UNIVERSITÄT LEIPZIG

Climate Dynamics (Summer Semester 2019)
J. Mülmenstädt

Today's Lecture (Lecture 1): Introduction

Reference

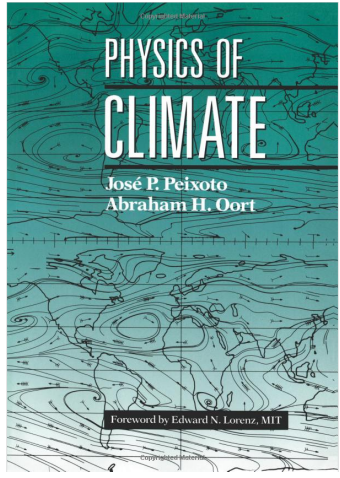
Hartmann, Ch. 3
Peixoto and Oort, Ch. 6 (much more detailed than our treatment)
Peixoto and Oort, Sec. 3.1, 3.2, 3.4, 3.5 (in preparation for next week); skip discussion of oceans until one week later

Organization

Lectures	Wednesdays 13:15—14:45 vor dem Hospitaltore
Exercises	First session on April 10 in the CIP Pool Wednesdays 15:00–15:45
Slide copies	On course web page: `https://home.uni-leipzig.de/jmuelmen/lehre/cd/cd2019.html`, with a link from the Sommersemester page
Language	Input: de/en, output: en
Miscellaneous	Please interrupt with questions! Comments welcome. Also by email: `johannes.muelmenstaedt@uni-leipzig.de`
Exams	July, by appointment, 30-minute oral exam

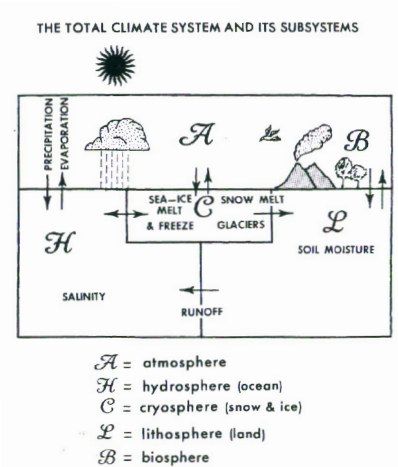
Course materials

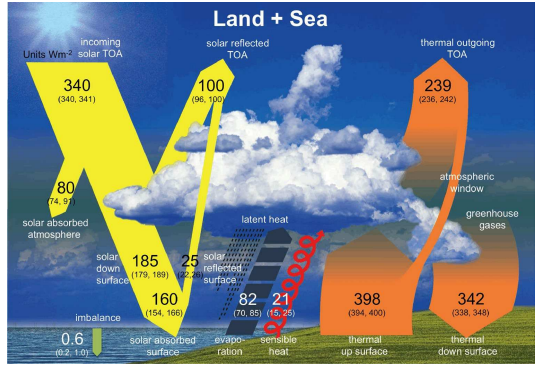
- Books available at the library or (ocean) online
- Papers (occasionally) linked from course web page



1 – Introduction

1.1 – The climate system





Conservation laws are fundamental to our physical understanding of the system

Figures: Peixoto and Oort; Wild et al. (2015)

Radiation

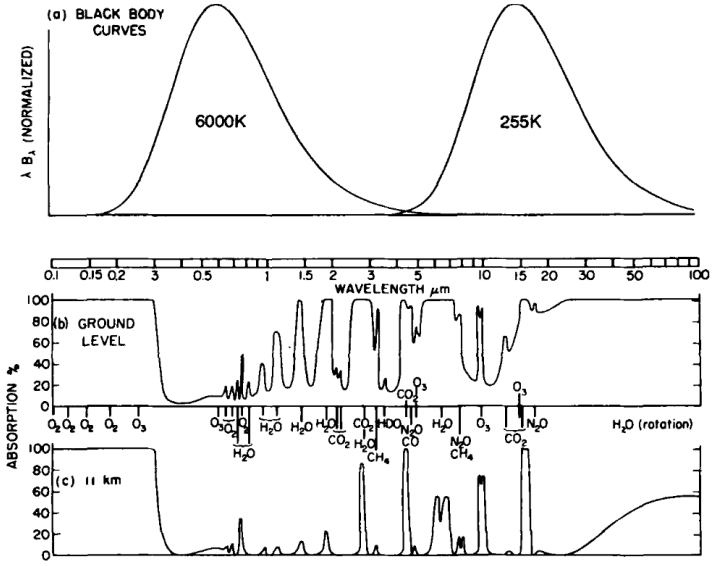
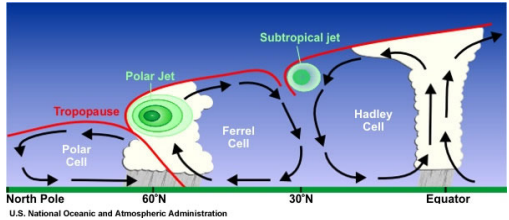
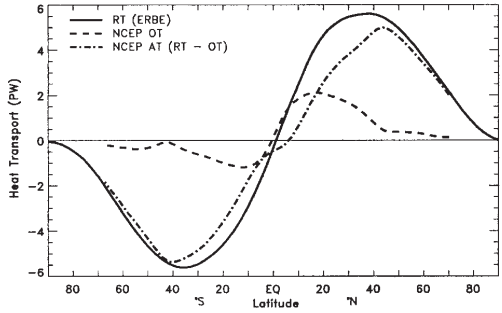


Figure: Goody and Yung (1989)

Atmosphere

- Primitive equations
- The role of water vapor, liquid water, ice
- The role of greenhouse gases
- The role of aerosols
- Atmospheric circulation
- Coupling to land and sea, perturbation response time scales
- What is the function of the atmosphere in the climate system?





Figures: NOAA; Trenberth and Caron, 2001

Ocean

- Primitive equations
- The role of salt
- "Thermohaline" (oceanic) circulation
- Coupling to atmosphere and cryosphere, perturbation response time scales
- What is the function of the ocean in the climate system?

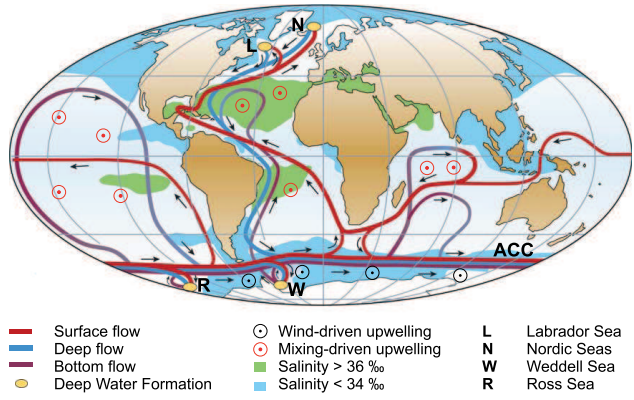


Figure: Kuhlbrodt et al., 2007

Land and cryosphere

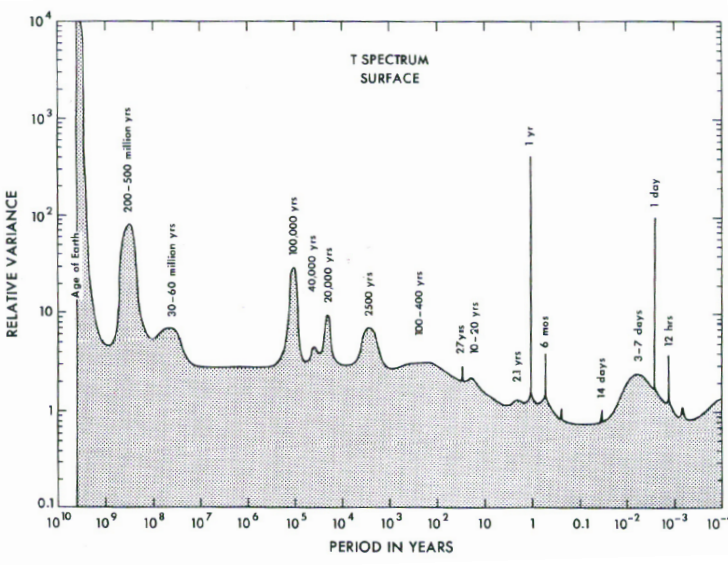
Land (lithosphere and biosphere)

- Primitive equations? – unknown
- Time scales from very short (energy cycle, diurnal) to very long (carbon cycle, geologic)

Cryosphere

- Primitive equations? – unknown
- Coupling to land, sea, atmosphere
  - Albedo change
  - Sea-level rise
  - Release of permafrost methane
- Response to perturbation very slow, but can be irreversibly "locked in" far in advance — example of "committed climate change"

1.2 – Internal variability

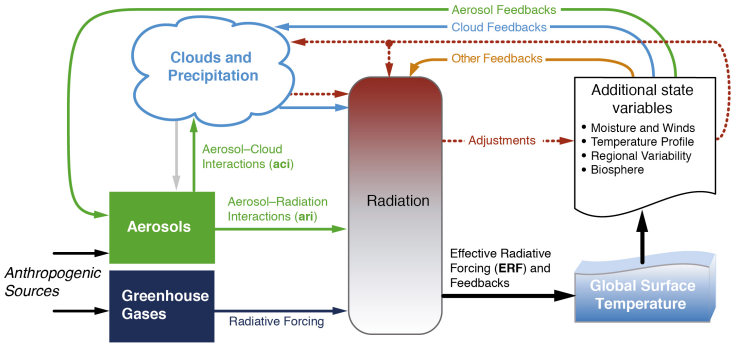


A variety of time scales

- Mid-latitude storms
- Madden–Julian oscillation
- ENSO
- Teleconnections
- PDO/NAO/AO

Figure: Peixoto and Oort

1.3 – Forcing and feedbacks



Forcing

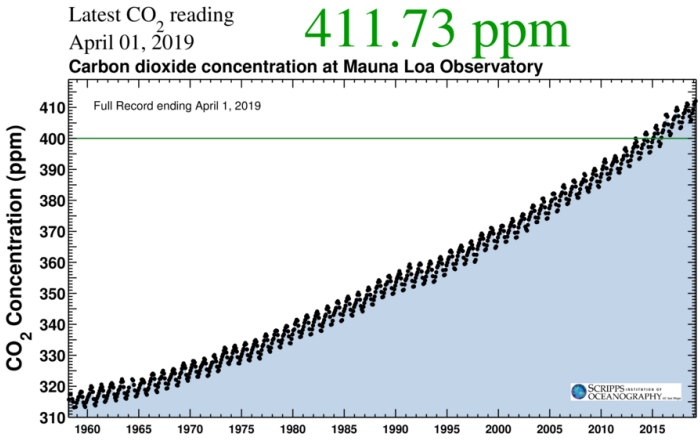
- Natural: solar cycles, orbital cycles, volcanic eruptions, geologic carbon cycle
- Anthropogenic: greenhouse gases, aerosols, land-use change

Feedbacks

- "Planck" feedback
- Water vapor feedback
- Lapse rate feedback
- Cloud feedback
- Ice albedo feedback

Figure: IPCC AR5

1.4 – Anthropogenic climate change – the uncontrolled experiment



- History
- Attribution
- Projections, uncertainties, and the role of models
- Mitigation, adaptation, geoengineering
- The scientist/policy-maker dichotomy
- How to counter denialists?

Figure: Scripps CO_2 program

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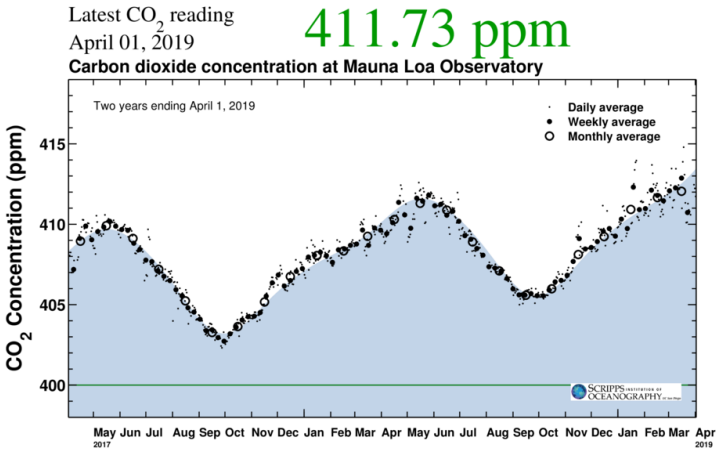

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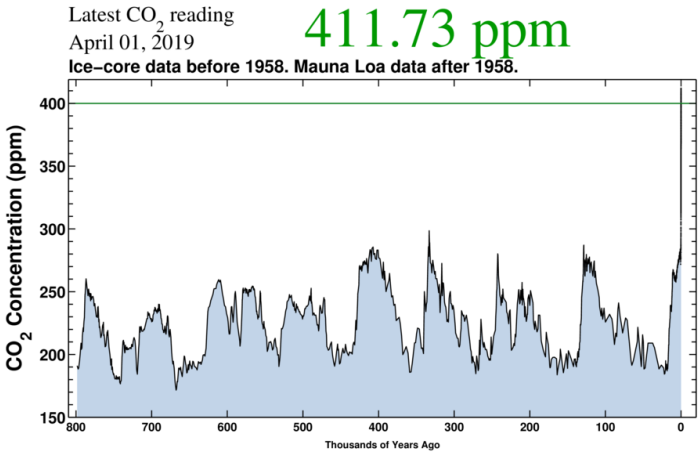

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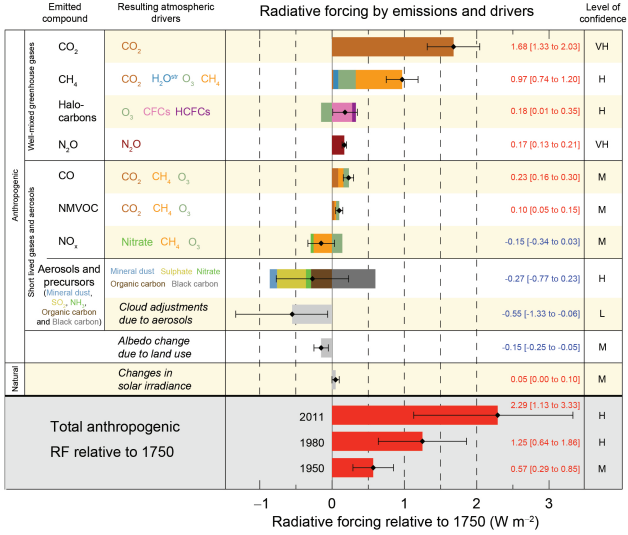

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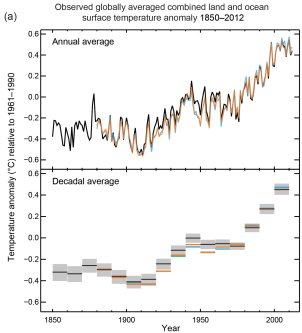

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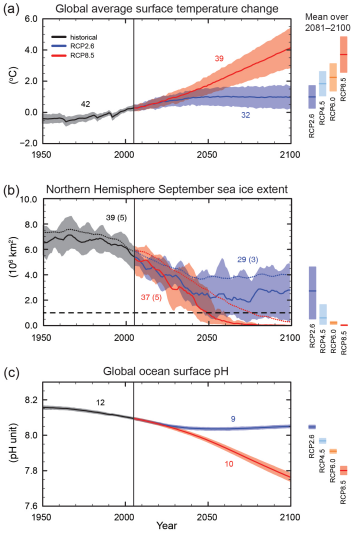

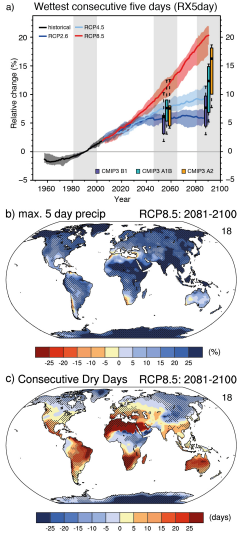

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What you should get out of this course

If you want to work in climate science: Context for your Master's thesis topic

If you want to work in any other area: A general introduction to the climate system

Either way: Respond knowledgeably when friends and family ask you about the climate or climate change

So please ask lots of questions!