Bringing MILAGRO Science to the Public, Students, and Educators through the Windows to the Universe Website – A Collaboration between Scientists and Educators

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MILAGRO

Megacity Initiative: Local and Global Research Observations

Intensive campaign to study gases and aerosol pollution in and around Mexico City, March 2006

- Transport of air pollutants from urban to regional and global environments impacts health, ecosystems, visibility, weather, greenhouse forcing
  - How are polluting agents eliminated from the atmosphere?
  - What are the regional and world-wide impacts of urban plumes?
- Numerous scientific participants from institutions across Mexico, Europe, US

- Collaborative effort to build a web-portal to MILAGRO on Windows to the Universe

Windows to the Universe

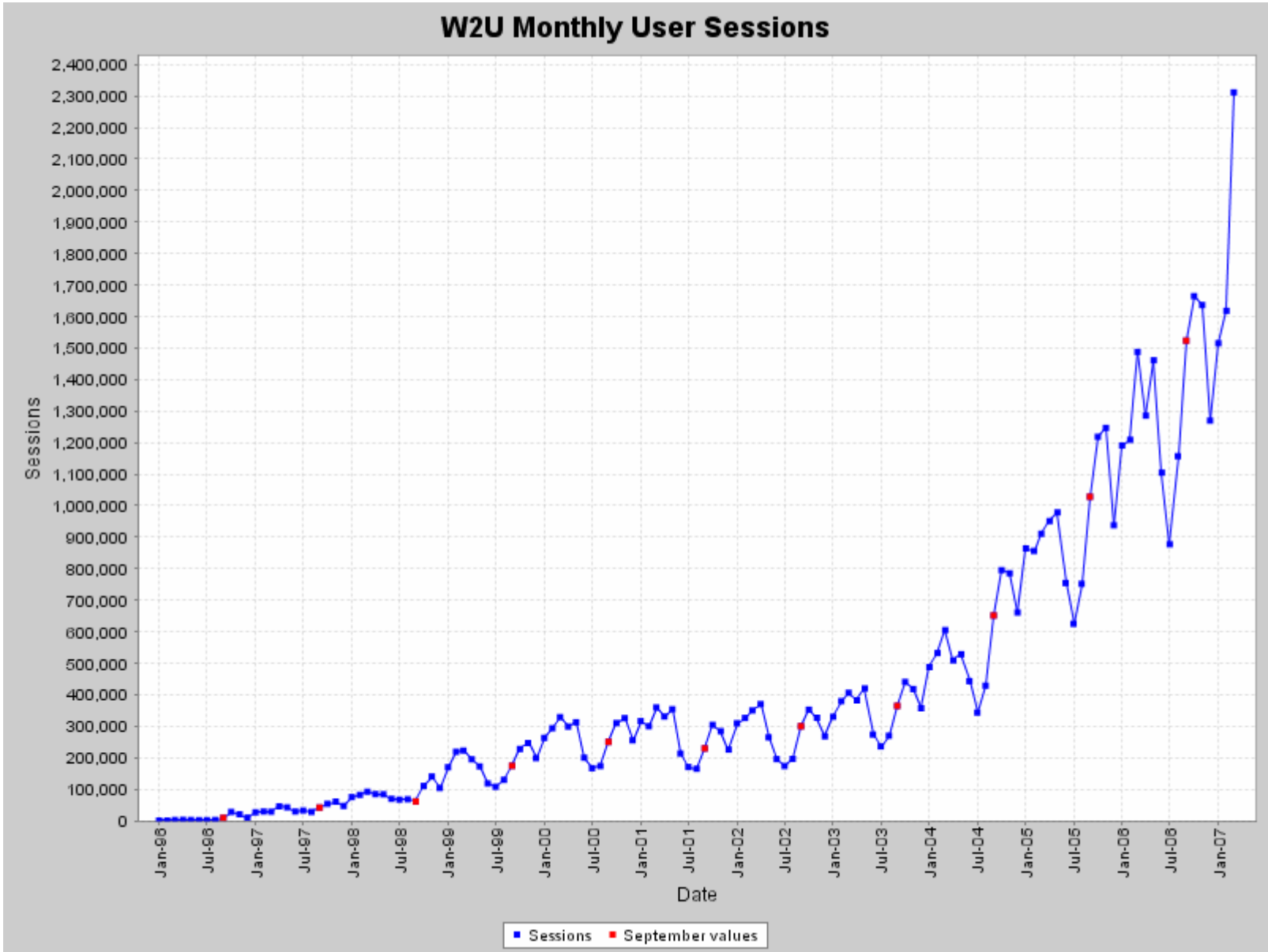
- Over 7000 interlinked web pages at three levels in English and Spanish
- Content spans Earth and space sciences, with connections to related fields (arts and humanities)
- Over 17.7 million visitors to website in past 12 months (~135 million page views)
  - Reached ~85 – 90K visitors per day in March
  - ~25% of traffic to Spanish version of website
- New monthly newsletter reaches ~7376 educators from 139 countries around the world (bilingual)
- Over 100 classroom activities for teachers

Content of the Site, Page 1

- The Sun
  - Interior, Surface and Atmosphere, Solar Activity, Solar Word Search Game, Solar Concentration Game, Solar Eclipses, Image Archives, Recent Images, Space Missions, Myth and Culture, Solar Facts, News and Discovery, Sun's Web
- Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto
  - For each, Interior and Surface, Atmosphere, Magnetosphere, Moon (when they exist, or Moons and Rings), Planetary Facts, Myth and Culture, Space Missions, Image Archives, Planet Discovery, Planet Web, Planet News (for Earth, add Water and Life, Ecosystems)
- Comets
- Asteroids
- Solar System
  - Sun, Planetary Systems, Solar System Formation, Asteroids, Comets, Solar System Facts, News and Discovery, Image Archives, Solar System Coloring Book
- The Universe
  - Astronomy Throughout History, Understanding the Sky, Constellations, Sky Maps, Stars, Star Dust, Strange Stuff in Space, Galaxies, The Cosmos, Space Science News, News and Discovery, Image Archives, Universe Web
- Space Weather
  - What's Happening in Space Today
  - Basic Facts about Space Weather
- Data
  - Weather, Earth Science, Space Science, Planetary Science, Astrophysics
- Headline Universe
  - Hot off the Press, Earth News, Solar System News, Universe News, Space Mission News, News Archive

Content of the Site, Page 2

- Geology
  - Minerals, Rocks and the Rock Cycle, Earth's Layers and Moving Plates, Fossils and Earth History, Scientists who study Rocks
- Life
  - Cells, Genetics, Diversity and Classification, Ecology, Evidence of Evolution Exploratour, Astrobiology, News about Life, Life Image Archive, Scientists who study Life
- Climate and Global Change
  - What Is Climate?, What Impacts Earth's Climate System?, Effects of Climate Change, Paleoclimates, Climate Web, Climate Image Archive
- Earth's Polar Regions – New section developed in support of the International Polar Year!
- Space Missions
  - Space Exploration, Manned Missions, Unmanned Missions, Space Missions Web
- Mythology
  - Sun, Earth, Moon, The Solar System, Sky, Constellations and Stars, Classical Mythology, Family Trees, World Mythology, Mythology Hangman, Mythology Web
- People and History of Science
  - Ancient Epoch, Middle Ages, Renaissance, Age of Enlightenment, Modern Era, Today's Scientists, Astronauts, Windows People, People Coloring Book, People Web
- Cool Stuff
  - Tours and Questions, Hot off the Press, Fun and Games, Virtual Postcard, Image Archives, Recent Images, Windows Chat, Ask A Scientist, Search Archives, Windows Web
- Art, Books, Films
  - Mythology Art Archive, People Art Archive, Books, Space Movies, Poetry, Stories and Folktales, Arts Web
- Kids' Space
  - Ask A Scientist, Fun and Games, Tools, Student Workbook, Virtual Postcard, Cool Kids Link, Space Art Museum, Student Projects, Artwork
- Teacher Resources
  - Teacher Workbook, Tools, Classroom Activities, Educational Links, Teacher Share-a-Thon, Educational Standards Search
- Games
  - Coloring book, Crossword Puzzle, Space Sense, Order it Up, Junk in Space, Concentration


W2U Monthly User Sessions
Sessions
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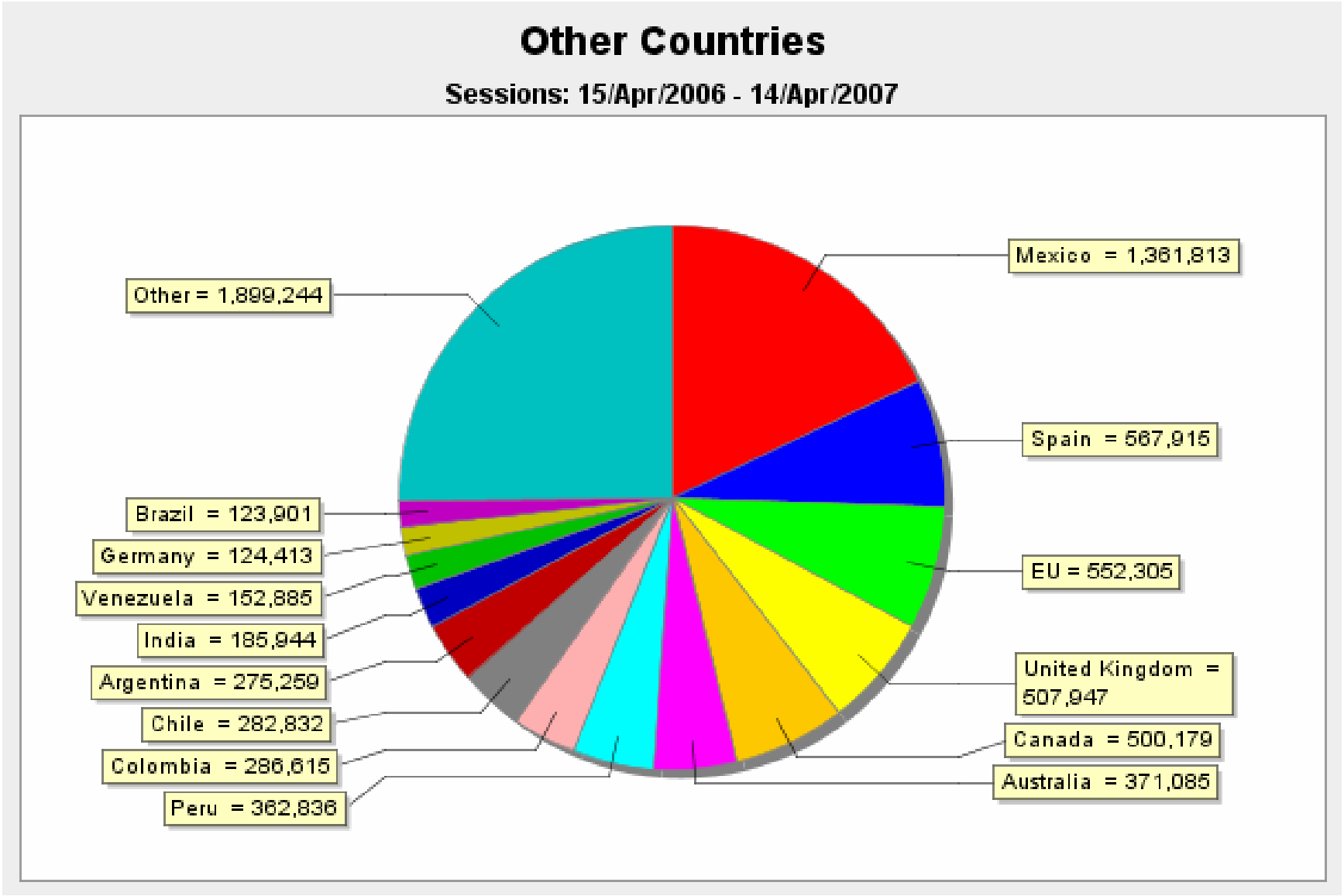
September values

~17.7 million sessions over past 12 months



Evolution of the Project

- October 2005 - Developed concept for education and outreach portal for MILAGRO campaign, in collaboration with MILAGRO scientists, submitted to National Science Foundation
- January 2006 – Began development of MILAGRO Education and Outreach portal:
  - Created ~60 web-pages to support (leveraging hundreds more already on the site)
  - Created new interface for scientists/teachers to submit Postcards
- End of February 2006:
  - Trained ~10 scientist/teachers on how to use interface in Mexico City
  - Spur-of-the-moment workshop for ~60 teachers in Veracruz arranged through meetings with the Secretary of Education in Veracruz
- March 2006
  - 1 March - Opened MILAGRO portal to the public
  - Teachers and students welcomed at the Field Operations Center in Veracruz for daily briefings throughout the month

MILAGRO EO Content

- About MILAGRO: campaign, instruments, aircraft
- Air Pollution: Effects – health, visibility, acid rain, water resources, property, forests/wildlife, tragedy of the commons; transport
- Atmospheric chemistry – 14 molecules
- Atmospheric structure
- Connections to climate change – greenhouse gases, nitrogen cycle, carbon cycle
- Scientists and Educators – bios from 9 participants
- Postcards from the Field – 34 posted over the month
- Links to resources for kids and teachers (including related curricula)

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Spanish

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Earth's Climate
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Space Missions
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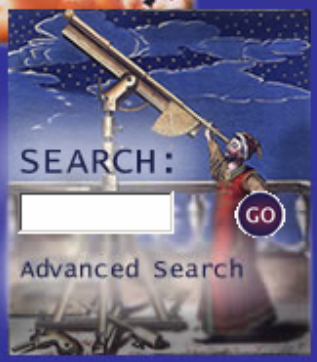
Our Planet

Our Solar System

Astronomy & the Universe



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Games & Puzzles

Journal Tool

Did you know that Earth's climate is warming up?

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National Science Foundation

NCAR
National Center for Atmospheric Research

MILAGRO

CMMAP

Postcards from the Field: Antarctica

Explore Adelie penguin colonies in Antarctica as chicks hatch and grow between December 2006 and January 2007!

Windows to the Universe Store

Featured product: The Windows to the Universe canvas tote bag

Teachers!

Join us for a workshop at the NSTA Conference on Science Education in St.Louis, MO, USA

Earth - Mozilla Firefox

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EARTH

Earth, our home planet, is a beautiful blue and white ball when seen from space. The third planet from the Sun, it is the largest of the inner planets. Earth is the only planet known to support life and to have liquid water at the surface.

Introduction to Milagro

This image shows the location of the country of Mexico and its capital, Mexico City. Mexico City is where the MILAGRO campaign will take place.
Click on image for full size (437 Kb)

MILAGRO stands for Megacity Initiative: Local and Global Research Observations. What that really means is that a team of researchers from around the world is in Mexico City to study the atmosphere there. The MILAGRO field campaign started in March 2006.

During MILAGRO, the scientists are using airplanes, radars, weather balloons, computers, and dozens of scientific instruments to study the atmosphere in and around Mexico City. Their purpose is to learn more about the air pollution that is given off by very large cities called megacities.

Air pollution affects visibility, human health, agriculture, and ecosystems. As cities around the world grow bigger than ever before, scientists are discovering that urban air pollution is powerful enough to affect Earth's weather and climate.

The MILAGRO team is focusing on how the air pollution particles released inside Mexico City change as the wind blows them downwind of the city. They also want to understand how chemistry in the atmosphere changes the pollution as it moves away from the city.

The researchers hope they can apply what they learn in Mexico City to other megacities around the world. They chose to hold MILAGRO in Mexico City because it ranks among the world's top three largest cities and has very polluted air.

Many people aren't familiar with field campaigns like MILAGRO. A field campaign is when a team of researchers—usually scientists, technicians, engineers and more—undertakes a large scientific research project in a certain location. Field campaigns can be large, lasting for weeks and involving many different people and different scientific instruments. After the campaign, the researchers often spend months and even years analyzing the data they got during the project.

Estudiando agentes contaminantes del aire en la Ciudad de México, 2da. ciudad más grande del mundo

MILAGRO

MILAGRO

Megacity Initiative: Local and Global Research Observations*

*Iniciativa de megaciudad, Observaciones de investigación local y global

Español Ingles

Introducción a Milagro

Los enlaces en color anaranjado lo llevan a las páginas en Inglés, que aún no han sido traducidas al Español.

Esta imagen muestra dónde se encuentran México y su capital, la Ciudad de México. La Ciudad de México es el lugar donde se llevará a cabo la campaña MILAGRO.

MILAGRO significa: Iniciativa de Megaciudad: Observaciones de Investigación Global y Local (por sus siglas en Inglés: Megacity Initiative: Local and Global Research Observations). Esto realmente significa que actualmente hay en Ciuda de México, un equipo de científicos provenientes de todo el mundo, que está allí para estudiar la atmósfera de la ciudad. Este proyecto comenzó en marzo del 2006.

Durante la campaña MILAGRO, los científicos usarán aviones, radares, globos climatológicos, computadoras, y docenas de instrumentos científicos que estudiarán la atmósfera de la ciudad y de sus alrededores. Su propósito es el aprender más acerca de la contaminación del aire que se genera en grandes ciudades conocidas como, megaciudades.

La contaminación del aire afecta la visibilidad, la salud de las personas, la agricultura y los ecosistemas. A medida que las ciudades de todo el mundo está creciendo más rapidamente que antes, los científicos están descubriendo que la contaminación del aire que se genera en las ciudades es lo suficientemente potente como para afectar los estados del tiempo y clima de todo el planeta.

El equipo de Milagro se enfoca en cómo cambian las partículas de contaminació

Studying air pollutants in Mexico City, the world's second largest city.

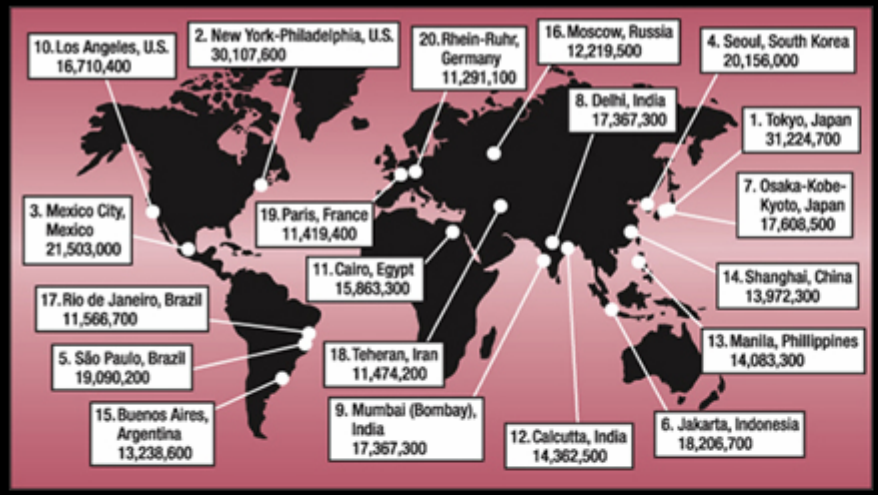
MILAGRO

MILAGRO

Megacity Initiative: Local and Global Research Observations

Spanish English

Megacities



This map shows the world's 20 most populous urban areas in 2004. With 21,503,000 people, Mexico City ranks third.
Click on image for full size (147)
Data courtesy of the World Gazetteer; illustration courtesy of Mike Shibao, UCAR.

Mexico City, where the field campaign MILAGRO takes place, is a "megacity." A megacity is defined as having 10 million or more inhabita

The 21st century is definitely shaping up to be the Urban Century. For th first time in human history, more people live in urban areas than do not. "urban" area is a city; the opposite is a "rural" area, which means in the countryside.) In 2000, the world supported 411 cities that each had mor than one million inhabitants. While the majority of the world's urban population used to live in Europe and North America, today the biggest growth is happening in developing nations, especially in Asia.

People are moving from the countryside into cities in search of more economic opportunities. That is, they expect to make a better living whil working in the city. During the last decade, for example, an estimated 1 million rural Chinese moved to the nation's urban areas, filling megacitie like Shanghai and Beijing.

In the future, more and more megacities will form. It is estimated that the number of megacities will reach 26 by 2015. Most cities lack the service to support so many new people coming into them, resulting in unsustain growth and the pollution that so often accompanies it.

Aircraft Used in the MILAGRO Campaign

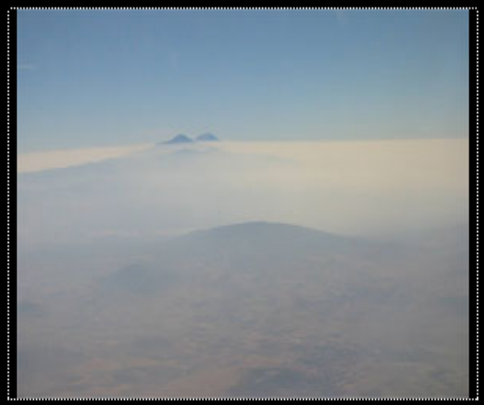
This is a photo of the Veracruz International Airport.
Click on image for full size (52 Kb)
Courtesy of UCAR

The MILAGRO scientists will use six different airplanes to study air pollution around M
different instruments onboard that will help scientists measure air pollution. They'll fly
45-minute flight east of Mexico City on the Gulf coast. This allows them to keep from
heavy commercial air traffic. (To avoid conflicts, they'll also be coordinating their fligh
the ground.) In addition, by taking off at sea level rather than in the higher, thinner air
feet/2,255 meters), the planes will be able to carry more weight and fuel and thereby

One challenge for the researchers during the flights could be locating the plume of po
The plume usually spreads northeast due to prevailing winds from the southwest; how
Nortes, winds that come from the north.

The six MILAGRO aircraft include:

Air Pollution



Air pollution over Mexico City.
Click on image for full size (21 Kb (JPEG))
Pending from Nicole

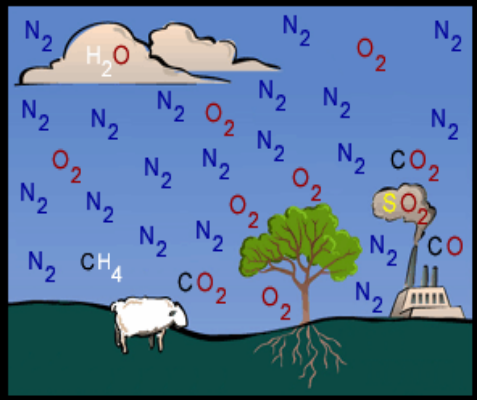
What do smog, acid rain, carbon monoxide, fossil fuel exhausts, and tropospheric ozone have in common? They are all examples of air pollution. Air pollution is not new. As far back as the 13 th century, people started complaining about coal dust and soot in the air over London, England. Since the beginning of the industrial revolution in the late 1700s, we have been changing the Earth's atmosphere and its chemistry. As industry spread across the globe, so did air pollution. Air pollution has many effects. In addition to being ugly, it can cause illness and even death. It damages buildings, crops, and wildlife. The worst air pollution happened in London when dense smog (a mixture of smoke and fog) formed in December of 1952 and lasted until March of 1953. 4,000 people died in one week. 8,000 more died within six months.

Air pollution is made up of solid particles and chemicals. Natural processes impacting the atmosphere include volcanoes, biological decay, and dust storms. Plants, trees, and grass release volatile organic compounds (VOCs), such as methane, into the air. We are more concerned with human-made pollution since we have the ability to control it. The pollutants include carbon monoxide, sulfur dioxide, VOCs, and nitrogen oxides. The largest source of human-made pollution is the burning of fossil fuels, including coal, oil, and gas, in our homes, factories, and cars.

Air pollution is either primary or secondary. Primary pollution is put directly to the air, such as smoke and car exhausts. Secondary pollution forms in the air when chemical reactions changes primary pollutants. The formation of tropospheric ozone is an example of secondary air pollution.

The atmosphere is a complex, dynamic and fragile system. Concern is growing about the global effects of air pollution, especially climate change. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health.

Atmospheric Chemistry of Earth's Troposphere



This cartoon shows some of the gases in Earth's troposphere. There is more nitrogen (N_2) than anything else. There is also a lot of oxygen (O_2). The cartoon also shows carbon dioxide (CO_2), water vapor (H_2O), methane (CH_4), sulfur dioxide (SO_2), and carbon monoxide (CO).
Click on image for full size (52 Kb JPEG)
Image courtesy UCAR, modified by Windows to the Universe staff (Randy Russell).

When you think of chemistry, do you think about mixing colored liquids in test tubes and maybe making an explosion... or at least a nice puff of smoke? Did you know that a lot of chemistry happens in Earth's atmosphere? There are many different kinds of chemicals in the air. Those chemicals often combine with each other in chemical reactions, making new and different chemicals. This is called "atmospheric chemistry".

Earth's atmosphere has different layers. The lowest layer is called the troposphere. We live in the troposphere. This page explains about atmospheric chemistry in the troposphere.

Most of the gas in our atmosphere is nitrogen. About 4/5ths of the air is nitrogen. What about the other 1/5th? Almost all of it is oxygen, the stuff in the air we need to breathe. There are also very small amounts of a bunch of other chemicals.

Have you heard of greenhouse gases? They are kinds of gases that trap the heat from sunlight in our atmosphere. Earth would be very cold if we didn't have any greenhouse gases. Carbon dioxide and methane are two very important greenhouse gases.

Some of the chemicals in the air come from pollution. When we burn coal in a factory or gasoline in our cars, we make air pollution. Coal and oil have sulfur in them. When they burn, they make chemicals called sulfur oxides. These can turn into sulfuric acid when they mix with water droplets in the air. These droplets of acid can fall to the ground as acid rain. Cars and trucks also give off chemicals called nitrogen oxides. Nitrogen oxides combine with other chemicals to make smog. They also help make nitric acid, which is another acid in acid rain.

Nature also does things to change the chemistry of the troposphere. Volcanoes, lightning, and wildfires all add chemicals to the air or change the ones that are already there. Energy from sunlight can make chemical reactions happen, changing one gas into another. Some chemicals move in cycles between the atmosphere, living creatures, and the oceans. The Carbon Cycle and the Nitrogen Cycles are two important cycles that change the chemistry of the atmosphere.

Chemical	Formula	Role in Tropospheric Chemistry
Carbon dioxide	CO_2	Carbon dioxide is a kind of greenhouse gas. When we breathe, we take in oxygen and breathe out carbon dioxide. Plants and some kinds of microbes use carbon dioxide during photosynthesis to make food. Burning fuels also puts carbon dioxide into the atmosphere.
Carbon monoxide	CO	When things burn, they mostly make carbon dioxide. Sometimes they make carbon monoxide, too. Carbon monoxide is a poisonous gas. Volcanoes and car engines make carbon monoxide.
Hydrocarbons	C_xO_y	Hydrocarbons are chemicals made up of hydrogen and carbon atoms. When fuel burns, it puts some hydrocarbons into the air. Hydrocarbons help to make smog, a kind of air pollution.
Methane	CH_4	Methane is a kind of greenhouse gas.
Nitrogen	N_2	Most of the gas in Earth's atmosphere is nitrogen. About 4/5ths of the air is nitrogen. The nitrogen cycle explains how nitrogen moves around in the environment. When fuel burns hot, like it does in the engine of a car, nitrogen combines with oxygen to make nitrogen oxides.
Nitrogen Oxides	NO & NO_2	Nitrogen oxides are a kind of pollution. Burning fuels like gasoline in air makes nitrogen oxides. Most nitrogen oxides come from cars and trucks. They help to make smog. They also mix with water droplets in the air to make nitric acid. Nitric acid is a part of acid rain.
Nitric Acid	HNO_3	Nitric acid is part of acid rain. Nitric acid forms when nitrogen oxides mix with water droplets in the air. Nitrogen oxides are a kind of pollution that comes from the engines of cars and trucks.
Oxygen & Ozone	O_2 & O_3	About 1/5th of the gas in the atmosphere is oxygen. When you breathe, your body uses the oxygen to keep you alive. Ozone is a special kind of oxygen that has three atoms instead of two.
PAN (Peroxyacytyl nitrate)	$C_2H_3O_5N$	PAN is a kind of air pollution. Smog has PAN in it. PAN forms when nitrogen dioxide, oxygen, and Volatile Organic Compounds (VOCs) get together.
Smog	-	Smog is a mixture of smoke and fog. Photochemical smog is a kind of air pollution. It has nitrogen oxides, ozone, VOCs, and PAN in it.
Photodissociation	-	When a photon of sunlight breaks apart a molecule.
Sulfur Oxides	SO_2 & SO_3	Sulfur dioxide and sulfur trioxide are types of pollution. People make them when we burn coal and oil. Volcanoes also give off sulfur oxides. Sulfur dioxide mixes with water droplets in the air to make sulfuric acid. Sulfuric acid is in acid rain.
Sulfuric Acid	H_2SO_4	Sulfuric acid is in acid rain. Sulfuric acid in the air is made when sulfur dioxide gas mixes with water droplets. The sulfur dioxide gas comes from volcanoes and from coal and oil that people burn for fuel.

Earth's Troposphere

Air Pollution Sources

Ozone in the Troposphere

Ozone peaks in urban areas during late afternoons.
Click on image for full size (23K)
Courtesy of UCAR

Did you know that ozone is found in two different layers of the atmosphere? You may have heard of the ozone hole problem - that is a lack of ozone in the stratosphere (the 2nd layer of the Earth's atomsphere). But ozone is also found in the troposphere, the first layer of the Earth's atmosphere. In the troposphere, ozone is NOT wanted! It can actually do a lot of damage.

Ozone is released naturally in the troposphere by plants and soil. These are such small amounts that they are not harmful to the health of humans, animals or the environment.

Ozone that increases because of certain human activities does become a problem at ground level and this is what we think of as 'bad' ozone. With increasing populations, more automobiles, and more industry (power plants and refineries in particular), there's more ozone in the lower atmosphere. Since 1900, the amount of ozone near the Earth's surface has more than doubled. In urban areas in the Northern Hemisphere, high ozone levels usually occur during the warm, sunny, summer months (from May through September). Typically, ozone levels reach their peak in mid to late afternoon, after the Sun has had time to react fully with the exhaust fumes from the morning rush hours. A hot, sunny, still day is the perfect environment for ozone pollution production. In early evening, the sunlight's intensity decreases and ground level ozone begins to decrease again.

When ozone pollution reaches high levels, pollution alerts are issued telling people with breathing problems to take extra precautions or to remain indoors. That's no fun! Smog can damage lung tissues, impair an athlete's performance, create more frequent attacks for individuals with asthma, cause eye irritation, chest pain, coughing, nausea, headaches and chest congestion. It can even worsen heart disease, bronchitis, and emphysema.

Studying air pollutants in Mexico City, the world's second largest city.

MILAGRO

Megacity Initiative: Local and Global Research Observations

Spanish English

Ozone in the Troposphere

Ozone peaks in urban areas during late afternoons.
Click on image for full size (23K)
Courtesy of UCAR

Did you know that ozone is found in two different layers of the atmosphere? You may have heard of the ozone hole problem - that is where ozone is missing in the stratosphere (the 2nd layer of the Earth's atomsphere). But ozone is also found in the troposphere, the first layer of the Earth's atmosphere. In the troposphere, ozone is NOT wanted! It can actually do a lot of damage.

Driving cars and burning fossil fuels (like coal and oil) produces more ozone in that first layer of the atmosphere. This is what we call 'bad' ozone!

It is bad because ozone helps create smog or pollution that can be harmful to people, animals and even plants! When ozone pollution reaches high levels, pollution alerts are put out telling people with breathing problems to stay inside. That's no fun! Smog can damage lung tissues, impair an athlete's performance, increase attacks for people with asthma, and give people headaches.

Rubber, cloth and certain paints may be damaged by ozone. Some elastic materials can become brittle and crack (take a look at old rubber bands!).

How do we help get rid of all of this "bad" ozone? You can help every day by choosing to take the bus or walk to

Ozone in the Troposphere

Ozone peaks in urban areas during late afternoons. Click on image for full size (23K)
Courtesy of UCAR

10% of the ozone in the Earth's atmosphere is found in the troposphere, the first layer of the Earth's atmosphere. In the troposphere, ozone is not wanted. Ozone is even more scarce in the troposphere than the stratosphere with concentrations of about 0.02 to 0.3 parts per million (ppm). But even in such small doses, this molecule can do a lot of damage.

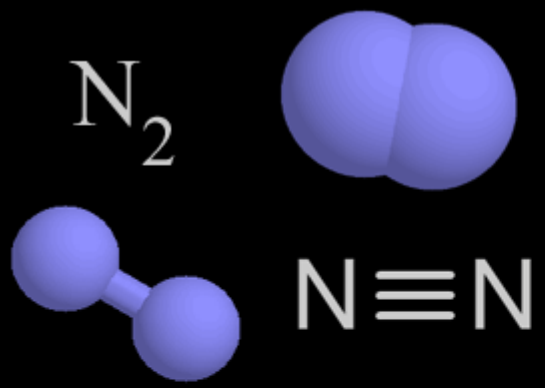
Ozone does occur naturally at ground-level in low concentrations. The two major sources of natural ground-level ozone are hydrocarbons, which are released by plants and soil, and small amounts of stratospheric ozone, which occasionally migrate down to the Earth's surface. Neither of these sources contributes enough ozone to be considered a threat to the health of humans or the environment.

Ozone that is a byproduct of certain human activities does become a problem at ground level and this is what we think of as 'bad' ozone. With increasing populations, more automobiles, and more industry, there's more ozone in the lower atmosphere. Since 1900, the amount of ozone near the Earth's surface has more than doubled. Unlike most other air pollutants, ozone is not directly emitted from any one source. Tropospheric ozone is formed by the interaction of sunlight, particularly ultraviolet light, with hydrocarbons and nitrogen oxides, which are emitted by automobiles, gasoline vapors, fossil fuel power plants, refineries, and certain other industries. In urban areas in the Northern Hemisphere, high ozone levels usually occur during the warm, sunny, summer months (from May through September). Typically, ozone levels reach their peak in mid to late afternoon, after the Sun has had time to react fully with the exhaust fumes from the morning rush hours. A hot, sunny, still day is the perfect environment for ozone pollution production. In early evening, the sunlight's intensity decreases and the photochemical production process that forms ground level ozone begins to subside.

When ozone pollution reaches high levels, pollution alerts are issued urging people with respiratory problems to take extra precautions or to remain indoors. Smog can damage respiratory tissues through inhalation. Ozone has been linked to tissue decay, the promotion of scar tissue formation, and cell damage by oxidation. It can impair an athlete's performance, create more frequent attacks for individuals with asthma, cause eye irritation, chest pain, coughing, nausea, headaches and chest congestion. It can worsen heart disease, bronchitis, and emphysema.

Rubber, textile dyes, fibers, and certain paints may be weakened or damaged by exposure to ozone. Some elastic materials can become brittle and crack, while paints

Nitrogen



There is more nitrogen gas in the air than any other kind of gas. About 4/5ths of Earth's atm

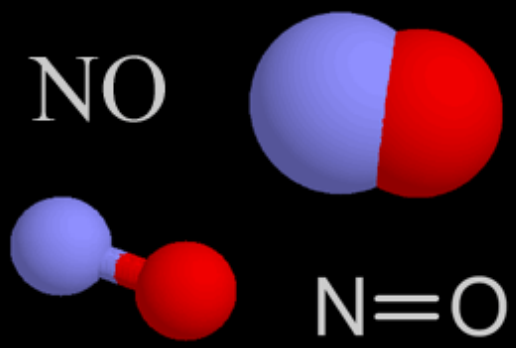
A molecule of nitrogen gas is made up of two nitrogen atoms. Some other kinds of importan them, too.

Nitric oxide (NO) and nitrogen dioxide (NO_2) are molecules that have nitrogen atoms in ther cause air pollution. They are made in the engines of cars and other places. They also help m help make peroxyacetyl nitrate (PAN), which is a nasty chemical in smog. They also help ma acid rain.

Nitrogen atoms are important parts of living creatures. The Nitrogen Cycle explains how nitr environment, including living things like you and me!

Here are four different ways chemists use to show a molecule of nitrogen. In colored molecule models like these, nitrogen is usually blue.
Click on image for full size (20 Kb GIF)
Windows to the Universe original artwork by Randy Russell.

Nitrogen oxides - Nitric oxide (NO) & Nitrogen dioxide (NO_2)



Here are four different ways chemists use to show a molecule of nitric oxide. In the colored molecule models, nitrogen is blue and oxygen is red.
Click on image for full size (19 Kb GIF)
Windows to the Universe original artwork by Randy Russell.

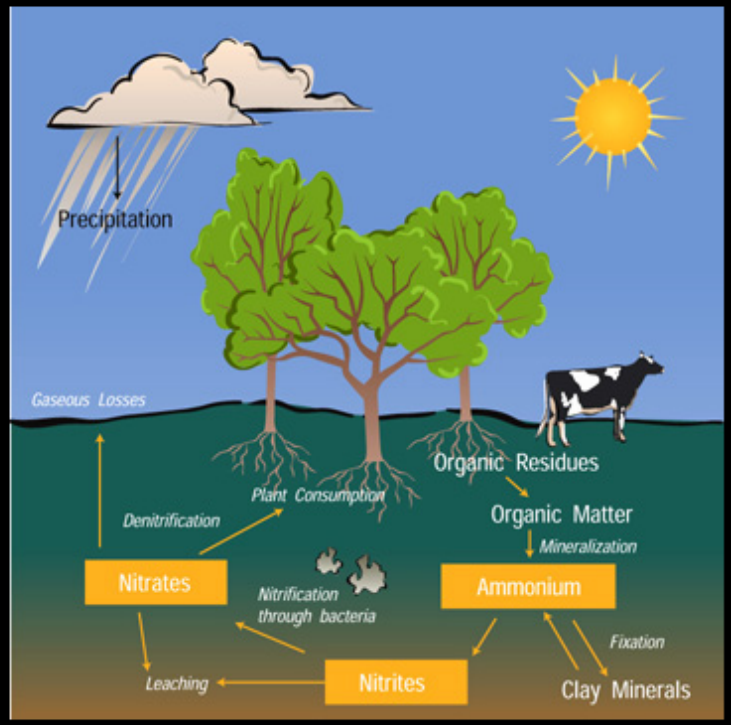
Nitric oxide (NO) and nitrogen dioxide (NO_2) are the names of two kinds of gases. Together, they are called nitrogen oxides. Nitrogen oxide molecules have nitrogen and oxygen atoms in them.

Nitrogen oxides help cause some kinds of air pollution. Nitrogen dioxide combines with other chemicals to make smog. It also combines with water droplets in the air to make nitric acid. Nitric acid is one of the kinds of acid in acid rain

Where do nitrogen oxides come from? Volcanoes and lightning make some of the nitrogen oxides in Earth's atmosphere. Humans make lots of nitrogen oxides, too. When fuel burns, nitrogen in the air combines with oxygen to make nitrogen oxides. The engines of cars, trucks, and buses make lots of nitrogen oxides.

Nitrogen oxides are not all bad. Humans use nitric oxide to make nitric acid. Nitric acid is used to make fertilizer and some kinds of explosives!

The Nitrogen Cycle



The illustration above shows how nitrogen travels through the living and non-living parts of the Earth system.
Click on image for full size (190)
NCAR

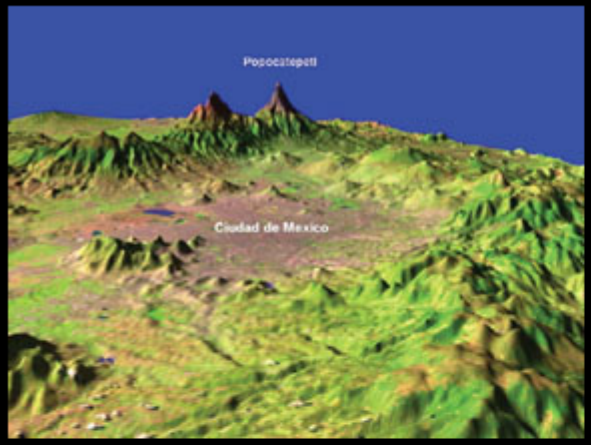
Nitrogen is an element. It is found in living things like plants and animals. It is also an important part of non-living things like the air above and the dirt below. Atoms of nitrogen don't just stay in one place. They move slowly between living things, dead things, the air, soil and water. These movements are called the **nitrogen cycle**.

Most of the nitrogen on Earth is in the atmosphere. Approximately 80% of the molecules in Earth's atmosphere are made of two nitrogen atoms bonded together (N_2). All plants and animals need nitrogen to make amino acids, proteins and DNA, but the nitrogen in the atmosphere is not in a form that they can use. The molecules of nitrogen in the atmosphere can become usable for living things when they are broken apart during lightning strikes or fires, by certain types of bacteria, or by bacteria associated with bean plants.

Most plants get the nitrogen they need to grow from the soils or water in which they live. Animals get the nitrogen they need by eating plants or other animals that contain nitrogen. When organisms die, their bodies decompose bringing the nitrogen into soil on land or into ocean water. Bacteria alter the nitrogen into a form that plants are able to use. Other types of bacteria are able to change nitrogen dissolved in waterways into a form that allows it to return to the atmosphere.

Certain actions of humans are causing changes to the nitrogen cycle and the amount of nitrogen that is stored in the land, water, air, and organisms. The use of nitrogen-rich fertilizers can add too much nitrogen in nearby waterways as the fertilizer washes into streams and ponds. The waste associated with livestock

Milagro Campaign - For Educators!



This is a computer generated 3-D rendering of the landscape surrounding Mexico City. Click on image for full size (105 Kb)

- Age-Appropriate Windows to the Universe Activities on Climate, Atmosphere and Weather
- Earth 911 Teachers' Section
- Educational Materials from the EPA
- Air Pollution - What's the Solution? A 6-12 Educational Project
- Outreach and Education on Air Quality, Climate Change, and Transportation: Youth Initiatives
- Teacher's Guide – Urban Explosion

Teacher Resources - Activities - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://www.windows.ucar.edu/tour/link=/teacher_resources/main/activity.html

Go

Studying air pollutants in Mexico City, the world's second largest city.

MILAGRO

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Megacity Initiative: Local and Global Research Observations

Spanish English

About MILAGRO | Air Pollution | Effects on Us | People | Field Reports | Research Results | Kids! | Educators | Links | Gallery

Windows to the Universe

Beginner | Intermediate | Advanced

Windows to the Universe

Lesson Plans and Activities for the Classroom

www.windows.ucar.edu

Intermediate Level

Welcome educators!

Click the topics to the right to find hands-on activites for your classroom that relate to Windows to the Universe content. Some of the activities in this section were developed by our team of content developers and expert teachers. Others are ones that we use and recommend.

These activities are appropriate (or could be easily adapted) for middle school (i.e.

Find activities about...

Science and Literacy

Our Solar System

Atmosphere and Weather

Geology and Geography

Climate, Water, and Life

Sun and Spaceweather

Physics and Chemistry

Climate, Water, and Life

- Climate and Global Change
  - Using the Carbon Cycle Interactive Game in the Classroom Through an online game, students learn how carbon cycles through the Earth system
  - Carbon Dioxide - Sources and Sinks Experiment with the carbon cycle!
  - Thermal Expansion and Sea Level Rise Discover how thermal expansion of water might affect sea level!
  - Mapping Ancient Coastlines Explore bathymetric contour lines and sea level change!
  - Paleoclimates and Pollen Conduct a classroom paleoclimate study!
  - Making Sedimentary Rocks! Students make a model of sedimentary rock layers to understand how rocks form layers and represent ancient environments.
  - The Geography of Land Planning Students plan towns and learn how planning affects the environment and the larger community.
  - The Difference Between Weather and Climate Students graph weather and climate data to learn the difference
  - Natural Records of Climate Change: Working With Indirect Evidence Students play a game to learn about indirect evidence, like those that record ancient climate changes.
  - Living During the Little Ice Age Discover how modest climatic cooling changed life for Europeans during the Little Ice Age
  - Where Have All the Glaciers Gone? compare "then and now" photographs to see how much glaciers have changed over the last century.
  - Graphing Sea Ice Extent in the Arctic and Antarctic Check the pulse of the seasons, compare opposite hemispheres, and see whether long-term trends in ice cover are changing as global temperatures rise.
  - Trees: Recorders of Climate Change Collect and analyse tree ring data to discover when the Little Ice Age occured.
  - Blooming Thermometers A graphing activity that allows students to discover how the timing of blooming has changed as climate changed
  - Sunspots and Climate Students investigate data to discover how Earth's climate is affected by changing quantities of sunspots.
  - Dark Skies: Volcanic Contributions to Climate Change Discover how volcanoes can alter the Earth's climate
  - The Little Ice Age Students investigate multiple pieces of data to learn about the Little Ice Age
  - Albedo and Earth's Energy Cycle Students investigate how color affects heat absorption
- Water
  - Build a Model Watershed
  - Exploring Density of Salt and Fresh Water: Par 5 A fun activity that involves the interaction between fresh water and salt water
  - Thermal Expansion and Sea Level Rise Discover how thermal expansion of water might affect sea level!
  - Mapping Ancient Coastlines Explore bathymetric contour lines and sea level change!
  - Graphing Sea Ice Extent in the Arctic and Antarctic Check the pulse of the seasons, compare opposite hemispheres, and see whether long-term trends in ice cover are changing as global temperatures rise.

Title:	**Traveling Nitrogen**
Summary:	Students play the role of nitrogen atoms traveling through the nitrogen cycle to gain understanding of the varied pathways through the cycle and the relevance of nitrogen to living things.
Source:	*Windows Original*
Grade level:	5-9
Time:	15 minutes prep time In class: 30-minute activity plus optional 20 minutes for assessment
Student Learning Outcomes:	• Students will learn that nitrogen cycles indefinitely through the Earth system and will understand the places that it is found on Earth. • Students understand that nitrogen is essential for living things. • Students will learn that the cycle is complex and nonlinear traveling between organisms and the physical environment.
Lesson format:	Non-competitive game and writing or drawing assessment
National Standards Addressed:	• 5-8 Content Standard D: Structure of the Earth System • 5-8 Content Standard C: Populations and Ecosystems • 9-12 Content Standard C: Interdependence of Organisms • 9-12 Content Standard D: Geochemical Cycles • Benchmarks: 5A/5 and 5E/2

MATERIALS AND WORKSHEETS:

- 11 dice
- *Dice Codes* for each reservoir station (print attached)
- 11 large signs with the reservoir names posted around the classroom or outside
- 11 different small rubber stamps

MILAGRO News

Postcards from the Field MILAGRO

Postcards from the Field from numerous researchers and teachers participating in the MILAGRO campaign can be accessed from the links postcards are given first, followed by links to lists of postcards sorted by submitter name or submission date. To find out more about the pe their name to reach a brief biography that explains who they are and what they're doing on the campaign.

Recent Postcards

- Peroxides Measured at the T1 Site from Judy Lloyd, March 29, 2006
- What does Tecamac mean? from Oscar Peralta, March 24, 2006
- Fire nearby T1 from Oscar Peralta, March 23, 2006
- Pollutants on the Ground from David Greenberg, March 22, 2006
- Map of Mexico City from Dara Salcedo, March 20, 2006

Postcards from the Field MILAGRO

Postcards by Name

Chris Cantrell

- 3/4/2006 First local C-130 flight from Veracruz
- 3/10/2006 Another C-130 flight over Mexico
- 3/10/2006 Instrument comparison in flight
- 3/15/2006 Ruins at Zempoala

David Greenberg

- 3/4/2006 Launching Our First Balloon
- 3/6/2006 Balloon Launch!
- 3/9/2006 Short Flight

Dr. Dara Salcedo

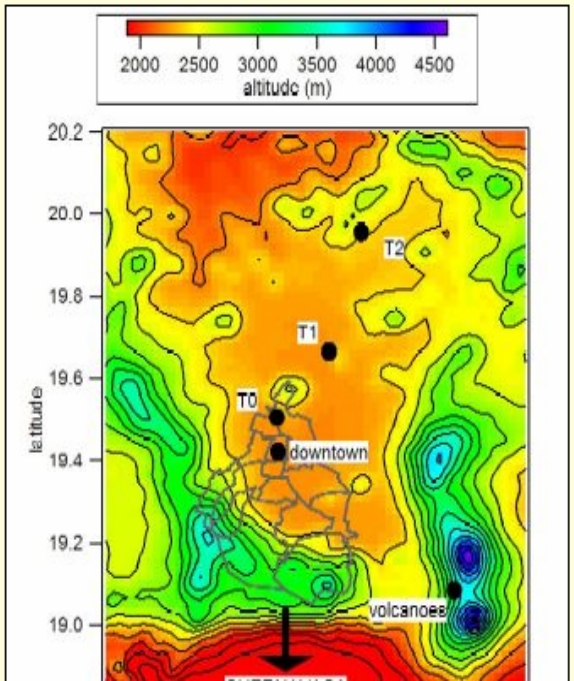
I am originally from Mexico City were I grew up and eventually got my Bachelor's degr college, I had many questions about molecules, reactions, colors, substances, and I t be answered in my classes. Soon, I realized that every time a question was answere By the time I got my degree, I knew that doing science to answer questions is a never Cambridge, MA to get my PhD. I chose the field of Atmospheric Chemistry because understand the environment. Also, I like to think that the research I do will be useful fo that will protect our health and environment. Now, I live in Cuernavaca, a city south fro city of the eternal spring" because it has a very mild weather and you can always find

During MILAGRO, I will be at T0 measuring particles. The objective is to learn about t and to deduce their history (where they were emitted and how they were transformed do the latter without the help of other colleagues measuring gases, temperature, wind about the MILAGRO project: every research group is doing a different measurement; together will be able to understand air pollution better (like pieces of a puzzle that form

When I am not doing science, I enjoy to be at home, cooking, hiking and going to the husband and we use every opportunity we have. This photo was taken last year in Sidney, Australia. Next April, we are going to visit some deserved trip after all the hard work in March during MILAGRO).

Postcards from the Field

MILAGRO



From: Dara Salcedo

T0, March 20, 2006

Map of Mexico City

Here is a map of the Valley of Mexico, where Mexico City is situated. As you can see, Mexico City is surrounded by mountains in the south, east and west, which is very unfortunate because the mountains make it very difficult for the wind to vent the city. Hence, all the emissions from cars and industries are trapped within the valley and air pollution can reach very high levels.

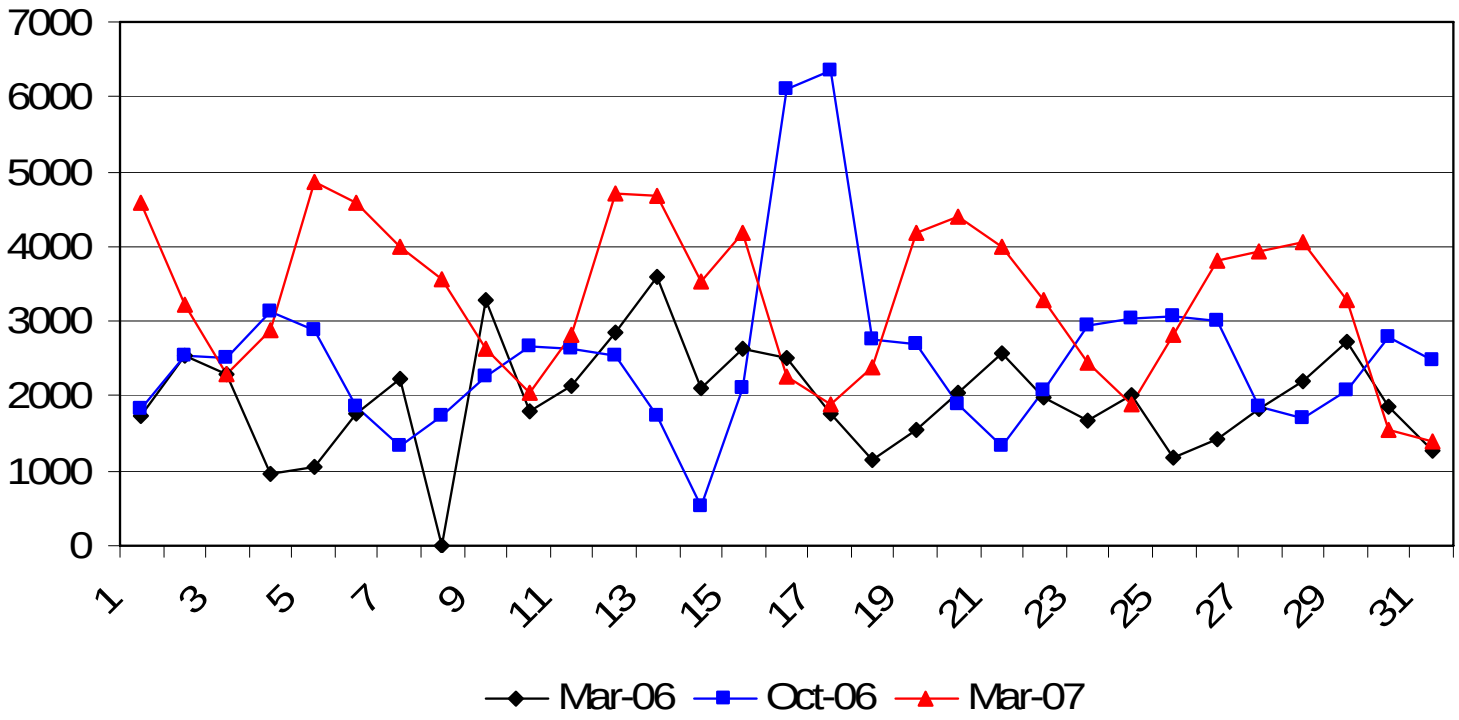
Towards the south, on the other side of the mountains, is Cuernavaca, where I live.

Air Pollution Sources

Some metrics

- Since 1 March, 2006:
  - over 400,000 sessions
  - 863,000 page views

Page Views to MILAGRO Portal per day



By-Products of MILAGRO EO Effort

- Spontaneous teacher workshop in Veracruz
- Daily student visits to operations center during the campaign, >500 students
- Invitation to present at the Mexican Science Teachers convention last fall in Puebla
- Participation of 6 Veracruz teachers in NCAR workshop last fall in Boulder – first sight of snow!
- MOU for collaboration with Veracruz Sub-Secretary for Education
- Expansion of Postcards from the Field to other topics
- Participation in upcoming AGU GIFT workshop in Acapulco next month

For more information

- Contact Roberta Johnson at rmjohnsn@ucar.edu
- Register for newsletter (free!) at http://www.windows.ucar.edu/cgi-bin/registration/registration.pl