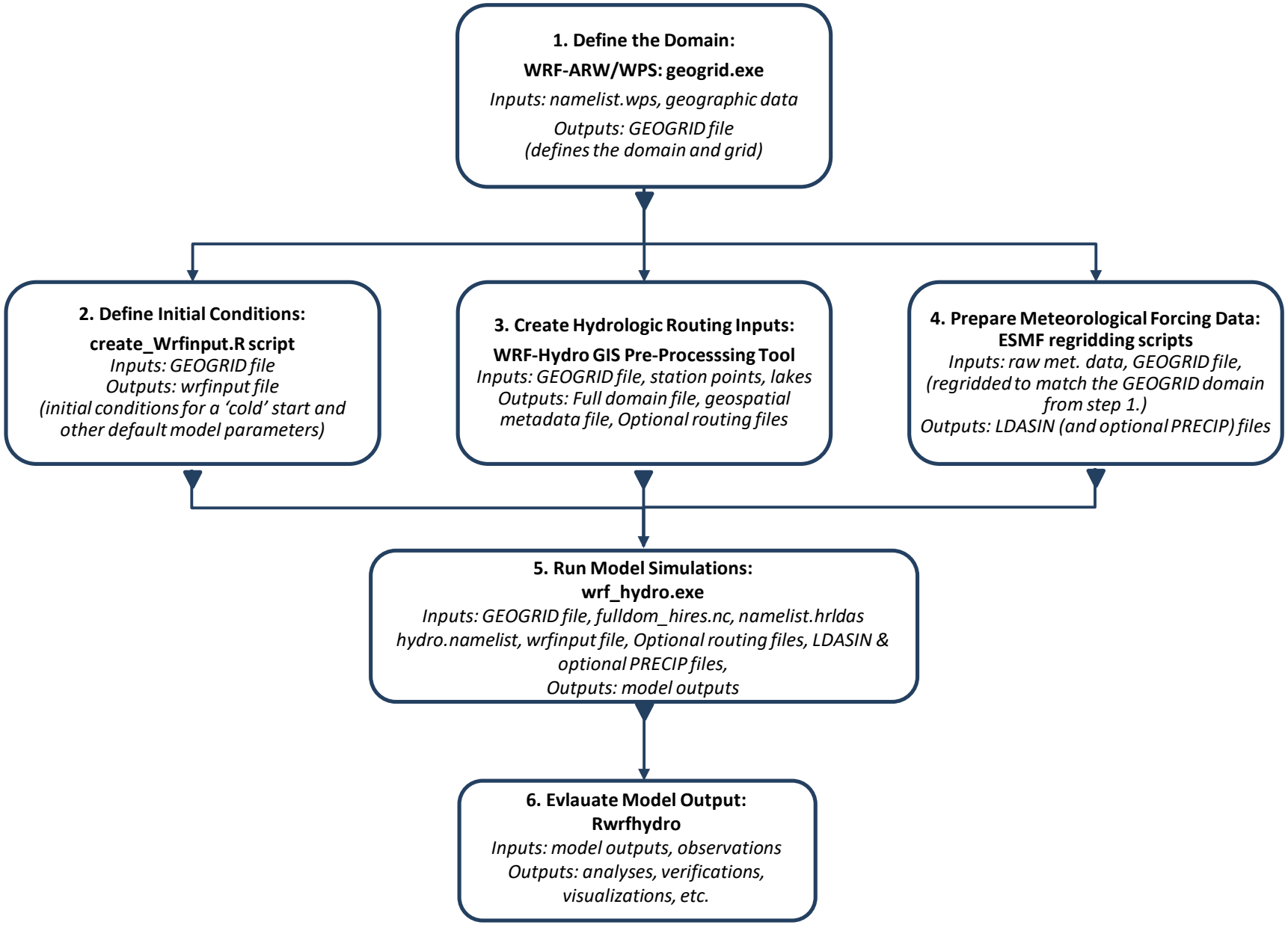
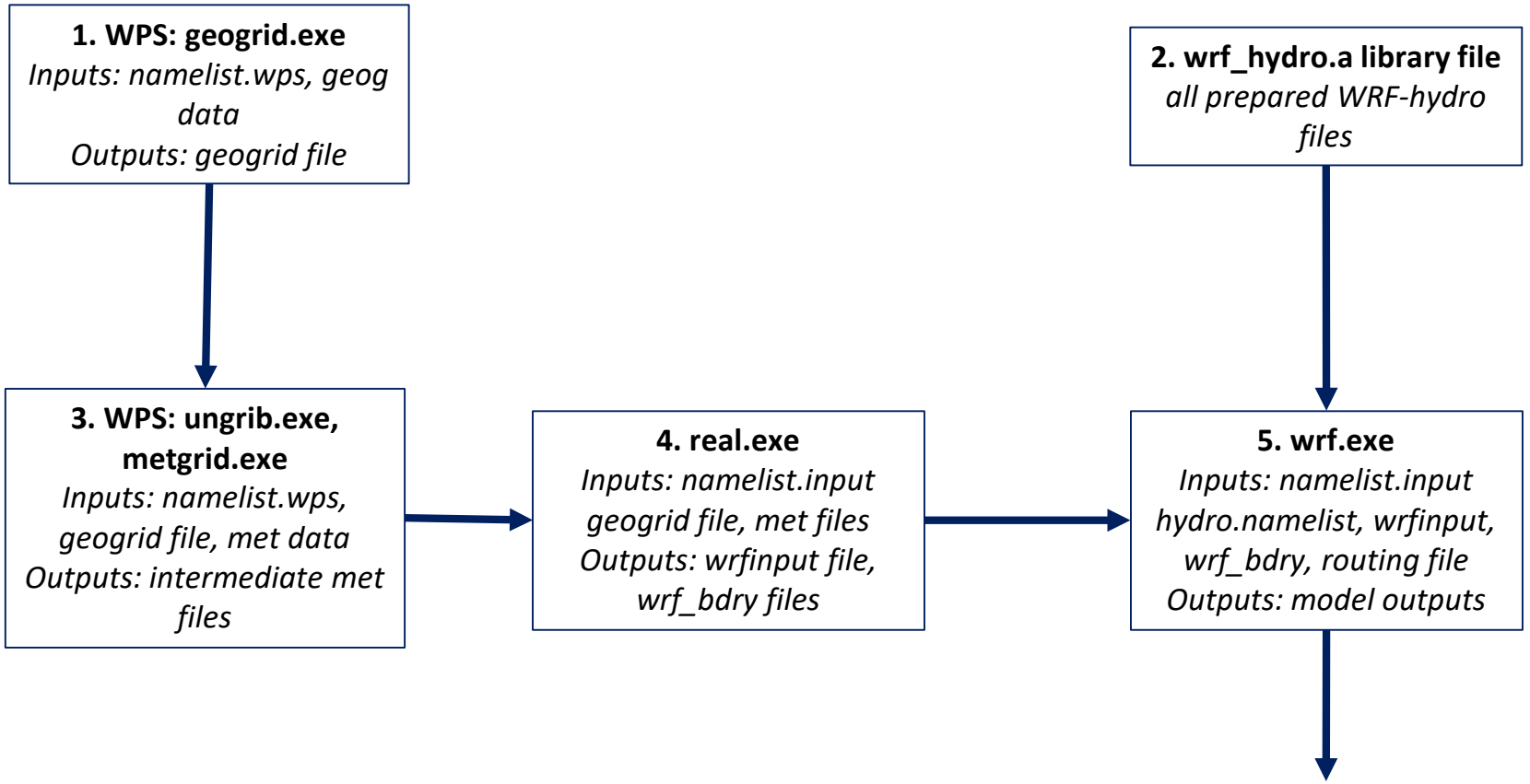
WRF & WRF-Hydro model coupling

National Center for Atmospheric Research

Uncoupled WRF-Hydro Workflow

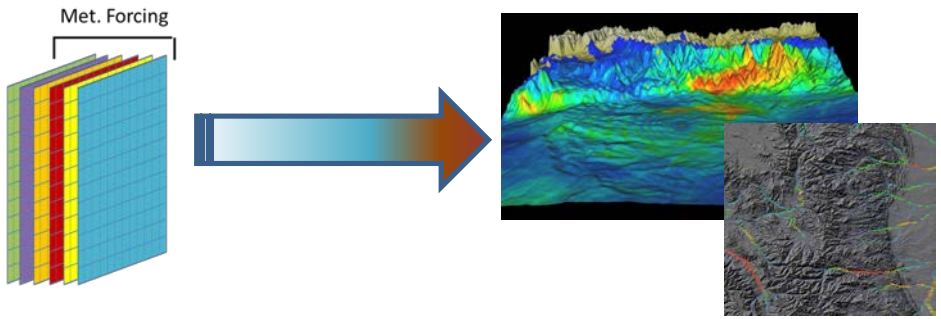


Coupled WRF-Hydro & WRF Workflow

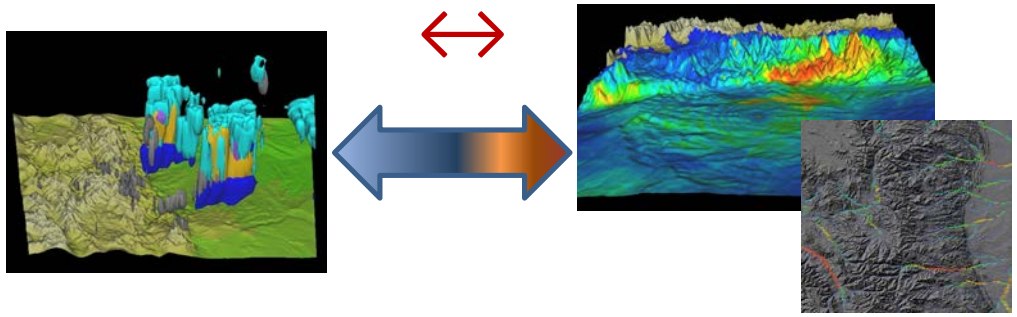


Two Modes of WRF-Hydro

One-way ('uncoupled') →



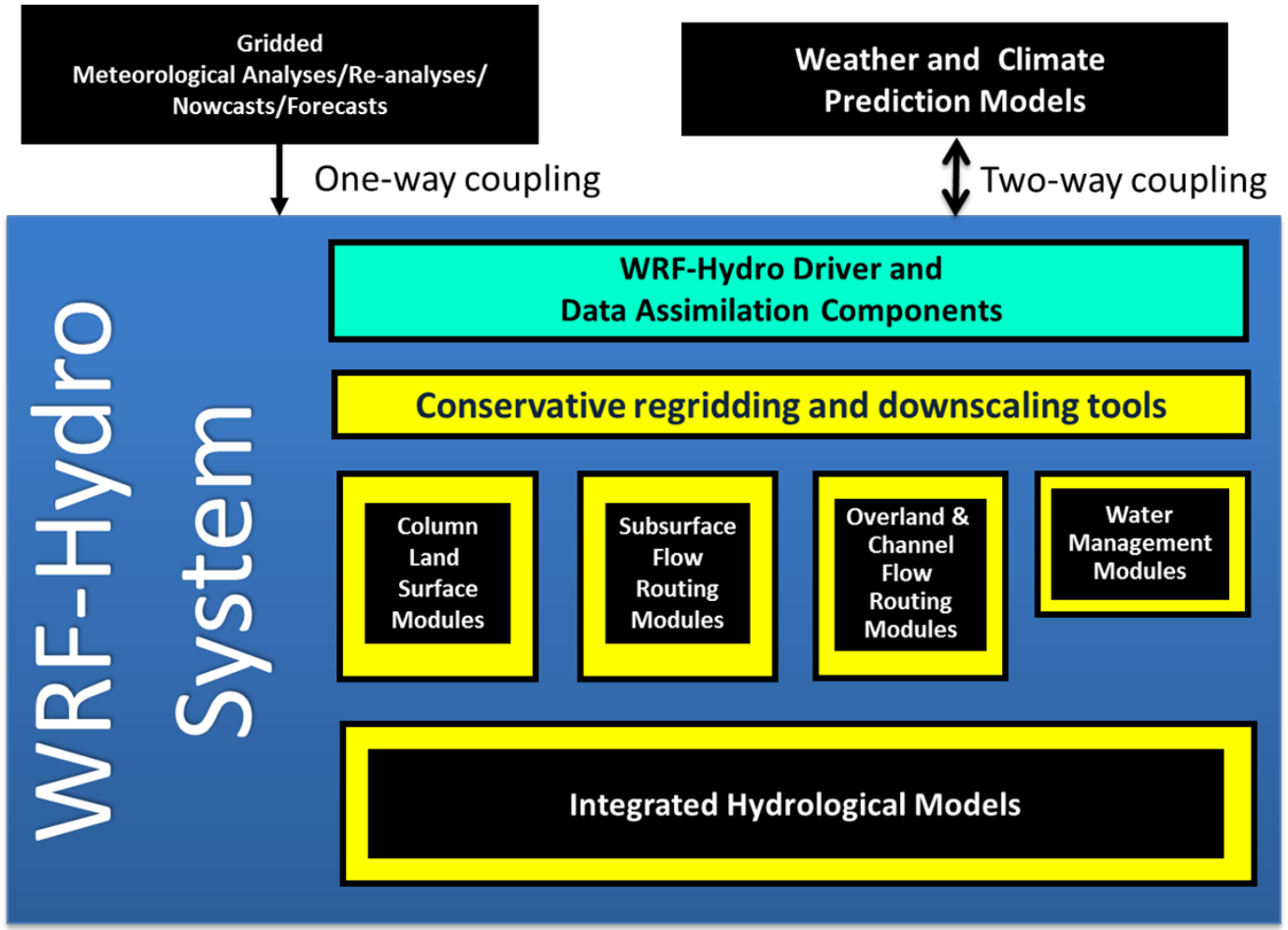
Two-way ('coupled') ↔



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

Conceptualization of WRF-Hydro

- Multi-scale/Multi-physics modeling…



Intro to the Weather Research & Forecasting Model (WRF)

Weather Research and Forecasting Model (WRF)

- Modeling system for atmospheric research and operational prediction
- Provide many core functionalities:
  - Data pre-processing (model initialization and boundary conditions)
  - 3-d non-hydrostatic, multi-physics, multi-scale atmospheric model
  - Fully-parallelized for high performance computing applications
  - Data assimilation frameworks (EnKF, grid nudging, 3d/4d variational analysis)
  - Post-processing to produce standardized datasets for ingest into many analysis and visualization software
- Directly ingestible into the Model Evaluation Tools (MET) software for verification

WRF Model Structure

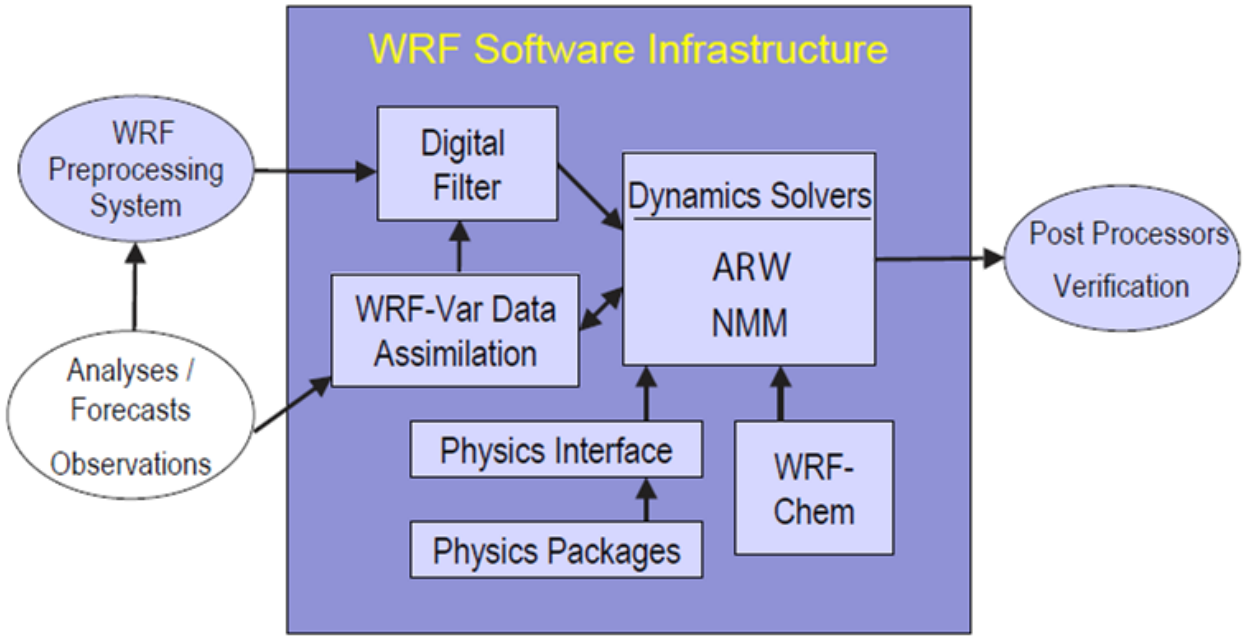


Figure 1.1: WRF system components.

WRF Model Physics

- Microphysics: Schemes ranging from simplified physics suitable for idealized studies to sophisticated mixed-phase physics suitable for process studies and NWP.
- Cumulus parameterizations: Adjustment and mass-flux schemes for mesoscale modeling. (dx > ~5km)
- Surface physics: Multi-layer land surface models ranging from a simple thermal model to full vegetation and soil moisture models, including snow cover and sea ice.
- Planetary boundary layer physics: Turbulent kinetic energy prediction or non-local K schemes.
- Atmospheric radiation physics: Longwave and shortwave schemes with multiple spectral bands and a simple shortwave scheme suitable for climate and weather applications. Cloud effects and surface fluxes are included.

WRF Model Structure: Domain

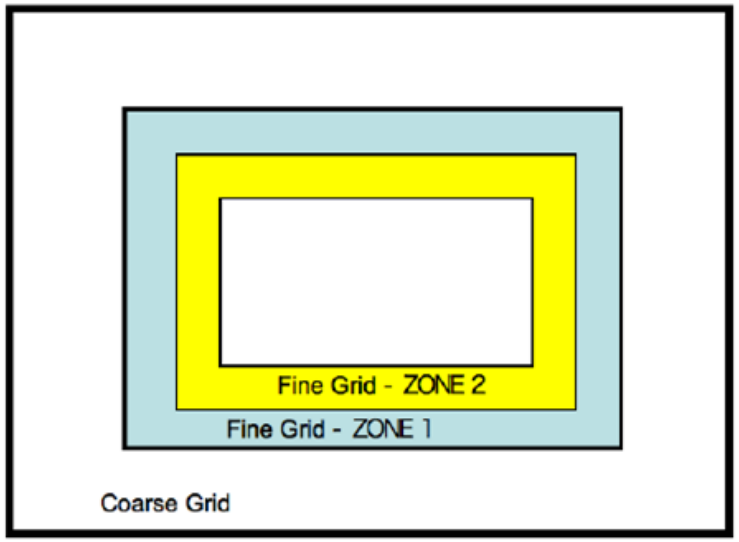
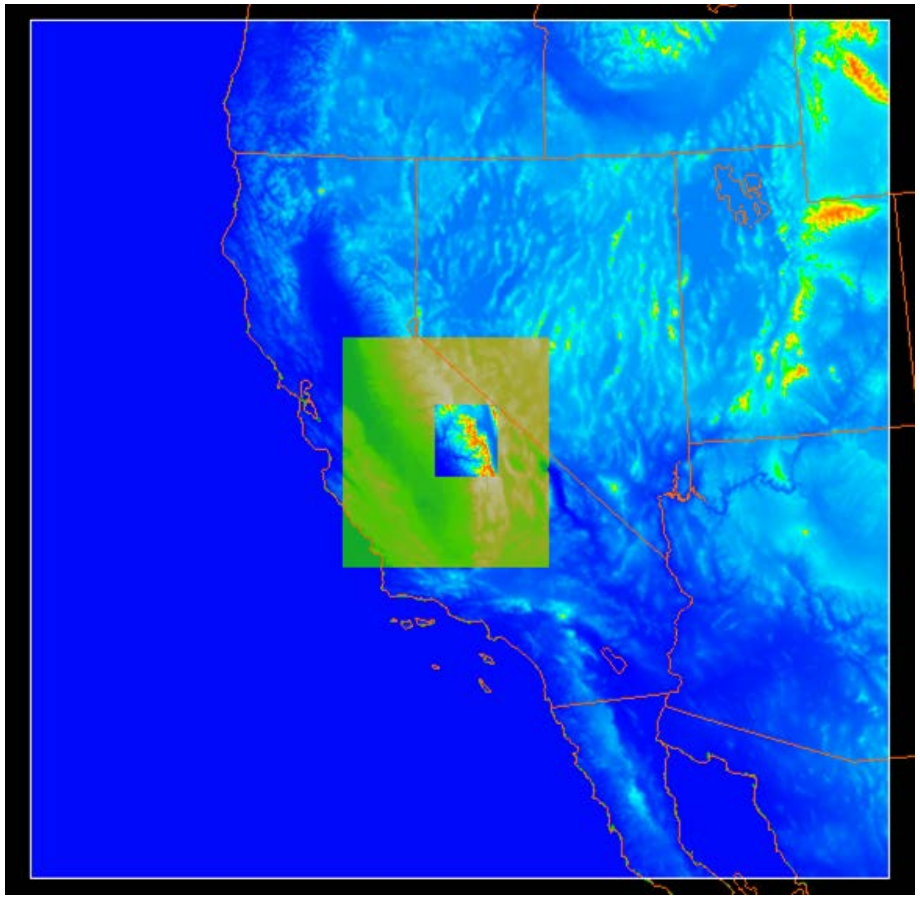
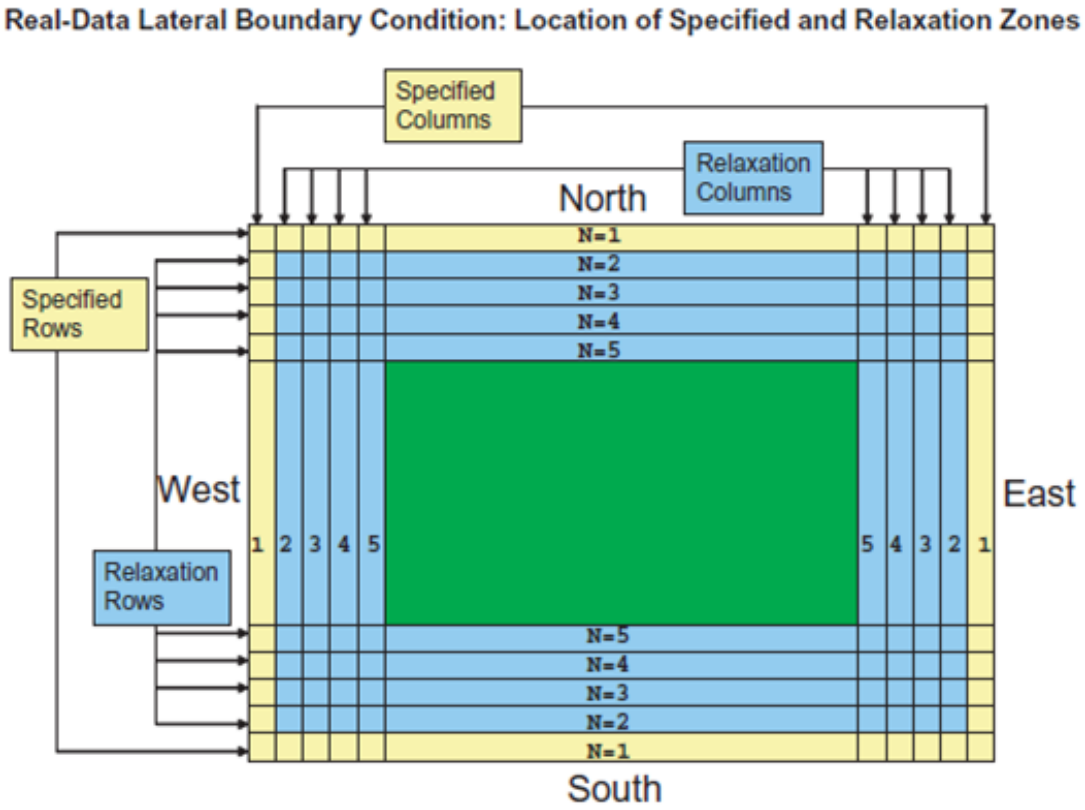


Figure 7.6: Zones of topographic blending for a fine grid. In the fine grid, the first zone is entirely interpolated from the coarse grid topography. In the second zone, the topography is linearly weighted between the coarse grid and the fine grid.

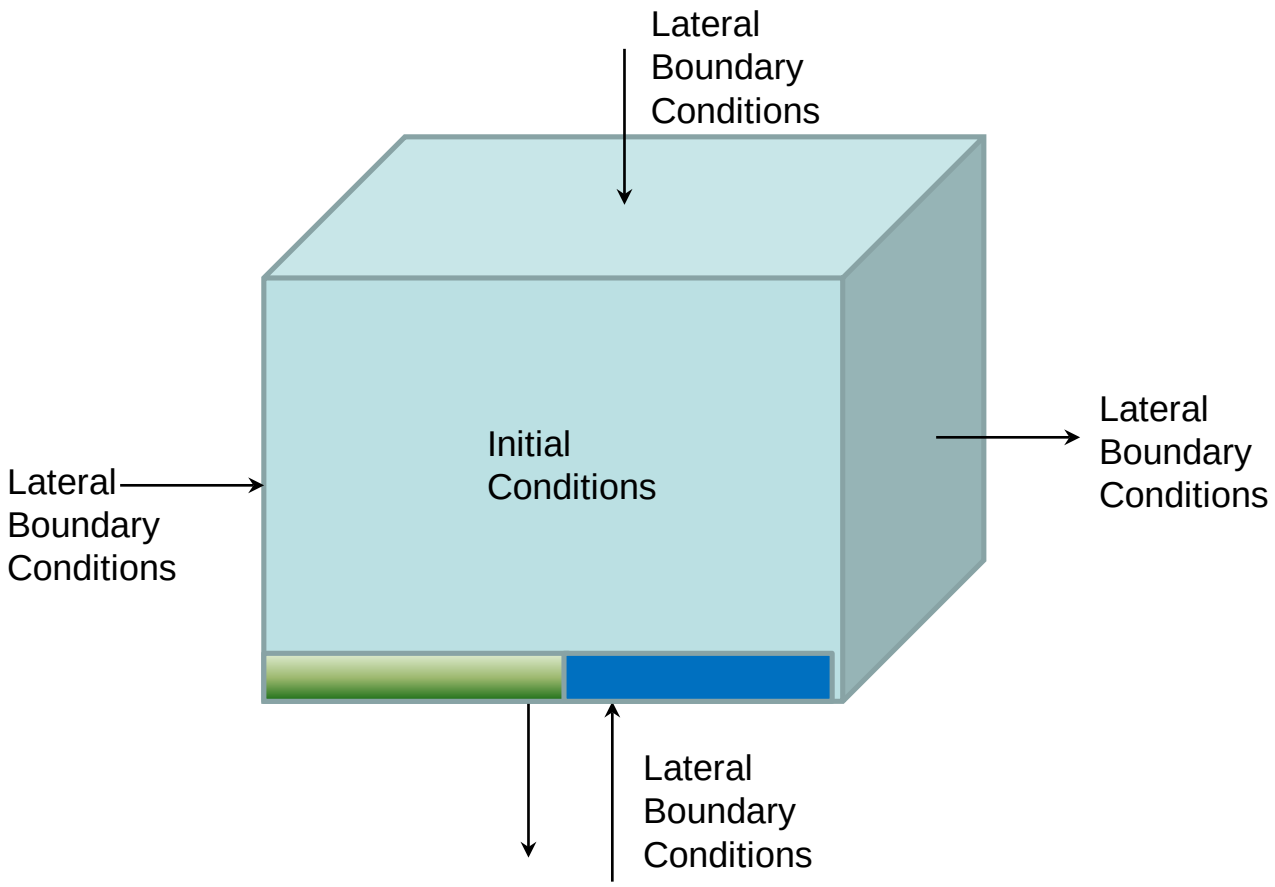
WRF Model Structure: Domain



WRF Model Structure: Domain



WRF Model Structure: Domain



WRF Model Structure: Initial & Boundary Conditions

- Initial conditions: Provides the initial ‘state’ of the atmosphere and land surface at time = 0.

- Lateral boundary conditions: Provides ‘forcing’ to the regional domain from the ‘sides’ of the model, necessary condition for any forward-integrating numerical modeling problem

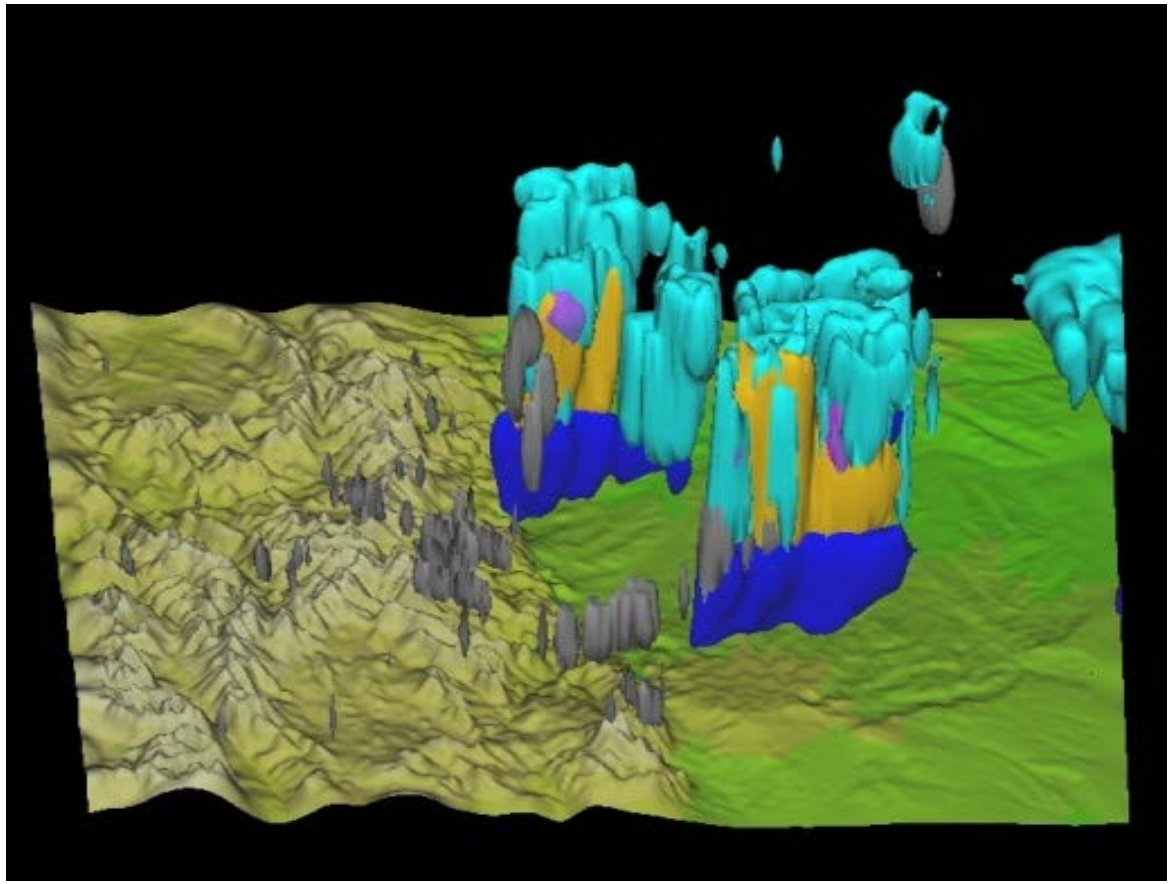
- The impacts of initial conditions can be very important or not very important depending on the problem and the variable of interest.
  - NWP – ‘initial value problem’, meaning the impact of initial conditions plays a ‘dominant’ role in the model solution along with model physics
  - ‘Climate modeling’ – ‘boundary value problem’, meaning the final solution is not as sensitive to initial conditions but, instead, more sensitive to boundary forcing and the model physics

WRF Model Workflow

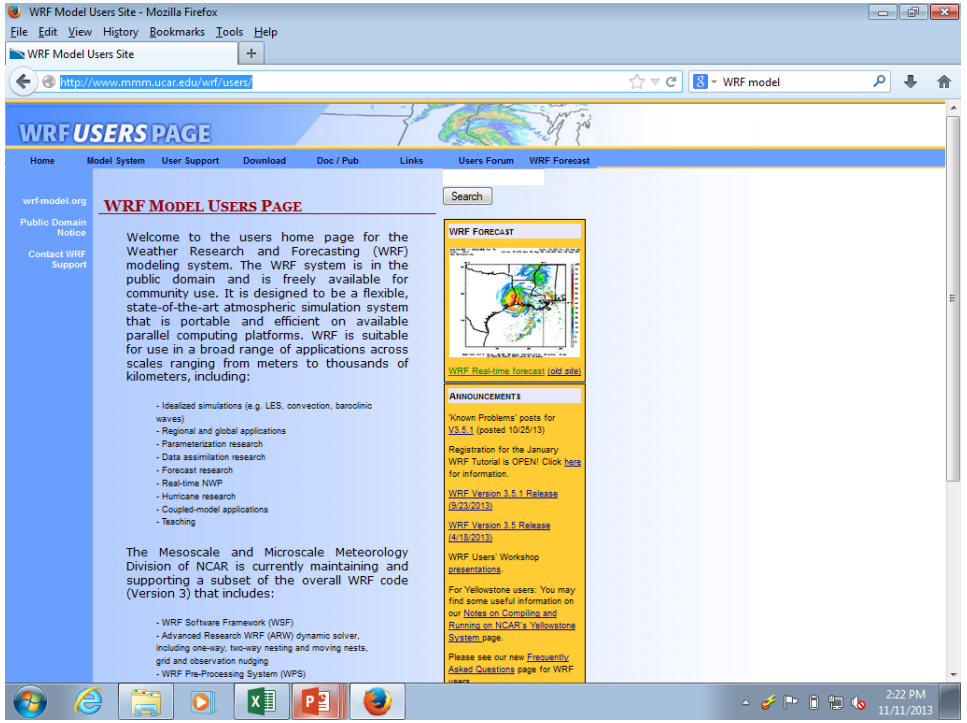
1. Compile required libraries and set environment variables for WRF and WRF-Hydro
2. Compile WRF (builds WRF-Hydro as a library) and WPS
3. Pull/point to data for ‘geogrid.exe’ execution: this is the WRF-WPS database
4. Dynamically edit the ‘namelist.wps’ file
5. Execute ‘geogrid.exe’ to create surface data
6. Get meteorological boundary condition data from a global server
7. Pull/point to data for ‘metgrid.exe’
8. Run ‘ungrib.exe’ from the WPS directory to prepare data for metgrid.
9. Execute ‘metgrid.exe’ to prepare atmospheric boundary conditions
10. Edit principle WRF model namelist for model setup (namelist.input)
11. Run executables: ‘real.exe’ and ‘wrf.exe’
12. Post-process results

WRF Model Products

- Detailed, physically-robust depictions of atmospheric phenomena for research and prediction applications



WRF Model Resources & Training

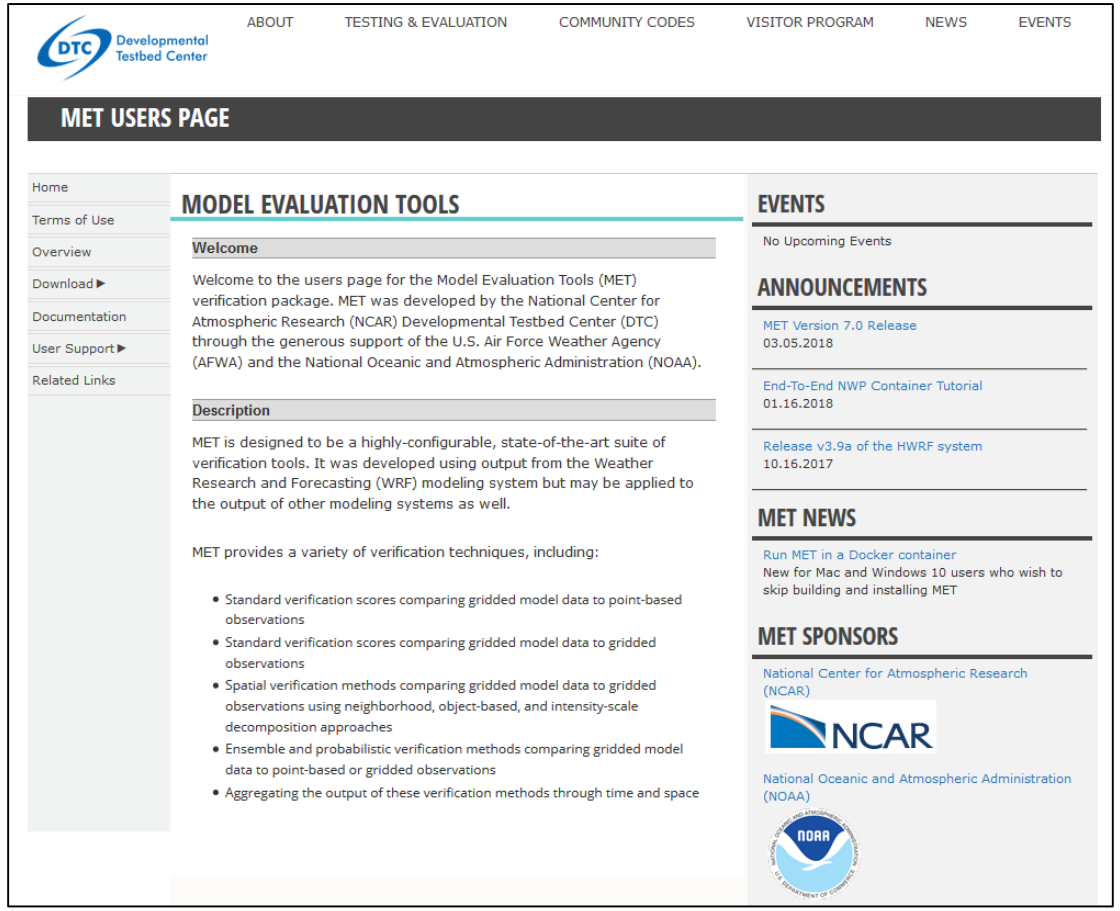


- Website for code, documentation, data, real-time forecasts, etc.

- Training material, model tutorials are available through website
- Lots to WRF model utility tools available through the website
- WRF model development team holds 2 week-long tutorials 2x per year
- Annual WRF User's workshop
- Many international training workshops each year

http://www.mmm.ucar.edu/wrf/users

MET for all things Verification



http://www.dtcenter.org/met/users/

- Suite of data processing and analysis tools to provide:

- Standard verification scores comparing *gridded model data to point-based observations*
- Standard verification scores comparing *gridded model data to gridded observations*
- *Spatial verification methods* comparing gridded model data to gridded observations using neighborhood, object-based, and intensity-scale decomposition approaches
- *Ensemble and probabilistic verification* methods comparing gridded model data to point-based or gridded observations

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- Colorado Water Conservation Board
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Resources

WRF-Hydro

- Technical Description and Users' Guide

WRF and WPS

- Technical Description
- Users' Guide
- Tutorials (online, in person, slides from previous tutorials)

Model verification

- MET

WRF-Hydro®

MODELING SYSTEM

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