IAGOS-RH/T Measurements: Update on QA Efforts

www.iagos.org

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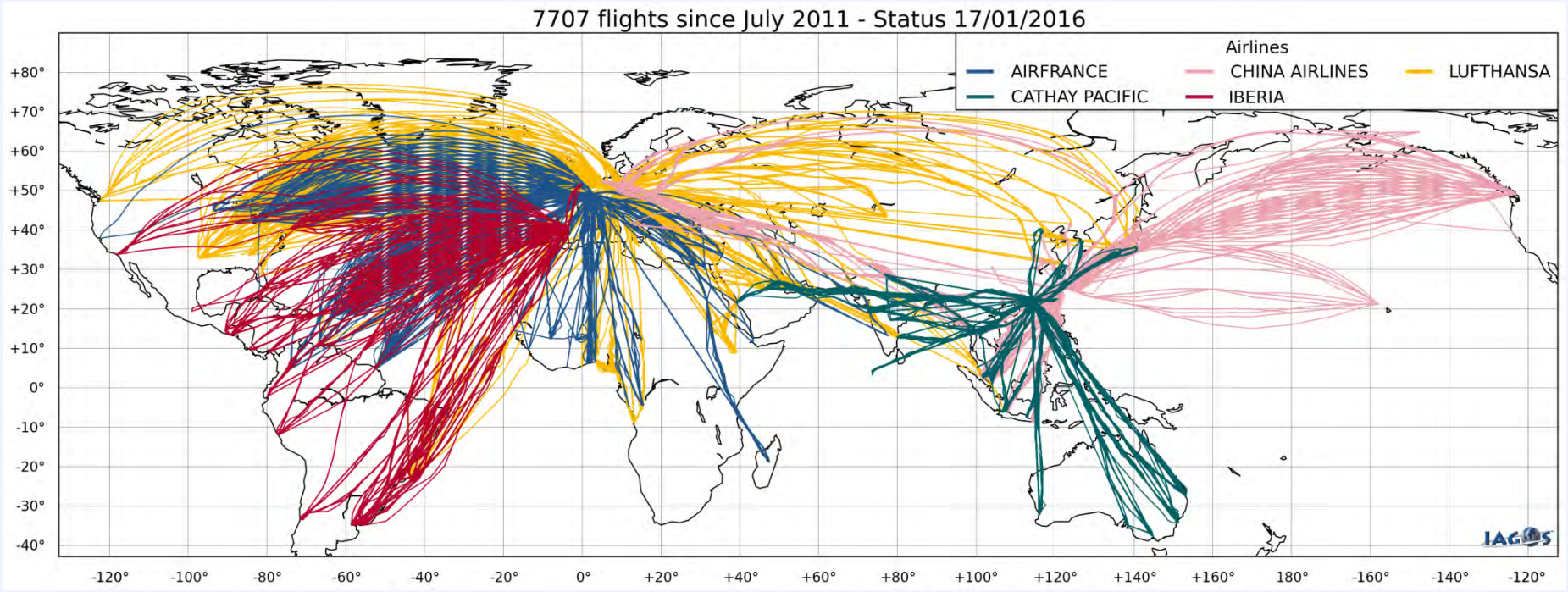
IAGOS - CORE Flight Map

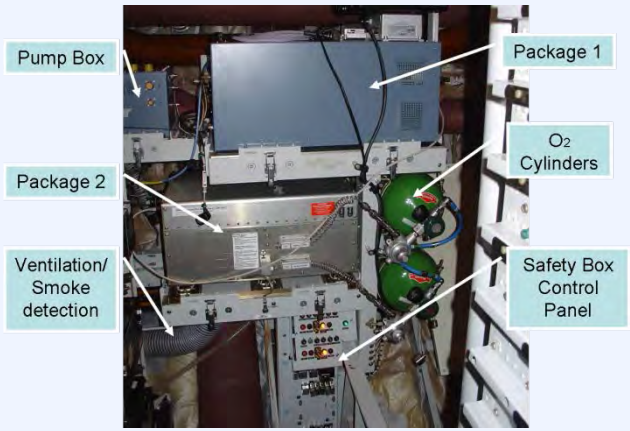
http://www.iagos.fr



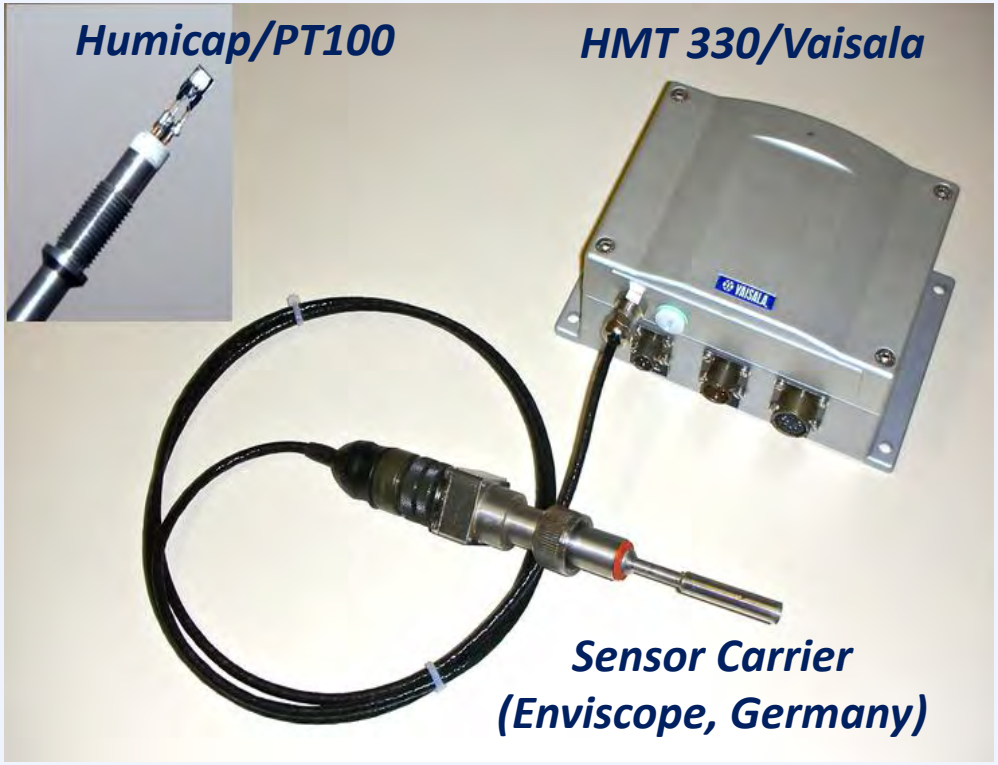
New 2017/2018: CAL#2, AF#2, HAL & Finnair

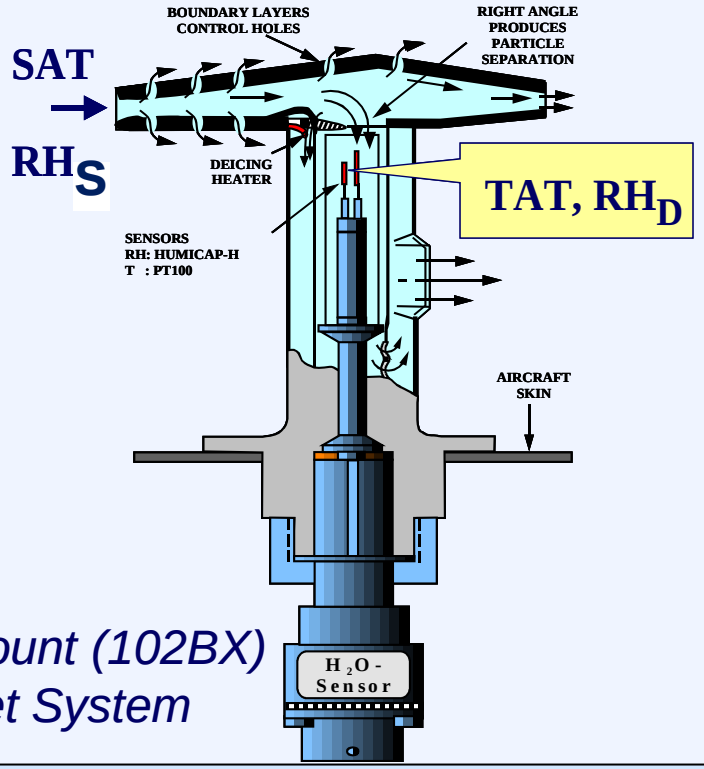
IAGOS-CORE aircraft schedule:

- In 2017/2018, 9 equipped aircraft in regular operation. Planned 15 A/C's in 2020
- Approx. 500 flights per aircraft per year
- More than 200 airports worldwide visited regularly



IAGOS & MOZAIC: RH,T Sensor in TAT-Inlet



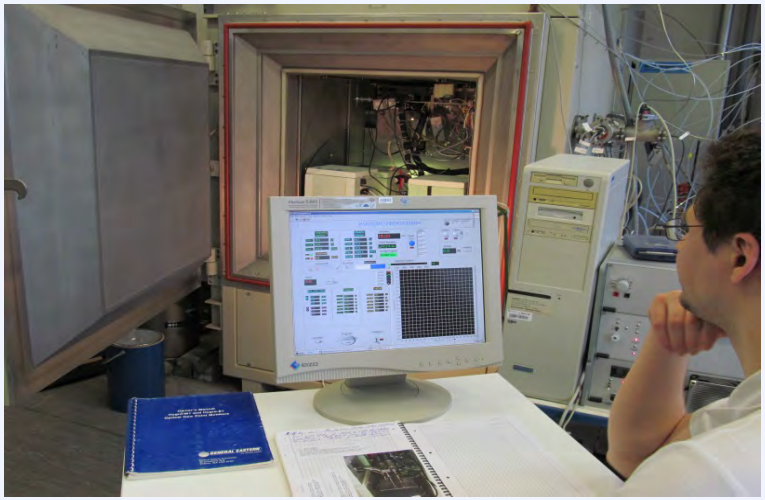


Rosemount (102BX) TAT-Inlet System

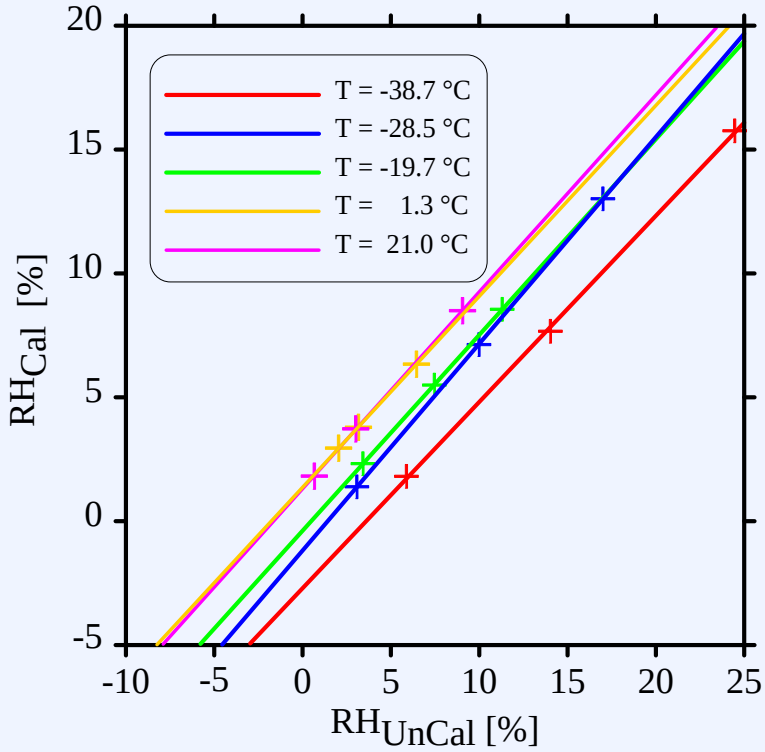
In inlet strong speed reduction (Mach≈0.8 to 0) with adiabatic conversion:

- Heating (SAT to TAT) : in UT ≈ 30°C
- Compression (P_S to P_D): in UT ≈ Factor 1.6
- **RH at detector (RH_D) more than factor 10 smaller than RH sampled air (RH_S)**

IAGOS & MOZAIC Capacitive Hygrometer (MCH & ICH): Pre- & Post-Flight Calibration



$$RH_{Cal}(T_i) = a(T_i) + b(T_i) \times RH_{UnCal}(T_i)$$



- Regular calibration (every 1000 flight hours in the ESF (Env.Sim.Fac.) at Juelich, Germany
- Since 2016, against MBW 373 LX Cryo-genic Frostpoint Hygrometer. Before Lyman(α)-fluorescence hygrometer at T_{Air} <-10 °C and Frost-point hygrometer at T_{Air}>-10 °C with relative uncertainty better than 5%
- Under realistic „flight“ conditions of humidity, temperature and pressure

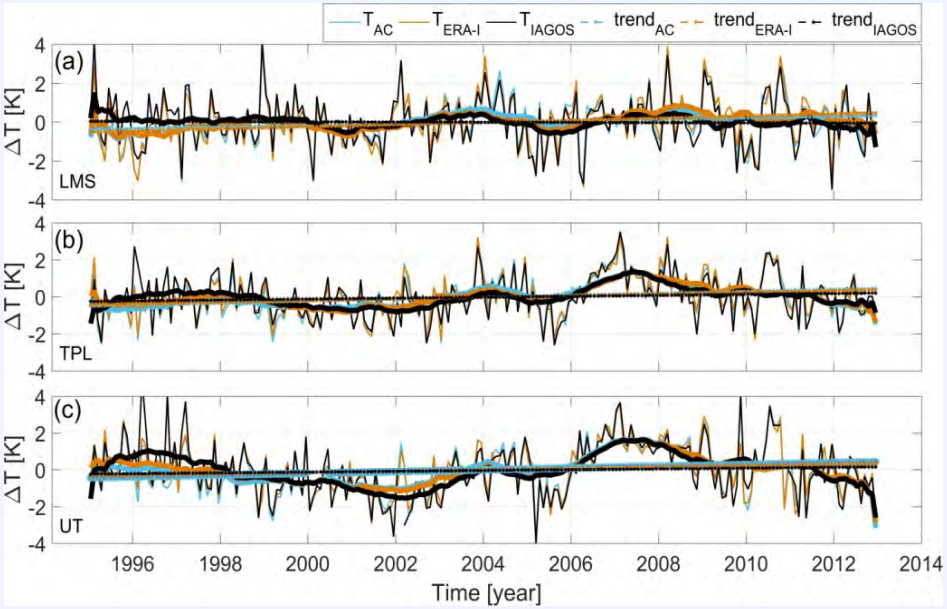
MOZAIC-Humidity Device: Performance

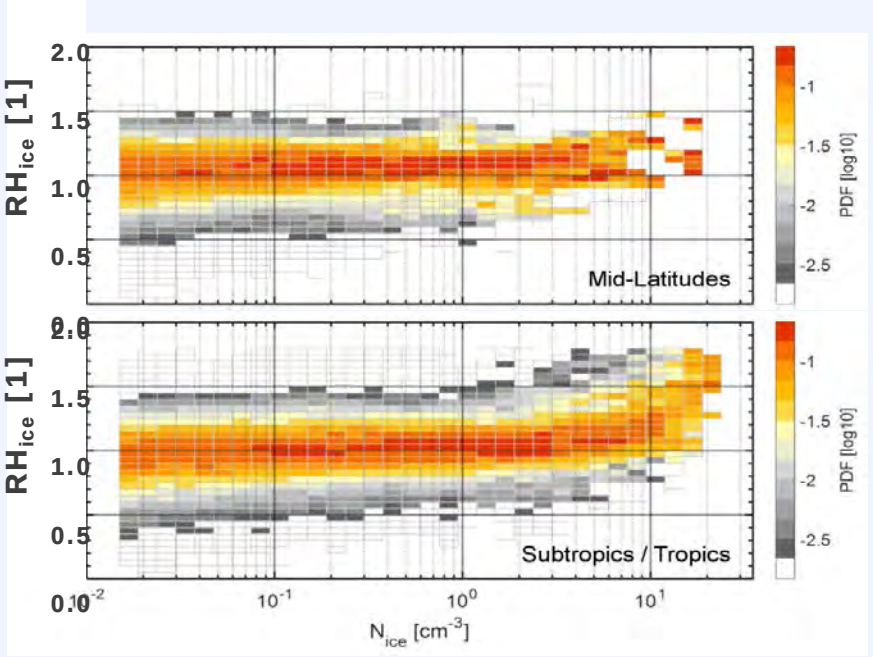
Horizontal resolution	**Relative Humidity:** **ΔX ≅ Aircraft speed x Response time** **ΔX ≅ 15 km @ Z ≅ 8-12 km cruise altitude**
Precision	**Relative Humidity:** **± (1-2)% RH @ Z=0-8 km** **± (2-4)% RH @ Z= 8-12 km** **Temperature** **± (0.1-0.2) K @ Z= 0-12 km**
Uncertainty	**Relative Humidity:** **± (5-6)% RH @ Z= 0-12 km** **Temperature:** **± (0.5-1.0) K @ Z= 0-12 km**

Temperature Trends

HIGHLIGHTS : UTLS TEMPERATURE AND CLOUDS

Cirrus Clouds





20 years of temperature measurements in the tropopause region indicate:

- De-seasonalized time series show:
  ⇒ no significant trends in the UTLS.
- This contradicts +0.56 K/decade predicted by ERA 40.

⇒ Details: Berkes et al., ACP 2017

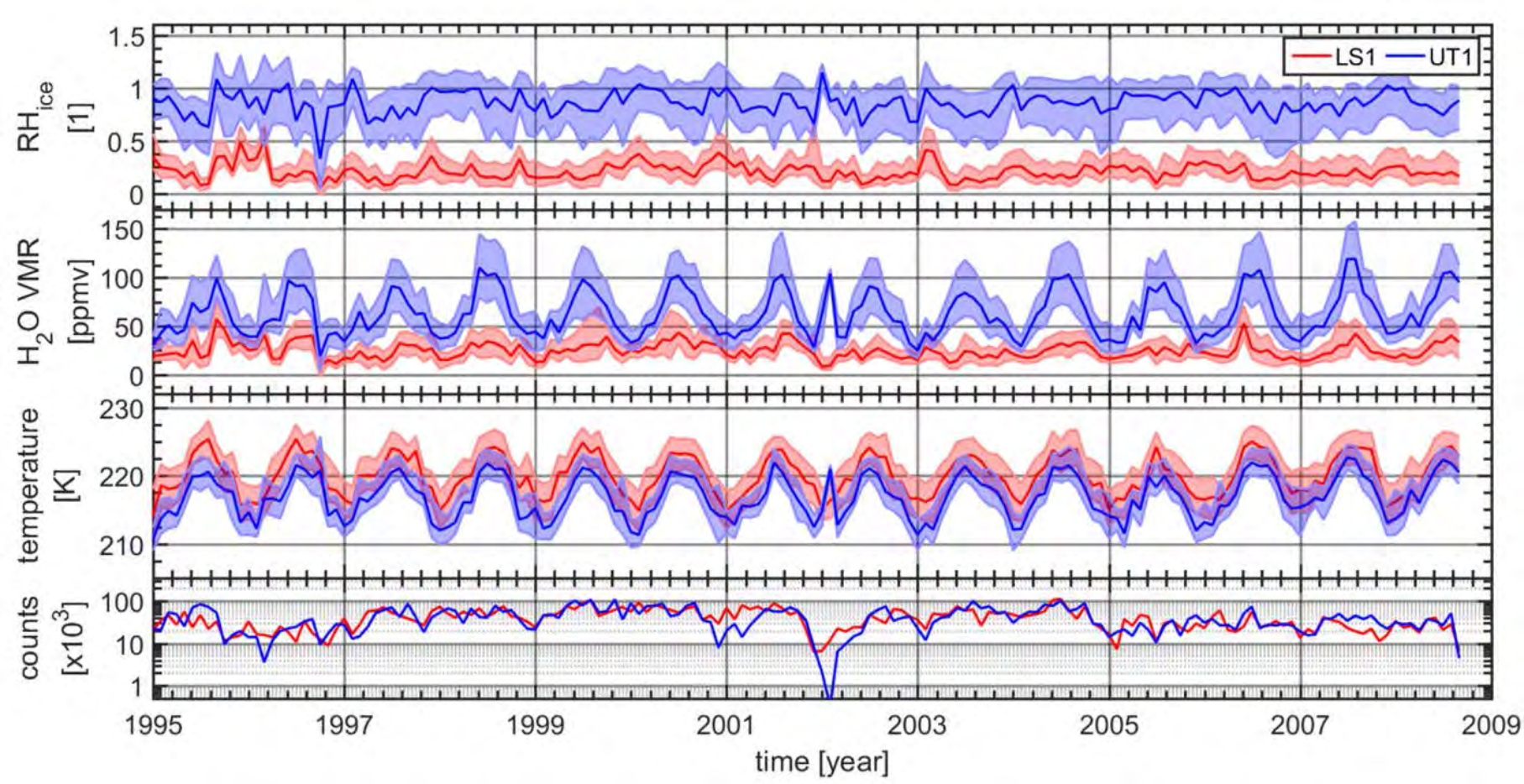
Observation of clouds and water vapour provide new insights in cirrus properties:

- Probability of higher dynamic equilibrium RH_{ice} correlates with higher N_{ice}.
- Thin cirrus ($N_{ice} < 0.1$ cm^{-3}) dominate cirrus at mid-latitudes.

⇒ Details: Petzold et al., Farad. Discuss. 2017

IAGOS-RH : TRENDS

Time series of IAGOS water vapour in the UTLS over the North Atlantic (40-60 °N, LS: PV>2.0 pvu & UT: PV < 2.0 pvu)



IAGOS-RH : TRENDS

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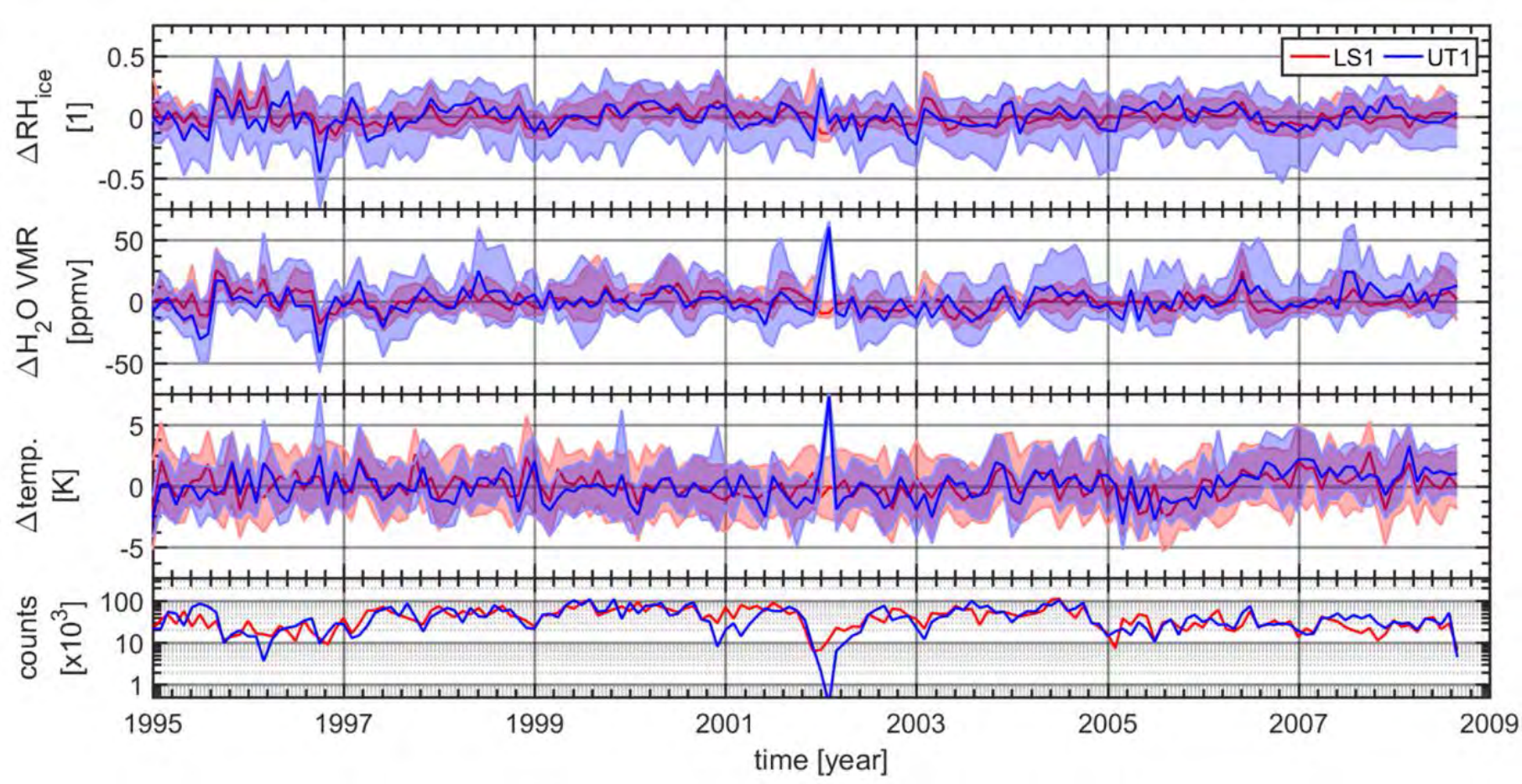


IAGOS-RH/T: Water Vapor & Temperature Trends

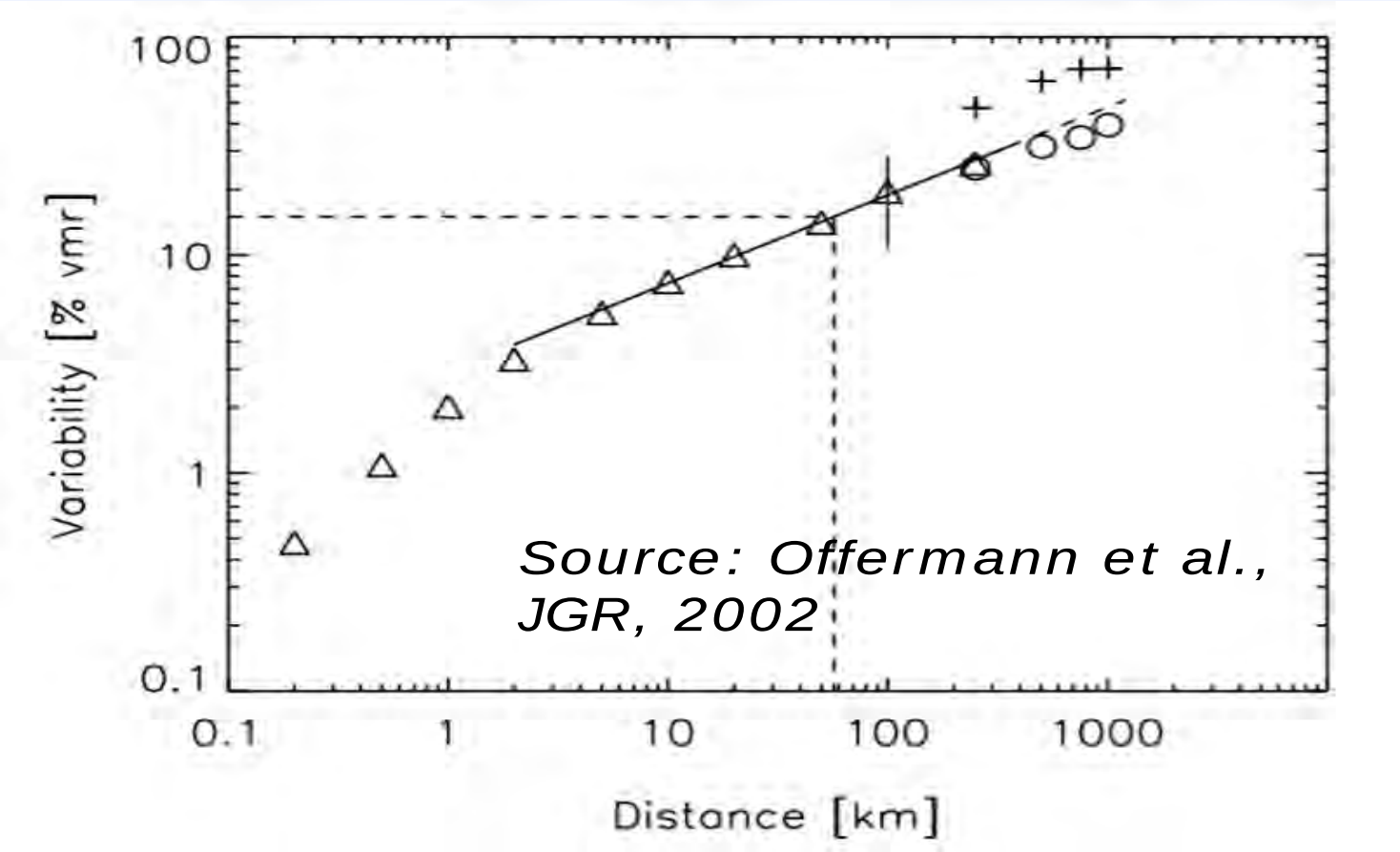
Estimation of numbers of years needed to detect a trend:
95 % confidence level, 90 % probability
(Wheatherhead et al., 1998; Whiteman et al., 2011)

$$n^* = \left[\frac{3.3\sigma_N}{|\omega_0|}\sqrt{\frac{1+\phi_N}{1-\phi_N}}\right]^{2/3}$$

n^* is the number of years to detect a trend,
ω_0 is the specified trend magnitude (% year^{-1}),
σ_N is the standard deviation of the total noise in the time series (% of mean value), and
Φ_N is the autocorrelation of the noise.

	RH_{ice}	H_2O VMR
Estimated Trend from Obs.	0.0 %/year	0.04 %/year
σ_N	11.6 %	17.5 %
Φ_N	0.26	0.29
n^* (ω_0 = 0.5 %/year)	21.5	28.9
n^* (ω_0 = 1 %/year)	13.5	18.2

High Natural Variability of Water Vaour in UT



High natural variability of H2O, already:

- > 20 % over distance of 100 km
- > 10 % over *distance of* 20 km
- < 1% over distance < 1 km

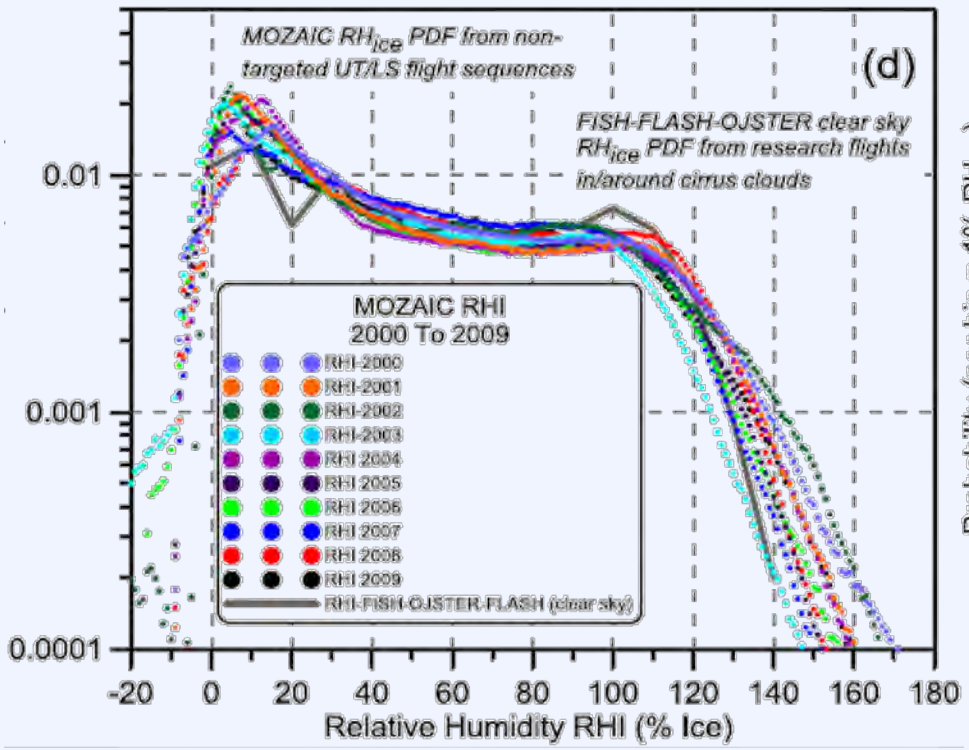
MOZAIC-Humidity Device (MHD): Application of In-Flight Calibration (IFC)

[Smit et al., J.Atm.Ocean.Tech., 2008]

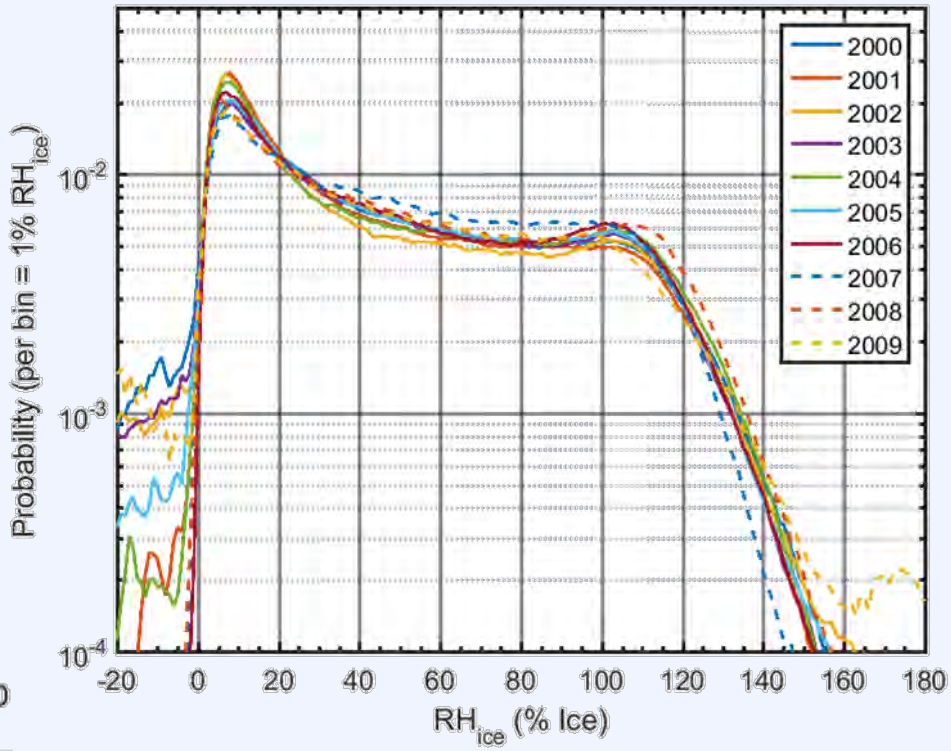
- Based on the technology and experience obtained during more than one decade of MOZAIC-RH/T operation.
- Long-term zero drift of MOZAIC-device, particularly at low temperatures, is the critical and accuracy determining parameter
- In-Flight determination of long term zero drift during dry stratospheric episodes as a function of temperature ($RH_0(T)$ at 5ppmv water vapor).
- Correction of zero drift of RH-measurements
- **Re-analysis of RH-Data in 2017/2018: Application of IFC on 20 years of MOZAIC-RH measurements**

2017/2018: Re-Analyis of 20 years of MOZAIC-Relative Humidity Measurements: Application of In-Flight Calibration (IFC)

Before:
(Smit et al., 2014))



After:
(Neis-Rohs-Smit)



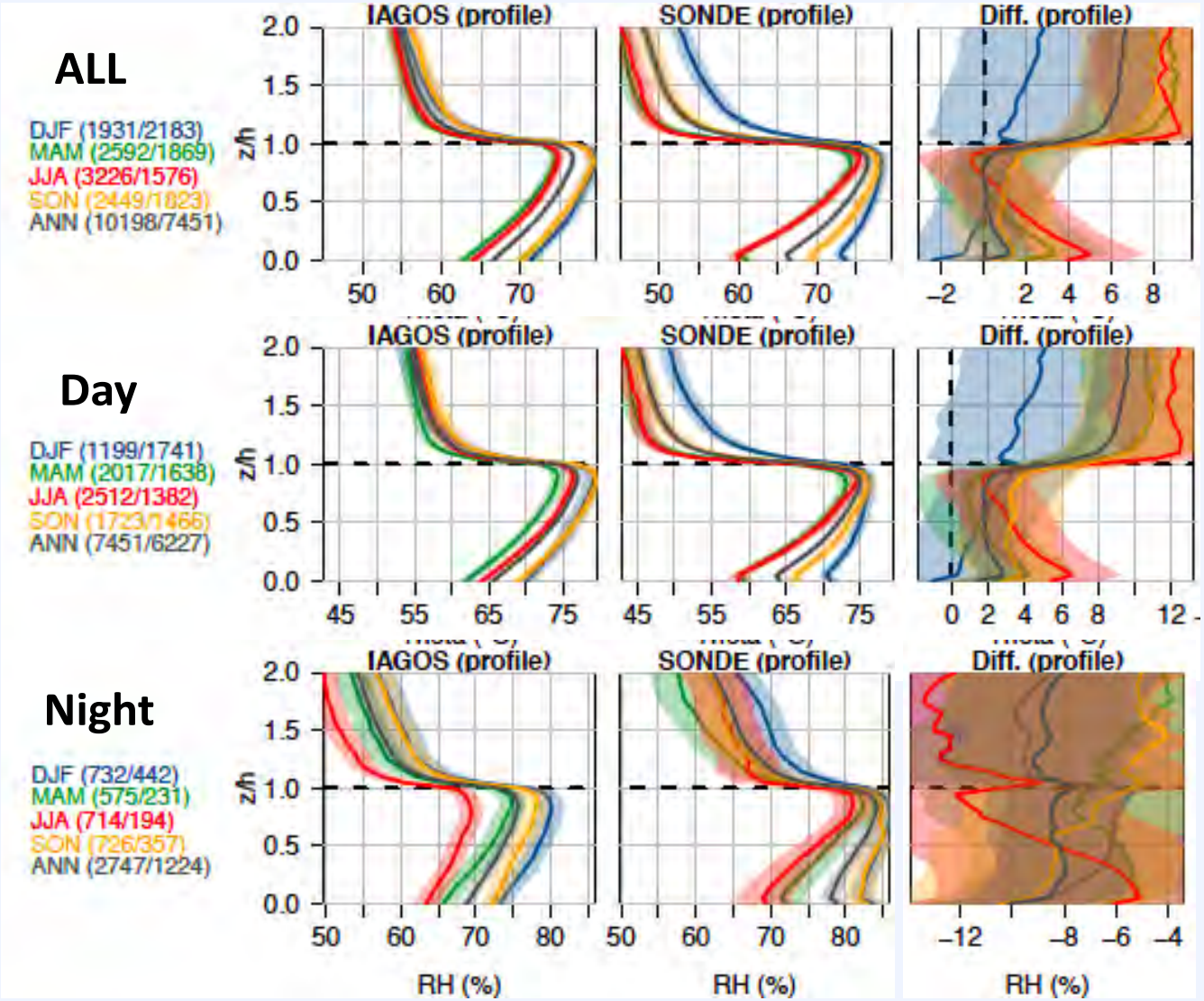
MOZAIC Versus Radiosondes: Comparison RH at PBL

Study by Herve Petitin, Submitted to ACPD , April 2018

Above PBL Day+Night
IAGOS: 55-60%
RS: 45-55%

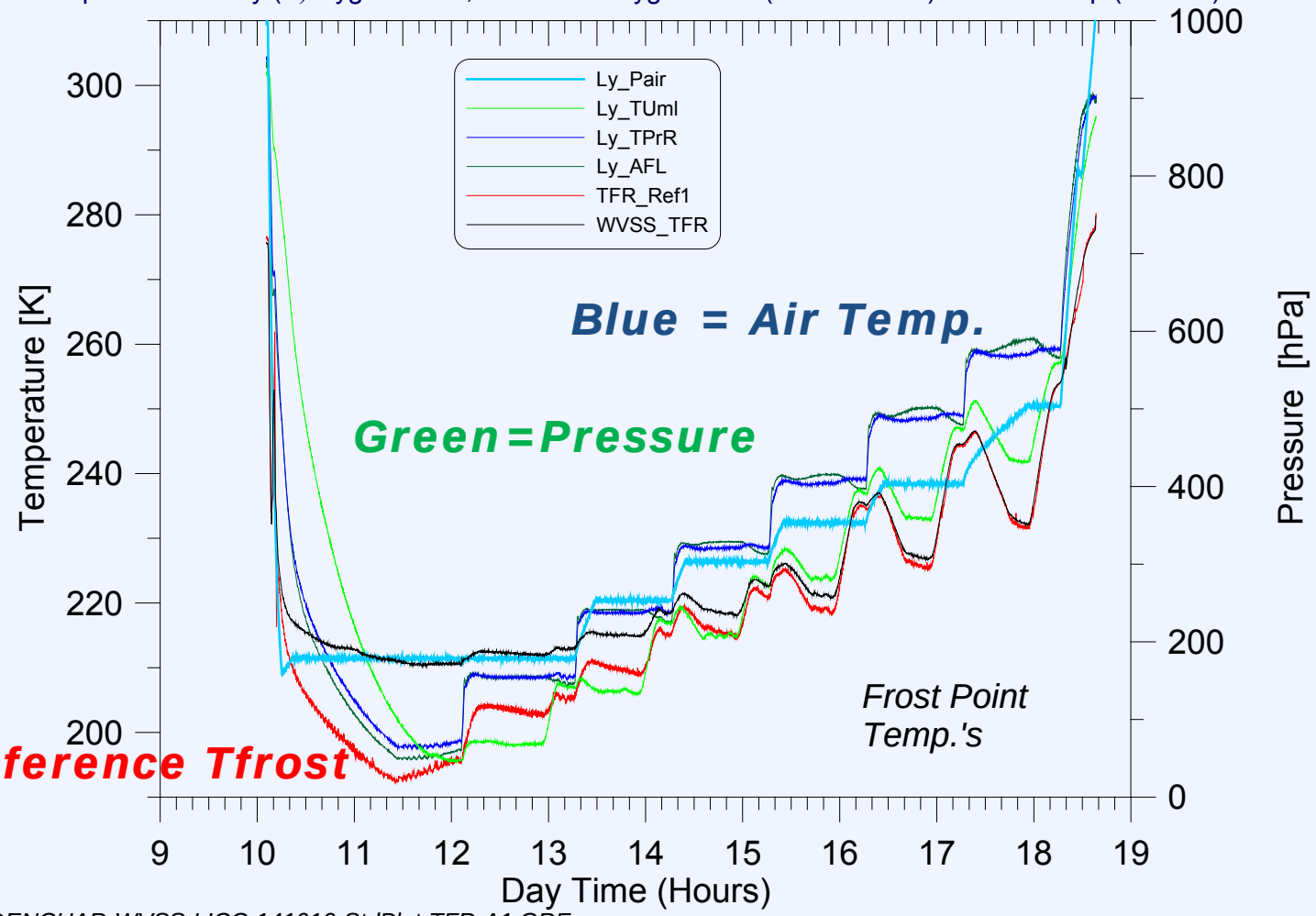
Above PBL at Day
IAGOS: 55-60%
RS: 45-55%

Above PBL at Night
IAGOS: 50-60%
RS: 60-70%



DENCHAR-LICC 2010: WVSS-II @ ESF
Perfomance P,T,H2O: 14 Oct.2010

DENCHAR-WVSS: LICC 2010 Performance WVSS versus ESF at Jülich DD. 14.October 2010:
Comparison with Ly (α) Hygrometer , Dew Point Hygrometer (Gen.Eastern) and Humicap (Vaisala)



File : DENCHAR-WVSS-LICC-141010-StdPlot-TFR-A1.GRF

Suggestions of Performance/Validation Studies or Intercomparisons of Different Hygrometers to be done in the ESF (Env.Sim.Facility at Jülich) in the scope of GRUAN or NDACC

1. CFH versus FPH against MBW 373 or other Hygrometer
2. New Instruments

- Advantage ESF: Entire sonde package under realistic atmospheric pressure, temperature, and humidity conditions
- Time schedule: 2019-2020

Any Interest from GRUAN ?