Program REAL

Description of General Functions

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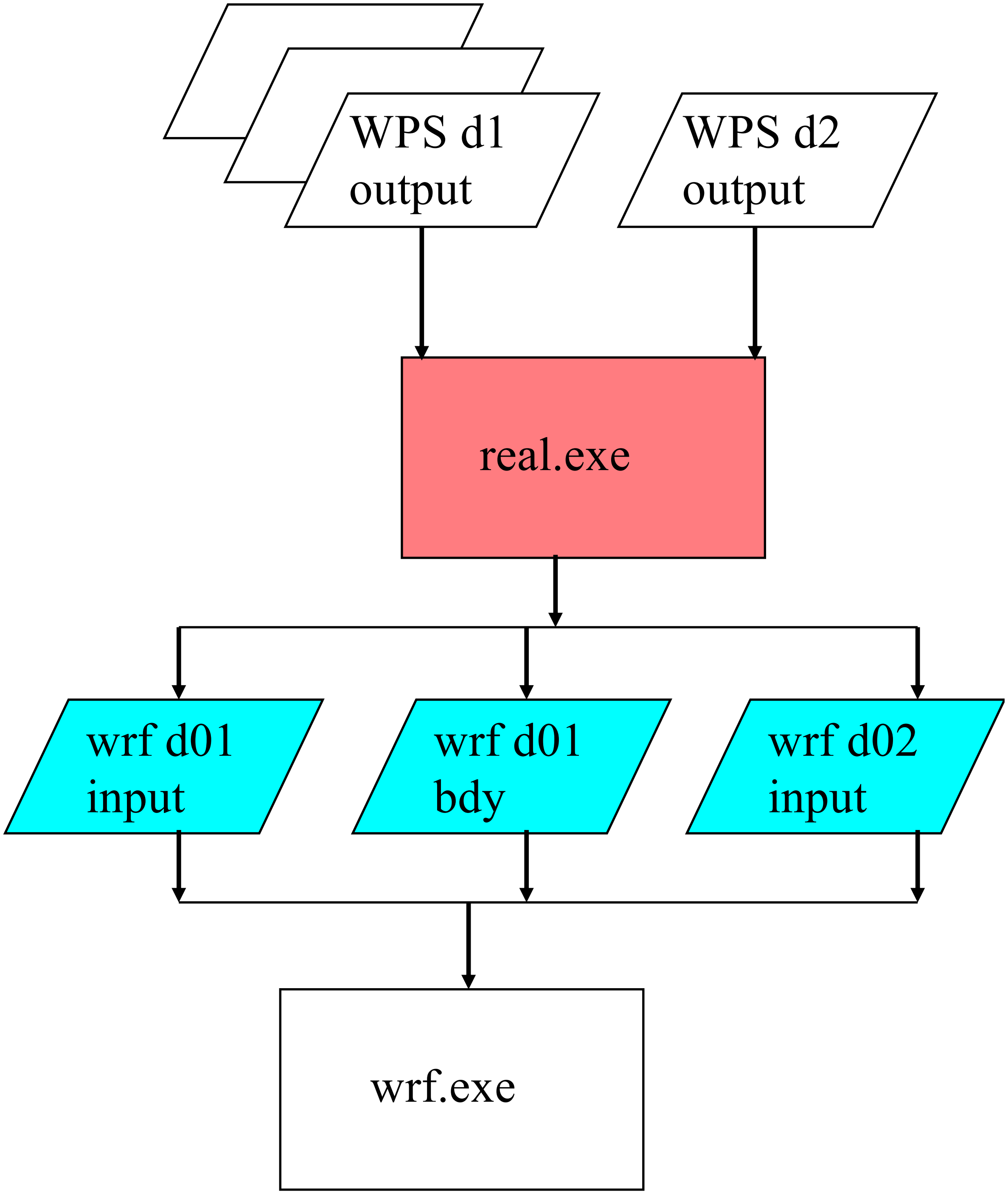


Real program in a nutshell

- Function
- Standard input variables
- Base State
- Standard generated output
- Vertical interpolation
- Soil level interpolation

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

- 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

Function

- **Run-time options**
  - specified in the Fortran namelist file (namelist.input for real and WRF)

- **Compile-time options**
  - Changes inside of the source code
  - Compiler flags
  - CPP ifdefs
  - Modifications to the Registry file

Standard Input Variables

- The metgrid program typically provides meteorological data to the real program.
- Coordinate:
  - The real program is able to input and correctly process any ***strictly monotonic*** vertical coordinate
    - Isobaric: OK
    - Sigma: OK
    - Hybrid: OK

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 – ***inside of the WRF model***
- No base state computations are required ***prior to the real program***

Hybrid Vertical Coordinate

- WRF has the capability to have a ***HVC*** hybrid vertical coordinate
  - a ***terrain following*** coordinate near the surface
  - relaxing to ***isobaric surfaces aloft***
- This is the ***default*** starting with version 4.0

Hybrid Vertical Coordinate

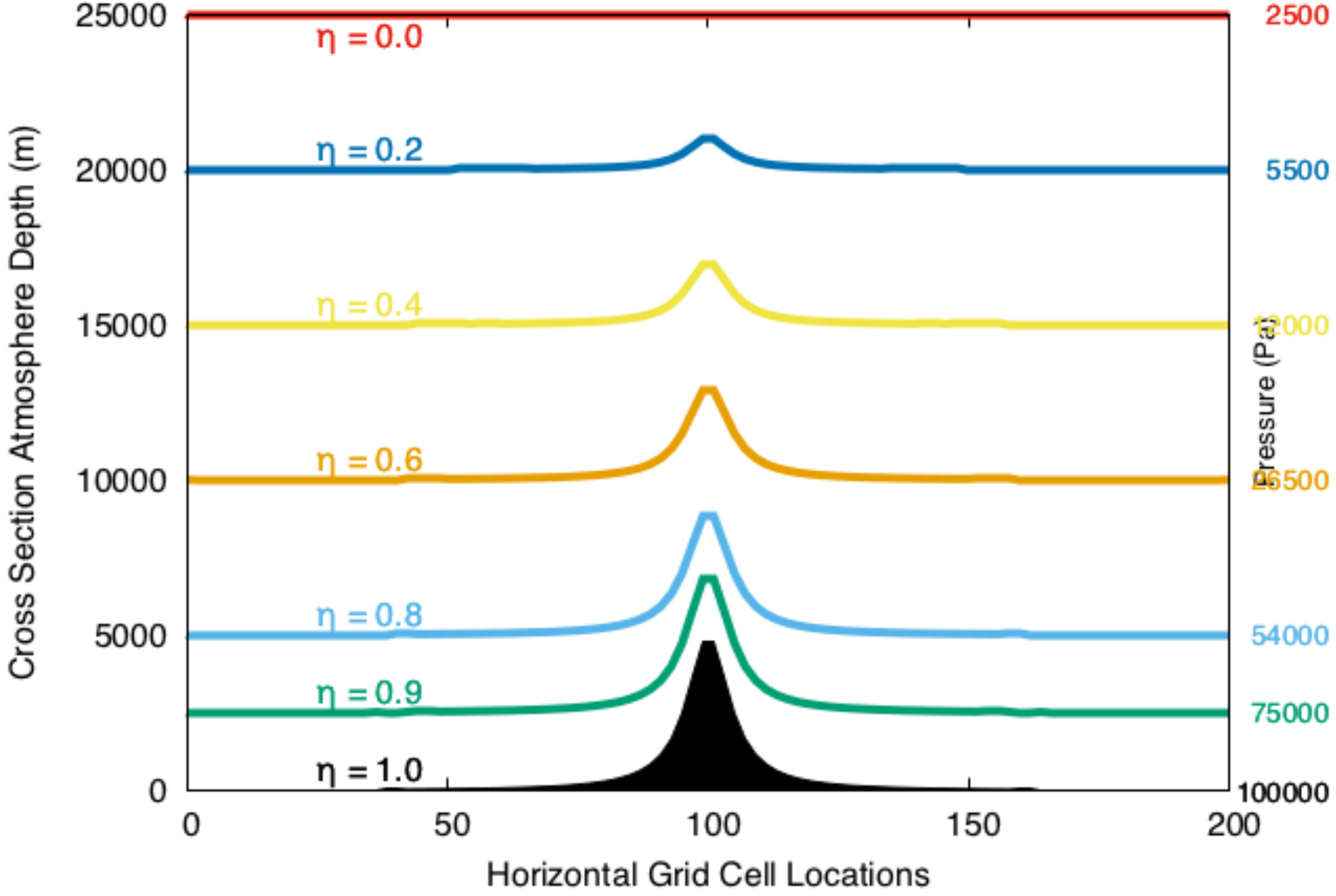
- The default run-time option is to use a hybrid vertical coordinate:

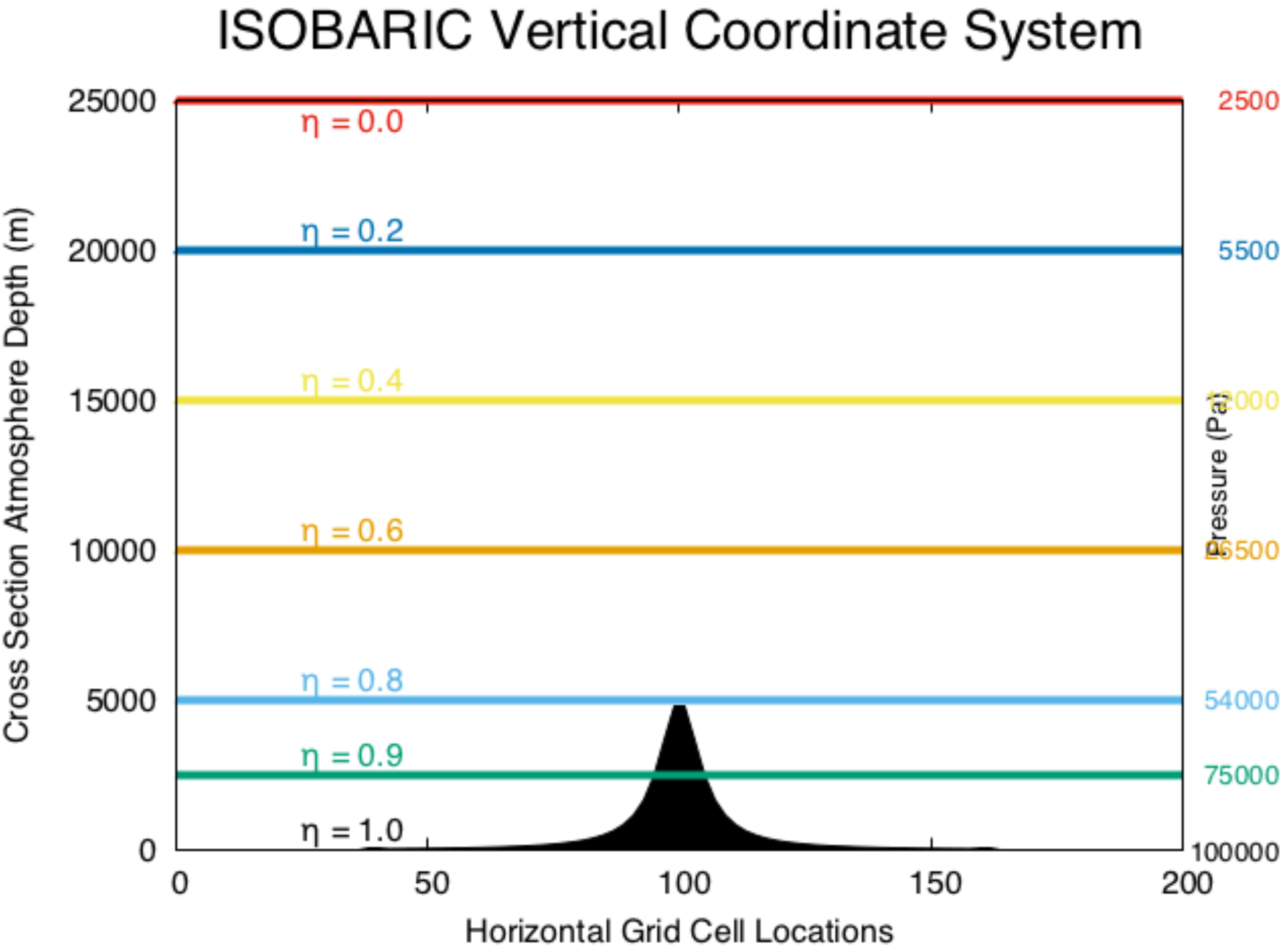
```
&dynamics
hybrid_opt = 2
/
```

- To turn the option off, to run with a terrain-following coordinate:

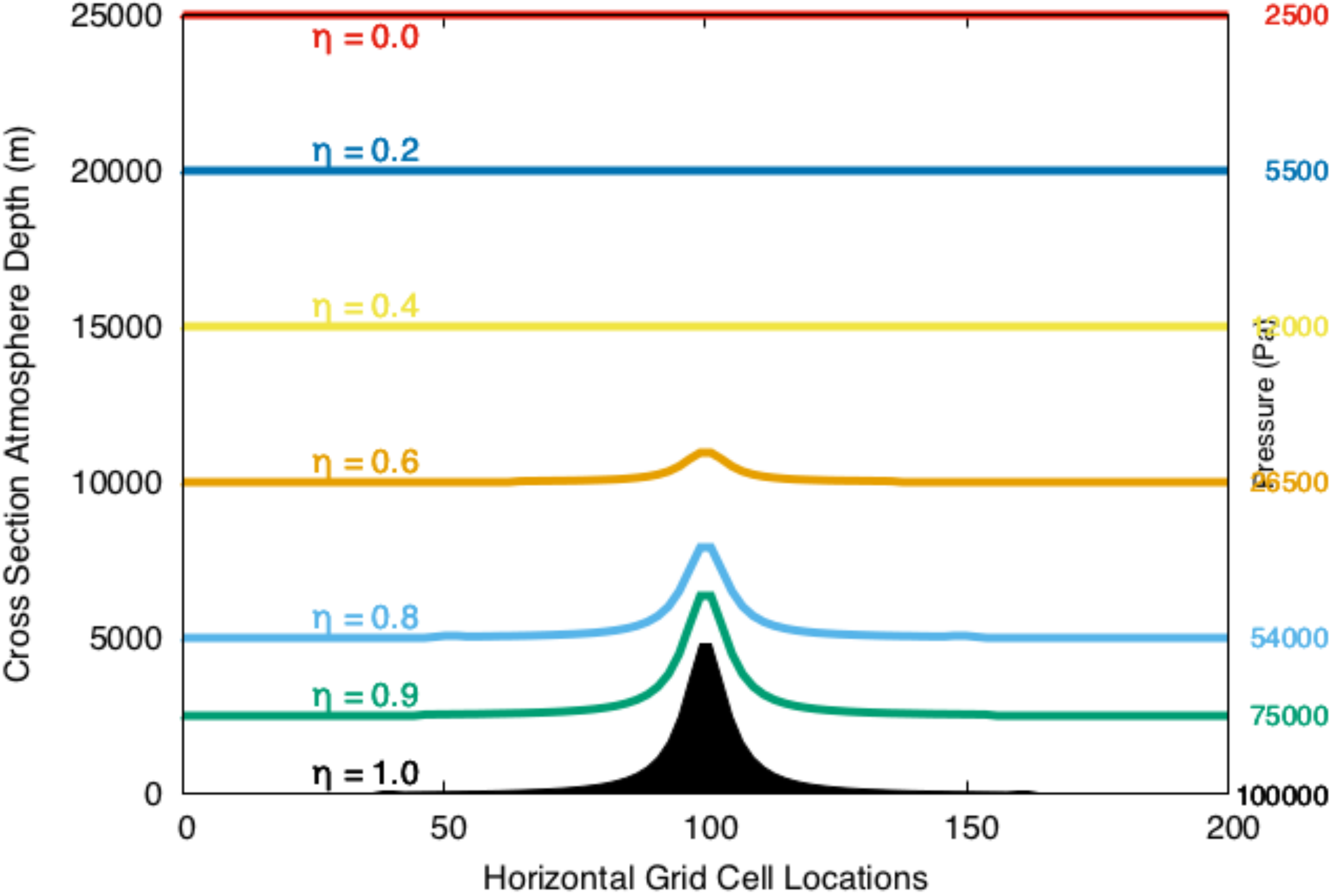
```
&dynamics
hybrid_opt = 0
/
```

TERRAIN FOLLOWING Vertical Coordinate Systen




ISOBARIC Vertical Coordinate System
Cross Section Atmosphere Depth (m)
25000
20000
15000
10000
5000
0
η = 0.0
η = 0.2
η = 0.4
η = 0.6
η = 0.8
η = 0.9
η = 1.0
2500
5500
12000
26500
54000
75000
100000
Pressure (Pa)
0
50
100
150
200
Horizontal Grid Cell Locations

HYBRID Vertical Coordinate System



Moist Potential Temperature

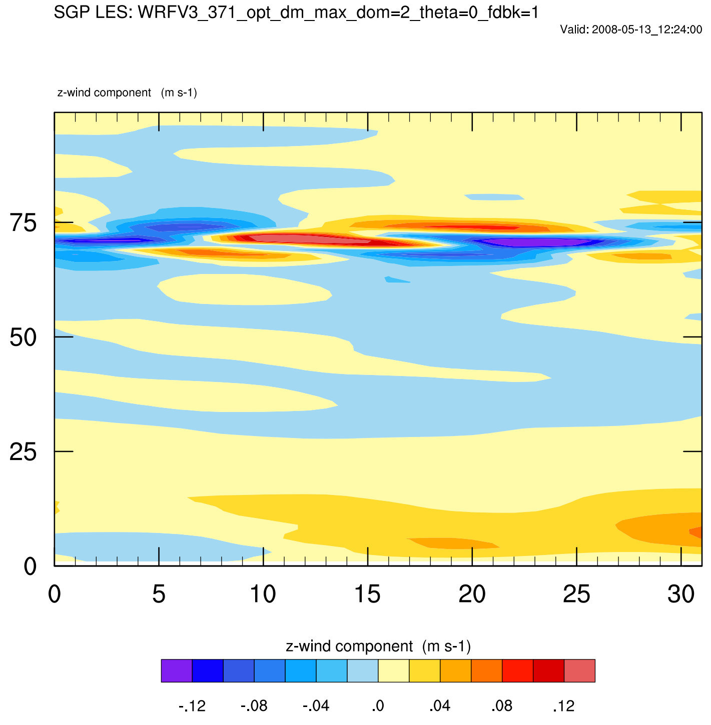
- The potential temperature outside of physics used in the WRF model equations may optionally be a “moist” potential temperature perturbation

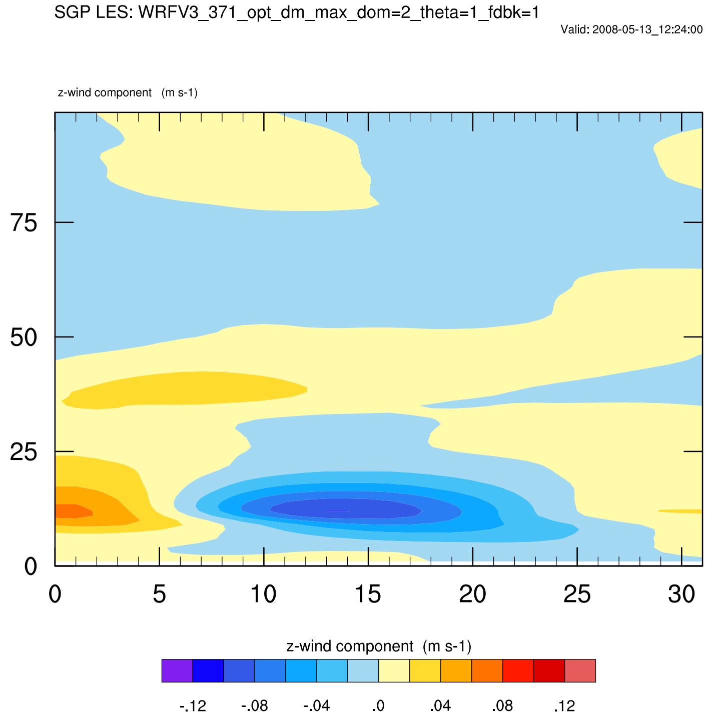
- WRF theta ***(dry)*** = T (p0 / p)^ (Cp / Rd) - 300
- WRF theta ***(moist)*** = T (p0 / p)^ (Cp / Rd) ***(1+Rv/Rd) Qv*** – 300

- The moist option is the ***default*** since v4.0

Moist Potential Temperature

- This has been found to give better and more stable solutions in some LES cases with vertical moisture gradients with vertical shear





Moist Potential Temperature

- The default run-time option is to use the moist potential temperature perturbation

```
&dynamics
use_theta_m = 1
/
```

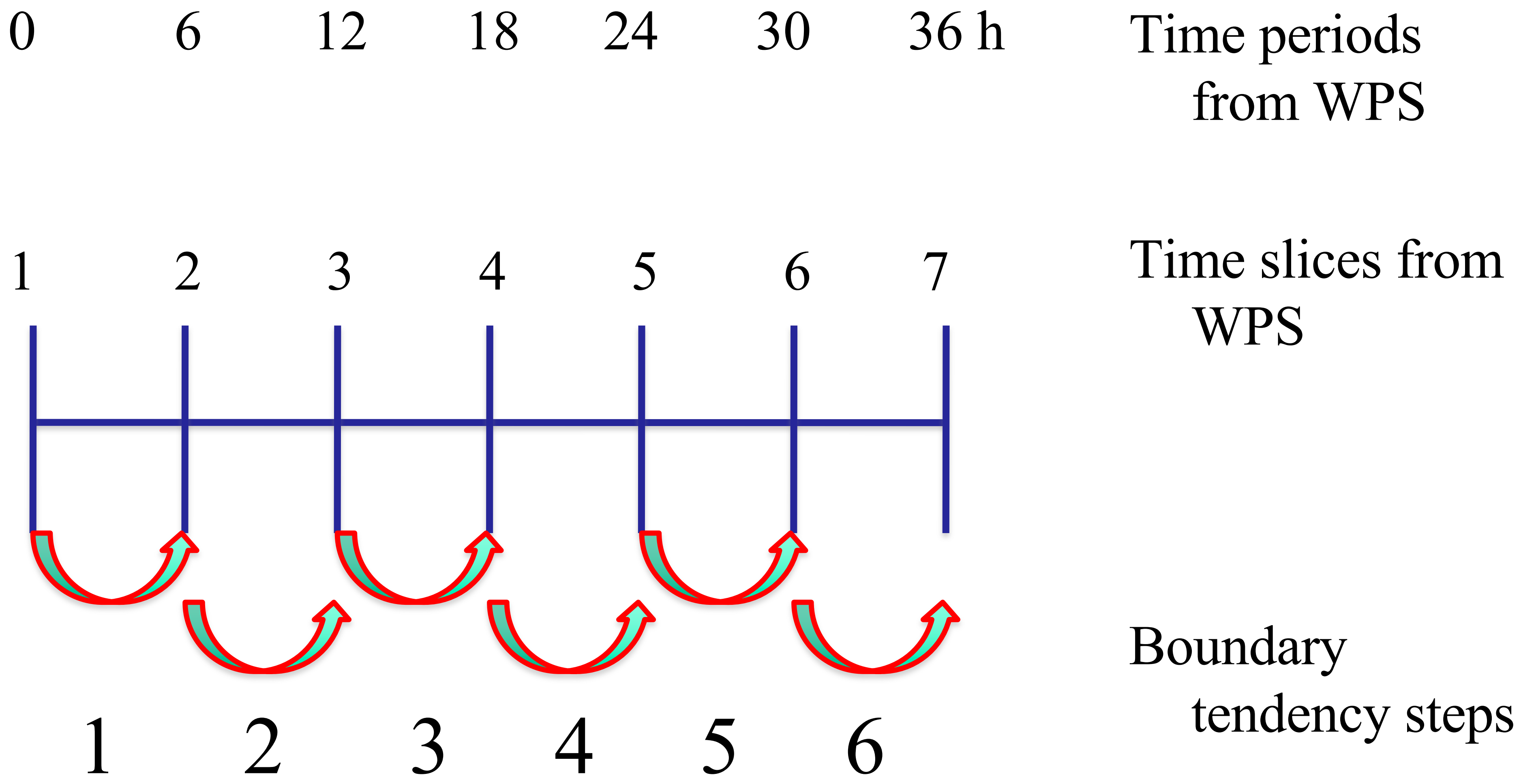
- To turn the option off, to run with the dry potential temperature

```
&dynamics
use_theta_m = 0
/
```

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 (look at MPAS for global simulations)
- 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

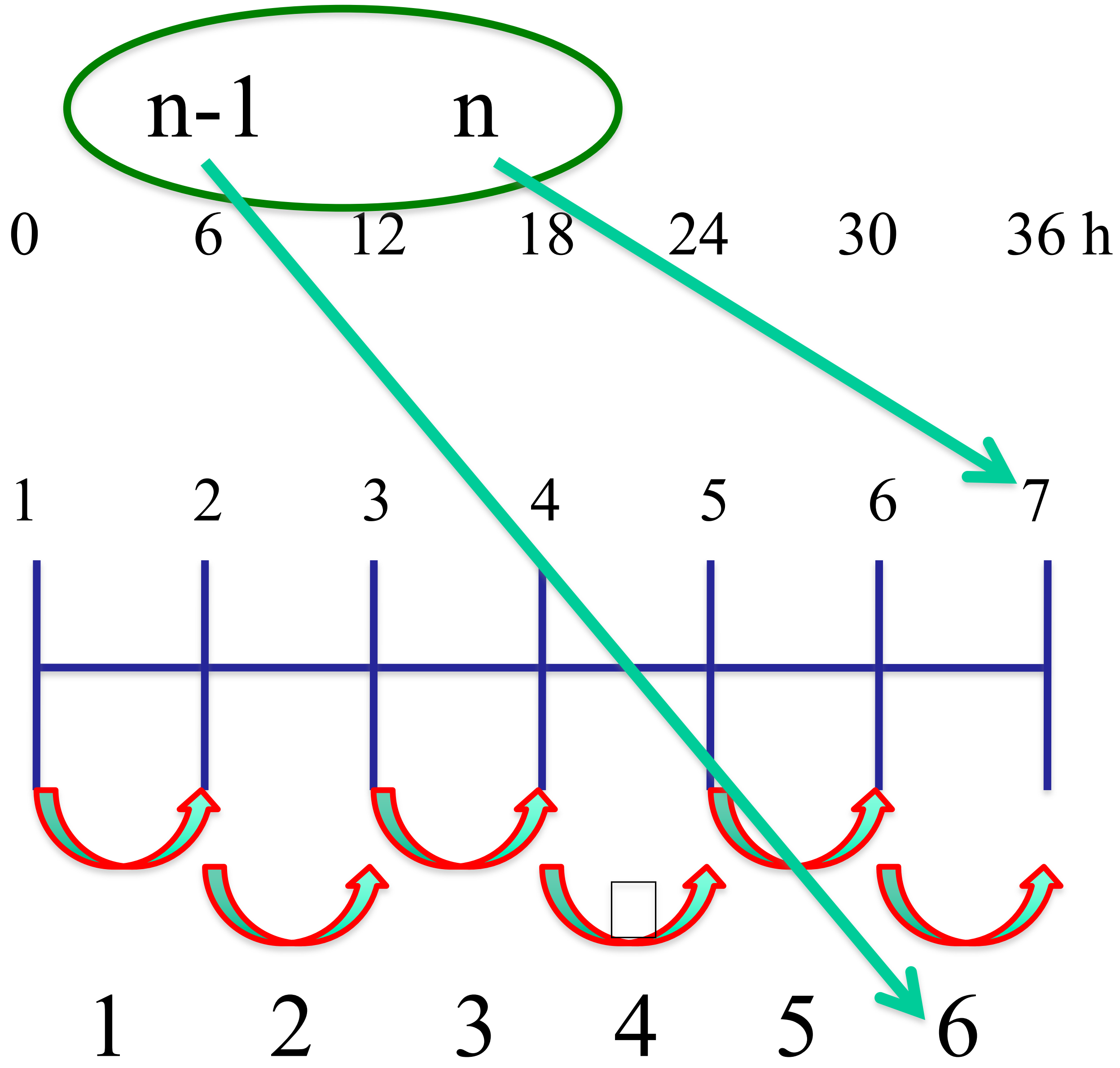
1 2 3 4 5 6 7

Time slices from WPS

Boundary tendency steps

1 2 3 4 5 6

Lateral Boundary Condition Times

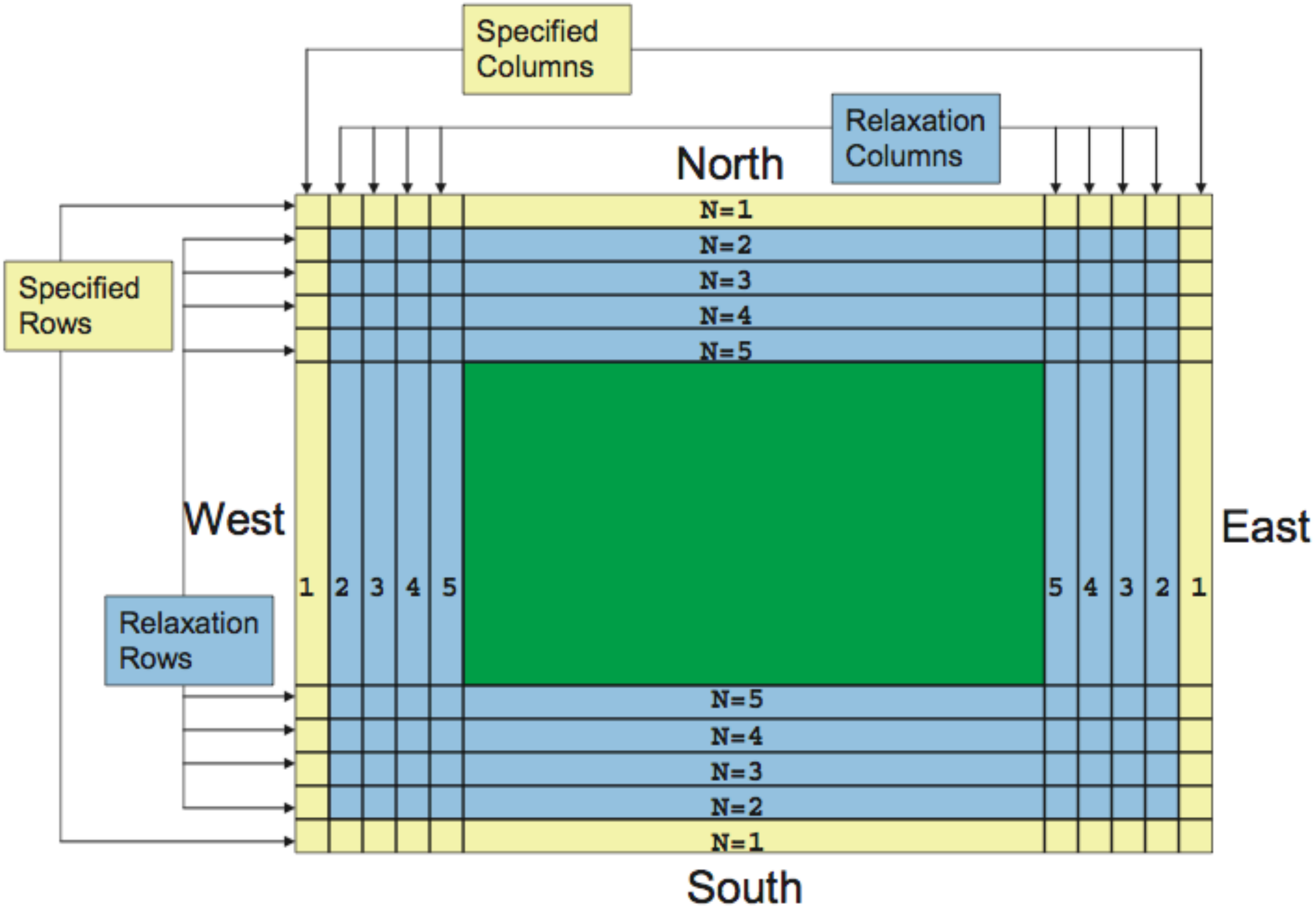


Time periods from WPS

Time slices from WPS

Boundary tendency steps

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



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

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

The ***η surfaces*** may be computed or selected

Vertically interpolate input fields in pressure to the ***η surfaces*** in dry pressure: default all variables linear in log(pressure)

Vertical Interpolation

- Select reasonable η 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
- It is ***SAFEST to NOT initially choose η values***
  - Initially, ***select the number*** of ετα levels
  - ***Plot profiles*** of the resultant heights
  - ***Adjust the η levels*** accordingly

- A few namelist options, the terrain elevation, and eta levels completely define the model coordinate for the WRF code

Vertical Interpolation

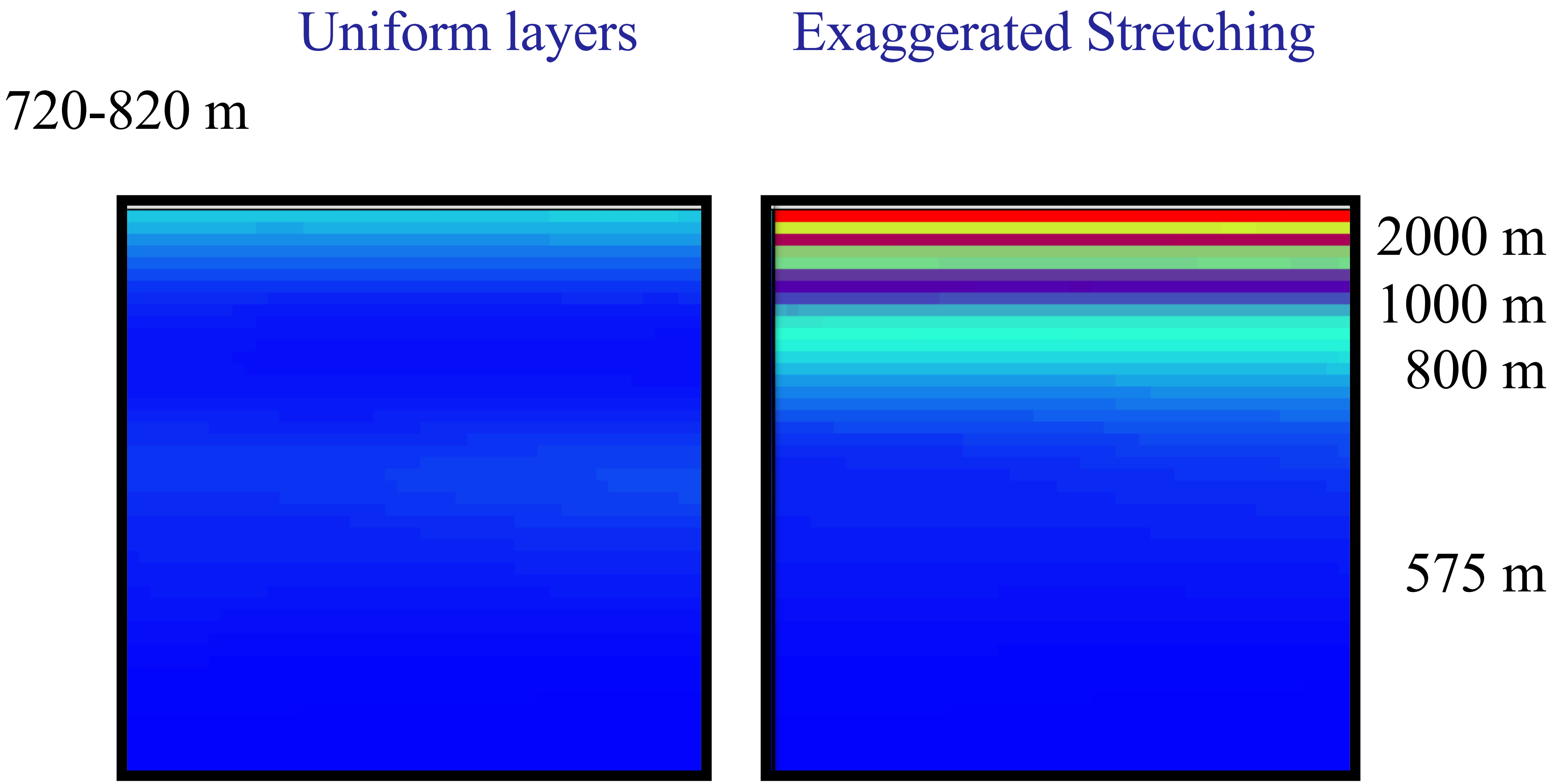
- The *η* ***surfaces*** are computed with a few NML parameters:

```
&domains
e_vert                = 50,     50,    50
p_top_requested       = 1000,

&dynamics
base_temp             = 290.
iso_temp              = 200
```

Vertical Interpolation

Vertical cross sections of THICKNESS of each model layer, with 50 vertical levels above the PBL, ptop = 10 hPa.



Uniform layers

Exaggerated Stretching

Physical Parameterization Settings

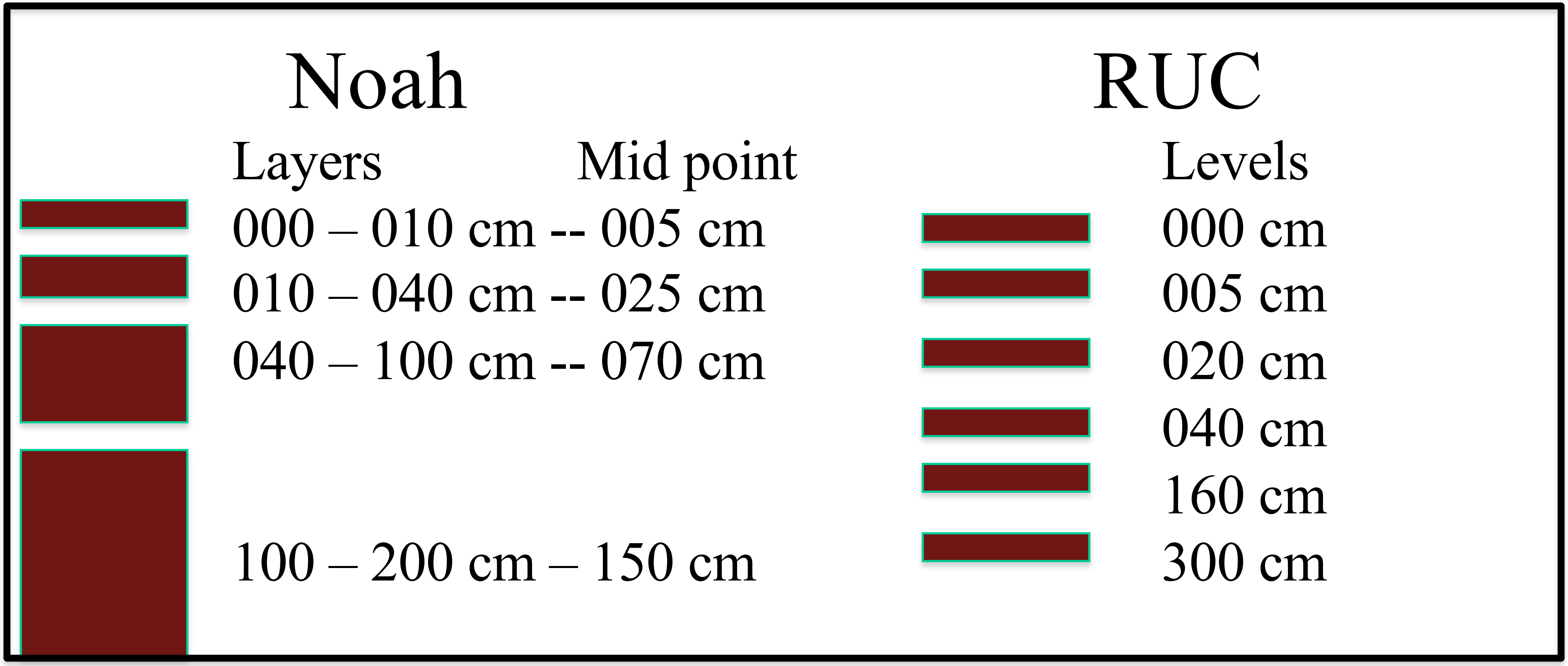
- The real program and the WRF model are ***tightly coupled***

- Many ***physical parameterization*** settings and other options used by the WRF model are ***initialized by the real*** program

- If you ***change physics options***, it is safest to ***re-run*** the real program

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

Layers Mid point

000 – 010 cm -- 005 cm

010 – 040 cm -- 025 cm

040 – 100 cm -- 070 cm

100 – 200 cm – 150 cm

RUC

Levels

000 cm

005 cm

020 cm

040 cm

160 cm

300 cm

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