Deciphering the Role of Desert Dust in the Climate Puzzle

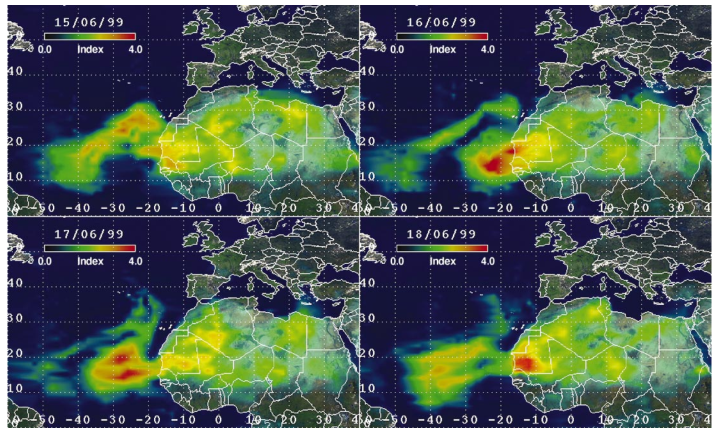
The Mediterranean Israeli Dust Experiment (MEIDEX)

Numerous studies have shown that aerosol particles may be one of the primary agents that can offset the climate warming induced by the increase in the amount of atmospheric greenhouse gases. Desert aerosols are probably the most abundant and massive type of aerosol particles that are present in the atmosphere worldwide.

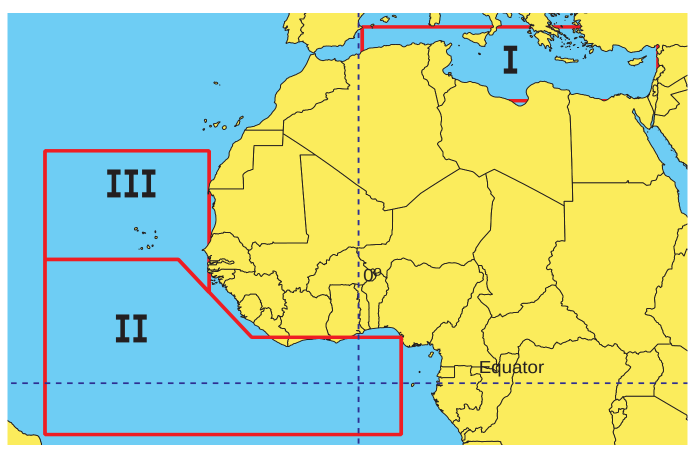
These aerosols are carried over large distances and have various global impacts. They interact with clouds, impact the efficiency of their rain production and change their optical properties. They constitute one of the primary sources of minerals for oceanic life and influence the health of coral reefs. They have direct effects on human health, especially by inducing breathing difficulties in children. It was lately discovered that desert particles carry pathogens from the Sahara desert over the Atlantic Ocean, a fact that may explain the migration of certain types of diseases.

Aerosols not only absorb solar radiation but also scatter it, so that their climatic effect is influenced not only by their physical properties and height distribution but also by the reflectivity of the underlying surface. This latter property changes greatly over land and is low over ocean surfaces.

Aerosol plumes are emitted from discrete, sporadic sources in the desert areas of the world and are transported worldwide by the atmosphere's wind systems. For example, Saharan dust reaches Mexico City, Florida, Ireland, Switzerland and the Mediterranean region, while Asian dust reaches Alaska, Hawaii and the continental United States. This means that in order to assess its global effects, one must observe dust from space. The Space Shuttle is a unique platform, because it flies over the major deserts of our planet, enabling measurements and remote sensing of the aerosols as they travel from source to sink regions. Such efforts must always be accompanied by in-situ data for validation and calibration, with direct sampling of the airborne particles. MEIDEX is a joint project of the Israel Space Agency (ISA) and NASA, under a cooperation agreement between the two agencies.



The long-range impact of the Saharan dry season can be seen in four days of images taken by the Total Ozone Mapping Spectrometer, June 15–18, 1999. The color scale shows the aerosol index from red (heaviest amounts of dust present) to green (the thinnest present). Under the darkest red the amount of ultraviolet sunlight is reduced to half its normal value, while under the green areas, UV sunlight is reduced by about 20 percent.



Three primary study areas for MEIDEX. The upper edge of Area I is the northern limit of *Columbia's* orbit.

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Background Information

Science

The primary mission of the Mediterranean Israeli Dust Experiment (MEIDEX) is to study the temporal and spatial distribution and physical properties of atmospheric desert aerosols over North Africa, the Mediterranean Sea and the adjacent Atlantic Ocean. This aim is achieved by a remote sensing experiment operated by the astronauts aboard the Space Shuttle. The second aim of the MEIDEX will be the inter-calibration of two primary current methods for the remote investigation of desert aerosols. Spectral channels of the MEIDEX radiometric camera combine in one multispectral camera, two wavelengths of the Total Ozone Mapping Spectrometer instrument in the ultraviolet band and four of the Moderate Resolution Imaging Spectroradiometer (on the Terra satellite) in the visible and near-infrared parts of the solar spectrum.

Secondary Observations

Sprites: The Xybion camera will be used for nighttime limb observations of Transient Luminous Events (sprites, jets and elves) associated with the electric discharges between thunderclouds and the lower ionosphere. The measurements of the optical emission will be correlated with ground based ELF/VLF electromagnetic measurements from several stations in Israel, the United States, and Antarctica.

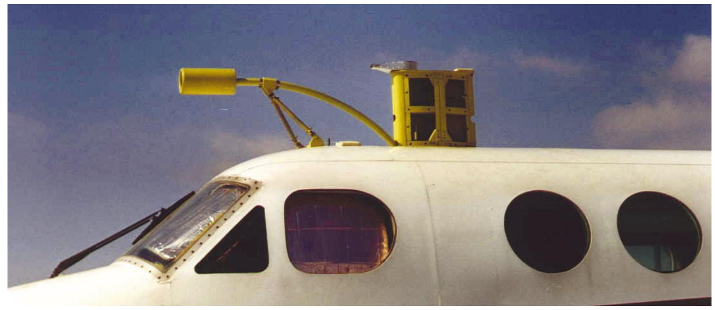
Sprite observed by a University of Alaska, Fairbanks, research aircraft.

Slant Visibility: The astronauts will observe a set of surface targets that are located close to observation stations that monitor the optical properties of the atmosphere. The observations by the astronauts of the first view of a target and its subsequent disappearance along an orbit will enable, together with analysis of the accompanying data on the optical and meteorological properties of the neighboring atmosphere, the construction of an experimental model of slant visibility.

Sea-Surface Bi-Directional Reflection Function (BDRF): The BDRF is a crucial parameter in remote sensing and in any problem involving climate and weather. The properties of the ocean BDRF are still a subject of investigation. The sea surface albedo will be measured directly by instruments aboard the aircraft, and measured from space by the MEIDEX cameras when there are no clouds or dust in the area.

These remote measurements will be complemented by airborne in-situ measurements of aerosol properties such as size distributions and chemical composition as well as other atmospheric parameters. Research flights will be conducted daily by a team of scientists in an instrumented airplane based in Sicily, when the Shuttle passes over the Mediterranean Sea. The co-location and simultaneity of Shuttle, aircraft and ground-based correlated data will enable the validation of the remote space based observations. Forecast models will be used in order to predict the location and extent of dust clouds.

The output of the remote sensing experiment will be sequences of images of the target areas. In order to derive the desert aerosol properties from these images, the radiance from each pixel in an image will be analyzed. The problem

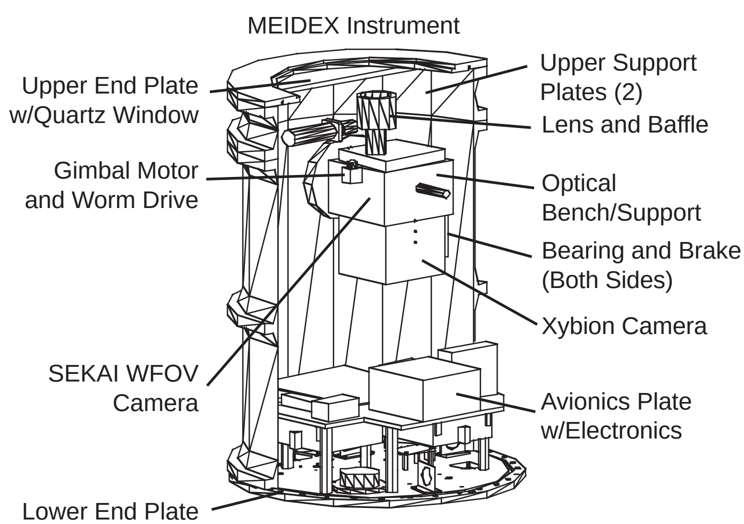


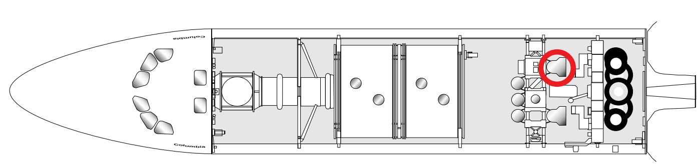
Dust collector mounted atop research aircraft.

of finding desert aerosol parameters will be the inversion of radiative transfer equations for a scattering and absorbing atmosphere above the surface with the given bi-directional reflection distribution functions (BDRF). Special computer models will be used to solve this problem.

Hardware

The payload consists of a radiometric camera (Xybion IMC–201) equipped with six narrow-band filters centered at 340 nm, 380 nm, 470 nm, 555 nm, 660 nm, and 860 nm. The Xybion camera has a field of view of 10.7 × 14.0°, with a nadir footprint (looking straight down) of 52 × 68 km. It is boresighted with a second, wide (60°) field of view video camera that functions as a viewfinder. Both cameras are mounted on a special gimbaled truss housed inside a pressurized Getaway Special canister with a coated quartz window. The truss can be tilted 22° to each side; this enables the crew to point the cameras to targets not directly below the Shuttle ground-track. Images from the cameras are recorded on three digital video recorders in the canister and inside the crew cabin. The MEIDEX canister is located on the aft side of FREESTAR in the payload bay.





Approximate location of MEIDEX aboard STS–107.