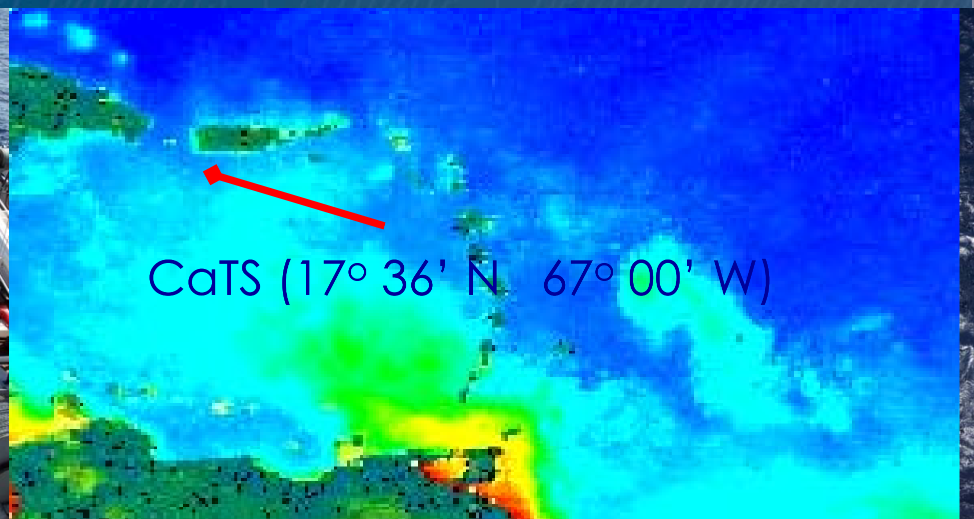
# Responsiveness of water mass properties to climate forcing at the Caribbean Time Series Station in the northeastern Caribbean basin

Marine Sciences, UPRM

Julio M. Morell, Jorge E. Corredor
University of Puerto Rico Mayagüez
Department of Marine Sciences




CaTS Timeline 1993- 2007


U.S. DEPARTMENT OF ENERGY

EPSCoR RESEARCH IN PUERTO RICO

OFFICE OF NAVAL RESEARCH

NASA

# Relevance

Sea surface temperature (SST)

Ecosystem:
- Coral bleaching
- Nitrogen cycling (nitrification/denitrification coupling)

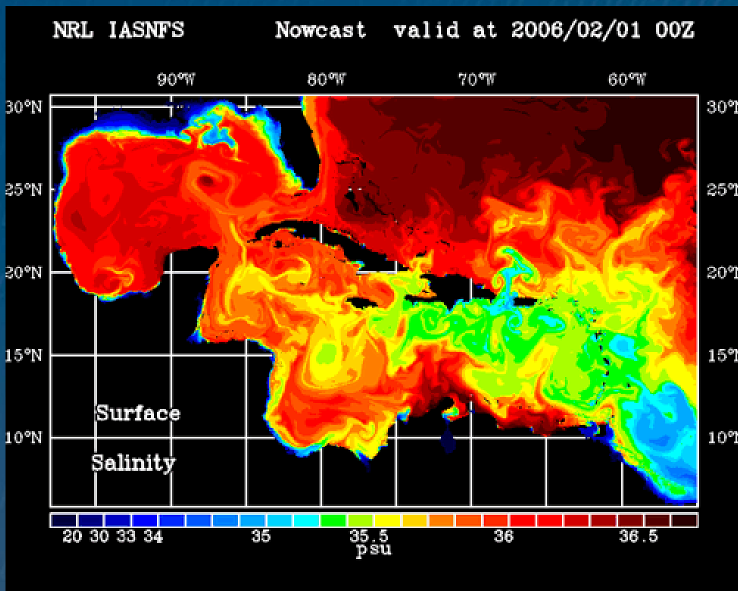
Climate:
- Hurricane intensification

Carbon dynamics
- River plumes (Orinoco, Amazon) promote C exchange

Meridional Overturning Circulation

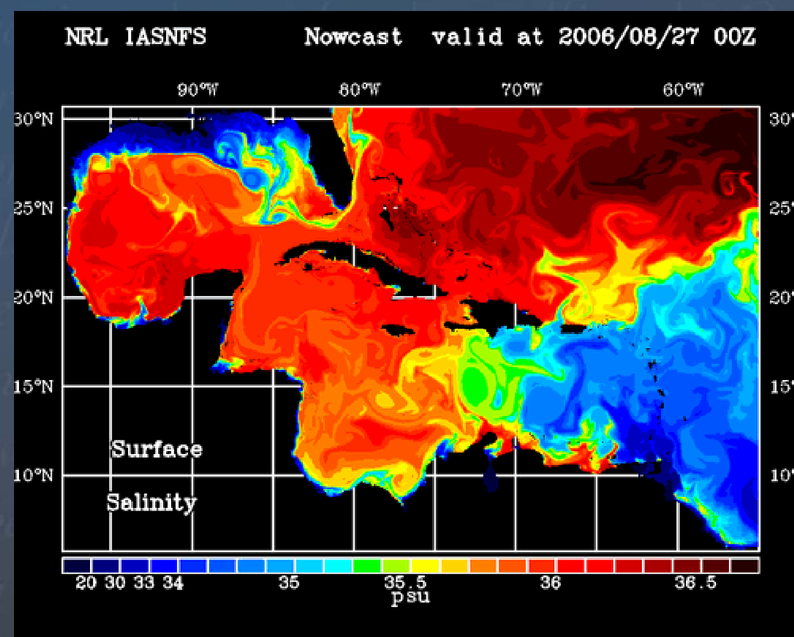
- "Thermocline water" circulation patterns can "short-circuit" MOC

# Caribbean Surface Water Seasonality




WINTER/SPRING:

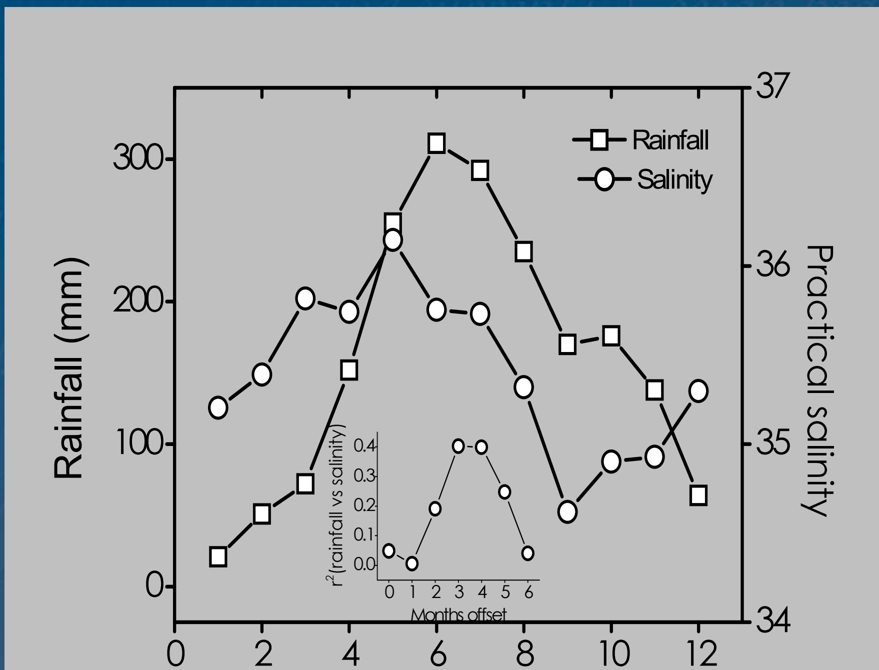
- Riverine influence is at its minimum
- Upwelling of SUW dominates Southern margin
- eddies transport upwelled waters to N. margin



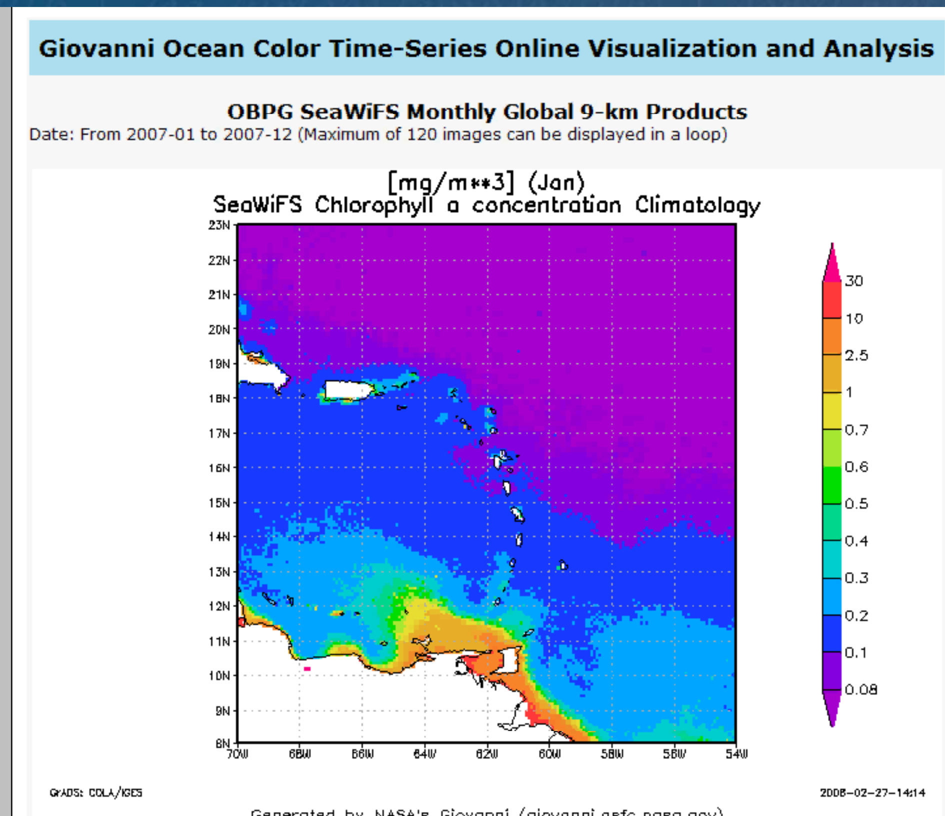

SUMMER/FALL:

- Amazon & Orinoco dominate E. Caribbean
- Eddies steer & stir

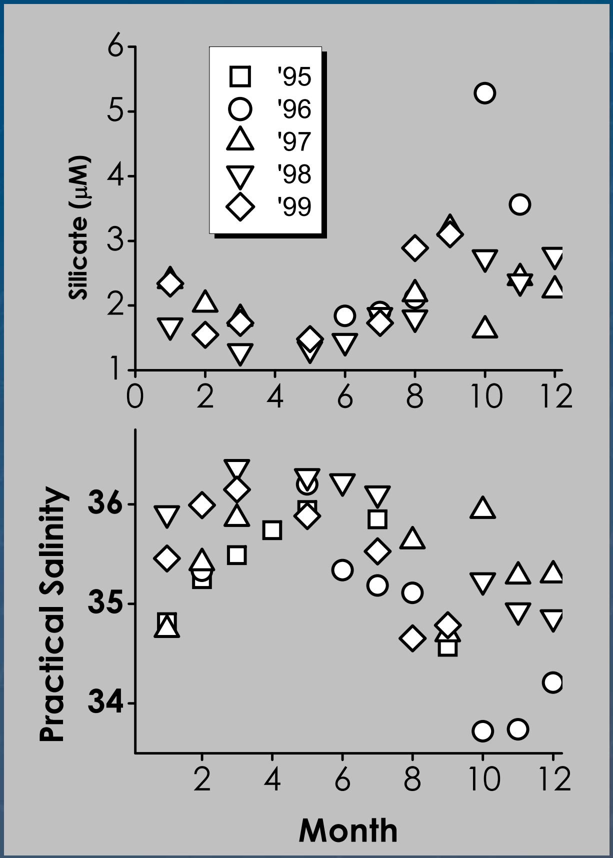
# Caribbean Surface Water Seasonality

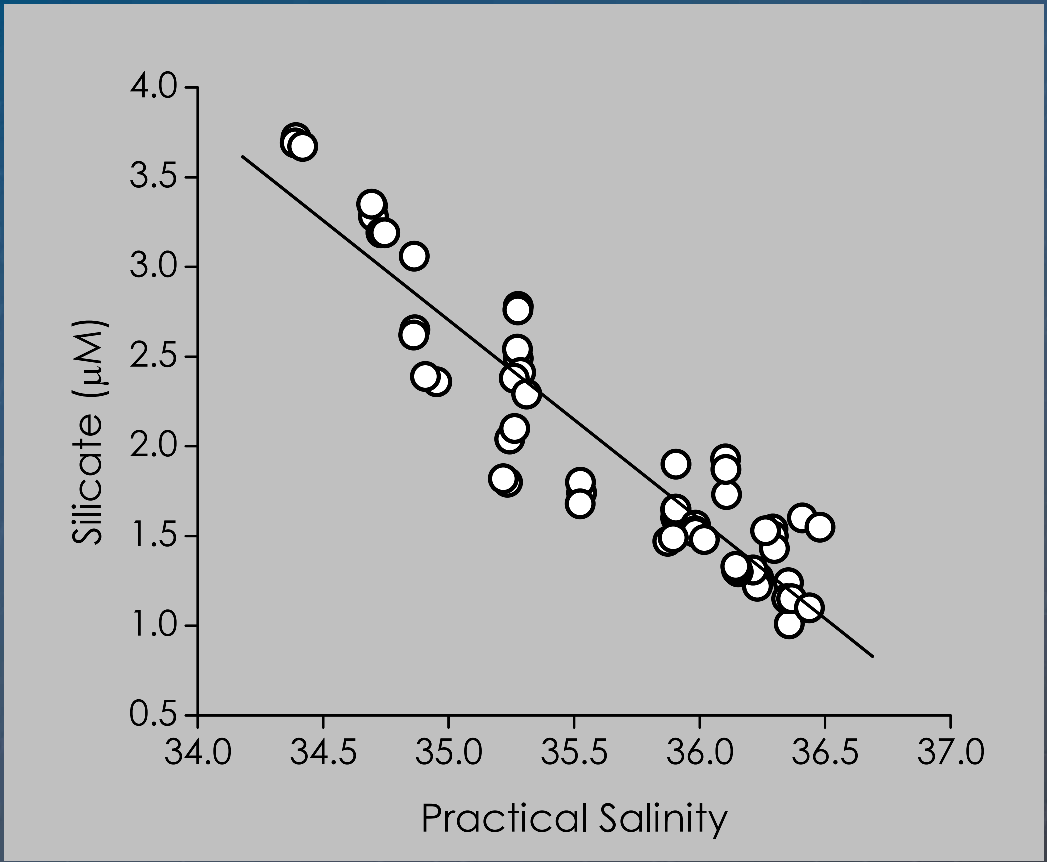



Multi-year averages (1994-1998) for rainfall in the Orinoco River basin and salinity at CaTS



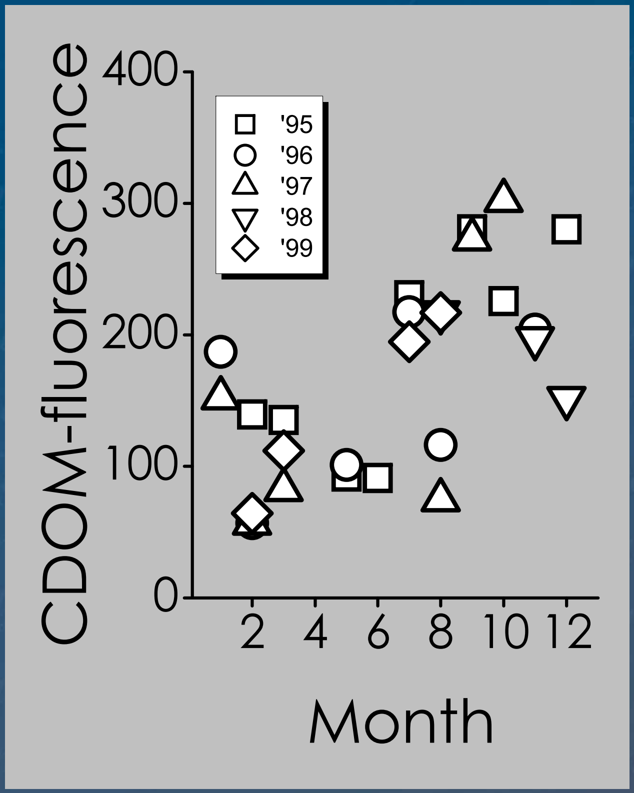
# Caribbean Surface Water Seasonality
# Salinity and Silicate



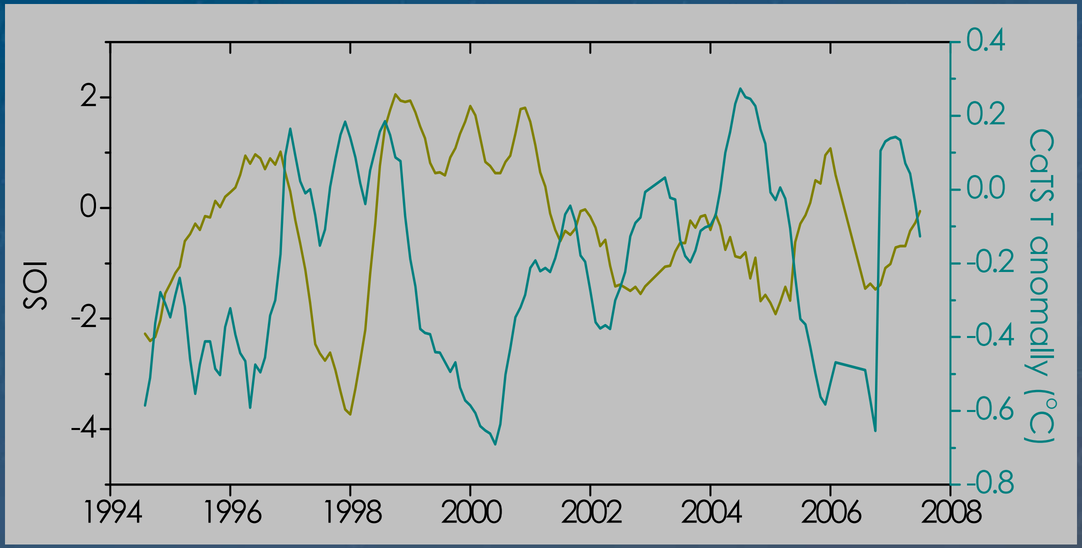

0.6 to 5.5 % of CSW at CaTS is of river origin.
River waters are present throughout the year
in the North Eastern Caribbean

# Caribbean Surface Water Seasonality
# Colored Dissolved Organic Matter - CDOM



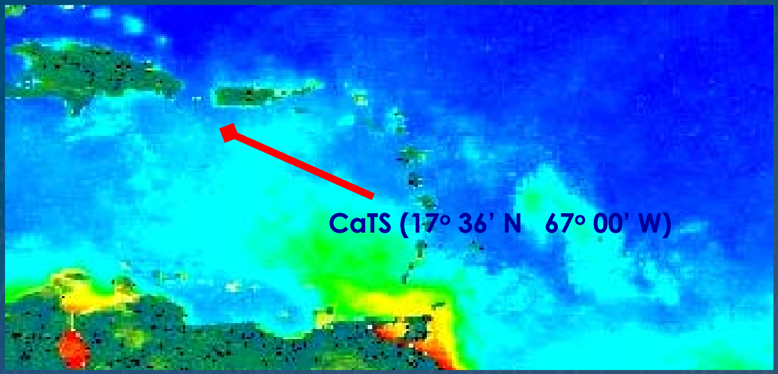

CDOM affects
- optics,
- phytoplankton community composition primary production
- pCO2

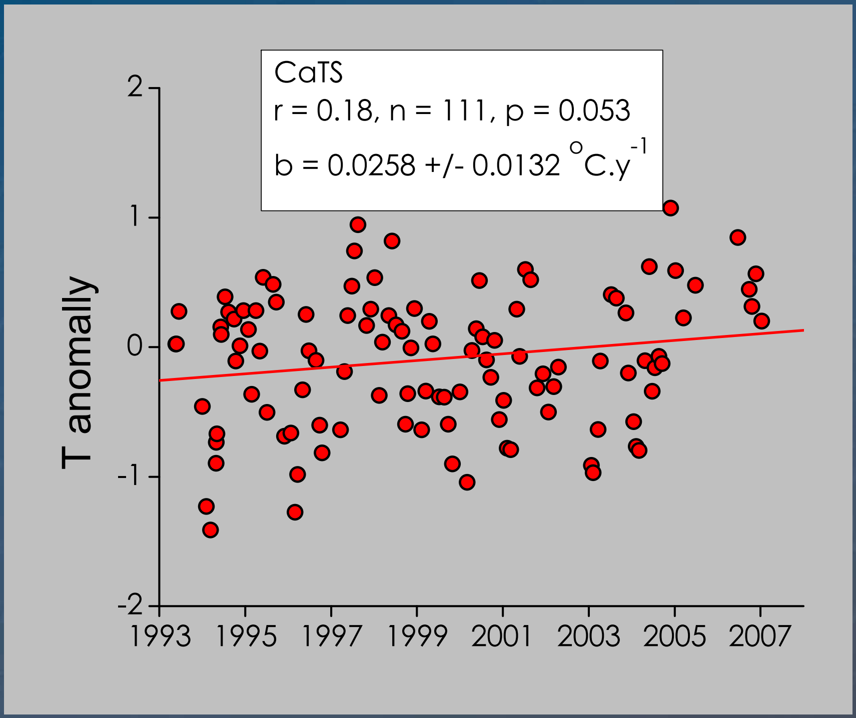
# Caribbean Surface Water: Climate forcing

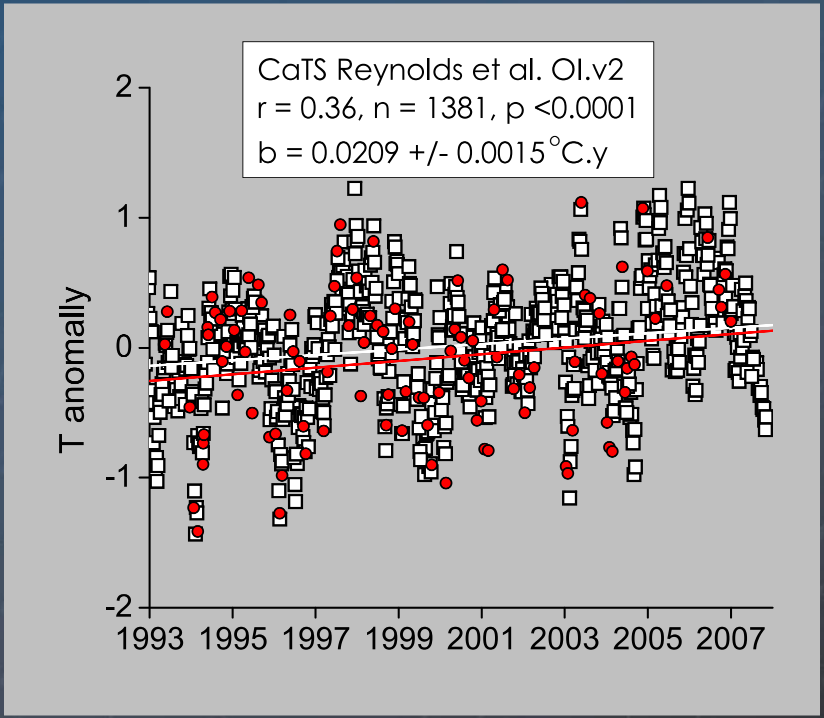



Positive anomalies in near-surface T (r= -.59) at a 3 month offset are consistent with reports linking negative SOI (El Nino) to positive temperature anomalies (and salinity) in the Caribbean. The water is warmer and saltier in El Nino years.

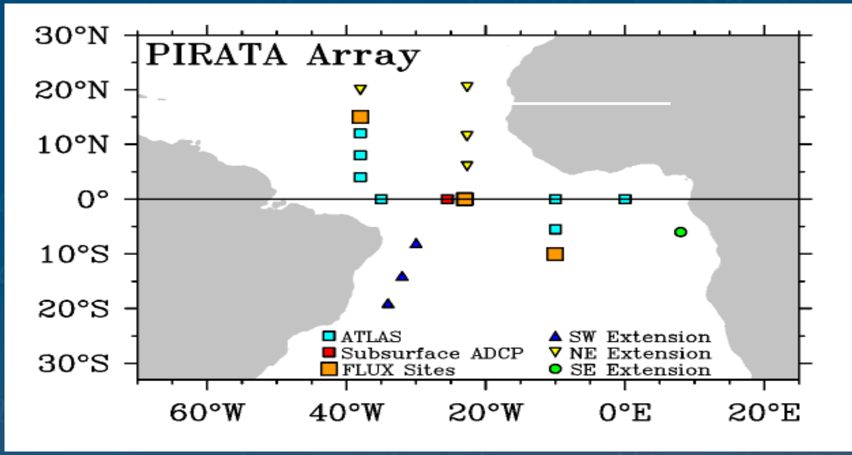
# CaTS SST Analysis



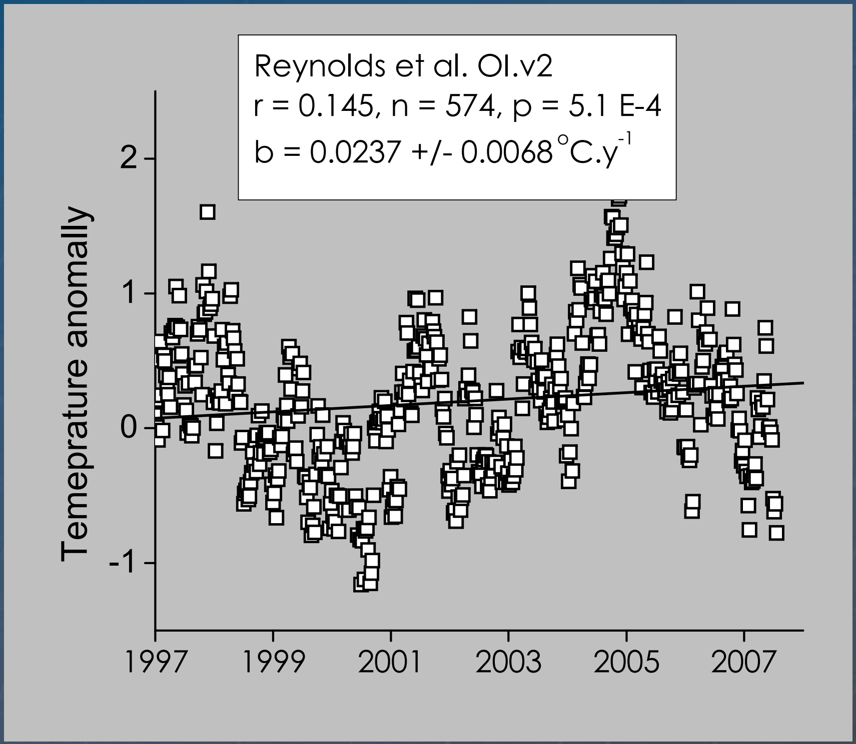



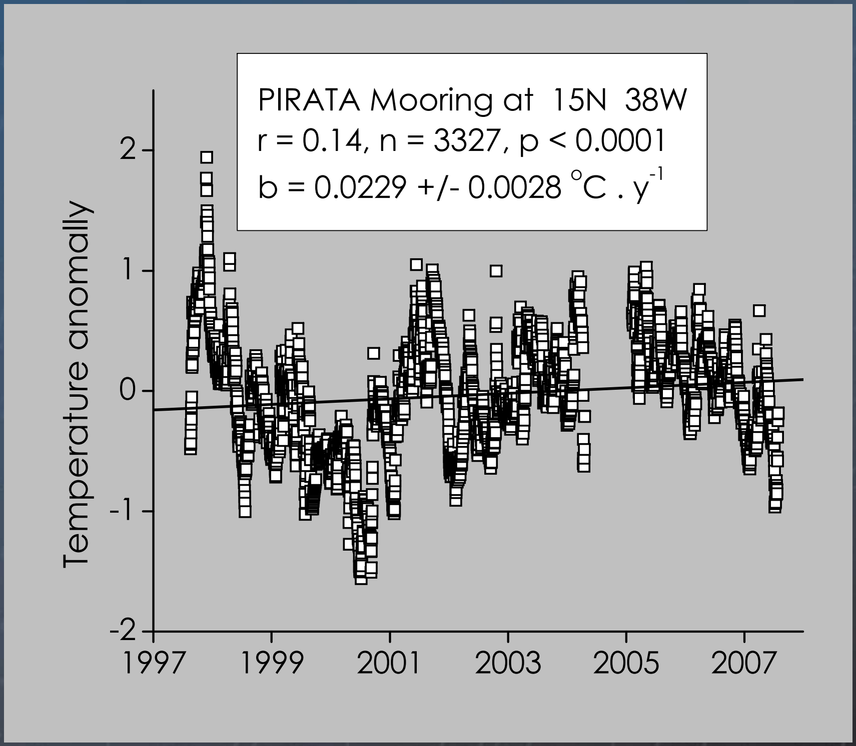



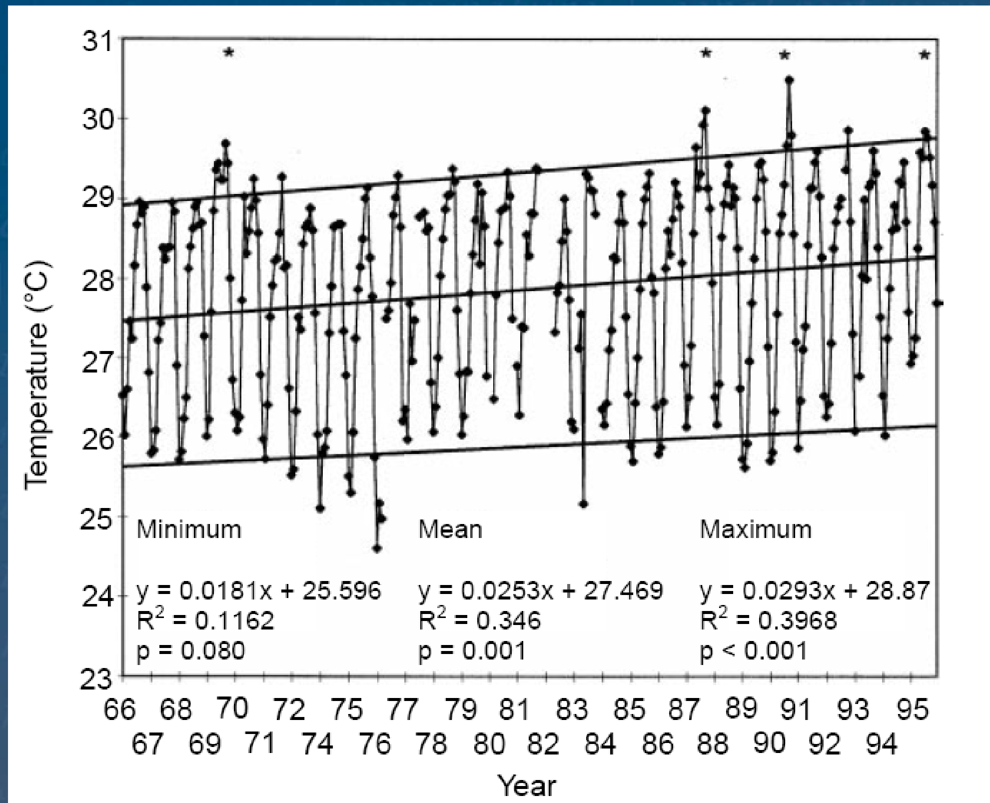
# SST at PIRATA Array 15 N




Data from:
TAO Project Office of NOAA/PMEL



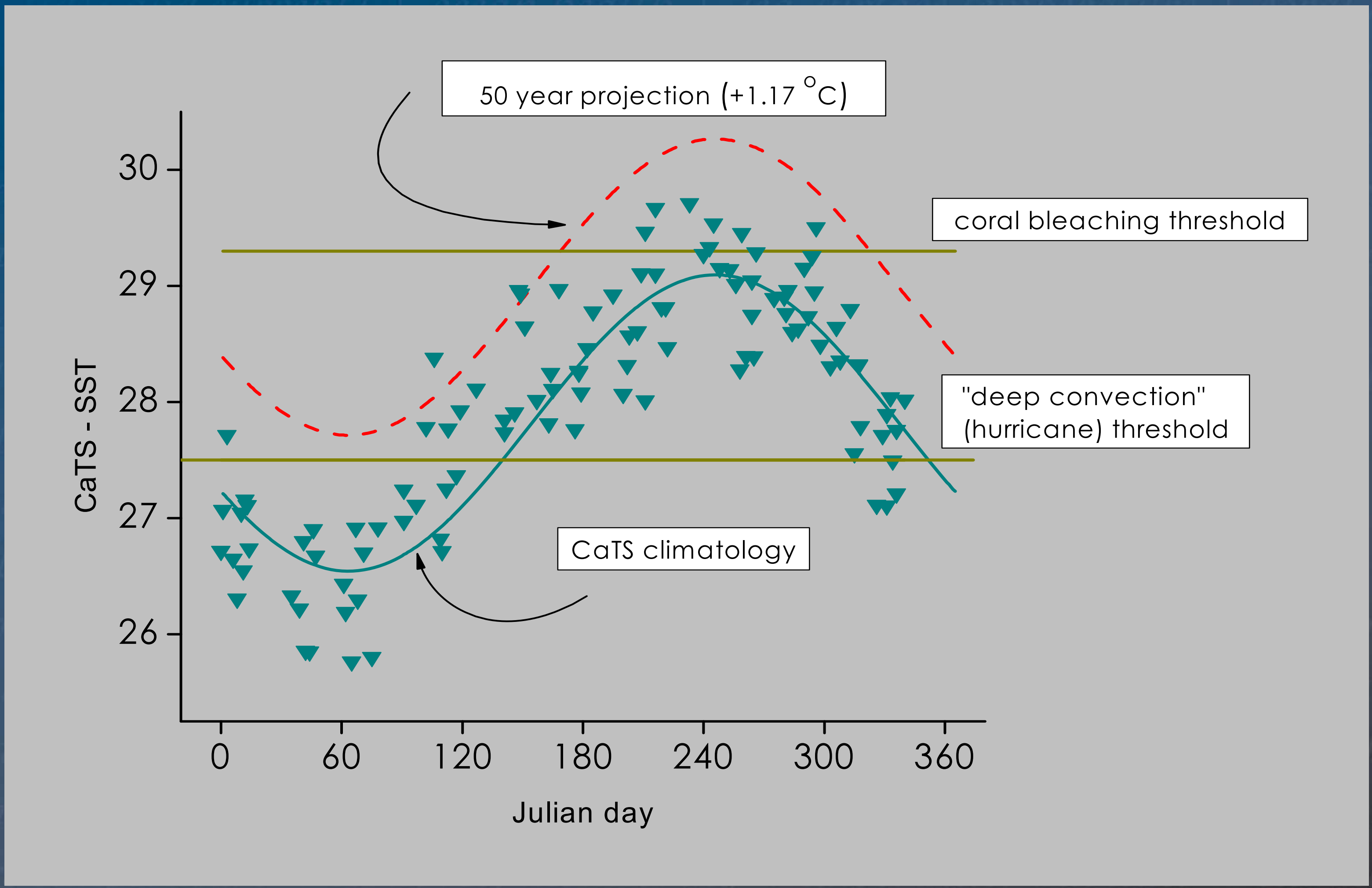



A. Winter · R. S. Appeldoorn · A. Bruckner
E. H. Williams. Jr. · C. Goenaga

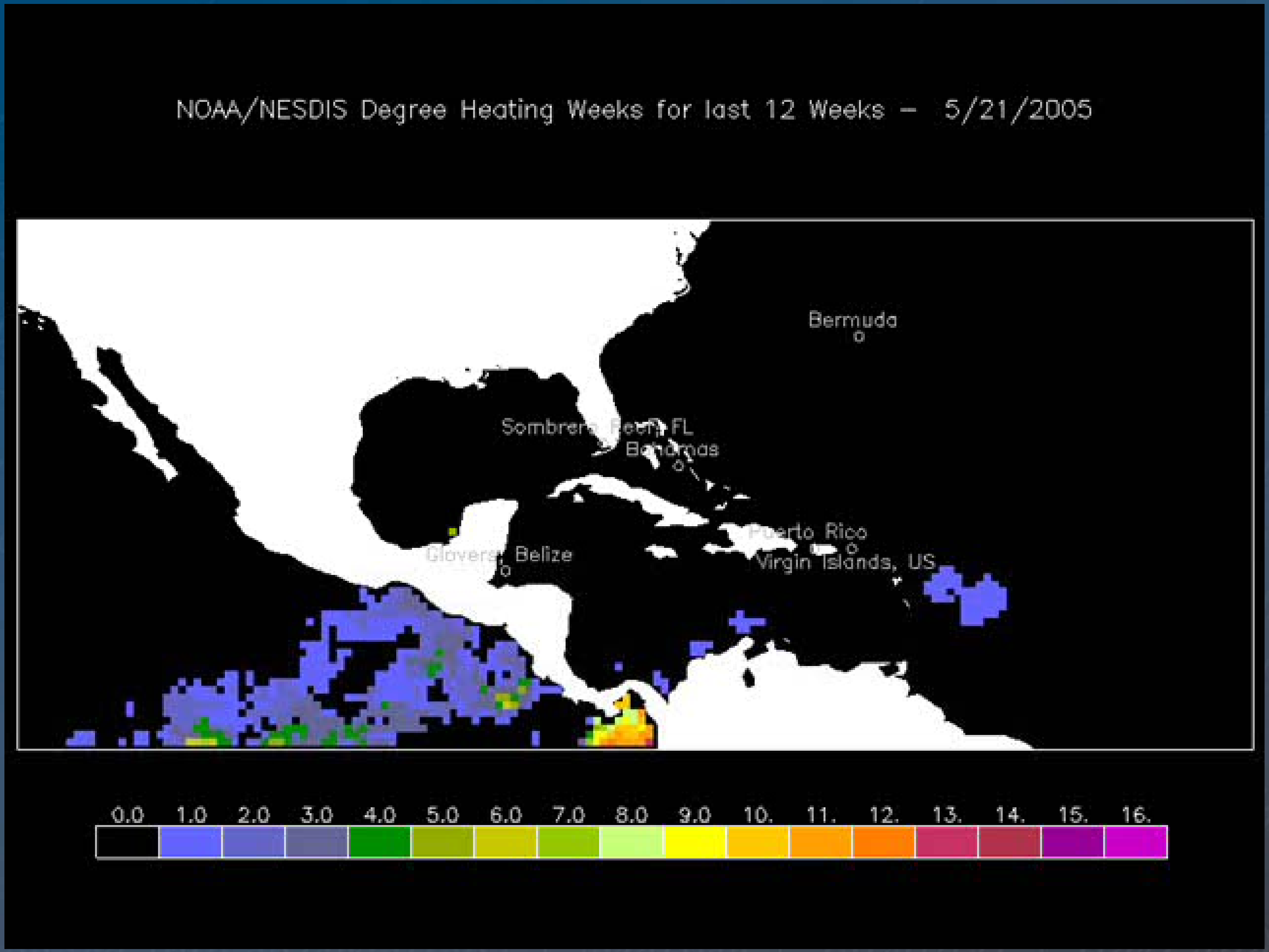
**Sea surface temperatures and coral reef bleaching off La Parguera, Puerto Rico (northeastern Caribbean Sea)**

# 50 year projection for CaTS SST

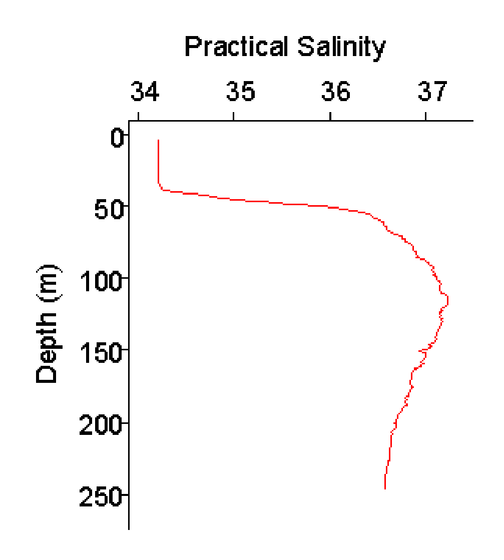
$$SST_{projected} = \text{climatological T} + 0.0233 * 50$$

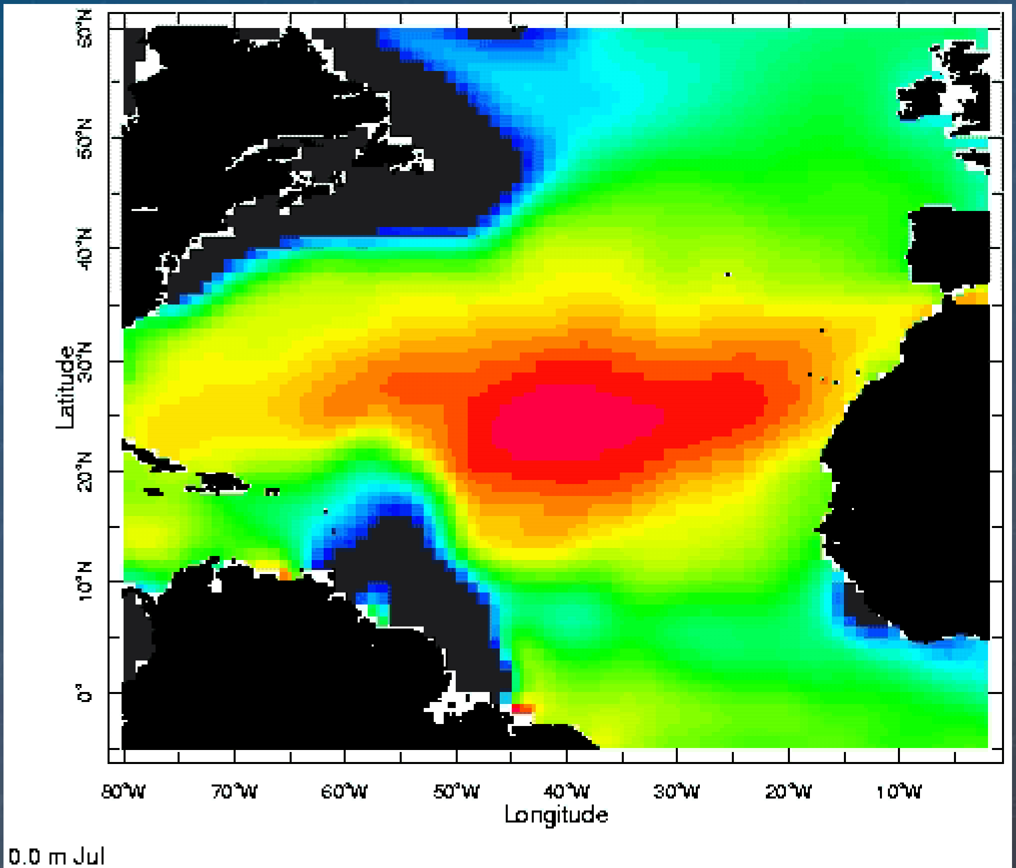


# Caribbean 2005 heating episode

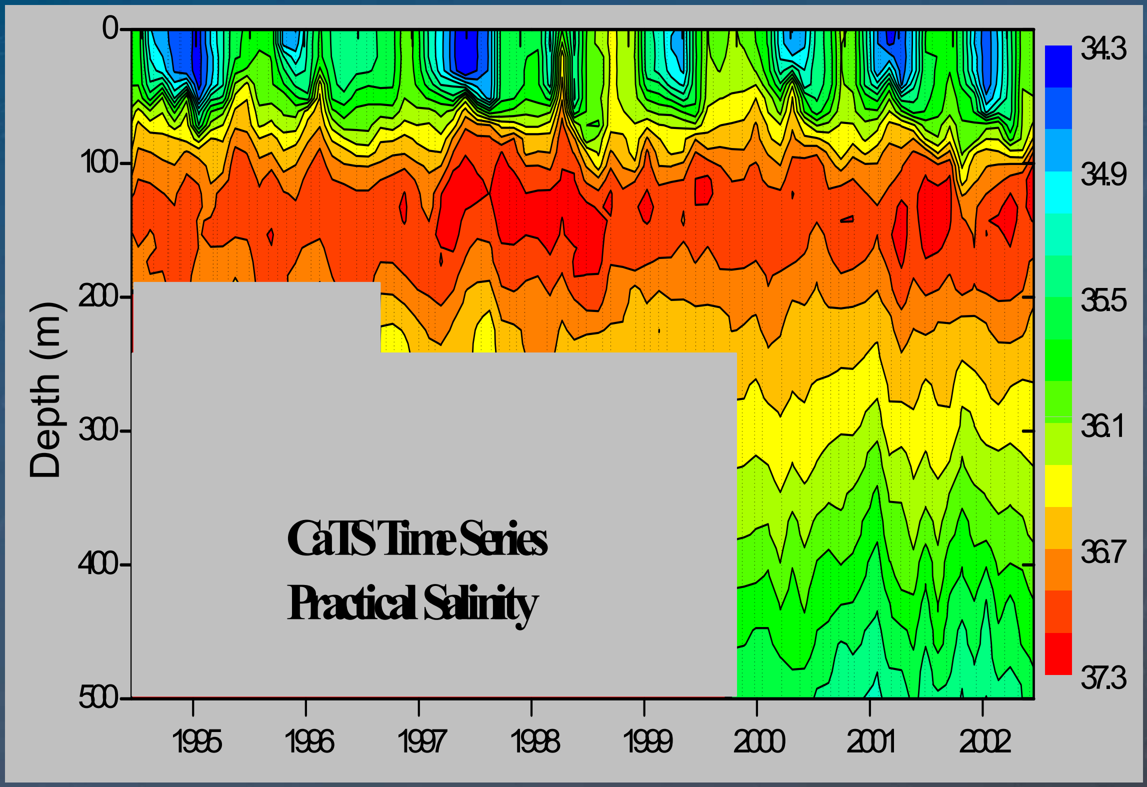


# Subsurface expression at CaTS: The Subtropical Underwater - SUW

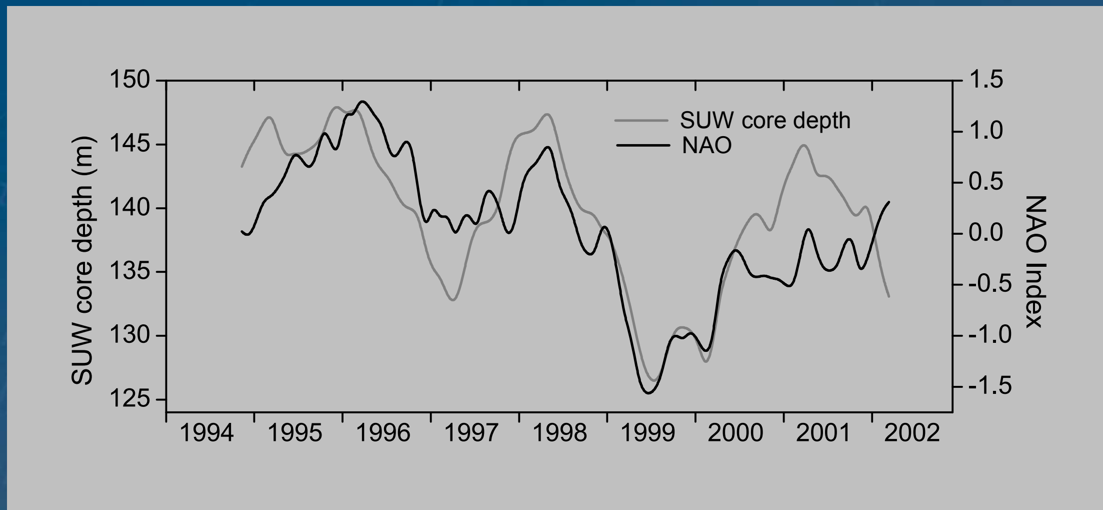


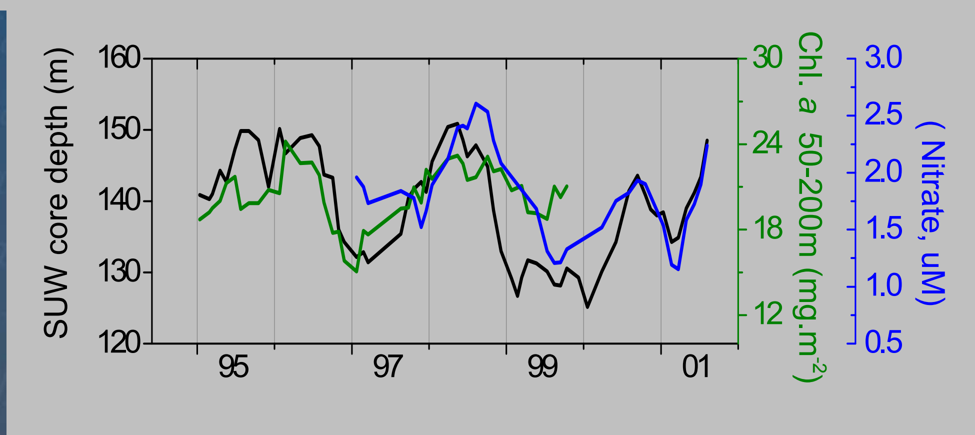



# Subsurface expression at CaTS: The Subtropical Underwater - SUW



# Subsurface expression at CaTS:
# The Subtropical Underwater - SUW




- North Atlantic Oscillation modulates SUW properties at CaTS with a 45 month lag and phytoplankton biomass (carbon drawdown) below the upper 50m

# Conclusions

- Seasonality of Caribbean surface water is modulated by remote (ENSO) climate forcing . “simulation of warming effects”
- Long term warming trend is evident apparent in SST record: implications in coastal ecosystems (eutrophication, coral bleaching)
- SUW responds to remote (NAO) climate forcing.: possible implications on ocean anthropogenic carbon drawdown

# CarICOOS: A Coastal Ocean Observing System for the N.E. Caribbean

J.Morell, J.Corredor, J.Capella, R.Watlington (UVI), A.Mercado, L.Aponte,

Collaborators:

N.Pettigrew (U. Maine), J.Titlow (WeatherFlow Inc.), B.Blanton (Renaissance I), D.Hill (Penn State), C. Von Hildebrandt (PSN), L. Cherubin (U. Miami) S.Strippling (NWS), (PR Sea Grant Program), DRNA,

CaRA Interns

J.Gonzalez, C.Anselmi, C.Sueiras, D.Ruiz, A. Amador

Caribbean Regional Association CaRA ARCA Asociación Regional del Caribe

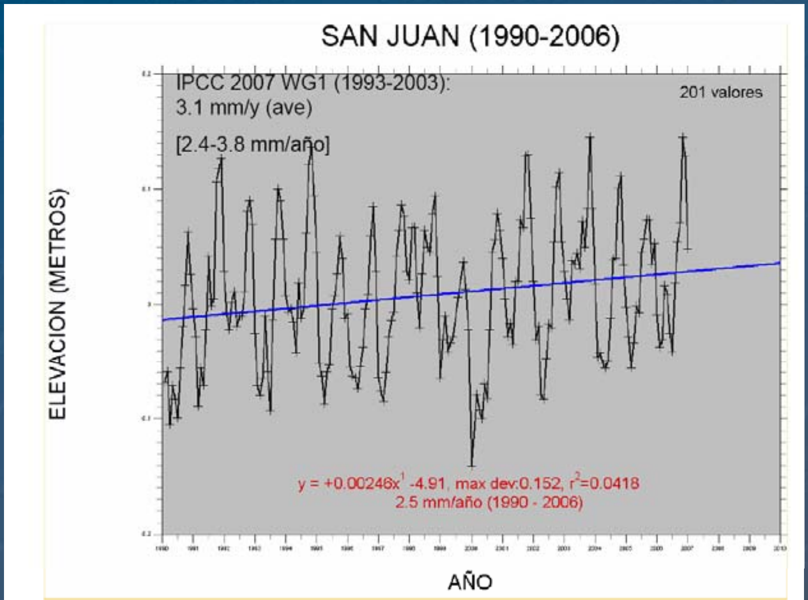
Marine Sciences, UPRM

INTEGRATED OCEAN OBSERVING SYSTEM

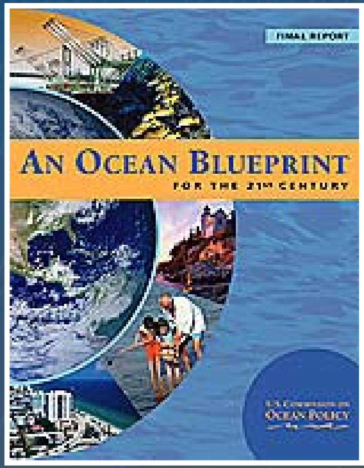
NOAA IOOS

Our society derives diverse benefits from coastal resources. Intense use (abuse?) of these resources in many cases results in extreme "conflicts". Today, many changes occurring in the oceans, from sea level rise and coastal flooding to harmful algal blooms and dead zones, have profound effects on our society. At present, we do not fully understand the magnitude of these changes, their causes, and their consequences, which can make it difficult to adequately prepare for, manage, and adapt to future change.

## Sea level change: a driver for future conflicts?




## IOOS : origin and purpose




September 20, 2004: U.S. Commission on Ocean Policy An Ocean Blueprint for the 21st Century,_"Ocean policy decisions should be based on the best available understanding of the natural, social, and economic processes that affect ocean and coastal environments.

December 17, 2004: President: U.S. Ocean Action Plan including the development and integration U.S. Ocean Observing Efforts into the Global Earth Observing System of System.

The Integrated Ocean Observing System (IOOS) is a system of systems that … continuously provides quality controlled data and information on current and future states of the oceans and Great Lakes……at rates required by decision makers to address seven societal goals.

## IOOS SOCIETAL GOALS:

- Improve predictions of climate change and weather and their effects on coastal communities and the nation
- Improve the safety and efficiency of maritime operations
- Mitigate the effects of natural hazards more effectively
- Improve national and homeland security
- Reduce public health risks
- Protect and restore healthy coastal ecosystems more effectively
- Enable the sustained use of ocean and coastal resources

The success of a U.S. IOOS depends on the coordinated development of observing and prediction systems.  These systems will link observations to the data and information needs of multiple users at the global, national, regional, and local scales.


IOOS Regional Associations (RAs) and Regional Coastal Ocean Observing Systems (RCOOSs) provide a vital and vast network to:

- identify and address regional priorities
- expand the coverage of the existing the U.S. IOOS
- and ensure that the system develops based on a strong customer focus and connection

# CaRA Structure
# http://cara.uprm.edu

- **Organizational structure**
  - Memorandum Of Agreement (signed on Dec 4, 2007)

  Membership:
  - 57 signatories
- **Affiliations**
  - Academics 18%
  - Government agencies 12%
  - Private Sector 40%
  - Federal Agencies 9%
  - Self Signatories 21%

# CaRA Governance

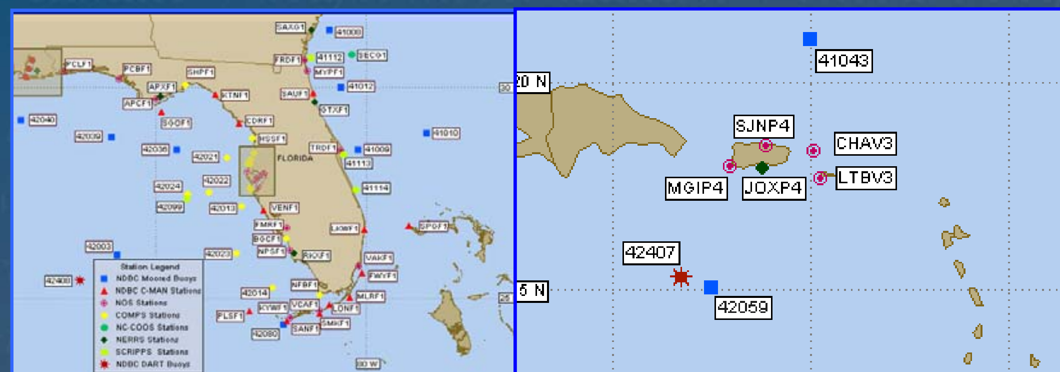
## Stakeholders Council

- 12 Council Members
  - 1 Council Chairman
  - 1 Council Secretary
  - Executive Committee (4 council members)
  - Membership and Nominations Committee
  - 4 additional committees to be empanelled:
    - » Education & outreach
    - » DMAC
    - » Observing systems
    - » Products and Services

# User group representation

- Academic
- State Government (eg DRNA)
- Federal sector (eg Caribbean Fisheries Management Council)
- Communications Area (TV media, Newspapers)
- Tourism
- Tour and Boat Charters
- Marine Transportation (Cruise ship docking, Interisland ferries, Barge Towing)
- Commercial Fishermen
- Private citizens

# Identified High-priority observational and forecast needs




- Coastal winds
- Coastal waves
- Coastal currents
- Coastal inundation
- Water quality (pathogens, visibility, sediments & pollutant plumes)
- Bathymetry (navigation, inundation and wave models)
- Temperature & salinity (climate change, riverine input)
- Benthic habitats

# CarICOOS

Initial phase of CarICOOS implementation : optimal deployment of observational assets ,regional "coverage" will be achieved using through modeling for nowcast and forecasts:

OBSERVATIONAL ASSETS (coordination by J. Corredor):

OCEAN:

2 COASTAL BUOYS (coll. with GOMOOS)

OFF NORTH AND SOUTH COASTS

METEO, CURRENTS, WAVES, WATER QUALITY


WATER QUALITY (remote sensing)

J. Trinanes-NOAA CoastWatch)

COASTS:

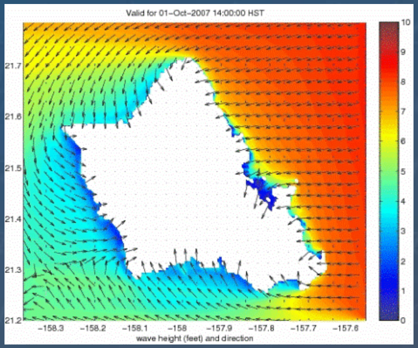
5 HURRICANE HARDENED METEO STATIONS IN PR,

4 IN USVI, Collaboration with WeatherFlow Inc.

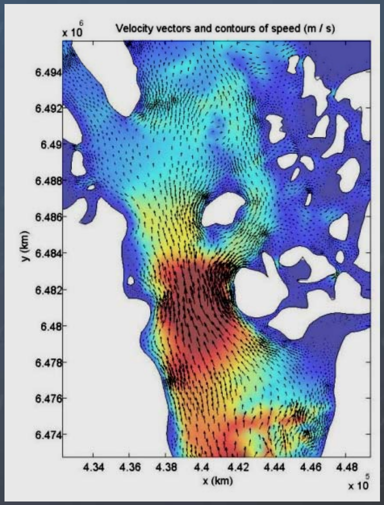
## MODELING ASSETS (NOWCASTS AND FORECAST),

## Coordiination by J. Capella & A Mercado

- coastal winds, WRF J. Gonzales-CaRA/UPRM, S. Strippling NWS-SJ)

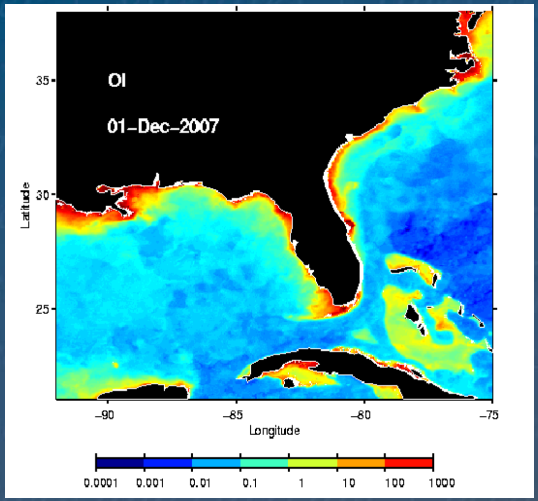



- coastal waves, SWAN ( C. Anselmi, CaRA-UPRM, J. C. Ortiz –UniNorte

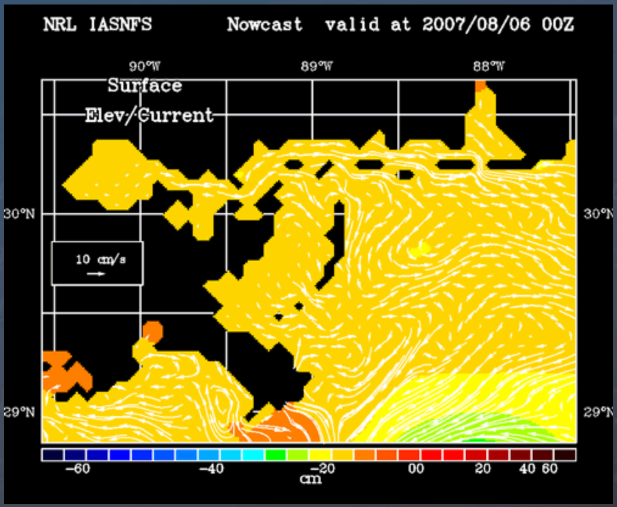



- coastal currents, ADCIRC (J. Capella-CaRA, Dave Hill,- Penn State)

- Storm surge-inundation  ADCIRC (J. Gonzalez, CaRA-UPRM, A. Mercado-UPRM, B. Blanton-Renaissance Institute ), collaboration DRNA




- offshore currents (HYCOM/ROMS)
 L. Cherubin-RSMAS, N. Idrissi-UVI),
IAS/NCOM (D. Ko-NRL)



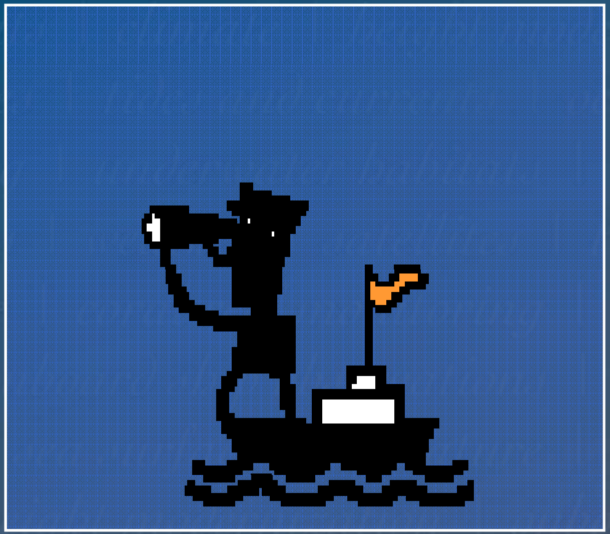
# PRODUCTS:

- Tailored to our clientele
  - From scientist to common citizen

- Easy to access
  - Accessible interfaces to be installed as part of a pilot project

- Easy to understand
  - Avoid (as much as possible) the need for training

# Preguntas?



WRF implementation, a CaRA-NWS collaborative effort

Juan Gonzales, Graduate Student, CIMA-UPRM