WRF Initialization Program for Real Data: *real*

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WRF Virtual Tutorial, July 2025

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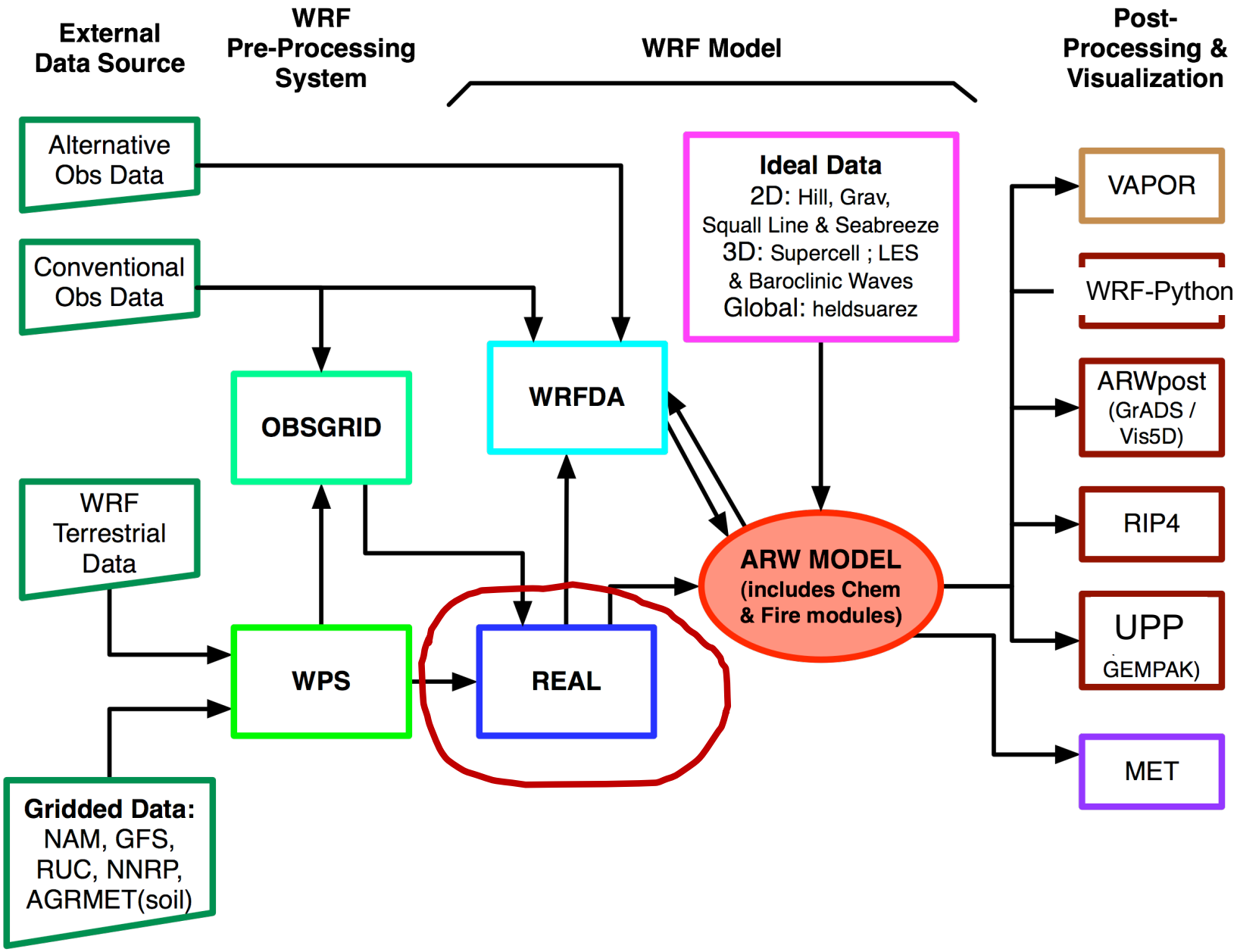
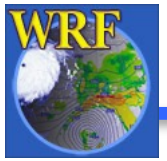
This material is based upon work supported by the National Center for Atmospheric Research, which is a major facility sponsored by the National Science Foundation under Cooperative Agreement No. 1852977.

WRF Modeling System Flow Chart



In this talk…

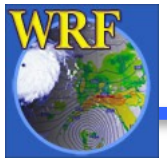
- Basic functions of the program
- Defining vertical coordinates
- Lateral boundary condition file
- Input / output from the program
- Data flow in the program
- Code
- Common user options



Purposes of Program *real*

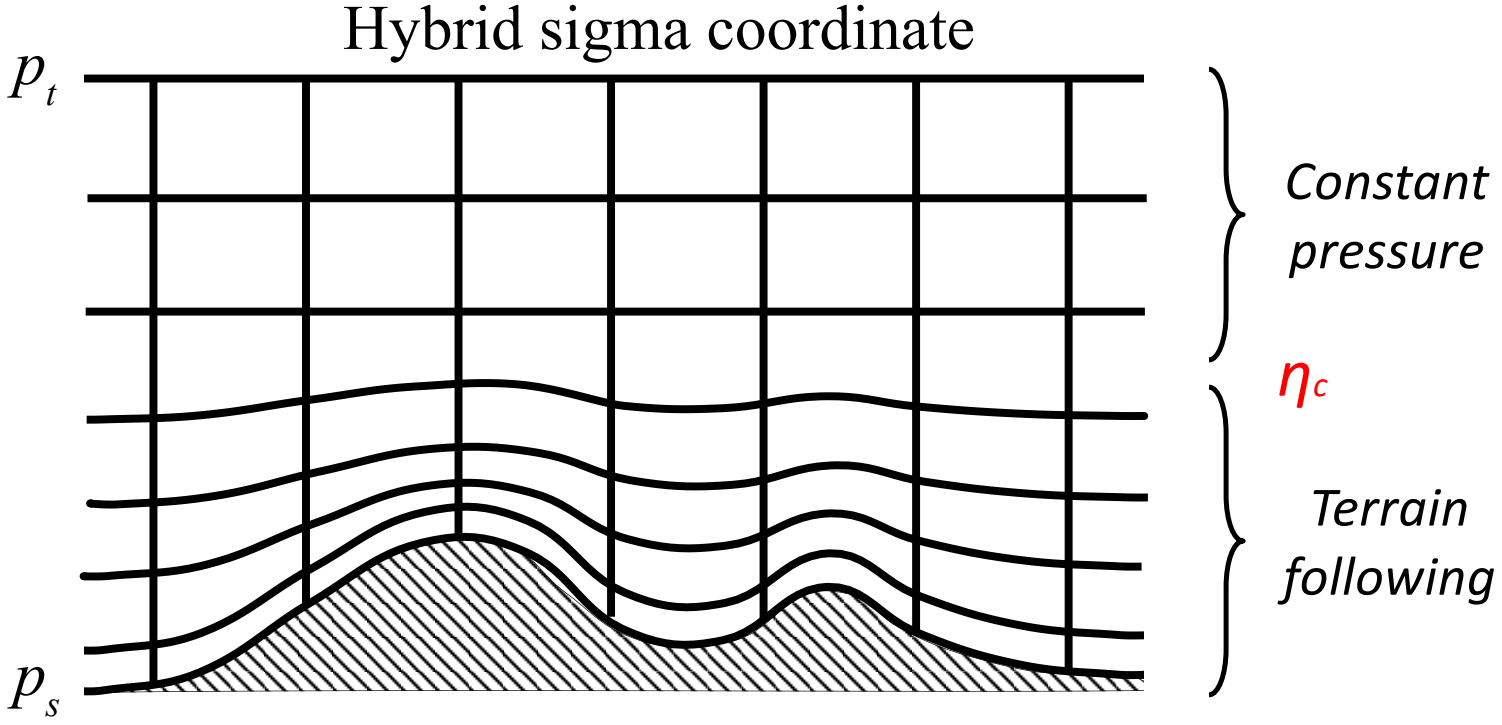
Getting data ready for WRF model integration

- **Defines model vertical coordinate levels**
- Defines model base state
- **Interpolates data in the vertical to model levels**
- Interpolates soil data below ground to land-surface model levels
- Adjusts soil data (*based on landmask*)
- Does vertical dynamic (*hydrostatic*) balance
- Computes model variables (*reference and perturbation variables, mixing ratio, geopotential, moist potential temperature, etc.*)
- Passes input for physics (*based on namelist choices*)
- **Creates initial and boundary condition files** for real-data cases from *WPS/metgrid* output
- **Creates initial condition files for all nests**



Vertical Coordinate

The vertical hybrid coordinate of WRF model is a *hybrid* between terrain-following near ground and constant pressure at upper levels



η_c *or etac is a namelist variable a user can adjust, etac = 0.2*

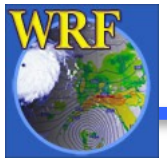
Defining Vertical Levels

Two ways to define vertical hybrid coordinate.

Coordinate Definition: $$\eta = \frac{p_d - p_t}{p_s - p_t}$$

First way, explicitly defining the coordinate values:

`e_vert`	Number of vertical (interface) levels
`p_top_requested`	Model top pressure
`eta_levels`	1.0, 0.992, 0.980,… 0.1 *(if you have access to the coordinate values)*



Defining Vertical Levels

Second way: more *analytical*

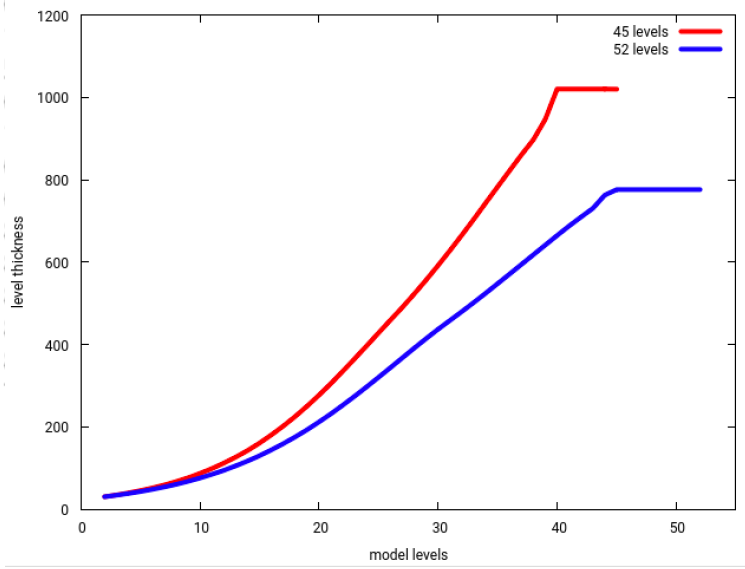
`e_vert`	Number of vertical (interface) levels
`p_top_requested`	Model top pressure
`dzbot`	Lowest model layer thickness (e.g. 30 m)
`max_dz`	Maximum layer thickness
`dzstretch_s`	Stretching factor near surface (PBL)
`dzstretch_u`	Stretching factor in free atmosphere

➡ *The goal is the have vertical grid spacing varying as smoothly as possible*

Defining Vertical Levels

When running *real* program, it will output the layer thickness values in rsl.out.0000 file:

```
Full level index =   22     Height =  2899.0 m     Thickness =  334.6 m
Full level index =   23     Height =  3264.2 m     Thickness =  365.2 m
Full level index =   24     Height =  3660.6 m     Thickness =  396.4 m
Full level index =   25     Height =  4088.5 m     Thickness =  427.9 m
Full level index =   26     Height =  4547.7 m     Thickness =  459.2 m
Full level index =   27     Height =  5037.7 m     Thickness =  490.0 m
Full level index =   28     Height =  5560.1 m     Thickness =  522.4 m
Full level index =   29     Height =  6116.3 m     Thickness =  556.2 m
Full level index =   30     Height =  6707.8 m     Thickness =  591.4 m
Full level index =   31     Height =  7335.7 m     Thickness =  627.9 m
Full level index =   32     Height =  8001.1 m     Thickness =  665.5 m
Full level index =   33     Height =  8705.1 m     Thickness =  704.
Full level index =   34     Height =  9448.2 m     Thickness =  743.
Full level index =   35     Height = 10230.7 m     Thickness =  782.
Full level index =   36     Height = 11052.3 m     Thickness =  821.
Full level index =   37     Height = 11912.4 m     Thickness =  860.
Full level index =   38     Height = 12809.4 m     Thickness =  897.
Full level index =   39     Height = 13756.0 m     Thickness =  946.
Full level index =   40     Height = 14775.8 m     Thickness = 1019.
Full level index =   41     Height = 15795.5 m     Thickness = 1019.
Full level index =   42     Height = 16815.3 m     Thickness = 1019.
Full level index =   43     Height = 17835.0 m     Thickness = 1019.
Full level index =   44     Height = 18854.8 m     Thickness = 1019.
Full level index =   45     Height = 19874.5 m     Thickness = 1019.
```



Defining Vertical Levels

Program ***real.exe:*** *Method 2 (See User's Guide)*

Minimum number of vertical levels (e_vert) for various ptop levels (mb) when ***auto_levels_opt=2, dzbot=30m, max_dz=1000m,*** *and* ***dzstretch_s = dzstretch_u,*** *and are set to values listed below*

dzstretch_s	dzstretch_u	ptop value (in mb)				
		50	30	20	10	1
1.1	1.1	50	53	55	59	72
1.2	1.2	35	38	40	44	57

Minimum number of vertical levels (e_vert) when ***auto_levels_opt=2, dzbot=30m, max_dz=1000m,*** *and* ***dzstretch_s*** *and* ***dzstretch_u*** *are set as listed below*

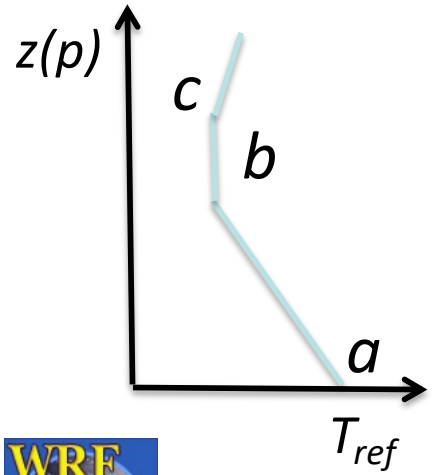
dzstretch_s	dzstretch_u	ptop value (in mb)				
		50	30	20	10	1
1.2	1.02	56	61	65	70	84
1.2	1.04	49	52	54	58	71
1.2	1.06	44	47	50	53	66

Base State Parameters

User-defined parameters (default available)

– related to defining reference state and perturbation fields

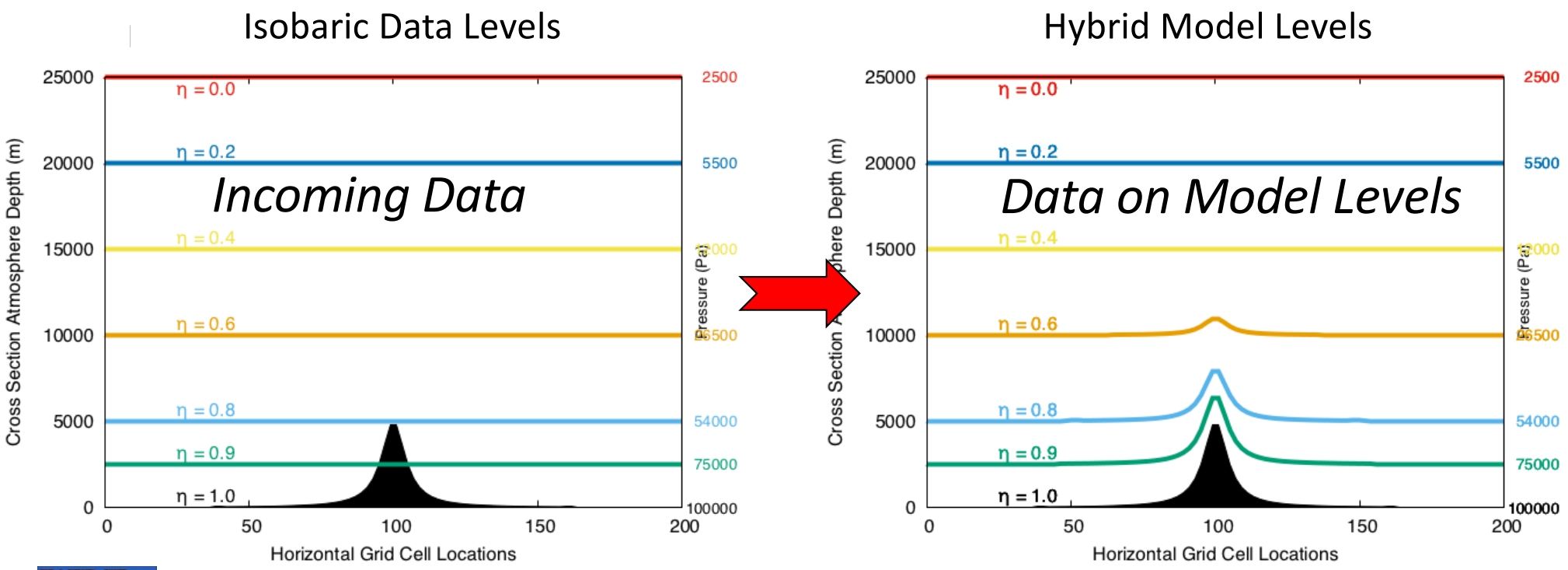
`base_temp`[a]	Base state surface temperature (290 K)
`iso_temp`[b]	Base state stratosphere temperature (200 K)
`base_pres_strat`[c]	Pressure at which the stratosphere temperature lapse rate changes (5500 hPa)



The purpose is to minimize perturbation fields to improve solution accuracy when discretized.

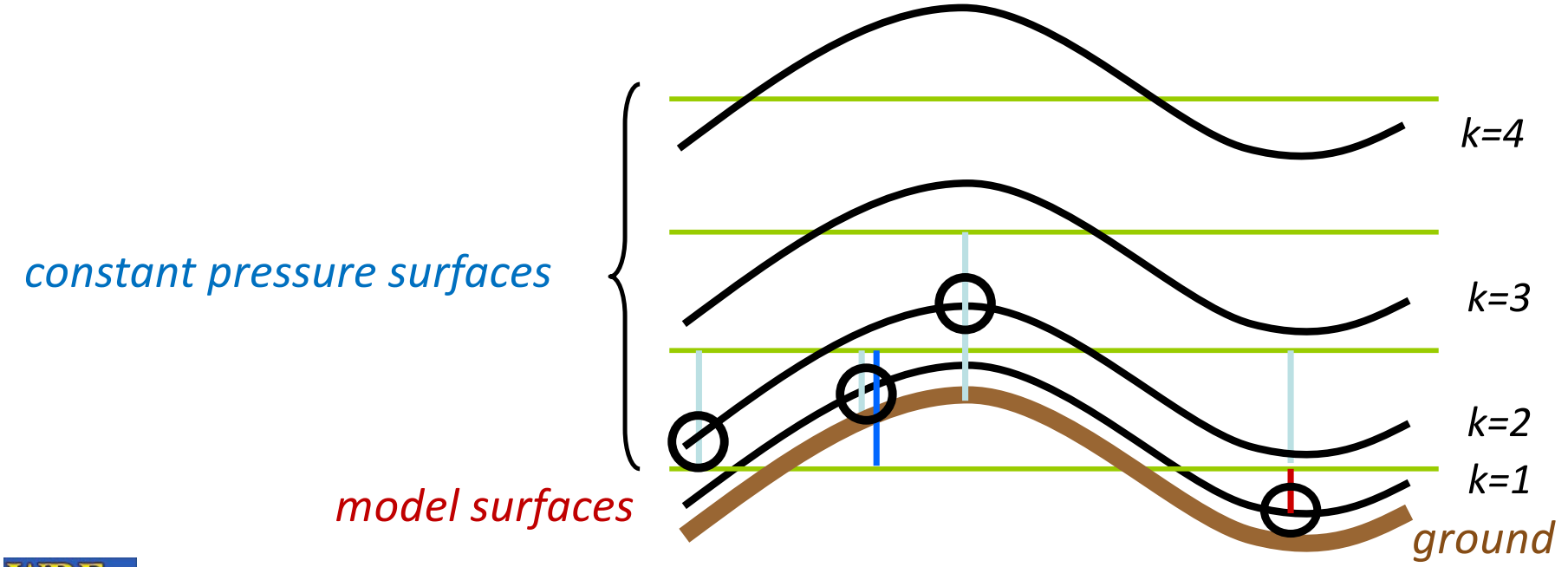
Vertical Interpolation in Atmosphere

real: Interpolates data from external sources to WRF model vertical coordinate



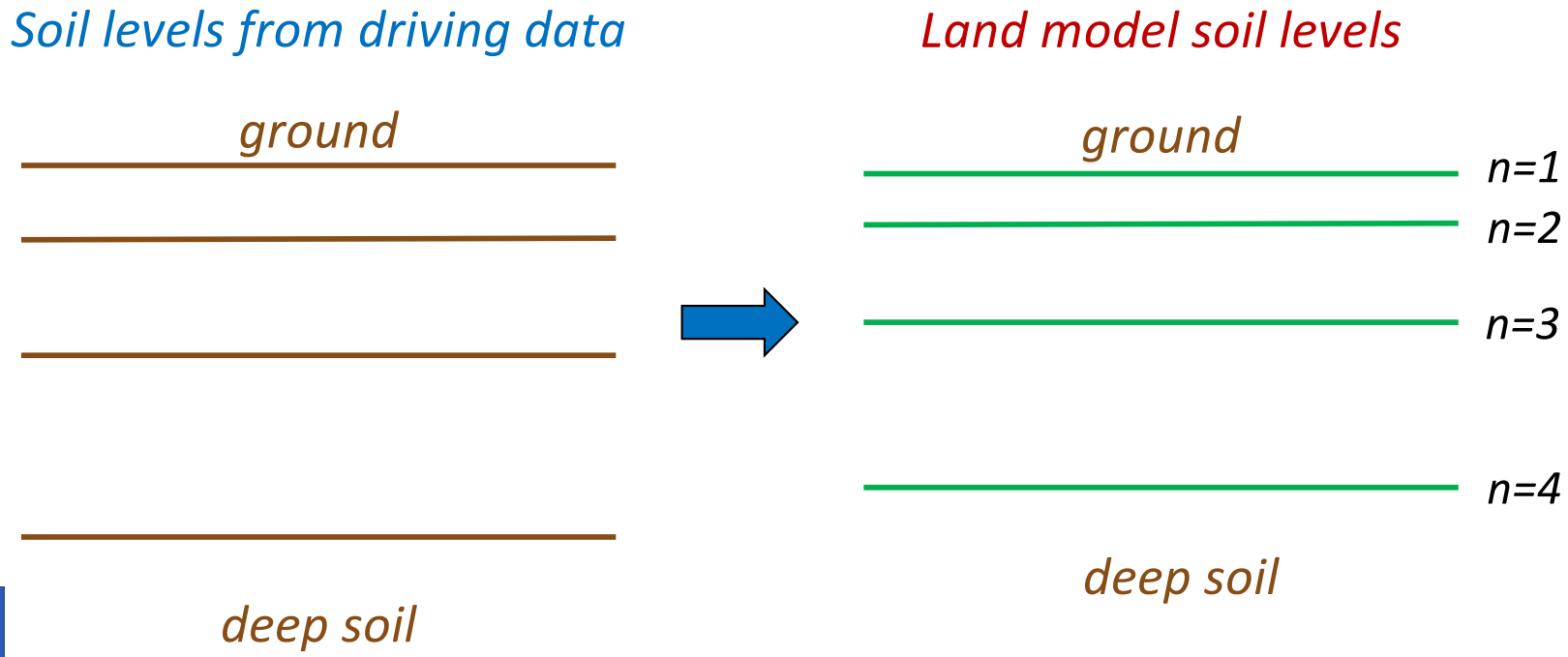
Vertical Interpolation in Atmosphere

- Vertical interpolation away from the ground (e.g. linear in log(p))
- Vertical interpolation near ground (e.g. do we want to use surface analysis)

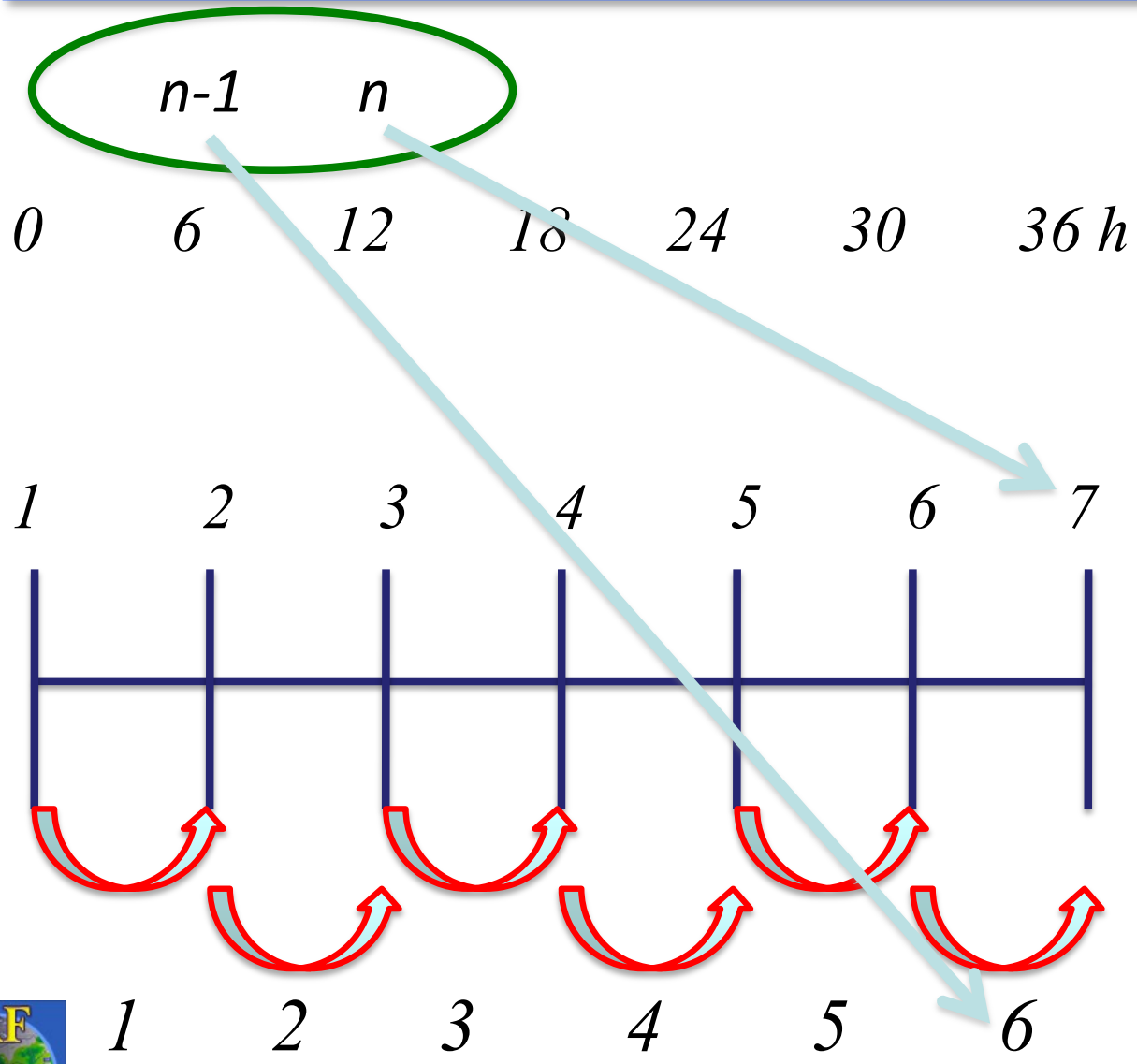


Vertical Interpolation in Soil

- Model soil levels may not be the same as those in driving data
- Number of soil levels depends on LSM choices.



Lateral Boundary Condition Times

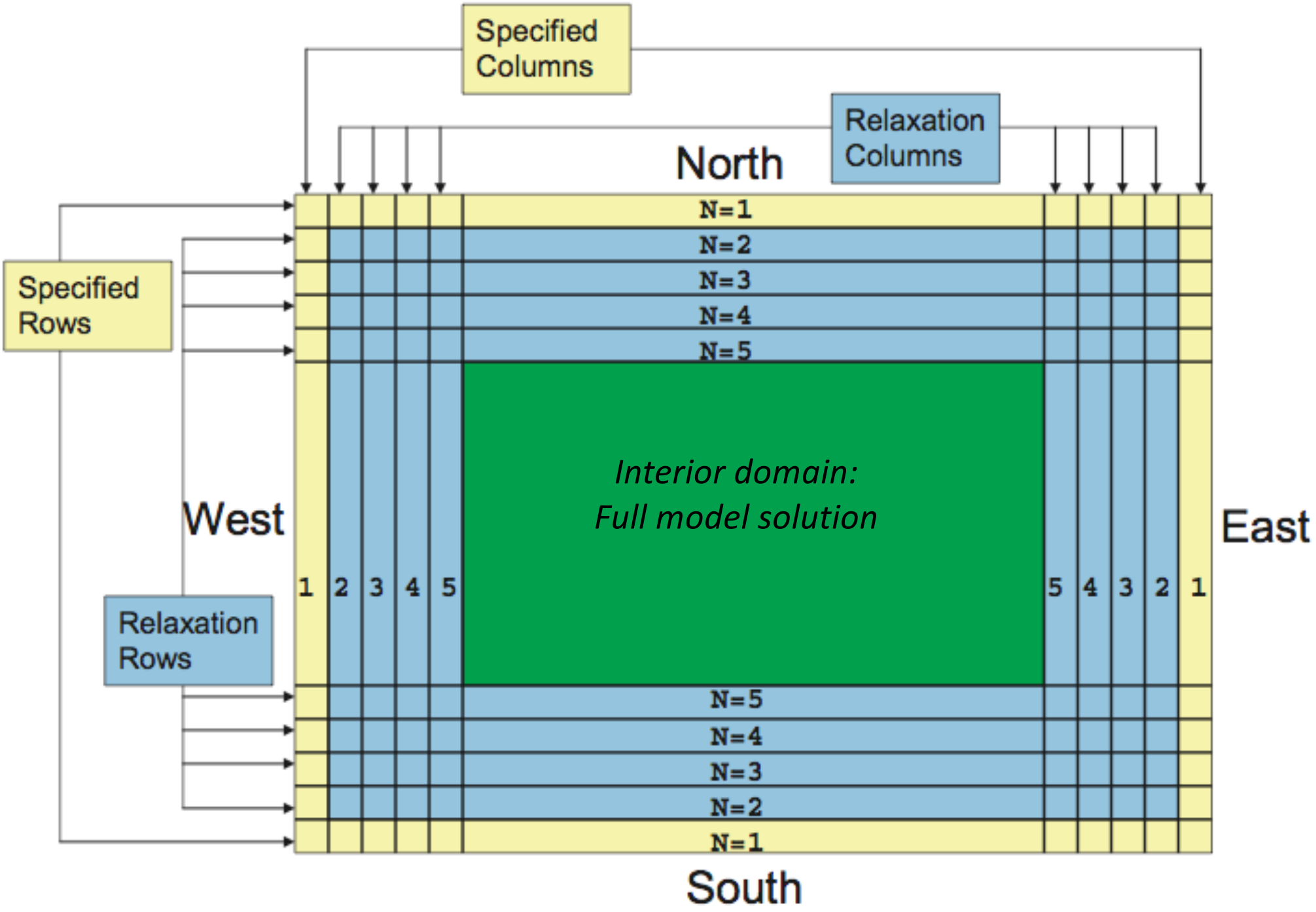


Time periods from WPS

Time slices from WPS

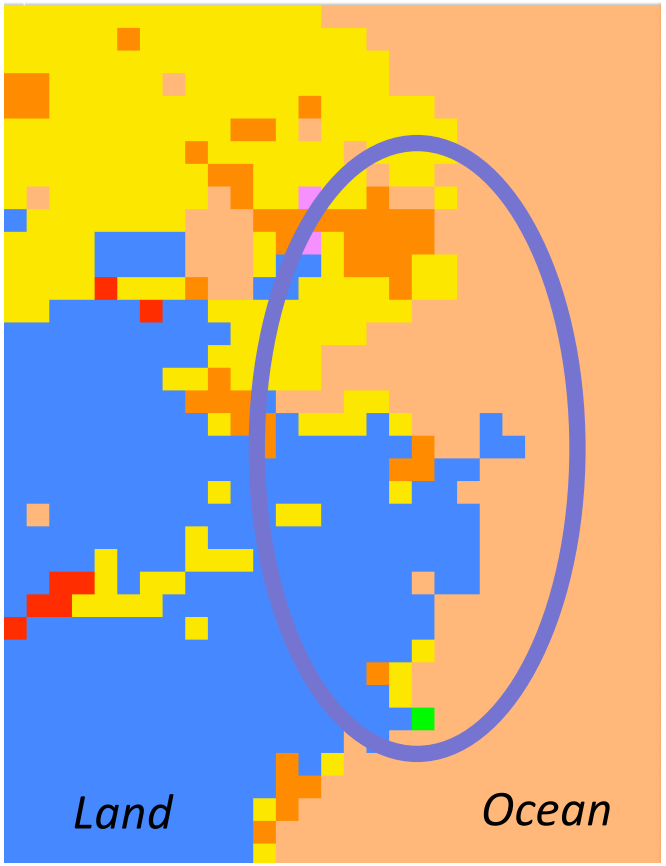
Boundary tendency steps

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

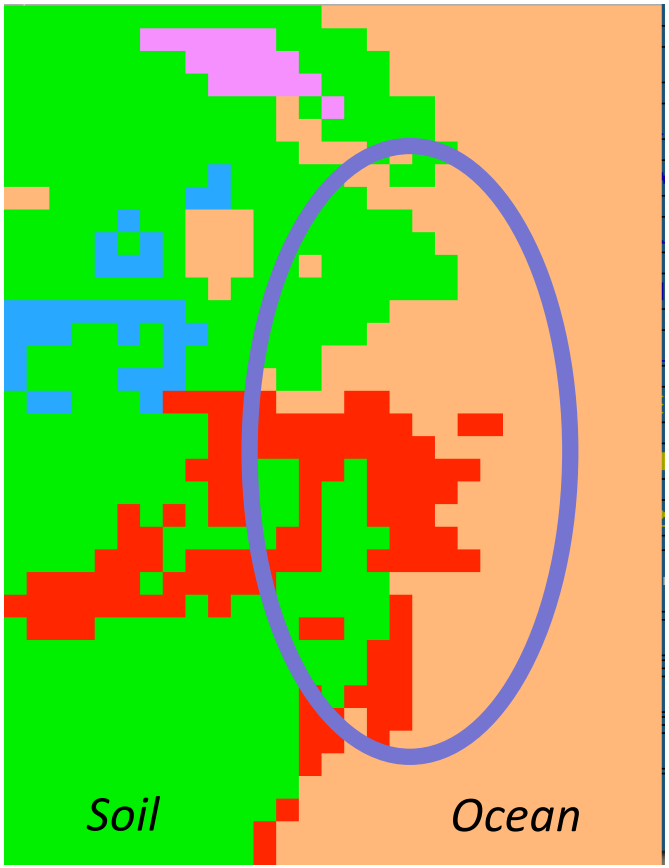


Soil Data Adjustment

Landuse Category Data



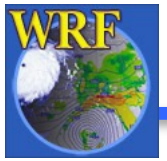
Soil Category Data



Need to adjusting Soil data based on landuse data

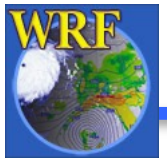
Input to *real*

- Meteorological data from external sources, either on constant pressure levels or native model levels:
  - **`met_em.d01.*`, `met_em.d02.*`, `etc.`**
- Mandatory fields required by the model:
  - 3D U, V, T, relative humidity (or specific humidity or water vapor mixing ratio), pressure, geopotential height
  - Surface pressure and/or MSLP, soil temperature and moisture, surface U, V, T, RH (or specific humidity or water vapor mixing ratio)
  - Static fields processed by geogrid program: terrain, landuse, soil categories, etc.



Output from *real*

- Model initial and boundary files – contains all meteorological data as well as static fields:
  - **`wrfinput_d01`**, **`wrfbdy_d01`**
  - **`wrfinput_d0*`** for nests
- Lower boundary files (*for long simulations*)
  - **`wrflowinp_d0*`**
- If nudging option is turned on:
  - **`wrffdda_d0*`**

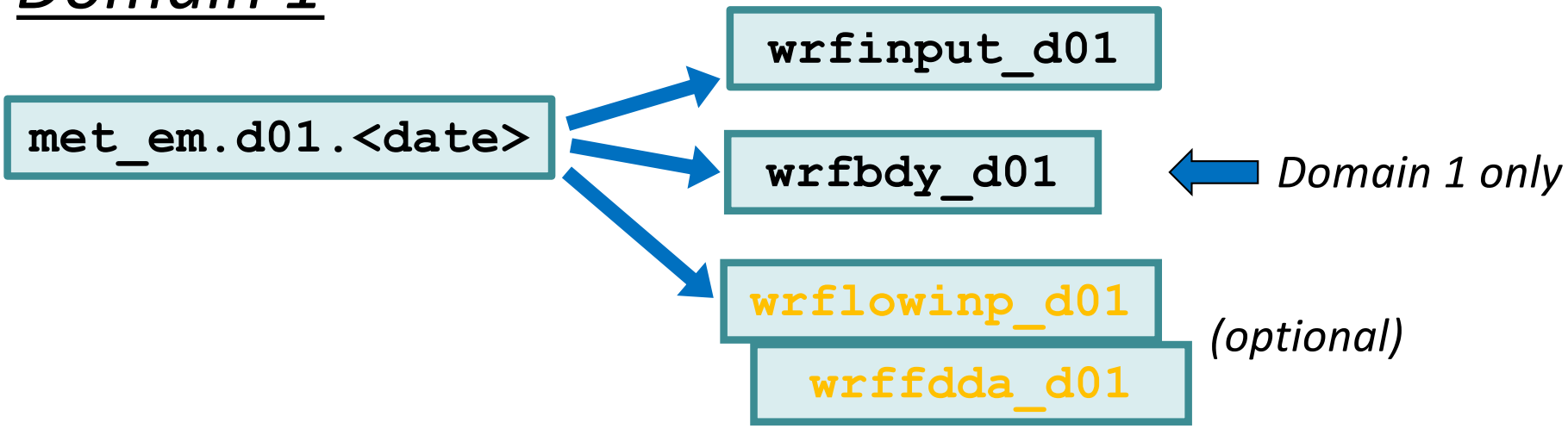


Output from *real*

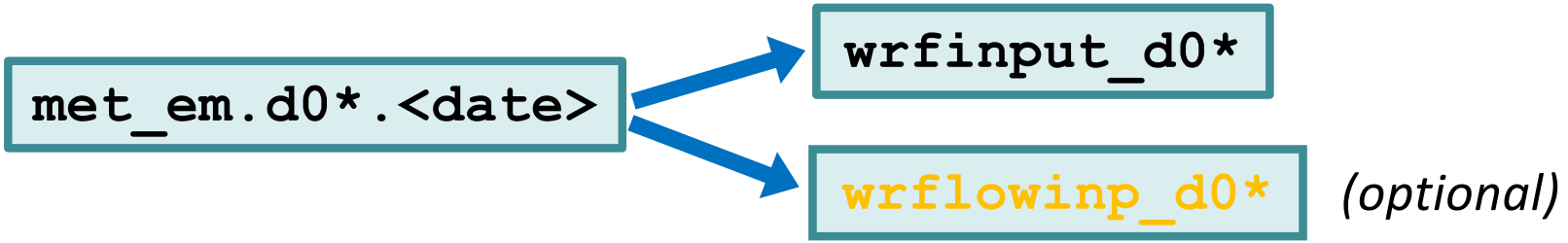
- **`wrfinput_<domain>`** files:
  - Atmospheric state at the model start time
  - 3D U, V, moist theta, water mixing ratio, base pressure, perturbation pressure, base geopotential, perturbation geopotential, microphysics fields (typically zero)
  - Dry column pressure, many other 2D fields
- **`wrfbdy_d01`** file:
  - Atmospheric variables at the beginning of the time window
  - Rate of change of the atmospheric variables in the time window
- **`wrflowinput_<domain>`** files:
  - SST, sea ice, vegetation fraction, etc.

Data Flow in Program *real*

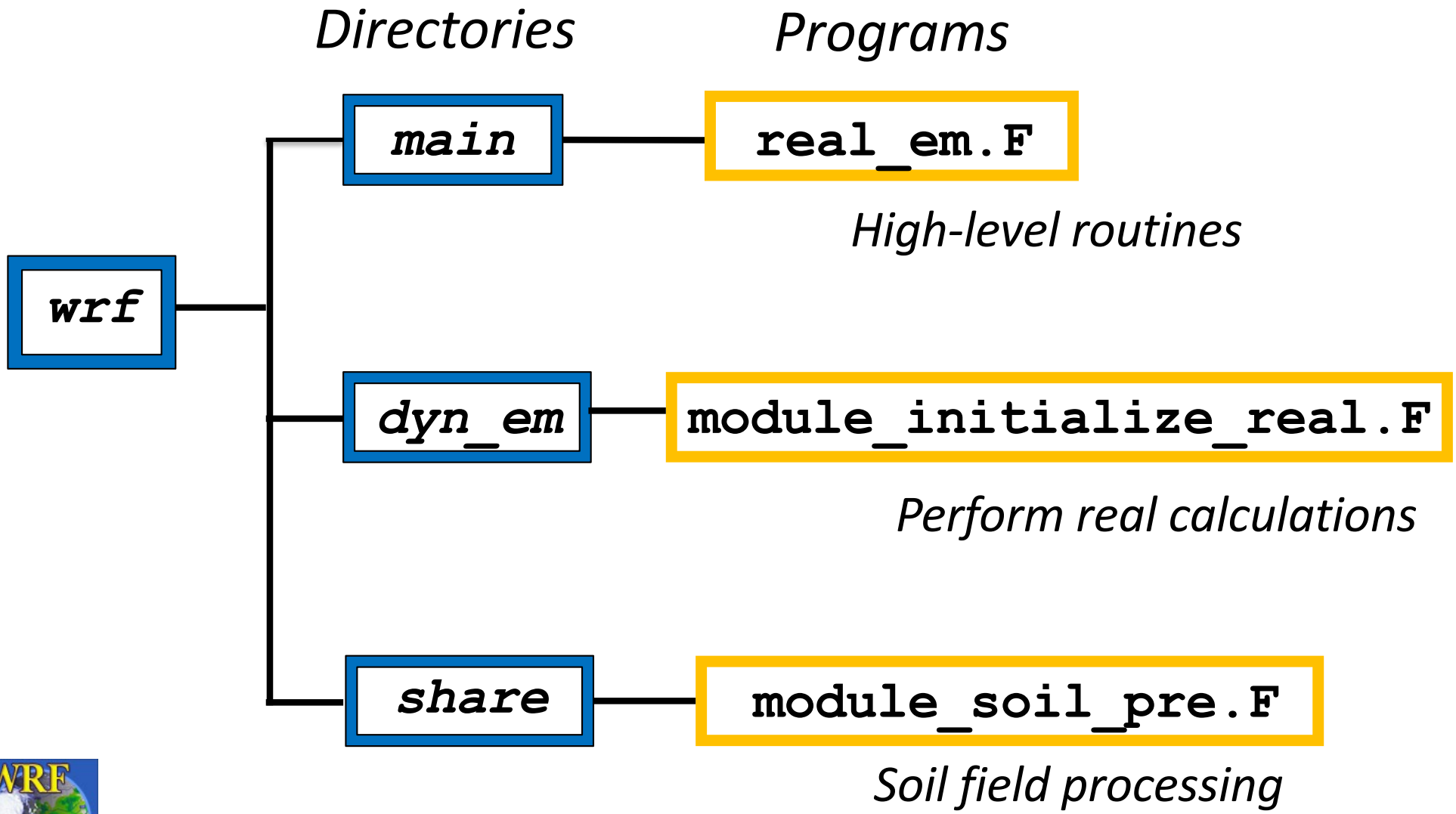
Domain 1



Nests



Source Code


Directories
Programs
main
real_em.F
High-level routines
wrf
dyn_em
module_initialize_real.F
Perform real calculations
share
module_soil_pre.F
Soil field processing

Common User Options

- Edit namelist.input, including all physics options – *some require special input data*
- Choose what land-surface model to use and number of land-model levels
- Choose and / or define number of model vertical levels (**`e_vert, eta_levels`**)

  - Require careful consideration
- Choose model top (**`ptop_requested`**)
- Choose lateral boundary zone – how many relaxation rows and columns