

# **EARTH'S CLIMATE: IS IT OFF COURSE?**

**V.M. CANUTO**

*NASA*

*GODDARD INSTITUTE FOR SPACE STUDIES*

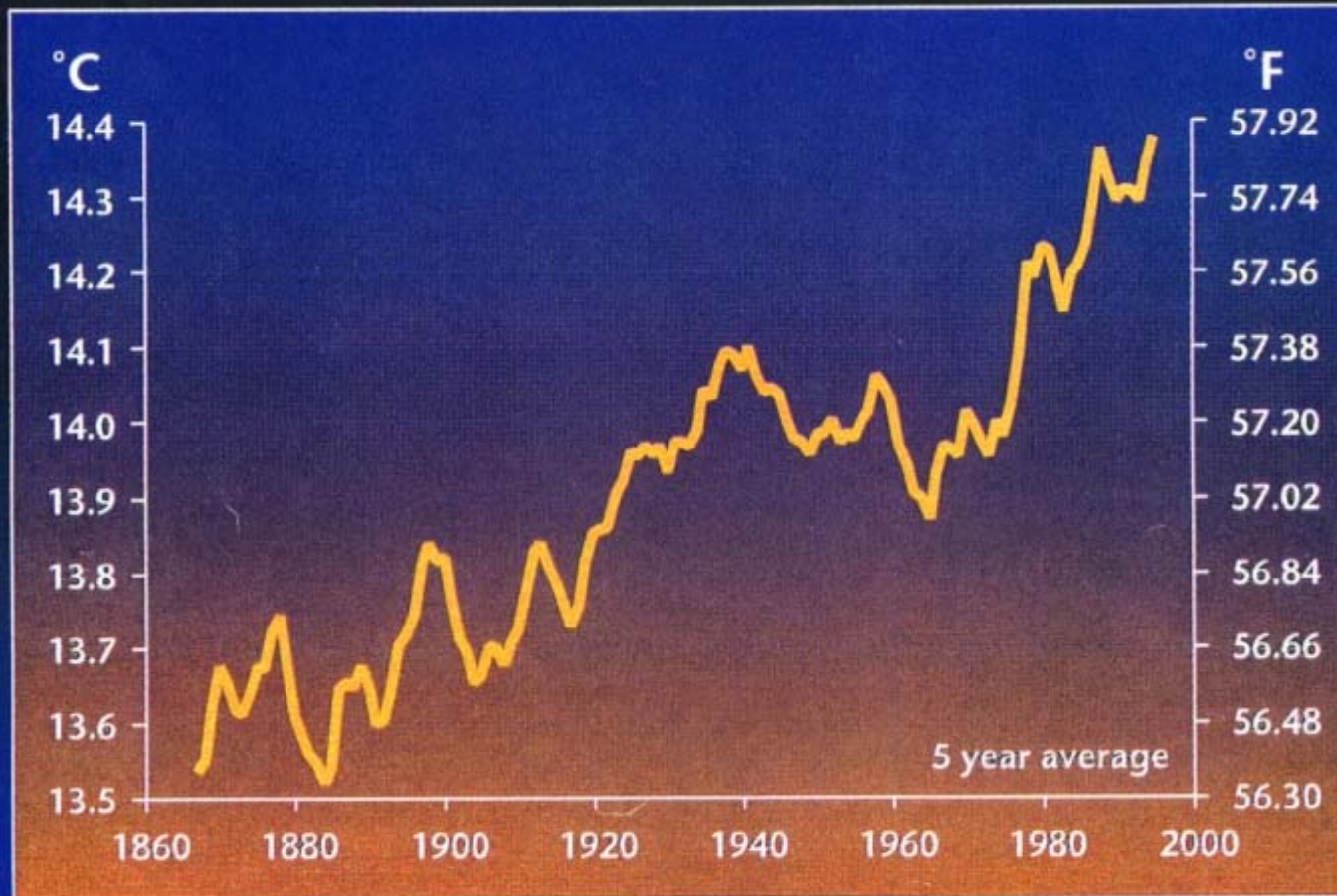
*NEW YORK*

*DEPT. APPLIED PHYS. AND APPLIED MATH.*

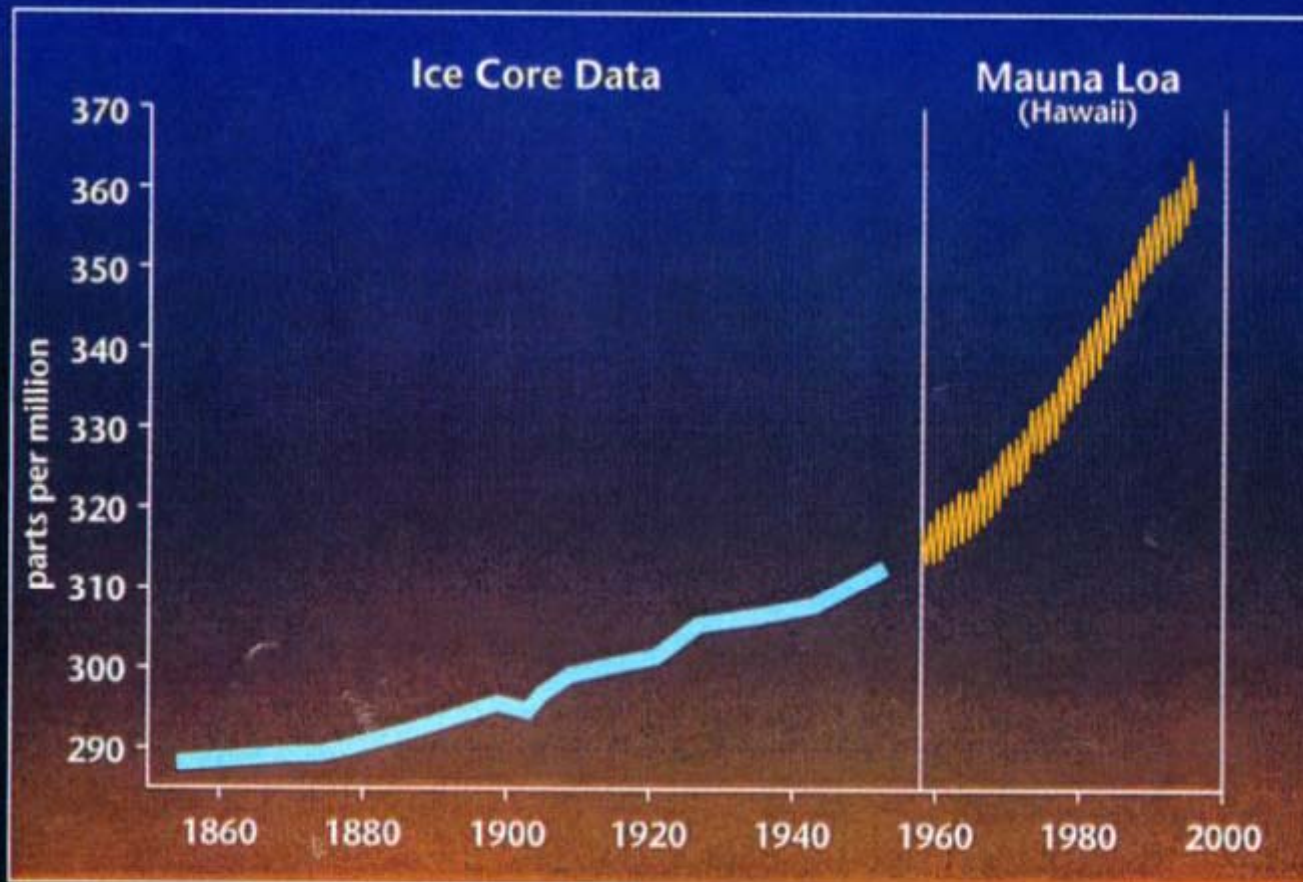
*COLUMBIA UNIVERSITY*

*NEW YORK*

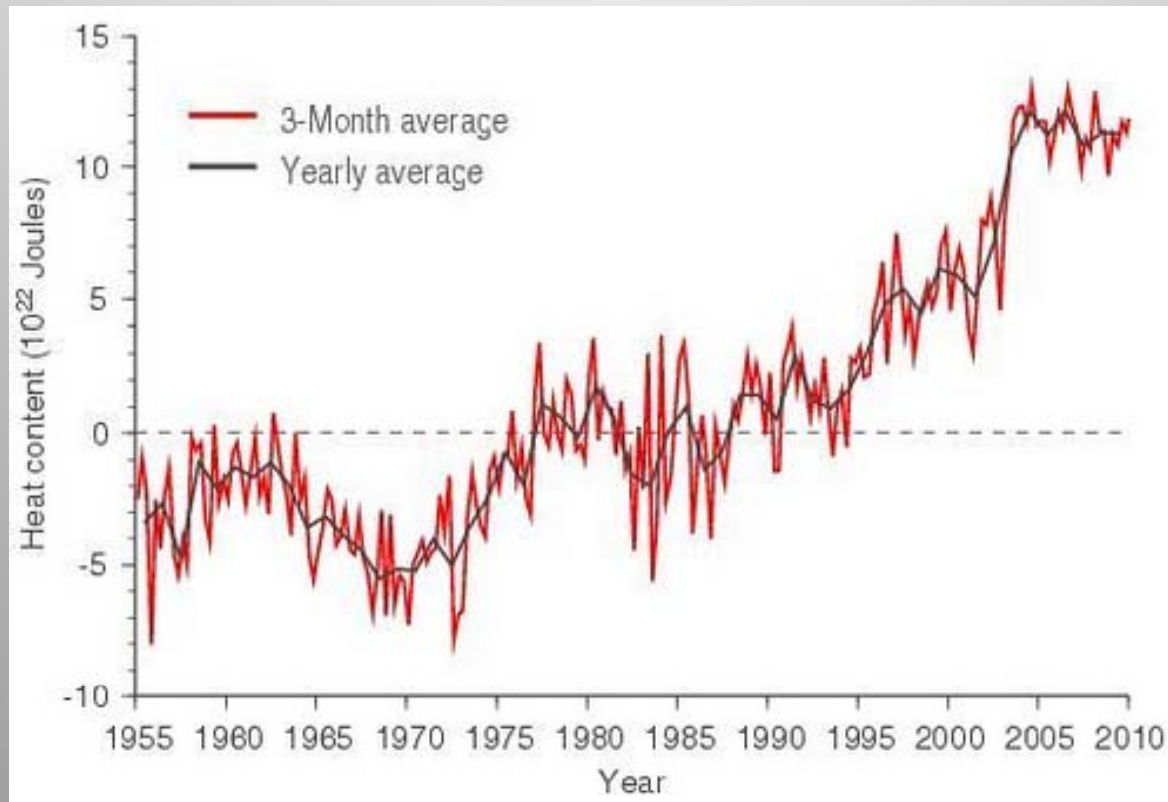
# Global Average Temperature

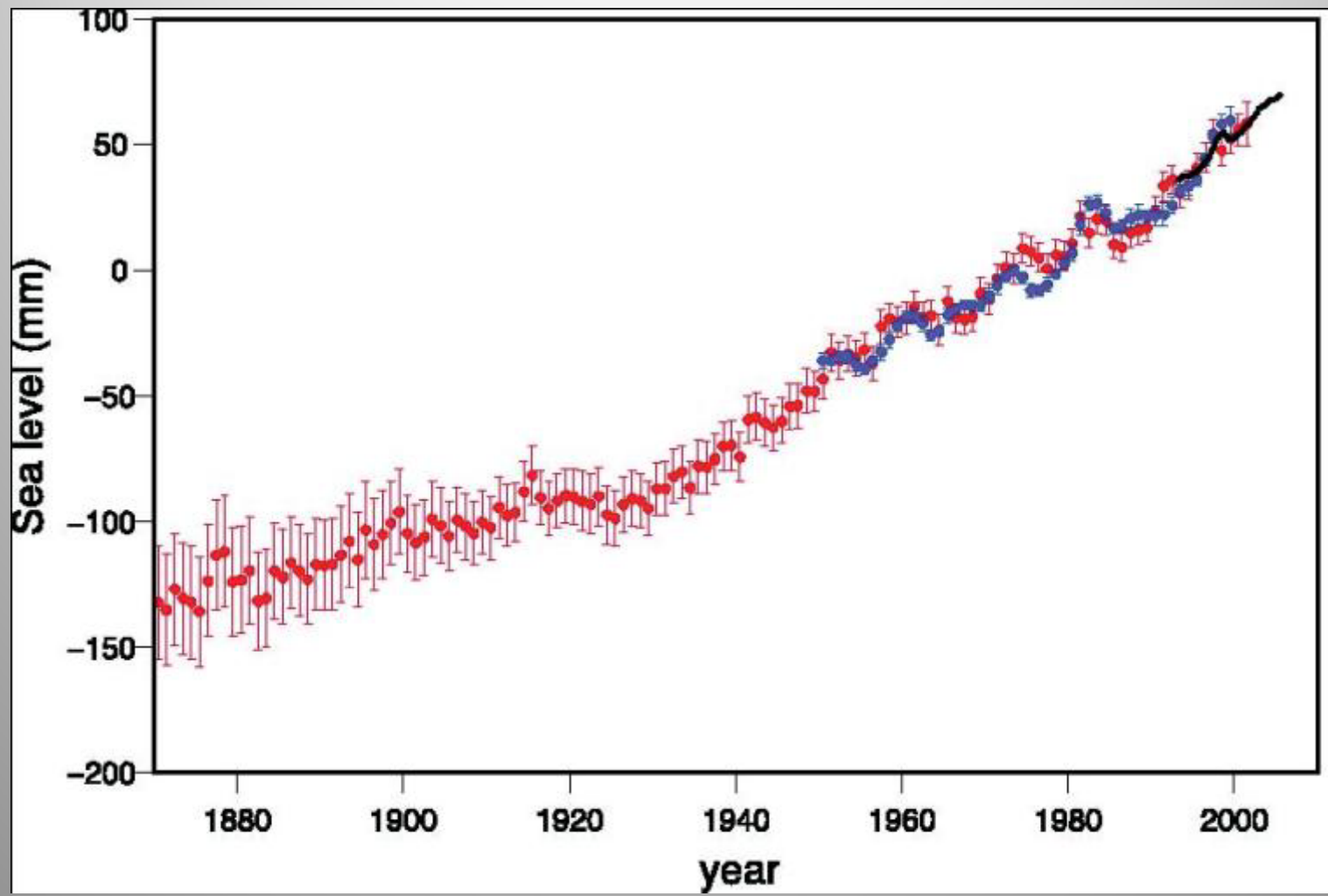


# Carbon Dioxide Concentrations

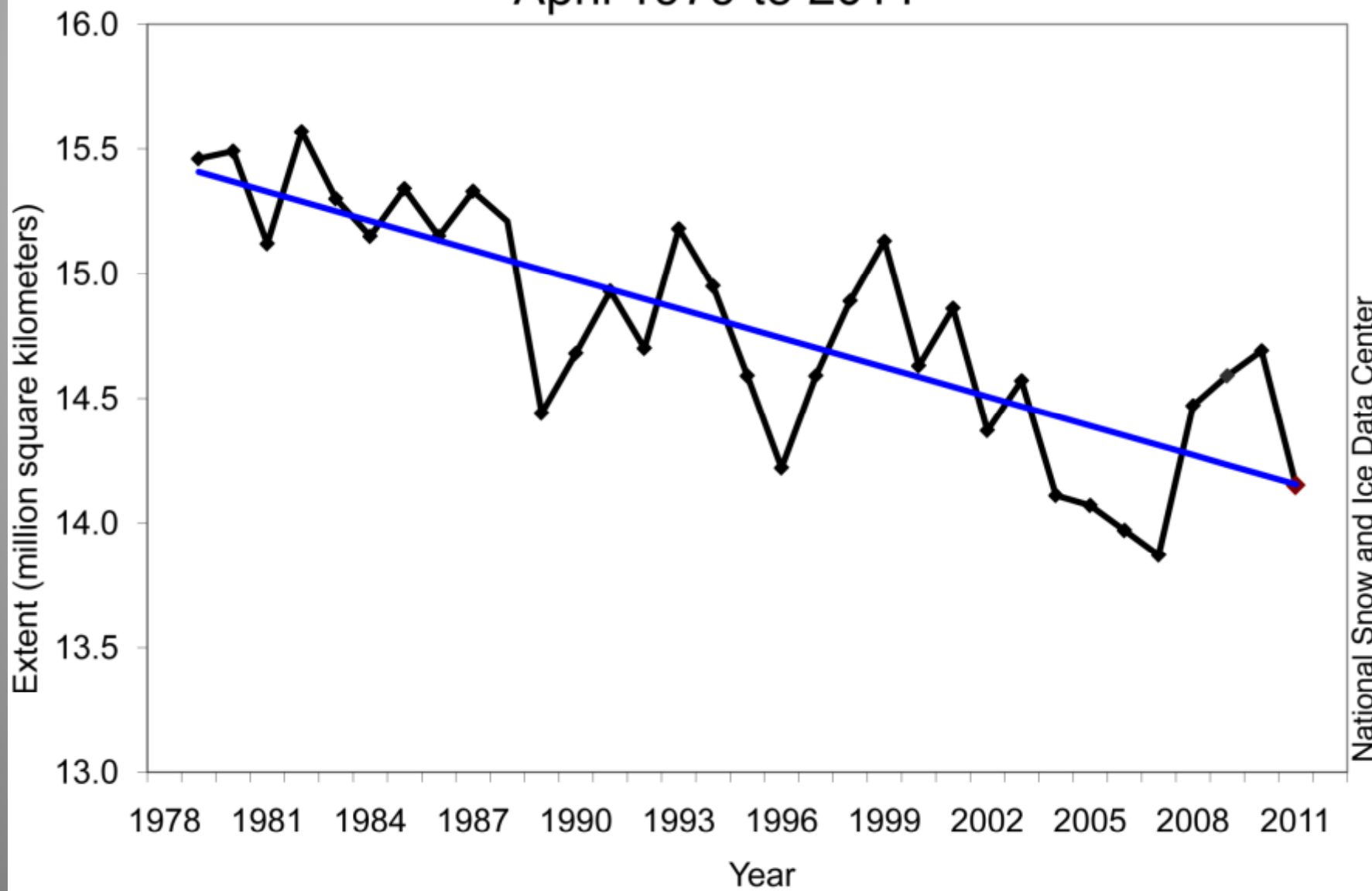


# OCEANS ARE WARMING UP

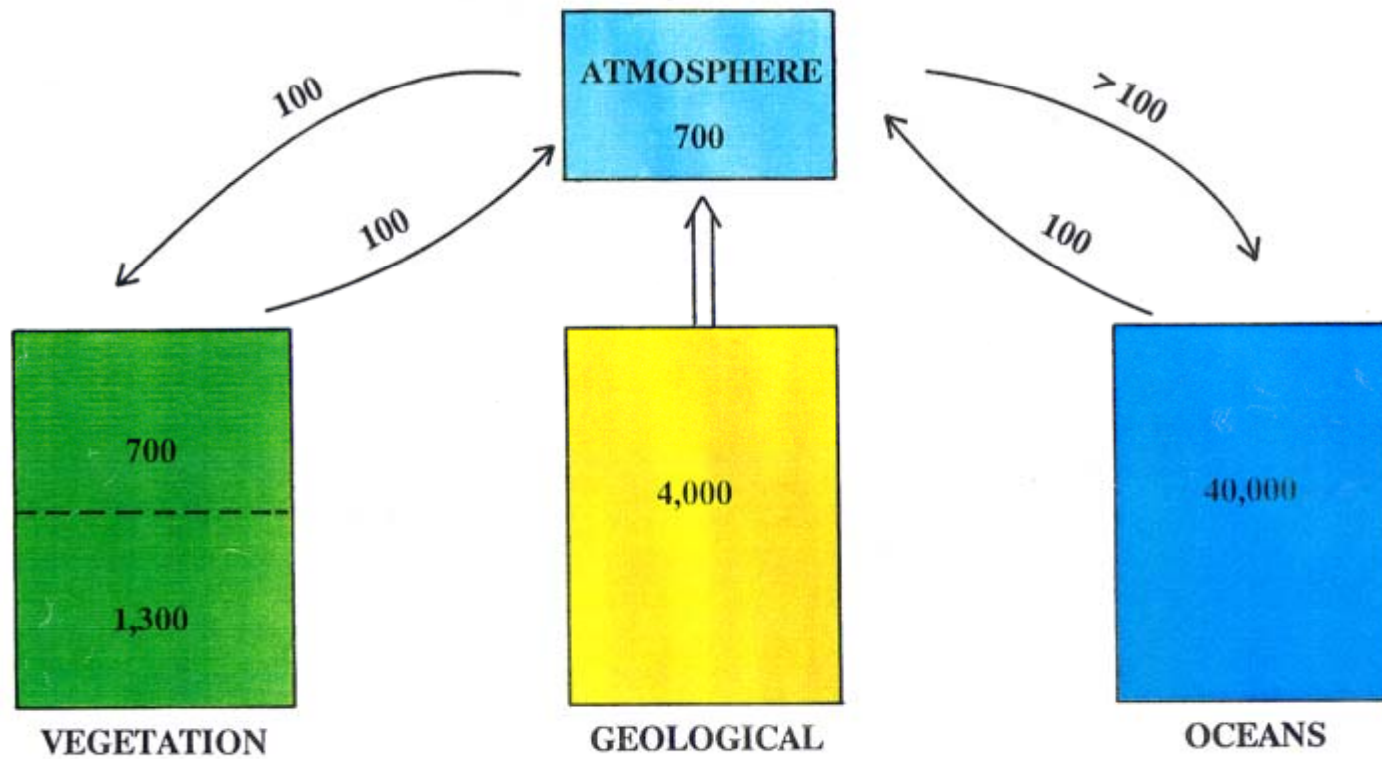


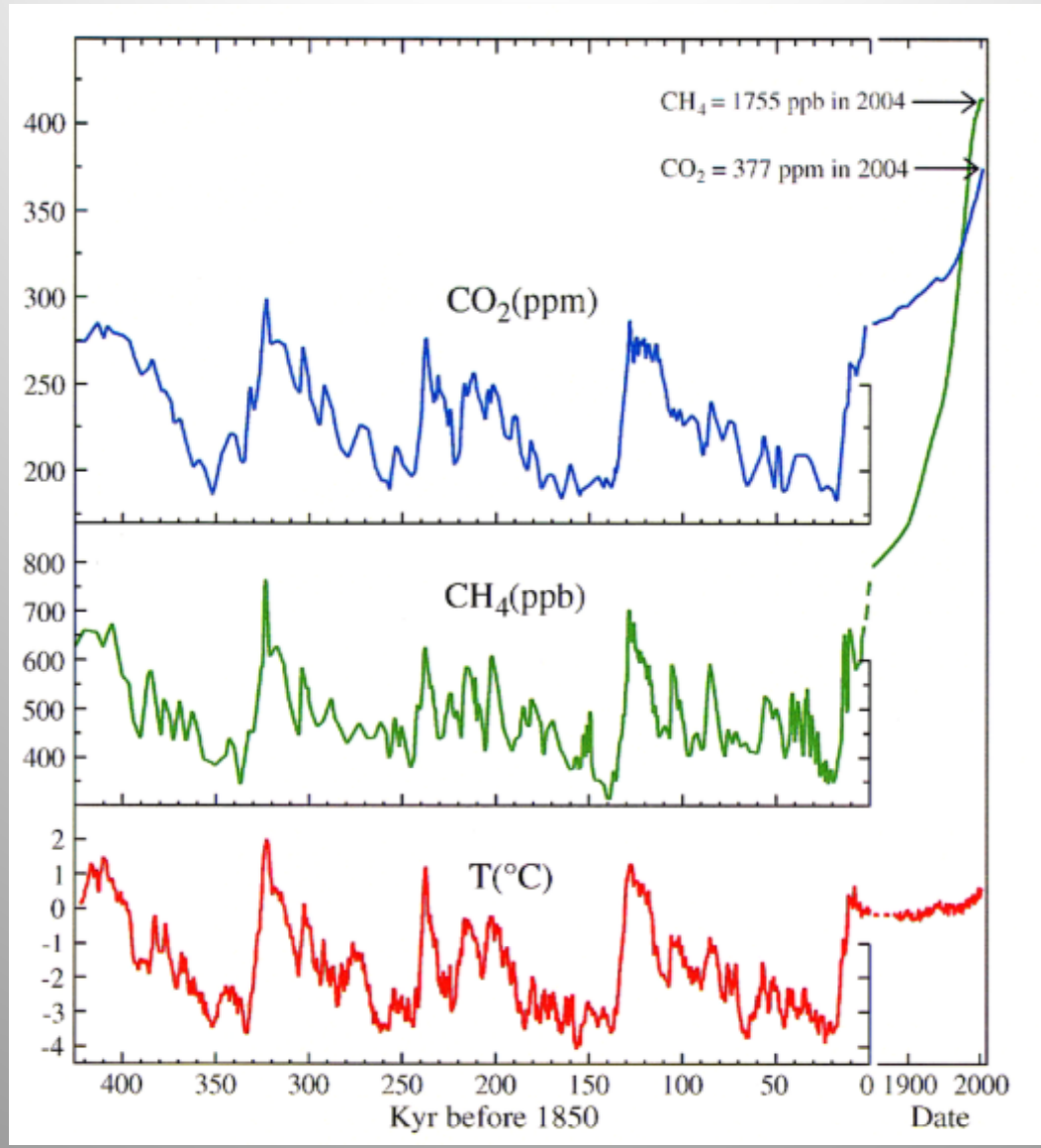


# Average monthly Arctic sea ice extent April 1979 to 2011



National Snow and Ice Data Center



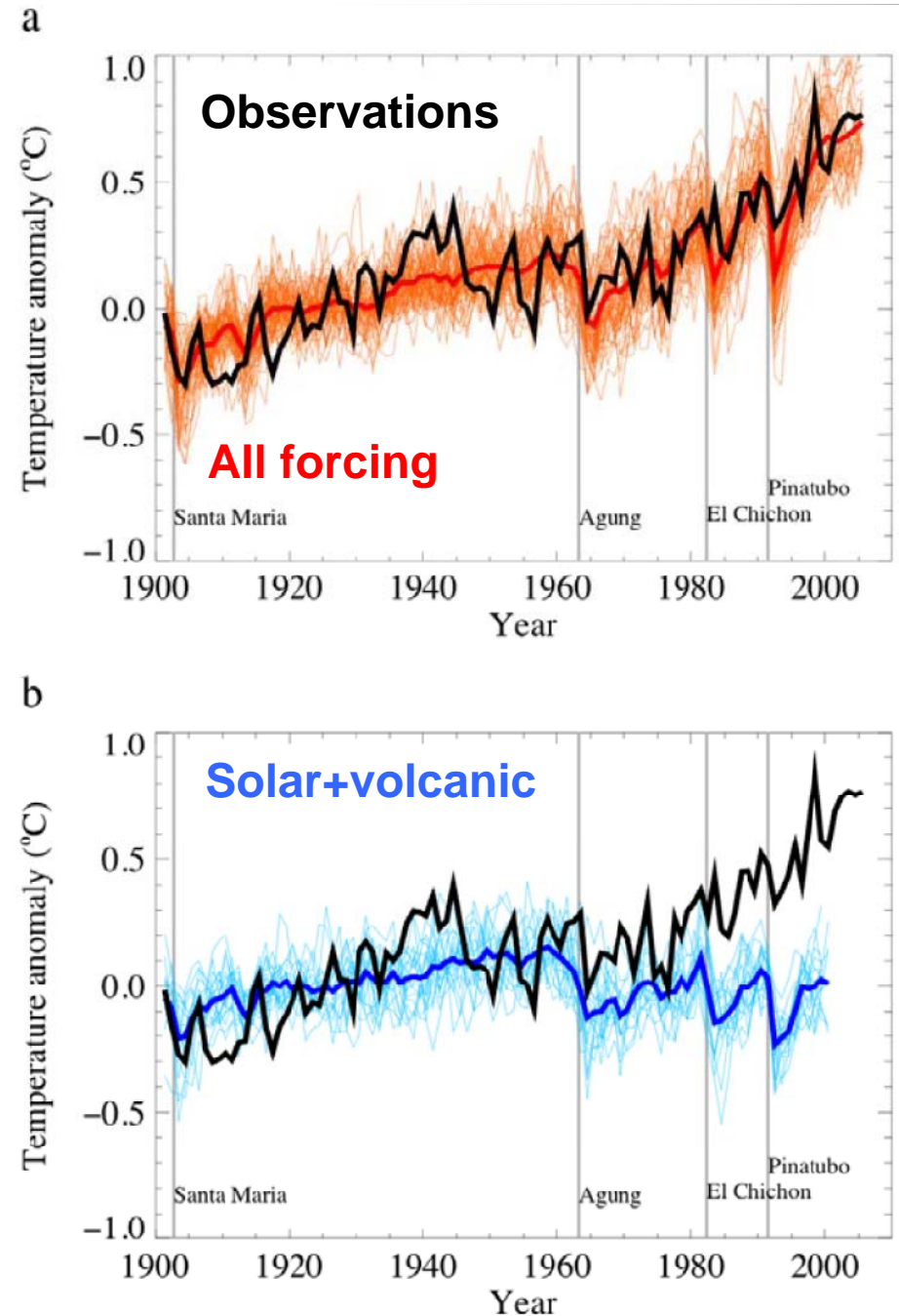


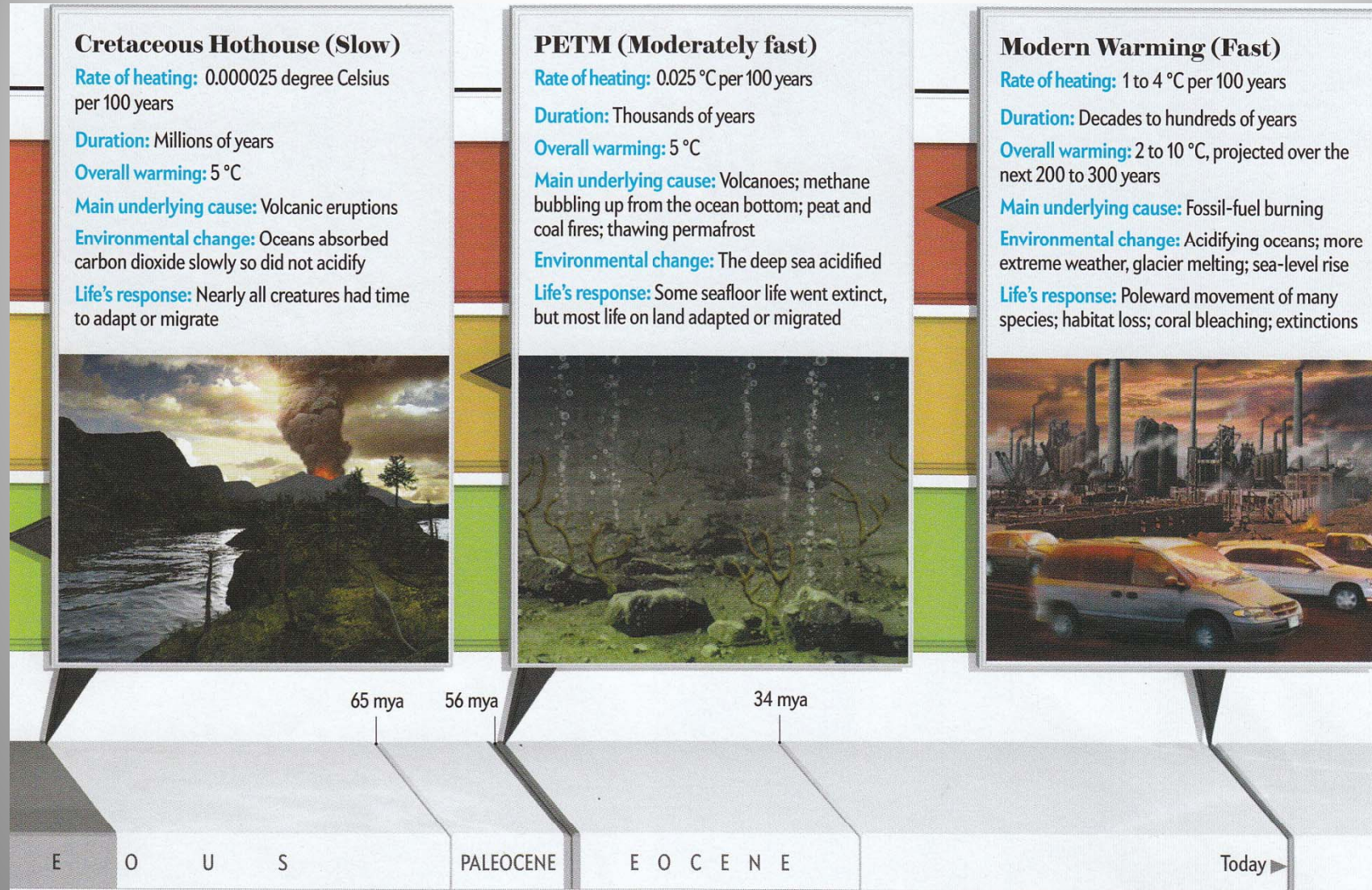
**S. Arrhenius:**

**We are evaporating our coal  
mines into the air**

# Attribution

- are observed changes consistent with
  - expected responses to forcings
  - inconsistent with alternative explanations





L.R. Kump, Scientific American, July 2011

**CO<sub>2</sub>**

- **40% STAYS IN THE ATMOSPHERE**
- **60% OCEAN AND VEGETATION**




**SINCE THE BEGINNING OF THE  
INDUSTRIAL REVOLUTION**

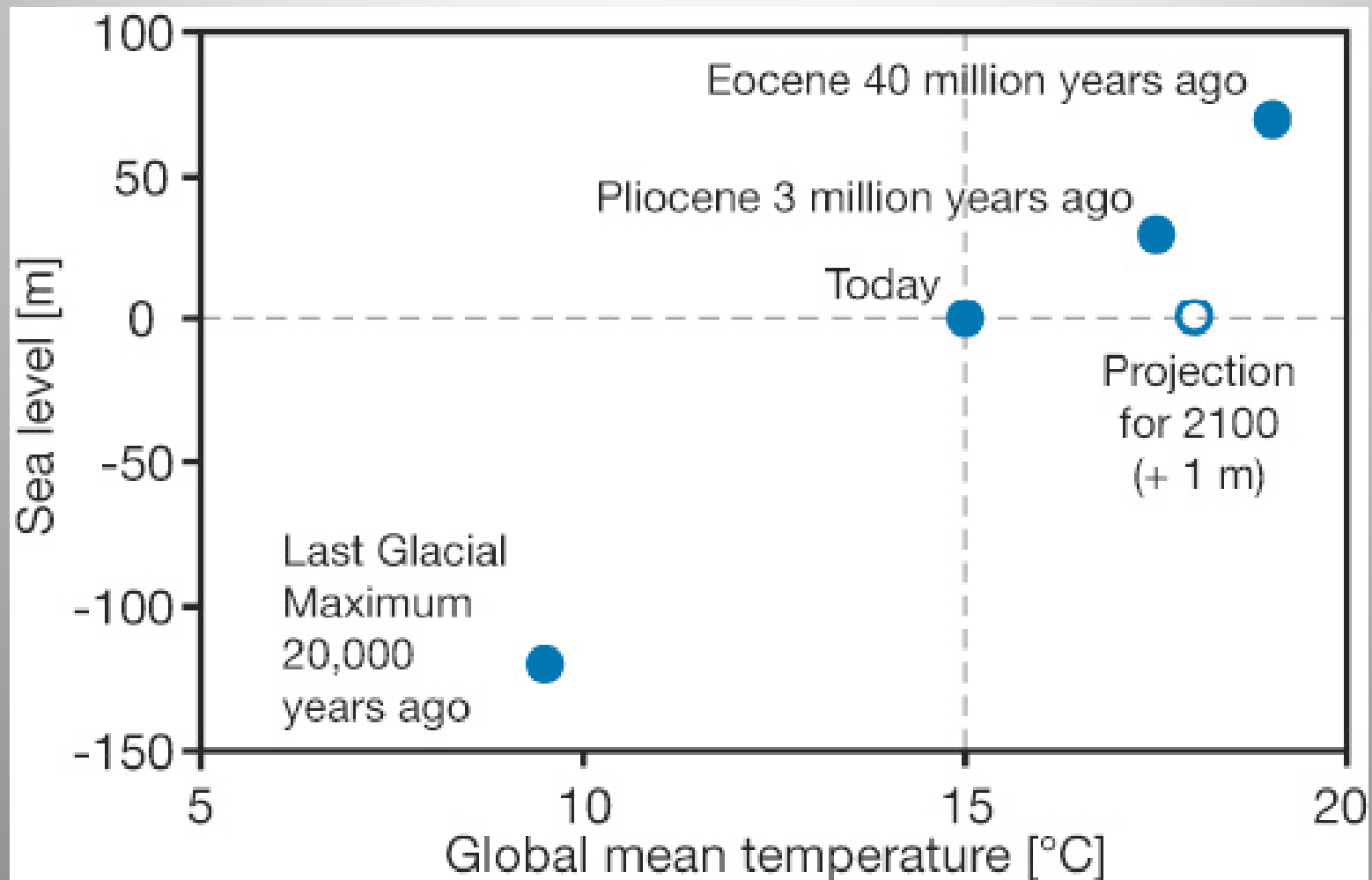
**ANTHROPOCENE**

**REAL WORLD:      TODAY: 380 ppm**

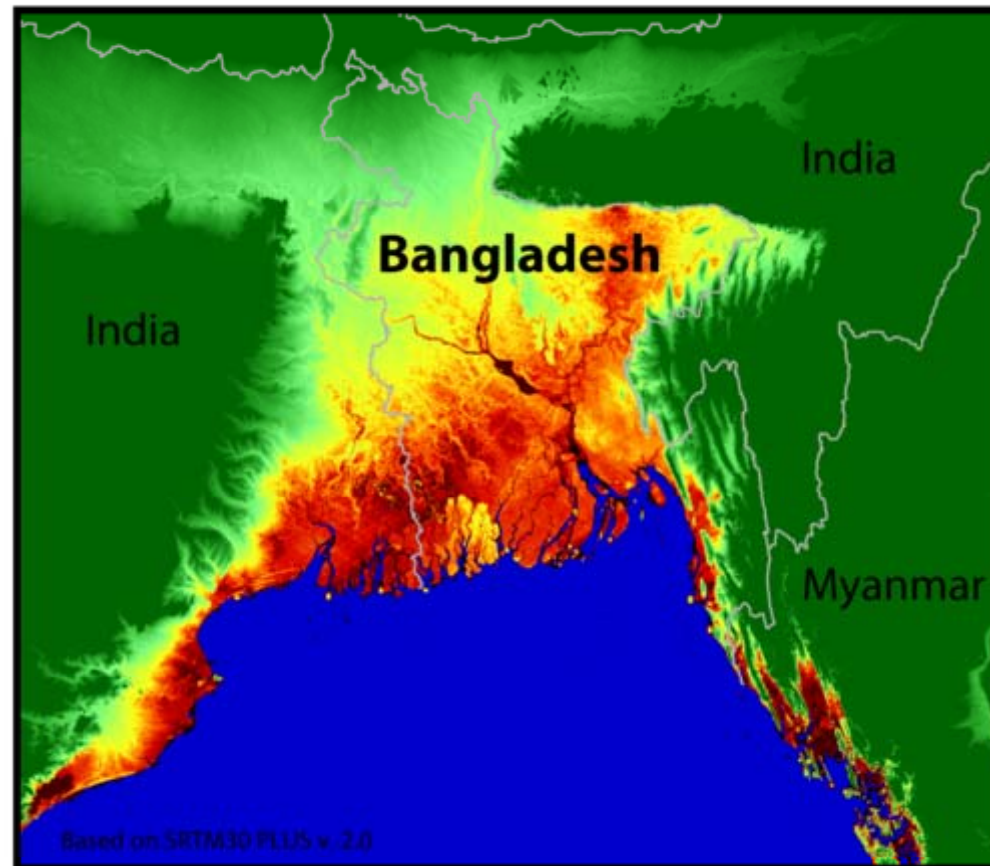
**NO OCEANS:      TODAY:**  
**380 + 55 = 435 ppm**

## **INCREASE CO<sub>2</sub>:**



- **MEAN TEMPERATURE** 
- **SEA LEVEL** 
- **OCEAN ACIDITY** 

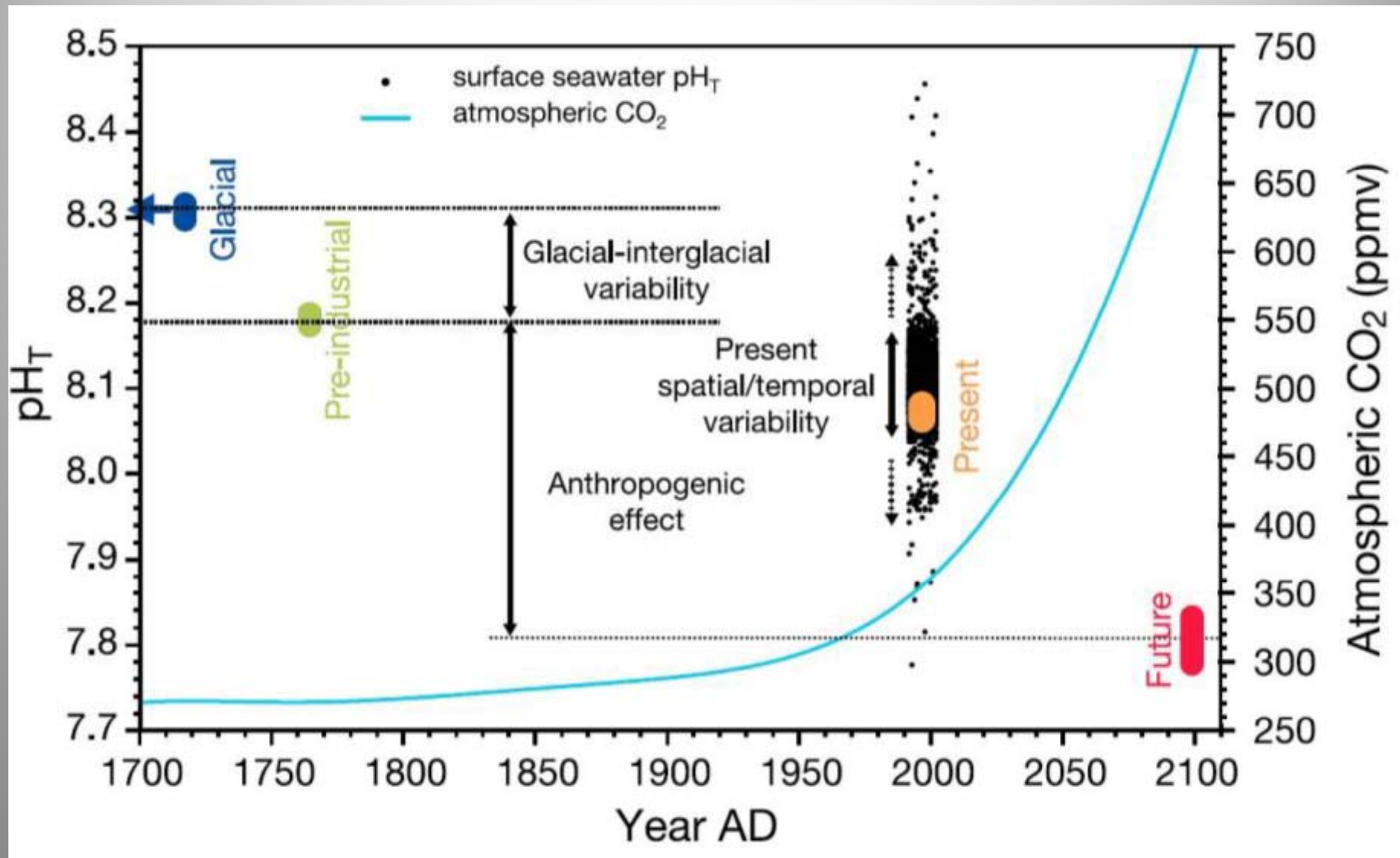


## Sea Level Risks - Bangladesh



# OCEAN ACIDIFICATION

- **OCEANIC pH** 
- **CALCIFICATION** 



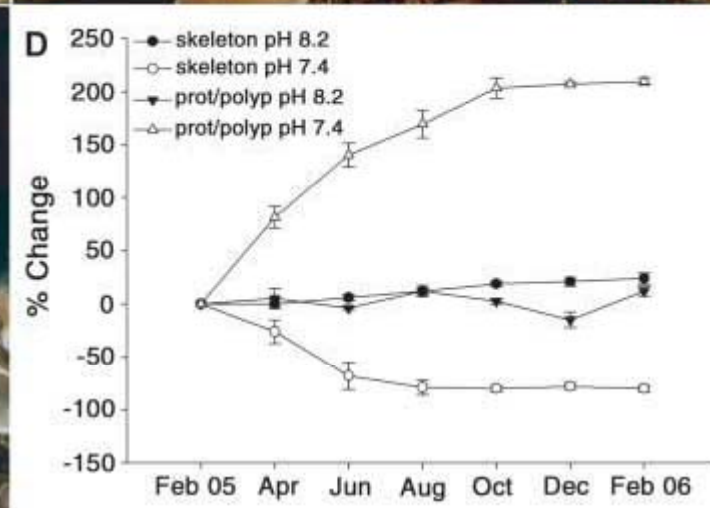
# DECALCIFICATION

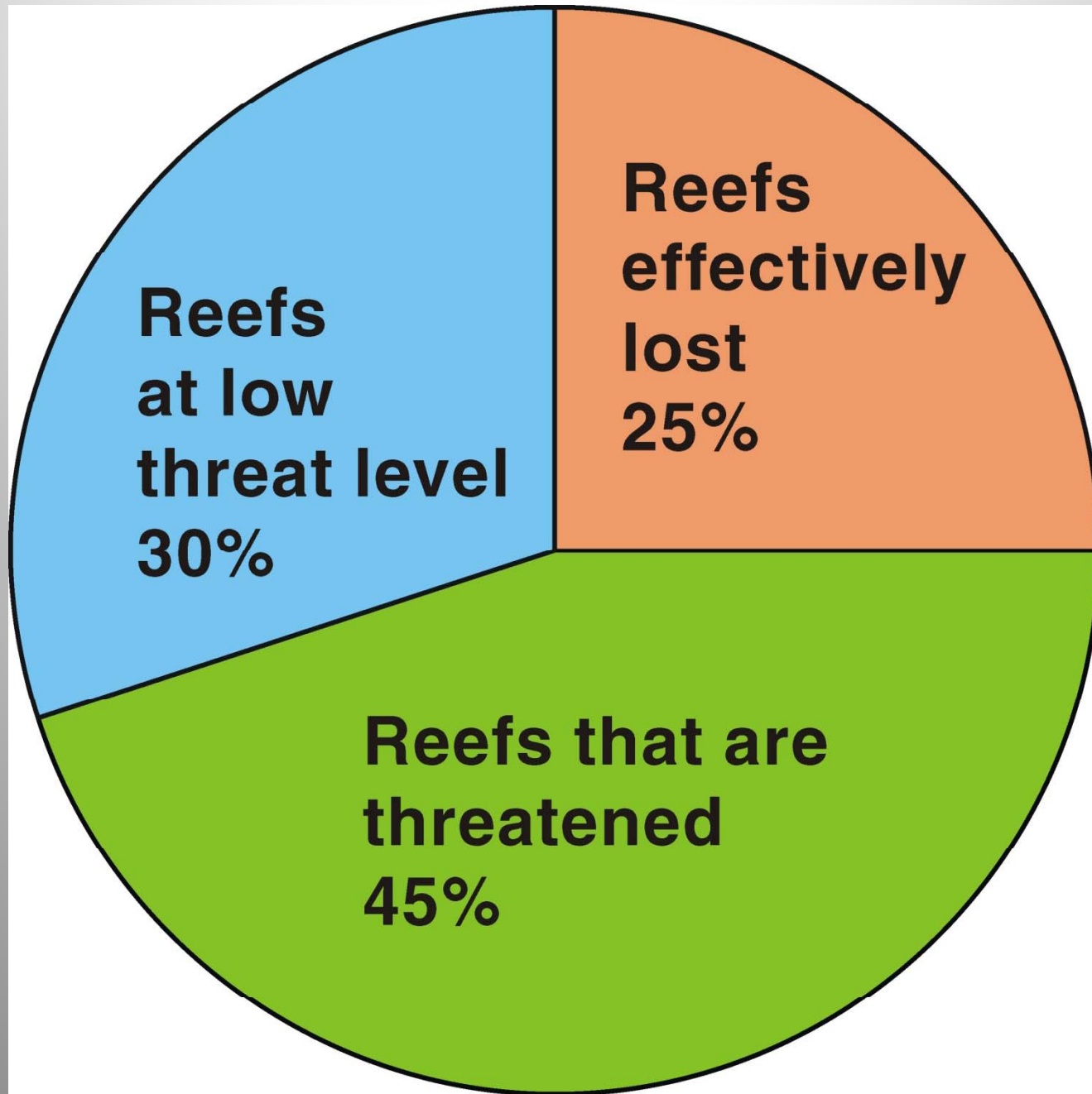
- ACIDIFICATION LOWERS THE SATURATION LEVEL OF  $\text{CaCO}_3$

ARAGONITE

- CORAL REEFS HARBOR 25% WORLD FISH POPULATION
- PTEROPODS, SNAILS, FOOD FOR SALMON, COD, MACKEREL







# **Future Oceans ...**

**Warming Up**

**Rising High**

**Turning Sour**

# OCEANS - LIFE

- $4 \times 10^9$  yrs ago: life on earth began in the oceans
- $500 \times 10^6$  yrs ago: life emerged from the oceans
- 0.004%: humankind on earth
- working against the oceans' buffering action  
as a CO<sub>2</sub> sink
- future: will the oceans suffocate us?

- **GROWTH RATE: 10,000 PEOPLE/HOUR**
- **ONLY A MADMAN (OR AN ECONOMIST)  
BELIEVES THAT EXPONENTIAL GROWTH CAN  
GO ON FOREVER**
- **TENDENCY IS NOT DESTINY**
- **HUMANITY: NOT THE SUM OF ITS PEOPLE  
SUM OF ITS NECESSITIES (J.P. SARTRE)**

MARKET FORCES BRING: **TECHNOLOGY**



TECHNOLOGY IS A PRODUCT OF: **INVENTIONS**

IT IS NOT SUFFICIENT TO HAVE INVENTIONS



WE NEED TO CONTINUE: **INVENTING INVENTIONS**



WHAT DO WE NEED TO DO THAT? **KNOWLEDGE**

**WHY?**

TECHNOLOGY GIVES **INFORMATION**

KNOWLEDGE GIVES **WISDOM**

## Greenhouse effect:

Irreversible in Time

Planetary in Scale

TransGenerational

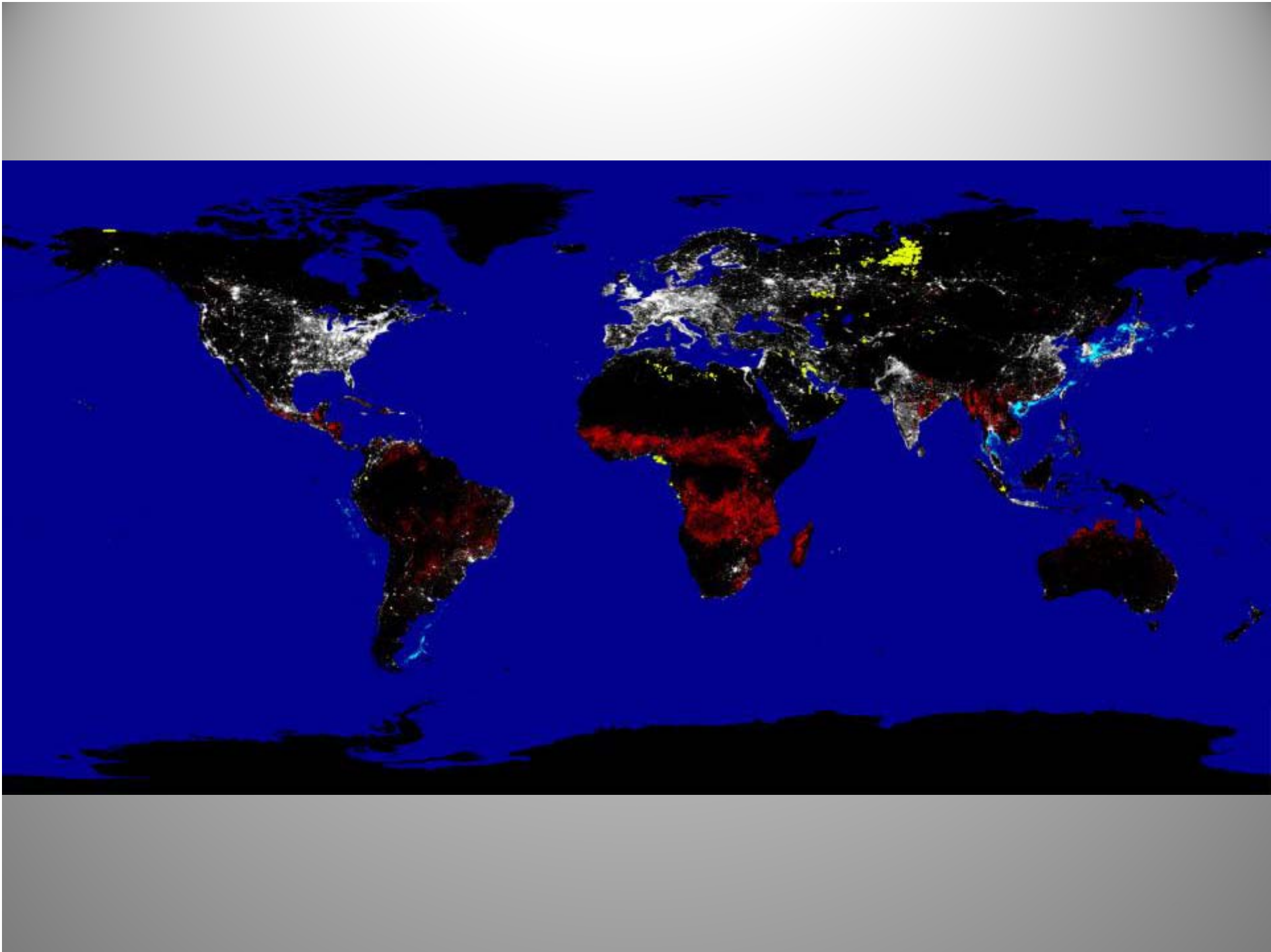
TransNational

A Trend, not an Event

**THE CHIEF AIM OF SCIENCE  
IS NOT TO OPEN THE DOOR TO  
INFINITE WISDOM**

**IT IS TO PUT SOME LIMIT TO  
INFINITE ERROR**

**Bertolt Brecht**



**CIVILIZATION :**

**AN INTERLUDE ?**