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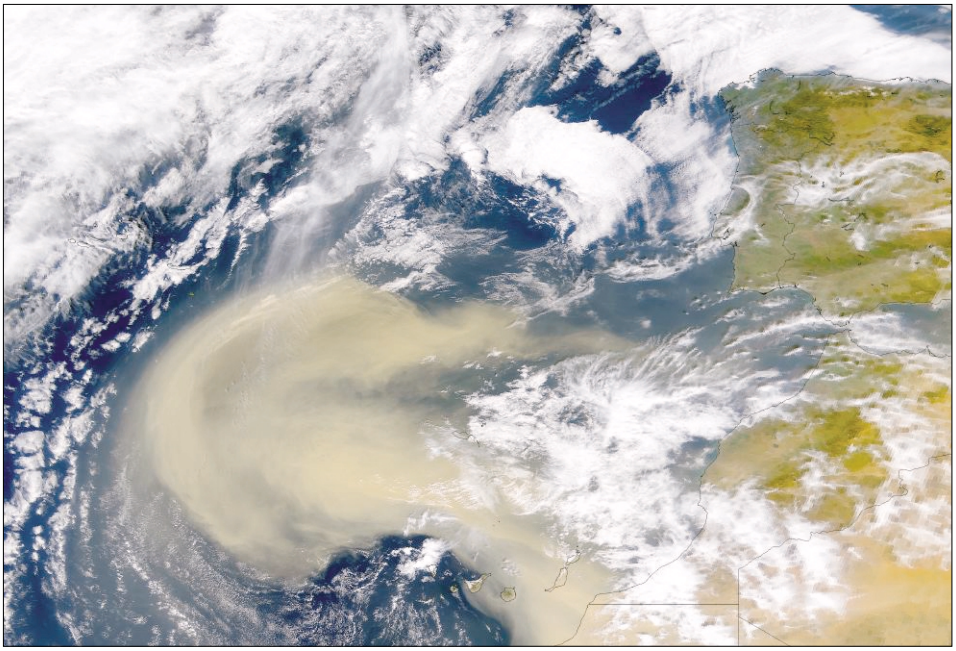
African Dust Causes Widespread Environmental Distress

Atmospheric transport of dust from North Africa to the western Atlantic Ocean region may be responsible for a number of environmental hazards, including the demise of Caribbean corals, red tides, amphibian diseases, increased occurrence of asthma in humans, and decrease of oxygen (eutrophication) in estuaries. Outbreaks of other unexplained environmental changes also may be attributable to the influx of African dust. Studies of satellite images suggest that hundreds of millions of tons of dust are transported annually at relatively low altitudes across the Atlantic Ocean from the expanding Sahara Desert in Africa to the Caribbean Sea and southeastern United States.



The satellite image at left, acquired by NASA/Goddard Spaceflight Center's SeaWiFS Project and ORBIMAGE on February 26, 2000, shows one of the largest Saharan dust storms ever observed by SeaWiFS as it moves out over the eastern Atlantic Ocean. Spain and Portugal are at upper right, Morocco is at lower right.

The USGS in collaboration with NASA/Goddard Spaceflight Center began a study to identify microbes and pesticides transported across the Atlantic in African soil dust. Of special interest is asthma, which is becoming prevalent in children of the Caribbean region, especially in Puerto Rico and Trinidad. Conventional wisdom says ultraviolet radiation from the sun would kill microbes during the 5- to 7-day trip across the Atlantic. Our studies thus far indicate that hundreds of viable microorganisms are making the aerial journey in each gram of dust apparently protected within the particles or shielded by overlying dust clouds. Dust from the extraordinary dust event of February 26, 2000, shown above, was collected by researchers at the University of the Azores. The smallest particles (one micrometer) were found to contain 2 parts per million of the element mercury, which is many times greater than amounts normally found in the air. The mercury may have originated from open-pit mercury mines in Algeria and from the rock formations from which the mercury is mined.

At the first sign of locusts, the countries of North Africa in the Sahel region apply large amounts of pesticides, including those banned in the U.S. to fight the pests. These pesticides are also present in the dust reaching the Caribbean and southern U.S.

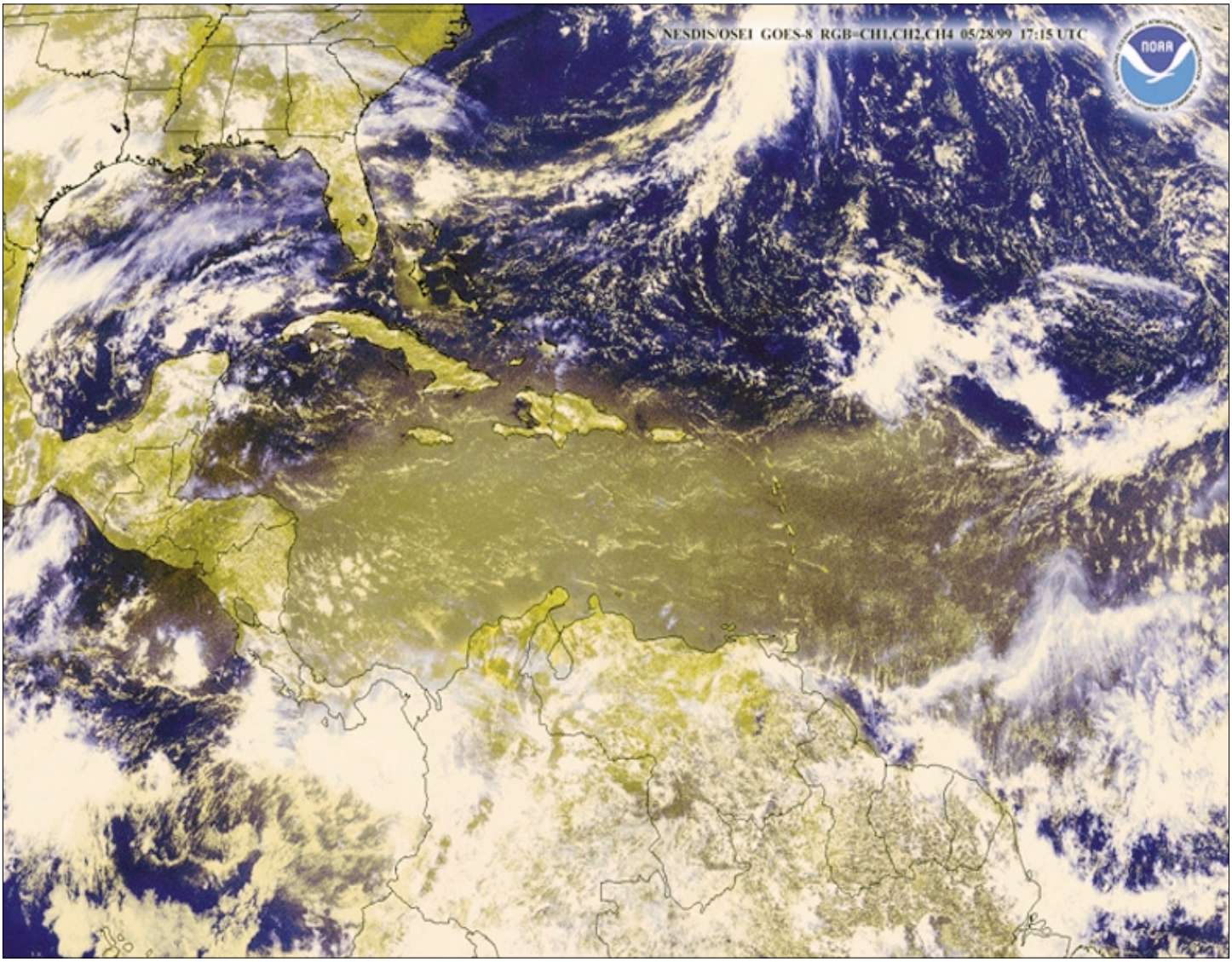
Brain coral infected with black-band disease. The band of tissue-killing bacterial slime radiates outward like a ringworm at a rate of up to 1 cm per day during summer warm-water conditions. The white area in the center is dead tissue-free coral skeleton. The dead skeleton will be attacked by boring algae, boring sponges, boring clams and parrot fish that will gnaw away the skeleton. Together these organisms remove about 1 cm (1/2 inch) per year. This means that in 100 years, a 1-meter high coral head will be completely consumed and converted to sediment. Black-band disease on brain corals was first reported in Bermuda in the early 1970s, but became rampant in other species in the Florida Keys, and elsewhere, beginning in 1985.

Results of research on the composition of dust at many locations indicate a long history of influx of African dust from across the Atlantic Ocean. Scientists of the U.S. Geological Survey's (USGS) Coastal and Marine Geology Program and Biological Resources Division, in cooperation with scientists at the University of Miami, Duke University, University of South Carolina Aiken, and the University of South Florida, conducted this work. This dust is known to play a positive role in maintaining rain forests and ecosystems of the Amazon River region. Recently, other studies concluded that dust transported from Asia provides essential nutrients for the rain forests of Hawaii.

African dust has been distinguished from other types of dust, such as volcanic, in soils and crusts from Barbados, San Salvador, the Bahamas, and the Florida Keys. A similar origin is suggested for soils and crusts in Bermuda. Pre-Colombian pottery from the eastern Bahamas contains chemical elements in ratios unique to dust from Africa, but definitely foreign to the region. For the most part, agriculture in the Bahamas depends on accumulation of African dust to form the red soils often referred to as pineapple loam.

USGS scientists have monitored coral reef vitality for nearly 40 years, and have observed that Caribbean coral reefs have been in a state of decline since the mid-1970s. Moreover, a number of other marine species, including the grazing sea urchin, *Diadema*, and sea fans, have experienced widespread and sudden demise roughly coincident with the deaths of coral populations. Environmental scientists have suspected that a pathogen was somehow released into the environment and spread across the Caribbean; however, the source of the pathogen remained elusive.

New studies at the University of South Carolina Aiken have identified several species of soil fungus, *Aspergillus*,



May 28, 1999 satellite image of southeast United States, Central America, and the Amazon region of South America showing a huge African dust cloud over the Caribbean. Hundreds of million tons of dust are deposited annually in this region. In June and July these dust clouds move farther north where they impact the Florida Keys, the Gulf of Mexico, the eastern United States, and the Bahamas.

in African dust samples collected in the Caribbean, one of which causes a disease in soft corals called sea fans, and there appears to be a correlation between increased amounts of dust and outbreaks of disease.

Atmospheric distribution of African dust containing pathogens could be the cause of the 1983 Caribbean-wide near extinction of reef-building staghorn corals and the sea urchin *Diadema*, vital to the continuing health of coral reefs. Various rapidly moving fungal infections of unknown origin recently decimated frog populations in Central America and Australia. Lung infections caused by several species of *Aspergillus* are a leading cause of mortality in AIDS victims. Also, many people without severe illness also reportedly suffer from lung infections caused by *Aspergillus*. As long ago as 1846, Darwin noted the ill medical effects of African dust while cruising near the Canary Islands.

In addition to hosting spores, African dust itself is composed of chemical elements such as iron, phosphorous, and sulfates, which have been proven to stimulate phytoplankton growth in tropical waters. Collaborators at the University of South Florida suspect that iron delivered with the dust stimulates a chain reaction leading to the bloom of microscopic organisms that cause red tides.

It has long been known that dust is transported from remote areas of the world, but the environmental impact of this dust is only now becoming more clearly understood.

Caribbean coral diseases were first reported in the 1970s, but these early reports received little attention until the late 1980s. In 1983, the herbivorous urchin *Diadema* experienced mass mortality throughout the Caribbean, and within one year the population was decimated. The effect of this die-off was immediate and obvious. Algae normally grazed by *Diadema* from dead coral surfaces proliferated, interfering with coral growth and with competition for recruitment space for new coral.

Almost at the same time, two important Caribbean reef-building coral species also experienced mass mortality. In the absence of *Diadema*, coral surfaces soon were overgrown by algae. In 1987, a second major disease event struck Caribbean populations of coral and sponges resulting in bleaching of coral surfaces. Bleaching, along with black-band disease, proliferated in the 1980s and accelerated in 1997-1998.

This brain coral has expelled the symbiotic algal cells that give it color, leaving it snow white. The condition, called bleaching, is associated with warm-water conditions, especially during the years of maximum dust transport. That dust alone causes bleaching is unproven.

Underwater photograph of the urchin *Diadema* on a dead coral head taken before 1983. In the summer of 1983 most of these urchins died throughout the Caribbean. Notice how the *Diadema* have kept the surface of this dead coral free of algae. Today, without the browsing of algae-eating urchins, dead coral surfaces such as this are coated with mats of fleshy algae. Algal growth retards establishment of coral larvae.

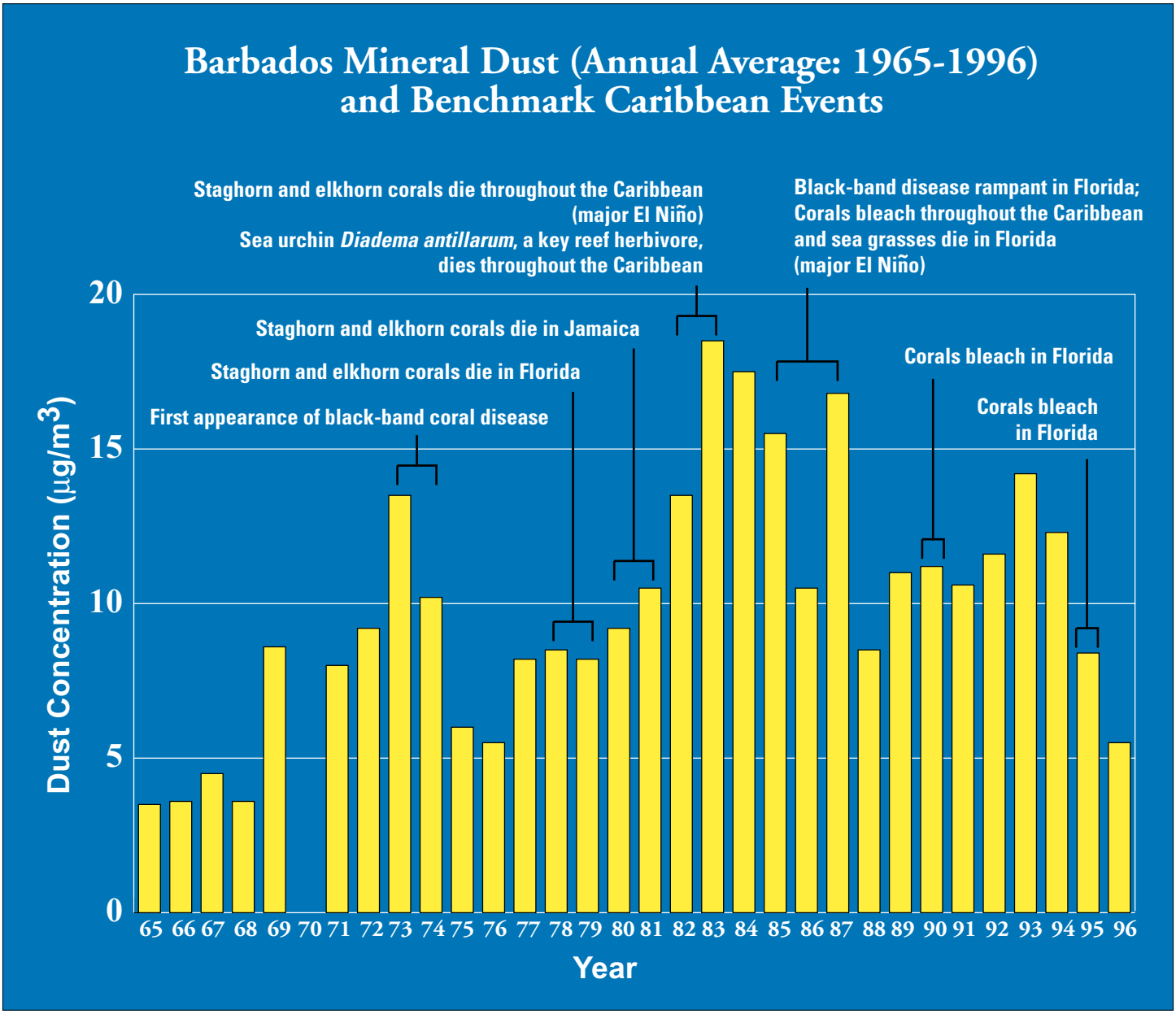
Each event coincided with increases in warm water associated with El Niño weather patterns and peaks in African dust production and transport. The years of highest cumulative dust flux occurred 1983 and 1987, based on data recorded in Barbados where aerosols have been collected since 1965. Indeed, fungal spores and bacteria had been identified in air over the Atlantic Ocean during the 1950s. On October 14 and 15, 1989, large African desert locusts were transported in dust clouds to Trinidad. It is not surprising that African dust would contain soil bacteria and fungus spores, because the dust is derived from the desertification of grasslands in the Sahel region of northern Africa. The situation is reminiscent of the dustbowl days of the U.S. Midwest between 1931 and 1939. Not until no-till farming was adopted in the Midwest was the problem mostly alleviated.

Contact Information:

Eugene A. Shinn
US Geological Survey
Center for Coastal Geology
600 4th Street South
St. Petersburg, FL 33701

Email: eshinn@usgs.gov
Telephone: 727-803-8747 x 3030

Learn more on the Web:
http://coastal.er.usgs.gov/african_dust/



This graph, courtesy of Dr. Joe Prospero, University of Miami, shows the overall increase in African dust reaching the island of Barbados since 1965. Barbados is situated in the Windward Islands, which are hidden beneath the cloud of dust shown in the satellite image on the second page. Notice that peak years for dust deposition were 1983 and 1987. These were also the years of extensive environmental change on Caribbean coral reefs.