Real

Description of General Functions

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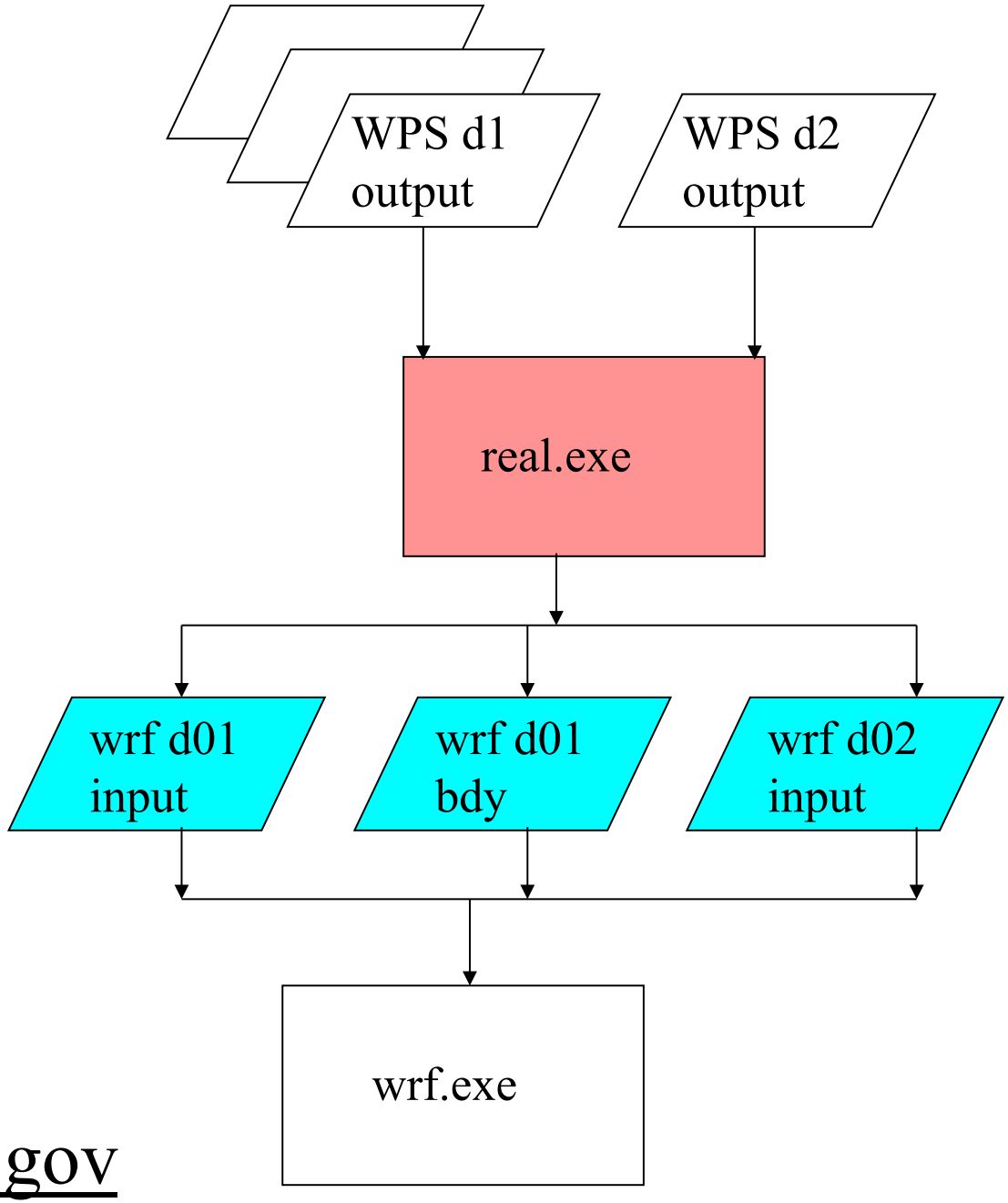

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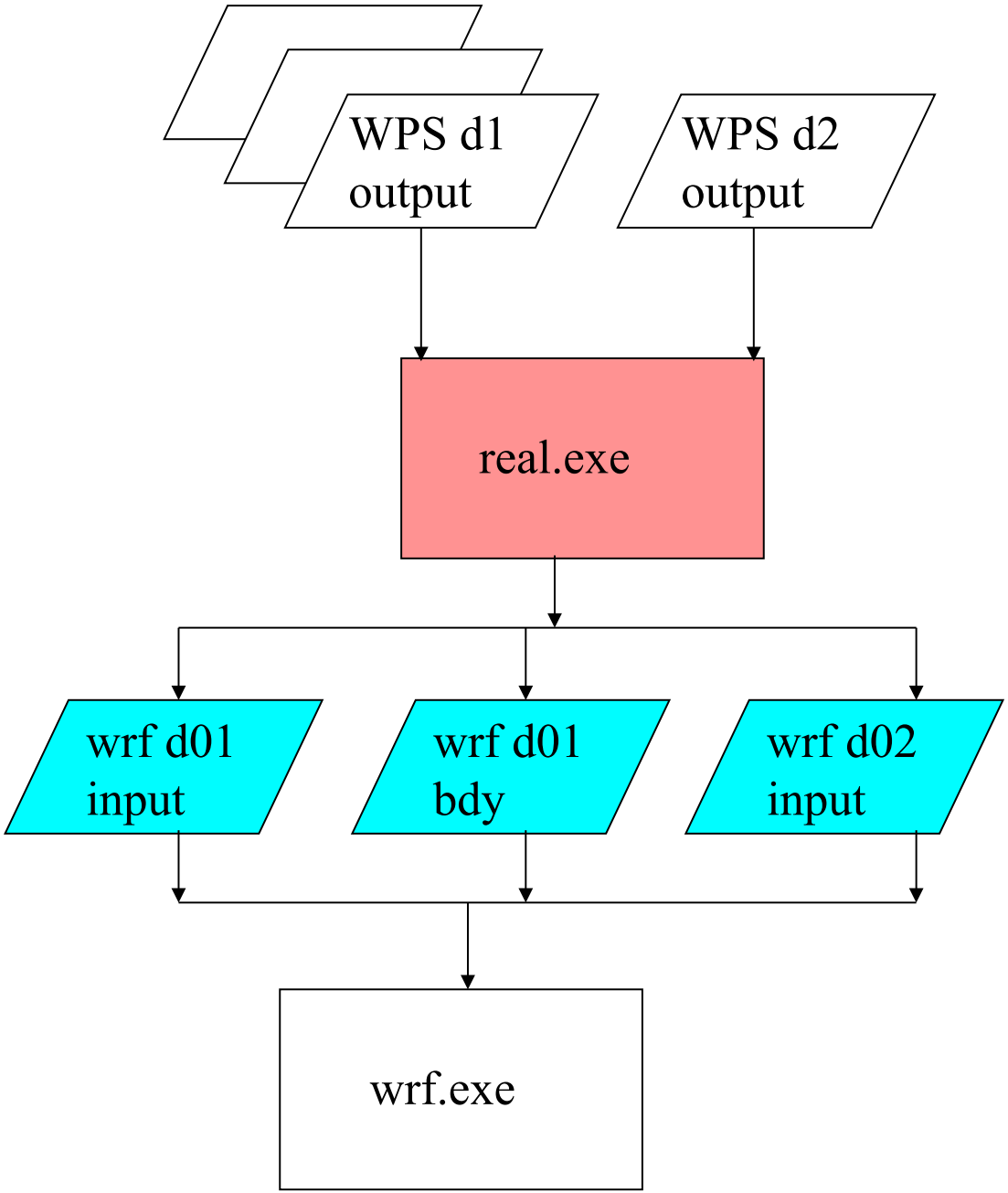

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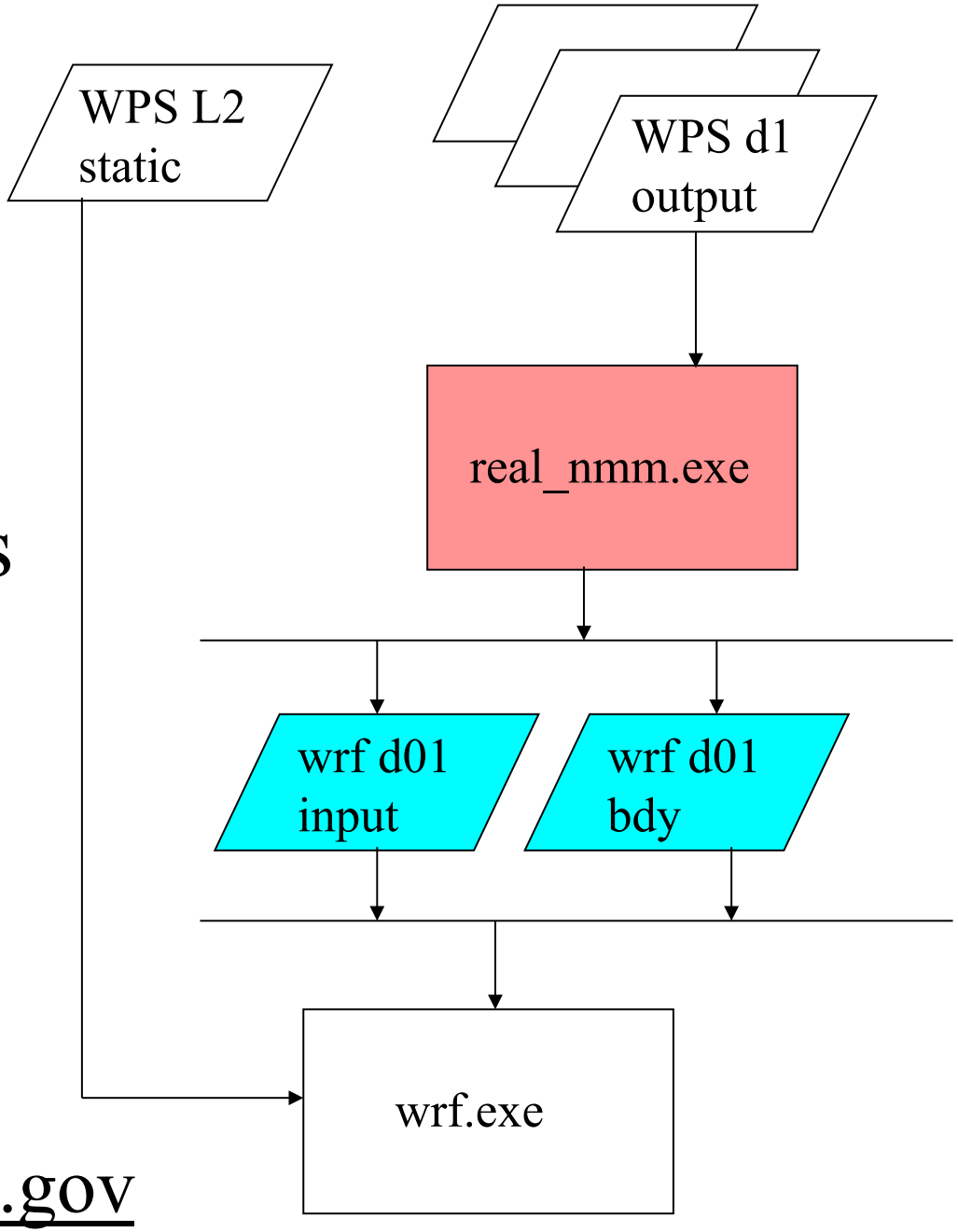

Real program in a nutshell

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

Real program in a nutshell

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- Base State for ARW
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- Water temperature initialization
- Sea-ice initialization
- Land/Water mask
- Nested processing in real for ARW

Function

- The WRF model pre-processor is ***real.exe***
- The real.exe program is 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 program takes data ***from WPS*** and transform the data ***for WRF***
- Similar to the ARW idealized data pre-processor, real.exe is tightly coupled to the WRF model through the ***Registry***

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)
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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)

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Function

- A non-Cartesian ***projected domain***
  - Lambert conformal, Mercator, polar stereographic, rotated latitude/longitude (global or regional)
- 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

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- 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 for each of the requested domains
- Creation of a ***lateral boundary file*** for the most coarse domain
- ***Vertical interpolation*** for 3d meteorological fields and for sub-surface soil data

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- 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

Standard Input Variables

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

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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 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
- These files contain data used directly by the WRF model
- The initial condition file may be ingested by the WRFDA code (referred to as a *cold-start*)
- If ***n*** times were processed with WPS and real, the lateral boundary file contains ***n-1*** time slices

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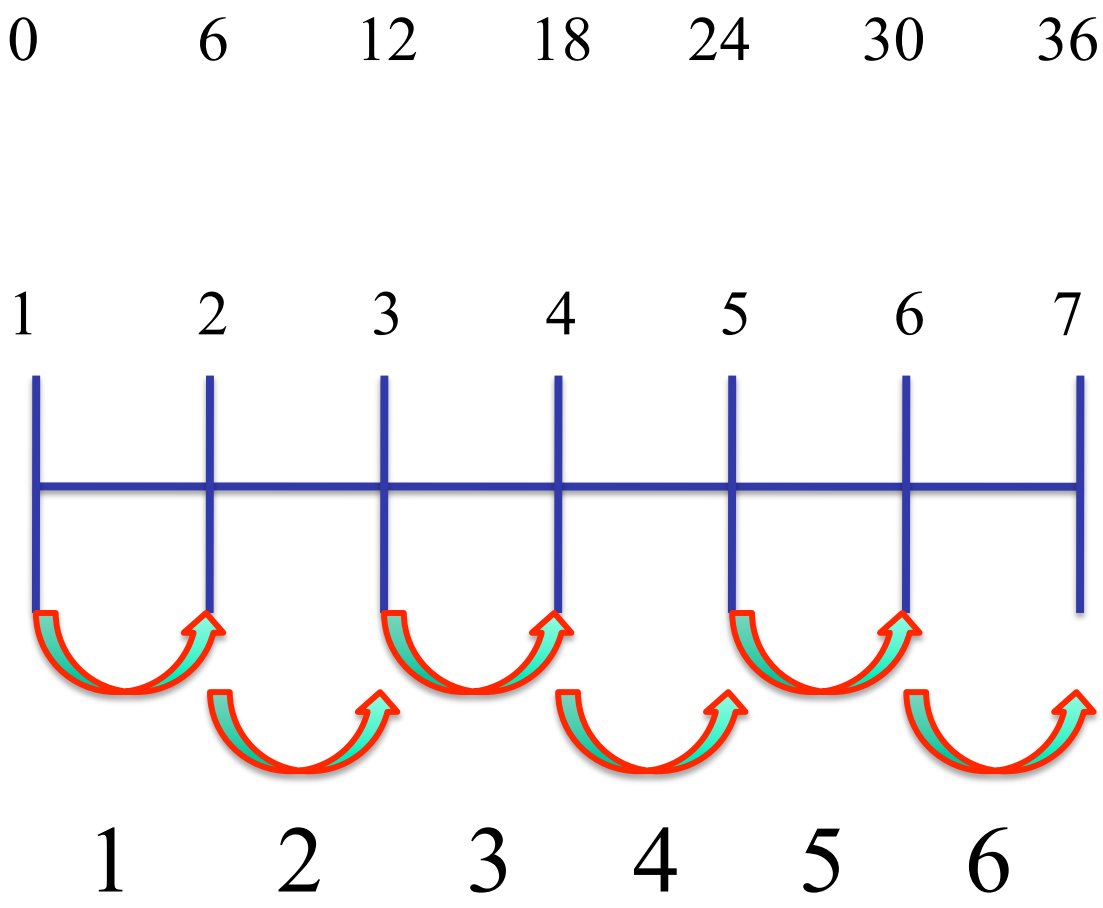
Lateral Boundary Condition Times



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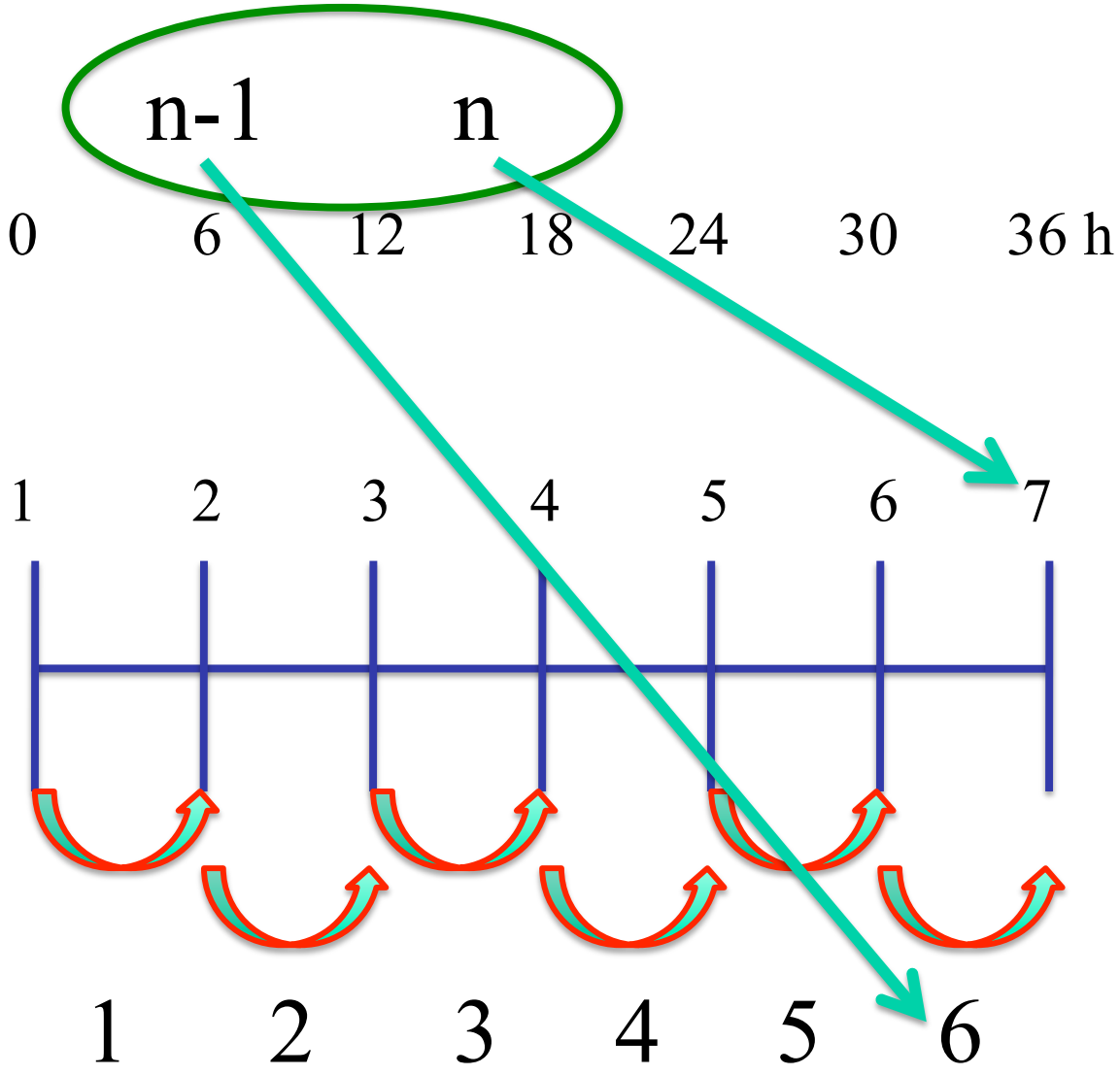
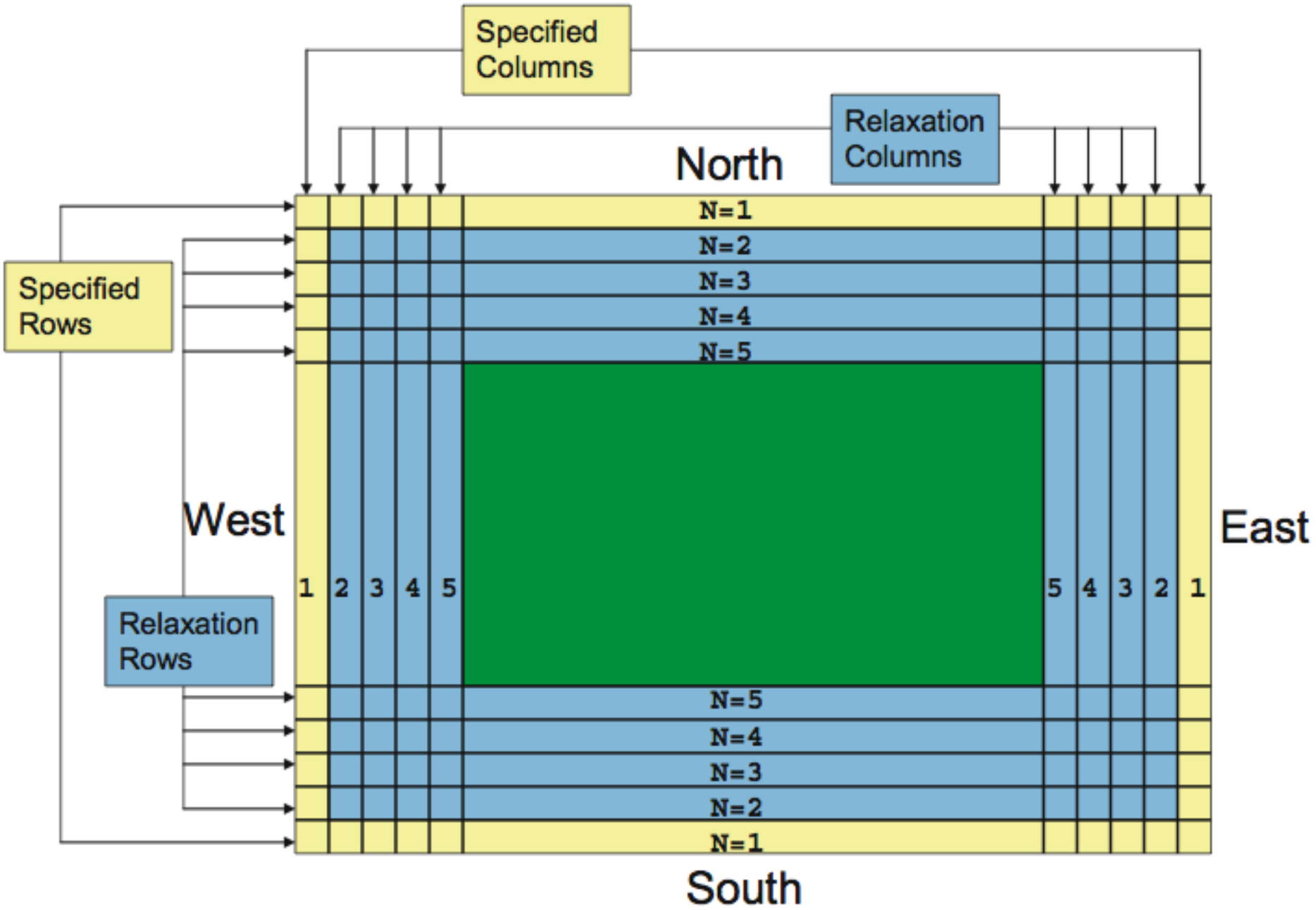


Time periods from WPS

Time slices from WPS

Boundary tendency steps

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



Optional Output

- WRF allow users to provide a lower boundary condition file (***wrflowinp_d01***), containing slowly changing files such as SST, sea-ice, greenness fraction

- Users have a large amount of control over what appears in optional files, based on the Registry. Stream #4 is currently used for lower boundary data, such as for SST.

```
state real SST ij misc 1 - \
i0124rhd=(interp_mask_water_field:lu_index,iswater)  \
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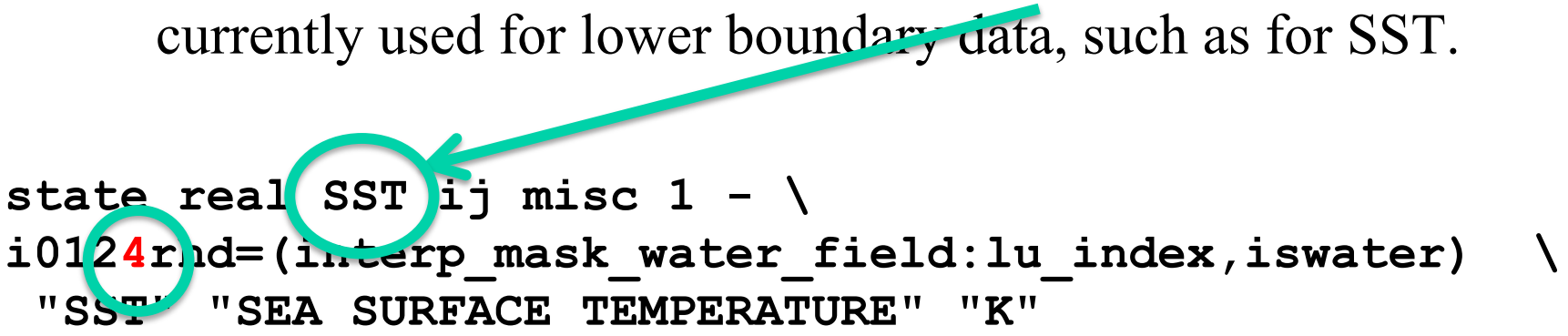

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state real SST ij misc 1 - \
i01r4rhd=(interp_mask_water_field:lu_index,iswater)   \
 "SST" "SEA SURFACE TEMPERATURE" "K"
```

ARW Optional Output

- 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***)

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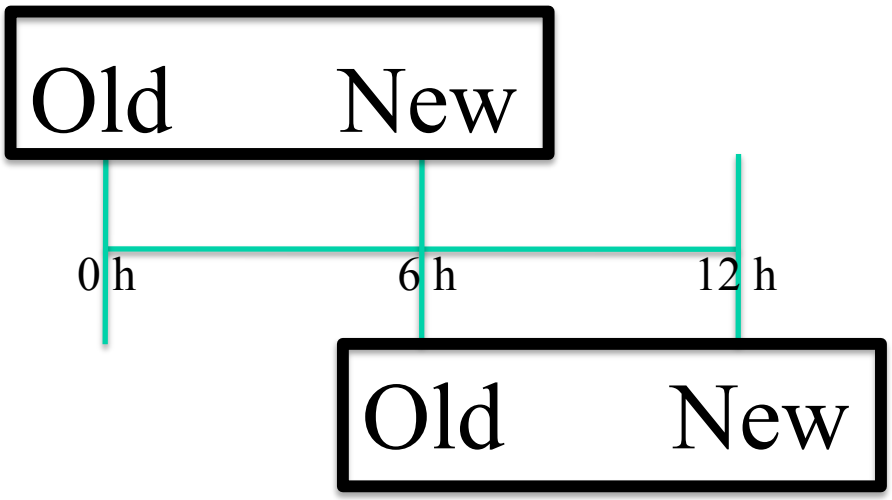
- Users who select to implement analysis nudging in the WRF model (also known as grid nudging) generate extra input fields for the model (***wrffdda_d01***)

- Each field to be nudged (horizontal wind components, temperature, moisture) has an "old" and a "new" time level



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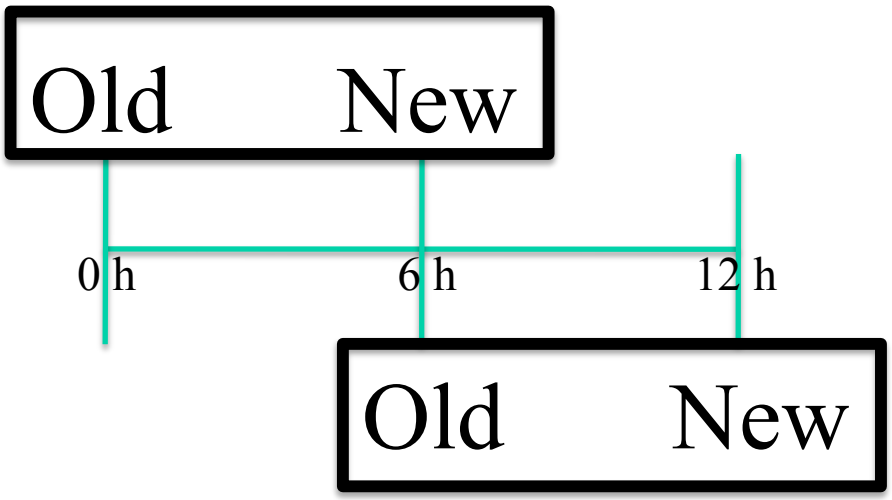


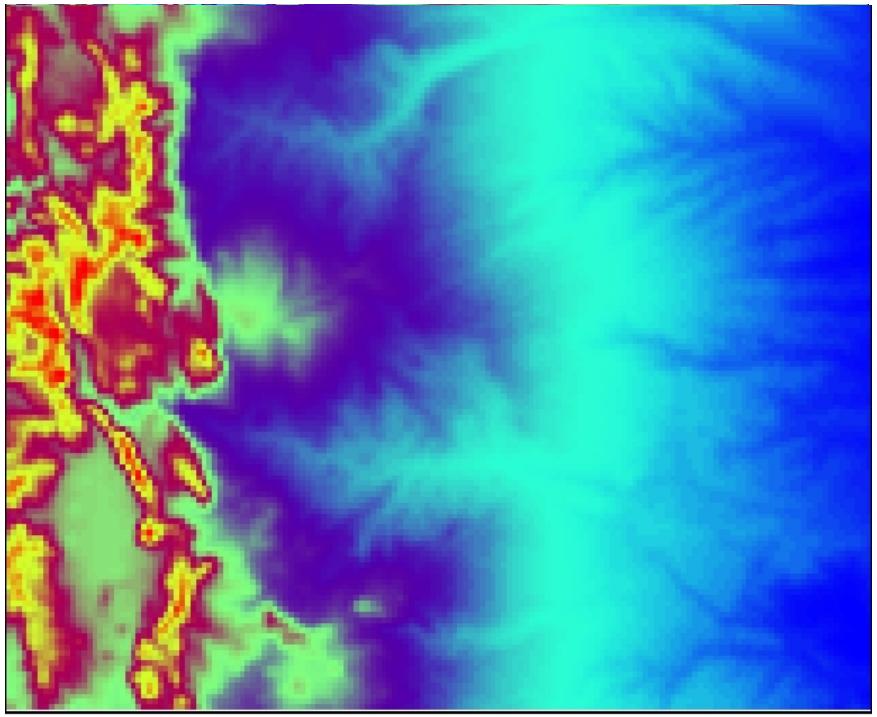
Vertical Interpolation

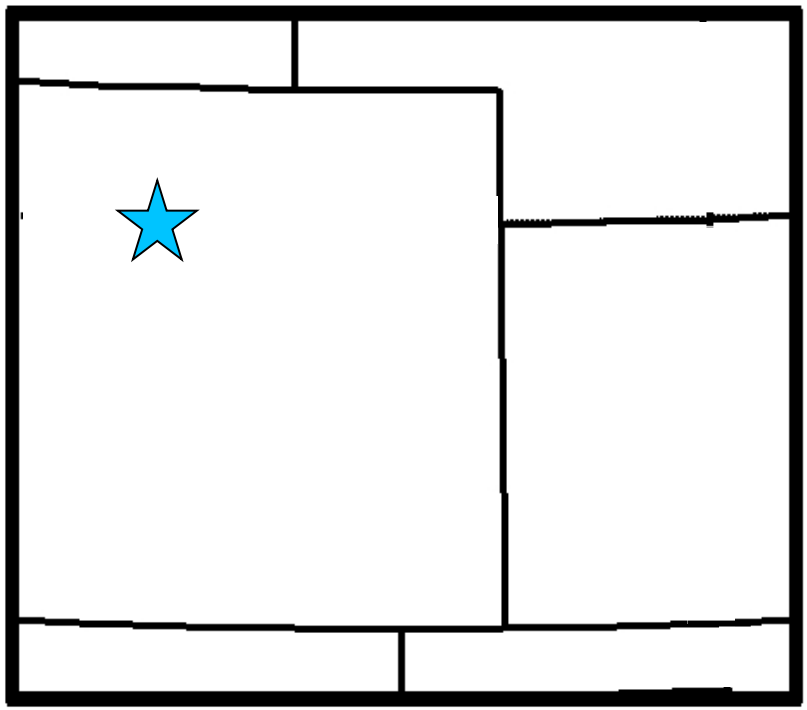
- A number of vertical interpolation options are available to users
- The options can have a significant impact on the initial conditions passed to the model
- More information is contained in the info file ***README.namelist*** in the ***run*** directory
- Options are located in the ***&domains*** namelist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

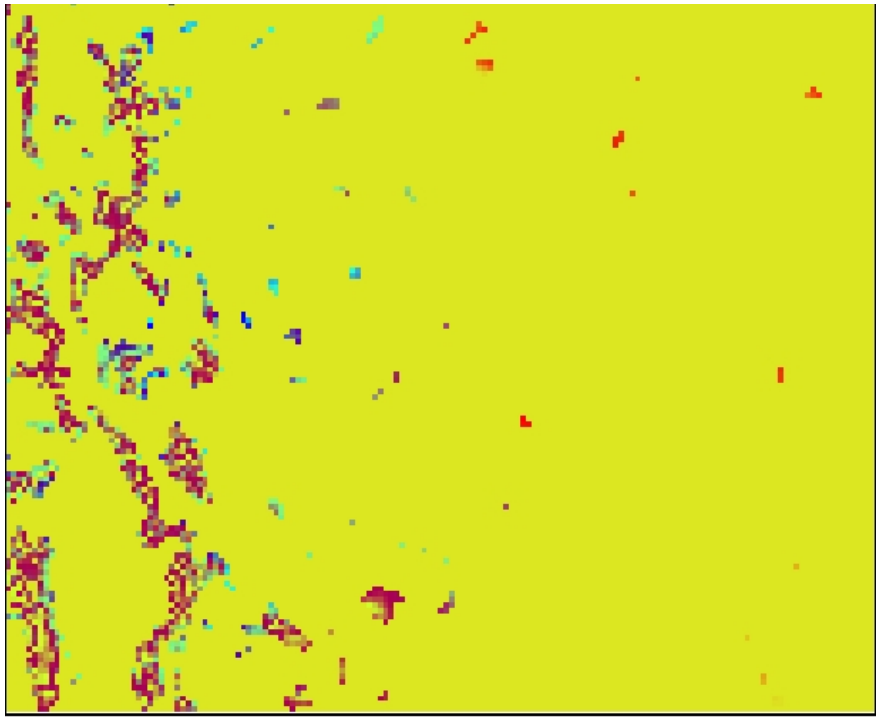




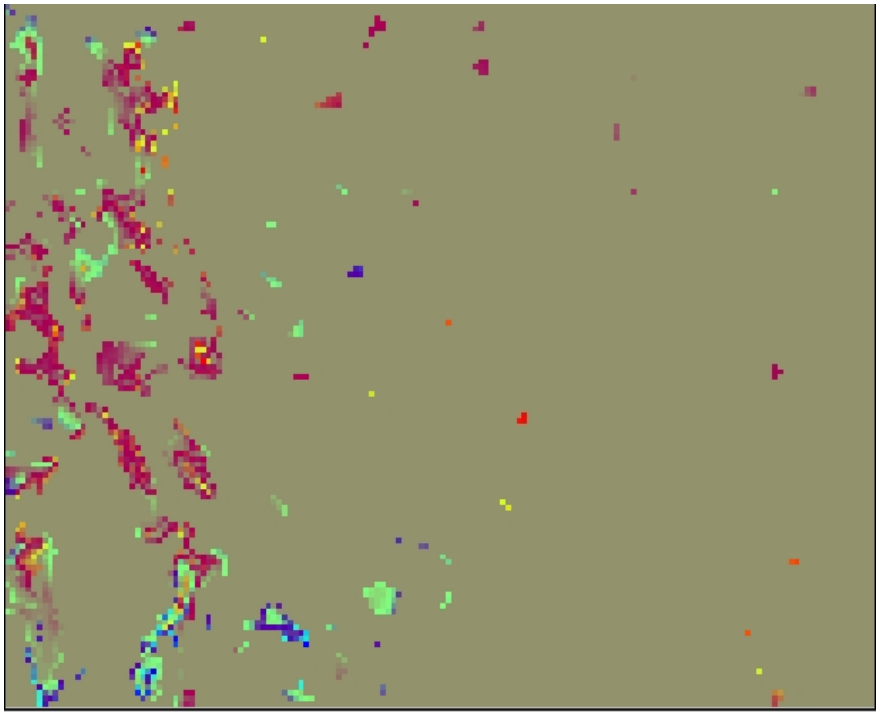
Vertical Interpolation

- Impact: few lowest levels only
- force_sfc_in_vinterp = 0
- h level 1

- Theta (-8 K blue, 0 K yellow)



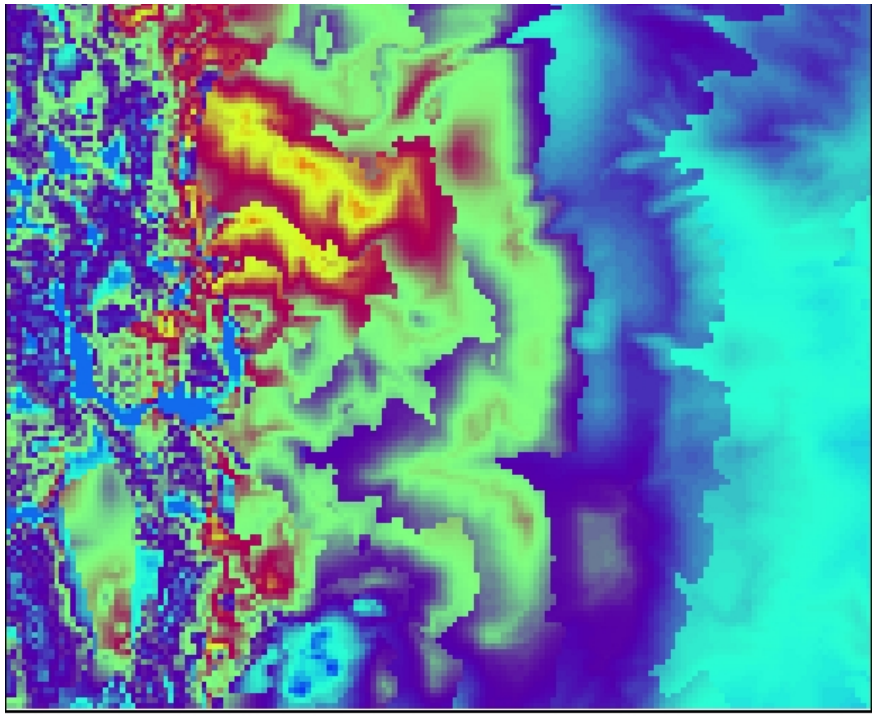
- U (-3 m/s blue, 2 m/s red)



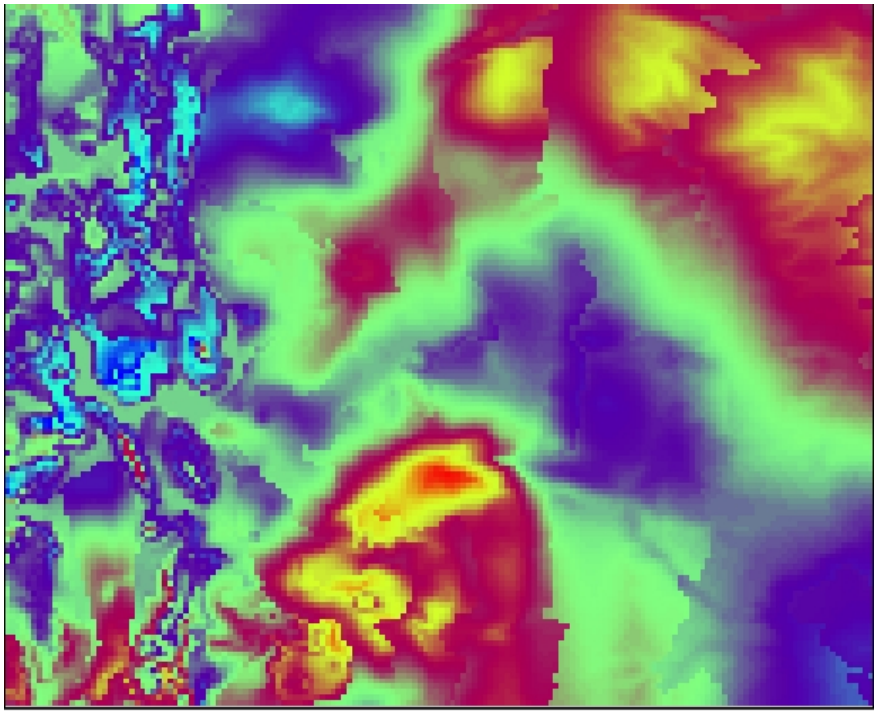
Vertical Interpolation

- Impact: few lowest levels only
- force_sfc_in_vinterp = 6
- h level 4

- Theta (0 K blue, 10 K red)



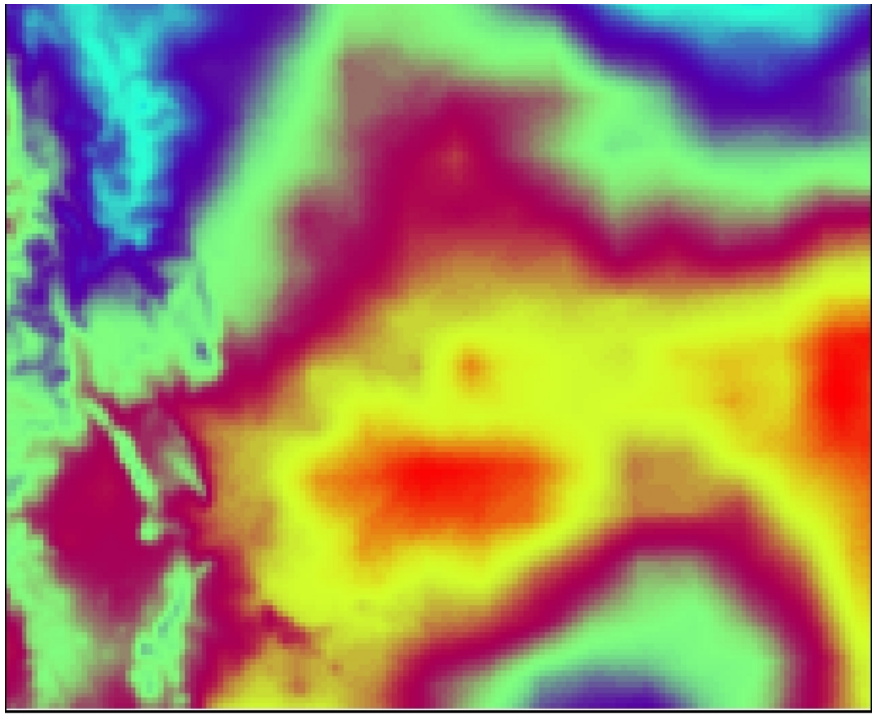
- U (-5 m/s blue, 6 m/s red)



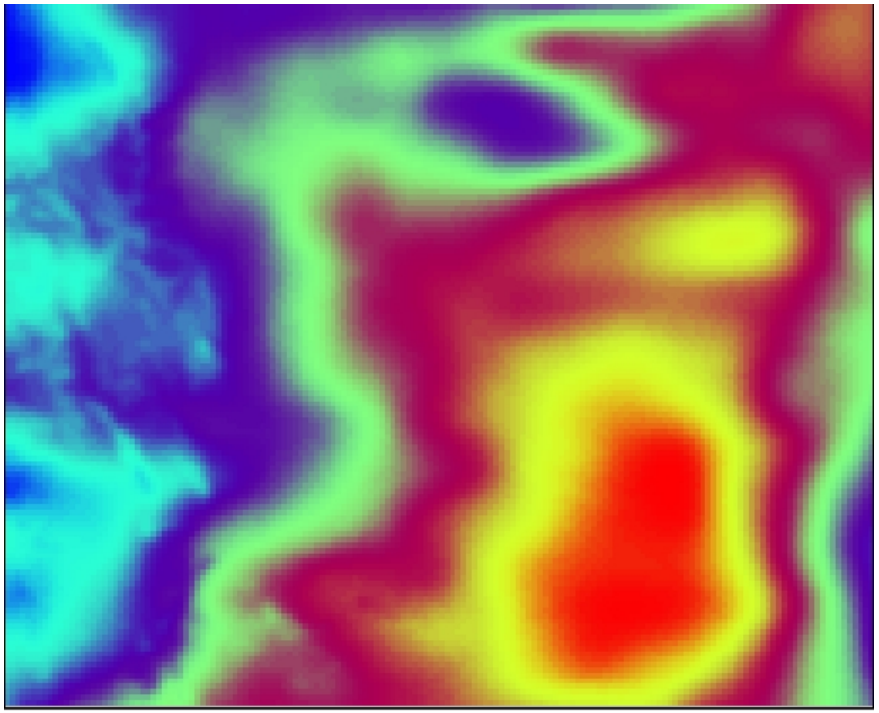
Vertical Interpolation

- Impact: above first 4 levels, most near tropopause
- lagrange_order = 2
- h level TOP

- Theta (0.7 K blue, 1.6 K red)



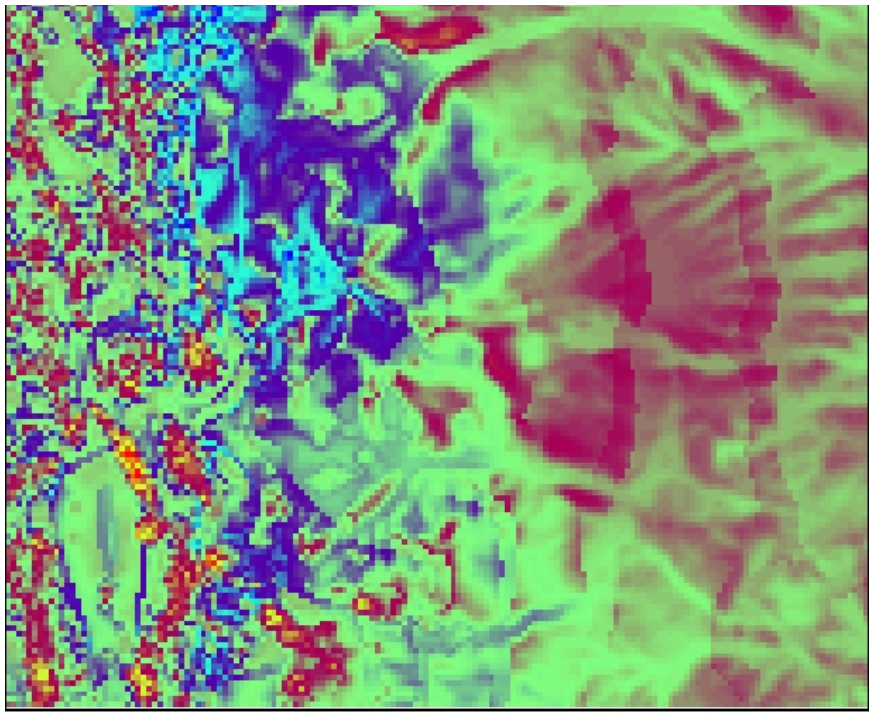
- U (0.4 m/s blue, 1.4 m/s red)



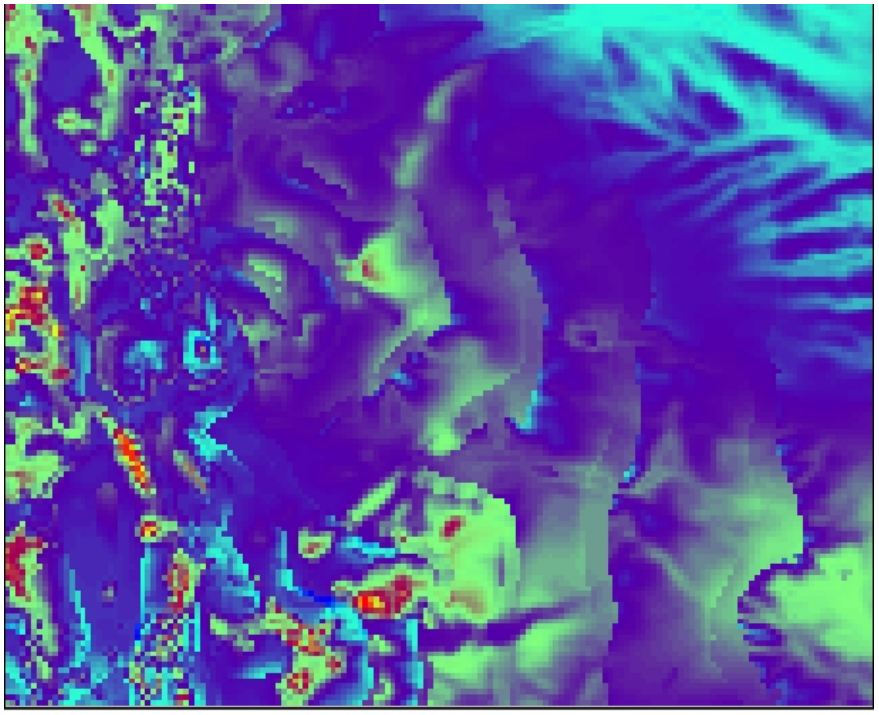
Vertical Interpolation

- Impact: lowest level only
- lowest_lev_from_sfc = T
- h 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
- h level 1

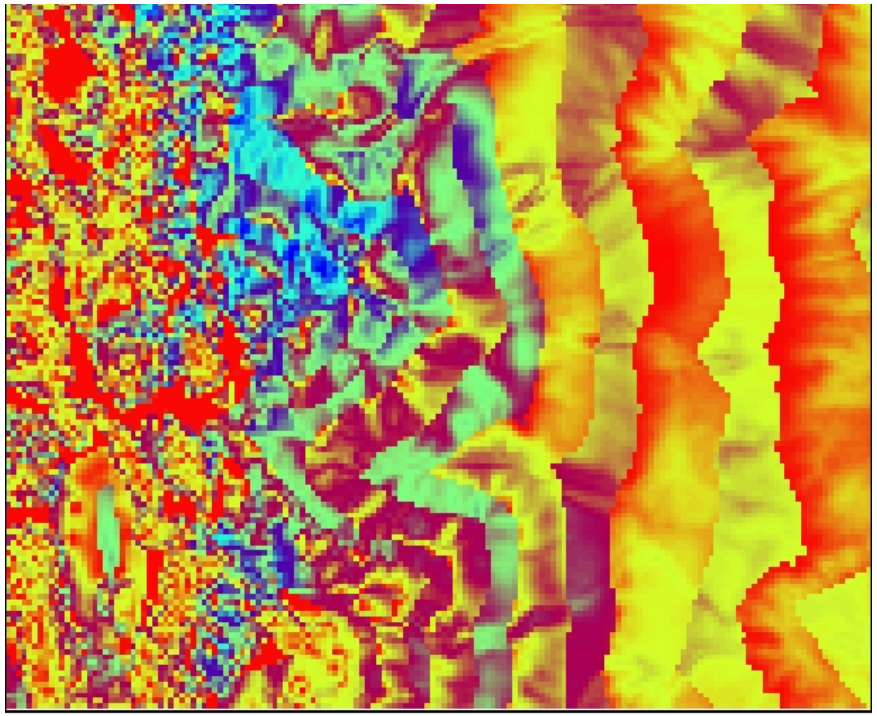
- Theta (-10 K blue, 9 K red)

- U (-6 m/s blue, 6 m/s red)

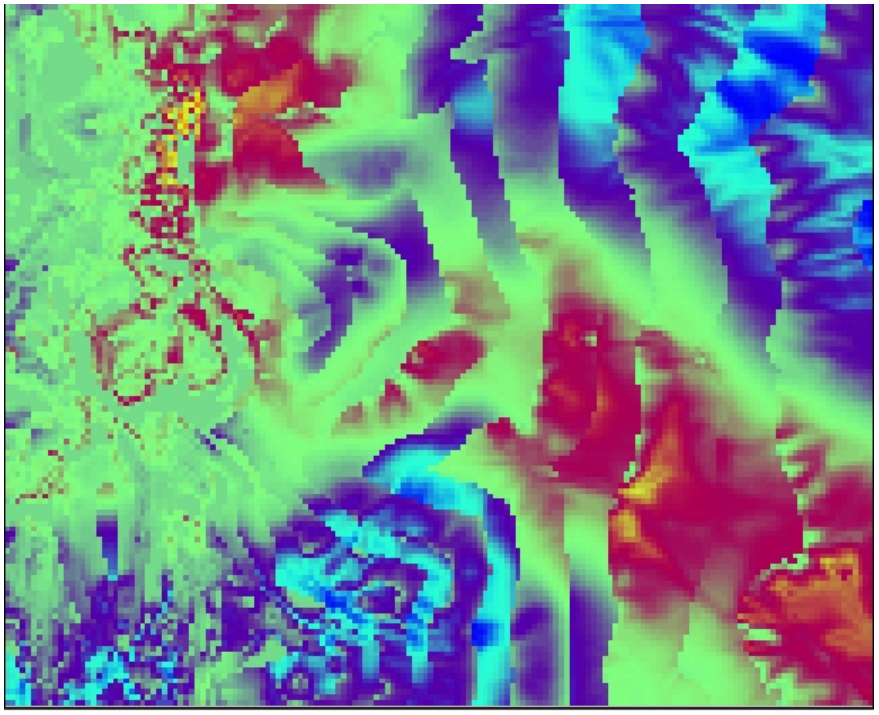
Vertical Interpolation

- Impact: lowest few levels
- use_surface = F
- h level 1

- Theta (-11 K blue, 0 K red)



- U (-3 m/s blue, 4 m/s red)



Vertical Interpolation

Make sure input data is vertically ordered as expected

Input 3-D pressure and T, topo, Z, moisture used to compute total surface pressure

Compute target vertical coordinate using normalized dry column pressure pressure

User specifies the selected h surfaces in the namelist (or can be computed)

Vertically interpolate input fields in pressure to the h surfaces in dry pressure: default all variables log

Vertical Interpolation

Make sure input data is vertically ordered as expected

Input 3-D pressure and T, topo, Z, moisture used to compute total surface pressure

Compute target vertical coordinate

- NMM - total surface pressure through dp/dz, 3d pressure
- ARW – normalized dry column pressure pressure

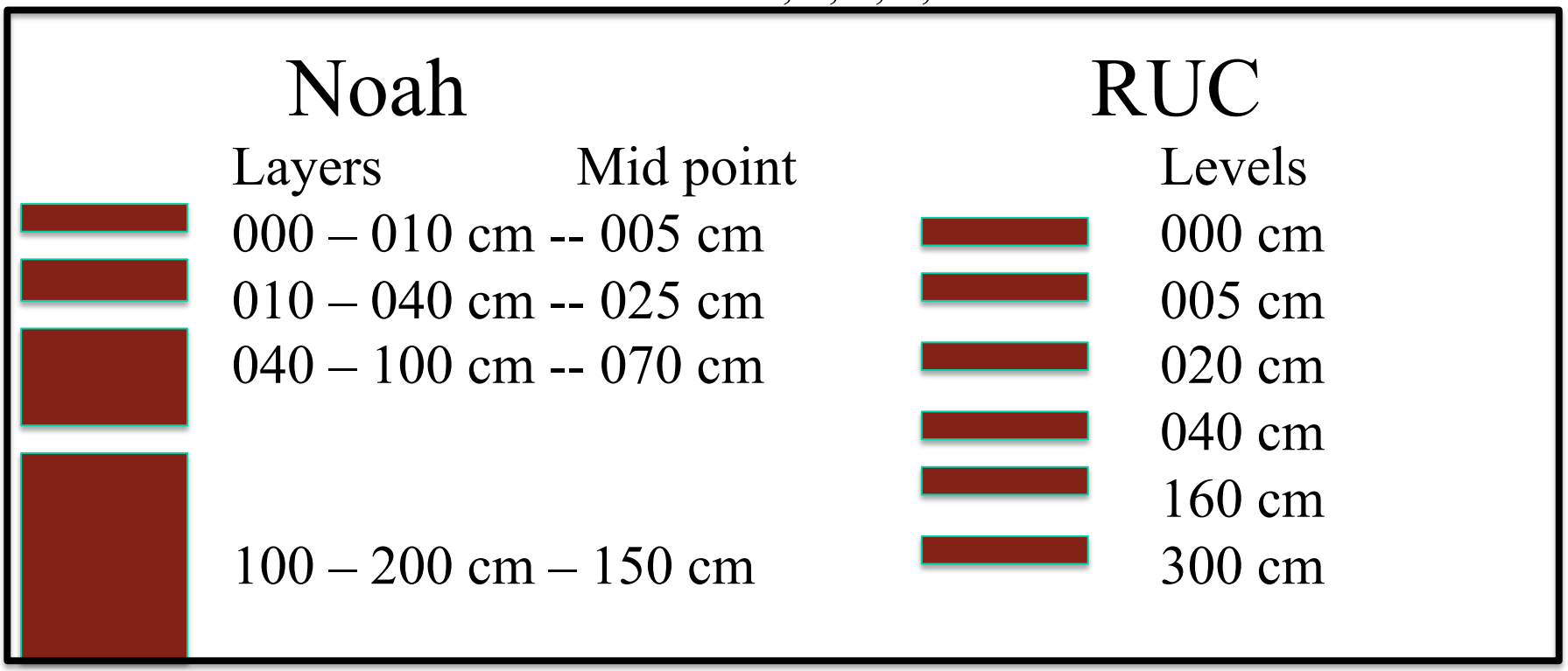
User specifies the selected h surfaces in the namelist (or can be computed)

Vertically interpolate input fields in pressure to the h surfaces in pressure

- NMM: total pressure: T, u, v linear ; mixing ratio log
- ARW: dry pressure: default all variables log

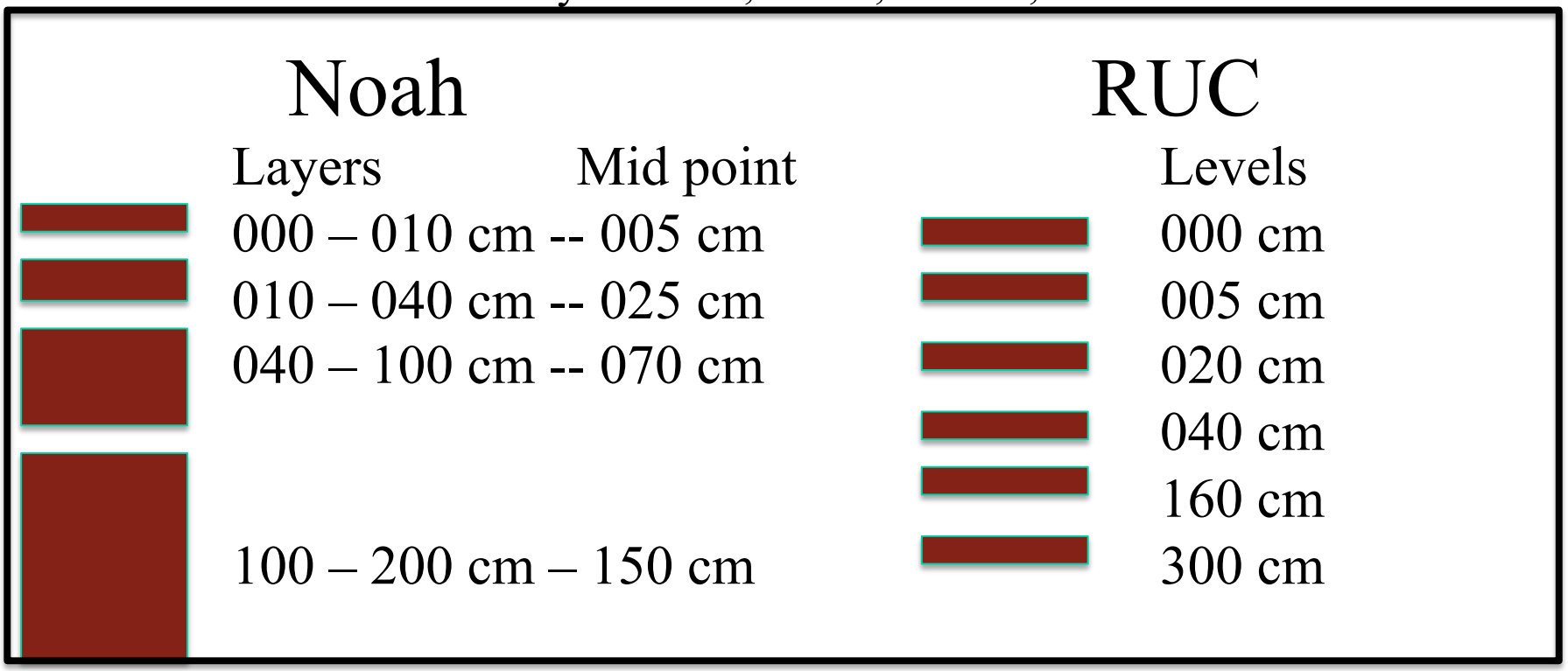
Soil Level Interpolation

- 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



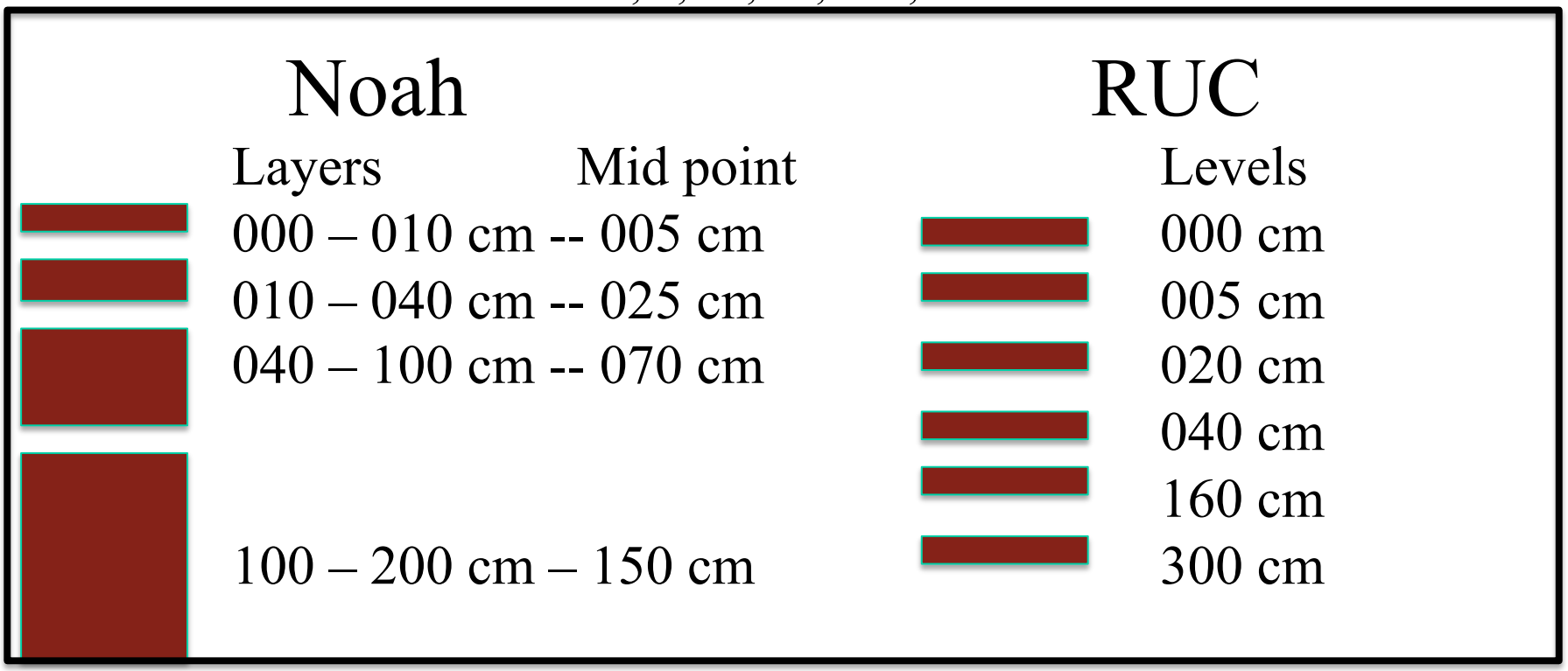
Soil Level Interpolation

- 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

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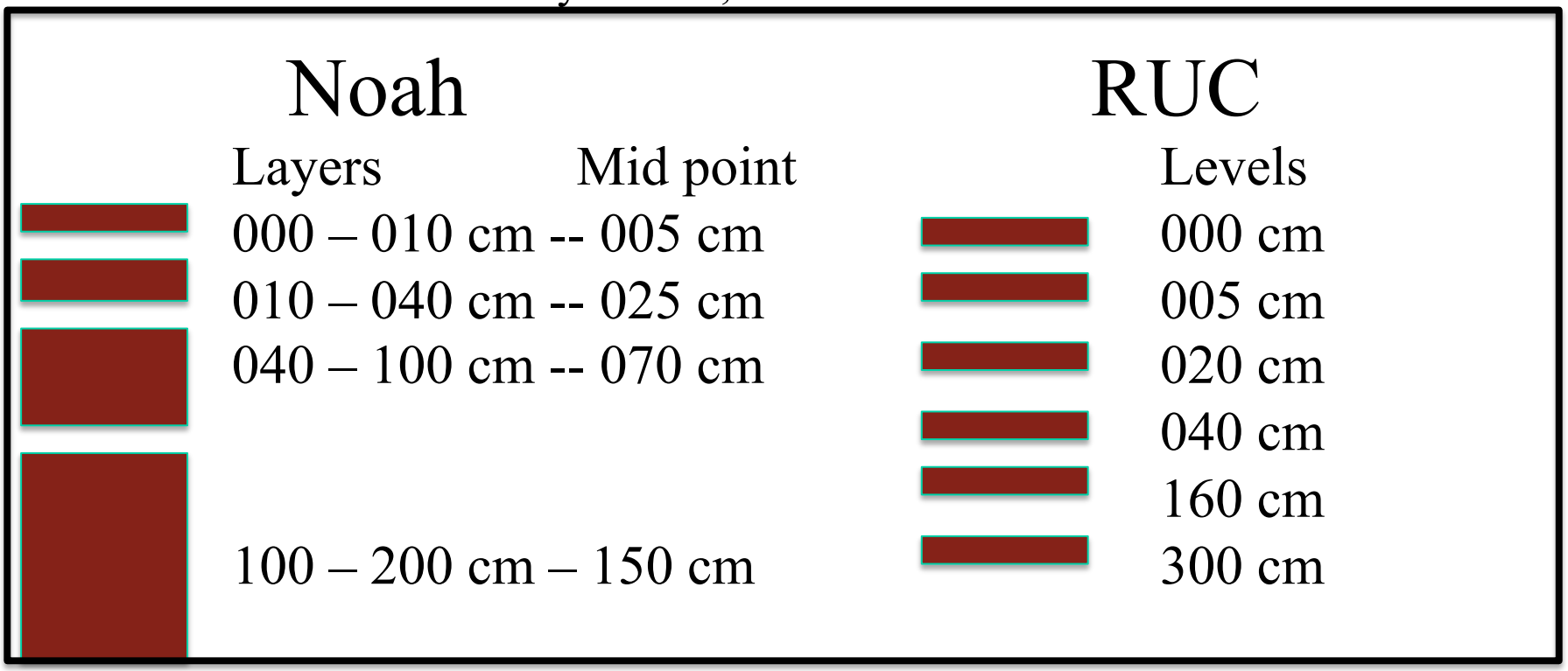
  - sf_surface_physics = 7, PX scheme
  - 2 layers
  - Defined with layers: 0-1, 1-100 cm



Soil Level Interpolation

- The real program accepts soil temperature and moisture 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
- Orientation:
  - the "first" level is near or at the model surface
  - 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
- An 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)

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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

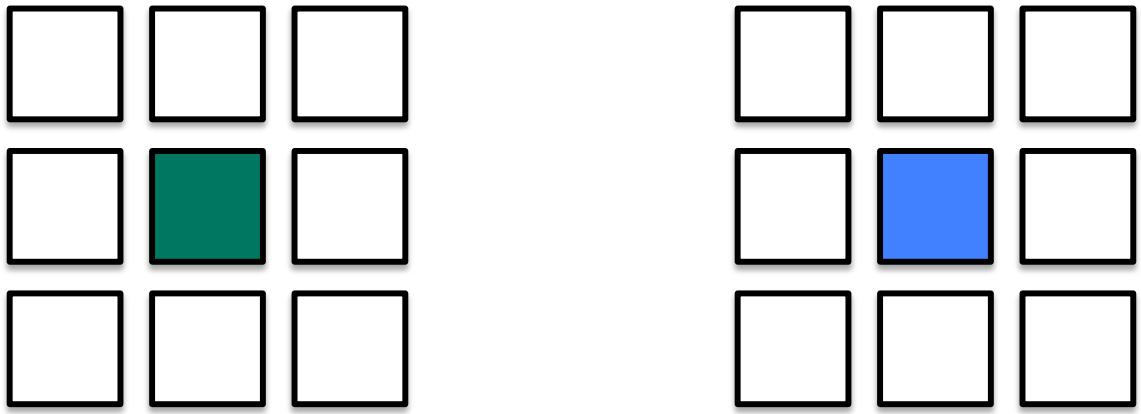
Sea-Ice Initialization

- ARW, users may set an arbitrary SST temperature in the real program, below which the water points are turned to ice

- Fractional sea-ice may cause model crashes with heterogeneous input data

Sea-Ice Initialization

- NMM, if a land or water point is surrounded by sea ice, turn the middle value into a sea ice point, reset the land mask to a water point



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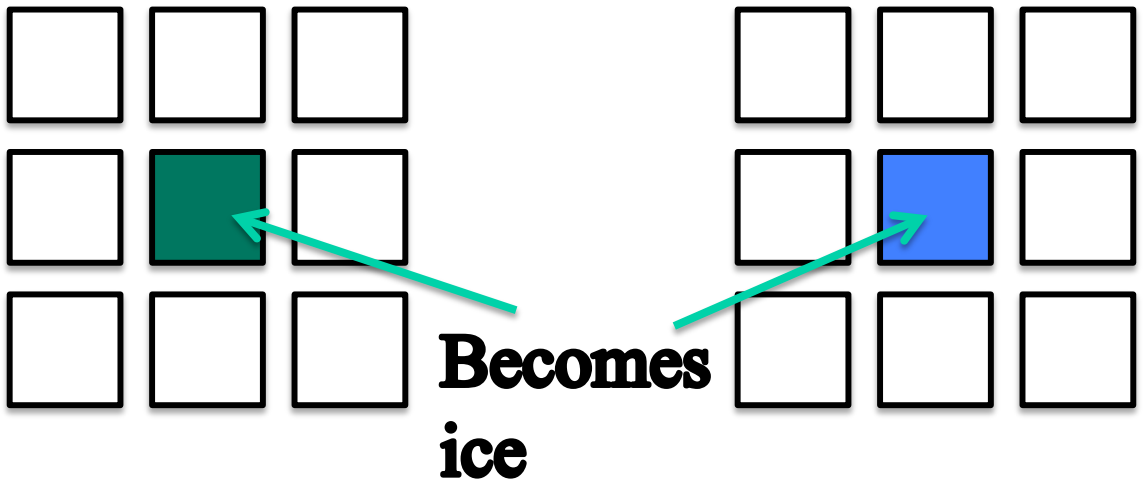

Land Water Mask

- 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

- 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

Nested Processing in real for ARW

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Real program in a nutshell

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- Base State
- Standard generated output
- Optional output
- Vertical interpolation
- Soil level interpolation
- Water temperature initialization
- Sea-ice initialization
- Land/Water mask
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(as close as possible, Klingon for *finis*)