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Analysis of Suspected Temperature Observations from Quality Control Process in Urban Areas

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1. Introduction

Data quality is very critical when observations from automatic surface weather stations (AWS) are applied to meteorological operations and researches. Therefore, quality control processes are necessary when using observations. There are several basic quality assurance (QA) methods available according to World Meteorological Organization (WMO), such as plausible value check, time consistency check and internal consistency check. Time consistency check consists of persistence test and step test (Zahumenský I., 2007).

Because temperature changes on different climatological conditions and is sensitive to surrounding environment. Temperature observations, especially those observations from highly urbanized areas, are likely to fail plausible value check or time consistency check when basic QA procedures are applied. However, these data might be important observations in studying extreme weather events and understanding the influence of environment (Shafer M., et al., 2000, Zahumenský I., 2007, Lussana C., et al., 2010). They need to be treated very carefully. Studying these suspected data may contribute to validating important doubtful data and improving the performance of temperature QA system.

Basic QA procedures are applied to hourly temperature observations (May in 2010 to April in 2011) of 18 AWS in a highly urbanized area (Shanghai Expo). Doubtful observations in this work include temperature dead band suspected data which fail the persistence test and temperature inconsistent suspected data which fail the step test. The distributions of these data are studied and possible causes are investigated.

2. Data and methods

2.1 Data

The hourly temperature observations (May in 2010 to April in 2011) were taken from 18 AWS located in a highly urbanized area-Shanghai Expo in China. Locations of Shanghai Expo, distribution of AWS and a photo of sensor are shown in Figure1. The 18 AWS are installed at different height: 10 m (8 sites), 20 m (4 sites), 30 m (2 sites), 50 m (1 sites), 60 m (2 sites), 165 m (1 sites). Hourly accumulative precipitation, cloud amount and sunshine duration observations come from Pudong meteorological station which is 4.6 km away from Shanghai Expo.

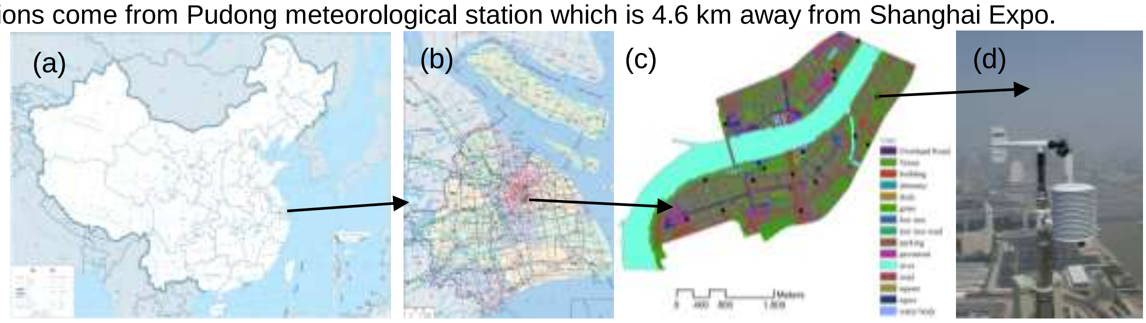

Figure 1. (a) Map of China; (b) Map of Shanghai city, the Expo was marked by red; (c) Land-use of the Expo and distribution of AWS (black dots) ; (d) Photo of sensor.

2.2 Methods

Plausible value check and time consistency check were applied in this work. Time consistency test consists of two parts: a persistence test and a step test. A persistence test focus on whether the number of successive data which are not changing exceeds a predefined number, while a step test focus on whether the rate of change between two successive data points exceeds predefined limit. Therefore, there are three steps in this QC procedure. The limit value for the first step is set to be -13 ℃ - 42 ℃. In the second step of QC, if the hourly temperatures are not changing over more than 6 hours, then all measurements in this period are flagged as doubtful. In the third step, one-hour variation is considered. Observations that fail this test are flagged as doubtful. According to WMO, doubtful data from the persistence test and the step test are called dead band suspected samples and inconsistent suspected samples.

3. Result and discussion

3.1 Temporal distribution

1) Temperature dead band suspected processes can last for 11 hours maximum. The temporal distributions of suspected dead band cases are analyzed. As is shown in Figure 2, most of these cases occur in winter season. The diurnal variation appears to be one-peak with the maximum around midnight (01:00 a.m.).

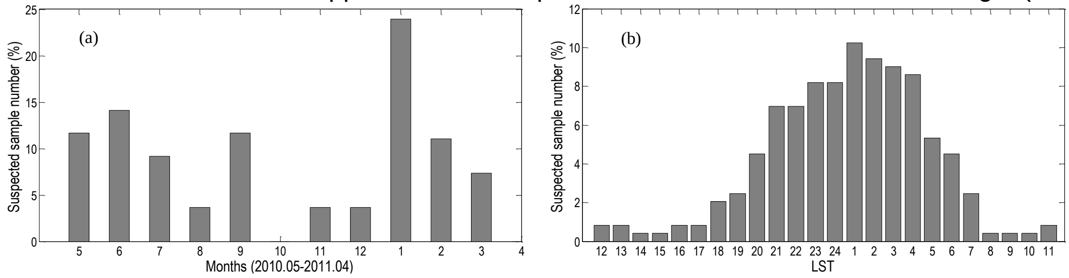

Figure 2. The temporal variations of suspected dead band samples (units: %).
(a) monthly variation; (b) Diurnal variation.

2) The inconsistent suspected cases can be grouped into two subsets: temperature jump cases and temperature slump cases. Their temporal distributions are different. The former group mostly occur in the autumn and winter, while the latter one mainly in the spring and summer. The temperature jump cases occur around sunrise, while the temperature slump cases occur in the afternoon or evening (Figure 3).

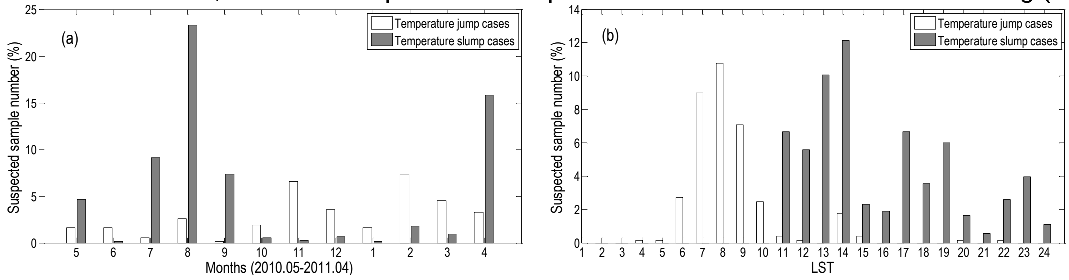

Figure 3. The temporal distribution of suspected samples of temperature jump and slump (units: %).
(a) monthly variation; (b) Diurnal variation.

3.2 Causes

3.2.1 Dead band suspected cases

Most (96%) suspected dead band cases occur in overcast conditions and over 50% cases on rainy days. Figure 4 indicates that precipitation intensity is very weak before and during suspected dead band processes.

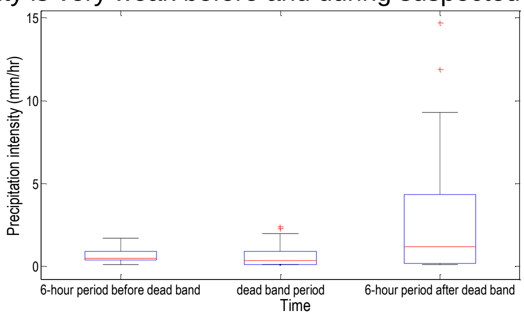

Figure 4. Distribution of precipitation intensity in dead band cases.

The occurrence of these suspected dead band cases may be closely related to the energy budget, as is shown in Figure 5. In overcast weather, the net shortwave radiation and longwave radiation are small due to the impacts of clouds (Kiehl J., Trenberth K., 1997). The latent heat flux is also small because the precipitation is weak.

In the daytime, the net radiation is balanced by latent heat flux when weak precipitation occurs, so that the sensible heat flux is low. At nighttime, the sensible heat flux is also low because the net radiation is very small when it is cloudy. Therefore, the variation of temperature at sheltered and blocked stations is insignificant.

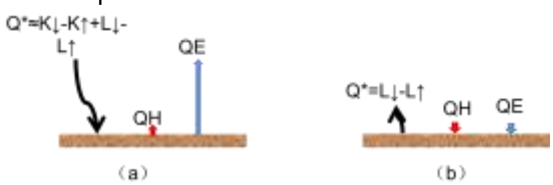

Figure 5. Sketch of energy budget during dead band process (a) daytime; (b) nighttime.
(Q: net all-wave radiation; K↓, K↑: incoming and outgoing shortwave radiation; L↓, L↑: incoming and outgoing longwave radiation; QH: sensible heat flux; QE: latent heat flux.)*

3.2.2 Inconsistent suspected cases

The suspected temperature jump cases mainly occur around sunrise on clear days. As solar altitude increases at sunrise, the sheltered stations are suddenly exposed to the sun and warm up dramatically (Figure 6).

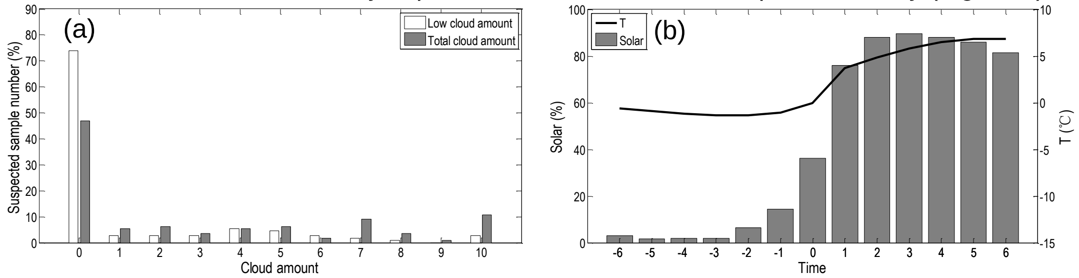

Figure 6. (a) The percentage of suspected samples with temperature increase under different cloud cover (08:00 LST); (b) Solar (percent with solar , bar) and temperature (anomaly relative to temperature at '0' moment, solid line) during warming up processes. On abscissa, '0' means the hour when temperature jump occurs, '1~6' mean different hours after that, '-1~-6' means different hours before that.

Similarly, some of suspected temperature slump cases are caused by decrease of solar altitude at sunset on clear days. However, the other suspected temperature slump cases are results of short-time heavy precipitation (Figure 7). Such cases mostly appear in cloudy weather when total cloud amount is more than 80%.

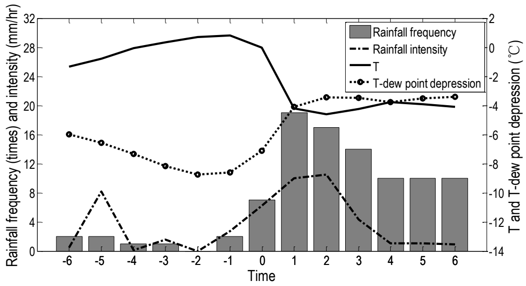

Figure 7. Precipitation frequency (bar), precipitation intensity (dashed line), humidity (dew point temperature minus temperature, dashed line with circles), temperature (anomaly relative to temperature at '0' moment, solid line) in temperature slump cases related to heavy precipitation.

4. Conclusions

The results show that most of temperature dead band suspected cases occur in winter season and in the evening. They are more likely to be observed at shielded and blocked stations in cloudy days. The sensible heat flux is low in these situations may be the reason that temperature keep the same for several hours.

The temperature inconsistent suspected cases consist of two groups: temperature jump cases and temperature slump cases. Their temporal distributions are different. The temperature jump cases mostly occur around sunrise in autumn and winter morning, while the slump cases mainly occur in spring-summer season and in the afternoon or evening. The occurrence of these cases are closely related to weather conditions. In temperature jump cases, as solar altitude increases at sunrise, the sheltered stations are suddenly exposed to the sun and warm up dramatically. Similarly, temperature goes down rapidly around sunset at the sheltered stations and temperature slump cases occur. In addition, the short-time heavy precipitation also causes dramatically cooling at stations.

Therefore, these suspected data are reasonable. They might be important observations in studying extreme weather events as well as environment effects on temperature. Multiple cross-checks are required when some observations from urban stations fail the QA test.

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