Preparatory work for the Modem radiosonde by the French GRUAN working group

Contributions to French GRUAN discussion group

- **IPSL/CNRS-INSU:** M. Haeffelin, D. Dionisi, JC. Dupont, MC. Gonthier, P. Keckhut
- **Université La Réunion/CNRS:** F. Posny, J.P. Cammas, V. Duflot, S. Evan, J. Leclair-de-bellevue, J.M. Metzger, H. Vérèmes
- **Météo-France:** F. Besson, F. Marin, J. Parent-du-chatelet, M-G. Renaudin, F. Zanghi
- **MODEM:** P. Charpentier, C. Raux, S. Mesmin, B. Charpentier
- **OPGC:** J-L. Baray
- **Meteoswiss:** R. Philipona, G. Levrat, G. Romanens
- **DWD:** H. Vömel, R. Dirksen, M. Sommer, T. Naebert

GRUAN ICM6 – Washington DC – 10-14 March 2014

Outline

- March 2013 - February 2014 activities
  - MALICCA RS + Lidar intercomparison (Maïdo): April 2013
  - Payerne RS intercomparisons and tests: Sept 2013
  - Lindenberg M10 tests (radiation pot and salt pots): Nov 2013
  - M10 tests performed by MODEM: continuously
  - Temperature corrections and uncertainties
  - Relative Humidity corrections and uncertainties
- Proposed activities 2014-2015

What does preparatory work include ?

1. Document thoroughly the radiosonde sensors operation
2. Document thoroughly of sensor calibrations
3. Document thoroughly data processing to convert raw data into geophysical parameter

→ 1 document for Temperature measurements

→ 1 document for Relative Humidity measurements

4. Study and understand effects and conditions that impact temperature and relative humidity measurements (effects of radiation, ventilation, temperature, pressure, …)
5. Perform tests to quantify these effects, and analyze data
6. Identify uncertainty sources and quantify them
7. Develop specific GRUAN code to
   - Introduce new corrections in data processing
   - Produce GRUAN M10 data files from M10 raw data

MALICCA (MAïdo LIdar Calibration CAmpaign)

Modem, Vaisala Radiosondes & Water Vapor Raman Lidar

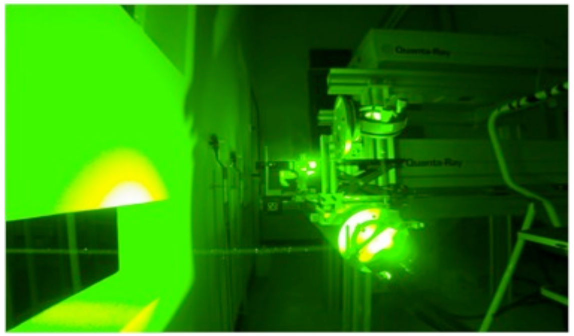
La Réunion (21°S, 55°E, 2155 masl) April 2-15 2013

Participants: F. Posny, J.L. Baray, J.P. Cammas, P. Hernandez, J.M. Metzger, H. Vérèmes (Univ. La Réunion); Y. Courcoux, D. Dionisi, P. Keckhut (IPSL)

April : transition period between wet and dry season

- 12 Modem M10 flights
- 10 Vaisala RS92 flights
- 35 hours 355-nm water vapor Raman lidar (quasi -stationary conditions)

- 4 dual RS92 + M10 flights w/ H20 lidar
  - 20130408 16h
  - 20130409 16h
  - 20130409 21h
  - 20130411 17h


Water vapor Raman lidar beam 1.2m diameter telescope, Dual Q-R laser Vaisala and Modem ground stations

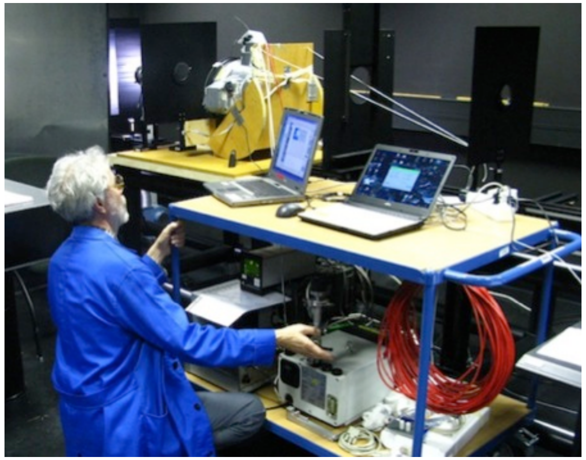
PAYERNE Radiosonde Intercomparisons (48°N)

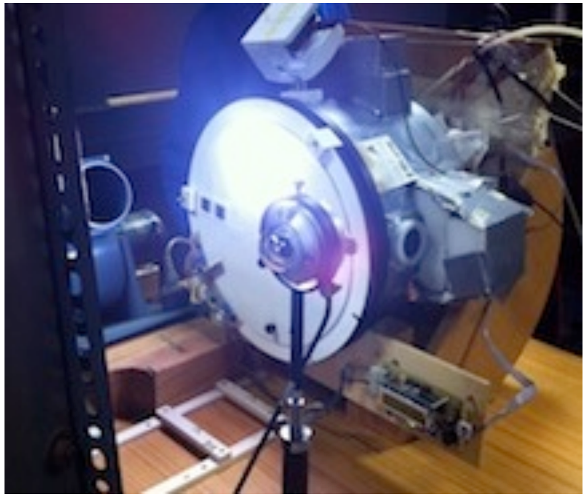
Modem, Meteolabor and Vaisala Radiosondes
Payerne (Switzerland) September 23-26 2013

▪**Participants:** R. Philipona, G. Levrat, G. Romanens (Meteoswiss); M. Haeffelin, JC. Dupont, MC. Gonthier, (IPSL); F. Zanghi (Meteo-France); P. Charpentier, S. Mesmin, B. Charpentier (Modem)

- Both moist and dry upper-tropo conditions
- 4 daytime flights (2xC34, 2xM10, 1xRS92)
  - 20130924 13h
  - 20130925 09h
  - 20130925 13h
  - 20130926 09h
- 2 nighttime flights (1xC34, 1xC34-SW, 2xM10, 1xRS92)
  - 20130924 21h
  - 20130925 21h

LINDENBERG Radiosonde Laboratory Tests





Modem & Vaisala Radiosondes

Lindenberg (Germany) November 20-22 2013

- **Participants:** H. Vömel, R. Dirksen, M. Sommer, T. Naebert (DWD); M. Haeffelin (IPSL); P. Charpentier (Modem)

- Test radiation and ventilation effects on Temperature measurements (M10+RS92)
  - Vacuum chamber, variable pressure and ventilation, 2500W radiation on/off
  - Pressure: 900, 300, 100, 30, 15, 10, 4 hPa. Ambient temperature
- Test Relative Humidity measurements in Salt solution chambers
  - 0% (molecular sieve), 11%, 33%, 75% to 100% RH and down.
  - Ambient temperature

Temperature corrections and uncertainties

Principle:

- PB5-41E-K1 thermistor manufactured by Shibaura Thermistor (Japan).
- Electronic circuit: 3 measurement ranges
- Voltage across the thermistor is measured by a Texas Instrument MSP430 microcontroller

Calibration:

- Low tolerance thermistor calibrated at room temperature + standard calibration curve

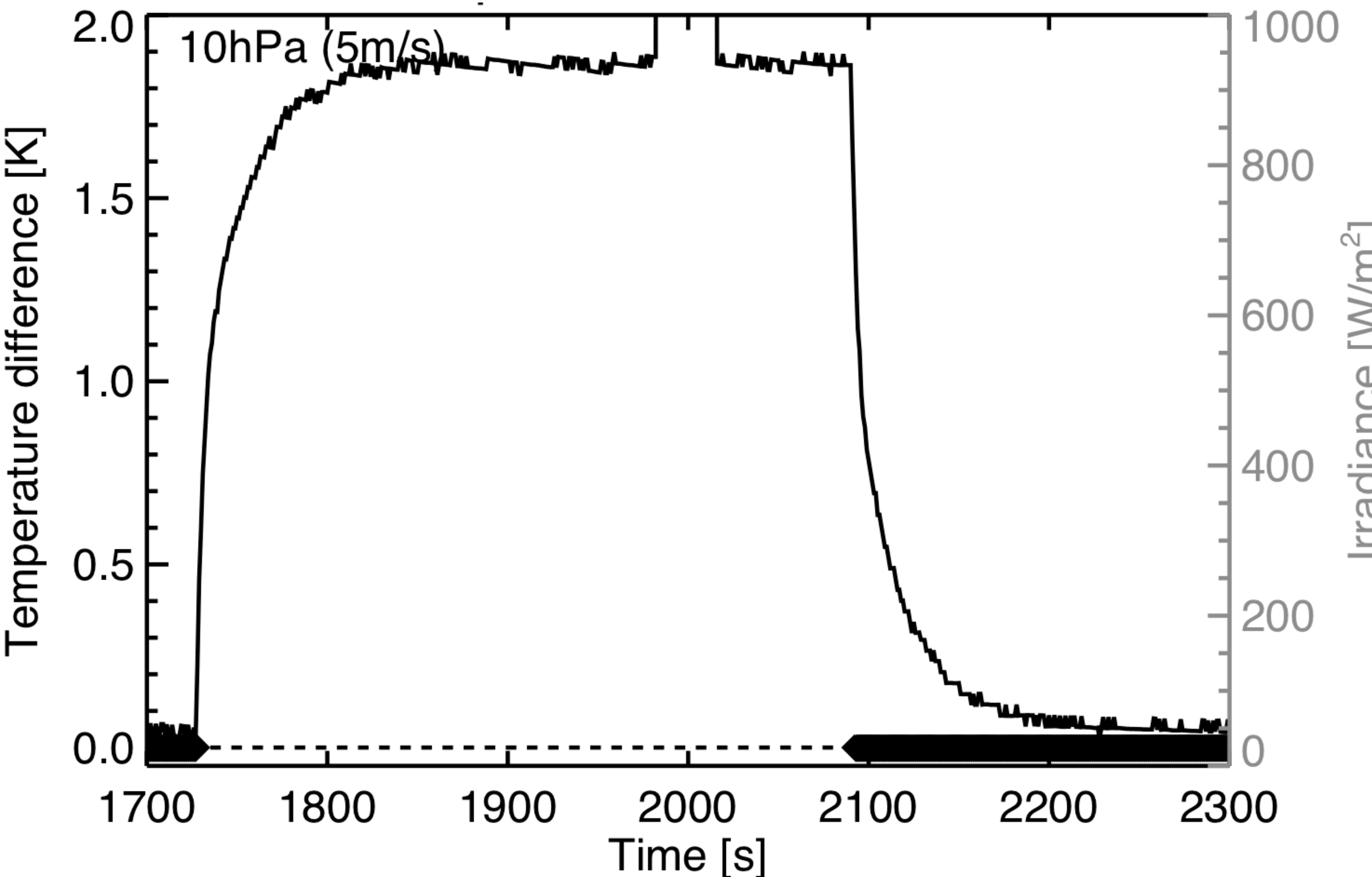
Corrections:

- Radiation balance on the sensor:
  - incoming solar radiation, I, absorbed by the sensor,
  - convective cooling proportional to atmospheric pressure and wind speed
  - conduction of heat through the wires that connect the sensor
- Radiation correction: $\Delta T \; \alpha \; I / (p.v)^{0.5}$ (Dirksen; Luers et al. (1998))

M10

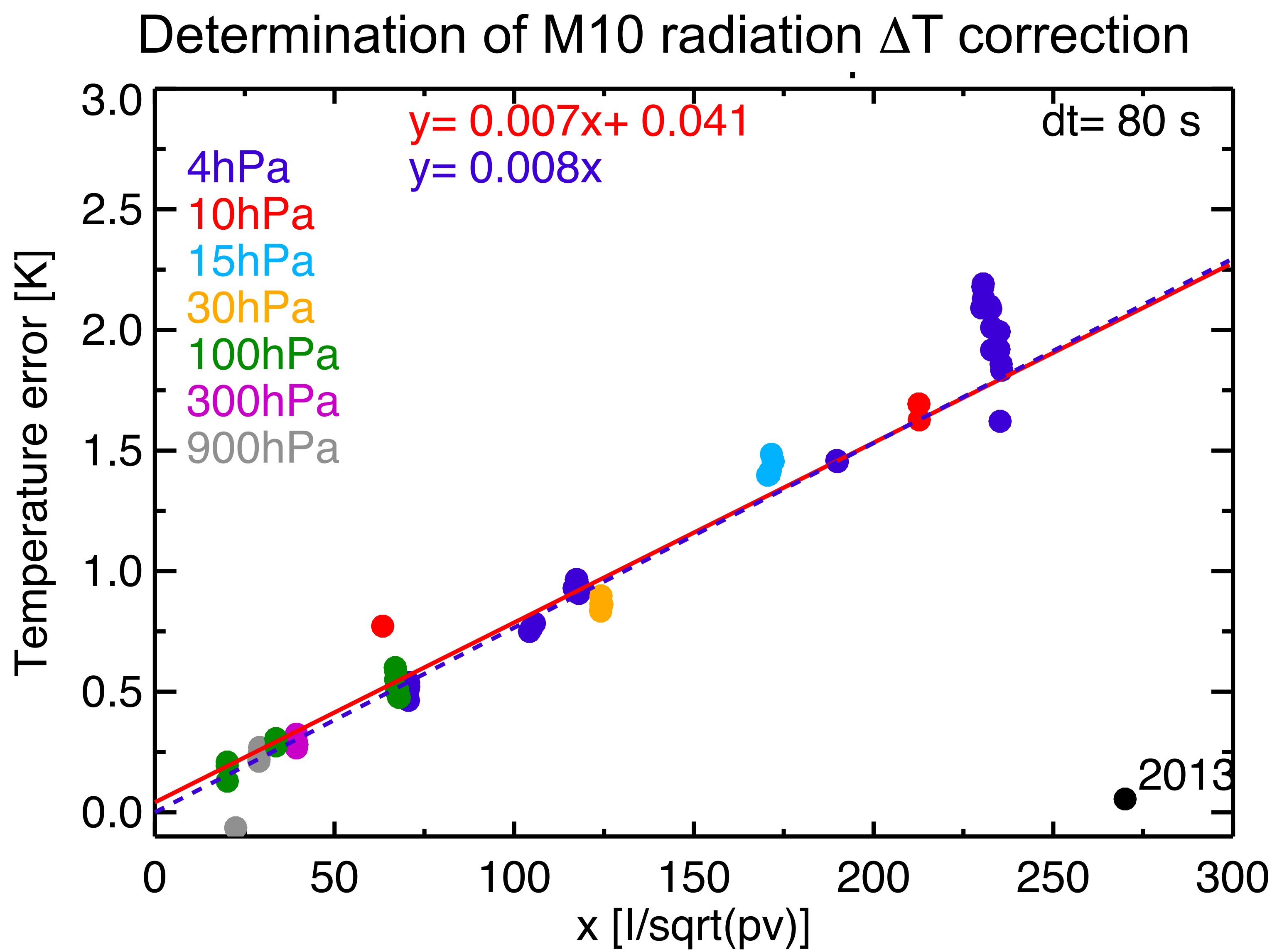
Temperature corrections and uncertainties

Determination of M10 radiation ΔT at 10hPa, 5m/s, 1800W/m2



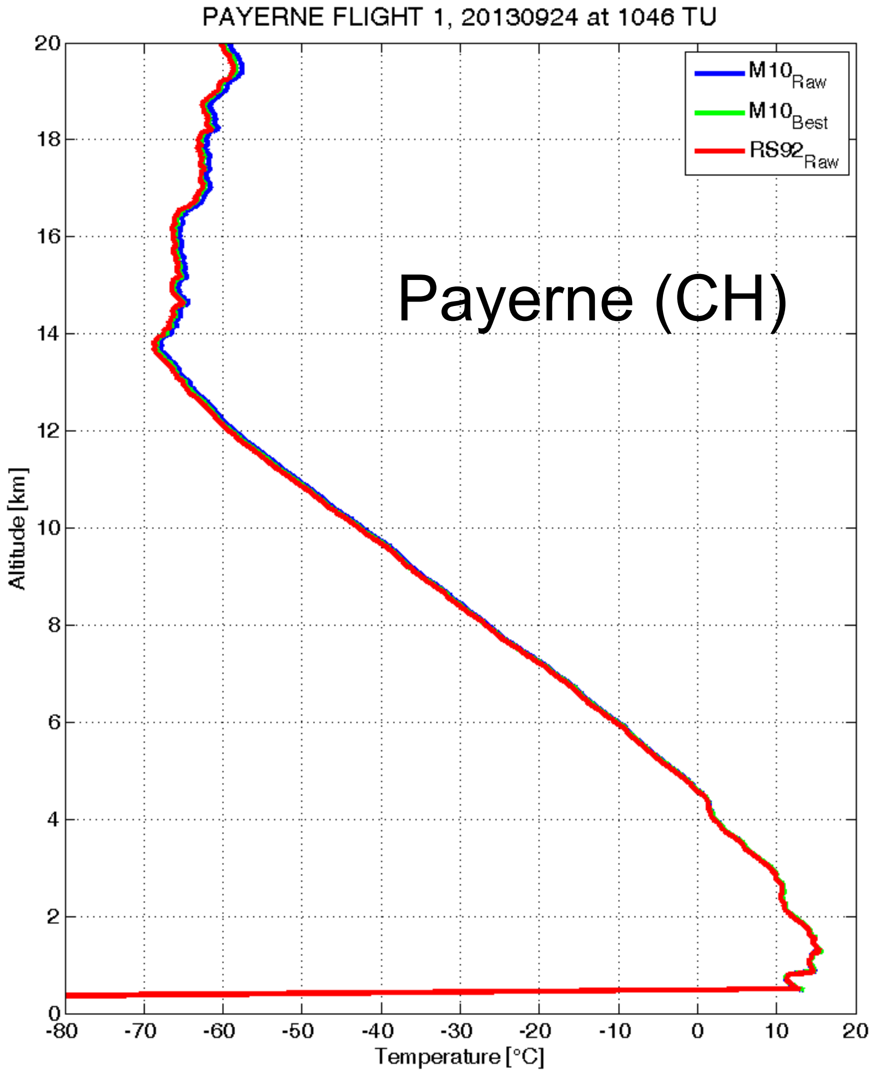
Fast response (3s): radiation on thermistor. Slow response (90s) heating of thermistor by the frame

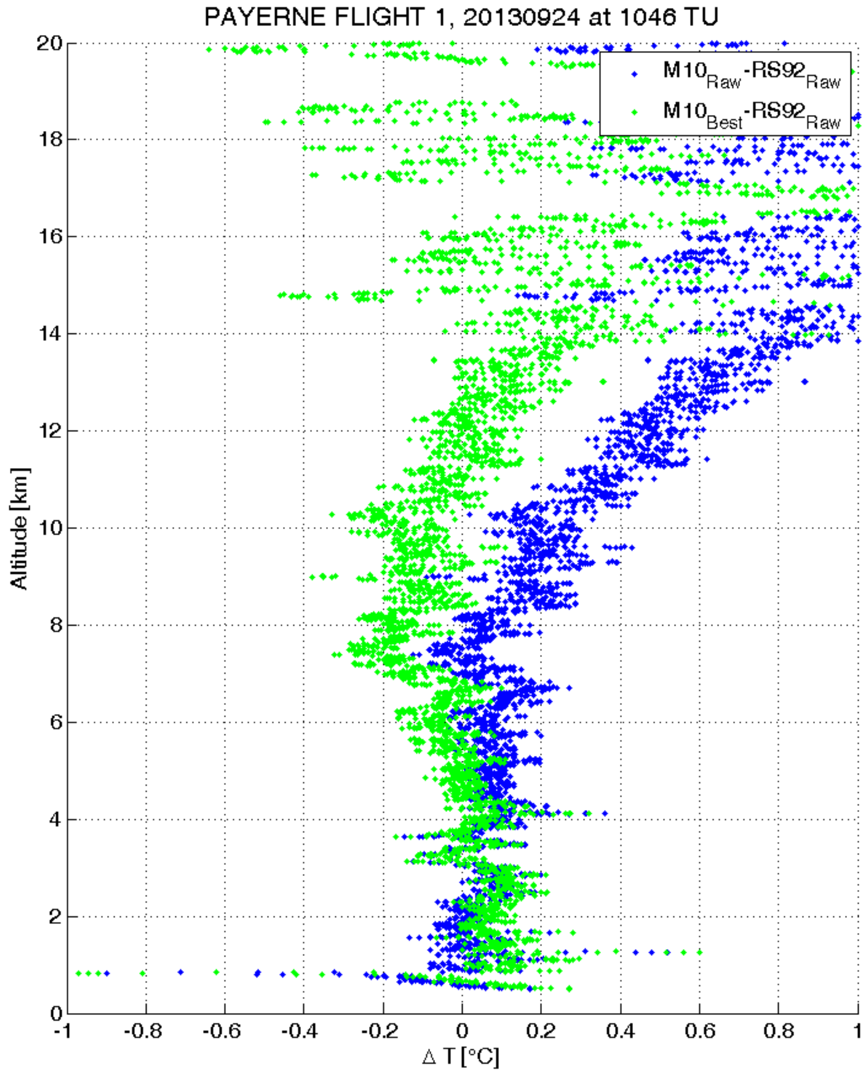
Temperature corrections and uncertainties



Behavior follows $\Delta T \propto I / (p.v)^{0.5}$ law proposed by Dirksen

Temperature corrections and uncertainties

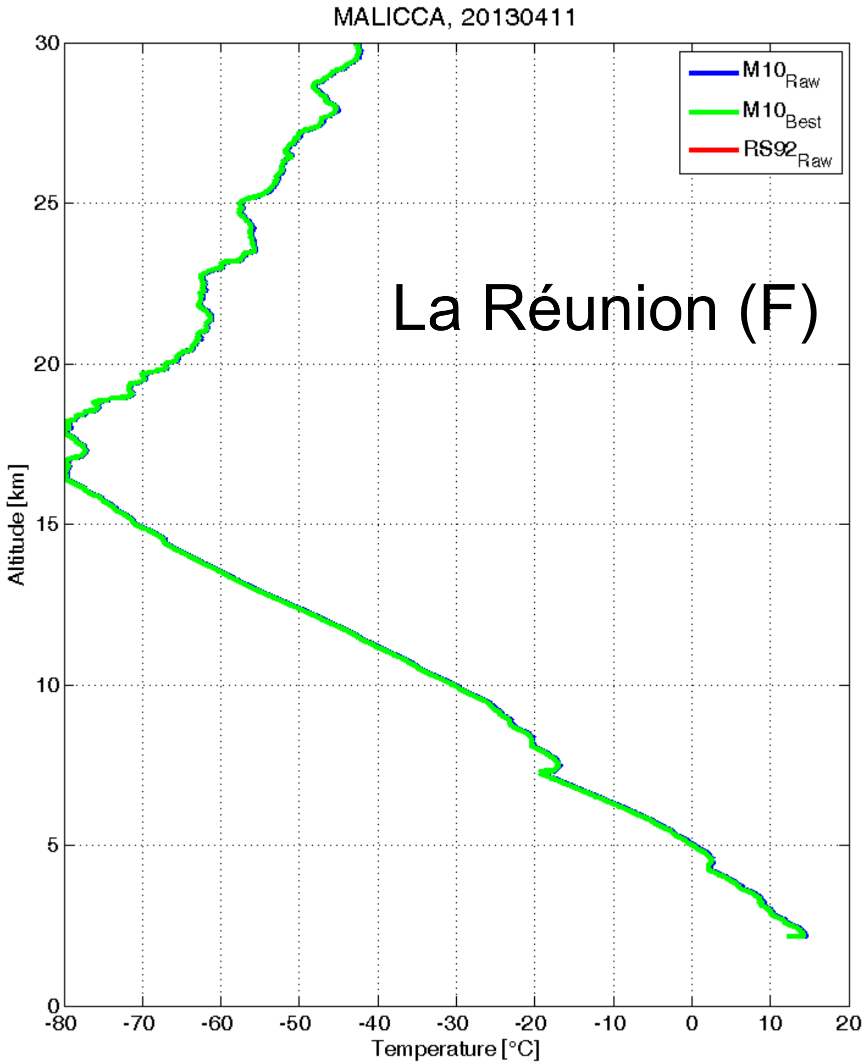


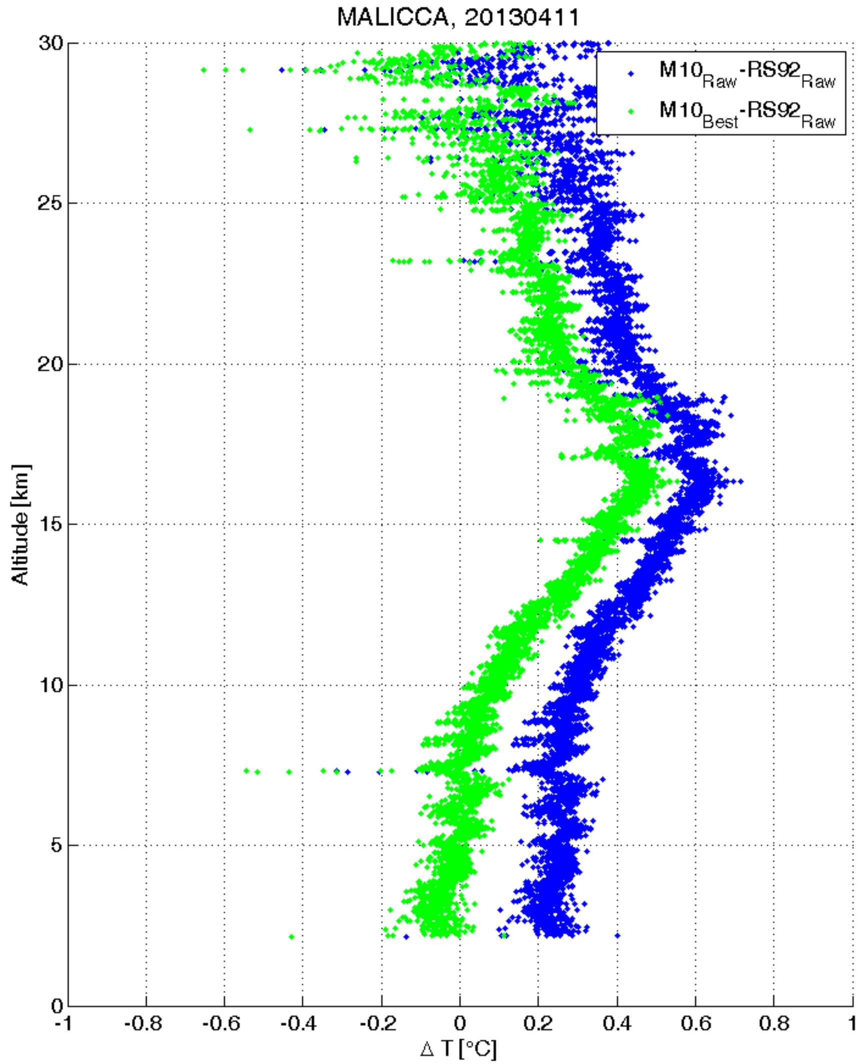


Troposphere (T> -50°C): Bias < 0.2°C

Stratosphere (T < -60°C): Bias ≈ 0.3-0.4°C

Temperature corrections and uncertainties



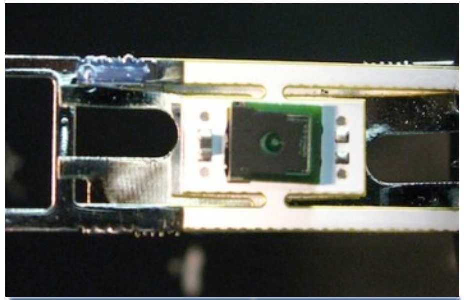


Next:

- Implement new radiative correction
- Perform statistics on all dual sonde profiles

Relative Humidity corrections and uncertainties

Principle
- Capacitor manufactured by UPSI (France)
- Oscillation frequency of the sensor is measured by a microcontroller



Calibration:
- Oscillation frequency at 55% RH

M10

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

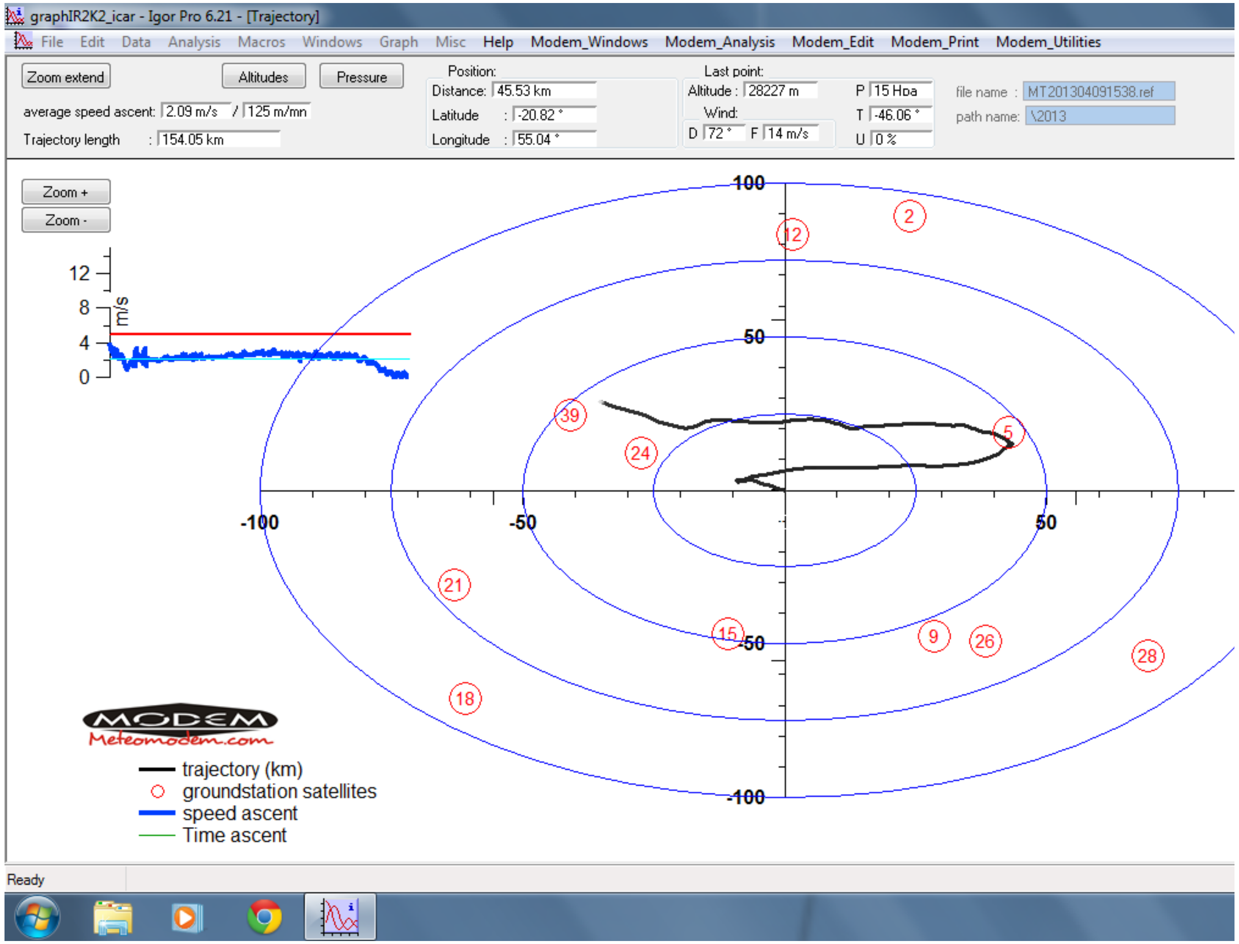
Relative Humidity corrections and uncertainties

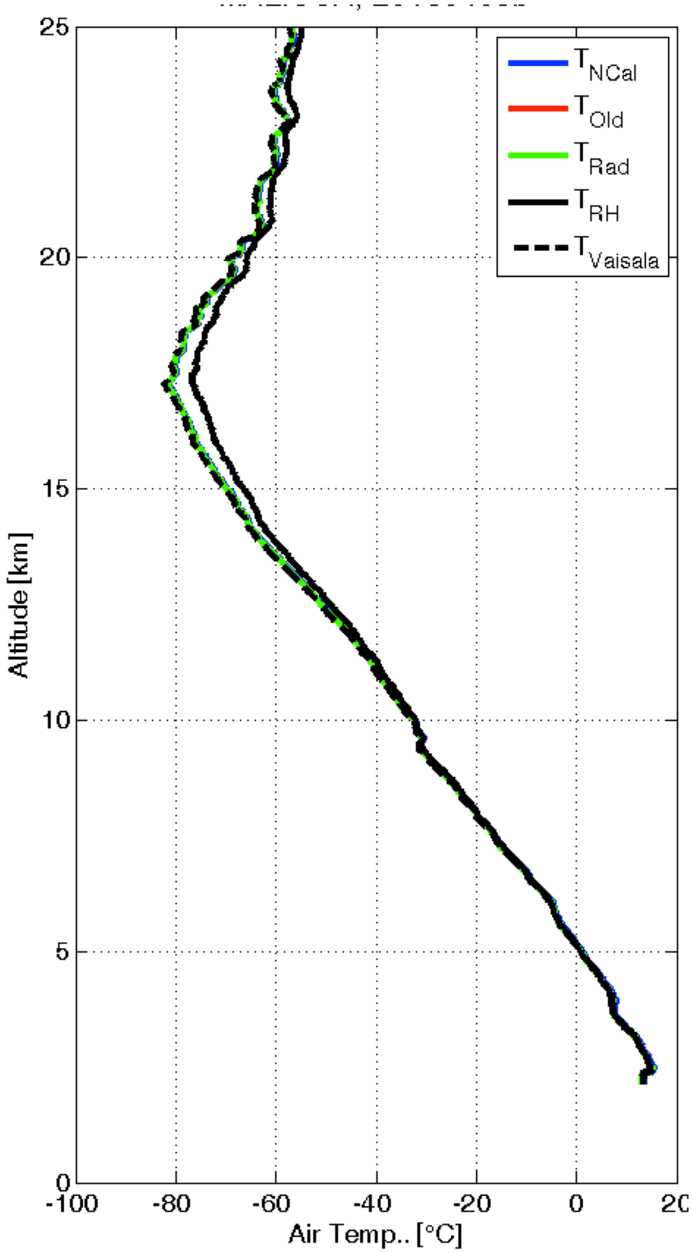
Corrections:

1. Capacitor frequency varies with temperature:
   - Laboratory characterized by UPSI
2. Diffusion of air molecules into the capacitor (issue near 0% and 100% RH)
   - Accounted for by modified HR-frequency polynomial
   - Tests in Lindenberg salt solutions shows that a better correction is necessary
3. 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 → x 1.05 – 2.00
   - Further tests would be useful
4. Time response of capacitor which is temperature dependent
   - Determination of time constant: 18s at -40°C; 90s at -60°C; 280s at -80°C using upward and downward data at tropopause

Relative Humidity corrections and uncertainties

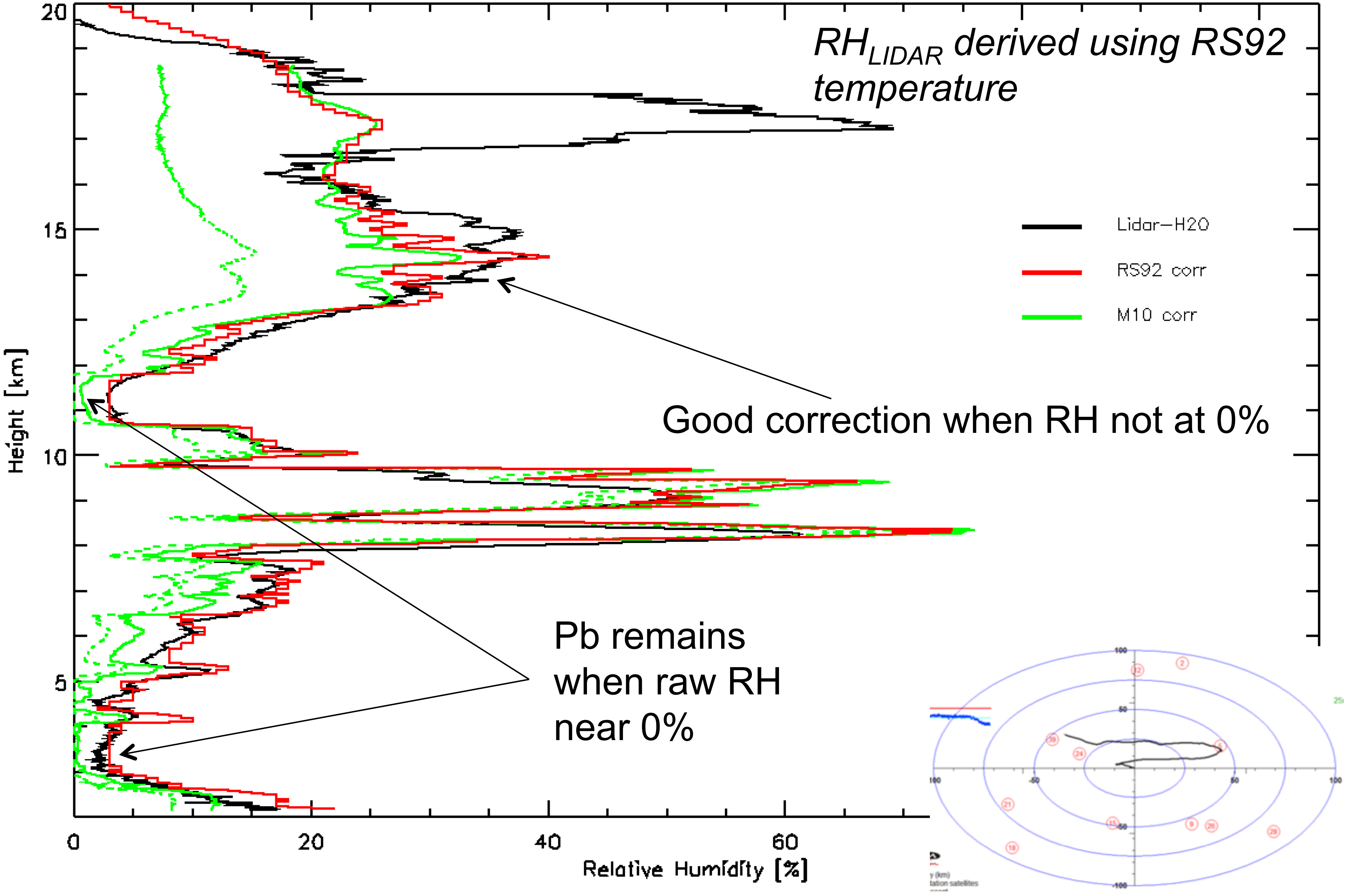
20130409 16h case





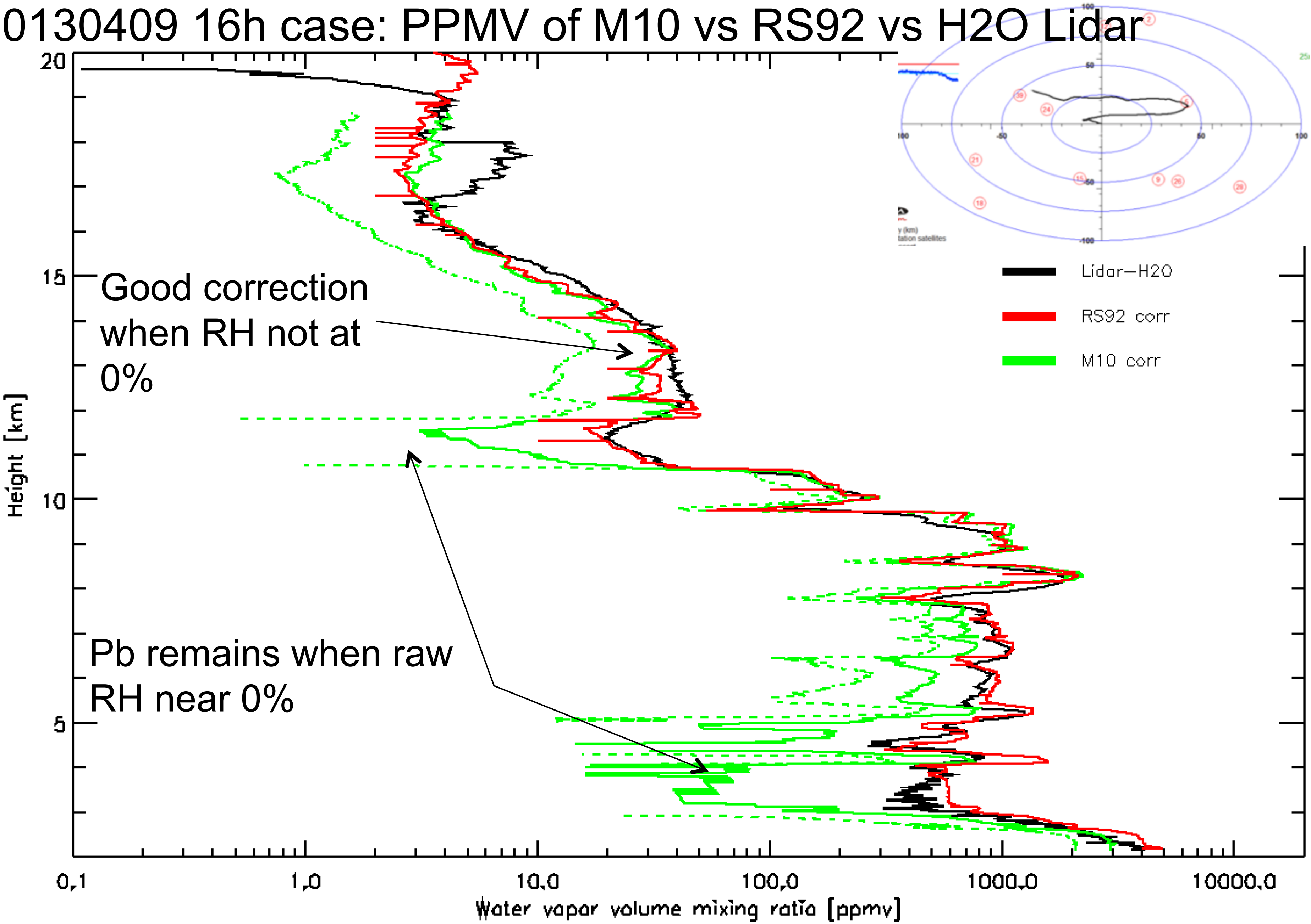
Relative Humidity corrections and uncertainties

20130409 16h case: RH of M10 vs RS92 vs H2O Lidar



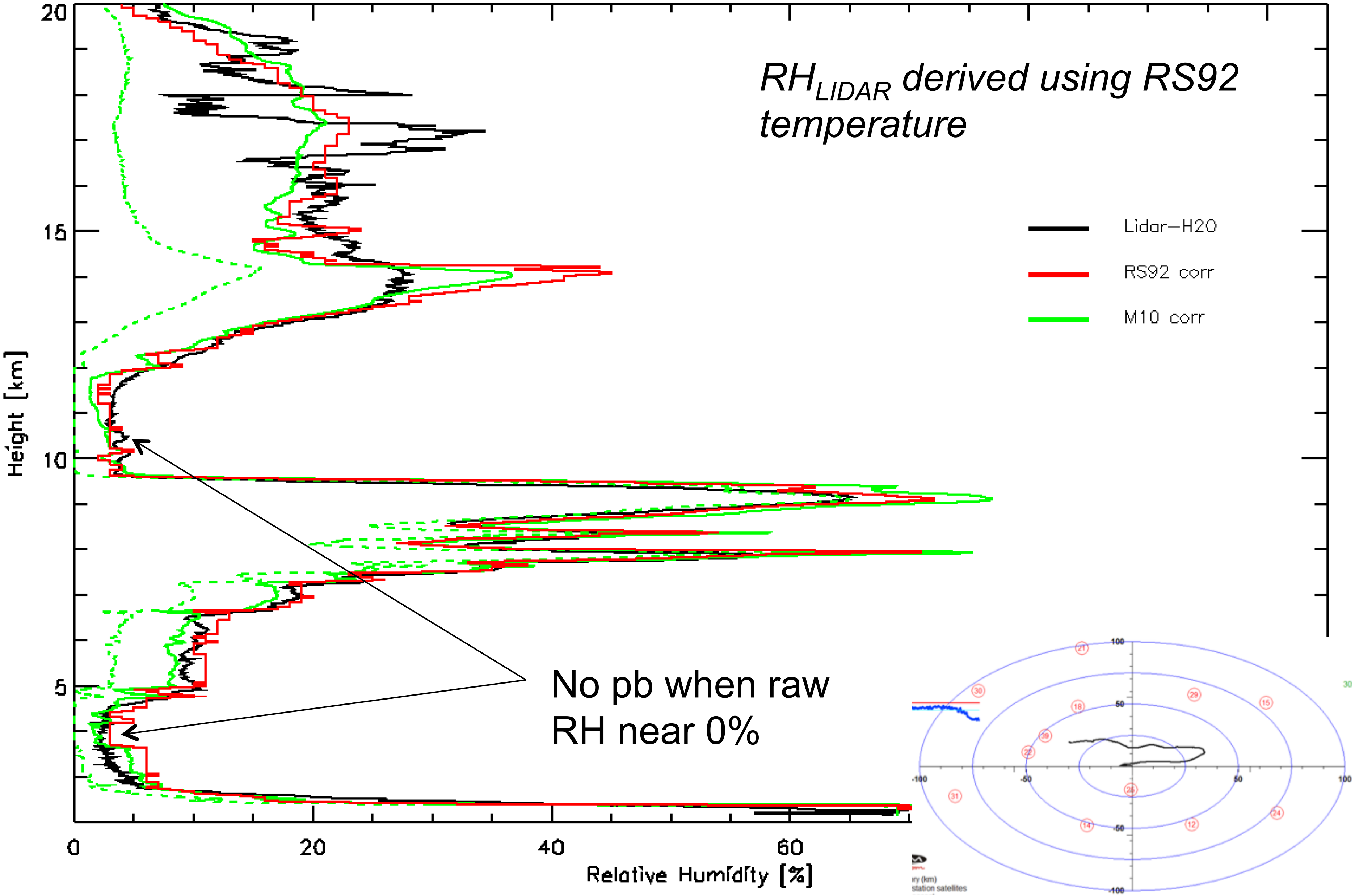
Relative Humidity corrections and uncertainties

20130409 16h case: PPMV of M10 vs RS92 vs H2O Lidar



Relative Humidity corrections and uncertainties

20130409 21h case: RH of M10 vs RS92 vs H_2O Lidar

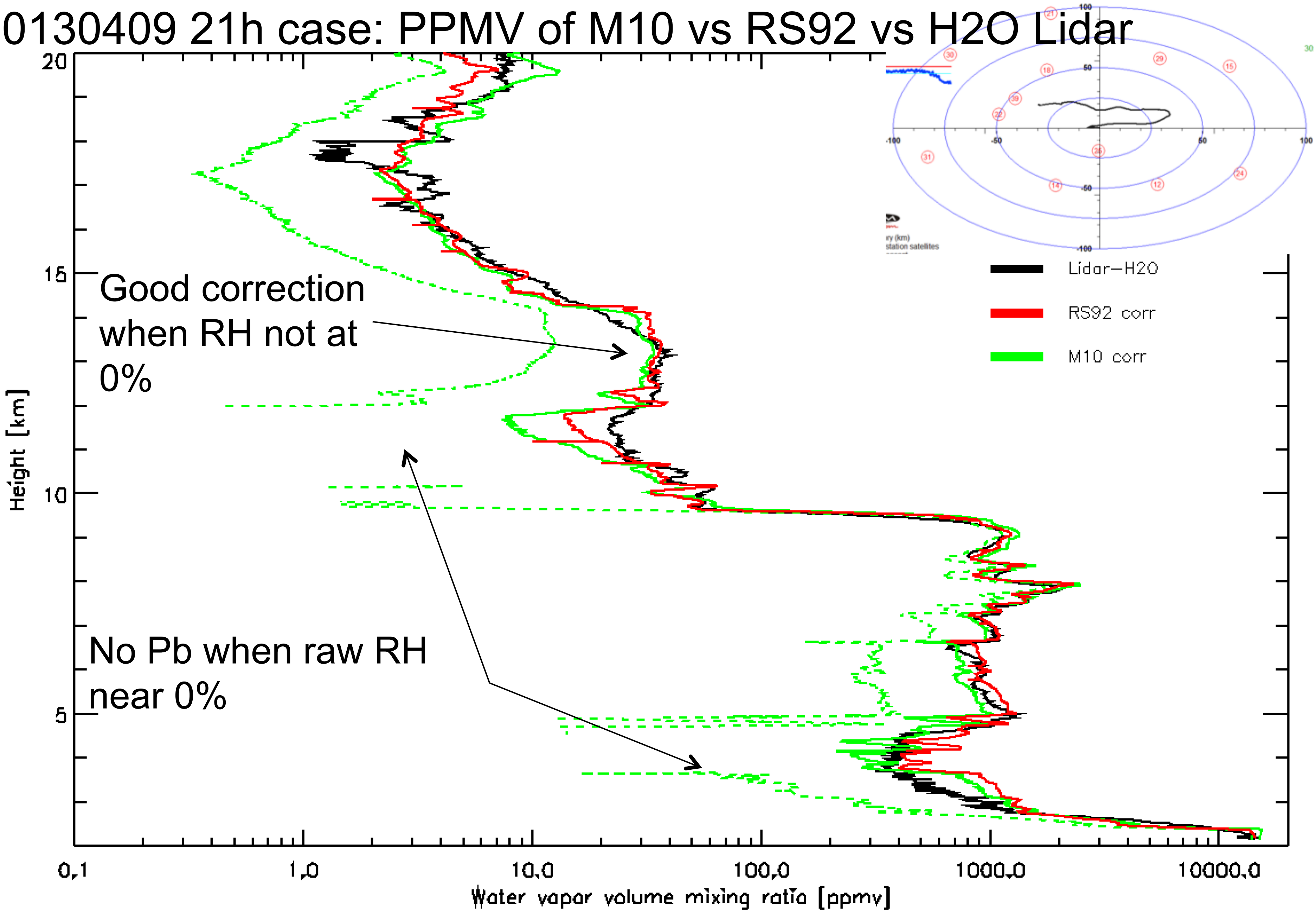


RH_{LIDAR} derived using RS92 temperature

No pb when raw RH near 0%

Relative Humidity corrections and uncertainties

20130409 21h case: PPMV of M10 vs RS92 vs H2O Lidar



Remaining M10 assessment steps ?

1. Derive Temperature measurement uncertainties
2. Derive Relative Humidity measurement uncertainties
3. Finalize M10 GRUAN processing code
4. Documentation
5. Publication (AMT end 2014 submission)

Further inter-comparison campaigns and tests:

- Spring 2014 – Lindenberg : further T and RH tests in low pressure chamber
- June 2014 – La Réunion: NASA field experiment including H2O Lidar, RS92 and M10 sondes
- June 2014 – Payerne: M10, RS92, C34 and SW

2014 - 2015 Activities

- Develop code to collect MODEM M10 Meta-data
- Develop procedure for data transfer with RS Launch
- Test GRUAN ground-check procedures at Météo-France

2014

- Implement GRUAN procedures at SIRTA based on daily M-F Robotsonde M10 radiosonde
- Implement GRUAN procedures at La Réunion based on weekly U. Réunion M10 radiosonde
- Deploy H2O-aerosol-cloud mw Raman Lidar at SIRTA
- Implement submission to LC
- Go through GRUAN certification

2015

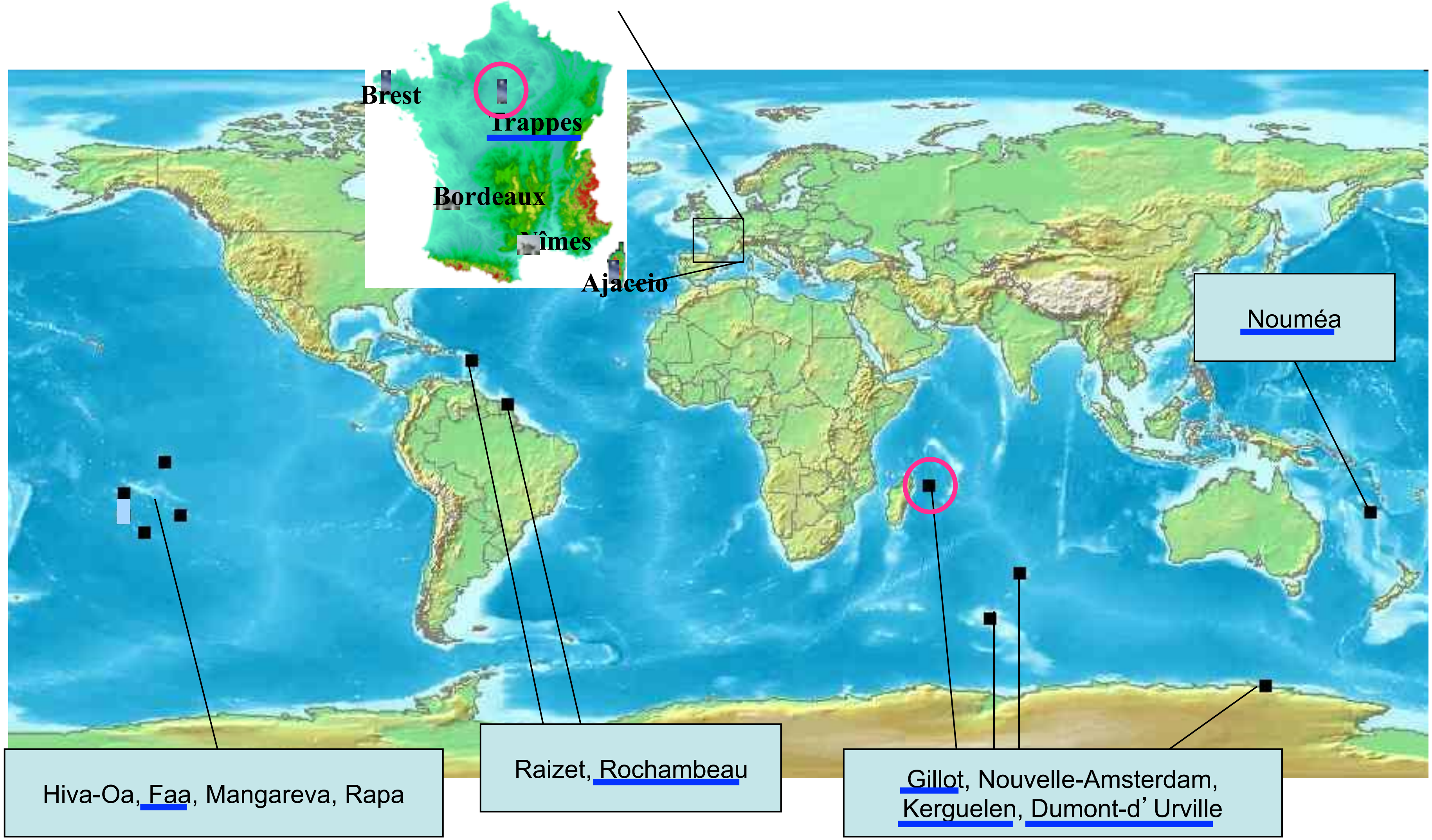
Conclusions

- Achieved significant progress in M10 sonde performance
- Established fruitful collaboration between French Universities, Météo-France and MODEM. And with Meteoswiss.
- Received great support from GRUAN Lead Center
- M10 profiles and Lidar measurements funded by national programs

Main difficulties

- Extra activities rely on unfunded work
- Implementation of GRUAN procedures at Météo-France highly constrained by operational considerations
- Implementation of GRUAN procedure at La Réunion highly constrained by budget issues (no funding for regular dual RS or for CFH profiles)

French Operational Radiosonde Network



METEO FRANCE
Toujours un temps d'avance

operates surface and upper air operational (24/7) networks including 15 radiosonde sites around the world (~24 sondes per day: > 8500 sondes/yr)

QUESTIONS OR COMMENTS ?