ATS 742 Tropical Meteorology- Spring 2023

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Course Description: Overview of the tropical atmosphere, theory of the tropical atmosphere and convection, intraseasonal variability, tropical-extratropical interactions, easterly waves and convectively-coupled waves, climate change and the Tropics.

Web: Class webpage is available on CSU's educational platform Canvas. Please let me know if you have trouble accessing anything on this page. Discussion papers will be posted on this site.

Class meets in ATS West 121 at 10 am-10:50 am MonWed.

Maloney Office Hours: By appointment

Contact hours: 2 (*At least 2 hours of effort are expected to complete homework and reading assignments outside of class for each hour of class time.)*

Student Learning Goals and Objectives: The successful student will gain a professional level foundation in tropical meteorology on which students can build to make contributions to the peer-reviewed scientific literature. In particular, students will be able to:

- Use theory to describe how the tropical atmosphere fundamentally differs from the midlatitudes.
- Distinguish between various tropical disturbances, and use theory to contrast their fundamental dynamics.
- Interpret climate-induced changes to tropical disturbances in the context of theory
- Evaluate and critique peer-reviewed scientific studies in the context of foundational course material on tropical meteorology.

Text: None. The course materials will be drawn from journal articles and lecture notes. This course will approach tropical meteorology from a decidedly large-scale perspective, with less emphasis on mesoscale aspects of tropical meteorology, although these will by necessity be brought in at points. We have a mesoscale meteorology course at the 600 level (ATS 641) and mesoscale dynamics course at the 700 level (ATS 735) that cover mesoscale aspects of tropical convective systems. Further, ATS 712 also covers tropical mesoscale systems. Hence, covering these topics here would be redundant.

The format of the class will be lecture/paper discussion. I intend to follow the outline included here. We will also spend time reading papers from the recent and seminal scientific literature and discussing them in class.

Grading: The course requirements and grading will be approximately as follows:

Participation in Paper/ Classroom Discussions: 50%
Final Paper: 40%
Broader Class Participation: 10%

Paper Discussion: Students will be expected to lead discussion of a journal article. Papers assignments will be discussed during the second week of class, as well as a list of journal articles we will cover during the semester.

Final Paper/Project: A final paper or project description of no more than 10 double-spaced pages is required. This will deal with a review of some topic of current interest in tropical meteorology, or some independent research if you prefer. Topics need to be defined and committed to by March 31. If desired, a first draft can be handed to me by April 28, during which I will make suggestions on style and content. This step is purely optional although some might find it of benefit. The final version is due at the end of finals week.

Course Outline:

Week 1: Overview: Mean distribution of meteorological variables, the seasonal cycle of the tropical atmosphere, phenomenology of the tropics

Week 2: Tropical budgets: heat, moisture, moist static energy, kinetic/potential energy

Week 3: Weak tropical temperature gradients.

Week 4: Modes of tropical convective heating and associated vertical velocity

Week 5: Modeling tropical precipitation with the moist static energy (MSE) budget

Week 6: Applications of the MSE budget to the tropical atmosphere

Week 7: Moisture and tropical convection: Observations and implications for parameterization.

Week 8: Equatorial wave dynamics.

Week 9: The Madden-Julian oscillation (MJO): observations and modeling

Week 10: MJO theory and diagnosis

Week 11: Moisture modes: Balanced disturbances and the weak temperature gradient

Week 12: MJO teleconnections

Week 13: Easterly waves: Observations

Week 14: Easterly waves: Theory

Week 15: Tropical variability and climate change

Statement on Academic Integrity

This course will adhere to the CSU Academic Integrity Policy as found in the General Catalog (http://catalog.colostate.edu/general-catalog/policies/students-responsibilities/#academic-integrity) and the Student Conduct Code (https://resolutioncenter.colostate.edu/student-conduct/code/). At a minimum, violations will result in a grading penalty in this course and a report to the Office of Conflict Resolution and Student Conduct Services.

Discussion Papers:

Week 3:

Bao, J., V. Dixit, and S. C. Sherwood, 2022: Zonal temperature gradients in the tropical free troposphere. *J. Climate*, **35**, 4337–4348. https://doi.org/10.1175/JCLI-D-22-0145.1.

Week 4:

Schumacher, C., R. A. Houze, I. Kraucunas, 2004: The Tropical Dynamical Response to Latent Heating Estimates Derived from the TRMM Precipitation Radar. *J. Atmos. Sci.*, **61**, 1341–1358. https://doi.org/10.1175/1520-0469(2004)061%3C1341:TTDRTL%3E2.0.CO;2.

Week 7:

Schiro, K. A., J. D. Neelin, D. K. Adams, and B. R. Lintner, 2016: Deep convection and column water vapor over tropical land versus tropical ocean: A comparison between the Amazon and the tropical western Pacific. *J. Atmos. Sci.*, **73**, 4043–4063, https://doi.org/10.1175/JAS-D-16-0119.1.

Week 8:

Wheeler, M., G. N. Kiladis, 1999: Convectively Coupled Equatorial Waves: Analysis of Clouds and Temperature in the Wavenumber–Frequency Domain. *J. Atmos. Sci.*, **56**, 374–399. [look at the figures on the AMS website. The PDF reproduction is poor]. https://doi.org/10.1175/1520-0469(1999)056%3C0374:CCEWAO%3E2.0.CO;2.

Week 10:

Adames, Á. F., and D. Kim, 2016: The MJO as a dispersive, convectively coupled moisture wave: Theory and observations. *J. Atmos. Sci.*, **73**, 913-941. https://doi.org/10.1175/JAS-D-15-0170.1.

Week 12:

Henderson, S. A., E. D. Maloney, and S.-W. Son, 2017: Madden-Julian oscillation teleconnections: The impact of the basic state and MJO representation in general circulation models. *J. Climate*, **30**, 4567–4587. https://doi.org/10.1175/JCLI-D-16-0789.1

Week 13:

Adames, Á, 2021: Interactions between Water Vapor, Potential Vorticity, and Vertical Wind Shear in Quasi-Geostrophic Motions: Implications for Rotational Tropical Motion Systems. *J. Atmos. Sci.,* **78**, 903-923. https://doi.org/10.1175/JAS-D-20-0205.1. (I may regret assigning this paper. Those interested getting deep in theory may wish to lead the discussion).

Week 15:

Bui, H. X., and E. D. Maloney, 2019: Transient response of MJO precipitation and circulation to greenhouse gas forcing. *Geophys. Res. Lett.*, **46**, 13546-13555. https://doi.org/10.1029/2019GL085328.