WRF ARW

Initialization for Real Data
real.exe

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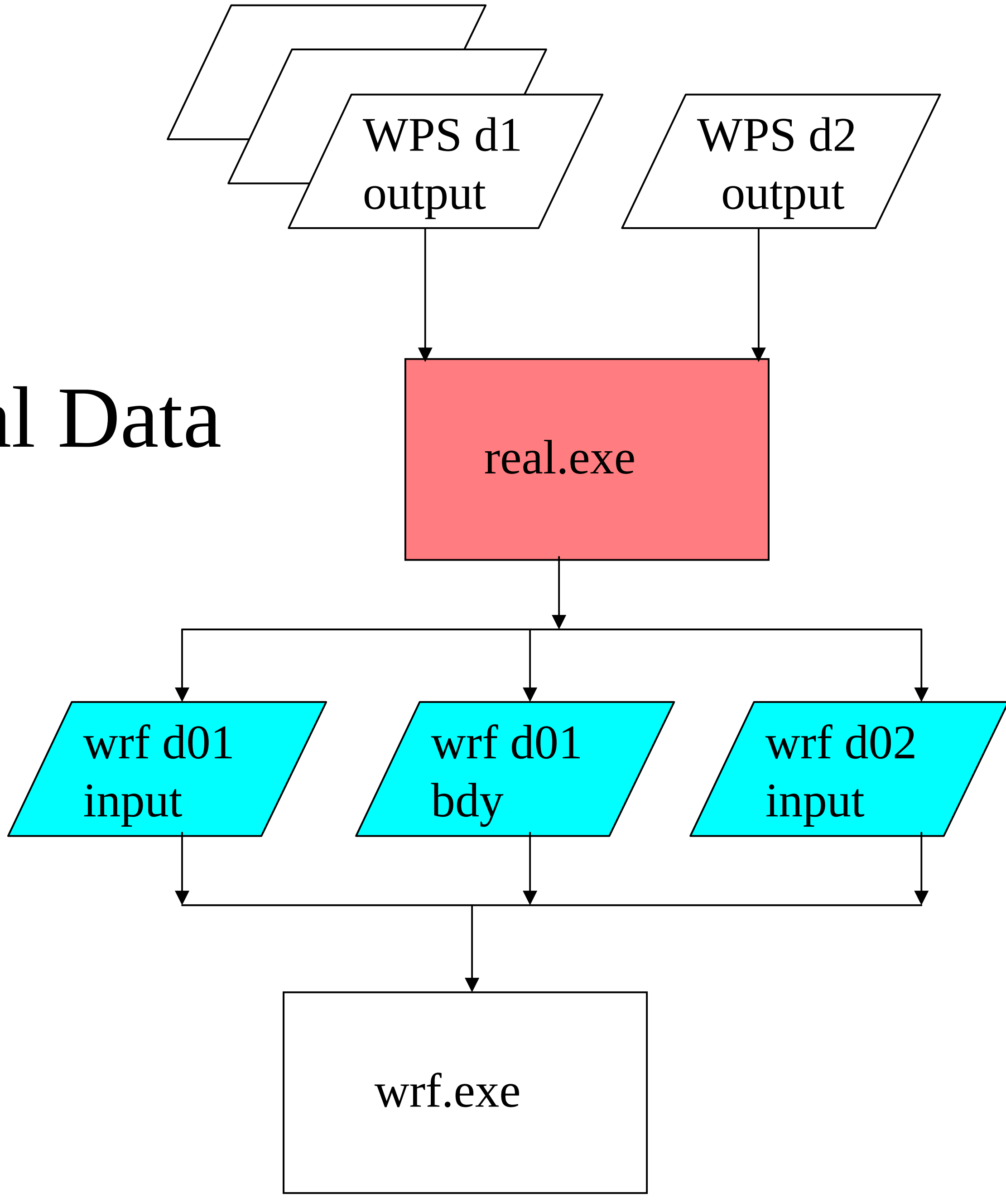

Real-Data Initialization - ARW

- Definition of Terms
- Purpose and Tasks of Initialization Program
- Files before and after

Definition of Terms: real.exe

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

Definition of Terms: Real Data Case

- 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

Definition of Terms: Real Data Case

- Projected domain: Lambert conformal, Mercator, polar stereographic
- Realistic static fields of topography, land use, vegetation, and soil category data
- Requirement of time dependent lateral boundary conditions (periodic in east-west with a global domain)

Definition of Terms: Initialization

- Not referring to *Variational* usage of Initialization
- Diagnostics necessary for assumed WRF model input
- Adjustment of input fields for consistency of static and time dependent fields (land mask with soil temperature, etc.)
- Computation of reference and perturbation fields
- Generation of initial state for model for each of the requested domains, and a lateral boundary file for the most coarse domain
- Vertical interpolation for 3d meteorological fields and for soil data

Purpose of the Initialization Program Files for the WRF Model

- Provide initial condition data from the WPS to the WRF model (possibly for multiple domains)
- Compute lateral boundary conditions for outer-most grid
- Optional file: lower boundary file with time dependent sea-surface temperature and sea ice
- Non-standard file: analysis nudging (FDDA) requires multiple time periods of data in the initial condition format

- Output from the real.exe program is suitable to be used as input to the WRF Var package for a “cold start”

Tasks of the Initialization Program

- Ingest time dependent upper-air (horizontal winds, potential temperature, mixing ratio), surface (dry surface pressure, sea ice, sea-surface temperature, skin temperature), and subsurface (soil temperature, soil moisture)
- Ingest static fields for terrestrial (elevation, land use, vegetation category, soil texture category) and projection (map factors, latitude and longitude, projection rotation angles)
- Multiple time periods of data are processed for the outer-most grid (for the lateral boundary conditions), while only the initial time of the fine grid domains are processed

Tasks of the Initialization Program Consistency Checks

- Defining sea ice based on user criteria: a water point and the skin temperature or sea-surface temperature is *cold enough* (user defined setting, default about 271 K)
  - Switching to a sea ice point requires changing approximately a dozen associated fields: turn the location into a land point, fix the soil category and land use category
  - Compute a sub-surface temperature, linearly interpolated from the sea-surface temperature and the skin temperature, 4 levels evenly spaced through a depth of 3 m for the Noah scheme

Tasks of the Initialization Program
Consistency Checks

- Figure out what optional data is available (soil data, sea-surface temperature, elevation of first guess data)
- Consistency check for land mask and time dependent fields
  – Land grid points require fields such as soil category, skin temperature, soil temperature (optionally soil moisture, depending on the surface physics selection)
  – If not all of these fields are available, the grid point is turned into a water point
  – Compute a sub-surface temperature, linearly interpolated from the sea-surface temperature and the skin temperature, 4 levels evenly spaced through a depth of 3 m for the Noah scheme

Tasks of the Initialization Program
Consistency Checks

- If the first guess elevation is available:
  - -6.5 K/km lapse rate is applied for the soil temperature and skin temperature fields
  - Large elevation adjustments (> 3 km) are bypassed as probably reflecting flag values in the first guess elevation
- Assignment of sea-surface temperature to the skin temperature array when the location is a water point as defined by the land mask field

Tasks of the Initialization Program
Consistency Checks

- Assignment of reasonable fields to skin temperature if the field is undefined at the location due to internal consistency checks or if the WPS provided a flag value: 0 – 10 cm soil temperature, sea-surface temperature, annual mean temperature
- Verify that necessary fields for each grid point are available (bounds check, stop code prior to model running)

Tasks of the Initialization Program Consistency Checks

- Both the static and the first-guess fields provide categories for land use and for soil texture.
- Static: 30 sec resolution, fractional values (24 USGS land use / vegetation type, 16 soil texture categories)
- First-Guess: the resolution of the data file, typically 40 km from Eta or 1 degree resolution from AVN
- User selects which to provide to the WRF model

Tasks of the Initialization Program
Soil Fields

- Fields: soil temperature, soil moisture, soil liquid
- Vertically interpolated to the levels required by the specified surface physics option from the input data
- At least two vertical levels must be provided from the WPS that surround the output levels requested
- Schemes: simple diffusion (5 layers, temperature only), Noah (4 layers), RUC (6 levels)

Tasks of the Initialization Program
3D Time Dependent Data from WPS

- The 3d fields are vertically interpolated to the η surfaces
  - SLP, topo, T, qv, height used to compute total surface p
  - Remove moisture in column for dry pressure
  - Vertically interpolate input fields in dry pressure
  - Options for pressure or log(pressure), and linear or 2nd order
  - User specify the selected η surfaces in the namelist

Tasks of the Initialization Program
3D Time Dependent Data from WPS

- Horizontal momentum (rotated to the domain's projection) potential temperature, and mixing ratio are provided by the SI on the WRF model's computational surfaces
- U, V, Qv, Θ are on the correct horizontal stagger
- U, V, Qv pass through without any modification, other than vertical interpolation
- Potential temperature has constant factor removed (300 K) for numerical round-off purposes

Tasks of the Initialization Program
Base State

- Mass coordinate (WRF model's computational surface) is reference pressure based, surfaces move up and down in pressure space
- Base state surface pressure is a function of terrain elevation plus several user supplied constants
  - Base surface pressure => base 3D pressure
  - Base 3D pressure => base 3D potential temperature
  - Base 3D pressure and potential temperature => base inverse density
  - Base inverse density integrated up => geopotential
- Base state computations follow the model's definition of the equation of state and the hydrostatic relation

Tasks of the Initialization Program
Base State

```
p_surf = p00 * EXP (-t00/a + ((t00/a)**2
  - 2.*g*ht(i,j)/a/r_d ) **0.5 )
```

User defined constants:

p00 – ref sea level pressure (10^5 Pa, fixed)

a – lapse rate (50 K, fixed)

t00 – ref sea level temperature (290 K, variable)

ht – terrain elevation (m)

Tasks of the Initialization Program
Base State

```
pb(i,k,j) = znu(k)*(p_surf - p_top) +
  p_top

t_init(i,k,j) = (t00 +
  A*LOG(pb(i,k,j)/p00))
  *(p00/pb(i,k,j))**(r_d/cp) - t0

alb(i,k,j) =
  (r_d/p1000mb)*(t_init(i,k,j)+t0)
  *(pb(i,k,j)/p1000mb)**cvpm
```

Reference 3d pressure, potential temperature, inverse density (defined at mass points, half levels)

Tasks of the Initialization Program
Base State

```
mub(i,j) = p_surf - p_top

phb(i,k,j) = phb(i,k-1,j) - dnw(k-
  1) *mub(i,j)*alb(i,k-1,j)
```

Reference geopotential (full levels, k=1 defined as terrain*g)

Tasks of the Initialization Program
Perturbation Fields

```
p(i,k,j) = p(i,k+1,j) - (mu_2(i,j)
  + qvf1*mub(i,j))/qvf2/rdn(k+1)
alt(i,k,j) = (r_d/p1000mb)*
  (t_2(i,k,j)+t0)*qvf*
 (((p(i,k,j)+pb(i,k,j))/p1000mb)
  **cvpm)
al(i,k,j) = alt(i,k,j) - alb(i,k,j)
```

- Integrate perturbation pressure downward (assumed = 0 at the model lid), diagnose perturbation inverse density

Tasks of the Initialization Program
Perturbation Fields

```
ph_2(i,k,j) = ph_2(i,k-1,j) -
   dnw(k-1) * (
   (mub(i,j)+mu_2(i,j))*al(i,k-1,j) +
   mu_2(i,j)*alb(i,k-1,j) )
```

- Integrate perturbation geopotential upward
- Assume that the surface geopotential is defined as g * terrain elevation
- The geopotential field is on full vertical levels, with k=1 defined at the ground surface, and the top level is defined at the model lid

Tasks of the Initialization Program
Output Fields to WRF

- Output fields for WRF model initial condition file for starting time of the model only (analysis FDDA option allows multiple times)
- Loop over all domains for data processing and output

Tasks of the Initialization Program Output Fields to WRF

- Couple momentum with total dry surface pressure and map factors for use in lateral boundary values and tendencies
- Geopotential, potential temperature, and moisture are coupled with total dry surface pressure for boundary conditions
- Boundary tendencies are linear centered differences valid between the bounding times provided from the WPS data's temporal availability
- The lateral boundaries are arrays for each of the four domain sides; defined for the entire length of the side, the entire height (for 3D arrays), and several rows/columns (user defined)
- One less boundary time period is created than time periods of WPS data processed

Tasks of the Initialization Program
Nest Domains

Loop over model domains

    Loop over time periods

        Input Data from WPS

        Process Data (consistency, base state, perturbation calculations)

        If time loop = 1 => output IC

        If time loop >1 => couple data, output BC

        If time loop = 1 & domain loop > 1 => exit

    End time period loop

End model domain loop

Tasks of the Initialization Program
Nest Domains

- Must have input data from the WPS for each domain processed
- No inter-domain consistency checks
- No horizontal interpolation from the parent domain to the child domain
- Fine domains are only processed at the first time provided to the outer-most grid from the WPS
- User must specify domains to process and that an additional input file is being supplied

Required Input Files

- The input files required by real.exe are output from the WPS (usually in netCDF, but this is IO API dependent)

```
cd ./WRFV2/test/em_real
ls ../../../WPS/met_em*
```

- The WPS output files are usually linked into the real-data directory
- Times and dimensions are checked
- Physics options are infrequently impacted by SI output EXCEPT for the surface physics choice – the real program must be re-run when changing that option in the WRF model

Generated Output Files

- Two standard types of output files are generated by the real.exe program: wrfinput_d01 and wrfbdy_d01
  - Multiple domain runs will create wrfinput_d*xx* files for each domain id # *xx*
- Initial time in wrfinput is the initial time of the WRF forecast (from the namelist)

```
ncdump –v Times wrfinput_d01
```

- Time periods from wrfbdy file cover forecast period (reported time is at the beginning of the lateral boundary interval)

Generated Output Files
Optional: Lower Boundary File

- An optional file that is available for output is the lower boundary condition file
- Contains time dependent sea-surface temperature and sea ice
- Values are provided, no tendencies
- The temporal resolution is the same as for the lateral boundary file
- Useful typically for long model runs, such as where a static sea-surface temperature is an invalid assumption

(as close as possible, Klingon for *finis*)