

NCEP's Unified Post Processor (UPP)

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Overview

- UPP was developed at the National Centers for Environmental Prediction (NCEP)
- Used operationally to post-process forecast output for a variety of models
- Included as the post-processing component for the UFS weather applications
 - UFS MRW v1.1.0 released on 10/6/2020
 - UFS SRW: v1.0.0 currently slated for Dec 2020
- Support and documentation for UPP provided through the Developmental Testbed Center (DTC)
 - <https://upp.readthedocs.io/en/ufs-v1.1.0/index.html>

Functions and Features

- The UPP
 - Ingests FV3 forecast files in binarynetcdf and NetCDF format
 - Performs vertical interpolation from model's native vertical coordinate to NWS standard output levels (e.g. pressure, height, and other levels/surfaces)
 - Produces numerous fields and diagnostic output quantities like those used operationally
 - Incorporates the Joint Center for Satellite Data Assimilation (JCSDA) Community Radiative Transfer Model (CRTM) to compute derived satellite brightness temperatures for various instruments and channels
 - Is an MPI parallel code
 - Outputs requested fields in standard WMO Grib2 format

Example Fields Generated

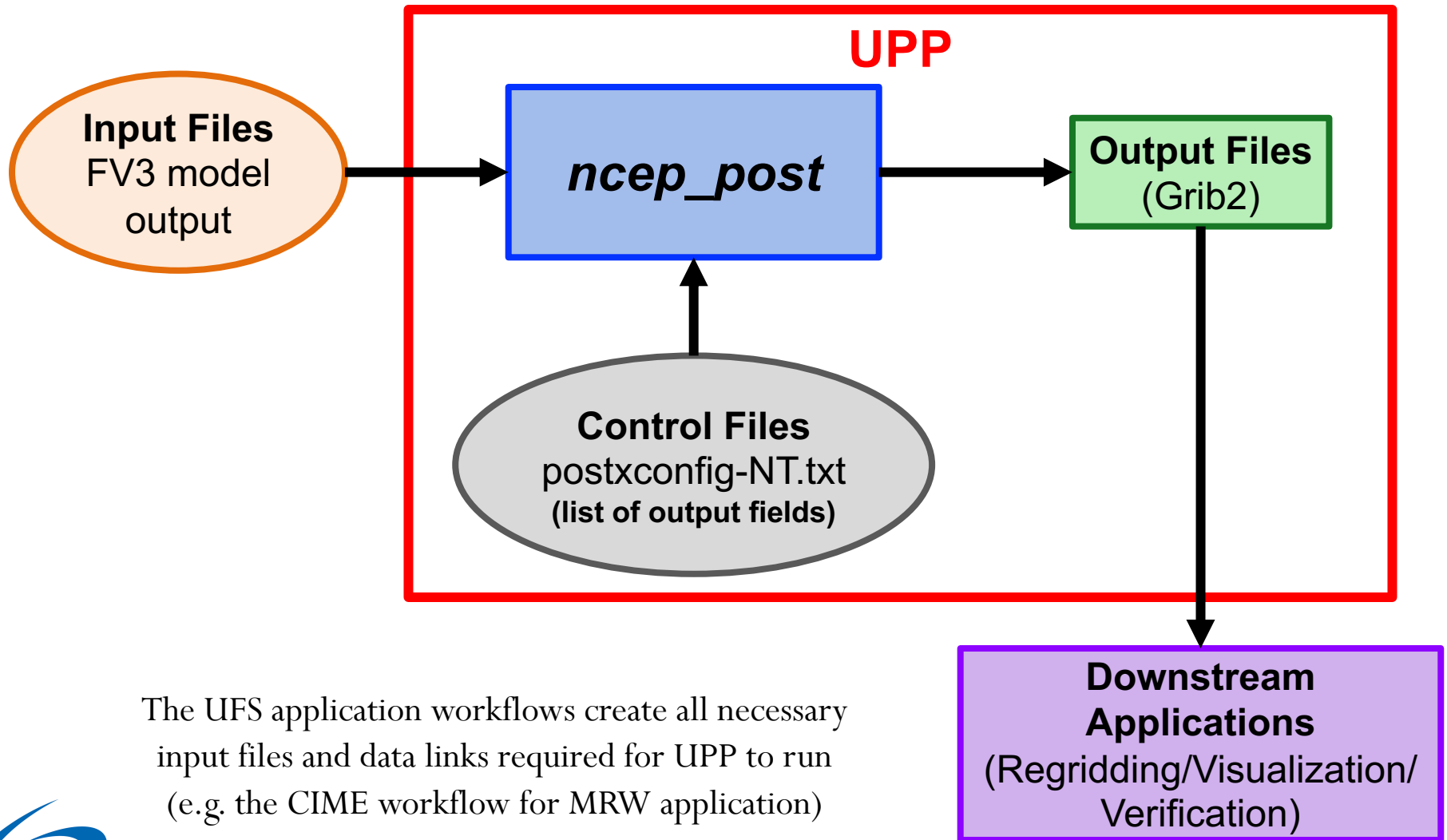
- T, Z, humidity, wind, cloud water, cloud ice, rain, and snow on isobaric levels
- SLP + shelter level T, humidity, and wind fields
- Precipitation-related fields
- PBL-related fields
- Diagnostic products (i.e. RH, CAPE, Vorticity)
- Radiative/Surface fluxes
- Cloud related fields
- Aviation products
- Synthetic satellite products

Full list of available fields are available within the UPP documentation for UFS applications

Vertical levels for Output

- Native model levels
- 47 isobaric levels: 2, 5, 7, 10, 20, 30, 50, 70, then every 25 hPa from 75 to 1000 hPa
- 15 flight/wind energy levels: 30, 50, 80, 100,, 2743, 3658, 4572, and 6000 m (AGL or MSL)
- Soil layers: varies depending on LSM
- Low, mid, high cloud layers
- 6 PBL layers: each averaged over a 30 hPa deep layer
- 2 AGL radar reflectivity levels: 1 and 4 km
- Surface and shelter levels

Components



Input Files

UPP requires the following input files that are all created and linked within the application workflow:

1. Model output file in binarynemsio or netcdf format
2. itag file (UPP namelist)
3. Control file (i.e. postxconfig-NT-GFS.txt) listing desired fields for output
4. Additional data files (e.g. micro lookup tables, coefficient files for satellite)

Model Output

- The UPP ingests FV3 model output in netcdf or binarynemsio mpiio format using the NCEPLibs WRF I/O library package
- By default, the UPP reads a set list of fields from the model output files for basic diagnostics
- Model output is found in the case workflow directory under /run and consists of 2 files
 - atmfh~~hh~~.nc - 3D fields on model levels
 - sfcfh~~hh~~.nc - 2D fields at surface and other levels



itag File

The **itag** namelist is read by the UPP and is generated automatically by the application workflow for each forecast hour.

Example MRW itag

atmf006.nc	Model output file with fields on model levels
netcdf	Format of the model output
grib2	Format of the UPP output
2019-08-29_06:00:00	Forecast valid time
GFS	Model name
sfcf006.nc	Model output file with fields on surface and other 2D levels

Control File

UPP reads a control file to determine which fields to post-process

- Default control files are used within the UFS Weather Applications; however, these can be customized to add/remove fields/levels
- Default MRW control files are located in a pre-configured location
 - **postxconfig-NT-GFS-F00.txt** (used to post-process model output at the 0-hour forecast lead time)
 - **postxconfig-NT-GFS.txt** (used to post-process model output at all other forecast lead times)

These files are not user friendly and users do not modify them directly for customization



UPP Output

- Output files are found in your case workflow directory under /run with naming convention GFSPRS.GrbF***HH***
- Output from the UPP is in standard Grib2 format
- Includes all fields that were requested in the control file
 - If an expected field is not in the output, it could be due to your specific model configuration
- For the MRW application, the output projection is on a Gaussian grid
 - To regrid to another projection, you can use the 3rd party software wgrib2

Optional: Customizing UPP Output

For the UFS Weather Application MRW v1.1.0, customization of the UPP output is functional

All files utilized for customization are found in the MRW application code directory under /src/post/parm

- **postcntrl_gfs(_f00).xml:** Lists requested fields for output
- **post_avblflds.xml:** Lists all available fields and details for Grib2 tables/output
- **postxconfig-NT-GFS(-F00).txt:** Created from the xml files, listing requested fields for output, and read directly by the UPP

Note: Customizing the parameter file requires knowledge about what variables can be output for your particular model and configuration



UPP Control File: postcntrl_gfs(_f00).xml

- **User modified xml file** listing all desired fields to be output by UPP
- Formatting is important; use provided file as a guide

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

```
<param>  
  <shortname>TMP_ON_ISOBARIC_SFC</shortname>  
  <level>50000. 70000. 85000. 100000.</level>  
  <scale>3.0</scale>  
</param>
```

Character name describing the product/field

Vertical coordinate levels desired

Grib precision packing



UPP Control File: post_avblflds.xml

- Lists **all** available fields and details for Grib2 tables/output
- Generally **not** modified, unless doing development

```
<param>  
  <post_avblfldidx>106</post_avblfldidx>  
  <shortname>TMP_ON_SPEC_HGT_LVL_ABOVE_GRND_2m</shortname>  
  <pname>TMP</pname>  
  <fixed_sfc1_type>spec_hgt_lvl_above_grnd</fixed_sfc1_type>  
  <level>2.</level>  
  <scale>4.0</scale>  
</param>
```

```
<param>  
  <post_avblfldidx>13</post_avblfldidx>  
  <shortname>TMP_ON_ISOBARIC_SFC</shortname>  
  <pname>TMP</pname>  
  <fixed_sfc1_type>isobaric_sfc</fixed_sfc1_type>  
  <scale>3.0</scale>  
</param>
```

Unique UPP ID

Character name describing the product/field

Field abbreviation used by grib2 libraries

Vertical coordinate type/level

Grib precision packing



Creating the postxconfig-NT-GFS(-F00).txt

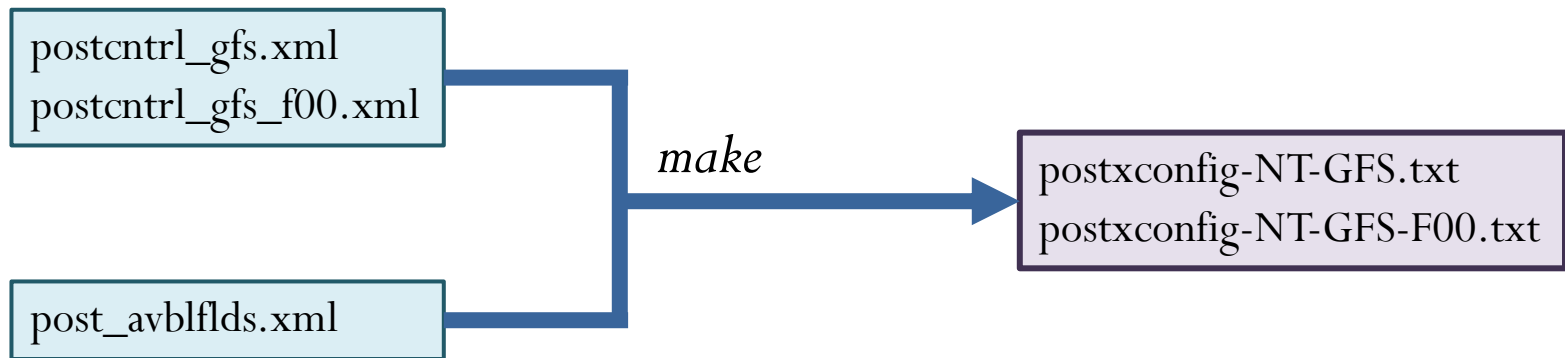
- UPP directly reads the postxconfig-NT-GFS.txt file, which lists the requested fields
- If you have modified the postcntrl_gfs.xml, you will need to run the following steps to convert to a new flat text file

1) > *cd src/post/parm*

2) Edit the postcntrl_gfs.xml to add/remove fields/levels

3) > *make*

- make calls a perl program that uses both the postcntrl_gfs.xml and post_avblflds.xml to do the conversion



Using the Customized Parameter File

- Once created, the new flat text files will need to be copied or linked within the CIME case directory to /SourceMods/src.ufsatm

```
cp postxconfig-NT-GFS.txt ${CASEROOT}/SourceMods/src.ufsatm
```

- CIME first looks in this directory for the UPP parameter file(s).
 - If they are not present, the workflow uses the default parameter file(s) in a pre-configured location
- You may then setup/build/run your case as usual and UPP will use the custom flat file(s).

Note: If you only customize one of the parameter files (postxconfig-NT-GFS.txt or postxconfig-NT-GFS-F00.txt), then CIME will use the custom config file placed in the /SourceMods/src.ufsatm directory and the default from the pre-configured location for the other parameter file.

Optional: Regridding Using wgrib2

- The model/UPP output for the MRW application is on a Gaussian grid and can be interpolated to a new projection using the wgrib2 utility
- Generic usage command:

wgrib2 -new_grid_winds W -new_grid A B C outfile

new_grid_winds

W = earth or grid

earth: U-wind is eastward; V-wind is northward

grid: U-wind goes from grid (i,j) to (i+1,j)

new_grid

A = grid type with parameters

B = x/longitude grid specifications

C = y/latitude grid specifications

<https://www.cpc.ncep.noaa.gov/products/wesley/wgrib2/index.html>

wgrib2 Examples

Latitude-Longitude Grid

```
wgrib2 -new_grid latlon lon0:nlon:dlon lat0:nlat:dlat outfile
```

Grid type

Longitude/latitude of first grid point in degrees

Number of longitudes/latitudes

Grid resolution in degrees of longitude/latitude

Lambert Conic Conformal Grid

```
wgrib2 -new_grid lambert:lov:latin1:latin2 lon0:nx:dx lat0:ny:dy outfile
```

Grid type with parameters

lov: Longitude where y axis is parallel to meridian in degrees

latin1/latin2: First/second latitude from pole which cuts the secant cone in degrees

Longitude/latitude of first grid point in degrees

Number of grid points along x/y

Grid cell size in meters in x/y direction

Optional: Downstream Applications

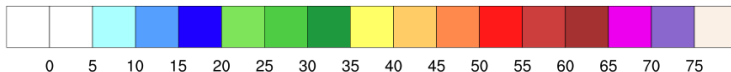
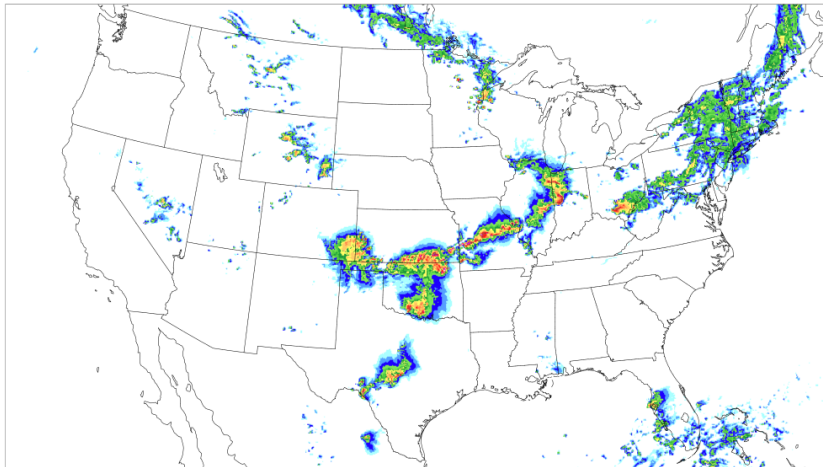
- The WMO standard Grib2 output can be used in a number of downstream applications

Visualization/Plotting Software

Composite Reflectivity (dBZ)

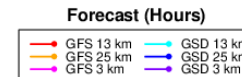
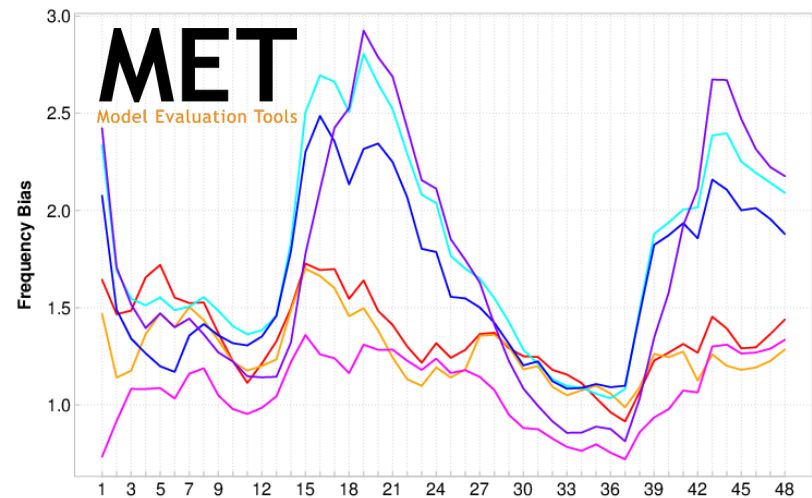
06/15/2019 (00:00) 30 hr fcst

Valid 06/16/2019 06:00 UTC



Verification Software

1 hr Accum Precipitation



Ongoing Activities

- Recent initiative to further *unify* the UPP by merging separate repositories and consolidating directory structures and building methods between applications
- Refactor project at EMC
 - Year 1 (FY19/20): Clean up and modernize code, develop reusable and interoperable modules, and document variable dependencies
 - Year 2 (FY21/22): Increase parallelism by adding decomposition in the X direction, validation and evaluation by code managers and developers of all models supported by UPP