NOTES AND CORRESPONDENCE

Displacements of the North Circumpolar Vortex during El Niño, 1963–83

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ABSTRACT

During the pronounced 1982–83 El Niño, the 300 mb north circumpolar vortex was displaced further toward Japan (from its mean seasonal locations) than observed since the beginning of the vortex record in 1963. However, during the strong 1972–73 El Niño, the vortex was displaced toward the 180th meridian, and during the weaker 1965–66 El Niño toward the eastern Pacific, so that vortex displacements are not indicated to have been the same for different El Niño episodes. Based on the full 21-year record, the vortex has tended to be displaced toward 90°W when sea surface temperature (SST) in the region 0°–10°S, 180–80°W was above average, but toward the 180th meridian when the magnitude of SST deviation from average is considered.

1. Introduction

It was shown in a previous paper (Angell and Korshover, 1983, p. 919) that there has been a significant tendency for the size of the 300 mb north circumpolar vortex (as defined by the area north of height contours in the main belt of westerlies on polar stereographic maps) to be a minimum approximately three seasons after the time of warmest sea surface temperature (SST) in the eastern equatorial Pacific (El Niño). This finding, based on data through the spring of 1982, is supported by the observation of a contracted vortex during 1983, presumably associated with the pronounced El Niño beginning in the autumn of 1982. The 300 mb vortex area in the summer of 1983 was 7% below average, the largest seasonal deviation from average since the beginning of the vortex record in 1963. The 300 mb pressure surface has been chosen for this analysis because, being near the surface of maximum wind, the polar vortex is well defined there.

In addition to the influence of El Niño on polar vortex size, there is also the question of the influence of El Niño on polar vortex location. This is of interest because changes in this location would be associated with at least subtle changes in atmospheric quantities through much of the Northern Hemisphere. The purpose of this note is to show how the displacement of the centroid of the 300 mb north circumpolar vortex from its mean seasonal locations (5° and 3° of latitude from the North Pole in the general direction of Japan in winter and autumn, respectively, but near the North Pole in spring and summer) has varied with sea surface temperature (SST) in eastern equatorial Pacific. For details concerning the variation in this SST and the El Niño–Southern Oscillation phenomenon in general, see Rasmusson and Wallace (1983).

2. Data and procedures

The size or extent of the 300 mb north circumpolar vortex has been estimated by planimetricing the area poleward of contours in the main belt of westerlies usually at 40–50°N (the 9280 m contour in spring and autumn, the 9120 m contour in winter, and the 9440 m contour in summer) on the mean-monthly polar stereographic maps prepared routinely since 1963 by the Institute for Meteorology of the Free University of Berlin (e.g., Labitzke et al., 1983). The center of circulation, or centroid, of this vortex has been estimated in a simple way (an antiquated way, according to some) by finding that location on the 90°W–90°E axis which, upon drawing a perpendicular to this axis through the given location, divides the mean-monthly vortex area into two equal areas, and similarly for the 0–180° axis. Because the planimetered area of each of these hemispheric estimates can only be obtained to within about 2%, the mean-monthly locations of these axial points is only accurate to the nearest 100 km, but mean-seasonal locations should be more accurate than this. The standard deviation of the seasonal vortex displacements along these axes, taken as deviations from long-term seasonal mean locations, is about 150 km over the period of record, so that at least the larger changes in vortex location should be meaningful. The variation in location of the polar vortex centroid is primarily a measure of the variation in trough-ridge position, and amplitude, of wave number 1, but the other wave numbers contribute too, making the centroid location an integrative measurement of a fairly unique sort (LaSuer, 1954).

The SST data to which the polar vortex data are compared are for the "El Niño region" of the eastern equatorial Pacific (0°–10°S, 180°–80°W), and have
been obtained from the Environmental Research Laboratories of NOAA at Boulder for years prior to 1980 ("Marine Deck"), and from "Oceanographic Monthly Summary," a publication of the National Weather Service and the National Environmental Satellite, Data, and Information Service of NOAA, Washington, DC for recent years. In the following analysis, the SST data, as well as the centroid data, have been smoothed by applying a one-to-one weighting (divided by four) twice to successive seasonal values.

3. Discussion

The small circles in Fig. 1 show the seasonal displacements of polar vortex centroids (relative to their mean seasonal locations) along axes 90°W-90°E and 0-180° from 1963 through 1981. Successive seasonal displacements of the vortex centroid during the 1982-83 El Niño are indicated by the dots connected by straight lines with arrowheads. It is emphasized that, since these are deviations from seasonal-mean locations, they do not represent the actual "path" of the vortex centroid. The numbers at the connected dots show the deviation from the mean SST, in the region 0°-10°S, 180°-80°W, in degrees Celsius. In the spring, summer and autumn of 1983, or shortly after this SST was a maximum, the vortex centroid is indicated to have been displaced considerably further in the direction of 90°E and 180° (or basically toward Japan) than observed since the beginning of the vortex record in 1963. The vortex is indicated to have been displaced toward the 180°-90°E quadrant also in the winter of 1982/83, and there may possibly be a discrepancy here with the finding of Quiroz (1983, Fig. 10b) of unusually strong 200 mb westerlies at 30°N in the 180°-90°W quadrant during this winter.

Comparison of the indicated vortex displacement during the 1982-83 El Niño with the indicated vortex displacements during the six other El Niño episodes since 1963 does not result in a consistent picture. During the strong 1972-73 El Niño the vortex centroid is indicated to have been displaced toward the 180th meridian, but during the weaker 1965-66 El Niño toward the eastern Pacific, and during the long-duration 1969 El Niño first toward 90°W and then toward the 180th

![Figure 1](image-url)  
**Fig. 1.** The small circles indicate the displacements of centroids of the 300 mb north circumpolar vortex along axes 90°W-90°E and 0-180° (positive if toward 90°E and 180°), based on seasonal deviations from mean seasonal locations for years 1963-81. Successive centroid displacements during 1982 and 1983 are shown by dots connected by straight lines with arrowheads (summer displacements specified), with the deviation from the mean-seasonal sea surface temperature (SST) in the region 0°-10°S, 180°-80°W plotted in degrees Celsius at the dots. The number of seasons SST was above average (plus) and below average (minus) for centroid displacements within the quadrants bounded by the axes is given at the corners.
meridian. The weaker El Niño episodes of 1963, 1976 and 1979 were associated with vortex displacements generally toward 90°W. Either the displacement of the north circumpolar vortex actually varies from El Niño to El Niño, or the technique used here to define these displacements is not sufficiently accurate so as to always yield representative results. We next consider the 21-year data record as a whole, dealing first with SST deviations above and below average, and then with the magnitude of these deviations.

The values in the corners of Fig. 1 indicate the number of seasons SST in the region 0°–10°S, 180°–80°W was above the long-term average (plus sign) and below the long-term average (negative sign) for polar vortex centroids located in the quadrants bounded by axes 90°W–90°E and 0°–180° (there are more positive values than negative values because this SST is taken as the deviation from seasonal averages extending back to 1867). There are appreciable differences in the number of plus and minus signs in the four quadrants. For example, in those seasons in which the vortex centroid was displaced toward 0° (Greenwich Meridian) and 90°E, this SST was above average 3 times but below average 17 times. Thus, below average SST in eastern equatorial Pacific has often been associated with a polar vortex displacement toward Europe. On the other hand, in those seasons in which the vortex centroid was displaced toward 90°W, this SST was above average 28 times but below average only 5 times. Thus, above-average SST in eastern equatorial Pacific has of-ten been associated with a polar vortex displacement toward the Western Hemisphere. The latter would be in accord with the finding from 80 years of surface pressure maps that a warm SST in the eastern equatorial Pacific has been related, in a significant fashion, with below average central pressures of the Aleutian Low, Pacific High and Atlantic High, and southward displacement of the Icelandic Low (Angell and Korshover, 1984, Fig. 5). There have been an almost equal number of above average (13) and below average (11) SST values when the polar vortex was displaced toward 180° and 90°E (upper right quadrant of Fig. 1), but 7 of these positive values come from the 1982–83 El Niño. On the basis of the 21-year record, the displace-ment of the polar vortex into the Eastern Hemisphere during this El Niño was atypical.

Figure 2 presents the average SST deviation from the mean as a function of vortex centroid displacement, determined by smoothing the SST values appropriate to all the centroid displacements in Fig. 1. The smoothing involved averaging the SST values in 40 km squares, finding the average value at the points of intersection of four squares (weighted according to the number of values in each square), and then finding a weighted average for each square based on the values at the four corners. This smoothing procedure extends the region of data coverage somewhat, as shown for example by comparison of the –0.4 isopleth at lower right in Fig. 2 with the location of the small circles in Fig. 1.
When the magnitude of the SST deviation is considered, the evidence is for a displacement of the north circumpolar vortex basically toward the 180th meridian at the time of El Niño. However, prior to the 1982–83 El Niño (which resulted in the large positive SST values shown at upper right in Fig. 2) the evidence would have been for a displacement of the vortex basically toward 180°–90°W (or the El Niño region) at the time of El Niño. It may well be that the vortex record is still too short to ensure representative results, to which must be added the question of the extent to which the technique used herein to estimate polar vortex displacements is a suitable one.

4. Conclusion

Based on the application of a simple planimetric technique to 21 years of 300 mb mean-monthly polar stereographic maps, the north circumpolar vortex has tended to be displaced toward 90°W when SST in the region 0°–10°S, 180°–80°W has been above average, but basically toward the 180th meridian when the magnitude of the SST deviation from average is considered (true El Niño conditions). During the very strong El Niño of 1982–83, moreover, the vortex is indicated to have been displaced unusually far toward Japan. It is not yet certain whether these findings reflect real differences in vortex displacement with different degrees of SST increase in eastern equatorial Pacific, or simply reflect problems with this manner of evaluating vortex displacement.

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REFERENCES