Building the Weather to Climate Bridge: The Caribbean Rain-belt

Teddy Allen
The International Research Institute for Climate and Society, Columbia University
Contact: tallen@iri.columbia.edu

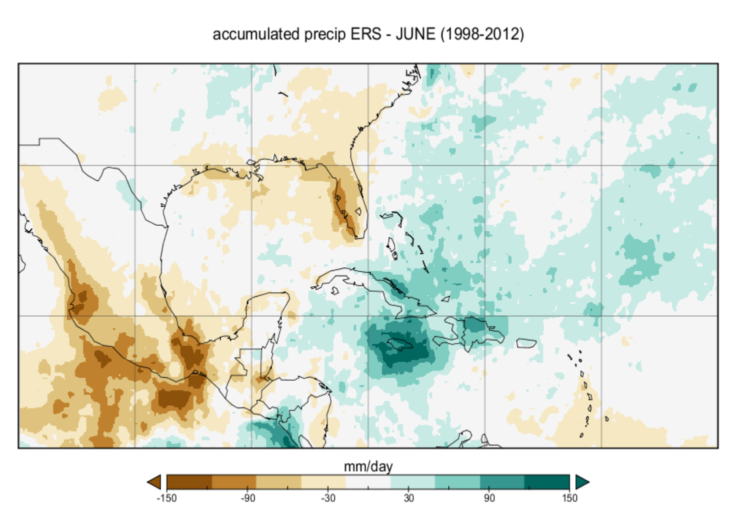
Introduction

The annual rainfall cycle in the Caribbean is characterized by a bimodal pattern with peaks in the late spring ("early rainfall season") and late summer ("late rainfall season") with a mid-summer minimum ("mid-summer drought"). The time average rainfall pattern during the early rainfall season reveals a distinct southwest to northeast spatial pattern , known as the Caribbean rain-belt, that is similar to other northern hemisphere subtropical rain-belts. A series of Caribbean farmer interviews guided my decision to focus on the dynamics and evolution of the Caribbean rain-belt. Results from farmer interviews reveal that their livelihoods are more vulnerable to variability in the timing and amount of the early season rains rather than variability in the mid-summer drying. Therefore, there is a strong social and economic relevance to understand rainfall dynamics during the Caribbean early rainfall season.

Method

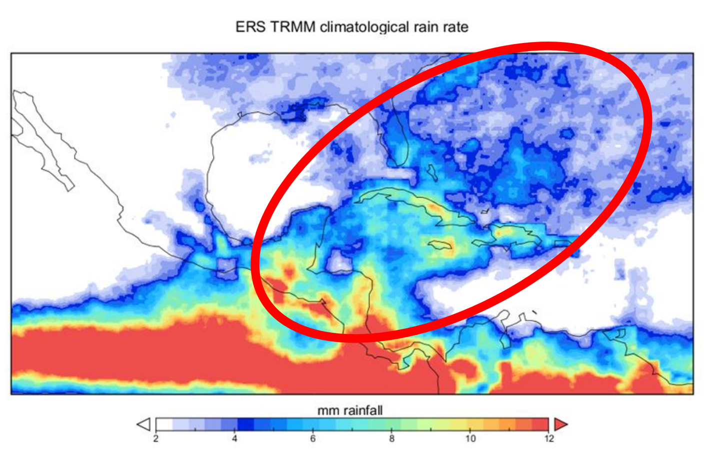
The atmospheric dynamics that contribute to the Caribbean rain-belt are diagnosed from the quasi-geostrophic omega equation from daily observations. Forcing for ascent at the upper troposphere is supported by positive zonal wind at 200hPa and jet streaks, while positive temperature advection from the tropics at 500hPa provides forcing for ascent in the mid-troposphere. Moisture availability for the Caribbean rain-belt is regulated by local sea surface temperature and by moisture advection from the tropics in the lower troposphere. The forcing for ascent weakens throughout the Caribbean and strengthens in the North Atlantic during the mid-summer drought period. Therefore, the mid-summer drought may be diagnosed in terms of weakened uplift dynamics.

Defining the Caribbean Early Rain Season (ERS)



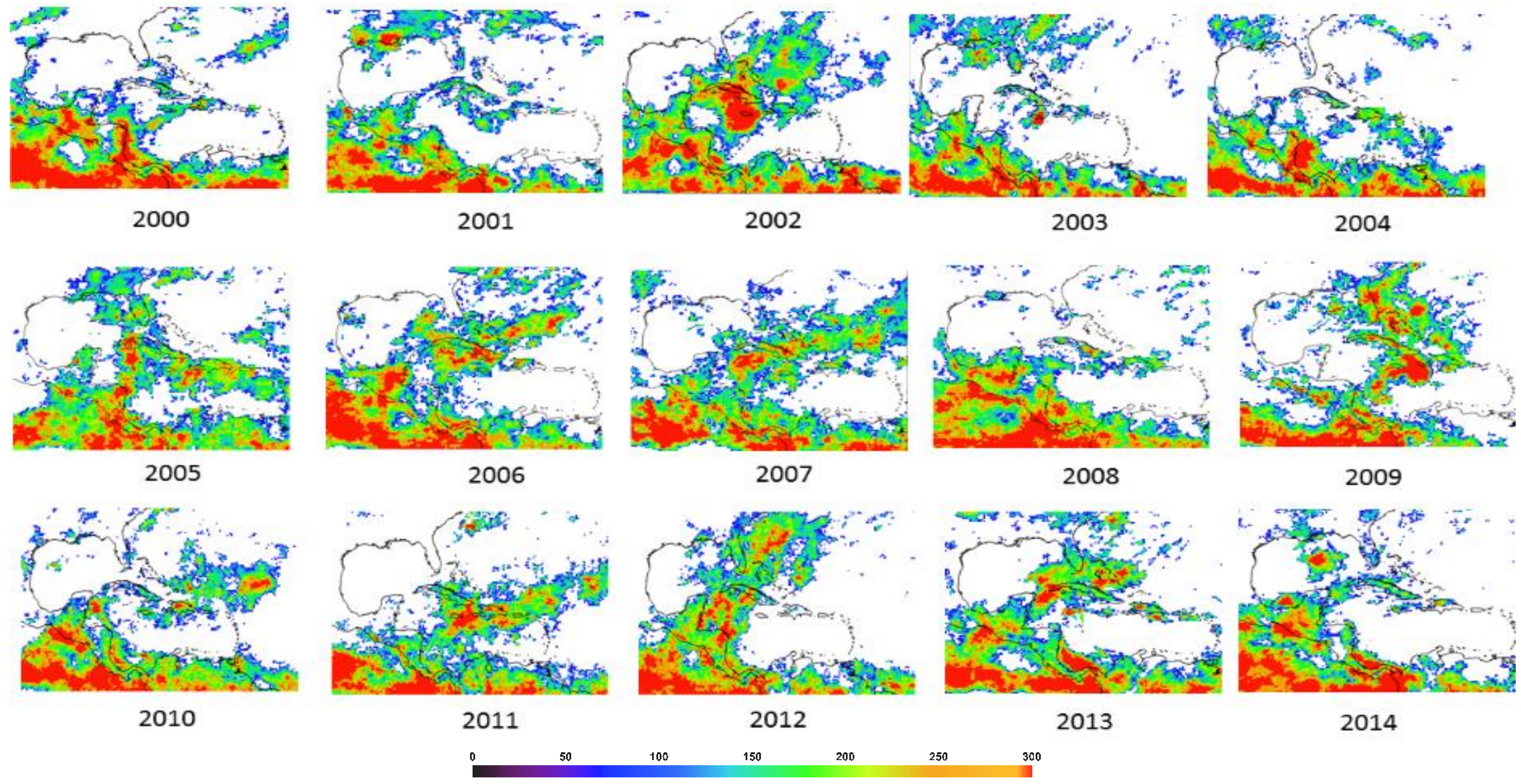
The difference between the average accumulated rainfall during June from the average accumulated rainfall during the May 15 – June 15 Early Rainfall Season. Average accumulated rainfall was computed from TRMM daily measurements.
Relying on only monthly mean rainfall from May or June would mis-diagnose the Caribbean rain-belt. Therefore, a mid-May to mid-June monthly mean produced from daily observations is created to accurately describe the early rain season period.

Caribbean Rain-Belt Climatology



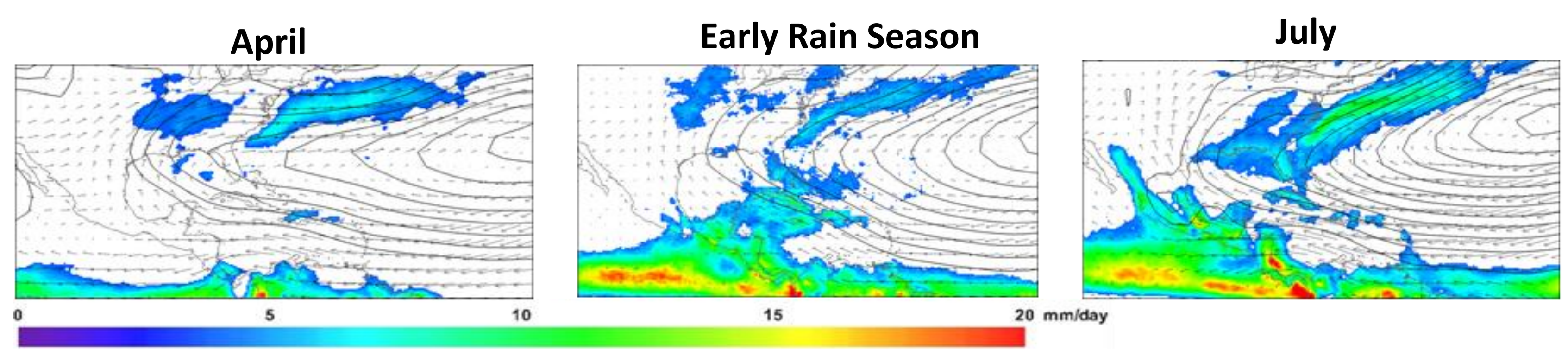
Early rainfall season (May 15- June 15) climatological rain rate averaged between 1998-2014 from TRMM. The Caribbean rain-belt is outlined in red.

Caribbean Rain-Belt Variability

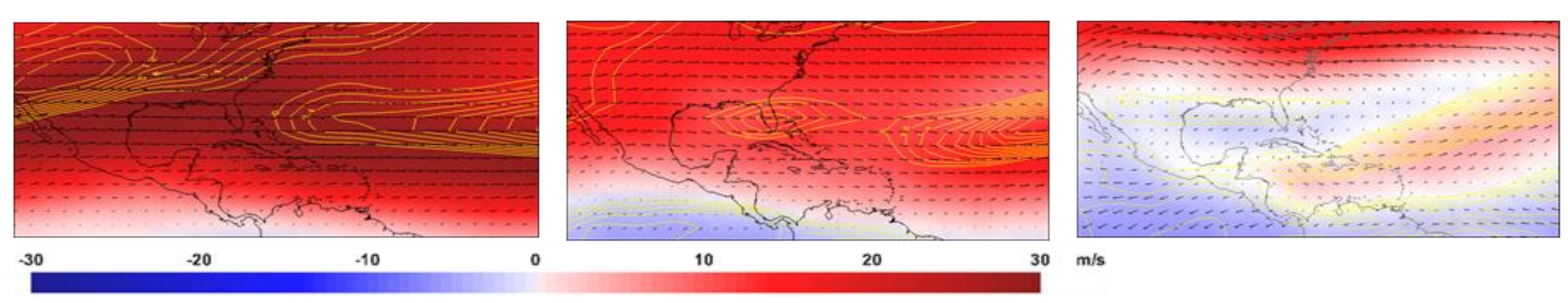


Accumulated Early Season rainfall measured by TRMM from 2000-2014.

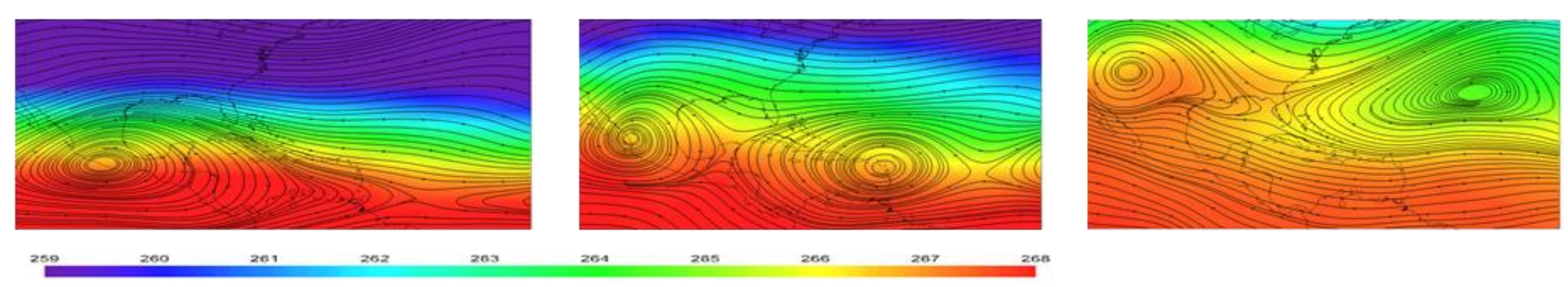
Climatology of the Caribbean Rain-Belt Related Dynamics



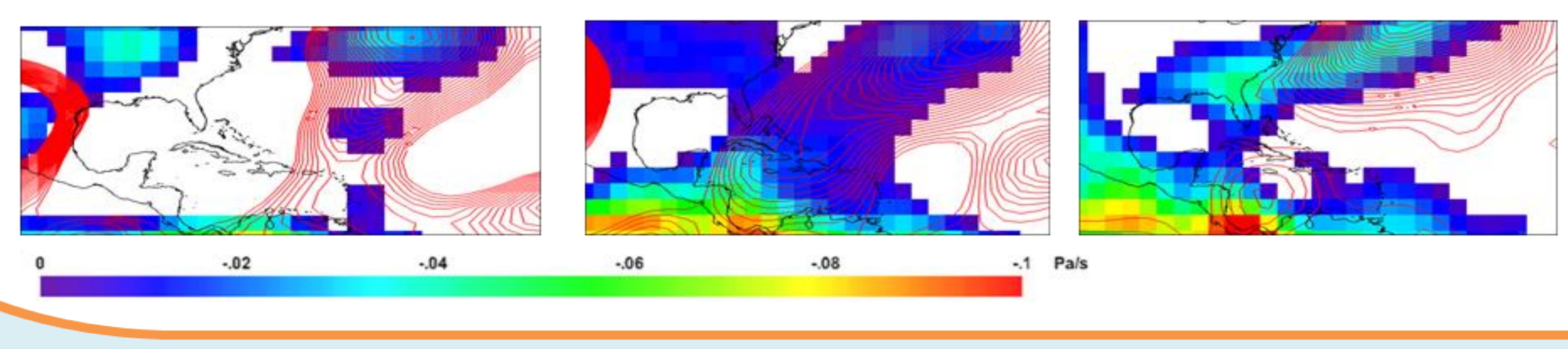
Average sea level pressure isobars (1hPa contours > 1014hPa), 850hPa wind vectors (max 10 meters per second), and TRMM rainrate (shaded) for April (left), Early Rainfall Season (middle), and July (right).



Average zonal wind (shading), positive relative vorticity (contours, 0.2 x 10 -5 s-1), and wind vectors (max 40m/s) at 200hPa for April (left), the Early Rainfall Season (middle), and July (right). Climatology calculated from 1998-2012.

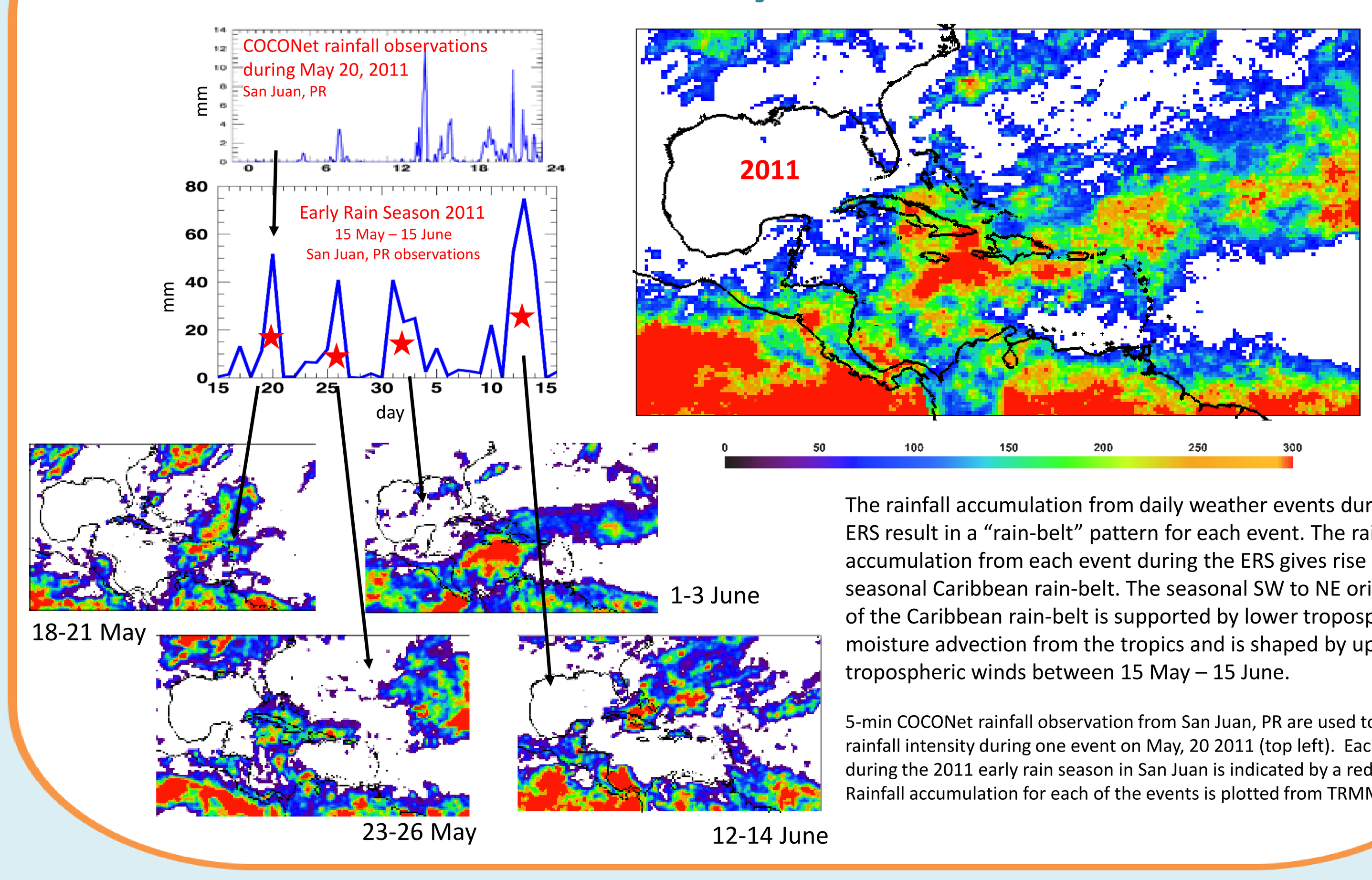


Average 500hPa temperature and 500hPa streamlines for April (left), the Early Rainfall Season (middle), and July (right).



Average horizontal positive temperature advection (contours, 0.03Ks-1 interval) and vertical velocity (shaded) at 500hPa for April (left), the Early Rainfall Season (middle), and July (right). Climatology calculated from 1998-2012.

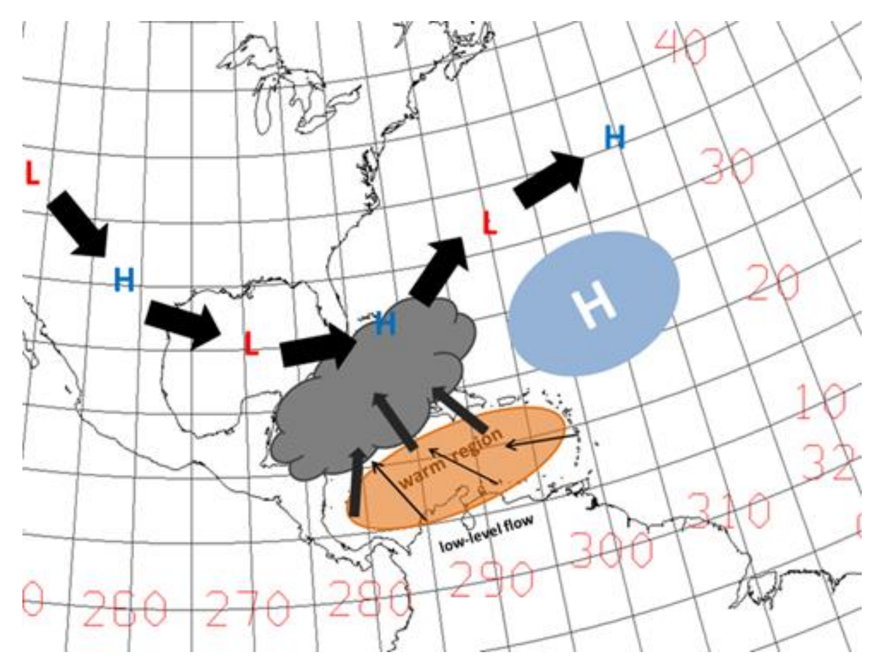
Seasonal "weather-events" during the 2011 Early Rain Season.



The rainfall accumulation from daily weather events during the ERS result in a "rain-belt" pattern for each event. The rainfall accumulation from each event during the ERS gives rise to the seasonal Caribbean rain-belt. The seasonal SW to NE orientation of the Caribbean rain-belt is supported by lower troposphere moisture advection from the tropics and is shaped by upper tropospheric winds between 15 May – 15 June.

5-min COCONet rainfall observation from San Juan, PR are used to show rainfall intensity during one event on May, 20 2011 (top left). Each event during the 2011 early rain season in San Juan is indicated by a red star. Rainfall accumulation for each of the events is plotted from TRMM.

Summary



Schematic diagram representing the environmental factors that contribute to the Caribbean rain-belt. Mid-tropospheric winds (medium black arrows) advect warm air from the tropics and induce ascending motion along the jet stream (thick black lines). The ascent favors convection (grey cloudy diagram) in the presence of low level southerly moisture transport (think black lines) along the western edge of the north Atlantic subtropical high. Transient disturbances are denoted by H and L and are steered by the jet stream.

I would like to graciously acknowledge the support from Brian Mapes, my PhD advisor, who helped to inspire and guide this research.