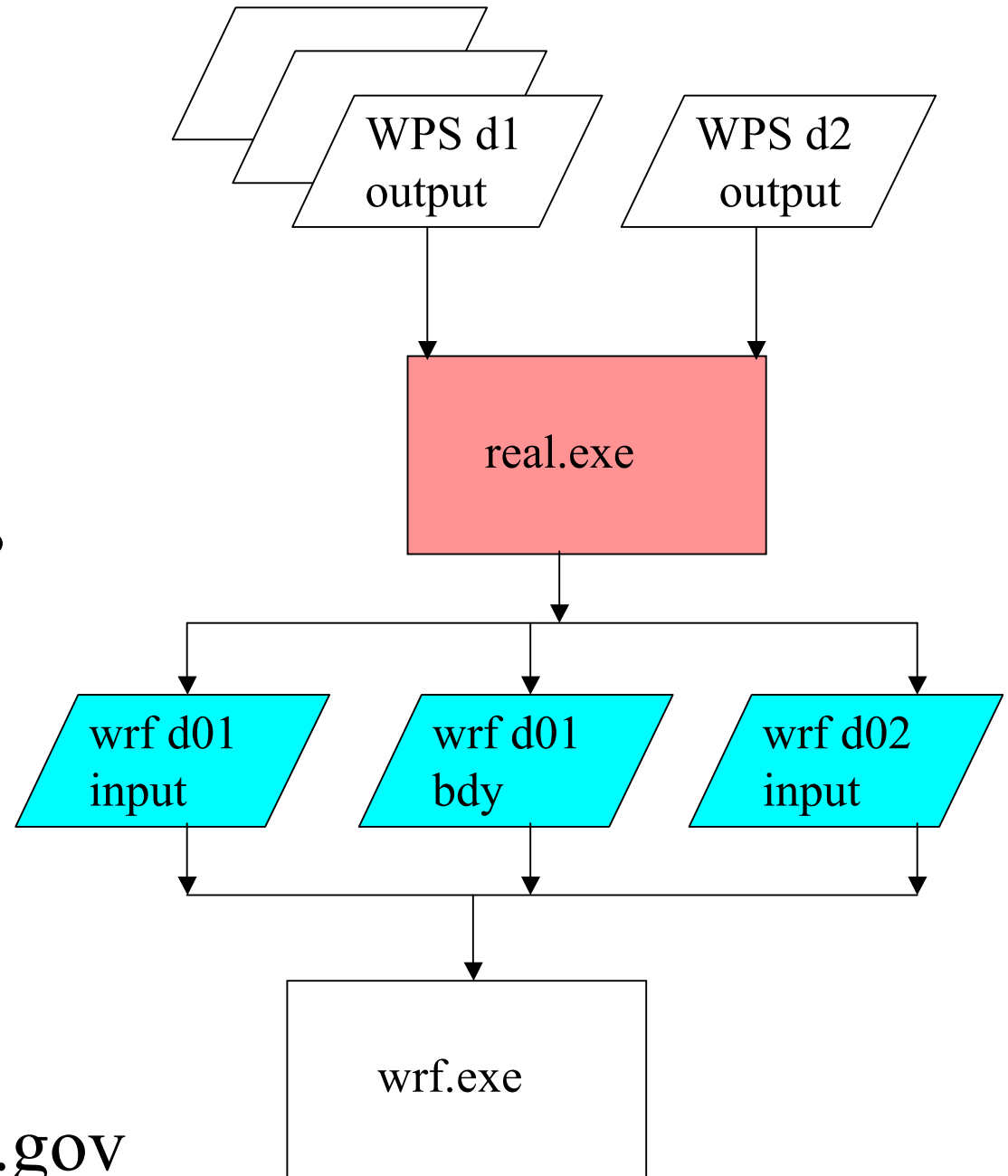


Real

Description of General Functions

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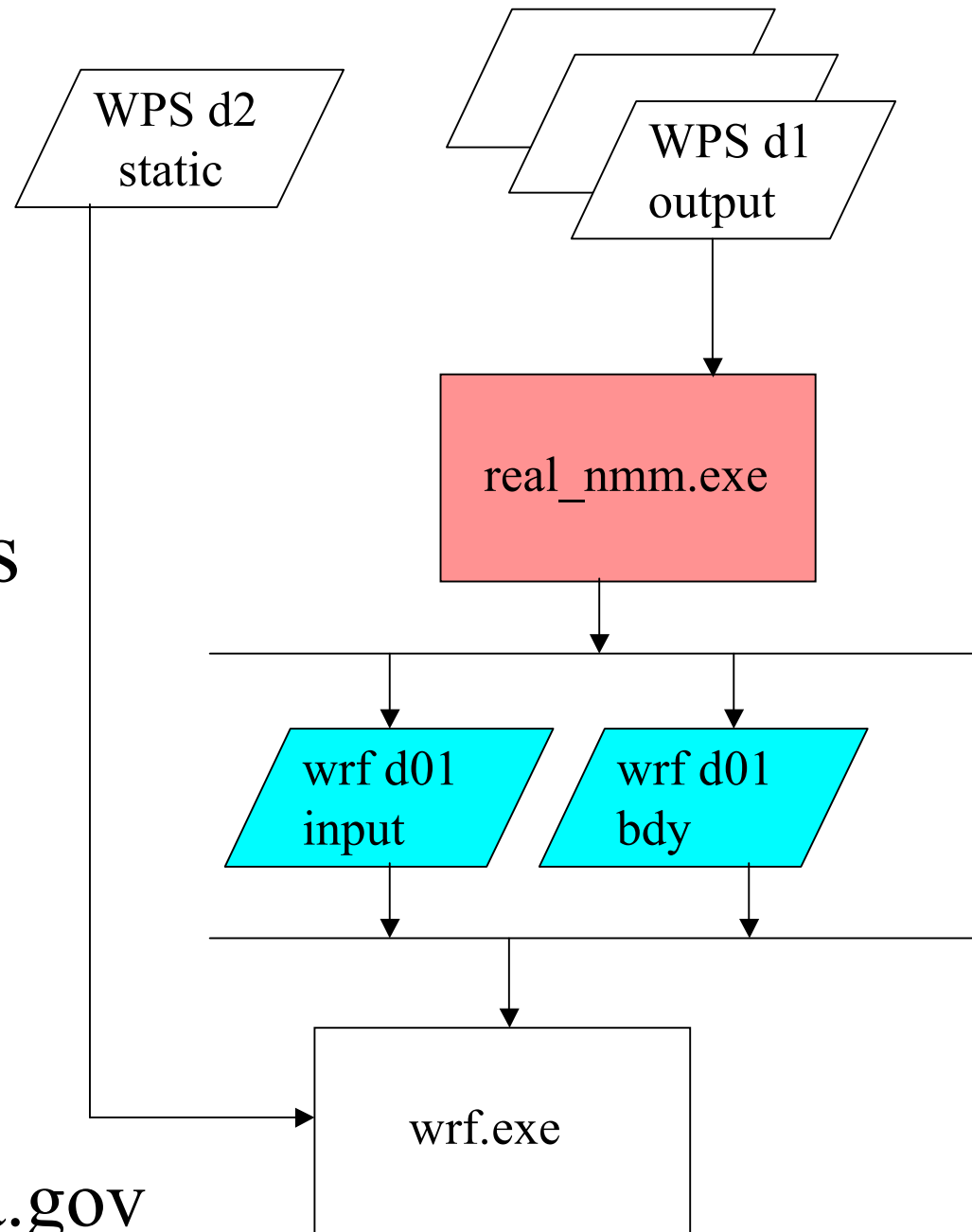


Real

Description of General Functions

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Real program in a nutshell

- Function
- Required input variables
- Base State for ARW
- Standard generated output
- Optional output
- Vertical interpolation
- Soil level interpolation
- Water temperature initialization
- Sea-ice initialization
- Land/Water mask
- Nested processing in real for ARW

Function

- The ARW WRF model pre-processor is *real.exe*
- The NMM WRF model pre-processor is *real_nmm.exe*
- The real.exe and real_nmm.exe programs are available *serial* or *DM parallel* (primarily for aggregate memory purposes, as opposed to timing performance)
- This program is automatically generated when the model is built and the requested use is for a real data case
- The real.exe and real_nmm.exe programs take data *from WPS* and transform the data *for WRF*
- Similar to the ARW idealized data pre-processor, both real.exe and real_nmm.exe are tightly coupled to the WRF model through the *Registry*

Function

- *3D forecast* or simulation
- *Meteorological input* data that primarily originated from a previous forecast or analysis, probably via the WPS package
- Anticipated *utilization of physics* packages for microphysics, surface conditions, radiation, convection, and boundary layer (ARW: maybe usage of nudging capabilities)

Function

- A non-Cartesian *projected domain*
 - ARW: Lambert conformal, Mercator, polar stereographic, rotated latitude/longitude (global or regional)
 - NMM: rotated latitude/longitude
- Selection of *realistic static fields* of topography, land use, vegetation, and soil category data
- Requirement of *time dependent* lateral boundary conditions for a regional forecast

Function

- Not referring to the *Variational* or the *Digital Filtering* usage of Initialization
- Generation of *diagnostics* necessary for assumed WRF model input
- Input field *adjustment* for consistency of static and time dependent fields (land mask with soil temperature, etc.)
- ARW: computation of *reference* and *perturbation* fields
- Generation of *initial* state
 - ARW: for each of the requested domains
 - NMM: for the coarse grid only
- Creation of a *lateral boundary file* for the most coarse domain
- *Vertical interpolation* for 3d meteorological fields and for sub-surface soil data

Required input Variables

- The metgrid program typically provides meteorological data to the real program.
- ARW mandatory:
 - 3d and surface: horizontal winds, temperature, relative humidity, geopotential height
 - 3d soil: soil temperature
 - 2d fields: surface pressure, sea-level pressure, land mask
- ARW optional (but desirable):
 - 3d soil: soil moisture
 - 2d fields: topography elevation of input data, SST, sea-ice, skin temperature

Required input Variables

- The metgrid program typically provides meteorological data to the real program.
- NMM mandatory:
 - 3d and surface: horizontal winds, temperature, relative humidity, geopotential height
 - 3d soil: soil temperature
 - 2d fields: surface pressure, land mask
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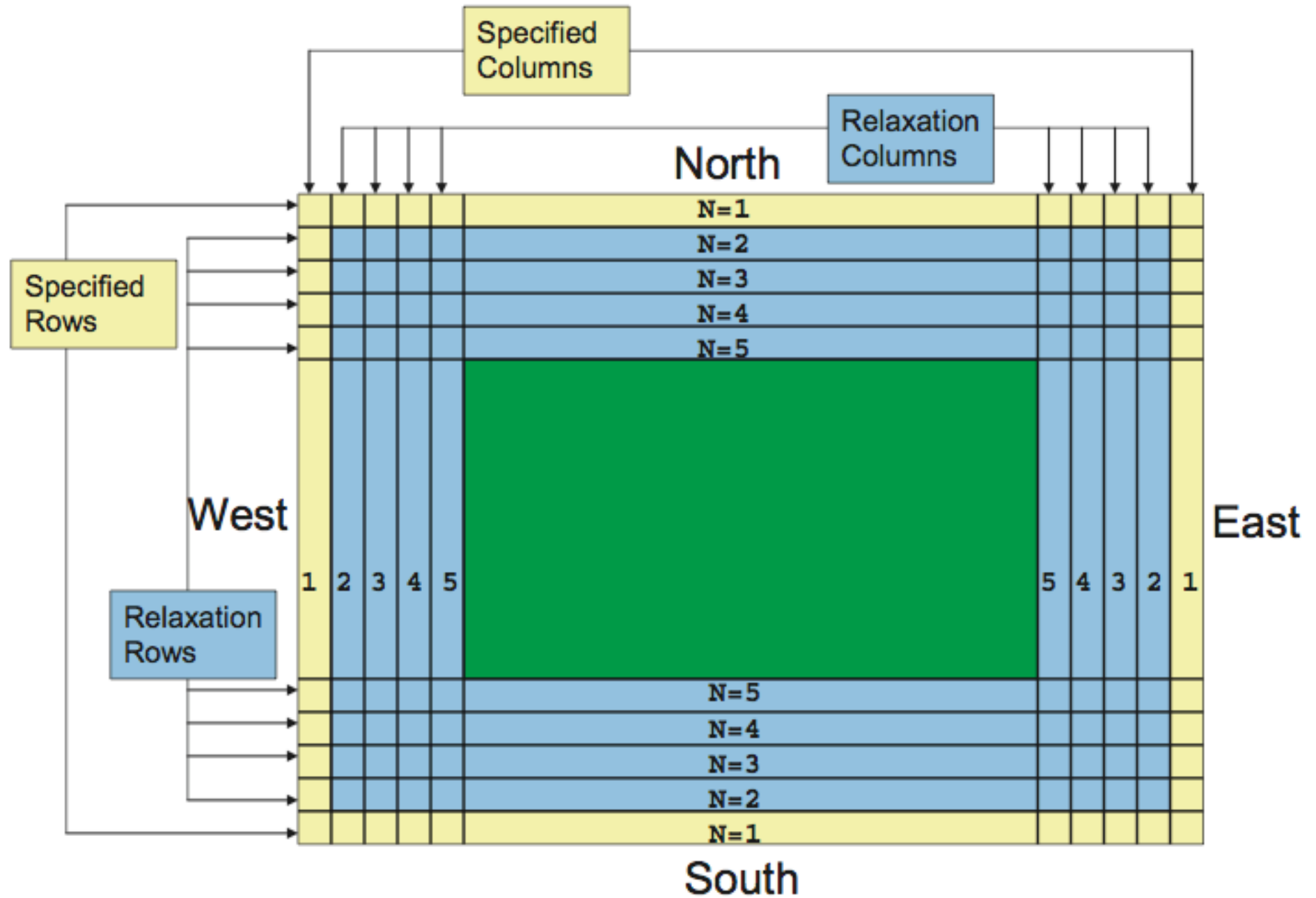
Base State for ARW

- Several of the mass-point fields are separated into a time-independent base state (also called a reference state) and a perturbation from the base state
- The base state fields are only functions of the topography and a few user-selectable constants
- If the topography changes, such as with a moving nest, the base state fields are modified
- Feedback for 2-way nesting also impacts base state fields through topographic averaging
- No base state computations are required prior to the real program

Standard Generated Output

- For regional forecasts, the real program generates both an initial (*wrfinput_d01*) and a lateral boundary (*wrfbdy_d01*)
- The boundary file is not required for global forecasts with ARW
- The initial condition file contains a single time period of data
- If *n* times were processed with real, the lateral boundary file contains *n-1* time slices
- These files contain data used directly by the WRF model
- The ARW initial condition file may be ingested by the WRFDA code

Real-Data Lateral Boundary Condition: Location of Specified and Relaxation Zones



Optional Output

- The ARW allows users to provide a lower boundary condition file (*wrflow_d01*), containing slowly changing files such as SST, sea-ice, greenness fraction

Optional Output

- ARW users may request that each time period of data generate an “initial condition” file, typically for diagnostic purposes (*wrfinput_d01.2000-01-24_18:00:00*)

Optional Output

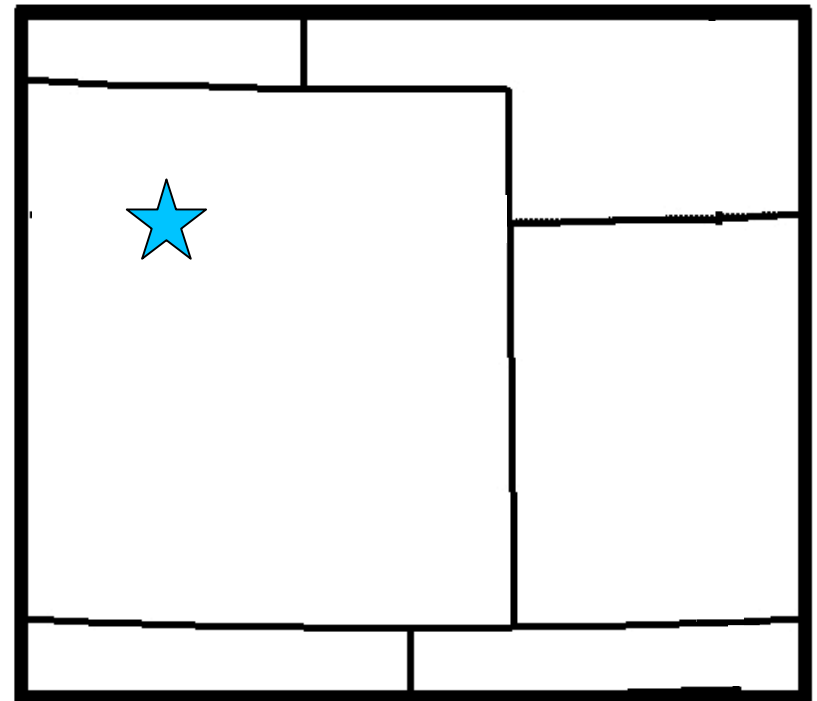
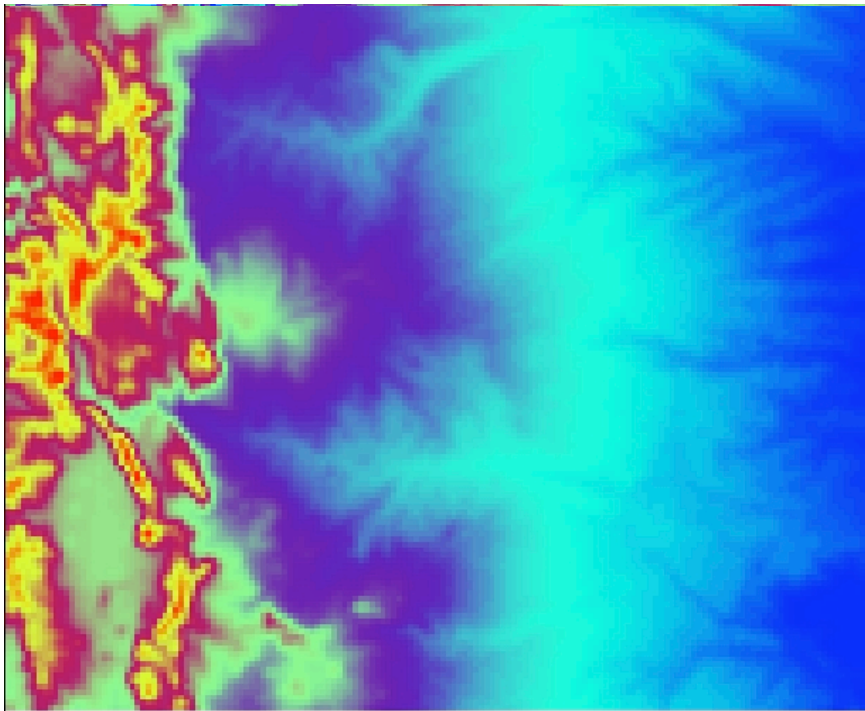
- ARW users who select to implement analysis nudging in the WRF model (also known as grid nudging) generate extra input fields for the model (*wrffdda_d01*)

Vertical Interpolation

- A number of vertical interpolation options are available to users
- The options can have a significant impact on the initial conditions passed to the model
- More information is contained in the info file *README.namelist* in the *run* directory
- Options are located in the *&domains* namelist record of *namelist.input*

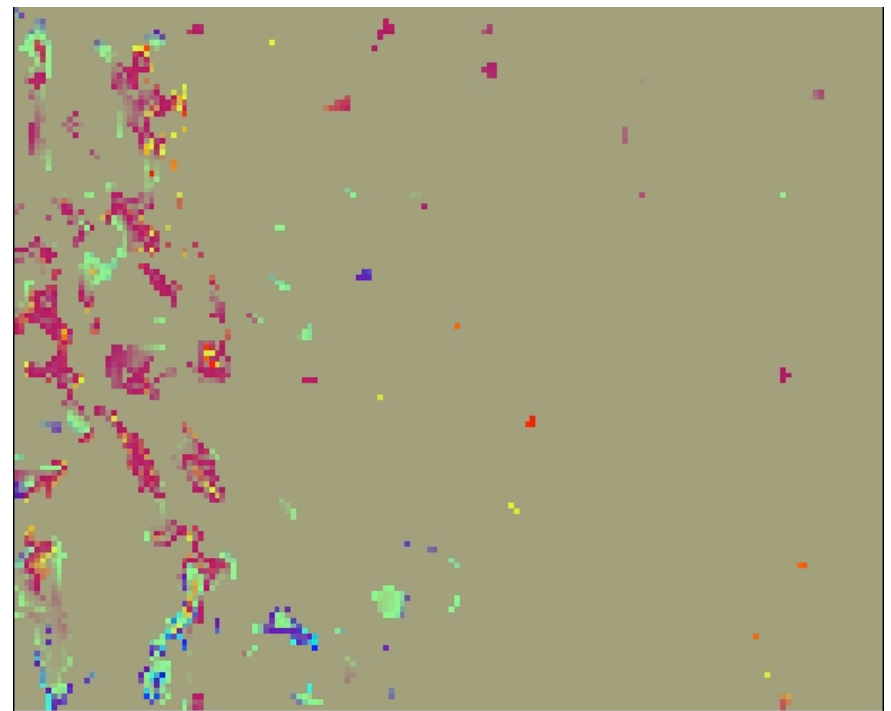
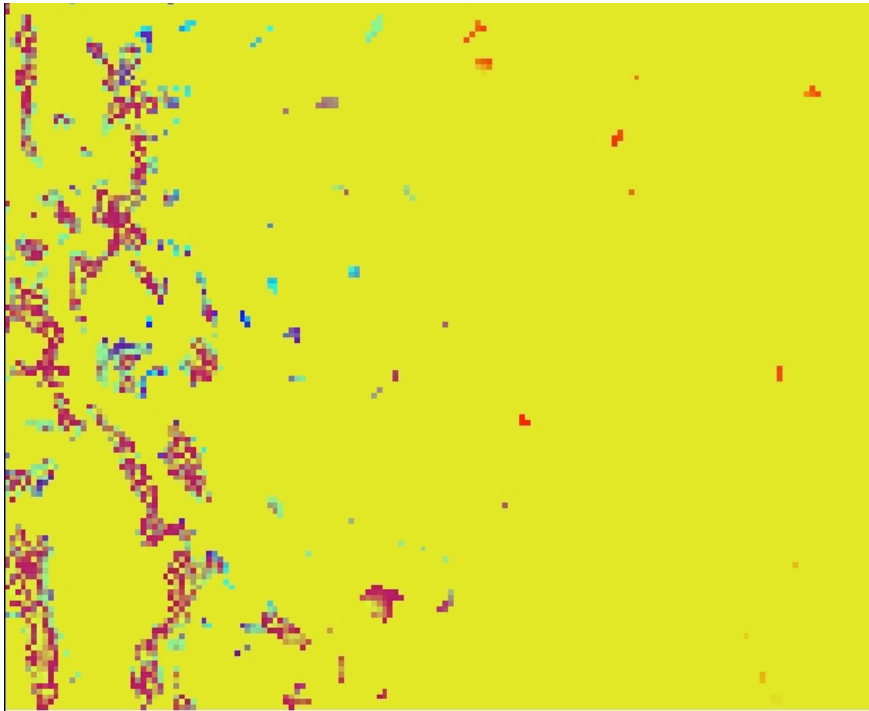
Vertical Interpolation

- Impact: *Expected region of changes*
 - *Non-standard setting*
 - Which level is being viewed
-
- Topography and domain for difference plots, 160x140, 4 km, input = 40 km NAM



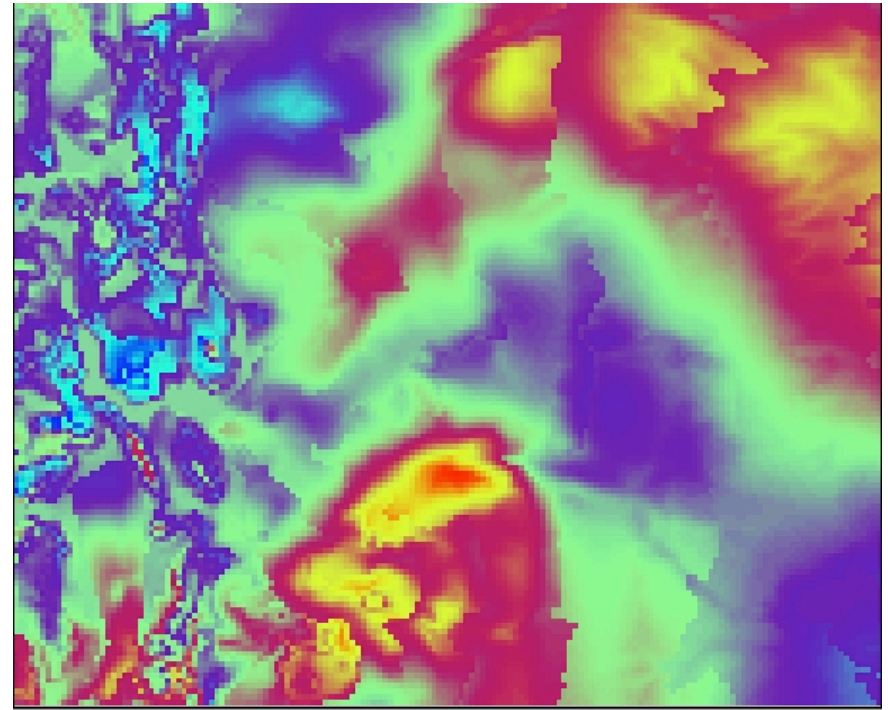
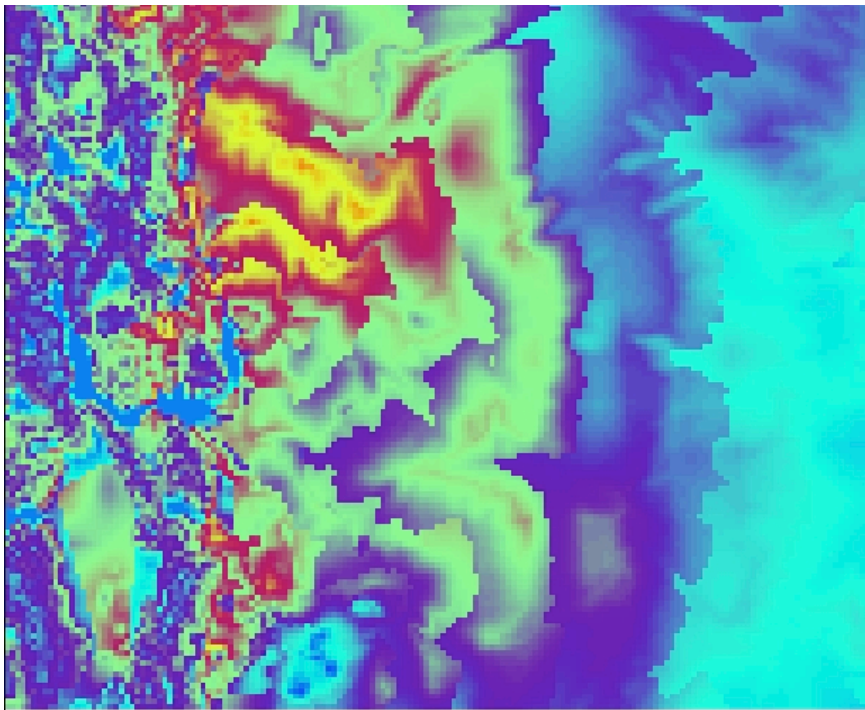
Vertical Interpolation

- Impact: few lowest levels only
 - `force_sfc_in_vinterp = 0`
 - η level 1
-
- Theta (-8 K blue, 0 K yellow)
 - U (-3 m/s blue, 2 m/s red)



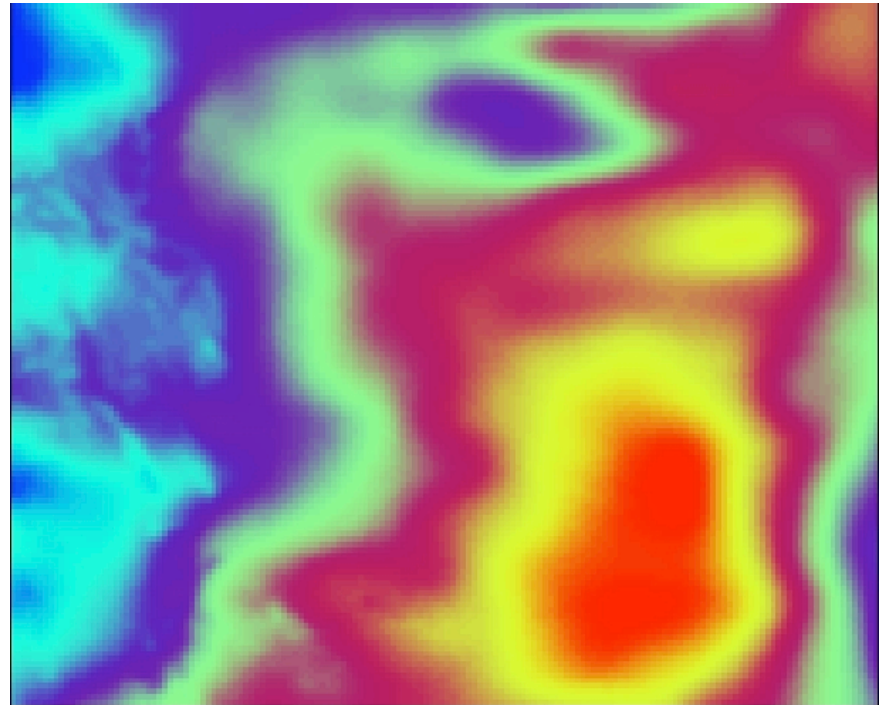
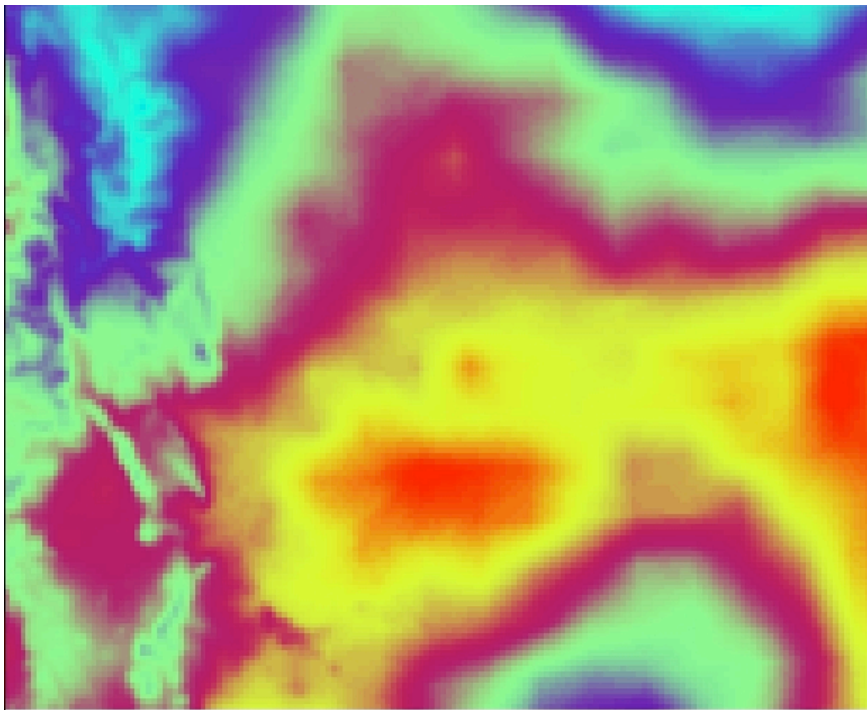
Vertical Interpolation

- Impact: few lowest levels only
 - `force_sfc_in_vinterp = 6`
 - η level 4
-
- Theta (0 K blue, 10 K red)
 - U (-5 m/s blue, 6 m/s red)



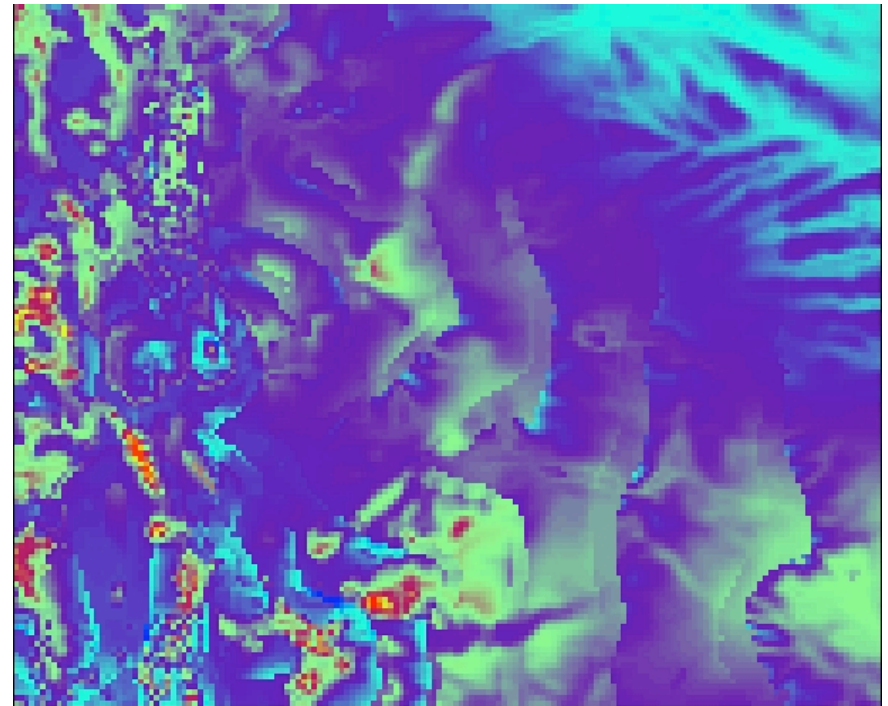
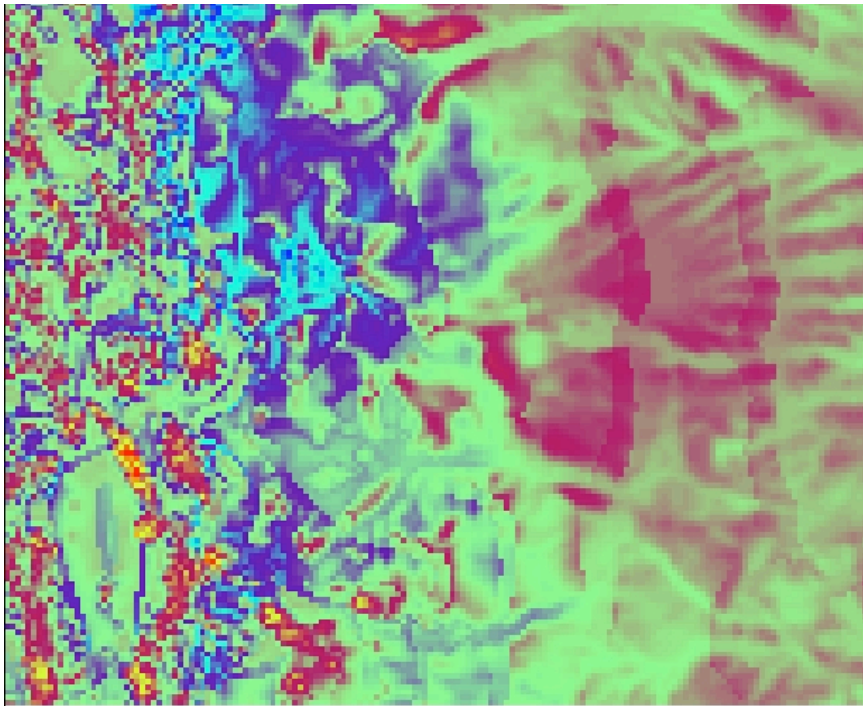
Vertical Interpolation

- Impact: above first 4 levels, most near tropopause
 - lagrange_order = 2
 - η level TOP
-
- Theta (0.7 K blue, 1.6 K red)
 - U (0.4 m/s blue, 1.4 m/s red)



Vertical Interpolation

- Impact: lowest level only
 - $\text{lowest_lev_from_sfc} = T$
 - η level 1
-
- Theta (-10 K blue, 8 K red)
 - U (-3 m/s blue, 7 m/s red)



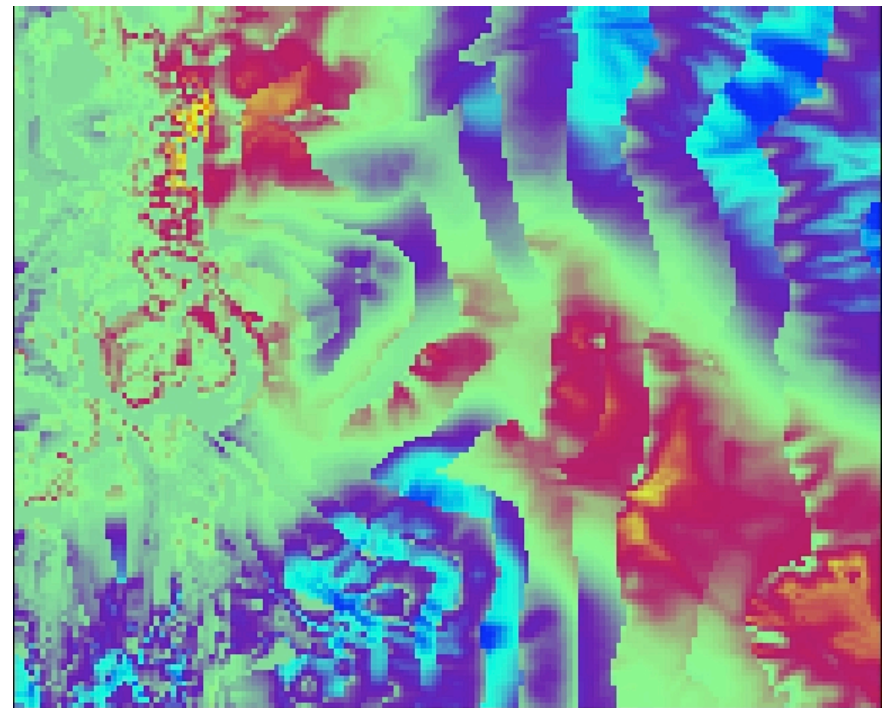
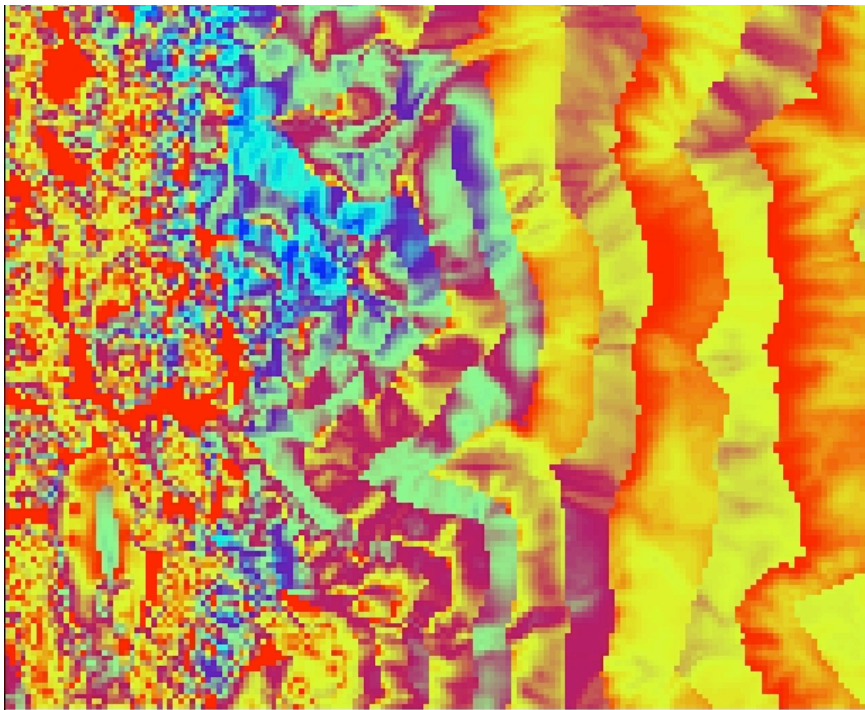
Vertical Interpolation

- Impact: outer few rows and column, amplitude damps upward
 - `smooth_cg_topo = T`
 - η level 1
-
- $\bar{\theta}$ (-10 K blue, 9 K red)
 - U (-6 m/s blue, 6 m/s red)



Vertical Interpolation

- Impact: lowest few levels
 - use_surface = F
 - η level 1
-
- Theta (-11 K blue, 0 K red)
 - U (-3 m/s blue, 4 m/s red)



Vertical Interpolation

- NMM
 - Make sure input data is vertically ordered as expected, limit hybrid topography deviation
 - Input 3-D pressure and T, topo, Z used to compute total surface pressure
 - Compute target vertical coordinate, total surface pressure through dp/dz , 3d pressure
 - User specifies the selected σ surfaces in the namelist (or can be computed)
 - Vertically interpolate input fields in pressure to the σ surfaces: T linearly in pressure; mixing ratio linearly in $\log(\text{pressure})$; u and v linear (then an adjustment if using a hybrid input source)

Soil Level Interpolation

- The WRF model supports several Land Surface schemes:
 - `sf_surface_physics = 1`, Slab scheme
 - 5 layers
 - Defined with thicknesses: 1, 2, 4, 8, 16 cm

Soil Level Interpolation

- The WRF model supports several Land Surface schemes:
 - `sf_surface_physics = 2`, Unified Noah scheme
 - 4 layers
 - Defined with layers: 0-10, 10-40, 40-100, 100-200 cm

Soil Level Interpolation

- The WRF model supports several Land Surface schemes:
 - `sf_surface_physics = 3`, RUC scheme (wilting perturbation)
 - 6 levels
 - Defined at levels: 0, 5, 20, 40, 160, 300 cm

Soil Level Interpolation

- The WRF model supports several Land Surface schemes:
 - `sf_surface_physics = 7`, PX scheme
 - 2 layers
 - Defined with layers: 0-1, 1-100 cm

Soil Level Interpolation

- The real program accepts soil temperature and soil data from metgrid with an arbitrary vertical distribution (though it is explicitly defined in the ungrib Vtable via the naming convention)
- Vertical interpolation is linear in depth below ground, where “layers” are assumed defined at their mid-point
- Temperature extrapolation:
 - Near or at the surface uses the skin temperature
 - Below the deepest input soil level uses the annual mean temperature (assumed to be at 300 cm)
- Moisture extrapolation uses the closest level

Soil Level Interpolation

- Mismatches in the land sea mask and the masked fields are typical when the input sources heterogeneous, though this is mostly handled in the metgrid program
- The “first” level is near or at the model surface, and the “last” level is the deepest of the soil information

Water Temperature Initialization

- Two general types of water temperatures are input by the ungrib program
 - Identified as a water temperature (SST)
 - Identified as a “ground” temperature, but over water (SKINTEMP)
- The real program is able to preferably use an SST over a water body, if the input field exists
- A new in-land water body capability in WPS is supported in the real program, with both the USGS and the MODIS sources
 - Locations identified as in-land water bodies use a daily-mean 2-m air temperature (if one exists)

Sea-Ice Initialization

- Most first-guess sources of data (such as GFS) provide a sea-ice field
- Originally, these were only flag values:
 - 0 = no sea-ice
 - 1 = sea-ice
- Some data sets provide a fractional sea-ice field
- ARW, users may set an arbitrary SST temperature in the real program, below which the water points are turned to ice
- NMM, if a land point or a water point is surrounded by sea ice, turn the middle value into a sea ice point, reset the land mask to a water point

Land Water Mask

- The distinction between land and water in the real program follows almost entirely from that defined by WPS
- Several masked fields rely upon this definition:
 - Land: soil temps, soil moisture, vegetation fraction
 - Water: sea-ice, SST
- If inadequate data exists (usually to support a declaration of a land point), it may be turned to a water point
- After all adjustments, insure that SST, skin temperature, land mask, soil temp and moisture, and sea ice all agree

Nested Processing in real for ARW

- May read multiple domain input files from metgrid
- Requires only the initial time for the fine domains, unless doing nudging or SST update
- No horizontal interpolation from coarse to fine
- No consistency checks between domains (handled in the feedback step for the WRF model)
- A *wrfinput_d0x* file is created for each processed input domain
- A lateral boundary file is created only for the most coarse domain

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