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This reports covers the aerosol ocean and land algorithm, the water vapor algorithm and our involvement in the fire algorithm. The work in this quarter concentrated on 3 topics:

- preparation of algorithms for the version 1 delivery
- validation of the algorithms and summary of the scientific results in publications
- Analysis of the SCAR field experiment data

1.0 Preparation of algorithms for the version 1 delivery

We interacted with the SDST team in preparation of the algorithm for the proper format, integration of the auxliary data and of data from other MODIS algorithms. The codes were tested for software accuracy/consistency and for robustness using sensitivity studies. Input data sets, like the aeorosol dynamical models were developed and implemented into the codes.

2.0 Aerosol Over Land Algorithm

Validation of Aerosol Over Land Algorithm

The measurements of reflectance from Landsat TM and AVIRIS at 0.47 and 0.64 micron are used to derive aerosol optical thickness in order to compare with ground-based Sunphotometer measurements as the initial step of the validation of the MODIS aerosol algorithm. The results of aerosol optical thickness retrieved sometimes are not easy to interpret by using continental model, mainly because of the complexity of the nature of aerosol particles which include smoke, sulfate and dust. It is found that the physical and optical properties of smoke, sulfate and dust can be far different from the continental background aerosols. The correction procedure based upon phase function and single scattering albedo which is based upon single scattering approximation may introduce bias when the optical thickness is large. Nevertheless, the preliminary results are encouraging from the cases studied so far. Listed below are the new comparisons of aerosol optical thickness retrieved for 0.47 and 0.64 micron channels with AERONET sunphotometer aerosol optical thickness data in different geographic locations. (Inside the parenthesis are the standard deviations).

data, date	red	blue	red	blue
	continental model		sunphotometer	
AV930714VA	0.44	0.56	0.33 (0.06)	0.65 (0.11)
AV930716VA	0.15	0.17	0.17 (0.04)	0.31 (0.08)
TM950606WI	0.47 (0.05)	0.63 (0.05)	0.39 (0.08)	0.68 (0.10)

TM930801BZ	0.47 (0.04)	0.52 (0.06)	0.231 (0.02)	0.46 (0.06)

	Corrected Model		sunphotometer	
AV930714VA	0.51	0.74	0.33 (0.06)	0.65 (0.11)
AV930716VA	0.16	0.20	0.17 (0.04)	0.31 (0.08)
TM950606WI	0.36 (0.10)	0.82 (0.14)	0.39 (0.08)	0.68 (0.10)
TM930801BZ	0.50 (0.05)	0.59 (0.07)	0.231 (0.02)	0.46 (0.06)

* VA: Virginia, USA; WI: Wisconsin, USA; BZ: Alta Floresta, Brazil

Error analysis of the land aerosol algorithm

The analysis of error sources of aerosol retrieval over land shows that approximately 3-5% errors are due to linear interpolation in the inversion of aerosol optical thickness, which is about 1/4 of the total uncertainties estimated. The overestimation (or underestimation) of aerosol optical thickness is partially responsible in the comparison with ground-based Sunphotometer measurements of aerosol optical thickness. Another element of error source playing a more important role is the surface reflectance. It is found in some cases that the surface reflectance inferred at 0.47 and 0.65 µm from 2.1 µm underestimates the true surface reflectance, which then overestimates the aerosol optical thickness retrieved, and vice versa. The calibration of reflectance from satellite measurements is shown to be an error source that should be cautiously monitored.

Surface reflectance properties used in the land aerosol algorithm

Study of the transmission and radiance at 3.7 and 3.9 micron coupled by the effect of surface emmisive properties, aerosol, cloud and gas constituent: The purpose of this study is to select which spectral band in the 4 µm window should be used to determine the surface reflectance in the visible channels. The test run of using MODTRAN code is successful on DEC alpha imported from HP computer. The simulation runs will be based upon a variety of surface properties (such as vegetation, forest, desert and snow), different aerosol extinction profiles (such as background and volcanic aerosols), atmospheric gas absorption (such as water vapor and nitrous oxide) and cloud effect. The transmission and radiance will be calculated as a function of viewing angle. Different surface temperature will also be considered to accommodate possible fires detected. Detailed results will be shown in the next report.

Data collected in San Diego CA in December 1995 were analyzed and added to the data base previously used to construct the relationship between the visible and 2.1 µm channel. The San Diego data differs in that they were measured by a hand held spectrometer on the ground or from a relatively low flying aircraft and have no need of atmospheric correction to derive surface reflectance. The data also differ from the previous data set in that the vegetation of the Southern California biome is adapted to a much drier environment than the SCAR-A data which dominates the original data base. Data collected from low flying aircraft show remarkable adherence to a constant relationship between the mid-IR and visible. The relationship differs slightly from the conclusions derived from data in the moist environment, but within expected uncertainties. The data collected on the ground does not promote a constant relationship. We conclude that the relationship is dependent on existence of shadows within the canopy, not leaf morphology and color. Spatial averaging is necessary for shadows to become important. The spatial averaging is achieved by measuring from moving aircraft or from satellite footprint. We will continue to use $\rho_{blue}=\rho_{2.1}/4$ and $\rho_{red}=\rho_{2.1}/2$ in the algorithm. A paper (Kaufman et al) was submitted.

Aerosol Models used in the land aerosol algorithm

The spectral dependence of industrial aerosol was compared to spectral dependence of the industrial aerosol model. The dynamic nature of the spectral dependence of the model agrees with observations of AERONET sun data, but is offset. The offset is shown to be the difference between retrieved sun and sky optical thickness, and was determined not to be important. A paper was begun to organize and present the model of sulfate-dominated urban/industrial aerosol.

3.0 Fire Algorithm

The fire detection algorithm was discussed at a short meeting that included participation by C. Justice, Y. Kaufman and L. Flynn of the Univ. of Hawaii. The MAS data from SCAR-B will be analyzed in its entirety so as to create a statistical data base of detailed fire characteristics using fine resolution data. The prototype program to do this analysis is nearing completion. We expect in the next quarter a data based of thousands of fires and their spectral properties. These data will be used to study the fire algorithm.

4.0 TARFOX planning

Y. Kaufman and L. Remer participated in a TARFOX planning meeting at Wallops in March. General strategy and logistical details were discussed. Our participation in TARFOX will include flying the ER-2 carrying MAS and LASE (except on the last mission when AVIRIS will replace LASE) and also to collect ground-based data at Wallops, at three other coastal sites, on Bermuda and aboard a commercial cruise ship which makes weekly transects through the TARFOX region. Locations have been scouted and arrangements are being made.

5.0 SCAR-B data analysis workshop

We hosted a SCAR-B data analysis workshop at Goddard to discuss preliminary data analyis and plan for future collaboration. Participants included P. Artaxo (Univ. of Sao Paulo) and his students, D. Ward (USFS), P. Hobbs (Univ of Washington), E. Prins (Univ. of Wisconsin), Y. Kaufman, M. King, B. Holben and their associates (NASA/GSFC).

6.0 Aerosol Remote Sensing Workshop

Preparation for an international aerosol remote sensing workshop organized by Kaufman, Tanre, Nakajima and Gordon to be held April 15-19. Special issue of JGR is scheduled edited by Kaufman and Tanre

7.0 Aerosol over Ocean Algorithm

The algorithm was applied to a simulated data set and to field data from teh SCAR experiments and to Landsat TM data from Africa. In each case the spectal optical thickness and/or measurements of the particles size are available. The algorithm performed remarkably well. The optical thickness fit the ground based measurements within the measurement/calibration accuracy. The algothm distinguised between the small smoke particles, the medium sulfate particles and the large dust particles. A paper describing the algorithm, the sensitivity study and the validation is available.

8.0 References

Gao, B.-C. and Y. J. Kaufman, "Selection of the 1.375 µm MODIS channel for remote sensing of cirrus clouds and stratospheric aerosols from space." *J. Atmos. Scii*, *52*, 4231-4237, 1996.

Kaufman, Y.J. and D. Tanré, "Direct and Indirect Methods for Correcting the Aerosol Effect on Remote Sensing", *Rem. Sens. of Environ*., 55, 65-79, 1996.

Kaufman, Y.J. , D. Tanré, L. Remer, E. Vermote and B.N. Holben"Remote Sensing of Tropospheric Aerosol from EOS-MODIS Over the Land Using Dark Targets and Dynamic Aerosol Models", submitted to JGR-Atmosphere,special issue on remote sensing of aerosol and atmospheric corrections, February, 1996

Remer, L. A., Y. J. Kaufman, and B. N. Holben "The size distribution of ambient aerosol particles: smoke vs. urban/industrial aerosol", , accepted *Global biomass burning,,* The MIT press, Cambridge MA, 1996.

Remer, L. A., S. Gassó, D. Hegg, Y. J. Kaufman, and B. N. Holben, "Urban/industrial aerosol: ground based sun/sky radiometer and airborne in situ measurements." submitted to JGR-atmospheres special issue on remote sensing of aerosol and atmospheric corrections Jan. 1996.

Tanré, D. , Y.J. Kaufman, M. Herman and S. Mattoo, "Remote senisng of aerosol over oceans from EOS-MODIS, submitted to JGR-atmospheres special issue on remote sensing of aerosol and atmospheric corrections March. 1996.