SOIL ACCRETION AND ORGANIC CARBON BURIAL OVER CENTENNIAL AND MILLENNIAL TIME SCALES ON MANGROVE ISLANDS IN THE LOWER FLORIDA KEYS

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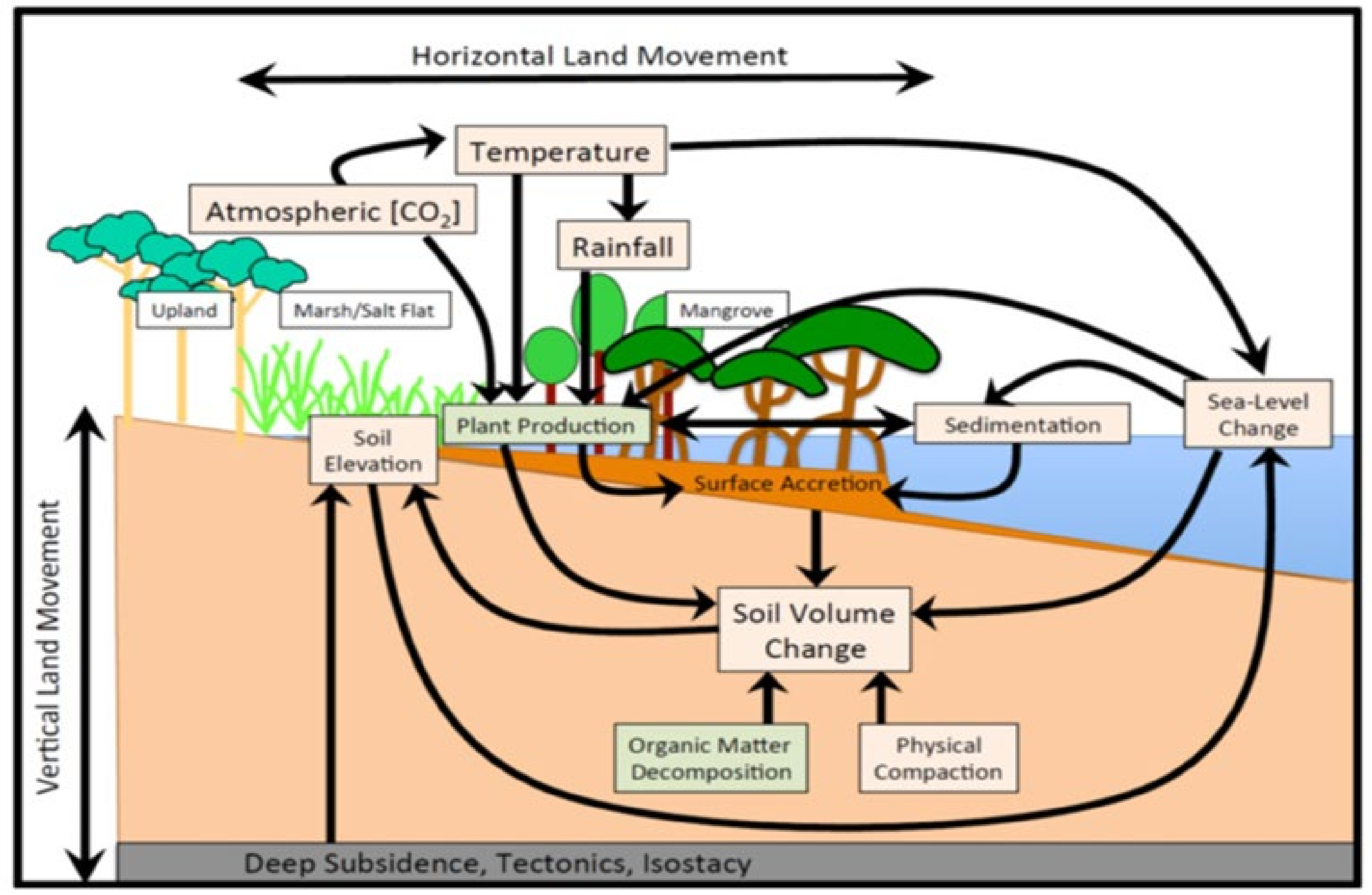
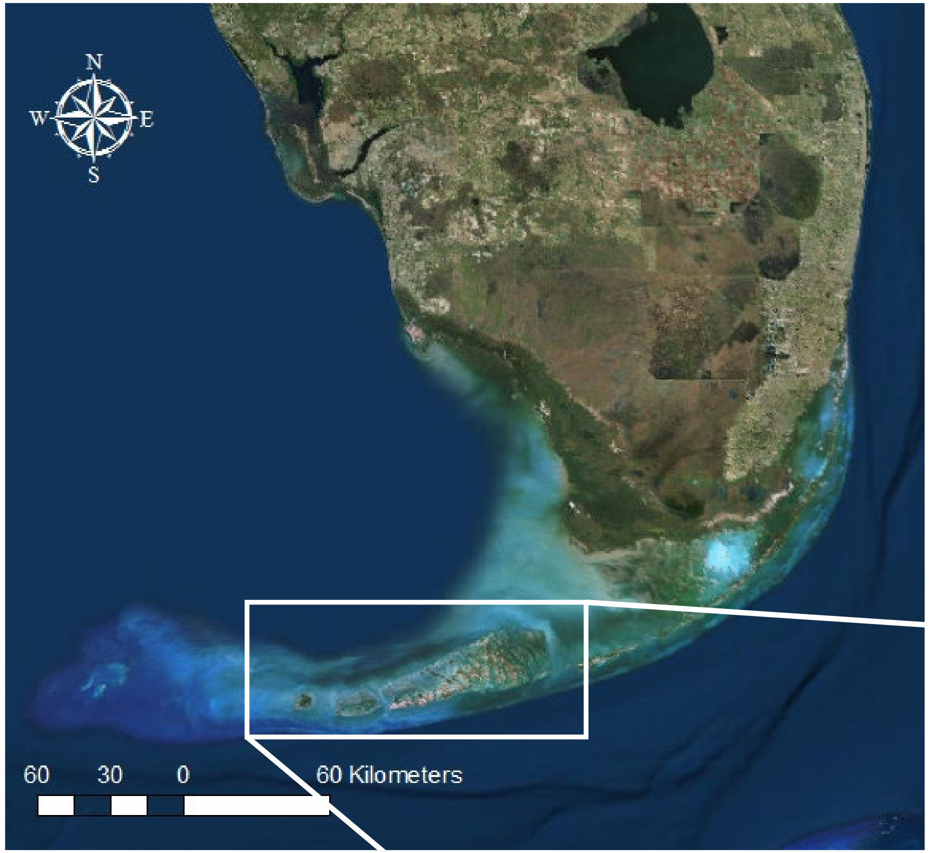
Rationale

- ❖Vertical soil accretion has kept pace with the rate of relative sea-level rise (SLR), however current rates are accelerating
- ❖Surpass observed rates of accretion
- ❖Assessing temporal variability in soil accretion and organic carbon (OC) burial rates can aid in more accurate predictions



Study area

Lower Florida Keys



Florida Keys National Wildlife Refuge Complex

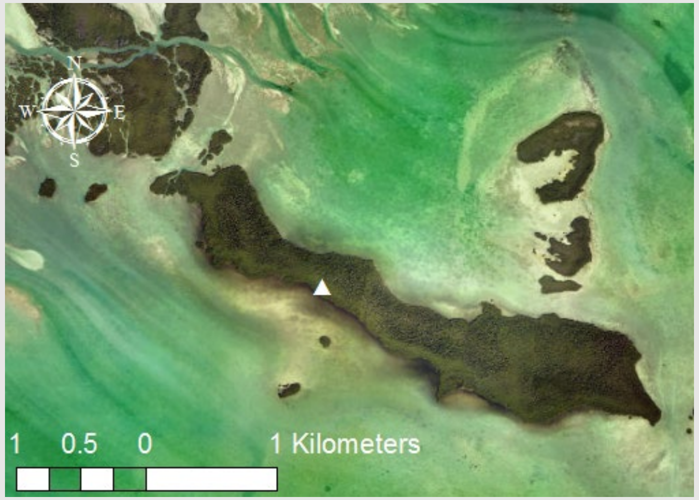
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS user community.

Coring locations

Marquesas Keys

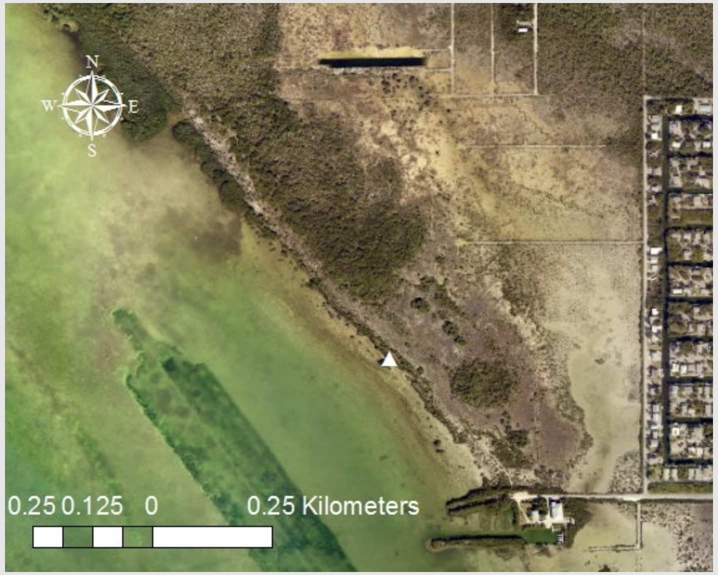
Overwash berms on exterior of island with a mangrove forest **basin** that surrounds a center lagoon

Snipe Key



Elongated island with a red mangrove forest **fringe**

Big Pine Key



Narrow mangrove **fringe**
Rapid transition to salt barren/marsh habitat
Near residential development

▲ = coring location

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS user community.

Objective

- ❖Compared temporal variability in sedimentation rates
  - ❖Soil accretion
  - ❖Organic carbon burial
- ❖Tested whether a strong nonlinearity existed temporally
- ❖Two different radiometric dating techniques
  - ❖Lead-210
  - ❖Carbon-14

Methods: Radiometric Dating

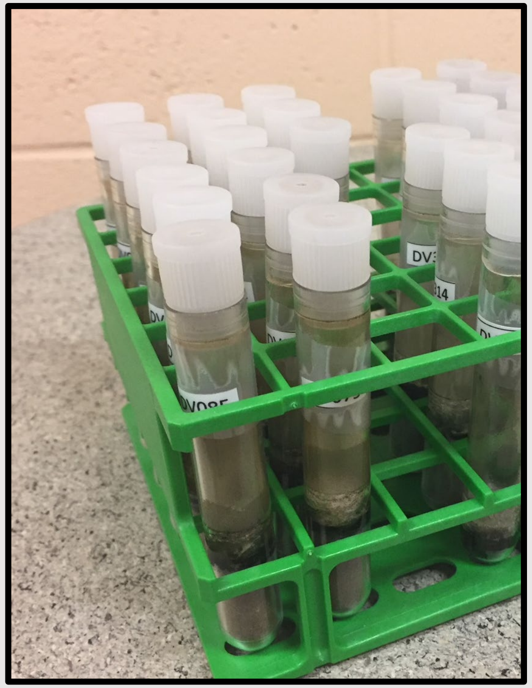
Core collection via push corer

Core extruding for gravimetric analysis

Carbon-14: macrofossils & mangrove pollen (NOSAMS)

Lead-210: Constant Rate of Supply (CRS) model

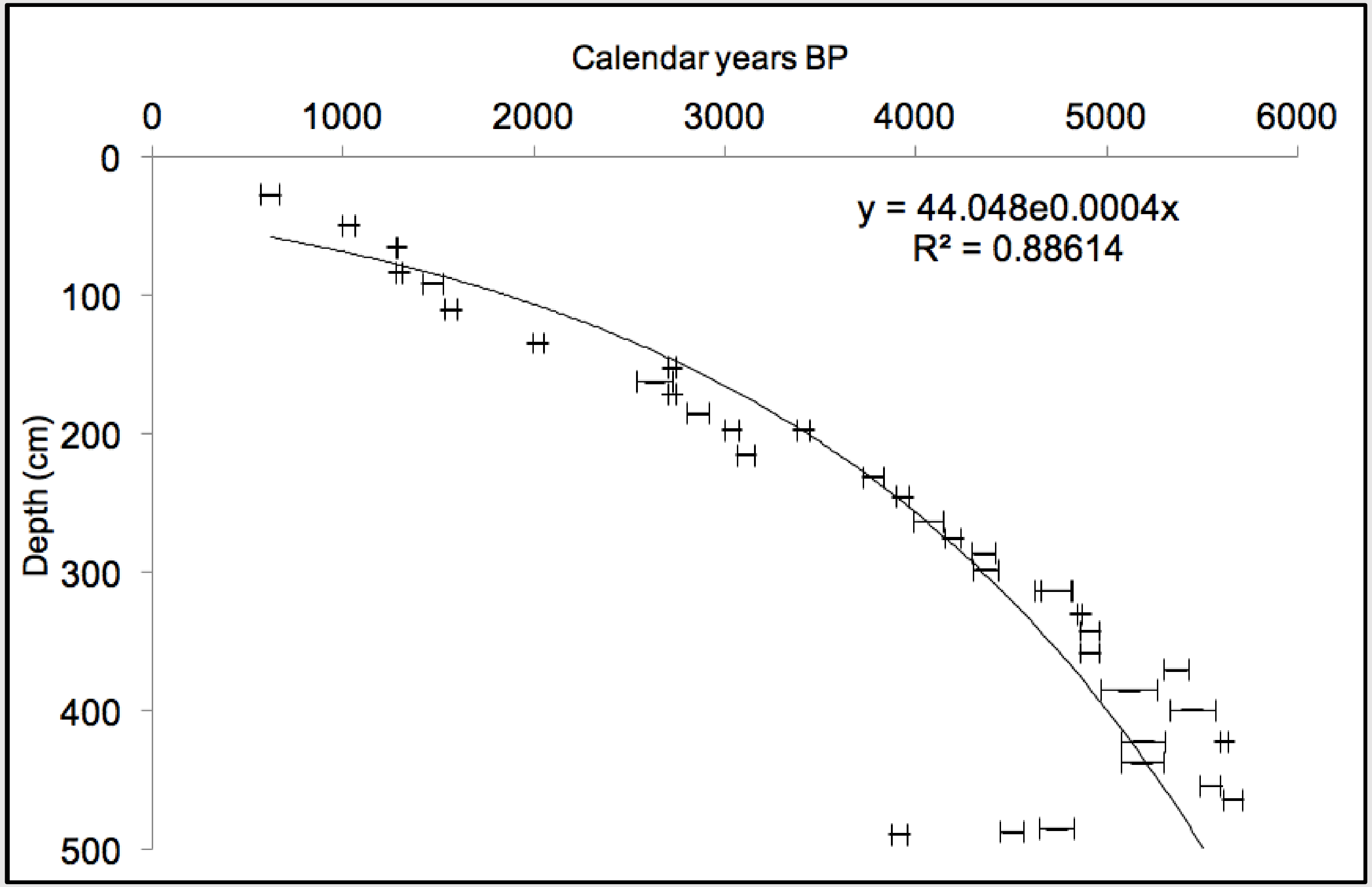
(Appleby & Oldfield 1978; Appleby 2001; Smoak et al. 2013; Breithaupt et al. 2014)



Intrinsic germanium well detector coupled to a multichannel analyzer

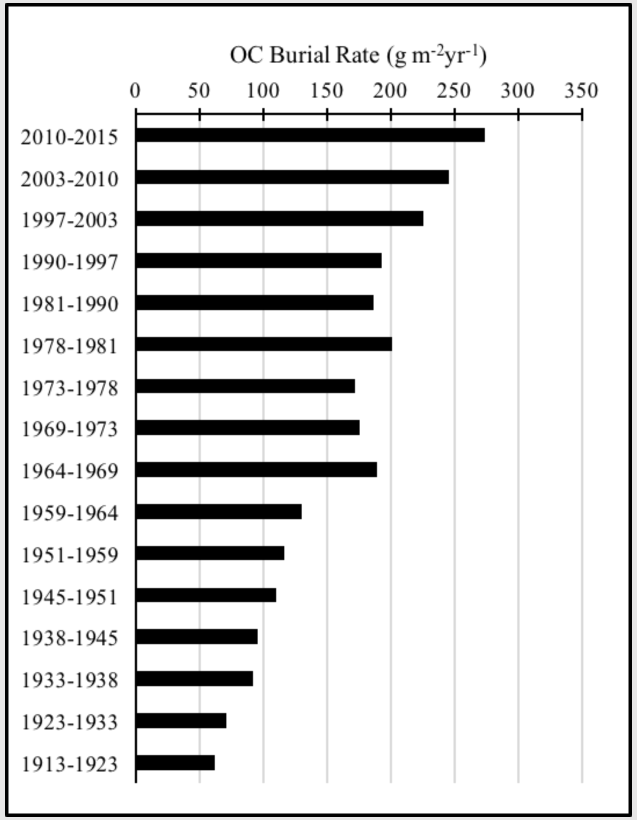
Radiocarbon age-depth model

- *In situ* peat production for approximately 6 ka BP (mid-Holocene)
- Limited age discrepancies
- Long-term accretion and OC burial rates calculated

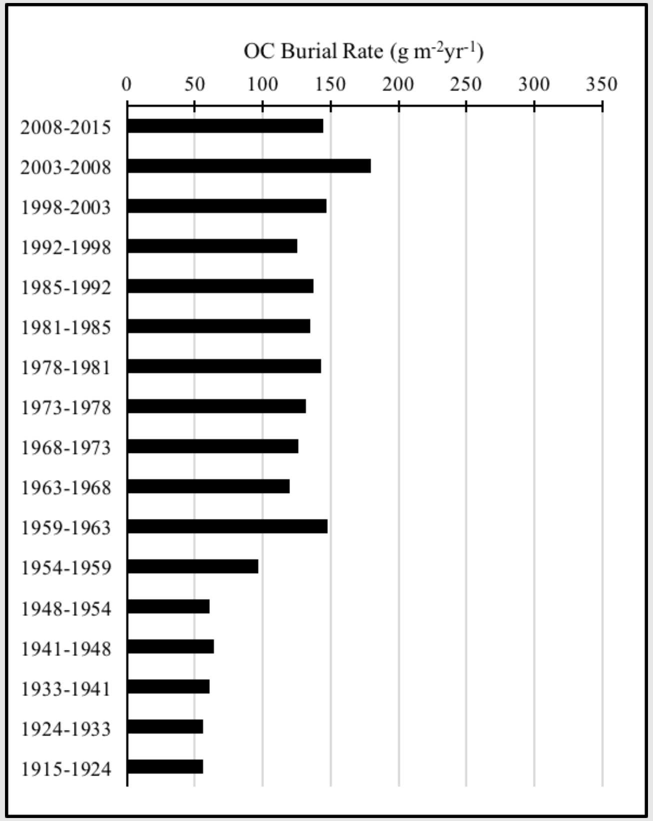


Calibrated ages: 616 ± 48.5 to 6092 ± 49.5 Cal yr BP

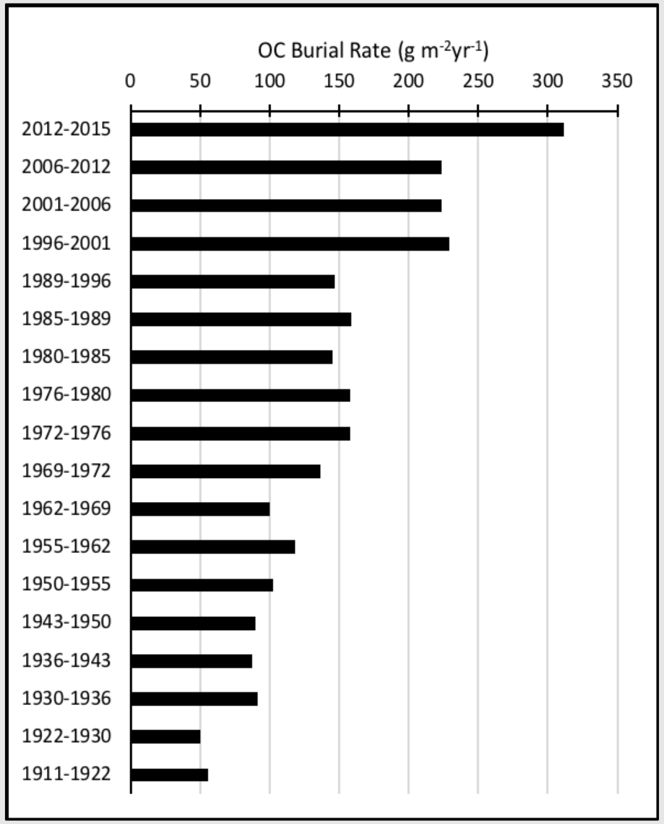
Determined: rates change over time



Marquesas Keys



Snipe Key



Big Pine Key

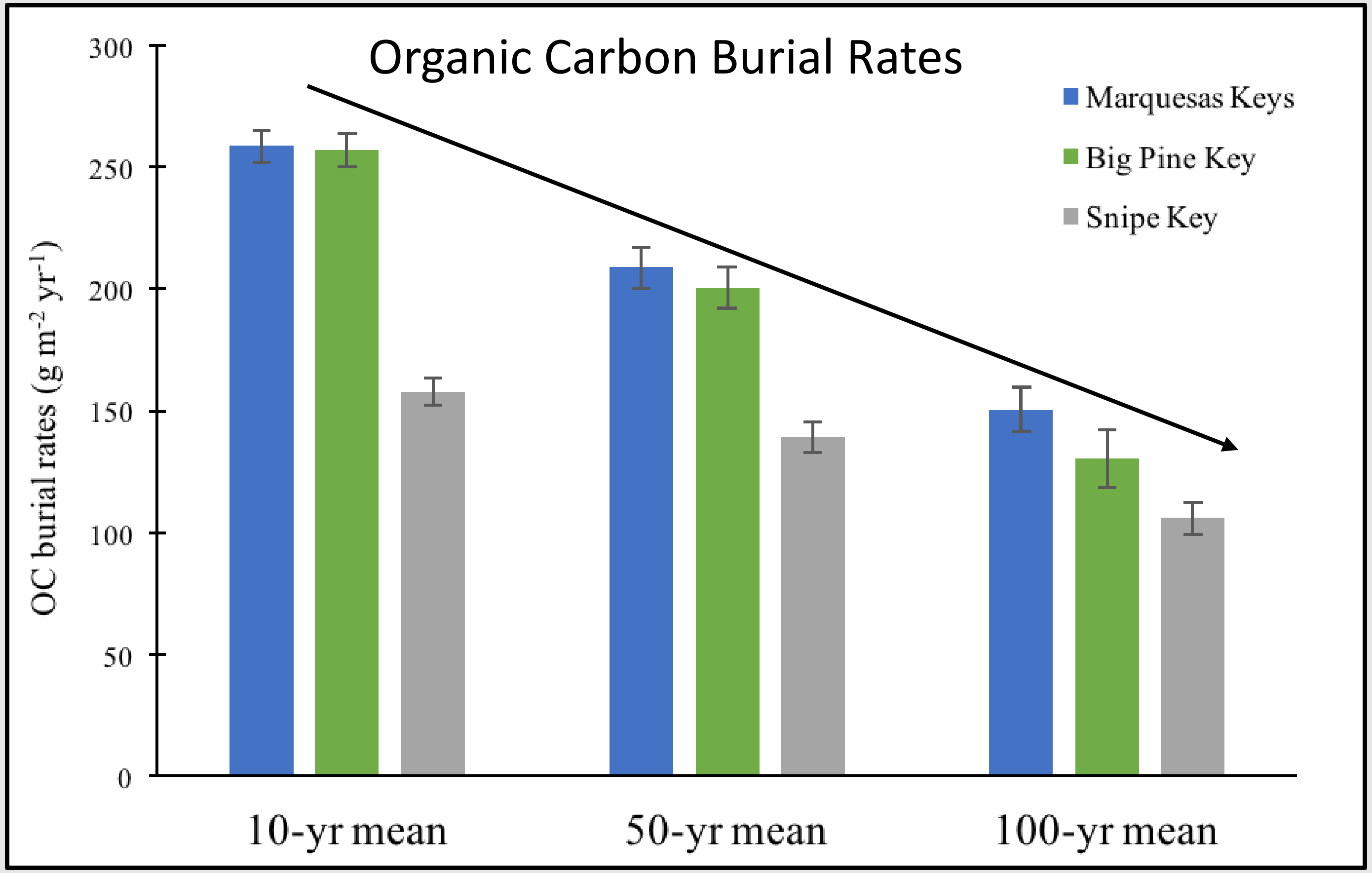
- Flux observed from one interval to the next is driven by changes to soil delivery rate and/or to soil degradation or removal rate (Zimmerman & Canuel 2000; Breithaupt et al. 2014)
- Coastal wetlands do not sequester carbon at a continuous rate (Breithaupt et al. 2012)

Organic carbon burial rates

Significant difference among timescales

100-year rates were lowest

- Changes in allochthonous input and autochthonous production
  (Breithaupt et al. 2012; Smoak et al. 2013; Breithaupt et al. 2014)
- Post-deposition transformations
  (DeLaune et al.1994; Parkinson et al. 1994; Kirwan & Megonigal 2013; Morris et al. 2016; Parkinson et al. 2017; Breithaupt et al. 2018)
- Changes in rates of SLR
  - Impact soil chemistry

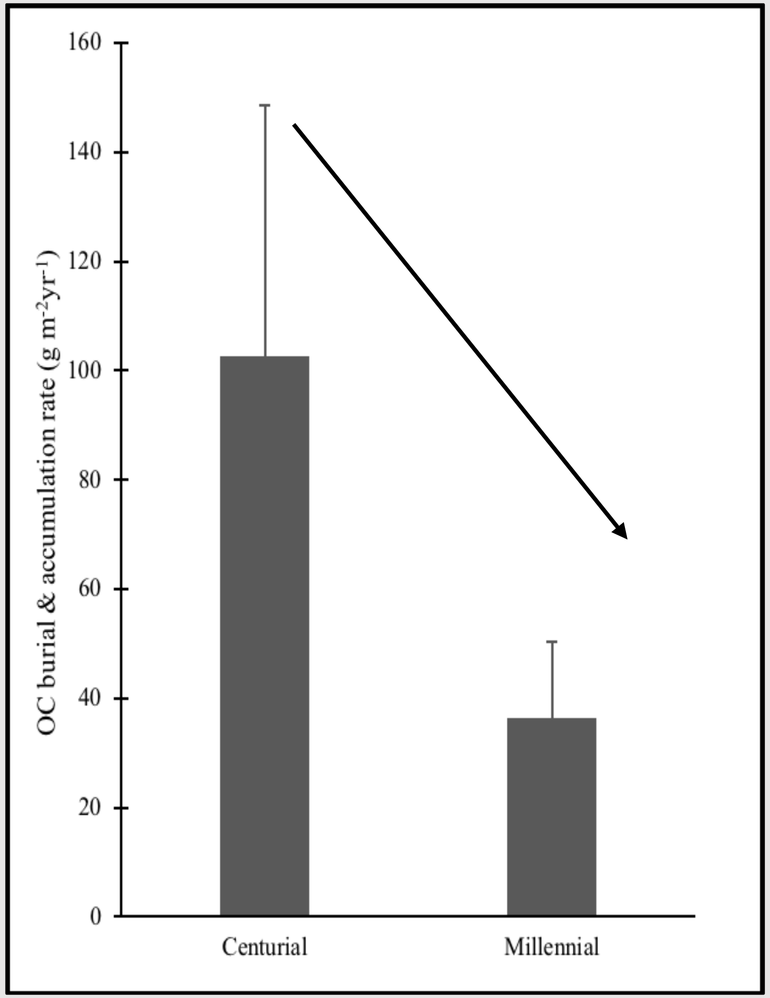


Centennial vs. millennial rates

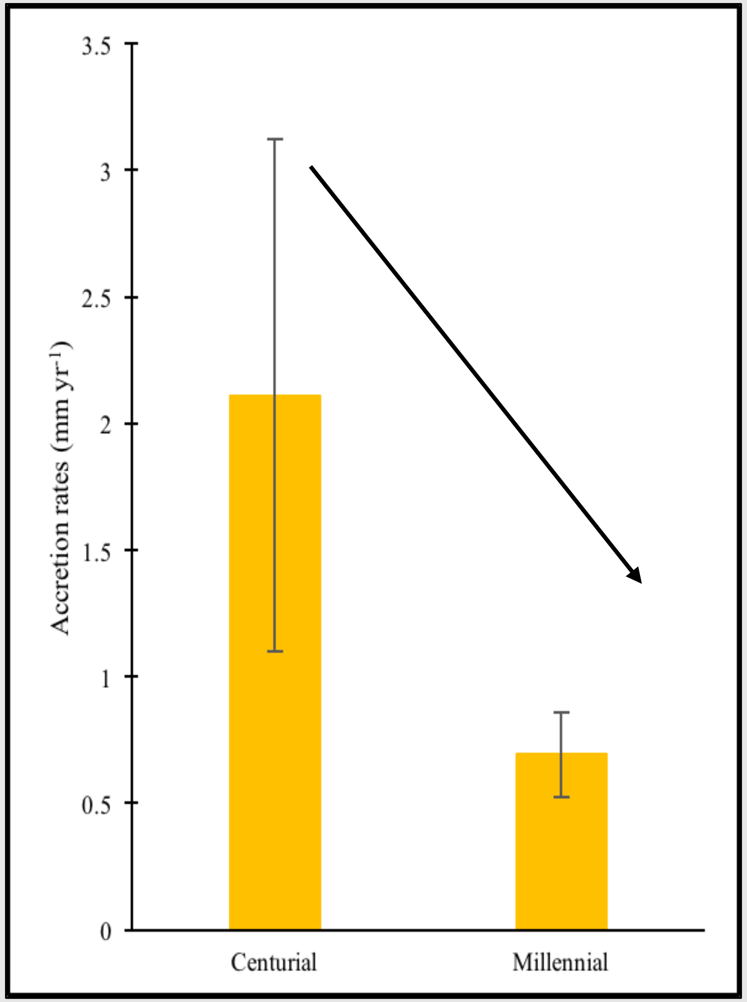
Millennial rates lower than centennial rates

- Feedback mechanisms happen over different timescale and change over time (Breithaupt et al. 2018)
  - Soil degradation
  - Microbial diagenesis
  - Nutrient reservoir & pump (Holguin et al. 2001; Dittmar et al. 2006; Chambers et al. 2011; Adame & Lovelock 2011; Maher et al. 2013; Breithaupt et al. 2018)
- Adjusting to sea-level rise?
  - Direct relationship with accretion rates (Kirwan & Megonigal 2013; Krauss et al. 2014; Woodroffe et al. 2016; Breithaupt et al. 2018)

Organic carbon burial rates

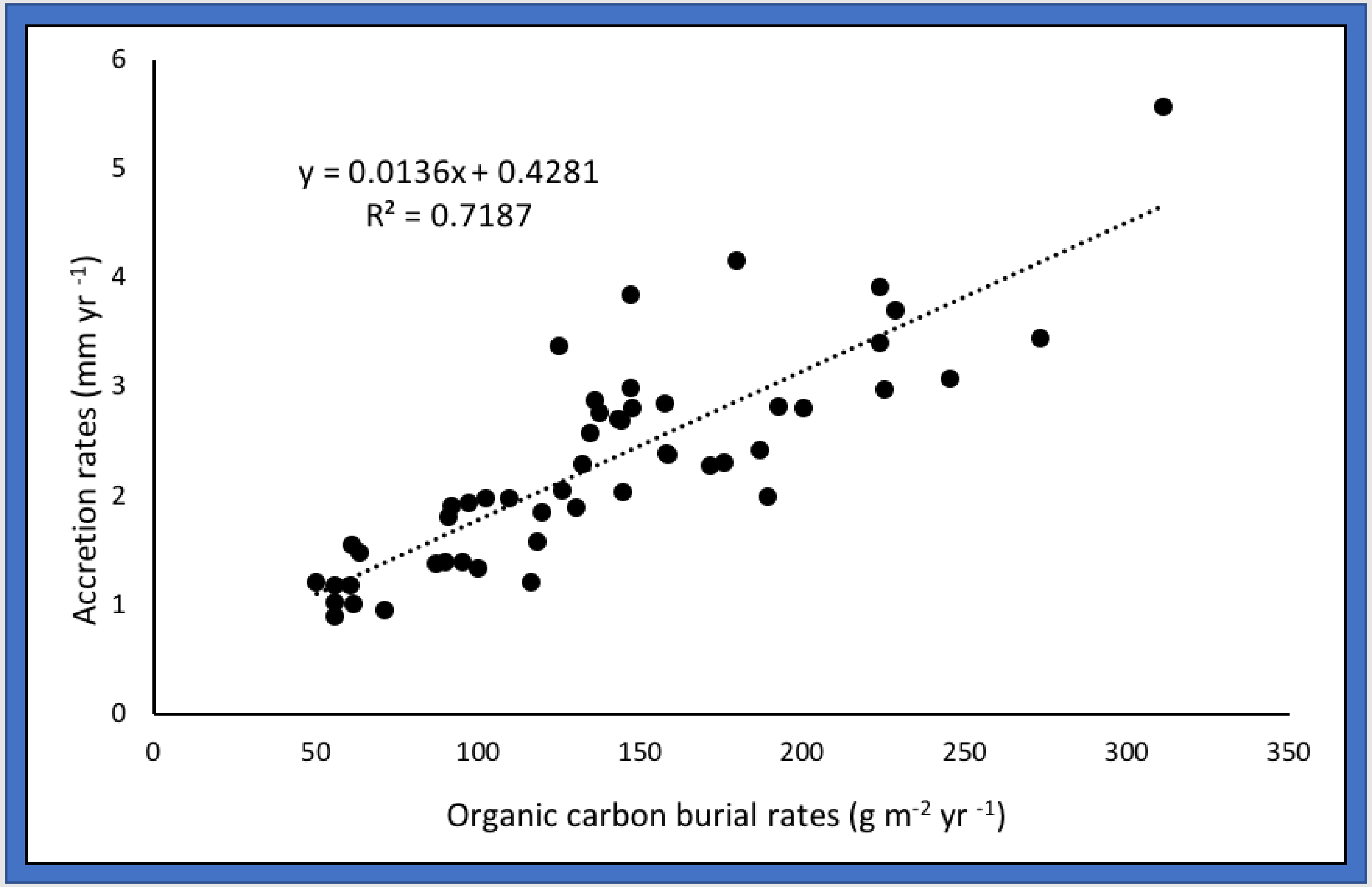


Accretion rates



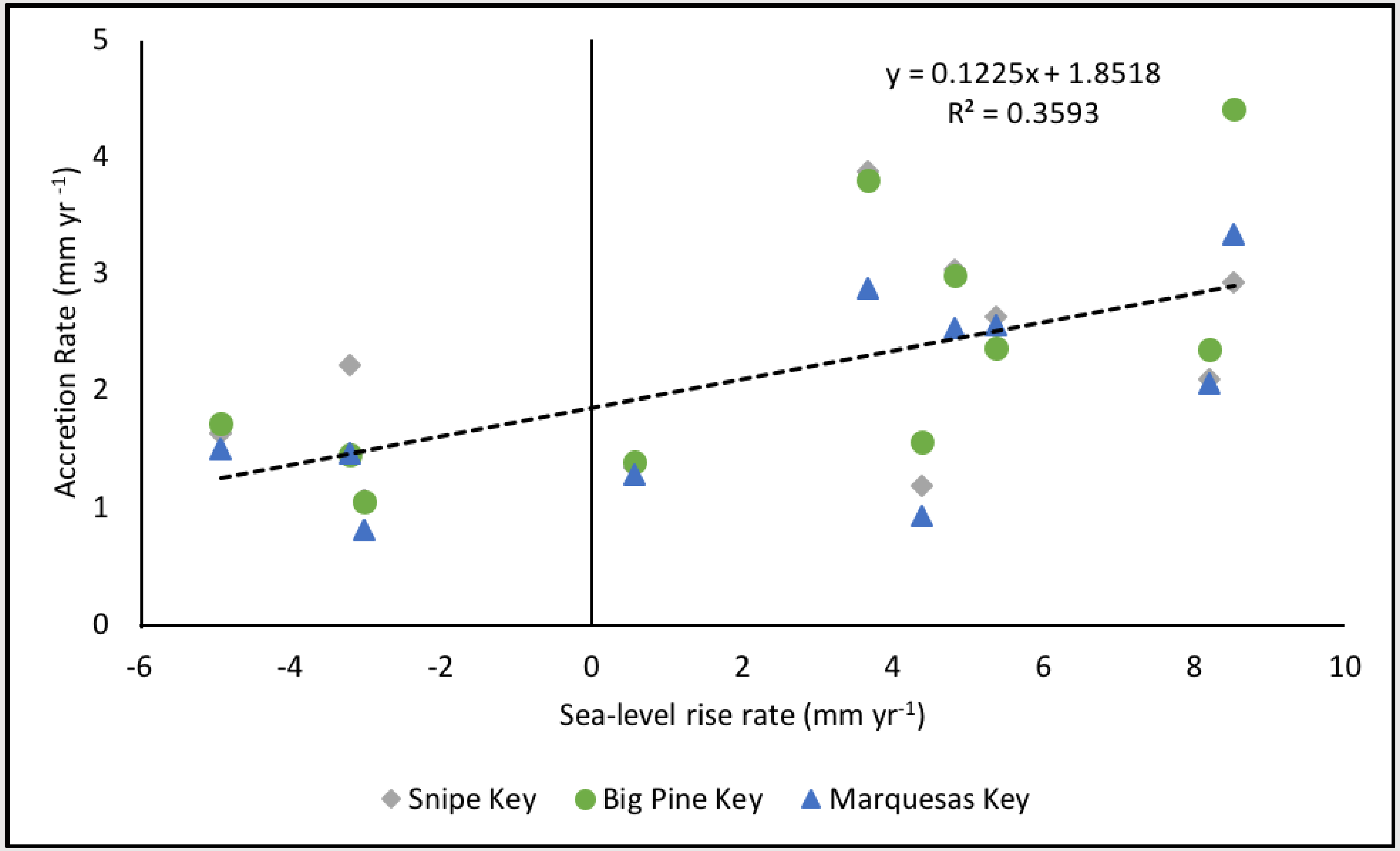
Organic carbon burial and accretion rates

- Organic carbon makes up 1/3 of soil organic matter (SOM)
- Significant relationship between OC burial and accretion rates
- SOM found as a driver of accretion rates (Breithaupt et al. 2017)
- *In situ* OC production induces soil accretion
  - Both influenced by SLR



Adjusting to increased rates of SLR?

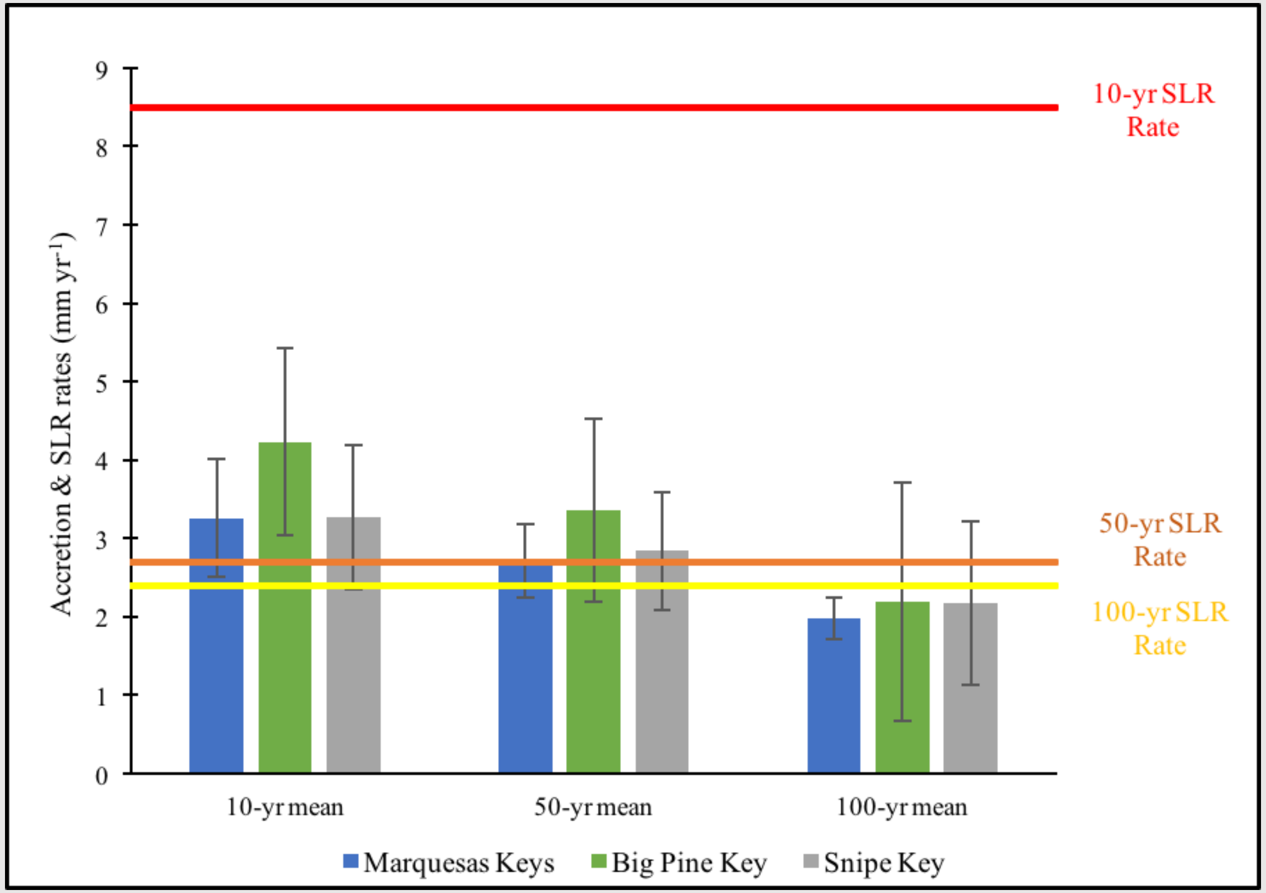
- Significant relationship exists between sea-level rise and accretion rates
- Low R^2 value
  - Lag between accretion rates adjusting to SLR rates?
- Relatively small data set
  - Need to build on this data from other sites in SW Florida



Regression analysis $R^2 = 0.36$; $p < 0.0001$

Accretion rates

Compared to rates of sea-level rise



Accretion rates falling below necessary vertical change to avoid submergence

- Direct relationship exist (Kirwan & Megonigal 2013; Krauss et al. 2014; Woodroffe et al. 2016; Breithaupt et al. 2018)
- The 50- and 100-yr mean accretion rates were within error of the 50- and 100- yr rates of SLR
- An increase in the mean rate of SLR in the most recent decade support a trend of acceleration (Wdowinski 2016)
- Tidal range 1 m (Key West tide gauge)

Conclusion

- ❖Mangrove peat has been deposited in the Florida Keys since mid-Holocene
- ❖Sediment delivery and soil preservation change over time
- ❖Significant difference among timescales
- ❖Caution necessary when comparing rates of different timescales
- ❖Centennial rates are most representative
- ❖Accretion rates are not keeping pace with most-recent decadal rate of SLR

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