

Weather and Climate for Educators

Location and Times

July 14-18, 2008

8:00-12:00, 1:00-4:30 daily

Atmospheric Science 100

Course Objective

The advent of standardized testing in science fields has pushed many teachers into teaching topics for which they lack adequate content knowledge, particularly in the science of the earth system. In addition, the current interest in climate and climate change means that many schools are trying to add climate content to their science courses; again, teachers may well lack content knowledge to do an effective job with this new material.

In this course we will help K-12 teachers acquire a working knowledge of the science of the atmosphere. Each topic will involve hands-on lessons that can easily be adapted to the K-12 classroom, making this course especially appropriate for teachers who need or want to more effectively teach these topics.

Course Instructors

The instructor of record will be Brian Jones, Instructor, Physics Department, assisted by Scott Denning, Associate Professor, Department of Atmospheric Science. Additional instruction will be provided by the Education Director of CMMAP, the Teacher in Residence with the Little Shop of Physics, and graduate students in the Department of Atmospheric Science.

Course Overview

This course is, really, a basic science course. Teachers will learn or refresh their knowledge of many basic science concepts that they will subsequently apply as they learn to understand atmospheric processes. For instance, a discussion of pressure and temperature in gases will nicely lead into a discussion of the variation of temperature and pressure with height.

The course will cover the following topics:

Basic physical concepts necessary to understand the science of the atmosphere, including:

- Energy and conservation of energy
- The electromagnetic spectrum
- Heat transfer
- Phase transitions
- Force and motion
- Pressure and temperature in gases

The science of the atmosphere, including:

- The motion of energy through the atmosphere
- The vertical motion of air in the atmosphere
- The importance of water in the atmosphere
- The horizontal motion of air in the atmosphere
- Patterns of global circulation in the atmosphere

Course Structure

The course will consist of 35 hours of classroom instruction, after which teachers will complete an assignment. Classes will meet daily from July 14 – July 18, with 7 hours of instruction each day, as noted in the following schedule.

Classroom instruction will be a mix of lecture and laboratory time. During the lab time, teachers will perform activities that can easily be adapted to their own classes. All lab activities will be done using commonly available items and can be adapted to any level K-12.

After the classroom piece is finished, teachers will prepare a lesson for their own classes that adapts and builds on the concepts presented in the formal part of the course. The focus will be on content; teachers will be expected to give a complete theoretical background to the topic they have chosen to teach, along with an analysis of how this topic connects to state science standards. Lessons will be evaluated for a final grade in the course; the main item to be assessed will be accuracy of the science content.

The formal classroom instruction will take place in summer 2008; the follow-up exercise that teachers will do with their classes will be done by the end of the fall term 2008.

Course Schedule

The schedule for the days of classroom instruction is outlined on the following pages.

Monday Morning

Course Overview and Pre-Test

What is Energy? Conservation of Energy, Weather vs. Climate

Engage and Explore

- Forms of energy
- Energy transfers
- Conservation of energy - (Emphasize follow the energy - What form does it start in? What form/s does it change into?)
- The difference between weather and climate, Parts 1 and 2

Explain

- Follow the Energy
- Weather vs. Climate (Hats)

Extend

- Difference between weather and climate: Extend Exercise led by Rachel using regional climatic and weather data

Monday Afternoon

Radiation and Seasons

Engage & Explore

- A romp through the electromagnetic spectrum:
- Rainbow glasses
- Near IR goggles
- Infrared Insects
- Far IR (Thermal Cam)
- Feel the Heat
- Radiation cooling

Explain

- Radiation, short wave and long wave, sunshine, infrared, solar radiation, differences in seasons and poles, outgoing trapped by greenhouse, interactions with clouds

Extend

- Angle of Incidence

Tuesday Morning

Pressure, Density, Temperature, Buoyancy

Engage & Explore

- Ideal gas laws (Molecules in a box)
- Weighing air
- If hot air rises—why is it cold in the mountains?
- Hot air balloon
- Tipping point

Explain

- Air, measures of energy, pressure, energy, temperature, buoyancy, ideal gas law, hot air rises, dry vertical motion

Extend

- Buoyancy rates Helium and liquid nitrogen activity

Tuesday Afternoon

Phases of Water, Latent Heat, and Clouds

Engage & Explore

- Double boiler melting chocolate
- Blowing on hands
- Super-cooled beverages Heat Packs
- IR thermometers (clear sky & cloudy)
- Water droplets and IR (IR thermometer and the fish tank)

Explain

- Water, what is a cloud, latent heat, vertical motion

Extend

- Cloud in a bottle, perhaps using instrumentation from Dave

Wednesday Morning

Convection and Precipitation

Engage & Explore

- Terminal velocity & water drop size (spray bottle, Misty Mate, humidifier droplets)
- Rain drops (Drag forces)
- Convection (fog in the fish tank)
- Convection Cells in pans

Engage

- Launch Weather Balloon

Explain

- Precipitation, rain, hail

Extend

- Skew T/weather balloon evaluation

Wednesday Afternoon

Forces and Winds

Explore

- Newton's laws
- Water waiter challenge (Vector nature of forces, acceleration)
- Centripetal Coaster
- Coriolis Chair
- Coriolis Came with extension: Making a hurricane
- Hoberman Sphere
- 3D Tug of War (Vector nature of forces)

Explain

- Pressure gradient forces, gravity, friction, apparent forces, horizontal forces, temperature and pressure gradient, Coriolis, $f=ma$, sea breezes and monsoons

Extend

- POGIL on weather maps

Thursday Morning

Rotation and Global Circulation

Engage & Explore

- Spin tank (LSOP will set up)

Explain

- Rotation, Hadley cell, waves in the jet, Coriolis, trade winds, westerlies, problems of north south heat transport, why jet stream, boundary cold air, warm air

Extend

- Thermal wind balance exercise and southern hemisphere weather maps

Thursday Afternoon

Fronts and Storms

Engage & Explore

- (shortened to 15 minutes) Fronts in the fish tank (ice cube warm water activity)

Explain

- (lengthened 1 hour 15 minutes) fronts, storms, solution to problem, basic weather features, north south temperature gradient

Extend

- weather map analysis, station plots, forecast models and forecast activity

Friday Morning

Climate Change & Global Warming, Impacts

Engage & Explore

- Radiative transfer and layers of the atmosphere (Glass plates)
- Making a model
- Feedback demo (Making a light bulb with wire, carbon)
- Feedback checkers
- Adding feedback to a model (Albedo)
- Chaos boards

Explain

- increasing CO₂, 4 watts per square meter, positive and negative feedbacks, climate models, predictions, “red herring”, impacts

Extend

- NOAA climate factors in Colorado, discuss trends and limitations, model data and future climate, Paleo data (tree ring data web site)

Friday Afternoon

Mitigating and Adapting to Climate Change

Engage & Explore

- Post-test
- How much energy things use
- Energy and environment activities (Different light bulbs, vehicles, heating)

Explain

- Alternative energy, economics of greenhouse forcing, IPCC, role of scientist as advocate, dollars per watt, carbon per watt

Extend

- Wedges: Carbon mitigation initiative game