(AVHRR and TM were ordered?)
To Flag order all AVHRR for BRAZIL 1993 June till Oct
Huethe California, all 5k for AVIRIS?

Quarterly review July - Sept. 1993

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1. Algorithm and software development.

Work have been completed on all the four ATBD's. Software will be delivered starting at the beginning of next year.

- Remote sensing of aerosol from MODIS by Kaufman and Tanré. This algorithm includes both the derivation of aerosol optical thickness over the land and the oceans and derivation of the aerosol size distribution over the ocean. The method over the ocean is lead by Tanré with help of a programmer in GSFC under the MODIS support of Kaufman. The work over the land meanwhile includes only application of dark targets identified in the mid IR and applied in the red and blue channels to detect the optical thickness. We plan to study the possibility of adding the contrast technique and to develop a technique that combines MISR optical thicknesses with these from MODIS. Didier Tanré is planning a sabbatical in GSFC where he will collaborate more closely on the development of these products and work on atmospheric corrections. We started to write two codes for remote sensing of aerosol over the oceans and continents respectively. We plan to deliver first versions in the beginning of next year.

- Remote sensing of fires by Kaufman and Justice. The ATBD includes a review of the present algorithms and a first suggestion for an algorithm that can be applied to MODIS, with two channels during the day and three channels during the night. The algorithm strongly depends on the decision on the saturation level of the 11 µm channel. A detailed sensitivity study will be required for assessment of the derived products. There is also a need of a fire dynamics model to relate the measured temperatures to the fire type and rate of consumption of biomass.

- Remote sensing of water vapor by Gao and Kaufman. The algorithm, based on previously published papers, describes the use of the near IR MODIS channels centered at 0.865, 0.905, 0.936, 0.940, and 1.24 µm for remote sensing of water. Techniques employing ratios of water vapor absorbing channels at 0.905, 0.936, and 0.94 µm with atmospheric window channels at 0.865 and 1.24 µm are used. The algorithm also includes a new sensitivity study. The software will be developed by Gao and expected to be ready by the beginning of next year.

- Atmospheric corrections The Algorithm Theoretical Basis Document was completed for the atmospheric corrections for the surface reflectance and ground-leaving radiances by E. Vermote and L. Remer with C. Justice, Y.J. Kaufman and D. Tanré. The algorithm will correct for molecular scattering and gaseous absorption at launch, and for aerosol effects and bidirectional reflectance after launch when the quality of the aerosol data and BRDF products over the land will be verified. The algorithm also addresses corrections for adjacency effects and cirrus contamination.

2. Field experiments and validation networks

SCAR -A

The first of a series of the SCAR experiments SCAR-A (Sulphates Clouds And Radiation -- America) took place July 12 to July 28 at Wallops Flight Facility. It was designed primarily to study clouds and aerosols simultaneously from satellite instruments (NOAA AVHRR and Landsat TM), airborne instruments (MAS, AVIRIS and in situ instrumentation) and a ground-based sunphotometer network. Other objectives included obtaining a database from which to validate MODIS algorithms, to measure surface reflectance properties and to study cirrus clouds. The experiment consisted of the ER-2 aircraft carrying the MODIS Airborne Simulator (MAS), the Airborne Visible / Infrared Imaging Spectrometer (AVIRIS) and a RC-10 mapping camera, and the University of Washington's C-131A research aircraft carrying a wide variety of instrumentation. In addition a ground-based sunphotometer network was installed supplemented by roving ground stations and light aircraft carrying sunphotometers. Abnormal meteorological conditions which caused the flood of '93 in the midwest also affected the weather in the mid-Atlantic region our area of interest. During the experiment an unusual amount of cloud-free and sometimes dry, non-humid conditions occurred. Other times cloud conditions were complicated by mid and upper level clouds. The opportunity to measure hazy conditions with boundary layer cumulus presented itself roughly four times during the three weeks. Difficulty of forecasting cumulus and instrument failure limited our data collection to one and a half good flights. Other flights were not wasted. The C-131A flew seven flights characterizing the aerosol and clouds onshore and off-shore, at various altitudes and under different meteorological patterns. This aircraft also measured surface bidirectional reflectance over ocean, deciduous and coniferous forests. The ER-2 also flew seven missions and obtained excellent data to validate MODIS algorithms for atmospheric correction, aerosol retrieval and cloud property retrieval, including cirrus clouds. The measurements during SCAR-A included haze free and hazy days. during which satellite (Landsat TM and AVHRR) data were acquired simultaneously with the ground based and airborne measurements. Two missions intercepted Landsat overpasses and three missions intercepted AVHRR overpasses. The experiment was a collaboration between our group with that of Mike King and Paul Menzel as well as the P. Hobbs group leaded by D. Hegg.

At the completion of the experiment, the meteorological and sunphotometer data were summarized and analyzed. Preliminary results were distributed at a September 15th meeting involving representatives from each of the research groups and Tim Suttles from NASA HQ. The other groups also presented their results. Among the most interesting is evidence from Dean Hegg and the University of Washington group that the CCN encountered are not dominated by sulphates but may be by organics.

Planning for SCAR-C

The SCAR-C (Smoke Clouds And Radiation -- California) field experiment is planned for September '94. The main purposes of this experiment are to collect data which will help validate MODIS fire detection and aerosol detection algorithms. Contact was made with Pete Fonda-Bonardi of the Los Angeles County Urban Research Department concerning coordination of our flight hours with control burns in Los Angeles County. There may be scheduling conflicts between the availability of the MAS instrument and LA County's timetable for control burns. Discussion continues. Several other MODIS team members plan to participate (Drs./Profs. Strahler, Wan, Huethe, Justice and Menzel). We are in contact with Robert Green at JPL regarding the possibility of using one day of AVIRIS data despite the high costs, by splitting it between several MODIS members and the other participants. Another possibility is to fly AVIRIS over a prescribed fire in California during an AVIRIS calibration flight (which is already approved by NASA Headquarter). Later we buy the AVIRIS data for the fire scenes at a cost of about $250 per tape.

We are looking for an alternative to Brazilian for the pre-SCAR-A experiment in 1994, due to the negative political climate for studies of biomass burning in Brazil.

The moveable network of the French sun/sky radiometers developed by Holben and Tanré and purchased by MODIS support for Kaufman, demonstrated its strong ability in the Eastern US during SCAR-A and the rest of the summer. Real time analysis of the aerosol loading and size distribution were available all the time from up to 5 locations. We plan to deploy some of the instruments in Bermuda and Barbados and later in China to generate a data set that will help us to understand the optical properties of aerosol in order to improve the aerosol models used in remote sensing.

3. Surface characterization for remote sensing of aerosol

The effort for surface characterization continues, and was used as a basis for the ATBD on aerosols. Currently Landsat TM data are being analyzed for the surface properties in the solar spectral region. From TM images over Northern Virginia and Maryland areas, it is found that for a 1 km MODIS pixel, a 0.2 pixel misregistration

along one direction results in an error of 2-3% in surface reflectances from TM band 4 (~0.86 μm), 3-5% from TM band 5 (~1.64 μm), and 7-10% from TM band 7 (~2.2 μm). Images from TM band 7 (~2.2 μm) have largest spatial variability.

Reflectance spectra of different surface targets compiled by Bowker et al. (1985) have been processed so that the data set can be viewed efficiently using the Interactive Data Language (IDL). It is found that the Bowker's data set has limited values for remote sensing simulation studies.

4. Spectral properties of smoke and clouds

The AVIRIS data of a fire smoke and clouds formed downwind from the fire were analyzed and are being compared with radiative transfer computations. Very different properties of the smoke were detected for smoke processed by the cloud that was formed on top of the fire from the properties of smoke not processed by the cloud. From the AVIRIS data, we found that smoke is readily observable in images between 0.4 and 0.75 μm. The smoke effects decrease with increasing wavelength. It is difficult to observe smoke from images beyond about 1 μm. A paper on this research was submitted to the AMS conference.

5. Theoretical studies

A paper was written on the theoretical calculations of the effect of clouds on sulfate aerosol size distribution and concentration. The paper by Kaufman and Tanré was submitted for publication. Using a computer model we show that the in the presence of variability of the cloud supersaturation the amount of effective CCNs is increased up to 4 times from that in the absence of such variability.

6. Interaction of dust particles with clouds

Collaboration with Visiting Scientist Zev Levin led us to examine several AVHRR images for evidence that Saharan dust plays a role in cloud formation over the Mediterranean. Preliminary results are encouraging. At least one image clearly suggests that the dust is being scavenged by a cloud.

7. IMGRASS workshop

Bo-Cai Gao participated the 2nd International Workshop on Inner Mongolia Grassland Atmosphere Surface Studies (IMGRASS) held in Beijing and Inner Mongolia of China between August 25 and 30, 1993, and made a presentation on remote sensing of dust aerosols using ground-based automatic Sun tracking photometers. Joint aerosol measurements of dust aerosols over China among Y.

Kaufman, T. Nakajima and Chinese scientists may start as early as spring of 1995.

8. Work plan for the next quarter

- Start of analysis of SCAR-A data

- Planning of SCAR-C and B

- Generation of a library of surface spectra from Landsat TM, AVIRIS and MAS data

- work on software for remote sensing of aerosol and water vapor and atmospheric corrections. We also hope to start to work on remote sensing of fires.

9. meetings

Yoram Kaufman represented the atmosphric team in most MODIS technical team meetings ans in the Ghost meeting. Bo-Cai Gao was on the calibration meetings.

Status of recent publications

Y.J. Kaufman and L. Remer, 1993: 'Remote Sensing of Vegetation in the mid-IR: the 3.75 µm channels', in revision to *IEEE J. Geosc. and Rem. Sens.* Feb. 93

Y.J. Kaufman, 1993: 'Measurements of the aerosol optical thickness and the path radiance - implications on aerosol remote sensing and atmospheric corrections', J. Geophys. Res. 98, 2677-2692.

Y.J. Kaufman, A. Gitelson, A. Karnieli, E. Ganor, R.S. Fraser, T. Nakajima, S. Mattoo, B.N. Holben, 1993: 'Size Distribution and Phase Function of Aerosol Particles Retrieved from Sky Brightness Measurements', submitted, in June to JGR-Atmospheres.

Yu. Mekler and Y.J. Kaufman, 1993: 'On possible causes of calibration degradation of the AVHRR visible and near IR channels', submitted in Sept. to Applied Optics.

Y.J. Kaufman, B.N. Holben, D. Tanré and D. Ward, 1993: 'Remote sensing of biomass burning in the Amazon', accepted to special issue on remote sensing of the Amazon in Rem. Sens. Rev. Dec 92

Y.J. Kaufman, D. Tanré: 1993: 'Variations in cloud supersaturation and the aerosol indirect effect on climate', submitted in Oct to *Nature*.