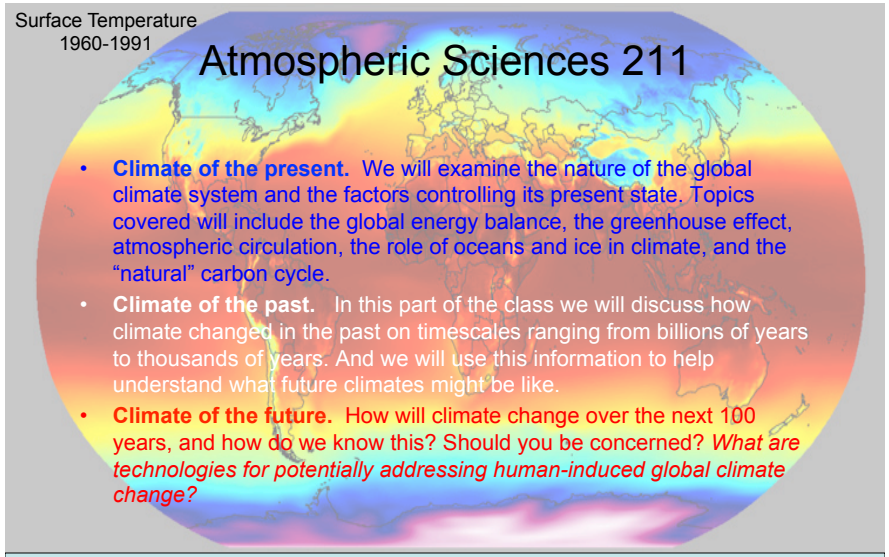
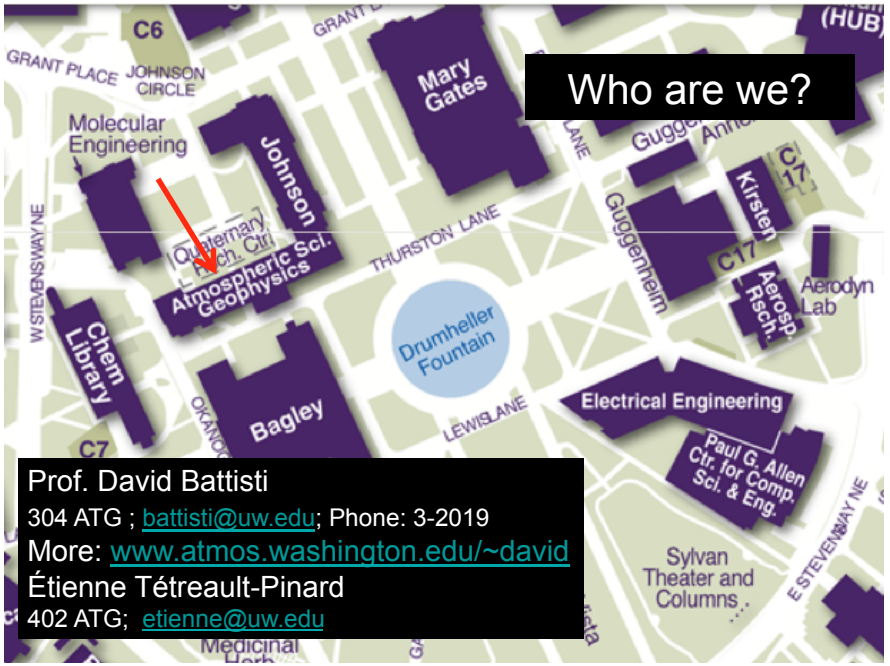


Atmospheric Sciences 211

- **Climate of the present.** We will examine the nature of the global climate system and the factors controlling its present state. Topics covered will include the global energy balance, the greenhouse effect, atmospheric circulation, the role of oceans and ice in climate, and the "natural" carbon cycle.
- **Climate of the past.** In this part of the class we will discuss how climate changed in the past on timescales ranging from billions of years to thousands of years. And we will use this information to help understand what future climates might be like.
- **Climate of the future.** How will climate change over the next 100 years, and how do we know this? Should you be concerned? *What are technologies for potentially addressing human-induced global climate change?*

www.atmos.washington.edu/academics/classes/2012Q4/211/



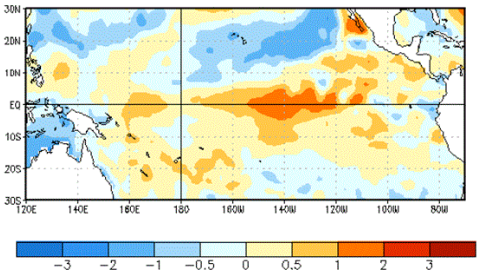
About Me

Prof. of Atmospheric Sciences
BS. In Physics, MS. In Oceanography, Ph.D. in Atmospheric Sciences

Scientific Interests:
- Year-to-Year Climate Variability (e.g., El Nino)
- Past Climates (e.g., Eocene, Ice Ages)
- Impacts of Climate Variability and Climate Change on Global Food Production

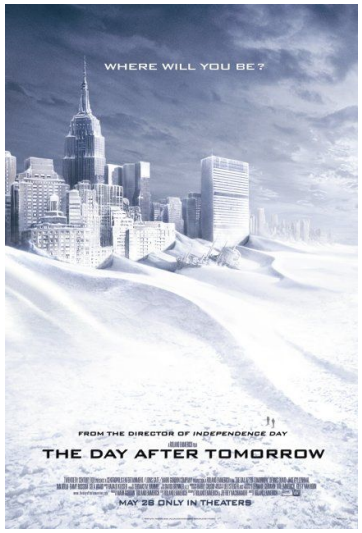
Sea Surface Temperature Anomalies

24-31 Aug 2012



My other hats
- Prof, University of Bergen Norway
- Affiliate Prof, Food Security and Environment Program, Stanford
- Chief Climate Scientist, *Global Food Bank, Svalbard Norway*

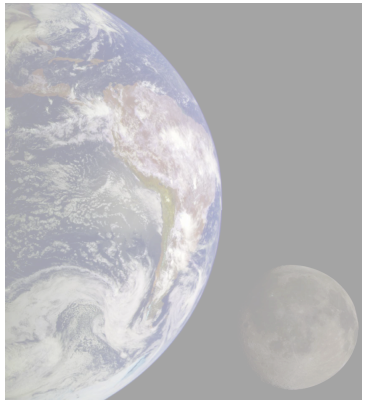
Course Goals



1. Develop an understanding of how the climate system works, how it has changed in the past, and how it is now being changed by human activity.

2. Learn skills to analyze and critically evaluate public discussions of climate issues.

What this course is/isn't about



YES: Science: the what, how, and why of climate and climate change

NO: philosophies, values, politics, etc

Course Overview

The Climate System (Present)

- Tools: Radiative Transfer & Energy Balance
- Earth's Energy Balance & Climate
- Tools: Force Balance and Winds
- General Circulation of the Atmosphere
- Regional Climates

Climate Change (Past-Present)

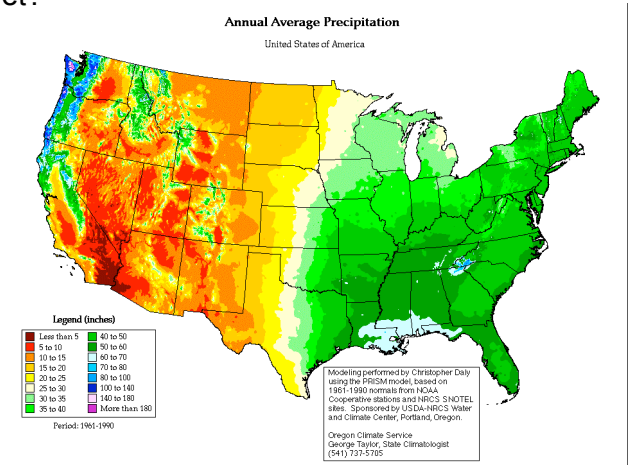
- How we know pre-instrumental climate
- Orbital Forcing & the Ice Ages
- Solar and Volcanic Forcing
- The natural carbon cycle and past warm climates
- The Human Influence on the climate of the 20th Century

Global Warming (Future)

- Projected forcing and climate response

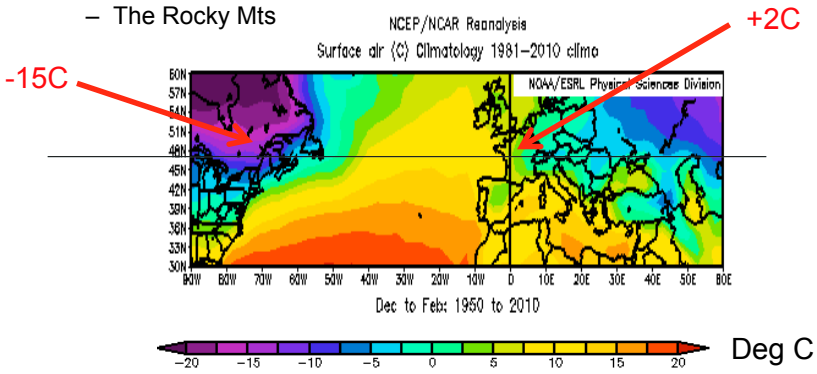
Things we will *understand*

- Why is Southern California so dry and Seattle so wet?

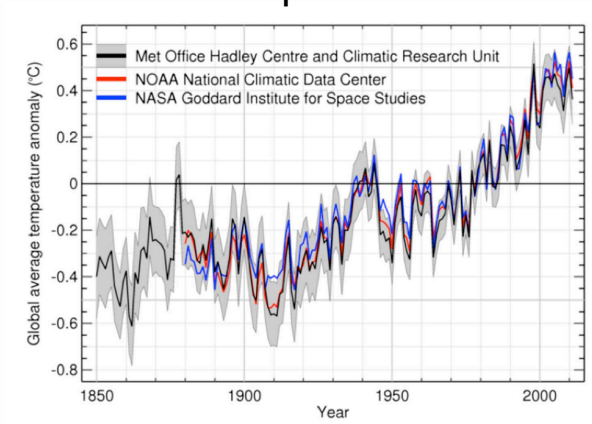


Things we will *understand*

- Why is Europe so warm in winter compared to New England?
  - The Gulf Stream
  - 350M Europeans release much more CO_2 than 20M N'Englanders and Canadians
  - The Rocky Mts

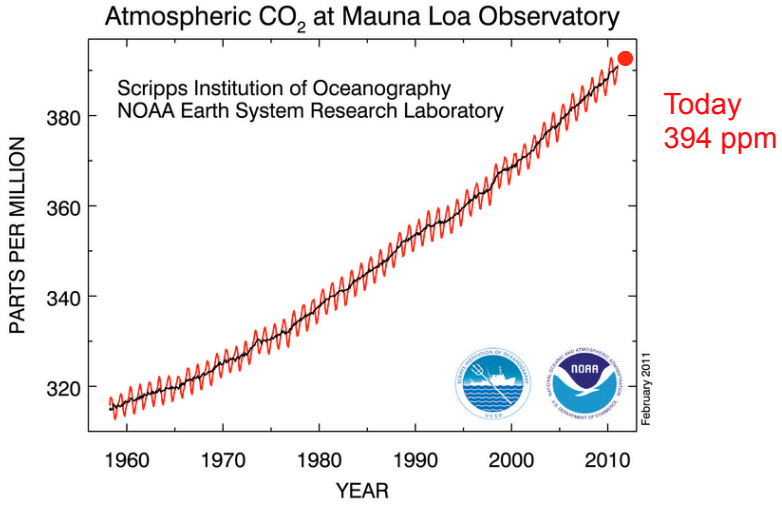


Annual Global Average Surface Temperature



- How do we *know* the 20th Century trend in is not due to natural variability? To changes in the Sun's output?

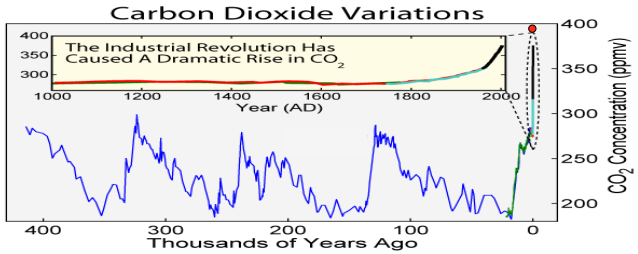
Carbon Dioxide in the Atmosphere



Today
394 ppm

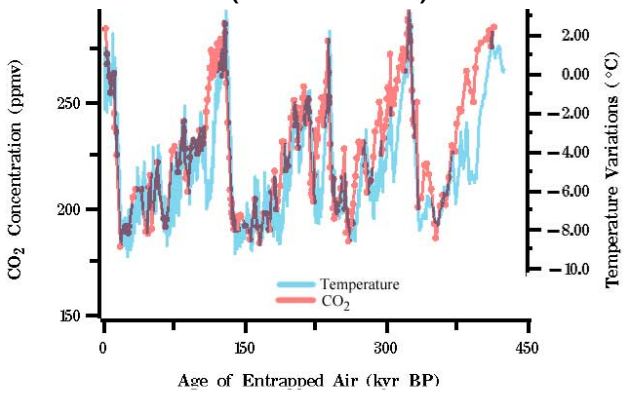
How do we know the 20th Century trend in CO_2 is not natural?

Atmospheric Carbon Dioxide



- What does the geological record tell us about the climates of the past, when CO_2 was much *lower* than today?

CO_2 and Temperature at the S. Pole (Vostok St)



At the S. Pole, temperature goes hand-in-hand with CO_2: high CO_2 goes with high temperature.

What does this imply about the globe? About causality?

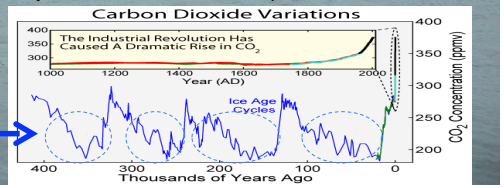
Things we will *understand:* the Great Ice Ages

- The Ice Ages lasted 2.6 Myr BP to about 10,000 yrs ago
- Large Ice sheets covered Northwestern Europe and Northern North America

Things we will *understand:* the Great Ice Ages

- The Ice Ages lasted 2.6 Myr BP to about 10,000 yrs ago
- Ice volume changes are coordinated with CO_2 changes (shift of carbon between atmosphere and oceans)

Times of High Land Ice Volume



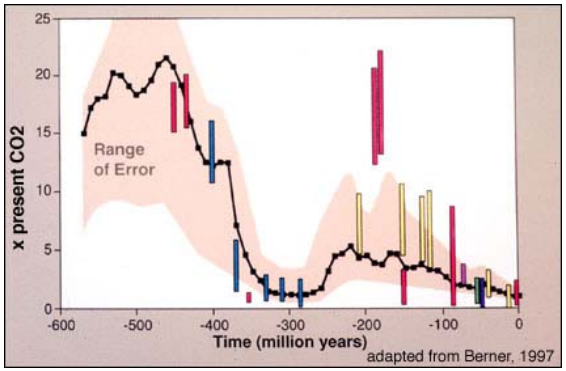
Things we will *understand:* the Great Ice Ages

- The Ice Ages lasted 2.6 Myr BP to about 10,000 yrs ago
- The Ice Ages are *caused* by orbitally induced changes in northern hemisphere summer insolation
  - Changes in CO_2 act enhance the temperature and land ice changes due to the insolation changes (a positive feedback)

Carbon Dioxide in the Atmosphere

GEOCARB II model
(black line; shaded area encloses model uncertainty)

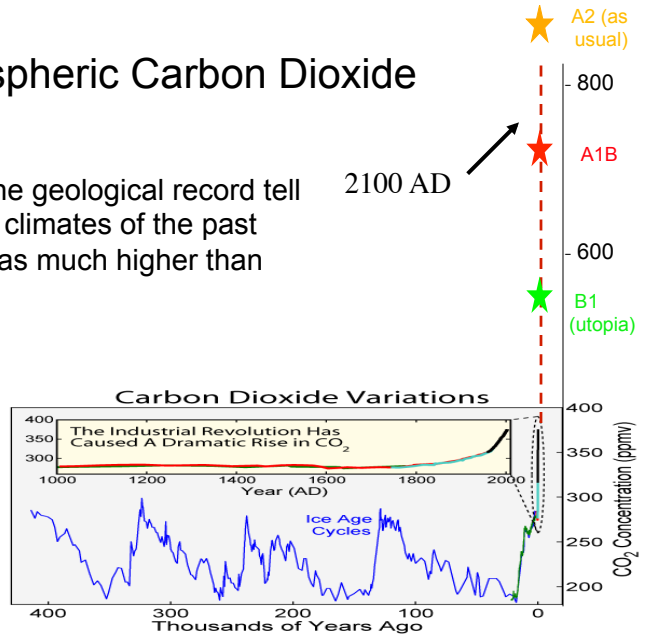
Estimate from plant stomata & C^{13}/C^{12}
(vertical bars)



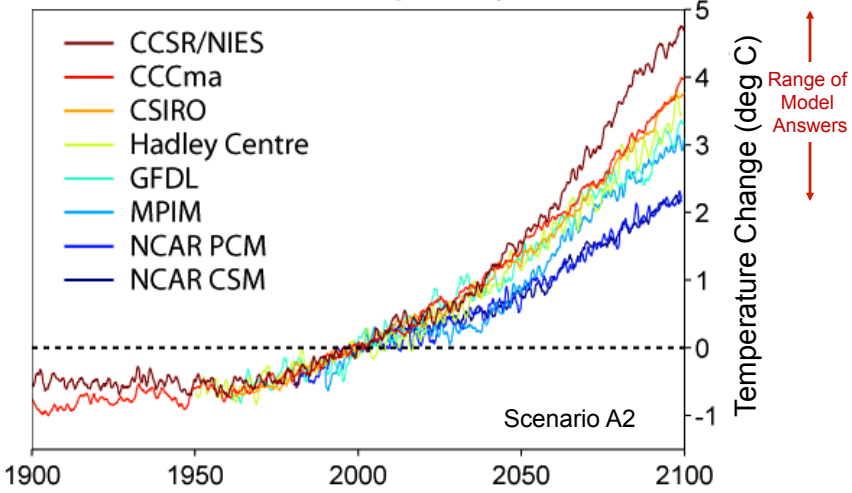
- CO_2 has been much higher in the past than today. How do we know the 20th Century trend in CO_2 is not due to natural causes?

Atmospheric Carbon Dioxide

- What does the geological record tell us about the climates of the past when CO_2 was much higher than today?



Global Warming Projections



How are these projections made and what do they say about the climate at the end of this Century?

In 100 years, the atmospheric CO_2 will reach 500-1000 ppm, which was last experienced during the EOCENE (55 to 36 million years ago)

The Eocene climate was warm, even at high latitudes:
- -palm trees flourished in Wyoming and Antarctica was a pine forest
- -crocodiles lived in the Arctic
- -deep ocean temperature was 55°F (today it is ~35°F)
- -sea level was at least 300 feet higher than today

* Climate models with mid-range climate sensitivity simulate an Eocene that is much too cold compared to the fossil records

Very Tentative Syllabus

Sept 24-27	Introduction; Origin of Earth's Atmosphere; Atmosphere Composition Today
Oct 1-4	Heat and Temperature; Heat Forms and Transport; Radiation; Concepts in EM Radiation; Solar Radiation and the Earth; Albedo
Oct 8-11	Energy Balance; Greenhouse gases and the Greenhouse Effect
Oct 15-18	Greenhouse Effect (cont.) Seasonal Temperature Cycles; Pressure Force, Hydrostatic Balance; Coriolis Effect and Geostrophic Wind; Jet Streams;
Oct 22-25	General Circulation of the Atmosphere; The Role of Mountains in Climate; The Role of the Ocean in Climate

Very Tentative Syllabus

Oct 29- Nov 1 Midterm 1st	The Cryosphere Today; Ice Ages and How We Know They Happened; Milankovitch Theory; Precessional Forcing
Nov 5-8	The Carbon Cycle and Warm Climates of the Past
Nov 13-15 *(12th Holiday)*	Natural and Human Induced Forcing and their Impact on Climate of the 20th Century
Nov 19-21 *(22nd Holiday)*	The 20th Century Climate (cont)
Nov 26-29	Projected Climate Change (today to 2100 and beyond)
Dec 3-6	Geo-engineering; wrap-up

Prerequisites & Required Materials

- Math is the language of the natural sciences
- You will see and learn to use a *few* equations
- This course and your grades are based on *concepts* (NOT mathematical ability)
- Textbook: Kump, Kasting, Crane, 3rd edition (2010) *The Earth System*

Logistics

- Lectures here MTWTh 10:30-11:20
- Discussion/Quiz Sections Friday
  10:30 JHN 111 or 11:30 JHN 175

Assessment & Grading Policy

- **Assessment**
  - Homework and Quizzes 35%
  - Mid-Term Exam (Nov 1) 30%
  - Final Exam 35%
    Tentative: Monday Dec 10 830-1020, OTB 014

- **Grading Method**
  - Likely course mean 2.8 – 3.2 (B- to B)
  - Curve if necessary

Assessment & Grading Policy (cont)

- There will be no makeup exams except in case of serious illness, death in the family or something of that nature. You must be excused by Prof. Battisti in advance of the date of the exam.

- **Plagiarism - Working Together**
  - see UW policy on plagiarism
  - discussions are encouraged!
  - on your own for exams, homework, etc

Course Guidelines and Philosophy

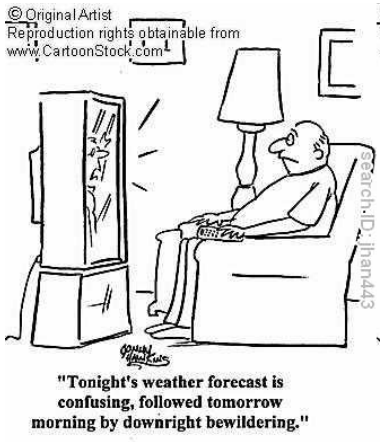
UW Credit Hours

- 2hrs/week outside per credit hour
- 15 hrs/week dedicated to this class (5 in class, 10 outside)

Lectures/Discussion

- **FOR YOUR BENEFIT!**
  Stop me, ask questions!
- ***Mix of writing on board and powerpoint slides***
- **Comfortable Atmosphere**
  Let me know immediately

We want you to do well!



1. COME TO CLASS
2. TAKE GOOD NOTES
3. REVIEW YOUR NOTES
4. TALK TO YOUR CLASSMATES, YOUR TA AND ME
5. TEST YOURSELF
6. RELAX

GET YOUR QUESTIONS ANSWERED!

Reading for this week

- Chapter 1
- Chapter 10
- Note: you can skip the blue-boxed text in both chapters

www.atmos.washington.edu/academics/classes/2012Q4/211/