METR 6313

Advanced Data Assimilation Methods

Instructor: Dr. Xuguang Wang (xuguang.wang@ou.edu)

When: Monday and Wednesday 11:30-12:45pm

Where: National Weather Center 5930

Office hours: Monday 12:45-1:30pm or upon email request

Prerequisites: MATH 3113 (ODE), 4163 (PDE), and 3333 (linear algebra); ENGR 3723 (numerical methods) or equivalent or permission of instructor. Programming experience is useful. Not limited to Meteorology students.

Reference texts:

- Course notes.
- Selected journal articles.
- E. Kalnay, 2012: *Atmospheric Modeling, Data Assimilation and Predictability*.
- G. Evensen, 2009: Data Assimilation.
- J. Lewis, S. Lakshmivarahan, and S. K. Dhall, 2006: *Dynamic data assimilation: A least square approach*.
- R. Daley, 1995: *Atmospheric Data Analysis.*

Grading policy:

- Exams (40%): Mid-term exam (15%), Final exam (25%)
- 4-5 Homework assignments (40%), due ~ two weeks after assigned
- In-class presentation (20%)

Objectives:

The course is designed to introduce students to the world of the ensemble Kalman filter data assimilation technique (EnKF), an advanced data assimilation method that has become popular in many scientific and engineering fields (Geoscience such as Meteorology and Hydrology, Ecological science, Petroleum Engineering, Data Science, etc). The students will learn the most popular EnKF techniques through lectures and hands-on project assignments, and learn the EnKF applications in different fields through in-class presentations and discussions. The students will not only learn various EnKF techniques and their applications, but also develop their skills in scientific thinking and synthesis, writing and oral communication throughout the course.

Tentative topics:

- Basic concepts of data assimilation
- Mathematical preparation: matrix algebra
- Least square and Bayesian contexts
- Brief review of statistical interpolation, 3DVAR and 4DVAR
- Classic Kalman filter and Extended Kalman filter
- Basic concepts of Ensemble Kalman filter
- Ensemble Kalman filter with perturbed observations
- Ensemble square root filter
- (Local) Ensemble Transform Kalman filter
- Common problems and treatments in ensemble Kalman filters
- Hybrid ensemble-variational method, ensemble smoother, particle filter, machine learning and data assimilation, and other special topics
- Applications of ensemble Kalman filters
- Guest lectures