Polar Meteorol. Glaciol., **12**, 124–129, 1998

COMPARISON OF TEMPERATURE DATA MEASURED BY RS2-91 AND RS2-80 RAWINSONDES AT SYOWA STATION, ANTARCTICA

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Abstract: Rawinsondes used for upper air observations at Syowa Station, Antarctica have been changed from type RS2-80 to type RS2-91 since January 1, 1995. To determine the temperature differences of two types of sonde at Syowa Station in winter, comparisons were made in September 1996. From these comparisons, we found that RS2-80 measured a higher temperature than RS2-91 at air temperature lower than about −65°C. It is suggested that the temperature dependence of the converter in the RS2-80 type may be the reason for this phenomenon.

1. Introduction

Aerological data measured by rawinsonde provide initial values for numerical weather prediction used as the basis of current weather forecasting, and are used in studies of the dynamic structure of the atmosphere and the vertical structure of flow. Increase or decrease of stratospheric ozone causes a change of heating rate in the stratosphere, which has been found to affect climate in recent years.

In Antarctica, it is possible for Polar Stratospheric Clouds (PSCs) to form because temperature in the stratosphere falls remarkably for polar night vortex to occur in winter. Because of PSCs, an Ozone Hole is formed in spring when the solar radiation comes back, and does not extinct until temperature in the stratosphere rises. Therefore, temperature measurement in the atmosphere is very important to watch these phenomenon.

At Syowa Station, Antarctica (69°00′S, 39°35′E) rawinsondes used for upper air observations have been changed from type RS2-80 to type RS2-91 since 00 UTC January 1, 1995. For consistency in using data it is necessary to compare the characteristics of both rawinsondes, so comparisons by means of tandem flight were carried out in four seasons by the 35th Japanese Antarctic Research Expedition (JARE-35) and the 36th Japanese Antarctic Research Expedition (JARE-36) (SATO *et al.*, 1997). The temperature differences between RS2-91 and RS2-80 behaved differently in winter than in other seasons. The results except in winter are consistent with similar comparisons at Tateno, Japan (36°03′N, 140°08′E) (YAGI *et al.*, 1996). To determine why the behavior was different in winter, similar comparisons were made in September 1996.

2. Method of Comparison

Comparison experiments were done at night to avoid influence of solar radiation. We launched rawinsondes eight times early in September 1996 and we successfully obtained observation data seven times.

Similar to the comparisons by JARE-35 and JARE-36, data from RS2-91 were received at the Meteorological Hut and processed as routine observations. RS2-80 data were processed as batch observations at the Meteorological Hut after being received at the Rocket Telemetry Hut and recorded on floppy disk by a digitizer. To launch, we used one meter long coupling rods made of bamboo; each sonde was fixed to each end, as in similar comparisons held by the Aerological Division of the Observations Department, Japan Meteorological Agency (ADOD/JMA)(1984).

3. Results

Figure 1 shows profiles of temperature differences ΔT (RS2-91 minus RS2-80) at each standard pressure level in the comparisons by JARE-37. ΔT from 200 hPa up to 30 hPa was negative.

In Fig. 2 the temperature measured by RS2-91 and RS2-80, and ΔT, are shown as functions of time elapsed from launch. Error caused by differences between the barometers used for both rawinsondes is omitted. All observations showed that there was little difference between the two types of sonde in the troposphere (0 through about 25 min after launch), in the lower stratosphere (about 30 through about 75 min-

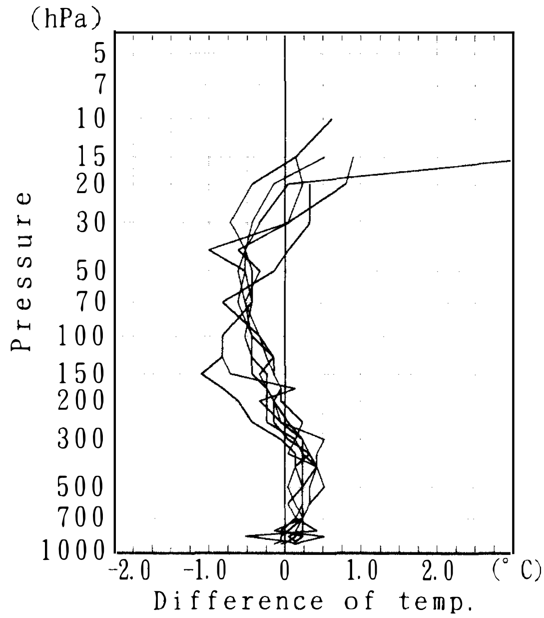

Fig. 1. Vertical profiles of temperature differences ΔT (RS2-91 minus RS2-80) at each standard pressure level at Syowa Station, in early September 1996.

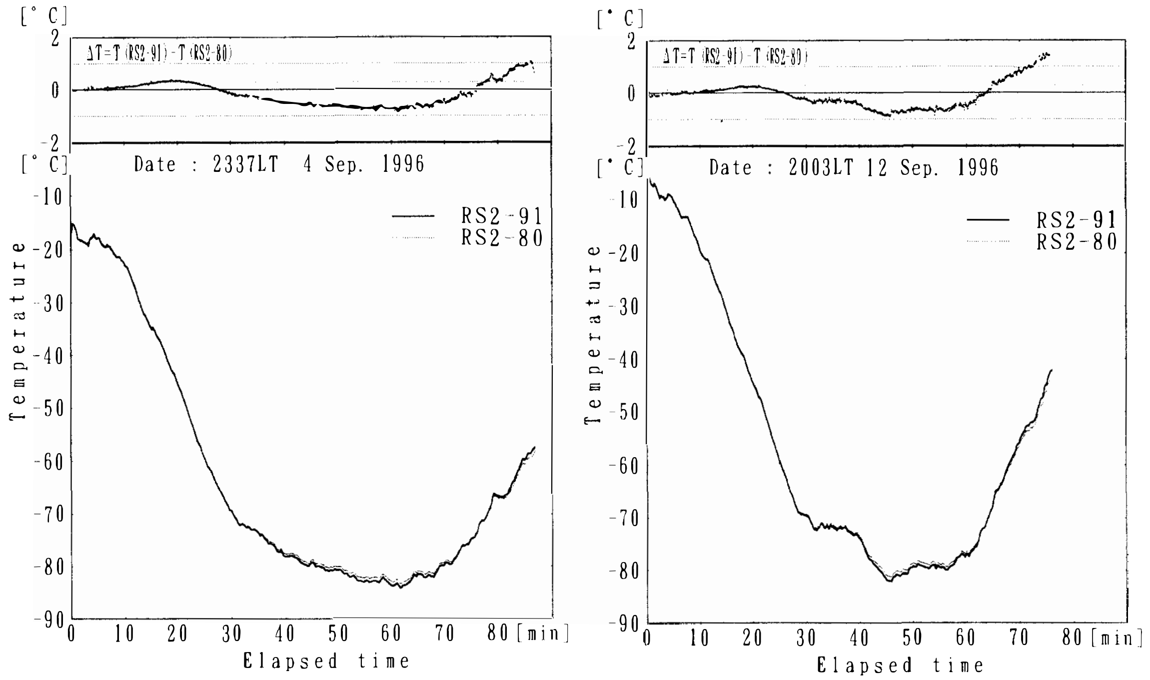

Fig. 2. Temperatures measured by RS2-91 and RS2-80, and the differences ΔT as functions of time elapsed from launch.

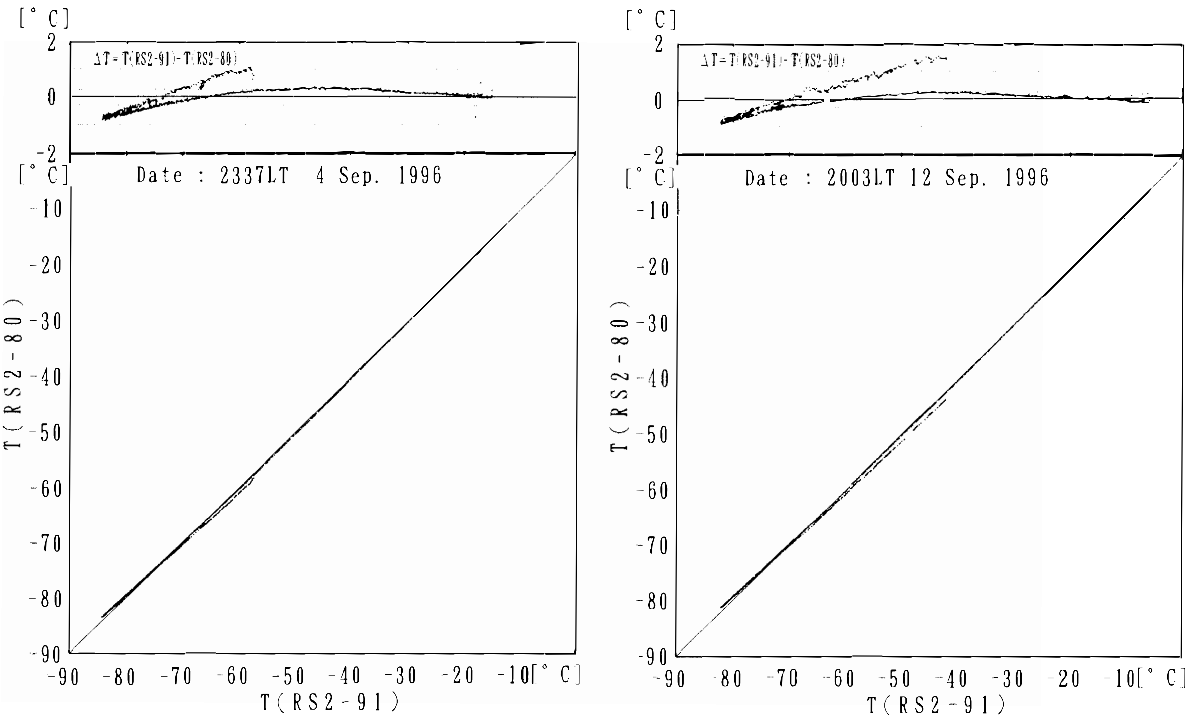

Fig. 3. Temperatures measured by RS2-80 and differences ΔT as functions of the temperature measured by RS2-91.

utes) RS2-80 measured higher temperature than RS2-91, but then RS2-80 became lower than RS2-91 with time.

Figure 3 shows the temperature measured by RS2-80 and ΔT as functions of the temperature measured by RS2-91 up elapsed time. As shown in Figs. 2 and 3, although there was little difference between two types of sonde from the surface to the level where the temperature reached about -65°C, RS2-80 measured higher temperatures at the temperature lower than -65°C, but then RS2-80 became lower than RS2-91 with height.

4. Discussion

SATO *et al.* (1997) reported as follows for ΔT at the standard pressure levels; ① absolute values of ΔT are small in the troposphere throughout the year, ② absolute values of ΔT tend to be large in the stratosphere throughout the year, ③ in the stratosphere, ΔT is negative in winter but positive in other seasons. The comparisons held by ADOD/JMA at Tateno, Japan had data similar to ① and ②, but ③ never occurred. The comparisons in this study had data similar to those from the comparisons in winter by SATO *et al.* (1997), so it will be considered that ③ is a unique phenomenon at Syowa.

Next, we consider the reason for the temperature differences between observations by RS2-80 and RS2-91. The temperature sensors used in these sondes are thermisters (ADOD/JMA, 1981; JMA, 1995). Measurement errors are produced by solar radiation, time constant, longwave radiation, Joule heat, and inadequate compensation for non-linearity in the thermister.

In these comparisons, there is no error due to solar radiation, and the error due to Joule heat can be ignored (NAKAMURA *et al.*, 1983). The time constants of RS2-80 and RS2-91 are 4.5 and 2 s, respectively (ADOD/JMA, 1981; JMA, 1995). According to ADOD/JMA (1984), the error due to the difference between the time constants of RS2-80 and the temperature reference sonde is estimated at less than 0.2°C. Figure 2 shows that there is dispersion caused by the difference between the time constants of RS2-80 and RS2-91, but this is not the reason for this phenomenon.

The reason why RS2-80 measures lower temperature above the 70 hPa level is assumed to be that the white-painted thermister in RS2-80 emits more longwave radiation than the thermister in RS2-91, which is coated with vacuum-evaporated aluminum to reduce the infrared radiation effect (YAGI *et al.*, 1996). Longwave radiation varies according to whether clouds exist at launch or not and so on, so calibration is quite difficult (NAKAMURA *et al.*, 1983).

In several comparisons between RS2-91 and the reference sonde by ADOD/JMA at Tateno recently, it is known that RS2-91 measures the correct temperature when there is no necessity to correct for solar radiation, even at temperature lower than -65°C. RS2-80 measured higher temperature at air temperature lower than about -65°C. According to ADOD/JMA (1982), the thermister in RS2-80 has been calibrated to -75°C at JMA and the observation error of the sensor itself is 0.3°C or less; this deviation does not deviated much down to -90°C. In RS2-80 and RS2-91, the same relation between temperature and thermister resistance has been used.

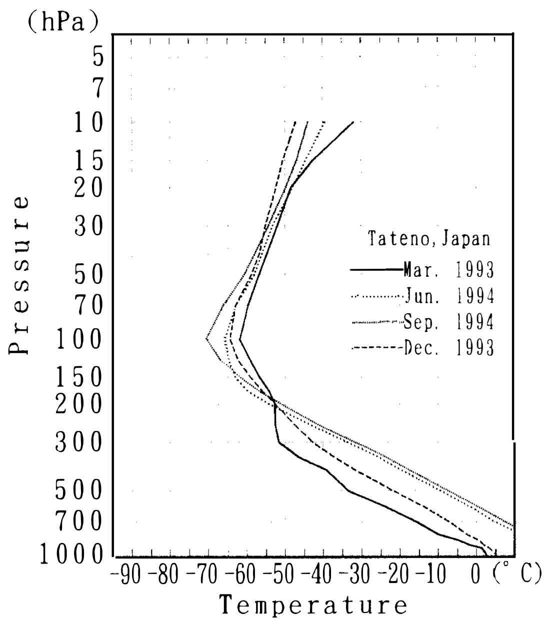

Fig. 4. Monthly mean temperature profiles at standard pressure levels in four seasons at Tateno, Japan.

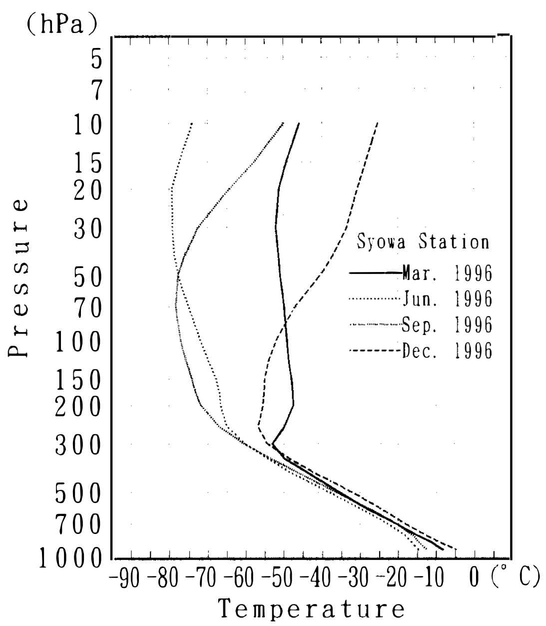

Fig. 5. Monthly mean temperature profiles at standard pressure levels in four seasons at Syowa Station, Antarctica.

However, the ranges of the resistance values over which temperature ranges are not equal, which may be the cause that produces this error.

If the relation between the temperature and thermister resistance is correct, the difference may be caused by temperature dependence of the processing unit in the sonde. A rawinsonde consists of sensors, converter, and transmitter. Both sondes use the same type of transmitter, so this cannot be the cause. The converter temperature characteristics have been checked to −40°C (ADOD/JMA, 1981), but not at lower temperature. Therefore, the difference might be caused by the RS2-80 converter temperature characteristics, including the effect of the lead lines to the thermister.

Next, we consider why this phenomenon appeared not at Tateno but only at Syowa. Figures 4 and 5 show monthly temperature profiles at standard levels in four seasons at Tateno and Syowa, respectively. Temperatures at Tateno, and at Syowa except in winter and early spring, never decreased below −65°C, except near the tropopause.

At Tateno, the temperature was below −65°C at less than 3 levels. On the other hand, as shown in Fig. 5, temperature decreases below −65°C from the tropopause up to 15 hPa at Syowa from winter to early spring. This is why this phenomenon appears in winter only at Syowa.

5. Conclusions

From the comparisons of JARE-37, we determined that RS2-80 measured higher temperature than RS2-91 when air temperature was lower than about −65°C.

Because the RS2-80 type is no longer used already, there is no influence on meteorology such as numerical weather prediction. But a temperature difference of 1°C at temperature lower than −65°C will influence climatology analysis because the temperature of the border which PSCs produces is contained in this temperature range. It is difficult to find this result from aerological observations in Japan because it is rare to observe temperature below −65°C in upper air in Japan. By comparison with these sonde and temperature reference sonde in Syowa and by investigating a cause of this phenomenon by laboratory examinations, the propriety of observation value of RS2-80 and RS2-91 should be inspected again and the correct value should be estimated to reduce influence to analysis on climatology.

References

ADOD/JMA (1981): RS2-80 gata rewin zonde ni tsuite (RS2-80 type rawin sonde). Sokko Jiho (Weather Serv. Bull.), **48.11-12**, 313–330.

ADOD/JMA (1982): RS2-80 gata rewin zonde no jido kentei shisutemu (Automatic calibration system for the RS2-80 type rawinsonde). Sokko Jiho (Weather Serv. Bull.), **49.3**, 143–169.

ADOD/JMA (1984): RS2-80 gata rewin zonde no kion kijun zonde tono hikaku kansoku ni tsuite (Comparisons of the RS2-80 type rawinsonde with the temperature reference sonde). Sokko Jiho (Weather Serv. Bull.), **51.5**, 367–377.

JMA (1995): Koso Kisho Kansoku Shishin. Tokyo, Japan Meteorological Agency.

NAKAMURA, T., HAYASHI, N. and MASUDA, K. (1983): RS2-80 gata rewin zonde no kion sensa ni shozuru shuju no mitsumori ni tsuite—Nissha hosei shiki ni tsuite— (Estimation of errors in measurement by the temperature sensor of RS2-80 rawinsonde—A method of correction for temperature errors due to solar radiation—). Sokko Jiho (Weather Serv. Bull.), **50.2**, 117–138.

SATO, T., TAKEKAWA, M., MIYAUCHI, S., NAKAMURA, T., YOSHIMI, H., INAGAWA, Y., YAMAMOTO, Y., TAGUCHI, Y., ABO, T. and IJIMA, O. (1997): Comparison of aerological data measured by means of RS2-91 rawinsonde and RS2-80 rawinsonde at Syowa Station, Antarctica (abstract). Proc. NIPR Symp. Polar Meteorol. Glaciol., **11**, 260.

YAGI, S., MITA, A. and INOUE, N. (1996): WMO International Rawinsonde Comparison—Phase IV—Final Report, WMO/TD-No.742, World Meteorological Organization, 130 p.

(Received December 25, 1997; Revised manuscript accepted June 19, 1998)