# ERTH 2800: Our Evolving Atmosphere

**Syllabus information may be subject to change. Significant changes will be communicated to the class.**

## Course and Instructor Information

**Course Title:** ERTH 2800: Our Evolving Atmosphere

**Class / Discussion Format:**

**Instructor:**

**Email:**

**Office Hours:**

## Required Course Materials

- **Textbook:** Meteorology Today 12th ed. by Ahrens & Henson (hardcopy or online)
- Spreadsheet software (Excel, Google Sheets, etc)

## Course Philosophy and Description

**Course Description:** Understanding weather and climate are critical for society. Our comprehension of weather enables us to prepare for extreme events such as hurricanes, floods, and heatwaves. Furthermore, energy production, transportation, and infrastructure depend on weather forecasts to operate efficiently and safely. By studying climate, we can identify trends, assess the impact of human activities, and develop strategies to mitigate and adapt to climate change. Additionally, agriculture relies on both weather and climate information for crop planning and management. Weather and climate also inform public health initiatives, helping to manage illnesses, air quality, and disease vectors.

Despite the importance of weather and climate in our lives, most people have a limited understanding of how the atmosphere works. This course introduces key concepts in atmospheric sciences and how they relate to our lives. Topics cover a wide range of temporal and spatial scales, providing an understanding of everything from local CT meteorology to global climate evolution and how human activities influence weather and climate. Lectures will cover:

- Composition and structure of the atmosphere
    - Evolution through time
    - Importance of an atmosphere for life on Earth
    - Role of greenhouse gases
- Earth's energy budget
    - Why we have weather
    - Temperature distribution in space and time
    - Current global energy imbalance
- Causes of clouds, precipitation, and evaporation
    - Reasons for floods and droughts
    - Conditions for severe storms
    - Role of air pollution
- Global and local atmospheric circulation
    - Role in daily weather
    - Role in distribution of climate and people

  - Interactions with ocean
- Weather systems and variability
  - Normal range of variability
  - Extreme events and how they are changing
  - Weather forecasting
- Global climate change
  - Past and current causes
  - Future consequences
  - Potential solutions

## Course Learning Objectives

At the completion of the course, students will be able to:

- Course LO-1. Describe the mechanisms that drive weather and climate and how they affect humans and society.
- Course LO-2. Know how to interpret a weather map and produce a forecast.
- Course LO-3. Explain the causes and consequences of anthropogenic climate change and how humans impact Earth's atmosphere and climate.
- Course LO-4. Know how to apply the fundamentals of atmospheric sciences to unique environments.

## Course Requirements and Grading

**Due Dates and Late Policy:** All course due dates will be provided well in advance through lecture, email, and on HuskyCT. Assignments should be submitted through HuskyCT by 11:59 pm on the due date. Late assignments will not be accepted without a valid excuse provided before the assignment deadline. Before you upload an assignment, make sure that it is the correct file. I grade what is submitted and will not follow up if the file is incorrect, incomplete, or corrupt.

*The instructor reserves the right to change dates accordingly as the semester progresses. All changes will be communicated in an appropriate manner.*

**Textbook and Readings**: Meteorology Today 12th ed. by Ahrens & Henson. Readings are noted on the course schedule and HuskyCT. Other readings and materials will be posted to HuskyCT. For exams, study the lectures and and assignments.

**Feedback and Grades:** I will make every effort to provide feedback and post assignment grades within two weeks of the due date. To track your performance in the course, refer to My Grades in HuskyCT. To be eligible for rounding of your final grade, you must be within 0.5% of the higher grade.

**Course Schedule and Grading**

**GRADING BREAKDOWN**

| **Participation: 15%** | | |
|---|---|---|
| | **Assignment Description** | **Due every class** |
| Daily | **Participation:** Participation includes attending class, engaging in class discussions, and completing assignments. | Points will be awarded for participation during each class. |

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| Homework: 30% | | |
|---|---|---|
| **Week** | **Assignment Description** | **Due** |
| 3, 9, 12 | **Homework:** There will be three homework assignments throughout the semester based on topics covered in lecture. They will require use of spreadsheet software. | 11:59 pm ET on<br>Feb 16<br>Mar 26<br>Apr 16 |
| **Project: 15%** | | |
| **Week** | **Assignment Description** | **Due** |
| Final | **Project:** The goal of this project is to apply the concepts you learned about in the course to predict past and future climate change in a region of interest. The 1-page report should include two main sections: 1) a description and explanation of the present-day climate in the region and 2) the expected climate change in the region at 2100, the reasons for the difference in climate relative to present-day, and the potential impacts of this climate change. | 11:59 pm ET on Apr 30 |
| **Exam 1: 20% / Exam 2: 20%** | | |
| **Week** | **Assignment Description** | **Date** |
| 8 | Exam 1 | Feb 29 |
| 15 | Exam 2 | Apr 25 |
| **Extra Credit: up to 2% added to final grade** | | |
| **Week** | **Assignment Description** | **Due** |
| Final | **Extra Credit:** Read the Technical Summary of the IPCC report. Then, write a 1-page summary about a topic discussed in the Technical Summary that was not discussed in class. | 11:59 pm ET on Apr 30 |

**Description of Assignment Types:**

**Homework:** There will be three homework assignments throughout the semester based on topics covered in lecture. They will require use of spreadsheet software. Each homework will be assigned two weeks before the due date. You may discuss homework assignments with each other but make sure that your final answers are in your own words.

- Homework 1 uses real radiosonde data to explore how weather conditions vary with increasing elevation and what that means for living in mountainous climates. In homework 1, you will also calculate Earth's energy balance and determining the role of greenhouse gases in moderating climate.
- Homework 2 uses real weather station and balloon data to explore how vertical profiles of temperature and humidity estimate atmospheric stability, precipitation type, and the likelihood of severe weather. You will also determine wind direction and speed using the balance of forces.
- Homework 3 uses weather station data to understand the relationship between specific humidity, relative humidity, and human comfort. The assignment also involves identifying the air masses, fronts, and circulation patterns that impact Connecticut.

**Project:** The goal of this project is to apply the concepts you learned about in the course to discuss present and future climate change in a region of interest. The 1-page report should include two main sections: 1) a description and explanation of the present-day climate in the region and 2) the expected

climate change in the region at 2100, the reasons for the difference in climate relative to present-day, and the potential impacts (temperature, precipitation, extreme events, impacts on humans) of this climate change.

**Exams**: There are two in-person exams in the course. Exam 1 covers about the first half of course material. Exam 2 covers all course material.

- *Make-up policy for exams:* Makeup exams will be allowed in cases with instructor's approval or prior arrangement. Check your schedule and note the exam dates. If you are unable to attend class during the scheduled exam date, a new date will be arranged with an alternate exam, such as an oral exam.

You should not collaborate on the exams or the project. They are meant to reflect your knowledge. Furthermore, the use of artificial intelligence programs is considered cheating. Evidence of cheating or plagiarism will result in a zero on the assignment. Please review the library's Plagiarism Resources.

**Grading Scale:**

| Grade | Letter Grade | GPA |
|---|---|---|
| 93-100 | A | 4.0 |
| 90-92 | A- | 3.7 |
| 87-89 | B+ | 3.3 |
| 83-86 | B | 3.0 |
| 80-82 | B- | 2.7 |
| 77-79 | C+ | 2.3 |
| 73-76 | C | 2.0 |
| 70-72 | C- | 1.7 |
| 67-69 | D+ | 1.3 |
| 63-66 | D | 1.0 |
| 60-62 | D- | 0.7 |
| <60 | F | 0.0 |

## Course Topics (Each topic represents key theme for the week)

- **Every lecture begins with a current weather report and forecast for CT.**

- Introduction
  - Syllabus
  - Target audience
  - Course expectations
  - Value of atmospheric sciences to humanity
- Composition and Structure (Chapter 1 of Ahrens and Henson)
  - History of meteorology and its role in society
  - Earth history and long-term impact of homo sapiens on climate
  - Atmospheric composition and the importance of greenhouse gases
  - Atmospheric layers – where does 'weather' occur?
- Energy Balance (Chapter 2 of Ahrens and Henson)
  - Energy in your daily life
  - Heat capacity and local cycles
  - Latent heat – from your sweat to the pineapple express
  - Conduction and why your puffy jacket keeps you warm

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    - Convection – from lava lamp to hurricanes
    - Electromagnetic radiation – energy is everywhere!
    - Energy balance and the effects of anthropogenic greenhouse gas increase
    - Space weather and the benefits of an upper atmosphere
- Seasons and days (Chapter 3 of Ahrens and Henson)
    - Distribution of radiation – why it gets colder as you head towards the poles
    - Earth's rotation on axis and why we have seasons in CT
    - Earth's rotation around the sun – we are not the center of the universe!
    - Seasonality and the consequences of location
    - Diurnal cycle and its impact on your day to day
    - Inversions and air pollution from the valley floor to the mountain top
    - Temperature measurement and the importance of standardization for communication
- Humidity (Chapter 4 of Ahrens and Henson)
    - Hydrologic cycle and its effect on regional water resources
    - Evaporation and the role of warming on drought
    - Saturation - what happens when your sweat no longer evaporates?
    - Types of humidity – relative humidity might not mean what you think!
- Condensation (Chapter 5 of Ahrens and Henson)
    - Cloud condensation nuclei and the role of anthropogenic aerosols
    - Cloud formation from cirrus to towering cumulus
    - Fog, visibility, and travel
    - Types of clouds and their effects on radiative balance
    - Satellites and the importance of global observations on weather forecasting
- Stability (Chapter 6 of Ahrens and Henson)
    - Adiabatic process – simplifying reality to improve understanding
    - Environmental lapse rates – when is the system unstable?
    - Types of stability and what it means for the day's weather
    - Convective clouds – what determines their height?
    - Types of lift – what triggers storms in CT?
- Precipitation (Chapter 7 of Ahrens and Henson)
    - Rain droplets in cartoons versus reality
    - Collision-Coalescence process and how long you have before it rains
    - Bergeron process and how long you have before it rains
    - Rain from the clouds to your head
    - Snow and why it is so hard to forecast
    - Hail – what leads to this form of severe weather?
    - Precipitation measurements and how to define drought
- Wind – Forces (Chapter 8 of Ahrens and Henson)
    - Pressure gradient force – why the wind blows
    - Thermal circulation – from Hadley cells to monsoons to sea breezes
    - Weather maps – what the maps on TV are actually showing
    - Coriolis force – how fast are we spinning right now?
    - Frictional force and how roughness produces lift
    - Centrifugal force from winds to your weight at the equator
    - Geostrophic, gradient, and surface winds – a wind for every occasion
- Wind – Small scale (Chapter 9 of Ahrens and Henson)
    - Scales of motion from the wind between buildings to global deserts
    - Viscosity – honey > water > wind
    - Turbulence – how do you know when to buckle your seatbelt?
    - Wind-surface interactions from forests to oceans to ice sheets

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  - Sea and mountain breezes – diurnal shifts in the local winds
  - Wind measurements – your personal experience may vary
- Wind – Large scale (Chapter 10 of Ahrens and Henson)
  - Aqua planet – sometimes the world is too complex
  - Intertropical convergence zone – the belt of storms depended upon by millions
  - Hadley, Ferrel, and Polar cells – your cell determines your climate
  - Jet streams – upper air winds that move storms and airplanes
  - Short waves, long waves, and the movement of weather systems
  - Upper ocean circulation – why are some locations productivity hotspots?
  - El Nino Southern Oscillation and seasonal forecasting for CT
- Air Masses (Chapter 11 of Ahrens and Henson)
  - Air mass types – CT sees them all!
  - Air mass sources and why we occasionally experience a polar vortex
  - Air-surface exchange – nothing acts in isolation
  - Surface fronts – types and how to identify their passage
  - Upper air fronts and their effects on the surface
- Mid-latitude Cyclones (Chapter 12 of Ahrens and Henson)
  - Cyclogenesis – converting potential to kinetic
  - Intensification from ripple to nor'easter
  - Dissipation – an internal shutoff
  - Formation regions – where do storms come from?
  - Jet stream interaction and the importance of tilt
  - Vorticity advection – exporting spin
- Severe Weather (Chapter 14, 15, and 16 of Ahrens and Henson)
  - Thunderstorm types and formation from tropics to Great Plains to New England
  - Lightning – it can strike the same place twice
  - Tornadoes – what makes the Great Plains so vulnerable?
  - Cyclostrophic wind – the importance of spin
  - Tropical cyclones and their impacts now and in the future
- Weather Forecasting (Chapter 13 of Ahrens and Henson)
  - Weather models – no model is perfect, but some are useful!
  - Input data from your backyard to satellites
  - Forecast types – you make a forecast every time you look outside
  - Forecast skill, not perfect but still better than other predictions of the future
- Climate Change (Chapter 17 and 18 of Ahrens and Henson)
  - Past climate proxies – how we know current climate change is anomalous
  - $CO_2$-temperature relationship and what it means for our future
  - Natural versus unnatural variability – changing extremes
  - Greenhouse gases – sources, sinks, and climate consequences
  - Aerosols – known for air quality but also important for climate
  - Polar amplification – why the poles will warm the most
  - Sea level change – potential impacts to CT and beyond
  - Future paths and what we can do to limit climate change