Large-Scale Antecedent Conditions Associated with 2014–2015 Winter Onset over North America and their Impact on Predictability

Lance F. Bosart, Alicia M. Bentley, Philippe P. Papin, Benjamin J. Moore, and Andrew C. Winters

Department of Atmospheric and Environmental Sciences
University at Albany/State University of New York at Albany, Albany, NY 12222

American Meteorological Society Meeting
28th Conference on Climate Variability and Change
New Orleans, Louisiana 70130
Tuesday 12 January 2016

Support Provided by NSF Grant AGS-1355960

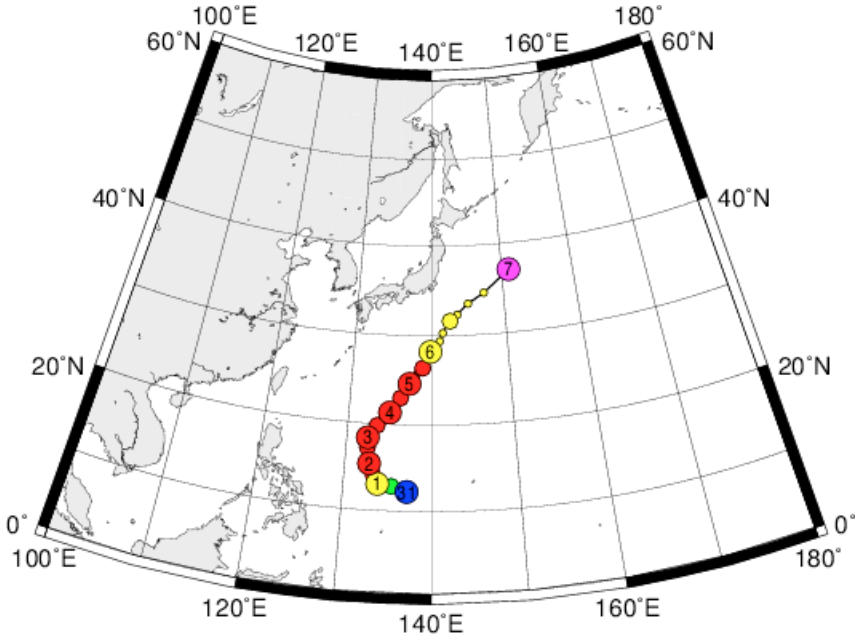
Motivation

- **Winter 2014–2015: Part I featured unexpected record CONUS November cold and early season snow. Many November 2014 minimum temperature and snowfall records were broken**

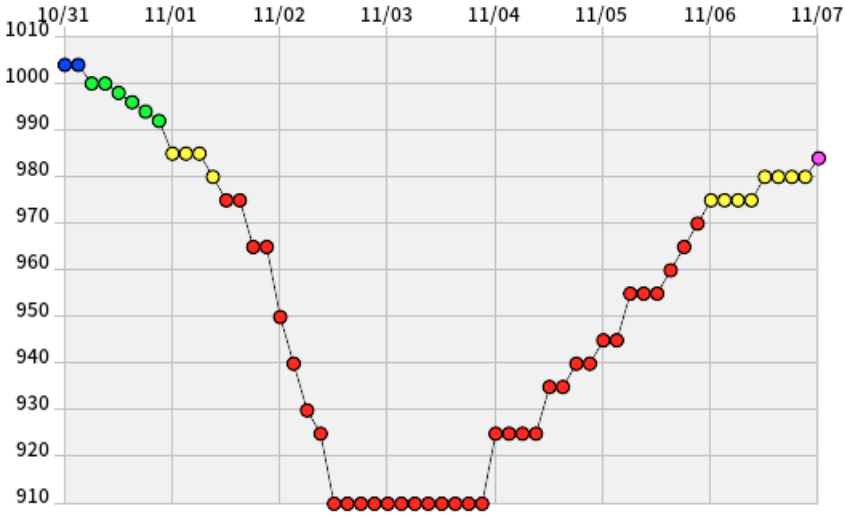
- **The ET/EC of STY Nuri ET/EC disrupted the NH flow, caused omega block formation downstream, opened the CONUS arctic air floodgates, and wrecked the CPC November temperature forecast**

Super Typhoon Nuri: 31 Oct – 7 Nov 2014

JMA: Best Track

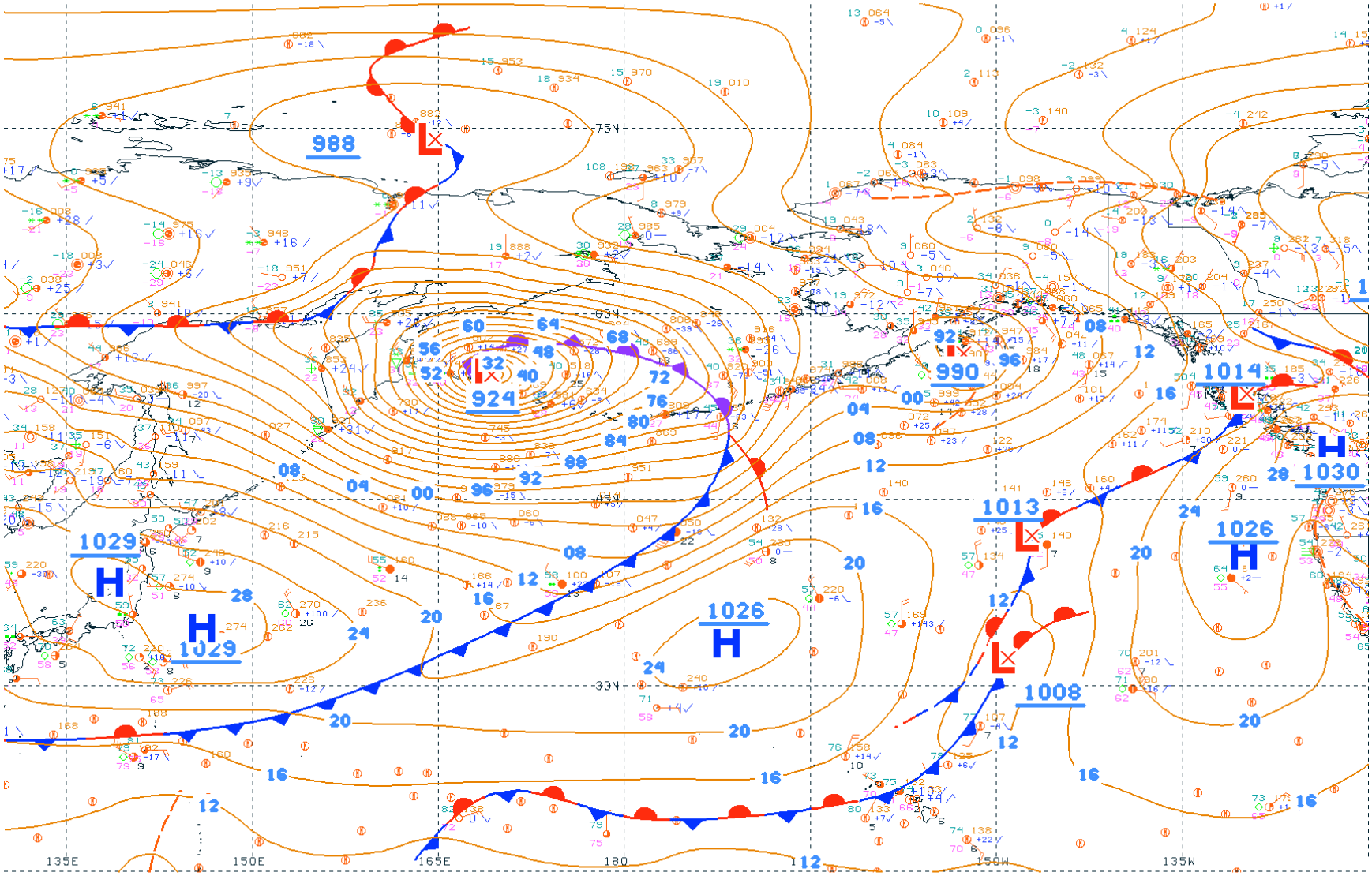


JMA: Minimum SLP (hPa)



Digital Typhoon (http://agora.ex.nii.ac.jp/digital-typhoon/index.html.en)

NCEP-OPC Surface Analysis: 0600 UTC 8 November 2014



Outline

- Supertyphoon Nuri (2014) induced NH circulation changes
- High-latitude Omega block formation
- Multiple arctic air surges into the CONUS
- Predictability issues

Data and Methodology

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

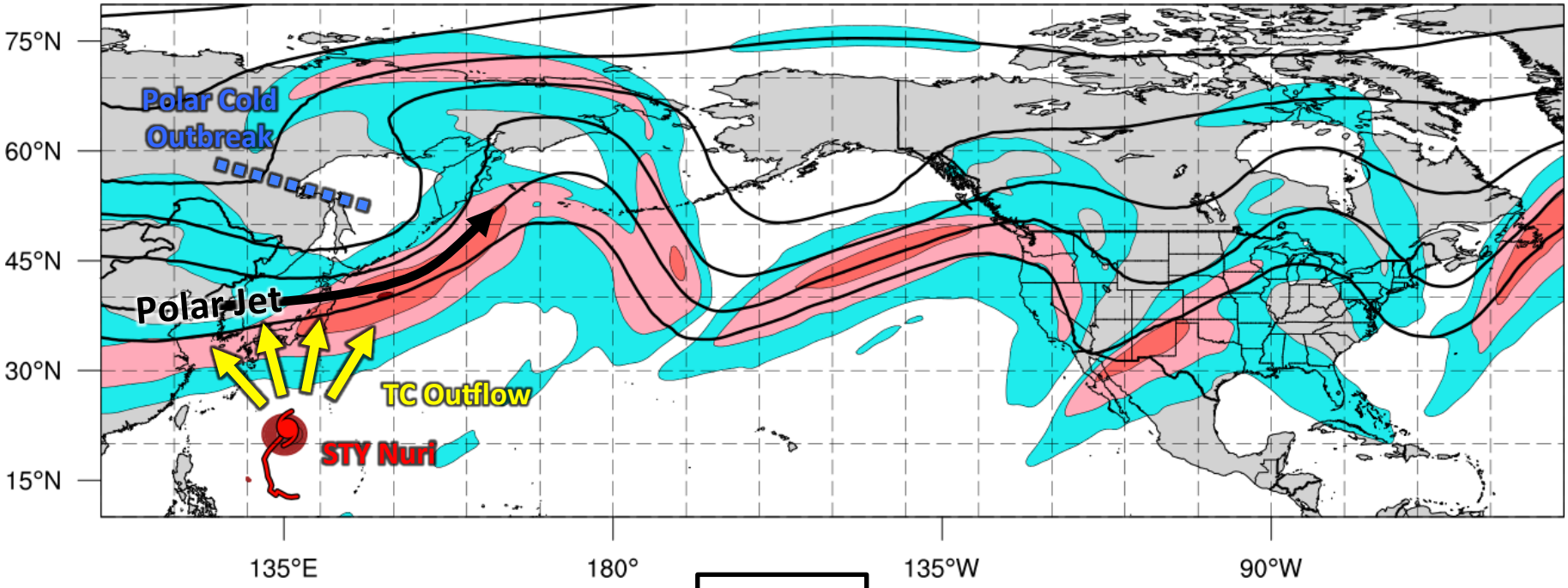
Science Question:

How can a reconfiguration of the downstream NH flow induced by a recurving Western Pacific STY trigger CONUS extreme weather events (EWEs)?

A Schematic Perspective on STY Nuri-Induced North Pacific Flow Evolution

Schematic – Synoptic Evolution November 2014

0000 UTC 4 November 2014

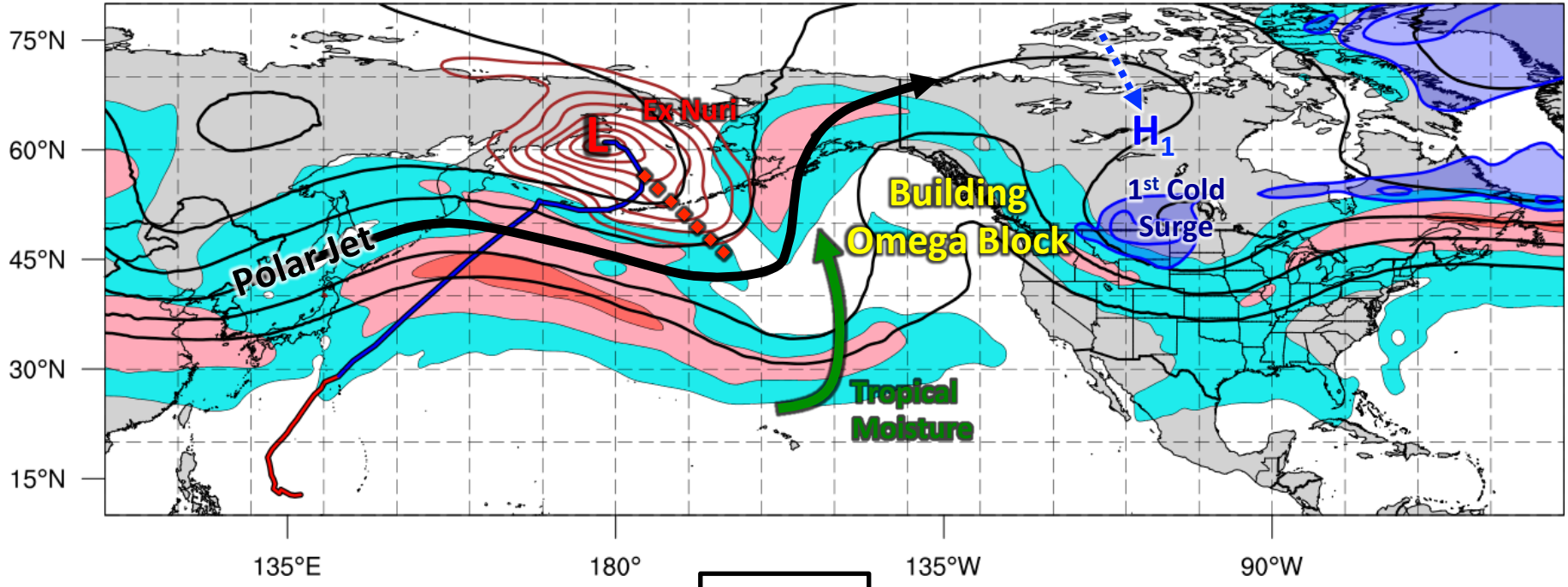


Legend

- L — Extratropical low pressure center
- H_1 — High pressure center
- Sea level pressure < 1000-hPa
- Cold front
- Tropical Cyclone
- Arctic air
- 200-hPa geopotential heights
- 200-hPa Isotachs: 30 50 70 90 [m s^{-1}]

Schematic – Synoptic Evolution November 2014

1200 UTC 11 November 2014

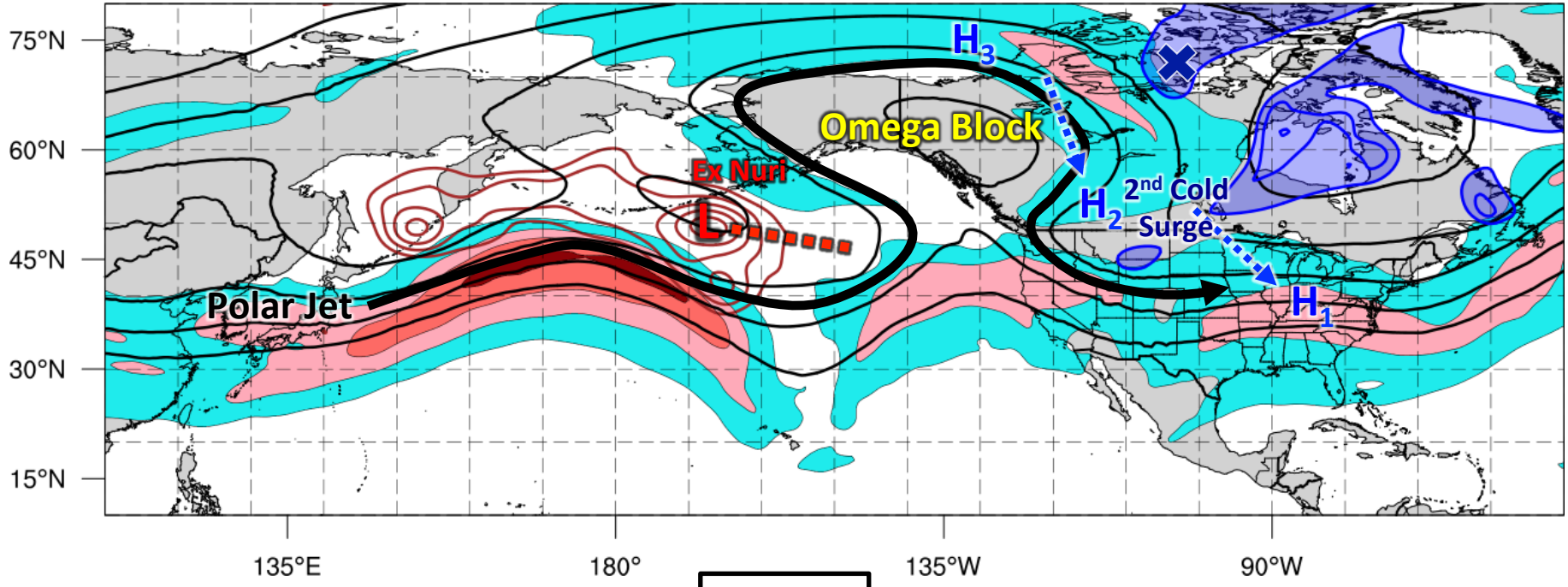


Legend

- L — Extratropical low pressure center
- H_1 — High pressure center
- Sea level pressure < 1000-hPa
- Cold front
- Tropical Cyclone
- Arctic air
- 200-hPa geopotential heights
- 200-hPa Isotachs: 30 50 70 90 [m s^{-1}]

Schematic – Synoptic Evolution November 2014

1200 UTC 15 November 2014

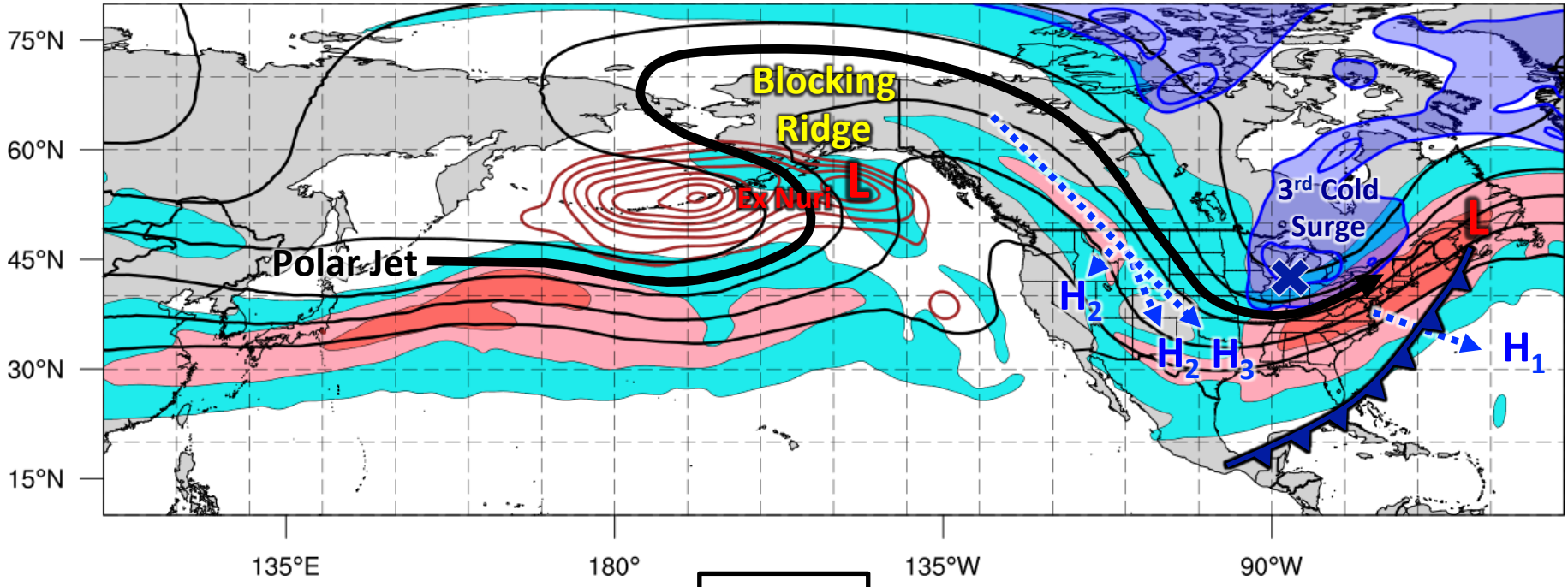


Legend

- L — Extratropical low pressure center
- H_1 — High pressure center
- Sea level pressure < 1000-hPa
- Cold front
- Tropical Cyclone
- Arctic air
- 200-hPa geopotential heights
- 200-hPa Isotachs (30, 50, 70, 90 [m s^{-1}])

Schematic – Synoptic Evolution November 2014

1200 UTC 18 November 2014

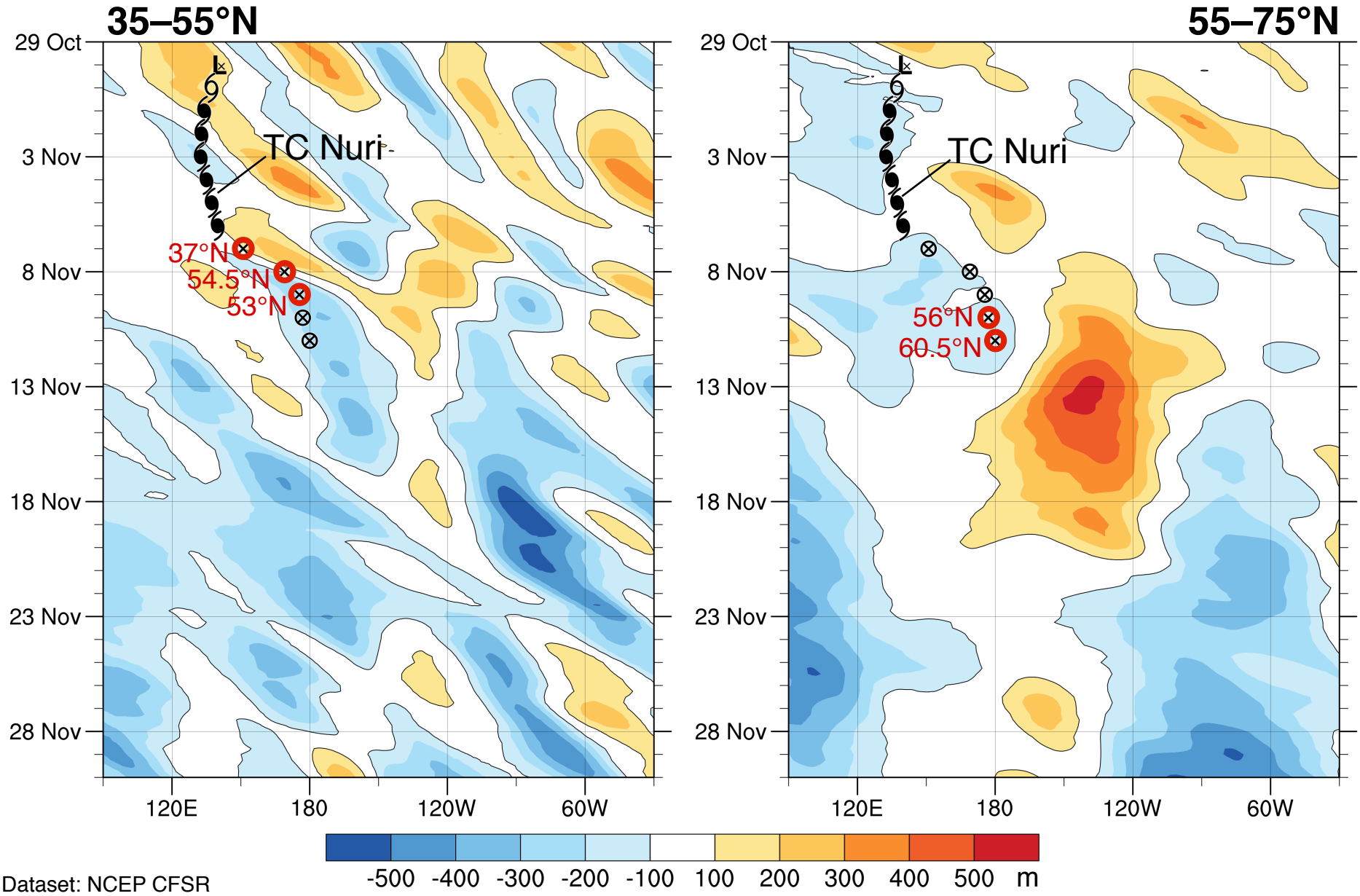


Legend

- L — Extratropical low pressure center
- H_1 — High pressure center
- Sea level pressure < 1000-hPa
- Cold front
- Tropical Cyclone
- Arctic air
- 200-hPa geopotential heights
- 200-hPa Isotachs (30, 50, 70, 90 [m s^{-1}])

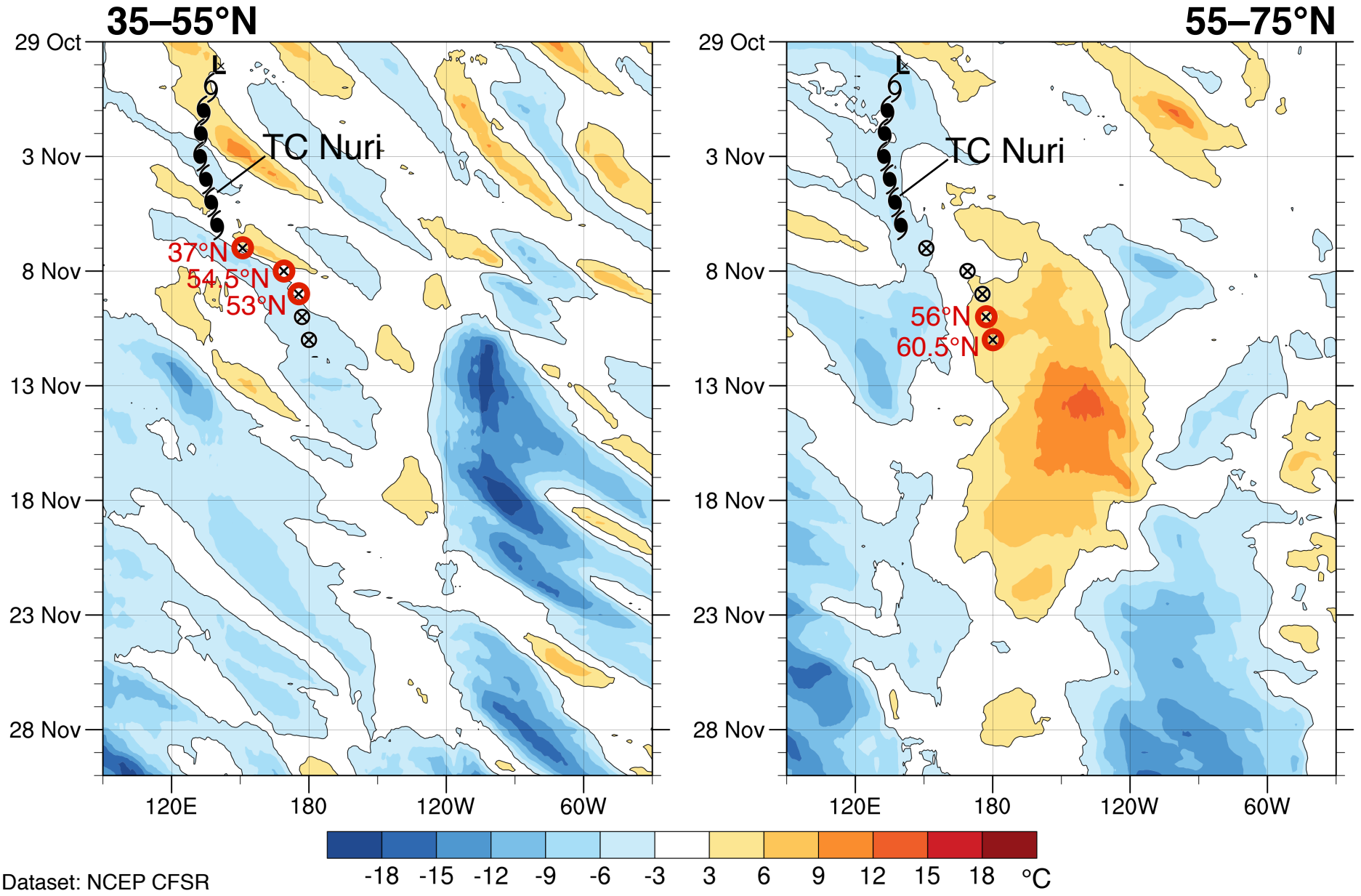
Summary of Large-Scale Circulation Evolution: Hovmoller Diagrams and Schematic Figures

250-hPa Geopotential Height Anomaly (m)
November 2014



Dataset: NCEP CFSR

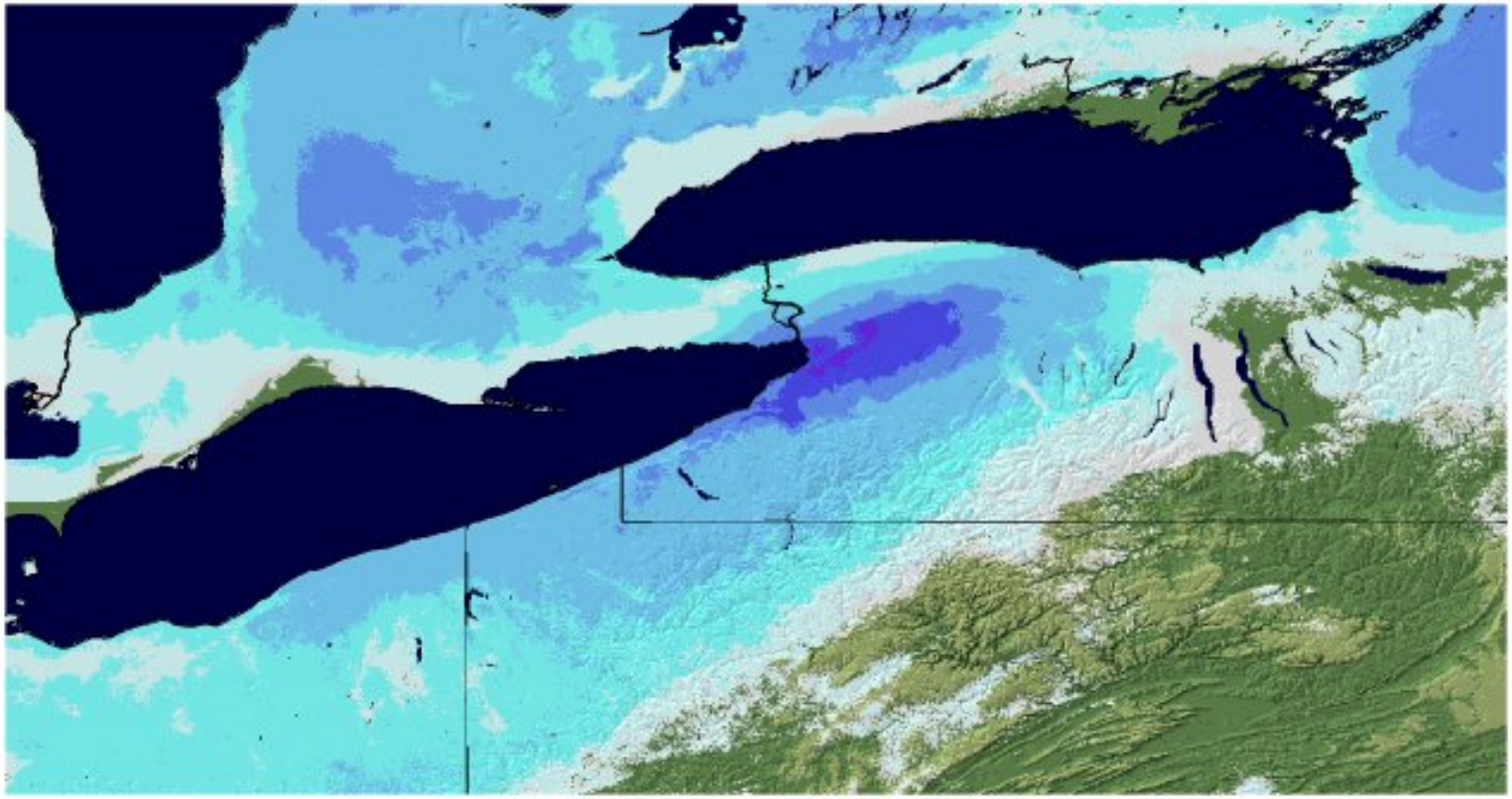
850-hPa Temperature Anomaly (°C)
November 2014



Dataset: NCEP CFSR

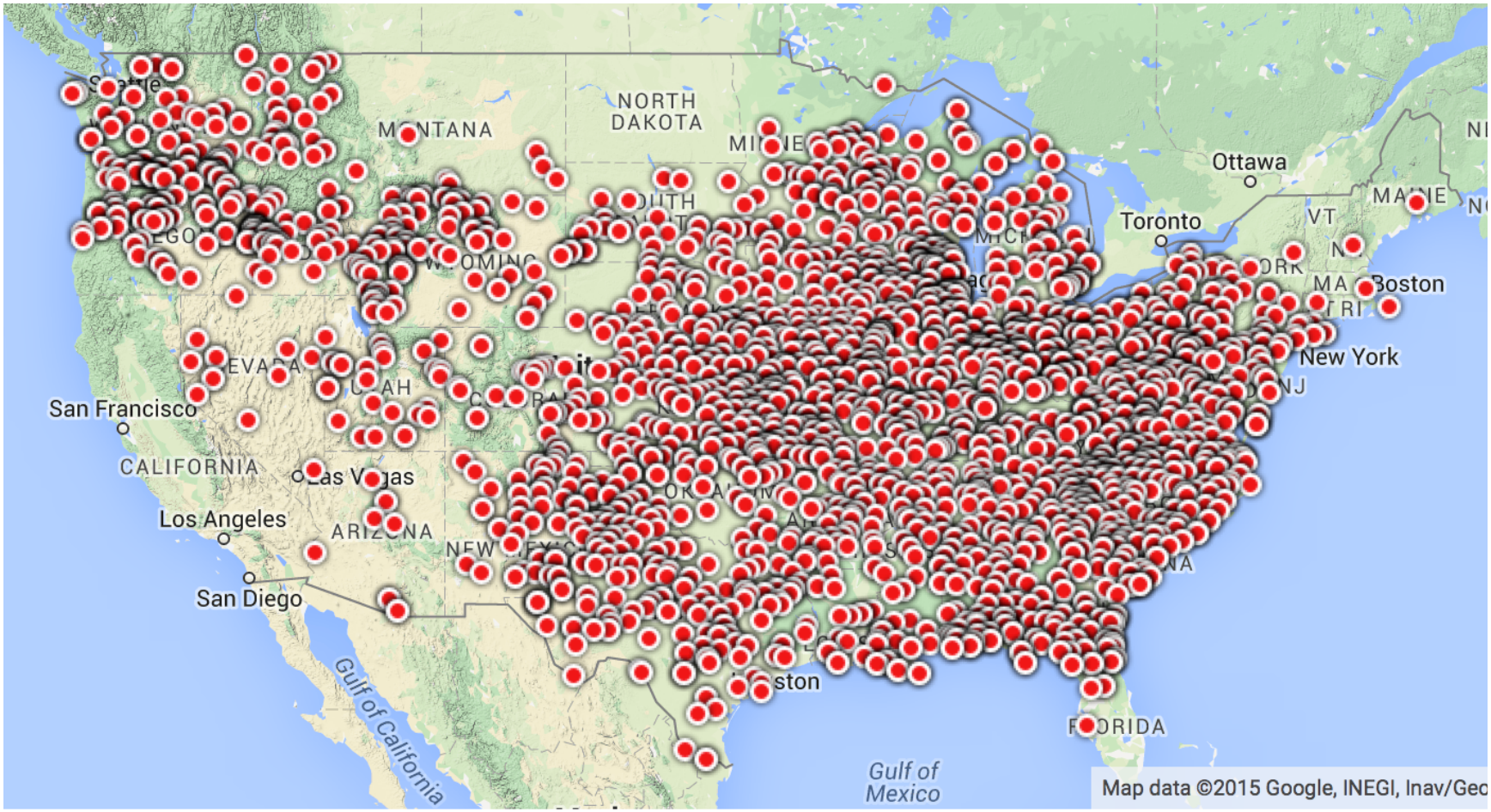
Impacts: Buffalo Snow and CONUS Cold

Snow Depth: 0600 UTC 21 November 2014



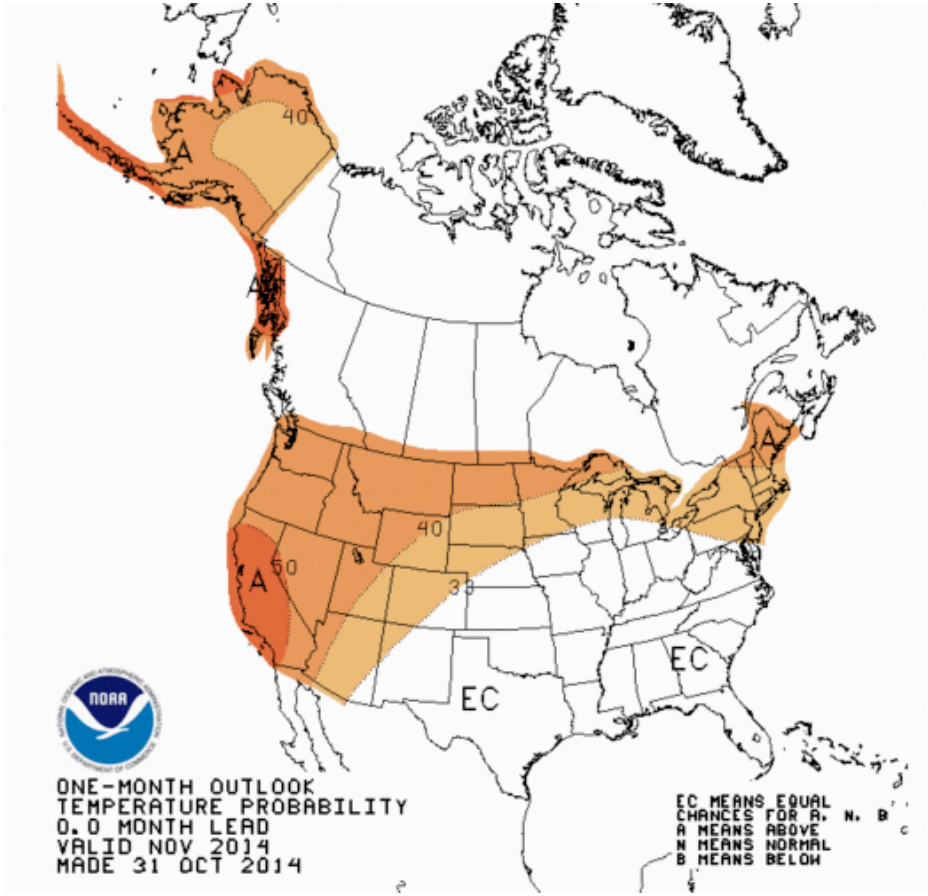
Minimum Temperature Records Broken: 16–22 November 2014 (N = 2677)

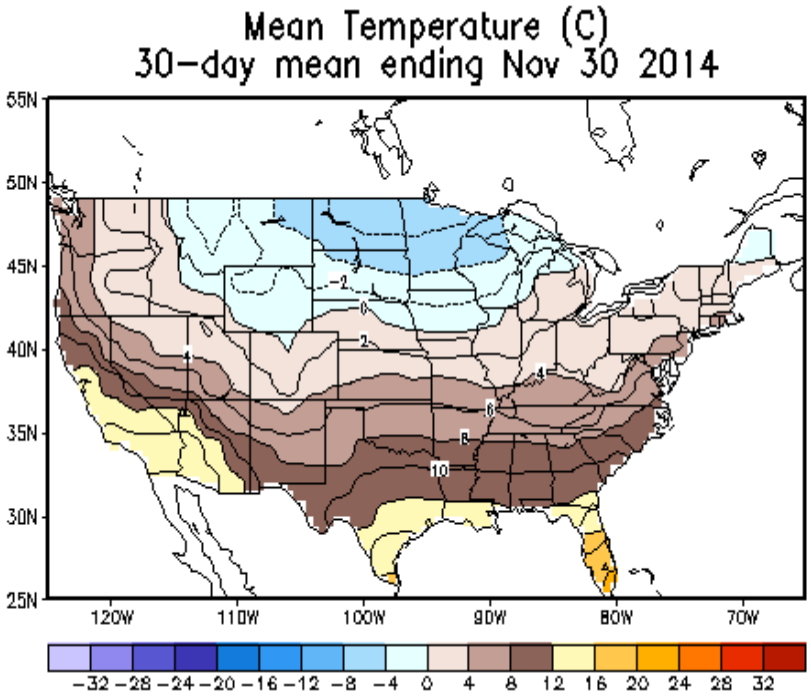
Source: NCDC

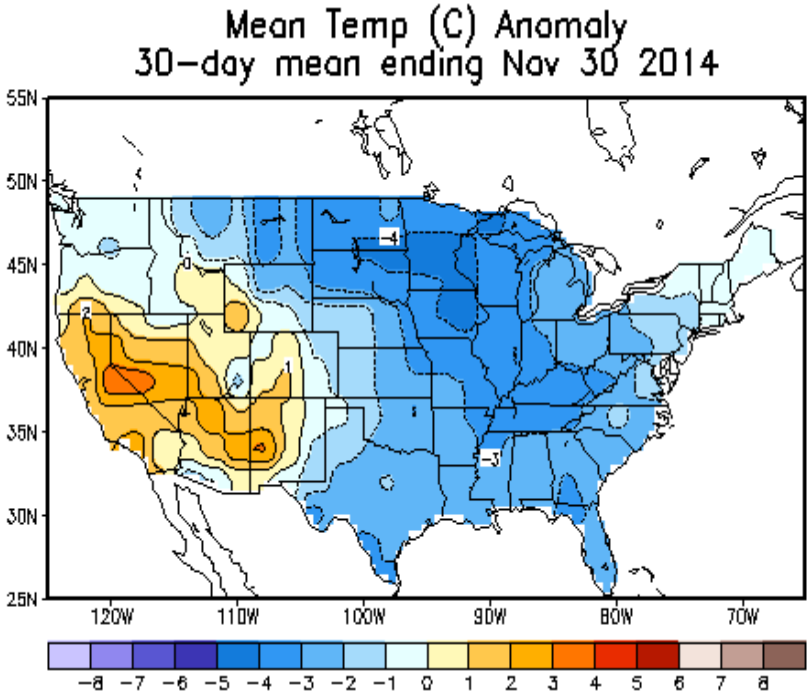


CPC November 2014 CONUS Temperature Forecast is Derailed

November 2014 CPC Forecast Temperature Anomaly Probability (Left); Mean and Observed Temperature Anomaly °C (right)

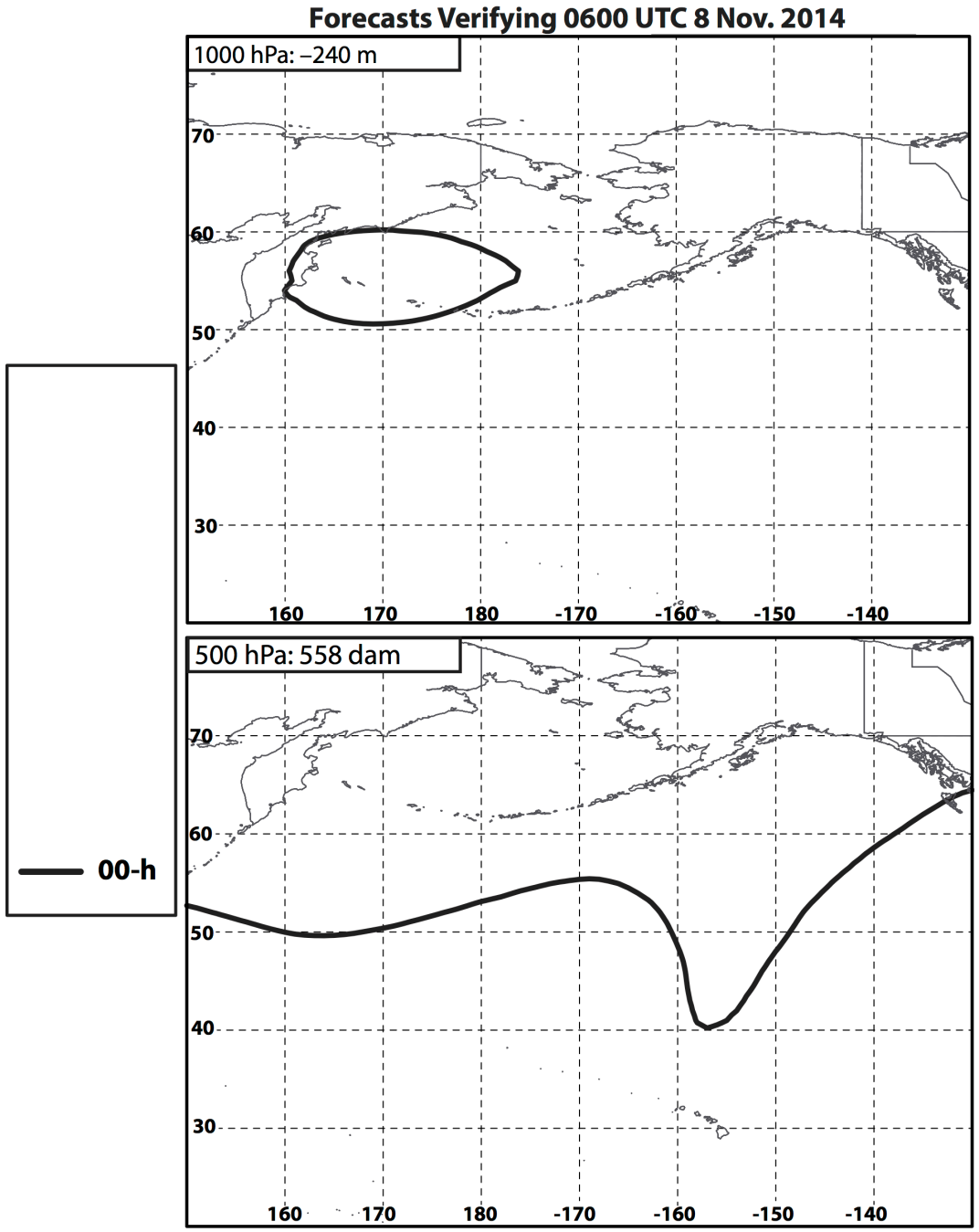




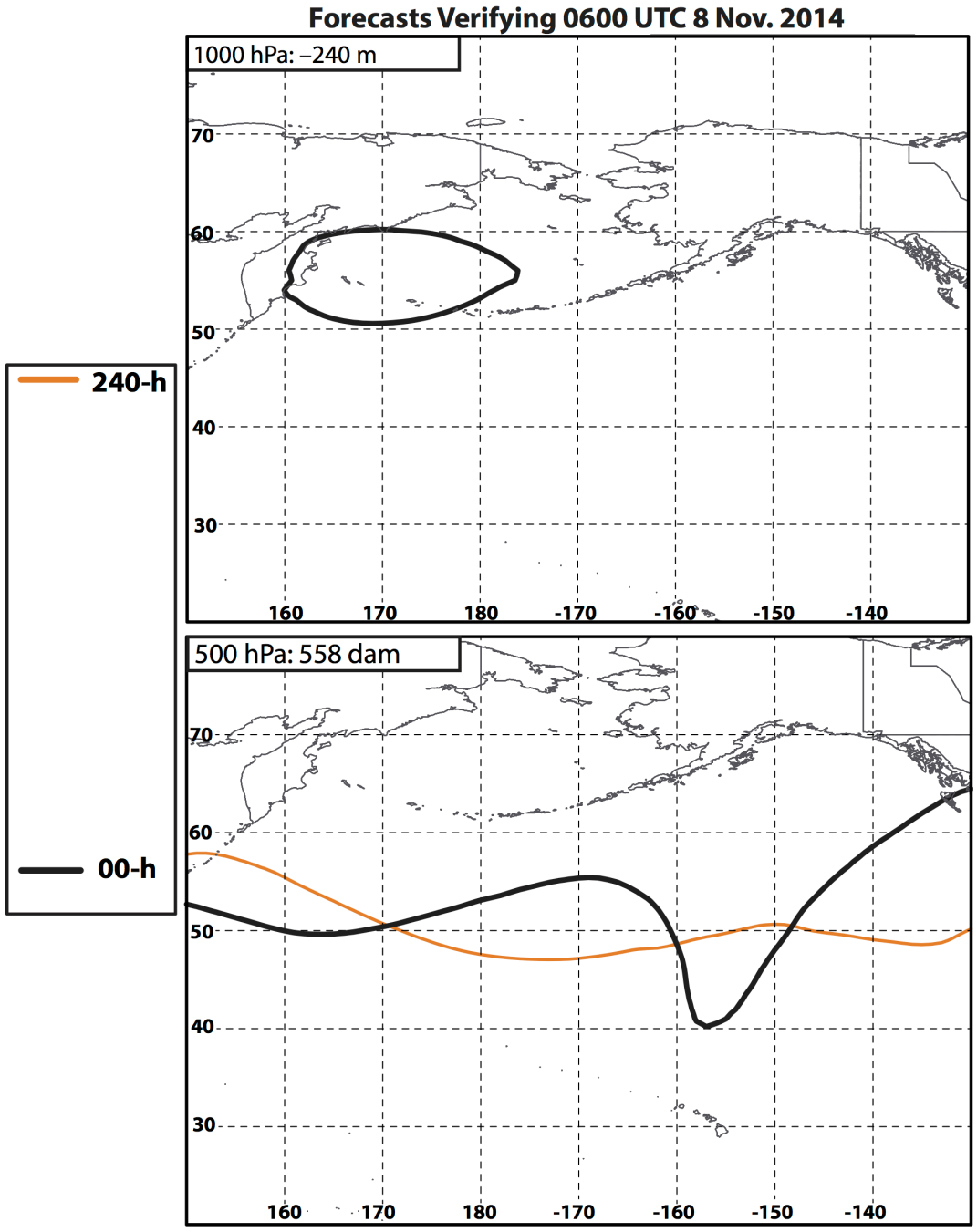


NH Flow Reconfiguration: Predictability Issues

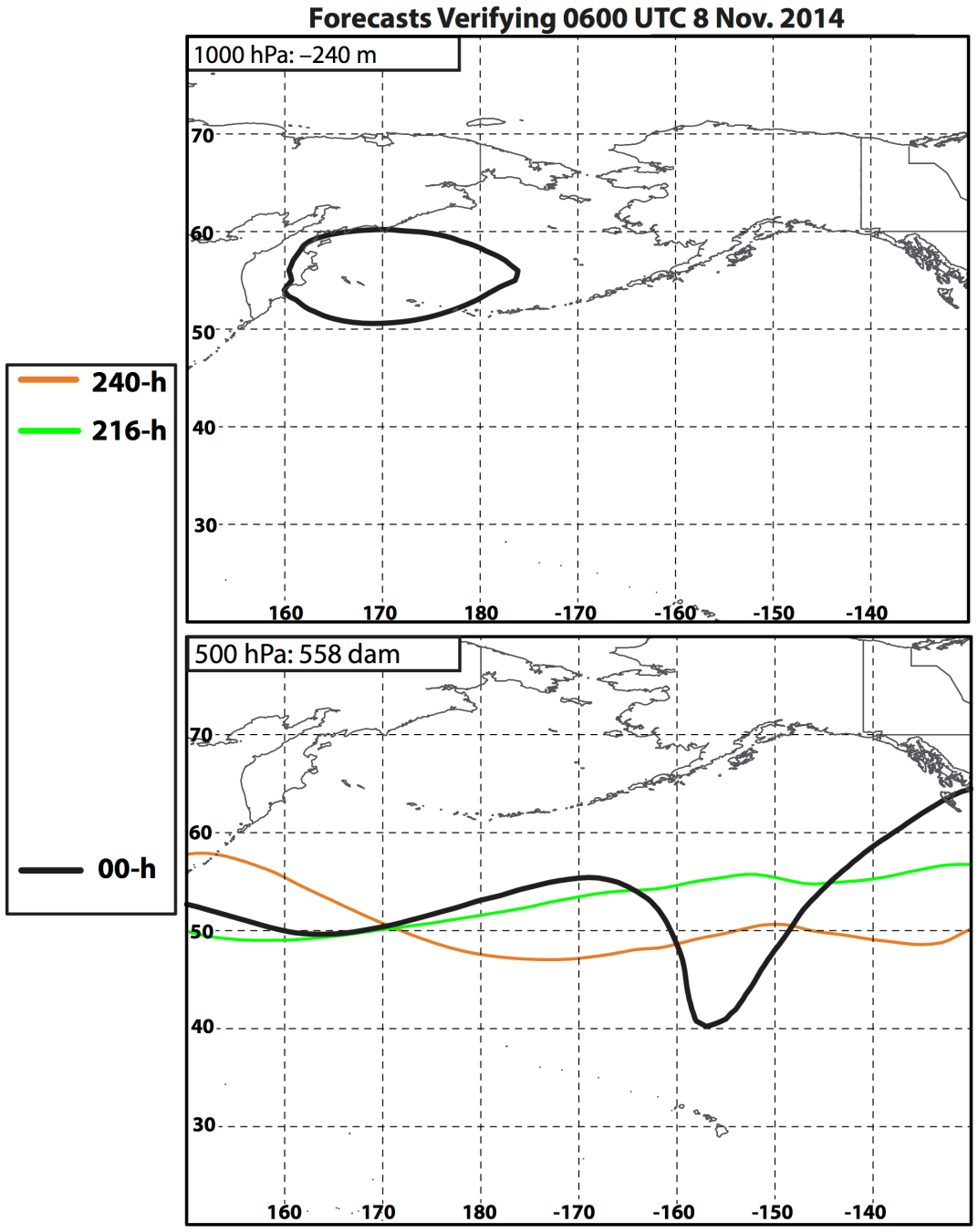
Nuri's ET – 8 Nov.



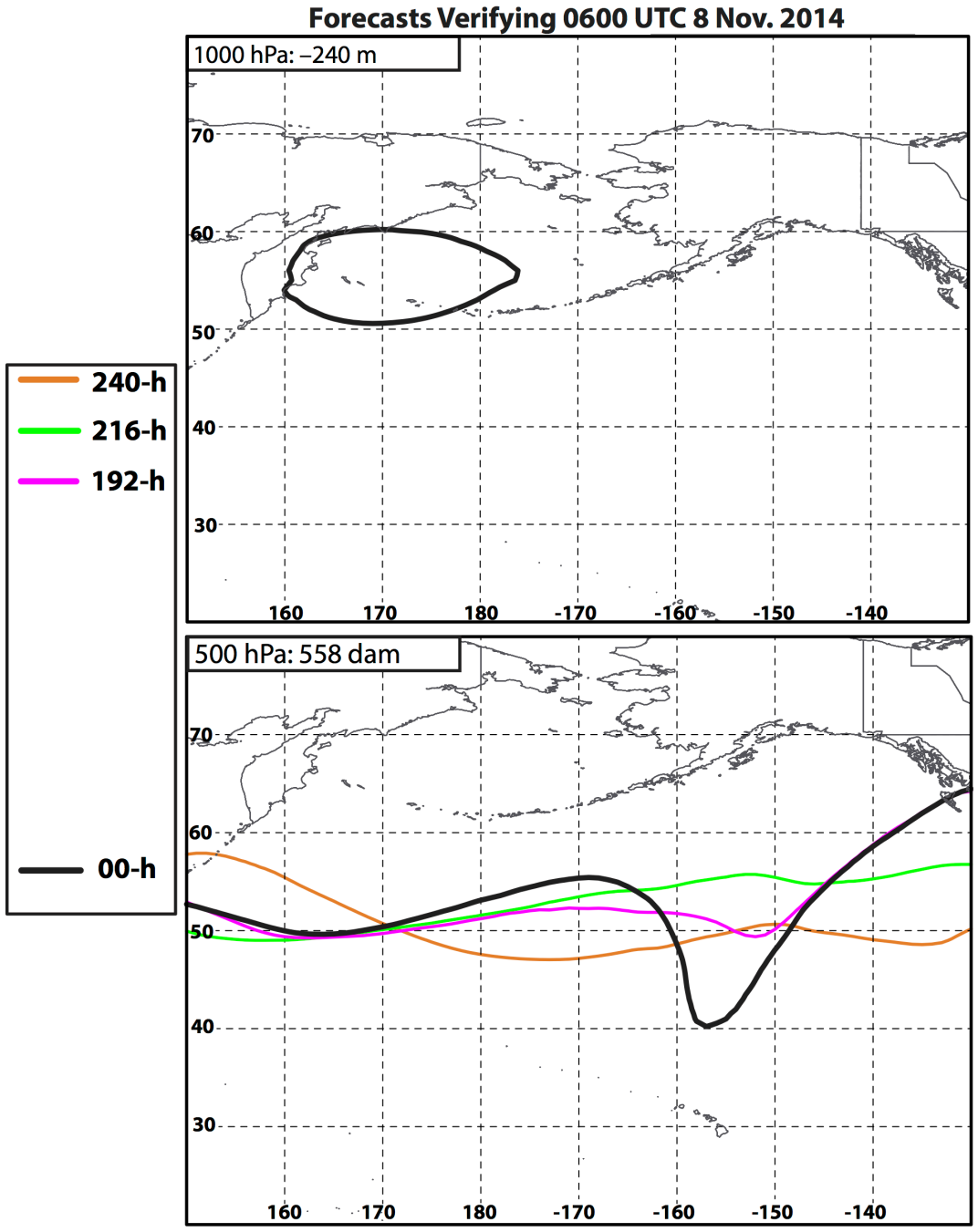
Nuri's ET – 8 Nov.



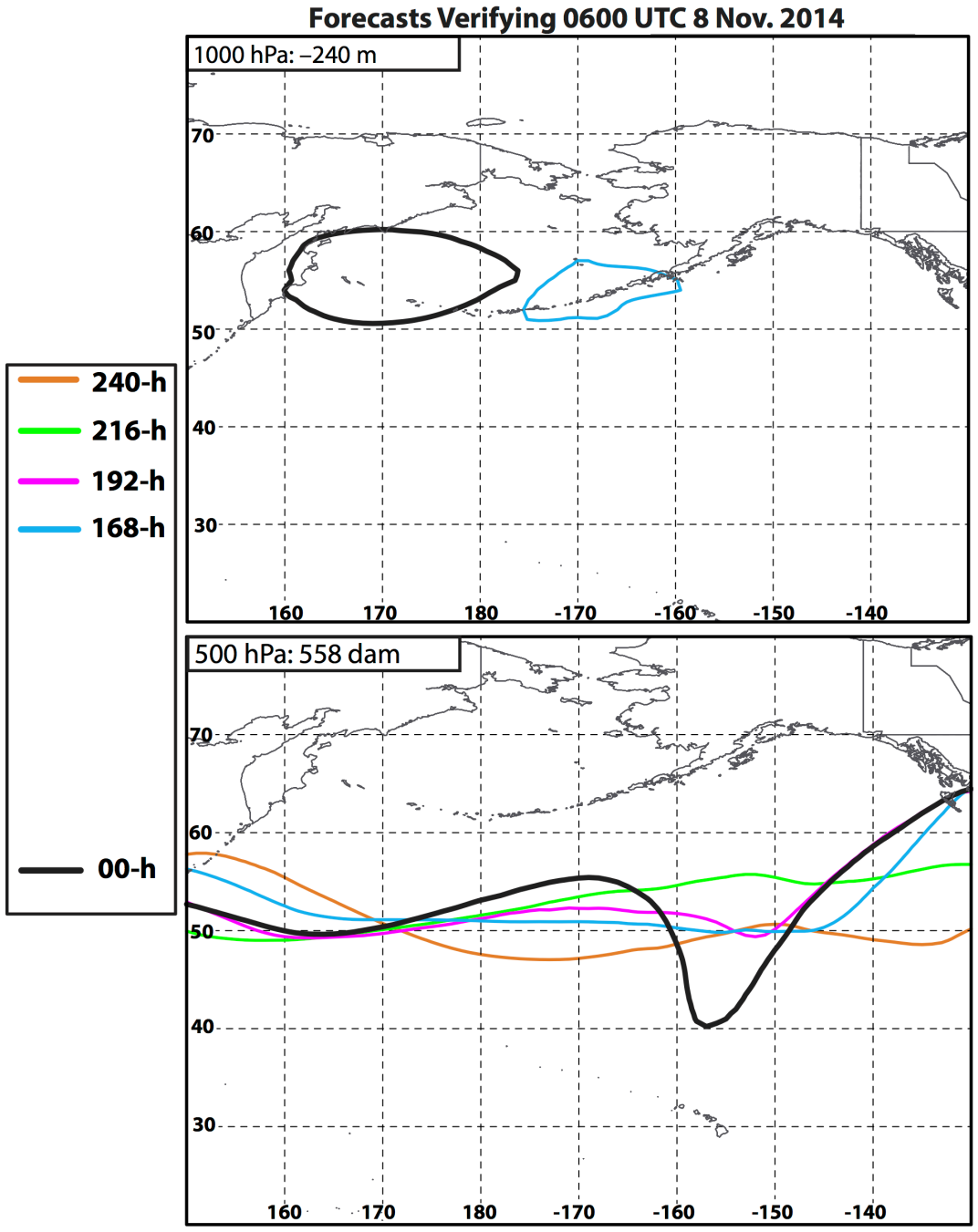
Nuri's ET – 8 Nov.

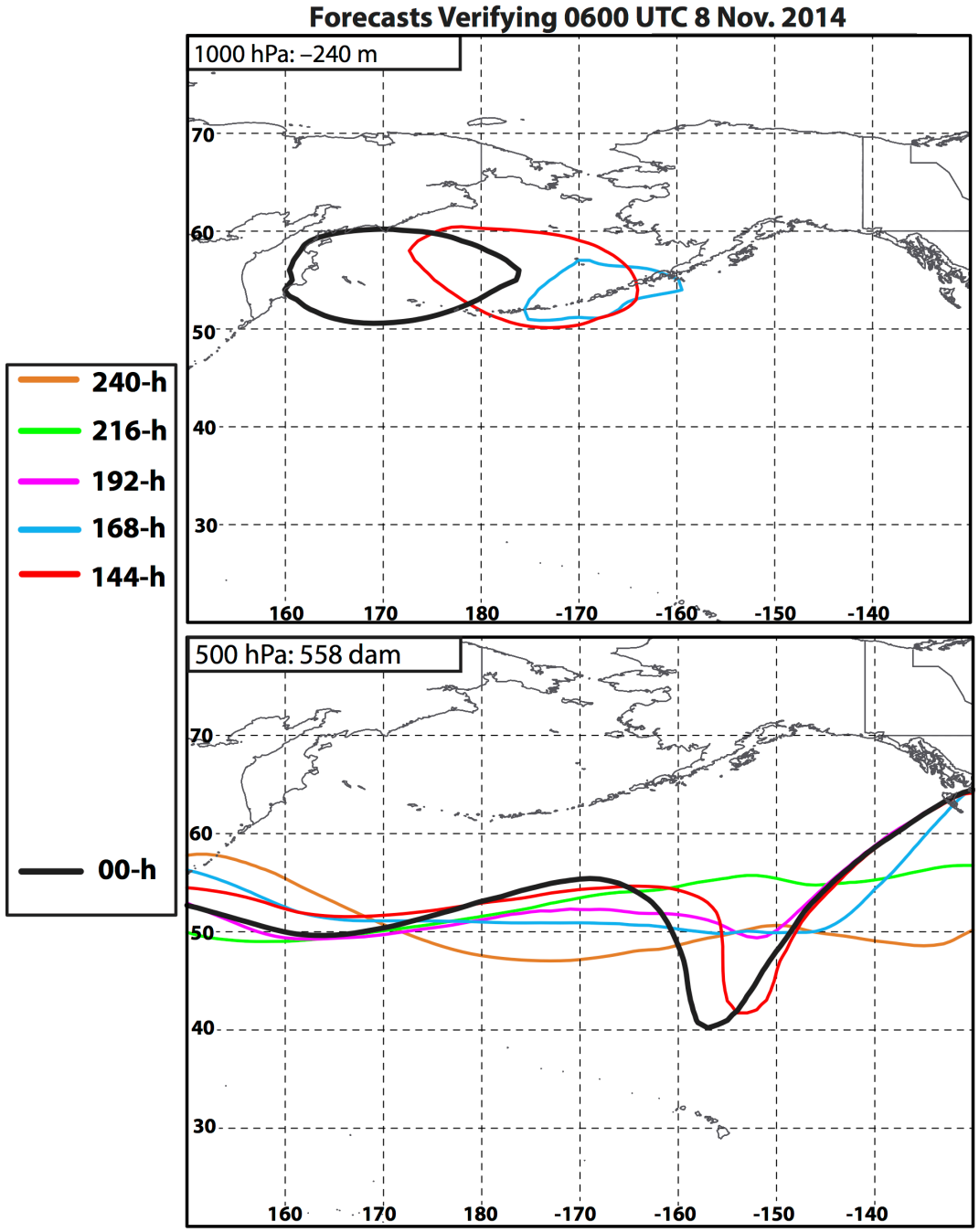


Nuri's ET – 8 Nov.



Nuri's ET – 8 Nov.



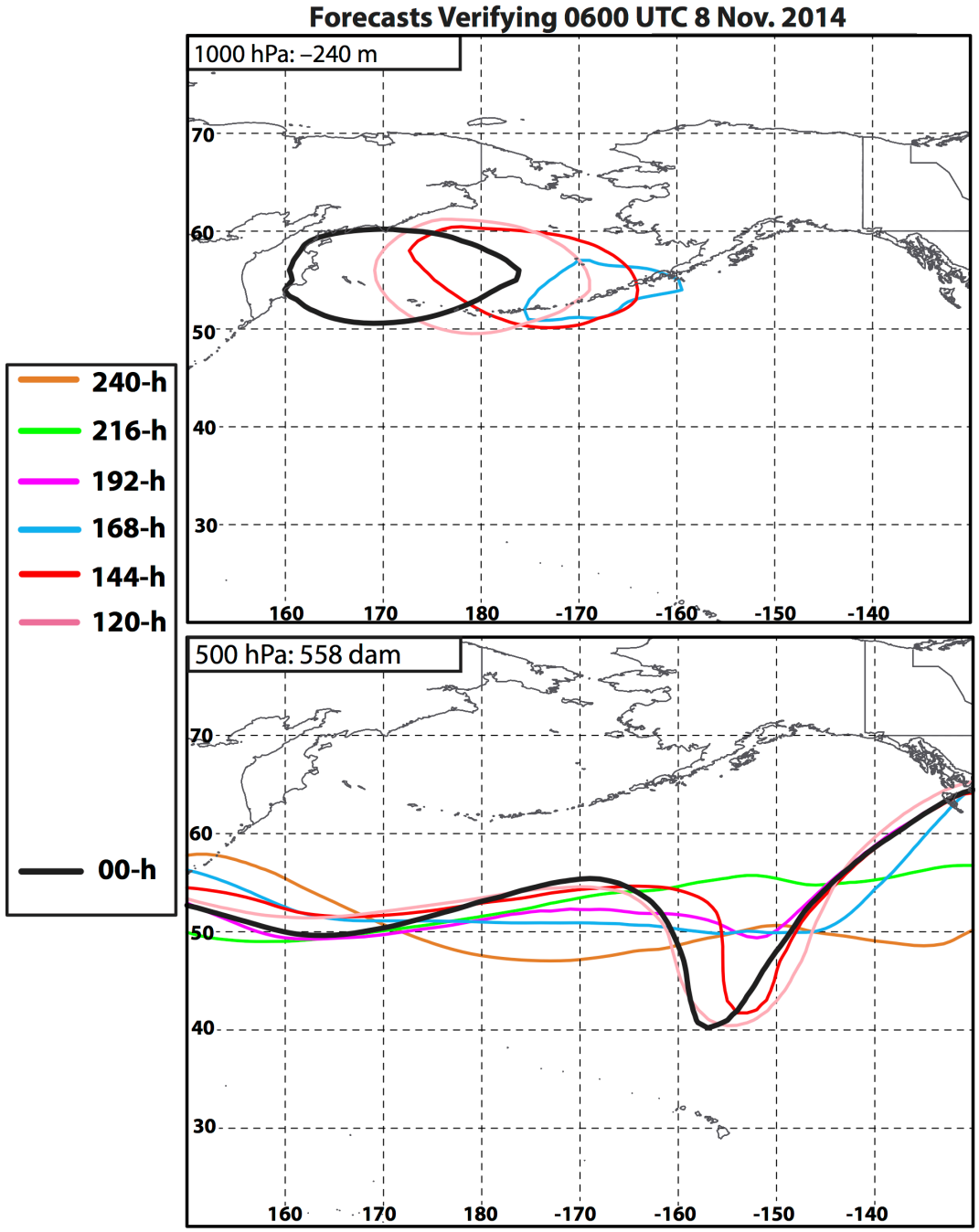


Nuri's ET – 8 Nov.

144-h forecast:

First forecast to show Nuri intensifying to levels that match observations.

Coincident with an indication of trough development poleward of Hawaii.

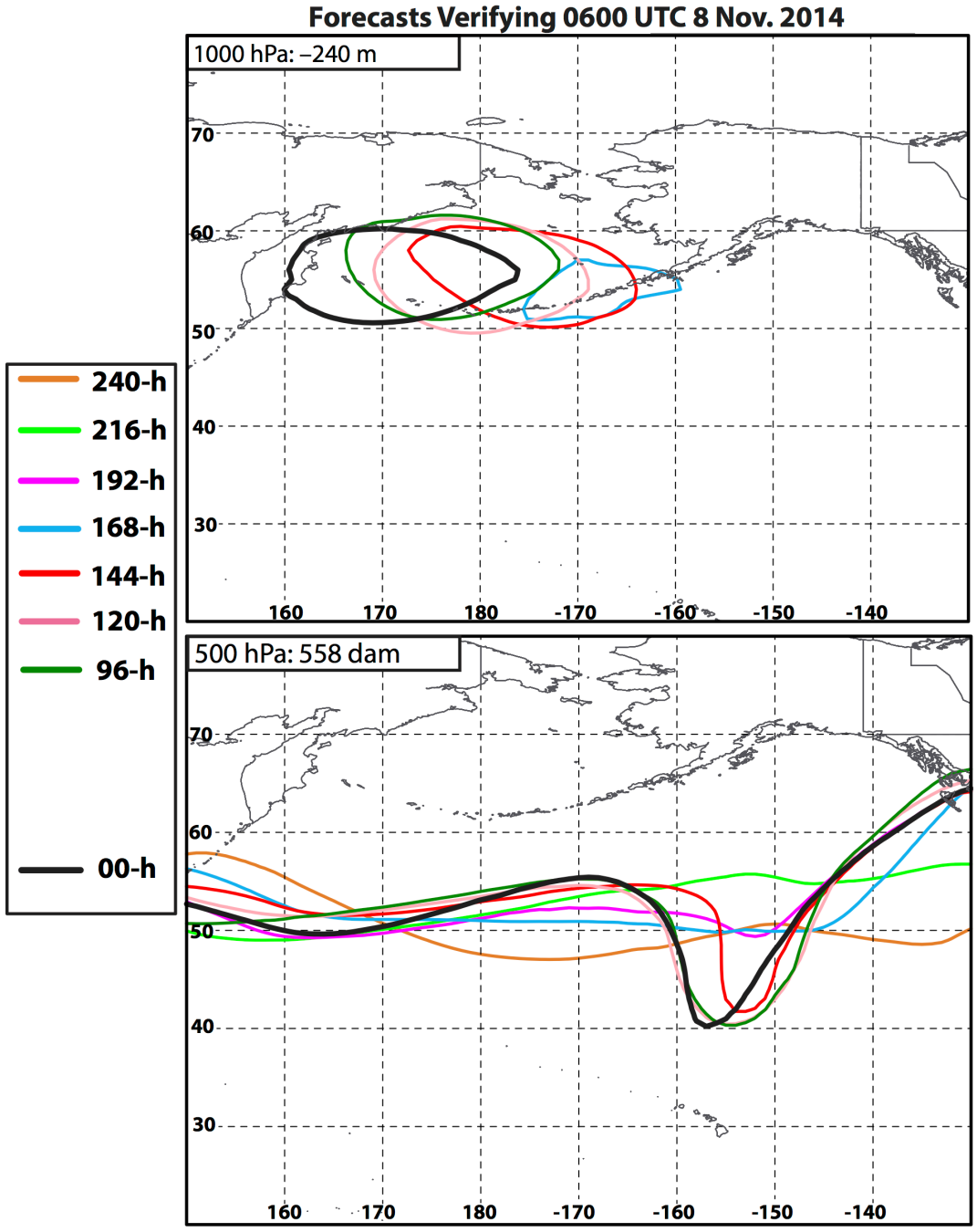


Nuri's ET – 8 Nov.

144-h forecast:

First forecast to show Nuri intensifying to levels that match observations.

Coincident with an indication of trough development poleward of Hawaii.

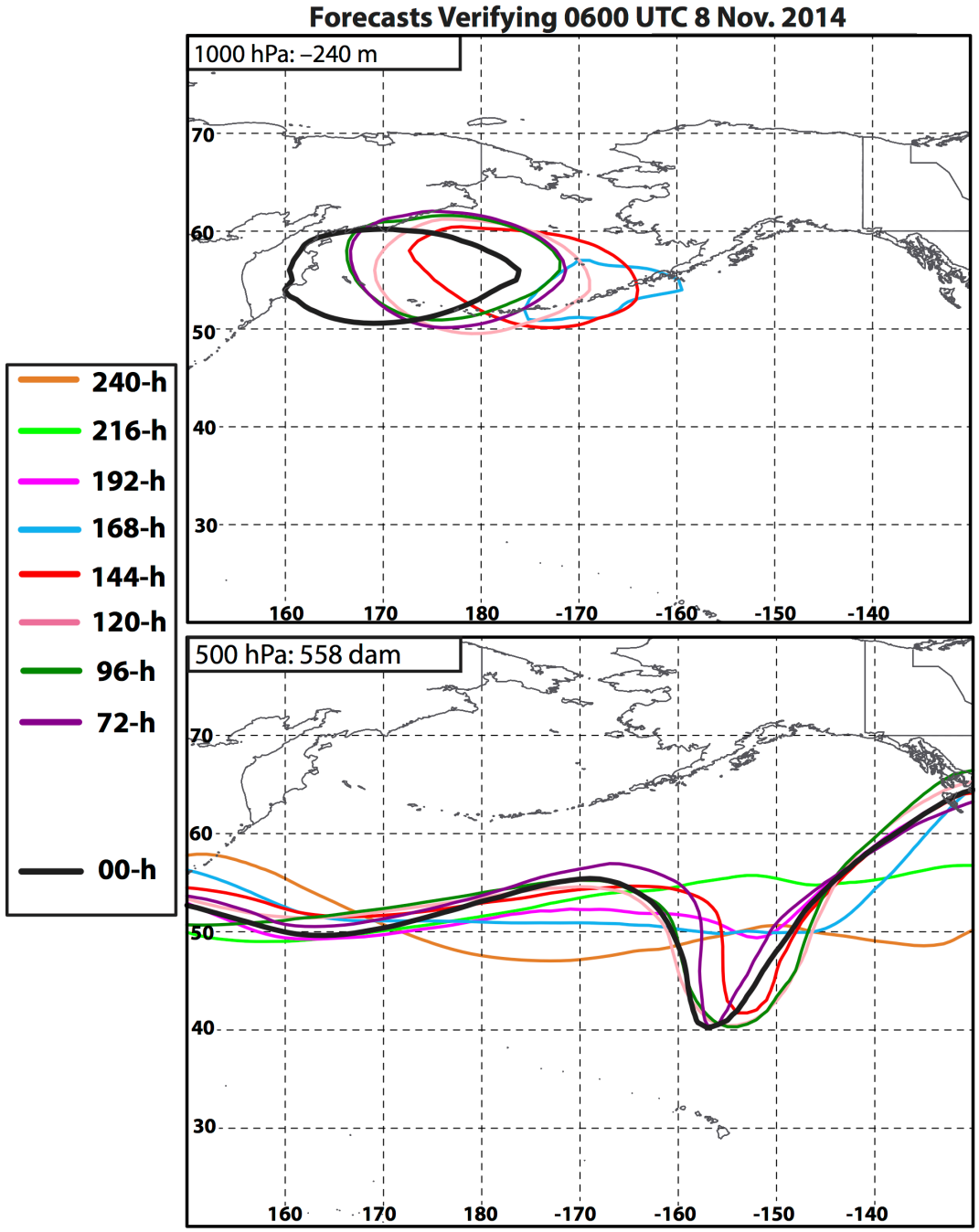


Nuri's ET – 8 Nov.

144-h forecast:

First forecast to show Nuri intensifying to levels that match observations.

Coincident with an indication of trough development poleward of Hawaii.

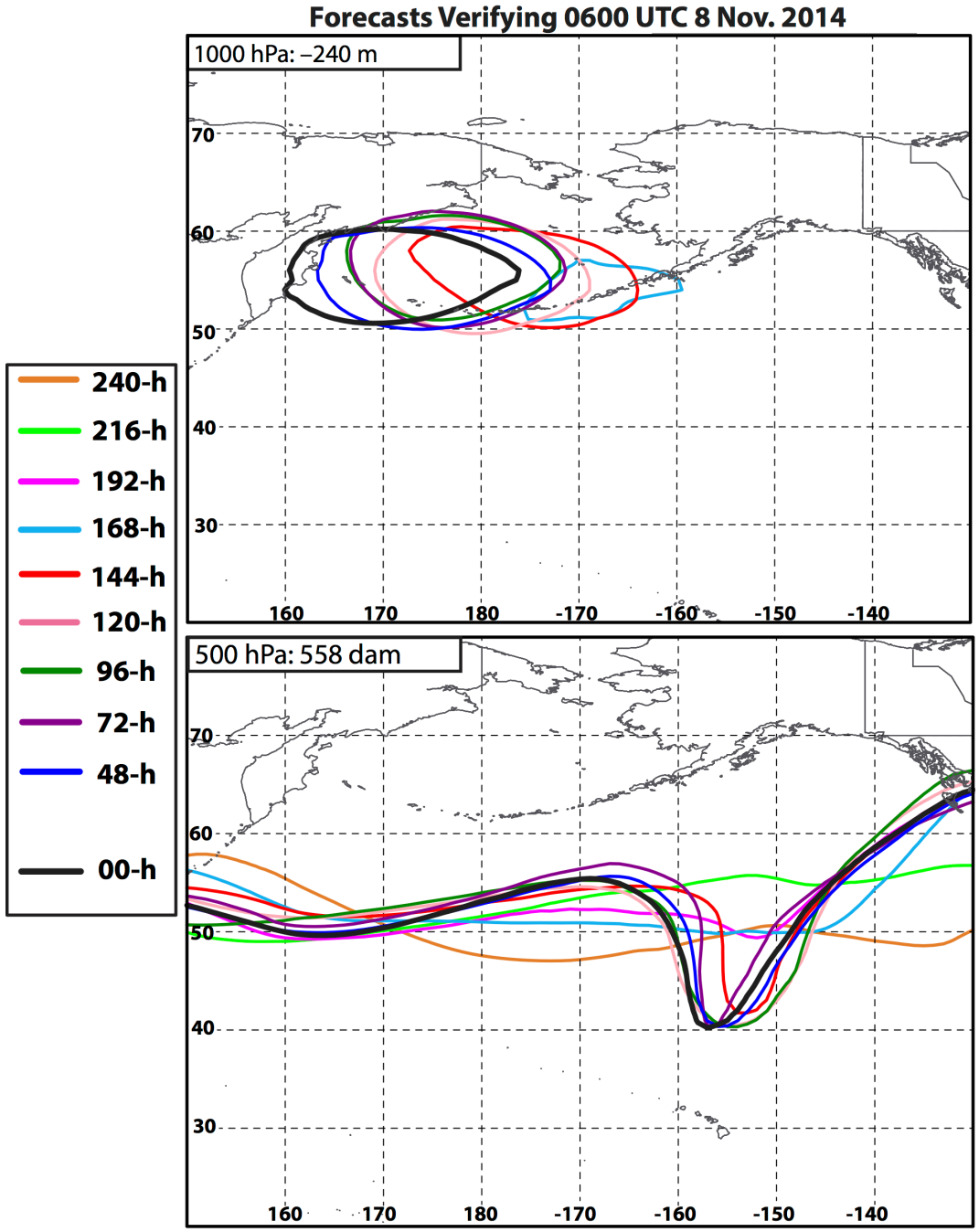


Nuri's ET – 8 Nov.

144-h forecast:

First forecast to show Nuri intensifying to levels that match observations.

Coincident with an indication of trough development poleward of Hawaii.

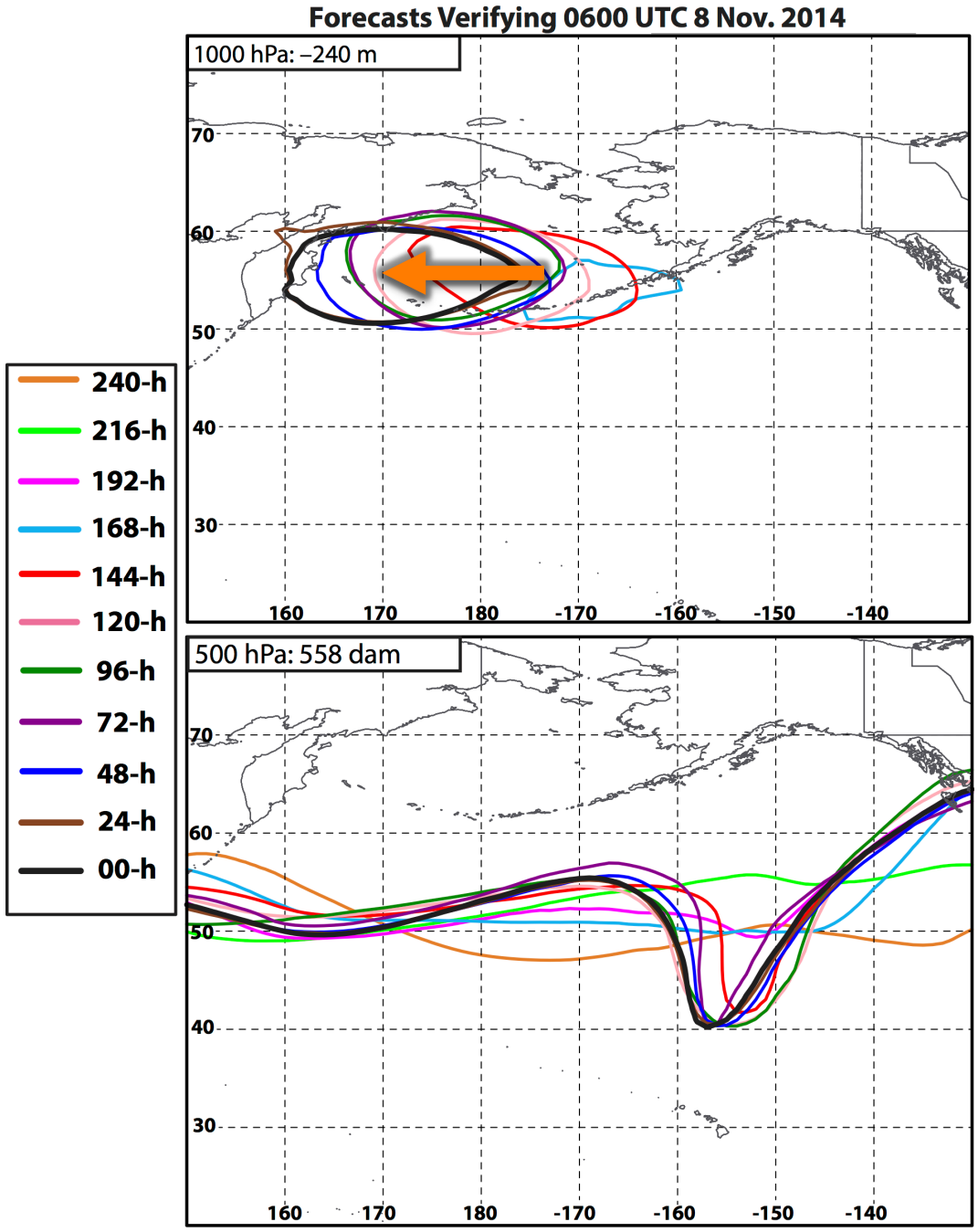


Nuri's ET – 8 Nov.

144-h forecast:

First forecast to show Nuri intensifying to levels that match observations.

Coincident with an indication of trough development poleward of Hawaii.



Nuri's ET – 8 Nov.

144-h forecast:

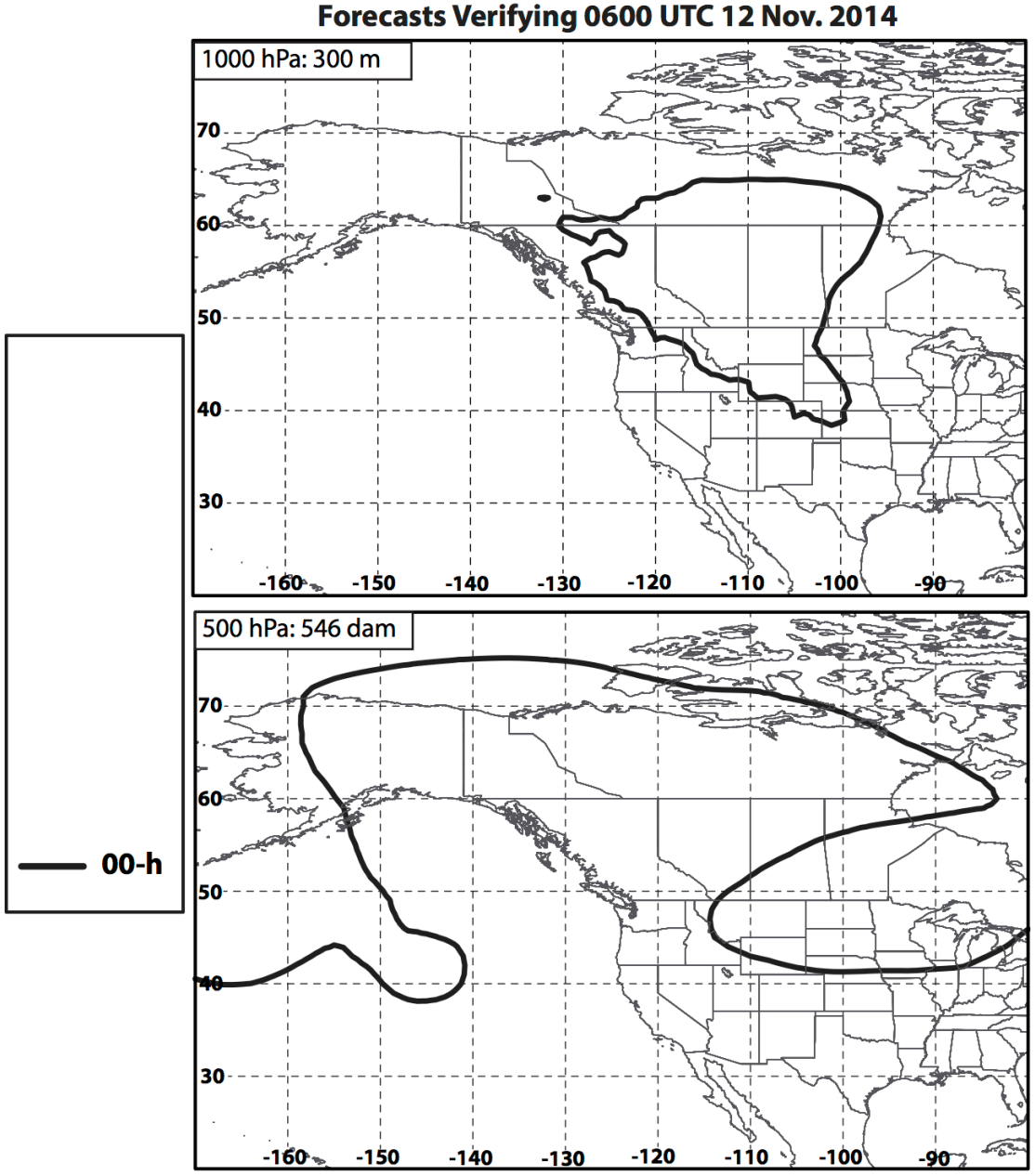
First forecast to show Nuri intensifying to levels that match observations.

Coincident with an indication of trough development poleward of Hawaii.

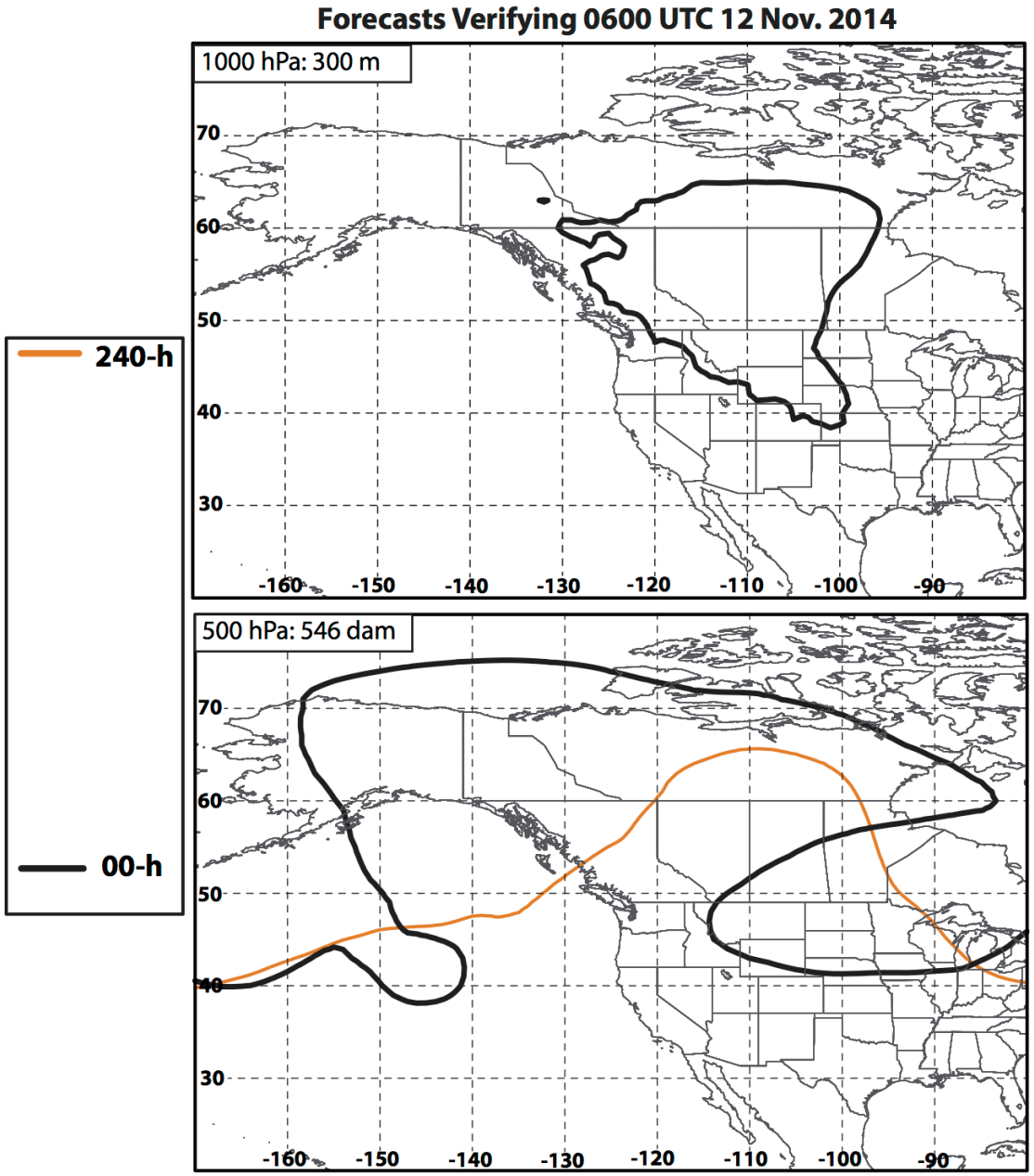
144-to-00-h forecast:

Westward shift in the location of post-ET Nuri in each subsequent forecast.

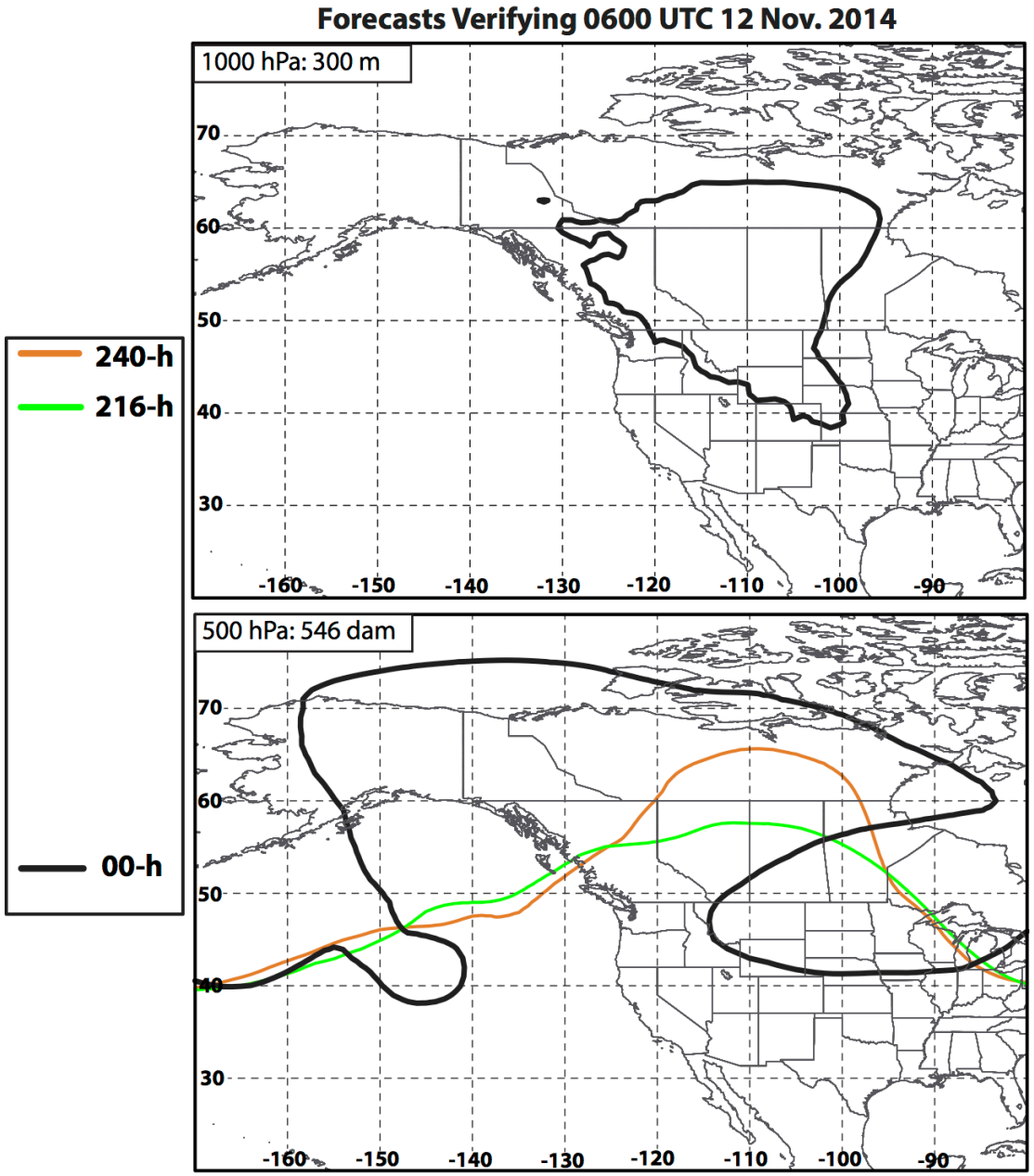
Eastern N. Pacific Ridge – 12 Nov.



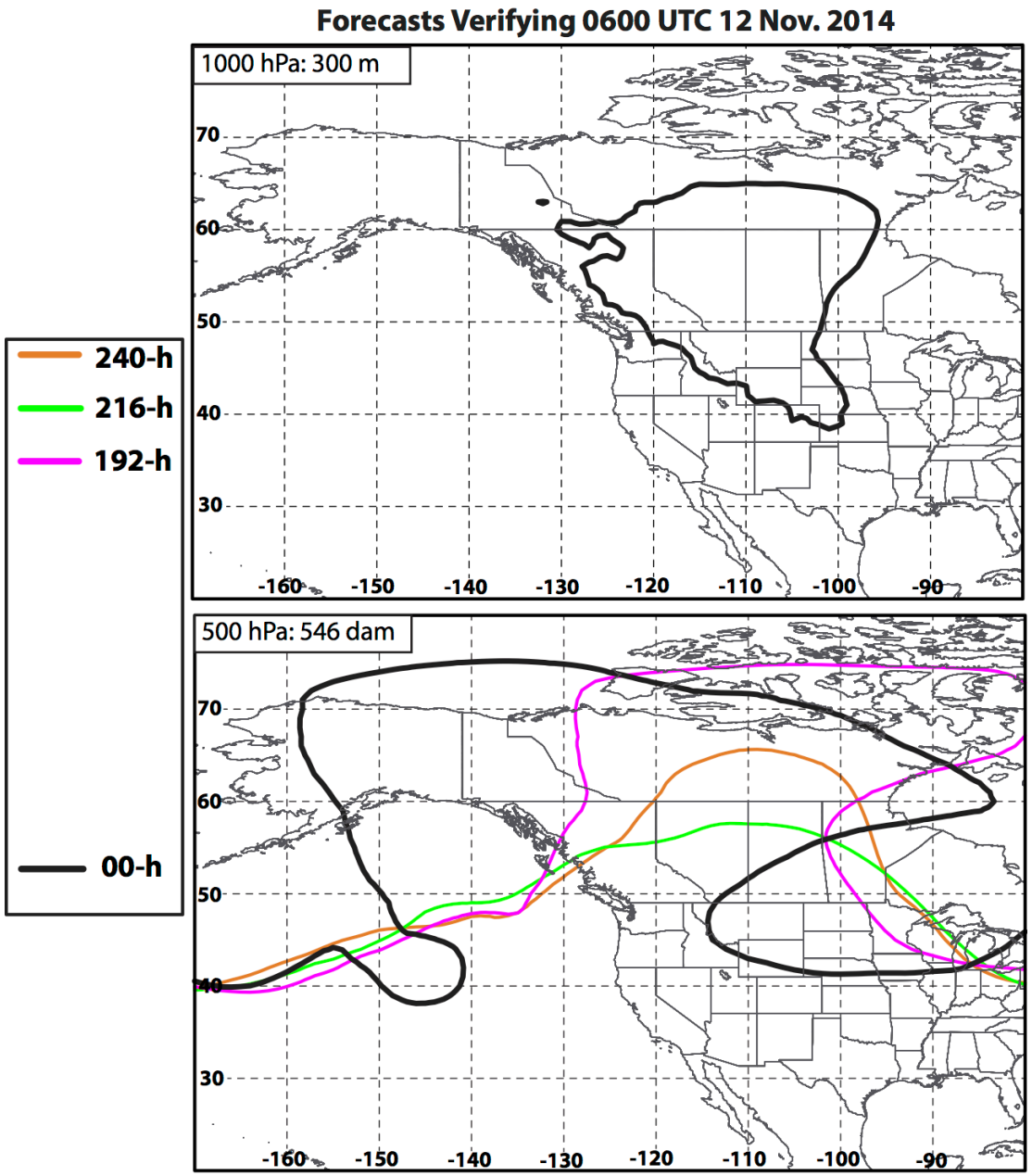
Eastern N. Pacific Ridge – 12 Nov.

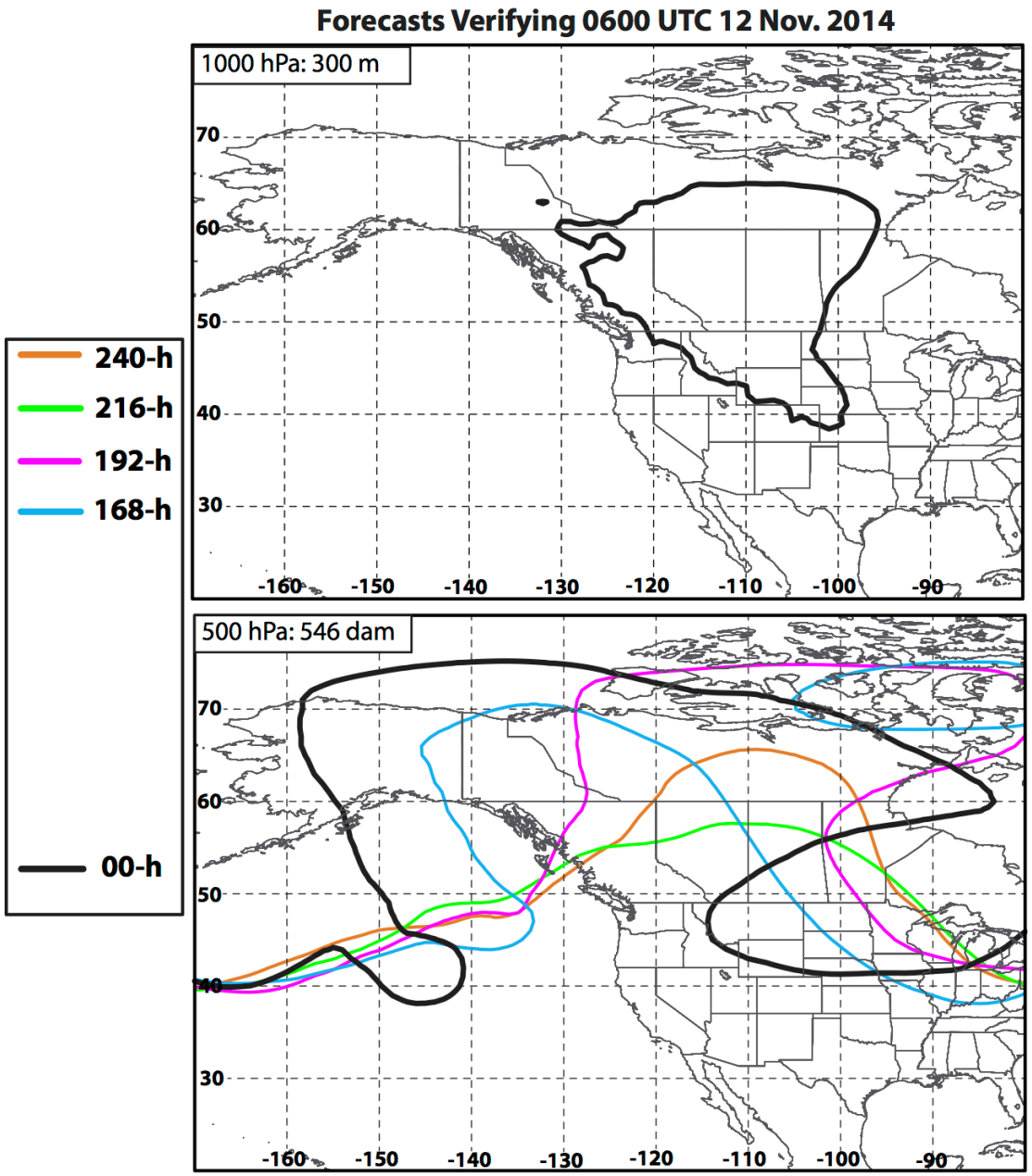


Eastern N. Pacific Ridge – 12 Nov.



Eastern N. Pacific Ridge – 12 Nov.

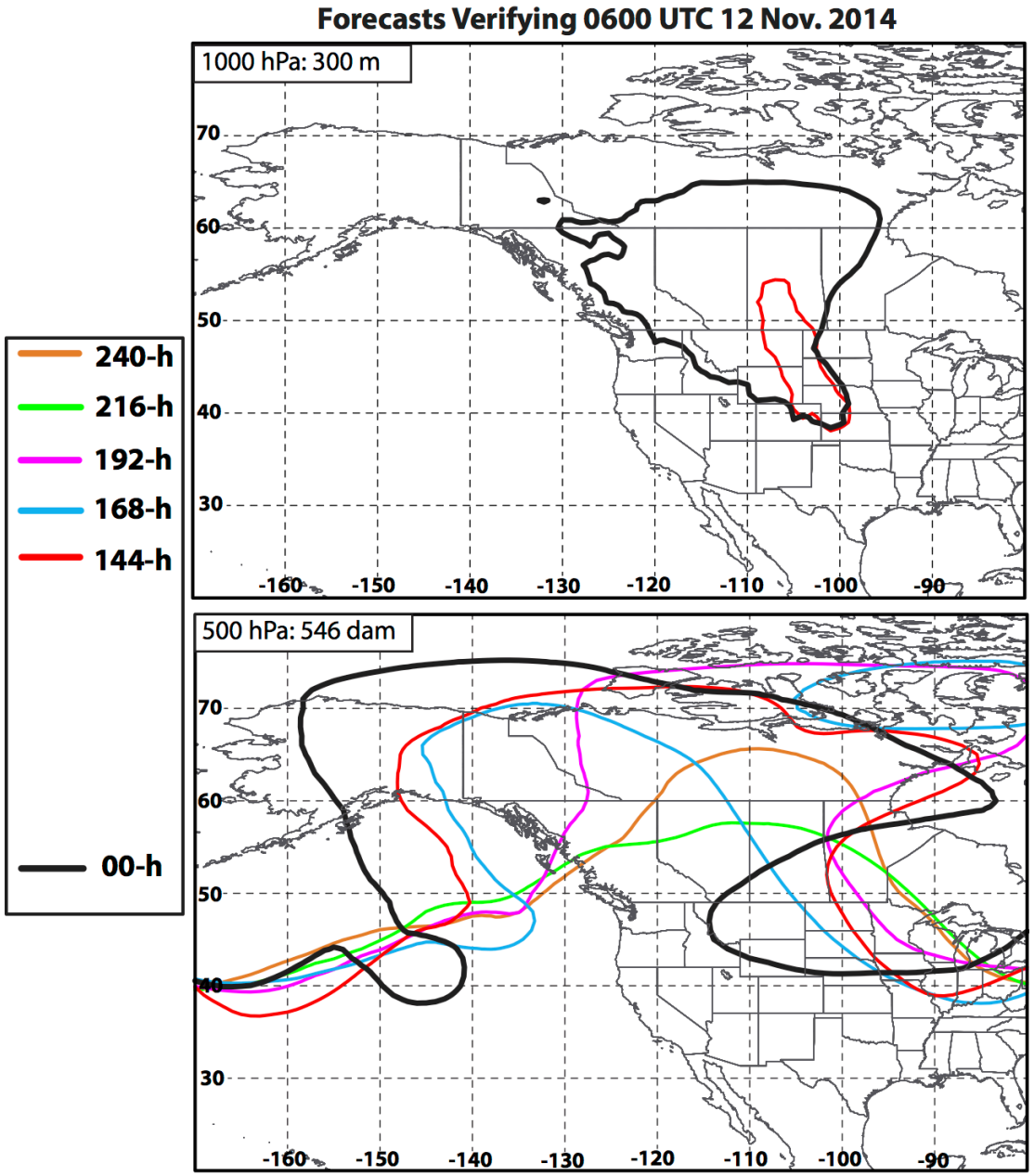




Eastern N. Pacific Ridge – 12 Nov.

168-h forecast:

First indication of negatively-tilted trough west of British Columbia.



Eastern N. Pacific Ridge – 12 Nov.

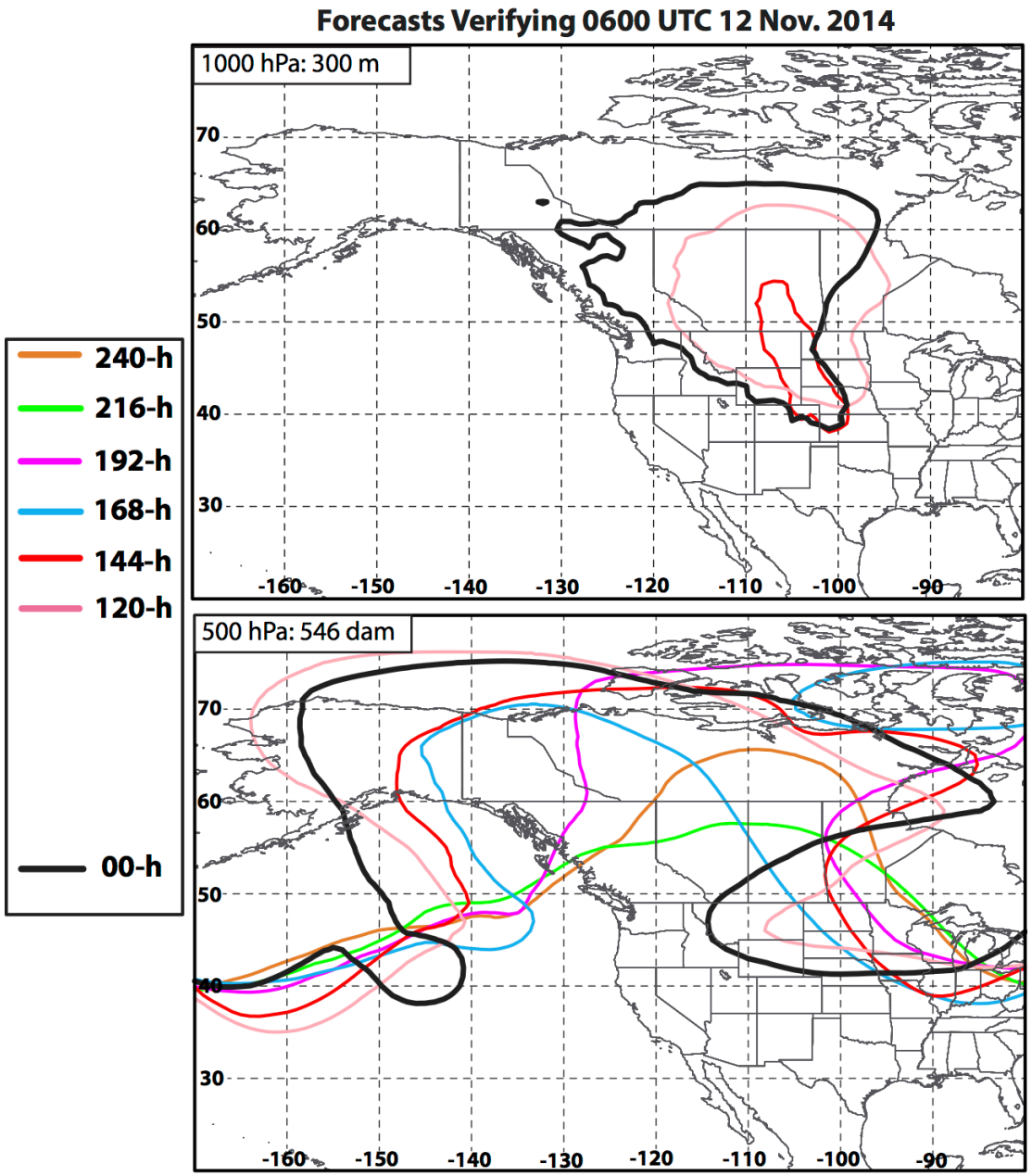
168-h forecast:

First indication of negatively-tilted trough west of British Columbia.

144-h forecast:

First indication of strong anticyclone (>300 m) east of the Rockies.

Coincides with better resolution of the eastern side of the omega block.



Eastern N. Pacific Ridge – 12 Nov.

168-h forecast:

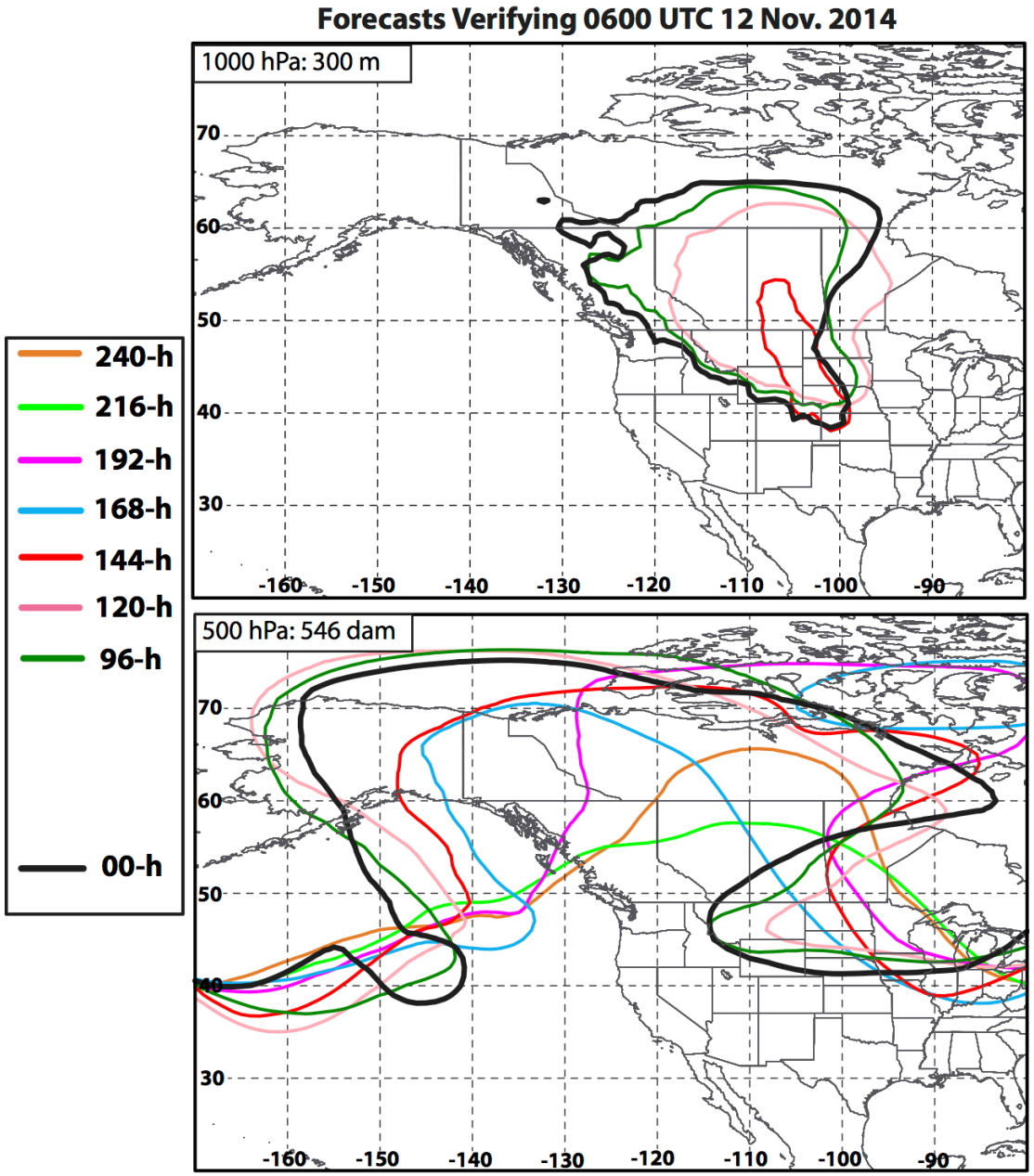
First indication of negatively-tilted trough west of British Columbia.

144-h forecast:

First indication of strong anticyclone (>300 m) east of the Rockies.

Coincides with better resolution of the eastern side of the omega block.

Forecasts improve once Nuri's ET occurs



Eastern N. Pacific Ridge – 12 Nov.

168-h forecast:

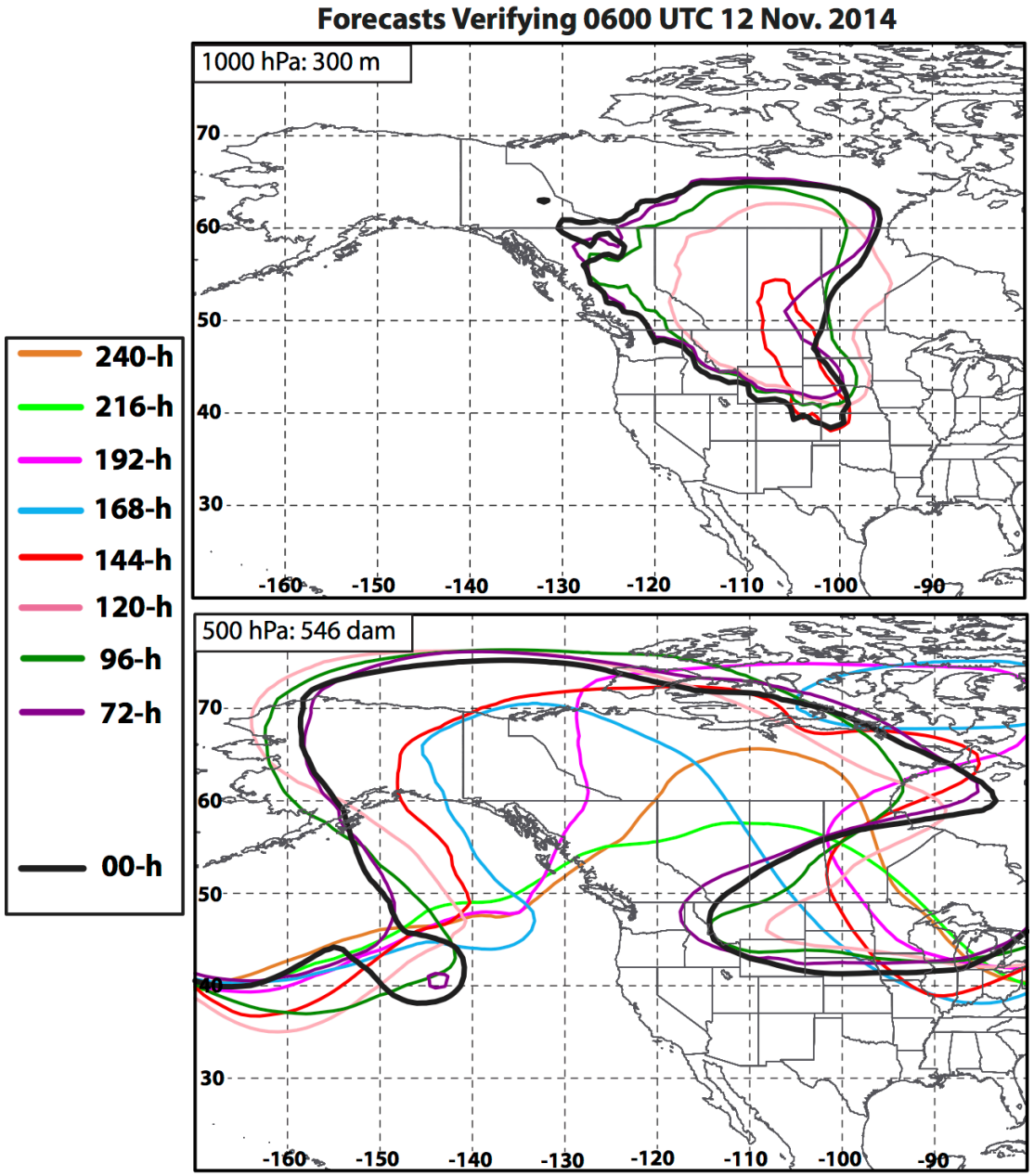
First indication of negatively-tilted trough west of British Columbia.

144-h forecast:

First indication of strong anticyclone (>300 m) east of the Rockies.

Coincides with better resolution of the eastern side of the omega block.

Forecasts improve once Nuri's ET occurs



Eastern N. Pacific Ridge – 12 Nov.

168-h forecast:

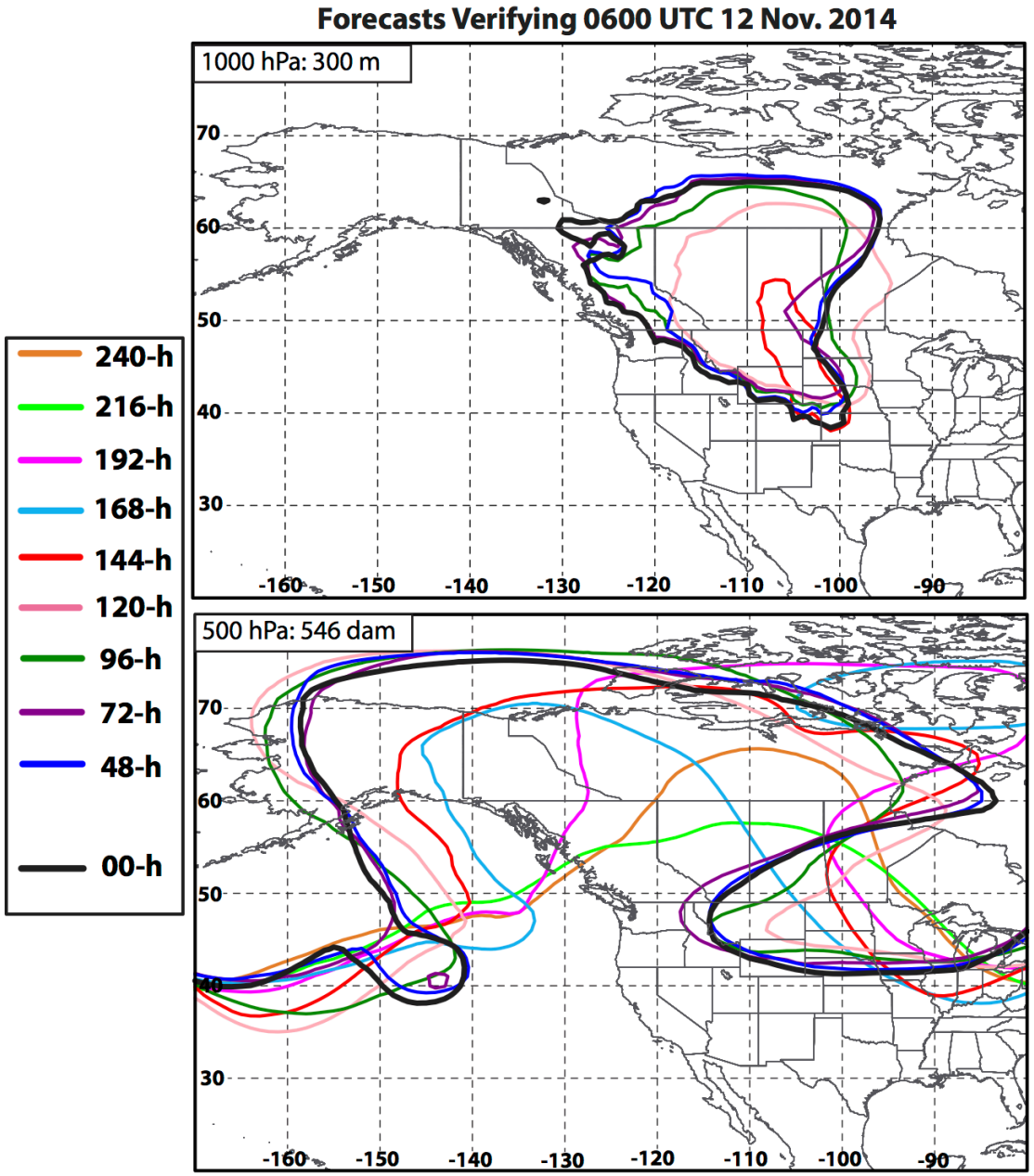
First indication of negatively-tilted trough west of British Columbia.

144-h forecast:

First indication of strong anticyclone (>300 m) east of the Rockies.

Coincides with better resolution of the eastern side of the omega block.

Forecasts improve once Nuri's ET occurs



Eastern N. Pacific Ridge – 12 Nov.

168-h forecast:

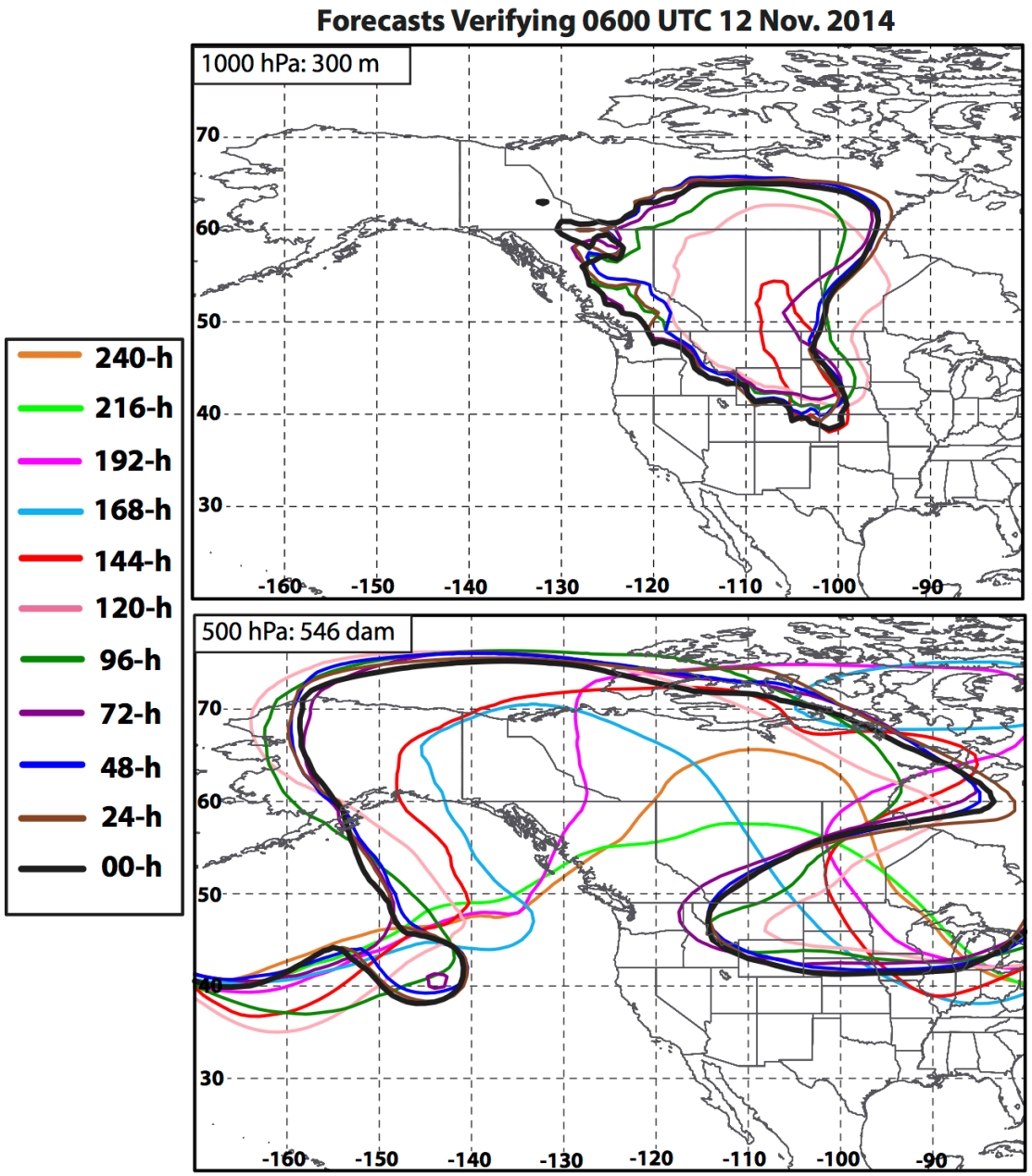
First indication of negatively-tilted trough west of British Columbia.

144-h forecast:

First indication of strong anticyclone (>300 m) east of the Rockies.

Coincides with better resolution of the eastern side of the omega block.

Forecasts improve once Nuri's ET occurs



Eastern N. Pacific Ridge – 12 Nov.

168-h forecast:

First indication of negatively-tilted trough west of British Columbia.

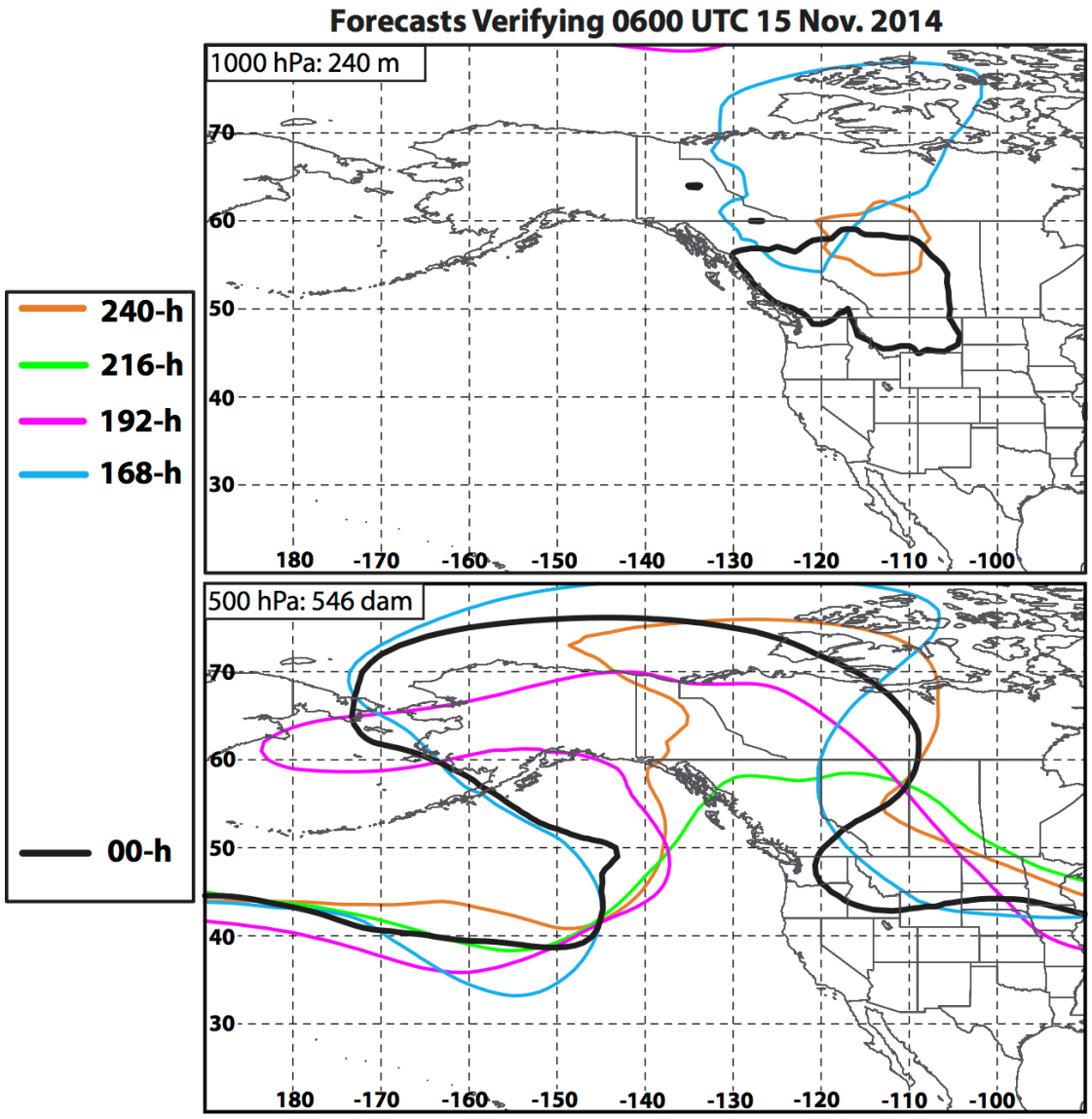
144-h forecast:

First indication of strong anticyclone (>300 m) east of the Rockies.

Coincides with better resolution of the eastern side of the omega block.

Forecasts improve once Nuri's ET occurs

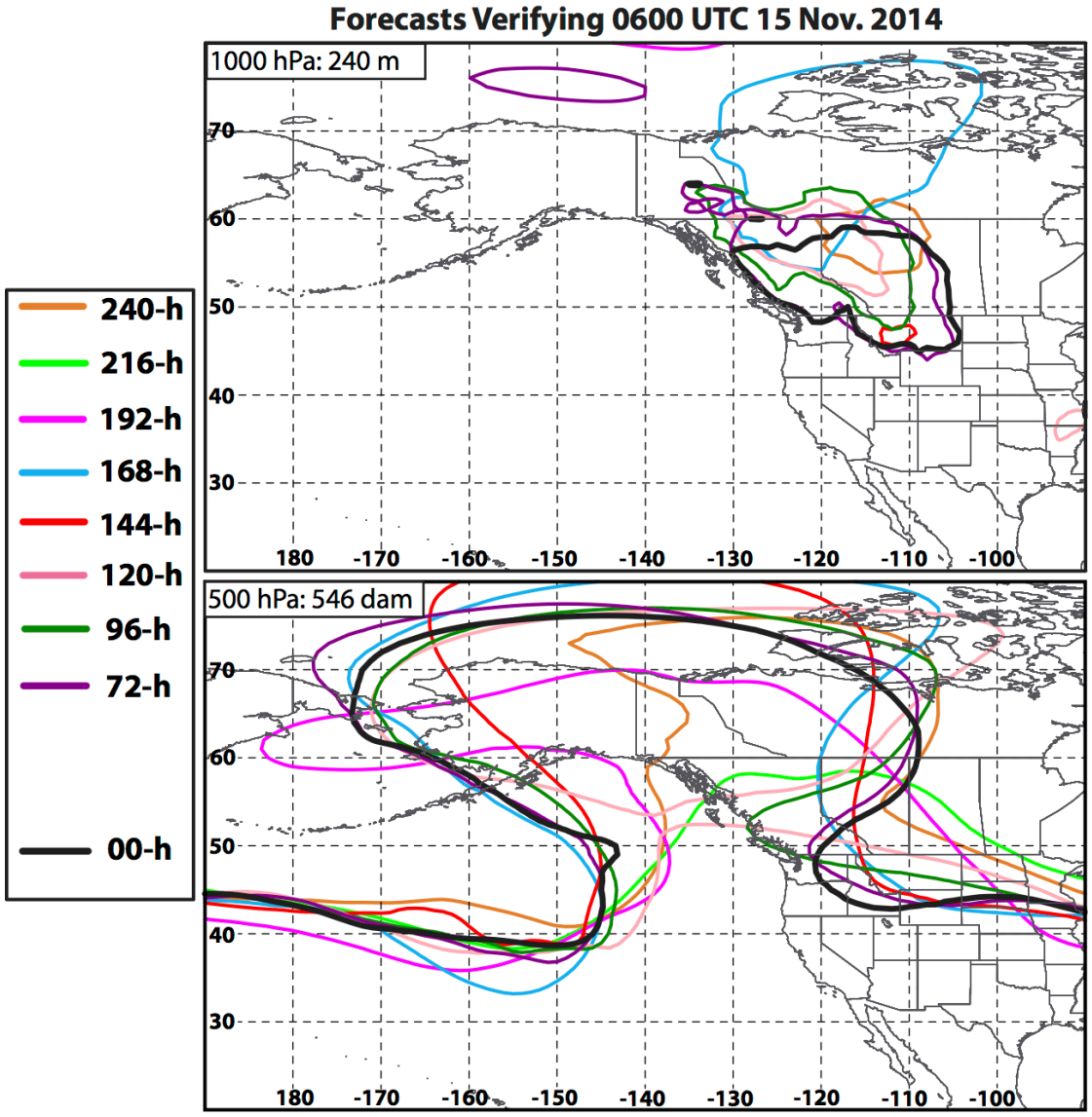
Eastern N. Pacific Ridge – 15 Nov.



168-h Forecast:

Once Nuri reached its minimum SLP, forecasts begin to resolve 500 hPa trough over the Pacific Northwest.

Eastern N. Pacific Ridge – 15 Nov.



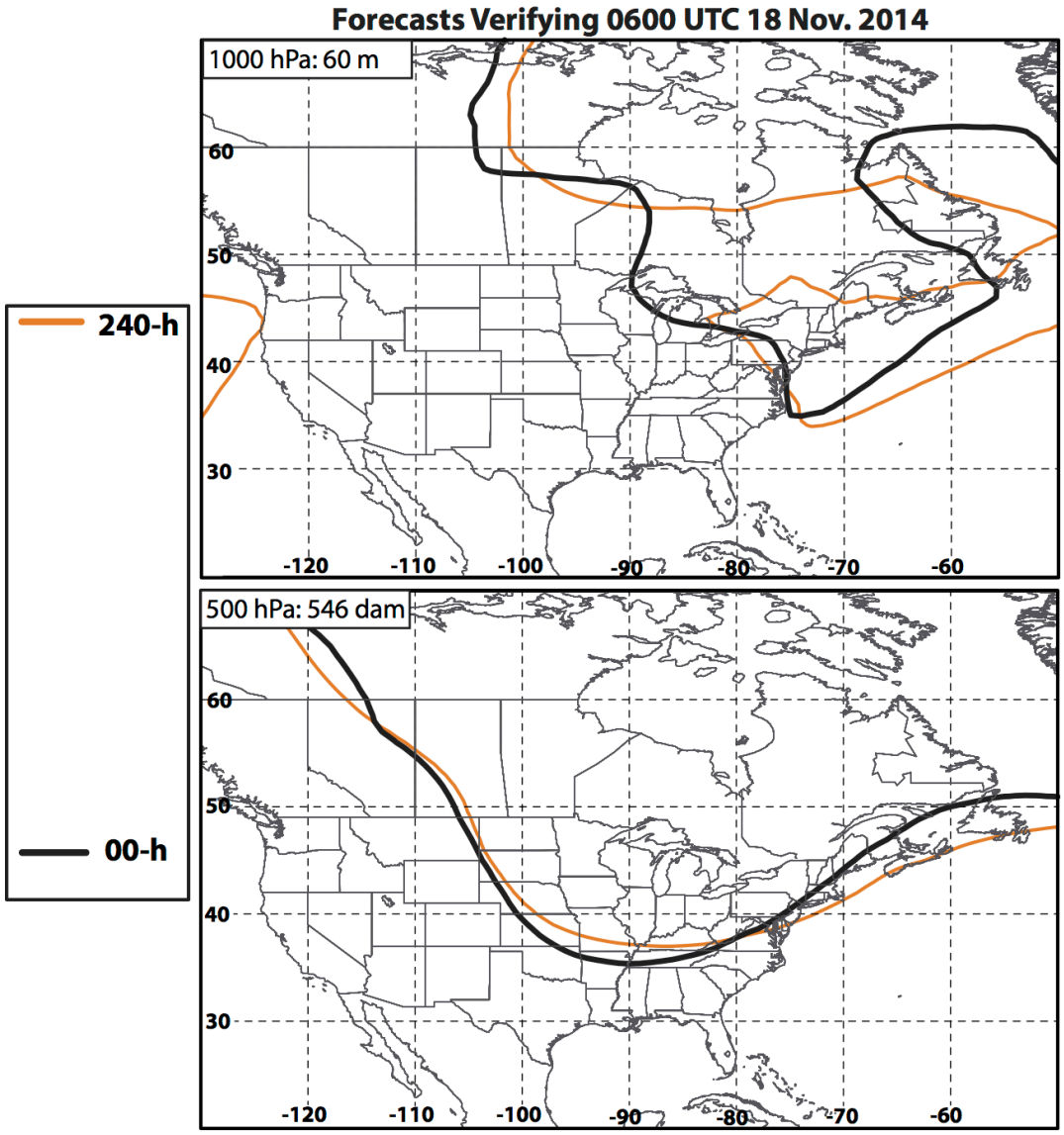
168-h Forecast:

Once Nuri reached its minimum SLP, forecasts begin to resolve 500 hPa trough over the Pacific Northwest.

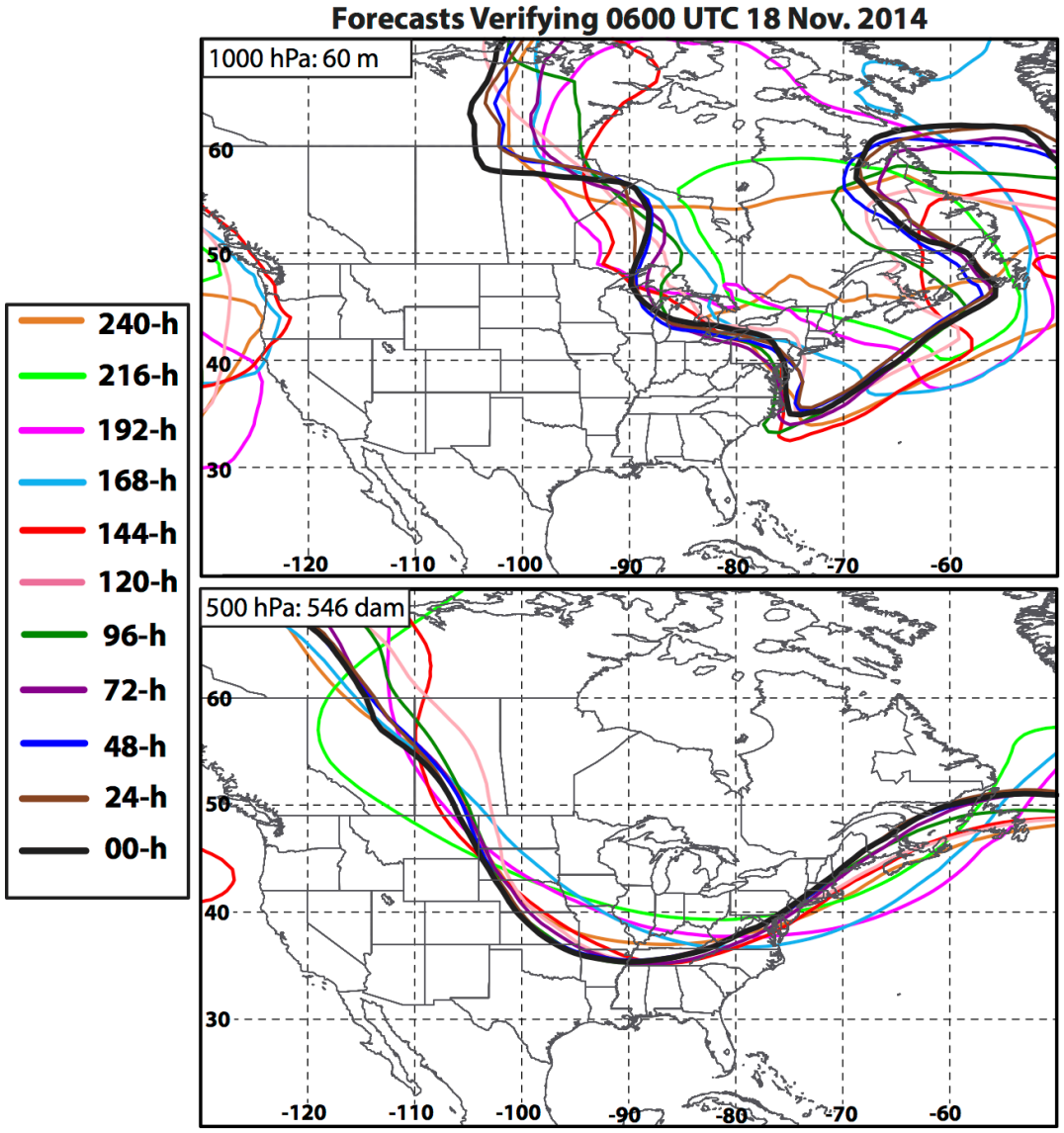
120-h Forecast:

Once ridge building begins, forecasts better resolve 1000 hPa anticyclone and 500 hPa ridge.

Buffalo Snow Event – 18 Nov.



Buffalo Snow Event – 18 Nov.



144-h Forecast:

Phase of upper-level trough becomes better established.

This forecast initialized on 12 Nov., when eastern N. Pacific ridge well established.

Model forecasts appear to show strongest agreement on this forecast compared to the previous diagrams.

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 whether or not EWEs occur**

Conclusions

- **The ET/EC of STY Nuri in Nov 2014 reconfigured the downstream flow, enabled Omega block formation, and allowed artic air to reach the CONUS**

- **Week two predictability was relatively low before STY Nuri's ET/EC and relatively high subsequent to downstream Omega block formation**

- **The variability of the limit of atmospheric predictability as a function of weather regime and synoptic situation needs to be better understood and appreciated**