Release Notes WRF-Hydro v5.0

Due to the significant number of updates since the previous WRF-Hydro v3.0 release, users with existing domain and setup files will need to adapt some files to be read by the new code. The significant updates and delayed release are attributed to the merging of the WRF-Hydro community model code base with the National Water Model (NWM) code base to provide access to many of the features of the NWM. This document provides a summary of those changes. Further details can be found in the accompanying Technical Description and user guide documentation available from our project website.

High-Level Highlights:

- New capability to aggregate and route flow with user-defined mapping over NHDPLUS catchments and reaches
- New capability to specify key hydrologic and vegetation parameters in 2 dimensions (and 3 in the case of soil properties).
- New Noah-MP surface resistance formulation that improves snowpack simulation.
- Updates to Noah-MP infiltration scheme to better handle high intensity rainfall events in fast-draining soils.
- Significant improvements to model output routines, including full CF compliance, new capabilities for applying internal scale/offset and compression to reduce file sizes, and built-in coordinate information to allow outputs to be read natively in GIS environments.
- New capability for streamflow nudging data-assimilation for the Muskingum-Cunge method
- New capability for engineering and regression testing is now available for WRF-Hydro. More information can be found here.

Details:

Namelists:

The `hydro.namelist` and `namelist.hrldas` files used to control model run options have changed. The existing v3.0 namelists should be replaced with the new files in the /template directory in the model code. The major changes are specified below.

Changes in hydro.namelist
- A new 2-dimensional file option for specifying hydrologic terrain routing parameters (HYDROTBL_F), which allows these parameter to be freely distributed across the domain as opposed to tied to a lookup table.
- The option to provide a Geospatial land metadata file "LAND_SPATIAL_META_FLNM" to write out CF compliant files. This can be generated by the *WRF-Hydro ArcGIS Pre-Processing Toolkit* under "Build Spatial Metadata file". Note: any spatial metadata file created before November, 2016 will need to be re-created due to an added attribute in the x/y variables. If this file is not provided, the output will **not** be CF compliant but the model will still run.
- io_form_outputs option: file outputs can now provide flexibility in the format of output (compressed, scale factor/add offset, etc.).
- The io_config_outputs option is used for switching between different predefined output variable sets

- New option to differentiate channel inflow components into surface and groundwater bucket model contributions in the model output (output_channelBucket_influx).
- New capability to specify distinct timesteps for channel (DTRT_CH) and terrain (DTRT_TER) routing modules.
- The UDMP_OPT and associated udmap_file option for allowing user-defined mapping such as the NHDPlus network used in the National Water Model (NWM).
- New options to support streamflow nudging data assimilation.

Output options: new features in the hydro.namelist
- frxst_pts_out: An option to turn on and off forecast points for gridded routing has been created. When frxstpts = 1 AND the user has specified frxstpts in the Fulldom_hires file generation (using the WRF-Hydro GIS Pre-processing Tool), then a `frxstpts_out.txt` file will be generated.
- CHANOBS_DOMAIN: An option to output frxstpts in netcdf format has been created. Control this option by specifying the CHANOBS = 1 (will output) and CHANOBS = 0 (off). The CHANOBS file will output streamflow at the frxstpts specified in the `Fulldom_hires.nc` file.
- output_gw: GW files can be output independently.
- The RTOUT files now have geospatial data appended, making it much easier to work with these files in GIS.

Changes in namelist.hrldas
- New option to specify key vegetation and surface properties in 2 dimensions and soil properties in 3 dimensions. This allows much more user flexibility in how these parameters are assigned and calibrated.
- Specification (dependency) of the geogrid file has been removed

Changes to parameter files
The following supplemental domain parameter files are new or have updates since the last release: `wrfinput_d0x.nc, soil_properties.nc,` and `hydro2dtbl.nc`
- New `soil_properties.nc` file, which can be created using the provided R script `create_soilProperties.R`. Note: the `soil_properties.nc` file is only active (and required) if the SPATIAL_SOIL compile option is selected. If the compile option is set to 0, the model will read from SOILPARM.TBL. The creation of this file has a dependency on "R" and several of its libraries.
- The model can now read a `hydro2dtblnc` file (HYDROTBL_F) instead of the `HYDRO.TBL` file, which enables easy manipulation of parameters. The model will create one for you if it is not provided, or if you use the R script to generate the `soil_properties.nc` file, it will also create the `hydro2dtbl.nc` file.
- Changes to the `wrfinput_d0x.nc` file to ensure consistency between the geogrid and the initial land surface model states. A new `wrfinput_d0x.nc` file is required due to some variable changes and can be generated using the `create_Wrfinput.R` script. Note: the v3.0 shell script for creating the `wrfinput_d0x.nc` file from the geogrid will not work for v5; use the v5 script provided on the [WRF-Hydro website](#). The creation of this file has a dependency on "R" and the "netCDF4" library. This script is currently only compatible with the Noah-MP land surface model.
- The water and urban land cover type flags are now read from geogrid file global attributes, allowing flexibility to use classification systems other than the previously supported USGS (e.g., MODIS).

Changes in Lakes

- For gridded routing (channel_option = 3) or Muskingum-Cunge routing with user-defined mapping active (channel_option = 2 and UDMP_OPT = 1), a LAKEPARM file can now be read in either in .TBL format or .nc format. The *WRF-Hydro GIS Pre-processing Toolkit* will generate either or both. Note that variable names have changed and to convert to the new format, use the `convert_LAKEPARM_to_V5.0.sh` script available on the website. Note: that lakes will not run at this time using reach-based routing (channel_option=2) unless paired with user-defined mapping (UDMP_OPT=1). Namelist checks will prevent users from running with a LAKEPARM supplied and channel_option=2 selected.

Groundwater

- The model now reads in netCDF versions of the GWBUCKPARM file and `gw_basins_geogrid.txt` file. These are required for running groundwater (GWBASESWCRT options 1 and 2). The *WRF-Hydro GIS Pre-processing Toolkit* can generate these files using a tool in the Utilities called "Build GWBUCKPARM Table": See details in the *WRF-Hydro GIS Pre-processing Toolkit* documentation for options for how to generate this file.

Bug Fixes

- A bug in the gridded lake code was fixed to properly translate inflows and outflows.
- An error in the calculation of the trapezoidal celerity for Muskingum-Cunge was corrected.
- An error in soil moisture accounting in the subsurface flow module was fixed.
- Accumulated variables in a few locations in the code were converted to single timestep accounting to minimize machine truncation errors on large values.
- Fixed issue with energy calculations that was leading to above freezing temperatures for very shallow snowpacks.