SIO 235 – Ocean-Atmosphere Interaction and Climate

Section ID: 810590

Spring 2014

Room: Spiess 330; **Meeting Time**: 9:30 - 10:50 AM, Mondays and Wednesdays
Instructor: Shang-Ping Xie, MESOM 323; Tel: 822-0053; sxie@ucsd.edu
Prerequisites: any two of the following: SIO 217A-B, SIO210, 211A-B, 212A-B, or consent of instructor

The importance of ocean for climate is evident: most of solar radiation is absorbed at the Earth surface and the ocean occupies seventy percent of the Earth surface. Examples of ocean-atmosphere interaction effects are abundant, including the spontaneous generation of El Nino/Southern Oscillation (ENSO) that affects global climate. The class addresses such fundamental questions as why climate varies from one year to another, how preferred patterns of climate variability arise, how climate will change in the face of increasing greenhouse gases in the atmosphere, and how predictable climate is. Ocean-atmosphere interaction dynamics is key to answering these questions.

We start with a description of major features of tropical climate, followed by discussions of interactive processes that cause climate to vary in space and time. We focus on tropical climate for two reasons: the ocean-atmosphere coupling is strongest there, and latent heat released in tropical convection drives the global atmospheric circulation. Subtropical climate and extratropical ocean-atmosphere interaction are also covered.

No single textbook is adequate for the class. Key references will be given in class notes, and students are encouraged to read. Each student is required to make a 15-minute presentation on a topic of your choice based on a journal paper, and/or original research. A list of topics and references will be distributed.

Learning objectives. To know major patterns of tropical climate, develop a coupled ocean-atmosphere perspective to understand climate variability and predictability, and appreciate the distinction in ocean-atmosphere interaction between the tropics and extratropics.

Grading (letter grade): final exam (30%), homework (40%), presentation (20%), and participation (10%).

1. Energy balance
Review of key concepts (geostrophy, Ekman effect, potential temperature, static stability), history of climate research, energy (im)balance, and heat transport.

2. Zonal-mean circulation
Hadley circulation, subtropical jet, role in precipitation and energy transport.

3. Major precipitation/convergence zones
ITCZ, SPCZ, SACZ, hydrological cycle, moisture convergence, sea surface temperature (SST) effect

4. Interaction of convection and circulation
Equatorial waves, weak temperature gradient, the Gill model, warm pool, Walker circulation

5. Subtropical high and trade winds
Trade wind inversion, marine low clouds, orographic rainfall, California climate

6. Madden-Julian Oscillation
Circum-global structure, propagation, equatorial waves, moist effect, super cloud clusters

7. Monsoons
Structure, seasonal march, land-sea thermal contrast, soil moisture, orographic effects;

8. Equatorial oceanography
Upwelling, 1.5-layer model, thermocline adjustment to wind change, mixed layer heat budget, surface heat flux

9. WES feedback and meridional asymmetry
Northward displaced ITCZ, cloud feedback, coupled model

10. Bjerknes feedback and El Nino/Southern Oscillation
Equatorial cold tongue, annual and interannual variability, coupled instability

11. ENSO cycle and predictability
Ocean memory, oscillatory mechanisms, phase locking, seasonal climate prediction

12. Global teleconnections
Stationary waves in the westerlies, Pacific North American pattern; extratropical influence on ITCZ

13. Indian Ocean variability
Semi-annual cycle, Indian Ocean dipole, Indian Ocean capacitor

14. Atlantic variability
Atlantic Nino and meridional modes; biases of climate models

15. Tropical cyclones
Climate control, genesis potential, maximum intensity, cold wake and ocean feedback

16. Extratropical ocean-atmosphere interactions
Atmospheric modes of variability, lagged o-a cross correlation, basin vs. meso-scale

17. Tropical response to global warming
Atmospheric stabilization, radiative control of global precipitation, slowdown of tropical circulation, ocean warming pattern effect

18. Regional climate change
Ocean warming patterns, regional changes in precipitation, circulation, and tropical cyclones; greenhouse gas vs. aerosols

At the class website (ted.ucsd.edu), class notes including slides will be posted in pdf after each lecture (look in “SIO 235/Content”; password: “sio-235”). The syllabus is posted at “SIO 235/Information.”

Reference books

Peixoto, J.P. and A.H. Oort, 1992: Physics of climate. AIP, pp. 520. (great atlas & budget analysis)
Wallace, J.M., and P.V. Hobbs, 2005 (WH05): Atmospheric Science. Academic Press, pp.483. (descriptive, dynamical and physical meteorology at the upper undergraduate level)
COMET at NCAR: http://www.meted.ucar.edu/resource_modlist.php
Wikipedia: http://www.wikipedia.org/

First half
Gill, A.E., 1982 (G82): Atmosphere-Ocean Dynamics. Academic Press, pp. 662. (Harmony of dynamics and observations)
Hartmann, D.L., 1994 (H94): Global Physical Climatology. Academic Press, pp. 411. (Blend descriptive and dynamical approaches by a distinguished dynamist)
Holton, J.R., 2004: An Introduction to Dynamic Meteorology. Academic Press, pp. 535.
Lindzen, R.S., 1990: Dynamics in Atmospheric Physics, Cambridge, pp. 310.

Second half
Philander, S.G.H., 1990 (P90): El Nino and the Southern Oscillation. Academic Press, pp.
Wang, C., S.-P. Xie, and J.A. Carton (eds), 2004 (WXC04): Earth Climate: The Ocean-Atmosphere Interaction. Geophys. Monogr., 147, AGU, pp. 414.

Access to journal articles. Most journals for this class are published by the American Meteorological Society (AMS) and American Geophysical Union (AGU). You have free access via UCSD subscription.

http://journals.ametsoc.org/
AMS: J. Climate (JC), J. Atmospheric Science (JAS), Monthly Weather Review (MWR), J. Physical Oceanography (JPO), Bulletin of the American Meteorological Society (BAMS)

http://publications.agu.org/journals/
AGU: J. Geophysical Research (JGR), Geophysical Research Letters (GRL), Review of Geophysics (RoG)