Development of new thermometer shields with the ventilation speed controller

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Introduction

In the atmospheric temperature observations near the ground surface, artificially-ventilated radiation shields are generally used for the measurement to ensure the observation accuracy. However, the power consumption for a ventilation fan shall be too large in case of using solar power supply, for example.

Therefore, we developed new thermometer shields using the capability of fan motor speed control with a vacuum insulation metal pipe in order to reduce power consumption for the fan motor while ensuring measurement performance.

Figure 1. Thermometer shield with the ventilation speed controller.

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Field observation

We started field observation with three different types of thermometer shields from April 2017 at Shionomisaki Wind Effect Laboratory, Disaster Prevention Research Institute, Kyoto University. Each shield consists of double tube structure, and contains a Pt-100 RTD sensor probe in the inner tube. The ventilator generates airflow from bottom to top.

We collected observation data not only temperature but also atmospheric pressure, humidity, precipitation, wind speed and wind direction, as well as global solar radiation. In addition to the meteorological elements, the rotation speed of the ventilation fan and its power consumption are also recorded every second by our data acquisition system. We calculated 1 minute moving averages based on every second data at every 10 seconds.

We used two general conventional artificially-ventilated shields, PVC-04 and TH-500. The ventilation speeds for them are about 3 m/s and about 6 m/s, respectively. We programmed the fan rotation speed for the new shield which we developed to configure the ventilation speed of six steps from 1 m/s to 6 m/s during the nighttime (blue bars in Figure 2), and from 3 m/s to 12 m/s during the daytime (red bars in Figure 2). Each step of fan-speed control continued for ten minutes.

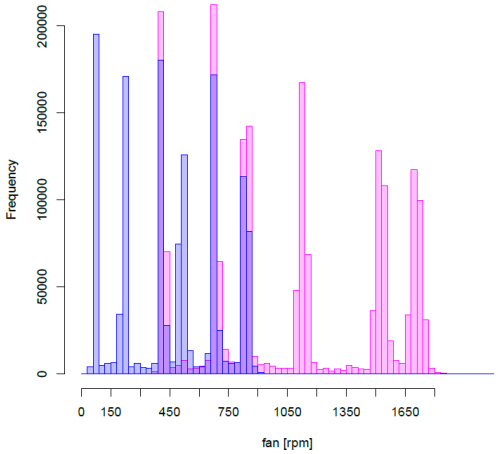

Figure 2. Distribution of fan rotation speed.

Results

We compared temperature data of daily mean, minimum and maximum values for each shield during the month in July 2017. Daily maximum reported from TH-500 were lower than those from two other shields. Differences of daily mean and that of daily minimum are relatively smaller.

To evaluate the ventilation performance of our new shield against the solar radiation, we compared the temperatures between our shield and the reference model (TH-500), considering the variation of the solar radiation and the rotation speed of the ventilation fan. In the daytime, during the slow fan speed, average of the temperature differences increased from 0 to more than 1 °C according to increase of the solar radiation (upper panels in Figure 3). When the fan rotation speed is getting higher, temperature differences were decreasing to less than 0.2 °C (lower right panel in Figure 3).

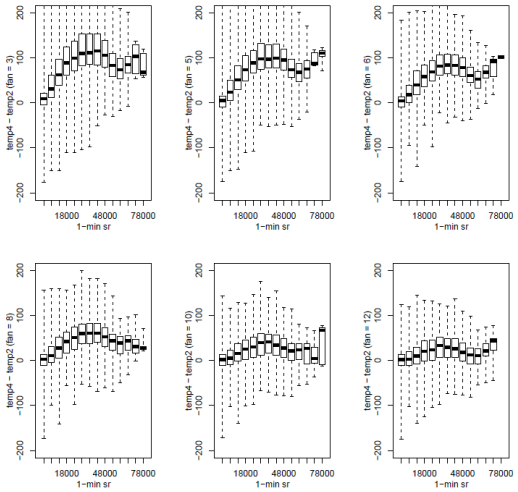

Figure 3. Distribution of temperature differences against solar radiation classes.

In this inter-comparison, our new ventilation shield saved electric power consumption up to 50% for the ventilation fan on average, and 85% in the nighttime, compared with the reference model TH-500.