THE MODEM SONDE DATA PRODUCT

PROGRESS AND PLANS

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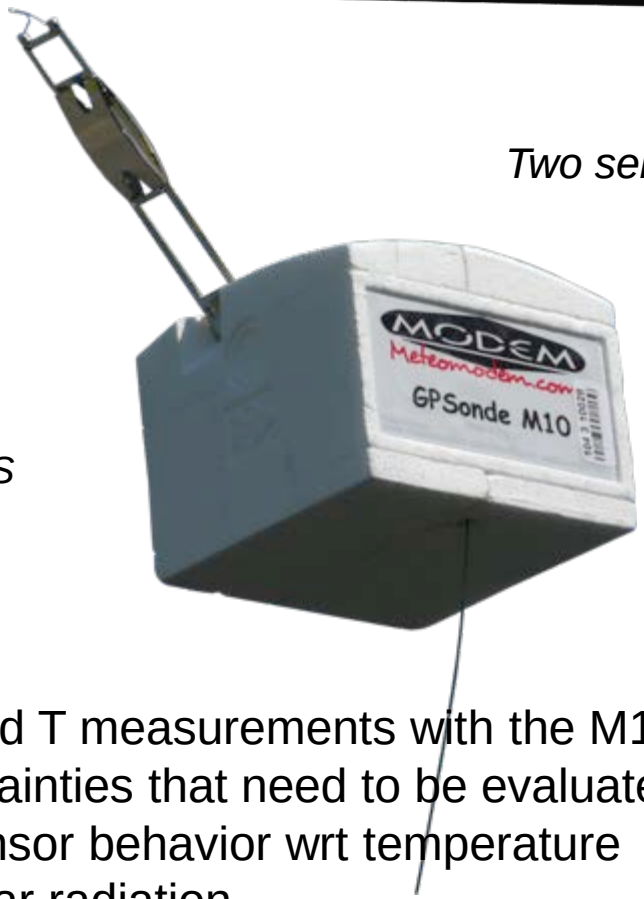
GRUAN ICM8 – 26 April 2016

Outline

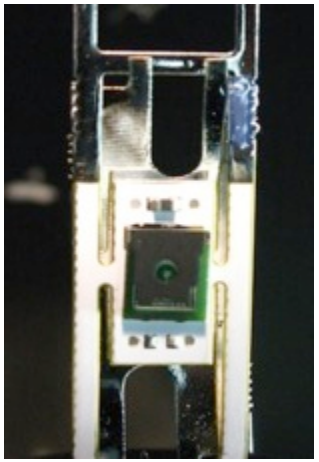
1. Measurement corrections and uncertainties
   - Relative humidity
   - Temperature
2. GRUAN M10 ground-check procedure
3. GRUAN M10 Robotsonde operations
4. GRUAN M10 data processing and Documentation
5. Future activities 2015-2016

Sonde manufacturer information

MODEM M10: P,T,U + GPS wind



Two sensors



Capacitive RH sensor

Thermistance T sensor

RH and T measurements with the M10 radiosonde are subject to physical and uncertainties that need to be evaluated for the GRUAN certification

- Sensor behavior wrt temperature
- Solar radiation
- Auto – heating
- RH sensor time lag (T < -30° C)
- Calibration uncertainties

MODEM
Meteomodem.com

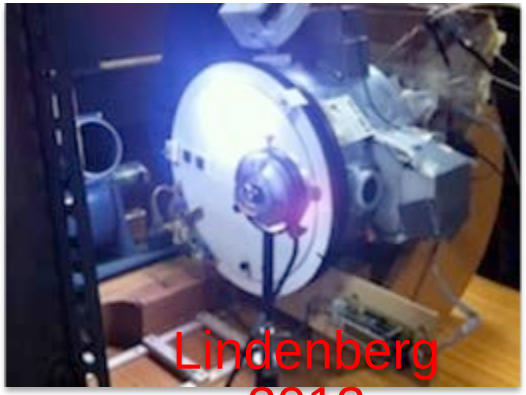
Past and future campaigns

Temperature

- radiation
- convection
- conduction

Relative Humidity

- Time lag
- Slow response of U sensor
- Sensor heating (solar radiation, conduction and convection)


Lindenberg 2013


Payerne 2013

Payerne 2014


Malicca 2014

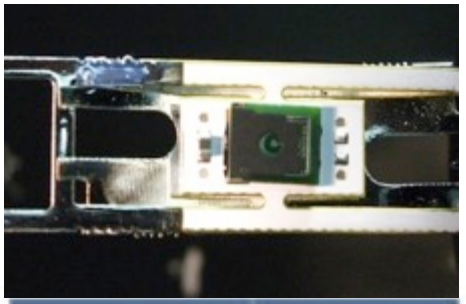

Morgane 2015


SIRTA 2016

Relative Humidity corrections and uncertainties

Principle

- Capacitive sensor
- Oscillation frequency of the sensor is measured by a microcontroller



Calibration:

- Oscillation frequency at 55% RH

Corrections:

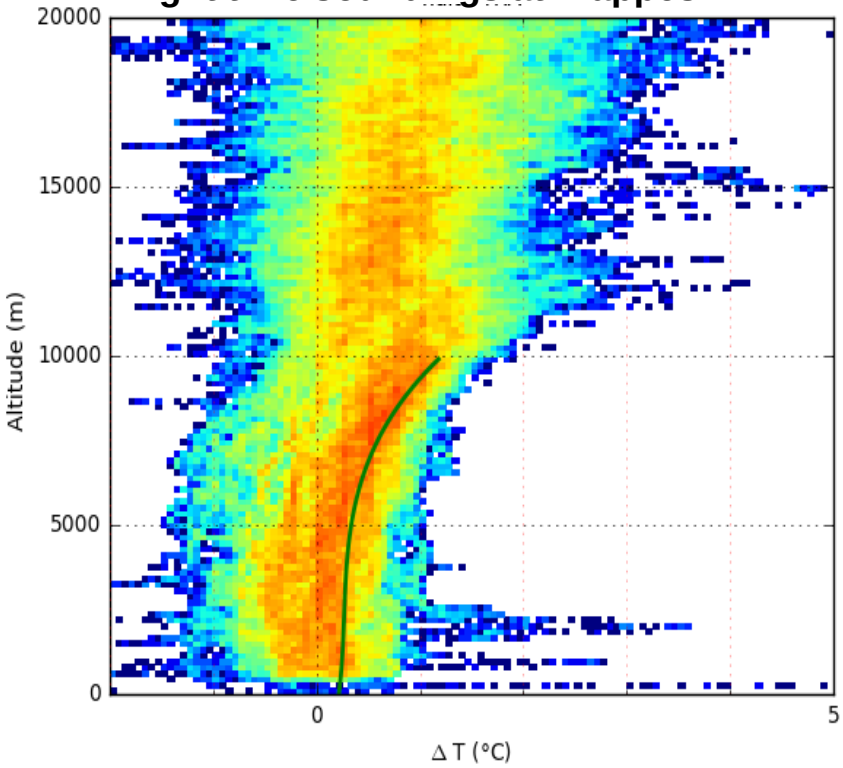
1. Capacitor frequency varies with temperature
2. Temperature difference between Air and Capacitor (RH is measured at capacitor temperature → dry bias)
3. Time response of capacitor which is temperature dependent – fast regime
4. Diffusion of air molecules into the capacitor (issue near 0% and 100% RH) – slow regime

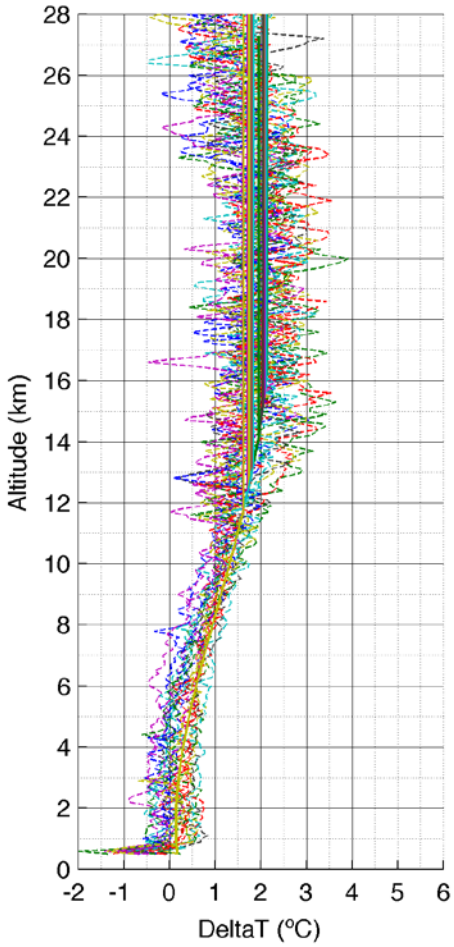
Heating effect (dry bias)

Corrections:

1. Temperature difference between Air and Capacitor (RH is measured at capacitor temperature → dry bias)
   - New correction takes into account mean ($T_{air} - T_{capacitor}$) model as a function of height and Air temperature
   - Tair: 0 to -80° C; ΔT: 1-6° C → RH x 1.05 – 2.0

(Tsensor-Tair) 2D histogram from 82 night time soundings at Trappes





Time response issues (time lag)

The response of U% capacitive sensors

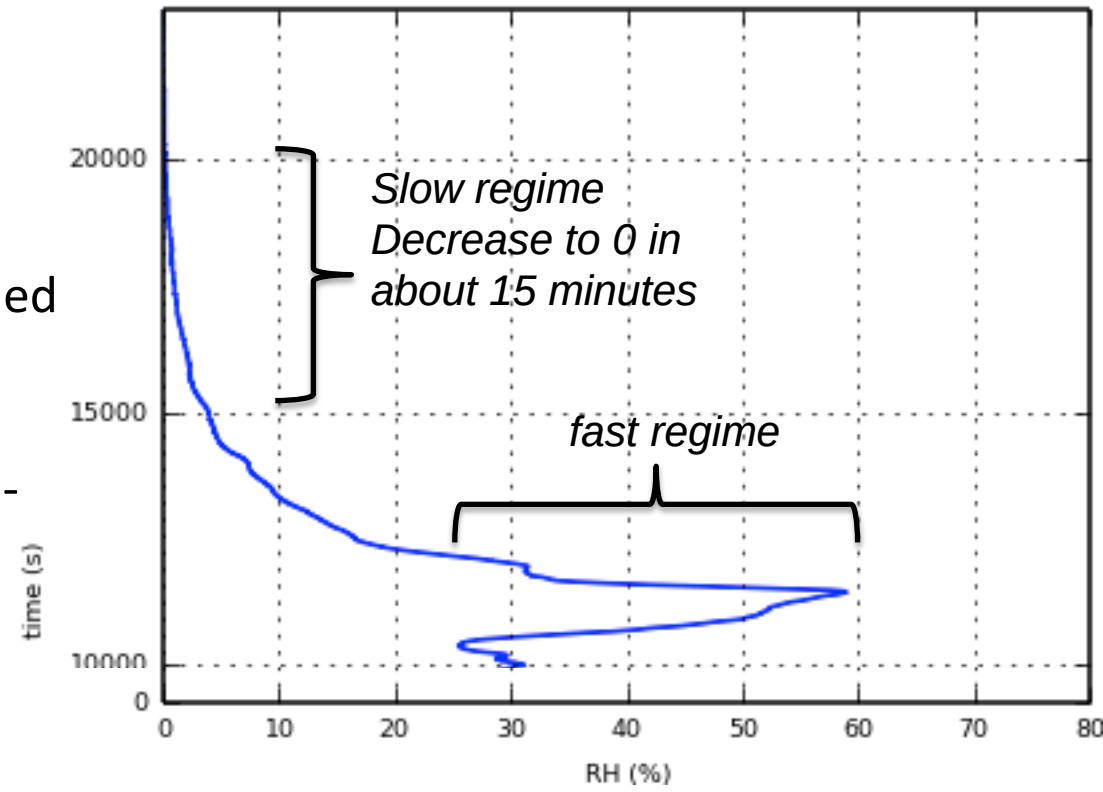
- humidity step → combination of fast and a slow regime

Fast regime:

- range of seconds
- > 95% of full humidity range reached
- Characterized by matching ascent/descent gradients at tropopause (18s at -40° C; 90s at -60° C; 280s at -80° C)

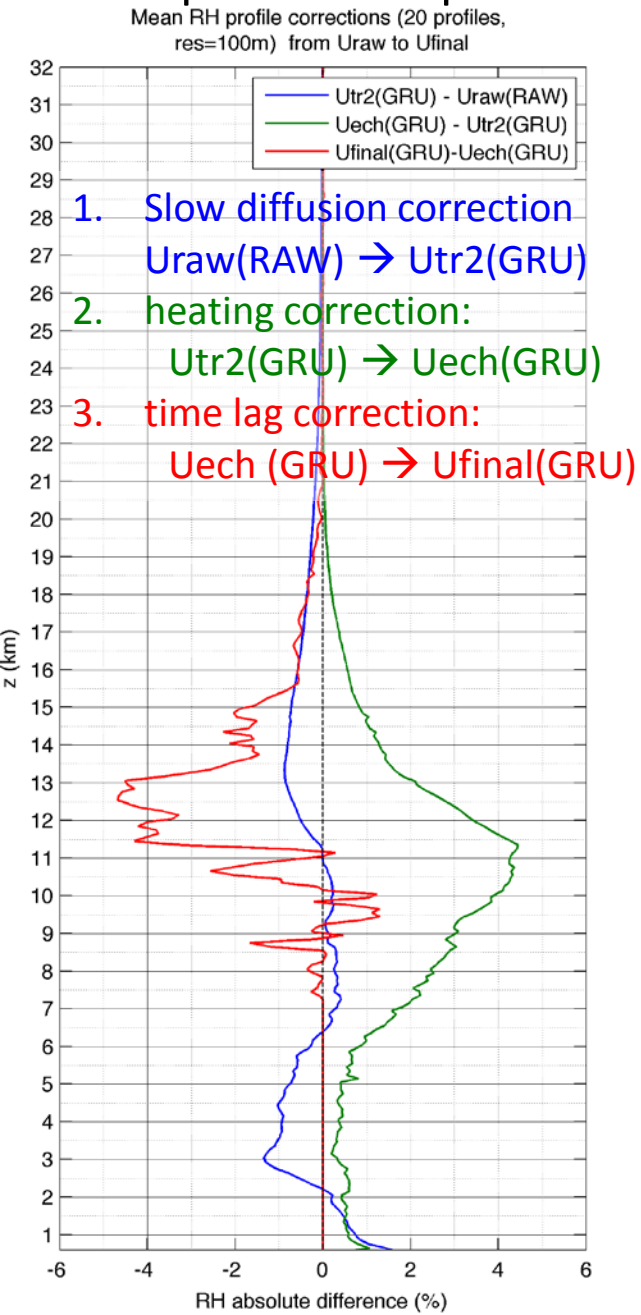
Slow regime:

- range of minutes
- RH slope < 2% per hour in a static environment
- Slow diffusion of wv in/out of the polymer

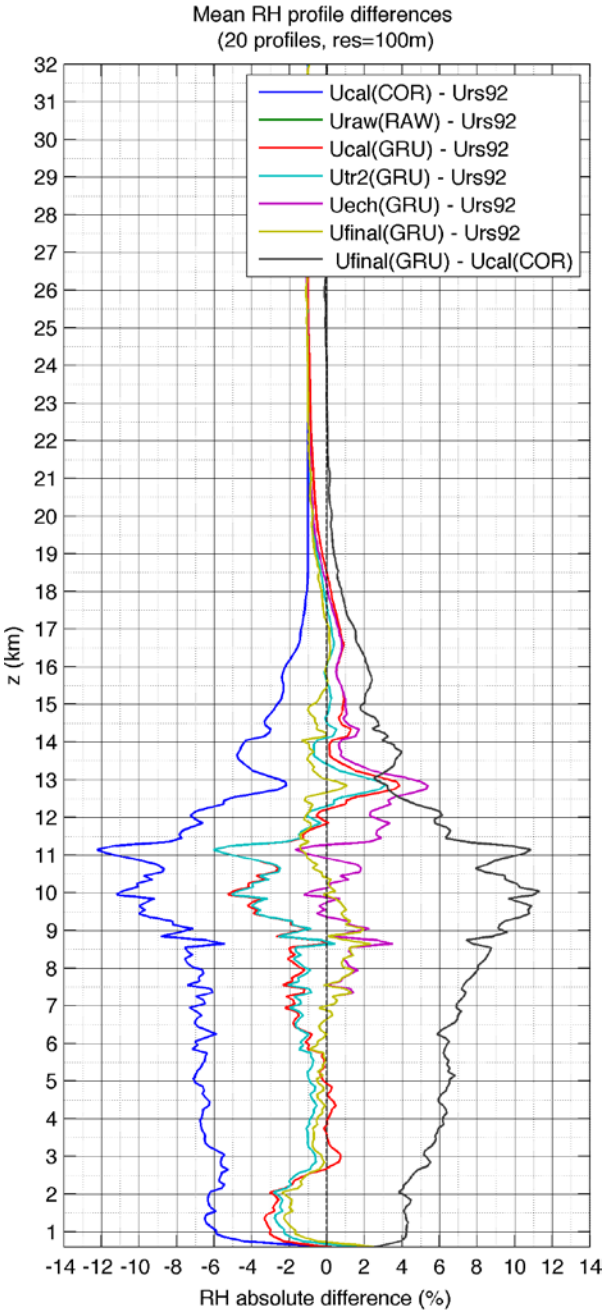


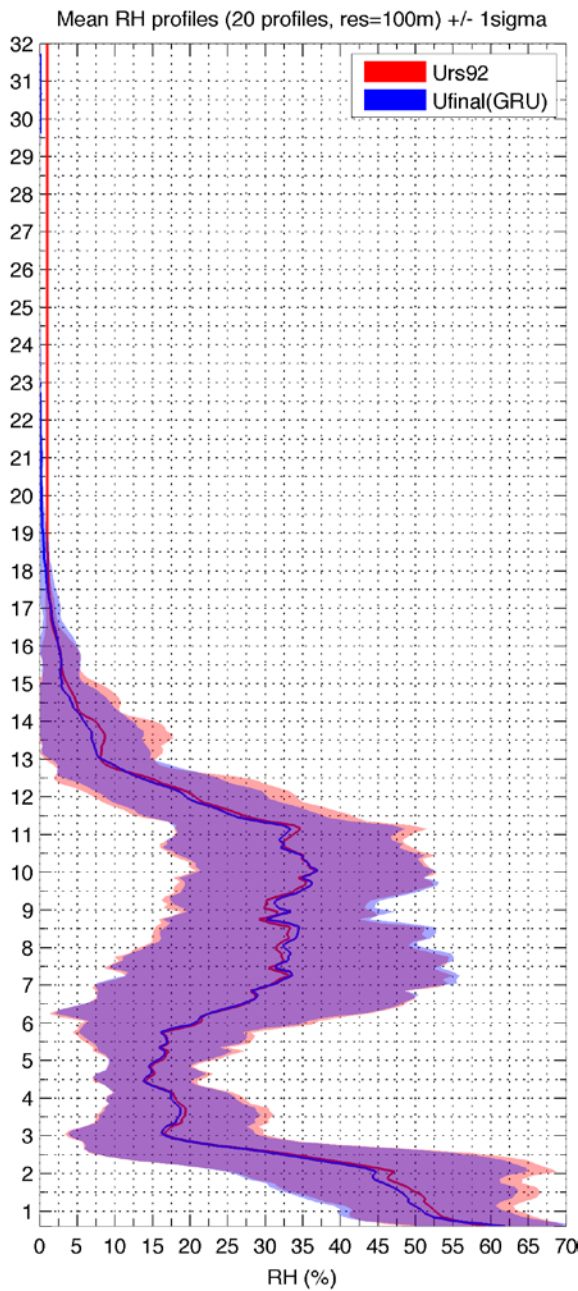
Relative Humidity corrections (DEMEVAP field campaign)

21 independent RS profiles



1. Slow diffusion correction
   Uraw(RAW) → Utr2(GRU)
2. heating correction:
   Utr2(GRU) → Uech(GRU)
3. time lag correction:
   Uech (GRU) → Ufinal(GRU)

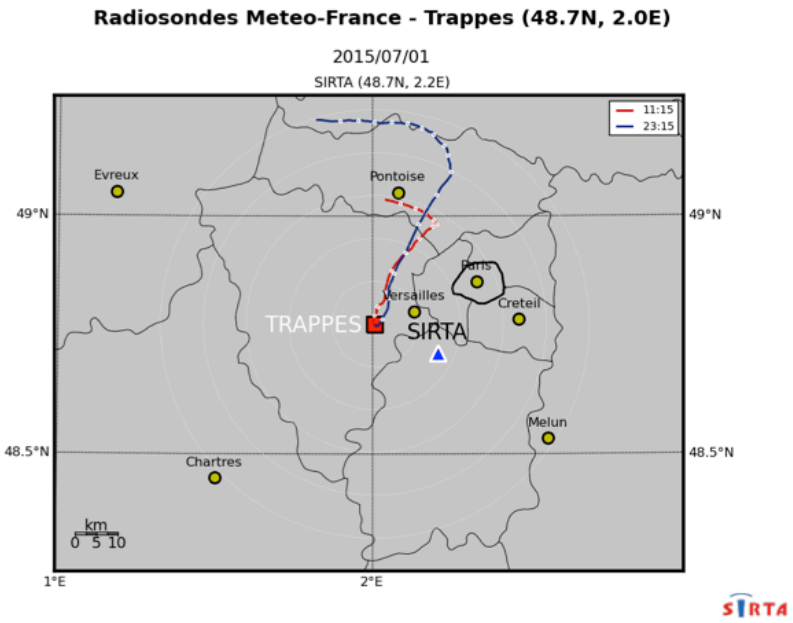


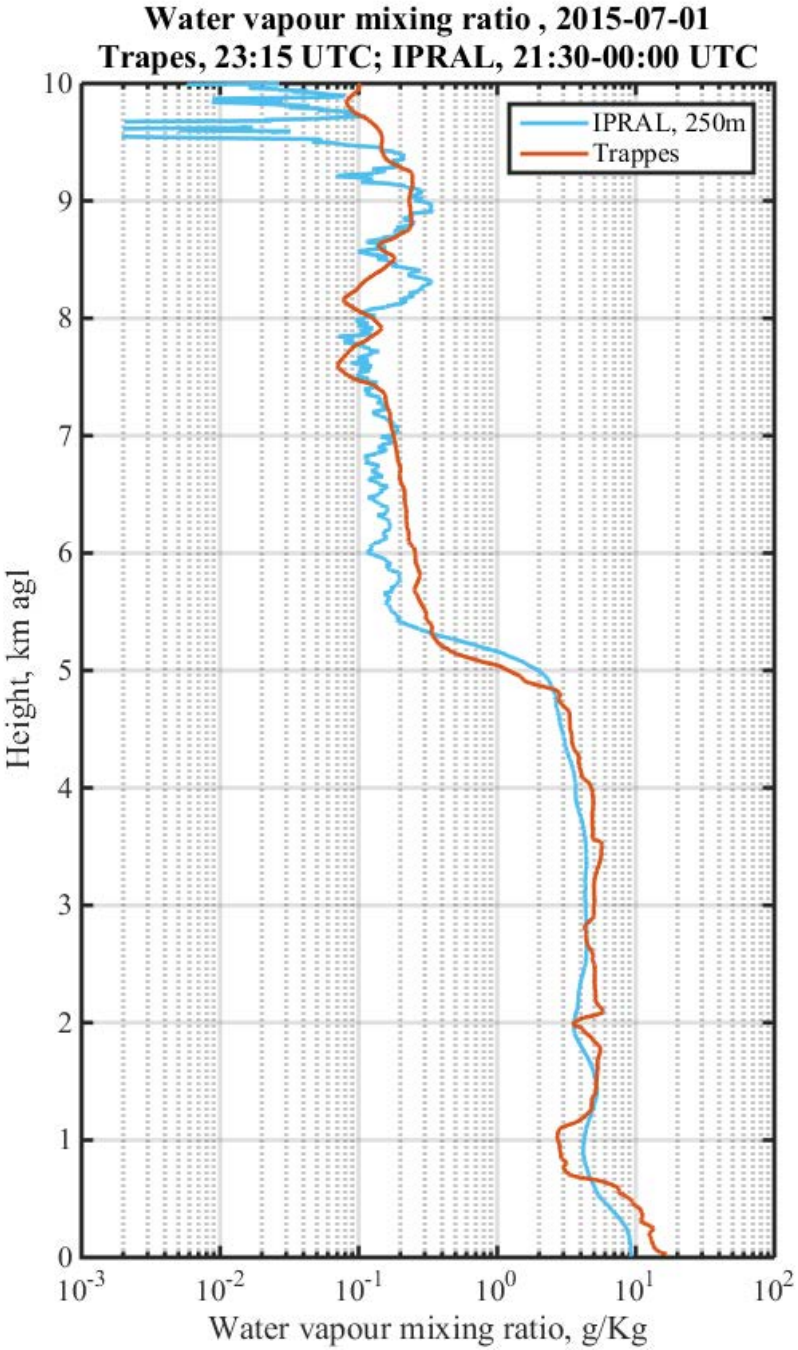


Mixing ratio retrieval: radiosonde vs lidar

To be highlighted:

1) No incomplete overlap effect
2) Minimum w value around 0,1 g/Kg at 9 km (depending on the smooth applied and the average time).
3) Day-time measurements (to be done)





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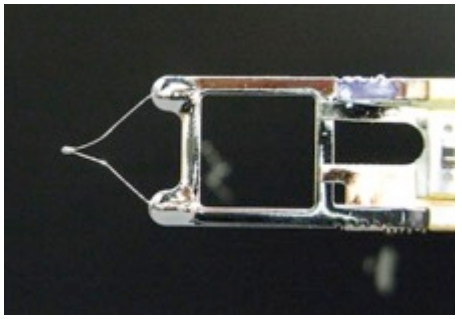
Temperature corrections

Principle/Calibration:

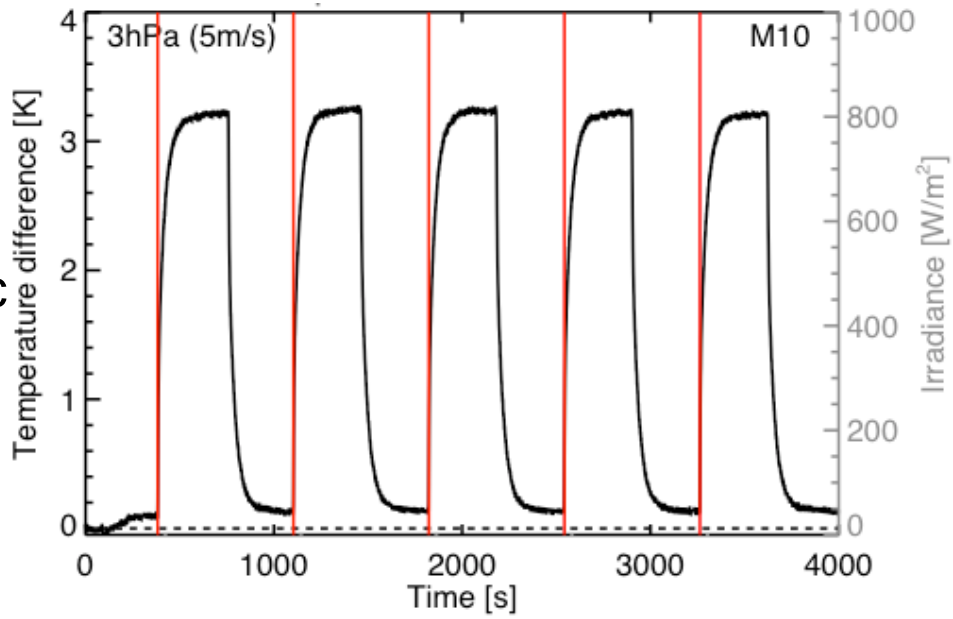
- Low tolerance thermistor calibrated at room temperature + standard calibration curve
- Electronic circuit: 3 measurement ranges



- Behavior was tested in DWD vacuum radiation chamber
- One thermistor is exposed to the lamp, one is not

Corrections:

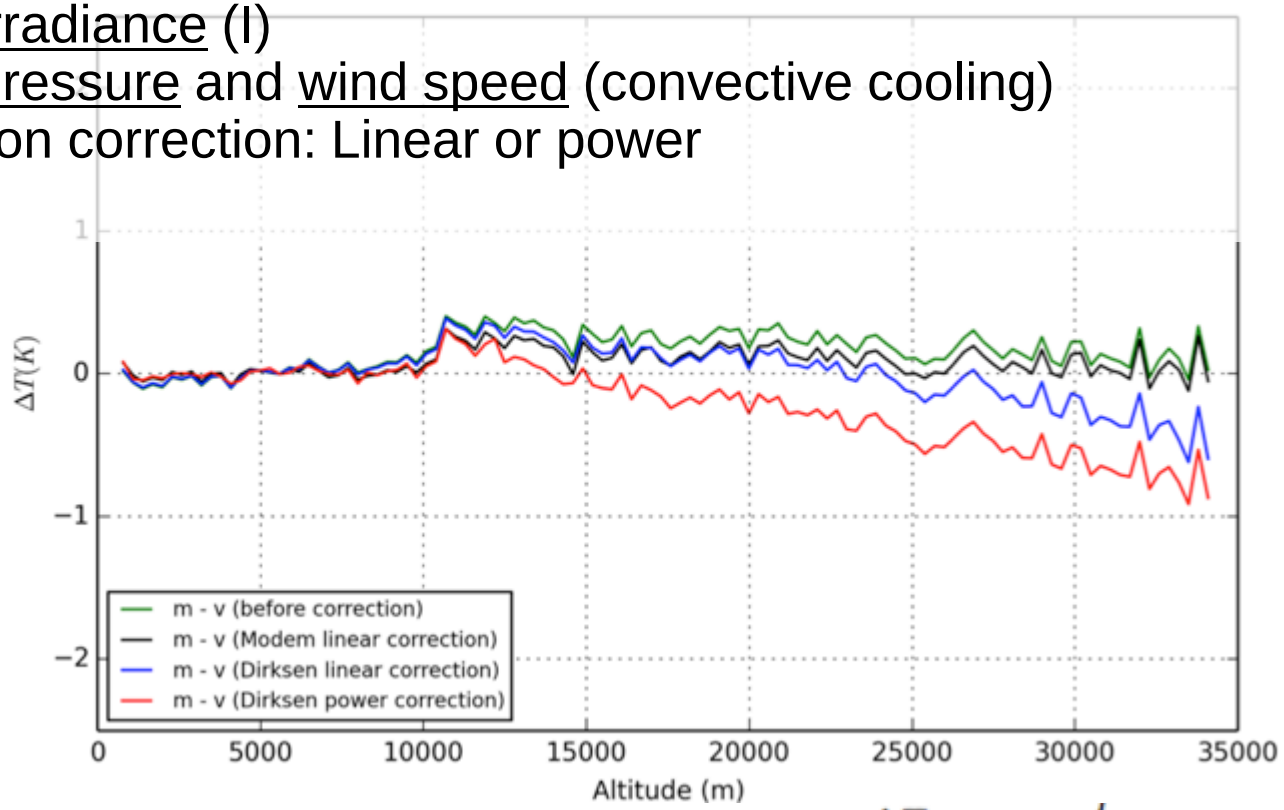
- Radiation balance on the sensor:
  - Actinic radiation flux,
  - convective cooling ~ atmospheric pressure and wind speed
  - conduction of heat through wires



Temperature corrections

Test protocol accounts for the radiation balance of the sensor:

- Fixed irradiance (I)
- Fixed pressure and wind speed (convective cooling)
- Radiation correction: Linear or power



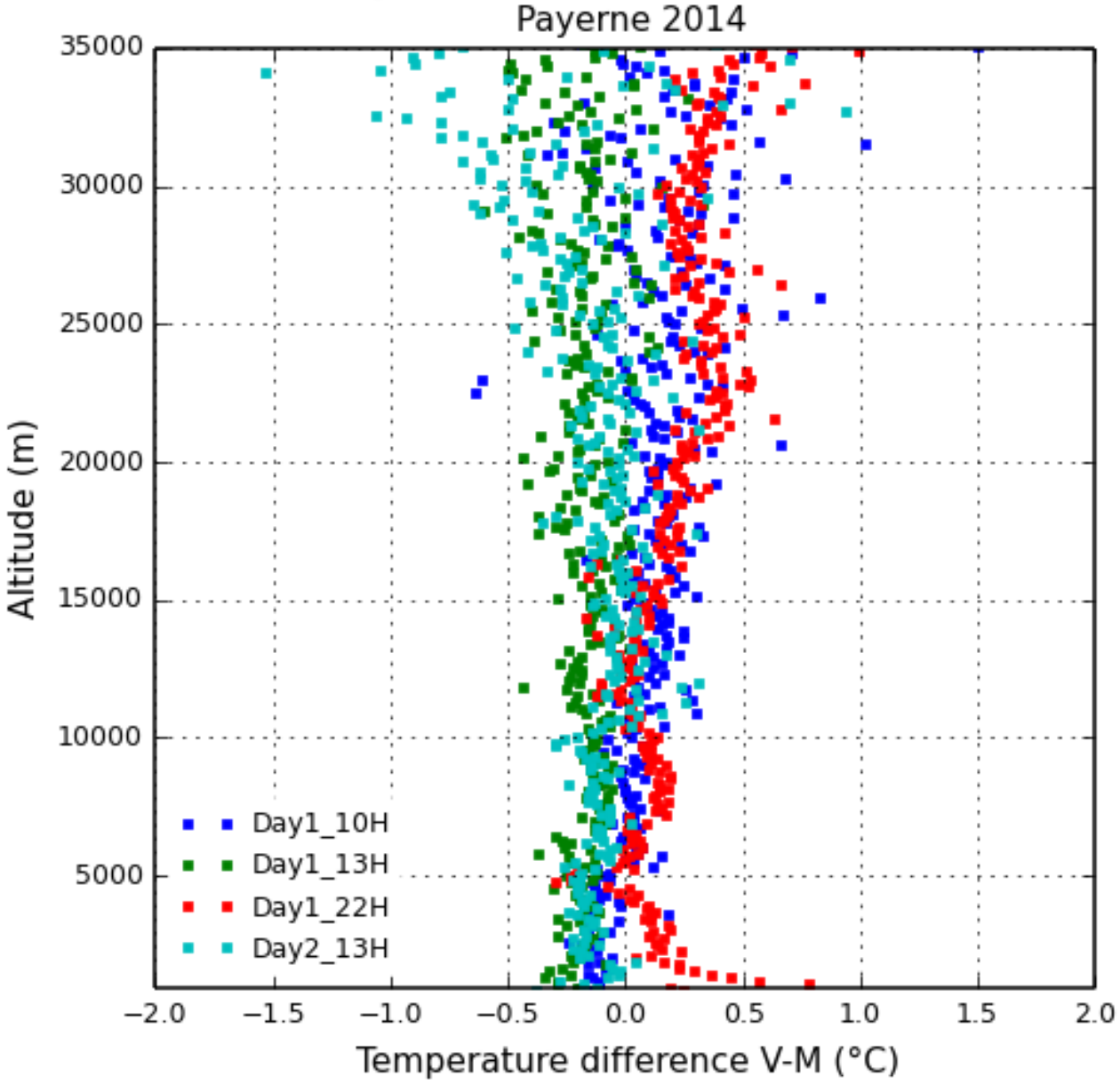
Dirksen “linear” correction: $\Delta T = a * \frac{I}{\sqrt{P*v}}$

(Dirksen, Luers et al. (1998))

Dirksen “power” correction: $\Delta T = a * log_{10}(\frac{I}{P*v})^b$

Modem linear correction: $\Delta T = a(I) * z + b$

Temperature corrections



GRUAN M10 ground-check

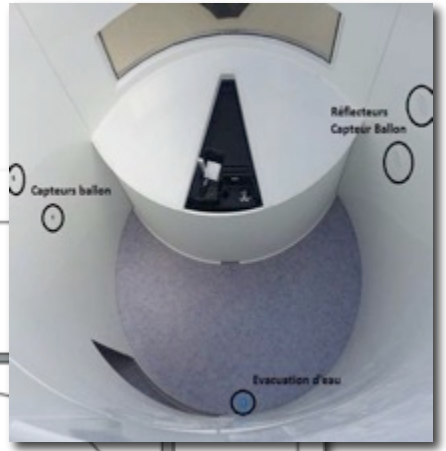
2-step ground-check (about 10 min per sonde):

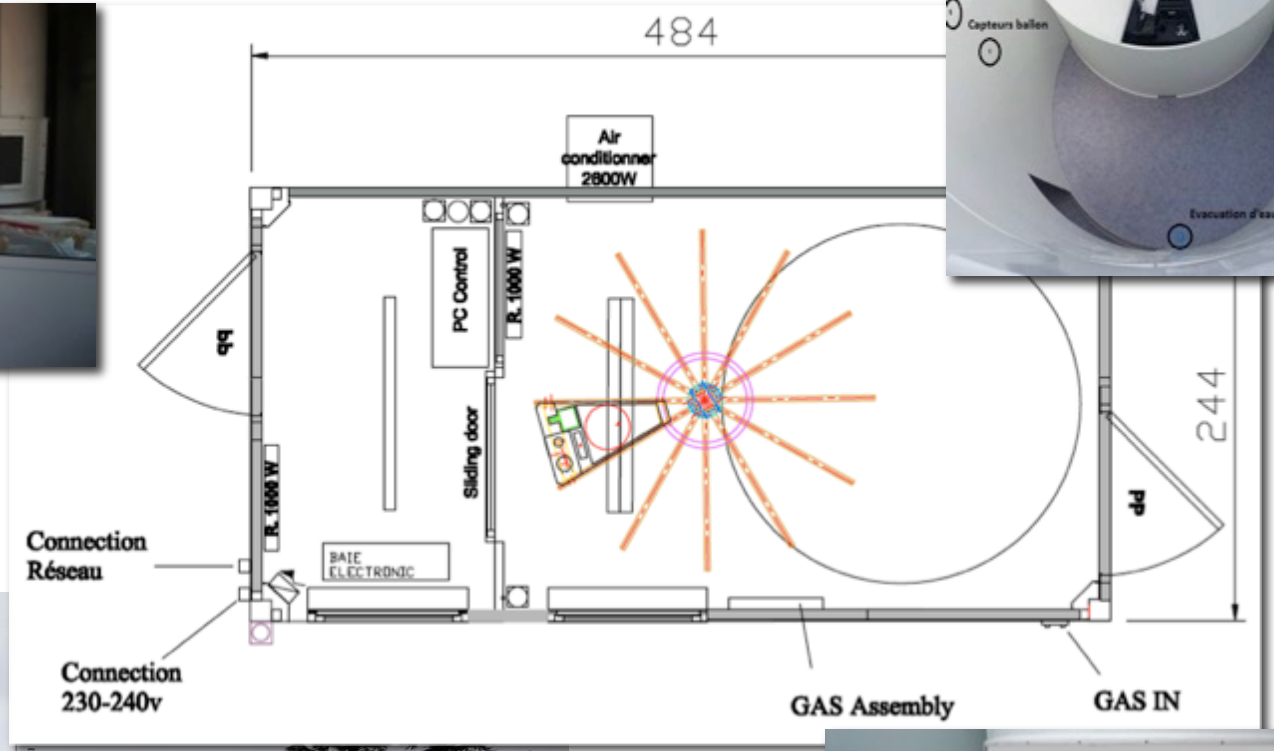
Comparison with calibrated temperature and RH sensors in ventilated hut – ambient conditions

RH measurement in saturated environment using SPRH100

GRUAN M10 Robotsonde operations

- Each sonde goes through GRUAN ground-check and is then loaded in the carrousel
- Robotsonde records ground-check and metadata

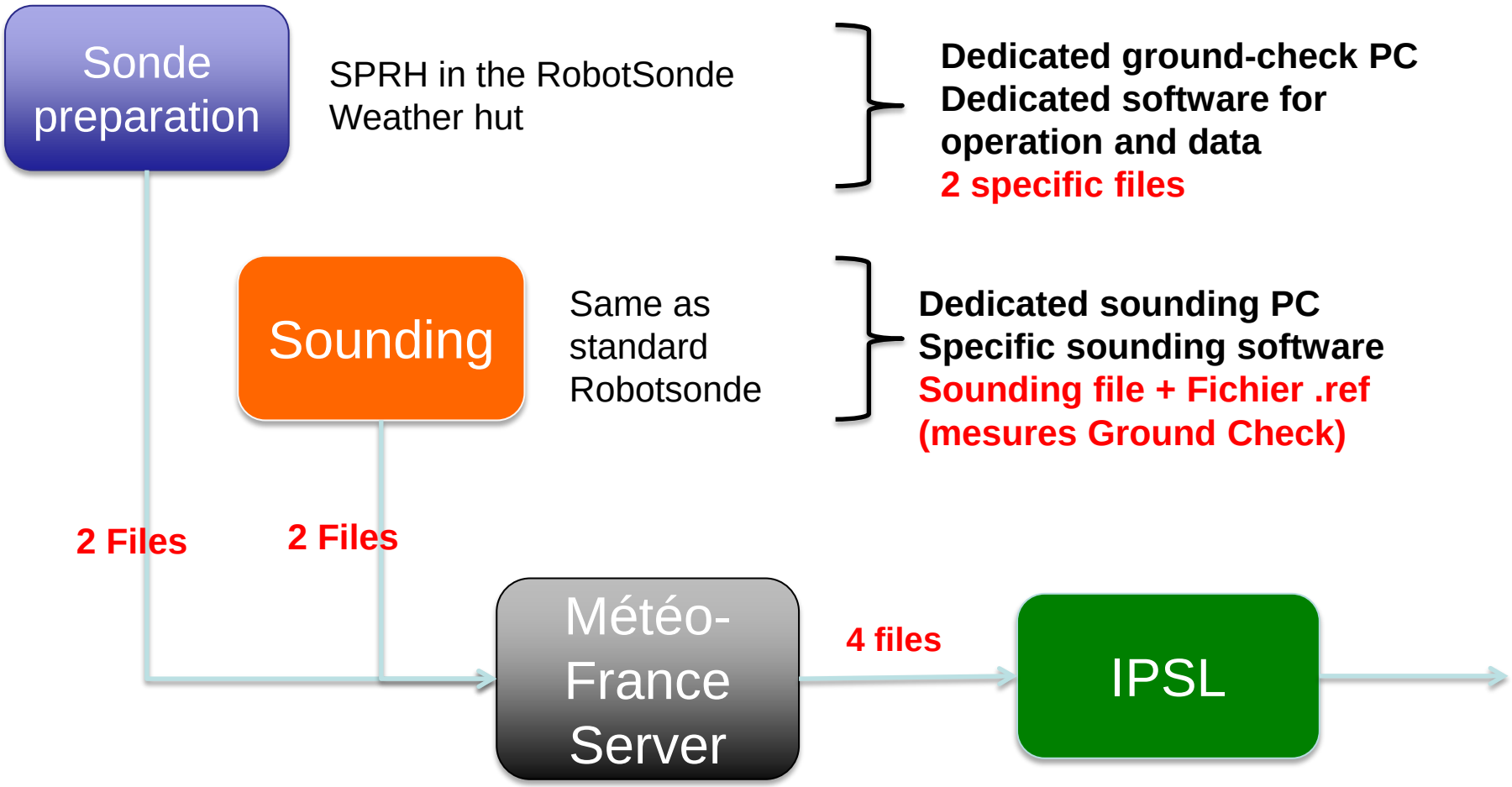




15 robotsondes in operation in the world

GRUAN – RobotSonde Protocol

GRUAN RobotSonde specifics:



GRUAN M10 data processing and documentation

- Ground check data and M10 metadata collected by Robotsonde → Metadata file
- RS profile data provided as “RAW M10” data file
- After the flight, Metadata + RAW datafiles sent by Météo-France to IPSL
- Specific GRUAN Python code converts RAW M10 data → GRUAN M10 data
- Metadata + GRUAN M10 data files → GRUAN data archive through RSLaunch client

Documentation

- Capacity sensor for RH measurements: description, corrections & uncertainties
- Thermistor for T measurements: detailed description, corrections & uncertainties
- Python code for M10 processing documentation
- *Badosa et al. M10 relative humidity measurements: description, corrections & uncertainties. Still in prep.*

2016 Activities

2016

- Finalize procedures for data processing and transfer through RS Launch
- GRUAN Robotsonde operations at Trappes station (Nov.)
- Prepare for GRUAN certification (finalize uncertainty estimates)

2017

- Daily M-F Robotsonde M10 radiosonde in Trappes with GRUAN procedure
- Go through GRUAN certification
- Implement GRUAN procedures at La Réunion based on weekly U. Réunion M10 radiosonde
- Deployment of Robotsonde on La Réunion

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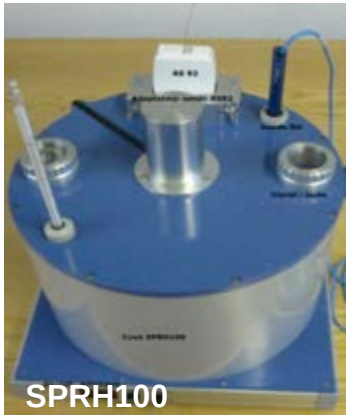
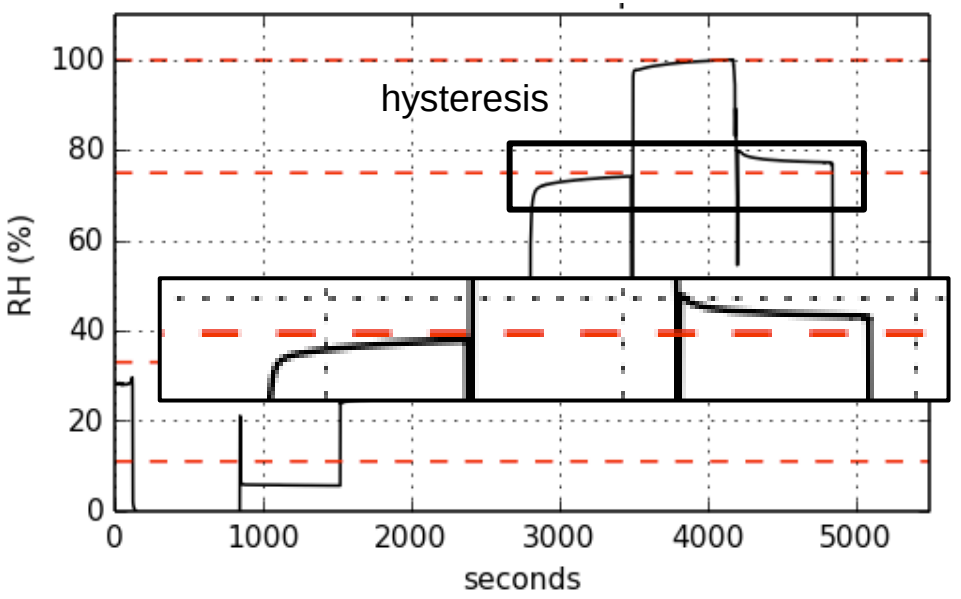
Thank you

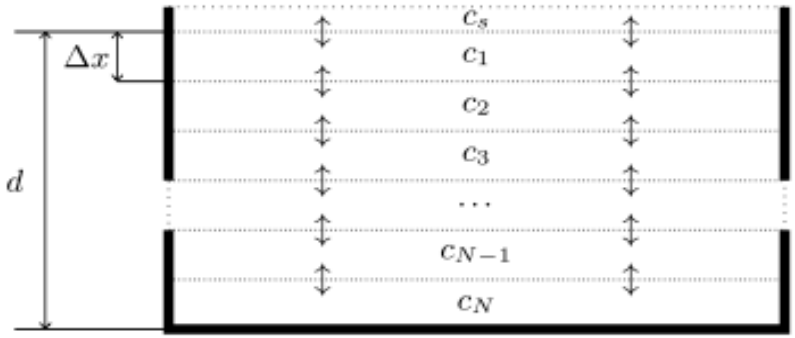
Time response issues (time lag)

Characterisation of the slow regime: wrt Temperature, ΔRH%, hysteresis





Wildmann et al., (AMT, 2014) model this response as multi-layer with exchange coefficients between layers.



Wildmann et al., AMT, 2014

Fig. 4. Sketch of the sensor model.