Interactive comment on "Construction of surface air temperature series of Qingdao in China for the period 1899 to 2014" by Yan Li et al.

Review ESSD-2017-58

Surface Air Temperature Qingdao

Important and positive to see these types of data sets emerge, both for the location and the century-long time scales.

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Reply to referees:

We appreciate the comments. And thanks a lot to the reviewer's works which have greatly improved our manuscript. The followed text is our point-by-point reply. The words with **blue colour are comments from referees**. The words with **black colour are the author's response.**

1. Easy access to a very clean .txt file. Easy to reproduce Figure 6. A .csv file might represent a more familiar format to many users?

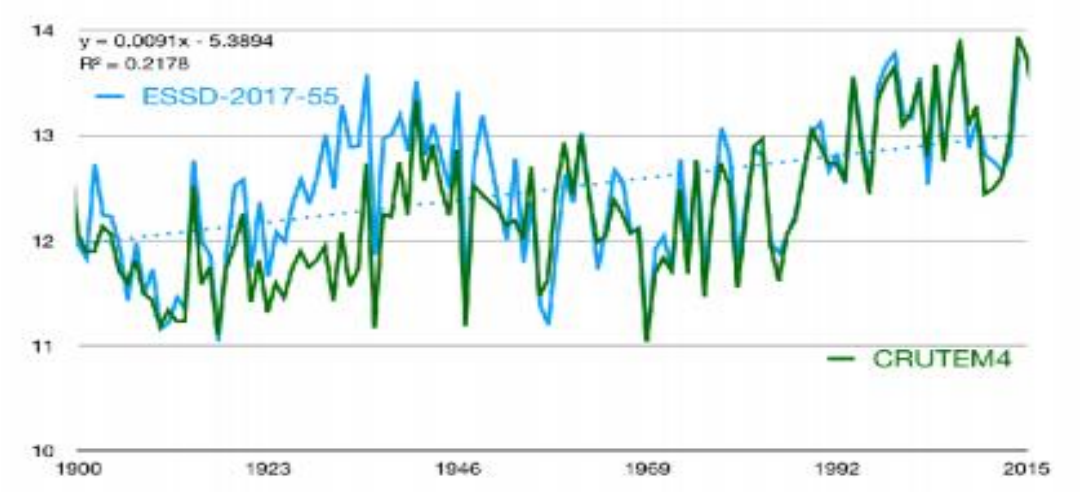
   Thank you for your suggestion. DWD hosts the station data of Qingdao on https://dx.doi.org/10.5676/DWD/Qing_v1. It is policy of DWD to provide station data only in ASCII format. That's why we cannot provide the time series of Qingdao in the formarts *.csv and *.xls.

2. For comparison and reference purposes we should have the relevant WMO station number? If not Qingdao then nearest reliable station? Or perhaps CMA has its own station numbers and perhaps reference stations? If so, helpful to know how this data fits within the CMA system?

   The relevant WMO station number of Qingdao is 54857. The Qingdao station is a national meteorological reference and basic station which is located at 36° 04′ N, 120° 20′ E. And the station is 76 meters above the sea level.

3. The descriptive manuscript seems to lack information on validation and

uncertainties? For validation I looked at CRUTEM4 (for access, start from https://doi.org/10.5194/essd-6-61-2014). I plotted the CRUTEM4 gridbox anomaly values for Qingdao (derived from multiple stations within that grid box) with these ESSD-2017-55 data (see below).



One sees, not surprisingly, remarkably good correspondence, no doubt because for most time periods CRUTEM4 and this data set access identical source data. But the time period 1920 to 1940 suggests some discrepancies. Either CRUTEM4 seems low or Willmott and Matsuura seem high? Do the authors have an explanation? Do the authors have sufficient confidence in the quality of this data to suggest a revision to CRUTEM4? Could this particular station differ substantially from the grid-box average over those two decades?

Due to wars, station relocation, change of observation methods and instruments, as well as the sparse of the stations, there are great uncertainties in the temperature change before 1950s. Previous study point out that the observation SAT from 1914 to 1960 was discontinuous with many missing data (Cao et al., 2013). For Qingdao station, before 1960 the missing times of records were in July 1914 to March 1915; Sep 1937 to Jan 1938; and Jan 1951 to Dec 1960. That is one reason why the period of 1920 to 1940 has some discrepancies in the two dataset, CRUTEM4 and Willmott

and Matsuura. Annual mean SAT time series from Willmott and Matsuura and observations in Qingdao during 1916 to 1950 are shown in Figure 1. These originally observed SAT from 1916 to 1950 are obtained from China Meteorological Administration (CMA). Daily mean SAT in this period is defined by calculating the average of daily maximum and minimum temperature. Then the monthly or yearly mean SAT is calculated from the average of each daily mean temperature in a month or a year. All data from 1916 to 1950 has not been homogenized. It can be seen that the annual mean SAT series from Willmott and Matsuura has the similar climate variability with that of the observations. But the values of Willmott and Matsuura are slightly lower than the observations. Thus, the values of CRUTEM4 are much lower than observations. The conclusion agrees with the previous study (Li et al., 2016). Though CRUTEM4 update set out to reduce a known bias in the dataset, identified in multiple studies, by improving land coverage which is a good SAT product for us to analyze the global warming, for the climate change study in a city, CRUTEM4 may have more uncertainties due to the lower spatial resolution, only 5 degree grid.

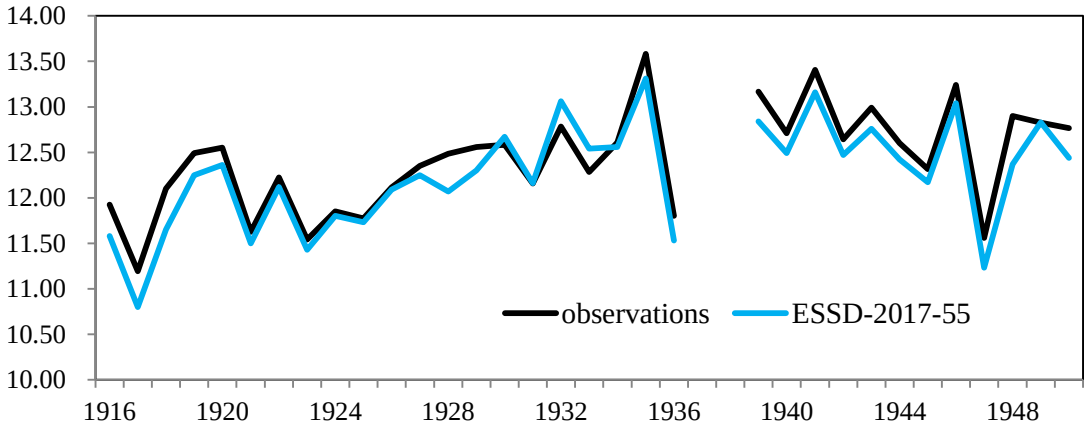


Figure 1. Annual mean SAT time series in Qingdao from 1916 to 1950

4. In this data set we find, monthly and annually, precise temperature values with no hints of uncertainty. But uncertainties must have arisen in, at minimum: a) the original measurements at all time periods; b) the digitisation process (presumably involving optical character recognition) of the German charts; c) the Willmott and Matsuura interpolation and gridding processes; d) the more recent (and, one

presumes, more accurate) CMA data processing; and e) the quality control and homogenisation processes described here. The authors should at least compile that information from the cited references as a guide and perhaps a caution to users of this time series? One would like to see error bars or coloured uncertainty ranges (presumably decreasing with time) on, for example, Figure 6. In my re-plot of data for Figure 6 I included a (not very high) correlation coefficient. The authors could do likewise and explain for readers and users the various reasons (natural variability plus measurement uncertainty) for the values they expect and achieve.

Thank you very much for these very good recommendations. These investigations are from our point of view are expensive and would give the paper second focus. We would like to study this in a separate paper together with your next point.

5. One could exploit this data for additional information? Perhaps a full analysis belongs in a separate science paper but, because of thrice daily data from 1899 to 1905 and hourly data from 1905 to 1914, the authors could at least hint or promote the possibilities of comparing early 20th century with present day daily temperature ranges. They could also look at differential warming, nocturnal vs diurnal. The authors mention rapid industrialization in and around Qingdao. Do the sub-daily data then and now reflect those changes?

Thank you for your wonderful suggestion. Hourly observations in the earlier of 20^{th} century make it possible to compare the extreme temperature and diurnal cycle of temperature with present-day observations. Here we finally chose the period from 1th Jan 1907 to 31th Dec 1913 with little missing data. Then we compare the maximum temperature (TX), minimum temperature (TN) and diurnal temperature range (Table 1) in the period from 1th Jan 1907 to 31th Dec 1914 to these in the period from 1th Jan 2007 to 31th Dec 2013 (100 hundred years interval). Hourly data from 1th Jan 2007 to 31th Dec 2014 are provided by the National Meteorological Information Center of the China Meteorological Administration (CMA). Yearly mean daily TX (TN/DTR) is defined by calculating the average of each daily TX (TN/DTR) in a year. Then the differences of TX, TN, DTR between the two periods are shown in Figure 2. In Figure

2, the TX and TN are found to have significantly increased at the range of 1.2~2.7℃ and 1.0~2.4℃. It means that relative to the years at the beginning of the 20th century, both of the TX and TN rise by ~2.0℃ at the beginning of the 21th century. However, there is no notable increase or decrease in the DTR. Global annually averaged surface air temperature has increased by 1.0 over the last 115 years (1901-2016) according to the Climate Science Special Report 2017 of USA. Compared to the global warming, extreme temperature warming in Qingdao is much stronger which may be caused by the rapid industrialization in and around Qingdao.

Table 1 Definitions of temperature indices used in this study.

Index	Descriptive name	Definition	Units
TX	maximum temperature	Yearly mean daily maximum temperature	℃
TN	minimum temperature	Yearly mean daily minimum temperature	℃
DTR	Diurnal temperature range	Yearly mean difference between daily maximum and minimum	℃

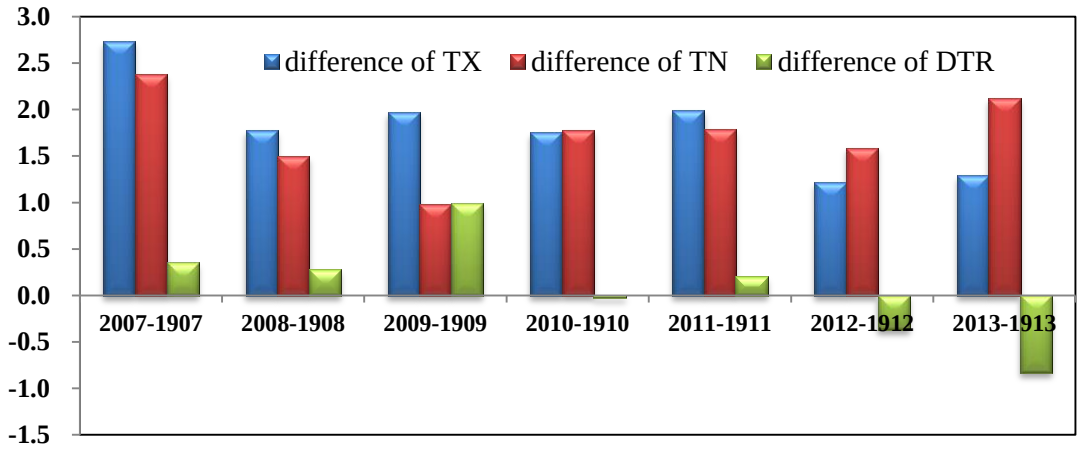


Figure 2 Differences of TX, TN, DTR between the period of 1907-1913 and the period of 2007-2013