Aviation Weather

teacher guide

Activity I: Satellites, Weather Charts, and a European Journey

lesson overview

Materials: web access and computers for student pairs or individuals OR printouts of web pages (about 9 pages), compasses and graph paper for drawing satellites and planet

Time for set-up: minimal - verify web access

Time for lesson: A: 1 - 1.5 hours, B: 2 - 3 hours (1 hour for student presentations, discussion, and decision-making).

Student Prerequisites: minimal familiarity with maps, newspaper or television weather images, ability to create a 2-D scale model

Icons for recommended subject areas where activities could be used: SS (Geography), PHY (Weather)

Objectives / Link to Standards Matrices:

* Students will understand how satellites obtain weather data
* Students will understand the history of weather satellite use, and graphically represent it
* Students will use satellite-generated images to interpret and forecast weather systems
* Students will understand the limitations to Satellite use.
* Students will understand how charts and symbols convey meaning regarding weather systems
* Students will interpret charts and symbols, to determine current weather conditions and forecast it
* Students will use satellite and chart data to plan a route of flight across Europe.
* Students will learn about typical weather patterns in Europe

Student Assessments: handout, satellite and planet chart, drawings, presentation (oral and graphic), discussion

Introduction

In this section, students learn how weather data is collected, presented in charts, and used to make decisions. **Activity I: Satellites, Weather Charts, and a European Journey**, provides internet resources that students use to understand the basic systems (satellites and charts) used in weather forecasting, and how these forecasts are used. In this section, students will become familiar with how weather is measured and depicted, using satellites, charts, and other images, then will use their knowledge to make decisions on a flight plan over Europe. **Part A - Understanding Satellites** addresses how satellites are used, the kinds of data they present, and the history of satellite use. Students finish this unit by providing a model of the orbits used by satellites and the frequency of satellites using those orbits. In **Part B - Understanding Weather Charts and Maps**, students learn how to use the symbols on weather charts and use this information to make decisions about a present flight across Europe.

Part A - Understanding Satellites

The English Meteorological Office has some wonderful, concise guides to reading maps and charts, and understanding satellites. Find these guides at
http://www.met-office.gov.uk/education/esleaflets/satellites.html
and
http://www.met-office.gov.uk/education/esleaflets/charts.html
and use the enclosed information to answer the following questions.

1. When was the first satellite launched?

   April Fool's Day 1960

2. What advantages do satellites provide meteorologists?

   Meteorologists can now identify systems over oceans, determine the vertical structure and composition of the atmosphere, and watch weather systems move and develop.

3. What are the two types of satellites?
   geostationary = orbits earth at height of 35,780 km and takes 24 hours for one orbit. (it appears to "hang" over same spot all of the time)
   polar orbiting = orbit at height of 879 km and take one hour and 42 minutes for one orbit, pass over earth from pole to pole

Activity I: Satellites, Weather Charts, and a European Journey

4. Why does the polar orbiting satellite see a new piece of the Earth every orbit?

Because the earth is spinning on its axis which is at a slight tilt. The earth turns about 25° with each orbit.

5. Based on the resolution and type of images, what do you think each type of satellite's images would be useful for doing? Write the name of the satellite type next to each idea below.

- Seeing the "big picture" about general cloud cover or clearness over continents and oceans
  Answer: Geostationary
- Evaluating small storms over a single country
  Answer: Polar-Orbiting
- Determining cloud structure
  Answer: Polar-Orbiting
- Determining relative size of the Earth's continents, oceans
  Answer: GeoStationary
- Evaluating the components of the atmosphere
  Answer: GeoStationary and some Polar-Orbiting
- Observing sea ice (icebergs)
  Answer: Polar-Orbiting

6. Explain how radiometers are used and what kind of information they can generate.

Radiometers measure radiation of different wavelengths by using mirrors to scan a region and reflect information back to a satellite.

The radiometer can measure reflected sunlight to produce an image like a white cloud (reflecting much of the light) or a dark ocean (absorbing or refracting much of the light).

Other radiometers use infrared radiation to measure heat of clouds or the Earth. High altitude clouds will appear lighter, while low-altitude clouds will appear darker.

7. Which radiometers can and cannot be used at night, and why?

Infrared radiometers can be used any time, while radiometers that reflect sunlight can only be used in the daytime (sunlight is not available at night!).

8. If both radiometers are used together, then we can better determine the type of weather situations in a region. Describe what the following images indicate. (visible light = vl, infrared radiation = ir)
   - both images show a white cloud
     Answer: thick, high (and thus cold) cloud
   - both images show a gray cloud
     Answer: cloud of moderate thickness, moderate temperature (and height)
   - both images show a dark cloud
     Answer: thin, low (warmer) cloud
   - vl = white cloud, ir = dark cloud
     Answer: thick, low (warmer) cloud; perhaps fog
   - vl = dark cloud, ir = white cloud
     Answer: thin, high (cold) cloud
   - vl = scattered, dark cloud, ir = white marks on Earth
     Answer: patchy (perhaps convective) thin clouds that are low and warm; this may be a fire.

9. What are the two types of clouds? Draw a picture and explain what kinds of weather they are associated with.

   layer clouds = cover large areas (satellite = area of uniform brightness), associated with depressions or weather fronts

   convective clouds = smaller clouds formed by rising warm-air currents in otherwise cool areas, associated with different ground and air temperatures, not necessarily associated with weather.

10. Sketch a picture of the Earth. If the radius of the Earth is 6.38×10^6 m, determine your scale factor and from that, sketch the following altitudes (in meters) as circular orbits around your planet.

- 350,000
- 480,000
- 600,000
- 750,000
- 900,000
- 1,100,000
- 1,400,000
- 35,780,000

Now place circles on your diagram to represent different satellites. Write next to each the year of launch, nationality of the satellite (if known), and the satellite's purpose (if known).

Teacher suggestion: Create one picture by splitting up the class into several groups. Use the answer key to determine how many/which satellites each group will be responsible for.

Altitudes for some satellites do not exactly fit the categories above. These exceptions are written prior to the satellite name, in the nearest altitude category.

Activity I: Satellites, Weather Charts, and a European Journey

The following key does not list the purposes of the satellites, in order to save space. However, students should be impressed to find how many satellies are used for research purposes.

* 350,000
  TRMM (1997)
* 480,000
  GRACE (2001)
* 600,000
  UARS(1991, USA)
  alt. 650-670 OKEAN 01-8(1994, Russia)
  alt. 600-650 RESURS 01-4 (1994, Russia)
  alt. 600-650 RESURS-0(1998, Russia)
  alt. 650 UOSAT-12(1999)
  ICESAT(2001, USA)
* 750,000
  alt. 720 TIROS-1(1960, USA)
  TIROS-6 (1963, USA)
  alt. 770 ESSA-1(1966, USA)
  alt. 820 NOAA-6 (1979, USA)
  alt. 780 ERS-1 (1991, Europe)
  alt. 785 ERS-2 (1995, Europe)
  alt. 797 ADEOS-1 (1996, Japan)
  alt. 705 TERRA (1999, USA)
  alt. 700 ACRIMSAT III (1999, USA)
  alt. 800 QUIKSCAT (1999)
  alt. 705 AQUA/EOS-PM(2000, USA)
  alt. 800 QUIKTOMS (2000, USA)
  alt. 800 ADEOS-2 (2000, Japan)
  alt. 780-820 ENVI-SAT-1 (2001, Europe)
* 900,000
  alt. 850 TIROS-N (1978, USA)
  alt. 960 NIMBUS-7 (1978)
  alt. 879 NOAA-12 (1991, USA)
  alt. 850 DMSP-F11 (1991, USA)
  alt. 850 DMSP-F13 (1993, USA)
  alt. 950 METEOR 2-21 (1993, Russia)
  alt. 879 NOAA-14 (1994, USA)
  alt. 830 NOAA-15 (1998, USA)
  alt. 835 FASAT-BRAVO (1998, Chile)
  alt. 870 FY-1C (1999, China)
  alt. 830 NOAA-L (2000, USA)
  alt. 830 NOAA-M (2001, USA)

alt. 830 NOAA-N (2001, USA)
alt. 870 FY-1D (2001, China)
alt. 830 NOAA-N1 (2001, USA)
alt. 827 METOP-1 (2003 * projected)
alt. 827 METOP-2 (2008 * projected)
* 1,100,000
NIMBUS-3 (1969)
alt. 1200 METEOR 3-5 (1991, Russia)
alt. 1200 METEOR 3-8 (1994, Russia)
* 1,400,000
NOAA-1 (1970, USA)
alt. 1336 JASON-1 (2000, USA)
* 35,780,000
ATS-1 (1966)
GOES-1 (1975, USA)
METEOSTAT-1 (1977, Europe)
METEOSTAT-2 (1981, Europe)
GOES-7 (1987, USA)
METEOSTAT-3 (1988, Europe)
METEOSTAT-4 (1989, Europe)
GMS-4 (1989, Japan)
INSAT 1d/2b (1990-93, India)
METEOSTAT-5 (1991, Europe)
METEOSTAT-6 (1993, Europe)
GOES-8 (1994, USA)
GOMS/Elektro1 (1994, Russia)
GMS-5 (1995, Japan)
GOES-9 (1995, USA)
GOES-10 (1997, USA)
FY-2 (1997, China)
METEOSTAT-7 (1997, Europe)
INSAT-2E (1999, India)
INSAT-3A (2000, India)
GOES-L (2000, USA)
FY-2B (2000, China)
MSG-1 (2000, Europe)
GOES-M (2001, USA)
GOES-N (2001, USA)
MSG-2 (2002, Europe)
MSG-3 (2006, Europe)

11. See what some of these satellites see!
At http://www.sat.dundee.ac.uk/ satellite images are posted (some in real time) that show everything from current weather conditions, weather anomolies, and volcano eruptions, to beautifully captured cloud formations, storm fronts, and man-made clouds (as from planes). Several of the satellites from question #10 are featured.

Part B - Understanding Weather Charts

use http://www.met-office.gov.uk/education/esleaflets/charts.html

1. What does high pressure look like on a weather chart? (Draw a picture.) What kinds of weather conditions does this bring in the winter and summer?

   2 or more concentric oval shapes with arrows depicting direction about the ovals and "high" written in the middle. High pressure mean cold, brisk winds in the winter and warm weather in the summer.

2. What does low pressure look like and what kinds of weather conditions are associated with it? Draw a picture and explain.

   2 or more concentric oval shapes, with arrows about the ovals and "low" written in the middle. This usually means disturbed weather (wind, rain, snow).

3. How do isobars represent strength of wind, pressure, and direction? Include a picture and a description.

   Bars are closer together if winds are strong. Arrows show direction of wind and pressure is shown in millibars or hectopascals (they are equivalent) next to the isobars.

4. What are the three most common fronts in the United Kingdom, and how are they depicted? Use the chart on the next page to explain.

Name: Date:

Most Common Weather Fronts in the UK

	Front Type	Symbol for Front	Weather Occurring Ahead of Front	Weather Occurring Behind Front	Pressure Before Front	Pressure Behind Front
1.	Warm front		wide rain belt, thick, clouds	occasional rain, cloudy	falls steadily and rapidly	steadies, falls less quickly
2.	Cold front		narrow rain belt, some clouds	brighter weather, NW winds	falls	rises
3.	Occluded front		narrow rain belt	NW winds, westerly clearance	Not Specified	Not Specified

5. When wind is depicted, and an arrow is seen, which side of the arrow shows where the wind it blowing to and where it is blowing from? What do the feathers on the tail of the arrow represent? Draw an arrow and label it appropriately.

Tip of arrow (circular part) points in direction from which wind is blowing. In other words, the wind starts at circle and blows along feathered tail and beyond. Feathers on the arrow at its tail show wind speed. This is easy to remember if students think about those feathers being able to move; the wind blow them to the orientation they are at, so wind must come from the tip of the arrow. If wind is very low (less than 1 knot of speed), no feather occurs and 2 concentric circles are seen , and feathers transition from lines to triangles when the wind speed grows past 48 knots. Generally the more feathers there are, the faster the wind.

6. How is visibility depicted? Provide an example and explain what it means.

A number is written to the left of the station circle from which it was measured. The number shows a visibility in tenths of kilometers (or 100 meter quantities). If visibility is greater than 5 km, then the numbers shown depict whole kilometers plus 50.

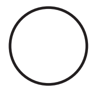
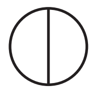
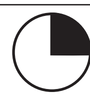
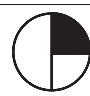
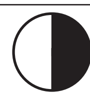
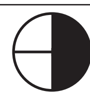
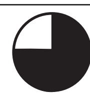
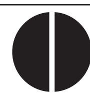
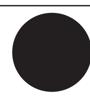
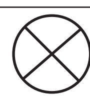
This is a great opportunity to ask students if they understand how feet, meters, and kilometers compare. Many students will not be able to conceptualize distances on the weather charts unless they are in feet. You may want to add and have students fill in a "visibility in feet" column in the chart below.

7. What are the following visibility measurements?

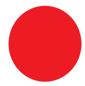
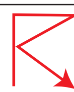
Station Mark	Visibility
• 5	500m
• 50	5000m or 5km
• 17	1700m or 1.7km
• 57	7km
• 80	30km
• 100	50km

Be sure you spend time discussing the last three station marks. Ask students why the "dot" 50 represents visibility of 5 km, but "dot" 57 represents visibility of 7 km (as opposed to 5.7 km). Answer: Special coding occurs after "dot" 50 (5 km). For "dot" x, the difference of x and 50 determines how much will be added to 5 km. For instance, "dot" 51 represents 6 km, because 51-50 = 1 and 1+ 5 = 6. Other examples: "dot" 59 represents 14 km ; "dot" 60 represents 15 km.

8. How is cloud cover depicted? Use a chart to show the symbols and their meanings.

	Cloud Cover Symbol	Meaning of Symbol
1.		Clear sky
2.		< 1/8 of cloud cover
3.		2/8 (1/4) cloud cover
4.		3/8 cloud cover
5.		4/8 (1/2) cloud cover
6.		5/8 cloud cover
7.		6/8 (3/4) cloud cover
8.		7/8 cloud cover
9.		Complete cloud cover
10.		Sky obscured (for example, by fog)

9. What are the weather symbols used on United Kingdom maps? Use a chart to show symbols and their meanings.

	UK Weather Symbol	Meaning of Symbol
1.		Rain
2.		Drizzle
3.		Shower
4.		Snow
5.		Fog
6.		Thunderstorm
7.		Hail

10. Work in small groups on your own region that the teacher will assign to you. Prepare to present your information in a very short oral and graphic presentation.

a. Obtain a weather chart from this web site and sketch it or print it out.

b. Next to each weather station, write a summary of the weather conditions.

c. Create a weather summary for the region that you could provide to pilots. This will require you to be discriminating. Pilots will not need all pieces of information, but will require some. Make your communication as concise as possible. Prepare to present it orally and as a very simple weather map.

d. Present your summary.

e. Listen to other summaries and take notes.

f. Determine where you will fly your class airplane and which regions you will avoid. Also discuss precautions you will take and specific regions you will follow up on, to check on weather developments.

g. Follow up with this activity over several days so you can get a sense about how decision making is dynamic, based on weather systems.

You may want to pass out World or European maps and have students work in teams to plan a trip. You could add fun and complexity to the task by requiring students to go to certain places BUT add restrictions to cost (make each air mile, meal, overnight stay, etc. worth some dollar amount), time flying (total or at any given time – pilots have to sleep!), and amount of wind or rain encountered.