ABE 498: Data and Uncertainty
(Spring 2026. CRN: 75684)

COURSE INFORMATION

Course Website : https://canvas.illinois.edu/courses/XXXX
Meeting time : Tuesday, 2 pm – 4:30 pm
Meeting Locations : Synchronous. Zoom
Credit Hours : **3** (undergraduate and graduate) laboratory/discussion
Instructors:

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Office hours : By appointment (in person or via videoconference).
Prerequisites : Background equivalent to Calculus II and Statistics.
Learning Objectives : Upon completion of the course, students will be able to:

- Explain (cognitive skill: **understand**) how data represent physical processes and systemic interactions related to Agricultural systems and how errors propagate in data and models (outcome 1).
- Compare (cognitive skill: **evaluate**) the techniques and models that can be applied to quantify models' sensitivity and their linkage to natural systems (outcome 4).
- Develop (cognitive skill: **create**) a data screening and sensitivity analysis to evaluate uncertainty in a model (outcome 2).
- Communicate (cognitive skill: **apply**) the methods, results, and conclusions related to uncertainty through written reports and oral presentations focused on critical thinking and problem-solving across disciplines where data science is applied (outcome 3).

Course Description

This course will introduce students to the principles of data screening and uncertainty analysis for data collection and models in engineering disciplines. In the first part of the course, we will cover definitions and basic concepts of errors (reading, calibration, and propagation) in data collection; sources of error; error limits; and techniques for identifying and representing deterministic and stochastic components in data. The second part of the course will focus on the practical application of sensitivity analysis to identify and quantify variable contributions in

complex models. We will use datasets and computational tools throughout the course, including spreadsheets, programming languages, and applications.

Course Format

The course will be delivered synchronously via CANVAS over 16 weeks, with videos presenting content and concepts. We will also use CANVAS for assignments, group work, reading materials, and discussions. Instructors and students will meet once per week for a 100-minute discussion/laboratory session. The class is structured as a workshop, with hands-on activities following a brief lecture and discussion on the assigned topic. Students are expected to work 4 hours per week outside of class to complete their homework and write the project reports.

Learning Resources

Course materials will be available on Canvas. Homework and laboratory reports will be submitted through Canvas. A project folder will be created on the network for each student to store their data and, if needed, the model. The following resources will be provided:

- Class notes: Available on Canvas
- https://ral.ucar.edu/solutions/products/camels

During our class, we may use generative AI tools such as ChatGPT, Copilot, or Gemini. You will be informed of when, where, and how these tools may be used, along with guidance on attribution. Any use outside the scope of explicit permission constitutes academic dishonesty and a violation of the University of Illinois Student Code.

Overview Course Requirements & Assessment

Attendance (5%): Students must attend all classes and arrive on time. Attendance will be taken at the start of each class. Students should contact the instructor as soon as possible if they expect to miss classes for reasons such as chronic illness, travel related to team sports, or other university activities.

Quizzes (10%): Four to six announced quizzes will be given throughout the semester. Each quiz will consist of questions about the lecture and will be taken online via Canvas.

Homework (30%): Four to six homework or machine problems will be assigned throughout the semester. Homework must be submitted via Canvas by the end of the week in which it was assigned, no later than 10 pm. Homework should be completed neatly, with the problem and solution clearly outlined. Final answers should include appropriate units and be circled or underlined. The clearer a problem is presented and solved, the more likely you are to receive partial credit. Late homework will not be accepted, and you will receive a grade of zero. Executable code, spreadsheets, data visualizations, and solid models will demonstrate your effort on machine problems and will be evaluated for precision, accuracy, and efficiency (see table below).

Project Reports (total: 40%): Project deliverables should be uploaded to Canvas on the working folder by 10 pm on the due date. Deliverables must be in the required format to receive full

credit for the projects and must include all requested information. Models should run without errors (see table below).

Final Project and Presentation (15%): The final report will be a write-up of the projects in which students describe how they developed their watershed model, from data acquisition through calibration. Students must also create a 5-minute video summarizing what they have learned in the course. Students are encouraged to use visual aids, such as PowerPoint slides or other applications, to enhance the quality of their presentations. Visual aids will be evaluated based on their clarity of presentation, use, and relevance.

The final Grade will be computed as the sum of the weighted grades and reported on a 100-point scale.

Final Grade: based upon a 100-point scale with grades assigned as follows, converted to each University system by your respective lecture leader:

A+: 100 – 97;	A: 96 – 93;	A-: 92 – 90;
B+: 89 – 86;	B: 85 – 83;	B-: 82 – 80;
C+: 79 – 76;	C: 75 – 73;	C-: 72 – 70;
D+: 69 – 67;	D: 66 – 63;	D-: 62 – 60;
F : 59 – 0		

Graduate vs. undergraduate credits: Graduate students must use more data in their models than undergraduate students. They must also conduct a model sensitivity analysis using at least three datasets. Graduate students must submit a final report comparable to a peer-reviewed manuscript.

Course Schedule: Tasks are due by 10 pm on the Friday of the week in which they were assigned. In comparison, Reports are due on Friday before 10 pm in the following week in which they are assigned.

Schedule

Week		Content	Topic	Task	Eval. Wght
1	Data	Syllabus. Definition of Uncertainty. Importance of Uncertainty	Explanation of the syllabus, rules, regulations, evaluation, and homework a. Data significant digits b. Uncertainty definition and examples c. Uncertainty vs. Sensitivity Analysis	Observational Uncertainty	3

2		Measurements, errors, and error propagation	a. errors in measurements b. error propagation c. epistemic uncertainty	Error Propagation	3
3		Data screening	a. Trends & Stochastic components. b. Components of data and sampling interval c. Sampling interval d. Screening of data	Trend separation	3
4		Data screening	a. Test for randomness (Serial correlation) b. Change point detection c. Test for the stability of variance d. Test for the stability of the mean	Change point detection	3
5		Data screening	a. Test for linear trend b. Probability distribution fitting c. Fourier	Trend separation	3
6		Consistency of data	a. Pre-whitening b. Double mass analysis c. Residual and cumulated residuals	Data consistency	5
7		Modeling stochastic components	a. autoregressive models	AR-1 Model	5
8		Modeling stochastic components	b. autoregressive models	AR-1 + X model	5
9		BREAK			
10	Uncertainty Analysis	Introduction to sources of uncertainty in models	a. Structural and parametric uncertainty b. Model diagnostic evaluation c. Decision analytics under uncertainty d. Predictive vs. exploratory analysis		
11		Sensitivity analysis basics	a. Definition of sensitivity analysis b. Sensitivity analysis vs. uncertainty analysis c. Local vs. global sensitivity analysis	Project 1	10

			d. One-At-a-Time vs. All-At-a-Time e. Sensitivity analysis methods f. Design of computational experiments g. Sensitivity indices		
12		Advanced topics in a sensitivity analysis	a. Model outputs and output signatures b. State-varying sensitivity analysis c. Sensitivity analysis tools		
13		Sensitivity analysis project	a. Python review b. Introduction to SALib c. Introduction to the sensitivity project	Project 2	10
14		Sensitivity analysis project	a. Python review b. Introduction to SALib c. Introduction to the sensitivity project		
15		Model calibration	a. Factor fixing, prioritization, and mapping b. Model evaluation and uncertainty analysis c. Model calibration paradigms d. GLUE e. Statistical and process-based models		
16		Project review		Final Project (Report + Presentation)	20

Projects Topics

- Project 1: Conceptual model development
- Project 2: Sensitivity Tools in Python
- Project 3: Sensitivity analysis and model calibration

Books

- Reed, P.M., Hadjimichael, A., Malek, K., Karimi, T., Vernon, C.R., Srikrishnan, V., Gupta, R.S., Gold, D.F., Lee, B., Keller, K., Thurber, T.B, & Rice, J.S. (2022). Addressing Uncertainty in Multisector Dynamics. Research [Book]. Zenodo. https://doi.org/10.5281/zenodo.6110623

- Saltelli, Andrea, Marco Ratto, Terry Andres, Francesca Campolongo, Jessica Cariboni, Debora Gatelli, Michaela Saisana, and Stefano Tarantola. Global sensitivity analysis: the primer. John Wiley & Sons, 2008.

Additional Resources

Academic Integrity. The University of Illinois at Urbana-Champaign Student Code should also be included in this syllabus. Students should carefully review Article 1, Part 4: Academic Integrity. Access the Code at this URL: http://studentcode.illinois.edu/. Academic dishonesty can lead to a failing grade. All students are expected to review and comply with the Academic Integrity Policy: https://studentcode.illinois.edu/article1/part4/1-401/. Ignorance of the policy does not excuse academic misconduct. You are responsible for reading the policy to prevent misunderstandings. If you are uncertain about what counts as plagiarism, cheating, or other violations, do not hesitate to ask the instructor(s).

Mental Health. Significant stress, mood changes, excessive worry, substance/alcohol misuse, or interference in eating or sleep can impact academic performance, social development, and emotional well-being. The University of Illinois offers confidential services, including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings, all of which are covered by the Student Health Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a wise and courageous thing to do for yourself and for those who care about you.

- Counseling Center (217) 333-3704
- McKinley Health Center (217) 333-2700
- National Suicide Prevention Lifeline (800) 273-8255
- Rosecrance Crisis Line (217) 359-4141 (available 24/7, 365 days a year)

If you are in immediate danger, call 911.

Community of Care. As members of the Illinois community, we each have a responsibility to express care and concern for one another. Suppose you come across a classmate whose behavior concerns you, whether regarding their well-being or yours. In that case, we encourage you to refer this behavior to the Student Assistance Center (217-333-0050 or http://odos.illinois.edu/community-of-care/referral/). Based on your report, the staff in the Student Assistance Center contacts students to ensure they have the support they need to remain healthy and safe.

Furthermore, as a Community of Care, we aim to support your overall well-being. We know that students sometimes face challenges that can impact academic performance (examples include mental health concerns, food insecurity, homelessness, and personal emergencies). Should you find that you are managing such a challenge and interfering with your coursework, you are encouraged to contact the Student Assistance Center (SAC) in the Office of the Dean of Students for support and referrals to campus and/or community resources.

Students with Disabilities. To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor immediately and provide the instructor with a Letter of Academic Accommodations from Disability Resources and Educational Services (DRES). To ensure that disability-related concerns are appropriately addressed from the outset, students with disabilities who require assistance in participating in this class should apply for services through DRES and consult the instructor as soon as possible. If you need accommodation for a disability, please speak with me after class or schedule an appointment during my office hours. DRES provides students with academic accommodations, access, and support services.

To contact DRES, visit 1207 S. Oak St., Champaign; call 217-333-1970; email disability@illinois.edu; or visit the DRES website at http://www.disability.illinois.edu/. Here is the direct link to apply for services at DRES: https://www.disability.illinois.edu/applying-services.

Disruptive Behavior. Behavior that persistently or grossly interferes with classroom activities is considered disruptive and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave the class for discussion and resolution of the problem and may be referred to the Office for Student Conflict Resolution (https://conflictresolution.illinois.edu; conflictresolution@illinois.edu; 333-3680) for disciplinary action.

Emergency Response Recommendations. Emergency response recommendations and campus building floor plans are available at the following website: https://police.illinois.edu/em/run-hide-fight/. We encourage you to review this website within the first 10 days of the course.

Religious Observances. Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices with respect to admissions, class attendance, and the scheduling of examinations and work requirements. Students should complete the Request for Accommodation for Religious Observances form should any instructors require an absence letter to manage their absence. To best facilitate planning and communication between students and faculty, students should request absence letters as early as possible in the semester the request applies.

Sexual Misconduct Reporting Obligation. The University of Illinois is committed to combating sexual misconduct. Faculty and staff members must report any sexual misconduct to the University's Title IX and Disability Office. An individual with the Title IX and Disability Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality is available at https://wecare.illinois.edu/resources/students/#confidential.

Additional information on resources and reporting is available at https://wecare.illinois.edu.