Geophysical Research Abstracts,
Vol. 11, EGU2009-0, 2009
EGU General Assembly 2009

Extreme Rainfall Intensities and Long-term Rainfall Risk from Tropical Cyclones

A. Langousis and D. Veneziano

Department of Civil and Environmental Engineering, MIT, Cambridge, 02139, MA, U.S.A. (andlag@mit.edu / Fax: 440-756-2310 / Phone: 617-407-0059)

We develop a methodology to estimate the rate of extreme rainfalls at coastal sites due to tropical cyclones (TCs). A basic component of the methodology is the probability distribution of $I_{D,max}$, the maximum rainfall intensity at the site over a period D during the passage of a TC with given characteristics $\underline{\theta}$. The long-term rainfall risk is obtained by combining the conditional distribution of $(I_{D,max}|\underline{\theta})$ with a recurrence model for $\underline{\theta}$.

The lack of extensive TC rainfall records and the many parameters needed to characterize the motion, size and intensity of tropical cyclones make it difficult to estimate the distribution of $(I_{D,max}|\underline{\theta})$ directly from data. Hence, we have resorted to a combination of physical modeling to obtain the mean rainfall field for a TC with given characteristics $\underline{\theta}$, and statistical analysis to include storm-to-storm variability, as well as intra-storm rainfall fluctuations due to rainbands and local convection. The vector $\underline{\theta}$ includes the maximum tangential wind velocity V_{max}, the radius of maximum winds R_{max} and the translation speed V_t of the storm, in addition to the distance y of the coastal site from the TC center.

The physical model of TC rainfall uses an extension of Smith's (1968) boundary layer (BL) formulation and simple moist air thermodynamics to calculate the vertical outflow of water vapor from the top of the TC boundary layer, which is assumed to be all converted into rainfall. However, the calculated rainfall field is not simply proportional to the vertical flux of moisture. This is because (1) the trajectory of moisted air parcels has an outward slant depending on distance from the TC center and (2) the ascending air parcels and descending rain drops are advected into a helical motion by the cyclonic circulation; therefore a parcel of air that leaves the TC boundary layer contributes rainfall to a range of azimuthal locations.

The statistical component of the model characterizes the distribution of $(I_{D,max}|\underline{\theta})$ by comparing the physical model results with precipitation radar (PR) data from the TRMM mission. Taylor's hypothesis is used to convert spatial rainfall intensity fluctuations to temporal fluctuations at a given location A.

To illustrate the use of the model for long-term rainfall risk analysis, we formulate a recurrence model for tropical cyclones in the Gulf of Mexico that make landfall between longitudes 85^o-95^oW and compare the intensity-duration-frequency (IDF) curves for New Orleans obtained by the present model with similar curves in the literature based on continuous rainfall records. The latter include all types of rainstorms. We find that for return periods of 100 years or more and long averaging durations (D around 12-24 hours), tropical cyclones dominate over other rainfall event types, whereas the reverse is true for shorter return periods or shorter averaging durations.

We also determine how the most likely TC scenario varies with the averaging duration D and the return period T. We do so by plotting the modal values of V_{max}, R_{max}, and V_t conditioned on exceeding the T-yr rainfall intensity for duration D. The mode of V_t decreases as T increases, because more intense rainfalls are generally produced by slower-moving systems. The mode of R_{max} decreases when D or T increase, whereas the opposite is true for V_{max}. For the distance y from the TC center, the modal value is always close to R_{max}, the location where maximum rainfall intensities tend to occur. These modal values can be used to define T-year scenario events.