Other Resources

Want to know more? Check out the following websites for more information about the ozone layer and the ozone hole:

Websites:

www.noaa.gov
www.oar.noaa.gov
www.al.noaa.gov
www.cmdl.noaa.gov
www.ozonelayer.noaa.gov

N.C. Standard Course of Study and Grade Level Competencies

Grade 7 – Competency Goal 3
The learner will make observations and build an understanding of weather concepts.

Objectives
3.05 Examine evidence that atmospheric properties can be studied to predict atmospheric conditions and weather hazards:

- Humidity.
- Temperature.
- Wind speed and direction.
- Air pressure.
- Precipitation.
- Tornadoes.
- Hurricanes.
- Floods.
- Storms.

Objectives
3.06 Assess the use of technology in studying atmospheric phenomena and weather hazards:

- Satellites.
- Weather maps.
- Predicting.
- Recording.
- Communicating information about conditions.

The Ozone Hole

. . . SOLVING A SCIENTIFIC MYSTERY

DEPARTMENT OF COMMERCE UNITED STATES OF AMERICA

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

U.S. Department of Commerce

National Oceanic and Atmospheric Administration

“The Ozone Hole”

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Acknowledgements:

- Antarctic ozone hole images provided courtesy of Alvin J. Miller and Ronald Nagatani, NOAA Natioanl Weather Service.
- Plot of CFC-12 observations provided courtesy of Stephen Montzka, NOAA Climate Monitoring and Diagnostics Laboratory.
- Plot of Halley Bay Antarctic ozone data courtesy of the British Antarctic Survey.
- Photo of Ross Ice Shelf from the NOAA Photo Library, NOAA Corps Collection. Photographed by Michael Van Woert, NOAA National Environmental Satellite, Data, and Information Service.
- Other photos and graphics courtesy of Susan Solomon, Dan Albritton, and Chris Ennis of the Aeronomy Laboratory.

NOAA Research Science Education

The Ozone Hole

Some Facts about the Ozone Hole

(Based on “Scientific Assessment of Ozone Depletion: 1998”, World Meteorological Organization Global Ozone Research and Monitoring Project Report No. 44,1999.)

- The springtime Antarctic ozone hole is a new phenomenon that appeared in the early 1980’s. It was discovered by scientists with the British Antarctic Survey, who have made ozone measurements since 1957 at the Halley Bay Station in Antarctica.

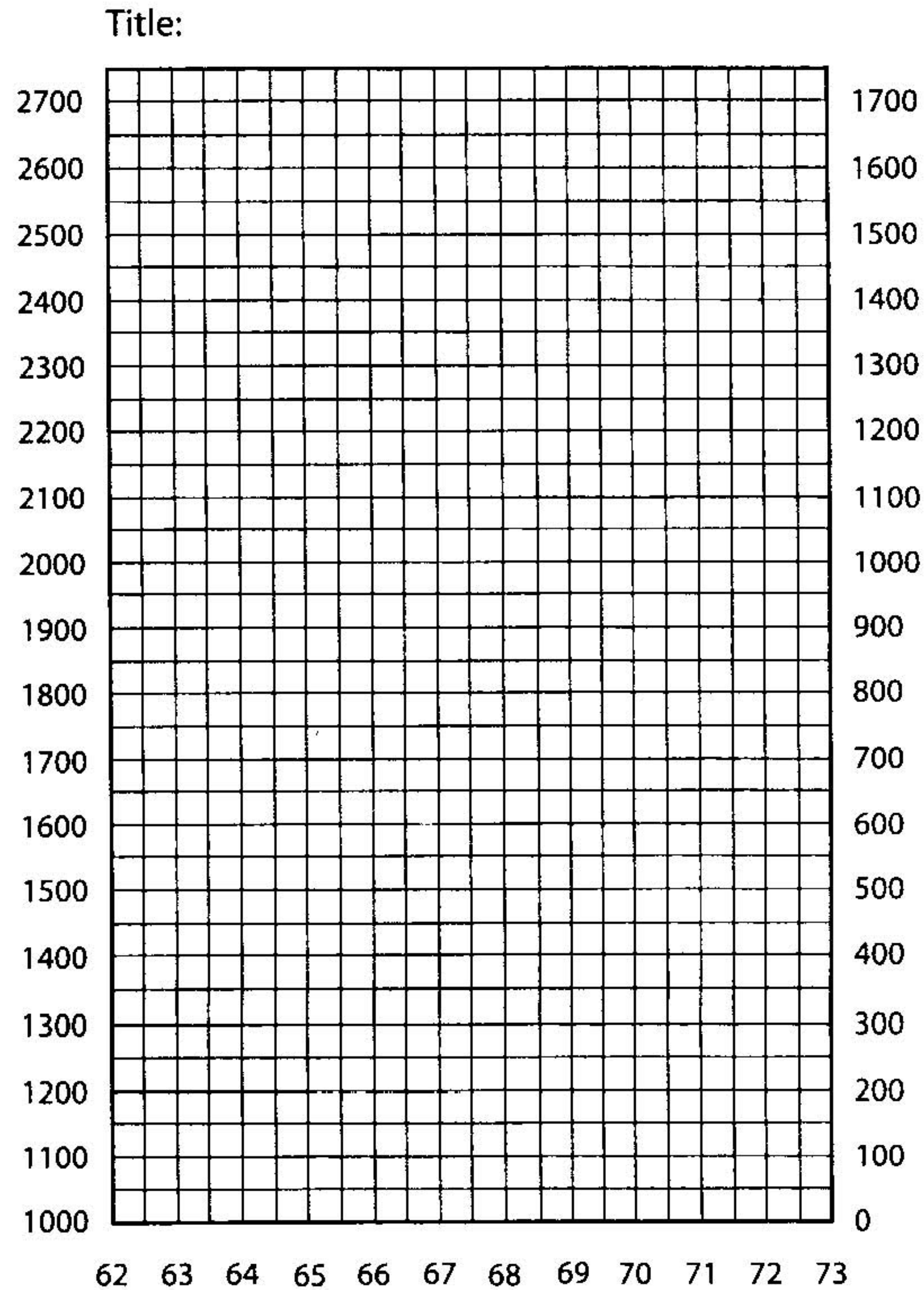
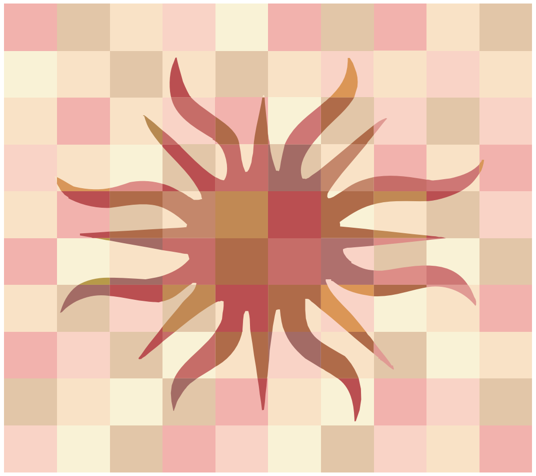


Table: Latitude, Ozone Concentration, and Chlorine Monoxide Concentration

Latitude (degrees South)	Concentration of Ozone (ppt)	Concentration of Chlorine Monoxide (ppt)
63.0	2474	62
63.5	2561	74
64.1	2554	77
64.5	2510	78
65.1	2511	81
65.6	2537	90
66.0	2611	100
66.4	2558	105
67.0	2454	117
67.6	2113	198
68.0	1718	427
68.4	1767	455
68.9	1469	724
69.3	1037	1080
69.9	1011	1164
70.6	1036	1155
71.0	1062	1163
71.4	1077	1166
71.8	1084	1176



- The ozone hole is formed each year when there is a sharp decline (up to 60%) in the total ozone over most of Antarctica for a period of about three months (September through November) during the Southern Hemisphere springtime. The ozone hole is therefore a seasonal phenomenon that does not occur year-round.

- The ozone hole has been shown to result from destruction of stratospheric ozone by gases containing chlorine and bromine, whose sources are mainly human-produced halocarbon gases that have uses such as refrigeration, electronics cleaning, and industrial solvents. Ice clouds that form in the cold Antarctic stratosphere, known as "polar stratospheric clouds" (PSCs), accelerate the chloine/bromine chemistry that destroys ozone.

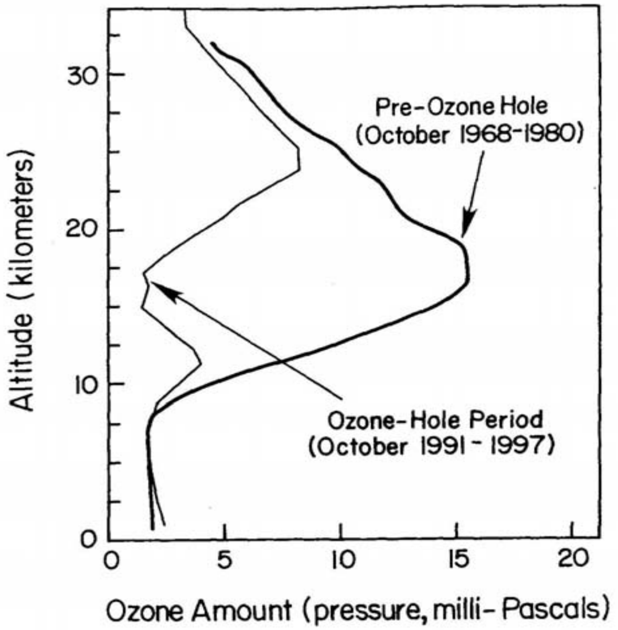
- The "ozone hole" is defined as the region with total ozone below 220 Dobson units. A Dobson unit is a measure that describes the thickness of the ozone layer in a column directly overhead. Before the ozone hole, a typical October number for the ozone above Antarctica was 275 Dobson units; in the "ozone-hole era", the October values have dipped below 100 Dobson units, with a minimum of 88 Dobson units observed in 1993.

- In 1999, 2000, and 2001, the area of the ozone hole reached a size of about 26 million square miles-roughly the size of North America. Researchers have observed a leveling-off of the ozone hole size, and they predict a slow recovery over the coming decades (barring changes in other factors such as climate or large volcanic eruptions, which would influence the ozone-destroying chemical processes).

- Observations from several ground stations in Antarctica and from satellite-based instruments reveal similar decreases in the springtime amounts of ozone overhead.

- Changes in stratospheric meteorology cannot explain the ozone hole. Extensive measurements from the ground, from aircraft, and from satellites give clear evidence of the importance of the chemistry of chlorine and bromine originating from human-produced compounds in depleting Antarctic ozone in recent years.

- Measurements of the ozone hole using balloonborne ozone instruments show that there are dramatic changes in the way ozone is distributed with altitude. As shown in the figure below, almost all of the ozone is destroyed at some altitudes as the ozone hole forms each springtime, compared to the normal ozone profile that existed before 1980:



Classroom Activity Sheet for Students

(Data for this activity came from the NOAA Aeronomy Laboratory and Harvard University. A world map of the Southern Hemisphere should be supplied by the teacher or student.)

Question: What causes the ozone to disappear every springtime above Antarctica?

Researchers used instruments on the ground, in balloons, and aboard aircraft to investigate the answer to this question. In one such experiment in 1987, instruments were placed on a high-altitude research aircraft, to make measurements as the aircraft flew from the southern tip of Chile (at 53° south latitude) to the edge of the Antarctic continent (at 72° south latitude). As the aircraft flew south, it entered the ozone hole region. Along the way, the instruments measured the amount of ozone in the air, in a unit known as "parts per billion", or ppb. The table below gives the data. They also measured a gas called chlorine monoxide in parts per trillion (ppt). This gas is a reactive chlorine-containing gas that is formed from the breakup of human-produced chlorofluorocarbons (CFCs) in the atmosphere.

Background Information: The amount of atmospheric gases, such as ozone and chlorine monoxide, can be measured in "parts" of a total number of air molecules. For example, the amount of atmospheric ozone might be 2474 parts per trillion (ppt), which means that out of a trillion molecules of air, 2474 molecules are ozone. Alternatively, that amount could be expressed as 2,474 parts per billion (ppb).

Student Exercise: Each of the data points in the Table represents an observation for the amount of ozone (ppt) and the amount of chlorine monoxide (ppt) observed by the instruments aboard the aircraft.

1. Using the data provided in the Table and the left-hand side of the (vertical) y-axis on the Graph, plot the points corresponding to the ozone concentration and latitude. Use a colored pencil to connect the points. Label the left-hand side of the y-axis with that color as well.

2. Using the data provided in the Table and the right-hand side of the y-axis on the Graph, plot the points corresponding to the chlorine monoxide concentration and latitude. Use a different colored pencil to connect the points. Label the right-hand side of the y-axis with that color as well.

3. Label the (horizontal) X-axis of the graph.

4. Print a title at the top of your graph.

Student Questions:

1. On a world map, find the starting point of the aircraft flight at Puenta Arenas, Chile (53.0° S latitude, 71° W longitude) and the turnaround point of the flight (72° S latitude, 60° W longitude).

2. At what approximate latitude does the aircraft seem to enter the ozone hole? Find this on your graph first; then find the location on your world map.

3. How do the ozone concentrations and the chlorine monoxide concentrations appear to be related (direct correlation; inverse correlation; inverse correlation; no correlation)?

4. Are the data in the figure consistent with the idea that human-produced chlorofluorocarbons cause the ozone hole?