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From: Bob Maxson
Acting Director
National Centers for Environmental Prediction

Subject: Upgrade of National Water Model
Effective: June 19, 2019

Effective on or about June 19, 2019, beginning with the 1200 Coordinated Universal Time (UTC) run, the National Centers for Environmental Prediction (NCEP) will begin operationally running version 2.0 of the National Water Model (NWM) and the post-processing application.

The NWM is an hourly cycling uncoupled analysis and forecast system that provides streamflow for over 2.7 million river reaches and other hydrologic information on grids ranging in resolution from 100m to 1km. NWM provides complementary hydrologic guidance at current NWS River Forecast Center (RFC) river forecast locations and significantly expanded guidance coverage and type in underserved locations.

The NWM ingests forcing from a variety of sources including Multi-Radar Multi-Sensor (MRMS) radar-gauge and Stage IV Multisensor Precipitation Estimator (MPE) observed precipitation data, along with High-Resolution Rapid Refresh (HRRR), Rapid Refresh (RAP), North American Model High-Resolution Nest (NAM-

Nest), Global Forecast System (GFS) and Climate Forecast System (CFS) Numerical Weather Prediction (NWP) forecast data.

U.S. Geological Survey (USGS) real-time streamflow observations are assimilated and all NWM configurations benefit from the inclusion of ~5,461 reservoirs. The core of the NWM system is the National Center for Atmospheric Research (NCAR)-supported community Weather Research and Forecasting (WRF)-Hydro hydrologic model.

WRF-Hydro is configured to use the Noah Multi-Parameterization (Noah-MP) Land Surface Model (LSM) to simulate land surface processes. Separate water routing modules perform diffusive wave surface routing and saturated subsurface flow routing on a higher-resolution grid, and Muskingum-Cunge channel routing down NHDPlusV2 stream reaches. River analyses and forecasts are provided across a domain encompassing the continental US (CONUS), Hawaii and additional hydrologically-contributing areas. Land surface output is available on a larger CONUS+ domain that extends beyond the CONUS into Canada and Mexico (roughly from latitude 19N to 58N) and covers Hawaii as well. In addition, NWM forcing datasets are provided on this domain at a resolution of 1km.

The NWM post-processing application ingests NWM raw channel, land forecast and forcing files and then creates subset data files and derived variables for the RFCs. The subsetting of data is intended to reduce system and network resource usage in obtaining NWM critical data of interest.

(A) List of Enhancements in the Model Version 2.0

-Addition of an Extended Analysis configuration (daily 28-hour look-back using RFC-based MPE precipitation from NCEP Stage IV dataset)

-Addition of Hawaii to NWM domain (including 3-hr Analysis and 60-hr Short-Range forecast--both forced by the NAM-Nest NWP model)

-Addition of a separate Long-Range Analysis configuration to initialize the Long Range forecast
-Addition of a Medium-Range ensemble forecast configuration (7 members 4 x day) (mem1=uses current GFS to 10 days, mem2-7=use time lagged GFS out to 8.5 days)
-Use of 13km GFS forcing (versus 0.25 degree in NWM V1.2)
-Improved downscaling of GFS and CFS forcing via RFC Mountain Mapper-based approach
-Improved physics (out-of-bank parameterization via compound channel, improved snow physics)
-Improved and expanded calibration of hydrologic parameters
-Corrections to stream connectivity
-Improved code modularity
-Refined land surface and hydrologic parameters by expanding calibration from ~1100 to ~1400 calibration basins and improving parameter regionalization process.
-Various hydrofabric improvements including:
-Fixes to 37 stream breaks
-Addition of 13,637 new flowlines (Hawaii stream reaches)
-Addition of OCONUS basins in the Hawaii domain (16,625 km2)
-Addition of 58 USGS stream gauges into assimilation routine (Hawaii domain)
-Addition of 3,955 CONUS reservoirs (now totaling 5,461)
-Addition of 10 new reservoirs in the Hawaii domain.
-Inclusion of a new elevation base that is harmonized with the NHDPlus channel network

(B) Model Output Changes
Data is available on the NCEP web services here:
https://nomads.ncep.noaa.gov/pub/data/nccf/com/nwm
ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/nwm
https://ftp.ncep.noaa.gov/data/nccf/com/nwm

1) New variable, "time", with attributes of "valid_min" and "valid_max" added to all model output and forcing files
2) GDAL-style "crs" variable that provides information on the Coordinate Reference Systems added to non-forcing files, replacing ProjectionCoordinateSystem variable.

3) T2D variable: missing and fill value changed from -999900 to -1009900 in Analysis forcing files

4) Q2D variable: long name changed to "2-m Specific Humidity, dimensionless ratio of the mass of water vapor (kg) to the total mass of the system (kg) "

5) SNOWH variable: missing and fill value changed from -9999000 to -99990000 in Analysis and Assimilation land output files

6) zwattablrt: valid range 0,100 changed to 0,1000 in Analysis and Assimilation terrain output files

7) UGDRNOFF: valid range changed from -500, 3000000 to -10000, 10000000 in Long-Range land output files

8) ACSNOM:

a) fill and missing value changed from -99990 to -999900

b) scale factor changed from 0.1f to 0.01f

c) valid range changed from 0, 1000000 to 0, 10000000 in Medium-Range and Long-Range land output files

9) ACCET: valid range changed from -100000, 1000000 to -100000, 100000000 in Long-Range land output files

10) SOILSAT and SOILSAT_TOP units changed from "fraction" to "1" in Long-Range land output files

11) Removed nv=2 dimension from Analysis and Assimilation, Short-Range and Medium-Range forcing files

12) T2D variable: missing and fill values changed from -999900 to -1009900 in Medium-Range forcing files

13) UGDRNOFF, ACCECAN, ACCEDIR, ACCETRAN variables: valid range change from -500, 3000000 to -10000, 10000000 in Medium-Range land output files

14) TRAD variable: valid range change from -10000, 10000 to 0, 4000 in Medium-Range land output files

15) SNLIQ valid range change from -50, 300000 to 0, 10000000, fill and missing values changed from -99990 to -999900, scale factor change from 0.1f to 0.01f in Medium-Range land output files

16) SNOWH valid range change from 0, 99999992 to 0, 1000000, fill and missing values changed from -9999000 to -99990000, scale factor changed for 0.001f to 0.0001f in Medium-Range land output files

17) ISNOW valid range changed from -10, 10 to 0, 10 in Medium-Range land output files

18) ACSNOM missing and fill values changed from -99990 to -999900, scale factor changed from 0.1f to 0.01f, valid range changed from 0, 1000000 to 0, 10000000 in Medium-Range land files

19) ACCET valid range changed from -100000, 1000000 to -100000, 100000000 in Medium-Range land files

20) SOILICE and SOILSAT_TOP units changed from "fraction" to "1" in Medium-Range land files

21) zwattablrt: valid range 0,100 changed to 0,1000 in Medium-Range terrain files

22) T2D variable: missing and fill values changed from -999900 to -1009900 in Short-Range forcing files

23) SOILSAT_TOP units changed from "fraction" to "1" in Short-Range land files

24) ACCET valid range changed from -100000, 1000000 to -100000, 100000000 in Short-Range land files

25) SNOWH valid range change from 0, 99999992 to 0, 1000000, fill and missing values changed from -9999000 to -99990000, scale factor changed for 0.001f to 0.0001f in Short-Range land files

26) zwattablrt: valid range 0,100 changed to 0,1000 in Short-Range terrain files

27) New variables are added to the preexisting Analysis, and new Extended and Long-Range Analysis and Assimilation configurations:

- "SNLIQ" is snow layer liquid water (units: mm)
- "ISNOW" is number of snow layers (units: count)
- "SOIL_M" is volumetric soil moisture (units: m3 m-3)
- "SOILICE" is fraction of soil moisture that is ice (units: 1)
- "SOIL_T" soil temperature (units: K)

28) qSfcLatRunoff and qBucket: fill value and missing value changed from -9999000 to -999900000, units changed from m3 to m3 s-1, scale factor changed from 0.001f to 1.e-05f, valid range changed from 0, 499999968 to 0, 2000000000 in Analysis and Assimilation and Short Range channel files.

29) SFCRNOFF: valid range changed from 0, 29999998 to 0, 100000000 in Long Range land files.

(C) Model Directory and Filename Changes on NCEP Web Services

-Medium range products are moved out of medium_range/ and into medium_range_memM/ where M is member number 1-7.

-Medium range filenames are changing to reflect the ensemble member that originated the data:

nwm.tCCz.medium_range.channel_rt.fHHH.conus.nc ->
nwm.tCCz.medium_range.channel_rt_M.fHHH.conus.nc
nwm.tCCz.medium_range.land.fHHH.conus.nc ->
nwm.tCCz.medium_range.land_M.fHHH.conus.nc
nwm.tCCz.medium_range.reservoir.fHHH.conus.nc ->
nwm.tCCz.medium_range.reservoir_M.fHHH.conus.nc
nwm.tCCz.medium_range.terrain_rt.fHHH.conus.nc ->
nwm.tCCz.medium_range.terrain_rt_M.fHHH.conus.nc
Where CC is cycle, M is ensemble member, and HHH is forecast hour

-New Hawaii Analysis and Hawaii Short-Range forecast products will go into their own directories:

analysis_assim_hawaii/
nwm.tCCz.analysis_assim.channel_rt.tm##.hawaii.nc
nwm.tCCz.analysis_assim.land.tm00.hawaii.nc
nwm.tCCz.analysis_assim.reservoir.tm##.hawaii.nc
nwm.tCCz.analysis_assim.terrain_rt.tm##.hawaii.nc
Where CC is cycle (00-23) and ## is 00-02
forcing_analysis_assim_hawaii/
nwm.tCCz.analysis_assim.forcing.tm##.hawaii.nc
Where CC is cycle and ## is 00-02
short_range_hawaii/
nwm.tCCz.short_range.channel_rt.f###.hawaii.nc
nwm.tCCz.short_range.land.f###.hawaii.nc
nwm.tCCz.short_range.reservoir.f###.hawaii.nc
nwm.tCCz.short_range.terrain_rt.f###.hawaii.nc
Where CC is cycle (00,06,12,18) and ## is 001-060
forcing_short_range_hawaii/

nwm.tCCz.short_range.forcing.f###.hawaii.nc
Where CC is cycle (00,06,12,18) and ### is 001-060

-New CONUS Extended and Long-Range Analyses products will go into new directories:

analysis_assim_extend/
nwm.tCCz.analysis_assim_extend.channel_rt.tm##.conus.nc
nwm.tCCz.analysis_assim_extend.land.tm##.conus.nc
nwm.tCCz.analysis_assim_extend.reservoir.tm##.conus.nc
nwm.tCCz.analysis_assim_extend.terrain_rt.tm##.conus.nc
Where CC is cycle (16) and ##is 00-27

forcing_analysis_assim_extend/
nwm.tCCz.analysis_assim_extend.forcing.tm##.conus.nc
Where CC is cycle (16) and ### is 00-27

analysis_assim_long/
nwm.tCCz.analysis_assim_long.channel_rt.tm##.conus.nc
nwm.tCCz.analysis_assim_long.land.tm##.conus.nc
nwm.tCCz.analysis_assim_long.reservoir.tm##.conus.nc
Where CC is cycle (00,06,12,18) and ## is 00-11

(D) Post-Processing Output Changes

Data is available on NCEP Web Services here:
https://nomads.ncep.noaa.gov/pub/data/nccf/com/nwm/post-processed/

- New NWM 2.0 ‘crs’ variable (Coordinate Reference System) replaces the Projection Coordination System variable in all netcdf data file output land files

- Bug fixed TEMPERATURE variable, intended unit conversion from Kelvin to Celsius was not working previously

- Changed title of static imagery generated from the NWM land forecast SOILSAT_TOP variable to include “Soil Saturation” in place of “Soil Moisture”

- Medium-Range products now include an ensemble member identifier in the filename:
nwm.tYYYYMMDDCCz.medium_range.channel_rt.GRID.nc

-> nwm.tYYYYMMDDCCz.medium_range.channel_rt_#.GRID.nc
Where YYYYMMDDCC is year, month, day and cycle, where # is (1 or 2) ensemble member, and where GRID is the grid output area.

- New RFC output created for the Alaska-Pacific River Forecast Center (including Hawaii) on the NCEP Web Services here:
../nwm/post-processing/RFC/AP

End users are able to view the output via the interactive map and image viewer on the Office of Water Prediction (OWP) website:
https://water.noaa.gov/about/nwm
Additionally, the full set of raw NWM model output and a subset of the post-processing forcing files are available on NCEP web services.

Users should refer to the V1.2, V1.1 and V1.0 SCNs/TINs for information on the other unchanged filename and directory structures.

https://www.weather.gov/media/notification/tins/tin16-30natl_water_model.pdf
https://www.weather.gov/media/notification/pdfs/scn17-41natl_water_modelaaa.pdf
https://www.weather.gov/media/notification/pdfs/scn18-16national_water_model.pdf

As in V1.2, users will find that long range products have enough of a lag time in creation that they may appear in the previous day's output directory. For example, long range mem 1 products for the 18z cycle will not show up until the day after their initialization time. For this reason, users are encouraged to look back in the previous dated directory for long range product availability.

Most NWM NetCDF output files are directly viewable using standard NetCDF visualization utilities. The exceptiond are the point-type NWM channel output files containing streamflow and other variables. In particular, due to storage space

limitations, the latitude and longitude of each point are stored outside of the file, but are available at:

http://www.nohrsc.noaa.gov/pub/staff/keicher/NWM_live/web/data_tools/NWM_nc_tools.tar.gz

This archive contains an ESRI file geodatabase (gdb), which provides full geospatial information for all NWM stream reaches. The gdb file can easily be used with ESRI ArcGIS software, and other GIS software, to associate the correct geospatial data with NWM channel_rt data by feature_id. A full text description of the gdb contents and basic use instructions are available as a separate file in the archive.

A consistent parallel feed of NWM model data is available on the NCEP server via the following URLs:
https://para.nomads.ncep.noaa.gov/pub/data/nccf/com/nwm/para
And here for the parallel post-processed data:
https://nomads.ncep.noaa.gov/pub/data/nccf/com/nwm/para/post-processed/

NCEP encourages all users to ensure their decoders are flexible and are able to adequately handle changes in content order and also any volume changes which may be forthcoming. These elements may change with future NCEP model implementations. NCEP will make every attempt to alert users to these changes prior to any implementations.

For more general information about the NWM, please see:
http://water.noaa.gov/about/nwm

Any questions regarding this implementation should be directed below. We will evaluate any feedback and decide whether to proceed.

For questions on the science aspects, please contact:

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NWS National Service Change Notices are online at:
https://www.weather.gov/notification/

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