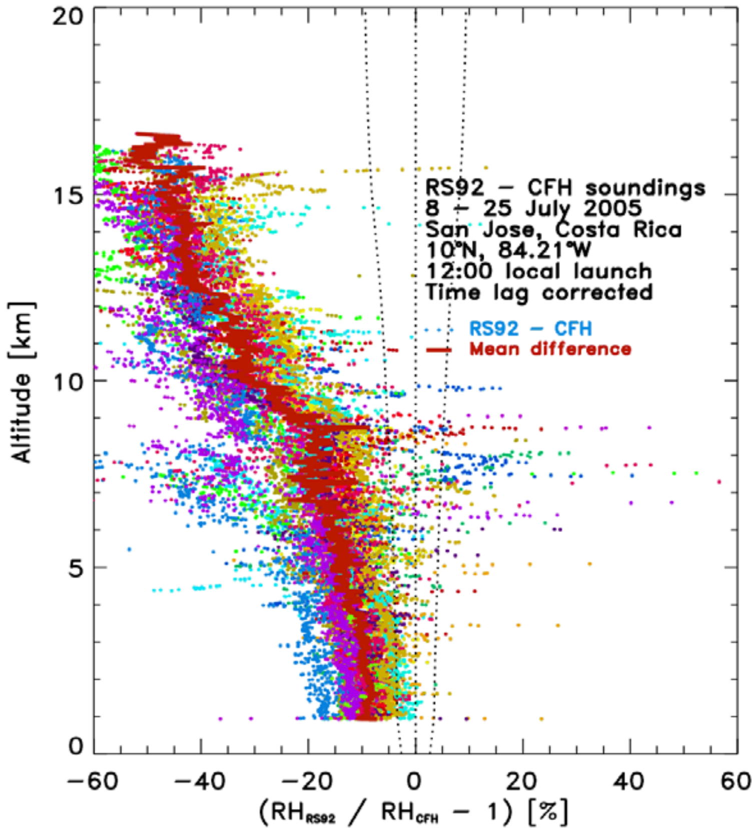
- CL=Leiterer TD-correction for RS80-A

- CM=Miloshevich TD-correction

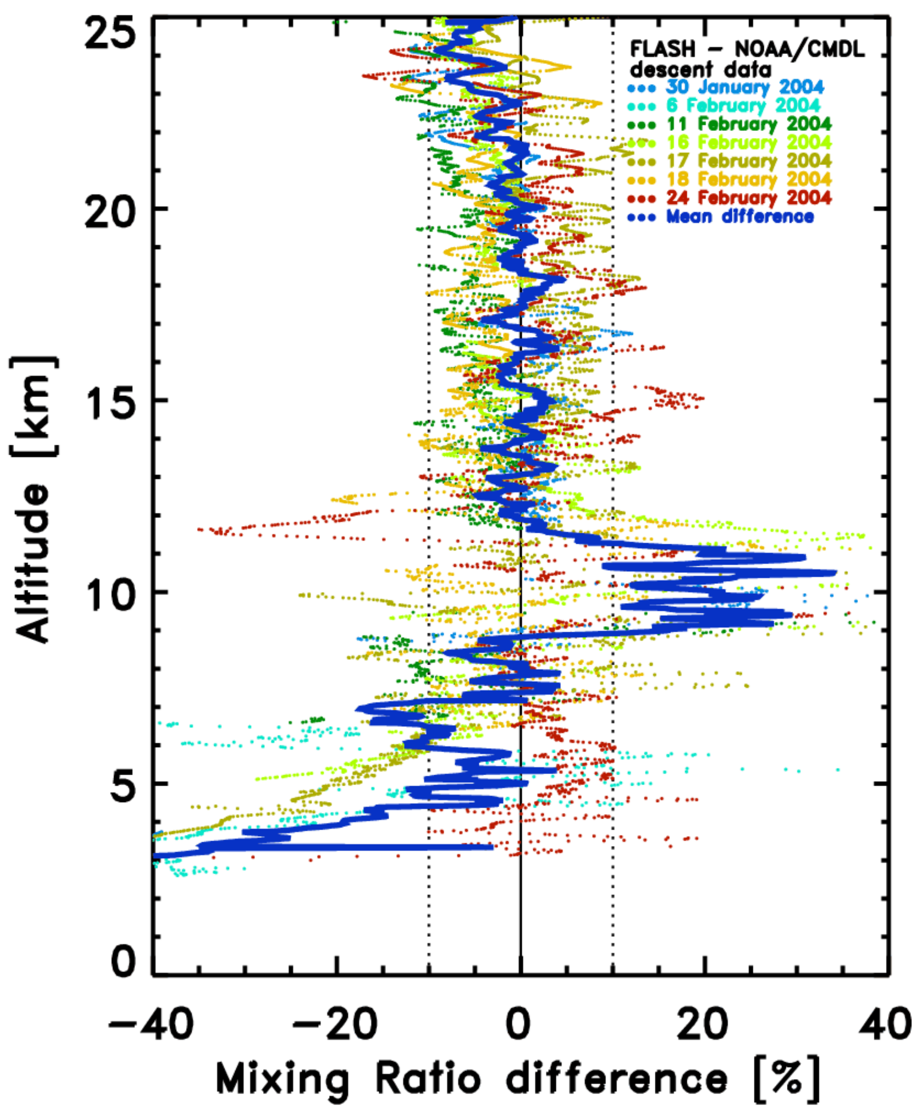


Holger Vömel et al.: Radiation dry bias of the Vaisala RS92 humidity sensor





FLASH - Lyman-α vs. NOAA, Figure from Holger Vömel's presentation



LAUTLOS publications:

- Deuber B., A. Haefele, D. G. Feist, L. Martin, N. Kampfer, G. E. Nedoluha, V. Yushkov, S. Khaykin, R. Kivi, H. Vomel, , Middle Atmospheric Water Vapour Radiometer: Validation and first results of the LAPBIAT Upper Tropospheric Lower Stratospheric Water Vapour Validation Project campaign, J. Geophys. Res., 110, 2005.
- Karpechko, A., A. Lukyanov, E. Kyro, S. Khaikin, L. Korshunov, R. Kivi and H. Vomel,The water vapour distribution in the Arctic lowermost stratosphere during LAUTLOS campaign and related transport processes including stratosphere-troposphere exchange, Atmos. Chem. Phys. Discuss., Vol. 6, pp 4727-4754, 13-6-2006.
- Maturilli M., F. Fierli, V. Yushkov, A. Lukyanov, S. Khaykin, and A. Hauchecorne, Stratospheric Water Vapour in the Vicinity of the Arctic Polar Vortex, Annales Geophysicae, accepted , 2006.
- Suortti, T. M., L. M. Miloshevich, A. Paukkunen, U. Leiterer, A. Kats, R. Kivi, H. Vomel, V. Yushkov, P. Ruppert, R. Neuber, N. Kampfer, The LAUTLOS-WAVAP: Tropospheric comparisons, Submitted to J. Atmos. Oceanic Technol., 2006.
- Vomel, H., V. Yushkov, S. Khaykin, L. Korshunov, E. Kyro, R.Kivi, Intercomparisons of stratospheric water vapor sensors: FLASH-B and NOAA/CMDL frost point hygrometer, undergoing review process in J. Atmos. Oceanic Technol., 2006.
- Yushkov, V., A. Lukyanov, S. Khaykin, L. Korshunov, R. Neuber, M. Mueller, E. Kyro, R. Kivi, H. Vomel,, I. Sasano, H. Nakane, Vertical distribution of water vapor in Arctic stratosphere based on LAUTLOS field campaign in January-February 2004, Izvestija Fizika Atmosferoe i Okeana, 2005, T. 41, No. 4, p. 1-9. /in Russian language/ udk 551.506:551.507

Mauritius WMO intercomparison of modern digital radiosondes February 2005

- Vaisala RS92 (Finland) [pressure sensor and GPS height]
- Graw DFM-97 (Germany) [pressure sensor and GPS height]
- MODEM M2K2 (France) [GPS height only]
- Sippican MKIIA (USA) [GPS height only]
- Meisei RS-01G (Japan) [GPS height only]
- Meteolabor, SRSD-C34 (Switzerland) [Hypsometer pressure sensor]

B. Pathack, *Mauritius Meteorological Services, Vacoas*, **J. Nash** and **R. Smout,** *Met Office, Exeter,UK*, and, **S. Kurnosenko** ,*Scientific software consultant, US:* ***Preliminary Results of WMO Intercomparison of high quality radiosonde systems, Mauritius, February 2005***

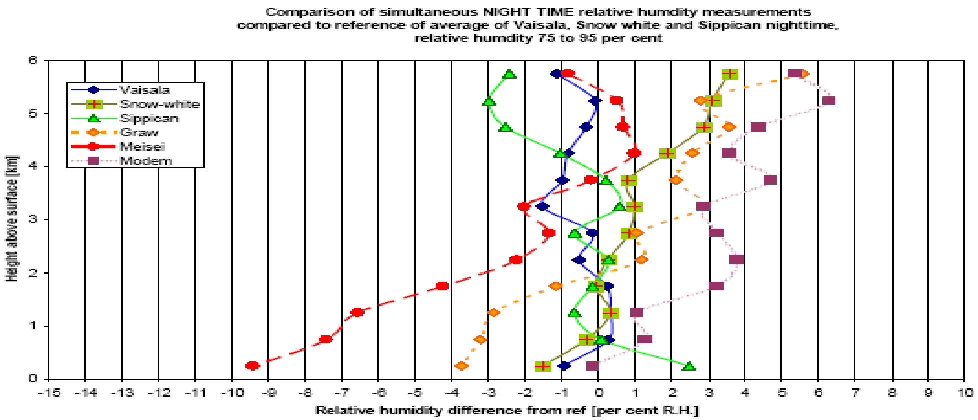


Fig. 7(a) Systematic bias for night time relative humidity , range 75 to 95 per cent, referenced to the average of Vaisala, Snow white and Sippican.

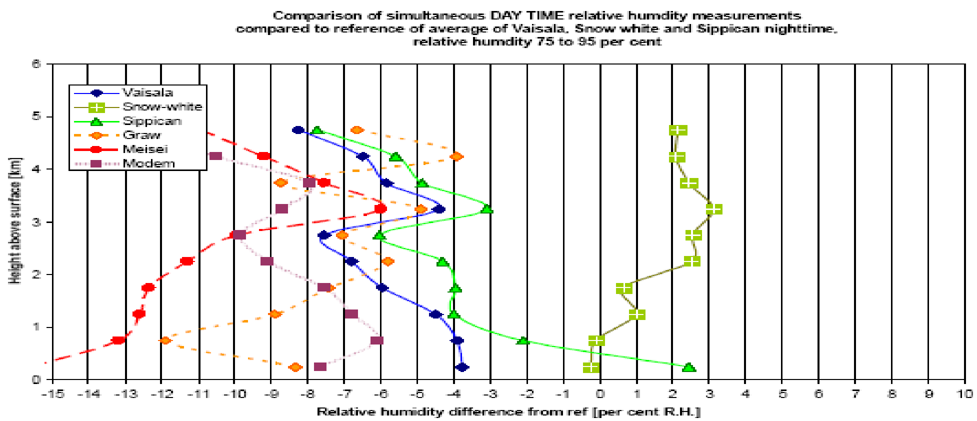


Fig. 7(b) Systematic bias for daytime relative humidity, range 75 to 95 per cent , referenced to the night time average of Vaisala, Snow white and Sippican,

B. Pathack, **J. Nash**, **R. Smout,** and **S. Kurnosenko**: ***Preliminary Results of WMO Intercomparison of high quality radiosonde systems, Mauritius, February 2005***

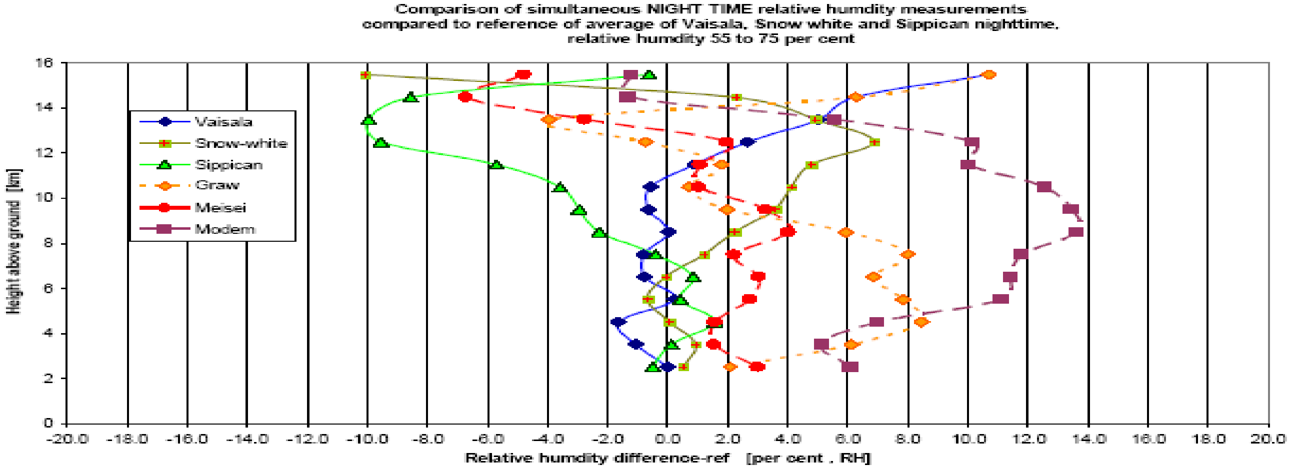


Fig. 7(c) Systematic bias for night time relative humidity , range 55 to 75 per cent, referenced to the average of Vaisala, Snow white and Sippican.

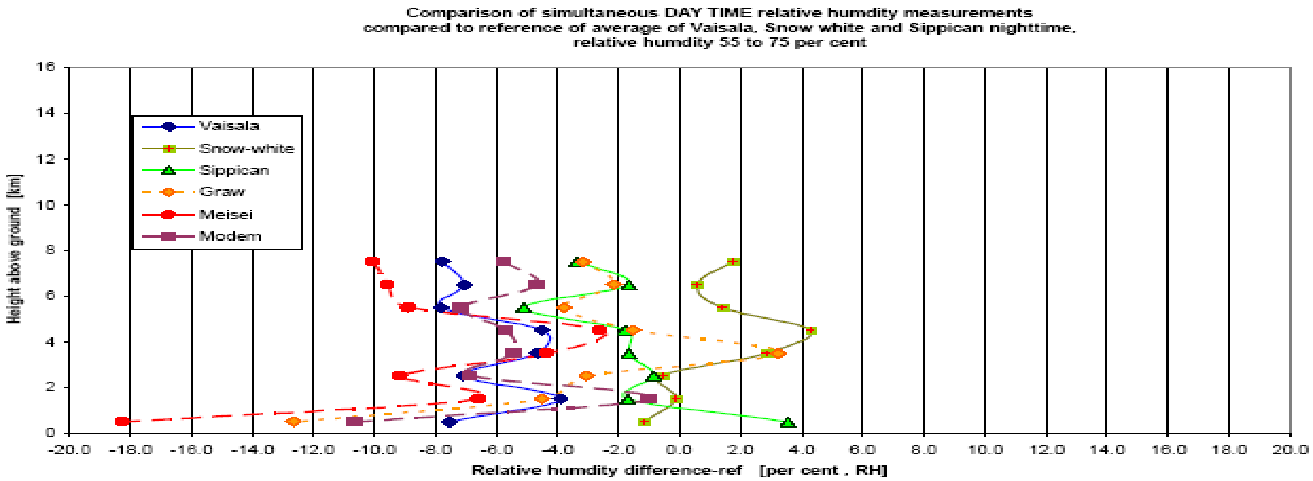


Fig. 7(d) Systematic bias for daytime relative humidity, range 55 to 75 per cent referenced to the night time average of Vaisala, Snow white and Sippican.

B. Pathack, **J. Nash**, **R. Smout,** and **S. Kurnosenko**: ***Preliminary Results of WMO Intercomparison of high quality radiosonde systems, Mauritius, February 2005***

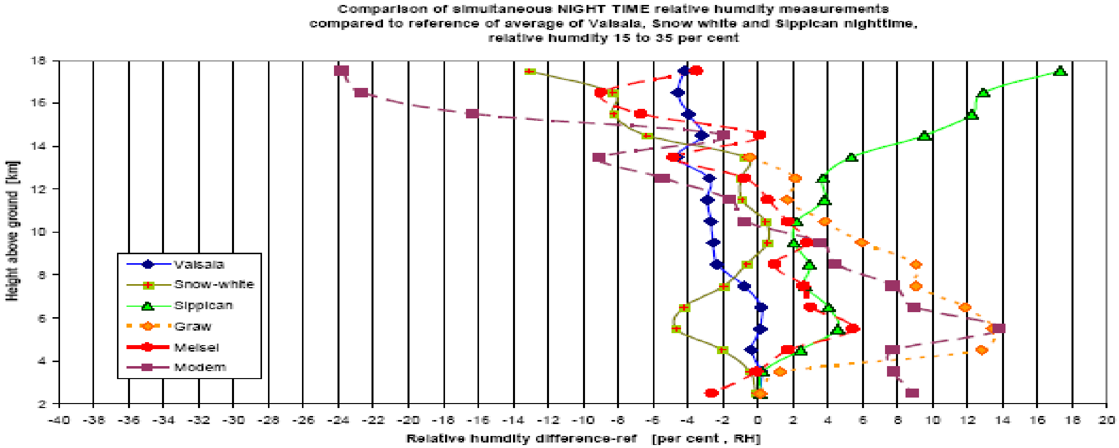
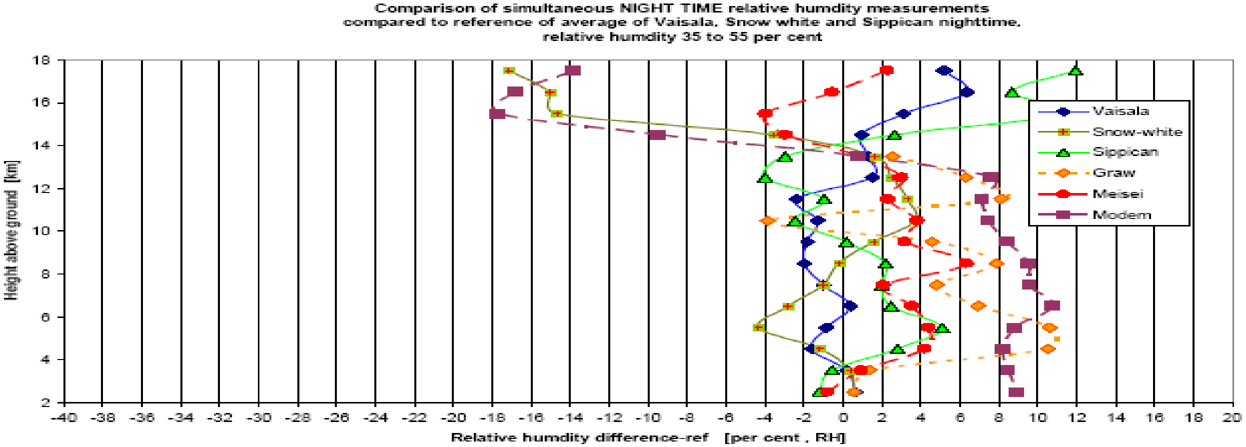


Fig. 7(g) Systematic bias for night time relative humidity, range 15 to 35 per cent, referenced to the average of Vaisala, Snow white and Sippican



.Fig. 7(e) Systematic bias for night time relative humidity, range 35 to 55 per cent, referenced to the average of Vaisala, Snow white and Sippican

B. Pathack, **J. Nash**, **R. Smout,** and **S. Kurnosenko**: ***Preliminary Results of WMO Intercomparison of high quality radiosonde systems, Mauritius, February 2005***

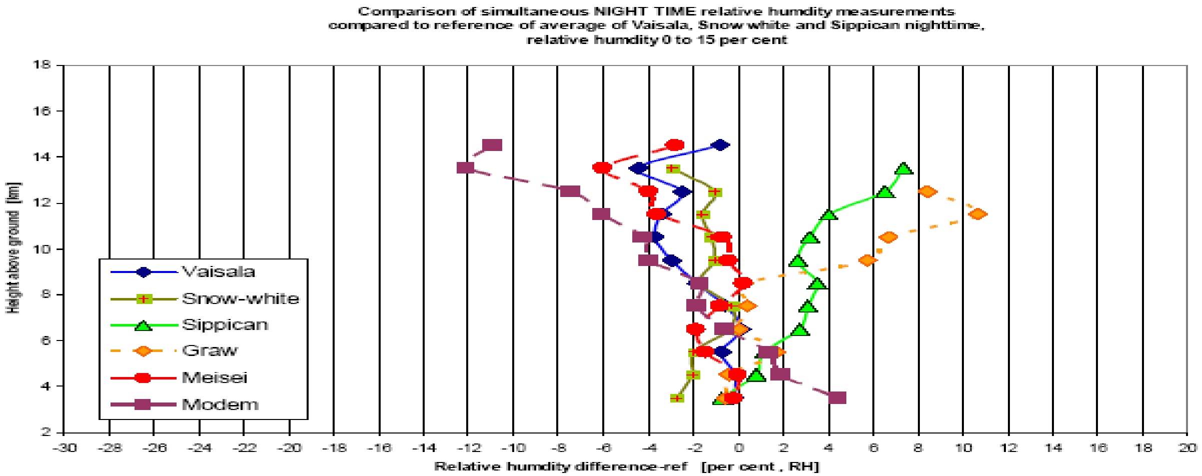


Fig. 7(i) Systematic bias for night time relative humidity, range 0 to 15 per cent, referenced to the average of Vaisala, Snow white and Sippican

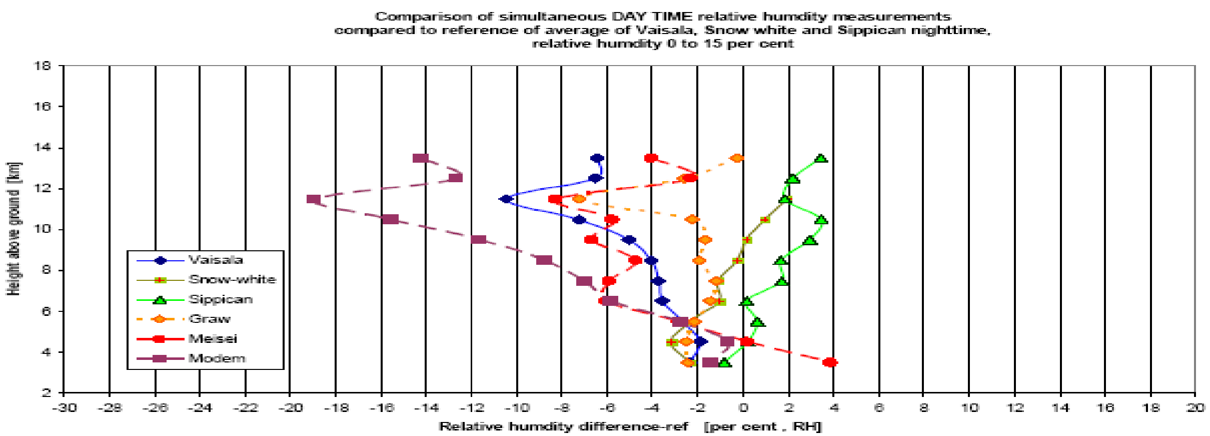


Fig. 7(j) Systematic bias for daytime relative humidity, range 0 to 15 per cent referenced to the night time average of Vaisala, Snow white and Sippican.

B. Pathack, **J. Nash**, **R. Smout,** and **S. Kurnosenko**: ***Preliminary Results of WMO Intercomparison of high quality radiosonde systems, Mauritius, February 2005***

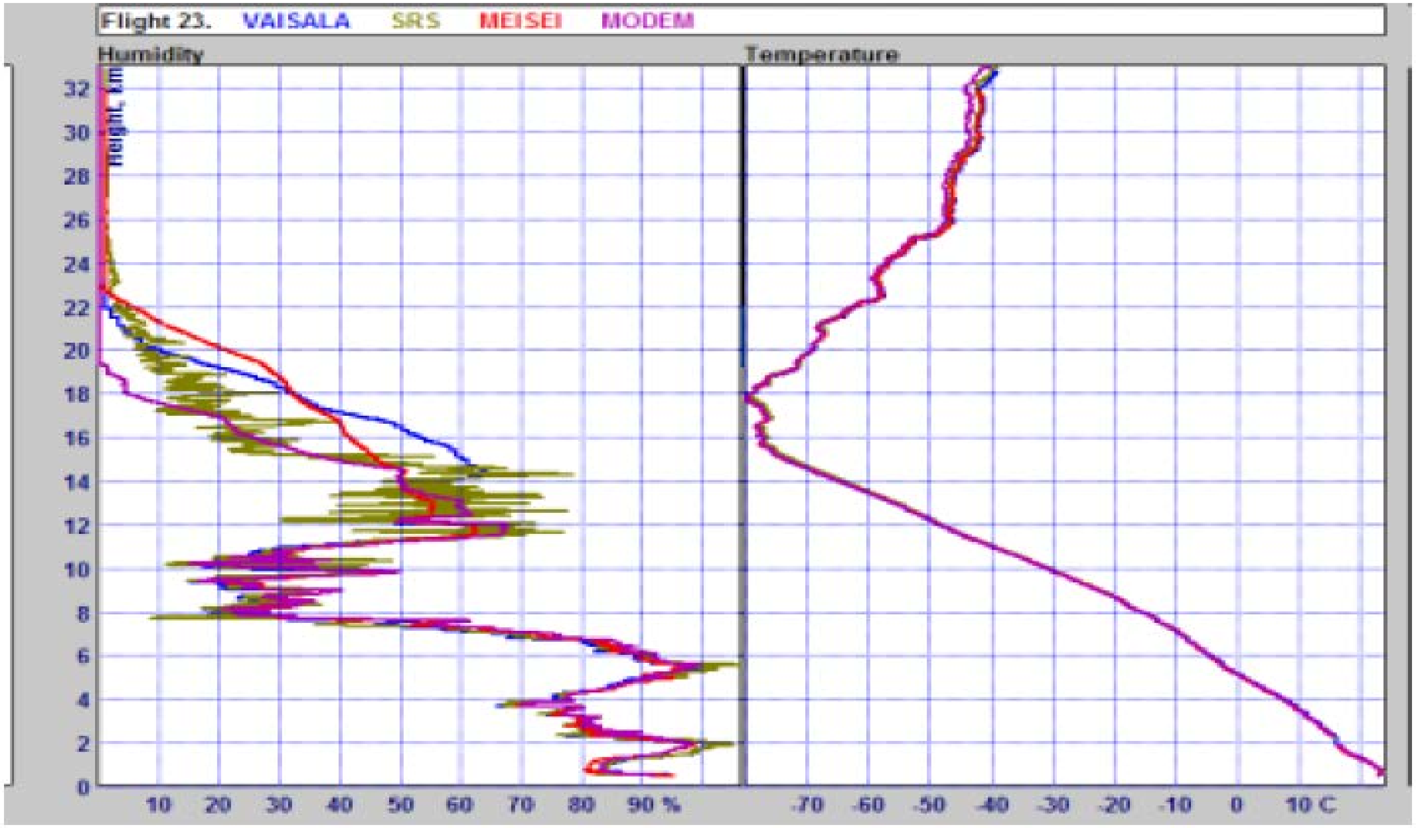


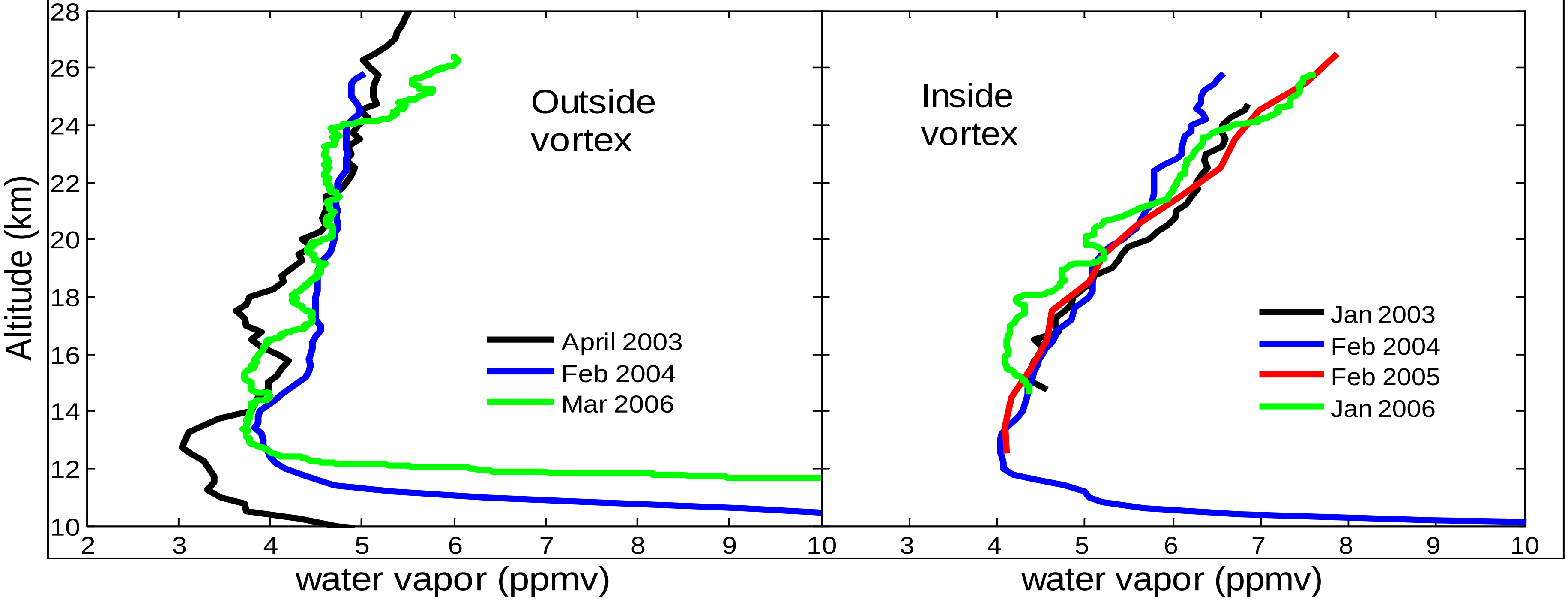
Fig.8 Night time relative humidity and temperature comparison between the Vaisala, Meisei –Modem group and SRS Snow White

Sodankylä stratospheric water vapor soundings

- **Observations 1996, 2002-2006**

Arctic H_2O observations in the LS

- Balloon borne frost point hygrometers flown in the winters of 2002/2003-2005/2006 in Sodankylä (67.4°N). Profiles inside the Arctic vortex (right) and in the vicinity of the vortex (left). From Kivi et al., 2006



Water vapour in the lower stratosphere during LAUTLOS

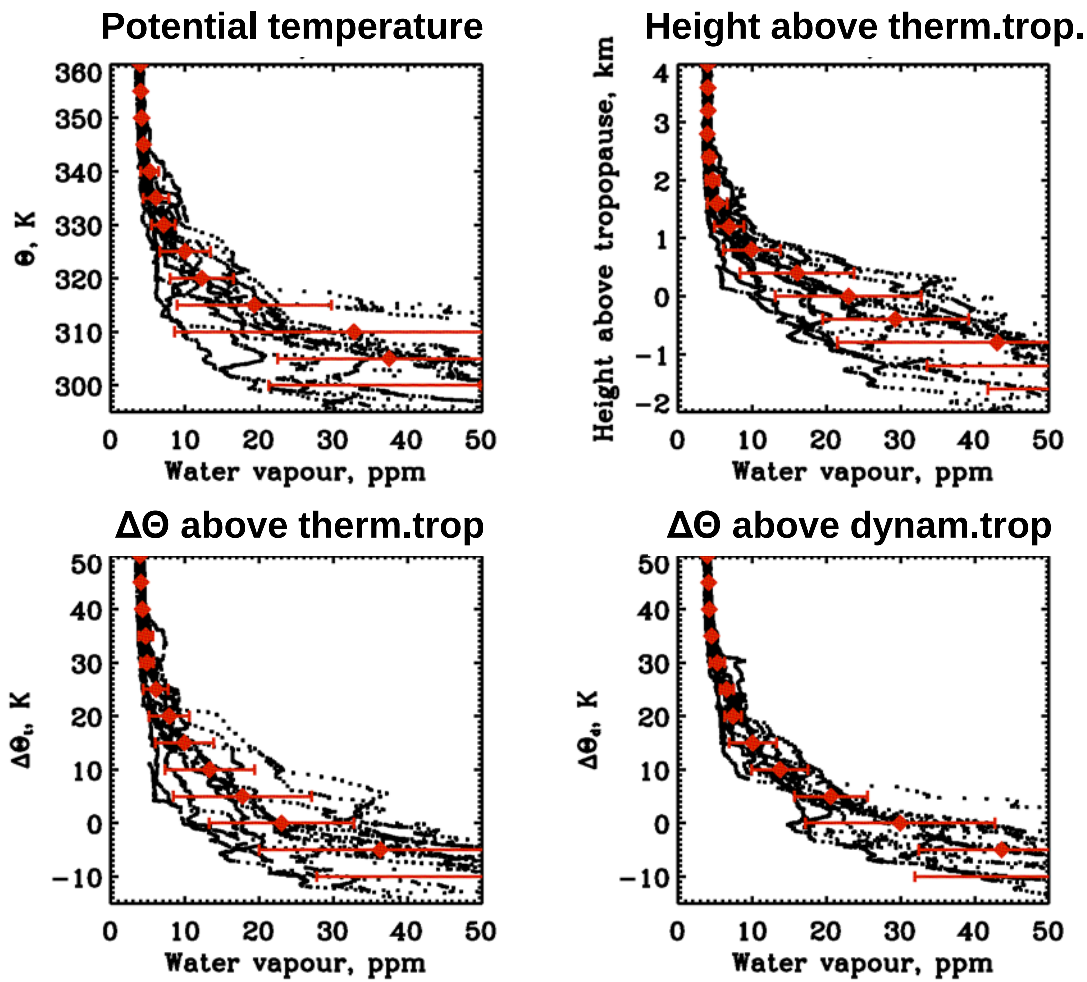
DATA:

11 balloon flights of FLASH-B hygrometer;
LAUTLOS campaign;
21.01.2004-27.02.2004;
Sodankylä, Finland.

RESULTS:

- **Troposphere-to-stratosphere transport (TST) occured mainly below 345K.**
- **Layer influenced by TST extended up to 2.5 km above local tropopause (or 30K in potential temperature scale)**

(*see Karpechko et al., ACPD, 2006*)



CFH vs. FLASH-B in Sodankylä, 2006

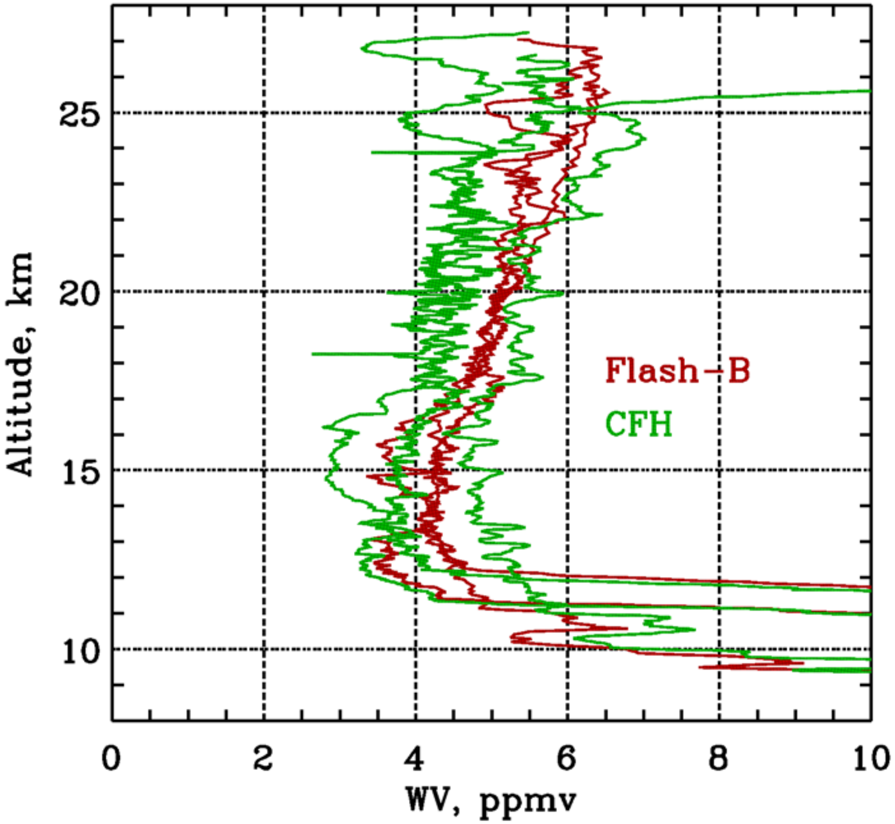


Table from Holger Vömel's presentation

	Claimed accuracy	Calibration	Limitations	Dynamic range	History	Cost	Ease of use	Engineering status
CFH	0.5°C DP/FP 4-9%	++	No "wet" clouds	++	+	- (o)	o	research / small series
Snow White	0.1°C DP/FP	+	Some clouds RH > 3-6% No stratosphere	o	+	o	++	production small series
Lyman-alpha (FLASH)	9% (20% below 2 ppmv)	+	Night time only Descent only No lower troposphere	+	o	--	+	research / small series
TDL (MayComm)	5% 0.5 ppmv	o	?	+	-	--	(++)	Proof of concept
Polymer (Vaisala RS92)	1% RH	-	No stratosphere Large radiation error Chemical contamination Very hard to trace sensor/calibration changes	-	+	++	+ (++)	Large scale production