Western Region Technical Attachment
No. 90-03
January 23, 1990

A SATELLITE-DERIVED CLIMATOLOGY OF POLAR LOW EVOLUTION IN THE NORTH PACIFIC

[Editor's Note: This Technical Attachment is a summary of an article by the same name authored by Brent Yarnal and Keith G. Henderson, which appeared on pages 551-566 in Volume 9 of the International Journal of Climatology (1989). Since this topic may be of interest to Western Region forecasters, SSD will make the entire article available upon request.]

A number of factors make the polar low a unique type of cyclone. As their name implies, polar lows form in polar or arctic air masses poleward of major fronts, usually over oceans and seas. They are single air mass storms, appearing as comma or spiral-shaped cloud masses on satellite imagery (Reed (1986), reported in Rasmussen and Lystad (1987)). These sometimes intense cyclones can be difficult to detect because they often have a life cycle as short as 6-24 hours, are about one-tenth the diameter of a typical synoptic-scale frontal cyclone, and occur over some of the most data-sparse areas of the globe. Therefore, the importance of polar lows as a meso-alpha scale, i.e., 100-1000 km, phenomenon has only become evident with the advent of medium to high resolution satellite imagery. In this paper, the principle objective is to determine whether all polar lows that form in the North Pacific continue to develop into mature storms or not. Attention is given to the location and typical characteristics of evolving and non-evolving cyclogenetic polar lows. The frequency and distribution of a special category of evolving polar low, the instant occlusion, is also presented.

The most difficult and time-consuming aspect of this study was the subjective interpretation of satellite mosaics. The data employed were the computer processed infrared (8-13 μm) 1:30 M half-hemisphere mosaics of the Defense Meteorological Satellite Program (DMSP) polar-orbiting system. Mosaics for seven 5-month winter seasons, November to March, 1976-1977 to 1982-1983 were used. In producing the climatology, 5° latitude by 5° longitude bins were employed to contour the data.

The cloud vortex classification system used in the study is a slight modification to that used by Carlton (1989) and is shown in Figure 1. Major extratropical fronts follow the sequence: type 1, type 4, type 5, type 7, type 8, type 9 and/or 10, type 11. The evolutionary sequence of polar lows is quite similar, with any particular cyclogenetic polar low forming as either a comma cloud (type 21) or spiraliform (type 22), and potentially passing in turn through the developing (type 6), mature (types 7 and 8), dissipating (type 9 and/or 10) and decaying (type 11) stages. From type 7 onward, evolving frontal waves and polar lows are often very similar morphologically, although they can usually be distinguished by means of their size and history.

Instant occlusions are included in this study as a special kind of cyclogenesis. This process takes place when a polar low in any stage of development (although usually cyclogenetic or developing) advances upon and interacts with a decelerating or stalled frontal wave. The effect of this combination is to cause a rapid cyclonic spin-up at the point of contact, appearing to occur "instantly" between successive satellite images.

Figure 2 (on page following Figures 1 and 4) gives the seven-year satellite climatology for polar low comma clouds. As can be seen, the western Pacific is much more active than the eastern portion of the basin for this phenomenon. In general, about two-thirds of these polar low comma clouds evolve beyond the incipient stage. Over the eastern Pacific, the phenomenon occurs much less frequently, and about half fail to develop.

For the spiraliforms (Figure 3), it appears in general, those that form away from coastlines are least likely to evolve, whereas those that form immediately upon leaving the land/ice edge stand a much better chance of developing beyond the cyclogenetic stage. An interesting feature is the virtual total failure of the spiraliforms forming in the Gulf of Alaska to evolve.

Figure 4 (directly below Figure 1), depicts the climatology for instant occlusions. At any stage in its development, a polar low can catch up to the frontal wave preceding it and initiate the instant occlusion process. In the seven seasons of this study, 81 instant occlusions were observed. They were almost always located where a blocking high had caused a frontal wave to stall, allowing an eastward-moving polar low to interact with the frontal wave. Given the high frequency of occurrence of blocking ridges near the west coast of North America, the distribution of instant occlusions is not surprising. The instant occlusion process is a potential initiator of explosive cyclogenesis. Thus, while the eastern Pacific is a minimum of polar low frequency, the potential for explosive cyclogenesis is much greater in this part of the basin due to the concentration of instant occlusions.

For forecasting purposes, once an incipient polar low has been identified on a satellite image, it is recommended that careful analyses of meteorological conditions and application of dynamic reasoning be employed to predict the likelihood of further development. Those specific areas where continued evolution is climatologically favored should be watched most carefully.

References

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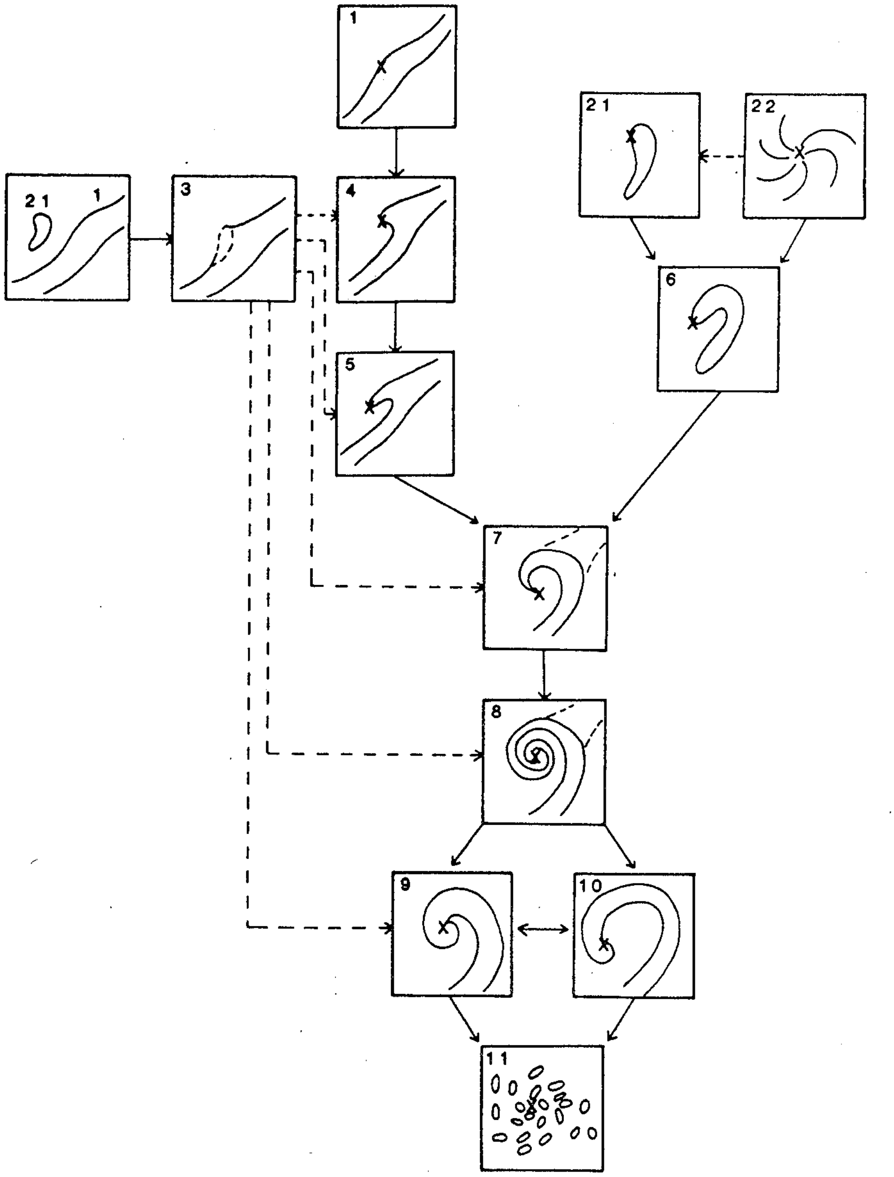

Figure 1. Cloud vortex signature types and their evolutionary sequence: 'x' indicates nominal vortex centre

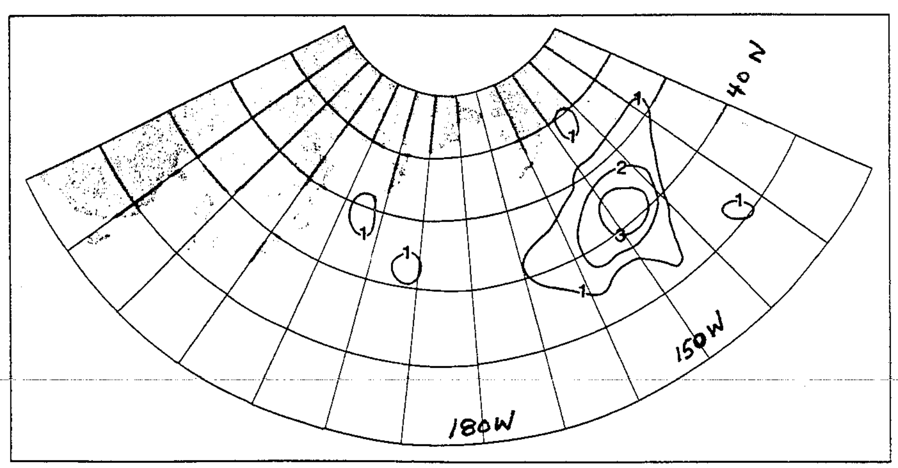

Figure 4. Observed number of instant occlusions (type 3) (contour interval = 1)

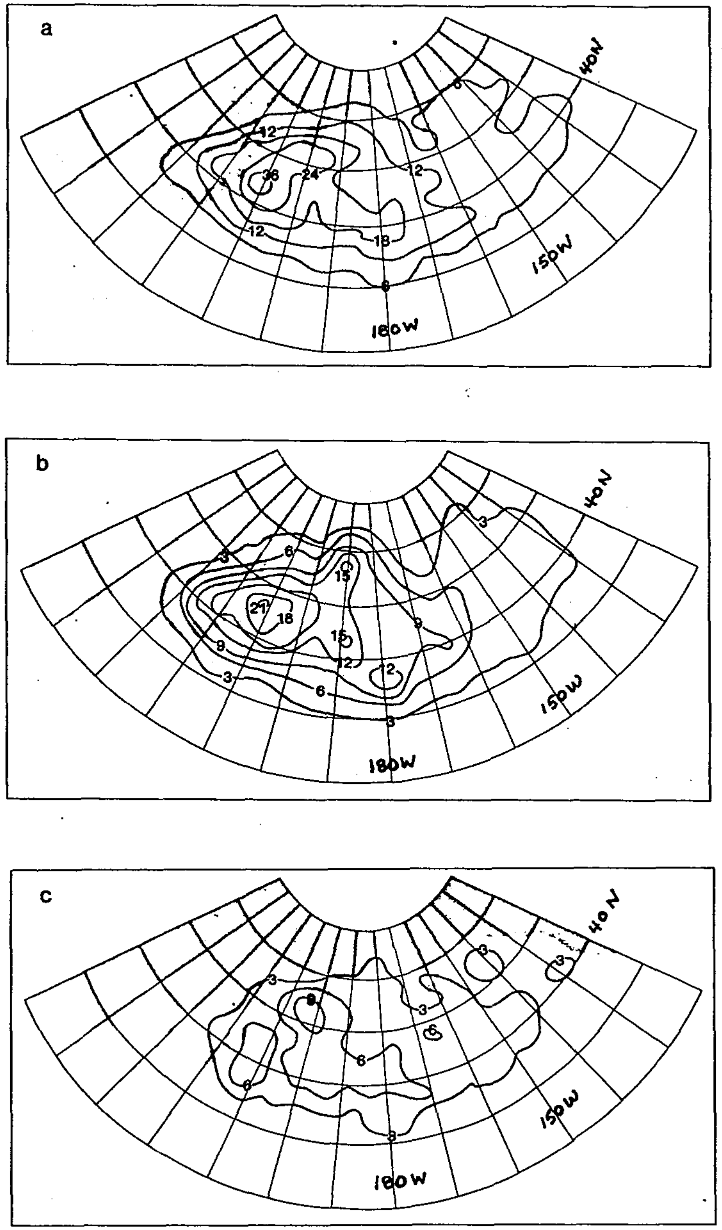

Figure 2. Observed number of (a) total comma clouds, (b) evolving comma clouds, and (c) non-evolving comma clouds (contour interval: a = 6; b and c = 3)

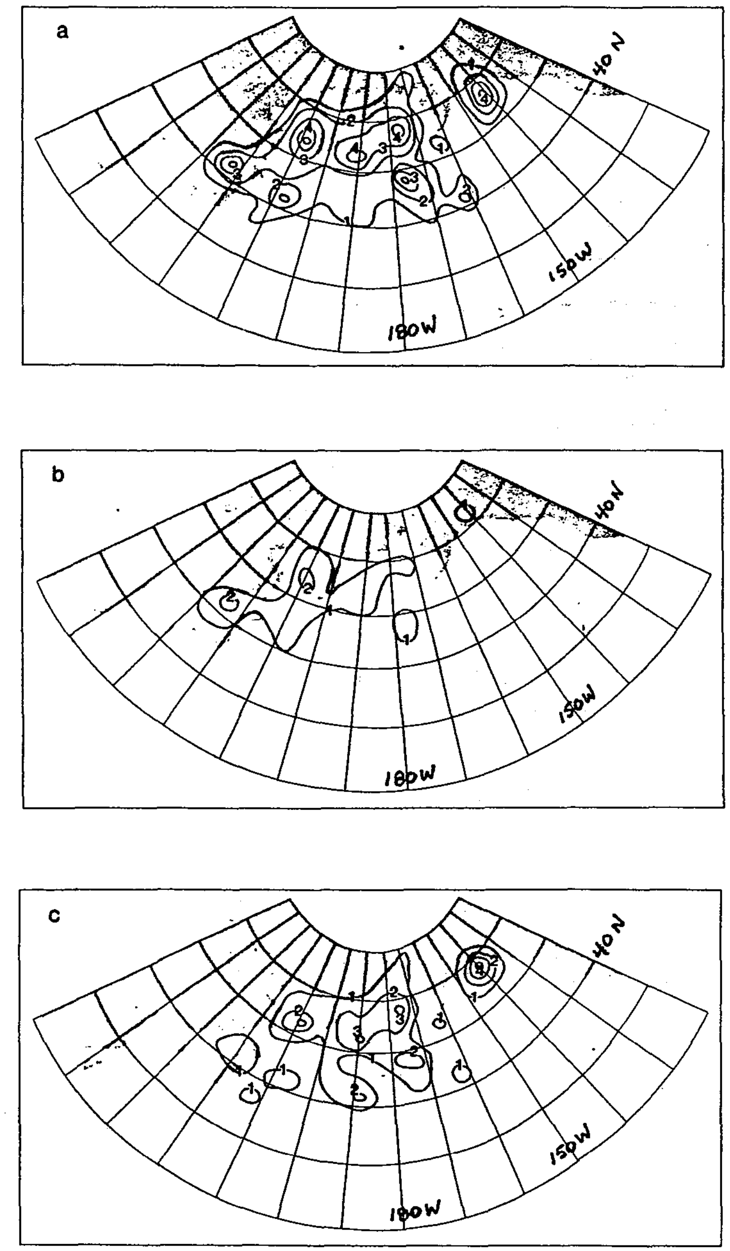

Figure 3. Observed number of (a) total spiraliforms, (b) evolving spiraliforms and (c) non-evolving spiraliforms (contour interval = 1)