FALL 2019

SYLLABUS

METR 5303 - Objective Analysis and Data Assimilation

Instructors: Dr. Ming Xue (mxue@ou.edu)
Office Hours: Tuesday, Thursday 2:15-3:00pm or by appointment)

When and Where: Tuesday, Thursday 1:00-2:15 pm; Room NWC 5930

Prerequisites: METR 5113 or concurrent enrollment; knowledge of a high-level programming language (e.g., Fortran, C, C++, IDL, Matlab, Python, Java, etc.). Or permission of instructor.

Texts: Eugenia Kalnay, 2002, *Atmospheric Modeling, Data Assimilation and Predictability*, Cambridge University Press, 341pp.

Roger Daley, 1995, *Atmospheric Data Analysis*, Cambridge University Press, 472pp.

Also, selected material from journals and review articles.
A web site has been set up for the course at http://twister.ou.edu/OBAN2019/.
Lecture notes and other course materials will be posted there.

Tests: Exam 1: Thursday, September 26
Exam 2: Thursday, November 7
Final Exam: Thursday, December 5

Grading Policy:

In-class exams (3):	20% each
Computer assignments (5-6)	40%

Objectives: This course focuses on methods and techniques, as well as their theoretical background, for creating 'analyses' of atmospheric fields on regular computational grids, from non-uniformly spaced observations of different types and spatial/temporal resolutions, so that such fields can be used for diagnostic studies of the atmospheric processes, for initializing numerical weather prediction (NWP) models, and/or for verifying model forecasts. The objective analysis part of the course discusses methods that typically don't involve an NWP model, while the data assimilation (DA) part has the main goal of creating 'optimal' analyses for model initialization. Advanced variational, Kalman filter/ensemble Kalman filter as well as hybrid ensemble-varational methods will be discussed, starting from the mathematical derivations of these algorithms. Practical applications of these methods in atmospheric research and operational NWP will be discussed. At the end of the class, you will have coded several objective analysis algorithms for producing weather maps from station observations, and studied and exercised a 3D variational code containing several algorithms. With a good understanding of the course materials, you will be in a position to carry out graduate research focusing on advanced data assimilation, using either conventional or remote sensing observations.

List of Topics:

1. General comments on observing systems; today's operational data base

2. Objective Analysis
   (a) General concepts; function fitting
   (b) Cressman, Barnes and Bratseth techniques
   (c) Filtering concepts
   (d) Statistical analysis
      (i) optimal interpolation
      (ii) multivariate O.I.

3. Data Assimilation Concepts, Mathematical tools

4. Optimal Estimation/Optimal Interpolation (OI)

5. Three-Dimensional Variational Data Assimilation (3DVAR)

4. Four-Dimensional Data Assimilation
   (a) Historical approaches; Newtonian relaxation or nudging
   (b) Variational Approaches; 4DVar
   (c) Adjoint techniques for minimization

5. Kalman Filters
   (a) Classic Kalman filter and extended Kalman Filter
   (b) Ensemble Kalman Filters
   (c) Hybrid ensemble-variational methods

6. Special Topics (if time allows)
   (a) Methods used in current operational forecast systems
   (b) Methods for mesoscale and storm-scale prediction
   (c) Observing System Simulation Experiments (OSSE)

Computer programs will be written as part of the homework assignments. Thus working knowledge of a programming language is required. By the end of the course each student will have at least three working objective analysis codes and have worked one or two simple variational analysis problems. Note that homework determines a significant part of the final grade, so that your efforts there will be rewarded.

Any student in this course who has a disability that may prevent him or her from fully demonstrating his or her abilities should contact me personally as soon as possible so we can discuss accommodations necessary to ensure full participation and facilitate your educational opportunities.

All students are expected to be familiar with and abide by the OU Academic Integrity Code. Misconduct Code. Related information can be found at http://www.ou.edu/integrity/students.