Intercomparison of Vaisala RS92 and RS41 sondes under controlled laboratory conditions

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Motivation

The Vaisala RS92-SGP radiosonde widely used at the global scale for profiling of standard meteorological variables in troposphere and stratosphere

In the fall of 2013, the Vaisala RS41 radiosonde was introduced as a replacement of the RS92 radiosonde, with the aim to improve the measurement accuracy of profiles of atmospheric temperature and humidity

To ensure the homogeneity and the highest quality standard of radiosounding time series to reliably detect climate changes, **intercomparison studies are needed to characterize the relevant differences between RS92 and RS41 in terms of biases, uncertainties and calibration**

Typically, intercomparisons of RS92 and RS41 are performed by dual radiosoundings

Objectives

✓Provide a further contribution to dual radiosoundings for the proper management of the transition from RS92 to RS41

✓ Investigate the differences between RS92 and RS41 sensors (in terms of sensitivity, stability and response time) at different T, RH, p and wind speed conditions controlled inside climatic chambers and similar to those measured in the real atmosphere

✓Assess the measurement accuracy of the two sonde types, using reference humidity and temperature sensors

Methodology

1° step: simultaneous T, RH measurements from the two sonde types inside the climatic chamber Kambic KK-105 CHLT, which simultaneously and independently controls RH and T inside. Reference T, RH sensors have been placed in the measurement region close to the sonde sensors

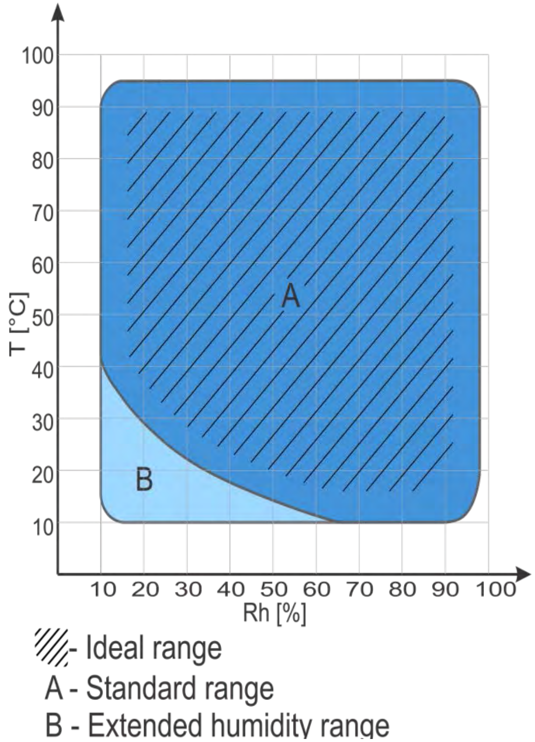
2° step: simultaneous T measurements from the two sonde types at their fast transitions between two climatic chambers set to different T, in order to study the response time of sonde T sensors

3° step: simultaneous T~~, RH~~ measurements from the two sonde types inside the climatic chamber with wind generation EDDIE **(E**arth **D**ynamics **D**irect **I**nvestigation **E**xperiment), which simultaneously and independently controls T, p and wind speed inside

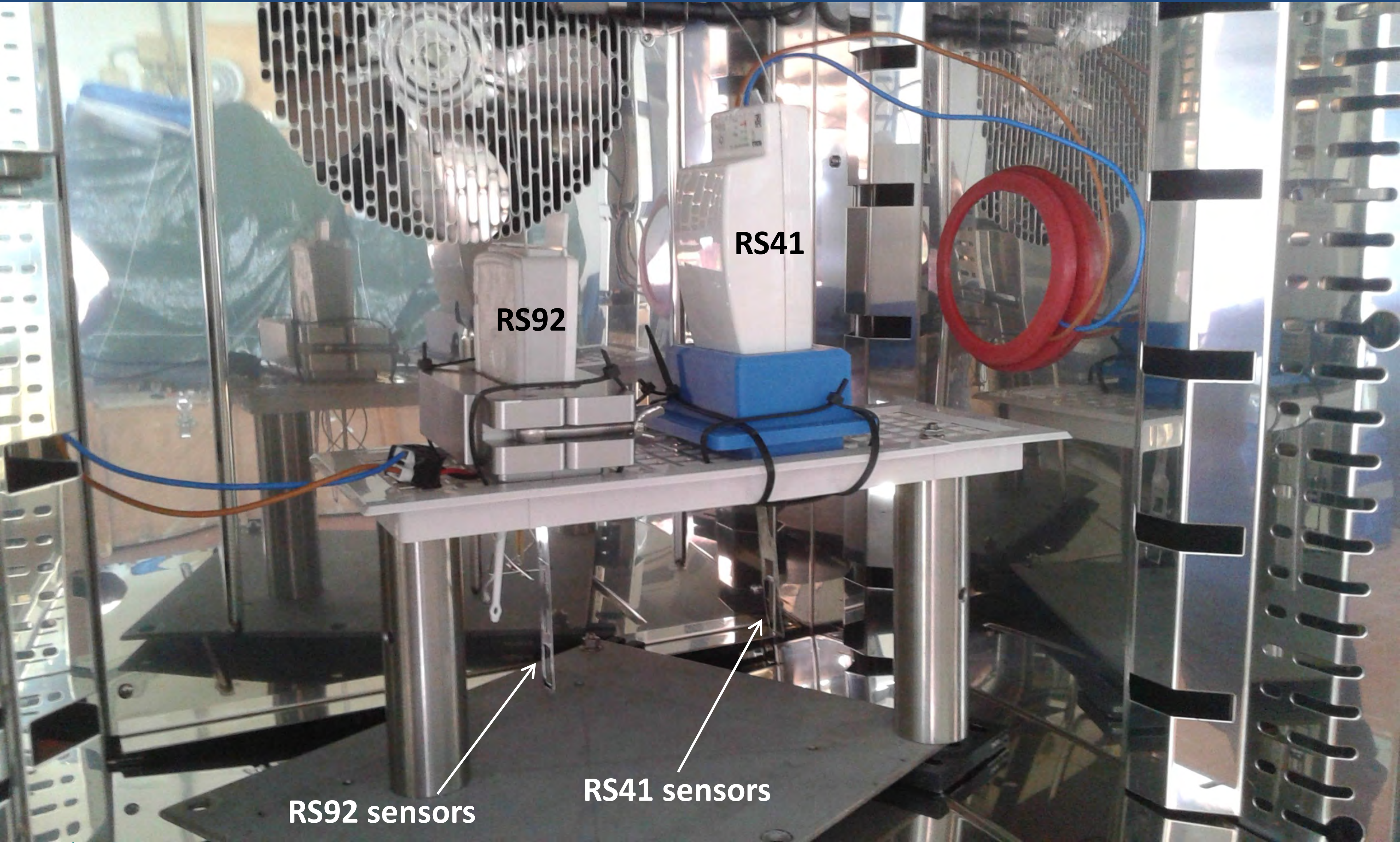
1° step: Climatic chamber Kambic

Kambic KK-105 CHLT

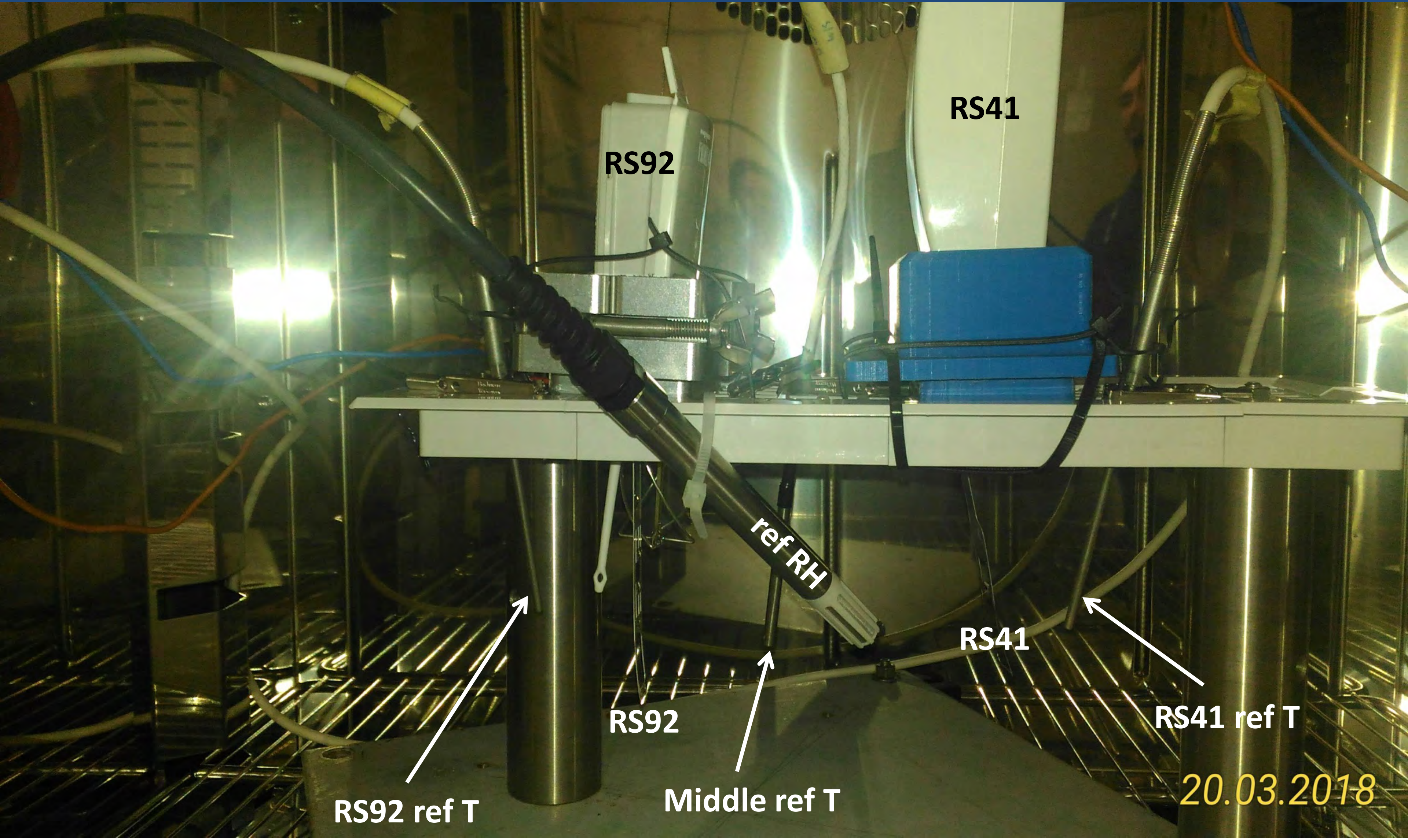
- T control in the range : -40°C…180°C
- T stability over time: ±0.1°C
- T uniformity: ±0.3°C
- RH control in the range: 10%…98% **only for T in the range: 10°C…95°C**
- RH stability over time: ±0.5 %



1° step: Measurement setup



1° step: Measurement setup



1° step: Measurements

Kambic points

- 20 (RH, T) points, with RH = 20%, 40%, 60%, 80%, 98% and T=10°C, 20°C, 30°C, 40°C

- 5 T points, with T= 0°C, -10°C, -20°C, -30°C, -40°C (no RH control)

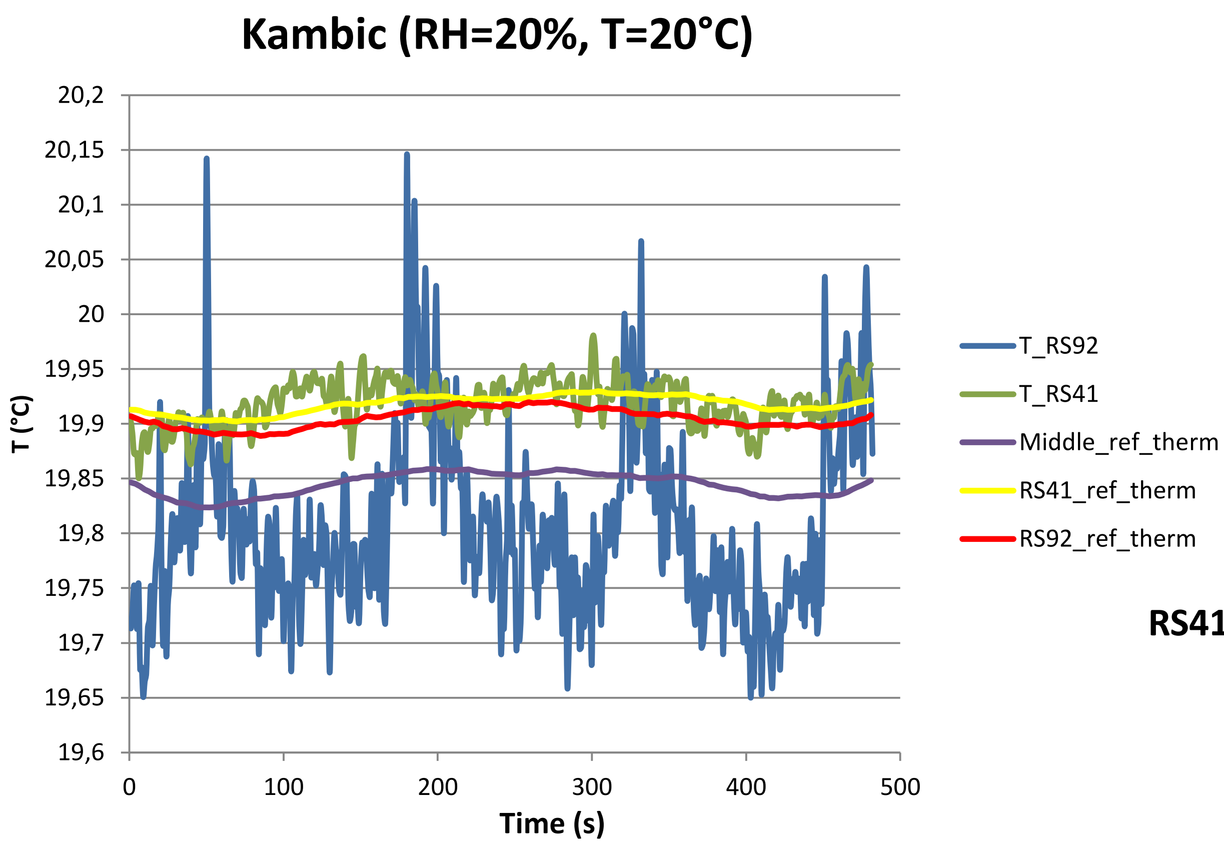
Acquisition

Time: during the stability conditions of chamber (minimum T, RH variations in the chamber control sensors or reference sensors)

Duration: from 5 to 10 min

Time resolution: 1 s (time resolution of raw data of Vaisala system)
Time resolution references: 3 s (lower resolution of Super-DAQ acquisition system)

1° step: Measurement results



Kambic stability: < 0.035°C
Kambic uniformity: < 0.08°C

RS41 stability: 0.13°C
RS92 stability: 0.5 °C

RS41~ 4 times more stable than RS92

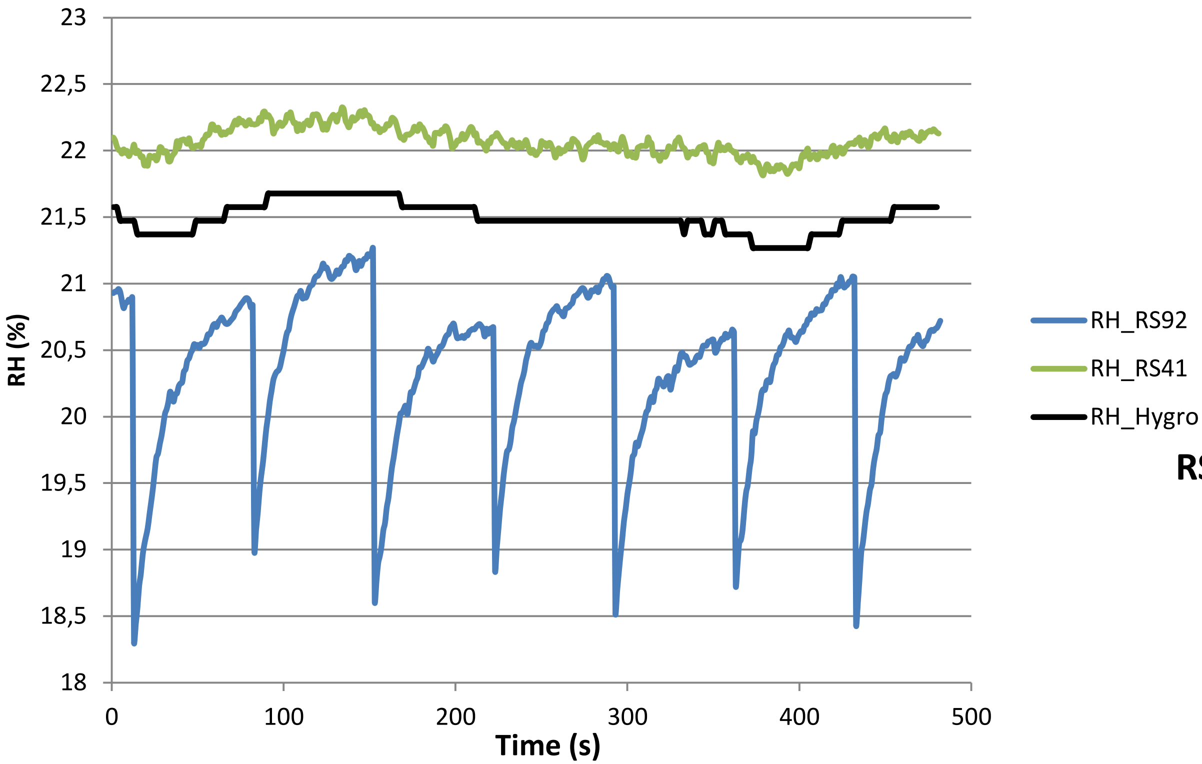
ΔT_{max} (RS41,RS92): 0.3°C

ΔT_{max} (RS41, ref_therm):0.13°C
ΔT_{max} (RS92, ref_therm):0.34°C

RS41~ 3 times more accurate than RS92

1° step: Measurement results

Chamber (RH=20%, T=20°C)



Kambic stability: < 0.4%

RS41 stability: 0.5%
RS92 stability: 3 %

RS41~ 6 times more stable than RS92

ΔRH_{max} (RS41,RS92): 3.7%

ΔRH_{max} (RS41, ref_hygro): 1%
ΔRH_{max} (RS92, ref_hygro): 3%

RS41~ 3 times more accurate than RS92

Vaisala Ground Check:
ΔRH_{RS92} = -0.6 %
ΔRH_{RS41} = 0.3 %

increase of difference with respect to the ref hygrometer for both sondes, making measurement accuracy worse

2° step: Twin chambers

Performed a series of fast temperature transitions:

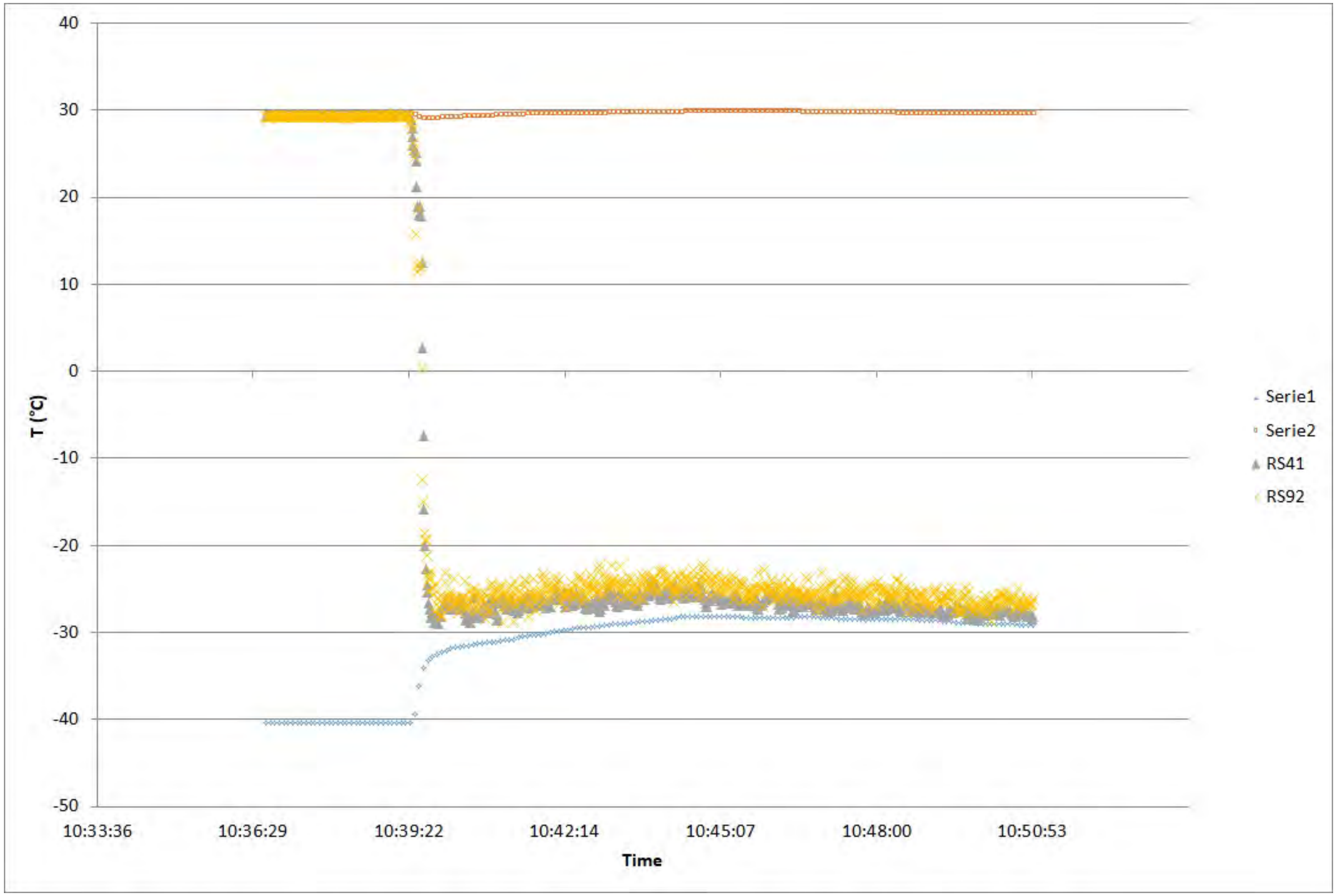
- -40 °C -> 20 °C -> -30 °C
- Repeated -30 °C -> 30 -> - 30 °C
- Repeated 0 °C -> 20 °C -> 0 °C

Sondes moved very quickly between climatic chambers, set at different temperatures.

Stabilities of initial and final temperature not so important for the determination of time constant.

2° step: Measurement results

Example of 30 °C / -30 °C transition



Very fast temporal response by the sondes

(both ~ 30 s)

But

Noise and DT is different after the transition!

(something to assess and to take into account)

3° step: Wind-pressure tunnel

Performed a series of fixed temperature/wind/pressure measurements using:

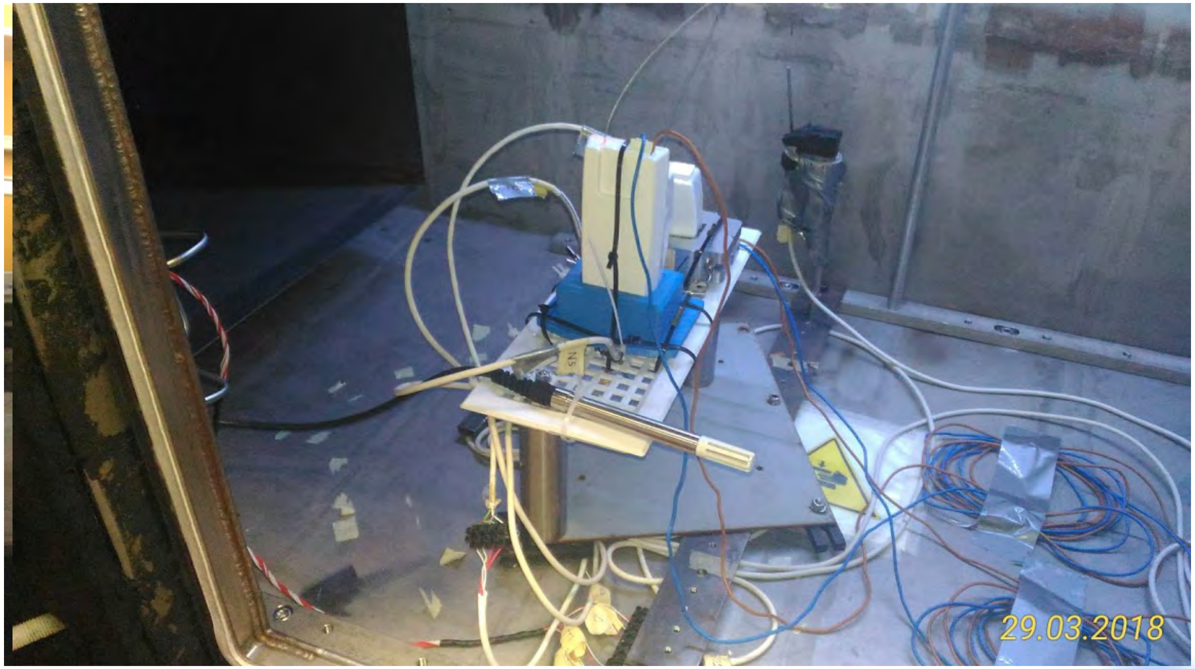
Earth
Direct
Dynamics
Investigation
Experiment

3° step: Measurement results

Performed a series of fixed Temperature – Wind – Pressure measurements using:

- 30 °C (2 m/s, 8 m/s, 15 m/s) atmospheric pressure
- 15 °C (2 m/s, 8 m/s, 15 m/s) atmospheric pressure
- 0 °C (2 m/s, 8 m/s, 15 m/s) atmospheric pressure
- -10 °C (2 m/s, 8 m/s, 15 m/s) atmospheric pressure
- -20 °C (5 m/s, 15 m/s)* @ (800 hPa, 500 hPa and **350 hPa)**

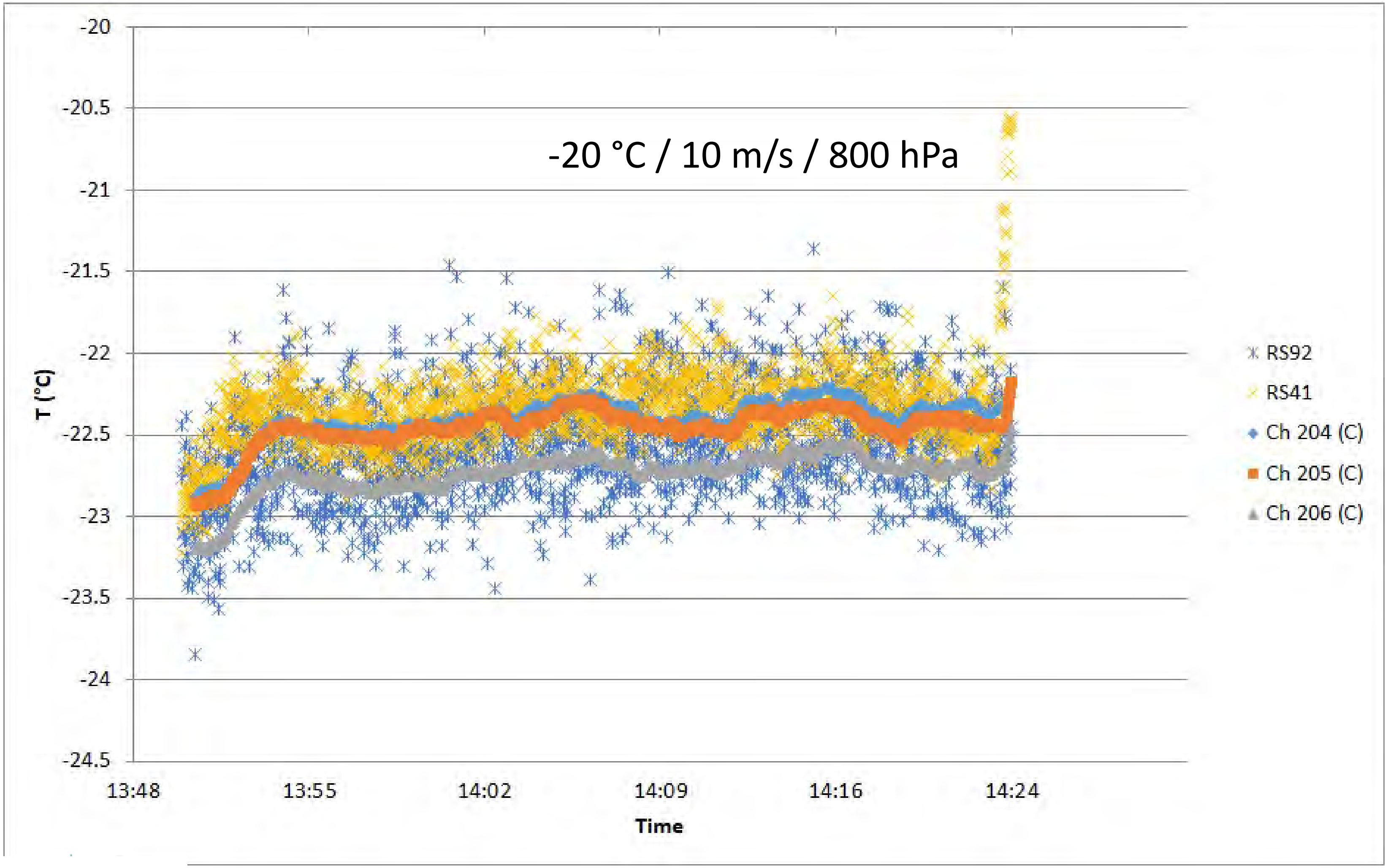
* (nominal value)



3° step: Measurement results

Some examples:

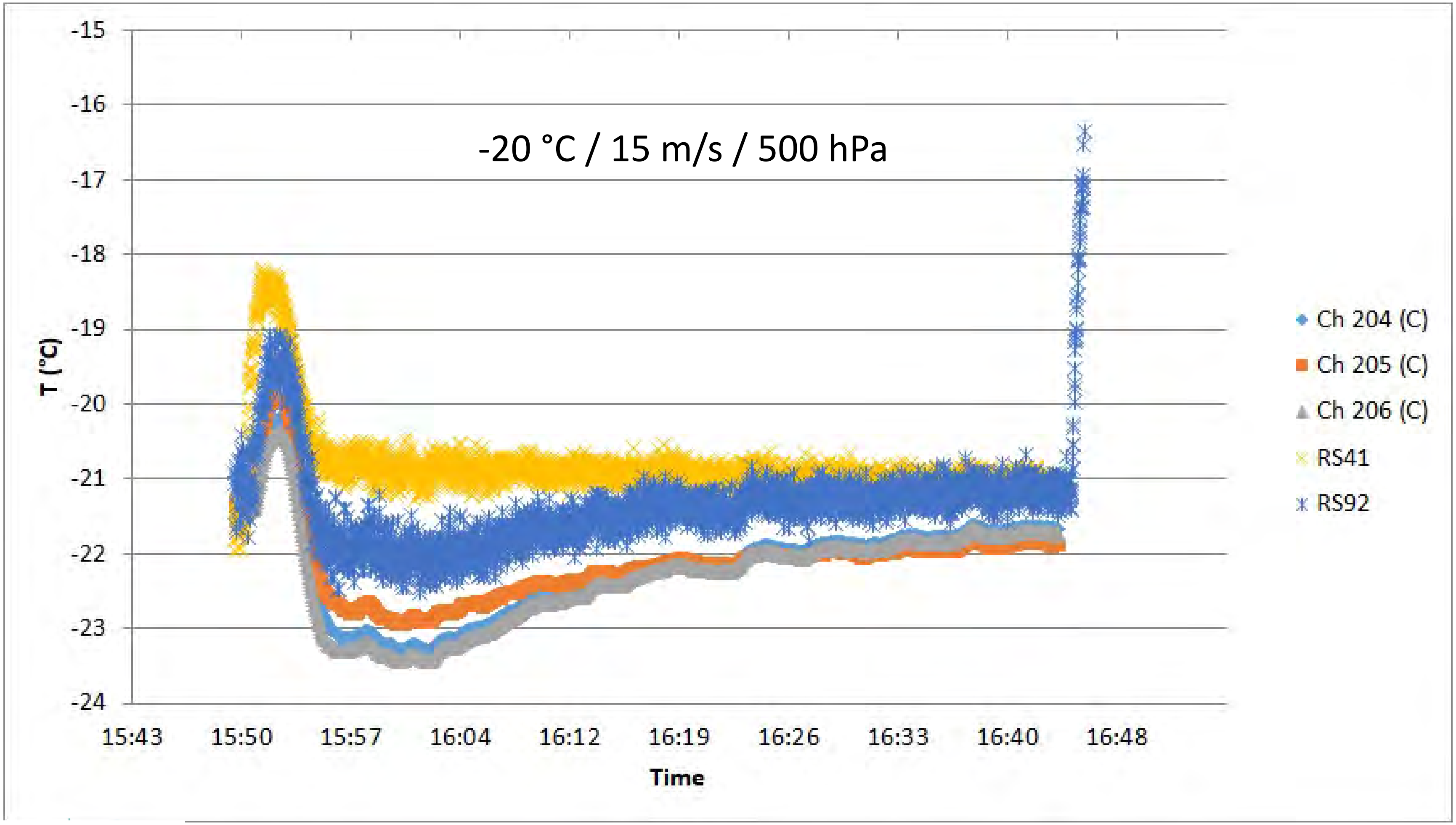
Noise *seems* to increase with altitude



3° step: Measurement results

Some examples:

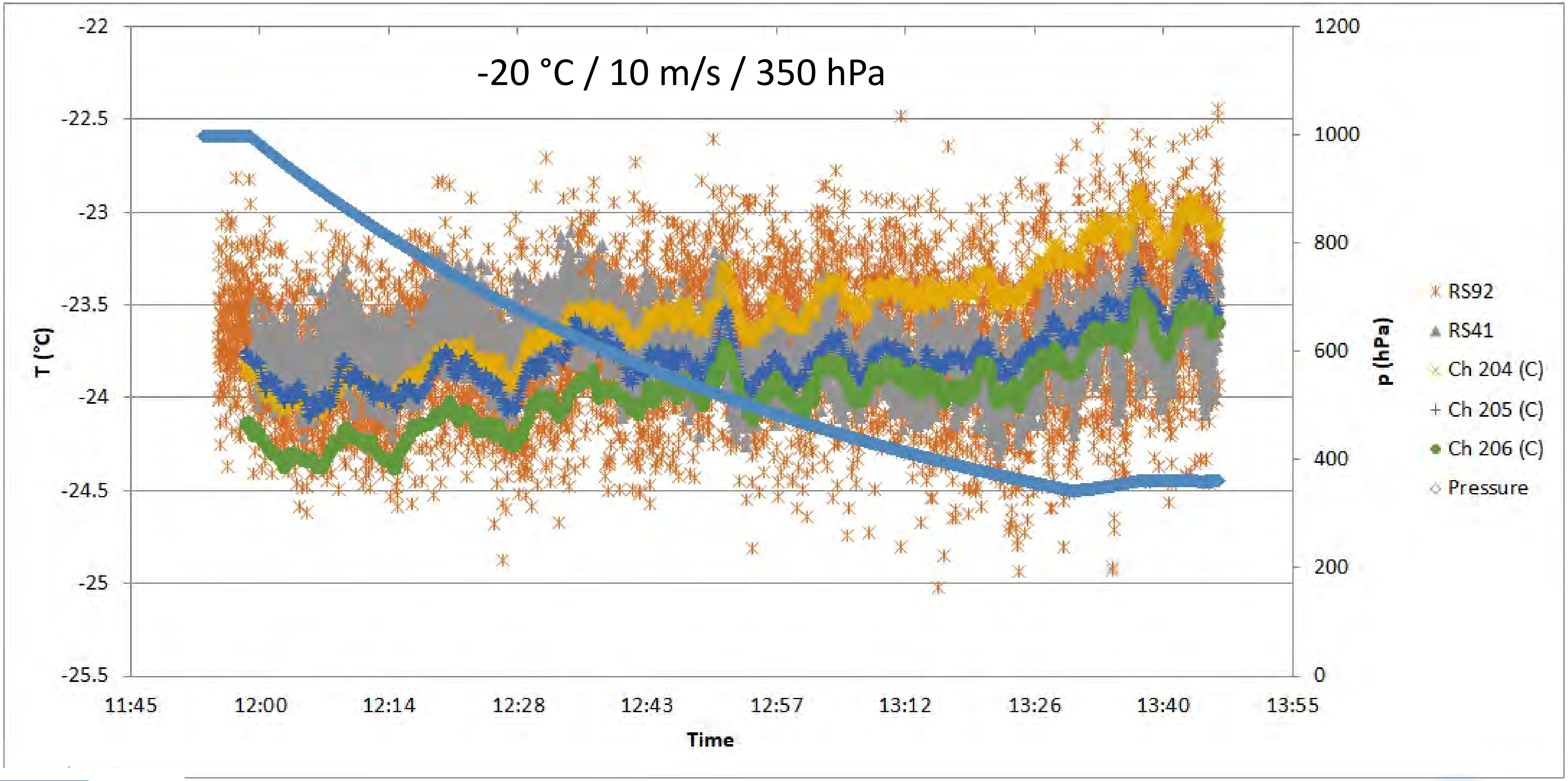
Reaction to a change in wind speed



3° step: Measurement results

Some examples:

Info on the influence of pressure



3° step: Measurement results

New tool available!

Earth
Dynamics
Investigation
Experiment 3

Designed to go much beyond 350 hPa -> few hPa reachable

Thanks for your attention!

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