An Investigation of the Skill of Week Two Temperature and Precipitation Forecasts in the Context of Two Recent Extreme Weather Events

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Motivation

- One or several extreme weather events (EWEs) during a single season can contribute disproportionately to temperature and precipitation anomaly statistics for that particular season.
- EWEs need to be considered in describing and understanding the dynamical and thermodynamic processes that operate at the weather–climate intersection and in constructing operational probabilistic temperature and precipitation forecasts for the 8–10-day time period.
- This study identifies the governing atmospheric flow patterns that were essential to the evolution of two recent EWEs over the continental U.S.:
  - **The 22–23 Dec 2013 ice storm that impacted the northeastern U.S.**
  - **The record cold during Nov 2014 that followed the extratropical transition (ET) of SuperTyphoon (STY) Nuri**

  and evaluates the skill of the NCEP Global Ensemble Forecast System (GEFS) in forecasting these events.

Data

- 1.0º x 1.0º NCEP Global Forecast System (GFS) analyses (available every 6-h) archived at the University at Albany, SUNY.
- 0.5º x 0.5º NCEP GEFS forecasts (available every 6-h) from the THORPEX Interactive Grand Global Ensemble dataset, which is archived at the European Centre for Medium-Range Weather Forecasts.

Conclusions

22–23 Dec 2013 Ice Storm

- The GEFS ensemble spread for 1200 UTC 22 Dec decreased sharply in forecasts with a lead time less than 96-h.
- The 96-h forecast verifying at 1200 UTC 22 Dec was initialized in the midst of an AWB event in the eastern N. Pacific.
- GEFS forecasts with a lead time less than 96-h more accurately depicted the development of a trough over the central U.S.
- The strength/position of the baroclinic zone over the northeast U.S. was consistent in forecasts with a lead time less than 96-h.
- Strong frontogenesis along the baroclinic zone aided in the production of frozen precipitation during the event.

Nov 2014 Cold / ET of STY Nuri

- GEFS forecasts with a lead time less than 168-h suggested that Nuri would reintensify by 0600 UTC 8 Nov.
- GEFS forecasts were highly dependent on the phasing of Nuri with a trough east of Japan at 0600 UTC 7 Nov.
- The ET of Nuri resulted in the downstream development of a trough over the central N. Pacific.
- This trough aided in the development of an omega block over the eastern N. Pacific that persisted for most of Nov 2014.
- The omega block subsequently facilitated the advection of a series of arctic air masses into the central and eastern U.S.

22–23 Dec 2013 Ice Storm

- Significant ice accumulations across the northeast U.S. occurred along a strong baroclinic zone and in the entrance region of an intense polar jet (Fig. 1d).
- The development of the surface cyclone was aided by a trough that propagated into the central U.S. by 1200 UTC 22 Dec (Figs. 1b,c,d).
- This trough developed in response to an anticyclonic wave breaking (AWB) event over the eastern N. Pacific on 18–19 Dec (Fig. 1a).

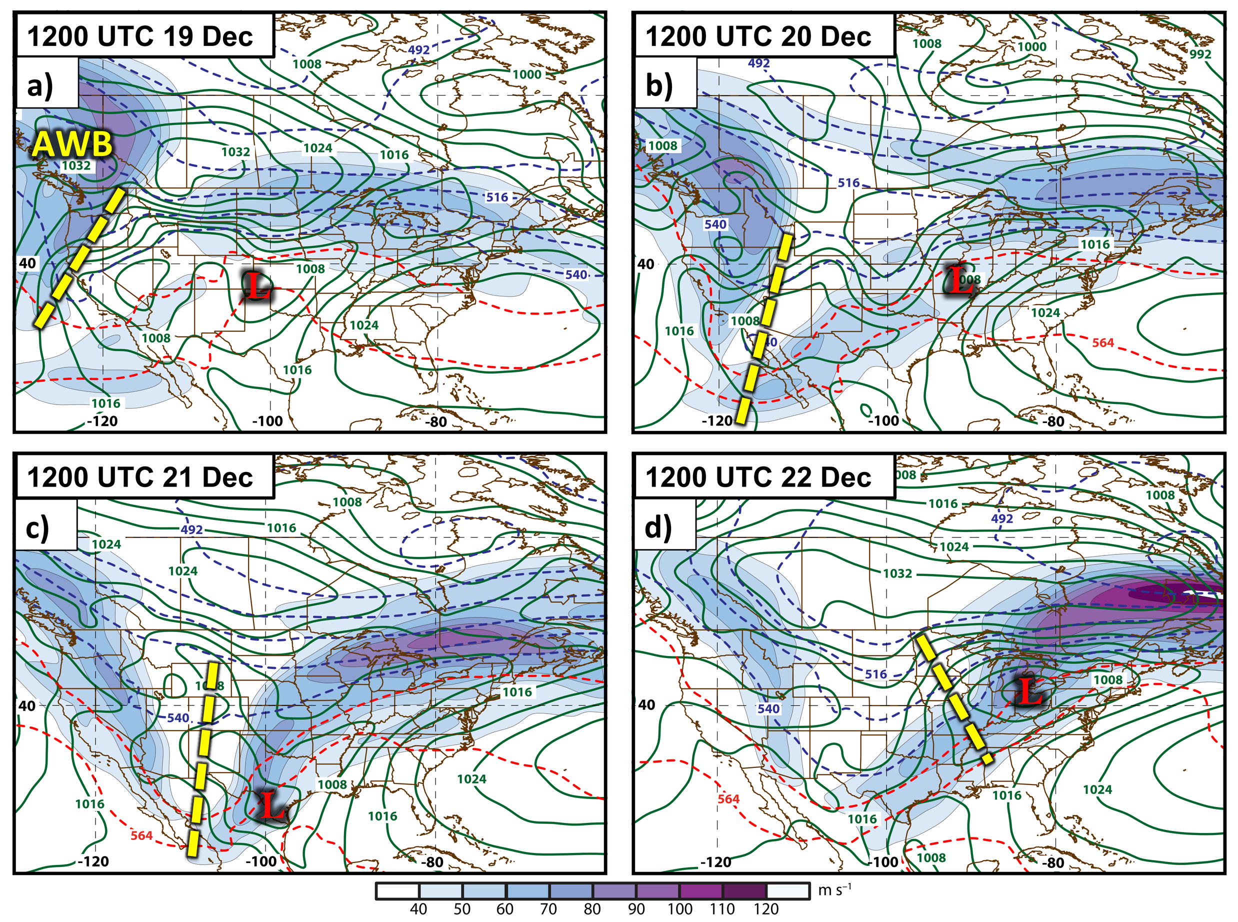
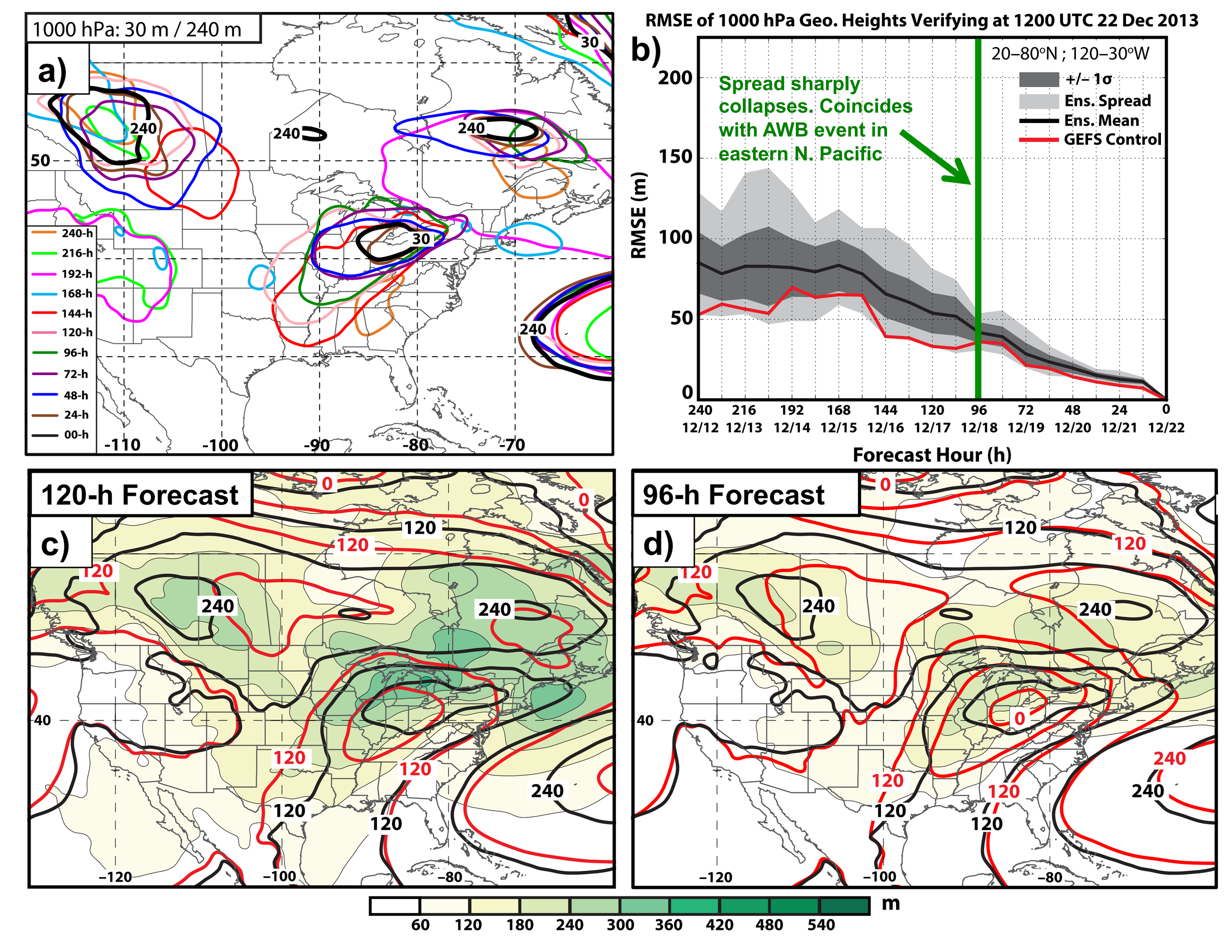


Figure 1: Mean SLP (green), 1000–500 hPa thickness (dashed red/blue), 250 hPa wind speed (fill pattern), and trough axes (yellow dashed) from the GFS analysis.

*Figure 2: **(a)** The forecasted position of the 30 and 240 m geo. height contours at 1000 hPa within a series of GEFS control forecasts verifying at 1200 UTC 22 Dec 2013. **(b)** Root-mean-square error of GEFS forecasts of 1000 hPa geo. height verifying at 1200 UTC 22 Dec 2013. **(c)** The GEFS ensemble mean 120-h forecast of 1000 hPa geo. height verifying at 1200 UTC 22 Dec 2013 (red), the ensemble spread in the GEFS 120-h forecast of 1000 hPa geo. height verifying at 1200 UTC 22 Dec 2013 (fill pattern), and the analyzed 1000 hPa geo. height at 1200 UTC 22 Dec 2013 (black). **(d)** As in (c) but for the 96-h forecast.*



- Sharp decrease in the ensemble spread for forecasts verifying at 1200 UTC 22 Dec with a lead time less than 96-h (Fig. 2b).
- The ensemble spread, which resulted from differences in the evolution of the central U.S. trough among ensemble members, reflected uncertainty in the position of the surface cyclone (Figs. 2c,d).
- GEFS control forecasts verifying at 1200 UTC 22 Dec persistently struggled to accurately depict the strength and position of the surface cyclone (Fig. 2a).

- Forecasts with a lead time less than 96-h positioned a stronger trough and ridge over the central and eastern U.S., respectively, at 1200 UTC 22 Dec (Figs. 3a,c,e,g).
- The stronger ridge over the eastern U.S. in forecasts with a lead time less than 96-h was also associated with a poleward shift in the position of the baroclinic zone over the northeast U.S. (Figs. 3b,d,f,h).
- Forecasts with a lead time less than 96-h progressively indicated stronger baroclinicity east of the surface cyclone (Figs. 3b,d,f,h).
- The stronger baroclinicity was characterized by strengthened frontogenesis in forecasts with a lead time less than 96-h (Figs. 3b,d,f,h).
- The position of the baroclinic zone had important ramifications for the type and amount of precipitation that locations would receive.

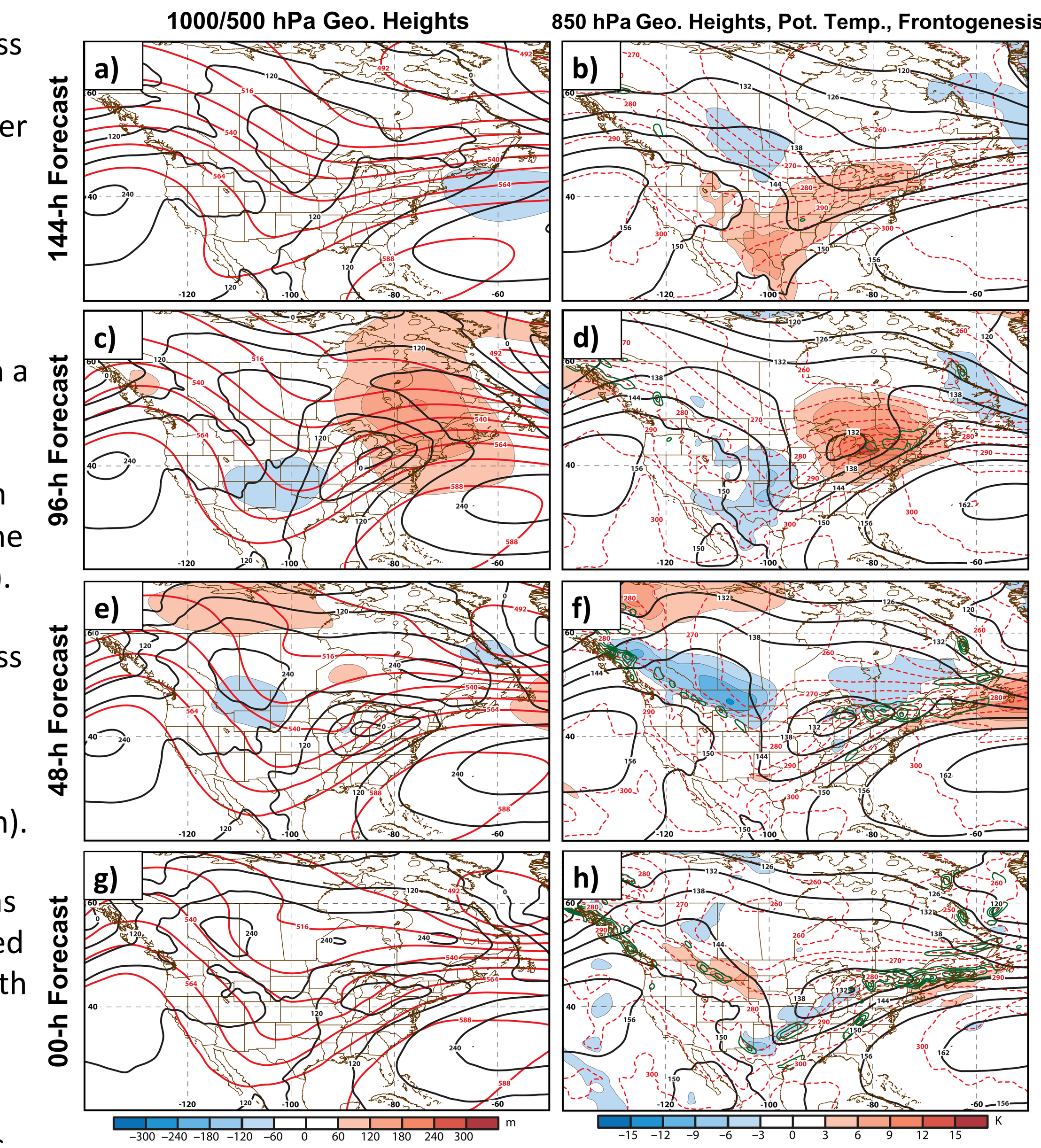


*Figure 3: **[a,c,e,g]** GEFS ensemble mean forecasts of 1000 hPa geo. height (black) and 500 hPa geo. height (red) verifying at 1200 UTC 22 Dec 2013. The difference between 500 hPa geo. height at the identified forecast time and geo. height in the forecast initialized 48-h earlier is shaded. **[b,d,f,h]** GEFS ensemble mean forecasts of 850 hPa height (black), pot. temp. (dashed red), and frontogenesis (green) verifying at 1200 UTC 22 Dec 2013. The difference between 850 hPa pot. temp. at the identified forecast time and pot. temp. in the forecast initialized 48-h earlier is shaded.*

Nov 2014 Cold / ET of STY Nuri

- Nuri interacted with a trough east of Japan on 7 Nov and deepened to 924 hPa at 0600 UTC 8 Nov following ET (Fig. 4).
- Nuri aided in establishing an omega block over the eastern N. Pacific that persisted for most of Nov 2014.
- The persistent omega block facilitated the advection of a series of arctic air masses into the central and eastern U.S. in mid-to-late Nov 2014.
- The cold temperatures over N. America stood in contrast to long-range forecasts of above-normal temperatures for much of the U.S. during Nov 2014.

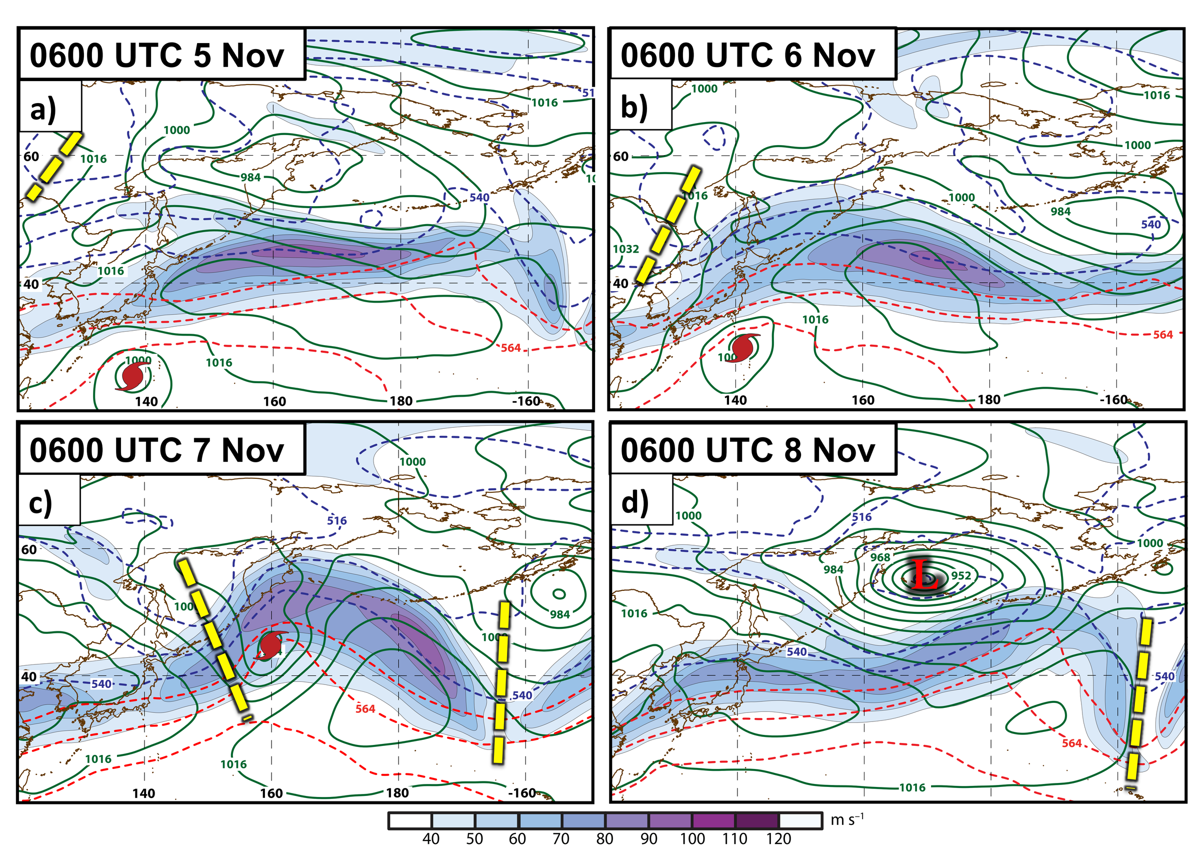
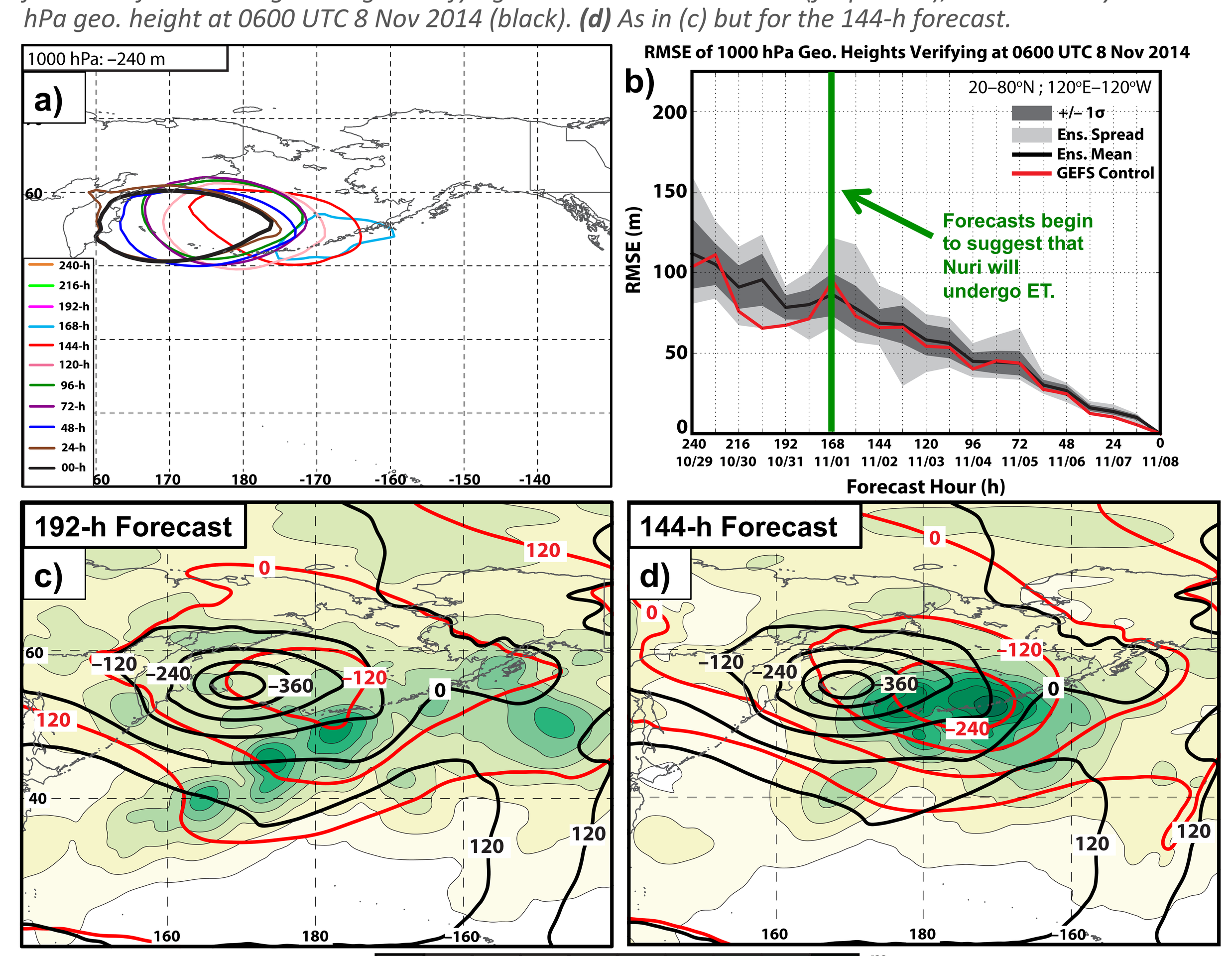


Figure 4: Mean SLP (green), 1000–500 hPa thickness (dashed red/blue), 250 hPa wind speed (fill pattern), and trough axes (yellow dashed) from the GFS analysis.

*Figure 5: **(a)** The forecasted position of the –240 m geo. height contour at 1000 hPa within a series of GEFS control forecasts verifying at 0600 UTC 8 Nov 2014. **(b)** Root-mean-square error of GEFS forecasts of 1000 hPa geo. height verifying at 0600 UTC 8 Nov 2014. **(c)** The GEFS ensemble mean 192-h forecast of 1000 hPa geo. height verifying at 0600 UTC 8 Nov 2014 (red), the ensemble spread in the GEFS 192-h forecast of 1000 hPa geo. height verifying at 0600 UTC 8 Nov 2014 (fill pattern), and the analyzed 1000 hPa geo. height at 0600 UTC 8 Nov 2014 (black). **(d)** As in (c) but for the 144-h forecast.*



- Forecasts verifying at 0600 UTC 8 Nov with a lead time less than 168-h suggested Nuri would reintensify to a level comparable with that shown in Fig. 4d (Figs. 5a,b).
- In the 192-h forecast, ensemble members showed Nuri interacting with upper-level zonal flow, with large differences in the degree to which Nuri reintensifies in that upper-level zonal flow (Fig. 5c).
- In the 144-h forecast, ensemble members showed Nuri interacting with a trough east of Japan, with large differences in the details of that interaction (Fig. 5d).

- Forecasts of Nuri's interaction with the trough east of Japan at 0600 UTC 7 Nov depicted a deeper trough over the central N. Pacific at lead times less than 144-h (Figs. 6a,c,e,g).
- This central N. Pacific trough aided in the development of a persistent omega block in the eastern N. Pacific.
- Forecasts with a lead time less than 96-h indicated a deeper trough east of Japan and a favorable environment for the ET of Nuri (Figs. 6a,c,e,g).
- Forecasts with a lead time less than 96-h also showed stronger irrotational outflow from Nuri, which promoted stronger ridge building at 250 hPa (Figs. 6b,d,f,h).
- The inability of forecasts to capture Nuri's interaction with the trough east of Japan at 0600 UTC 7 Nov resulted in significant changes to the forecasted intensity and position of Nuri at 0600 UTC 8 Nov (Fig. 5a).

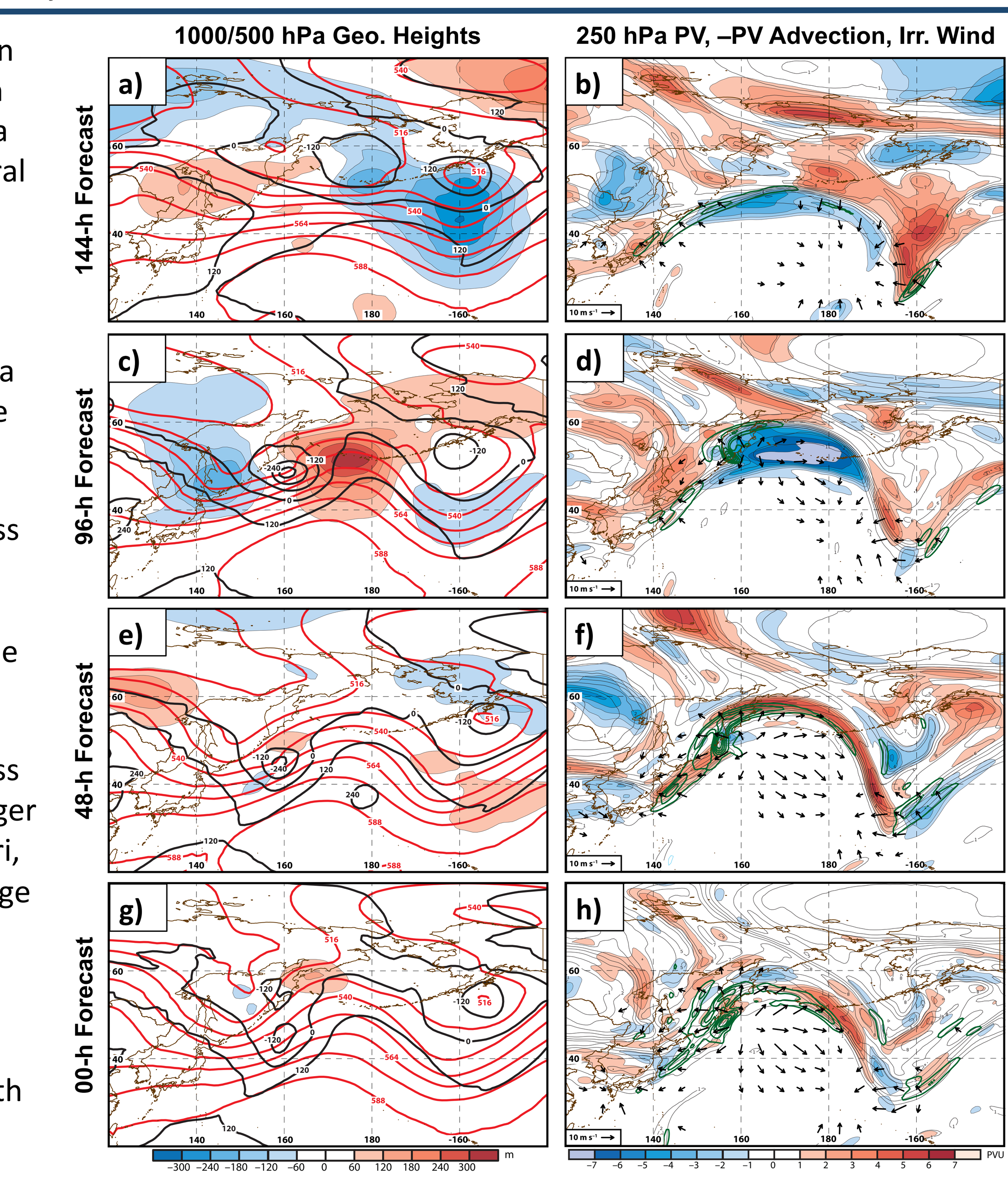


*Figure 6: **[a,c,e,g]** GEFS control forecasts of 1000 hPa geo. height (black) and 500 hPa geo. height (red) verifying at 0600 UTC 7 Nov 2014. The difference between 500 hPa geo. height at the identified forecast time and geo. height in the forecast initialized 48-h earlier is shaded. **[b,d,f,h]** GEFS control forecasts of 250 hPa PV (black), neg. PV adv. (green), and irrotational wind (vectors) verifying at 0600 UTC 7 Nov 2014. The difference between 250 hPa PV at the identified forecast time and PV in the forecast initialized 48-h earlier is shaded.*