Running the WRF Preprocessing System
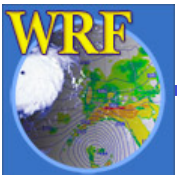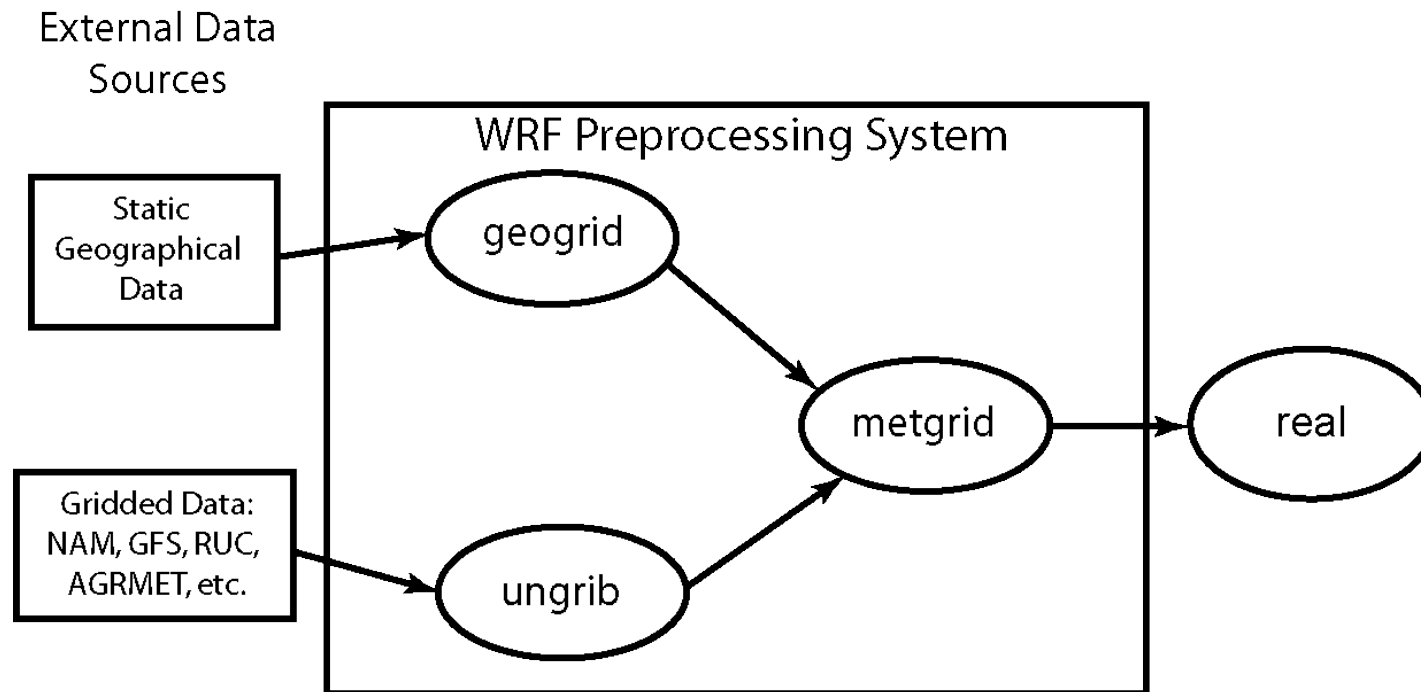
Michael Duda
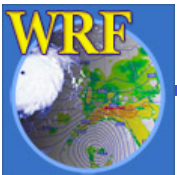
Review

- Briefly recall the programs in the WPS

External Data Sources

WRF Preprocessing System

Static Geographical Data → geogrid

Gridded Data: NAM, GFS, RUC, AGRMET, etc. → ungrib

geogrid → metgrid

ungrib → metgrid

metgrid → real

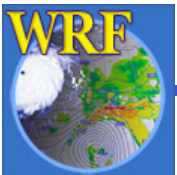# Review

- **geogrid** (think <u>geo</u>graphical)

  – Define size/location of model domains and interpolate static terrestrial fields to simulation grids

- **ungrib** (think <u>un</u>+<u>grib</u>)

  – Extract meteorological fields from GRIB files

- **metgrid** (think <u>met</u>eorological)

  – Horizontally interpolate meteorological fields (from ungrib) to simulation grids (defined by geogrid)

Overview

- How to run through the WPS for basic cases

  - Basic steps for running WPS

    - Geogrid

    - Ungrib

    - Metgrid

- WPS utility programs

- Common WPS mistakes

Running geogrid

STEP 1: Edit `namelist.wps`

For geogrid, only the &share and &geogrid namelists need to be edited in namelist.wps
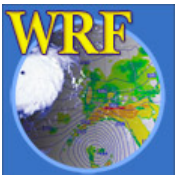
&share
```
wrf_core = 'ARW',
max_dom = 2,
io_form_geogrid = 2,
/
```

&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

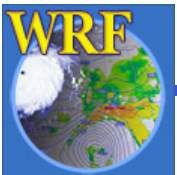**STEP 1**: Edit `namelist.wps`

Which WRF core?
For ARW, set to 'ARW'
For NMM, set to 'NMM'

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

Total number of model domains,
including nests, for ARW; number
of nesting levels for NMM.

Format for geogrid output files;
2=netCDF is recommended.

Running geogrid

STEP 1: Edit `namelist.wps`

&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',

    . . .
```
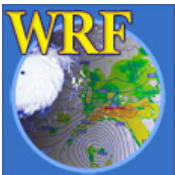
Nesting: Who is the parent? What is the grid ratio for each nest? Where is it located in its parent?

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? '30s', '2m', '5m', or '10m'?

Running geogrid

STEP 1: Edit `namelist.wps`

&geogrid

…

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

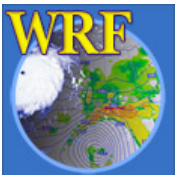**Map projection**: What projection to use? What are the parameters of the projection?

geog_data_path = '/data/static/geog/'

/

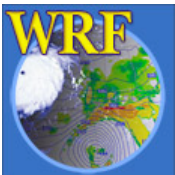**Static data**: Where are the data directories (e.g., topo_30s) located?

Running geogrid

STEP 2: Make sure GEOGRID.TBL is linked to the correct version of GEOGRID.TBL

- There are multiple GEOGRID.TBL files to support multiple dynamical cores in WRF

- GEOGRID.TBL.ARW must be used for ARW

- GEOGRID.TBL.NMM must be used for NMM

```
> ls geogrid/GEOGRID.TBL

GEOGRID.TBL -> GEOGRID.TBL.ARW
```

Running geogrid

<u>STEP 3</u>: Run geogrid.exe

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

Geogrid processes each domain individually. There will be one section of messages for each domain or nesting level.

As each field is processed, a message will be written to the screen and to the geogrid.log file.
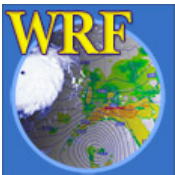
Running geogrid

STEP 4: Check that geogrid ran successfully
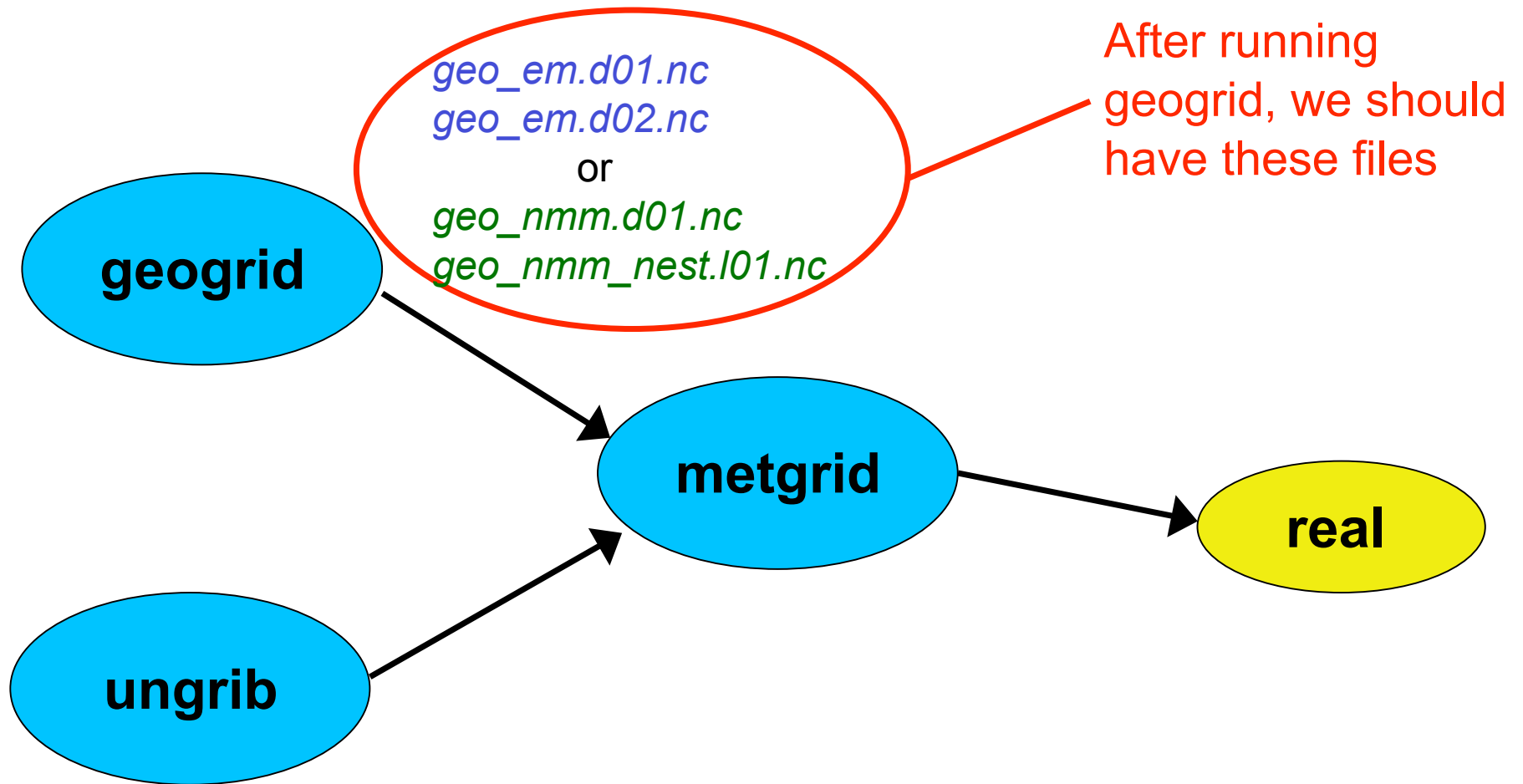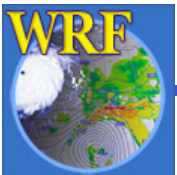
If geogrid ran sucessfully, this message should be printed:

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

If there was an error, check for an ERROR or WARNING message in the `geogrid.log` file, or for a system error, like "Segmentation fault".

Running geogrid

geo_em.d01.nc
geo_em.d02.nc
or
geo_nmm.d01.nc
geo_nmm_nest.l01.nc

After running geogrid, we should have these files

geogrid

metgrid

real

ungrib

Running ungrib

STEP 1: Edit `namelist.wps`

For ungrib, only the &share and &ungrib namelists 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

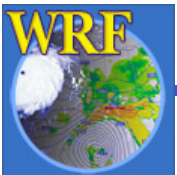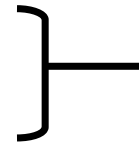## <u>STEP 1</u>: Edit `namelist.wps`

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

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

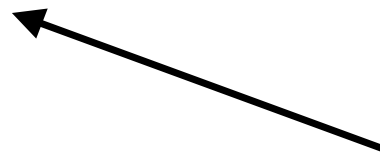 interval_seconds = 21600

  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

STEP 1: Edit `namelist.wps`

Intermediate file format: Which format to use for intermediate files? 'WPS', 'SI', or 'MM5' are possible; 'WPS' is recommended.
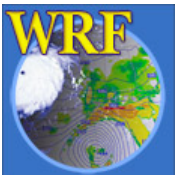
&ungrib
    out_format = 'WPS',

    prefix = 'GFS',
/

Intermediate file names: Gives prefix for intermediate files.
Prefix can include a path.
E.g., 'XZY' would give intermediate files named XYZ:*yyyy-mm-dd_hh.*

Running ungrib

STEP 2: Link the correct Vtable to the file name "Vtable" in the run directory

- Some Vtables are provided with WPS in the **WPS/ungrib/Variable_Tables** directory
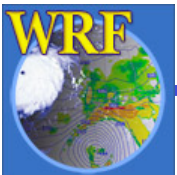
    - E.g., Vtable.GFS, Vtable.SST, Vtable.ECMWF

- Ungrib always expects to find a file named **Vtable** in the run directory

> ln –s ungrib/Variable_Tables/Vtable.GFS Vtable
>
> ls Vtable
>
> Vtable -> ungrib/Variable_Tables/Vtable.GFS

Running ungrib

STEP 3: Link GRIB files to the correct file
  names in the run directory

- Ungrib always expects GRIB files to be named
  `GRIBFILE.AAA`, `GRIBFILE.AAB`, `GRIBFILE.AAC`,
  etc., in the run directory

- The `link_grib.csh` script can be used to link GRIB
  files to these file names:

  > link_grib.csh /data/GRIB/GFS/gfs*   *See p. 3-12*

  > ls GRIBFILE.*

  GRIBFILE.AAA -> /data/GRIB/GFS/gfs_060401_00_00

Running ungrib

STEP 4: Run 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

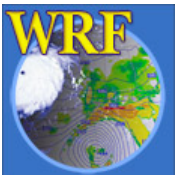**STEP 5**: Check that ungrib ran successfully

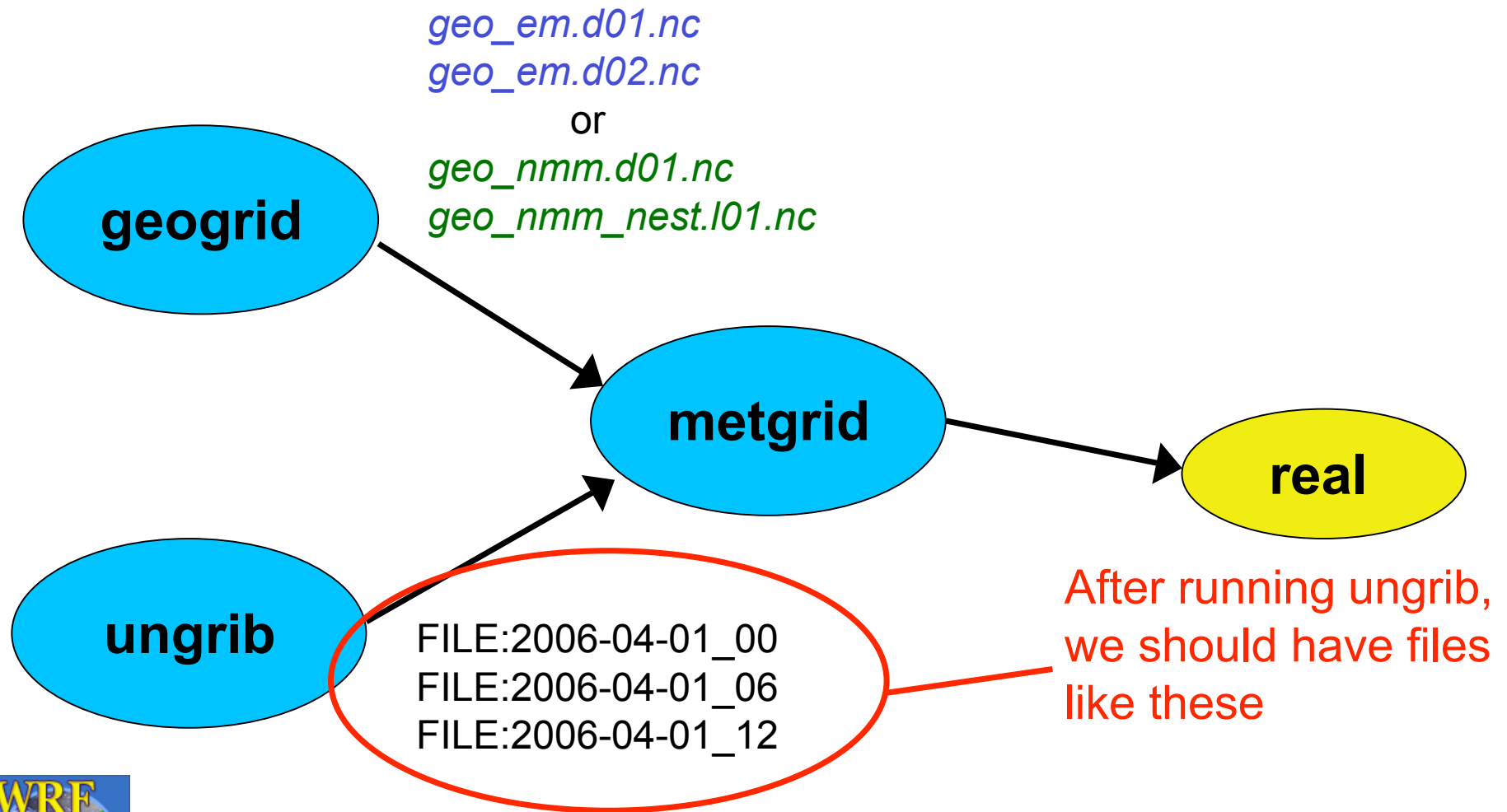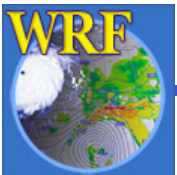If ungrib ran successfully, this message should be printed:

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

If there was an error, check for error message in ungrib's printout or in the `ungrid.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.

Running ungrib

geo_em.d01.nc
geo_em.d02.nc
or
geo_nmm.d01.nc
geo_nmm_nest.l01.nc

geogrid

metgrid

real

ungrib

FILE:2006-04-01_00
FILE:2006-04-01_06
FILE:2006-04-01_12

After running ungrib, we should have files like these

Running metgrid

STEP 1: Edit `namelist.wps`

For metgrid, only the &share and &metgrid namelists need to be edited
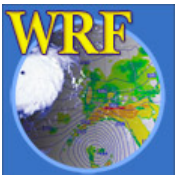
```
&share
   wrf_core = 'ARW',
   max_dom = 2,
   start_date  = '2006-04-01_00:00:00',  '2006-04-01_00:00:00',
   end_date   = '2006-04-01_12:00:00',  '2006-04-01_00:00:00',
   interval_seconds = 21600
   io_form_geogrid = 2,
/
```

```
&metgrid
   fg_name = 'GFS',
   constants_name = 'SST:2006-04-01_00',
   io_form_metgrid = 2,
/
```

Running metgrid

STEP 1: Edit `namelist.wps`

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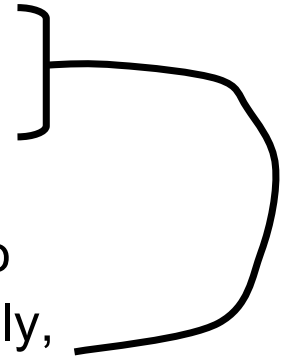 wrf_core = 'ARW',
  max_dom = 2,

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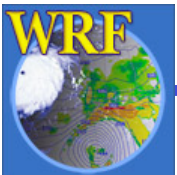 end_date   = '2006-04-01_12:00:00', '2006-04-01_00:00:00',

  interval_seconds = 21600
  io_form_geogrid = 2,
/

Data time range: Time range to process *for each domain*. Usually, only the initial time is needed <u>for ARW nested domains</u>. Only coarse domain needed for NMM.

See p. 3-14, 3-16, and 3-32

Running metgrid

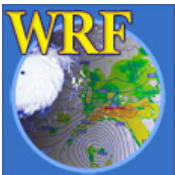## STEP 1: Edit `namelist.wps`

Intermediate file prefixes: Prefix (or prefixes) of intermediate files to interpolate to model domain. Should match prefix given to ungrib.

See p. 3-18

&metgrid
   fg_name = 'GFS',

   constants_name = 'SST:2006-04-01_00',

   io_form_metgrid = 2,
/

Constant fields: Optional name of an intermediate file with fields to be used for every time period.

Metgrid I/O format: Which I/O format to use for metgrid output? 2=netCDF is recommended.
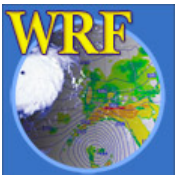
See p. 3-14, and 3-36

Running metgrid

STEP 2: Make sure METGRID.TBL is linked to the correct version of METGRID.TBL

- There are multiple METGRID.TBL files to support multiple dynamical cores in WRF

- Generally, METGRID.TBL.ARW must be used for ARW and METGRID.TBL.NMM for NMM

```
> ls metgrid/METGRID.TBL

METGRID.TBL -> METGRID.TBL.ARW
```
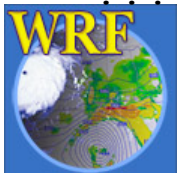
Running metgrid

<u>STEP 3</u>: Run metgrid.exe

```
Processing domain 1 of 2
    SST:2006-04-01_00

 Processing 2006-04-01_00
    GFS
 Processing 2006-04-01_06
    GFS
 Processing 2006-04-01_12
    GFS

Processing domain 2 of 2
    SST:2006-04-01_00
 Processing 2006-04-01_00
    GFS
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!  Successful completion of metgrid.  !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

Fields from constant files (given using `constants_name`) are processed before any time varying fields.

Metgrid processes all time period for one domain before processing for the next domain

Running metgrid

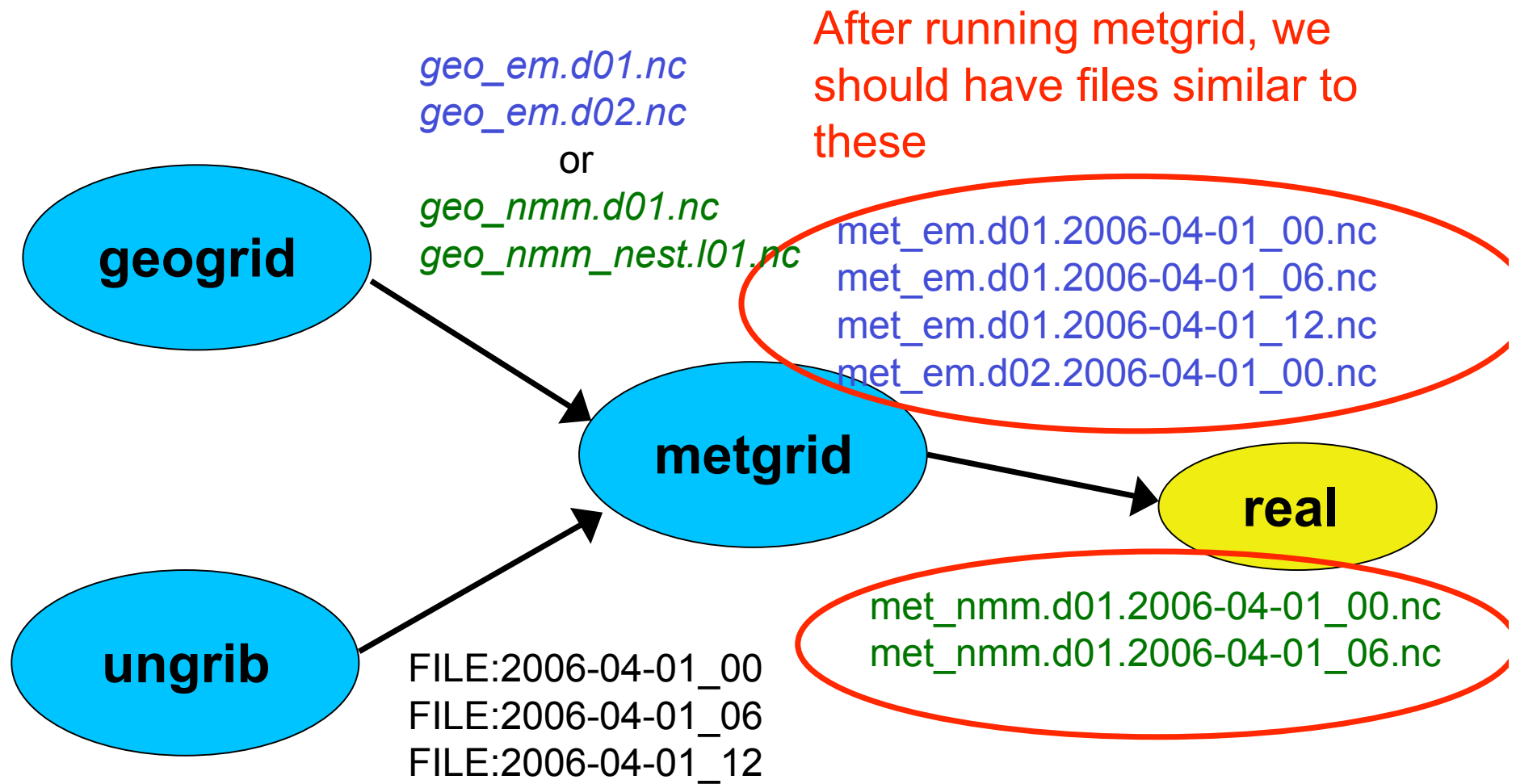**<u>STEP 4</u>**: Check that metgrid ran successfully

If metgrid ran successfully, 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".**
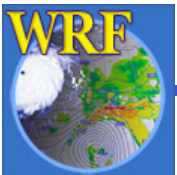
Running metgrid

geo_em.d01.nc
geo_em.d02.nc
or
geo_nmm.d01.nc
geo_nmm_nest.l01.nc

After running metgrid, we should have files similar to these

geogrid

metgrid

met_em.d01.2006-04-01_00.nc
met_em.d01.2006-04-01_06.nc
met_em.d01.2006-04-01_12.nc
met_em.d02.2006-04-01_00.nc

real

ungrib

FILE:2006-04-01_00
FILE:2006-04-01_06
FILE:2006-04-01_12

met_nmm.d01.2006-04-01_00.nc
met_nmm.d01.2006-04-01_06.nc
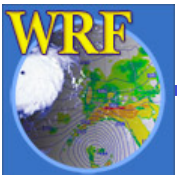
Overview

- How to run through the WPS for basic cases

    - Basic steps for running WPS

        - Geogrid

        - Ungrib

        - Metgrid

- WPS utility programs

- Common WPS mistakes

WPS Utility Programs

- Besides geogrid, ungrib, and metgrid, some simple utility programs are distributed with WPS:

  – For checking contents of intermediate format files

  – For listing contents of GRIB1 & GRIB2 files

  – To assist in locating domains

- Some programs use NCAR Graphics libraries for plotting

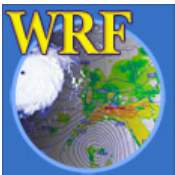 – For these utilities, *NCAR Graphics must be installed*

WPS Utility Programs

The utility programs that come with WPS can be helpful when diagnosing problems with WPS output

- All utilities are found in the **WPS/util** directory

- Users are encouraged to make use of these utilities to examine WPS input and output files

Utility: plotgrids

The *plotgrids* program plots the location of grids defined in *namelist.wps*

● *plotgrids can be used to iteratively refine the locations of grids.*

● *plotgrids* uses the namelist.wps file only, so there is no need to run geogrid first!
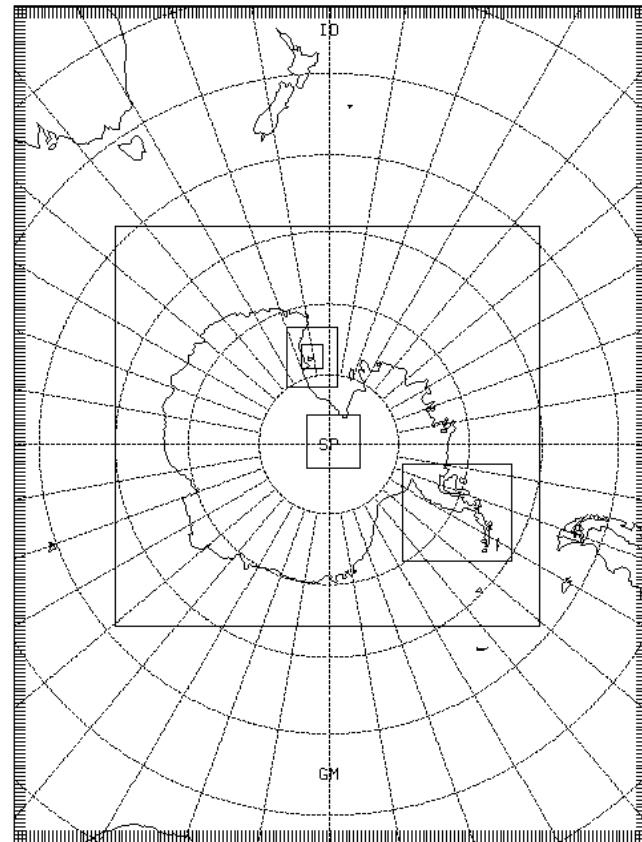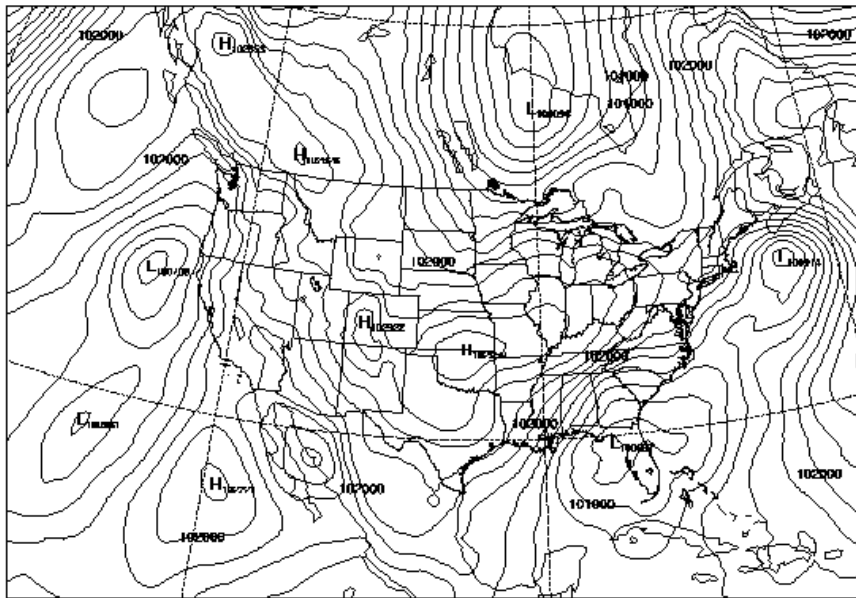
Utility: rd_intermediate

The rd_intermediate lists information about the fields found
in an intermediate-format file

```
====================================================
FIELD = TT
UNITS = K DESCRIPTION = Temperature
DATE = 2000-01-24_12:00:00 FCST = 0.000000
SOURCE = unknown model from NCEP GRID 212
LEVEL = 200100.000000
I,J DIMS = 185, 129
IPROJ = 1
   REF_X, REF_Y = 1.000000, 1.000000
   REF_LAT, REF_LON = 12.190000, -133.459000
   DX, DY = 40.635250, 40.635250
   TRUELAT1 = 25.000002
DATA(1,1)=295.910950
====================================================
```

Utility: plotfmt

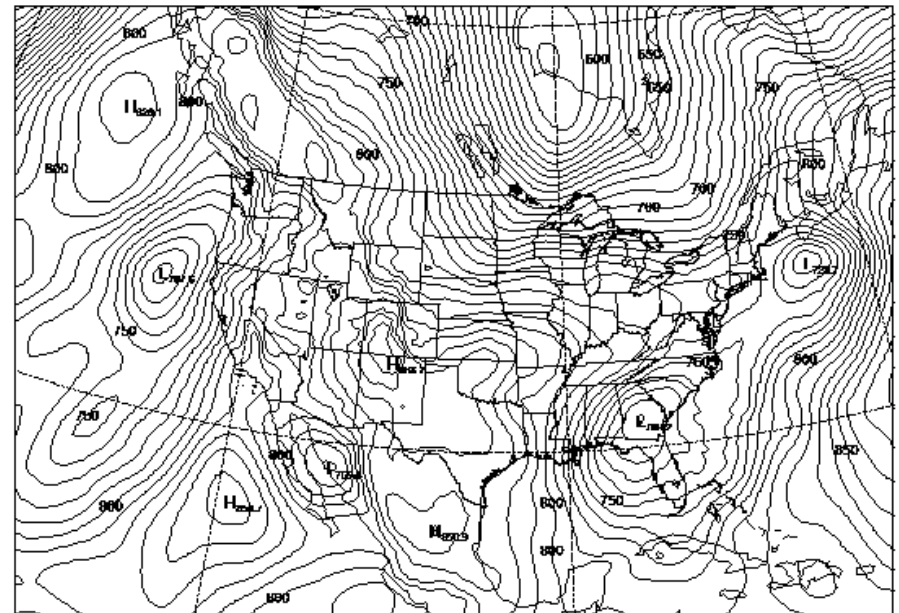The plotfmt program plots the fields in the ungrib intermediate-formatted files

201300 PMSL

Pa

Sea-level Pressure
WPS intermediate format

CONTOUR FROM 100200 TO 103200 BY 200
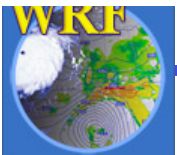
unknown model from NCEP GRID 212

92500 GHT

m

Height
WPS intermediate format

CONTOUR FROM 580 TO 880 BY 10

unknown model from NCEP GRID 212
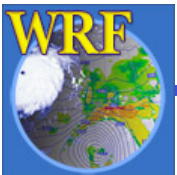
Utility: g1print and g2print

The *g1print* and *g2print* programs list the contents of a GRIB1 or GRIB2 file:

rec num	Prod Disc	Cat	Param num	Lvl code	Lvl one	Lvl two	Name	Time	Fcst hour
1	0	3	5	100	100000	0	HGT	2006-08-16_12:00:00	00
2	0	3	5	100	97500	0	HGT	2006-08-16_12:00:00	00
3	0	3	5	100	95000	0	HGT	2006-08-16_12:00:00	00
4	0	3	5	100	92500	0	HGT	2006-08-16_12:00:00	00
5	0	3	5	100	90000	0	HGT	2006-08-16_12:00:00	00
6	0	3	5	100	85000	0	HGT	2006-08-16_12:00:00	00
7	0	3	5	100	80000	0	HGT	2006-08-16_12:00:00	00
8	0	3	5	100	75000	0	HGT	2006-08-16_12:00:00	00
9	0	3	5	100	70000	0	HGT	2006-08-16_12:00:00	00
10	0	3	5	100	65000	0	HGT	2006-08-16_12:00:00	00

Overview

- How to run through the WPS for basic cases

  - Basic steps for running WPS

    - Geogrid

    - Ungrib

    - Metgrid

- WPS utility programs

- Common WPS mistakes

Common WPS Mistakes

1) All 3-d fields must have same number of levels in
metgrid

```
WRF_DEBUG: Warning DIM                    4 , NAME
 num_metgrid_levels REDIFINED  by var GHT           27
 26  in wrf_io.F90 line          2347
 ERROR: Error in ext_pkg_write_field
```
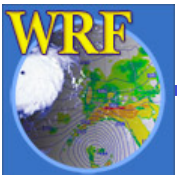
- This is usually corrected by ensuring that all 3-d
meteorological fields have surface level data

- Try setting debug_level=1000 in &share namelist, and
checking metgrid.log for a table showing which fields
are on which levels
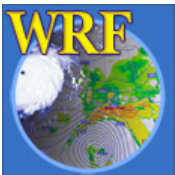
Common WPS Mistakes

2) When using a regional data set (e.g., NAM), ensure that model domain is completely covered by the data

    - The metgrid program will stop if the model domain has grid points that are not covered by data

3) For native vertical coordinate data sets (e.g., RUCb, ECMWF), ensure that both pressure and geopotential height fields are available

Questions?