The January-February 2015 Winter Blitzkrieg over the Northeastern United States: Significant Predictability Issues and Communicating Uncertainty Problems

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IMPACTS: Major Weather Events and Impacts of 2015
New Orleans, Louisiana 70130
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Motivation

- Winter 2014–2015 featured “epic” Northeast snowstorms between 24 January – 16 February 2015
- Persistent West Coast ridging and a downstream trough favored a North Atlantic coastal storm track
- Predictability uncertainties associated with the storm of 27–28 January 2015 created forecast challenges along the I-95 corridor

Outline

- **Winter 2014–2015: Northeast Snow Blitzkrieg**

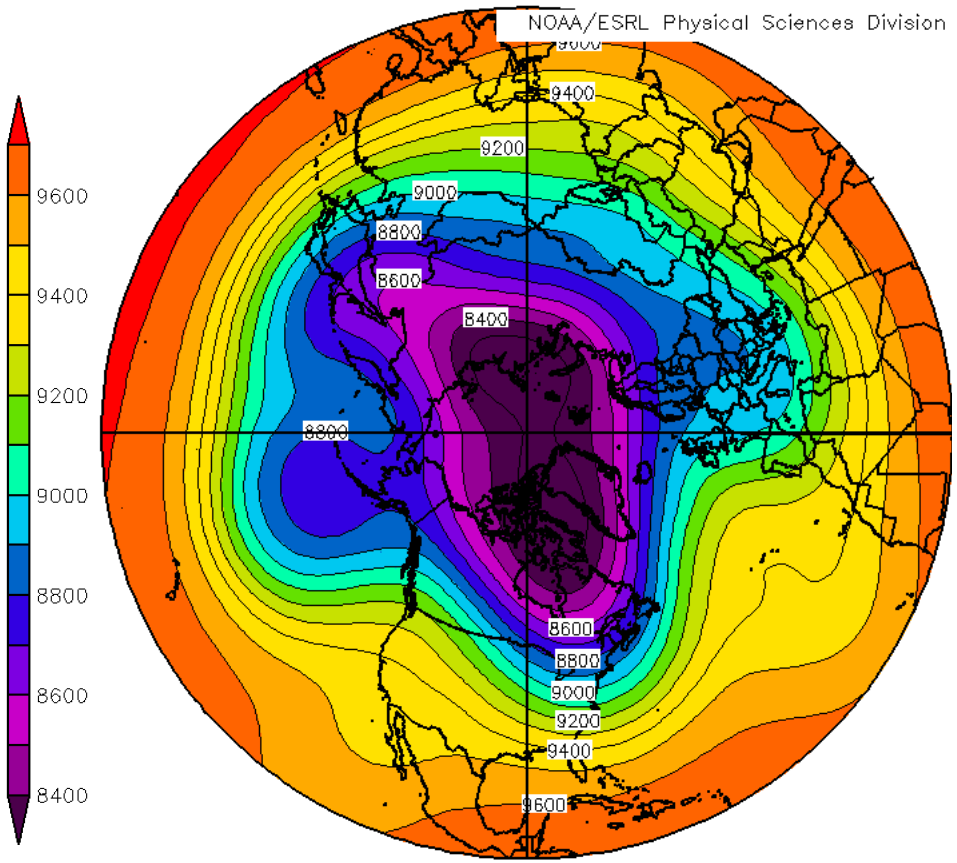
- **North Pacific and Siberia act as a source of PV disturbances**
- **West Coast ridge steers PV disturbances to the eastern CONUS**
- **Migratory PV disturbances trigger sequential Northeast cyclones**
- **Predictability issues posed by migratory PV disturbances**

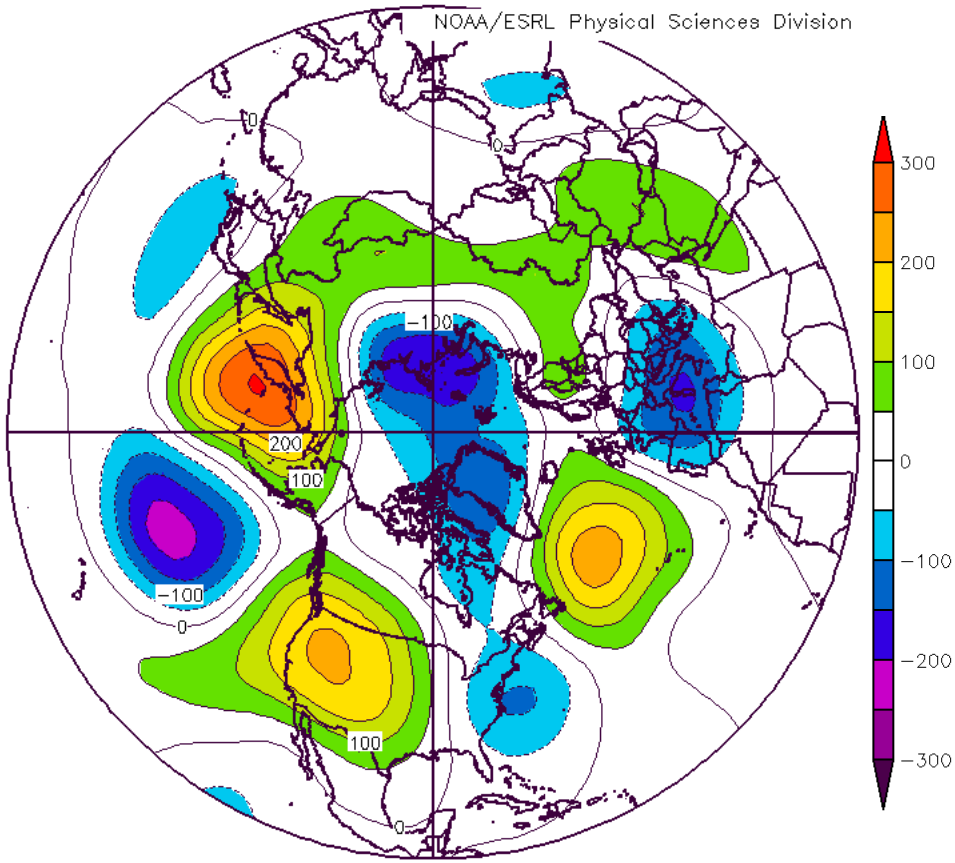
Data and Methodology

- CFSR 0.5° gridded datasets are used
- A multiscale analysis perspective is adopted
- Forecast sensitivity is addressed

“Apocalyptic” Snows in the Northeast: 24 January – 16 February 2015

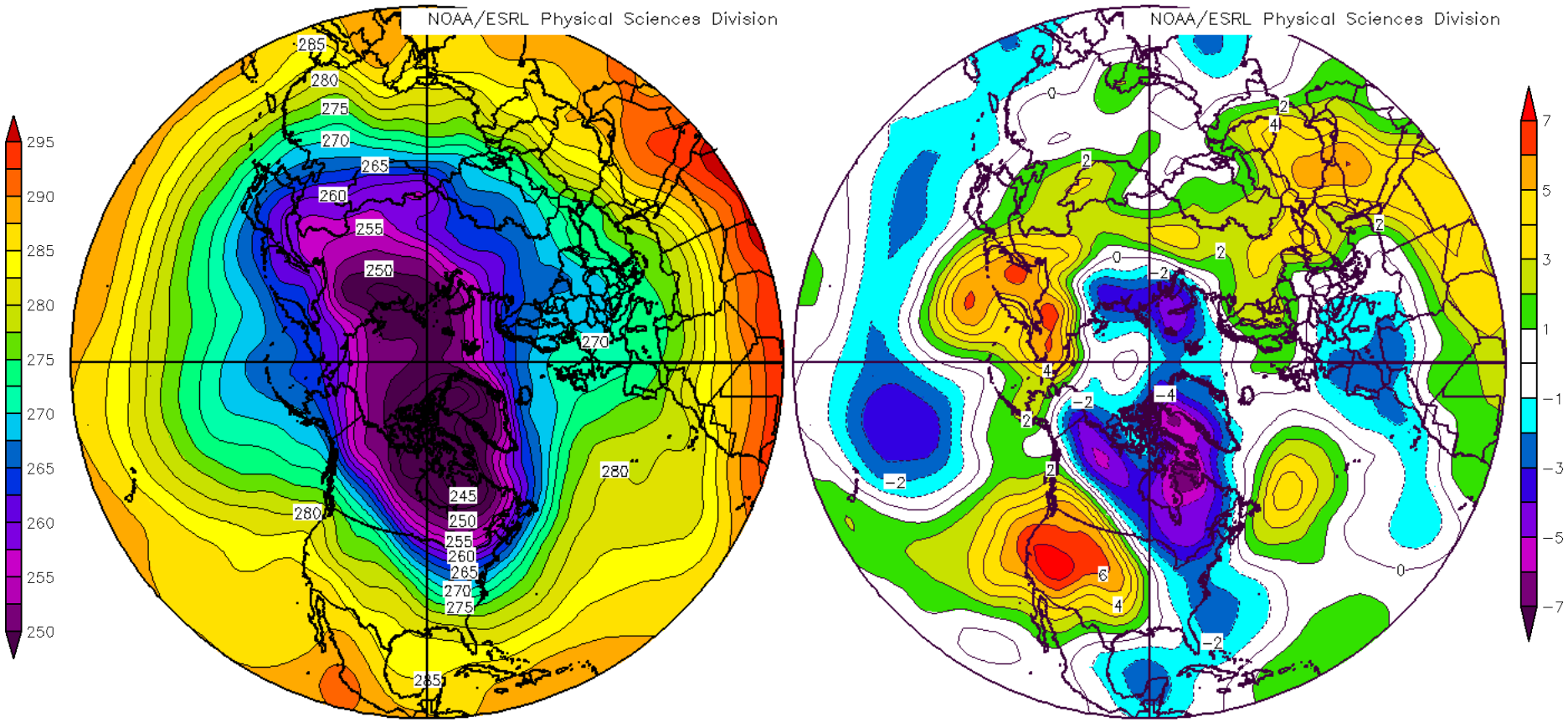
300-hPa Mean (left) and Anomaly (right) Geopotential Height (m, shaded)
24 Jan – 16 Feb 2015





Source: NOAA/ESRL/PSD

850-hPa Mean (left) and Anomaly (right) Temperature (K, shaded)
24 Jan – 16 Feb 2015



Source: NOAA/ESRL/PSD

The 27–28 January 2015 Snowstorm: Buried in Boston and Life on the "Edge" in New York City: A "Tale" of Tails

Event Statistics

- Two **sequential cyclogenesis** events impacted East Coast in January 2015.
- Snowfall totals for the second storm were **>1 m (3 ft)** in some locations.
- Considerable coastal flooding reported in MA with wind gusts **>60 kts**.
- Worcester, MA, **tallied 87 cm (34.5 in.)** (all-time record).
- Delta pre-emptively canceled **600 flights** on 26 Jan.
- The second storm was characterized by considerable **forecast uncertainty**.

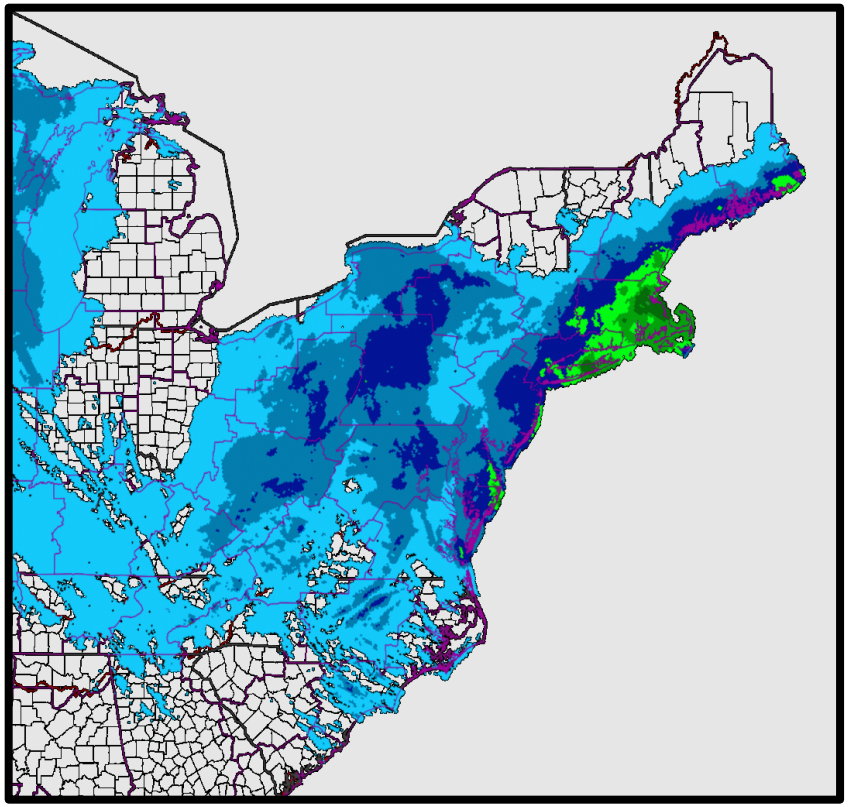
Times Square


Boston

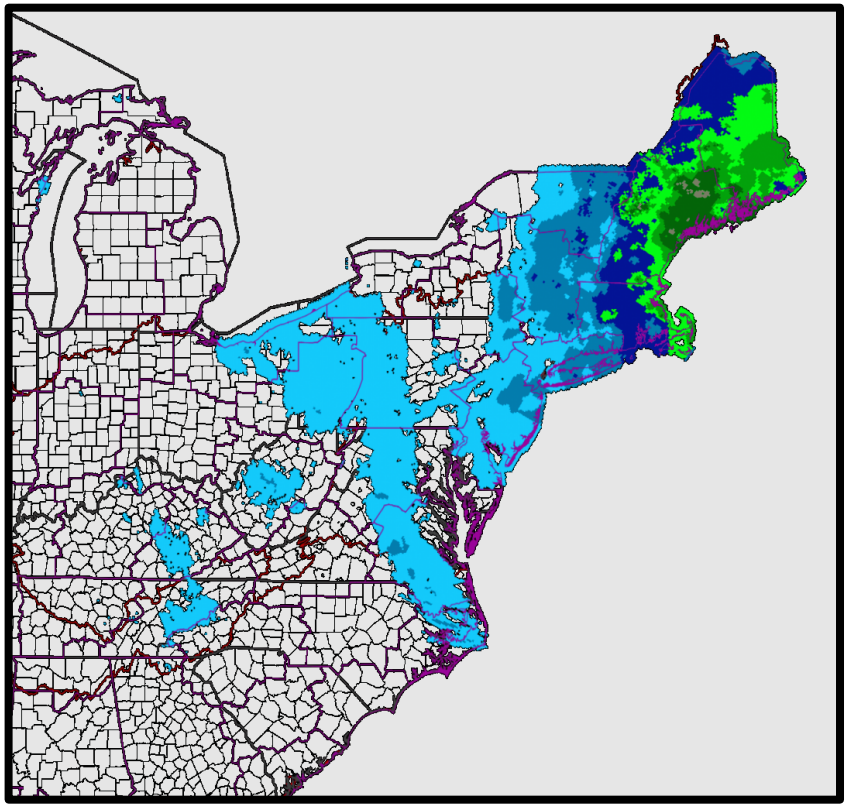
AP Photos

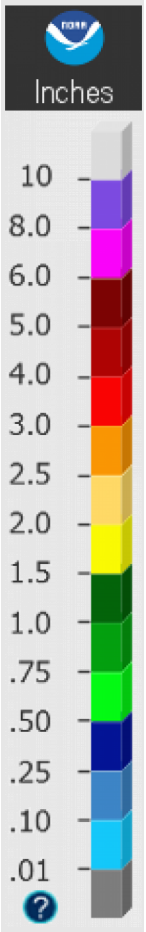
NOAA 24-h Quantitative Precipitation Estimates

Ending: 1200 UTC 27 Jan. 2015



Ending: 1200 UTC 28 Jan. 2015



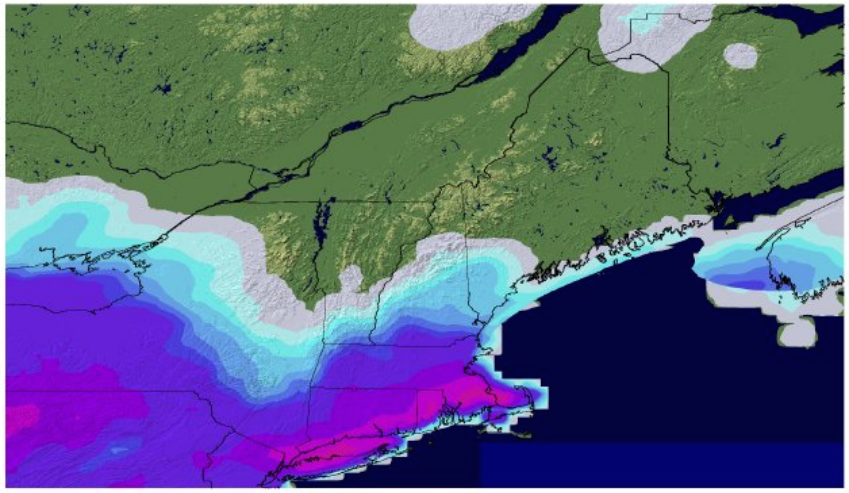


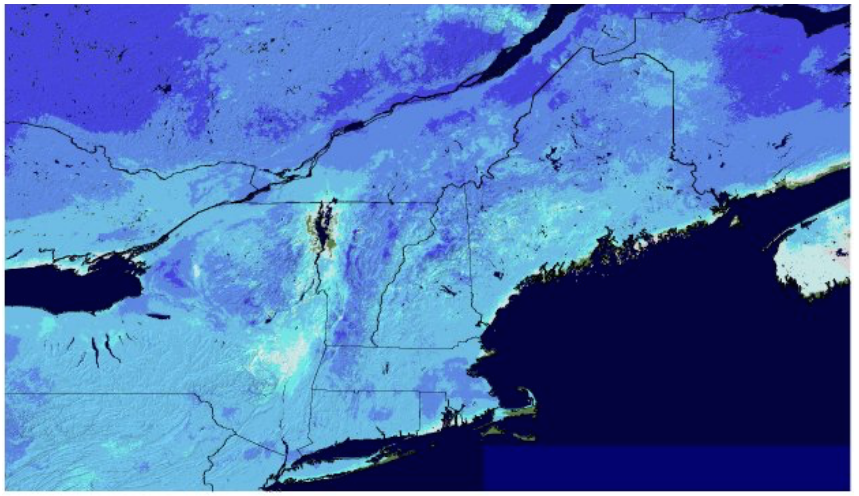
NOAA National Snow Analysis Statistics

Snow Precipitation

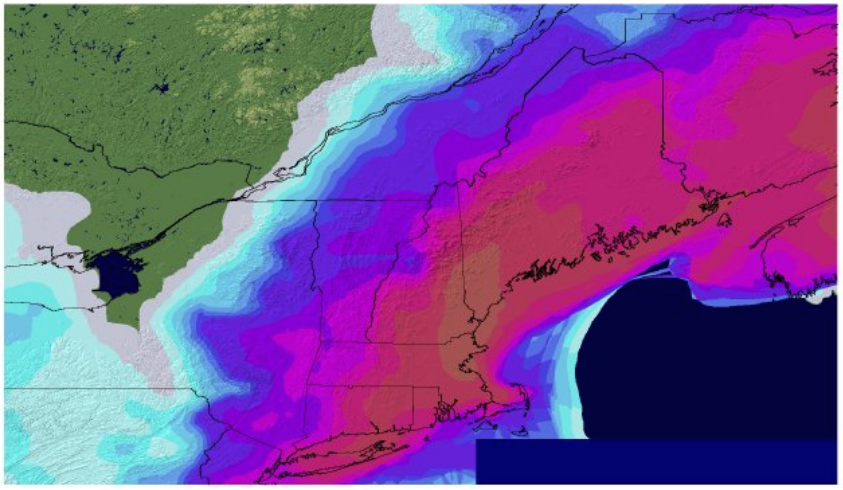
Snow Depth

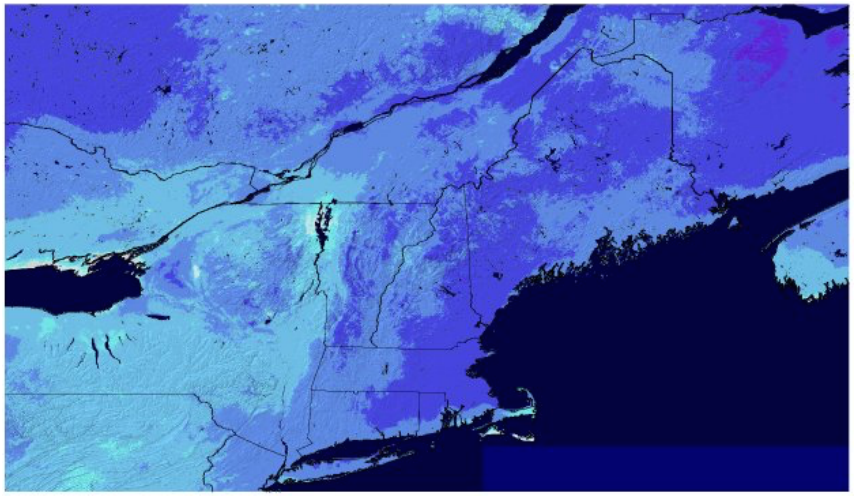
0600 UTC 27 Jan. 2015





0600 UTC 28 Jan. 2015





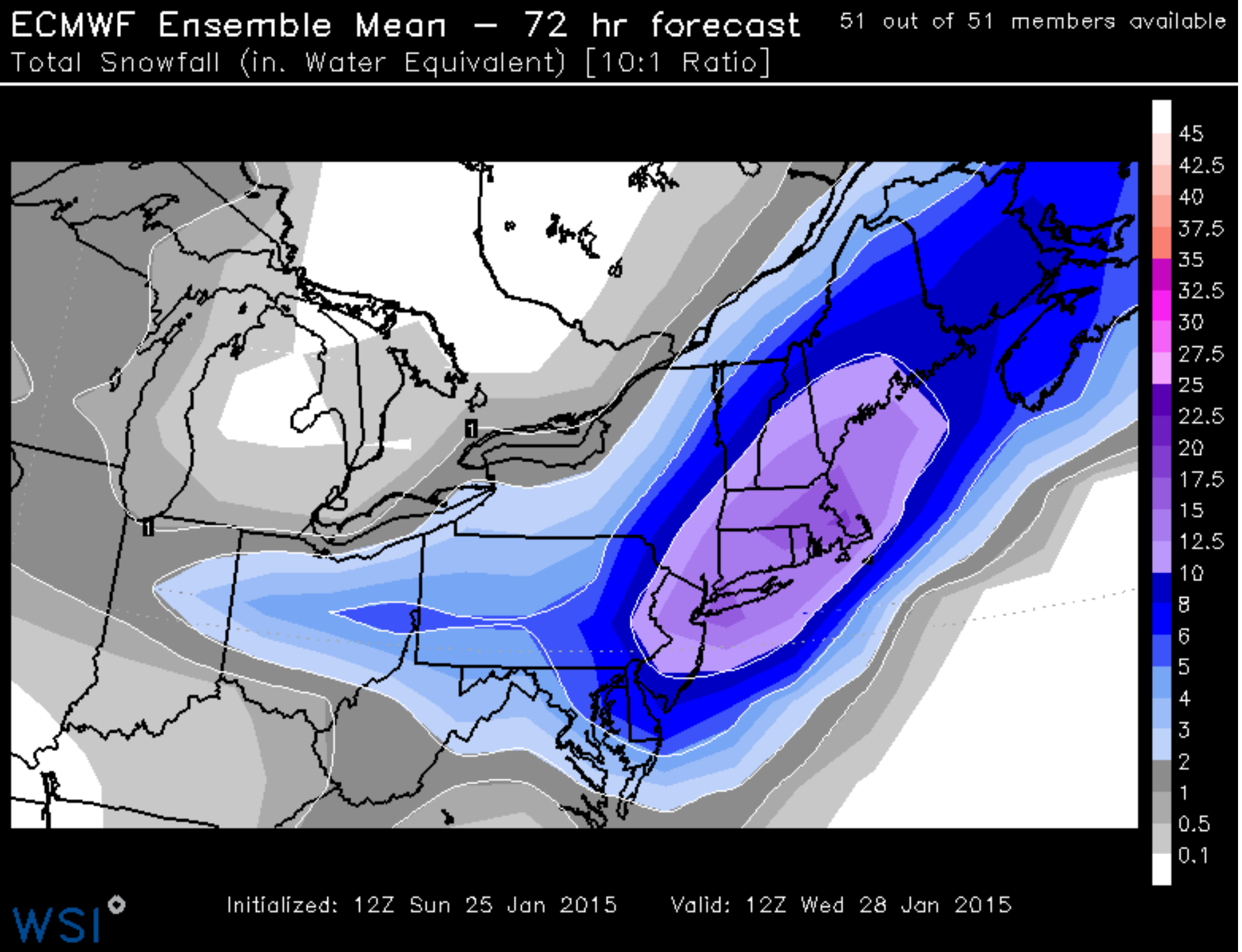
0.1 1 3 5 15 25 50

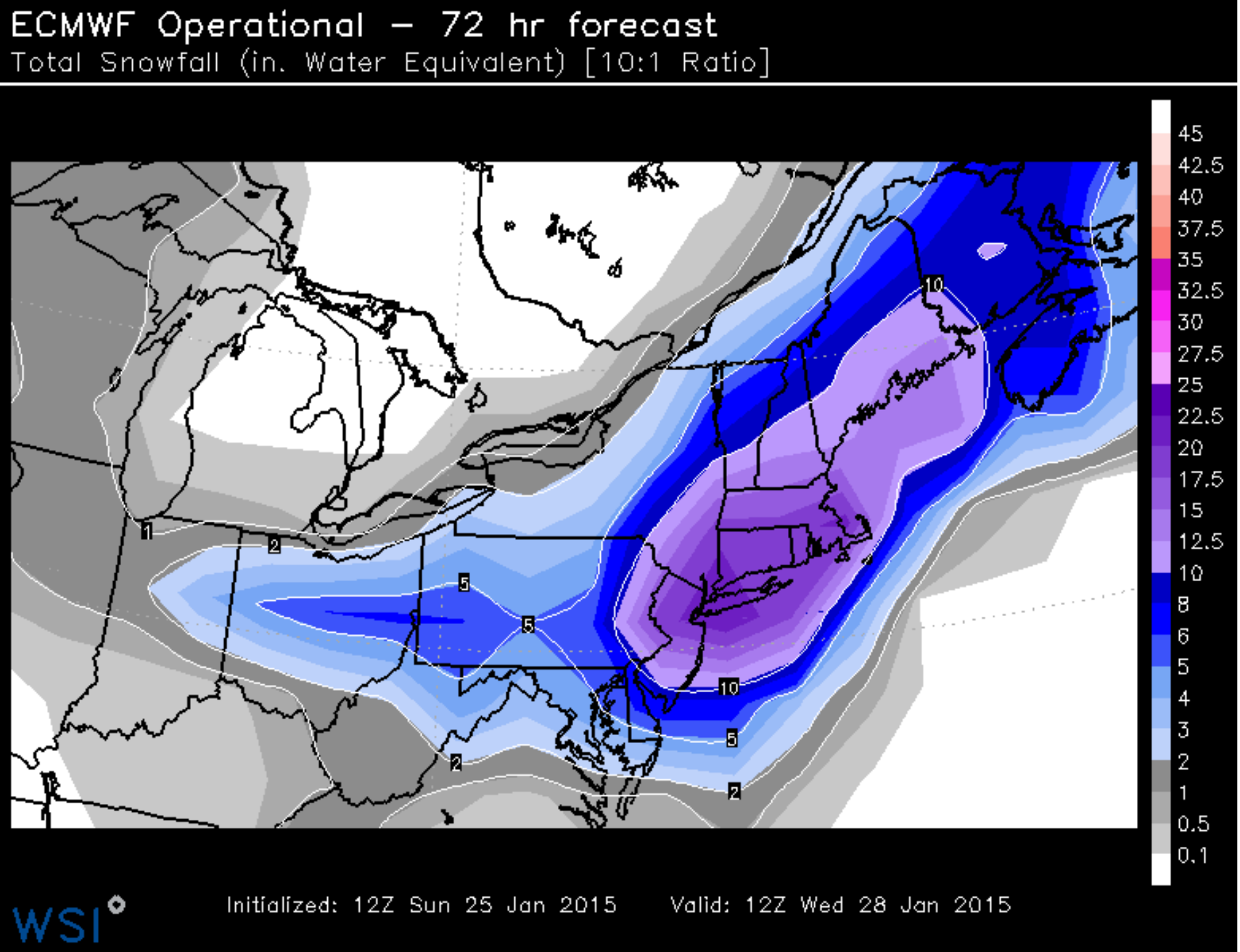
cm

1 10 50 150 500 1000

cm

The I-95 Corridor Forecast Challenge


ECMWF Ensemble Mean – 72 hr forecast
51 out of 51 members available
Total Snowfall (in. Water Equivalent) [10:1 Ratio]
45
42.5
40
37.5
35
32.5
30
27.5
25
22.5
20
17.5
15
12.5
10
8
6
5
4
3
2
1
0.5
0.1
WSI
Initialized: 12Z Sun 25 Jan 2015
Valid: 12Z Wed 28 Jan 2015


ECMWF Operational – 72 hr forecast
Total Snowfall (in. Water Equivalent) [10:1 Ratio]
45
42.5
40
37.5
35
32.5
30
27.5
25
22.5
20
17.5
15
12.5
10
8
6
5
4
3
2
1
0.5
0.1
1
2
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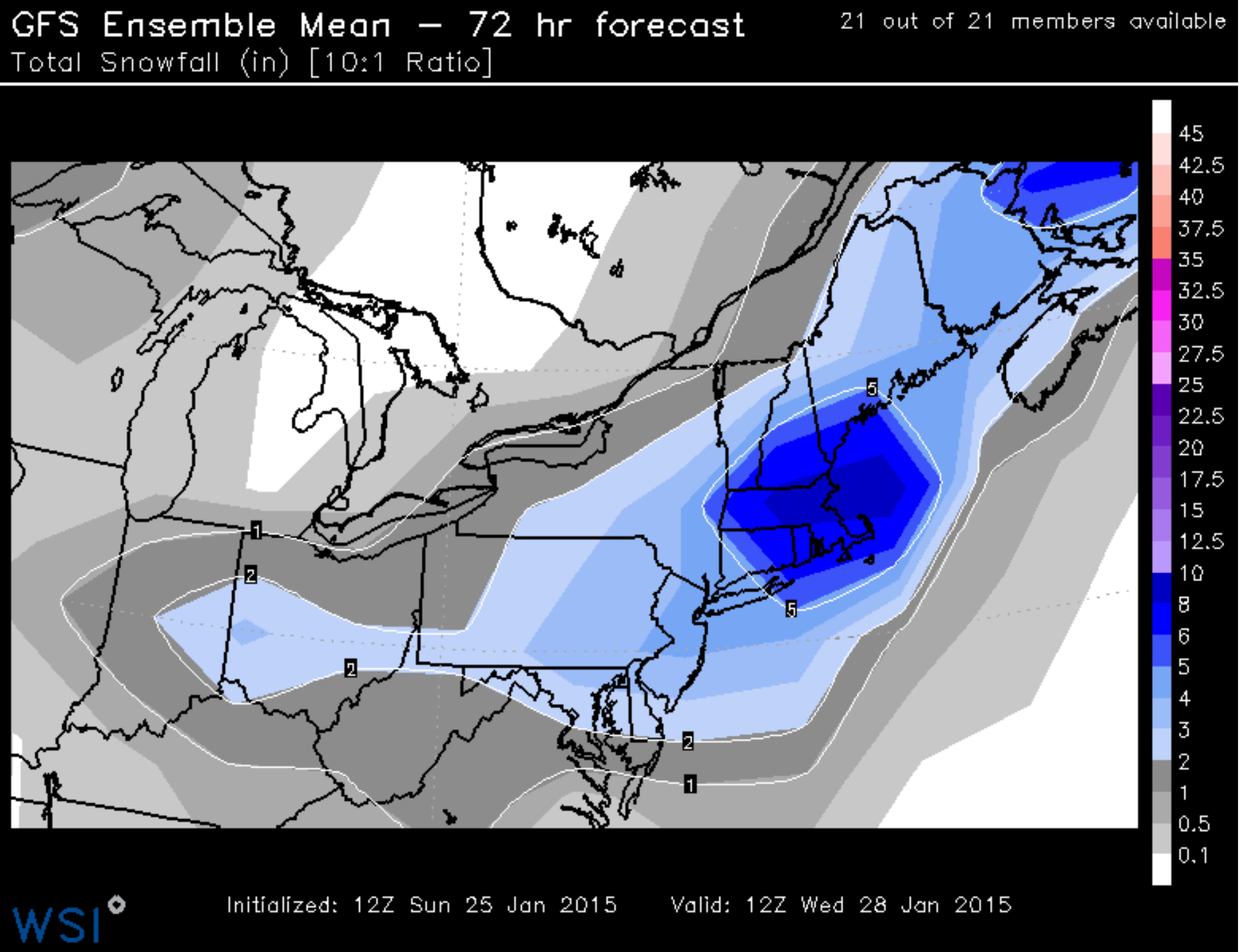
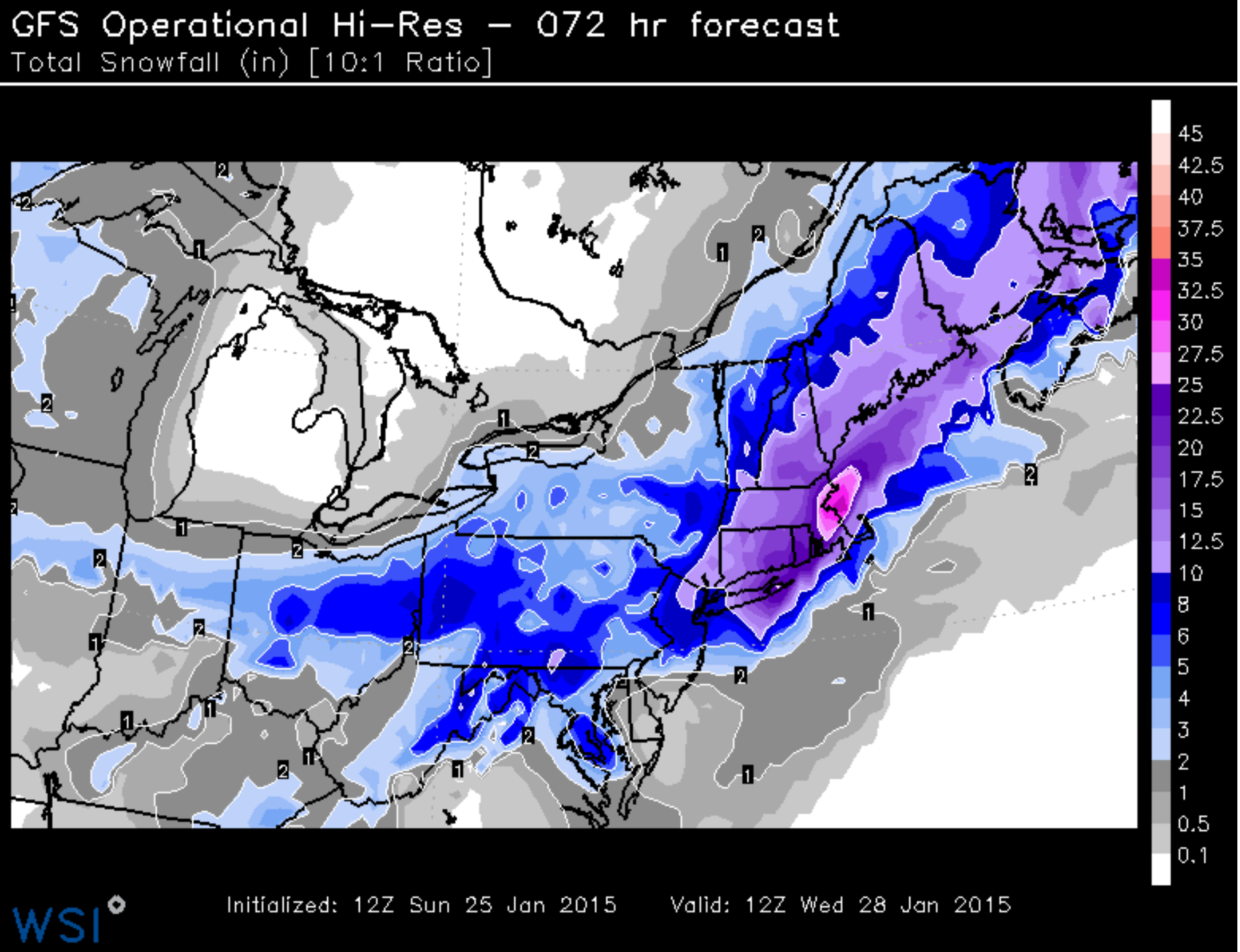
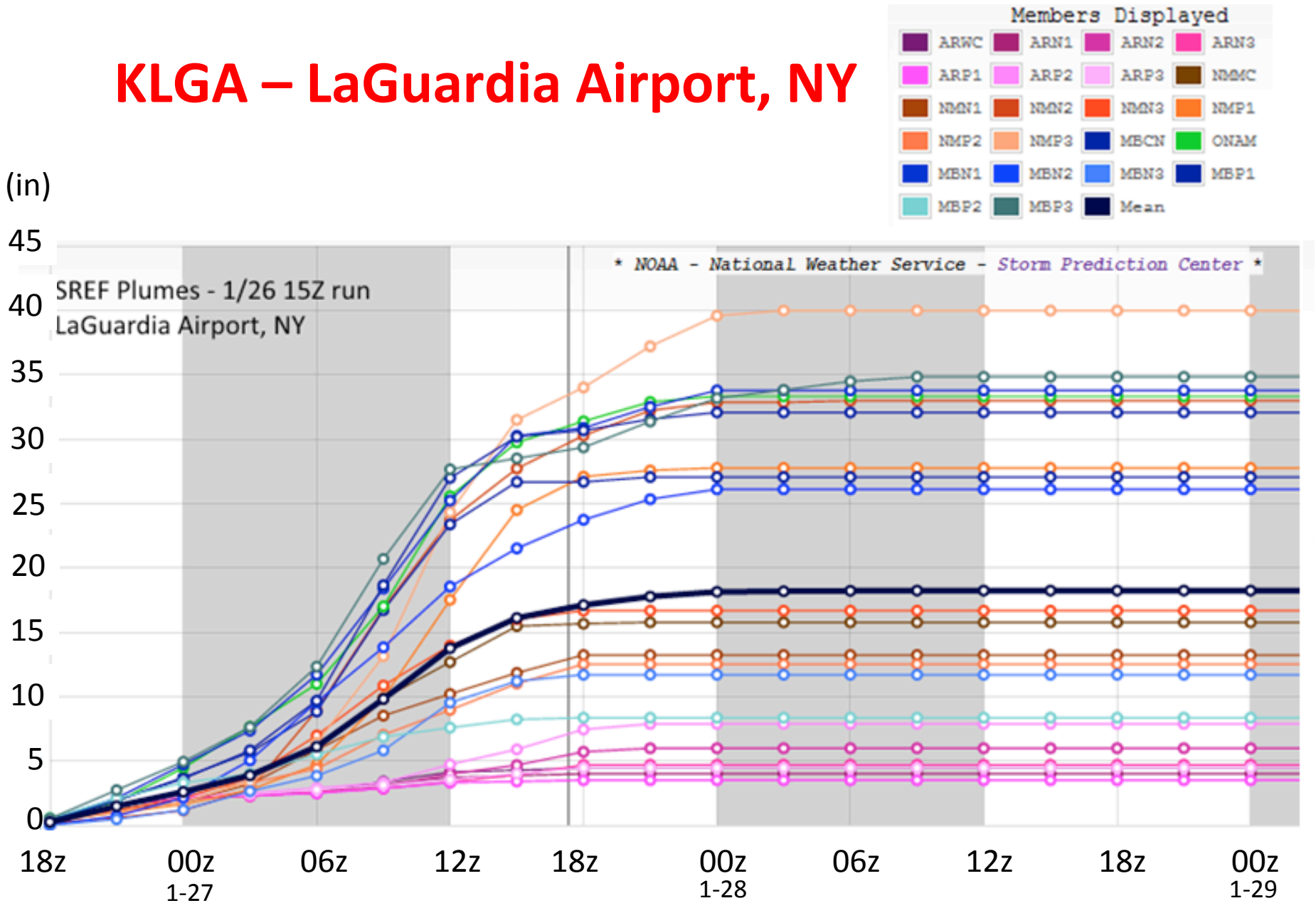
2
10
WSI
Initialized: 12Z Sun 25 Jan 2015
Valid: 12Z Wed 28 Jan 2015


GFS Ensemble Mean – 72 hr forecast
21 out of 21 members available
Total Snowfall (in) [10:1 Ratio]
45
42.5
40
37.5
35
32.5
30
27.5
25
22.5
20
17.5
15
12.5
10
8
6
5
4
3
2
1
0.5
0.1
Initialized: 12Z Sun 25 Jan 2015
Valid: 12Z Wed 28 Jan 2015
WSI


GFS Operational Hi-Res – 072 hr forecast
Total Snowfall (in) [10:1 Ratio]
45
42.5
40
37.5
35
32.5
30
27.5
25
22.5
20
17.5
15
12.5
10
8
6
5
4
3
2
1
0.5
0.1
WSI
Initialized: 12Z Sun 25 Jan 2015
Valid: 12Z Wed 28 Jan 2015

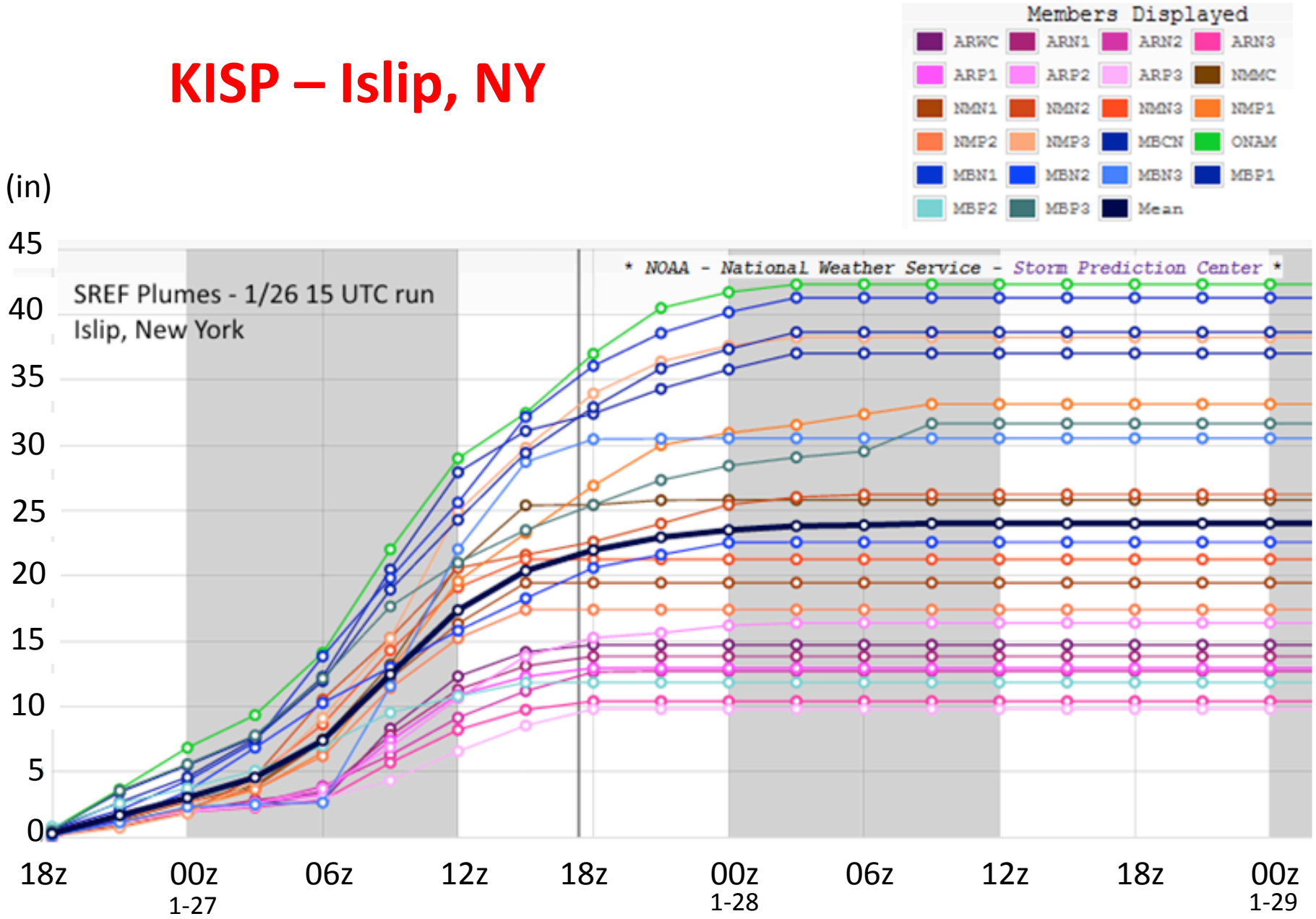
SREF Plumes Snowfall Forecast

KLGA – LaGuardia Airport, NY



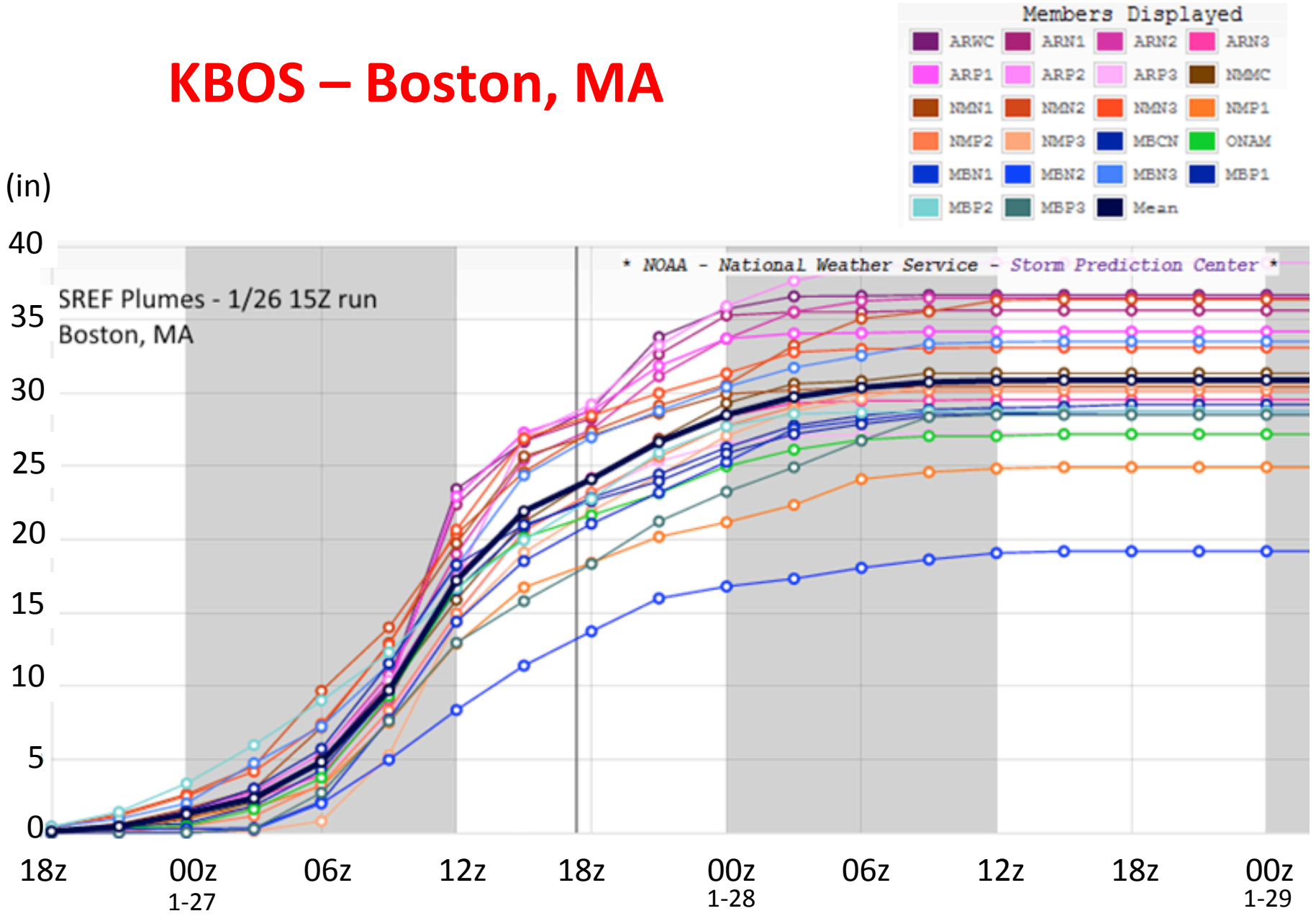
SREF Plumes Snowfall Forecast

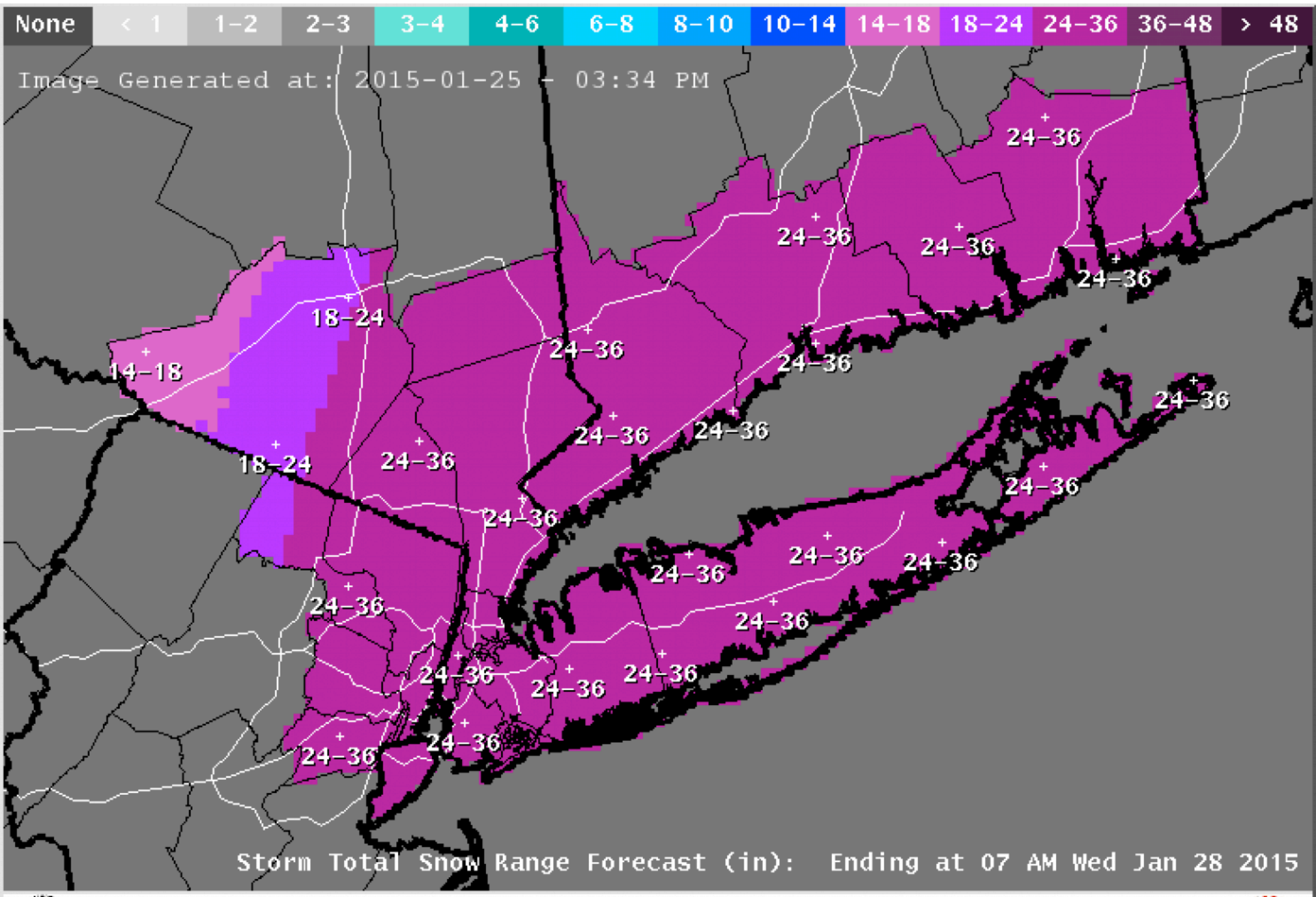
KISP – Islip, NY



SREF Plumes Snowfall Forecast

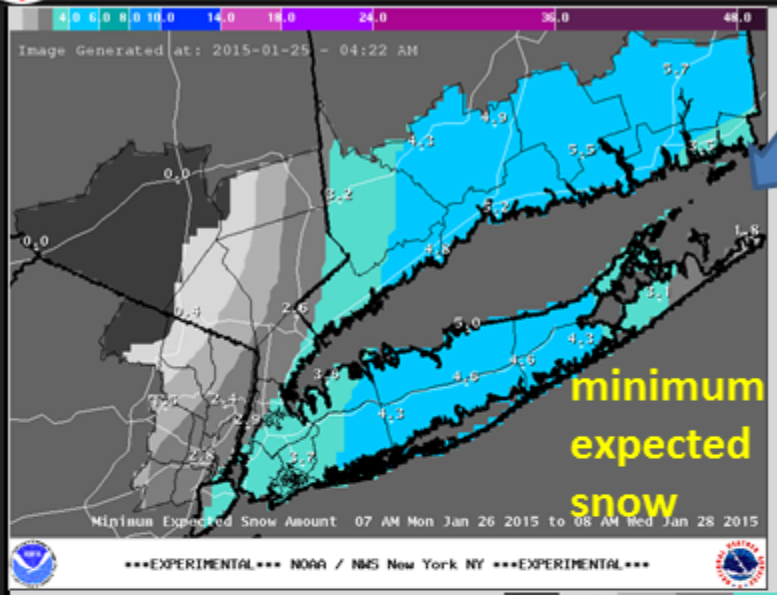
KBOS – Boston, MA



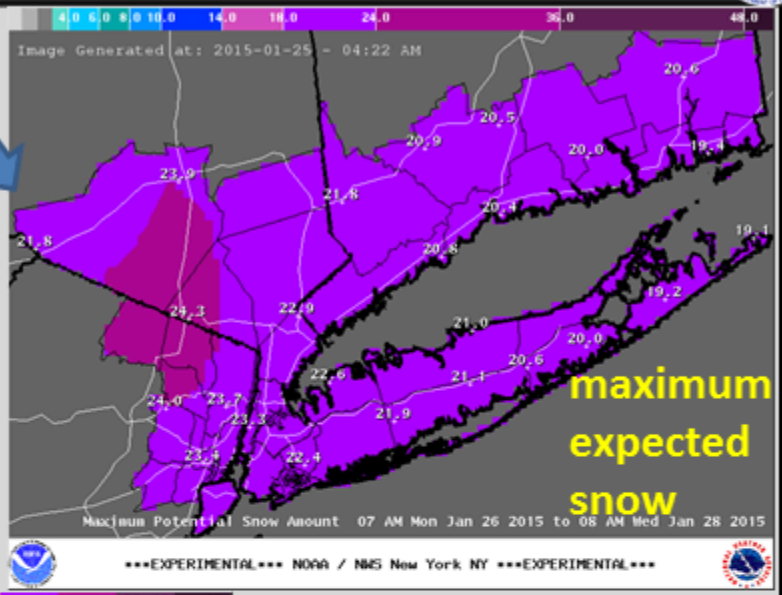


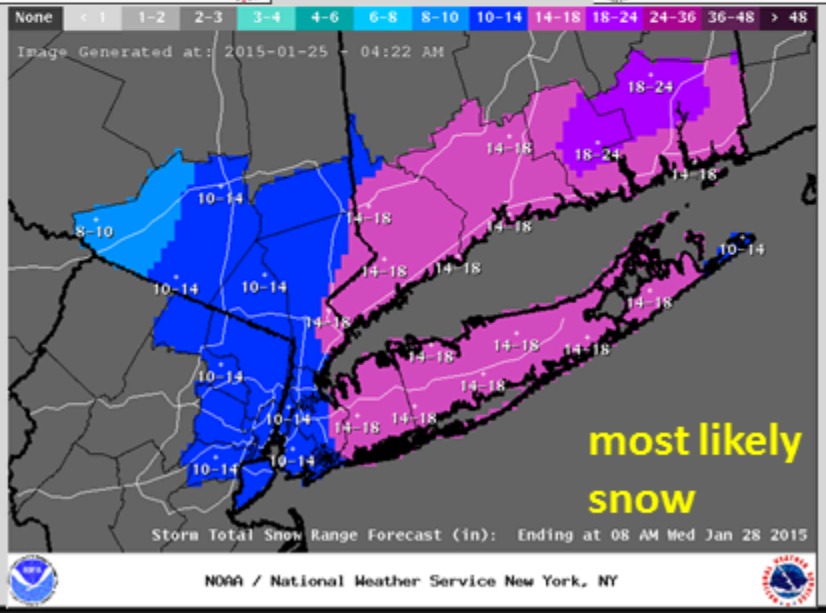
NOAA / National Weather Service New York, NY

MIN/MAX/MOST LIKELY SNOWFALL FORECASTS



experimental



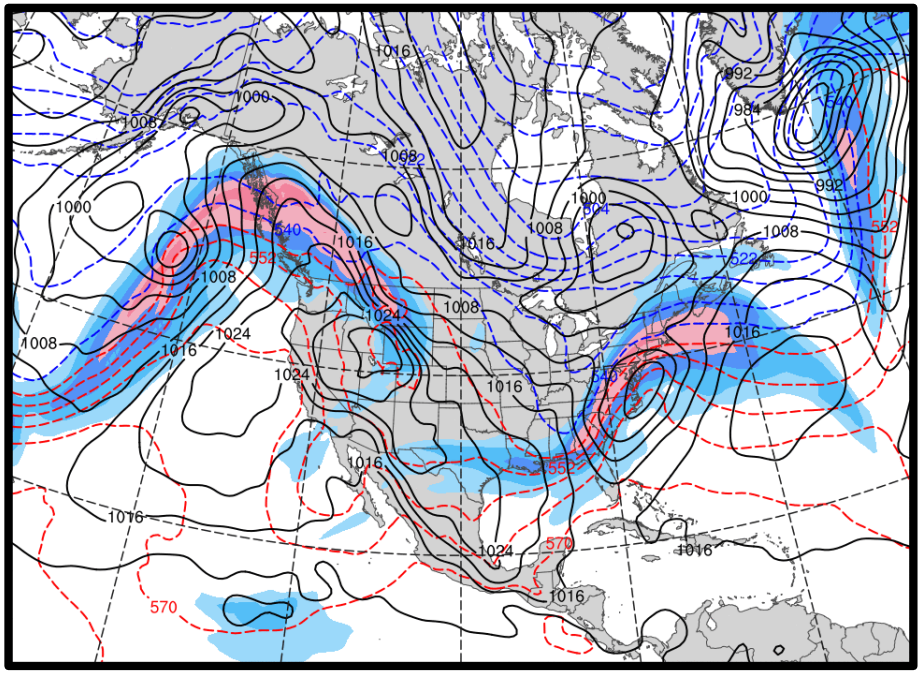


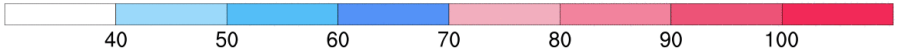
National Weather Service – New York, NY

A Large-Scale North American Perspective: SLP, Thickness, and Dynamic Tropopause

Synoptic Evolution – Late-January 2015

1200 UTC 24 January 2015



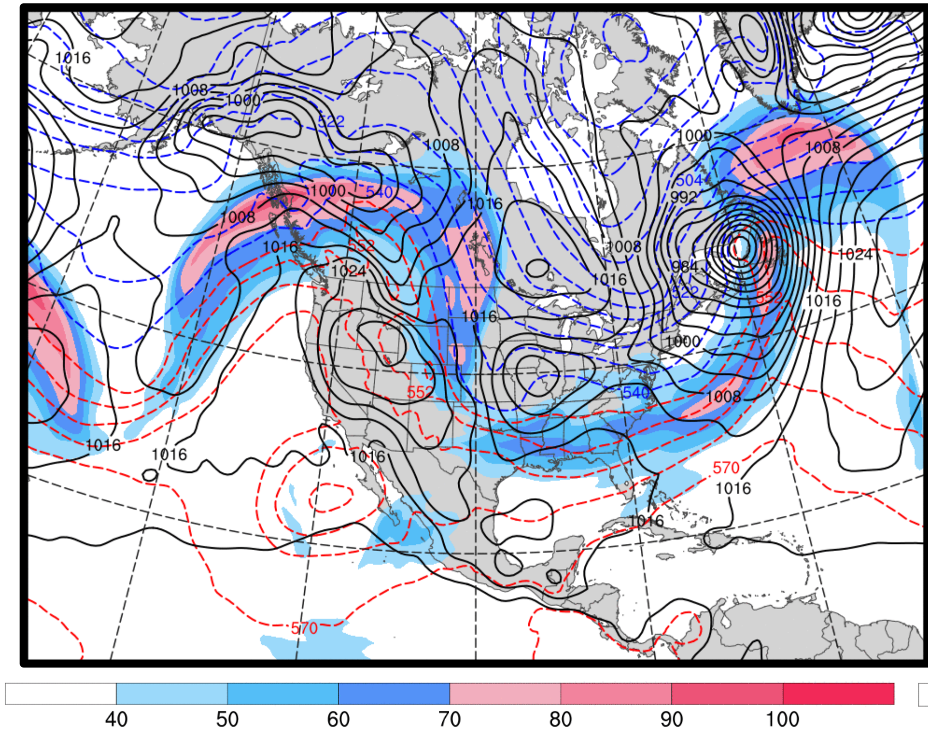


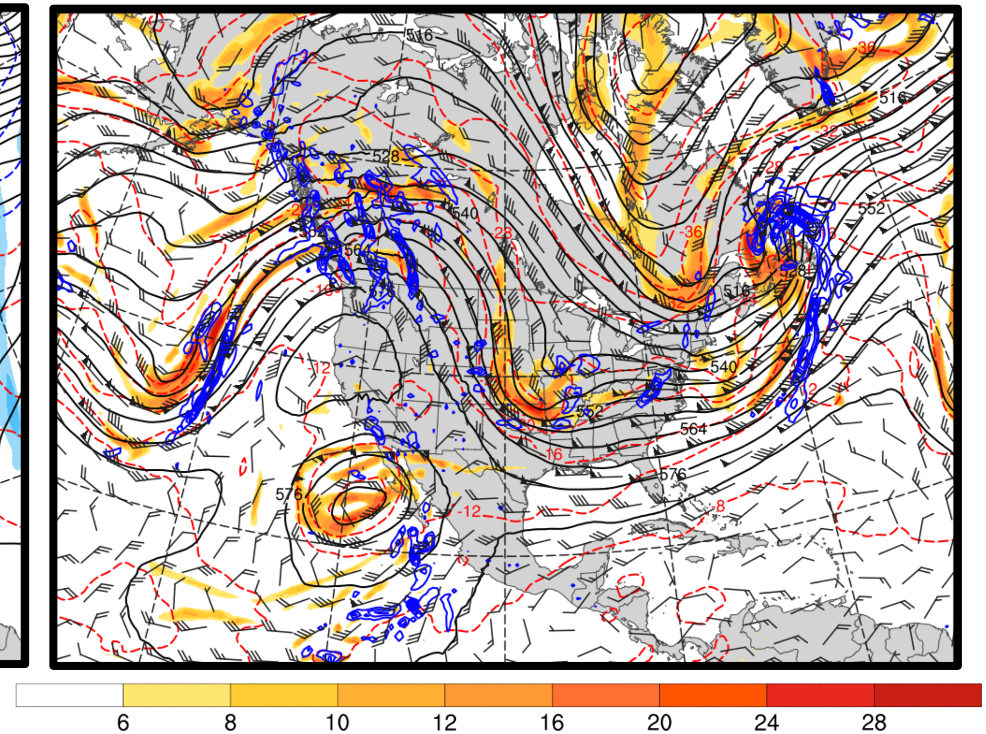
SLP (hPa; black)
1000–500 hPa Thickness (dam; dashed)
250 hPa Jet (ms^{-1}; fill pattern)

500 hPa Heights (dam; black)
500 hPa Winds (kts; barbs)
500 hPa Rel. Vor. (10^{-5} s^{-1} fill pattern)
500 hPa Temp. (°C; dashed red)
500 hPa Ascent (dPa s^{-1}; blue)

Synoptic Evolution – Late-January 2015

1200 UTC 25 January 2015



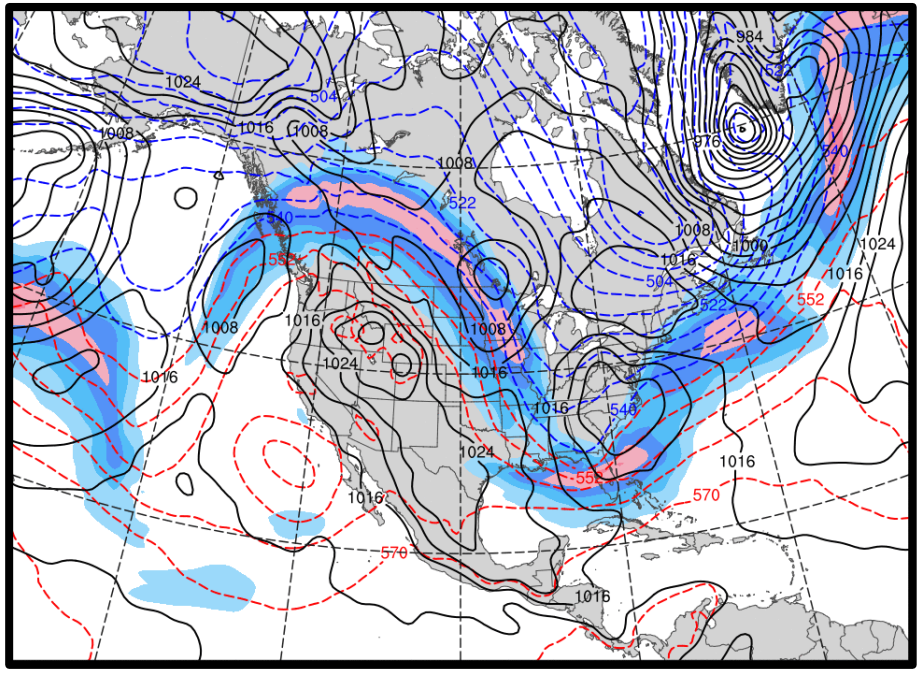


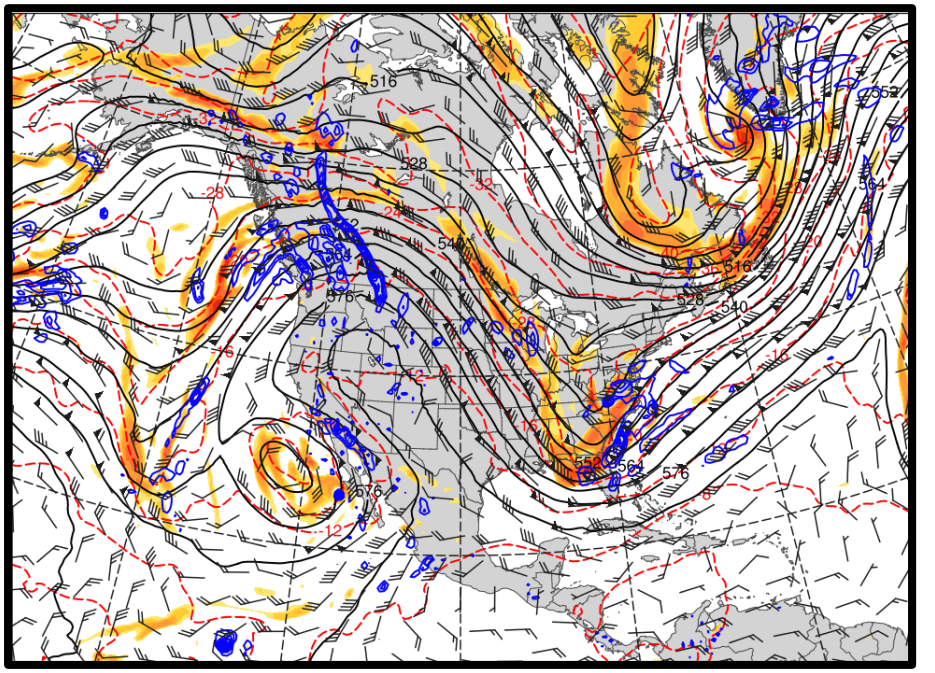
SLP (hPa; black)
1000–500 hPa Thickness (dam; dashed)
250 hPa Jet (ms^{-1}; fill pattern)

500 hPa Heights (dam; black)
500 hPa Winds (kts; barbs)
500 hPa Rel. Vor. (10^{-5} s^{-1} fill pattern)
500 hPa Temp. (^{o}C; dashed red)
500 hPa Ascent (dPa s^{-1}; blue)

Synoptic Evolution – Late-January 2015

1200 UTC 26 January 2015



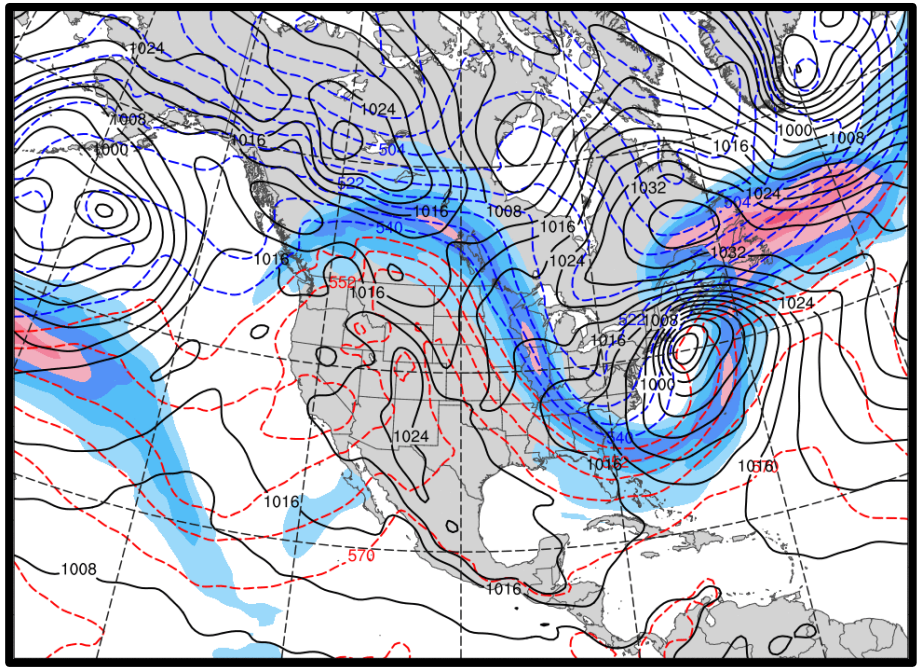


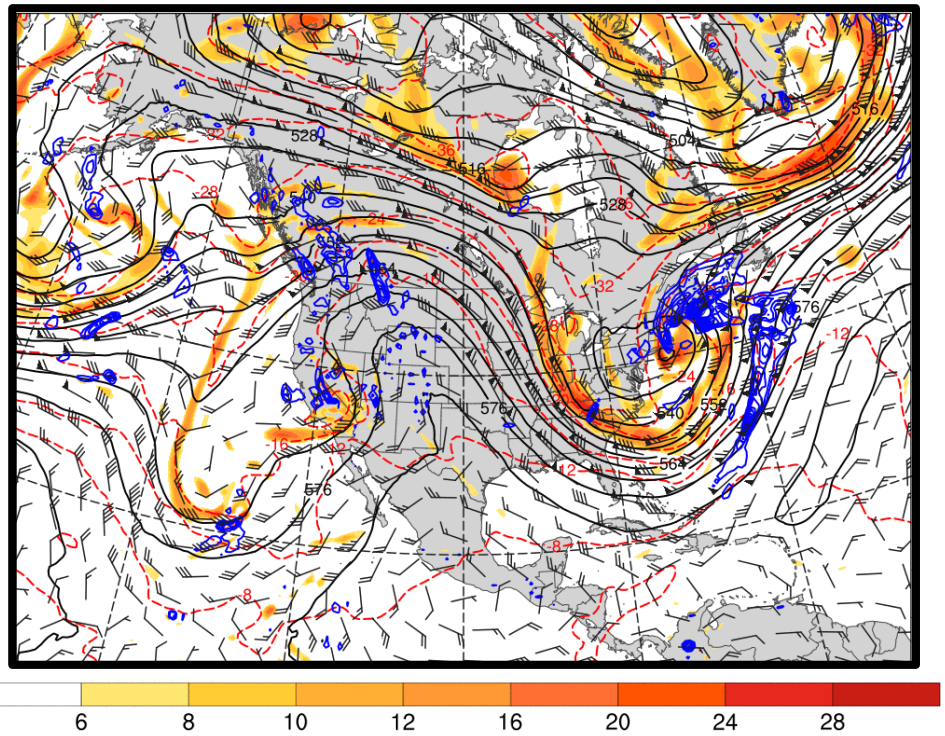
SLP (hPa; black)
1000–500 hPa Thickness (dam; dashed)
250 hPa Jet (ms^{-1}; fill pattern)

500 hPa Heights (dam; black)
500 hPa Winds (kts; barbs)
500 hPa Rel. Vor. (10^{-5} s^{-1} fill pattern)
500 hPa Temp. (°C; dashed red)
500 hPa Ascent (dPa s^{-1}; blue)

Synoptic Evolution – Late-January 2015

1200 UTC 27 January 2015

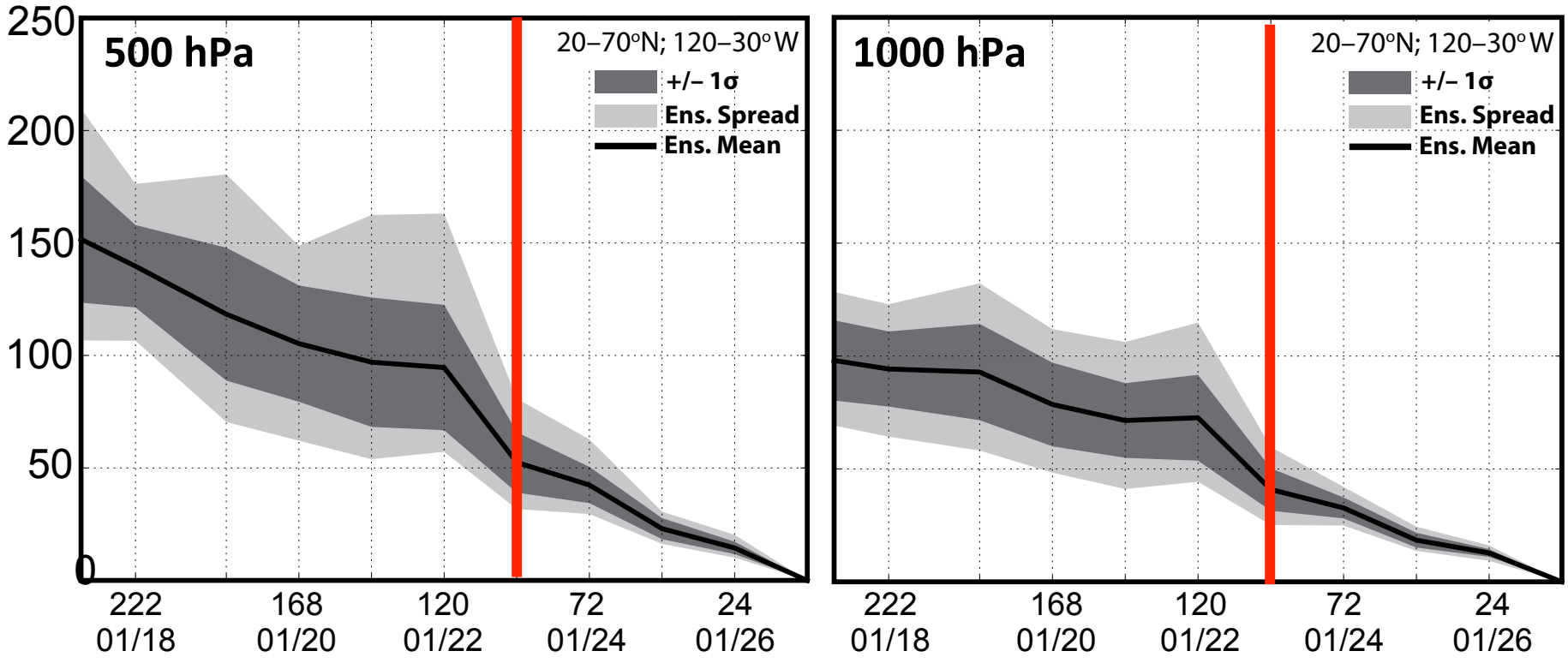




SLP (hPa; black)
1000–500 hPa Thickness (dam; dashed)
250 hPa Jet (ms^{-1}; fill pattern)

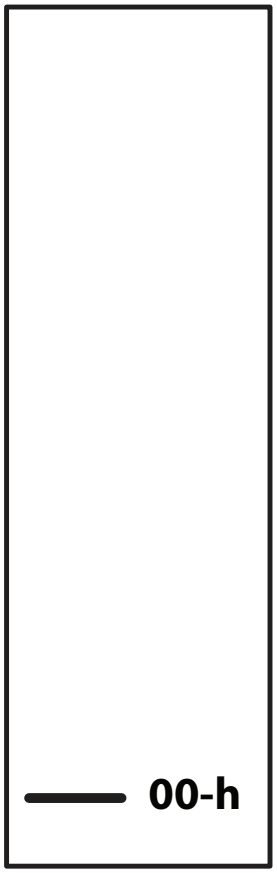
500 hPa Heights (dam; black)
500 hPa Winds (kts; barbs)
500 hPa Rel. Vor. (10^{-5} s^{-1} fill pattern)
500 hPa Temp. (^{o}C; dashed red)
500 hPa Ascent (dPa s^{-1}; blue)

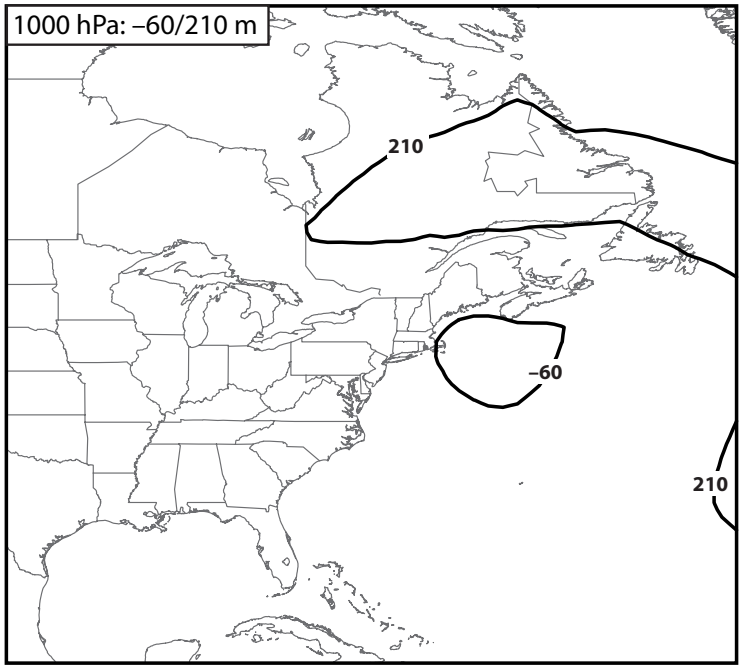
RMSE of Geopotential Heights (m) Verifying 1800 UTC 27 January 2015

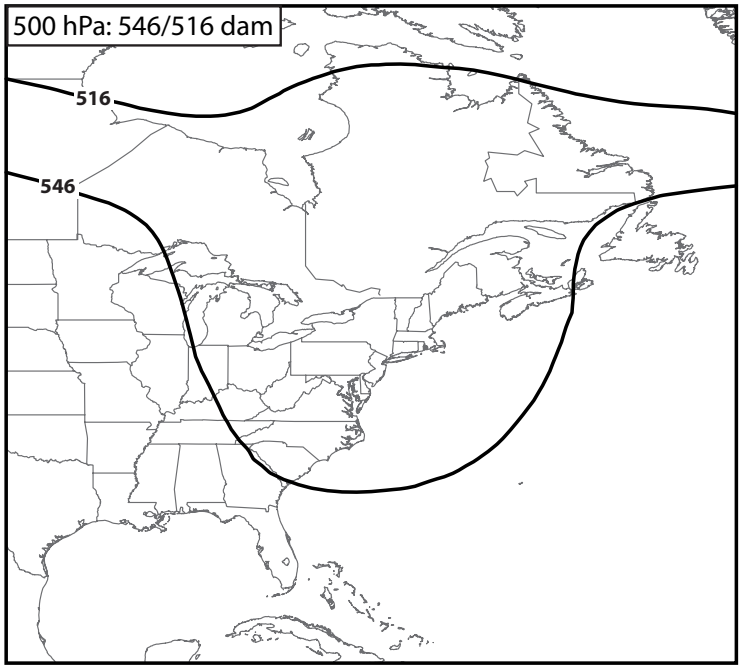


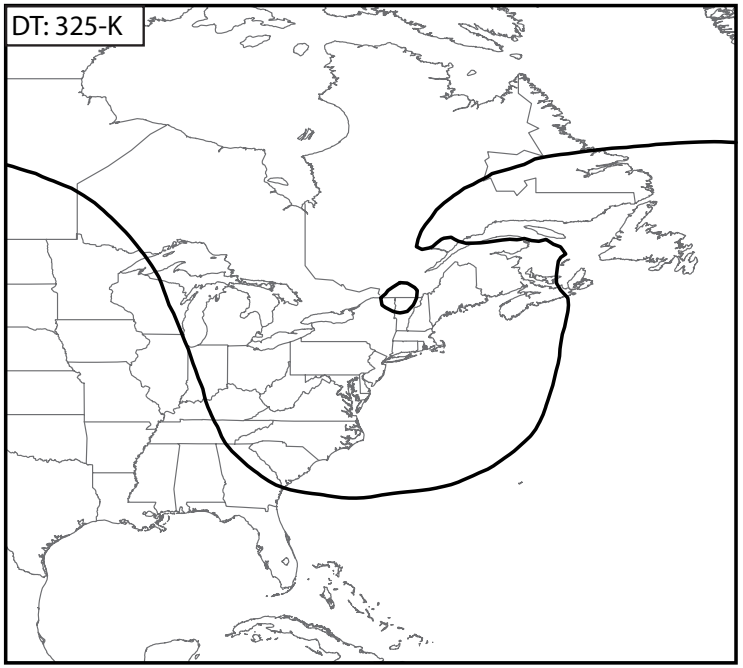
96-h: GEFS Forecasts improve after ridge amplification begins in the eastern N. Pacific (1800 UTC 23 Jan.)

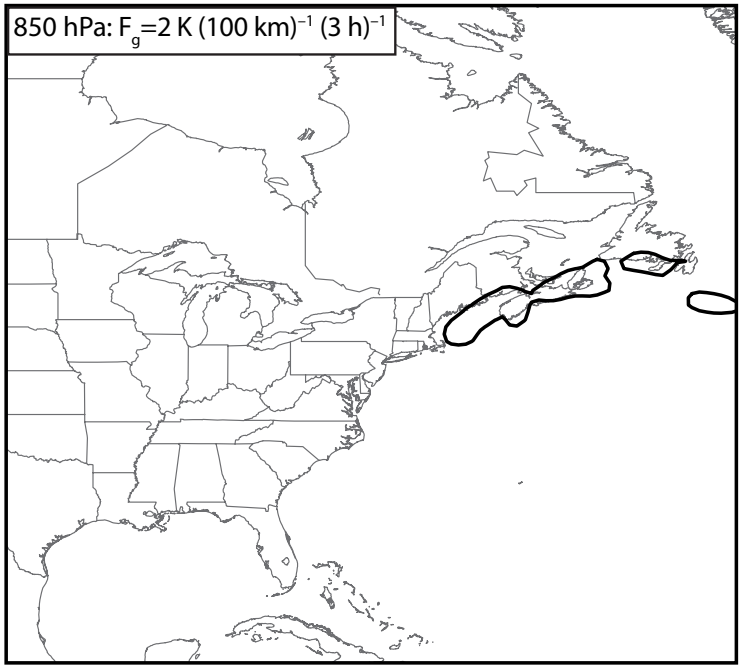
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015







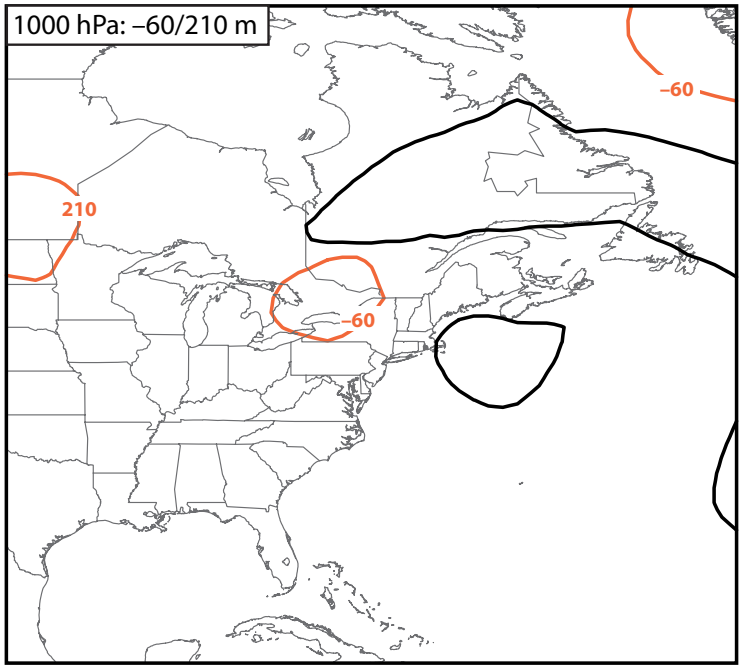


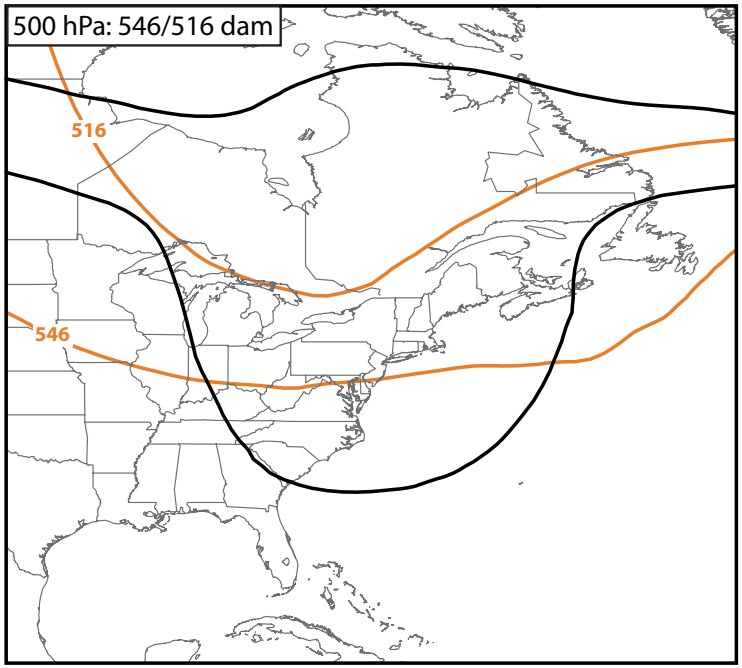


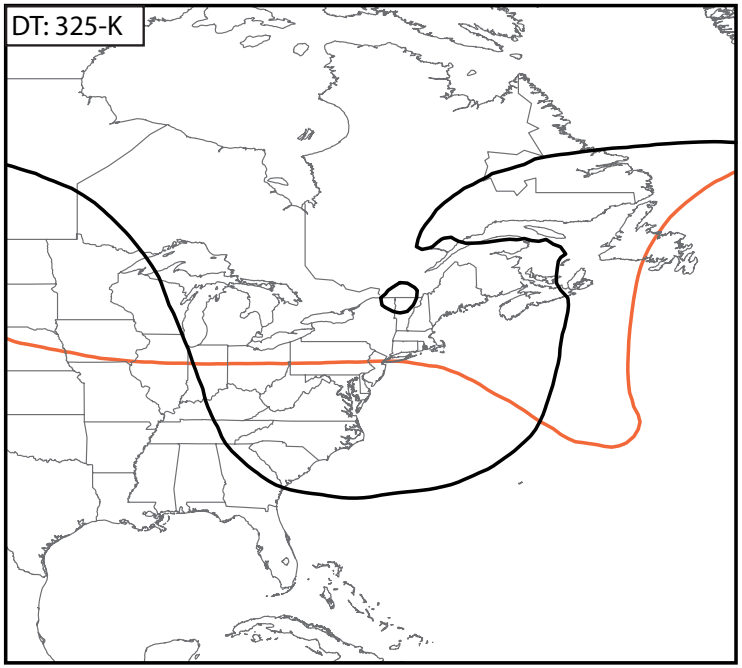
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015

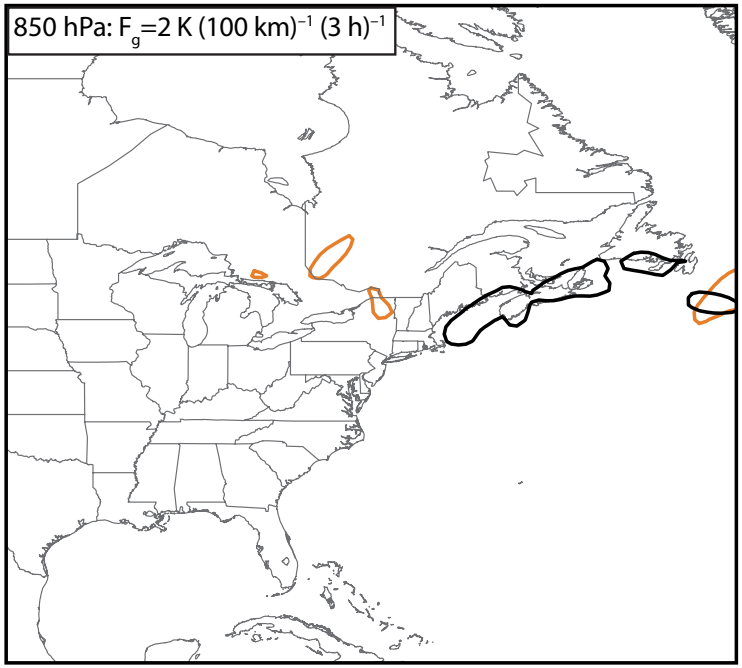
240-h

00-h







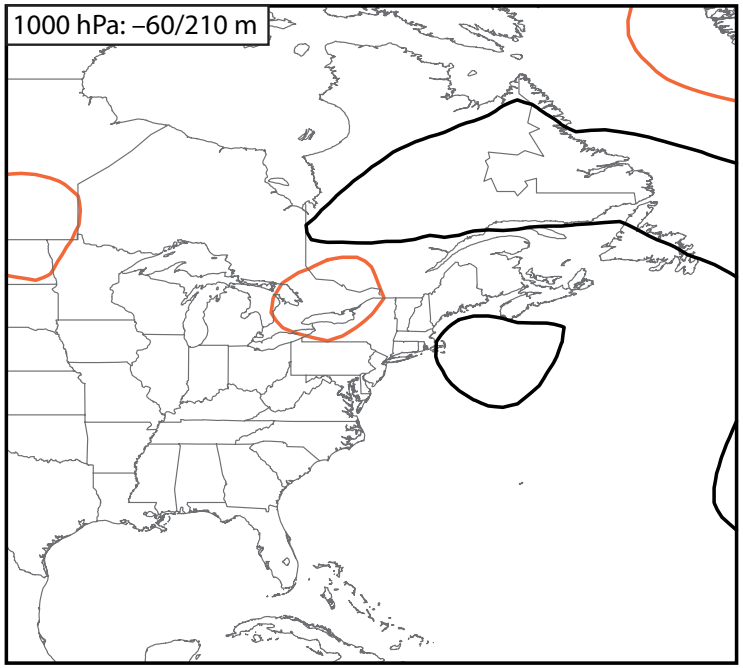


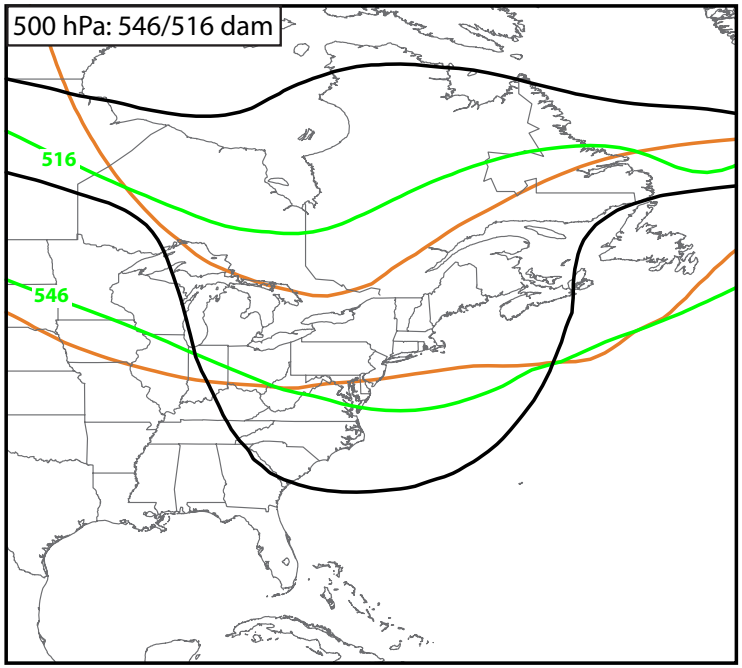
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015

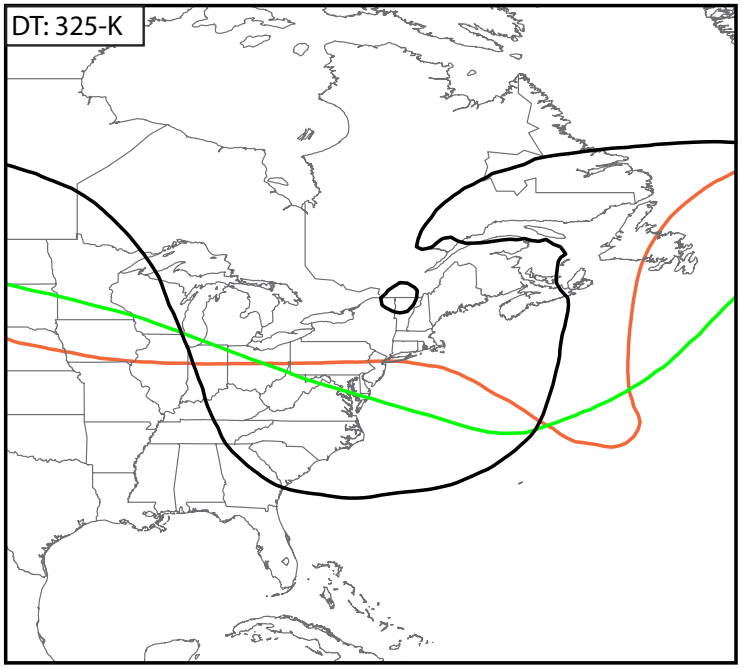
240-h

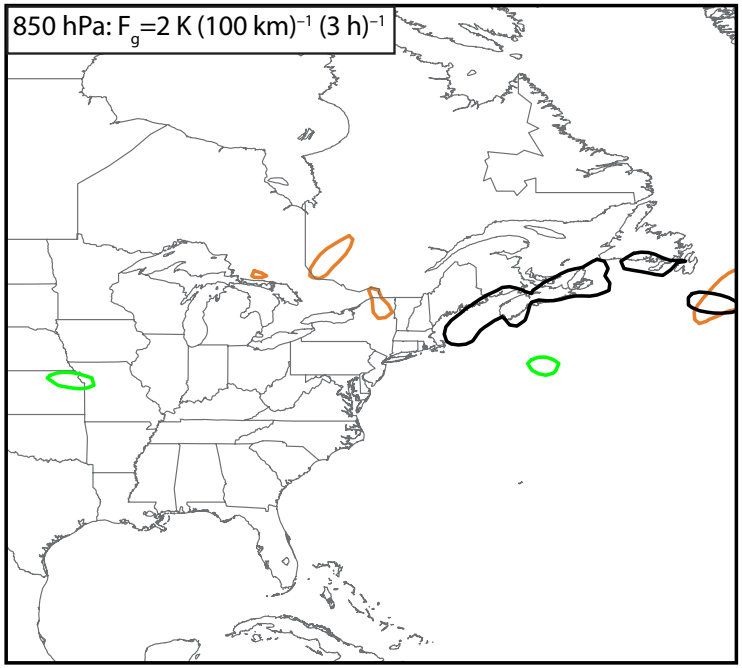
222-h

00-h

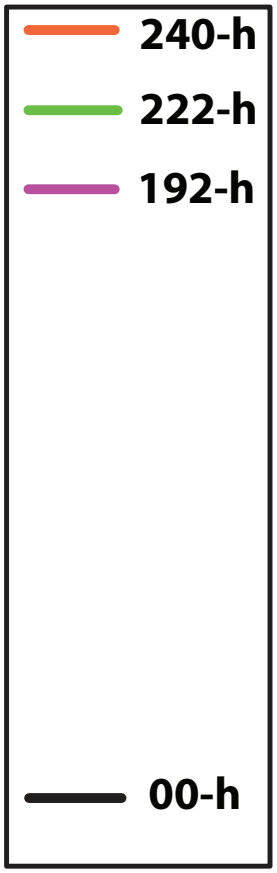


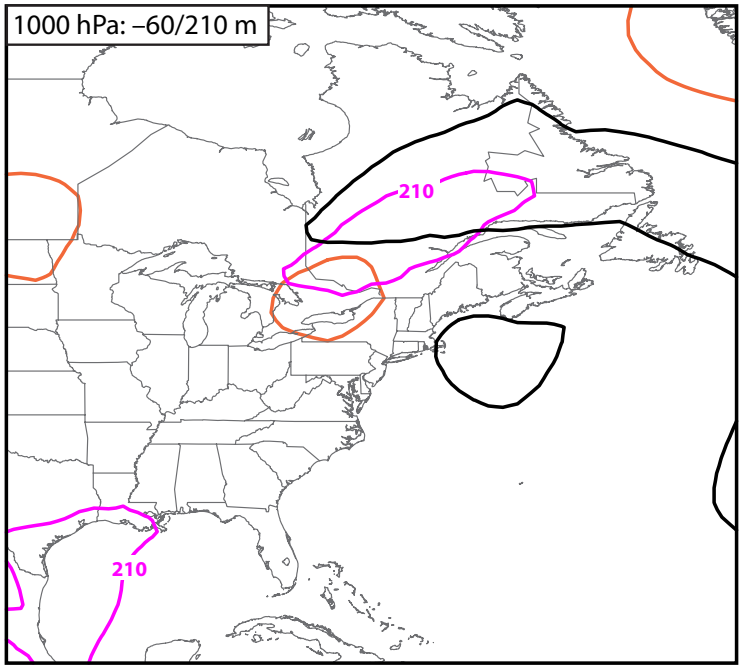


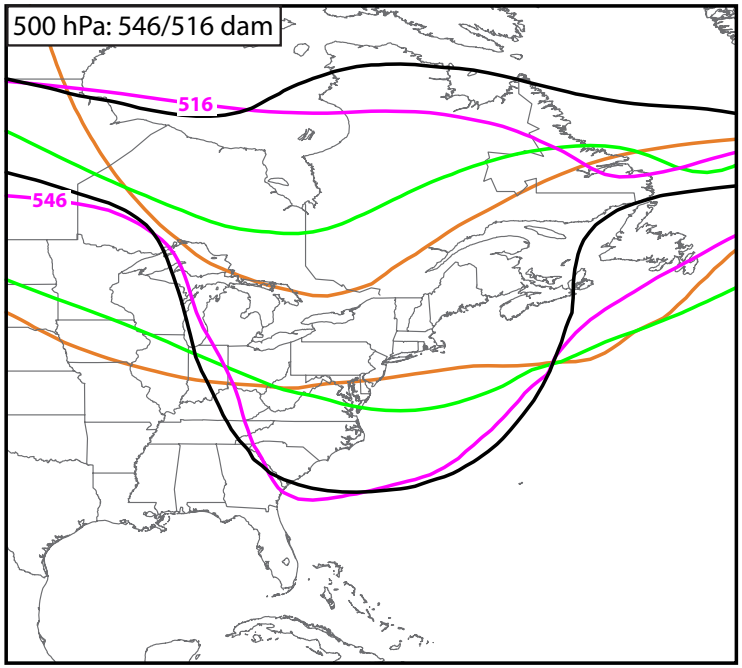


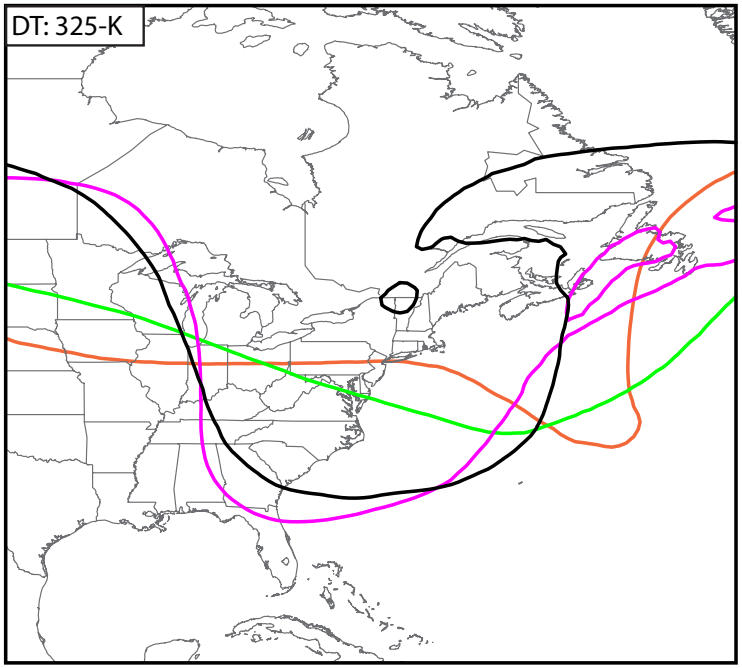


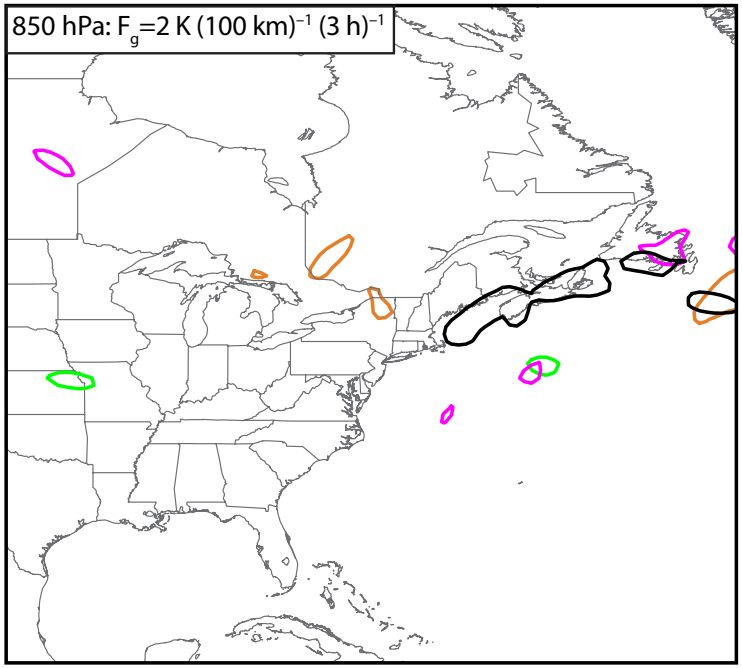
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015





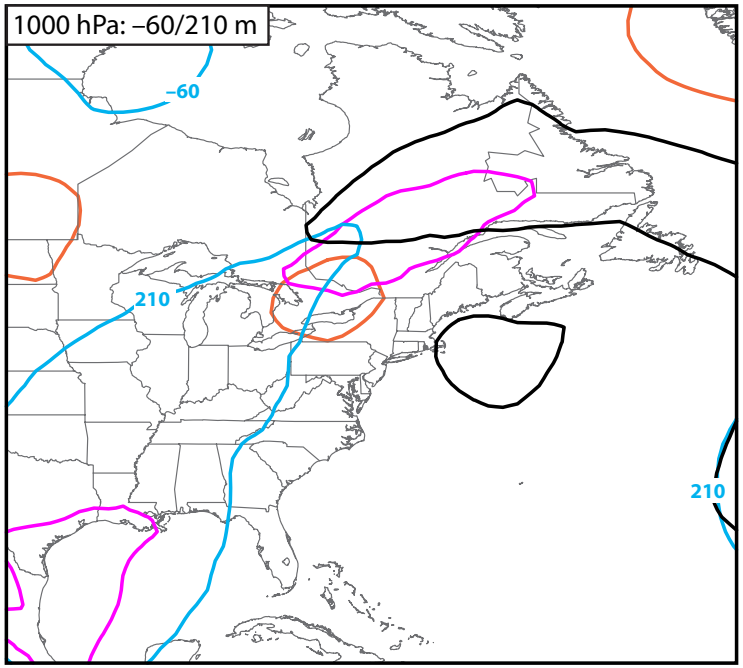


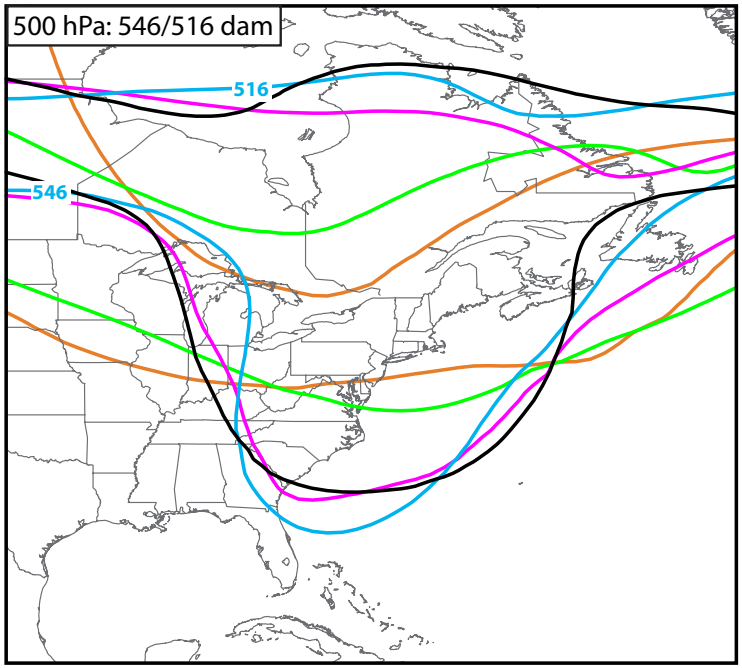


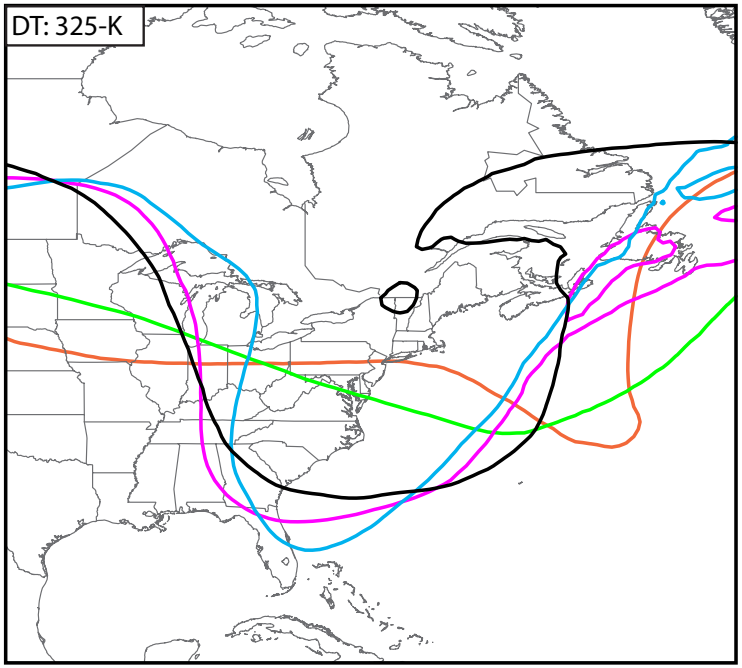


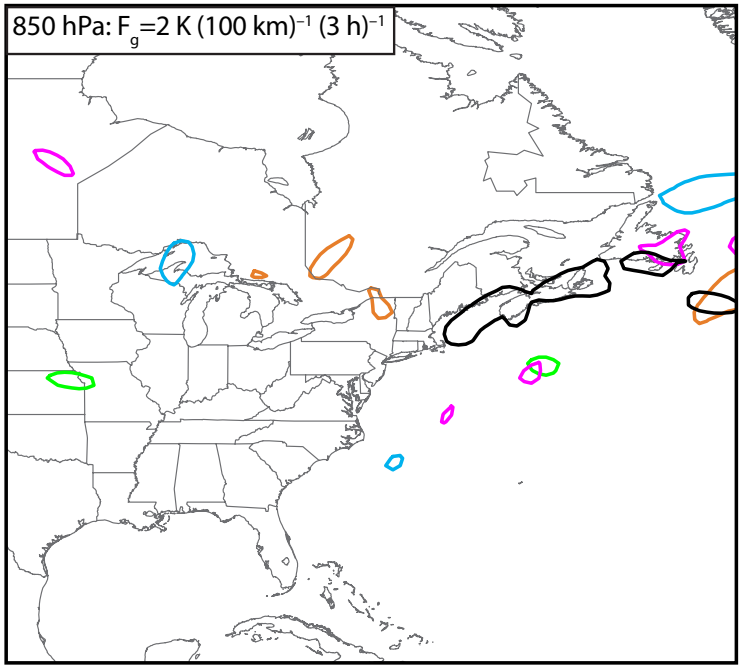
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015

240-h
222-h
192-h
168-h
00-h

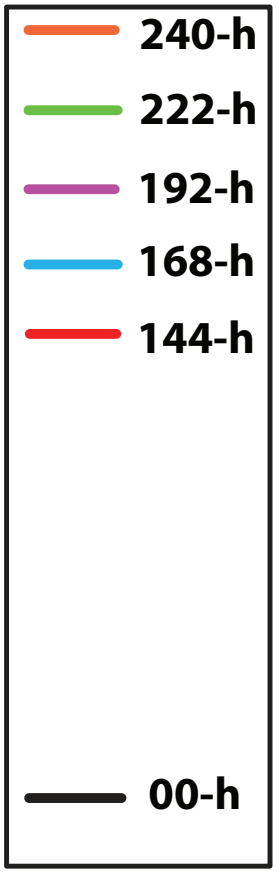


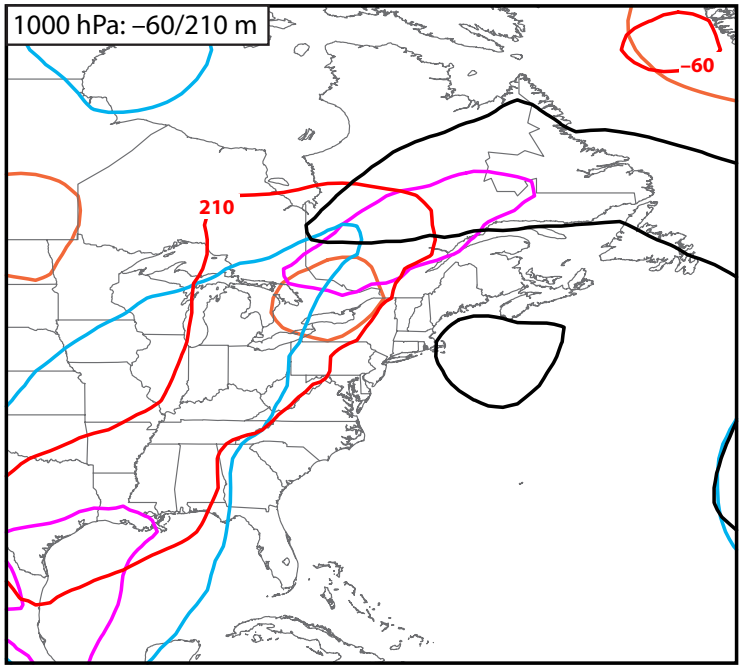


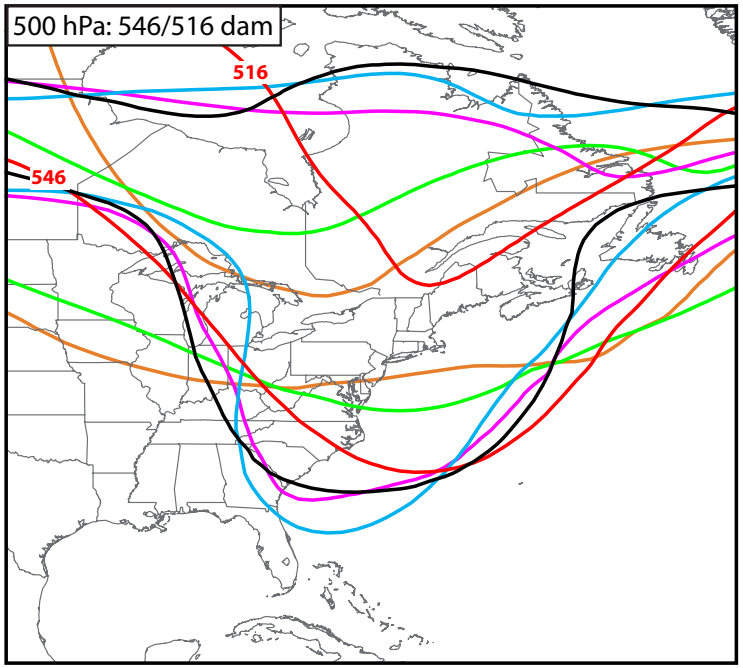


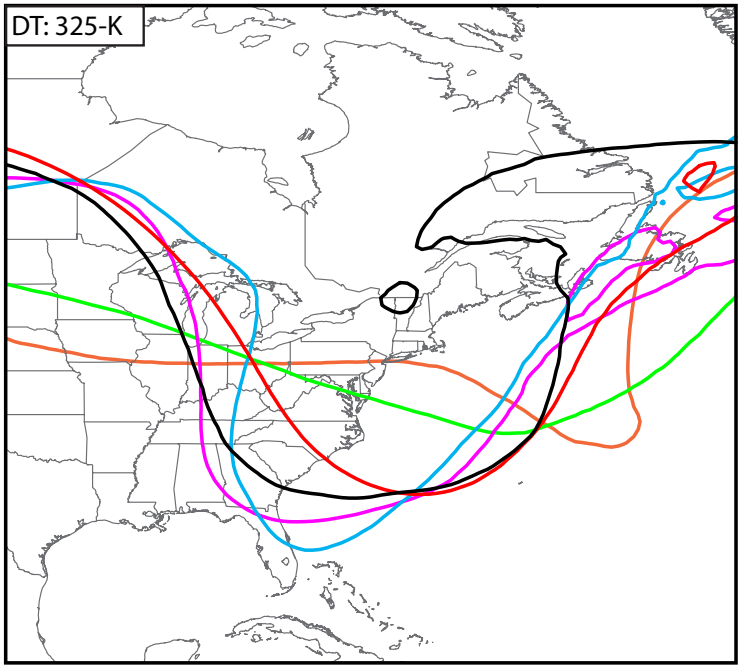


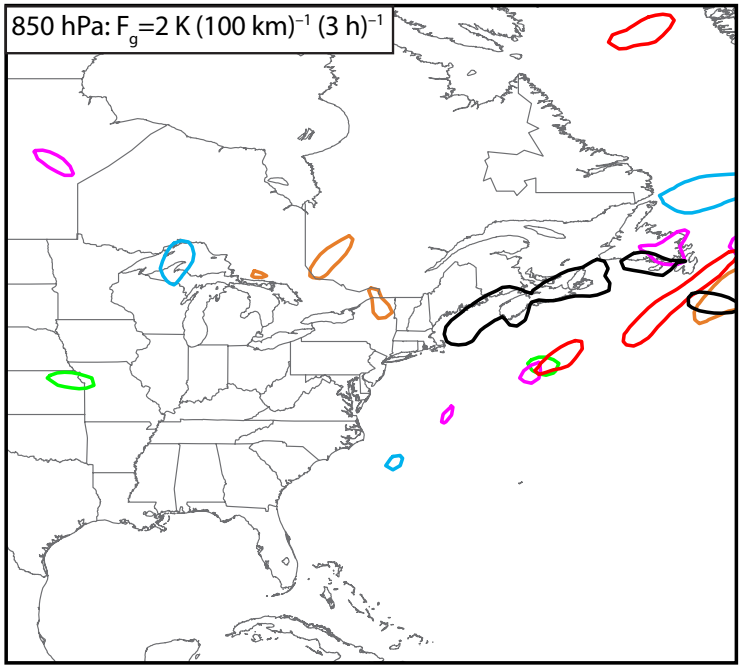
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015





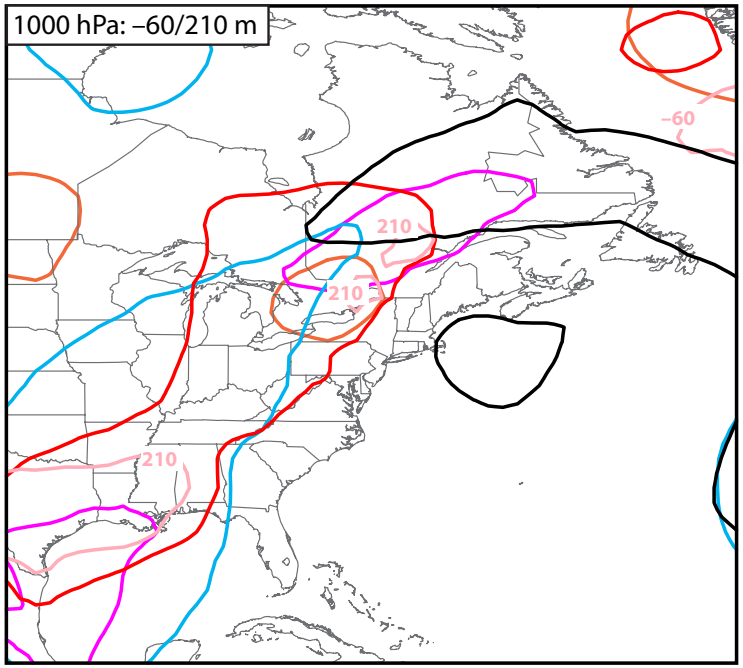


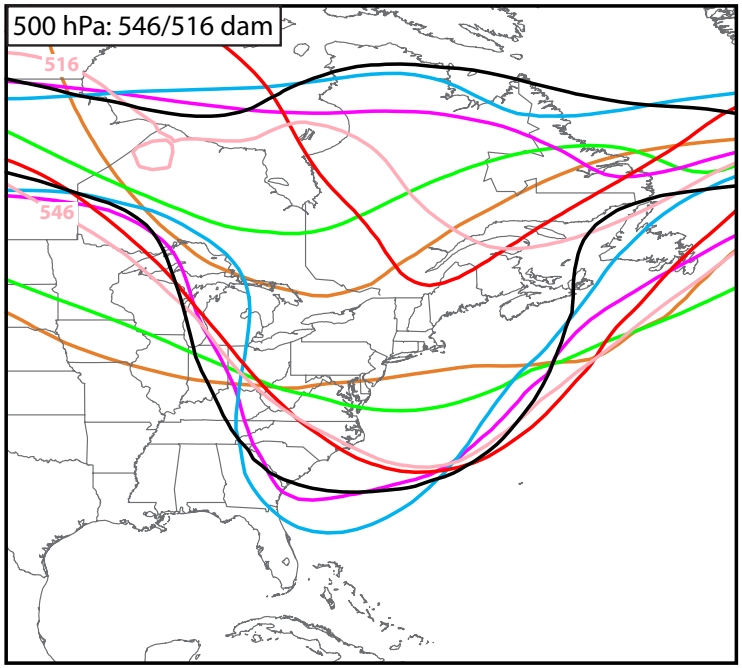


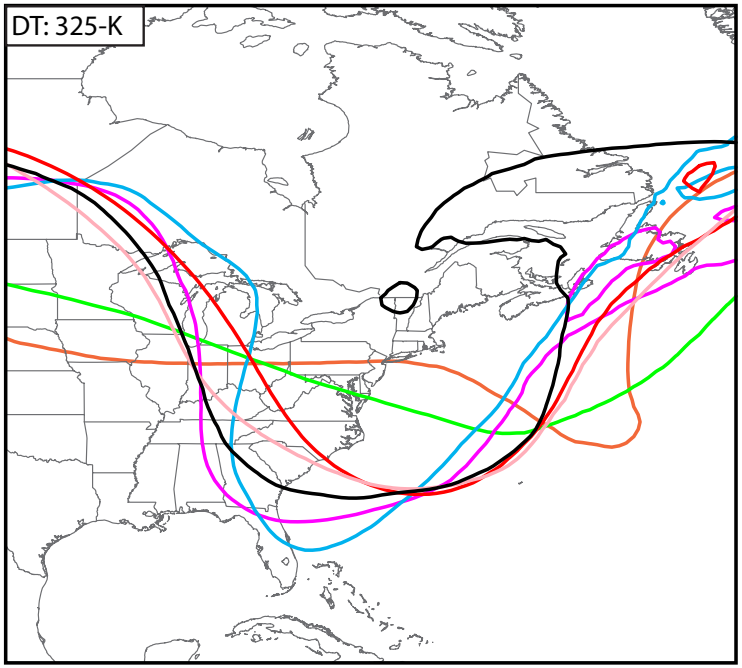


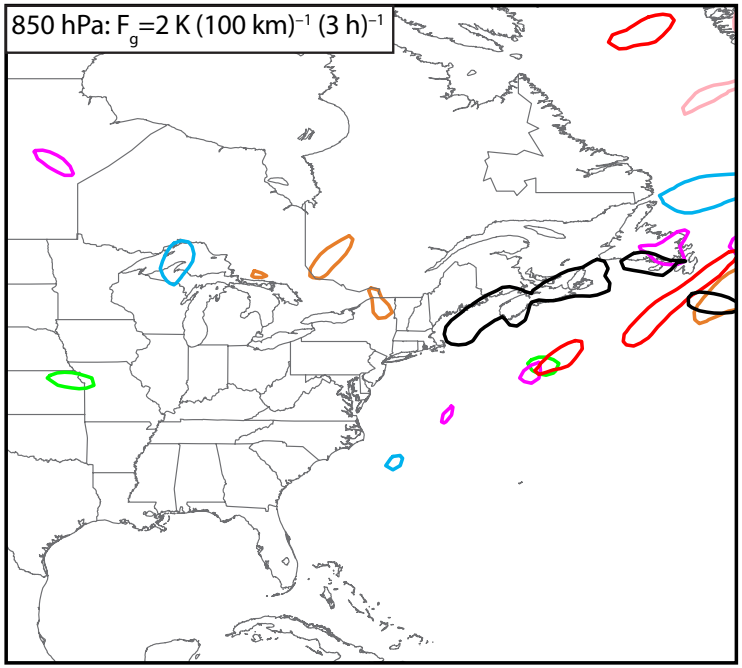
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015

240-h
222-h
192-h
168-h
144-h
120-h
00-h

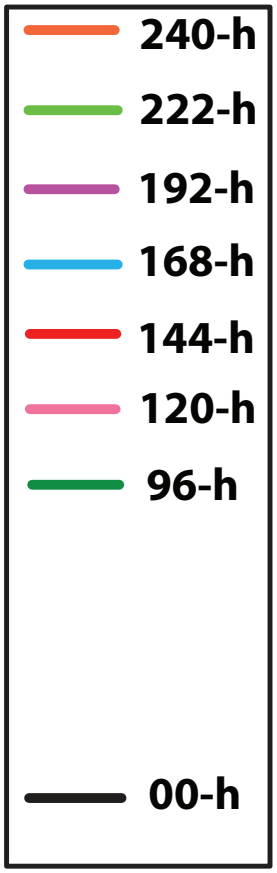


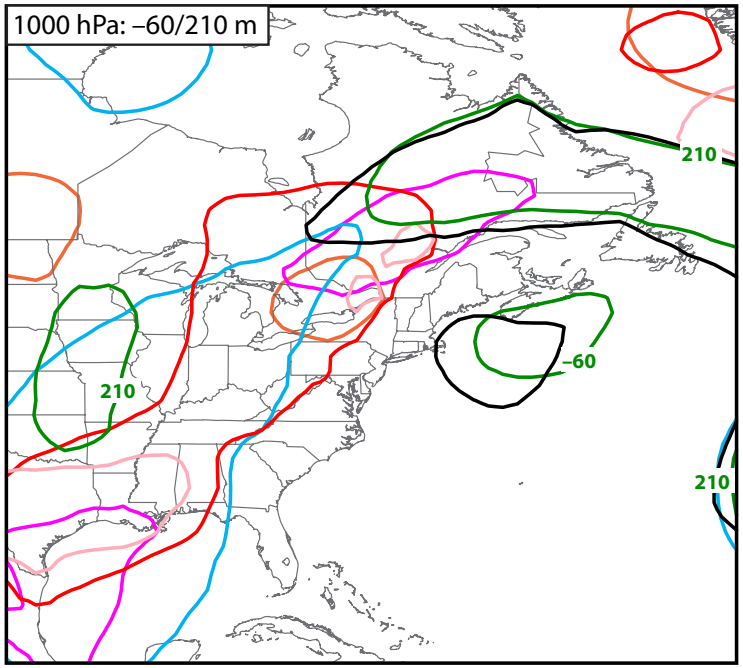


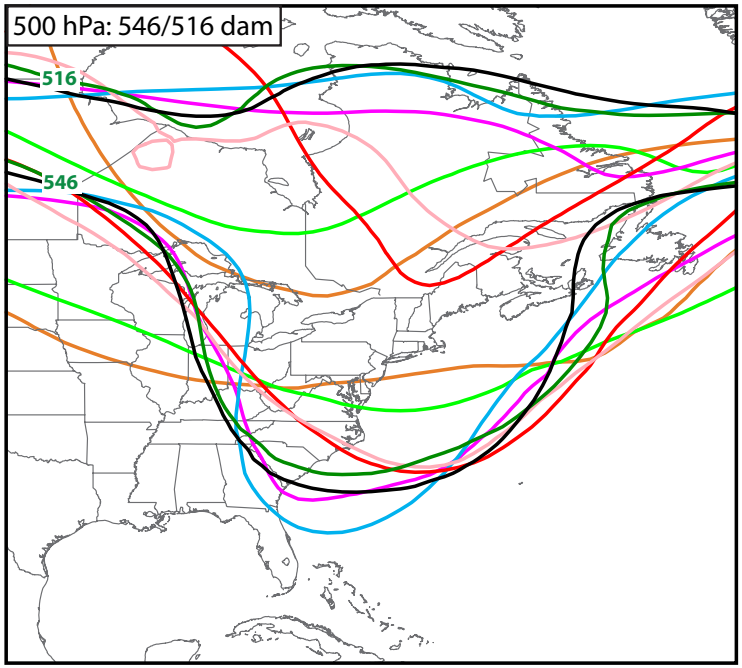


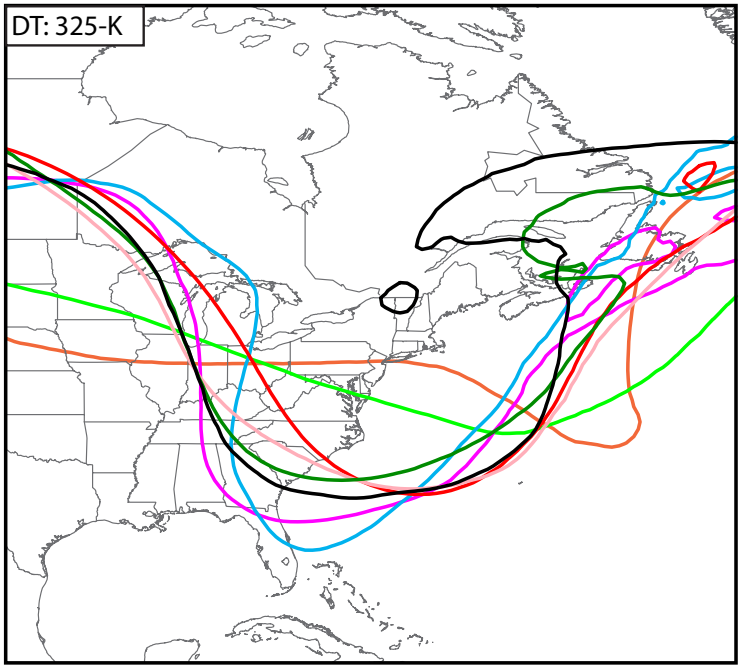


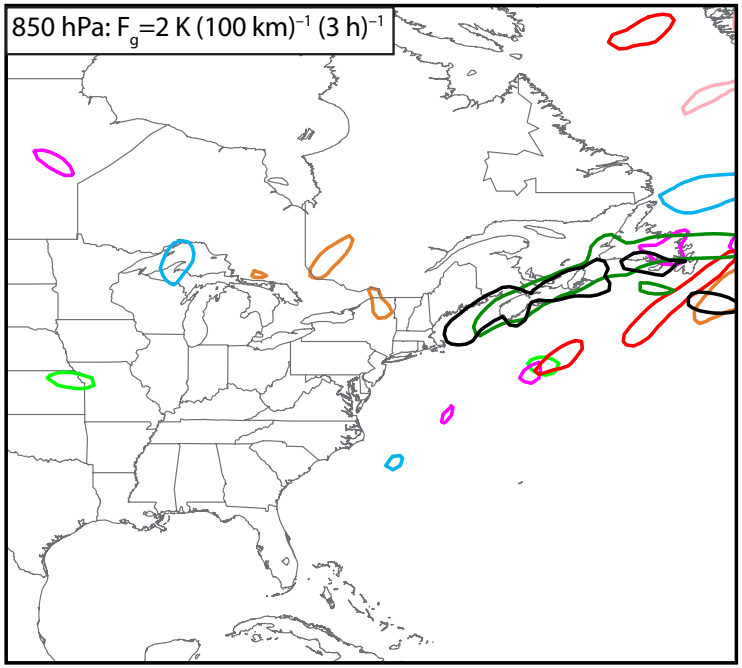
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015



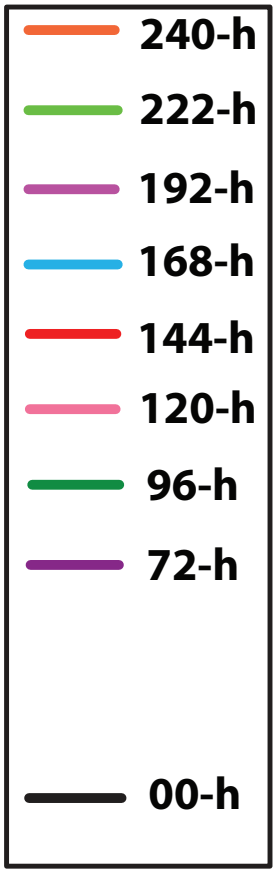


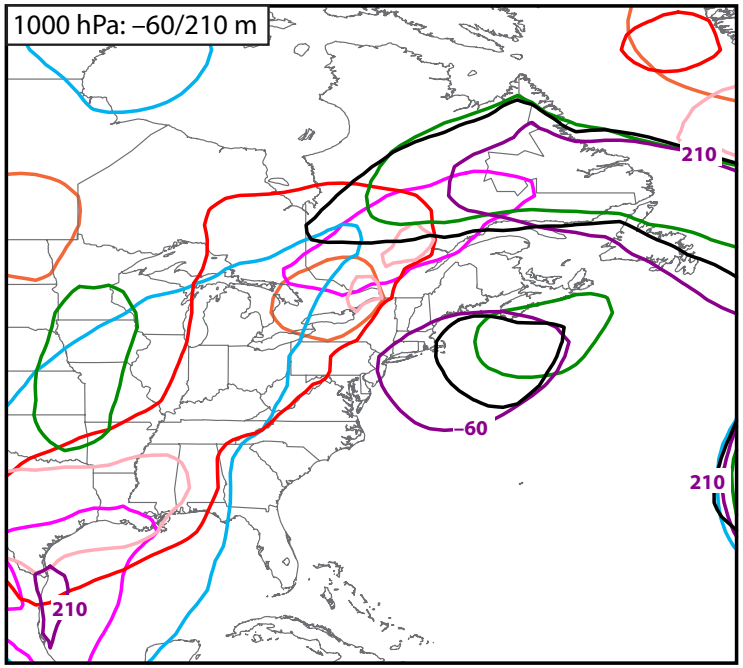


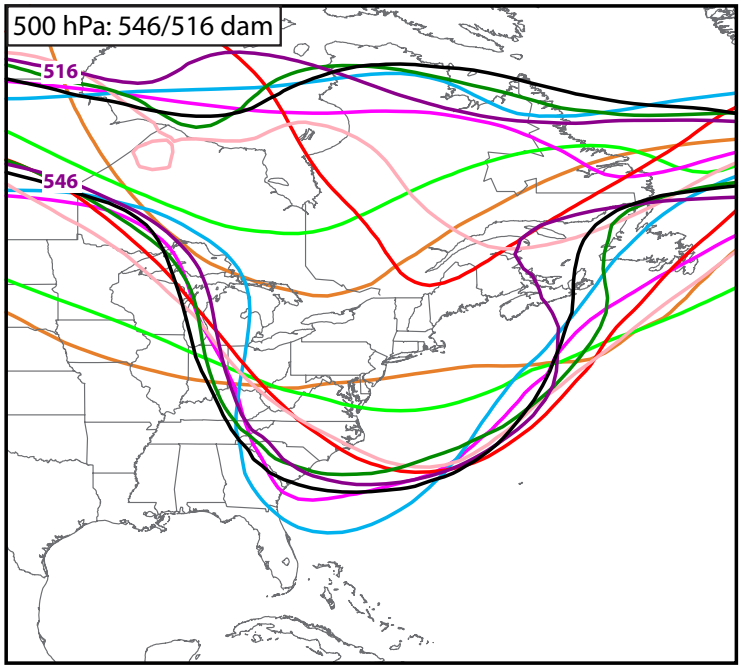


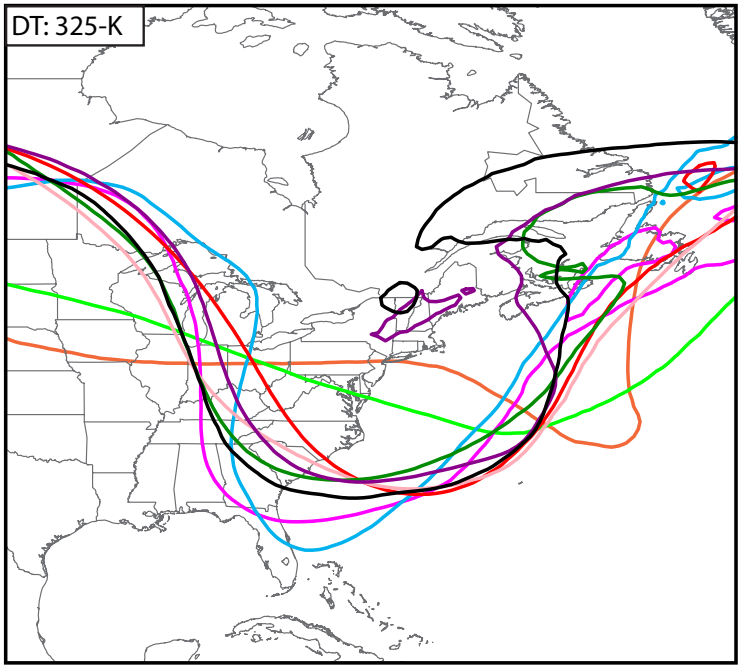


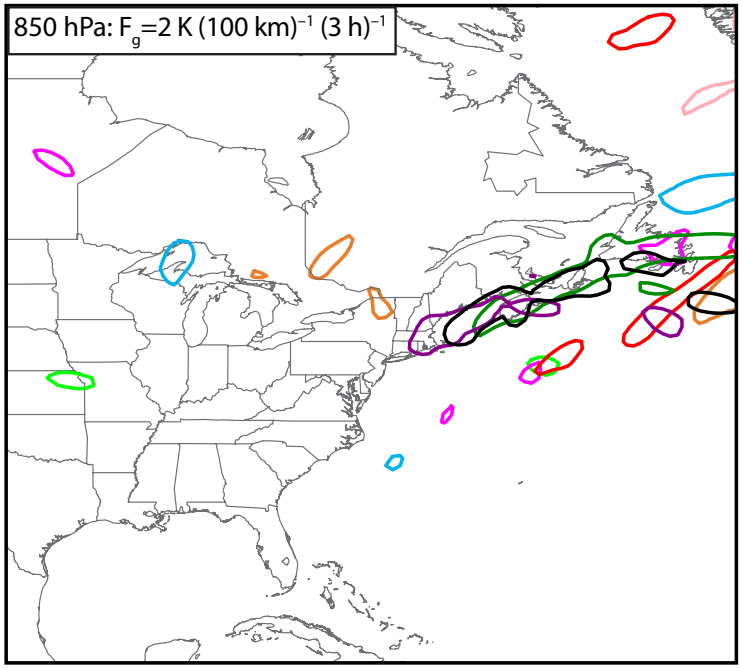
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015



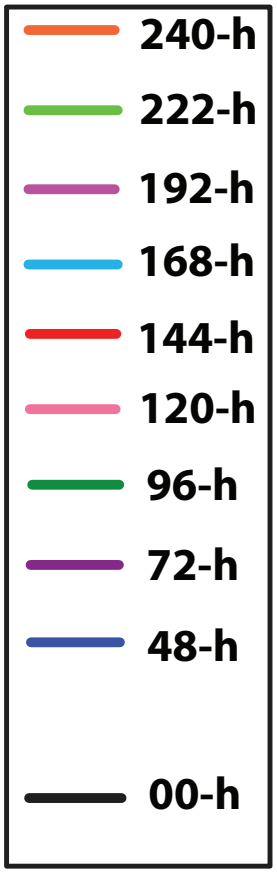


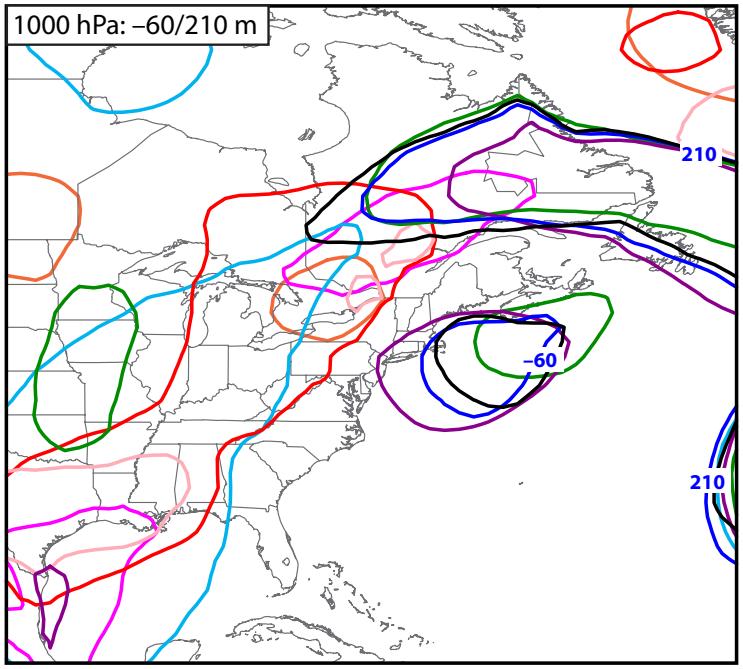


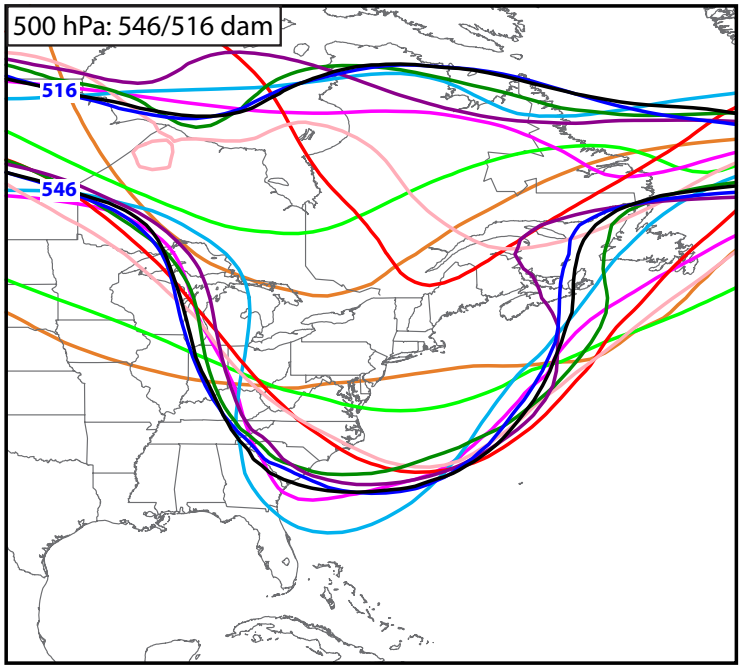


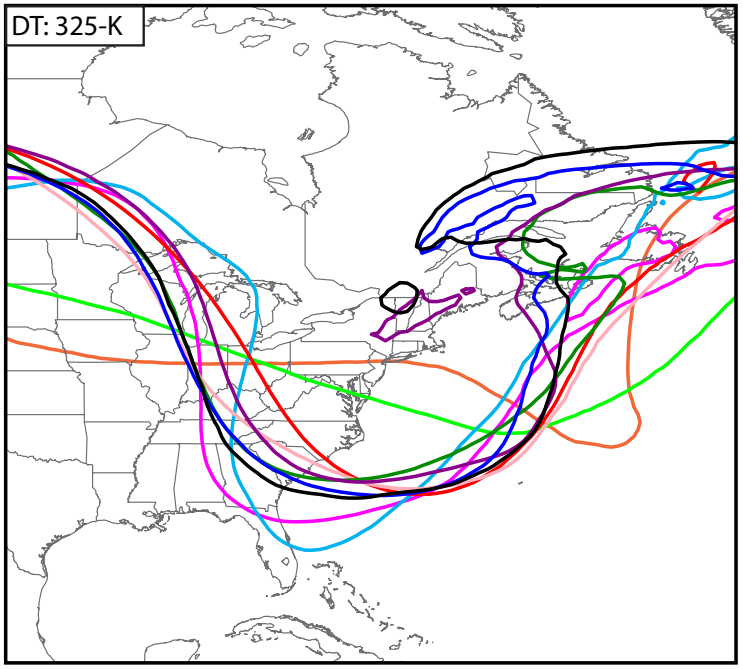


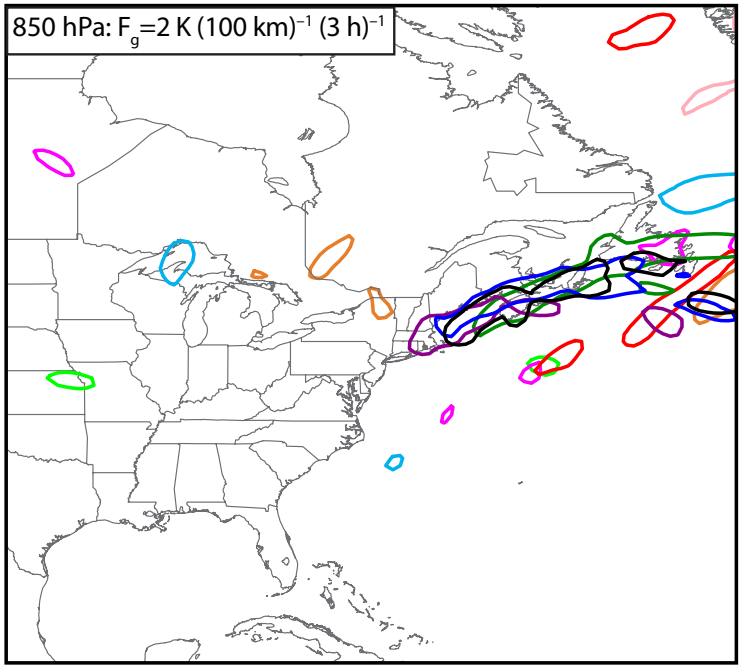
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015



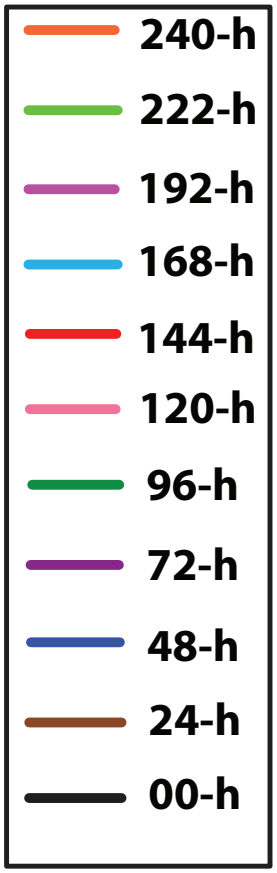


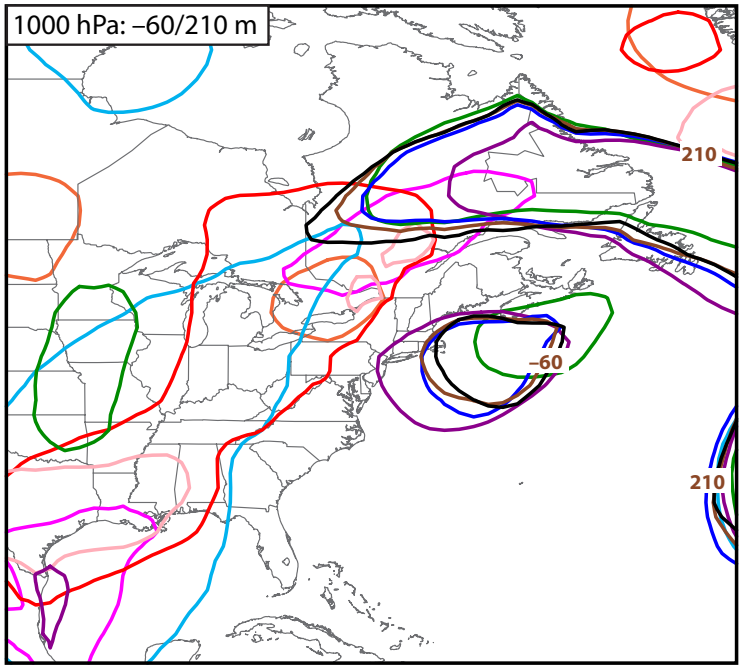


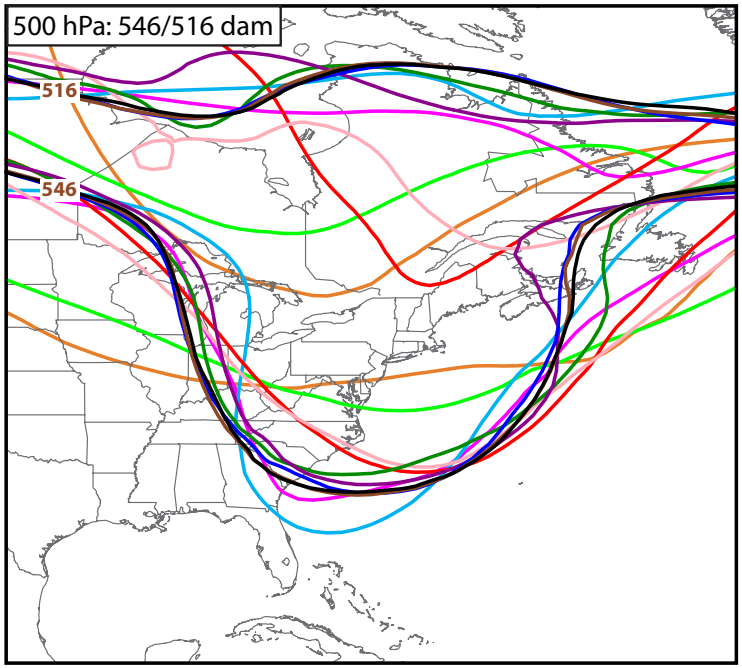


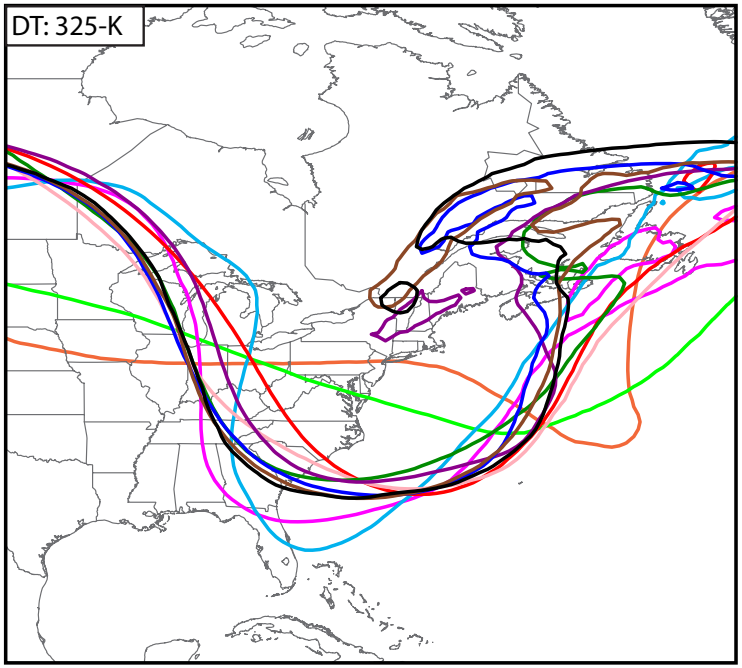


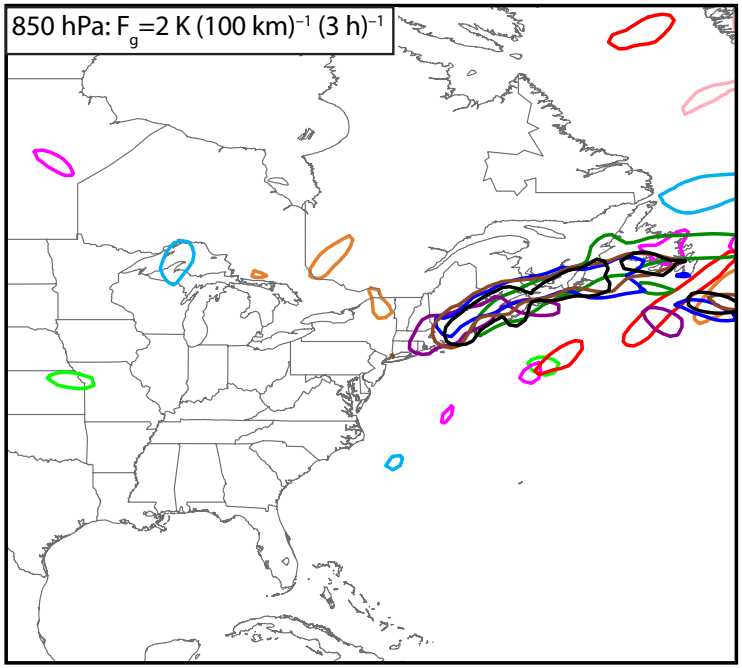
GFS Deterministic Forecasts Verifying 1800 UTC 27 January 2015





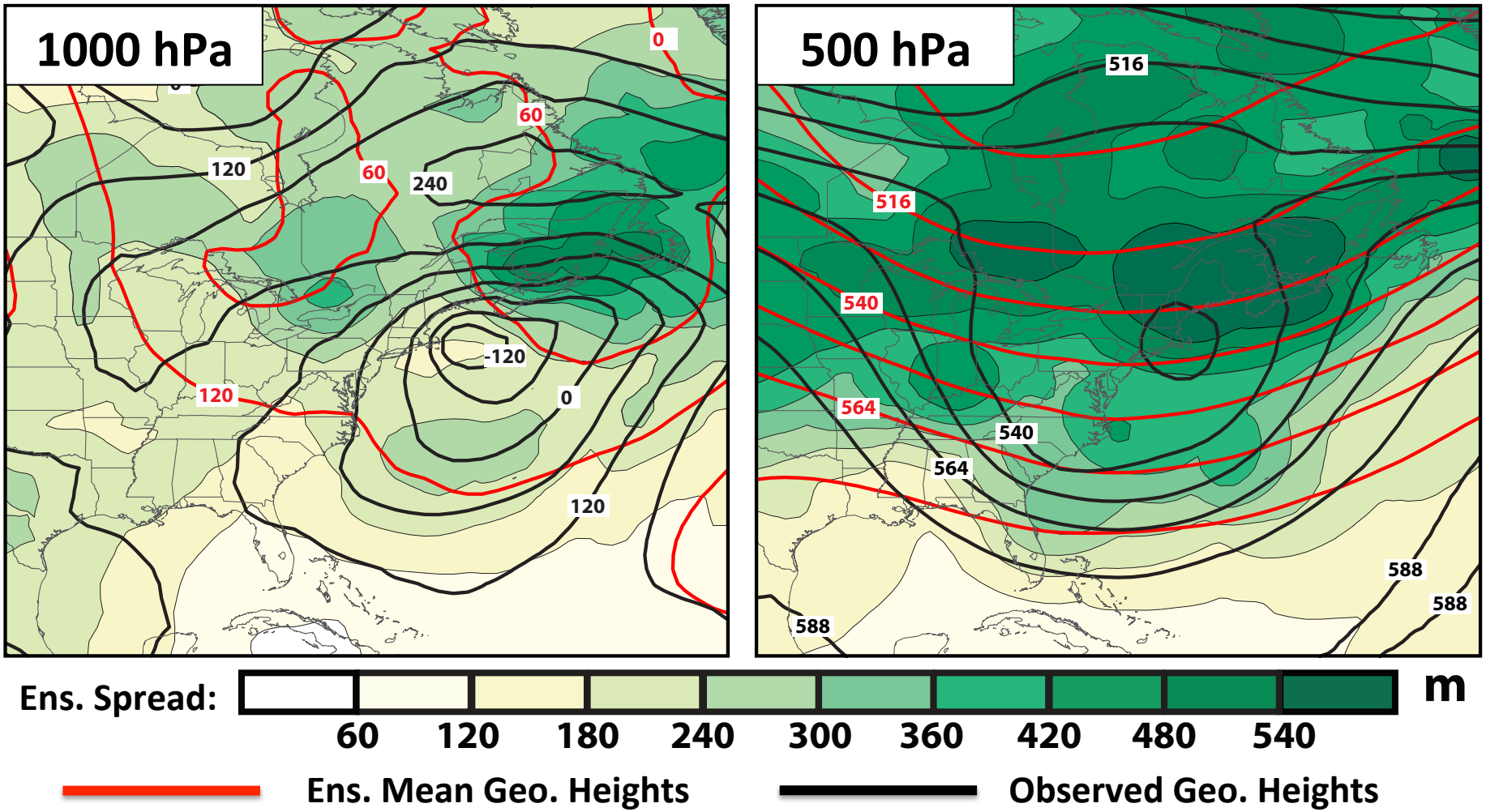






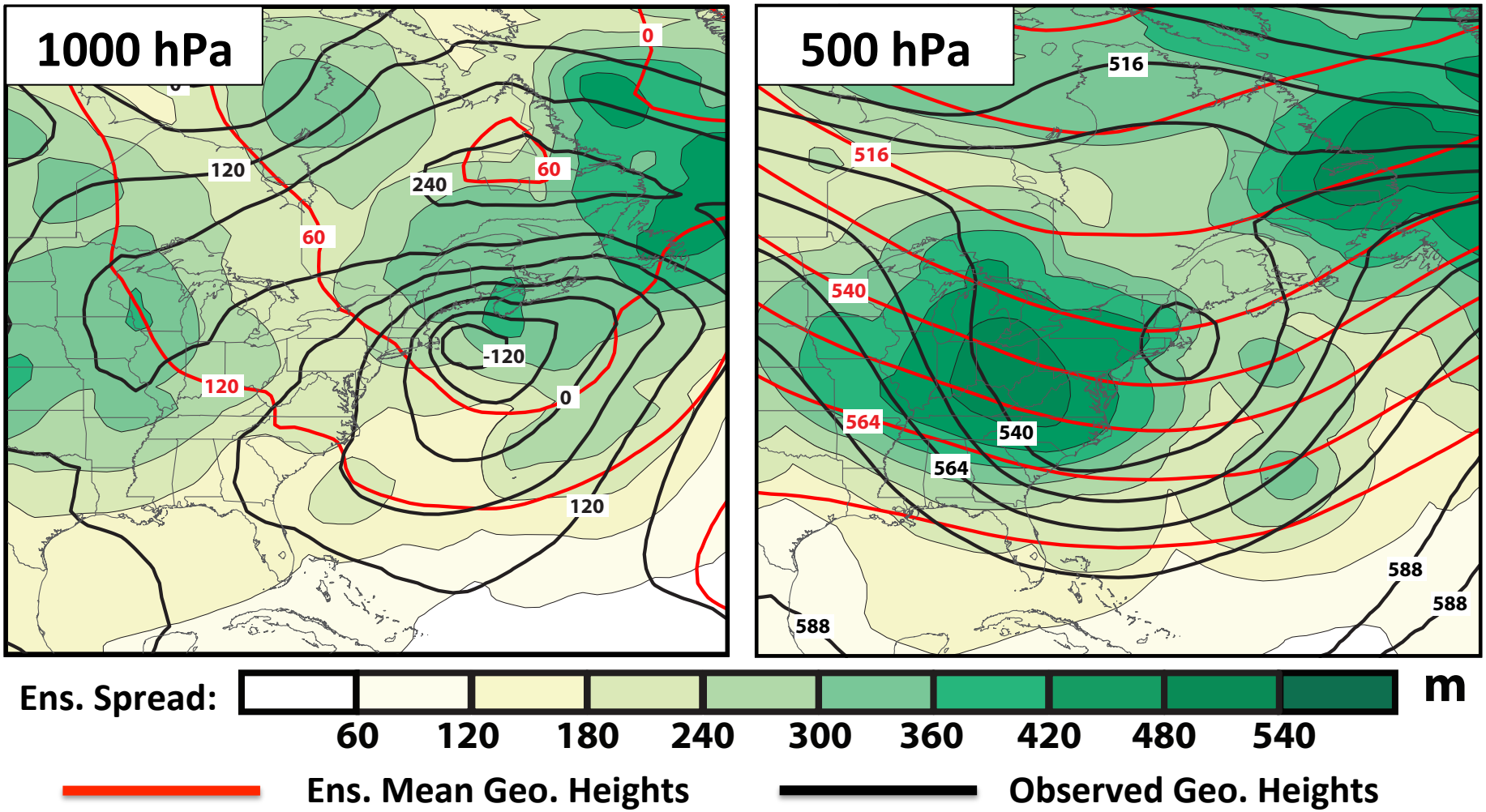
GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

240-h Forecast



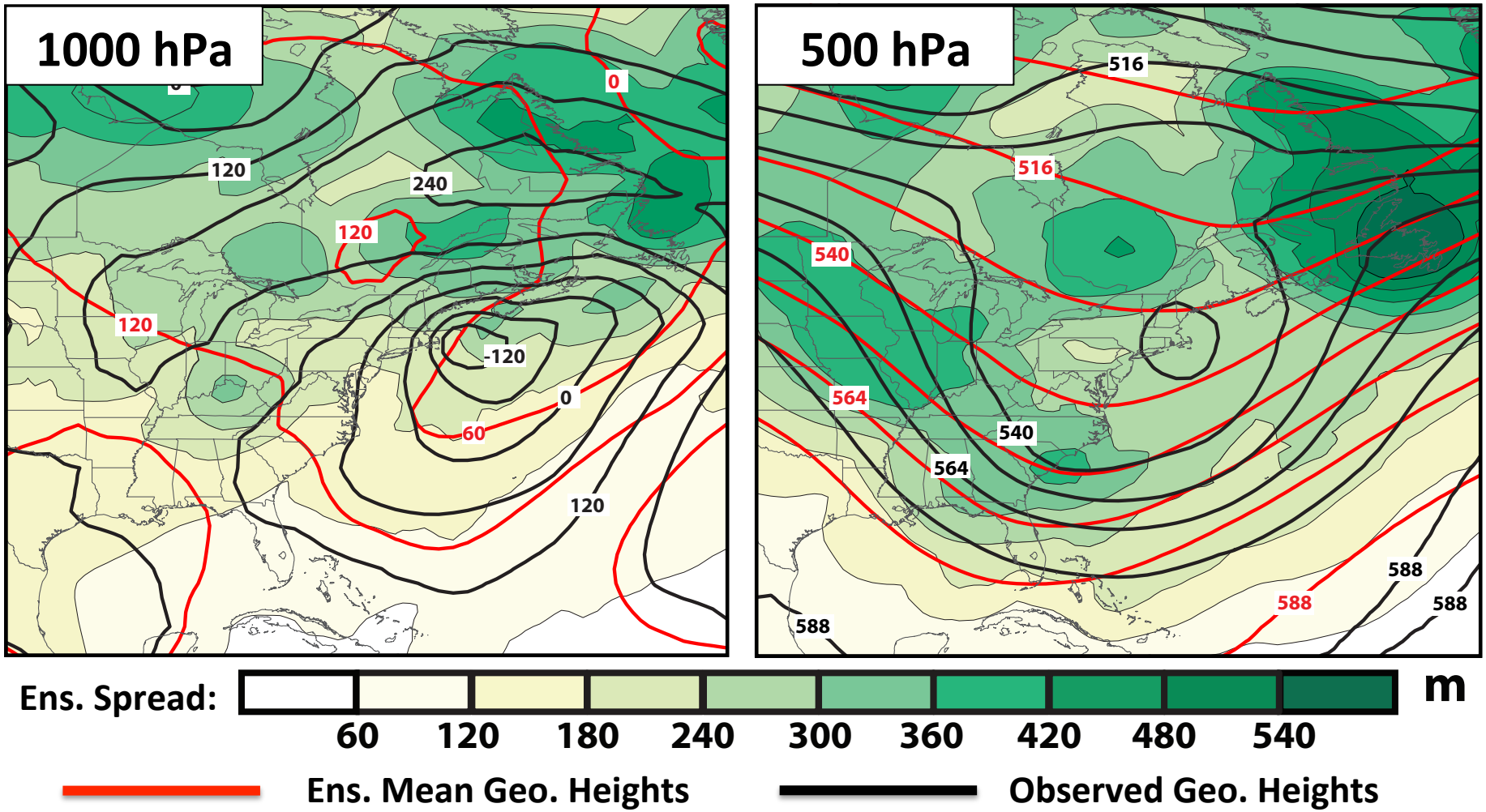
GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

222-h Forecast



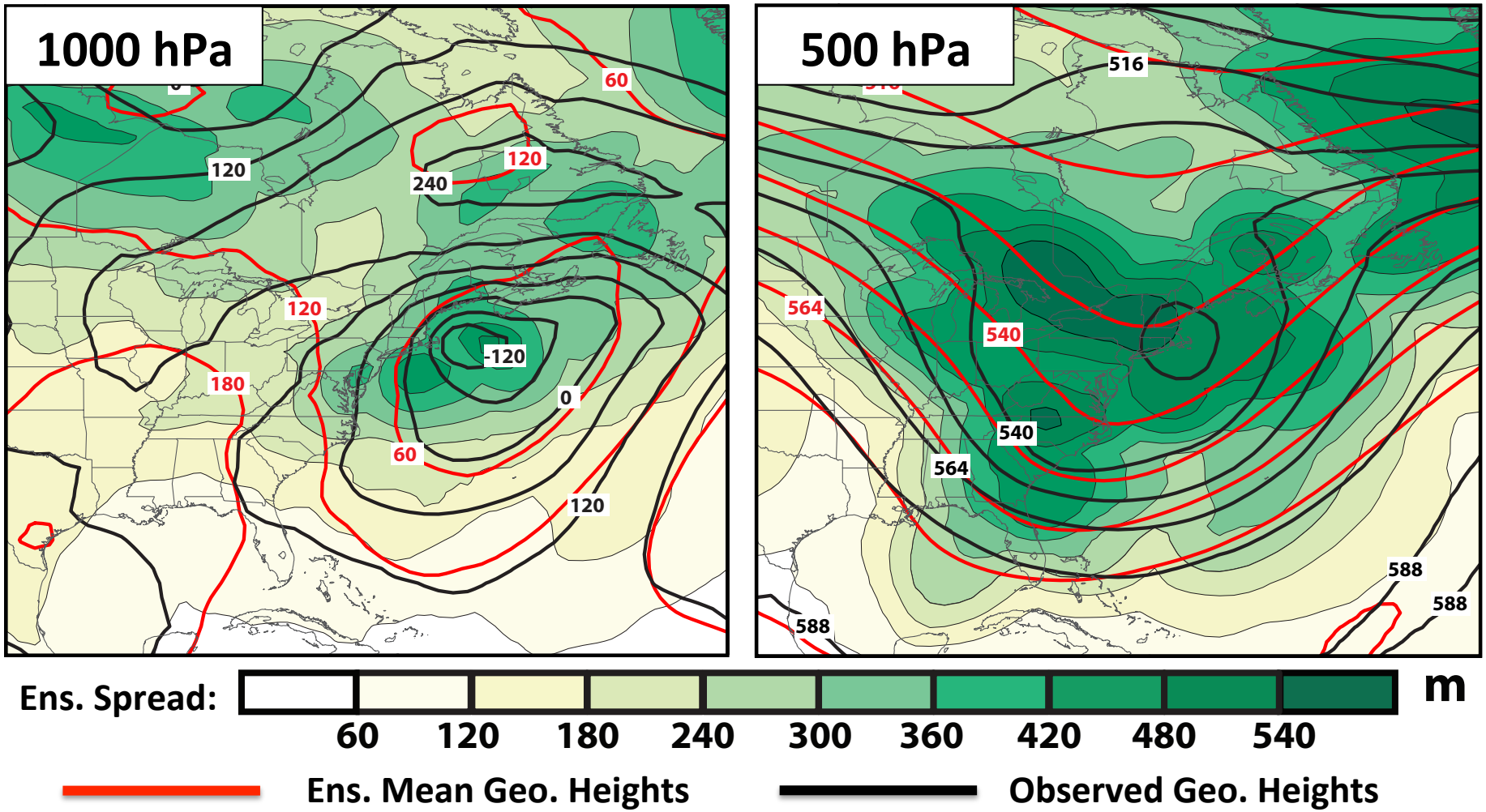
GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

192-h Forecast



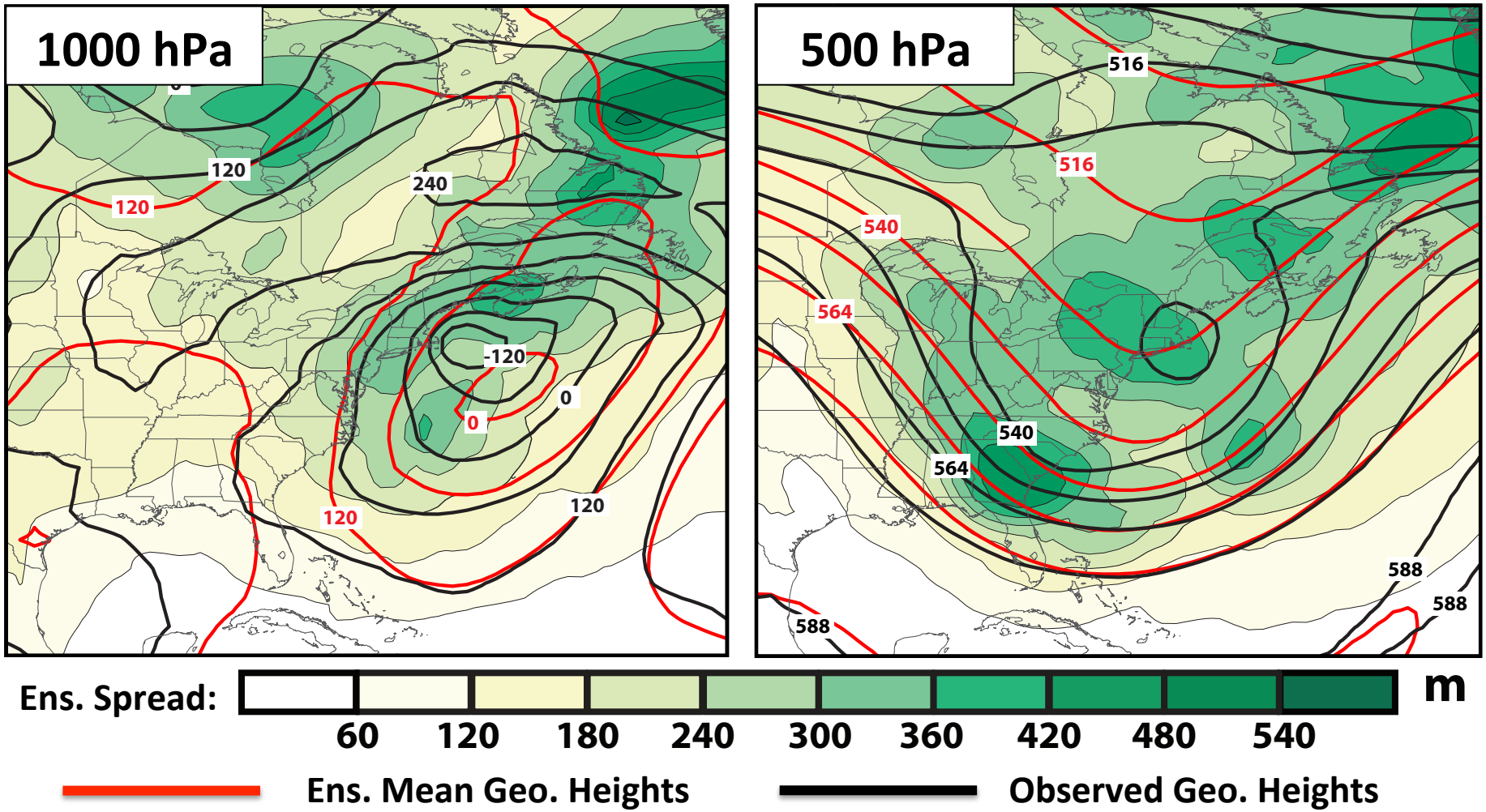
GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

168-h Forecast



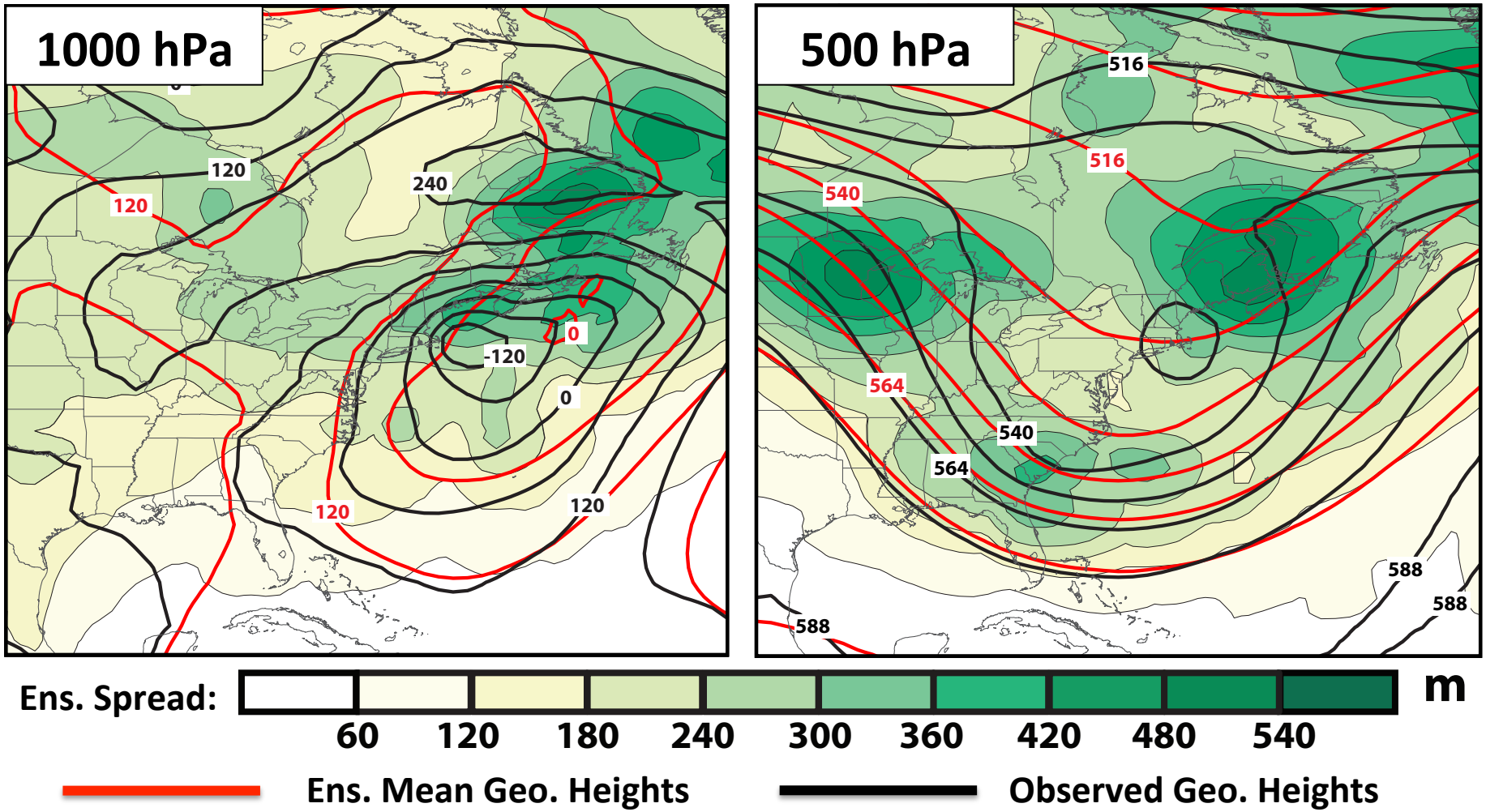
GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

144-h Forecast



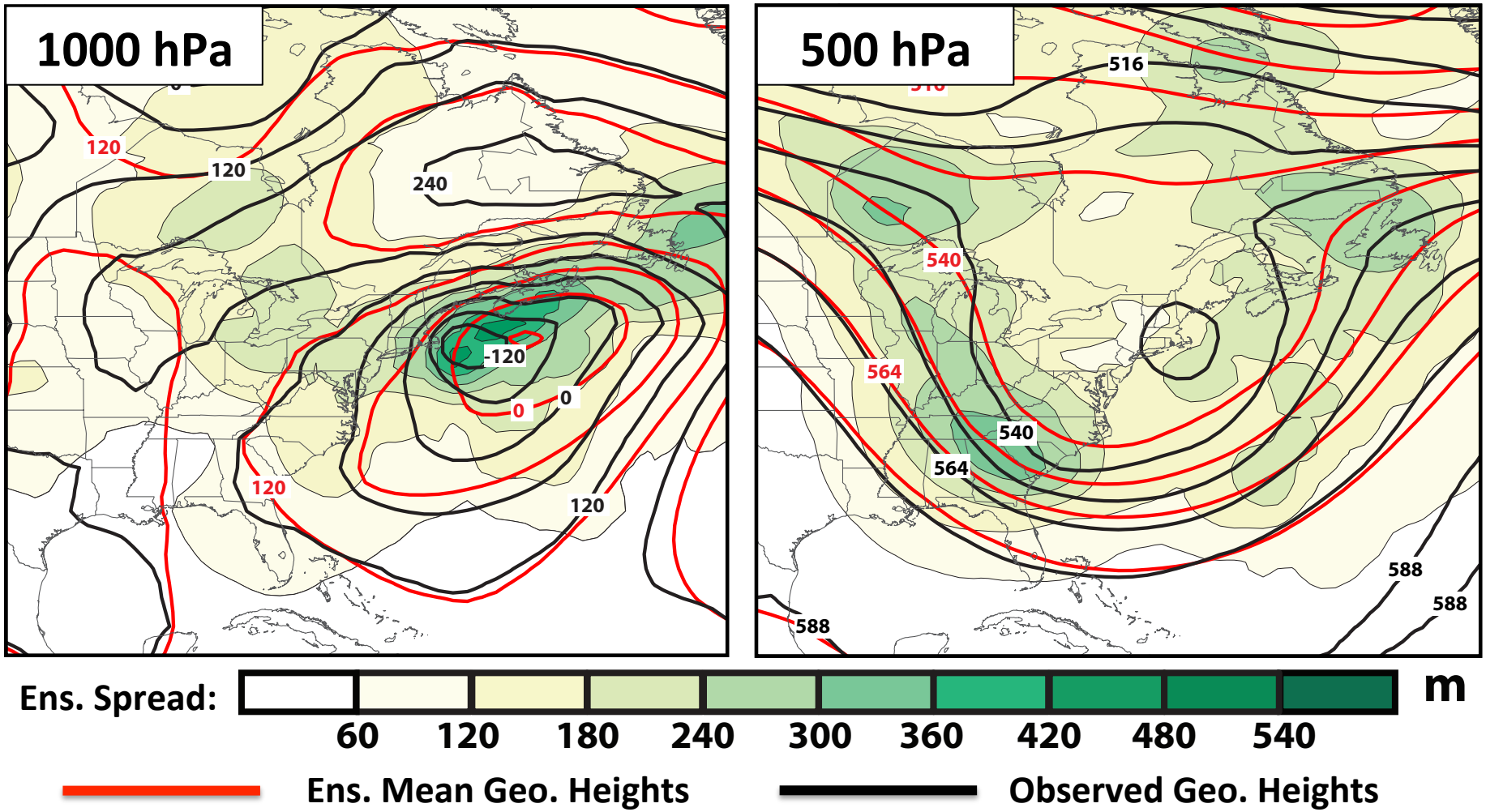
GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

120-h Forecast



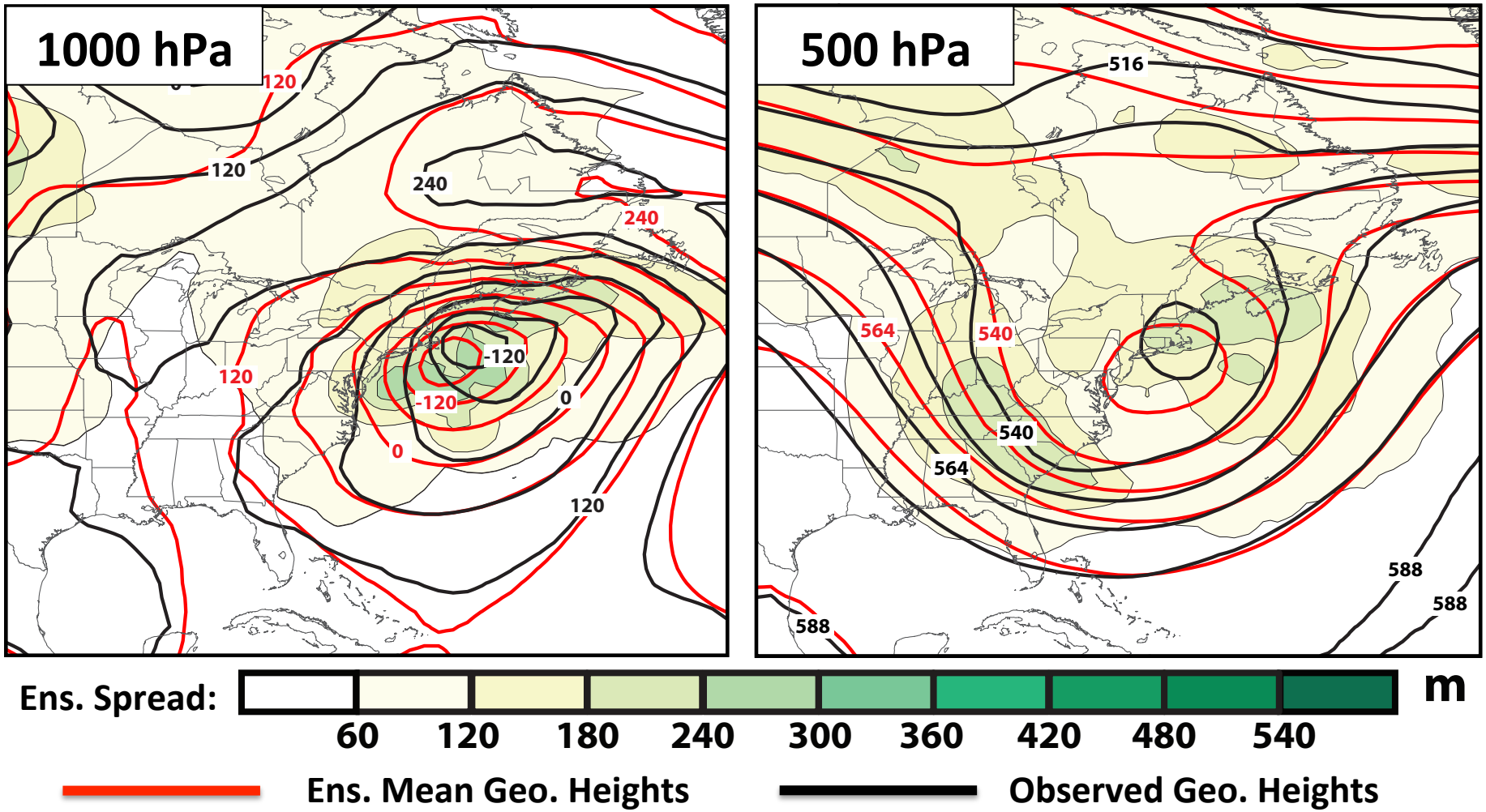
GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

96-h Forecast



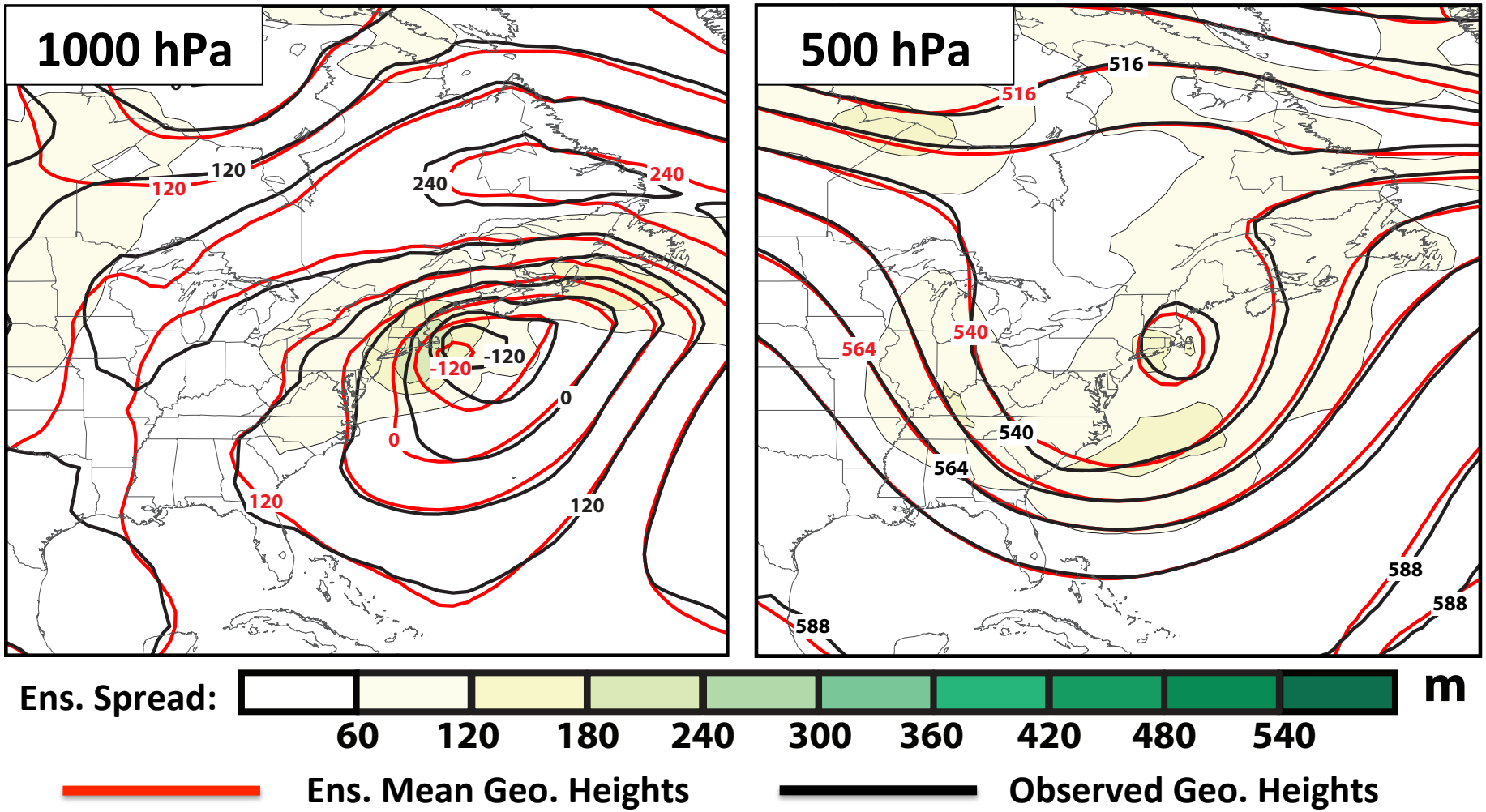
GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

72-h Forecast



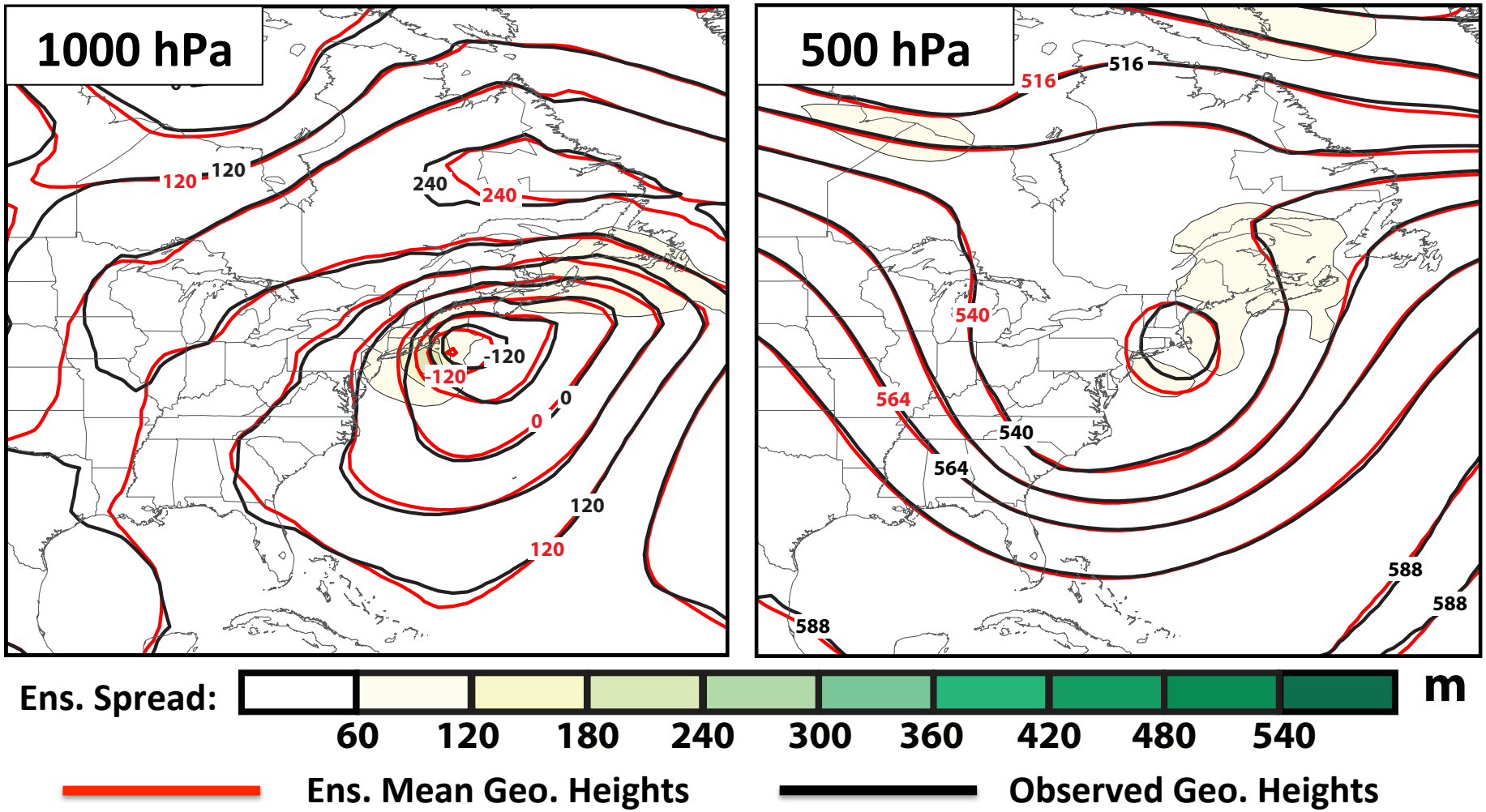
GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

48-h Forecast



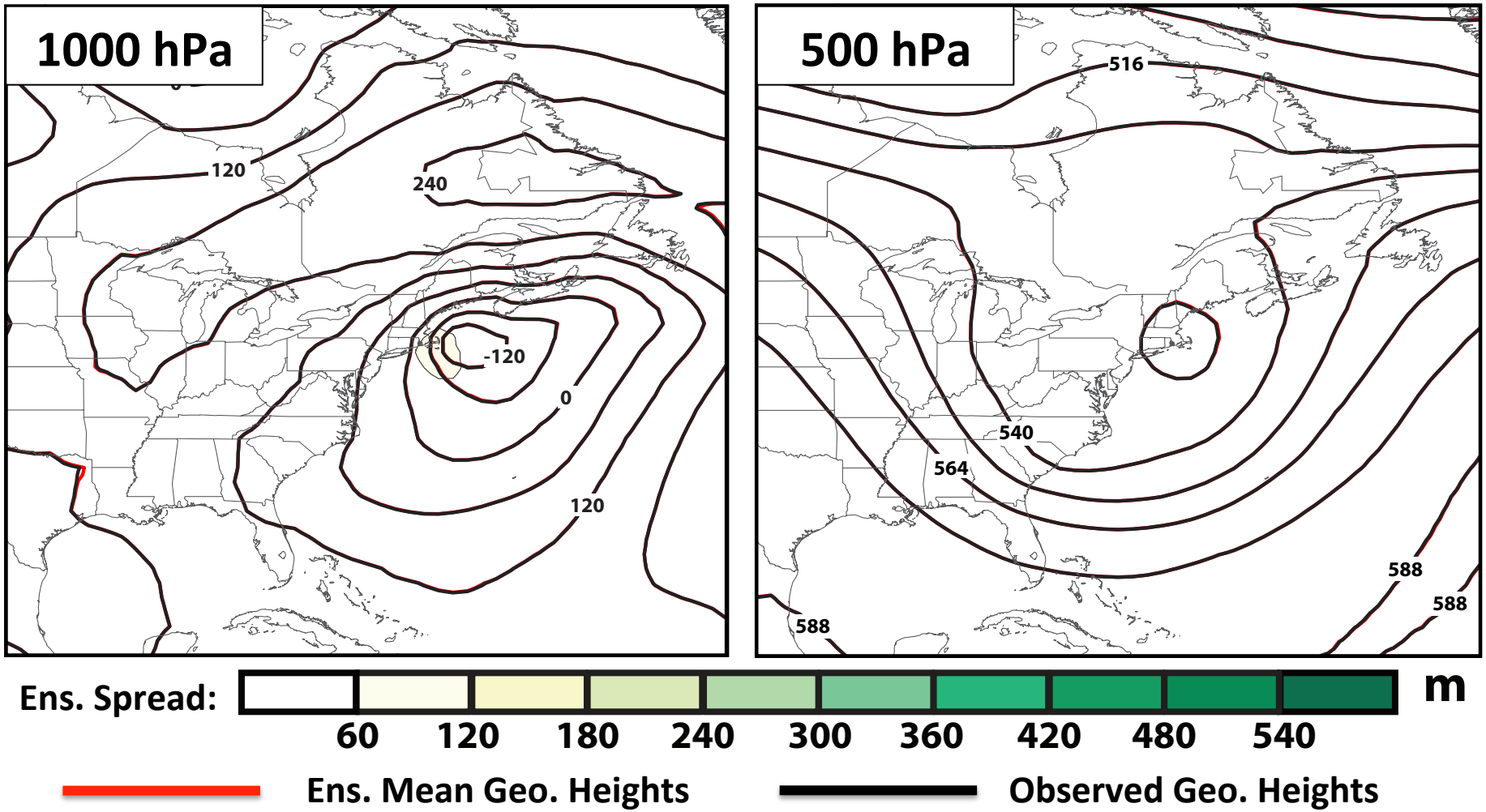
GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

24-h Forecast

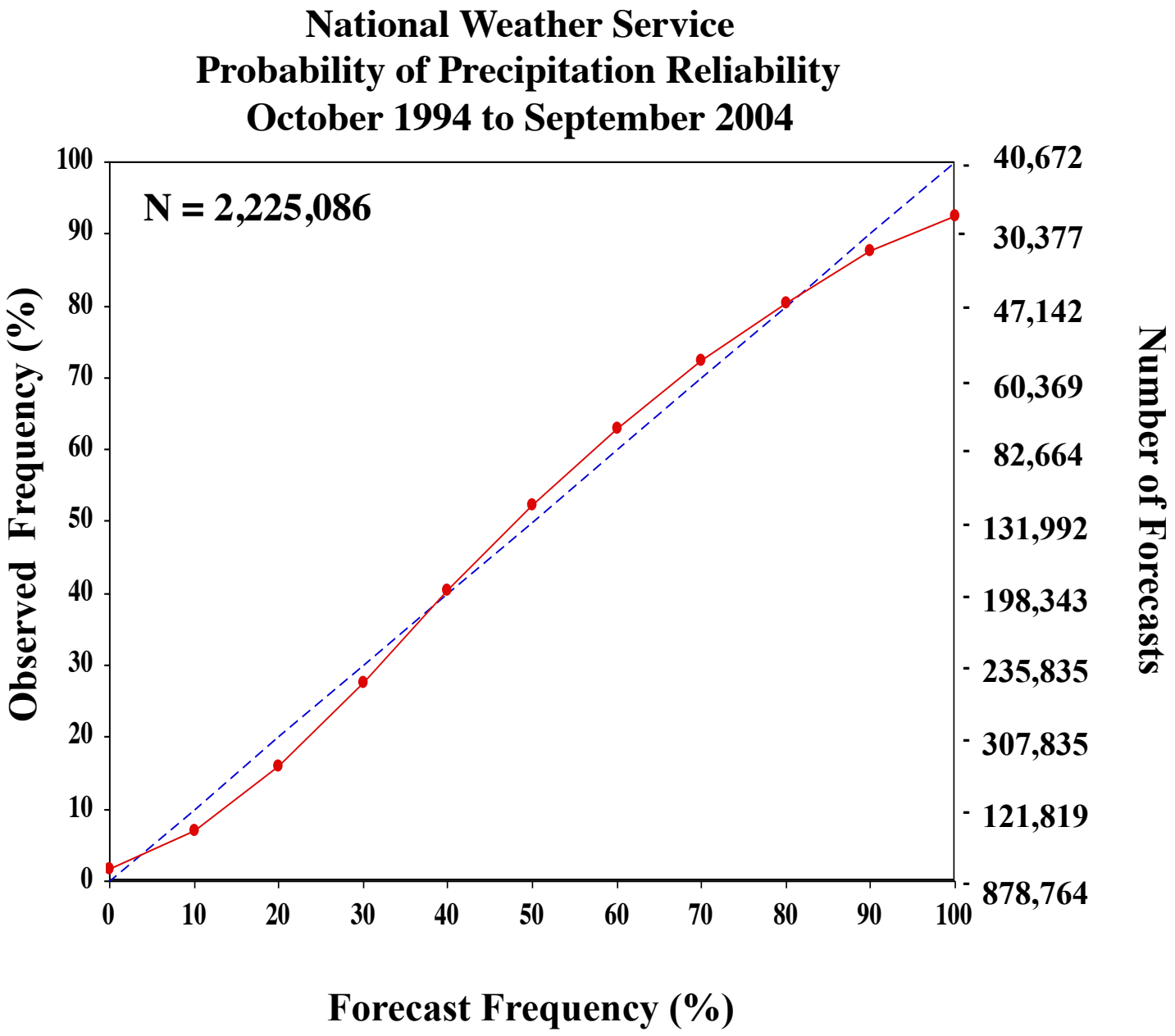


GEFS Ensemble Spread of Geo. Heights (m)
Verifying 1800 UTC 27 January 2015

00-h Forecast



Will Probabilistic Forecasting Go Viral Anytime Soon?


National Weather Service
Probability of Precipitation Reliability
October 1994 to September 2004
N = 2,225,086
Observed Frequency (%)
Forecast Frequency (%)
Number of Forecasts
0
10
20
30
40
50
60
70
80
90
100
40,672
30,377
47,142
60,369
82,664
131,992
198,343
235,835
307,835
121,819
878,764

So, Why Does Dr. Strangelove's Deterministic Right Arm Keep Going Up?

- There are good reasons….

- Deciders want cover for unpopular decisions
- Cost-loss ratio thinking is not a household term
- Emergency managers make yes-no decisions
- Elected officials are very risk averse
- Probabilistic thinking remains an educational challenge

Probabilistic Outreach

- A transition towards probabilistic forecasting will require a hard-nosed assessment of the challenges of operating in a deterministic world
- Push ahead slowly but steadily:
  - Start with confidence levels (low, medium, and high)
  - Make graphical probabilistic forecasts widely available on web sites
  - Show simple plume graphs (rain amount, temperature) in the media
  - Focus initially on longer lead (beyond 72 hours) forecasts
  - Education, education, education!
  - Communicate better and make common cause with social scientists
  - And (tongue planted firmly in cheek) start a weather lottery
- Hewson: "The impact of suddenly admitting that we don't really know what is going to happen tomorrow, having been telling people for years how accurate our forecasts are, should not be underestimated!!!"

Science and Forecast Implications

- **Extreme weather events (EWEs) during a single season can contribute disproportionately to temperature and precipitation anomaly statistics for a given month or season**

- **EWEs need to be considered in documenting and understanding the dynamical and thermodynamical processes that operate at the weather-climate intersection**

- **The skill of operational probabilistic temperature and precipitation forecasts during the week two (8–14 day) period will likely be very sensitive to "weather or knot" EWEs occur**

Conclusions

- **PV disturbances of North Pacific and Siberian origin interacted to trigger the coastal Northeast snowstorm of 27–28 January 2015**

- **Antecedent disturbances played a critical role in re-establishing baroclinicity just prior to the 27–28 January 2015 storm**

- **Snow amount and location predictability was relatively low until 72–96 h before the heaviest snow fell.**