Global Weather and Climate: Detailed Outline

Day 1, AM: Energy, radiation & the greenhouse effect

Key Points

Radiation is an important means of energy transfer. Understanding radiation means understanding some properties of electromagnetic waves and how they interact with matter.

Molecules in the atmosphere absorb and re-radiate thermal radiation. The radiation is absorbed and reemitted at every level. What we feel at the surface is a weighted average of the "stack." *The greenhouse effect is about the vertical redistribution of heat in the atmosphere*.

Outline of the Session

8:30 Introductions and Overview

- Introductions / Teachers / Course presenters
- Overview of content and pedagogy
- Overview of course structure / assignment / credit / instructional approach / mixing / practical details

9:00 Engage: What do the infrared thermometers measure?

- "Leslie cube": Measure temperature of warm pop cans at different spots. Explain the difference in temperature measurements.

9:15 Explore: A series of exercises on energy & radiation

- Rainbow glasses & the electromagnetic spectrum
- Quick calculation: Peak wavelength of incandescent bulb?
- Thermal radiation: Discussion and demonstration: What do the thermometers measure, and how?
- Thermal cameras: What do these tell us about the world? What surprises do we find by using them?
- Thermal radiation and the body: A quick calculation.
- Why does it get colder on clear nights than cloudy nights? Measurement of sky temperatures, discussion

10:15 Break

10:30 Explain: Thermal radiation and the atmosphere

11:30 Extend: How does the atmosphere keep the earth warm?

- **Question:** Will adding plates affect the temperature of the lower plate? Why?
- Question: How will the temperatures vary if you turn the stack upside down?

11:50 Evaluate

- **Question:** Which has a higher *average* temperature at the equator, the earth or the moon? What factors are important to consider?

12:00 Lunch & Informal Discussion

Day 1, PM: Forcing, response, sensitivity and feedback

Key Points

A central theme that will recur throughout the course is the idea of "stocks and flows". For instance, a difference in thermal radiation in and out will result in a rate of change of temperature. After some time, a new equilibrium state will be reached.

In such a process, how large is the rate of change? That's sensitivity. As the temperature changes, so does the difference in radiation that drives the change. This is a feedback.

Outline of the Session

12:45 Science in Context: Different Visions

1:00 Question Time: Get to know the presenters, participant questions.

1:15 Engage: Color and cooling: A thermal radiation puzzle.

1:30 Explore: A series of exercises on radiation and temperature and climate

- What is a model?
  - Run 1: Normal
  - Run 2: Enhanced emission
- How does the climate change?
- Feedback tracks & feedback poker

2:30 Break

2:45 Explain: Forcing, response, sensitivity & feedback

3:30 Break

3:45 Extend & Evaluate

- Stocks & Flows: Simple model
- Stocks & Flows: More complex model
- **Question**: Why is August hotter than June?

4:15 Feedback for Presenters, Details, Next Steps

4:30 Adjourn

5:30 - 6:30 LSOP

6:30 - ? Lagoon Concert: Mark Sloniker

Day 2, AM: Vertical motion & weather

Key Points

If you look at energy exchange with the sun and with space, the atmosphere is heated from the bottom, but it cools from the top. Over the course of the day, energy must be transported upward, by rising air, by condensing water vapor. This vertical motion of air and water explains the changes we see in the weather over a typical summer day.

8:30 Question Time

8:45 Engage: If hot air rises... When teh air cools in the bottle, explain what you are seeing from two different points of view:

- Energy
- Molecular level

9:00 Explore: A series of exercises on pressure, temperature, phase transitions.

- Molecules in a box: Modeling pressure & temperature
- If hot air rises... One more time.
- **Evaluate:** Explain how the cooling happens in the atmosphere
- Cloud in a bottle (Can Cities Affect the Weather?)
- Cloud in a bottle, with diffraction rings and rainbows
- Heat packs (How Can Freezing Make Something Warmer?)
- Blowing on your hand (How Do Clouds Keep the Air Warmer?)
- **Evaluate:** Explain what you are seeing here.
- Do Plants “Sweat”?
- How Does Humidity Affect Cooling?
- Be the Parcel
- Giant Beach Ball

10:15 Break

10:30 Explain: Vertical Motion & Weather

11:30 Extend & Evaluate: Stability & Temperature Profiles

12:00 Liquid Nitrogen Ice Cream

12:00 Lunch & Informal Discussion

Day 2, PM: Circulation, weather & climate

Key Points

If you look at net inflows and outflows, the earth warms at the equator but cools at the poles. And so energy must be transported—by moving air and by ocean currents—from the equator to the poles. This poleward motion of matter and energy is complicated by a simple fact: The earth rotates. The poleward motion of matter and energy combined with the rotation of the globe leads to broad patterns in the earth's weather—climate zones.

Outline of the Session

12:45 Science in History: Discovery of the Stratosphere (Thomas Birner)

1:00 Question Time: Get to know the presenters, participant questions.

1:15 Engage: Spin Tanks: Set them up, watch them evolve

1:30 Explore: A series of exercises on radiation variation & forces in the atmosphere.

- Why is it Tropical in the Tropics?
- Coriolis Circle
- Coriolis Line Dance
- "Hammer Time"
- Why do Hurricanes Go Counterclockwise?
- Hoberman Spheres

2:15 Explain, Part I: Circulation, weather and climate

3:00 Break

3:15 Explain, Part II: Explain: Circulation, weather and climate

3:45 Extend & Evaluate

- Which Way Does The Wind Blow?

4:15 Clouds in a Glass of Beer

4:30 Adjourn

Evening Thursday Night Live, "Jurassicasters"

Day 3, AM: Models & Climate & Climate Change

Key Points

If scientists can't predict the weather, how can they predict the climate? How can we make projections of what the climate will be two hundred years from now when we can accurately project (and never will be able to) what the weather will be two weeks from now? Answering these questions means understanding the difference between weather and climate and understanding how we can model the earth's climate and how it is changing.

8:30 Question Time

8:45 Engage: Measuring the solar constant in W/m^2.

9:00 Explore: A series of activities on models of climate and climate change.

- Weather vs. Climate, Part I: Candy
- Weather vs. Climate, Part II: Chaos
- Netlogo model
- Simple Climate Model (Randy's)

10:00 Break

10:15 Explain: Carbon Cycle, Models, Climate & Climate Change

11:15 Extend & Evaluate: EarthCarbon App activities

12:00 Lunch & Informal Discussion

Day 3, PM: Mitigation and Adaptation

Key Points

If you are going to talk about climate change, you need to finish with a positive message: What can be done about it? Changing lightbulbs is a good thing, but it's not enough. Understanding the scale of the climate change problem and how we can limit its scope and adapt to its effects requires some details and some numbers. How much carbon are we adding, and how? What changes will occur with different atmospheric levels? And if we make changes, how long will it be before we see effects?

Outline of the Session

12:45 Science in History: Ozone Hole (Thomas Birner)

1:00 Question Time: Get to know the presenters, participant questions.

1:15 Engage: Measuring Energy Use of Appliances (and find CO2 per hour)

1:30 Explore: A series of exercises on energy & carbon dioxide

- What Makes a Greenhouse Gas a Greenhouse Gas?
- Measuring Human Efficiency
- Measuring CO_2 from Cars
- Emission of car exhaust
- Efficiency & generators
- Can Your Carbon Footprint Become a Carbon Toe-Print?

2:30 Explain, Part I: Mitigation and Adaptation

3:00 Break

3:15 Explain, Part II: Mitigation and Adaptation

3:45 Extend & Evaluate

- Wedges "Light Edition"

4:15 Feedback, Next Steps, Closing

4:30 Adjourn