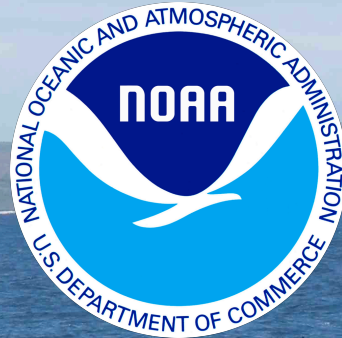


A Brief History of El Niño: the Last 25,000 Years

Athanasios Koutavas

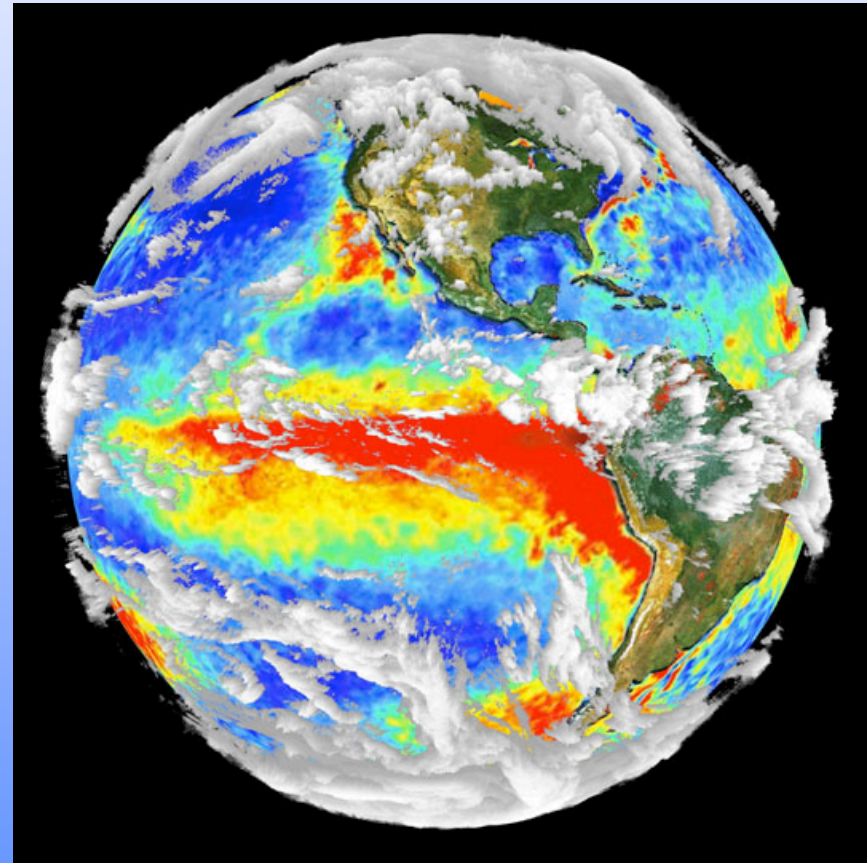
College of Staten Island and Graduate Center
City University of New York
athanasios.koutavas@csi.cuny.edu



NOAA Climate and Global Change Postdoctoral Program
20th Anniversary Celebration
NOAA Auditorium and Science Center
Silver Spring, MD
April 14-15, 2011

Why Is El Niño interesting?

- Global impacts
- Not well understood
- Climate wildcard
- Mysterious history intertwined with humans



Once Upon A Time...

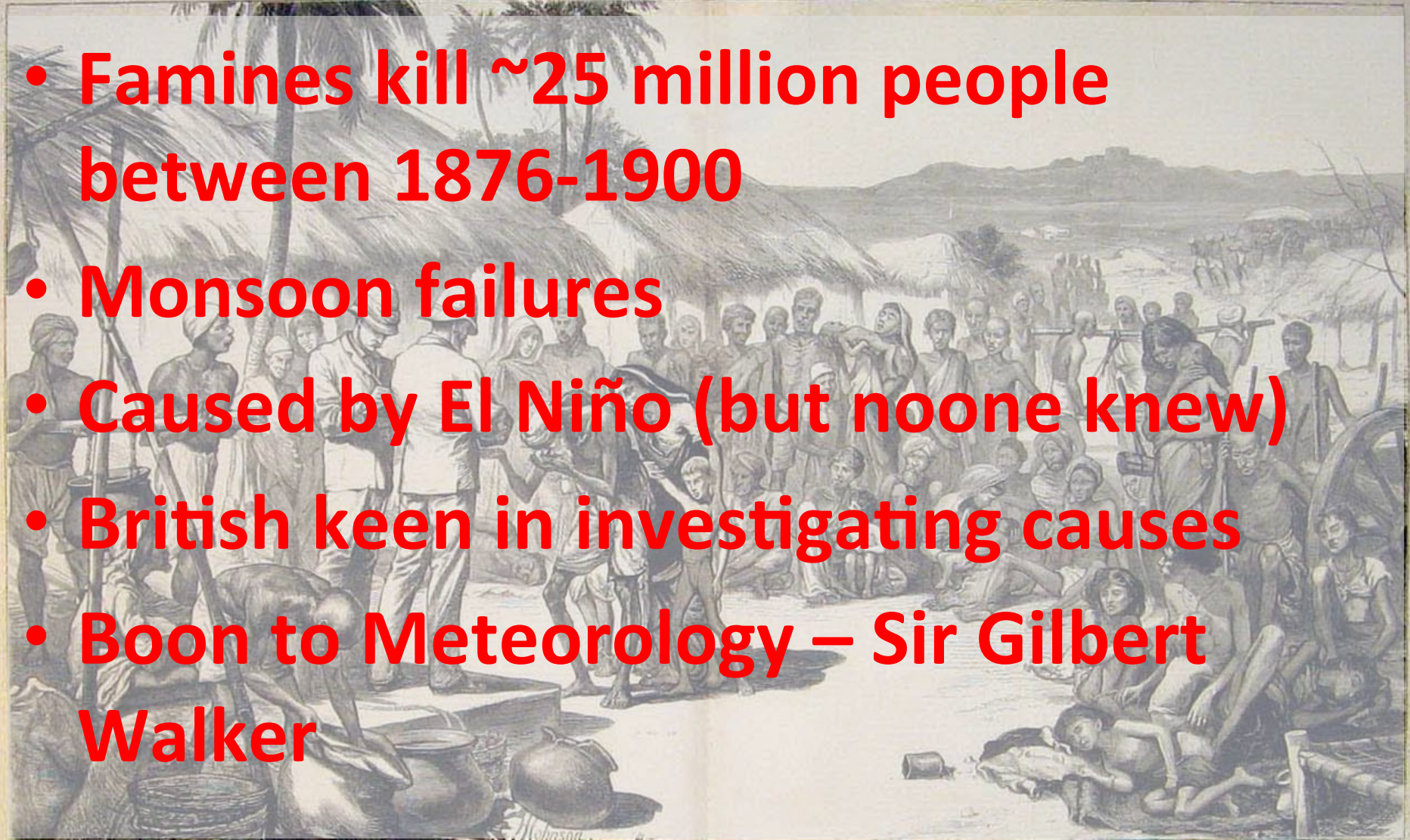
- 19th century Peru
- Fishermen observed coastal warmings
- Appeared around Christmas
→ **El Niño**
- Accompanied by low fish catches
- But along came rains !
- Greening of deserts
- Bountiful crops
- “*Años de abundancia*”
 - (S.G. Philander, 2004: *Our Affair with El Niño*)



Fishermen off Peru in April 2009 –
onset of the 2009 El Niño

Meanwhile, in India...

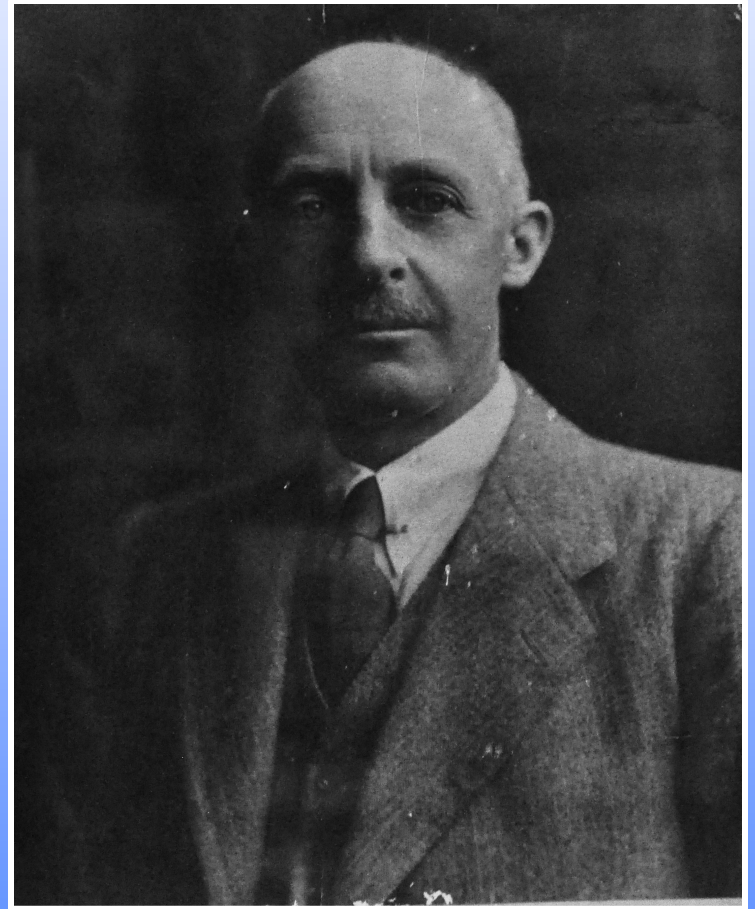
- Famines kill ~25 million people between 1876-1900
- Monsoon failures
- Caused by El Niño (but no one knew)
- British keen in investigating causes
- Boon to Meteorology – Sir Gilbert Walker



THE FAMINE IN INDIA—DISTRIBUTION OF RELIEF TO THE SUFFERERS AT BELLARY, MADRAS PRESIDENCY

Indian Meteorological Institute

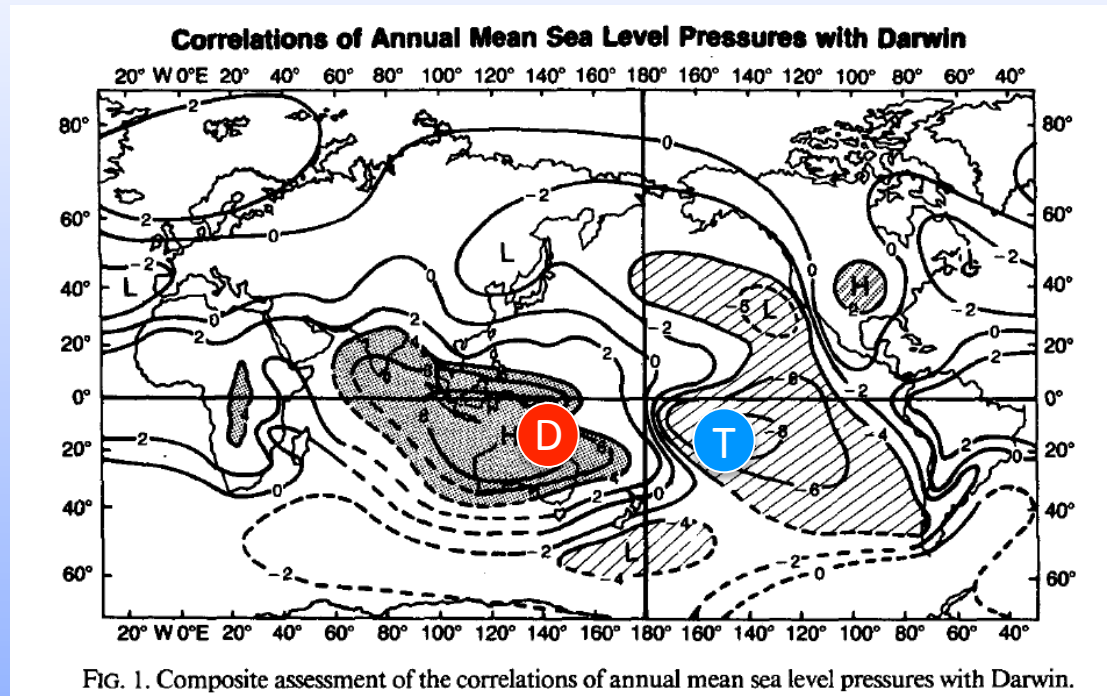
- Founded 1875
 - Sir H. F Blanford (1875-89)
 - Sir John Eliot (1879-1904)
 - **Sir Gilbert Walker (1904-24)**
- Walker is credited with discovering the Southern Oscillation



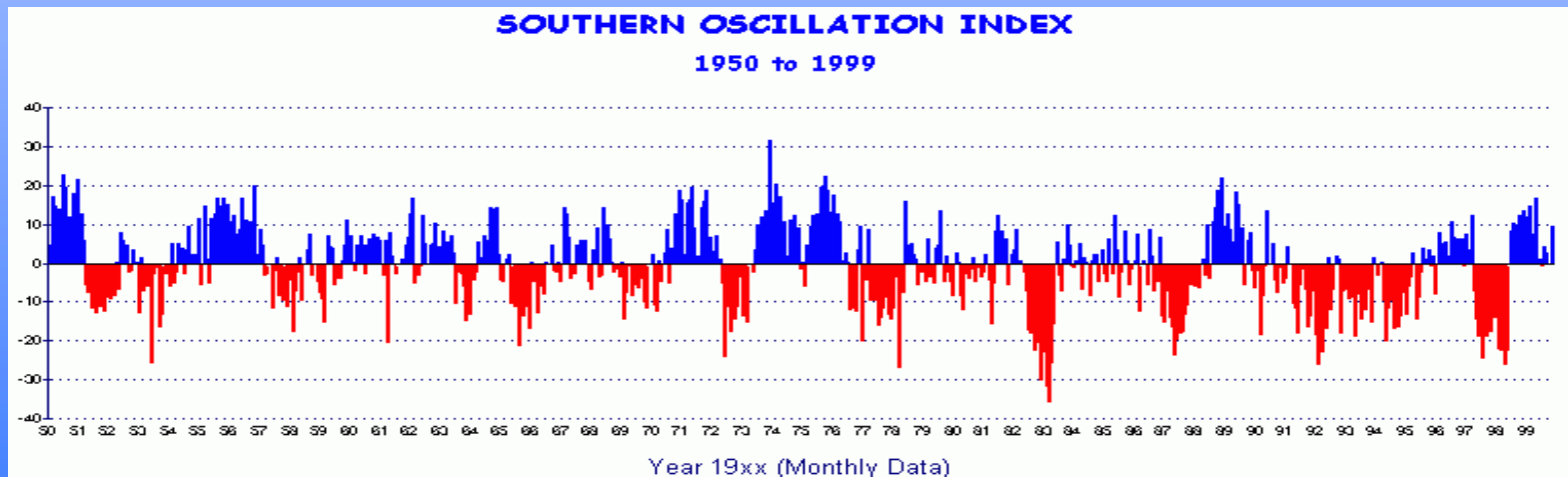
Sir Gilbert Walker

Walker's Southern Oscillation

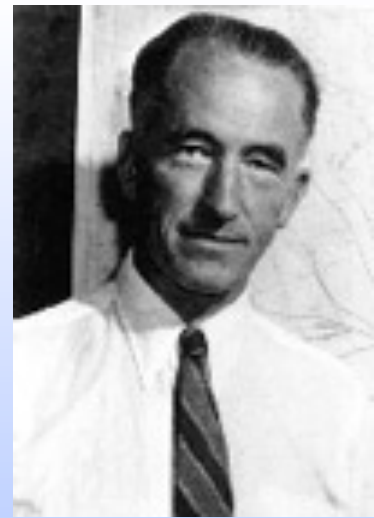
- Pressure seesaw between East and West Pacific
 - Tahiti minus Darwin, Australia
- Atmospheric response to Sea Surface Temperature anomalies



Trenberth and Shea, 1987



1966-1969: Jacob Bjerknes links Southern Oscillation with El Niño



- Correlations between pressure and SST
- Walker circulation
- Coupled ocean-atmosphere interaction
- Bjerknes feedback

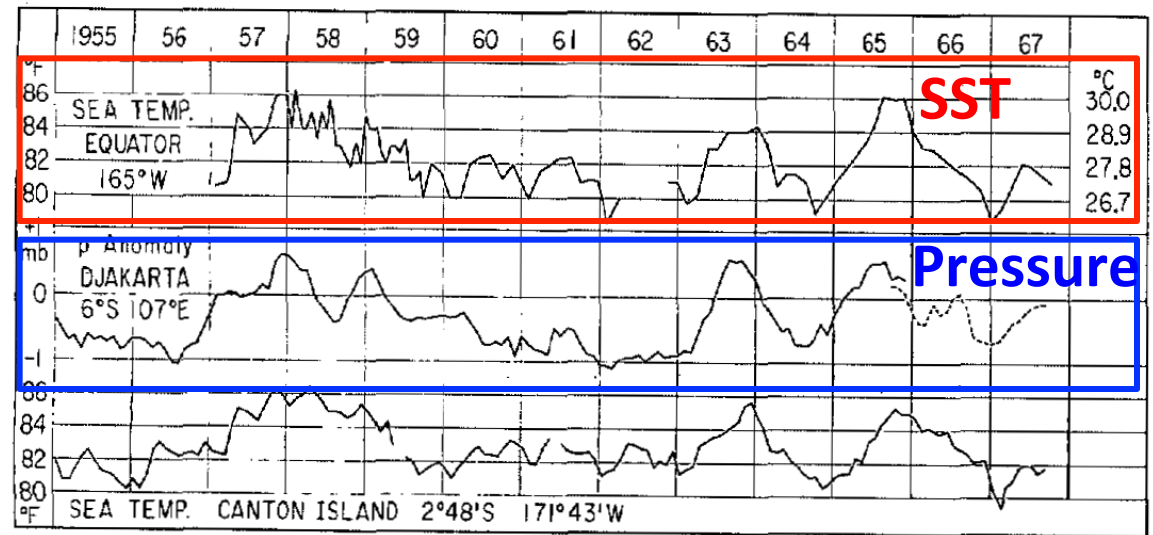
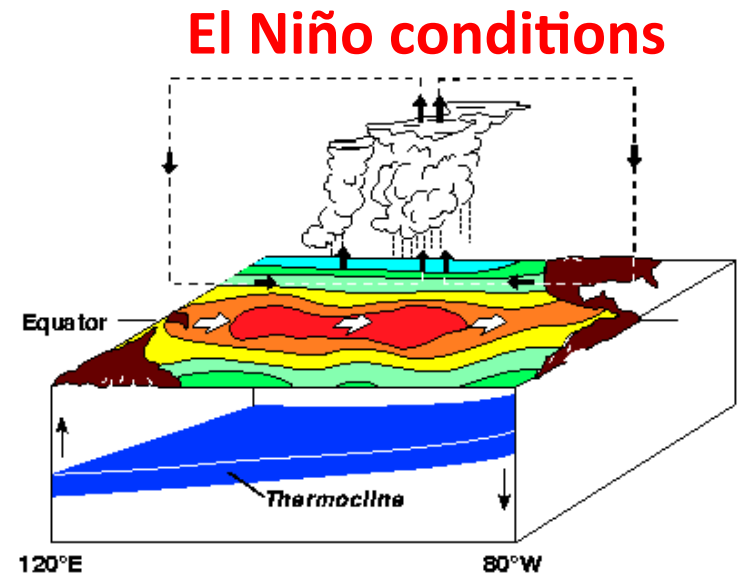
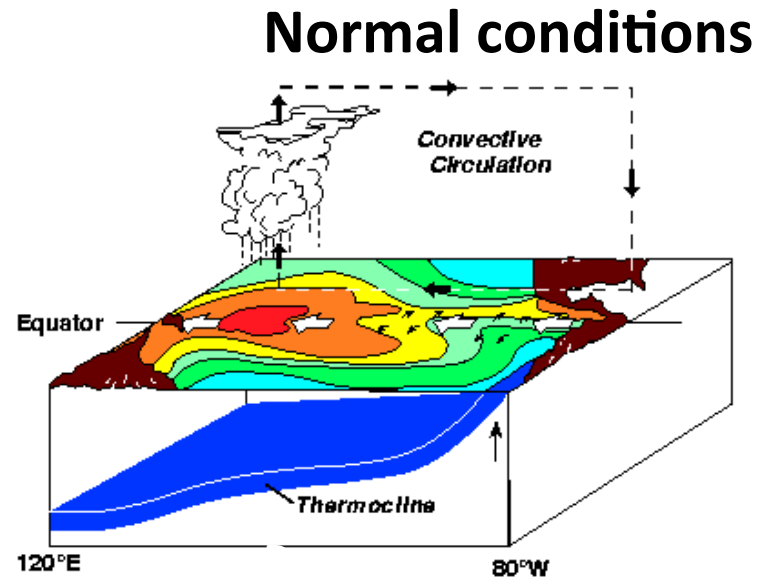


FIGURE 11.—The Southern Oscillation from 1955 to 1967 represented by 6-mo overlapping averages of Djakarta monthly pressure anomalies. Dashed curve based on Singapore data. On same time scale: sea temperature at the Equator at approximately 165°W, and sea temperature by monthly averages at Canton Island.

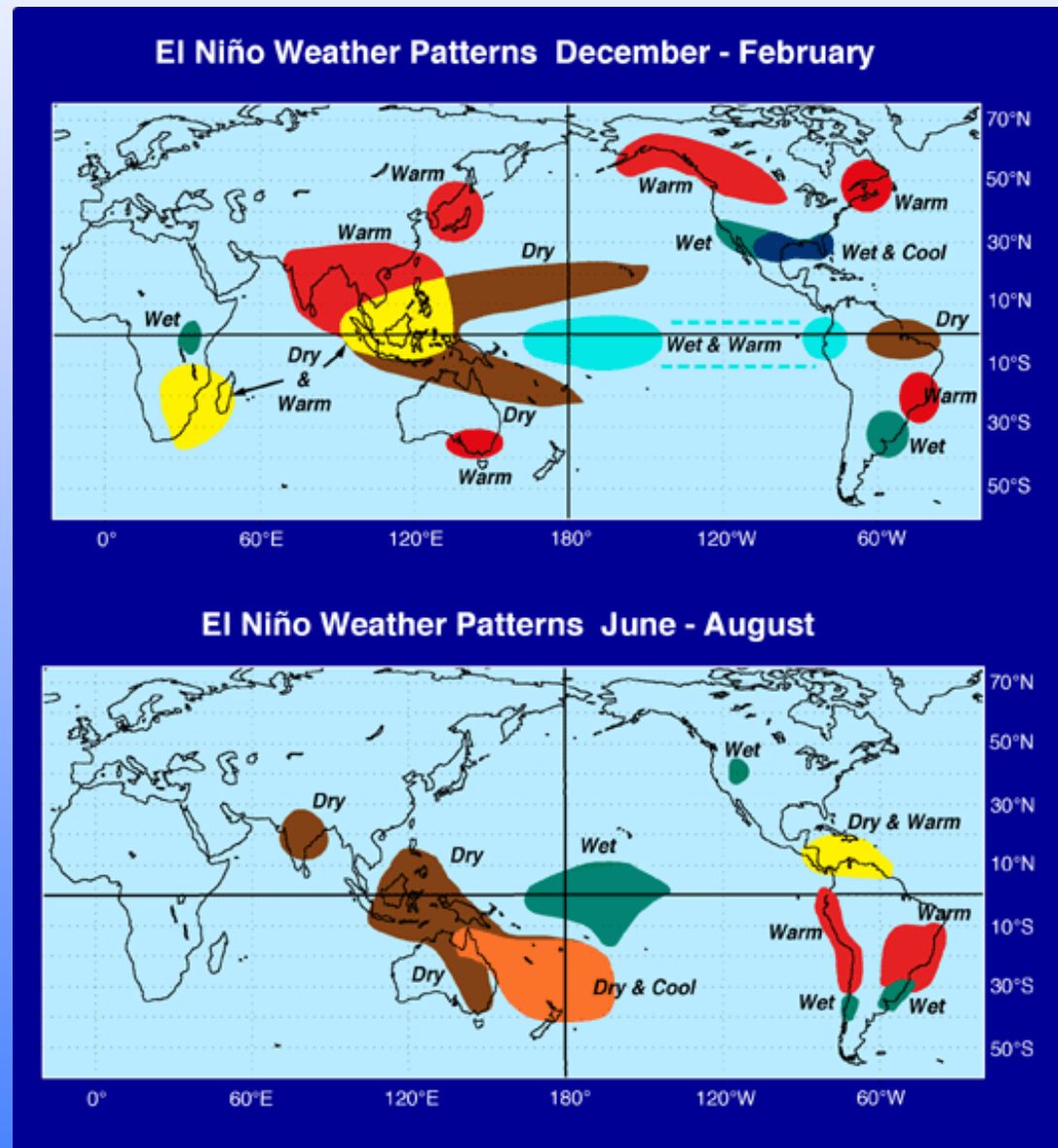
Bjerknes Feedback

- East-West SST gradient
- Drives easterly winds
- Winds drive upwelling
- Upwelling cools the east (shallow thermocline)
- Increases the SST gradient, stronger winds, more upwelling and so on
- Positive Feedback → instability
- El Niño - La Niña
- Delayed Oscillator theory explains why events end

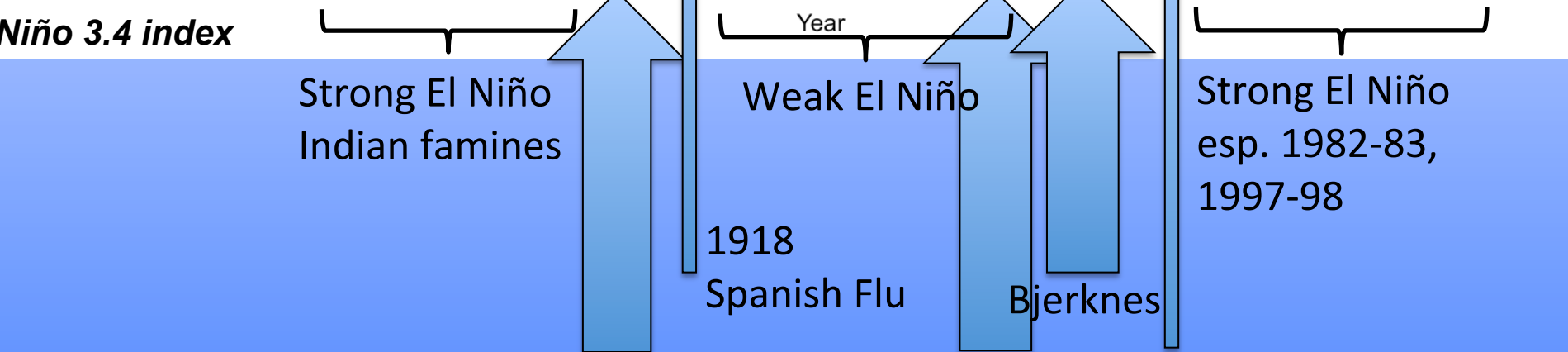
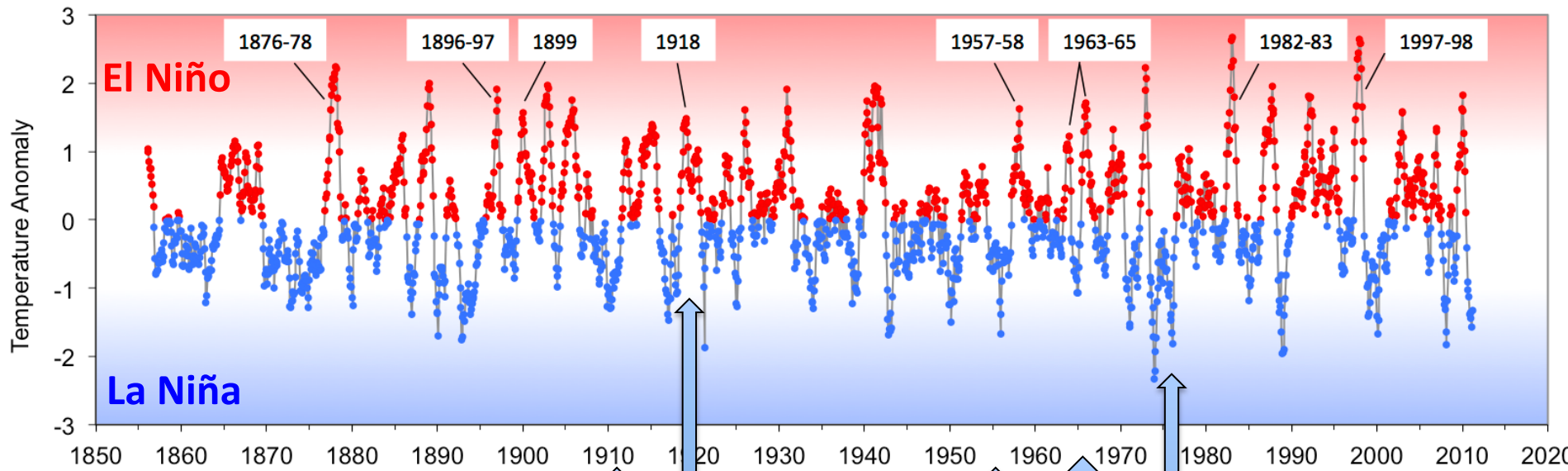


El Niño teleconnections

- Indicate probable outcomes based on past relationships
- These relationships are not fixed. They may strengthen or weaken as El Niño or the background climate changes



El Niño in the last 150 years

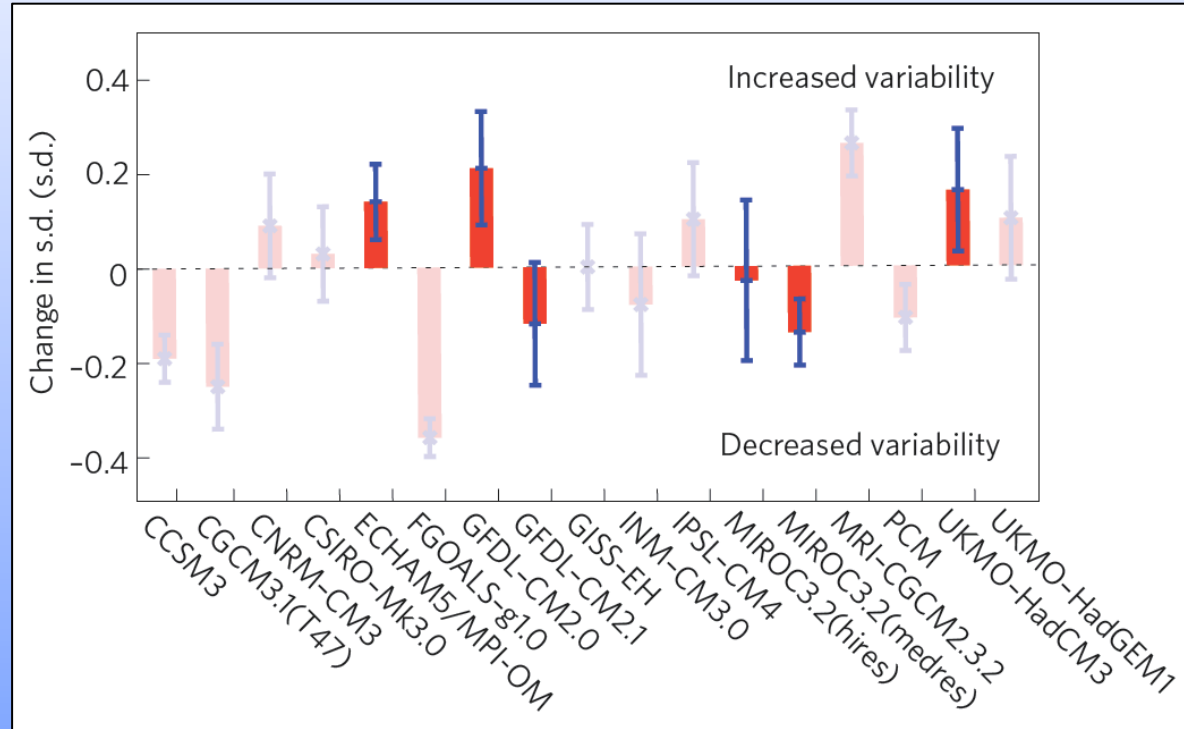


- **El Niño underwent clear changes**
 - Walker
 - Weak SO - Walker's results are questioned
 - 1976 climate shift: Period changed from 3 to 5 yr Thermocline deepened

Will El Niño change in the future?

Three approaches to this question:

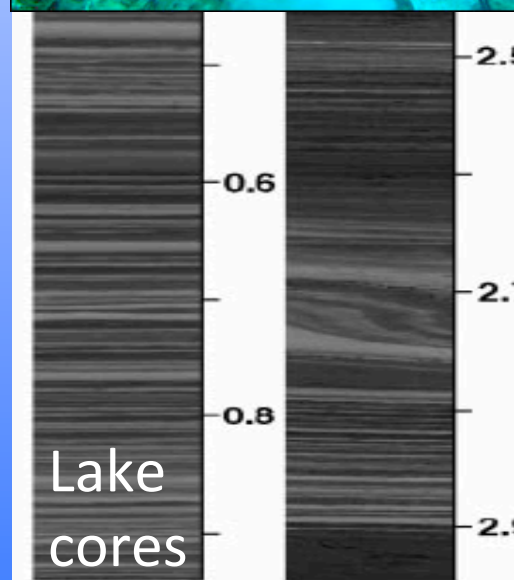
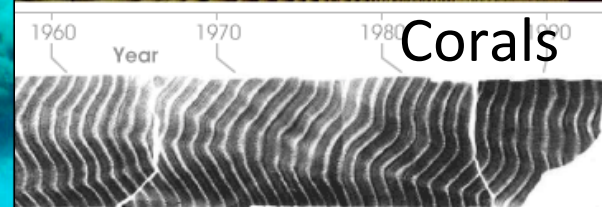
1. Models/ Theory
 - No convergence
2. Observations
 - Too short
3. Experiments
 - (Past El Niño reconstructions)
 - Too spotty



Predicted changes in El Niño amplitude as a result of global warming in 17 CMIP3 models (Collins et al., 2010)

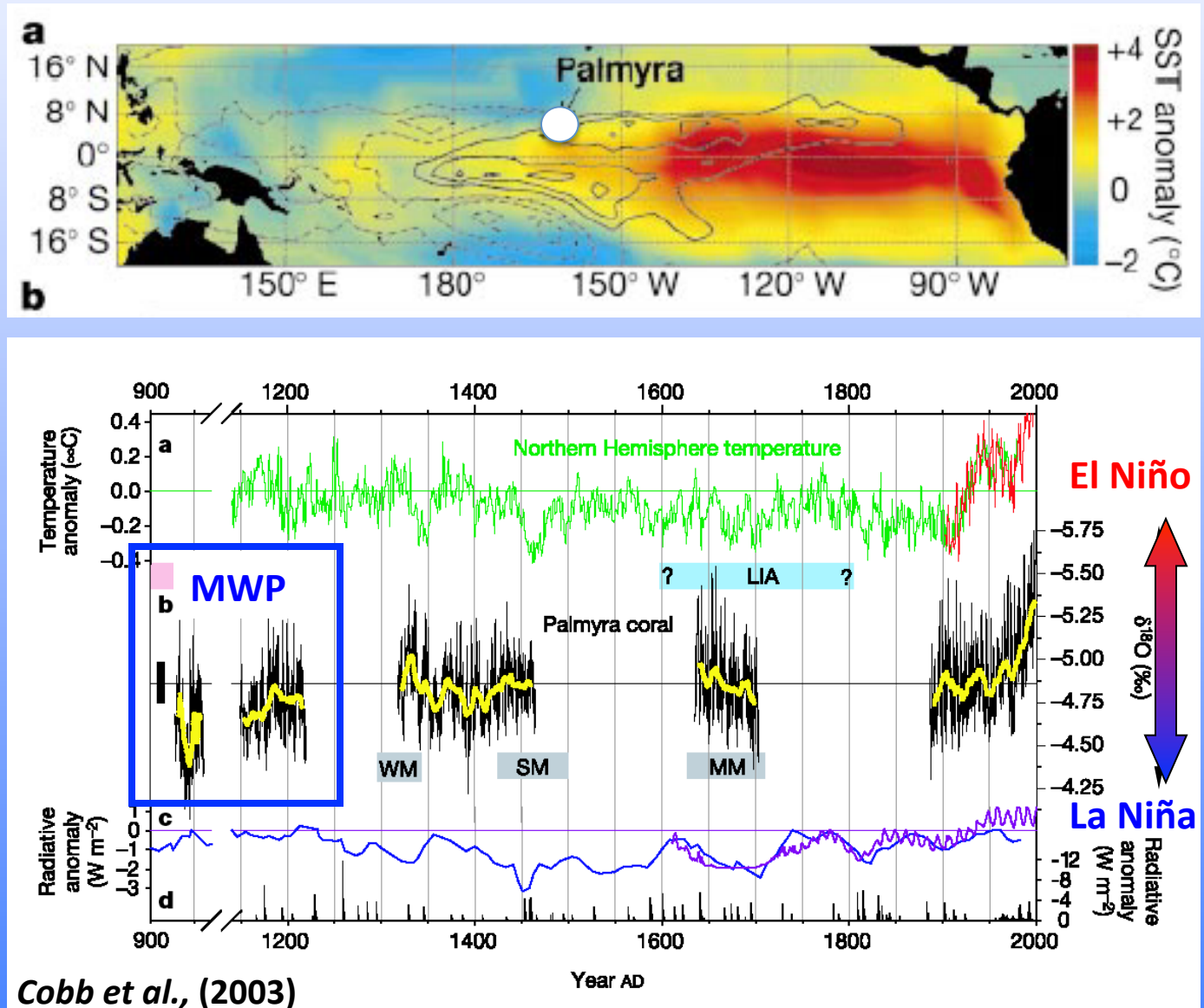
El Niño in the past: What do we know?

- Last 1000 years
- Holocene: last 10 ky
- Last Ice-Age: 20-24 ky



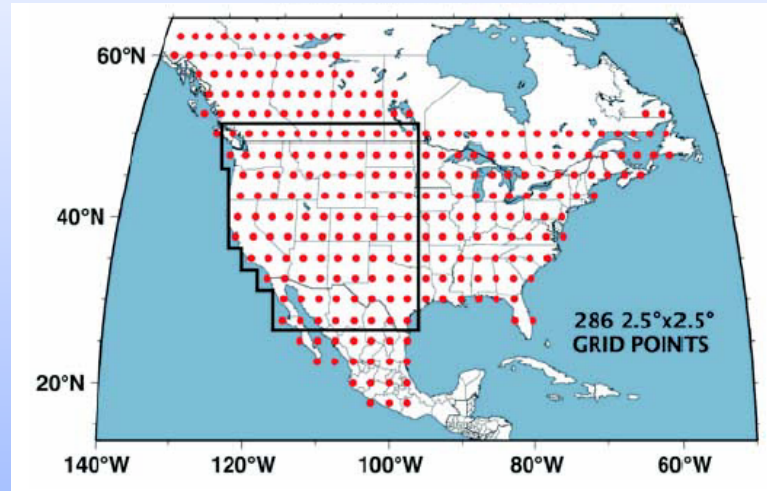
1000-yr coral record of El Niño from Palmyra Atoll

- El Niño was active in the last millennium
- Medieval Warm Period 900-1300 AD may have been La Niña-like



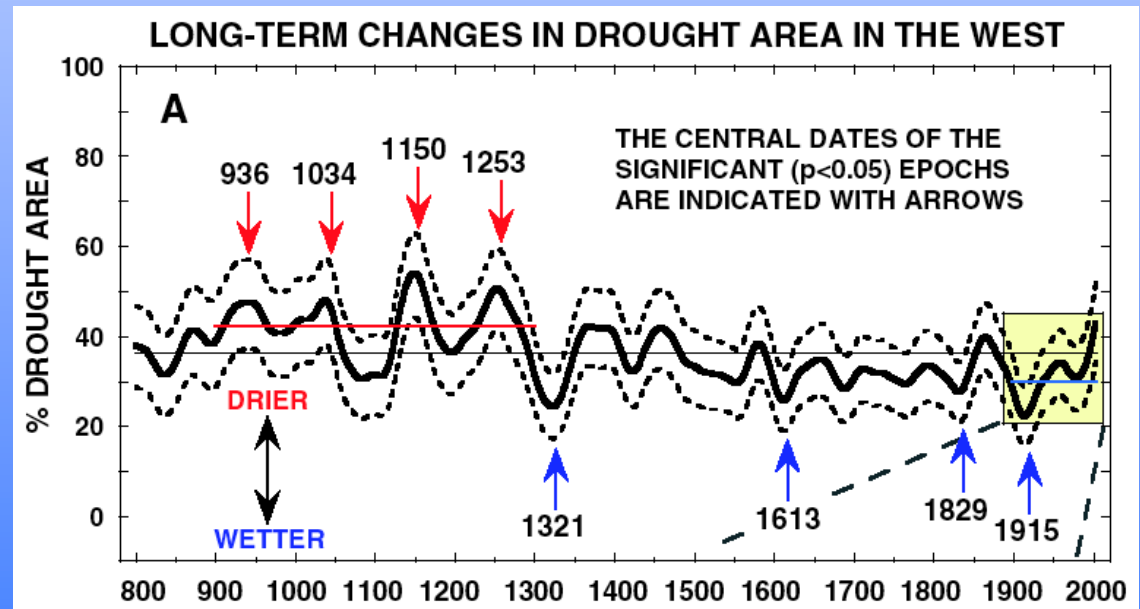
Medieval droughts in Western US from tree-rings

- Other drought evidence
 - Charcoal
 - Fire scars in Sequoia groves
 - Tree stumps
 - Lake levels and salinity



Cook et al., 2004

- Medieval droughts are consistent with La Niña conditions, but result needs confirmation



Drought was a factor in collapse of Anasazi culture in Southwest US in 13th century AD



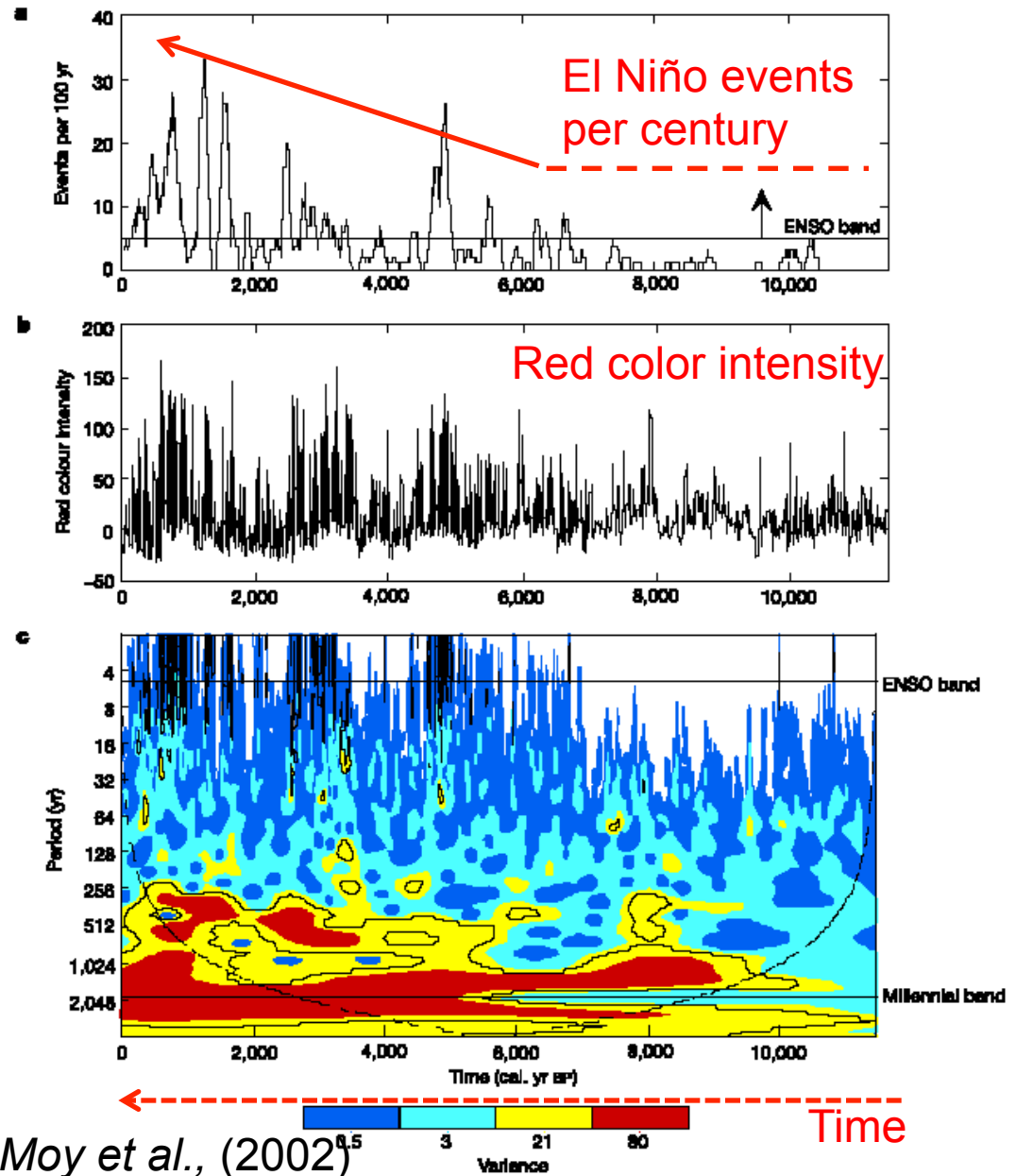
Pueblo Bonito,
Chaco Canyon



Cliff Palace, Mesa Verde

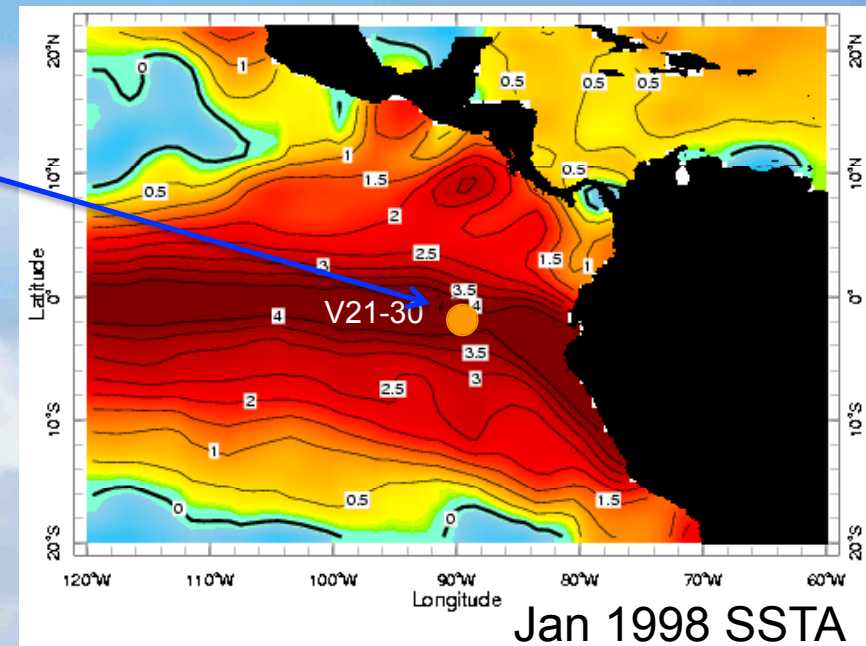
Holocene El Niño (last 10,000 years)

- Lake Pallcacocha, Ecuador - sediments
- Was there no El Niño before ~6000 y ago?



El Niño from ocean sediments

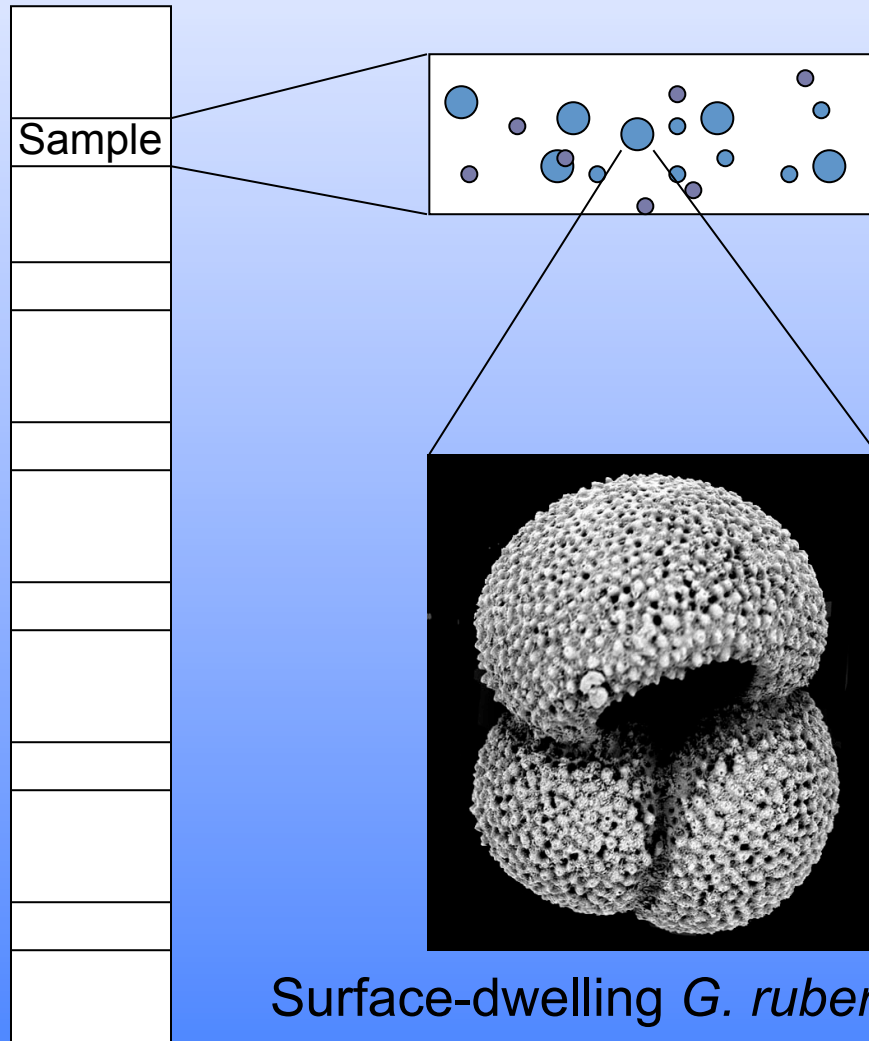
- Site V21-30
- Galapagos Islands
- Site reoccupied and re-cored in April 2009 on RV Knorr



Española Island viewed from the core site

Approach: use individual foraminifera in the sediments - lifespan of a few weeks

Sediment Core

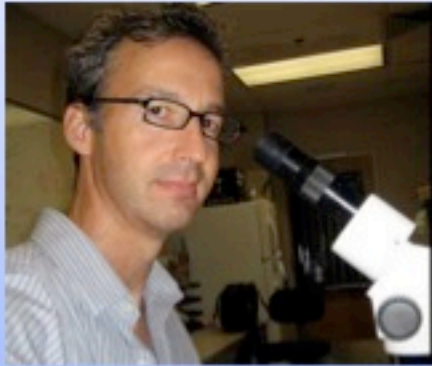


1-cm wide sample=
about one century

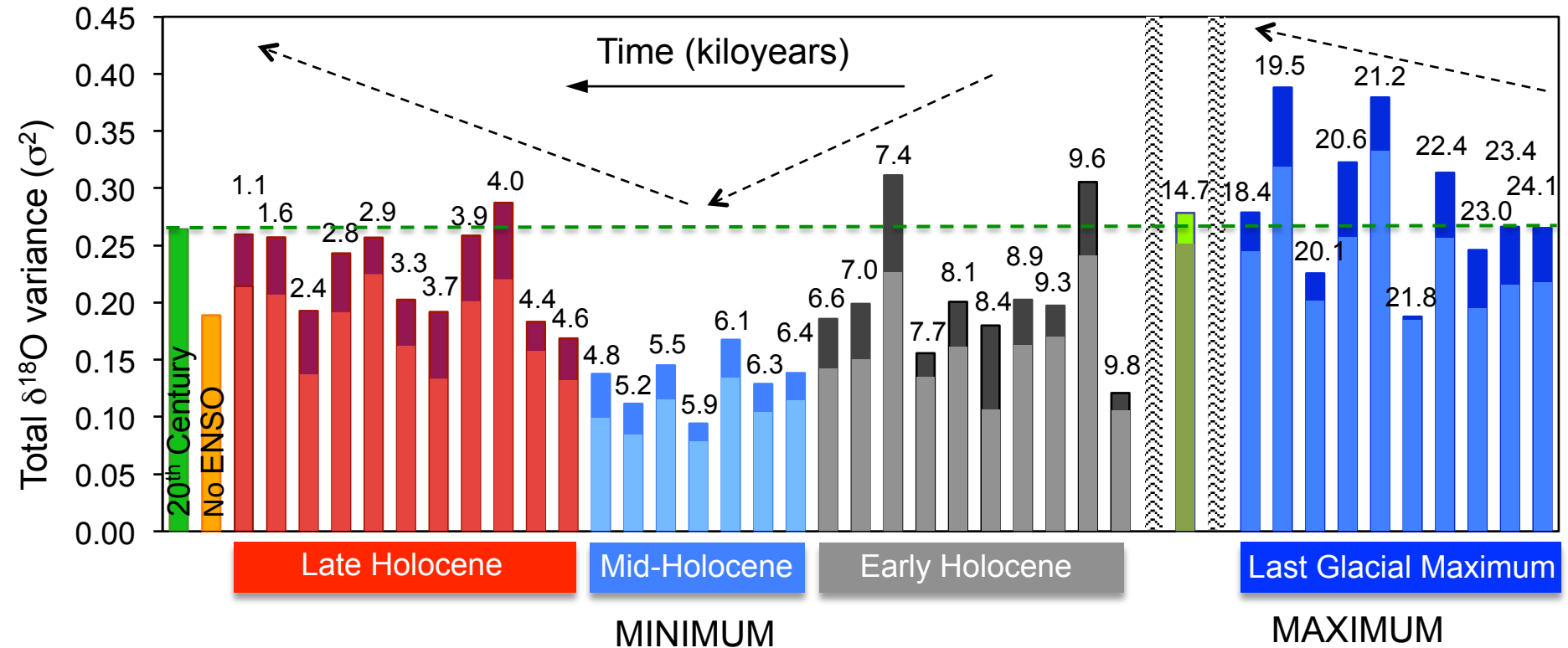
- Analysis of 50-60 individuals
- $\delta^{18}\text{O}$: Temperature and salinity
- The spread in values increases with stronger El Niño variability

Surface-dwelling *G. ruber*
2-4 week lifespan

Analysis in the laboratory



El Niño Variability from Single Forams



- Each bar is about a century (sample age is at the top)
- Minimum variability at 4,000-7,000 years ago
- Maximum at 18,000-24,000 years ago (LGM)
- Large signal: factors of 2-4x

Summary

- El Niño remains *terra incognita*
- The paleoclimate records give us glimpses of very dynamic behavior on long timescales
- Wildcard in past and future climates

Communicating Climate Science

- **Students - Media - Public**
 - Undergraduate students
- **Challenges**
 - Global Warming remains controversial
 - Some students are unwilling to accept it
 - Some come with political baggage (if Al Gore says it it must be wrong!)
 - Students can't conceptualize
 - different spatial and temporal scales
 - Inertia / delayed responses
 - uncertainty,
 - non-linearity
 - In a classroom setting exclusiveness is not an option

What does not work

- Speaking from a position of authority:
 - “We know that...”
 - “It is a fact that....”
 - “The science is settled...”
 - “So-and-so says said this so it must be true”

What Does Work

- Inclusiveness
- Cultivate a kinship with the work of scientists
- Bring students into the world of research
- Give them ownership of a science project
- **Have them do real science:**
 - Do fieldwork - Collect samples
 - Measure something in the lab
 - Produce original data
 - Analyze data on their computers
 - Make a poster - give a talk
 - Go to a conference
 - Co-author a paper

My Model

- Small group projects for 3-4 students
- Real Science - Original Data
- Four components: (1) field work, (2) lab work, (3) data analysis, (4) poster presentation
- One activity that has worked really well is **dendrochronology (tree-rings)**. [Others: Weather station]
 - Ease of sampling
 - Safe
 - Intuitive
 - Can acquire lots of data fast
 - Pleasant field work, painless lab work
 - Dedicated computer software for data analysis
 - Central relevance for climate change issues

