User's Guide for the NCEP Unified Post Processor (UPP) Version 3

Table of Contents

Acknowledgments:
The adaptation of the original WRF Post Processor package and User's Guide (by Mike Baldwin of NSSL/CIMMS and Hui-Ya Chuang of NCEP/EMC) was done by Lígia Bernardet (NOAA/ESRL/DTC) in collaboration with Dusan Jovic (NCEP/EMC), Robert Rozumalski (COMET), Wesley Ebisuzaki (NWS/HQTR), and Louisa Nance (NCAR/RAL/DTC). Upgrades to WRF Post Processor versions 2.2 and higher were performed by Hui-Ya Chuang, Dusan Jovic and Mathew Pyle (NCEP/EMC). Transitioning of the documentation from the WRF Post Processor to the Unified Post Processor was performed by Nicole McKee (NCEP/EMC), Hui-ya Chuang (NCEP/EMC), and Jamie Wolff (NCAR/RAL/DTC). Implementation of the Community Unified Post Processor was performed by Tricia Slovacek and Kate Fossell (NCAR/RAL/DTC).

NCEP Unified Post Processor (UPP)

UPP Introduction

The NCEP Unified Post Processor has replaced the WRF Post Processor (WPP). The UPP software package is based on WPP but has enhanced capabilities to post-process output from a variety of NWP models, including WRF-NMM, WRF-ARW, Non-hydrostatic Multi-scale Model on the B grid (NMMB), Global Forecast System (GFS), and Climate Forecast System (CFS). At this time, community user support is provided for the WRF-based systems and NMMB.

In addition to the option to output fields on the model's native vertical levels, UPP interpolates output from the model's native grids to National Weather Service (NWS) standard levels (pressure, height, etc.) and standard output grids (AWIPS, Lambert Conformal, polar-stereographic, etc.) in NWS and World Meteorological Organization (WMO) GRIB format. With the release of UPPv3.0, preliminary capabilities to output in GRIB Edition 2 (GRIB2) format for select models has been included and a simple template is available for users to modify to fit their needs. Caution should be taken when utilizing GRIB2; exhaustive testing has not been conducted and it is recommend to use this feature in testing/exploratory mode at this time. Updates will be provided as GRIB2 output capabilities become available and more comprehensive information will be included in the Users' Guide.

UPP incorporates the Joint Center for Satellite Data Assimilation (JCSDA) Community Radiative Transfer Model (CRTM) to compute model derived brightness temperature (T_B) for various instruments and channels. This additional feature enables the generation of a number of simulated satellite products including GOES and AMSRE products for WRF-NMM, Hurricane WRF (HWRF), WRF-ARW and GFS. For CRTM documentation, refer to http://www.dtcenter.org/upp/users/docs/user_guide/crtm_ug/CRTM_User_Guide.pdf.

UPP Software Requirements

The Community Unified Post Processor requires the same Fortran and C compilers used to build the WRF model. In addition, the netCDF library, the JasPer library, the PNG library, Zlib, and the WRF I/O API libraries, which are included in the WRF model tar file, are also required. UPP uses WRF I/O libraries for data processing of all models and as a result UPP is dependent on a WRF build. The JasPer library, PNG library, and Zlib are new requirements with the release of UPPv2.0 and higher, due to the addition GRIB2 capabilities. NCEP provides these necessary codes for download: http://www.nco.ncep.noaa.gov/pmb/codes/GRIB2/

The UPP has some sample visualization scripts included to create graphics using either GrADS (http://cola.gmu.edu/grads/gadoc/gadoc.php) or GEMPAK (http://www.unidata.ucar.edu/software/gempak/index.html). These are not part of the UPP installation and need to be installed separately if one would like to use either plotting package.

UPP has been tested on LINUX platforms (with PGI, Intel and GFORTRAN compilers).

Obtaining the UPP Code

The UPP package can be downloaded from:
http://www.dtcenter.org/upp/users/docs/user_guide/V3/upp_users_guide.pdf.

*** Note:* Always obtain the latest version of the code if you are not trying to continue a pre-existing project. **UPPV3.0 is just used as an example here.**

Once the ***tar*** file is obtained, ***gunzip*** and ***untar*** the file.

> ***tar –zxvf UPPV3.0.tar.gz***

This command will create a directory called ***UPPV3.0***.

UPP Directory Structure

Under the main directory of ***UPPV3.0*** reside seven subdirectories (* indicates directories that are created after the configuration step):

> **arch:** Machine dependent configuration build scripts used to construct ***configure.upp***
>
> **bin***: Location of executables after compilation.
>
> **scripts**: contains sample running scripts to process ***wrfout*** and ***nmmb_hist*** files.
> - **run_unipost**: run ***unipost***, ***ndate*** and ***copygb***.
> - **run_unipost andgempak**: run ***unipost, ndate, copygb***, and GEMPAK to plot various fields.
> - **run_unipost andgrads**: run ***unipost***, ***ndate***, ***copygb***, and GrADS to plot various fields.
> - **run_unipost _frames**: run ***unipost***, ***ndate*** and ***copygb*** on a single ***wrfout*** file containing multiple forecast times.
> - **run_unipost _gracet**: run ***unipost***, ***ndate*** and ***copygb*** on ***wrfout*** files with non-zero minutes/seconds.
> - **run_unipost _minute**: run ***unipost***, ***ndate*** and ***copygb*** for sub-hourly ***wrfout*** files.
> - **run_unipostandgrads_global**: run ***unipost***, ***ndate*** and ***copygb*** and GrADS for global ***wrfout*** files; results in single GRIB1 file. (WRF data only)

include*: Source include modules built/used during compilation of UPP

lib*: Archived libraries built/used by UPP

parm: Contains the parameter files, which can be modified by the user to control how the post processing is performed.

src: Contains source codes for:
- **copygb:** Source code for ***copygb***
- **ndate:** Source code for ***ndate***
- **unipost:** Source code for ***unipost***
- **lib**: Contains source code subdirectories for the UPP libraries
  - **bacio**: Binary I/O library
  - **crtm2**: Community Radiative Transfer Model library
  - **g2:** GRIB2 support library
  - **g2tmpl:** GRIB2 table support library
  - **gfsio:** GFS I/O routines
  - **ip**: General interpolation library (see ***lib/ip/iplib.doc***)
  - **nemsio**: NEMS I/O routines
  - **sfcio**: API for performing I/O on the surface restart file of the global spectral model
  - **sigio**: API for performing I/O on the sigma restart file of the global spectral model
  - **sp**: Spectral transform library (see ***lib/sp/splib.doc***)
  - **w3emc**: Library for coding and decoding data in GRIB1 format
  - **w3nco**: Library for coding and decoding data in GRIB1 format
  - **wrfmpi_stubs**: Contains some ***C*** and ***FORTRAN*** codes to generate ***libmpi.a*** library used to replace MPI calls for serial compilation.
  - **xml**: XML support – GRIB2 parameter file

Installing the UPP Code

UPP uses a build mechanism similar to that used by the WRF model. There are two environment variables that must be set before beginning the installation: a variable to define the path to a similarly compiled version of WRF and a variable to a compatible version of netCDF. The UPP code makes use of the i/o routines in WRF, therefore making it necessary to build WRF code even if processing NMMB forecast data. If the environment variable ***WRF_DIR*** is set by (for example),

setenv WRF_DIR** /home/user/**WRFV3

this path will be used to reference WRF libraries and modules. Otherwise, the path

../WRFV3

will be used.

In the case neither method is set, the configure script will automatically prompt you for a pathname.

To reference the netCDF libraries, the configure script checks for an environment variable (***NETCDF***) first, then the system default (***/user/local/netcdf***), and then a user supplied link (***./netcdf_links***). If none of these resolve a path, the user will be prompted by the configure script to supply a path.

Type ***configure***, and provide the required info. For example:

./configure

You will be given a list of choices for your computer.

Choices for LINUX operating systems are as follows:

1. Linux x86_64, PGI compiler (serial)
2. Linux x86_64, PGI compiler (dmpar)
3. Linux x86_64, Intel compiler (serial)
4. Linux x86_64, Intel compiler (dmpar)
5. Linux x86_64, Intel compiler, SGI MPT (serial)
6. Linux x86_64, Intel compiler, SGI MPT (dmpar)
7. Linux x86_64, gfortran compiler (serial)
8. Linux x86_64, gfortran compiler (dmpar)

Note*: If UPP is compiled with distributed memory, it must be linked to a dmpar compilation of WRF.*

Choose one of the configure options listed. Check the ***configure.upp*** file created and edit for compile options/paths, if necessary. For debug flag settings, the configure script can be run with a ***–d*** switch or flag.

To compile UPP, enter the following command:

./compile >& compile_upp.log &

When compiling with distributed memory (serial) this command should create 13 (14) UPP libraries in ***UPPV3.0/lib/*** (***libbacio.a***, ***libCRTM.a***, ***libg2.a***, ***libg2tmpl.a***, ***libgfsio.a***, ***libip.a***, ***(libmpi.a)***, ***libnemsio.a***, ***ibsfcio.a***, ***libsigio.a***, ***libsp.a***, ***libw3emc.a, libw3nco.a, libxmlparse.a***) and three UPP executables in ***bin/*** (***unipost.exe***, ***ndate.exe***, and ***copygb.exe***).

To remove all built files, as well as the ***configure.upp***, type:

./clean

This action is recommended if a mistake is made during the installation process or a change is made to the configuration or build environment. There is also a ***clean –a*** option which will revert back to a pre-install configuration.

UPP Functionalities

The UPP,

- is compatible with WRF v3.3 and higher.
- can be used to post-process WRF-ARW, WRF-NMM, NMMB, GFS, and CFS forecasts (community support provided for WRF-based and NMMB forecasts).
- can ingest WRF history files (***wrfout****) in netCDF format.
- can ingest NMMB history files (*nmmb_hist**) in binary.

The UPP is divided into two parts:

1. ***Unipost***
    - Interpolates the forecasts from the model's native vertical coordinate to NWS standard output levels (e.g., pressure, height) and computes mean sea level pressure. If the requested parameter is on a model's native level, then no vertical interpolation is performed.
    - Computes diagnostic output quantities (e.g., convective available potential energy, helicity, relative humidity). A full list of fields that can be generated by ***unipost*** is shown in Table 1.
    - Outputs the results in NWS and WMO standard GRIB1 format (for GRIB documentation, see http://www.nco.ncep.noaa.gov/pmb/docs/).
    - Destaggers the WRF-ARW forecasts from a C-grid to an A-grid.
    - Outputs two navigation files, ***copygb_nav.txt*** (for WRF-NMM output only) and ***copygb_hwrf.txt*** (for WRF-ARW and WRF-NMM). These files can be used as input for ***copygb***.
        - ***copygb_nav.txt:*** This file contains the GRID GDS of a Lambert Conformal Grid similar in domain and grid spacing to the one used to run the WRF-NMM. The Lambert Conformal map projection works well for mid-latitudes.
        - ***copygb_hwrf.txt***: This file contains the GRID GDS of a Latitude-Longitude Grid similar in domain and grid spacing to the one used to run the WRF model. The latitude-longitude grid works well for tropics.
    - Except for new capabilities of post processing GFS/CFS and additions of many new variables, UPP uses the same algorithms to derive most existing variables as were used in WPP. The only three exceptions/changes from the WPP are:
        - Computes RH w.r.t. ice for GFS, but w.r.t. water for all other supported models. WPP computed RH w.r.t. water only.
        - The height and wind speed at the maximum wind level is computed by

assuming the wind speed varies quadratically in height in the location of the maximum wind level. The WPP defined maximum wind level at the level with the maximum wind speed among all model levels. The static tropopause level is obtained by finding the lowest level that has a temperature lapse rate of less than 2 K/km over a 2 km depth above it. The WPP defined the tropopause by finding the lowest level that has a mean temperature lapse rate of 2 K/km over three model layers.

2. ***Copygb***
   - Destaggers the WRF-NMM forecasts from the staggered native E-grid to a regular non-staggered grid. (Since ***unipost*** destaggers WRF-ARW output from a C-grid to an A-grid, WRF-ARW data can be displayed directly without going through ***copygb***.)
   - Destaggers the NMMB forecasts from the staggered native B-grid to a regular non-staggered grid.
   - Interpolates the forecasts horizontally from their native grid to a standard AWIPS or user-defined grid (for information on AWIPS grids, see http://www.nco.ncep.noaa.gov/pmb/docs/on388/tableb.html).
   - Outputs the results in NWS and WMO standard GRIB1 format (for GRIB documentation, see http://www.nco.ncep.noaa.gov/pmb/docs/).

   Note: *Copygb only works with GRIB1 format; for GRIB2, use wgrib2. (for downloading the source code and information on compiling on your system, see http://www.cpc.ncep.noaa.gov/products/wesley/wgrib2/)*

In addition to ***unipost*** and ***copygb***, a utility called ***ndate*** is distributed with the UPP tarfile. This utility is used to format the dates of the forecasts to be posted for ingestion by the codes.

Setting up the WRF or NMMB model to interface with UPP

The ***unipost*** program is currently set up to read a large number of fields from the WRF and NMMB model history files. This configuration stems from NCEP's need to generate all of its required operational products. When using the netCDF or NEMS binary read, this program is configured such that it will run successfully even if an expected input field is missing from the WRF or NMMB history file as long as this field is not required to produce a requested output field. If the pre-requisites for a requested output field are missing from the WRF or NMMB history file, ***unipost*** will abort at run time.

Take care not to remove fields from the ***wrfout*** or ***nmmb*** files, which may be needed for diagnostic purposes by the UPP package. For example, if isobaric state fields are requested, but the pressure fields on model interfaces (PINT for WRF-NMM, P and PB for WRF-ARW) are not available in the history file, ***unipost*** will abort at run time. In general, the default fields available in the ***wrfout*** or ***nmmb*** files are sufficient to run UPP. The fields written to the WRF (NMMB) history file are controlled by the settings in the Registry (solver state) (for WRF: see ***Registry.EM, Registry.EM_COMMON)*** or

Registry.NMM(_NEST) files in the ***Registry*** subdirectory of the main ***WRFV3*** directory; for NMMB: see ***solver_state.txt***). ***Note:*** It is necessary to re-compile the WRF model source code after modifying the Registry file.

UPP is written to process a single forecast hour, therefore, having a single forecast per output file is optimal. However, for WRF based forecasts, UPP can be run across multiple forecast times in a single output file to extract a specified forecast hour.

UPP Control File Overview

a) GRIB1 control file

Note: This section pertains to outputting GRIB1 format only. This format is currently the preferred output format since GRIB2 (next section) is still in a development stage.

The user interacts with ***unipost*** through the control file, ***parm/wrf_cntrl.parm*** for WRF runs, or ***nmb_cntrl.parm*** for NMMB. Note that these two files are identical with the exception of the "DATSET" used for prefix of the output name. This was done in effort to maintain distinction between WRF and NMMB output.

The control file is composed of a header and a body. The header specifies the output file information. The body allows the user to select which fields and levels to process.

The header of the ***wrf_cntrl.parm*** (*nmb_cntrl.parm*) file contains the following variables:

- **KGTYPE**: defines output grid type, which should always be 255.
- **IMDLTY:** identifies the process ID for AWIPS.
- **DATSET**: defines the prefix used for the output file name. Currently set to "***WRFPRS***" *("NMBPRS").* Note: the run_* scripts assume "***WRFPRS***" is used for WRF runs and "***NMBPRS***" is used for NMMB runs.

The body of the ***wrf_cntrl.parm*** (*nmb_cntrl.parm*) file is composed of a series of line pairs similar to the following:

```
(PRESS ON MDL SFCS   ) SCAL=( 3.0)
L=(11000 00000 00000 00000 00000 00000 00000 00000 00000 00000 00000
00000 00000 00000)
```

where,

- The top line specifies the variable (e.g. PRESS) to process, the level type (e.g. ON MDL SFCS) a user is interested in, and the degree of accuracy to be retained (SCAL=3.0) in the GRIB output.
    - SCAL defines the precision of the data written out to the GRIB format. Positive values denote decimal scaling (maintain that number of significant

digits), while negative values describe binary scaling (precise to 2^{SCAL}; i.e., SCAL=-3.0 gives output precise to the nearest 1/8). Because ***copygb*** is unable to handle binary precision at this time, negative numbers are discouraged.

- A list of all possible output fields for ***unipost*** is provided in Table 1. This table provides the full name of the variable in the first column and an abbreviated name in the second column. The abbreviated names are used in the control file. Note that the variable names also contain the type of level on which they are output. For instance, temperature is available on "model surface" and "pressure surface".

- The second line specifies the levels on which the variable is to be posted. In this case, "0" indicates no output at this level and "1" indicates output the variable specified on the top line at the level specified by the position of the digit and the type of level defined for this variable. For flight/wind energy fields, a "2" may be specified, such that "2" requests AGL and "1" requests MSL.

Controlling which variables *unipost* outputs

To output a field, the body of the control file needs to contain an entry for the appropriate variable and output for this variable must be turned on for at least one level (see next section: "*Controlling which levels unipost outputs"*). If an entry for a particular field is not yet available in the control file, two lines may be added to the control file with the appropriate entries for that field.

Controlling which levels *unipost* outputs

The second line of each pair determines which levels ***unipost*** will output. Output on a given level is turned off by a "0" or turned on by a "1".

- For isobaric output, 47 levels are possible, from 2 to 1013 hPa (*2, 5, 7, 10, 20, 30, 50, 70 mb and then every 25 mb from 75 to 1000 mb*). The complete list of levels is specified in ***sorc/unipost/CTLBLK.f***.
  - Modify specification of variable LSMDEF to change the number of pressure levels: LSMDEF=47
  - Modify specification of SPLDEF array to change the values of pressure levels:

  (/200.,500.,700.,1000.,2000.,3000.
  &,5000.,7000.,7500.,10000.,12500.,15000.,17500.,20000., …/)
- For model-level output, all model levels are possible, from the highest to the lowest.
- When using the Noah LSM, the *soil layers* are 0-10 cm, 10-40 cm, 40-100 cm, and 100-200 cm.
- When using the RUC LSM, the *soil levels* are 0 cm, 5 cm, 20 cm, 40 cm, 160 cm, and 300 cm. For the RUC LSM it is also necessary to turn on two additional output levels in the ***wrf_cntrl.parm*** (*nmb_cntrl.parm*) to output 6 levels rather than the default 4 layers for the Noah LSM.

- When using Pliem-Xiu LSM, there are two layers: 0-1 cm, 1-100 cm
- For PBL layer averages, the levels correspond to 6 layers with a thickness of 30 hPa each.
- For flight level, the levels are 30 m, 50 m, 80 m, 100 m, 305 m, 457 m, 610 m, 914 m,1524 m,1829 m, 2134 m, 2743 m, 3658 m, 4572 m, and 6000 m.
- For AGL radar reflectivity, the levels are 4000 and 1000 m (see Appendix A for details).
- For surface or shelter-level output, only the first position of the line needs to be turned on.
    - For example, the sample control file ***parm/wrf_cntrl.parm*** has the following entry for surface dew point temperature:

      ```
      (SURFACE DEWPOINT    ) SCAL=( 4.0)
      L=(00000 00000 00000 00000 00000 00000 00000 00000 00000 00000
      00000 00000 00000 00000)
      ```

      Based on this entry, surface dew point temperature will not be output by ***unipost***. To add this field to the output, modify the entry to read:

      ```
      (SURFACE DEWPOINT    ) SCAL=( 4.0)
      L=(10000 00000 00000 00000 00000 00000 00000 00000 00000 00000
      00000 00000 00000 00000)
      ```

b) GRIB2 file

Note: This section describes the control file for outputting GRIB2 format. Disclaimer: This feature is still in preliminary stages and not fully tested; use with caution. Updates will be provided as they become available.

Version 3.0

- The xml file ***parm/postcntrl.xml*** replaces the ***wrf_cntrl.parm*** file to declare which fields you want to output from UPP. The samples in ***parm/wrfcnrtl.xml and parm/nmbcntrl.xml*** are not exhaustive at this time and is provided as a template only. Note that it will require edits by the user to expand beyond the basic testing setup.
- A list of available GRIB2 fields is in ***parm/post_avblflds.xml***. UPP uses this file to define certain field parameters. Users may look in this file to view a full list of available GRIB2 fields. Again, as new fields are added or modified they will be provided.
- To run grib2, copy a xml template to be named postcntrl.xml in the DOMAINPATH/parm/ directory as outlined below. Edit the xml file as needed.

Version 3.1

- For outputting GRIB2 format using version 3.1, a preprocessing step is required by the user to convert the xml file ***parm/postcntrl.xml*** to a flat text file ***postxconfig-NT.txt***. This new flat file is quicker to process than the old xml file. The user will still need to edit the postcntrl.xml file to declare which fields are to be output from UPP.
- In order to ensure that the user-edited xml files are error free, XML stylesheets (***parm/EMC_POST_CTRL_Schema.xsd*** and ***EMC_POST_Avblflds_Schema.xsd***) are used to validate both the ***postcntrl.xml*** and ***post_avblflds.xml*** files respectively. Confirmation of validation will be given (e.g. postcntrl.xml validates) or otherwise return errors if it does not match the schema. To run the validation:

  xmllint --noout --schema EMC_POST_CTRL_Schema.xsd <postcntrl.xml>

  xmllint --noout --schema EMC_POST_Avblflds_Schema.xsd <post_avblflds.xml>

- Once the xmls are validated, the user will need to generate the flat file. Edit the ***parm/makefile*** if necessary to point to the correct flat file directory and xmls. The makefile will call the perl program ***parm/POSTXMLPreprocessor.pl*** to generate the post flat file ***postxconfig-NT.txt***. Generate the flat file:

  make

  Note: The new flat file can only be used for running version 3.1 and is not backwards compatible with version 3.0.

Running UPP

Seven scripts for running the UPP package are included in the tar file:

run_unipost
run_unipostandgrads
run_unipostandgempak
run_unipost_frames
run_unipost_gracet
run_unipost_minute
run_unipostandgrads_global

<u>Before running any of the above listed scripts, perform the following instructions:</u>

1. ***cd*** to your ***DOMAINPATH*** directory.

2. Make a directory to put the UPP results.

   mkdir postprd

3. Make a directory to put a copy of ***wrf_cntrl.parm (nmb_cntrl.parm)*** file if running grib1 or ***postcntrl.xml*** for v3.0 (***postxconfig-NT.txt*** for v3.1) file if running grib2.

mkdir parm

4. Copy over the relevant control file to your working directory to customize ***unipost***.
For Grib1, copy the default ***UPPV3.0/parm/wrf_cntrl.parm*** (***nmb_cntrl.parm***) file
For Grib2, copy a template ***UPPV3.0/parm/wrfcntrl.xml (nmbcntrl.xml)*** file to be named ***postcntrl.xml*** if using v3.0 or ***UPPV3.1/parm/postxconfig-NT_WRF.txt (postxconfig-NT_NMB.txt)*** to be named ***postxconfig-NT.txt*** if using v3.1.

5. Edit the ***wrf_cntrl.parm*** (*nmb_cntrl.parm*) file to reflect the fields and levels you want ***unipost*** to output. (For Grib2: Edit the ***postcntrl.xml*** file for v3.0 or the ***postxconfig-NT.txt*** file for v3.1)

6. Copy over the (***UPPV3.0/scripts/run_unipost****) script of your choice to the ***postprd/***.

7. Edit the run script as outlined below.

Once these directories are set up and the edits outlined below are complete, the scripts can be run interactively from the ***postprd*** directory by simply typing the script name on the command line.

Overview of the scripts to run the UPP

Note: It is recommended that the user refer to the ***run_unipost**** scripts in the ***script/*** while reading this overview.

Since V3.0, user modified variables are now all contained at the top of the ***run_unipost**** script in one user-edit section, along with a brief description. Descriptions below follow the ***run_unipost*** script.

1. Set up basic path variables:
   TOP_DIR : Top level directory for source codes (*UPPV3.0* and *WRFV3)*
   DOMAINPATH : Working directory for this run
   WRFPATH : Location of compiled *WRFV3*
   UNIPOST_HOME : Location of the *UPPV3.0* build directory
   POSTEXEC : Location of the *UPPV3.0* executables
   ***modelDataPath* :** Location of the model output data files to be processed
   : e.g. "wrfprd/" for WRF-based runs; "nemsprd/" for NMMB forecasts.
   paramFile : Name and location of cntrl.parm (*wrf_cntrl.parm* or *nmb_cntrl.parm*) text file that lists desired fields for GRIB1 output. Template in *UPPV3.0/parm/*
   ***xmlCntrlFile* :** Name and location of *postcntrl.xml*.XML file that lists desired fields for GRIB2 output for version 3.0. Templates in

UPPV3.0/parm/wrfcntrl.xml or UPPV3.0/parm/nmbcntrl.xml
txtCntrlFile : Name and location of *postxconfig-NT.txt* file that lists desired fields for GRIB2 format for version 3.1. This file is generated by the user following the steps list above.

Note: The scripts are configured such that ***unipost*** expects the WRF history files (***wrfout**** files) to be in ***wrfprd/***, the ***wrf_cntrl.parm (postcntrl.xml*** or ***postxconfig-NT.txt)*** file to be in ***parm/*** and the postprocessor working directory to be called ***postprd/***, all under ***DOMAINPATH***. Similarly with NMMB, NMMB history files (***nmmb_hist*)*** are to be in ***nemsprd/***, ***nmb_cntrl.parm (postcntrl.xml*** or ***postxconfig-NT.txt)*** file to be in ***parm***, and the output to be in ***postprd***, all under ***DOMAINPATH.***

This set up is for user convenience to have a script ready to run, paths may be modified but be sure to check run script to make sure settings are correct.

2. Specify dynamic core being run ("NMM" or "ARW" or "NMB")
   dyncore : What model core is used ("NMM" or "ARW" or "NMB")

3. Specify the format for the input model files and output UPP files.
   inFormat : Format of the model data
   arw – "netcdf"
   nmm – "netcdf"
   nmb – "binarynemsio"
   outFormat : Format of output from UPP
   grib
   grib2 - NOTE: GRIB2 is not extensively tested, use with caution. No GRIB2 destaggering support for NMB or NMM grids; Suggested use with ARW only at this time.

4. Specify the forecast cycles to be post-processed
   startdate : Forecast start date (YYYYMMDDHH)
   fhr : First forecast hour to be post-processed
   lastfhr : Last forecast hour to be post-processed
   incrementhr : Increment (in hours) between forecast files
   * Do not set to 0 or the script will loop continuously *

5. Set up how many domains will be post-processed
   domain_list : List of domains for run (e.g. "d01 d02")

6. Set/uncomment the run command for your system. (i.e. serial, mpirun, etc).
   RUN_COMMAND : System run command for serial or parallel runs

   - The default execution command in the distributed scripts is for a single processor: ./***unipost.exe*** > unipost_${domain}.${fhr}.out ***2>&1***.
   - To run ***unipost*** using mpi (dmpar compilation), the command line should

be:
>> LINUX-MPI systems: ***mpirun -np N unipost.exe > outpost 2>&1***
(Note: on some systems a host file also needs to be specified: ***–machinefile*** "***host***")
>> IBM: ***mpirun.lsf unipost.exe < itag > outpost***

7. Set ***copygb*** grid definitions (mandatory for NMM or NMMB)
   copygb_opt : Copygb grid option to destagger and regrid NMM or NMB
   "lambert" = Grid spec for ***copygb*** generated internally for lambert data
   Reads ***copygb_gridnav.txt***
   "lat-lon" = Grid spec for ***copygb*** generated internally for lat-lon data
   Reads ***copygb_hwrf.txt***
   "awips" = Use a predefined awips grid, e.g. 212
   ** Uncomment "export awips_id= " and add desired grid number.
   "custom" = Specify your own grid
   ** Uncomment "export custom_gds= " and add grid description.

   Note: More information about ***copygb*** is provided below under ***"Examples of copygb". Copygb*** runs on GRIB1 format only. For GRIB2 format, ***wgrib2*** is required, with more information provided below under ***"Examples of wgrib2".***

8. Set naming convention for prefix and extension of output file name
   i. ***comsp*** is the initial string of the output file name (by default it is not set and the prefix of the output file will be the string set in ***wrf_cntrl.parm (nmb_cntrl.parm)*** **DATSET**, if set it will concatenate the setting to the front of the string specified in ***wrf_cntrl.parm (nmb_cntrl.parm)*** **DATSET**)
   ii. ***tmmark*** is used for the file extension (in ***run_unipost***, *tmmark=tm00*, if not set, it is set to *.GrbF*)

Since V3.0, the ***itag*** that will be read in by ***unipost.exe*** from stdin (unit 5) is generated automatically in the ***run_unipost*** script based on the user-defined options above. It should not be necessary to edit this. For description purposes, the namelist (***itag)*** contains 5 lines:

i. Name of the WRF or NMB output file to be posted.
ii. Format of WRF or NMB model output (netcdf, binarynemsio).
iii. Format of UPP output (GRIB1 or GRIB2)
iv. Forecast valid time (not model start time) in WRF or NMB format (the forecast time desired to be post-processed).
v. Dynamic core used (NMM or NCAR).

Note: With the addition of GRIB2 output capabilities, a fifth line has been added to the namelist. If the third line (i.e., UPP output type) is not set, UPP will default the output file format to "grib1".

If scripts ***run_unipostandgrads*** or ***run_unipostandgempak*** are used, additional steps are taken to create image files (see **Visualization** section below).

Upon a successful run, ***unipost*** and ***copygb*** will generate output files ***WRFPRS_d**nn.hh* (***NMBPRS_d**nn.hh*)and ***wrfprs_d**nn.hh **(nmbprs_d**nn.hh)*, respectively, in the post-processor working directory, where "*nn"* refers to the domain id and "*hh"* denotes the forecast hour. In addition, the script ***run_unipostandgrads*** will produce a suite of png images named ***variablehh_GrADS.png***, and the script ***run_unipostandgempak*** will produce a suite of gif images named ***variablehh.gif***.

If the run did not complete successfully, a log file in the post-processor working directory called ***unipost_dnn.hh.out***, where "*nn"* is the domain id and "*hh"* is the forecast hour, may be consulted for further information.

Examples of copygb

Sample command line for calling ***copygb***:
copygb.exe –xg"grid [kgds]" input_file output_file
where ***grid*** refers to the output grid to which the native forecast is being interpolated.

The output grid can be specified in three ways:

i. As the grid id of a pre-defined AWIPS grid number (*gridno*):

copygb.exe -g${gridno} -x input_file output_file

For example, using grid 218:
copygb.exe -xg"218" WRFPRS_$domain.${fhr} wrfprs_$domain .${fhr}

ii. As a user defined standard grid, such as for grid 255:

copygb.exe –xg"255 kgds" input_file output_file

where the user defined grid is specified by a full set of kgds parameters determining a GRIB GDS (grid description section) in the ***W3fi63*** format. Details on how to specify the kgds parameters are documented in file ***lib/w3lib/w3fi71.f***. For example:

copygb.exe -xg" 255 3 109 91 37719 -77645 8 -71000 10433 9966 0 64 42000 42000" WRFPRS_$domain.${fhr} wrfprs_$domain.${fhr}

iii. From a file: When WRF-NMM output is processed by ***unipost***, two text files, ***copygb_gridnav.txt*** and ***copygb_hwrf.txt***, are created. These files contain the GRID GDS of a Lambert Conformal Grid (file ***copygb_gridnav.txt***) or lat/lon grid (***copygb_hwrf.txt***) similar in domain and grid spacing to the one used to run the WRF-NMM model. The contents of one of these files are read into variable ***nav*** and can be used as input to

copygb.exe.

copygb.exe -xg"$nav" input_file output_file

For example, when using "***copygb_gridnav.txt***" for an application, the steps include:

read nav < 'copygb_gridnav.txt'
export nav
copygb.exe -xg"${nav}" WRFPRS_$domain.${fhr}
wrfprs_$domain.${fhr}

It should be noted that ***copygb*** is a flexible program that can accept several command line options specifying details of how the horizontal interpolation from the native grid to the output grid should be performed. Complete documentation of ***copygb*** can be found at: http://www.dtcenter.org/met/users/support/online_tutorial/METv5.0/copygb/copygb.txt

Examples of wgrib2

Wgrib2 is a versatile program that has the ability to convert grib2 files from one grid to another for various user-defined grids as well as pre-defined NCEP grids. Complete documentation with examples of re-gridding can be found at: http://www.cpc.ncep.noaa.gov/products/wesley/wgrib2/new_grid.html.

Sample command line usage for calling wgrib2:

wgrib2 –new_grid_winds W –new_grid A B C outfile

W = earth or grid
earth: winds oriented to the earth's north and south directions
grid: winds are rotated so that north is relative to the grid
A, ***B***, and ***C*** represent the output grid description

Sample lat-lon grid description:

A = latlon
B = lon0:nlon:dlon
lon0 is longitude of first grid point in degrees
nlon is number of longitudes
dlon is grid resolution in degrees of longitude
C = lat0:nlat:dlat
lat0 is latitude of first grid point
nlat is number of latitudes
dlat is grid resolution in degrees of latitude

Note: At this time, wgrib2 is not distributed within the UPP tar file. Users may download and install from *http://www.cpc.ncep.noaa.gov/products/wesley/wgrib2/*.

Visualization with UPP

GEMPAK

The GEMPAK utility ***nagrib*** is able to decode GRIB files whose navigation is on any non-staggered grid. Hence, GEMPAK is able to decode GRIB files generated by the UPP package and plot horizontal fields or vertical cross sections.

A sample script named ***run_unipostandgempak***, which is included in the ***scripts*** directory of the tar file, can be used to run ***unipost***, ***copygb***, and plot the following fields using GEMPAK:

- ***Sfcmap_dnn_hh.gif:*** mean SLP and 6 hourly precipitation
- ***PrecipType_dnn_hh.gif:*** precipitation type (just snow and rain)
- ***850mbRH_dnn_hh.gif:*** 850 mb relative humidity
- ***850mbTempandWind_dnn_hh.gif:*** 850 mb temperature and wind vectors
- ***500mbHandVort_dnn_hh.gif:*** 500 mb geopotential height and vorticity
- ***250mbWindandH_dnn_hh.gif:*** 250 mb wind speed isotacs and geopotential height

This script can be modified to customize fields for output. GEMPAK has an online users guide at
http://www.unidata.ucar.edu/software/gempak/help_and_documentation/manual/.

In order to use the script ***run_unipostandgempak***, it is necessary to set the environment variable ***GEMEXEC*** to the path of the GEMPAK executables. For example,

setenv GEMEXEC /usr/local/gempak/bin

Note: For GEMPAK, the precipitation accumulation period for WRF-NMM is given by the variable ***incrementhr*** in the ***run_unipostandgempak*** script.

GrADS

The GrADS utilities ***grib2ctl.pl (g2ctl.pl)*** and ***gribmap*** are able to decode GRIB1 (GRIB2) files whose navigation is on any non-staggered grid. These utilities and instructions on how to use them to generate GrADS control files are available from:
http://www.cpc.ncep.noaa.gov/products/wesley/grib2ctl.html for GRIB1 and
http://www.cpc.ncep.noaa.gov/products/wesley/g2ctl.html for GRIB2.

The GrADS package is available from: http://cola.gmu.edu/grads/gadoc/gadoc.php.

GrADS has an online User's Guide at: http://cola.gmu.edu/grads/gadoc/users.html and a list of basic commands for GrADS can be found at: http://cola.gmu.edu/grads/gadoc/reference_card.pdf.

A sample script named ***run_unipostandgrads***, which is included in the ***scripts*** directory of the Unified Post Processing package, can be used to run ***unipost***, ***copygb***, and plot the following fields using GrADS:

- ***Sfcmaphh_dnn_GRADS.png***: mean SLP and 6-hour accumulated precipitation.
- ***850mbRHhh_dnn_GRADS.png***: 850 mb relative humidity
- ***850mbTempandWindhh_dnn_GRADS.png***: 850 mb temperature and wind vectors
- ***500mbHandVorthh_dnn_GRADS.png***: 500 mb geopotential heights and absolute vorticity
- ***250mbWindandHhh_dnn_GRADS.png***: 250 mb wind speed isotacs and geopotential heights

In order to use the script ***run_unipostandgrads***, it is necessary to:

1. Set the environmental variable ***GADDIR*** to the path of the GrADS fonts and auxiliary files. For example,

   setenv GADDIR /usr/local/grads/data

2. Add the location of the GrADS executables to the ***PATH***. For example

   setenv PATH /usr/local/grads/bin:$PATH

3. Link script ***cbar.gs*** to the post-processor working directory. (This scripts is provided in UPP package, and the ***run_unipostandgrads*** script makes a link from ***scripts/*** to ***postprd/***.) To generate the plots above, GrADS script ***cbar.gs*** is invoked. This script can also be obtained from the GrADS library of scripts at http://cola.gmu.edu/grads/gadoc/library.html.

Note: For GrADS, the precipitation accumulation period for WRF-NMM is plotted over the subintervals of the ***tprec*** hour (set in ***namelist.input***).

Fields produced by *unipost*

Table 1 lists basic and derived fields that are currently produced by ***unipost***. The abbreviated names listed in the second column describe how the fields should be entered in the control file (***wrf_cntrl.parm***).

Table 1: *Fields produced by* ***unipost*** *(column 1), abbreviated names used in the* ***wrf_cntrl.parm (nmb_cntrl.parm)*** *file (column 2), corresponding GRIB identification number for the field (column 3), and corresponding GRIB identification number for the*

vertical coordinate (column 4).

Field Name	**Name In Control File**	**Grib ID**	**Vertic al Level**
Radar reflectivity on model surface*	RADAR REFL MDL SFCS	211	109
Pressure on model surface	PRESS ON MDL SFCS	1	109
Height on model surface	HEIGHT ON MDL SFCS	7	109
Temperature on model surface	TEMP ON MDL SFCS	11	109
Potential temperature on model surface	POT TEMP ON MDL SFCS	13	109
Dew point temperature on model surface	DWPT TEMP ON MDL SFC	17	109
Specific humidity on model surface	SPEC HUM ON MDL SFCS	51	109
Relative humidity on model surface	REL HUM ON MDL SFCS	52	109
Moisture convergence on model surface	MST CNVG ON MDL SFCS	135	109
U component wind on model surface	U WIND ON MDL SFCS	33	109
V component wind on model surface	V WIND ON MDL SFCS	34	109
Cloud water on model surface	CLD WTR ON MDL SFCS	153	109
Cloud ice on model surface	CLD ICE ON MDL SFCS	58	109
Rain on model surface	RAIN ON MDL SFCS	170	109
Snow on model surface	SNOW ON MDL SFCS	171	109
Cloud fraction on model surface	CLD FRAC ON MDL SFCS	71	109
Omega on model surface	OMEGA ON MDL SFCS	39	109
Absolute vorticity on model surface	ABS VORT ON MDL SFCS	41	109
Geostrophic streamfunction on model surface	STRMFUNC ON MDL SFCS	35	109
Turbulent kinetic energy on model surface	TRBLNT KE ON MDL SFC	158	109
Richardson number on model surface	RCHDSN NO ON MDL SFC	254	109
Master length scale on model surface	MASTER LENGTH SCALE	226	109
Asymptotic length scale on model surface	ASYMPT MSTR LEN SCL	227	109
Radar reflectivity on pressure surface*	RADAR REFL ON P SFCS	211	100
Height on pressure surface	HEIGHT OF PRESS SFCS	7	100

Temperature on pressure surface	TEMP ON PRESS SFCS	11	100
Potential temperature on pressure surface	POT TEMP ON P SFCS	13	100
Dew point temperature on pressure surface	DWPT TEMP ON P SFCS	17	100
Specific humidity on pressure surface	SPEC HUM ON P SFCS	51	100
Relative humidity on pressure surface	REL HUMID ON P SFCS	52	100
Moisture convergence on pressure surface	MST CNVG ON P SFCS	135	100
U component wind on pressure surface	U WIND ON PRESS SFCS	33	100
V component wind on pressure surface	V WIND ON PRESS SFCS	34	100
Omega on pressure surface	OMEGA ON PRESS SFCS	39	100
Absolute vorticity on pressure surface	ABS VORT ON P SFCS	41	100
Geostrophic streamfunction on pressure surface	STRMFUNC ON P SFCS	35	100
Turbulent kinetic energy on pressure surface	TRBLNT KE ON P SFCS	158	100
Cloud water on pressure surface	CLOUD WATR ON P SFCS	153	100
Cloud ice on pressure surface	CLOUD ICE ON P SFCS	58	100
Rain on pressure surface	RAIN ON P SFCS	170	100
Snow water on pressure surface	SNOW ON P SFCS	171	100
Total condensate on pressure surface	CONDENSATE ON P SFCS	135	100
Mesinger (Membrane) sea level pressure	MESINGER MEAN SLP	130	102
Shuell sea level pressure	SHUELL MEAN SLP	2	102
2 M pressure	SHELTER PRESSURE	1	105
2 M temperature	SHELTER TEMPERATURE	11	105
2 M specific humidity	SHELTER SPEC HUMID	51	105
2 M mixing ratio	SHELTER MIX RATIO	53	105
2 M dew point temperature	SHELTER DEWPOINT	17	105
2 M RH	SHELTER REL HUMID	52	105
10 M u component wind	U WIND AT ANEMOM HT	33	105
10 M v component wind	V WIND AT ANEMOM HT	34	105
10 M potential temperature	POT TEMP AT 10 M	13	105
10 M specific humidity	SPEC HUM AT 10 M	51	105
Surface pressure	SURFACE PRESSURE	1	1
Terrain height	SURFACE HEIGHT	7	1
Skin potential temperature	SURFACE POT TEMP	13	1
Skin specific humidity	SURFACE SPEC HUMID	51	1

Skin dew point temperature	SURFACE DEWPOINT	17	1
Skin Relative humidity	SURFACE REL HUMID	52	1
Skin temperature	SFC (SKIN) TEMPRATUR	11	1
Soil temperature at the bottom of soil layers	BOTTOM SOIL TEMP	85	111
Soil temperature in between each of soil layers	SOIL TEMPERATURE	85	112
Soil moisture in between each of soil layers	SOIL MOISTURE	144	112
Snow water equivalent	SNOW WATER EQUIVALNT	65	1
Snow cover in percentage	PERCENT SNOW COVER	238	1
Heat exchange coeff at surface	SFC EXCHANGE COEF	208	1
Vegetation cover	GREEN VEG COVER	87	1
Soil moisture availability	SOIL MOISTURE AVAIL	207	112
Ground heat flux - instantaneous	INST GROUND HEAT FLX	155	1
Lifted index—surface based	LIFTED INDEX—SURFCE	131	101
Lifted index—best	LIFTED INDEX—BEST	132	116
Lifted index—from boundary layer	LIFTED INDEX—BNDLYR	24	116
CAPE (4 types) ***	CNVCT AVBL POT ENRGY (Levels 1-4)	157	1
CIN (4 types) ***	CNVCT INHIBITION (Levels 1-4)	156	1
Column integrated precipitable water	PRECIPITABLE WATER	54	200
Column integrated cloud water	TOTAL COLUMN CLD WTR	136	200
Column integrated cloud ice	TOTAL COLUMN CLD ICE	137	200
Column integrated rain	TOTAL COLUMN RAIN	138	200
Column integrated snow	TOTAL COLUMN SNOW	139	200
Column integrated total condensate	TOTAL COL CONDENSATE	140	200
Helicity	STORM REL HELICITY	190	106
U component storm motion	U COMP STORM MOTION	196	106
V component storm motion	V COMP STORM MOTION	197	106
Accumulated total precipitation	ACM TOTAL PRECIP	61	1
Accumulated convective precipitation	ACM CONVCTIVE PRECIP	63	1
Accumulated grid-scale precipitation	ACM GRD SCALE PRECIP	62	1
Accumulated snowfall	ACM SNOWFALL	65	1
Accumulated large scale snow	ACM GRD SCALE SW ICE	79	1
Accumulated total snow melt	ACM SNOW TOTAL MELT	99	1
Precipitation type (4 types) – instantaneous	INSTANT PRECIP TYPE	140	1
Precipitation rate - instantaneous	INSTANT PRECIP RATE	59	1

Composite radar reflectivity*	COMPOSITE RADAR REFL	212	200
Low level cloud fraction	LOW CLOUD FRACTION	73	214
Mid level cloud fraction	MID CLOUD FRACTION	74	224
High level cloud fraction	HIGH CLOUD FRACTION	75	234
Total cloud fraction	TOTAL CLD FRACTION	71	200
Time-averaged total cloud fraction	AVG TOTAL CLD FRAC	71	200
Time-averaged stratospheric cloud fraction	AVG STRAT CLD FRAC	213	200
Time-averaged convective cloud fraction	AVG CNVCT CLD FRAC	72	200
Cloud bottom pressure	CLOUD BOT PRESSURE	1	2
Cloud top pressure	CLOUD TOP PRESSURE	1	3
Cloud bottom height (above MSL)	CLOUD BOTTOM HEIGHT	7	2
Cloud top height (above MSL)	CLOUD TOP HEIGHT	7	3
Convective cloud bottom pressure	CONV CLOUD BOT PRESS	1	242
Convective cloud top pressure	CONV CLOUD TOP PRESS	1	243
Shallow convective cloud bottom pressure	SHAL CU CLD BOT PRES	1	248
Shallow convective cloud top pressure	SHAL CU CLD TOP PRES	1	249
Deep convective cloud bottom pressure	DEEP CU CLD BOT PRES	1	251
Deep convective cloud top pressure	DEEP CU CLD TOP PRES	1	252
Grid scale cloud bottom pressure	GRID CLOUD BOT PRESS	1	206
Grid scale cloud top pressure	GRID CLOUD TOP PRESS	1	207
Convective cloud fraction	CONV CLOUD FRACTION	72	200
Convective cloud efficiency	CU CLOUD EFFICIENCY	134	200
Above-ground height of LCL	LCL AGL HEIGHT	7	5
Pressure of LCL	LCL PRESSURE	1	5
Cloud top temperature	CLOUD TOP TEMPS	11	3
Temperature tendency from radiative fluxes	RADFLX CNVG TMP TNDY	216	109
Temperature tendency from shortwave radiative flux	SW RAD TEMP TNDY	250	109
Temperature tendency from longwave radiative flux	LW RAD TEMP TNDY	251	109
Outgoing surface shortwave radiation - instantaneous	INSTN OUT SFC SW RAD	211	1
Outgoing surface longwave radiation - instantaneous	INSTN OUT SFC LW RAD	212	1
Incoming surface shortwave	AVE INCMG SFC SW RAD	204	1

radiation - time-averaged			
Incoming surface longwave radiation - time-averaged	AVE INCMG SFC LW RAD	205	1
Outgoing surface shortwave radiation - time-averaged	AVE OUTGO SFC SW RAD	211	1
Outgoing surface longwave radiation - time-averaged	AVE OUTGO SFC LW RAD	212	1
Outgoing model top shortwave radiation - time-averaged	AVE OUTGO TOA SW RAD	211	8
Outgoing model top longwave radiation - time-averaged	AVE OUTGO TOA LW RAD	212	8
Incoming surface shortwave radiation - instantaneous	INSTN INC SFC SW RAD	204	1
Incoming surface longwave radiation - instantaneous	INSTN INC SFC LW RAD	205	1
Roughness length	ROUGHNESS LENGTH	83	1
Friction velocity	FRICTION VELOCITY	253	1
Surface drag coefficient	SFC DRAG COEFFICIENT	252	1
Surface u wind stress	SFC U WIND STRESS	124	1
Surface v wind stress	SFC V WIND STRESS	125	1
Surface sensible heat flux - time-averaged	AVE SFC SENHEAT FX	122	1
Ground heat flux - time-averaged	AVE GROUND HEAT FX	155	1
Surface latent heat flux - time-averaged	AVE SFC LATHEAT FX	121	1
Surface momentum flux - time-averaged	AVE SFC MOMENTUM FX	172	1
Accumulated surface evaporation	ACC SFC EVAPORATION	57	1
Surface sensible heat flux – instantaneous	INST SFC SENHEAT FX	122	1
Surface latent heat flux - instantaneous	INST SFC LATHEAT FX	121	1
Latitude	LATITUDE	176	1
Longitude	LONGITUDE	177	1
Land sea mask (land=1, sea=0)	LAND/SEA MASK	81	1
Sea ice mask	SEA ICE MASK	91	1
Surface midday albedo	SFC MIDDAY ALBEDO	84	1
Sea surface temperature	SEA SFC TEMPERATURE	80	1
Press at tropopause	PRESS AT TROPOPAUSE	1	7
Temperature at tropopause	TEMP AT TROPOPAUSE	11	7
Potential temperature at tropopause	POTENTL TEMP AT TROP	13	7
U wind at tropopause	U WIND AT TROPOPAUSE	33	7
V wind at tropopause	V WIND AT TROPOPAUSE	34	7
Wind shear at tropopause	SHEAR AT TROPOPAUSE	136	7

Height at tropopause	HEIGHT AT TROPOPAUSE	7	7
Temperature at flight levels	TEMP AT FD HEIGHTS	11	103
U wind at flight levels	U WIND AT FD HEIGHTS	33	103
V wind at flight levels	V WIND AT FD HEIGHTS	34	103
Freezing level height (above mean sea level)	HEIGHT OF FRZ LVL	7	4
Freezing level RH	REL HUMID AT FRZ LVL	52	4
Highest freezing level height	HIGHEST FREEZE LVL	7	204
Pressure in boundary layer (30 mb mean)	PRESS IN BNDRY LYR	1	116
Temperature in boundary layer (30 mb mean)	TEMP IN BNDRY LYR	11	116
Potential temperature in boundary layers (30 mb mean)	POT TMP IN BNDRY LYR	13	116
Dew point temperature in boundary layer (30 mb mean)	DWPT IN BNDRY LYR	17	116
Specific humidity in boundary layer (30 mb mean)	SPC HUM IN BNDRY LYR	51	116
RH in boundary layer (30 mb mean)	REL HUM IN BNDRY LYR	52	116
Moisture convergence in boundary layer (30 mb mean)	MST CNV IN BNDRY LYR	135	116
Precipitable water in boundary layer (30 mb mean)	P WATER IN BNDRY LYR	54	116
U wind in boundary layer (30 mb mean)	U WIND IN BNDRY LYR	33	116
V wind in boundary layer (30 mb mean)	V WIND IN BNDRY LYR	34	116
Omega in boundary layer (30 mb mean)	OMEGA IN BNDRY LYR	39	116
Visibility	VISIBILITY	20	1
Vegetation type	VEGETATION TYPE	225	1
Soil type	SOIL TYPE	224	1
Canopy conductance	CANOPY CONDUCTANCE	181	1
PBL height	PBL HEIGHT	221	1
Slope type	SLOPE TYPE	222	1
Snow depth	SNOW DEPTH	66	1
Liquid soil moisture	LIQUID SOIL MOISTURE	160	112
Snow free albedo	SNOW FREE ALBEDO	170	1
Maximum snow albedo	MAXIMUM SNOW ALBEDO	159	1
Canopy water evaporation	CANOPY WATER EVAP	200	1
Direct soil evaporation	DIRECT SOIL EVAP	199	1
Plant transpiration	PLANT TRANSPIRATION	210	1
Snow sublimation	SNOW SUBLIMATION	198	1

Air dry soil moisture	AIR DRY SOIL MOIST	231	1
Soil moist porosity	SOIL MOIST POROSITY	240	1
Minimum stomatal resistance	MIN STOMATAL RESIST	203	1
Number of root layers	NO OF ROOT LAYERS	171	1
Soil moist wilting point	SOIL MOIST WILT PT	219	1
Soil moist reference	SOIL MOIST REFERENCE	230	1
Canopy conductance - solar component	CANOPY COND SOLAR	246	1
Canopy conductance - temperature component	CANOPY COND TEMP	247	1
Canopy conductance - humidity component	CANOPY COND HUMID	248	1
Canopy conductance - soil component	CANOPY COND SOILM	249	1
Potential evaporation	POTENTIAL EVAP	145	1
Heat diffusivity on sigma surface	DIFFUSION H RATE S S	182	107
Surface wind gust	SFC WIND GUST	180	1
Convective precipitation rate	CONV PRECIP RATE	214	1
Radar reflectivity at certain above ground heights*	RADAR REFL AGL	211	105
MAPS Sea Level Pressure	MAPS SLP	2	102
Total soil moisture	TOTAL SOIL MOISTURE	86	112
Plant canopy surface water	PLANT CANOPY SFC WTR	223	1
Accumulated storm surface runoff	ACM STORM SFC RNOFF	235	1
Accumulated baseflow runoff	ACM BSFL-GDWR RNOFF	234	1
Fraction of frozen precipitation	FROZEN FRAC CLD SCHM	194	1
GSD Cloud Base pressure	GSD CLD BOT PRESSURE	1	2
GSD Cloud Top pressure	GSD CLD TOP PRESSURE	1	3
Averaged temperature tendency from grid scale latent heat release	AVE GRDSCL RN TMPTDY	241	109
Averaged temperature tendency from convective latent heat release	AVE CNVCT RN TMPTDY	242	109
Average snow phase change heat flux	AVE SNO PHSCNG HT FX	229	1
Accumulated potential evaporation	ACC POT EVAPORATION	228	1
Highest freezing level relative humidity	HIGHEST FRZ LVL RH	52	204
Maximum wind pressure level	MAX WIND PRESS LEVEL	1	6
Maximum wind height	MAX WIND HGHT LEVEL	7	6
U-component of maximum wind	U COMP MAX WIND	33	6
V-component of maximum wind	V COMP MAX WIND	34	6
GSD cloud base height	GSD CLD BOT HEIGHT	7	2
GSD cloud top height	GSD CLD TOP HEIGHT	7	3

GSD visibility	GSD VISIBILITY	20	1
Wind energy potential	INSTN WIND POWER AGL	126	105
U wind at 80 m above ground	U WIND AT 80M AGL	49	105
V wind at 80 m above ground	V WIND AT 80M AGL	50	105
Graupel on model surface	GRAUPEL ON MDL SFCS	179	109
Graupel on pressure surface	GRAUPEL ON P SFCS	179	100
Maximum updraft helicity	MAX UPDRAFT HELICITY	236	106
Maximum 1km reflectivity	MAX 1km REFLECTIVITY	235	105
Maximum wind speed at 10m	MAX 10m WIND SPEED	229	105
Maximum updraft vertical velocity	MAX UPDRAFT VERT VEL	237	101
Maximum downdraft vertical velocity	MAX DNDRAFT VERT VEL	238	101
Mean vertical velocity	MEAN VERT VEL	40	108
Radar echo top in KDT	ECHO TOPS IN KFT	7	105
Updraft helicity	UPDRAFT HELICITY PRM	227	106
Column integrated graupel	VERT INTEG GRAUP	179	200
Column integrated maximum graupel	MAX VERT INTEG GRAUP	228	200
U-component of 0-1km level wind shear	U COMP 0-1 KM SHEAR	230	106
V-component of 0-1km level wind shear	V COMP 0-1 KM SHEAR	238	106
U-component of 0-6km level wind shear	U COMP 0-6 KM SHEAR	239	106
V-component of 0-6km level wind shear	V COMP 0-6 KM SHEAR	241	106
Total precipitation accumulated over user-specified bucket	BUCKET TOTAL PRECIP	61	1
Convective precipitation accumulated over user-specified bucket	BUCKET CONV PRECIP	63	1
Grid-scale precipitation accumulated over user-specified bucket	BUCKET GRDSCALE PRCP	62	1
Snow accumulated over user-specified bucket	BUCKET SNOW PRECIP	65	1
Model level fraction of rain for Ferrier's scheme	F_rain ON MDL SFCS	131	109
Model level fraction of ice for Ferrier's scheme	F_ice ON MDL SFCS	132	109
Model level riming factor for Ferrier's scheme	F_RimeF ON MDL SFCS	133	109
Model level total condensate for Ferrier's scheme	CONDENSATE MDL SFCS	135	109

Height of sigma surface	HEIGHT OF SIGMA SFCS	7	107
Temperature on sigma surface	TEMP ON SIGMA SFCS	11	107
Specific humidity on sigma surface	SPEC HUM ON S SFCS	51	107
U-wind on sigma surface	U WIND ON SIGMA SFCS	33	107
V-wind on sigma surface	V WIND ON SIGMA SFCS	34	107
Omega on sigma surface	OMEGA ON SIGMA SFCS	39	107
Cloud water on sigma surface	CLOUD WATR ON S SFCS	153	107
Cloud ice on sigma surface	CLOUD ICE ON S SFCS	58	107
Rain on sigma surface	RAIN ON S SFCS	170	107
Snow on sigma surface	SNOW ON S SFCS	171	107
Condensate on sigma surface	CONDENSATE ON S SFCS	135	107
Pressure on sigma surface	PRESS ON SIG SFCS	1	107
Turbulent kinetic energy on sigma surface	TRBLNT KE ON S SFCS	158	107
Cloud fraction on sigma surface	CLD FRAC ON SIG SFCS	71	107
Graupel on sigma surface	GRAUPEL ON S SFCS	179	107
LCL level pressure	LIFT PCL LVL PRESS	141	116
LOWEST WET BULB ZERO HEIGHT	LOW WET BULB ZERO HT	7	245
Leaf area index	LEAF AREA INDEX	182	1
Accumulated land surface model precipitation	ACM LSM PRECIP	154	1
In-flight icing	IN-FLIGHT ICING	186	100
Clear air turbulence	CLEAR AIR TURBULENCE	185	100
Wind shear between shelter level and 2000 FT	0-2000FT LLWS	136	106
Ceiling	CEILING	7	215
Flight restriction	FLIGHT RESTRICTION	20	2
Instantaneous clear sky incoming surface shortwave	INSTN CLR INC SFC SW	161	1
Pressure level riming factor for Ferrier's scheme	F_RimeF ON P SFCS	133	100
Model level vertical velocity	W WIND ON MDL SFCS	40	109
Brightness temperature	BRIGHTNESS TEMP	213	8
Average albedo	AVE ALBEDO	84	1
Ozone on model surface	OZONE ON MDL SFCS	154	109
Ozone on pressure surface	OZONE ON P SFCS	154	100
Surface zonal momentum flux	SFC ZONAL MOMEN FX	124	1
Surface meridional momentum flux	SFC MERID MOMEN FX	125	1
Average precipitation rate	AVE PRECIP RATE	59	1
Average convective precipitation rate	AVE CONV PRECIP RATE	214	1
Instantaneous outgoing longwave	INSTN OUT TOA LW RAD	212	8

at top of atmosphere			
Total spectrum brightness temperature	BRIGHTNESS TEMP NCAR	118	8
Model top pressure	MODEL TOP PRESSURE	1	8
Composite rain radar reflectivity	COMPOSITE RAIN REFL	165	200
Composite ice radar reflectivity	COMPOSITE ICE REFL	166	200
Composite radar reflectivity from convection	COMPOSITE CONV REFL	167	200
Rain radar reflecting angle	RAIN RADAR REFL AGL	165	105
Ice radar reflecting angle	ICE RADAR REFL AGL	166	105
Convection radar reflecting angle	CONV RADAR REFL AGL	167	105
Model level vertical velocity	W WIND ON P SFCS	40	100
Column integrated super cool liquid water	TOTAL COLD LIQUID	168	200
Column integrated melting ice	TOTAL MELTING ICE	169	200
Height of lowest level super cool liquid water	COLD LIQ BOT HEIGHT	7	253
Height of highest level super cool liquid water	COLD LIQ TOP HEIGHT	7	254
Richardson number planetary boundary layer height	RICH NO PBL HEIGHT	7	220
Total column shortwave temperature tendency	TOT COL SW T TNDY	250	200
Total column longwave temperature tendency	TOT COL LW T TNDY	251	200
Total column gridded temperature tendency	TOT COL GRD T TNDY	241	200
Total column convective temperature tendency	TOT COL CNVCT T TNDY	242	200
Radiative flux temperature tendency on pressure level	RADFLX TMP TNDY ON P	216	100
Column integrated moisture convergence	TOT COL MST CNVG	135	200
Time averaged clear sky incoming UV-B shortwave	AVE CLR INC UV-B SW	201	1
Time averaged incoming UV-B shortwave	AVE INC UV-B SW	200	1
Total column ozone	TOT COL OZONE	10	200
Average low cloud fraction	AVE LOW CLOUD FRAC	71	214
Average mid cloud fraction	AVE MID CLOUD FRAC	71	224
Average high cloud fraction	AVE HIGH CLOUD FRAC	71	234
Average low cloud bottom pressure	AVE LOW CLOUD BOT P	1	212
Average low cloud top pressure	AVE LOW CLOUD TOP P	1	213
Average low cloud top	AVE LOW CLOUD TOP T	11	213

temperature			
Average mid cloud bottom pressure	AVE MID CLOUD BOT P	1	222
Average mid cloud top pressure	AVE MID CLOUD TOP P	1	223
Average mid cloud top temperature	AVE MID CLOUD TOP T	11	223
Average high cloud bottom pressure	AVE HIGH CLOUD BOT P	1	232
Average high cloud top pressure	AVE HIGH CLOUD TOP P	1	233
Average high cloud top temperature	AVE HIGH CLOUD TOP T	11	233
Total column relative humidity	TOT COL REL HUM	52	200
Cloud work function	CLOUD WORK FUNCTION	146	200
Temperature at maximum wind level	MAX WIND TEMPERATURE	11	6
Time averaged zonal gravity wave stress	AVE Z GRAVITY STRESS	147	1
Time averaged meridional gravity wave stress	AVE M GRAVITY STRESS	148	1
Average precipitation type	AVE PRECIP TYPE	140	1
Simulated GOES 12 channel 2 brightness temperature	GOES TB – CH 2	213	8
Simulated GOES 12 channel 3 brightness temperature	GOES TB – CH 3	214	8
Simulated GOES 12 channel 4 brightness temperature	GOES TB – CH4	215	8
Simulated GOES 12 channel 5 brightness temperature	GOES TB – CH5	216	8
Cloud fraction on pressure surface	CLD FRAC ON P SFCS	71	100
U-wind on theta surface	U WIND ON THETA SFCS	33	113
V-wind on theta surface	V WIND ON THETA SFCS	34	113
Temperature on theta surface	TEMP ON THETA SFCS	11	113
Potential vorticity on theta surface	PV ON THETA SFCS	4	113
Montgomery streamfunction on theta surface	M STRMFUNC ON THETA	37	113
	S STAB ON THETA SFCS	19	113
Relative humidity on theta surface	RH ON THETA SFCS	52	113
U wind on constant PV surface	U WIND ON PV SFCS	33	117
V wind on constant PV surface	V WIND ON PV SFCS	34	117
Temperature on constant PV surface	TEMP ON PV SFCS	11	117
Height on constant PV surface	HEIGHT ON PV SFCS	7	117
Pressure on constant PV surface	PRESSURE ON PV SFCS	1	117
Wind shear on constant PV surface	SHEAR ON PV SFCS	136	117

Planetary boundary layer cloud fraction	PBL CLD FRACTION	71	211
Average water runoff	AVE WATER RUNOFF	90	1
Planetary boundary layer regime	PBL REGIME	220	1
Maximum 2m temperature	MAX SHELTER TEMP	15	105
Minimum 2m temperature	MIN SHELTER TEMP	16	105
Maximum 2m RH	MAX SHELTER RH	218	105
Minimum 2m RH	MIN SHELTER RH	217	105
Ice thickness	ICE THICKNESS	92	1
Shortwave tendency on pressure surface	SW TNDY ON P SFCS	250	100
Longwave tendency on pressure surface	LW TNDY ON P SFCS	251	100
Deep convective tendency on pressure surface	D CNVCT TNDY ON P SF	242	100
Shallow convective tendency on pressure surface	S CNVCT TNDY ON P SF	244	100
Grid scale tendency on pressure surface	GRDSCL TNDY ON P SFC	241	100
	VDIFF MOIS ON P SFCS	249	100
Deep convective moisture on pressure surface	D CNVCT MOIS ON P SF	243	100
Shallow convective moisture on pressure surface	S CNVCT MOIS ON P SF	245	100
Ozone tendency on pressure surface	OZONE TNDY ON P SFCS	188	100
Mass weighted potential vorticity	MASS WEIGHTED PV	139	100
Simulated GOES 12 channel 3 brightness count	GOES BRIGHTNESS-CH 3	221	8
Simulated GOES 12 channel 4 brightness count	GOES BRIGHTNESS-CH 4	222	8
Omega on theta surface	OMEGA ON THETA SFCS	39	113
Mixing height	MIXHT HEIGHT	67	1
Average clear-sky incoming longwave at surface	AVE CLR INC SFC LW	163	1
Average clear-sky incoming shortwave at surface	AVE CLR INC SFC SW	161	1
Average clear-sky outgoing longwave at surface	AVE CLR OUT SFC LW	162	1
Average clear-sky outgoing longwave at top of atmosphere	AVE CLR OUT TOA LW	162	8
Average clear-sky outgoing shortwave at surface	AVE CLR OUT SFC SW	160	1
Average clear-sky outgoing shortwave at top of atmosphere	AVE CLR OUT TOA SW	160	8

Average incoming shortwave at top of atmosphere	AVE INC TOA SW	204	8
Transport wind u component	TRANSPORT U WIND	33	220
Transport wind v component	TRANSPORT V WIND	34	220
Sunshine duration	SUNSHINE DURATION	191	1
Field capacity	FIELD CAPACITY	220	1
ICAO height at maximum wind level	ICAO HGHT MAX WIND	5	6
ICAO height at tropopause	ICAO HGHT AT TROP	5	7
Radar echo top	RADAR ECHO TOP	240	200
Time averaged surface Visible beam downward solar flux	AVE IN SFC VIS SW BE	166	1
Time averaged surface Visible diffuse downward solar flux	AVE IN SFC VIS SW DF	167	1
Time averaged surface Near IR beam downward solar flux	AVE IN SFC IR SW BE	168	1
Time averaged surface Near IR diffuse downward solar flux	AVE IN SFC IR SW DF	169	1
Average snowfall rate	AVE SNOWFALL RATE	64	1
Dust 1 on pressure surface	DUST 1 ON P SFCS	240	100
Dust 2 on pressure surface	DUST 2 ON P SFCS	241	100
Dust 3 on pressure surface	DUST 3 ON P SFCS	242	100
Dust 4 on pressure surface	DUST 4 ON P SFCS	243	100
Dust 5 on pressure surface	DUST 5 ON P SFCS	244	100
Equilibrium level height	EQUIL LEVEL HEIGHT	7	247
Lightning	LIGHTNING	187	1
Goes west channel 2 brightness temperature	GOES W TB – CH 2	241	8
Goes west channel 3 brightness temperature	GOES W TB – CH 3	242	8
Goes west channel 4 brightness temperature	GOES W TB – CH 4	243	8
Goes west channel 5 brightness temperature	GOES W TB – CH 5	244	8
In flight icing from NCAR’s algorithm	NCAR IN-FLIGHT ICING	168	100
Specific humidity at flight levels	SPE HUM AT FD HEIGHT	51	103
Virtual temperature based convective available potential energy	TV CNVCT AVBL POT EN	202	1
Virtual temperature based convective inhibition	TV CNVCT INHIBITION	201	1
Virtual temperature on model surfaces	VTEMP ON MDL SFCS	012	109
Virtual temperature on pressure	VTEMP ON PRESS SFCS	012	100

surfaces			
Virtual temperature on flight levels	VTEMP AT FD HEIGHTS	012	103
Ventilation rate	VENTILATION RATE	241	220
Haines index	HAINES INDEX	250	1
Pressure at flight levels	PRESS AT FD HEIGHTS	1	103
Time-averaged percentage snow cover	TIME AVG PCT SNW CVR	238	1
Time-averaged surface pressure	TIME AVG SFC PRESS	1	1
Time-averaged 10m temperature	TIME AVG TMP AT 10M	11	105
Time-averaged mass exchange coefficient	TAVG MASS EXCH COEF	185	1
Time-averaged wind exchange coefficient	TAVG WIND EXCH COEF	186	1
Temperature at 10m	TEMP AT 10 M	11	105
Maximum U-component wind at 10m	U COMP MAX 10 M WIND	253	105
Maximum V-component wind at 10m	V COMP MAX 10 M WIND	254	105
Simulated GOES 12 channel 2 brightness temperature with satellite angle correction	GOESE TB-2 NON NADIR	213	8
Simulated GOES 12 channel 3 brightness temperature with satellite angle correction	GOESE TB-3 NON NADIR	214	8
Simulated GOES 12 channel 4 brightness temperature with satellite angle correction	GOESE TB-4 NON NADIR	215	8
Simulated GOES 12 channel 5 brightness temperature with satellite angle correction	GOESE TB-5 NON NADIR	216	8
Simulated GOES 11 channel 2 brightness temperature with satellite angle correction	GOESW TB-2 NON NADIR	241	8
Simulated GOES 11 channel 3 brightness temperature with satellite angle correction	GOESW TB-3 NON NADIR	242	8
Simulated GOES 11 channel 4 brightness temperature with satellite angle correction	GOESW TB-4 NON NADIR	243	8
Simulated GOES 11 channel 5 brightness temperature with satellite angle correction	GOESW TB-5 NON NADIR	244	8
Simulated GOES 15 channel 5 brightness temperature with satellite angle correction	GOES-15 NON-NADIR (Levels 1-4 = Channels 2-5)	118 (241-244)	109

Simulated GOES 13 channel 2 brightness temperature with satellite angle correction	GOES-13 NON-NADIR (Levels 1-4 = Channels 2-5)	118 (237-240)	109
Simulated AMSR-E channel 9 brightness temperature	AMSRE TB – CH 9	176	8
Simulated AMSR-E channel 10 brightness temperature	AMSRE TB – CH 10	177	8
Simulated AMSR-E channel 11 brightness temperature	AMSRE TB – CH 11	178	8
Simulated AMSR-E channel 12 brightness temperature	AMSRE TB – CH 12	179	8
SSMI F13 (19H, 19V, 37H, 37V, 85H, 85V)	F13 SSMI NON-NADIR (Levels 1-6)	118 (176-181)	109
SSMI F14 (19H, 19V, 37H, 37V, 85H, 85V)	F14 SSMI NON-NADIR (Levels 1-6)	118 (182-187)	109
SSMI F15 (19H, 19V, 37H, 37V, 85H, 85V)	F15 SSMI NON-NADIR (Levels 1-6)	118 (188-193)	109
SSMIS F16 (183H, 19H, 19V, 37H, 37V, 85H, 85V)	F16 SSMIS NON-NADIR (Levels 1-7)	118 (194-200)	109
SSMIS F17 (183H, 19H, 19V, 37H, 37V, 85H, 85V)	F17 SSMIS NON-NADIR (Levels 1-7)	118 (201-207)	109
SSMIS F18 (183H, 19H, 19V, 37H, 37V, 85H, 85V)	F18 SSMIS NON-NADIR (Levels 1-7)	118 (208-214)	109
SSMIS F19 (183H, 19H, 19V, 37H, 37V, 85H, 85V)	F19 SSMIS NON-NADIR (Levels 1-7)	118 (215-221)	109
SSMIS F20 (183H, 19H, 19V, 37H, 37V, 85H, 85V)	F20 SSMIS NON-NADIR (Levels 1-7)	118 (222-228)	109
MTSAT-1r imager channels 1-4 (backup for mtsat2)	MTSAT1R NON-NADIR (Levels 1-4 = Channels 1-4)	118	109
MTSAT2 imager channels 1-4	MTSAT2 NON-NADIR (Levels 1-4 = Channels 1-4)	118	109
Seviri brightness temperature	SEVIRI NON-NADIR	118	109

channels 5-11	(Levels 1-7 = Channels 1-7)	(230-236)	
Insat 3d brightness temperature IR channels 1-4	INSAT 3D NON-NADIR (Levels 1-4 = Channels 1-4)	118	109

* See Appendix A

*** 4 types of CAPE and CIN can be output with use of the Levels control line in the ***wrf_cntrl.parm (nmb_cntrl.parm file).*** Surface based CAPE/CIN is output at one grib record, while the remaining three types are output within one grib record in 3 levels.

Level 1: Surface Based CAPE/CIN
Level 2: Best Boundary Layer CAPE/CIN
Level 3: Mixed Layer CAPE/CIN
Level 4: Most Unstable CAPE/CIN

Appendix A: UPPV3.1 Reflectivity field descriptions

Reflectivities are filled/computed depending on the model core and microphysics options.

UPP uses model derived reflectivity (REFL_10CM from WRF or NMM-B) for model runs using the Thompson microphysics option (mp=8). Other combinations use algorithms within UPP code.

Work is underway to provide more user flexibility when selecting reflectivity computations. For more information on model computed reflectivity, e.g. REFL_10CM, please see model documentation.

Relevant routines for reflectivity. Some or all of these may need to be modified if the user desires to change where/how reflectivity is processed. It is recommended that the user have knowledge of the model output and reflectivity computations before trying to modify the UPP code. Email upp-help@ucar.edu for further questions.

INITPOST* - Separate routines for each different model core (e.g. ARW, NMM, NEMS, etc.). Reads model fields, e.g. REFL_10CM, REFD_MAX

MDLFLD.f - Computes DBZ or fills DBZ arrays with model computed Reflectivity.
- Fills 3-D model level reflectivity array (UPP ID: 250)
- Fills 2-D composite reflectivity array (UPP ID: 252)

MDL2AGL.f - Interpolates relevant DBZ array to AGL reflectivity (UPP ID: 253)

- Outputs model computed maximum hourly reflectivity (REFD_MAX; UPP ID: 421)

MDL2P.f - Interpolates relevant DBZ array to pressure levels (UPP ID: 251)

Acknowledgement

If significant help was provided via the UPP helpdesk for work resulting in a publication, please acknowledge the Developmental Testbed Center Mesoscale Modeling Team.

For referencing this document please use:

UPP Users' Guide V3.0, 34 pp. [available online at http://www.dtcenter.org/upp/users/docs/user_guide/V3/upp_users_guide.pdf]