AOS 801: TOPICS IN THEORETICAL METEOROLOGY
FALL 2015 – RADIATION AND ENERGY IN THE CLIMATE SYSTEM

SYLLABUS

Instructor

Prof. Tristan L'Ecuyer
Office: AOSS 1331
E-mail: tristan@aos.wisc.edu

Schedule

Lectures: T/Th 1 to 2:25 pm (nominal) Rm. 811
Extended make-up lectures may extend to 2:50 pm

Course Overview

This course focuses on recent progress and current challenges in quantifying radiative and energetic processes in the climate system. Through a combination of overview lectures, reviews of seminal papers, and class projects, students will gain familiarity with foundational research into the key factors governing the principal flows of energy in the Earth-atmosphere system. Topics include: energy balance and heat transport, radiative forcing, radiative-convective equilibrium, climate thermodynamics, climate sensitivity, and feedbacks. Prior completion of ATM OCN 640 "Radiation in the Atmosphere and Ocean" is strongly recommended.

Grading

Lead Class Paper Reviews (3)	30%
Participation in Paper Reviews	10%
Team Project	20%
Term Paper	20%
Final Presentation	20%

Grades for this course will be primarily based on a term project elucidating the finer points of a key topic covered in the course. A short paper and in-class presentation describing the outcomes of this project will constitute 40% of the final grade. Students will also collaborate on a broader group project related to material covered during the first half of the course. The remainder of the grade will come from participation in class paper reviews. Each student will lead the review of three seminal papers (or groups of related papers) over the course of the semester and all students are expected to read all review articles and actively participate in class discussions.

Rough Schedule and Reference Materials

In addition to lecture notes that will be provided periodically throughout the semester, the primary reference materials for this class will be the following papers from the peer-reviewed literature that can be found on the course website:

Blue – student presentation
Yellow – covered in lecture
Green – additional reading

WEEK 1: REVIEW OF RADIOMETRIC CONCEPTS

Topics: Refresher of basic laws: Kirchhoff, Planck, Wien, Boltzmann, etc; Radiances vs. fluxes; Basic radiative transfer theory; Two-stream approximation; Radiative heating and cooling

References

1. PPT or written class notes

WEEKS 2 AND 3: EARTH'S ENERGY BUDGET AND HEAT TRANSPORT (2 CLASSES)

Topics: Top of atmosphere energy balance; Greenhouse effect; Turbulent heat fluxes; Zonal imbalances; Heat transport

References

1. Pioneering Work: Dines (1917); Vonder Haar and Suomi (1971)
2. Imbalances: Hansen et al. (2005); Trenberth et al. (2014)
3. Modern Controversy: Trenberth et al. (2009); Stephens et al. (2012); L'Ecuyer et al. (2015)
4. Transports: Hartmann et al. (1985); Trenberth and Caron (2001)

WEEKS 4-5: RADIATIVE FORCING OF CLIMATE

Topics: Forcing and response; Forcing by greenhouse gases; Cloud forcing; Aerosol forcing; Cloud-aerosol interactions

References

1. Forcing and Response: Hansen et al. (1997)
2. Water Vapor: Stephens and Greenwald (1991a)
3. Clouds: Harrison et al. (1990); Ockert-Bell and Hartmann (1992); Hartmann et al. (1992); Gleckler et al. (1995); Stephens and Greenwald (1991b); Ramanathan et al. (1989)
4. Aerosols: Yu et al. (2006); Wild et al. (2005); Matus et al. (2015)
5. Aerosol-Cloud Interactions: Twomey (1977); Albrecht (1989); Stevens and Feingold (2009)

WEEKS 6-7: RADIATIVE EQUILIBRIUM AND CONVECTIVE ADJUSTMENT

Topics: Convection; Atmospheric latent heating; Radiative equilibrium; Convective adjustment

References

1. Foundational Papers: Manabe and Moller (1961); Manabe and Strickler (1964); Manabe and Wetherald (1967)
2. Role of Clouds: Stephens and Webster (1981)
3. Modern Applications: Posselt et al. (2008); van den Heever et al. (2011); Emanuel et al. (2006); Chavas and Emanuel (2014)

WEEKS 8-9: ENERGY BALANCE MODELS

Topics: Energy balance theory of climate; Ice-albedo feedback and ice catastrophe; Faint young sun paradox; Time-dependent EBMs; Stochastically-forced EBMs

References

1. Pioneering Papers: Budyko (1969); Sellers (1969)
2. Summary: North et al. (1981)
3. Time-dependent: Lorenz (1979); North and Cahalan (1981)
4. Stochastically-forced: Hasselman (1976); Robock (1978); Kim and North (1992)

WEEKS 10-11: FEEDBACKS IN THE CLIMATE SYSTEM

Topics: Introduction to feedbacks; Greenhouse gas feedbacks; Biological feedback; Cloud feedback

References

1. GHG: Rasool and de Bergh (1970); Held and Soden (2000)
2. Biological: Watson and Lovelock (1983); Wood et al. (2008)
3. Clouds: Ramanathan and Collins (1991); Clement et al. (2009); Dessler (2010)
4. Iris Controversy: Lindzen et al. (2001); Hartmann and Michelsen (2002); Lin et al. (2002)

WEEKS 12-13: CLIMATE SENSITIVITY

Topics: Equilibrium Climate Sensitivity

References

1. Methods: Gregory et al. (2004); Hansen et al. (2005)
2. Observations: Forster and Gregory (2006)
3. CMIP5: Andrews et al. (2012a)
4. Rapid vs. Equilibrium Responses: Andrews et al. (2012b), Andrews et al. (2015)
5. Separating Forcing, Response, and Feedback: Chung and Soden (2015)
6. Kernels: Soden et al. (2008); Zelinka et al. (2012)

WEEK 14: ADDITIONAL TOPICS (TIME-PERMITTING)

Topics: Entropy and climate (entropy of radiation, Prigogine's theorem, Ziegler's principle of maximum dissipation); Hydrology and climate

References

1. Entropy Foundations: Paltridge (1975); Paltridge (1978); Paltridge (1981)
2. Entropy Observations and Models: Stephens and O'Brien (1993); O'Brien and Stephens (1995)
3. The Global Water Cycle: Trenberth et al. (2008); Rodell et al. (2015)
4. Water Cycle Trends: Wentz et al. (2005); Stephens and Ellis (2008)