An Ontario Jet Stream Core Climatology

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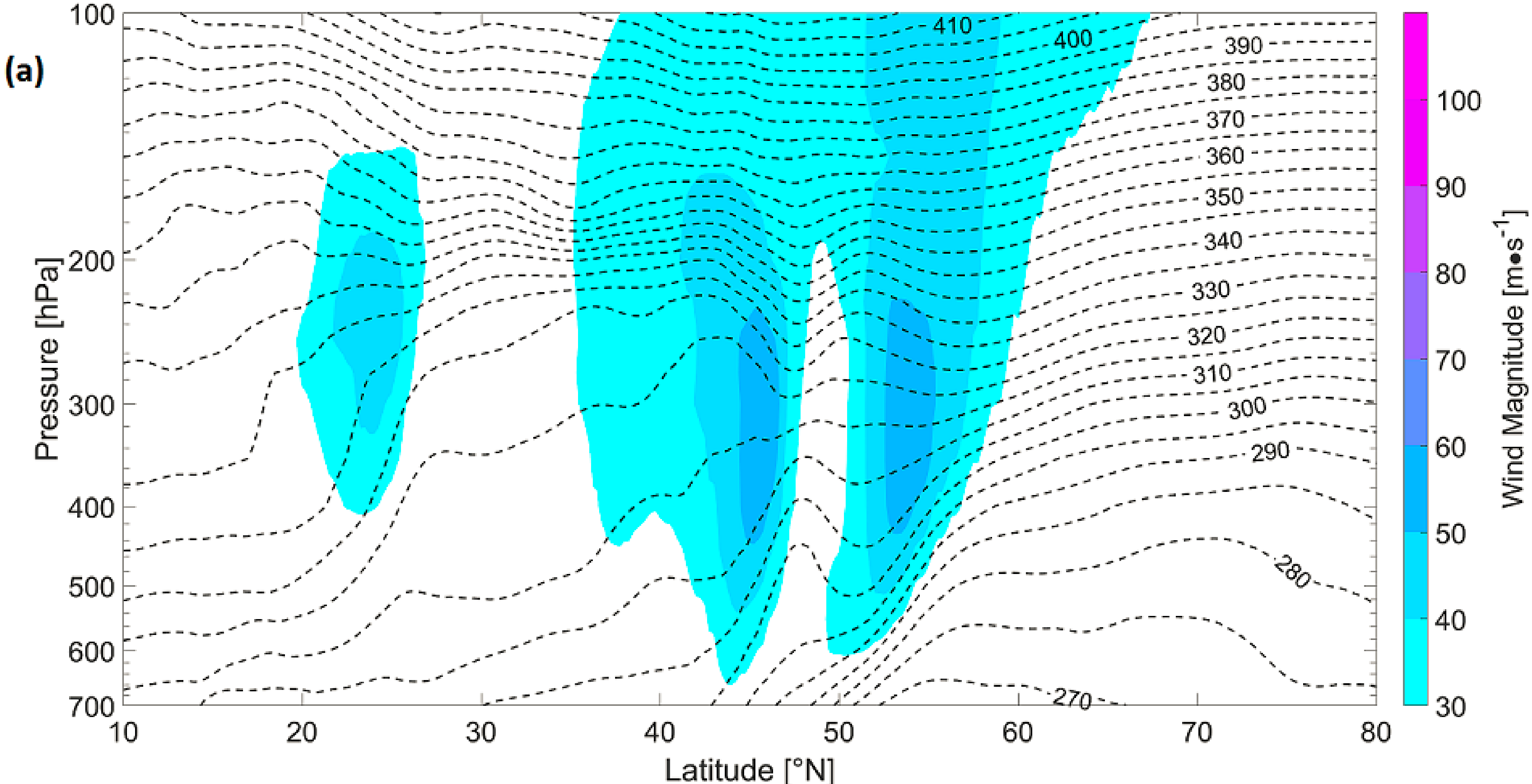
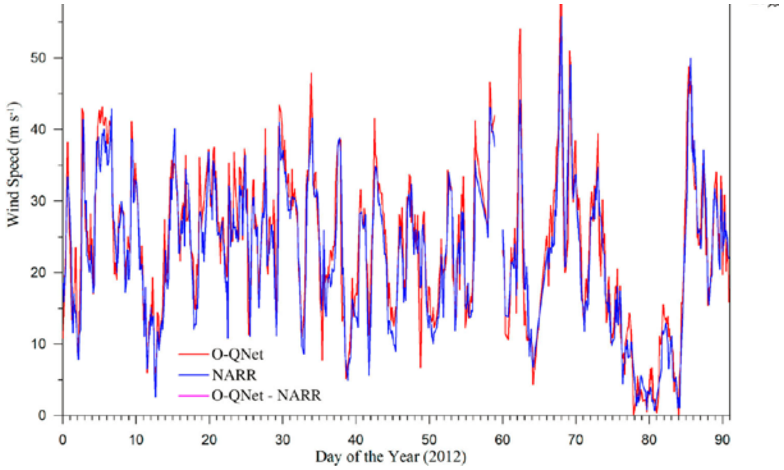


Source of the data

Using the high resolution North American Regional Reanalysis (NARR), this study aims to create a preliminary jet stream, and more specifically a jet core, database for a relatively narrow region in eastern North America covering the period 1979 through 2016 inclusive. We use regional maxima in the smoothed horizontal wind field to locate both the latitudinal, and vertical (pressure) location of jet cores along specific meridians.

Taylor et al (2016): Upper-Level Winds over Southern Ontario: O-QNet Wind Profiler and NARR Comparisons, Atmosphere-Ocean, DOI:10.1080/07055900.2016.1231658) compared several years of upper level winds (500 and 250 hPa) measured by a network of VHF wind profilers over Ontario and Quebec with National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Prediction (NCEP) North American Regional Reanalysis (NARR) (Mesinger et al. 2004) data. Noting that the VHF profiler winds were not assimilated in the NARR reanalyses, agreement between observed and reanalysis upper level winds was excellent and provides sufficient support to use the NARR data for developing a jet-stream climatology for this region and its surrounding areas.



Comparison of the Egbert wind speed at 5500 m above the local terrain for the winter months (JFM) of 2012. NARR data interpolated to 5500 m. Similar results at 10,000m and other times.

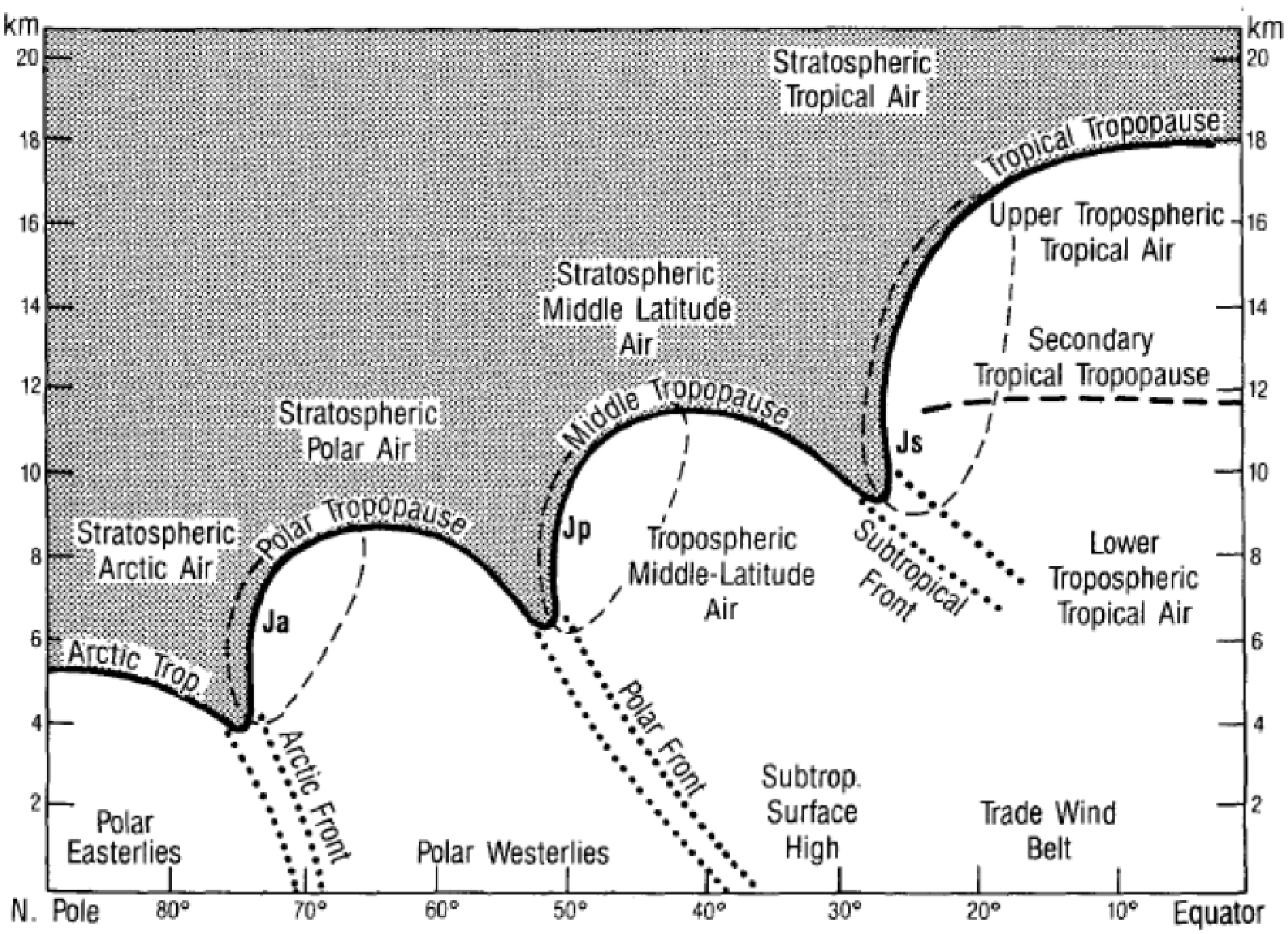
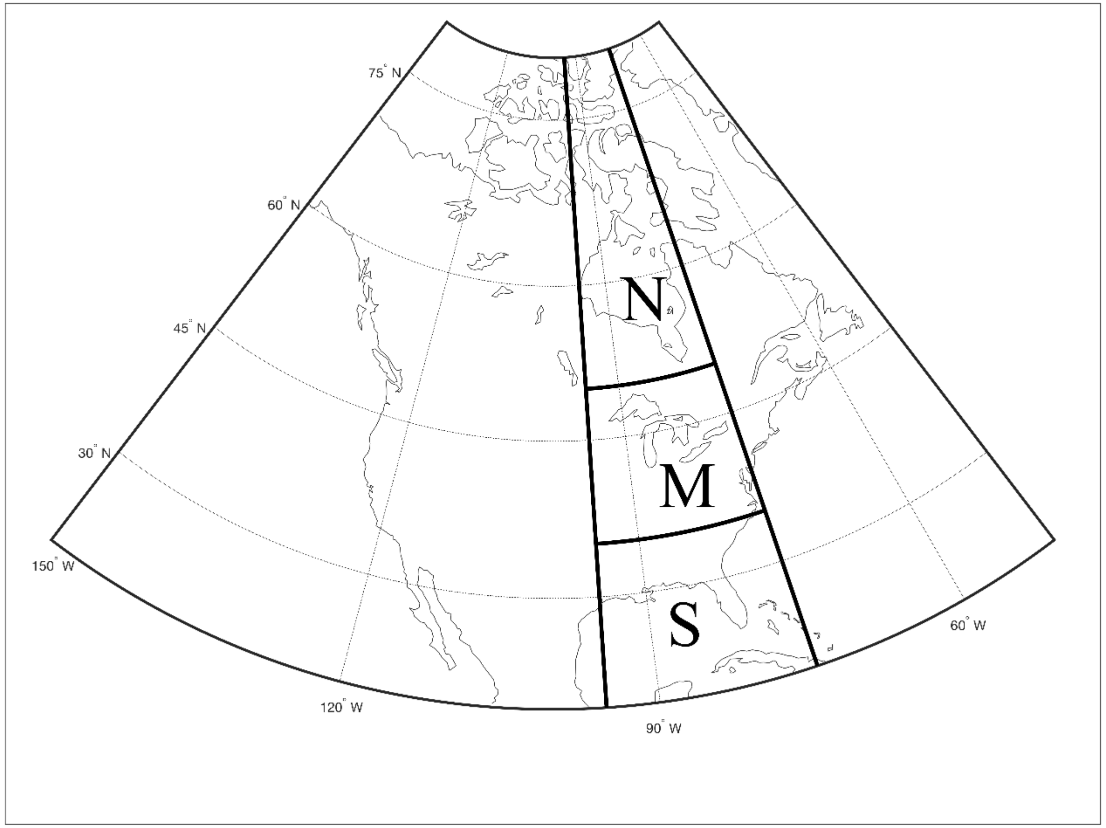


Figure 1. Same as Fig.17 in Shapiro et al. (1987). The threefold meridional structure of the tropopause. Potential vorticity discontinuity tropopause (or dynamic tropopause), heavy solid line, with stratosphere stippled. The primary frontal zones are bounded by the heavy dotted lines and labeled. The 40 ms^{-1}) isotach, thin dashed lines, encircle the cores of the three primary jet streams; the Arctic, Ja; the polar, Jp; and the subtropical, Js. The secondary (thermal) tropical tropopause is indicated by the heavy dashed line. Major tropospheric and stratospheric air masses, tropopause surfaces, and selected wind systems are also labeled in the meridional cross-section.

Polar Jet or EDJ (Eddy Driven Jet)?

After the interpolation of a single time-step's worth of data (on a three-dimensional pressure and Lambert Conformal spatial array) to a regular 1° x 1° latitude-longitude grid, the data are then further reduced to two dimensions by selecting specific longitudes. For the purposes of this study, we analyze wind data along the following five longitudes: 95°W, 90°W, 85°W, 80°W, and 75°W. This approximately covers the longitudinal span of Ontario. We also narrow the meridional extent of the region of interest to 20°N to 80°N, inclusive (see figure for an outline of the region of interest). At this point, the absolute wind maximum over the two-dimensional array (latitude and pressure) is identified; however, given that multiple jet-streams may exist at a given instant for a given longitude, we search the array for "regional" wind maxima and their array locations (with the imregionalmax function from MATLAB, 2016). This will limit jet core locations to the data set latitudes (1° resolution) and pressure levels (50 or 25 hPa resolution). When we first applied this searching algorithm, too many "regional" wind maxima that were associated with the same jet core were identified. In order to minimize this issue and improve the identification of distinct jet cores, we smoothed the interpolated two-dimensional array using a low pass Gaussian filter. We also require a minimum threshold wind speed, 30 ms^{-1} for June, July, August, and September, 35 ms^{-1} for April, May, and October, and 40 ms^{-1} for November, December, January, February, and March.



For some analyses we break the region into 3 latitude bands.

How many jets, instantaneous or averages (time or zonal)? Zonal wind or wind speed? We work with instantaneous (NARR 3 hr interval) local maxima of smoothed horizontal wind speeds across fixed longitude, latitude-pressure planes.

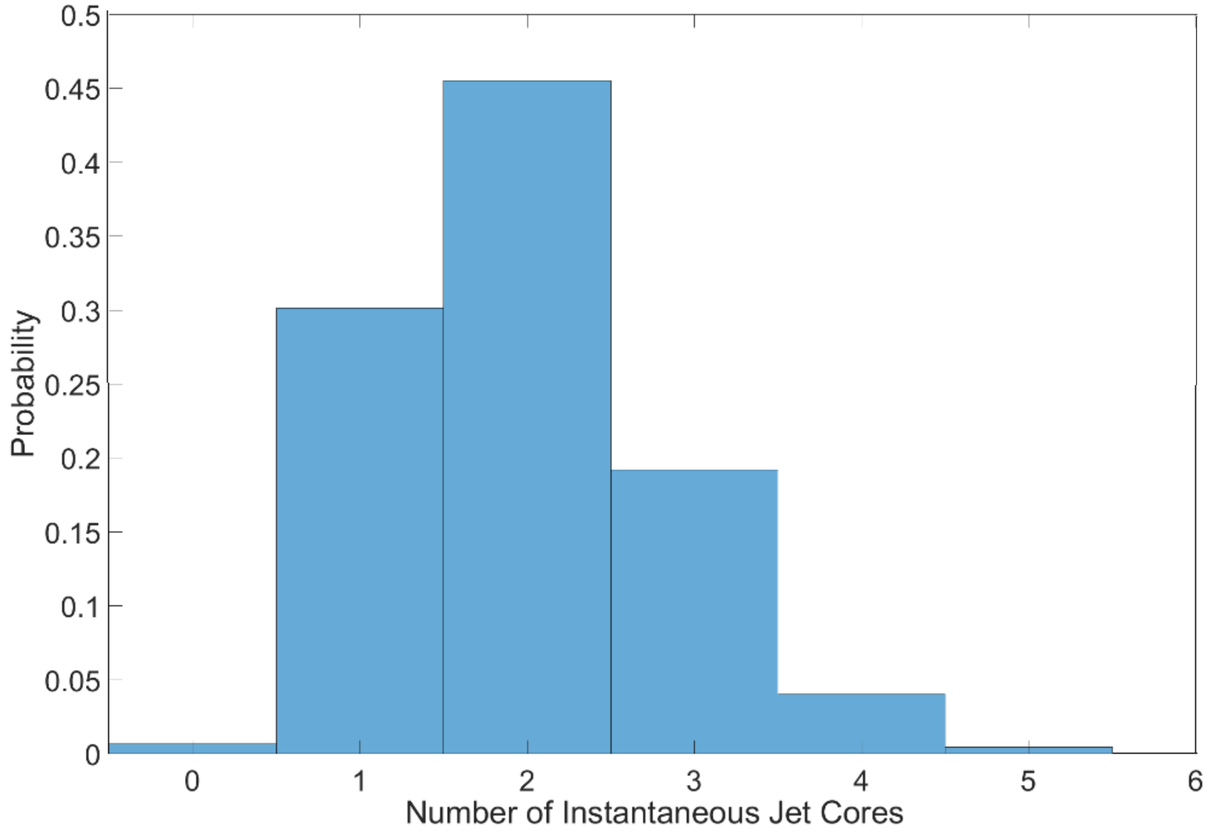
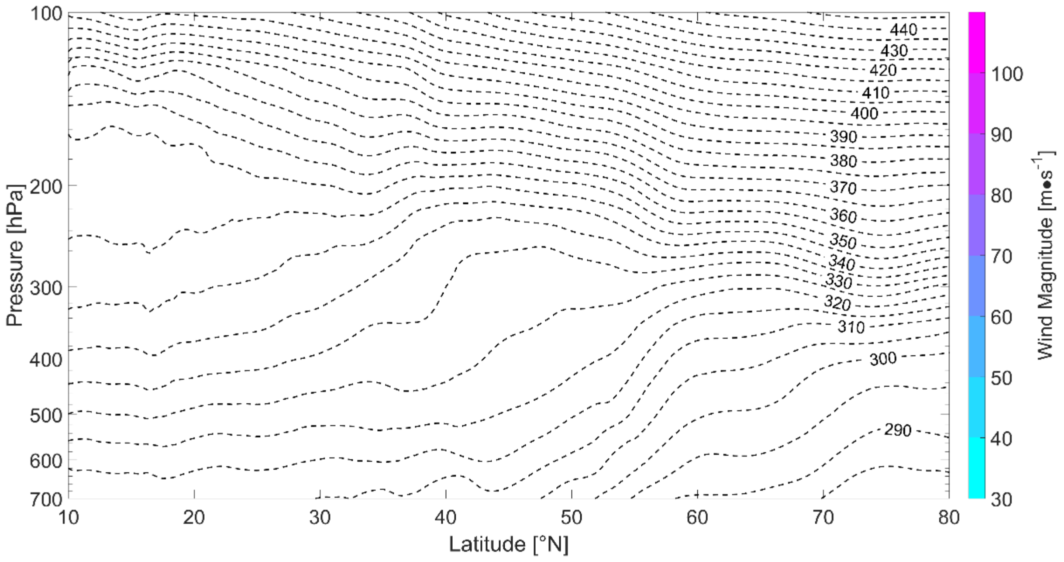


Figure 4. PDF of the number of instantaneous jet cores along all five meridians of interest.



A zero jet core example, 03 UTC 25 August 1979, along 95°W

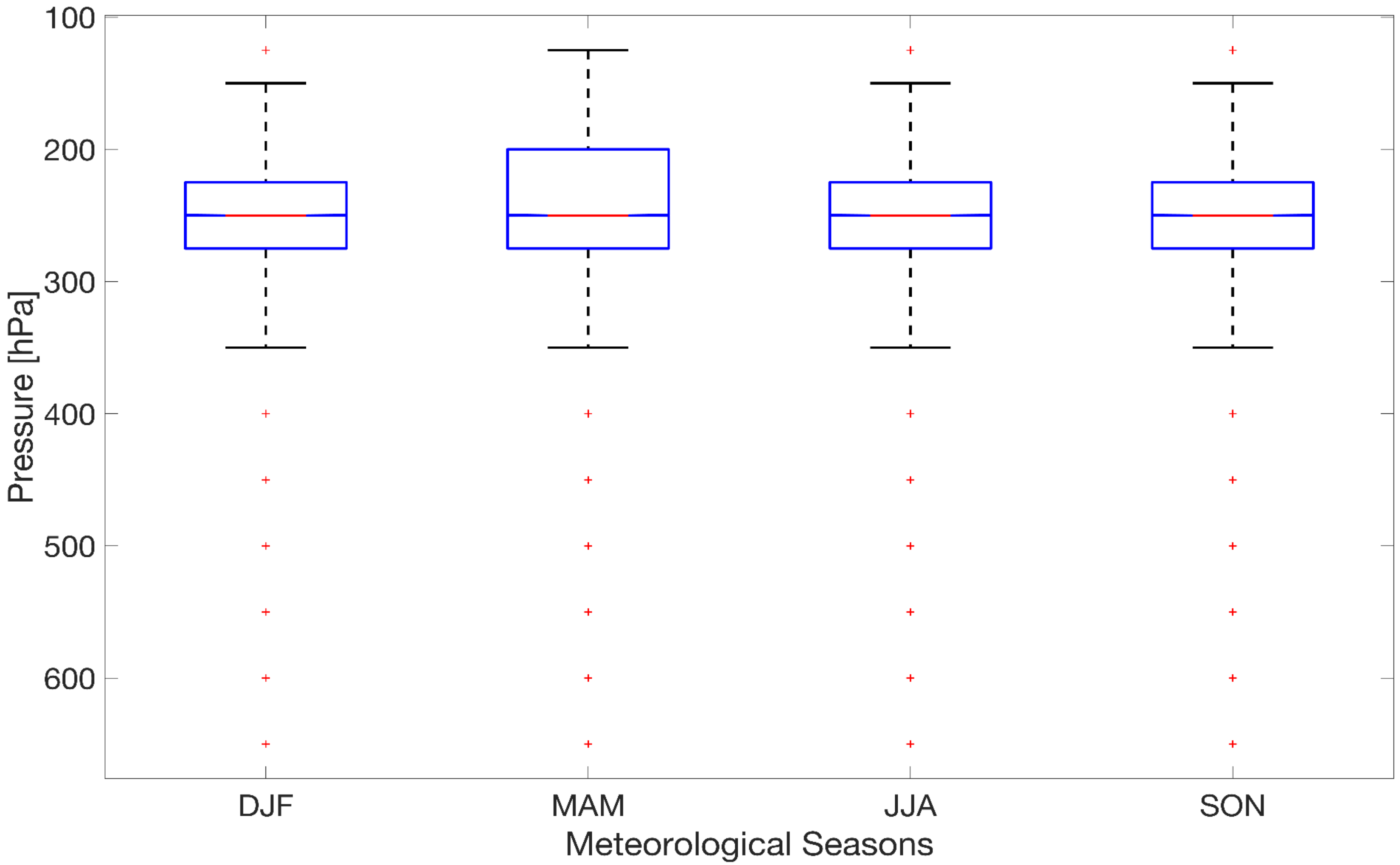


Figure 5. Seasonal box plots of jet core pressure levels based on the meteorological seasons. The red line denotes the median (or 50th percentile) while the blue boxes denote the 25th and 75th percentiles. The whiskers extend to the lowest and highest data points still within 1.5 times the inter-quartile range of the quartiles. Outliers are denoted by red pluses.

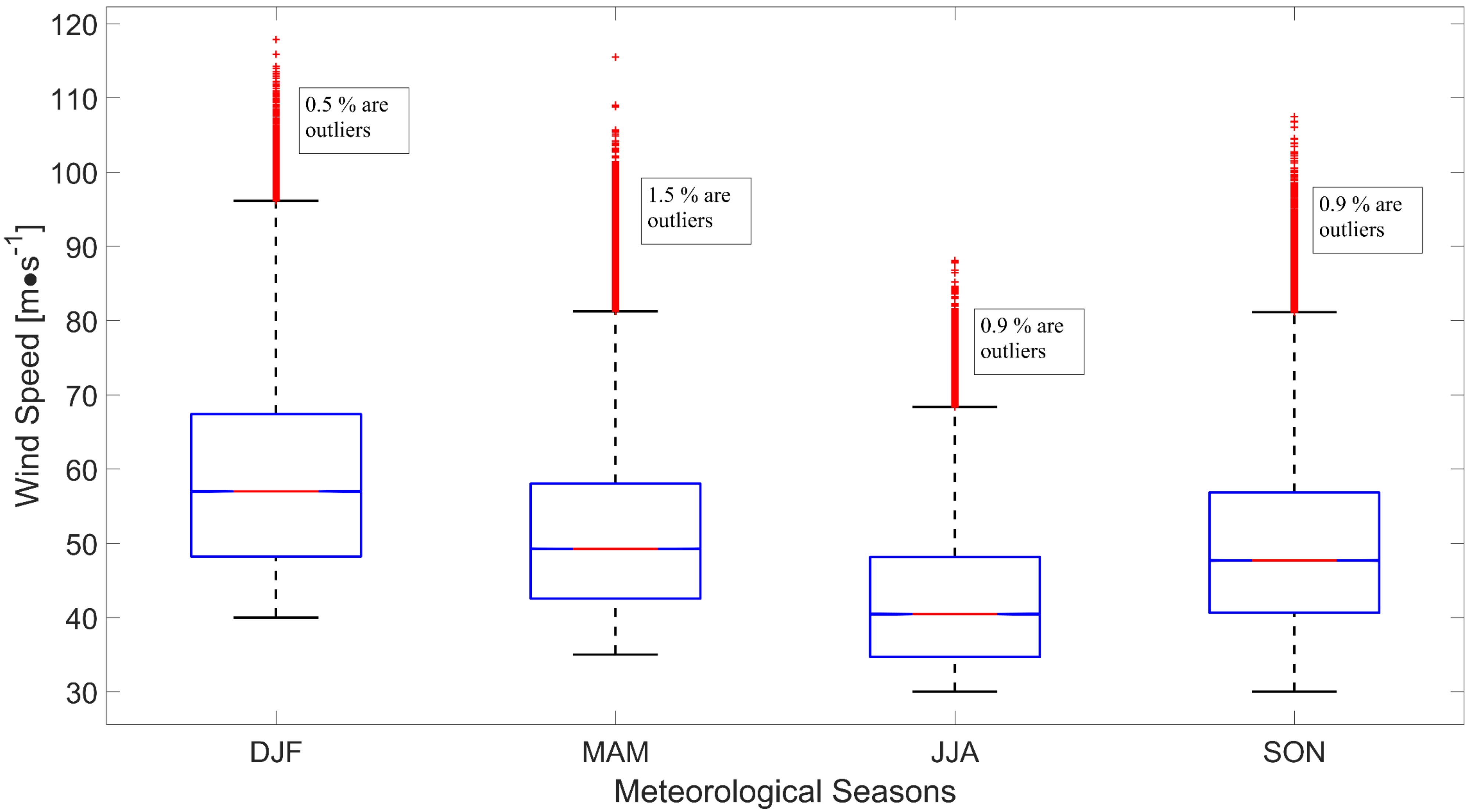


Figure 6. Seasonal box plots of jet core horizontal wind speed. Lower whiskers are affected by threshold values.

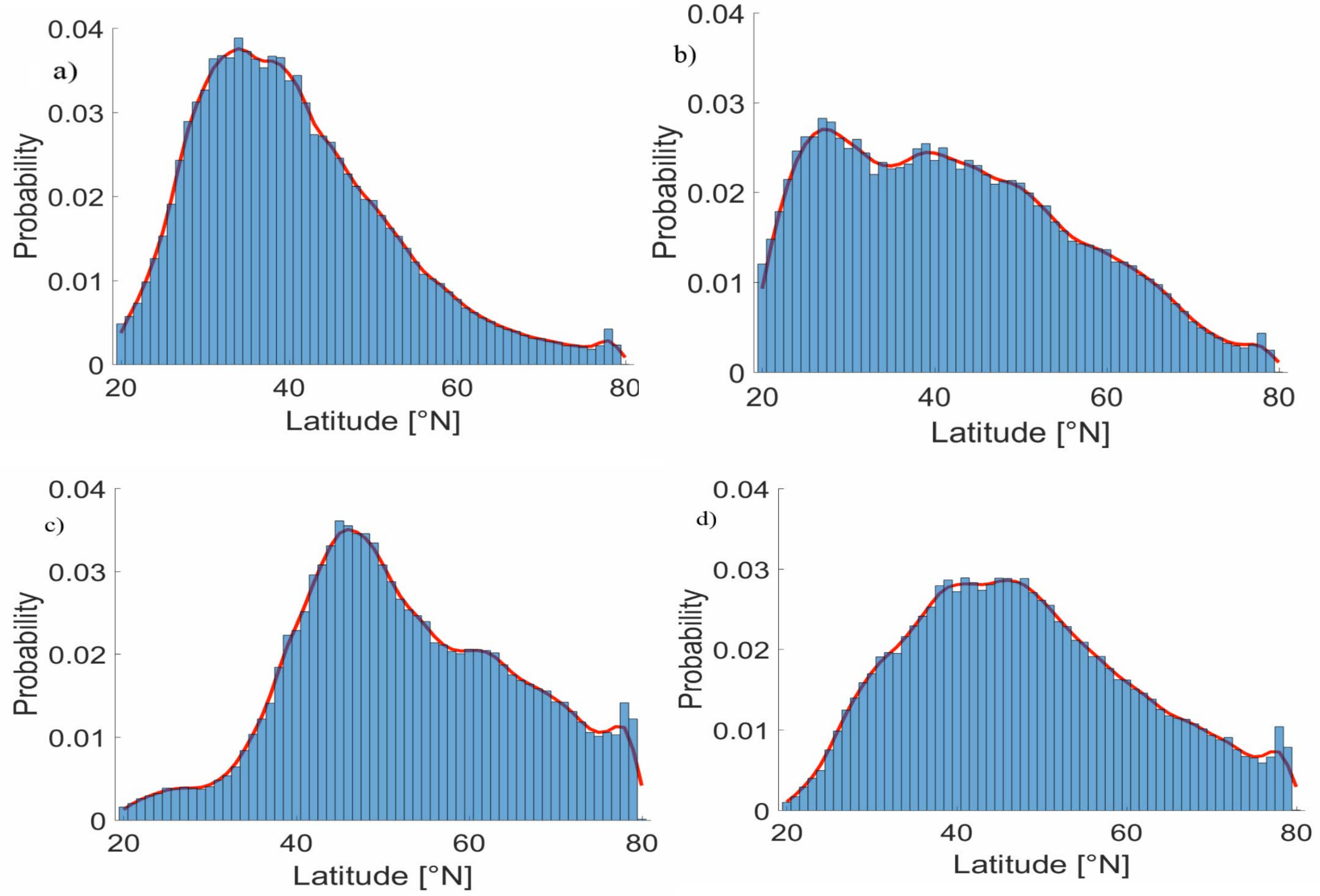


Figure 7. Seasonal PDFs of latitude (each bin corresponds to one degree of latitude, the spatial resolution used in this study), along with the kernel density estimate of the PDF (red line), for the jet cores in: (a) DJF,
(b) MAM, (c) JJA, and (d) SON.

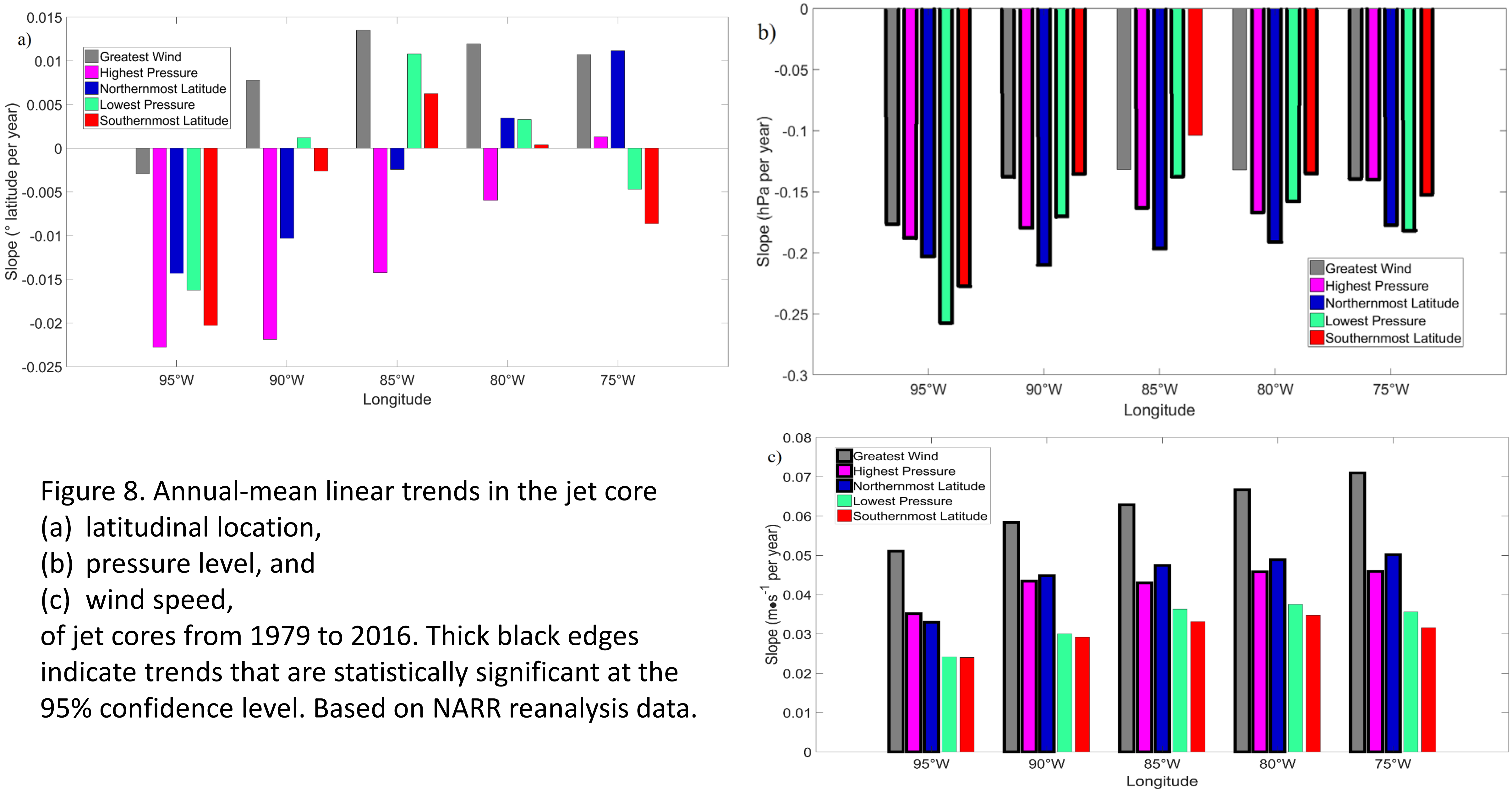
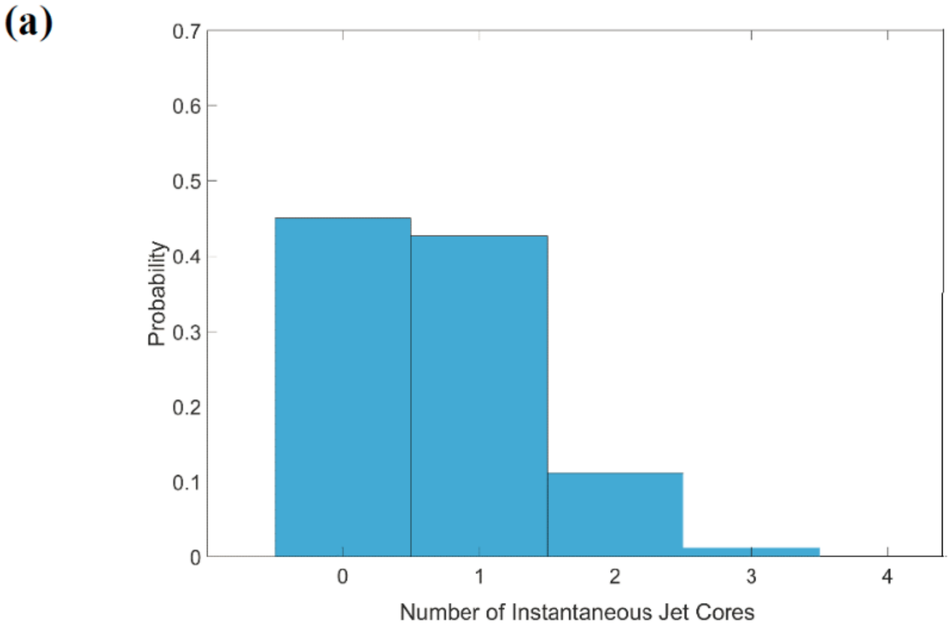
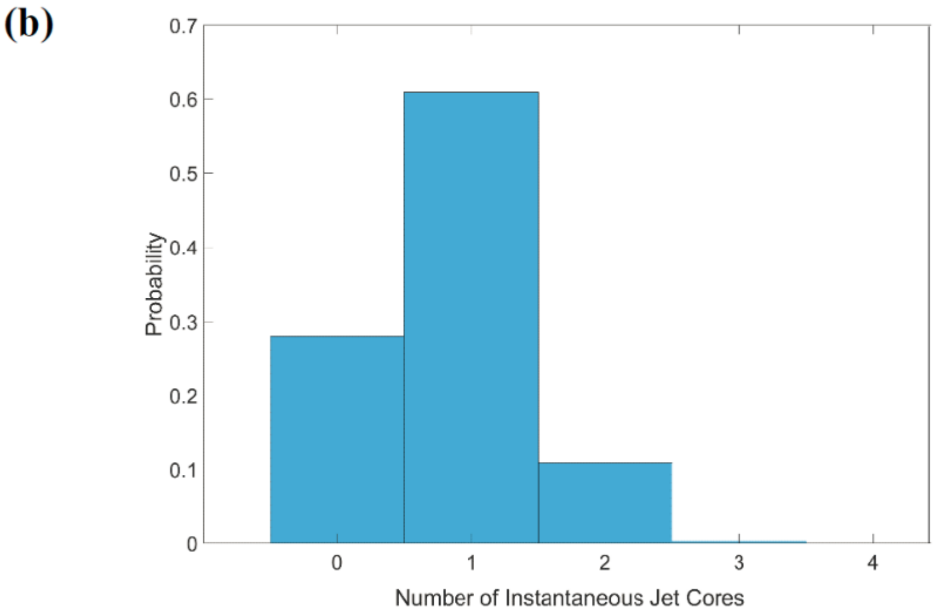
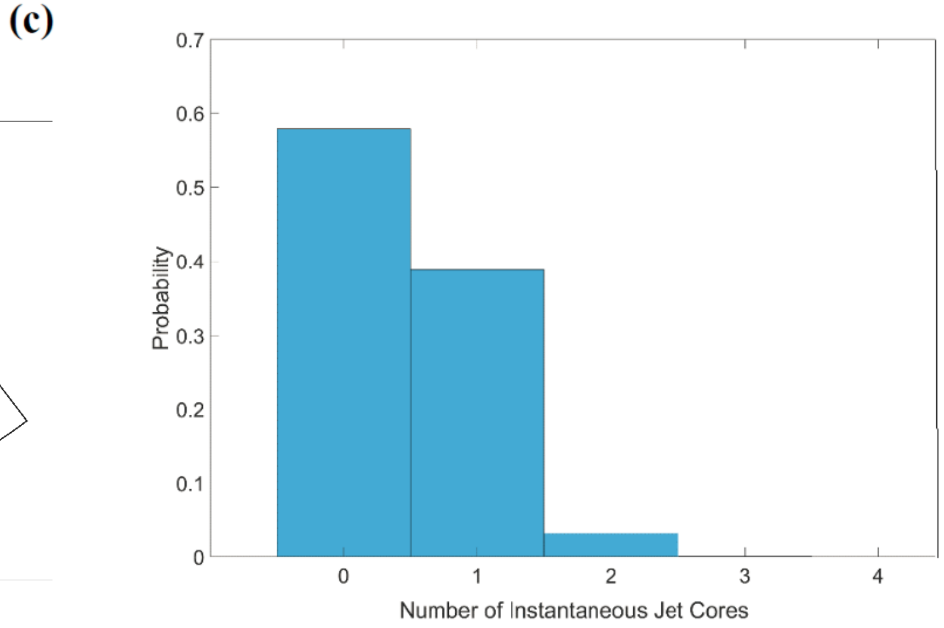


Figure 8. Annual-mean linear trends in the jet core
(a) latitudinal location,
(b) pressure level, and
(c) wind speed,
of jet cores from 1979 to 2016. Thick black edges indicate trends that are statistically significant at the 95% confidence level. Based on NARR reanalysis data.







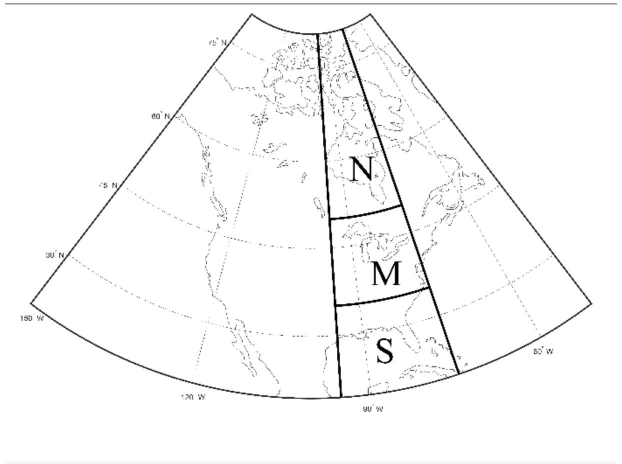
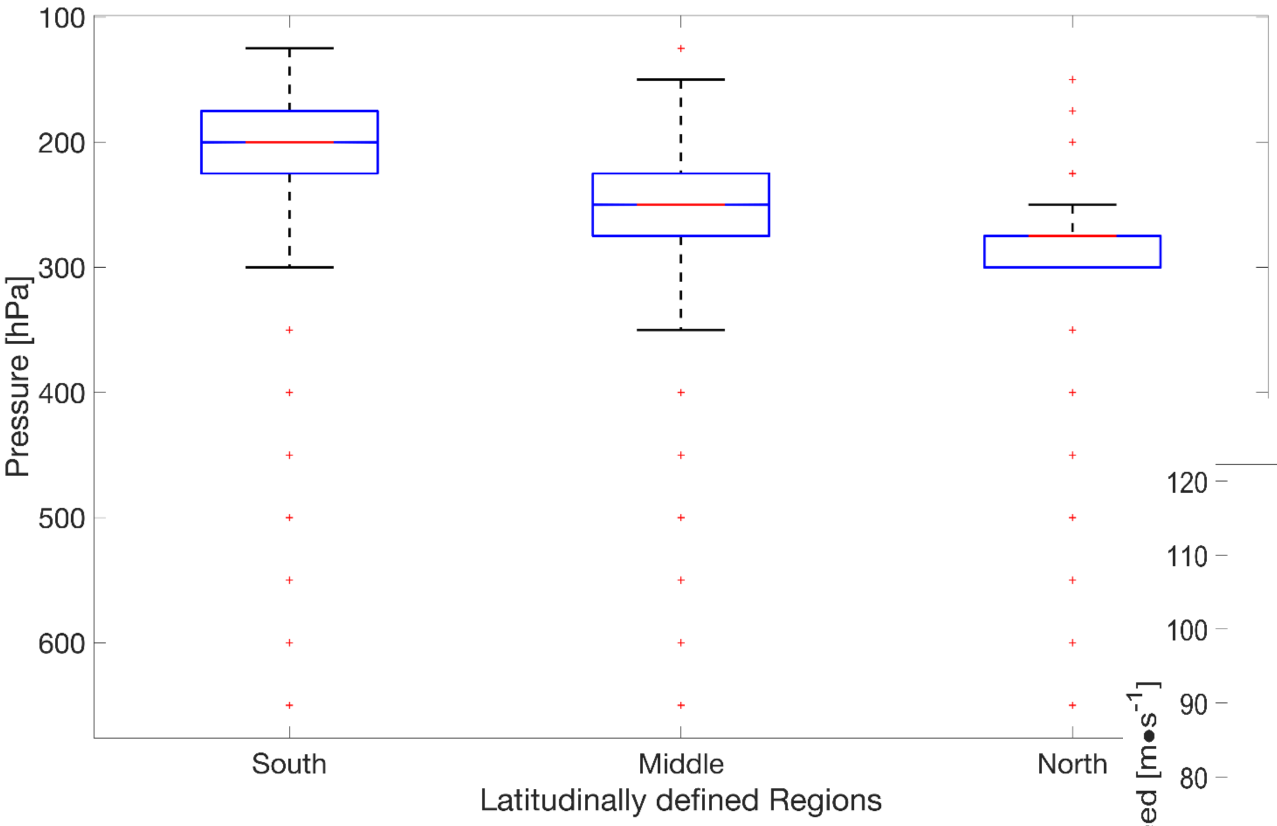
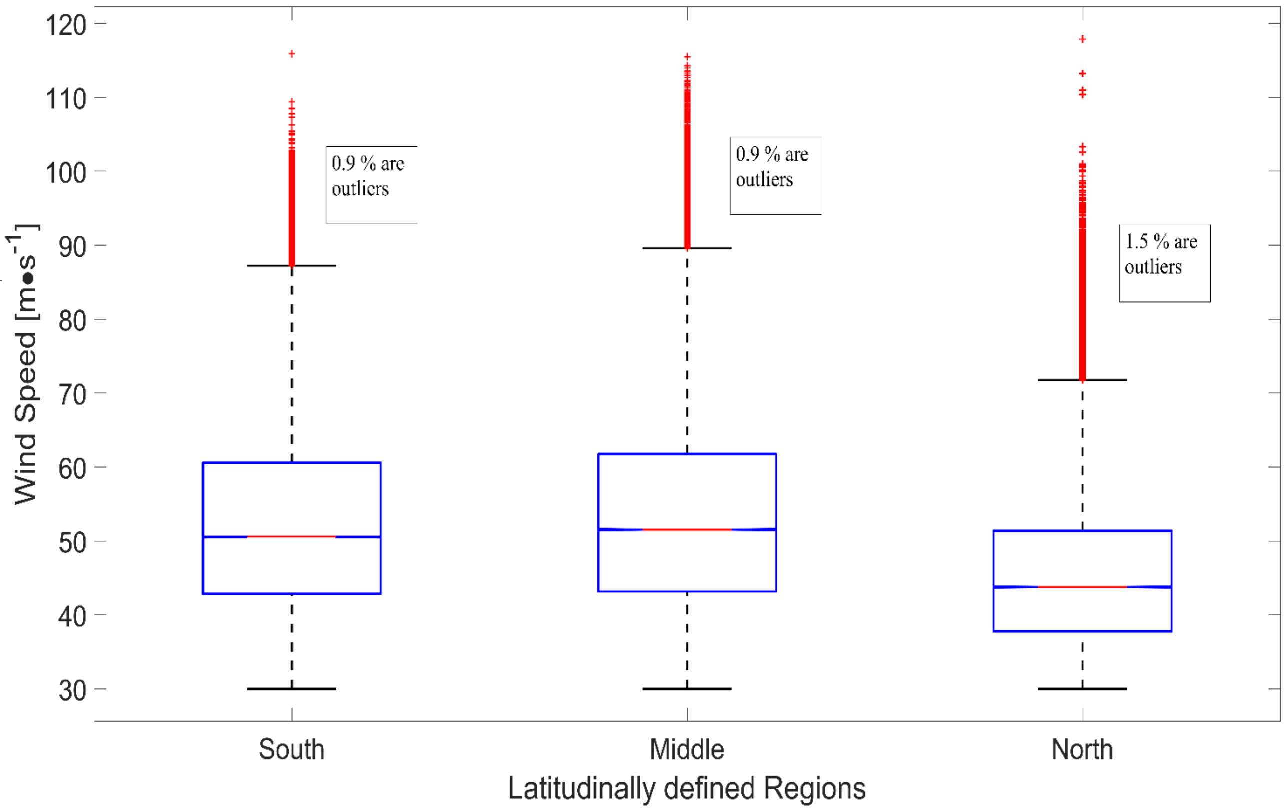


Figure 9. As in Fig. 4, but for
(a) the north bin,
(b) the middle bin, and
(c) the south bin.





Figures 10, 11. Box plots of jet core pressure level and wind speed, based on the latitudinally defined bins.

	Variable			
Bin	**Latitude** (° latitude per year)	**Pressure Level** (hPa per year)	**Wind Speed** (ms^{-1} per year)	**|MCI|** *(per year)*
Unbinned	-0.003	**-0.17**	+0.04	$+2.3 \times 10^{-4}$
North	-0.02	**-0.29**	**+0.03**	-5.4×10^{-4}
Middle	-0.006	**-0.17**	**+0.05**	$+3.1 \times 10^{-4}$
South	-0.004	**-0.18**	+0.001	$+3.6 \times 10^{-4}$

Table 1. Slope parameters for the methods-based average annual linear trends of latitude, pressure level, wind speed, and |MCI| for the un-binned and binned data from 1979-2016. Bold values denote those trends that were statistically significant at the 95% confidence level.

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