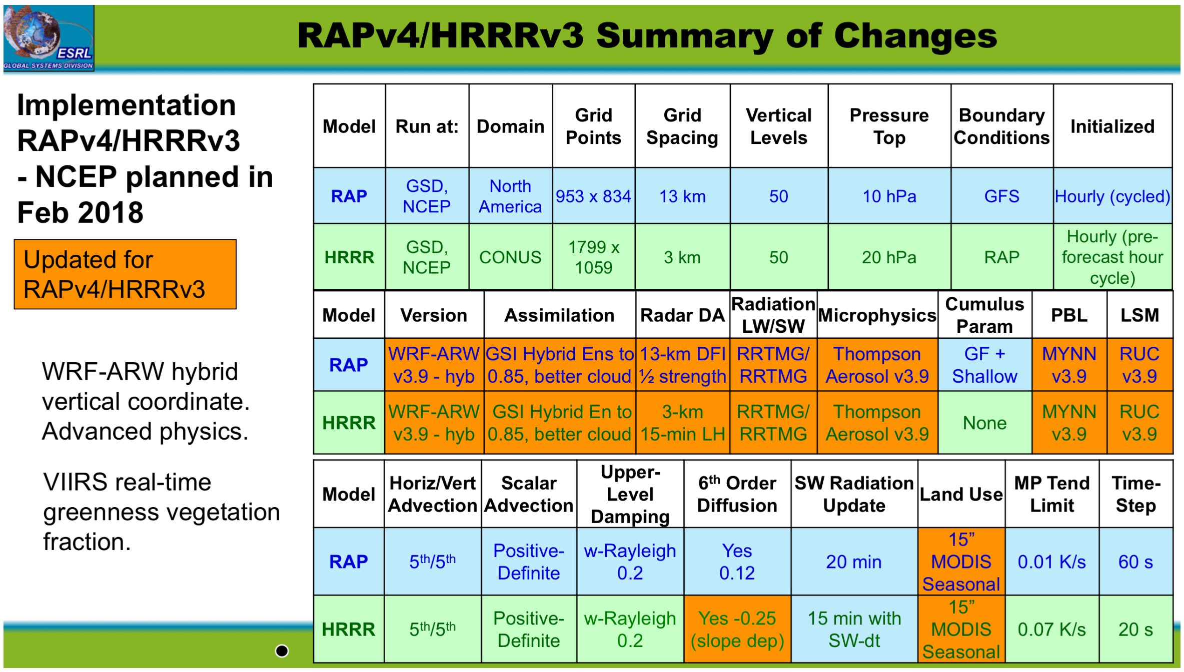
Stormscale-mesoscale physics parameterization suite for the NOAA 3km HRRR and 13km RAP models and other applications

Joseph B. Olson, Georg Grell, Tatiana Smirnova, Jaymes Kenyon,
John Brown, Curtis Alexander, Stan Benjamin
NOAA Earth System Research Laboratory, Boulder, Colorado USA. Joseph.B.Olson@noaa.gov



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)
HRRR	GSD, NCEP	CONUS	1799 x 1059	3 km	50	20 hPa	RAP	Hourly (pre-forecast hour cycle)

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 cloud	13-km DFI ½ strength	RRTMG/ RRTMG	Thompson Aerosol v3.9	GF + Shallow	MYNN v3.9	RUC v3.9
HRRR	WRF-ARW v3.9 - hyb	GSI Hybrid En to 0.85, better cloud	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 changed areas are shaded in orange.

The physics parameterization suite used in NOAA for the 3km High-Resolution Rapid Refresh (**HRRR**) and 13km Rapid Refresh (**RAP**) hourly updated models has been refined over the past few years for all-season boundary-layer forecasting including clouds, precipitation, and convective environment. Both physics and data assimilation refinements have contributed to the improved near-surface and upper-air skill as shown in Benjamin et al 2016 (B16). 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. Specifically, the HRRR/RAP physics suite is described in B16, section 3.

In 2017, a yet further improved set of physical parameterizations has been developed for RAPv4 and HRRRv3 with this set of physics changes (Fig. 1) results in consistent improved upper-air forecast skill (Fig. 2). The most important parameterization improvements in RAPv4/HRRRv3 are those for the MYNN boundary scheme, the Thompson-Eidhammer cloud microphysics scheme, and the RUC land-surface model.

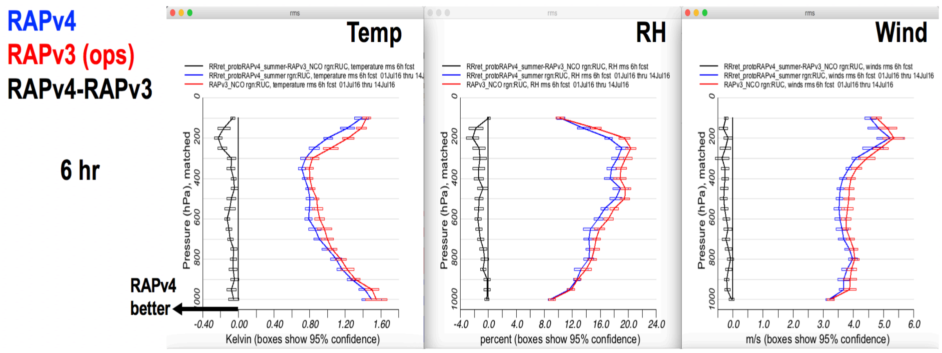


Fig 2. RMS error in temp/RH/wind 6h forecasts vs.raobs from RAPv4 (blue) vs. RAPv3 (red) for July 2016. Improvements to RAP (RAPv4) and HRRR (HRRRv3) models are expected in early 2018 at NOAA/NCEP.

The HRRR and RAP models use this common suite of physical parameterizations with yearly improvements:

1. Grell-Freitas convection – deep and shallow (Grell and Freitas 2014).
2. MYNN PBL – Olson/Kenyon improvements for WRFv3.9 (B16, App. B)
3. RUC land-surface model - 9 soil layers, 2 snow layers - WRFv3.9 version (B16, Smirnova et al 2016). Now includes use of VIIRS greenness vegetation fraction.
4. Thompson aerosol-aware cloud microphysics (Thompson and Eidhammer 2014).

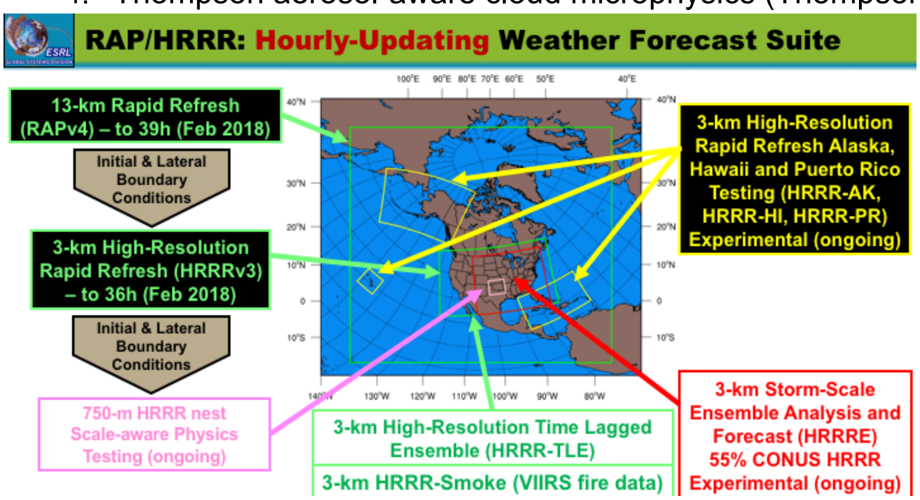


Fig 3. Experimental versions of 3km HRRR and running at NOAA Earth System Research Lab, with Feb 2018 upgrade of operational version of HRRR model at NCEP.

The experimental versions of the RAP and HRRR models described to the left in Fig. 3 all use the new RAPv4/HRRRv3 physics suite shown in Fig. 1.

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Grell, G.A., and S. Freitas, **2014**: A scale and aerosol aware stochastic convective parameterization for weather and air quality modeling. *Atmos. Chem. Phys*., **14**, 5233-5250, doi:10.5194/acp-14-5233-2014.

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