NCEP's UNIFIED POST PROCESSOR (UPP)

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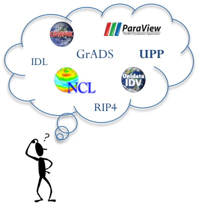
Outline

- Overview
- Components and Functions
- Sample fields generated
- Installing UPP
- Running *unipost*
  - Controlling output generation
- Running *copygb*
  - Specifying target grid
- Visualization

What is Post Processing and Why do I need it? Which one do I use?



- Turns model output into something meaningful:
  - Computes new fields not calculated in the model itself

    Ex. RH is not output, only the variables T and water vapor needed to calculate RH are output

    Ex. Height fields interpolated from model levels to 500mb and other pressure surfaces
  - Create maps and plots to visualize data
- Each has its strengths and weaknesses, often multiple are used to address specific needs

  - Need to ask yourself questions:

  What do I need in the end?
  Do I need nice 3d graphics to illustrate a phenomena?
  Do I need flexibility to customize and manipulate fields?
  Do I need a software that handles large files?

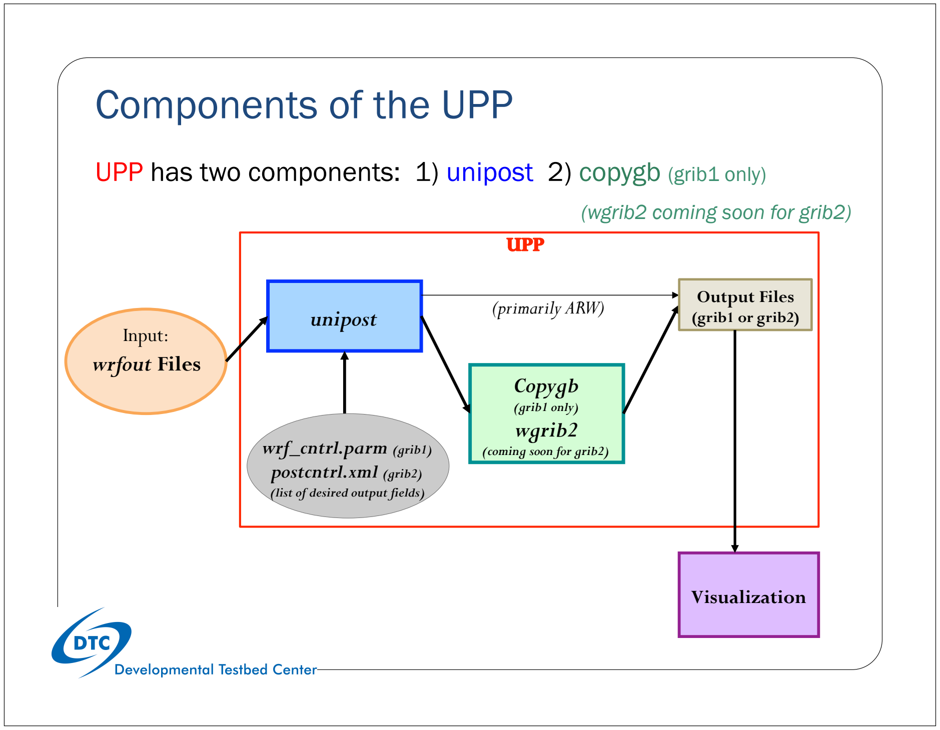
UPP Overview

- UPP is one of the many post processing packages available
- NCEP Developed & Supported Operationally
  - GFS, GEFS, NAM, SREF, RAPR, HRRR, HWRF, etc.
- NCAR Supports community code for WRF Post Processing

Why would you want to use UPP?

- Generates output in GRIB1 and GRIB2 format.
- Produces hundreds of products like those used operationally on same operational grids.
- Enables product generation on any output grid.

  E.g. MET: Regrid model data to match a observational grid for verification
- Processes model output from the NMM and the ARW dynamical cores (additionally NEMS-NMM-B).
- Produces requested diagnostics and fields, but does not plot or visualize data.
- MPI parallelized code



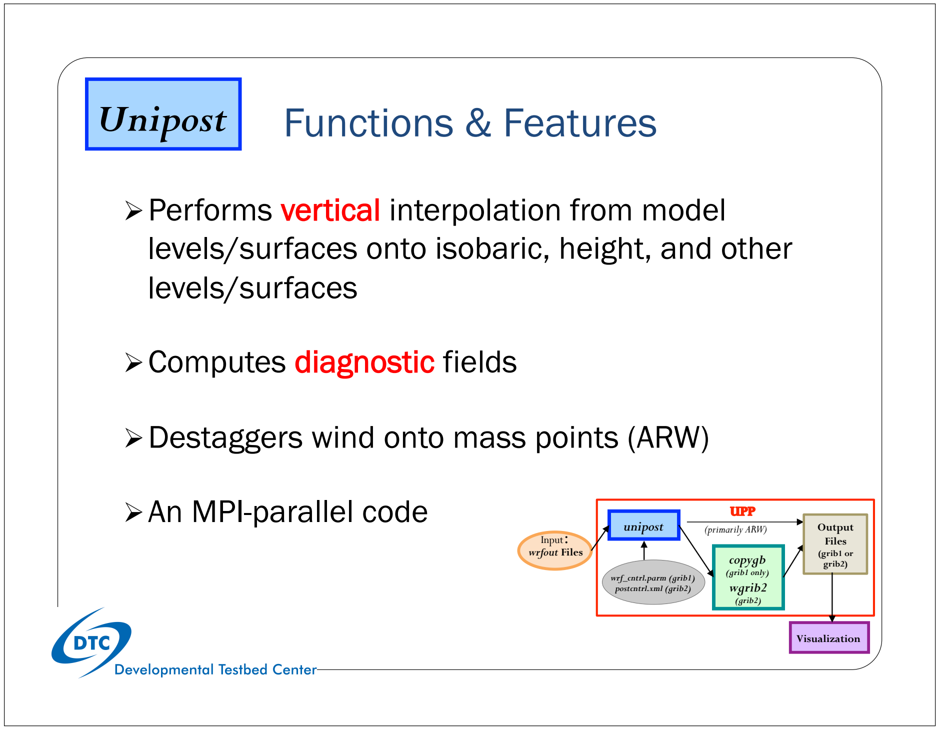
Components of the UPP

UPP has two components: 1) unipost 2) copygb (grib1 only)

(wgrib2 coming soon for grib2)

UPP
Input:
wrfout Files
unipost
(primarily ARW)
Output Files
(grib1 or grib2)
Copygb
(grib1 only)
wgrib2
(coming soon for grib2)
wrf_cntrl.parm (grib1)
postcntrl.xml (grib2)
(list of desired output fields)
Visualization

DTC Developmental Testbed Center



Unipost Functions & Features

- Performs vertical interpolation from model levels/surfaces onto isobaric, height, and other levels/surfaces
- Computes diagnostic fields
- Destaggers wind onto mass points (ARW)
- An MPI-parallel code

UPP
Input:
wrfout Files
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(primarily ARW)
Output Files
(grib1 or grib2)
copygb
(grib1 only)
wgrib2
(grib2)
wrf_cntrl.parm (grib1)
postcntrl.xml (grib2)
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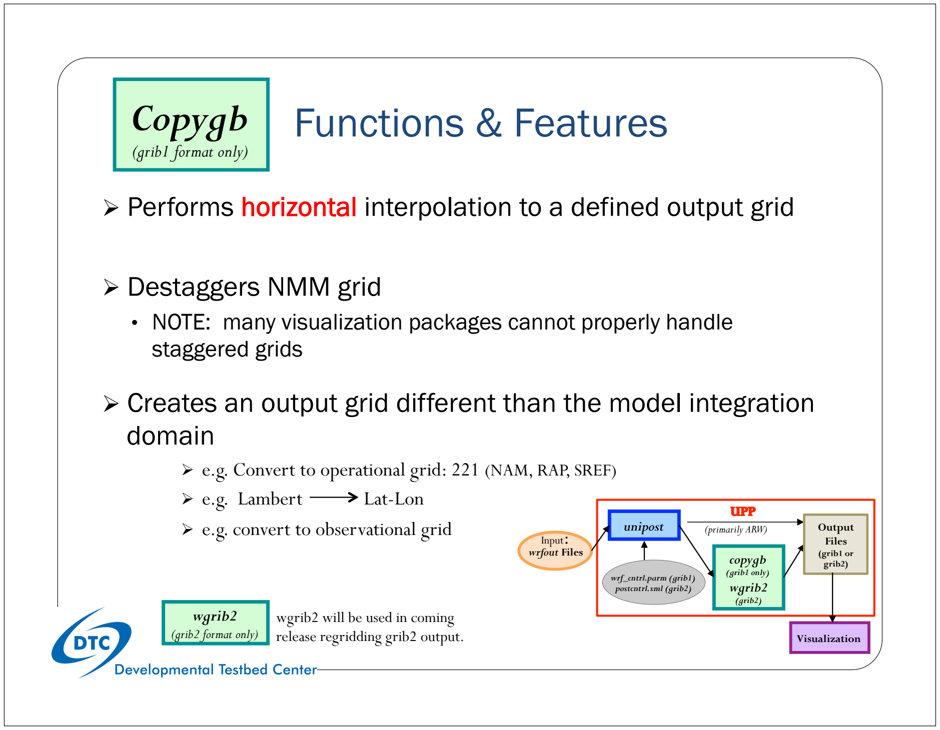
DTC Developmental Testbed Center



Copygb (grib1 format only) Functions & Features

- Performs horizontal interpolation to a defined output grid
- Destaggers NMM grid
  - NOTE: many visualization packages cannot properly handle staggered grids
- Creates an output grid different than the model integration domain
  - e.g. Convert to operational grid: 221 (NAM, RAP, SREF)
  - e.g. Lambert ⟶ Lat-Lon
  - e.g. convert to observational grid

wgrib2 *(grib2 format only)* wgrib2 will be used in coming release regridding grib2 output.

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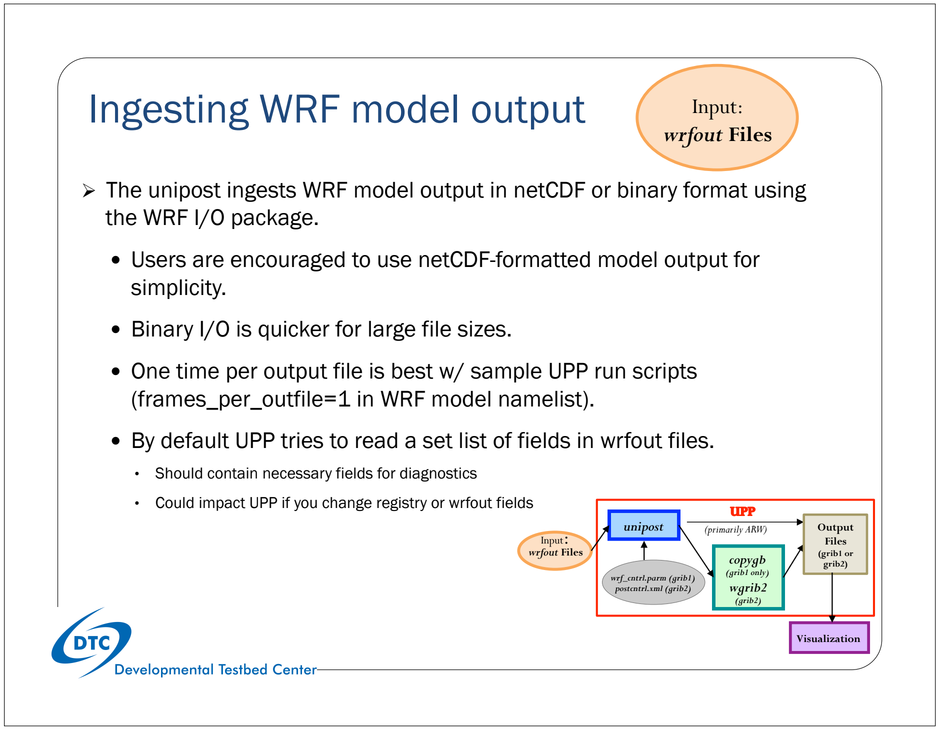

Ingesting WRF model output

Input: *wrfout* Files

- The unipost ingests WRF model output in netCDF or binary format using the WRF I/O package.
  - Users are encouraged to use netCDF-formatted model output for simplicity.
  - Binary I/O is quicker for large file sizes.
  - One time per output file is best w/ sample UPP run scripts (frames_per_outfile=1 in WRF model namelist).
  - By default UPP tries to read a set list of fields in wrfout files.
    - Should contain necessary fields for diagnostics
    - Could impact UPP if you change registry or wrfout fields

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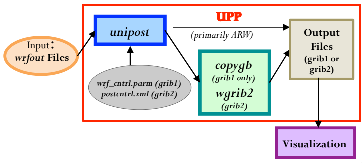
Fields generated by the UPP

Output Files
(Grib1 or Grib2)

- **The UPP currently outputs hundreds of possible fields.**
  - Complete list in the Post Processing Utilities Chapter of the user guide
  - Fields are output in Grib1 format (some limited Grib2 format)

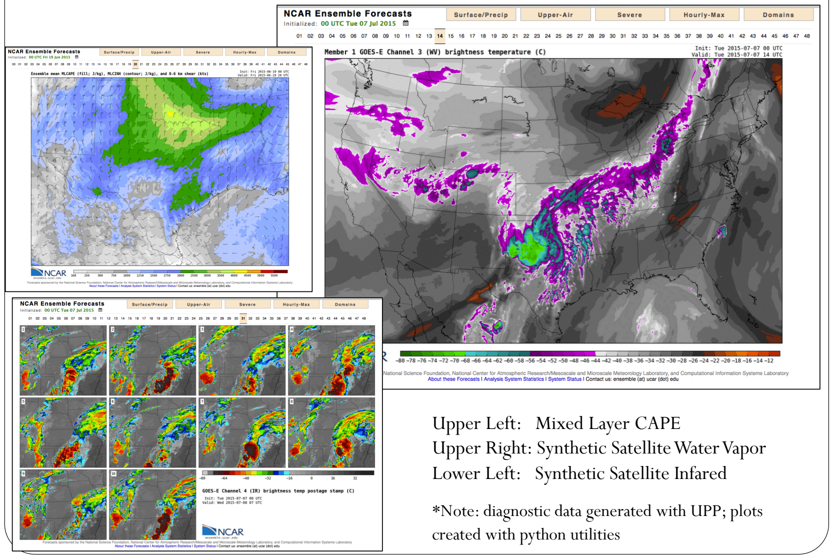
- **Sample fields generated by UPP:**
  1) T, Z, humidity, wind, cloud water, cloud ice, rain, and snow on isobaric levels
  2) SLP + shelter level T, humidity, and wind fields
  3) Precipitation-related fields
  4) PBL-related fields
  5) Diagnostic products (i.e. RH, radar reflectivity, CAPE)
  6) Radiative/Surface fluxes
  7) Cloud related fields
  8) Aviation products
  9) Satellite look-alike products



Outputting fields on different vertical coordinates

- *unipost* outputs on several vertical coordinates:
  - Native model levels
  - 47 isobaric levels: Default: 2, 5, 7, 10, 20, 30, 50, 70, then every 25 hPa from 75-1000 hPa.
  - 15 flight/wind energy levels: 30, 50, 80, 100, …, 2743, 3658, 4572, 6000 m (above ground or above MSL)
  - 6 PBL layers: each averaged over a 30 hPa deep layer
  - 2 AGL radar levels: 1000 & 4000
- Except for AGL radar and isobaric levels, vertical levels are listed from the ground surface up in *wrf_cntrl.parm (postcntrl.xml).*

Example of UPP Products: NCAR Ensemble Forecasting System (www.ensemble.ucar.edu)


NCAR Ensemble Forecasts
Initialized: 00 UTC Tue 07 Jul 2015
Surface/Precip
Upper-Air
Severe
Hourly-Max
Domains
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Member 1 GOES-E Channel 3 (WV) brightness temperature (C)
Init: Tue 2015-07-07 00 UTC
Valid: Tue 2015-07-07 14 UTC
Init: Fri 2015-06-19 00 UTC
Valid: Fri 2015-06-19 20 UTC
GOES-E Channel 4 (IR) brightness temp postage stamp (C)
NCAR

Upper Left: Mixed Layer CAPE
Upper Right: Synthetic Satellite Water Vapor
Lower Left: Synthetic Satellite Infared

*Note: diagnostic data generated with UPP; plots created with python utilities

UPP download and compile

UPP Dependencies & Required Libraries

- UPP build relies on the existence of a built WRF source directory. Uses WRF i/o routines.
- UPPV2.1+ depends on WRFV3.5 or later releases.
- Libraries required:
  - netCDF
  - JasPer
  - PNG
  - Zlib
  - WRF i/o libs

Downloading the UPP source code

- The UPP source code can be obtained from: *http://www.dtcenter.org/upp/users/downloads/index.php*
  - The latest version available is: UPPV3.0.tar.gz
- Unpack the downloaded file:

```
tar  –zxvf  UPPV3.0.tar.gz
```

- *cd* to newly created UPPV3.0/ directory
  - Important Directories:
    - scripts/: sample scripts for running UPP and generating graphics
    - parm/: contains the files used to request output fields when running the unipost (i.e. wrf_cntrl.parm, postcntrl.xml) *wrf_cntrl.parm (grib1)* *postcntrl.xml (grib2)*
    - clean, configure, compile: scripts used in the build process

Compile source codes

- The build mechanism follows the WRF model build paradigm:

  ./configure : respond to screen prompts about target computing platform

- *./compile >& compile_upp.log*

Compile source codes (cont.)

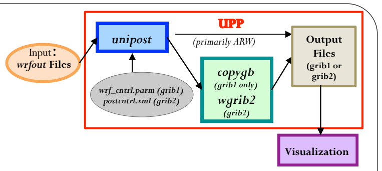
- If compilation is successful, these three executables will be present in bin/ :

  copygb.exe
  ndate.exe
  unipost.exe

- Currently have build options established for IBM (AIX) and Linux (PGI/Intel/Gnu compilers)
- The arch/configure.defaults file has compilation options for various platforms, and is where new computers or compilers might be added.

Running unipost and copygb

Running UPP



* Use sample scripts as a template or guide to run UPP *

Run Script: ./run_unipost >& script_output.log &

- run_unipost is a korn shell script that runs UPP end to end: unipost + copygb (if needed)
- User edits paths, date, time, command syntax (serial vs. parallel) in script.
- Links all required files, loops over times/files and processes fields requested fields from wrf_cntrl.parm, runs copygb if necessary.
- Unipost.exe output/error messages is redirected to log files, e.g. unipost_d01.00.out. Look in these files for information about errors.

Unipost Running unipost.exe

** Requires 3 input files to run **

1) *itag*: 4-5 line text file that details WRF model output to process. Also referred to as the namelist.

wrfout_d01_2010-06-27_00:00:00	← *WRF history filename*
netcdf	← *WRF output format (netcdf/binary)*
grib2	← *extra line only if writing GRIB2*
2010-06-27_00:00:00	← *validation time*
NCAR	← *model name: "NMM" -or- "NCAR" (ARW)*

2) *wrf_cntrl.parm (grib1)* : control file specifying fields/levels to output in GRIB1 (*text file*)
postcntrl.xml (grib2) : control file specifying fields/levels to output in GRIB2 (*xml file*)

wrf_cntrl.parm
postcntrl.xml

3) *eta_micro_lookup.dat*: binary look-up table for Ferrier MP (linked from WRF)

*** In the sample scripts/run_unipost* scripts, these files are automatically generated (itag) or linked (wrf_cntrl.parm & eta_micro_lookup.dat).

unipost control file for grib1 : *wrf_cntrl.parm (Grib1)*

- ➢ User controlled and modified text file that lists fields and level(s) of fields to output; each product described by 2 lines (Examples next slides)
- ➢ The included parm/*wrf_cntrl.parm* file has entries for most output fields. ** Use this as template! ** (Text file fixed width format)
- ➢ The users' guide "Fields produced by *unipost*" (Table 3) more fully explains the character string abbreviations used in the wrf_cntrl.parm file.

unipost control file: *wrf_cntrl.parm*

wrf_cntrl.parm
(Grib1)

- Each field described by 2 lines: product description and levels

```
(PRESS ON MDL SFCS   ) SCAL=(6.0)
L=(11000 00000 00000 00000 00000 00000 00000…
(HEIGHT ON MDL SFCS ) SCAL=(6.0)
L=(11000 00000 00000 00000 00000 00000 00000…
```

GRIB packing precision**

Levels to output: Each column represents a single model/isobaric level:
“1” (or “2” - special case) = output, “0” = no output

Product description – unipost code keys on these character strings.

** larger values → more precision, but larger GRIB files.

Examples

wrf_cntrl.parm
(Grib1)

- Output T every 50 hPa from 50 hPa to 1000 hPa:

```
 (TEMP ON PRESS SFCS   ) SCAL=( 4.0)
L=(00000   01001    01…)
          2    5    7  10  20      30  50  70  75  100
```

*** Isobaric levels increase from left to right:
2, 5, 7, 10, 20, 30, 50, 70, then every 25 hPa from 75-1000 hPa.
(Default/standard – can manually change code for different pressure levels)

Isobaric levels every 50 hPa:

```
L=(00000 01001 01010 10101 01010 10101 01010 10101 01010 10000 00000 00000 00000 00000)
```

Isobaric levels every 25 hPa:

```
L=(00000 01011 11111 11111 11111 11111 11111 11111 11111 10000 00000 00000 00000 00000)
```

Examples

wrf_cntrl.parm
(Grib1)

- Output instantaneous surface sensible heat flux:

```
(INST SFC SENHEAT FX ) SCAL=( 4.0)
L=(10000 00000 00000 00000 00000 00000 00000 00000 00000 00000…)
```

- Output the U-wind component at the 5 lowest model levels:

```
(U WIND ON MDL SFCS   ) SCAL=( 4.0)
L=(11111 00000 00000 00000 00000 00000 00000 00000 00000 00000…)
```

- Output U-wind component at 30, 50, and 80 m AGL:

```
(U WIND AT FD HEIGHT) SCAL=( 4.0)
L=(22200 00000 00000 00000 00000 00000 00000 00000 00000 00000…)
```

For the flight/wind energy level fields:
- “2” requests AGL.
- “1” requests above mean sea level.

unipost control file for grib2 :

postcntrl.xml
(Grib2)

- User controlled xml file that lists desired fields to be output by UPP.
- The included parm/*postcntrl.xml* file has examples of the template to follow. More fields to be added and as they are tested.
- The included parm/*post_avblcntrl.xml* file has a listing of all available field names, shortnames, parameter info.

unipost control file: *post_avblflds.xml*

postcntrl.xml (Grib2)

- Lists all available fields and details for grib2 tables/output
- Does not need to be modified unless adding new variables or modifying from default.

```
<param>
    <post_avblfldidx>2</post_avblfldidx>
    <shortname>TMP_ON_HYBRID_LVL</shortname>
    <pname> TMP</pname>
    <fixed_sfc1_type>hybrid_lvl</fixed_sfc1_type>
    <scale>4.0</scale>
 </param>

 <param>
    <post_avblfldidx>70</post_avblfldidx>
    <shortname>DPT_ON_SPEC_PRES_ABOVE_GRND</shortname>
    <pname>DPT</pname>
    <fixed_sfc1_type>spec_pres_above_grnd</fixed_sfc1_type>
    <scale>3.0</scale>
 </param>
```

- Character name describing the product/field
- Vertical coordinate type
- Grib precision packing
- Field type abbreviation used by internal libraries

unipost control file: *postcntrl.xml*

postcntrl.xml (Grib2)

- User modified xml file to list all desired fields to be output by UPP
- Use provided file as a guide

```
<param>
    <shortname>TMP_ON_SPEC_HGT_LVL_ABOVE_GRND_2m</shortname>
    <scale>-4.0</scale>
</param>

<param>
     <shortname> UGRD_ON_ISOBARIC_SFC</shortname>
     <scale> -4.0 </scale>
     <level> 50000. 70000. 85000. 92500. 100000. </level>
</param>
```

- Character name describing the product/field
- Vertical coordinate levels desired
- Grib precision packing

Copygb *(grib1 format only)* When to run it

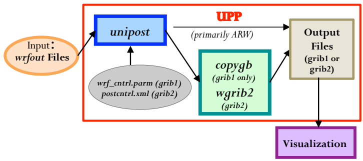
1) If using NMM – need to run copygb to de-stagger the grid.

   - Sample scripts contain a flag for NMM that will run it automatically
   - Default in scripts uses grid navigation file generated by UPP.
   - Must edit the script to use pre-defined grid or custom grid.

2) If you want your output on a grid different from the model

   i.e. changing from lambert projection to lat-lon projection

*** Testing underway for a utility to de-stagger and regrid grib2 output. Will be released when ready. ***

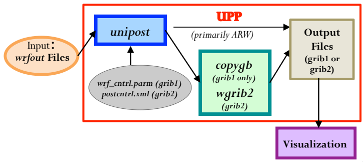


Copygb *(grib1 format only)* target grid definition

- The generic command to run copygb and horizontally interpolate onto a new grid is:

```
copygb.exe –xg"${grid}"  in.grb   out.grb
```

- Three options on how to specify the target $grid:
  1. Pre-defined NCEP standard grid number
  2. Grid navigation file created by *unipost* (NMM only)
  3. User-defined grid definition



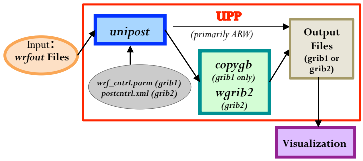
Run *copygb* – Option 1

Copygb
(grib1 format only)

- Interpolate to a pre-defined NCEP standard grid (restrictive but simple)
  - For example, to interpolate onto NCEP grid 212:

```
copygb.exe –xg212   in.grb    out.grb
```

Descriptions of NCEP grids are available online:
http://www.nco.ncep.noaa.gov/pmb/docs/on388/tableb.html



Run *copygb* – Option 2

Copygb
(grib1 format only)

- Read in grid navigation file created by *unipost* (NMM only, simple, restrictive)
  - Running *unipost* on WRF-NMM output produces two ASCII files containing grid navigation information which is similar in domain and grid spacing to the model integration domain.
    - *copygb_gridnav.txt* for a Lambert Conformal grid
    - *copygb_hwrf.txt* for a regular Lat-Lon grid

For example:

```
read nav < 'copygb_gridnav.txt'
copygb.exe –xg"${nav}" in.grb out.grb
```

Run *copygb* – Option 3a

Copygb
(grib1 format only)

- Create a user-defined ***Lambert Conformal*** grid by specifying a full set of grid parameters (complicated but flexible).

255 indicates user-defined grid

map type (3=LC)

# of points

SW corner (millidegrees)

Proj cent lon (millidegrees)

```
copygb.exe  –xg"255  3  NX NY  STARTLAT STARTLON  8  CENLON DX DY
      0  64  TRUELAT1   TRUELAT2 "  in.grb  out.grb
```

horizontal spacing (meters)

Proj true latitudes (millidegrees)

```
copygb  –xg"255  3  185  129   12190  -133459  8   -95000  40635  40635
      0     64   25000    25000"  in.grb    out.grb
```

Run *copygb* – Option 3b

Copygb
(grib1 format only)

- Create a user-defined ***Polar Stereographic*** *grid* by specifying a full set of grid parameters (complicated but flexible).

map type (5=STR)

```
copygb.exe –xg"255   5   NX NY   STARTLAT STARTLON   8  CENLON DX  DY
        0   64"  in.grb  out.grb
```

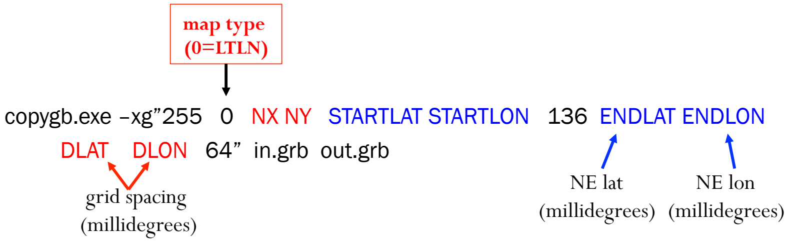
Center flag (0=NH ; 1=SH)

```
copygb –xg"255  5  580  548  10000  -128000  8  -105000   15000 15000
         0    64"  in.grb    out.grb
```

Run *copygb* – Option 3c

Copygb
(grib1 format only)

- Create a user-defined ***Latitude-Longitude*** *grid* by specifying a full set of grid parameters (complicated but flexible).



map type (0=LTLN)

copygb.exe –xg”255 0 NX NY STARTLAT STARTLON 136 ENDLAT ENDLON DLAT DLON 64” in.grb out.grb

---

copygb –xg”255 0 401 401 10000 -130000 136 50000 -90000 100 100 64” in.grb out.grb

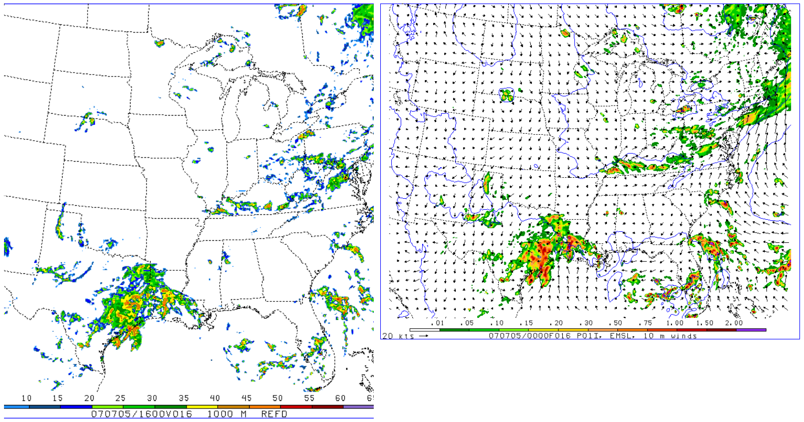
Visualization: GEMPAK

- The GEMPAK utility “nagrib” reads GRIB files from any non-staggered grid and generates GEMPAK-binary files that are readable by GEMPAK plotting programs
- GEMPAK can plot horizontal maps, vertical cross-sections, meteograms, and sounding profiles.
- Package download and user guide are available online:

  http://www.unidata.ucar.edu/software/gempak/index.html

- A sample script named *run_unipostandgempak* is included in scripts/ that can be used to run *unipost*, *copygb*, and then plot various fields using GEMPAK.
- Further details on this script and using GEMPAK are available in the user’s guide.

Forecast plotted with GEMPAK : Precipitation and derived Radar reflectivity



Visualization: GrADS

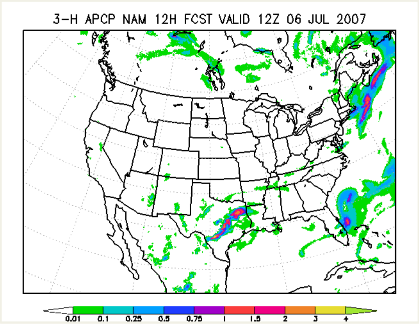
- GrADS also has utilities to read GRIB files on any non-staggered grids and generate GrADS “control” files. The utilities grib2ctl and gribmap are available via: http://www.cpc.ncep.noaa.gov/products/wesley/grib2ctl.html
- Package download and user guide for GrADS are available online:

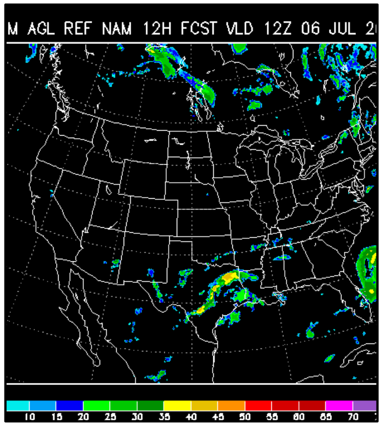
  http://grads.iges.org/grads/gadoc/

- A sample script named *run_unipostandgrads* is included in scripts/ that can be used to run *unipost*, *copygb*, and then plot various fields using GrADS.

Forecast plotted with GrADS:

Precipitation and derived Radar reflectivity





Future plans

- Improvement of generation of GRIB2 output.
- Utility for regridding / destaggering grib2 output (similar to copygb for grib1)
  - wgrib2 to be released in future versions
- Continue adding new products to the released UPP code as they are developed, and expand code portability.

Helpful Links:

New UPP Website:
http://www.dtcenter.org/upp/users/index.php

UPP Users' Guide available at:
http://www.dtcenter.org/upp/users/docs/user_guide/V3/upp_users_guide.pdf

UPP FAQ's Page:
http://www.dtcenter.org/upp/users/overview/upp_faqs.php

UPP Questions Contact: upp-help@ucar.edu

Questions???