Composite Analyses of Low-Skill Arctic Cyclones During Summer

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1) Background

- Arctic cyclones (ACs) are synoptic-scale low pressure systems that frequently form over the Arctic or move into the Arctic from Eurasia during summer (e.g., Crawford and Sienze 2016).
- Interactions between ACs and the synoptic-scale flow over the Arctic, baroclinic processes, and latent heating may influence the evolution of ACs and the synoptic-scale flow over the Arctic (e.g., Tao et al. 2017; Yamagami et al. 2017).
- It is anticipated that relatively low forecast skill of ACs and the synoptic-scale flow over the Arctic may be attributed in part to forecast error growth accompanying interactions between ACs and the synoptic-scale flow over the Arctic, baroclinic processes, and latent heating.
- The purpose of this study is to examine dynamical and thermodynamic quantities characterizing the Arctic environment and low-skill ACs during periods of low and high forecast skill of the synoptic flow over the Arctic.

2) Data and methods

Evaluation of Arctic forecast skill

- Utilize day-5 forecasts of 500-hPa geopotential height initialized at 0000 UTC during June, July, and August of 2007–2017 from 11-member GEFS reforecast dataset v2 (Hamill et al. 2013). Calculate standard deviation of area-averaged root mean square error (RMSE; ERA-Interim used as verification) of 500-hPa geopotential height over the Arctic (≥70°N) following Moore (2017).
- Refer to forecasts initialized five days prior to low-skill days and high-skill days as low-skill forecasts and high-skill forecasts, respectively.
- Refer to forecasts initialized five days prior to low-skill days and high-skill days as low-skill forecasts and high-skill forecasts, respectively.
- Refer to time periods through day 5 encompassed by low-skill forecasts and high-skill forecasts as low-skill periods and high-skill periods, respectively.
- Identify low-skill ACs

3) Quantities characterizing the Arctic environment

- Create a 2007–2017 summer AC climatology by obtaining cyclone tracks from 1 ERA-Interim (Dee et al. 2011) cyclone climatology prepared by Sprenger et al. (2017), and requiring cyclones to last ≥2 days and spend at least some portion of their lifetimes in the Arctic (≥70°N).
- Track ACs in forecasts from GEFS reforecast dataset v2 initialized 120 h prior to time of lowest sea level pressure (SLP) of ACs when located in the Arctic during low-skill periods and high-skill periods using an objective cyclone tracking algorithm (Crawford et al. 2020).
- Calculate 120-h intensity RMSE (ERA-Interim used as verification) based on minimum SLP of ACs as aforementioned time of lowest SLP, and refer to ACs associated with the top 25% of 120-h intensity RMSE for low-skill periods and high-skill periods, respectively.

4) Quantities characterizing low-skill ACs

- Table 1. Area-averaged 500-800-hPa Eady growth rate (day−1), higher values of IVT (Fig. 1c), and higher values of upper-tropospheric divergence (Fig. 1f) likely contribute to these ACs being statistically significantly strong (Fig. 2a).
- The aforementioned latent heating and statistically significantly high values of lower-to-midtropospheric Eady growth rate surrounding low-skill ACs during low-skill periods (Fig. 2c) likely contribute to these ACs being statistically significantly strong (Fig. 2a).
- Forecast error growth that may accompany 1) the interaction of low-skill ACs during low-skill periods with the synoptic-scale flow, 2) baroclinic processes (related to Eady growth rate), and 3) latent heating may contribute to the low forecast skill of these ACs and to the statistically significantly low forecast skill of the synoptic-scale flow surrounding these ACs (Fig. 2g).
- An example low-skill AC during a low-skill period intensifies in a region of strong baroclinicity (Fig. 3a) downstream of a midtropospheric vorticity maximum (Fig. 3b) as the AC interacts with moderately amplified synoptic flow (Fig. 3c; Table 1).
- Relatively high lower-to-midtropospheric Eady growth rates associated with the strong baroclinicity (Fig. 3d, Table 1), midtropospheric forcing for ascent (suggested by Fig. 3b), upper-tropospheric jet coupling (Fig. 3a), and relatively high values of IVT (Fig. 3c; Table 1) likely support the relatively high values of lower-to-midtropospheric ascent and upper-tropospheric divergence in the vicinity of the example low-skill AC (Fig. 3c; Table 1) and the concomitant intensification of the AC.
- The most extreme values of the quantities for the example low-skill AC given in Table 1 are high with respect to the corresponding distributions for low-skill ACs during low-skill periods given in Fig. 2.

5) Example low-skill AC during a low-skill period

- FIG. 3. ERA-Interim analyses valid at 0000 UTC 14 Aug 2016. The cyan dot shows the location of the example low-skill AC occurring at the aforementioned time during a low-skill period, and the 1000-km radius black circle surrounding the location of the AC shows where the area-averaged quantities given in Tables 1 and 2 are calculated.

Table 1. Values of area-averaged quantities including 500-800-hPa Eady growth rate (day−1), higher values of IVT (Fig. 1c), and higher values of upper-tropospheric divergence (Fig. 1f) likely contribute to these ACs being statistically significantly strong (Fig. 2a).

References