HRRR Ensemble (HRRRE) Guidance

2018 HWT Spring Experiment

https://rapidrefresh.noaa.gov/hrrr/HRRRE/

GRIB-2 output grids also available via FTP

ESRL/GSD

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Goals and General Description

The HRRRE is an experimental convective-allowing ensemble analysis and forecasting system run at NOAA/ESRL/GSD. It is being developed and tested for three main reasons: (1) improving 0-12 h high-resolution forecasts through ensemble-based, multi-scale data assimilation, (2) testing ensemble-design concepts for 0-36 h forecasts produced with a single model, and (3) providing a foundation for experimental, on-demand, very-high-resolution applications such as Warn-on-Forecast. HRRRE has been run experimentally with initial versions in 2016 and 2017. This document describes the HRRRE version that will run during the 2018 HWT Spring Experiment.

The deterministic HRRR currently assimilates observations with a hybrid ensemble-variational (EnVAR) method, and the background ensemble for this assimilation is the 80-member GDAS (GFS) ensemble. One idea being tested in the HRRRE is using a higher-resolution, convective-allowing ensemble instead for assimilation.[1] A background ensemble with explicit convection enables direct assimilation of high-resolution observations such as radar reflectivity in convective storms. This high-resolution, ensemble-based assimilation could lead to improved forecasts, particularly in the 0-12 h range.

Longer forecasts require more attention to model error. Soil-moisture perturbations and stochastic parameter perturbations to the MYNN PBL scheme have both been tested as ways to introduce realistic growth of ensemble spread during the 0-36 h forecast. Stochastic parameter perturbations to other parameterization schemes will also be tested in the coming year. HRRRE forecasts with stochastic physics will be evaluated internally in 2018 before becoming a candidate ensemble for the 2019 Spring Experiment.

[1] The HRRRE, like the HRRR, is still linked to the GFS and GDAS through partial cycling.

A new development for the 2018 Spring Experiment is the coordinated design of the NCAR Ensemble and HRRRE. The 2018 NCAR Ensemble and HRRRE share features such as hourly cycling, a large outer analysis grid with 15-km grid spacing, and a nested grid with 3-km grid spacing. Forecast-model and data-assimilation codes will also be made as similar as possible. *One primary difference between the two systems is continuous cycling in the NCAR Ensemble versus once-daily partial cycling in the HRRRE.* This difference between the two systems will be analyzed to help determine best practices for future systems.

During the 2018 Spring Experiment, the HRRRE analyses and forecasts will provide initial and boundary conditions for a prototype Warn-on-Forecast system run at the National Severe Storms Laboratory. The Warn-on-Forecast project is developing on-demand, high-resolution, ensemble-based, 0-3 h numerical weather prediction capabilities to support warnings of severe convective storms and flash flooding.

Specific Information

Model

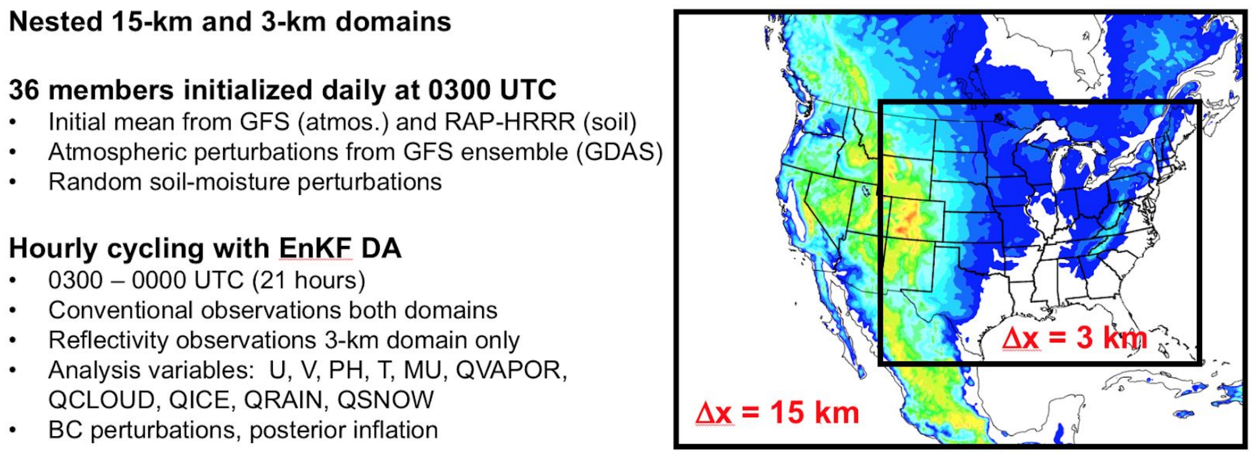
- WRF-ARW version 3.8+, combining elements of versions 3.8 and 3.9 plus other GSD-specific features
- Configuration identical to [2]HRRR v3, except that the 3-km domain covers the central and eastern US only (60% of HRRR domain[3]), and a standard vertical coordinate is used instead of a hybrid coordinate.
- Physics is as described in Benjamin et al. 2016, MWR http://journals.ametsoc.org/doi/abs/10.1175/MWR-D-15-0242.1 except that a deep convection parameterization is not used on the 3-km domain.

Data-Assimilation Ensemble

- 36 members
    - Nested grids with 15-km and 3-km horizontal grid spacing
    - Initial ensemble-mean atmospheric state from GFS 3-h forecast
    - Atmospheric spatial perturbations from members 1-36 of GDAS 9-h forecast ensemble

[2] https://ruc.noaa.gov/ruc/ppt_pres/Alexander_WRFworkshop_2017_Final.pdf
[3] Expanding the HRRRE high-resolution domain to match the full-CONUS HRRR domain will be considered in fall 2018.

- Initial ensemble mean of land-surface state from RAP and HRRR
    - Random soil-moisture perturbations added to each member at initial time
    - Boundary conditions from GFS 0-60 h forecast
    - Random perturbations to MU, U, V, T, and QVAPOR added to boundary conditions of each ensemble member
- Initialization at 0300 UTC, followed by hourly cycling for 21 h to 0000 UTC



Hourly Data Assimilation

- Observations
    - NCEP bufr conventional observations, as in HRRR (http://www.emc.ncep.noaa.gov/mmb/data_processing/data_processing/)
    - MRMS gridded radar reflectivity observations, thinned in horizontal and vertical directions
- Gridpoint Statistical Interpolation (GSI) for observation preprocessing and calculation of ensemble priors
- Ensemble adjustment Kalman filter (EAKF) for assimilation
    - Two assimilation software packages being tested: DART and NOAA EnKF
    - Analysis variables: U, V, T, PH, MU, QVAPOR, QCLOUD, QICE, QRAIN, QSNOW
    - Gaspari-Cohn compact pseudo-gaussian for localization
    - Horizontal localization radius (full radius, where weight reaches zero) 300 km and 18 km for conventional and radar observations, respectively

    - Vertical localization radius (full radius, where weight reaches zero) 8 km and 6 km for conventional and radar observations, respectively
- Relaxation to prior spread (inflation factor 1.2) after assimilation each hour

Ensemble Forecasts

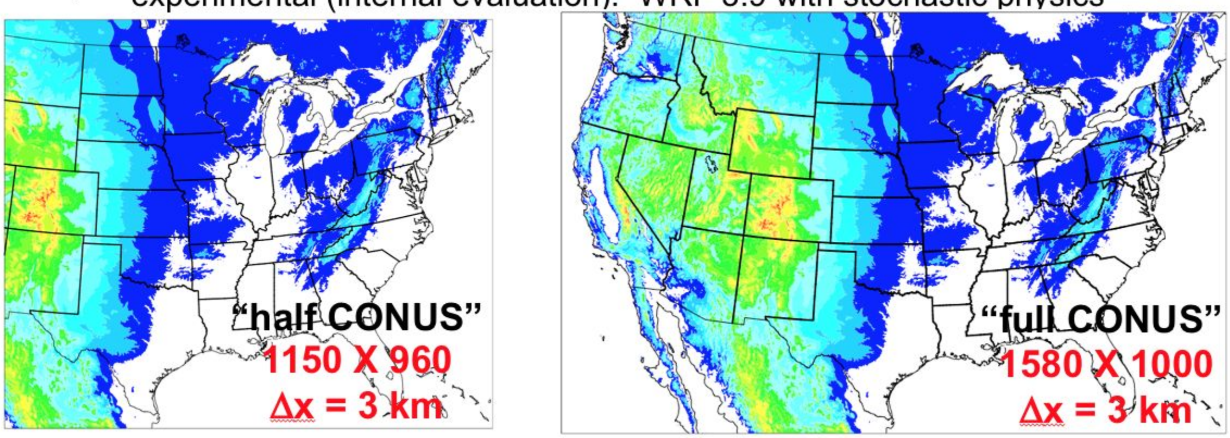
- 3-km horizontal grid spacing
- 9-member, half-CONUS, 48-h forecasts initialized from first 9 members of data-assimilation ensemble (nested 15-km and 3-km analyses) at **1200 UTC**
    - *24-h forecast typically available at 1600 UTC*
    - *48-h forecast typically available at 1800 UTC*
- 9-member, half-CONUS, 18-h forecasts initialized from first 9 members of data-assimilation ensemble (nested 15-km and 3-km analyses) at **1800 UTC**
- 9-member, half-CONUS, 18-h forecasts initialized from first 9 members of data-assimilation ensemble (nested 15-km and 3-km analyses) at **2100 UTC**
- 9-member, full-CONUS, 36-h forecasts initialized from first 9 members of data-assimilation ensemble (nested 15-km and 3-km analyses) at **0000 UTC**
    - Control version (real-time distribution): WRF 3.8 without stochastic physics
    - Parallel version (internal evaluation only): WRF 3.9 with stochastic physics
- Random perturbations to MU, U, V, T, and QVAPOR added to boundary conditions of each ensemble member
- Post processing: An ensemble post-processing system is applied to the nine HRRRE forecast members to produce all-season weather hazard probabilities including heavy rainfall as is done with the time-lagged HRRR. HRRRE probabilities are the fraction of members that exceed a given threshold, or predict a given precipitation type, at a point. The final probability field (100*(n/total)) is smoothed using a Gaussian filter of width 25 km.

Half-CONUS 3-km forecasts initialized from 3-km analyses

- 9-member, 48-h forecast at 1200 UTC
- 9-member, 18-h forecast at 1800 UTC
- 9-member, 18-h forecast at 2100 UTC

Full-CONUS 3-km forecasts initialized from 3-km and 15-km analyses

- 9-member, 36-h forecast at 0000 UTC
  - control (real-time distribution): WRF 3.8 without stochastic physics
  - experimental (internal evaluation): WRF 3.9 with stochastic physics



High Performance Computing

- The HRRRE runs on xjet: Intel Haswell CPU, 24 cores/node, and 64 GB memory/node. Hourly cycling requires 144 nodes (3456 processors). Resources for the free ensemble forecasts vary according to the requirements of specific real-time demonstrations.

Future Plans

We are working towards merging HRRR, HRRRE, and HRRR-TLE activities. We are exploring the possibility of the HRRR being a control member of the HRRRE, with the HRRR initialized with GSI hybrid data assimilation using the HRRRE as the background ensemble. We also plan to apply the post processing in the HRRR-TLE to the combined system.

The ultimate goal of the HRRRE effort is to inform the design of a future operational, single-model, hourly-updated, convective-allowing ensemble analysis and forecasting system developed jointly with EMC. We are also involved in the development and testing of FV3, to support the unification of NWP applications from global to local scales. Some of this development involves transitioning capabilities in the existing WRF-ARW version of the RAP-HRRR system to FV3. We are testing an enhanced version of the operational GSI-EnKF code that includes directly reflectivity data assimilation and will use it for real-time runs with verification. HREF, the current operational convective-allowing ensemble prediction system, is a multi-model system. Through verification of HREF and HRRRE forecasts, we will compare and contrast the forecast spread produced by the multi-model and single-model approaches.

Contributors

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