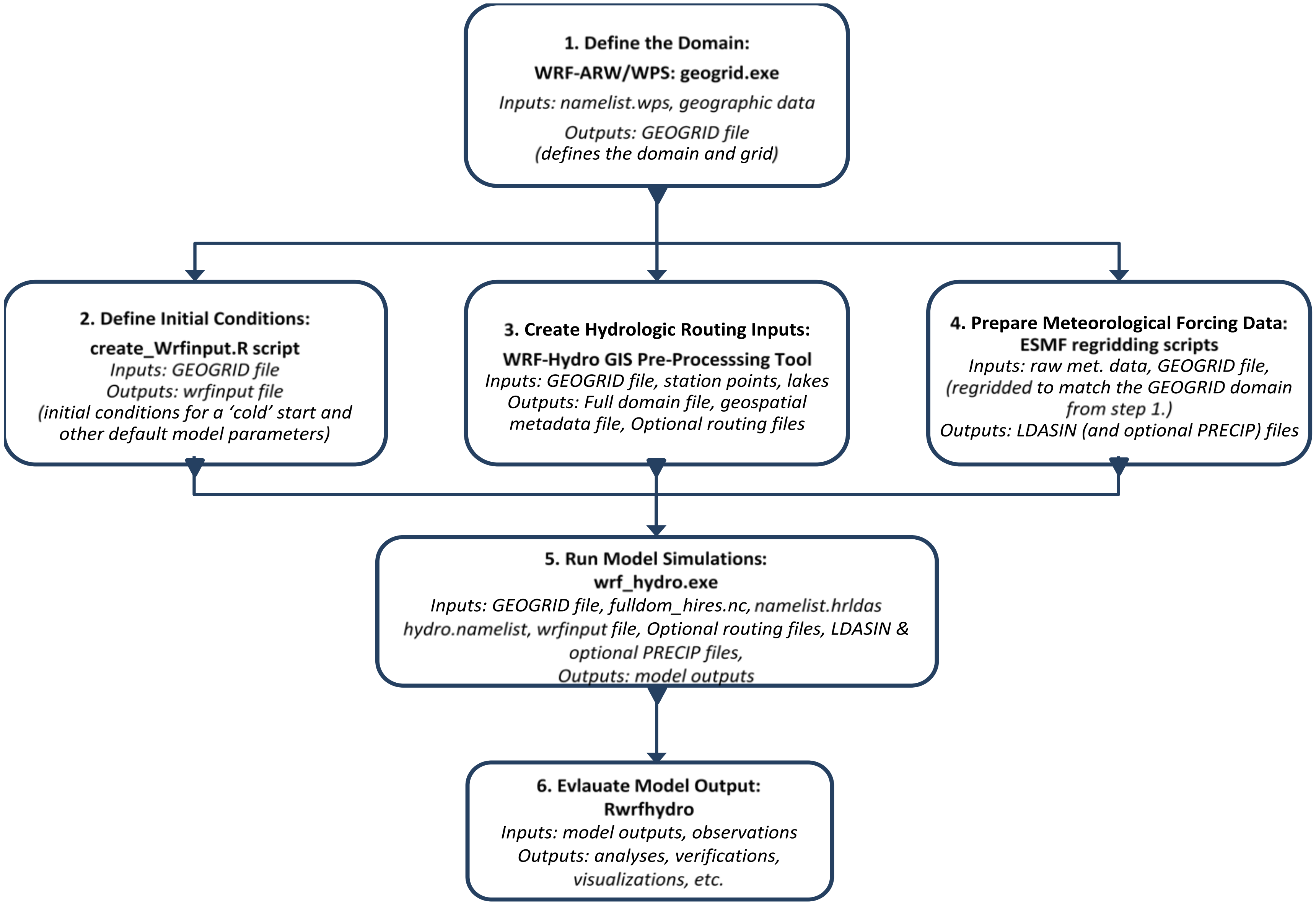
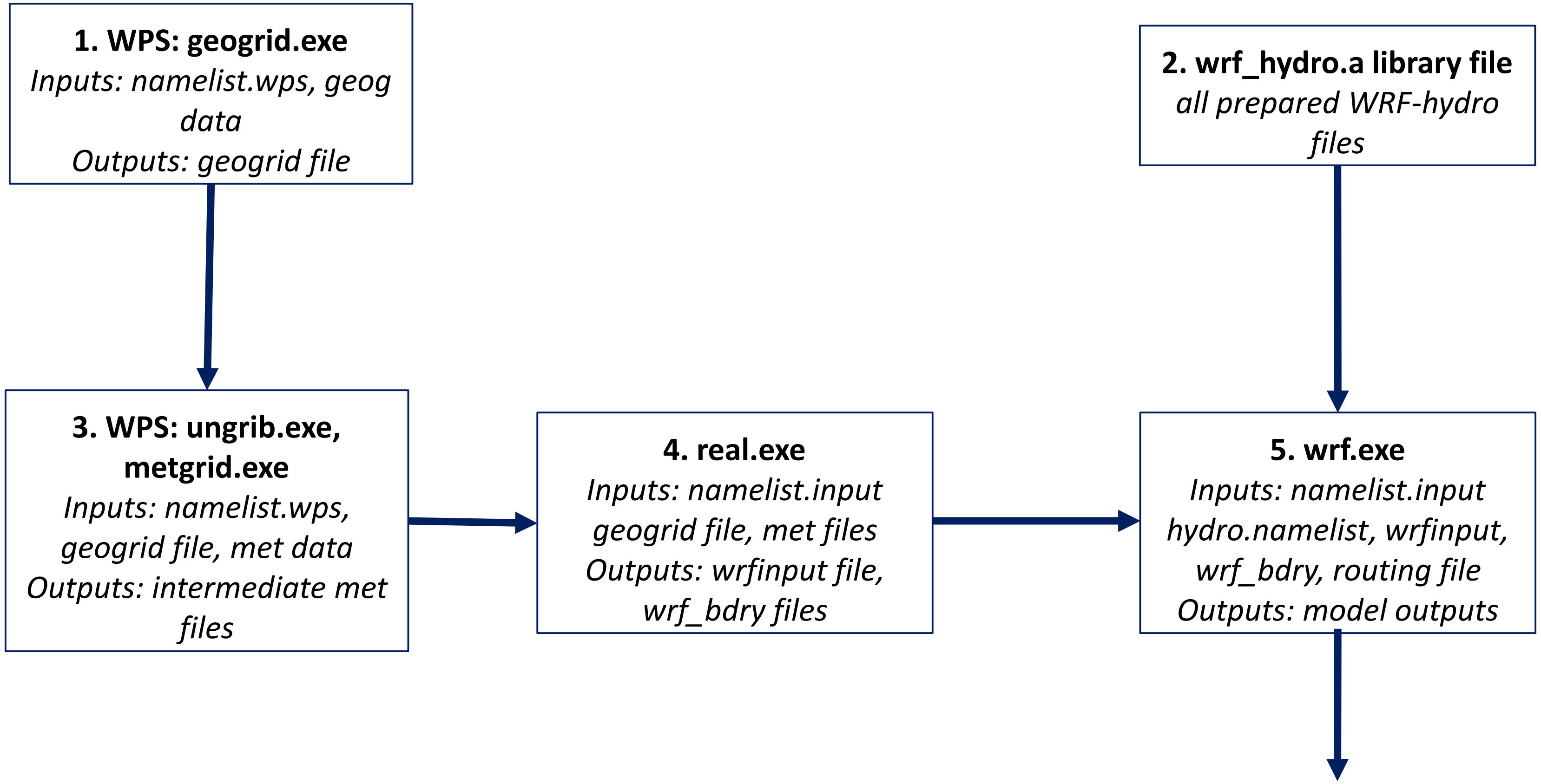
WRF-Hydro Implementation & Best Practices

National Center for Atmospheric Research

Uncoupled WRF-Hydro Workflow

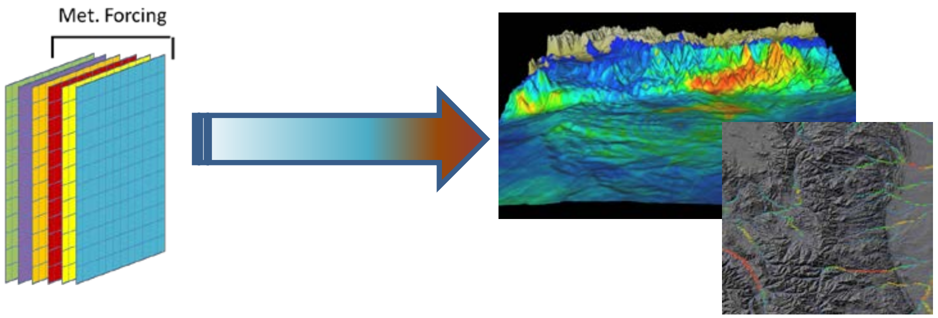


Coupled WRF|WRF-Hydro Workflow

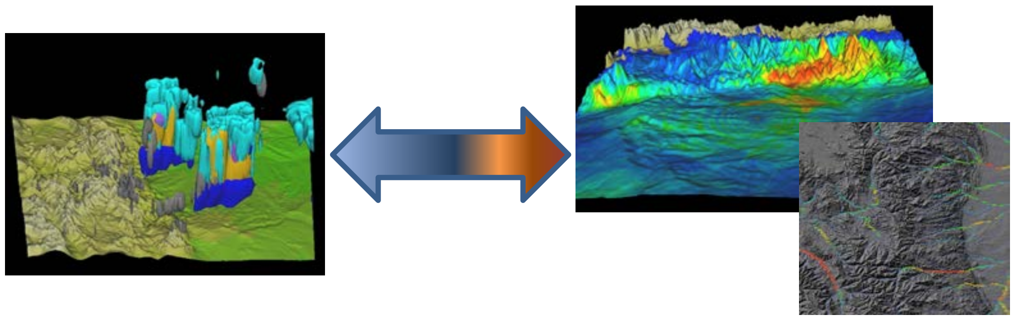


WRF-Hydro Model Architecture

One-way ('uncoupled') →



Two-way ('coupled') ↔



- Uncoupled mode critical for spinup, data assimilation and model calibration
- Coupled mode critical for landatmosphere coupling research and long-term predictions
- Model forcing and feedback components mediated by WRFHydro:
  - • Forcings: T, Press, Precip., wind, radiation, humidity, BGC-scalars
  - • Feedbacks: Sensible, latent, momentum, radiation, BGC-scalars

Suggested WRF-Hydro Implementation Steps

Tips from our helpdesk regarding setup and preprocessing

1. See our Frequently Asked Questions (FAQs) webpage https://ral.ucar.edu/projects/wrf_hydro/faqs
   – See the requirements and example installation

2. Check that you have the correct NetCDF libraries installed
   – NetCDF C Version 4.4.1.1, NetCDF F Version 4.4.4
   – If coupling with WRF check that the netcdf4 flag is **enabled**

3. For working with the WRF-Hydro ArcGIS Preprocessing Tool
   – Have a valid version of ArcGIS
   – Have Spatial Analyst Extension **enabled**
   – Do not write your files to a geodatabase or network location.
   – Specify that your output file goes to a directory on disk which exists
   – Check your installation: It helps to have 64-bit Background Geoprocessing module installed, and Background Geoprocessing enabled.
   – Check that your directory names and/or file names do not have spaces or special characters in them.
   – Make sure that your DEM encompasses the entire extent of the Geogrid domain

4. When preparing your forcing data make sure that there are **no missing data**

Suggested WRF-Hydro Implementation Steps

This procedure will help isolate problems which may otherwise be difficult and/or timeconsuming to diagnose in many implementations: 1. Derive and QC all inputs…(time mean fields, accumulation fields, screen for anomalies…)

2. Conduct offline simulations…

3. Start with ‘idealized’ forcing (FORC_TYP = 4)

4. Run WRF_Hydro with no routing

5. Then sequentially add routing components:

    1. Sfc/subsfc
    2. GW/baseflow
    3. Channel flow
    4. Reservoirs

6. If all above works, then non-forcing input grids and components are functional (though not guaranteed accurate!)

7. Do offline runs with FORC_TYP set to data input format

8. After all that and calibration, then run coupled WRF-Hydro

Model Evaluation: Multi-scale model analysis over intensive observational testbeds

3 legs of the model 'fidelity' stool:

1. Temporal Domain:

- Assessing high and low frequency behavior in model simulated flow responses
- Diagnosing extremes in hydrological models

2. Spatial Domain:

- Capturing patterns of heterogeneity and organization in hydrologic states (GW, snow, S.M.)
- Representing changes in runoff productivity across climate-topographic gradients
- Reproducing the appropriate upscale behavior of runoff and streamflow from headwater to large river system

3. Multi-variate model characterization:

- Energy and Radiation fluxes
- Inundation
- Groundwater-critical zone interactions
- Shallow soil moisture

Routing Options

Type	When/Why To Use	Benefits	Drawbacks
Subsurface Routing			
SUBRTSWCRT	When local topography is important to flow processes or your fluxes/states of interest	Allows lateral water movement between cells, better representing convergence/divergence patterns (e.g., water converging into a valley) and residence times	More computationally expensive
Overland Flow Routing			
OVRTSWCRT	When fast surface flow processes are of interest/importance (e.g., flood forecasting vs. water supply forecasting)	Better represents local ponding and re-infiltration; required to capture land runoff directly to channels and lakes	More computationally expensive
Channel Routing			
CHANRTSWCRT	When you want streamflow in the channel		
Muskingham- **Reach** channel_option = 1	When you want an approximate solution as efficiently as possible (e.g., over a large domain or with limited compute resources)	Computationally cheap and fast	Limited to uniform fluxes/states per reach (not ideal if reaches are long); no backwater effects
Muskingham-Cunge-**Reach** channel_option = 2	When you want an approximate solution as efficiently as possible (e.g., over a large domain or with limited compute resources)	Computationally cheap and fast; more "stable" in terms of propagating flow one-way down the channel	Limited to uniform fluxes/states per reach (not ideal if reaches are long); no backwater effects
Diffusive Wave- **Gridded** channel_option = 3	When you need a more precise/accurate local solution and have sufficient compute resources (e.g., small or high-resolution domains, conditions where hydraulic processes are important)	Captures backwater flow; provides higher spatial detail on channel flow (e.g., every channel grid cell); only option that allows (limited) water fluxes from land to lake	More computationally expensive, can be sensitive to parameters and internal time steps

Computational Considerations

- Domain Size - Smaller domains require fewer resources
- Routing Options - Do initial testing with routing off and add options incrementally to isolate problems should they arise
- Output Options - Reduce to only those you need
- Output Timestep - Reduce the frequency to save disk space and improve runtime
- Restart Files - Costly - produce only a couple times during a simulation as needed

WRF-Hydro: http://www.ral.ucar.edu/projects/wrf_hydro/