RUNNING WPS & WRF

Kelly Werner

NCAR/MMM

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PRESENTATION OUTLINE

WPS/WRF Flow

Running WPS

Running WRF

WRF Log Files

Troubleshooting WRF Errors

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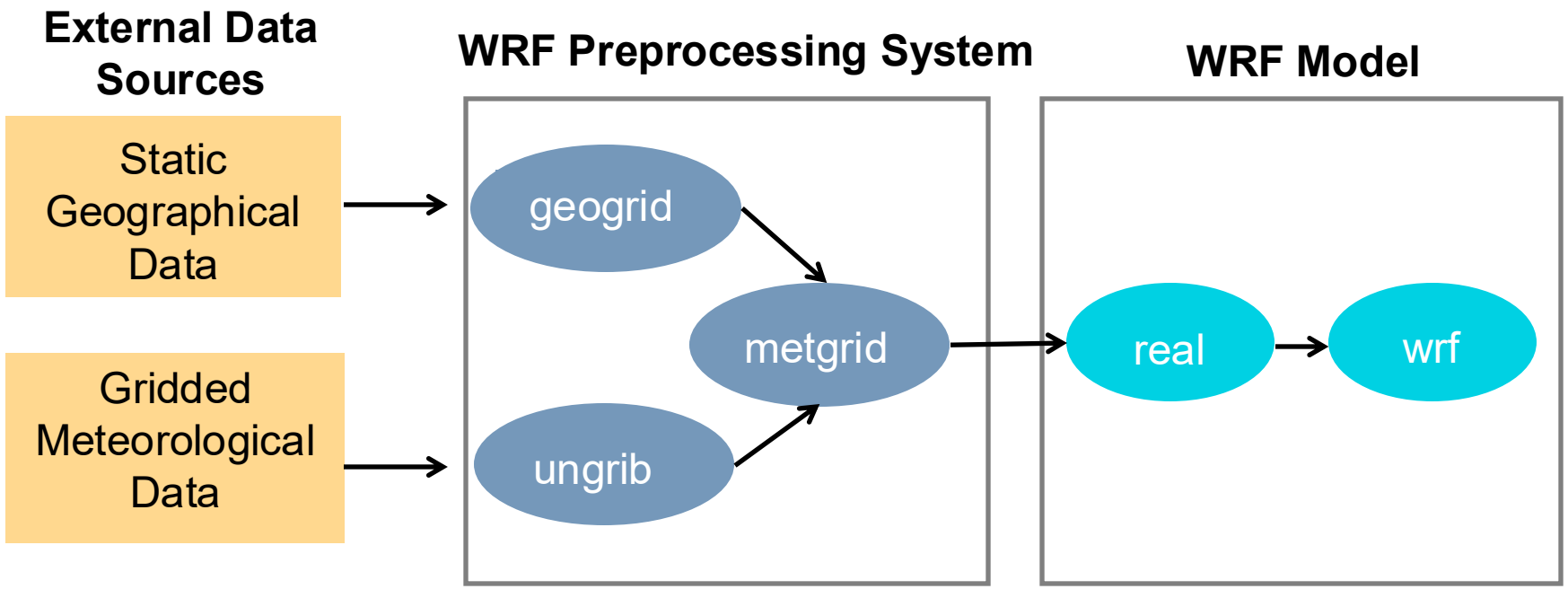
WPS AND WRF FLOWCHART: REAL-DATA CASE



PRESENTATION OUTLINE

WPS/WRF Flow

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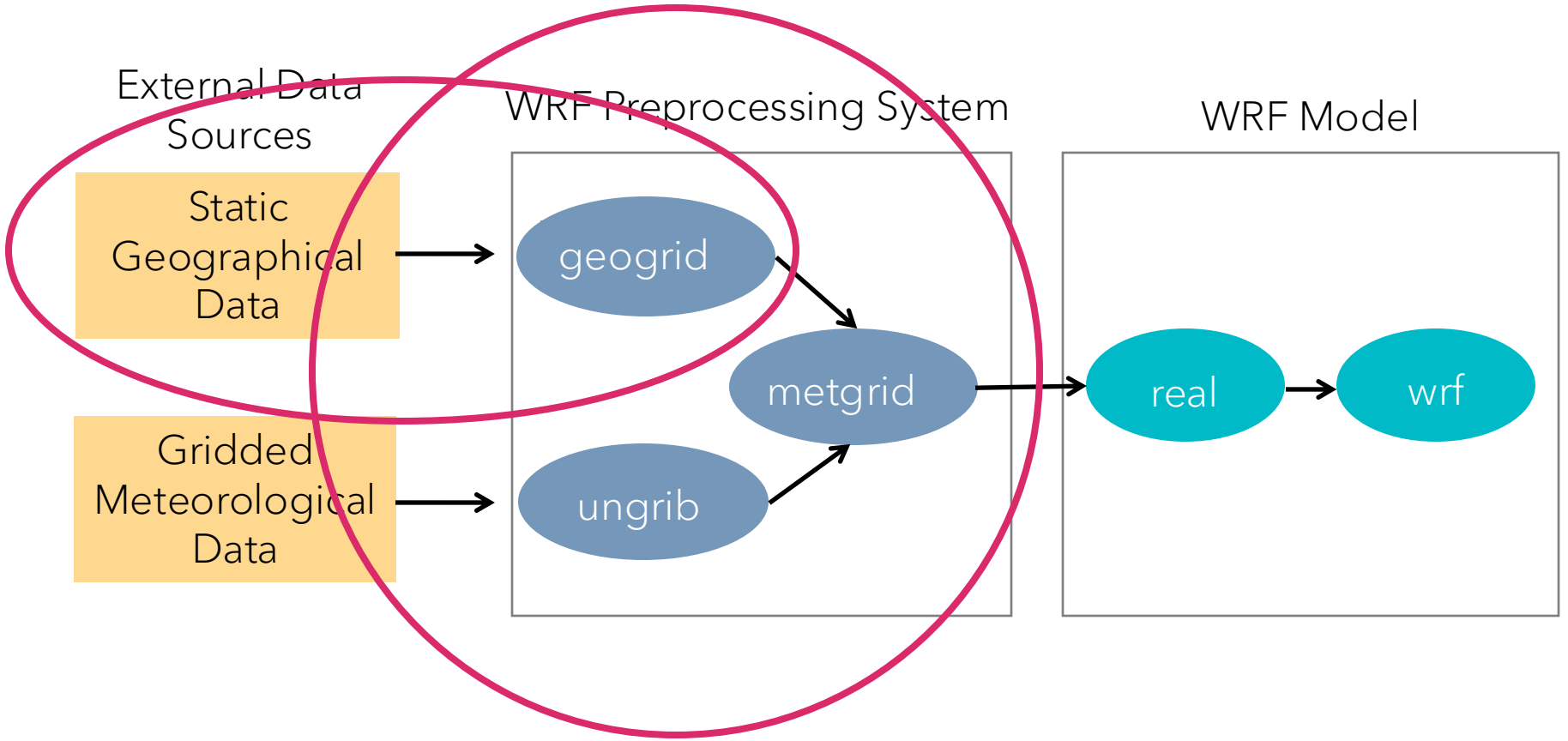
RUNNING WPS: GEOGRID

Geogrid
Defines the domain and interpolates static fields to that domain



https://www2.mmm.ucar.edu/wrf/users/wrf_users_guide/build/html/wps.html#

GEOGRID: STATIC DATA

https://www2.mmm.ucar.edu/wrf/users/download/get_sources_wps_geog.html

THIS IS THE ONE YOU WANT

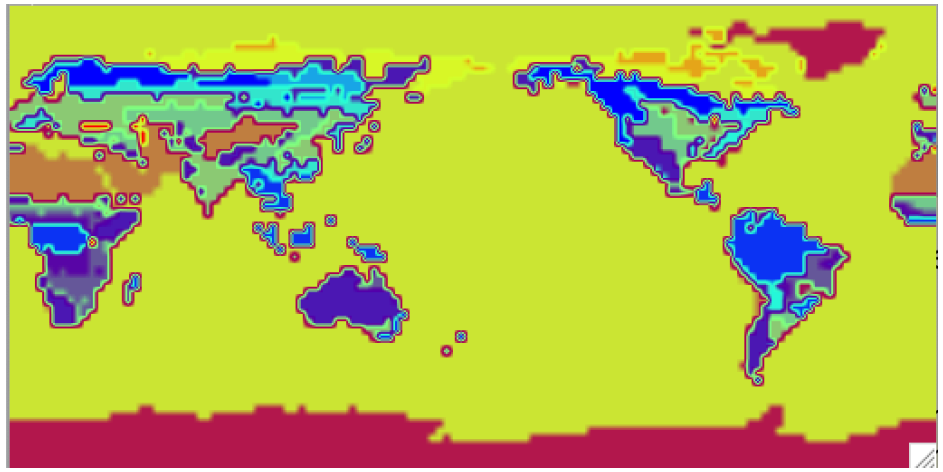
~ 29 GB when uncompressed

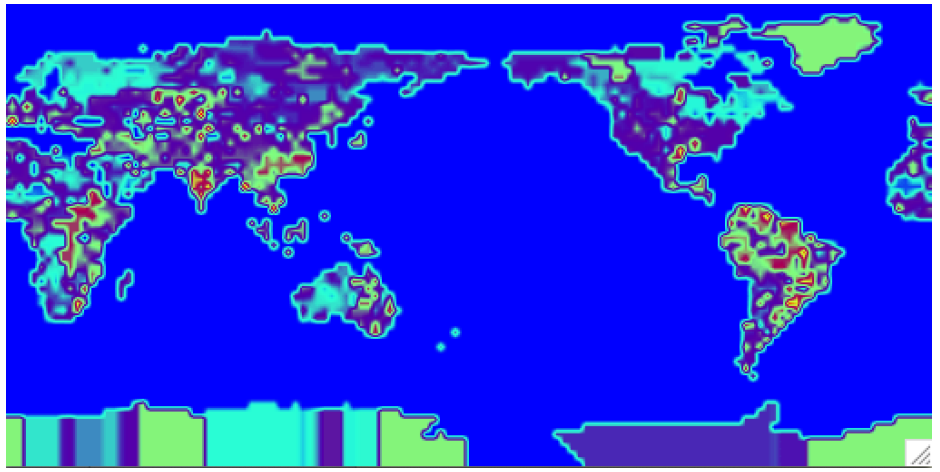
WRF Preprocessing System (WPS) Geographical Input Data Mandatory Fields Downloads

Click on file (link) below to download individual data files	Download Highest Resolution of each Mandatory Field *Note: ~29G Uncompressed (2.6G Compressed)	Download Lowest Resolution of Each Mandatory Field
albedo_modis	x	x
greenfrac_fpar_modis	x	x
greenfrac_fpar_modis_5m		x
lai_modis_10m	x	x
lai_modis_30s	x	
maxsnowalb_modis	x	x

GEOGRID: STATIC DATA

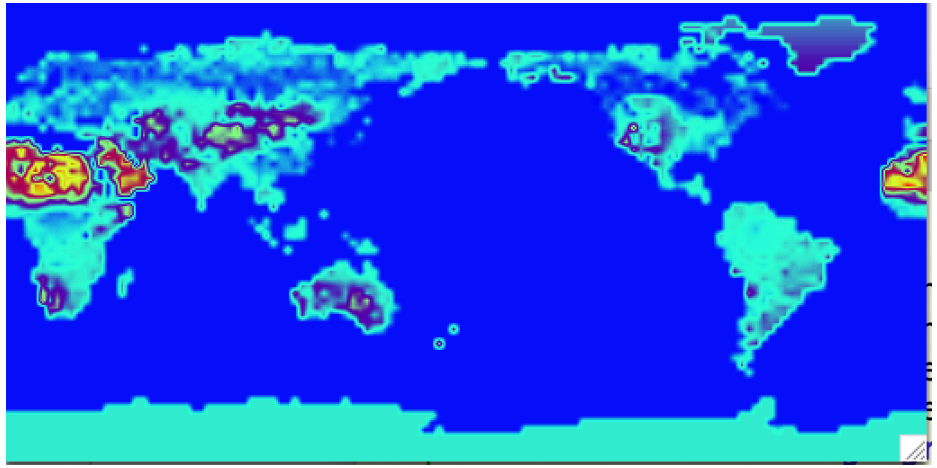
Landuse

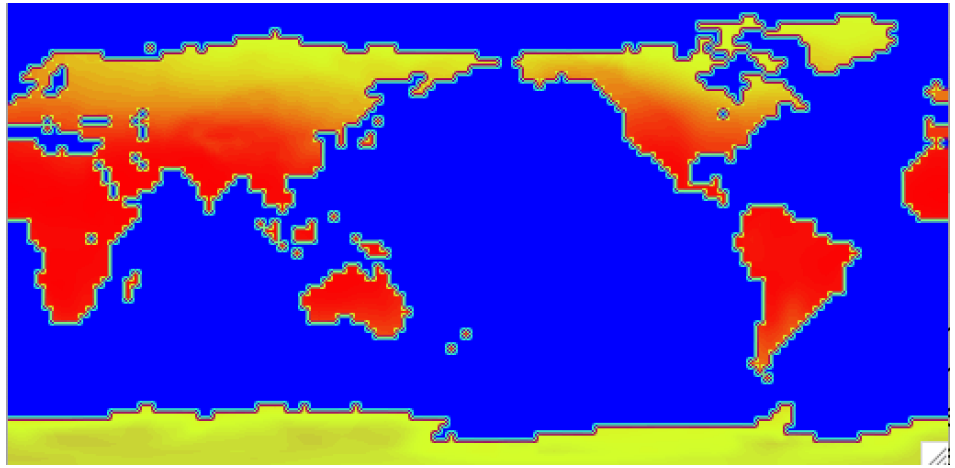




Clay Fraction

Albedo





Soil Temp

Plus many other fields…

MODIFYING NAMELISTS

1. Move to the "wps" directory (`cd` : change directories)

```
> cd wps
```

2. Edit the *namelist.wps* file

- Fortran namelist : list of user-specified runtime options the executables read during execution

- namelist files may contain multiple namelist records
  - **&share**
  - **&geogrid**
  - **&ungrib**
  - **&metgrid**

```
&share   (record open)
parameter = setting
/        (record close)
```

Namelists use specific formatting - edit with care. Parameters have either:

- Settings for multiple columns: domain dependent
- Only a single column setting: value valid for all domains

```
e_we      =  150,   220,
e_sn      =  130,   214,

ref_lat   = 33.00,
ref_lon   = -79.00,
```

GEOGRID: NAMELIST SET-UP

Edit *namelist.wps*

Geogrid only reads namelist records:

&share
&geogrid

```
&share
    wrf_core = 'ARW',
    max_dom = 2,
/
```

```
&geogrid
    parent_id             =   1,   1,
    parent_grid_ratio     =   1,   3,
    i_parent_start        =   1,   53,
    j_parent_start        =   1,   25,
    e_we                  =  150,  220,
    e_sn                  =  130,  214,
    geog_data_res         = 'default', 'default',
    dx                    = 15000,
    dy                    = 15000,
    map_proj              = 'lambert',
    ref_lat               = 33.00,
    ref_lon               = -79.00,
    truelat1              = 30.0,
    truelat2              = 60.0,
    stand_lon             = -79.0,
    geog_data_path        = '/data/static/WPS_GEOG/'
/
```

GEOGRID: NAMELIST SET-UP

Which WRF core?
- for ARW, set to 'ARW'

```
&share
     wrf_core     = 'ARW',
     max_dom      = 1,
/
```

Total number of model domains, including nests

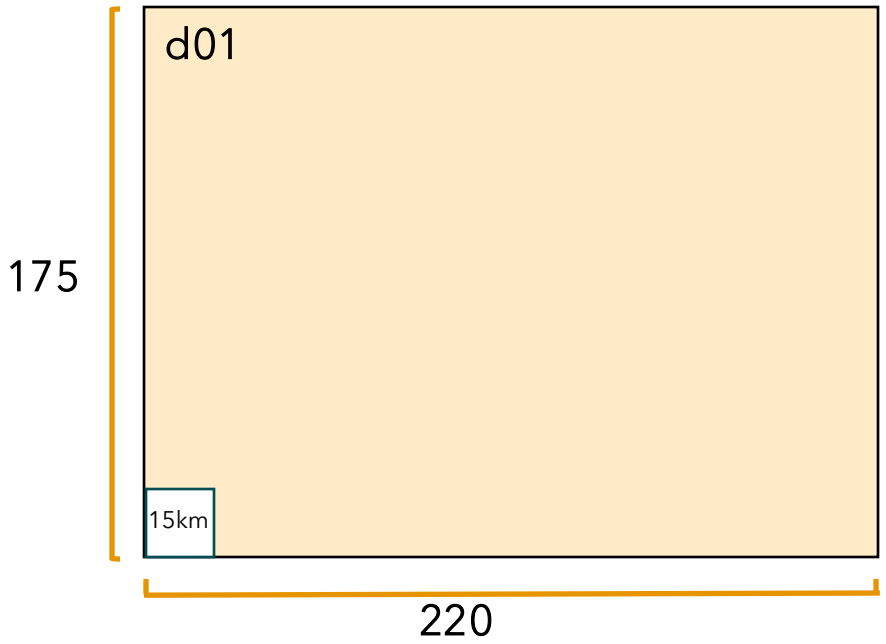
http://www2.mmm.ucar.edu/wrf/users/namelist_best_prac_wps.html

GEOGRID: NAMELIST SET-UP

```
&geogrid
  parent_id    =  1, 1,
  parent_grid_ratio  =  1, 3,
  i_parent_start  =  1, 20,
  j_parent_start  =  1, 17,

  e_we =  220, 181,
  e_sn =  175, 181,
  dx    = 15000,
  dy    = 15000,

  geog_data_res =  'default', 'default',
  geog_data_path = '/data/static/geog/'
/
```

Domain Size

- (*e_we, e_sn*) : Number of grid points in W-E and S-N directions
- (*dx/dy*) : Grid spacing/resolution



http://www2.mmm.ucar.edu/wrf/users/namelist_best_prac_wps.html

GEOGRID: NAMELIST SET-UP

```
&geogrid
  parent_id    =  1, 1,
  parent_grid_ratio   =  1, 3,
  i_parent_start  =  1, 20,
  j_parent_start  =  1, 17,

  e_we =  220, 181,
  e_sn =  175, 181,
  dx    = 15000,
  dy    = 15000,

  geog_data_res =  'default', 'default',
  geog_data_path = '/data/static/geog/'
/
```

Static Data

- *geog_data_res* : Static data source
  - Default : MODIS 30s
  - See *wps/geogrid/GEOGRID.TBL* or Users Guide for other options
- *geog_data_path* : Path to static data directories

http://www2.mmm.ucar.edu/wrf/users/namelist_best_prac_wps.html

GEOGRID: NAMELIST SET-UP

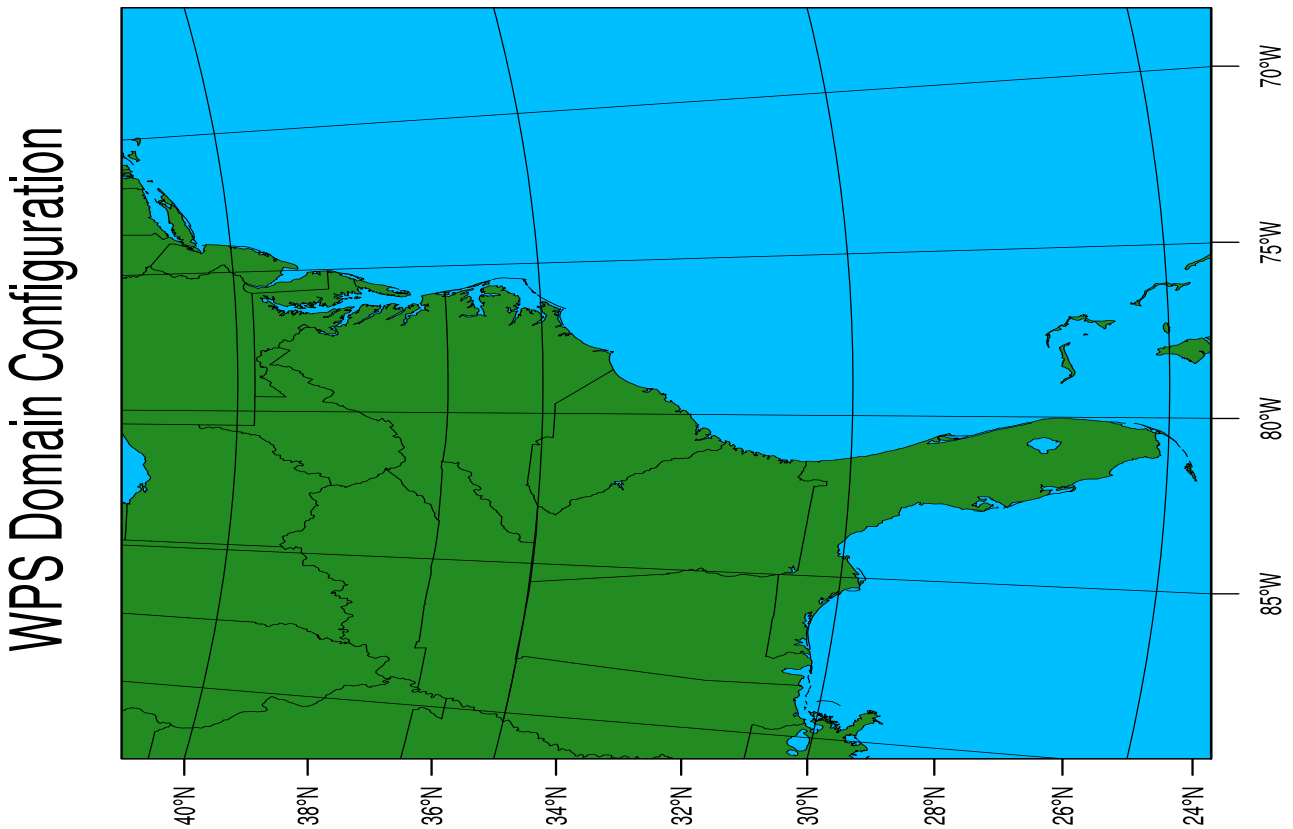
```
&geogrid

    map_proj  = 'lambert',
    ref_lat   = 37.0,
    ref_lon   = -97.0,
    truelat1  = 45.0,
    truelat2  = 30.0,
    stand_lon = -97.0,
/
```

Map Projection and Global Location

- Specify which projection to use
- Specify projection parameters

http://www2.mmm.ucar.edu/wrf/users/namelist_best_prac_wps.html

GEOGRID: DOMAIN



*Plotted using **util/plotgrids_new.ncl**

Run geogrid:

```
> ./geogrid.exe
```

Processing messages are written

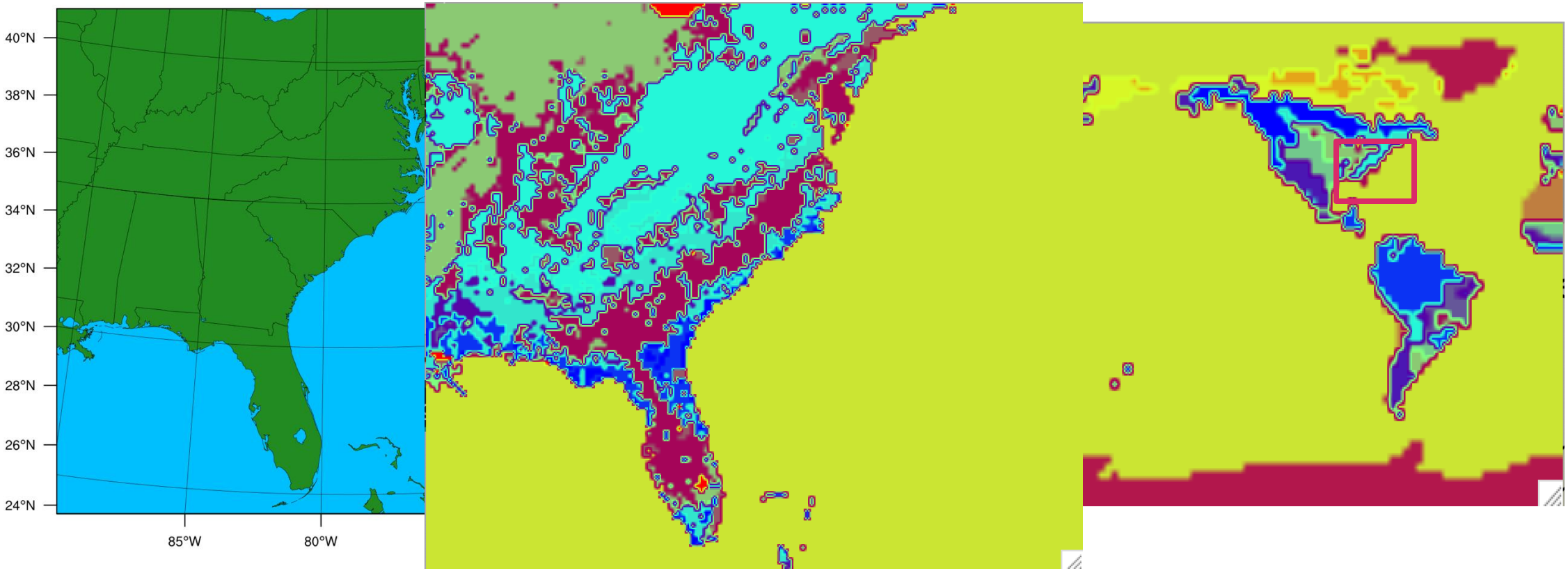
- To the ***geogrid.log*** file
- To the screen

```
Parsed 11 entries in GEOGRID.TBL
Processing domain 1 of 2
  Processing XLAT and XLONG
  Processing MAPFAC
  Processing F and E
  Processing ROTANG
  Processing LANDUSEF
  Calculating landmask from LANDUSEF
  Processing HGT_M

  …

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!  Successful completion of geogrid.          !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

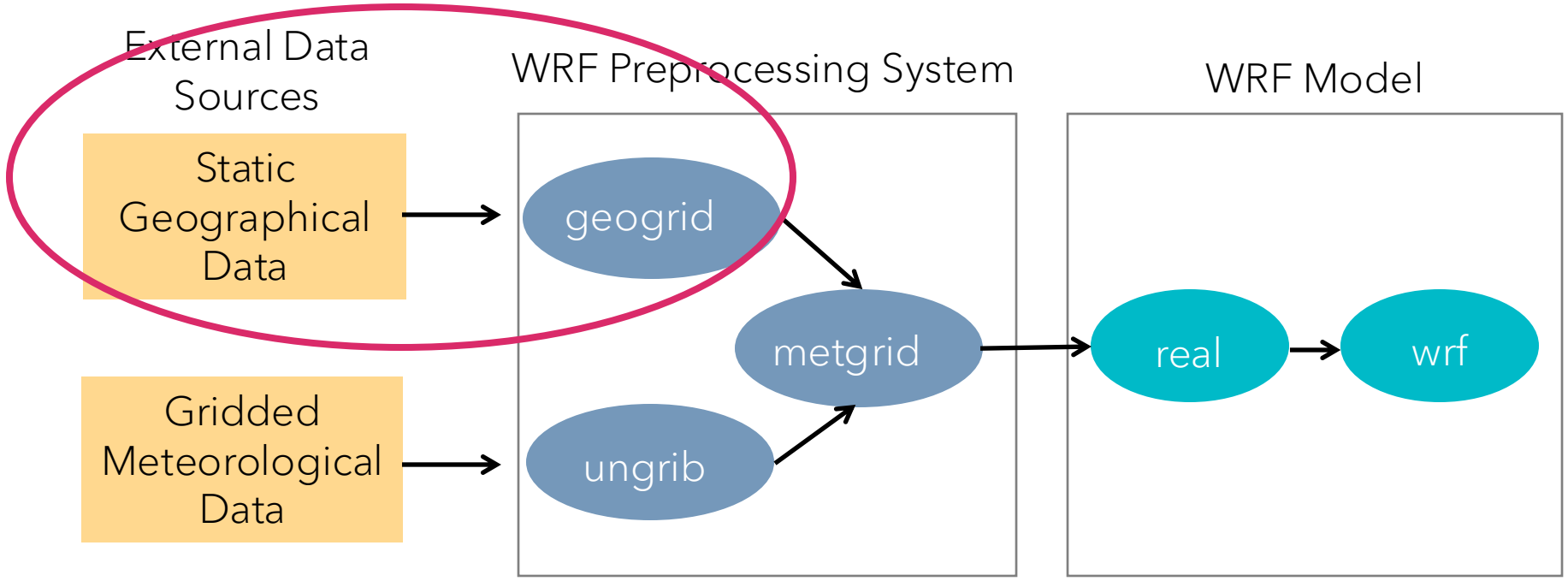
Output
geo_em.d01.nc

geo_em	file prefix
d01	domain 01
.nc	netCDF format

WPS Domain Configuration



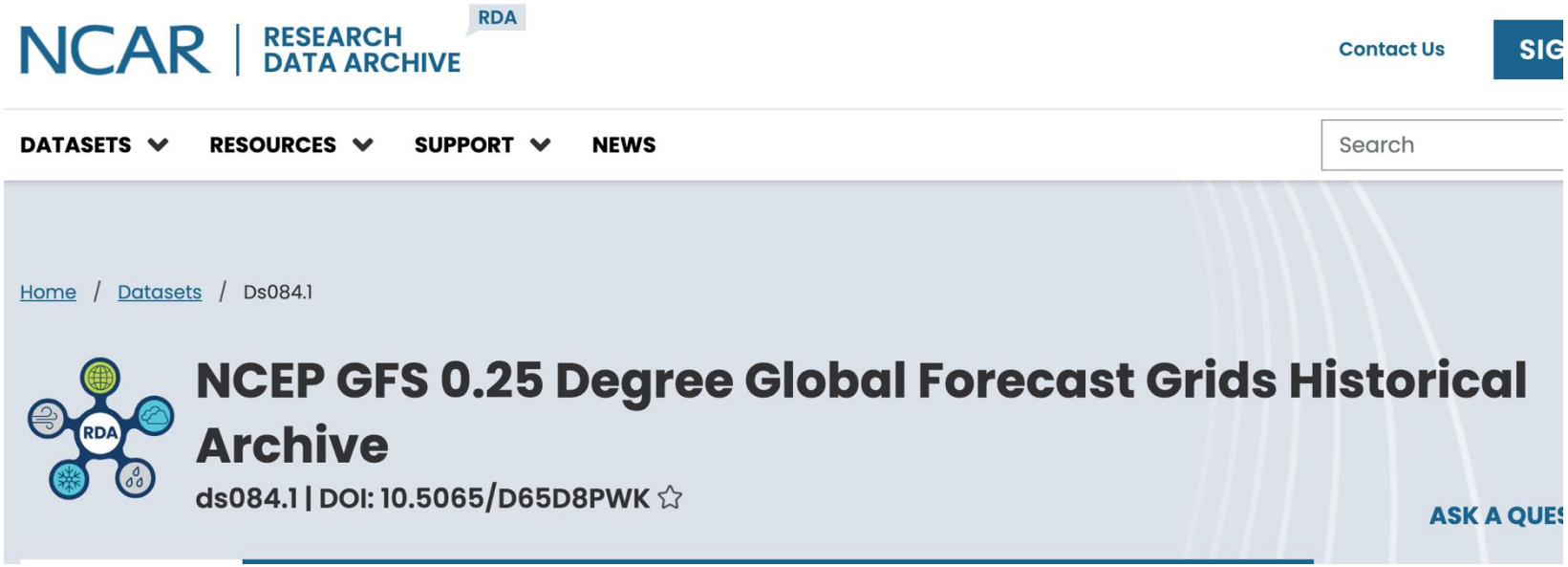
RUNNING WPS: UNGRIB



Ungrib

Restructures GRIB-formatted meteorological data into "intermediate" format (*expected by metgrid)*

UNGRIB: OBTAINING INPUT DATA



See https://www2.mmm.ucar.edu/wrf/users/download/free_data.html for additional input options

```
gfs.0p25.2019090412.f000.grib2
gfs.0p25.2019090412.f003.grib2
gfs.0p25.2019090412.f006.grib2
gfs.0p25.2019090412.f009.grib2
gfs.0p25.2019090412.f012.grib2
```

gfs	file prefix
0p25	0.25 degree resolution
2019090412	Sept 4, 2019, initialized at 12 UTC
f003	valid for 3 hrs after 12 UTC
.grib2	GRIB2 format

Obtain files to span the entire time of your simulation

UNGRIB: NAMELIST SET-UP

```
gfs.0p25.2019090412.f000.grib2
gfs.0p25.2019090412.f003.grib2
gfs.0p25.2019090412.f006.grib2
gfs.0p25.2019090412.f009.grib2
gfs.0p25.2019090412.f012.grib2
```

```
&share
    wrf_core = 'ARW',
    max_dom = 1,

    start_date  = '2019-09-04_12:00:00',
    end_date    = '2019-09-05_00:00:00',

    interval_seconds = 10800

/
```

ungrib only reads namelist records:

&share
&ungrib

Data Time Range

ungrib processes data between these times

Data Frequency

Number of seconds between ungrib output files
- E.g., 10800 s = 3 hrs

UNGRIB: NAMELIST SET-UP

```
&ungrib
    out_format = 'WPS',
    prefix = 'GFS',
/
```

Intermediate File Format

Which format to use for intermediate files
- Use 'WPS' here

Intermediate File Names

Desired prefix for intermediate files (ungrib output)
- prefix can include a path
- This example setting outputs files like:
GFS:YYYY-MM-DD_hh

Link input meteorological and surface data to the wps directory

Use the ***link_grib.csh*** script provided in the wps directory

> ./link_grib.csh *path-to-your-grib-files/gribfile-prefix*

E.g.:

./link_grib.csh ../data/gfs.0p25.20190904

> ls -ls GRIBFILE*

```
GRIBFILE.AAA -> ../data/gfs.0p25.2019090412.f000.grib2
GRIBFILE.AAB -> ../data/gfs.0p25.2019090412.f003.grib2
GRIBFILE.AAC -> ../data/gfs.0p25.2019090412.f006.grib2
GRIBFILE.AAD -> ../data/gfs.0p25.2019090412.f009.grib2
GRIBFILE.AAE -> ../data/gfs.0p25.2019090412.f012.grib2
```

UNGRIB: LINK TO THE VTABLE

Link the correct Vtable to a file named “Vtable” in the WPS directory

- See *wps/ungrib/Variable_Tables* directory for existing Vtables
- Ungrib expects to find a file named “Vtable” in the wps directory.

```
> ln -sf ungrib/Variable_Tables/Vtable.GFS Vtable
> ls -ls Vtable
```

```
Vtable -> ungrib/Variable_Tables/Vtable.GFS
```

Run ungrib:

```
> ./ungrib.exe
```

Processing messages are written to:

- **ungrib.log** file
- the screen

Output

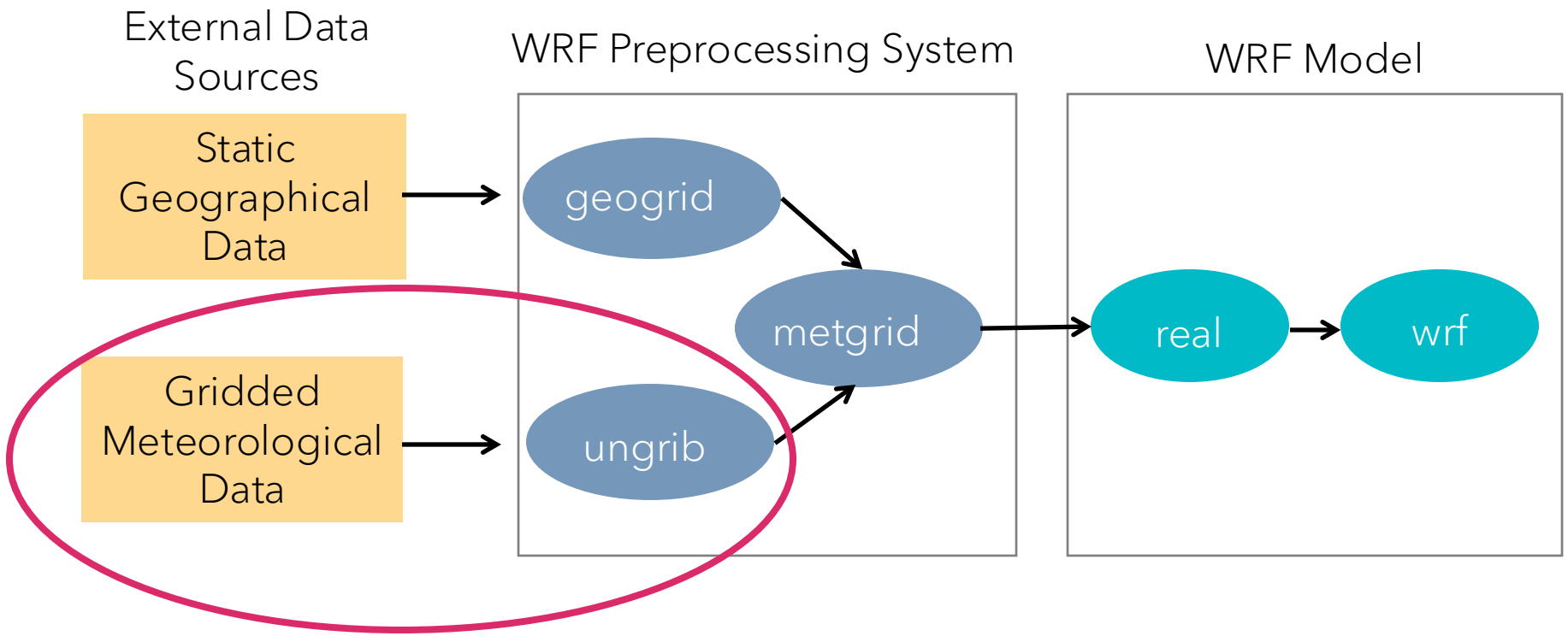
```
GFS:2019-09-04_12
GFS:2019-09-04_15
GFS:2019-09-04_18
GFS:2019-09-04_21
GFS:2019-09-05_00
```

```
 *** Starting program ungrib.exe ***
Start_date =  2019-09-04_12:00:00 ,      End_date = 2019-
09-05_00:00:00
output format is WPS
Path to intermediate files is ./
 ungrib - grib edition num             2

##################################################################
####
Inventory for date = 2019-04-09 12:00:00

PRES    TT        UU        VV        RH        HGT
-------------------------------------------------------------
----
2013.0  O         O         O         O         O         O
2001.0  X         X         X         X         O         X
1000.0  X         X         X         X         X
 975.0  X         X         X         X         X
 950.0  X         X         X         X         X
 925.0  X         X         X         X         X
 900.0  X         X         X         X         X

…

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!  Successful completion of ungrib.          !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

RUNNING WPS: METGRID

Metgrid

Horizontally interpolates the reformatted meteorological data onto the domain



METGRID: NAMELIST SET-UP

```
&share
    wrf_core = 'ARW',
    max_dom = 1,

    start_date   = '2019-09-04_12:00:00',   '2019-09-04_12:00:00',
    end_date     = '2019-09-05_00:00:00',   '2019-09-05_00:00:00',

    interval_seconds = 10800
    io_form_geogrid = 2,
/
```

metgrid only reads namelist records:

&share
&metgrid

Data Time Range

Time range to process for each domain.

Intermediate File Prefixes

Setting should match the prefix given in &ungrib

```
&metgrid
    fg_name = 'GFS',
 /
```

Run metgrid:

```
> ./metgrid.exe
```

Processing messages are written to

- **metgrid.log** file
- the screen

```
Processing domain 1 of 1
Processing 2012-01-27_00
    FILE
Processing 2012-01-27_06
    FILE
Processing 2012-01-27_12
    FILE
Processing 2012-01-27_18
    FILE
Processing 2012-01-28_00
    FILE
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!   Successful completion of metgrid.    !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

Output

```
met_em.d01.2019-09-04_12:00:00.nc
met_em.d01.2019-09-04_15:00:00.nc
met_em.d01.2019-09-04_18:00:00.nc
met_em.d01.2019-09-04_21:00:00.nc
met_em.d01.2019-09-05_00:00:00.nc
```

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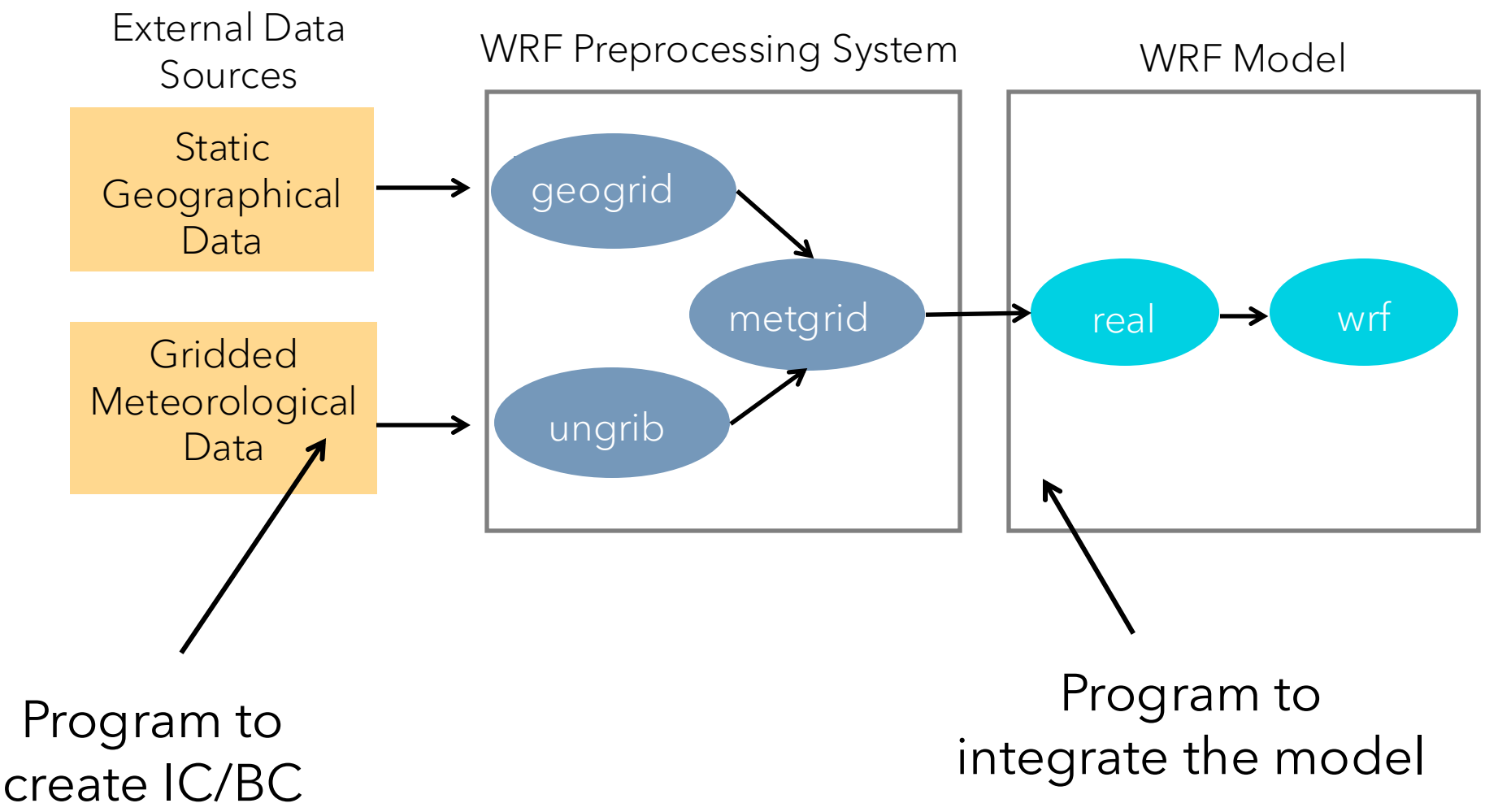
WPS AND WRF FLOWCHART: REAL-DATA CASE



RUNNING WRF FOR A REAL-DATA CASE

WRF/TEST/EM_REAL DIRECTORY

Move to the appropriate directory to run real.exe and wrf.exe

```
> cd wrf/test/em_real
```

LANDUSE.TBL
GENPARM.TBL
SOILPARM.TBL
VEGPARM.TBL
URBPARM.TBL
RRTM_DATA
RRTMG_SW_DATA
RRTMG_LW_DATA
ozone.formatted
ozone_lat.formatted
ozone_plev.formatted
…

Model physics data files:

- either for initializing physics variables, or improving physics computation speed

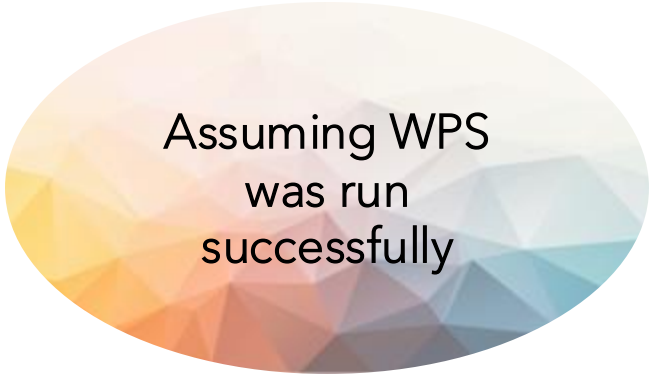
* Some are editable text files

namelist.input

real.exe
wrf.exe
ndown.exe
…. (many more)

Executables

COPY/LINK METGRID OUTPUT FILE TO WRF RUNNING DIRECTORY



- ✓Created model domain with static data
- ✓Prepared meteorological data
- ✓Created *met_em.d0** files for multiple time periods
  - used for creating initial and boundary conditions

```
> ln -sf ../../../WPS/met_em.d0* .
```

Note: " .. " Unix command translates to "the parent of the current directory." The WPS directory is typically 3 domains up from the em_real directory.

EDIT NAMELIST.INPUT: &TIME_CONTROL

```
&time_control

 run_days            = 0,
 run_hours           = 12,
 run_minutes         = 0,
 run_seconds         = 0,

 start_year          = 2019, 2019,
 start_month         = 09,   09,
 start_day           = 04,   04,
 start_hour          = 12,   12,
 end_year            = 2019, 2019,
 end_month           = 09,   09,
 end_day             = 05,   05,
 end_hour            = 00,   00,

 interval_seconds     = 10800
 history_interval     = 60,  60,
 frames_per_outfile   = 1, 1,

 restart              = .false.,
 restart_interval     = 7200,

  /
```

run_* variables

Model simulation length

- Not domain-dependent. Only set a single value.
- Only read by wrf.exe

start_* and end_* variables

- "real" program uses WPS output (*met_em**) between these times to produce lateral and boundary conditions
- Can be used to specify simulation length if *run_** variables are not set (or are set to 0)

Input & output intervals

interval_seconds = seconds between input files
history_interval = how often history is written/recorded
frames_per_outfile = how many history times in each output file

restart & restart_interval

Whether this is a restart run, and the time interval (mins) between restart output files (*wrfrst_d0**)

EDIT NAMELIST.INPUT: &DOMAINS

```
&domains
 time_step                  = 90,
 time_step_fract_num        = 0,
 time_step_fract_den        = 1,



 e_we                       = 220,  220,
 e_sn                       = 175,  214,



 e_vert                     = 45,   45,


 num_metgrid_levels         = 34,

 num_metgrid_soil_levels = 4,


 dx                         = 15000,
 dy                         = 15000,
/
```

time_step* variables

Time step (in s) for model integration

- Use *_*num* (numerator) and *_*den* (denominator) for fractional time steps
- *time_step*: set <= 6xDX!

e_we and e_sn

west-east and south-north dimensions of the domain

e_vert

Number of vertical model levels

num_metgrid_levels

Number of metgrid (input) data levels

num_metgrid_soil_levels

Number of metgrid (input) soil data levels

dx and dy

Grid distance (resolution) in meters

EDIT NAMELIST.INPUT: &DOMAINS

```
&domains
  p_top_requested    = 5000,


  eta_levels = 1.0, 0.996, 0.99, 0.98, …, 0.0
 /
```

p_top_requested

Pressure value at the model top

- Determined by the input data
- Default value - 5000 Pa - recommended lowest model top

eta_levels

Option to specify your own model levels from 1.0 to 0.0

- If not specified, program *real* calculates a reasonable set

RUN INITIALIZATION PROGRAM: REAL.EXE

Serial or smpar compile

```
> ./real.exe >& real.log
```

Parallel (dmpar) compile

```
> mpiexec -np N ./real.exe
```

N : number of processors requested
- outputs *rsl.out.** and *rsl.error.** for each processor

Look at the end of the log file (e.g., **real.log)** or ***rsl.out.0000*** file for:

```
SUCCESS COMPLETE REAL_EM INIT
```

Output Files

`wrfinput_d01`

- Initial conditions
- Single time level data at model's start time

`wrfbdy_d01`

- Lateral boundary data
- Available at the beginning of each time period processed

RUN WRF MODEL: WRF.EXE

Serial or smpar compile

```
> ./wrf.exe >& wrf.log
```

Parallel (dmpar) compile

```
> mpiexec –np N ./wrf.exe
```

N : number of processors requested
- creates *rsl.out*.* and *rsl.error*.* for each processor

Look at the end of the log file (e.g., **wrf.log)** or ***rsl.out.0000*** file for:

```
SUCCESS COMPLETE WRF
```

Output Files

`wrfout_d01_YYYY-MM-DD_hh:mm:ss`

Model output at the interval specified by *history_interval*, and dependent on *frames_per_outfile*

`wrfrst_d0x_YYYY-MM-DD_hh:mm:ss`

- Restart output if *restart_interval* is set to a time within the range of the forecast time
- Use to restart the model at the time of this file

RUNNING A RESTART

- In the initial run, set *restart_interval* to a value within the model integration time
  - A restart file will be created during the initial run
    - e.g., **`wrfrst_d01_2019-09-05_00:00:00`**

- When running the restart simulation,
  - Set *restart* = *.true.*
  - Set *start_time* to the restart initial time
  - Set *run_** to the desired time length to run
  - Run WRF as usual

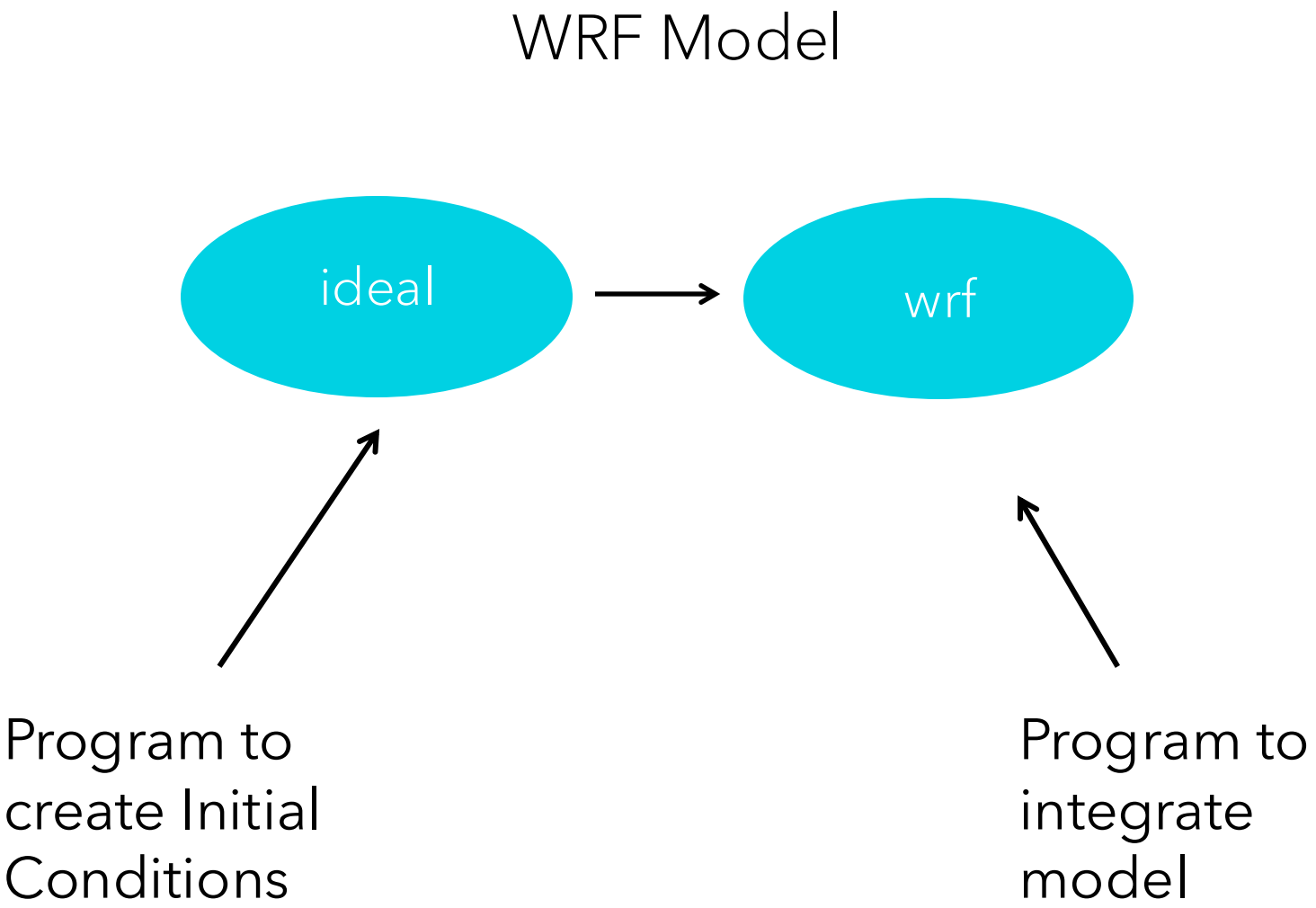
```
./wrf.exe >& wrf.log
```

or

```
mpiexec -np N ./wrf.exe
```

RUNNING WRF FOR AN IDEALIZED CASE

WRF FLOWCHART: IDEALIZED CASE



WPS is not used when running idealized cases

Typically, the only required input is the namelist.input file, and the input sounding files (provided with the code)

Ideal Case Options

```
em_b_wave
em_convrad
em_esmf_exp
em_fire
em_grav2d_x
em_heldsuarez
em_hill2d_x
em_les
em_quarter_ss
em_real
em_scm_xy
em_seabreeze2d_x
em_squall2d_x
em_squall2d_y
em_tropical_cyclone
```

Move to the appropriate idealized case running directory

```
> cd wrf/test/em_<CASE>
```

RUN INITIALIZATION PROGRAM: IDEAL.EXE

Serial or smpar compile

```
> ./ideal.exe >& ideal.log
```

Parallel (dmpar) compile – for 3D cases only

```
> mpiexec -np 1 ./ideal.exe
```

Even when compiled for parallel execution, *ideal.exe* must be run with a single processor

Look at the end of the log file or rsl.out.0000 file for:

```
SUCCESS COMPLETE IDEAL INIT
```

Input

Typically a sounding file named *input_sounding*, or a pre-defined 2D input (e.g., *input*_jet in the em_b_wave case)

Output File

`wrfinput_d01`

- Single time level data at model's start time
- No boundary file for ideal cases

RUN WRF MODEL FOR IDEAL CASE: WRF.EXE

Serial or smpar compile

```
> ./wrf.exe >& wrf.log
```

Parallel (dmpar) compile – for 3D cases only

```
> mpiexec -np N ./wrf.exe
```

N : number of processors requested

Look at the end of the log file or rsl.out.0000 file for:

```
SUCCESS COMPLETE WRF
```

Output

wrfout_d01_YYYY-MM-DD_hh:mm:ss

Model output at the interval specified by *history_interval*, and dependent on *frames_per_outfile*

ADDITIONAL NOTES FOR IDEAL CASES

- Edit *namelist.input* to change options
- Option to provide your own sounding
- Option to modify *dyn_em/module_initialize_<CASE>.F* to change other aspects of the initialization.

WHERE SHOULD YOU START?

See namelist templates and descriptions in *test/em_real*

- README.namelist
- examples.namelist

Helpful Documentation

- WRF Users' Guide (see chapters on "WPS" and "Running WRF")
- Namelist Best Practice web pages:
  WPS: http://www2.mmm.ucar.edu/wrf/users/namelist_best_prac_wps.html
  WRF: http://www2.mmm.ucar.edu/wrf/users/namelist_best_prac_wrf.html

PRESENTATION OUTLINE

WPS/WRF Flow

Running WPS

Running WRF

WRF Log Files

Troubleshooting WRF Errors

The standard out and error will go to the following files:

Serial or smpar compile

```
>./wrf.exe >& wrf.log
```

All standard output and errors print to the requested wrf.log file. This file can be named whatever the user wants.

Parallel (dmpar) compile

```
> mpiexec -np N ./wrf.exe
```

```
rsl.out.0000      rsl.error.0000
rsl.out.0001      rsl.error.0001
rsl.out.0002      rsl.error.0002
rsl.out.0003      rsl.error.0003
```

There is a pair of files for each processor requested

WHAT IS IN A WRF LOG OR RSL FILE?

Model Version & Decomposition Info

```
Ntasks in X  4, ntasks in Y  4
WRF V4.7.0 MODEL
```

Computational Timing Info

```
Timing for main: time 2000-01-24_20:03:00 on domain   1:    0.89475 elapsed seconds
Timing for main: time 2000-01-24_20:06:00 on domain   1:    0.09011 elapsed seconds
Timing for main: time 2000-01-24_20:09:00 on domain   1:    0.08634 elapsed seconds
Timing for main: time 2000-01-24_20:12:00 on domain   1:    0.09004 elapsed seconds
```

Timing Info for Writing History and Restart Files

```
Timing for Writing wrfout_d01_2000-01-25_00:00:00 for domain 1: 1.17091 elapsed seconds
```

Model Errors

```
5 points exceeded cfl=2 in domain 1 at time 4.200000 MAX AT i,j,k: 123 48 3
    cfl,w,d(eta)= 4.165821
```

Errors are typically at the end of rsl files.
CFL errors are embedded in the text.

PRESENTATION OUTLINE

WPS/WRF Flow

Running WPS

Running WRF

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Troubleshooting WRF Errors

TROUBLESHOOTING

- Check the *rsl.error.0000* file for errors
- See the WRF Frequently Asked Questions Page
- Check the WRF & MPAS-A Support Forum to see if your issue has previously been addressed. If not, post to the forum.

QUESTIONS?