**Instructor**: Dien Wu (dien.wu@colostate.edu); Office: ATS West 230
**Class time**: 9-9:50 am, Tuesday & Thursday, 212B ACRC
**Learning Objectives**:

- Students will learn about the mass/tracer, energy/heat, and momentum exchanges between the land surface and the atmosphere (esp. within the boundary layer) → a holistic viewpoint toward complex land-atmosphere processes and interactions in past and future climate
- Students will get exposed to legacy and advanced observations (esp. satellites) and modeling tools → What are they? When/how to use them for varied research goals?

**Instructional Styles**: 100 mins per week per topic:

- 10 mins of mini discussions on recent events
- ~70 mins of introduction of basic concepts
- ~20 mins research-related discussion on papers, existing modeling and observational tools, and coding projects.

**Assessments**: Mini presentations and three research projects

| | OBJECTIVE | WHAT IS IT ABOUT? | HOW TO ASSESS? |
|---|---|---|---|
| Mini presentations (15%)<br><br>**Real-world events**<br>Sept-dec 2025 | Apply theoretical concepts to real-world phenomena | For the first 15 minutes of each class, each will lead a discussion of one event that is relevant to this course. (Dien will lead the first few ones) | Briefly introduce the news/event via 1-2 slides, identify underlying land-atmos processes, and consider quantitative estimates or qualitative implications. |
| Project 1 (25%)<br>**In situ observations**<br>Sept 2025 | Describe how C/water/energy fluxes are measured and processed | Tour an eddy-covariance site (and potentially a SIF site) - location US-GLEE (need a headcount!) | Post-process and analyze the data and write a short report on what you discovered with the data. |
| Project 2 (30%)<br><br>**Land surface modeling**<br>Oct 2025 | Assess the impact of key processes in a modeling framework | Run a simplified land surface model, generate model outputs, and modify the model by adding an additional module or process. | Write a report summarizing your model modifications and impacts on model outputs. Explain what make sense or what not against your hypothesis. (e.g., add an aerosol layer with specific type/loading and explain its impact on model results) |
| Project 3 (30%)<br><br>**Remote sensing applications**<br>Nov 2025 | Describe how land surface and atmospheric composition satellite retrieval works, its | Choose a question related to this class and your research, determine one or two remote sensing data products, and defend your choice | Download the data, perform data analysis, and write a report on how the remote sensing data help inform the applied question with some |

| | | |
|---|---|---|
| advantages and limitations toward studying applied problems | based on retrieval basis, limitation, and benefits. | preliminary results (e.g., trend in VI over specific regions) |

**Textbooks**:

- Stull, R. B. (2012). An introduction to boundary layer meteorology (Vol. 13). Springer Science & Business Media. Pdf available from https://link.springer.com/book/10.1007/978-94-009-3027-8.

- Bonan, G. (2015). Ecological climatology: concepts and applications, https://doi.org/10.1017/CBO9781107339200.

**Week 1: Introduction**

- (what) topics would be covered?
- (why) these topics/modules are important?
- (how) they are internally linked (e.g., via climate forcing) and linked to classes you've taken before?

**Weeks 2 - 4: Atmospheric (BL) characteristics and processes (~Sept)**

- Boundary layer structure and properties
- Advection, waves, and turbulence
- Vertical profiles and global distribution of tracers
- Momentum, energy/heat, water, tracer (carbon, nitrogen) budgets
- Eddy covariance field trip to Wyoming GLEE site (**Project 1 ~late Sept 2025**)
- Observations (tracers, isotope)
- Flux estimates from atmospheric perspectives
    - Flux gradient and flux variance approaches
    - Inverse modeling (briefly)

**Weeks 5-9: Land surface characteristics and processes (~Oct/Nov)**

Natural ecosystem vs. managed landscape

- Soil
    - vertical profile, hydraulics/moisture, texture, porosity
    - C/N-related processes (decomposition, respiration)
    - novel observations and in-class soil experiments

- Canopy
    - Energy and radiation transfer
    - plant physiology (stomatal, leaf-level)
    - photosynthesis & transpiration
    - seasonal phenology

    - environmental drivers (VPD, soil moisture) and external forcing
    - vegetation dynamics
- Agriculture:
    - irrigation, fertilization, and tillage
    - crop yield and water use efficiency
    - succession, and age sequences
- Remote sensing observation
    - legacy remote sensing (e.g., NDVI, EVI, LST)
    - advanced remote sensing (e.g., SIF, LIDAR, VOD, soil moisture, canopy structure)
- Modeling (simple land surface modeling, **Project 2, ~Oct 2025**)

**Weeks 10-14: Application of land-atmosphere Interaction (~Nov/Dec)**

Interactions under climate variability and human forcing

- Vegetation impact
    - □ energy/momentum/trace gas fluxes/cloud/aerosol
    - □ direct/diffuse energy/cloud cover, precipitation/irrigation
    - Soil moisture – precipitation feedback
    - Carbon-water coupling
- Anthropogenic impact
    - combustion
    - land use land change (deforestation and reforestation)
- Carbon-climate and chem-climate feedback
    - Impact from climate extremes: Drought, heat waves, floods, etc.
    - Impact from climate mitigation/adaptation: emission reduction, fire suppression, prescribed fires, nature-based solutions
- Remote sensing application (**Project 3, ~Nov 2025**)