Change management

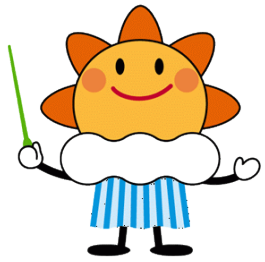
- Implementation of a new radiosonde for manual launch site in JMA -

- March 12, 2014 -

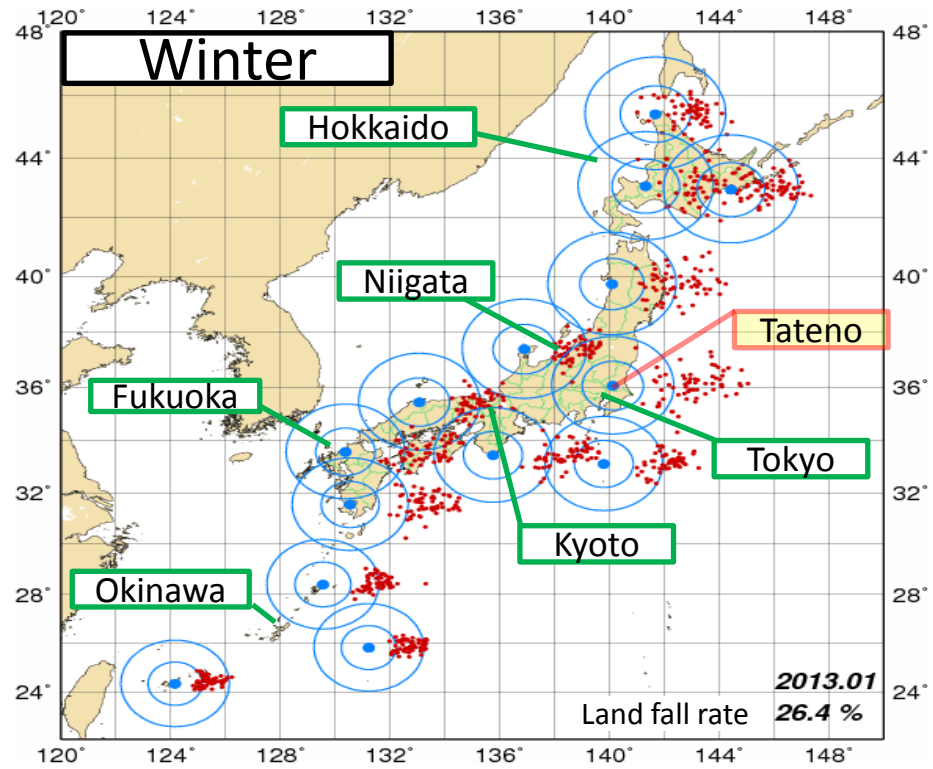
Nobuhiko Kizu (Tateno/JMA HQ)

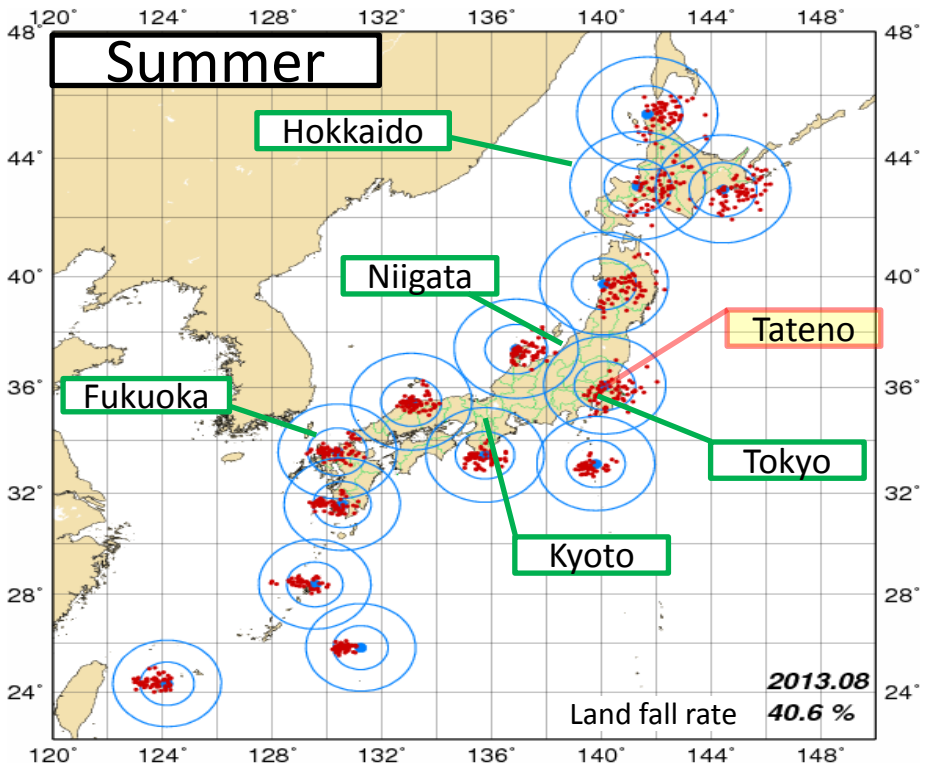
Overview

- 1. Motivation of the new radiosonde implementation
- 2. Creation of the procurement specifications
- 3. Result of the competitive tender
- 4. Summary of the new radiosonde (RS-11G)
- 5. Action in the future

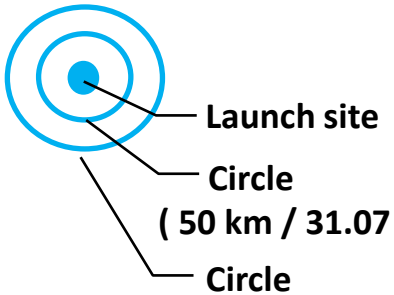


Falling Radiosonde point in Japan





Remarks



● Falling radiosonde point

Notes

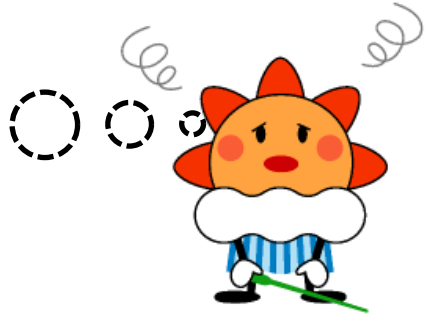
- **Winter:**
  Launched radiosonde is fell in over populated area where include Kyoto, Kobe and Niigata.
- **Summer:**
  Launched radiosonde is fell in over populated area where include Tokyo, Fukuoka (Hakata) and Hokkaido (Sapproro).
- **All season:**
  Lanched radiosonde is sometimes caught in overhead wire and power line, as a result, it will be a power failure or train stop.

Impact of falling Radiosonde -1

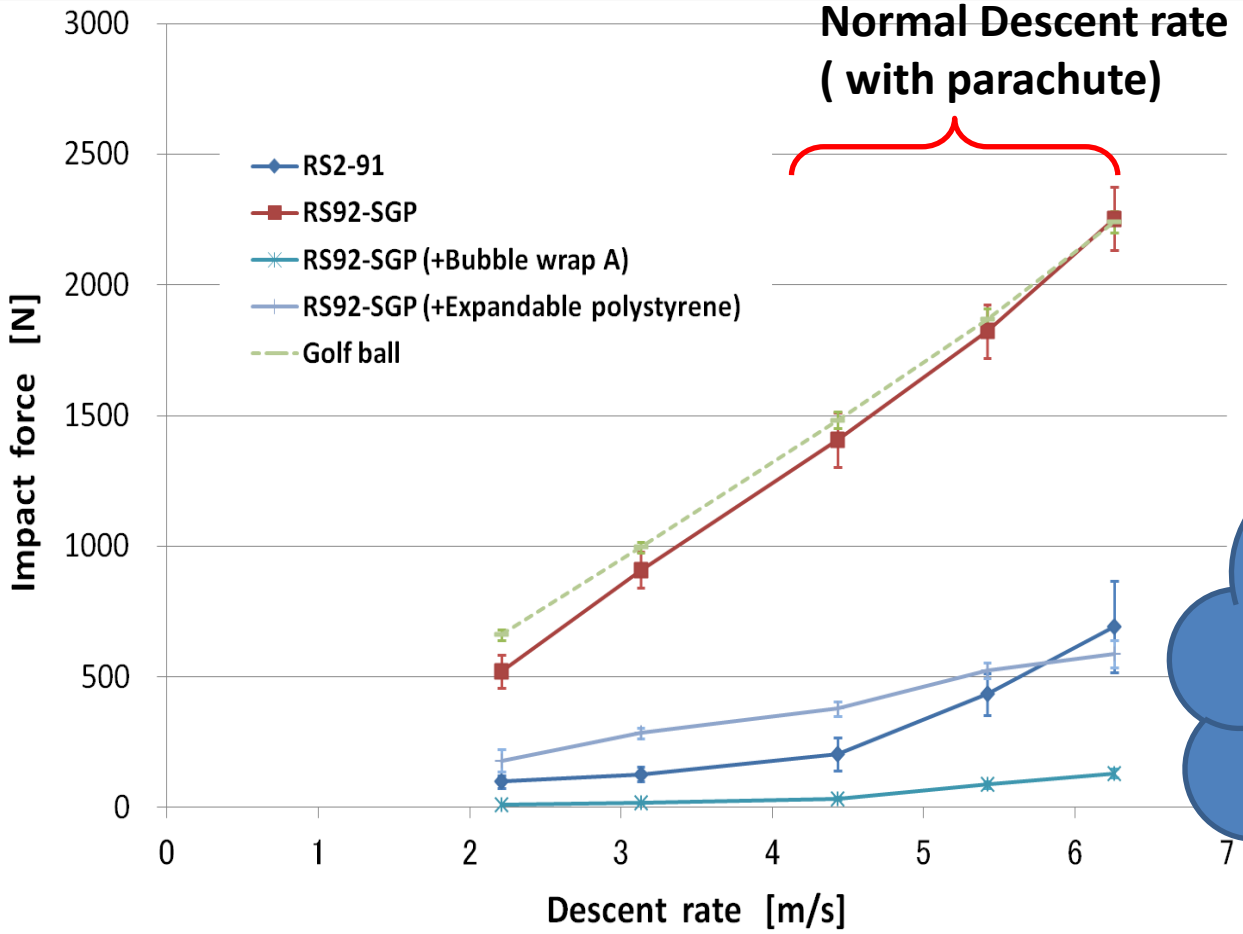
This Radiosonde set, hit the building wall in descending, and fell in shatters.

@ Test sounding at Fukuoka site (November, 2009)

If the batteries are hit to the person …
Sounding will not be able to continue in my country…



Impact force of falling Radiosonde



If the falling radiosonde hit to the person, What shall we do?
It was a major concern for us.

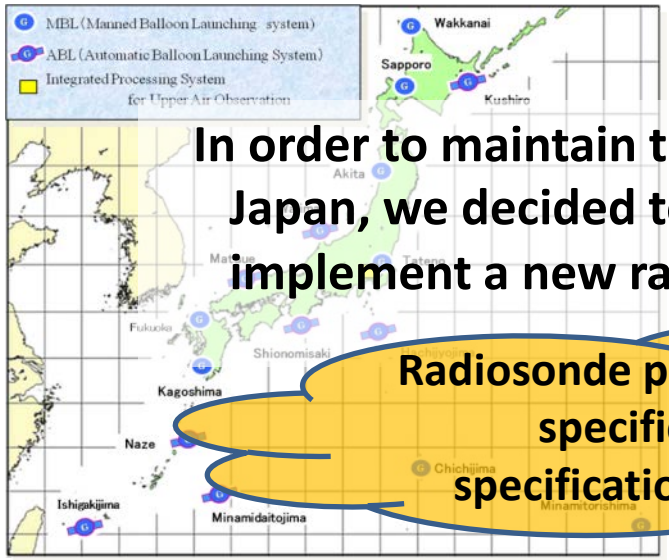
- **Parachute is not always 100% open!**
- **And if we not use the parachute, impact force is immeasurable!**

Budget cut

- On the other hand -

- **Mar.11, 2011, a monstrous earthquake and tsunami crushed northeastern Japan. And radiation leak occurred at the Fukushima Daiichi nuclear power plant.**
- **For this reason, the national budget of Japan has been used for reconstruction.**

To budget cut of the sounding equipment



In order to maintain the soundings of two times a day at 16 sites in Japan, we decided to change the procurement method, and implement a new radiosonde .

Radiosonde procurement was to production specifications (from purchase specifications) for competitive tender.

In order to production specification for JMA requirement.

We were performed following concepts

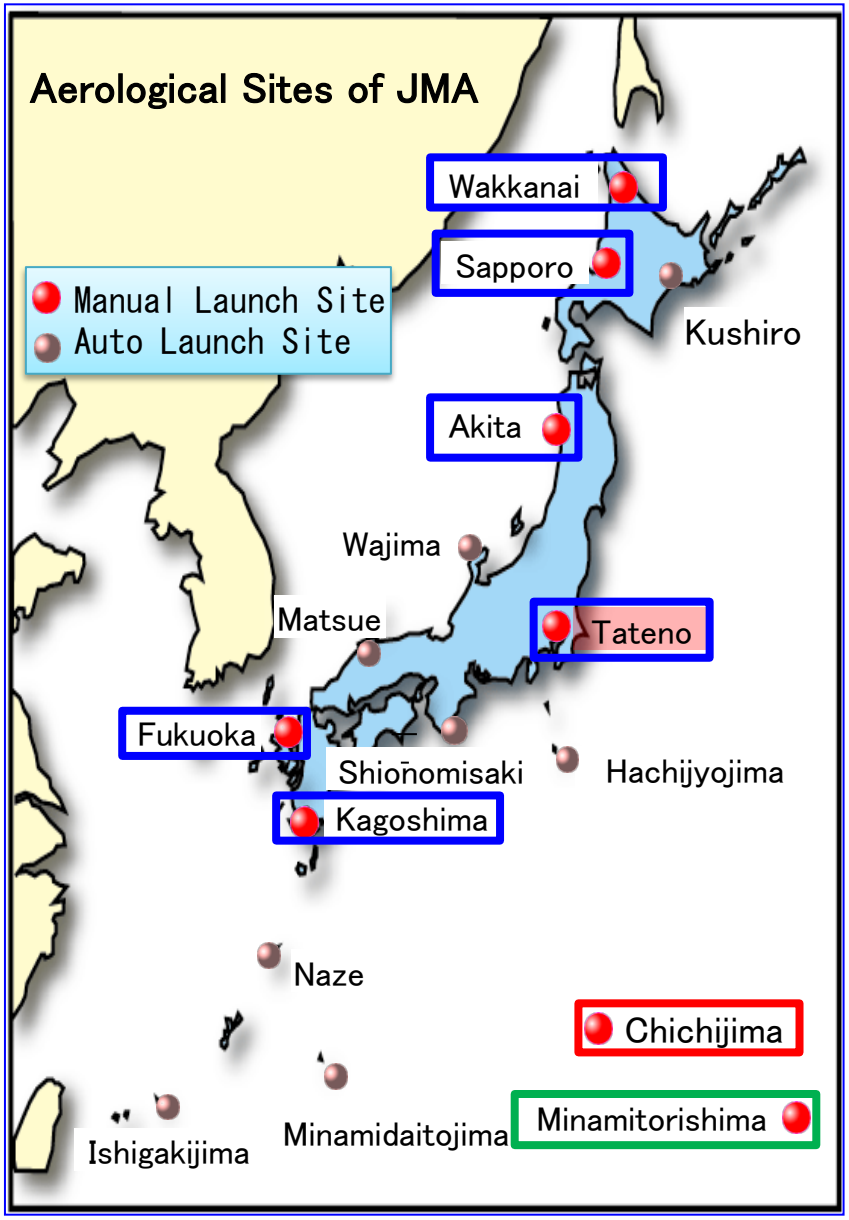
- **Make a method that can many radiosonde suppliers participate in the radiosonde tender !**
  (To production specifications from purchase specification)

- **To procure the radiosonde that required for JMA !**
  e.g. High precision and high accuracy as possible. Relieve of the impact force etc.

- **Radiosonde of currently using is also possible to participate in the tender !**
  (However, the impact force is relieved)

Thereby, it would not be necessary that ground equipment manufacturer equal Radiosonde manufacturer.

Result of competitive tendering



Tender 1

Opening day : Apr.15

Successful tender

RS-11G (Meisei)

14,500Yen (US$145)

(Before opening)

RS92-SGP (Vaisala)

25,000Yen (US$250)

Tender 2

Opening day : Apr.18

Successful tender

LMS6 (L.M.Sippican)

19,800Yen (US$198)

(Before opening)

LMS6 (L.M.Sippican)

25,771Yen(US$257)

Tender 3

Opening day : Apr.18

Successful tender

RS-11G (Meisei)

20,000Yen (US$200)

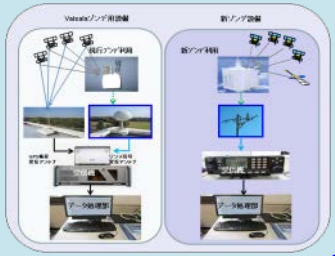
(Before opening)

RS-06G (Meisei)

28,000Yen (US$280)

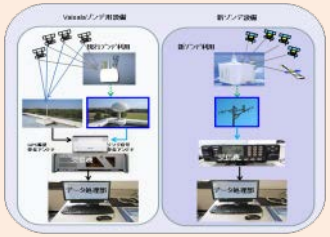
Conventional Radiosonde (Vaisala RS92) V.S New Radiosonde

- Wakkanai
- Sapporo
- Akita
- Tateno
- Fukuoka
- Kagoshima



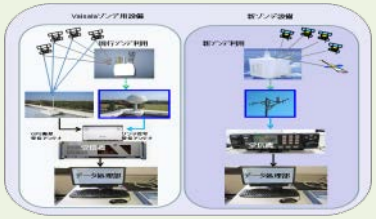
Conventional Radiosonde (Lockeed Martin Sippican LMS6) V.S New Radiosonde

- Chichijima



Conventional Radiosonde (Meisei RS-06G) V.S New Radiosonde

- Minamitorishima
- (Naha)



Comparison table of old and new Radiosonde

Before (RS92-SGP)	Item	New sonde (RS-11G)
GBAS	Differential correction method of GPS	SBAS
Silicon	Barometer	dismounted
Capacitive wire	Temperature sensor	Thermistor
Thin-film capacitor (twin)	Humidity sensor	Thin-film capacitor
<20s at -40°C (6m/s1000hPa)	Time-constant of the Humidhity sensor	<4s at -40°C (6m/s 1000hPa)
275g	Radiosonde Weight	85g
>20m/s	Terminal descent rate	>9m/s
Rigid plastic	Radiosonde housing	Polystyrene foam
410cm3	Radiosonde measure	887cm3
>2000N (measured)	Impact force	604N (Calculated)
15m	Strings	10m
14g	Weight of unwinder	12g

- Feature of the New Radiosonde (RS-11G)
  - -The humidity sensor is quick response under low temperature, but weak to icing.
    - -> now, reviewing the shape of the rain cap.
  - - The impact to the temperature sensor of the heat flow from the own housing is low.

- Advantages of the new radiosonde procurement

- Because the general competitive tender,
  - Cost of radiosonde is down.
    Ground equipment is also inexpensive.
  - Latest technology is mounted to new radiosonde.
- Sounding process is easy to understand, because this process is opened to public.
- Direct damage of Falling radiosonde is reduced.
- Reduction of fall to the Power line / Overhead wire.
- Balloon burst point is high-altitude, because the radiosonde is very light weight.

- Disadvantages of the new radiosonde procurement

- When the each time tender, radiosonde might change.
- If the radiosonde changes, it is necessary the task of examining the characteristics of old and new radiosonde

Future Plan

-To produce a report on this change management .
(include the radiosonde comparison between the RS92 and RS-11G)

- Creating a GRUAN data by the data product of RS-11G.

In addition,
- Will be consider whether to implement a reference temperature sensor and water vaper sensor (MTR ,CFH, etc.).

- Will be consider whether to implement a new sensor.
e.g. CPS (Cloud particle sensor)

- Will be implement a high-performance, small, and low impact force radiosonde .


～ Thank you ！ ～
“Rolling Sun” Syowa Station /Antarc

Links

▪Separation of radiosonde and ground equipment
- Described to the JMA specifications for new radiosonde -

-Reason for inseparable 1

(Bottleneck) Conventional system, that doing the GPS differential correction on the ground equipment side (GBAS).

-> (JMA Spec.) Radiosonde that does not have a barometer, be used to SBAS for GPS correction.

- Reason for inseparable 2

(Bottleneck) Signal format that is output from radiosonde is readable only by ground equipment of the same manufacturer.

-> (JMA Spec.) Signal format from radiosonde must be output by JMA format. This format has been published. And sounding software created JMA.

Thereby, it would not be necessary that ground equipment manufacturer equal Radiosonde manufacturer.

- Requirement of a new radiosonde specification for JMA

(Concept for a new radiosonde)

- **New radiosonde sensor which has a equivalent or higher than conventional radiosonde performance.**
- **Avoidance of social impact of falling radiosonde**

(JMA radiosonde specification)

- Reduce the impact force of falling radiosonde

-Radiosonde housing

It should be a material that impact performance is not spoiled at low pressure and low temperature, and should be a white styrene form or equivalent materials.

-Radiosonde

It should be a light and compact as follows, it can be fall slowly without a parachute.

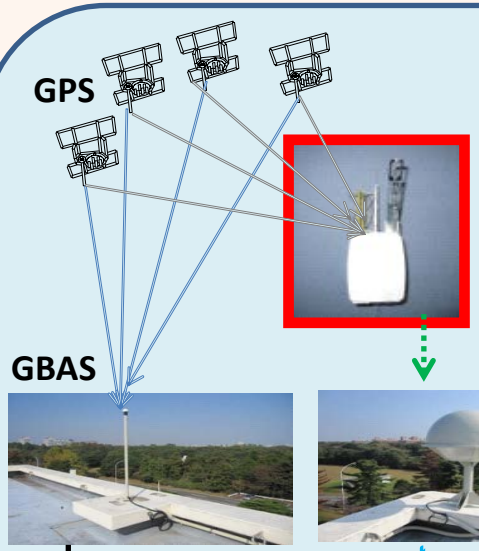
Weight : < 180g
Capacity : <1000cm3
Terminal velocity of a falling radiosonde alone : <12m/s
Impact force : < 850N

-Strings

It should be a 10m for reduction of fall to the Power line / Overhead wire.

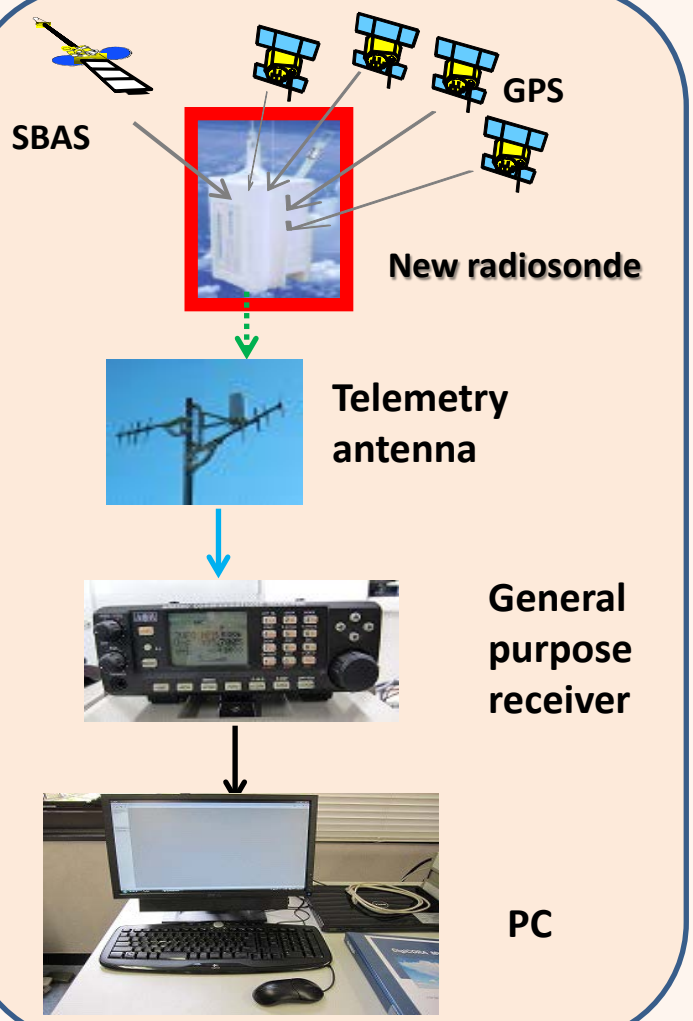
- Radiosonde of currently using is also possible to participate in the tender

Conventional ground equipment

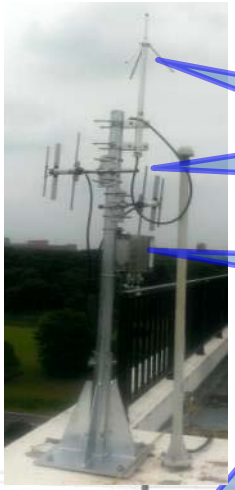


V.S

New ground equipment



- Ground equipment for new radiosonde in Tateno site



Omni antenna (Brown antenna)

Directional antenna (Yagi antenna X 2)

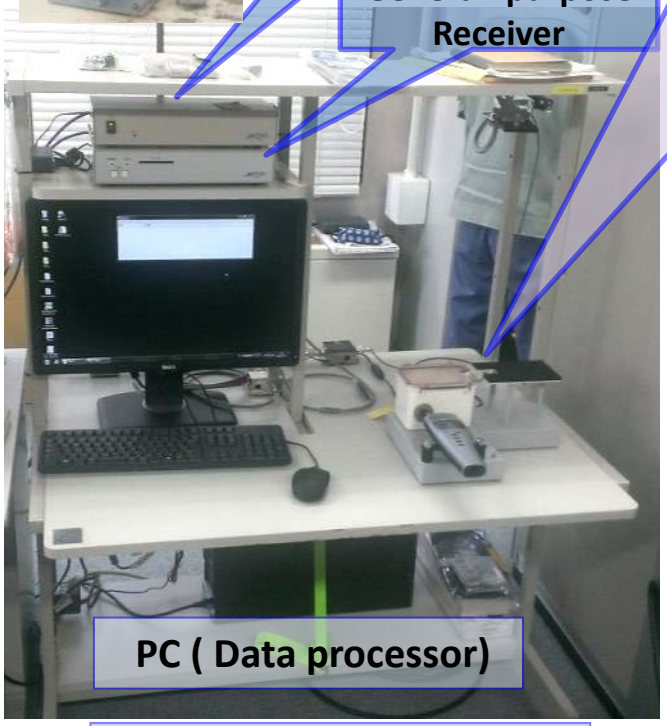
Pre-amplifier

Groud equipment is all general-purpose products, except the Ground Checker of radiosonde manufacturer

Antenna SW

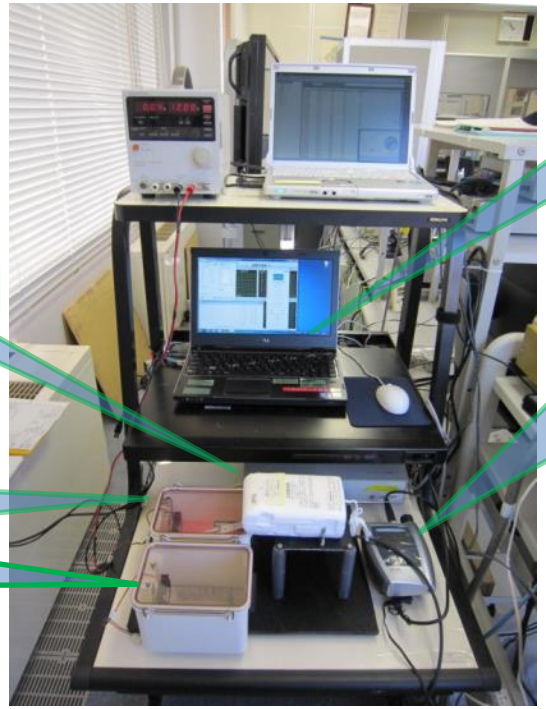
GC / Room atmosphere (Radiosonde manufacturer accessory)

General -purpose Receiver



PC (Data processor)

Ground equipment



GC Data processer

Radiosonde

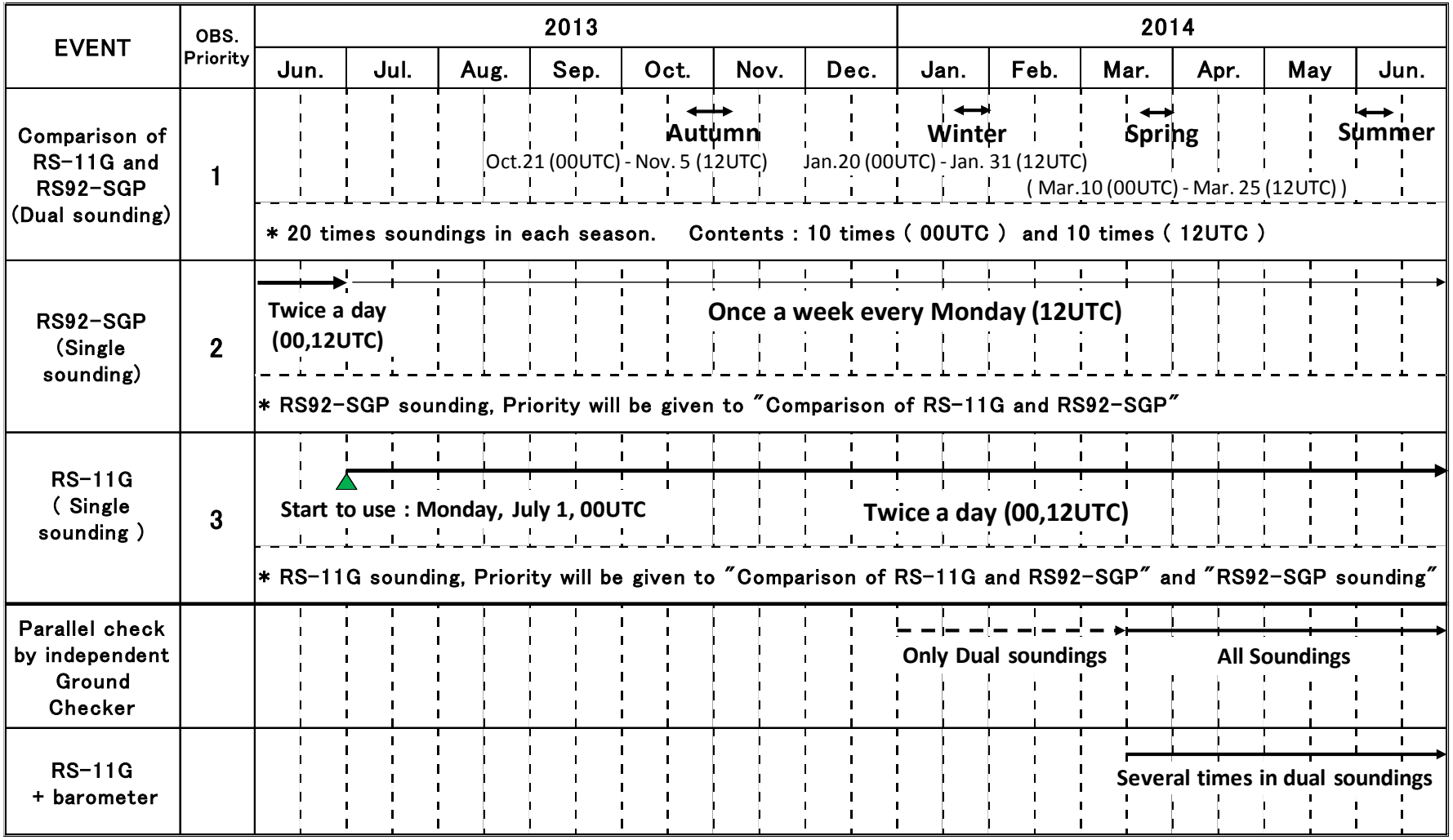
Reference temperature and humidity measuring device

100 % chamber

0 % chamber

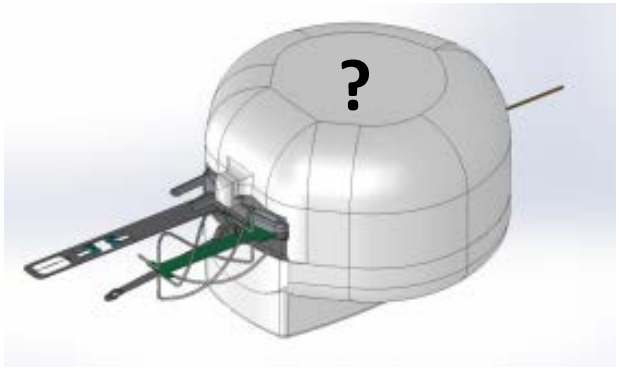
GC (independent of the manufacturer)

- Radiosonde Launch schedule



New Radiosonde lineup!

Current generation



RS92-SGP + styrene form : JMA spec. (Vaisala)

RS-11G (Meisei)

??? - ??? (???????)

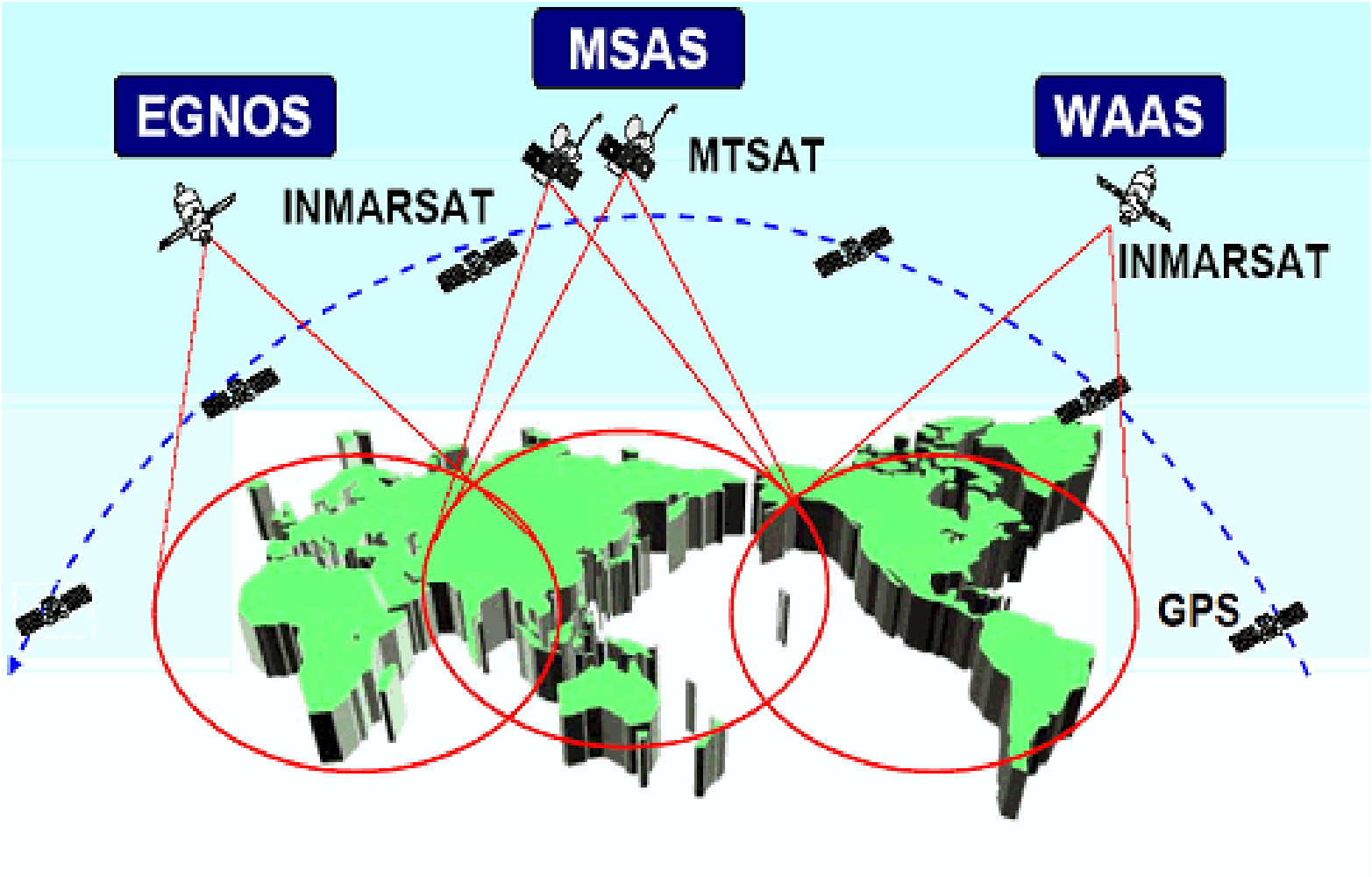
New generation

RS41-SG (styrene form housing : JMA spec.) (Vaisala)

iMS-100 (Meisei)

??? - ??? (???????)

Links 2



SBAS is mounted in a stationary satellite, and used for GPS correction of radiosonde in JMA

GPSsonde Transmission Format (JMA Format)

Frame 1 (240bit)

Item	Data 0	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8	Data 9	Data 10	Data 11	Data 12	Data 13	Data 14
Bit Number	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Content	SC	DC	Sonde Serial NO.	Sonde Production date	Sonde Information	Sub-frame NO.	Output Element 1-1	Output Element 1-2	Output Element 2-1	Output Element 2-2	Output Element 3-1	Output Element 3-2	Output Element 4-1	Output Element 4-2	BCC

Frame 2 (240bit)

Item	Data 15	Data 16	Data 17	Data 18	Data 19	Data 20	Data 21	Data 22	Data 23	Data 24	Data 25	Data 26	Data 27	Data 28	Data 29
Bit Number	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Content	SC	Internal Sensor State	Battery Voltage	Sonde Freq.	Transmit Data (Press.)	Transmit Data (Temp.)	Transmit Data (Hum.)	Ref. Freq. (Hi-ref.)	Corr. (Press.)	Corr. (Temp.)	Corr. (Hum.)	PDOP	Using Satellite 1	Using Satellite 2	BCC

Frame 3 (240bit)

Item	Data 30	Data 31	Data 32	Data 33	Data 34	Data 35	Data 36	Data 37	Data 38	Data 39	Data 40	Data 41	Data 42	Data 43	Data 44
Bit Number	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Content	SC	GPS Week NO.	GPS Second 1	GPS Second 2	GPS Leap Second	Latitude 1	Latitude 2	Longitude 1	Longitude 2	GPS Altitude 1	GPS Altitude 2	Wind Direction	Wind Speed	External Sensor Information	BCC

Frame 4 (240bit)

Item	Data 45	Data 46	Data 47	Data 48	Data 49	Data 50	Data 51	Data 52	Data 53	Data 54	Data 55	Data 56	Data 57	Data 58	Data 59
Bit Number	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Content	SC	Vacancy or (ECC Current)	Vacancy or (ECC Temp.)	Vacancy or (Pump Current)	Vacancy or (Reaction tube Temp.)	Vacancy	Vacancy	Vacancy	Vacancy	Vacancy	Vacancy	Vacancy	Vacancy	Vacancy	BCC

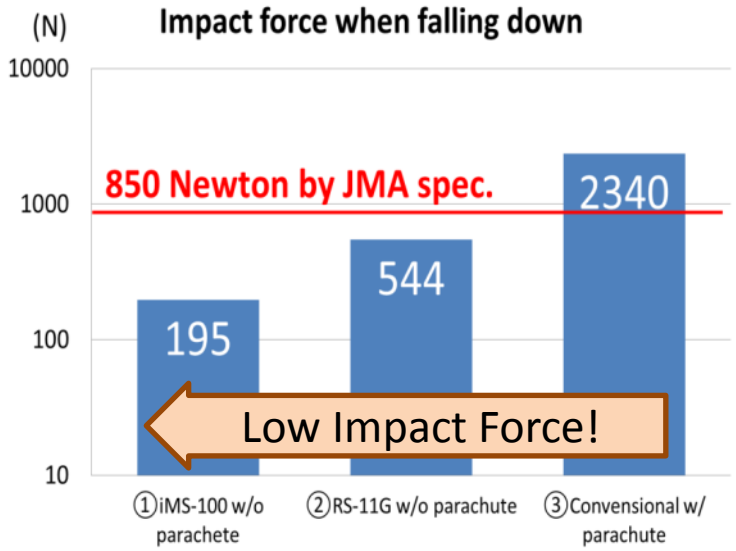
Frame1(240bit)+Frame1(240bit)+Frame1(240bit)+Frame1(240bit)=960bit/second
GPSsonde Transmitting rate :1200bit/second

Description : JMA format is open format that describes the raw data of 1 second intervals from the radiosonde.

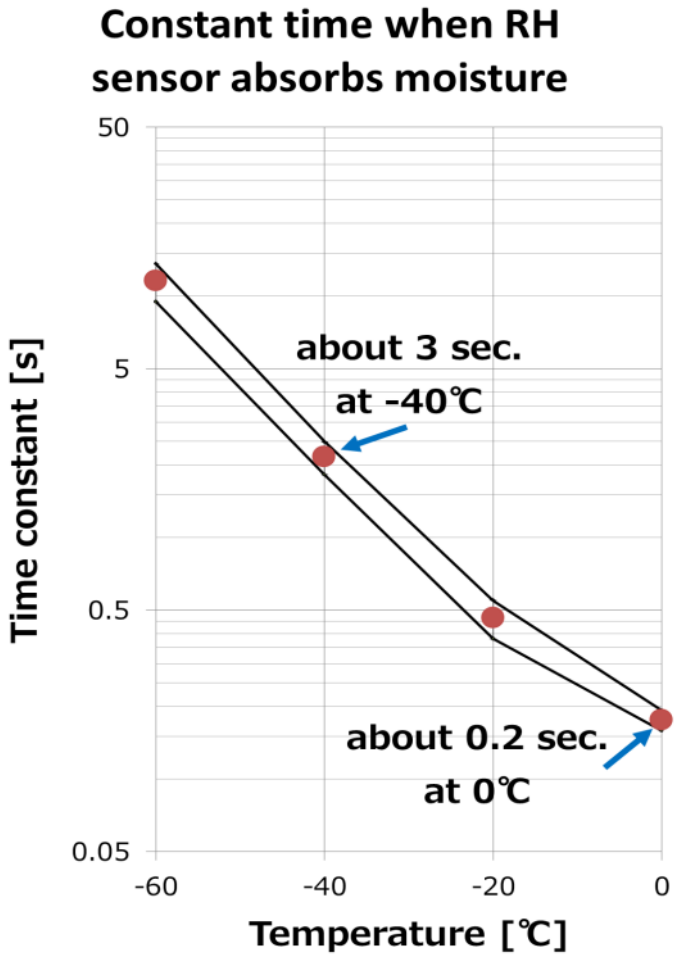
iMS-100

- Sensor : As same as RS-11G
- Housing : Polystyrene foam
- Weight : 37g
  cf. RS-11G (85g)
  RS92-SGP (270g)

Low impact force!



High-response humidity sensor



Reference

JMA format (Frame 1)

Frame 1 (240bit)

Data NO.	Bit Number	Content	Detailed description
0	16	SC	Sync code Frame1 (FFF0), Frame1 (FFF1), Frame3 (FFF2), Frame4 (FFF3) : Fixation
1	16	DC	Data Couner Data count after Sonde start-up (0-65535)
2	16	Sonde Serial NO.	Five-digit serial number. Do not be the same number in the several years. (0-65535)
3	16	Sonde Production data	Top two digits is the last two digits of the calendar year. The day of year that is "001" on January 1. e.g.) 2012/Jul/04-> 12186　2013/Jan/4 -> 13004
4	16	Sonde Information	Describes the version information of sonde.(Multiply by 1,000 to get the version number) No version is set to "FFFF"
5	16	Sub-frame NO.	Sub-frame Number. See "Discription(Sub-frame)" sheet.
6 7	32	Output Element 1 (1-1)+(1-2)	32-bit output elements by 1-1 and 1-2. Sends the contents of the "sub-frame 1" of output element of the "Discription(Sub-frame) " sheet. Sonde type name is expressed using the ASCII code. No transmission data is set to "FFFF".
8 9	32	Output Element 2 (2-1)+(2-2)	32-bit output elements by 2-1 and 2-2. Sends the contents of the "sub-frame 2" of output element of the "Discription(Sub-frame) " sheet. Sonde type name is expressed using the ASCII code. No transmission data is set to "FFFF".
10 11	32	Output Element 3 (3-1)+(3-2)	32-bit output elements by 3-1 and 3-2. Sends the contents of the "sub-frame 3" of output element of the "Discription(Sub-frame) " sheet. Sonde type name is expressed using the ASCII code. No transmission data is set to "FFFF".
12 13	32	Output Element 4 (4-1)+(4-2)	32-bit output elements by 4-1 and 4-2. Sends the contents of the "sub-frame 4" of output element of the "Discription(Sub-frame) " sheet. Sonde type name is expressed using the ASCII code. No transmission data is set to "FFFF".
14	16	BCC	Block check character (BCC). From the following data of SC to the front of the BCC , the BCC value is calculated by the horizontal parity (exclusive OR).

JMA format (Frame 2)

Frame 2 (240bit)

Data NO.	Bit Number	Content	Detailed description
15	16	SC	Sync code Frame1 (FFF0), Frame1 (FFF1), Frame3 (FFF2), Frame4 (FFF3) : Fixation
16	16	Internal Sensor State	In order from the MSB, Frequency (0), Battery voltage (1), Pressure (2), Temperature(3), Humidity (4), PDOP(5), GPS week (6), GPS second (7), GPS leap second (8), Number of Satellite (9), Latitude (10), Logitude (11), Altitude(12), Wind direction (13), Wind speed (14), Indicating rhe SBAS correction (15). The bit value "1" is normal, and "0" is abnormal or no use.
17	16	Battery Voltage	The numerical value multiplied by 100 to the battery voltage of the sonde. e.g. 12.0V -> 12.0 × 100 = 1200
18	16	Sonde Frequency	The numerical value multiplied by 100 to the battery voltage of the sonde. e.g. 404.5MHz -> 404.5×100＝40450
19	16	Transmit Data (Press.)	Raw data of the pressure sensor (frequency output). The frequency data obtained by 0.01Hz units, are multiplied by 100. Max 50000. e.g. 300.00Hz -> 30000 Refer to the sheet 1 for the calculation to physical quantity.
20	16	Transmit Data (Temp.)	Raw data of the temperature sensor (frequency output). The frequency data obtained by 0.01Hz units, are multiplied by 100. Max 50000. e.g. 300.00Hz -> 30000 Refer to the sheet 1 for the calculation to physical quantity.
21	16	Transmit Data (Hum.)	Raw data of the humidity sensor (frequency output). The frequency data obtained by 0.01Hz units, are multiplied by 100. Max 50000. e.g. 300.00Hz -> 30000 Refer to the sheet 1 for the calculation to physical quantity.
22	16	Reference Frequency	The value of reference instrument (resistance or capacitance) convert to a frequency (corresponding to the high reference). The frequency data obtained by 0.01Hz units, are multiplied by 100. Max 50000. e.g. 499.81Hz -> 49981
23	16	Correction (Pressure)	This correction data obtained by 0.01hPa units, are multiplied by 400. e.g. 0.12hPa -> 48 Correction value is calculated by the following formula. ⊿P=-(Pbl*Ps/P0) ⊿P (hPa): Correction value (hPa), Pbl (hPa) : Pressure deviation at BL check Ps (hPa) : Any pressure Po (hPa) : Surface pressure at the balloon launch
24	16	Correction (Temperature)	This Solar radiation correction data obtained by 0.01℃ units, are multiplied by 100. e.g. 0.26℃ -> 26 If the "infrared radiation", it is includes this correction.
25	16	Correction (Humidity)	This Humidity correction data obtained by 0.1%RH units, are multiplied by 100. e.g. 2.3%RH -> 230
26	16	PDOP	PDOP is multiplied by 100.
27 28	32	Using Satellite	GPS PRN number which starting with 1 for the MSB (SVN is not). The Received Satellite is '1', otherwise is "0".
29	16	BCC	Block check character (BCC). From the following data of SC to the front of the BCC , the BCC value is calculated by the horizontal parity (exclusive OR).

JMA format (Frame 3)

Frame 3 (240bit)

Data NO.	Bit Number	Content	Detailed description
30	16	SC	Sync code Frame1 (FFF0), Frame1 (FFF1), Frame3 (FFF2), Frame4 (FFF3) : Fixation
31	16	Week Number	The week number obtained from the navigation message of GPS. It starts from zero week on August 22, 1999
32 33	32	GPS Seconts	The addition seconds from the 00h00m00sUTC on Sunday, obtained from the navigation message of GPS.
34	16	GPS leap seconds	The leap seconds obtained from the navigation message of GPS.
35 36	32	Latitude	The 32-bits by the latitude1 and latitude2. Latitude is calculated to 0.0000001 degree, and multiplied by 10 million. North latitude is positive. South latitude is negative. A negative number is taken as the complement of 2.
37 38	32	Longitude	The 32-bits by the longitude1 and longitude2. Longitude is calculated to 0.0000001 degree, and multiplied by 10 million. East longitude is positive. West longitude is negative. A negative number is taken as the complement of 2.
39 40	32	GPS Altitude	The 32-bits by the altitude1 and altitude2. The GPS altitude calculated by 0.01 meters, and multiplied by 100. A negative number is taken as the complement of 2.
41	16	Wind Direction	The moving direction of the sonde calculated by 0.01degree, and multiplied by 100. For example, in the case of 360.00 degrees (north wind), since it flows to South direction, it becomes 180.00 degrees.
42	16	Wind speed	The moving speed of the sonde calculated by 0.01m/s, and multiplied by 100.
43	16	External sensor flag	In order from the MSB, Data No46 (0), Data No47 (1), Data No.48 (2), Data No.49 (3), Data No.50 (4), Data No.51 (5), Data No.52 (6), Data No.53 (7), Data No.54 (8), Data No.55 (9), Data No.56 (10), Data No.57 (11), Data No.58 (12). The bit value "1" is normal, and "0" is abnormal or no use.
44	16	BCC	Block check character (BCC). From the following data of SC to the front of the BCC , the BCC value is calculated by the horizontal parity (exclusive OR).

JMA format (Frame 4)

Frame 4 (240bit)

Data NO.	Bit Number	Content	Detailed description
45	16	SC	Sync code Frame1 (FFF0), Frame1 (FFF1), Frame3 (FFF2), Frame4 (FFF3) : Fixation
46	16	Vacancy	Free channel. When using the Ozone sonde, ECC electric current is set between 0 to 65535. The current data obtained by 0.001 μA units, are multiplied by 100 and plus 10000. (For example, 0 μA is 10000. 55.535 μA is 65535.).
47	16	Vacancy	Free channel. When using the Ozone sonde, ECC temperature is set between 0 to 65535. The temperature data obtained by 0.01 K degree, are multiplied by 100.
48	16	Vacancy	Free channel. When using the Ozone sonde, pump moter electric current is set between 0 to 65535. The current data obtained by 0.01 mA, and are multiplied by 100.
49	16	Vacancy	Free channel. When using the Ozone sonde, reaction tube temperature is set between 0 to 65535. The temperature data obtained by 0.01 K degree are multiplied by 100.
50	16	Vacancy	Unused channel. If necessary, set the data between 0 and 65535.
51	16	Vacancy	Unused channel. If necessary, set the data between 0 and 65535.
52	16	Vacancy	Unused channel. If necessary, set the data between 0 and 65535.
53	16	Vacancy	Unused channel. If necessary, set the data between 0 and 65535.
54	16	Vacancy	Unused channel. If necessary, set the data between 0 and 65535.
55	16	Vacancy	Unused channel. If necessary, set the data between 0 and 65535.
56	16	Vacancy	Unused channel. If necessary, set the data between 0 and 65535.
57	16	Vacancy	Unused channel. If necessary, set the data between 0 and 65535.
58	16	Vacancy	Unused channel. If necessary, set the data between 0 and 65535.
59	16	BCC	Block check character (BCC). From the following data of SC to the front of the BCC , the BCC value is calculated by the horizontal parity (exclusive OR).

JMA format (Sub-frame)

Coefficient comparison table – Various address for sending

Sub-Frame	Output element 1
0	Sonde type
1	Calibrated temperature 1
2	Calibrated temperature 2
3	Calibrated temperature 3
4	Calibrated temperature 4
5	Calibrated temperature 5
6	Calibrated temperature 6
7	Calibrated temperature 7
8	Calibrated temperature 8
9	Calibrated temperature 9
a	Calibrated temperature 10
b	Calibrated temperature 11
c	FFFF
d	FFFF
e	FFFF
f	FFFF

Sub-Frame	Output element 2
0	Sonde type
1	Calibration resister 1 for temperature
2	Calibration resister 2 for temperature
3	Calibration resister 3 for temperature
4	Calibration resister 4 for temperature
5	Calibration resister 5 for temperature
6	Calibration resister 6 for temperature
7	Calibration resister 7 for temperature
8	Calibration resister 8 for temperature
9	Calibration resister 9 for temperature
a	Calibration resister 10 for temperature
b	Calibration resister 11 for temperature
c	FFFF
d	FFFF
e	FFFF
f	FFFF

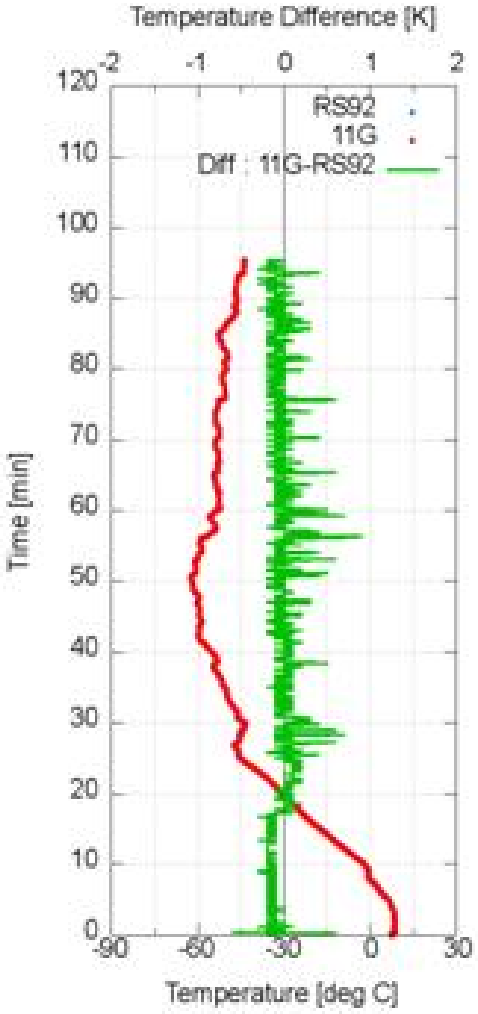
Sub-Frame	Output element 3
0	Sonde type
1	Temperature coefficient (A0)
2	Temperature coefficient (A1)
3	Temperature coefficient (A2)
4	Temperature coefficient (A3)
5	Pressure coefficient (P0)
6	Pressure coefficient (P1)
7	Pressure coefficient (P2)
8	Pressure coefficient (P3)
9	Pressure coefficient (P4)
a	Pressure coefficient (P5)
b	FFFF
c	FFFF
d	FFFF
e	FFFF
f	FFFF

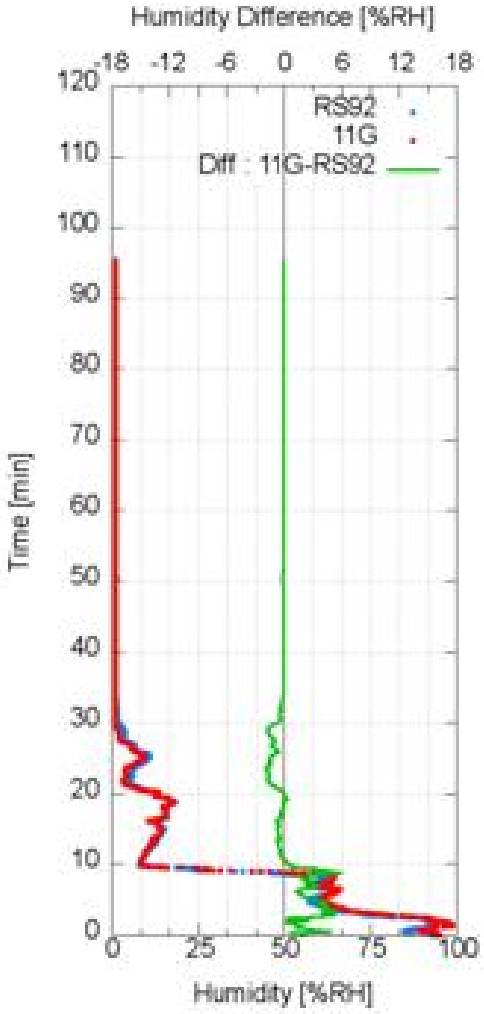
Sub-Frame	Output element 4
0	Sonde type
1	Humidity coefficient (B0)
2	Humidity coefficient (B1)
3	Humidity coefficient (B2)
4	Humidity coefficient (B3)
5	FFFF
6	FFFF
7	FFFF
8	FFFF
9	FFFF
a	FFFF
b	FFFF
c	FFFF
d	FFFF
e	FFFF
f	FFFF

Sonde type name, use the (8Byte, 8 characters) 128 bits of output elements 1-4.
And fills from the MSB using the ASCII code.
The margin fill in blank (0x20).

Comparison between old and new radiosonde sounding

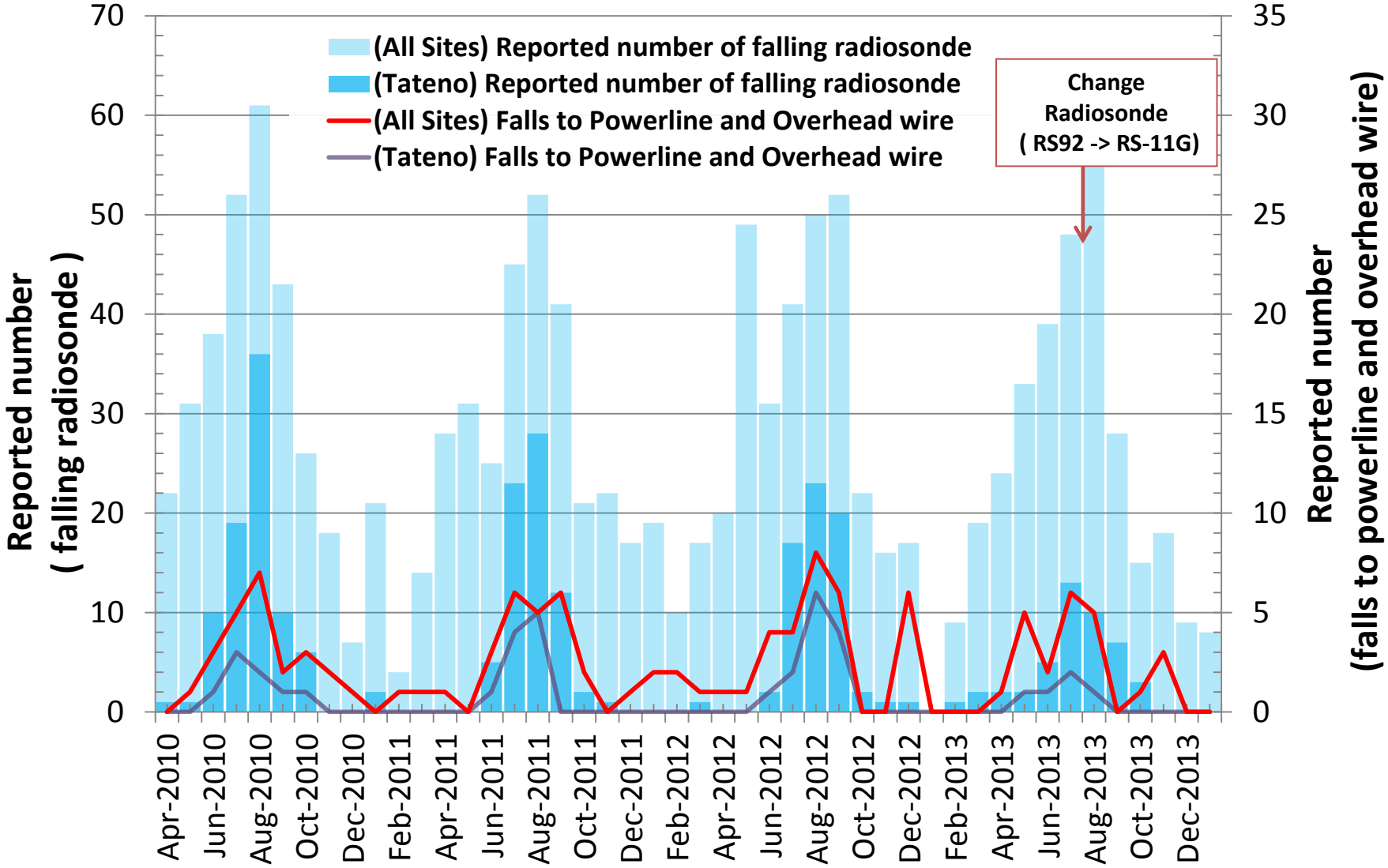
We are currently analyzing





-Comparative example of dual launch sounding at 12UTC on January 30, 2014

Falling Radiosonde report



-JMA has 16 Sites including Tateno site, and receives 50 falling radiosonde report in summer.

-Tateno site, Reports from the Tokyo metropolitan area will be 20 to 30 cases.

Impact of falling Radiosonde -1

Case

Radiosonde hit the house roof!

Aug.8, 2012
Launch site : Tateno
Falling point : Chiba Pref.
Reparation : 55,000 yen
(US$ 550)

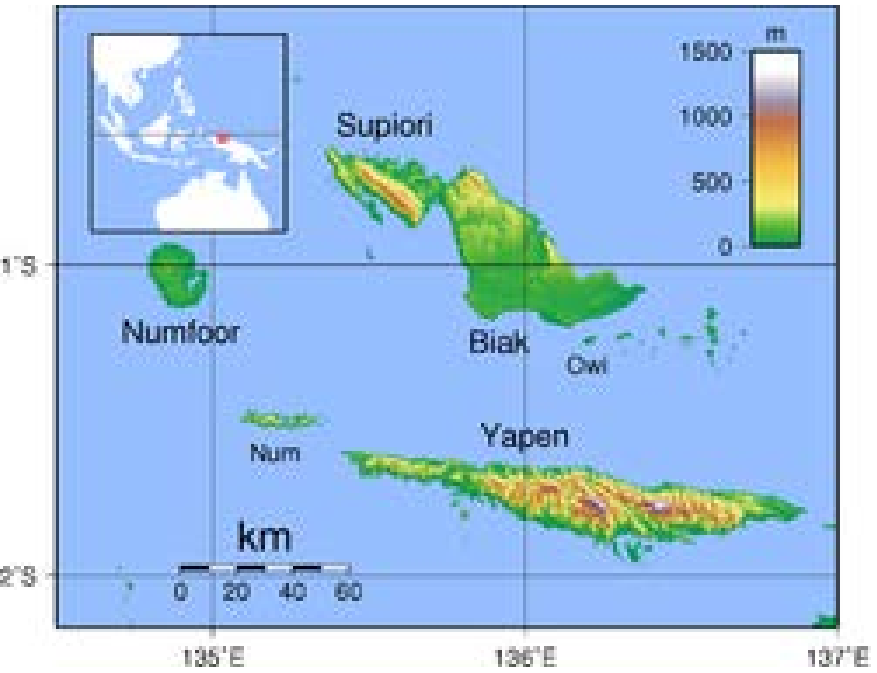
Case

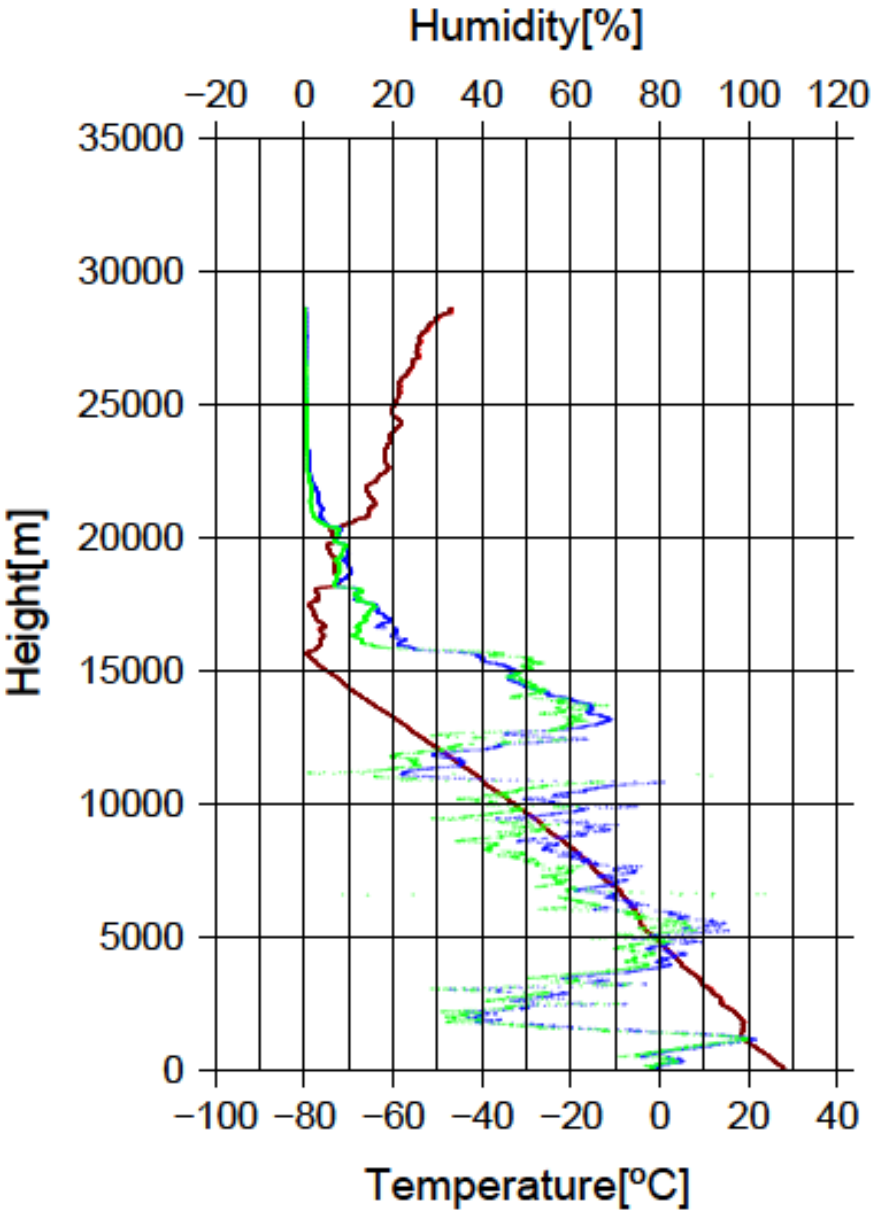
Radiosonde hit the Car!

July. 21, 2013
Launch site : Sapporo
Falling point : Sapporo
Reparation : 370,000 yen
(US$3,700)

Comparison between the RS11G (High response) Humidity sensor and the CFH by dual sounding

At 09UTC on Feb.26, 2014
Biak Is. /Indonesia

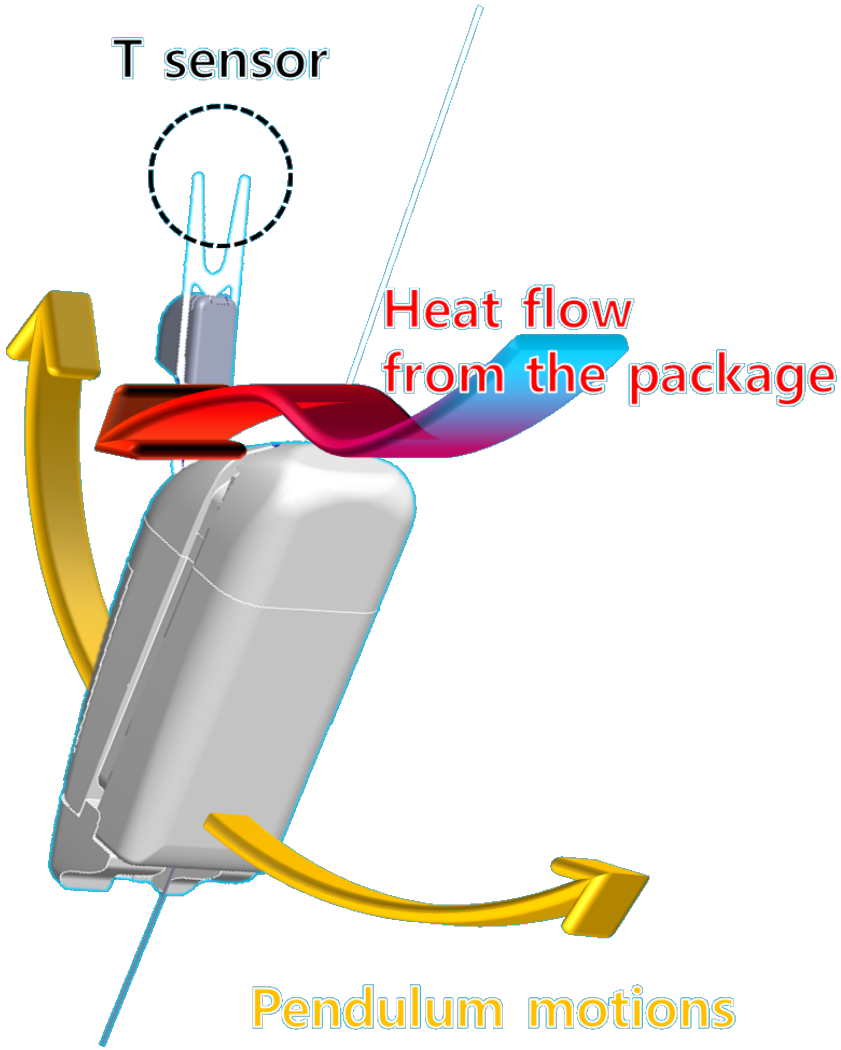




RS-11G T
RS-11G U
RS-06G T
CFH U

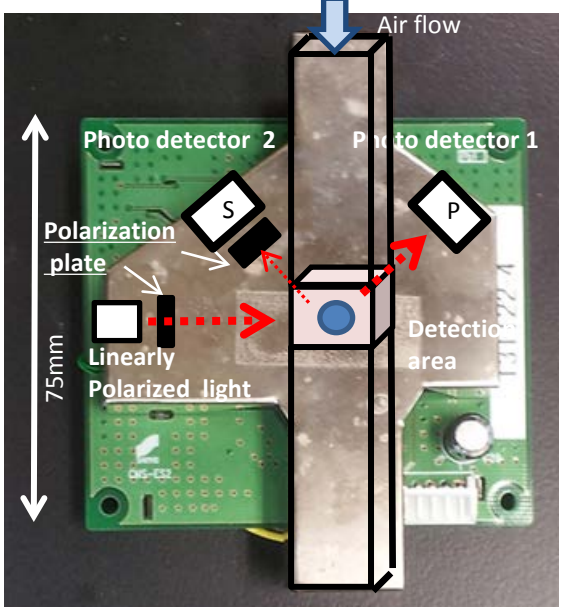
-Humidity :
Only use the Temperature correction

Heat flow of the RS-11G (iMS-100)

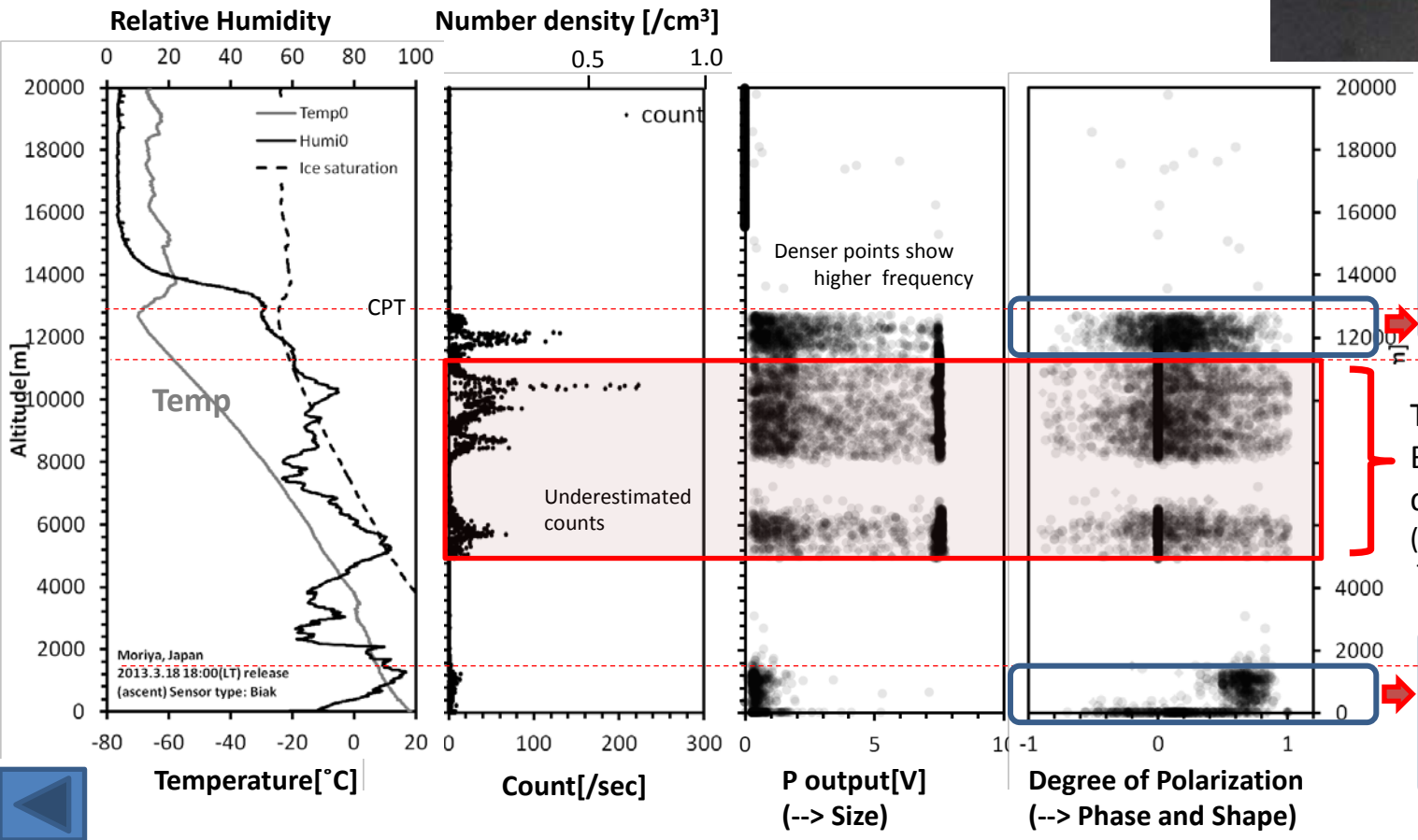


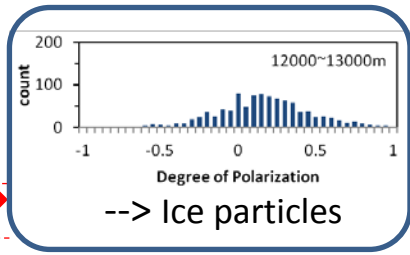
Cloud Particle Sensor (CPS)

(by Hokkaido University, Meisei Electric Co. LTD. and SHINYEI Technology Co. LTD.)



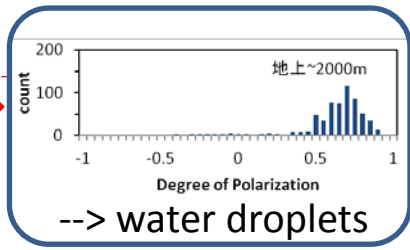
- The CPS has been developed to measure cloud-particle number density, size distribution, and the phase (i.e., liquid water or ice).
- A low-cost and light-weighted (~200 g, including batteries) particle counter based on a pollen sensor.
- The CPS can optically detect the particle.





--> Ice particles

The CPS detects clouds. But, these clouds are too dense for CPS.
(due to multiple scattering)
The detection limit is about **1 /cm³**



--> water droplets