Running the WRF Preprocessing System

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*NCAR is sponsored by the National Science Foundation

Overview

- How to run through the WPS for a single-domain case
  - 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 = 1
/
```

```
&geogrid
   map_proj   = 'lambert'
   truelat1   = 45.0
   truelat2   = 30.0
   stand_lon  = -105.25
   ref_lat    = 40.0
   ref_lon    = -105.25
   e_we       =  220
   e_sn       =  175
   dx         = 15000
   dy         = 15000
   geog_data_res = 'default'
   geog_data_path = '/data/static/geog/'
/
```


Running geogrid

STEP 1: Edit `namelist.wps`

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

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

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

See p. 3-8 and 3-37

Running geogrid

STEP 1: Edit `namelist.wps`

```
&geogrid
  ...
  map_proj     = 'lambert'
  truelat1     = 45.0
  truelat2     = 30.0
  stand_lon    = -105.25
  ...
/
```

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

See p. 3-9 and 3-40

Running geogrid

STEP 1: Edit `namelist.wps`

```
&geogrid
  ...
  ref_lat              = 40.0
  ref_lon              = -105.25

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

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

Domain location: Where on Earth is the center of the domain?

Domain size: 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? Where to find data on the filesystem? *(See "Extra slides"...)*

See p. 3-9, 3-19, and 3-38

Running geogrid

STEP 2: Run geogrid.exe

```
Parsed 11 entries in GEOGRID.TBL
Processing domain 1 of 1
  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

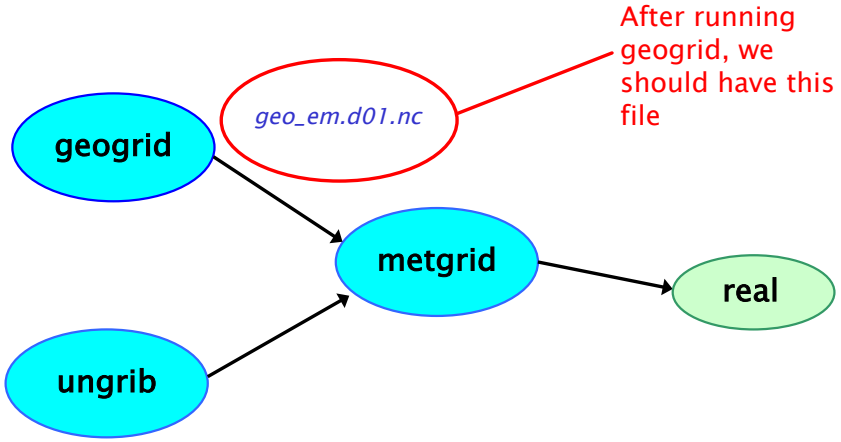
STEP 3: Check that geogrid ran successfully

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



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 = 1
   start_date  = '2006-04-01_00:00:00'
   end_date    = '2006-04-01_12:00:00'
   interval_seconds = 21600
/
```

```
&ungrib
   prefix = 'GFS'
/
```


Running ungrib

STEP 1: Edit `namelist.wps`

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

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

   interval_seconds = 21600

/
```

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`

```
&ungrib
   prefix = 'GFS'
/
```

Intermediate file names: Gives prefix for intermediate files.
Prefix can include a path.
E.g., 'XYZ' 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 *See p. 3-15*
- 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

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

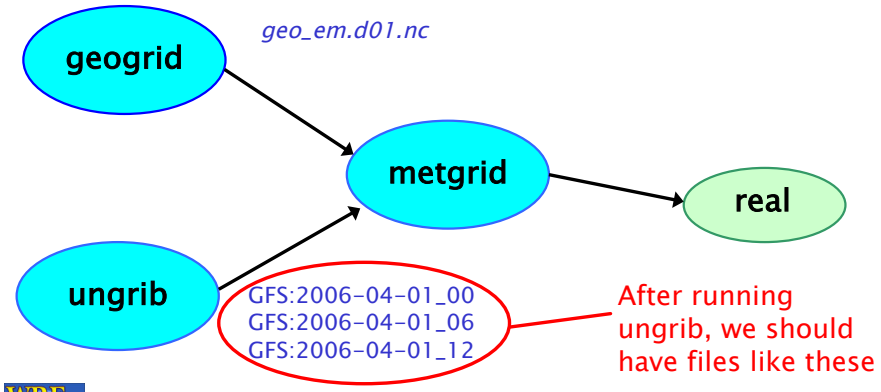
If ungrib ran successfully, this message should be printed:

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!  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



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 = 1
   start_date   = '2006-04-01_00:00:00'
   end_date     = '2006-04-01_12:00:00'
   interval_seconds = 21600
/
```

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


Running metgrid

STEP 1: Edit `namelist.wps`

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

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

   interval_seconds = 21600
/
```

Data time range: Time range to process.

Interval between intermediate files created by ungrib

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.

See p. 3-17 and 3-24

```
&metgrid
   fg_name = 'GFS'

   constants_name = 'SST:2006-04-01_00'
/
```

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

See p. 3-17, and 3-41

Running metgrid

STEP 2: Run metgrid.exe

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

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

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

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

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

Running metgrid

STEP 3: Check that metgrid ran successfully

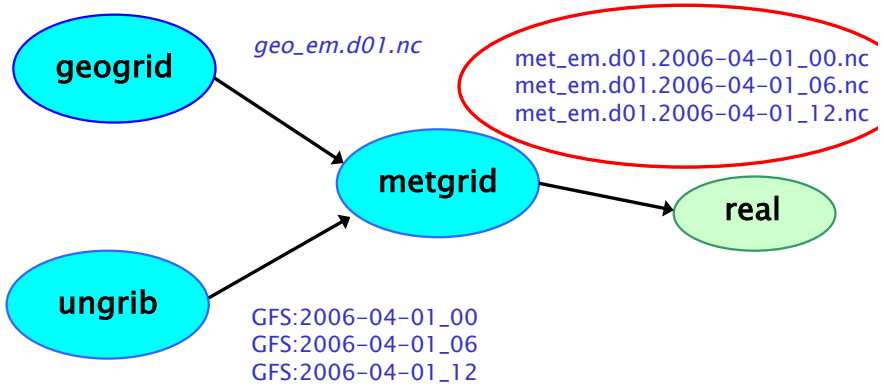
If metgrid ran successfully, this message should be printed:

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!  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



Overview

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  - Basic steps for running WPS
    - Geogrid
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    - Metgrid
- WPS utility programs
- Common WPS mistakes

WPS Utility Programs

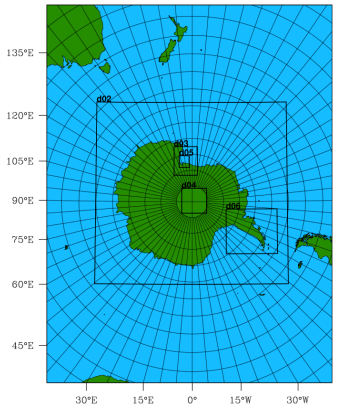
- Besides geogrid, ungrib, and metgrid, some simple utility programs are distributed with WPS:
  - For checking contents of intermediate format files
  - For listing contents of GRIB1 & GRIB2 files
  - To assist in locating domains
  - For computing 3d pressure field for ECMWF data
- Some programs use NCAR Graphics libraries for plotting
  - For these utilities, *NCAR Graphics must be installed*

See p. 3-27

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

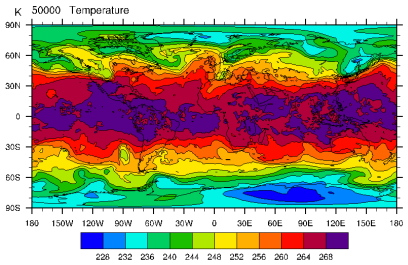
The rd_intermediate lists information about the fields found in an intermediate-format file

```
================================================
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
================================================
```

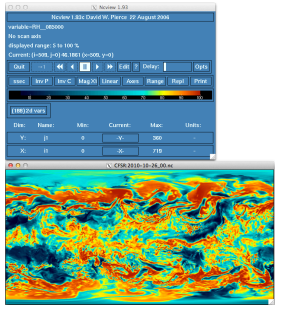

Utility: int2nc + plotfmt_nc.ncl

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

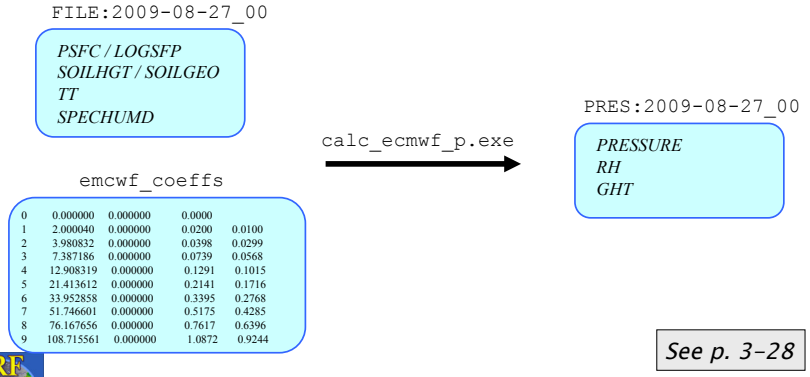
Utility: g1print and g2print

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

```
-------------------------------------------------------------------------------
 rec Prod Cat Param  Lvl     Lvl      Lvl   Name          Time           Fcst
 num Disc     num    code    one      two                                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
```

Utility: calc_ecmwf_p

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



See p. 3-28

Overview

- How to run through the WPS for basic cases
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    - 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

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?

Extra slides

Choosing Static Datasets

WPS v3.9 supports several land cover datasets and two different topography datasets

Land use:

- USGS 24-class, 30-arc-second resolution
- USGS 24-class + inland water, 30-arc-second resolution
- MODIS 20-class, 30- and 15-arc-second resolution
- MODIS 20-class + inland water, 30-arc-second resolution
- NLCD 2011 40-class, 9-arc-second resolution

Terrain:

- GTOPO30
- GMTED2010

Choosing Static Datasets

Selection of alternate static datasets is performed using the `geog_data_res` namelist option in the &geogrid record

Prefix the usual `geog_data_res` selection with the name for the land use or topography dataset to be used.

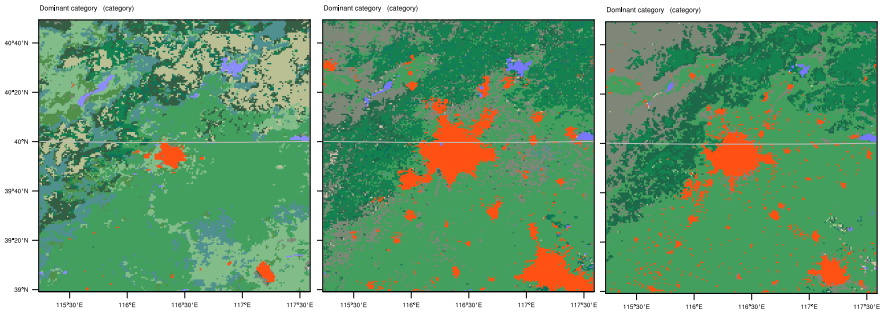
E.g.,

```
geog_data_res = 'nlcd2011_9s+default'
```

to use NLCD 2011 9-arc-second land cover, and default resolution for other static fields.

Global Land Cover Datasets

Consider an example 1-km domain centered over Beijing:



USGS 30-arc-second resolution, from ~1993 data; select using `'usgs_30s'`

MODIS 30-arc-second resolution, from 2001(?) data; the MODIS data are used by default

MODIS 15-arc-second resolution, most prevalent category between 2001 and 2010; select using `'modis_15s'`

Identifying Inland Water Bodies

Two land cover datasets also provide a special category to identify "inland water bodies", which can sometimes require special treatment, e.g., when initializing SST field or running the lake model in WRF.

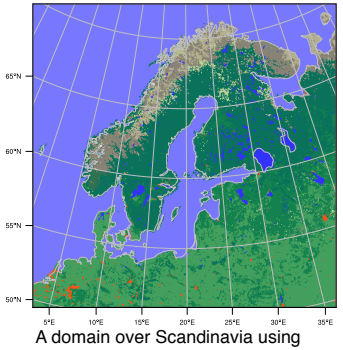
MODIS 30-arc-second:

- Selected using `'modis_lakes'`

USGS 30-arc-second:

- Selected using `'usgs_lakes'`

We'll discuss the use of lake categories for initializing the SST field in the "WPS Advanced Features" talk on Wednesday.



A domain over Scandinavia using MODIS 21-class land cover; lake category shown in dark blue.

NLCD Land Use (Continental U.S. Only)

For the WRF domains over the Continental U.S., one can use high-resolution land cover from the National Land Cover Database (NLCD).

NLCD 2011 9-arc-second:

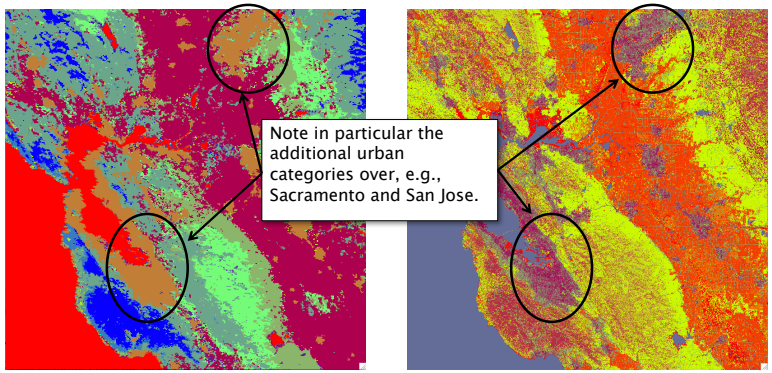
- Selected using `'nlcd2011_9s'`

Besides high spatial resolution, the NLCD data provides four new urban categories:

1. Developed Open Space
2. Developed Low Intensity
3. Developed Medium Intensity
4. Developed High Intensity

NLCD Land Use (Continental U.S. Only)

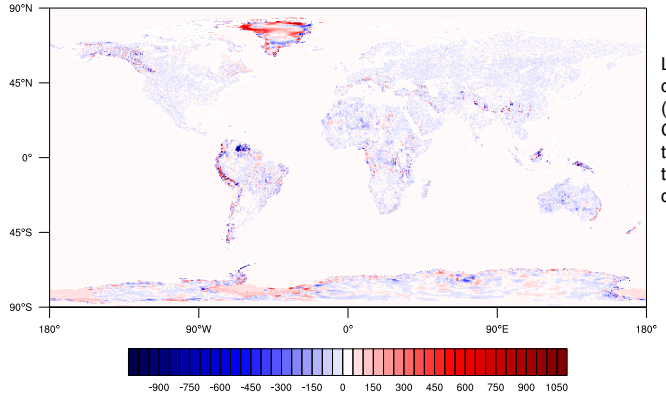
For the WRF domains over the Continental U.S., one can use high-resolution land cover from the National Land Cover Database (NLCD).



Above: (left) A 250-m WRF domain covering San Francisco Bay using MODIS 15-arc-second land cover data; (right) the same domain using NLCD 2011 9-arc-second data.

GMTED2010 Terrain

WPS v3.8 and newer replace the GTOPO30 dataset with a newer, more accurate terrain dataset from the USGS: GMTED2010*.



Left: Terrain elevation difference in meters (GMTED2010 minus GTOPO30). Note that the scale does not cover the full range of the differences.

*https://lta.cr.usgs.gov/GMTED2010