THE MODEM SONDE DATA PRODUCT

PROGRESS AND PLANS

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GRUAN ICM7 – Matera, Italy – 23 February 2015

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

Relative Humidity corrections and uncertainties

Principle

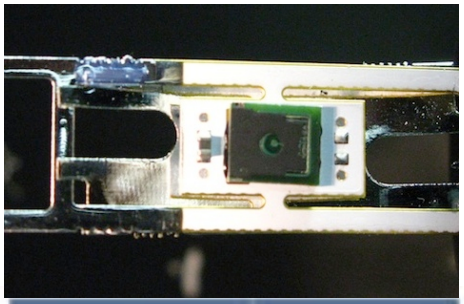
- Capacitive sensor
- Oscillation frequency of the sensor is measured by a microcontroller

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



M10

Tests and intercomparisons

Radiation chamber
salt solution pots
Nov-Dec 2013

Temperature and humidity tests
Dec 2014

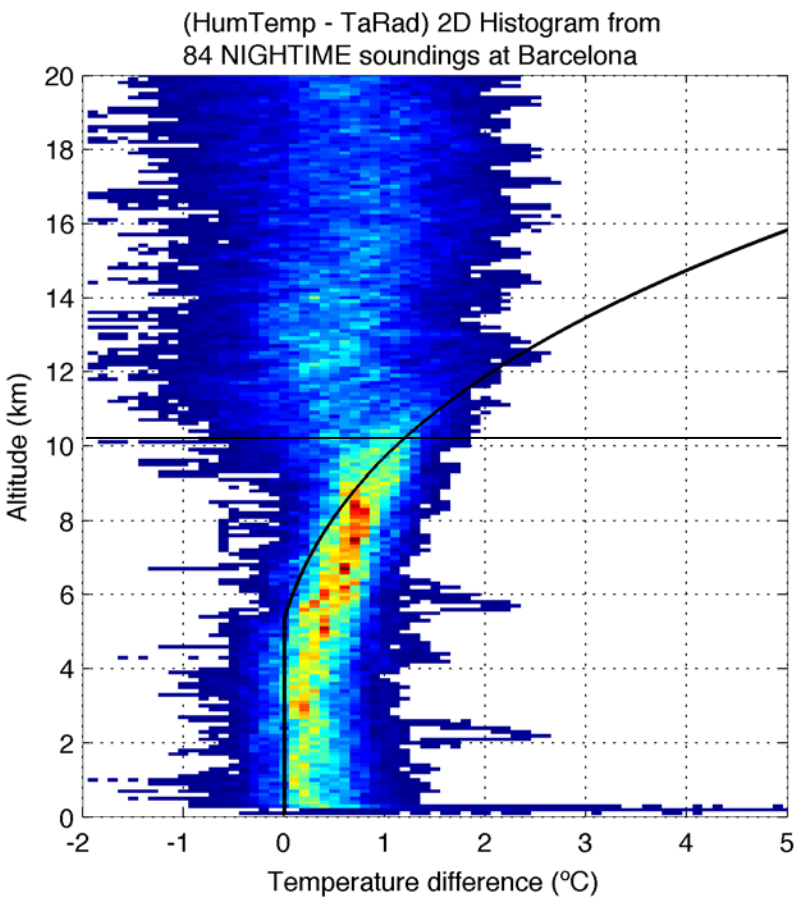
Sonde intercomparisons
RS92, M10, C34, SW
June 2013; June 2014

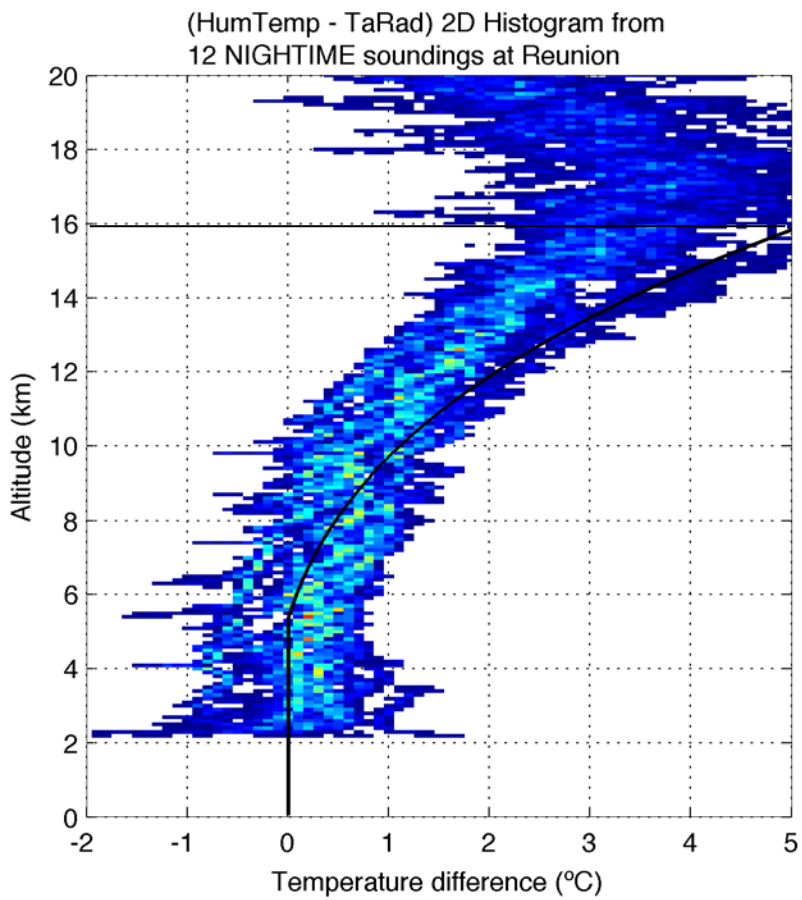
Humidity sensor tests
2014

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 – 2.00





Time response issues (time lag)

The response of U% capacitive sensors

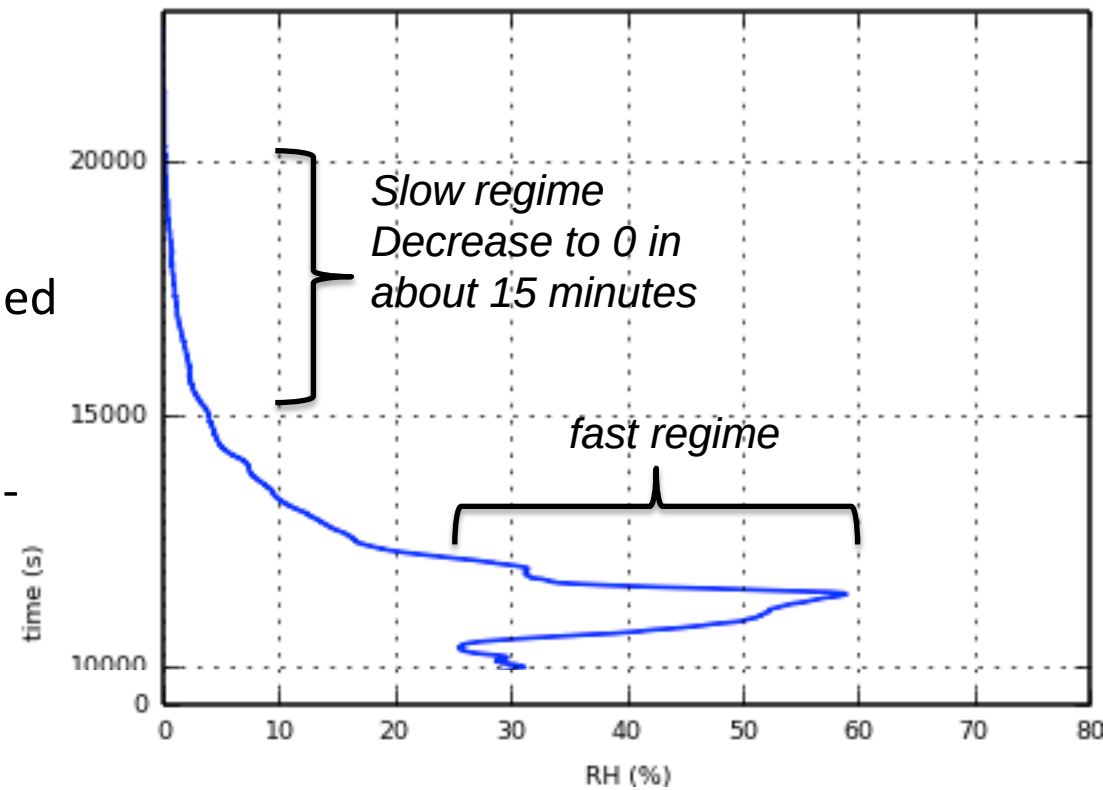
- humidity step → combination of fast and a slow regime

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)

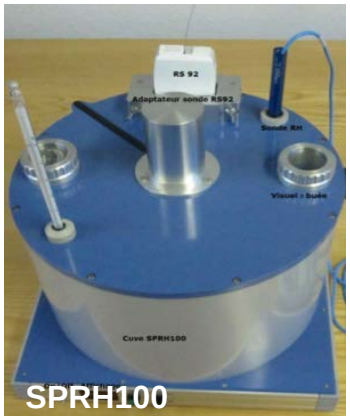
Slow regime:

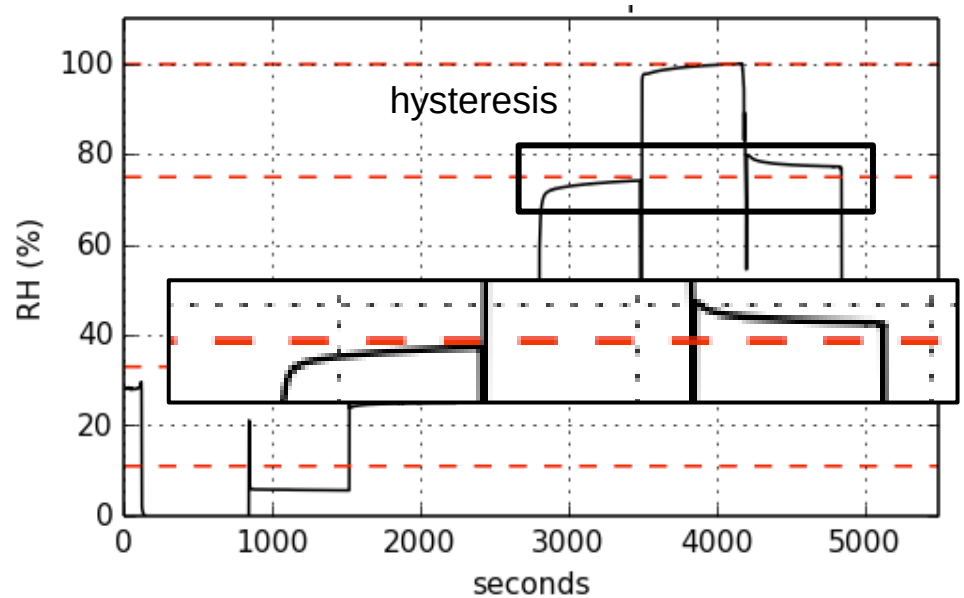
- range of minutes
- RH slope < 2% per hour in a static environment
- Characterization in progress



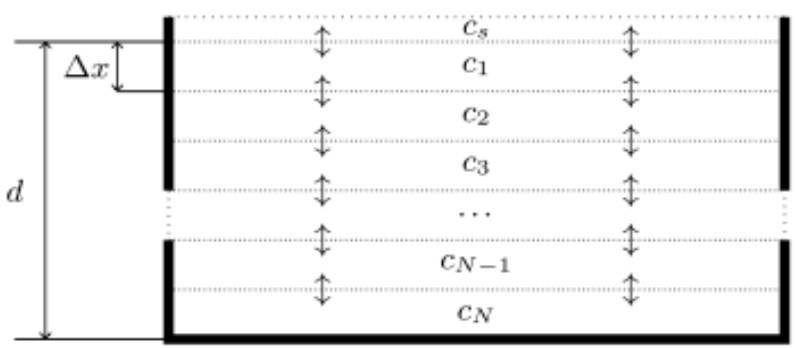
Time response issues (time lag)

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



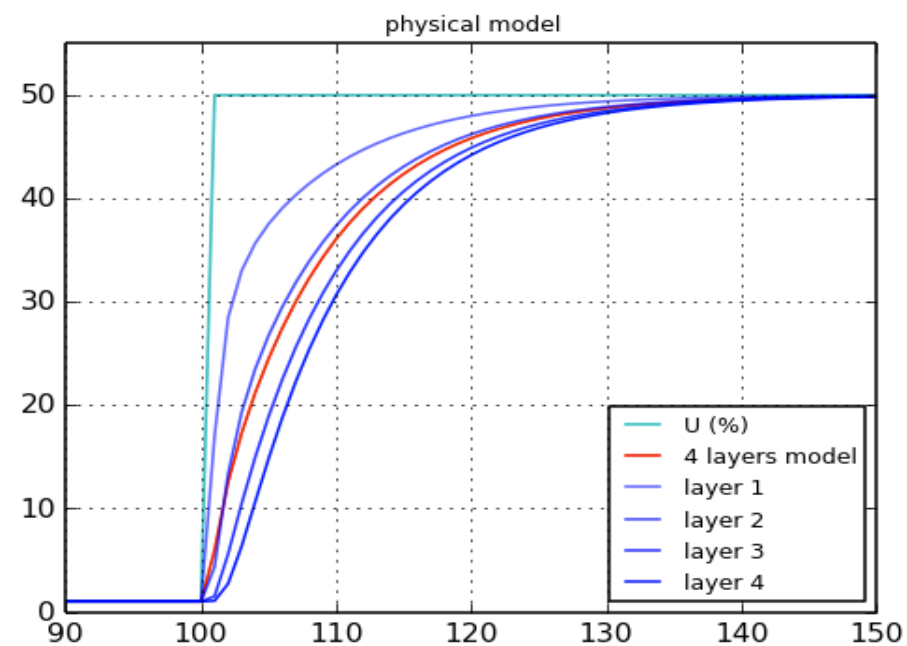


Wildmann et al., (AMT, 2014) model this response as multi-layer with exchange coefficients between layers.



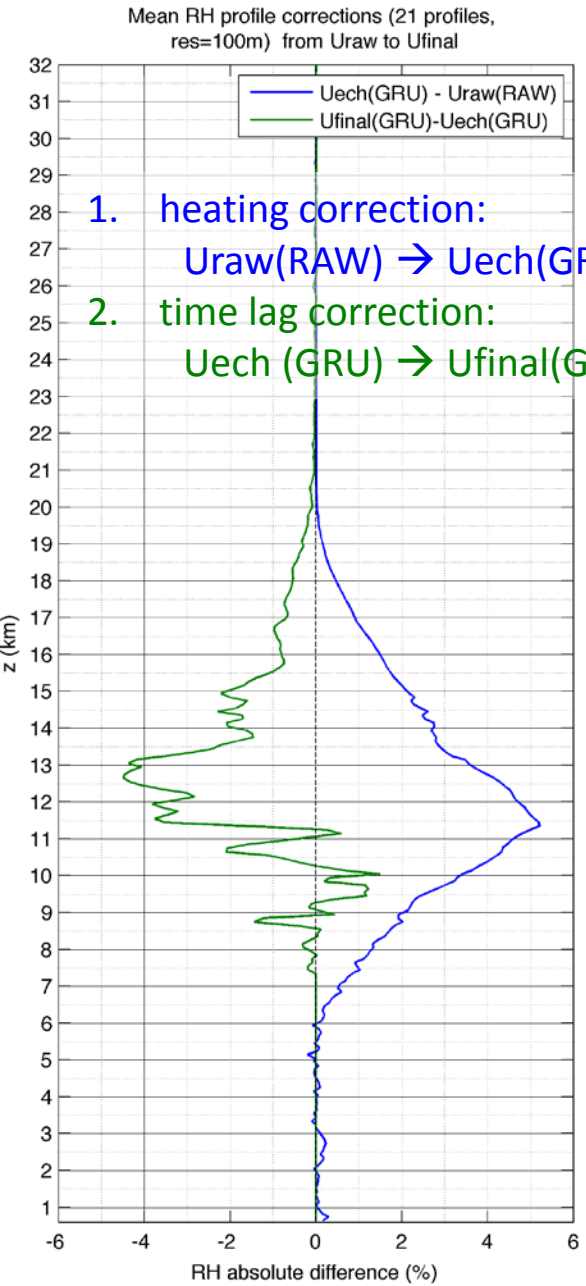
Wildmann et al., AMT, 2014

Fig. 4. Sketch of the sensor model.

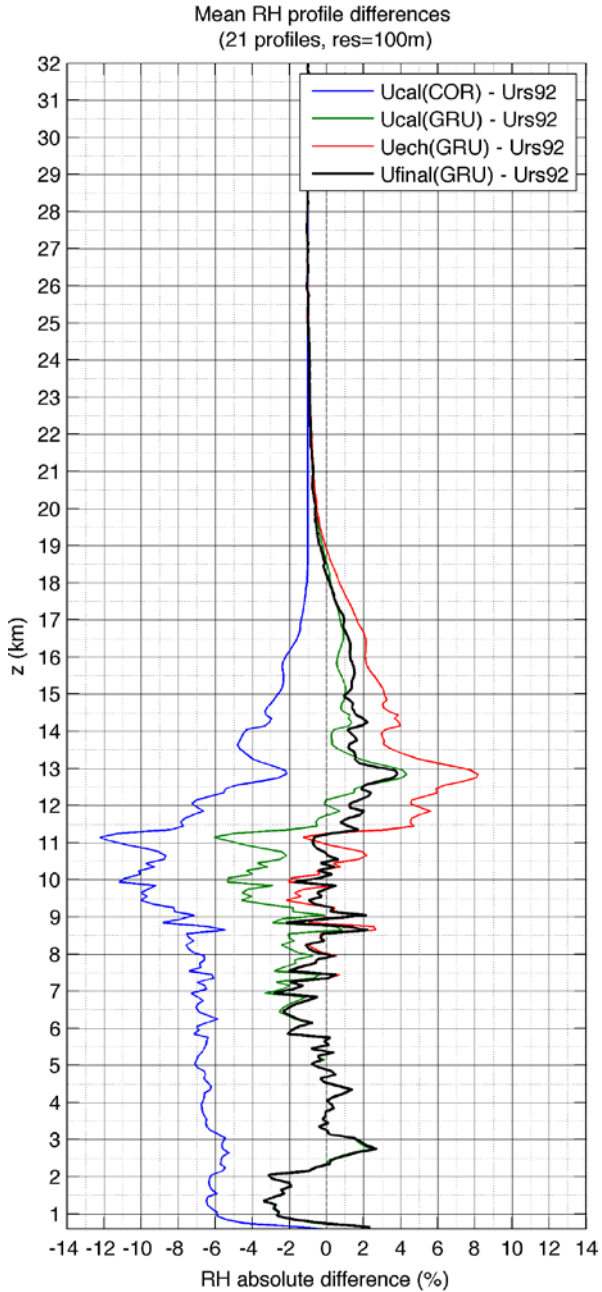


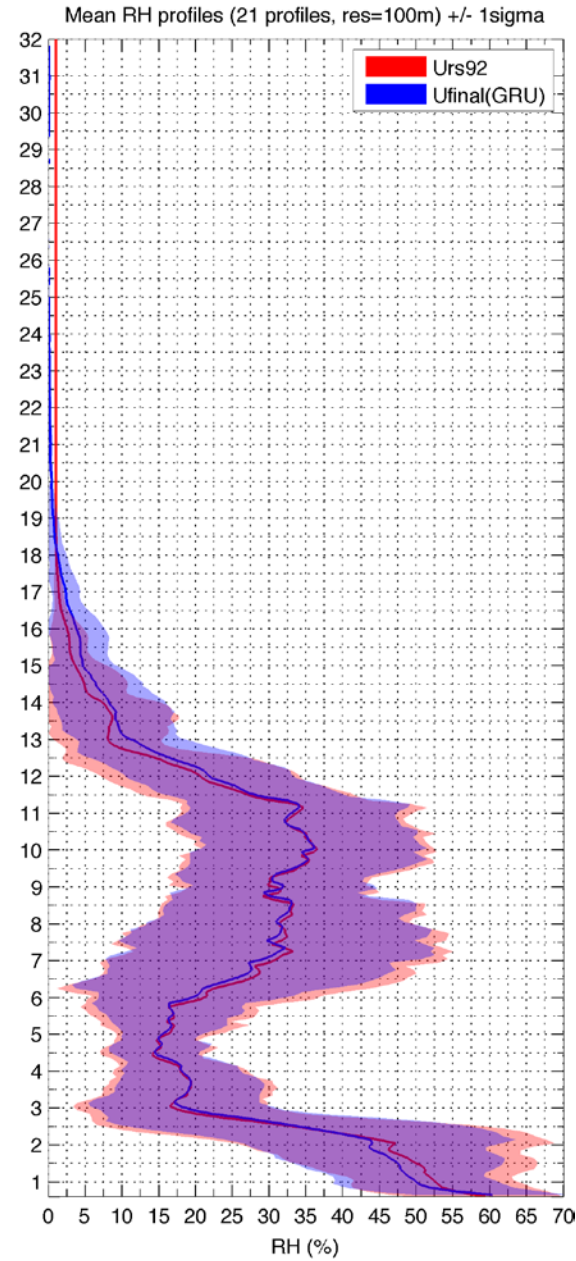
Relative Humidity corrections (DEMEVAP field campaign)

21 independent RS profiles



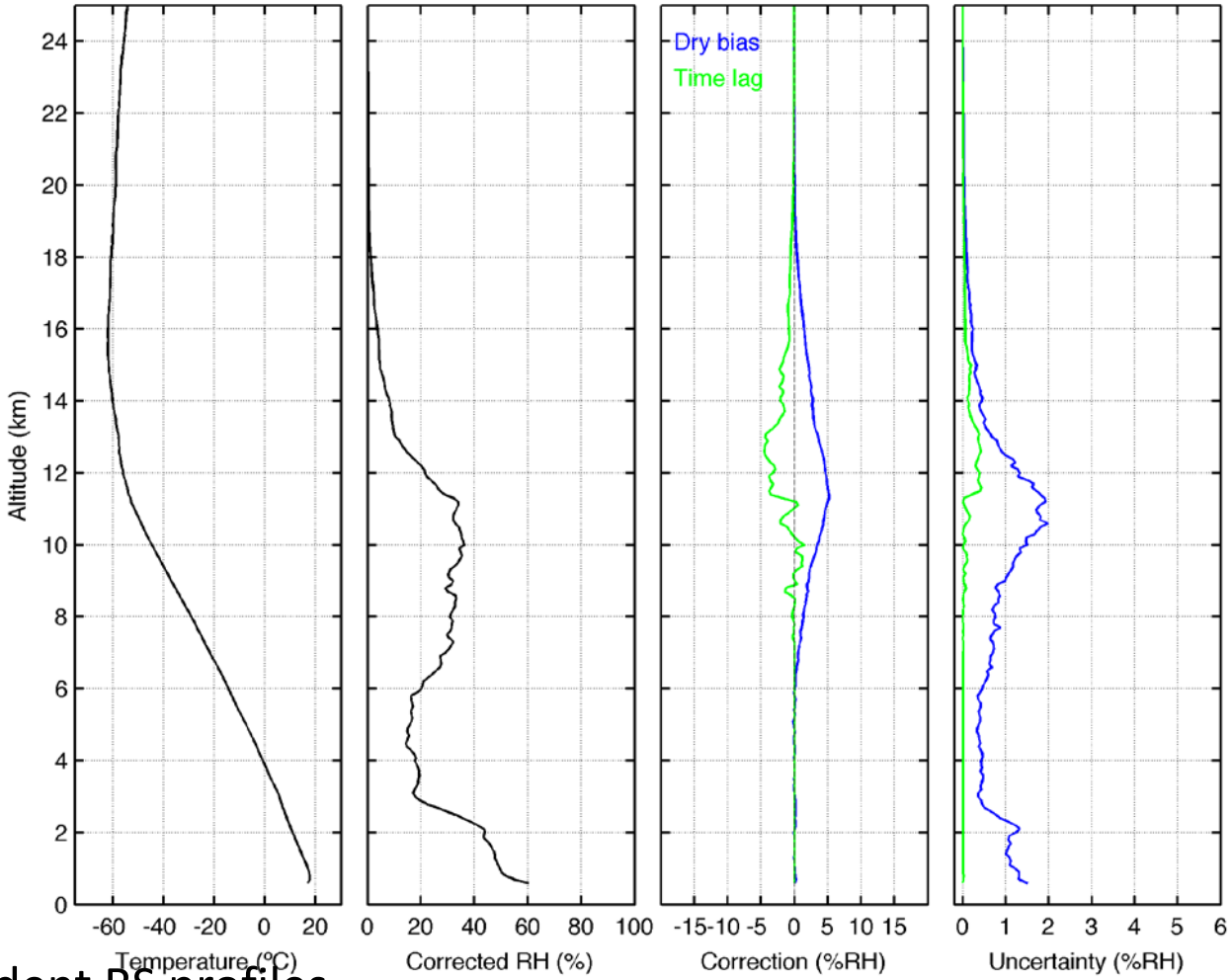
1. heating correction:
   Uraw(RAW) → Uech(GRU)
2. time lag correction:
   Uech (GRU) → Ufinal(GRU)





Relative humidity uncertainties (preliminary)

- Uncertainty in capacitive sensor temperature (dry bias)
- Uncertainty in time constant (time lag)



21 independent RS profiles

- Revise uncertainty calculations
- Must add calibration uncertainty

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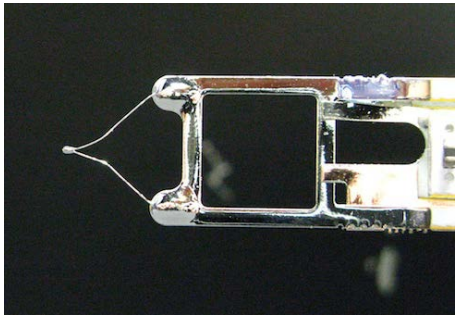
Temperature corrections

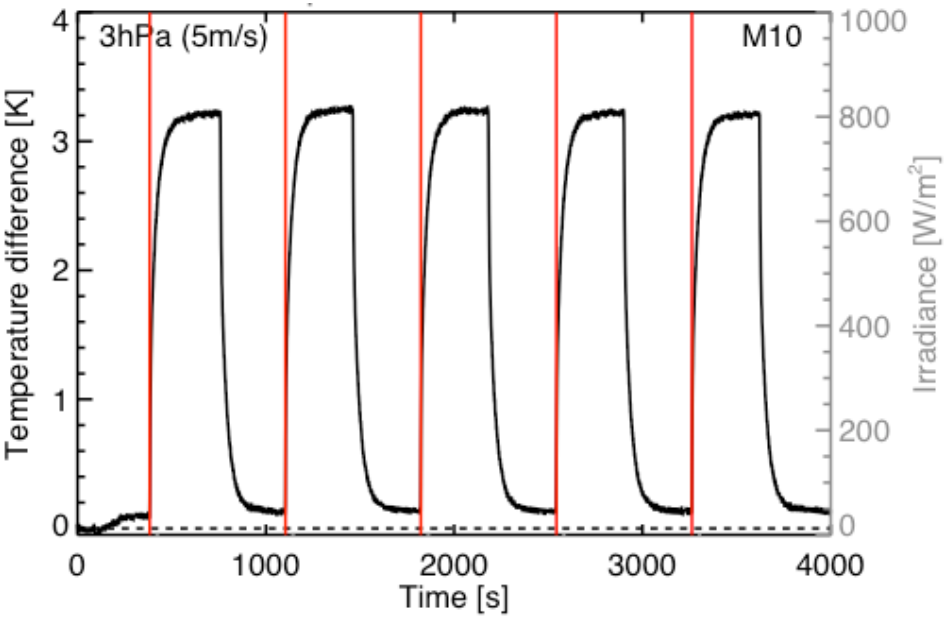
Principle/Calibration:

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



Corrections:

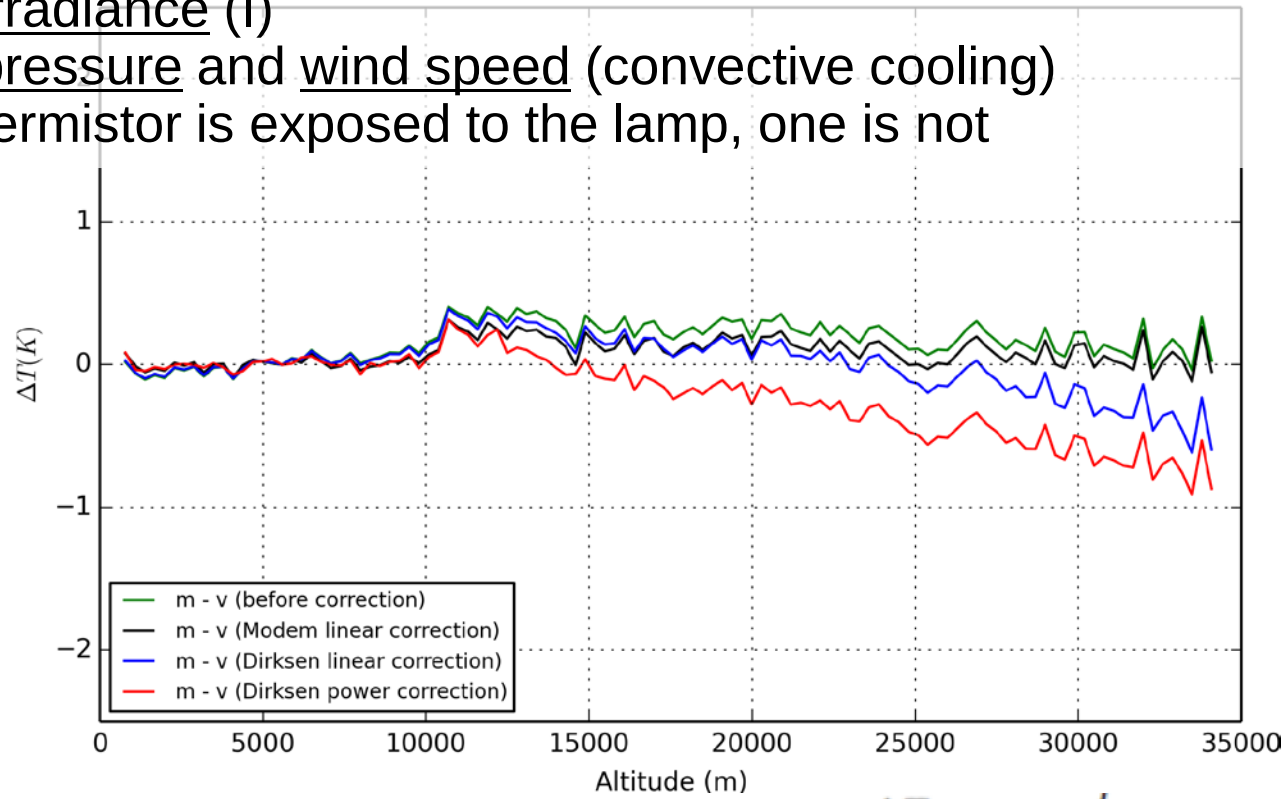
- Radiation balance on the sensor:
  - Actinic radiation flux,
  - convective cooling ~ atmospheric pressure and wind speed
  - conduction of heat through wires
- Behavior tested in DWD vacuum radiation chamber
- Radiation correction: Linear or power



Temperature corrections

Test protocol accounts for the radiation balance of the sensor:

- Fixed irradiance (I)
- Fixed pressure and wind speed (convective cooling)
- One thermistor is exposed to the lamp, one is not



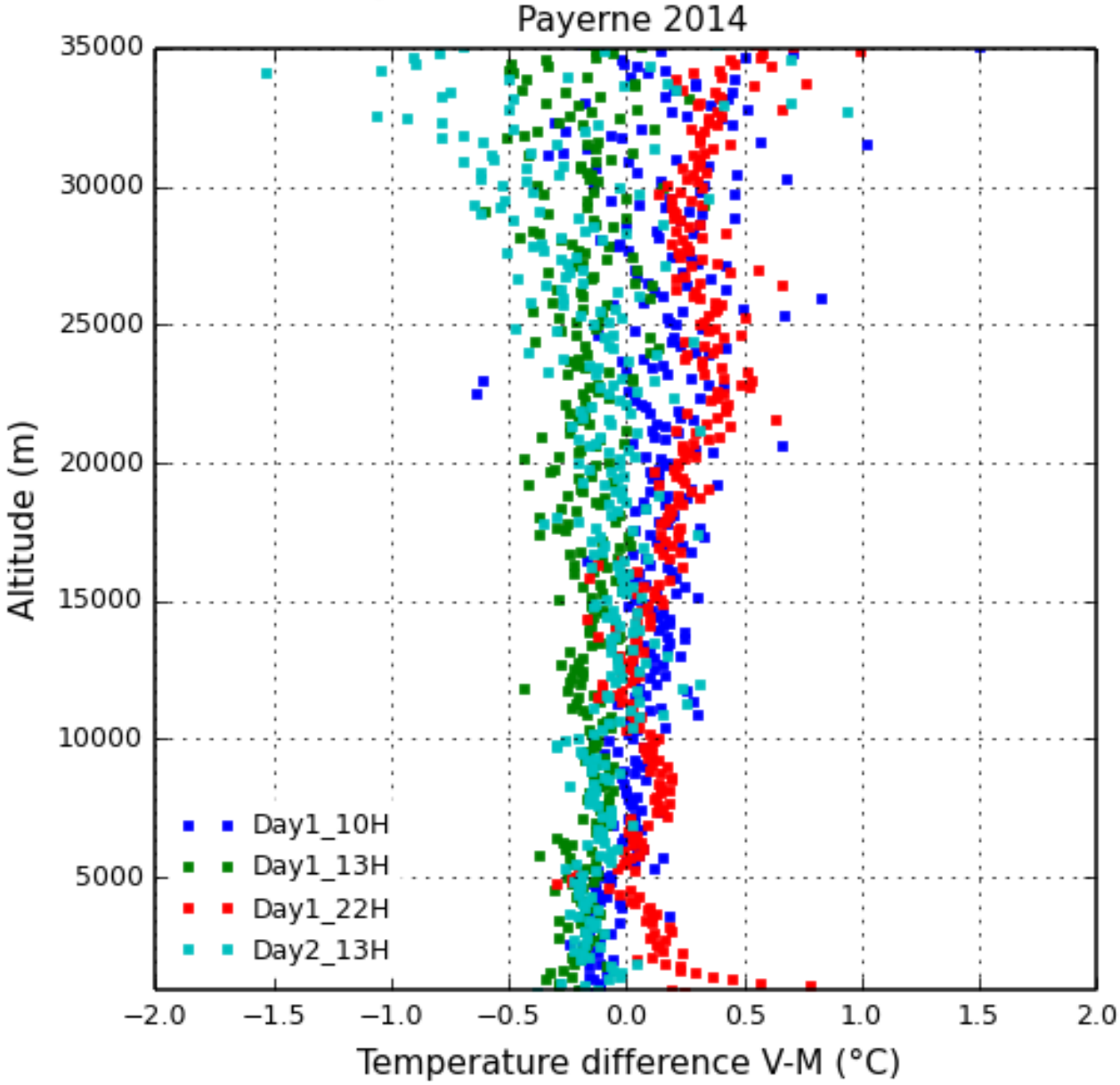
Dirksen "linear" correction: $\Delta T = a * \frac{I}{\sqrt{P*v}}$

(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



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GRUAN M10 ground-check

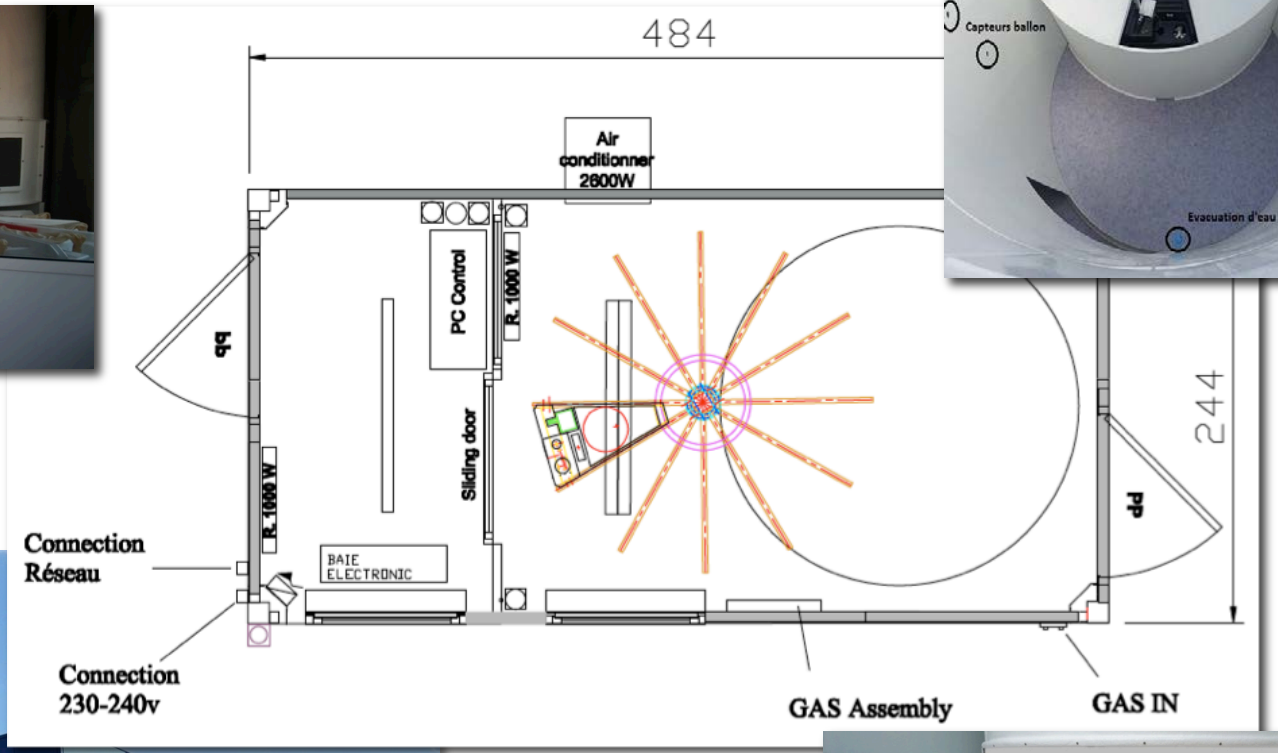
2-step ground-check (about 10 min per sonde):

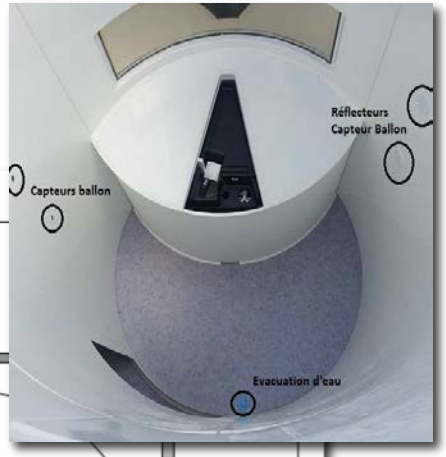
Comparison with calibrated temperature and RH sensors in ventilated hut – ambient conditions

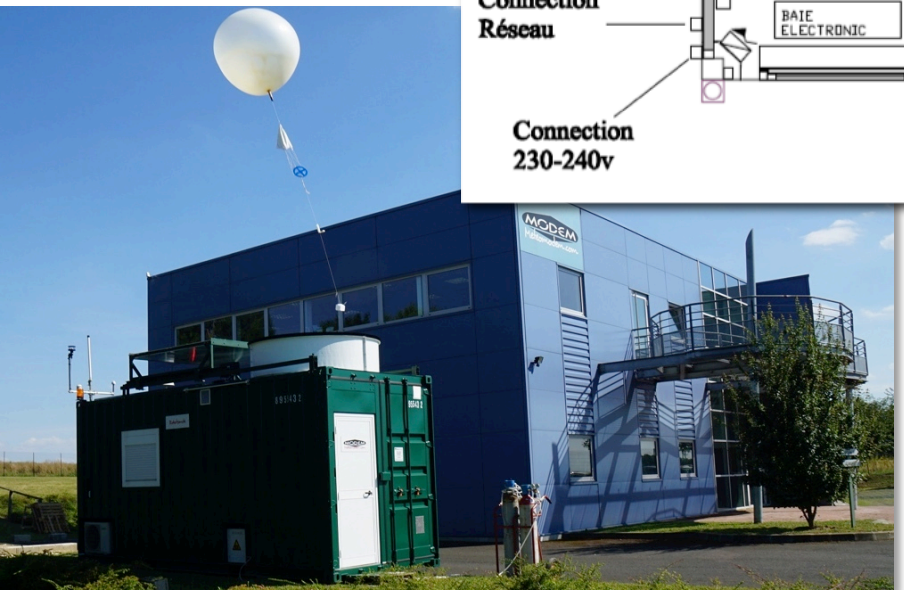
RH measurement in saturated environment using SPRH100

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 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 to IPSL (independent from
- 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. AMT 2015. In prep.*

2015 - 2016 Activities

2015

- Deployment of Robotsonde at Trappes station (spring)
- Finalize procedures for ground-check, data processing and transfer through RS Launch
- Prepare for GRUAN certification (finalize uncertainty estimates)

2016

- 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: fall 2016

Further inter-comparisons and tests

- April 2015 – La Réunion: MORGANE (NDACC/NASA) field experiment including H2O Lidar, RS92, M10, CFH sondes
- Summer 2015 – Paris: operate H2O-aerosol-cloud mw Raman Lidar at SIRTA, intercomparisons with M10 radiosondes.

Worldwide impact of M10 GRUAN investigations

MODEM
Meteomodem.com

Upper-air operational stations

40 000 profiles per year

Acknowledgments

The French GRUAN discussion group

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European partners

- **Meteoswiss:** R. Philipona, G. Levrat, G. Romanens
- **DWD:** H. Vömel, R. Dirksen, M. Sommer, T. Naebert

QUESTIONS OR COMMENTS ?