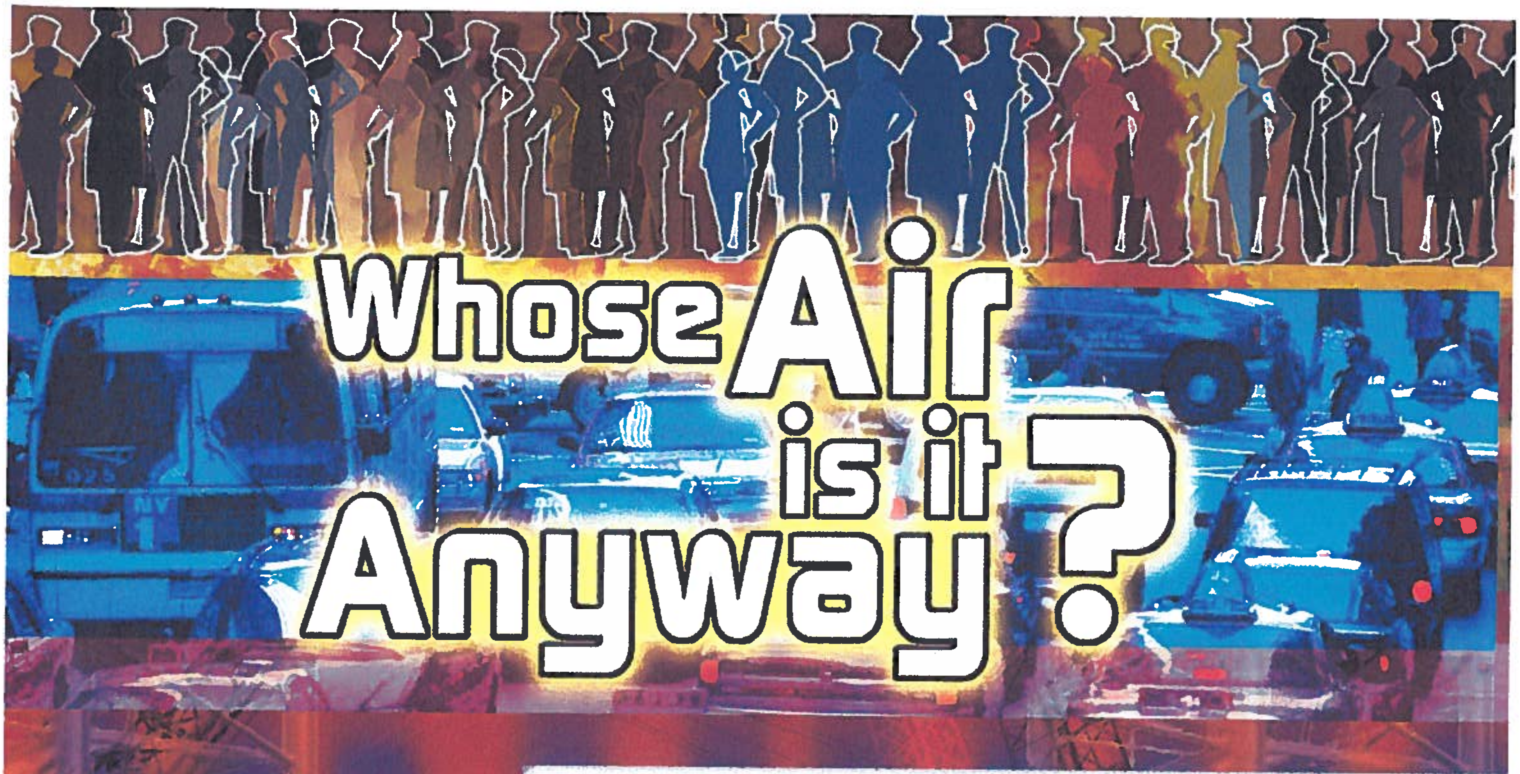


Whose Air is it Anyway?

By Jeannie Allen

It's a fact of life. We live on the Earth and in the air. As for your share of that air—do you know where it's been?

DIGITAL VISION

1 Air is arguably the closest and most important biological connection we have with the rest of the world. We breathe air into our bodies every few seconds. Like it or not, we share the air we breathe with the people around us, whether friends or strangers.

2 Yuck, you may say! But it's how our world is constructed. We don't get a new air supply every day. We simply "recycle" the same air over and over. As one atmospheric chemist pointed out, "Air may not look like much, but try breathing something else!"

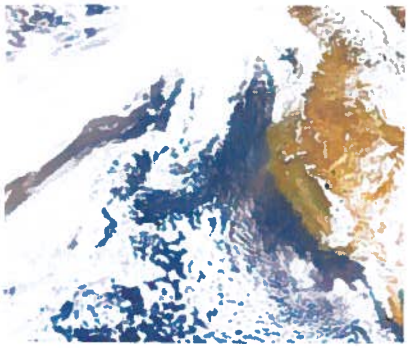
3 We share the air we breathe not only with other people but also with the rest of our environment—cars, trucks, buses, factories, airports, trees, grass, livestock and wildlife, lakes and oceans—you name it. Air is in constant motion, ever blowing and breezing from one place to another. The air we breathe and the stuff that's in it have come from somewhere else.

4 Moving air carries some interesting baggage, including moisture, dust, bacteria, fungal spores, viruses, and varying traces of chemical constituents worthy of our attention, like ozone (O_3), nitrogen oxides (NO_x), and sulfuric acid (H_2SO_4). As for any air travel, some passport checking is in order. For our health and safety, we need to know where our air comes from, what it's carrying, and what happens to it before it reaches us.

5 Curious about where your air has been? So is NASA. Scientists working with data from NASA's Earth-observing satellites have been discovering, often to their amazement, that air pollution is quite an inter-continental traveler! Dust from the Sahara has turned up on coral reefs in Florida, and dust from the Asian Gobi Desert has appeared as far away as the East Coast of North America. Air pollution from the northeastern United States sometimes reaches Europe, and, occasionally, European pollution travels the opposite direction in return.

6 Sea salt and frozen plankton that traversed the Pacific Ocean via Hurricane Nora appeared over the midwestern United States in 1997. Satellite photos have revealed smoke from Asian fires crossing the Pacific to reach southern California. Air pollution from China often drifts directly over Japan.

7 All of this air travel has significant political impacts. It's becoming obvious that countries, despite their own efforts to curb pollution, won't have clean air until their neighbors do.



SeaWiFS satellite image of the West Coast of North America on April 25, 1998, shows the arrival of airborne dust from China. The dust is visible in the clouds at the center of the left edge of the image, and as streaks of light brown haze over Cape Mendocino on the California coast.

ABOVE PHOTO: ORBIMAGE© ORBITAL IMAGING CORPORATION AND PROCESSING BY NASA GODDARD SPACE FLIGHT CENTER

Tracking ozone

8 Ozone in the lower atmosphere is one of the pollutants of greatest concern to NASA. Ozone in the upper atmosphere (stratosphere) protects us against harmful ultraviolet radiation from the sun, but ozone where we breathe harms us. The effect of breathing ozone is somewhat akin to a slow burn. Ozone is an oxidizer, readily donating one atom of oxygen to other "willing" molecules. Over time, breathing too much ozone can permanently reduce our lung capacity.

9 Hate getting up early? If you're into sports, you might prefer doing your summer workouts in the cooler morning hours. You may even find breathing a little easier at that time. Ozone levels tend to be low in the morning, before the chemical soup of nitrogen oxides and hydrocarbons has time to build up from vehicle traffic and other sources. They're the chemical ingredients for ozone formation, a group of chemical reactions that really get going as sunlight becomes more intense later in the day. You can read more about that in "Chemistry in the Sunlight" on pages 22–24.

10 Ozone concentrations vary widely around the globe. With recent improvements in satellite technology and the availability of more data, atmospheric scientists are only now recognizing the extent of ozone's travels.

11 Anne Thompson is one of the trailblazers in ozone tracking at NASA Goddard Space Flight Center. She and her colleagues want to be able to predict ozone concentrations and distribution. She explains, "What we're trying to do is to parse out which ozone comes from natural causes and which ozone comes from human activity. It's extremely hard to separate natural and man-made sources of gases. The precursors of ozone such as nitrogen oxides are not labeled 'I came from an aircraft engine', 'I came from the stratosphere', 'I came from the ground', or 'I came from lightning'. You have to measure other related chemicals that fingerprint the source."

12 Thompson and her colleagues recently focused on a region off the West Coast of Africa. She describes the research in these words:

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Anne Thompson NASA scientist, and Agnes Phahlane, a meteorologist of the South African Weather Service, prepare for a balloon launch during the SAFARI-2000 campaign in Zambia. The balloon carried both an ozonesonde instrument to measure ozone and a radiosonde to measure temperature, pressure, and relative humidity—conditions that can affect ozone concentrations and distribution.

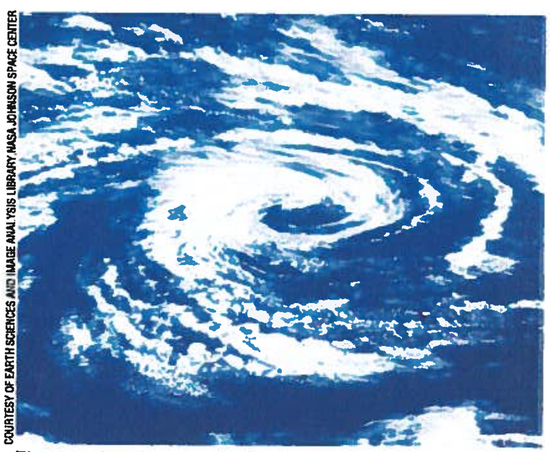
13 "We would combine all the data we could get from various sources. We would get real-time weather data from many sources. We would get real-time satellite data on ozone concentrations from the Total Ozone Mapping Spectrometer (TOMS satellite) and the Optical Transient Detector (OTD) Lightning Sensor. Then, we would combine all of them to make our best forecast of where the ozone, dust, biomass burning, and lightning would make their impact, and so where we should direct the NASA research aircraft to make observations for us. We would forecast and fly, analyze our observations, and then forecast and fly again to extend our understanding."

14 Thompson notes that she has developed a healthy respect for how variable the atmosphere is. "Weather systems in the troposphere are constantly moving and mixing the air, and at the same time, chemical reactions are changing the air's chemical composition."

15 Major patterns of air circulation have enormous impacts on ozone and its precursors, the airborne chemicals that react to form it. Thompson's group was particularly interested in an anticyclone in the South Atlantic Ocean that delivers pollution from both African and South American fires over the Atlantic. By this process, ozone from fires all across southern Africa rises up and mixes into the circulating air, which may carry the pollution hundreds of miles. Sometimes parcels of polluted air spin off, streaming out over the Atlantic, the Indian Ocean, and as far away as the Pacific.

A complete, detailed, global picture of the travels of ozone and its precursors requires more research, but some trends are becoming clear. Background concentrations of ozone—amounts that are usually there—generally range from about 25–55 parts of ozone per billion parts of air (ppb) in surface air over the United States. Much of this ozone probably comes from outside the United States.

16 Keeping tabs on ozone levels is important because the U.S. National Air Quality Standard is 80 ppb over 8 hours, an amount not to be exceeded more than 3 times a year. But even if people in North America succeeded



COURTESY OF EARTH SCIENCES AND IMAGE ANALYSIS LIBRARY NASA JOHNSON SPACE CENTER

The ever-changing and complex nature of troposphere, the lower atmosphere, makes it difficult to trace the chemical reactions that produce ozone.

Smoke Bugs

A Texas student shows us that living spores can go up in smoke and survive.

As often occurs in science, Sarah Mims's discovery happened when she wasn't really looking for it. Sarah had a good idea for a science fair project. After reading about traveling air currents and the particles they carry, she decided to sample the air near her home in Seguin, TX. Her plan was to search for fungal spores she suspected were arriving with dust from Asia.

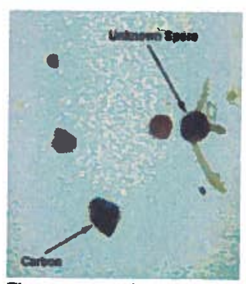
But when she looked at a NASA SeaWiFS satellite image, Sarah found that on the day of her sampling, a large cloud of smoke from fires in Mexico had passed over Seguin. Could the smoke have delivered the *living* fungal spores she collected that day? "I was really surprised," Sarah said. She had to be sure. "Did the fungal spores I captured come from Central America?"

PHOTOS COURTESY OF SARAH MIMS

With help from friends, Sarah exposes Petrifilm to smoke from a grass fire.

Sarah decided to do an experiment to find out if fungal spores could actually survive burning. She burned several kinds of plants—making sure to follow local fire department rules. Then she exposed pieces of a water-soluble gel, Petrifilm, to the smoke. She placed the film in culture containers and stored them at conditions favorable to fungal growth. In two or three days, she had her answer. There were colonies of at least 10 different species of fungi growing in the dishes. Clearly, fungal spores are tough enough to withstand toasting!

What makes Sarah's research so important is that some fungal spores spread plant diseases. Farmers in tropical countries regularly set fires to clear fields of old crop residues, making room for new plantings. Sarah demonstrated that infected plants may release living fungal disease spores when they burn. Because the lightweight spores can travel vast distances on air currents, the risk of fungal infection in healthy crops seems obvious.



The presence of carbon told Sarah that the fungal spores were accompanying smoke from biomass burning.

After reading about the project recently, Eugene Shinn, a scientist with the U.S. Geological Survey, wrote this to Sarah: "I think there is great potential in what you are doing. We have been identifying microbes including fungi in African dust that crosses the Atlantic. And, believe it or not, it reaches where you are living. One thing that has puzzled us for some time is why the number of fungal spores ... in dust fluctuates over time. We have always thought it had to do mainly with the source area. Now I wonder if it is related to fires in the Congo ... Could it be the smoke is the main source of the fungi? I encourage you to continue [your work]."

Sarah plans to submit her findings to a scientific journal. If her research is corroborated, it will provide strong evidence that agricultural diseases can spread from one continent to another—in *smoke*!

For Sarah, science research is an exciting challenge. "The reason I do science projects is because the benefits are incredible," says Sarah. "I enter competitions such as the Junior Academy of Science. You really have to understand the science ideas well to answer the judges' questions."

And it doesn't hurt to be organized! Sarah advises, "Doing science projects also requires a great deal of discipline. You can't wait till the last minute to do the experiment and throw a report together."

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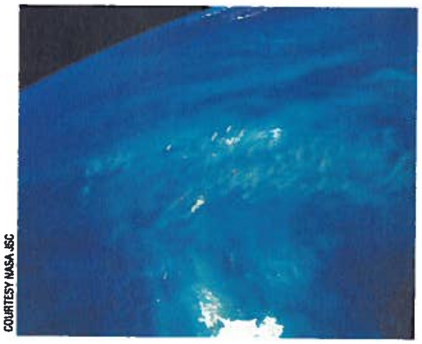

COURTESY NASA JSC

Space Shuttle astronauts photographed these smoke plumes from the Amazon rain forest in Western Brazil in September 1984. "Slash-and-burn" techniques are sometimes used to clear forest land for agricultural purposes—for raising crops or for developing pastureland for cattle. Peak burning periods occur during the dry season, which for this Southern Hemisphere region is June through September.

in reducing their emissions of nitrogen oxides and hydrocarbons by 25%, the ozone problem would persist. Emissions expected from Asia by 2010 could completely wipe out that gain in clean air.

17 "For the cooperation required to control air pollution, we need an international agreement," explains Guy Brasseur, an expert in making mathematical models of the atmosphere at the Max Planck Institute for Meteorology and the National Center for Atmospheric Research. "But before we can move to such an agreement, we need to understand the problem scientifically. Satellites are key to our research."

18 "NASA's Aura spacecraft will provide us with the first truly global view of tropospheric ozone… .We'll be able to track ozone both regionally within continents and from one continent to another," explains Reinhold Beer, principal investigator for one of Aura's four instruments.

19 Daniel Jacob, atmospheric scientist at Harvard University notes that satellite observations are changing the way atmospheric chemistry is done. "Our field is undergoing a revolution, because my community is having to think about satellite observations. Interpreting satellite observations is a very difficult task … . But we need to understand what satellite observations are saying to us, because we need that global scale [perspective]."

Jeannie Allen is a science writer at the NASA Goddard Space Flight Center in Greenbelt, MD. She is a frequent contributor to the Earth Observatory, NASA's award-winning website at http://earthobservatory.nasa.gov.