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Support for Spatially Gridded Component-based Models in the Next Generation Water Resources Modeling Framework

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Next Generation Water Resources Modeling Framework (NextGen)

NOAA's Office of Water Prediction (OWP) leads development of the Next Generation Water Resources Modeling Framework (NextGen), in coordination with federal water prediction partners. NextGen provides increased flexibility for dealing with the hydrologic heterogeneity that exists across CONUS by allowing different hydrologic models to be used for disjoint subbasins within larger basins. Streamflow predictions for the numerous subbasins are then combined via flow routing on a "hydrofabric" network to provide predictions for the larger basins. NextGen enables users to experiment with and then choose the most performant models in the different subbasins.

This work provides the first demonstration of the ability to run a spatially gridded hydrologic model in NextGen.

The TopoFlow Hydrologic Model

- A spatially gridded, component-based model.
- Written in Python/Numpy as a Python package.
- Includes many plug-and-play hydrologic process components to choose from. See **Figure 4.**
- Each process component has a Basic Model Interface (BMI) and uses CSDMS Standard Names for variables.
- Includes a large collection of utilities:
  - D8 toolkit (direction, area, slope, etc.)
  - radiation calculator (long & shortwave)
  - soi property calculator (pedotransfer)
  - file I/O, data preparation & visualization
- Output is written to netCDF with rich metadata.
- Plots & movies created automatically from output.
- Documented w/ HTML Help & Jupyter notebooks
- Open-source: *github.com/peckhams/topoflow36*

Running a Spatially Gridded Hydrologic Model in NextGen

NextGen uses a **hydrofabric** that partitions the hydrologic landscape into a set of watershed polygons, or **catchments**, and **nexus** locations where streamflows from catchments are combined. NextGen allows different models to be used for different catchments. Many models (e.g. Topmodel) treat each catchment in the hydrofabric as a computational cell. However, a modeler may wish to explore the potential benefit of modeling the hydrology of some catchments with increased spatial resolution. This requires a gridded model that further subdivides a catchment into smaller grid cells.

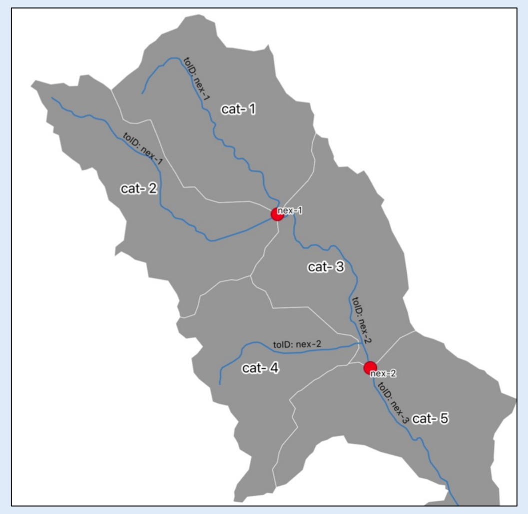


Figure 1. Hydrofabric concepts.

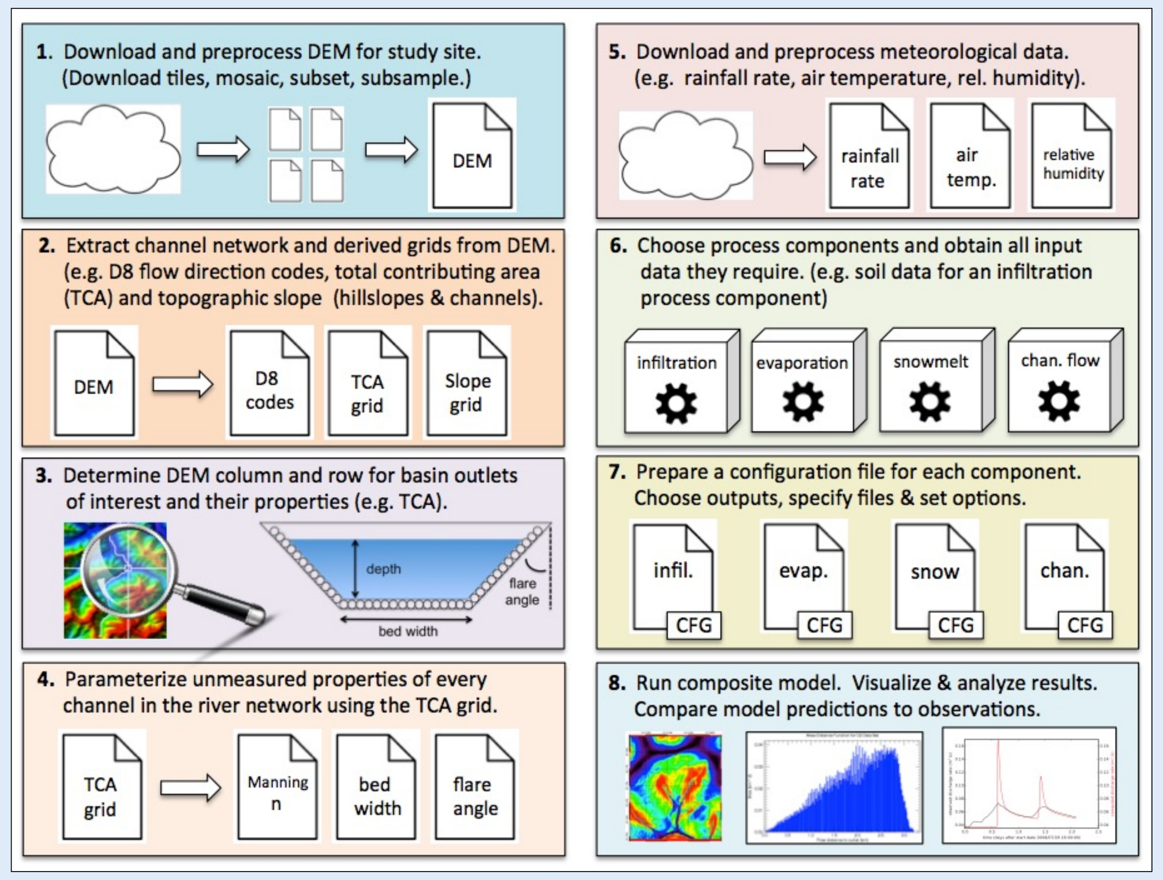


Figure 2. Typical workflow used to set up and run a spatiallly gridded, component-based hydrologic model like TopoFlow. Now fully automated.

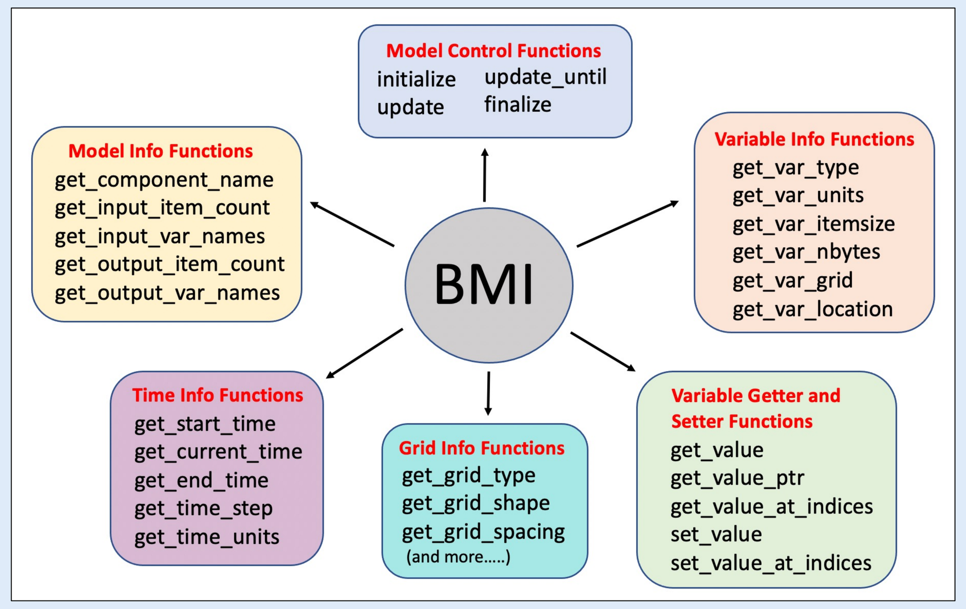


Figure 3. The main functions of the Basic Model Interface v. 2.0, grouped by their purpose. Every TopoFlow process component has this interface.

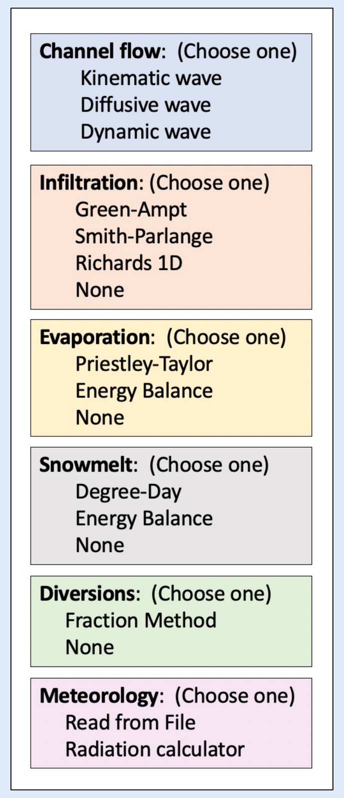
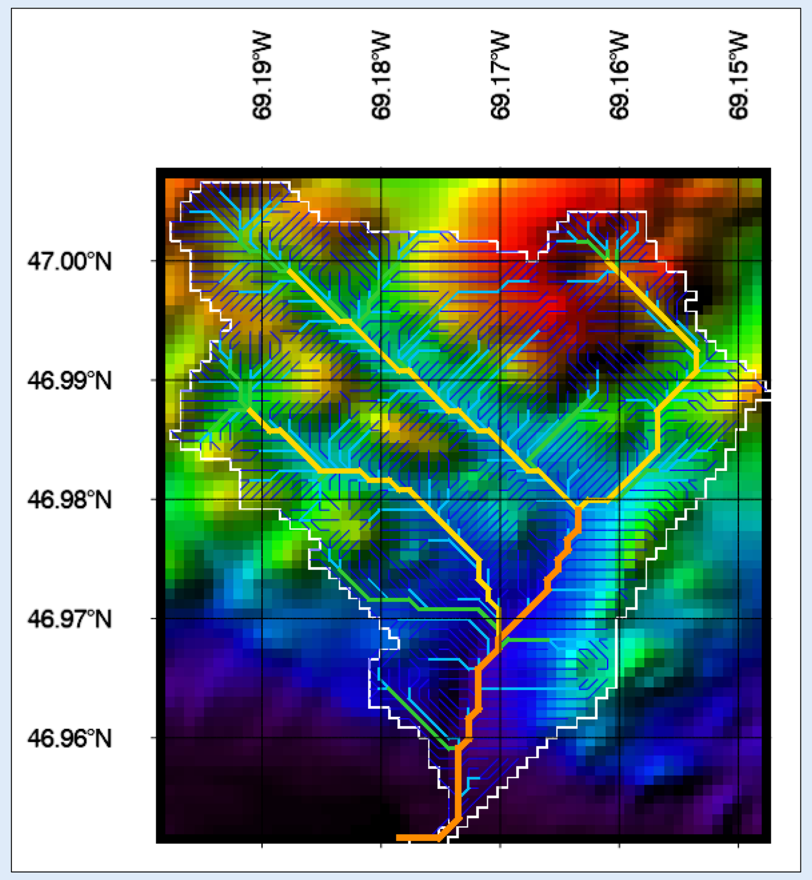


Figure 4. TopoFlow components



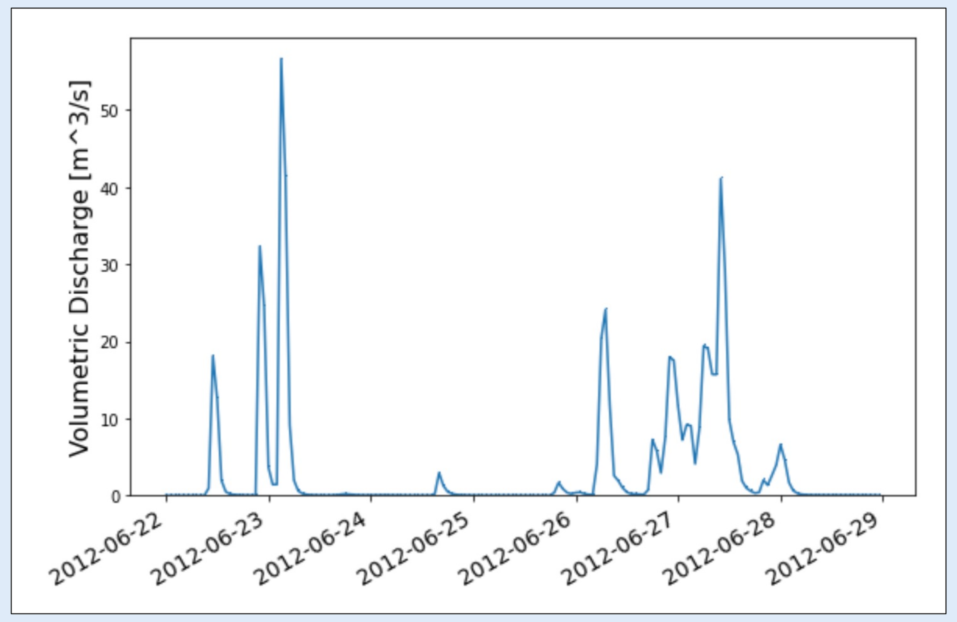


Figure 5. A shaded relief image (left) that also shows the basin boundary (white) and channels for "cat-209", a headwater catchment in the NextGen HUC01 hydrofabric.

Figure 6. A simulated hydrograph (above) for "cat-209", due to June 2012 rain storms (AORC data)

TopoFlow Extensions for NextGen

Three sets of utilities were developed to facilitate running TopoFlow in NextGen.

Hydrofabric Tools: (utils/hydrofab_tools.py)
Given a user-chosen catchment (e.g., "cat-84"), these functions derive info such as geographic bounding box and outlet coordinates from the GeoJSON files that define the NextGen hydrofabric. These are used to automatically clip and download a GeoTIFF DEM for the catchment from a CONUS-wide, high-res DEM stored in an Amazon S3 bucket in virtual raster (VRT) format.

Multi-Component BMI: (framework/multi_bmi.py)
This couples a collection of BMI-enabled TopoFlow process components and presents it to NextGen as a single BMI model component. It is based on EMELI.

Input File Preparation: (utils/prepare_inputs.py)
Given a DEM, this utility *automatically* generates all other required input files, such as cfg files & grids for slope, aspect, total contributing area, channel width & roughness, soil properties, and forcing grid stacks.

Why Run a Model in NextGen?

The NextGen framework provides models with many added-value capabilities that are expected to accelerate advancements in hydrology. For example, it can:

- ✓ Provide meteorological forcing data, such as NOAA's AORC (Analysis of Record for Calibration) data.
- ✓ Provide other data such as DEMs and soil properties and speed up the model setup process.
- ✓ Write output at a desired interval in various formats with standardized metadata.
- ✓ Facilitate sharing values of variables between BMI-enabled models.
- ✓ Provide a consistent, nation-wide hydrofabric.
- ✓ Provide models with calibration services.
- ✓ Allow the model to run for any subset of catchments in the USA.
- ✓ Take advantage of high-performance computing to allow running a set of models for many catchments simultaneously.

ACKNOWLEDGEMENTS:

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