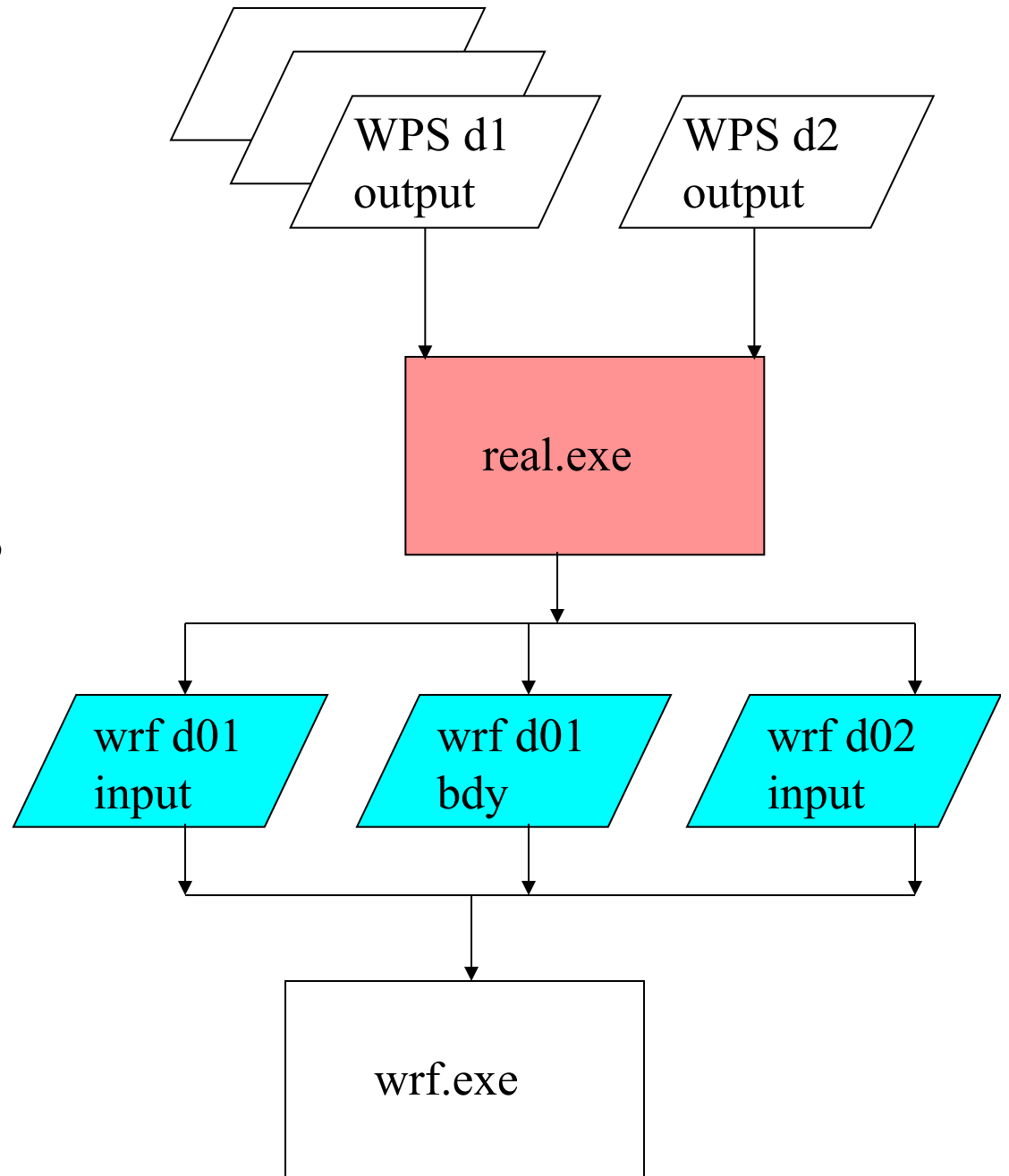


Real

Description of General Functions

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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

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

- *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 (maybe usage of nudging capabilities)

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

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 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

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

Base State

- 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
- 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

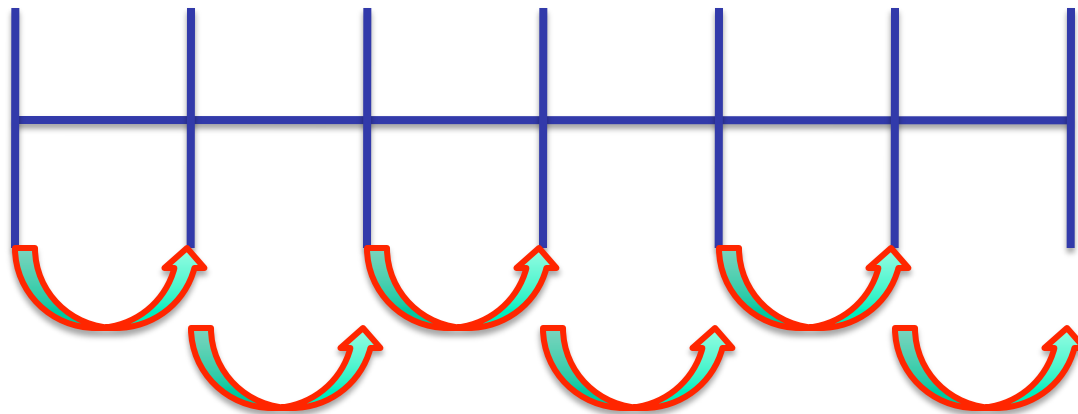
Lateral Boundary Condition Times

0 6 12 18 24 30 36 h

Time periods
from WPS

1 2 3 4 5 6 7

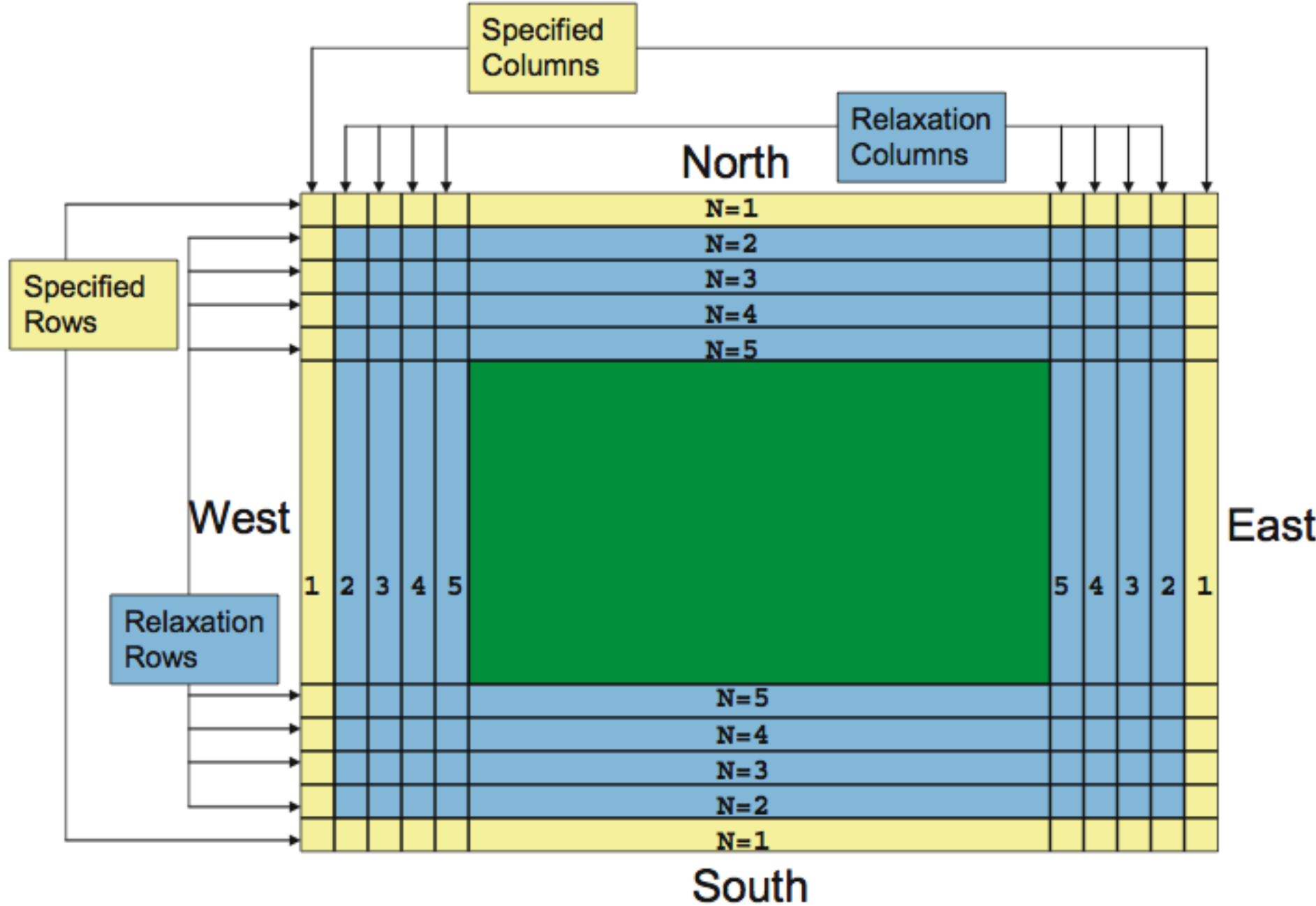
Time slices from
WPS



Boundary
tendency steps

1 2 3 4 5 6

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



Optional Output

- WRF allows 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.

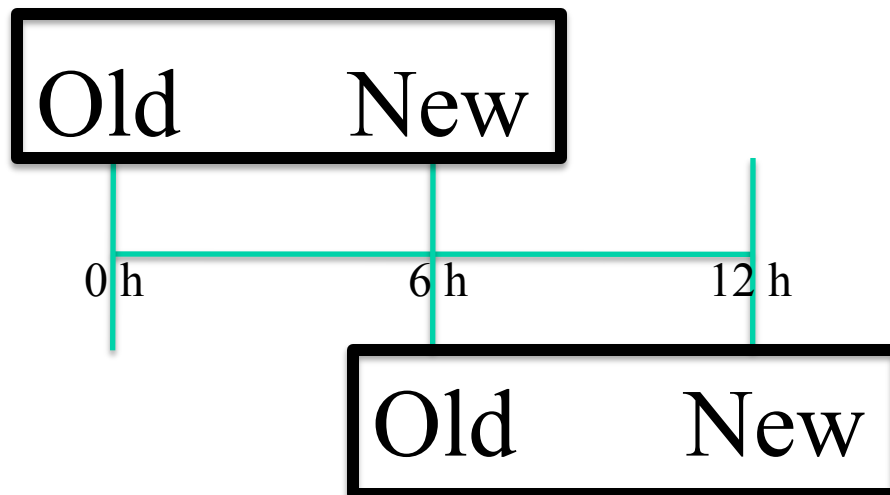
```
state real SST ij misc 1 - \  
i0124rhd=(interp_mask_water_field:lu_index,iswater) \  
"SST" "SEA SURFACE TEMPERATURE" "K"
```

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*)

Optional Output

- 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

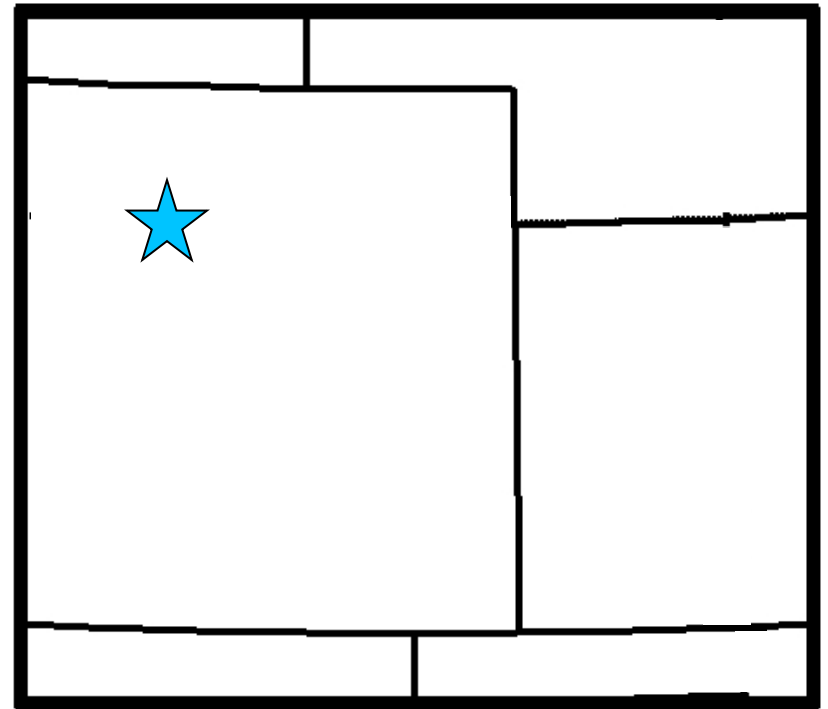
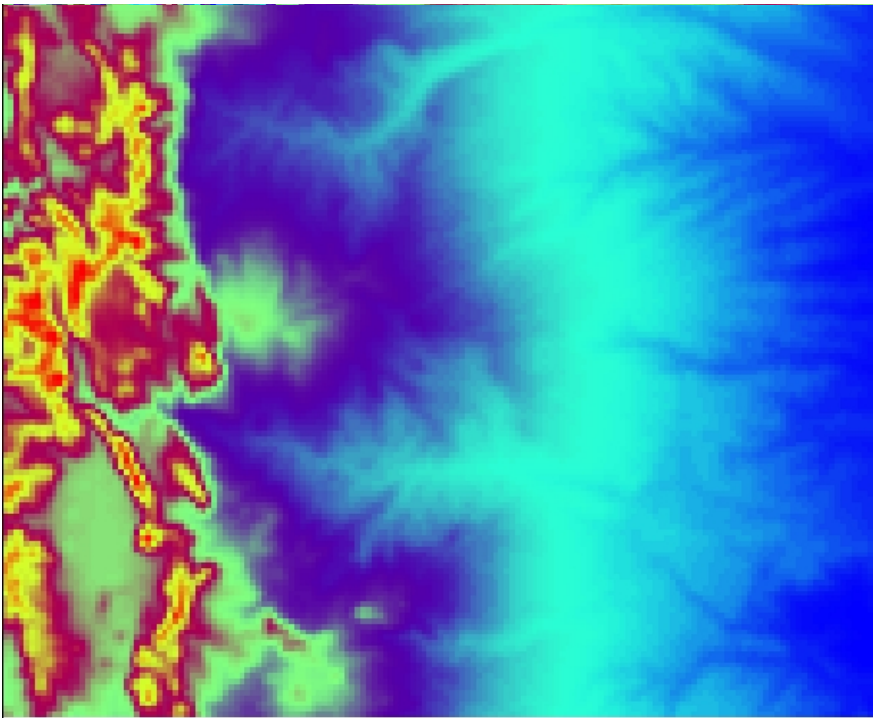


Vertical Interpolation

- 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*

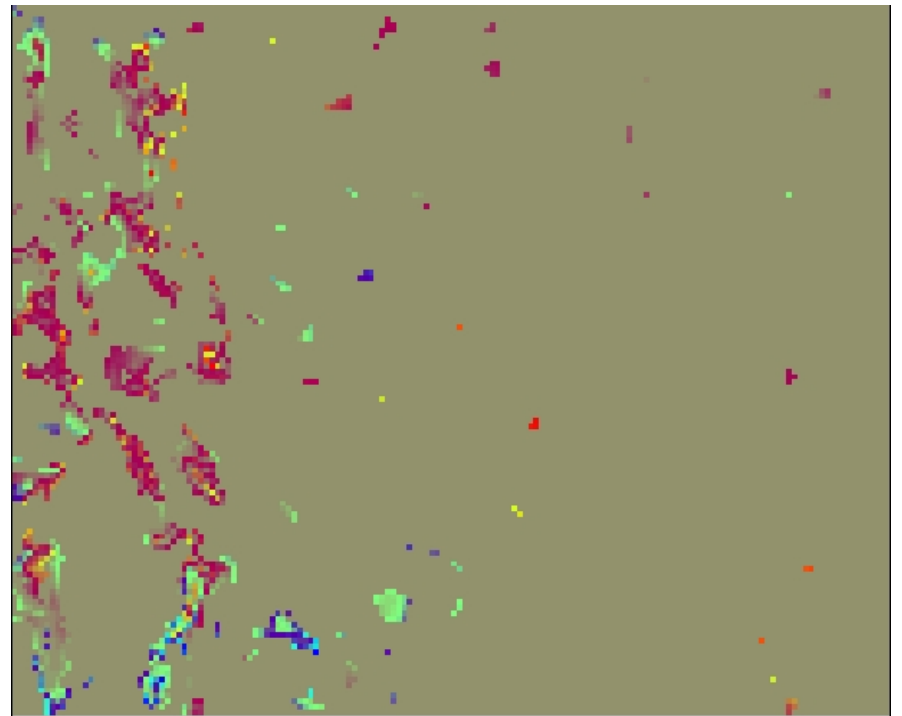
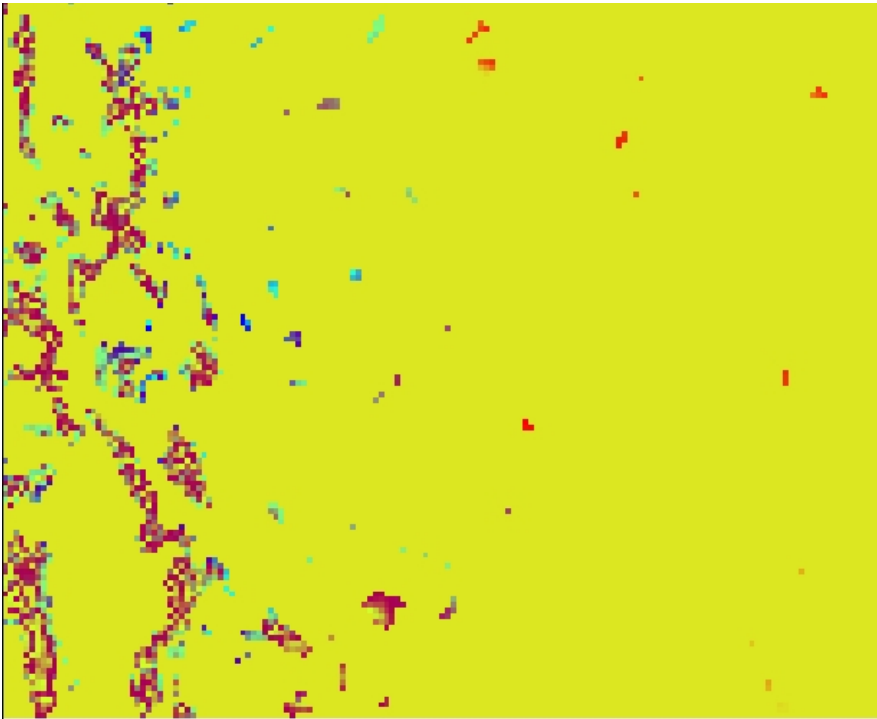
Vertical Interpolation

- 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



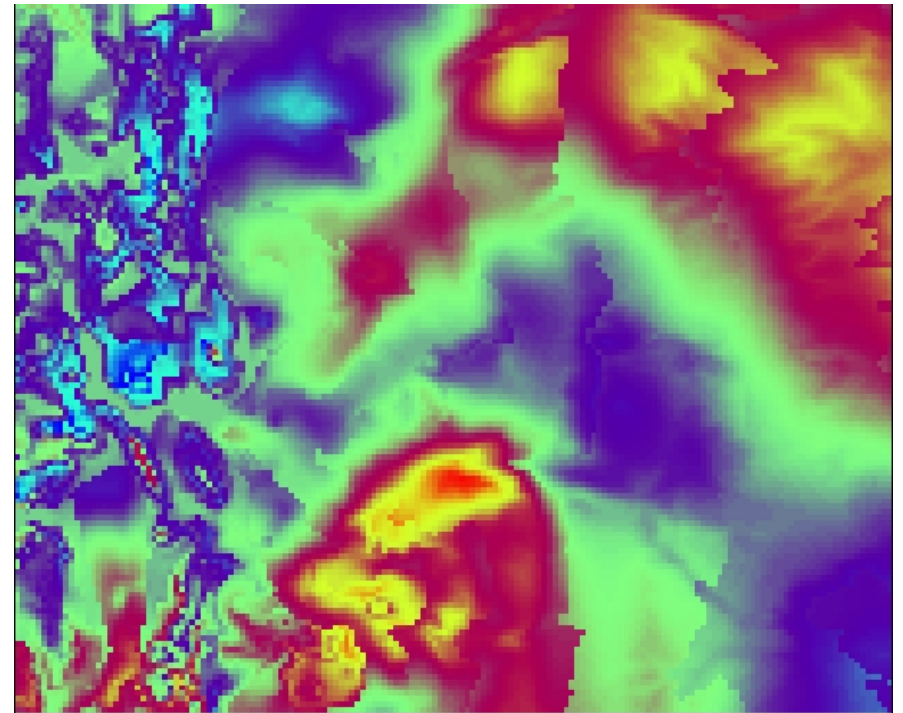
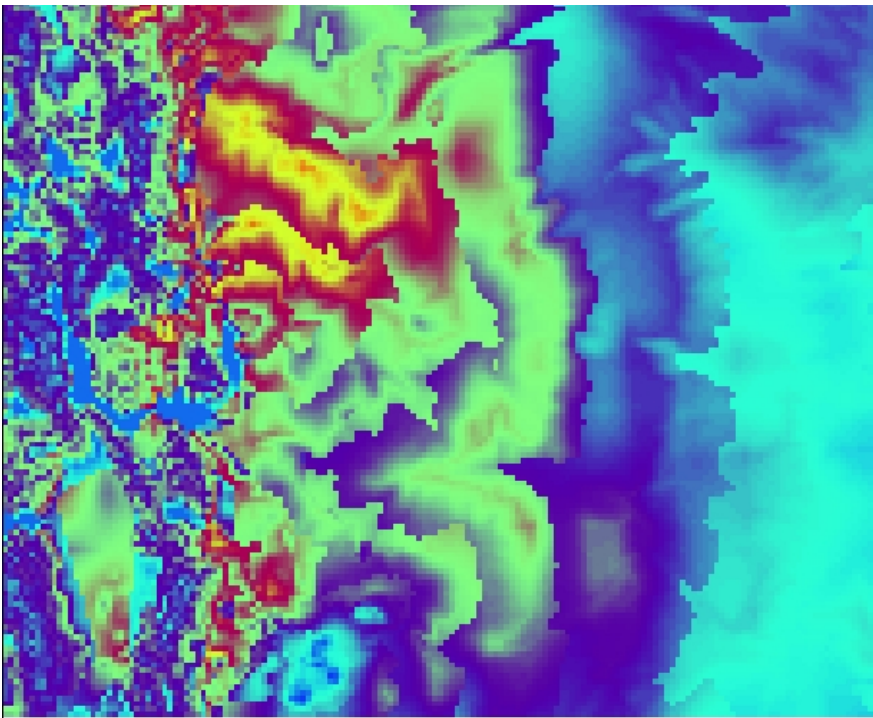
Vertical Interpolation

- Impact: few lowest levels only
 - $\text{force_sfc_in_vinterp} = 0$
 - h level 1
-
- Theta (−8 K blue, 0 K yellow)
 - U (−3 m/s blue, 2 m/s red)



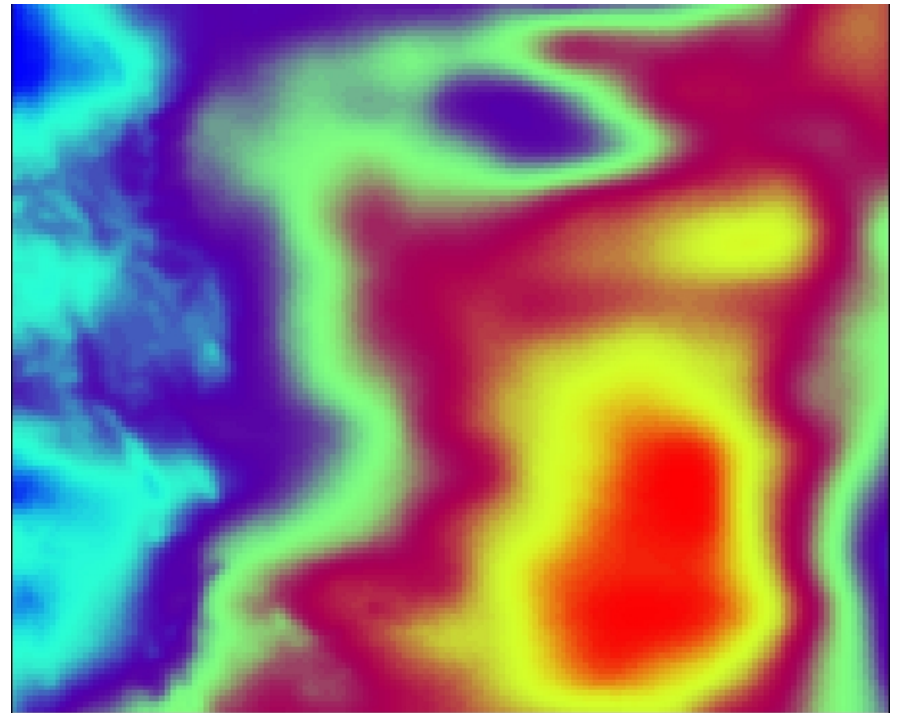
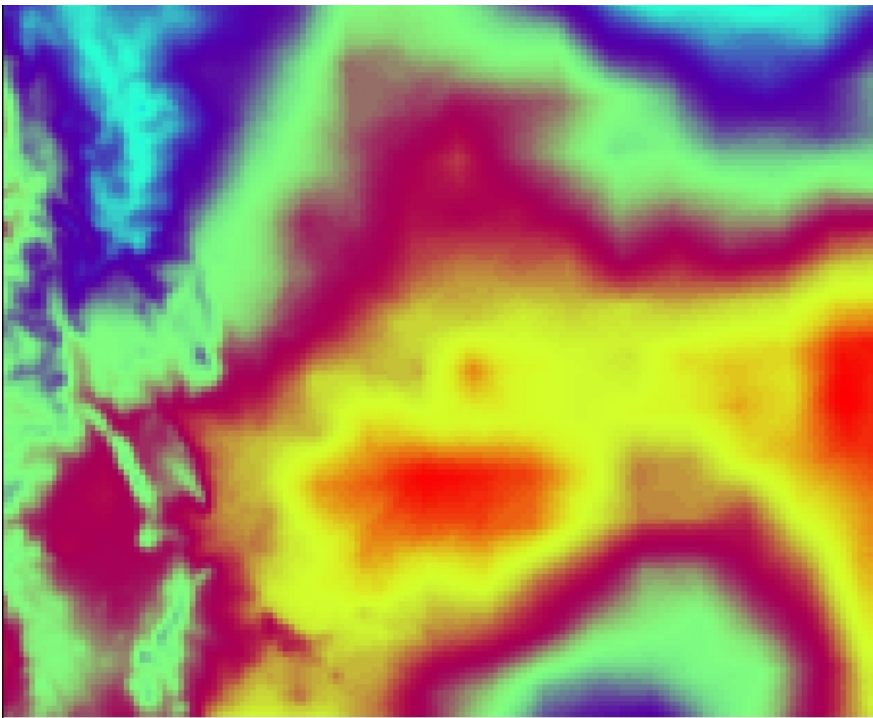
Vertical Interpolation

- 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)



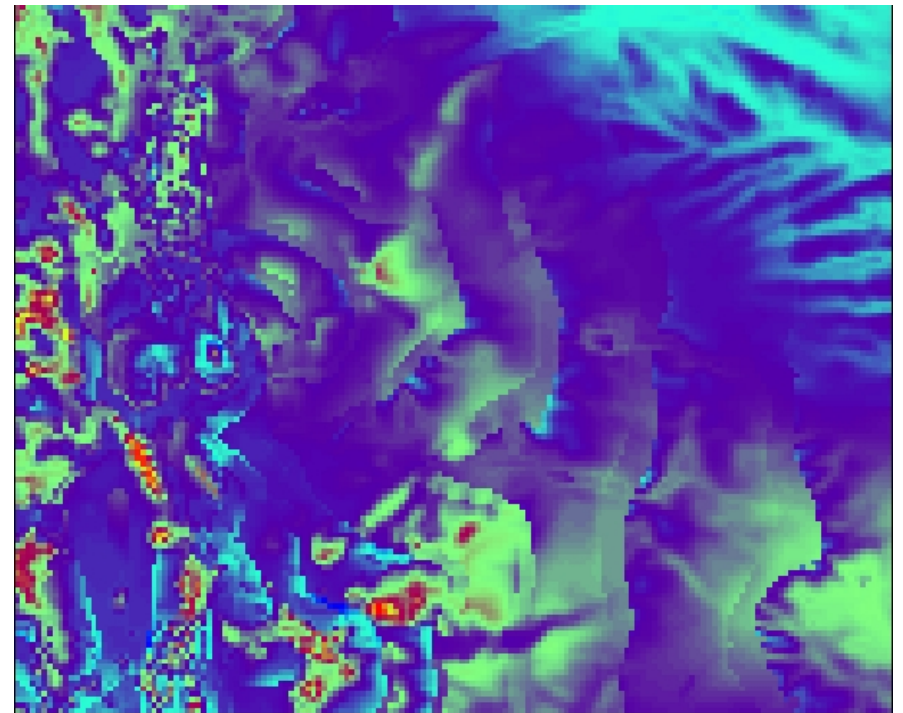
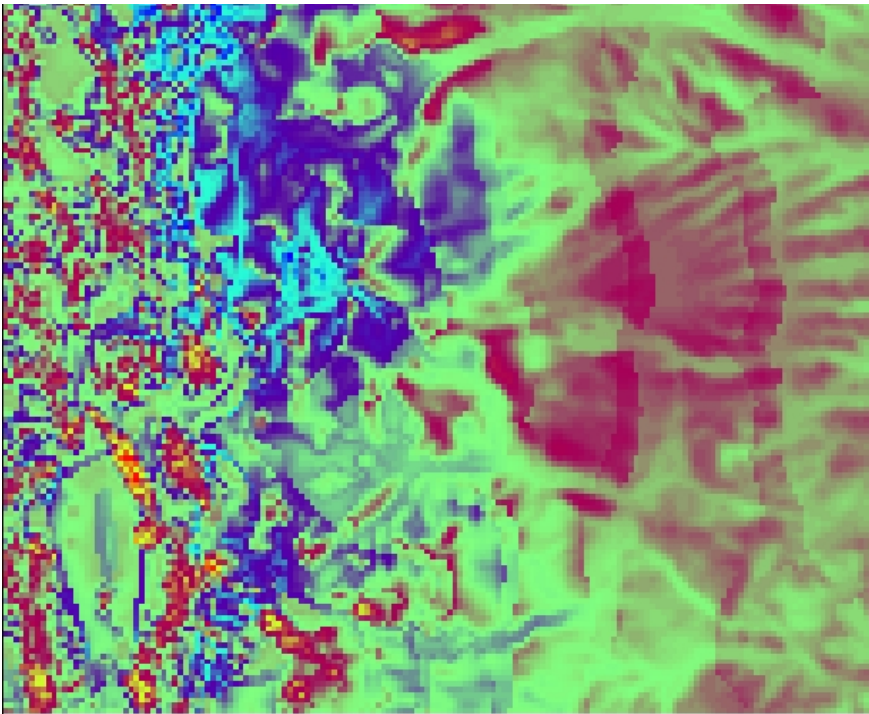
Vertical Interpolation

- 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)



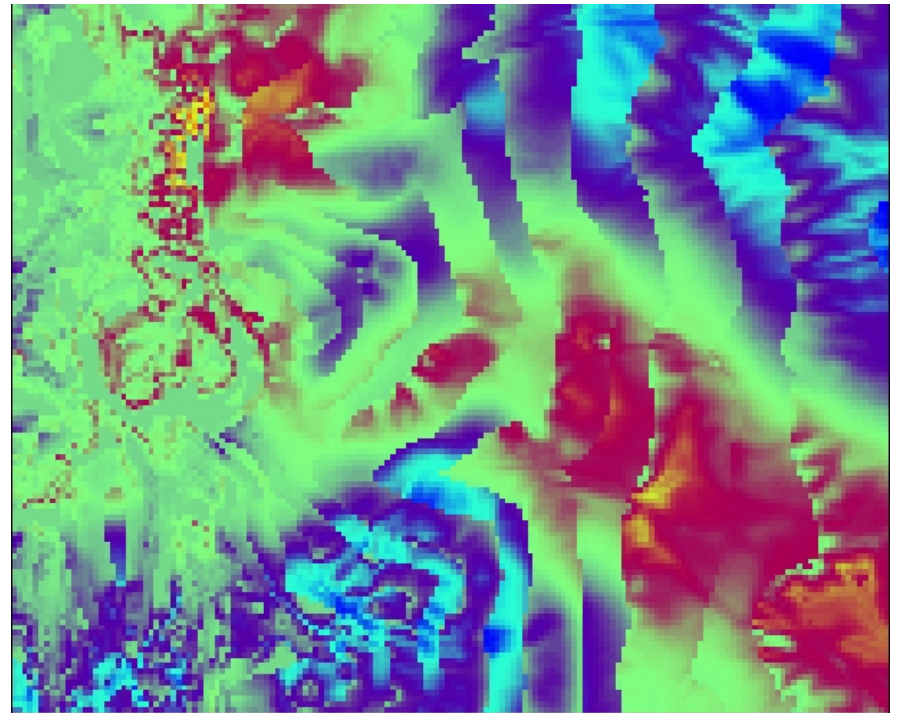
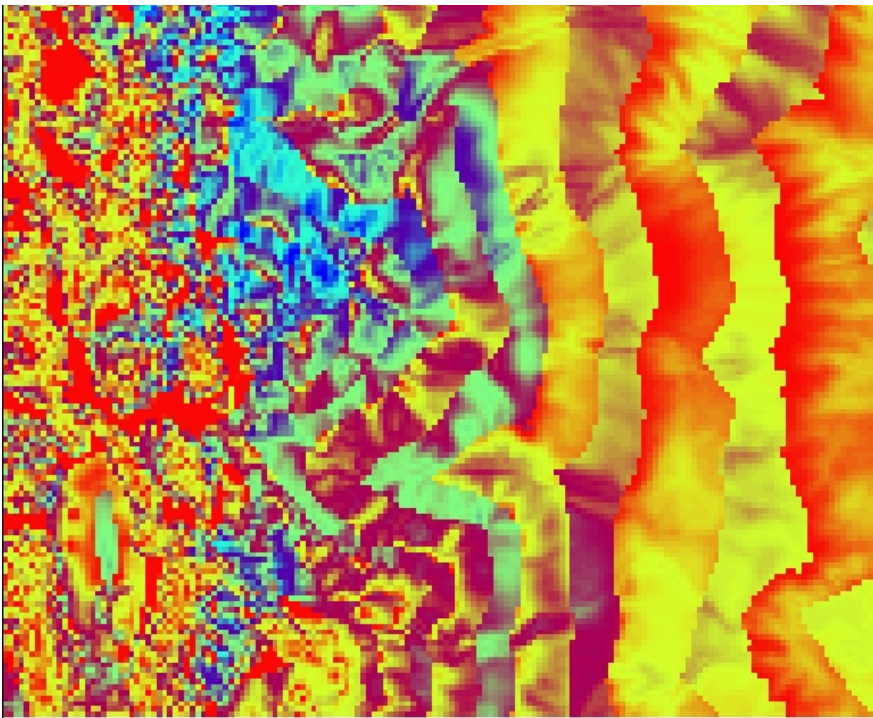
Vertical Interpolation

- 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

- Select reasonable h levels, or let the real program do it for you
- Verify that the “thicknesses” are acceptable, generally about the same value in the free-atmosphere and less than 1000 m

Vertical Interpolation

- Adjusted with a few parameters:

`&domains`

`e_vert` = 50, 50, 50

`p_top_requested` = 1000,

`&dynamics`

`base_temp` = 290.

`iso_temp` = 200

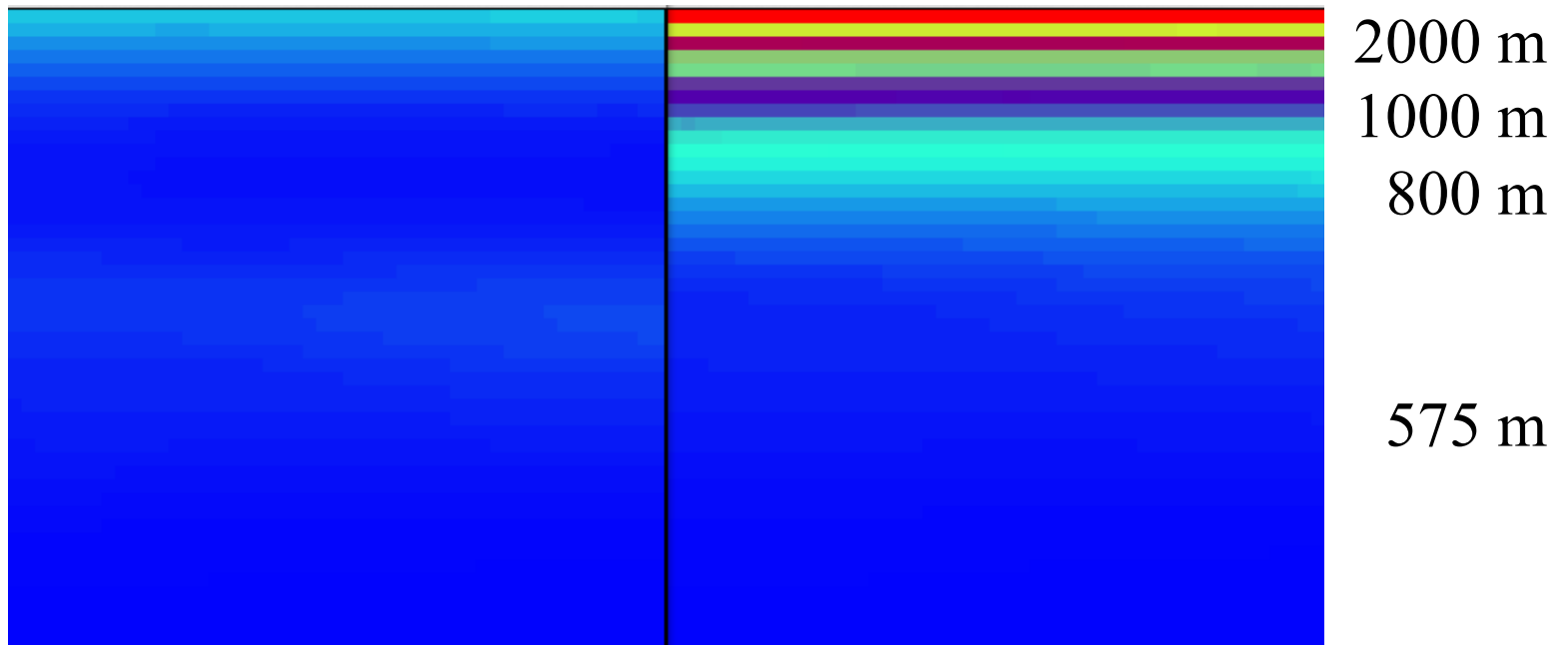
Vertical Interpolation

Vertical cross sections of model height field, with 50 vertical levels and $p_{\text{top}} = 10$ hPa, above the PBL.

Uniform layers







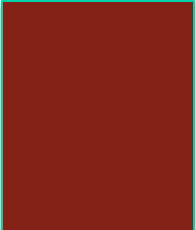



Exaggerated Stretching

720-820 m









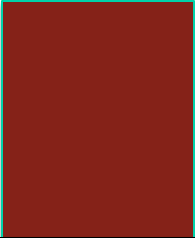



Soil Level Interpolation

- 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

Noah		RUC	
Layers	Mid point		Levels
	000 – 010 cm -- 005 cm		000 cm
	010 – 040 cm -- 025 cm		005 cm
	040 – 100 cm -- 070 cm		020 cm
	100 – 200 cm – 150 cm		040 cm
			160 cm
			300 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

Noah		RUC	
Layers	Mid point		Levels
	000 – 010 cm -- 005 cm		000 cm
	010 – 040 cm -- 025 cm		005 cm
	040 – 100 cm -- 070 cm		020 cm
	100 – 200 cm – 150 cm		040 cm
			160 cm
			300 cm











Soil Level Interpolation

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

Noah		RUC	
Layers	Mid point		Levels
	000 – 010 cm -- 005 cm		000 cm
	010 – 040 cm -- 025 cm		005 cm
	040 – 100 cm -- 070 cm		020 cm
	100 – 200 cm – 150 cm		040 cm
			160 cm
			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

Noah		RUC	
Layers	Mid point		Levels
	000 – 010 cm -- 005 cm		000 cm
	010 – 040 cm -- 025 cm		005 cm
	040 – 100 cm -- 070 cm		020 cm
	100 – 200 cm – 150 cm		040 cm
			160 cm
			300 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)

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

- WRF 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

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

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