Climatological Variation of Storms

Semi-Annual Report

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1. Outline of the Research Performed

The long-term data available since 1916 to the present (1990) are the annual number of tornadoes and their breakdown to the Fujita tornado scale (F scale). No other reliable parameters are available continuously for 75 years, 1916-90.

Because the reporting efficiency varies with year due to public awareness and data collection/confirmation methods, the annual number of reported tornadoes was very low in early data years, 1916-1950. During the 1950s, the number of reported tornadoes increased from about 200 to 700 per year. During the recent reporting years since 1960, the reported number reached the plateau.

The most difficult problem was to normalize the reported tornadoes into the constant number as defined by the average reported number in recent reporting years. Various normalization methods were generated by Fujita and tested successfully. Now we are seeing a green light at the far end of the climatological tunnel.

The existence of a periodicity has already been speculated and is being confirmed. The most likely period of the variation of tornado activities is nine (9) years and the variation is in phase with that of El Nino in 1982-83 winter and 1991-92 winter. This research will be continued into the second semi-annual period.

2. New Tornado Parameters Developed

It is necessary to establish a series of new parameters for normalizing tornado activities in the past 75 years. These parameters begin with windspeeds of F-scale tornadoes and their annual distribution.

A sequence of six parameters, F-scale winds, reported, smoothed, long-term constant numbers of tornadoes were defined in establishing the multiplier for normalization. Finally, the normalized number of tornadoes was defined and is being computed.

A summary of the newly-defined numbers is presented below:

1. FUJITA TORNADO SCALE (F-scale)

Eq.(1) $V_F = 6.3\,(F+2)^{1.5}$ m/sec   F-scale windspeed

Eq.(1a) $E_K = \frac{1}{2}\,\rho\,6.3^2\,(F+2)^3$ m²/sec²   F-scale kinetic energy

2. REPORTED NUMBER (R)

Eq.(2) R --- Reported Number (annual, monthly, etc.) of tornadoes

Eq.(2a) R_F --- Reported Number of specific F or stronger tornedoes

Eq.(2b) r_F --- Reported Number of F-scale tornadoes $r_F = R_F - R_{F+1}$

3. SMOOTHED NUMBER ($\bar{R}$)

Eq.(3) $\bar{R}$ --- Smoothed Number (annual, monthly, etc.) of tornadoes

Eq.(3a) $\bar{R}_F$ --- Smoothed Number of specific F or stronger tornadoes

Eq.(3b) $\bar{r}_F$ --- Smoothed Number of F-scale tornadoes $\bar{r}_F = \bar{R}_F - \bar{R}_{F+1}$

4. LONG-TERM CONSTANT (C)

Eq.(4) C --- Long-term Constant Number (1916 - 1990) of tornadoes

Eq.(4a) C_F --- Long-term Constant of specific F or stronger tornadoes

Eq.(4b) c_F --- Long-term Constant of F-scale tornadoes $c_F = C_F - C_{F+1}$

5. MULTIPLIER FOR NORMALIZATION (M)

Eq.(5) $M = C/\bar{R}$ --- Multiplier for normalizing R into N

Eq.(5a) $M_F = C_F/\bar{R}_F$ --- Multiplier for normalizing R_F into N_F

Eq.(5b) $m_F = n_F/r_F$ --- Multiplier for normalizing r_F into n_F, $n_F = N_F - N_{F+1}$

6. NORMALIZED NUMBER (N)

Eq.(6) $N = R \times M$ --- Normalized Number (annual, etc) of tornadoes

Eq.(6a) $N_F = R_F \times M_F$ --- Normalized Number of specific F or stronger tornadoes

Eq.(6b) $n_F = N_F - N_{F+1}$ --- Normalized Number of F-scale tornadoes

3. Reported Number of F or Stronger Tornadoes

The annual variation of reported tornadoes is presented in graphical form. It is evident that the medium-frequency (3 to 15 years) are super-imposed upon the long-term increase caused by human factors, rather than by natural causes.

R_F, Reported Number of F or Stronger Tornadoes
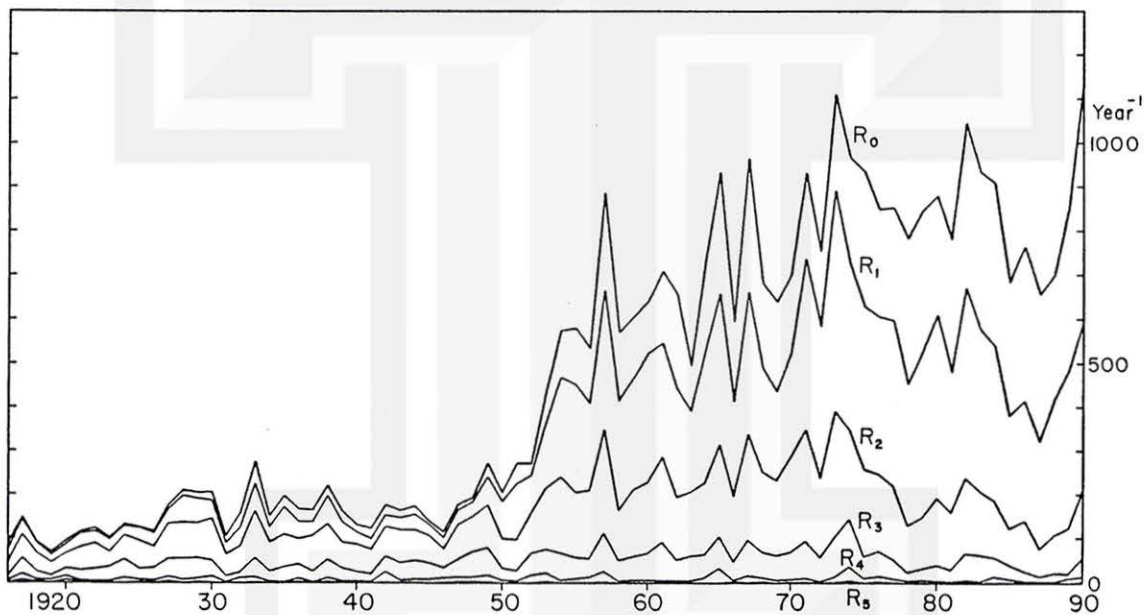
4. Smoothed Number of F or Stronger Tornadoes

In an attempt to establish the long-term variation of the reported number, hand-smoothed curves were obtained by eliminating the medium-frequency (3 to 15 years) variations.

These curves clearly show that the increase in the number of tornadoes during the 1950s was due mainly to the increased reporting of F0 and F1 tornadoes, rather than the increased tornado activities.

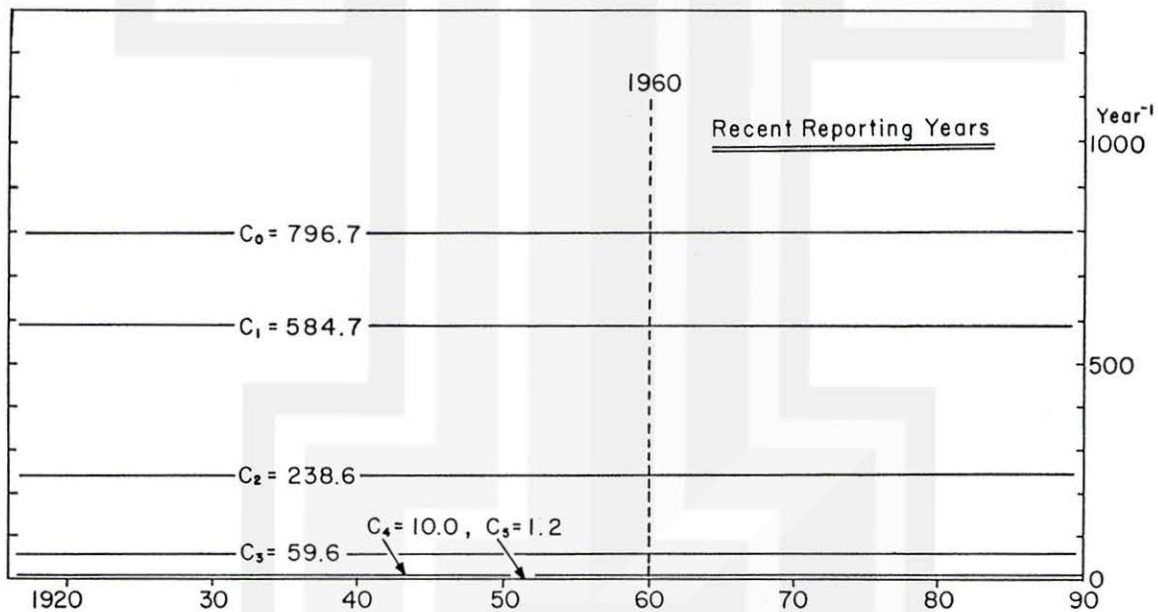$\bar{R}_F$, Smoothed Number of F or Stronger Tornadoes
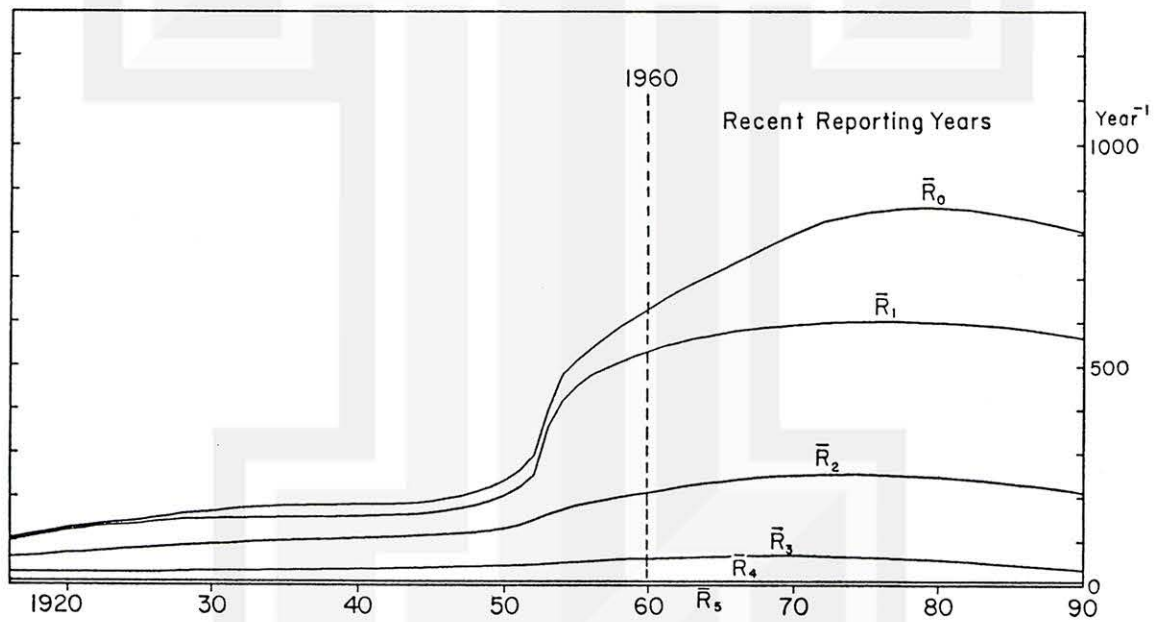
5. Long-Term Constant Number of Tornadoes

Under the assumption that the number in recent reporting years represents the long-term constant number of U.S. tornadoes, the constant was determined as the number averaged over the recent 30-year (1960-89) period.

The annual number of tornadoes, after successful normalization, should distribute up and down on both sides of the constant, horizontal line. Because the constant varies with the F-scale, there are six different Cs corresponding to each of the 6-point F scale.

## C_F, Long-Term Constant of F or Stronger Tornadoes

6. Normalized Number of F or Stronger Tornadoes

The result of normalization as of January 1992 turned out to be excellent because the normalized number vary on both sides of the long-term constant while preserving the medium-frequency (3 to 15 years) variations.

Historically, the peak tornado activity in recent years were:

1965	Palm Sunday Tornadoes
1974	Jumbo Tornado Outbreak
1982-83	El Nino Winter
1982	Peak year of normalized number of 973
1991-92	El Nino Winter
1992	Unknown

N_F, Normalized Number of F or Stronger Tornadoes
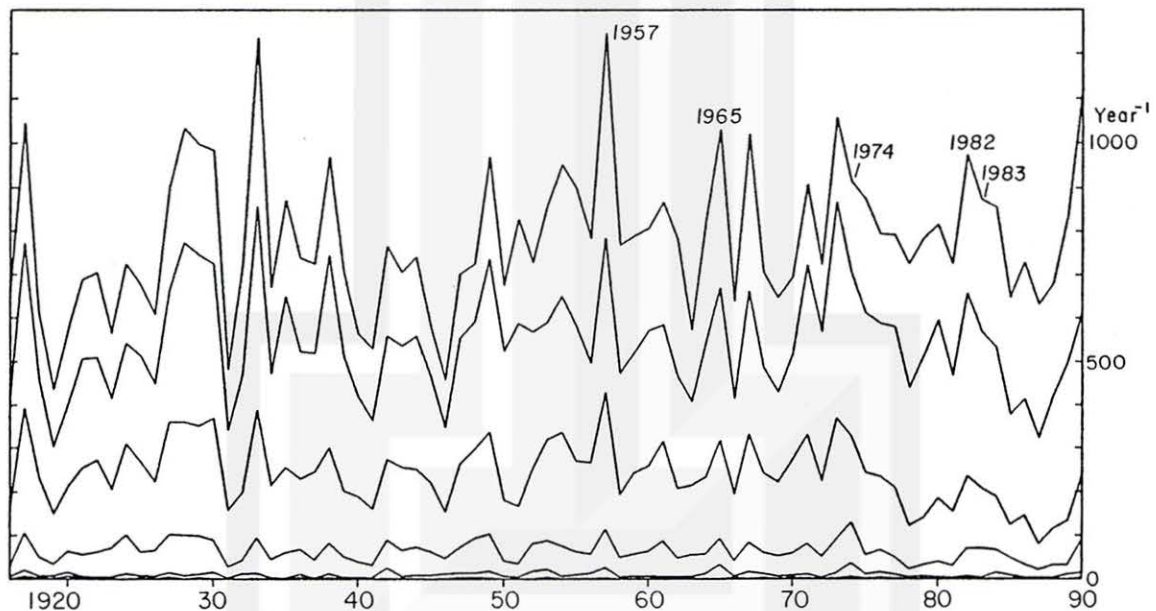
7. Proposed Research

In view of successful results in isolating the 9-year variation of tornado activities, it could be related to the El Nino phenomenon in the equatorial Pacific. If this speculative relationship is true, the spring following the El Nino winter could be the active tornado season.

It is proposed that this research will continue in an attempt to relate tornado activities with other climatological changes.