Syllabus

GEOL585 – Science of Hazard Prediction (3 units)

Advanced treatment of probabilistic forecasting of natural hazards: physical-process modeling, statistical forecasting, representations of uncertainty, proper scoring, testing, and use in risk analysis and decision-making. Prerequisites: MATH 407, MATH 408.

Academic Rationale and Learning Objectives: Earth's natural hazards—ranging from windstorms, droughts, floods and landslides to earthquakes, tsunamis and volcanic eruptions—are notoriously difficult to predict owing the scale and complexity of the geosystems that produce them. Nevertheless, the proper functioning of society demands ever-more-informative hazard predictions that are *scientific*; i.e., formulated to describe measurable events, respectful of physical laws, as accurate as possible, and testable against observations. The purpose of this course is to prepare students for advanced research in the science of hazard prediction. Students who complete this course will learn how to develop probabilistic hazard forecasts, calibrate and test forecasts against observations, and communicate forecasting results to end-users.

Instructor: Tom Jordan (tjordan@usc.edu); office hours: Mon 07:00-09:00 or by appointment, ZHS-267.

Schedule:

Week	Topic
1	Hazard, risk, and decision-making
2	Introduction to probabilistic hazard analysis
3	Earthquake rupture forecasting
4	Earthquake ground-motion prediction
5	Aleatory variability, epistemic uncertainty, and ontological error
6	Introduction to weather and climate forecasting
7	Hurricane forecasting
8	Forecasting El Niño–Southern Oscillation
9	The Anti-Prediction Critique
10	Proper scoring methods for forecast validation
11	Introduction to Bayesian inference
12	Bayesian forecasting methods
13	Complete probabilistic models, epistemic uncertainty, and the ontological null hypothesis
14	Severe testing and the processes of forecast validation
15	Experimental concepts for testing the ontological null hypothesis
16	Presentations of student research projects

Format: 3-unit class with a mix of formal lectures (60%) and student presentations on assigned readings and term projects (40%), 2 meetings per week, 1.5 hours per meeting.

Grades: Based on in-class presentations (40%), homework (20%), and term project (40%).

In-class presentations: Each classroom session will include a lecture by the instructor (50 min) and a student-led discussion of the readings (30 min). Students assigned as discussion leaders on a rotating basis will begin the discussion with a brief (10 min) summary of the reading materials. All students are expected to be active participants in the discussions of the course readings.

Homework: Students are expected to spend approximately 6 hours per week on reading the assigned material, answering study questions, and working on their term projects.

Term project: Each student will prepare a 10-15 page paper on a regionalized hazard forecasting enterprise, such as Pacific tsunami forecasting, California earthquake forecasting, or Cascadia volcano forecasting. The paper will summarize forecasting methodology, operational forecasting models, and validation procedures, and it will assess forecasting performance and the potential for forecasting improvements. Draft papers will be due two weeks before the end of classes. Students will present their projects orally in 15-minute presentations during the last week of classes. Final drafts of the term papers will be due on the last day of classes. Project grades will be based on the written paper (70%) and oral presentation (30%).

Readings (in order of discussion):

Silver, N. (2012). *The Signal and the Noise: Why So Many Predictions Fail – But Some Don't.* Penguin Books, 534 pp. ISBN: 978-1594204111.

Orrell, D. (2008). *The Future of Everything: The Science of Prediction*. Basic Books, ISBN: 978-1568583693.

Baker, J. W. (2008). An Introduction to Probabilistic Seismic Hazard Analysis, On-Line Notes V.1.3, Oct 1, 2008.

Field, E. H., et al. (2017). A Synoptic View of the Third Uniform California Earthquake Rupture Forecast (UCERF3), *Seismol. Res. Lett.*, 88, 1259-1267.

Boore, D., and Atkinson, G., 2008. Ground-motion prediction equations for the average horizontal component of PGA, PGV, and 5%-damped PSA at spectral periods between 0.01 and 10.0 s, *Earthquake Spectra*, 24, 99–138.

Al Atik, L., et al., 2010. The variability of ground-motion prediction models and its components, *Seismol. Res. Lett.*, 81, 794-801.

Zebiak, S.E. and M.A. Cane, 1987. A model of El Niño-Southern Oscillation, *Mon. Wea. Rev.,* **115**, 2262–2278.

Oreskes, N., K. Shrader-Frechette & K. Belitz (1994). Verification, validation, and confirmation of numerical models in the Earth sciences, *Science*, 263, 641-646.

Pilkey-Jarvis, L., and O. H. Pilkey (2008). Useless Arithmetic: Ten points to ponder when using mathematical models in environmental decision making, *Pub. Admin. Rev.*, 470-479.

Bauer. P., A. Thorpe & G. Brunet (2015). The quiet revolution of numerical weather prediction, *Nature*, 525, 47-55.

Murphy, A. H. & R. L. Winkler (1987), A general framework for forecast verification, *Mon. Weath. Rev.*, **115**, 1330-1338.

Carvalho, A. (2016). An overview of applications of proper scoring rules, *Decision Analysis*, **13**, 223-242.

Gneiting, T., & M. Katzfuss (2014), Probabilistic forecasting, *Annu. Rev. Stat. Appl.*, **1**, 125-151.

J. O. Berger (1985). *Statistical Decision Theory and Bayesian Analysis*, Springer-Verlag, New York, Chapters 1-4.

Marzocchi, W., & T. H. Jordan (2014), Testing for ontological errors in probabilistic forecasts of natural systems, *Proc. Nat. Acad. Sci.*, **111**, 11973-11978, doi/10.1073/pnas.1410183111.

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems:

Student Counseling Services (SCS) – (213) 740-7711 – 24/7 on call. Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. engemannshc.usc.edu/counseling

National Suicide Prevention Lifeline – 1 (800) 273-8255. Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. www.suicidepreventionlifeline.org

Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900 – 24/7 on call. Free and confidential therapy services, workshops, and training for situations related to gender-based harm. engemannshc.usc.edu/rsvp

Sexual Assault Resource Center. For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: sarc.usc.edu

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086. Works with faculty, staff, visitors, applicants, and students around issues of protected class. equity.usc.edu

Bias Assessment Response and Support. Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. studentaffairs.usc.edu/bias-assessment-response-support

The Office of Disability Services and Programs. Provides certification for students with disabilities and helps arrange relevant accommodations. dsp.usc.edu

Student Support and Advocacy – (213) 821-4710. Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. studentaffairs.usc.edu/ssa

Diversity at USC. Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. diversity.usc.edu

USC Emergency Information. Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible. emergency.usc.edu

USC Department of Public Safety – UPC: (213) 740-4321 – HSC: (323) 442-1000 – 24-hour emergency or to report a crime. Provides overall safety to USC community. dps.usc.edu