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Service Change Notice 20-46 Updated
National Weather Service Headquarters Silver Spring MD
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From: Brian Gross
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National Center for Environmental Prediction

Subject: Updated: Upgrade to the RAP and HRRR Analysis and Forecast System, including change to location of North America Rapid Refresh Ensemble (NARRE) data Effective December 2, 2020

Updated to change the implementation date to December 2, 2020.

Effective on or about December 2, 2020, beginning with the 1200 Coordinated Universal Time (UTC) run, the National Centers for Environmental Prediction (NCEP) will implement Version 5 of the Rapid Refresh (RAP) and Version 4 of the High-Resolution Rapid Refresh (HRRR) systems.

Major Changes will include:
- Updated versions of the Advanced Research WRF core of the Weather Research and Forecasting Model (WRF-ARW) model, the Gridpoint Statistical Interpolation (GSI) analysis code, and the Unified Post Processor (UPP)
- Extended forecast length for four RAP and four HRRR cycles each day
- Introduction of a storm-scale ensemble data assimilation component for the CONUS HRRR
- Explicit handling of wildfire smoke and new smoke output
- Numerous data assimilation changes

- New lake model for small lakes
- Assimilation of NOAA Great Lakes Environmental Research Laboratory (GLERL) water temperatures and ice concentration for the Great Lakes in the CONUS HRRR
- Move the North America Rapid Refresh Ensemble (NARRE) data out of RAP directory structure and into its own area

A) Analysis Changes

- The RAP and HRRR will both use an updated version of the Gridpoint Statistical Interpolation (GSI) analysis code.
- The CONUS HRRR will begin using a HRRR Data Assimilation System (HRRRDAS), a storm-scale (3km) ensemble data assimilation process in which 36 members are integrated for one hour, and ensemble Kalman Filter data assimilation is performed including direct reflectivity assimilation. The ensemble mean then provides the initial conditions for the HRRR spin-up and analysis process. The Alaska HRRR will continue to use initial conditions from the RAP.
- The CONUS HRRR will use the GLERL temperatures and ice concentrations for the Great Lakes.
- The assimilation of GOES-16 radiances, TC Vitals for tropical cyclone position/intensity, VIIRS/MODIS fire radiative power observations, and aircraft and raob moisture observations at pressures lower than 300 hPa will be added to the RAP and HRRR.

B) Changes to Model

- The RAP and HRRR will both begin using WRF version 3.9.1; both will continue to use the ARW core.
- The RAP and HRRR will both use a new model for temperatures for small lakes (smaller than the Great Lakes).
- The RAP and HRRR will use an improved version of the MYNN PBL scheme, enhanced gravity wave drag, and reduced 6th-order diffusion (especially for hydrometeor fields).
- The HRRR will use an implicit-explicit vertical advection (IEVA) scheme to permit stronger convective updrafts with the same model time step and allow removal of a limit to the microphysical latent heating rate.

- The HRRR model top will be raised from 20 hPa to 15 hPa resulting in a slight upward shift of the pressure for the native model level sigma values.
- The RAP will use an enhanced version of the Grell-Freitas convective scheme.
- The RAP and HRRR will use radiation modifications that better account for subgrid clouds.
- The RAP and HRRR will have sources and sinks for aerosols and the explicit transport of smoke.

C) Evaluation Web Site

The formal evaluation of RAPv5 and HRRRv4 was led by EMC's Model Evaluation Group (MEG). Links to information about the upgrade, presentations on the evaluation, verification statistics, and graphics from retrospective runs can be found on the web site for the evaluation:
https://www.emc.ncep.noaa.gov/users/meg/rapv5_hrrrv4/

For more general information about the RAP and HRRR, please see:
http://rapidrefresh.noaa.gov

D) Extended Cycles and Product Delays

- The RAP and HRRR will be extending the forecast length of the four cycles per day that are already extended beyond the standard forecast length (18 hours for HRRR and 21 hours for RAP). The RAP will be extended out to 51 hours for the 03, 09, 15, and 21 UTC cycles. The HRRR (both CONUS and Alaska) will be extended out to 48 hours for the 00, 06, 12, and 18 UTC cycles. The HRRR sub-hourly output, however, will not cover these forecast extensions; it will continue to be available only through hour 18 for all cycles. These forecast extensions will facilitate being able to extend HREF products to 48 hours in Version 3, scheduled to be implemented in FY2021.

- Due to the addition of the HRRRDAS, HRRR analysis products will be delivered approximately 5-8 minutes later than they currently are. For all cycles that are run to only 18 hours,

these product delays will persist through the length of the forecast. For the cycles extended to 48 hours, however, the forecast job is run with more nodes, such that by around forecast hour 15, the product delivery time will become earlier than currently in ops. The amount of earlier delivery increases with forecast length, such that the forecast hour 36 products will become available approximately 10 minutes earlier than currently in operations.

E) Output Changes on NCEP Web Services

Table 1: RAP Grid definitions

Abbreviation	Definition
wrfprs	13-km full domain pressure level
wrfnat	13-km full domain native level
awip32	32-km full domain
awp130pgrb	13-km CONUS pressure level
awp130bgrb	13-km CONUS native level
awp200	16-km Puerto Rico pressure level
awp243	Eastern North Pacific lat-lon
awp242	11-km Alaska pressure level
awp252pgrb	20-km CONUS pressure level
awp252bgrb	20-km CONUS native level
awp236pgrb	40-km CONUS pressure levels

Table 2: HRRR Grid definitions

wrfprs	pressure level output
wrfnat	native level output
wrfsfc	surface level output
wrfsubh	sub-hourly output

1. New RAP and HRRR smoke products

a) Surface smoke concentration (MASSDEN at 8m above ground level) added to the following files

- rap.tCCz.XXXfHH.grib2

Where CC is cycle, XXX is awp242, awip32, awp130bgrb, awp130pgrb, awp243, wrfnat, or wrfprs, and HH is forecast hour

- DOMAIN/hrrr.tCCz.XXXfHH.grib2
  Where DOMAIN is alaska and conus, CC is cycle, XXX is wrfnat, wrfprs, or wrfsfc, and HH is forecast hour

b) Full 3-D profile of smoke concentrations (MASSDEN at all levels) added to the following files

- rap.tCCz.XXXfHH.grib2
  Where CC is cycle, XXX is awp130bgrb or wrfnat, and HH is forecast hour
- DOMAIN/hrrr.tCCz.wrfnatfHH.grib2
  Where DOMAIN is alaska and conus, CC is cycle, and HH is forecast hour

2. Removal of Vertical Profile of Total Cloud Cover (TCDC) on RAP and HRRR native level output

The full vertical profile of total cloud cover percentage on native levels is removed in the RAP and HRRR, as both already contain a fraction of cloud cover parameter. This is the case for the following files

- rap.tCCz.wrfnatfHH.grib2
  Where CC is cycle and HH is forecast hour
- DOMAIN/hrrr.tCCz.wrfnatfHH.grib2
  Where DOMAIN is alaska and conus, CC is cycle, and HH is forecast hour

3. New RAP parameters in multiple files

- rap.tCCz.XXXfHH.grib2
  Where CC is cycle, XXX is awp242, awip32, awp130pgrb, or wrfprs, and HH is forecast hour

a) Cloud Fraction in the Planetary Boundary Layer (TCDC)
b) Depth of Layer Supporting Dendritic Growth (LAYTH) at layer depth between 256 and 261K

- rap.tCCz.XXXfHH.grib2
  Where CC is cycle, XXX is awip32, awp130pgrb, or wrfprs, and HH is forecast hour

a) Convective Available Potential Energy (CAPE) in the 0-3000 meter above ground layer
b) Effective Storm-Relative Helicity (discipline=0 center=7 local_table=1 parmcat=7 parm=204) at the surface

c) Critical Angle (discipline=0 center=7 local_table=1 parmcat=7 parm=206) at 0-500 m above ground
d) Enhanced Stretching Potential (discipline=0 center=7 local_table=1 parmcat=7 parm=205) 0-3000 m above ground

- rap.tCCz.XXXfHH.grib2
  Where CC is cycle, XXX is awip32, awp130bgrb, awp200, awp236pgrb, awp243, awp252bgrb, awp252pgrb, or wrfnat, and HH is forecast hour
a) Freezing Rain (FRZR) accumulation

- rap.tCCz.XXXfHH.grib2
  Where CC is cycle, XXX is awp130bgrb, awp200, awp243, or awp252bgrb, and HH is forecast hour
a) Categorical Freezing Rain (CFRZR)

- rap.tCCz.XXXfHH.grib2
  Where CC is cycle, XXX is awip32, awp130pgrb, or wrfprs, and HH is forecast hour
a) Height of the level of Free Convection (HGT no_level) (Height at fixed surface type 14)

- rap.tCCz.XXXfHH.grib2
  Where CC is cycle, XXX is wrfnat or wrfprs, and HH is forecast hour
a) Aerosol Optical Thickness (AOTK) for the entire atmosphere (considered as a single layer)
b) Column-Integrated Mass Density (COLMD) for the entire atmosphere (considered as a single layer)
c) Cloud Forcing Net Solar Flux (CFNSF)

4. New RAP parameters in 13-km full domain pressure level files only
- rap.tCCz.wrfprsfHH.grib2
  Where CC is cycle, and HH is forecast hour
a) Vegetation Fraction (VEG) at the surface
b) Radar-based vertically integrated liquid water (RADARVIL) (discipline=0 center=7 local_table=1 parmcat=16 parm=201) entire atmosphere
c) Annual Maximum Vegetation Fraction (discipline=2 center=7 local_table=1 parmcat=0 parm=231) at the surface

d) Annual Minimum Vegetation Fraction (discipline=2 center=7 local_table=1 parmcat=0 parm=232) at the surface
e) Leaf-Area Index (LAI) at the surface

5. New RAP parameters in 13-km full domain native level files only
 - rap.tCCz.wrfnatfHH.grib2
     Where CC is cycle, and HH is forecast hour
a) Total Column-Integrated Cloud Water (TCOLW)
b) Total Column-Integrated Cloud Ice (TCOLI)

6. New HRRR parameters in multiple files for Alaska and CONUS domains
 - hrrr.tCCz.XXXfHH.grib2
      Where CC is cycle, XXX is wrfnat, wrfprs, or wrfsfc and HH is forecast hour
a) Aerosol Optical Thickness (AOTK) for the entire atmosphere (considered as a single layer)
b) Column-Integrated Mass Density (COLMD) of smoke for the entire atmosphere (considered as a single layer)
c) Mean Satellite-detected Fire Radiative Power (FRP; labeled as Cloud Forcing Net Solar Flux (CFNSF))

 - hrrr.tCCz.XXXfHH.grib2
      Where CC is cycle, XXX is wrfsfc or wrfsubh, and HH is forecast hour
a) Radar-based vertically integrated liquid water (RADARVIL) (discipline=0 center=7 local_table=1 parmcat=16 parm=201) entire atmosphere
b) Total Column-Integrated Cloud Water (TCOLW)
c) Total Column-Integrated Cloud Ice (TCOLI)

7. New HRRR parameters in surface level files for Alaska and CONUS domains
 - hrrr.tCCz.wrfsfcfHH.grib2
      Where CC is cycle and HH is forecast hour
a) Vertical Velocity (DZDT) at 700 hPa
b) Surface Max Hail Size (HAIL)
c) Lightning Potential Index (LPTINX) (discipline=0 master_table=2 parmcat=17 parm=1) at 1m and 2m above ground
d) Vegetation Fraction (VEG) at the surface

e) Annual Maximum Vegetation Fraction (discipline=2 center=7 local_table=1 parmcat=0 parm=231) at the surface
f) Annual Minimum Vegetation Fraction (discipline=2 center=7 local_table=1 parmcat=0 parm=232) at the surface
g) Leaf-Area Index (LAI)
h) Total Boundary Layer Cloud (TCDC boundary layer cloud layer)

8. New HRRR parameters in sub-hourly files for Alaska and CONUS domains
 - hrrr.tCCz.wrfsubhfHH.grib2
      Where CC is cycle and HH is forecast hour
a) Accumulated Precipitation (APCP)
b) Water Equivalent of Accumulated Snow Depth (WEASD)
c) Accumulated Sleet (labeled as Frozen Rain (FROZR))

9. New HRRR parameters in multiple files for CONUS domain only
 - hrrr.tCCz.XXXfHH.grib2
      Where CC is cycle, XXX is wrfnat, wrfprs, or wrfsfc and HH is forecast hour
a) CAPE in the 0-3000 m above ground layer
b) Effective Storm-Relative Helicity (discipline=0 center=7 local_table=1 parmcat=7 parm=204) at the surface
c) Critical Angle (discipline=0 center=7 local_table=1 parmcat=7 parm=206) at 0-500 m above ground
d) Depth of Layer Supporting Dendritic Growth (LAYTH) at layer depth between 256 and 261K
e) Enhanced Stretching Potential (discipline=0 center=7 local_table=1 parmcat=7 parm=205) 0-3000 m above ground
f) Height of the level of Free Convection (HGT no_level) (Height at fixed surface type 14)

10. Addition of Volumetric Soil Moisture Content Fraction (SOILW) at 0-0 m below ground and 0.01-0.01 m below ground to alaska/hrrr.tCCz.wrfnatfHH.grib2
      Where CC is cycle, HH is forecast hour

11. Move of North America Rapid Refresh Ensemble (NARRE) data to standalone directory structure
  NARRE output will move from com/rap/prod/narre.YYYYMMDD to com/narre/prod/narre.YYYYMMD on all NCEP web services
      Where YYYY is year, MM is month, and DD is day

12. All rap_eh.YYYYMMDD directories will be removed. Users are encouraged to use the files under rap_e.YYYYMMDD as replacements.

13. Creation of index files for all RAP wrfprs grids will be added with the name format rap.tCCz.wrfprsfHH.grib2.idx

F. Changes to existing parameters

1. Change to Cloud-Base Height/Pressure

The cloud base height/pressure fields will include use of a sub-grid-scale cloud fraction as a means to determine the cloud base height instead of relying upon only explicit cloud hydrometeor values from the microphysics. The cloud ceiling field diagnostic remains unchanged.

2. Change to Cloud-Cover Percentages

The low, middle, high, and total cloud cover percentages will now include use of a sub-grid-scale cloud fraction in model column layers to determine cloud-cover percentages instead of using only explicit cloud hydrometeor coverage across a large celestial dome.

G. Changes to data on NOAAPORT

There will be no changes to the contents of RAP and HRRR data on NOAAPORT/SBN, but the product timing changes discussed earlier in this change notice will affect the delivery times of the HRRR products on NOAAPORT/SBN.

H. Parallel Data Available

A consistent parallel feed of data will become available on the NCEP server via the following URLs:
https://para.nomads.ncep.noaa.gov/pub/data/nccf/com/hrrr/para
https://para.nomads.ncep.noaa.gov/pub/data/nccf/com/rap/para
https://para.nomads.ncep.noaa.gov/pub/data/nccf/noaaport/

For more general information about the RAP and HRRR, please see:
http://rapidrefresh.noaa.gov

NCEP urges all users to ensure their decoders can handle changes in content order, changes in the scaling factor component within the product definition section (PDS) of the GRIB files, and volume changes. These elements may change with future NCEP model implementations. NCEP will make every attempt to alert users to these changes before implementation.

NCEP will evaluate all comments to determine whether to proceed with this upgrade.

For questions regarding this implementation, please contact:

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

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