Metadata for Colorado small catchment hydrology dataset: Front Range, 2016-2019

This dataset contains hydrologic data from small research catchments organized along an elevation gradient in the Colorado Front Range. Catchments are located in either persistent or intermittent snow zones. Catchments are Michigan River (persistent), Andrews Creek (persistent), Dry Creek (intermittent), Bighorn Creek (intermittent), and Mill Creek (intermittent). These sites each have stream stage/discharge, rain, soil moisture, and temperature data. Data available for water years 2016-2019 at daily time steps. Some sensors have shorter time step data available on request. NA indicates missing data or data screened out for errors.

The following files are available:

Geospatial: frontrange_locations.zip contains a shapefile (frontrange_locations.shp) and a kmz file (frontrange_locations.kmz) giving the sensor locations for each catchment. Catchments each have two points, one for stream gage locations and the other for rain gage, snow depth, temperature, and soil moisture monitoring locations.

Rating curve: rating.csv contains the stage-discharge measurements for Mill Creek, Dry Creek, and Bighorn Creek. The other two sites (Michigan and Andrews) have USGS gaging stations.

Daily data: file names by site are Mill_daily_1619.csv, Dry_daily_1619.csv, Bighorn_daily_1619.csv, Andrews_daily_1619.csv, Michigan_daily_1619.csv.

Column labels are:
Date as m/d/y
Snow_depth_cm for snow depth in cm
P_mm for precipitation from rain gauge in mm
Ta_C for air temperature in degrees C
Ts_C for 5 cm depth soil temperature in degrees C
VWC_depth for soil moisture at the indicated depth in cm. Volumetric water contents/unitless
Discharge_Ls for average daily stream discharge in L/s
Q_mm for total daily discharge normalized by the drainage area of the watershed in mm
PRISM_P_mm is precipitation from PRISM (prism.oregonstate.edu) in mm
PRISM_Ta_C is air temperature from PRISM in degrees C

Sensor descriptions for each site:

Mill Creek:

- *Rain gauge:* Texas Electronics TE525 tipping bucket rain gauge with Onset Hobo event logger. 0.3 mm per tip. Column label P_mm. Values likely not accurate for snow precipitation.
    - Duration:
        - Oct 22, 2015 to Apr 22, 2019

- *Snow depth:* Time lapse camera pointed at snow pole marked in 5 cm increments. Column label Snow_depth_cm.
    - Duration:
        - Oct 26, 2015 to May 24, 2019
- *Air temperature*: Decagon ECT temperature probe. Column label Ta_C.
    - Duration:
        - Oct 22, 2015 to Aug 25, 2019
- *Soil temperature:* Decagon EC-TM soil moisture and temperature probe. 5 cm depth. Column label Ts_C.
    - Duration:
        - Oct 22, 2015 to Aug 25, 2019
- *Soil moisture:* Decagon EC-TM soil moisture and temperature probe at 5 cm depth, EC-5 soil moisture probes at 20 and 50 cm depth. Column labels VWC_5, VWC_20, VWC_50. Values are volumetric water contents (unitless).
- *Stream discharge:* In situ rugged troll unvented pressure transducer measuring stream stage. Corrected for barometric pressure with In situ baro troll; gaps in baro troll record filled using barometric pressure data from Bighorn Creek. Pressure measurements have +/- 2 cm sensor noise. Stage converted to discharge using a rating curve based on salt slug discharge measurements, and rating curve fit is moderate, with discharge values only accurate to +/- 3 L/s. Values provided as discharge in L/s (Discharge_Ls) and as discharge normalized by drainage area (Q_mm).

Bighorn Creek:

- *Rain gauge:* Rainwise tipping bucket rain gauge with Onset Hobo event logger. 0.3 mm per tip. Column label P_mm. Values likely not accurate for snow precipitation.
    - Duration:
        - April 3, 2017 to Sept 25, 2018
- *Snow depth:* Time lapse camera pointed at snow pole marked in 5 cm increments. Column label Snow_depth_cm.
    - Duration:
        - Feb 18, 2016 to Dec 25, 2018
- *Air temperature*: Vaisala HMP45C temperature probe. Column label Ta_C.
    - Duration:
        - Feb 18, 2016 to Sep 30, 2019
- *Soil moisture:*Delta T devices Ltd. SM150 soil moisture probes at 5, 20 and 50 cm depth. Column labels VWC_5, VWC_20, VWC_50. Values are volumetric water contents (unitless).
- *Stream discharge:* In situ rugged troll unvented pressure transducer measuring stream stage. Corrected for barometric pressure with In situ baro troll. Pressure measurements have +/- 2 cm sensor noise. Stage converted to discharge using a rating curve based on salt slug discharge measurements. Rating curve fit is poor-moderate; all discharge values except one within +/- 3 L/s. Values provided as discharge in L/s (Discharge_Ls) and as discharge normalized by drainage area (Q_mm).

Dry Creek:

- *Rain gauge:* Texas Electronics TE525 tipping bucket rain gauge with Onset Hobo event logger. 0.3 mm per tip. Column label P_mm. Values likely not accurate for snow precipitation.
    - Duration:
        - Oct 18, 2016 to Sep 30, 2019
- *Snow depth:* Time lapse camera pointed at snow pole marked in 5 cm increments. Column label Snow_depth_cm.
    - Duration:
        - Oct 1, 2016 to Aug 9, 2019
- *Air temperature*: Decagon ECT temperature probe. Column label Ta_C.
    - Duration:
        - Sep 18, 2016 to Sep 30, 2019
- *Soil temperature:* Decagon EC-TM soil moisture and temperature probe. 5 cm depth. Column label Ts_C.
    - Duration:
        - Sep 18, 2016 to Sep 30, 2019
- *Soil moisture:* Decagon EC-TM soil moisture and temperature probe at 5 cm depth, EC-5 soil moisture probes at 20, 40, and 50 cm depth. Column labels VWC_5, VWC_20, VWC_40, VWC_50. Values are volumetric water contents (unitless).
- *Stream discharge:* Two values, one from in situ rugged troll unvented pressure transducer corrected for barometric pressure with In situ baro troll and the other from TruTrak WT-HR V2 1000 mm capacitance rod. Converted to discharge using rating curve from salt slug discharge measurements. Rating curve fit moderate, with discharge values only accurate to within +/- 5 L/s. Column labels Discharge_Ls_pt and Q_mm_pt for pressure transducer and Discharge_Ls_cr, Q_mm_cr for capacitance rod.

Michigan River:

- *Rain gauge:* Texas Electronics TE525 tipping bucket rain gauge with Onset Hobo event logger. 0.3 mm per tip. Column label P_mm. Gage does not function during the winter, so values should only be used for snow-free times of year.
- *Snow depth:* Time lapse camera pointed at snow pole marked in 5 cm increments. Column label Snow_depth_cm.
    - Duration:
        - Dec 3, 2015 to Dec 26, 2018
- *Soil temperature:* Decagon EC-TM soil moisture and temperature probe. 5 cm depth. Column label Ts_C.
    - Duration:
        - Dec 3, 2015 to Sep 30, 2019
- *Soil moisture:* Decagon EC-TM soil moisture and temperature probe at 5 cm depth, EC-5 soil moisture probes at 20, 40, and 50 cm depth. Column labels VWC_5, VWC_20, VWC_40, VWC_50. Values are volumetric water contents (unitless).
    - Duration:
        - Dec 3, 2015 to Sep 30, 2019

- *Stream discharge:* From USGS 06614800 Michigan River near Cameron Pass, CO. Column labels Discharge_Ls and area-normalized discharge as Q_mm.

Andrews Creek:

- *Precipitation gauge:* From Alter shielded NOAH IV electronic rain gauge with 0.01 inch precision maintained for the National Atmospheric Deposition Program by Loch Vale Watershed Research program and USGS Water, Energy, and Biogeochemical Budgets (WEBB) program.
- *Snow depth*: From USGS WEBB program, Akie et al. 2020, measurements from a sonic depth sensor, Campbell Scientific SR50-A.
- *Soil temperature:* Decagon EC-TM soil moisture and temperature probe. 5 cm depth. Column label Ts_C.
    - Duration:
        - Mar 1, 2016 to Jan 31, 2018
- *Soil moisture:* Decagon EC-5 soil moisture and temperature probe at 5 cm depth, EC-5 soil moisture probes at 40, and 50 cm depth. Column labels VWC_5, VWC_40, VWC_50. Values are volumetric water contents (unitless).
    - Duration:
        - Mar 1, 2016 to Jan 31, 2018
- *Stream discharge:* From USGS 401723105400000 ANDREWS CREEK-LOCH VALE-RMNP. Column labels Discharge_Ls and area-normalized discharge as Q_mm.

Data processing notes

Snow depth: Depth increments on poles are every 5 cm. Sometimes the photo interpreter would visually estimate depth increments <5 cm, but these are not precise estimates. Multiple photos were taken each day, but poles were not always easily seen in photos depending on light angle. Depth usually represents the snow depth for the image where the pole could best be seen. Consequently depths for each day do not always represent a consistent time of day.

Rain gauge: Tipping bucket rain gauge data show the precipitation quantities determined from rain gauge tips. No adjustment has been made to account for the type of input - rain vs. snowmelt.

Soil moisture and temperature: Soil moisture and temperature data were screened by comparing sensor time series to those of other sensors in the area measuring the same variable. Screening removed errors such as high or low spikes that did not correspond with wetting or drying times and periods of sensor drift in which the sensor time series stopped tracking with other sensors. Soil moisture sensors were not calibrated specifically for each installation location. Consequently, some values from the standard calibration gave VWC<0. All negative VWC values were set to NA.

Stream stage: Stream stage measurements were compared to manual stage measurements at staff plates in the stream. The sensor stage values were offset-adjusted so that their stage values matched those of the staff plate. Sometimes sensor stage would be offset after a data download, possibly because the sensor was not replaced in exactly the same position. If the sensor stages stopped tracking with the manual stages, this often indicated that a sensor download caused a stage offset. Any evident offsets during data downloads were adjusted by computing the difference between the stage measurements before and after download. If stage differences remained between sensors and field measurements after these offset adjustments, they were not corrected and were used to evaluate the relative accuracy of manual and sensor stage measurements. For streams that dried, the stage of 0 flow was determined from the staff plate.

Stream discharge: rating.csv contains the stage-discharge values used to create rating curves and the predicted discharge for each rating curve. Discharge measurements were collected using the salt dilution method following guidance in Hudson and Fraser (2005), who also describe potential sources of uncertainty in this method. Discharge values are also uncertain based on the range of stages represented in the rating curve and the strength of the curve fit.

For the sites in this study, the rating curves are:

Mill Creek: discharge_Ls = 0 - 0.008497*Square(manual_stage_cm) + 3.3486e-5*Square(manual_stage_cm)^2

RMSE = 1.6

Discharge measurements were conducted for stages ranging from 18-28 cm; sensor stage range was 15-38 cm (15 is zero flow level)

Dry Creek: discharge_Ls = 0 + 0.0074297*Square(manual_stage_cm) + 0.000349*Square(manual_stage_cm)^2

RMSE = 3.1

Discharge measurements were conducted for stages ranging from 5-16 cm; sensor stage range was 5-20 cm

Bighorn Creek: discharge_Ls = -12.87584 + 0.9586232*manual_stage_cm + 0.057358*(manual_stage_cm-17.7778)^2

RMSE = 3.2

Discharge measurements were conducted at stages ranging from 9-24 cm; sensor stage range was 4-37 cm

References

Hudson R, Fraser J. (2005). Introduction to Salt Dilution Gauging for Streamflow Measurement Part IV: The Mass Balance (or Dry Injection) Method. Streamline Watershed Management Bulletin Vol. 9/No. 1 Fall