NCEP's UNIFIED POST PROCESSOR (UPP)

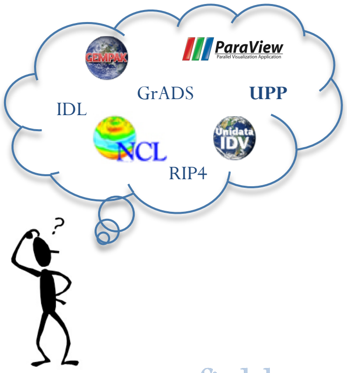
Presented by Kate Fossell

fossell@ucar.edu

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?
Why do I need it?
Which one do I use?



Post processing takes your model output and makes it meaningful – computes new fields not calculated in the model itself, like Relative Humidity or 500mb Heights, and/or makes pretty maps and plots to visualize data

Model output is a set of gridded numbers. Model output is often limited (e.g. RH itself is not output, but only the variables T and water vapor needed to calculate RH are output. Or height fields are interpolated to 500mb and other pressure surfaces)

Depends. Each has its strengths and weaknesses, often multiple are used to address specific needs. Need to ask yourself questions like 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?

* More on this and what various features different post processing packages offer in later talk by Cindy Bruyere

UPP Overview

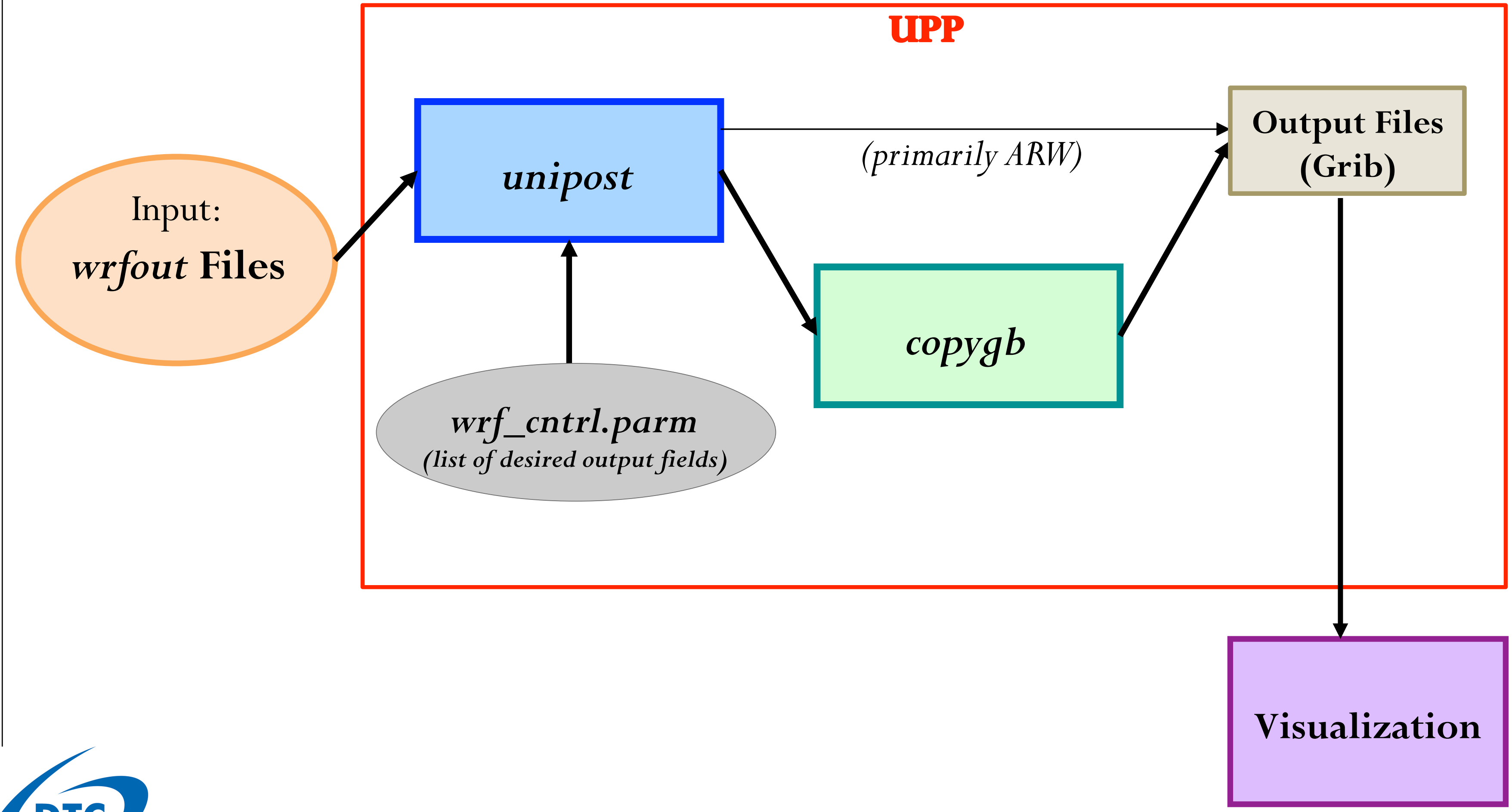
- UPP is one of the many post processing packages available
- NCEP Developed & Supported Operationally
- NCAR Supports community code for WRF Post Processing

Why would you want to use UPP?

- Produces products like those used operationally on same operational grids.
- Processes model output from both the NMM and the ARW dynamical cores.
- Generates output in GRIB format.
- Enables product generation on any output grid.
- Produces requested diagnostics and fields, but does not plot or visualize data.

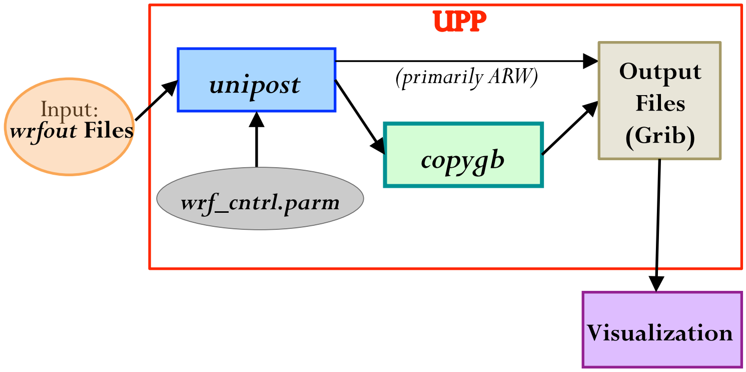
Components of the UPP

UPP has two components: 1) unipost 2) copygb



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

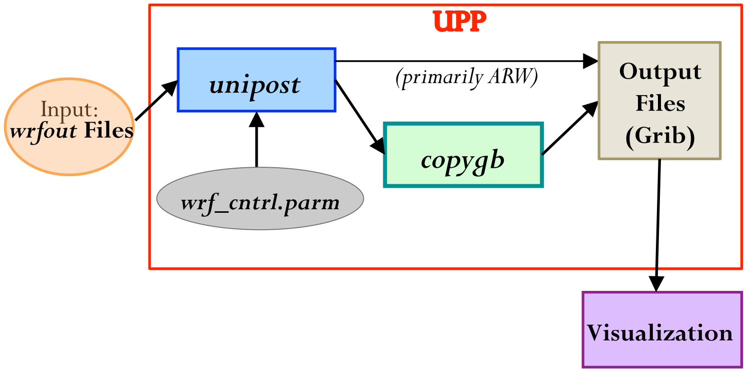


copygb Functions & Features

- Performs horizontal interpolation to a defined output grid

- Destaggers NMM grid
  - NOTE: many visualization packages cannot properly handle staggered grids

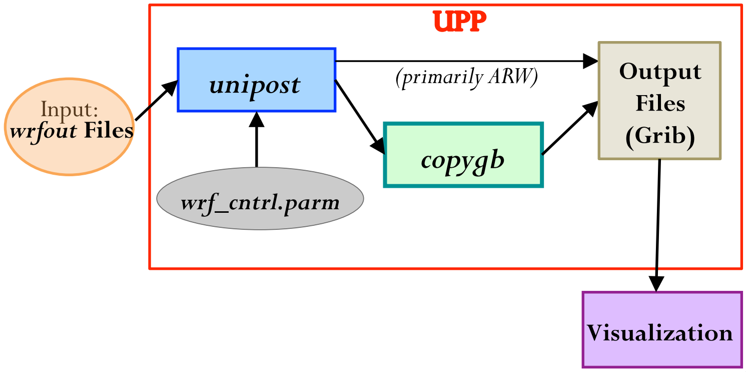
- Creates an output grid different than the model integration domain. e.g. Lambert → Lat-Lon



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. DTC is working to improve binary support using MPI-IO.
  - One time per output file is best w/ sample UPP run scripts (frames_per_outfile=1 in WRF model namelist).



UPP
Input: *wrfout* Files
unipost
(primarily ARW)
copygb
wrf_cntrl.parm
Output Files (Grib)
Visualization

Ingesting WRF model output

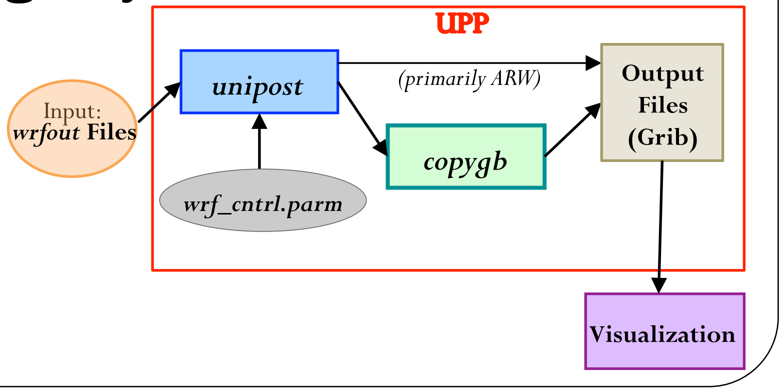
Input:
wrfout **Files**

- By default the WRF model should provide necessary fields that the unipost needs to ingest.

- The Users' Guide Table 1 & 2 lists the fields read in by the unipost for both dynamical cores (by WRF Registry file variable names)

  ** The list continues to change as new fields are added, effort is underway to make sure it is up to date.*

- Not a concern unless modifying the Registry.

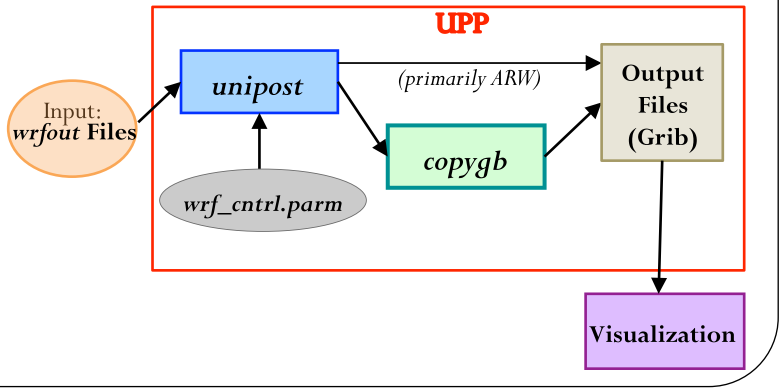


Fields generated by the UPP

Output Files (Grib)

- **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

- **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



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/wrf-nmm/users/downloads

  - The latest version available is: UPPV2.2.tar.gz

- Unpack the downloaded file:

  tar –zxvf UPPV2.2.*tar.gz*

- *cd* to newly created UPPV2.2/ 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) *wrf_cntrl.parm*
    - **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/ :

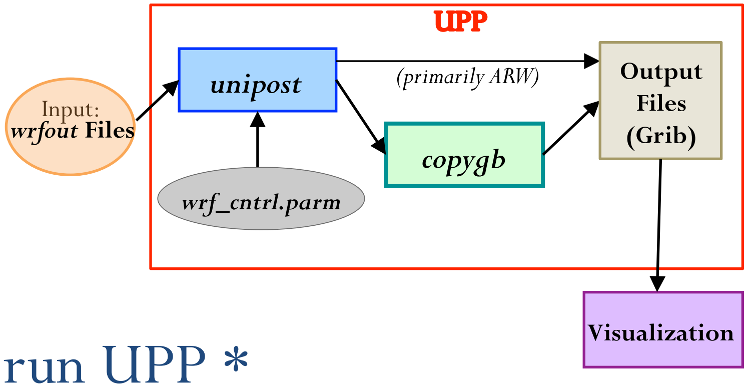
  copygb.exe
  ndate.exe
  unipost.exe

- 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. Look in these files for information about errors.

Running unipost.exe

** Requires 3 input files to run **

1) *itag*: 4 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 – currently broken so don't try this yet!*

2010-06-27_00:00:00 ← *validation time*

NCAR ← *model name: NMM -or- NCAR (ARW)*

2) *wrf_cntrl.parm*: control file specifying fields/levels to output in GRIB1 (text file) *wrf_cntrl.parm*

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: ***wrf_cntrl.parm***

- 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.

- *Generation of GRIB2 remains a work in progress (i.e., it isn't yet working correctly), but uses an XML file to request fields instead of the wrf_cntrl.parm file*

unipost control file: *wrf_cntrl.parm*

wrf_cntrl.parm

- 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.

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*.

Examples

wrf_cntrl.parm

- 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   125 150
```

*** 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

- 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.

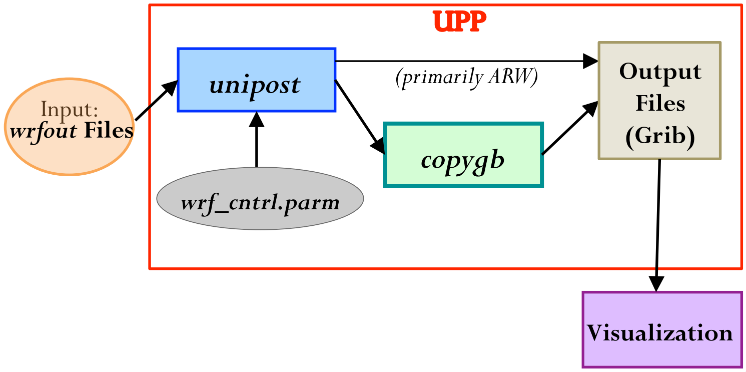
copygb When to run it

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

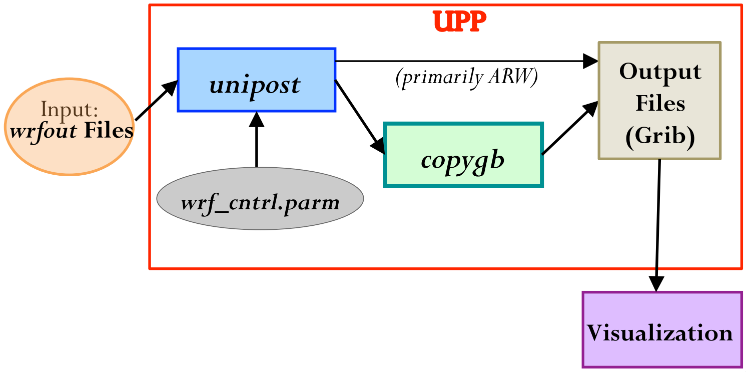


copygb target grid definition

- 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

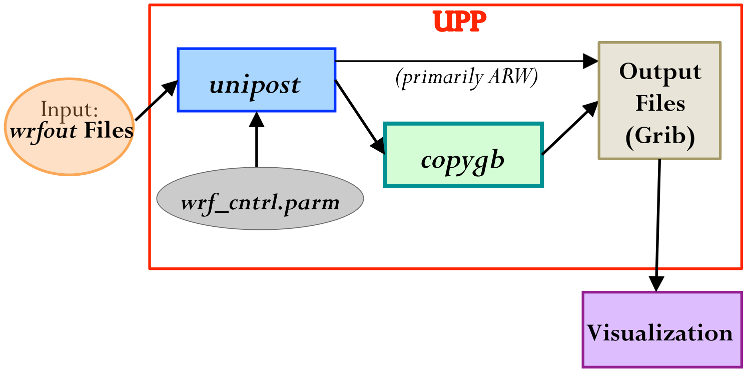
- Interpolate to a pre-defined NCEP standard grid (restrictive but simple)

  - 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

- 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

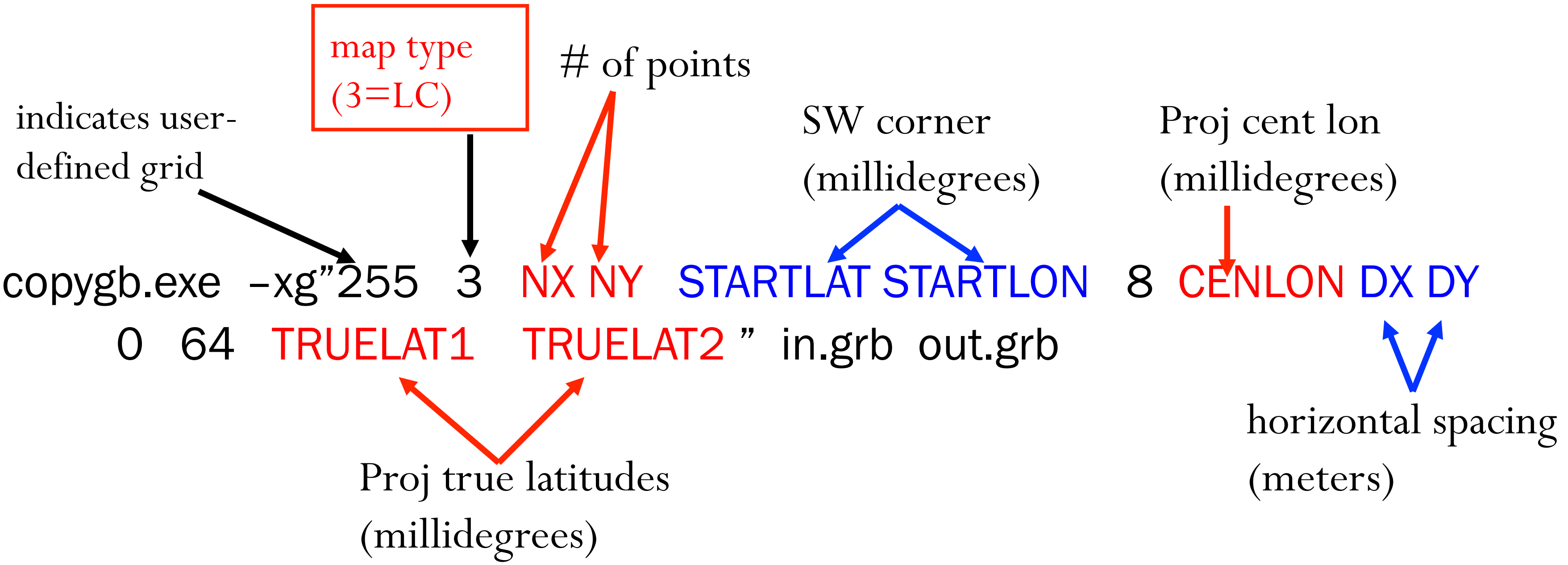
For example:

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

Run *copygb* – Option 3a

copygb

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



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

- 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)

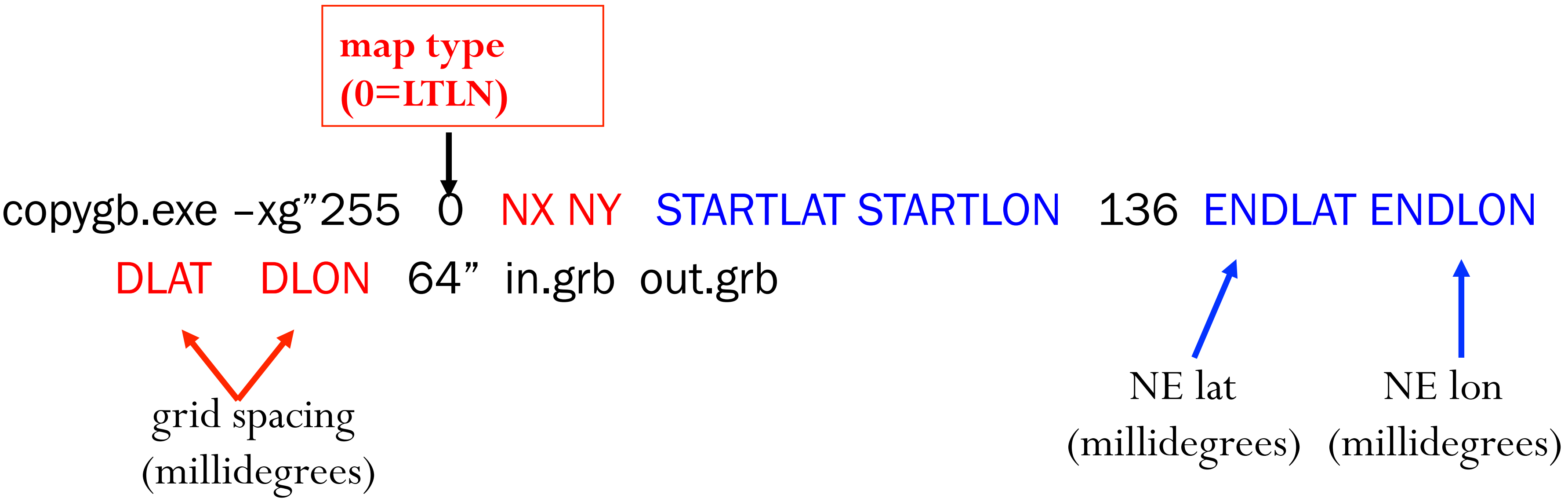
```
copygb –xg”255  5  580  548  10000  -128000  8  -105000   15000 15000
        0   64”  in.grb   out.grb
```

Developmental Testbed Center

Run *copygb* – Option 3c

copygb

- 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
```

grid spacing (millidegrees)

NE lat (millidegrees)

NE lon (millidegrees)

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

GRIB file visualization with 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.

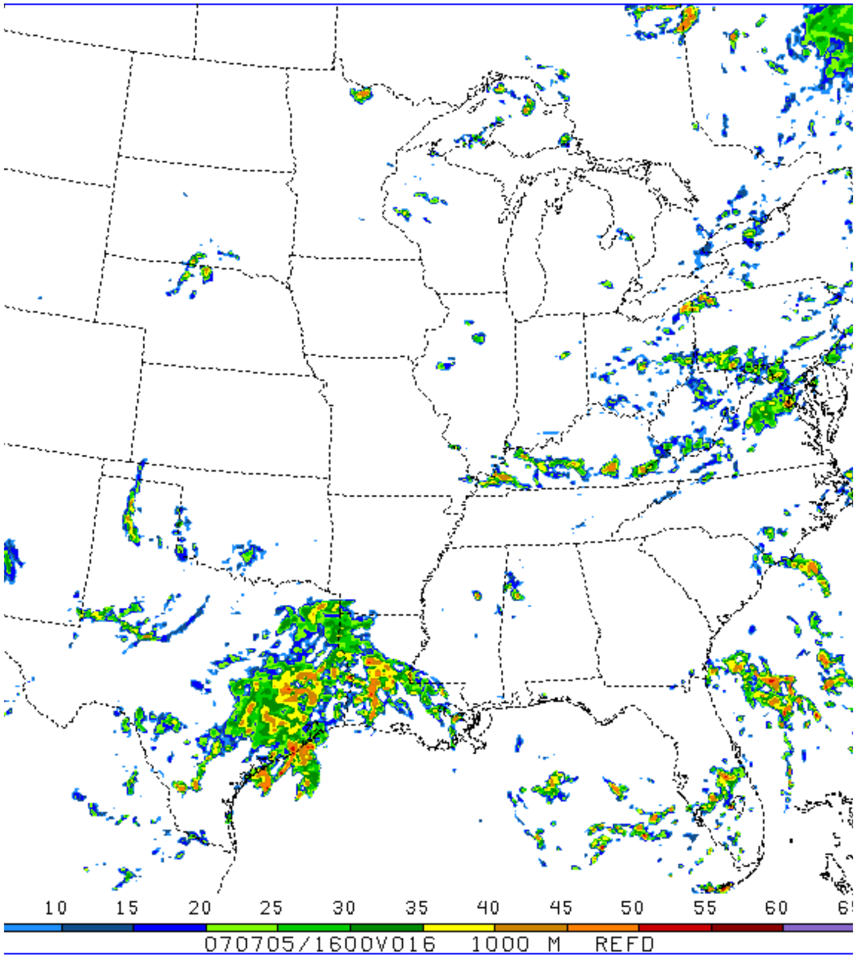
- Package download and user guide are available online:

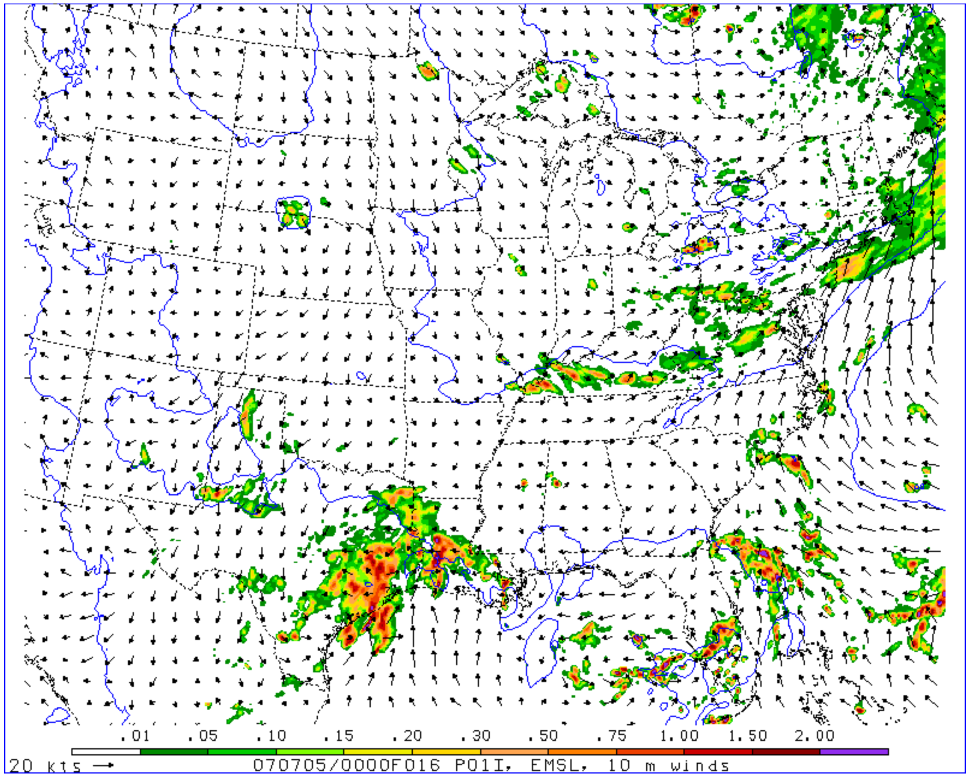
  http://www.unidata.ucar.edu/content/software/gempak/index.html

- 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





Developmental Testbed Center

GRIB file visualization with 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

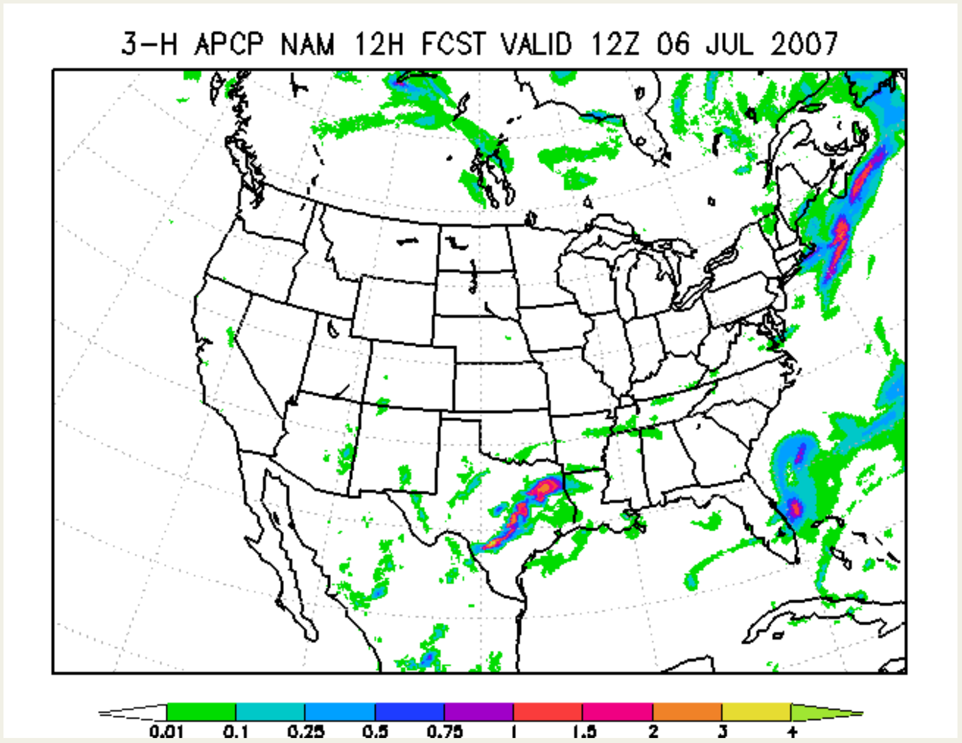
- Package download and user guide for GrADS are available online:

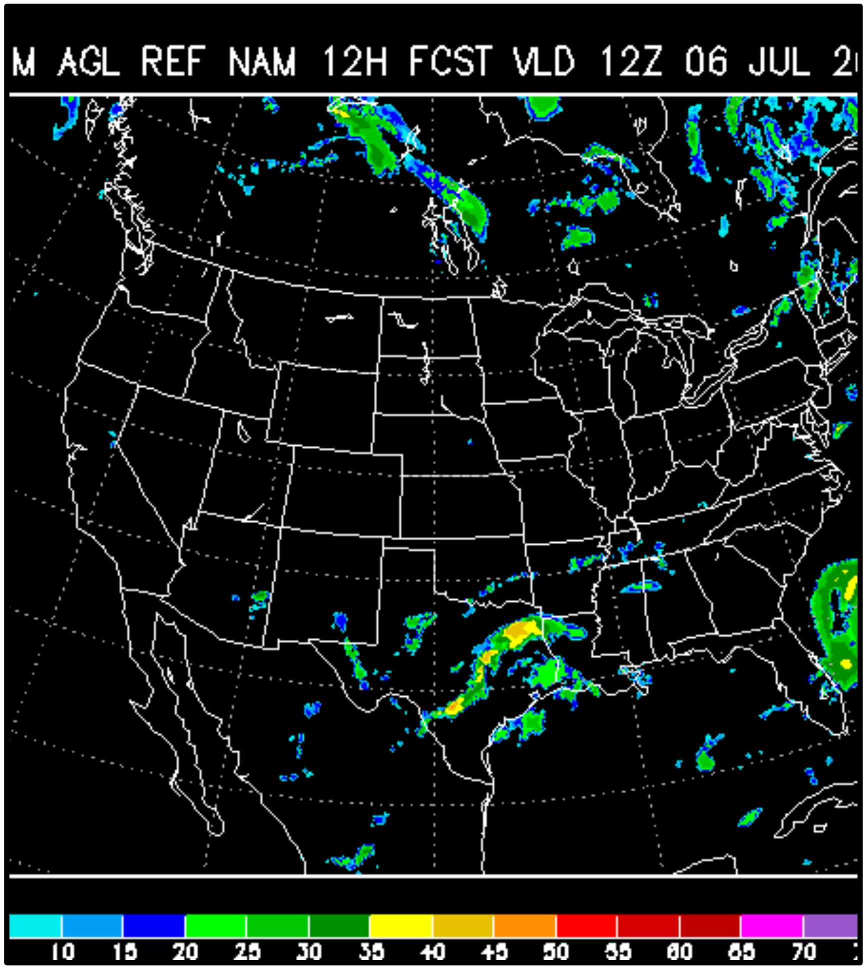
  http://grads.iges.org/grads/gadoc/

- 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

- Fix problem(s) in the generation of GRIB2 output.
  - NCEP currently working on this

- Continue adding new products to the released UPP code as they are developed, and expand code portability.

UPP Users' Guide available at:

www.dtcenter.org/wrf-nmm/users/docs/user_guide/V3/users_guide_nmm_chap7.pdf

Questions???