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Tropical Intercontinental Network of Aerosol Observations

Brent N. Holben
NASA/Goddard Space Flight
Center
Earth Resources Branch/Code
923
Greenbelt, MD 20771
(301) 286-2975
USA

Didier Tanré
Lab. d'Optique Atmosphérique
U.S.T. de Lille
59655-Villeneuve d'Ascq
(33) 20-43-47-67
France

Thomas F. Eck
ST Systems Corporation
Code 923
Greenbelt, MD 20771
(301) 286-6559

François Lavenu
LERTS
Centre Spatial de Toulouse
18, ave Ed. Belin
31055 - Toulouse
(33) 61-27-30-67
France

John A. Reagan
Electrical and Computer
Engineering Dept.
Univ. of Arizona
Tucson, Az 85721
(602) 621-2434
USA

Alberto Setzer
INPE
Sao José dos Campos, SP
Brazil
55-123-418-997

ABSTRACT

A new generation of portable sunphotometers will be used to monitor aerosol concentration and optical properties diurnally and annually in West Africa and South America beginning in 1992.

SUMMARY

Objective

A systematic aerosol optical properties monitoring program across West Africa and Brazil's Amazon Basin is planned to begin in 1992. These regions are subject to extensive anthropogenic biomass burning and subsequent smoke and trace gas emissions including elevated levels of ozone. Aeolian erosion in West Africa has been cited as an important source of phosphate fertilization of the Amazon forest.. A ground truth data base of aerosol optical thickness, water vapor and ozone will allow analysis of temporal and spatial patterns. The relationship between aerosol size distributions and water vapor will be studied as they relate to the burning and non burning seasons or to dust events and background conditions. The data will be prepared to make atmospheric corrections on satellite imagery and aircraft measurements. The data base will be used in support of ground truth for satellite and/or aircraft derived smoke, trace gas emission measurements, dust transport and for verification of algorithms which automatically correct AVHRR images and aircraft data. This work will scientifically contribute to other international investigations such the two French IGBP projects called "Erosion Eolienne en regions arides et semi-arides" which involves several French and African laboratories, and SALT, "Les SAVANES à Long Terme" which is a cooperative study between the Laboratoire d'Ecologie Vegetale de l'ENS of Paris et le LERTS of toulouse. An aspect of the HAPEX-SAHEL project in 1992 is an investigation of the interactions between the land and the atmosphere, the instruments will be checked and validated during this experiment. The NASA/Brazilian TRACE-A experiment also in 1992 will benefit from these data.

Justification

"Aerosols are the source of our greatest uncertainty about climate forcing. Tropospheric aerosols are difficult to monitor because of their spatial inhomogeneity, but they are a crucial variable because of the strong anthropogenic influence on their amount" (Hanson and Lacis, 1990). Sahelian regions are the most important sources of aeolian aerosols in West Africa and soil loss by erosion is a common phenomenon in these regions owing to poor land management and/or low and variable rainfall. As a result, the land is more and more subject to wind erosion and may lead to an increased desertification. Aerosol loading and corresponding transport monitoring is a good indicator of land degradations.

The generation of dust in the sahelian regions was shown by many studies (D'Almeida, 1986, and Ben Mohamed and Frangi, 1983). The production of dust is related to the wind speed, the sparse cover of vegetation, the soil texture and moisture. The use of the aerosol optical thickness is a good way to monitor the dust content in the atmosphere, its transport and its short and long term variations. Such phenomena need to be better understood and monitored. The spectral dependance of the optical thickness depends on the size distribution of the particles and may be used as an indicator of mass transport.

Fires in the African savanna/forest regions of Zaire, Cameroon and Central African Republic have been shown to contribute up to a 50% increase in tropospheric ozone above ambient levels during the burning season (Fishman et al., 1990). Kendall and Justice (1991) have shown fire distributions as a function of vegetation type and measured approximately 228,450 fires in the northern African savanna during 1988. The particulate emissions have essentially never been optically measured by sunphotometry or satellite.

The Amazon basin during July and August 1987 was a source of aerosols and trace gases due to biomass burning from forest clearing and rangeland management practices, estimated to be equivalent to one half of the particulate expulsion of the El Chichon eruption which had measurable global impacts (Setzer, 1988). Therefore monitoring the Amazonian aerosols is of specific importance to regional and global climate forcing. Additionally, remote sensing of green vegetation dynamics is affected by atmospheric attenuation and scattering from aerosols which vary greatly over space and time. Because we have no direct information on the aerosol content nor the scattering characteristics, the satellite level reflectance from vegetation may be significantly different from the surface level. For the Amazon basin, no ground data exist on the temporal and spatial variability in the aerosol optical thickness and scattering properties.

Approach and Analysis

In the Amazon Basin a gridded network of 18 instruments will be spaced across the Amazon basin in a 5 degree latitude by longitude grid from 45 to 65⁰ West by 0 to 15⁰ south. In West Africa a similar network of 21 hand held sunphotometers will be spaced across a 5 degree grid extending from 5°N to 15°N and from 15°E to 15°W. Four extra instruments will be used for calibration, replacement and ancillary studies. Sky, aureole and sun data will be taken hourly at all sites for eight spectral wavelengths (from the UV to the near infrared). Downwelling sky radiance will be computed at view directions which approximate the path radiance to the satellite. The aerosol optical thickness, wavelength dependence, total column water vapor and ozone content and mean particle radius will be calculated from the sun and aureole observations and spatial and temporal distribution of these variables will be studied.

Instrumentation

The instruments used for this investigation will have the following spectral characteristics:

<u>USE</u>	<u>Center Wavelength</u>	<u>Band width</u>
Ozone	305nm	10nm
Ozone	325nm	10nm
Aerosol	440nm	10nm
Aerosol	500nm	10nm
Aerosol	620nm	10nm
Aerosol	870nm	10nm
Water Vapor	940nm	10nm
Water Vapor	940nm	50nm

The 305 and 325nm bands are very experimental at this point. Soviet made filter instruments have used the differential absorption of ozone in longer wavelength UV bands to estimate total ozone to within 15% of Dobson measurements when turbidity is high (Bojkov, 1969) however Basher and Mathews (1977) have shown considerable improvement since that time. We have simulated the spectral transmission in this region at the bottom of the atmosphere for a large range of total ozone and the associated Rayleigh component. The 305 nm absorption band has a factor of 4 decrease in transmission from low to high ozone and the ratio of the 325 to 305 nm transmissions range from 4 to 12 from the low to high ozone amounts. This indicates good sensitivity to ozone variations across the range of total column ozone levels expected under all conditions.

The 440, 500, and 870 nm bands are the critical aerosol bands and are standard in sunphotometry. The two 940nm bands, a narrow band and a broad band, account for the broadening of energy absorption by water vapor as the water vapor amount increases. The 850 and 940 proximity also allows computation of the water vapor by the Reagan method (Reagan et al., 1987) which has been shown to be accurate to within ± 0.3 cm of radiosonde observations (Holben and Eck, 1990). Sunphotometry at longer wavelengths is not possible with the silicon detectors to be used in this instrument therefore a "complete" inversion of the solar spectrum is not possible.

The instrument will be designed to be used as a radiometer such that the sky radiance can be measured in an almucanter and principal plane mode. The sky is from 4 to 6 orders of magnitude darker than the sun. This change in intensity is solved by including a wider field of view and 16 bit electronics.

An important feature of the new sunphotometer is the ability to internally store and transmit the data via the ARGOS system of polar orbiting satellites. This feature will allow near real time analysis of the data and subsequent identification of problems associated with data collection such as weak batteries, calibration or electrical problems which could take months to identify otherwise. Additionally this system will eliminate data entry costs and errors.

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