

Friends and Partners in Aviation Weather



NOAA Weather Modeling with the RAP/HRRR

24 October 2013

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Hourly Updated NWP Models



FPAW - 2013

• RAP/HRRR Model Status

HRRR Users and Applications

Aviation Weather Center (AWC): 2-D grids Federal Aviation Administration (FAA) Command Center National Center for Atmospheric Research (NCAR): 2-D, 3-D, 15-min grids **Operational evaluation in CoSPA** Storm Prediction Center (SPC): 2-D grids Severe Weather Operational severe weather forecasting and evaluation National Severe Storms Laboratory (NSSL): 2-D, 3-D and 15-min grids Mesoscale analysis, Short-term precipitation forecasts National Centers for Environmental Prediction (NCEP): 15-min grids Real Time Mesoscale Analysis (RTMA) Department of Energy/NOAA Wind Forecast Improvement Project (WFIP) ~12 energy private sector companies via WFIP (WindLogics, 3Tier, AWS Truepower, Iberdrola, Weather Channel, etc.) **Renewable Energy** Real-time forecasts of turbine-level wind and solar irradiance Colorado State University (CSU/CIRA): 2-D grids Verification of solar irradiance forecasts at SURFRAD sites Air Resources Laboratory (ARL): Tiled 3-D HRRR grids Dispersion forecasts, Local wind forecasts in complex terrain National Weather Service (NWS): 2-D and 3-D grids Operational weather forecasting United States Air Force (USAF): 2-D grids Operational weather forecasting

FPAW - 2013

RAP/HRRR Model Status

Forecasting

Aviation

RAP: Data assimilation engine for HRRR





- Partial cycle atmospheric fields introduce GFS information 2x/day Cycle hydrometeors
- Fully cycle all land-sfc fields (soil temp, moisture, snow)



Hourly Observations	RAP 2013 N. Amer
Rawinsonde (T,V,RH)	120
Profiler – NOAA Network (V)	21
Profiler – 915 MHz (V, Tv)	25
Radar – VAD (V)	125
Radar reflectivity - CONUS	1km
Lightning (proxy reflectivity)	NLDN, GLD360
Aircraft (V,T)	2-15K
Aircraft - WVSS (RH)	0-800
Surface/METAR (T,Td,V,ps,cloud, vis, wx)	2200- 2500
Buoys/ships (V, ps)	200-400
Mesonet (T, Td, V, ps)	flagged
GOES AMVs (V)	2000- 4000
AMSU/HIRS/MHS radiances	Used
GOES cloud-top press/temp	13km
GPS – Precipitable water	260
WindSat scatterometer	2-10K
Nacelle/Tower/Sodar	20/100/10

AMB Model Development and Eval



RAP/HRRR Verification System

Intensity Threshold Domain Precipitation Rainfall Rate (in/hr) Rainfall Rate (in/hr) Reflectivity Echo 120°W 105°W 90°W 75°W Intensity Intensity Stratiform Convective in (dBZ) Level Less Than 0.1 Less Than 0.2 Min. Signal - 30 Weak Light R B 45°N 45°N 0.2 - 1.1 31 - 40 0.1 - 0.5 Northeast Moderate Moderate 0.5 - 1.0 1.1 - 2.2 41 - 45 Strong Heavy 40°N 40°N 2.2 - 4.5Very Strong Very Heavy 1.0 - 2.0 46 - 50 2.0 - 5.0 4.5 - 7.1 51 - 57 Intense Intense 35°N 35°N More Than 7.1 > 57 More Than 5.0 Extreme Extreme East West Highest precipitation top in area in hundreds of feet MSL (45,000 feet MSL). 30°N 30°N 10 15 20 25 30 35 40 45 50 55 60 65 70 75 5 20 dBZ Southeast 20 25 30 35 40 45 50 55 60 65 70 75 25°N 25°N **30 dBZ** 30 35 40 45 50 55 60 65 70 75 120°W 110°W 100°W 90°W 80°W 40 45 50 55 60 65 70 75 **40 dBZ**

Resolution of Verification



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RAP/HRRR Model Status

24 October 2013

No Data

CR

FA

Hit

HRRR Availability – "We want it"

HRRR 12 hr fcst availability Includes all missed/incomplete runs











HRRR Latency – "We want it now"

2013 HRRR changes permitted ~45 min reduction in latency



12-hr HRRR Forecast Latency

HRRR Run Date

FPAW - 2013

RAP/HRRR Model Status

• 24 October 2013

RAP/HRRR Implementation Map

ESRL – experimental version

- RAPv1 used in 2011
 - Initialized 2011 HRRR
 - effective but too many storms
- RAPv2 used in 2012-2013
 - Initialized 2012-2013 HRRR
 - Better use of surface obs / radar, storm bias eliminated, Hybrid DA
- HRRR 2012
 - Major improvement over 2011
 HRRR, storm coverage/accuracy
- HRRR 2013
 - 3km/15min radar assimilation
 - Initialized from RAPv2-2013
 - Available 45 min earlier, much more accurate 0-15h storm forecasts, more reliable 2-computer

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RAP/HRRR Model Status

NWS-NCEP - operational

- Implemented 1 May 2012
 - RAPv2 Scheduled to be implemented in Dec 2013

• HRRRv1 – Scheduled to be implemented in 2014



HRRR Forecast Behavior

2012

- (1) Coarse 00-hr analysis
- (2) Convective "spin-up"
- during forecast period
- (3) Low echo top bias
- (4) Latency of 2-3 hrs
- (5) Single HPCS reliability

RAP/HRRR Model Development and Evaluation

2013 Targets

(1) 3-km scale at 00-hr

(2) Reduced "spin-up" during

forecast period

(3) Optimal echo top bias

(4) Reduced latency of 1-2 hrs

(5) Dual HPCS reliability

Key Advantage of 3-km HRRR

13-km 6hr forecast

HRRR 6hr forecast



HRRR Forecasts for Aviation

CoSPA: Collaborative effort: ESRL/GSD, NCAR/RAL, MIT/LL

Provide 0-8 hr thunderstorm intensity and echo top guidance to aviation community

HRRR 15 UTC 08 July 2011 CoSPA 17 UTC 08 July 2011 6 hr forecast valid 21 UTC 4 hr forecast valid 21 UTC Blend with **CIWS** Echo Top

Observation Valid 21 UTC 08 July 2011



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• R.

RAP/HRRR Model Status

HRRR Aviation Websites

http://rapidrefresh.noaa.gov/hrrraviation/ (hourly output)

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http://rapidrefresh.noaa.gov/hrrraviation15min/ (sub-hourly output)

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FPAW - 2013

• RAP/HRRR Model Status



Observation 01z 21 June 2012

HRRR 4 hr forecast

Valid 06/21/2012 01:00 UTC

HRRR 06/20/2012 (21:00) 4h fcst - Experimental



Echo Tops (kft)

Echo Top 28 31 34 37 4043 46 25

2012 low bias in echo tops

FPAW - 2013

• RAP/HRRR Model Status

• 24 October 2013



Observation 01z 21 June 2012

HRRR 4 hr forecast



Echo Tops (kft)



Calibration of echo tops to produce improved bias

FPAW - 2013

• RAP/HRRR Model Status

• 24 October 2013

HRRR ET Diagnostic Verification



FPAW - 2013

RAP/HRRR Model Status

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HRRR ET Diagnostic Verification



FPAW - 2013

RAP/HRRR Model Status

2012 HRRR Initialization from RAP



2013 HRRR Initialization from RAP







FPAW - 2013

RAP/HRRR Model Status



FPAW - 2013

RAP/HRRR Model Status



FPAW - 2013

RAP/HRRR Model Status



FPAW - 2013

RAP/HRRR Model Status



RAP/HRRR Model Status

FPAW - 2013



FPAW - 2013

• RAP/HRRR Model Status



FPAW - 2013

RAP/HRRR Model Status



FPAW - 2013

• RAP/HRRR Model Status









HRRR Real-Time Exper Products

	Background	Dimensionality	Updated
2012 HRRR model initialization	13-km RAP	3-D	Hourly
2013 HRRR model initialization	13-km RAP	3-D	Hourly
Rapidly Updating Analysis (RUA-HRRR)	3-km HRRR 1 hr fcst	3-D	Hourly
Real-Time Meso Analysis (RTMA-HRRR)	3-km HRRR 1 hr fcst	2-D	Hourly (15 min planned)
Time-Lagged HRRR (HCPF)	3-km HRRR Fcsts	2-D	Hourly

FPAW - 2013

• RAP/HRRR Model Status

Time-lagged Ensemble

Forecasts valid 21-22z 27 April 2011

Forecasts valid 22-23z 27 April 2011



All six forecasts combined to form probabilities valid 22z 27 April 2011



Example: 28 August 2013

Atypical summer convection embedded in NW flow with "back-door" cold front in New England



FPAW - 2013

• RAP/HRRR Model Status

Example: 28 August 2013

Convection develops in NYC terminal areas around 16 UTC



FPAW - 2013

RAP/HRRR Model Status

• 24 October 2013

HCPF - HRRR deterministic forecasts (reflect > 35 dBZ) overlaid on convective probability

Attempt to capture uncertainty through measure of hourly forecast consistency

AWC beginning evaluation of product

HRRR Convective Probability Forecast (%) and Reflectivity (dBz) 06 hr fcst valid 08/28/2013 16 UTC 20 60 80 100 10 15 20 25 30 35 40 45 50 55 60 65 70 75

06 hr fcst valid 16z 28 Aug 2013

First hints of convection in NE PA



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RAP/HRRR Model Status

• 24 October 2013

04 hr fcst valid 16z 28 Aug 2013

Increasing convective intensity and coverage in NE PA and N NJ

Probability exceeds 20%



HRRR Convective Probability Forecast (%) and Reflectivity (dBz) 04 hr fcst valid 08/28/2013 16 UTC

FPAW - 2013

RAP/HRRR Model Status

24 October 2013

02 hr fcst valid 16z 28 Aug 2013

Convective coverage now over much of extreme E PA and NJ

Probability exceeds 40%



HRRR Convective Probability Forecast (%) and Reflectivity (dBz) 02 hr fcst valid 08/28/2013 16 UTC

FPAW - 2013

RAP/HRRR Model Status

24 October 2013

Analysis valid 16z 28 Aug 2013

Probability exceeds 60% with centroid west of NYC



HRRR Convective Probability Forecast (%) and Reflectivity (dBz) 00 hr fcst valid 08/28/2013 16 UTC

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RAP/HRRR Model Status

24 October 2013

Probabilities slowly evolve providing identifiable run-to-run trends

Convective structure (permeability etc...) still accessible



FPAW - 2013

RAP/HRRR Model Status





FPAW - 2013

RAP/HRRR Model Status

Summary and Plans

- Moist bias reduced in 2012 RAP and HRRR
 - Reduced false alarms, lower precipitation bias
 - GSI enhancements and WRF upgrade to v3.3.1
 - Reflectivity diagnostic consistent with microphysics
- Science: Focus on 3-km assimilation for 2013
 - 3-km variational analysis
 - 3-km non-variational cloud analysis
 - 3-km radar reflectivity data assimilation
- Technical: Reduced latency for 2013 (2-3 hrs now)
 - Approximate 1-hr reduction in execution time (1-2 hrs)
 - Faster post-processing with parallelization
 - Direct GRIB2 generation

RAP/HRRR Model Status

HRRR Transition to NCEP

2013 - early 2014 – 2 computers running identical HRRR (and RAPv2) – interim solution

- Boulder computer 1
- Fairmont, WV computer 2
- Expected reliability at 98.5-99% via coordination of downtimes for Boulder vs. Fairmont computers

• 2014 – NCEP running RAPv2 (FYQ1) and HRRR (FYQ2)

- RAPv2 running in NCEP/NCO testing now
- Effort underway to begin testing HRRR at NCEP
- Conclusion: Interim HRRR computing for 2013 on 2 sites to provide "real-time experimental" HRRR from NOAA for NWS, FAA, DOE/energy users until HRRR impl @NCEP