A Comparison of the Predictability of Arctic and Atlantic Basin Cyclones

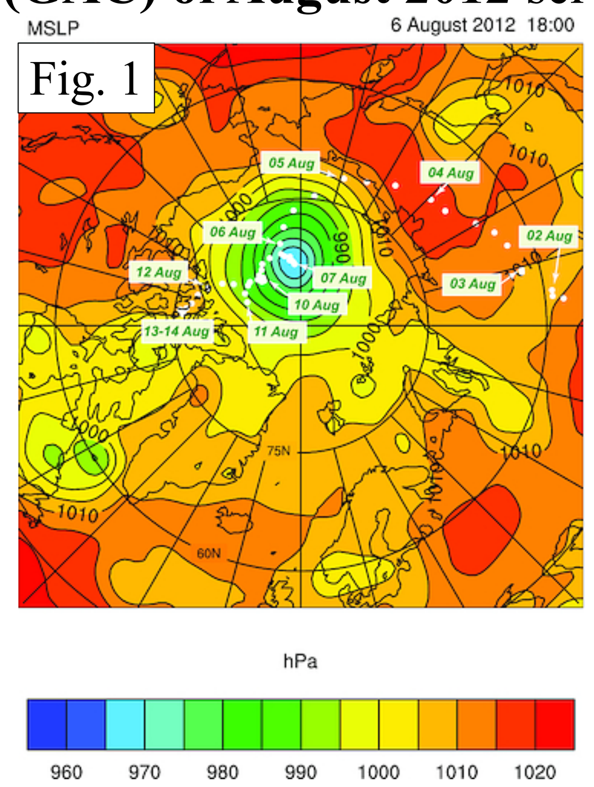
Peyton K. Capute and Ryan D. Torn

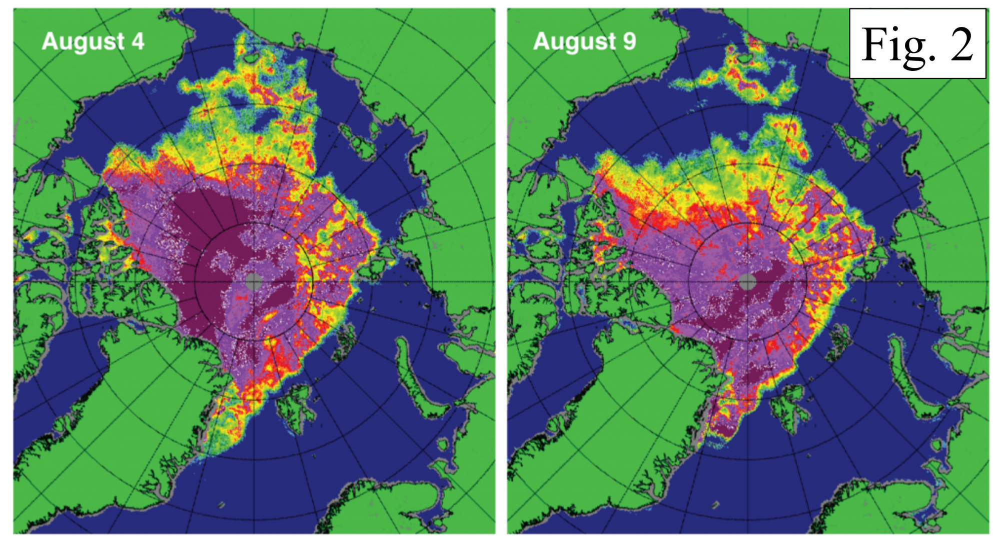
University at Albany, SUNY

UNIVERSITY AT ALBANY
State University of New York

Motivation:

Strong winds associated with Arctic cyclones may contribute to Arctic sea-ice depletion during the summer months (Zhang et al. 2013). This opens the possibility for ocean vessels to travel through the Northwest passage; however, we know very little about the predictability of these features. Therefore, it is important to establish the predictability of Arctic cyclones by comparing to midlatitude Atlantic Basin cyclones. The **Great Arctic Cyclone (GAC) of August 2012** serves as motivation for this project. Figure 1 shows the lifecycle of this cyclone, as it entered the Arctic Ocean from the eastern Siberian coast on August 4th and strengthened to 964 millibars over the central Arctic Ocean on August 6th. Figure 2 illustrates the sea ice concentration before the cyclone passes through the region versus after. It is estimated that sea ice extent dropped by about 200,000 square kilometers (National Snow & Ice Data Center).





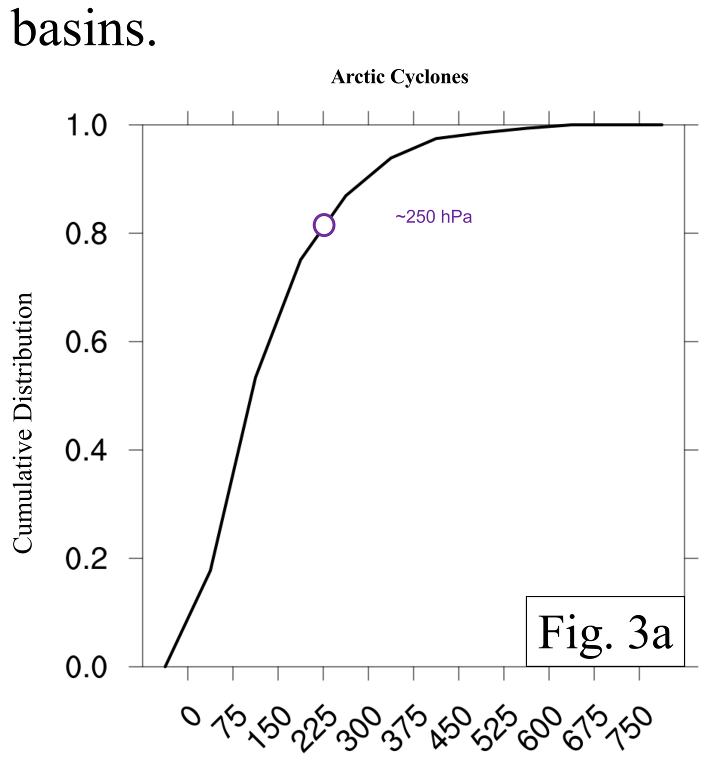
Goal: Use ensemble datasets to compare the uncertainty in Arctic cyclone position and intensity forecasts vs. midlatitude counterparts.

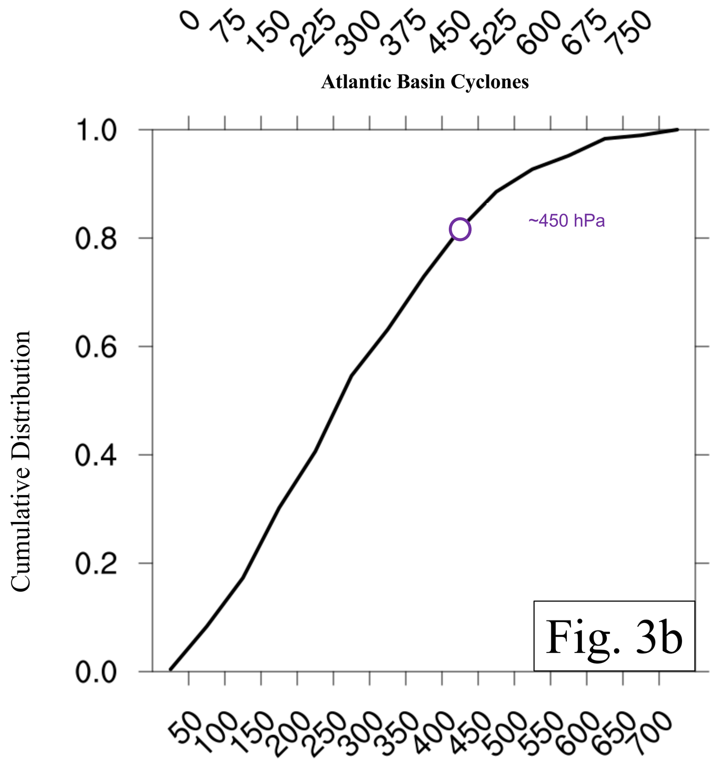
Background:

- There is a much better understanding of the predictability of midlatitude cyclones than Arctic cyclones.
- The dynamics associated with the development of Arctic and midlatitude cyclones share many of the same properties, specifically the formation through baroclinic instability (Simmonds and Rudeva 2012).
- A majority of the strongest Arctic cyclones have been associated with Tropopause Polar Vortices (TPVs), intense tropopause based troughs that can remain in the Arctic for a long duration of time.
- Yamazaki et al. (2015) compared forecasts for the GAC of 2012 with and without special radiosonde observations and found that including the observations yielded better forecasts.

Data and Methodology:

In order to compare Arctic and midlatitude cyclones, it is necessary to identify similar strong cyclones in both basins.





- **Using Sprenger et al. (2017) Cyclone Climatology (6-hourly data):**
  - 32-year climatology (1985-2016)
  - Summer months (Jun - Aug) for the Arctic and Winter months (Nov-Mar) for the Atlantic Basin
  - Cyclone must be tracked for at least 3 days (12 six-hourly periods)
  - Arctic cyclones must be north of 70N for at least 80% of life cycle (ensures cyclones are primarily in the Arctic Ocean and not midlatitude cyclones moving into the Arctic)
  - Atlantic cyclones must undergo cyclogenesis off the East Coast of the United States (cyclogenesis frequency maximum)

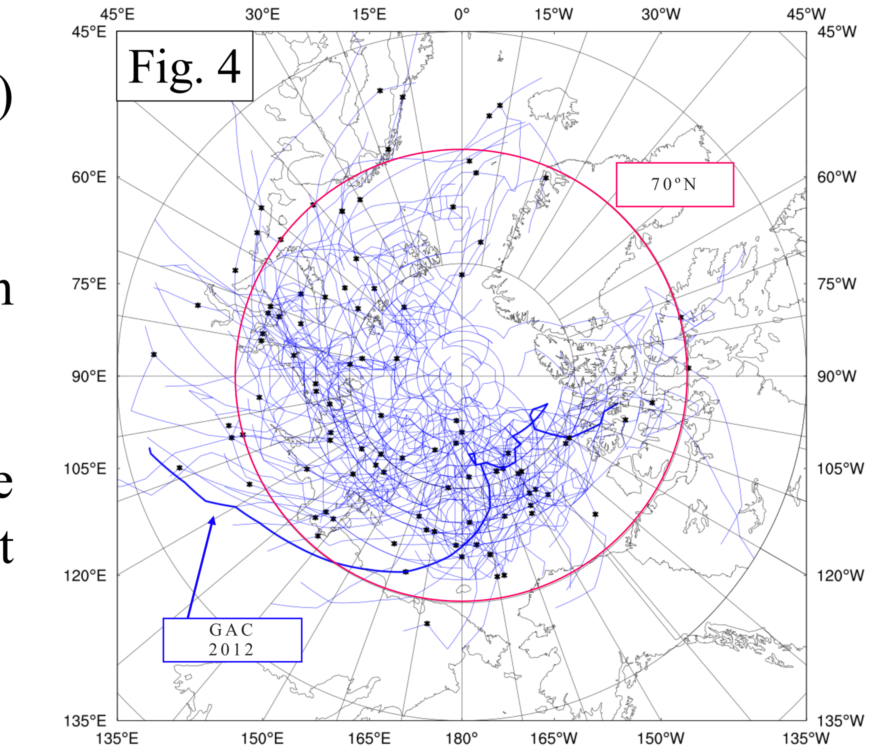
- **To determine strongest cyclones:**
  - Pressure Difference = Last closed contour – cyclone minimum pressure
  - Integrated Pressure Difference $= \frac{\sum pressure\ differences}{total\ number\ of\ periods}$
  - Similar to Accumulated Cyclone Energy (ACE) but using pressure difference, rather than maximum wind speed
- For Arctic cyclones a cyclone pressure ACE of 250-hPa was chosen (Fig. 3a)
- For Atlantic Basin cyclones a cyclone pressure Ace of 450-hPa was chosen (Fig. 3b)

Strongest 80th percentile of Arctic Cyclones and Atlantic Basin Cyclones:

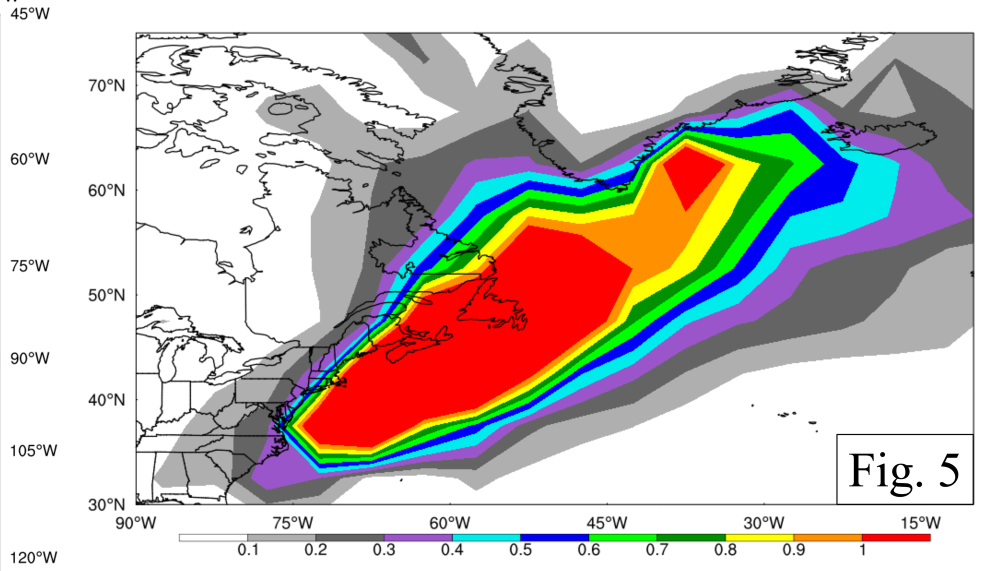
After applying the set of criteria:

- Arctic Cyclones tracks (N=102) are plotted (Fig. 4)
- The GAC of 2012 is denoted in a thicker blue track (Fig. 4)
- The black dots denotes when the pressure difference reached at least 12-hPa (Fig. 4)

Arctic Cyclones



Atlantic Basin Cyclones



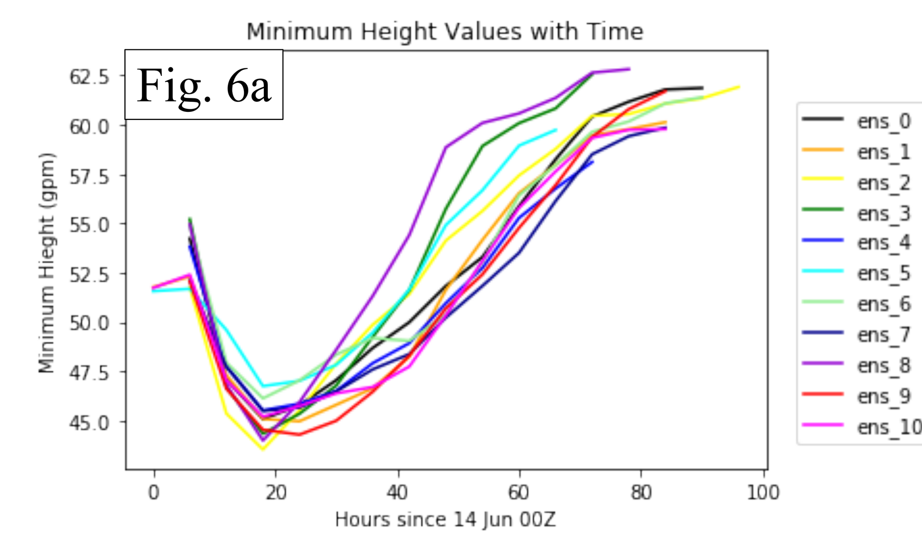
Position Density of Atlantic Cyclones selected by the above method (units: cyclones per year).

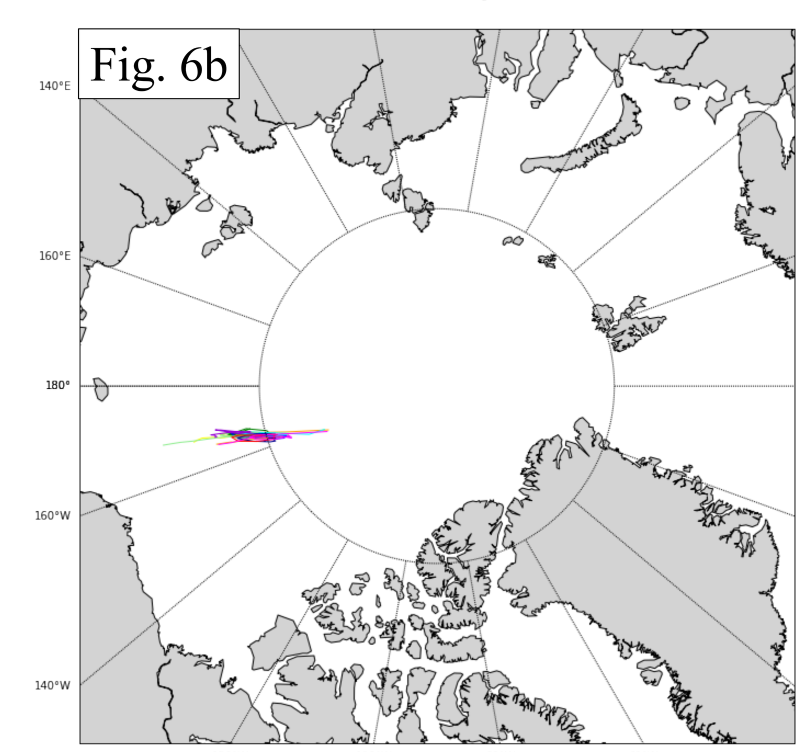
Arctic Cyclone Case and Atlantic Basin Cyclone Case Ensemble Tracks

Using NCEP Global Ensemble Forecasting System (GEFS) Reforecast Data:

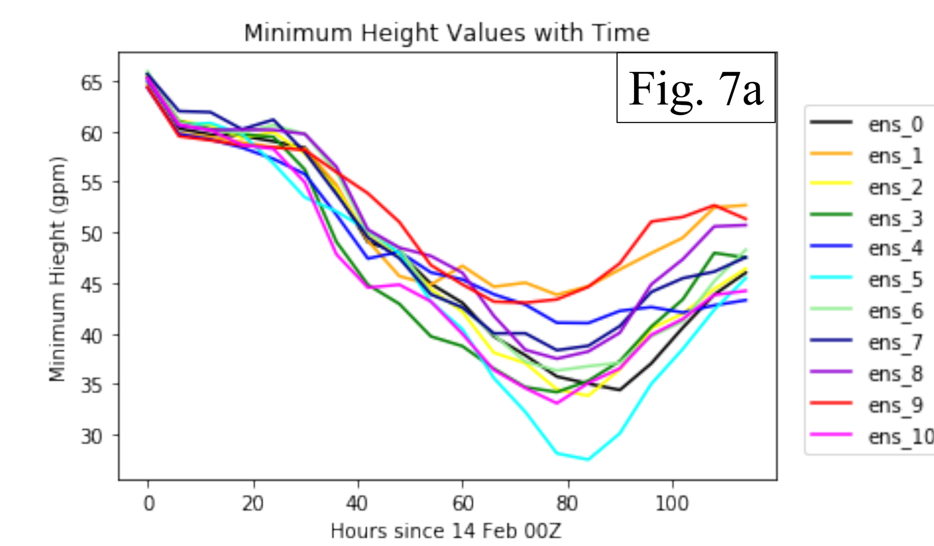
- 11 ensemble members (control + 10 perturbed members)
- Initialized each day at 0000 UTC over same period
- Cyclones tracked via 925-hPa area-averaged vorticity
- Initialization time: timestep reaches a pressure difference of at least 12-hPa

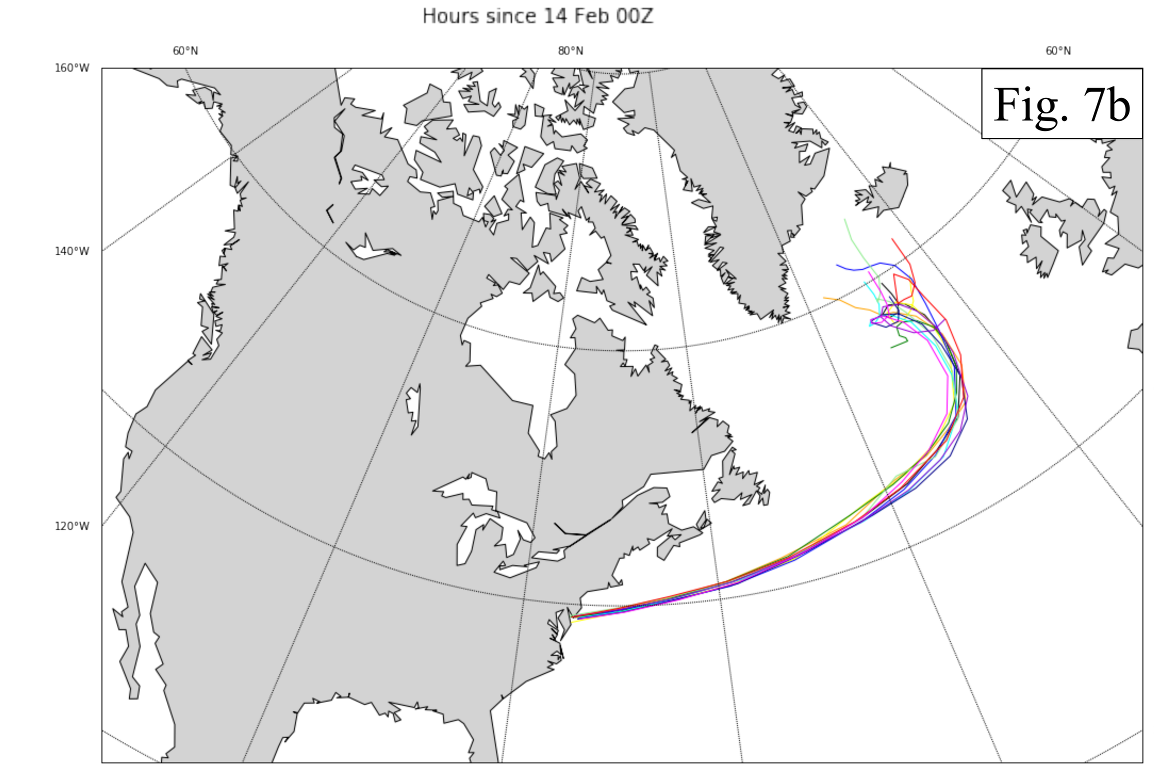
14 June 1990 Arctic Cyclone





14 February 2013 Atlantic Basin Cyclone





Conclusions and Future Work:

- Use NCEP GEFS reforecast data to get ensemble forecasts for all 100 Arctic cyclones and 130 Atlantic Basin cyclones that were selected using the criteria described here.
- Test whether Arctic cyclones have lower average predictability by computing the mean cyclone position and intensity standard deviation for Arctic cyclones vs. midlatitude cyclones in the Atlantic Basin as a function of lead time
- Longer term: Use an ensemble-based sensitivity method to analyze what processes limit Arctic cyclone predictability for cases that are characterized by larger position or intensity uncertainty

***Acknowledgements*:** Funding was provided by the Office of Naval Research (ONR)

References: National Snow & Ice Data Center: http://nsidc.org/arcticseaicenews/2012/08/a-summer-storm-in-the-arctic/
Simmonds, I., and I. Rudeva, 2012: The great Arctic cyclone of August 2012. *Geophys. Res. Lett.,* **39,** L23709.
Sprenger, M., G. Fragkoulidis, H. Binder, M. Croci-Maspoli, P. Graf, C.M. Grams, P. Knippertz, E. Madonna, S. Schemm, B. Škerlak, and H. Wernli, 2017: Global Climatologies of Eulerian and Lagrangian Flow Features based on ERA-Interim. *Bull. Amer. Meteor. Soc.,* **98**, 1739–1748,
Yamazaki, A., J. Inoue, K. Dethloff, M. Maturilli, and G. König-Langlo, 2015: Impact of radiosonde observations on forecasting summertime arctic cyclone formation. *J. Geophys. Res. Atmos.,* **120,** 3249–3273.
Zhang, J., R. Lindsay, A. Schweiger, and M. Steele, 2013: The impact of an intense summer cyclone on 2012 Arctic sea ice retreat. *Geophys. Res. Lett.,* **40,** 720–726.