ASEN 6055 Data Assimilation and Inverse Methods for Earth and Geospace Observations

Lecture: T/TH 10:05-11:20am, SEEC N125
Office Hours: TBD
Zoom meeting ID: 915 1676 5637
Webpage: Canvas (https://canvas.colorado.edu)
Instructor: Prof. Tomoko Matsuo
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Course Description

Data assimilation and inverse methods play a key role in integrating remote-sensing and in-situ Earth and Geospace observations into a model of the Earth and Geospace system or subsystems, enabling weather prediction and climate projection of high societal relevance. This course covers selected topics in probability theory, spatial statistics, estimation theory, numeric optimization, and geophysical nonlinear dynamics that form the foundation of commonly used data assimilation and inverse methods in the Earth and Space Sciences. The course materials are organized into three sections: (1) Statistical Principles and Background, (2) Building Blocks for Spatial Problems, and (3) Building Blocks for Spatial-Temporal Problems. Hands-on computational homework and projects provide opportunities to apply classroom curricula to realistic examples in the context of data assimilation.

Class Learning Goals

The goal of this course is to provide the fundamental statistical background and context of commonly used data assimilation and inverse methods in the Earth and Space Sciences, and to equip students with the knowledge and skills to construct a data assimilation system on their own. Students will: (1) attain a deeper understanding of the underlying statistical principles of data assimilation and inverse methods; (2) actively apply their own understanding of the fundamentals and tradeoffs of different approaches in critiquing current data assimilation research; and (3) develop the skills, confidence and creativity to design and build a data assimilation system of their own.

Prerequisites

Some basic understanding of random vectors and matrices, estimation theory, numerical optimization techniques

Texts

All the reading material required for the course will be provided through the Canvas course webpage. Suggested (not required) text books on the topics covered in this course include:

- ¶ Statistical methods in the atmospheric sciences, Daniel Wilks (2011) - *eBook at CU library*
- ¶ Inverse methods for atmospheric sounding: Theory and Practice, Clive D. Rodgers (2000) - *eBook at CU library*
- ¶ Atmospheric modeling, data assimilation and predictability, Eugenia Kalnay (2003) - *on reserve in CU library*
- ¶ Atmospheric data analysis, Roger Daley (1991) - *on reserve in CU library*
- ¶ Data assimilation: the ensemble Kalman filter, Geir Evensen, (2007, 2009) - *eBook at CU library*
- ¶ Inverse problem theory and methods for model parameter estimation, Albert Tarantola (2004) - *eBook at CU library*

Community Data Assimilation Software

Some well-documented community data assimilation software widely used by researchers in the Earth and Space Sciences can be found at:

- ¶ NCAR Data Assimilation Research Testbed, https://dart.ucar.edu/
- ¶ DTC GSI, http://www.dtcenter.org/com-GSI/users/
- ¶ Parallel Data Assimilation Framework http://pdaf.awi.de

Class Format

The course will involve weekly lectures and group discussion on the course content outlined above. Distance learning and remote students are asked to participate in discussion via Zoom, Piazza, and/or e-mails. Homework assignments will provide opportunities to apply the statistical principles to realistic examples. Brief feedback about your learning experience and self-assessment will be requested weekly, and will be discussed in the following class. A midterm take-home exam will be given to assess students' understanding on the fundamentals and to

¶ **Online** (Asynchronous): activity via lecture capture or other online learning tools available through Canvas course webpage; students can participate when it is convenient for them within a specified time window.

If an **In-Person** mode turns out to be impractical for various reasons including health and safety concerns, the instructor reserves the right to switch ASEN 6055-001 into a **Remote** delivery mode. ASEN 6055-001B is a distance learning section that will be delivered in an **Online** mode as usual. In addition to the scheduled lectures, additional office hours will be offered in a **Remote** mode per guidelines.

Classroom Behavior

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the policies on classroom behavior and the Student Code of Conduct.

Requirements for COVID-19

dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code.