Running the WRF Preprocessing System

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Review

- Briefly recall the programs in the WPS

![Diagram showing the WRF Preprocessing System with nodes for geogrid, metgrid, ungrib, and real, with external data sources including static geographical data and gridded data: NAM, GFS, RUC, AGRMET, etc.]

The WRF Users’ Basic Tutorial
26 – 30 January 2015, Boulder, CO
Review

- **geogrid** *(think geographical)*
  - Define size/location of model domains and interpolate static terrestrial fields to simulation grids

- **ungrib** *(think un+grib)*
  - Extract meteorological fields from GRIB files

- **metgrid** *(think meteorological)*
  - 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 the 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,
ady = 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

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

Which WRF core?
For ARW, set to ‘ARW’
For NMM, set to ‘NMM’

Total number of model domains,
including nests, for ARW.

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

See p. 3–8 and 3–37
Running geogrid

**STEP 1: Edit namelist.wps**

```plaintext
&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’?

*See p. 3–9, 3–19, and 3–38*
Running geogrid

**STEP 1: Edit namelist.wps**

```plaintext
&geogrid

... 

  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/

/
```

- **Map projection**: What projection to use? What are the parameters of the projection?
  
  *See p. 3–9 and 3–40*

- **Static data**: Where are the data directories (e.g., topo_30s) located?
  
  *See p. 3–41*
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

**STEP 3: 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.

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

After running geogrid, we should have these files:

- geo_em.d01.nc
- geo_em.d02.nc

Diagram:

- geogrid
- ungrrib
- metgrid
- real

Text:

Running geogrid

After running geogrid, we should have these files:

- geo_em.d01.nc
- geo_em.d02.nc
## 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',
/
```
STEP 1: 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

See p. 3–14, and 3–38
**Running ungrib**

**STEP 1: Edit namelist.wps**

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

**Intermediate file format:** Which format to use for intermediate files? ‘WPS’, ‘SI’, or ‘MM5’ are possible; ‘WPS’ is recommended.

**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.

*See p. 3-14, 3-23, and 3-41*
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*
  > ls GRIBFILE.*
  GRIBFILE.AAA -> /data/GRIB/GFS/gfs_060401_00_00
  ```

  See p. 3-15
### 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

<table>
<thead>
<tr>
<th>PRES</th>
<th>TT</th>
<th>UU</th>
<th>VV</th>
<th>RH</th>
<th>HGT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013.0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>O</td>
</tr>
<tr>
<td>1000.0</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>975.0</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>950.0</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>925.0</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>900.0</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
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

After running ungrib, we should have files like these:

- geo_em.d01.nc
- geo_em.d02.nc
- 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,
/

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Running metgrid

**STEP 1: Edit** namelist.wps

```plaintext
&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 for ARW nested domains.

See p. 3–17 and 3–37
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.

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.

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

See p. 3-17 and 3-24

See p. 3-17, and 3-41
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
- METGRID.TBL.ARW should be used for ARW
- METGRID.TBL.NMM should be used for NMM

```bash
> ls metgrid/METGRID.TBL
METGRID.TBL -> METGRID.TBL.ARW
```
Running metgrid

**STEP 3: Run metgrid.exe**

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

---

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.

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!
! Successful completion of metgrid. !
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Running metgrid

**STEP 4:** 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

After running metgrid, we should have files similar to these:

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

Files similar to these:

- geo_em.d01.nc
- geo_em.d02.nc

Files generated by ungrib:

- FILE:2006-04-01_00
- FILE:2006-04-01_06
- FILE:2006-04-01_12
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
  - For computing 3d pressure field for ECMWF data

- 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 \texttt{WPS/util} directory

– Users are encouraged to make use of these utilities to examine WPS input and output files
Utility: plotgrids.ncl

The `plotgrids.ncl` script plots the locations of grids defined in `namelist.wps`.

- `plotgrids` can be used to iteratively refine the locations of grids.
- `plotgrids.ncl` 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.
The int2nc program converts an ungrib intermediate file to a standard NetCDF file.

- Users may then visualize fields with ncview, NCL, or other graphical packages.

Visualize NetCDF intermediate fields using `plotfmt_nc.ncl` script

Visualize NetCDF intermediate fields using ncview
Utility: g1print and g2print

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

<table>
<thead>
<tr>
<th>rec num</th>
<th>Prod Disc</th>
<th>Cat num</th>
<th>Param code</th>
<th>Lvl one</th>
<th>Lvl two</th>
<th>Name</th>
<th>Time</th>
<th>Fcst hour</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0</td>
<td>3</td>
<td>5</td>
<td>100</td>
<td>100000</td>
<td>0</td>
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<td>2</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>100</td>
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<td>3</td>
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<td>100</td>
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<td>HGT</td>
<td>2006-08-16 12:00:00</td>
</tr>
<tr>
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<td>3</td>
<td>5</td>
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<td>92500</td>
<td>0</td>
<td>HGT</td>
<td>2006-08-16 12:00:00</td>
</tr>
<tr>
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<td>0</td>
<td>HGT</td>
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<tr>
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<td>85000</td>
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<td>0</td>
<td>3</td>
<td>5</td>
<td>100</td>
<td>80000</td>
<td>0</td>
<td>HGT</td>
<td>2006-08-16 12:00:00</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>100</td>
<td>75000</td>
<td>0</td>
<td>HGT</td>
<td>2006-08-16 12:00:00</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>100</td>
<td>70000</td>
<td>0</td>
<td>HGT</td>
<td>2006-08-16 12:00:00</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>100</td>
<td>65000</td>
<td>0</td>
<td>HGT</td>
<td>2006-08-16 12:00:00</td>
</tr>
</tbody>
</table>
Utility: calc_ecmwf_p

The *calc_ecmwf_p* utility creates intermediate files with a pressure (and possibly GHT and RH) field.

**FILE:** 2009-08-27_00

- **PSFC / LOGSFP**
- **SOILHGT / SOILGEO**
- **TT**
- **SPECHUMD**

**emcwf_coeffs**

<table>
<thead>
<tr>
<th></th>
<th>PSFC</th>
<th>LOGSFP</th>
<th>SOILHGT</th>
<th>SOILGEO</th>
<th>TT</th>
<th>SPECHUMD</th>
</tr>
</thead>
<tbody>
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<td>0.0100</td>
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<td>0.000000</td>
<td>0.0398</td>
<td>0.0299</td>
<td></td>
<td></td>
</tr>
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<td>0.0568</td>
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<td></td>
</tr>
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<td>0.1015</td>
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</tr>
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</tr>
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</tr>
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<td>0.4285</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
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<td>0.000000</td>
<td>0.7617</td>
<td>0.6396</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>108.715561</td>
<td>0.000000</td>
<td>1.0872</td>
<td>0.9244</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**PRES:** 2009-08-27_00

- **PRESSURE**
- **RH**
- **GHT**

See p. 3-28
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 available at each level
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?