**Syllabus**

ATMO/HWRS 545: Introduction to Data Assimilation

**Class Hours**
11:00 am – 11:50 am Monday, Wednesday, Friday (MWF)

**Class Location**
Mines and Metallurgy, Rm 213

**Instructor**
Assoc. Prof. Avelino F. Arellano, Jr. (Ave)
afarellano@email.arizona.edu
Harshbarger 314C, 520-626-3015
Office Hours, Mon/Wed 12:00-1:30pm or by appointment

**Course Description**
Data assimilation (DA) involves combining information from observations and “models” of a particular physical system in order to best define and understand the evolving state of the system. It is currently applied across a wide range of Earth sciences, including weather forecasting, oceanography, atmospheric chemistry, hydrology, and climate studies. This course provides an introduction to the theory and applications of DA in atmospheric and related sciences. Topics include common DA methods like optimal interpolation, Kalman filtering and variational schemes within the context of estimation theory. The course is designed as a hands-on approach to key DA concepts that are currently used today.

**Textbook**
There are no required textbooks for this course. Handouts will be distributed during class (mainly based from notes by Saroja Polavarapu, Environment Canada). See also reference section of this syllabus for recommended materials.

**Goals & Expectations**
My intent as an instructor is to convey applied concepts of data assimilation, in a manner that will a) enhance your appreciation of DA and its practical applications, b) stimulate your curiosity, and c) enable you to use DA techniques for your own research.

The course is designed as an introduction to data assimilation under a mostly hands-on learning environment. You are encouraged to engage yourselves (before, during and after lectures). At the end of the course, you should be able to have a good appreciation of the key DA concepts, which you can apply as tools for your own research. Students who desire more advanced topics (e.g. mathematical/statistical concepts) not included in this course are encouraged to pursue graduate courses in the Department of Mathematics (or consult instructor).

Prerequisites for this class include a) a strong desire to learn how to combine models and observations, b) a basic understanding of linear algebra & elementary statistics, and c) a basic skill in programming (e.g. Matlab).
Course Assessment

There is no exam for this course. Students will be assessed on how they are able to grasp the key concepts through assignments and one individual project. The percentage distribution of your grade will be as follows:

Assignments: 60%
Project: 40%

Unless otherwise noted, assignments either follow the demo exercises in class (computer toy models/Matlab) or practice exercises (e.g. derivation, problem solving). Assignments are typically given after a major section has been discussed. See Course Outline and Dates and Deadlines for details.

A large part of the grade will be through individual student project, which will be designed by the students themselves depending on their particular research interest or application of choice. Projects should be more comprehensive than exercises in class. They can either include but not exclusively: a) use of data and model output (1D to 3D) with a DA algorithm of choice, b) development of new algorithms or modification of algorithms discussed in class, c) critique of a DA paper. The project should be something that can be made as a short paper/report (i.e. includes introduction, methods, theory, implementation, results, discussion, conclusion). The project will be assessed throughout the course (i.e. project proposal-10%, project presentation-20%, final project report -10%).

A student may be allowed to hand-in assignments after their due date provided one of the following conditions: 1) involvement in university-sponsored activities on exam or homework due dates, or 2) extenuating personal circumstances (i.e. serious or life-threatening illness). Appropriate and verifiable documentation will be required by any student making such requests in all cases.

Letter grades are determined using the following scale:

A: \( \geq 90.0\% \)
B: 80 to 89.9 %
C: 65.0 to 79.9 %
D: 55.0 to 64.9 %
E: below 55.0 %

Student Responsibilities

To learn this course, you are expected to be involved all throughout. As a student, you are responsible in a) actively asking and answering questions during class and review sessions, b) doing your assignments (including reading materials) after class, and c) responding to d2l class announcements/surveys. Doing so will greatly enhance your learning experience. As your instructor, I invite you to make use of our office hours if you have some pressing questions.

From the University perspective, you are expected to devote a minimum of two (2) hours outside class (for study, reading, homework) for every contact hour (or 50 minutes) in classroom.

Attendance

You will be responsible for learning this course. Regular, frequent and punctual attendance is strongly encouraged but not required.

Academic Integrity

Note that associated with your learning experience are sets of ‘rules’ to diligently follow. From the University perspective, you are expected to adhere to the University’s "Code of Academic Integrity" and "Student Code of Conduct". You are responsible for knowing these codes (and revisions), including pertinent implications. If you still haven’t done this, please see deanofstudents.arizona.edu/policiesandcodes.
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Introduction to Data Assimilation

Classroom Behavior

You are expected to behave as courteous adults and in a manner consistent with enhancing the learning environment of your fellow students. You are expected not to talk to your neighbors during class, turn off your electronic devices (e.g. cell phones, pagers, BlackBerry, iPod, mp3, etc), and to remain seated until the instructor dismisses the class. Destructive behavior in the classroom or any perceived threatening behavior towards fellow students or the teaching staff will be dealt with. See University policy: policy.web.arizona.edu/threatening.pdf

Course Withdrawal

Last day to drop the course without it appearing on your transcript is Sunday, Sept. 16, 2018.

Final Note

Some information in this syllabus may be subject to change with advance notice as deemed appropriate by the instructor. Your comments are welcome and appreciated.

Students with Disability

If you anticipate barriers related to the format or requirements of this course, please meet with me so that we can discuss ways to ensure your full participation in the course. If you determine that disability-related accommodations are necessary, please register with Disability Resources (621-3268; drc.arizona.edu) and notify me of your eligibility for reasonable accommodations. We can then plan how best to coordinate your accommodations.

Reference Materials


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Introduction to Data Assimilation

Course Outline

Below is our tentative schedule. We may extend/shorten the lecture/discussion of some sections (e.g. special topics) depending on the average progress of the class. Project dates on the other hand are fixed.

Course Syllabus/Introduction
Aug 20, 22

Data Assimilation and Information
Observations & Models of the Earth System
Aug 22, 24, 27

Guest Lecture
Solar Power Forecasting
Aug 29

Concept of Least Squares
Sep 5, 7, 10, 12

Introduction to Estimation Theory
Bayes Theorem
Sep 14, 17

Concepts of Probabilistic Estimation
Sep 17, 19, 21

Least Squares Estimation
Sep 24, 26

Common Algorithms
Optimal (Statistical) Interpolation
Sep 28, Oct 1, 3, 5, 8, 10

Proposal Presentations
Oct 12, 15, 17

Kalman Filter
Oct 19, 22, 24, 26, 29, 31, Nov 2

4D-Var
Nov 2, 5, 7, 9, 14, 16, 19

Guest Lecture
Math/Stat Perspectives of DA
Nov 26

Longer View
Reanalysis, OSSEs
Nov 28

Project Presentations
Nov 30, Dec 3, 5

Project Report Due
No later than Dec 12, 2018 1230pm

Dates and Deadlines

Last Day of Dropping:
Sep 16, 2018

Project Deadlines:
Proposal Presentation
(Oct 12-17, 2018)
Project Presentation
(Nov 30-Dec 5, 2018)
Project Report
(Dec 12, 2018 12:30pm)

Assignment Deadlines:
Sept 5 & 17, 2018
Oct 1 & 10, 2018
Oct 22 & 31, 2018
Nov 7 & 19, 2018
Nov 28 & Dec 5, 2018

Holidays/No Classes:
Aug 31, 2018
Sep 3, 2018
Nov 12, 2018

Thanksgiving Recess:
Nov 22-25, 2018

Last Day of Classes:
Dec 05, 2018

Useful Websites

Department Website
www.atmo.arizona.edu/courses/fall18/atmo545

D2L Website
d2l.arizona.edu

Instructor Website
arellano.faculty.arizona.edu

Dates and Deadlines

Last Day of Dropping:
Sep 16, 2018

Project Deadlines:
Proposal Presentation
(Oct 12-17, 2018)
Project Presentation
(Nov 30-Dec 5, 2018)
Project Report
(Dec 12, 2018 12:30pm)

Assignment Deadlines:
Sept 5 & 17, 2018
Oct 1 & 10, 2018
Oct 22 & 31, 2018
Nov 7 & 19, 2018
Nov 28 & Dec 5, 2018

Holidays/No Classes:
Aug 31, 2018
Sep 3, 2018
Nov 12, 2018

Thanksgiving Recess:
Nov 22-25, 2018

Last Day of Classes:
Dec 05, 2018

Useful Websites

registrar.arizona.edu
deanofstudents.arizona.edu