

# Community Unified Post Processor (UPP) Code Management Plan

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## 1 Introduction

The Unified Post Processor (UPP) software package was developed by the Environmental Modeling Center (EMC) of the National Centers for Environmental Prediction (NCEP) and is used operationally for models maintained by NCEP. This package provides the Numerical Weather Prediction (NWP) community with a common tool to post-process output from multiple models, ranging from global to regional scales. UPP can be used to post-process output from a variety of NWP models, including the Weather Research and Forecasting (WRF) Advanced Research WRF (ARW) and Non-hydrostatic Mesoscale Model (NMM), Non-hydrostatic Multi-scale Model on the B grid (NMMB), Global Forest System (GFS), Climate Forecast System (CFS), and Finite-Volume Cubed Sphere (FV3).

The Developmental Testbed Center (DTC) will serve to establish a link between the operational and research communities by maintaining community UPP branch(es) in the repository and providing regular public releases and user support for this software package. In order to benefit the entire NWP community, the community UPP repository must be maintained in a way that allows future updates and enhancements to be contributed by, and shared between, both the operational and research communities.

Supporting and managing a version of the UPP package applicable to community and operational users requires a plan for coordinating the sharing of code between developers with diverse needs. The DTC will be responsible for maintaining a community UPP package that is kept in sync with the operational UPP package (O2R). Community users may contribute modifications and enhancements to the UPP package; these modifications will be tested and made available to the operational community (R2O). This document outlines the policies and procedures used to maintain a robust and flexible community UPP software package. The document contains descriptions pertaining to:

- Community UPP code repository
- Code Contributions
- Synchronizing the DTC Community UPP  $\leftrightarrow$  NCEP UPP code repositories
- Release Schedule and User Support

## 2 Community UPP Code Repository

### 2.1 Physical Storage

The hardware, version control software, and repositories used to store and access the community UPP repository are administered by the National Oceanic Atmospheric

Association (NOAA) / National Weather Service (NWS) via GitHub which makes use of Git as its version control system. In 2018, the community UPP code and repositories were moved from SVN-based version control to Git, and in 2019 the repository was pushed to GitHub.

## 2.2 Software Directory Structure

One physical Git repository exists on GitHub to house both operational EMC code and the community UPP package. This repository is called *EMC\_post* and can be found at: [https://github.com/NOAA-EMC/EMC\\_post](https://github.com/NOAA-EMC/EMC_post). The develop branch of *EMC\_post* constitutes the operational source code. A branch called *DTC\_post* exists within the *EMC\_post* repository to house the community UPP package. The *DTC\_post* branch is further described in section 2.2.1.

### 2.2.1 Community UPP Repository

The UPP community repository is by design a direct branch of the *EMC\_post* repository. This community branch is called *DTC\_post* and is a mirror image of the develop branch of the *EMC\_post* repository, but also contains additional files for DTC specific build support, library source code and submodule links to the CRTM library, and any other community specific needs. The unipost source code is kept in sync between branches except where the need for difference is determined to be necessary or unavoidable. A DTC preprocessor flag (COMMCODE) is used to facilitate the sharing of files with minor code variations.

The structure of the *DTC\_post* community branch is illustrated below:

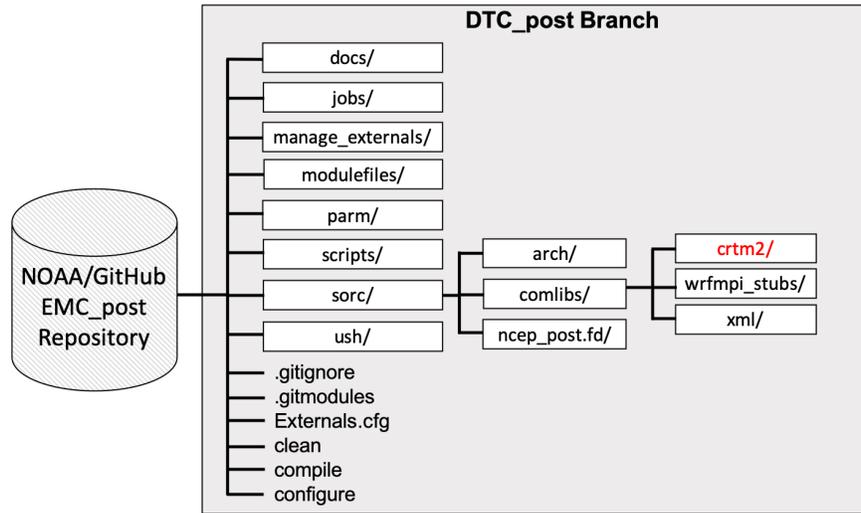


Figure 1. High-level overview *DTC\_post* directory content. Directories in red indicate a submodule link to another external repository.

The *DTC\_post* branch is the central location of the code needed to create executables for *unipost*. The scripts: *clean*, *configure*, and *compile* are the command directives used to create the executables. These scripts use information in the *src/arch/* directory to build a version of UPP which is compatible with the system/architecture it has been installed on. The *src/ncep\_post.fd* directory contains all the source code for *unipost*. The *src/comlibs/* directory contains a few libraries required to build UPP that are not available in the external NCEPLibs pre-requisite build, and include *wrfmpi\_stub* and *xml* library source code, as well as a directory for CRTM, which contains a submodule link to an external library repository.

The contents of these directories are further expanded and defined in the following table.

Directory Name	Description
<b>clean</b>	Script to remove compilation files
<b>configure</b>	Script to configure for compile
<b>compile</b>	Script to compile
<b>Externals.cfg</b>	Configuration file for Manage Externals
<b>docs/</b>	User Guide files
<b>jobs/</b>	Scripts to submit operational jobs
<b>manageExternals/</b>	Utility to manage remote repositories
<b>modulefiles/</b>	Module files for operational builds
<b>parm/</b>	Output control parameter files
<b>scripts/</b>	Scripts to run unipost
<b>src/arch/</b>	Architecture dependent support code

<b>sorc/comlibs/crtm2/</b>	Community Radiative Transfer Model [Submodule to GitHub Repository]
<b>sorc/comlibs/xml/</b>	XML support – GRIB2 parameter file
<b>sorc/comlibs/wrfmpi_stubs/</b>	Serial compilation support
<b>sorc/ncep_post.fd/</b>	Unipost source code
<b>ush/</b>	Scripts for running operational tests

Table 1: DTC\_post branch comupp directories

### 2.2.2 External Libraries and Pre-Requisites

There are several libraries that are required to build and run UPP. A subset of these libraries is contained within the EMC\_post repository in the DTC\_post branch, under *sorc/comlibs/* as described in section 2.2.1. These include: xml, wrfmpi\_stubs and crtmm libraries. Due to the size of the complete CRTM library, a subset of only the necessary code is housed in a separate GitHub repository that is maintained by the DTC. A submodule for the CRTM GitHub repository is linked to the *DTC\_post/sorc/comlibs/crtm2* directory such that a clone of the *DTC\_post* branch automatically populates the *crtm2* directory with the proper code. This CRTM library repository can be found at: [https://github.com/NCAR/UPP\\_CRTM](https://github.com/NCAR/UPP_CRTM). Development of any of the libraries packaged with the UPP should be discussed with the DTC prior to proposing code changes within the repository.

The others required libraries are variants of NOAA/EMC’s NCEP Libraries. The DTC maintains a separate repository for these libraries called NCEPLibs (<https://github.com/NCAR/NCEPLibs>) under the NCAR GitHub organization. This repository hosts derivatives of the NOAA/EMC’s *nceplib* repositories, with the differences few and minor and only as required to support community portability. These libraries are now a pre-requisite required to build prior to compiling the UPP code. Information about how to build these libraries can be found in the README within the repository. These libraries will strive to be identical to the versions used by the operational UPP except where the need for difference is determined to be necessary. A DTC preprocessor flag is used to facilitate the sharing of files with minor code variations. The libraries will be upgraded as needed remain current with NOAA/EMC operations.

### 2.2.3 Additional Utilities

In previous community releases of the UPP, a utility called *copygb* was also included in the package. This utility allows a user to perform grid manipulations on grib1 output files, e.g. re-project map, re-grid to new resolution, etc. Since the community release v4.1 in Spring of 2020, this utility has been removed and is contained within its own repository (<https://github.com/NCAR/copygb>). The utility can still be downloaded, built, and used in conjunction with UPP grib1 output, but it is no longer supported by the DTC.

## 3 Code Contribution Outline

### 3.1 Management of Repository

A developers' committee (DC) exists, which will govern the contributions made to the community UPP branch. Initial membership of the DC will include representatives from NOAA/EMC and the DTC. The DC will meet on an as needed basis. Code managers (CM) are assigned to specific branches and applications of EMC\_post and are identified along with contact information on the GitHub repository wiki. In general, the DTC is responsible for community branches, and EMC is responsible for operational branches. Each CM will be responsible for maintaining their specific branch or application and assisting developers with code contributions, and also coordinating between CMs for repository consistency.

### 3.2 Access to Repository

The EMC\_post GitHub repository is public and available for read access to any user. Write access is restricted to CMs and approved developers. In the event that the repository cannot be accessed or cloned, the DTC will provide a code package for the individual to do their development, and the DTC will manage checking in new code changes to the repository as needed.

### 3.3 Working with the Repositories

Users wishing to contribute code modifications are expected to use GitHub Forks. A fork is personal copy of the repository in which the user can make changes to the code without impacting the authoritative repository ([more info](#)). The general procedures for creating a fork, checking out the code, and experimenting with code changes, are outlined below:

1. Users should create a fork from the EMC\_post GitHub page.  
Navigate to [https://github.com/NOAA-EMC/EMC\\_post](https://github.com/NOAA-EMC/EMC_post)  
Select "fork" button in upper right corner to create new fork or go to your existing fork.  
Your fork of the repository will be called [https://github.com/username/EMC\\_post](https://github.com/username/EMC_post)
2. Clone the DTC\_post branch and checkout a local branch  
Users must clone the specific DTC\_post branch in order to obtain the CRTM submodule as well. (Cloning the EMC\_post develop branch and then trying to checkout the DTC\_post branch will result in an empty *crtm* directory and necessitate extra steps to populate its contents). An important note is that when a user makes a copy of the DTC\_post, the submodule to any external library repositories are NOT branched, unless they are explicitly changed.

```
git clone -b DTC_post --recurse-submodules https://github.com/username/EMC\_post  
git checkout -b your_branch
```

3. Add modifications, enhancements or additions into your local branch. All code changes proposed for inclusion to the community branch of the repository must meet the coding standards described in Appendix A.
4. Run available regression tests on modified code, if applicable. Contact a CM to inquire on required testes. Run any specific computing and scientific tests the developer may have to ensure the modifications are behaving as intended and have not adversely impacted existing UPP capabilities.
5. Commit your changes to your local branch  
git checkout your\_branch  
git commit -a
6. Push your branch to your fork (remote: origin) on GitHub  
git checkout your\_branch  
git push origin
7. Ensure your branch is synchronized with the authoritative EMC\_post repository *DTC\_post* branch. If not, you need to merge with *DTC\_post* first. Retesting after the merge is required.

### 3.4 Request to Accept Change into UPP Repository

Once the user is satisfied with the validity of their code changes in their fork, they can propose these modifications to be accepted into the authoritative EMC\_post repository using a pull request (PR: [more info](#)).

A PR can be created via the GitHub web interface for your repository fork and branch.

Navigate to: [https://github.com/<yourusername>/EMC\\_post](https://github.com/<yourusername>/EMC_post)  
Use the drop-down menu on the left-side to select a branch to view your development branch  
Use the button just right of the branch menu, to start a “New Pull Request”  
Fill in a short title (one line)  
Fill in a detailed description, including reporting on any testing you did  
Click on “Create pull request”

CMs monitor new PRs and the appropriate CM will be assigned to the PR for review and testing. The CM will evaluate the PR, perform tests and iterate with the developer on any necessary changes or testing that may be required. The CM will discuss proposed changes with other CMs as needed to evaluate overall impact for all applications. The CM will decide to accept or reject the PR and will provide detailed explanation for any rejection of code. Upon acceptance, the CM will merge the PR into the *DTC\_post* branch.

## 4 Synchronizing the DTC Community UPP ⇔ NCEP UPP code repositories

To maintain a strong connection between the research and operational communities, the DTC community UPP branch must be kept synchronized with the NCEP operational branch. This will require the DTC to merge all NCEP operational changes into the community UPP branch, as well as present the community changes accepted by the DC into the community branch to NCEP for possible inclusion in the operational branch. A primary and secondary point of contact (POC) will be designated from the DTC staff who will work with the NCEP primary CM to accomplish this goal. The remainder of this section outlines the communication required for repository synchronization.

### 4.1 DTC ⇒ NCEP

The DTC will submit non-NCEP initiated changes accepted by the DC into the community UPP branch to NCEP for acceptance into the *EMC\_post* repository. The documentation submitted to initiate the DC approval process will act as the documentation provided to NCEP. The DTC will open an issue and/or PR in GitHub for each request submitted to NCEP. The DTC POC will work directly with EMC CMs to incorporate the proposed changes and will authorize the final acceptance through code review for the changes to be merged in the develop branch of *EMC\_post*.

### 4.2 NCEP ⇒ DTC

NCEP will send notification of updates via email messages generated by the GitHub notification system or communicated by the NCEP principal CM to the DTC POC.

#### 4.2.1 Operational UPP Software Modification

The DTC POC receives email notification that the operational UPP software has been modified. The Git logs should describe the files that changed and provide a description of the change. The DTC will proceed as follows:

- The DTC will update the community branch, *DTC\_post*, to pull in NCEP changes.
- The DTC will make a branch based off the community *DTC\_post* branch.
- The NCEP changes will be incorporated.
- The DTC will run regression tests.
- Upon successful completion of the regression tests, the modification will be brought into *DTC\_post* branch.
- The details in Section 3.4 (Request to Accept Change into UPP Repositories) further explain the remaining procedure. The DTC will act as the originator during this procedure.

#### 4.2.2 Acceptance of a Community Contribution

The DTC POC receives email notification that a community contribution has been accepted in to the operational UPP repository (develop branch of the *EMC\_post* repository). The DTC determines if the accepted operational implementation matches the initial submission or if modifications have been made. Variations to white space (blanks, tabs, and newlines) are not considered a modification for this purpose. If the change is

identical there is no work to be done in the repository. The DC will be notified that the change was accepted by NCEP. The DTC will then update the tracking database as discussed in Section 4.1, DTC  $\Rightarrow$  NCEP, to reflect the acceptance of the contribution. White space changes will be reconciled by the DTC if necessary to keep the code as close as possible with the NCEP operational branch. The DTC may use the procedure outlined in Section 3.4 to modify the community branch with these changes.

In the event the modifications made by NCEP include variations to the initial DTC submittal the DTC will notify the DC of the changes made by NCEP. If any questions arise from the DC, the DTC will communicate those back to NCEP and iterate, as necessary, until a final version is agreed upon. Any code changes from the initial DTC submission to NCEP will terminate the acceptance of the current approval and reinitiate the process with the most recent modifications. Upon acceptance of the modifications, the DTC will follow the outline found in Section 4.2.1. All communication shall be documented in the GitHub issue and/or PR initially opened.

#### 4.2.3 Decline of a Community Contribution

NCEP has full authority over what is accepted into the operational UPP repository. They may, for any reason, decide to not accept a community contribution. An explanation of refusal shall be included in the notification email sent to the DTC. Any explanation of why the contribution was declined, including possible changes which would make the modification acceptable, will be supplied to the DC. The GitHub issue and/or PR will be updated to identify the contribution as existing in the community UPP repository only (submitted and declined).

The compile flag `COMMCODE` may be used to allow code to exist in the DTC repository while EMC is not ready or willing to accept the change.

## 5 Community UPP Release and Support

The DTC will be responsible for regular code releases to the community. The DTC will participate in pre-release testing and evaluation that will go beyond the limited regression tests used for on-going maintenance. The release procedure will consist of:

- The community UPP *DTC\_post* branch of the *EMC\_post* repository will be placed in a “frozen” state.
- During the “freeze” period the DC will only review bug fix contributions.
- Regular release meetings will be held during the freeze period. At the first release meeting, the additions/modifications available in the up-coming community UPP software package will be determined and documented. This document will be made available before or in conjunction with the release.

*Tags* are used to store snapshots of the community UPP package when a version is officially released to the user community. These releases include the formal annual release and any bug fixes that are posted as a code revision. In the event of numerous user contributions, at any given time *tags* may be used to help insure the order of the code changes to the repository. A user may tag a branch; however, no development is to occur in the *tags/* directory.

Community UPP users can utilize the helpdesk email account [upp-help@ucar.edu](mailto:upp-help@ucar.edu) to submit questions regarding any aspect of UPP. The DTC will serve as the frontline for this task. Although the DTC will be responsible for responding to user inquiries, developers will need to assist with inquiries that go beyond the expertise of the DTC staff. Thus, once any new feature is released, the owners of those additions will automatically become part of the support team (helpdesk) who may need to answer questions from users. Code contributors will also be responsible for supplying pertinent documentation upon submission of any new code. The DTC will be responsible for reviewing and updating official UPP documentation with each new release.

## Appendix A. CODE PRACTICES

### PREAMBLE

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The reason for putting this document together, apart from establishing some minimum standard for code quality from developers outside EMC or JCSDA, is to provide a basis for consistency amongst the many UPP developers.

One thing to remember other people will be reading and trying to understand your code – be nice to them.

### STYLE

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- Use free format syntax.
- Indentation: begin in first column for statements such as `PROGRAM`, `MODULE` and `CONTAINS`, and recursively indent all subsequent blocks by *at least* two spaces.
- Do not use tab characters – they are not part of the Fortran character set.
- Name `ENDS` fully, including the program unit name.
- When creating new code (this includes refactoring<sup>1</sup> old code), use the style guidelines above within the context of your personal style. If you use a syntax sensitive editor, as an experiment, turn off the syntax coloring to see if your code is still easily readable.
- When modifying old code, adhere to the style of the existing code.

### COMMENTS/DOCUMENTATION

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- For cryptic variable names, state description in a comment immediately preceding declaration or on end of the declaration line.
- For procedures and modules, insert a contiguous documentation block immediately following its declaration containing a *brief* overview followed by an optional detailed description.
- Ensure procedure argument documentation in the doc block is consistent with additions and/or deletions from the calling list.
- Procedure argument documentation in the doc block should briefly describe what are the arguments and their units. In some cases, this level of documentation may be unnecessary (e.g. the arguments to a generic interpolation procedure.) If in doubt, err on the side of documenting the argument list.

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<sup>1</sup> Refactoring involves improving the design of existing code. It doesn't change the observable behavior of the software; it improves its internal structure. Refactoring does not fix bugs or add new functionality. See <http://en.wikipedia.org/wiki/Refactoring> or Fowler, M., "Refactoring", 2000, Addison-Wesley.

- Document any modifications made by using a short, but descriptive, log message when checking the modified code into the software repository. Don't just say *what* has changed – since differencing versions provides that information – but *why*.
- Do not document changes within the code with comments that include the user's name or initials.

## VARIABLE DECLARATIONS

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- Declare all variables (`IMPLICIT NONE`)
- Use meaningful, understandable names for variables and parameters.
- Do not use Fortran intrinsic function names for variable names.
- Declare `INTENT` on all dummy arguments.
- Declare `DIMENSION` attribute for all non-scalars.
- Line up attributes within variable declaration blocks.
- Any scalars used to define extent must be declared prior to use.
- Declare a variable name only once in a scope, including `USE MODULE` statements.

## MODULES

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- Use modules to group related procedures and/or shared data.
- Use the `ONLY` attribute on `USE` statements as required.
- Declare `IMPLICIT NONE`.
- Include a `PRIVATE` statement and explicitly declare public attributes.

## SUBROUTINES AND FUNCTIONS

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- Group all dummy argument declarations first, followed by local variable declarations.
- Declare `INTENT` on all dummy arguments.
- To avoid null or undefined pointers, pointers passed through an argument list must be allocated.

## CONTROL CONSTRUCTS

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- Name control constructs (e.g., `DO`, `IF`, `SELECT CASE`) which span a significant number of lines or form nested code blocks.
- No numbered do-loops.
- Name loops that contain `CYCLE` or `EXIT` statements.
- Do not use `GOTO`.

- Use Fortran95-style relational symbols, e.g., >= rather than .GE., /= rather than .NE..
- For multiple selection tests, use case statements with case defaults rather than if-constructs wherever possible.

## MISCELLANEOUS

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- Always initialize pointer variables in their declaration statement using the NULL () intrinsic, e.g.  
`INTEGER, POINTER :: x => NULL ()`
- Use modules (not common blocks) for sharing large segments of data.
- Remove unused variables.
- Do not use, *if at all possible*, compiler specific functions or calls. Doing so limits portability of the code. If compiler specific functions or calls must be used, localize the impact by wrapping the compiler extensions within a generic procedure and call that generic procedure. Document the potential portability problem in the calling code.
- Always use generic, not specific, intrinsic functions, e.g. COS rather than DCOS.
- Remove code that was used for debugging purposes once the debugging is complete.
- A standard naming convention has been adopted for variables and routines which refer to tangent linear and adjoint values, use suffixes “\_tl” and “\_ad” respectively.

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APPENDIX A WAS TAKEN FROM THE BOULDER COMMUNITY GSI CODE MANAGEMENT PLAN (2009)

## Appendix B. REGRESSION TESTING

A suite of regression tests will be made available for users to run while doing development and prior to requests for committing system modifications back into the community UPP repository. These regression tests will be broken down into code functionality, allowing users to better match their modifications to an appropriate test. To aid developers in understanding the available tests and their application a brief explanation of the software architecture has been included here.

The UPP begins by reading in a file named ITAG. This file specifies the input filename, model, and input data format. There is other information in this file that will not be discussed here. Based on the model and input format, the input data is read. There is minimal calculation done at this point. The code returns to a central flow to read in the control file (*wrf\_cntrl.parm* or *postxconfig-NT.txt*) which specifies which outputs are requested. The computation of the output variables begins at this point. This processing is broken into parameter type. Output of the data occurs as the data is processed. Figure 3. UPP Code Process Flo shows the UPP code process flow.

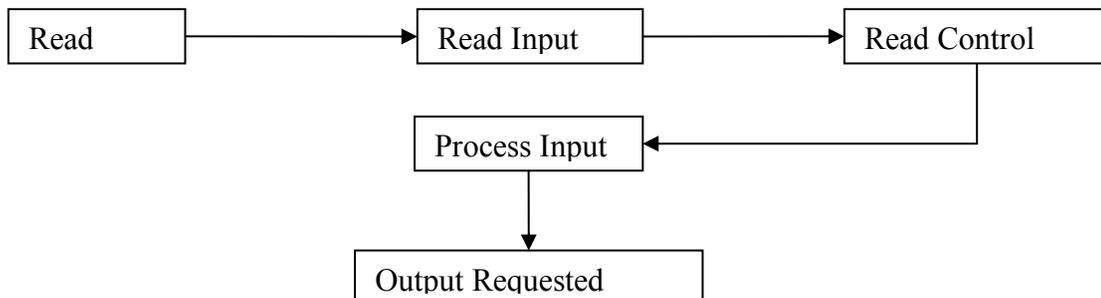


Figure 3. UPP Code Process Flow

Table 2. UPP Input Types shows the actual subroutines called to process each model and input type. UPP is currently set up to ingest model output from WRF in NetCDF format and FV3GFS in NEMSIO binary format. They are binary files with WRF and NEMSIO headers respectively to identify what model variables each record represents. UPP also has two options to read WRF binary files, the sequential read in INITPOST\*BIN and record independent MPI IO read in INITPOST\*MPIIO. When a user makes a modification based on an input type the modifications should be propagated to all routines which are affected. When testing, all routines should be verified to ascertain that their functionality has not been compromised.

<b>Model</b>	<b>Input Format</b>	<b>UPP “itag” input value</b>	<b>Read Routine</b>	
ARW / RAPR/HRRR	netCDF	netcdf	INITPOST	
ARW/RAPR	WRF binary	binarympiio	INITPOST_BIN_MPIIO	Deprecate d with V4.0
NMM	netCDF	netcdf	INITPOST_NMM	
NMM	WRF binary	binarympiio	INITPOST_NMM_BIN_MPIIO	Deprecate d with V4.0
GFS	Grib	grib	INITPOST_GFS	Deprecate d with V4.0
GFS	NEMSI O binary	binarynemsio	INITPOST_GFS_NEMS	
NMM	NEMSI O binary	binarynemsio	INITPOST_NEMS	Deprecate d with V4.0
FV3GFS	NEMSI O binary	binarynemsio mpii o	INITPOST_GFS_NEMS_MPII O	

**Table 2. UPP Input Types**

Upon successfully reading the input into the UPP data structures, processing to compute desired outputs occurs. Table 3. UPP Calculation Routines outlines a high-level representation of where variables are calculated and output.

<b>Process Routine</b>	<b>Description</b>
<b>MDLFLD</b>	Called first; initializes values used throughout / computes model surface values
<b>MDL2P</b>	Interpolates model data to pressure surfaces
<b>MDLSIGMA</b>	Additional interpolation of model data
<b>MDL2SIGMA2</b>	Additional interpolation of model data
<b>MDL2AGL</b>	Interpolates model data to AGL height surfaces
<b>SURFCE</b>	Handles surface based fields
<b>CLDRAD</b>	Handles sounding, cloud related, and model posted radiation fields
<b>MISCLN</b>	Handles TPAUSE level Z,P,T,U,V and vertical shear; max wind level Z,P, U and V; FD level T, Q, U and V; Freezing level Z and RH; constant mass (boundary) fields, LFM look-alike fields; NGM look-alike fields
<b>FIXED</b>	Handles time independent “fixed” fields

<b>MDL2THANDPV</b>	Interpolates model data to THETA and P surfaces
<b>CALRAD_WCLOUD</b>	Derives model “brightness” T using CRTM

**Table 3. UPP Calculation Routines**

Regression tests will be created to test capabilities based on model, input format, and type of parameter calculated. Note that testing related to WRF-NMM NetCDF input format is managed by the HWRF group. Table 4. Supported Platforms/Compilers/Data shows the types of models, data formats, platforms, and compilers that require testing.

		<b>NetCDF</b>		<b>binarynemsio mpiio</b>	
		<b>ARW</b>	<b>FV3GFS</b>	<b>ARW</b>	<b>FV3GFS</b>
<b>Linux - ifort</b>	serial	X	N/A	N/A	N/A
	dmpar	X	N/A	N/A	X
<b>Linux – GNU</b>	serial	X	N/A	N/A	N/A
	dmpar	X	N/A	N/A	X
<b>Linux - PGI</b>	serial	X	N/A	N/A	N/A
	dmpar	X	N/A	N/A	X

**Table 4. Supported Platforms/Compilers/Data**