|  |  |  |
| --- | --- | --- |
| WORLD METEOROLOGICAL ORGANIZATIONCOMMISSION FOR BASIC SYSTEMSOPAG on DPFS**MEETING OF THE CBS (DPFS) EXPERT TEAM** **ON OPERATIONAL WEATHER AND FORECASTING PROCESS AND SUPPORT**MONTREAL, CANADA09-13 MAY 2016 |  | CBS-DPFS/ET-OWFPS/Doc. 5.1.3(03.V.2016)\_\_\_\_\_\_\_Agenda item: 5.1ENGLISH ONLY |

**North American Ensemble Forecast System**

*(Submitted by Yuejian Zhu)*

##### Summary and purpose of document

This document provides the update and summary of the North American Ensemble Forecast System (NAEFS), post-processing and downscaled probabilistic products (downscaled products are only applied to CONUS and Alaska region). An overview is given of the services available to WMO members, including support to SWFDP.

##### Action Proposed

The meeting is invited to note the information in the document.

**4.1.9 NAEFS (North American Ensemble Forecast System – Jointly developed with MSC)**

(*By Bo Cui and Yuejian Zhu, Acknowledgement: Andre Methot*)

1. ***General description.*** The Canadian (Meteorological Service of Canada, MSC), the Mexican (National Meteorological Service of Mexico, NMSM), and the US (National Weather Service, NWS) NMS established the North American Ensemble Forecast System (NAEFS) which was inaugurated in November 2004, and the first operational implementation of NAEFS products occurred in May 2006. In December 2007, downscaling products for the Continental United States (CONUS) have been implemented in NWS/US operations. In December 2010, downscaling products for the Alaska region have been implemented in NWS/US operations. The latest major implementation was in March 2016. All downscaling products have increased their horizontal resolution from 5km to 2.5km for CONUS and from 6km to 3km for Alaska.

NAEFS ensemble producing centers (currently MSC and NWS):

1. Exchange in real-time their raw forecast data (operational since September 2004) and bias corrected forecast (operational since March 2011);
2. Statistically post-process (include downscaling) all ensemble members;
3. Jointly develop and produce end products with other members (currently NMSM) based on the combined ensemble of forecasts;
4. Participate in the NAEFS workshop held every other year. The 5th workshop was in May 2010 in Cuernavaca, Mexico. The 6th NAEFS workshop was in May 2012 in Monterey CA, USA. The 7th NAEFS workshop was in June 2014 in Montreal, Canada. The 8th NAEFS workshop will be held in June 2016 in College Park, MD, USA.

The operational data exchange between centers is providing a strong basis for the development of contingency plans in case of major production disruption at any of the producing centers. Meanwhile, combined ensemble (NAEFS) is providing best performance than either US or Canada’s individual ensemble. Figure 1 shows the day which a yearly average raw ensemble mean anomaly correlation reached 60% (AC=0.6) for Northern Hemisphere 500hPa geopotential height since 2008.

Figure 1, Days at which ensemble mean forecast loses useful skill (AC=0.6) for Northern Hemisphere 500hPa geopotential height calendar year means. NCEP is for US Global Ensemble Forecast System (GEFS), CMC is for Canadian Global Ensemble Forecast System, and NAEFS is for combined US and Canadian ensembles.

2. ***Basic products.***

Statistical post-processing involves:

(a) The correction of all ensemble members for biases (first and higher moments),

(b) The establishment of weights for the combination of all members which include bias corrected high resolution deterministic forecast (named hybrid), and

(c) The expression of each bias-corrected forecast member in terms of percentile values within a long-term climatological distribution of the NCEP-NCAR reanalysis (CFSR reanalysis replaced NCEP-NCAR reanalysis in 2014).

The participating centers collaborate in the development of post-processing algorithms and software and share a common procedure to generate the basic products of bias-corrected forecasts, the corresponding weights and climatological percentile values. The products for probabilistic forecast (10%, 90%, 50%, mean, mode and spread) have been generated after statistical bias correction for all ensemble members. These basic products were operationally implemented in May 2006, December 2007 and December 2010. The products are freely accessed through NCEP NOMADS ( <http://nomads.ncep.noaa.gov/> ) worldwide.

3. ***End products.*** The final goal of the NAEFS is the generation of end products for the use of the participating and other NMS, including those used for severe weather warnings. Downscaled probabilistic products for CONUS and Alaska region are generated on the NDGD (National Digital Guidance Database) grid by using the Real Time Mesoscale Analysis (RTMA) as a proxy truth. Some of the end products are developed jointly (such as the North American week-2 temperature and precipitation anomaly forecast) with NCEP service centers, while others will be provided by individual participating centers. In all cases, end-products will be based on the common set of basic products described above, ensuring the consistency of all NAEFS end products. NAEFS participants actively seek input from potential users in the immediate Region IV neighborhood: Central America and Caribbean, as well as other developing countries worldwide regarding desired end products for these areas.

4. ***Expansion of NAEFS.*** The current NAEFS could be considered as a prototype for a multi-center, multi-model ensemble forecast system, envisaged by the THORPEX research program. The US Navy Fleet Numerical Meteorology and Oceanography Center (FNMOC) ensemble is planned to be next to join NAEFS, while the US Air Force Weather Agency (AFWA) will remain as a user. The NAVY FNMOC generate both raw ensemble and bias corrected forecasts and is shared with NAEFS in real-time (operational since March 2016).These possible expansions will broaden the scope of the NAEFS and may lead to the development of a Global Ensemble Forecast System (GEFS) as the ensemble forecast component of the Global Interactive Forecast System (GIFS), foreseen by the THORPEX program and other international collaboration. The NAEFS, and a possible future GEFS would well represent the spirit of the enhanced international collaboration sought by the THORPEX research program. In particular, the NAEFS would provide a framework of operational requirements and constraints which new research initiatives must be conceived on, and will offer a receiving end for any new methods developed based on the THORPEX Interactive Grand Global Ensemble (TIGGE) data archive, or related to other THORPEX initiatives. In the future, the development of NAEFS will continue to collaborate/coordinate with THORPEX legacy projects, such as HIW, S2S and PPP.