A Comparison of Arctic Cyclones between Periods of Low and High Forecast Skill of the Synoptic-scale Flow over the Arctic

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Motivation

- Yamagami et al. (2018a,b) show that forecast skill of strong Arctic cyclones (ACs) can be low

- Forecast skill of the synoptic-scale flow over the Arctic may be low at times relative to climatology

- It is anticipated that low forecast skill of the synoptic-scale flow over the Arctic may be attributed in part to low forecast skill of ACs

Purpose

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

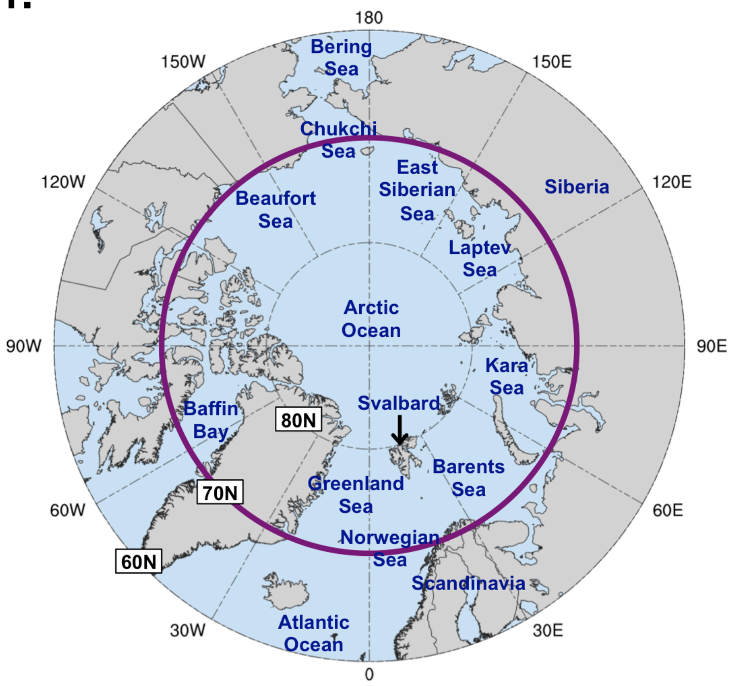
Data and Methods: AC Identification

- Create a 2007–2017 AC climatology
- Obtain cyclone tracks from 1° ERA-Interim 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

- Calculate standardized anomaly of ensemble forecast spread of 500-hPa geopotential height (σ_{anom}) following Torn (2017) and determine area-weighted average of σ_{anom} over the Arctic (≥70°N)

- Utilize forecasts initialized at 0000 UTC during 2007–2017 and valid at day 5 from:
  - 11-member GEFS reforecast dataset v2 (Hamill et al. 2013)
  - 51-member ECMWF Ensemble Prediction System (EPS; Buizza et al. 2007)



Data and Methods: Forecast Skill Evaluation

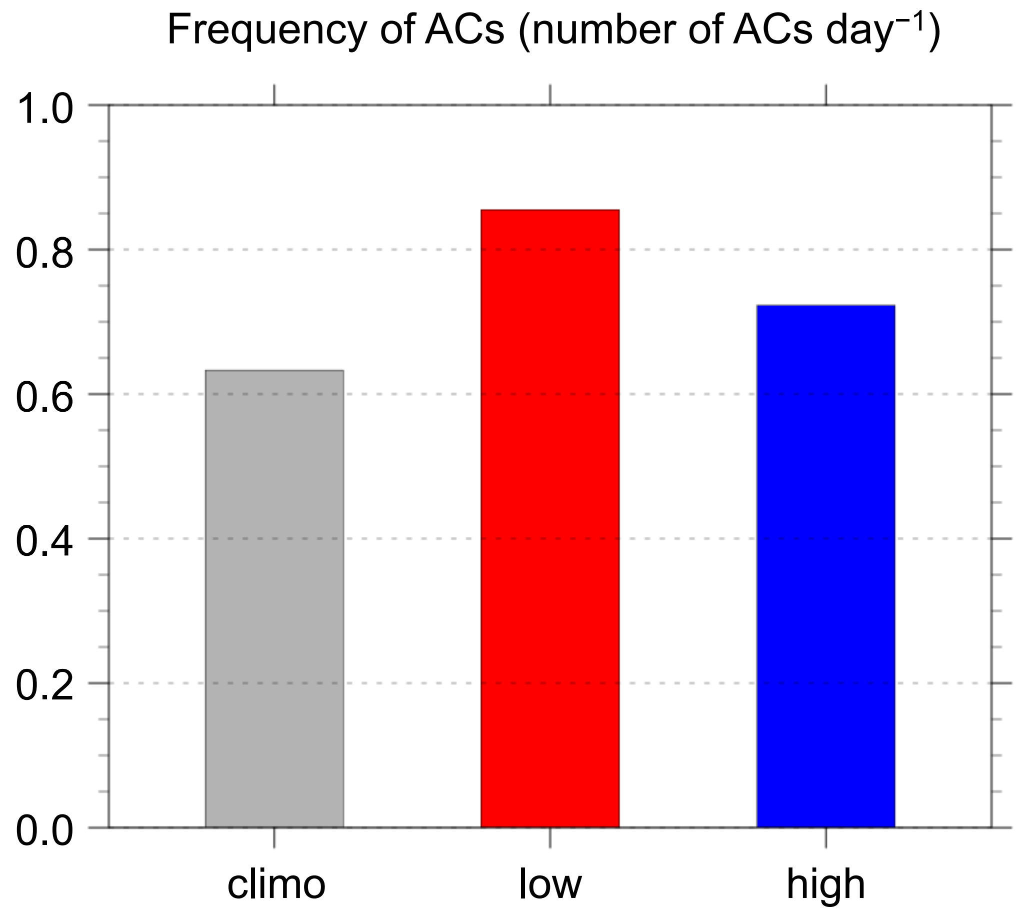
- Forecast days valid at day 5 associated with the top and bottom 10% of the area-weighted average of σ_{anom} in both the GEFS and ECMWF EPS are referred to as **low and high skill days,** respectively

- Time periods beginning five days prior to day 5 (i.e., day 0) through day 5 are referred to as **low and high skill periods**

- ACs that exist in the Arctic (>70°N) at any time within the low and high skill periods are identified

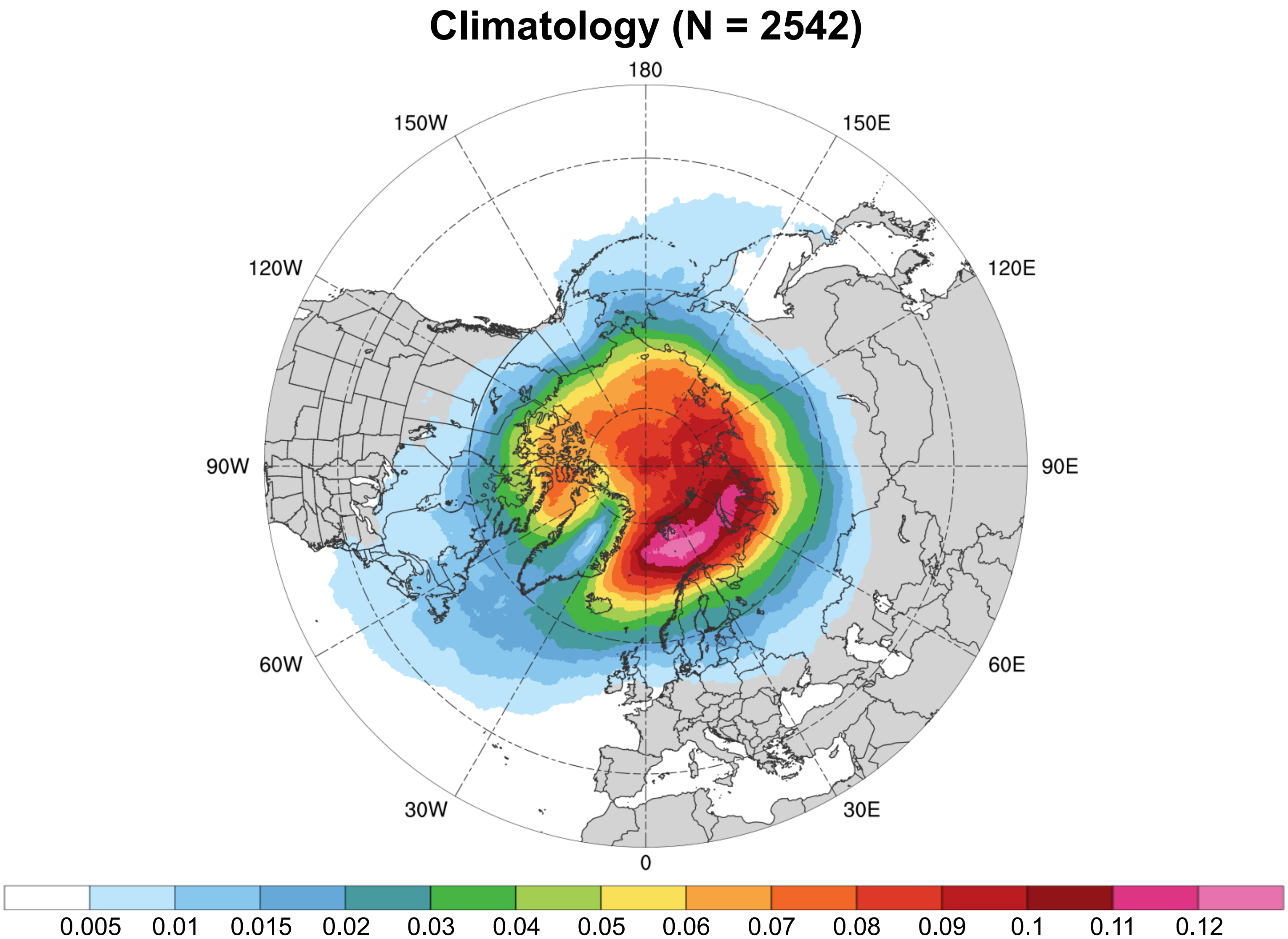
Number and Frequency of ACs

Period	Number of days in period	Number of ACs in period
Climo	4018	2542
Low skill	469	401
High skill	477	345



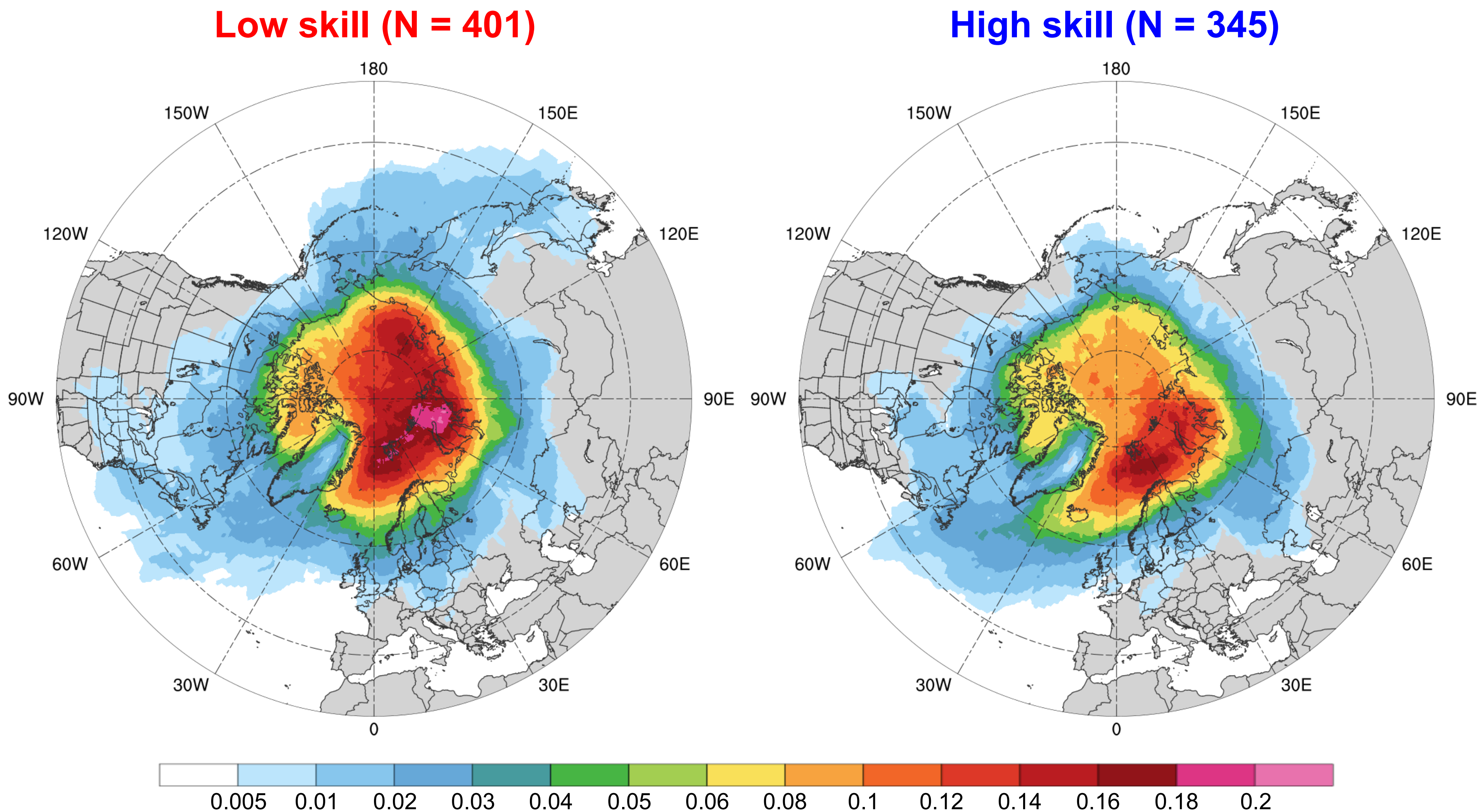
Frequency = number of ACs within period / number of days within period

AC Track Frequency



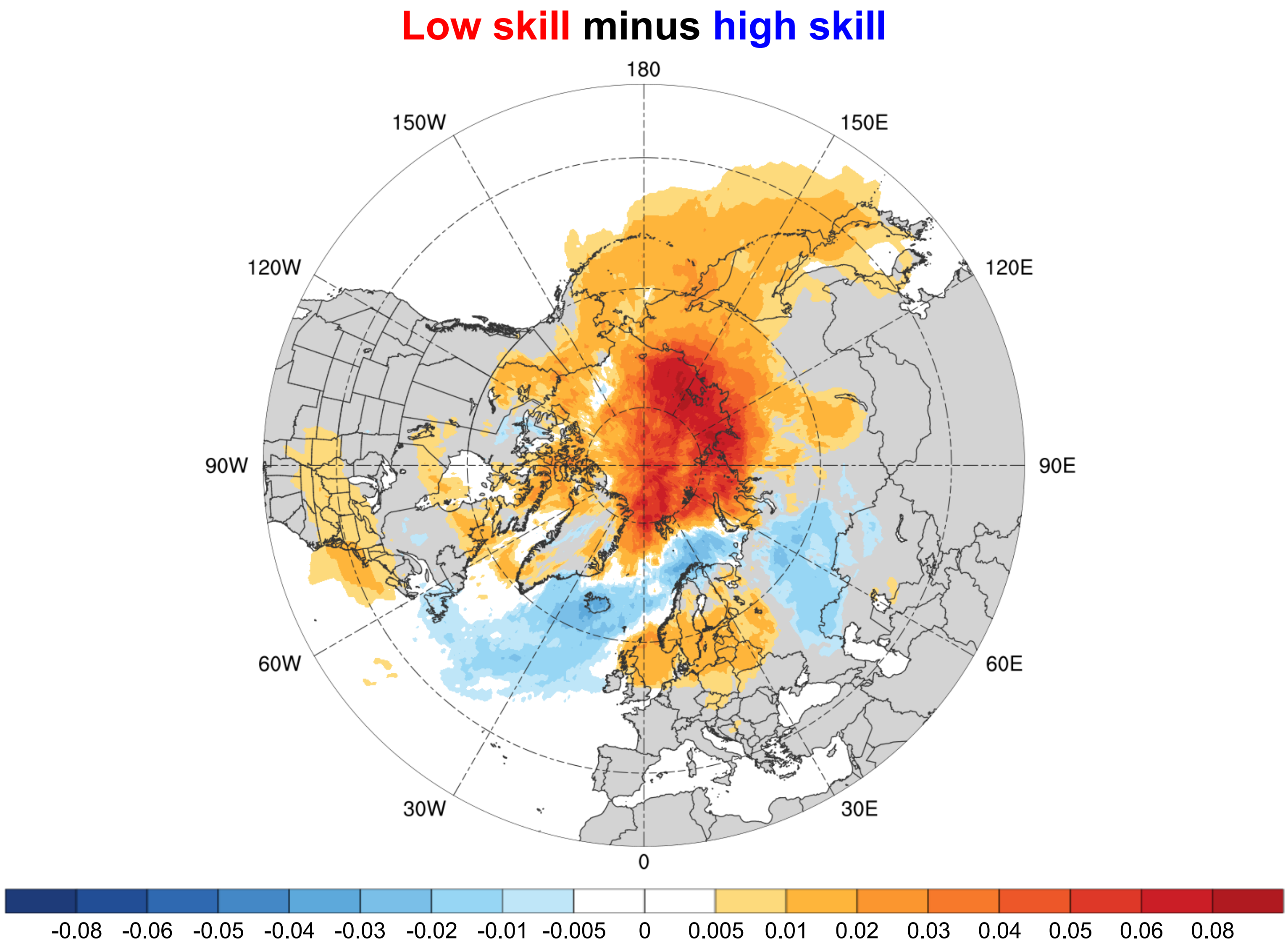
Total number of ACs within 500 km of a grid point, divided by number of days in climatology (number of ACs day^{-1})

AC Track Frequency



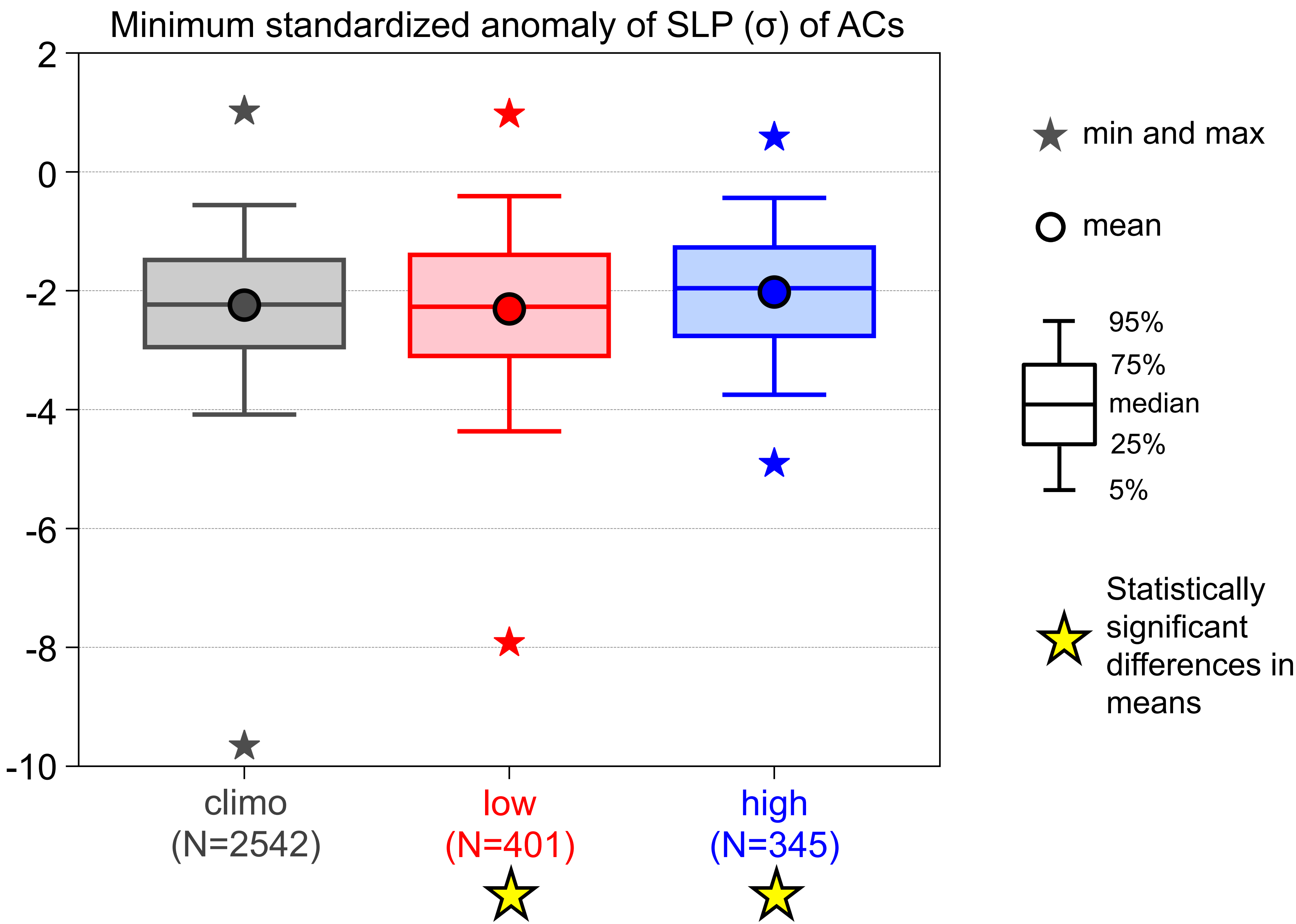
Total number of ACs within 500 km of a grid point, divided by number of days in period (number of ACs day^{-1})

AC Track Frequency Differences

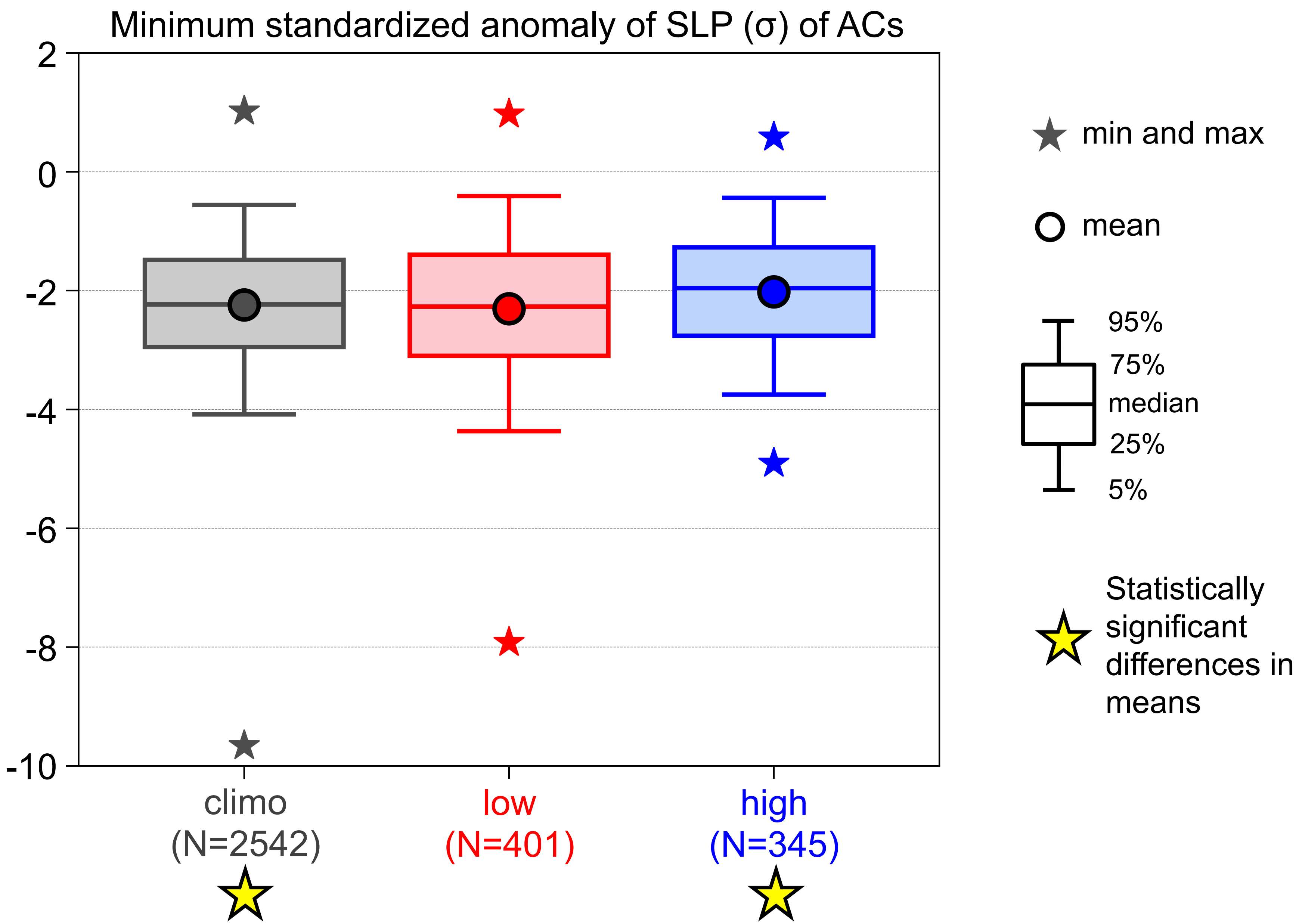


Difference in AC track density (number of ACs day^{-1})

Intensity


Minimum standardized anomaly of SLP (σ) of ACs
2
0
-2
-4
-6
-8
-10
climo
(N=2542)
low
(N=401)
high
(N=345)
min and max
mean
95%
75%
median
25%
5%
Statistically significant differences in means

Intensity



Minimum standardized anomaly of SLP (σ) of ACs
2
0
-2
-4
-6
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climo
(N=2542)
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min and max
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95%
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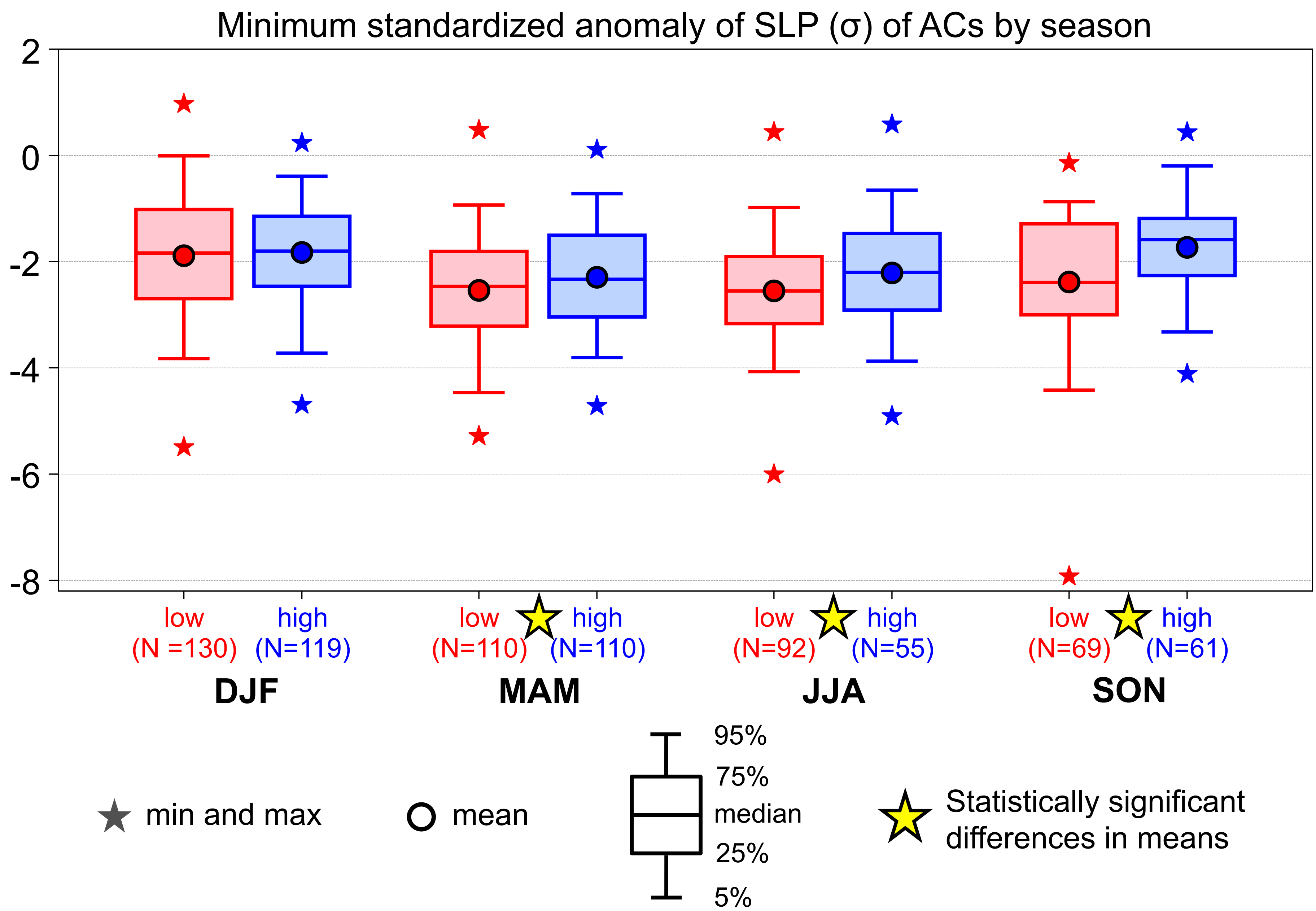
Statistically significant differences in means

Intensity


Minimum standardized anomaly of SLP (σ) of ACs by season
2
0
-2
-4
-6
-8
low
(N =130)
high
(N=119)
DJF
low
(N=110)
high
(N=110)
MAM
low
(N=92)
high
(N=55)
JJA
low
(N=69)
high
(N=61)
SON
min and max
mean
95%
75%
median
25%
5%
Statistically significant differences in means

Flow Amplitude

- Calculate absolute value of standardized anomaly of 500-hPa v-wind (hereafter $\boldsymbol{\sigma}_v$) using ERA-Interim

- Calculate area-weighted average of $\boldsymbol{\sigma}_v$ over the Arctic (≥70°N) for low and high skill periods

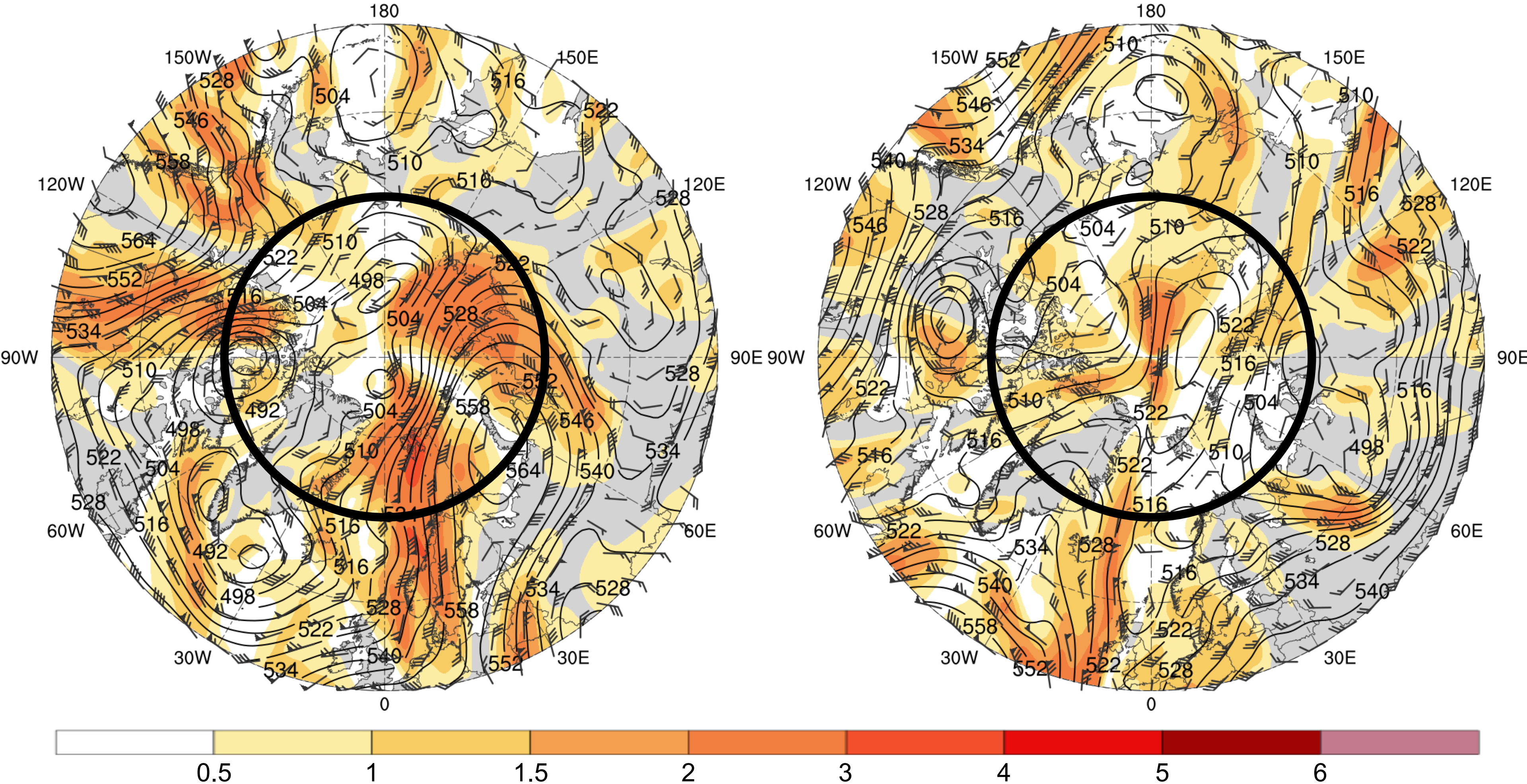
Flow Amplitude

Low skill

0000 UTC 1 Jan 2016

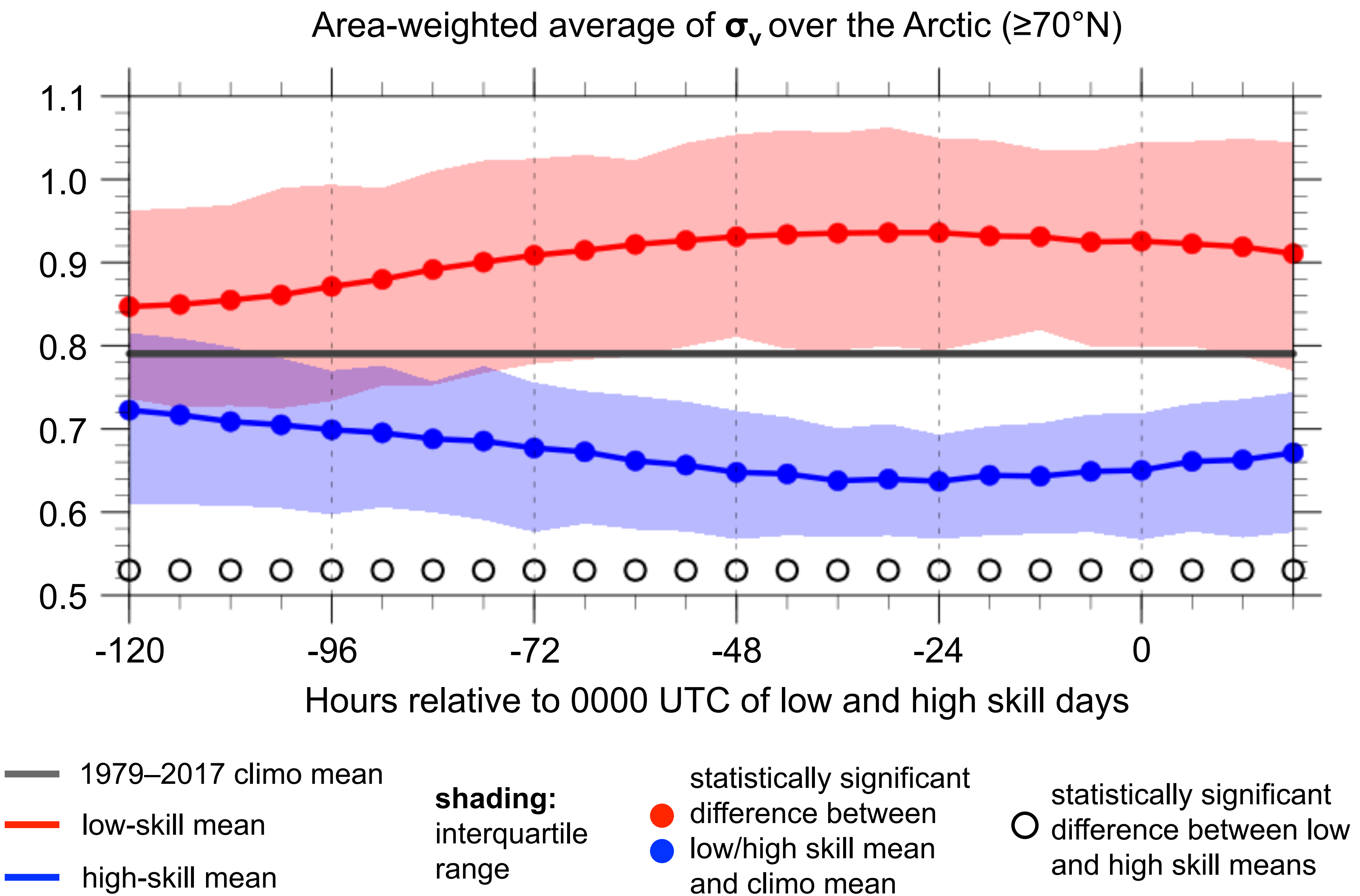
High skill

0000 UTC 6 Feb 2009



500-hPa geopotential height (dam, black), wind (flags and barbs, m s^{-1}), and $\boldsymbol{\sigma}_{\mathbf{v}}$ (shading) from ERA-Interim

Flow Amplitude



Summary

- Arctic cyclone frequency is higher for low skill periods compared to high skill periods

- Arctic cyclones during low skill periods occur more frequently over northern portions of central and eastern Eurasia and much of the adjacent Arctic Ocean relative to Arctic cyclones during high skill periods

- Arctic cyclones during high skill periods occur more frequently over the northern North Atlantic and the adjacent Norwegian and Barents Seas relative to Arctic cyclones during low skill periods

Summary

- Arctic cyclones tend to be stronger during low skill periods compared to high skill periods

- The synoptic-scale flow over the Arctic tends to be significantly more amplified during low skill periods compared to high skill periods

Questions? *Email: kbiernat@albany.edu*

- Arctic cyclones tend to be stronger during low skill periods compared to high skill periods

- The synoptic-scale flow over the Arctic tends to be significantly more amplified during low skill periods compared to high skill periods

References

- Buizza, R., J. R. Bidlot, N. Wedi, M. Fuentes, M. Hamrud, G. Holt, and F. Vitart, 2007: The new ECMWF VAREPS (Variable Resolution Ensemble Prediction System). *Quart. J. Roy. Meteor. Soc.,* **133,** 681–695.
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- Sprenger, M., and Coauthors, 2017: Global climatologies of Eulerian and Lagrangian flow features based on ERA-Interim. *Bull. Amer. Meteor. Soc.,* **98,** 1739–1748.
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Extra Slides

Data and Methods: Forecast Skill Evaluation

- At each grid point (i), day of the year (d), and forecast lead time (f), σ_{anom} is calculated following Torn (2017) as:

$$\sigma_{anom}(i,d,f) = \frac{\sigma(i,d,f) - \sigma_{mean}(i,d,f)}{\sigma_{stdv}(i,d,f)}$$

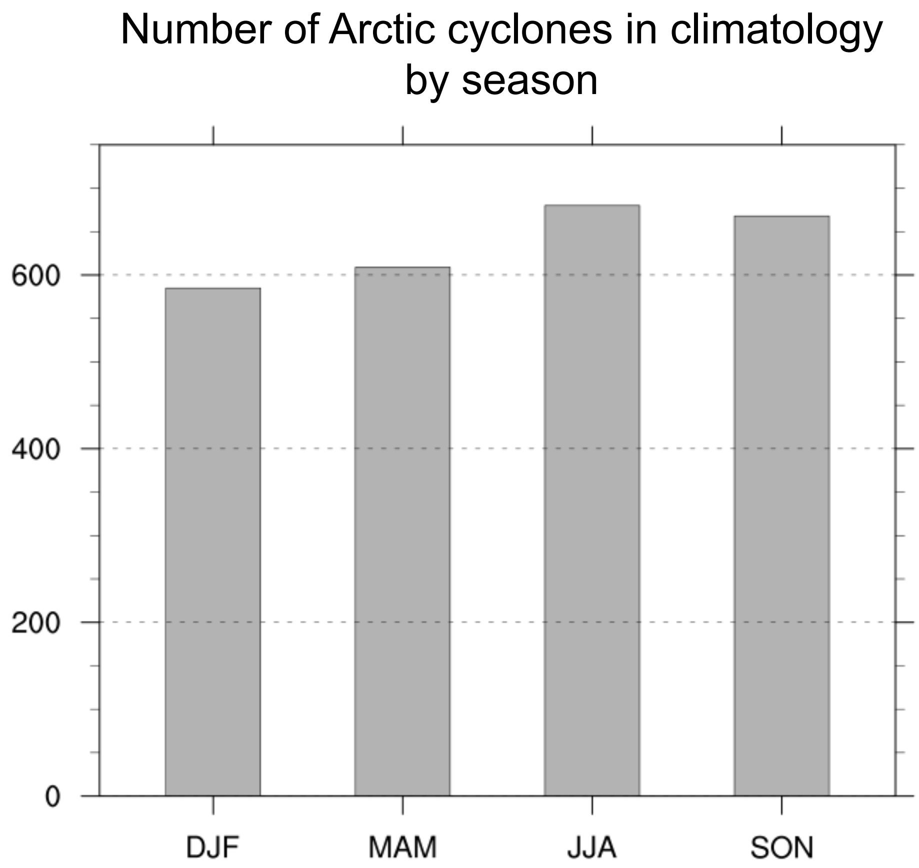
σ = raw ensemble spread

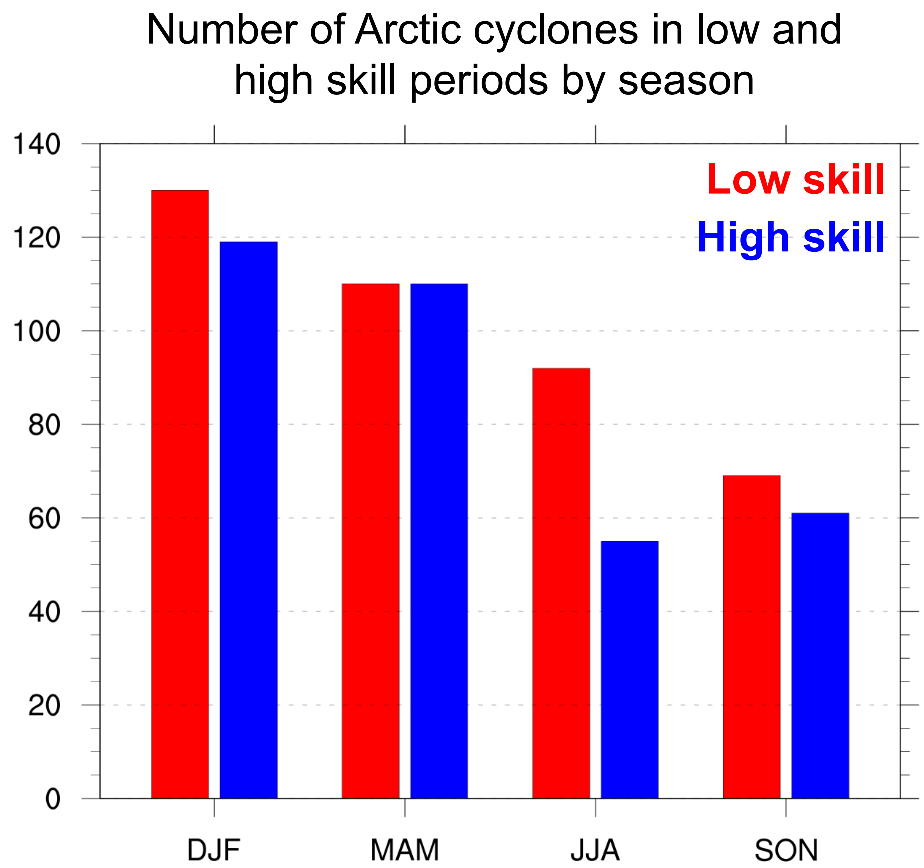
σ_{mean} = climatological mean ensemble spread

σ_{stdv} = climatological standard deviation of ensemble spread

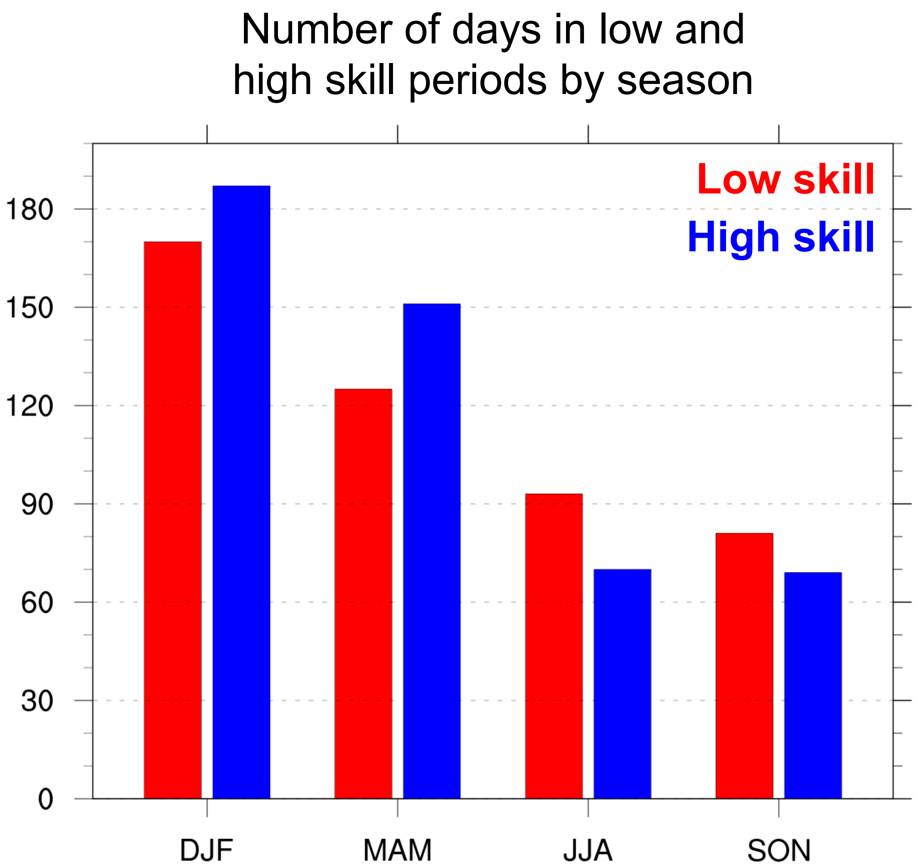
- σ_{mean} and σ_{stdv} are calculated for 1985–2017 period from the GEFS reforecast dataset v2

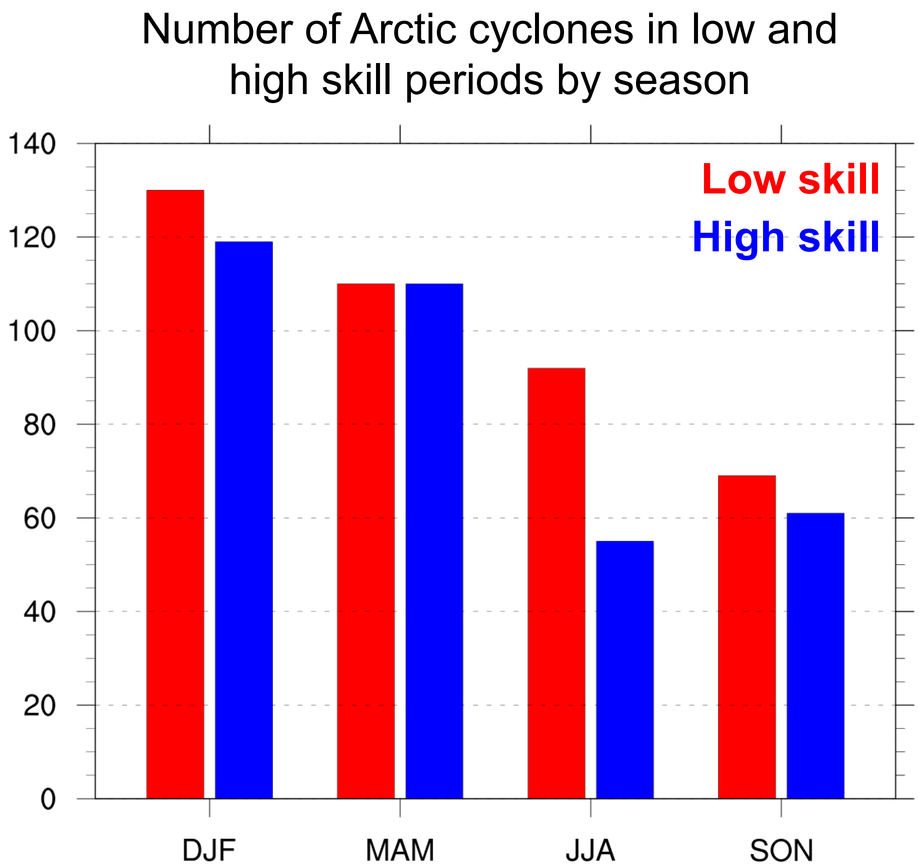
Number of Arctic Cyclones by Season



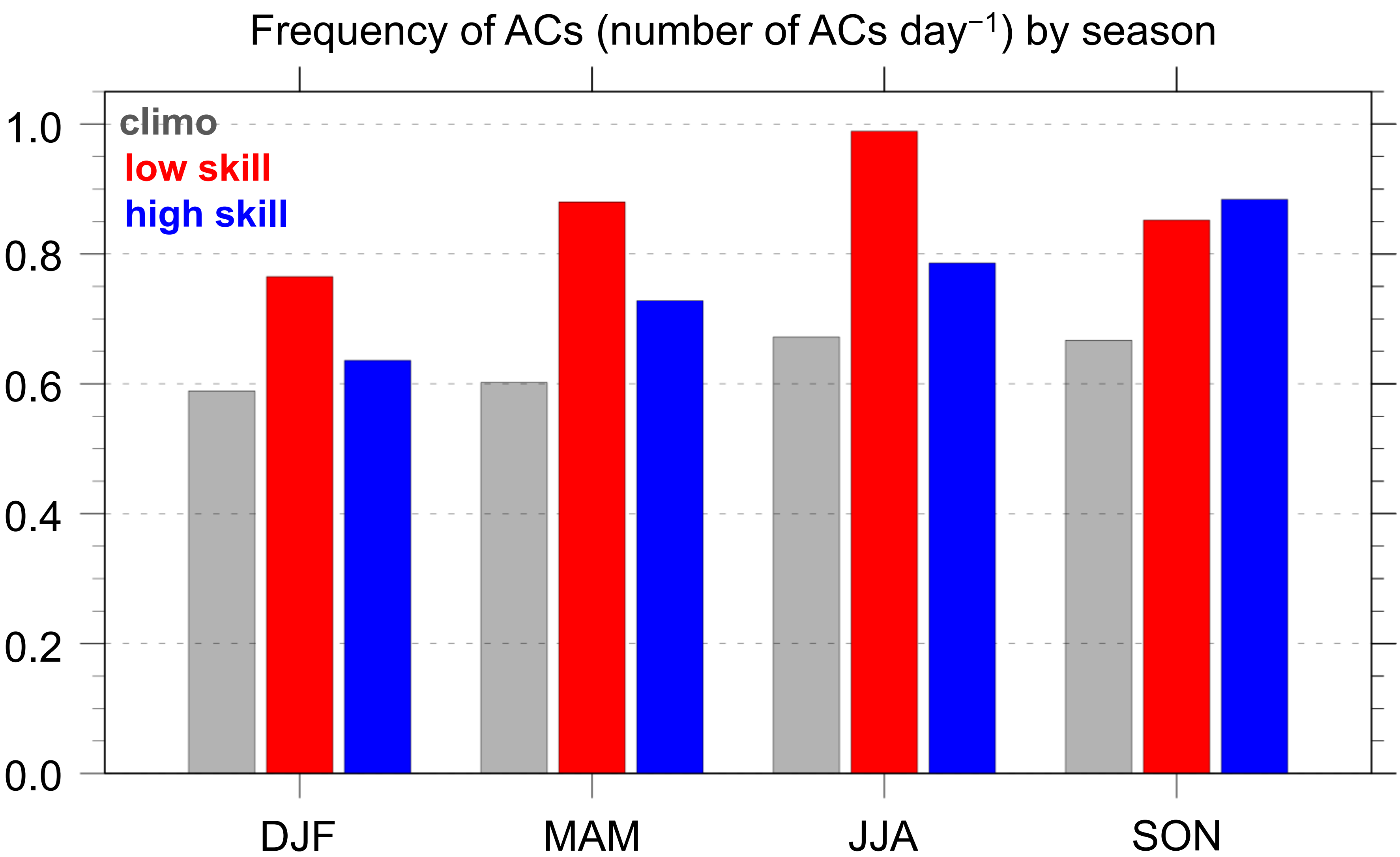


Number of Arctic Cyclones by Season



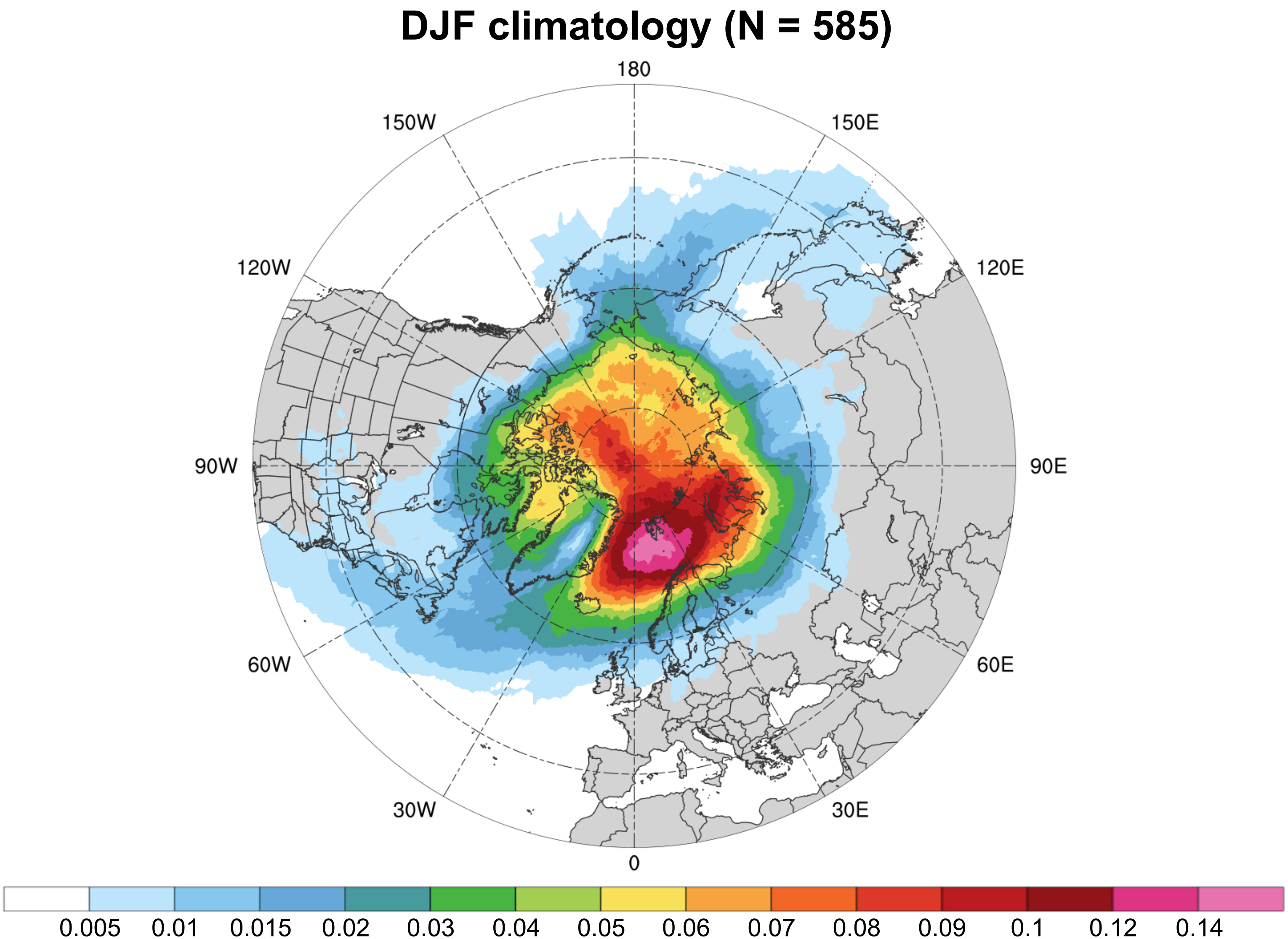


Frequency of ACs by Season



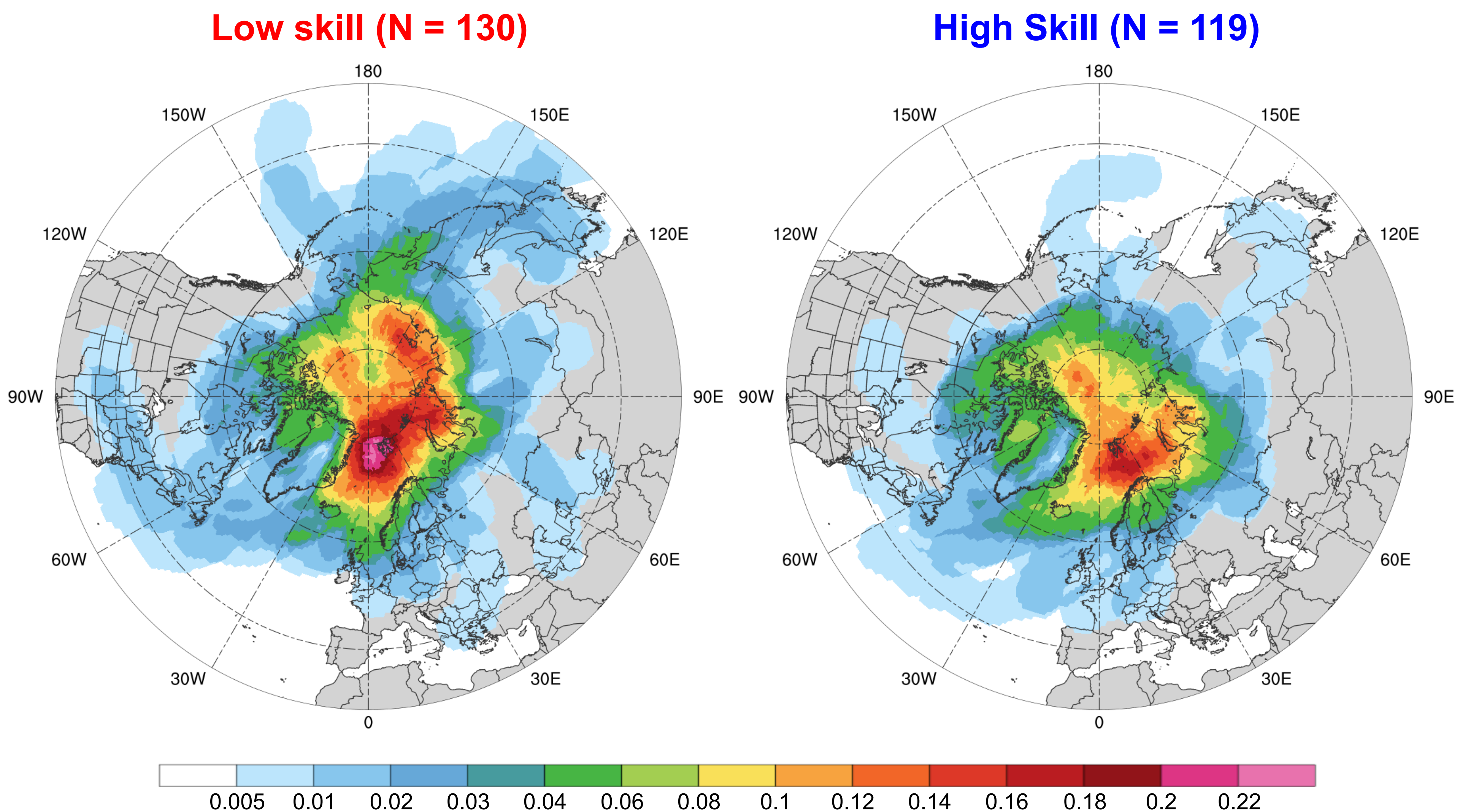
Frequency = number of ACs within period / number of days within period

Track Frequency (DJF)



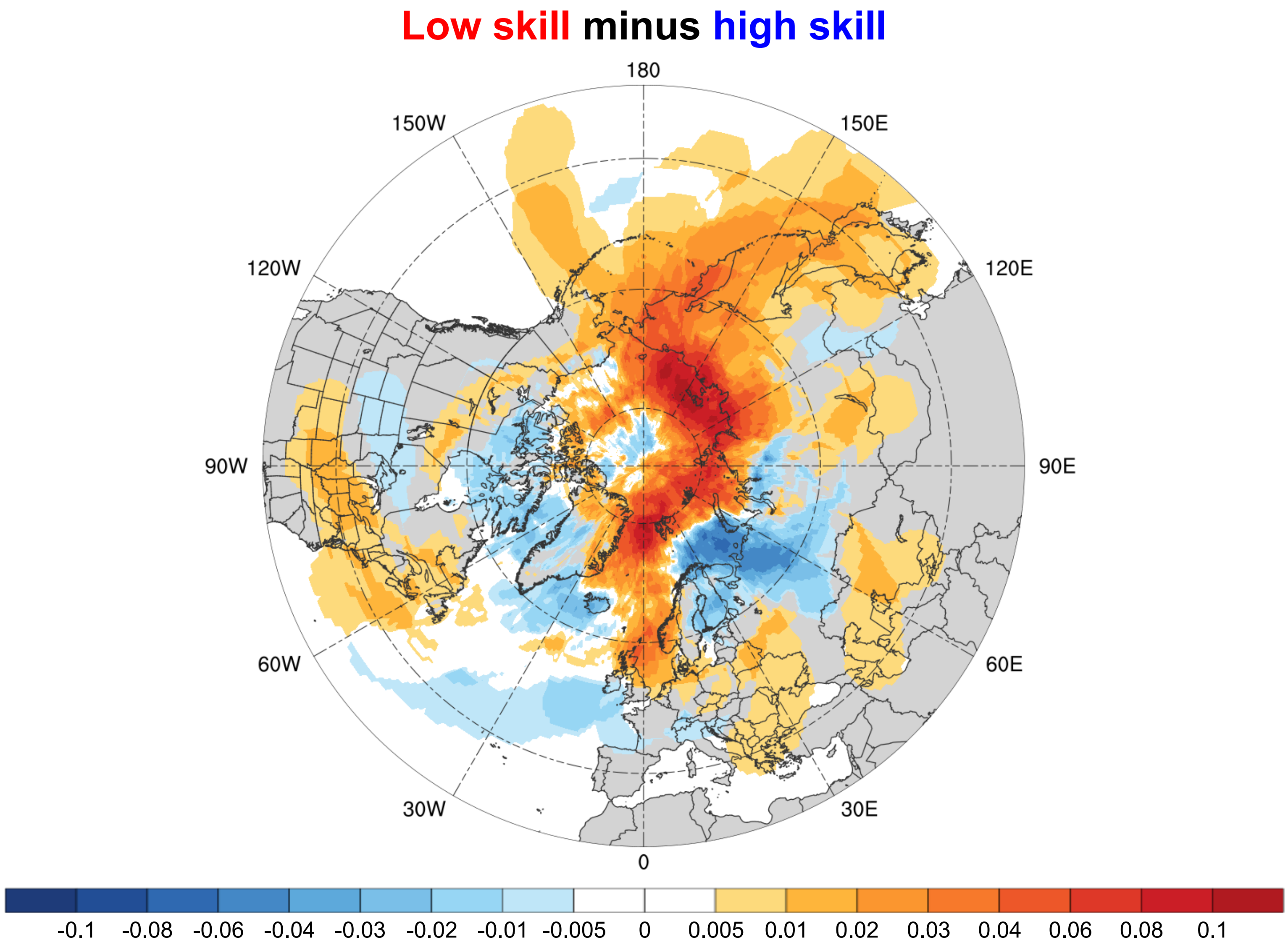
Total number of ACs within 500 km of a grid point,
divided by number of days in climatology during DJF (number of ACs day^{-1})

Track Frequency (DJF)



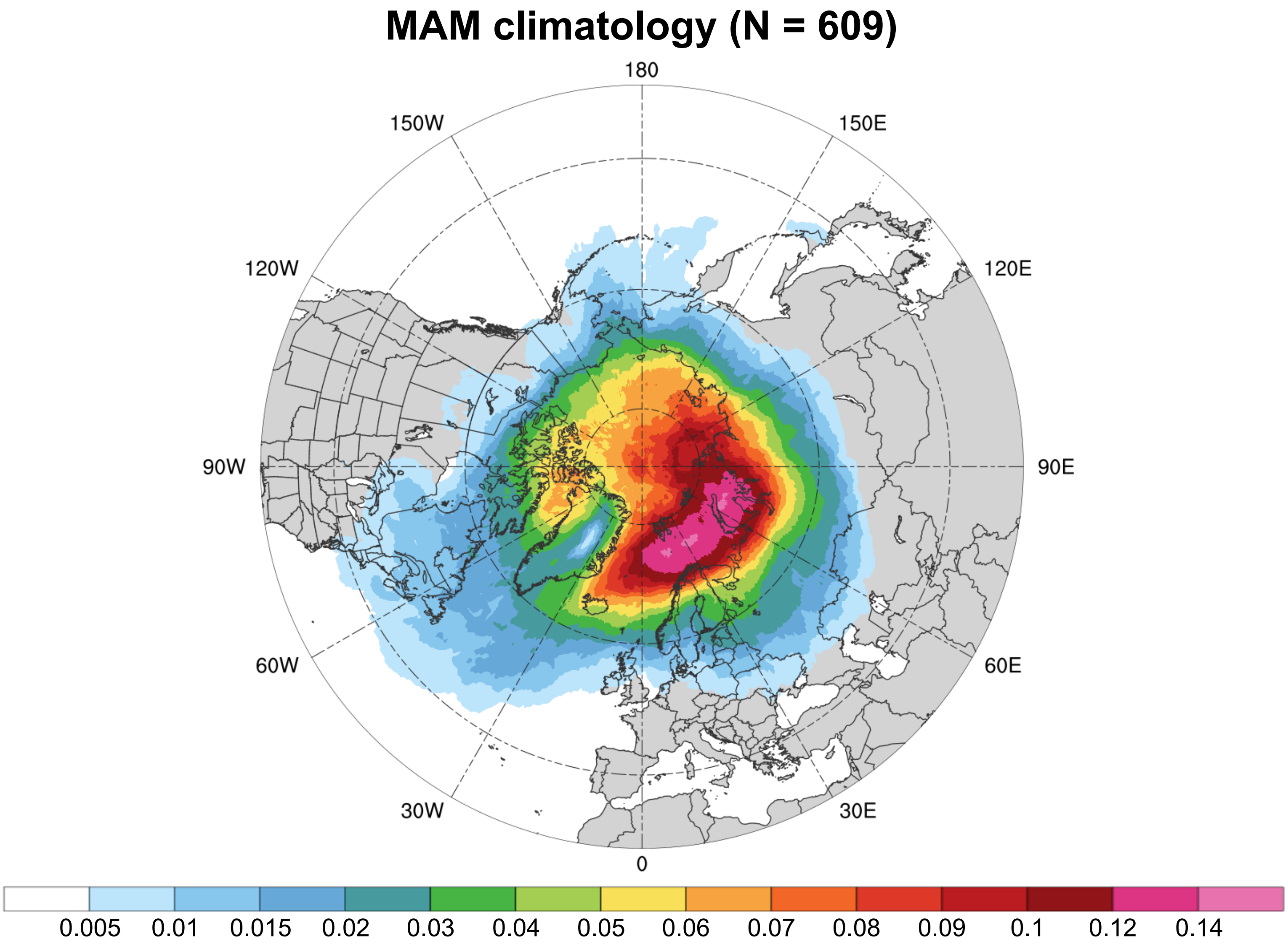
Total number of ACs within 500 km of a grid point,
divided by number of days in period during DJF (number of ACs day^{-1})

Track Frequency Differences (DJF)



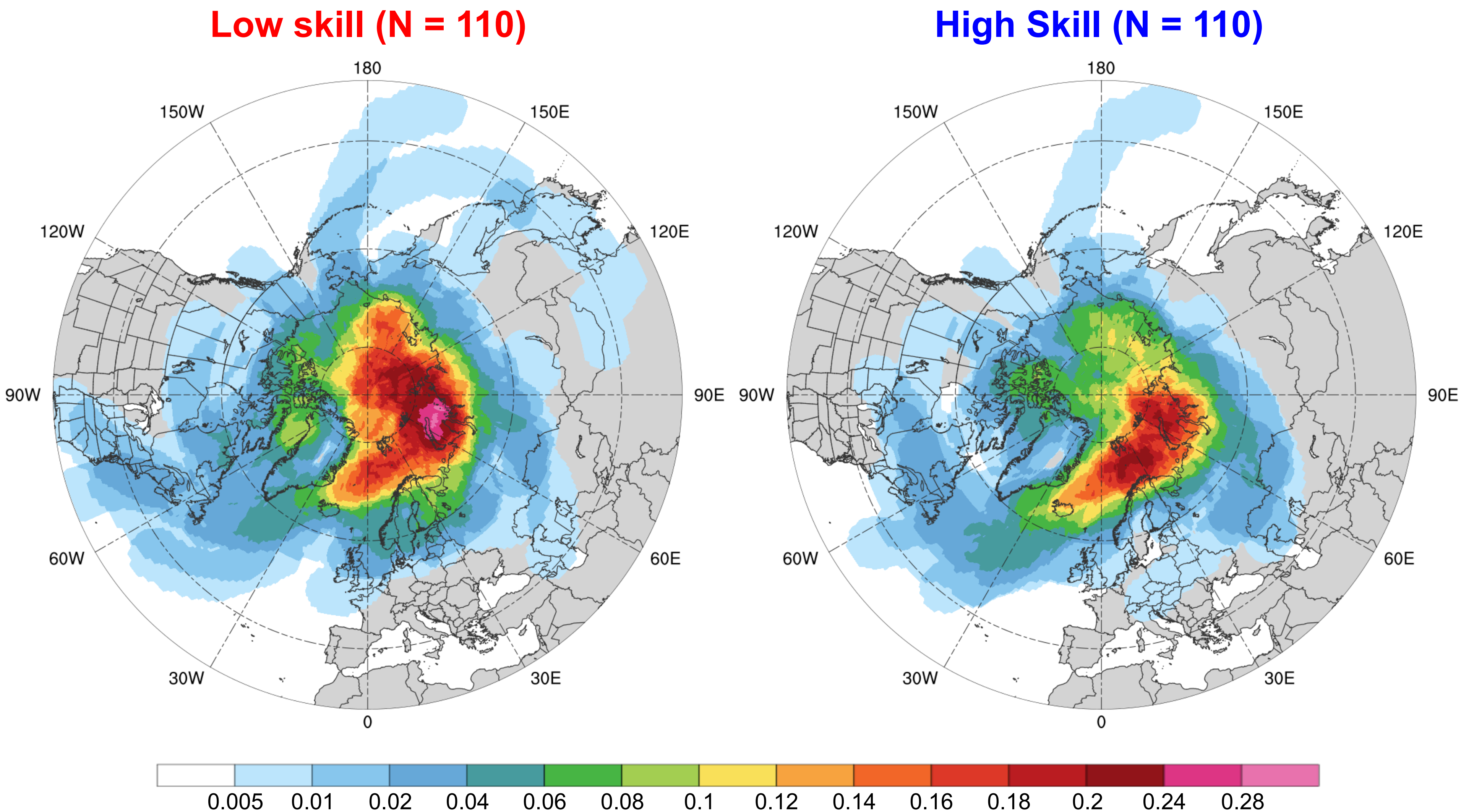
Difference in AC track density during DJF (number of ACs day^{-1})

Track Frequency (MAM)



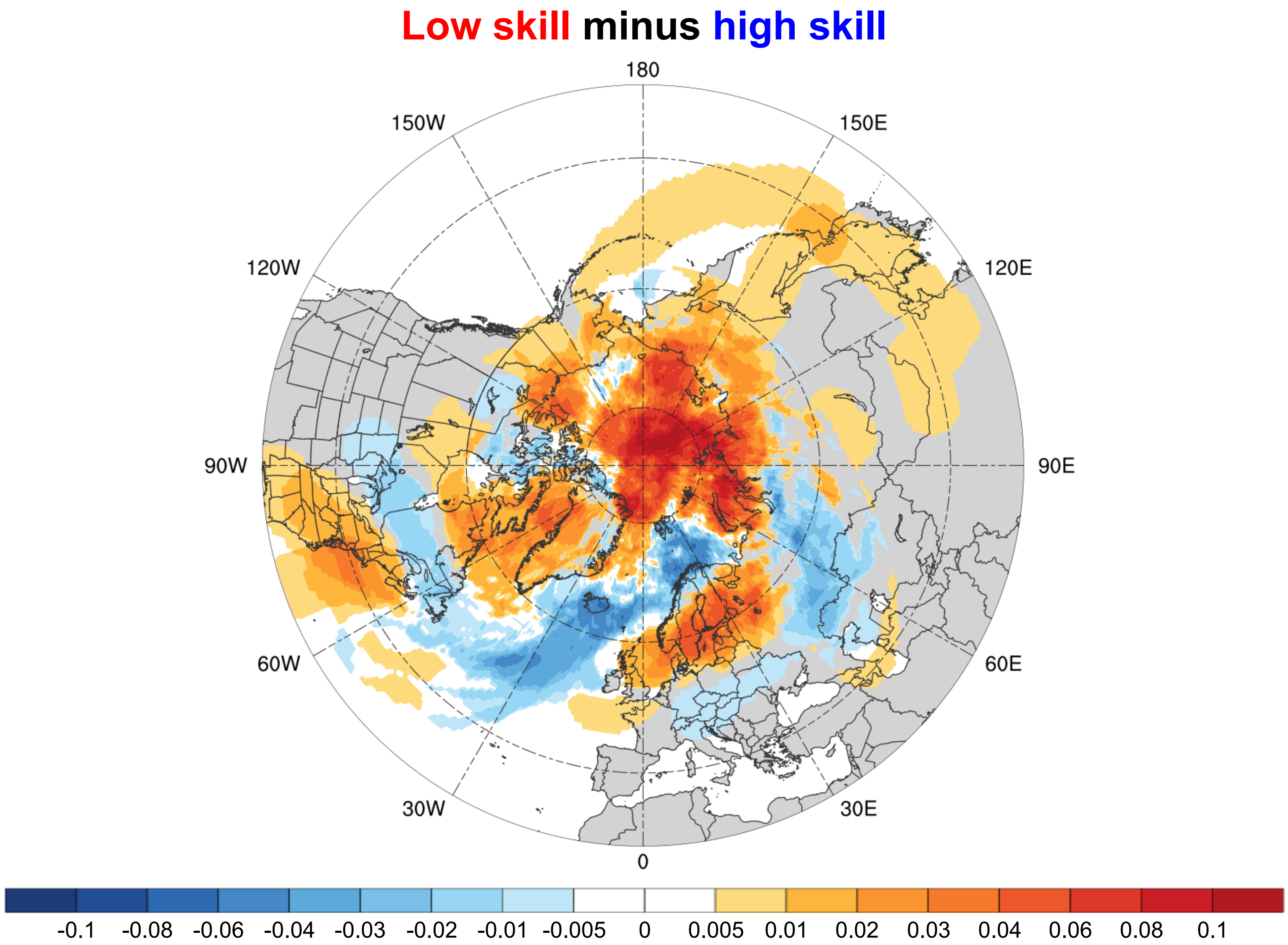
Total number of ACs within 500 km of a grid point,
divided by number of days in climatology during MAM (number of ACs day^{-1})

Track Frequency (MAM)



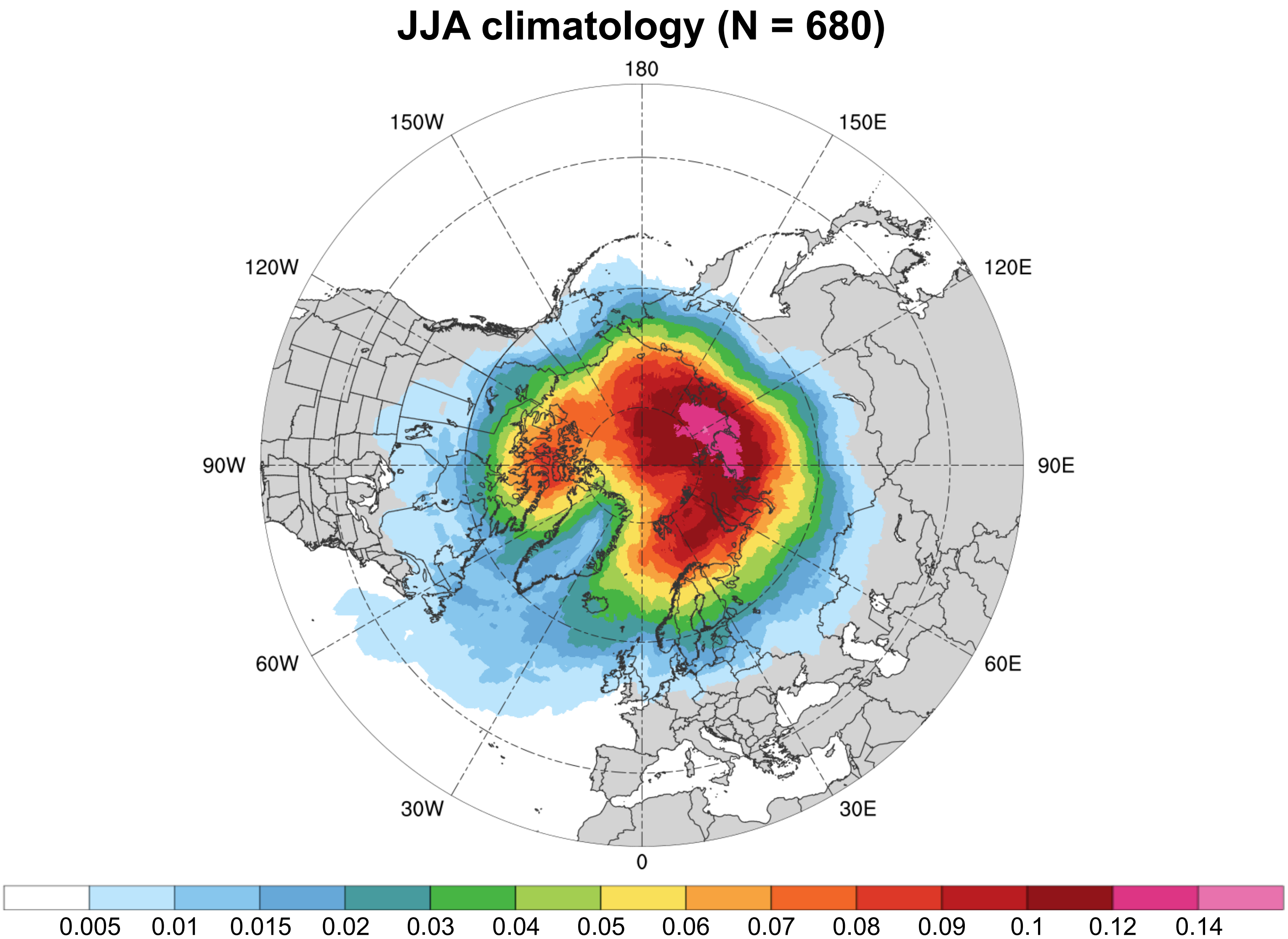
Total number of ACs within 500 km of a grid point,
divided by number of days in period during MAM (number of ACs day^{-1})

Track Frequency Differences (MAM)



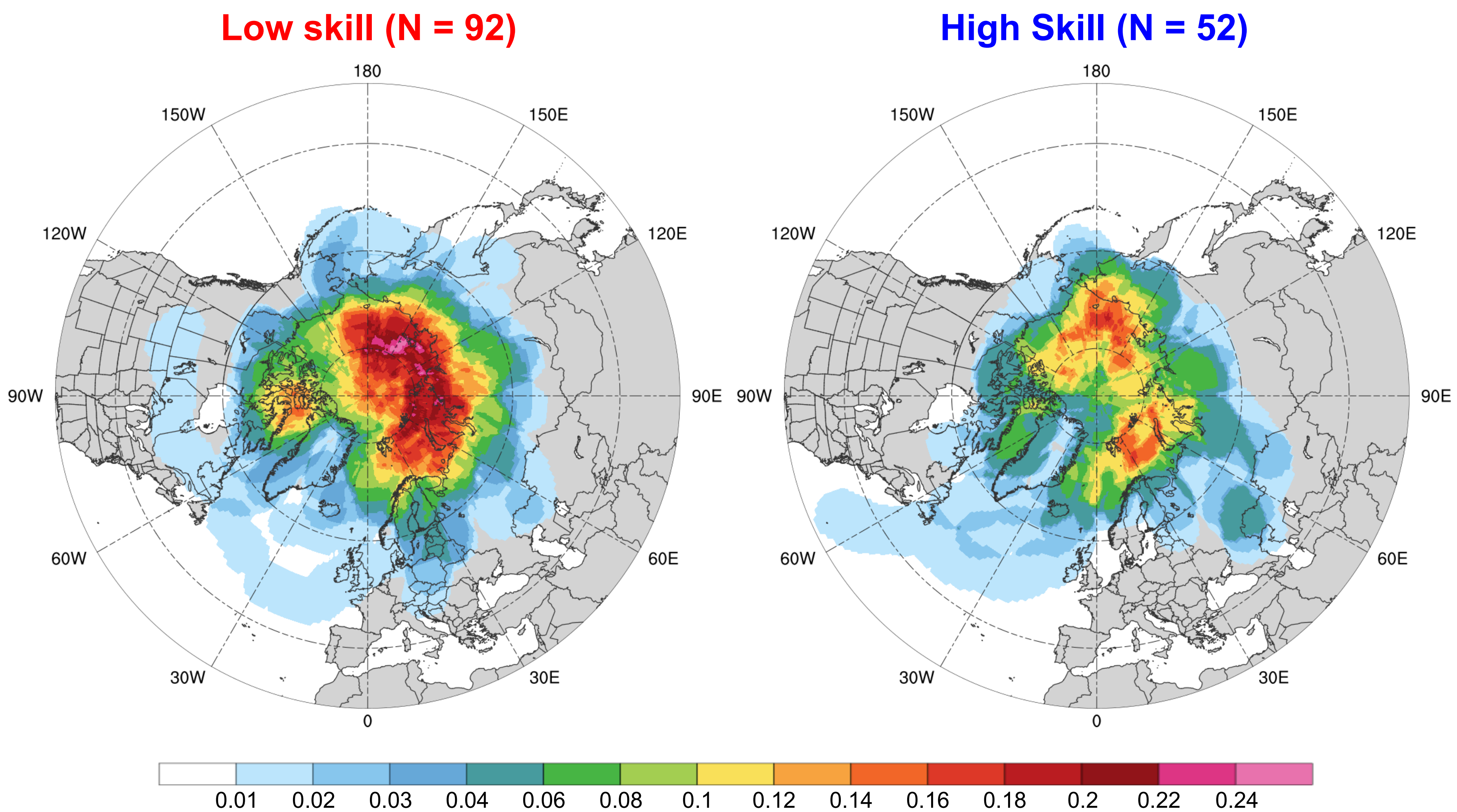
Difference in AC track density during MAM (number of ACs day^{-1})

Track Frequency (JJA)



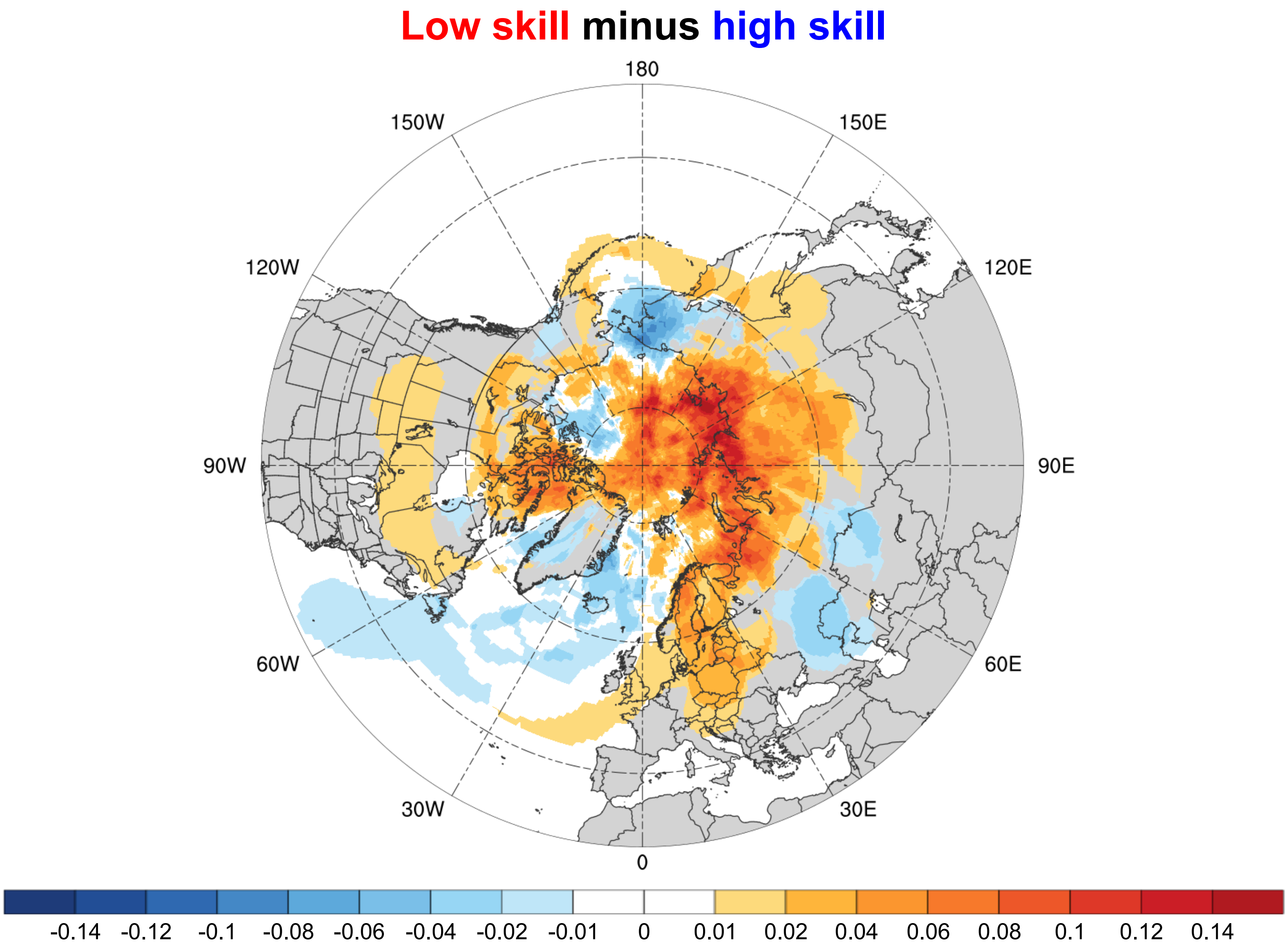
Total number of ACs within 500 km of a grid point,
divided by number of days in climatology during JJA (number of ACs day^{-1})

Track Frequency (JJA)



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

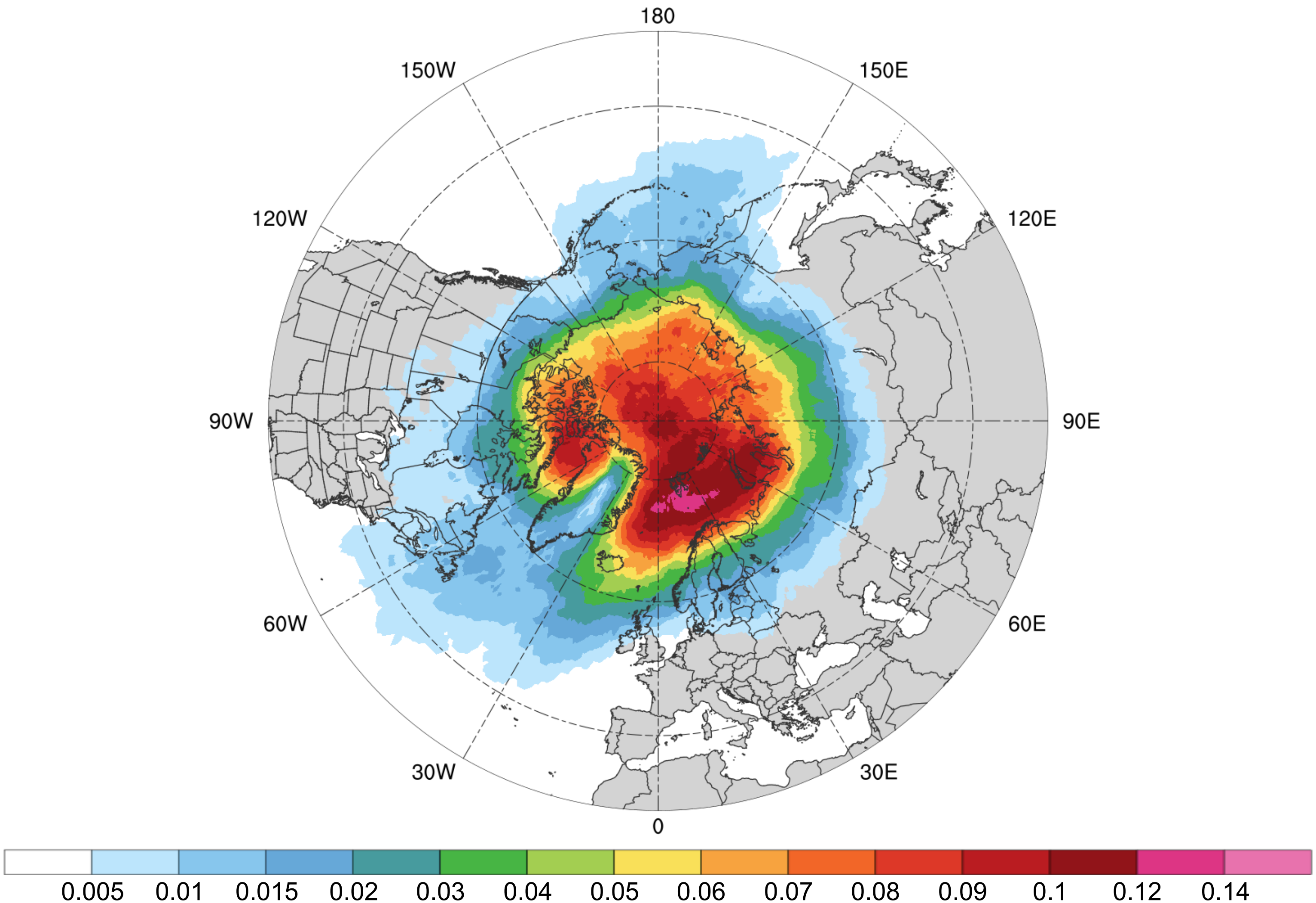
Track Frequency Differences (JJA)



Difference in AC track density during JJA (number of ACs day^{-1})

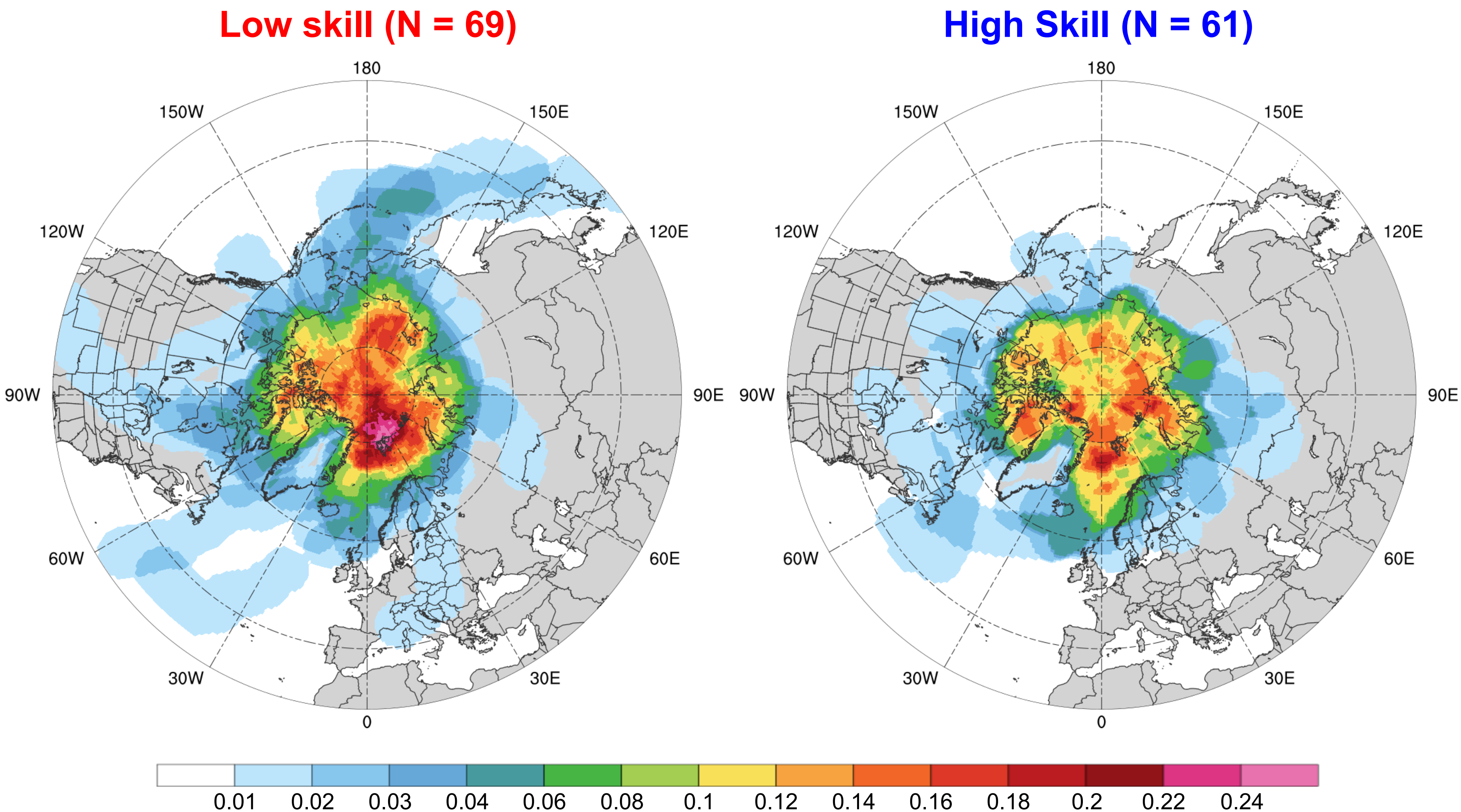
Track Frequency (SON)

SON climatology (N = 668)



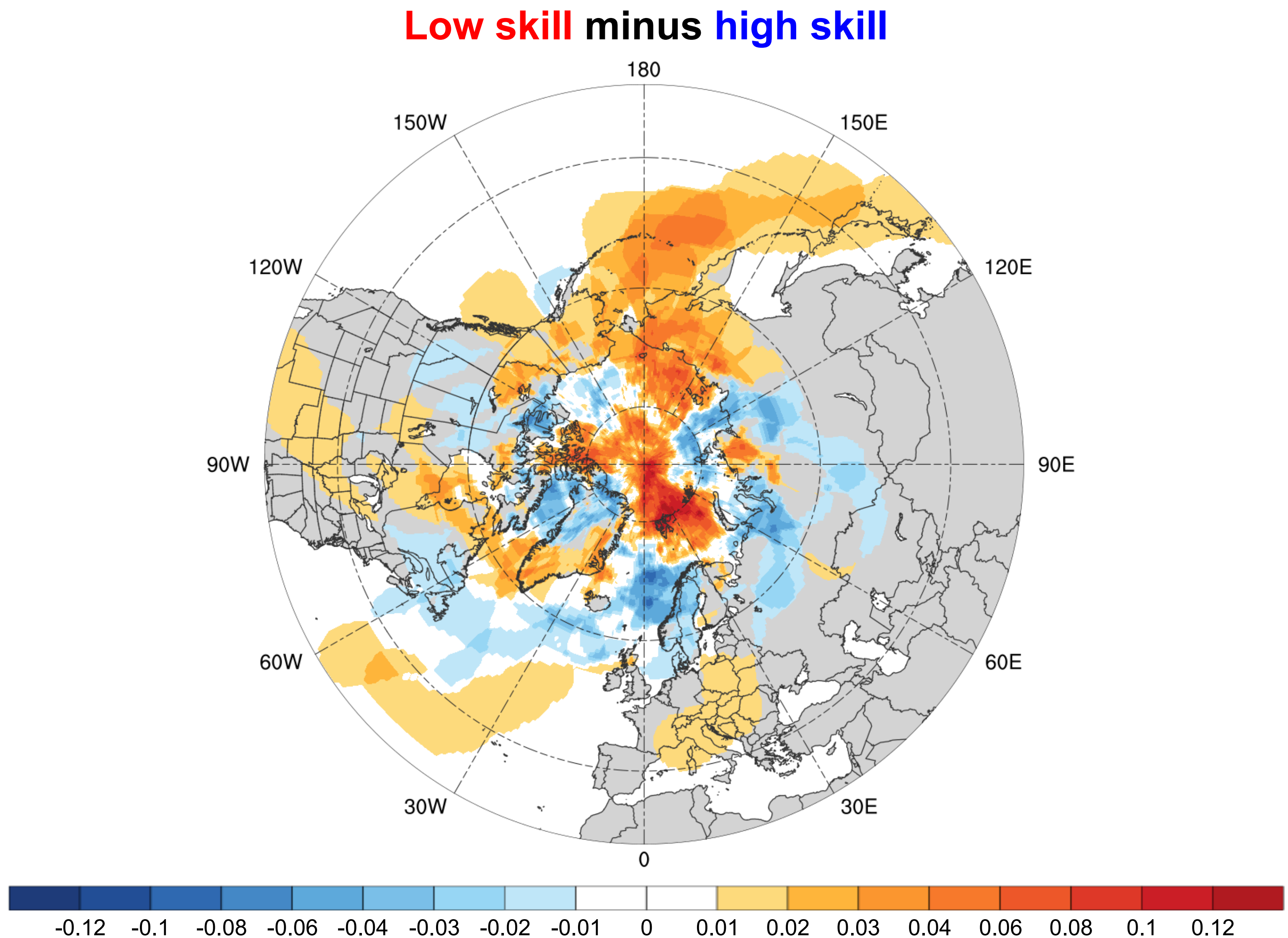
Total number of ACs within 500 km of a grid point,
divided by number of days in climatology during SON (number of ACs day^{-1})

Track Frequency (SON)



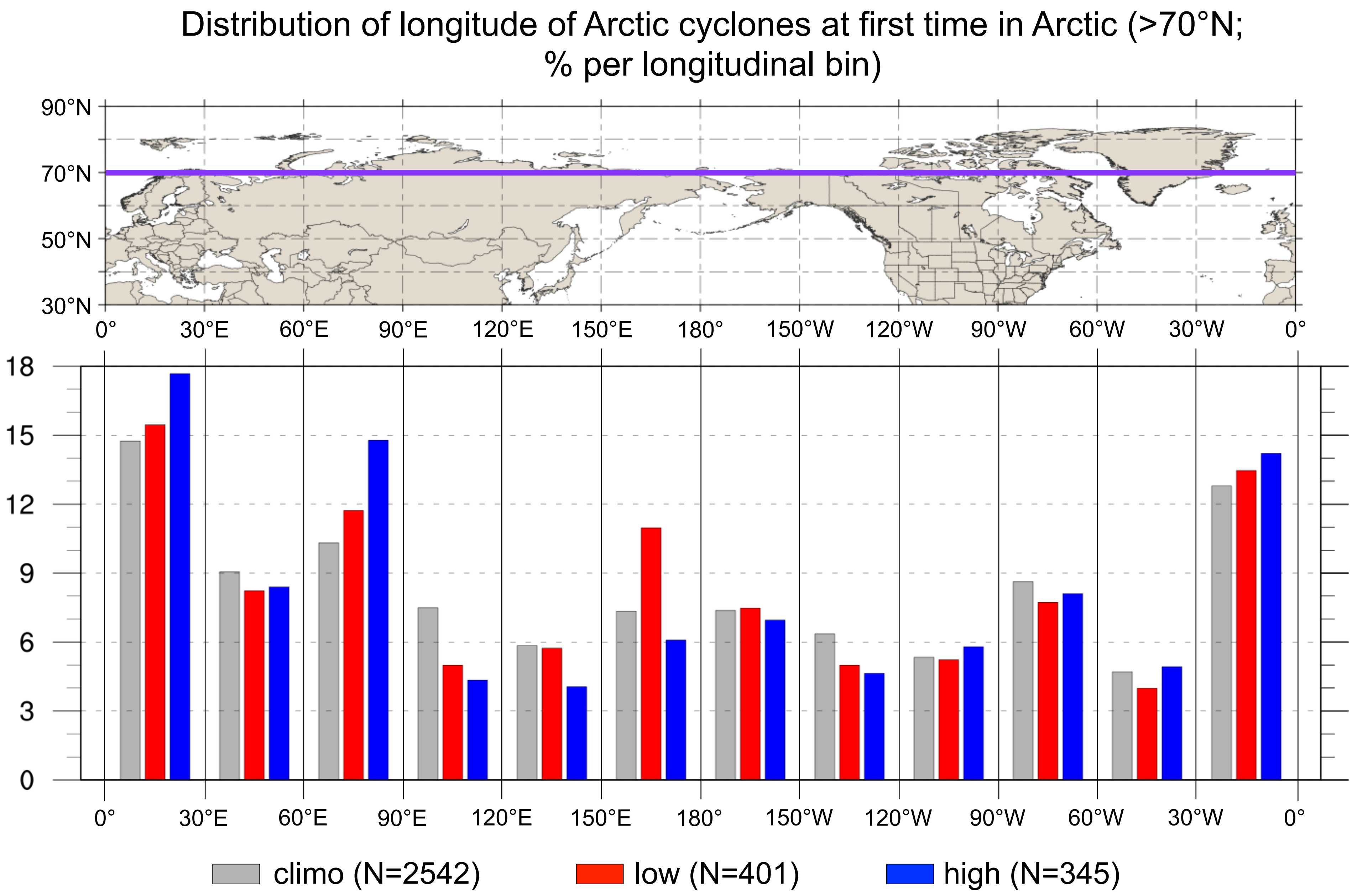
Total number of ACs within 500 km of a grid point, divided by number of days in period during SON (number of ACs day^{-1})

Track Frequency Differences (SON)

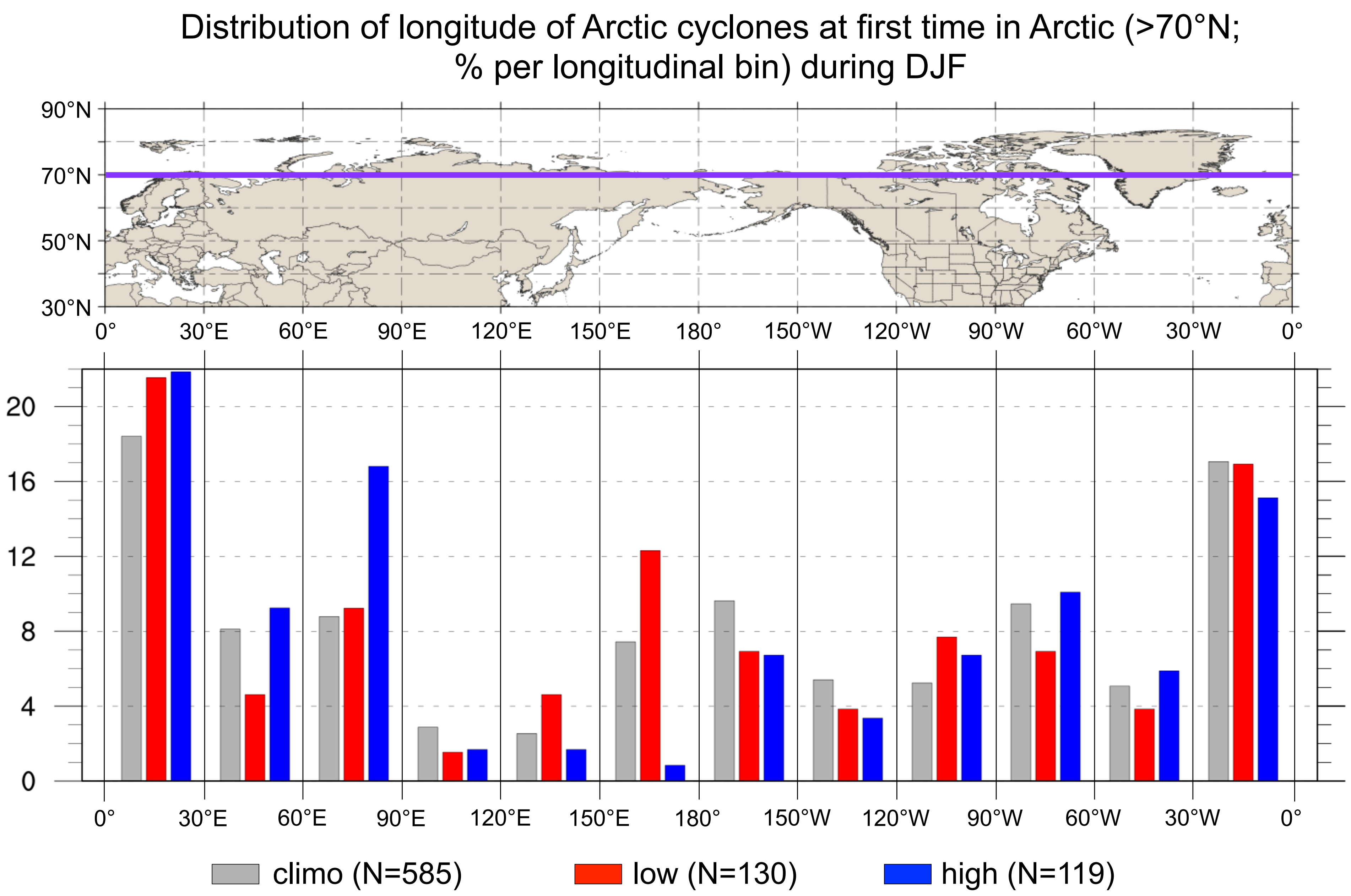


Difference in AC track density during SON (number of ACs day^{-1})

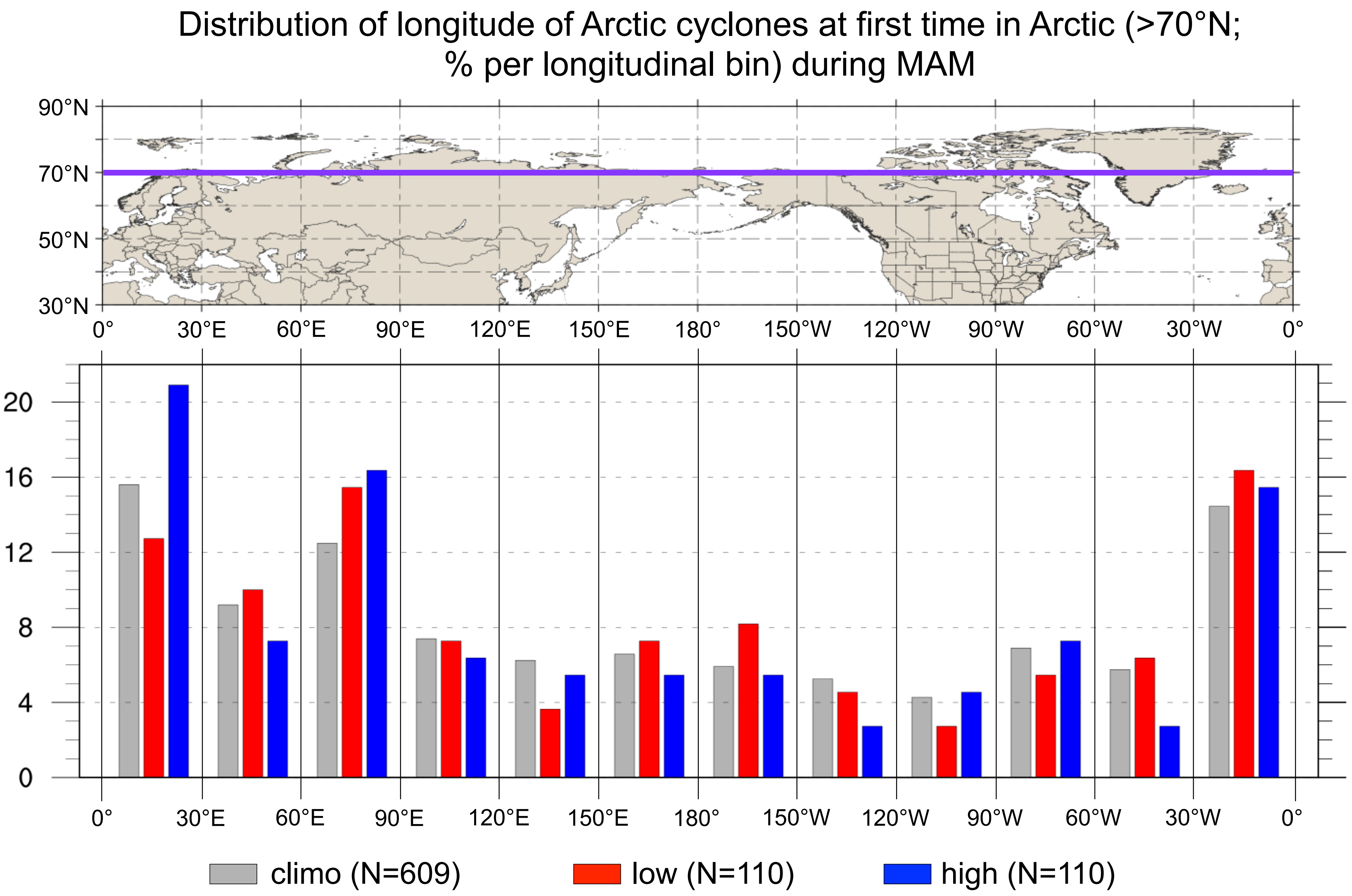
Preferred Longitudinal Corridors



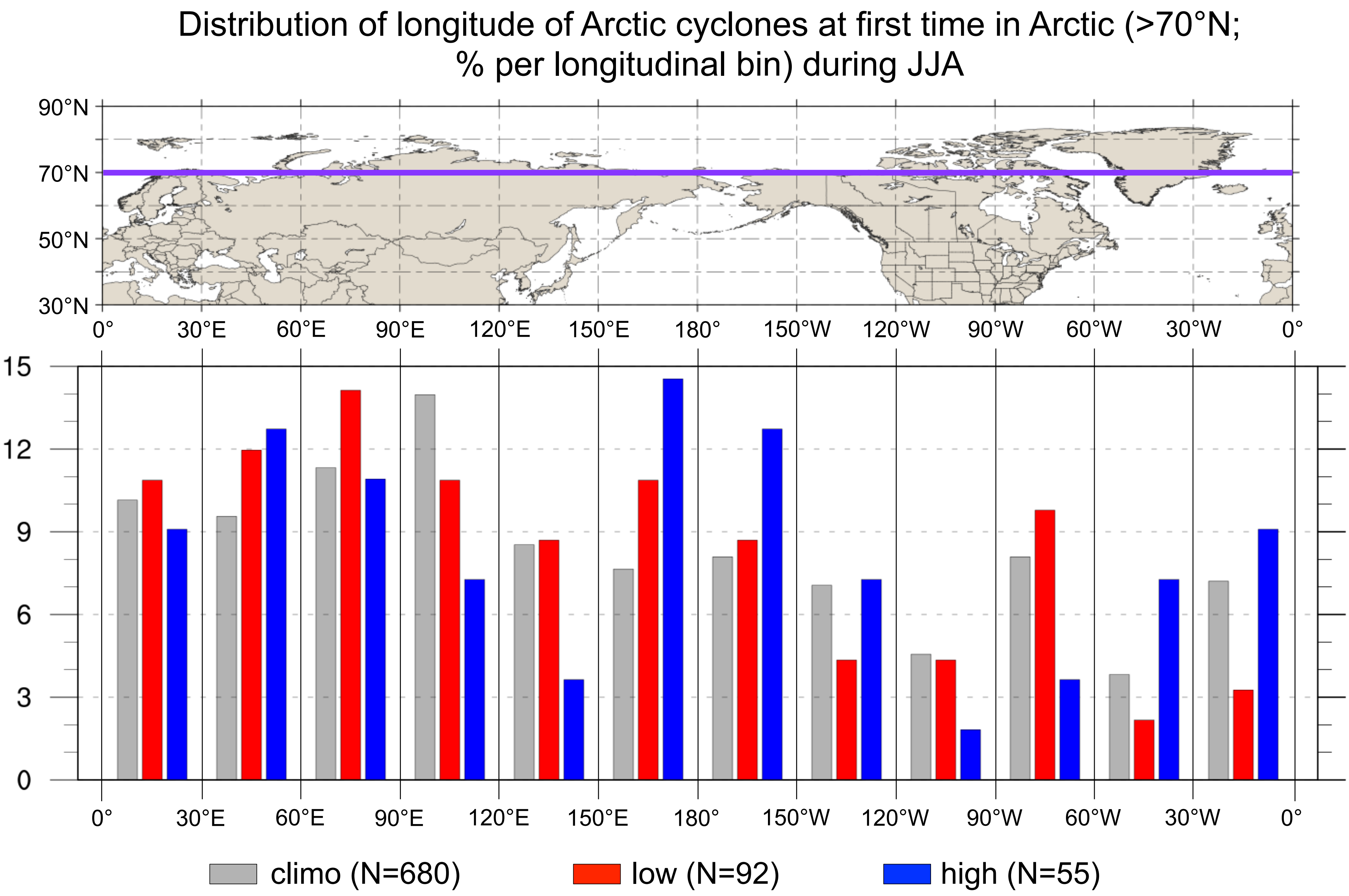
Preferred Longitudinal Corridors (DJF)



Results: Preferred Longitudinal Corridors (MAM)

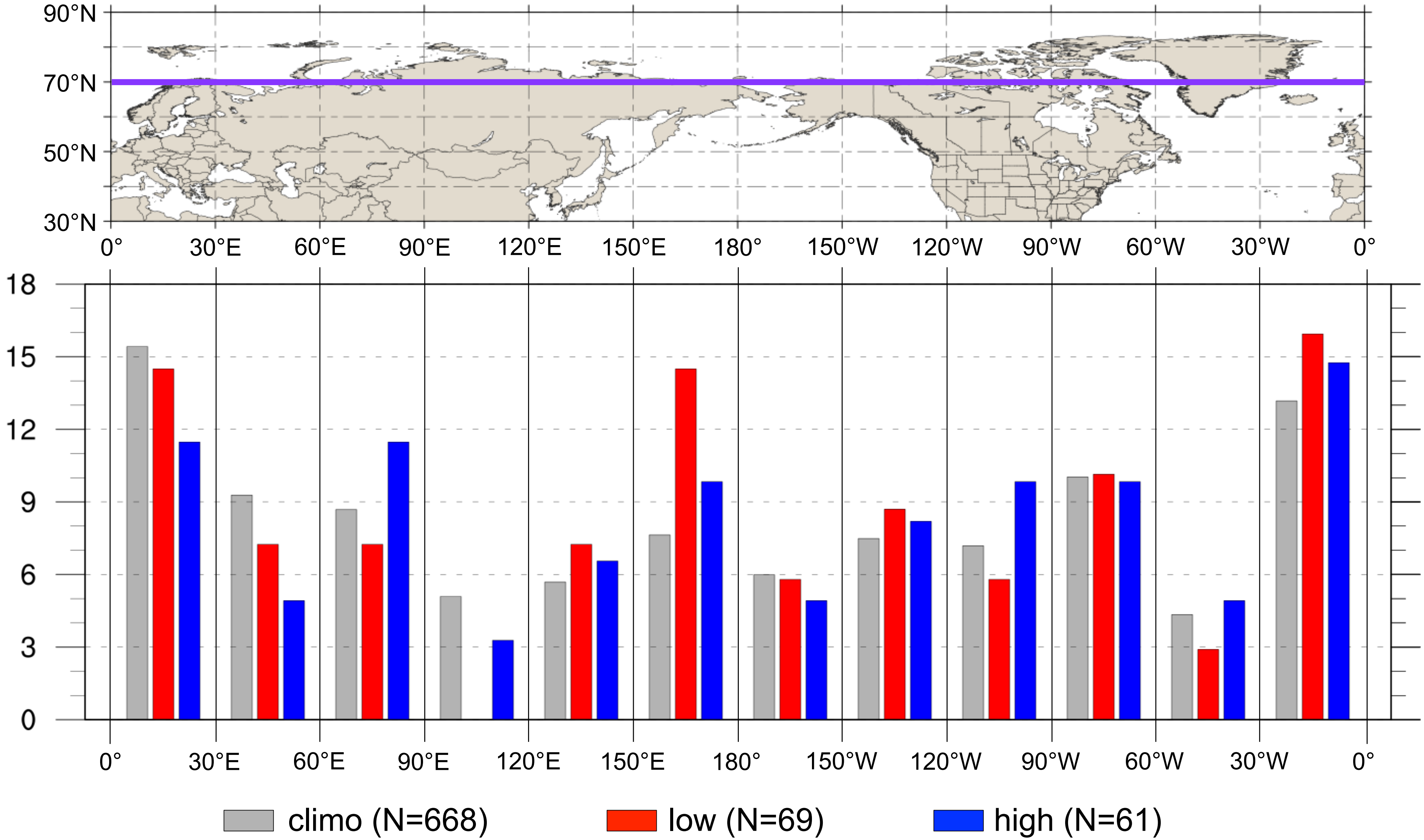


Preferred Longitudinal Corridors (JJA)

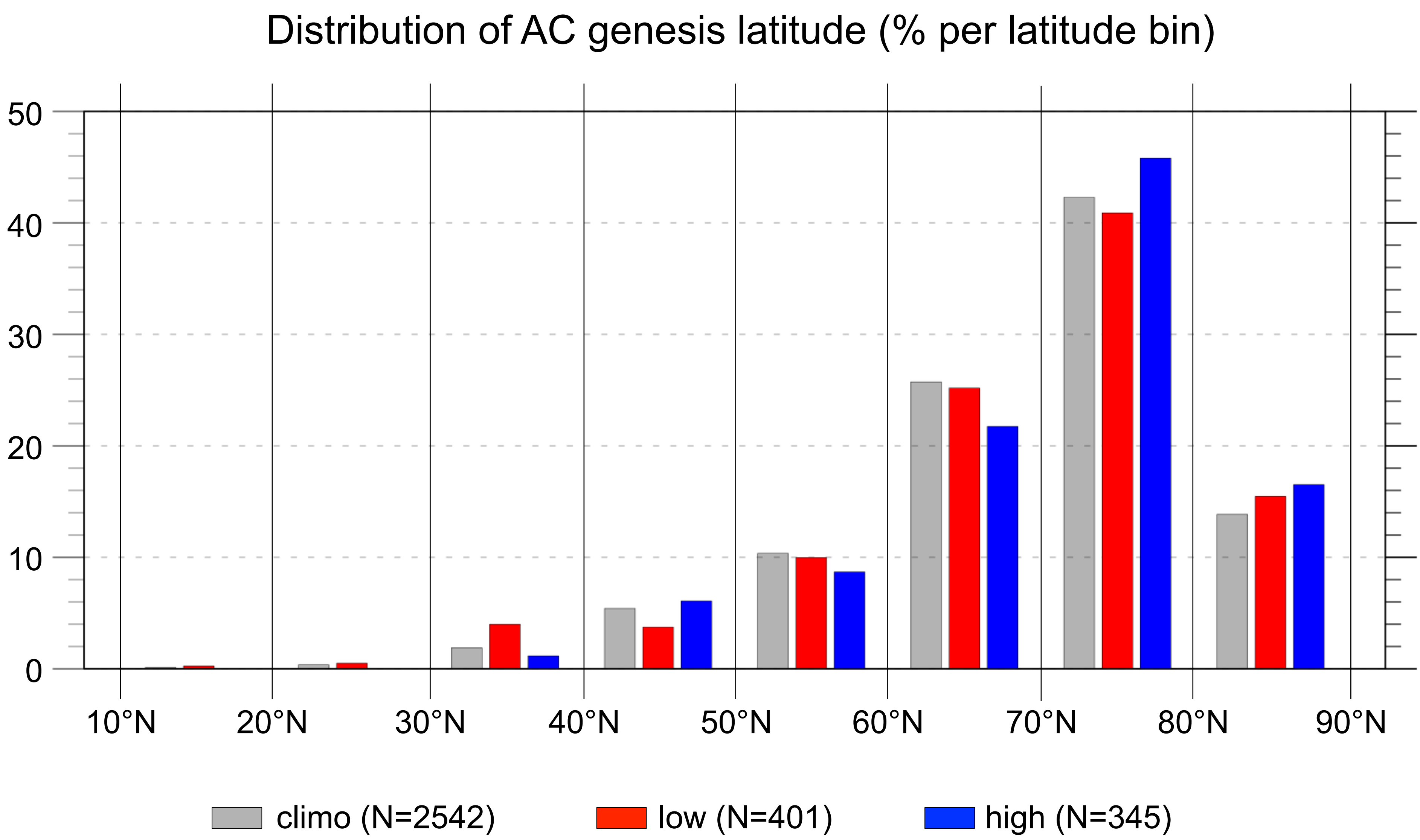


Results: Preferred Longitudinal Corridors (SON)

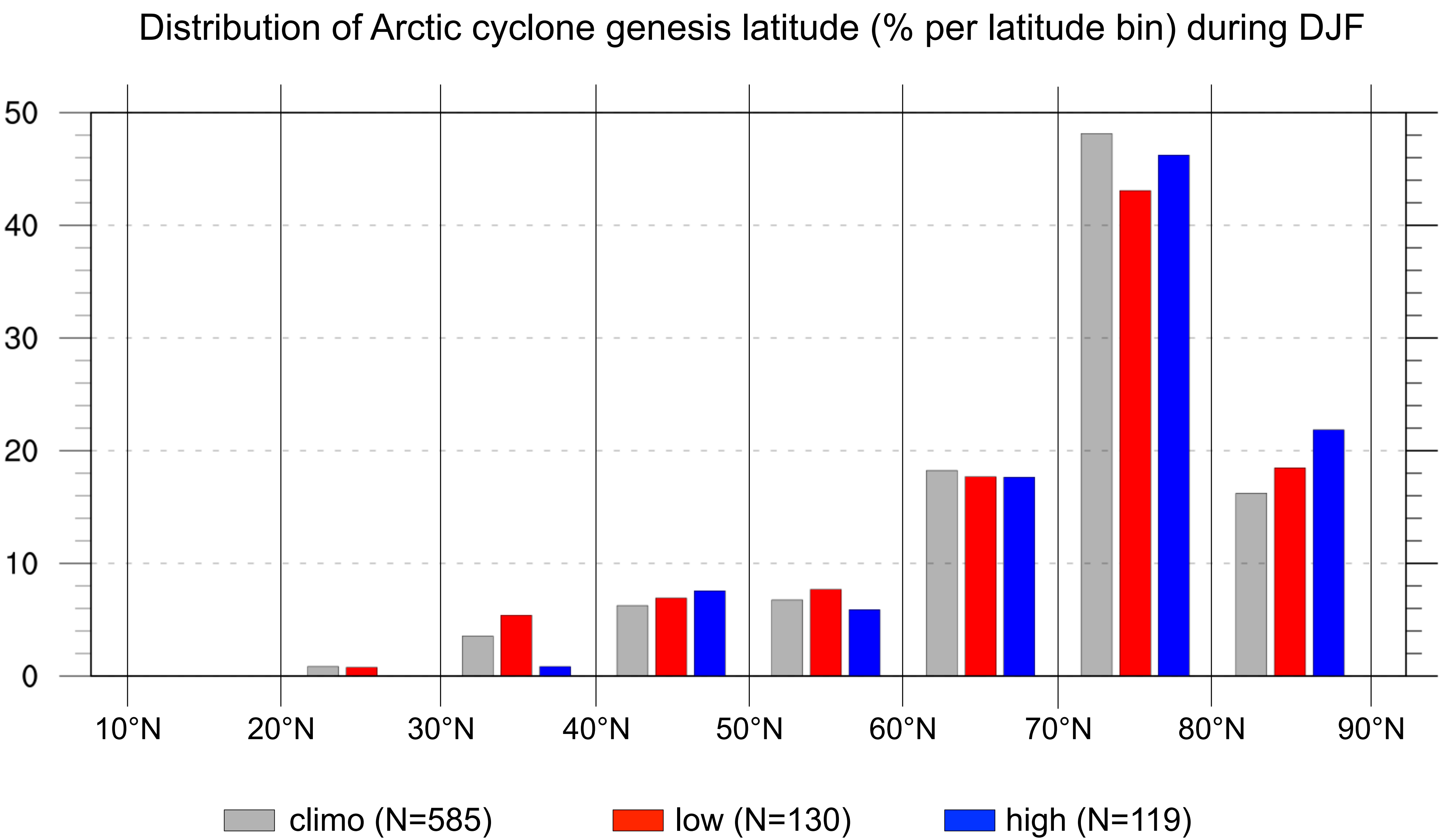
Distribution of longitude of Arctic cyclones at first time in Arctic (>70°N; % per longitudinal bin) during SON



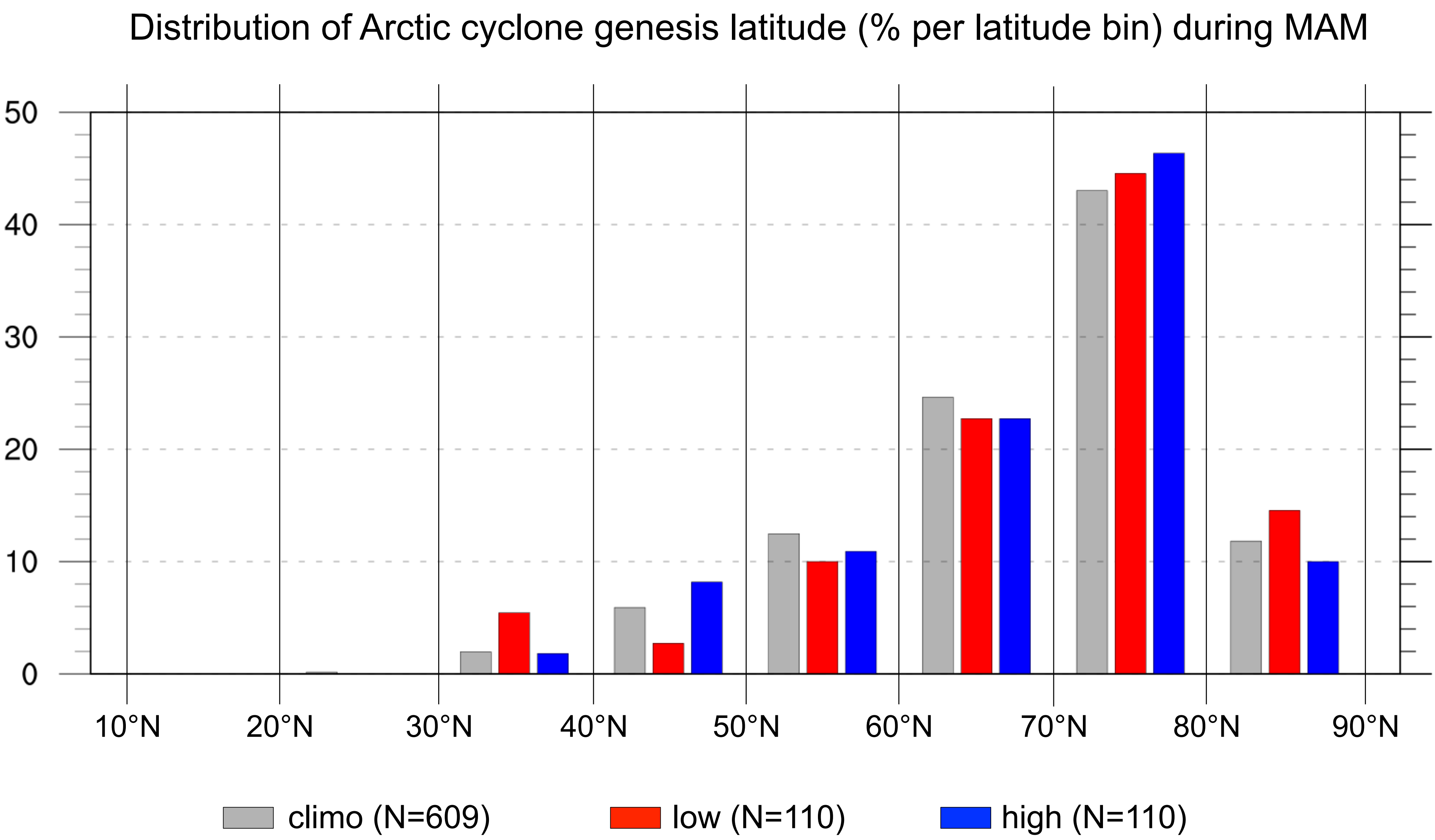
Genesis Latitude



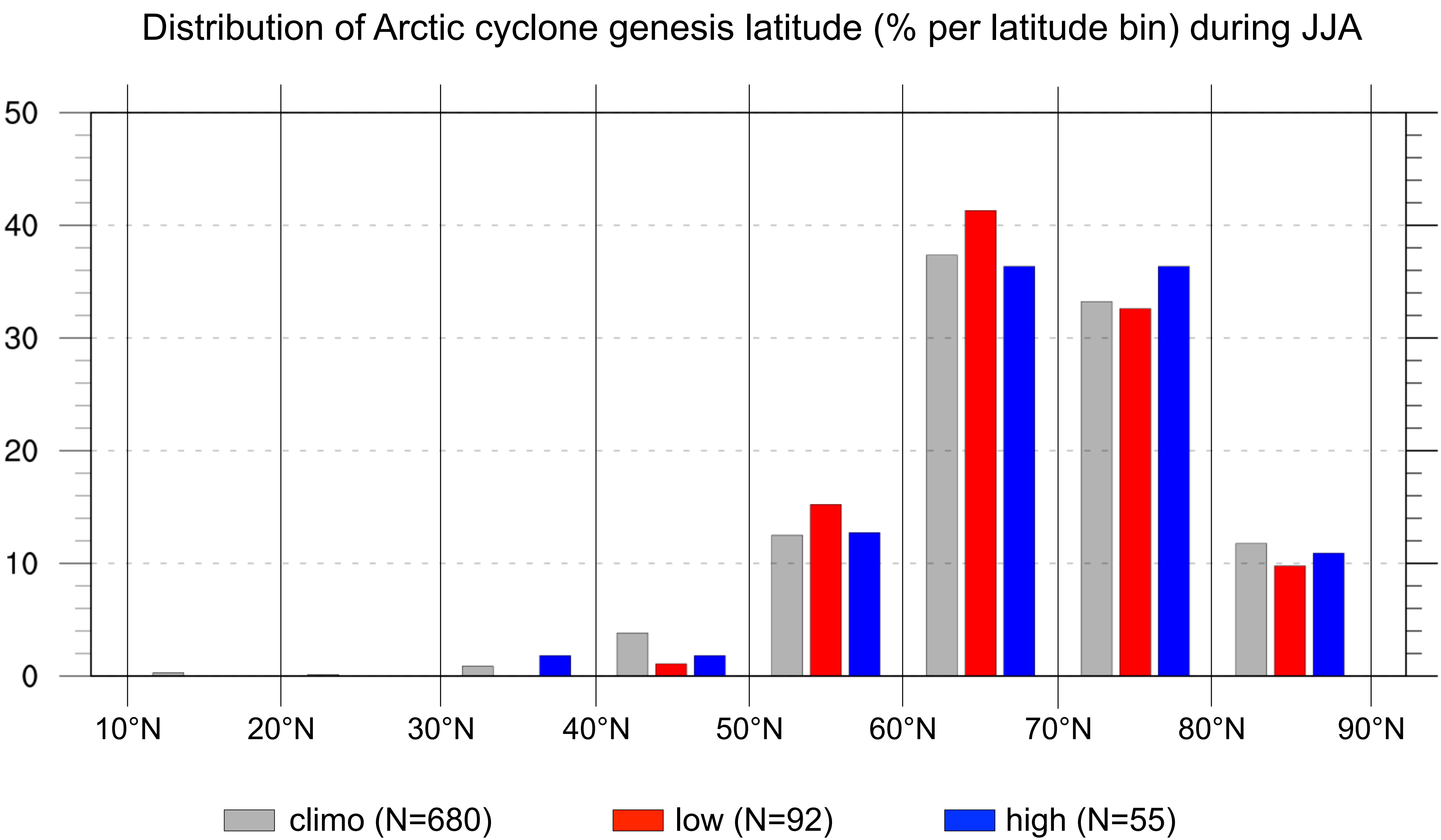
Genesis Latitude (DJF)



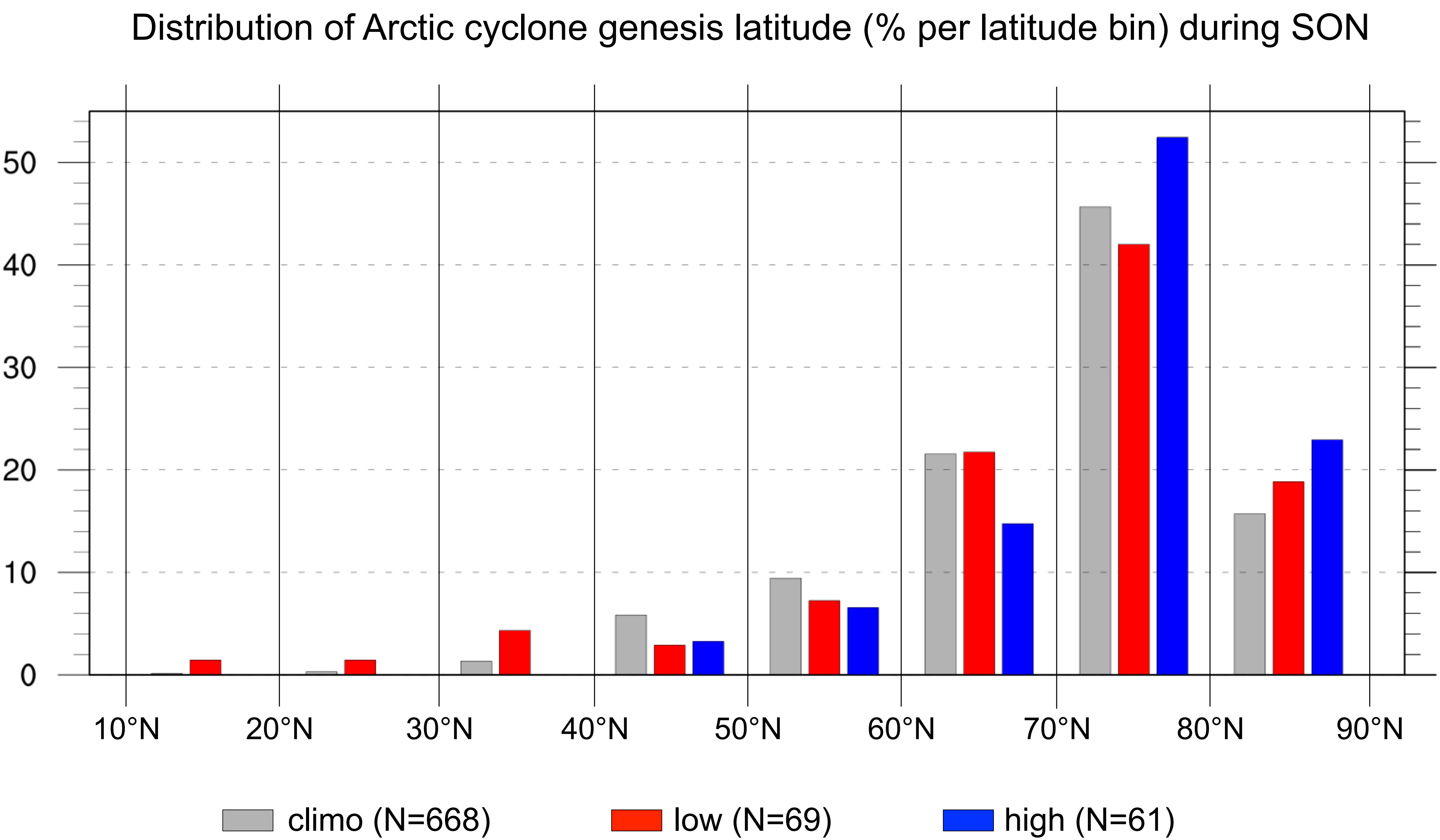
Genesis Latitude (MAM)



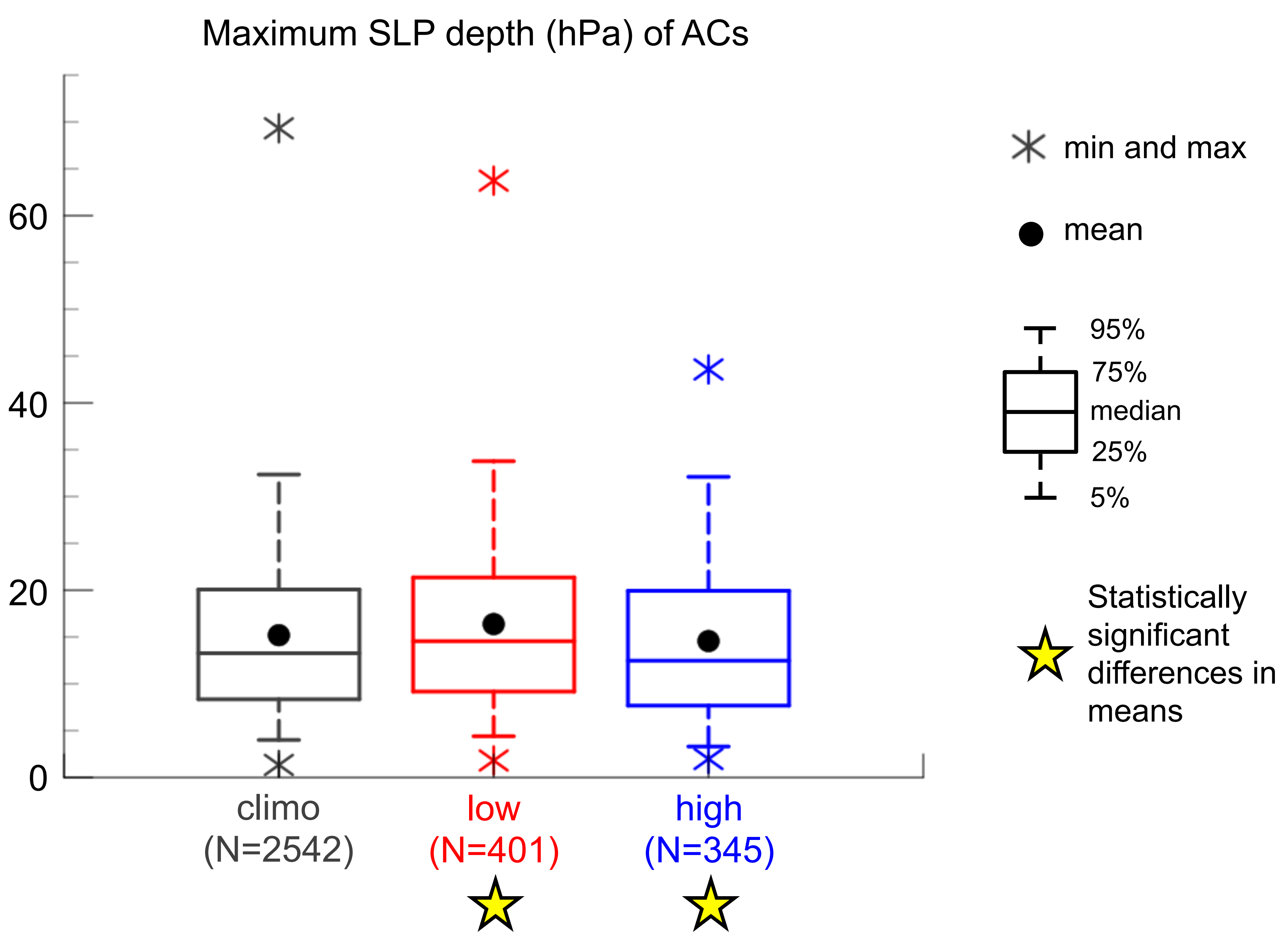
Genesis Latitude (JJA)



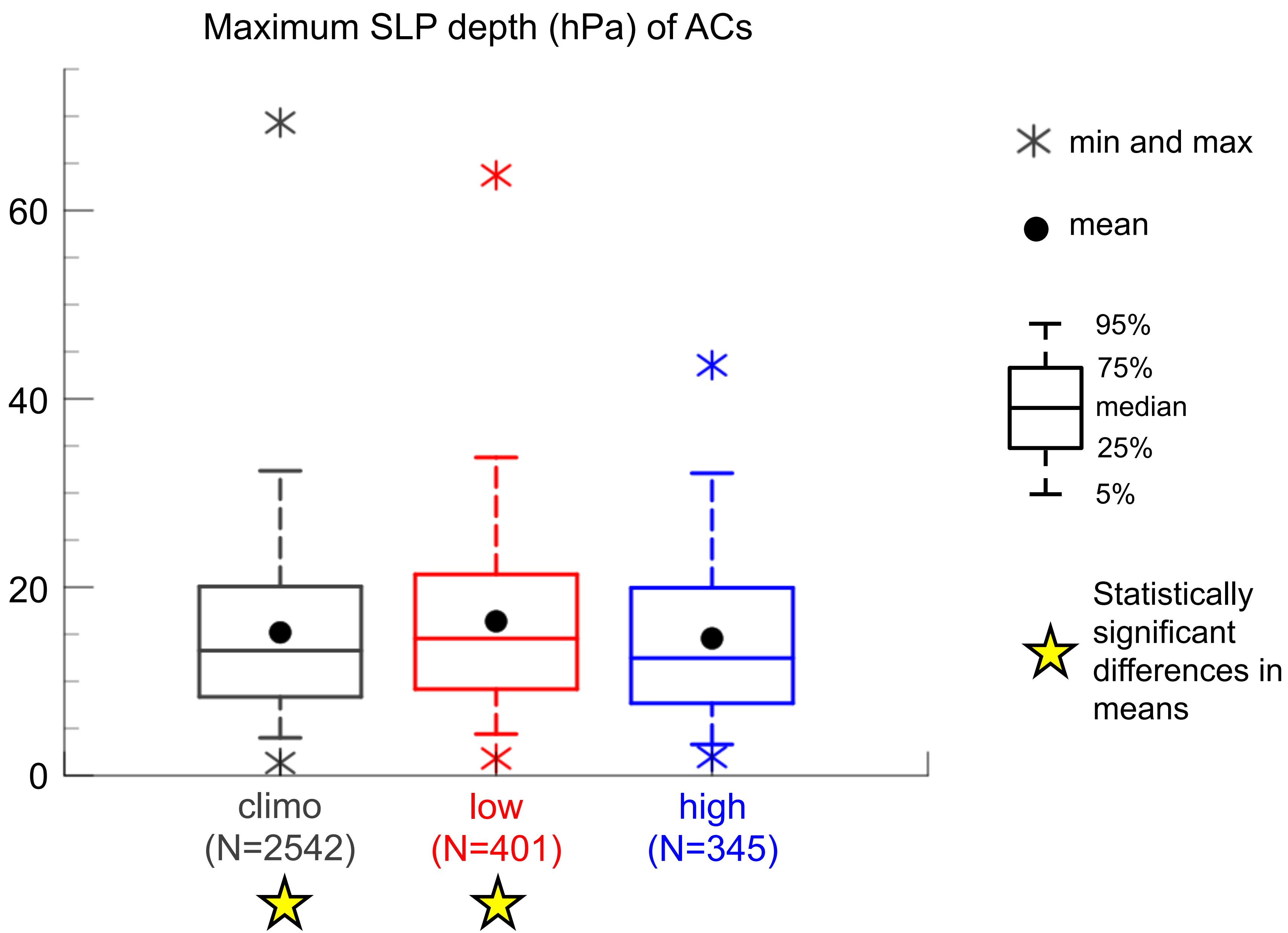
Genesis Latitude (SON)



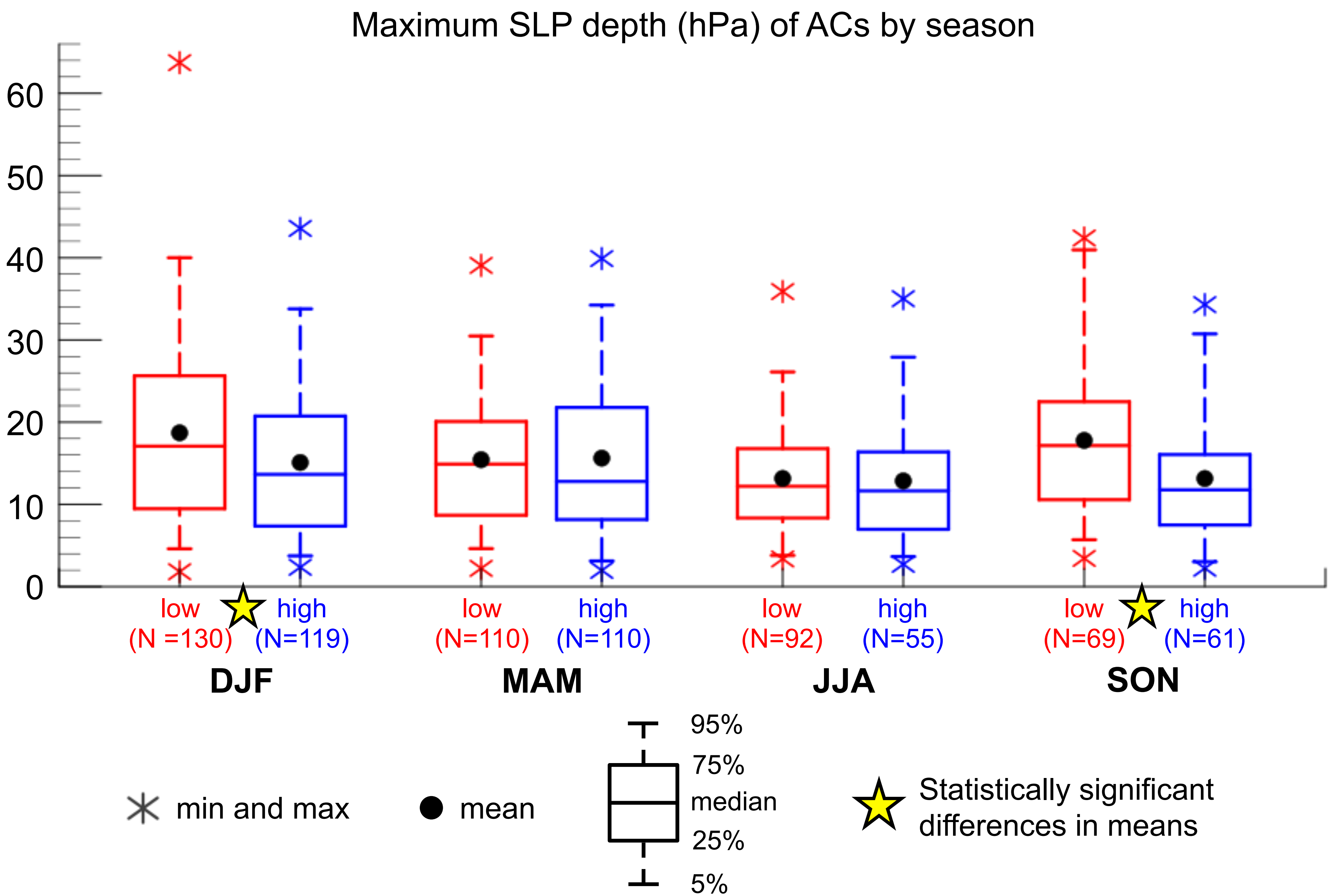
Intensity: Maximum SLP Depth



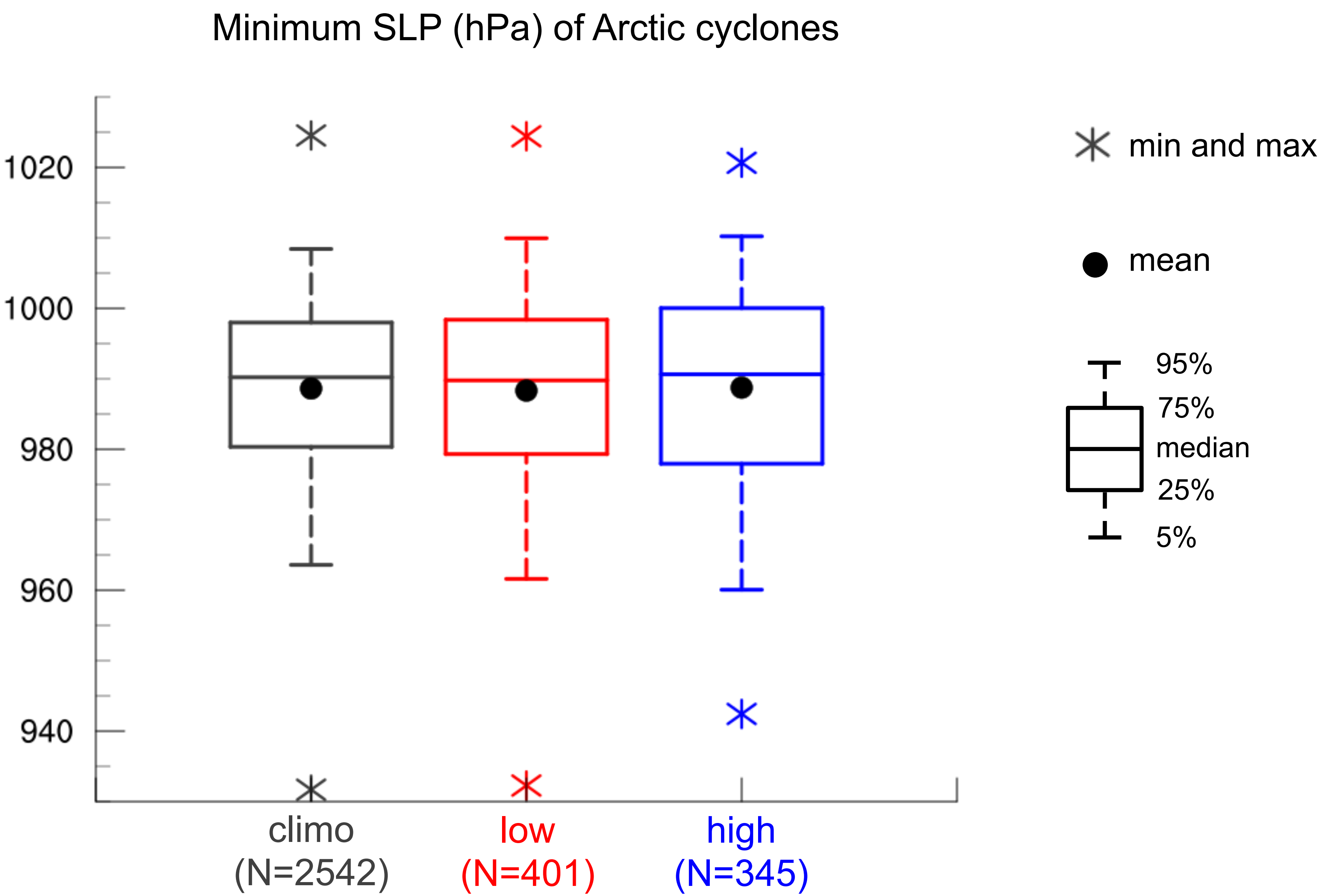
Intensity: Maximum SLP Depth



Intensity: Maximum SLP Depth



Intensity: Minimum SLP



Intensity: Minimum SLP