Evaluating the Effect of Regridding Methods in Conversion from Grid to Catchment Representation Using the NextGen Forcings Engine

Virtual Poster Slam Session #3

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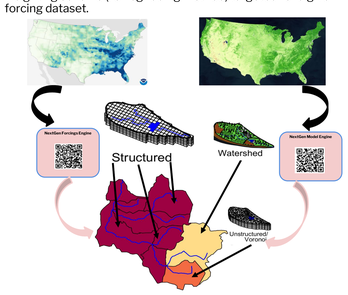
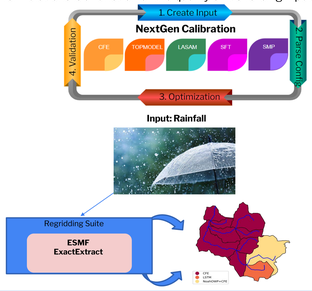
NextGen Motivation

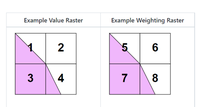
- NextGen supports multiple discritizations in a single model runtime, which requires forcing providers capable of rescaling global datasets across a variety of domain configurations.
- The quality of a given forcing provider is a function of its weighting scheme (i.e. regridding method) targeted for a given forcing dataset.
- NextGen allows flexible design of experiments to select performant models and module components over geographically varying regions.
- Calibration and model optimization for a suite of model formulations is a function of the quality of it's forcing inputs





Regridding Methods

ExactExtract Weighting Scheme



- ExactExtract (ExactExtract, 2024) provides a fast and accurate algorithm for summarizing values in the portion of a raster dataset that is covered by a polygon (e.g. zonal statistics).
- Single threaded fast/efficient regridding technique ➡
- ExactExtract calculates weighted averages based on the percent coverage each grid cell intersects the catchment polygon.

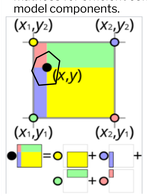
$$Weight(i,j) = \frac{V(i,j) * CF(i,j)}{\sum CF(i,j)}$$

$$y = \sum Weights(i,j)$$

CF=Coverage fraction of grid cell; V= Value of grid cell

ESMF Bilinear Weighting Scheme

- The Earth System Modeling Framework (ESMF) is a suite of software tools for developing high-performance, multi-component Earth science modeling applications (ESMF, 2024).
- Parallelized regridding approach for computational efficiency.
- ESMF provides a suite of regridding approaches (bilinear, patch, conservative) that will produce interpolation weight matrices for efficient communication of data fields between model components.

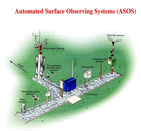


$$Weight(i,j) = V(i,j)\frac{(x - x_i)(y - y_j)}{(dx * dy)}$$

$$y = \sum Weights(i,j)$$

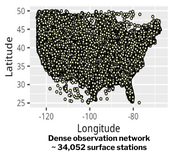
x,y = target coordinates; x(i),y(j) = source grid coordinates; dx,dy = grid spacings

Scope of Statistical Analysis



ASOS (2024)

Mesonet (2024)



- Applied quality control flags based on signal/noise filtering mechanisms to only extract best quality data available from surface stations.
  - Analysis time period: 2023-08-30 12:00:00 until 2023-09-03 12:00:00 UTC.
  - Grid cell/catchment centroid ≤ 10km from surface observation centroid.
  - Observation station recorded variance in rainfall timeseries (~1000 stations).

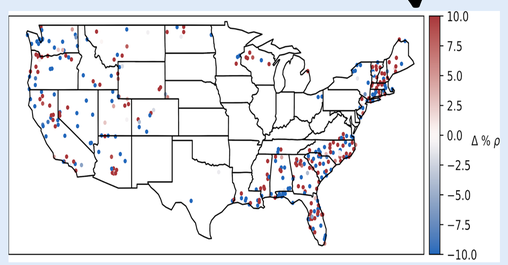
Reanalysis Datasets

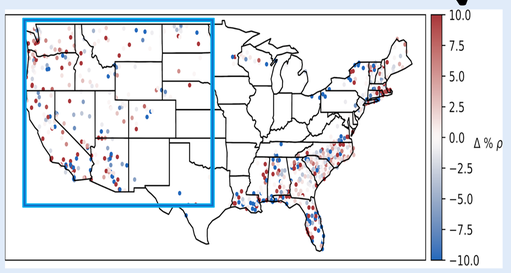
Analysis of Record for Calibration (AORC) 1km
High Resolution Rapid Refresh (HRRR) 3km
ECMWF Reanalysis v5 (ERA5) 28km

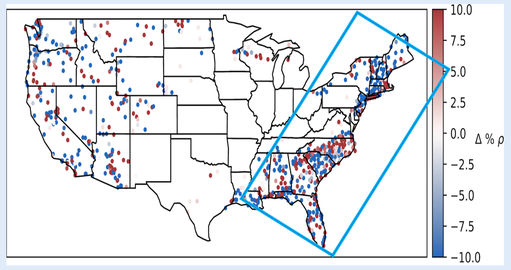
The choice of regridding schemes impact the quality of catchment representation in meteorological forcings based on dataset resolution, weather patterns, & catchment features. NextGen users can leverage this knowledge to appropriately rescale forcing inputs based on the scope of their analysis.

ERA5 28km ✓ | **HRRR 3km** ✓ | **AORC 1km**

ESMF Bilinear



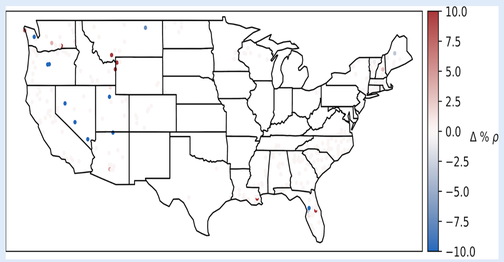




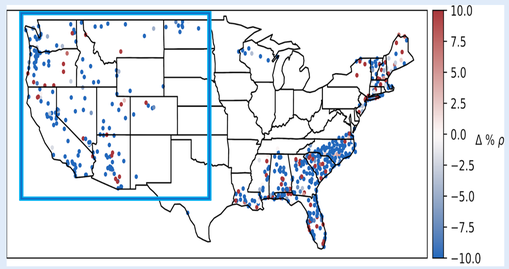
$$\Delta\%\rho = \frac{\rho_{ESMF,EE} - \rho_{NN}}{\rho_{NN}} * 100$$

ESMF= ESMF Bilinear
EE= ExactExtract
NN= Nearest Neighbor

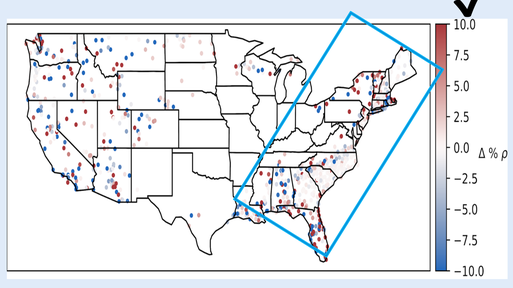
ExactExtract



- ExactExtract showed no difference essentially from near neighbor approach



- Distance weighted regridding scheme performing well over sparse rainfall event features in Western US, slight benefit in rainfall features in Southeastern US.



- ExactExtract area-weighted approach begins resolving dynamical rainfall gradients and shows a net benefit for rescaling high resolution rainfall fields.

AORC 1km grid cells

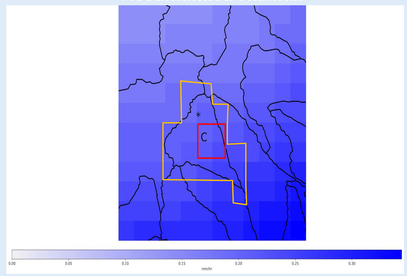
ESMF Bilinear weighted grid cells

ExactExtract weighted grid cells

C ~ centroid of the overlapping catchment

* ~ ASOS station location

Accumulated Rainfall

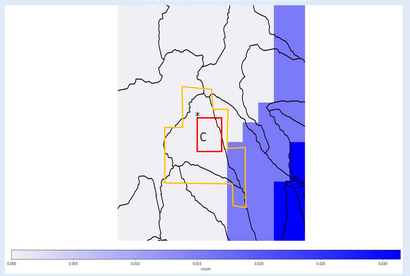


Station ~ 1.17 mm/hr

ESMF Bilinear ~ 0.41 mm/hr
ExactExtract ~ 0.74 mm/hr ✓

- Weighted coverage fraction properly accounts for gradient across the entire catchment feature

Accumulated Rainfall

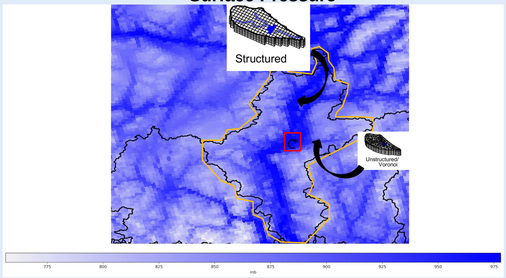


Station ~ 0.00 mm/hr

ESMF Bilinear ~ 0.00 mm/hr ✓
ExactExtract ~ 0.15 mm/hr

- Area weighted schemes over sparse rainfall features may lead to an overestimation in catchment rainfall estimates

Surface Pressure



Station ~ 965 mbs

ESMF Bilinear ~ 955 mbs
ExactExtract ~ 870 mbs

- Caution should be taken with catchment representation of meteorological forcings over heterogeneous regions. Downscaled formulations are warranted in this case for a given NextGen application.

ACKNOWLEDGEMENTS:

iposter QR code

REFERENCES:

ExactExtract, 2024; exactextract documentation, https://isciences.github.io/exactextract/

ESMF, 2024; esmf documentation, https://earthsystemmodeling.org/regrid/

ASOS, 2024; asos documentation, https://www.weather.gov/asos/

Mesonet, 2024; mesonet documentation, https://nationalmesonet.us/

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