RAPID REFRESH (RAP)
Upgrade V4.0.0
HIGH-RESOLUTION RAPID REFRESH (HRRR)
Upgrade V3.0.0

NCEP Director's Briefing
February 2, 2018

Presented by: Geoff Manikin
Collaborators: Ben Blake, Corey Guastini, Curtis Alexander, Stan Benjamin, Steve Weygandt, David Dowell, Ming Hu, Tanya Smirnova, Joseph Olson, James Kenyon, Georg Grell, Eric James, Haidao Lin, Terra Ladwig, John Brown, Trevor Alcott, and Isidora Jankov

AGENDA

- Geoff Manikin (EMC)
- Emily Niebuhr (AR)
- Israel Jirak (SPC)
- Mark Klein (WPC)
- Steve Lack (AWC)
- Judy Ghiradelli (MDL)
- Open Floor for Comments

RAP/HRRR: Hourly-Updating Weather Forecast Suite

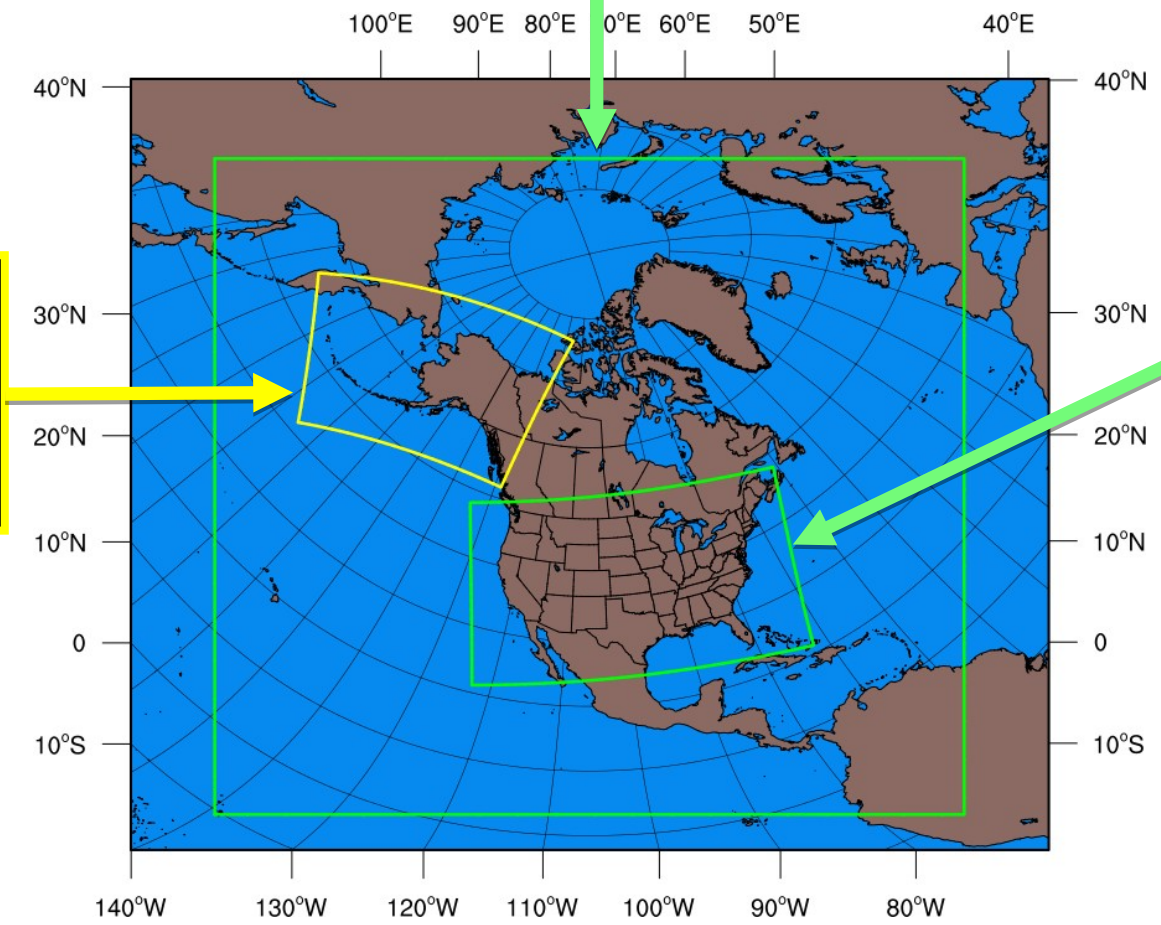
13-km Rapid Refresh (RAPv4) – to 39h (May 2018)

Initial & Lateral Boundary Conditions

Initial & Lateral Boundary Conditions

3-km High-Resolution Rapid Refresh Alaska (HRRR-AK) 36 hr (May 2018)

3-km High-Resolution Rapid Refresh (HRRRv3) – to 36h (May 2018)



Quick Overview of Changes

- Updated versions of WRF-ARW model (3.8.1), GSI, and post
- Introduce HRRR-Alaska (run every third hour)
- Extend 4 RAP and 4 HRRR cycles each day
- Change to hybrid vertical coordinate
- Improved convective scheme (RAP only), microphysics, LSM, and PBL scheme
- Refined roughness lengths over various land use types
- Give more ensemble weight to hybrid DA
- Assimilate AMVs over land and TAMDAR
- New radiances assimilated in RAP; lightning and radar radial velocities assimilated in HRRR
- METAR and GOES cloud building made consistent

http://www.emc.ncep.noaa.gov/mmb/bblake/rap_hrrr/

Forecast Extensions

- RAP will be extended to 39 hours at 03/09/15/21z
- HRRR will be extended to 36 hours at 00/06/12/18z
- HRRR-AK will have same extensions as CONUS HRRR
- potential inclusion of HRRR extensions in HREFv2.1 or v3.0

DEVELOPMENT TESTING

- RAPv4/HRRRv3 developed/tested at GSD for 2+ years
- Code frozen Spring 2017
- Built at EMC in summer 2017
- Had many difficulties getting runs through the development machine
- Moved to white space on cray during fall
- Still some issues with disk space filling up, but runs have generally been reliable
- Using EMC parallel for cold season stats; using GSD parallel from last summer for warm season stats
- MEG briefings given on 8/17, 11/16 , 12/21, and 1/25
- First implementation asked to adhere to new EE2 standards

RESOURCES

- HRRRv2 has HWM ~115 nodes
- HRRRv3 has HWM ~135 nodes

- RAPv3 has HWM ~60 nodes
- RAPv4 has HWM ~65 nodes

- HRRR-AK has HWM ~90 nodes

/com storage:

RAP ops: 665 GB/day
RAP v4: 818 GB/day

HRRR ops: 2.386 TB/day
HRRR v3: 3.443 TB/day

COMBINED HWM > 400 nodes

Summary of Evaluations

- Reviews presented at 1/25/18 MEG meeting
- ER, CR, WR, SR, AR all recommend implementation; same for WPC, AWC, SPC
- Evaluations highlighted significant usefulness of forecast extensions
- Overall synoptic benefit was evaluated as either neutral or slightly positive

The Good

- Clear improvement in first few hours of HRRR reflectivity/precip forecasts
- Some improvement seen in cloud fields
- Noticeable positive reduction in light shower activity
- Fewer spurious dew point bullseyes in RAP analyses
- Likely benefits to NBM and RTMA
- Convective systems showed a more realistic and cohesive structure in new system
- Positive subjective evals at HWT SFE and HMT FFaIR

Concerns

- WPC noted reduction in high QPF amounts
- Some concerns about delayed triggering of convection (SPC)
- Problems with eastern CO inversions (WFO BOU)
- Possible degradation of LMP cool season ceiling forecasts

Comments on Extensions

- They meet aviation and other short term forecasting requirements **Eastern Region**
- Benefits of the extended forecasts include convective applications (timing, mode, coverage), aviation applications, precip type/intensity, and wind shift timing **Southern Region**
- They help with the day 2 forecasting efforts **Central Region**
- This will be a significant help to local office forecast operations and help the NBM **Western Region**
- They'll help very much. Many of our wind/precip events are multi-day requiring warning products that span a few days **Alaska Region**

Comments on Extensions cont.

- The extensions will be helpful for day 1 (e.g. forecasts initialized at 00z valid through the next convective day) and day 2 forecasts, especially when viewed from an ensemble perspective **SPC**
- The extensions of the RAP/HRRR provide critical support to our Day 1-2 QPF and winter weather forecasts as well as our Day 1 and 2 Excessive Rainfall outlooks **WPC**
- The extensions allow us to extend the automated Traffic Flow Management Convective Forecast (TCF) beyond its current eight hour forecast times **AWC**
- They will help the AWC/NAM staff in supporting the FAA PERTI effort in regards to planning for the next day **AWC/NAM**

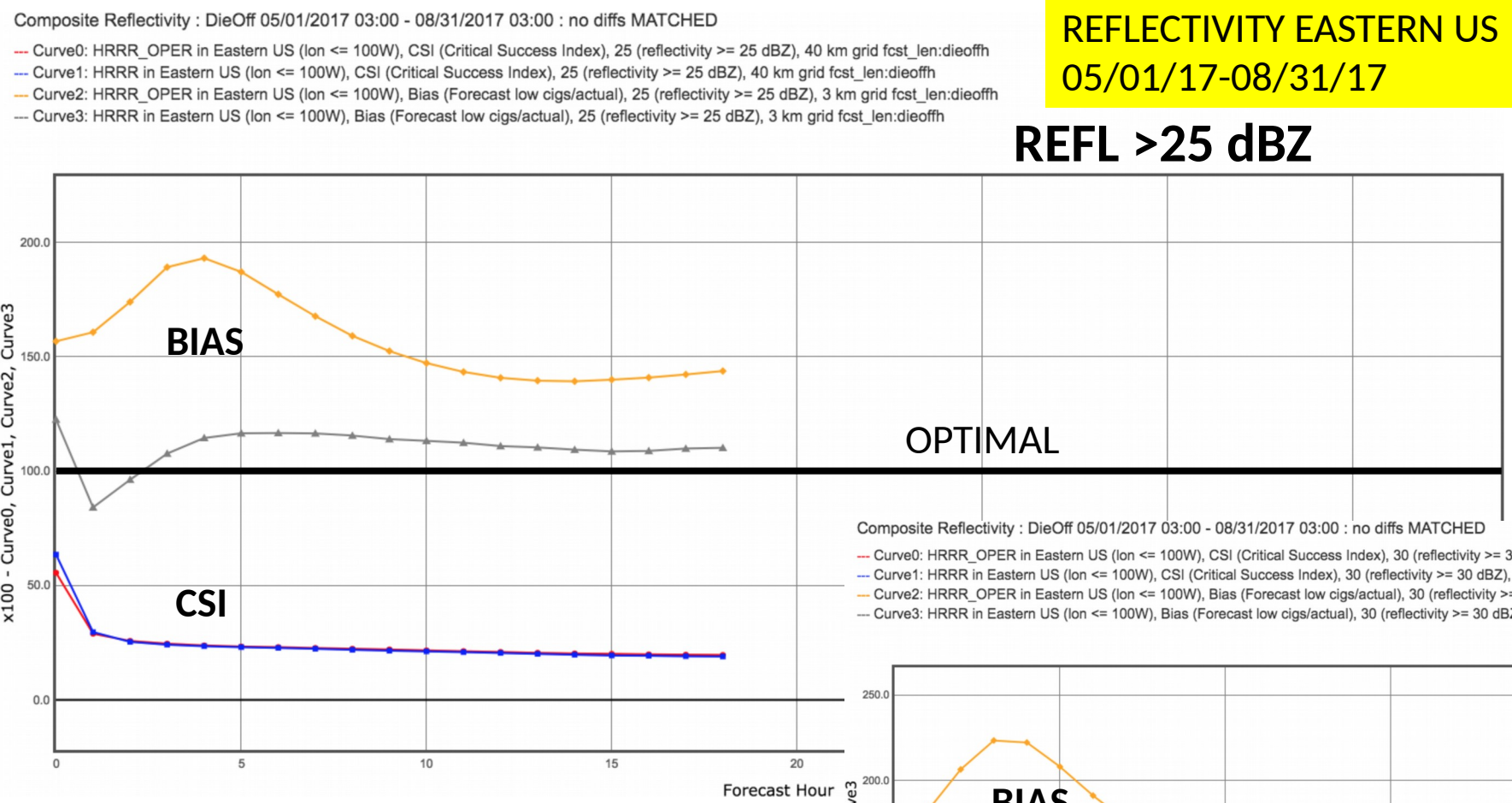
WARM SEASON STATS

HRRR OPS (v2) or RAP OPS (v3)

HRRRX (v3) or RAPX (v4)

REFLECTIVITY EASTERN US
05/01/17-08/31/17

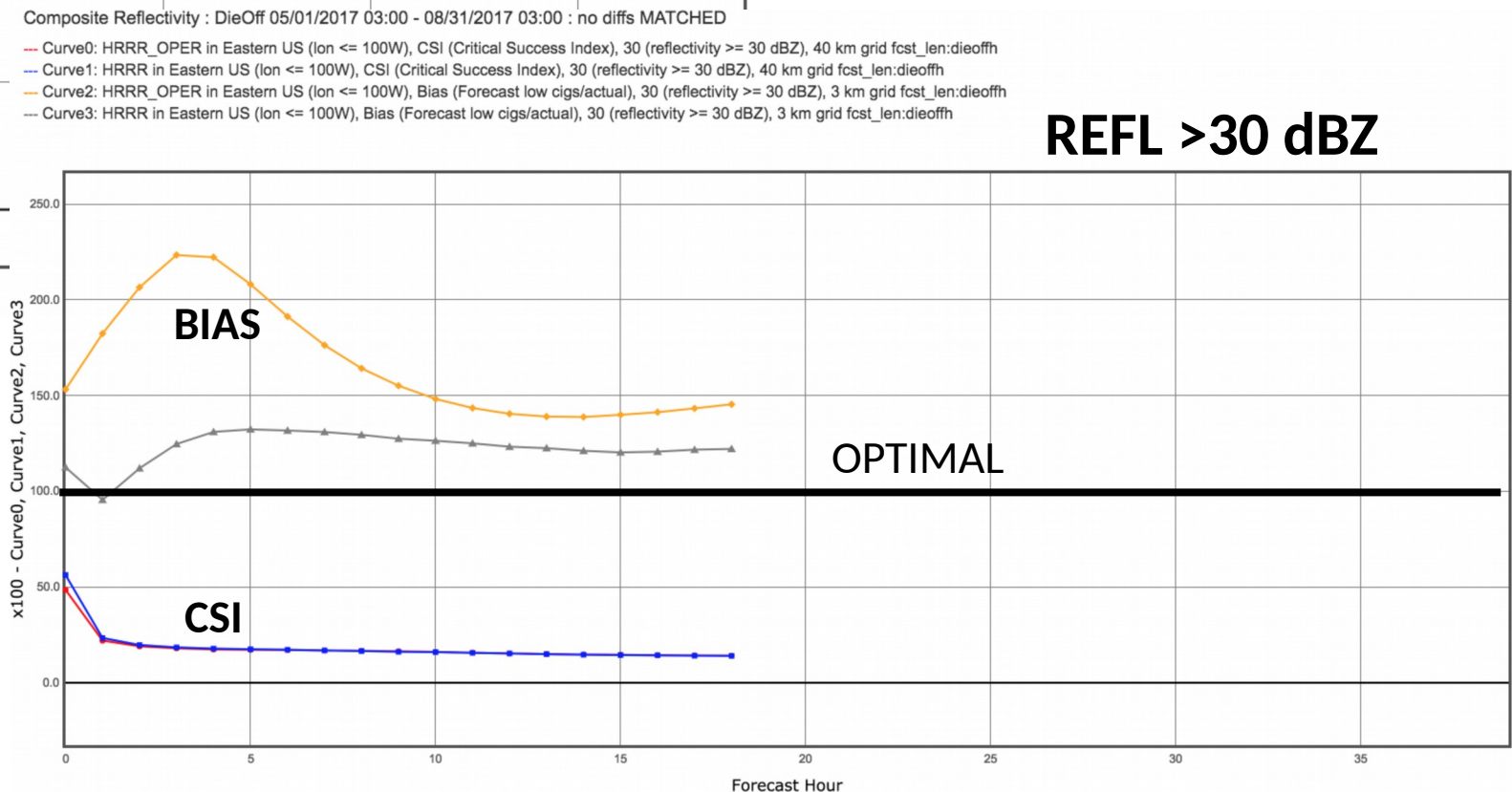
REFL >25 dBZ



Large reduction in high reflectivity bias in first few hours

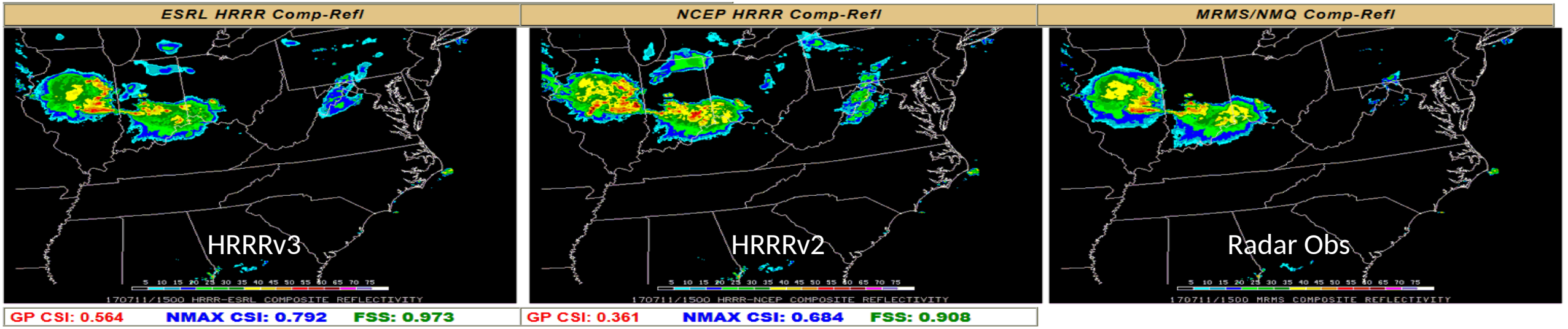
- HRRR OPS
- HRRR OPS
- HRRR EMC PARA
- HRRR EMC PARA

REFL >30 dBZ



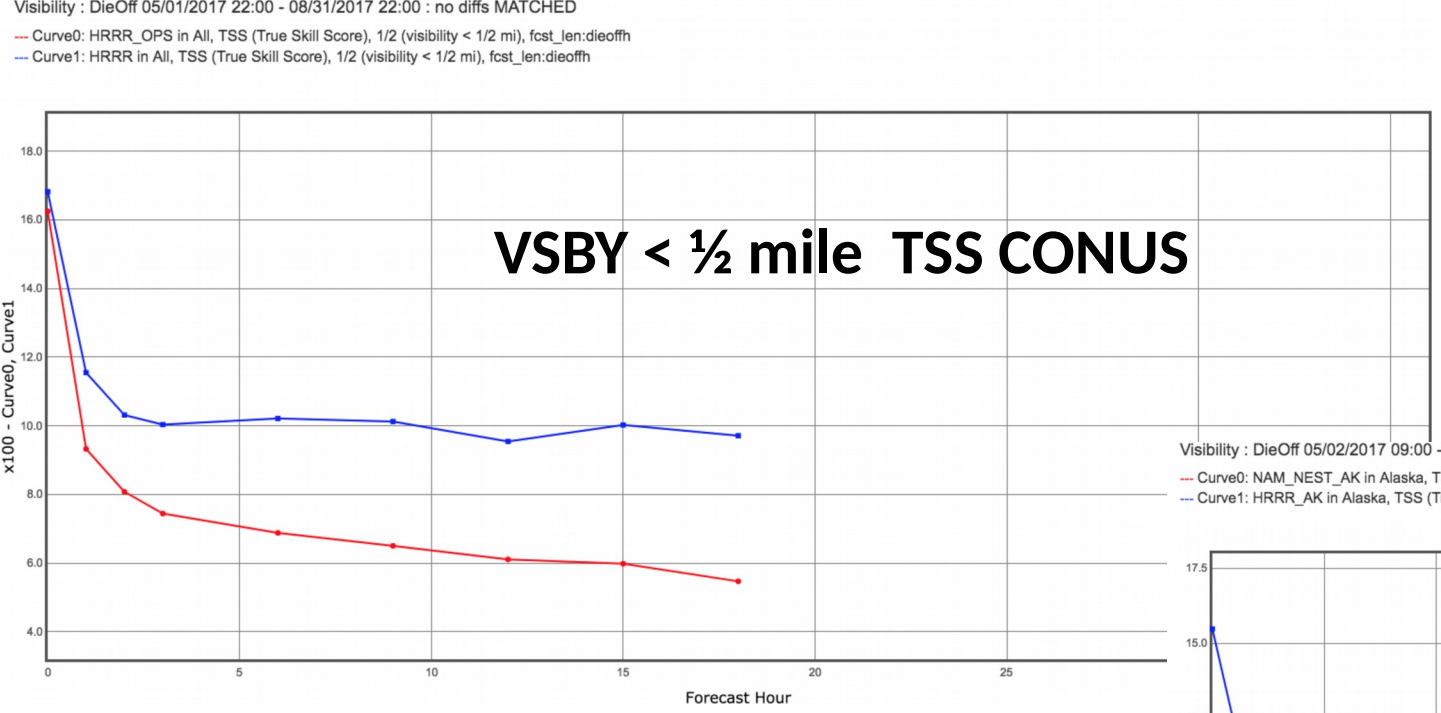
SPC HRRRv3 Evaluation
15Z HRRR: 00-h Analysis Example

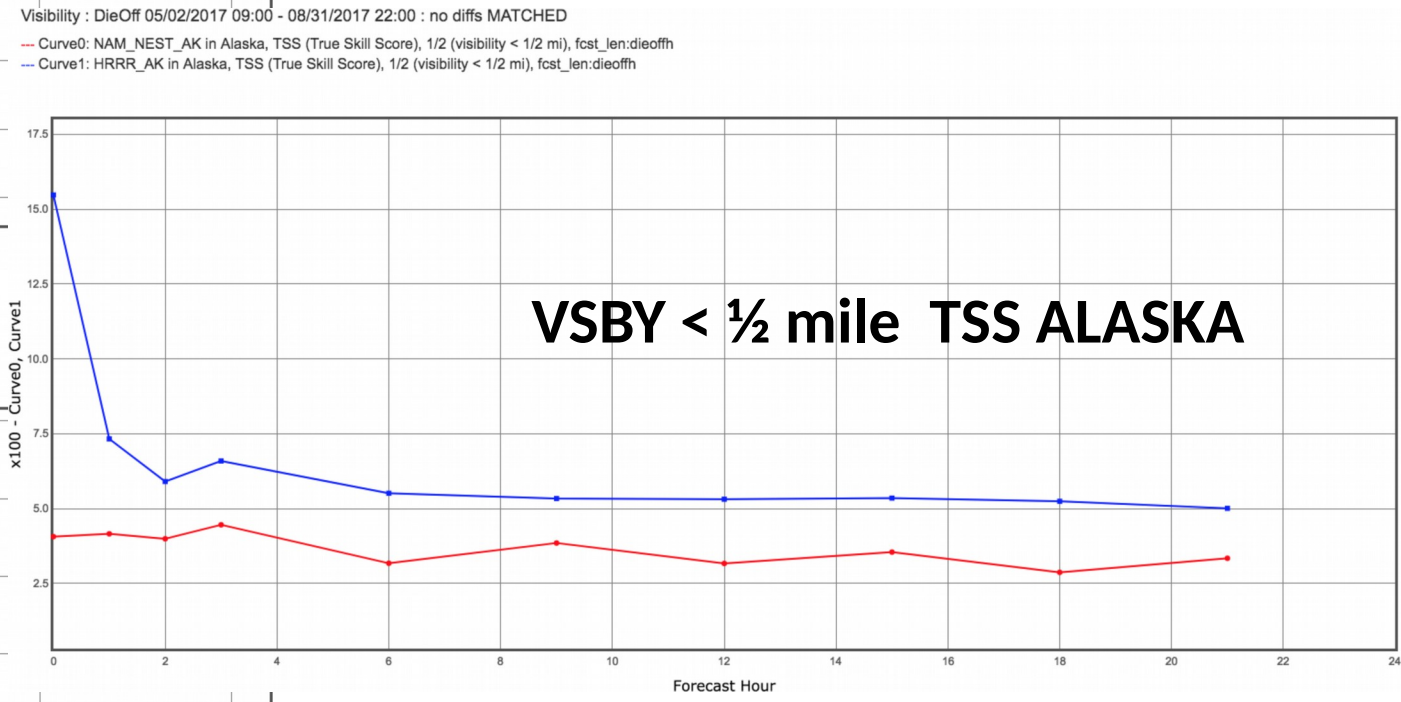
- For the analysis (fh00) at 15Z, the HRRRv3 (left) is better at matching observed radar details (right) compared to HRRRv2 (center).
- This includes placement of high reflectivity core structures and a reduction in spurious low reflectivity regions.

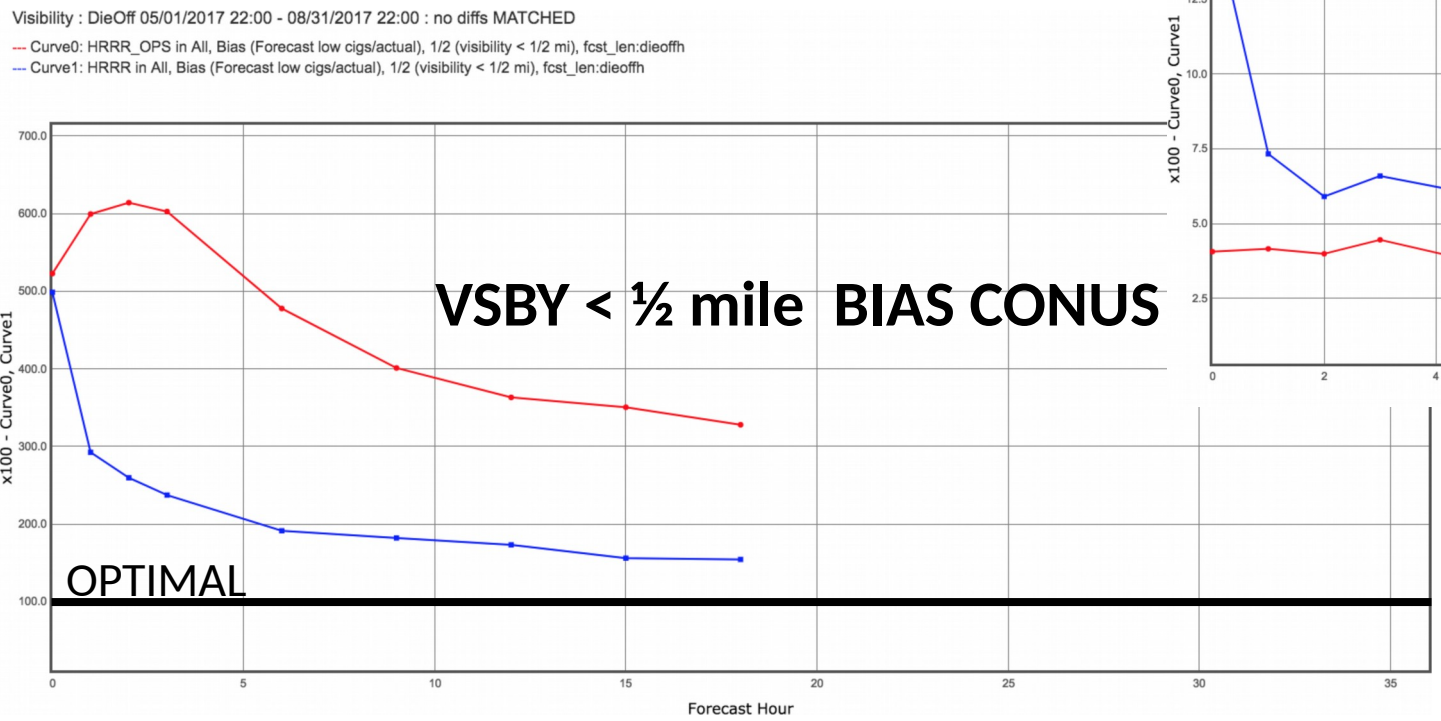


00-h Analyses of Composite Reflectivity
Valid 15Z on 11 July 2017

VISIBILITY
05/01/17-08/31/17

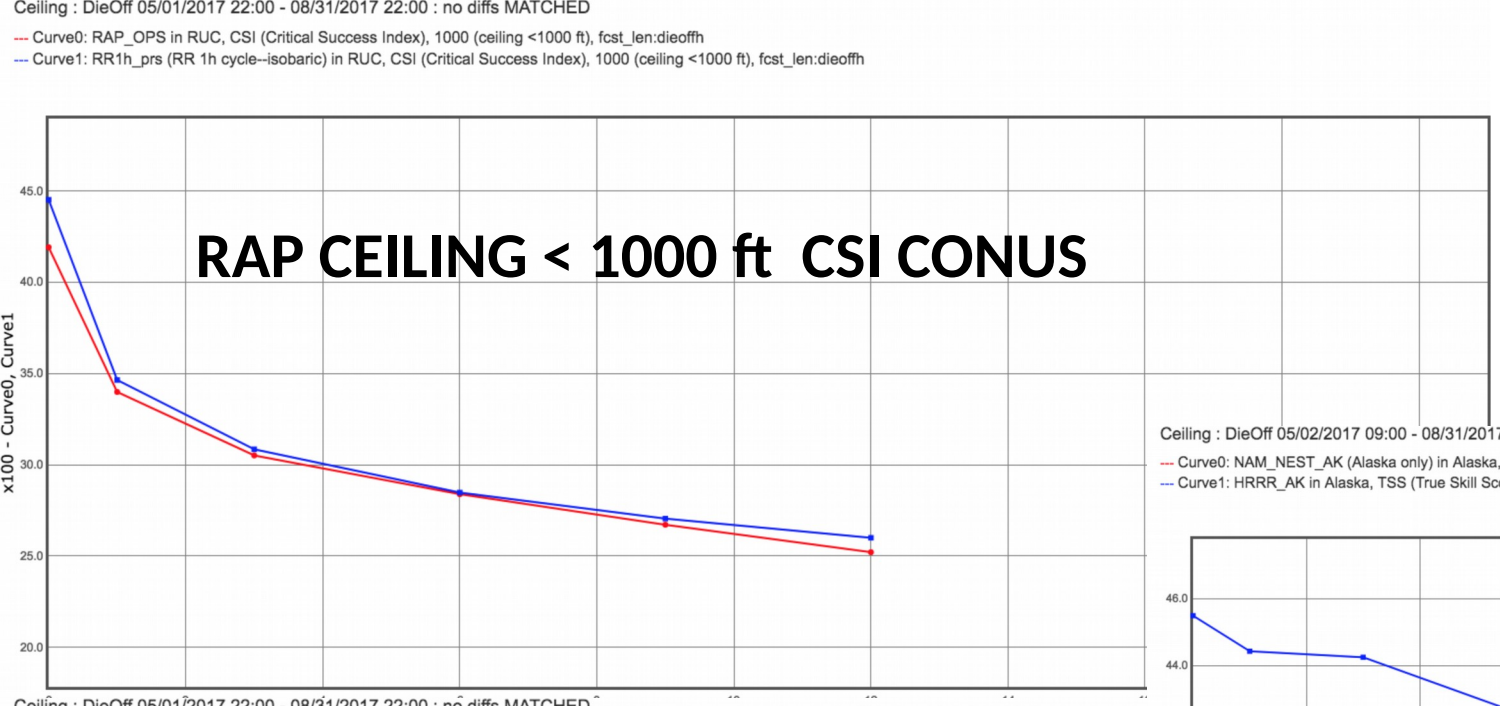


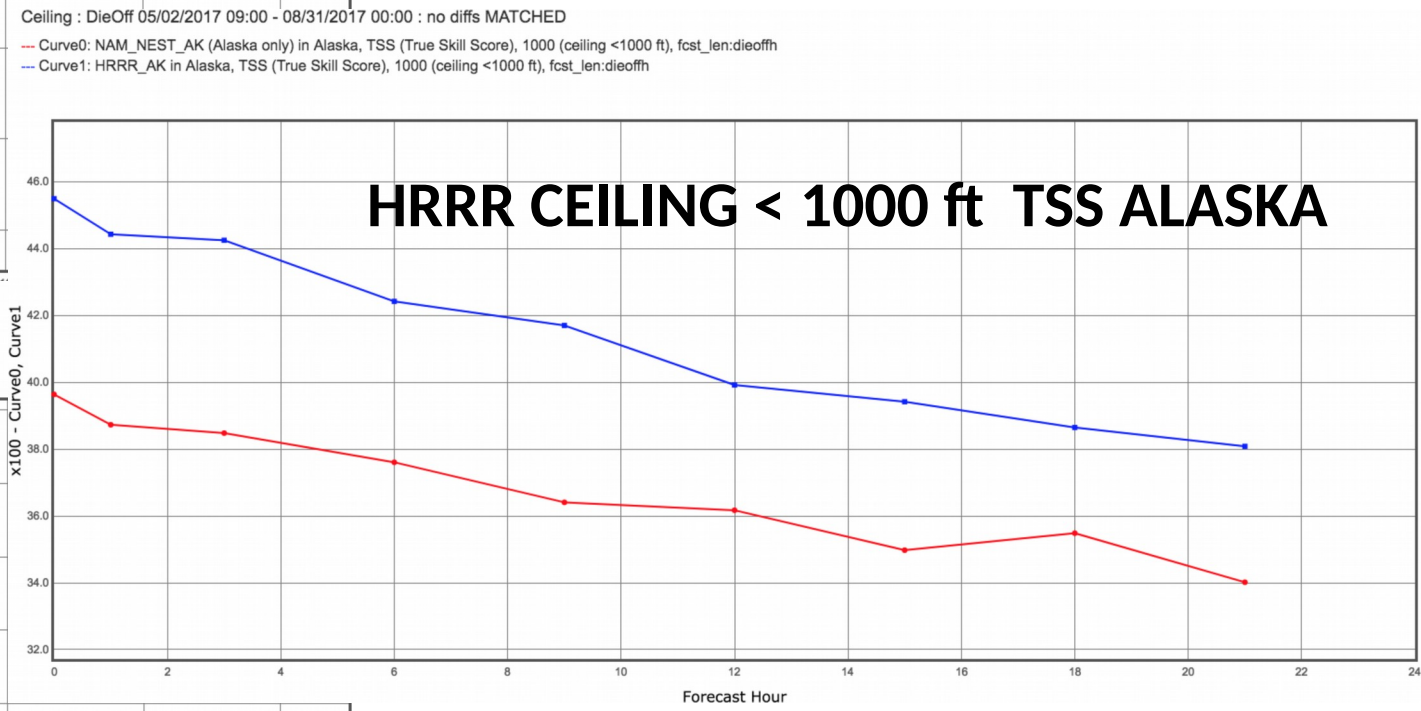


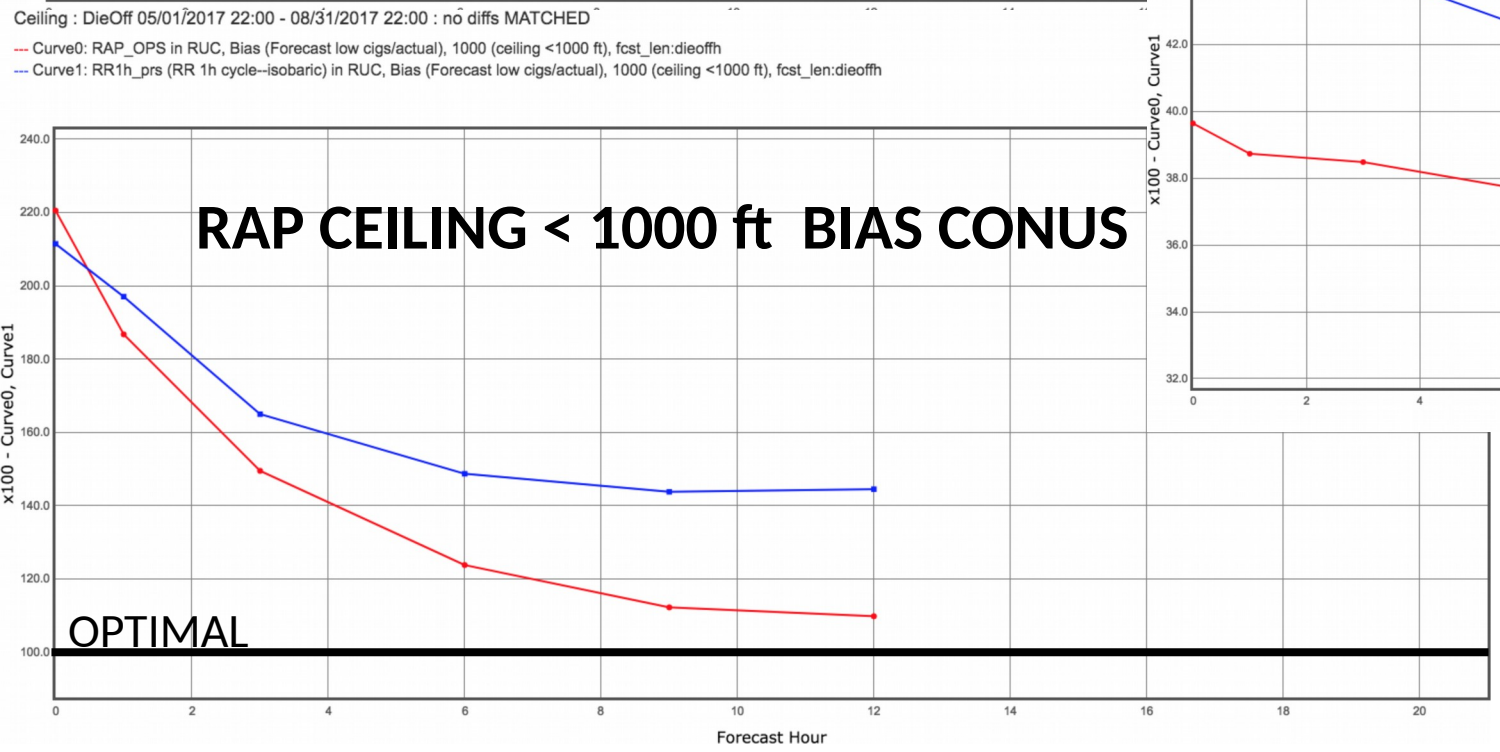


- HRRR OPS
- HRRR EMC PARA

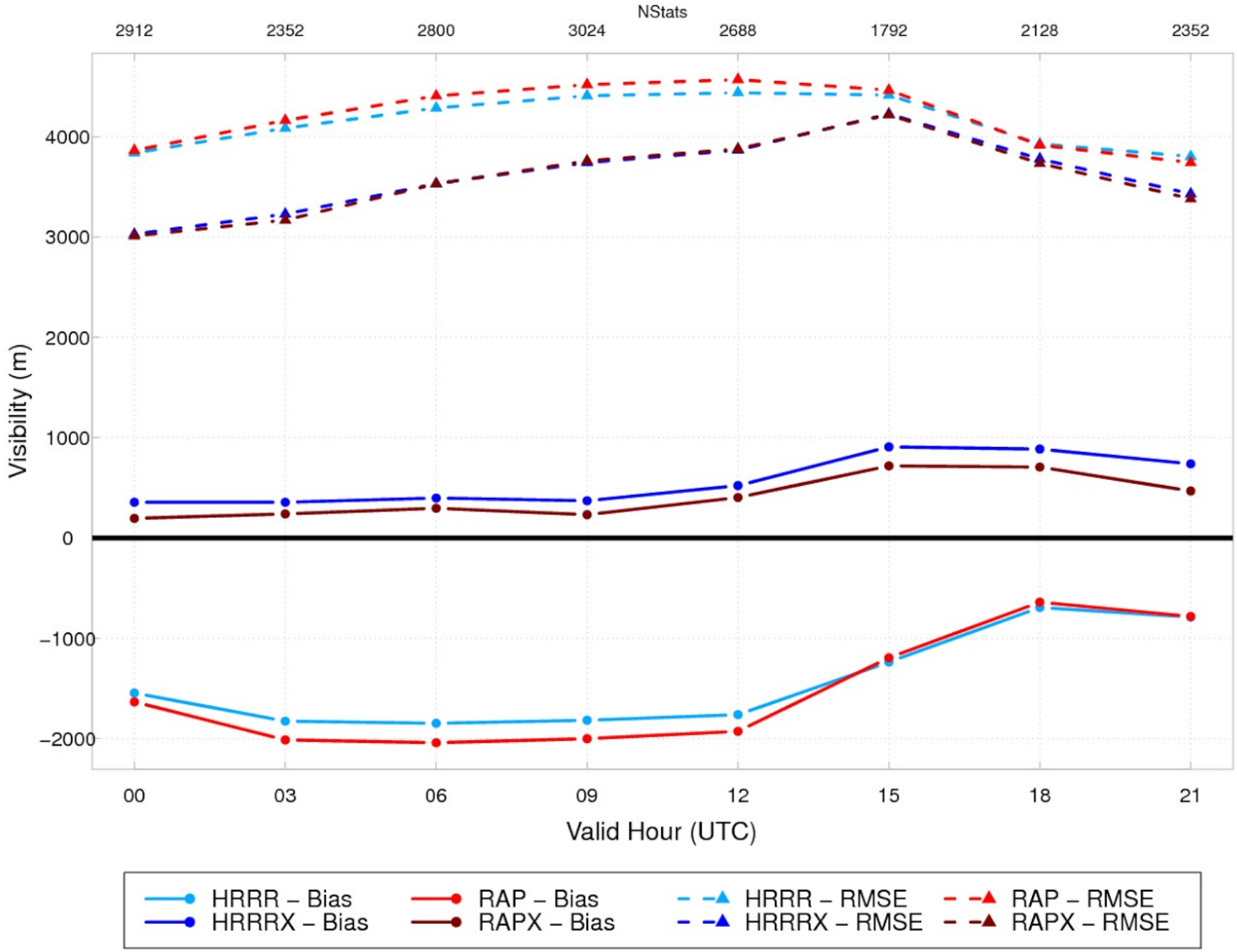
CEILING
05/01/17-08/31/17







COOL SEASON STATS


VIS CONUS: 20 Nov 2017 – 20 Jan 2018: 12–h forecasts
NStats
2912
2352
2800
3024
2688
1792
2128
2352
4000
3000
2000
1000
0
−1000
−2000
Visibility (m)
00
03
06
09
12
15
18
21
Valid Hour (UTC)
HRRR – Bias
HRRRX – Bias
RAP – Bias
RAPX – Bias
HRRR – RMSE
HRRRX – RMSE
RAP – RMSE
RAPX – RMSE

RAP Scorecard

for RAPv4 and RAPv3

2017-11-20 00:00:00 - 2018-01-20 18:00:00

			CONUS							
			f00	f03	f06	f09	f12	f15	f18	f21
Bias	Temperature	2-m							▲	▲
		850-mb			▲		▲		▲	
		700-mb	▼		▼		▼		▼	
	Dew Point Temperature	2-m	▼							
	Wind Speed	10-m		▲						
	Wind Gust Potential	SFC	▼	▼	▼	▼	▼	▼	▼	▼
	Geopotential Height	850-mb	▲		▲		▲		▲	
		700-mb	▲		▲		▲		▲	
		500-mb	▲		▼				▼	
	Sea Level Pressure		▲	▲	▲	▲	▲	▲	▲	▲
	Visibility	SFC	▲	▲	▲	▲	▲	▲	▲	▲
	Cloud Ceiling		▲	▼			▲	▲	▲	▲
RMSE	Temperature	2-m			▴	▲	▲	▲	▲	▲
		850-mb			▲		▲		▲	
		700-mb			▲					
	Dew Point Temperature	2-m	▼	▼	▼	▾				
	Wind Speed	10-m		▲						
	Wind Gust Potential	SFC	▼	▼	▼	▼	▼	▼	▼	▼
	Geopotential Height	850-mb			▲		▲			
		700-mb			▼		▲			
		500-mb			▼				▼	
	Sea Level Pressure		▲	▲	▲	▲	▲	▲	▲	▲
	Visibility	SFC	▲	▲	▲	▲	▲	▲	▲	▲
	Cloud Ceiling		▲	▼	▴					
Bias	Vector Wind	850-mb								
		500-mb								
		250-mb			▲		▲		▲	
RMSE	Vector Wind	850-mb								
		500-mb			▲		▴		▲	
		250-mb			▲				▲	

▲	RAPv4 is better than RAPv3 at the 99.9% significance level
▴	RAPv4 is better than RAPv3 at the 99% significance level
	RAPv4 is better than RAPv3 at the 95% significance level
	No statistically significant difference between RAPv4 and RAPv3
	RAPv4 is worse than RAPv3 at the 95% significance level
▾	RAPv4 is worse than RAPv3 at the 99% significance level
▼	RAPv4 is worse than RAPv3 at the 99.9% significance level
	Not statistically relevant

HRRR Scorecard

for HRRRv3 and HRRRv2

2017-11-20 00:00:00 - 2018-01-20 18:00:00

			CONUS						
			f00	f03	f06	f09	f12	f15	f18
Bias	Temperature	2-m				▾	▾	▼	
		850-mb			▲		▲		▲
		700-mb	▼		▼		▼		▼
	Dew Point Temperature	2-m		▼	▼	▼	▾		
	Wind Speed	10-m		▲	▲				
	Wind Gust Potential	SFC	▼	▼	▼	▼	▼	▼	▼
	Geopotential Height	850-mb			▼		▲		
		700-mb			▼		▲		▼
		500-mb	▼		▼		▼		▼
	Sea Level Pressure					▲	▲	▲	▲
	Visibility	SFC	▲	▲	▲	▲	▲	▲	▲
	Cloud Ceiling		▲		▲	▲	▲	▲	▲
RMSE	Temperature	2-m							
		850-mb	▾						
		700-mb					▼		▼
	Dew Point Temperature	2-m		▴	▲		▲	▲	▲
	Wind Speed	10-m		▲	▲				
	Wind Gust Potential	SFC	▼	▼	▼	▼	▼	▼	▼
	Geopotential Height	850-mb			▲				
		700-mb			▴		▴		
		500-mb	▼		▼				▼
	Sea Level Pressure					▲	▲		
	Visibility	SFC	▲	▲	▲	▲	▲	▲	▲
	Cloud Ceiling		▴	▼	▲	▲	▴	▲	▲
Bias	Vector Wind	850-mb					▲		▴
		500-mb			▾				
		250-mb					▴		▲
RMSE	Vector Wind	850-mb							
		500-mb			▲				▴
		250-mb			▴				▴

▲	HRRRv3 is better than HRRRv2 at the 99.9% significance level
▴	HRRRv3 is better than HRRRv2 at the 99% significance level
	HRRRv3 is better than HRRRv2 at the 95% significance level
	No statistically significant difference between HRRRv3 and HRRRv2
	HRRRv3 is worse than HRRRv2 at the 95% significance level
▾	HRRRv3 is worse than HRRRv2 at the 99% significance level
▼	HRRRv3 is worse than HRRRv2 at the 99.9% significance level
	Not statistically relevant

HRRR AK Scorecard

for HRRR AK and NAM AK Nest

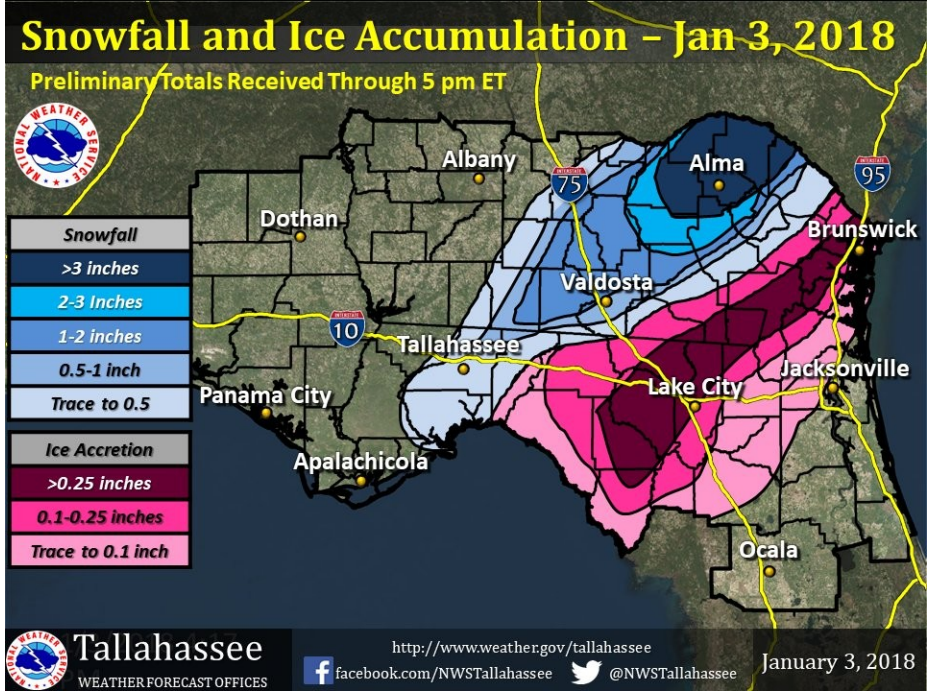
2017-11-20 00:00:00 - 2018-01-20 18:00:00

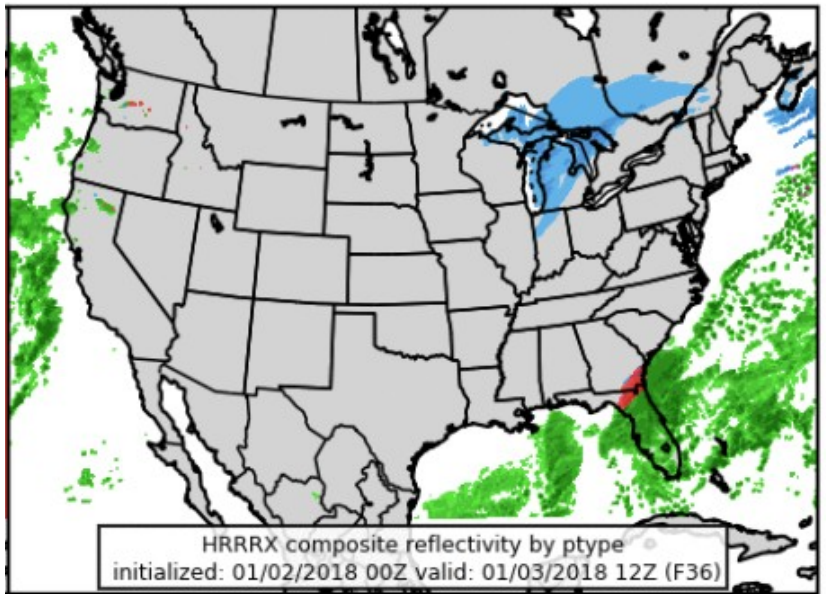
			CONUS												
			f00	f03	f06	f09	f12	f15	f18	f21	f24	f27	f30	f33	f36
Bias	Temperature	2-m	▾	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
		850-mb	▼								▼		▼		▼
		700-mb	▲		▼		▼		▼		▼		▼		▼
	Dew Point Temperature	2-m	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
	Wind Speed	10-m	▼				▼	▼	▼	▼	▼	▼	▼	▼	▼
	Wind Gust Potential	SFC	▼	▲	▲	▲	▲		▲						▲
	Geopotential Height	850-mb	▲				▲		▲		▲		▼		▼
		700-mb	▲				▲		▴		▲		▲		▲
		500-mb			▼		▾		▼		▼		▼		▼
	Sea Level Pressure		▼	▼	▼	▼	▼	▼	▼	▼	▲	▲	▲	▲	▲
	Visibility	SFC	▲	▲	▲			▼	▼	▼	▼	▼	▼	▼	▼
	Cloud Ceiling		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
RMSE	Temperature	2-m	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
		850-mb	▼		▼		▼		▼		▼		▼		▼
		700-mb	▼		▼		▼		▼		▼		▼		▼
	Dew Point Temperature	2-m			▾						▼	▼	▼	▼	▼
	Wind Speed	10-m	▼				▼	▼	▼	▼	▼	▼	▼	▼	▼
	Wind Gust Potential	SFC	▲	▲	▲	▲	▲	▲	▴	▴	▴	▴		▴	
	Geopotential Height	850-mb			▼				▼		▼		▼		▼
		700-mb			▾		▴		▼		▼		▼		▼
		500-mb			▼		▾		▼		▼		▼		▼
	Sea Level Pressure		▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
	Visibility	SFC	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
	Cloud Ceiling		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
Bias	Vector Wind	850-mb	▴		▼								▲		▲
		500-mb	▲								▲				▼
		250-mb	▴						▼		▼				▼
RMSE	Vector Wind	850-mb	▼		▼				▾		▼		▼		▼
		500-mb	▼				▾		▼		▼		▼		▼
		250-mb	▲		▼		▾		▼		▼		▼		▼

▲	HRRR AK is better than NAM AK Nest at the 99.9% significance level
▴	HRRR AK is better than NAM AK Nest at the 99% significance level
	HRRR AK is better than NAM AK Nest at the 95% significance level
	No statistically significant difference between HRRR AK and NAM AK Nest
	HRRR AK is worse than NAM AK Nest at the 95% significance level
▾	HRRR AK is worse than NAM AK Nest at the 99% significance level
▼	HRRR AK is worse than NAM AK Nest at the 99.9% significance level
	Not statistically relevant

CASES from the STI SOO-based CAM team

- Stephen Bieda WFO AMA
- Marc Chenard NCEP/WPC
- Adam Clark NOAA/NSSL
- Mike Evans WFO ALY
- Tom Hultquist WFO MPX
- Israel Jirak NCEP/SPC
- Geoff Manikin NCEP/EMC
- Andy Taylor WFO FGZ
- Pete Wolf WFO JAX

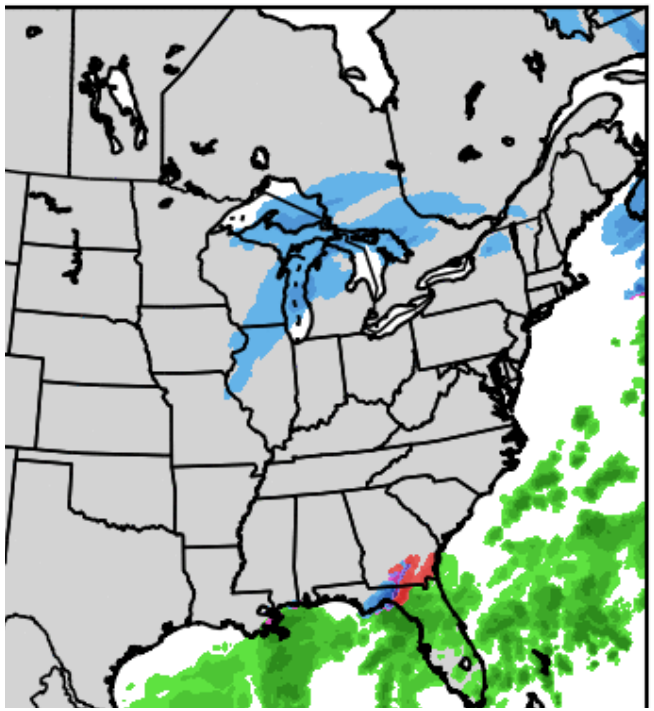


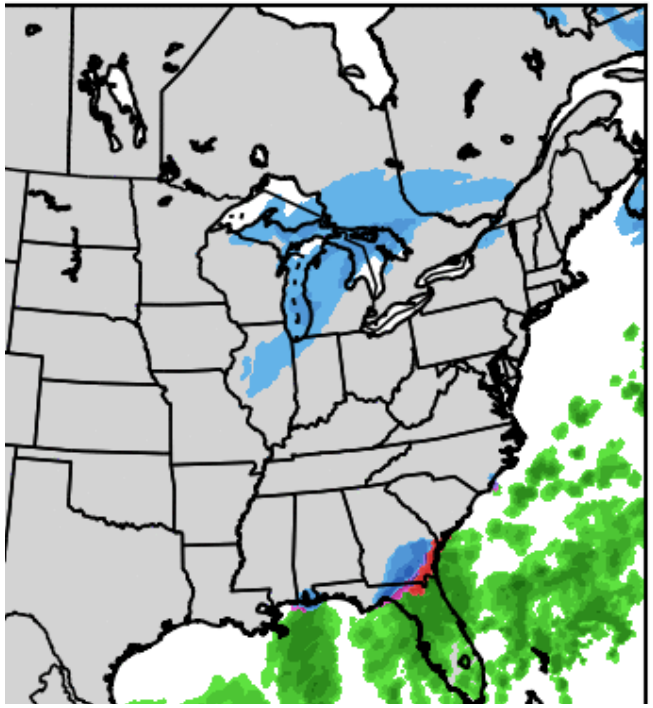


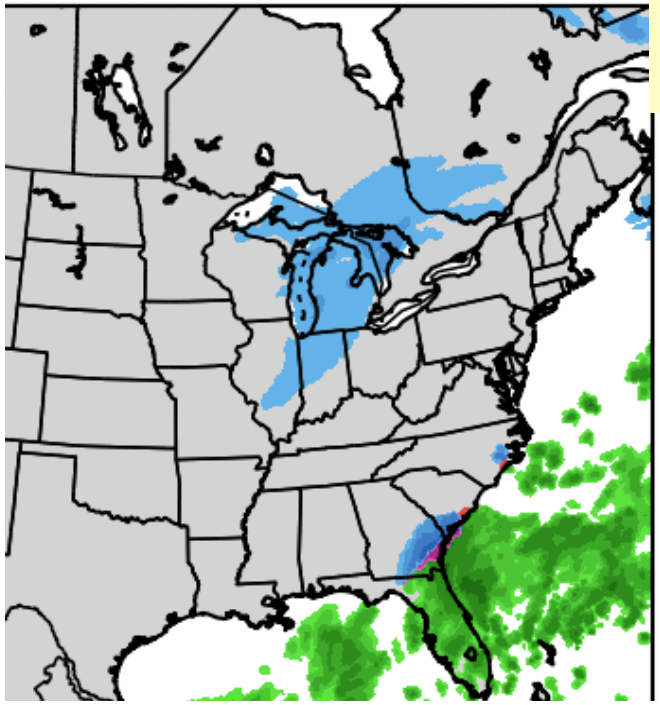
HRRRX 36hr forecast valid at start of ice event.

Similar for later run's 33hr forecast.

For precip. type and amount, the HRRRx and RAPx performed impressively for such a rare event, and in dealing with shallow cold air environments that models have performed poorly with in the past.

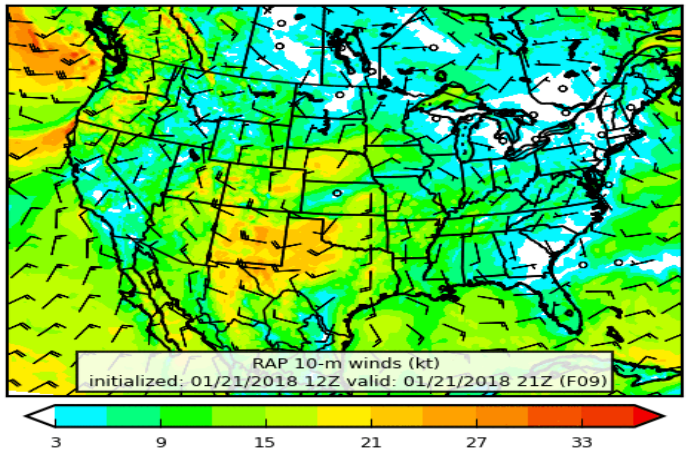


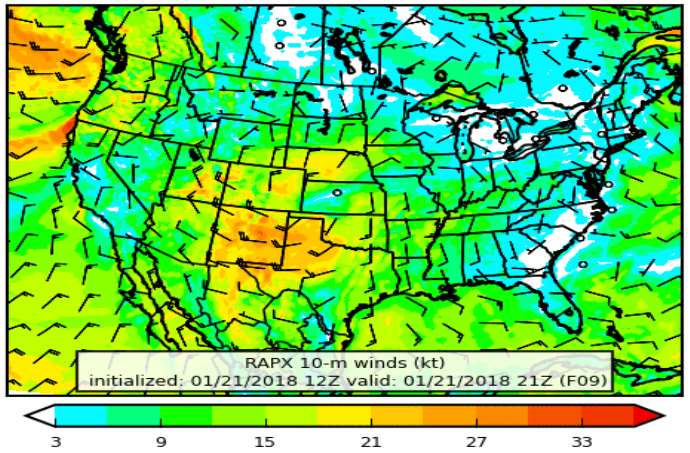


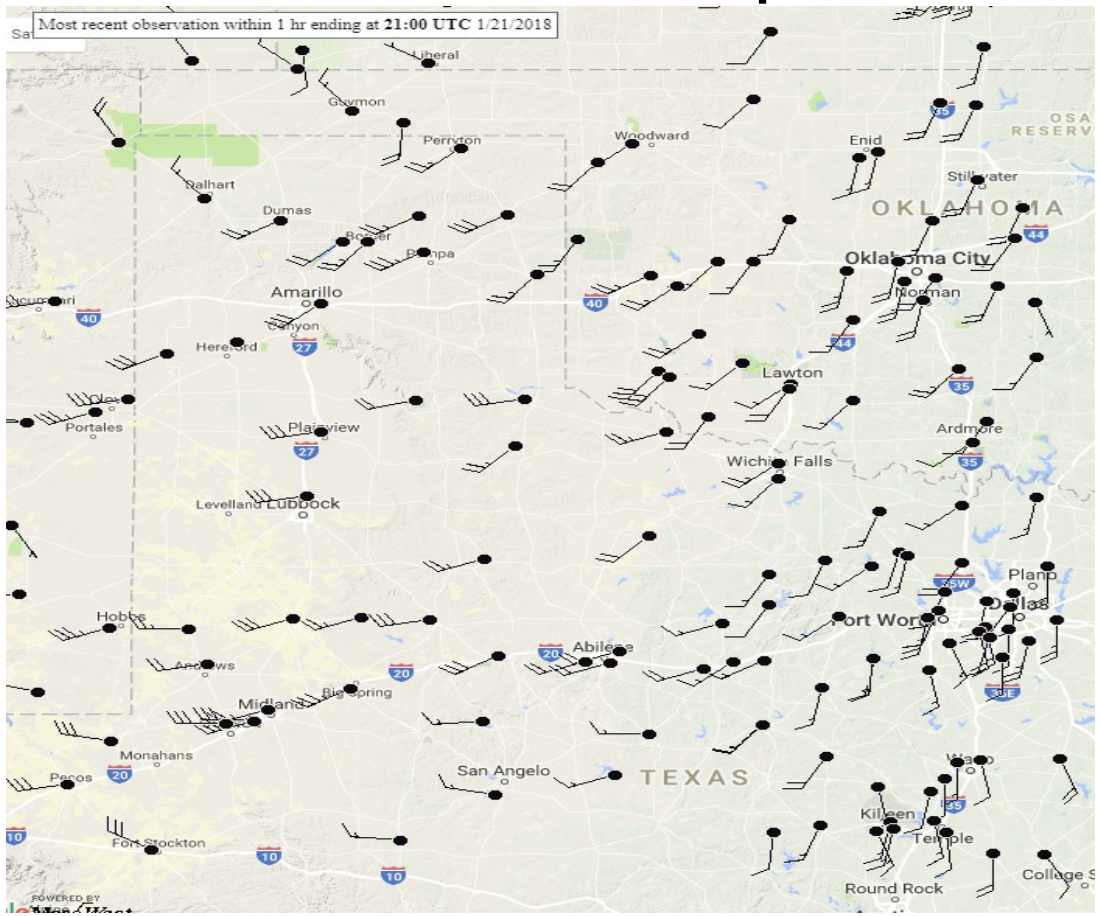


Accurate representation of transition toward snow (some heavy) 12-15z.
Images are 30, 33, and 36hr forecast precip. type from 03z Jan 2 HRRRx.

10-m Winds (kts) from 1/21 12Z run
9 hour forecast RAPv4 vs operational RAP



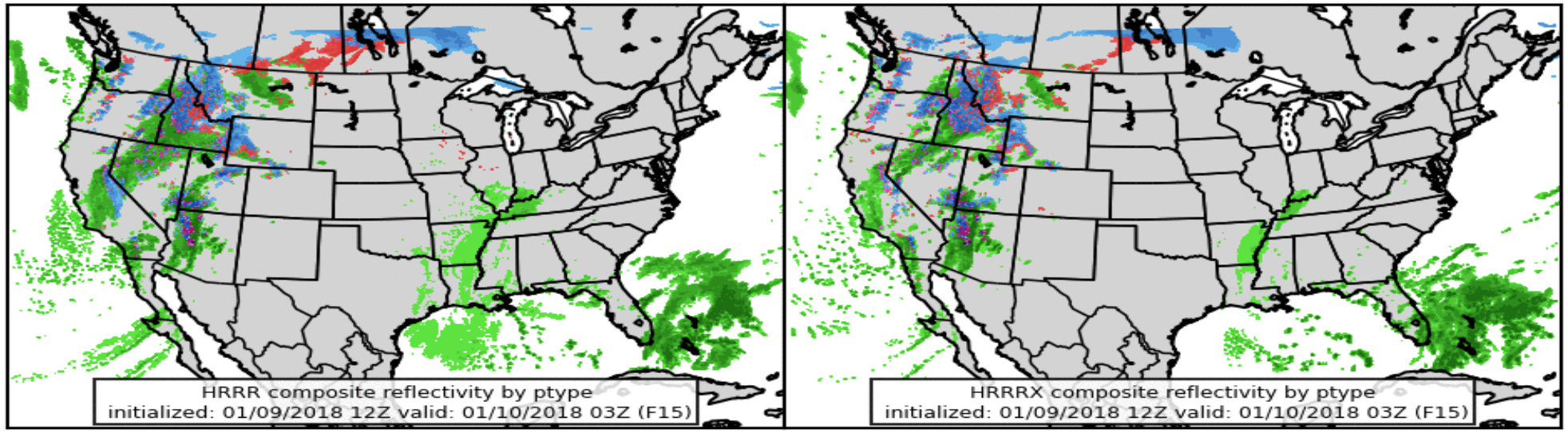




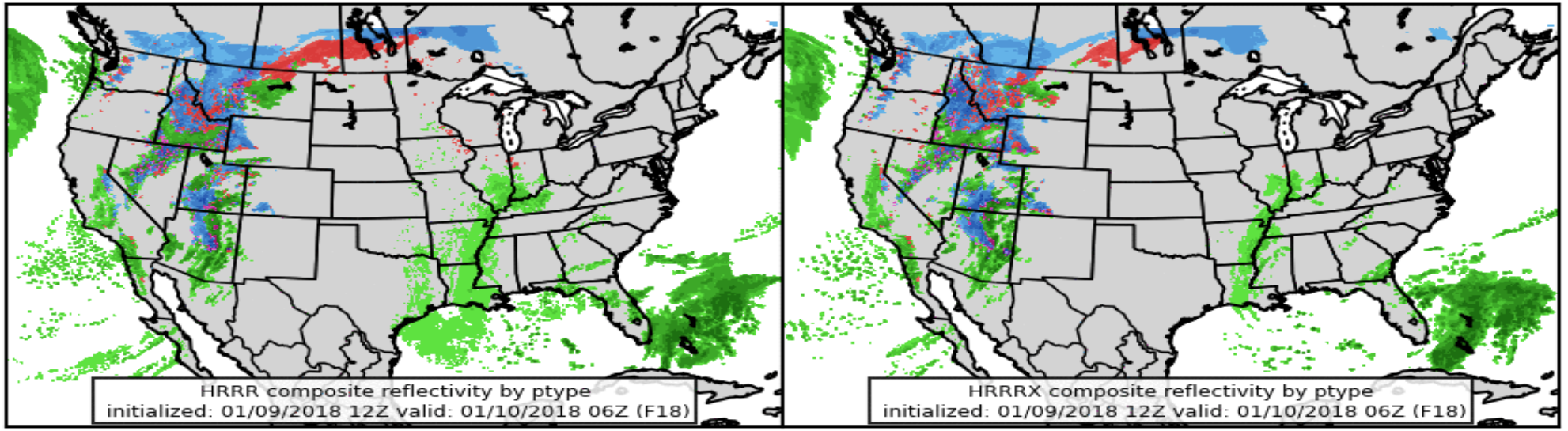
- 30-35 kt wind pronounces on southern High Plains @ 21Z.
- RAPX has stronger winds overall.
- Overall representation of winds was about 5-10 kts too light in strongest sustained wind corridors.

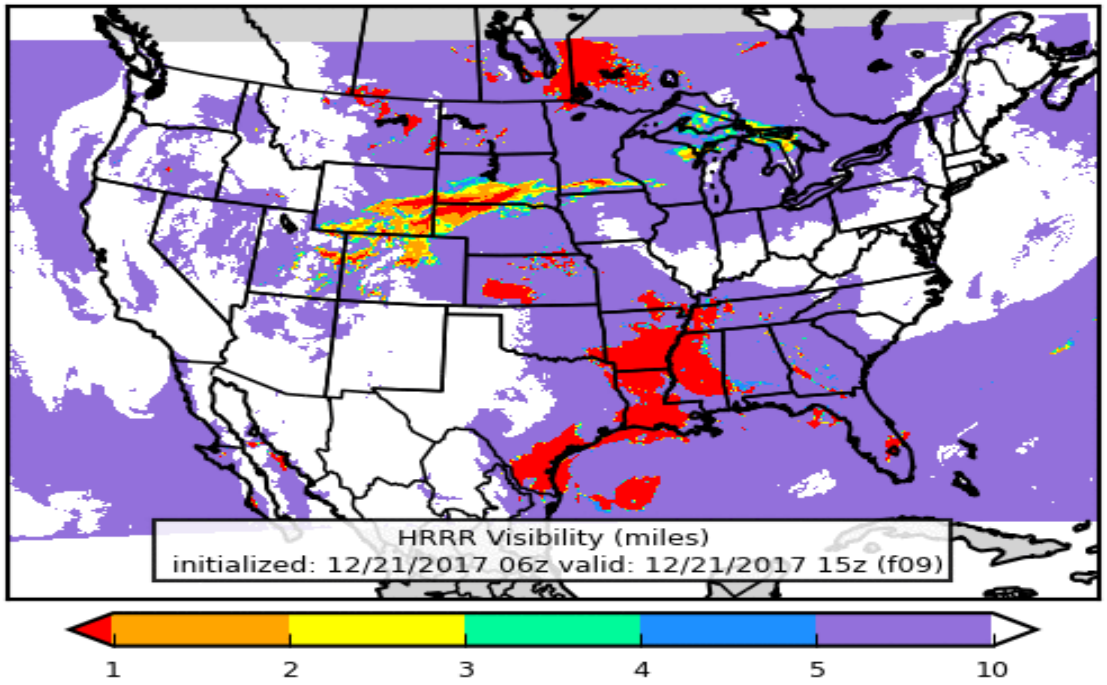
HRRR vs HRRRx P-type 12z 1/9/18

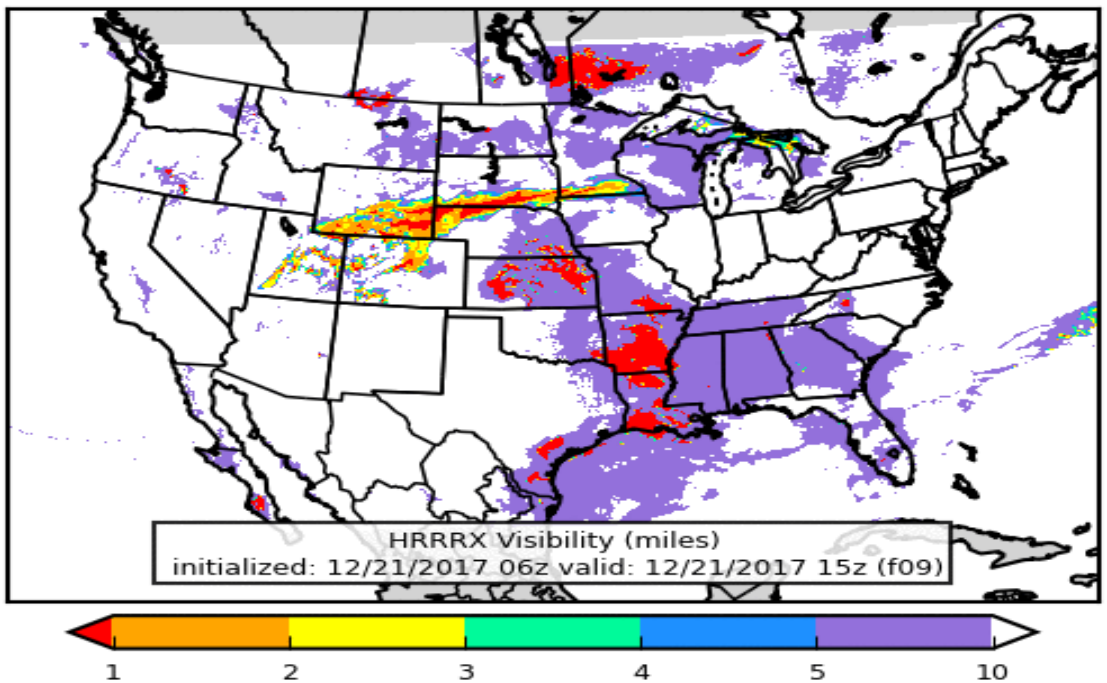
KFLG 100257Z
21008G16KT 3SM **RA**

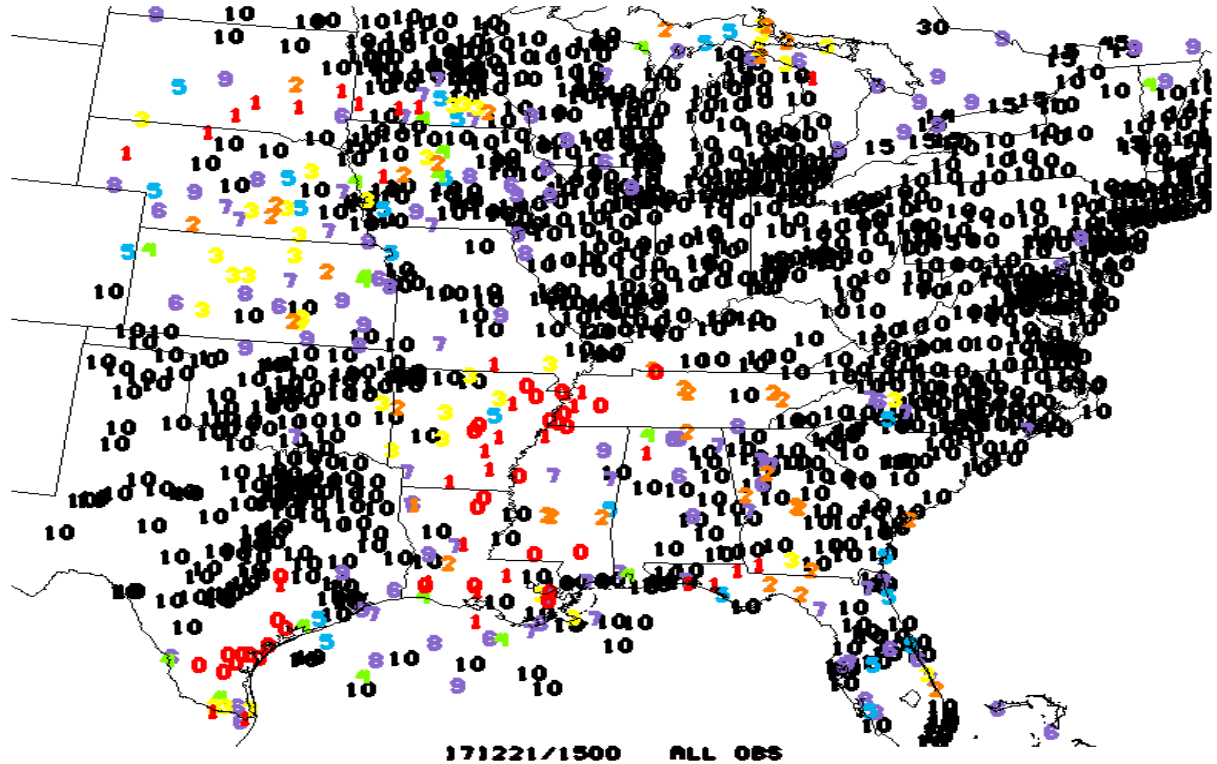


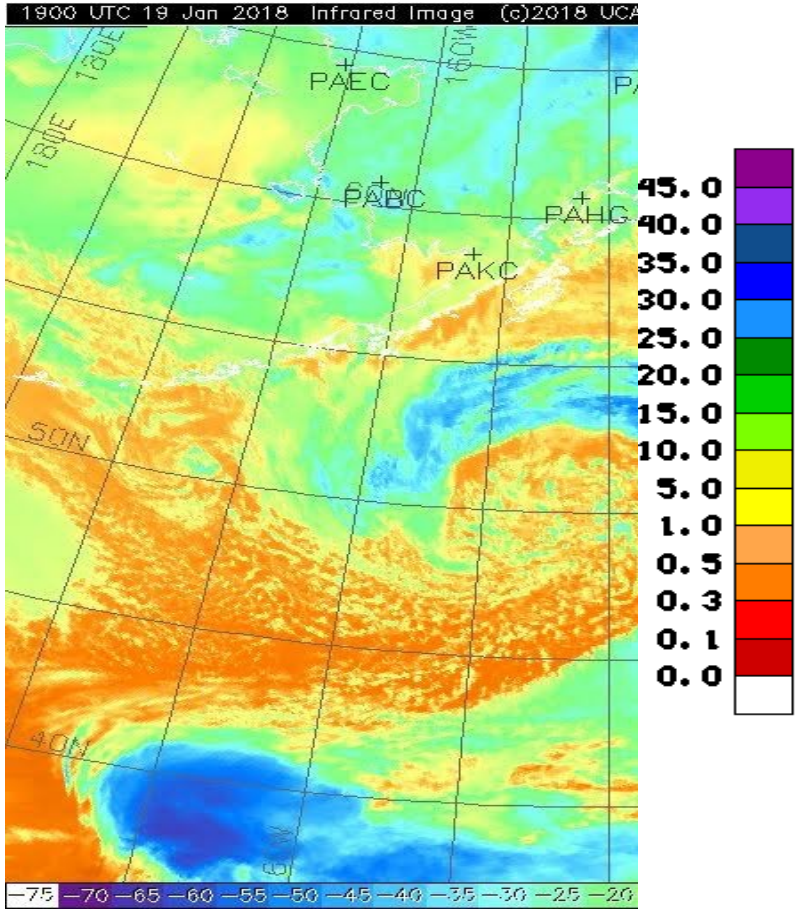
KFLG 100557Z
00000KT 1/2SM **SN** FG

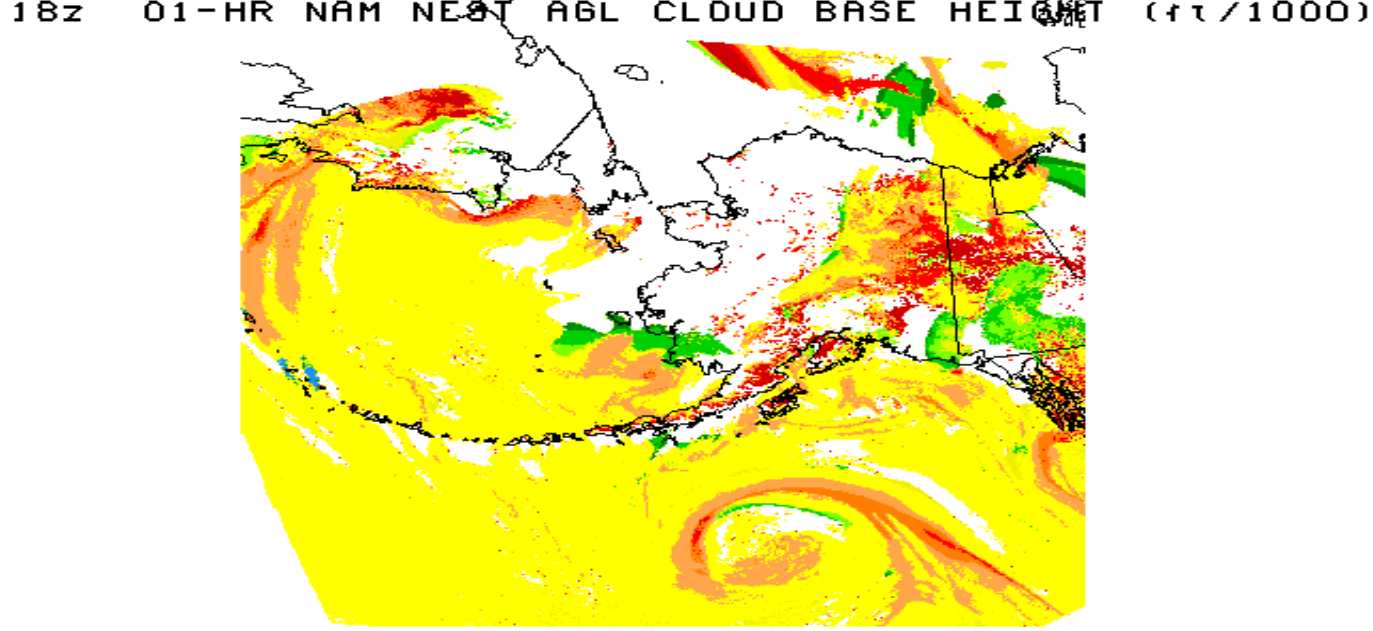



HRRR Visibility (miles)
initialized: 12/21/2017 06z valid: 12/21/2017 15z (f09)
1
2
3
4
5
10

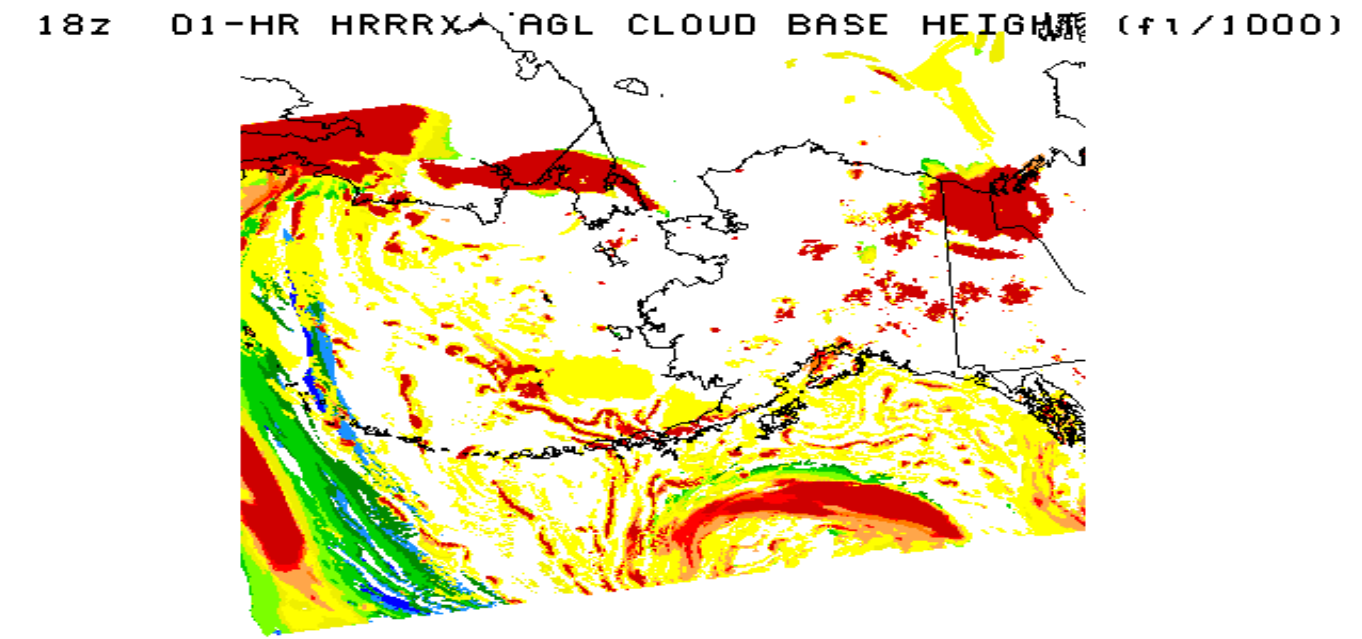

HRRRX Visibility (miles)
initialized: 12/21/2017 06z valid: 12/21/2017 15z (f09)
1
2
3
4
5
10


171221/1500 ALL OBS

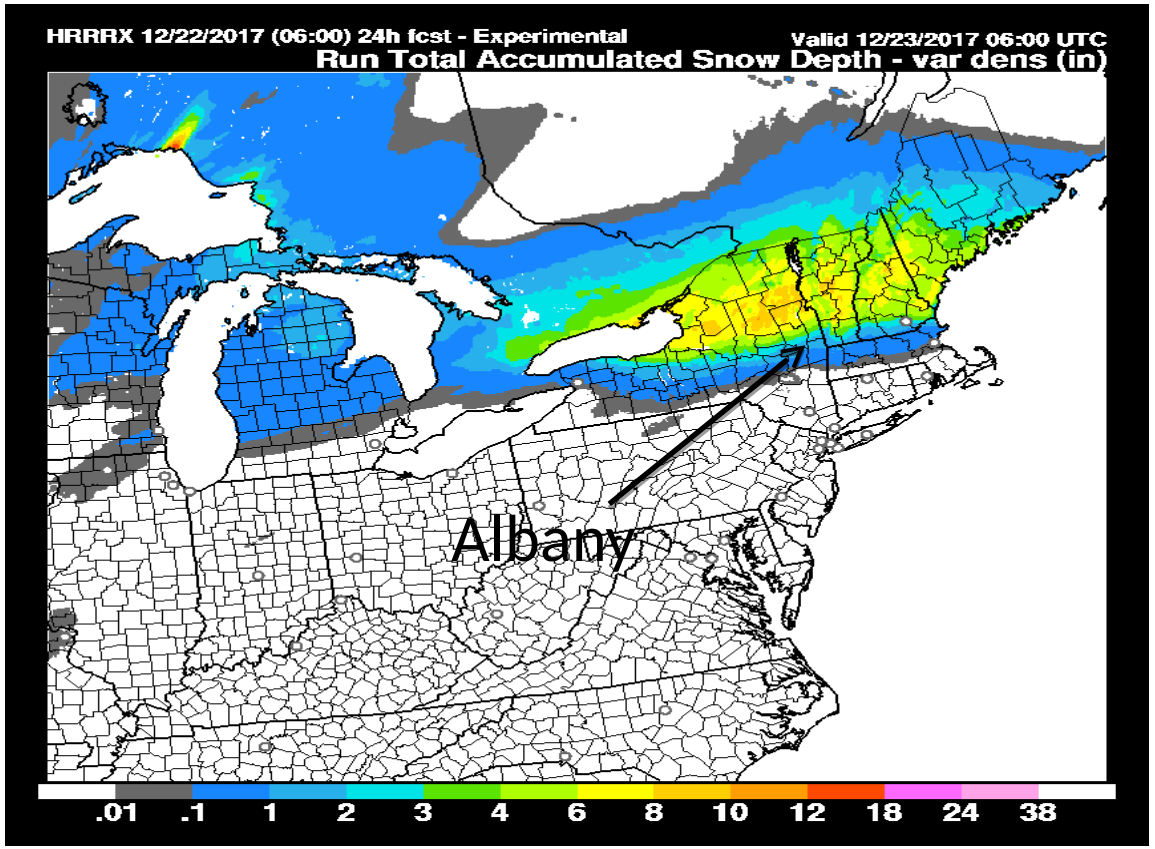


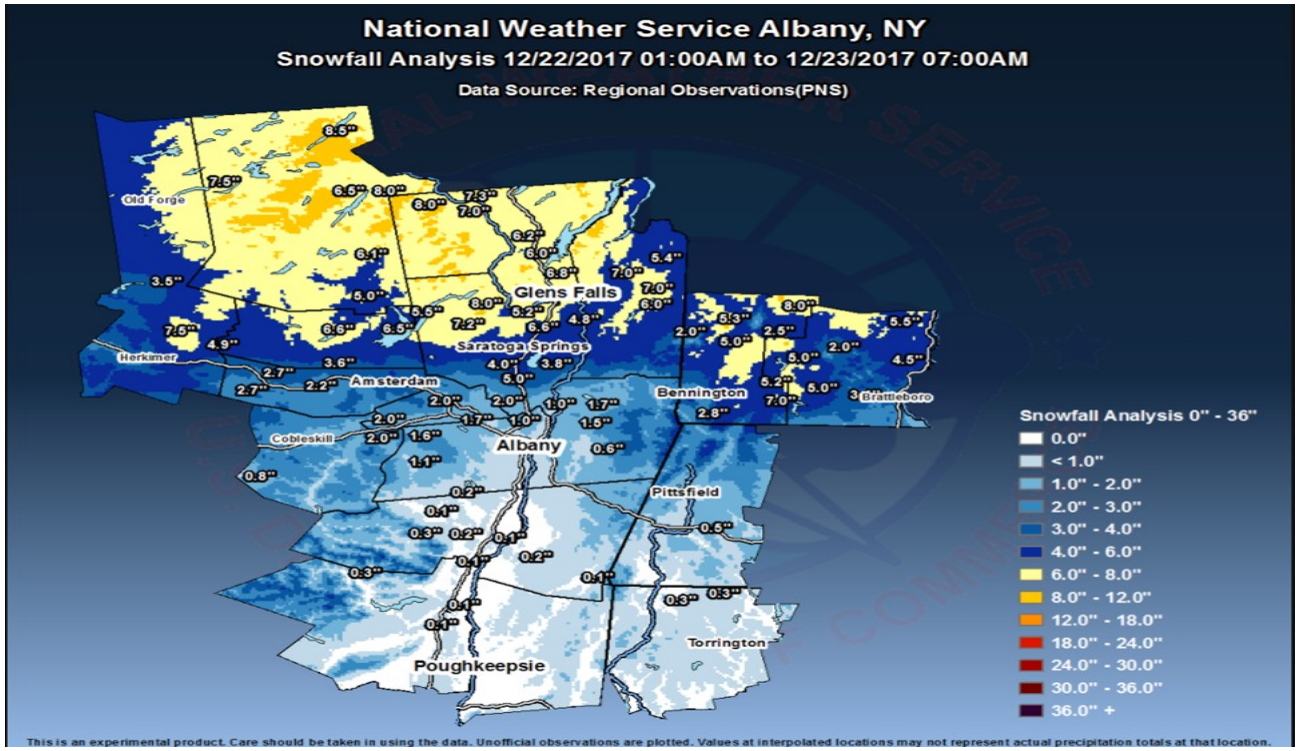


FCST MADE 18Z 01/19

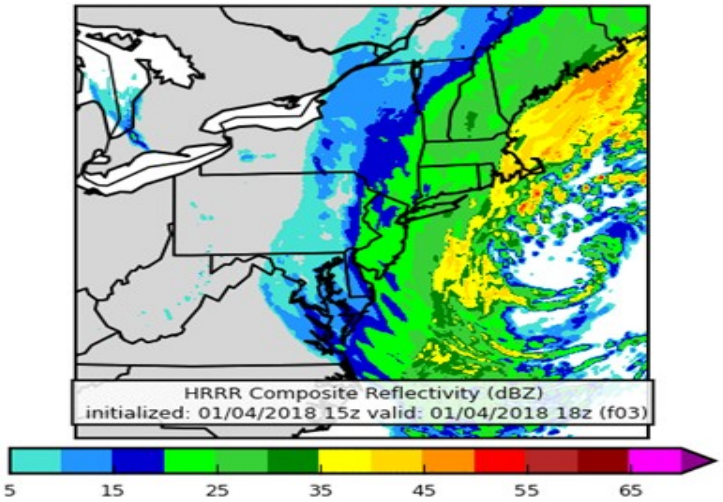


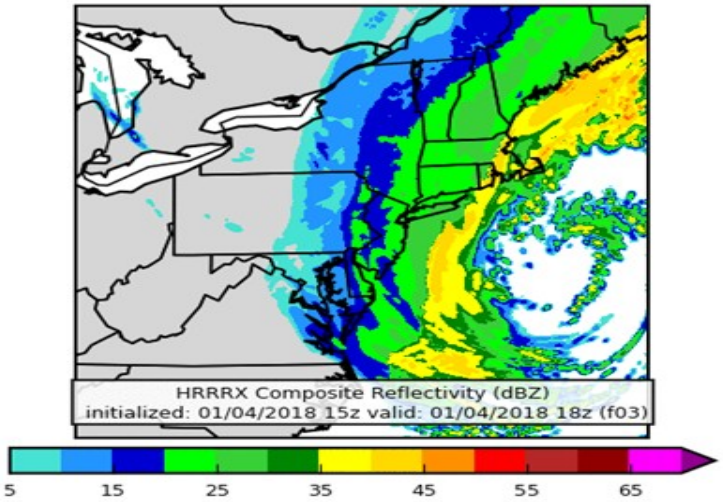
HRRRX accumulated snow depth 12/22 6z cycle

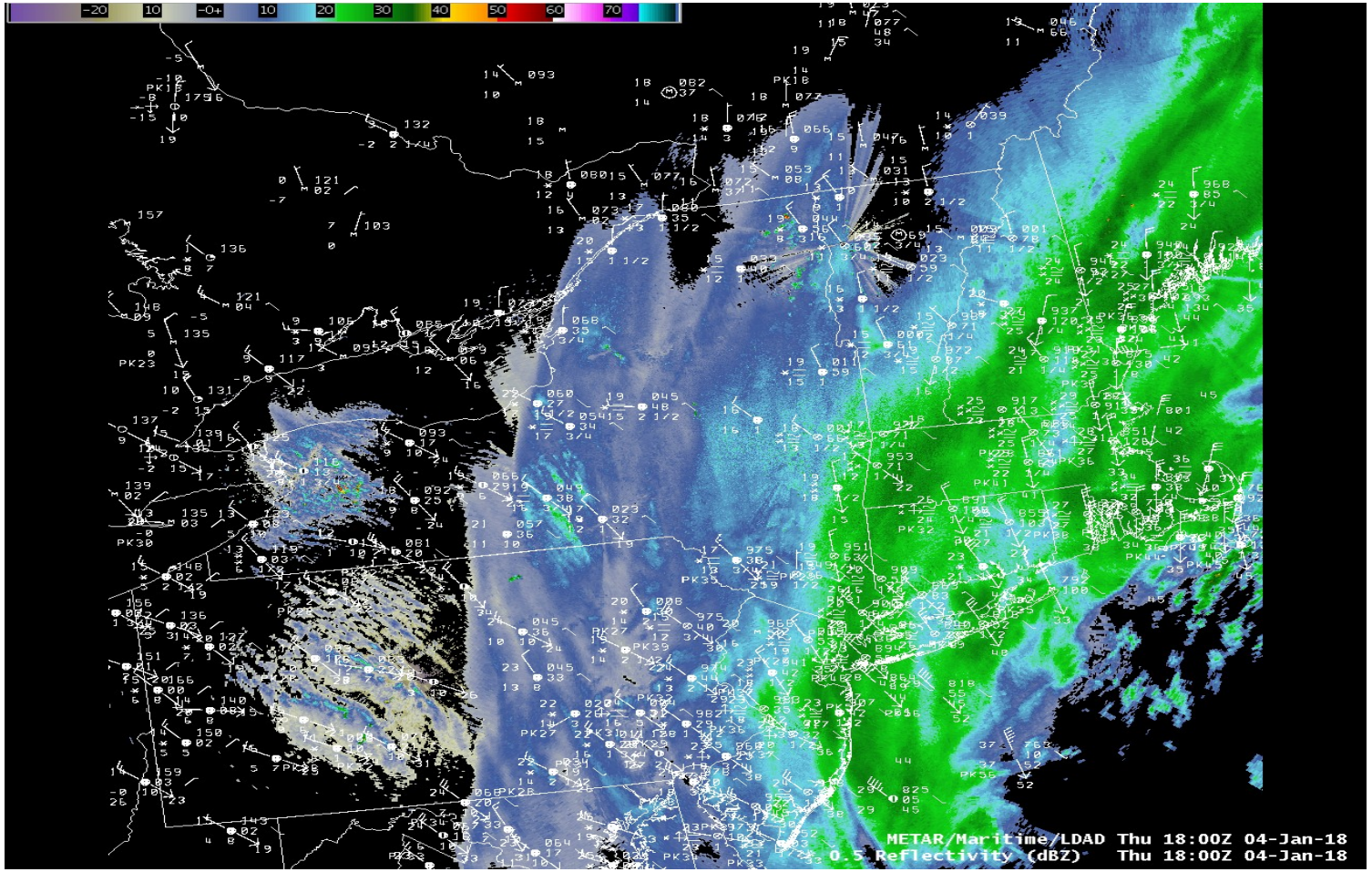




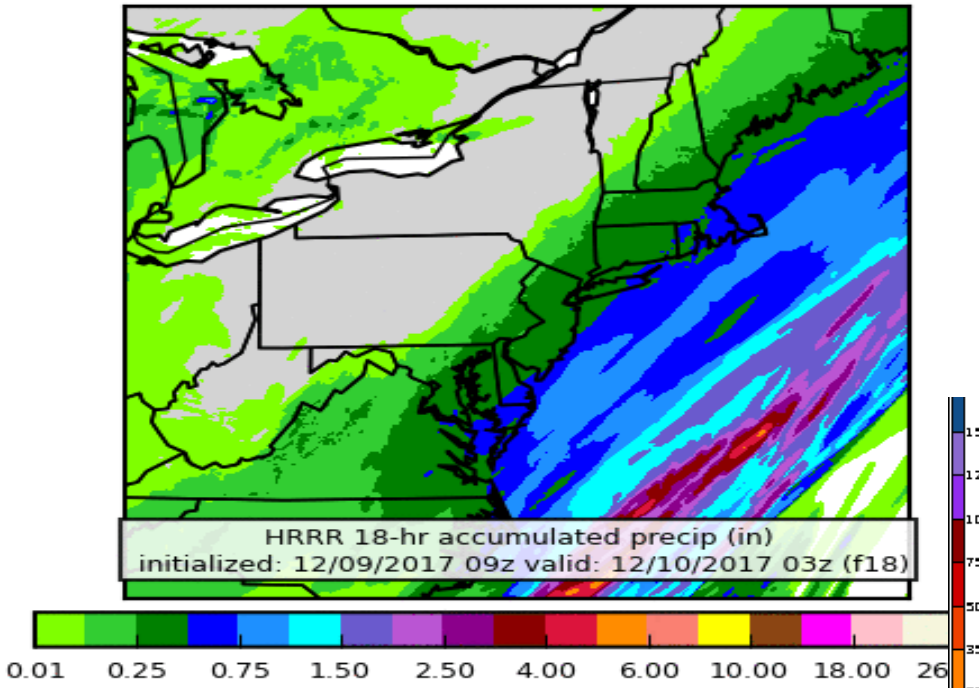
Radar – 18z Jan 4

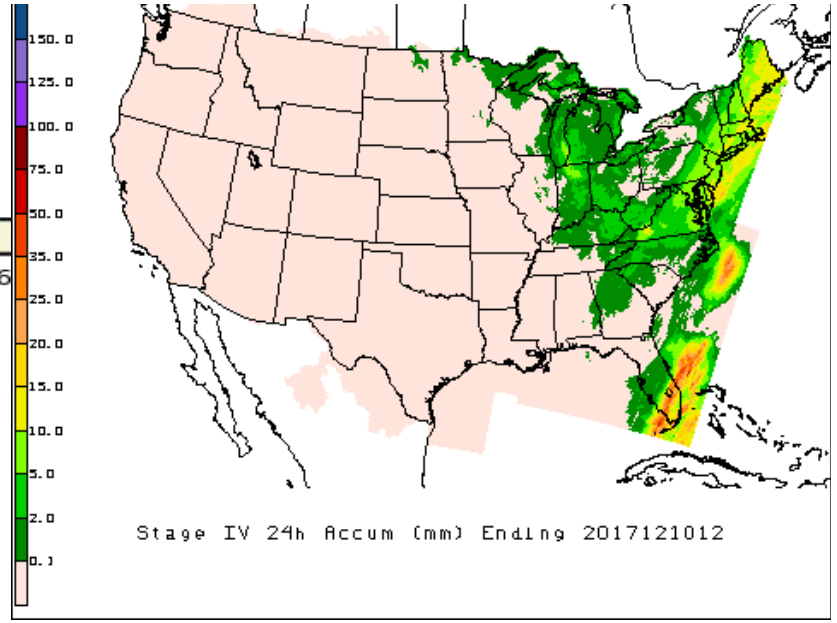


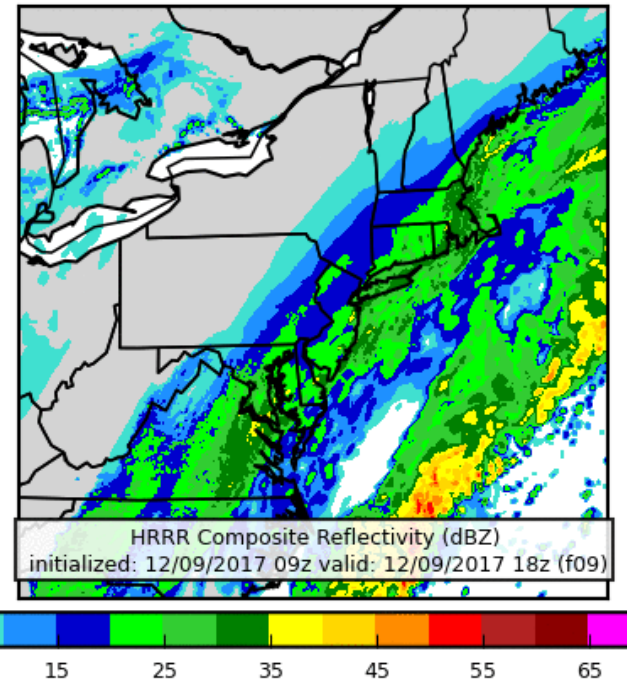


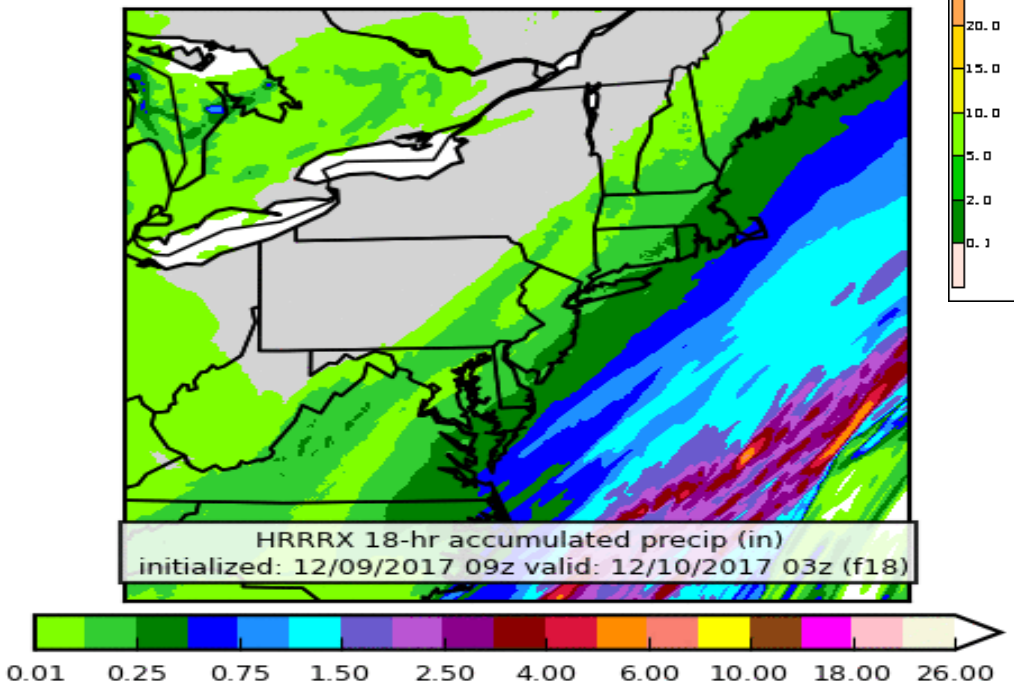


Huge challenge for HRRR and other hi-res guidance to predict this significant snow bands

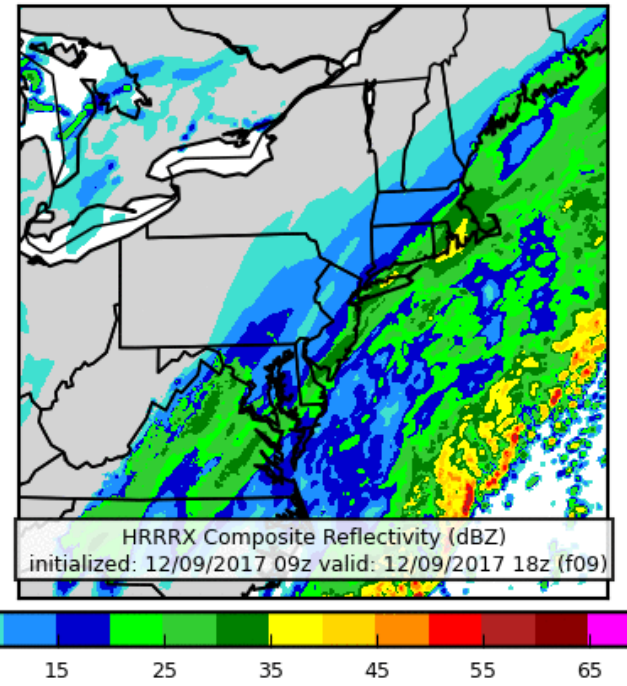




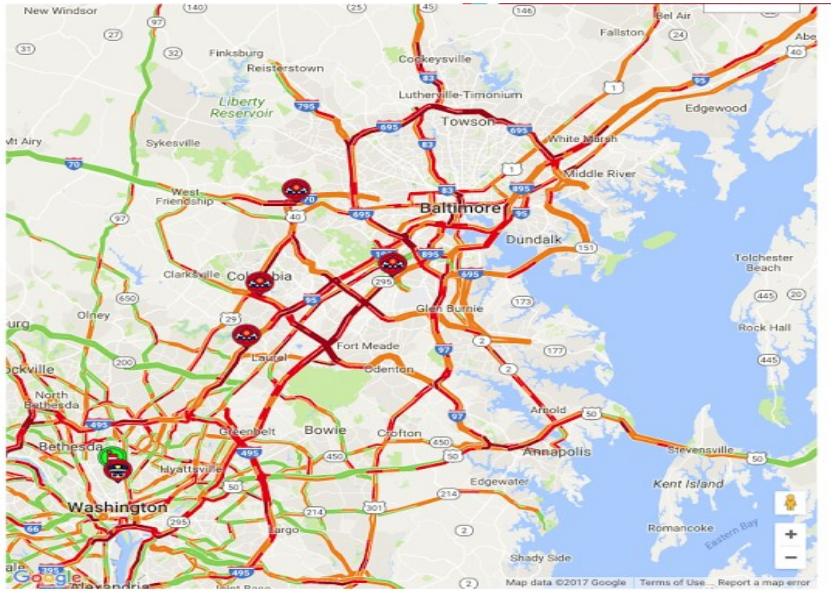


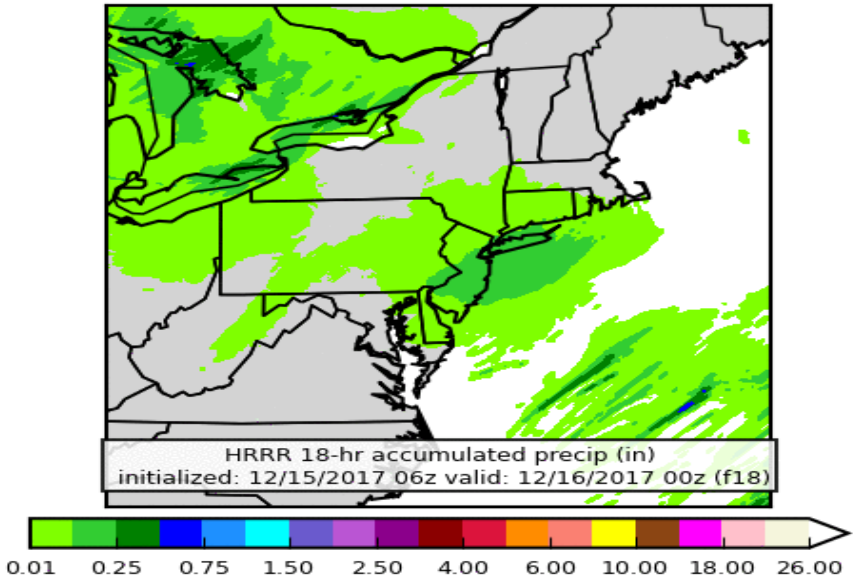


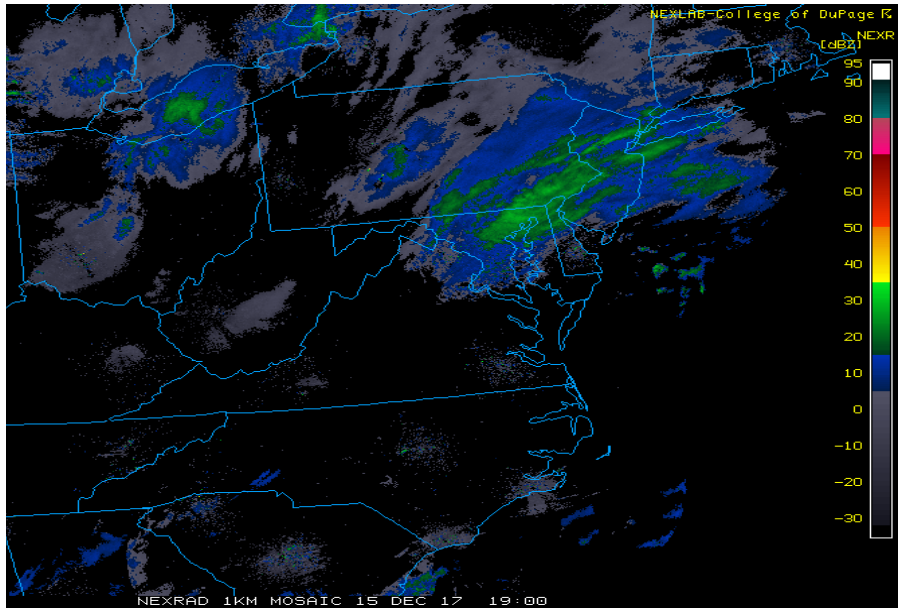
HRRRX too light with precip

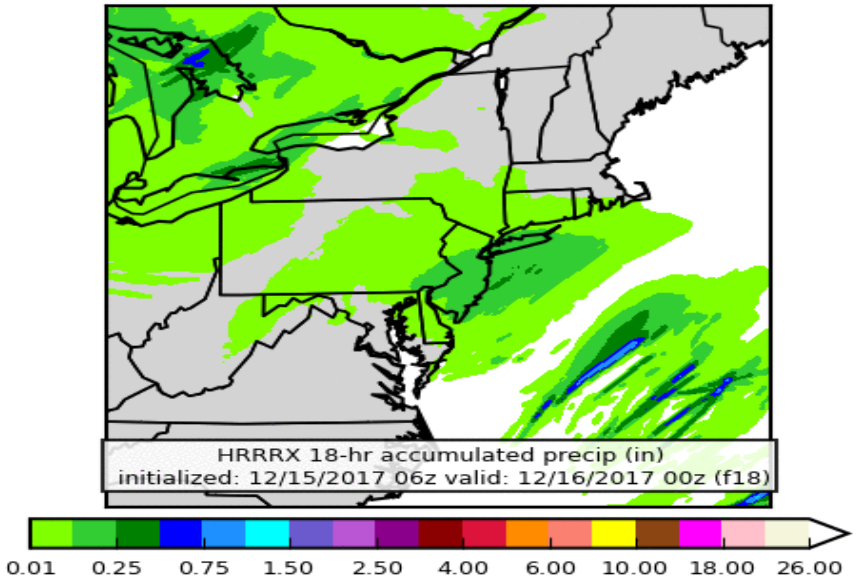


12/15 LIGHT EVENT w COLD TEMPS

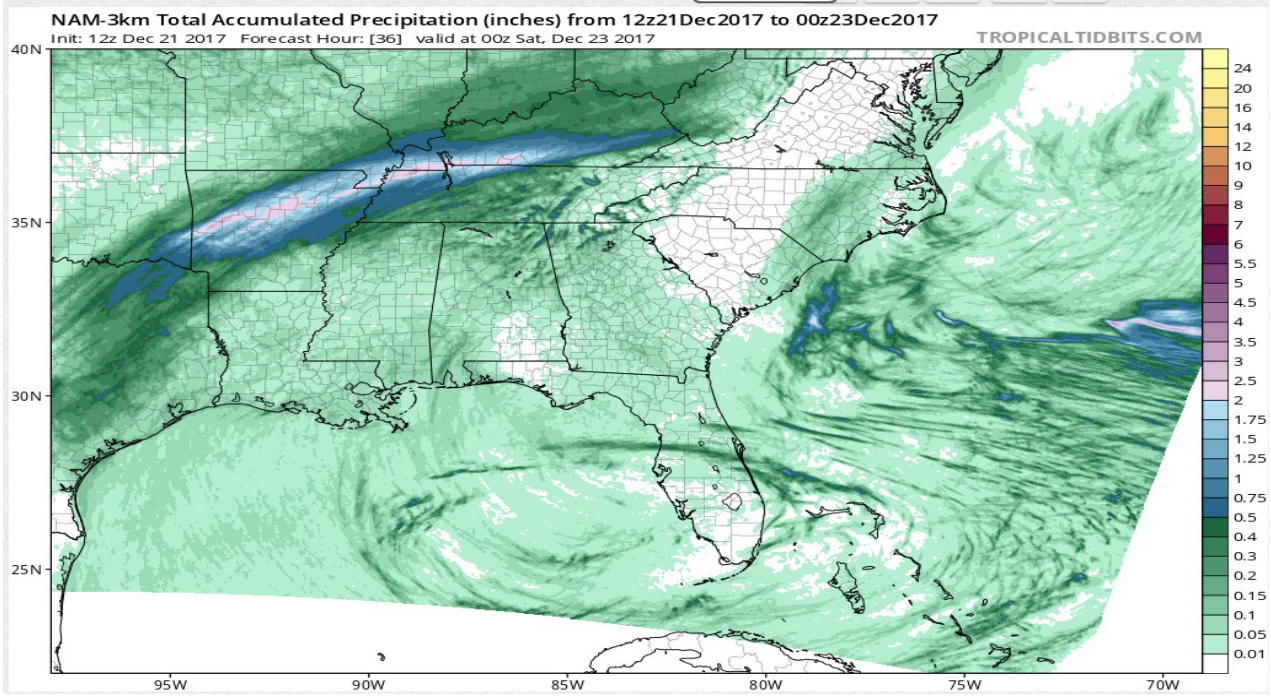


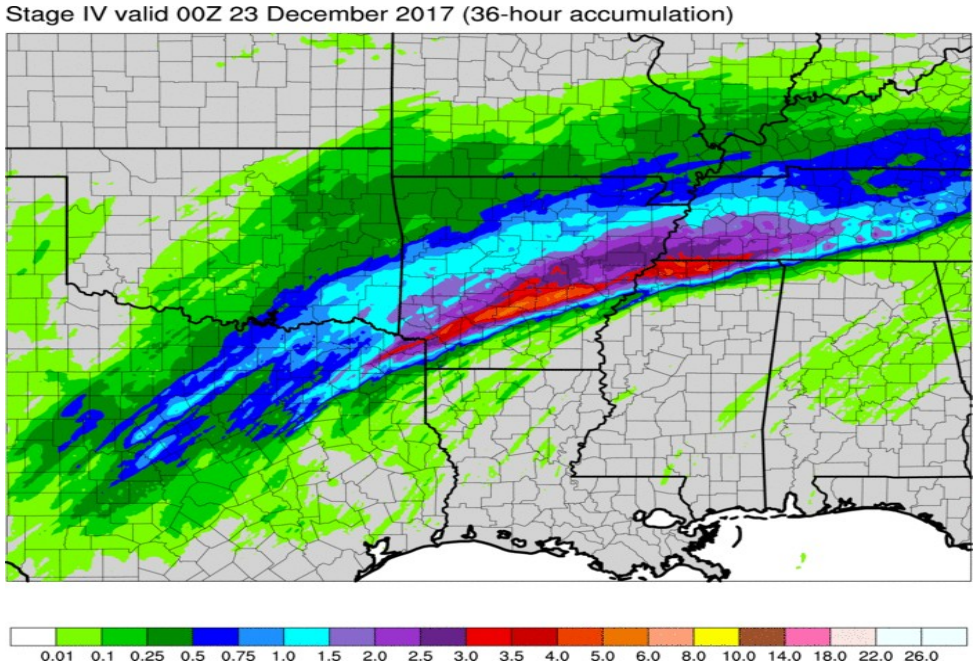


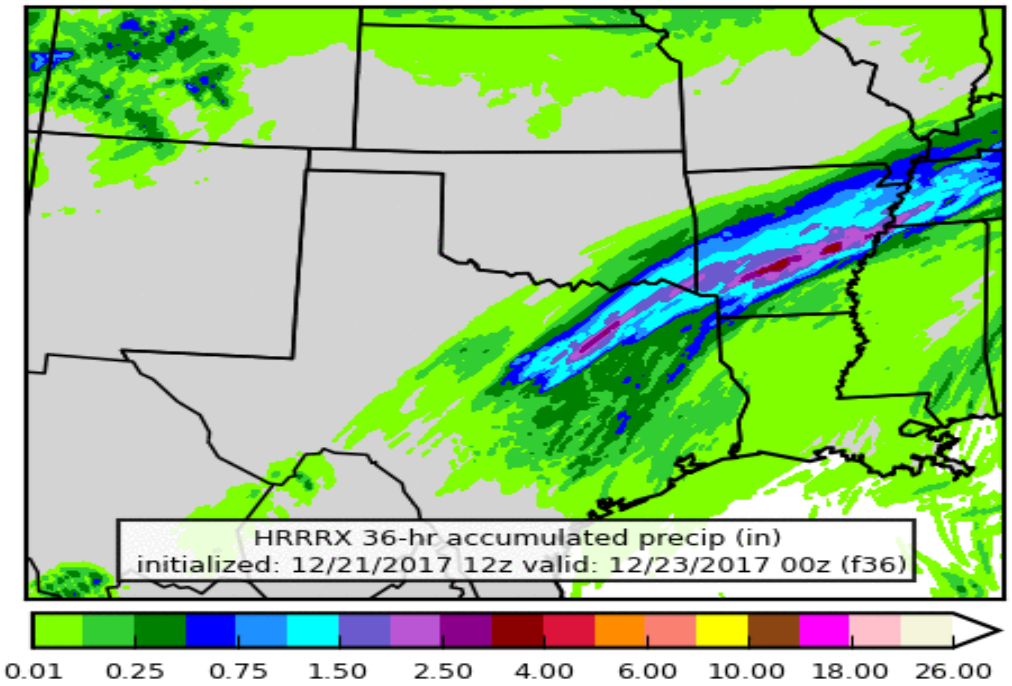


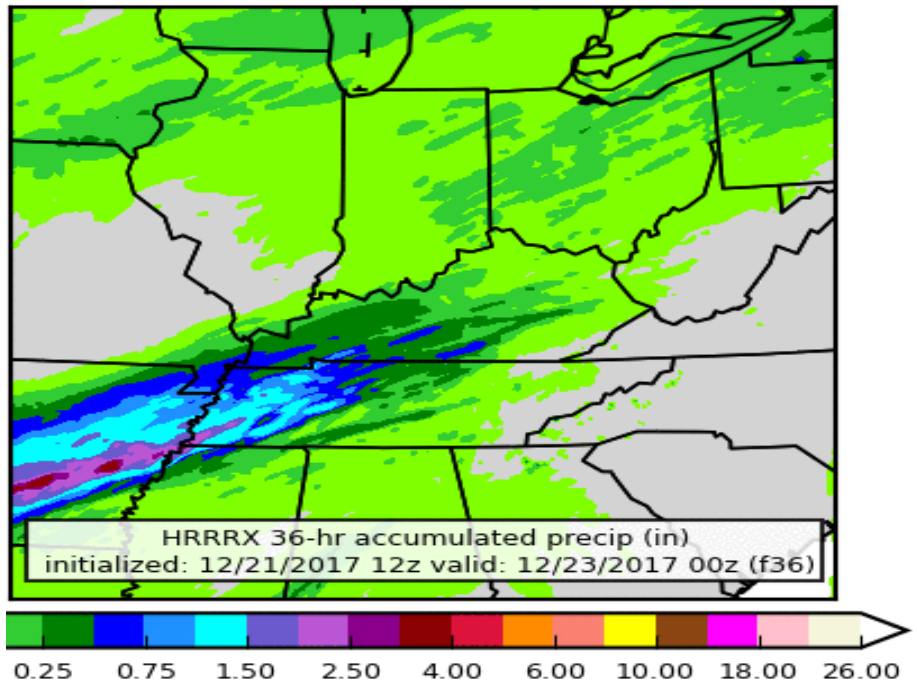


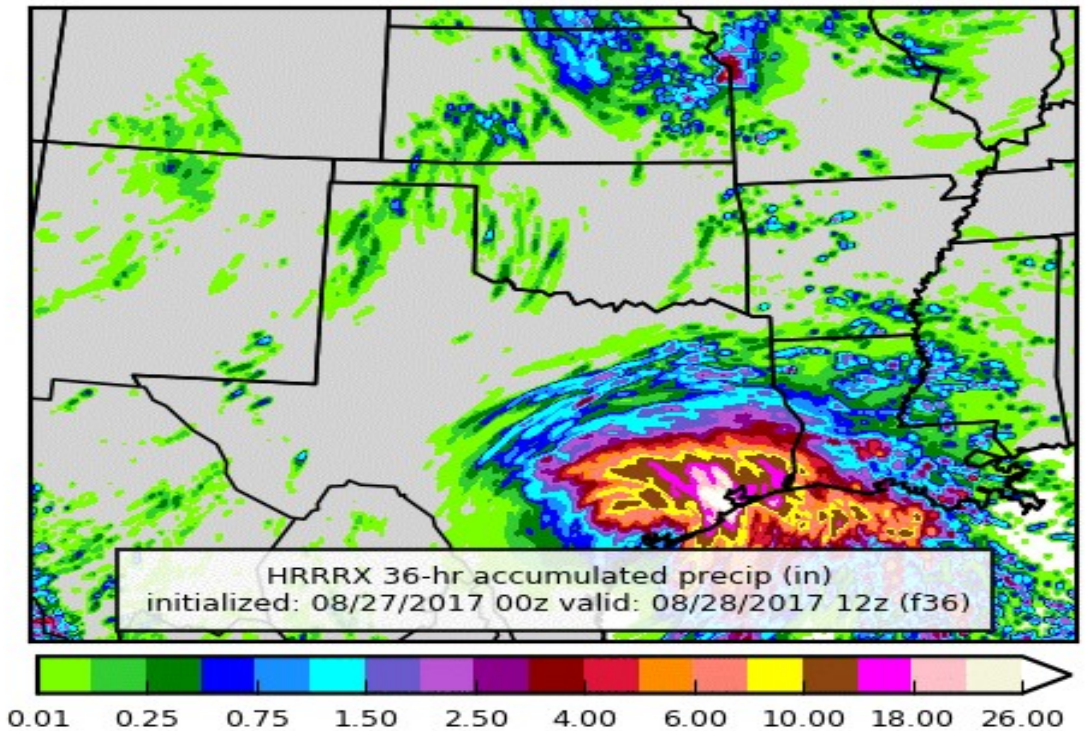
DAY 2 APPLICATIONS


NAM-3km Total Accumulated Precipitation (inches) from 12z21Dec2017 to 00z23Dec2017
Init: 12z Dec 21 2017 Forecast Hour: [36] valid at 00z Sat, Dec 23 2017
TROPICALTIDBITS.COM
40N
35N
30N
25N
95W
90W
85W
80W
75W
70W
24
20
16
14
12
10
9
8
7
6
5.5
5
4.5
4
3.5
3
2.5
2
1.75
1.5
1.25
1
0.75
0.5
0.4
0.3
0.2
0.15
0.1
0.05
0.01

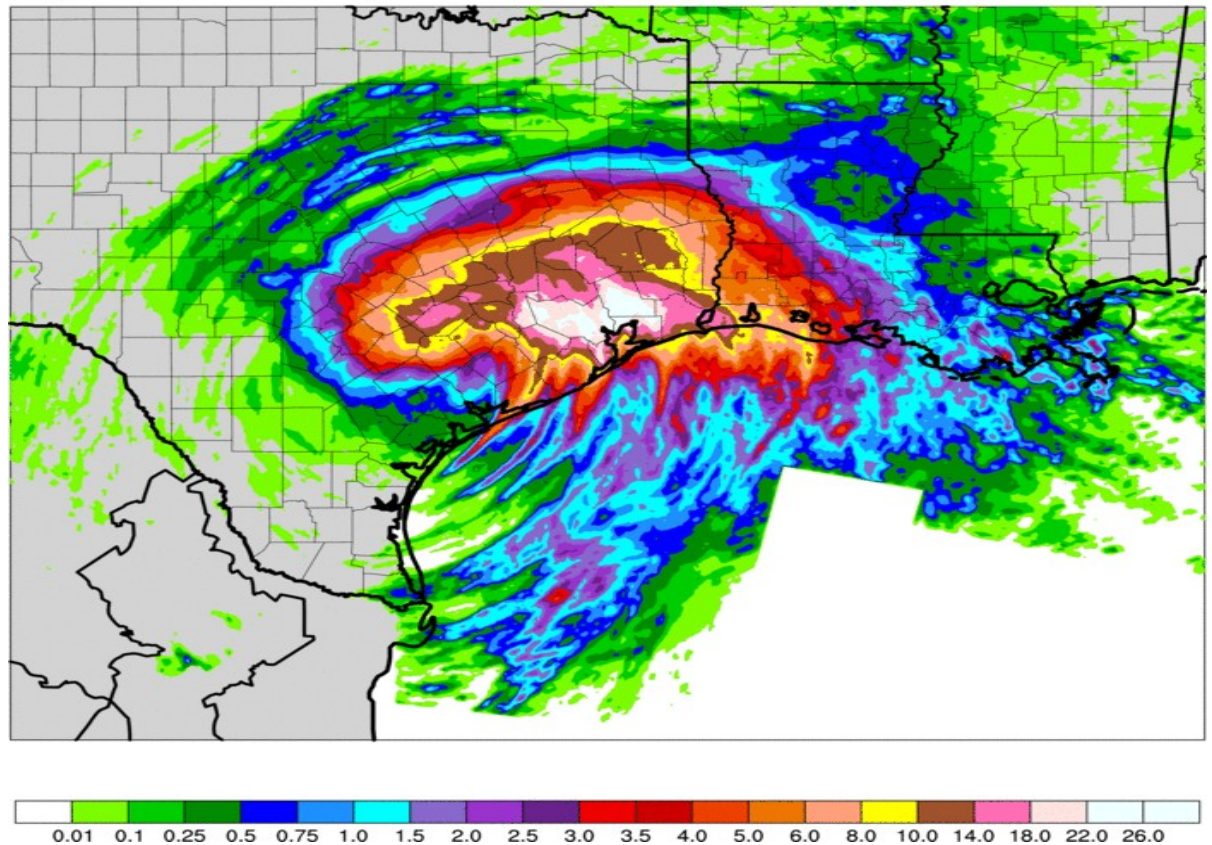

Stage IV valid 00Z 23 December 2017 (36-hour accumulation)
0.01 0.1 0.25 0.5 0.75 1.0 1.5 2.0 2.5 3.0 3.5 4.0 5.0 6.0 8.0 10.0 14.0 18.0 22.0 26.0


HRRRX 36-hr accumulated precip (in)
initialized: 12/21/2017 12z valid: 12/23/2017 00z (f36)
0.01 0.25 0.75 1.50 2.50 4.00 6.00 10.00 18.00 26.00


HRRRX 36-hr accumulated precip (in)
initialized: 12/21/2017 12z valid: 12/23/2017 00z (f36)
0.25 0.75 1.50 2.50 4.00 6.00 10.00 18.00 26.00



Stage IV valid 12Z 28 August 2017 (36-hour accumulation)



FINAL THOUGHTS

- Evaluations are overall positive, and all recommend implementation
- Stats are somewhat mixed, although generally very favorable for C & V
- Overall synoptic improvement is limited as expected, with most of the upgrade targeted for C & V
- Evaluations generally saw some improvement in cloud fields
- Clear reduction in HRRR high reflectivity bias in first few hours
- The extensions will be clearly be a help to NWS (and other) operations
- Alaska Region is excited for HRRR-AK
- Some issues (later initiation in weakly forced events in HRRR, too light in some weaker winter events, …)
- Implementation target: mid-May