Update of the IAGOS-H2O On-Going Aircraft Measurements and its QA-Efforts

www.iagos.org

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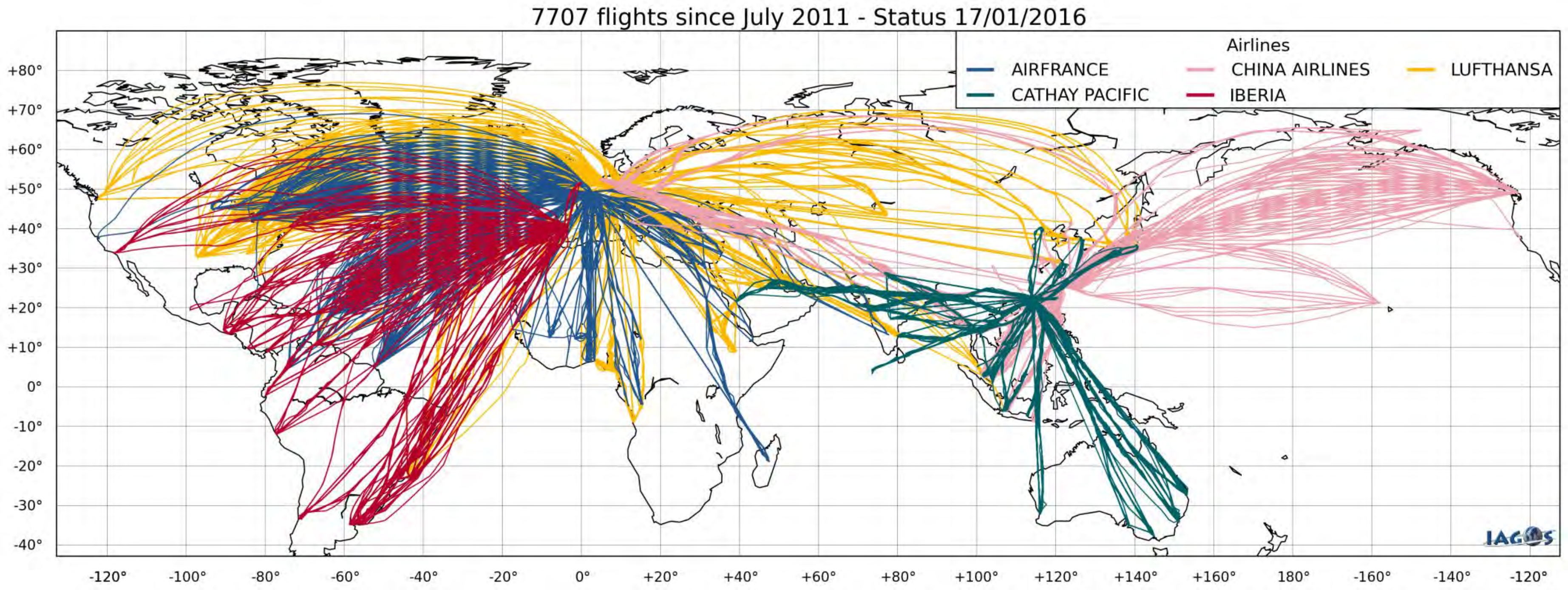
IADGOS - CORE Flight Map

http://www.iagos.fr

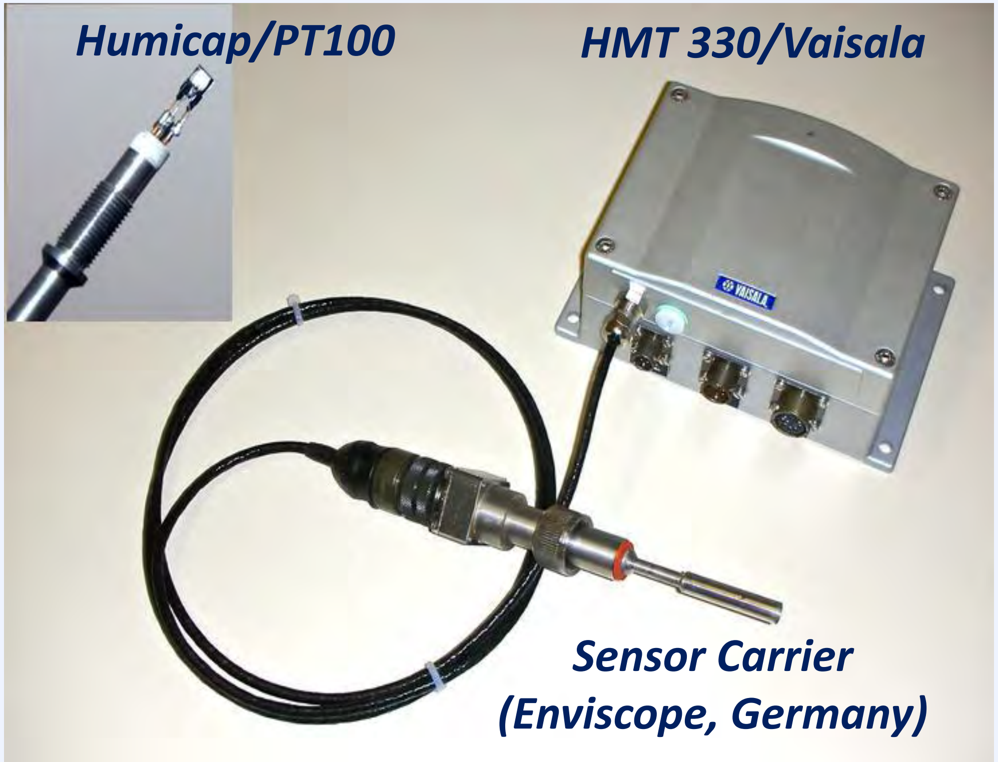


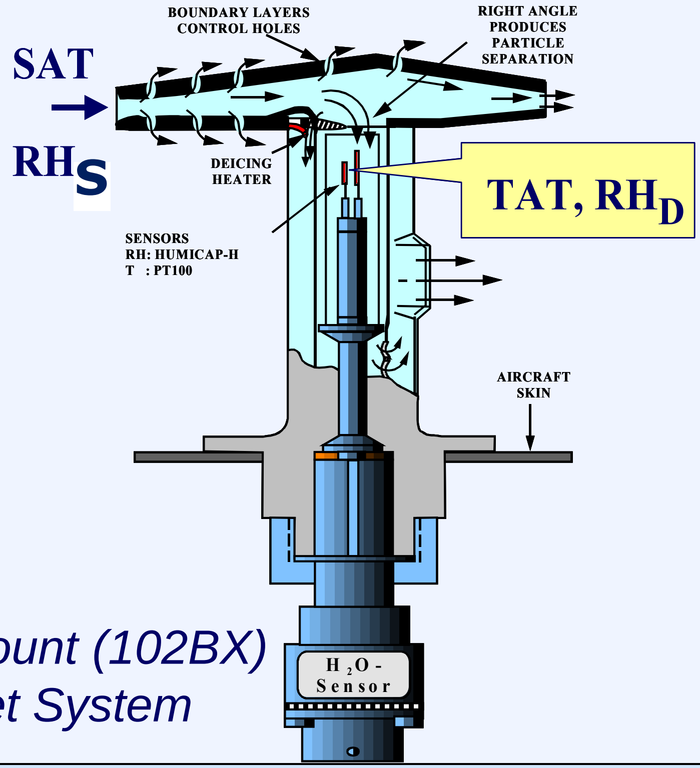
New 2016/2017: CAL#2, LH#2, AF#2 and HAL

IAGOS-CORE aircraft schedule:

- In 2016/2017, 8 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



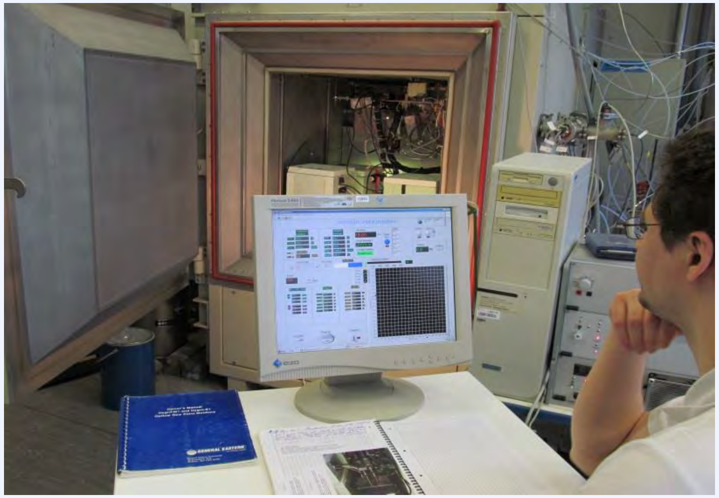


Rosemount (102BX)
TAT-Inlet System

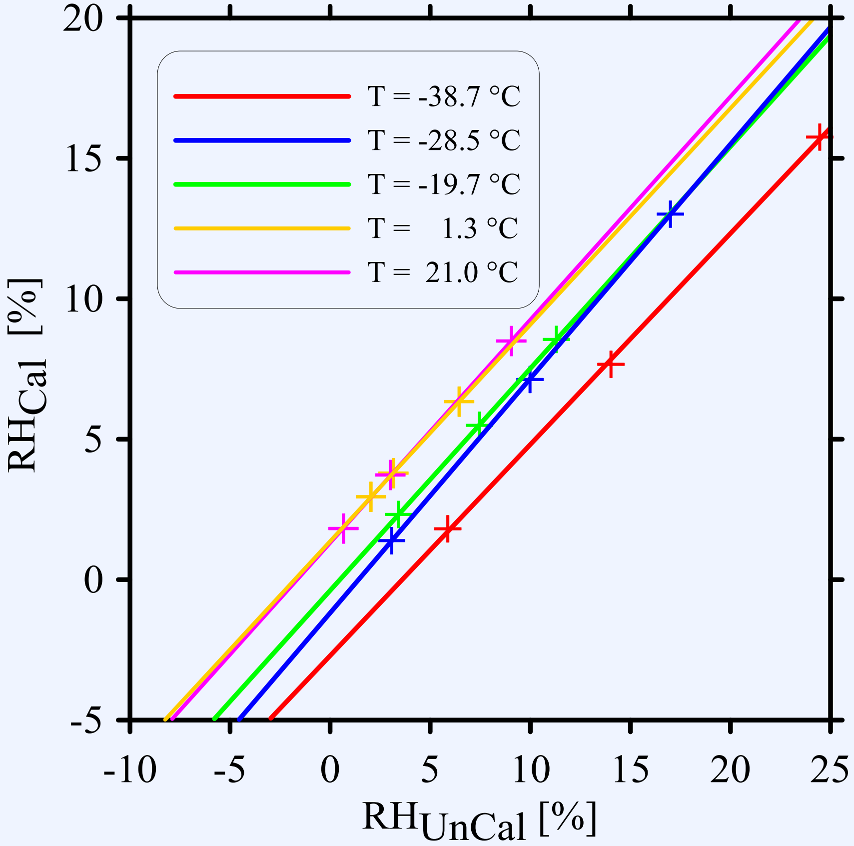
In inlet strong speed reduction (Mach≈0.8 to 0) with adiabatic conversion:

- 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



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

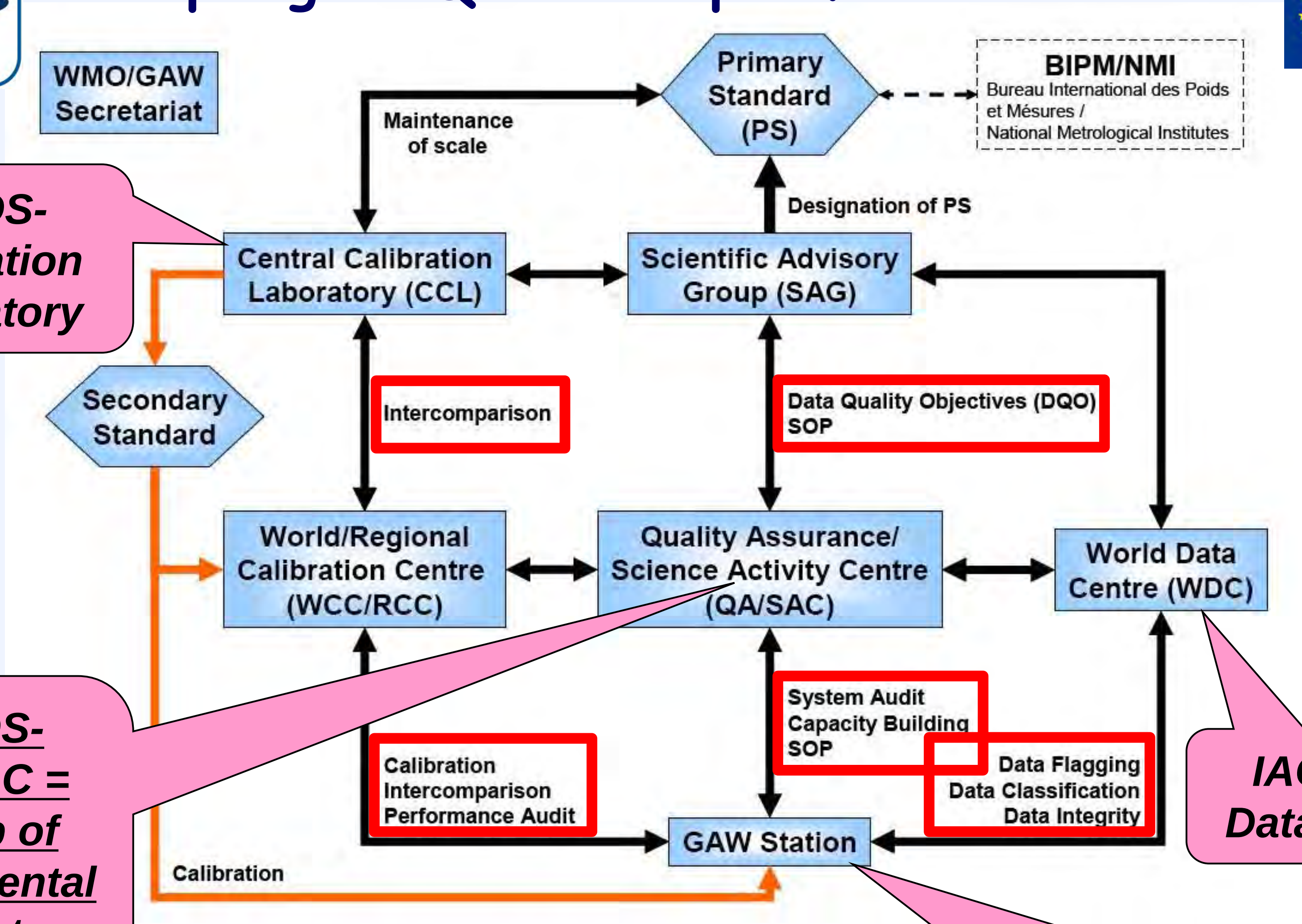


- Regular calibration (every 500-1000 flight hours in the environmental simulation chamber at Juelich, Germany
- Against Lyman(α)-fluorescence hygrometer at T_{Air} <-10 °C and Frost-point hygrometer at T_{Air}>-10 °C with relative uncertainty better than 5%
- Under realistic „flight“ conditions of humidity, 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

IAGOS-QA/QC:
Adapting to QA-Concept of WMO/GAW



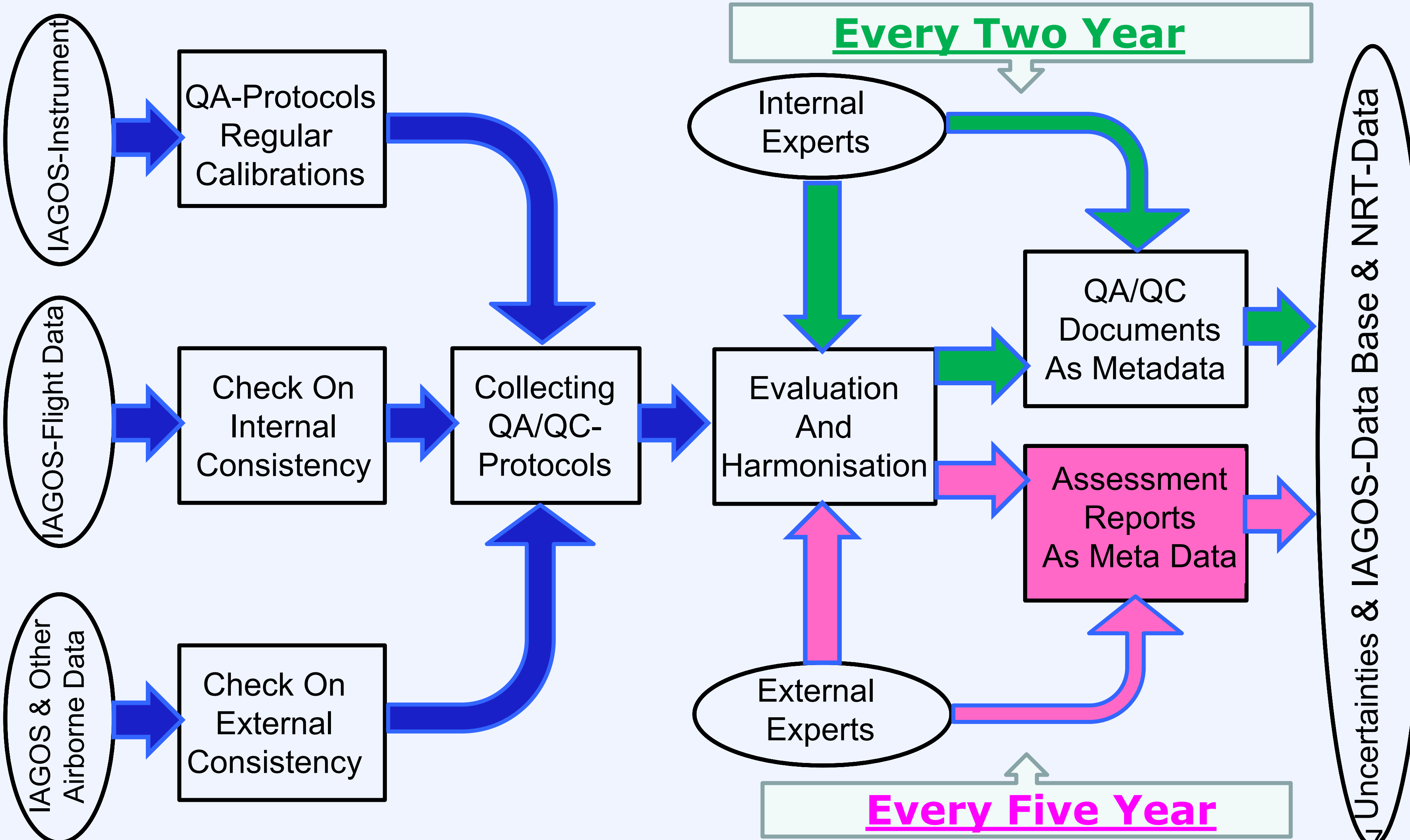
IAGOS-Calibration Laboratory

<u>IAGOS-QA/SAC = Group of Instrumental Experts</u>

IAGOS-Data Base

IAGOS-Instrument/Observation

IAGOS-QA/SAC
Concept QA/QC Evaluation & Harmonisation



IAGOS-QA/SAC:

Evaluation and harmonisation of data quality in routine aircraft observations

SOP's
Standard Operating Procedures

1. Instrument layout and operation
2. Calibration procedure and traceability
3. Calculation of results from raw (L0) to final (L2)
4. Uncertainty Analysis
5. Maintenance
6. Validation and flagging scheme
7. Storage of data

QA/QC Protocolls

1. Performance over flight period
2. Regular Calibration
3. Internal Consistency : IAGOS A/C by A/C
4. External Consistency: IAGOS A/C with other platforms
5. Automatic tools to match in time and space (incl. use of trajectory analysis)

IAGAS-QA/SAC

Evaluation and harmonisation of data quality in routine aircraft observations

Regular QA/QC & Assessment Reports

For each measured compound:

- Collecting all QA/QC-protocols over 1-2 years
- Prepare regular (every 1-2 years) QA/QC-report.
- Internal review of QA/QC-report by IAGOS-PI's
- Prepare regular (every 5 years) QA/QC-assessment report
- Review by panel of external experts
- Feedback to IAGOS Data Base on impact of archived data

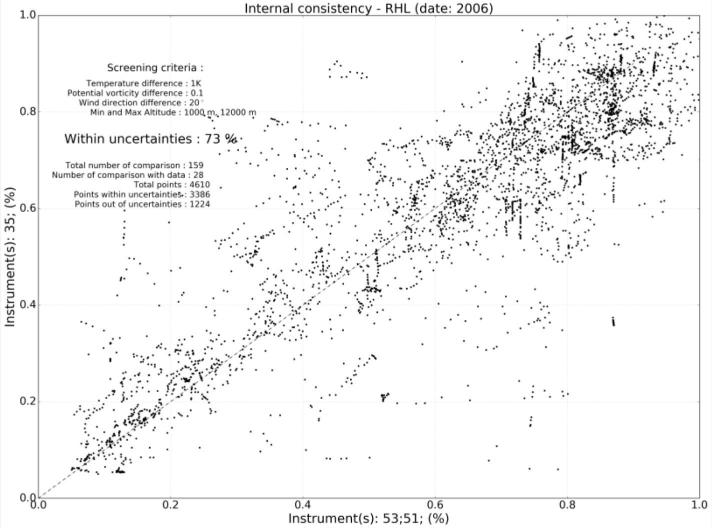
Implementation QA/QC Into IAGOS & WMO/GAW

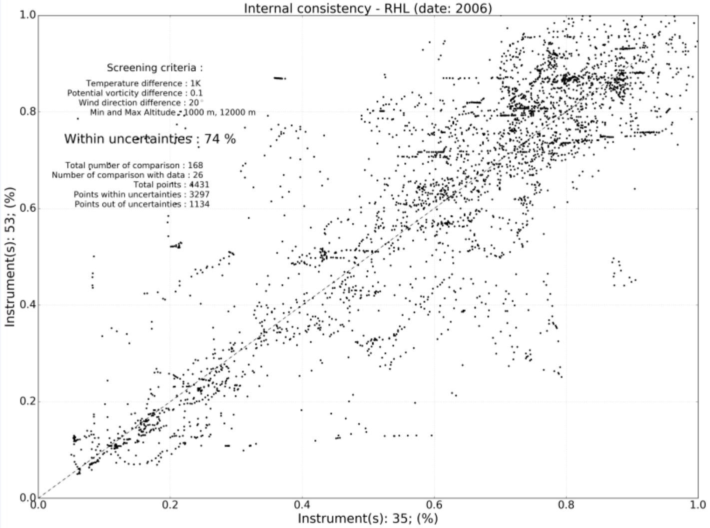
Migration of IAGOS-QA-Concept into a WMO/GAW - QA/SAC (SAC= Scientific Activity Center), which means:

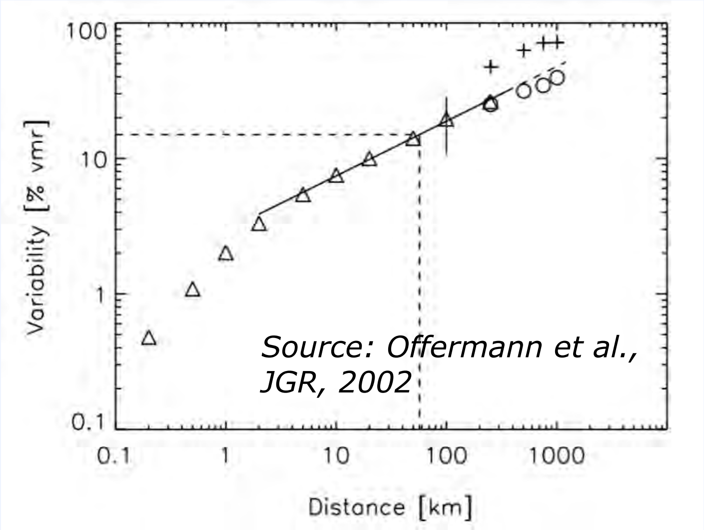
I. Establishment of IAGOS-QA/QC concept into operation as part of IAGOS-AISBL

II. Link to WMO-GAW QA/QC infrastructure with a IAGOS-QA/SAC; incl. link to its SAG's (Scientific Advisory Groups)

Internal Consistency of RH by MCH & ICH: Direct Matching in Space and Time of two Aircraft



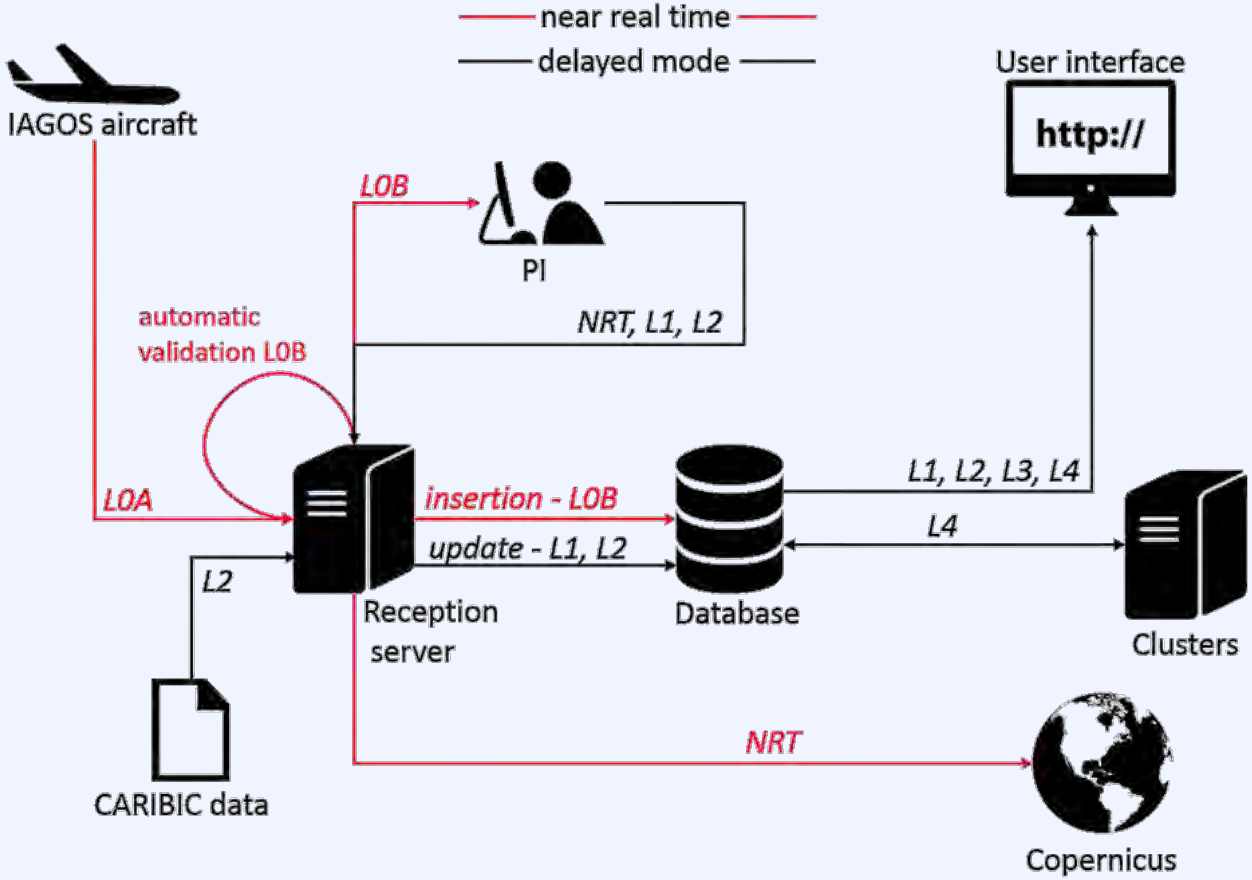




1. Natural variability of H2O already:
   - > 20 % over radius = 100 km
   - > 10 % over radius = 20 km
   - < 1% over radius < 1 km

2. When matching in time and space H2O internal consistency cannot be done on statistical base but only by careful flight by flight and by use of trajectory analysis

IAGOS - CORE Data Flow



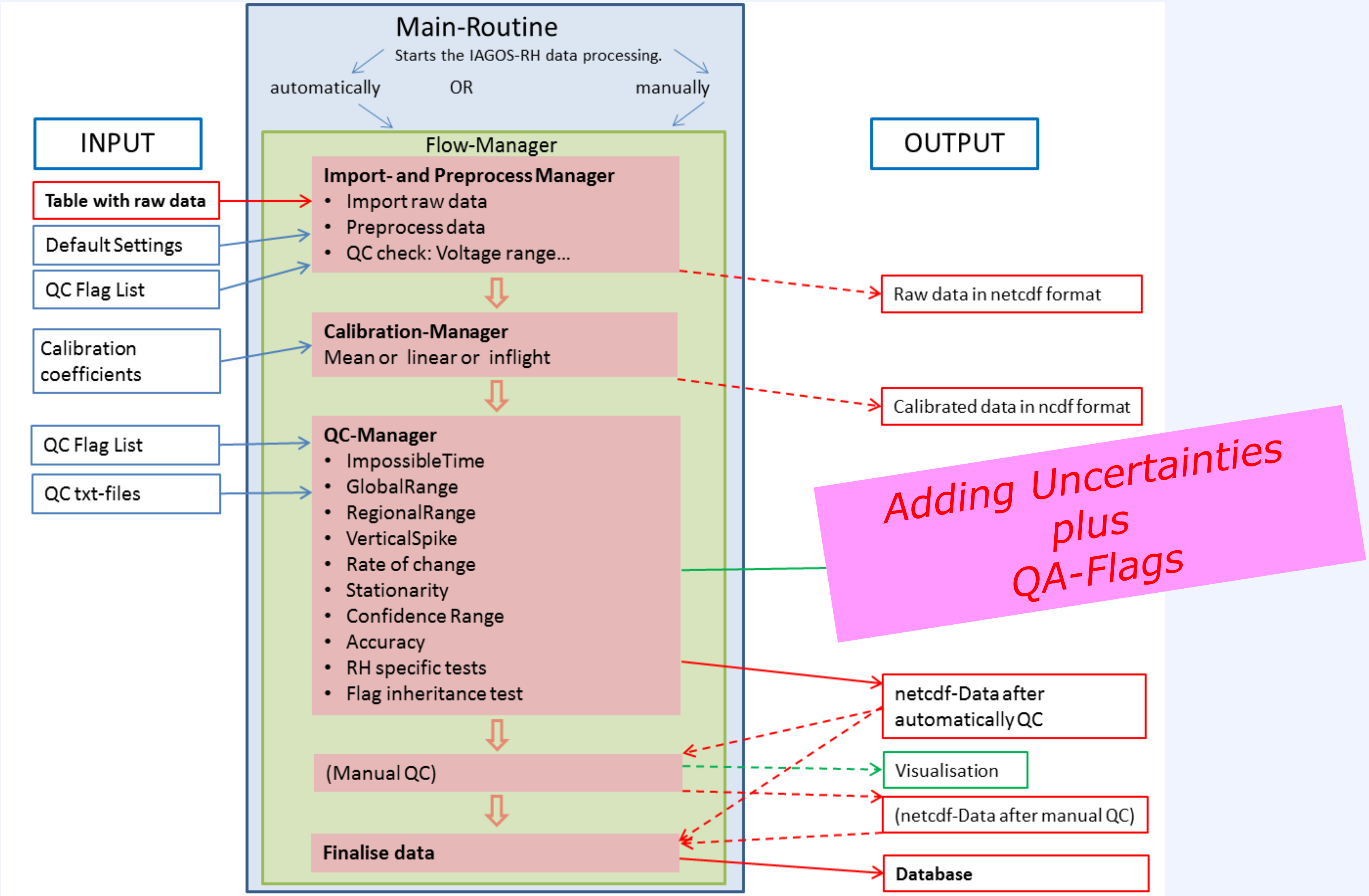
Level	Description
L0A	raw data
L0B	automatically validated data
NRT	NRT for Copernicus use, bad data removed
L1	data validated by PI (preliminary data)
L2	calibrated data (final data)
L3	averaged data and climatologies
L4	added-value products

The IAGOS central database hosted by AERIS (CNES-CNRS/INSU) in Toulouse.
Date access is free and open, the database can be accessed at www.iagos.org

IAGOS-ICH-NRT Data Flow: New 2017

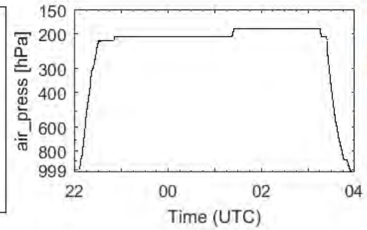
1. Data provision within about 24 hours to Copernicus service: Validation of Weather and Air Quality Forecasting by ECMWF
2. ICH-data transmitted digitally (RS232) to IAGOS-Data acquision system and stored aboard the aircraft.
3. At end of flight data transmitted by 3G-mobile network to surface station at CNRS/Toulouse (France).
4. ICH data automatically transferred to FZJ/Juelich (Germany) for QA-screening & flagging, and then transferred back to CNRS-Toulouse who put the data in BUFR format on the GTS to provide ECMWF with the data for validation of the forecastings of the weather and air quality

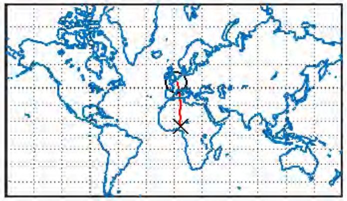
IAGOS-ICH-NRT Data Quality Screening

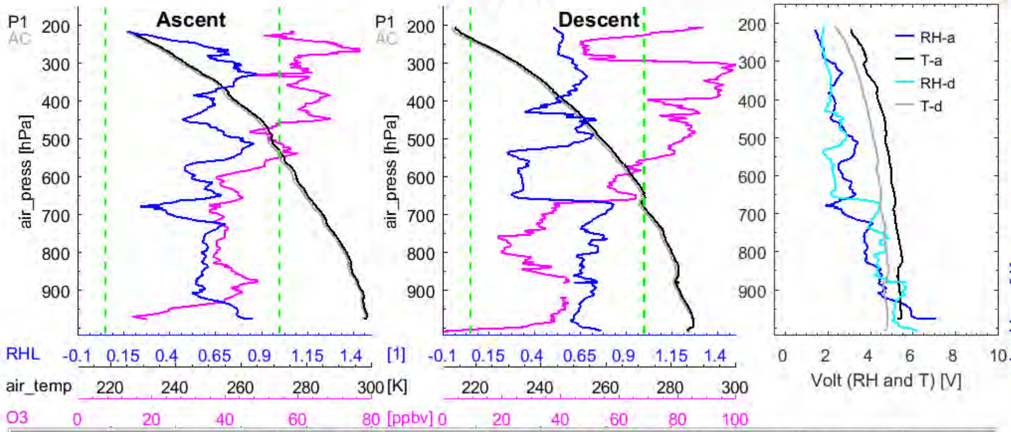


Quick Look

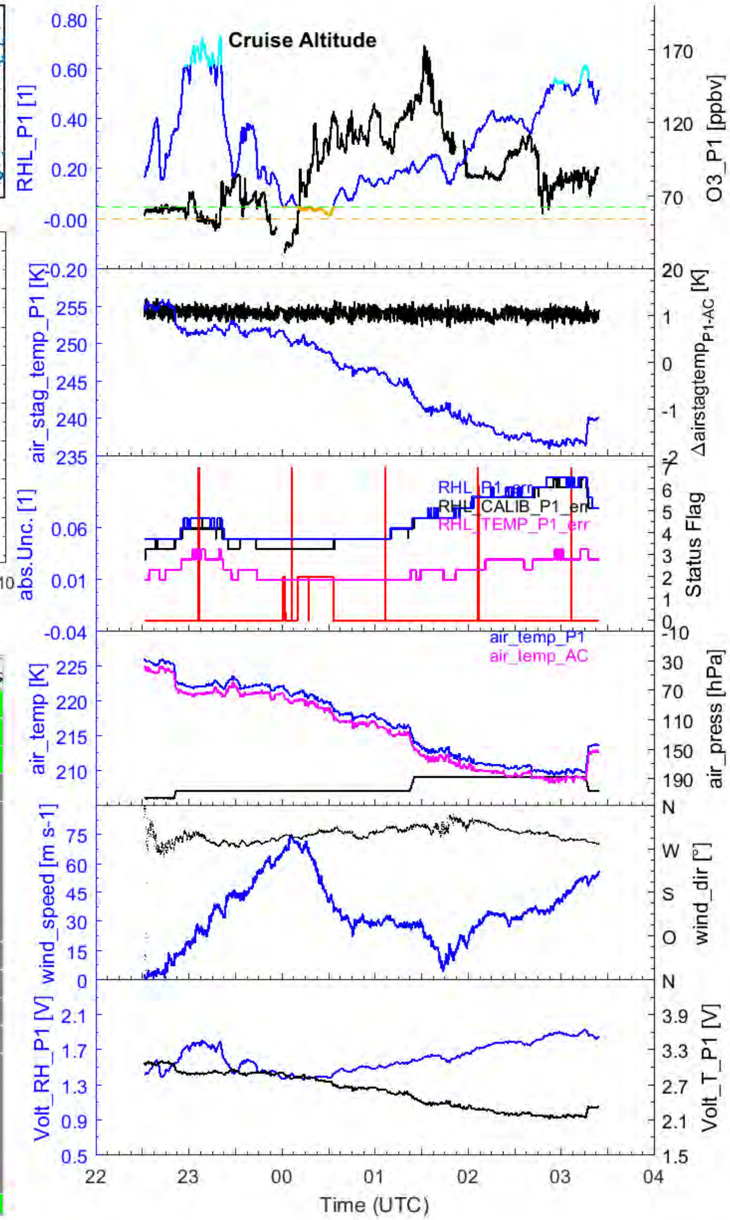
File: H2O20170607220632l2
Depart.: 2017-06-07 22:06
Dest.: Abuja to Paris
R.Nr: 544, Sensor: SN014
TM: 4540104, unc: No
A/C: 14 [657], Pack-Nr.: 12
Calib.: 20161007, 19940101
Processed: 20170609, NRT



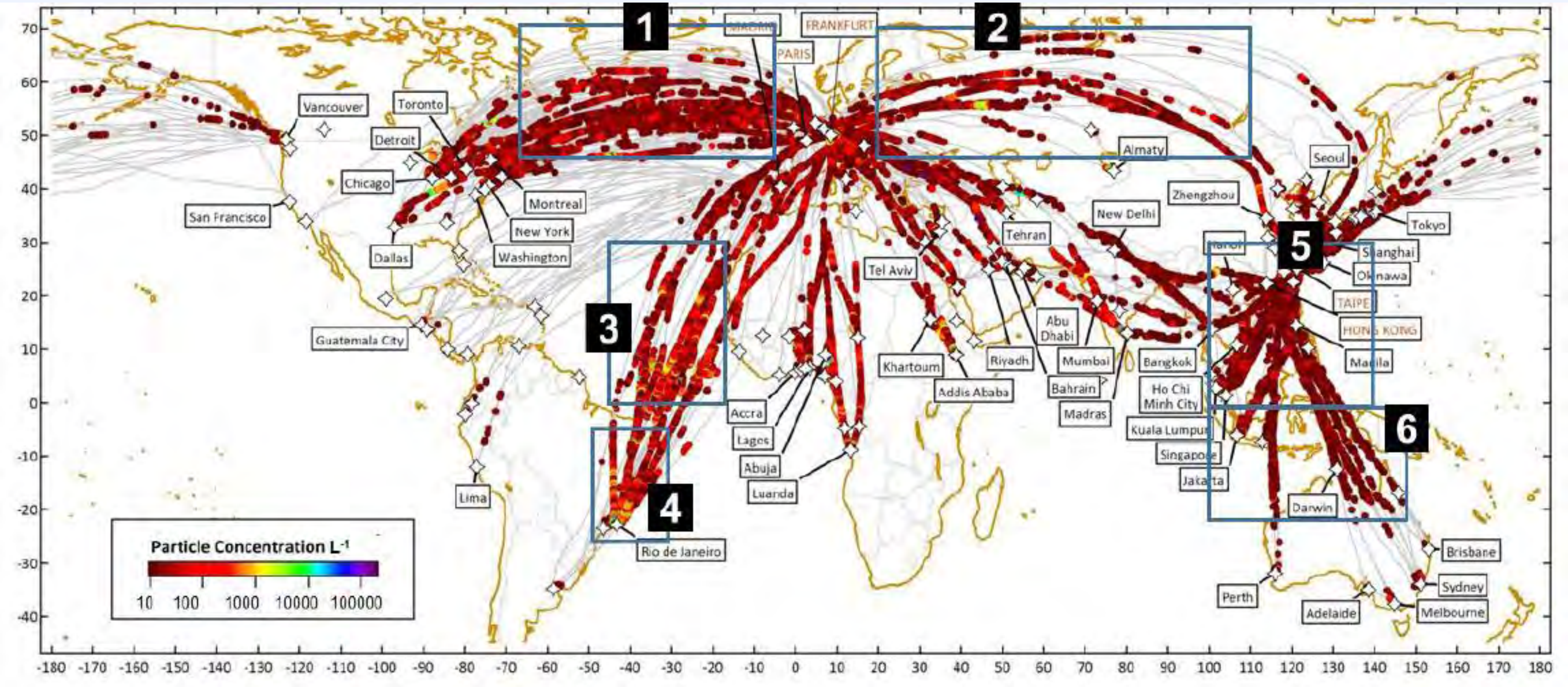




	Volt_RH_P1	Volt_T_P1	air_temp_...	air_temp_...	RHL_P1	Avionics	Preprocess	air_press
isnanRPPP	12 (0)	12 (0)	0 (0)	12 (0)	12 (0)	X	X	0 (0)
GlobalMinRPPP	0 (0)	0 (0)	0 (0)	0 (0)	0 (363)	X	X	0 (0)
GlobalMaxRPPP	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	X	X	0 (0)
voltRHeqT_RPSet	0 (0)	0 (0)	X	X	X	X	X	X
dynamicRangeRPPP	0 (0)	0 (0)	X	X	X	X	X	X
voltRHorT_SetPP	0 (0)	0 (0)	X	X	X	X	X	X
SpikeOrNoiseRPPP	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	X	X	X
manual_flaggingPP	X	X	X	0 (0)	0 (0)	X	X	X
t_ac_SetPP	X	X	X	0 (0)	0 (0)	X	X	X
Preproc+Avionik	X	X	X	X	X	0 (0)	12 (0)	X
isrealSet	X	X	X	X	0 (0)	X	X	X
cruise_humidSet	X	X	X	X	0 (0)	X	X	X
uncertainty_max	X	X	X	X	0 (0)	X	X	X
TempRangeSet	X	X	0 (0)	0 (0)	X	X	X	X
Stationarity	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	X	X	X
ichtoocoldSet	X	X	X	X	0 (0)	X	X	X
only_one_calibSet	X	X	X	X	X	X	X	X
VFlag2RH_u_TSet	X	X	X	0 (0)	0 (0)	X	X	X
total	12 (0)	12 (0)	0 (0)	12 (0)	12 (363)	0 (0)	12 (0)	0 (0)



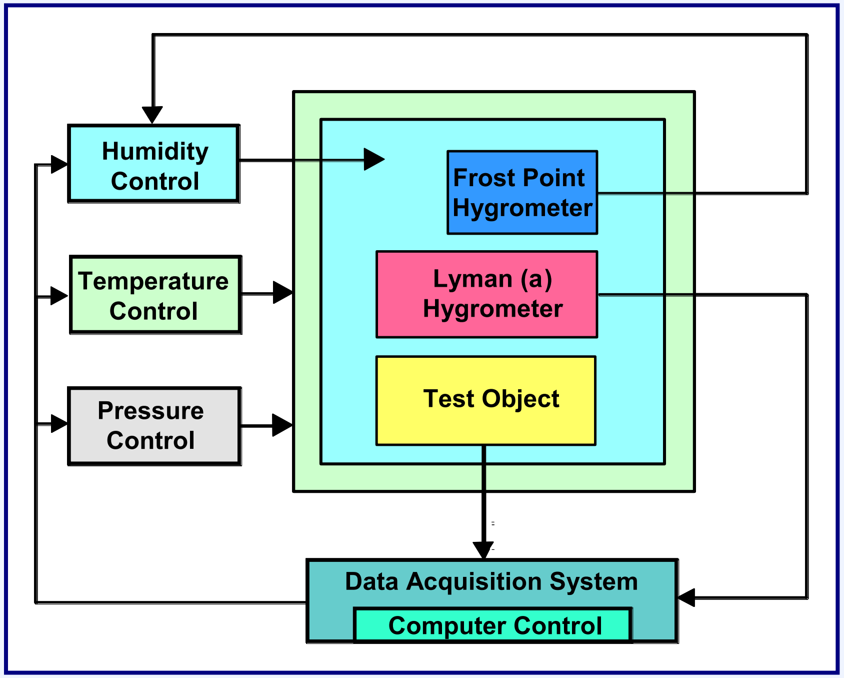
Global Observation of Clouds

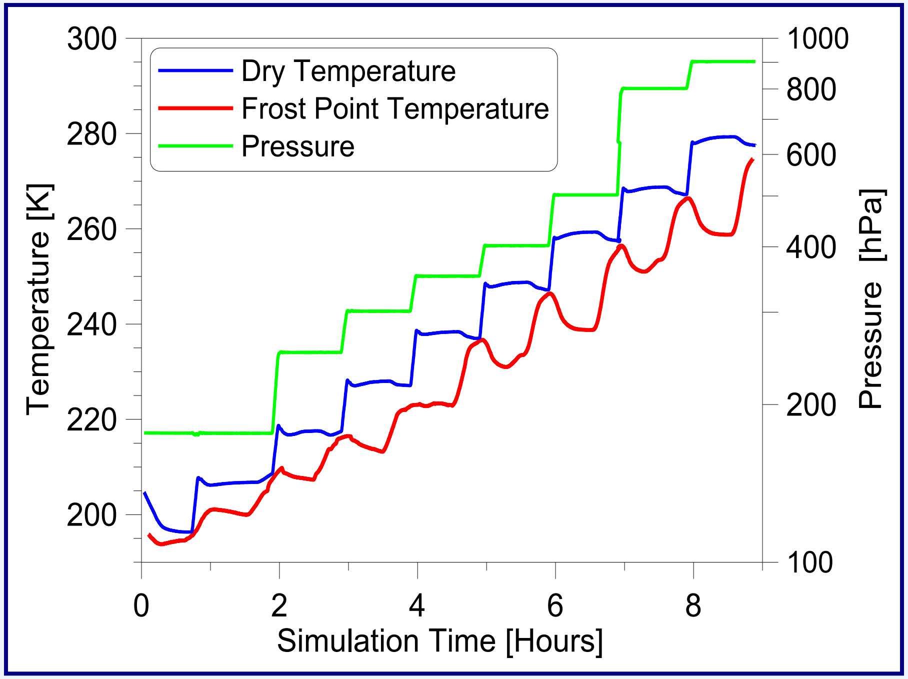


This map lays out a summary of all the flight trajectories of the five aircraft from 2012 to 2014. The filled circles mark cloud encounters. The color is proportional to the number concentration. The six numbered regions are (1) Extratropical Atlantic, (2) Extratropical Eurasia, (3) Tropical Atlantic, (4) Eastern Brazil, (5) Southeast Asia Maritime/Continental and (6) New Guinea Maritime/Continental. K. Beswick et al., Tellus B 2015

Environmental Simulation Facility (ESF) at Jülich to Test and Calibrate Airborne Humidity Sensors (1)

Environmental Simulation Facility (ESF) at Jülich to Test and Calibrate Airborne Humidity Sensors (2)

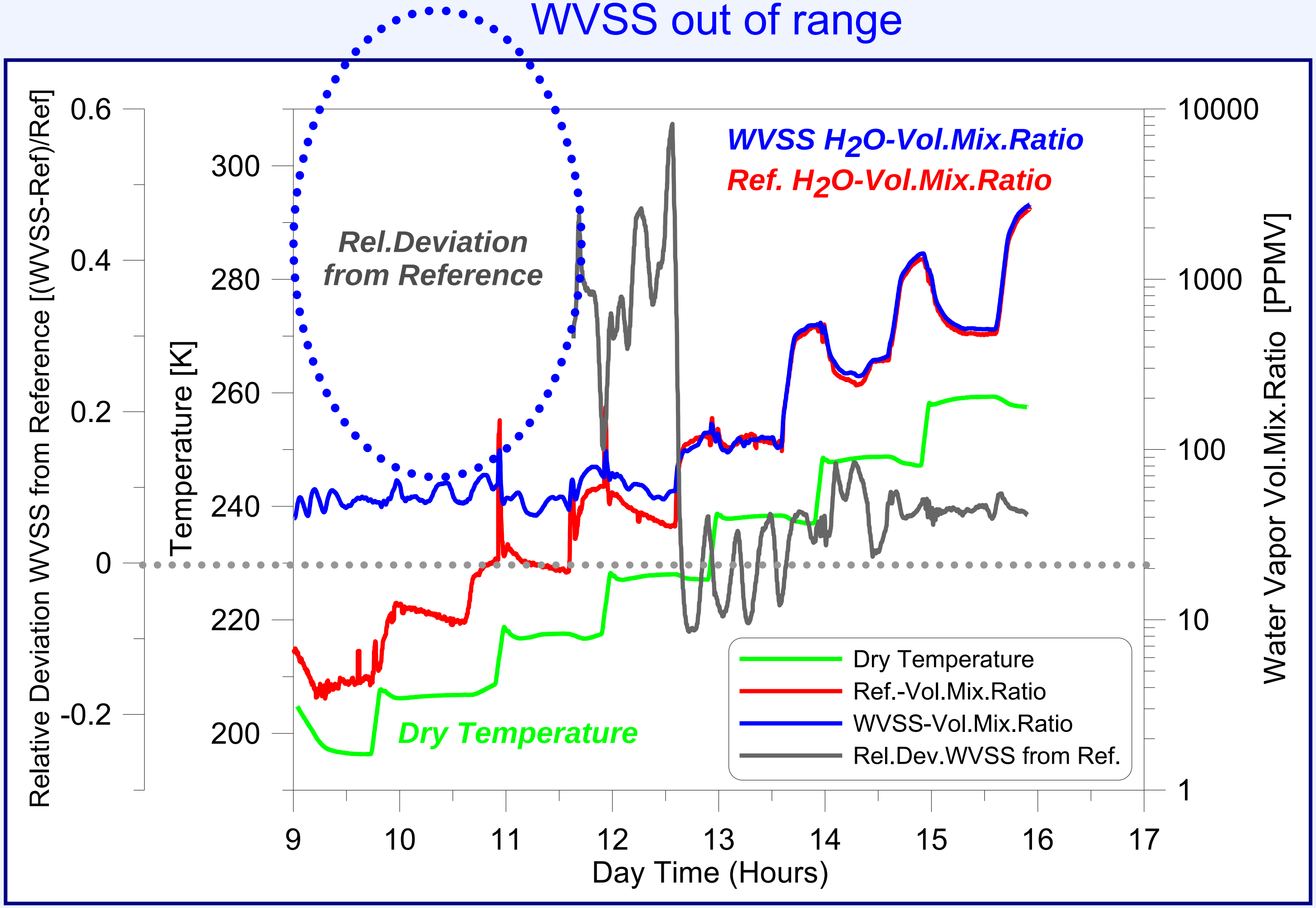




- Wall temperature determines the frost point temperature inside the test room
- At constant air temperature different humidities by varying wall temperature
- Actual humidity measured by Lyman (α) hygrometer (1-1000 ppmv) and frost point hygrometer (>1000 ppmv).

Since 2016 reference instruments replaced by cryogenic frostpoint hygrometer MBW 373 traceable to primary standard: Uncertainty 0.1-0.2 K

Evaluation of Performance of WVSS-II in Summer 2005: Comparison with Reference [Lyman(α) & Frost Point]



Suggestions of Performance/Validation Studies or Intercomparisons of Different Hygrometers to be done in the ESF in the scope of GRUAN or NDACC

1. CFH versus FPH against MBW 373 or other Hygrometer

2. Different types of Radiosondes

3. New Instruments

- Advantage ESF: Entire sonde under realistic atmospheric pressure, temperature, and humidity conditions

- Time schedule: End of 2018-2019-2020

Any Interest from GRUAN ?

Reserve Slides

IAGOS-QA/SAC Preparatory Work: Preparation SOP's & Factsheets

(Iterated in 2 evaluation rounds @ end of Year #2 & #3)

No	Instrument	PI	SOP	Fact Sheet	Internal Experts	External Experts
1	I-Core-O3-UV	Nedelec	V4 ready	V3 Ready	Zahn	Zellweger
2	I-Core-CO-IR	Nedelec	V4 ready	V3 Ready	Gerbig	Zellweger
3	I-Core-RH/T	Smit	V4 ready	V3 Ready	Zahn	Hurst
4	I-Core-BCP	Gallagher	V4 ready	V3 Ready	Petzold	Nott
5	I-Core-Aerosol-A/B	Bundke	V4 ready	V3 Ready	Hermann	Baumgardner
6	I-Core-CO2-CRDS	Gerbig	V4 ready	V3 Ready	Rauthe-Schöch	Andrews
7	I-Core-CH4-CRDS	Gerbig	V4 ready	V3 Ready	Rauthe-Schöch	Andrews
8	I-Core-CO-CRDS	Gerbig	V4 ready	V3 Ready	Rauthe-Schöch	Zellweger
9	I-Core-H2O-CRDS	Gerbig	V4 ready	V3 Ready	Smit	Hurst
10	I-Core-NOX/NOY-CL	Berkes	V4 ready	V3 Ready	Ziereis	Brunner
11	I-Carb-O3-UV&-CL	Zahn	V4 ready	V3 Ready	Nedelec	Zellweger
12	I-Carb-H2O-CR2 &-PAS	Zahn	V4 ready	V3 Ready	Smit	Hurst
13	I-Carb-Aerosols-A/B	Hermann	V4 ready	V3 Ready	Petzold	Baumgardner
14	I-Carb-NOY-CL	Ziereis	V4 ready	V3 Ready	Volz-Thomas	Brunner

Implementation IAGOS-QA/QC Concept into Infrastructures of IAGOS & WMO/GAW (1)

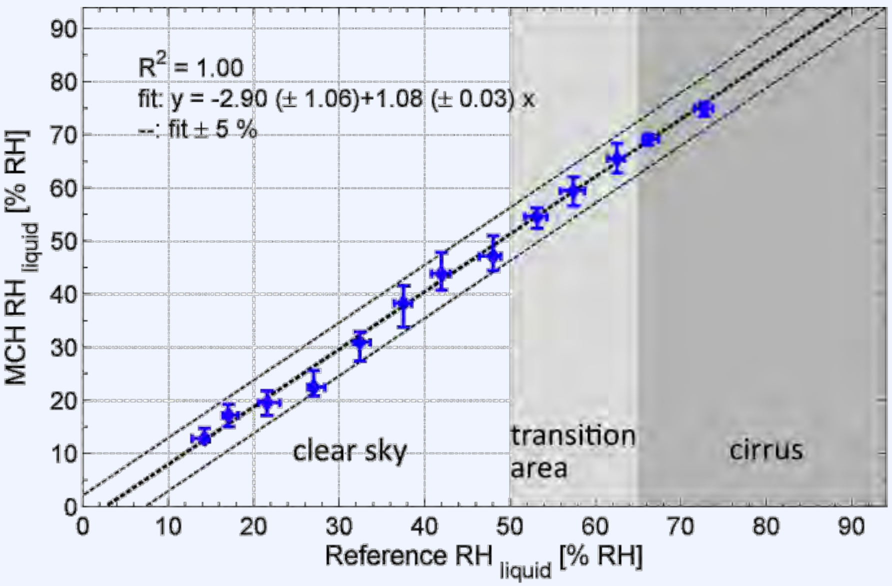
IGAS-WP4 has successfully developed and tested the IAGOS-QA/QC Evaluation Concept, its QA/QC Procedures and Tools such that it can now be rapidly implement into IAGOS operational infrastructure.

- **Available components in IAGOS-AISBL:**
  1. IAGOS-instruments (observations) : installed & operated @ aircraft
  2. IAGOS-calibration & maintenance facilities
  3. IAGOS-Data Base
  4. IAGOS-QA/QC evaluation frame work with tools to test on consistency

- **Next steps:**
  I. Establishment of QA/QC evaluation frame work as an additional component of IAGOS-operation
  II. Constitute the IAGOS-QA/SAC as an entity that consists of IAGOS-instrument PI's coordinated by the IAGOS-AISBL secretary
  III. Linkage to WMO-GAW QA/QC infrastructure with a IAGOS-QA/SAC; Incl. link to the GAW-SAG's (Scientific Advisory Groups)

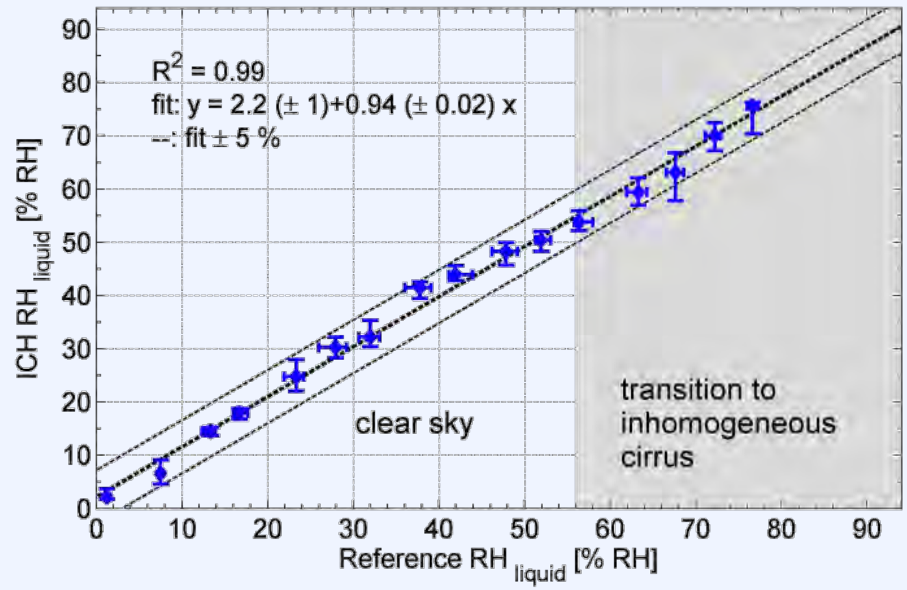
Transition MOZAIC-H2O (MCH) into IAGOS-H2O (ICH): In-Flight Intercomparisons with FISH as Reference On Board of a Research Aircraft (Learjet)

CIRRUS-2006: MCH versus FISH



Neis et al., AMT 2015

AIRTOSS-2013: ICH versus FISH

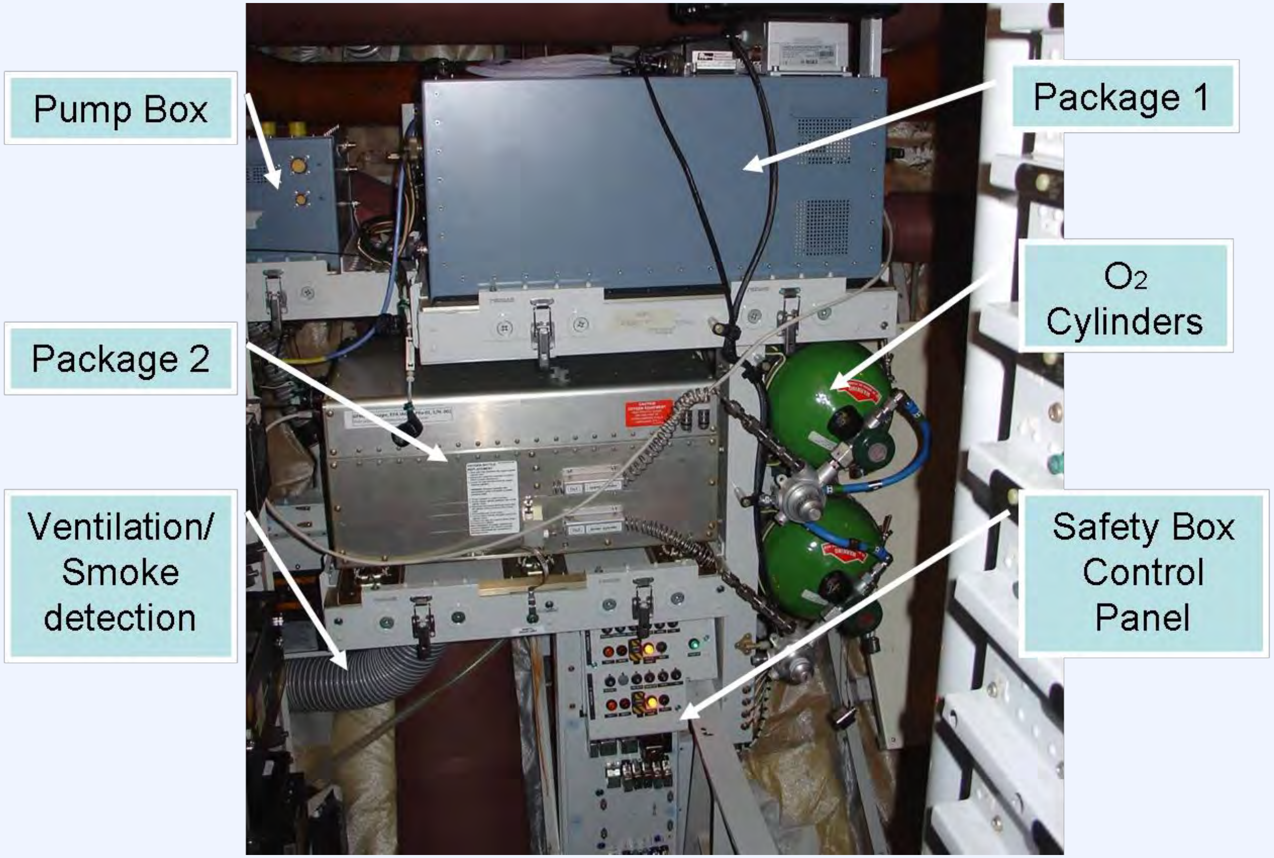


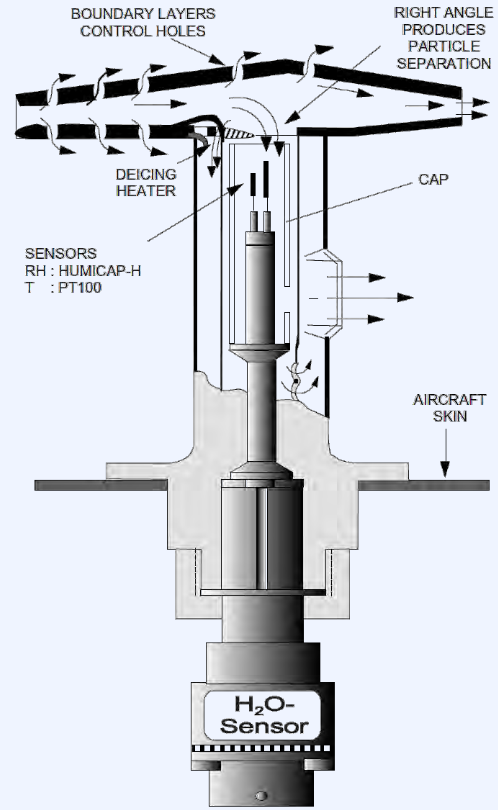
Neis et al., Tellus 2015

- Agreement MCH and ICH with FISH within 5% RHL-uncertainty
- No bias at transition from MCH- to ICH-instruments

FISH= Fast In-situ Stratospheric Hygrometer (Ly(a) Fluorescence Detection)

IAGOS - CORE Instrumentation

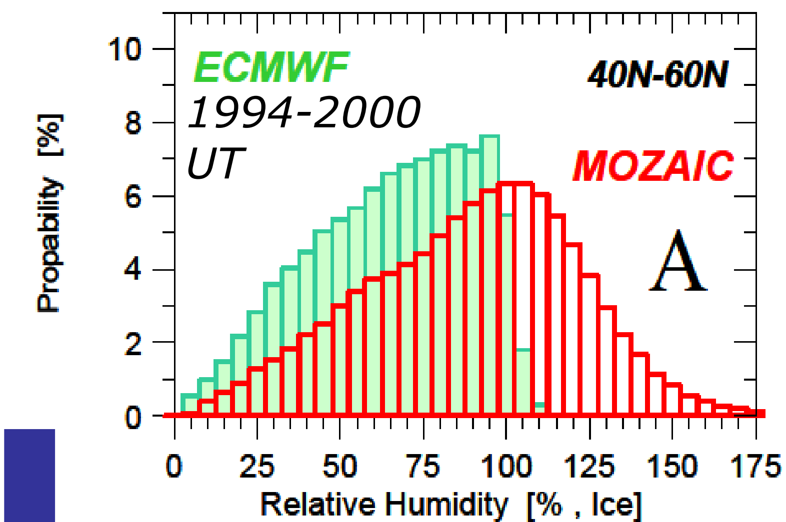




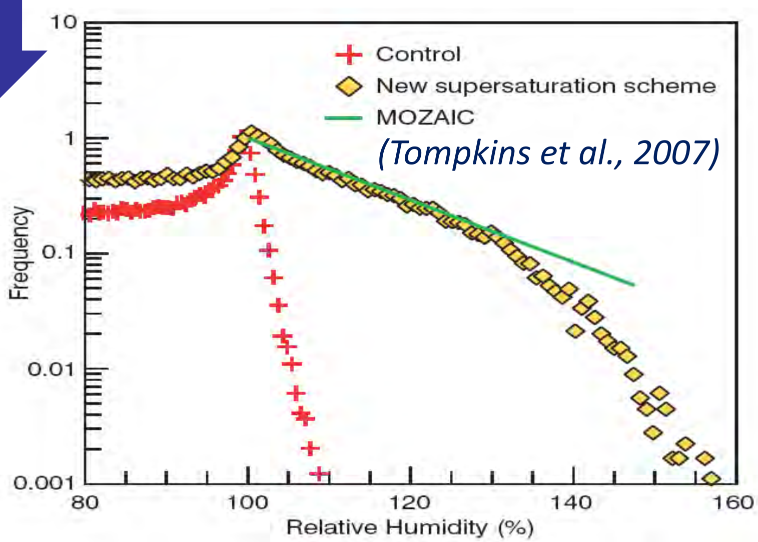
LEFT: IAGOS-CORE rack installed on an A340-300 a/c (120 kg)

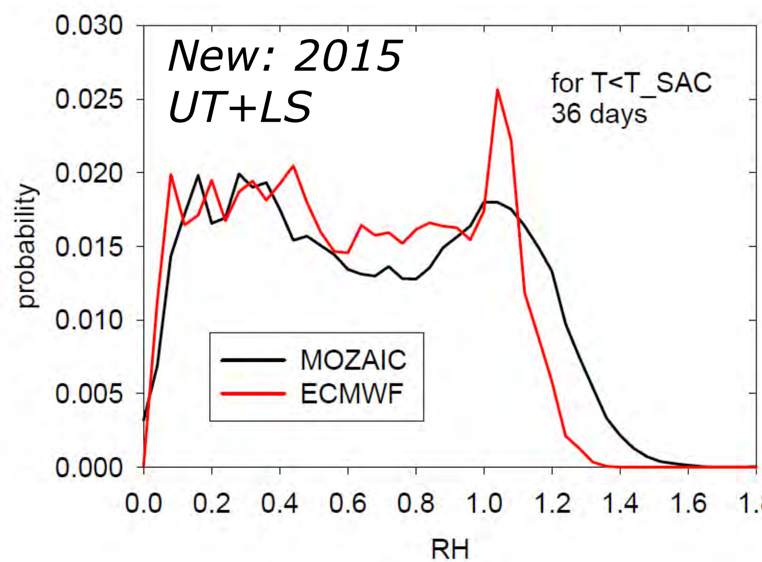
RIGHT: IAGOS Capacitive Hygrometer

MOZAIC: RH_{ice} in UT (Z=9-12 km, PV≤2.0) Over North Atlantic: Observations against ECMWF



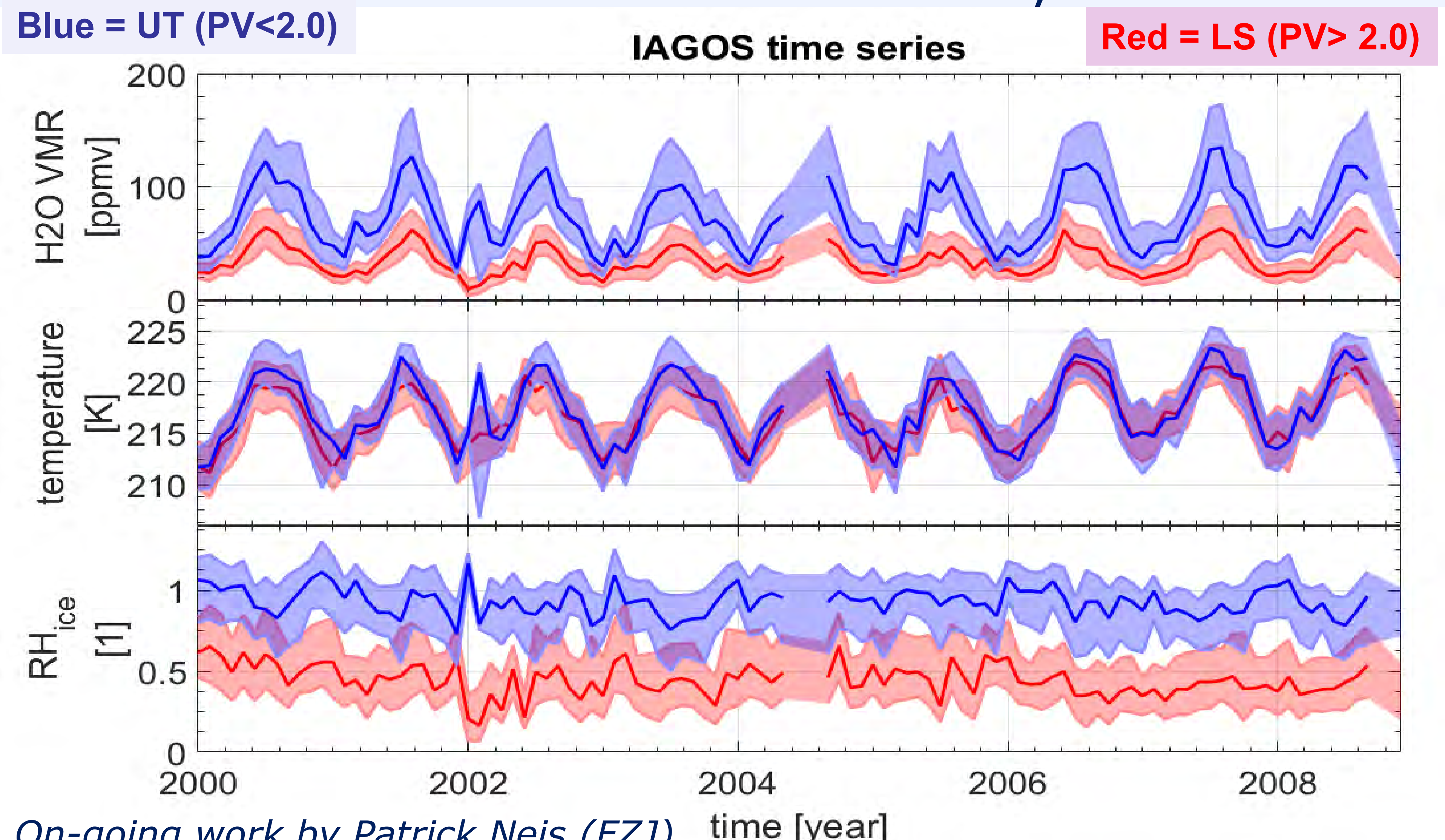
- UTH show large variability in time and space
- UT considerably more wet (up to factor 2)
- Significant part of MOZAIC-UTH (20-30%) show ice super saturation
- Ice super saturation associated with cirrus (sub-visible)





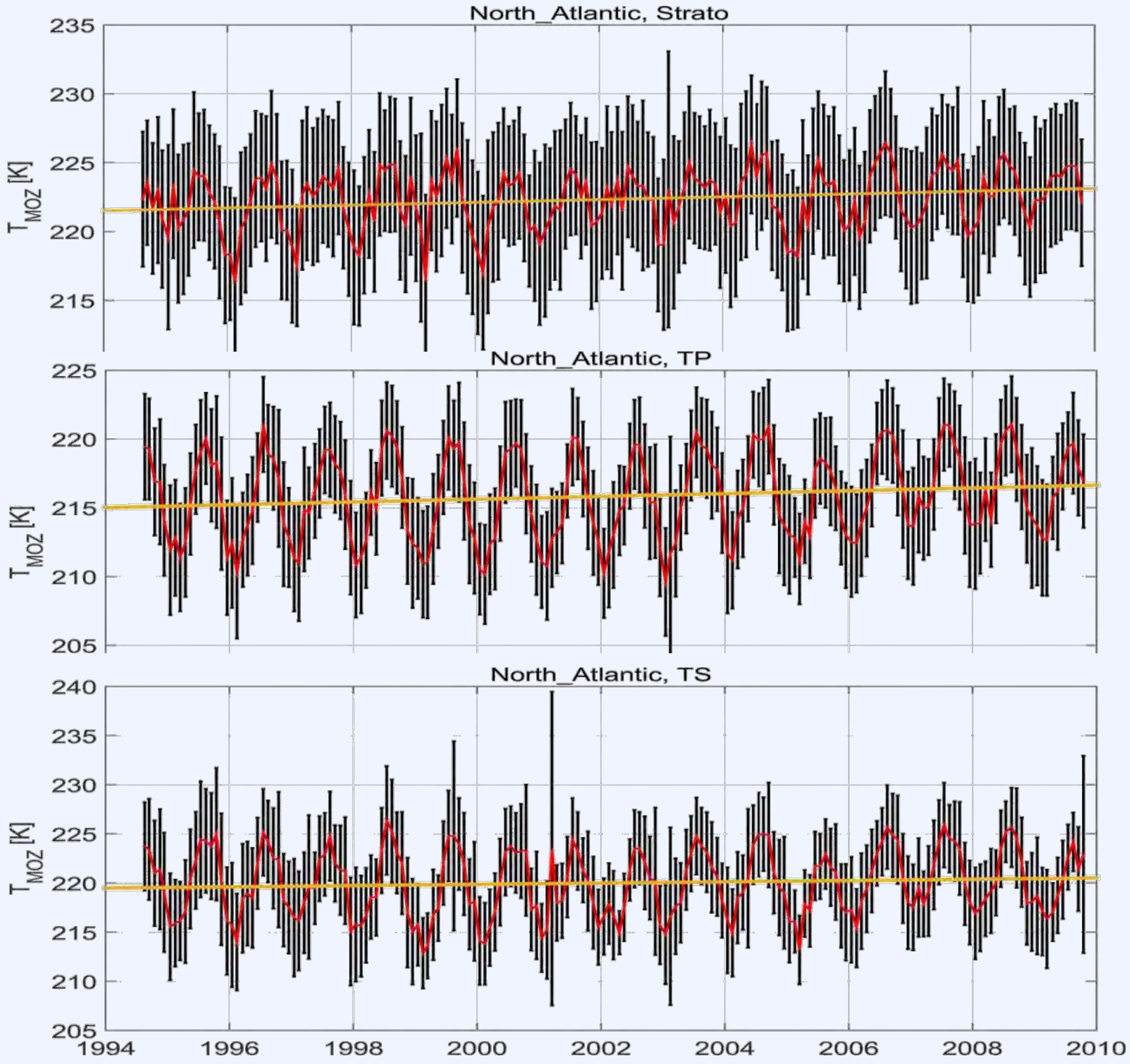
All RH over Ice!

UTLS-Humidity and Temperature over North Atlantic: Seasonal-Inter Annual Variation Measured by MOZAIC-MCH



On-going work by Patrick Neis (FZJ)

MOZAIC: Temperature



Intercomparison of 15 years of air temperature data from MOZAIC / IAGOS data.

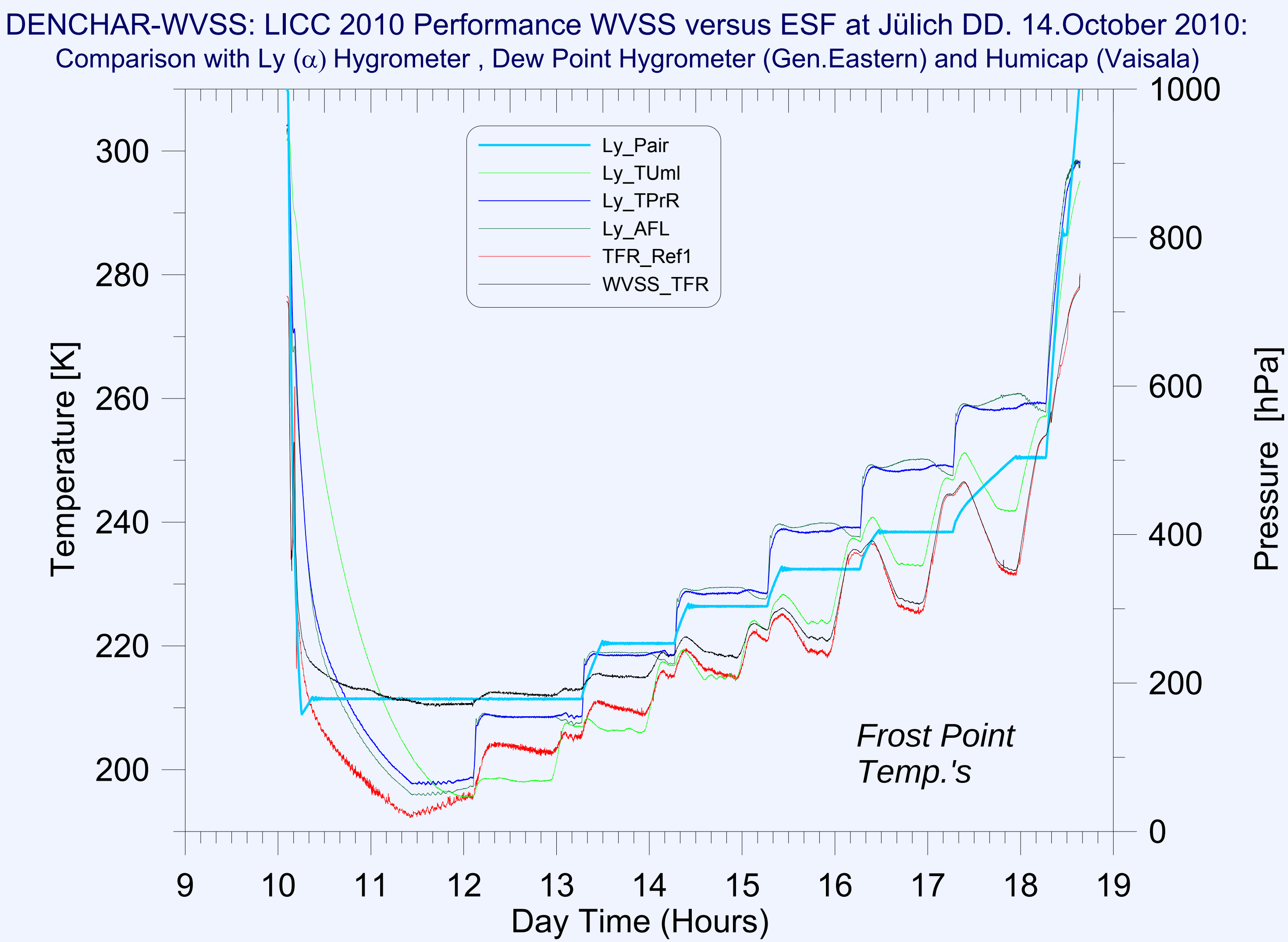
Reference temperature for trend analysis was calculated as monthly average over the full period.

Observed temperature trends:

LMS	1.5K/15 yr
TP	1.5K/15 yr
UT	1.0K/15 yr

Work in progress
by Florian Berkes, FZ Juelich

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



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