Streamlining Community Modeling through Automated Data Processing
for the Next Generation Water Resources Modeling Framework

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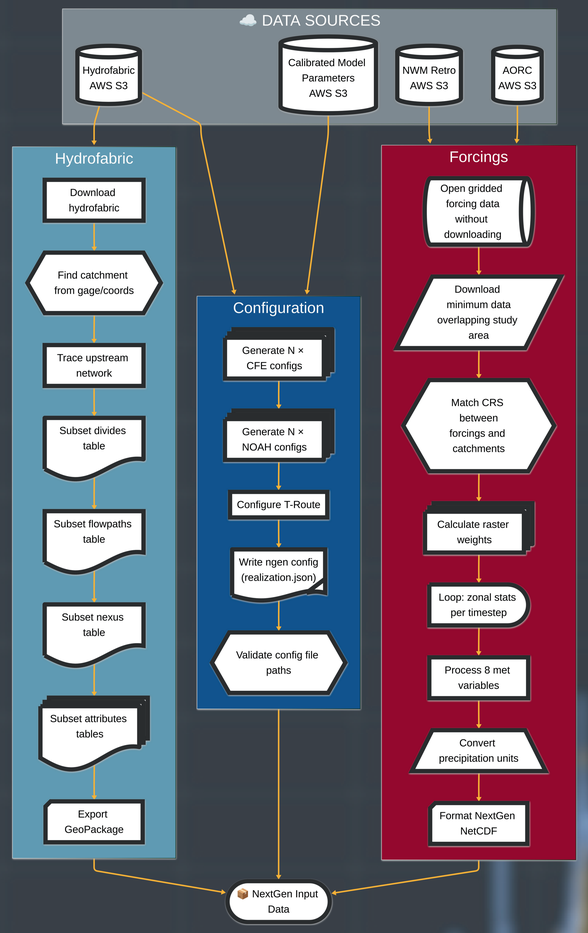
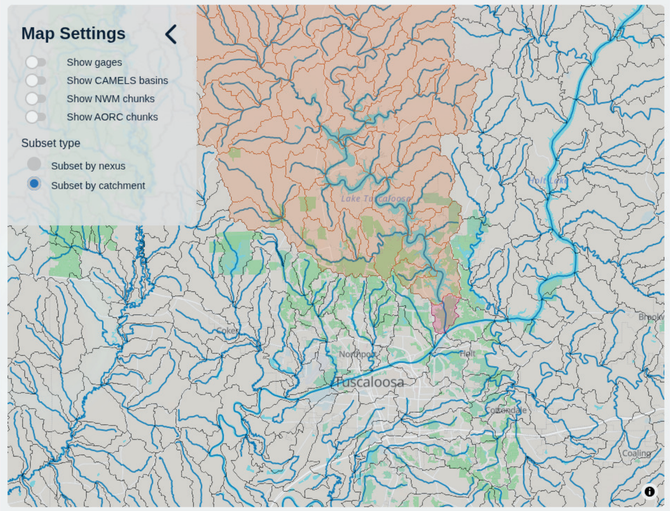
The Challenge

NextGen hydrological simulations require extensive manual data preparation:

- Downloading a national hydrofabric
- Tracing upstream networks
- Extracting database tables
- Processing terabytes of meteorological data
- Computing catchment-averaged forcings
- Generating configuration files.



Select catchments by clicking!



01 Spatial Domain Extraction

Extracts watershed boundaries and attributes from the NOAA OWP v2.2 CONUS hydrofabric using graph-based upstream traversal (igraph).

- Accepts USGS gage ID, lat/lon, or catchment ID
- Extracts 10 related tables: geometry, attributes, network topology
- Outputs self-contained GeoPackage with spatial indices

02 Meteorological Forcing Preparation

Retrieves gridded forcings from cloud-optimized Zarr archives on AWS S3.

- Sources: NWM Retrospective v3 or AORC v1.1 (1km, hourly, 1979–present)
- Parallel S3 downloads via custom S3ParallelFileSystem
- Precise catchment averaging with exactextract
- Multi-core processing with shared memory (~60% memory reduction)
- Local caching prevents redundant downloads

03 Model Configuration Generation

Generates all NextGen configuration files from hydrofabric attributes and calibrated parameters (when available).

- Per-catchment CFE and NOAH-OWP-Modular configs
- T-Route routing with memory-aware loop sizing
- Complete realization.json assembly

```
22:06|josh@aradon:~$ time uvx ngiab-prep -i gage-10154200 --start 1980-10-01 --end 2020-10-01 --source aorc -o poster_speed -sfr
2025-12-10 21:58:56,562 - INFO - Found cat-2863631 from gage-10154200
2025-12-10 21:58:56,562 - INFO - Processing cat-2863631 in /home/josh/ngiab_preprocess_output/poster_speed
2025-12-10 21:58:56,917 - INFO - Subsetting hydrofabric
2025-12-10 21:58:57,877 - INFO - Subsetting complete.
2025-12-10 21:58:57,877 - INFO - Downloading forcings from 1980-10-01 00:00:00 to 2020-10-01 00:00:00...
2025-12-10 22:03:16,065 - INFO - Successfully cached gridded forcing data
2025-12-10 22:03:16,784 - INFO - Computing zonal stats in parallel for all timesteps
2025-12-10 22:03:18,677 - INFO - Total steps: 8, Number of time chunks: 1, Number of variables: 8
Forcings processed in 26.585591 seconds ━━━━━━━━━━━━━━━━━━━━━━━━ 100% 8/8 •  Elapsed Time: 0:00:23  Remaining Time: 0:00:00
2025-12-10 22:03:45,264 - INFO - Forcing generation complete!
2025-12-10 22:03:48,718 - INFO - Creating configuration from 1980-10-01 00:00:00 to 2020-10-01 00:00:00...
2025-12-10 22:03:49,031 - INFO - downloaded calibrated parameters for gage-10154200
2025-12-10 22:03:49,052 - INFO - Realization creation complete.
2025-12-10 22:03:49,052 - INFO - All operations completed successfully.
2025-12-10 22:03:49,052 - INFO - Output folder: file:////home/josh/ngiab_preprocess_output/poster_speed

real    4m54.908s
```

Performance Features

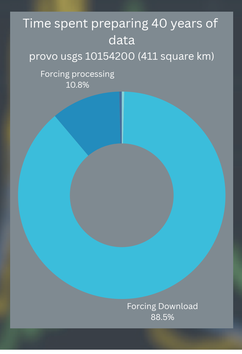
- Parallel S3 range requests reduce data transfer time
- Shared memory blocks allow fast multiprocessing of forcings
- Memory-aware chunking automatically adapts to available system RAM
- Pre-built network graphs enable sub-second upstream traversal even for watersheds with thousands of catchments

Our Solution

- Open-source Python tool automating the complete data preparation pipeline
- A single command transforms location identifier into ready-to-run NextGen simulation package
- Available via web map interface or CLI—no local installation required with uvx.

Community Impact

- Reduces data preparation from hours of manual work to minutes of automated processing
- Reproducible CLI workflows can be shared, scripted, and version-controlled
- Cloud-native data access eliminates need for local terabyte-scale storage
- Web map interface lowers barrier for users unfamiliar with command-line tools
- Extensible architecture accommodates new model configurations as NextGen evolves
- Open source and community maintained—contributions welcome



Future work

- Expand configuration generation to more models, currently only supports cfe+noah-owp-modular and lstm.
- Refactor submodules for easier use in external scripts
- Preprocess 40 year retrospective forcings and save the output in s3 (should be roughly 3% the size of current gridded forcings
- Update to fetch forecast forcing data

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