The Distribution of Rainfall in Landfalling Tropical Cyclones

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* Talk transferred from original transparencies

ABSTRACT

The "Unified Data Set" of gridded precipitation analyses from the U.S. Climate Prediction Center (CPC) on a .25 X .25 grid are used to examine precipitation after landfall in tropical cyclones. The gridded analyses incorporate approximately 14,000 daily rain gauge observations from multiple sources. A Barnes analysis is used by CPC to construct the gridded fields.

The algorithm proposed by Kraft (1958) for maximum precipitation along the track of a tropical cyclone is R = 100 / V, where R is in inches and the storm speed of motion V is in mph. Before testing the algorithm, the maximum precipitation in the gridded analyses was compared to the point value maxima. For most storms (those with precipitation maxima exceeding two or three grid points in area), the analyzed maximum was only 0.5-1.5 inches smaller than the point value maximum. For the less usual case of extremely small-scale rainfall maxima in a storm, such as in Danny (1997), the gridded analysis could be as much as 50-60% below the point value maximum.

It was found that 100/V overestimated the maximum rainfall in the majority of storms, even after adjustment for the analyzed fields being less than the point value maximum. It was found that 70/V provided a better estimate. Nevertheless, the scatter was large, and it is clear that storm motion is only one of the variables that has a significant influence on maximum rainfall. For instance, storms striking Texas, which is likely to have a drier environment than in other hurricane-prone parts of the US, fell most strongly below the 100/V formula.

The symmetry of precipitation with respect to the track was also examined for a large number of storms. The direction of motion did not correlate highly with the rainfall asymmetry, i.e., maximum storm total precipitation was sometimes left and sometimes right of the track. Instead, the direction of the vertical wind shear vector was the dominant influence. These results support those found earlier by Corbosiero (2000), who found that vertical wind shear was the dominant influence on the azimuthal lightning distribution in tropical cyclones. It appears that the distribution of total precipitation, not just convective precipitation measured by lightning frequency, is strongly influenced by the vertical wind shear.

Unified Precipitation Data Set

- 12 UTC – 12 UTC daily precipitation data set created by NCEP/CPC

- Includes ~14,000 daily rainfall amounts from NCDC and CPC cooperative rain gauge stations analyzed to a .25° x .25° grid using a Barnes analysis scheme for the area 20° – 60° N, 140° – 60° W

- Plot rainfall distributions using the GIS software package ArcView

- **Rainfall maxima that cover 3 or more grid boxes (~2,500 km^2) are well represented in the Unified Data Set and are on average .5 – 1.5 inches below the rain gauge values in the same region**

- **Smaller scale maxima are co-located with the actual rain gauge maxima but may be as small as half of the actual rainfall amount**

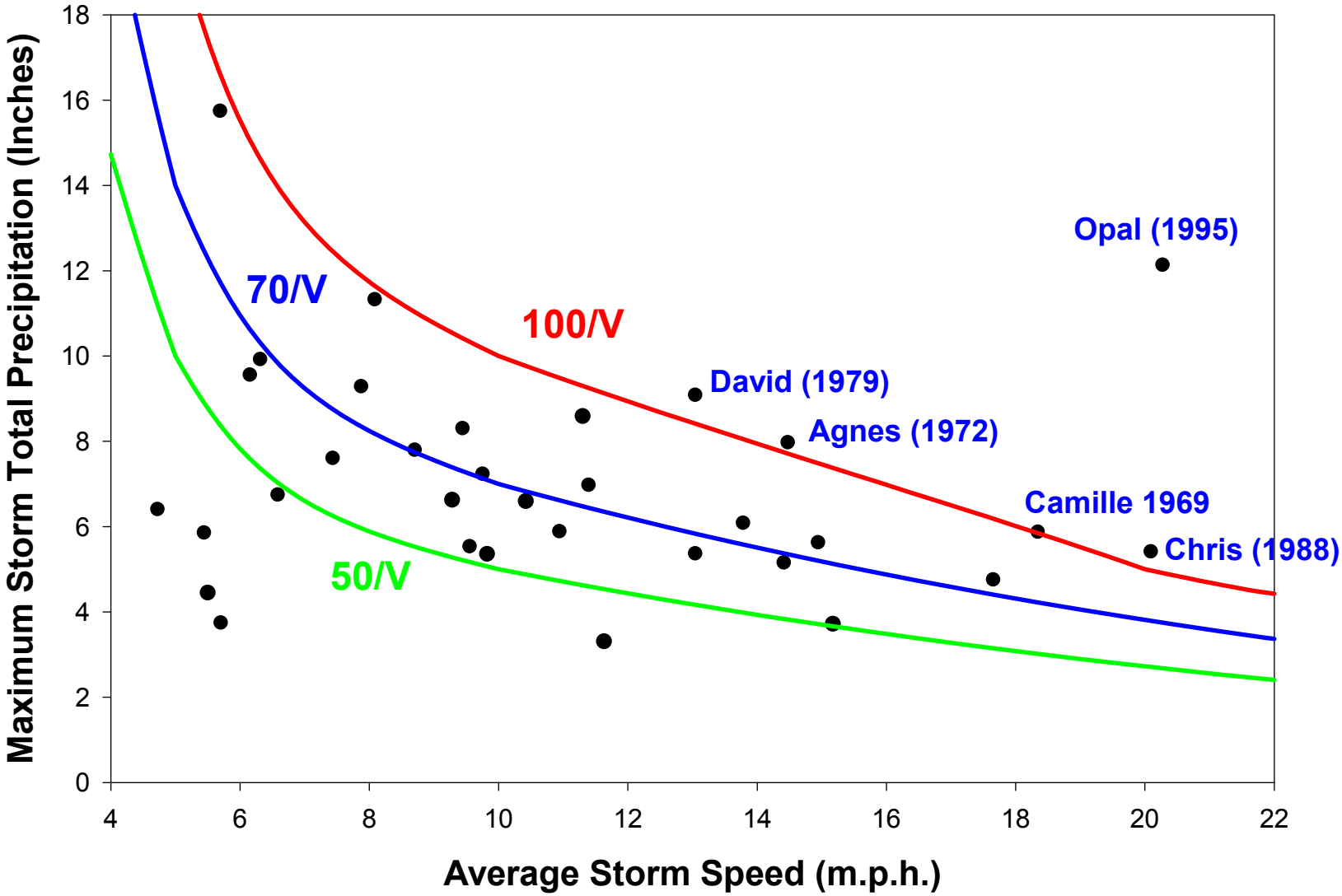
Testing 100/V

- An algorithm proposed by Kraft (1958) for predicting the maximum amount of rainfall produced by a landfalling tropical cyclone is

$$R = 100/V$$

  where R is the rainfall amount in inches and V is the forward speed of the cyclone in m.p.h.

- Evaluate this algorithm on a storm total basis using the Unified data set rainfall amounts and NHC best track data set to calculate storm motion


Maximum Storm Total Precipitation vs. Average Storm Speed
Maximum Storm Total Precipitation (Inches)
Average Storm Speed (m.p.h.)
0
2
4
6
8
10
12
14
16
18
4
6
8
10
12
14
16
18
20
22
Opal (1995)
70/V
100/V
David (1979)
Agnes (1972)
Camille 1969
Chris (1988)
50/V

- 100/V overestimates the maximum along track storm total rainfall amounts in 28 of 33 tropical cyclones examined

- The exceptions being storms which interacted with mid-latitude troughs

- 70/V is a better fit to the data points and a recommended update to the algorithm

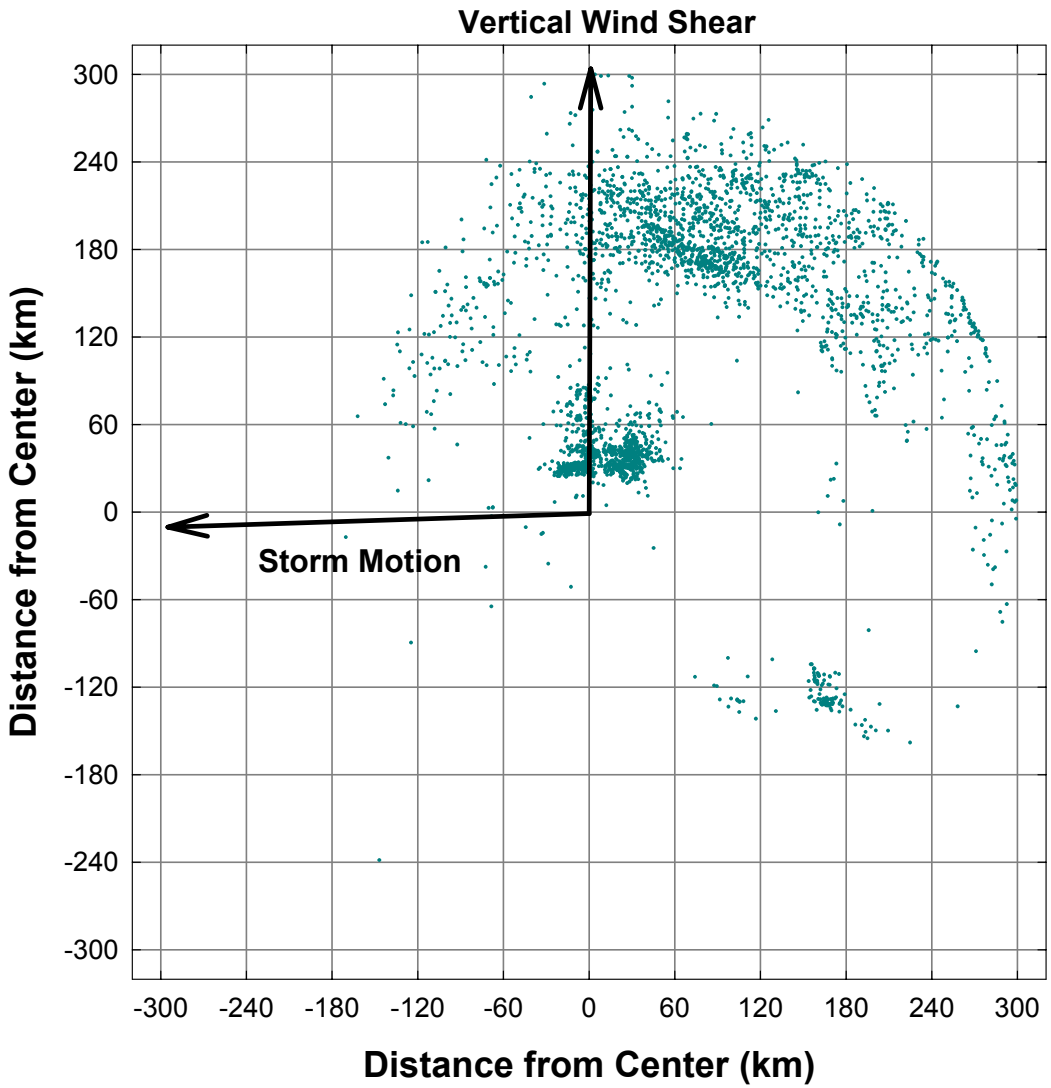
Rainfall Symmetry

- Examine symmetry about the track of rainfall distributions in tropical cyclones with respect to both vertical wind shear and storm motion

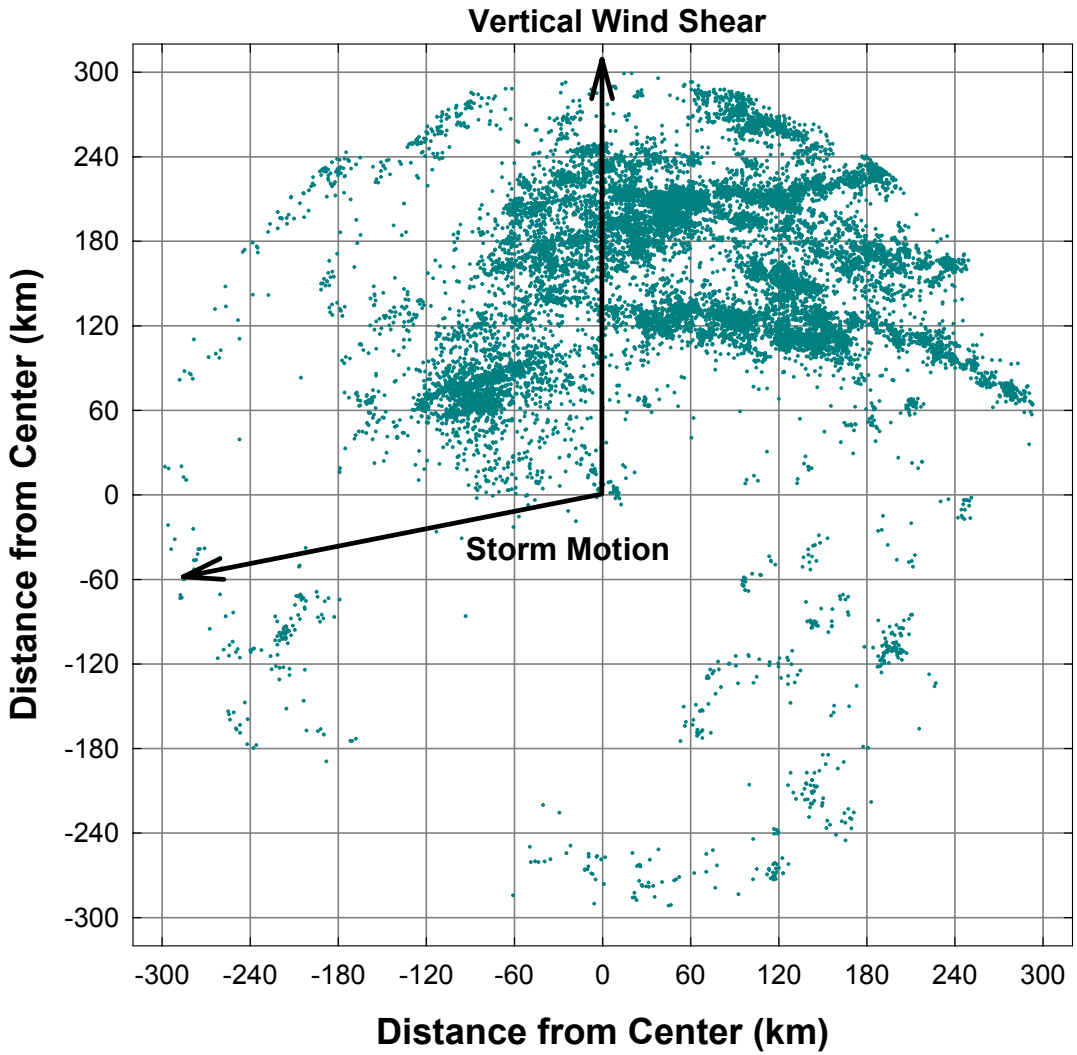
- Previous work with lightning data has shown that flashes in tropical cyclones preferentially occur downshear of the center and to the right of motion, with a clear dominance of the downshear signal

- Rainfall maxima may occur to either side of the track, but are seen to be consistently downshear of the center, in agreement with previous studies using lightning data

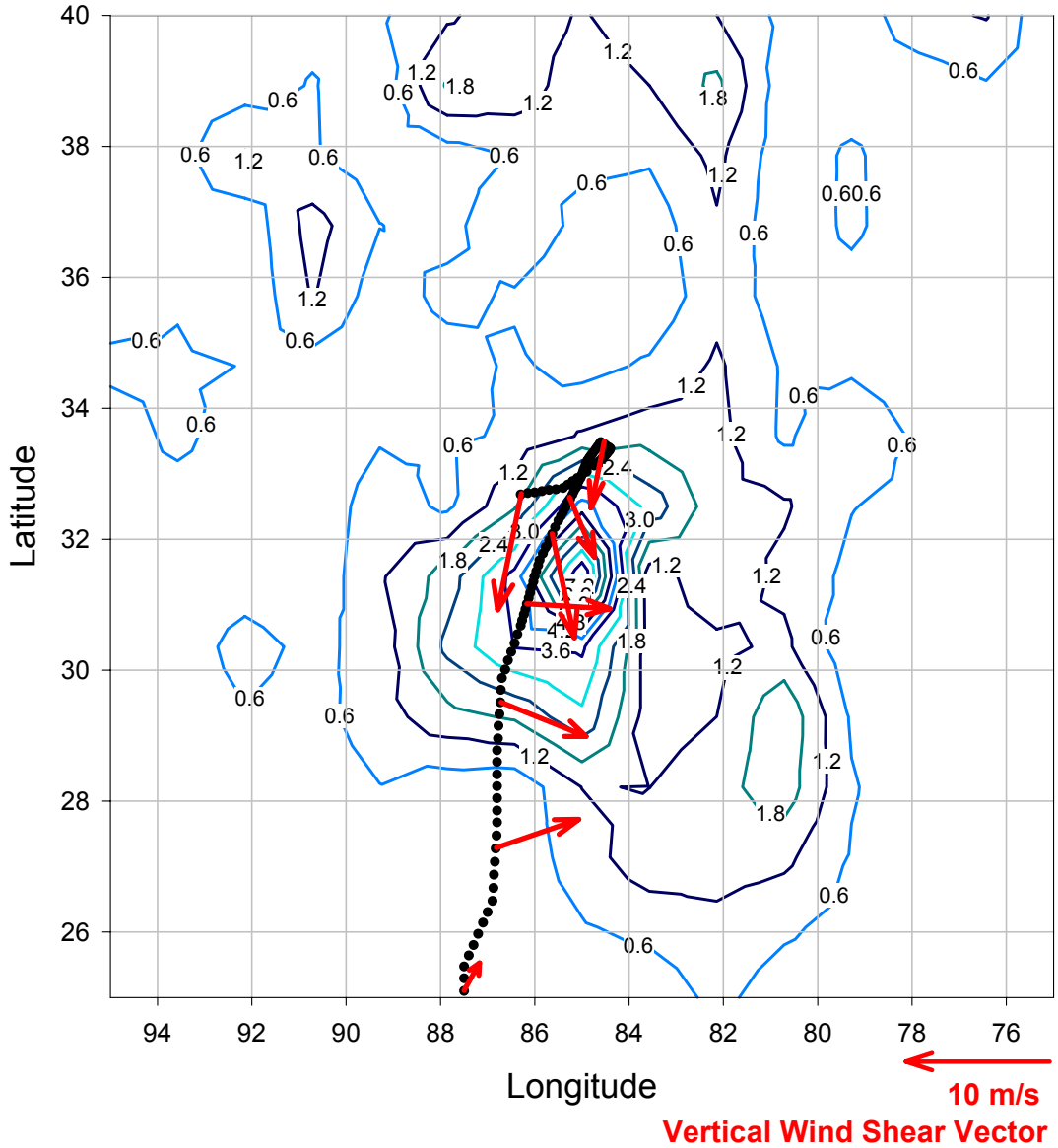
Lightning Distribution in Bertha 1996
Rotated with Respect to the Shear Vector Pointing Due North
06 UTC 11 July - 06 UTC 14 July



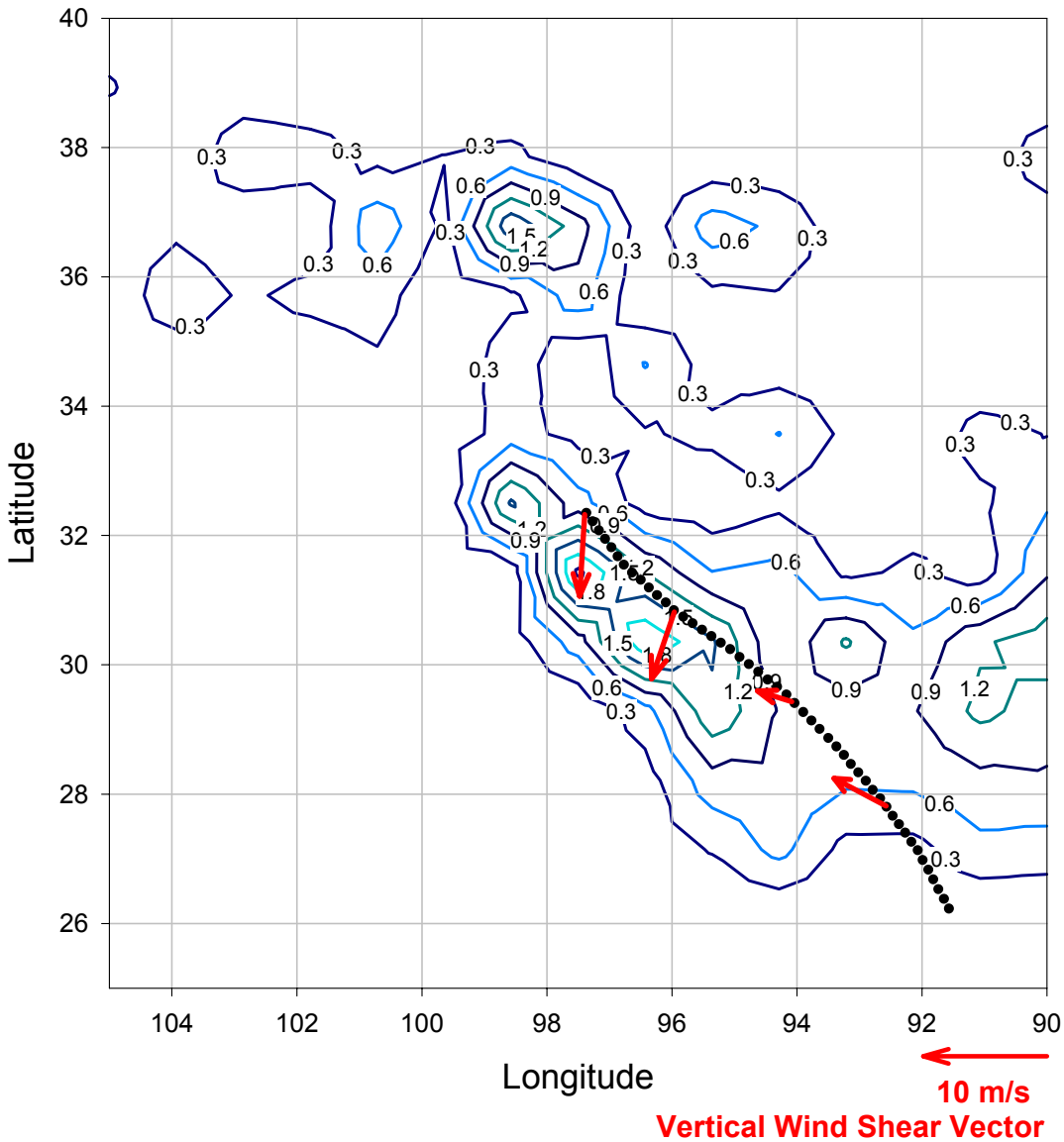
Distribution of Lightning in Alberto 1994
Rotated with Respect to the Shear Vector Pointing due North
06 UTC 3 July - 06 UTC 6 July



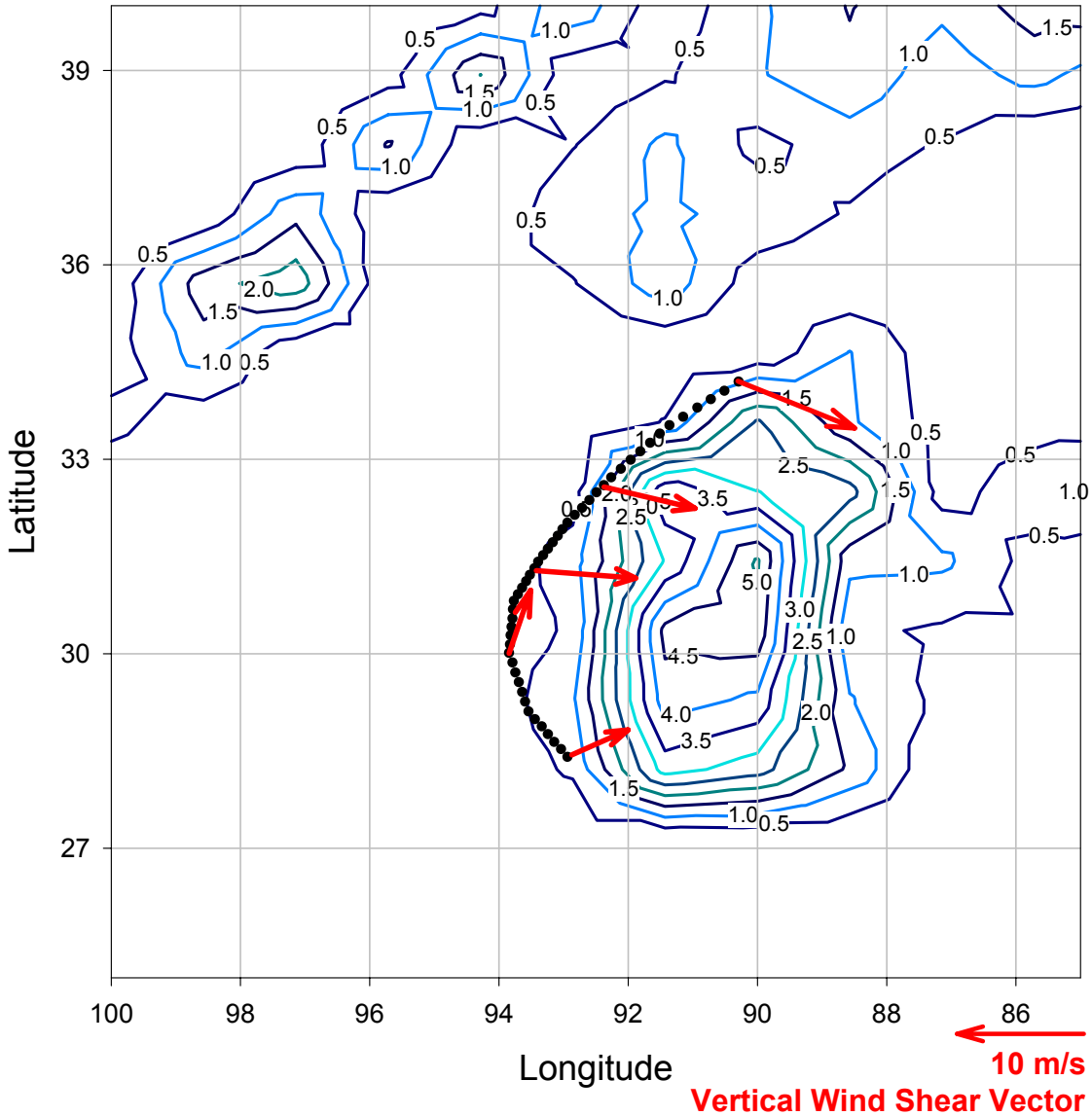
Alberto 1994
Storm Total Precipitation (Inches)
July 3 - 7



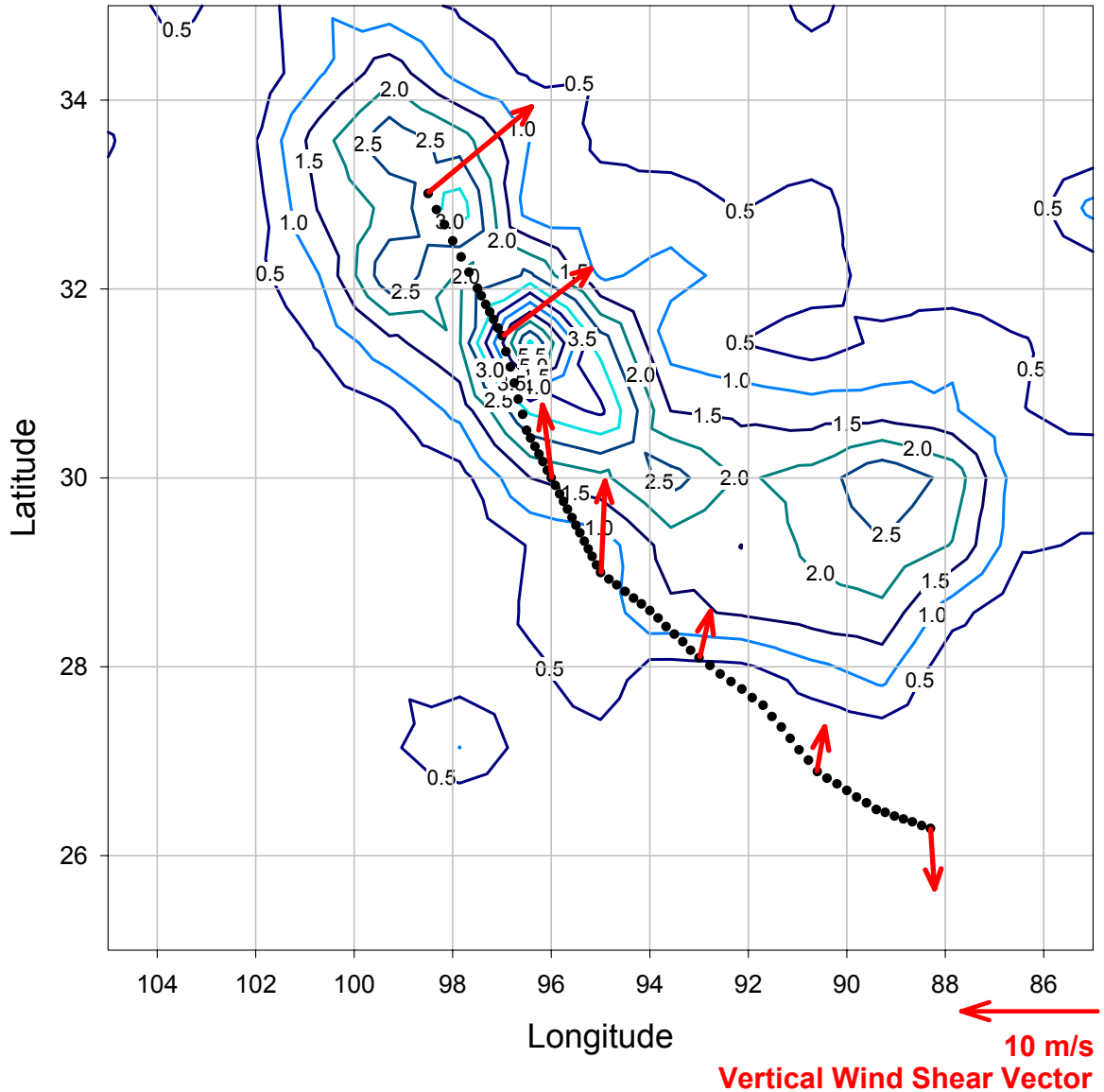
Chantal 1989
Storm Total Precipitation (Inches)
August 1-2



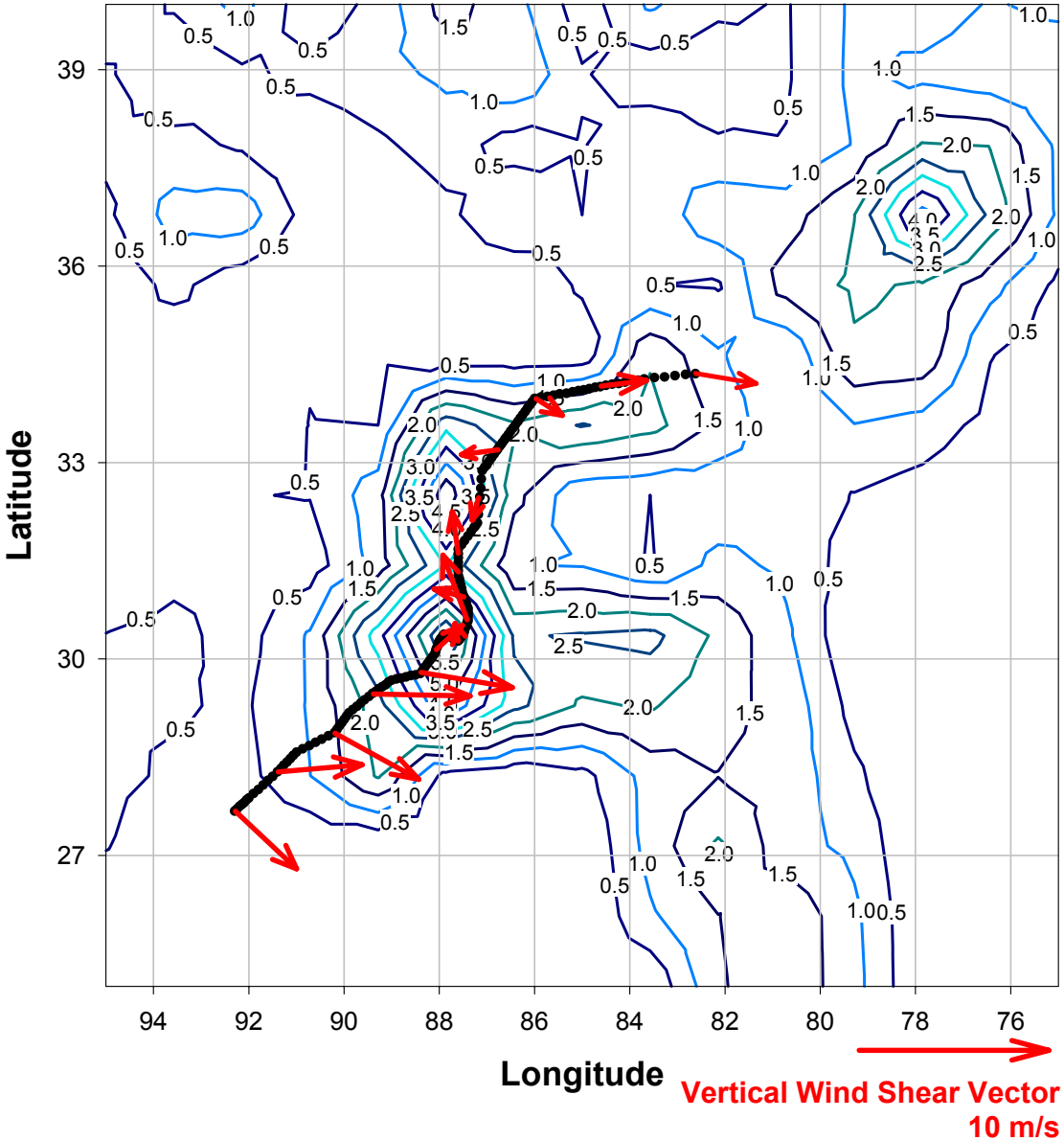
Andrew 1992
Storm Total Precipitation (Inches)
July 26-27



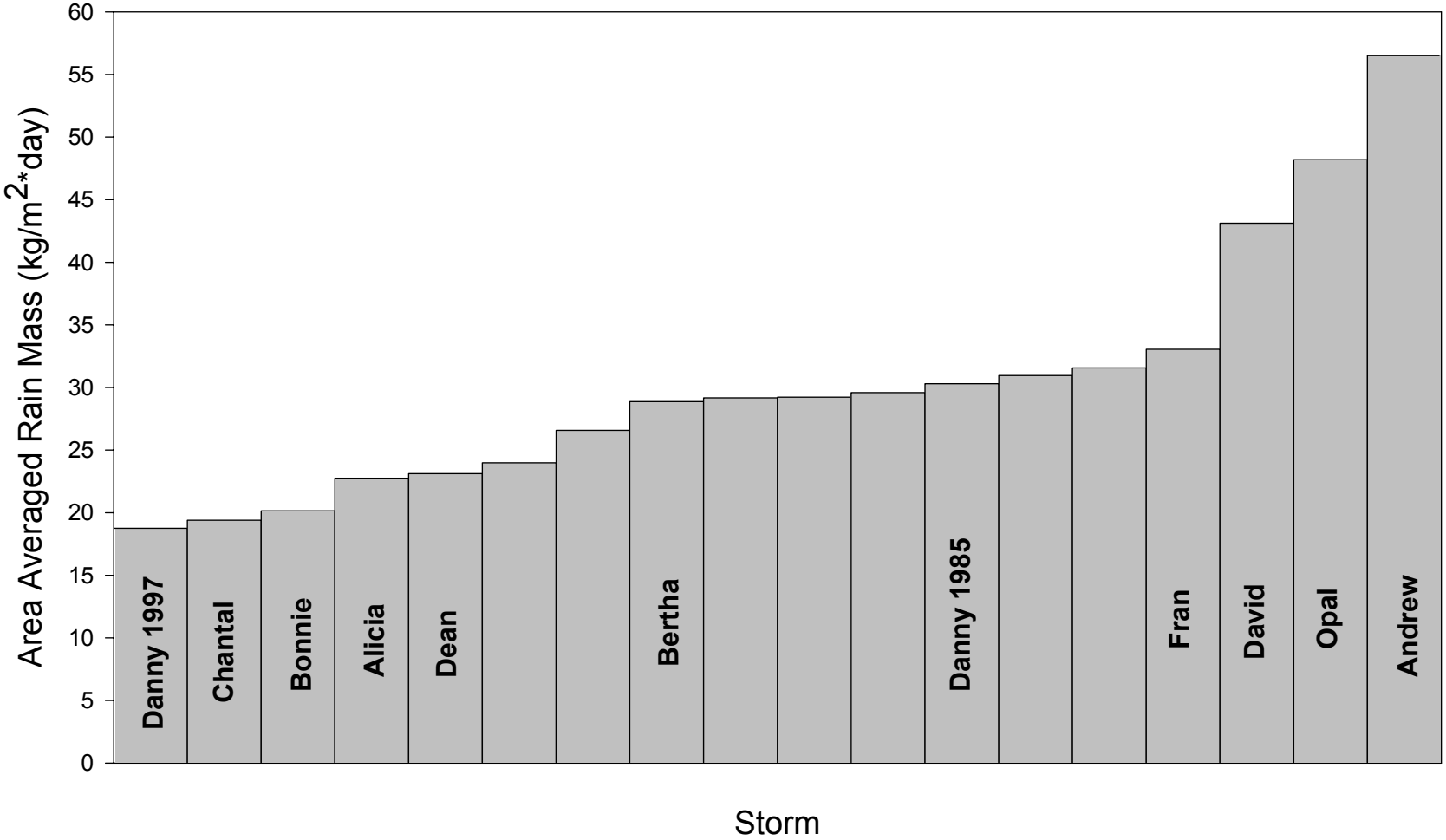
Dean 1995
Storm Total Precipitation (Inches)
July 30 - August 1



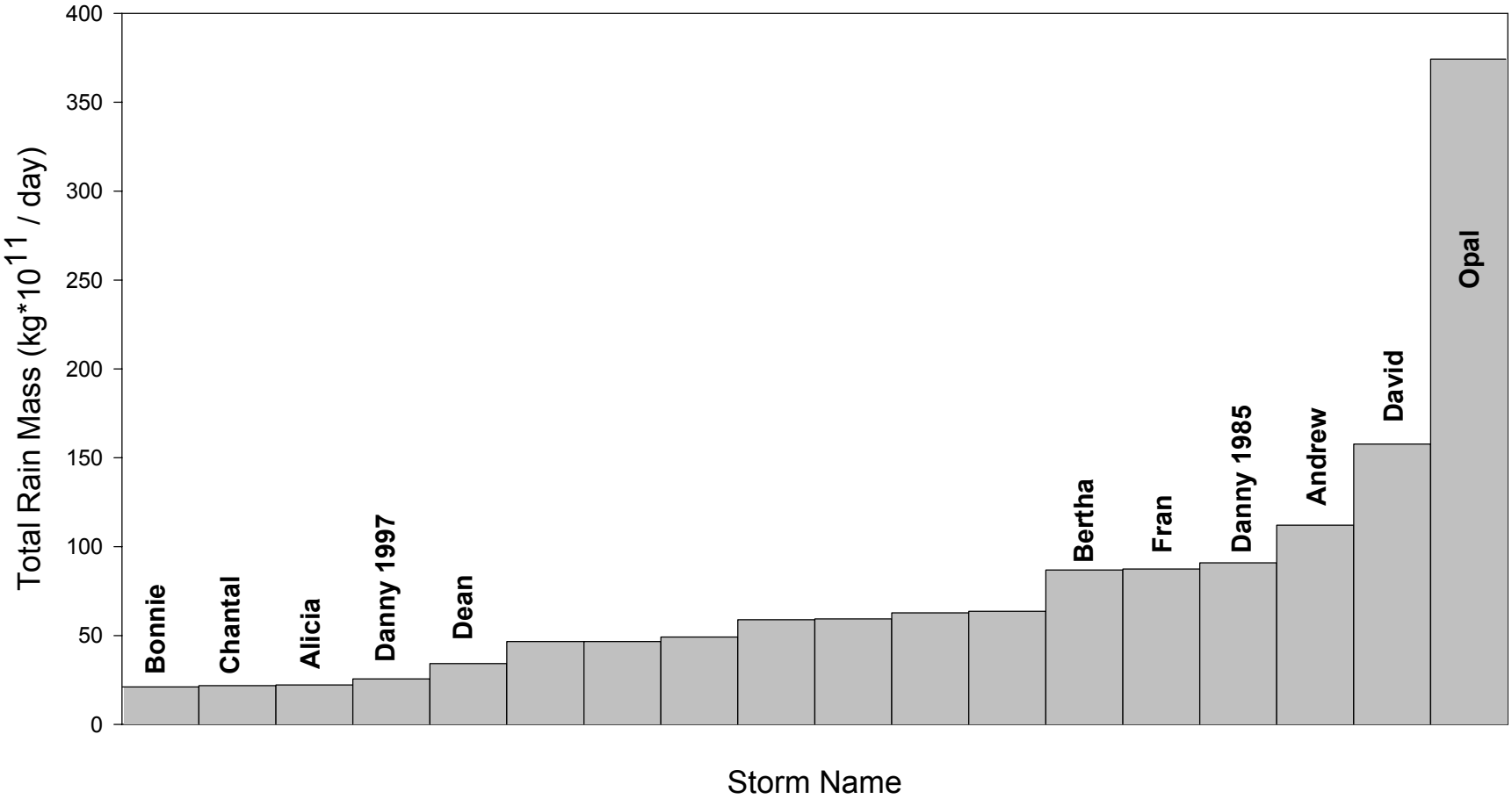
Danny 1997
Storm Total Rainfall
July 17 - 23



Distribution of Rainfall Intensity



Distribution of Daily Rain Mass



Distribution of Area Averaged Rain Mass