Public Health Impacts

Selected Earth System Science Applications in the Western Hemisphere

Public health is impacted by the dynamics of the Earth system that connect land masses, oceans, and the atmosphere. This poster provides examples from throughout the Western Hemisphere that illustrate a variety of harmful exposures, including infectious diseases, chemical toxic agents, increased ultraviolet radiation, flooding, dust, and ash. Public health therefore needs to be incorporated into education on Earth system science applications. This will enable Earth system scientists and public health specialists to take advantage of a growing understanding of the Earth system in order to better protect the public's health in a changing world.

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Dust and Ash Plumes in Southern California Wildfires

Wildfires spread in Southern California in October 2003 as dry, hot winds blew into dry foliage. The fires burned over 750,000 acres, claimed 24 lives and caused over 200 injures, while destroying over 3,600 homes and leaving over 3,000 families homeless. The Federal Emergency Management Agency declared federal disaster areas in five counties: Los Angeles, Riverside, San Bernardino, San Diego, and Ventura.

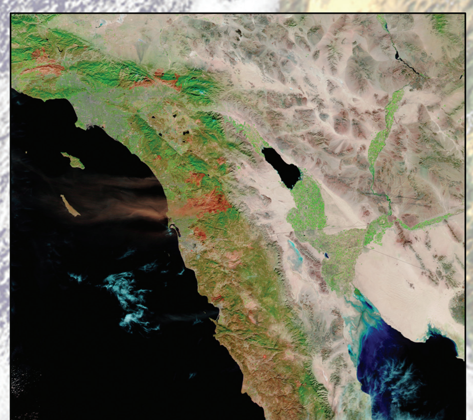
The wildfires generated dust and ash (see figure), which threatened respiratory health, especially for the most vulnerable individuals with preexisting respiratory conditions, such as asthma and chronic bronchitis. Particulates from the burn areas remained airborne for months after the fires, a challenging problem for air quality in southern California.

Cassmassi J. 2004. Air quality forecasting during the Southern California wildfires. 2004 National Air Quality Conference: Your Forecast to Breathe By, February 22 -25, 2004, Baltimore, Maryland. http://www.epa.gov/airnow/2004conference/tuesday/cassmassi_technical.ppt

Federal Emergency Management Agency. 2004. Declared Disasters. California Wildfires Declared October 27, 2003. http://www.fema.gov/news/event.fema?id=2543

National Aeronautics and Space Administration (NASA)/Goddard Space Flight Center (GSFC). 2003. Southern California fires continue. Oct. 31, 2003. http://www.gsfc.nasa.gov/topstory/2003/1031cafires.html

Zucker M. 2001. Wildfires threaten respiratory health. Pulmonary Reviews 6 (8) http://www.pulmonaryreviews.com/aug01/pr_aug01_wildfires.html



October's massive wildfires in Southern California stripped the ground of the vegetation that holds soil in place. The freshly exposed surface and the overlying ashes are vulnerable to winds, as this false color Moderate Resolution Imaging Spectroradiometer (MODIS) image shows. Here, a red plume of dust and ash is blowing over the Pacific Ocean and San Clemente Island. In this image, newly burned areas appear red while vegetation is green, water is black, and clouds are light blue. The dust is clearly coming from the burn scar left by the Cedar fire near San Diego. The Terra satellite captured this image on November 27, 2003.

Source: Jacques Descloitres, MODIS Rapid Response Team, NASA/GSFC. http://visibleearth.nasa.gov/cgi-bin/viewrecord?26153

Transport of Soil Dust and Microbes from Africa to the Caribbean

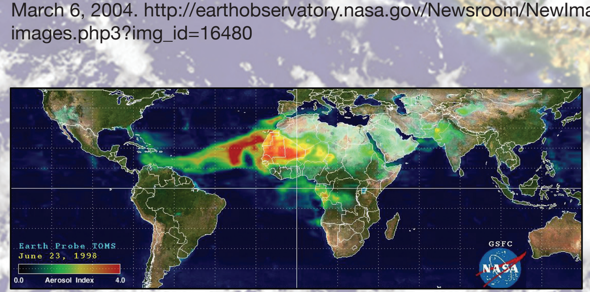
Satellite imagery has confirmed that trade winds carry soil dust from Africa across the Atlantic Ocean to the Caribbean, flowing from the southern to the northern islands and even into the southeastern United States (see figure). Biological studies have shown that the dust contains viable microbes similar to those found in West Africa.

The impact of this dust on people and ecosystems is under active investigation. Iron and other minerals in African dust appear to fertilize the growth of ocean plants. Retrospective studies have linked peaks in African dust to the occurrence of events of coral bleaching and disease outbreaks in reef species. Over the course of a few decades, the transport of African dust has increased as has the incidence of asthma in the Caribbean. However, a more detailed study of daily samples of African dust in Barbados failed to find a correlation with asthma cases recorded at the local hospital emergency room.

Blades E. 2003. The transport of soil dust and microbes from Africa and their relationship to asthma in Barbados. In: Climate Variability and Change and their Health Effects in the Caribbean (Aron JL, Corvalan CF, Philippeaux H, eds.), May 21 – 25, 2002, St. Philip, Barbados, West Indies, World Health Organization (WHO), Geneva. http://chiex.net/publications_2003.htm

Kellogg C. 2003. Characterization of microbial communities associated with African desert dust and their implications for global human and ecosystem health. In: Climate Variability and Change and their Health Effects in the Caribbean (Aron JL, Corvalan CF, Philippeaux H, eds.), May 21 – 25, 2002, St. Philip, Barbados, West Indies, WHO, Geneva.. http://chiex.net/publications_2003.htm

NASA Earth Observatory. 2004. African dust blows over the Atlantic. March 6, 2004. http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=16480



Earth Probe TOMS Aerosol Index for June 23, 1998, showing African dust being transported westward over the Atlantic Ocean, extending as far west as the Caribbean Islands and even into Florida.

Source: Dave Larko, Ozone Processing Team, NASA/GSFC.

Dispersal of Chemical Pollutants in the Arctic Ecosystem

The Arctic ecosystem receives many chemical pollutants through long-range dispersal from more southern regions of the world. These pollutants not only persist in cold temperatures but also bioaccumulate in lipid tissue as they move up the food chain. As an example, a study of Arctic marine mammals revealed the distribution of organochlorine contaminants derived from various pesticides and industrial chemicals (see figure). Humans are exposed to these toxic substances when consuming wild game.

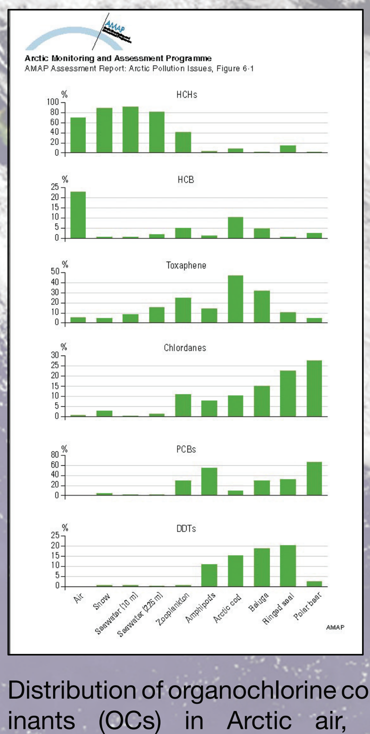
Concerns about pollution are set in a broader context of Arctic environmental change. Two important factors are rising temperatures, which alter the distribution of animal species and interfere with surface transportation over frozen tundra, and the depletion of the stratospheric ozone layer. Global change issues in the Arctic are addressed by the Arctic Council, which is an intergovernmental forum of eight Arctic Rim nations: Canada, Denmark, Finland, Iceland, Norway, the Russian Federation, Sweden, and the United States of America.

Arctic Monitoring and Assessment Program (AMAP). 2003. AMAP Assessment 2002: Human Health in the Arctic. AMAP, Oslo, Norway. http://www.amap.no

AMAP. 2003. AMAP Assessment 2002: The Influence of Global Change on Contaminant Pathways to, within, and from the Arctic. AMAP, Oslo, Norway. http://www.amap.no

AMAP. 2004. AMAP Assessment 2002: Persistent Organic Pollutants in the Arctic. AMAP, Oslo, Norway. http://www.amap.no

Corell RW. 2004. Arctic Climate Impact Assessment. Testimony to the United States Senate Committee on Commerce, Science, and Transportation. March 3, 2004. http://www.acia.uaf.edu



Distribution of organochlorine contaminants (OCs) in Arctic air, snow, seawater, and the marine mammals food chain. Data for the six major classes of OCs are plotted for each compartment or species as the percent of OCs in that compartment or species to demonstrate the changing importance of residue classes in the process of transfer between compartments and bioaccumulation in the marine mammals food chain.

Source: AMAP. 1998. AMAP Assessment Report. Arctic Pollution Issues. AMAP, Oslo, Norway. AAR Figure 6.1 from Norstrom RJ, Muir DCG. 1994. Chlorinated hydrocarbon contaminants in Arctic marine mammals. Sci Total Environ http://www.amap.no

Fish Kill in Southeast Caribbean Linked to Heavy Rainfall in Northern South America

A massive kill among reef fish occurred in the Southeast Caribbean from Trinidad and Tobago to Barbados during the period of July to October in 1999 (see figure). A freshwater bacterium, *Streptococcus iniae*, was isolated from dead and dying fish collected in Barbados. The explanation for these deaths is tied to the rainfall in northern South America, which was unusually heavy during that time period. Satellite imagery showed large quantities of fresh water from the Amazon and Orinoco river basins flowing into the Southeast Caribbean in the form of retroflection eddies, thus causing lower salinities, higher temperatures, and reverse currents.

Pan American Health Organization (PAHO). 2000. Fish mortality in southeastern Caribbean countries. PAHO Epidemiological Bulletin 21 (2). http://www.paho.org/english/sha/be_v21n2-fish.htm

Siung-Chang AM. 2003. Unusual climatic conditions associated with mass fish mortalities in the Southeast Caribbean from Trinidad and Tobago to Barbados, during the period July to October, 1999. In: Climate Variability and Change and their Health Effects in the Caribbean (Aron JL, Corvalan CF, Philippeaux H, eds.), May 21 – 25, 2002, St. Philip, Barbados, West Indies, WHO, Geneva. http://chiex.net/publications_2003.htm

Dead fish collected in southeastern Caribbean during massive fish kill in 1999: 1. Spotlight parrotfish: *Sparisoma viride*; 2. Bermuda chub: *Kyphosus sectatrix*.

Source: Avril M. Siung-Chang, PAHO, Port of Spain, Trinidad and Tobago.

Ozone Hole Over the South Pole Reaches South America

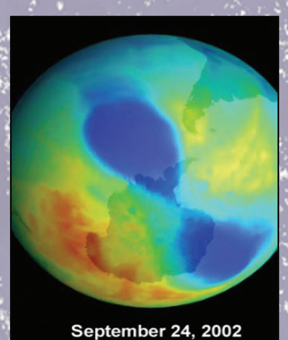
The stratospheric ozone layer over the South Pole becomes dramatically thinner during September and October, the austral spring. This is the 'ozone hole', which is caused by the interaction of industrial chemicals (chlorofluorocarbons) and the very cold temperatures. Weather conditions affect its size, which fluctuates from year to year (see figures).

A thinner ozone layer permits more ultraviolet radiation-B (UV-B) to reach the surface of the Earth. Increased exposure to UV-B increases the risk of skin cancer, cataracts, and a suppressed immune system. The ozone hole has reached populated areas in southern Chile and Argentina. Health authorities advise the local populations to limit exposure to the sun during those days when the ozone layer is thin. Excessive UV-B exposure can also damage terrestrial plant life and aquatic ecosystems.

Lloyd SA. 2001. The changing chemistry of Earth's atmosphere. In: Ecosystem Change and Public Health: A Global Perspective (Aron JL, Patz JA, eds.). Johns Hopkins University Press, Baltimore, Maryland.

United Nations Environment Programme (UNEP). 2003. Environmental Effects of Ozone Depletion and its Interactions with Climate Change: 2002 Assessment. UNEP, Nairobi, Kenya. http://www.unep.org/ozone/

World Meteorological Organization (WMO). 2003. Scientific Assessment of Ozone Depletion: 2002. WMO Global Ozone and Research Monitoring Project. Report No. 47. WMO, Geneva. http://www.unep.org/ozone



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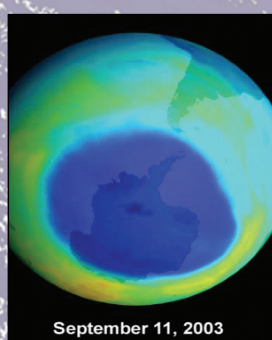


September 11, 2003

In 2003, colder temperatures and calmer winds allowed chemical reactions that break down ozone to occur at about the same time as in previous years. However, unusually moderate Antarctic temperatures and highly variable upper atmosphere winds in 2002 kept the ozone 'hole' relatively small, about 40% smaller in area than the record sizes seen in 2000, 2001, and 2003. In 2002, the 'hole' also split into two parts for the first time since 1979, also due to unusual weather patterns. These comparisons pit the near-record size of the 2003 'hole' against 1) the small area of the 2002 hole and 2) the split shape from 2002. Data from TOMS-EP.

Source: NASA/GSFC. 2003 ozone 'hole' approaches, but falls short of record. Sept. 25, 2003. http://www.gsfc.nasa.gov/topstory/2003/0925ozonehole.html

Heavy Rainfall in Western South America Caused by El Niño Phenomenon

The El Niño phenomenon is part of the El Niño/Southern Oscillation (ENSO), which produces warming and cooling of the equatorial Pacific Ocean and associated fluctuations in atmospheric pressure every two to seven years. ENSO is the largest influence on global climate variability on a seasonal to interannual time scale.

A major ENSO event occurred in 1997-1998. The northern coastal zone of Peru received unusually heavy rains and suffered major flooding (see figure). The transmission of malaria and cholera in the area increased. The heavy rainfall also affected Ecuador, whose coastal provinces became partially isolated from the rest of the country and experienced increased transmission of several diseases.

Fisher GW. 2001. An earth science perspective on global change. In: Ecosystem Change and Public Health: A Global Perspective (Aron JL, Patz JA, eds.). Johns Hopkins University Press, Baltimore, Maryland.

International Research Institute for Climate Prediction. 2004. ENSO Web. http://iri.columbia.edu/climate/ENSO/index.html

PAHO. 2004. Impact of El Niño on Water and Sewerage Infrastructure. Experience from Ecuador 1997-1998 (in Spanish). PAHO, Washington DC. http://www.cepis.org.pe/bvsade/pub/elnino/elnino.html

WHO. 2004. Global Environmental Change and Health. Publications. http://www.who.int/globalchange/publications/

Flooding in northern coastal Peru in 1998 during "El Niño."

Source: Palmira Ventosilla, Instituto de Medicina Tropical, Universidad Peruana Cayetano Heredia, Lima, Peru.

Deforestation and a Rise in Malaria Incidence in Para State in Amazonian Brazil

The Castanhal municipality in Para State in Amazonian Brazil lost much of its dense forest during the period 1984 to 2002 (see figures). The land was being developed rapidly, especially through cattle ranching. This process was associated with a dramatic increase in cases of malaria in the mid-1990s.

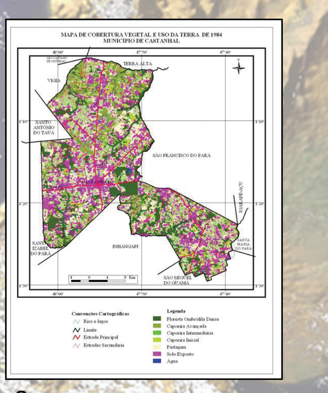
Deforestation in the Amazonian region is also of interest for a variety of global change issues. Deforestation affects the global carbon cycle, which influences global climate through its connections to the global energy cycle and the global water cycle. On a smaller scale, a study in Rondonia State in Amazonian Brazil found that a deforested region experienced higher rainfall and warmer temperatures.

Aron JL, Shiff CJ, Buck AA. 2001. Malaria and global ecosystem change. In: Ecosystem Change and Public Health: A Global Perspective (Aron JL, Patz JA, eds.). Johns Hopkins University Press, Baltimore, Maryland.

Confalonieri UEC. 2004. Climate variability and human health impacts in Brazil. Research. Climate and Health Information Exchange http://chiex.net

NASA Earth Observatory. 2004. Tropical deforestation. Deforestation and the global carbon cycle. http://earthobservatory.nasa.gov/Library/Deforestation/deforestation_3.html

NASA/GSFC. 2004. NASA data shows deforestation affects climate in the Amazon. June 9, 2004. http://www.gsfc.nasa.gov/topstory/2004/0603amazondry.html



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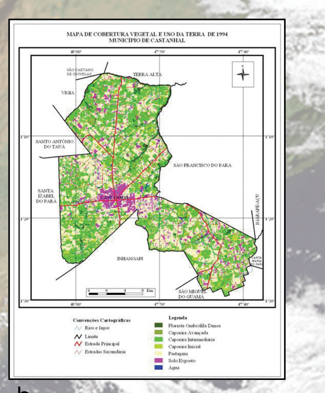

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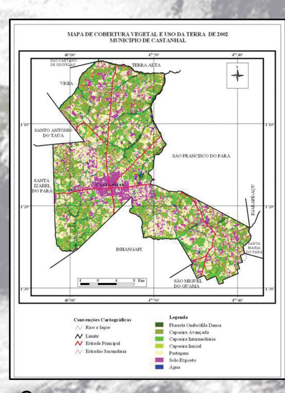

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Landsat MSS images of the land cover classification of Castanhal municipality in Para State in Amazonian Brazil: a) July 27, 1984; b) June 21, 1994; c) September 7, 2002. The land cover shows a loss of dense forest and an increase in secondary growth and pasture. The Portuguese categories in the classification correspond to dense forest, secondary growth (initial, intermediate, advanced), pasture, exposed soil, and water.

Source: Ulisses E. C. Confalonieri, Oswaldo Cruz Foundation, Rio de Janeiro, Brazil.

Poster visual design by Ryan Byrnes of USRA. Image of Western Hemisphere is *Earth—The Blue Marble* from NASA's Visible Earth (VE Record ID 557), created by Reto Stockli with the help of Alan Nelson, under the leadership of Fritz Hasler.