Tropical Meteorology (MR3252; Spring Quarter 2023)
Instructor: Scott Powell (Root 255)
Room: Root 117
Meeting times: M,W: 1100–1250; T,R: 1100–1200
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. One student will lead discussion of the bolded paper.) Search or ask for other papers if interested. This syllabus might get moved around depending on how we proceed with the hybrid format, but I will try to stick to schedule as closely as possible.

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

Week 1 (Mar. 27–31): 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 will be discussed on Tuesday of Week 2.

Week 2 (Apr. 3–7): 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
Monday: Modules 1.4–1.5
Wednesday: Modules 1.6–1.7
*Weeks 1 and 2 paper discussion will be held Tuesday and Thursday, respectively.

Week 3 (Apr. 10–14): 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 Monday

Week 4 (Apr. 17–21)*:* Basic TC Structure. Requirements for tropical cyclogenesis and maintenance. Secondary eyewall formation.
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 5 (Apr. 24–28): 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 6 (May 1–5): 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 7 (May 8–12): 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 8 (May 15–19): 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 9 (May 22–26): 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 10 (May 30): No class on May 29 (Memorial Day). 2-hour class on Tues., May 30. 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 11 (May 31): Take-home exam will be circulated on May 30. You will have until June 9 to complete.

Starting Week 2: Paper discussion on Tuesdays. One student will lead paper discussion in which all students will participate. In Week 2, we will do paper discussions on Tuesday and Thursday.

Starting Week 3: TC forecasts on Mondays and Wednesdays, 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.

Grading

Homework (15%)
TC Forecasts (30%)
Leading Paper discussion (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. Some class time will be reserved each day (except for during student led paper discussions on Tuesdays) for discussion of the course material.

3. Written transcripts for the videos as well as slides displayed during the videos are available on the course website.

4. Student paper discussions: Each student is required to lead one discussion during the quarter. Bolded papers above for each week indicate the required reading about which the discussion will take place. The discussions are expected to last 30–45 minutes, although students should prepare 15–20 minutes of material to leave time for discussion. Instructor will meet with student during an afternoon prior to discussion to advise on content and interpretation of material.

5. Submitting assignments: Please email all assignments as a PDF document with your last name at the start of the file name. Failure to submit your assignment as a PDF document with your last name as the start of the file name will be considered the same as not submitting the assignment and you may not receive credit for it.

6. 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.