



The WRF Preprocessing System

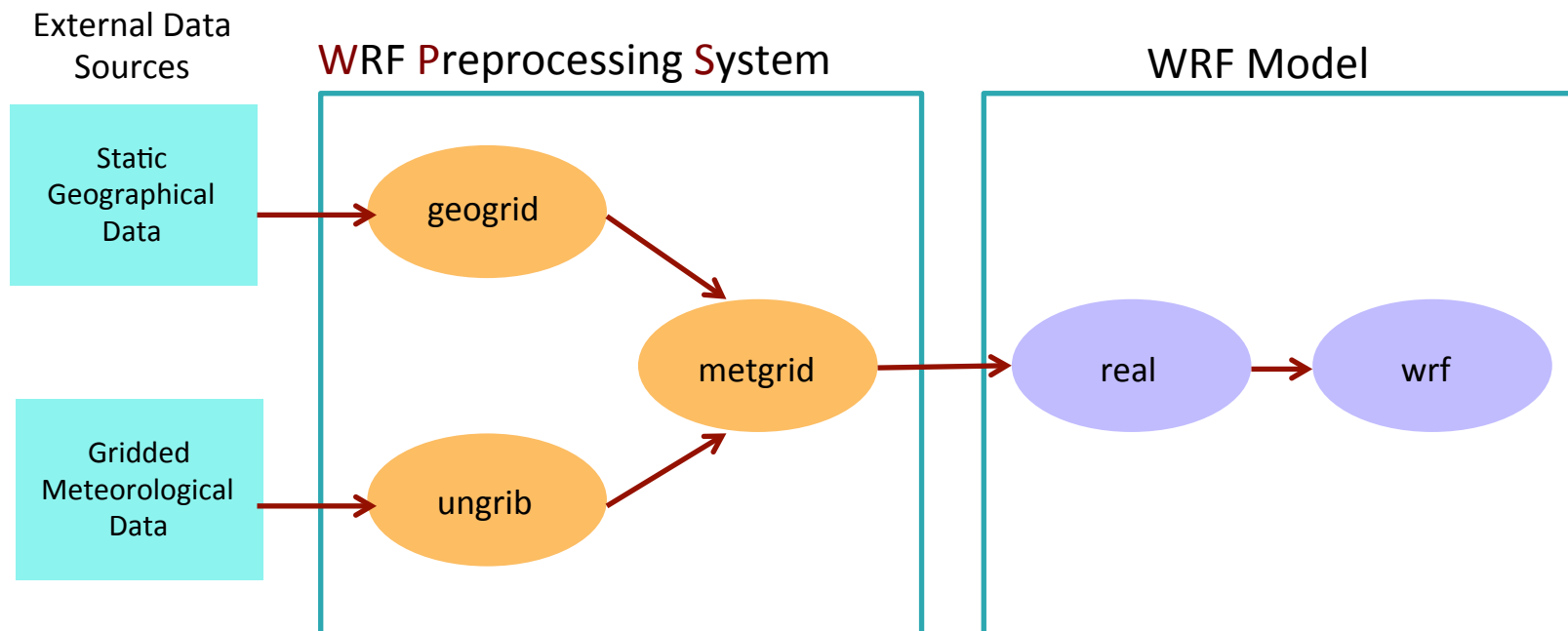
Kelly Keene – August 2016



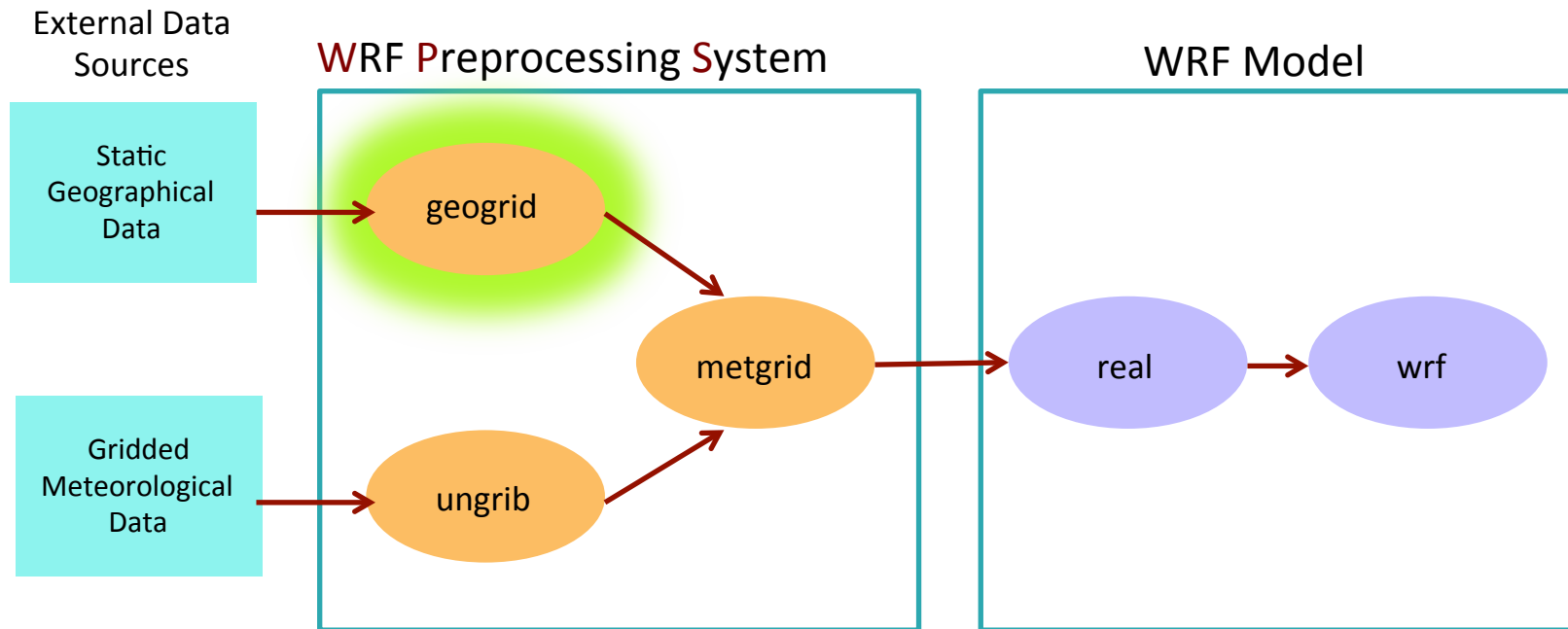
Purpose of the WPS

- Prepares input to WRF for real-data simulations
 - Defines simulation coarse domain and nested domains
 - Computes latitude, longitude, map scale factors, and Coriolis parameters at every grid point
 - Interpolates time-invariant terrestrial data to simulation grid (e.g., terrain height and soil type)
 - Interpolates time-varying meteorological fields from another model onto simulation domains

WRF/WPS Flowchart



The *geogrid* Program



geogrid: think geographical

The *geogrid* Program

- For WRF model domains, geogrid defines:
 - Map projection (all domains must use the same projection)
 - Geographic location of domains
 - Dimension of domains

- Geogrid provides values for static (time-invariant) fields at each model grid point
 - Computes latitude, longitude, map scale factor, and Coriolis parameters at each grid point
 - Horizontally interpolates static terrestrial data
 - E.g., topography height, land use category, soil type, vegetation fraction, monthly surface albedo

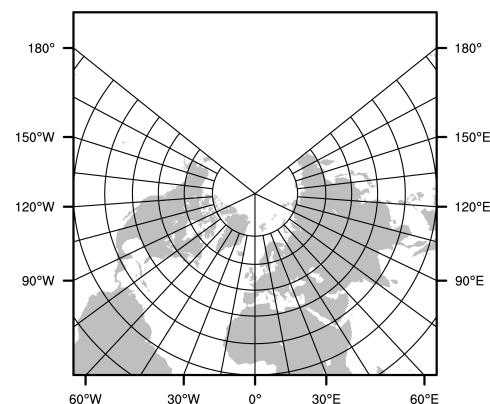
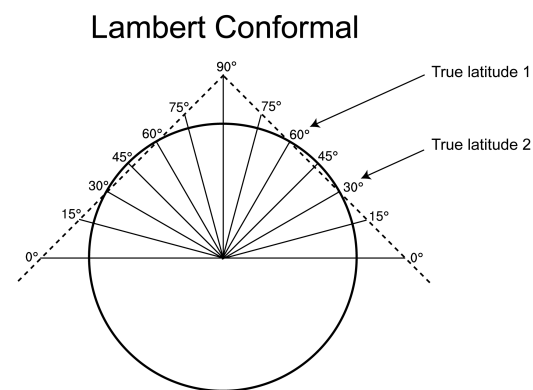
geogrid: Defining Model Domains

- Choose a map projection to use for your domains
 - The real earth is (roughly) an ellipsoid, but WRF computational domains are defined by rectangles in the plane

- Can use any of the following projections:
 - Lambert conformal
 - Mercator
 - Polar stereographic
 - Latitude-longitude (must be chosen for a global domain!)

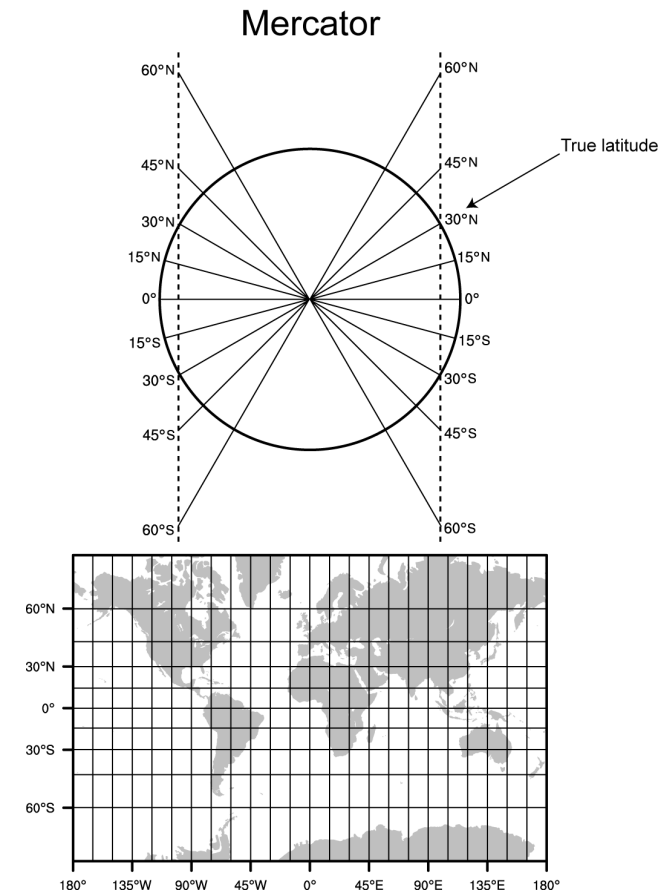
geogrid Projections: Lambert Conformal

- Well-suited for mid-latitudes
- Domain cannot contain either pole
- Domain cannot be periodic in west-east direction
- Either one or two 'true latitudes' may be specified
 - If 2 are given, the order doesn't matter



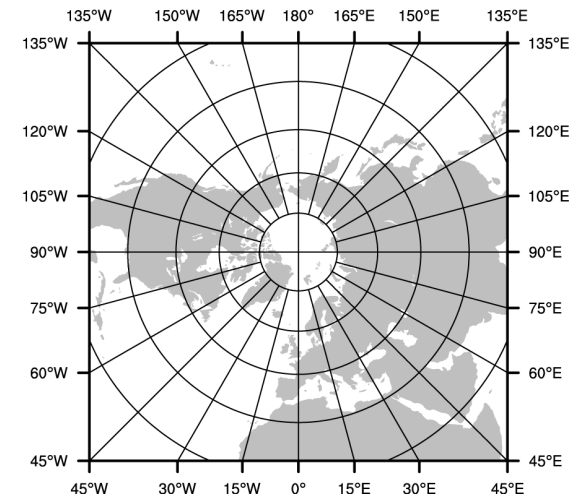
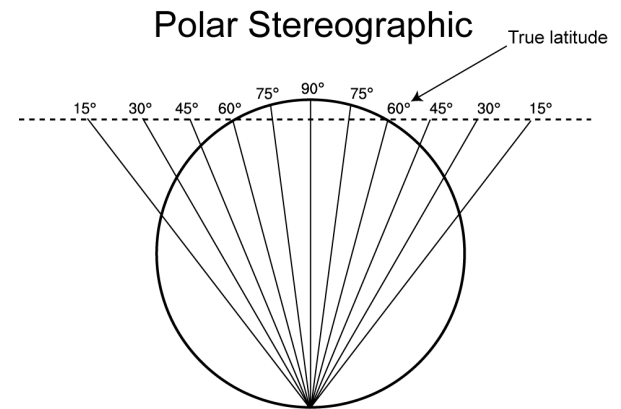
geogrid Projections: Mercator

- Well-suited for low-latitudes (near equator)
- May be used for periodic domains in the west-east direction
- A single “true latitude” is specified
 - Cyclinder intersects the Earth’s surface at +/- truelat



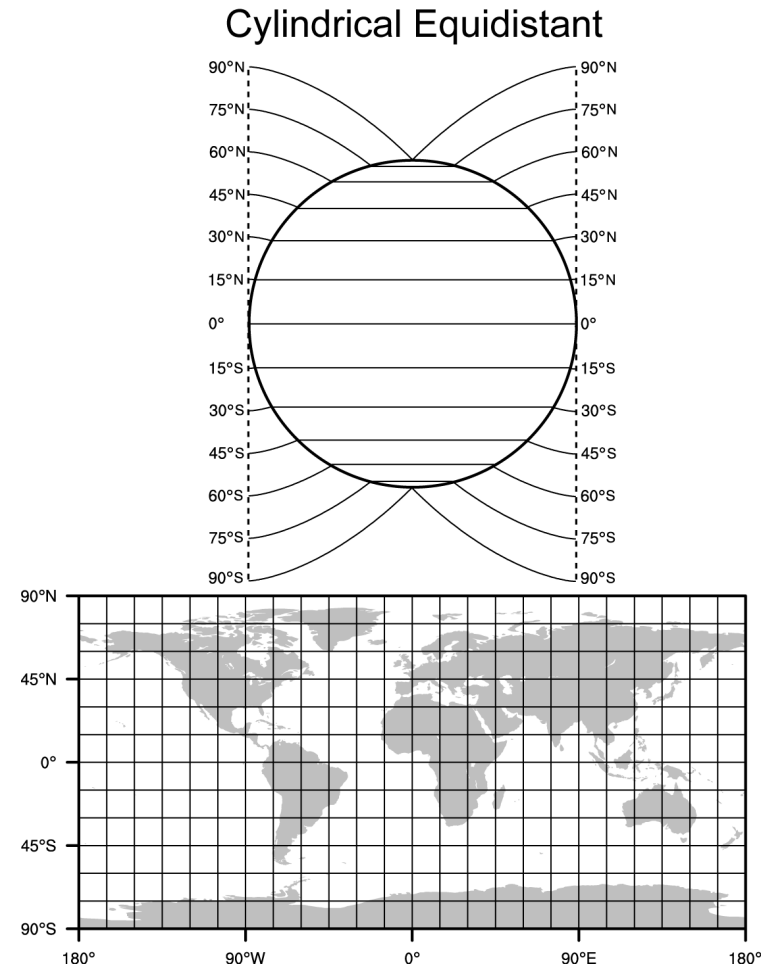
geogrid Projections: Polar Stereographic

- Good for high-latitude domains, especially if the domain must contain a pole
- A single “true latitude” is specified



geogrid Projections: Latitude-longitude

- Required for global domains
- May be used for regional domains
- Can be used in its normal or rotated aspect



geogrid: Defining Model Domains

All parameters reside in the &geogrid section of the namelist.wps file

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

➤ Parameters for defining map projection

- **MAP_PROJ**: 'lambert', 'mercator', 'polar', or 'lat-lon'
- **TRUELAT1**: First true latitude
- **TRUELAT2**: Second true latitude (only for Lambert conformal)
- **POLE_LAT, POLE_LON**: Location of North pole in WRF computational grid (only for lat-lon)
- **STAND_LON**: The meridian parallel to the y-axis

geogrid: Defining Model Domains

All parameters reside in the &geogrid section of the namelist.wps file

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

➤ Parameters for location and size of domain

- **REF_LAT, REF_LON**: The (lat/lon) location of a known location in the domain (by default, the center point of the domain)
- **DX/DY**: Grid distance (resolution)
 - For Lambert, Mercator, and Polar: **meters**
 - For (rotated) lat-lon: **degrees**
- **E_WE**: Number of velocity points in the west-east direction
- **E_SN**: Number of velocity points in the south-north direction

Running *geogrid*: Namelist Set-up

- Edit **namelist.wps** file
 - For *geogrid*, only the ***&share*** and ***&geogrid*** namelists need to be edited

&share

```
wrf_core = 'ARW',
max_dom = 2,
io_form_geogrid = 2,
```

/

&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,
geog_data_res  = '5m',  '2m',
dx             = 15000,
dy             = 15000,
map_proj       = 'lambert',
ref_lat        = 37.0,
ref_lon        = -97.0,
truelat1       = 45.0,
truelat2       = 30.0,
stand_lon      = -97.0,
geog_data_path = '/data/static/geog/'
```

/

Running *geogrid*: Namelist Set-up

```
&share
```

```
wrf_core = 'ARW',  
max_dom = 2,  
io_form_geogrid = 2,  
/
```

Which WRF core?

- for ARW, set to 'ARW'

Total number of model domains,
including nests

Format for geogrid output files
2 = netCDF is recommended

Running *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 = '5m',  '2m',
geog_data_path = '/data/static/geog/'

```

Used for nesting purposes

- What is the grid ratio for each nest?
- Where is it located inside its parent?

Domain sizes: How many grid points does the domain have? What is the grid spacing?

Static data:

- What resolution of source data to interpolate from for each domain
 - default is 30s USGS
 - other options: 2m, 5m, 10m
- path to static data

Running *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:

- What projection to use
- What are the parameters of the projection?

Running *geogrid*: Check for Success

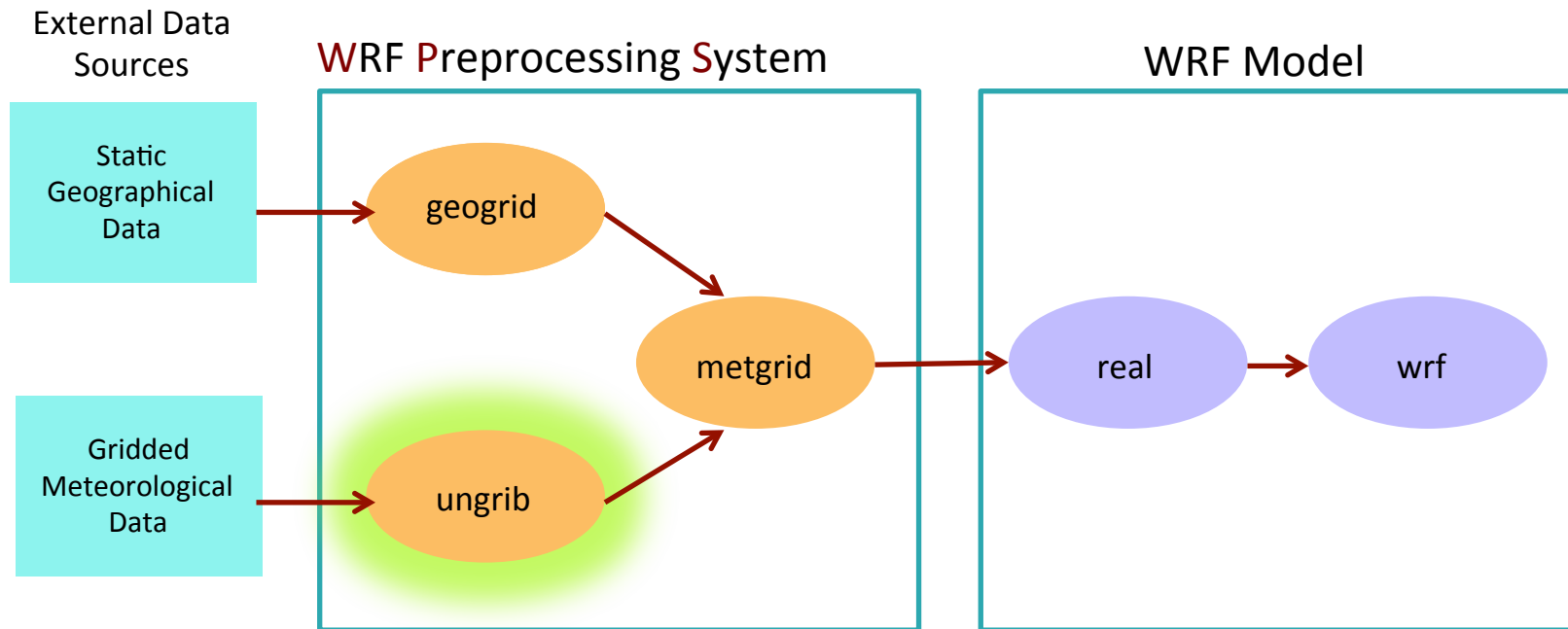
- Check that *geogrid* ran successfully. If so, this message should be printed:

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

- And you should have a *geo_em.d0X* file for each domain

If there was an error, check for an ERROR message in the *geogrid.log* file, or for a system error, like “Segmentation fault”.

The *ungrib* Program



ungrib: think un + grib

The *ungrib* Program

➤ What is a GRIB file?

- Files that contain meteorological/atmospheric data (3D and surface)
- GRIB is a WMO standard file format for storing regularly-distributed (e.g., gridded) fields
- Fields in a file are identified only by coded numbers
 - These numbers must be referenced against an external table to determine the corresponding field

ungrib: Vtables

- How does ungrib know which fields to extract?
- Using Vtable (Variable Tables)
 - Files that give the GRIB codes for fields to be extracted from GRIB input files
 - One Vtable for each source of data
 - Vtables are provided for many sources of data (e.g., NAM, GFS, Reanalysis 2, CFSR, ECMWF, etc.)

ungrib: Vtables

Vtable for GRIB1 Data

GRIB1 Param	Level Type	From Level1	To Level2	UNGRIB Name	UNGRIB Units	UNGRIB Description
11	100	*		T	K	Temperature
33	100	*		U	m s-1	U
34	100	*		V	m s-1	V
52	100	*		RH	%	Relative Humidity
7	100	*		HGT	m	Height
11	105	2		T	K	Temperature at 2 m
52	105	2		RH	%	Relative Humidity at 2 m
33	105	10		U	m s-1	U at 10 m
34	105	10		V	m s-1	V at 10 m
1	1	0		PSFC	Pa	Surface Pressure
130	102	0		PMSL	Pa	Sea-level Pressure
144	112	0	10	SM000010	kg m-3	Soil Moist 0-10 cm below grn layer (Up)
144	112	10	40	SM010040	kg m-3	Soil Moist 10-40 cm below grn layer
144	112	40	100	SM040100	kg m-3	Soil Moist 40-100 cm below grn layer
144	112	100	200	SM100200	kg m-3	Soil Moist 100-200 cm below gr layer
85	112	0	10	ST000010	K	T 0-10 cm below ground layer (Upper)
85	112	10	40	ST010040	K	T 10-40 cm below ground layer (Upper)
85	112	40	100	ST040100	K	T 40-100 cm below ground layer (Upper)
85	112	100	200	ST100200	K	T 100-200 cm below ground layer (Bottom)
91	1	0		SEAICE	proprtn	Ice flag
81	1	0		LANDSEA	proprtn	Land/Sea flag (1=land,2=sea in GRIB2)
7	1	0		HGT	m	Terrain field of source analysis
11	1	0		SKINTEMP	K	Skin temperature (can use for SST also)
65	1	0		SNOW	kg m-2	Water equivalent snow depth
223	1	0		CANWAT	kg m-2	Plant Canopy Surface Water
224	1	0		SOILCAT	Tab4.213	Dominant soil type category
225	1	0		VEGCAT	Tab4.212	Dominant land use category

ungrib: Vtables

Vtable for GRIB2 Data

metgrid Description	GRIB2 Discp	GRIB2 Catgy	GRIB2 Param	GRIB2 Level
Temperature	0	0	0	100
U	0	2	2	100
V	0	2	3	100
Relative Humidity	0	1	1	100
Height	0	3	5	100
Temperature at 2 m	0	0	0	103
Relative Humidity at 2 m	0	1	1	103
U at 10 m	0	2	2	103
V at 10 m	0	2	3	103
Surface Pressure	0	3	0	1
Sea-level Pressure	0	3	1	101
Soil Moist 0-10 cm below grn layer (Up)	2	0	192	106
Soil Moist 10-40 cm below grn layer	2	0	192	106
Soil Moist 40-100 cm below grn layer	2	0	192	106
Soil Moist 100-200 cm below gr layer	2	0	192	106
Soil Moist 10-200 cm below gr layer	2	0	192	106
T 0-10 cm below ground layer (Upper)	0	0	0	106
T 10-40 cm below ground layer (Upper)	0	0	0	106
T 40-100 cm below ground layer (Upper)	0	0	0	106
T 100-200 cm below ground layer (Bottom)	0	0	0	106
T 10-200 cm below ground layer (Bottom)	0	0	0	106
Ice flag	0	2	0	1
Land/Sea flag (1=land, 0 or 2=sea)	2	0	0	1
Terrain field of source analysis	2	0	7	1
Skin temperature (can use for SST also)	0	0	0	1
Water equivalent snow depth	0	1	13	1
Dominant soil type cat.(not in GFS file)	2	3	0	1
Dominant land use cat. (not in GFS file)	2	0	198	1

ungrib: Vtables

- What if a data source has no existing Vtable included in the WPS code?
- Create a Vtable
 - Obtain a listing of GRIB codes for fields in the source
 - Check documentation from originating center, or
 - Use utility such as g1print/g2print (found in WPS/util/), or wgrib
 - Use existing Vtable as template
 - Check documentation in Chapter 3 of the WRF Users' Guide for more information about Vtables
 - http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_V3.8/users_guide_chap3.htm

ungrib: Intermediate File Format

- After extracting fields listed in the Vtable, *ungrib* writes those fields to intermediate format
- For meteorological data sets not in GRIB format, the user may write to intermediate format directly
 - Detailed information in Chapter 3 of the WRF Users' Guide:
http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_V3.8/users_guide_chap3.htm

Running *ungrib*: Namelist Set-up

- ➔ For *ungrib*, only the **&share** and **&ungrib** sections of the namelist will need to be edited

&share

```
wrf_core = 'ARW',  
max_dom = 2,  
start_date = '2006-04-01_00:00:00',  
end_date = '2006-04-01_12:00:00',  
interval_seconds = 21600  
io_form_geogrid = 2,
```

&ungrib

```
out_format = 'WPS',  
prefix = 'GFS',
```

Running *ungrib*: Namelist Set-up

```
&share
```

```
wrf_core = 'ARW',  
max_dom = 2,
```

```
start_date = '2006-04-01_00:00:00',  
end_date   = '2006-04-01_12:00:00',
```

```
interval_seconds = 21600
```

```
io_form_geogrid = 2,  
/
```

Data time range: between which times should ungrib process GRIB data?

Data frequency: How many seconds Between output files for ungrib?
- E.g., 10800 s = 3 hrs

Running *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: Gives prefix for
Intermediate files.

- prefix can include a path
- E.g., 'GFS' would give intermediate files
named *GFS:YYYY-MM-DD_hh*

Running *ungrib*

- Link the GRIB files to the running directory
 - Use the *link_grib.csh* that is provided in the WPS/ directory
 - `./link_grib.csh path_to_your_grib_files/gribfile_prefix`
 - The ungrib program looks for files named *GRIBFILE.AAA*, *GRIBFILE.AAB*, *GRIBFILE.AAC*, etc. in the run directory
 - *GRIBFILE.AAA* - > `/data/GRIB/GFS/gfs_060401_00_00`

- Link to the correct Vtable
 - In `-sf ungrib/Variable_Tables/Vtable.xxx` Vtable

Running *ungrib*

➔ Run `ungrib`: `./ungrib.exe`

```

*** Starting program ungrib.exe ***
Start_date = 2006-08-16_12:00:00 ,      End_date = 2006-08-16_12:00:00
output format is WPS
Path to intermediate files is ./
  ungrib - grib edition num           2

#####
Inventory for date = 2006-08-16 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

```

Running *ungrib*: Check for Success

- Check that *ungrib* ran successfully. If so, this message should be printed

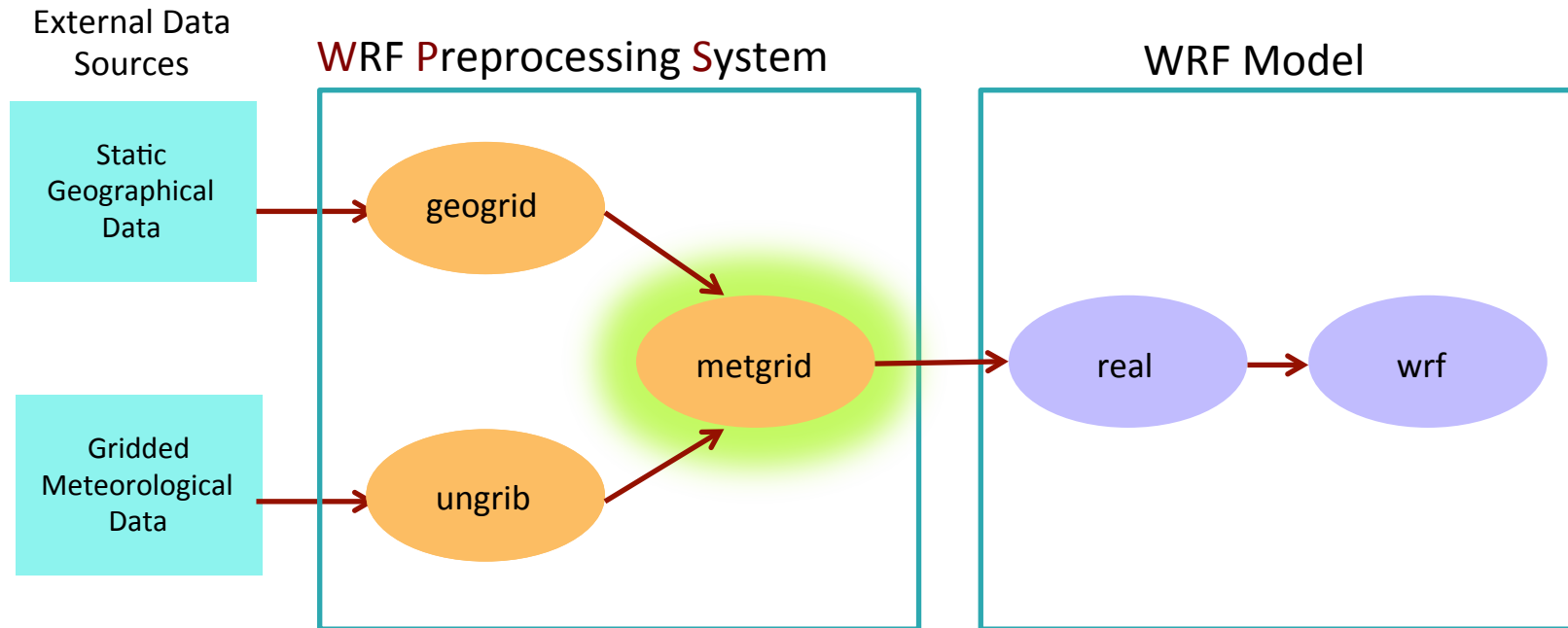
```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!   Successful completion of ungrib.                               !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

- And you should have files with a format similar to
FILE:YYYY-MM-DD_hh for each data file you used

If there was an error, check for error message in *ungrib*'s printout or in the *ungrib.log* file.

Common errors are related to incorrect date specifications in the *&share* namelist, or because GRIB2 data was used with a version of WPS compiled without GRIB2 libraries.

The *metgrid* Program



metgrid: think meteological

The *metgrid* Program

- Horizontally interpolates meteorological data (extracted by ungrib) to simulation domains (defined by geogrid)
- Rotates winds to WRF grid
 - i.e., rotates so that the U-component is parallel to the x-axis, and the V-component is parallel to the y-axis

Running *metgrid*: Namelist Set-up

- ➔ For *metgrid*, only the **&share** and **&metgrid** sections of the namelist will be edited

&share

```
wrf_core = 'ARW',  
max_dom = 2,  
start_date = '2006-04-01_00:00:00', '2006-04-01_00:00:00',  
end_date = '2006-04-01_12:00:00', '2006-04-01_00:00:00',  
interval_seconds = 21600  
io_form_geogrid = 2,  
/
```

&metgrid

```
fg_name = 'GFS',  
io_form_metgrid = 2,  
/
```

Running *metgrid*: Namelist Set-up

&share

```
wrf_core = 'ARW',  
max_dom = 2,
```

```
start_date = '2006-04-01_00:00:00', '2006-04-01_00:00:00',  
end_date   = '2006-04-01_12:00:00', '2006-04-01_00:00:00',
```

```
interval_seconds = 21600  
io_form_geogrid = 2,
```

/



Data time range: Time range to process *for each domain*.

Running *metgrid*: Namelist Set-up

```
&metgrid  
  fg_name = 'GFS',  
  
  io_form_metgrid = 2,  
/
```

Intermediate file prefixes: Prefix(es) of Intermediate files to interpolate to model Domain.

- This should match the prefix given in ungrid

Metgrid I/O format: Which I/O format to use For metgrid output?

- 2= netCDF is recommended

Running *metgrid*

➔ Run metgrid: `./metgrid.exe`

```
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.   !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

Metgrid output files:

```
met_em.d01.2012-01-27_00:00:00.nc
met_em.d01.2012-01-27_06:00:00.nc
met_em.d01.2012-01-27_12:00:00.nc
met_em.d01.2012-01-27_18:00:00.nc
met_em.d01.2012-01-28_00:00:00.nc
```

The metgrid output files will be used to run real.exe!

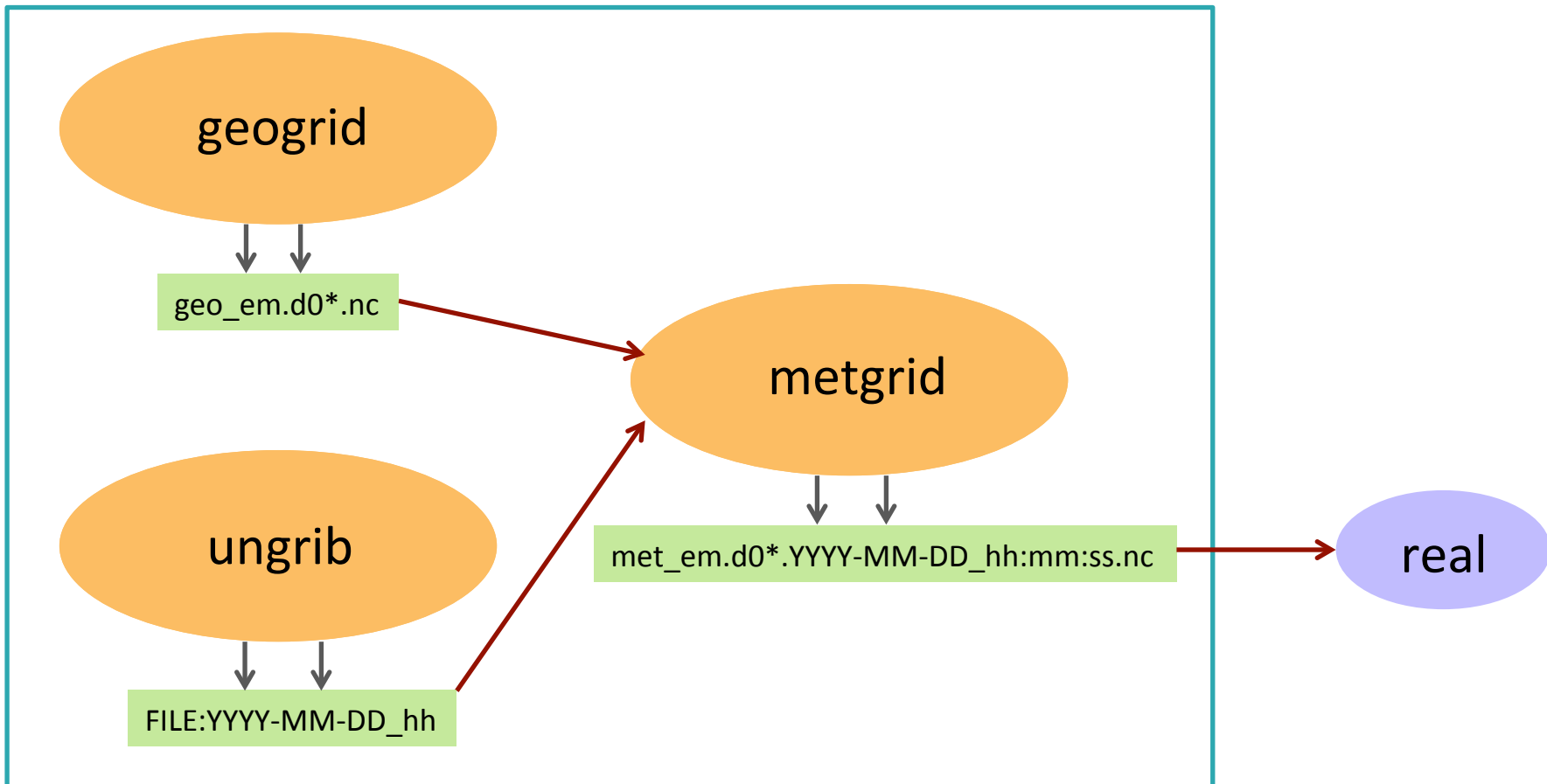
Running *metgrid*

- Check that `metgrid` ran successfully. If so, this message should be printed:

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!  
!   Successful completion of metgrid.           !  
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

If there was an error, check for an **ERROR** or **WARNING** message in the `metgrid.log` file, or for a system error, like “Segmentation fault”.

The WPS Process





Questions?