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science for a changing world

Florida's History in Context: Past Patterns of Climate Change and Ecological Responses to Change

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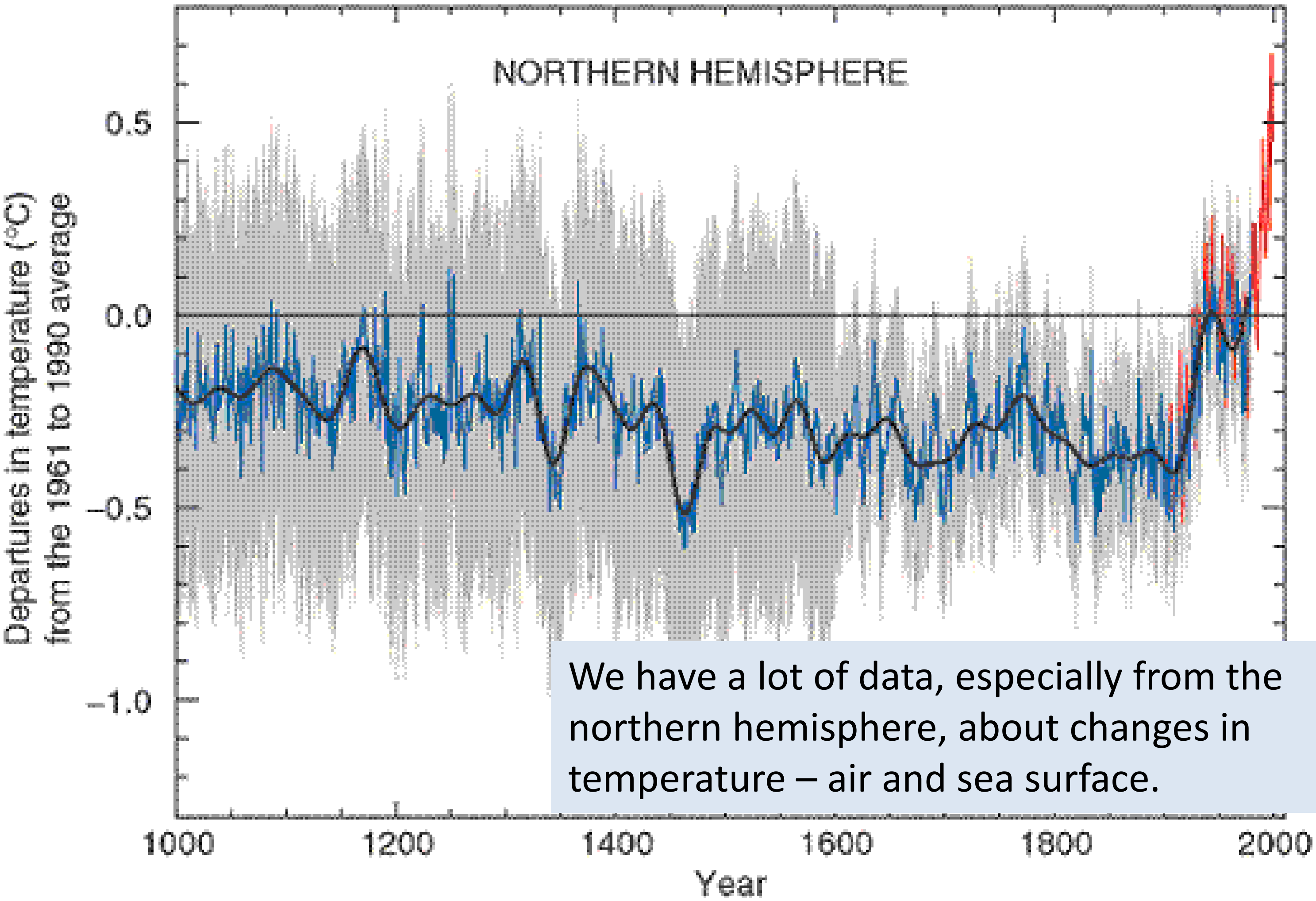
What do we know about past climate?



We have a lot of data, especially from the northern hemisphere, about changes in temperature – air and sea surface.

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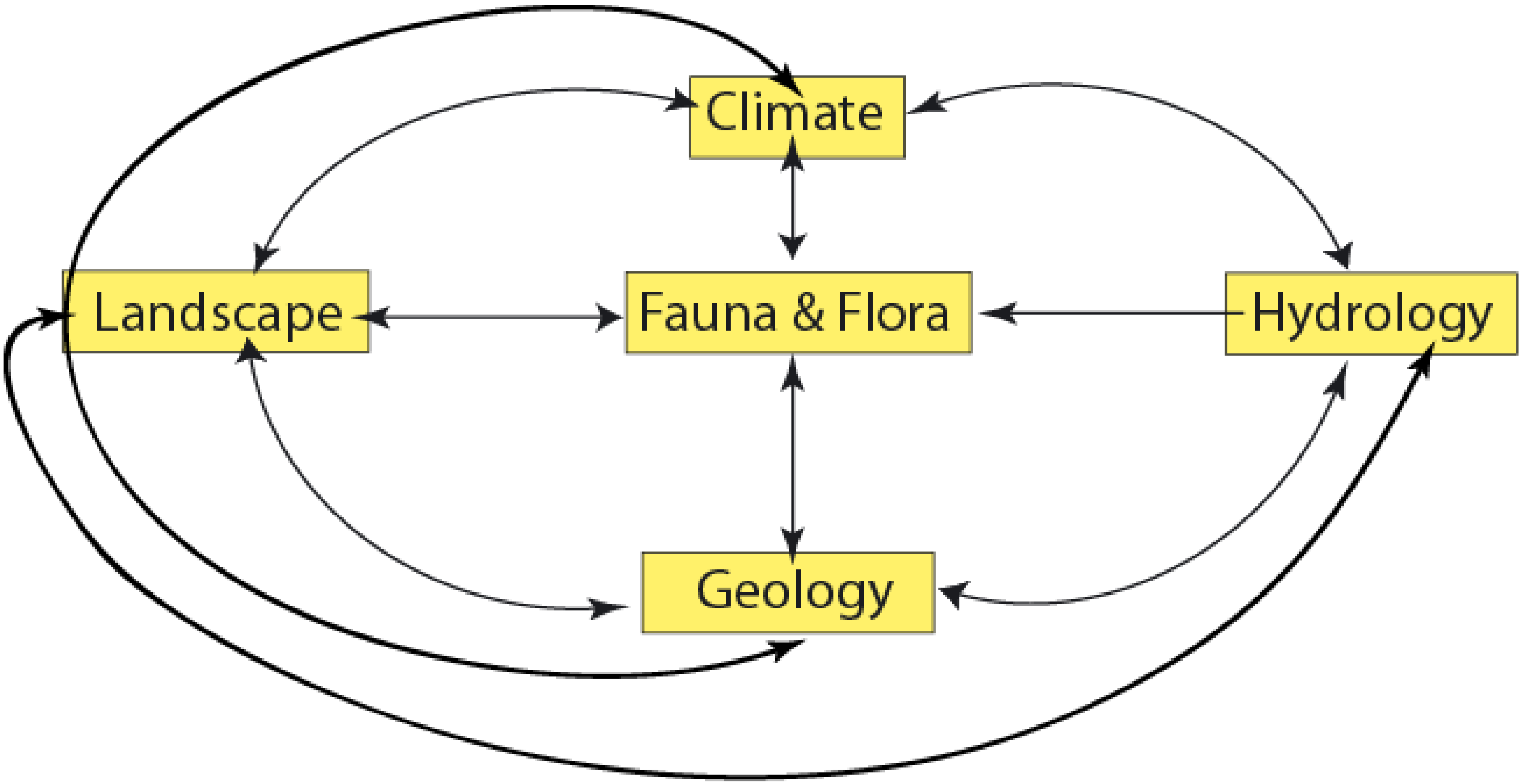
What do we know about ecological responses to climate change?

Difficult to isolate effects of climate change

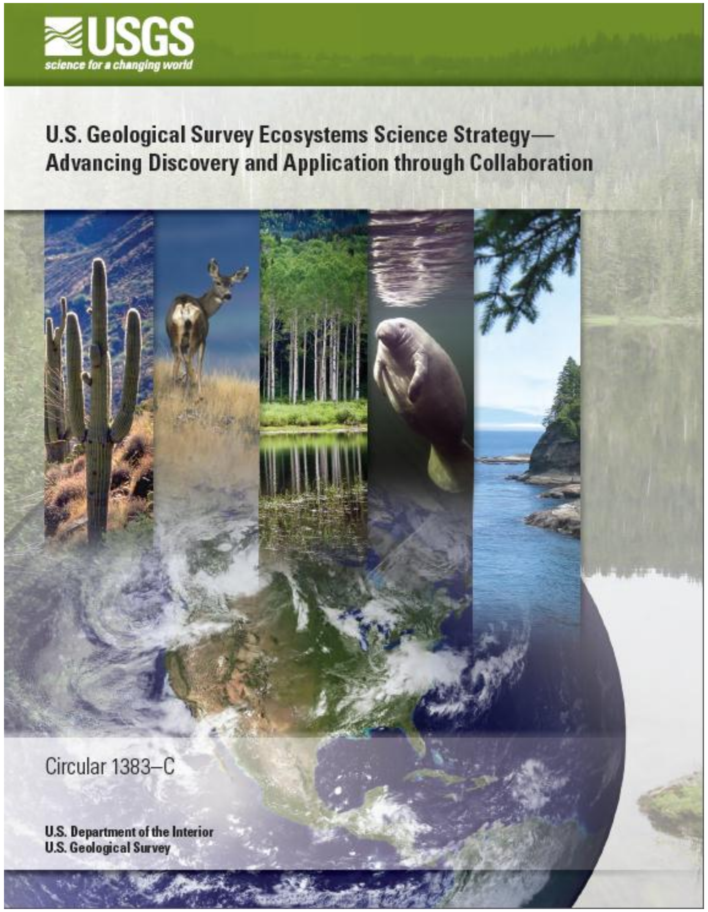


What do we know about ecological responses to climate change?

A lot of paleoecologic and ecological data exist about biotic responses to change

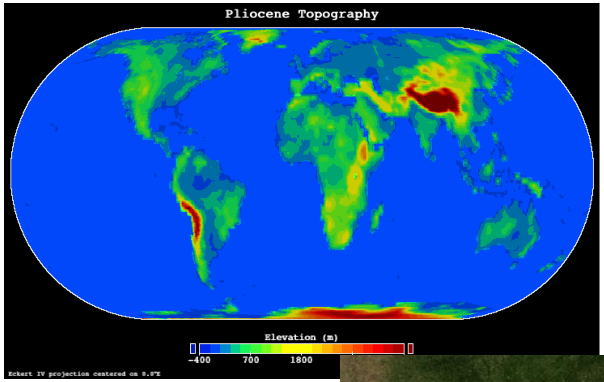
Problem – it hasn't been compiled, synthesized and analyzed in the same way that the physical data (temperature, rainfall, CO2, etc.) have been to show cross-ecosystem / regional scale responses to change

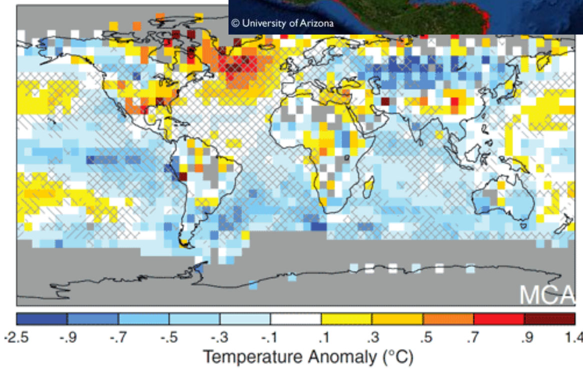
Part of USGS Science plans for Ecosystems and Climate Change Mission Areas over next decade



Three Past Analogs of a Warmer Earth

- Mid-Pliocene
  - 3.3 to 2.9 million ybp
- Pleistocene
  - last interglacial –
    130,000 to 120,000 ybp
- Medieval Warm Period +
  - 950-1250 CE
  - Followed by LIA -
    1400-1700 CE
  - Look at detailed 1000 year
    record of change





Analog 1 – Mid-Pliocene

3.3 to 2.9 myr bp

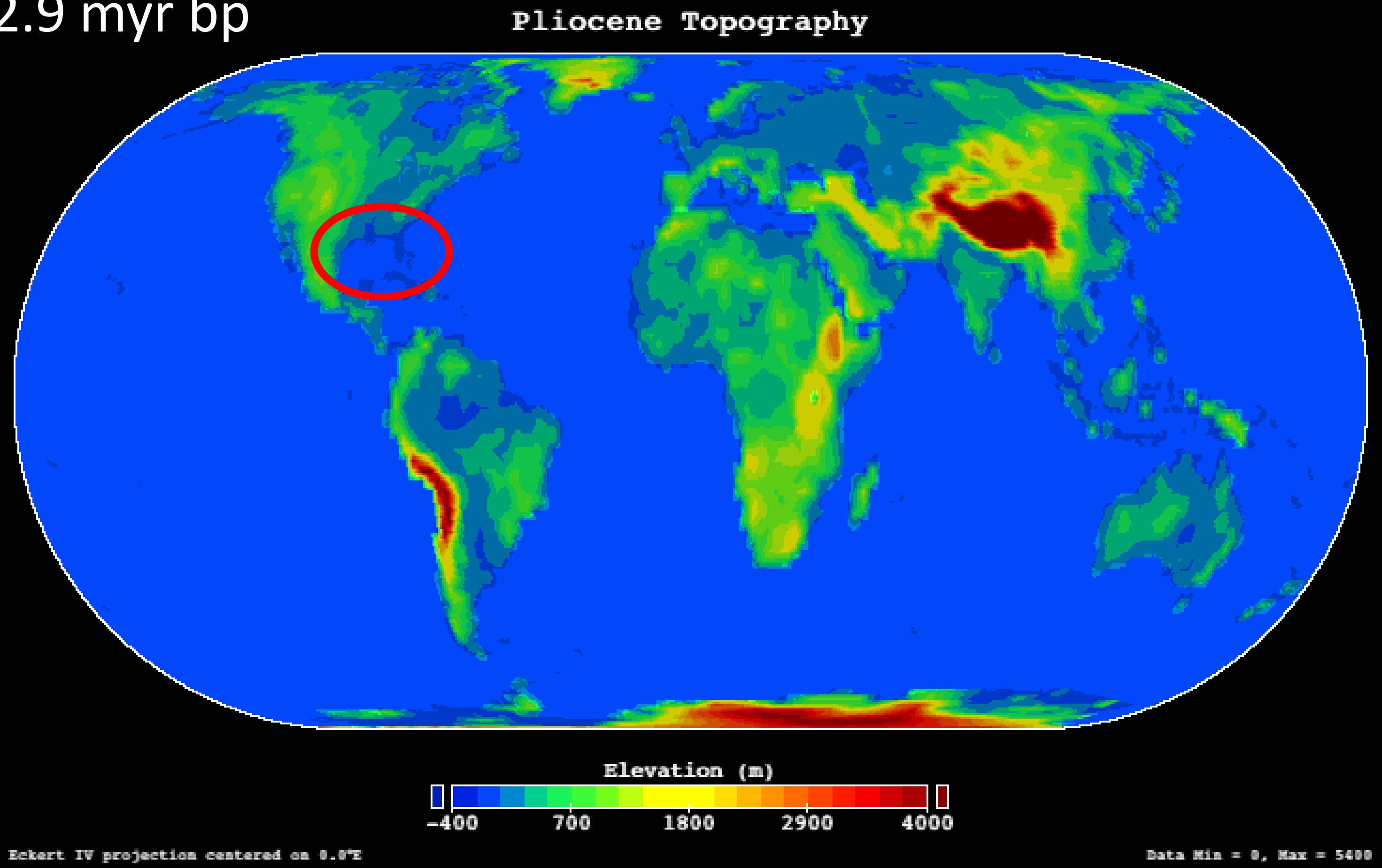
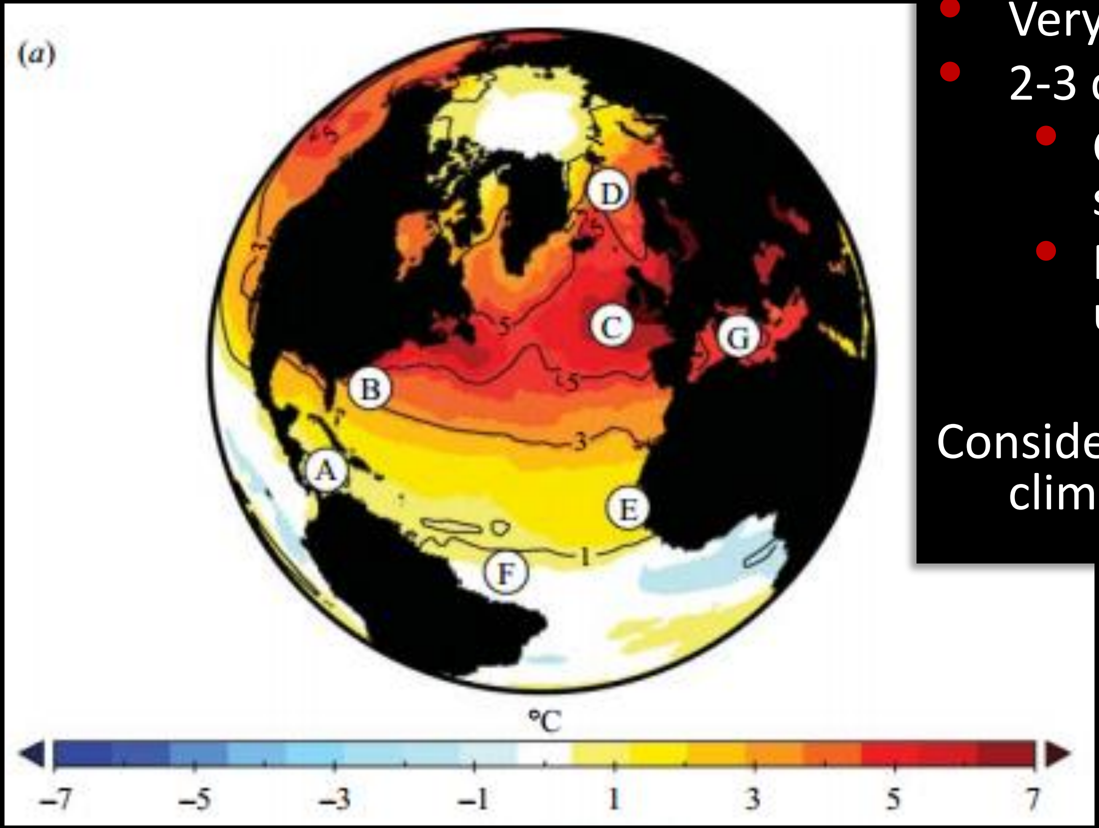


Image courtesy of USGS PRISM Project, H. Dowsett

Analog 1 – Mid-Pliocene

3.3 to 2.9 myr bp



Sea Surface Temperature (SST) Anomaly Relative to Present

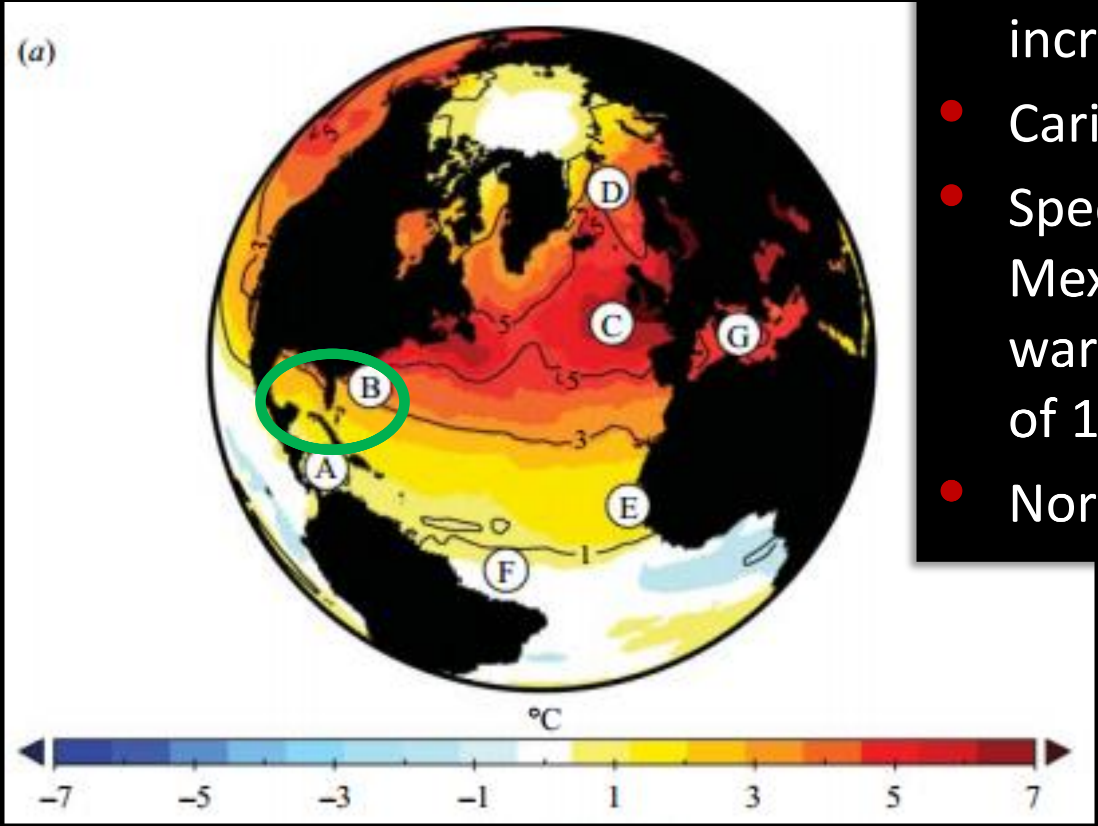
Compared to present:

- Very little ice cover – SL 25 m higher
- 2-3 deg C warmer
  - Climate difference most significant in polar regions
  - Florida peninsula – essentially underwater

Considered best analog to predicted climate of 2nd half of 21st century

Analog 1 – Mid-Pliocene

3.3 to 2.9 myr bp



Sea Surface Temperature (SST) Anomaly Relative to Present

SST anomalies relative to present increase with latitude:

- Caribbean SST – 1 deg C warmer
- Specific sites in Florida and Gulf of Mexico show no evidence of SST warming or possibly slight cooling of 1 deg C
- North Atlantic sites SST > 3 deg C

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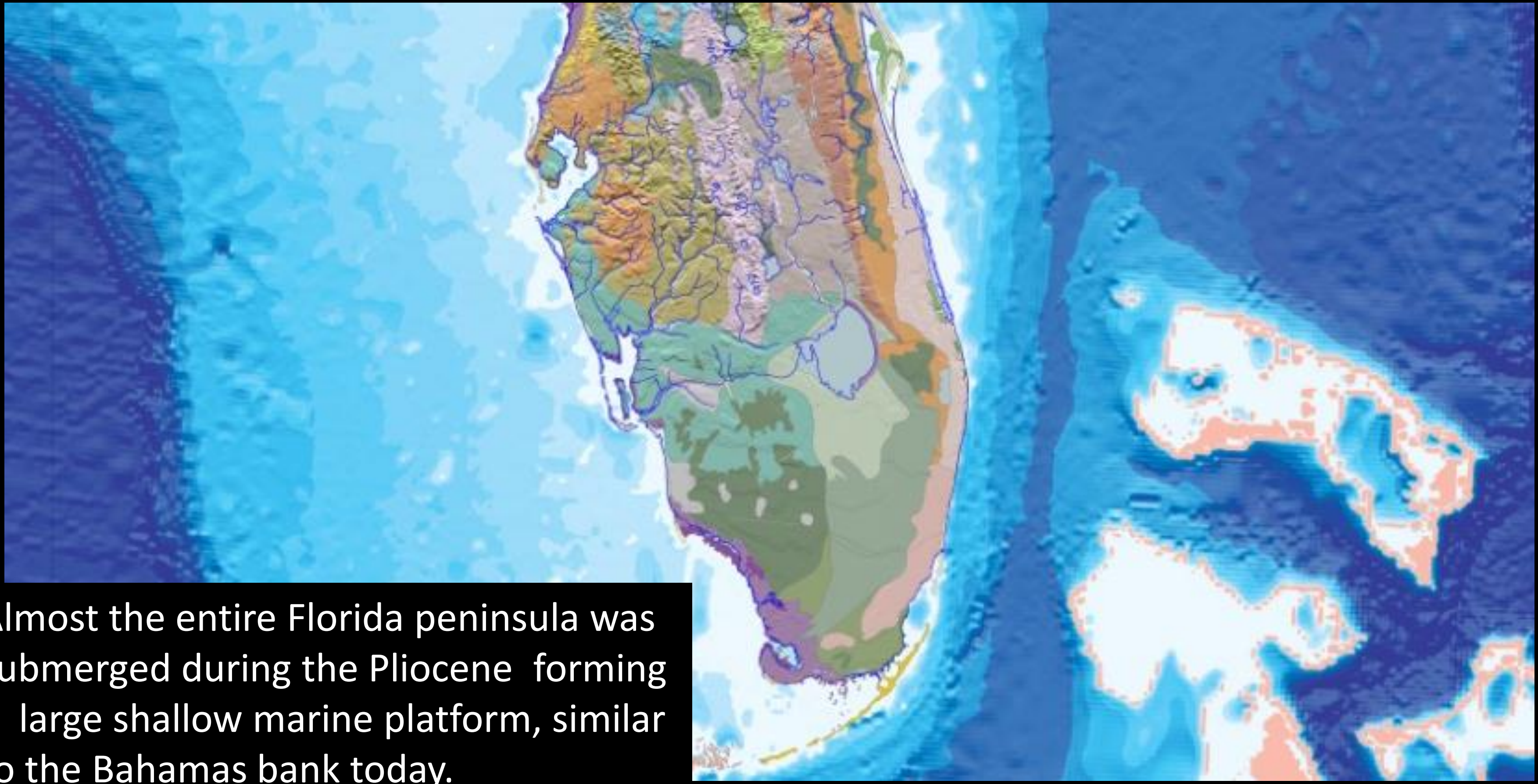
Dowsett et al. 2009 Phil. Trans. Royal Soc, v 367

Analog 1 – Mid-Pliocene



Almost the entire Florida peninsula was submerged during the Pliocene forming a large shallow marine platform, similar to the Bahamas bank today.

Analog 1 – Mid-Pliocene

Benthic Invertebrates "remarkably similar"

Analog 1 – Mid-Pliocene

Modern

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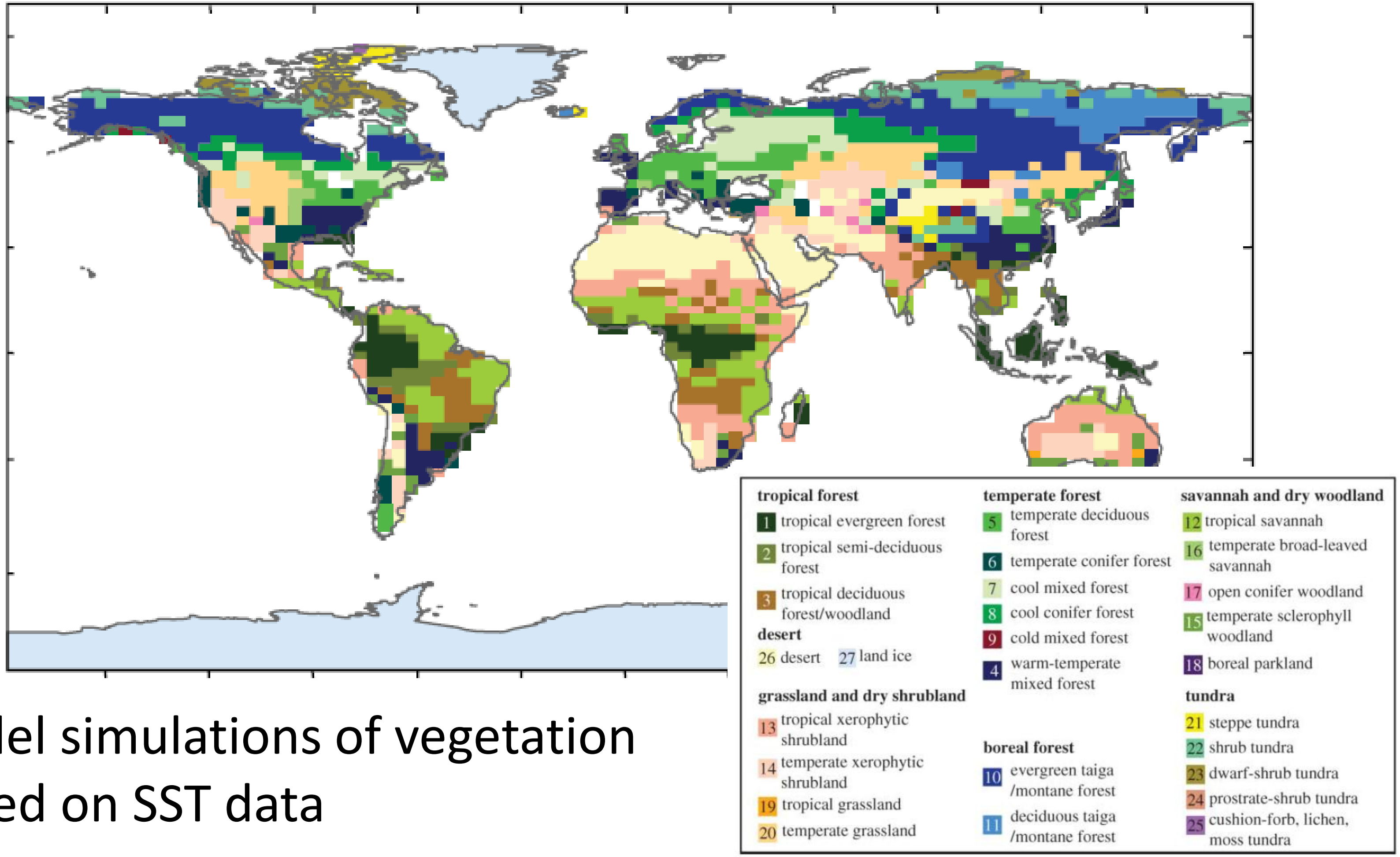
Analog 1 – Mid-Pliocene

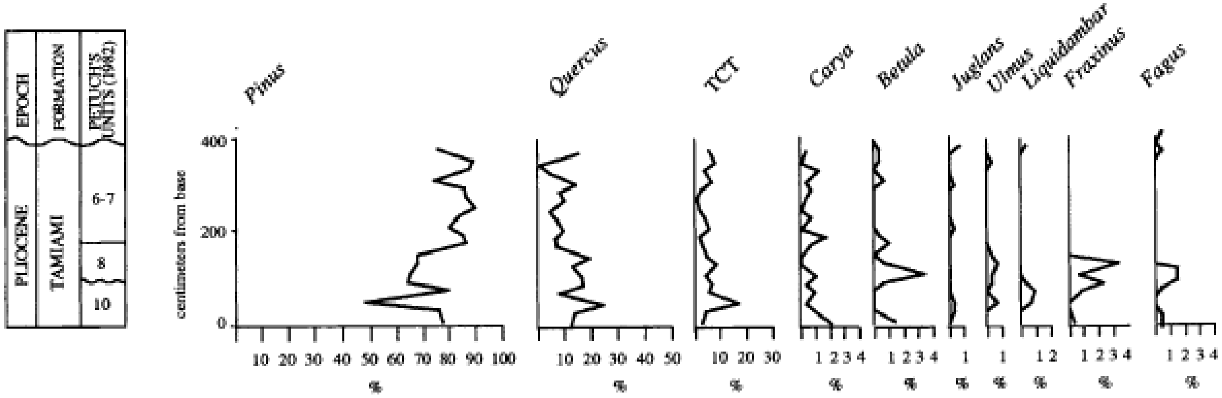


Model simulations of vegetation based on SST data

Salzmann et al. 2009 Phil. Trans. Royal Soc, v 367

Analog 1 – Mid-Pliocene

Analysis of pollen assemblages from Mid-Pliocene sites in Florida indicates where there was terrestrial habitat, it was very similar to today - slash and longleaf pine dominated forests

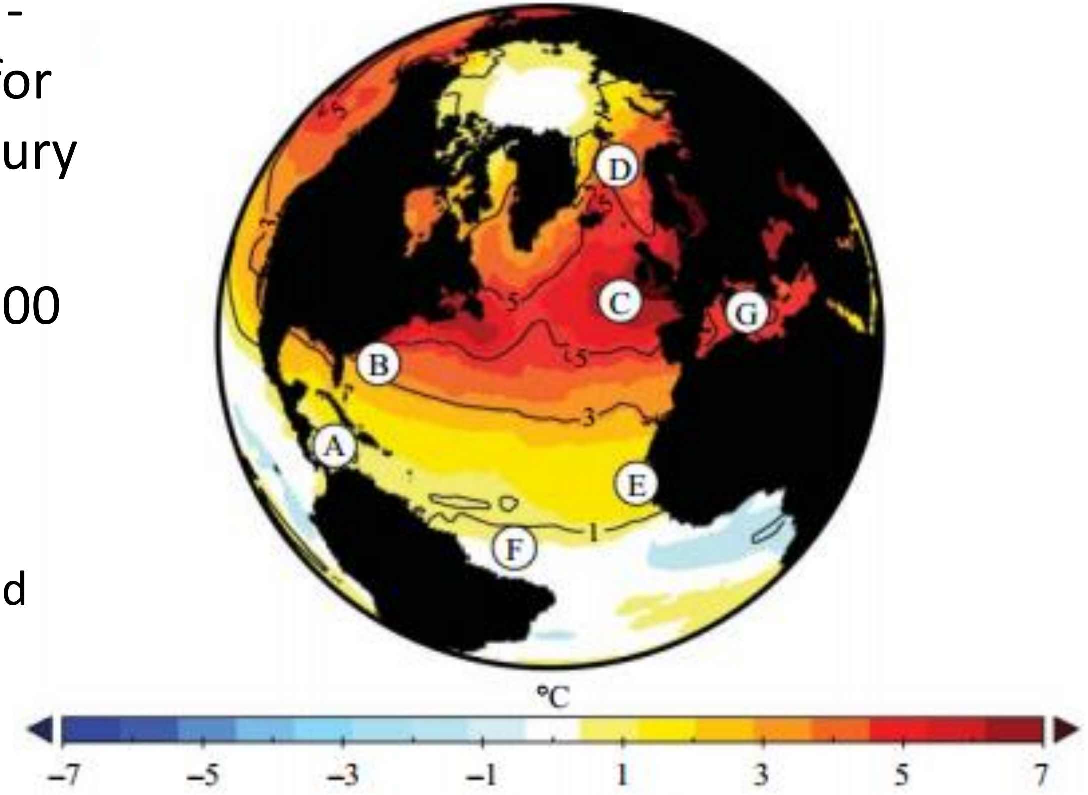


Willard 1994 Rev. Paleobotany & Palynology v 83

What does Mid-Pliocene tell us?

- Globally warmer air and SST - similar to what is predicted for the 2nd half of the 21st century
- Very high sea levels – higher than most predictions for 2100
- Ecologically –
  - No substantial differences in benthic invertebrate faunal composition of Caribbean and Gulf of Mexico
  - No substantial differences in terrestrial plants

3.3 to 2.9 myr bp



Sea Surface Temperature (SST) Anomaly Relative to Present

Dowsett et al. 2009 Phil. Trans. Royal Soc, v 367

Analog 2 – The Last Interglacial

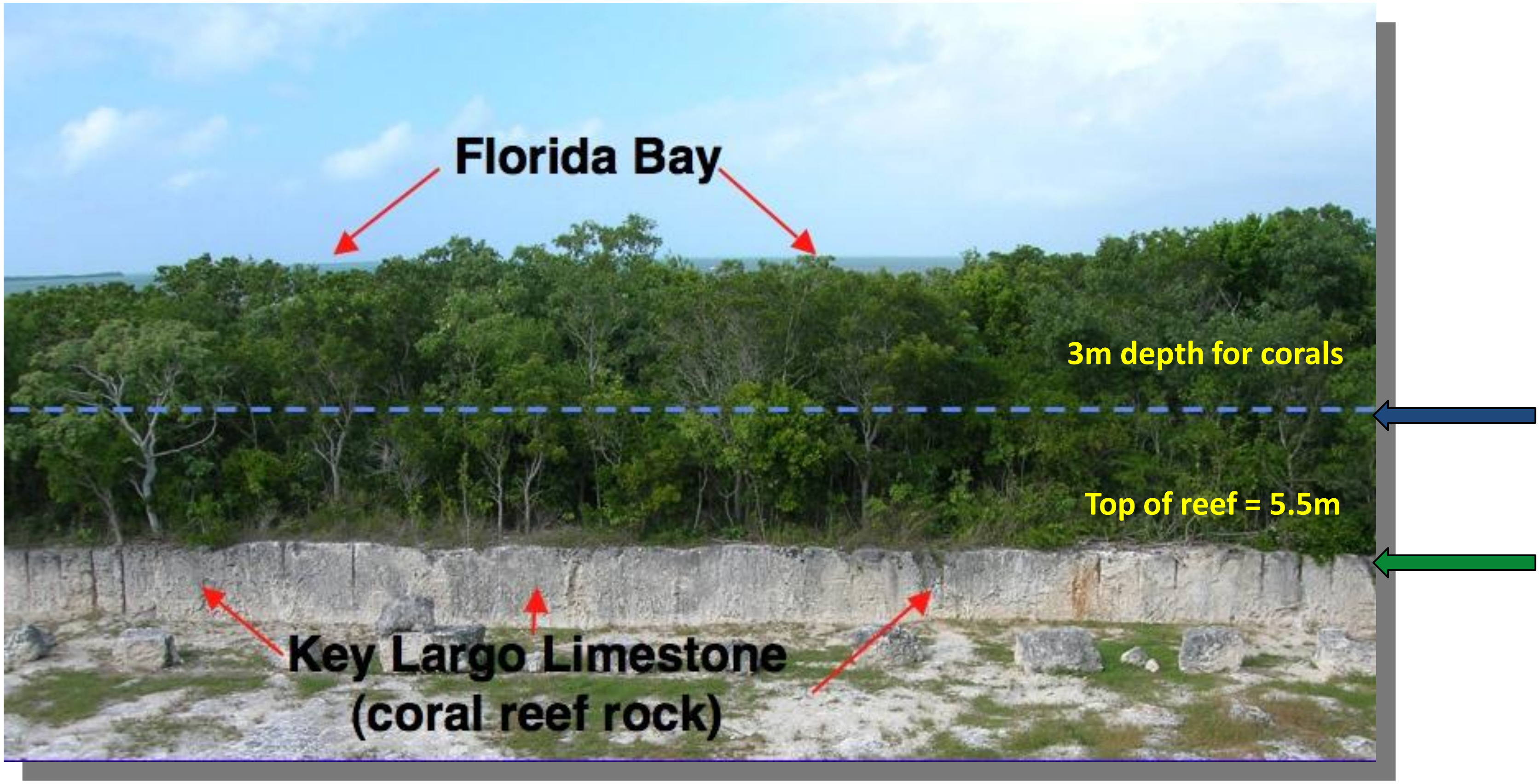
130,000 to 120,000 ybp

- **Sea level was ~ 6-8 meters higher**
- **Probably due to partial melting Greenland Ice Sheet and part of West Antarctic Ice Sheet**

Analog 2 – The Last Interglacial

130,000 to 120,000 ybp

Windley Key Quarry, Florida



Paleo-sea level = 5.5 m + 3.0 m = 8.5 m above present

Analog 2 – The Last Interglacial

130,000 to 120,000 ybp

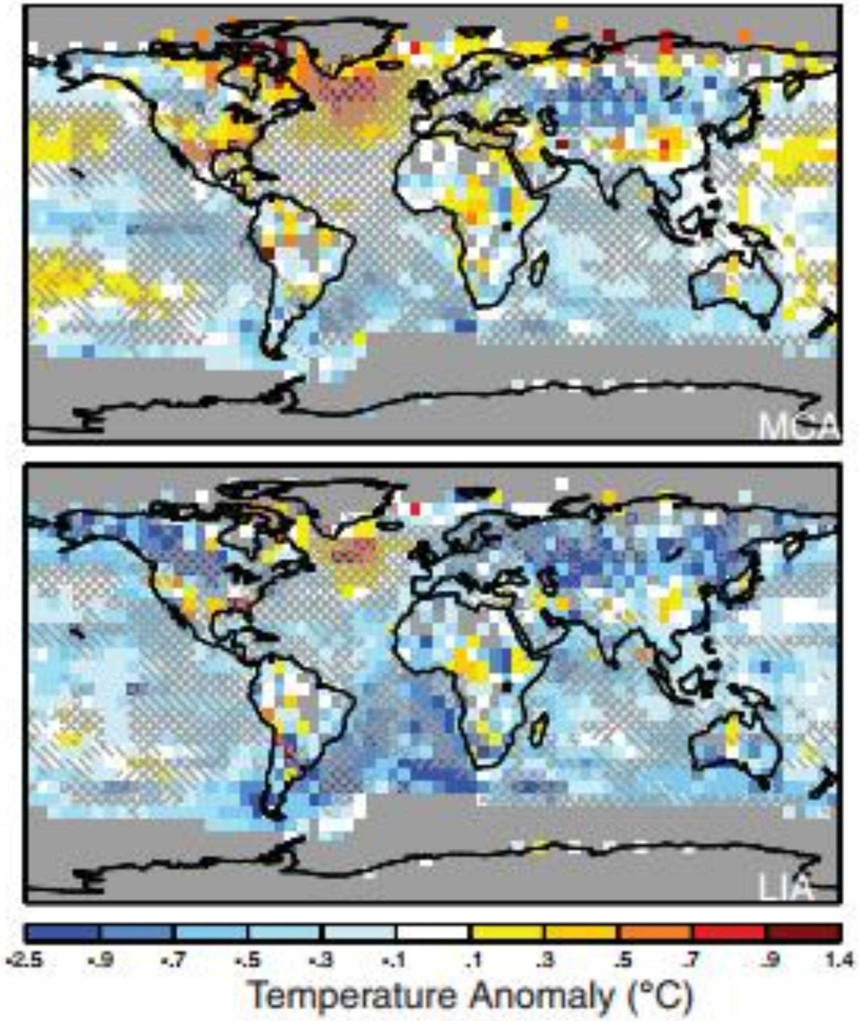
Windley Key Quarry, Florida

What does the Last Interglacial tell us?

130,000 to 120,000 ybp

- Globally warmer air and SST
- Significantly higher sea level
- Ecologically - no substantial differences in benthic invertebrate faunal composition of Caribbean and Gulf of Mexico

Analog 3 – Medieval Warm Period +



Medieval Warm Period (MWP)
~ 950-1250 CE

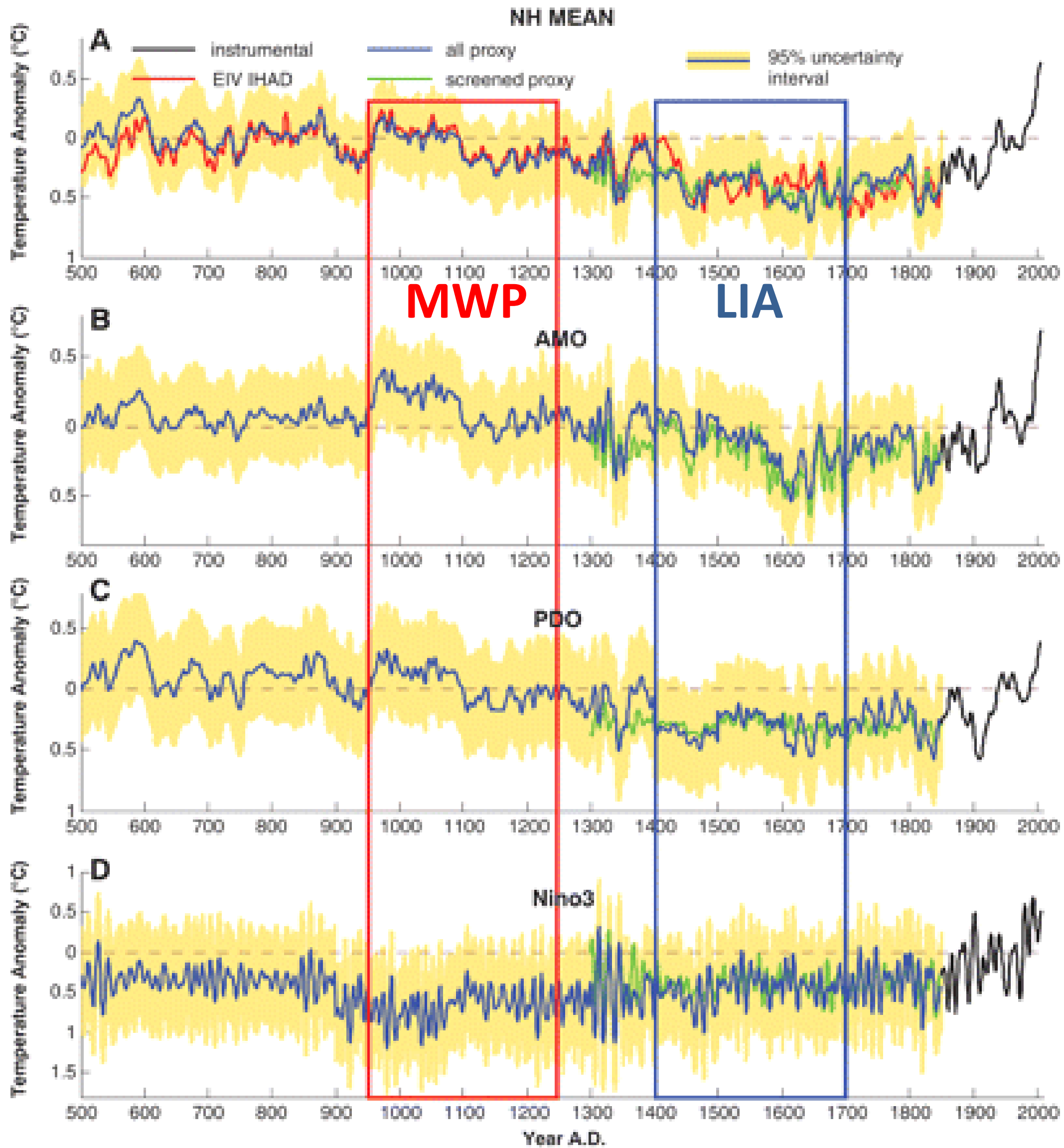
Little Ice Age (LIA)
~ 1400-1700 CE

Analog 3 – Medieval Warm Period +

> 1000 yr record of change

Surface Temperature Data Relatively Abundant

Spatial patterns poorly understood



Decadal Average Surface Temp

Northern Hemisphere

North Atlantic SST

North Pacific SST

Central Pacific SST

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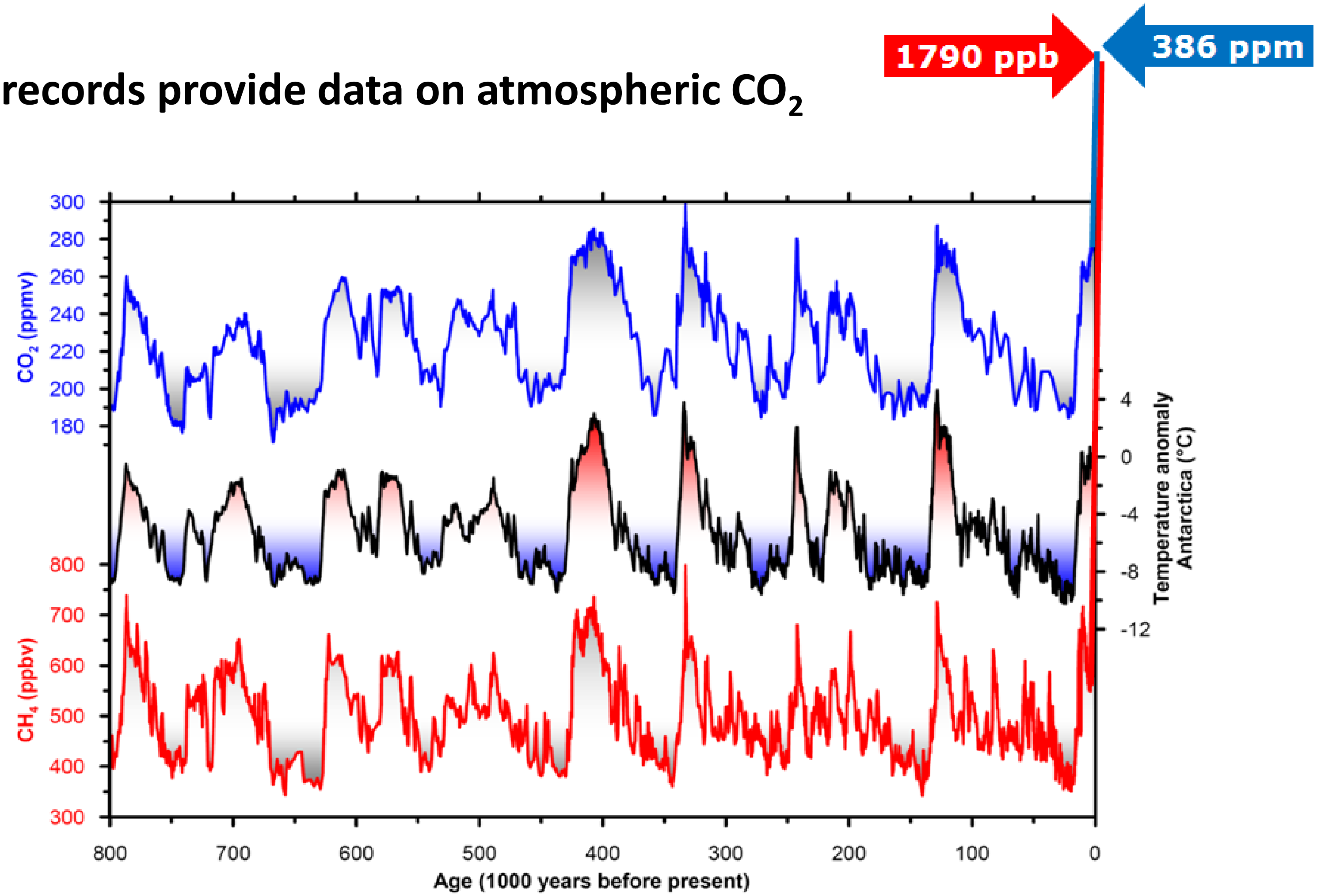
Mann et al. 2009 Science v. 326

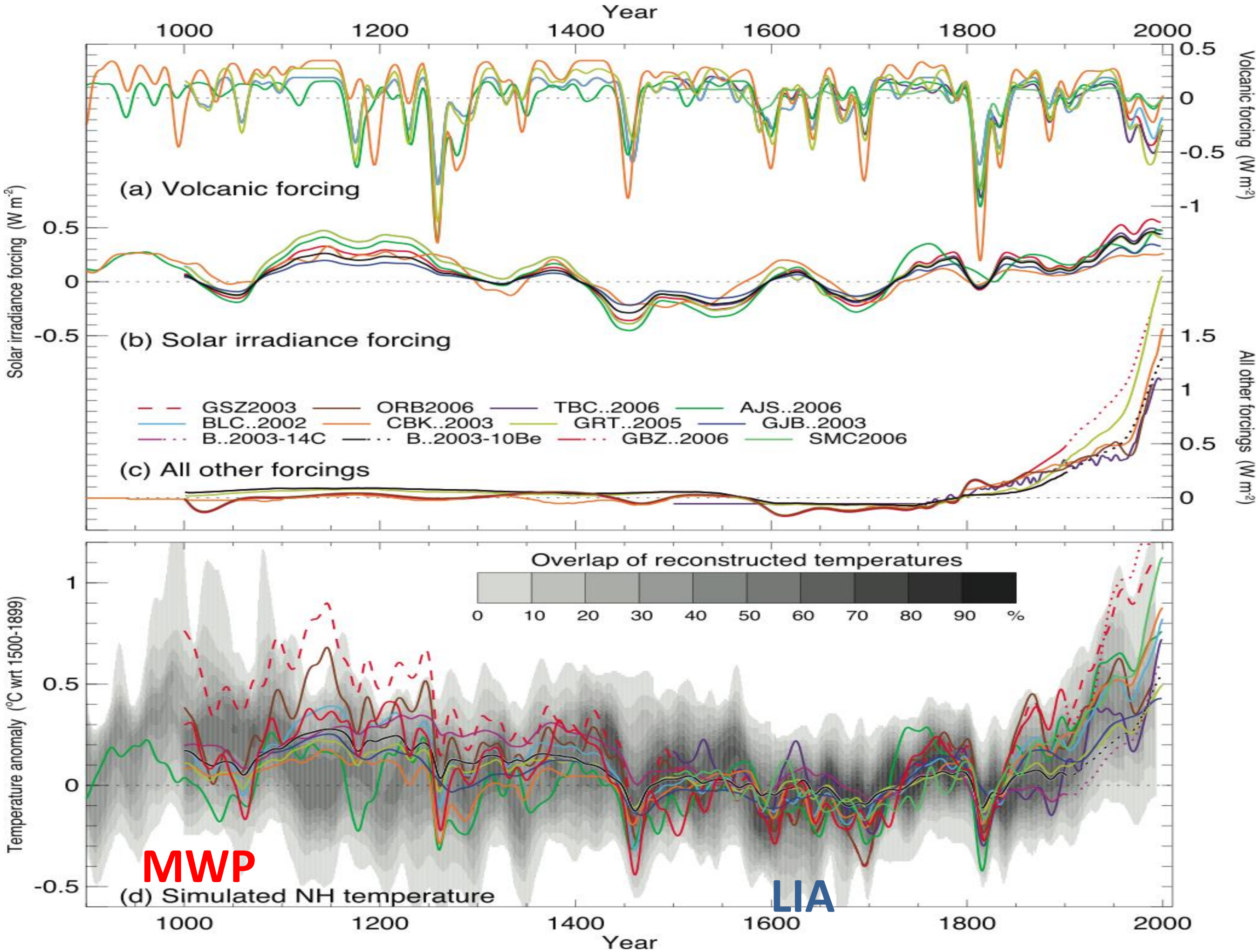
Analog 3 – Medieval Warm Period +

Ice core records provide data on atmospheric CO_2

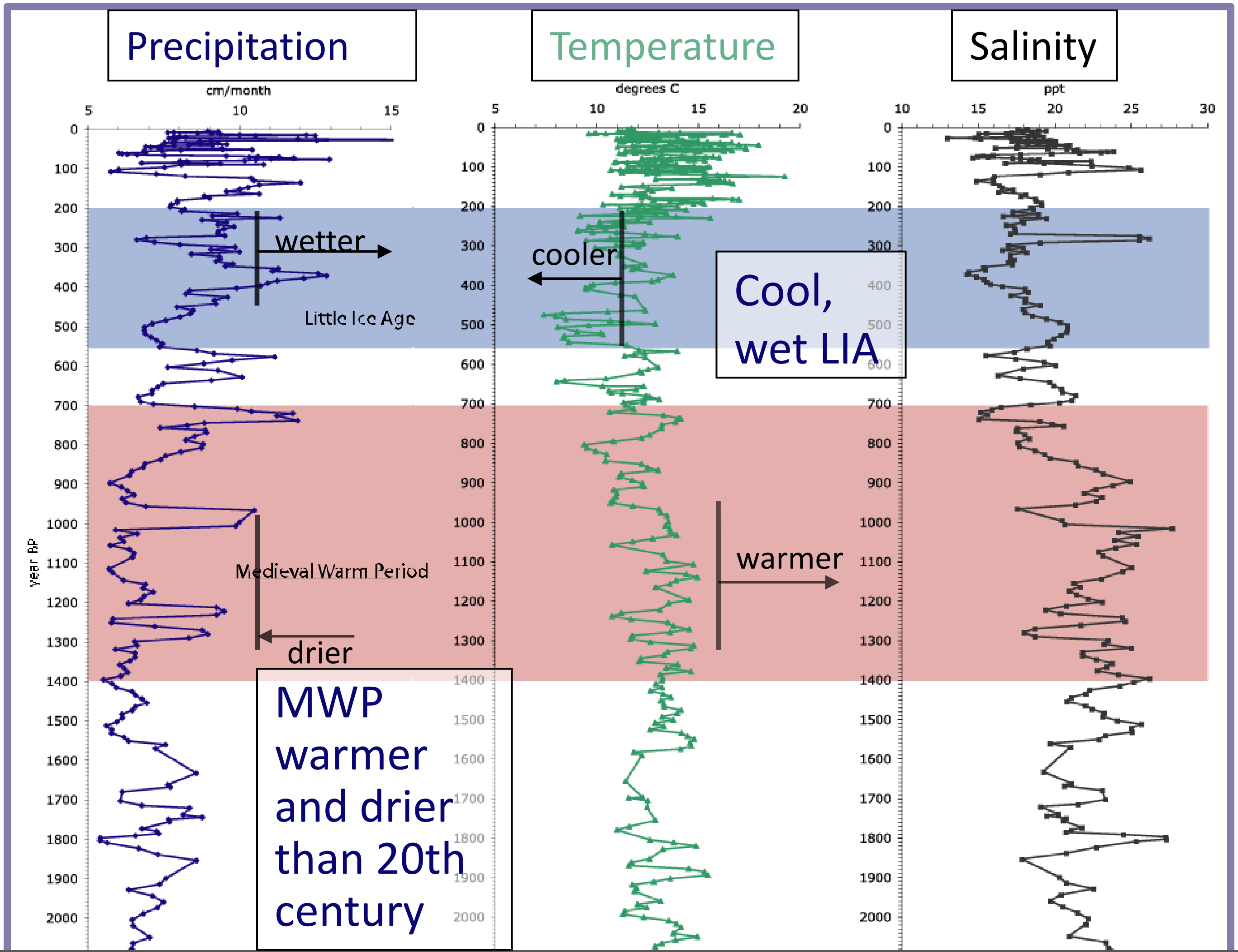


Analog 3 – Medieval Warm Period +

Patterns and causes of temperature change

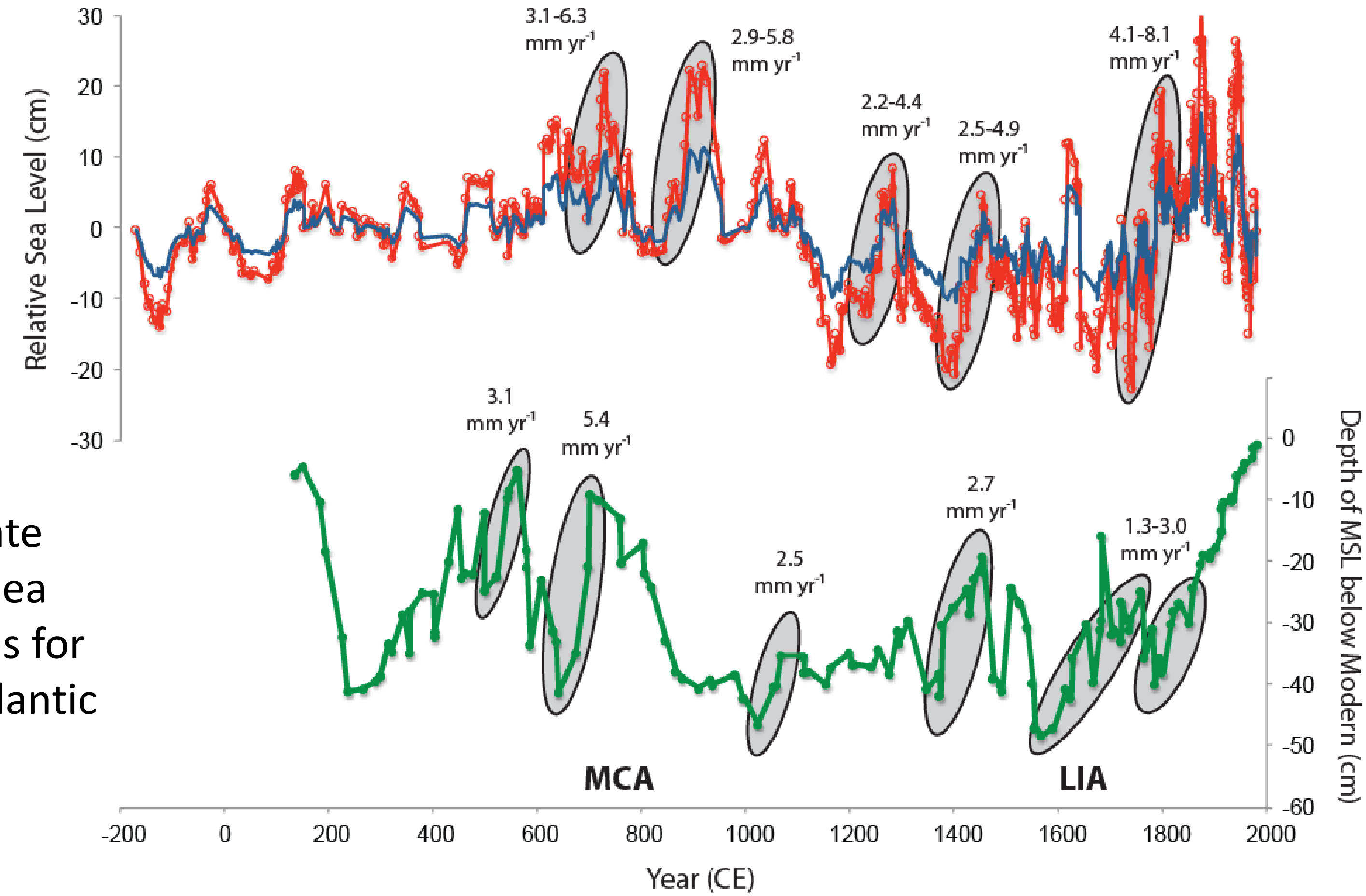


Analog 3 – Medieval Warm Period +



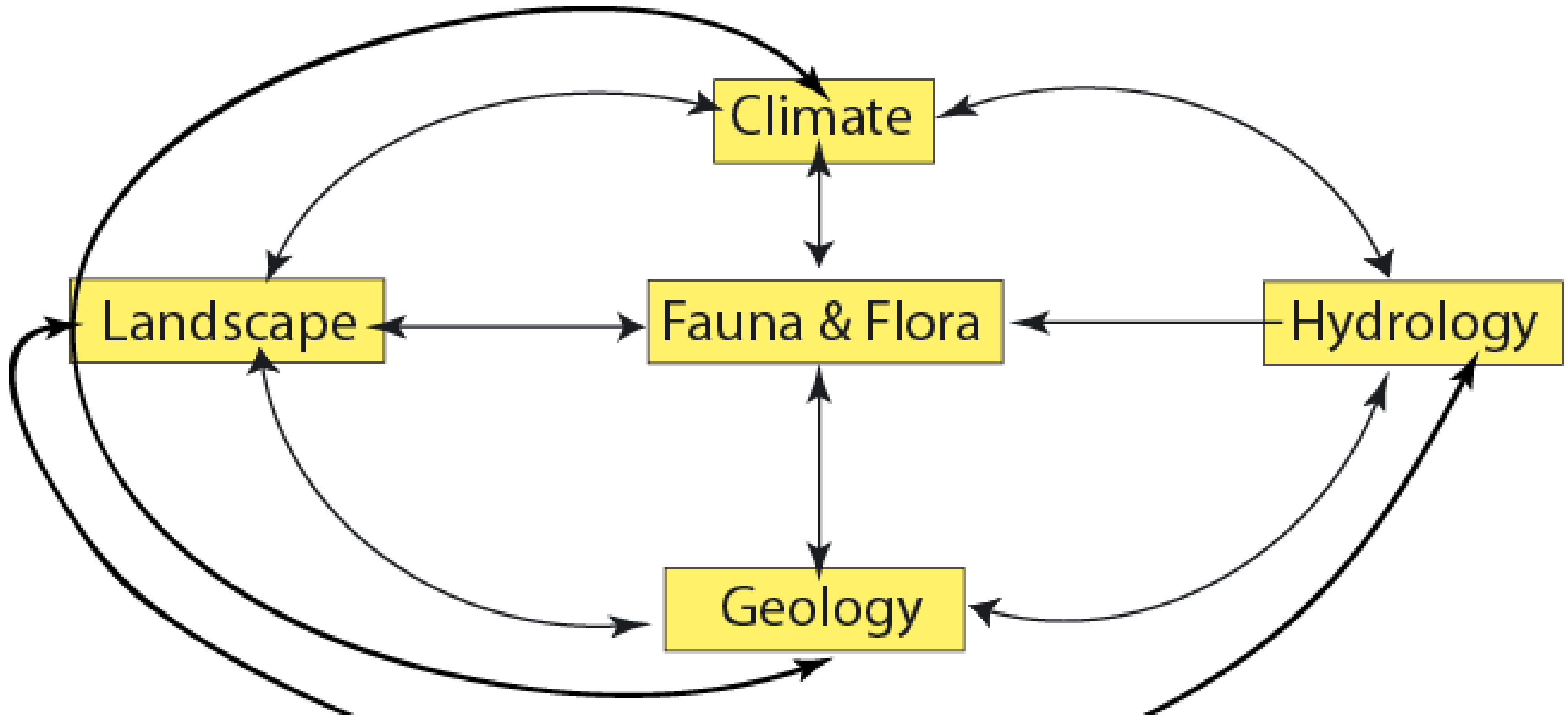
Cronin et al. 2003, 2006, 2010.

Analog 3 – Medieval Warm Period +



Regional Late Holocene Sea Level curves for the Mid-Atlantic

Ecological Responses to Change

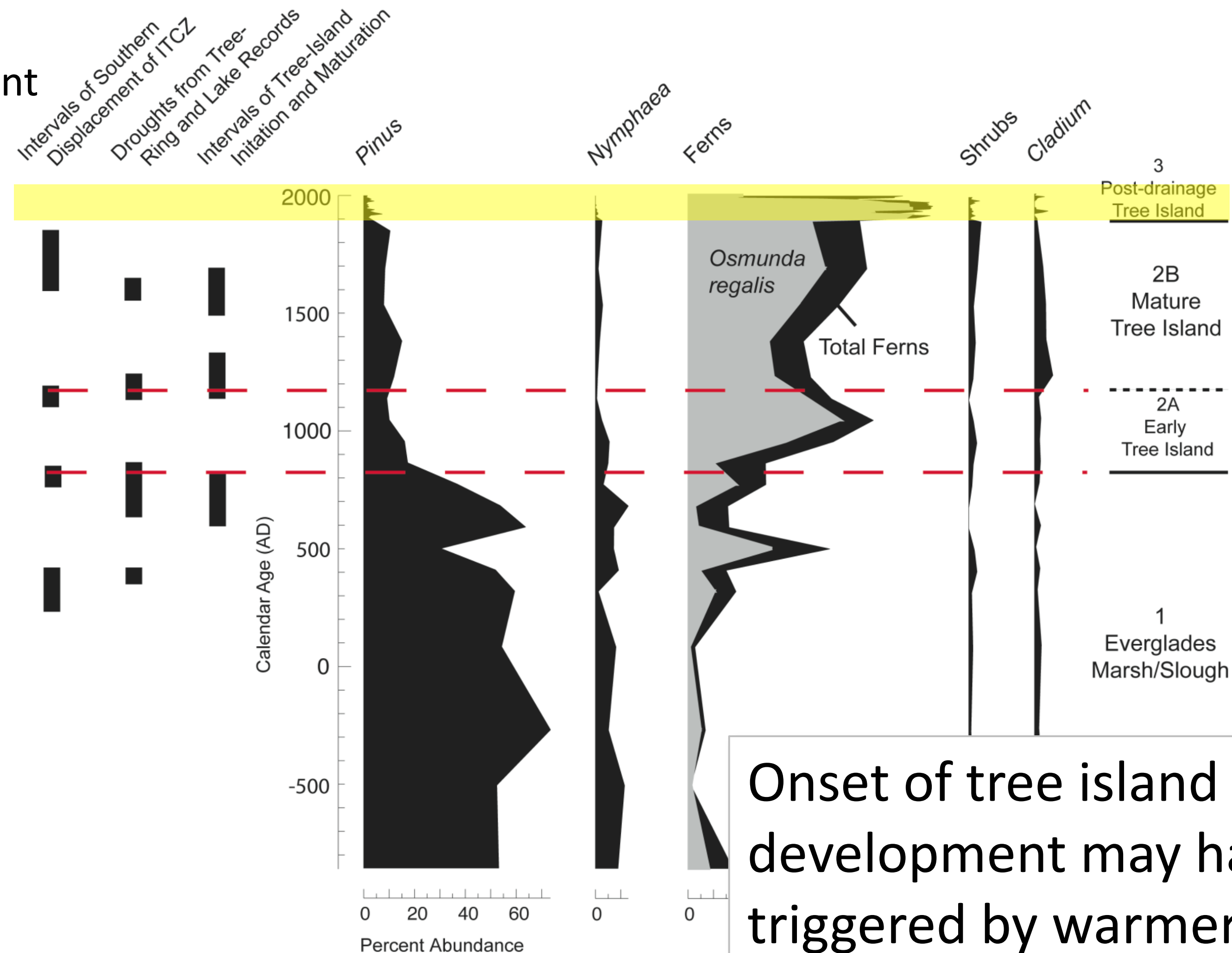


For the last 1000 years - have detailed information on many key ecosystem drivers

Ecological Responses to Change

Tree Island Development

MWP



Impacted

Natural Changes

Onset of tree island development may have been triggered by warmer drier climate of MWP

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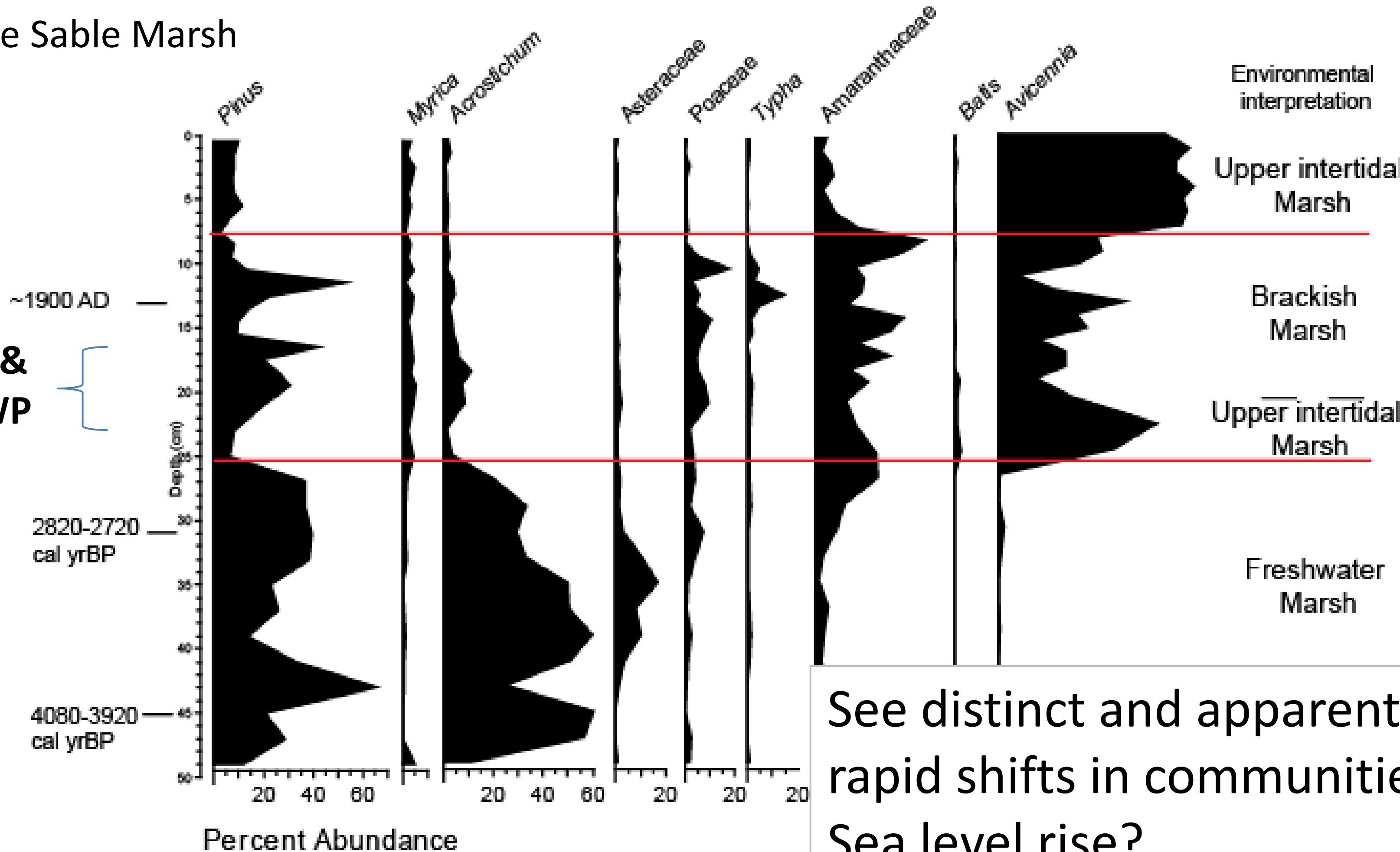
Ecological Responses to Change

Cape Sable Marsh

LIA & MWP



See distinct and apparently rapid shifts in communities – Sea level rise?

Bernhardt, unpub.

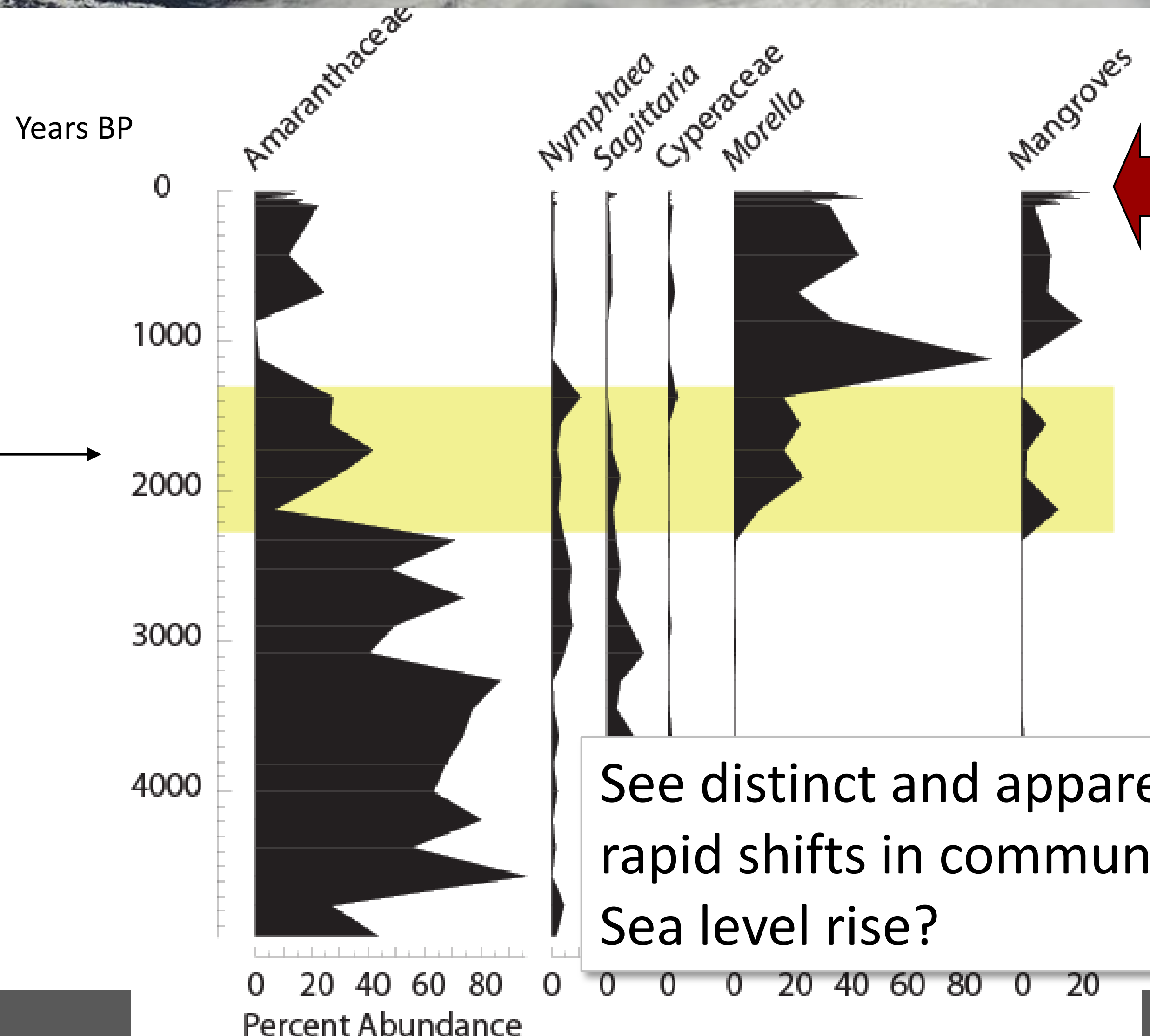
Ecological Responses to Change

Tarpon Bay

Mangrove swamp – ~1 ka to present

Transition from fresh to mangrove - ~2.2 to 1.2 ka

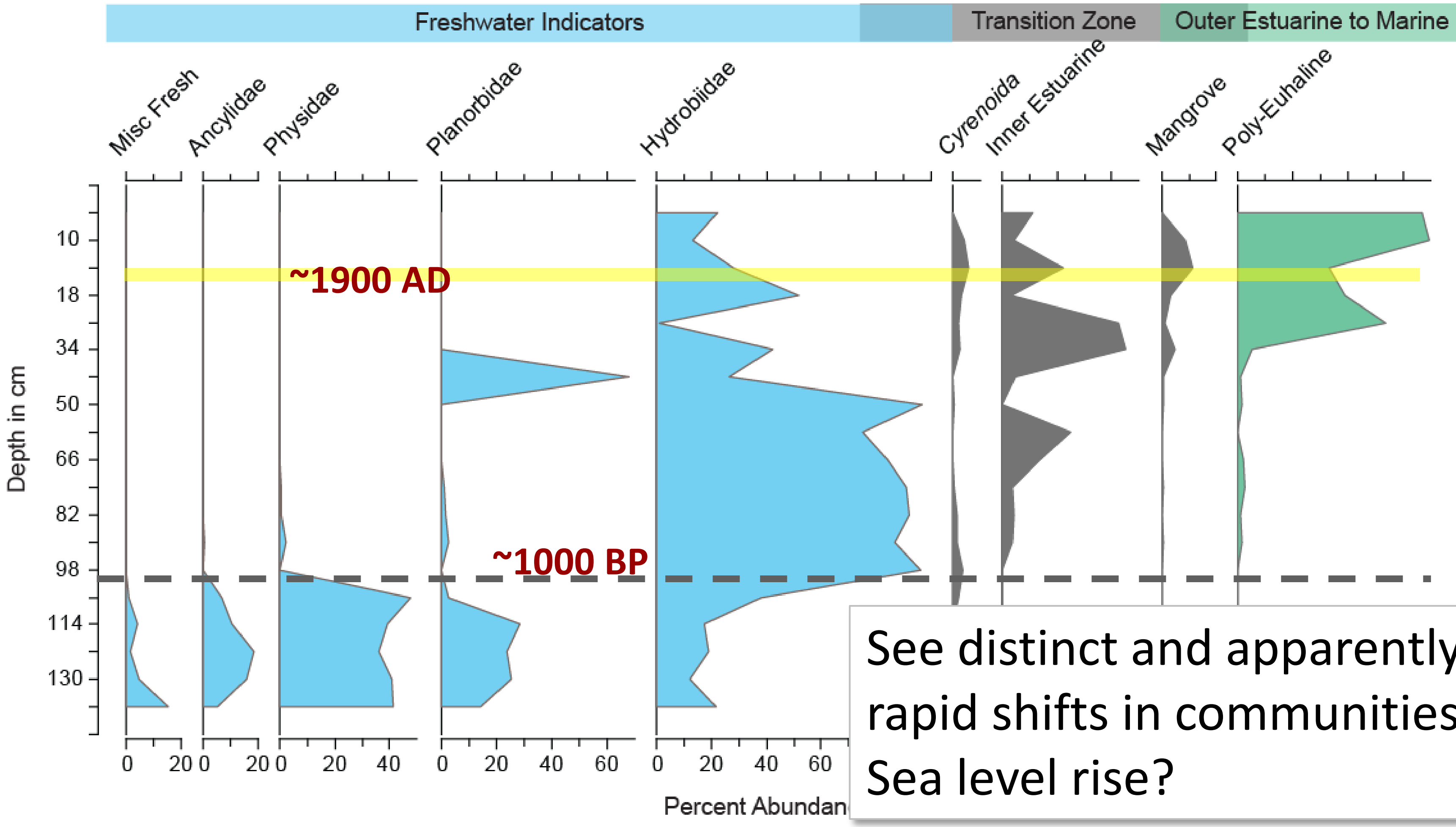
Freshwater marsh – Prior to ~2.2 ka



See distinct and apparently rapid shifts in communities – Sea level rise?

Ecological Responses to Change

Shark River Slough

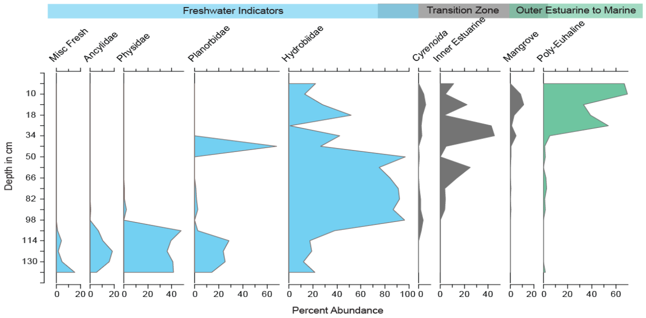


See distinct and apparently rapid shifts in communities – Sea level rise?

Wingard, unpub.

What do paleoecologic records in South Florida tell us?

- Over the last 3 to 4 million years the general faunal and floral composition of Florida has not changed dramatically in response to global changes



  - Locally habitats have shifted - most likely in response to climate and sea level
  - Near the coast the shifts tend to happen rapidly, then new periods of stability are formed
  - In the 20th century local drivers – land use and water management have had a significant impact on the habitats

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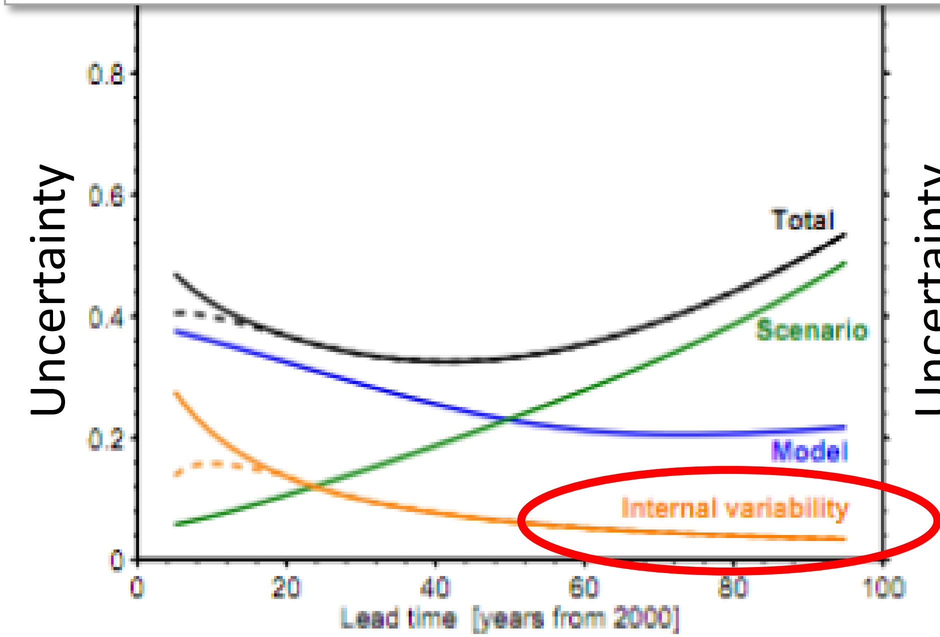
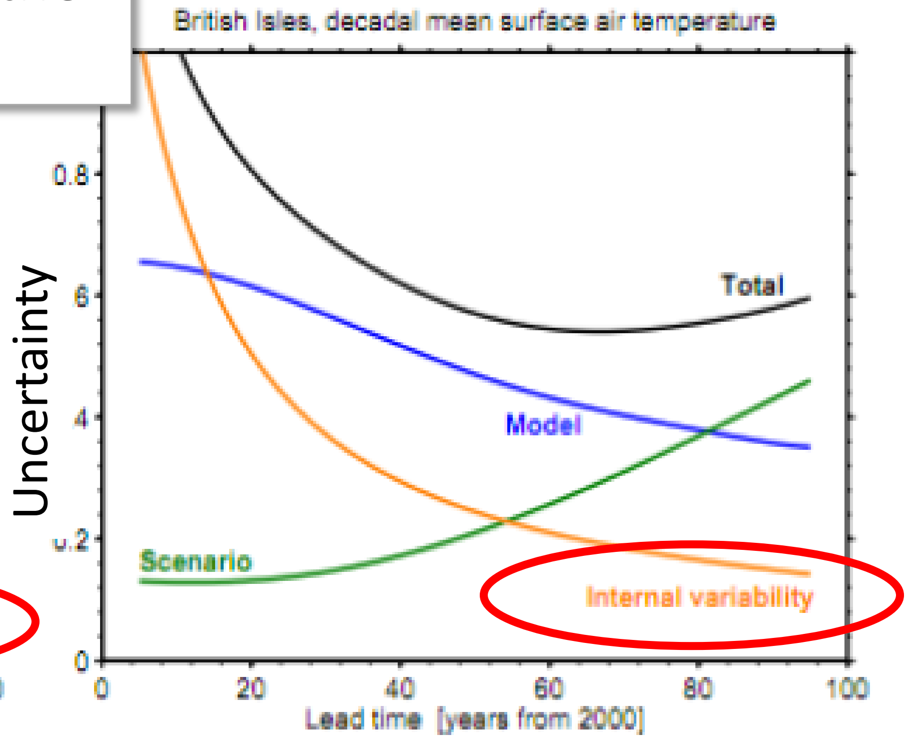
Are past records of change a key to the future?

- Yes and No
- Past records tell us how ecosystems and organisms have responded to change – but can be difficult to tell what drivers have caused the change
- An important aspect that long term records give us is information about variability and cumulative / additive responses
- Records of response to anthropogenic change are much shorter (~100 years for S. FL), and we don't understand the cumulative effects so difficult to project responses that haven't been seen yet
- Key to anticipating future responses of ecosystems to change is to understanding this interaction between natural and anthropogenic change

Future Directions

Long term data sets help reduce the uncertainty in models

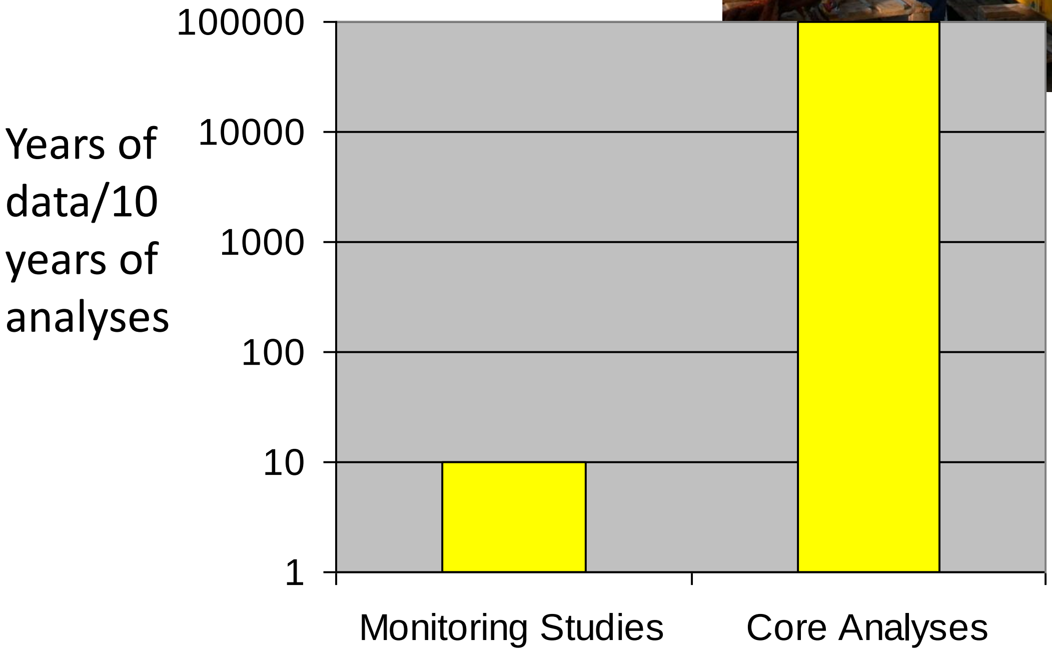




Lead Time in Years

Future Directions

- Core analyses provide appropriate temporal scales for global change analysis



Future Directions

- Cores from playas in Florida Bay – potential to trap long term history of storms and sea level
- Examine hypothesis that potentially large storms have been the drivers of change in Florida Bay and the Southwest coast by causing incremental jumps in sea level

Future Directions

Future Directions

Need to compile, synthesize and analyze existing data sets from a variety of ecosystems to understand interconnections, and feedback mechanisms

Fill in information gaps

Use the historical record to identify indicators

Examine change at a variety of scales