Autolaunchers: progress update, including conclusions from breakout session

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Objectives and Key questions

- Objectives

1. Assess the advantages and disadvantages of manual vs. auto launches written up and submitted to the peer reviewed literature and/or a technical document.

2. Find a way to get GRUAN certification for radiosonde data products taken with Automatic Radiosonde Launchers (ARLs).

- Key questions:

1. Can we create a GRUAN Data Product (GDP) from ARLs observations?

2. How is the quality of flight data from auto-launcher systems in comparison with data from manually launches? Is there a bias between manual and automatic radiosonde launches?

3. Does the random uncertainty change?

4. Pre-launch/at-launch checks – how to implement manufacturer independent ground check?

Activities in the task

- Writing a manuscript to submit to peer-reviewed literature to initially assess the performance of Automatic Radiosonde Launchers (ARLs).
- Collection of sites’ experience with autolaunchers.
- Providing ideas for possible experiments to improve autosonde “traceability” (i.e. using independent GC).

Manuscript: structure current status

1. Introduction
2. Description of existing autolaucher systems
3. Technical performances
4. Stability and ground calibration
5. Measurement performances
6. Automatic launchers performance evaluated using forecast model
7. Discussion and conclusions

The manuscript has been sent out last Friday to all the sites, the GRUAN interested experts, LC and co-chairs.

- Section 3 is still missing and must be discussed (if to include and how).
- Section 6 to be written
- A few other issues to discuss, text and figures to improve.

Description of existing ARLs

Vaisala AS41 autosonde system operational at the Finnish Meteorological Institute GRUAN site in Sodankylä

Modem Robotsonde launching a balloon at Station Tasiilaq (WMO index = 04360, photo from https://www.dmi.dk/fileadmin/user_upload/Rapporter/TR/2015/DMI-TR-15-12.pdf=)

Meisei Automatic Balloon Launcher and simulation of the simulation of the internals of ASR container in its most updated configuration.

Technical performances

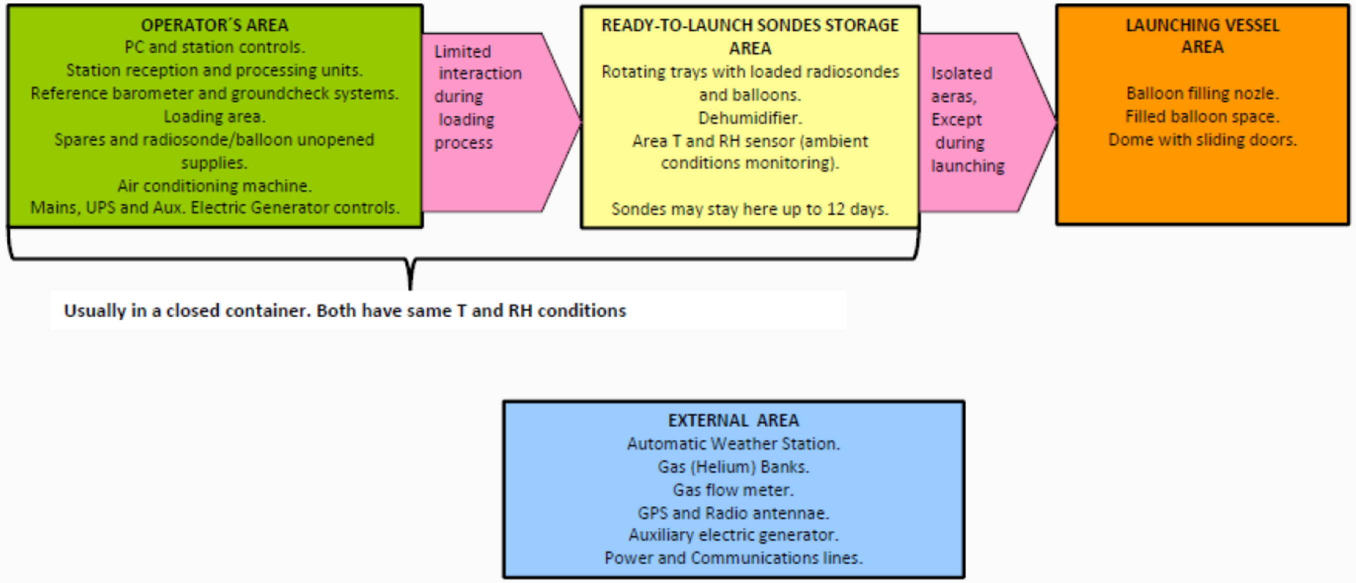
- Describe, theoretically, advantages and drawbacks of the autolauncher compared to manual launches.

- Report the analysis of advantages, limitations and technical issues outcome from the sites' feedbacks focussing on aspects like:
  - Continuity of operations (e.g failures and re-launches)
  - Maintenance
  - Performances at remote sites (e.g power failure, severe weather conditions)
  - Resources (Personnel and costs)

Information from the sites

"The typical main areas of an auto-launcher station" summarized by Miguel Hernandez (Tenerife)

Before answering the questions, for the sake of clarity, let me describe graphically the typical main areas of an auto-launcher station as I refer in the answers to some of them.



SCHEME OF A TYPICAL AUTO-LAUNCHER STATION: FOUR MAIN AREAS

(Functional blocks, no real layout)

Tenerife

STAGE	AUTO-LAUNCHER ISSUES	MANUAL LAUNCHING
Loading	Several radiosonde mananagement. Manofacturer defined groundcheck Easy radiosonde input/output. (Useful for instance for repeating groundchecks).	No loading concept, just preparation of a single radiosonde. Manual groundcheck.
Waiting for launching	Response stability while in storing area, specially for T and RH. Balloon stability while in storing area.	No waiting for launching concept.
Launching	Remote. Weather conditions are set. Can be more violent.	Smoother manual launch. Can wait to a right weather conditions moment.
In Flight, ascent	Parachute inside (in Vaisala) balloon.	Parachute outside (more elements precede radiosonde).
In Flight, descent	??	??

Technical performances – GRUAN sites

To improve the homogeneity of the provided information and to facilitate their analysis and understanding, GRUAN sites have been proposed to fill in the following table.

Station	Automatic	Manual
Automatic launcher		
RS type		
Ballon type		
Ballon size		
Number of launches		
Percentage of failure		
Percentage of spare		
Sondes above 10 hPa		
Max. Ascent speed		
Min. Ascent speed		

This will be reported along with a general summary of the sites' feedback.

Does it make sense? Sounds reasonable? Sounds feasible? Do we want to reshape Section 3 of the manuscript?

ARL stability

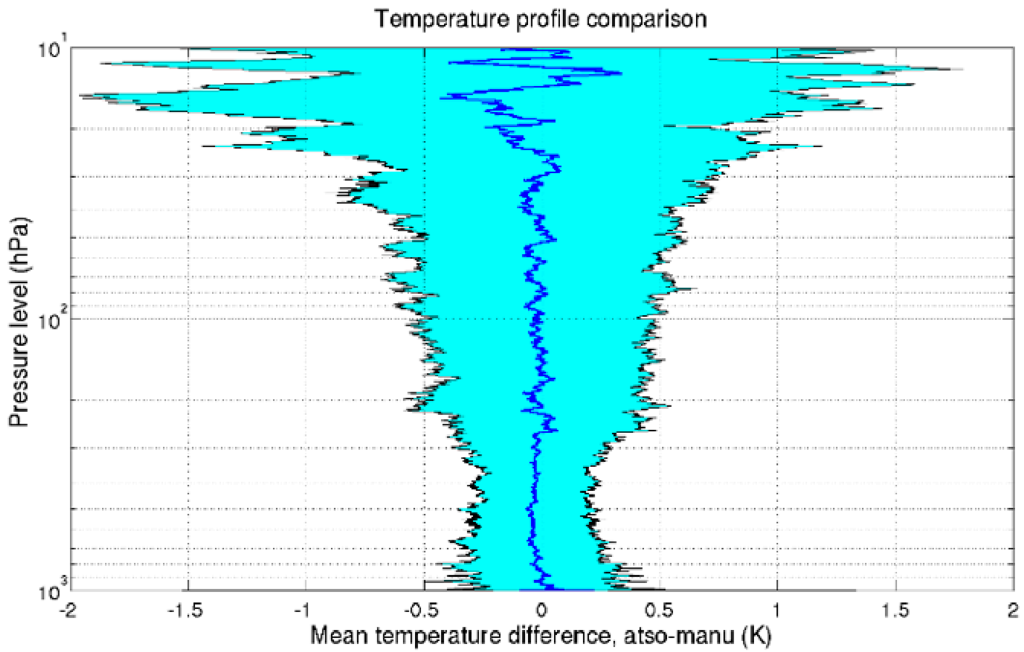
- Stability has been studied through the time series of the temperature correction applied during the GC procedure in ARL and manual systems.
  - RS92 time series from Sondankyla and Potenza from 2004 to 2012 with a more intensive sampling since 2006. MeteoSwiss has provided additional data.
  - Absolute value of the difference within 0.1-0.2 K.

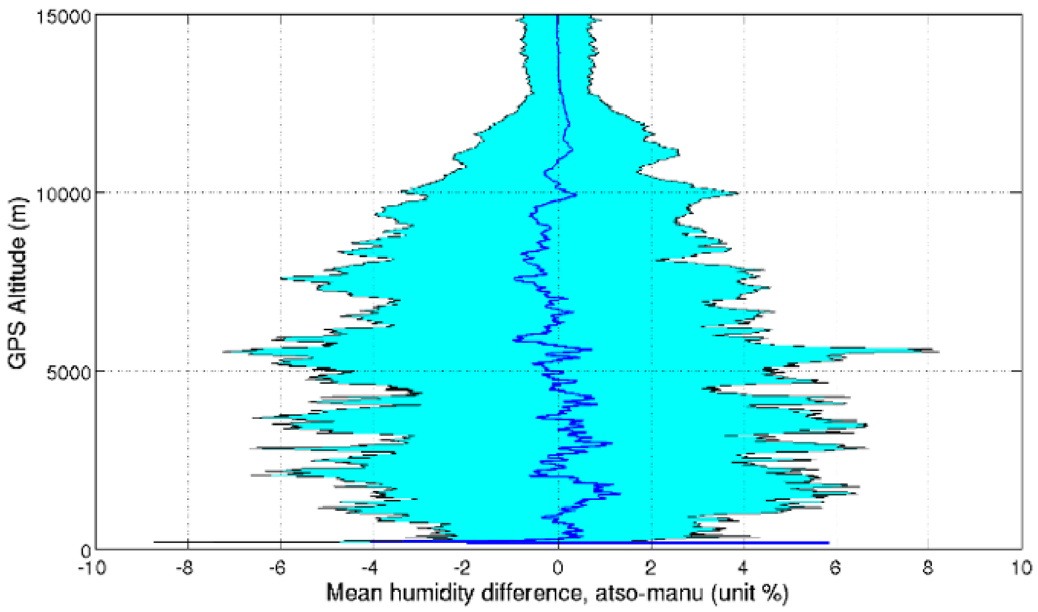
- Vertical profiles of the difference in the RH measured with the manual and automatic system in Sodankylä has been studied as a function of the time period between ground check and launch.
  - No significant biases.

Measurement performances: parallel soundings

Vaisala

No significant biases





Temperature (left panel) and RH (right panel) mean difference between ASR and manual for the six-year dataset of parallel soundings collected at Sodankylä station at all the pressure levels up to 10 hPa.

Standard deviation at each pressure level is reported using the cyan area in the plot.

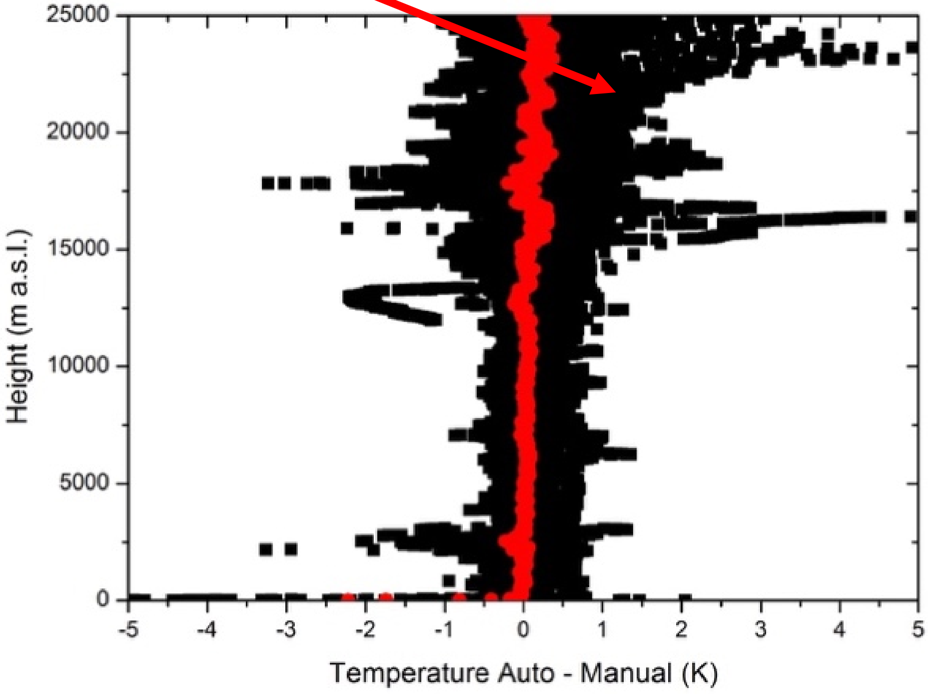
Measurement performances: parallel soundings

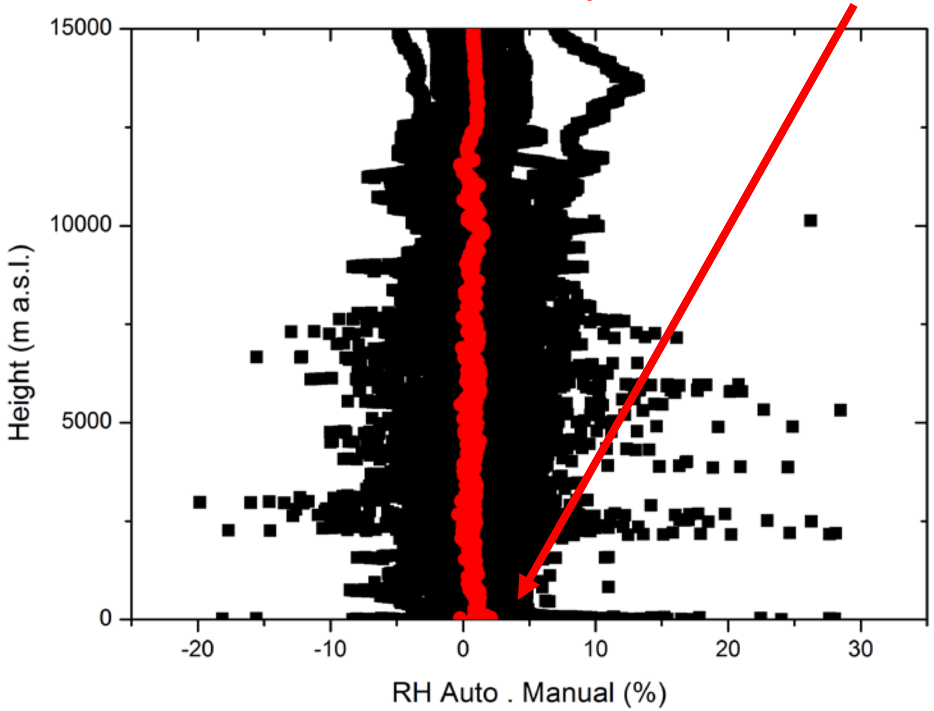
No significant biases

Skewed distribution

Modem

Except for RH close to the ground



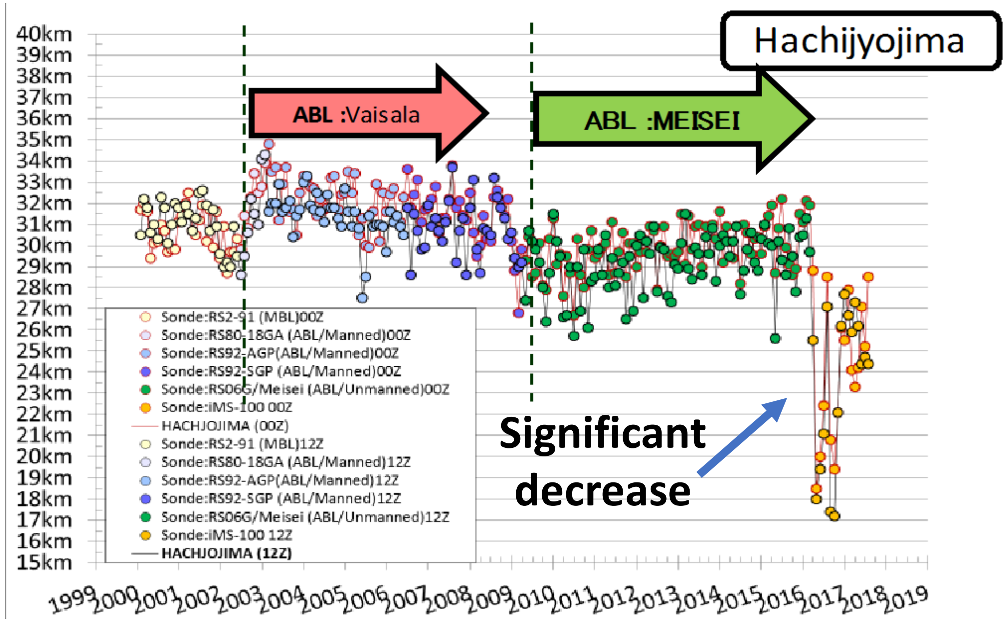


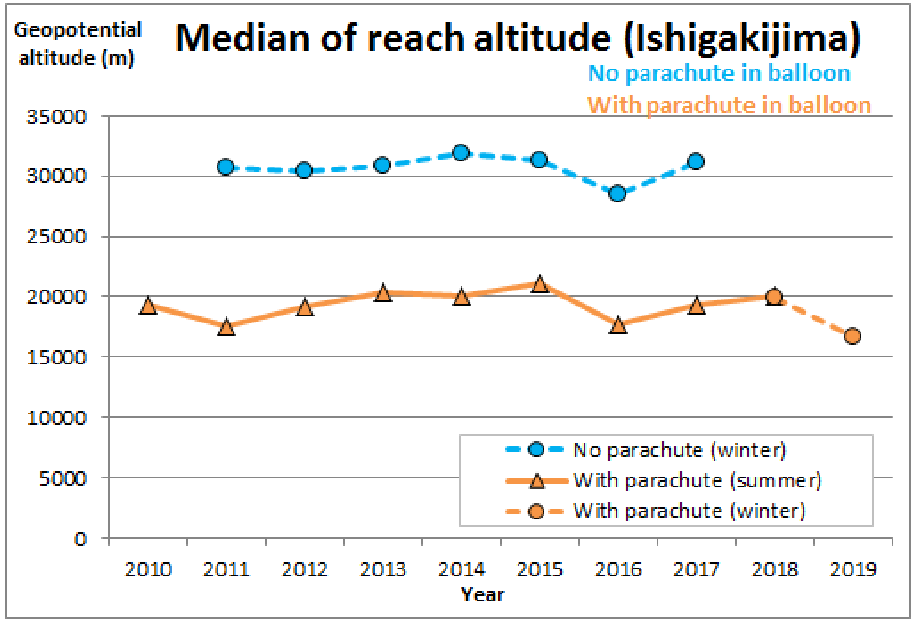
Balloon burst km a.g.l.
Manual Day: 26.7 - 31.9
Auto Day 27.8 – 30.8
Manual Night: 24.9 – 30.6
Auto Night 27.4 - 30.1

Left panel, difference between ASR and manual launcher values of temperature (left panel) and RH (right panel) are reported for all the 21 parallel soundings performed at Faa'a station (French Polinesie) and at all the altitude levels up to 25 km a.g.l.
Red dots are the vertical profile of the mean difference.

Measurement performances: burst altitude

Meisei

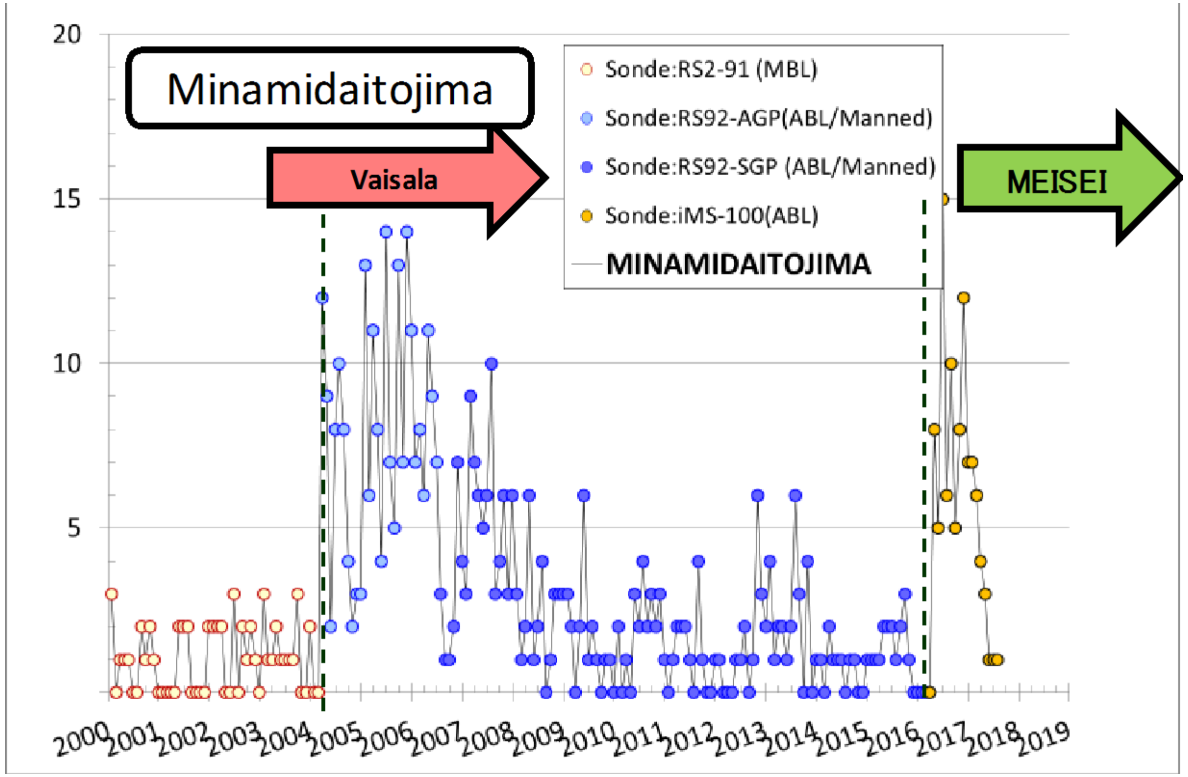




- Balloon burst altitude for the launches performed since 2000 at the station of Hachijyojima (33°07.3’, 139°46.7’, 854 m a.s.l.).
- Changes from manual to the Vaisala ARL (2003-2010) and finally to the Meisei ARL
- Parachute-included balloons tend to lower the burst altitude.

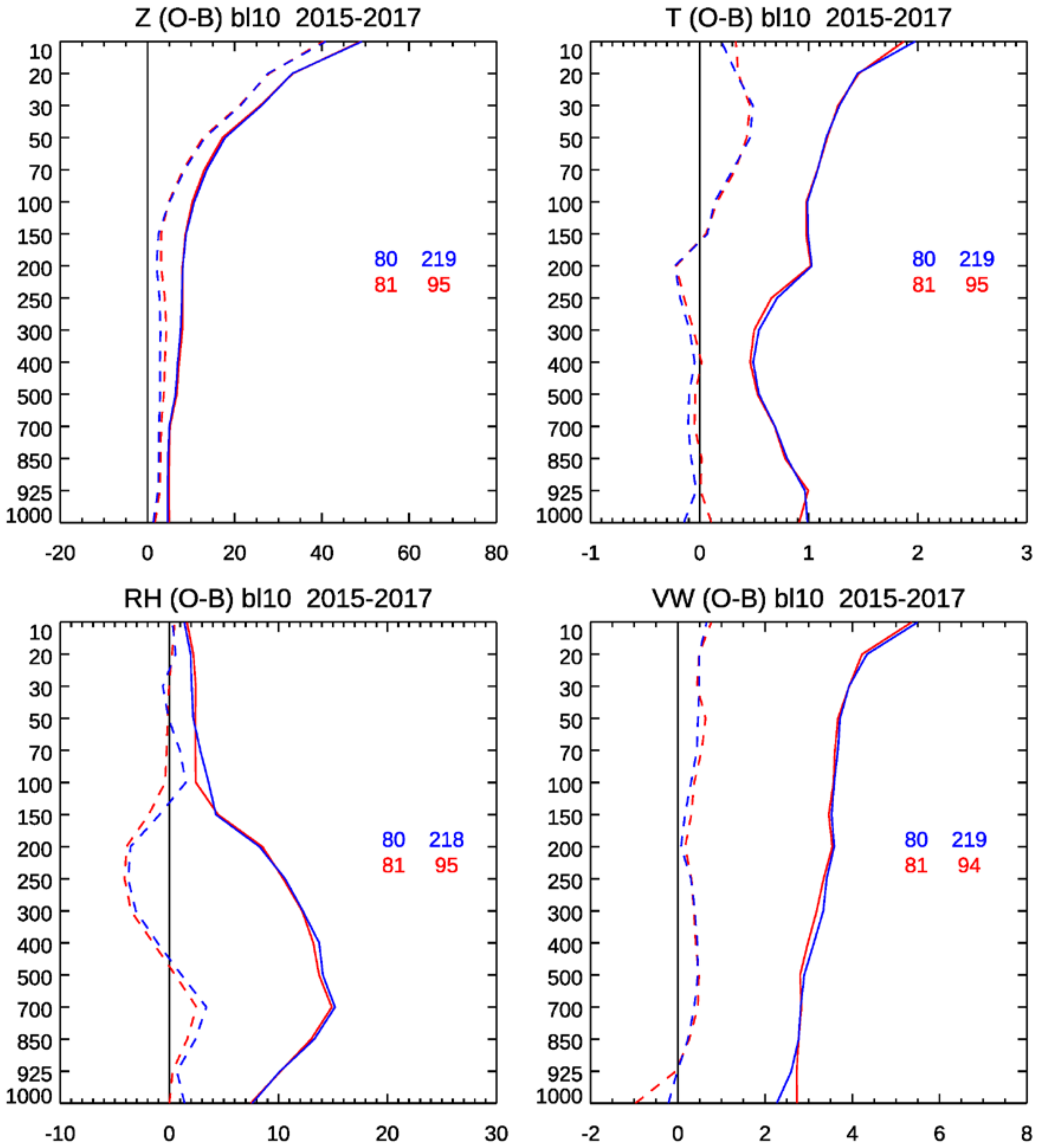
Measurement performances: number of re-launches

Meisei



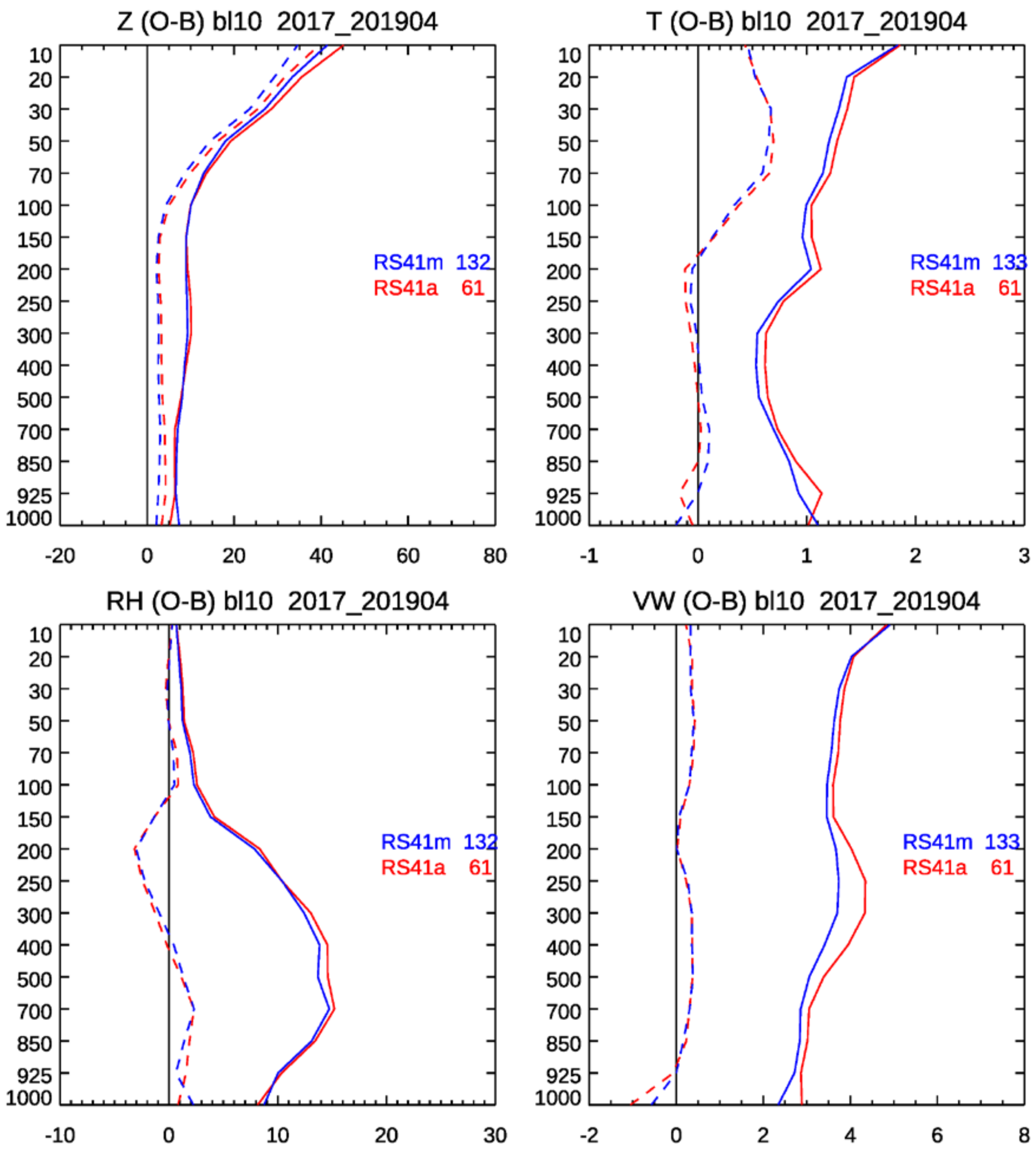
- The number of re-launches increased after the introduction of automatic launchers.
- In March 2010, when the ARS was introduced at three of the four sites, the re-launch criterion was relaxed from 100 hPa to 150 hPa.
- In March 2017 when the system was updated, the number substantially increased to a number of 10-15 re-launches per year.

Observation minus Background statistics – RS92



Mean (dashed) and rms (solid) O-B statistics for German RS92 ascents, 2015-2017: blue - manned, red - ASL. Results for geopotential height (top left), temperature (top right), relative humidity (bottom left) and wind (mean wind speed and rms vector wind; bottom right). The key gives the radiosonde type (80 or 81) and the number of reports in hundreds.

- The RS92 results are very similar between manned and ASL stations (small differences at 1000 hPa).
- The upper tropospheric humidity has minor systematic differences probably due to humidity time-lag and radiation corrections being introduced at different dates at different stations.



Observation minus Background statistics –RS41

- In contrast and surprisingly, the RS41 results show rather larger rms(O-B) differences for ARL stations - especially for temperature and wind.

- Possible reasons is the accuracy of the reported pressure values - measured for the RS92 but calculated for the RS41 (in most cases; a version of the RS41 with a pressure sensor is available).

- The RS41 pressures are calculated starting from a surface pressure measurement and (at other stations) some problems have been reported with the calculation of measurement height.

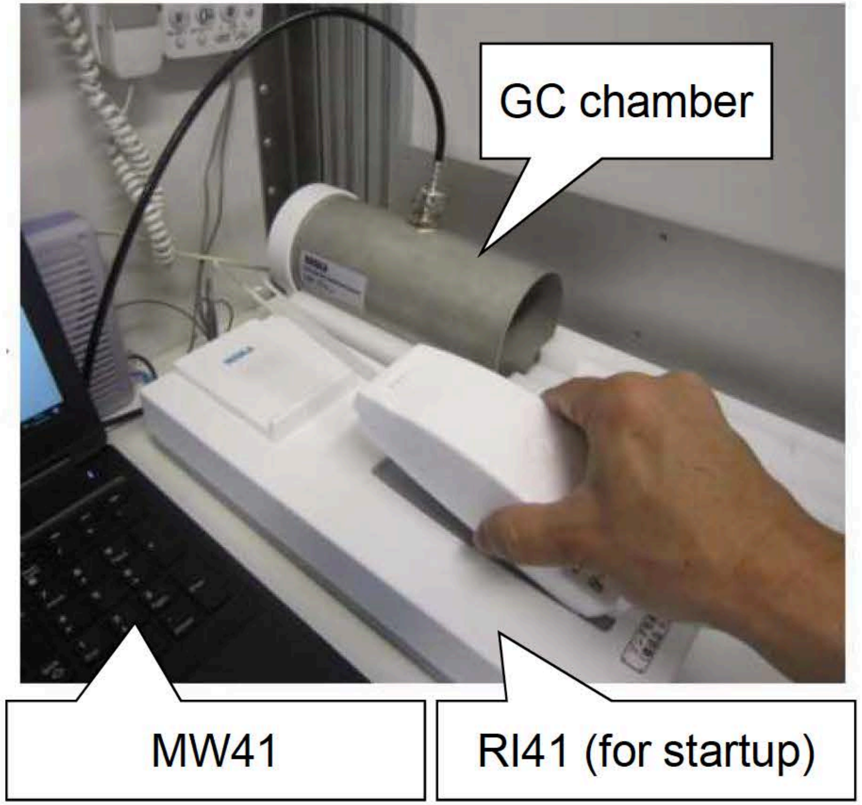
Autosonde traceability

Experiments have been proposed to achieve the future goal of "traceability" for the autosonde measurements:

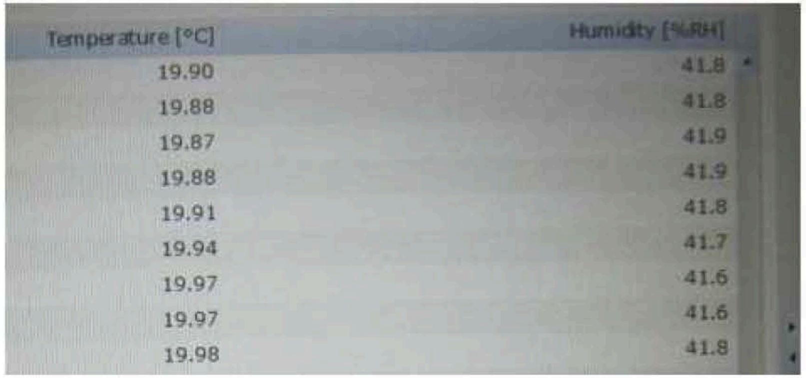
- Use of a SHC (+ a reference termometer) immediately after the manufacturer GC and prior to upload the sonde (Ruud's suggestion);
- Use of T and RH reference sensors within the autolauncher's carousel (suggestions by Holger Voemel, Larry Miloshevich and Fabio Madonna).
- Use of pre-launch data at Ny Ålesund (and possibly at other sites) to identify the best option for the traceability in the ARLs.
- JMA additional ground check.

Autosonde traceability: JMA experience

Additional GC system



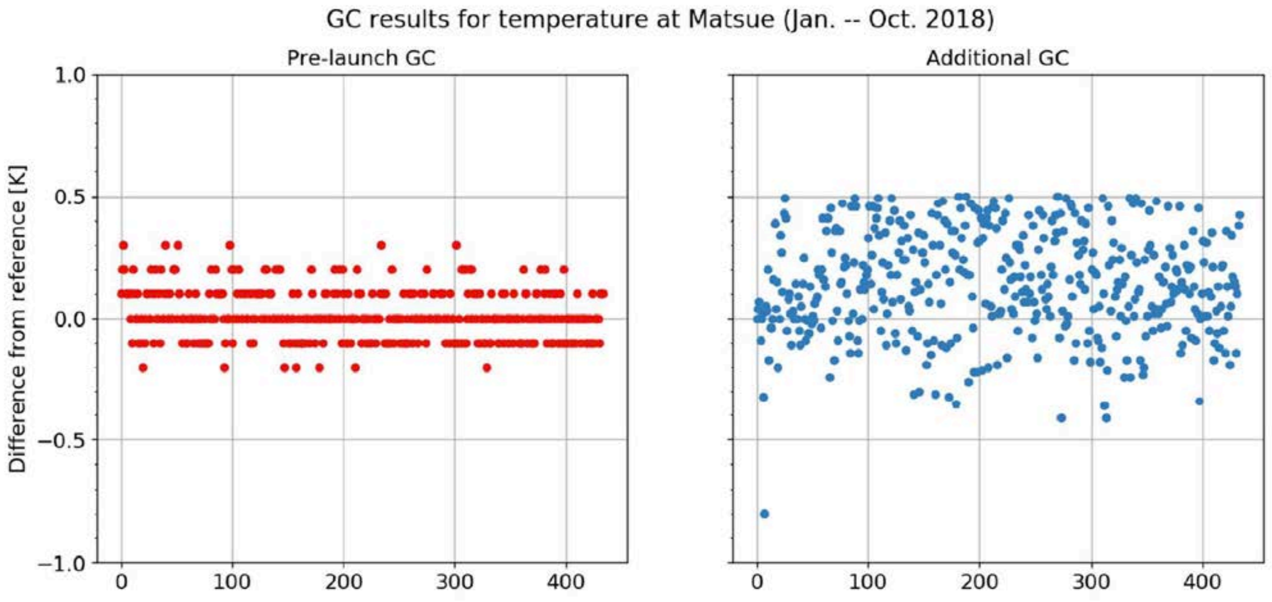
Display for Reference Sensor



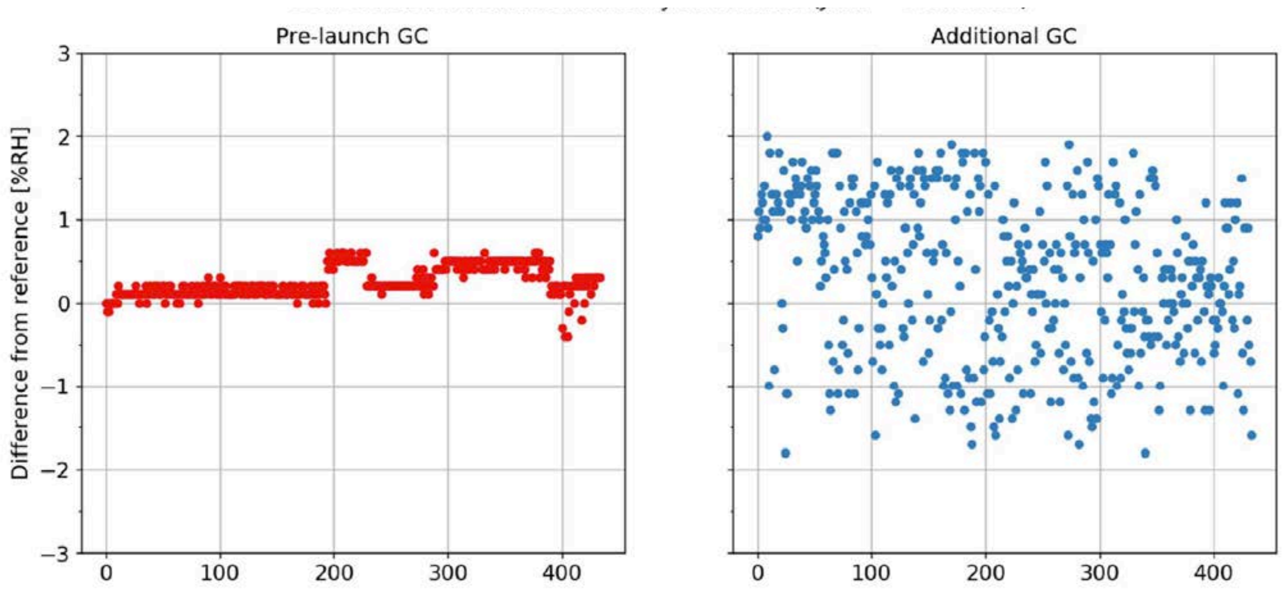
Temperature [°C]	Humidity [%RH]
19.90	41.8
19.88	41.8
19.87	41.9
19.88	41.9
19.91	41.8
19.94	41.7
19.97	41.6
19.97	41.6
19.98	41.8

Sonde data are obtained by MW41

Autosonde traceability: JMA experience



Temperature



Relative Humidity

Breakout session on Autolauncher 10:00-12:00 Wed. 22 May 2019

Participants: 16 in total

- Masatomo Fujiwara
- Rigel Kivi
- Fabio Madonna
- Damien Vignelles
- Christoph von Rohden
- Matt Tully
- Takuji Sugidachi
- Shunsuke Hoshino
- Mark Benoit
- David Edwards
- Gonzague Romanens
- Bruce Ingleby
- Hannu Jauhieinen
- Petteri Survo
- June Wang
- Ruud Dirksen

Discussion on the contents of the ARL manuscript

- The main message of the paper is that there is no essential differences in temperature and humidity data quality between manually launched and autolauncher data.
- In this first paper, we would like to cover all the three systems available on the market, nevertheless RS41 available are not sufficent yet, and we cannot wait for e.g. another one year to collect these data.
- State-of-the-art radiosonde (RS41) and its autolaunching system will be included at least considering the GC comparison. Examples already delivered by MeteoSwiss.
- Results on the implementation of manufacturer independent ground check, and others would be discussed in a follow-on GRUAN-wide community paper.
- JMA results on the balloon burst altitudes and re-launches may or may not directly be related to the autolaunching system itself. Manufacturers may want to check the text and the entire manuscript as well.
- Is the direction above appropriate or do new need for this first paper to restrict the results to Autosonde and RS92 at Sodankyla?

Steps toward the GRUAN data product (GDP) for ARL data

Issues that need to be solved toward a GDP (with publication of the required documentation):

- Launch detection issue.
- Traceability.
- Change management: not only for radiosonde type and software, but also for autolauncher type and software.

For traceability:

- Additional (manufacturer-independent) GC issue: Shunsuke Hoshino presented the additional GC specially installed on 4 JMA Autosonde systems (at non-GRUAN sites).
- Traceability: Modem is proposing to use a Rotronic sensor as the reference.
- The other experiment mentioned in previous slides may be helpful to find a solution. Need a common strategy to define and sites volunteering to carry on the experiments.

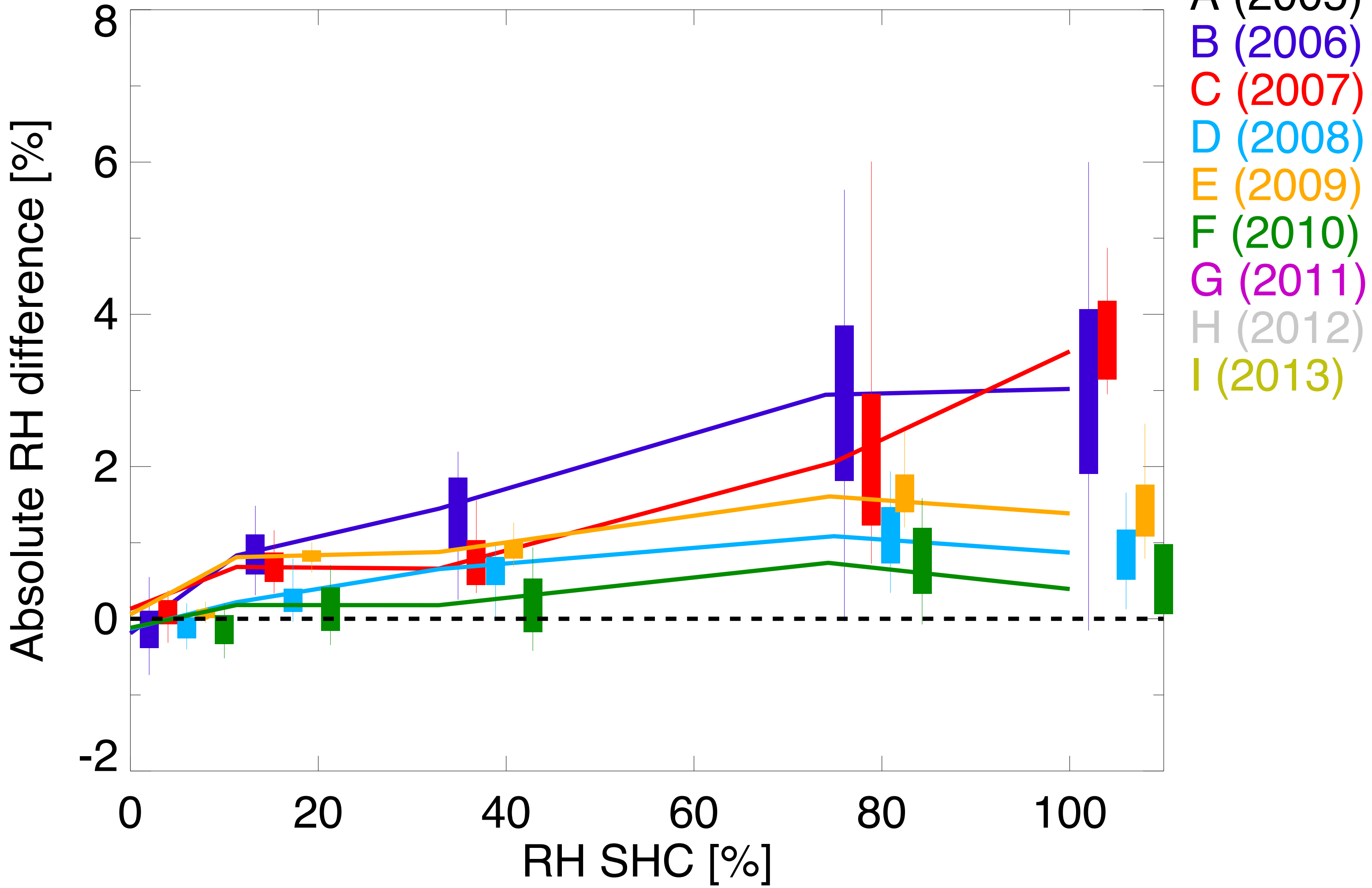
General issues surrounding manufacturer-independent GC

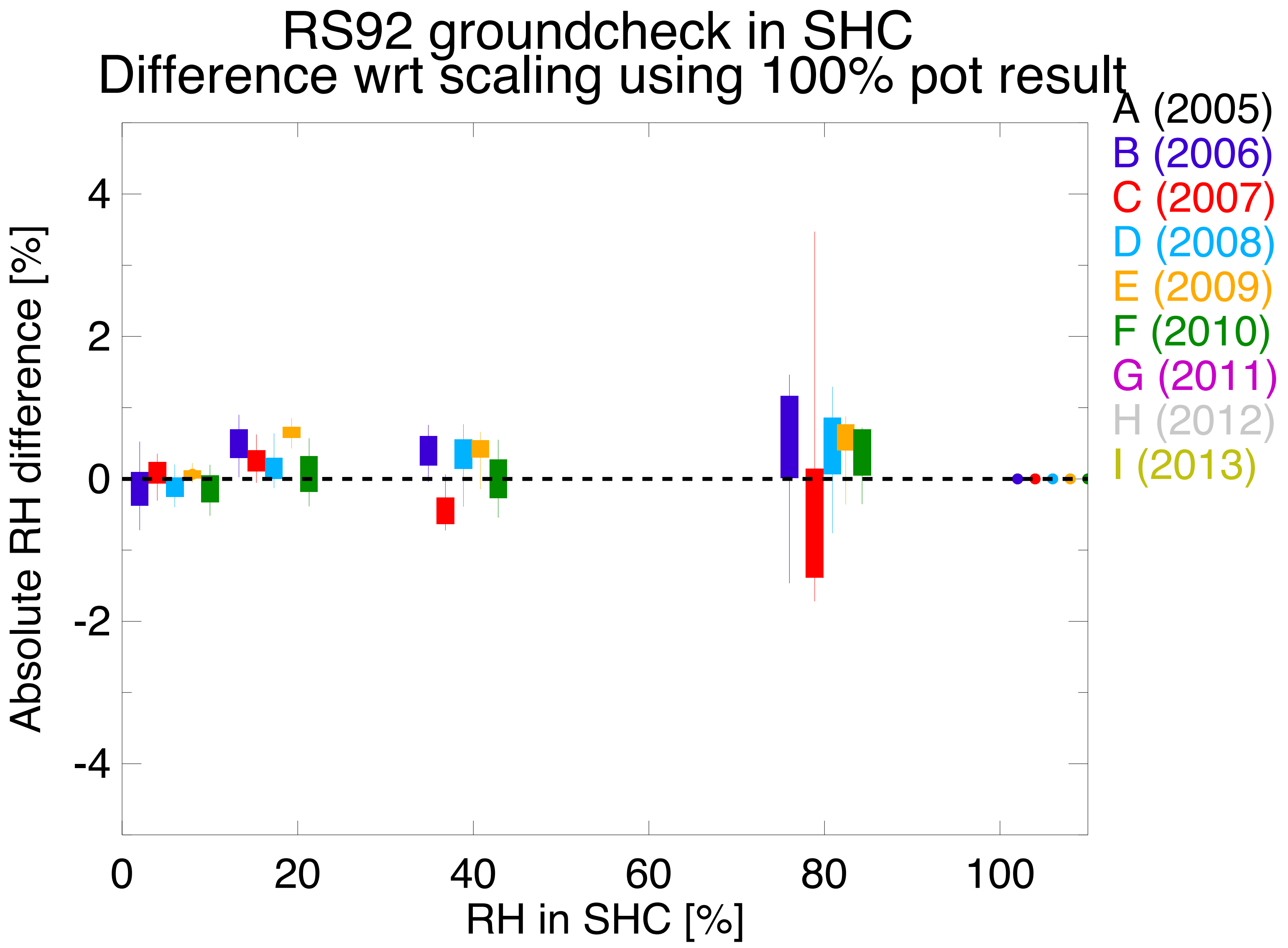
- Relaxation time issue (10 sec, 60 sec? need a guideline?).
- Ventilation issue (5 m/s needed?).
- Closed/shielded chamber with controlled air or open chamber with room air.
- Reference sensor choice: same throughout the network?
- 100%RH is must? 70%RH works? Can lower RH check be scaled? → 100%RH check shows differences much clearer than lower RH and 0%RH.
- The current use of this GC? → only for check, not for data correction; but, in the future it may be used for correction.
- The batch information for each sensor (temperature sensor or humidity sensor), rather than that for radiosonde would be more useful because the production of sensors and assembling to a radiosonde are different in timing.

CIAO from Dian Seidel

BACK-UP SLIDES

RS92 groundcheck in SHC





RS92 groundcheck in SHC
Difference wrt scaling using 100% pot result
A (2005)
B (2006)
C (2007)
D (2008)
E (2009)
F (2010)
G (2011)
H (2012)
I (2013)
Absolute RH difference [%]
4
2
0
-2
-4
0
20
40
60
80
100
RH in SHC [%]

Modem Experiment: reccommendations

1. Try to reduce the time gap between the two launches as much as possible (must be almost simultaneous).

2. Balloon filling should be well calibrated to avoid strong differences between the ascent speed of the two ballons (the use of inflation kit for the manual launch may help, unless you are already using it).

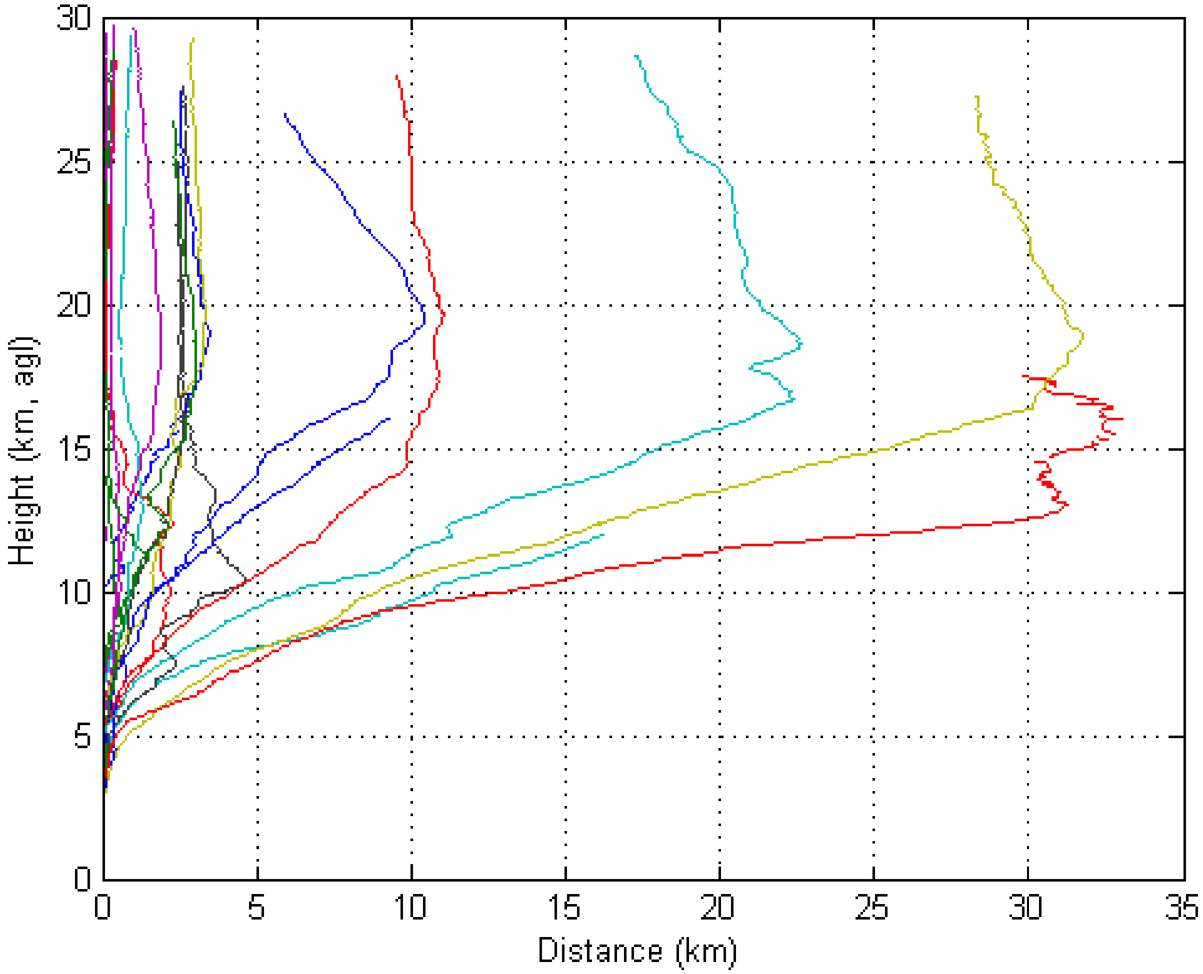
3. Collect as many metadata as possible, like comparisons with external references (e.g temperature probe or SHC).

4. Collect also descent data, if possible.

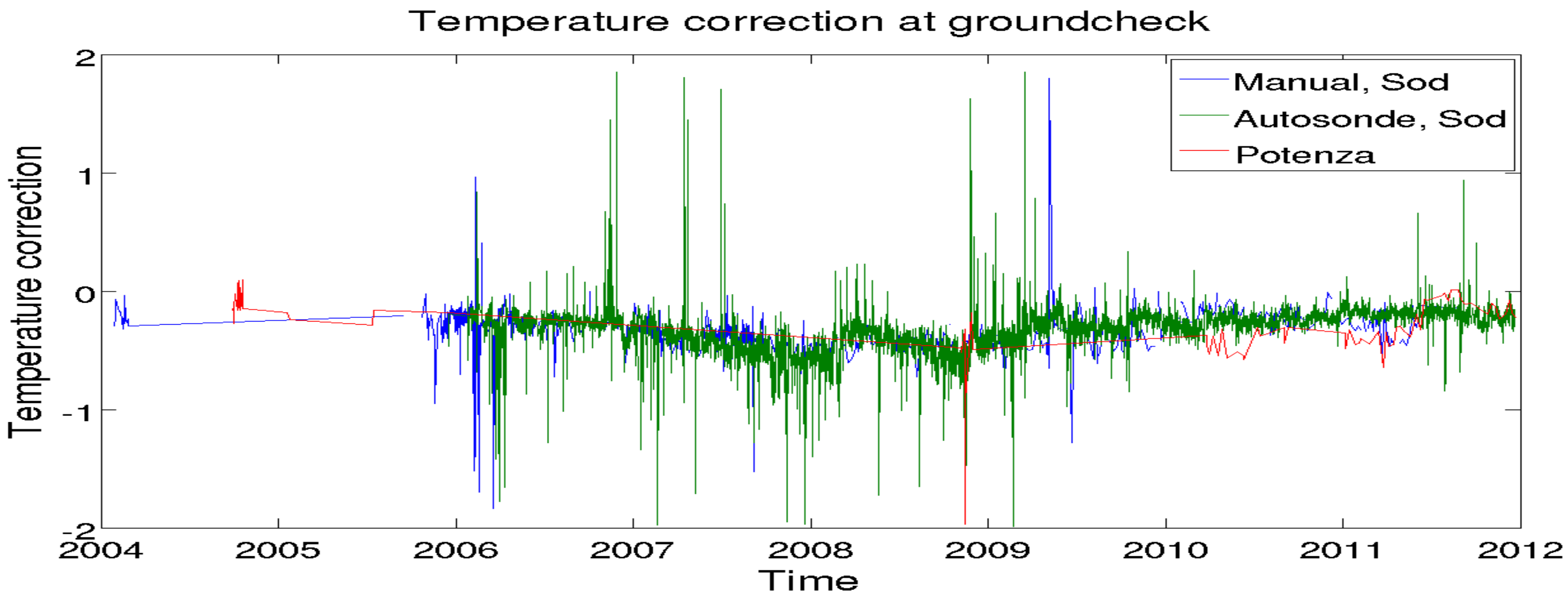
5. Another nice experiment could be to have at least a couple of autosonde launches vs a dual soundings (using three sondes in total).

Measurement performances: parallel soundings

Modem

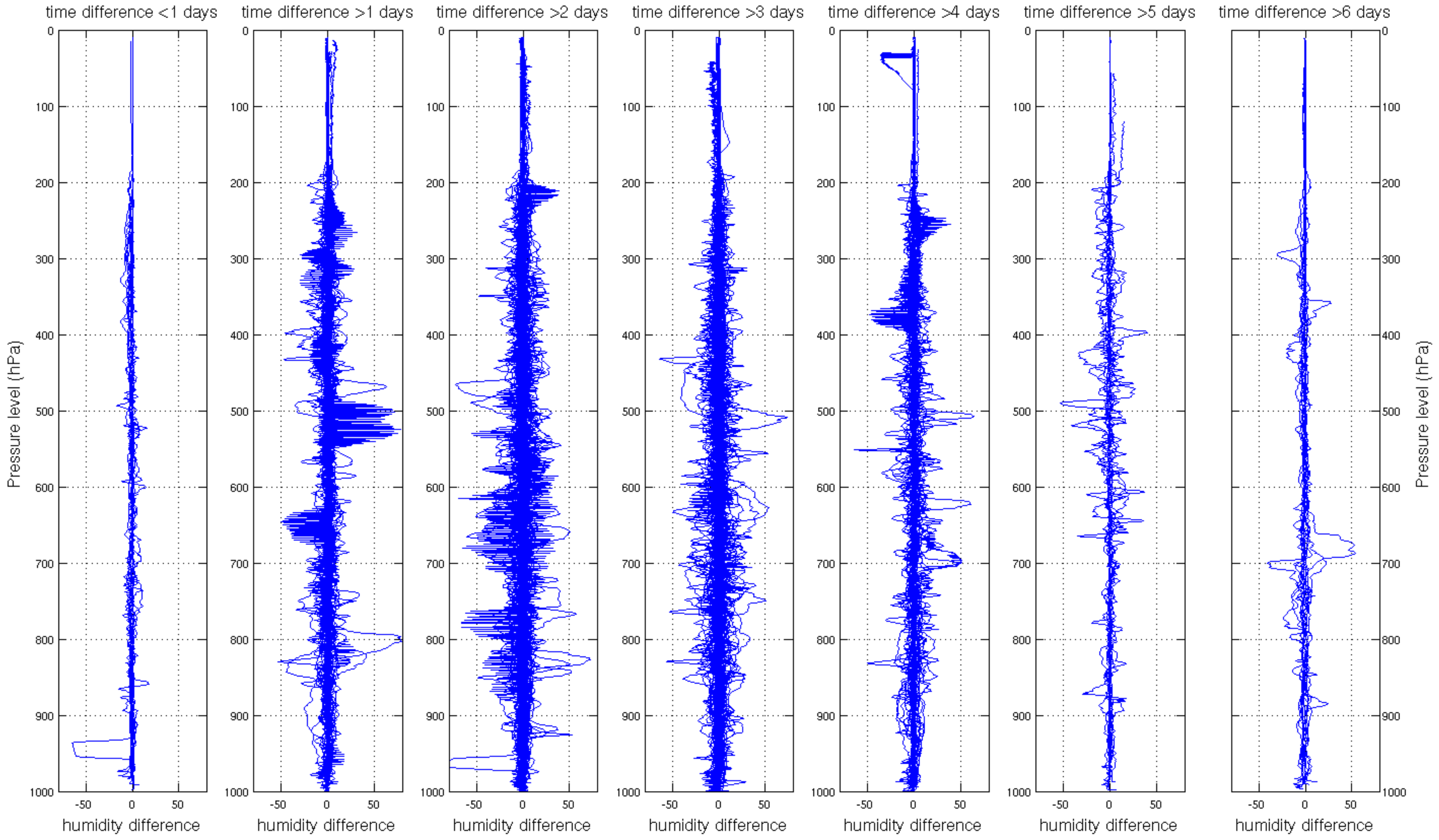


Stability and ground calibration



Time series of the temperature correction applied during the GC procedure for the RS92 sondes launched at Sondankyla, both manually (blue line) and automatically (green line), and at Potenza (red line) from 2004 to 2012 with a more intensive sampling since 2006.

Stability and ground calibration



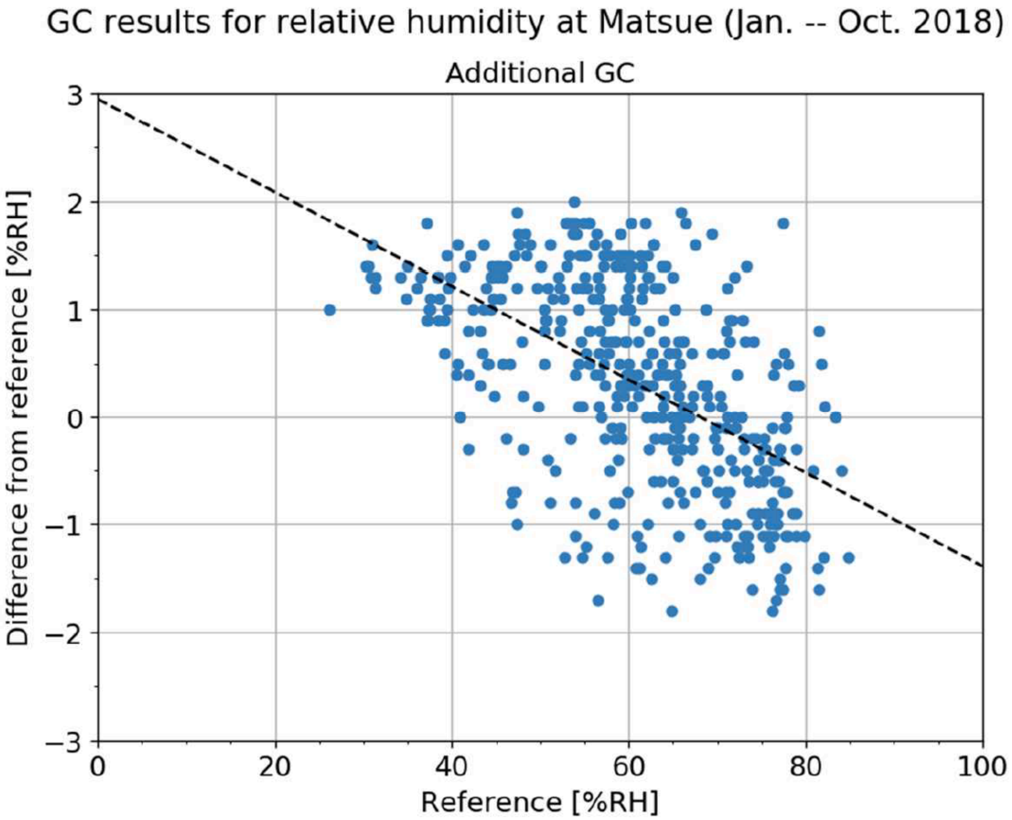
No significant biases

Increase in the variability from 2^{nd} day to 6^{th} day.

Vertical profiles of the difference in the RH measured with the manual and automatic system in Sodankylä as a function of the time period between ground check and launch; form the left to the right, the time period increase from 1 to 6 days.

Autosonde traceability: JMA experience

Issues of RH error in additional GC



Error seems to depend on RH

Time	ΔT	ΔU
1	0.27	0.90
2	0.26	1.80
3	0.21	0.40

Error of RH varies by each comparison with the same radiosonde (N5020002)
-> The characteristics of RH sensor changes by reconditioning?

Proposed experiments

- Use of a SHC (+ a reference termometer) immediately after the manufacturer GC and prior to upload the sonde (Ruud’s suggestion);
- Use of T and RH reference sensors within the ASR carousel (suggestions by Holger Voemel, Larry Miloshevich and Fabio Madonna).

Other aspects or dataset to investigate:

- In some cases a bubble of dry, warm air from the Modem Robotsonde affects results for the first few decametres
- For radiosondes without a pressure sensor care is needed to supply the software with an accurate local pressure measurement and its height at the launch time.
- Investigation of pre-launch data at Ny Ålesund (and possibly at other sites) by M. Sommer for thinking about how to achieve the traceability in the ARS system for the near future.
- New experiment for Modem at Trappes station: suggestion or recommendations? Can we come up with a joint strategy aiming at assessing the most critical aspect for ARLs?