The Meisei sonde data product

- Progress and plans -

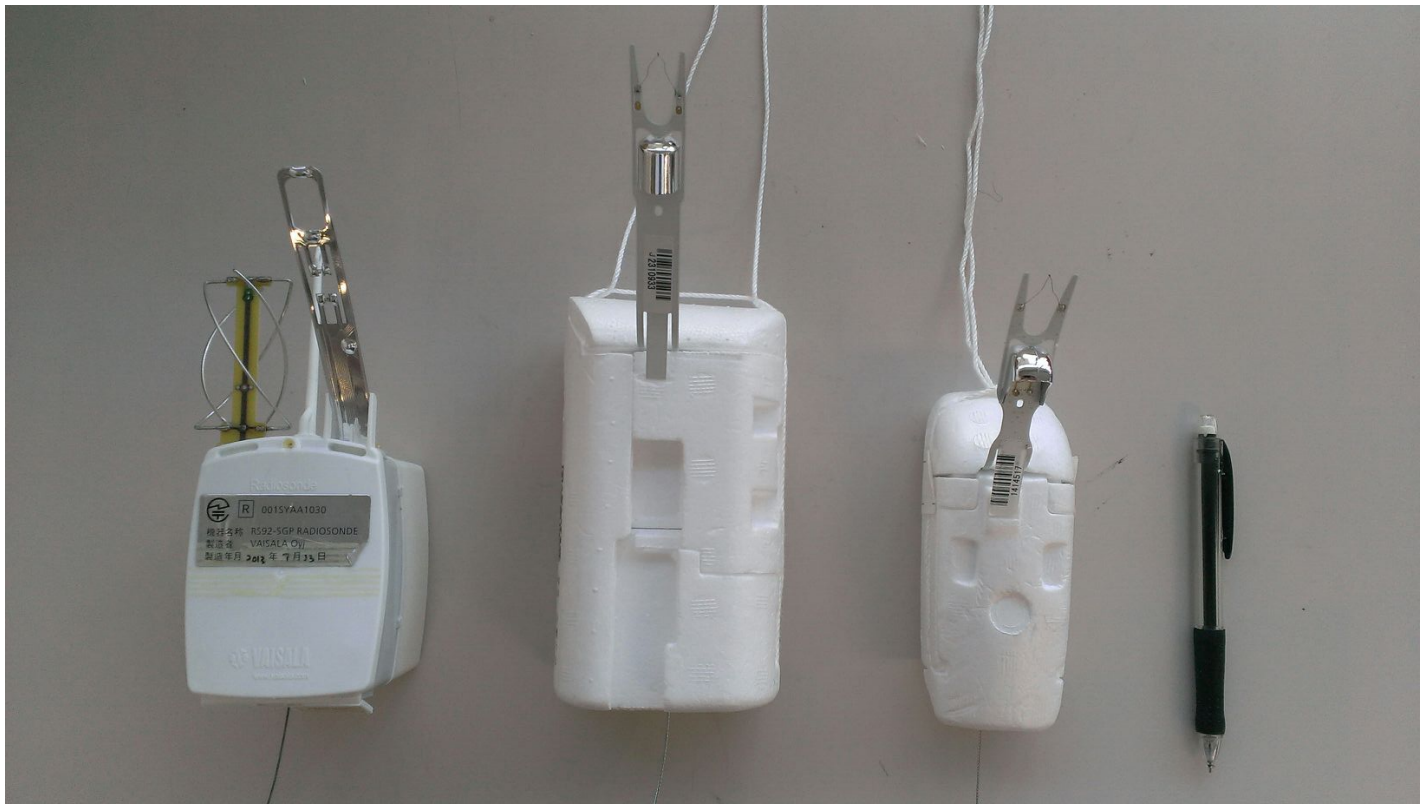
- February 24, 2015 -

Nobuhiko Kizu (Tateno/JMA HQ)

Overview

- 1. Outline of Meisei radiosondes
- 2. GRUAN Data Product for Meisei radiosonde
  - Outline of Technical note
  - Temperature and humidity correction algorithm
- 3. Comparison with other sonde
- 4. Progress of GDP and schedule
- 5. Action in the future

1. Outline of Meisei radiosonde (RS-11G / iMS-100)



(RS92-SGP) RS-11G iMS-100

JMA Requirements for procurement to radiosonde - For damage reduction by falling radiosonde

Item	RS92-SGP D Previously used	JMA requirements	RS-11G	iMS-100
Volume	410 cm^3	<1000 cm^3	893 cm^3	262 cm^3
Weight	160g	< 180 g	85 g	38 g
Terminal velocity (Only sonde)	>20m/s	<12m/s	9m/s	9m/s
Radiosonde housing	Rigid plastic	Nonrigid plastic	Polystyrene foam	Polystyrene foam
Impact force	>2000N (measured)	<850N	604N (Calculated)	330N (Calculated)
Strings	15m	10m	10m (JMA only)	10m (JMA only)
Weight of unwinder	14 g	More lightweight	12 g	12 g

RS92-SGP (Vaisala)

For safety !

RS-11G (Meisei)

iMS-100 (Meisei)

Performance of RS-11G and iMS-100 Hardware

Item	RS92-SGP D Previously used	RS-11G	iMS-100
D-GPS method	GBAS	SBAS	
Barometer	Silicon	dismounted	
Temperature sensor (time-constant)	Capacitive wire 1000 hPa : < 0.4s 100 hPa : < 1s 10 hPa : < 2.5s (6m/s flow)	Thermistor 1000hPa : 0.374s 100hPa : 0.94s 10hPa : 2.36s (6m/s flow)	
Humidity sensor (time-constant)	Thin-film capacitor +20 °C : <0.5s - 40 °C : <20s (6m/s, 1000 hPa)	Thin-film capacitor +20 °C : 0.03s - 40 °C : 4.99s (5m/s, 1000 hPa)	

2. GRUAN Data Product for Meisei radiosonde (RA-11G/iMS-100)

- Outline of Technical note -

Technical note contests

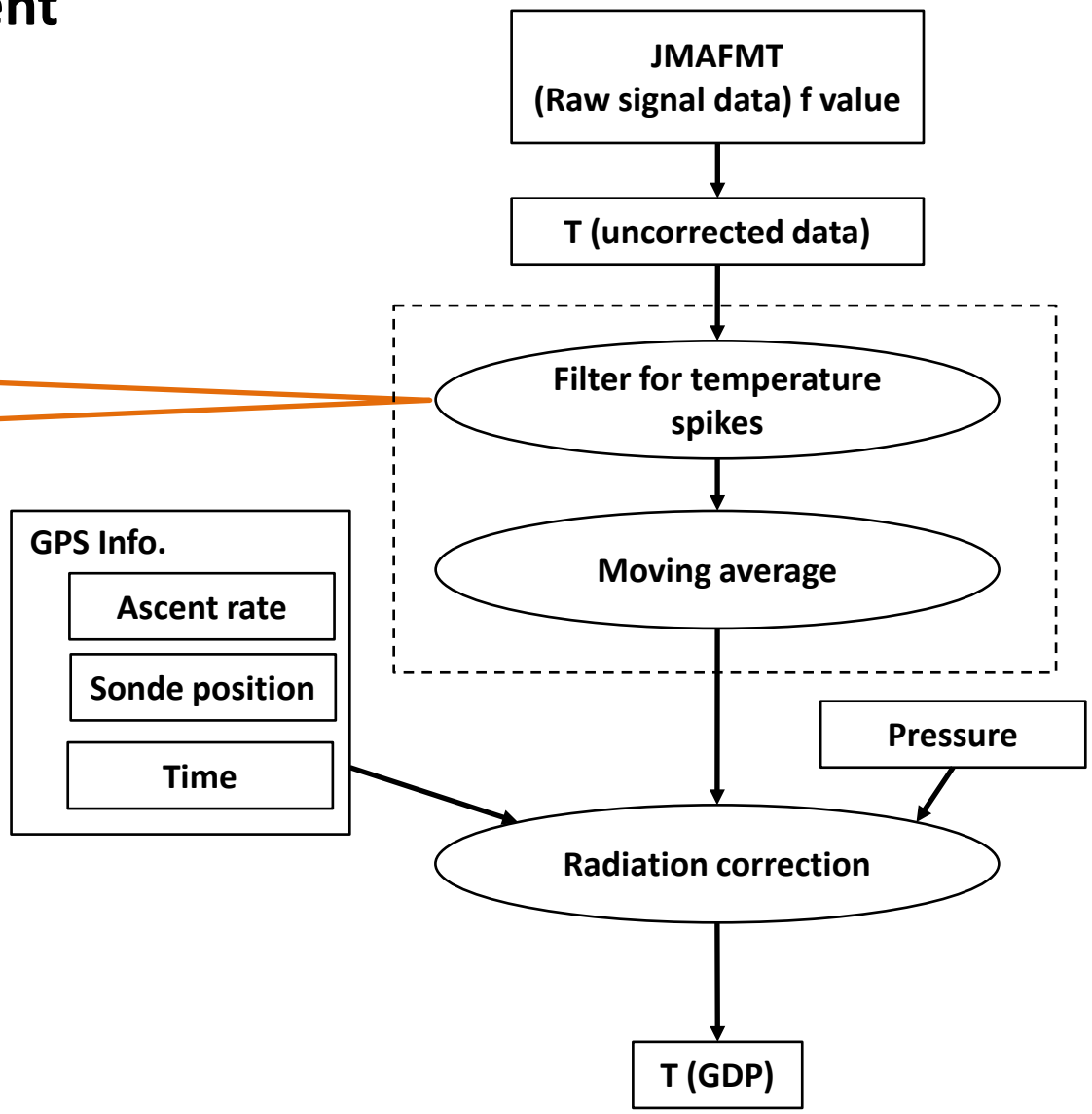
2. GRUAN Data Product for Meisei radiosonde (RA-11G/iMS-100)

Temperature and humidity correction algorithm for GDP

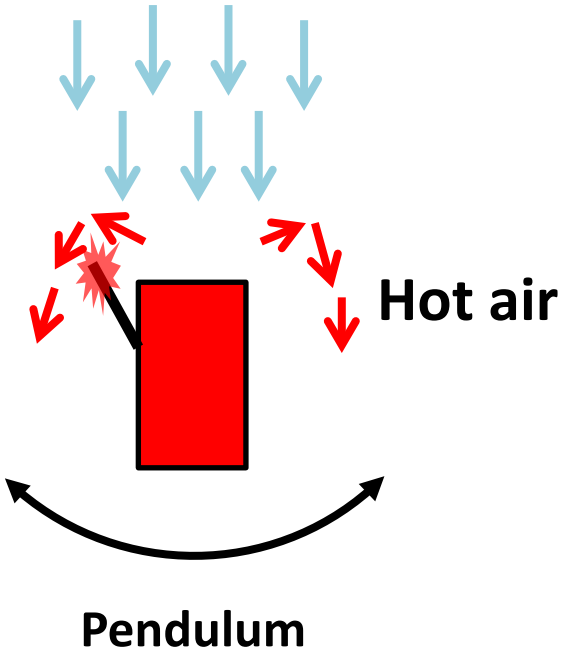
Temperature Measurement

Correction 1

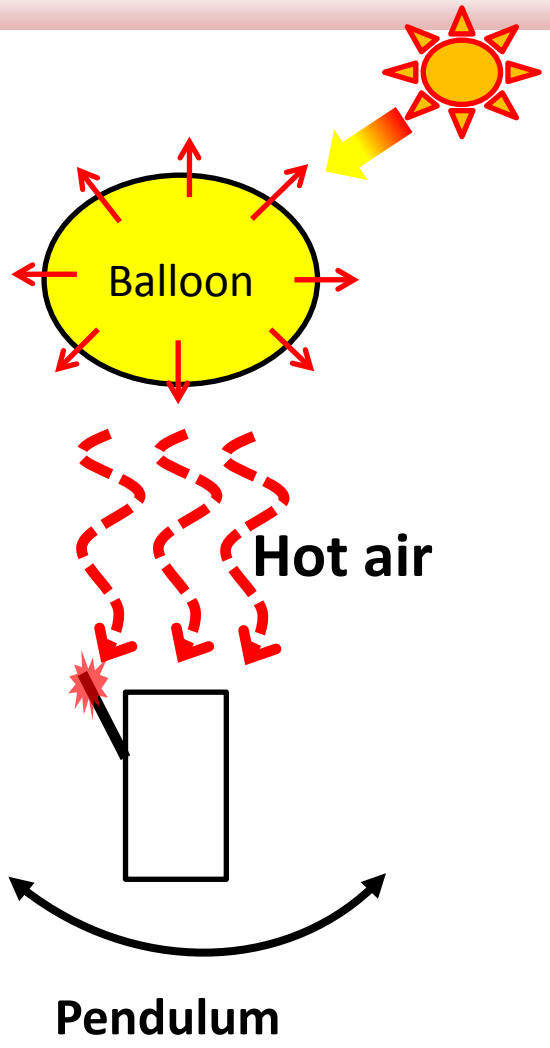
Heat Spike removal



Factor of Heat spike

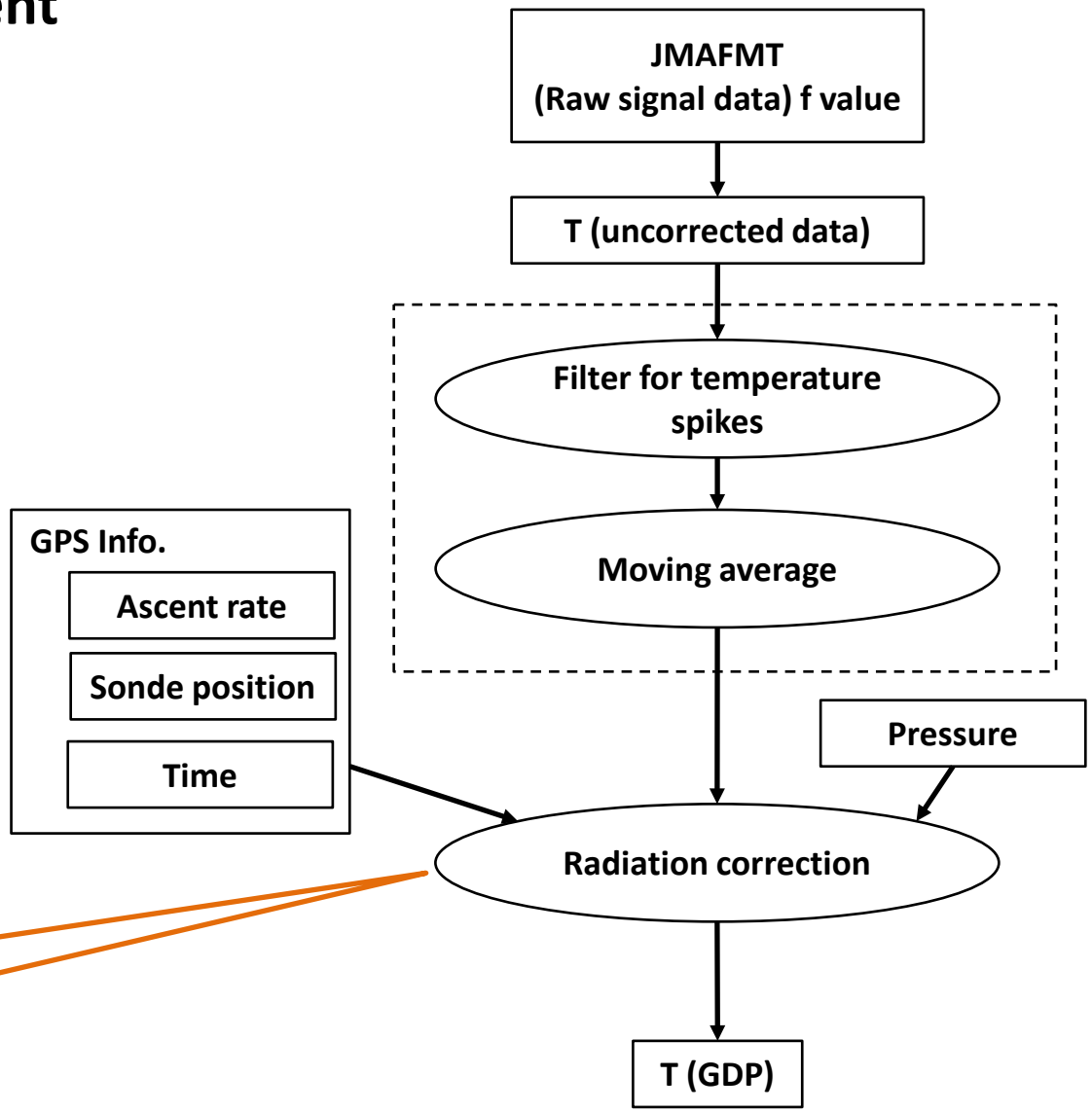


Case 1 : Heat pulse



Case 2 : Balloon's slipstream

Temperature Measurement



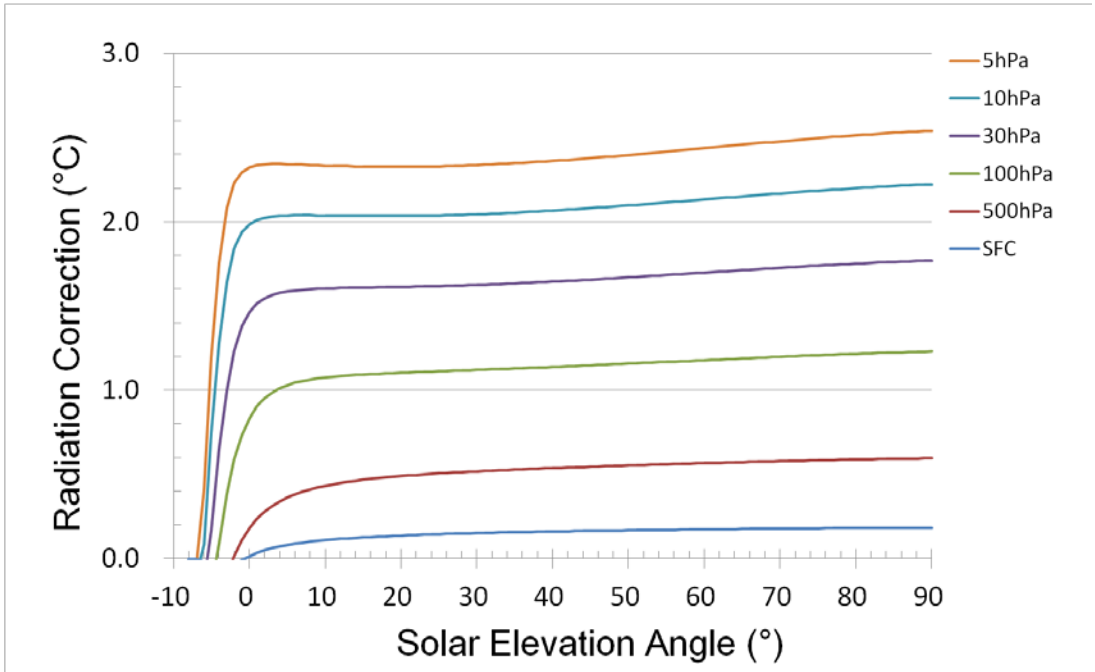
Correction 2

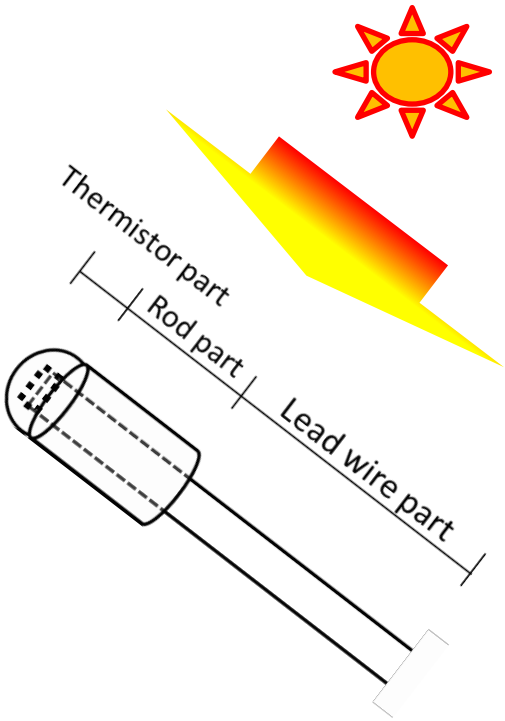
Radiation Correction

T correction 2 : Radiation Correction

Amount of radiation correction on the sensor parts, obtained by solving the differential equation of heat balance in consideration of the heat transfer between the heat exchange and parts of the surrounding air.

In JMA, find the amount of heat that received at three parts (part of sensor, rod and lead) by the theoretical formula.

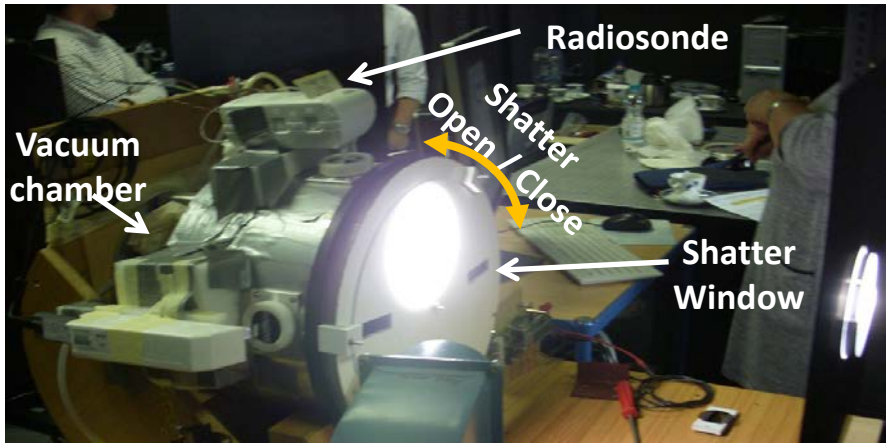




Radiosonde Thermistor

Verification of radiation correction (1)

Lindenberg experiments (Oct 13, 2014)



Experiment condition

Pressure Level [hPa]

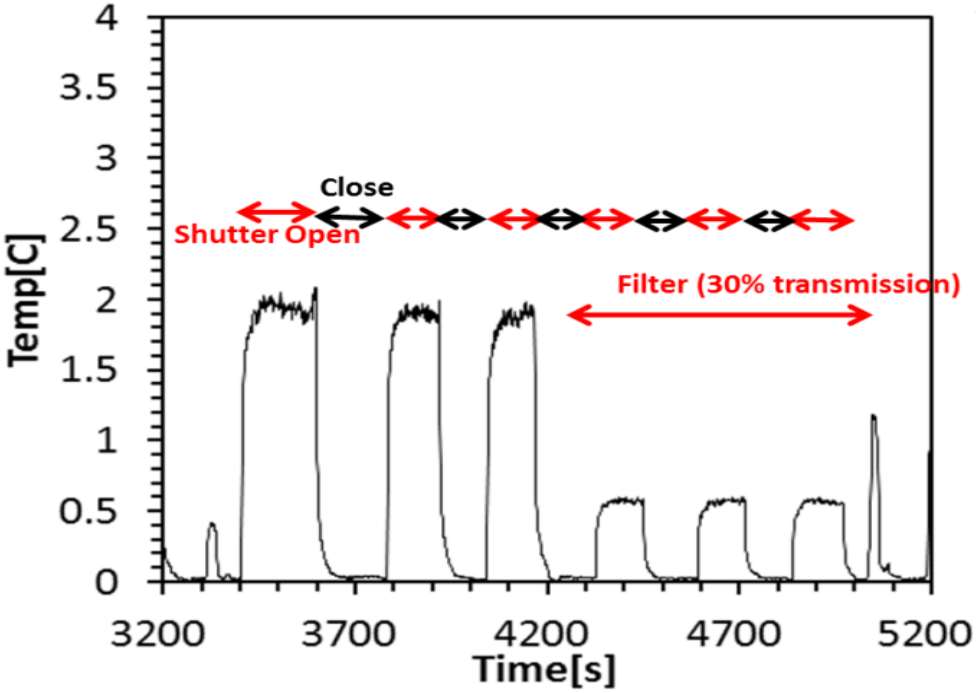
5, 10, 30, 100, 300, 900hPa

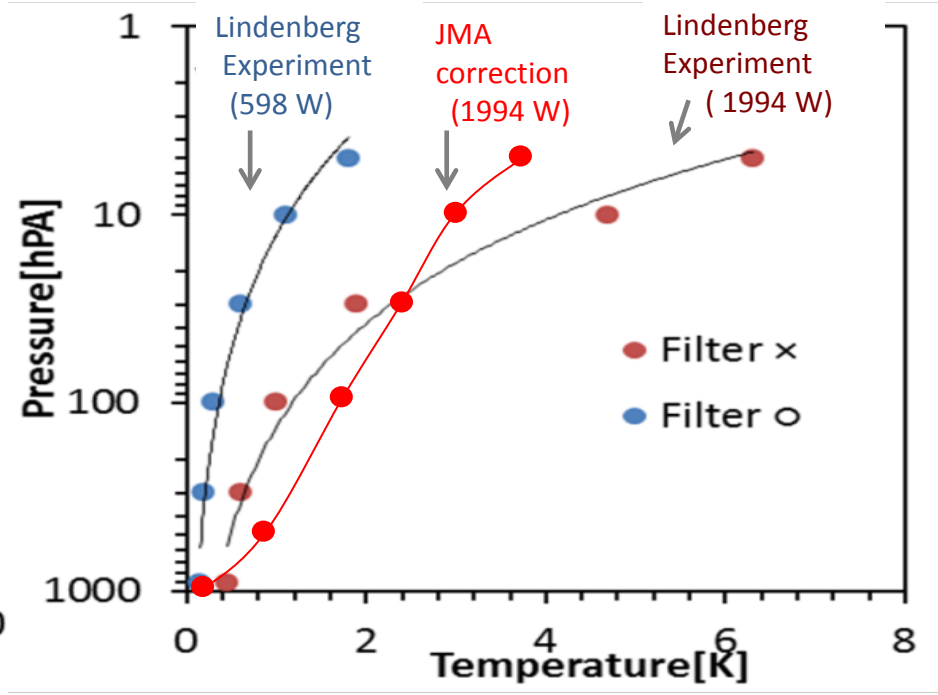
Xe Lamp [W]

0 W (shatter close)

598 +/- 0.6 W (shatter open / use ND filter)

1994 +/- 2.0 W (shatter open / no ND filter)

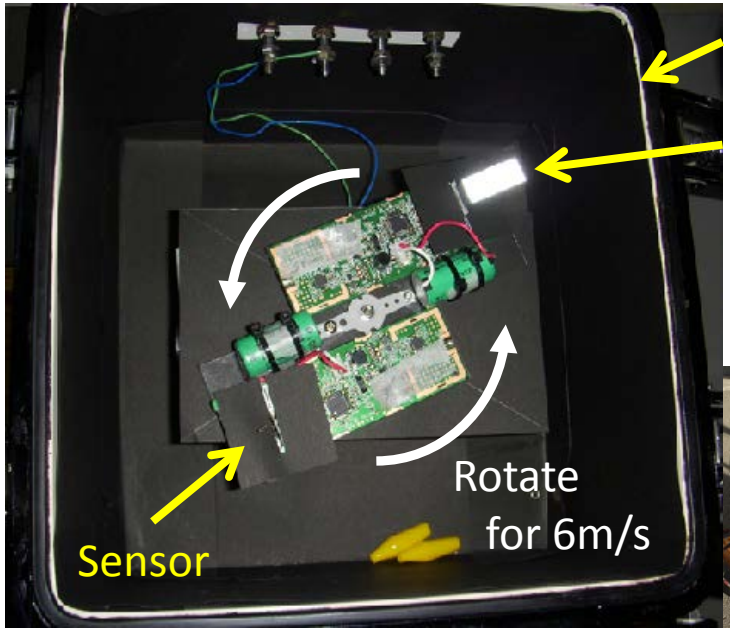


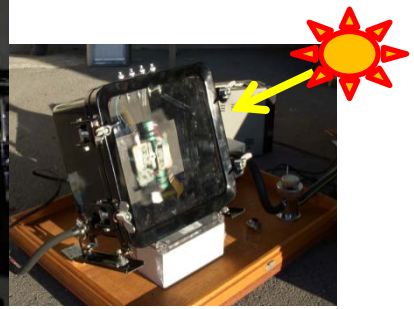


Why?
Amount of JMA correction and the L/C experimental results were different about 1K in 10hPa.

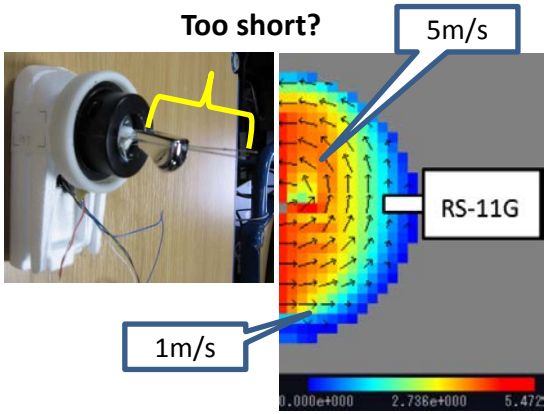
Maybe?
RS-11G sensor boom is so short, prescribed wind speed (5m/s) was not obtained?

Re-experiment in Japan





Too short?



Flow distribution in the chamber

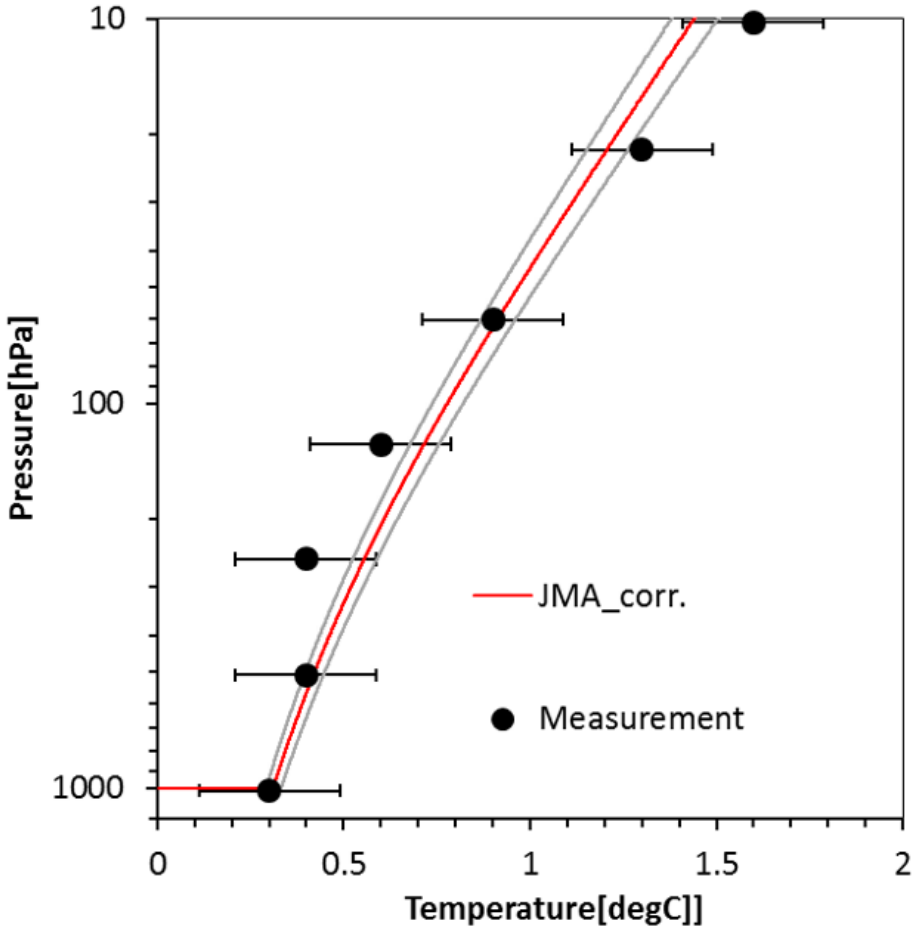
Experiment condition

Pressure Level [hPa]
10, 20, 60, 125, 250, 500 1017hPa

Sun light
1069.9W/m^2

sensor speed
6m/s

Experimental result



Error bars show uncertainty derived from the calibration of the thermistor (k = 2).

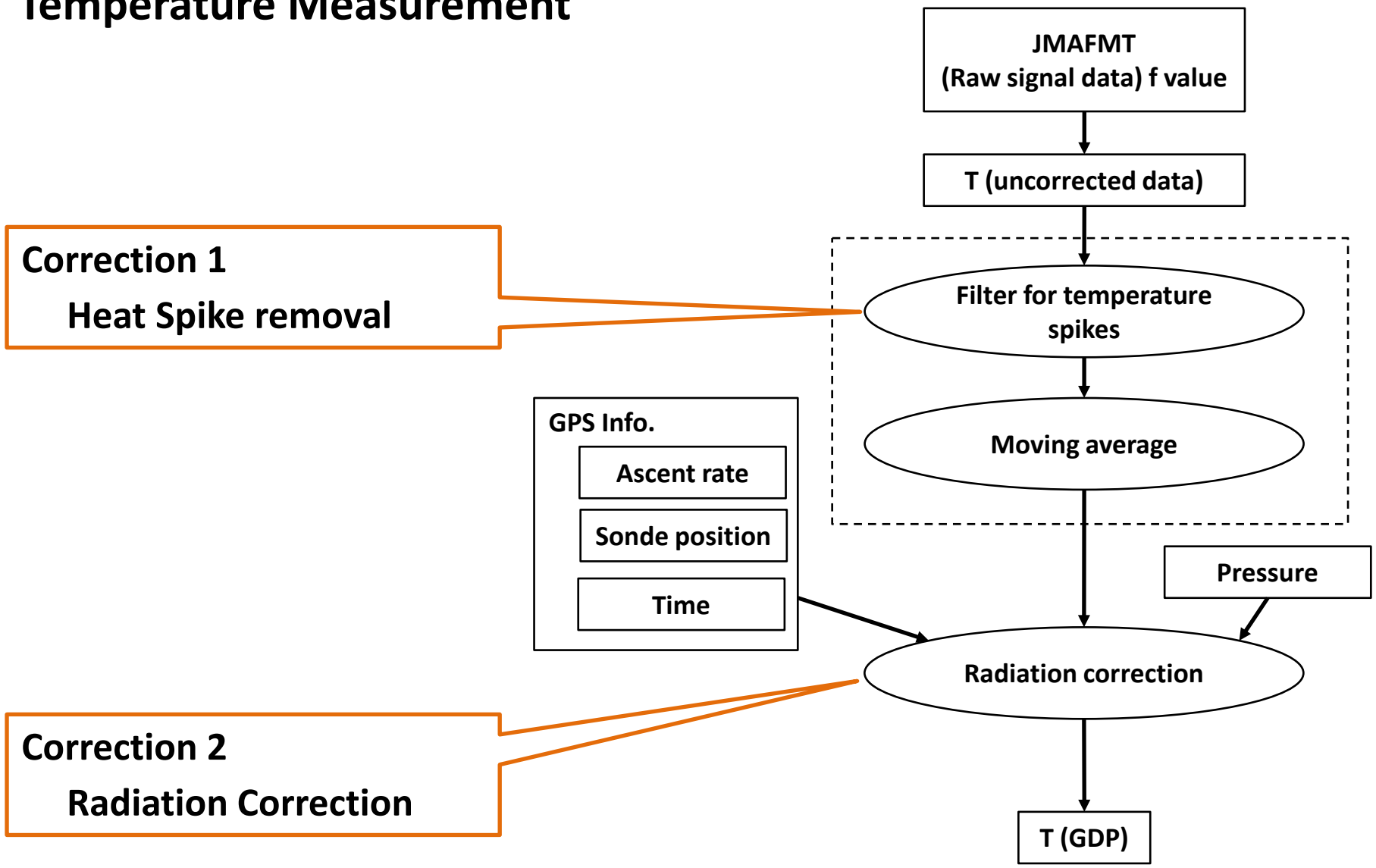
Red line : JMA radiation correction amount

Gray line : uncertainty of JMA radiation correction

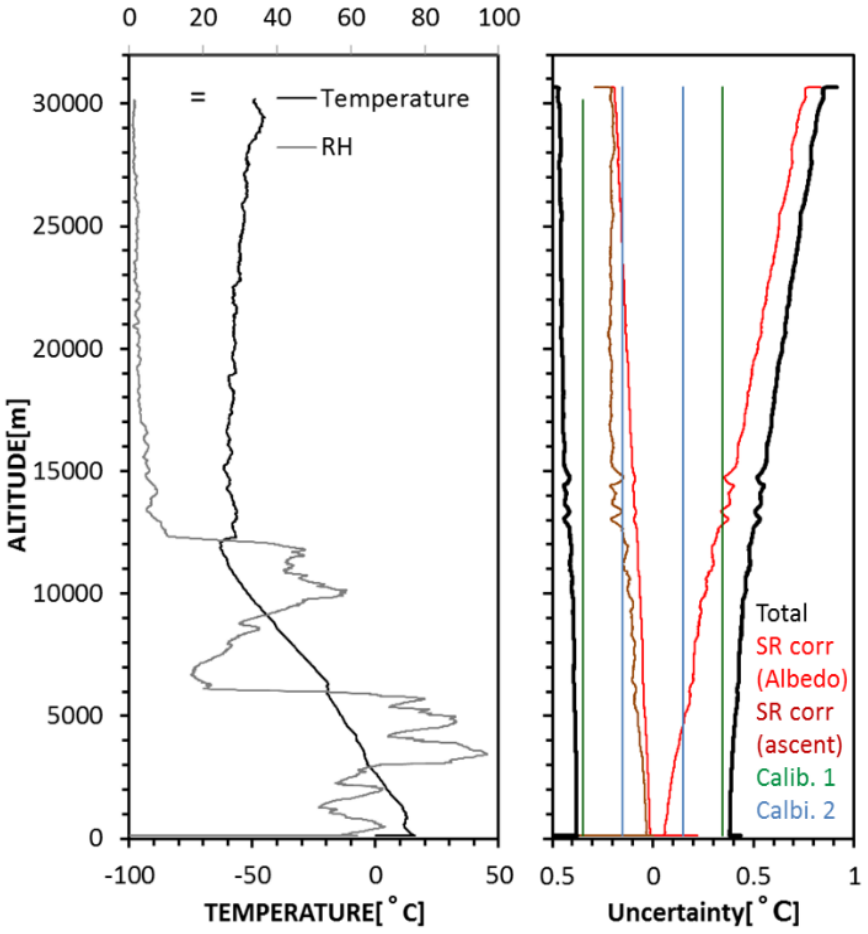
<- This uncertainty is derived from the uncertainty of the amount of solar radiation and uncertainty of wind speed measurement.

JMA radiation correction is the experimental results and match within the range of uncertainty.

Temperature Measurement



Temperature uncertainty

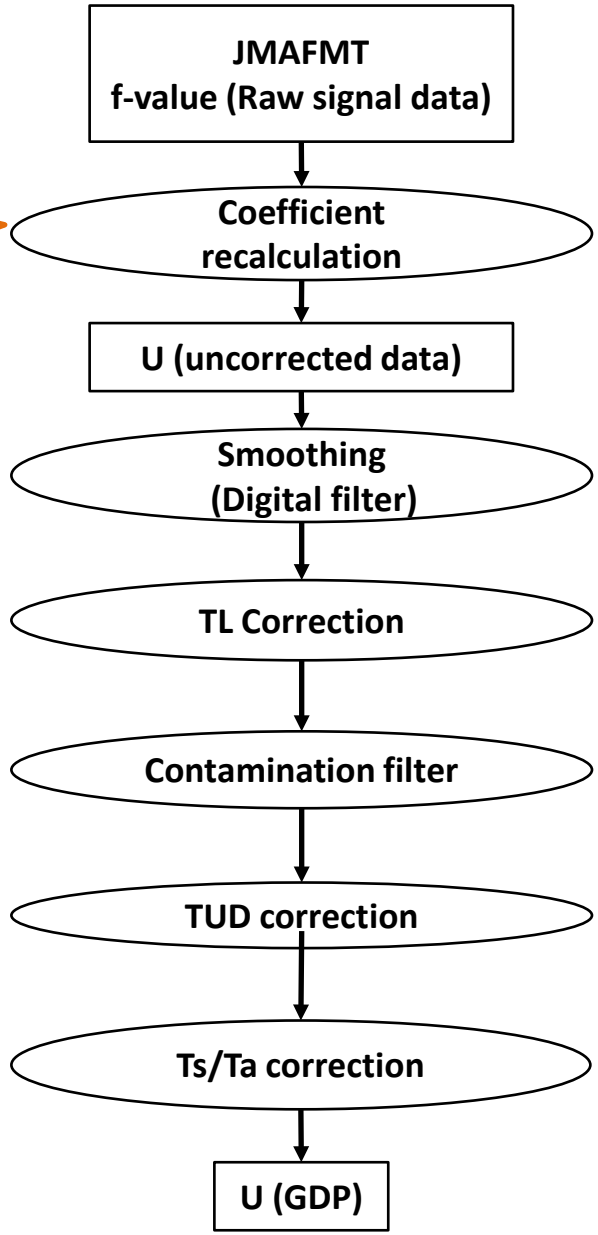


Parameter	value	Corrected
Thermistor calibration	0.3/2√3	-
Variability in calibration chamber	0.13/2√3	-
Solar radiation (albedo)	$\lvert I_{clear} - I_{cloudy} \rvert / 2\sqrt{3}$	Corrected
Solar radiation (ventilation)	ΔT (Ascent rate +3 m/s)/√3	Corrected
Heat spike	0	Uncorrected

(e.g. 07 Oct. 2014 14:00LT at Lindenberg experiment)

Humidity Measurement

Correction 1
Recalculate the conversion coefficient of humidity by result of SHC



Humidity conversion equation

$$u = B0 + B1 \times f + B2 \times f^2 + B3 \times f^3$$

U : humidity
B0, B1, B2, B3 : coefficient
F : humidity frequency of radiosonde (Raw signal data)

At the Manufacturer

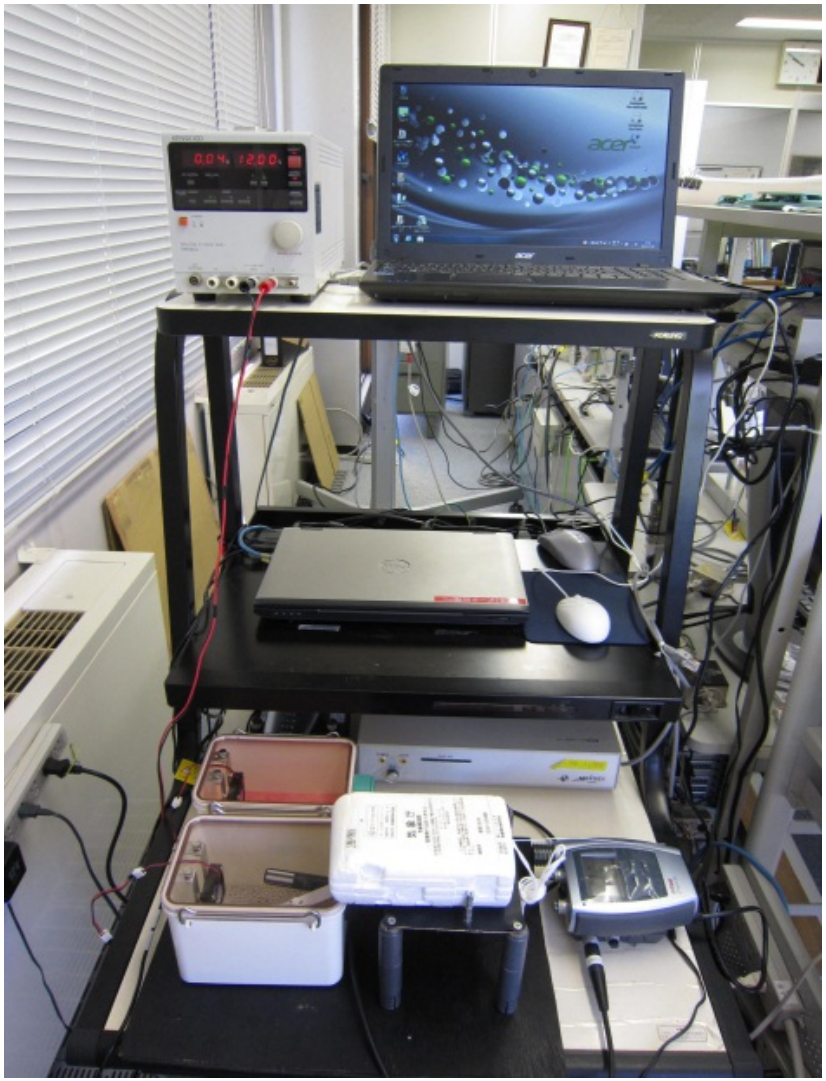
Ref Instrument (Humidity)	(100%)	95%RH	90%RH	70%RH	50%RH	30%RH	15%RH	(0%RH)
Radiosonde Signal Freq. (=capacitance)	(Extra-Polation)	Freq. 1	Freq. 2	Freq. 3	Freq. 4	Freq. 5	Freq. 6	(Extra-Polation)

Create a coefficient of humidity (cubic equation) by the 6 calibration points!

In Tateno GDP, manufacturer data plus SHC data (0%RH,100%RH) used.

Ref Instrument (Humidity)	97%RH	95%RH	90%RH	70%RH	50%RH	30%RH	15%RH	0%RH
Radiosonde Signal Freq. (=capacitance)	Freq.0 (SHC)	Freq. 1	Freq. 2	Freq. 3	Freq. 4	Freq. 5	Freq. 6	Freq.7 (SHC)

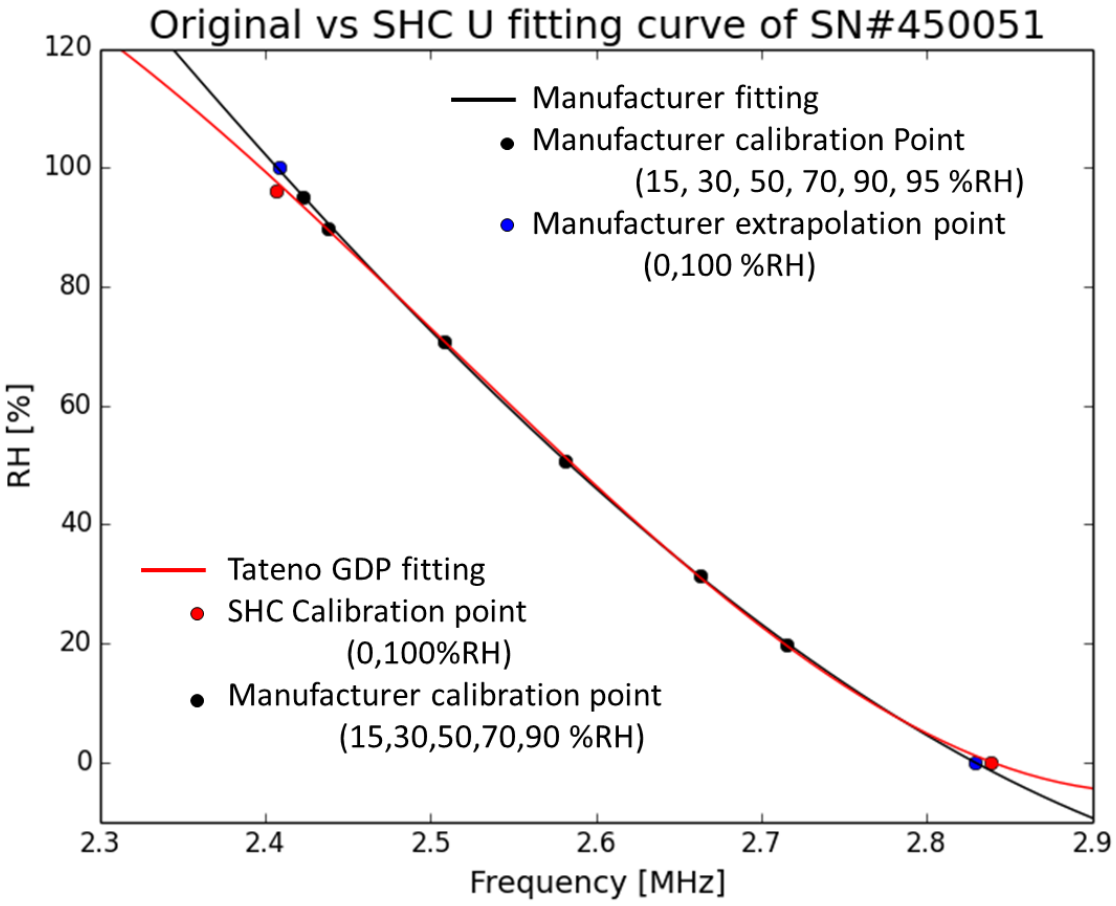
Create a coefficient of humidity (cubic equation) by the 8 calibration points!



Entire state of the SHC system

SHC chambers

The SHC used in Tateno



Comparison of the original fittings and GDP fitting (SHC use)

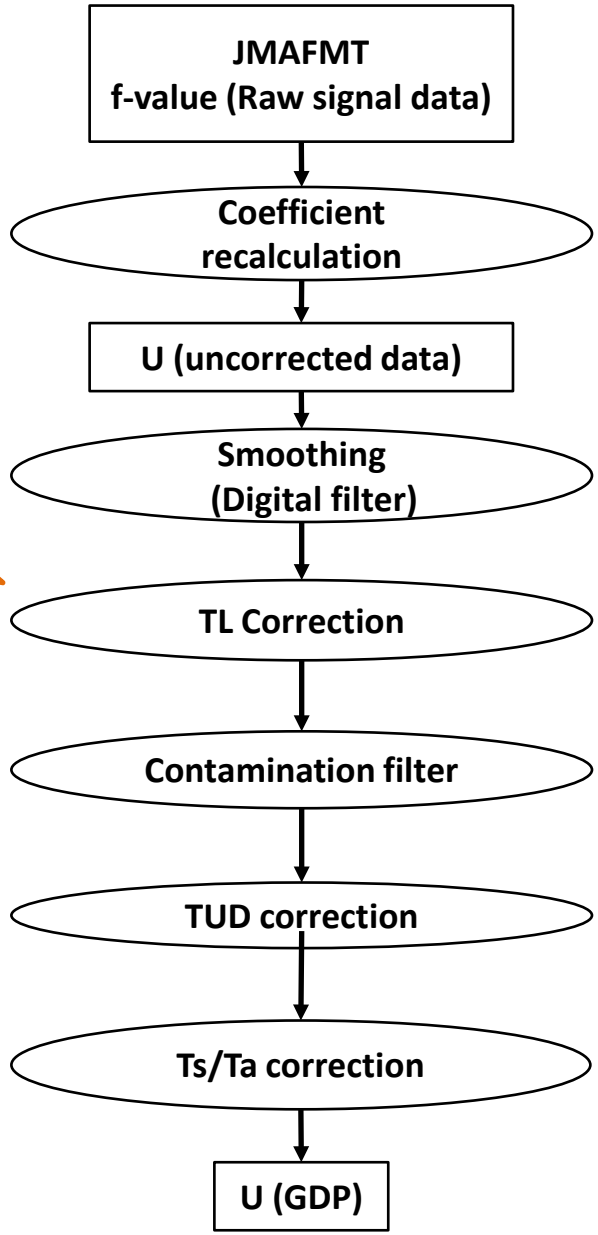
GDP fitting error is smaller than original fitting.

e.g. S/N 450051	100%RH	70%RH	50%RH	30%RH	0%RH
⊿obs.（Original fitting - Reference）	4.03%	-0.38%	0.14%	-0.17%	-1.40%
⊿GDP（SHC + Original fitting - Reference）	1.51%	0.13%	0.68%	-0.29%	0.08%

Humidity Measurement

Correction 2

Time Lag correction



Time lag correction (correction of the time constant delay)

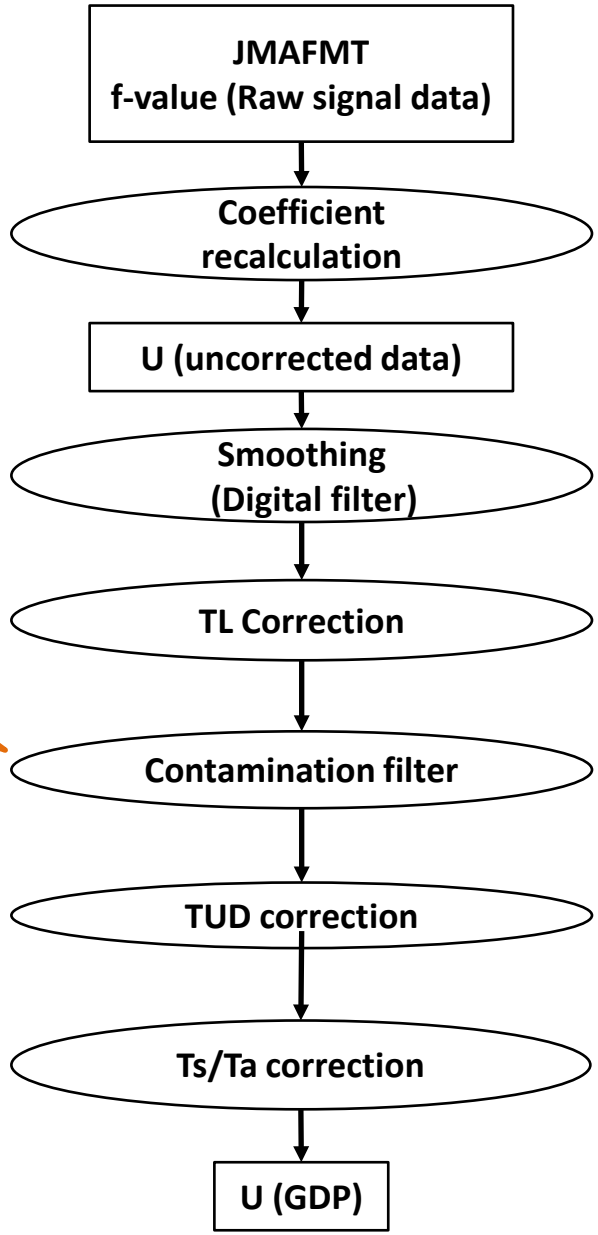
Time constant of the humidity sensor, tends to be slow with decreasing temperature.
→ humidity profile is smoothed (low-temperature range)

To correct the time constant delay, implement a time constant delay correction (as the following equation (Miloshevich et al.(2004))

$$U_1(t) = \frac{U_0(t) - U_0(t-\Delta t)e^{-\frac{\Delta t}{\tau(T)}}}{1 - e^{-\frac{\Delta t}{\tau(T)}}}$$

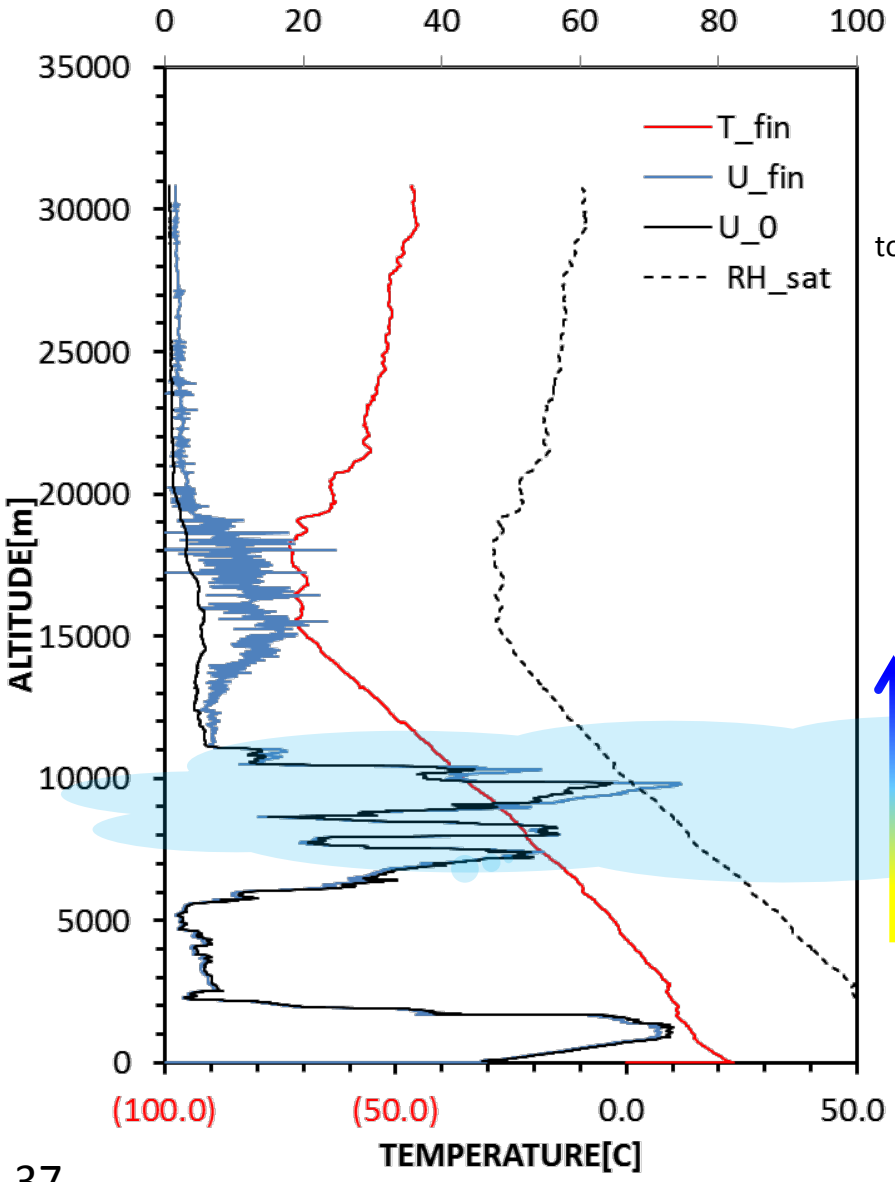
$U_1(t)$ **: The value of RH after the TL correction**
$U_0(t)$ **: The value of RH before the TL correction**
Δt **: time interval (sampling rate)**
$\tau(T)$ **: the temperature of the humidity sensor**

Humidity Measurement



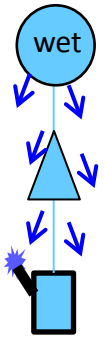
Correction 3

Moist air Contamination removal



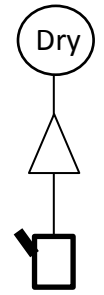
Remove the moist air contamination from wet equipments !

to ascend by balloon



Pass through the clouds or rain
-> Equipment (sonde cap, parachute, string, balloon) is wet
-> Moist air from wet equipment contaminate the humidity sensor

Cloud and/or Rain

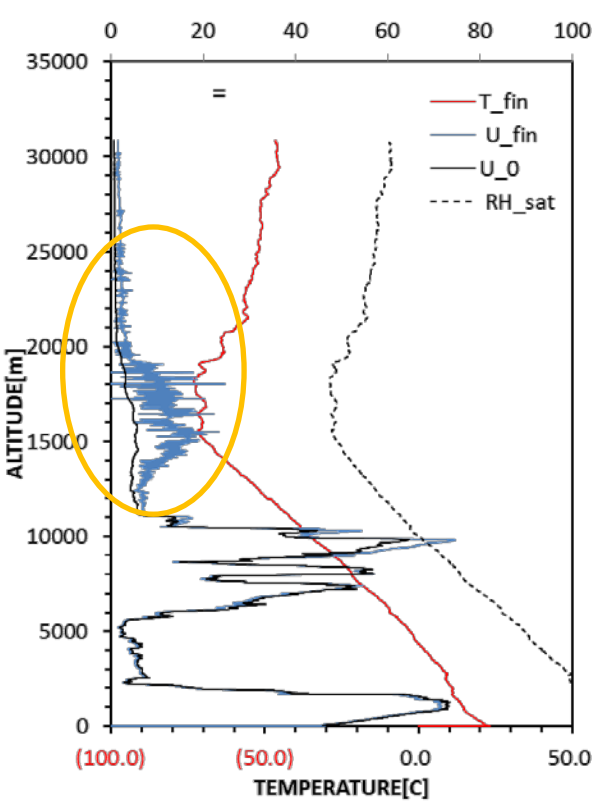


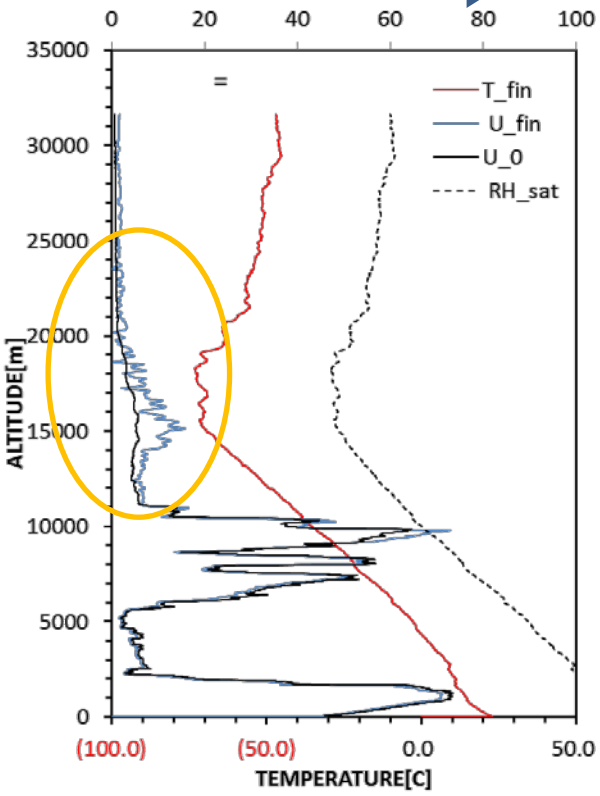
Need to remove the moist air contamination from the wet equipments !

For removing the moist air contamination

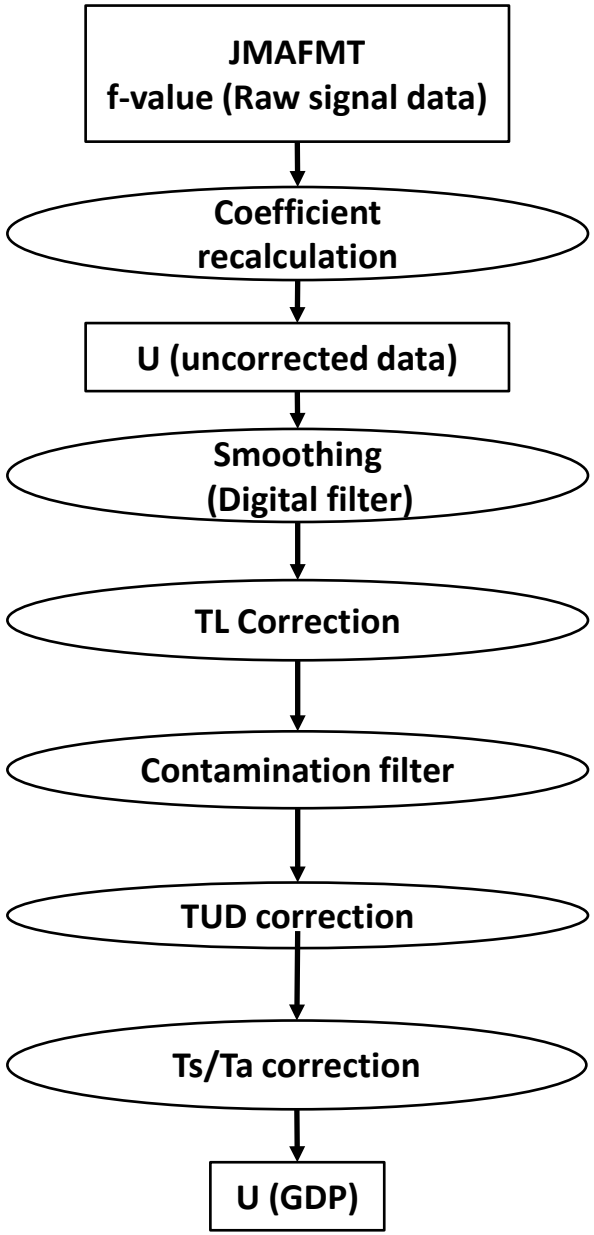
Step 1 : Extract minimum value in the pendulum period
Step 2 : Smoothing with moving average (the width of the pendulum period)

Moist air Contamination removal





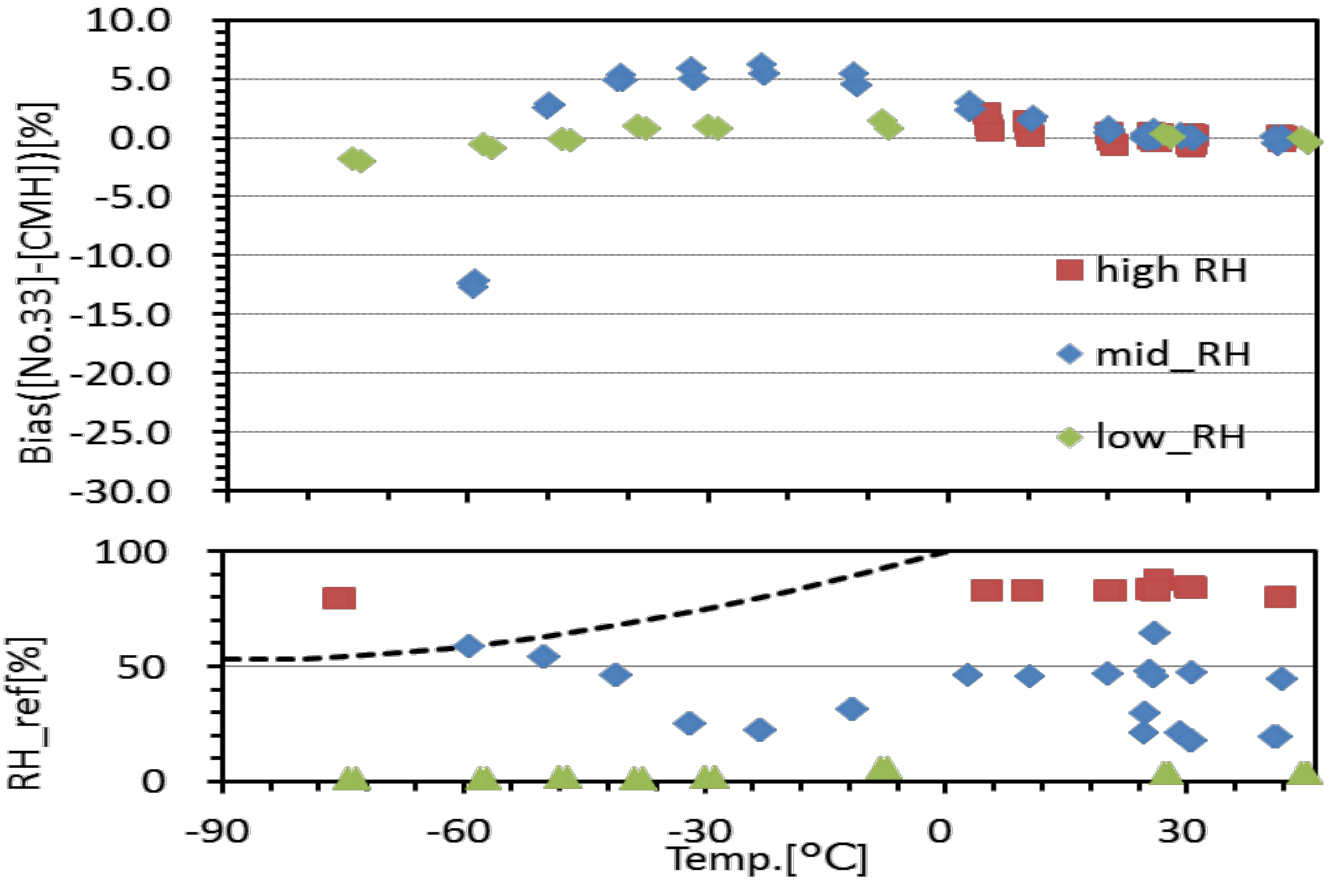
Humidity Measurement



Correction 4
"Temperature dependence of the humidity sensor" correction

A thin-film polymer humidity sensor has the temperature dependence at low temperature conditions.

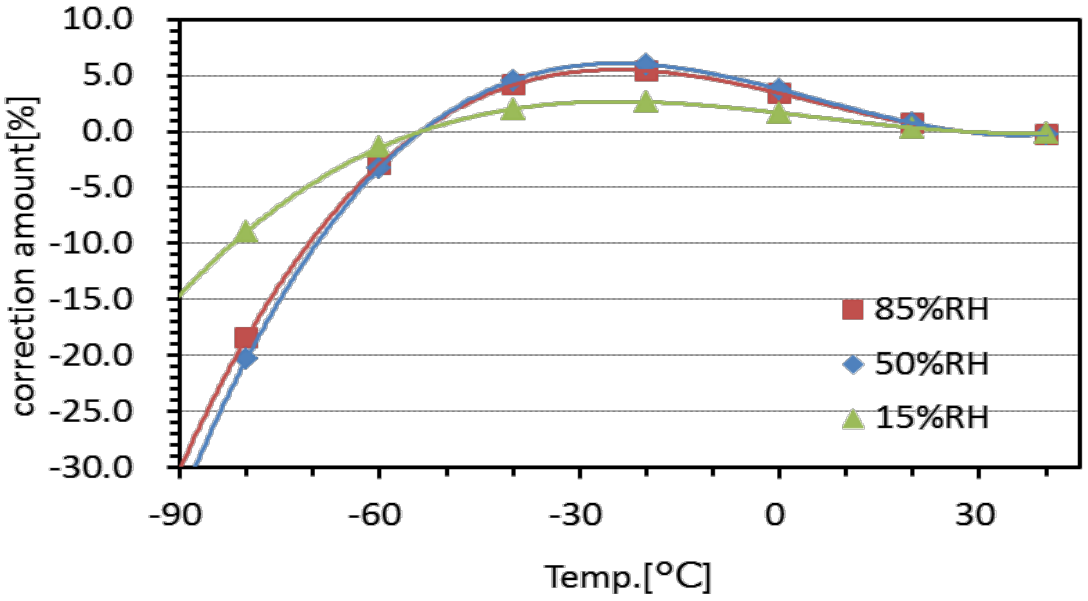
Temperature dependence of the humidity sensor to be used in the RS-11G or iMS-100, It was as follows by the experimental results.



Determined the following correction formula by the result of this experiment.

$$\Delta U = (K_0 + K_1 T_s + K_2 {T_s}^2 + K_3 {T_s}^3)(K_4 + K_5 U_1 + K_6 {U_1}^2)$$

ΔU (%) : correction amount
Ts : Sensor temperature
U_1 : uncorrected RH
K0-K6 : constant



Humidity Measurement

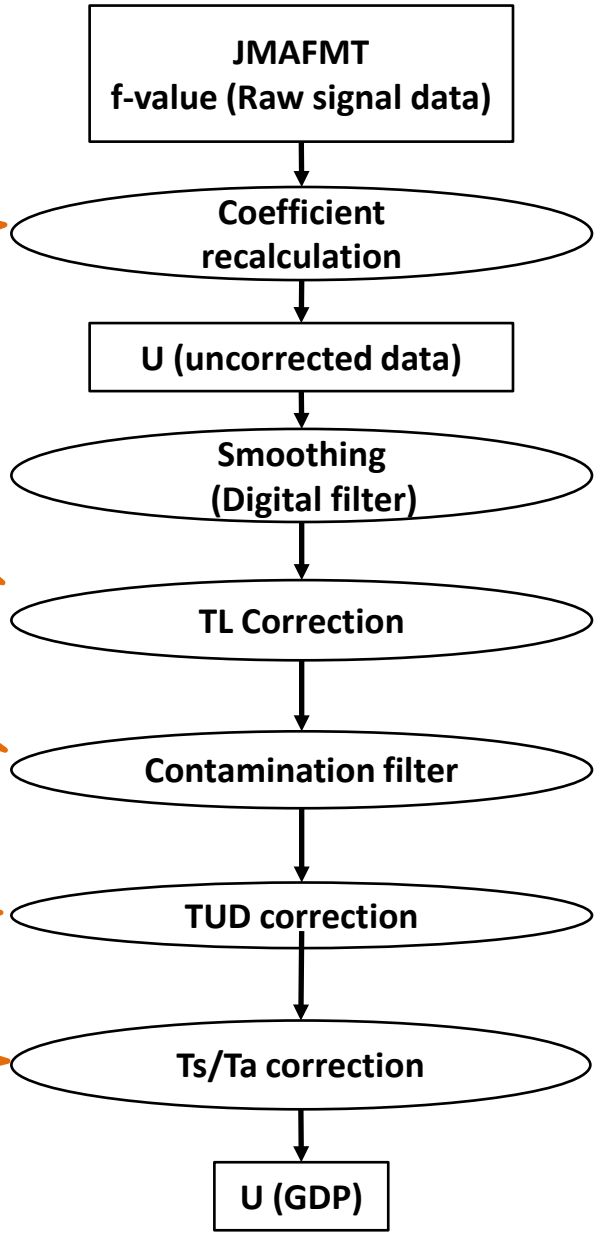
Correction 1
Recalculate the conversion coefficient of humidity by result of SHC

Correction 2
Time Lag correction

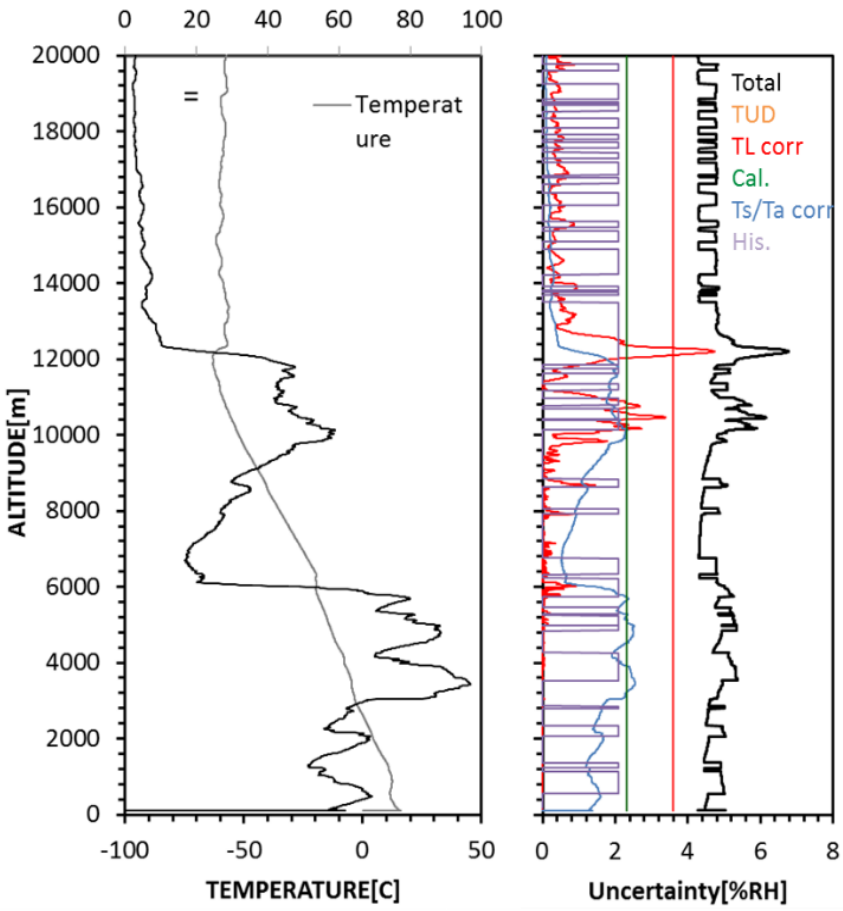
Correction 3
Moist air Contamination removal

Correction 4
"Temperature dependence of the humidity sensor" correction

Correction 5 (only RS-11G)
"Sensor temperature / Air temperature" correction



Humidity uncertainty

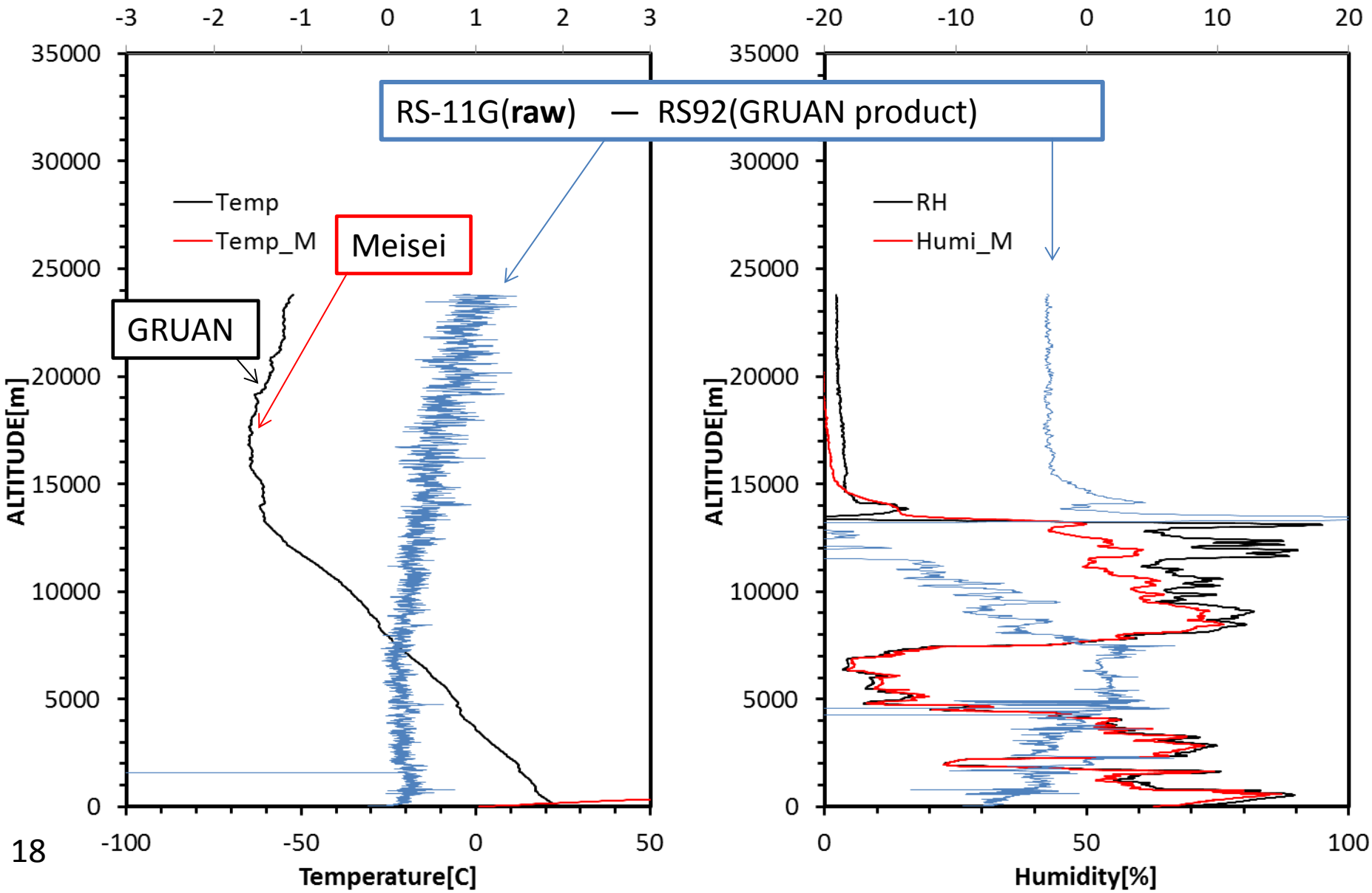


(e.g. 07 Oct. 2014 14:00LT at Lindenberg experiment)

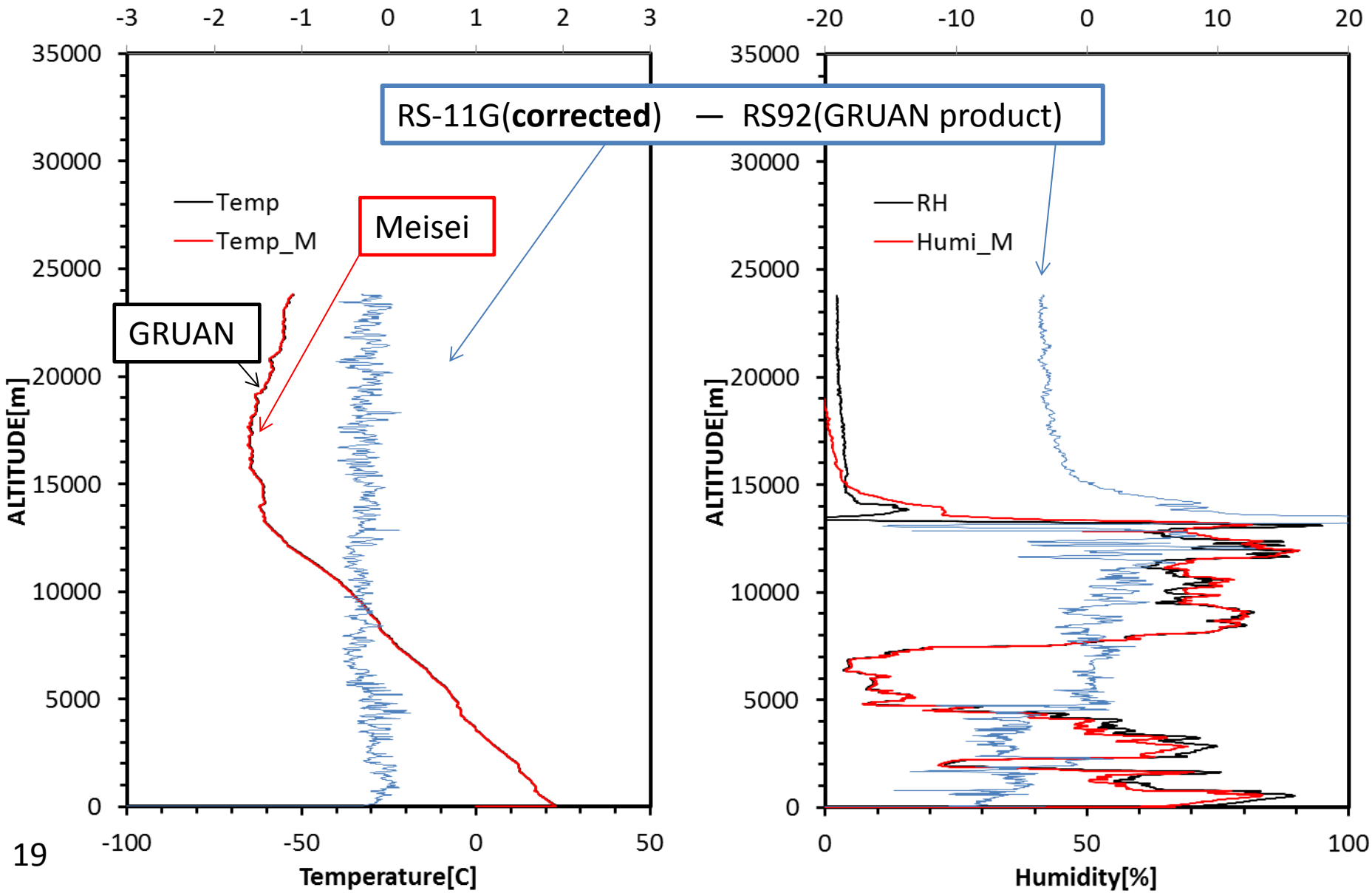
Parameter		Value[%RH]	Corrected
sensor calibration		2/√3	-
SHC correction	Uncertainty of the calibrating a reference	(1.00)	Corrected
	Uncertainty of repeatedly measured quantities	(0.72)	
	Uncertainty of the bias of distribution in a chamber	(0.15)	
	Uncertainty of the dispersion of radiosonde measurement	(0.26)	
	Total	1.27	
BL check (check only)		-	-
Time-lag correction		U(T) u(τ)= 0.25τ	Corrected
Contamination		Under evaluation	Corrected
TUD correction		Under evaluation	Corrected
Ts/Ta correction		U(⊿T) ⊿T =0.3 K/√3	Corrected
Hysteresis		< 1.8	uncorrected

3. Comparison with other sonde

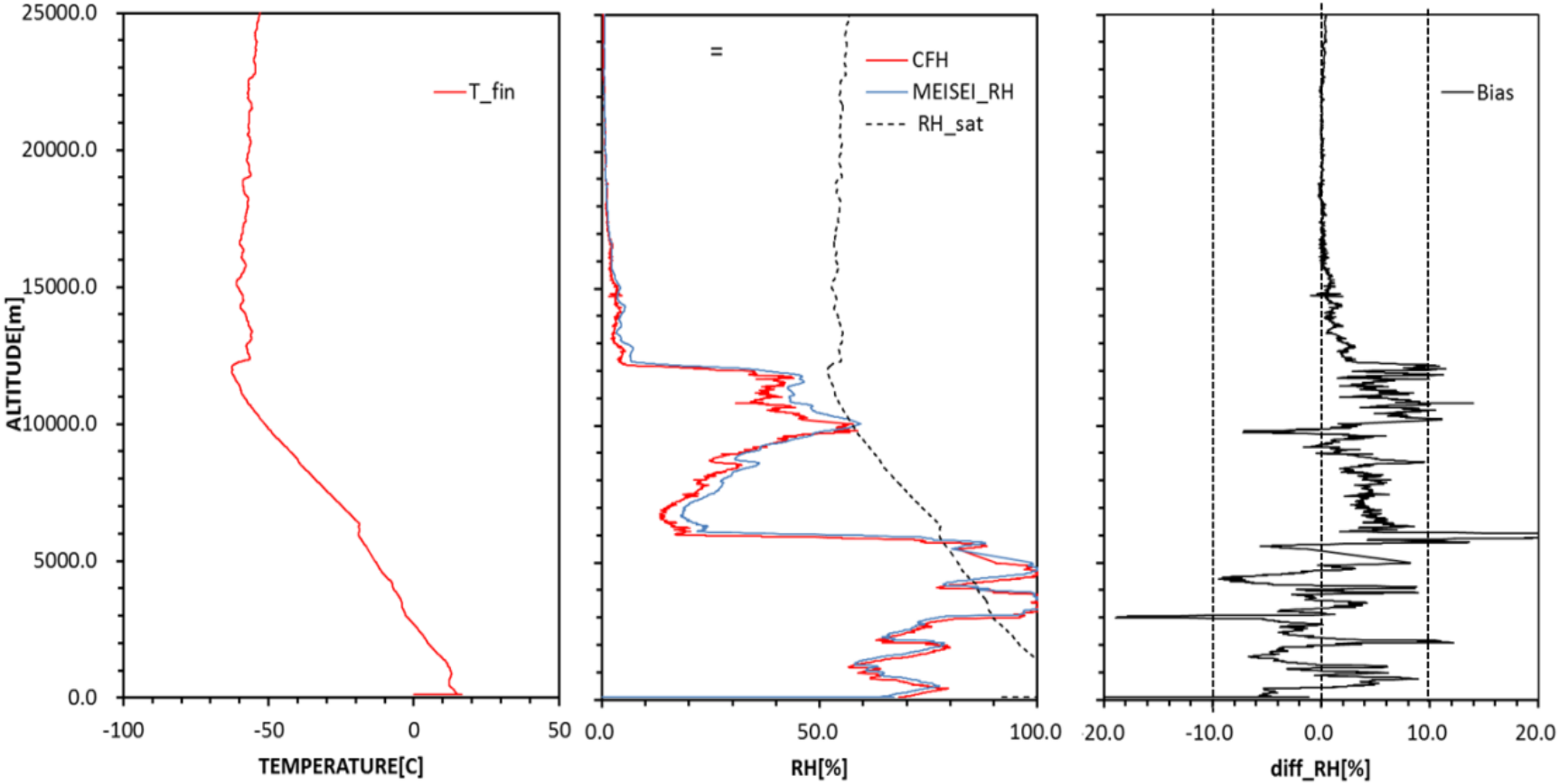
Comparison with RS92-SGP in Tateno (17 Jun, 2014 at 00 UTC (09 LT, Daytime))



Comparison with RS92-SGP in Tateno (17 Jun, 2014 at 00 UTC (09 LT, Daytime))

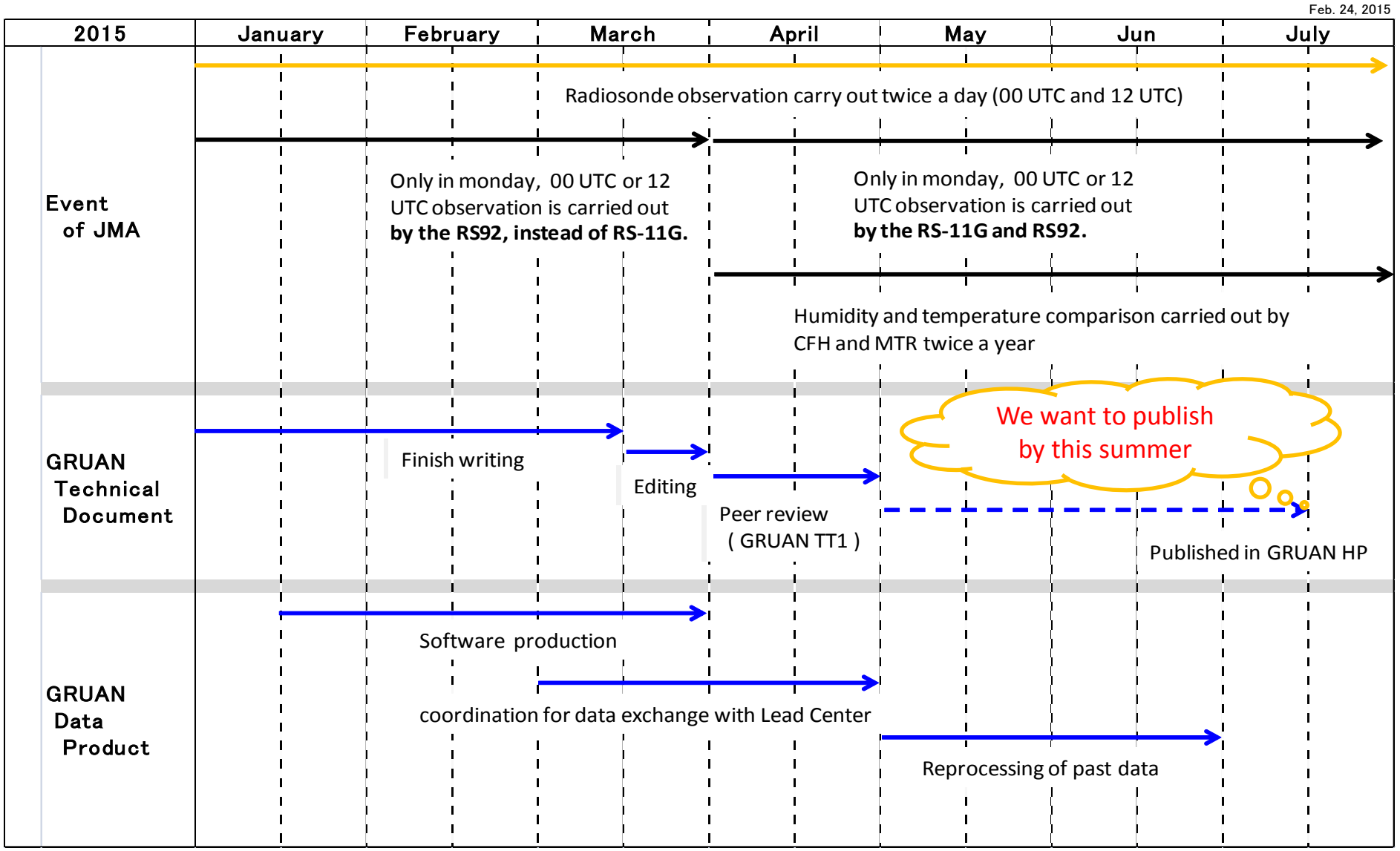


Comparison with CFH in Lindenberg experiment (07 Oct, 2014 at 00 UTC (Daytime))



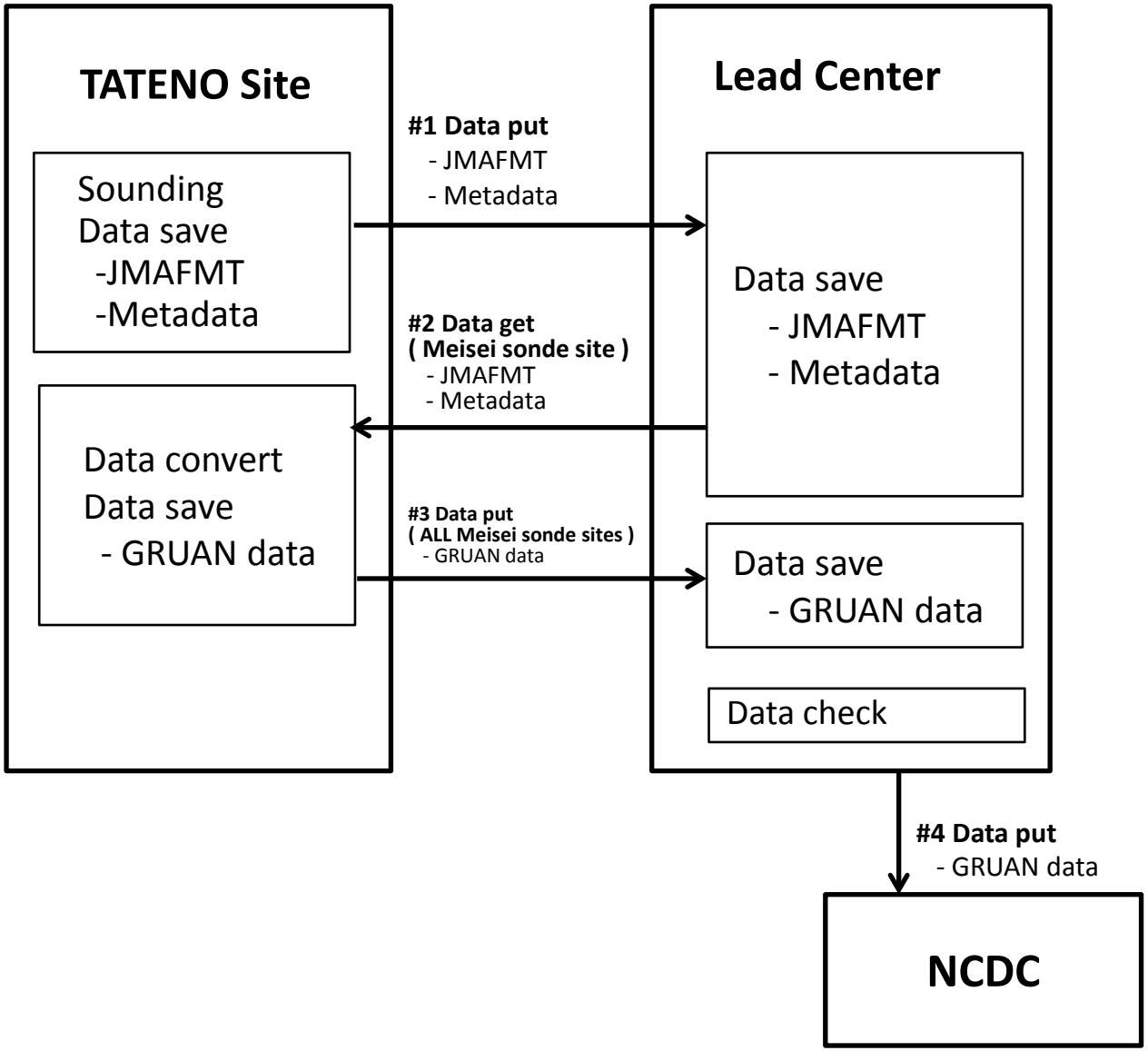
4. Progress of GDP and schedule

Schedule of GRUAN GDP and Technical document for RS-11G and iMS-100

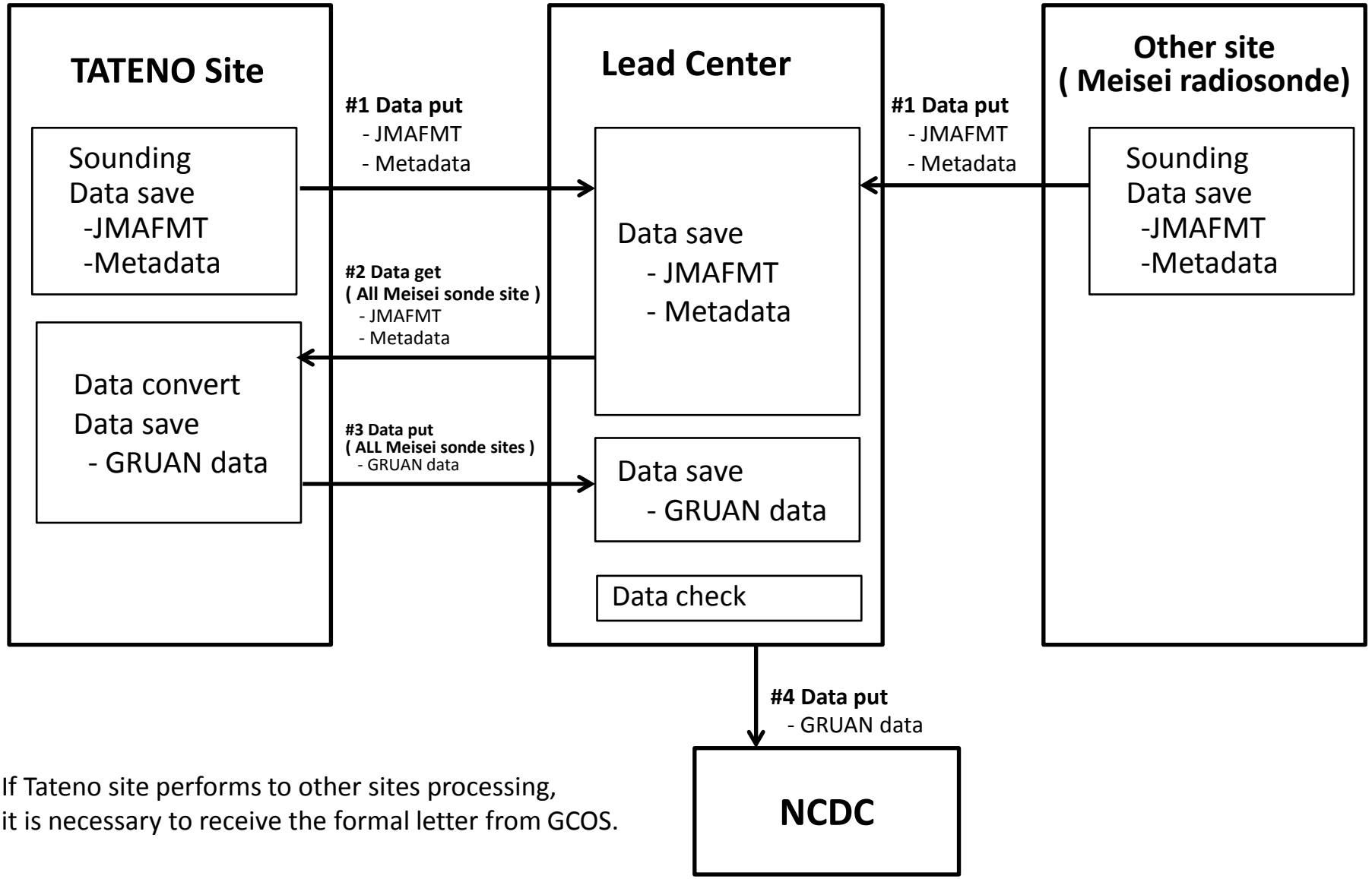


5. Action in the future

Near future : GDP DATA Stream for Meisei radiosonde site (Tateno)



Future (proposal) : GDP DATA Stream for All Meisei radiosonde sites

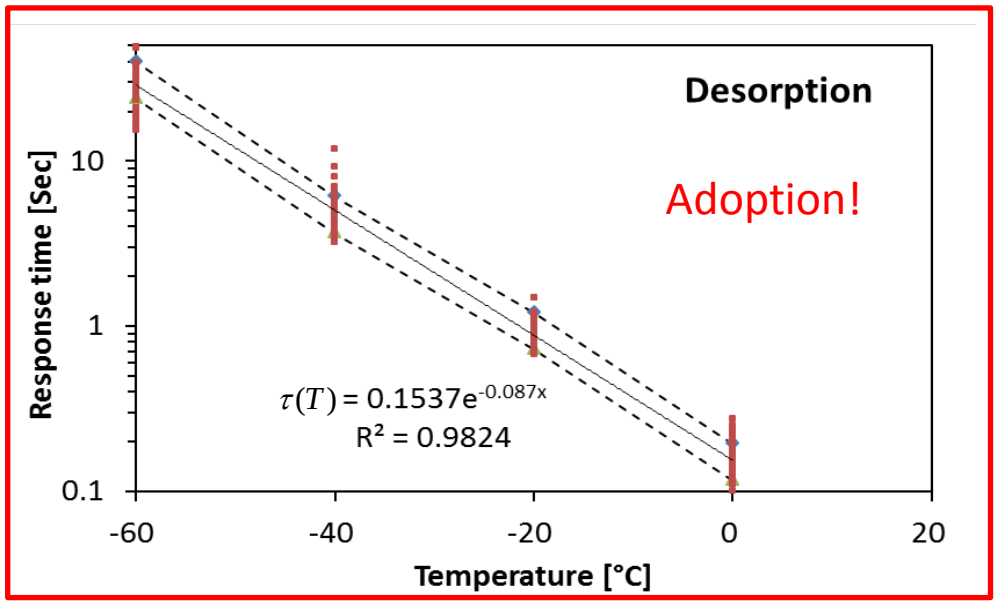


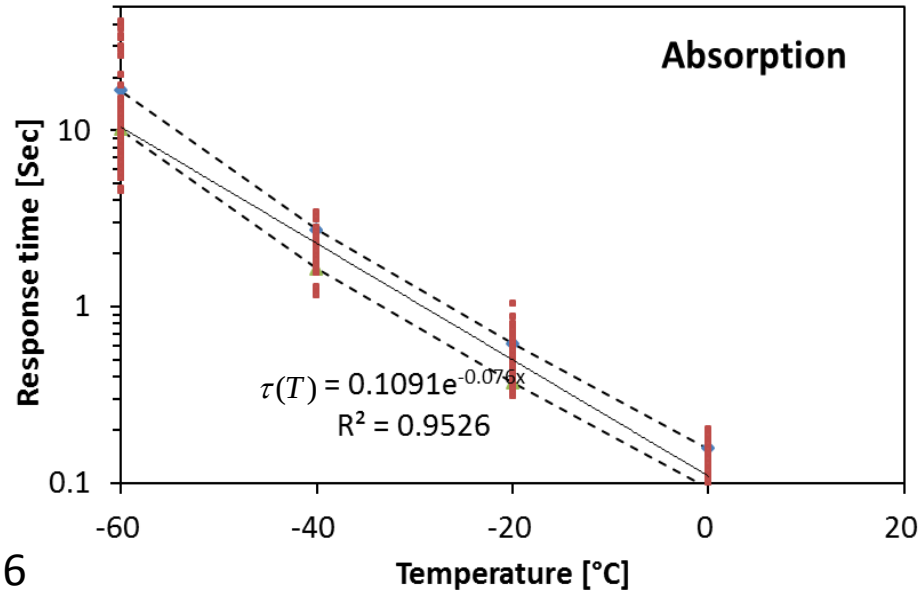
If Tateno site performs to other sites processing,
it is necessary to receive the formal letter from GCOS.

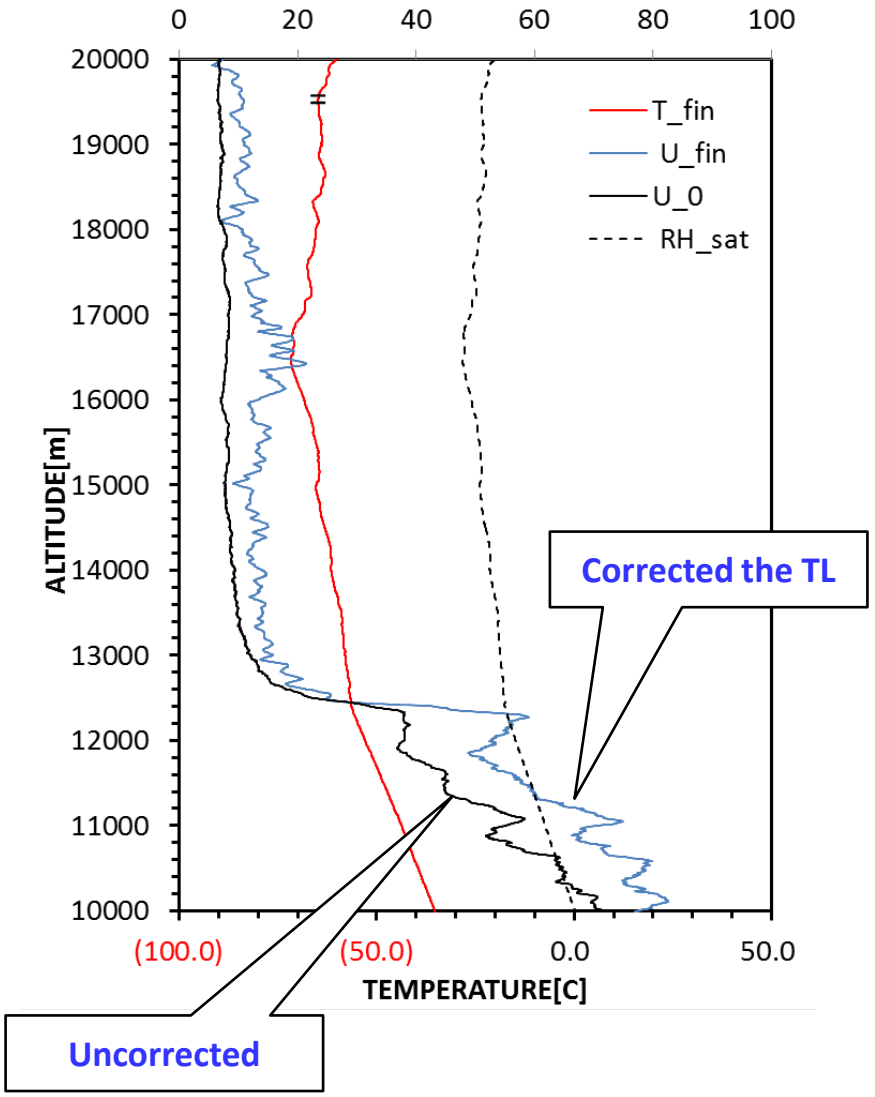

～ Thank you ！ ～
“Sastrugi” Near Dome F /Antarctica

Reference

Time constant of RS-11G and iMS-100

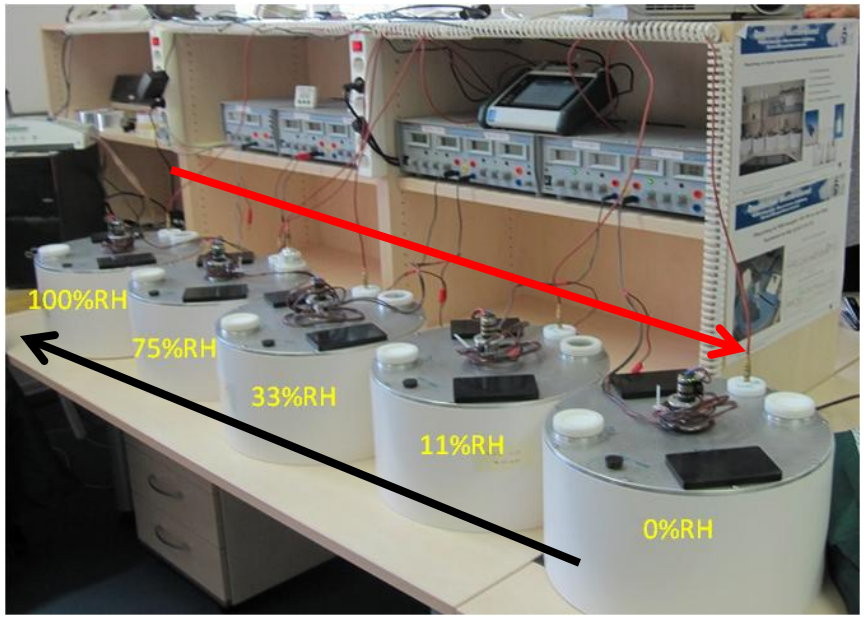






RH correction : Hysteresis

Lindenberg experiments

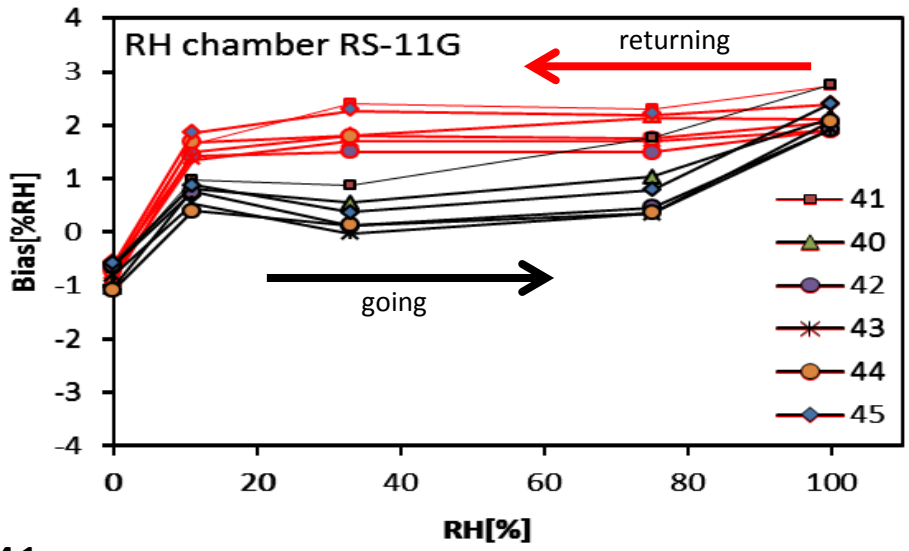


Put the humidity sensor of the radiosonde into the next order,

low humidity chamber

>>> high humidity chamber

>>> low humidity chamber



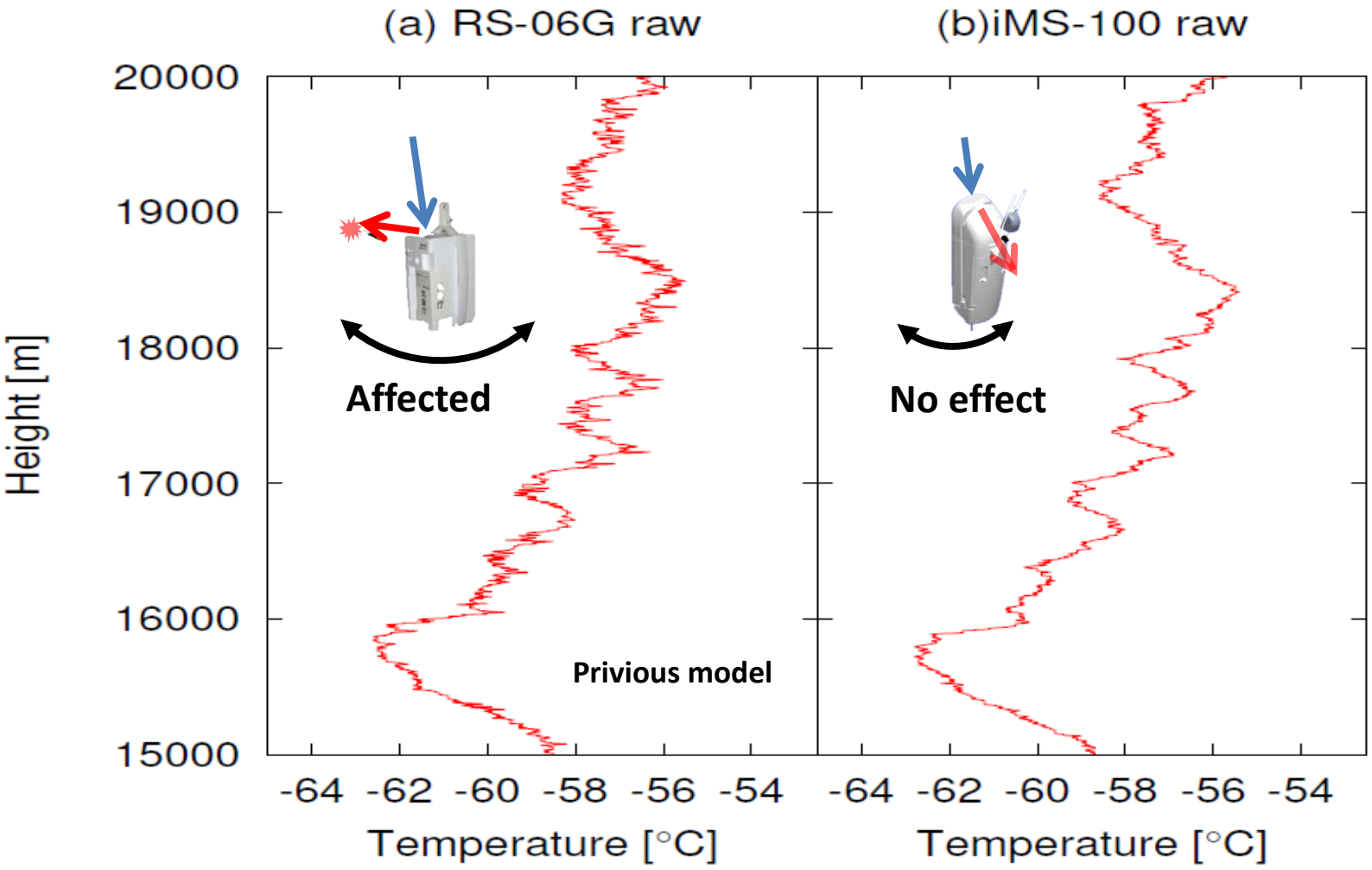
(Result)

When returning from high humidity to low humidity, (maximum) 1.5% hysteresis was observed.

However, it is not possible to correct this phenomenon.

Therefore, estimate as the amount of uncertainty.

Removal of the Heat Pulse

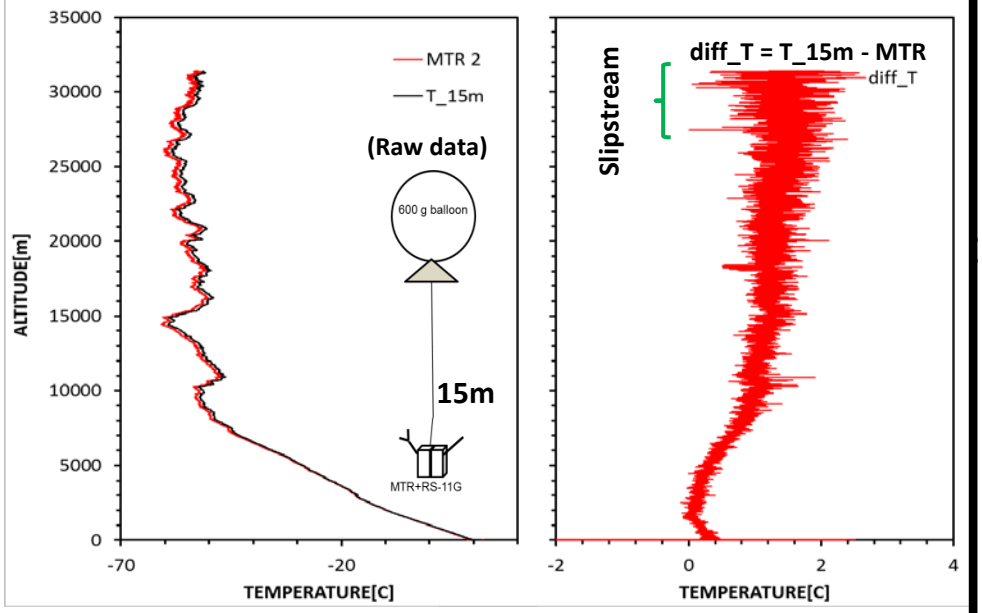


Heat spike (Balloon's slipstream) removal

Strings =10m and 15m simultaneously launch experiment by RS-11G & MTR

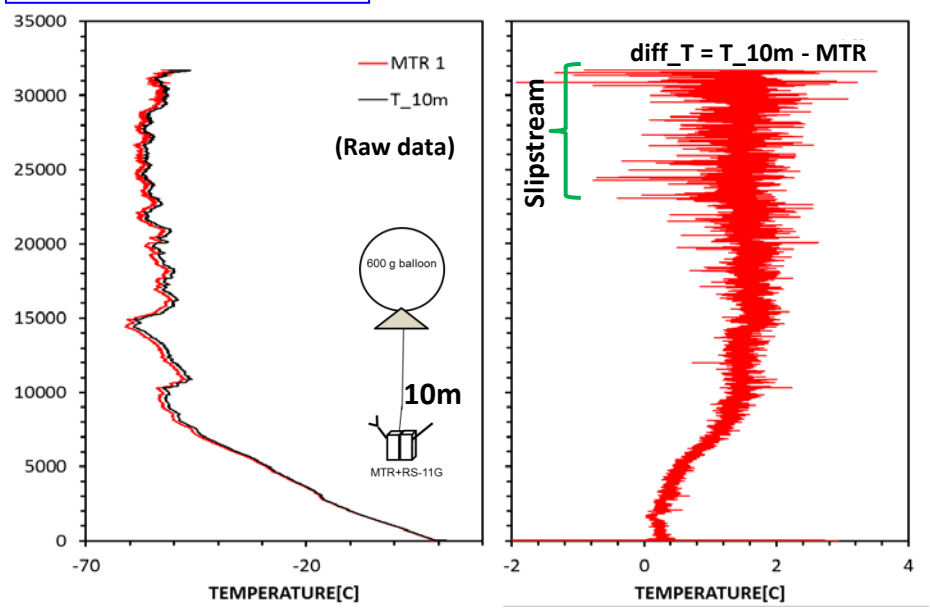
Launch : Feb. 6, 2015 at 14h30m LT (daytime)

Strings =15m



- Heat pulse (noise) of balloon's slipstream was observed <u>at 27km (17hPa)</u> or more upper layer

Strings =10m



- Heat pulse (noise) of balloon's slipstream was observed at 23km (30hPa) or more upper layer

GDP

Tateno use a 10m strings for radiosonde, because of the social impact is very large.
As a result, to use the heat spike filter at 30hPa or more upper layer.
-> Within the window frame (3s) of the half of period of the pendulum, it calculate the moving average of lowest values of temperature .

At the other sites for use the Meisei radiosonde, the height for use the heat spike filter, is determined by the strings length.

Heat spike (Balloon's slipstream) removal

simultaneously launch experiment by RS-11G & MTR at Tateno