Instructor:

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MCZ 435E

Description:

This seminar course will generally focus on recent advances in understanding hydrometeorological and hydroclimatological processes, with implications for weather forecasting, climate modelling, agriculture, human health and water resources management. Students will read and present journal articles on relevant topics, and will rotate responsibility for leading discussions. Specific topics will vary each year offered.

In spring 2019, this course will focus on the hydrological causes and consequences of drought. We will discuss key mechanisms that determine drought onset, intensity and duration, and study examples from around the world. We will also cover impacts of drought on the terrestrial carbon budget, food security, water resources and extreme weather.

Learning outcomes:

By the end of this course, students will understand in detail key mechanisms and broader implications of a topic in hydrometeorology and/or hydroclimatology

Meeting day/time/location:

Fridays, 12:45-2:45 pm in Geological Museum 413.

Office hours:

Fridays, 3-4 pm in MCZ 435E.

Background reading:

Droughts are a hydrological phenomenon. For those new to hydrology, the textbook below will provide useful background reading. The most relevant chapters are 7.2, 7.3, 7.4 (all on the unsaturated zone), chapter 8 (evaporation), and chapter 10 (runoff and streamflow).

Margulis, S. (2017) *Introduction to Hydrology*, freely available at https://margulis-group.github.io/teaching/

Grading:

Participation in class discussions: 30%

Students are expected to do the assigned reading before class, and come prepared to engage in discussion and ask questions.

Leading class discussion: 40%

Students will present the reading and lead the discussion twice per semester (depending on enrollment). They are expected to give a short presentation summarizing the readings, and prepare questions to stimulate discussion.

Final presentation: 30%

Students will give 20 minute final presentations on projects they will conduct over the course of the semester. Projects may range in scope from a thorough literature review of a topic related to the course (but not covered in class), to a proposal for research on a related topic, to results of a small research project on a related topic. Students are expected to choose a topic and have their project ideas approved by the professor by week 4. Presentations will take place during the final class meeting (week 14).

Prerequisites:

Recommended: Familiarity with ordinary differential equations (e.g., APM 105, 201, 202 or equivalent) and an introductory course in atmospheric dynamics/oceanography/climate science (e.g., EPS 232, MIT

12.800 or equivalent); or with permission of instructor.

Class website:

The syllabus, readings, and other class materials will be posted on Canvas.

Approximate course schedule:

This schedule is subject to change. Changes will be announced in class and posted on the class website.

Week 1 (week beginning January 28): preliminary scheduling meeting on Friday, February 1 at 12:45 pm.

Week 2 (week beginning February 4): What is a drought?

- **Mukherjee, Sourav, Ashok Mishra, and Kevin E. Trenberth. 2018. â€œClimate Change and Drought: A Perspective on Drought Indices.â€ *Current Climate Change Reports* 4 (2): 145â€“63.**

Week 3 (week beginning February 11): Drought prediction and sources of predictability

- **Shukla, S., J. Sheffield, E. F. Wood, and D. P. Lettenmaier. 2013. â€œOn the Sources of Global Land Surface Hydrologic Predictability.â€ *Hydrology and Earth System Sciences* 17 (7): 2781â€“96.**

Week 4 (week beginning February 18): Local amplification of droughts by land-atmosphere feedbacks

- Led by: Ned
- **Berg, Alexis, Kirsten Findell, Benjamin Lintner, Alessandra Giannini, Sonia I. Seneviratne, Bart van den Hurk, Ruth Lorenz, et al. 2016. â€œLandâ€“Atmosphere Feedbacks Amplify Aridity Increase over Land under Global Warming.â€ *Nature Climate Change* 6 (9): 869â€“74.**
- **Miralles, D. G., M. J. van den Berg, A. J. Teuling, and R. A. M. de Jeu. 2012. â€œSoil Moisture-Temperature Coupling: A Multiscale Observational Analysis.â€ *Geophysical Research Letters* 39 (21).**

Week 5 (week beginning February 25): Mega-droughts and the history of drought in North America

- Led by: Matt

- **Cook, Benjamin I., Edward R. Cook, Jason E. Smerdon, Richard Seager, A. Park Williams, Sloan Coats, David W. Stahle, and JosÃ© Villanueva DÃaz. 2016. â€œNorth American Megadroughts in the Common Era: Reconstructions and Simulations: North American Megadroughts in the Common Era.â€ *Wiley Interdisciplinary Reviews: Climate Change* 7 (3): 411â€“32.**
- **Cook, Benjamin I., Toby R. Ault, and Jason E. Smerdon. 2015. â€œUnprecedented 21st Century Drought Risk in the American Southwest and Central Plains.â€ *Science Advances* 1 (1): e1400082.**

[Students should discuss subject of final presentation with the professor outside of class by this week.]

Week 6 (week beginning March 4): The future of drought in a warming world

- Led by: Marissa

- **Roderick, Michael L., Peter Greve, and Graham D. Farquhar. 2015. â€œOn the Assessment of Aridity with Changes in Atmospheric CO2.â€ *Water Resources Research* 51 (7): 5450â€“63.**
- **Cook, Benjamin I., Jason E. Smerdon, Richard Seager, and Sloan Coats. 2014. â€œGlobal Warming and 21st Century Drying.â€ *Climate Dynamics* 43 (9): 2607â€“27.**

Week 7 (week beginning March 11): Case study: drought in the Sahel

- Led by: Aleyda

- **Giannini, A., R. Saravanan, and P. Chang. 2003. â€œOceanic Forcing of Sahel Rainfall on Interannual to Interdecadal Time Scales.â€ *Science* 302 (5647): 1027â€“30.**

- **Schewe, Jacob, and Anders Levermann. 2017. â€œNon-Linear Intensification of Sahel Rainfall as a Possible Dynamic Response to Future Warming.â€ *Earth System Dynamics* 8**

(3): 495â€“505.

Week 8 (week beginning March 18): Spring recess (no class)

Week 9 (week beginning March 25): Impacts on the carbon cycle

- Led by: Aleyda

- **Humphrey, Vincent, Jakob Zscheischler, Philippe Ciais, Lukas Gudmundsson, Stephen Sitch, and Sonia I. Seneviratne. 2018. â€œSensitivity of Atmospheric CO 2 Growth Rate to Observed Changes in Terrestrial Water Storage.â€ *Nature* 560 (7720): 628â€“31.**
- **Supplementary Materials to Humphrey et al. (2018)**
- **Trugman, A.T., Medvigy, D., Mankin, J.S., Anderegg, W.R.L., 2018. Soil Moisture Stress as a Major Driver of Carbon Cycle Uncertainty. Geophysical Research Letters 45, 6495â€“6503.**

Week 10 (week beginning April 1): Impacts on food security

- Led by: Marissa

- **Rosenzweig, C., Elliott, J., Deryng, D., Ruane, A.C., MÃ¼ller, C., Arneth, A., Boote, K.J., Folberth, C., Glotter, M., Khabarov, N., Neumann, K., Piontek, F., Pugh, T.A.M., Schmid, E., Stehfest, E., Yang, H., Jones, J.W., 2014. Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. PNAS 111, 3268â€“3273.**
- **Lobell, D.B., Burke, M.B., 2010. On the use of statistical models to predict crop yield responses to climate change. Agricultural and Forest Meteorology 150, 1443â€“1452.**

Week 11 (week beginning April 8): Impacts on water supply

- Led by: Matt

- **Saft, M., Western, A.W., Zhang, L., Peel, M.C., Potter, N.J., 2015. The influence of multiyear drought on the annual rainfall-runoff relationship: An Australian perspective. Water Resources Research 51, 2444â€“2463.**
- **Hughes, J.D., Petrone, K.C., Silberstein, R.P., 2012. Drought, groundwater storage and stream flow decline in southwestern Australia. Geophysical Research Letters 39.**

Week 12 (week beginning April 15): Impacts on extreme weather

- Led by: Ned
- **Gudmundsson, L., Rego, F.C., Rocha, M., Seneviratne, S.I., 2014. Predicting above normal wildfire activity in southern Europe as a function of meteorological drought. Environmental Research Letters 9, 084008.**

- **Tosca, M.G., Randerson, J.T., Zender, C.S., Flanner, M.G., Rasch, P.J., 2010. Do biomass burning aerosols intensify drought in equatorial Asia during El Nino? Atmos. Chem. Phys. 14.**

Week 13 (week beginning April 22): Final presentations of student projects

Week 14 (week beginning April 29): Final presentations of student projects