Smoke, Cloud and Radiation - SCAR Experiment

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in collaboration with

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OBJECTIVES

The overall objective of the experiment is to study the radiative and physical effects of biomass burning on the atmosphere, and to prepare a comprehensive data set for the evaluation of remote sensing procedures from aircraft and satellites (e.g., AVHRR and MODIS). The data set should include ground and air measurements of the optical and physical properties of aerosol particles, cloud drops, fires and the surface reflectance.

The specific objectives are:

Remote sensing science:

- To compare aerosol and cloud properties measured in situ with those remotely sensed from aircraft and satellite platforms.
- To test the proposed methods for remote sensing of water vapor from MODIS with spectral channels in the near IR.
- To test the capability of MODIS for remote sensing of fires.
- To measure the effect of smoke on remote sensing of the surface reflectance in the solar and mid IR parts of the spectrum.

Atmospheric science:

- To measure the interaction of aerosol particles with clouds.
- To measure the effect of the distribution of water vapor on aerosol and cloud properties.
- To measure the relation between the properties and concentration of the emitted smoke and trace gases.
- To measure the relation between the properties of the emitted smoke and the extent and characteristics of the fires.

Biosphere science:

- To measure the optical and physical characteristics of tropical vegetation.
- To measure the relation between surface properties and the fire type before and after

the fire.

JUSTIFICATION

There is increased interest in tropospheric aerosol, its remote sensing and its interaction with water vapor, clouds and the radiation field. The purpose of this experiment is to measure all of these in a systematic manner. Since this discipline involves several research topics that are currently funded to some extent by NASA and other agencies, namely the development of MODIS and MISR algorithms, remote sensing science, atmospheric processes and the carbon cycle, the purpose of this document is to suggest an integrated field experiment that may not require extensive additional funding.

The systematic presence of smoke during the dry season in Brazil makes it an ideal location where hygroscopic aerosol and broken cloud fields can be found on most days. Therefore, the interaction of smoke with clouds and water vapor in Brazil can be used to examine the interaction of other aerosol types, which is important in its own right due to the large and increasing quantities of smoke generated in the tropics. In several places in Brazil the surface is covered by homogeneous forest or broken into small fields of low vegetation, bare soil, and forest areas. This also is a benefit for some of the remote sensing algorithms that require different surface types.

The organization of the experiment will be based on previous experiments conducted in Brazil by US (NASA, USFS) and Brazilian (IBAMA, INPE) scientists. It will be based on an international agreement of collaboration between the US Forest Service and IBAMA that also involves the participation of NASA.

METHODOLOGY

The experiment will be organized as a joint effort between several US (NASA/GSFC, NASA/ARC, USFS/Fire Chem. Lab., Universities of Arizona, Maryland, and Washington), Brazilian (IBAMA and INPE), French (Univ. of Lille) and Japanese (Univ. of Tokyo) scientists. It is expected to occur during 5 weeks in the fall of 1993 (August-Sept.). The following is a list of the tentative investigators, investigations and status of funding:

Item #	Investigator	Investigation	Existing funds for this experiment	Additional funds required and possible sources
1	B. Holben	Sunphotometer network in Brazil	NASA/Carbon cycle	no
2	R. Fraser Y. Kaufman M. King V. Kirchhoff A. Setzer D. Tanré T. Nakajima	Interaction of aerosol particles and clouds	NASA/Atmospheric processes – $60K	no
3	M. King Y. Kaufman C. Justice A. Huete P. Menzel D. Tanré J. Spinhirne	MODIS-N airborne simulator, airborne lidar, and EO camera on the ER-2 aircraft	MODIS science team investigators – $200K	$50K (?) NASA
4	P. Hobbs M. King P. Pilewskie F. Valero	C-131A to measure aerosol and cloud drops, and the radiation field	NASA/Atmospheric processes – $150K	$350K NSF, NASA, USFS
5	J. Brass P. Riggan B. Dias P. Artexo A. Setzer V. Kirchhoff	Fire radiometer and AVHRR analysis	NASA/Carbon cycle –$50K	$50K NASA, USFS
6	D. Ward A. Setzer V. Kirchhoff P. Artexo B. Holben Y. Kaufman	Sampling of trace gases and aerosol	NASA/Carbon cycle – $30K	$40K NASA, USFS
7	B. Holben Y. Kaufman A. Setzer	Upward radiation field using calibrated photography	$20K	no

1) Network of 9-10 instruments that will measure the aerosol optical thickness, precipitable water vapor and the sky radiance that can be inverted into the aerosol size distribution and scattering phase function. These automatic instruments will collect daily data in several locations in Brazil.

2) This investigation will cover measurements from the ground with a movable network of 6 sunphotometers (same as in 1) of the aerosol optical characteristics and precipitable water vapor. Sampling of aerosol particles for electron-microscope analysis of the size distribution, shape and the chemistry of individual particles. Measurements from the INPE aircraft of vertical profiles of the aerosol optical thickness and the radiation field, analysis of Landsat-TM and AVHRR data.

3) MODIS-N airborne simulator (MAS) measurements in the solar spectrum (0.5-2.2 μm), the mid-IR (3.7 μm) and the thermal IR (8-11 μm) of the reflected and emitted radiation field. Airborne lidar will be used to detect the vertical structure (up to 20 km) of the aerosol and clouds. An electro-optical camera (1000×1000 element CCD array camera) mounted in the nose of the ER-2 aircraft will also measure the reflected solar radiation in 6 spectral channels (or 2 channels with 3 polarizations) as the camera scans both fore and aft. This complement of instruments will measure remotely the optical properties of aerosol particles, water vapor, and clouds.

4) Measurements of the vertical and horizontal distribution of the physical, chemical and optical properties of aerosol particles, cloud droplets and water vapor. The cloud absorption radiometer (CAR), a multispectral scanning radiometer mounted in the nose of the University of Washington C-131A aircraft, will measure the upward and downward radiation distribution (0.3-2.3 μm). A Nd:YAG monostatic lidar will measure the structure of the boundary layer and cloud and aerosol vertical distributions by either looking zenith or nadir. A TDDR (Total-Direct-Diffuse Radiometer) will also measure the spectral flux (both direct and diffuse) at selected spectral channels between 0.4 and 1.0 μm, enabling net flux and spectral aerosol optical thickness to be determined.

5) A multispectral scanning IR radiometer with channels around 0.65, 2.2, 3.7 and 11 μm will measure the optical properties of fires around the burned area. The instrument will be flown from the either the NCAR King Air, the INPE plane, or the University of Washington C-131A, and will make measurements as a function of height, thus determining the effect of aerosol, subpixel clouds and water vapor on fire detection.

6) Measurements of the relation between the mixed aerosol concentration and the concentration of the trace gases. Sampling of aerosol particles for analysis of composition and size distribution.

7) Detection of the directional upward radiation field in 4 spectral bands located at 0.47, 0.66, 0.86 and 0.94 μm using an imaging system of spectrally filtered wide FOV cameras. The measurements will take place from 300-4000 m above the surface. The system will fly on the INPE plane.

Additional questions and possibilities:

- A possibility exists that the NASA/Ames airborne sunphotometer could be mounted on one of the planes (C-131A or INPE plane).
- The airborne version of POLDER could possibly be mounted on the ER-2 aircraft.
- The French ground station for optical thickness and sky radiance might be available.
- J. D. Spinhirne's sunphotometer for optical thickness measurements out to 4.0 μm could possibly be utilized.
- AVIRIS on the ER-2.
- Interantional agreements
- Project funding and organization