Stormy Weather: Instructor Guide

Title

Stormy Weather

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Discipline

Geography

Target Audience

Introductory, nonmajors

Keywords

Fronts, geography, mid-latitude cyclones, weather

Length of Time/Staging

One two hour lab, 40 minutes of another, 10 minutes of the last.

Abstract

Where will it rain? Where will it clear up? And what will the weather be like where you are? Students will not only answer these questions, but they must explain their answers by applying material they learned in lecture and lab.

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Format of Delivery

1. **Information Prior to Problem:** Physical Geography students have covered the following topics: (1) Geographic Grid, (2) Rotation, (3) Earth-Sun Relationships, (4) Seasons, (5) Energy Balance, (6) Temperature, (7) Pressure, Circulation and Wind, (8) Moisture and Humidity, (9) Air Masses, (10) Lifting and Stability, (11) Condensation, Clouds and Precipitation and, finally, (12) Mid-latitude Cyclones.
2. **Assignments Prior to Problem:** Students had assignments where they explain changes in particular elements such as temperature because of local changes and because of fronts and air mass changes. They have also used station models, meteograms, surface maps, and other weather-related imagery.
3. **Organization:** Students work in groups of four to five. Each group has two computer monitors. Professors can set up a webpage including the necessary weblinks or download maps and meteograms beforehand. The second approach limits access to easy sources of forecast information (e.g. Weather.com). If computers are unavailable, professors can print most materials in advance.
4. **Parts 1 and 2:** Groups receive the first two parts of the problem (usually in a lab setting) and computer access. Students have two hours.
5. **Discussion:** Give each group five minutes to discuss what they would need to answer the questions. Elicit their responses and then move into the explanation.
6. **Explanation:** Because students have used maps and other materials previously, I mainly describe the product I expect. For the first problem, groups give a short explanation. For the second part, they estimate values for each day and explain why they chose those values.
7. **Product:** Each group turns in answers to their questions. I make a copy.
8. **Wrap-up:** Each group takes a short oral quiz before leaving.
9. **Part 3:** I return their original answers. Each group looks at the new data and analyzes their results. They amend their explanations where necessary. Groups then explain their rationale to another group who critiques their work. Groups turn in their original answers along with their second set of answers. I expect this part to take less than 30 minutes. My explanation is minimal.
10. **Discussion:** Once they turn in their modified answers, we spend 10 minutes discussing their answers for the local area. Then the lab begins other activities.
11. **Final Discussion:** Spend five to 10 minutes in the next lab discussing their second set of answers for the local area. Move on to other activities.

Student Learning Objectives

Knowledge-based outcomes:

On completion of this problem, students should be able to demonstrate that they:

1. Are able to recognize and explain the weather changes that occur as fronts pass and new air masses arrive.
2. Are able to predict future weather based on instrument data, weather maps, and their understanding of fronts and mid-latitude cyclones.
3. Are able to evaluate the accuracy of their weather prediction.

Skills-based outcomes:

On completion of this problem, students should be able to demonstrate that they:

1. Are able to work effectively as a group.
2. Are able to use the computer and the internet to find weather data.
3. Are able to read and interpret station models and surface data maps.
4. Are able to read and interpret meteograms.
5. Are able to clearly present results in oral and written form.

Student Resources

Introduction:

Below are a series of links to maps on the Unisys site. Each user must tailor the links for a specific city and a particular date. The links below are included as an example of where to find the information. My examples use the location of West Bend, Wisconsin, and the data of July 7, 2003.

Part 1 - Data Resources:

1. US Surface Data Maps:

Day 2: weather.unisys.com/archive/sfc_map/0307/03070512.gif

Day 1: weather.unisys.com/archive/sfc_map/0307/03070612.gif

Day 0: weather.unisys.com/archive/sfc_map/0307/03070712.gif

Since I cannot revise this particular example daily, the sample Day 0 link connects to the archive for the sample date that I listed above. To acquire the surface map for the current day, use the link below.

Day 0: weather.unisys.com/surface/sfc_map.html

2. US Enhanced Infrared Image:

Last 12 hours: weather.unisys.com/satellite/sat_ir_enh_us_loop-12.html

3. US Meteograms:

Link to map: weather.unisys.com/surface/meteogram/

4. Map Legend:

Link to explanation: weather.unisys.com/surface/details.html#sfc_map

5. Meteogram explanation:

Link to explanation: weather.unisys.com/surface/meteogram/details.html

Instructor Resources

Internet Resources for Maps and Meteograms

Main Sources:

Unisys Weather: weather.unisys.com

Current Surface Map: weather.unisys.com/surface/sfc_map.html

Enhanced Infrared Satellite Image: weather.unisys.com/satellite/sat_ir_enh_us_loop-12.html

Surface Meteograms: weather.unisys.com/surface/meteogram/

University of Wyoming, Department of Atmospheric Science

Weather: weather.uwyo.edu

Surface Observations: http://weather.uwyo.edu/surface/index.html

Alternative Sources:

Interactive Weather Information Network (IWIN): iwin.nws.noaa.gov/iwin/graphicsversion/bigmain.html

Ohio State University Weather Server: twister.sbs.ohio-state.edu

National Weather Service: www.nws.noaa.gov

Weather Matrix Weather Maps: http://www.accuweather.com/en/weather-blogs/weathermatrix

Weather Underground: www.wunderground.com

Internet References for Basic Information

Weather World 2010 project (Department of Atmospheric Sciences (DAS) at the University of Illinois Urbana-Champaign (UIUC))

Print References for Basic Information

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Moran, J.M. and Morgan, M.D. (1997). *Meteorology* (5th ed.). Upper Saddle River: Prentice Hall.

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Strahler and Strahler. (2002). *Physical geography* (2nd ed.). New York: John Wiley and Sons.

Author's Teaching Notes

Introduction:

Few Physical Geography lab manuals have exercises on weather prediction. Instead, they usually stop with weather map interpretation. This is not so much an omission as an acknowledgement that full-blown weather prediction is outside the scope of most introductory physical geography courses. Still, even a simplified version of weather prediction helps students synthesize much of the basic information concerning air masses, fronts, and mid-latitude cyclones and helps them understand mid-latitude climates.

Class Organization:

I teach a five credit Physical Geography where students meet for lab for two hours twice a week. Each lab section has about 25 people. I divide lab sections into five groups of five. Each group works together for two to three weeks (four to six class periods) before they switch to a new and randomly chosen group. By the time students do weather prediction, they have worked in groups for most of the semester and are used to the process.

Pre-Problem Preparation:

Students receive a copy of each assignment a week prior to the class in which it is used. They have read text assignments, listened to lectures and performed two other labs that directly relate to mid-latitude cyclones. Before those labs, they have been through a series of assignments that take them through temperature, pressure, wind, humidity, lifting, and more. They have also used station models, meteograms, weather maps, and other weather image prior to the problem.

Timing:

I do Parts 1 and 2 during one two-hour lab. There is usually time left over. By itself, the second part may take as much as an hour. Students do the last part in the next lab (I arrange the schedule so that the next lab is over three days away). Part 3 takes less than a full lab (though the amount of discussion can vary) so I include other activities on that day.

Alternatively, the problem could be a three-day affair. Though I intend Part 1 as a tune-up for the second problem, it could be part of another lab on another day.

Assessment Strategies

Day 1 Part 1 Worksheet:

1. Each group (or each student, if you prefer) lists on worksheet (1), which they return to you, the cities they selected for each question. For each city, students explain the weather.
2. At this point, you do not grade the sheets. You only collect the sheets and make a photocopy of each.

Day 1 Part 2 Worksheet:

1. Each group (or each student, if you prefer) fills in a table with their predictions for the weather for the next three days at the location they choose.
2. Each group writes an explanation of the predicted weather and attaches the explanation to worksheet (2).
3. Each group turns in both sheets. At this point, you do not grade the sheets. You only collect the sheets and make a photocopy of each.

Day 1 Oral Quizzes:

1. When a group has finished both Parts 1 and 2, it takes an oral quiz.
2. Each group member must answer at least one question.
3. Each group has two chances to answer a question if someone gets it wrong. The next person in line has to answer the missed question.
4. No one in a group leaves until after a quiz.
5. Because they work together, students leave with a better understanding of the material than when everyone worked as individuals.
6. Questions are simple and relate directly to the information needed to complete the problem (*e.g.* Interpret this station model. How does pressure (or some other variable) change when a warm front passes?).

Day 2 Part 1 Worksheet:

1. Return the original worksheets to each group
2. Each group reevaluates their predictions for the last three days.
3. Collect the sheets before the final discussion. Groups should have not had much trouble with the predictions for this part. Mainly check for a good faith effort. In short, their explanation hit the main points. The worksheet is worth only a few points.

Solution Notes

1. Introduction:

This problem is entirely open-ended. No one knows exactly what the weather will be. Given that fact, you do not assess students on how close their prediction is to the actual weather; instead, you assess how well students apply what they learned about the elements of weather. In short, do students understand what air masses are and how they affect the weather? Do students understand how weather changes when fronts pass? And do students understand how a mid-latitude cyclone controls the location of fronts and air masses?

2. *Part 1 - National Weather*

1. Introduction.

Part 1 is a warm-up question for the second part of the problem. In Part 1, students need to predict and explain one-day changes or lack thereof in the weather. Students should examine (1) the location of mid-latitude cyclones and fronts, (2) determine the movement of fronts in the next 24-hours, and (3) understand what conditions will most likely lead to storms.

2. Fronts.

The first two questions ask for changes from stormy to clear or clear to stormy. Estimating the movement of fronts using the surface observations and the enhanced infrared 12 hour loop is the easy way to answer. More specifically, cold and warm fronts have somewhat more predictable velocities than occluded fronts and show well on surface maps. Moreover, cold fronts tend to move faster and have smaller precipitation cross-sections. Most students choose cities that are east of a cold front when they say they the weather will turn stormy or under the influence of a cold front when they say the weather will clear.

3. Lift and Adiabatic Cooling.

Answers should also include something about the mechanism that causes precipitation. Prior to this point, students have learned about lift and adiabatic cooling. Therefore, the groups should include in their explanations how a lack of a lifting mechanism leads to clear skies or that frontal lifting causes precipitation given that other factors are in place.

4. Instability.

Students may not discuss instability unless they choose an area that is will have storms because of convectional lifting in unstable air masses. In addition, in spring, it might be an important component along with frontal or convergent lifting around mid-latitude storms. In fall, it becomes a less important factor. If you teach this course in summer, however, it may become especially significant in areas dominated by mT air masses. In that case, students should also spend some time talking about the characteristics of air masses.

5. High Pressure.

Usually, the safe choice for a city with unchanging conditions is some area dominated by dry, cold, high pressure Canadian air masses. When blocking highs or lows lock weather patterns in place, this is an extremely easy choice. When patterns are shifting, students have to be more careful about watching the movement of fronts.

3. *Part 2 - Local Weather*

1. Introduction.

In this part of the problem, students should take into account (1) the position of mid-latitude cyclones and fronts relative to their location, (2) the movement of the cyclone and fronts, (3) what fronts are approaching, (4) what types of air masses accompany these fronts, and (5) what characteristics those air masses possess.

2. **Mid-latitude Cyclones.**

Given three days of weather maps, students will have to estimate the speed and direction of mid-latitude cyclone that might affect their location. Their estimate of the future location of the low pressure center and the fronts will especially affect their prediction of wind speed, wind direction, and cloud cover.

3. **Air Masses.**

Students should be able to determine which air mass will affect the atmosphere once a front moves through. The students base their determination on what is most likely for the area, the air mass source area, and the characteristics displayed on the surface maps. When they estimate temperature, humidity, and so forth, they will generally be looking at the surface maps and tracking the change in each of these characteristics as the fronts move. But to explain the changes, students must explain how and why the air masses are responsible and how the air masses alter with time as they travel.

4. **Cloud Cover.**

The actual amount of cloud cover is difficult to predict, but students should be able to say something about the change in cloud cover as warm and cold fronts advance and recede. Their answers should show a basic understanding of which types of clouds tend to occur with each front (e.g. the sequence of stratus type clouds generally associated with warm fronts) and how large the area of clouds is that is associated with each front or with the low pressure center.

5. **Precipitation.**

Precipitation is difficult enough for professional forecasters to predict. More than likely, students will miss this portion entirely. Once again, what is most important is that they understand what circumstances are responsible for precipitation and that their predictions and their explanations demonstrate their knowledge of those conditions.

6. **Possible Problems.**

Not all places will experience significant weather changes. It may be best to adjust the duration or the locality to increase the chances of major changes associated with mid-latitude cyclones. Even so, subtle weather changes can still fuel a discussion.

4. *Part 3 - Evaluation*

1. **Introduction.**

In the last section, students evaluate their results. This process takes them back past the original data, it takes them through the new data, and it makes them revise their thinking in light of actual events. Student learning increases, because they are responsible for assessing and amending their own conclusions.

2. **Cyclone and Frontal Location.**

Because geography students do not generally spend much time discussing topics such as upper-level winds, divergence and convergence in the upper atmosphere, and vorticity, they may have some trouble explaining why low pressure centers and fronts moved in unexpected directions. Still, they may be able to pick out the influence of other surface pressure areas on the movement of mid-latitude cyclones. The lack of comprehension in this area can also function as a lead-in to a discussion of upper level tropospheric structures.

3. **Air Mass Characteristics.**

Student answers mainly depend on the location of the front and the type of air mass. Predictions for the first day are usually not far off the mark. With succeeding days, errors increase, especially if multiple systems pass through their location. The most obvious sources of variation—such as having a front come through a day early or late—are easy for students to explain. Other deviations are more challenging and provide more chance for learning. For example, explaining how cloud cover or its lack influenced temperature, explaining how land cover affected temperature and humidity, or how local topography and vegetation may affect wind.

4. **Precipitation.**

Precipitation predictions are most likely to be incorrect. They also offer a lot of interesting discussion points. In some cases, students may be wrong only because the storm distributed precipitation unevenly over space or time. What is more likely is that they will have to broach more complicated explanations having to do with how much moisture was available in the first place or how much lift was available (which ties into temperature, humidity and frontal movement). Students now have to return to the original problem of the storm's direction of movement.