Departmento de Recursos Naturales y Ambientales

Climate Change - Coastal and Marine Ecology

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Científico Marino - Director

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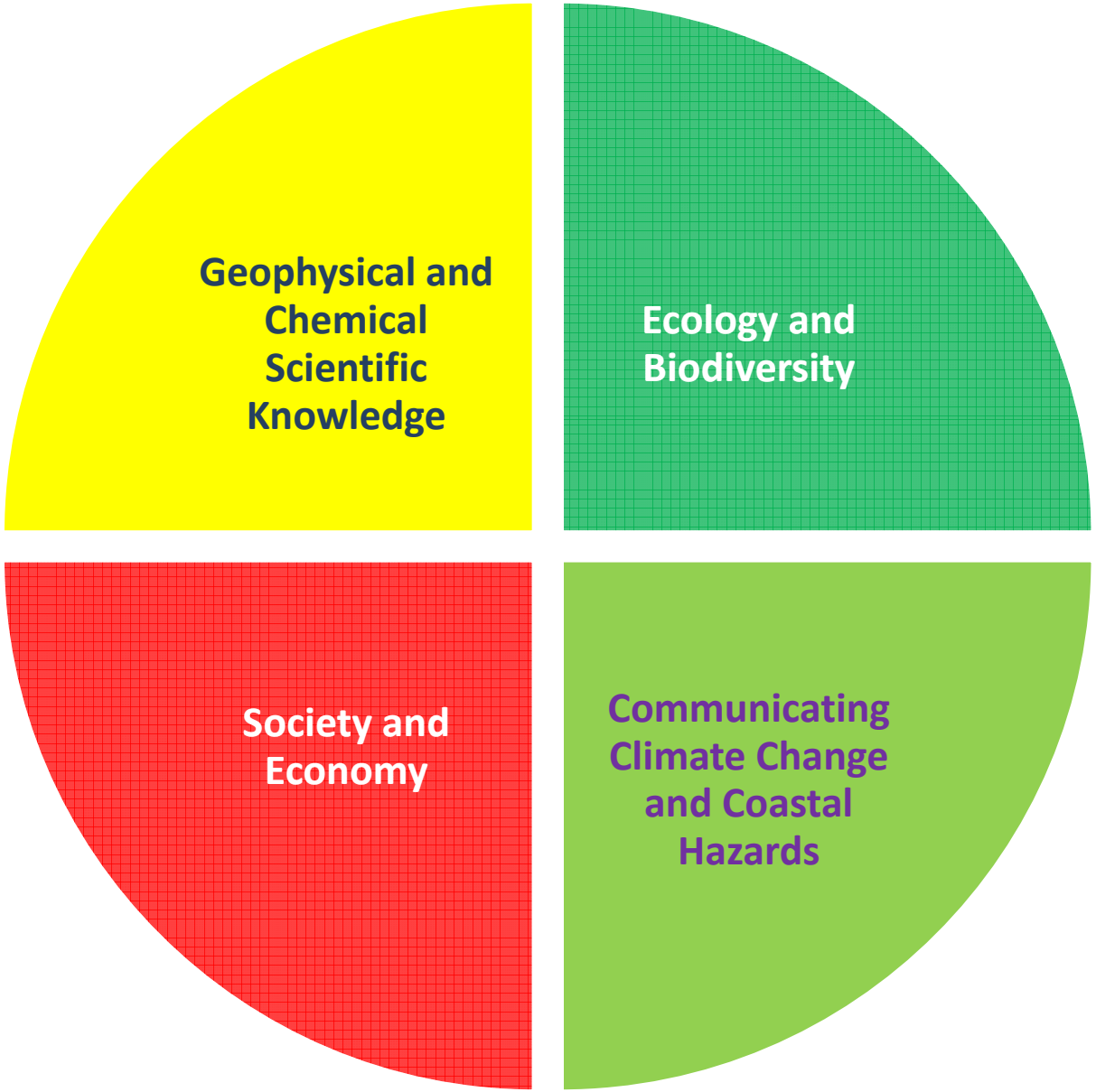
Four Working Groups for the Puerto Rico Climate Change Council (PRCCC)



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WG1: Historical trends and projections:

1. Atmospheric temperature
2. Precipitation
3. Extreme events (downpours)
4. Hurricanes
5. Sea surface temperature
6. Winter swells
7. Sea level rise
8. Ocean acidification

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WG 2: Ecología y Biodiversidad

1. Wetlands
2. Mangroves
3. Coral reefs
4. Beach systems
5. Seagrasses (SAV)
6. Coastal lagoons
7. Estuaries
8. Keys and islets
9. Bioluminescent bays
10. Sea turtles
11. Fisheries
12. Marine mammals
13. Reptiles
14. Anphibians
15. Forests
16. Wildlife

WG 2: Ecology and Biodiversity

Coastal and marine resources will be affected by a number of consequences of climate change, including:

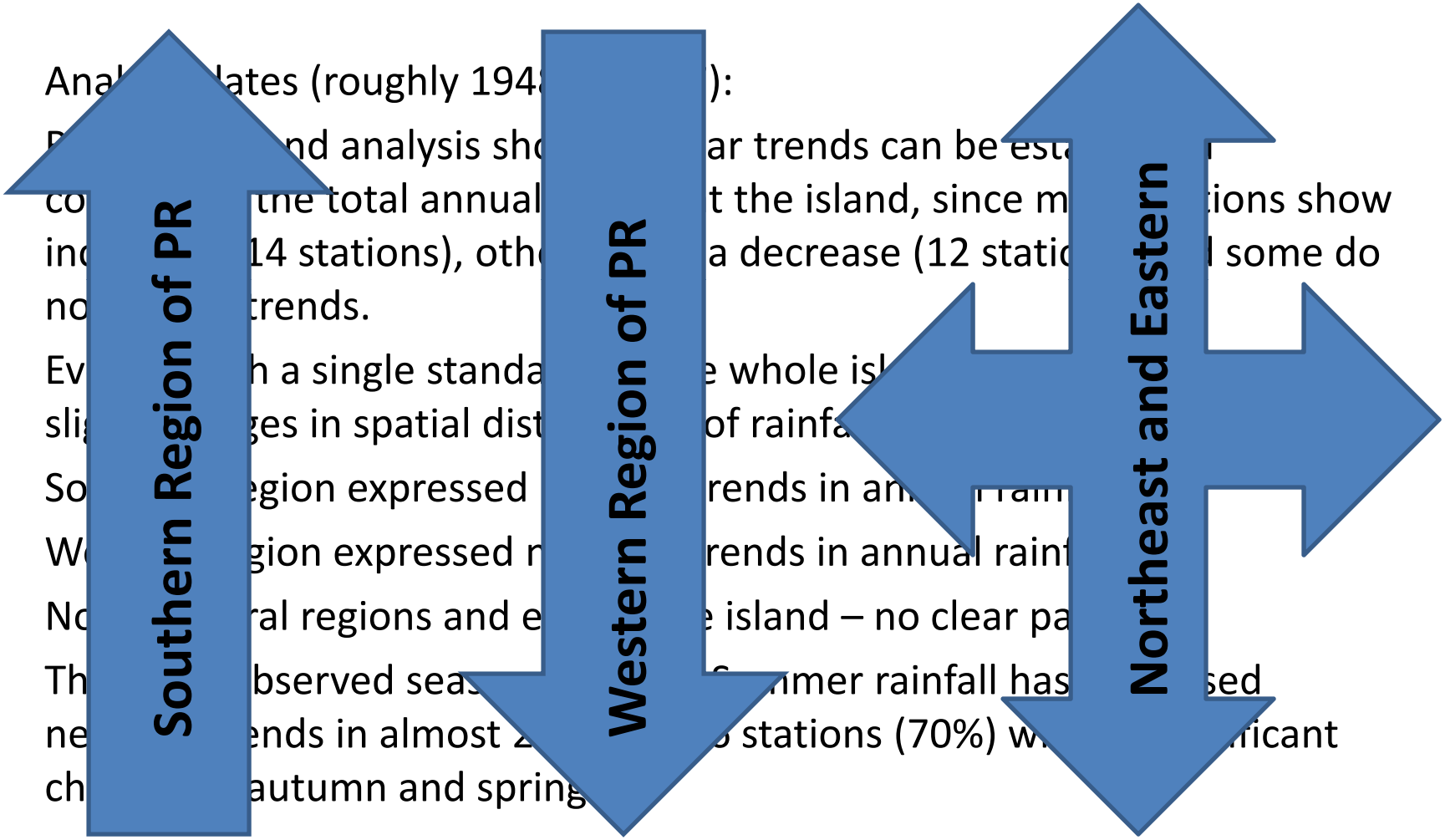
- Higher sea levels
- Higher sea temperatures
- Changes in precipitation patterns and coastal runoff
- Changes in storm tracks, frequencies, and intensities

Air Temperature

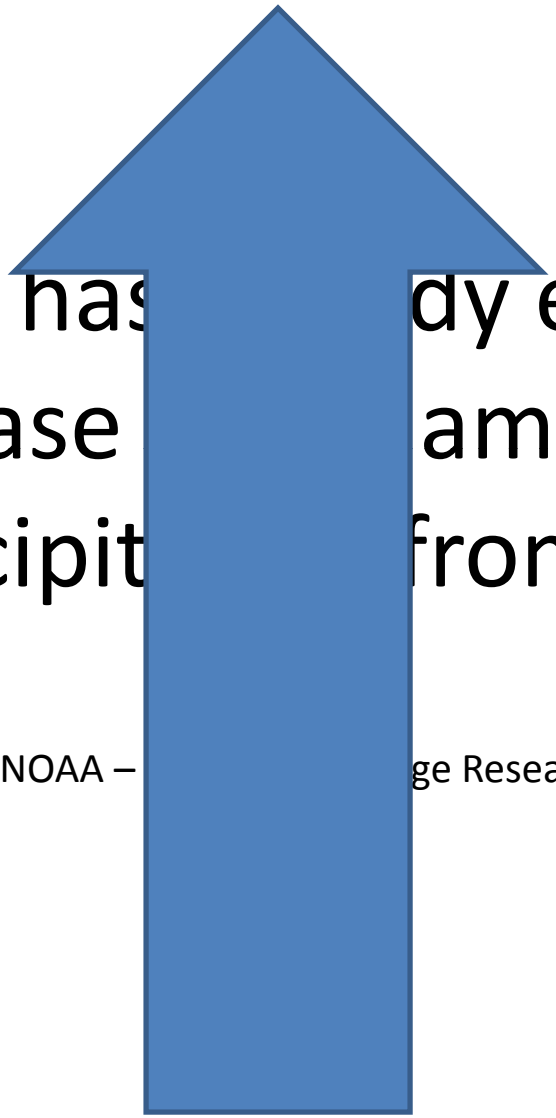
- On average, the te reased island-wide annually 0.014°C fro 995
- 12 stations out of 16 ed throughout the island expressed positive tr n ~1948 to 2007
- There is evidence of ds within Puerto Rico as well. Velázquez-Loza 2006) mention that the temperature of City c n has grown at a rate of 0.06 ° C over the pas .
- Therefore, Puerto Ric g a little warmer which is consistent with regio bean) and global trends.

Precipitation

- Anal lates (roughly 194):
- R nd analysis sho ar trends can be est
  co the total annual t the island, since m tions show
  inc 14 stations), othe a decrease (12 static some do
  no trends.
- Ev h a single standa e whole isl
  sli ges in spatial dist of rainfa
- So egion expressed rends in an
- W gion expressed n rends in annual raint
- No ral regions and e island – no clear pa
- Th bserved seas mer rainfall has sed
  ne nds in almost 2 stations (70%) w ficant
  ch autumn and spring

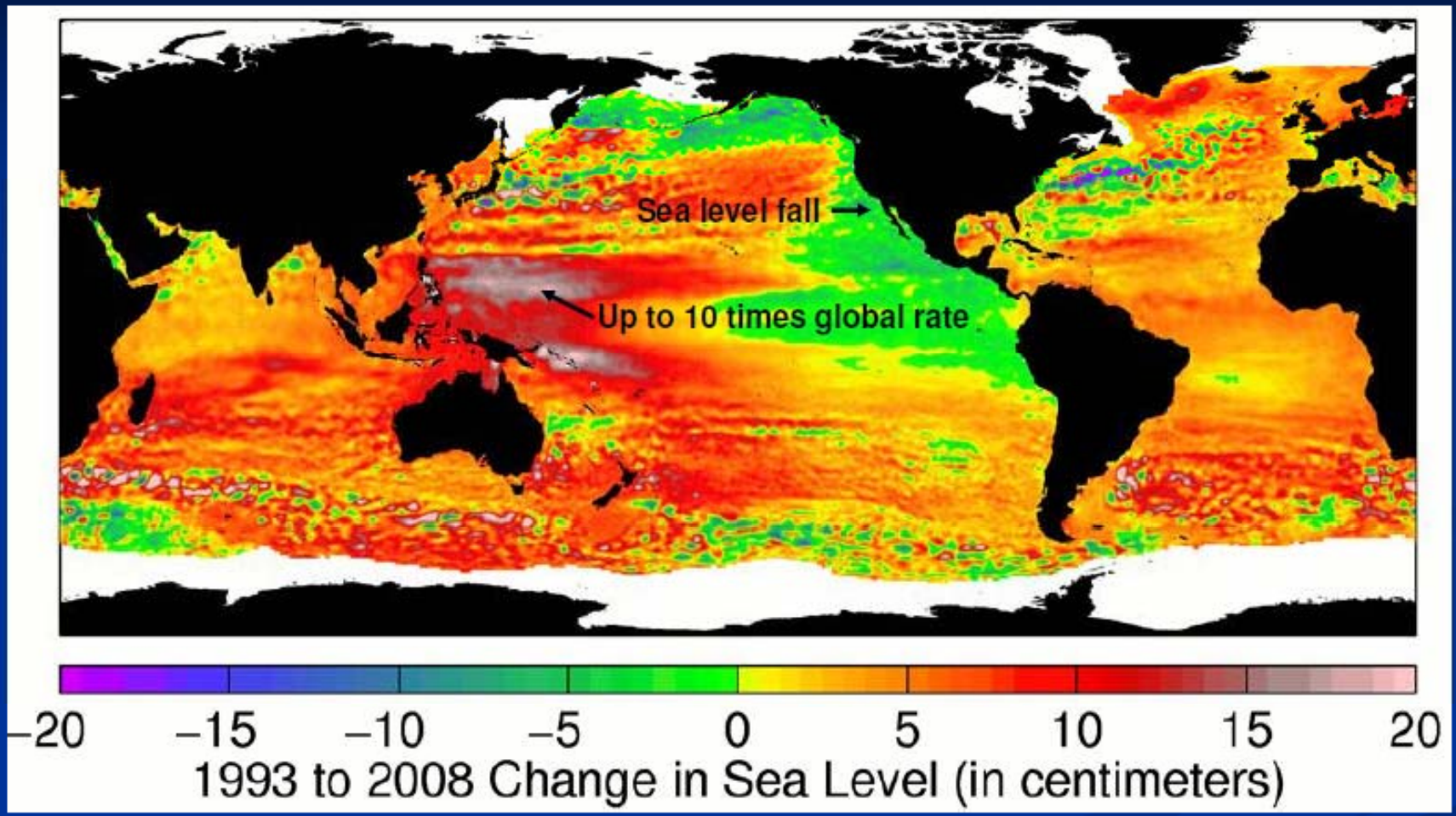


Puerto Rico has already experienced a 37% increase in the amount of very heavy precipitation from 1958-2007

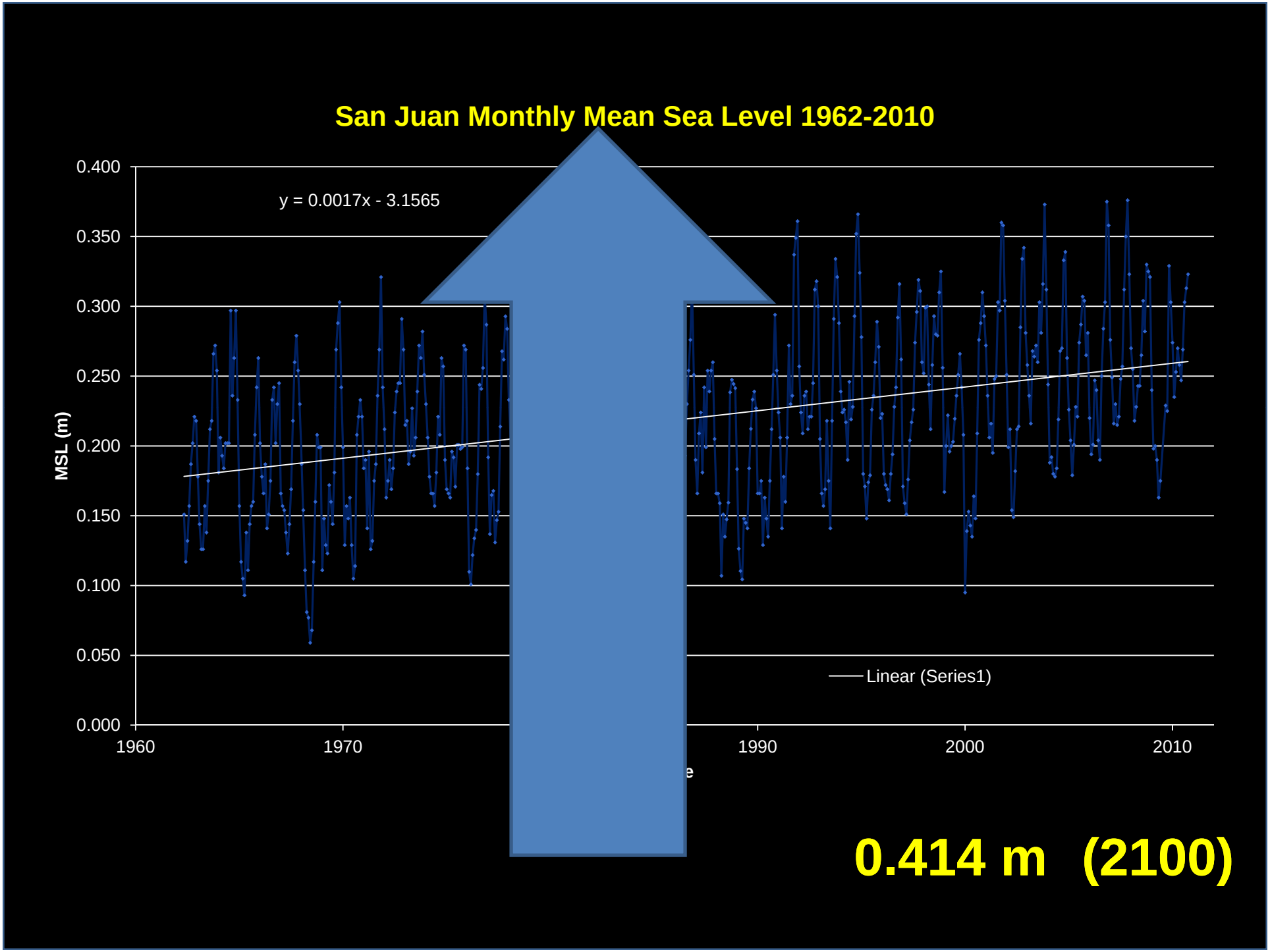


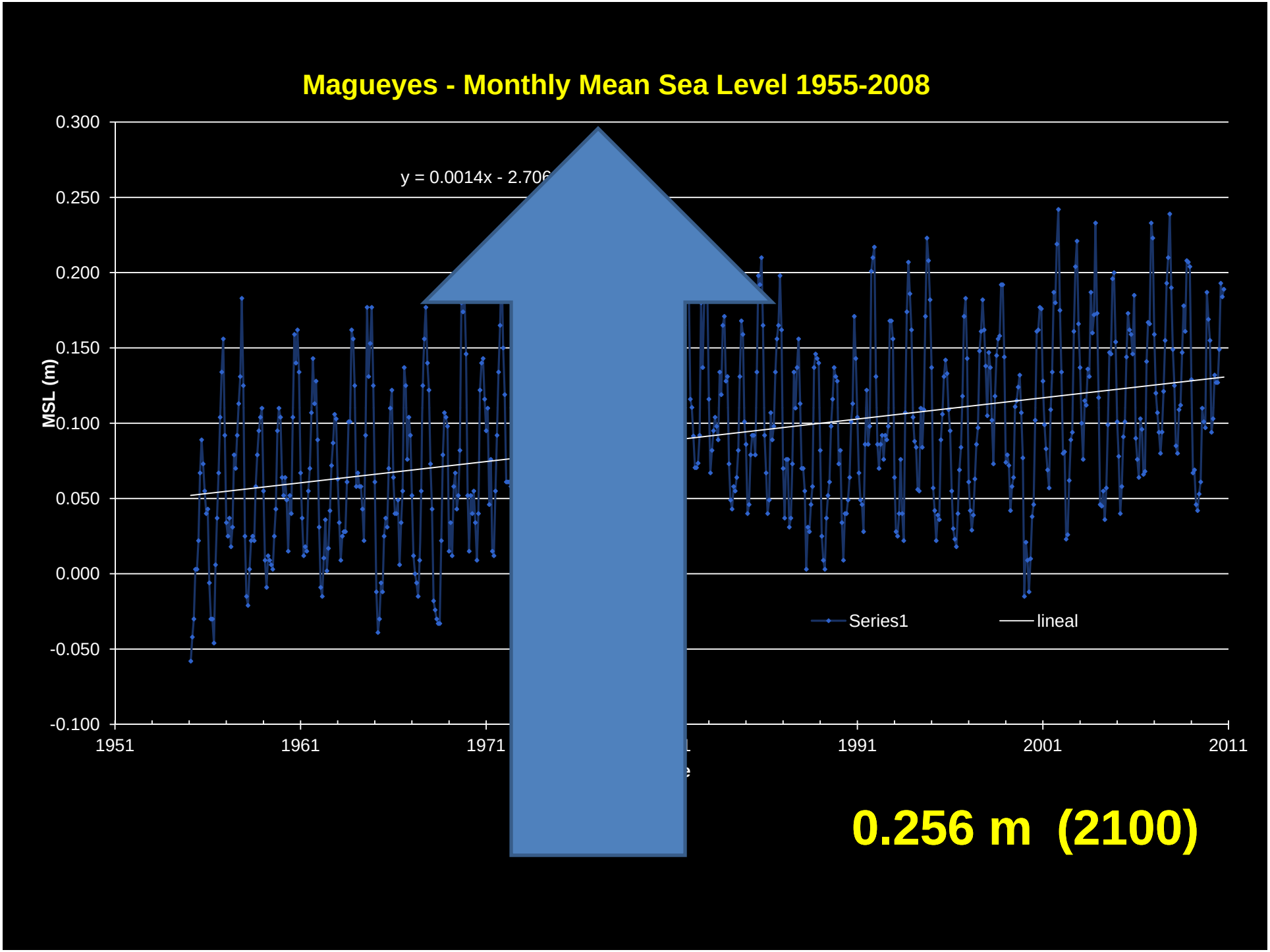
Source: NOAA – Climate Change Research Program

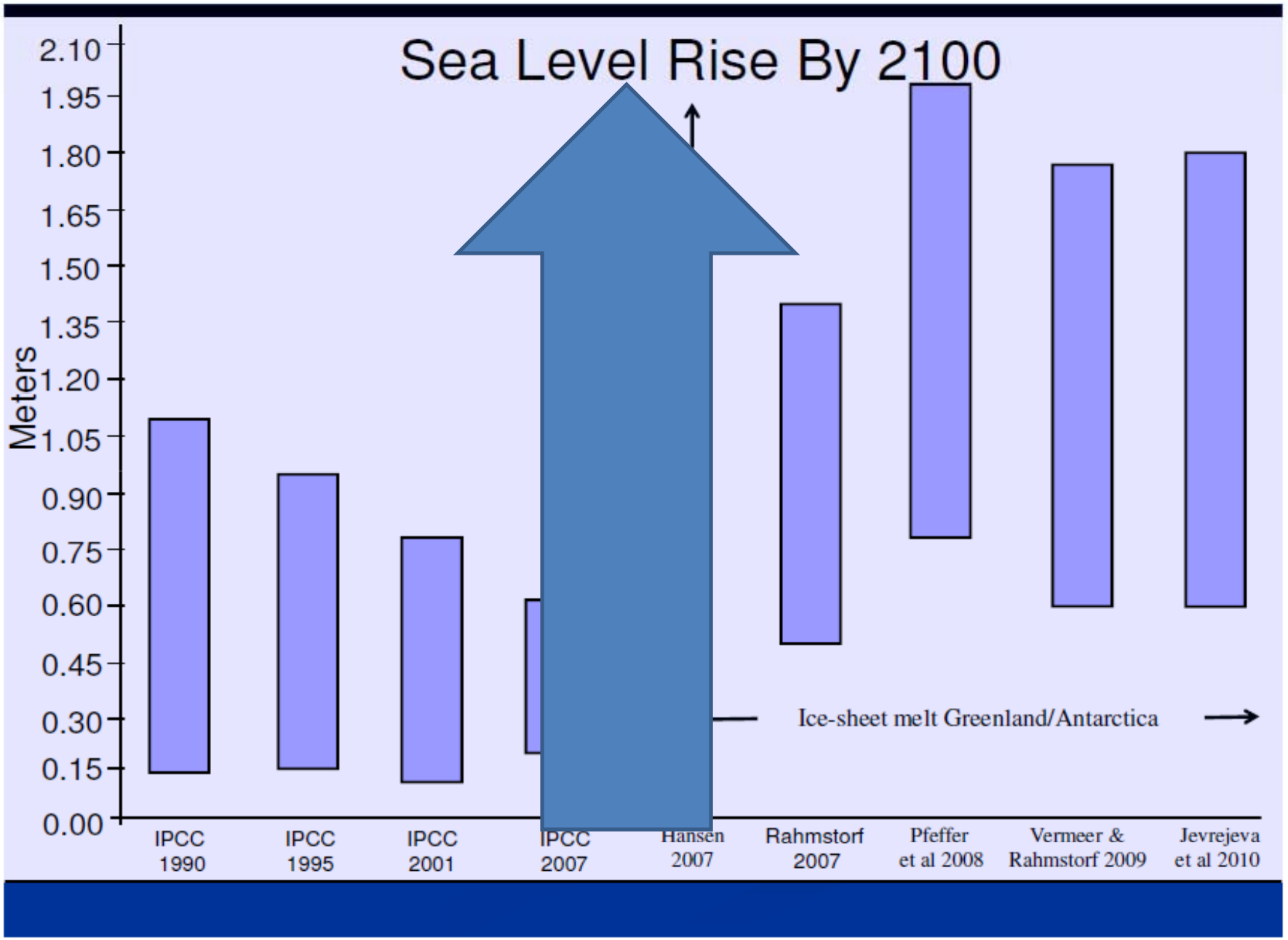
Sea Level Rise Is Spatially Very Non-Uniform



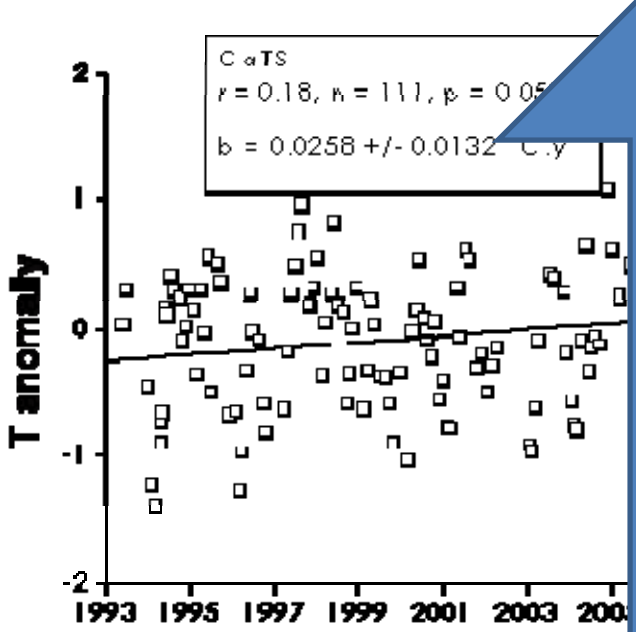
Satellite altimeter measurements over 15 years

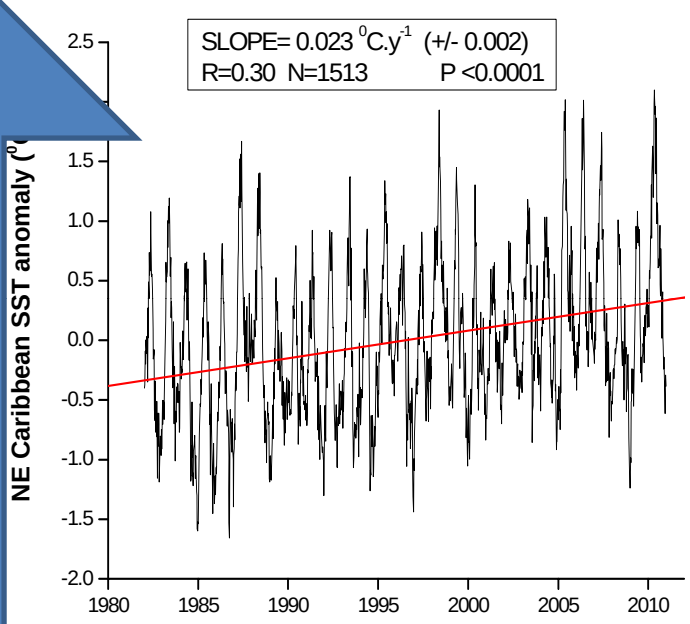

San Juan Monthly Mean Sea Level 1962-2010
y = 0.0017x - 3.1565
MSL (m)
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
1960
1970
1990
2000
2010
Linear (Series1)
0.414 m (2100)


Magueyes - Monthly Mean Sea Level 1955-2008
0.300
0.250
0.200
0.150
0.100
0.050
0.000
-0.050
-0.100
MSL (m)
y = 0.0014x - 2.706
Series1
lineal
1951
1961
1971
1991
2001
2011
0.256 m (2100)


Sea Level Rise By 2100
Meters
2.10
1.95
1.80
1.65
1.50
1.35
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
Ice-sheet melt Greenland/Antarctica
IPCC 1990
IPCC 1995
IPCC 2001
IPCC 2007
Hansen 2007
Rahmstorf 2007
Pfeffer et al 2008
Vermeer & Rahmstorf 2009
Jevrejeva et al 2010

Sea Surface Temperatures (SSTs) - Ca COOS





SST data from CaTS. The slope or S trend between 1993 and 2007 was estimated at 0.026 (+/-.01) degree per year

SST anomaly data from OI.v2 SST product for the CaTS region (Northeastern Caribbean) from 1982 to 2011. A linear fitting of the data yields a slope of 0.023 degrees (+/- 0.002) Celcius per year.

Biophysical effects of relative sea level rise (climate and nonclimate factors, from Nicholls, 2002).

Biogeophysical effect		Other relevant factors	
		Climate	Nonclimate
Inundation, flood and storm damage	Surge	Wave and storm climate, morphological changes, sediment supply	Sediment supply, flood management, morphological changes, land claim
	Backwater effect (river)	Runoff	Catchment management and land use
Wetland loss or change		CO_2 fertilization Sediment supply	Sediment supply, migration space, direct destruction
Beach Erosion		Sediment supply, wave and storm climate	Sediment supply
Saltwater intrusion	Surface waters	Runoff	Catchment management and land use
	Groundwater	Rainfall	Land use, aquifer use
Rising water tables/impeded drainage		Rainfall	Land use, aquifer use

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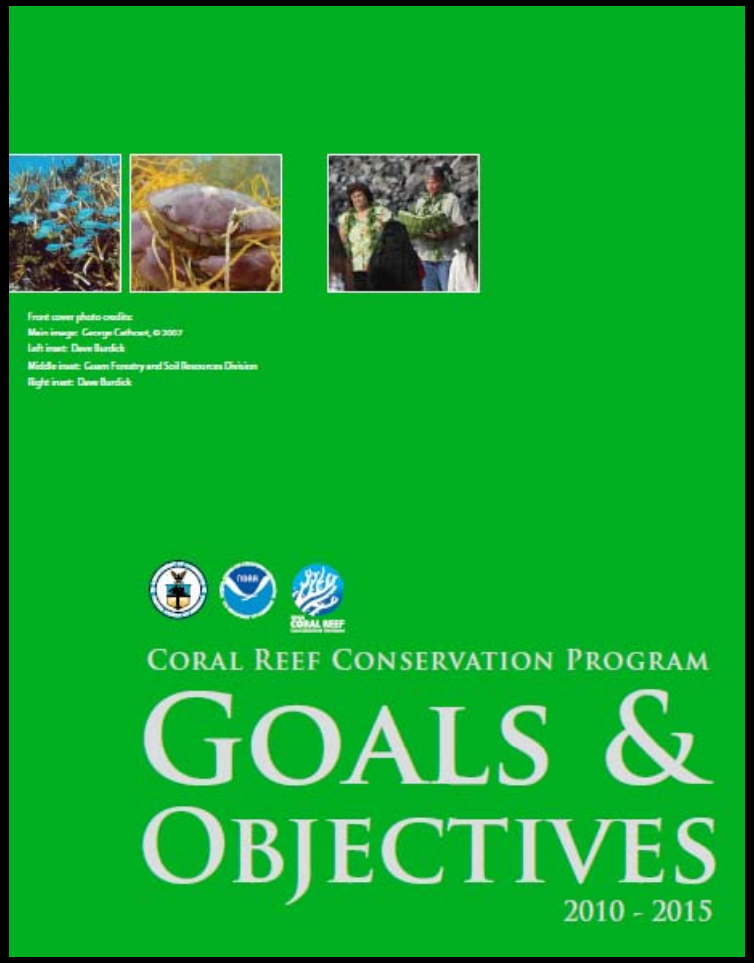
WG 2: Ecología y Biodiversidad

1. Humedales*
2. Manglares*
3. Arrecifes de coral*
4. Playas*
5. Vegetación acuática –yerbas marinas*
6. Lagunas costeras
7. Estuarios
8. Cayos e islotes
9. Bahías bioluminescentes
10. Tortugas marinas*
11. Pesquerías*
12. Mamíferos marinos*
13. Reptiles
14. Anfibios
15. Bosques*
16. Vida Silvestre

Coral Reef Stressors



- Climate Change
- Land-based Sources of Pollution
- Fisheries Impact
- Disease
- Recreational Overuse
- Lack of Awareness

Climate Change impacts on coral reefs

Climate change impacts are identified as the greatest global threats to coral reef ecosystems:

- **Bleaching**
- **Disease and Mortality**
- **Ocean acidification**

Climate Change impacts on wetlands

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- **Agriculture**
- **Urban sprawl**
- **Flood control projects:**
  (Water dams and levees restrict natural supply of sediment and fresh water to coastal wetlands)
- **Coastal erosion**
- **Case study: Humacao**

ADAPTATION: WETLANDS

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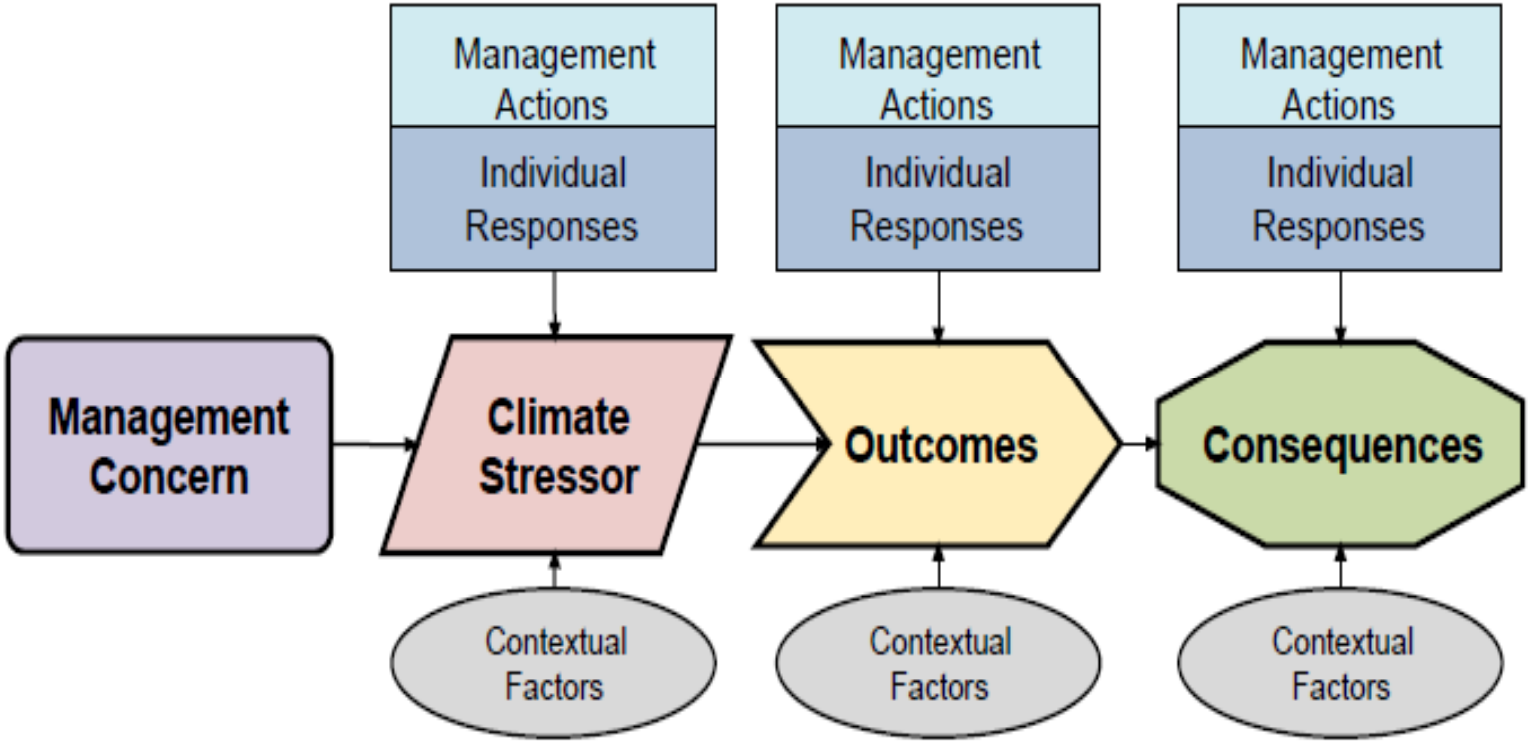
- The ability of wetlands to migrate inland to areas of decreasing tidal inundation along undeveloped shores is another way coastal wetlands can persist in spite of rising seas (Ross et al., 2000).
- In many areas coastal development just above the extreme high tide line has limited or eliminated opportunities for wetland migration, a phenomenon that has been labeled “coastal squeeze” (Twilley, 1997).
- As human development and climate change progress coastal resources and infrastructure become more vulnerable.


Management Actions
Individual Responses
Management Actions
Individual Responses
Management Actions
Individual Responses
Management Concern
Climate Stressor
Outcomes
Consequences
Contextual Factors
Contextual Factors
Contextual Factors

Concurrent Breakout Groups

Coral Reefs

Facilitators: Antares Ramos and Sean Griffin

Fisheries

Facilitators: Lisamarie Carrubba and Michelle Scharer

Wetlands

Facilitators: Ernesto Díaz and Bill O'Beirne

Marine Mammals and Sea Turtles

Facilitators: Nilda Jiménez and Carlos Diez