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Service Change Notice 21-65 Updated
National Weather Service Headquarters Silver Spring MD
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From: Mike Farrar, Director
National Centers for Environmental Prediction

Subject: Updated: Implementation of the Whole Atmosphere Model-Ionosphere Plasmasphere Electrodynamics (WAM-IPE) Forecast System (WFS), a New Space Weather Product from the Space Weather Prediction Center (SWPC): Effective July 14, 2021

Updated to reflect new implementation date of July 14, 2021.

SWPC is pleased to announce that on or about July 14, 2021, a new ionosphere and whole atmosphere model, Whole Atmosphere Model-Ionosphere Plasmasphere Electrodynamics (WAM-IPE) Forecast System (WFS), will be implemented into production at the National Centers for Environmental Prediction (NCEP). In the event of a Critical Weather Day (CWD), the implementation may be delayed.

The coupled Whole Atmosphere Model-Ionosphere Plasmasphere Electrodynamics (WAM-IPE) Forecast System (WFS) provides a specification of ionosphere and thermosphere conditions with forecasts two days in advance in response to solar, geomagnetic and lower atmospheric forcing. Model outputs are used at the Space Weather Forecast Office (SWFO) at SWPC for issuing warnings and alerts related to aviation communication and Global Navigation Satellite System (GNSS) scintillations. The real-time neutral density fields will also be available for orbit prediction and space traffic management purposes.

The WAM is an extension of the Global Forecast System (GFS) with a spectral hydrostatic dynamical core utilizing an enthalpy thermodynamic variable to 150 vertical levels on a hybrid pressure-sigma grid, with a model top of approximately 3 x 10-7 Pa (typically 400-600km depending on levels of solar activity). Additional upper atmospheric physics and chemistry, including electrodynamics and plasma processes, are included.

The IPE model provides the plasma component of the atmosphere. It is a time-dependent, global 3-dimensional (3-D) model of the ionosphere and plasmasphere from 90 km to approximately 10,000km. The flux-tube solver is based on the Field Line Interhemispheric Plasma (FLIP) model and flux-tube structures are defined by the International Geomagnetic Reference Field (IGRF). Seamless perpendicular plasma transport pole-to-pole and self-consistent electrodynamics are included.

WAM fields of winds, temperature and molecular and atomic atmospheric composition are coupled to IPE to enable the plasma to respond to changes driven by the neutral atmosphere. The coupling is based on time-dependent 3D re-gridding in the space weather mediator. The model ingests solar wind and geomagnetic inputs, provided both by direct observation and as forecast by SWFO. The WAM-IPE Forecast System (WFS) provides products out to two days using these drivers as initialized by the data assimilation (DA) system.

The WAM state is updated using 3DVar DA in the lowest 60km of the atmosphere using a modified version of the Gridpoint Statistical Interpolation (GSI) software. An Incremental Analysis Update (IAU) method is used to apply the increment across the assimilation window to prevent the damping of tidal waves from the DA process. This comprises the WAM-IPE Data Assimilation System (WDAS).

WFS has been validated against historical storm-time simulations -- specifically, November 2003, March 2013 and March 2015 geomagnetic storms -- using all available observations including in situ neutral density, neutral composition O/N2 and ionospheric observations such as Total Electron Content (TEC), vertical drifts, etc. WAM captures storm-time neutral density enhancement as well as neutral composition changes during the recovery phase of the geomagnetic storms. The quiet-time seasonal variation of thermospheric temperature, composition, and tidal amplitudes also well reproduce the results from the empirical Mass Spectrometer and Incoherent Scatter Radar (MSIS) thermospheric model and satellite observations.

The ionospheric products include the two-day forecast of TEC and Maximum Usable Frequency (MUF). These are the key products for SWFO to issue space weather advisories related to communication and navigation systems for the International Civil Aviation Organization's (ICAO's) global aviation space weather network. In addition, the neutral density from the model will be a new product allowing the SWFO to issue warnings that directly impact satellite operators and ground-tracking systems for space traffic management.

Output Availability:

Visualized WFS output will be available beginning July 14, 2021, on the following SWPC web services:

https://www.swpc.noaa.gov/products/wam-ipe

Model simulation data will be available on NCEP web services (NOAA Operational Model Archive and Distribution System (NOMADS)/ftpprd) here:

https://nomads.ncep.noaa.gov/pub/data/nccf/com/wfs
ftp://ftp.ncep.noaa.gov/pub/data/nccf/com/wfs

The directory structure will be: wfs.YYYYMMDD/CC
where YYYY is the year, MM is the month, DD is the day, and CC is the cycle (00, 06, 12 or 18).

There are four types of files, all in NetCDF format, with the two-dimensional (2D) fields available at five-minute cadence (ipe05, gsm05), and the 3D fields available at ten-minute cadence (ipe10, gsm10). These files will be distributed in hourly tar files, where each tar file contains all four file types for the given forecast valid time.

wfs.tCCz.yyyymmdd_hh.tar
where yyyy is the forecast year, mm in the forecast month, dd is the forecast day, and hh is the first hour.

The output contained within these files are as follows:

2D fields:
wfs.tHHz.ipe05.yyyymmdd_hhmmss.nc: ionosphere TEC, NmF2, and HmF2.
wfs.tHHz.gsm05.yyyymmdd_hhmmss.nc: thermosphere column integrated O/N2 ratio and neutral density at 400km (interpolated from hybrid pressure-sigma grid).

3D fields:
wfs.tHHz.ipe10.yyyymmdd_hhmmss.nc (fixed height grid): ionosphere density (O+, H+, He+, N+, NO+, O2+, N2+), ionosphere temperature (Ti, Te), and ExB drift velocities.
wfs.tHHz.gsm10.yyyymmdd_hhmmss.nc (hybrid pressure-sigma grid): height, neutral atmosphere temperature, density (O, O2, N2) and neutral wind velocities.

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 gridded binary (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.

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 this new model forecast guidance, please contact:

Tzu-Wei Fang
SWPC
Boulder, CO
tzu-wei.fang@noaa.gov

Tim Fuller-Rowell
SWPC
Boulder, CO
tim.fuller-rowell@noaa.gov

Adam Kubaryk
SWPC
Boulder, CO
adam.kubaryk@noaa.gov

For questions on the data flow aspects, please contact:

Anne Myckow
NCEP Central Operations Dataflow Team Lead
College Park, MD
ncep.pmb.dataflow@noaa.gov

National Service Change Notices are online at:

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

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