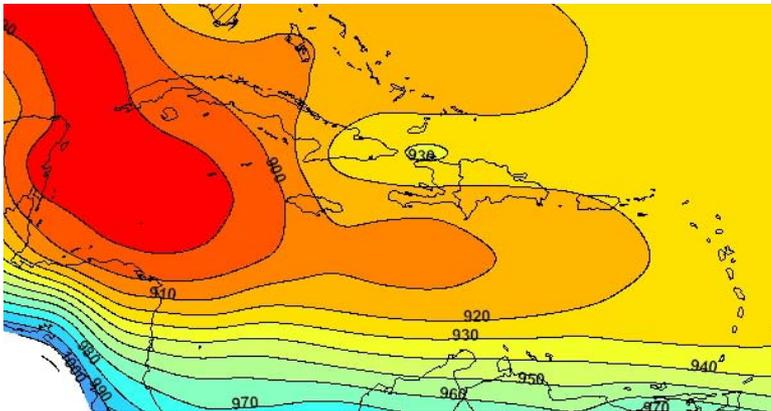


Design Wind Speeds for the Caribbean for use with the Wind Load Provisions of ASCE 7



Prepared by
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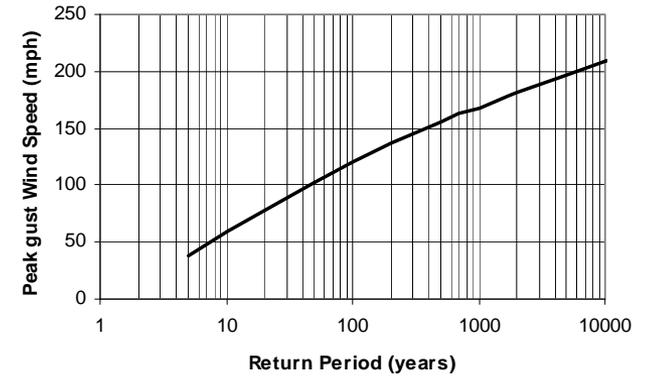
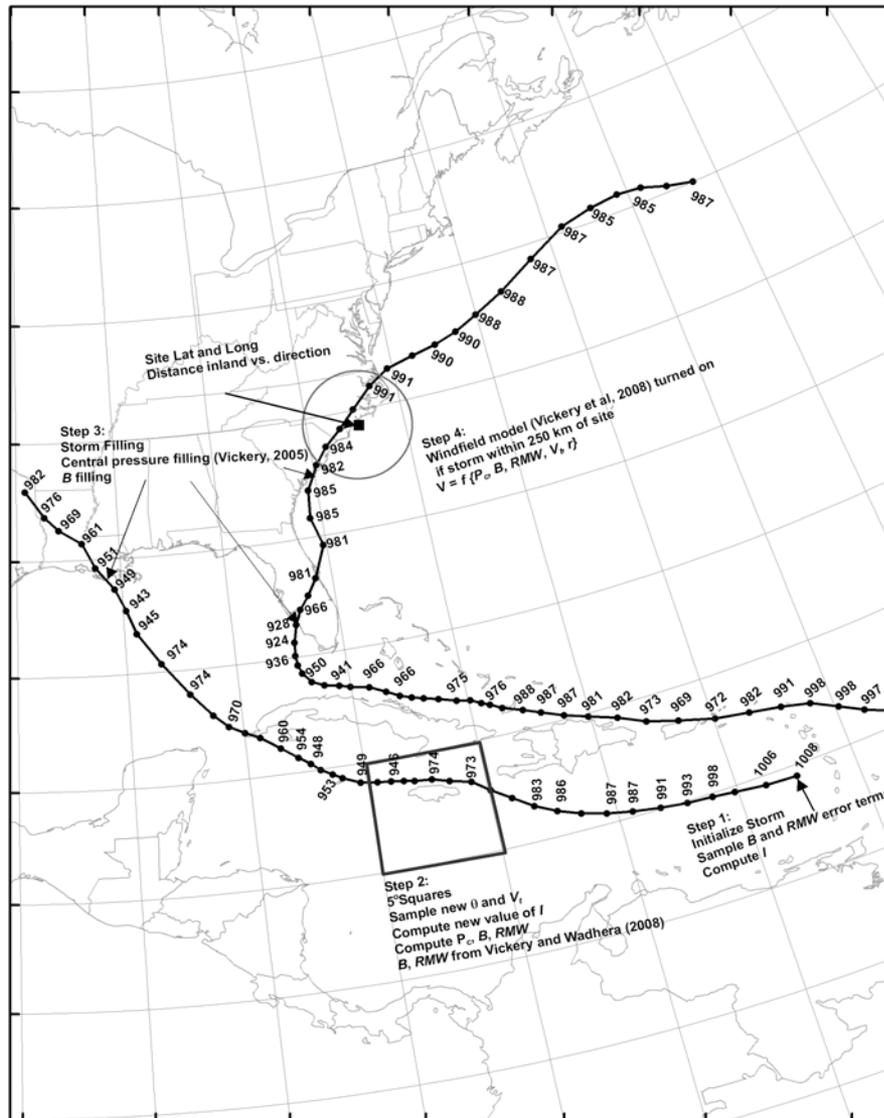
Under a special grant from the Office of Foreign Disaster Assistance of the United States Agency for International Development (OFDA/USAID).



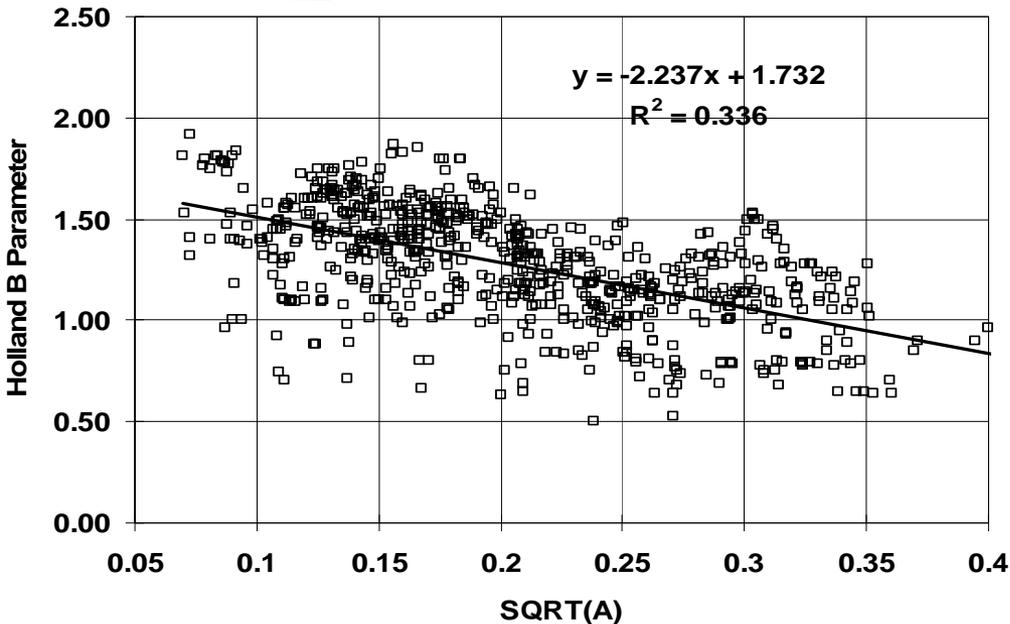
Overview

- Simulation Methodology
 - B and RMW models
 - Sea Surface Drag Coefficient Model
 - Hurricane Boundary Layer Model
- Model Validation
- Design Wind Speeds
- Summary

Simulation Approach and Flow Chart



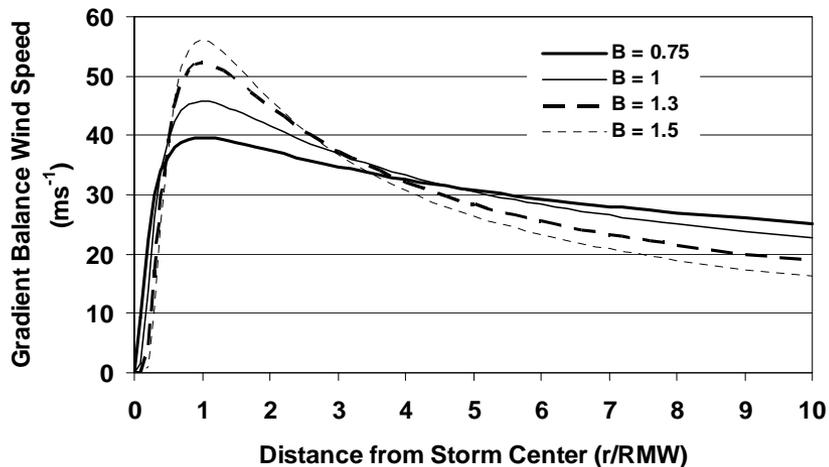
Holland B Parameter



- B estimates derived from upper level flight data and H*Wind snapshots of hurricane wind fields.
- B modeled as a function of A where

$$A = \frac{RMW \cdot f_c}{\sqrt{2R_d T_s \cdot \ln\left(1 + \frac{\Delta p}{p_c \cdot e}\right)}}$$

R_d is the gas constant for dry air, p_c is the central pressure, T_s is the sea surface temperature ($^{\circ}\text{C}$), Δp is central pressure difference, RMW is radius to maximum winds



Vickery and Wadhwa (2008), "Statistical Models of Holland Pressure Profile Parameter and Radius to Maximum Winds of Hurricanes from Flight Level Pressure and H*Wind data" *In Press JAMC*

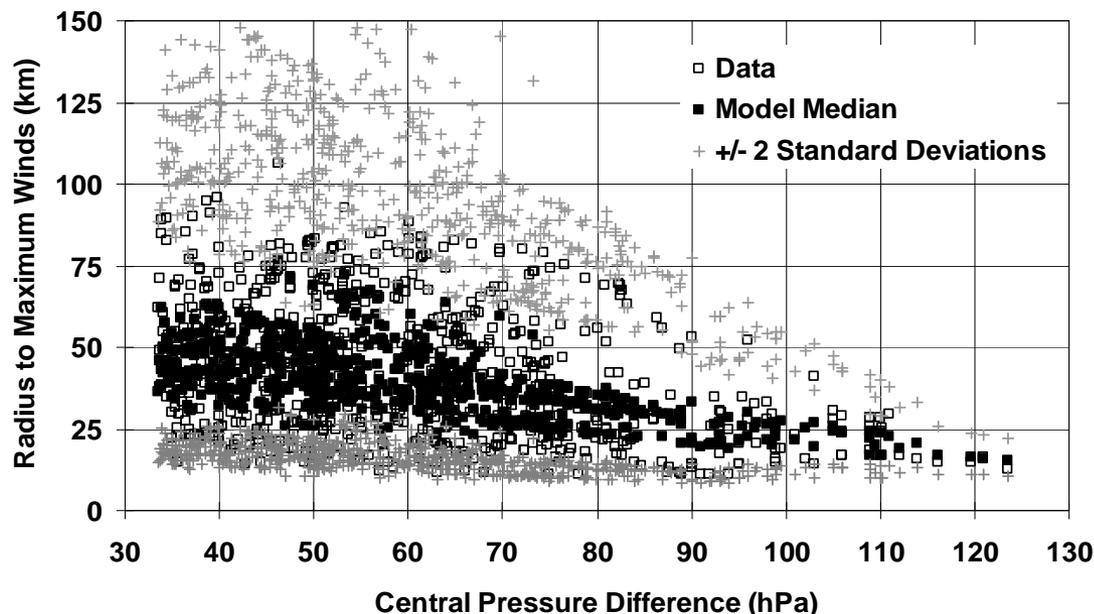
RMW Models

■ Atlantic Region

$$\ln(RMW) = 3.015 - 6.291 \times 10^{-5} \Delta p^2 + 0.0337\Psi + \varepsilon \quad r^2=0.297, \sigma_{\ln RMW}=0.441$$

Δp is central pressure difference, Ψ is the latitude and ε is the random error term. The error, $\sigma_{\ln RMW}$, is modeled in the form:

$$\begin{aligned} \sigma_{\ln RMW} &= 0.448 & \Delta p \leq 87 \text{ hPa} \\ \sigma_{\ln RMW} &= 1.137 - 0.00792\Delta p & 87 \text{ hPa} \leq \Delta p \leq 120 \text{ hPa} \\ \sigma_{\ln RMW} &= 0.186 & \Delta p > 120 \text{ hPa} \end{aligned}$$



Hurricane Boundary Layer Model

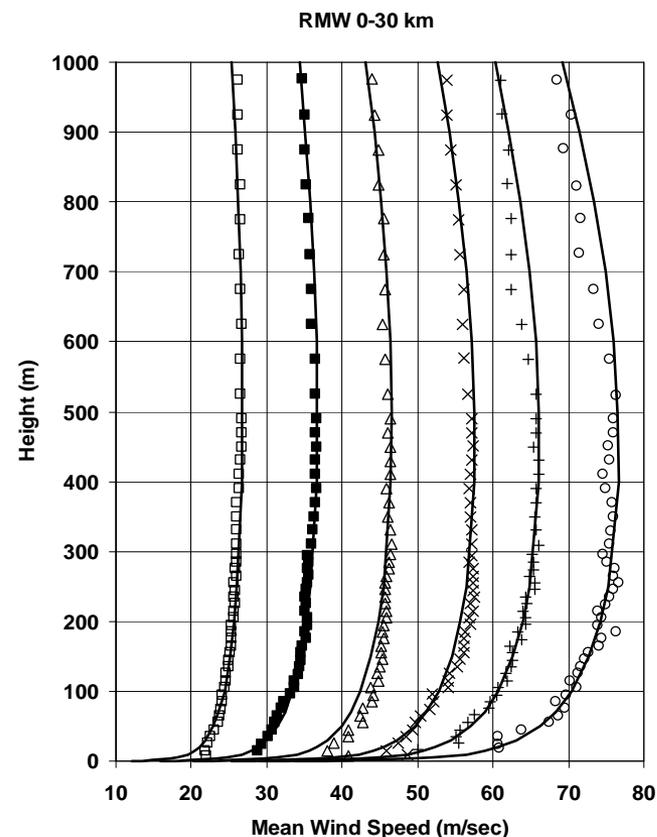
- Boundary Layer Model developed using Dropwindsonde data.
- Includes the radial variation of BL height
- Marine Boundary Layer Model given by:

$$U(z) = \frac{u_*}{k} \left[\ln\left(\frac{z}{z_o}\right) - a\left(\frac{z}{H^*}\right)^n \right]$$

- Boundary layer Height given by:

$$H^* = 343.7 + 0.260/I \quad r^2 = 0.75, \quad \sigma_e = 99m$$

Vickery et al (2008), "A Hurricane Boundary Layer and Wind Field Model for Use in Engineering Applications", *In Press JAMC*



Drag Coefficient over the Ocean

Powell, 1980

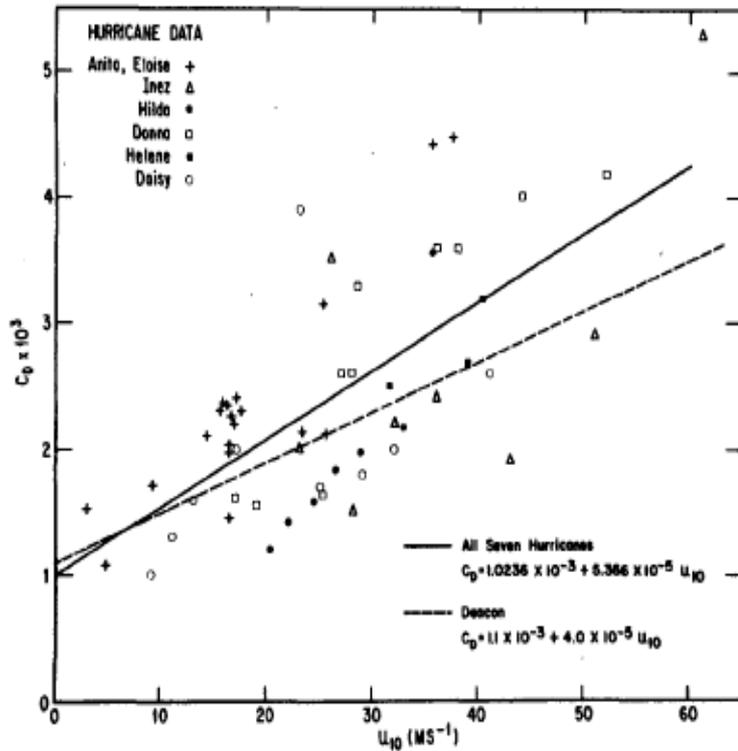
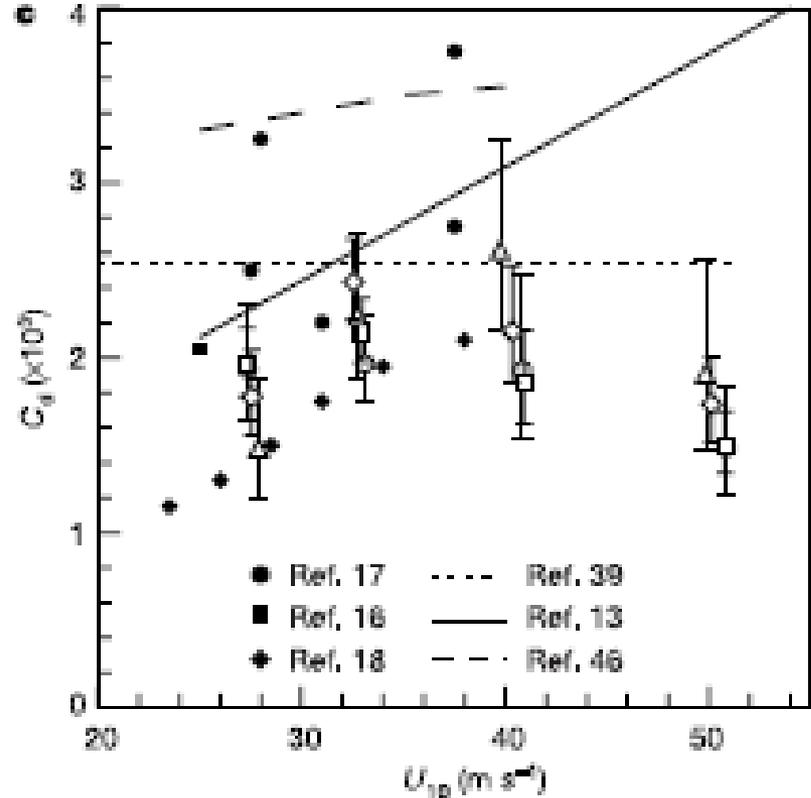


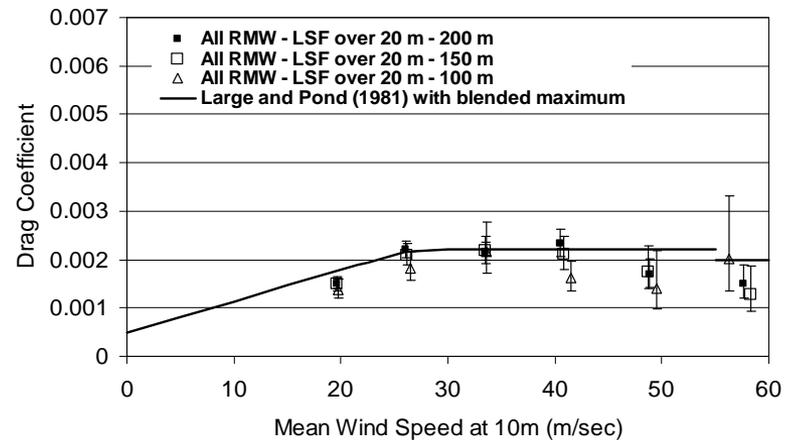
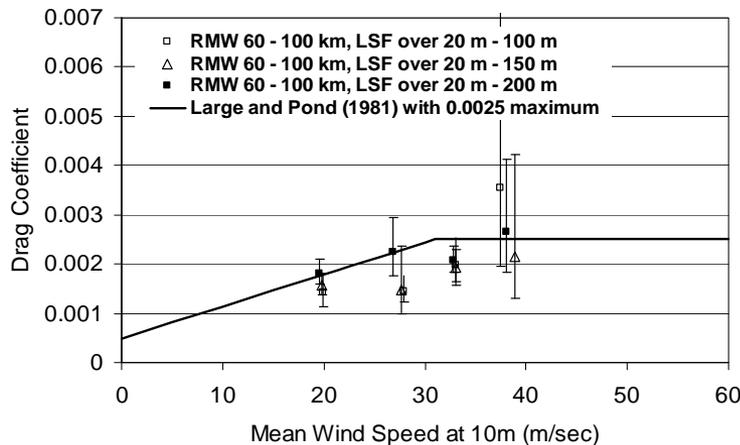
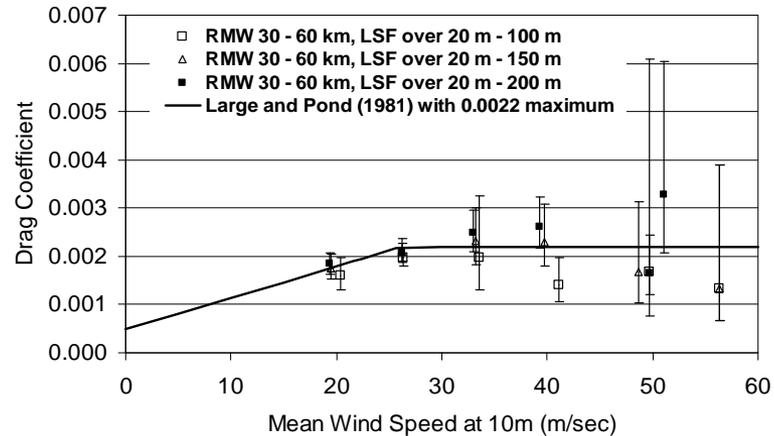
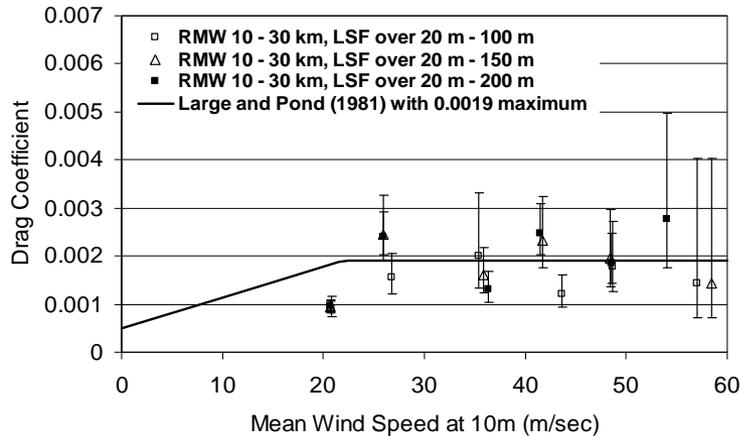
FIG. 5. Ten meter level neutral drag coefficient from several studies plotted versus wind speed.

Powell, et al, 2003

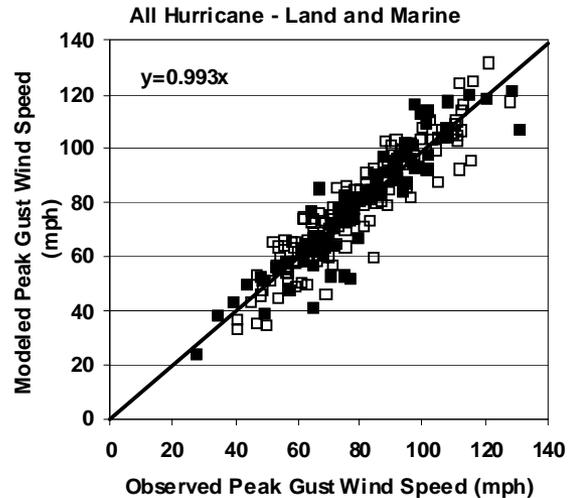
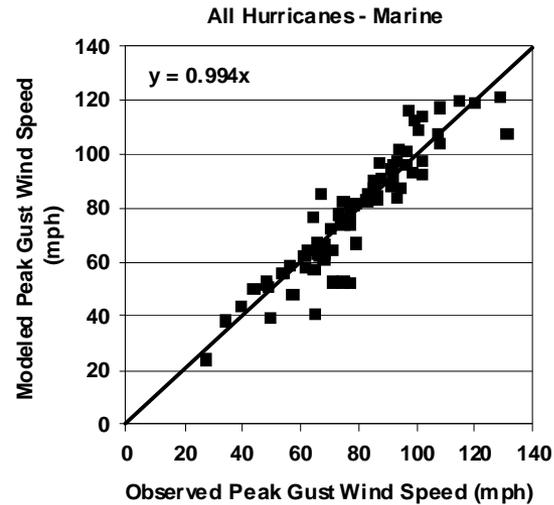
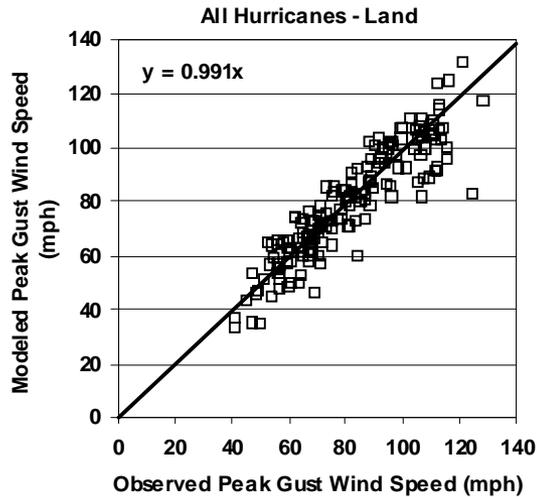


C_D open terrain = 0.00471

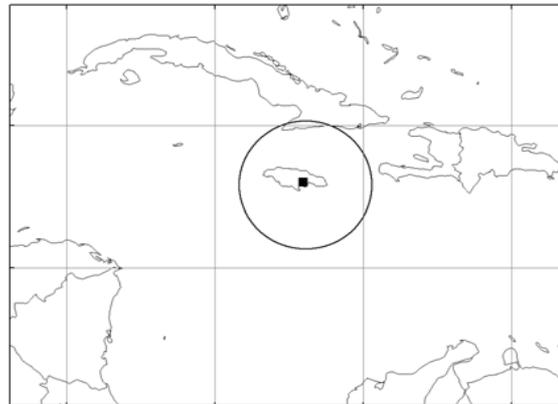
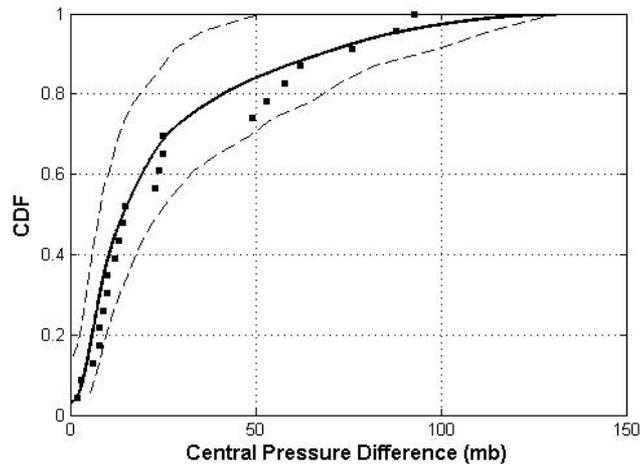
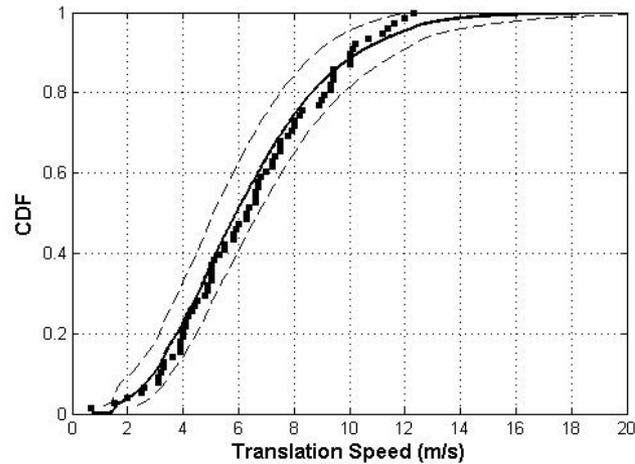
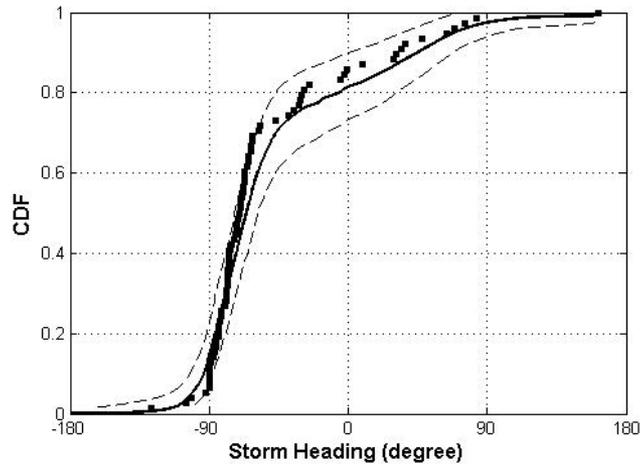
Sea Surface Drag Coefficient Model



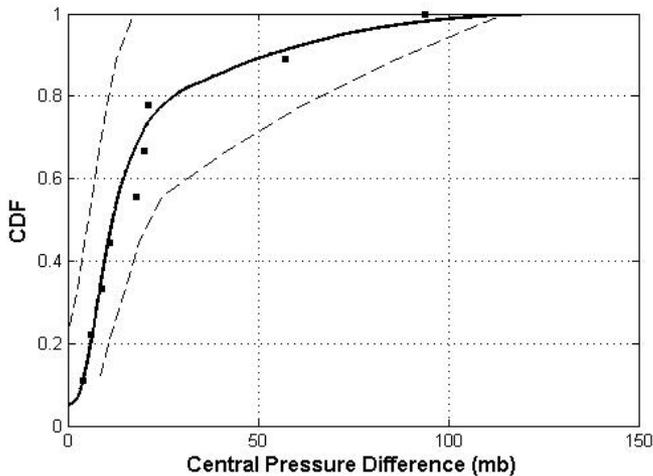
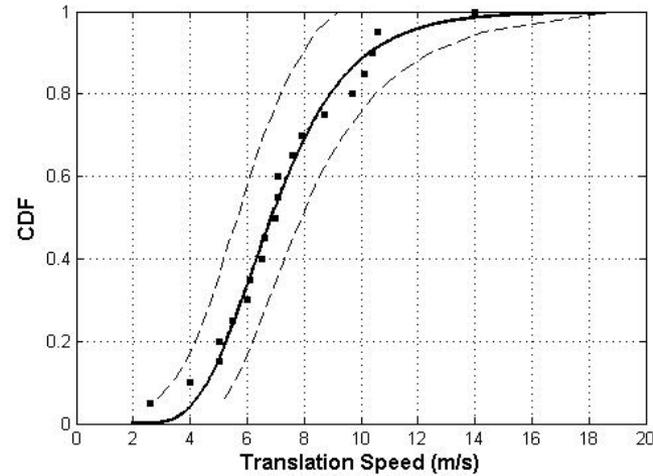
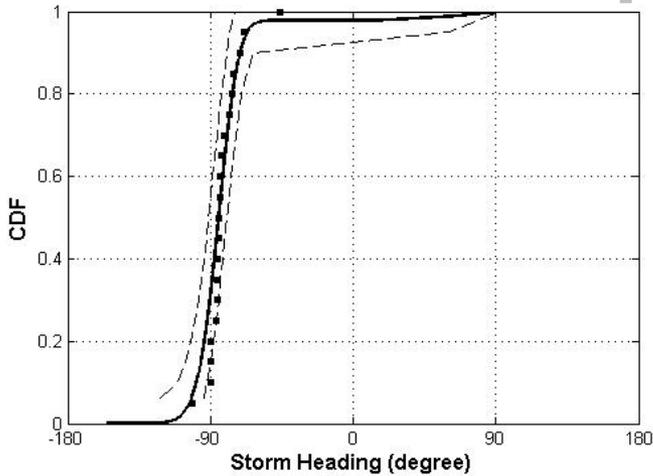
Wind Field Model Validation



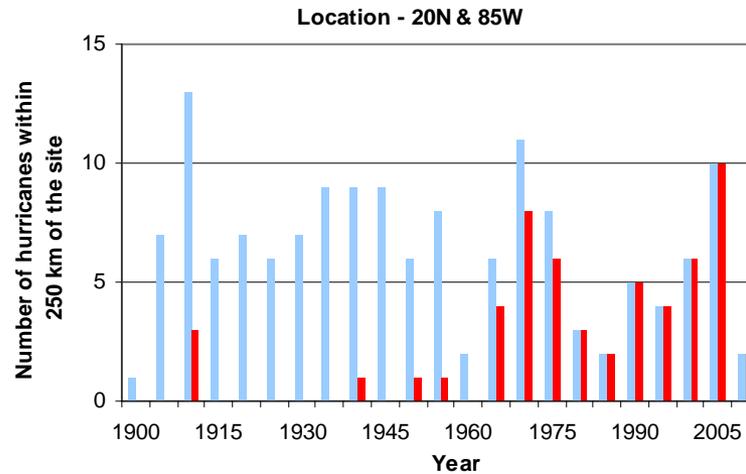
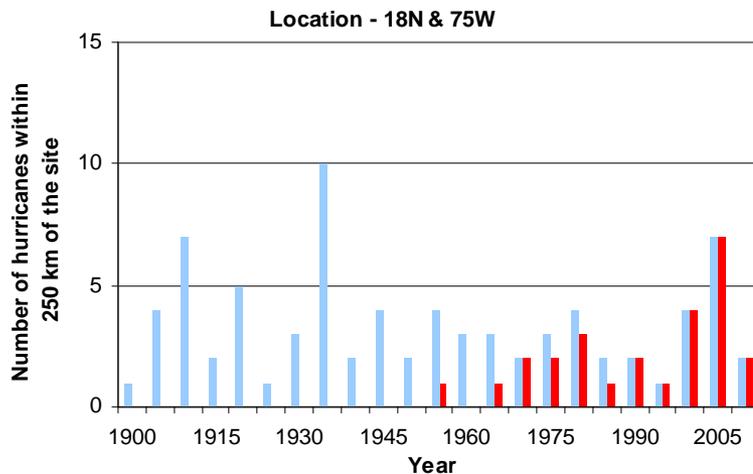
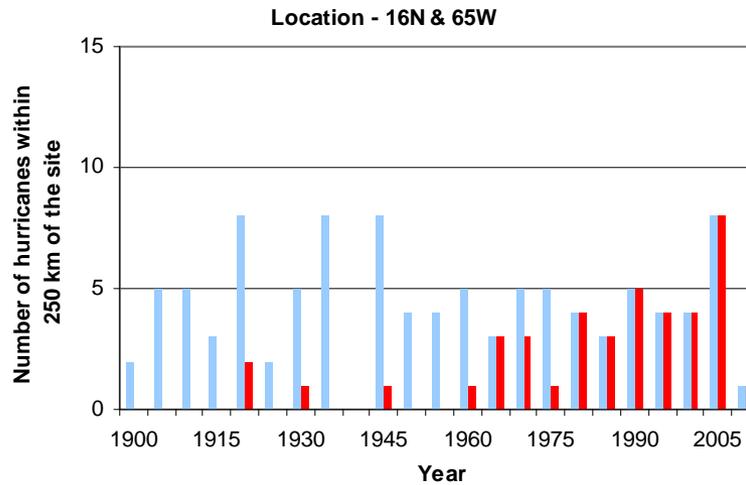
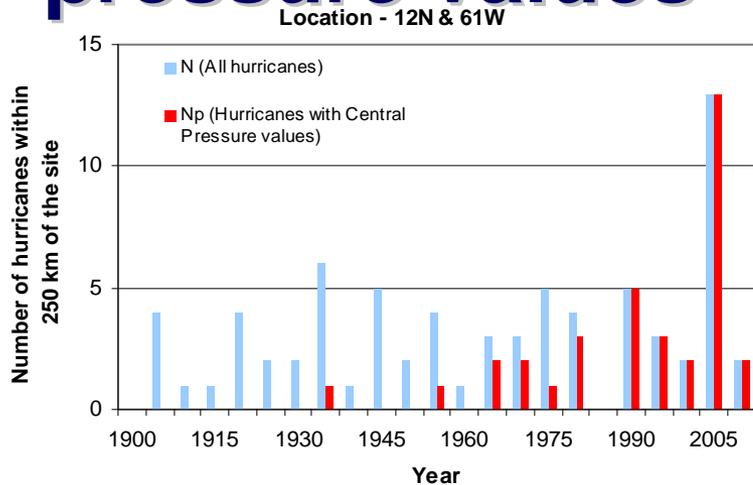
Modeled and Observed Heading, Translation Speed and Central Pressure



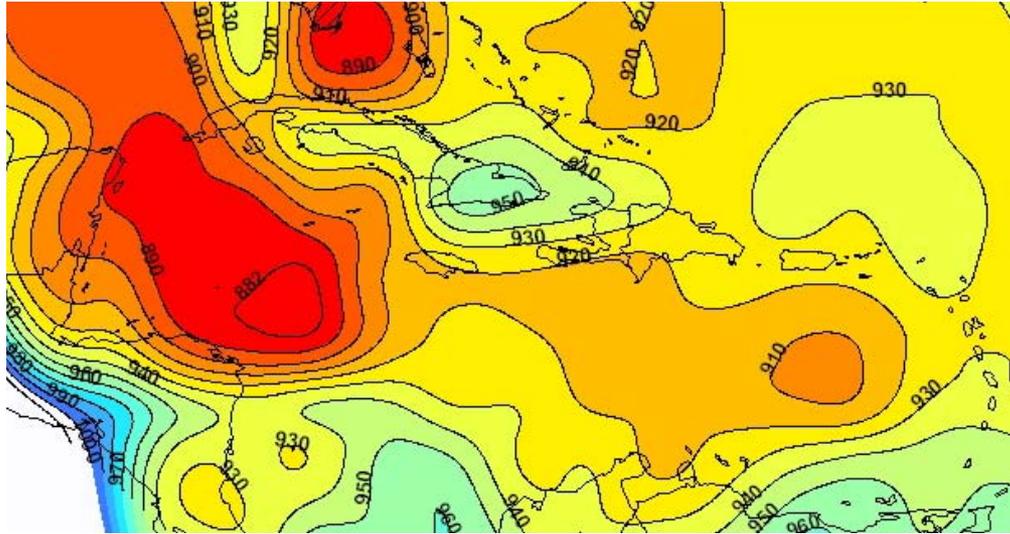
Modeled and Observed Heading, Translation Speed and Central Pressure



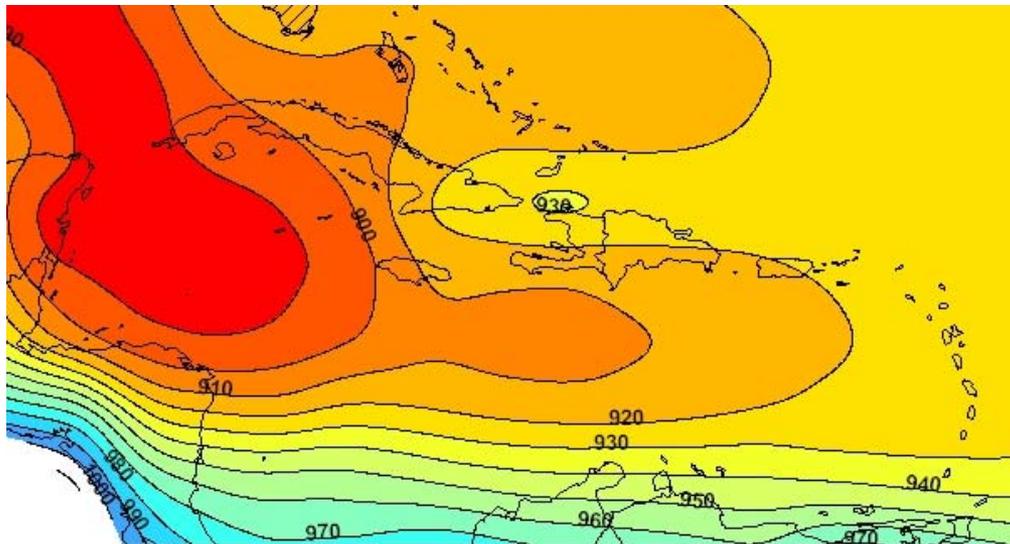
Number of Hurricanes with central pressure values



Comparison of observed and Modeled Central Pressures

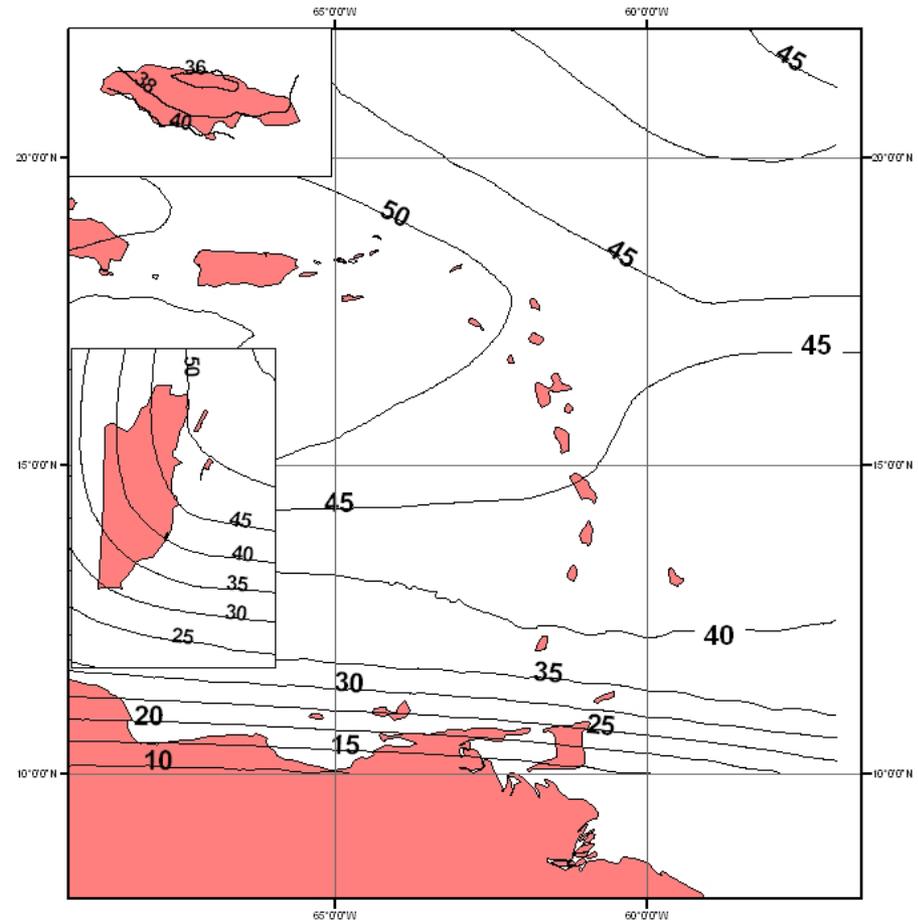
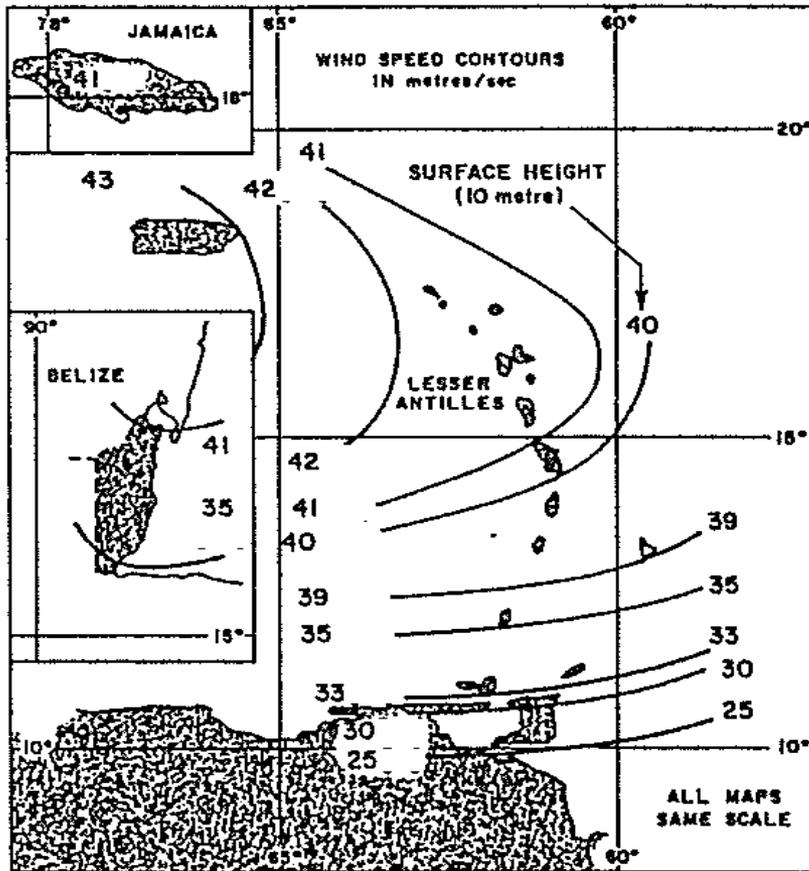


Observed minimum central pressure within 250 km of a location



Minimum 50 year modeled central pressure within 250 km of a location

Comparison of 100 Year Modeled Wind Speeds with Values from Georgiou (1986)



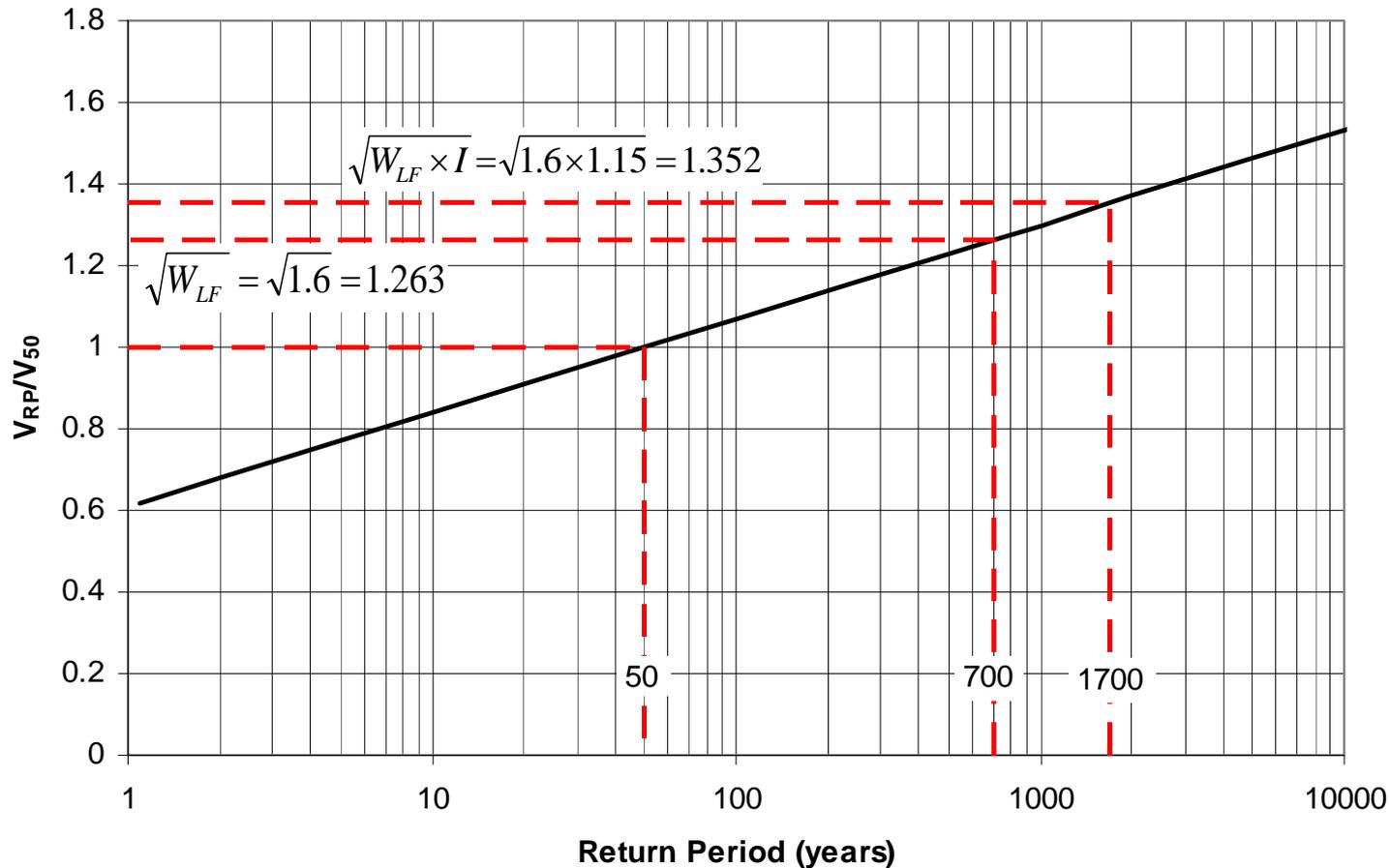
Wind Speeds are representative of 10-30 minute mean values over marine exposure

Comparison of 100 Year Modeled Wind Speeds with CUBiC

Location	This Study (ms ⁻¹)	CUBiC (ms ⁻¹)
Trinidad (S)	14.3	29.6
Trinidad (N)	38.0	38.0
Grenada	47.8	47.1
Barbados	50.1	51.2
Saint Vincent	49.6	52.4
Saint Lucia	53.2	53.2
Antigua and Barbuda	59.9	55.5
Montserrat	60.3	55.8
St. Kitts and Nevis	61.7	55.8
Dominica	55.4	56.2

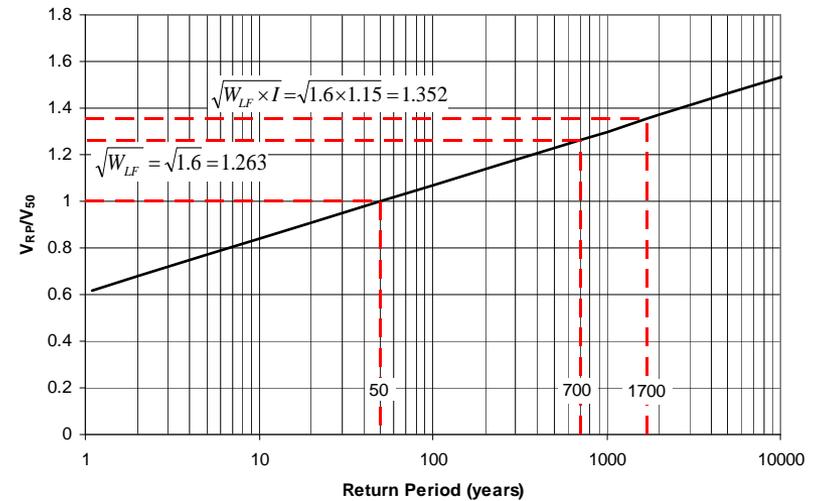
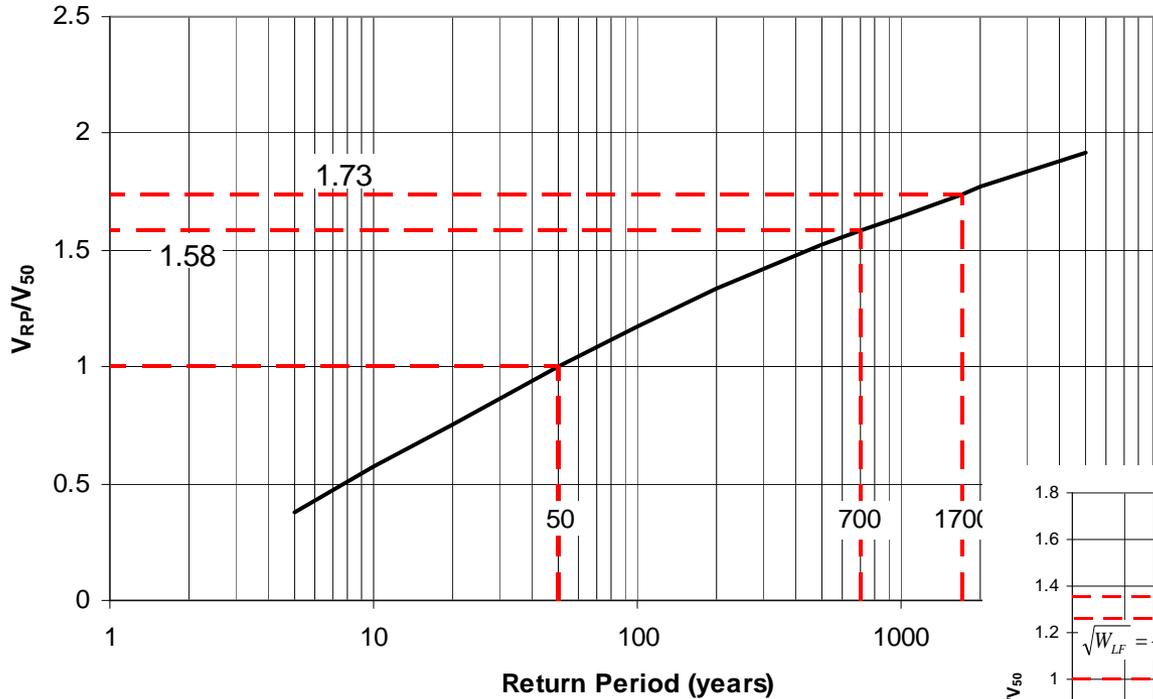
Wind Speeds are representative of 2-3 sec gusts

Basic Non-Wind Speed Definition from ASCE 7

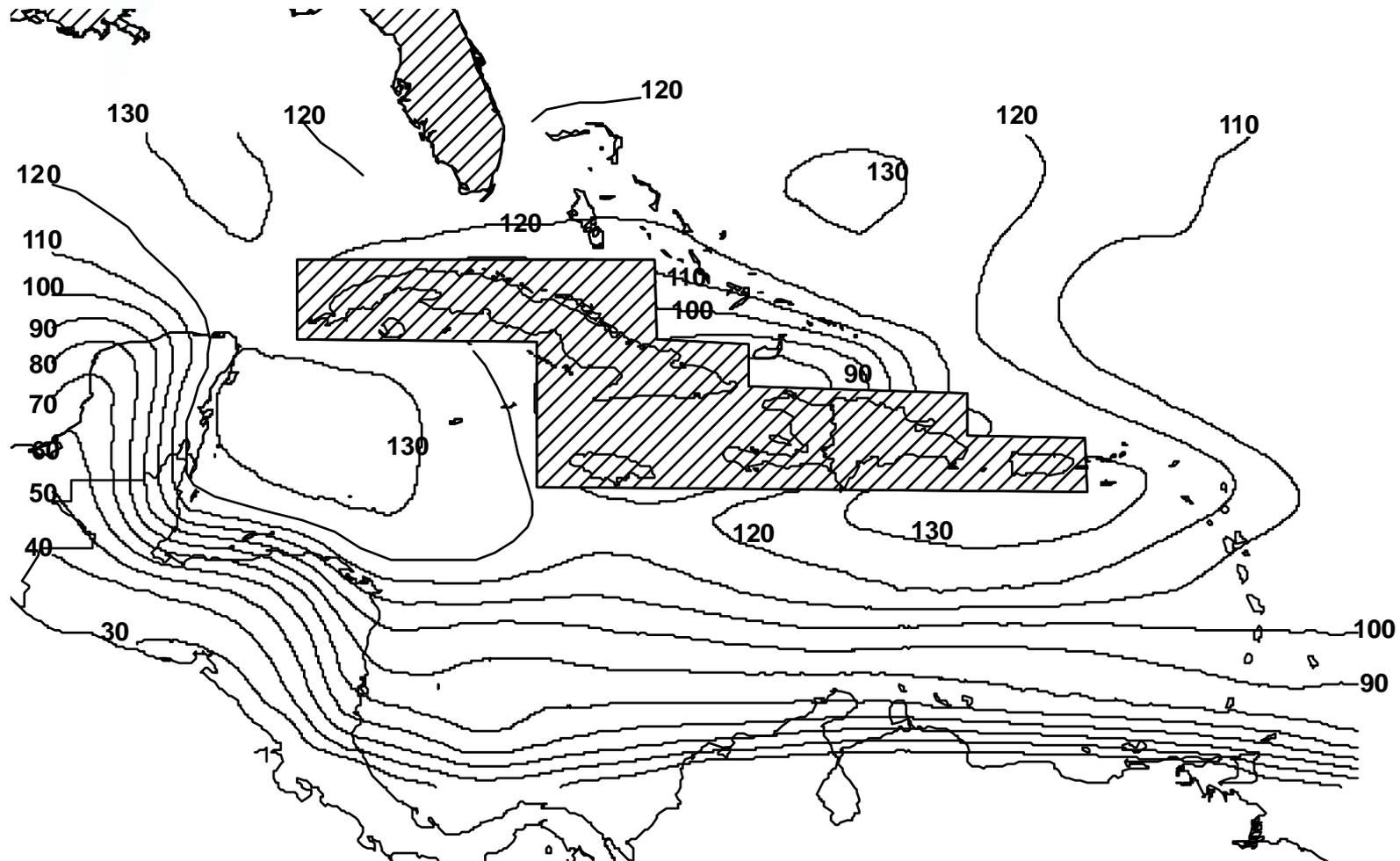


Basic Wind Speed Definition from ASCE7

Jamaica

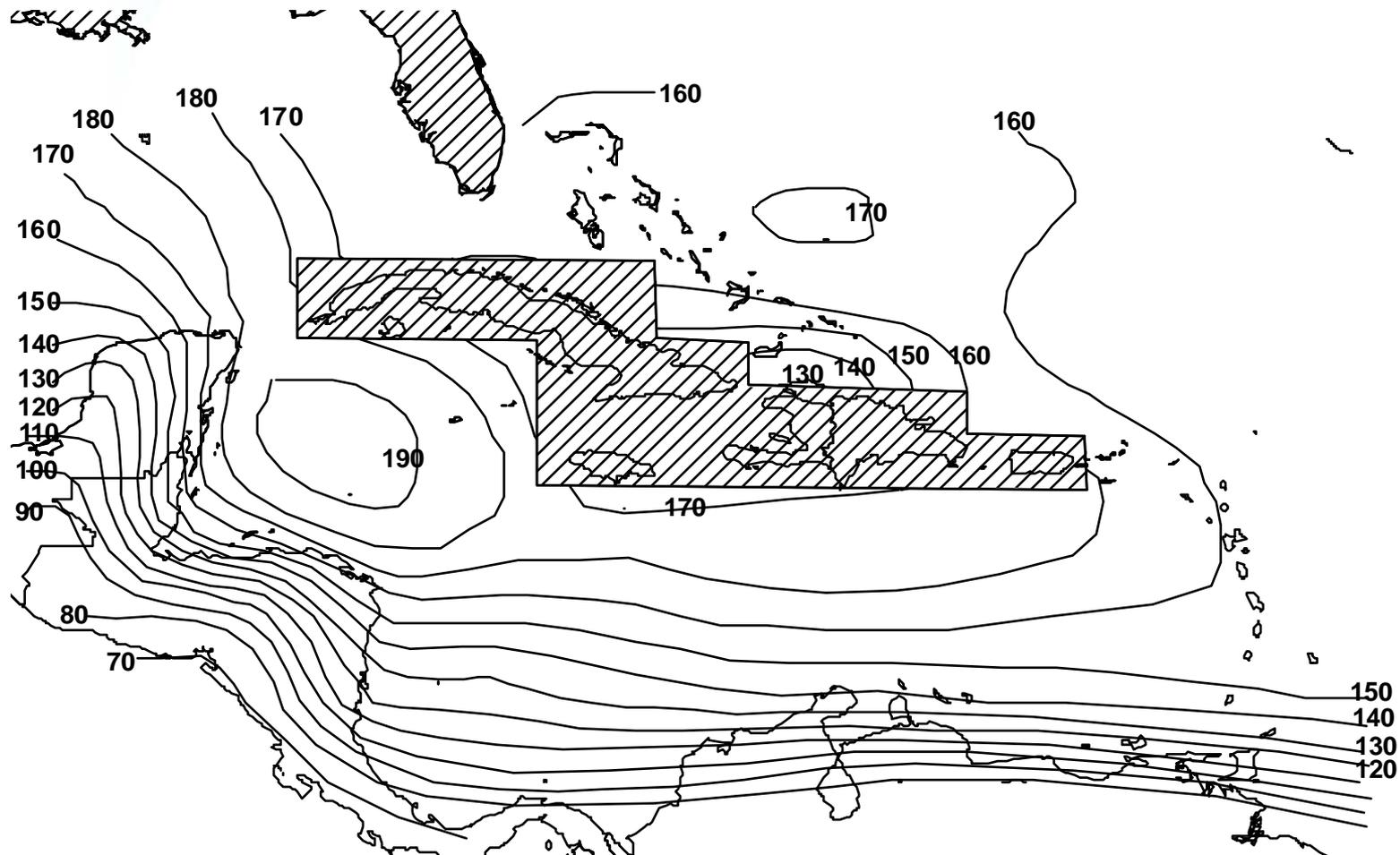


50 Year Wind Speeds for Caribbean



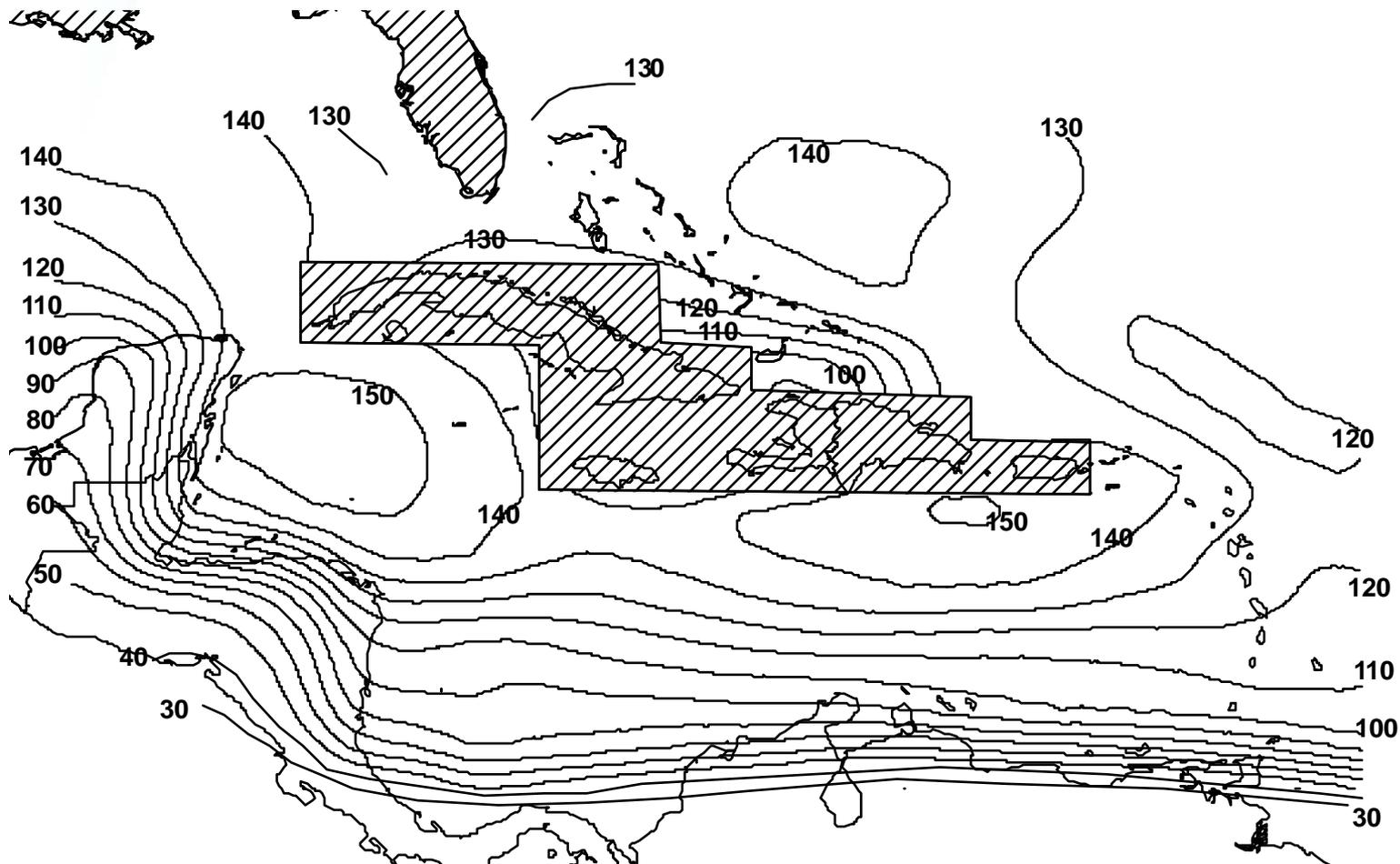
Wind speeds are 3 sec gusts at a height of 10m in flat open terrain

700 Year Wind Speeds for Caribbean



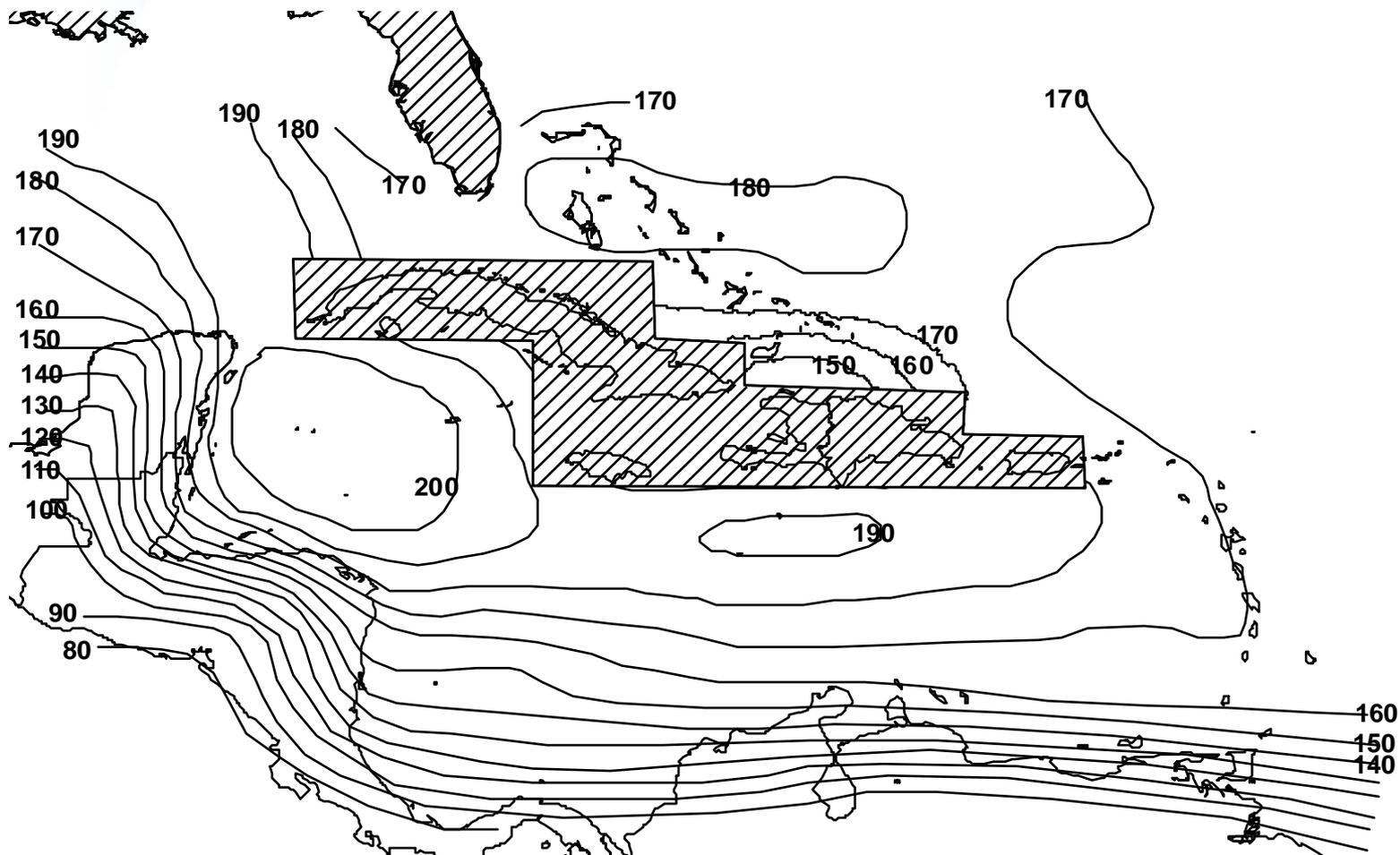
Wind speeds are 3 sec gusts at a height of 10m in flat open terrain

100 Year Wind Speeds for Caribbean



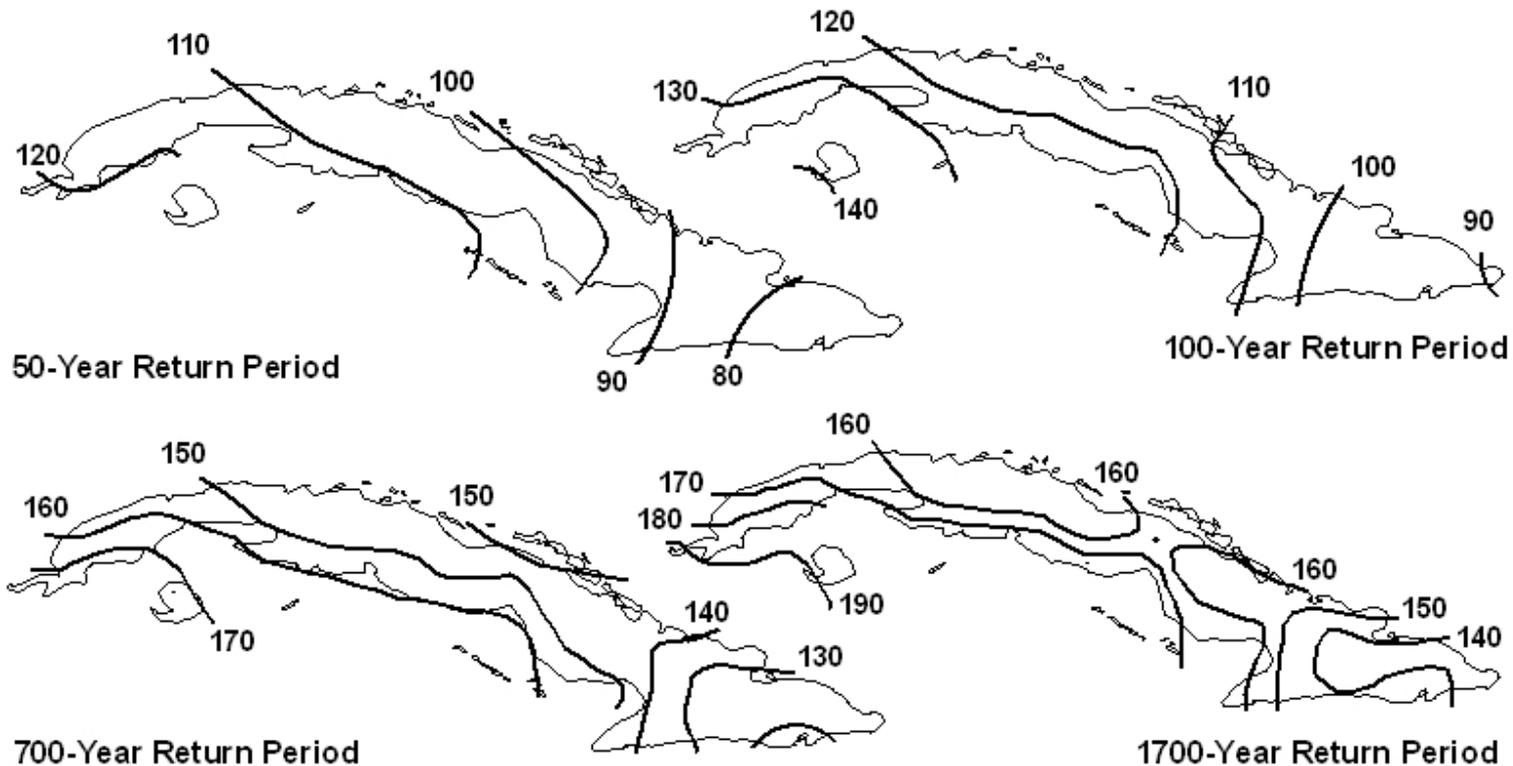
Wind speeds are 3 sec gusts at a height of 10m in flat open terrain

1700 Year Wind Speeds for Caribbean



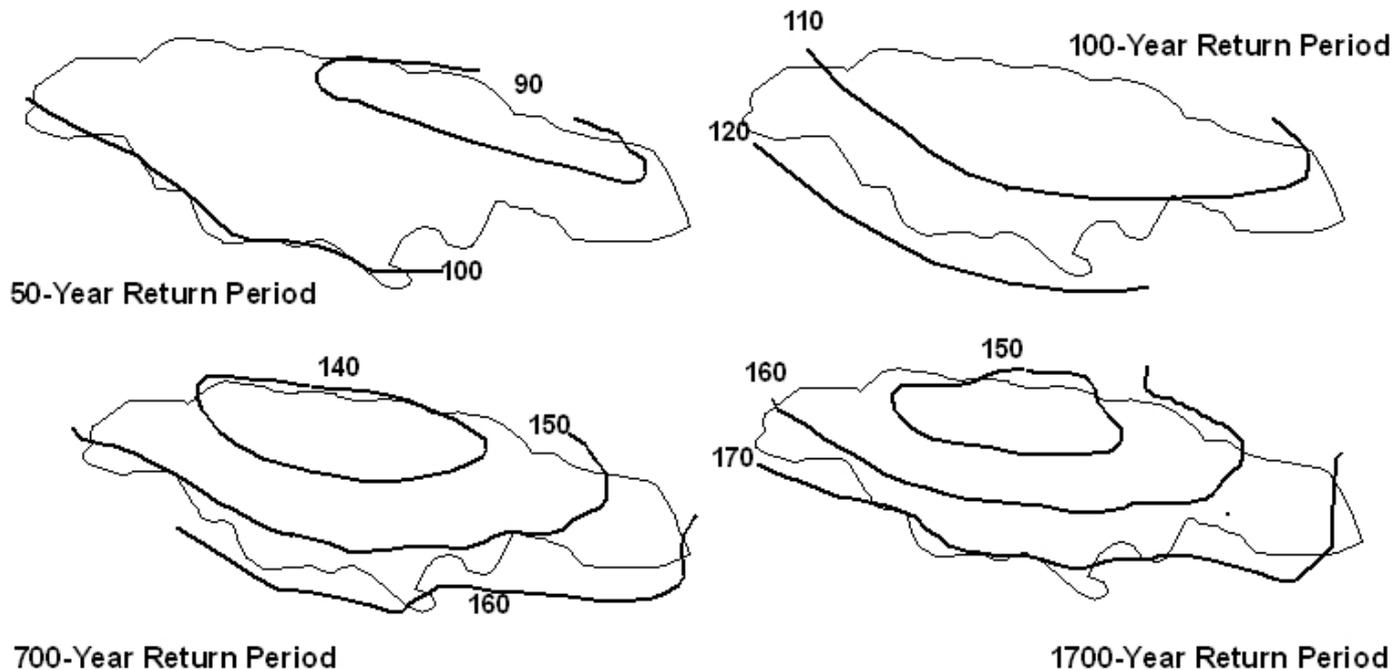
Wind speeds are 3 sec gusts at a height of 10m in flat open terrain

50, 100, 700 and 1700 Year Wind Speeds for Cuba



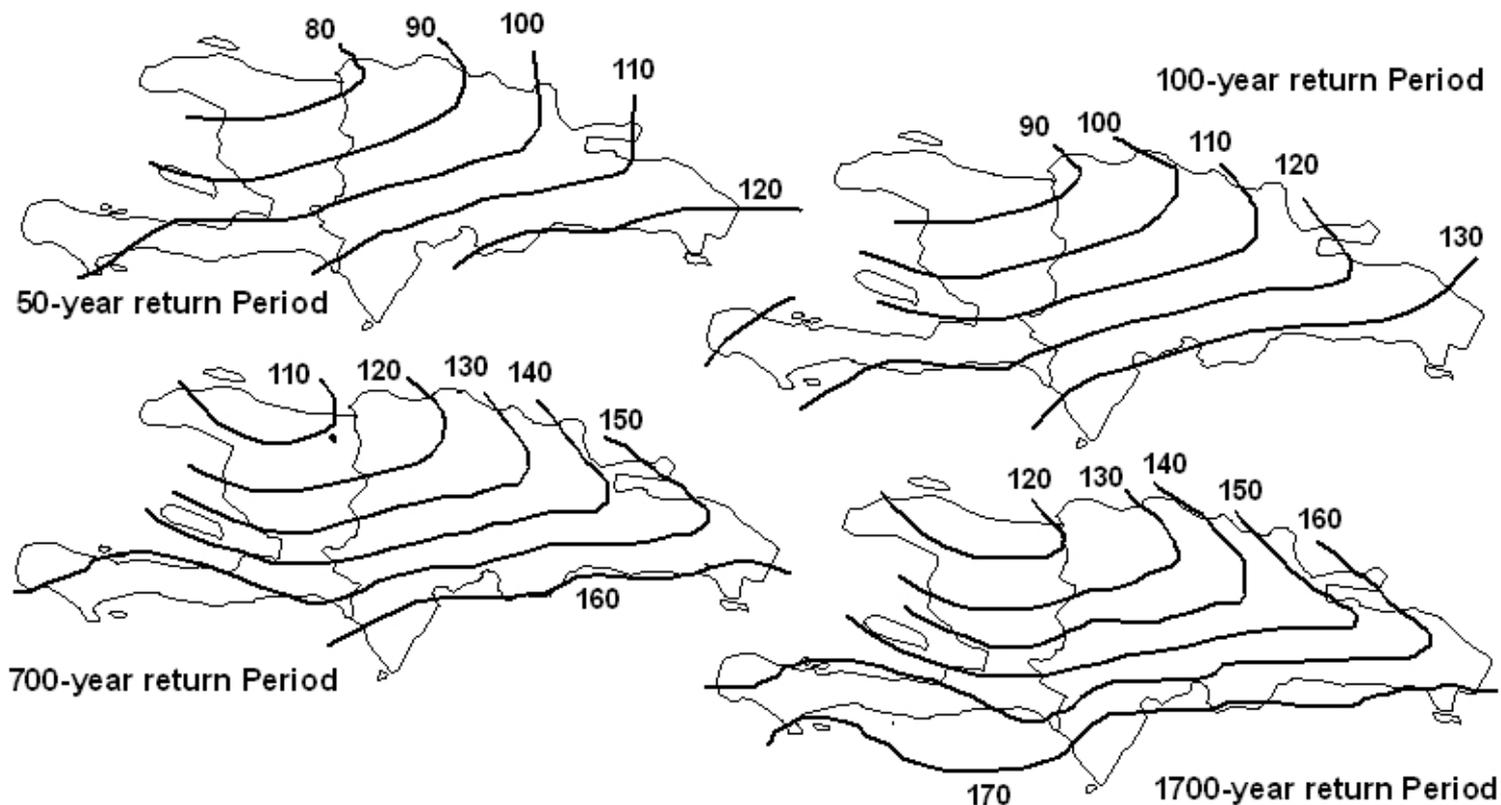
Wind speeds are 3 sec gusts at a height of 10m in flat open terrain

50, 100, 700 and 1700 Year Wind Speeds for Jamaica



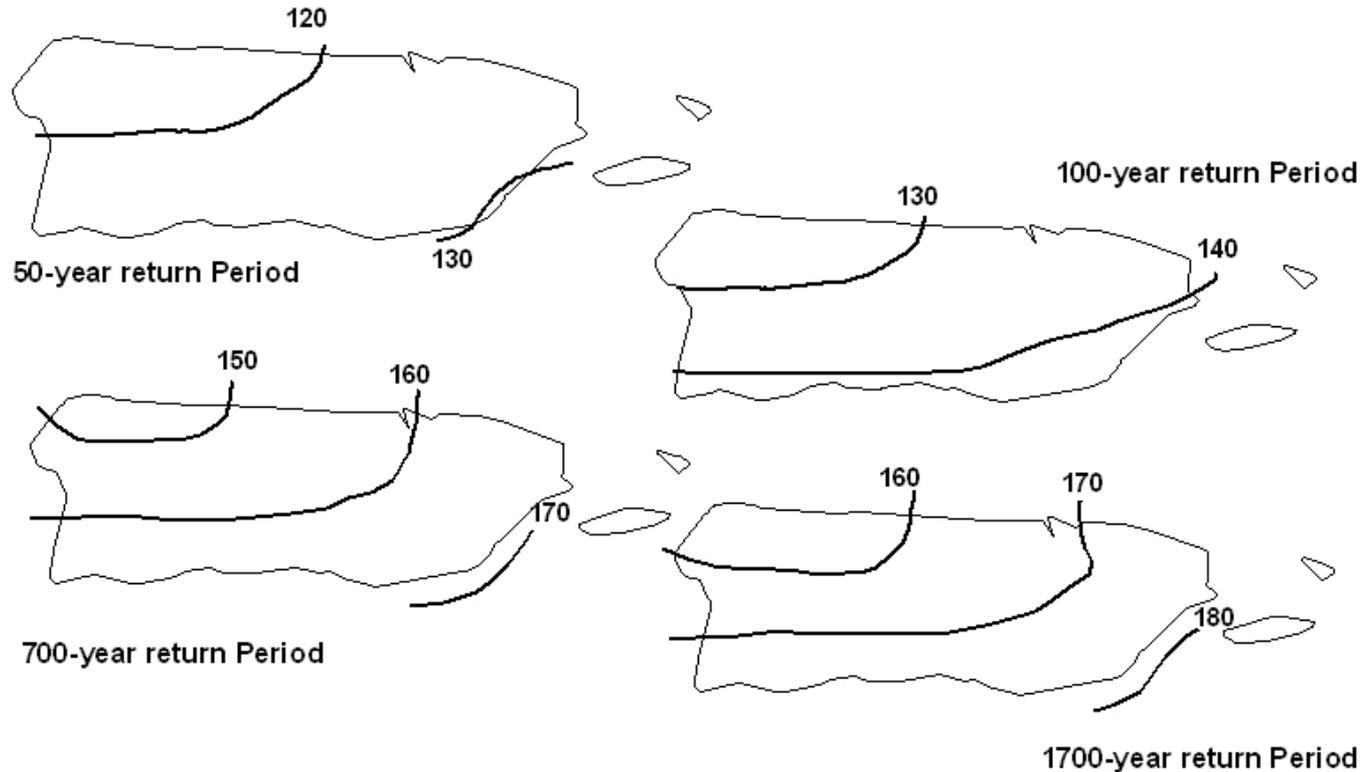
Wind speeds are 3 sec gusts at a height of 10m in flat open terrain

50, 100, 700 and 1700 Year Wind Speeds for Hispaniola



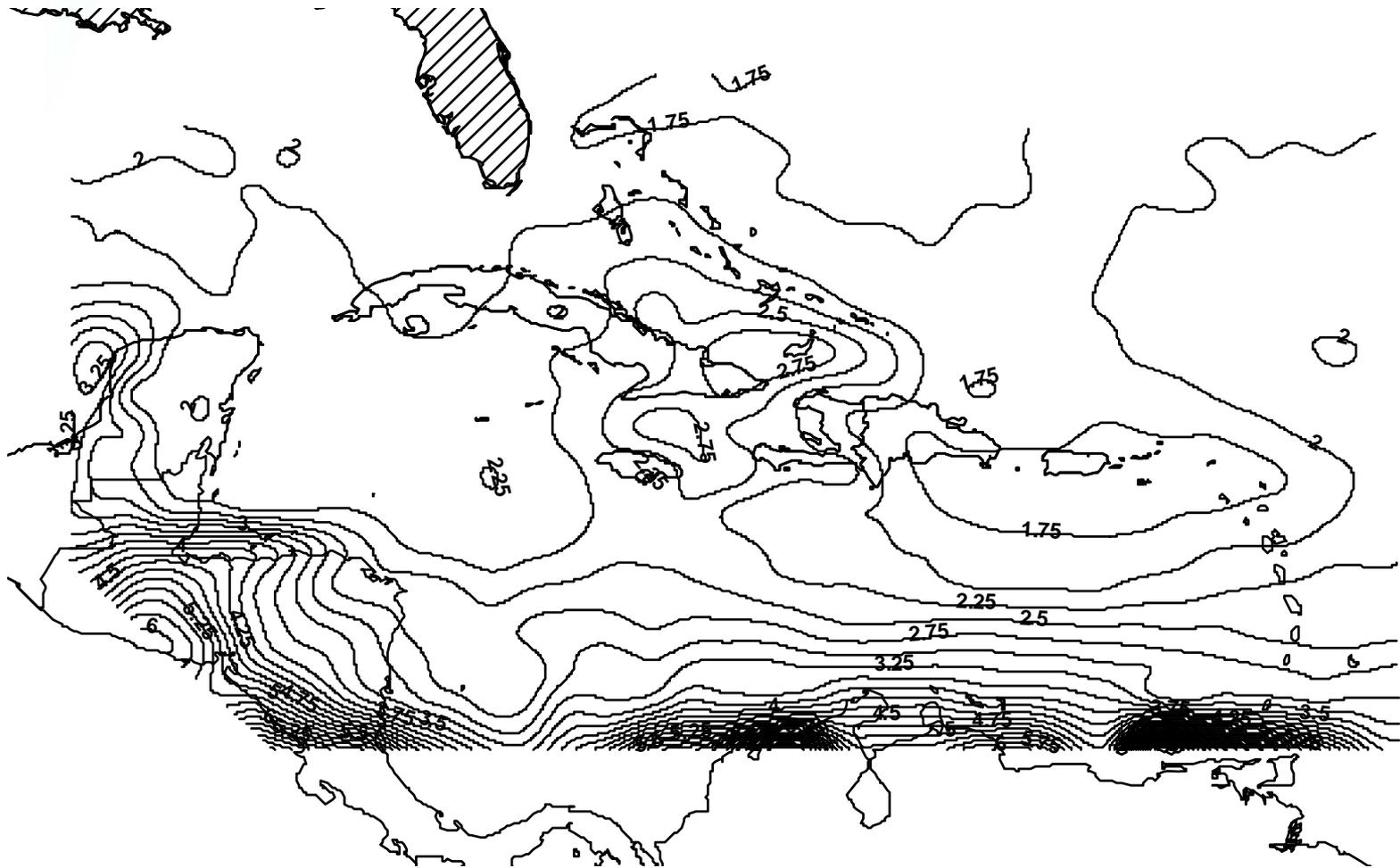
Wind speeds are 3 sec gusts at a height of 10m in flat open terrain

50, 100, 700 and 1700 Year Wind Speeds for Puerto Rico



Wind speeds are 3 sec gusts at a height of 10m in flat open terrain

Load Factor $(V_{700}/V_{50})^2$



Summary

- A hurricane simulation method is used to estimate design wind speeds for the Caribbean region. Wind speed maps for return periods of 50, 100, 700 and 1700 year have been developed.
- The model has been validated through comparisons to the historical observations of central pressure difference, storm heading, translation speed and minimum distance of approach.
- 700 year and 1700 year return period wind speeds are given as design wind speeds for category 2 and Category 3 & 4 structures respectively (with wind load factor=1)
- Provides design wind speeds for the Caribbean that can be used with ASCE 7 wind provisions

This presentation has been made possible through the financial support of the Division of Humanitarian Assistance, Peace and Security of the Canadian International Development Agency (HAPS/CIDA) and the Office of Foreign Disaster Assistance of the United States Agency for International Development (OFDA/USAID).