

## Hourly updated NOAA 3km High-Resolution Rapid Refresh model

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The time scale or lifetime of many weather phenomena can be from around 1 h (rotating convective storms) down to several minutes or less (e.g., individual clouds, eddies, etc.), a motivation for rapid updating NWP using recent observations to represent the current situation in the model state for these phenomena. The NOAA 3km High-Resolution Rapid Refresh (HRRR) now assimilates radar every 15 min. Data assimilation and model configuration in the HRRR has been refined over the past few years for all-season boundary-layer forecasting including clouds, precipitation, and

convective environment. The HRRR model is described in Benjamin et al 2016 (B16). HRRR forecast skill for radar reflectivity has continued to improve consistently each year through 2015 (Fig. 2).

RAPv4/HRRRv3 Summary of Changes - Feb 2018									
<b>Implementation RAPv4/HRRRv3</b>	Model	Run at:	Domain	Grid Points	Grid Spacing	Vertical Levels	Pressure Top	Boundary Conditions	Initialized
	RAP	GSD, NCEP	North America	953 x 834	13 km	50	10 hPa	GFS	Hourly (cycled)
Larger RAP Domain	HRRR	GSD, NCEP	CONUS	1799 x 1059	3 km	50	20 hPa	RAP	Hourly (pre-forecast hour cycle)
Newer Model Version More Ensemble Weight Advanced Physics	Model	Version	Assimilation	Radar DA	Radiation LW/SW	Microphysics	Cumulus Param	PBL	LSM
	RAP	WRF-ARW v3.9 - hyb	GSI Hybrid Ens to 0.85, better cld	13-km 3dLH-DFI	RRTMG/ RRTMG	Thompson Aerosol v3.9	GF + Shallow	MYNN v3.9	RUC v3.9
Seasonal Vegetation Fraction/Leaf Area Index	HRRR	WRF-ARW v3.9 - hyb	GSI Hybrid Ens to 0.85, better cld	3-km 15-min LH	RRTMG/ RRTMG	Thompson Aerosol v3.9	None	MYNN v3.9	RUC v3.9
	Model	Horiz/Vert Advection	Scalar Advection	Upper-Level Damping	6th Order Diffusion	SW Radiation Update	Land Use	MP Tend Limit	Time-Step
	RAP	5th/5th	Positive-Definite	w-Rayleigh 0.2	Yes 0.12	20 min	15" MODIS Seasonal	0.01 K/s	60 s
	HRRR	5th/5th	Positive-Definite	w-Rayleigh 0.2	Yes -0.25 (slope dep)	15 min with SW-dt	15" MODIS Seasonal	0.07 K/s	20 s

Fig 1. Characteristics including physical parameterizations for 3km HRRRv3 and RAPv4, expected for implementation at NCEP in February 2018. Key changes from HRRRv2/RAPv3 are shaded in red.

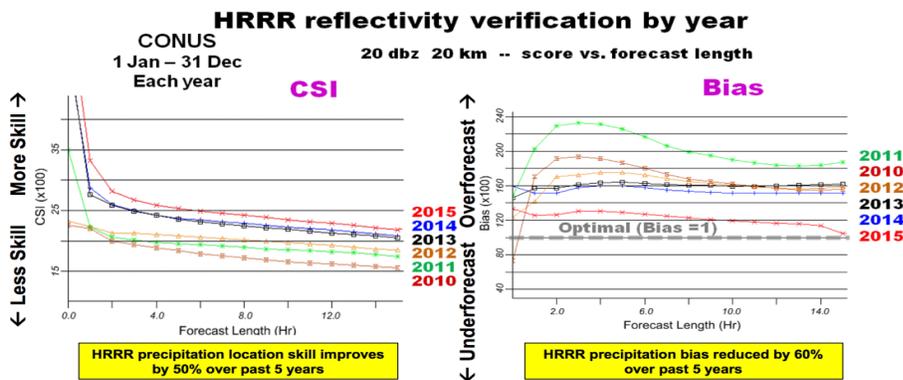


Fig 2. Radar reflectivity verification (Critical Success Index on left, bias on right) for 3km HRRR model for 2010-2015. HRRR and radar observations are averaged at 20km scale and threshold is 20 dBZ reflectivity.

The HRRR and RAP models were recently updated (HRRRv2/RAPv3) at NOAA/NCEP in August 2016. An overall description of the RAPv3/HRRRv2 configuration for model and assimilation details are described in B16.

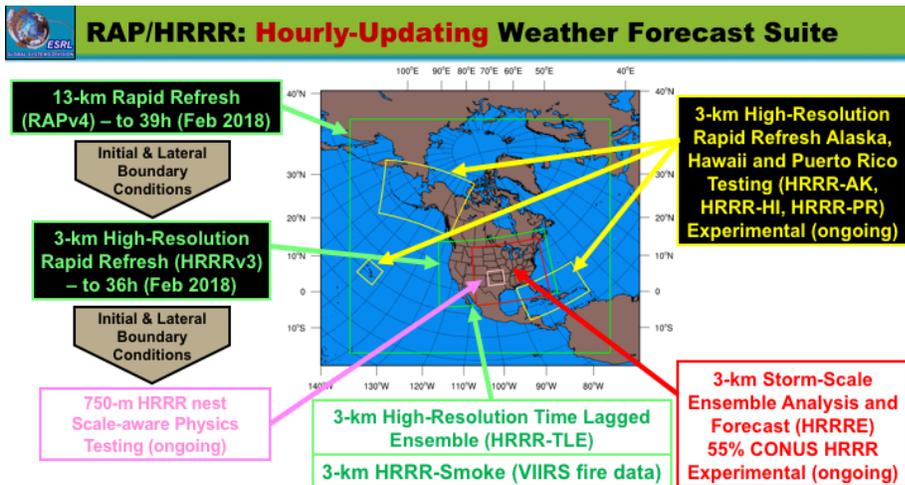


Fig 3. Experimental versions of High-Resolution Rapid Refresh (HRRR) running at NOAA Earth System Research Lab, with Feb 2018 upgrade of operational version of HRRR model at NCEP.

In 2017, a HRRR Ensemble was tested and evaluated with a 40-member 3km ensemble for data assimilation showing for 1-7h duration improved reflectivity (Fig. 4) vs. the HRRR with non-3km-ensemble data assimilation. Improved versions of the HRRR Ensemble will be tested in 2018. A description of the HRRR Ensemble (version 2017) is

provided in Figure 5, including hourly assimilation with 36 members running at 3km. Ensemble forecasts were run with 9 members every 3 hours.

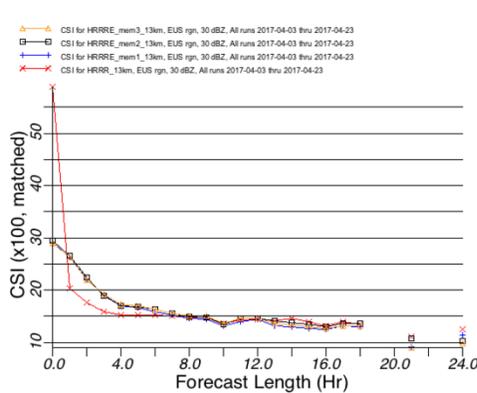


Fig 4. Radar reflectivity Critical Success Index verification for deterministic HRRR (red) and 3 members of the HRRR Ensemble. 2018 upgrade of operational version of HRRR

### HRRRE 2017 (01 March – 30 June 2017)

**55% CONUS HRRR**

Proof-of-concept  
Real-time demonstration  
With NSSL Experimental  
WoF System for ensembles  
"NEWS-e"

Real-Time Web Graphics  
<https://rapidrefresh.noaa.gov/hrrr/HRRRE>

- Single core (ARW)
- Ensemble DA (DART and GSI-EnKF)
- RAP mean + GDAS perturbations w/more inflation
- Conventional observations
- Radar reflectivity observations
- Stochastic physics
- Cloud analysis
- Soil adjustments
- HRRR-TLE post-processing

Assimilation	Forecast
36 members	12z – Nine members to 18 hrs
1 hr cycling	15z – Nine members to 18 hrs
15 fcsts / day	18z – Nine members to 18 hrs
Start 09z day one	21z – Nine members to 18 hrs
End 00z day two	00z – Nine members to 36 hrs

Fig 5. Description of the experimental 2017 HRRR Ensemble data assimilation and model system run by NOAA Earth System Research Laboratory.

Benjamin, S.G., S.S. Weygandt, M. Hu, C.A. Alexander, T.G. Smirnova, J.B. Olson, J.M. Brown, E. James, D.C. Dowell, G.A. Grell, H. Lin, S.E. Peckham, T.L. Smith, W.R. Moninger, G.S. Manikin, **2016**, A North American hourly assimilation and model forecast cycle: The Rapid Refresh. *Mon. Wea. Rev.*, **144**, 1669-1694. <http://dx.doi.org/10.1175/MWR-D-15-0242.1>