FactSheet

National Aeronautics and
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Biomass Burning: A Hot Issue in Global Change

Biomass burning is the burning of living and dead vegetation. It includes the human-initiated burning of vegetation for land clearing and land-use change as well as natural, lightning-induced fires. Scientists estimate that humans are responsible for about 90% of biomass burning with only a small percentage of natural fires contributing to the total amount of vegetation burned.

Burning vegetation releases large amounts of particulates (solid carbon combustion particles) and gases, including greenhouse gases that help warm the Earth. Greenhouse gases may lead to an increased warming of the Earth or human-initiated global climate change. Studies suggest that biomass burning has increased on a global scale over the last 100 years, and computer calculations indicate that a hotter Earth resulting from global warming will lead to more frequent and larger fires. Biomass burning particulates impact climate and can also affect human health when they are inhaled, causing respiratory problems (Fig. 1).

Fig. 1 Ground-level view of burning savanna grasslands in South Africa. Greenhouse gas carbon dioxide and solid carbon soot particulates are components of the emissions. When inhaled, the particulates lead to respiratory problems.

Since fires produce carbon dioxide, a major greenhouse gas, biomass burning emissions significantly influence the Earth's atmosphere and climate. Biomass burning has both short- and long-term impacts on the environment. Vegetation acts as a sink—a natural storage area—for carbon dioxide by storing it over time through the process of photosynthesis. As burning occurs, it can release hundreds of years worth of stored carbon dioxide into the atmosphere in a matter of hours. Burning also will permanently destroy an important sink for carbon dioxide if the vegetation is not replaced.

What is the annual, global amount of greenhouse gases that are released into the atmosphere due to biomass burning? How does biomass burning impact the Earth's atmosphere and climate? Researchers involved in the Biomass Burning Program at NASA Langley Research Center are currently working to answer these questions. The major goal of this research is to quantify the effects of global fires on the composition and chemistry of the atmosphere and the Earth's climate.

Field experiments

From 1986-1993, Langley scientists conducted 12 field experiments from aircraft to measure the amount of gases and particulates from fires in six different ecosystems. Measurements were taken during chaparral fires in California (1986, 87), wetland fires in Florida (1987, 88), boreal forest fires in Canada (1987, 88, 89, 90), tropical rainforest fires in Mexico (1990, 91), savanna grassland fires in South Africa (1992), and boreal forest fires in Siberia (1993).

Langley scientists also studied the southeast Asia fires in 1997. These fires were unique since they involved both the burning of above-ground vegetation and below-ground peat—a form of coal. Smoldering peat produces more gases and particulates than burning vegetation per unit area. These fires covered an area of more than 45,000 square kilometers—an area comparable to the combined area of Rhode Island, Delaware, Connecticut, and New Jersey. The fire's thick smog cloud covered almost all of southeastern Asia, resulting in more than 20 million cases of smog-related health problems. Gases and particulates produced during the 1997 fires were measured as far away as Hawaii.

From these field experiments, scientists measured greenhouse gases (carbon dioxide, methane, and nitrous oxide), chemically active gases (carbon monoxide and nitric oxide), and particulates from diverse ecosystems. This research showed how the production of gases and particulates from fires varies with the type of ecosystem burned, the fire's characteristics, and the vegetation's moisture content. As a result of these measurements, Langley researchers developed a fire combustion model to determine emissions from each ecosystem based on fire temperature. Knowing the amount of emissions is important for accurate estimates of the environmental impacts of these greenhouse gases. In addition, this model is useful for determining the contribution of biomass burning to the total production of greenhouse gases, a requirement for the Kyoto Treaty. This international treaty limits the amount of greenhouse gas emissions of certain industrialized nations.

Researchers also discovered that bacteria in soil enhance production of the greenhouse gas nitrous oxide. Nitrification is a biological process where bacteria convert ammonium, found naturally in soil and also in fire ash, to nitric oxide and nitrous oxide. They believe that the increased concentrations of ammonium in the ash lead to more nitrification after a fire, thereby releasing additional nitric oxide and nitrous oxide. The amount of these gases produced by bacteria after a fire may surpass the amount released during biomass burning.

Space measurements

The only way to accurately determine the exact location and extent of fires is to have a global perspective from space, making space-based measurements extremely important. Since no satellite has ever been dedicated to fire monitoring and measuring, most observations of fires from space are obtained from existing satellites developed for other purposes. Astronauts also photograph fires from the Space Shuttle (Fig. 2). Fire measurements come from the Defense Meteorological Satellite Program (DMSP) satellites and the Advanced Very High Resolution Radiometer (AVHRR) on the National Oceanic and Atmospheric Administration (NOAA) satellites. DMSP nighttime images provide

Fig. 2 Burning of savanna grasslands in Mozambique in southern Africa as photographed by astronauts aboard the Space Shuttle. The fire plumes containing particulates and gases travel thousands of kilometers from their origin.

information about the location and frequency of active fires, while AVHRR satellites can help determine the size of the area burned. Remote sensing of global fires indicates that Africa is the "fire center" of the planet with more biomass consumed by fire in Africa than anywhere else on Earth (Fig. 3).

Future research

The year 2000 was one of the worst fire years ever recorded in the United States. As of November 14, 2000, a total of 90,674 wildfires burned 7.26 million acres across the United States as compared to the previous ten-year average (1990-1999) of 3.79 million acres burned. On one day, August 29, 2000, 84 large fires (100 acres or more) were burning simultaneously. Total fire suppression cost in 2000 was about $1.6 billion, making fire monitoring an important social, health, economic, and national security concern.

Scientists are continuing to develop new instruments for measuring and monitoring fire from aircraft and spacecraft. This research will help assess the impact of fire-produced gases and particulates on atmospheric composition and chemistry and on climate. In August 2000 and January 2001, researchers set controlled fires at the Langley Impact Dynamics Research Facility to test new fire monitoring and measurement instrumentation that will eventually help researchers study global fires (Fig. 4 and Fig. 5). Tests like these will support the Interagency Agreement signed in November 2000 between NASA Langley Research Center and the United States Department of Agriculture Forest Service.

In this partnership, NASA Langley will develop instruments for the remote sensing of fires to be flown on aircraft by the Forest Service. Instruments will monitor active fires, measure fire temperature and the area burned, and provide an exact geographical location of a fire. Information from these instruments will also help fire fighters more efficiently and economically plan how to control and fight fires. The fire monitoring instrumentation will provide information about the fire to the ground in real time, giving fire fighters an unique and comprehensive perspective to help meet the growing demands of fire control in the United States.

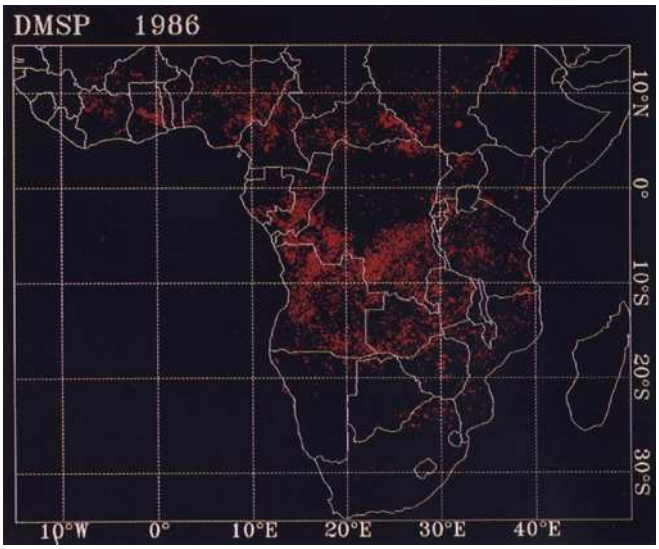

Fig. 3 Africa is the fire center of our planet with more biomass burned on an annual basis than anywhere else. The photograph shows the annual distribution of fires, represented by red dots, on savanna grasslands in Africa in 1986 based on nighttime measurements obtained by DMSP.

For more Biomass Burning information, please contact:
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Or see the Biomass Burning Program Home Page for additional information:
http://asd-www.larc.nasa.gov/biomass_burn/biomass_burn.html

Fig. 4 Igniting the controlled fire at the base of the Impact Dynamics Research Facility at NASA Langley on January 31, 2001. This facility, previously named the Lunar Landing Research Facility, was originally used by the Apollo astronauts to practice lunar landings.

Fig. 5 About 165 feet above the controlled fire in the gantry of the Impact Dynamics Research Facility, visible and infrared fire monitoring instruments, at bottom right, record the fire temperature, the rate of fire spread, and the area burned. These instruments are being readied for flights over wildfires on United States Forest Service airplanes.