Tropical Meteorology (MR3252; Spring Quarter 2024)
Instructor: Scott Powell (Root 255)
Room: Root 117
Meeting times: R: 0800–1000, F: 1100–1400 (subject to change)
Office hours: by appointment in office or Teams
Course webpage: https://swpowell.github.io/MR3252.html

Course Objectives

- Develop a holistic understanding of how large-scale circulations and moist convection (including tropical cyclones) interact in the Tropics.
- Interpret in situ and remotely sensed observations of the environment to diagnose the favorability of deep convection and identify various tropical phenomena.
- Improve ability to forecast tropical weather—such as MJO or tropical cyclones—that occur on time scales of days to weeks through activities focused on their prediction.

Syllabus

(Bolded papers or book chapters indicate required reading for that week.) You can find these papers on the course website. Search or ask for other papers if interested. The summary for each week's bolded paper will be due Thursday of the following week.

For each week, YouTube material is listed. The videos that student should familiarize themselves with before class that week are listed.

Week 1 (Apr. 1–5): Introduction. Spatial distribution of important quantities through the Tropics. Seasonal cycles. Ingredients needed to support deep, widespread tropical convection. Understanding the role of entrainment, environmental humidity, surface fluxes, and static stability on buoyancy of convection.
Papers: Adames et al. (2020), Hohenegger and Stevens (2013), **Derbyshire et al. (2004)**
YouTube: Playlist: Lecture Series 1, Intro + Modules 1.1–1.3
*Week 1 paper summary will be due in Week 2.

Week 2 (Apr. 8–12): Interpreting Skew-T charts. Introduction to important quantities in large-scale tropical dynamics.
Papers: **Holloway and Neelin (2009)**, Zhang and McPhaden (1995), Raymond et al. (2009), Inoue and Back (2015)
YouTube: Playlist: Lecture Series 1
Thursday: Modules 1.4–1.5
Friday: Modules 1.6–1.7

Week 3 (Apr. 15–19): First and second baroclinic modes of tropical heating. Convective and stratiform precipitation. Mesoscale convective systems. Vertical velocity in convection. Radiative heating impacts. Diurnal variability of tropical convection.
Papers: Hartmann et al. (1984); **Schumacher et al. (2004)**, Houze (2004)

YouTube: Modules 2.1–2.4, Review 3.1 by Thursday

Weeks 4 and 5: No class. However, students are still responsible for following along with material through course material online as listed below. We will quickly cover the material in class when I return.

Week 4 (Apr. 22–26): No new material. Paper summary from Week 3 is due Thursday.

Week 5 (Apr. 29–May 3)*:* Basic TC Structure. Requirements for tropical cyclogenesis and maintenance. Secondary eyewall formation. No paper summary due this week.
Papers: Houze (2010), Didlake and Houze (2011), **Willoughby et al. (1982)**
YouTube: Modules 3.1–3.4
Additional Reading: https://www.meteo.physik.uni-muenchen.de/~roger/TCLecs/Tropical%20Cyclones_Dynamics.html

Week 6 (May 6–10): Fundamentals of TC vortex dynamics.
Papers: **Hendricks et al. (2004)**, Montgomery and Kallenbach (1997), Montgomery et al. (2006),
YouTube: Modules 3.4–3.5

Week 7 (May 13–17): Easterly wave structure and AEJ instability. Monsoon dynamics.
YouTube: Modules 3.6–3.7, 4.3
Papers: Thorncroft et al. (2008), Li and Yanai (1996), **Chakraborty et al. (2002), Boos and Kuang (2010)**

Week 8 (May 20–24): Large-scale tropical circulations. Hadley circulation. Walker circulation. ENSO, Indian Ocean Dipole
YouTube: Modules 4.1, 4.2
Papers: Bjerknes (1966), Vallis (2006) Chapter 11, Webster et al. (1999), Battisti and Sarachik (1995)

Week 9 (May 28–31): Equatorial waves. Gravity wave dynamics. Weak temperature gradient.
YouTube: Modules 5.1–5.3
Papers: Matsuno (1966), Gill (1980), Mapes (2000), Kiladis et al. (2009), **Wheeler and Kiladis (1999)**

Week 10 (Jun. 3–7): Moisture modes and the Madden-Julian Oscillation. S2S forecasting and its application to tropical cyclogenesis predictability. Connection of MJO with equatorial waves.
Papers: Sobel et al. (2001); Sobel and Maloney (2013); Adames and Wallace (2016); **Powell and Houze (2015)**
YouTube: Module 5.4

Week 11 (Jun. 10–14): Tropical-extratropical teleconnections and impacts on mid-latitude weather.
Youtube: Module 4.4
Papers: Hoskins and Karoly (1981), Simmons (1982), Trenberth et al. (1998), Henderson et al. (2016), **Mundhenk et al. (2018)**

Week 12: Take-home exam will be circulated around June 13. You will have until June 20 to complete.

Paper summaries: During most weeks, a paper is assigned for reading in a topical area pertinent to the course material covered during the same time. (In Week 7, two short papers on the same topic are assigned.) For each paper, students will be given a few basic questions to answer. For example, what are the primary research questions and hypotheses? Why are the authors studying these questions? What were their methods? What data and models did they use? What were their central conclusions? What were key limitations of the study? In addition, a small number of questions specific to one week's paper may be added. You may (and should) discuss the papers with each other as much you like, but the answers you submit in your paper summaries should be your own thoughts and writing.

Starting Week 3: TC forecasts during a portion of class meetings, conditions permitting. Discussion will be open to everyone. Students will work in groups of 2 (or 3 if there is an odd number of students) and submit forecasts at end of class. The forecasts will include 1) a current observational analysis of the TC and its environment, 2) a one-paragraph discussion of model guidance for future track and forecast, and 3) a forecast latitude/longitude position and intensity at 12, 24, 36, 48, 72, 96, and 120 hours, or up until the time the low is forecasted to dissipate or other lose its identity (such as through merger with a larger low). An example template will be provided during the first forecasting session.

Grading

Homework (15%)
TC Forecasts (30%)
Paper Summaries (15%)
Final Exam (40%)

Course Structure:

1. All course material will be available at or linked on the course webpage.

2. Lectures are broken up into short modules, which are available at the class YouTube channel, linked on the course webpage. Students are responsible for reviewing this material ***before*** class. Students are expected to spend an average of up to 3 hours weekly reviewing lecture material online. Class time will be spent to cover key points and dig deeper into questions raised by students.

3. Written transcripts for the videos as well as slides displayed during the videos are available on the course website. "Note taking worksheets" are also available on the course website for each lecture series. You may use these to guide your note taking, but they will not be collected or graded. Also, your note taking need not be restricted to just the materials on the worksheets.

4. Submitting assignments: For homework assignments, hard copies are preferred. Paper summaries and TC forecasts should be submitted electronically. Please submit your files via email as PDF documents, in which the filename starts with your last name (or names if working in a group for TC forecasts). Following this seemingly little detail helps a lot!

5. If you have any concerns, comments, questions that you do not want to broadcast to the rest of the class, etc., please feel free to email me to discuss or set up a private meeting on Teams.