Microclimatology: Boundary Layer Climatology (Geography 5921)
Spring 2023
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Office Hours: T 4:00–5:00 p.m., TR 4:00–5:00 p.m. and by appointment. Office hours are in person (1124 Derby Hall).

If you are not available during my regular office hours, please feel free to contact me to setup a meeting at a time that works for you.

Lectures: Tuesday and Thursday, 11:10 a.m. – 12:30 p.m., 1064 Smith Lab

Required Materials:
Boundary Layer Climates, 2nd Edition (1987), Oke, ISBN-13: 9780415043199

Class Website: carmen.osu.edu

Course Objectives:
The **boundary layer** is the part of the atmosphere that is affected by interactions with the surface. This course covers the fundamentals (processes, spatial and temporal variations and methods for measuring and modeling) of atmosphere-surface interactions, including:
(1) radiation fluxes,
(2) turbulent heat, moisture, and momentum fluxes, and
(3) subsurface conductive fluxes.

The boundary layer is where humans, animals and plants live. Therefore, it is an important part of the atmosphere and it has a direct impact on the biosphere. Human activities both control, and are controlled by, boundary layer climates. For example, atmospheric pollutants are concentrated near the surface and diffuse into the atmosphere by turbulence. Land use/land cover regulates the daily and seasonal cycles of energy and moisture exchange between the surface and the atmosphere. Large-scale atmospheric motions are influenced by surface energy exchanges.

Students will gain the conceptual framework necessary to understand and quantify surface-atmosphere interactions. The course will also explore the various ways that anthropogenic activities influence these interactions (especially at local to regional scales).

The lectures will provide the theoretical background for the class. The homework assignments will give students the opportunity to apply these principles. The research project will provide the students with an opportunity to explore in greater depth a topic that is of interest to them.

Learning Objectives:
As a result of taking this course you should know certain things (knowledge objectives) and be able to do certain things (skill objectives).

Knowledge objectives (Things you should know by the end of the course):

- Describe the processes that are responsible for energy, moisture and momentum exchange between the surface and the atmosphere [Goal A: 1c, 1d]
- Describe the spatial and temporal variations in each component of the surface energy and moisture budgets [Goal A: 1a, 3a], and the physical processes that are responsible for these patterns [Goal A: 3d]
- Describe how each component of the surface energy and moisture budget are measured and modeled and the biases (errors) in each of the measuring and modeling techniques [Goal A: 2a, 2c]
- Evaluate how human activities influence moisture and energy fluxes in the boundary layer at local, regional and global scales [Goal A: 1e]
- Evaluate how human activities are influenced by moisture and energy fluxes in the boundary layer at local, regional and global scales [Goal A: 1e]
- Critically evaluate and identify sources of uncertainty measurements and models of surface energy and water exchanges [Goal B: 3b]

Skill objectives (Things you should be able to do by the end of the course):

- Calculate and interpret a surface energy budget [Goal B: 3h]
- Calculate and interpret a surface water budget [Goal B: 3h]
- Quantify the influence of atmospheric stability on energy, moisture and momentum fluxes [Goal B: 3f]
- Use Python to visualize data using maps and graphs [Goal B: 3a]
- Generate graphs and maps for your research paper and oral presentation [Goal C: 1g]
- Write a scientific report that answers a research question based on an analysis of data. This paper will conform to the standard for publication in a peer-reviewed journal [Goal C: 1i]
- Deliver a clear and concise oral presentation on the research that you completed during the semester [Goal C: 1d]

Grading:
Your grade will be calculated as follows:

Exercises	35%
Mid-term exam	20%
Research project	20%
Oral presentation	5%
Final exam	20%

Exercises (35% each)
The exercises will require you to apply what you learn in this class. There will be 10 exercises assigned during the semester. The exercises will be assigned one week before they are due. These are individual assignments and each student must submit their own work. However, you may discuss the questions and work collaboratively. **There are no makeup assignments and late submissions are not accepted.**

Exams (20% each)
The two exams will be based on the material covered in the lectures, readings, and exercises. The final exam will be cumulative. They will involve short answer, application and problem solving (based on the exercises), and paragraph/essay questions.

- **Midterm Exam** (Thursday, March 9)
- **Final exam** (Monday, May 1, 10:00-11:45 am)

*Barring extraordinary circumstances, there will be no make-up exams. Written documentation will be required and verified before a make-up exam will be considered. Students must contact the instructor **prior** to any exam to be considered for a make-up exam.*

Research Project (20%)
The research project will provide you with an opportunity to do an in-depth analysis of meteorological data using Python on a topic related to boundary layer climates that is of interest to you. This project will be an opportunity to utilize the Python skills that you have developed over the semester. You will write a project report that summarizes the research question, data and methods, Python code, and results of your analysis. The project report is due on Monday, April 25 (worth 20% of your final grade).

You are welcome to select any topic that relates to boundary layer climates. I have listed examples of a number of topics that would be appropriate:

- How does land use/land cover influence the surface energy budget? You can focus on characterizing the energy budget for a specific location or comparing multiple locations.
- How strong is the urban heat island in [city of your choice]? How does the strength of the urban heat island vary over time and space?
- What factors affect the air quality in [city of your choice]?
- How does atmospheric stability influence dispersion and transport of air pollution?
- How does urbanization influence precipitation patterns?
- How is tornadic frequency (or intensity or width) influenced by land surface characteristics (surface roughness, elevation, slope, etc.)?
- How do droughts influence the surface energy budget?
- What is the impact of the land surface on hurricanes (i.e., brown ocean)? Compare and quantify these impacts for one or more hurricanes.

Oral Presentation (5%)
Each student will record a 5-minute video that summarizes the results of your research project. The presentation should include a description of your research question, datasets and methods, results and conclusions. You will upload your presentation to Carmen on Friday, April 29 (worth 5% of your final grade). I will distribute a grading rubric and discuss the requirements of the presentation in class.

The grading scale is:

A	= 93 to 100%
A-	= 90 to 92%
B+	= 87 to 89%
B	= 83 to 86%
B-	= 80 to 82%

C+ = 77 to 79%
C = 73 to 76%
C- = 70 to 72%
D+ = 67 to 69%
D = 63 to 66%
D- = 60 to 62%
E = <59%

Expectations of students

- Attend all classes, be on time, and actively participate in the class.
- You will be responsible for understanding all the material covered in lecture and that is part of the assignments.
- Complete all assignments.
- Read assigned material. Wider reading is encouraged.
- Submit assignments on time. **No late assignments will be accepted.**
- Some material that will be presented in class is not in the textbook, so make arrangements to get notes if you are absent.

Class Policies

No private conversations or other distracting behavior will be tolerated.
All cellphones must be silent during class. Please refrain from email/texting during class.

Statement on Academic Misconduct

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct at http://studentlife.osu.edu/csc/.

Disability Services

The University strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability (including mental health, chronic or temporary medical conditions), please let me know immediately so that we can privately discuss options. You are also welcome to register with Student Life Disability Services to establish reasonable accommodations. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion.

SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Tentative Class Schedule

The following course schedule is a guide and it may change as the class evolves. ***The exam dates are fixed****.*

Date	**Lecture**
Jan. 10	Syllabus and Introduction to boundary layer climates **(recorded lecture provided on Carmen)**
Jan. 12	Introduction to Python and Jupyter Notebook Exercise #1: Introduction
Jan. 17	Importance of the atmospheric boundary layer; Radiation (pp. 4-17)
Jan. 19	Python: Syntax, Data Types and Mathematical Operators Exercise #2: Radiation
Jan. 24	Surface Radiation Balance (pp. 8-27)
Jan. 26	Python: Numpy arrays and calculations Exercise #3: Surface radiation budget
Jan. 31	Surface Radiation Balance (pp. 8-27)
Feb. 2	Python: Plotting and visualization with Matplotlib Exercise #4: Solar geometry
Feb. 7	Surface Energy Budget (pp. 33-76)
Feb. 9	Python: Flow control: interactive, conditional statements Exercise #5: Sensible heat
Feb. 14	Vertical Wind Profile (pp. 37-42; 54-59)
Feb. 16	Python: Mapping Exercise #6: Ground heat
Feb. 21	Ground Heat (pp. 42-48)
Feb. 23	Python: Input/output
Feb. 28	Evaporation & Latent Heat (pp. 63-71)
Mar. 2	Python: MetPy Exercise #7: Vertical wind profile
Mar. 7	Exam review
Mar. 9	**Midterm Exam**
Spring break (March 13 to 17)	
Mar. 21	Midterm Results & Research Projects
Mar. 23	Latent heat (part 1) Exercise #8: Research project outline
Mar. 28	Latent heat (part 2)
Mar. 30	Urban boundary layer Exercise #9: Surface energy budget
Apr. 4	Boundary layer of hurricanes
Apr. 6	Python: Project support (in-class assistance) #1: Data and methods
Apr. 11	Air pollution & dispersion
Apr. 13	Python: Project support (in-class assistance) #2: Analysis
Apr. 18	Land surface-atmosphere interactions (e.g., vegetation, soil moisture)
Apr. 20	Python: Project support (in-class assistance) #3: Visualization of results
May 1	**Final Exam (10:00 am to 11:45 am)**