HadISDH.extremes Update Document

Kate Willett (MOHC), 17th April 2024

General Notes:

The HadISDH.extremes.1.1.0.2023f contains all 12 months of 2023. It is a minor new version (Y element + 1) because a new formula is used to calculate the wet-bulb temperature from dewpoint temperature and air temperature, and a bug fix in the parent dataset HadISD has resulted in a generally higher rate of error flagging (https://hadisd.blogspot.com/2023/10/bug-in-buddy-checks.html, https://hadisd.blogspot.com/2024/01/hadisd-v3402023f-future-look.html). A minor bug fix specific to HadISDH.extremes (rather than HadISDH.land) was also undertaken, which has not affected the underlying data.

A new wet-bulb temperature algorithm is now available which reduces moist bias errors at high temperature/low humidity (reaching +1.3 °C) and dry bias errors at low temperature/high humidity (approaching -1 °C). The new Non-iterative Evaluation of Wet-bulb Temperature (NEWT) method has been developed by Rob Warren at the Bureau of Meteorology and coded in python. Its errors are far smaller at ± 0.01 °C. Rogers and Warren (2024) introduce the new method and compare it against the Stull (2011) and other methods (https://essopenarchive.org/users/714325/articles/698601-fast-and-accurate-calculation-of-wet-bulb-temperature-for-humid-heat-extremes). Here we use their python code to calculate adiabatic wet-bulb temperatures using polynomial fits from surface pressure, air temperature and specific humidity. This change only affects the wet-bulb temperature fields and differences are negligible in large-scale means and far less than 1 °C for the most part. Differences are largest over hot/dry and cold/humid air conditions.

The HadISD bug fix was to correct the application of the buddy check which hasn't been working since the 2017f versions but was only detected late last year. The buddy check compares quality controlled neighbouring stations and can remove error flags where neighbouring stations support the candidate value. The bug resulted in more flagged observations being unflagged than should be. The correction has resulted in a higher flagged error removal rate. This, and the slight change to station network historically, as various updates are applied to the source dataset ISD, results directly in small changes to coverage and indirectly through influencing the homogenization process, which also results in removed data.

The minor bug fix implemented the use of numpy.isclose when comparing equality (between a and b) with floats, using the default tolerance of rtol = 1e-05 and atoll = 1e-08 such that:

absolute(a - b) <= ($atol$ + $rtol$ * absolute(b)).

Testing on a sample of 100000 random numbers between -1 and 2 for equality with 0.0, 0.5 and 1.0 made no difference compared to the original code.

All other processing steps for HadISDH.extremes remain identical. The new version of HadISD (3.4.0.2023f) has pulled through some historical changes to stations which are passed on to HadISDH.land resulting in 9667 compared to 9555 initial stations. The end station count is further reduced after completeness checks and homogeneity assessment. The homogeneity scores differ slightly due to sensitivity to the addition and loss of stations, historical changes to stations previously included and the additional 12 months of data.

The combined effect of the new wet-bulb algorithm and improved removal of random error, in addition to any historical updates made to the ISD source database, has collectively resulted in an overall increase in gridbox coverage compared to last year's version. This is because these differences result in differences in the detection of inhomogeneity changepoints and application of homogeneity adjustments by the PHA algorithm, which is very sensitive. Although overall there

were more stations passing through the various checks in the previous version (1.0.0.2022f), the final number of extremes stations used were very similar at 4453 for 1.1.0.2023f compared to 4460 for 1.0.0.2022f. However, looking at overall gridbox coverage where each gridbox month has to have a homogenization quality score (HQscore) less than 7 and at least 70% completeness over the 1973-2023 time period, there has been an addition of ~60 new gridboxes (depending on variable) and a loss of ~10 other gridboxes (depending on variable) in this year's version (1.1.0.2023f). The additional gridboxes are mainly over the extratropics and tropics.

More information can be found at https://hadisdh.blogspot.com/2024/04/2023-update-from-hadisdhextremes1102023f.html.

Rogers, C.D.W. and Warren, R.A. (2024). Fast and Accurate Calculation of Wet-bulb Temperature for Humid-Heat Extremes. ESS Open Archive. January 18, 2024. DOI: 10.22541/essoar.170560423.39769387/v1

Stull, R., 2011: Wet-Bulb Temperature from Relative Humidity and Air Temperature. J. Appl. Meteor. Climatol., 50, 2267–2269, https://doi.org/10.1175/JAMC-D-11-0143.1.

Version Number X.Y.Z.0000p/f:
1.1.0.2023f

Major Changes X:

- None

Bug fixes and minor changes Y:

- Change of wet-bulb temperature formula from Stull (2011) to the Non-iterative Evaluation of Wet-bulb Temperature (NEWT) method - https://essopenarchive.org/users/714325/articles/698601-fast-and-accurate-calculation-of-wet-bulb-temperature-for-humid-heat-extremes.
- Bug fix in HadISD (parent dataset) buddy check, resulting in a greater number of observations being flagged as errors and removed - https://hadisd.blogspot.com/2023/10/bug-in-buddy-checks.html, https://hadisd.blogspot.com/2024/01/hadisd-v3402023f-future-look.html.

Minor bug fixes / historical data updates Z:

- Implementation of numpy.isclose to compare equality of floats within the allocation of homogeneity quality scores (HQscore).
- 9667 compared to 9555 initial selection stations last year.
- Use of HadISD.3.4.0.2023f as the basis which includes retrospective improvements (to correct data, add or remove data sections) to the historical data in NCEI's ISD archive are ongoing. These are not documented.

Start Date DD.MM.YYYY: 1973-01-01
End Date DD.MM.YYYY: 2023-12-31
HadISDH Data Format (Baseline documentation): https://zenodo.org/record/7963175
Reference:

- Willett, K, 2023: HadISDH.extremes Part 1: a gridded wet bulb temperature extremes index product for climate monitoring. Advances in Atmospheric Sciences, 40, 1952-1967, doi: 10.1007/s00376-023-2347-8. http://www.iapjournals.ac.cn/aas/en/article/doi/10.1007/s00376-023-2347-8
- Willett, K. 2023: HadISDH.extremes Part 2: exploring humid heat extremes using wet bulb temperature indices. Advances in Atmospheric Sciences, 40, 1968-1985,

doi: 10.1007/s00376-023-2348-7.
http://www.iapjournals.ac.cn/aas/en/article/doi/10.1007/s00376-023-2348-7

Other notes: The update blog post is here: https://hadisdh.blogspot.com/2024/04/2023-update-from-hadisdhextremes1102023f.html

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