

# METEOROLOGY FORCING

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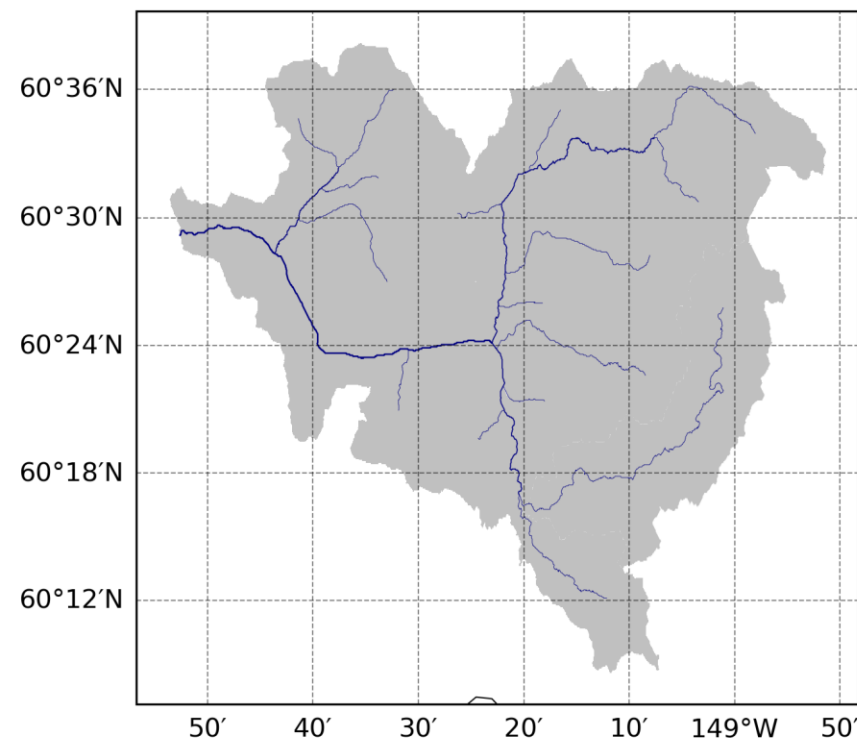
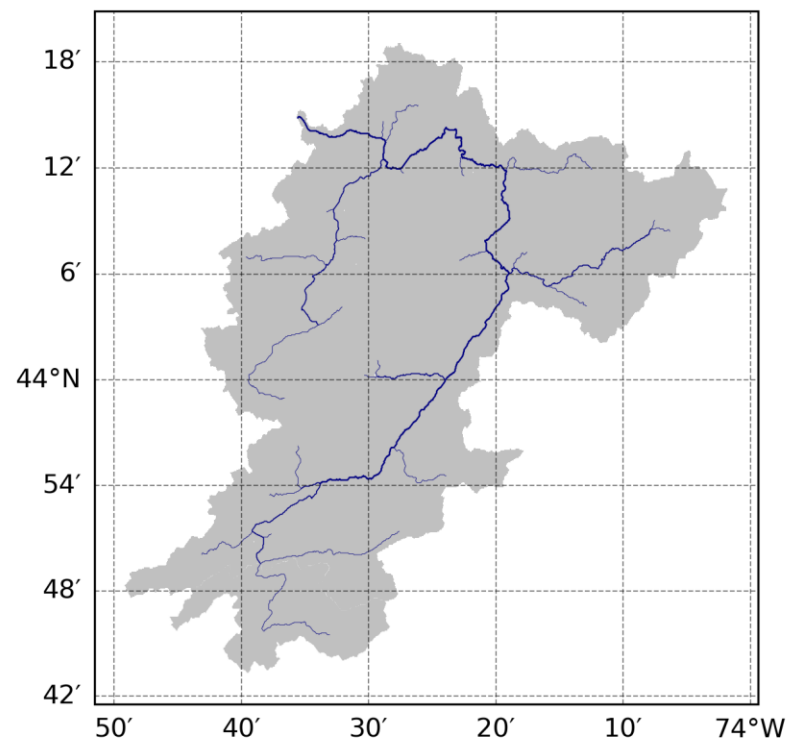
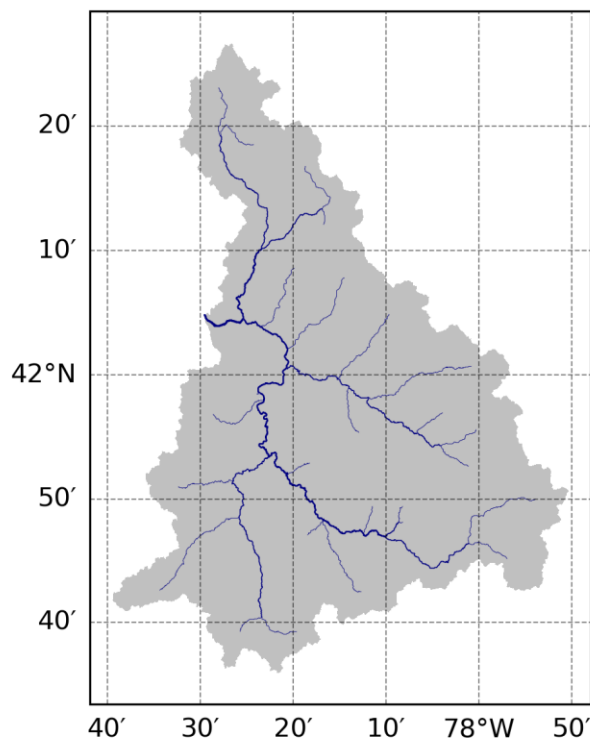
Open-Source Hydro Data Analytics

Nov 12<sup>th</sup> 2025

 **University at Buffalo** The State University of New York



# Basin selection!



# Meteorological forcing data

- A set of **weather variables** like temperature, precipitation, humidity, wind speed, air pressure, etc., which are used as input data to drive hydrological models

## Meteorological Forcings, Required in all simulations:

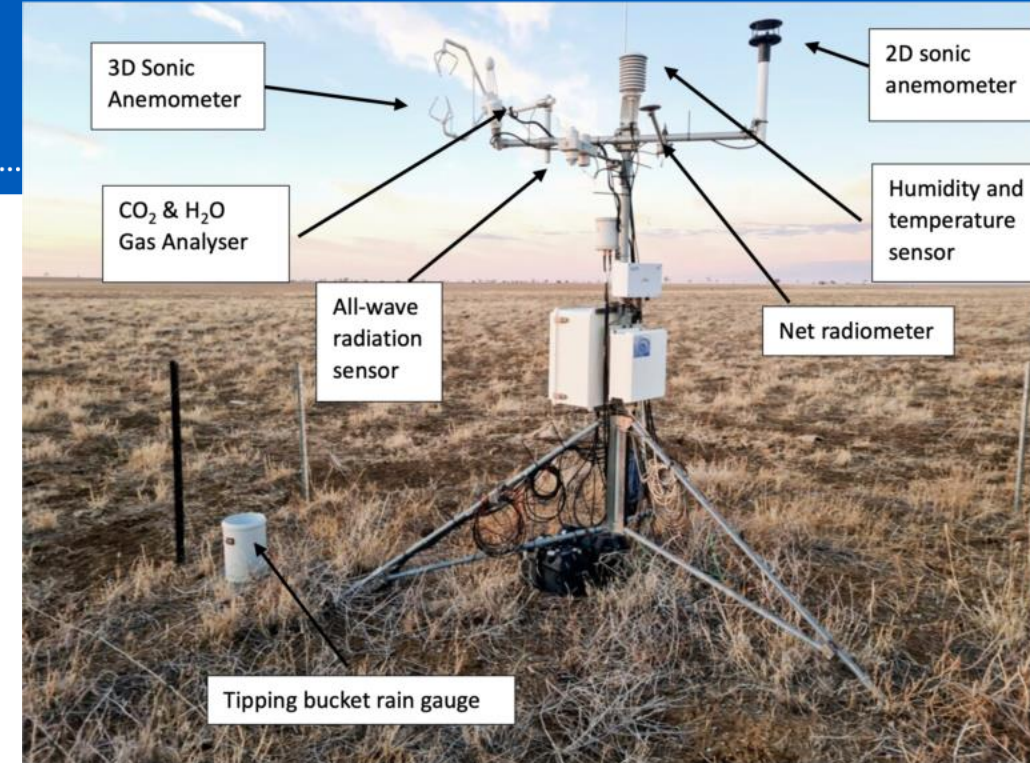
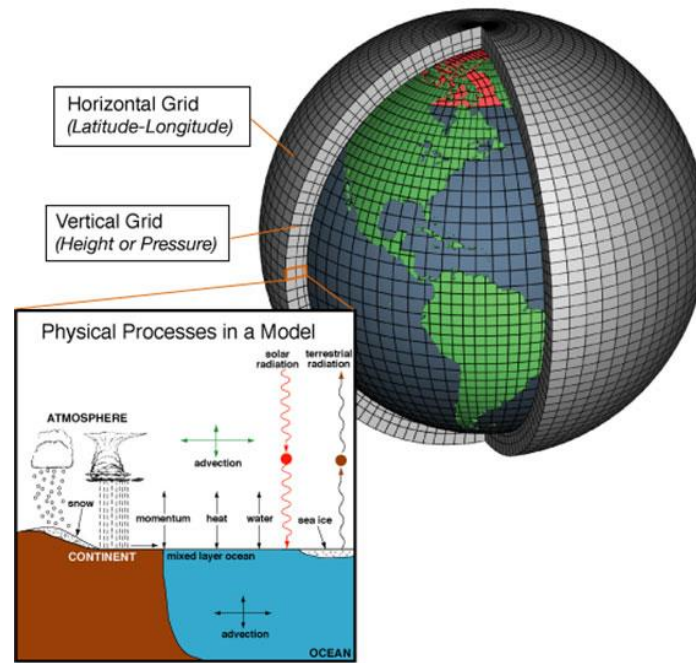
Variable	Description	Units
AIR_TEMP	Average air temperature	C
PREC	Total precipitation (rain and snow)	mm
PRESSURE	Atmospheric pressure	kPa
SWDOWN	Incoming shortwave radiation	W/m <sup>2</sup>
LWDOWN	Incoming longwave radiation	W/m <sup>2</sup>
VP	Vapor pressure	kPa
WIND	Wind speed	m/s

mm/timestep

*This value would be different for 3-hourly versus daily timesteps*

# Source of meteorological data

- Onsite observations
- Remote sensing
- Earth System Models



# Ameriflux

- Ameriflux is a network of PI-managed sites measuring ecosystem CO<sub>2</sub>, water, and energy fluxes in North, Central, and South America.
- It usually provides measurements of all necessary variables for hydrologic modeling
  - Extra quality control might be required

<https://ameriflux.lbl.gov/>

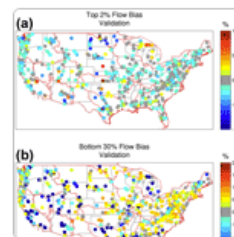


# Large sample watershed-scale dataset for the contiguous U.S.

Research article | Highlight paper | 

14 Jan 2015

Development of a large-sample watershed-scale hydrometeorological data set for the contiguous USA: data set characteristics and assessment of regional variability in hydrologic model performance



A. J. Newman , M. P. Clark, K. Sampson, A. Wood, L. E. Hay, A. Bock, R. J. Viger, D. Blodgett, L. Brekke, J. R. Arnold, T. Hopson, and Q. Duan

Research article | Highlight paper | 

20 Oct 2017

The CAMELS data set: catchment attributes and meteorology for large-sample studies

Nans Addor , Andrew J. Newman, Naoki Mizukami, and Martyn P. Clark


**Abstract.** We present a new data set of attributes for 671 catchments in the contiguous United States (CONUS) minimally impacted by human activities. This complements the daily time series of



# Large sample watershed-scale dataset globally

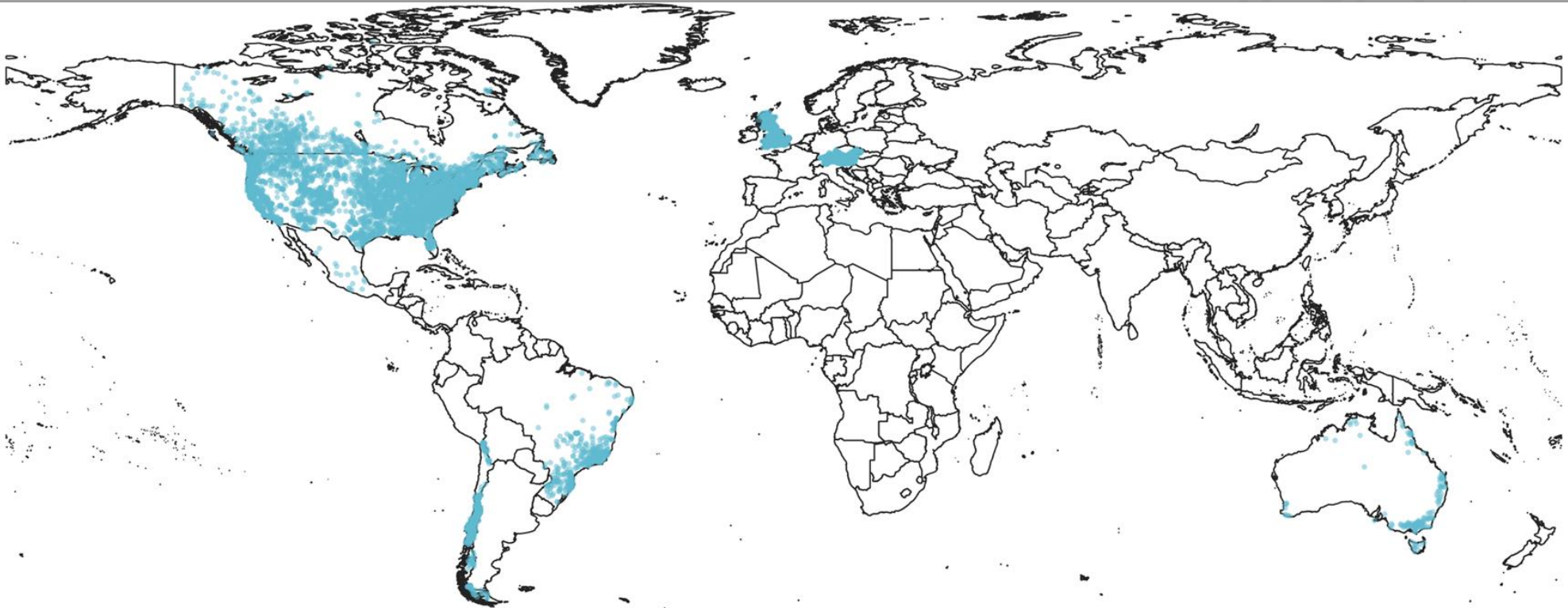
Data Descriptor | [Open access](#) | Published: 31 January 2023

## **Caravan - A global community dataset for large-sample hydrology**

[Frederik Kratzert](#) , [Grey Nearing](#), [Nans Addor](#), [Tyler Erickson](#), [Martin Gauch](#), [Oren Gilon](#), [Lukas Gudmundsson](#), [Avinatan Hassidim](#), [Daniel Klotz](#), [Sella Nevo](#), [Guy Shalev](#) & [Yossi Matias](#)

[Scientific Data](#) **10**, Article number: 61 (2023) | [Cite this article](#)

**34k** Accesses | **194** Citations | **278** Altmetric | [Metrics](#)




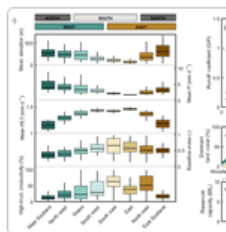
# Large sample watershed-scale dataset globally

Data description paper | 

12 Oct 2020

## CAMELS-GB: hydrometeorological time series and landscape attributes for 671 catchments in Great Britain

Gemma Coxon , Nans Addor, John P. Bloomfield, Jim Freer, Matt Fry, Jamie Hannaford, Nicholas J. K. Howden, Rosanna Lane, Melinda Lewis, Emma L. Robinson, Thorsten Wagener, and Ross Woods

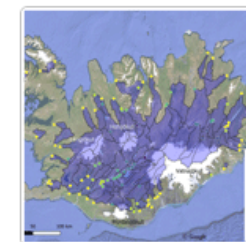


Data description paper | 

13 Jun 2024

## LamaH-Ice: LARge-SaMple DAta for Hydrology and Environmental Sciences for Iceland

Hordur Bragi Helgason  and Bart Nijssen

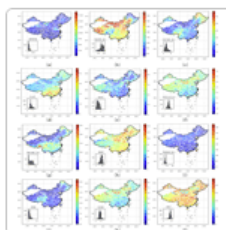


Data description paper | 

03 Dec 2021

## CCAM: China Catchment Attributes and Meteorology dataset

Zhen Hao , Jin Jin , Runliang Xia, Shimin Tian, Wushuang Yang, Qixing Liu, Min Zhu, Tao Ma, Chengran Jing, and Yanning Zhang

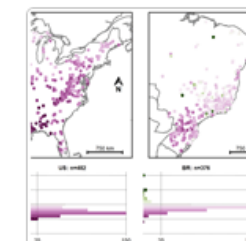


Research article | Highlight paper | 

12 Sep 2024

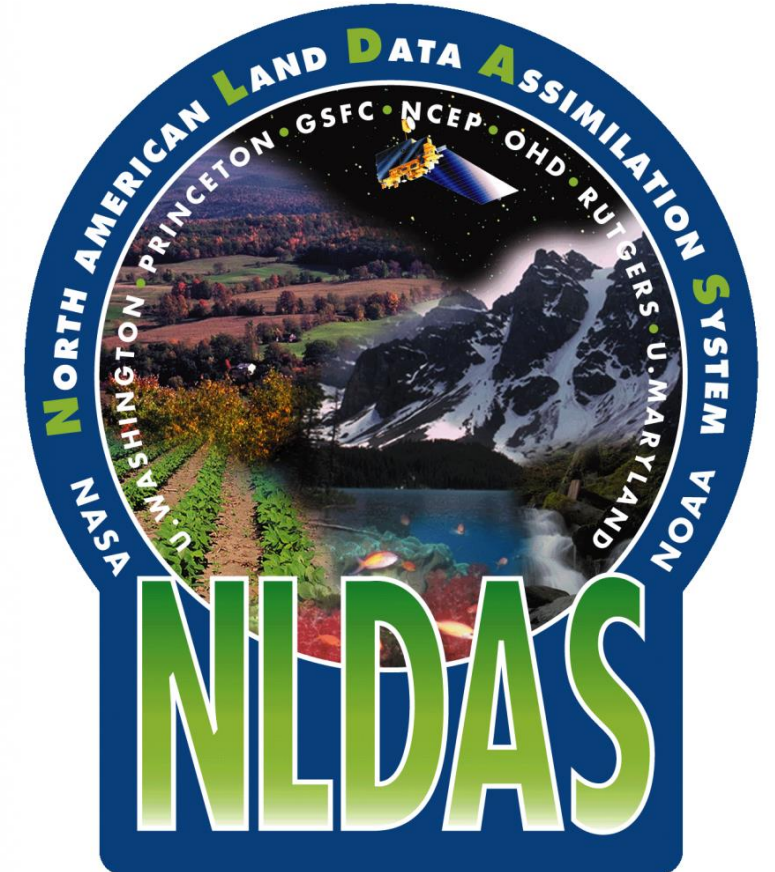
## Large-sample hydrology – a few camels or a whole caravan?

Franziska Clerc-Schwarzenbach , Giovanni Selli, Mattia Neri, Elena Toth, Ilja van Meerveld, and Jan Seibert



# Grid-based meteorological datasets (operational)

- ERA5
  - <https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-v5>
  - ERA5 is the fifth generation ECMWF reanalysis for the global climate and weather for the past 8 decades
- GLDAS/NLDAS
  - <https://ldas.gsfc.nasa.gov/nldas>
  - North American Land Data Assimilation System (NLDAS) aims to construct quality-controlled, and spatially and temporally consistent, land-surface model (LSM) datasets from the best available observations and reanalyses to support modeling activities.



# Grid-based meteorological datasets

- Daymet (<https://daymet.ornl.gov/>)
  - Daymet provides long-term, continuous, gridded estimates of daily weather and climatology variables by interpolating and extrapolating ground-based observations through statistical modeling techniques.
- GMET (<https://ncar.github.io/hydrology/models/GMET>)
  - Gridded Meteorological Ensemble Tool (GMET) allows for quantification of uncertainty for station-based gridded precipitation and temperature datasets
- gridMET (<https://www.climatologylab.org/gridmet.html>)
  - gridMET is a dataset of daily surface meteorological data covering the contiguous US from 1979-yesterday.

**Compared to ERA5 and NLDAS, what are the major differences for these datasets?**

# Grid-based meteorological datasets

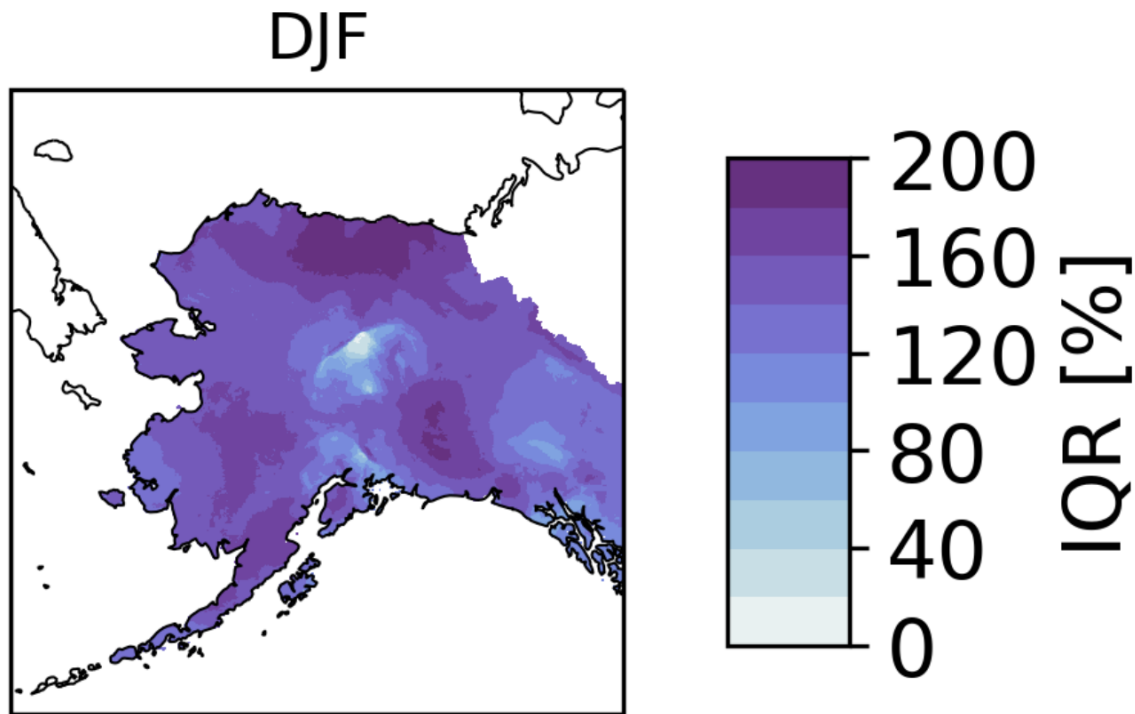
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High resolution  
(1km)

Uncertainty  
Quantification

Semi-operational  
(Downscaled NLDAS)

# Biases exist in the gridded meteorological forcings



Example: Relative Interquartile Range for GMET data in Alaska

$$IQR = \frac{P_{75\%} - P_{25\%}}{(P_{75\%} + P_{25\%})/2}$$

**Biases in the met forcings are major sources for biases in the hydrologic modeling simulations!**

# Example: Steps to process meteorological forcings from NLDAS

- Step 1: Download the datasets
- Step 2: Concatenate the hourly files into the targeted format
- Step 3: Convert the units of the variables to the units required by the VIC model
- Step 4: If necessary, regridding the met forcing data to the targeted domain grid

**Live Demo**

<https://ldas.gsfc.nasa.gov/nldas>

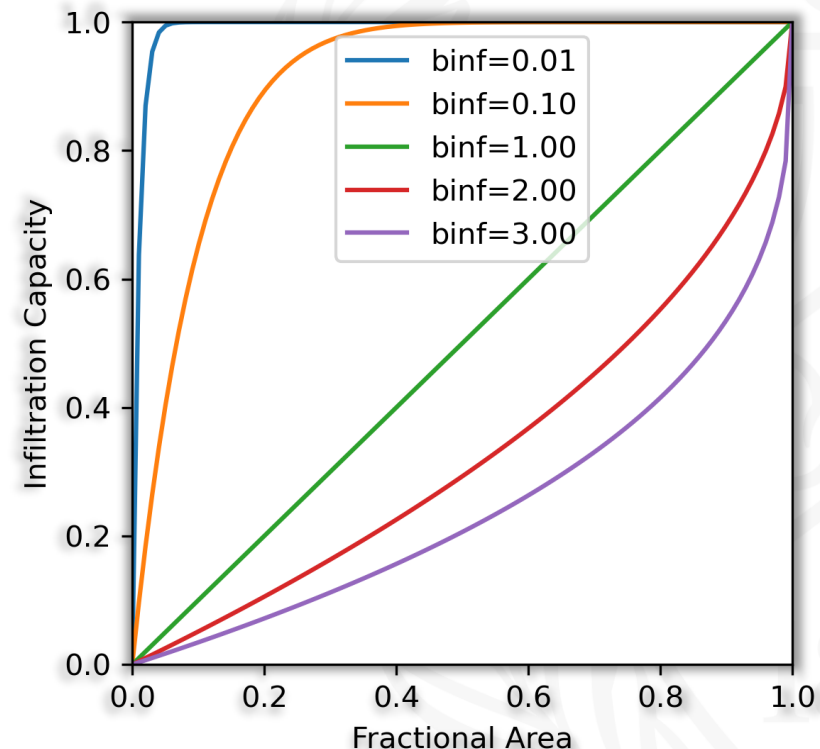
# General rules when preparing meteorological forcings...

When the spatial resolutions of land surface/parameter datasets and meteorological forcing are different, it is recommended to **regrid the met forcing**.

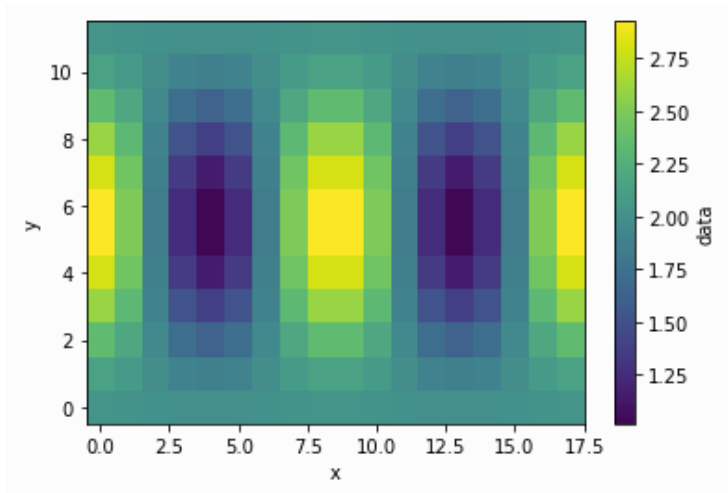
**Question: Why don't we regrid land surface datasets?**

20% clay 80% silt	60% clay 40% silt
$B_{inf}=0.1$	$B_{inf}=1$

**The arithmetic average works when calculating soil composition but it won't work when calculating non-linear parameters!**

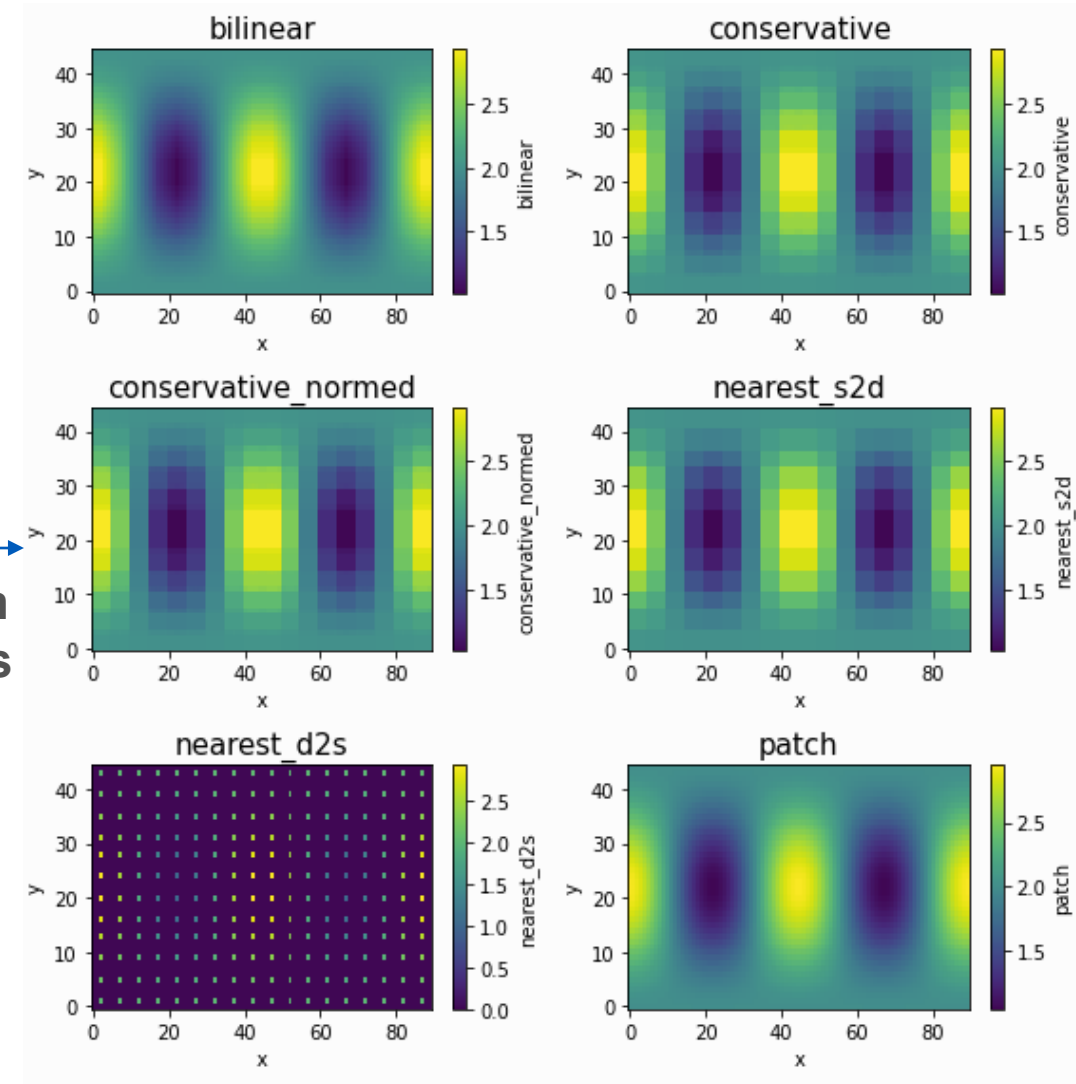


# Regridding



Regrid

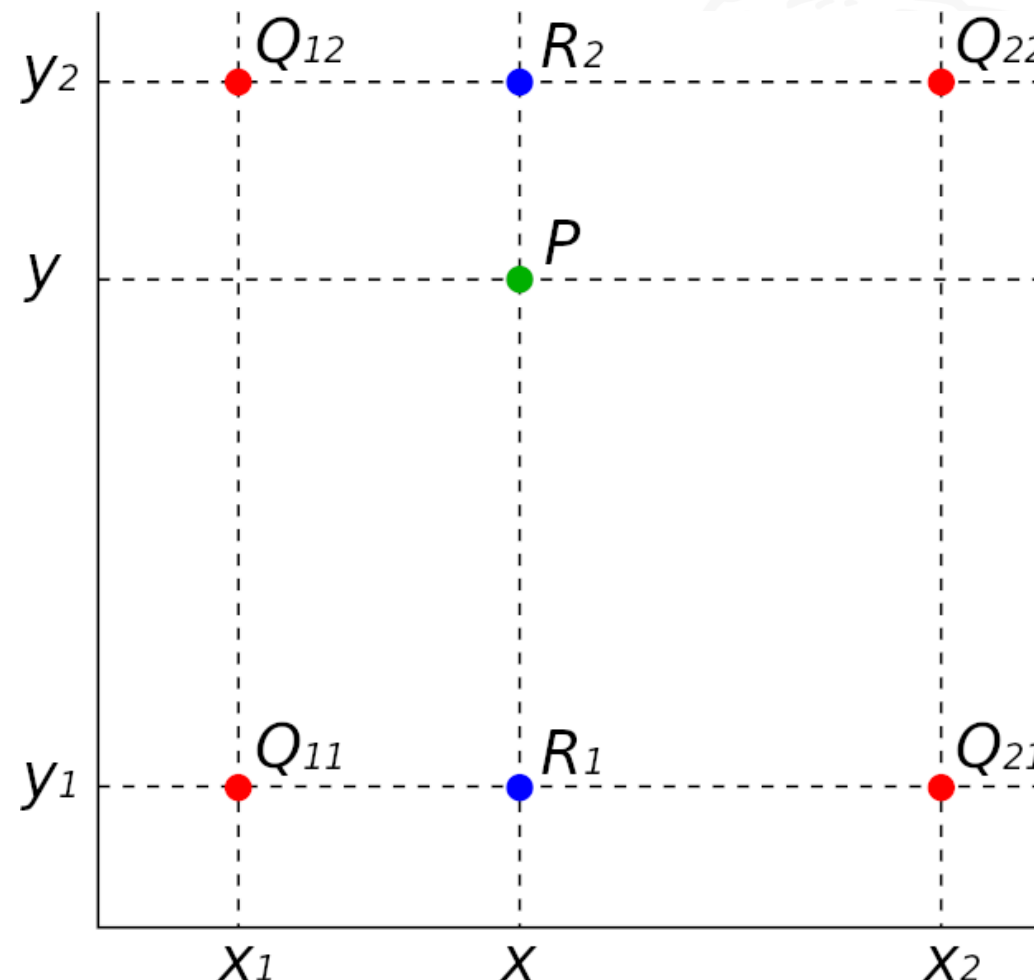
When the spatial resolution of meteorological forcing is different than the model domain



# Bilinear

## How does bilinear (2-D) interpolation work?

Let's assume that we have defined a set of data coordinates  $(x_k, y_k)$ , where  $k = 1, 2$ . These coordinates define the position of the points  $Q_{11}$ ,  $Q_{21}$ ,  $Q_{12}$ , and  $Q_{22}$ . For any given  $x$  and  $y$  coordinates, which are located between the  $x_k$  and  $y_k$  points, by applying the bilinear interpolation technique, we can find the  $P$  point (defined by  $x$  and  $y$ ).



# Questions?

