

SEA-LEVEL RISE AND CLIMATE CHANGE AT THE COASTAL BOUNDARY: OBSERVATIONS, PROJECTIONS, AND ISSUES OF CONCERN FOR RESOURCE MANAGEMENT

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Greater Everglades Ecosystem Restoration Conference

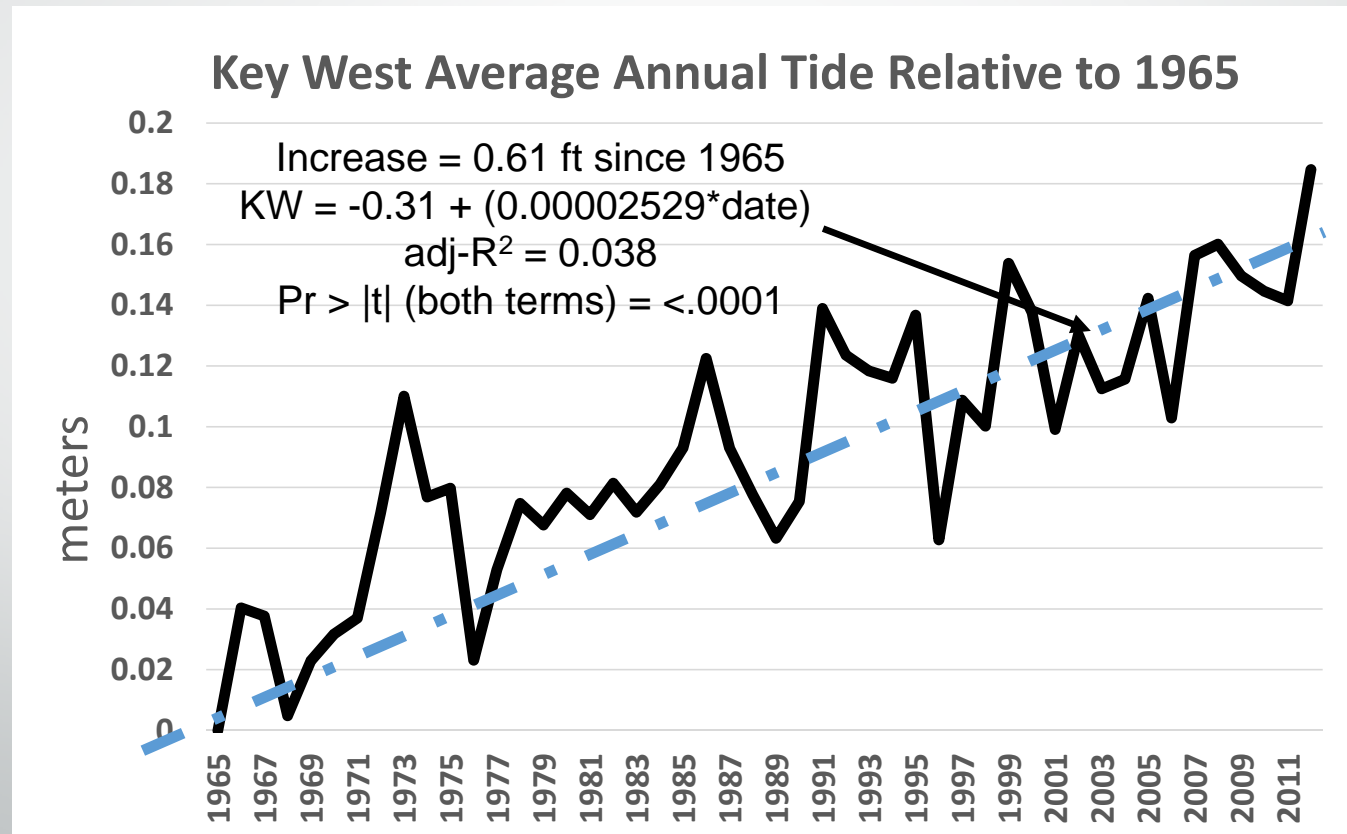
April 21, 2015

General Observations - What Do We Know?

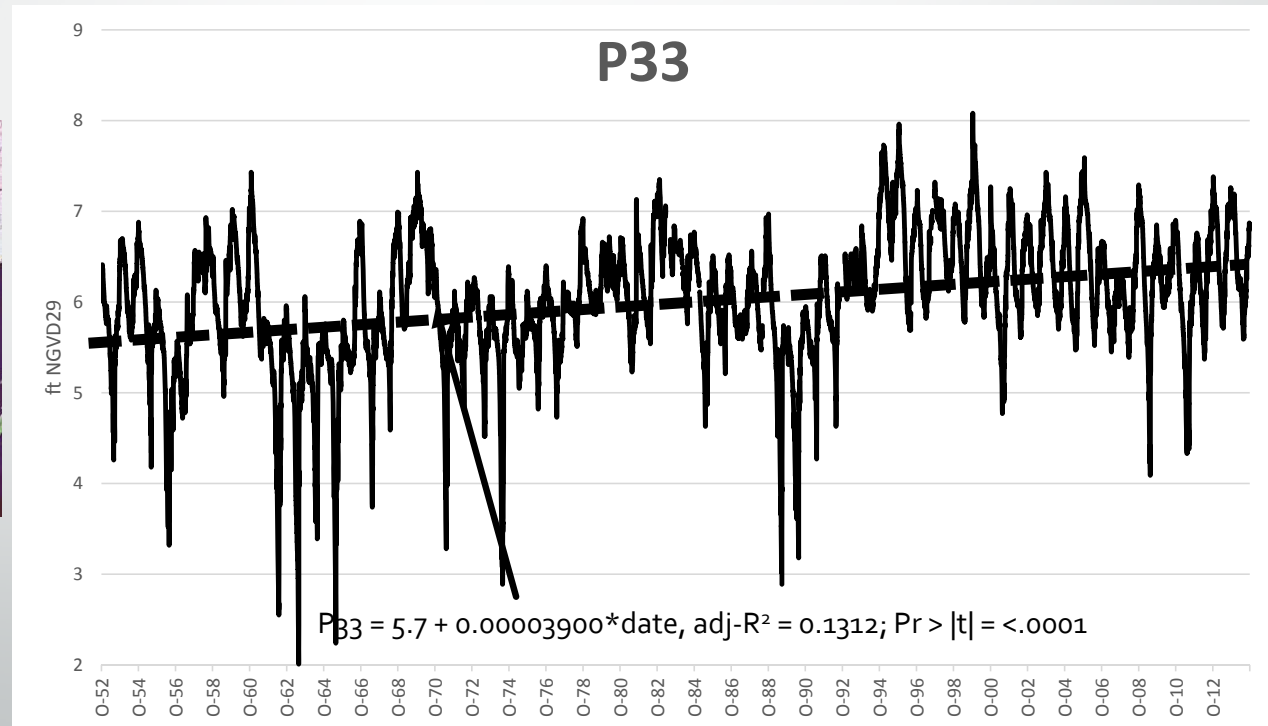
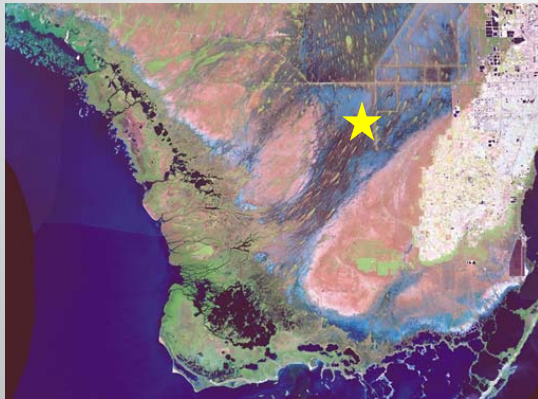
- Sea level is rising at an increasing rate
- Flooding now occurs on an annual basis
- Saltwater intrusion has impacted wellfields and is worsening
- Coastlines are shifting
- 2014 was the warmest year in the US since 1880 when record begins
- With exception of 1998, the 10 warmest years have occurred since 2000

From Kimball and Stabenau (2014) and www.nasa.gov

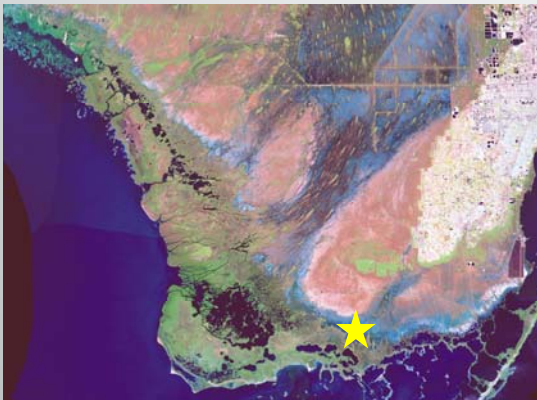
Observations: Increase in South Florida Sea Level



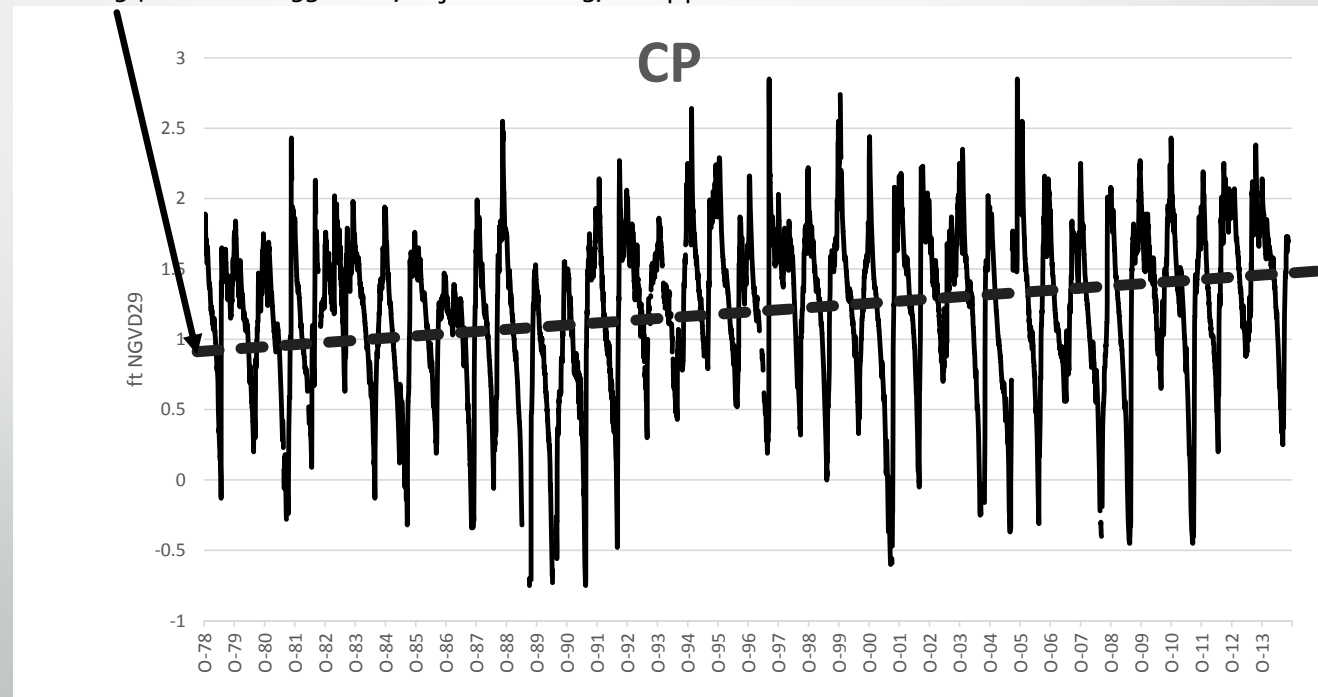
Observations: Water Levels in Everglades Freshwater Marshes are Increasing



Observations: Water Levels in Everglades Freshwater Marshes are Increasing



$$CP = 0.94 + 0.00002153 * \text{date}, \text{adj-}R^2 = 0.0213; \text{Pr} > |t| = <.0001$$



Observations: Physical Effects of SLR on Greater Everglades Coastal Features

- SLR over ~3000 yrs created transgressing mangroves and then destroyed them to create Whitewater Bay and Huston Bay¹
- Coastal deposits in south Florida have accumulated at rates similar to SLR²
- In Florida Bay SLR filled Hawk Channel first, then the Bay was flooded from west by rising Gulf of Mexico³
- Mud banks and islands are Holocene deposits developed over last 4000 years by SLR⁴

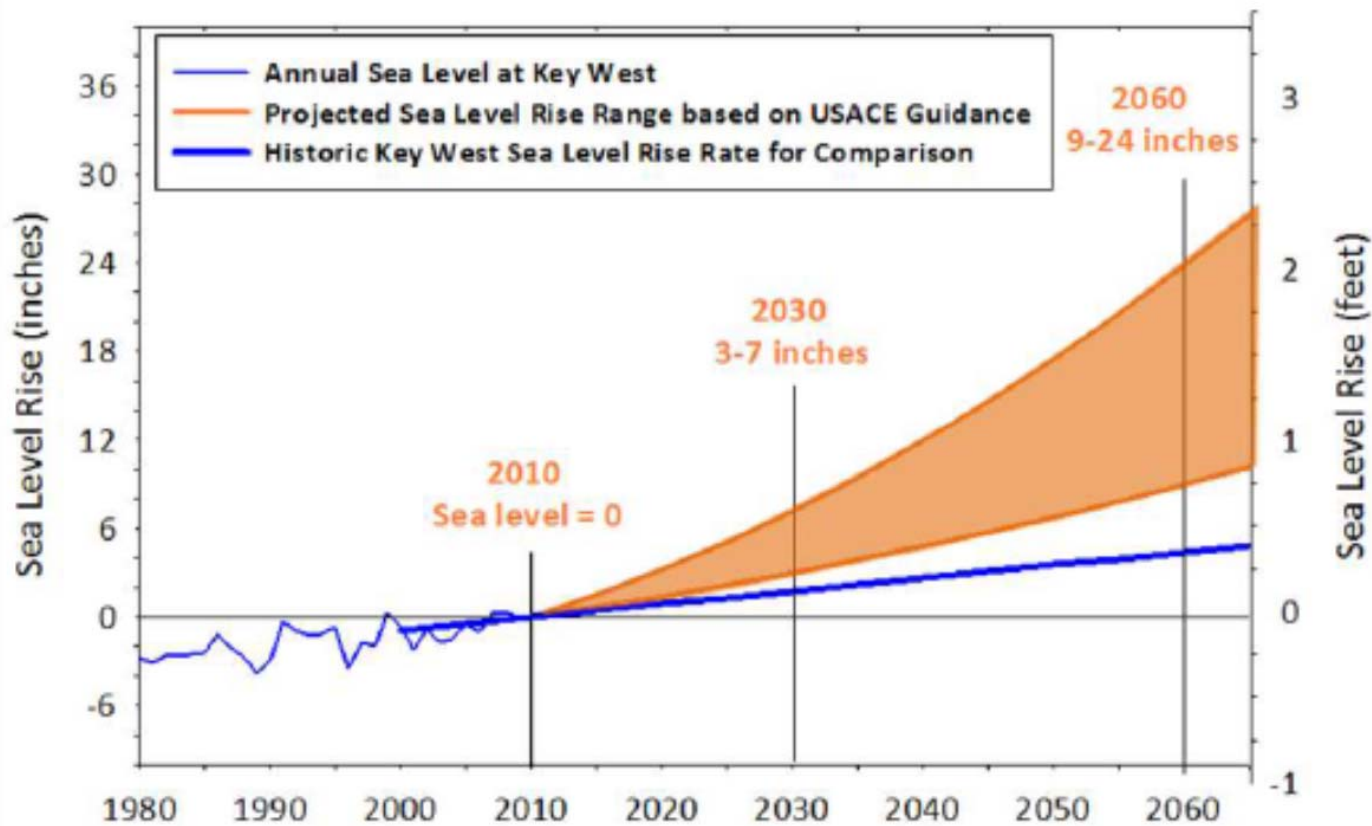
¹Scholl (1964); ²Scholl, Craighead, and Stuiver (1969); ³Wilkinson (<http://keyshistory.org/keysgeology.html>); ⁴Swart and Kramer (1997);

Observations: Physical Effects of SLR on Florida Bay Features, cont.

- Because of SLR mudbanks in east FL Bay are in a destructive phase and mudbanks in the west are in a construction phase⁵
- Mudbanks in west are accreting about 0.5 in/yr, faster than SLR⁶
- Current rapid SLR may convert mangrove swamps into open embayments and other shallow water features⁷
- However bank and shoal accretion may mute the salinity increase caused by SLR⁸

⁵Wanless and Tagett (1989); ⁶Halley (1994; 1996; 1998); ⁷Lodge (2004); ⁸Marshall and Cosby (2014)

Projections: Local SLR From Southeast Florida Regional Climate Change Compact



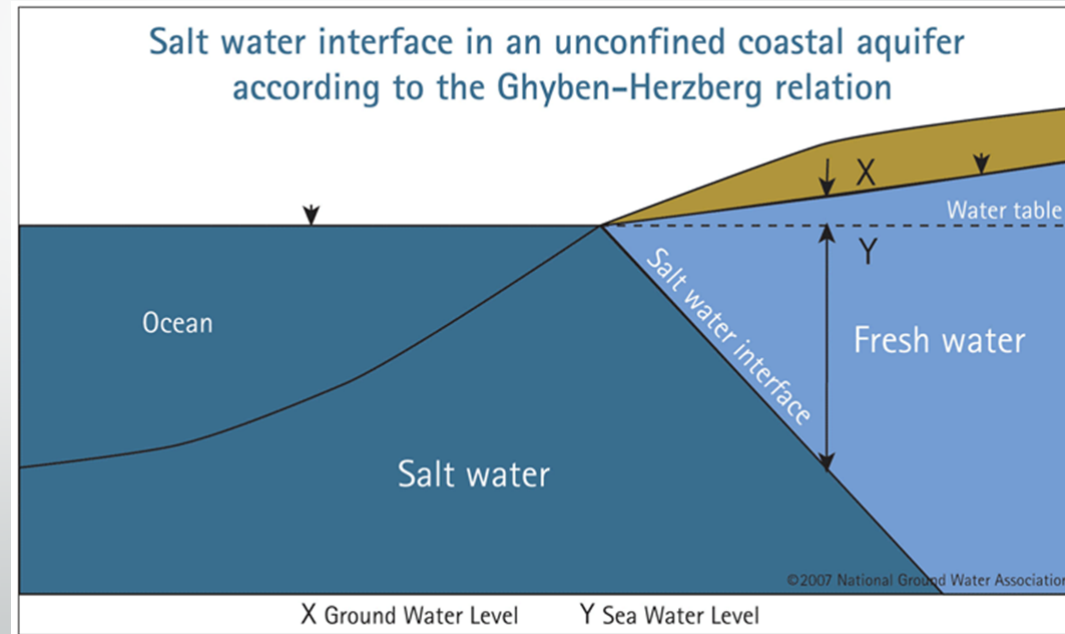
Projections: Long Term Effects of SLR and Climate Change in Florida Bay

- Changes to salinity will be related to changes to rainfall and evaporation
- Global effect of climate change on rainfall and evaporation in south Florida is still uncertain
- Western boundary salinity will change
- Freshwater runoff from upstream marshes will increase

From Marshall and Cosby (2014) - See next presentation in this session by Jack Cosby

Projections: Effects of SLR and Climate Change on Soil and Groundwater Conditions

- Increasing groundwater levels (already rising)
- Reduction of infiltration and soil storage capacity
- Increased runoff
- Reduction of discharge capacity of outfalls
- Drainage wells that become artesian



Projections: Potential Effects on Greater Everglades Coastal Habitats

- SLR will alter shore erosion, salinity, and wetland dynamics
- Future tidal marsh acreage with SLR will be determined by:
 - capacity of marsh to raise the surface elevation to match the rate of SLR
 - rate of erosion of the seaward boundary of the marsh
 - availability of space for the marsh to migrate inland
- Loss / reduction of wetland areas may reduce population sizes of wetland-dependent species of fish and birds
- Loss / reduced size of marsh islands may reduce available nesting opportunities for birds, especially those that need protection from predators

From U.S. Climate Change Science Program (2009)

Projections: General Effects on Greater Everglades Coastal Habitats

- Climate change and SLR will affect Greater Everglades coastal wetlands including changes to:
 - fire regime
 - rainfall accumulation
 - salinity gradients and transgression
 - sediment supply
 - peat accretion
 - nutrient cycling
 - tidal channel dynamics
- Increased sedimentation from storms may have some benefit to marshes and mangroves

From Wingard and Lorenz (2014)

Projections: Effects on Florida Bay Habitat Suitability for Fishes and Invertebrates

- Temperature increases negatively affect optimal habitat for many species
- Goldspotted killifish, pinfish, and rainwater killifish may lose optimal habitat
- Optimal habitat for lobsters increases with increasing salinity and decrease of poor habitat
- SLR and climate change may not be detrimental to all species

From Kearney et al. (2014);

Projection: Coastal Squeeze

- **Coastal squeeze** by SLR is a result of a fixed high water location by a feature and continued migration of low water mark
- Rapid SLR and coastal squeeze may reduce marsh and mangrove area and cause:
 - dispersion of fauna
 - simpler patch edges and less connected patches
 - lesser potential for food and refugia

Based on information in Torio and Chumra (2013)

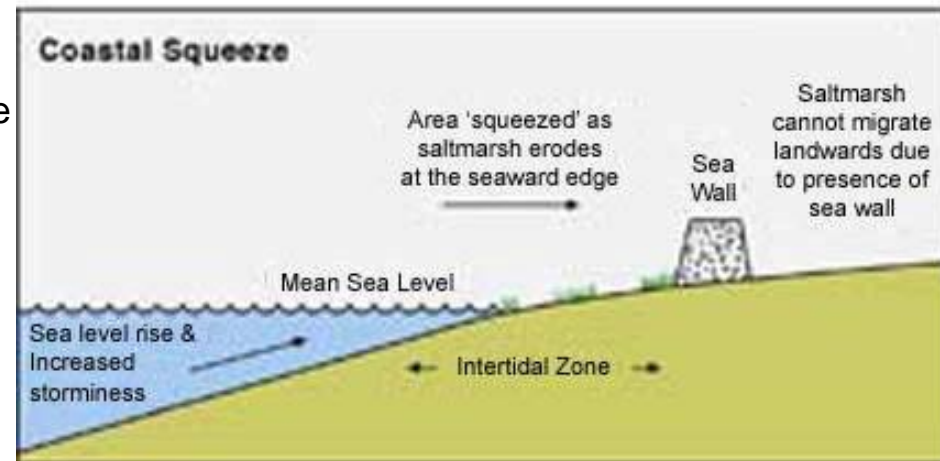
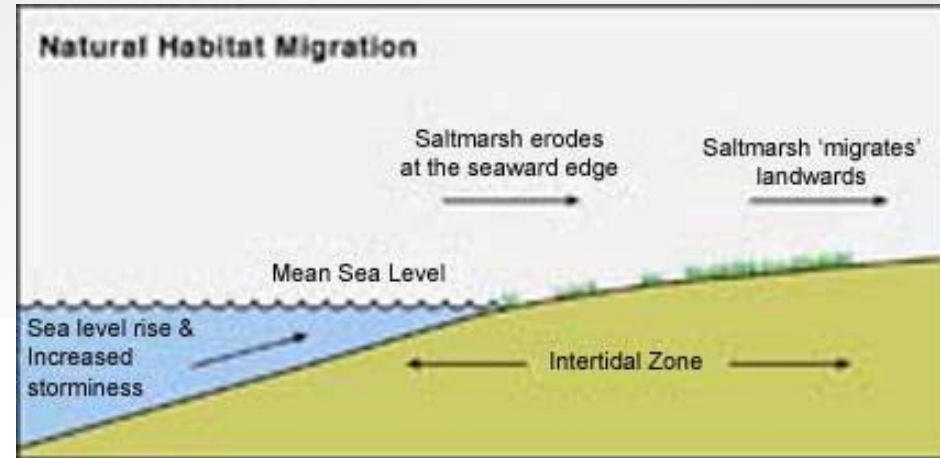


Image from Wikipedia

ISSUES OF CONCERN FOR RESOURCE MANAGEMENT

Uncertainties exist in projecting wetland vulnerability including:

- maximum sustained vertical accretion rates
- interactions and feedbacks affecting soil organic matter accretion
- spatial variability in accretion dynamics and sediment supply
- information on tidal wetland accretionary processes

ISSUES OF CONCERN FOR RESOURCE MANAGEMENT

- Loss of tidal flats and potential impacts to wetland-dependent species, particularly birds
- Reductions in SAV coverage
- Degradation of fish and shellfish production
- Impacts to marsh bird and marsh island species

Summary - Observations

- Sea level is rising in south Florida at an increasing rate
- The level of freshwater in ENP marshes is increasing
- SLR is already causing geomorphological changes in Greater Everglades coastal areas including Florida Bay
- There is uncertainty how the combined changes in sea level, coastal discharge and exchange, and geomorphology will alter coastal ecosystems

Summary - Projections

- Sea level will continue to rise
- In 2060 it will be ~9-24 in. higher than 2010 levels
- Air temperature will increase by about 1 -2 degrees C by 2050
- Rainfall and evaporation changes are somewhat uncertain
- There is increased potential for large storms
- Geomorphological changes in Florida Bay will mute some of the effects of SLR but salinity will increase and residence time in basins will be reduced

Conclusions – Issues for Resource Managers

- Observations on SLR and climate change are relatively abundant
- Most projections are based on model output which includes some uncertainty
- Information on the how the physical environment and the ecosystem will respond is lacking at this time
- Bottom line - there is considerable work to be done

Thank You!

CONCLUSIVE PROOF OF STABLE SEA LEVELS

STILL ONLY COMES
HALF-WAY UP A DUCK

