What final GRUAN observations may consist of and look like

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Overview

- Motivation
- Measurement uncertainties
- What reference data may look like

Measured quantities

What GRUAN wants to measure:

- **Temperature**
- **Water Vapor**
- **Pressure**
- **Ozone**
- **Wind**
- **....**

Focus on temperature and water vapor

Principle should apply to all reference measurements

Temperature and water vapor

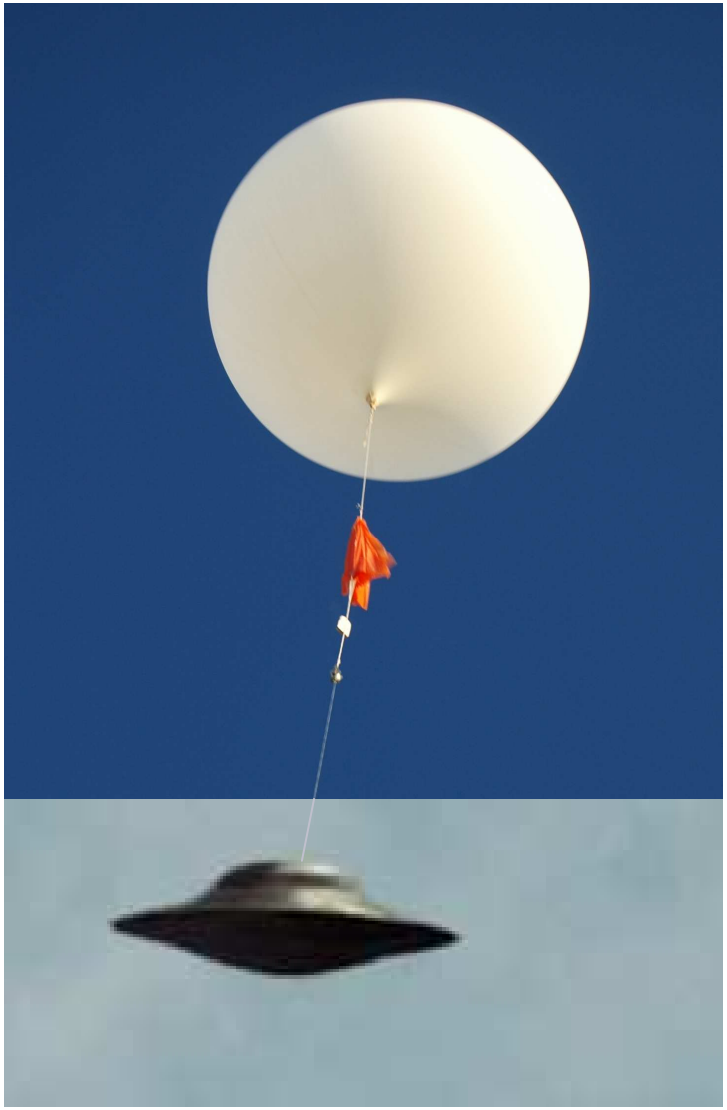
Accuracy requirement:

Water vapor:	**2%**
Temperature:	**0.1K (troposphere)**
	0.2K (stratosphere)

Long term stability:

Water vapor:	**1%**
Temperature:	**0.05K**

Reference radiosonde: Current status



Quality quantification

- Quality control fails,
  criteria are too stringent for the sensors we have

- Try quality quantification
  - Quantify how good sensors are
  - Quantify how good sensors are as function of altitude

Sources of uncertainty

- **Sensor calibration:**
  - Accuracy of calibration reference
  - Accuracy of calibration model, …..
- **Sensor integration:**
  - Integration into radiosonde
  - Telemetry limitations, …..
- **Sensor characterization:**
  - Time lag variation of polymer sensor
  - Controller stability of frostpoint hygrometer
  - Production variability , …..
- **External influences:**
  - Radiation error
  - Balloon contamination
  - Sensor icing , …..

GRUAN as reference

Distinguish between sources of uncertainty that:

- **Can be corrected**
  ➔ correct and quantify remaining uncertainty

- **Can not be corrected**
  ➔ flag as questionable

GRUAN as reference

GRUAN data (as Reference data) should:

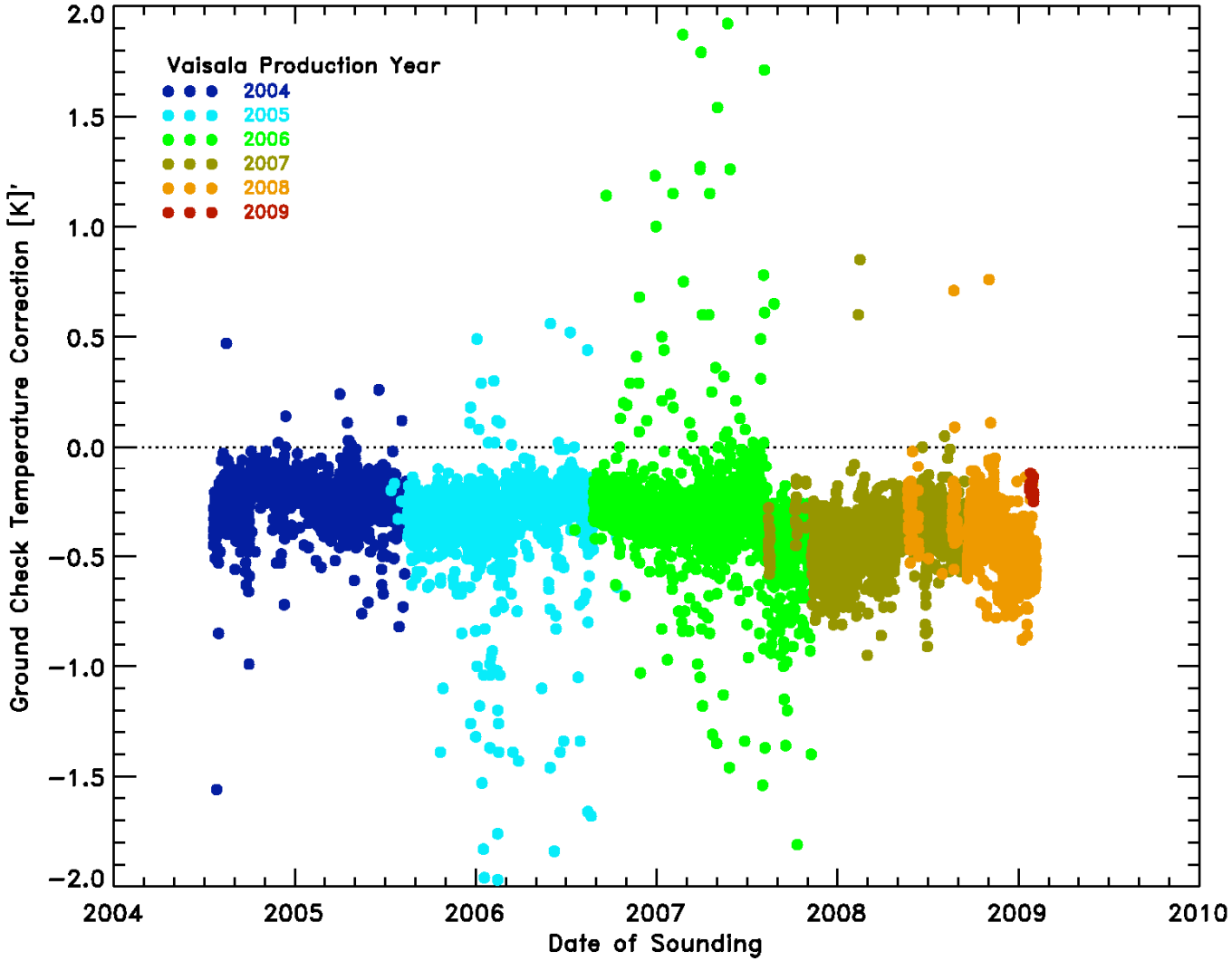
- **Capture and describe uncertainty**
- **Quantify uncertainty**
- **Test uncertainty where feasible**

Sources of uncertainty
Example : Temperature

	Vaisala RS92 daytime
Sensor calibration:	
Accuracy of calibration reference	0.01K (est.)
Accuracy of calibration model	0.01K (est.)
Sensor integration:	
Integration into radiosonde	? *
Telemetry limitations	-
Sensor characterization:	
Time lag variation of polymer sensor	
Controller stability of frostpoint hygrometer	
Production variability	
External influences:	
Radiation error	0.2 K * (strat.)
Balloon contamination	?
Sensor icing	>1.0K (temporarily)

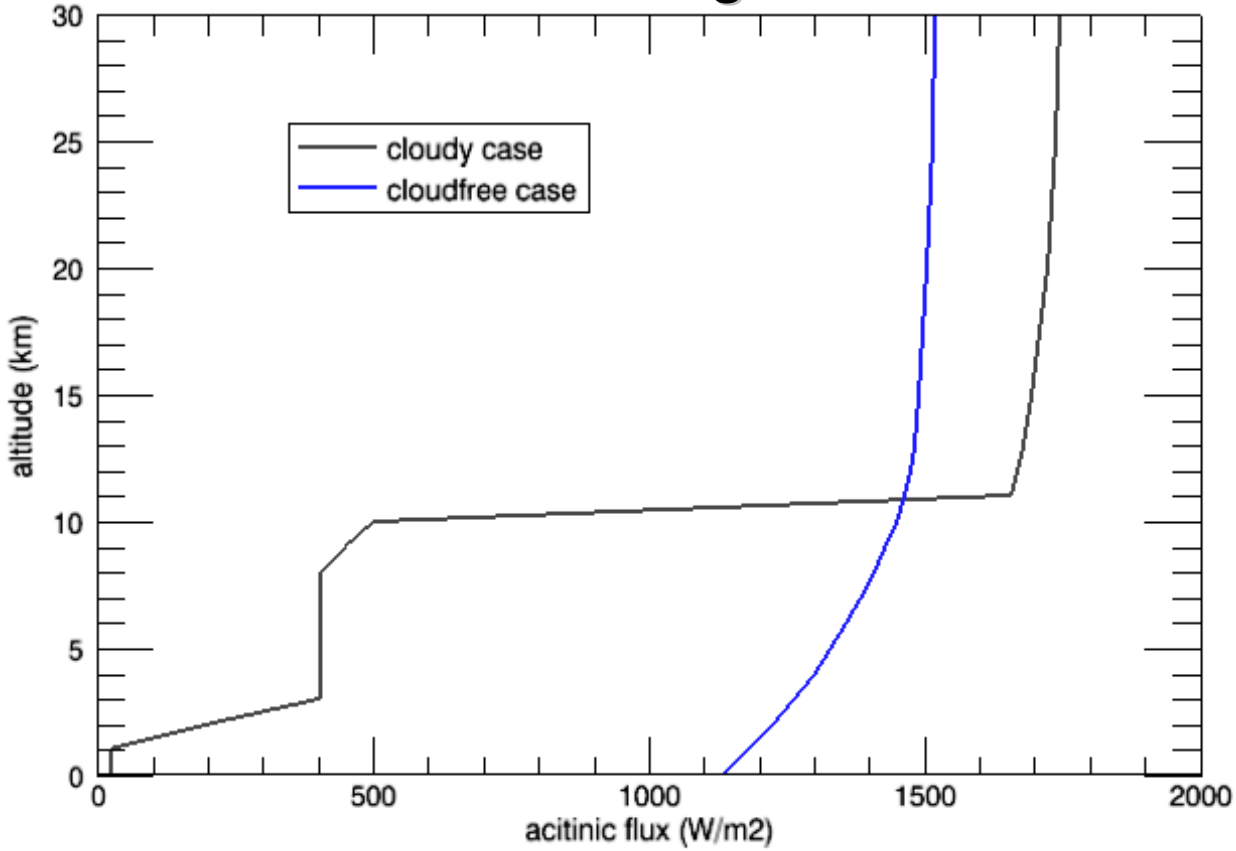
(* after correction is applied)

Temperature: Ground check



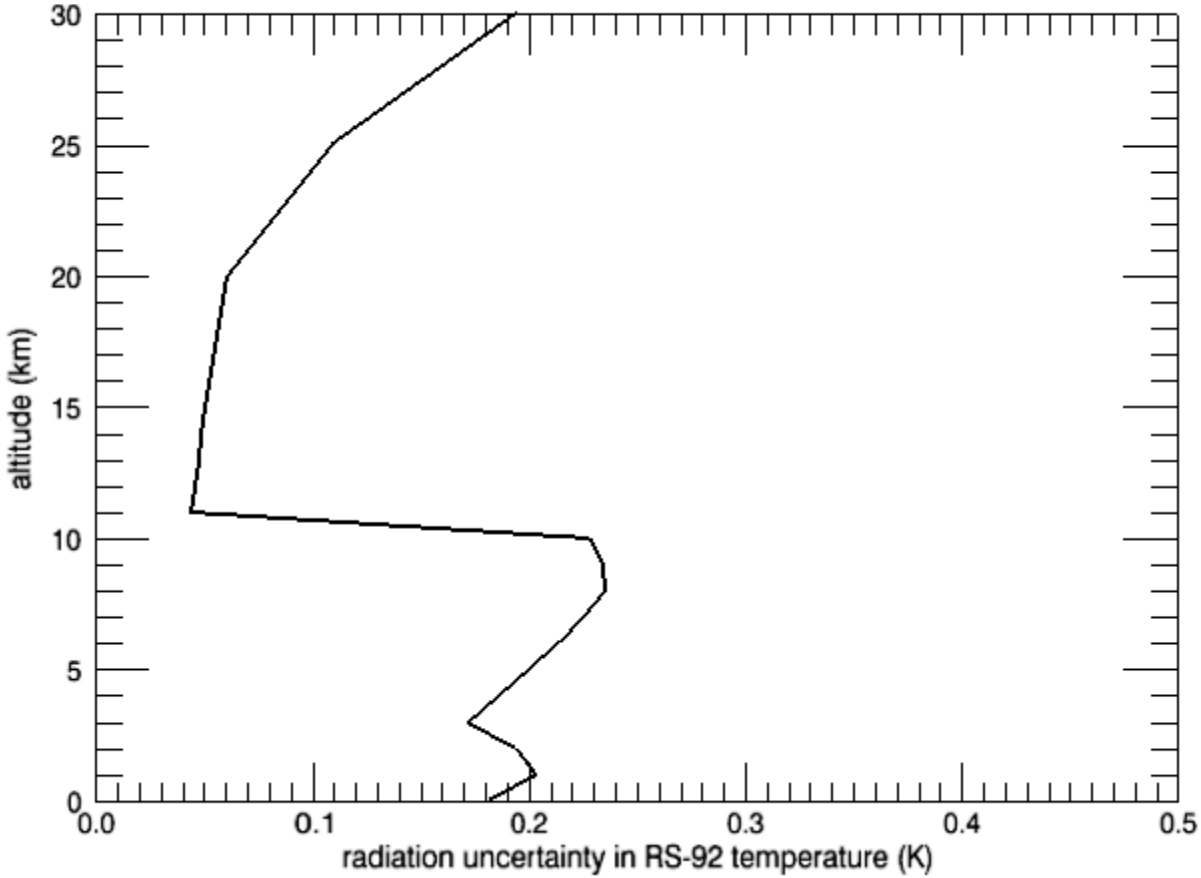
Temperature: Radiation effect

Actinic flux example: - Lindenberg (LUAMI)
- low level stratus
- high level cirrus



Temperature: Radiation uncertainty

Remaining uncertainty after radiation correction (Vaisala RS92 only)



Sources of uncertainty
Example: Humidity

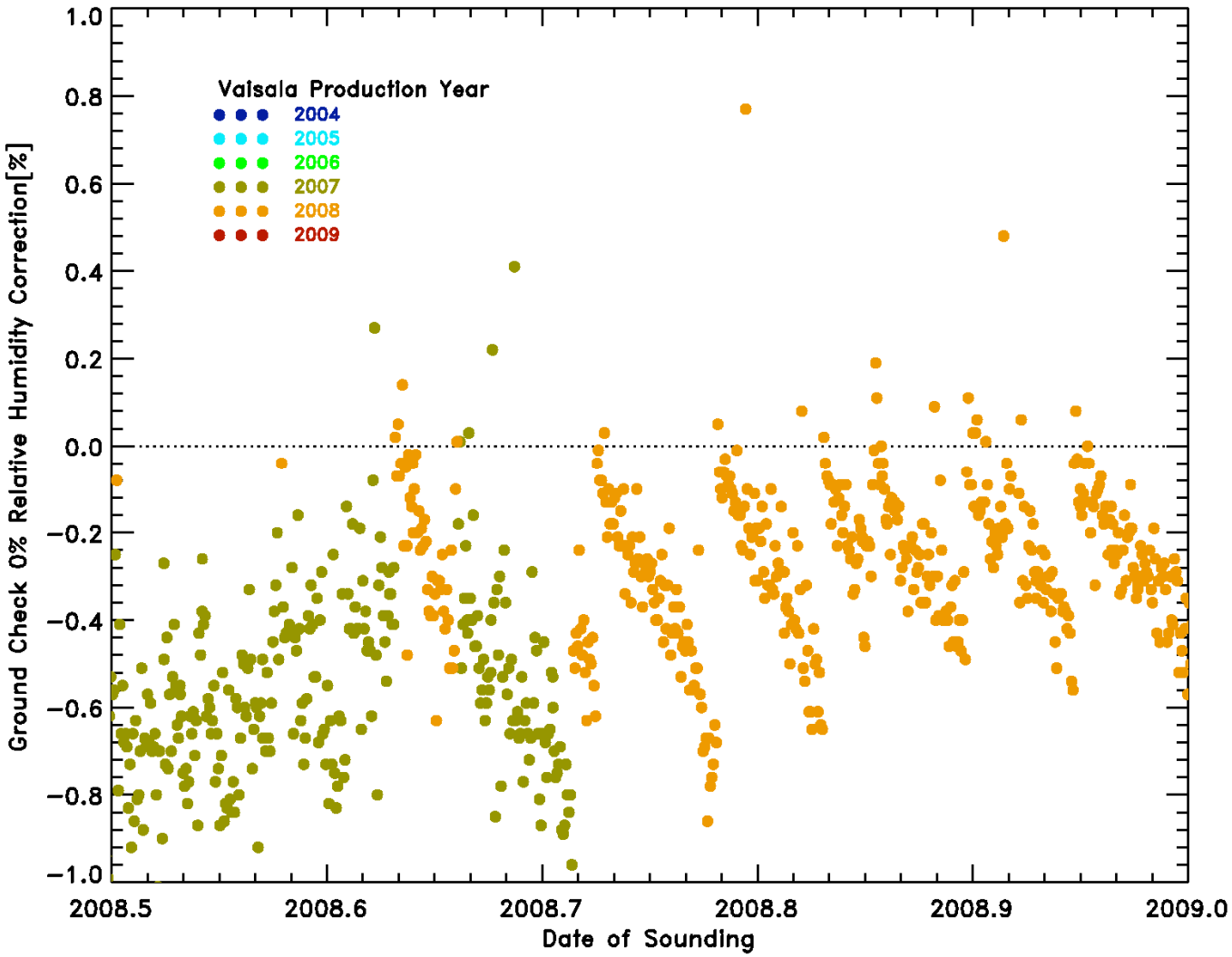
Vaisala RS92 daytime

- Sensor calibration:
  - Accuracy of calibration reference — **0.1% RH (est.)**
  - Accuracy of calibration model — **0.1% RH (est.)**
- Sensor integration:
  - Integration into radiosonde — **< 5% RH**
  - Telemetry limitations — **1% (default setting)**
- Sensor characterization:
  - Time lag variation of polymer sensor — **10% ?**
  - Controller stability of frostpoint hygrometer
  - Production variability
- External influences:
  - Radiation error — **> 40 % (rel. error)**
  - Balloon contamination — **? (troposphere)**
  - Sensor icing — **?**

(No correction are applied)

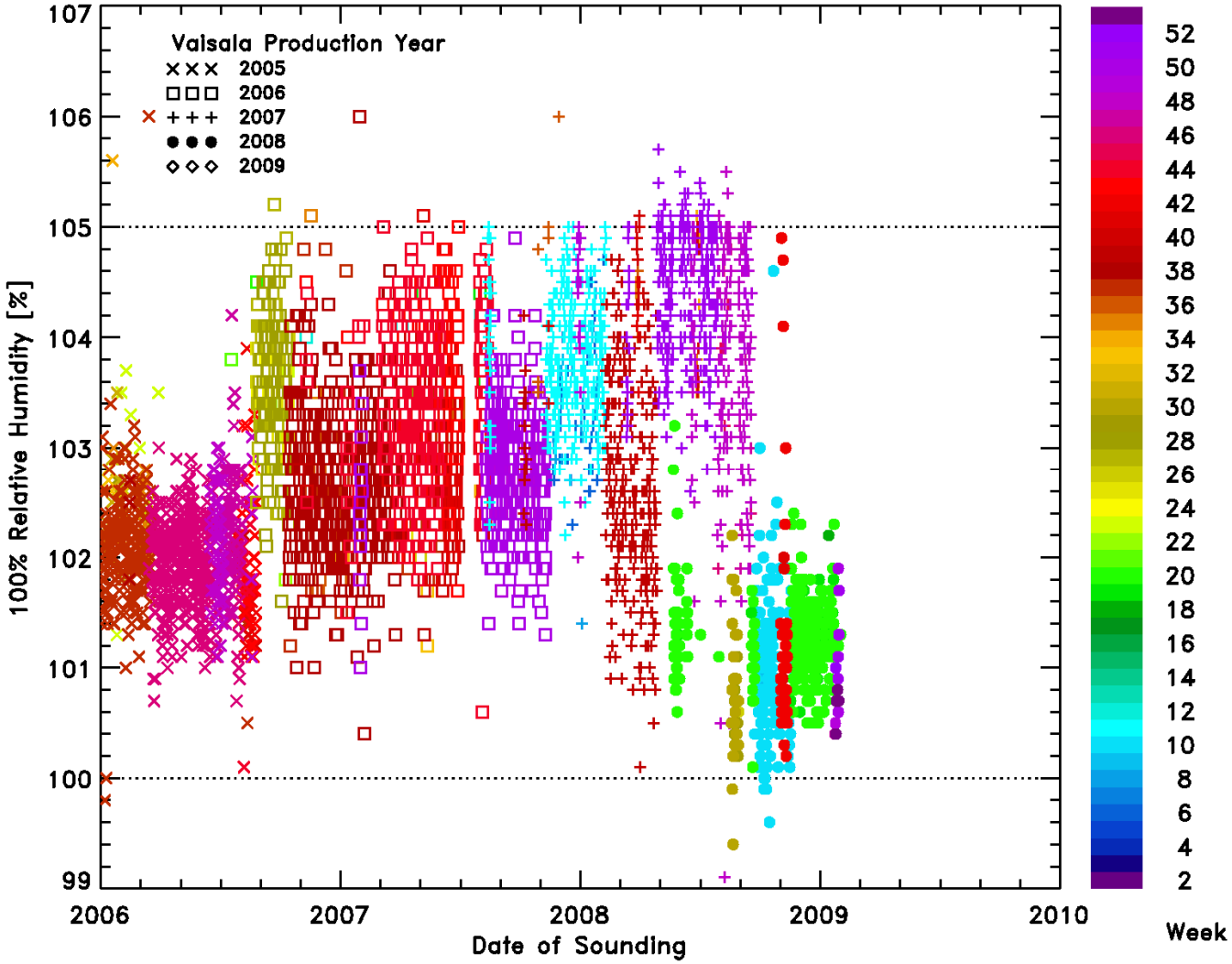
Example Humidity: Ground check 0%

0% check

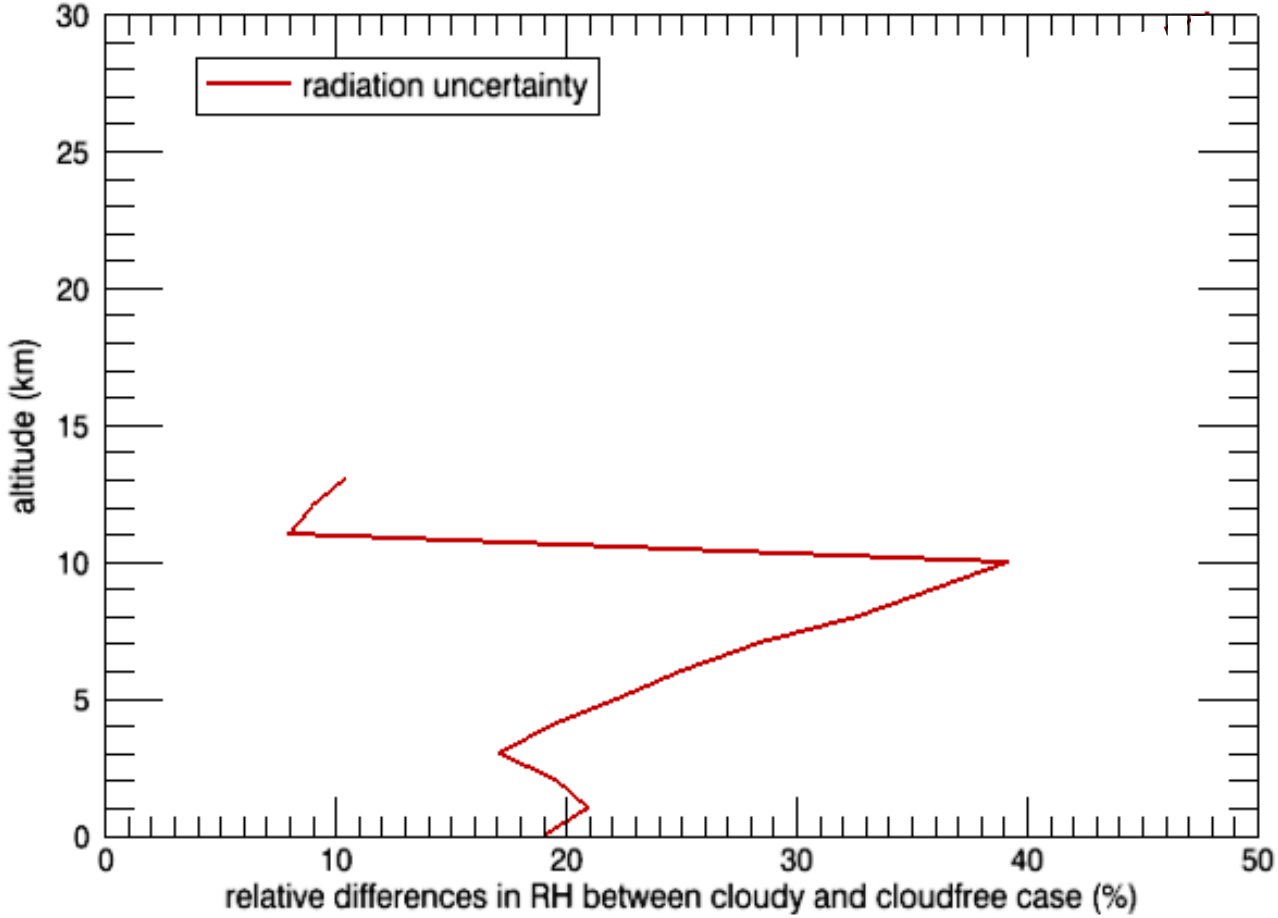


Example Humidity: Ground check 100%

100% check



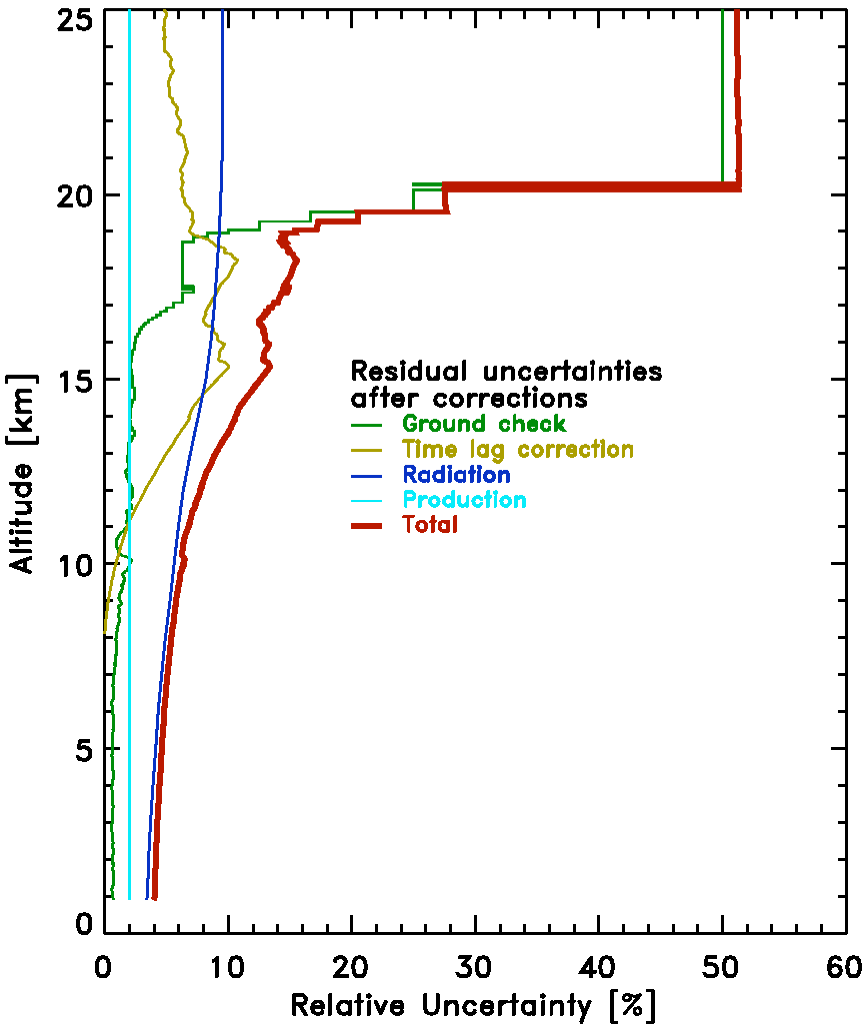
Example Humidity: Radiation error



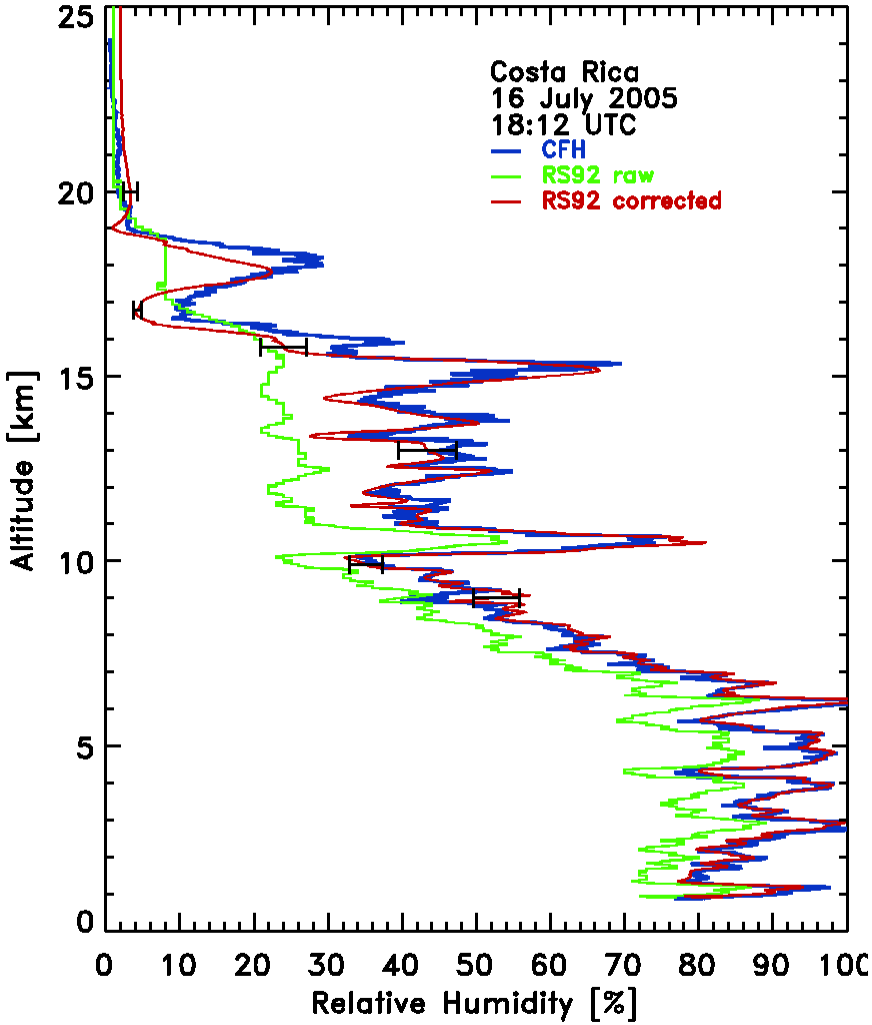
Example Humidity: Combined uncertainies

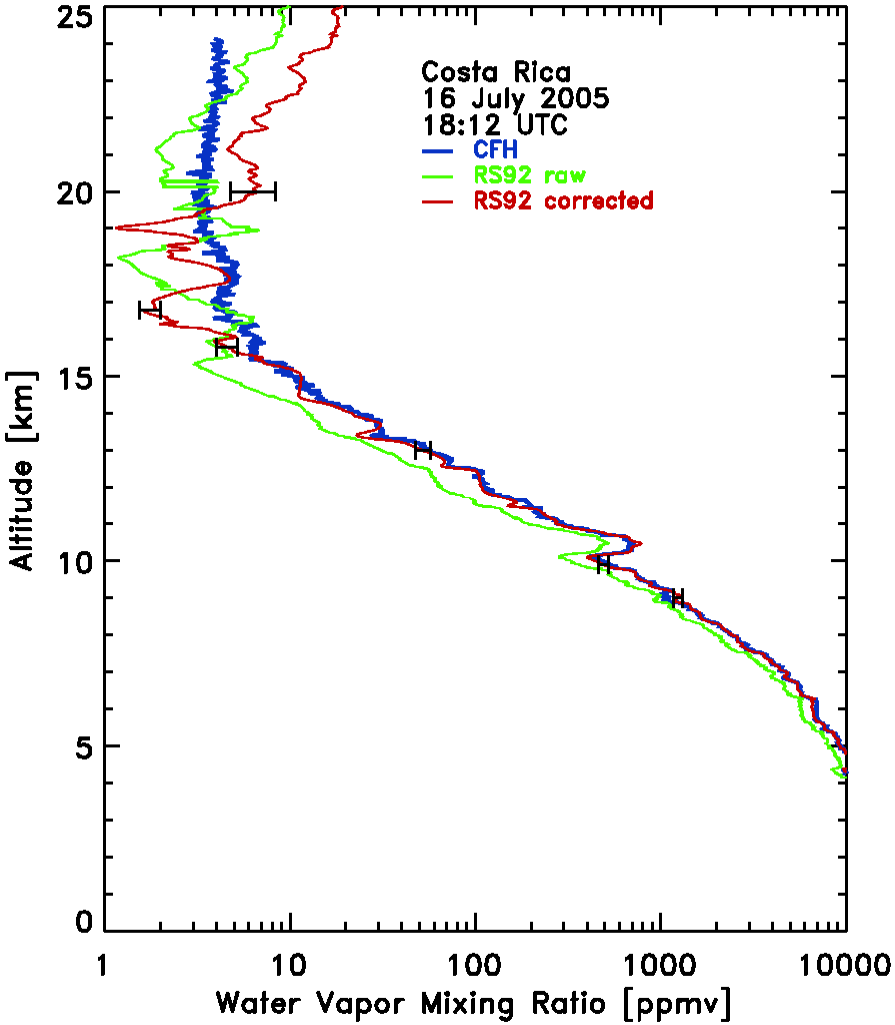
Uncertainties considered:

- **Ground check:** +/- 0.5% absolute
- **Integer resolution:** +/- 0.5% absolute
- **Radiation correction:** < 10% relative
- **Time lag correction:** < 10% relative
- **Production variability:** < 4% relative



Example Humidity:
Corrected profile including uncertainties





GRUAN data: Generalization

Final data contain:

- **Manufacturer output data**
- **All known corrections**
- **Vertically resolved uncertainties**
- **Ground check independent of manufacturer‘s ground check (where feasible)**
- **Reference to corrections and processing**
- **Meta data for complete description**

GRUAN data: Generalization

For traceability need:

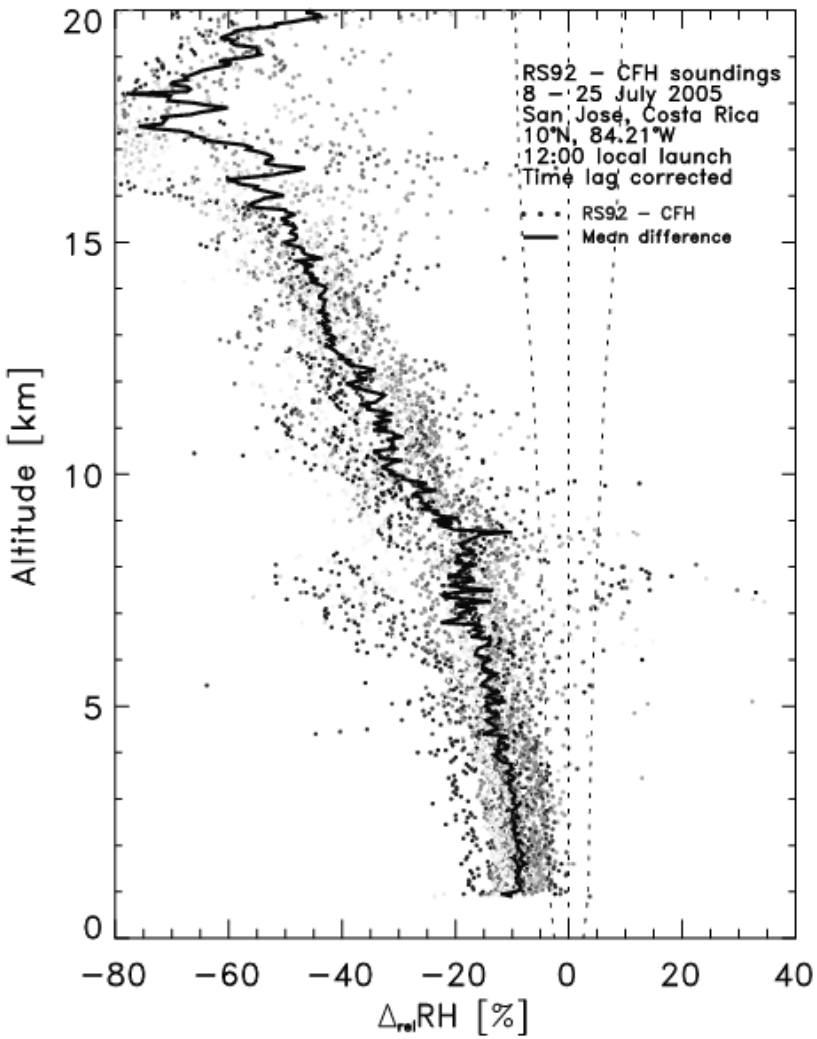
- **Raw phyiscal data (e.g. temperature or water vapor, no filtering, no smoothing, no corrections)**
- **Documentation of all corrections (preferred published papers)**
- **Some engineering data (e.g. Humidity sensor temperature, raw frostpoint optics signal, ozone cell current and pump temperature, ...)**
- **Version number of data**

GRUAN data: Generalization

Application of vertical uncertainty profile:

- **Metric for sensor comparison**
- **Quantification of sensor ‘Agreement‘**
- **Quantification of vertical range of sensor output**
- **Quantification of ‘Reference’ instrument**
- **Identification of need for improvement**

Humidity: Radiation correction



Humidity: Ground check 0%