Atmospheric Temperature and Humidity Measurements of Vaisala Radiosonde RS41

Petteri Survo, Eero Hiltunen, Hannu Jauhiainen, Johanna Lentonen, Jukka Leppänen, Tomi Salo, Markus Turunen

17th Symposium on Meteorological Observation and Instrumentation
Outline

1. Sensor technology and product overview
2. Stability tests
3. Uncertainty analysis
4. Results in soundings
5. Conclusions
RS41 Temperature measurement

Platinium resistor technology
  - Linearity and stability
  - No ground check correction needed

Sensor and boom design optimization
  - Response time
  - Radiation error
  - Water repellent treatment

SI-traceable calibration references (NIST)
RS41 Humidity measurement

Capacitive Humicap® technology
- Integrated temperature sensor
- Integrated heating element

Sensor concept features
- Accuracy under solar exposure
- Icing prevention
- Reconditioning for contaminant removal
- Zero humidity correction without dessicants

SI-traceable calibration references (NIST)
Stability test results
RS41 Temperature measurement

- Storage 6 months, measured at 20°C
- Test equipment uncertainty = 0.07°C (k=2)
Stability test results
RS41 Humidity measurement

- Storage 6 months & ground check
- Measured in standard humidity chamber SPRH 100

![Humidity condition 100 % RH chart]

- Radiosonde reading [% RH]
- J3840019, J3840020, J3840021, J3840024, J3840037, J3840039, J3840040, J3840042, J3840063
Stability test results
RS41 Humidity measurement

- Storage 6 months & ground check
- Measured in dry conditions (RH < 0.1 %)
Uncertainty analysis according to GUM 2007

Uncertainty analysis model:

- Calibration
  - Reference measurements
  - Calibration process
  - Unit under calibration
- Sensor models
- Storage (T), Reconditioning & Zero humidity correction (U)
- Sounding
  - Dynamic conditions
  - Solar radiation
Uncertainty analysis according to GUM 2007

Uncertainty analysis model:
- Calibration
  - Reference measurements
  - Calibration process
  - Unit under calibration
- Sensor models
- Storage (T), Reconditioning & Zero humidity correction (U)

= Accuracy after ground preparations
Accuracy after ground preparations
RS41 Temperature measurement

- Stability of Pt-resistor - No corrections applied
Accuracy after ground preparations
RS41 Humidity measurement

- Reconditioning for chemical contamination removal
- Zero humidity correction

![Graph showing uncertainty in relative humidity as a function of temperature and relative humidity]
Uncertainty analysis according to GUM 2007

Uncertainty analysis model:
- Calibration
  - Reference measurements
  - Calibration process
  - Unit under calibration
- Sensor models
- Storage (T), Reconditioning & Zero humidity correction (U)
- Sounding
  - Dynamic conditions
  - Solar radiation

= Accuracy in sounding
Accuracy in sounding
RS41 Temperature measurement

- U.S. Standard Atmosphere 1976
- Solar angle 60°
- Ascend rate 6 m/s
- Coverage factor k=2
Accuracy in sounding
RS41 Humidity measurement

- U.S. Standard Atmosphere 1976
- Solar angle 60°
- Ascend rate 6 m/s
- Coverage factor k=2
Sounding campaign results

- Vantaa, Finland
- FMI, Sodankylä, Finland
- Penang, Malaysia
- CHMI, Libus, Chech Republic
- UK Met Office, Camborne, UK
Temperature reproducibility, daytime
Direct differences and standard deviations
20 flights, Camborne UK

RS41 - RS41

RS92 - RS92

Variable: Temperature. Data resolution: Time 1 sec. 20 flights.
Restriction: Not applied

30 km
20 km
10 km

0.2°C
Humidity reproducibility, daytime
Direct differences and standard deviations
20 flights, Camborne UK

RS41 - RS41

RS92 - RS92

Variable: Humidity. Data resolution: Time 1 sec. 20 flights.
Restriction: Not applied

30 km
20 km
10 km
1% RH
Temperature difference: RS92 – RS41
Camborne UK

Night-time, 10 flights

Daytime, 20 flights
Humidity difference: RS92 – RS41
Camborne UK

Night-time, 10 flights

Daytime, 20 flights
RS41 Temperature measurement vs. multi sensor instrument
Direct differences and standard deviations, 20 flights

![Graph showing temperature measurement comparison]
RS41 Humidity measurement vs. Cryogenic Frostpoint Hygrometer

Tropical daytime
Conclusions

RS41 introduces new measurement technologies for upper air observations.

A comprehensive uncertainty analysis has been conducted.

RS41 has been tested in various climate conditions and verified against reference instruments and technologies. Compared to RS92, the results demonstrate improved precision and accuracy.
Thank you!