NCEP's UNIFIED POST PROCESSOR (UPP)

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2018 HWRF Tutorial

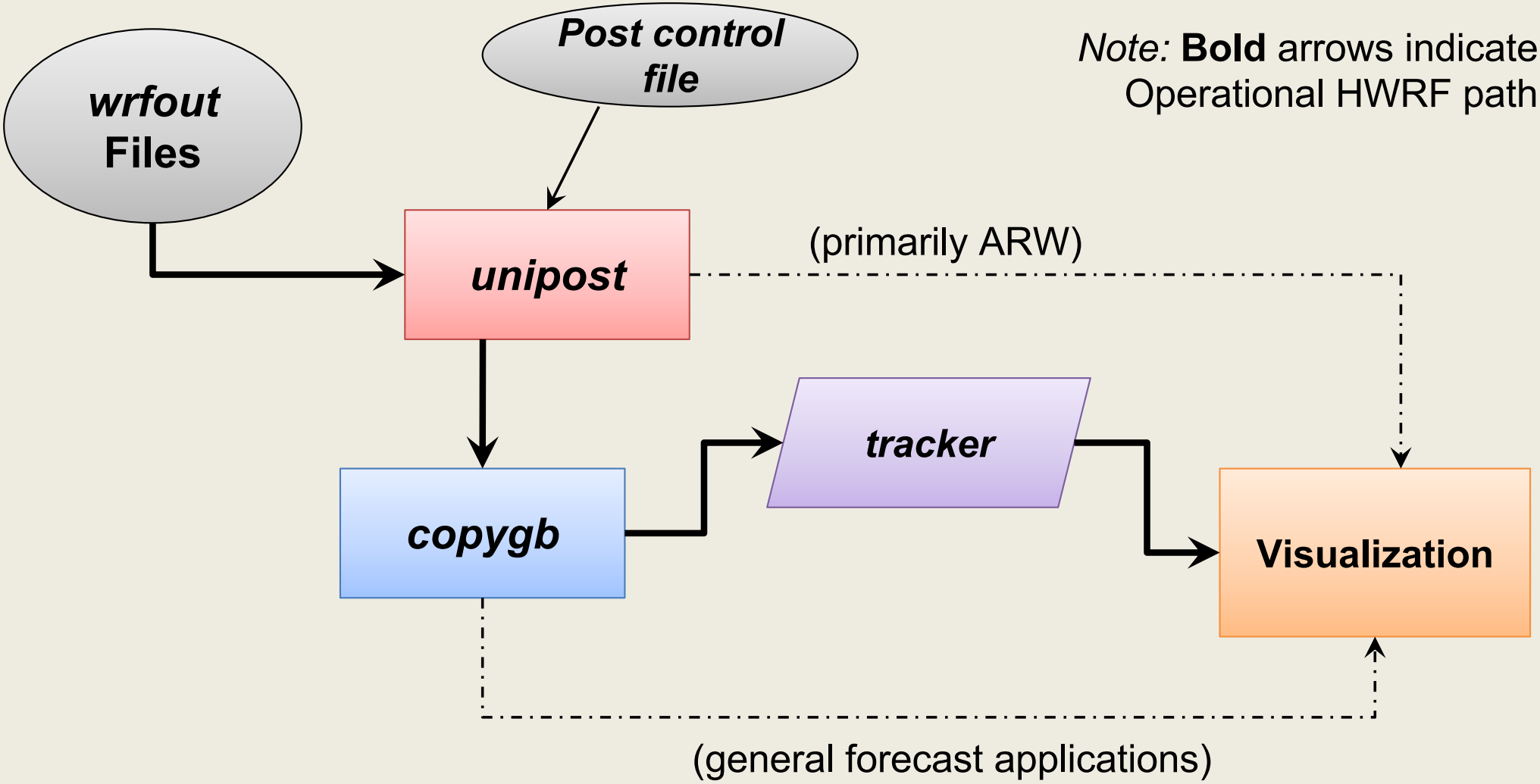
Outline

- Overview
- Components and Functions
- Sample fields generated
- Running ***unipost***
  - Controlling output generation
- Running ***copygb***
  - Specifying target grid
  - Combining parent and nest domains
- Visualization

The critical big picture overview

- Processes model output from **both** the NMM and the ARW **dynamic cores**
- The UPP generates output in **GRIB1 or GRIB2**
- The UPP enables product generation on **any output grid up to** 3 decimal points of precision

Components of Post-Processing



Functions and features of *unipost*

- Performs **vertical interpolation** onto isobaric and other non-model surfaces
- **Computes** diagnostic fields
- **De-staggers** wind onto mass points for ARW core only
- An MPI parallel code that will run faster with more processors

Functions of *copygb*

- Perform **horizontal interpolation** onto a defined output grid
- Useful for both cores in creating an output grid not fixed by the model integration domain
- **Combines** the *nest* data onto the *parent* domain
- Performs **de-staggering** for NMM core only
  - Many visualization packages cannot properly handle staggered grids

Ingesting WRF model output

- *unipost* reads in WRF model output in netCDF format using the WRF I/O API package
  - A single time per *wrfout* file works best with sample UPP run scripts (*frames_per_outfile=1* in WRF namelist)
- By default, the WRF model will provide all fields that *unipost* **requires**
  - Only a concern if you are modifying the Registry file
- **All** model fields read in by *unipost* for both dynamic cores can be found in the respective User Guides (listed by WRF Registry file variable names)

Fields generated by the UPP

- The UPP currently outputs hundreds of possible fields
  - Complete list in the Post Processing Utilities chapter of the ARW or NMM User Guides

    http://www.dtcenter.org/wrf-nmm/users/docs/user_guide/V3/users_guide_nmm_chap1-7.pdf
- **Sample fields** generated by UPP
  - T, Z humidity, wind, cloud water, cloud ice, rain, and snow on isobaric levels
  - Shelter level T, humidity, and wind fields
  - SLP (two types)

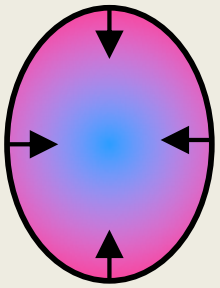
Fields generated by the UPP

- Precipitation-related fields: accumulated and instantaneous precipitation for total, convective, and grid scale
- PBL-related fields
- Diagnostic fields: satellite look-alike, isentropic, vorticity, and simulated radar reflectivity
- Radiative fluxes
- Cloud-related fields
- Aviation products

Derivation of sea level pressure

- Standard NCEP SLP:
  - Based on underground temperatures extrapolated using a constant lapse rate, but subject to the Shuell correction.
  - Can be very noisy over mountainous terrain in higher-resolution model runs

- Membrane NCEP SLP:
  - Underground temperatures recomputed by solving $\nabla^2 T_v = 0.$ using successive overrelaxation method.
  - Hydrostatic integration of this smooth underground temperature field yields a much smoother SLP field.



Computation of Satellite Look-Alike Products

- They are derived by calling Community Radiative Transfer Model (CRTM) forward model using model predicted cloud, moisture, and surface fields as input
- Allow users to make direct comparisons between satellite observations and model forecast
- HWRF has been generating simulated GOES and F-17 SSMIS operationally for several years
- EMC has also been generating NADIR simulated GOES products operationally for both GFS and NAM since 2007

Fields required by the tracker

- Input for the tracker program
  - **Primary**
    - MSLP
    - Relative vorticity* at 10m, 850 and 700 hPa
    - Geopotential height at 850 and 700 hPa
  - **Secondary**
    - Winds (u/v) at 10m, 850 and 700 hPa
      - also used to extract intensity

*UPP outputs absolute and the tracker derives relative

Running *unipost and copygb*

UPP directory contents (subset)

- **sorc/:** source codes
- **scripts**/: sample scripts for running UPP and generating graphics
- **lib**/: libraries used in the build
- **parm**/: control file used when running *unipost* to specify which variables to output
- **exec/:** UPP executables
- **configure**: script to configure how to compile post
- **compile**: script to compile the UPP code
- **clean**: script to clean created files and executables

Input to run *unipost*

- *Post* needs three input files in addition to model output
  1. **itag**: specifies details on model output to process
     - model output file name
     - format of model output (binary or netcdf)
     - forecast validation time
     - model name (NMM or NCAR)
  2. ***wrf_cntrl.parm, hwrf_cntrl.nosat, or hwrf_cntrl.sat*** : control file to let users specify which fields/levels to output
  3. ***eta_micro_lookup.dat***: binary look-up table for Ferrier MP
- In the scripts provided in with tutorial, these files are automatically generated or linked

unipost control file: *wrf_cntrl.parm*

- Users specify which fields and which level(s) of fields to output by modifying control file

GRIB packing precision**

```
(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…
```

Each column represents a single model/isobaric level:
"1" = output, "0" = no output

Product description – unipost code keys on these character strings.

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

unipost control file

- The ***wrf_cntrl.parm*** file has entries for every possible output field

- The ***hwrf_cntrl.nosat*** file has entries required by the tracker plus some additional diagnostics

- Table 3 in previously mentioned users' guide explains the character string abbreviations used in the control file:

http://www.dtcenter.org/wrf-nmm/users/docs/user_guide/V3/users_guide_nmm_chap1-7.pdf

Outputting fields on different vertical coordinates

- *unipost* outputs on several vertical coordinates:
  - **Native model levels**
  - 47 **isobaric levels**: 2, 5, 7, 10, 20, 30, 50, 70, then every 25 hPa from 75-1000 hPa
  - 7 **flight levels** above MSL: 914, 1524, 1829, 2134, 2743, 3658, and 6000 m
  - 6 **PBL layers**: each averaged over 30 hPa AGL layer
  - 2 **AGL levels**: 1000 & 4000 m (radar reflectivity).
- ***Except for AGL and isobaric levels, vertical levels are counted from the ground surface up in the parameter control file***

Examples of using *Post* control file

- 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.

- Output instantaneous surface sensible heat flux:

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

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* include:
  - Pre-defined NCEP standard grid number
  - Defined grid definition
    - Operational HWRF grid definition
    - User-defined grid definition
  - Grid navigation file created by *unipost*

Run *copygb* – Option 1

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

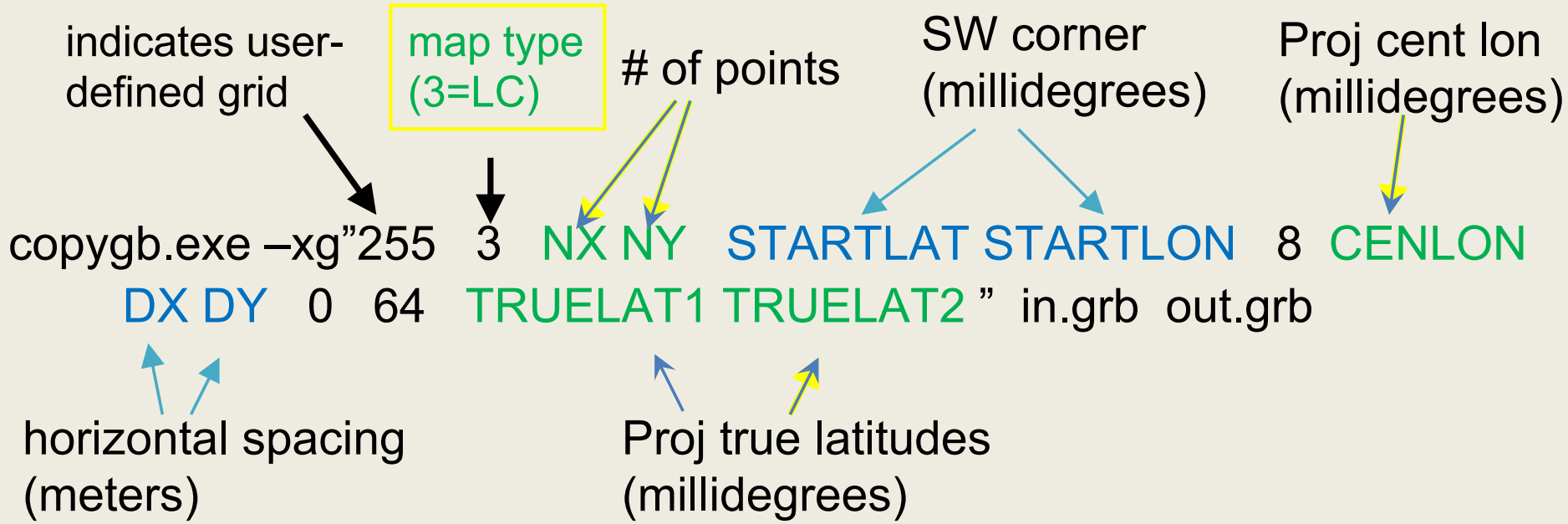
    copygb.exe –xg212 *in.grb out.grb*

- Description of NCEP grids are available online:

  http://www.nco.ncep.noaa.gov/pmb/docs/on388/tableb.html

Run *copygb* – Option 2a

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



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

Run *copygb* – Option 2b

- 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 2c

- 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

NE lat (millidegrees)

NE lon (millidegrees)

grid spacing (millidegrees)

Example of create an operational HWRF output domain:

copygb –xg"255 0 **1101 901 66700 334800 136 -23300 224800 100 100 0**"
in.grb out.grb

Run *copygb* – Option 3

- Read in grid **navigation file** created by *unipost* (simple, restrictive)
  - Running *unipost* produces up to 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 (NMM only)
    - *copygb_hwrf.txt* for a regular Lat-Lon grid (ARW and NMM)
  - For example:

read nav < 'copygb_hwrf.txt'

copygb.exe –xg "*$nav* **" in.grb out.grb**

Note: This file is **not** used in operations

Combine input files with *copygb*

- Put *nest* data onto the *parent* domain and generates a new GRIB file with the combined data

copygb.exe –g”*$grid* **” -xM** *parent_in.grb nest_in.grb*

GRIB file visualization with GrADS

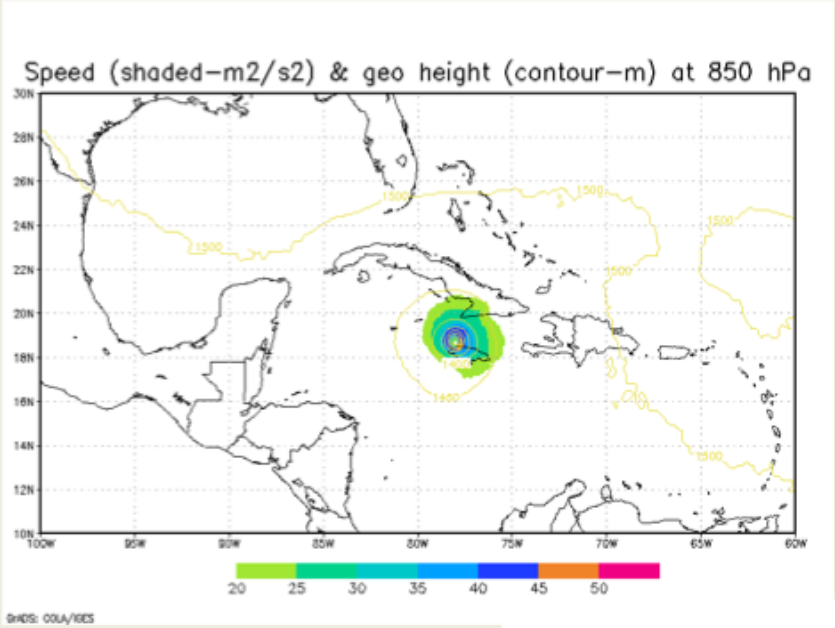
- GrADS has utilities to read GRIB files on any non-staggered grids and generate GrADS "control" files. The utilities *grib2ctl* and *gribmap* are available via: http://www.cpc.ncep.noaa.gov/products/wesley/grib2ctl.html

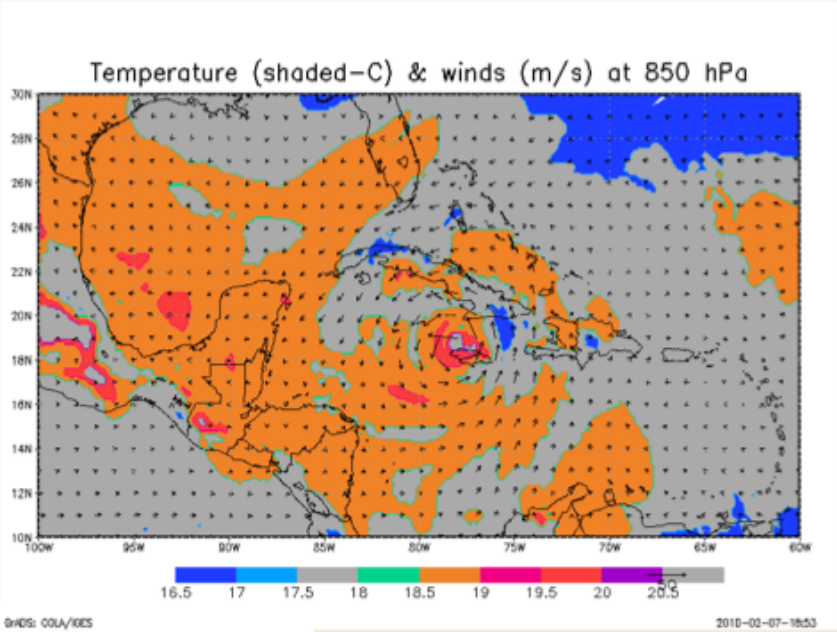
- Package download and user guide for GrADS are available online:

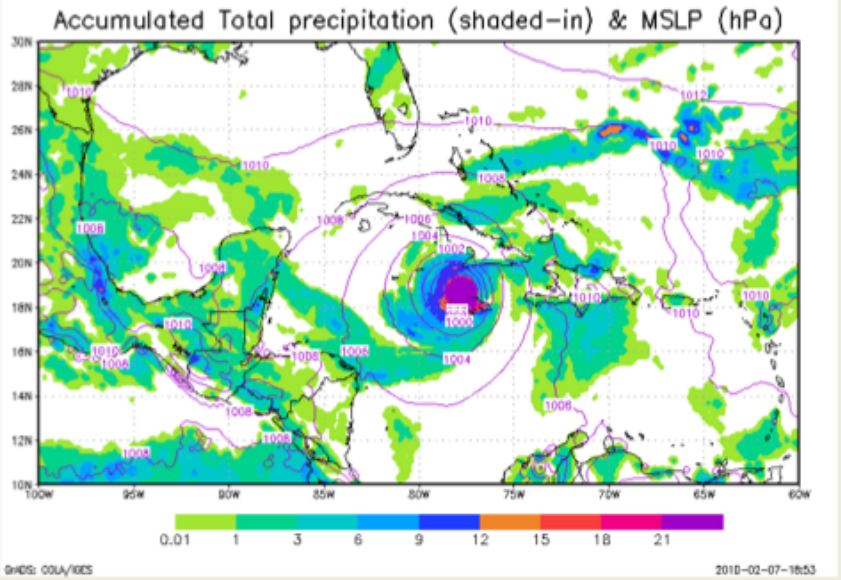
  http://grads.iges.org/grads/gadoc/

- A sample script named ***run_grads*** is included in *hwrf_utilities/scripts/* that can be used to plot various fields using GrADS

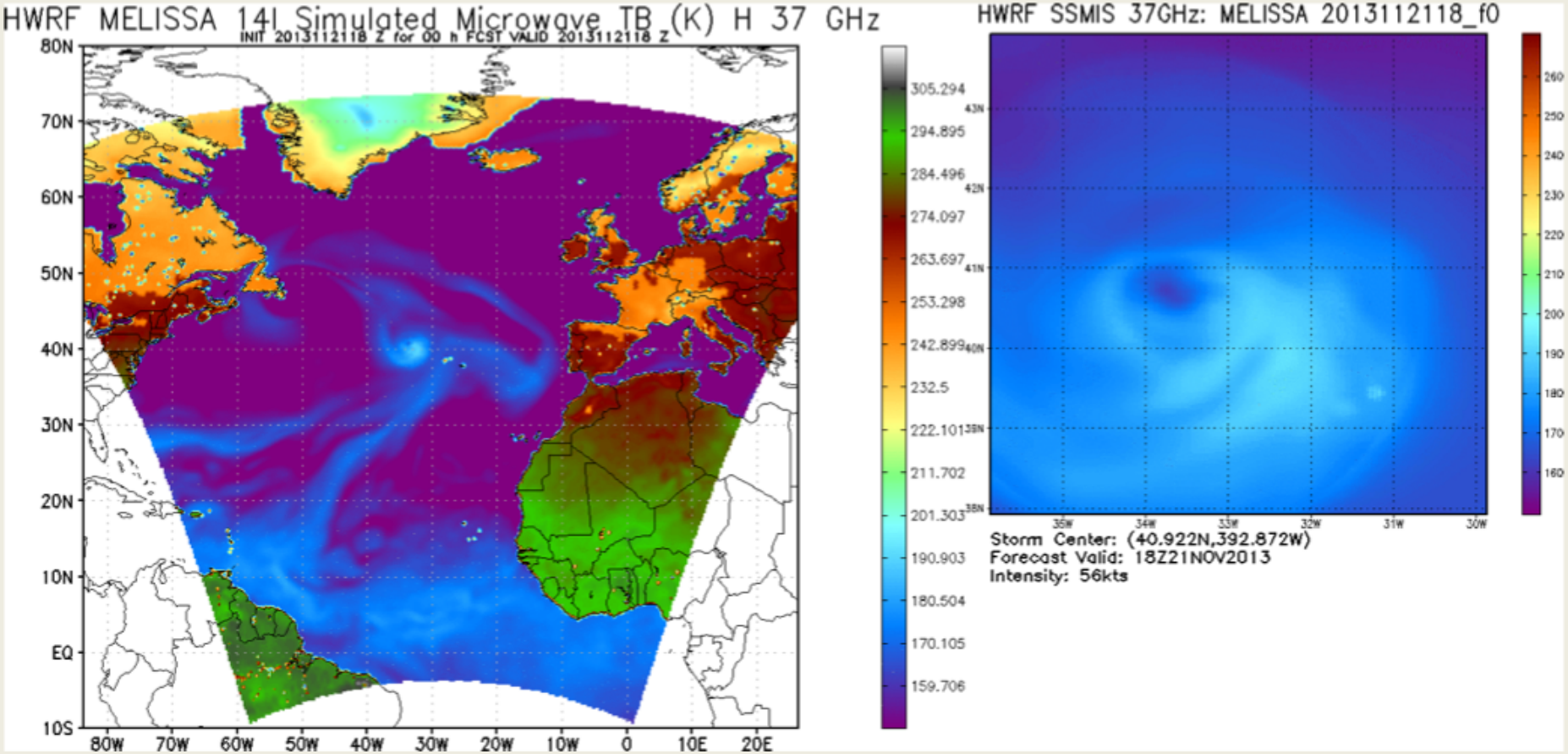
Forecast plotted with GrADS:







HWRF Simulated SSMIS for Hurricane Melissa Also Plotted with GrADS



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://my.unidata.ucar.edu/content/software/gempak/index.html
- Further details on this script and using GEMPAK are available in the user’s guide

Future Plans

- Continue to add new products, improve efficiency, and expand code portability
- HWRF will be switching from MTSAT-2 synthetic brightness temperatures to Himawari 8 in its West Pacific and East Indian Ocean storms
- Transition all operational models to output GRIB2. Benefits include better representation of fine resolution grid and up to 50% saving in memory. New utility “wgrib2” is used operationally to perform horizontal interpolation and will be available to users

Additional Resources

- WRF-NMM Users Page
http://www.dtcenter.org/wrf-nmm/users/

- WRF-NMM Users Guide
http://www.dtcenter.org/wrf-nmm/users/docs/users_guide/V3/users_guide_nmm_chap1-7.pdf

- WRF-ARW Users Page
http://www.mmm.ucar.edu/wrf/users/

- WRF-ARW Users Guide
http://www.mmm.ucar.edu/wrf/users/docs/user_guide_V3/contents.html

- HWRF Users Page
http://www.dtcenter.org/HurrWRF/users/docs/index.php

- Questions regarding UPP can be directed to: wrfhelp@ucar.edu

Questions?