NCEP's Unified Post Processor (UPP)

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Outline

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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
    - UPP release tag: ufs-v1.1.0
  - UFS SRW: v1.0.1 released on 9/16/2021
    - UPP release tag: upp_v9.0.1
- Support and documentation for UPP provided through the Developmental Testbed Center (DTC)
  - Users Guide: https://upp.readthedocs.io/en/upp_v9.0.1/
  - UFS Community Support Forum: https://forums.ufscommunity.org/

Functions and Features

- The UPP
  - Ingests FV3 forecast files in binarynemsiompiio 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

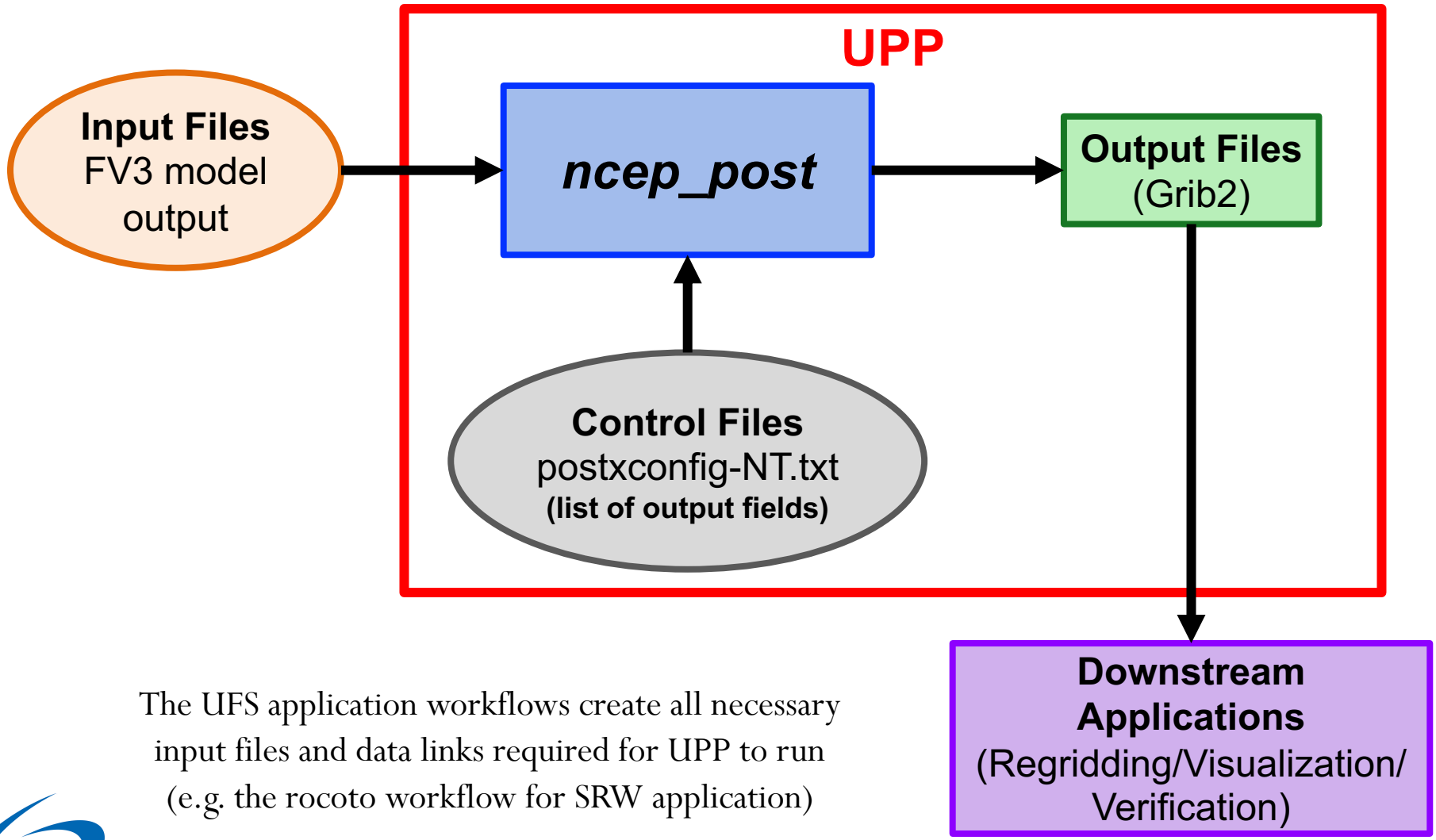
Full list of available fields are available within the UPP documentation

https://upp.readthedocs.io/en/upp_v9.0.1/UPP_GRIB2_Table.html

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



The UFS application workflows create all necessary input files and data links required for UPP to run (e.g. the rocoto workflow for SRW application)

Input Files

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

1. Model output file in binarynemsiompiio or netcdf format
2. itag file (UPP namelist)
3. Control file (i.e. postxconfig-NT-fv3lam.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 binarynemsiompiio 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 experiment directory for each initialization and consists of 2 files for each forecast hour
  - dynf***hhh***.nc - 3D fields on model levels
  - phyf***hhh***.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 SRW itag

dynf006.nc	Model output file with fields on model levels
netcdf	Format of the model output
grib2	Format of the UPP output
2019-06-15_06:00:00	Forecast valid time
FV3R	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
- The default SRW control file is located in the ufs-srweather-app/src/EMC_post/parm directory
  - postxconfig-NT-fv3lam.txt (used to post-process model output for the FV3 LAM)

The flat txt files are not user friendly and users do not modify them directly for customization

UPP Output

- Output files are found in your experiment directory for each initialization under /postprd with naming convention:
  - BGRD3D_{YY}{JJJ}{hh}{mm}f{fhr}00 → {domain}.t{cyc}z.bgrd3df{fhr}.tmXX.grib2
  - BGDAWP_{YY}{JJJ}{hh}{mm}f{fhr}00 → {domain}.t{cyc}z.bgdawpf{fhr}.tmXX.grib2
- 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 SRW application, the output projection is on a 25/13/3 km Lambert Conformal grid, depending on the grid length chosen
  - To regrid to another projection, you can use the 3rd party software wgrib2

Optional: Customizing UPP Output

For the UFS SRW v1.0.1, customization of the UPP output is functional

All files utilized for customization are found in the SRW application code directory under ufs-srweather-app/src/EMC_post/parm

- **fv3lam.xml:** Lists requested fields for output
- **fv3lam_post_avblflds.xml:** Lists all available fields for FV3LAM and details for Grib2 tables/output
- **postxconfig-NT-fv3lam.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: fv3lam.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: fv3lam_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-fv3lam.txt

- UPP directly reads the postxconfig-NT-fv3lam.txt file, which lists the requested fields
- If you wish to modify the fv3lam.xml, you will need to run the following steps to convert to a new flat text file

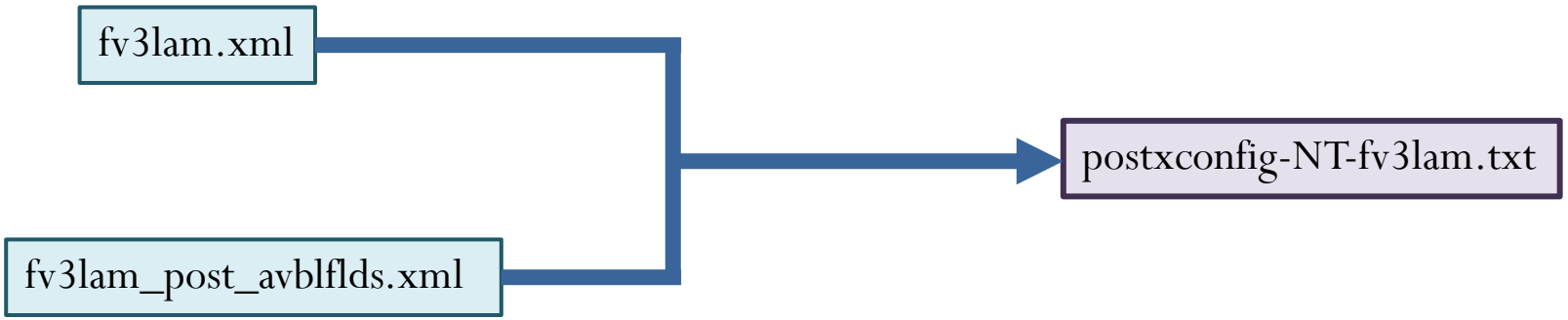
1) > cd ufs-srweather-app/src/EMC_post/parm

2) Edit the fv3lam.xml to add/remove fields/levels

*3) > /usr/bin/perl PostXMLPreprocessor.pl fv3lam.xml *

fv3lam_post_avblflds.xml postxconfig-NT-fv3lam.txt

- The perl program uses both the fv3lam.xml and fv3lam_post_avblflds.xml to do the conversion



Using the Customized Parameter File

- To use a customized flat txt file, add the following lines to your ufs-srweather-app/regional_workflow/ush/config.sh

```
USE_CUSTOM_POST_CONFIG_FILE="TRUE"
CUSTOM_POST_CONFIG_FP="/path/to/postxconfig-NT-fv3lam.txt.${USER}"
```

- The path must contain the filename
- You may then generate and run the case workflow as usual and UPP will use the custom flat txt file in the specified path.

Note: If this is set to TRUE and the file path is not found, then an error will occur when trying to generate the SRW Application workflow.

Optional: Regridding Using wgrib2

- The UPP output for the SRW application is on a Lambert Conformal grid and can be interpolated to a new projection using the wgrib2 utility
- Generic usage command:

wgrib2 infile -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 Example

Latitude-Longitude Grid

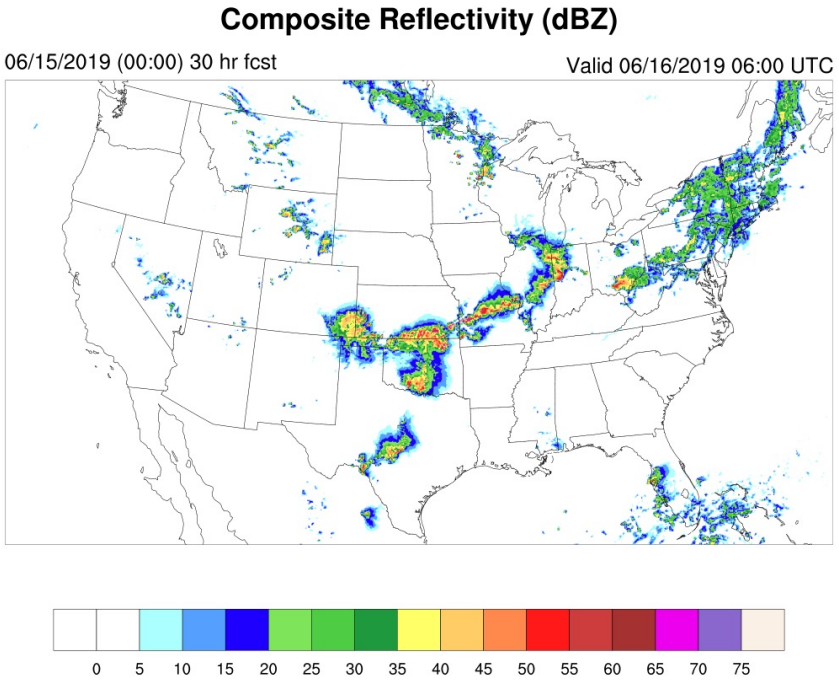
wgrib2 infile -new_grid latlon lon0:nlon:dlon lat0:nlat:dlat outfile

Grid type
Longitude/latitude of first grid point in degrees
Number of longitudes/latitudes
Grid resolution in degrees of longitude/latitude

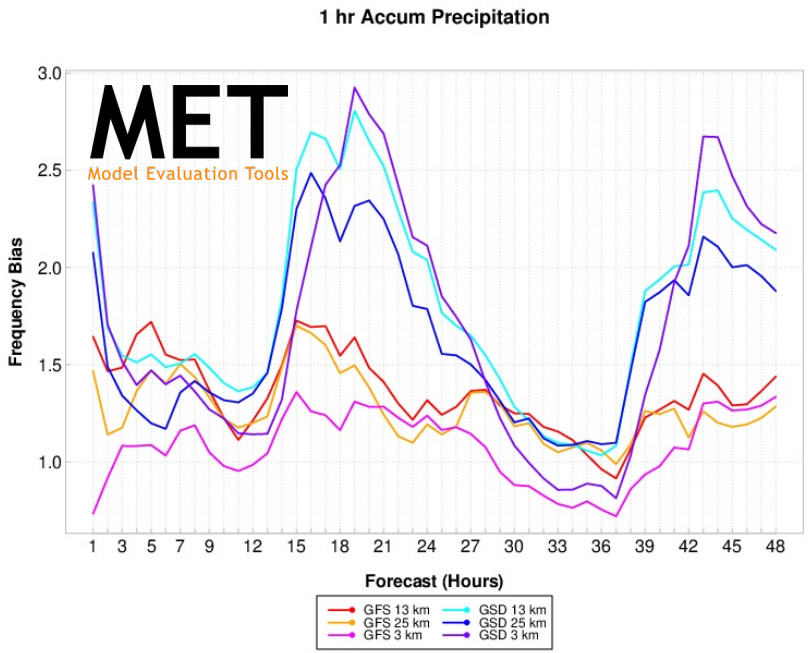
Optional: Downstream Applications

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

Visualization/Plotting Software



Verification Software



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): **Complete!** 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