Weather Station Data on the Juneau Icefield

Last Revision: 5/2019

SUMMARY

Since the 1940's, the Juneau Icefield Research Program (JIRP) has been measuring surface mass balance on the Juneau Icefield. This is the longest ongoing program of its kind in North America. The program nominally occurs between late June and late August, traversing between Juneau, Alaska and Atlin, British Columbia. JIRP has examined the surface mass balance of the Juneau Icefield since 1946, with principal efforts focused on Lemon Creek Glacier and Taku Glacier. Glaciological, geodetic, and meteorological data have been collected by JIRP to characterize the interaction between the climate and glaciers of the Juneau Icefield.

Measurements of meteorological data are made at many permanent camp facilities on the Juneau Icefield. This portion of the data release includes select weather data that has received basic quality control and assurance. Data is released at three different levels of processing, level 0, 1 and 2. Level 0 data contains compiled raw data, before QC procedures are applied, at the original timestep recorded by the instrument. Level 1 data has received a plausible value check, and minimal manual error identification (e.g. errors noted on field visits). Level 2 data has been through more extensive quality control procedures and is provided at both the original instrument timestep as well as aggregated hourly and daily values. Data at many JIRP sites consist of a single temperature sensor, recording in a Stevenson-type shield. Automated weather stations at Camp 10, 17, and 18 have measured additional meteorological variables in recent years. Both are presented in this data release.

PURPOSE

Weather data is collected at high-elevation locations adjacent in order to track changes in environmental conditions over time, and for use in mass balance calculations. There are many other potential uses for this data, including ecological, hydrological, and geophysical research questions among others.

QUALITY CONTROL PROCESSING STEPS

Automated quality control steps are well-developed for temperature and precipitation data. A coarse plausible value check is performed for other variables, informed by World Meteorological Organization (WMO) guidelines (Zahumensky, 2004). Data is presented at three levels of quality control – level 0, 1, and 2 labeled respectively as LVL0, LVL1, LVL2. Details of quality control used to reach each level of QC are presented below.

All Data

All Sensors

1. For all meteorological variables measured, data is adjusted for time-slips in the logger, setting values recorded to the nearest 15-minute value.
1. Additionally, a manual log identifying specific time periods of sensor malfunctions identified in the field or office, not captured by automated processing, is used to remove select faulty data.
    - **LVL0 Data**

Temperature Data

All temperature sensors

1. Plausible value check - remove values below -40, above +30 ° C. This is informed by knowledge of the specific sites in our analysis.
    - **LVL1 Data**

2. Remove transient malfunctions with a median-based filter. A moving window of 8 values (2 hours for 15 min data) is used to identify sensor spikes. Where the absolute difference of a single observation from the 8-observation rolling median is >4 ° C, the value is set to window median.

Create site-best temperature

1. If multiple temperature sensors exist at the site, the records are compared and combined to create a timeseries of the best site temperature. If an aspirated temperature sensor exists at the site, this is considered the primary sensor due to better performance in calm, sunny conditions; passive temperature sensors are secondary.
2. In primary (aspirated) temperature sensor record, replace values with passive-sensor median where:
    - Absolute difference between aspirated sensor and mean of passive sensors > 2 °C and
    - Passive sensors agree with each other within 0.5 °C and
    - More than one passive sensor record is available. These values come from Zahumensky (2004).
3. Fill remaining gaps in primary temperature sensor record with median of all other sensors available, when the standard deviation among the remaining sensors is < 1.5. Secondary sensors may be composed of a secondary aspirated, 2 passive sensors, or some other combination thereof.
4. Remove outliers due to intermittent sensor noise with a hampel filter. A hampel filter uses a moving window of 7 values, identifying outliers as values > 3 median absolute deviations from the window median. This is only applied in locations where the initial timestep of the logged data is sub-hourly.
5. Remove remaining transient outliers in final 'best-temperature' time series via an 8-sample median-based filter, as above.
    - **LVL2 Data.** This QC'd temperature is reported in a column named "site_temp".

Precipitation Data

1. Remove maintenance-related noise from the record, resulting from precipitation gage liquid filling and emptying from the record. If the sum of incremental precipitation received in 45 minutes is over 6 cm, the incremental precipitation received during this period is set to null, as well as the timesteps immediately preceding and after to ensure entire maintenance impacts are removed from the record.
    - **LVL1 Data**
2. Remove high-amplitude noise related to wind with a median-based hampel filter.
    - A 6-sample hampel filter identifies measurements > 2 median absolute deviations from period median, and fills with median. Window examines 3 measurements before and after each, for a window period of 45 min on either side of examined value for 15-minute data.
3. Remove transient sensor malfunctions, resulting from electronic noise, using the daily median of incremental precipitation for the original timestep of data (15 minutes). If a single value of incremental precipitation is over 1 cm, that measurement is removed, and set to the median of incremental precipitation that day.
4. Remove low-amplitude noise, including wind and temperature-related diurnal fluctuation noise, with a smoother that retains total precipitation catch, while creating a monotonically increasing timeseries, as defined by Nayak (2010). Preserves timing and quantity of precipitation, while removing 'negative' precipitation measurements, a result of temperature and wind-related noise.
    - **LVL2 Data**

Wind Data

Wind Speed

1. Plausible value check, setting wind speeds of > 75 m/s to nan.

2. Check for a minimum variability in wind speed of at least 0.5 m/s every hour, indicating that instrument is not rimed, and is recording wind speed.
    - **LVL1 & LVL2 Data**

Wind Direction

1. Plausible value check; remove values > 360° and < 0°.
2. Minimum variability check; remove data where wind direction measured changes < 10° in 3 hours. The WMO recommendation is for 10 ° in 1 hour, but for data measured at high frequency.
    - **LVL1 & LVL2 Data**

Radiation Data

Radiation data should be used with caution at this time. Little effort has been made to correct for sensor drift, issues with rime accumulation, and other confounding factors. Raw data is provided here with these caveats.

1. Plausible value check; remove values < 0 and > 1600 W/ m^2 (Zahumensky, 2004). Values < 0 are set to 0.
    - **LVL1 & LVL2 Data**

Air Pressure Data

1. Plausible value check; remove values < 50 kPa, > 110 kPa.
    - **LVL1 & LVL2 Data**

PROGRAM HISTORY

Data from two origins are presented in this release. The first are temperature data from hobo loggers, recording in independent loggers at the sites in Stevenson-type wooden shields. These are labeled simply with the site elevation. At three sites, an automated weather station is recording additional meteorological data; this is denoted by a label of "AWS", and the camp name at which the logger is located. All elevations and corresponding camp names can be found in the location file, WeatherStationLocations.csv. Data from the AWS sites has been recorded and telemetered somewhat intermittently. Future updates to this data release may fill in temporal gaps, as possible.

DATA ORGANIZATION:

In the files below, *glacier* is a generic placeholder for the glacier (or icefield) name; it should be replaced with the name of the glacier in the actual file structure. Each weather station location is named via its approximate elevation, referred to by the generic term *Site.*

Organized into folders by glacier, and level of QC. The exact process for each sensor type and QC level is detailed above.

Glacier Folder:

Files within labeled by site, with the convention [*glacier][Site]_[timestep]_[QCLevel].*

LVL0 folder:

Data which has received little QC; organized and concatenated raw logger data.

LVL1 folder:

Data which has received minimal QC; process described in detail above.

LVL2 folder:

Data which has received more substantial QC and been time-aggregated to daily and hourly data. Process described in detail above. All measured parameters are included in the time-aggregated hourly and daily files, for convenience. They have received only the QC specified above (i.e. L0 or L1; no additional QC is applied, only time-aggregation, for convenience of use). For temperature data, multiple quantities are reported for time-binned data (hourly or daily). A suffix indicates minimum temperature ("min"), maximum temperature ("max"),

a straight all-value mean temperature ("USGS"), or average temp computed as the mean of high and low temperatures (WMO).

***glacier_station*_predigital_weatherdata_daily.csv**

Pre-digital, daily weather data is also present at many of the long-term sites. None is present in the data release at this time, but it may be added in future updates, in a format parallel to that in the USGS Benchmark Glacier Weather Data Release at https://doi.org/10.5066/P9EUXIPE

Temperature: daily mean temperature in degrees Celsius

Precipitation: total daily precipitation in millimeters as measured with a cumulative stage gage. For a value comparable to that measured with a more modern weighing-style gage, measured values should be multiplied by the site-specific factor given in the Program History portion of this document.

WeatherStationLocations.csv

Locations of weather stations at the glaciers. Columns are:

Location: glacier or icefield name
Elevation: approximate elevation of the site, in meters. Used as a site identifier.
Latitude: latitude in decimal degrees (WGS 84; EPSG 4326)
Longitude: longitude in decimal degrees (WGS 84; EPSG 4326)
Elevation: Elevation, used as the identifier for the specific weather station

Meteorological Data Column Names:

The type of data within a site's csv file is indicated by the column title. These are standardized across sites, and indicate the following variables are being measured, with the accompanying units:

Temperature

If more than one temperature sensor is available at a site, the sensors are numbered accordingly; this is no indication of relative performance, only that multiple sensors hav existed.

TPassive – Air temperature, as measured with a passively-aspirated temperature sensor in degrees Celsius. Value is the interval-average.

TAspirated – Air temperature, as measured with a mechanically-aspirated temperature sensor in degrees Celsius. Value is interval average.

Precipitation

Precip_Weighing_Cumulative – Cumulative precipitation, measured by a weighing-style gage, in meters of water equivalent (m. w.e.). The weighing gage used is a Sutron Total Precipitation Gage (TPG).

Precip_Weighing_Incremental – Incremental precipitation recorded by a weighing-style gage during the specified timeperiod, in millimeters of water equivalent (mm w.e.)

Precip_Stage_Cumulative – Cumulative precipitation, measured by a stage-style gage, in meters of water equivalent (m. w.e.). The precipitation gage used is an older style "Rocket" gage, no longer in use by USGS. For a value comparable to that measured with a more modern weighing-style gage, measured values should be multiplied by the site-specific factor given in the Program History portion of this document.

Precip_Stage_Incrmental – Incremental precipitation, measured by a stage-style gage, in millimeters of water equivalent (mm w.e.). For a value comparable to that measured with a more modern weighing-style gage, measured values should be multiplied by the site-specific factor given in the Program History portion of this document.

Wind

VecAvgWindDir – vector average wind direction, giving average direction of wind of time interval indicated in degrees.

WindDir – wind direction average over the interval specified, not taking speed into account, indicated in degrees.

WindSpeed – average wind speed measured over interval, in meters per second.

WindGustSpeed – highest three-second gust measured during logging interval in meters per second.

Radiation

RadiationIn – incoming shortwave radiation, measured in watts per meter squared.

RadiationOut – outgoing shortwave radiation, as measured in watts per meter squared.

LWRadiationIn – incoming longwave radiation, measured in watts per meter squared.

LWRadiationOut – outgoing longwave radiation, measured in watts per meter squared.

Other

RelHum – relative humidity. Reported in percent, from 0 to 100.

Barom – barometric pressure, measured in kilo-Pascals (kPa).

LOCATIONS OF WEATHER STATIONS

Table 1: Locations of local weather on or adjacent to the Juneau Icefield (WGS84; EPSG 4326). This table is also included in the data release as WeatherStationLocations.csv.

Location	Elevation	Latitude	Longitude
C-10	1196	59.57564	-133.70982
C-17	1285	58.64721	-134.20635
C-26	1435	58.36737	-134.36638
C-9	1555	59.01664	-134.12104
C-29	1618	58.712433	-134.182217
C-18	1705	59.34211	-134.10221
C-8	2050	58.83497	-134.27643
C-25	2121	58.8067	-134.13613

SUGGESTED CITATION:

Baker, E. H., McGee, S., Campbell, S. W., Pierce, J. L., McNeil, C. J., 2019, Weather Station Data on the Juneau Icefield (ver. 1.0, June 2019): U.S. Geological Survey data release, https://doi.org/10.5066/P90RCN51.

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