Correction for radiative heating errors in naturally ventilated air temperature measurements made from AWS on the Antarctic Plateau

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Temperature errors in naturally ventilated shield

Dome Fuji

UW radiation shield

Gill radiation shield (Japan-AWS)

Ventilation Fan

Forced ventilation (FV)

Natural ventilation (NV)

Radiative heating

Low wind + High solar radiation

Gill radiation shield (Japan-AWS)

Air flow

Sensor

Radiative Errors
AWSs with forced ventilation shield are increasing over the Plateau.

Japan-US AWS Network (Queen Maud Land)

★ AWSs with forced ventilation shield are increasing over the Plateau

US-AWS

Mizuho

Relay Point

Dome Fuji

Japan-AWS

H128

50E

70S Relay Point

75S

NDF
Japan AWS Network (New Dome Fuji: NDF)

New Dome Fuji (NDF)  
< 50 km SW from DF >

► Observation Period
27/12/2017 〜 on going

► Items
- Air Temperature (2m)
  Naturally ventilated shield  x 1
  Mechanically ventilated shield  x 1
- Relative Humidity
- Wind
- Pressure
- Shortwave radiation
- Longwave radiation
- Snow depth
- Snow temperature (10ch.)
Ventilated and Unventilated Temperature

★ Measurement Errors during a clear sky condition at NDF
★ QCed Hourly data ( QC was completed by UW method )

Mean wind speed < 4 m/s

Mean wind speed > 4 m/s

8°C
Seasonal fluctuations of temperature errors

★ Temperature errors = Radiative heating/cooling of sensor

- **Heating**: Absorption of SW in the shield \( (SW\uparrow) \)
- **Cooling**: Air flow past the sensor surface (Wind speed)

Motoyama et al. [2019]
Correction of temperature errors (NDF)

★ Simple regression model (Nakamura and Mahrt, 2005)

\[
\Delta T = C_0 X^{C_1}
\]

- \( C_{0.1} \): empirical coefficients
- \( X \): non-dimensional number
- \( \rho \): density of air (0.86 kg/m\(^{-3}\))
- \( C_p \): specific heat capacity (1004 JK\(^{-1}\)kg\(^{-1}\))

\[
X = \frac{SW^\uparrow}{\rho C_p U T}
\]

\[
\Delta T = 6.3 \times X^{0.7}
\]

(R=0.93)
Correction for US-AWSs

Temperature errors highly depend on both sensor and radiation shield (shape and material).
( Gil, 1983; Payne, 1987; Harrison, 2011 etc.)

UW-AWSs
Sensor: Weed Platinum residence (Pt1000Ω)
Shield: Vertical piece of aluminum tube

Map showing locations of Mizuho, Relay Point, and Dome Fuji with images of Mizuho, RP, and DF stations.
Comparison between NDF and RP

★ ΔT of RP(US-AWS) is less than half of NDF with Gill shield.
★ Radiation shield with US-AWS is better performance than Gill shield.

NDF

Relay Point

ERA5

Day 2018

Day 2019

>100 W/m²

2 m/s

4 °C

>100 W/m²
Clear dependence with respect to short-wave radiation and wind speed.

Relay Point

Heating

\[ \Delta T = 6.1 \times X \quad (R = 0.91) \]

Cooling

\[ \Delta T = 6.1 \times X \quad (R = 0.91) \]
Temperature errors highly depend on both sensor and radiation shield (shape and material).
( Gil, 1983; Payne, 1987; Harrison, 2011 etc.)

**Correction for US-AWSs**

**UW-AWSs**
- **Sensor:** Weed Platinum residence (Pt1000Ω)
- **Shield:** Vertical piece of aluminum tube

**Locations:**
- **Mizuho**
- **Relay Point**
- **Dome Fuji**

**Images:**
- Mizuho
- RP
- DF
- Sensor
Correction of temperature errors (DF)

★ NV at DF (US-AWS) vs. FV at NDF

Extract days with matching temperature changes in summer.

Jan 2018 – Apr 2019

SW↑ + SW↓ > 1200 W/m²

Dependence with respect to wind speed matches between Relay Point (RP) and Dome Fuji (DF)

\[ \Delta T = 6.1 \times \]

Before 2.40

After 1.13

1:1
Warm biases of naturally ventilated shield can be removed by an empirical model using wind speed and shortwave radiation.

An empirical model for Relay Point works for correction of warm biases at Dome Fuji.

Simple radiation shields (aluminum tube) are better performance than the common Gill shield on the Plateau.
Gill shield of naturally ventilated sensor was covered by frost in summer due to weak-wind conditions.

Reference: