EXTENDED ABSTRACT

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Analysis of Extratropical Cyclones in the Northern Hemisphere Using the NOAA Historical Reanalysis.

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A number of recent studies (for example (McCabe et al. 2001; Paciorek et al. 2002; Serreze et al. 1997; Wang et al. 2006; Zhang et al. 2004)) have documented a significant pole-ward shift of the storm track in the Pacific and Atlantic ocean basins, a decrease in extratropical cyclone (ETC) frequency in mid-latitudes, and a corresponding increase in ETC activity at higher latitudes. These studies have generally been restricted to the latter half of the 20th Century. A new analysis of surface pressure data has extended the availability of pressure field data back to the late 19th Century. When we examine this much longer record a different picture emerges. In the early part of the 20th Century, high latitude ETC occurrence was higher than mid-century activity and equivalent to the latter part of the 20th Century. In contrast, mid-latitude ETC in the early 20th Century was considerably lower than in the recent period. When this much longer record is analyzed for linear trends, an opposite result is obtained. There is an overall upward trend in ETC occurrence in mid latitudes and no trend for high latitude ETCs as shown in Figure 1.

The results were broken into regional sectors, specifically North America, Atlantic-Europe, Asia, and Pacific as defined in Table 1. The regional results reveal high latitude ETC counts have decreased in the North American and Pacific sectors with little change elsewhere. Conversely, mid-latitude ETC counts have increased in all sectors. These results imply a substantial shift over the North American and Pacific sectors.

A more detailed examination of the time series in Figure 1 suggests 3 broad epochs. During the late 19th/early 20th Centuries, ETC counts were high in the high latitudes and low in the mid latitudes. During the middle of the 20th Century, mid latitude counts were quite high while high latitude counts were considerably lower than in the earlier epoch. During the late 20th/early 21st Centuries, mid latitude counts were lower than in the previous epoch.

We broke the analysis into 3 epochs, informed by the mid-latitude results of Fig. 1: early (1901-1935), middle (1936-1970), and late (1971-2005). We examined the spatial patterns of the differences among these epochs, using the late epoch as the reference (Fig. 2). The mid-latitude differences between the early and late periods indicate higher ETC counts in the late period most notably over the eastern Pacific, North America and the western Atlantic. It is possible that less dense pressure data over the oceans led to missing ETCs. However the increases are seen also over North America where data

availability was better and this spatial coherency supports the reality of these patterns. In the North Atlantic, there is couplet of lower counts to the north (just south of Greenland) and higher counts to the south, implying that the storm track was further south in the late period. The lack of a coherent increase in the far North Pacific also implies that the average storm track was further south in the late period.

The differences between the late and middle periods (Fig. 2b) are more subtle. A negative-positive couplet in the North Atlantic implies that the storm track was further south in the late period while in the North Pacific a shift to the north in the late period is implied by a couplet of opposite phase. Differences over the land masses of North America and Europe-Asia are comparatively small and lack large-scale coherence.

Techniques summary:

To accomplish this study mean sea level pressure fields from the individual runs of the 56 member 20th Century Reanalysis (Compo et al. 2006; Compo et al. 2010) were analyzed every 6 hours to locate local pressure minima enclosed by an isobar 2 hPa greater than the minimum, similar to McCabe et al (2001) and Serreze et al (1997). These candidate ETC points were then linked from one 6 hour period to the next to construct tracks. The tracks discussed here had a minimum lifetime of 72 hr and traveled a minimum of 1000 km. The ETC activity values shown are the average number of tracked ETCs in a 6 hour period over all 56 ensemble members for the months of November through March for the area given.

Table 1: Trends (% per century) in ETC activity. Bold (italicized) values indicate statistical significance at the 99% (95%) level of confidence.

Pacific 140E-130W	North America 130W-70W	Atlantic-Europe 70W-50E	Asia 50E-140E	ALL	Latitude band	Nov-Mar Seasons
-18	44	17	8	13	Polar 60-90	Recent term 1950-2005
3	*-28*	*-22*	18	-8	Mid-lat 30-60	
-36	**-38**	**14**	*14*	-1	Polar 60-90	Long term 1892-2005
13	**36**	**14**	**21**	**17**	Mid-lat 30-60	

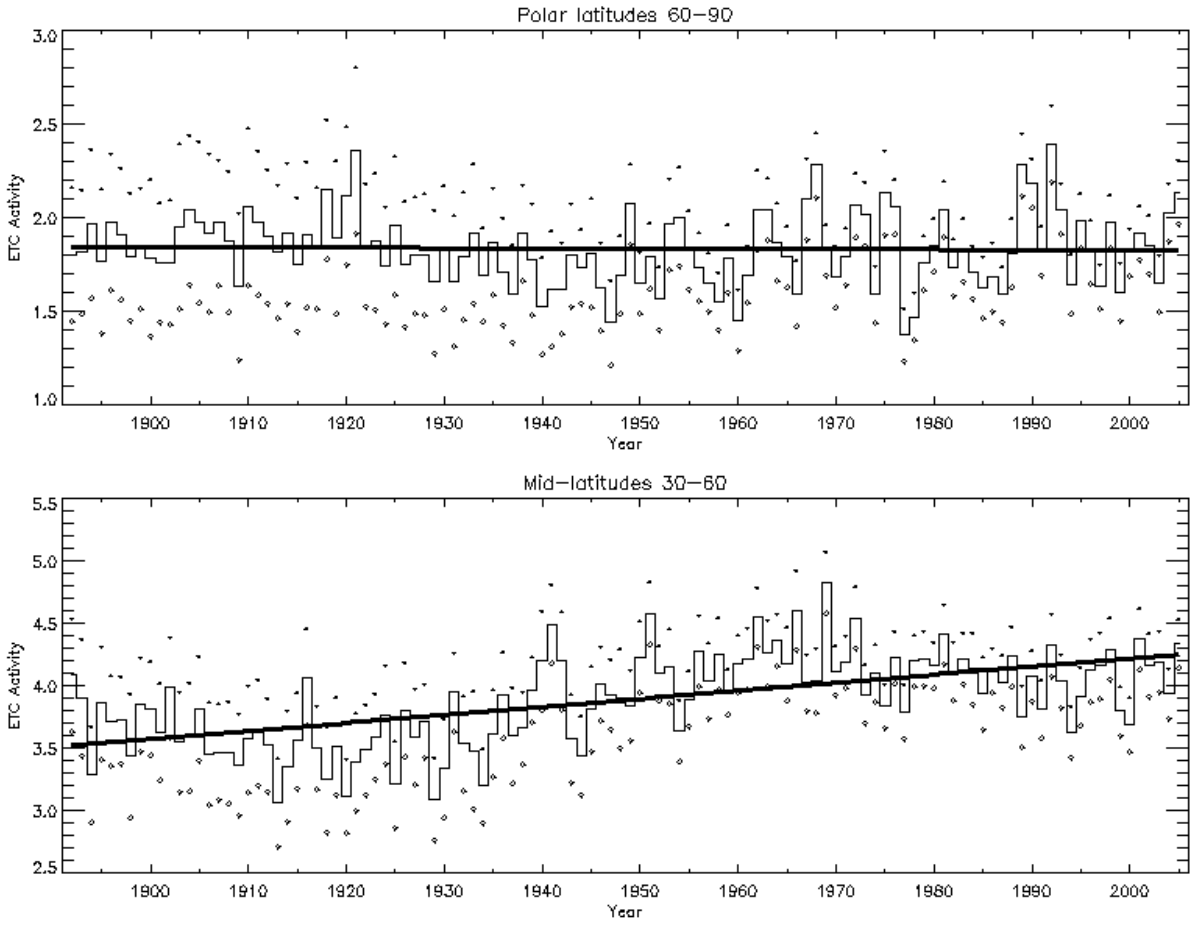

Figure 1: The solid line shows the mean ETC activity for months Nov-March ending in the year indicated. Filled and hollow diamonds indicate values +/- 2 standard deviations away from the mean for a given year. The heavy solid line is the least squares fit to the mean values.

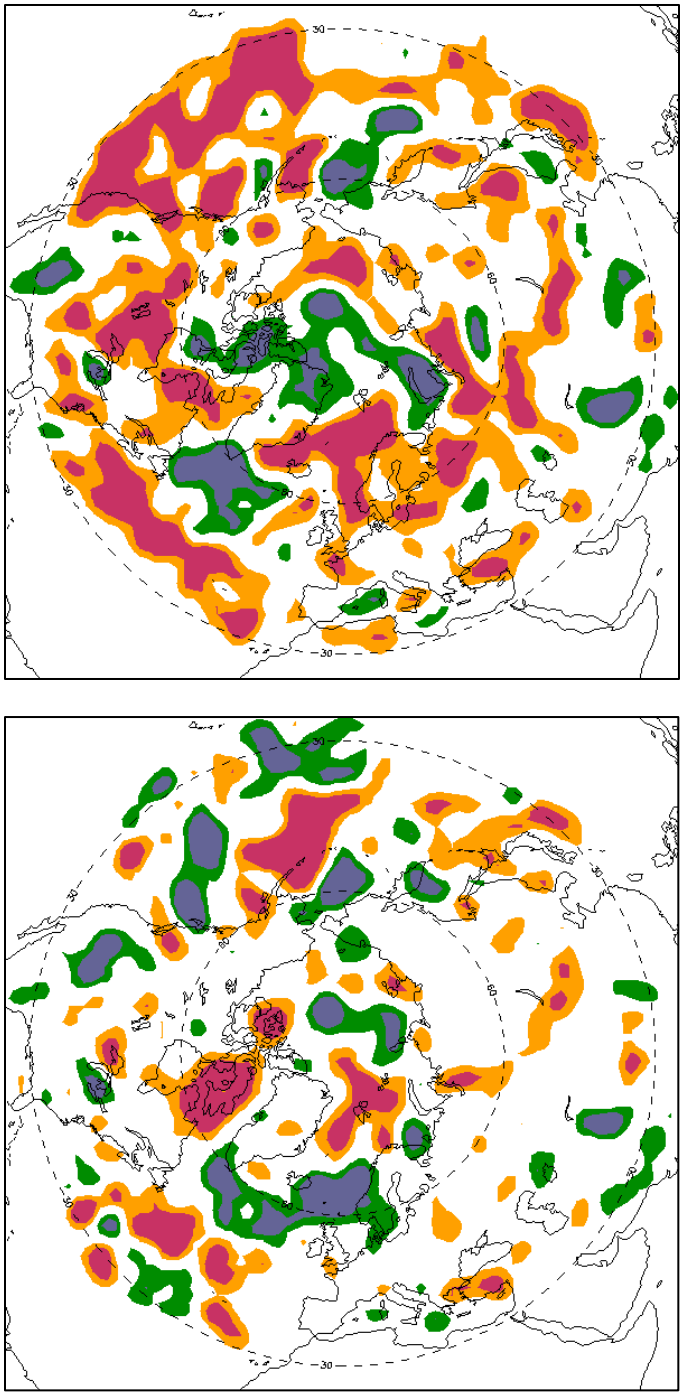

Figure 2: Differences in ETC activity between the late and early epochs (above) and late and middle epochs (below). Values at each grid point are the difference between the total ETC activity for the periods indicated divided by the average activity for the two periods. Red [> 0.5], orange [0.25, 0.5], green [-0.25, -0.50], blue [< -0.5]. For example, a value of 0.25 in the first figure indicates that the early epoch had 0.78 times the ETC activity as the late epoch.

References:

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