Examining the Forecast Skill of the Synoptic-Scale Flow Associated with Arctic Cyclones

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Motivation

- Arctic cyclones (ACs) are synoptic-scale cyclones that originate within the Arctic or move into the Arctic from lower latitudes (e.g., Crawford and Serreze 2016)

- ACs may be associated with the poleward advection of warm, moist air, which can contribute to alterations of the synoptic-scale flow over the Arctic

- It is anticipated that relatively low forecast skill of the synoptic-scale flow over the Arctic may be attributed in part to forecast error growth accompanying alterations of the synoptic-scale flow induced by ACs

Purpose

- Investigate whether there are differences in the frequency, location, and intensity of ACs, and in the synoptic-scale flow patterns associated with ACs, between periods of low and high forecast skill of the synoptic-scale flow over the Arctic

Data and Methods: AC Identification

- Created a 2007–2017 AC climatology by obtaining cyclone tracks from 1° ERA-Interim (Dee et al. 2011) cyclone climatology prepared by Sprenger et al. (2017)

- ACs are deemed cyclones that last ≥ 2 d and spend at least some portion of their lifetimes in the Arctic (> 70°N)

Data and Methods: Forecast Skill Evaluation

- Utilized forecasts of 500-hPa geopotential height initialized at 0000 UTC during 2007–2017 from 11-member GEFS reforecast dataset v2 (Hamill et al. 2013)

- Calculated area-averaged ensemble forecast spread of 500-hPa geopotential height over the Arctic (≥70°N)

- Calculated area-averaged root mean square error (RMSE) of 500-hPa geopotential height over the Arctic, using ERA-Interim as verification

- Calculated standardized anomaly of area-averaged ensemble spread (σ_{spread}) and of area-averaged RMSE (σ_{RMSE}) following Moore (2017)

Data and Methods: Forecast Skill Evaluation

- Forecast days valid at day 5 associated with the top and bottom 10% of σ_{spread} and σ_{RMSE} are referred to as **low and high skill days,** respectively

- Forecasts initialized five days prior to low and high skill days are referred to as **low and high skill forecasts**, respectively

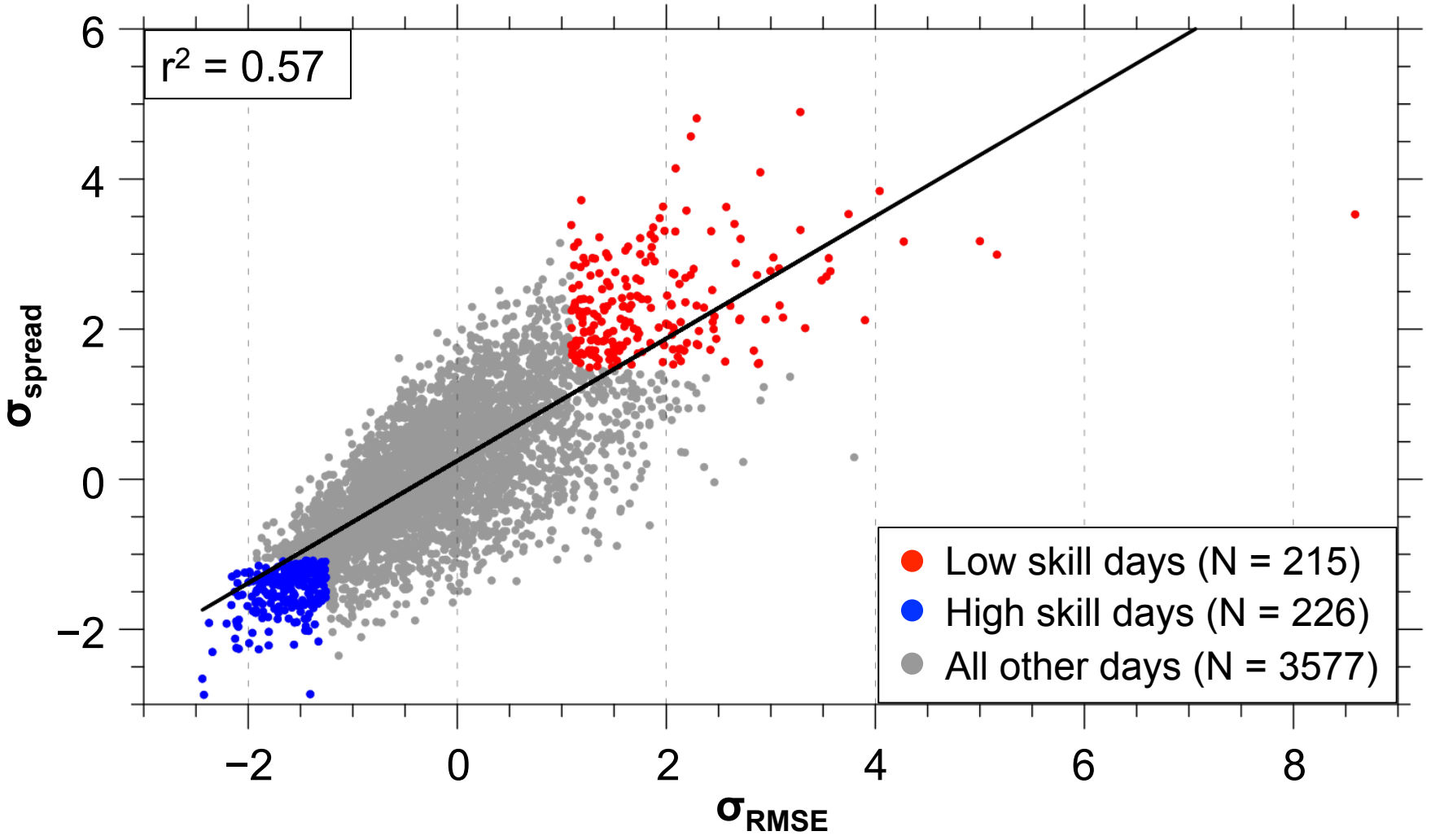
- Time periods through day 5 encompassed by low and high skill forecasts are referred to as **low and high skill periods**, respectively

- ACs that exist in the Arctic (> 70°N) within the low and high skill periods are selected for further analysis

Forecast Skill

- There is greater variability in σ_{spread} and σ_{RMSE} for low skill days compared to high skill days, with some low skill days characterized by very large values of σ_{spread} and σ_{RMSE}

Forecast Skill



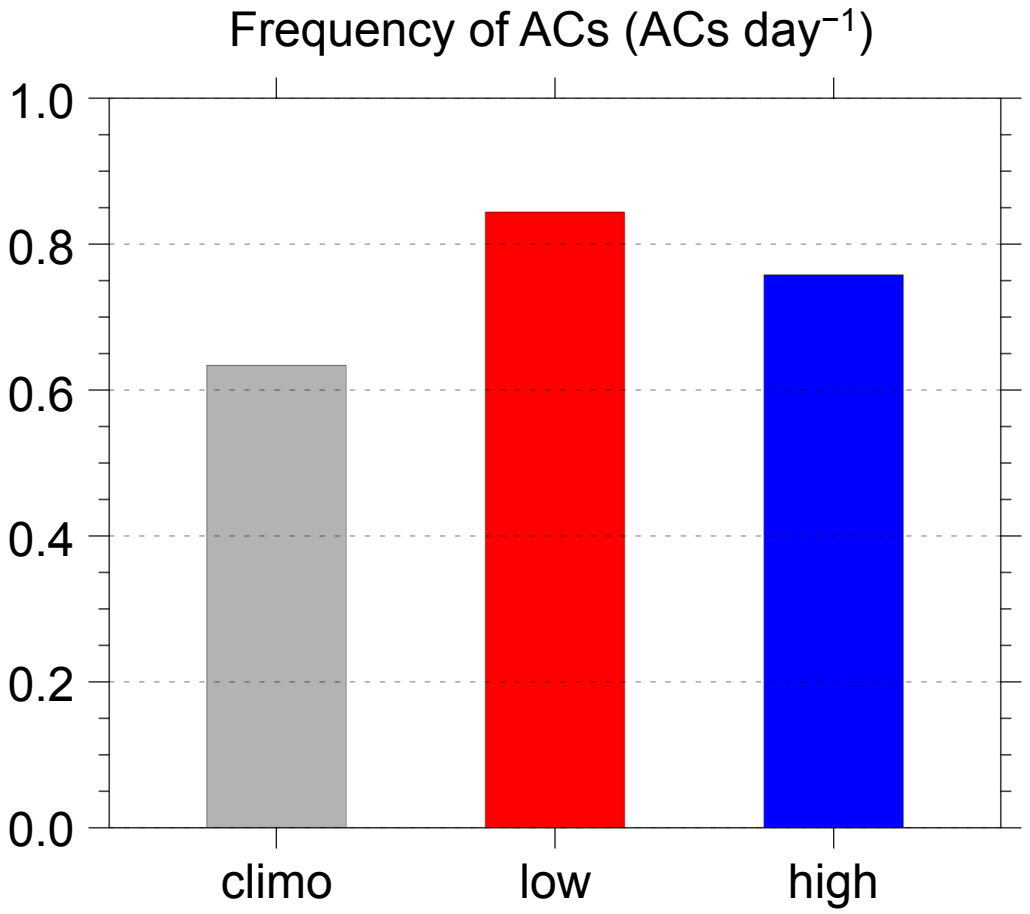
Day-5 σ_{RMSE} and σ_{spread} from low and high skill forecasts valid at 0000 UTC on low skill days (red) and high skill days (blue), respectively, and from all other 2007–2017 forecasts valid at 0000 UTC on all other days (gray)

Number and Frequency of ACs

- AC frequency is higher for low skill periods compared to high skill periods

Number and Frequency of ACs

Period	Number of days in period	Number of ACs in period
Climo	4018	2549
Low skill	801	676
High skill	800	606



Frequency = number of ACs within period / number of days within period

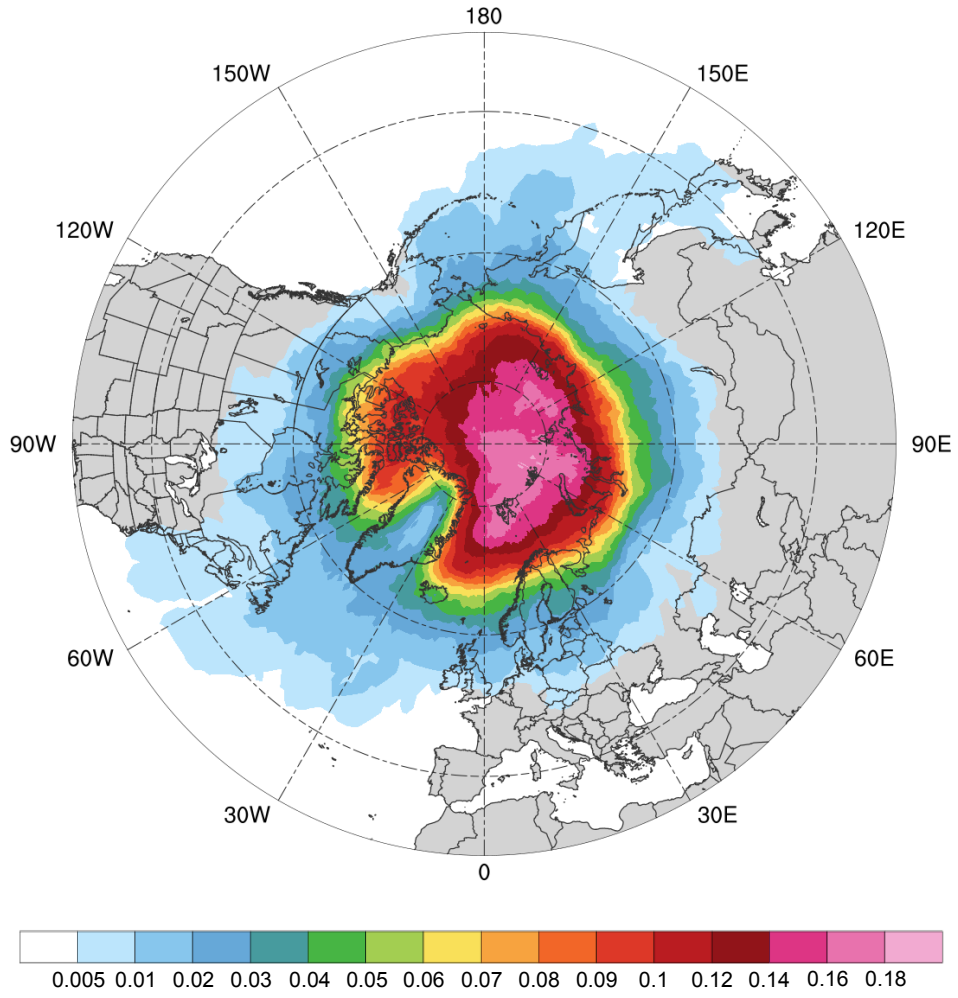
AC Track Frequency

- ACs during low skill periods occur more frequently over eastern Eurasia and much of the Arctic Ocean relative to ACs during high skill periods

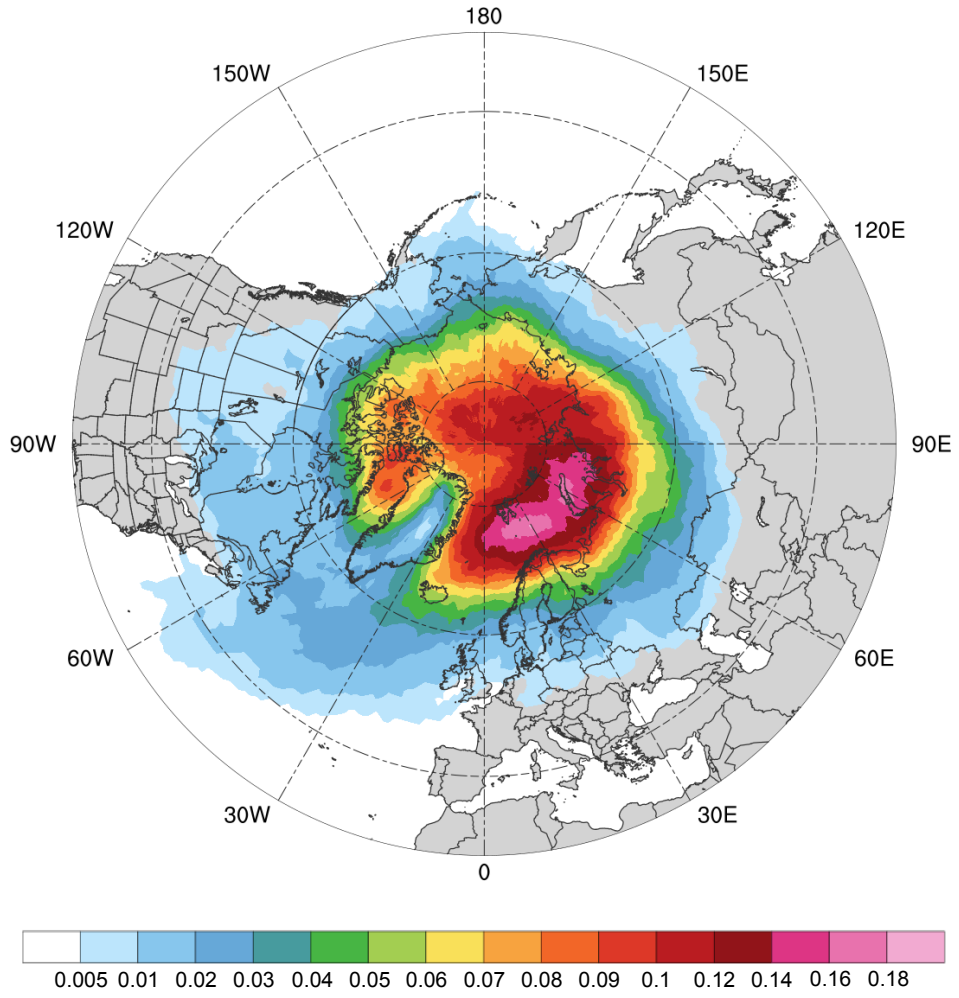
- ACs during high skill periods occur more frequently over the North Atlantic, Barents Sea, and western Eurasia relative to ACs during low skill periods

AC Track Frequency

Low skill (N = 676)

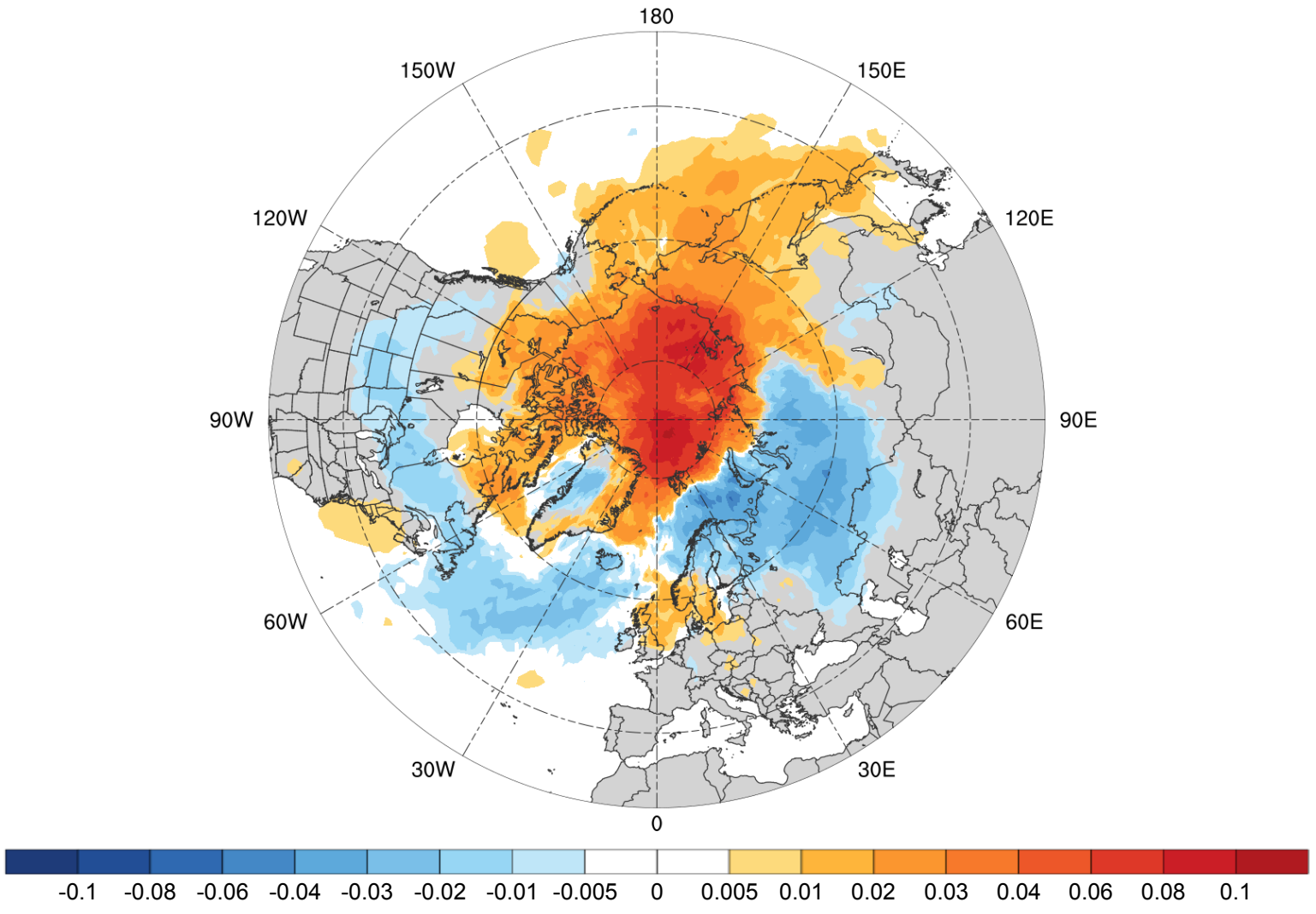


High skill (N = 606)



Total number of ACs within 500 km of a grid point divided by number of days in period (ACs day^{-1})

AC Track Frequency Difference



Flow Amplitude over Arctic

- There tends to be significantly amplified and deamplified synoptic-scale flow over the Arctic relative to climatology during low and high skill periods, respectively

Flow Amplitude over Arctic

- Calculated absolute value of standardized anomaly of 500-hPa v-wind (hereafter σ_v) using ERA-Interim

- Calculated area average of σ_v over the Arctic (≥ 70°N) for low and high skill periods

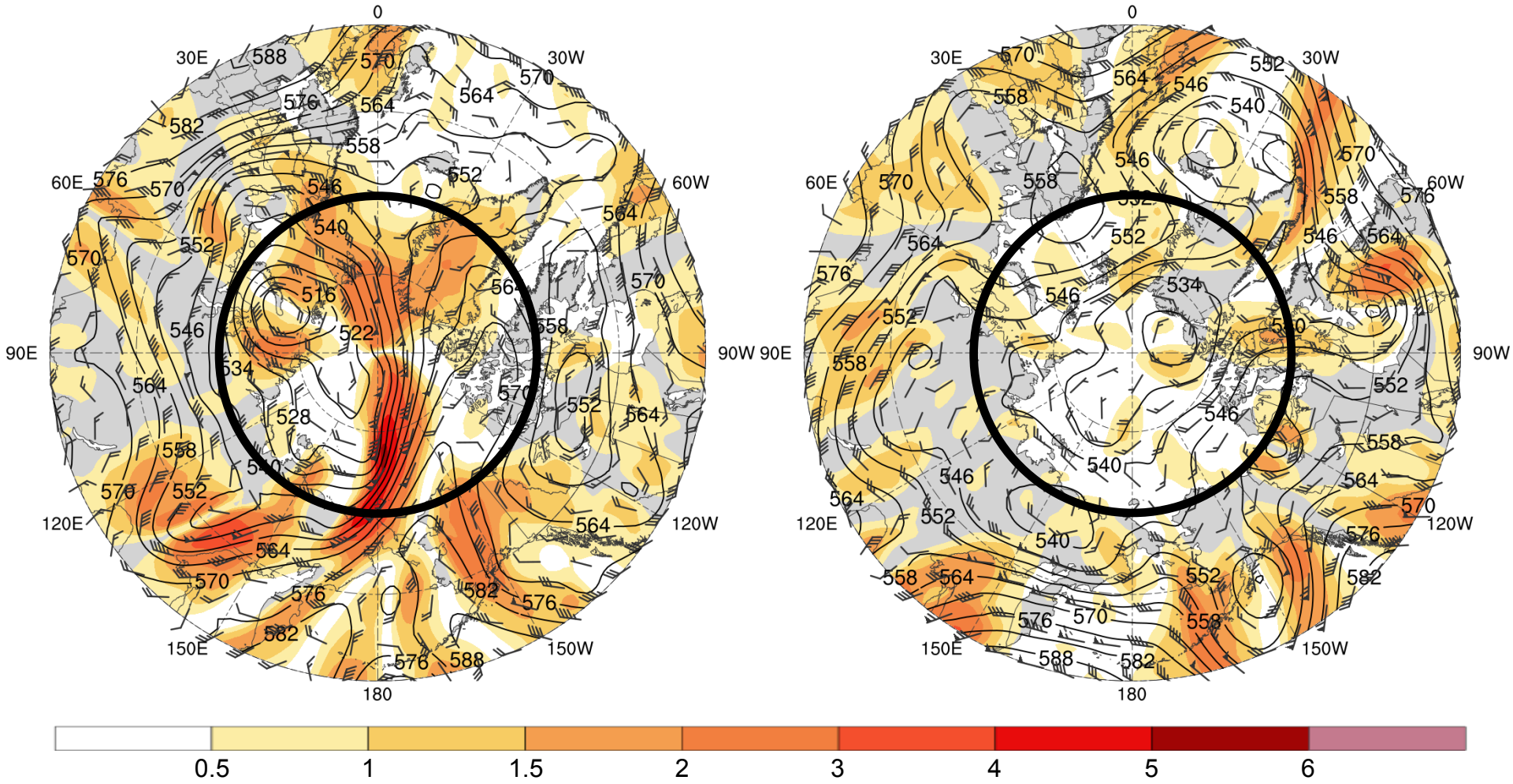
Flow Amplitude over Arctic

Low skill (avg. σ_v = 1.14)

0000 UTC 28 Aug 2016

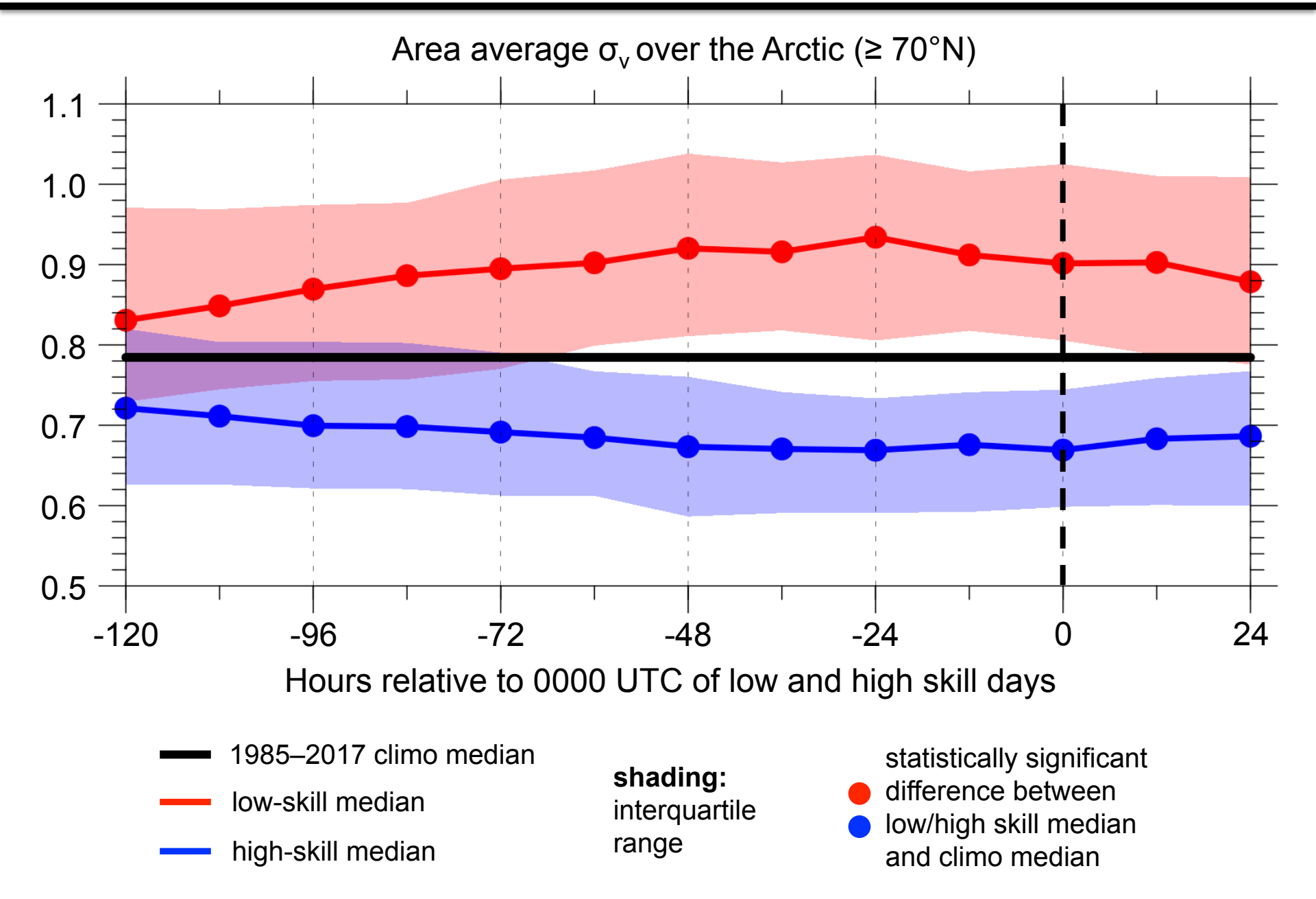
High skill (avg. σ_v = 0.45)

0000 UTC 3 Sep 2011



500-hPa geopotential height (dam, black), wind (flags and barbs, m s^{-1}), and σ_v (shading) from ERA-Interim

Flow Amplitude over Arctic



Moisture in Arctic

- There tends to be significantly large and small amounts of moisture over the Arctic relative to climatology during low and high skill periods, respectively

Moisture in Arctic

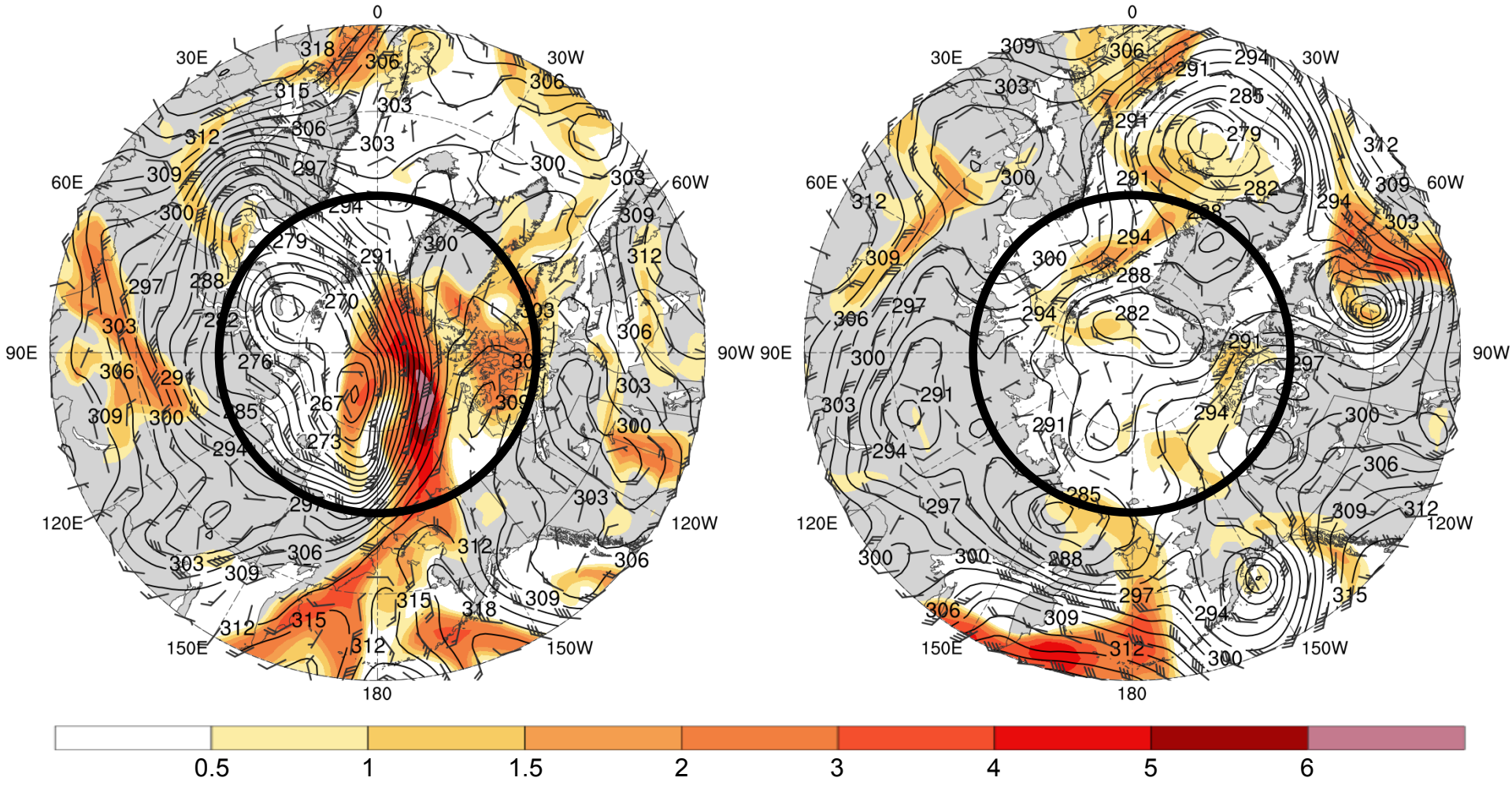
- Calculated standardized anomaly of PW (hereafter σ_{PW}) using ERA-Interim

- Calculated area average of positive values of σ_{PW} over the Arctic (≥ 70°N) for low and high skill periods

Moisture in Arctic

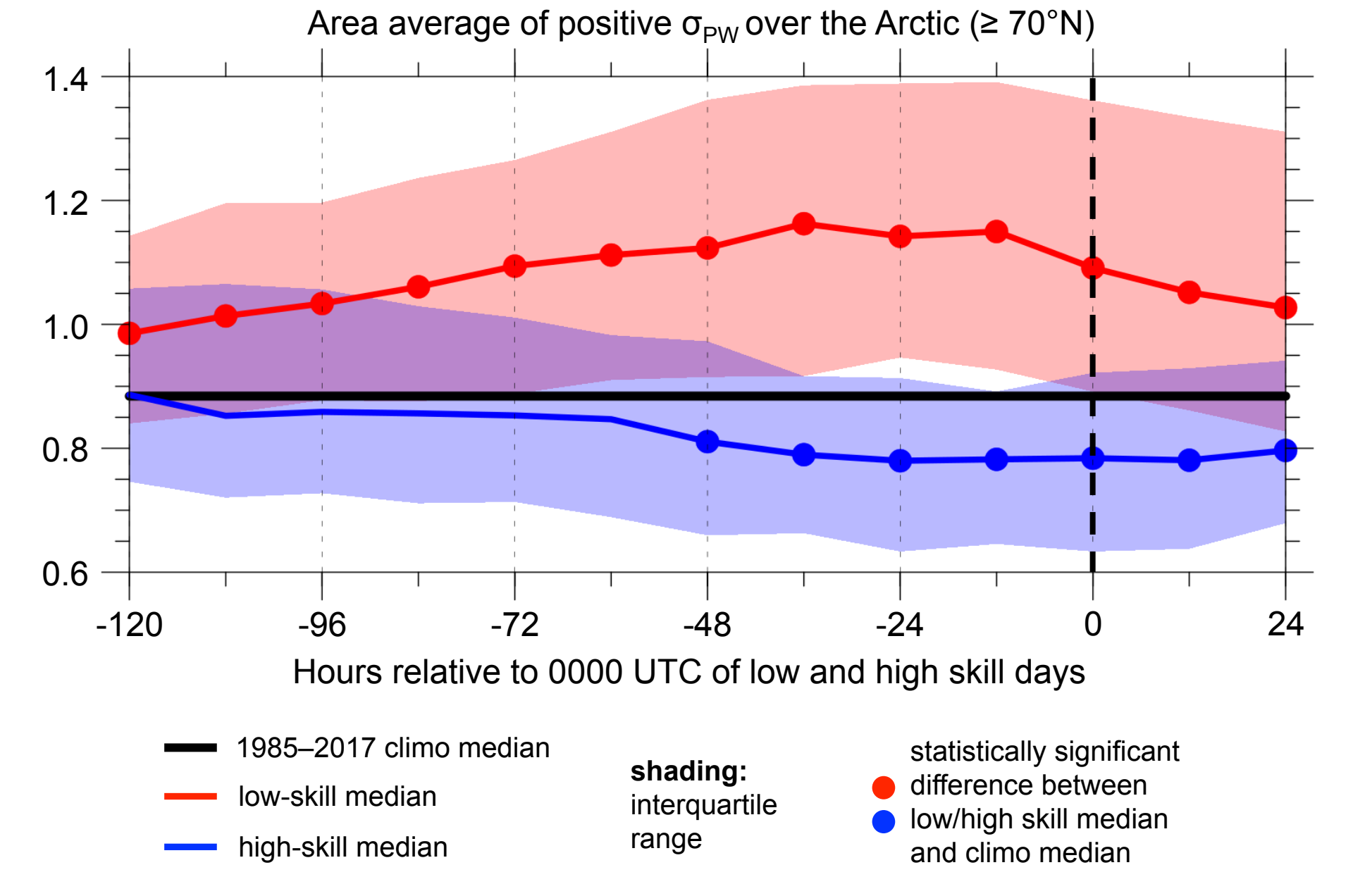
Low skill (avg. positive σ_{PW} = 1.82)
0000 UTC 28 Aug 2016

High skill (avg. positive σ_{PW} = 0.63)
0000 UTC 3 Sep 2011



700-hPa geopotential height (dam, black) and wind (flags and barbs, m s^{-1}), and positive σ_{PW} (shading) from ERA-Interim

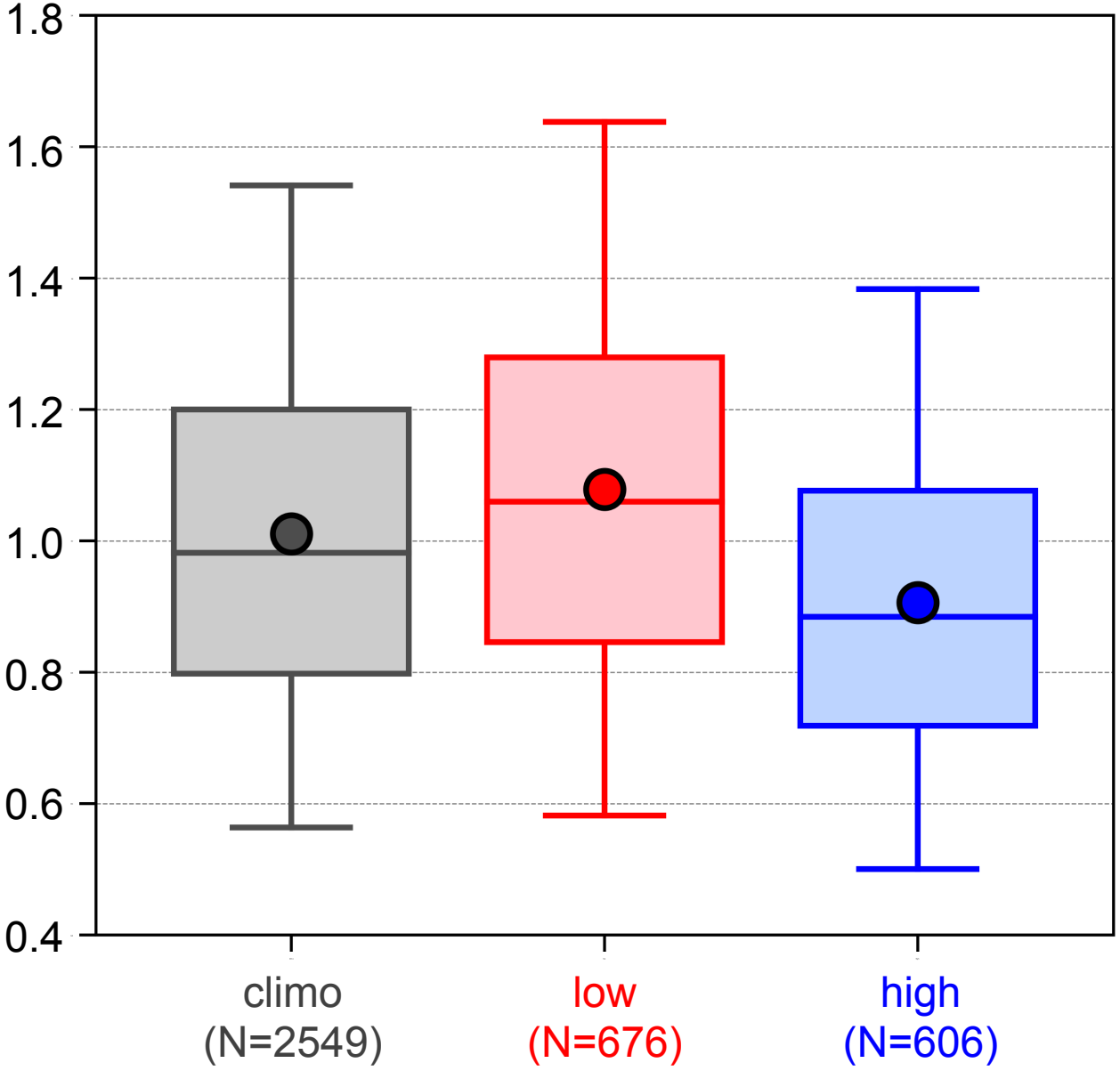
Moisture in Arctic



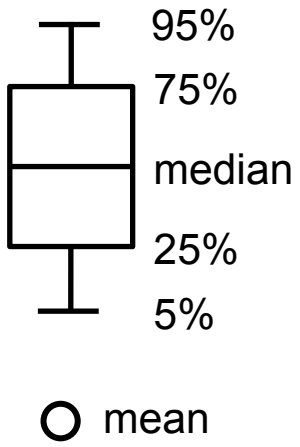
AC Characteristics

- ACs during low skill periods tend to be embedded within a region of more amplified flow, tend to be associated with larger amounts of moisture, and tend to be stronger relative to ACs during high skill periods

Highest Average σ_v Surrounding ACs

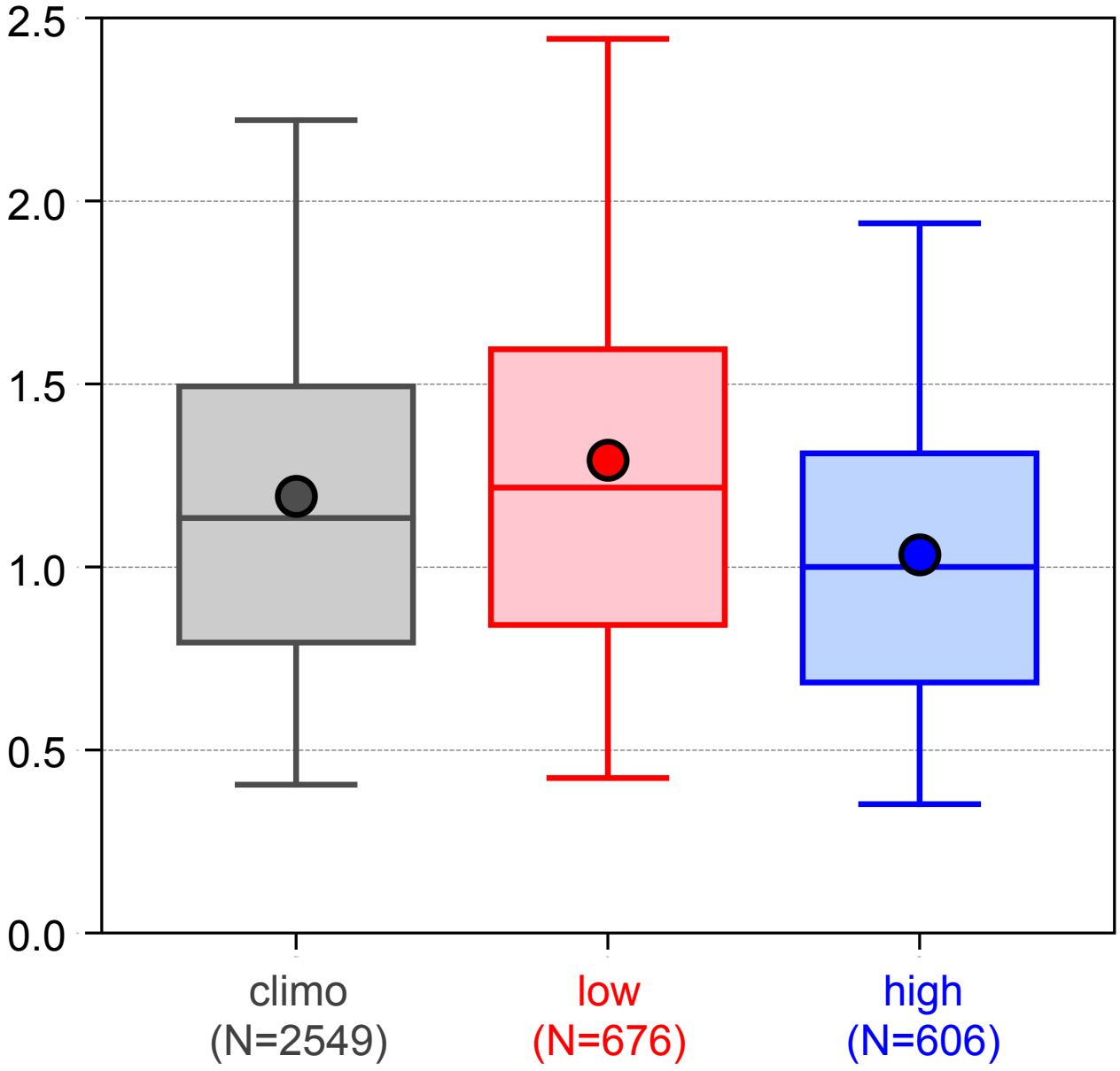


Highest value of average σ_v within 1000 km of AC centers in the Arctic

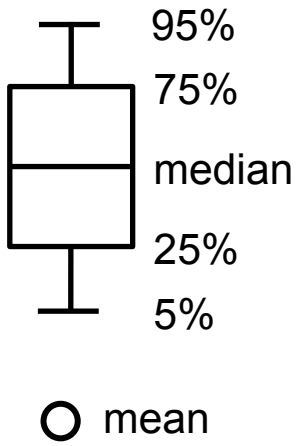


Differences in mean value between each category are statistically significant at 95% confidence level using bootstrap resampling

Highest Average Positive σ_{PW} Surrounding ACs

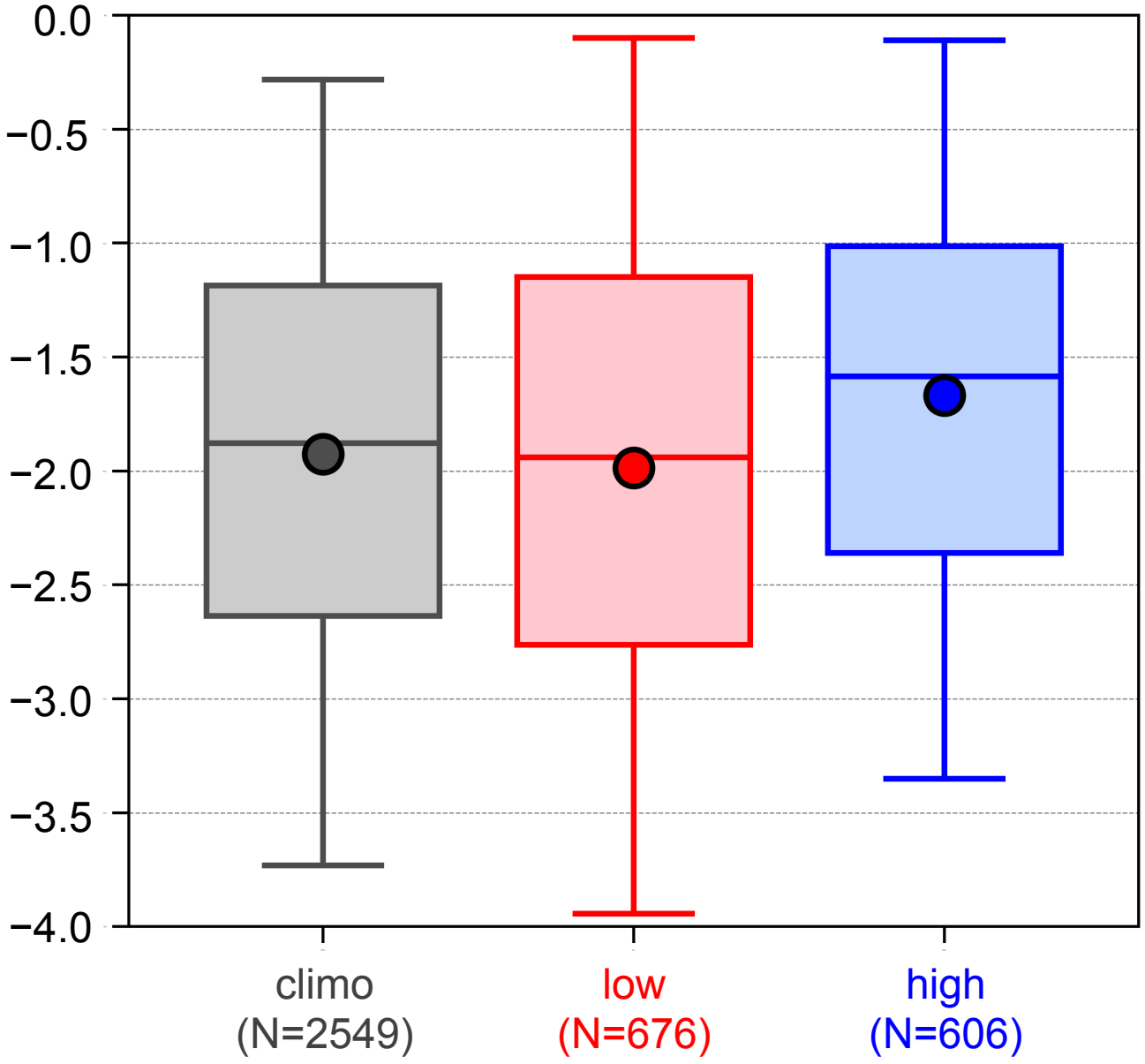


Highest value of average positive σ_{PW} within 1000 km of AC centers in the Arctic

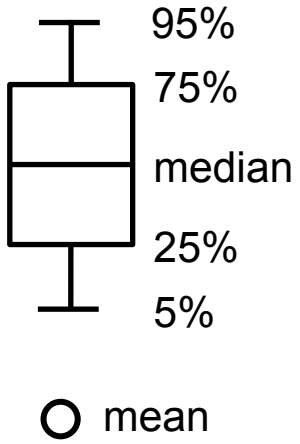


Differences in mean value between each category are statistically significant at 95% confidence level using bootstrap resampling

Maximum Intensity of ACs



Lowest standardized anomaly of SLP at AC center in Arctic



Differences in mean value between each category are statistically significant at 95% confidence level using bootstrap resampling, except between climatology and low skill

Summary

- AC frequency is higher for low skill periods compared to high skill periods
- ACs during low skill periods occur more frequently over eastern Eurasia and much of the Arctic Ocean relative to ACs during high skill periods
- ACs during high skill periods occur more frequently over the North Atlantic, Barents Sea, and western Eurasia relative to ACs during low skill periods
- ACs during low skill periods tend to be embedded within a region of more amplified flow, tend to be associated with larger amounts of moisture, and tend to be stronger relative to ACs during high skill periods

References

- Crawford, A., and M. Serreze, 2016: Does the summer Arctic frontal zone influence Arctic Ocean cyclone activity? *J. Climate,* **29,** 4977–4993.

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