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PNSWSH

Service Change Notice 20-75
National Weather Service Headquarters Silver Spring MD
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To: Subscribers:
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 -NOAA Weather Wire Service
 -Emergency Managers Weather Information Network
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From: Brian Gross
 Acting Director
 National Centers for Environmental Prediction

Subject: Announcement of upgrade to the Global Ensemble
 Forecast System (GEFS), coupled with the Global Wave
 Ensemble System (GWES) and the NEMS GFS Aerosol
 Component (NGAC), effective September 23, 2020, and
 request for comments.

Effective on or about Wednesday, September 23, 2020, beginning with the 1200 Coordinated Universal Time (UTC) run, the NCEP Global Ensemble Forecast System (GEFS) will be updated from Version 11.3 to Version 12.0.

The GEFSv12 upgrade includes implementation of Finite Volume Cubed Sphere (FV3) dynamical core, and integration of wave (GWESv3.0.9) and aerosol (NGACv2.5.1) components via coupling following the Unified Forecast System (UFS) framework.

Specifics are below, and additional science and technical information can be obtained from the Public Information Notice 20-07 released on March 4 2020:

<https://www.weather.gov/media/notification/pns20-07gefs.pdf>

A. Specifics on Upgrade of Atmospheric Component

- * Use the latest Global Forecast System (GFS) model with the FV3 dynamical core (GFSv15.1), replacing the Global Spectral Model (GSM v12.1).
- * Upgrade the physical parameterization schemes to those implemented with GFSv15.1 including new Geophysical Fluid Dynamics Laboratory (GFDL) microphysics.
- * New perturbation techniques including 5-scale Stochastic Perturbation of Physical Tendencies (SPPT) scheme and Stochastic Kinetic Energy Backscatter (SKEB) scheme.
- * Expand the number of ensemble members from 21 (20 perturbed and 1 unperturbed/control) to 31 (30 perturbed and 1 unperturbed/control) members.

- * Increase model horizontal resolution to 0.25 degree (~25 km) and maintain the same resolution throughout the forecast period for the atmosphere.
- * Improved interpolation of grib2 files from the model's native Gaussian grid (see Note on Interpolation below).
- * Removal of lower resolution output, and inclusion of new 0.25 deg output onto NCEP web services.
- * Provide the capability for weeks 3-4 forecast guidance for atmospheric model only. Once a day at the 00Z cycle, the forecast length will extend to 35 days with the same 31 ensemble members and uniform horizontal resolution.

B. Specifics on Upgrade and Integration of Wave Ensemble

This upgrade includes integration of the Global Wave Ensemble System (GWES) via one-way coupling to the atmospheric model using NEMS mediator. The GWES becomes GEFsv12-wave with the following changes:

- * Spherical spatial grid with increased resolution from 0.5 to 0.25 degree on average.
- * Increase in number of members from 21 to 31.
- * Extended forecast range from 10 to 16 days.
- * Increased wind field intake stride from 3h to 1h due to coupling.
- * Improved physics from source-term coefficients that were tuned using an objective framework.

C. Specifics on Upgrade and Integration of Aerosol Component

This upgrade also includes integration of the NEMS GFS Aerosol Component (NGAC) via one-way coupling to the atmospheric model using NEMS mediator. The NGAC becomes GEFsv12-Aerosols (one additional member of GEFsv12) with the following changes:

- * Increase in horizontal resolution from 1 degree to 0.25 degree (25 km) resolution grid.
- * Update to the latest version of NASA/ESRL GOCART aerosol model.
- * Implementation of the ARL Fengsha dust emissions model.
- * Use of Global Biomass Burning Emissions Product extended (GBBEPx) directly on the FV3 grid.
- * Update the sulfate anthropogenic emissions to the Community Emissions Data System (CEDS) 2014 base version.
- * Increase from 2 to 4 cycles per day.
- * Improved interpolation of grib2 files from the model's native Gaussian grid (see Note on Interpolation below).

More details on GEFsv12-Aerosol component are documented here:

https://www.nco.ncep.noaa.gov/pmb/changes/Global_Aerosols_5day_Fcsts.pdf

D. Note on Interpolation of Output from Native Model Grid

For the atmospheric and aerosol components, the interpolation of grib2 files from Gaussian grid to lat-lon grids is improved in GEFs v12 by (1) using the latest version of grib2 library, (2) employing a more advanced utility with higher computational precision and (3) applying more

accurate interpolation schemes for special parameters such as LAND variables, precipitation types, amount and rate.

E. Product Changes and Removals Associated with GEFSv12

The GEFSv12 is the first global-scale coupled forecast system at NCEP following the Unified Forecast System (UFS) framework. Because of this, there are significant changes in the data structure, resolution and ensemble membership of products due to system unification (combining GEFS, WAVE and NGAC), increased model horizontal resolution, and adding an additional 10 perturbed ensemble members for atmosphere and wave.

A significant increase in the product data volume is expected due to these changes. The GEFSv12 products disseminated via the NWS and NCEP web servers will have some changes in the directory structures and content as well.

E-1. Directory Structure Changes on NCEP Web Services

* Wave and chemistry/aerosol output will be moving into the "gens" directory structure, and atmospheric GEFS output will be moved into an "atmos" subdirectory alongside the "wave" and "chem".

Top level web pages

NOMADS: <https://nomads.ncep.noaa.gov/pub/data/nccf/com>

NCEP FTP: <ftp://ftp.ncep.noaa.gov/pub/data/nccf/com>

Current and new directory structure under top level web pages:

current --> new

Atmospheric (GEFS)

gens/prod/gefs.\$PDY/\$CYC/ --> gens/prod/gefs.\$PDY/\$CYC/atmos/

Wave (GWES)

wave/prod/gwes.\$PDY/ -----> gens/prod/gefs.\$PDY/\$CYC/wave/

Chemistry/Aerosol (NGAC)

ngac/prod/ngac.\$PDY/ -----> gens/prod/gefs.\$PDY/\$CYC/chem/

Where

#{PDY}=YYYYMMDD {Year, Month, Day; e.g. 20200908}

#{CYC}=Cycle of the day; e.g. 00/06/12/18 UTC

* These changes will also be reflected in the NOMADS OpenDAP/dods and grib filter applications as following:

- OpenDAP/DODS changes for GEFS output
 - 1 deg "combined" output featuring all GEFS pgrb2 output will be replaced with 0.5 deg pgrb2a and pgrb2b output in separate files.
 - Directory structure
 - [https://nomads.ncep.noaa.gov/dods/gens/gens\\$PDY\\$CYC](https://nomads.ncep.noaa.gov/dods/gens/gensPDYCYC)
 - will become
 - [https://nomads.ncep.noaa.gov/dods/gefs/gefs\\$PDY\\$CYC](https://nomads.ncep.noaa.gov/dods/gefs/gefsPDYCYC)
 - Filename pattern
 - ge#{mem}_#{CYC}z
 - will become
 - ge#{mem}_#{CYC}z_pgrb2(a|b)

- Existing grib filter scripts for all models will be replaced
 - GEFS
 - old scripts:
 - filter_gens.pl
 - filter_gens_0p50.pl
 - new scripts:
 - filter_gefs_atmos_0p25s.pl
 - filter_gefs_atmos_0p50b.pl
 - filter_gefs_atmos_0p50a.pl
 - NGAC
 - old scripts:
 - filter_ngac_a2d.pl
 - filter_ngac_a3d.pl
 - filter_ngac_aod.pl
 - new scripts:
 - filter_gefs_chem_0p25.pl
 - filter_gefs_chem_0p50.pl
 - WAVE
 - old script:
 - filter_wave_gwes.pl
 - new script:
 - filter_gefs_wave_0p25.pl

E-2. New and Changed Atmospheric (GEFS) Products

Under gens/prod/gefs.\$PDY/\$CYC/atmos/

* New products

- The "pgrb2sp25" sub-directory contains commonly used variables at 0.25 degree resolution. Forecast hour 000 has 22 variables, all other forecast hours have 34 variables - see Appendix 1.

The new file names are:

pgrb2sp25/ge\${mem}.t\${CYC}z.pgrb2s.0p25.f\${hhh}

Where

\${mem}=ensemble member/product; e.g. avg (mean); spr (spread);

c00 (control); p01; p02; ...; p30

\${hhh}=forecast hour; e.g. 000; 003; 006; ...; 384

- The "bufr" sub-directory contains the newly added bufr station files organized in its own sub-directories for each member (c00, p01-p30) plus ensemble average (avg) as an extra member. Each member-specific sub-directory contains station data time series (also known as BUFR sounding) up to 180 hours for all available (2109) sounding locations. In addition, 9 collective files are generated for the 9 geographic regions of the world.

The new directory and file names are:

bufr/\${mem}/bufr.\${station}.\${PDY}\${CYC} - station data

bufr/\${mem}/ge\${mem}_collective{1...9}.fil - collectives

Where

\${mem}=ensemble member/product; e.g. avg (mean); c00 (control);

p01; p02; ...; p30

\${station}={6 digits station ID; e.g. 724017}

\${PDY}=YYYYMMDD {Year, Month, Day; e.g. 20200908}

\${CYC}=Cycle of the day; e.g. 00/06/12/18 UTC

* Existing products gaining new variables and extension to 35 days at 00 UTC

- The files in the "pgrb2ap5" and "pgrb2bp5" sub-directories contain a total of 590 (473 for f000) variables (see Appendix 2) at 0.5 degree resolution, output every 3 hours out to 10 days, then every 6 hours out to 16 (35 days for 00UTC only) days for all members. 76 new variables are included in the "pgrb2bp5" sub-directory (see Appendix 3).

- The 00Z cycle atmosphere-only forecast for 16 to 35 days are conducted in 4 groups outside the primary 3-hour GEFS window and the new files for 390 to 840 hours will be generated much later, up to 21 hours after the 384 hour products.

Existing filenames are:

```
pgrb2ap5/ge${mem}.t${CYC}z.pgrb2a.0p50.f${hhh}
pgrb2bp5/ge${mem}.t${CYC}z.pgrb2b.0p50.f${hhh}
```

Where

`\${mem}`=ensemble member/product; e.g. avg (mean); spr (spread);
c00 (control); p01; p02; ...; p30
`\${CYC}`=Cycle of the day; e.g. 00/06/12/18 UTC
`\${hhh}`=forecast hour; e.g. 000; 003; 006; ...; 237, 240, 246,
...., 384; and (00UTC only) 390; 396;; 840

* Existing products increasing in size

- With the changes in grib2 file interpolation, the data is written with higher precision, leading to substantial increase in the storage size for each grib2 record compared with the current production. The exact amount of increase can vary with the forecast lead time and the nature of the meteorological parameters. For typical examples, the pgrb2ap5 files, with the number of records unchanged, are about 16% larger in size. The pgrb2bp5 files have 18% more records and their sizes are 20-40% larger.

* Replacement of existing initial condition products

- The "init" sub-directory contains the initial conditions of GEFSv12 atmospheric model integration. The file names and contents are not the same as the current operation due to the change of the model dynamical core from GSMto FV3.

The following files will be removed:

```
init/gec00.t${CYC}z.sfc anl
init/ge${mem}.t${CYC}z.sanl
```

Where

`\${mem}`=ensemble member; e.g. c00 (control); p01; p02; ...; p20
`\${CYC}`=Cycle of the day; e.g. 00/06/12/18 UTC

They are replaced by gfs (atmosphere) and surface (sfc) data files for each of the 6 FV3 tiles, as well as a control (ctrl) file, for each individual member, saved in member-specific sub-directories with the following file names:

```
init/${mem}/gfs.ctrl.nc
init/${mem}/gfs.data.tile{1...6}.nc
init/${mem}/sfc.data.tile{1...6}.nc
```

Where

`\${mem}`=ensemble member; e.g. c00 (control); p01; p02; ...; p30

E-3. Timing Changes for all Components

* GEFS-ATMOS

As a major change in the daily schedule of NCEP production suite, GEFS will have its time window expanded from approximately one hour to about 3 hours, starting about one hour earlier and finishing about one hour later. Consequently, the timing of product files availability are changed substantially. The files for 192 hour lead time will be available at about the same time as in current production, while the 000 hour products are about 57 minutes earlier and the 384 hour files 58 minutes later.

As stated previously, the 00Z cycle atmosphere-only forecast for 16 to 35 days are conducted in 4 groups outside the primary 3-hour GEFS window and the new files for 390 to 840 hours will be generated much later, up to 21 hours after the 384 hour products.

* GEFS-WAVE

As GWES becomes a component of GEFS v12 starting earlier and the output is written in separate files for each output hour, the existing gridded files of gefs/wave products for individual members will be available much earlier than those in the current production. For example, the f000 files will be about 140 minutes earlier. The f240 files will be about 30 minutes earlier. However, the files for mean/spread/prob and station time series will be later than the current production by approximately 40-45 minutes due to the extension of forecast range from 240 hours to 384 hours.

* GEFS-CHEM

For similar reasons, the gefs/chem aerosol products will also be delivered earlier than their NGAC counterparts in the current production. The range of the gap will be from 216 minutes earlier for the f000 files to 84 minutes delayed for the last output of 120 hours.

E-4. New and Changed Wave Products

Under gens/prod/gefs.\$PDY/\$CYC/wave/

* The "gridded" sub-directory contains all grib2 field products, including individual member output and ensemble mean, ensemble spread, and ensemble_based probabilistic forecast files. The new products replace the previous data, providing a higher spatial resolution, 0.25 degree on a spherical grid, and include additional parameters (fields).

* Gridded grib2 file names for individual members will be changed from

 gwes\${mem}.glo_30m.t\${CYC}z.grib2
to
 gefs.wave.t\${CYC}z.\${mem}.global.0p25.f\${hhh}.grib2

Where

 \${mem}=ensemble member/product; e.g. avg (mean); spr (spread);
 c00 (control); p01; p02; ...; p30

 \${CYC}=Cycle of the day; e.g. 00/06/12/18 UTC

$\{hhh\}$ =forecast hour; e.g. 000; 003; 006; ...; 237, 240, 246, ..., 384

* The filenames for ensemble mean, ensemble spread and probabilistic forecast, will be changed from

gwes.mean.t $\{CYC\}$ z.grib
gwes.spread.t $\{CYC\}$ z.grib
gwes.probab.t $\{CYC\}$ z.grib

to

gefs.wave.t $\{CYC\}$ z.mean.global.0p25.f $\{hhh\}$.grib2
gefs.wave.t $\{CYC\}$ z.spread.global.0p25.f $\{hhh\}$.grib2
gefs.wave.t $\{CYC\}$ z.prob.global.0p25.f $\{hhh\}$.grib2

Where

$\{CYC\}$ =Cycle of the day; e.g. 00/06/12/18 UTC

$\{hhh\}$ =forecast hour; e.g. 000; 003; 006; ...; 237, 240, 246, ..., 384

* The number of wave model parameters in gridded files will be expanded from 19 to 23. The following new parameters will become available:

- the zero-crossing period
- mean wave direction
- wave height for a third spectral swell partition
- wave period for a third spectral swell partition

* The "station" sub-directory contains output at selected points (station files) providing mean, spread and probability of exceedance of wave-heights and periods and surface wind speeds for a selection of output locations. Two-dimensional spectra and bulletins will no longer be made available for individual members output.

* Average station data files will change names as follows:

- Bulletins

Current Name: gwes.t $\{CYC\}$ z.bull_tar
New name: gefs.wave.t $\{CYC\}$ z.bull_tar

- Time series

Current Name: gwes.t $\{CYC\}$ z.station_tar
New name: gefs.wave.t $\{CYC\}$ z.station_tar

Where

$\{CYC\}$ =Cycle of the day; e.g. 00/06/12/18 UTC

E-5. New and Changed Chemistry (Aerosol) Products

Under gens/prod/gefs.\$PDY/\$CYC/chem/

* The "pgrb2ap25" sub-directory contains the 31 records (one for each of 31 two-dimensional aerosol species) files at 0.25 degree lat-lon resolution. These files will be renamed.

Current name: ngac.t $\{CYC\}$ z.a2df $\{hhh\}$.grib2
New name: gefs.chem.t $\{CYC\}$ z.a2d_0p25.f $\{hhh\}$.grib2

Where

$\{CYC\}$ =Cycle of the day; e.g. 00/06/12/18 UTC

$\{hhh\}$ =forecast hour; e.g. 000; 003; 006; ...; 237, 240, 246,

....., 384

* The "pgrb2ap5" sub-directory contains 960 records (15 parameters for all 64 hybrid model levels) at 0.5 degree lat-lon resolution. These files will be renamed.

Current name: ngac.t\${CYC}z.a3df\${hhh}.grib2

New name: gefs.chem.t\${CYC}z.a3d_0p50.f\${hhh}.grib2

Where

\${CYC}=Cycle of the day; e.g. 00/06/12/18 UTC

\${hhh}=forecast hour; e.g. 000; 003; 006; ...; 237, 240, 246,

....., 384

E-6. Discontinued Products on SBN/NOAAPORT, and NCEP and NWS FTP Web Services

* GEFS-atmos

- All 1.0 degree (pgrb2a and pgrb2b and pgrb2 subdirectories), 1.25 degree (wafs sub-directory) and 2.50 degree (ensstat, pgrb2alr and pgrb2blr subdirectories) data are terminated.

- The following analysis files in pgrb2ap5 and pgrb2bp5 subdirectories are terminated:

ge\${mem}.t\${CYC}z.pgrb2a.0p50.anl

ge\${mem}.t\${CYC}z.pgrb2b.0p50.anl

Where

\${CYC}=Cycle of the day; e.g. 00/06/12/18 UTC

- The retention period of the GEFS output will be decreased from 8 days to 4 days.

- GEFS 1.0 degree output will be discontinued on SBN/NOAAPORT feeds. The headers that will be removed are contained in the Public Information Statement 19-37 linked below.

- Due to the discontinuation of the GEFS 1.0 degree output on the SBN/NOAAPORT, these products are also being removed from the NWS FTP server.

ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/MT.ensg_CY.\${CYC}/RD.\${PDY} will no longer be populated

Where

\${PDY}=YYYYMMDD {Year, Month, Day; e.g. 20200908}

\${CYC}=Cycle of the day; e.g. 00/06/12/18 UTC

Additional information on discontinuation of GEFS-atmos products is provided in the Public Information Statement 19-37 (released on December 2 2019)

https://www.weather.gov/media/notification/pns19-7gefs_product_removal.pdf

* GEFS-wave

- The following products will be removed from NCEP Web Services, including NOMADS grib filter, OpenDAP, and FTP.

gwes\${mem}.gfs_30m.t\${CYC}.wind

gwes\${mem}.t\${CYC}z.bull_tar.gz

gwes\${mem}.t\${CYC}z.spec_tar.gz

bulls.t\${CYC} (directory with expanded bulletins)

Where \${mem}=ensemble member/product; e.g. avg (mean); spr (spread);
c00 (control); p01; p02; ...; p30
\${CYC}=Cycle of the day; e.g. 00/06/12/18 UTC

A full description of discontinued global wave ensemble products is provided in the Public Information Statement 20-20 of 4/7/20:
https://www.weather.gov/media/notification/pns20-20gwes_removal.pdf

* GEFS-chem

- All 1.0 degree resolution outputs are terminated, and the aerosol variables will be available at a much higher resolution as described in E-5.

A consistent parallel feed of data from the new GEFS will become available on the para NOMADS NCEP server once the model is running in parallel or real time on the NCEP Weather and Climate Operational Supercomputing System (WCOSS). The parallel data will be available via the following URL:

[https://para.nomads.ncep.noaa.gov/pub/data/nccf/com/gens/para/gefs.\\$PDY/\\$CYC/\\$COMPONENT](https://para.nomads.ncep.noaa.gov/pub/data/nccf/com/gens/para/gefs.$PDY/$CYC/$COMPONENT)

Where

\${COMPONENT}=sub-directory for each ensemble component; e.g.
atmos/wave/chem

Specific information regarding the GEFSv12 implementation can be found in the NCEP Office of Director (OD) briefing and the evaluation of Global Ensemble Forecast System (GEFS) V12.0.0 here:

<https://www.emc.ncep.noaa.gov/users/meg/gefsv12/>

Additional information:

https://www.emc.ncep.noaa.gov/gmb/yzhu/html/imp/202003_imp.html

<https://ral.ucar.edu/sites/default/files/public/events/2019/8th-ncep-ensemble-user-workshop/docs/01.4-zhou-xiaqiong-the-ncep-global-ensemble-forecast-system.pdf>

Disclaimer: NCEP would encourage all users to ensure their decoders are flexible and are able to adequately handle changes in content order, parameter fields changing order, changes in the scaling factor component within the Product Definition Section (PDS) of the GRIB files 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 implementation.

Any questions, comments, or requests regarding this implementation should be directed to the contacts below. We will review any feedback and decide whether to proceed.

For questions regarding these changes, please contact:

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For questions regarding the dataflow aspects, please contact:

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Appendix 1: List of 35 selected variables for pgrb2sp25 files

1. Wind Gust (instantaneous)
2. Surface Pressure;
3. Surface Height (f000 only)
4. Soil Temperature at 0-10 cm;
5. Soil Moisture at 0-10 cm;
6. Water equiv. of accum. snow depth (WEASD)
7. Snow depth (SNOD);
8. Ice Thickness;
9. 2-meter Temperature (T2m);
10. 2-meter Dew-point Temperature;
11. 2-meter Relative Humidity;
12. 2-meter Maximum Temperature (Tmax);
13. 2-meter Minimum Temperature (Tmin);
14. 10-meter Zonal Wind;
15. 10-meter Meridional Wind;
16. Total precipitation; (APCP)
17. Categorical Snow;
18. Categorical Ice Pellets;
19. Categorical Freezing Rain;
20. Categorical Rain;
21. Latent heat net flux;
22. Sensible heat net flux;
23. Convective Available Potential Energy (CAPE) from Surface;
24. Convective Inhibition (CIN) from Surface
25. Precipitable Water (PWAT);
26. Total Cloud Cover (TCDC);
27. Downward shortwave radiation flux at surface;
28. Downward longwave radiation flux at surface;
29. Upward shortwave radiation flux at surface;
30. Upward longwave radiation flux at surface;
31. Upward longwave radiation flux from top of atmosphere;
32. Helicity at 0-3000m;
33. Convective Available Potential Energy (CAPE) 180-0 mb;
34. Convective Inhibition (CIN) 180-0 mb;
35. Pressure at Mean Sea Level (PRMSL);

Appendix 2: Complete list of 590 variables/products
Total of 590 variables (shared documentation as an example of

variable list) at 0.5 degree lat-lon grid resolution
pgrb2ap5 - total 85 variables
pgrb2bp5 - total 505 variables

Appendix 3: 76 new variables

1. HGT On Cloud Ceiling (1)
- 2-3. Surface variables (SNOHF and SNOWC) (2)
- 4-5. PV on isentropic levels (310 and 350K levels) (2)
- 6-10. Vertical velocity on pressure levels (10, 20, 30, 50, 70 hPa) (5)
- 11-22. More isentropic levels (U, V, T, PV at 450, 550 and 650 K levels) (4x3=12)
- 23-52. More Pressure levels (H, T, U, V, q, w at 1, 2, 3, 5, 7 hPa levels) (6x5=30)
- 53-76. Sigma levels (H, T, P, U, V, RH at lowest 4 sigma levels) (6x4=24)

Appendix 4: List of variables for GEF5-chem

2-dimensional variables (fields; total 31):

1. AER_OPT_DEP_at340nm (total)
2. AER_OPT_DEP_at440nm (total)
3. AER_OPT_DEP_at550nm (total)
4. AER_OPT_DEP_at670nm (total)
5. AER_OPT_DEP_at870nm (total)
6. AER_OPT_DEP_at1p63um (total)
7. AER_OPT_DEP_at1p1um (total)
8. DUST_AER_OPT_DEP_at550nm
9. SEASALT_AER_OPT_DEP_at550nm
10. SULFATE_AER_OPT_DEP_at550nm
11. ORGANIC_CARBON_AER_OPT_DEP_at550nm
12. BLACK_CARBON_AER_OPT_DEP_at550nm
13. SSALBK Single Scattering Albedo [Numeric]
14. ASYSFK Asymmetry Factor [Numeric]
15. SCTAOTK_Total_at550nm
16. SCTAOTK_Dust_at550nm
17. SCTAOTK_Seasalt_at550nm
18. SCTAOTK_BC_at550nm
19. SCTAOTK_OC_at550nm
20. SCTAOTK_SULF_at550nm
21. DUST25_SFC_MASS_CON (dust pm2.5)
22. SEAS25_SFC_MASS_CON (sea salt pm2.5)
23. PM10_SFC_MASS_CON
24. PM25_SFC_MASS_CON
25. PM10_COL_MASS_DEN
26. PM25_COL_MASS_DEN
27. DUST_COL_MASS_DEN (PM2.5)
28. SEAS_COL_MASS_DEN (PM10)
29. BC_COL_MASS_DEN
30. OC_COL_MASS_DEN
31. SULF_COL_MASS_DEN

3-dimensional variables (fields) (total 960 records)

- DUST1 on the 64 hybrid levels
- DUST2 on the 64 hybrid levels
- DUST3 on the 64 hybrid levels
- DUST4 on the 64 hybrid levels
- DUST5 on the 64 hybrid levels
- SEASALT1 on the 64 hybrid levels
- SEASALT2 on the 64 hybrid levels
- SEASALT3 on the 64 hybrid levels
- SEASALT4 on the 64 hybrid levels
- SEASALT5 on the 64 hybrid levels
- BCPHILIC on the 64 hybrid levels
- BCPHOBIC on the 64 hybrid levels
- OCPHILIC on the 64 hybrid levels
- OCPHOBIC on the 64 hybrid levels
- SO4 on the 64 hybrid levels

National Weather Service Change Notices and Public Statements:

<https://www.weather.gov/notification/>

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