NCEP's WRF POST PROCESSOR

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Outline

- Overview
- Sample fields generated by WRF post package
- Derivation of commonly used fields
- Installation
- Controlling what to output
- Visualization

Introduction I

- NCEP's WRF post processor can post process model output from both the WRF NMM and WRF ARW cores.
- NCEP uses the WRF post processor as a common post processor so that forecasts from different models can be compared and verified fairly.

Introduction II – I/O

- The WRF post reads in model output in either binary or netcdf format using the WRF I/O API.
- Users are encouraged to use netcdf formatted model output for simplicity. NCEP uses binary output for speed.
- Output is on NCEP standard or user-defined grids in NWS & WMO standard GRIB format, which can be read by GEMPAK and GrADS (and other plotting software).

Introduction III – Components of the WRF post package

The WRF post package has two components: wrfpost and copygb.

- wrfpost:
  - performs **vertical** interpolations onto pressure and other levels.
  - computes diagnostic fields.
  - horizontally interpolates wind onto mass points (ARW).
  - An MPI-parallel code

Introduction III – Components of the WRF post package (cont.)

- copygb:
  - performs **horizontal** interpolation and de-staggering (for NMM core) onto a defined output grid.
  - Note that most graphics packages can not handle staggered grids, so copygb is an important step for processing NMM core output.
  - Useful for both cores in creating an output grid not fixed by the specified model integration domain.

Fields generated by WRF post package

- The WRF post package currently outputs 288 fields. Complete list can be found in Table 1 of your user guide or online:

http://wwwt.emc.ncep.noaa.gov/mmb/papers/chuang/2/wrfpost.txt

- Sample fields generated by WRF post package:

  1) T, Z, humidity, 3D wind, cloud water, cloud ice, rain, and snow on 47 isobaric levels (8 levels above 75 mb and then every 25 mb from 75 to 1000 mb);

  2) Shelter level T, humidity, and wind fields;

Fields generated by the WRF post package

3) SLP (two types);

4) Precipitation-related fields:

a) Accumulated and instantaneous precipitation for total, convective, and grid scale,

b) Radar reflectivity, visibility, and precip types;

5) PBL-related fields: PBL height, 6 layers of PBL 30 mb layer-averaged temperature, humidity, and wind;

6) Diagnostic fields: Vorticity and geostrophic stream function;

Fields generated by the WRF post package

7) Radiative fluxes: instantaneous and time-averaged downward and upward shortwave and longwave;

8) Surface fluxes: instantaneous and time-averaged sensible, latent, and ground heat fluxes.

9) Cloud related fields:

a) Cloud fraction,

b) Cloud top/bottom p, Z, and T (total, conv, GS)

10) Aviation products: in-flight icing and ceiling.

Computation of atmospheric isobaric fields

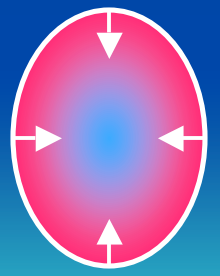
- Vertical interpolation of all state fields from model to pressure levels is performed in linear in ln(p) fashion.
- The WRF-NMM model does not output a height field, so the wrfpost generates model level heights for the NMM by integrating the hypsometric equation.

Computation of underground isobaric fields

- All underground winds are set equal to the winds at the first model level above ground.
- Temperature uses a constant θ_v computed from an average of the 2nd and 3rd model levels above ground to extrapolate underground.
- Humidity fields are defined by maintaining the average RH of the 2nd and 3rd model levels above the surface.

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 relaxing $\nabla^2 T_v = 0.$ using successive overrelaxation.
  - Hydrostatic integration of this smooth underground temperature field yields a much smoother SLP field.



Computation of simulated radar reflectivity

- Different algorithms are used depending on the microphysics (MP) option used in the model run:
  - Ferrier MP scheme: consistent with assumptions made in Ferrier MP scheme (details in Ferrier's 94 JAS publication).
  - Other MP schemes: adopted from RIP4. More information can be found online:

    http://www.mmm.ucar.edu/wrf/users/docs/ripug.htm
  - If users want to use the RIP4 algorithm on Ferrier MP based runs to get a fair reflectivity comparison, e-mail Hui-Ya (Hui-ya.Chuang@noaa.gov) for instructions.

Shelter level fields and PBL height

- Shelter level fields and PBL height are directly output from the WRF model, and are not interpolated or diagnosed in the WRF post.
- This procedure ensures that these fields are derived within the model based on surface and PBL physics used in your model runs.

Computation of other fields

- Computation of many other fields can be found in ETA post documentation online:

http://www.emc.ncep.noaa.gov/mmb/papers/chuang/1/OF438.html

- There are some differences between WRF and ETA post when looking through this documentation. Two major differences are the vertical coordinate and how to ingest various model constants.

- Eta post documentation will soon be updated to become WRF post documentation.

Download

- The tar file wrfpost_v2.2.1.tar containing all the source code, scripts, and libraries is available from DTC site:

  http://www.dtcenter.org/wrf-nmm/users/downloads

Installation I – Untar package

- Un-tarring the wrfpost_v2.2.1.tar file creates directories, a configure file, and master makefiles for the two supported platforms (IBM, linux):
  - **sorc**/: Source codes
  - **scripts**/: Sample scripts for the post and graphics generation
  - **lib**/: libraries used in the build
  - **parm**/: control files used when running the wrfpost.
  - **configure**: Sets up makefiles based on user-specified computing platform and paths to software used for I/O.
  - **makefile**: master makefile to compile all of the lib and sorc.

Installation II – Compile source codes

- Run “configure”. Users will be prompted to specify:

  1) platform: enter “1” for LINUX or “2” for IBM
  2) path to your netcdf installation
  3) path to your WRF model source code

- Compile all libraries and source code by executing the master makefile in the top directory.

Installation III – Run wrfpost

- wrfpost needs three input files:
  - **itag**: read in via unit 5 to provide information on
    - model output file name
    - format of model output (netcdf or binary)
    - forecast verifying time in WRF format
    - model name (NMM or NCAR)
  - **wrf_cntrl.parm**: control file specifying fields to be output
  - **eta_micro_lookup.dat**: look-up table containing MP coefficients used by Ferrier scheme.

Installation III –Sample run_wrfpost script

```
#!/bin/sh

cat > itag <<EOF
wrfout_d01_2005-04-27_00:00:00
netcdf
2005-04-27_00:00:00
NMM
EOF

rm -f fort.*
ln -sf ../parm/wrf_cntrl.parm fort.14
ln -sf griddef.out fort.110
ln -sf ../parm/eta_micro_lookup.dat .
../exec/wrfpost.exe < itag > outpost_wrf
```

creating file itag in the script

← *file name of WRF history file*
← *format of WRF output*
← *validation time*
← *model name (NMM or NCAR)*

← *linking to control file*

← *linking to Ferrier's lookup table*
← *execute WRF post*

Installation IV – Description of wrfpost control file wrf_cntrl.parm

specifying grid number

KGTYPE******I5*******:(00255)********START OF THIS OUTPUT
IMDLTY *I5* :(00089)
DATSET *A6* :(WRFPRS)
(PRESS ON MDL SFCS) SCAL=(3.0)
L=(11000 00000 00000 00000 00000 00000 00000 00000 00000
(HEIGHT ON MDL SFCS) SCAL=(-5.0)
L=(11000 00000 00000 00000 00000 00000 00000 00000 00000

GRIB packing precision

switch to specify which level of field to output with "1" being yes

abbreviated name used in post source code for each field

Installation V – Controlling output

- To output a desired field:
  - Look through the field names in Table 1 of the user guide to see if the WRF post produces this field.
  - If yes, note the corresponding abbreviated name in the 2nd column of Table 1 and look for it in wrf_cntrl.parm; *the control file supplied in the tar file lists all available fields.*
  - Make sure that the switch is turned onto “1”.

Installation V – Outputting fields on multiple levels

- wrfpost outputs fields on several vertical coordinates:
  - Native model levels
  - 47 isobaric levels: 2, 5, 7, 10, 20, 30, 50, 70 mb, then 75 to 1000 mb every 25 mb
  - 7 flight levels above MSL: 914, 1524, 1829, 2134, 2743, 3658, and 6000 m.
  - 6 PBL layers (values averaged over 30 mb deep layers)
  - 2 AGL levels: 1000 m and 4000 m for radar reflectivity.
- Except for AGL and isobaric levels, vertical levels are counted from the ground surface up in wrf_cntrl.parm.

Installation V – Outputting fields on multiple levels

- To output temperature at 75 and 125 mb:

```
(TEMP ON PRESS SFCS  ) SCAL=( 3.0)
L=(00000 00010 10000 00000 00000 00000 00000 00000…
```

- To output 30 mb PBL mean U from 30 to 60 mb and then from 90 to 120 mb AGL:

```
(U WIND IN BNDRY LYR ) SCAL=( 3.0)
L=(01010 00000 00000 00000 00000 00000 00000 00000…
```

Installation VI – run copygb

- To use copygb to perform horizontal interpolations:

  copygb –xg"${grid}" in.grb out.grb

- Two ways to specify the target grid ${grid}:
  - Use a predefined NCEP standard grid. For example, to interpolate your GRIB file onto NCEP grid 212:

    copygb –xg212 in.grb out.grb

    Descriptions of NCEP grids are available online:

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

Installation VI – run copygb - Continued

- 2nd way is to create a user-defined grid by specifying ${grid} = '255 INT(GRIB GDS values)'

For example, interpolation to a user-defined Lambert Conformal grid is specified as:

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

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

The SW corner (STARTLAT/LON), central longitude (CENLON), and true latitudes (TRUELAT1/2) of the grid are specified in millidegrees. The grid spacing DX and DY is specified in meters.

Installation VI – run copygb - Continued

- Running wrfpost produces two ascii files containing grid navigation information that can be used by copygb:
  - copygb_gridnav.txt for Lambert Conformal grid (NMM only)
  - copygb_hwrf.txt for Lat-Lon grid
- The sample scripts run_wrfpostandgempak and run_wrfpostandgrads demonstrate how to use copygb and the above two text files to interpolate onto a user-defined grid.
- More instructions on how to run copygb can be found in the file copygb.doc in the copygb source code.

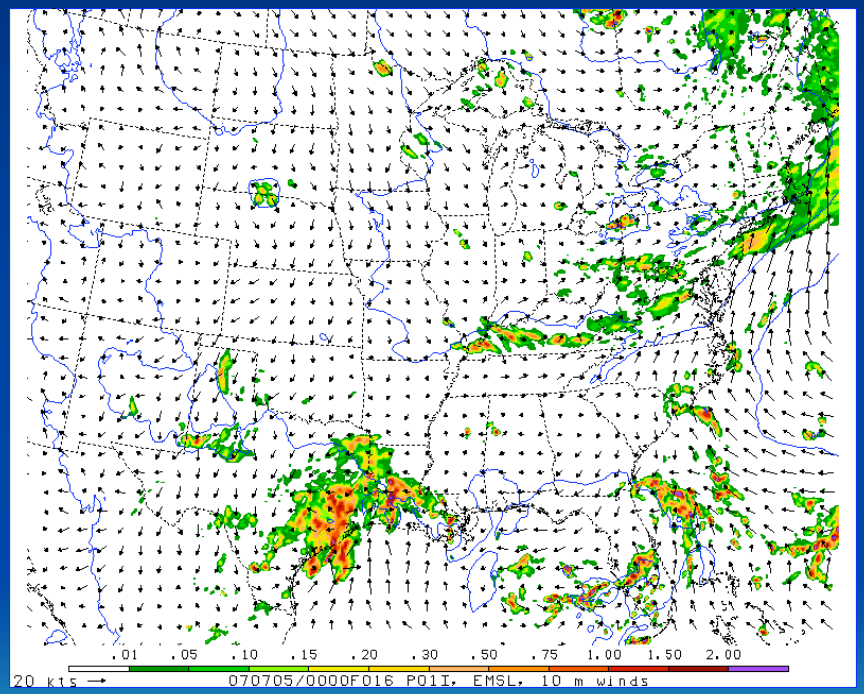
GRIB file visualization with GEMPAK

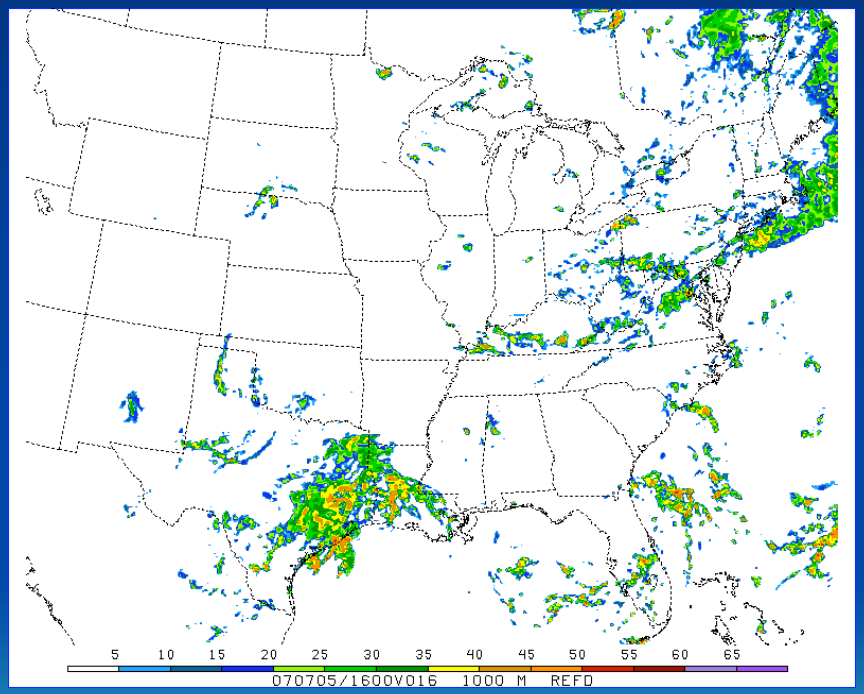
- The GEMPAK utility “nagrib” reads GRIB files from any non-staggered grid and generates GEMPAK-binary files that are readable by GEMPAK plotting programs
- GEMPAK can plot horizontal maps, vertical cross-sections, meteograms, and sounding profiles.
- Package download and user guide are available online:
  http://my.unidata.ucar.edu/content/software/gempak/index.html

GRIB file visualization with GEMPAK

- A sample script named run_wrfpostandgempak is included in scripts/ that can be used to run wrfpost, copygb, and plot various fields using GEMPAK.
- Further details on this script and using GEMPAK are available in the users' guide.

WRF NMM forecast plotted with GEMPAK : Precipitation and derived Radar reflectivity





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:

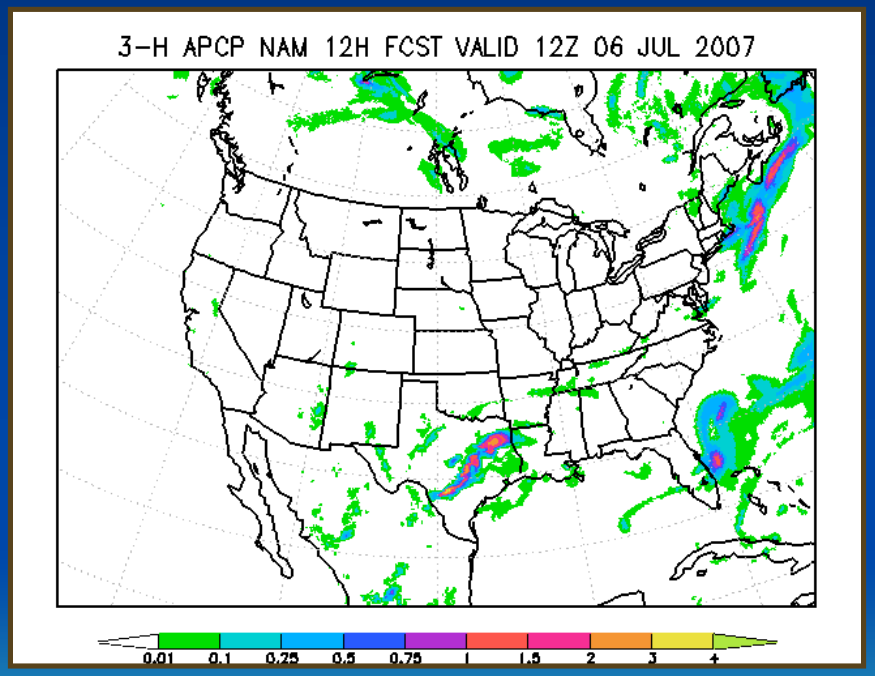
  http://www.cpc.ncep.noaa.gov/products/wesley/grib2ctl.html

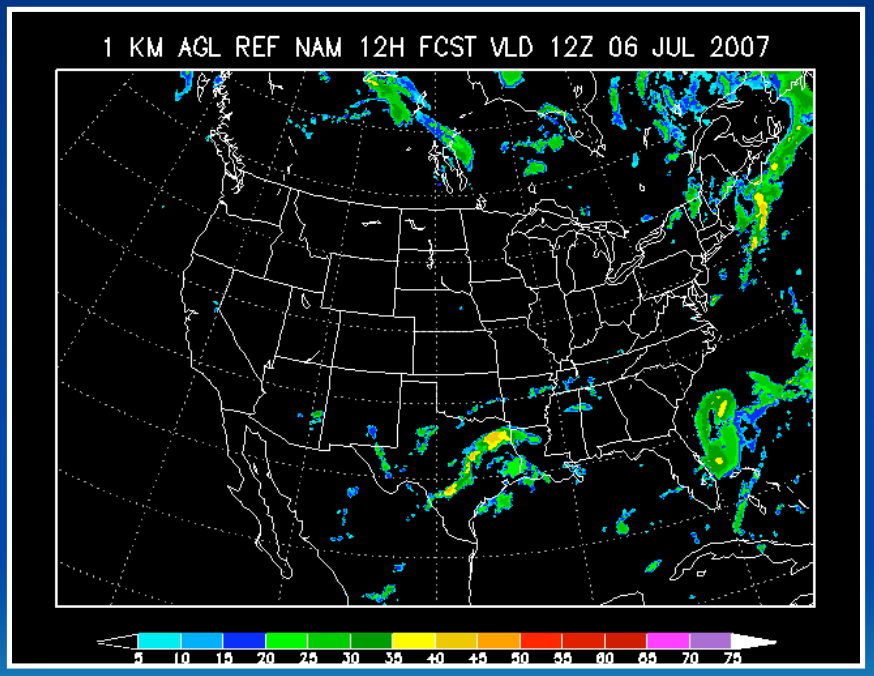
- Package download and user guide for GrADS are available online:

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

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

WRF NMM forecast plotted with GrADS: Precipitation and derived Radar reflectivity





Model fields ingested by the WRF post

- A list of fields (listed by WRF Registry file variable names) that are read in by the WRF post for both the WRF NMM and the WRF ARW can be found in tables 2 and 3 in your user guide or online:

  http://wwwt.emc.ncep.noaa.gov/mmb/papers/chuang/2/wrfpost.txt

- All of these fields should be in the model output so that WRF post can compute and output each field properly.

- These fields should be in your model output by default, but they can be added as needed through modification of the WRF Registry file. The Registry file will be discussed later in the week.

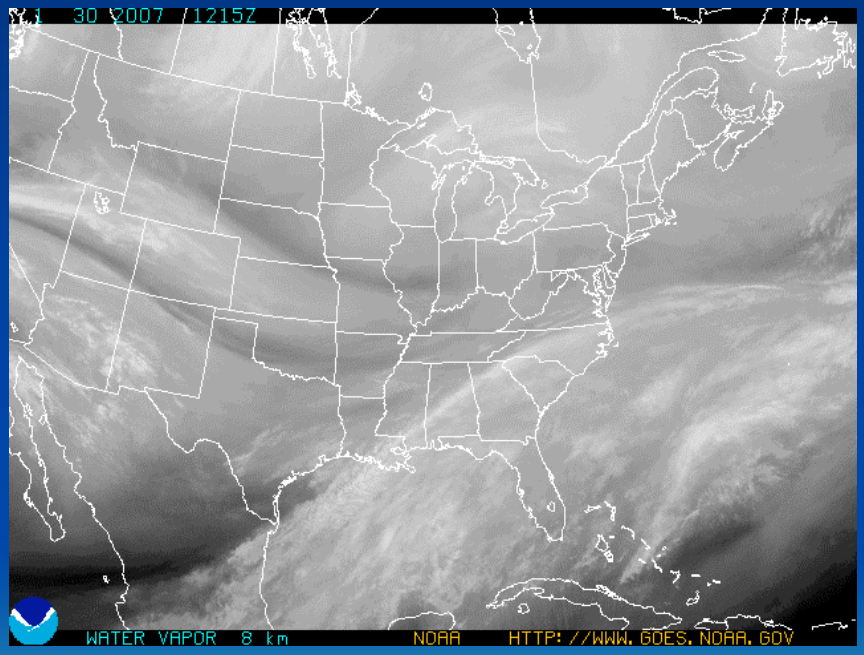
Some tips and suggestions

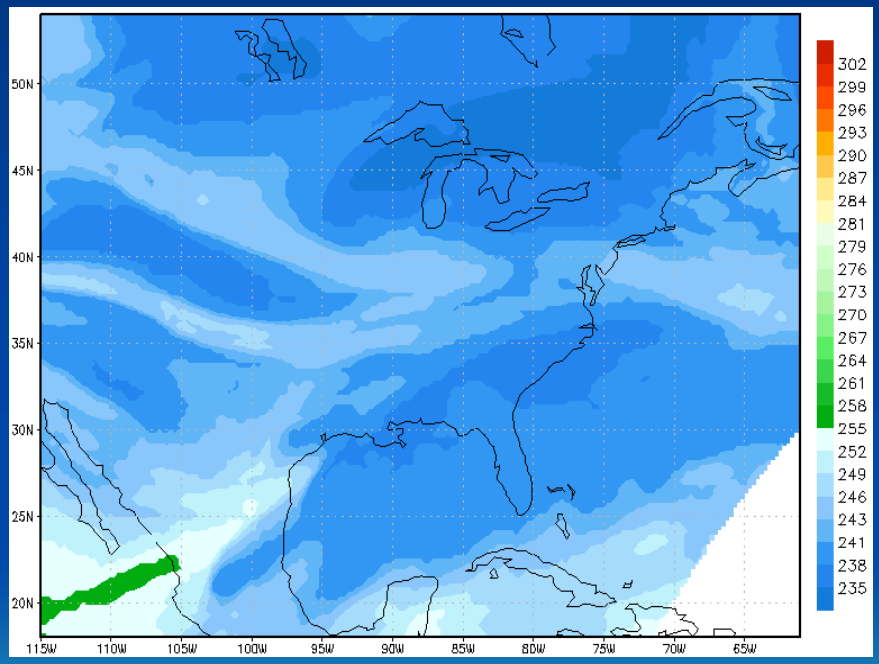
- To reduce the size of the GRIB file, users can modify the control file wrf_cntrl.parm to output only desired fields.
- If a field in the GRIB file has non-physical values, it is likely that required fields are missing from the model output. For example, unreasonable vorticity may be due to missing grid spacing fields (dx,dy) in the model output.

Future plans

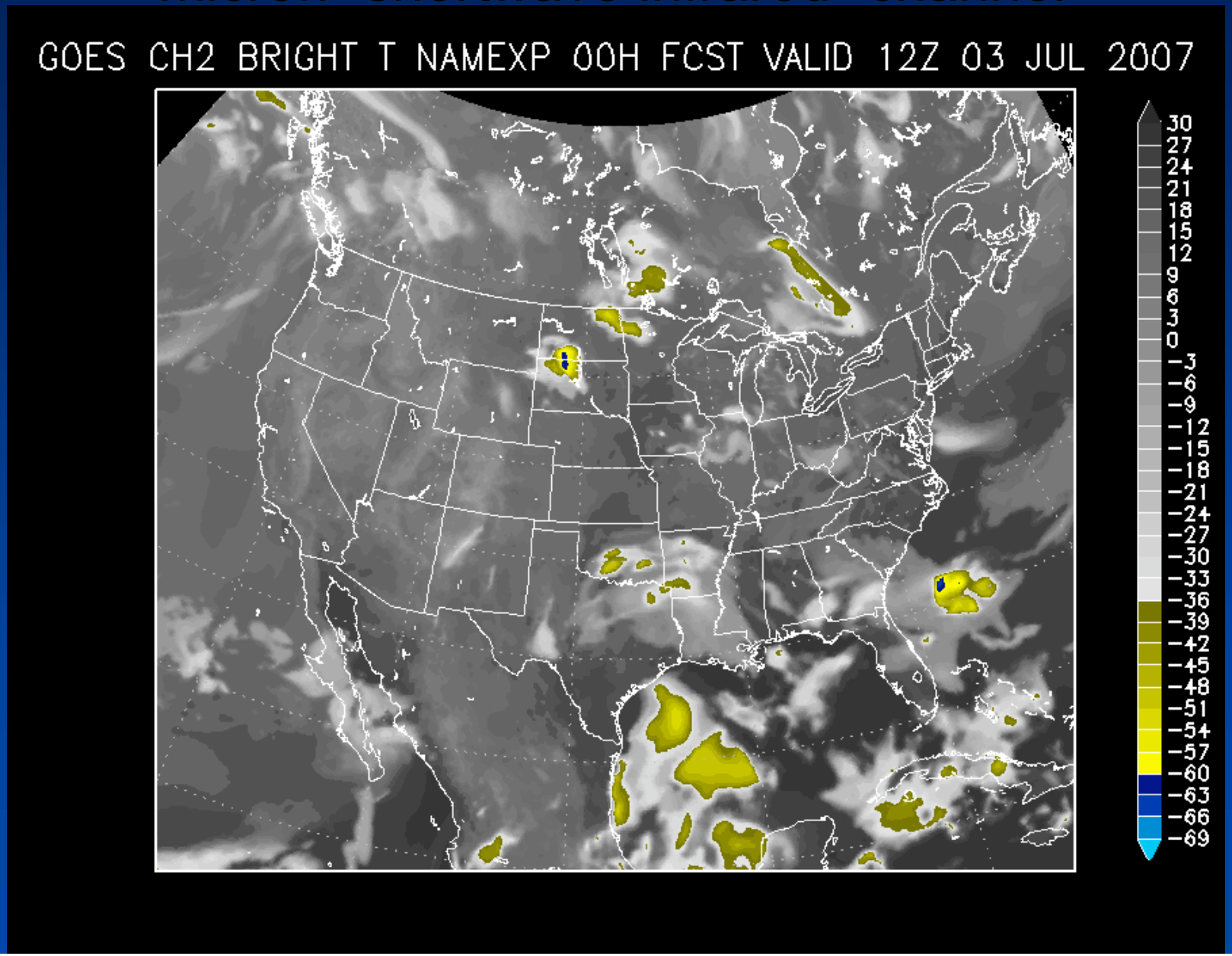
- The WRF post processor is constantly updated to add more fields and to make bug fixes. NCEP and DTC will work together to distribute new versions to users ASAP.
- Planned upgrades for the WRF post processor:
  - Incorporate the community radiative transfer model to more accurately simulate model derived brightness temperature for different instruments and channels such as GOES IR and water vapor channels (currently running as a parallel test at NCEP).
  - Convert all code to Fortran 90/95, modernize the software.

Observed (L) and model derived (R) brightness temperature for GOES water vapor channel





Model-derived brightness temp for GOES 3.9 micron “shortwave infrared” channel



How to change the number or values of output pressure levels

- Modify specification of variable LSM in the file CTLBLK.comm to change the number of pressure levels:

  PARAMETER (LSM=47)

- Modify specification of SPL array in the subroutine POSTDATA.f to change the values of pressure levels:

```
   DATA SPL/200.,500.,700.,1000.,2000.,3000.
  &,5000.,7000.,7500.,10000.,12500.,15000.,17500.,20000., …
```