Comments on "Determining Cyclone Frequencies Using Equal-Area Circles"

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18 August 1995 and 10 October 1995

The equal-area circle method for determining cyclone frequency as described by Changnon et al. (1995), has been used for many years at the NOAA Tropical Prediction Center (TPC) [formerly known as the National Hurricane Center (NHC)]. This is brought to your attention since your historical literature review implies little, if any, use of the method. Also, comments are made on some other aspects of your study.

The TPC/NHC and SAIC use this equal-area sampling strategy to determine areal distribution of tropical cyclone frequency and for the distribution of other tropical cyclone parameters. The TPC/NHC initial use of this methodology, mostly for internal needs and for support of the NASA spaceflight program, dates back to the late 1960s. A simple computer logic routine determines whether a given point is within some great circle distance from any point. Hope and Neumann (1970) used the method (for a single point rather than a grid) to select analogs in an early tropical cyclone prediction model, and this can be schematically noted in their Fig. 5.

The first TPC/NHC formal publication demonstrating the method for counting cyclones was Neumann and Pryslak (1981). In this latter study, a grid of equal-area overlapping circles was positioned across the Atlantic tropical cyclone basin, and tabulations were made of various storm parameters such as frequency, motion, and intensity. A modification of the technique was also used by Neumann and Pelissier (1981) in preparing their charts of tropical cyclone forecast error across the Atlantic.

Later, Xue and Neumann (1984) used the equal-area circle method to prepare tropical cyclone frequency and motion charts for the western North Pacific. They present charts, similar to your Fig. 1, which specifically illustrates their sampling strategy. Also, the TPC/NHC HURISK (hurricane risk) model (Neumann 1987), widely used by government and private interests, makes explicit use of the methodology in determining hurricane risk. In chapter 1 of a recent World Meteorological Association publication (WMO 1993), equal-area circles, positioned around the globe, were used in the preparation of worldwide tropical cyclone frequency and motion maps.

Taylor (1986) provided an exhaustive mathematical treatment of the advantages and disadvantages of using various geometrical shapes in assessing cyclone frequency. He cites the Neumann and Pryslak (1981) study as an example of an unbiased method for providing these assessments.

In your article, you point out that the grid shown in your Fig. 1 is used as an overlay for counting intersections of surface cyclones with the grid area. Tabulations of this type are greatly facilitated by having a digital representation of storm tracks. In all of the TPC/NHC tropical cyclone studies noted above, the authors utilize

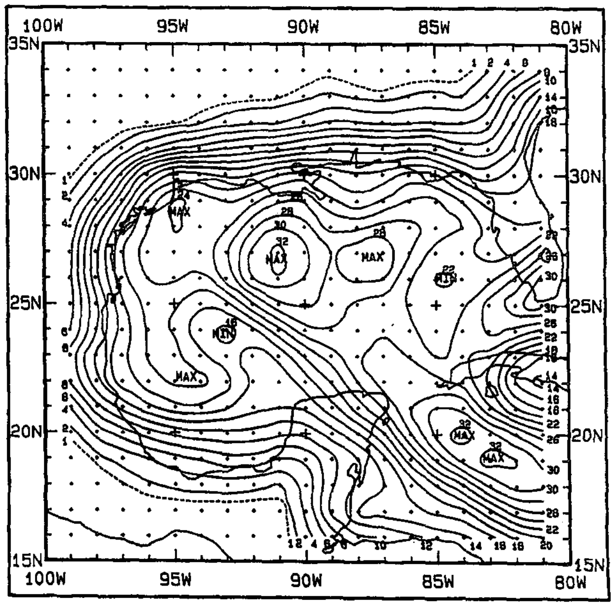

FIG. 1. Contours, at two-storm intervals, give number of hurricanes per 100 years passing within 139 km (2.5° of latitude) of any map location. Analysis is based on period of record, 1886–1994.

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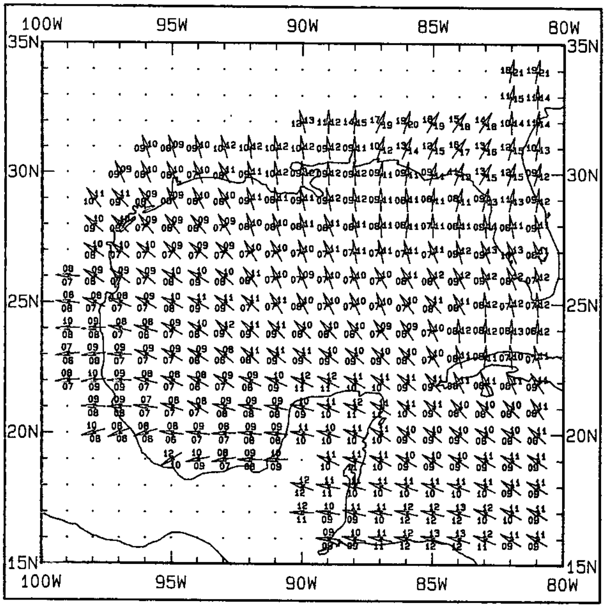

FIG. 2. Vector direction, vector translational speeds (kt), and scalar translational speeds (kt) of hurricanes used in the preparation of Fig. 1. Scalar speeds plotted on the right side of the arrow are always greater than or equal to the vector speeds as plotted on the left side of the arrow. Large (small) differences in speeds imply large (small) variation in motion. Data are not computed for grid circles having insufficient cases.

computer files of storm tracks and associated intensity (maximum wind and central pressure) at 6-h intervals. These are then interpolated to hourly positions using the method of Akima (1970) and mathematical polygon intersection methods are now used in tabulating "hits."

When using digitized data, the problem you mention about intersecting circles does not enter into the picture. Indeed, intersecting circles are preferred since this provides a means of smoothing the data. For example, Fig. 1, depicting hurricane frequency over and around the Gulf of Mexico, was prepared using 2.5° latitude (139 km) overlapping circles centered at each 1° latitude–longitude intersection. That particular distance was chosen since it represents a typical damage swath from tropical cyclones. Other distances could just as easily have been used. Normalizing the data to 100 years permits easy comparison with similarly normalized data from other basins having different periods of record. Also, it provides for an easy estimation of the Poisson parameter, which can be used (Xue and Neumann 1984) in obtaining probabilities of discrete occurrences of hurricanes over various consecutive year periods.

Another advantage to having the data in a digitized format is that other storm parameters, such as intensity, vector, and scalar motion, can also be tabulated. Figure 2, for example, gives details on storm motion. This example and that shown in Fig. 1, uses methodology developed for use in the TPC/NHC and the SAIC HURISK models, cited earlier. The procedure is 100% automated and it takes only a few minutes of time to produce such charts. Still another advantage of using automated methodology is that irregular tabulation areas (such as the latitude bands you use) can be mathematically defined. Also, defining very irregular areas such as states, counties, islands, etc. is relatively easy.

As pointed out earlier, digitized tropical cyclone tracks have been available for many years. Recently, digitized extratropical cyclone tracks have also become available and are included on a CD-ROM jointly published by the U.S. Navy and the National Climatic Data Center. These data, which also include global tropical cyclone tracks, are described by Blackadar (1995). Thus, it should be possible to produce extratropical counterparts of Figs. 1 and 2 for any seasonal period, any central pressure threshold, and for any map base or location.

REFERENCES

Akima, H., 1970: A new method of interpolation and smooth curve fitting based on local procedures. *J. Assoc. Comput. Mach.*, **17**, 589–602.

Blackadar, A. K., 1995: Global tropical and extratropical cyclone climatic atlas. *Weatherwise*, **48**, 44.

Changnon, D., J. J. Noel, and L. H. Maze, 1995: Determining cyclone frequencies using equal-area circles. *Mon. Wea. Rev.*, **123**, 2285–2294.

Hope, J. R., and C. J. Neumann, 1970: An operational technique for relating the movement of existing tropical cyclones to past tracks. *Mon. Wea. Rev.*, **98**, 925–933.

Neumann, C. J., 1987: The National Hurricane Center risk analysis program (HURISK). NOAA Tech. Memo. NWS NHC 38, 56 pp.

——, and J. M. Pelissier, 1981: An analysis of Atlantic tropical cyclone forecast errors, 1970–1979. *Mon. Wea. Rev.*, **109**, 1248–1266.

——, and M. J. Pryslak, 1981: Frequency and motion of Atlantic tropical cyclones. NOAA Tech. Rep. NWS 26, 64 pp.

Taylor, K. E., 1986: An analysis of the biases in traditional cyclone frequency maps. *Mon. Wea. Rev.*, **114**, 1481–1490.

WMO, 1993: *Global Guide to Tropical Cyclone Forecasting.* WMO Tech. Doc. 560, World Meteorological Organization, Geneva, Switzerland, 341 pp.

Xue, Z., and C. J. Neumann, 1984: Frequency and motion of Western N. Pacific tropical cyclones. NOAA Tech. Memo. NWS NHC 23 (PB85106466), 89 pp.