|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Method** | **Originator** | **Description** | **Reference** | **Domain** | **Quality check type** |
| 0 | C3S 311a Lot 2 | These tests check both the station metadata and also reasonable limits for the hourly observed values.  The station itself is flagged if:  • Latitude == longitude == 0  • Latitude > 90, latitude < -90  • Longitude > 180, longitude < -180  • Elevation < -432.65, elevation > 8850 (missing elevation encoded as e.g. -999 is allowed)  • Timeseries starting before 1650  • Timeseries ending after the present (date of QC run)  Each meteorological variable is checked to ensure that it also falls within reasonable limits. These should be redundant as following checks (e.g. world records) would capture these, however the intention is to move these further upstream in the processing chain to when the ingested data are converted to our internal format. Retaining these here should identify systematic issues in upstream processes. The test checks that at least 99.5% of the observed values fall within the bounds listed below. If this is not the case (more than 0.5% fall outside of the bounds), then all times where observations fall outside of these bounds are flagged.  • -75 <= Temperature <= 75 C  • -75 <= dew point temperature <= 75 C  • 300 <= station level pressure <= 1200 hPa  • 870 <= sea level pressure <= 1090 hPa  • 0 <= wind speed <= 50 m/s  • 0 <= wind direction <= 360 degrees  [temperature, dew point, station level pressure, sea level pressure, wind speed wind direction] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  *Logic Checks* |
| 1 | C3S 311a Lot 2 | This test looks for temporally isolated hourly observations. Without nearby observations to compare to, it is difficult to determine whether these observations are good. Small clusters of up to 6 observations in a period of up to 12 hours separated from other observations by 28 days or more are flagged. This test will also remove observations where the year has been mis-transmitted – e.g. transmitting 1973 as 1963 which appears to be a prevalent issue in many USAF stations whereby in (at least) the decade prior to station commencement (and the decade after for closed stations) ghosted observations exist.  [temperature, dew point, station level pressure, sea level pressure, wind speed] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  Odd Cluster |
| 2 | C3S 311a Lot 2 | This test identifies values which occur more frequently than would be expected. The variables that this test runs on have a roughly Gaussian distribution. The expectation of a smoothly varying distribution is used to identify bins which are much larger than expected. For each calendar month, a distribution is calculated using a bin width corresponding to the reporting resolution of the observations (typically 1.0 or 0.5 K/hPa/ms-1). Using a rolling set of 7 bins, the central one is tested to see if it is the locally largest, contains more than 50% of the data and also more than the data count threshold (120 observations, uniform across all tests). If these requirements are met, this bin is noted. Then, for each year within these calendar months, the distribution is assessed again, with the identified bins re-checked on an annual basis. If they still meet the requirements all observations within this bin are flagged. We note that this will flag some good observations, but does ensure the flagging of many spurious values, especially in the tails.  [temperature, dew point, station level pressure, sea level pressure] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  Frequent Values |
| 3 | C3S 311a Lot 2 | This test is run on temperature only as this variable has a robust diurnal cycle for stations not at the poles. Hence it is only run for stations with latitudes below 60°N/S. Firstly, a diurnal cycle is calculated for each day with at least four observations spread across at least three quartiles of the day by fitting a sine curve with amplitude equal to half the range of the reported temperatures. The phase of the sine curve is determined to the nearest hour by minimising a cost function, namely the mean squared deviations of the observations from the curve. The climatologically expected phase for a given calendar month is that with which the largest number of individual days phases agrees. If a day’s temperature range is less than 5K, no attempt is made to determine the diurnal cycle for that day. It is then assessed whether a given day’s fitted phase matches the expected phase within an uncertainty estimate. This uncertainty estimate is the larger of the number of hours by which the day’s phase must be advanced or retarded for the cost function to cross into the middle tercile of its distribution over all 24 possible phase-hours for that day. The uncertainty is assigned as symmetric. Any periods>30 days where the diurnal cycle deviates from the expected phase by more than this uncertainty, without three consecutive good or missing days or six consecutive days consisting of a mix of only good or missing values, are deemed dubious and the temperature elements are flagged.  [temperature] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  Diurnal Cycle |
| 4 | C3S 311a Lot 2 | This test uses the distribution of monthly anomalies to look for asymmetries in this distribution. For each calendar month, monthly average values are calculated, and then standardised using their average and spread. Months which have a large offset from zero (>5) are flagged. Then the months are sorted and, proceeding outwards from the median, the pair of months either side are compared. Flagging is triggered if the anomaly in one month is at least twice as distant from the median as its pair. This and all months further from zero on the relevant tail of the distribution are flagged.  [temperature, dew point, station level pressure, sea level pressure] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  Distribution |
| 5 | C3S 311a Lot 2 | This test uses all observations, converted to hourly anomalies and assesses if there are secondary populations separated from the main distribution. This test compares all the normalised anomalies for a given calendar month over all years and looks for outliers or secondary distributions. A Gaussian (allowing for non-zero skew) is fitted to the distribution of the normalised anomalies, and threshold values are set at the next empty bin outward from zero after this fitted curve passes y=0.12. Any values further from zero than these thresholds are flagged. As the signals from intense storms are likely to be flagged in the pressure data by this test, the wind speed is used to cross check, looking for high values. If the wind speed anomaly is more than 5 times the spread at the same time as a pressure flag has been set, then this could be a storm and should be kept. The flags are removed for these periods.  [temperature, dew point, station level pressure, sea level pressure] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  Distribution |
| 6 | C3S 311a Lot 2 | We check that each observation falls within the bounds for the global records as held by the WMO.  • -89.2 to 56.7 C temperature  • -100 to 56.7 C dewpoint  • 0 to 113.2 m/s wind speed  • 870 to 1083.3 hPa sea level pressure  In the future, we intend to use regional (or national, where available) records for this check.  [temperature, dew point, sea level pressure, wind speed] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | World Records  Hourly |
| 7 | C3S 311a Lot 2 | This test looks for streaks of single values which occur for longer than expected. Using the first differences between neighbouring observations, the distribution of repeated values is calculated (number of times 2, 3, 4 etc. observations in a row occurs). This distribution is fitted with a 1/x curve. To determine the threshold where longer streaks are flagged, we use the first empty bin after the point where this fitted curve falls below 0.1. Any streaks which are longer than this threshold are flagged.  [temperature, dew point, station level pressure, sea level pressure, wind speed, wind direction] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  Streaks |
| 8 | C3S 311a Lot 2 | This test identifies individual values which fall beyond the climatologically expected distribution. Monthly climatologies are calculated for each hour of the day using winsorised data (removing the effects of outliers) when there are data for at least 5 unique years. The raw observations are then standardised using these climatologies and the spread of the observations for that month and hour.  To protect low variance stations, the minimum value for the spread is 1.5. The final values are then low-pass filtered to remove any long-timescale signal from anthropogenic climate change that could affect the removals at the beginning and end of the timeseries. The distribution of these standardised anomalies is fitted with a Gaussian (allowing for a non-zero skew) and threshold values set at the next empty bin outward from zero after the fitted line crosses y=0.1. Any anomalies further from zero than these thresholds are flagged. As this test would frequently flag storm signals in pressure data, it is not applied to either pressure measure.  [temperature, dew point] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  Climatological |
| 9 | C3S 311a Lot 2 | This test identifies locations where there are two entries for a single timestamp in the files and the values for the observations are not identical and the test flags both entries.  [temperature, dew point, station level pressure, sea level pressure, wind speed] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  Timestamp |
| 10 | C3S 311a Lot 2 | This test looks for short term departures from a smoothly varying timeseries. The first differences between observation values for the appropriate temporal difference are used for spikes of length one, two or three observations. As in the streak check, the distribution of first differences is used to determine above what level the jumps between values are unreasonable. The threshold is set using  the same fitting procedure (1/x curve) and determination of the threshold (next empty bin after the curve drops below 0.1). Any values which have a first difference larger than this threshold on the entry and exit of a spike are flagged.  [temperature, dew point, station level pressure, sea level pressure, wind speed] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly Spike |
| 11 | C3S 311a Lot 2 | These tests check for super saturation (dewpoint temperature greater than temperature) and long streaks of zero dew point depression (dewpoint temperature equal to the temperature). The former flags any location where this occurs. The latter looks at the streaks where these two parameters are equal. Using the same approach as the streak check, unreasonably long periods of repeated instances are flagged.  [dewpoint temperature] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  Humidity |
| 12 | C3S 311a Lot 2 | This test identifies months where the within month variance of normalised anomalies is sufficiently greater than the median for that calendar month over the period of record, using winsorised data (5%, Afifi & Azen, 1979). For each calendar month (120 obs per hour-of-day within each calendar month (e.g. all 12:00s for all Januaries)), we remove the diurnal cycle to make anomalies using an hourly average value. These anomalies are then normalised by their spread. Then for each year in this calendar month, the variance is calculated.  Months where the variance differs from the average by more than 8 times the spread of the monthly variances are flagged. Pressure and wind data are afforded extra checks to ensure that they are not erroneously removed due to tropical storms being present that month. Any month where the largest number of consecutive positive or negative changes in the values exceeds 10 points is not flagged given the progressive nature of the change. Also, months where high wind speeds and low-pressure values (difference from the average is greater than 4 times the spread) are concurrent are not flagged.  [temperature, dewpoint temperature, station level pressure, sea level pressure, wind speed] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Afifi, A.A. & A Azen, S.P. Statistical Analysis: A Computer Oriented Approach, New York San Francisco London Academic Press cop.1979  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly Variance |
| 13 | C3S 311a Lot 2 | • Observations where there is no wind direction, but a wind speed of zero (calm) are checked. Convention is for the wind direction to be given as 0° in these cases. When this convention is not adhered to, the direction is flagged.  • Negative wind speeds are flagged.  • Negative wind directions are flagged.  • Wind directions > 360° are flagged.  • Non-zero wind directions where the wind speed is 0 (calm) are flagged.  • Northerly wind direction is by convention given as 360°, so directions of 0° with a non-zero wind speed are flagged.  In the future, a number of these tests may try to fix the recorded values to match the conventions, but so far this has not been implemented. | Degaetano, Arthur. (1997). A Quality-Control Routine for Hourly Wind Observations. Journal of Atmospheric and Oceanic Technology - J ATMOS OCEAN TECHNOL. 14. 10.1175/1520-0426(1997)014<0308:AQCRFH>2.0.CO;2.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly  Winds |
| 14 | C3S 311a Lot 2 | The closest 20 neighbours which are within 500km distance and 200m elevation are identified. In regions of the world with sparse station coverage, there are instances where fewer than 20 neighbours are identified. For each variable, the difference series between the target station and each neighbour station is  constructed. Each calendar month is then processed in turn, and the spread of the differences calculated overall years for this target-neighbour pair (e.g. all Januaries in the record). Locations where the difference is greater than 5 times the spread are identified. A value is then flagged if at least 2/3 of the neighbours have identified the difference to be greater than 5 times the spread. For the pressure variables, we account for the passage of deep low-pressure systems (e.g. tropical cyclones or extra tropical depressions) by counting the number of positive and negative differences when the neighbours are further than 100km away. This is to prevent flagging of extreme low-pressure observations in the core of these systems if they pass close to the target station. If the majority of differences (>2/3) are negative, then only the positive differences are flagged and the  negatives (presumed to be storm signals) retained.  [temperature, dew point temperature, sea level pressure, station level pressure, wind speed] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly Neighbour (Buddy) Checks |
| 15 | C3S 311a Lot 2 | This test identifies months where more than 60% of the observations have been flagged by other tests and flags the remainder. It is likely that there are still undetected issues in these remaining observations which could not be picked up because of the existing pervasive issues. Summary of harmonized holdings.  [temperature, dew point temperature, station level pressure, sea level pressure, wind  speed, wind direction] | Dunn, R. J. H., (2019), HadISD version 3: monthly updates, Hadley Centre Technical Note  Dunn, R. J. H., et al. (2016), Expanding HadISD: quality-controlled, sub-daily station data from 1931,  Geoscientific Instrumentation, Methods and Data Systems, 5, 473-491  Dunn, R. J. H., et al. (2012), HadISD: A Quality Controlled global synoptic report database for  selected variables at long-term stations from 1973-2011, Climate of the Past, 8, 1649-1679  Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  All the code to run the land QC checks on hourly data can be found at  <https://github.com/glamod/glamod_landQC> | Land | Hourly Clean Up |
| 16 | NOAA's National Centers for Environmental Information | This test checks “the duplication of sequences of data in different time periods, such as two different years having exactly the same data, or two different months in the same year having exactly the same Data” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly duplicate check |
| 17 | NOAA's National Centers for Environmental Information | “The gap checks examine the frequency distributions  of observations for individual elements and calendar months. They flag values that compose the distribution’s tail when the tail is unrealistically separated from the remaining values. The gap threshold, or maximum allowable separation of the tail from the remainder of the distribution, differs among elements, but is independent of location and time. The algorithm first sorts all of an element’s values observed in a particular calendar month throughout a station’s period of record from smallest to largest. Differences between consecutive sorted values are then calculated. If a value is separated by more than the gap threshold from the next largest value, all of the element’s values on the far side of the gap (i.e., in the tail of the distribution) are flagged.” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly gap check |
| 18 | NOAA's National Centers for Environmental Information | “Internal consistency checks test for violations  of logical or physical relationships between two or more  elements (e.g., TMAX , TMIN)” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly internal consistency check |
| 19 | NOAA's National Centers for Environmental Information | The test checks for “consecutive runs of the same value (i.e., streaks) or frequent occurrences of the same value (i.e., identical values that are closely spaced in time but are not necessarily consecutive).Values are flagged not only if they occur on consecutive days, but also when they continue across days for which no data are available. For the frequent-value checks, observations are flagged if the group overall consists of more than a specified minimum number of observations and if those values exceed a specified climatological percentile. In both tests, the minimum number of values that constitute an error and the method for handling values of zero vary by element” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly streak/frequent-value check |
| 20 | NOAA's National Centers for Environmental Information | This test checks for “the reporting of multiday precipitation  and snowfall totals by some observers who were  unable to make daily measurements on one or more  preceding days” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly check on length of multiday period |
| 21 | NOAA's National Centers for Environmental Information | “The megaconsistency checks are listed in Table 5. The  principle behind these checks is to ensure that, after all  other QA procedures have been applied, certain relationships hold for each station’s entire record of unflagged values. There are three such checks: the extremes megaconsistency check, the snow–temperature megaconsistency check, and the snow season reality check” “, (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly megaconsistency check |
| 22 | NOAA's National Centers for Environmental Information | This test checks four erroneous zeros. “For example zero is sometimes used incorrectly as a missing value code. consequently, both TMAX and TMIN are flagged if both are 0oC both are flagged or if both are -17.8oC (i.e., 0oF). Likewise, a precipitation total (PRCP, SNOW, or SNWD) is flagged if the value is greater than zero and the data measurement flag indicates that only a trace of precipitation was recorded” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly naught check |
| 23 | NOAA's National Centers for Environmental Information | “The climatological outlier checks compare each observation to parameters computed from all observations at the given location and time of year” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly climatological outlier check |
| 24 | NOAA's National Centers for Environmental Information | “ the lagged range test, looks for differences in excess of 408C (i) between TMAX and the warmest TMIN reported on the previous, same, and following days and (ii) between TMIN and the coldest TMAX in the 3-day window centered on the day of the TMIN. The inclusion of the lagged comparisons in the range check avoids the flagging of dynamically induced temperature changes, such as those that can occur in conjunction with frontal passages in interior North America. (Note that there are actually six variations of the lagged range test when TOBS is also included.)” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly lagged range check |
| 25 | NOAA's National Centers for Environmental Information | “ these tests involve comparing an observation with concurrent observations at surrounding sites, or ‘‘neighbors.’’ The approach usually employs a statistical technique (such as regression or interpolation) to generate an estimate at the ‘‘target’’ station and  then to flag those target values that deviate excessively from the neighbor-based estimates” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly spatial consistency check |
| 26 | NOAA's National Centers for Environmental Information | “Temporal consistency checks, on the other hand, compare one element’s values on consecutive days, usually to identify unrealistic spikes or dips” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly temporal consistency check |
| 27 | NOAA's National Centers for Environmental Information | “Internal consistency checks for precipitation elements  typically include comparisons between SNOW and SNWD, SNOW and liquid-equivalent PRCP, and SNOW and TMIN (i.e., nonzero snowfall at temperatures considered too warm for snow)” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly temperature too warm for snow |
| 28 | NOAA's National Centers for Environmental Information | “ The world record exceedance checks identify values  that cannot be valid under any circumstance, either because they are physically impossible or because they fall outside the range of what has been observed anywhere on the earth” (Durre et al., 2010). | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly failed bounds check |
| 29 | NOAA's National Centers for Environmental Information | Values are flagged as a result of an official Datzilla investigation. Datzilla is a web-based system used to report and track errors in NOAA datasets and Data-Products. | Durre, I., M. J. Menne, B. E. Gleason, T. G. Houston, and R. S. Vose, 2010: Comprehensive automated  quality assurance of daily surface observations. J. Appl. Meteor. Climatol., 49, 1615–1633,  doi:10.1175/2010JAMC2375.1.  <https://datzilla.srcc.lsu.edu/datzilla/docs/html/DatzillaOverview.html>  Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston, 2012: An overview  of the Global Historical Climatology Network-Daily Database. Journal of Atmospheric  and Oceanic Technology, 29, 897-910, doi:10.1175/JTECH-D-11-00103.1 | Land | Daily and monthly flagged as a result of an official Datzilla investigation |

Headers are:

Method – trace back to qc\_table – assigned when entry accepted

Originator – free text – who originated the qc

Description – free text - brief description

Reference – link to code, paper or other documentation of method

Domain – Land, marine, upper-air etc. consistent with similar instances elsewhere in the documentation.

Quality check type – outlier, spike, record, buddy, variability, distributional etc. etc. *Do we need to define a legal list of these?*