Climate System Physics-GEO 387P/347P

Spring 2013

Prerequisites: Two semesters of calculus and one of calculus-based physics
3 credits.

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What can you expect from this course?

Earth's climate state and variability are fundamentally controlled by the energy balance of its climate system, which is largely determined by the physical properties and chemical composition of the Earth's climate system. These physical processes, through their control on energy and water, drive winds and ocean currents, and actively interact with the dynamic, chemical, biological and geological processes of the climate system. The purpose of this course is to understand and quantify the most important physical processes in determining the basic state and variation of climate, especially through their roles in regulating water cycle. The applications of these processes to climate variability and change issues and their interaction with dynamic, chemical, biological and geological processes will be discussed.

At the end of this course, I hope you will be able to take home the principles and formulations for a few fundamental processes that control the atmosphere and ocean physical properties and its interaction with underlying earth's surface, and how they can be applied to explain and predict the climate state and its variations and changes. This course will also provides some basic tools that can be used in graduate research in climate and earth sciences, air pollution and environmental and wind power engineering.

Text Book: "Atmospheric Science-an introductory survey" by Wallace and Hobbs, the 2nd edition, published by Elsevier Inc.

References (not required): Thermodynamics of atmosphere and Oceans, Curry and Webster; Cloud Dynamics, Houze; Microphysics of clouds and precipitation by Pruppacher and Klett; The atmosphere Boundary Layer, Garratt

Where?

Location:	JGB 2.202
Class Meeting Times:	Tuesday, Thursday 2:30 - 4:00pm,
Office hours:	Thursday: 1:30-2:30 pm or by appointment. Emails will be replied within 24 hours unless the instructor is on travel.

All class materials will be posted online.

What do you expected to do?

One in-class exam: 20% of total the course grade.

Assignments/Lab: *40%*
Research project: presentation (AGU style) and report (GRL style): 30%
Class participation: 10%

Outline of the topics and tentative schedule:

Why does earth's climate vary so much, yet remain habitable?

1. An integrated earth system: Components of the Climate System, their links and impacts on climate system physical properties at different temporal and spatial scales
    Week-1: Tuesday: lecture, Thursday: In-class Exercise and discussion

2. Composition and structure of the atmosphere and ocean: Fundamental factors that determine climate condition of the earth
    Week-2: Tuesday: lecture, Thursday: In-class Exercise and discussion

What control earth's climate system energy balance?

3. Radiation in the atmosphere and surface ocean: Energy balance of the earth system
    Week-3: Quick review of principles of radiation for atmosphere, clear sky, aerosols and clouds, Tues: Lecture, Thur: Exercises applying these principles)
    Week-4: Discussion: Water vapor, clouds feedbacks and satellite remote sensing, Tues: Lecture, Thur. Lab: NCAR radiative transfer scheme (RTS)

Assignment-1: Use RTS model to determine impacts of greenhouse gases and clouds.

What control changes of air and water density gradients, which drive atmosphere and ocean circulation?

4. Thermodynamics principles of the atmosphere and ocean
    Week-5: Tues: lecture, Thur: lab: dry static energy and potential temperature, moist static energy and equivalent potential temperature, convective available potential energy and convective inhibition energy,

Exam: Week-6, Tuesday

What control water cycle in the earth's climate system?

Thermodynamics Lab: Week-6, Thur. Radiative-convective model (single column CCM)

Assignment-2: Determine impact of changing greenhouse gases on atmospheric temperature profiles through radiative and convective adjustment using a single column atmospheric model

5. Atmospheric boundary layer: Interface between atmosphere and earth surface
    Week-7: Tu: Lecture M-O turbulence, mixing layer over smooth surface, Thur: Lab: profiles of wind, temperature and humidity in stable, and unstable ABL, Thur: Lab: A slab boundary layer model

Week-8: Tu: Lecture Turbulence and energy, water and wind fluxes over inhomogeneous surface (e.g., rough ocean, topography, vegetated and urban surfaces), Lab: Large-eddy simulations (LES)

Spring break: Week-8, Title and abstract of the class project due

Assignment-3: Use LES models to test influence of surface conditions and atmospheric flow at the top of the boundary layer on winds, entrainment and detrainment, and clouds of the boundary layer.

6. Water cycle of the earth system (weeks 10-14)

Week-9: Tu: evaporation and evapotranspiration

Th: Lab: Analyzing surface flux data over oceans and land with different vegetation types

Week-10: Tu: Formation of the cloud and precipitation

Th: Lab: Exercises, analyzing satellite cloud data samples

Week-12: Tu: Mesoscale convection

Thu: Lab: Discuss the influences of dynamic, thermodynamic and topographic conditions on cloud and rainfall formation based on recent literature

Assignment-4: Use data and model to exam links between convection and environmental conditions

Week-13: Tu: Role of aerosols on clouds, precipitation

Thu: Lab. Test impacts of aerosols on radiation and clouds

Week-14: Tu: physical processes important to formation of monsoon, desert climate, drought and flood

Thu: student lead discussion on latest research related to change of extreme climate events such as drought, flood, tropical storms/hurricanes, heat waves

7. Presentations of the projects that synthesize earth system physical processes

Week-15: AGU style (totally 15 minutes, 12 minutes presentation + 3 minutes question/answer