MODIS Semi-Annual Report, December 1998

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This reports covers the **aerosol ocean** and **aerosol land** algorithm, and our involvement in the **NIR water vapor**, **Cirrus** and the **fire** algorithms.

Main topics addressed in this period:

AEROSOL OVER LAND

1. Development of a new method for remote sensing of aerosol absorption (*Kaufman, Tanre, Remer*)
2. Derived and analyzed aerosol optical properties from AVIRIS data in SCAR-B using MODIS aerosol algorithm (*Chu, Kaufman, Tanre*)
3. Remote sensing of dust in the IR.
4. Analysis of spectral properties of land across a transition from desert to vegetation (*Wald, Remer, Kleidman*)
5. Generation of dust look-up table assuming a mixture of spherical and non-spherical particles (*Chu and Kaufman*)
6. Analysis of effect of heavy smoke on aerosol radiative forcing using SCAR-C AVIRIS data (*Kaufman, Li)*
7. Analysis of data from Mexican smoke event (*Remer*)

AEROSOL OVER OCEAN

8. Analysis of TARFOX data over ocean (*Tanre, Remer, Mattoo, Kaufman,*)
9. Sensitivity study of aerosol retrieval over ocean using TARFOX data (*Levy, Mattoo, Kaufman, Fraser)*

WATER VAPOR

10. Validation of total precipitable water in SCAR-B using MODIS total precipitable water algorithm (*Chu and Kaufman*)
11. Study of 0.94 and 0.86 μm channel ratio for total precipitable water and cloud height (*Kleidman, Kaufman*)

COMBINED AND OTHER TOPICS

12. Application of MODIS aerosol, water vapor and cloud mask algorithms to TARFOX and SCAR-B MAS data (*Li, mattoo, Remer*)
13. Application of cirrus cloud detection/correction algorithm to AVIRIS data (*Li, Gao, Kaufman)*
14. Calibration of hand-held sunphotometers (Microtop II) (*Ichoku, Li, Kaufman, Remer*)
15. Development of MODIS aerosol visualization software (*Ichoku, Kaufman, Remer*)

16. Using global transport models to estimate the limitations of MODIS estimates of aerosol forcing (*Remer, Kaufman, Levin*).
17. Submission of updated aerosol ATBD (*Remer, Mattoo*)
18. Papers published to JGR SCAR-B and EOS-AM1 special issue (*Kaufman, Remer, Chu, Wald, Kleidman*)
19. Meetings attended (*Kaufman, Remer, Chu, Mattoo, Li, Kleidman, levy, Ichoku*)

1. Development of a new method for remote sensing of aerosol absorption

Simultaneous spaceborne and ground-based solar radiation measurements create a powerful novel tool to determine absorption of solar radiation by dust. Absorption is a key component of the dust radiative forcing of climate at the top of the atmosphere. It affects the temperature profile and cloud formation. We use Landsat spaceborne measurements at 0.47 to 2.2 μm over Senegal with ground based sunphotometers to find that Saharan dust absorption of solar radiation is two to four times smaller than in models. Though dust absorbs in the blue, the absorption for wavelengths > 0.6 μm is 0 to 1% (±0.5%) of the total light extinction, much smaller than the 10-35% in present models. The new finding increases by 50% recently estimated solar radiative forcing by dust at the top of the atmosphere, and decreases the estimated dust heating of the lower troposphere. Dust transported from Asia shows slightly higher absorption (0-7%) probably due to the presence of black carbon from populated regions. A paper was submitted.

2. Derived and analyzed aerosol optical properties from AVIRIS data in SCAR-B using MODIS aerosol algorithm

Derived and analyzed aerosol optical thickness, single scattering albedo, and Angstrom coefficients from AVIRIS data collected in SCAR-B experiment. Good agreement is found for aerosol optical thickness derived at 0.66 μm assuming single scattering albedo = 0.91, which is consistent with the results obtained using MAS measurements (Chu et al., 1998). More absorption is apparently required at 0.47 μm in order to avoid significant bias when compared to sunphotometer measurements. It shows that the single scattering albedo is equal to 0.88 for the best match between AVIRIS-derived optical thickness and sunphotometer observations. The results are comparable with the single scattering albedos derived using two other completely different methods with more absorption at 0.47 than 0.66 μm. Angstrom coefficients are also derived and analyzed for smoke aerosol. The average value of Angstrom coefficients is about 1.67 calculated for optical thicknesses at 0.47 and 0.66 μm, comparable with sunphotometer results.

3. Remote sensing of dust in the IR.

Continued validation work on dust-over-desert algorithm. HIRS data over Senegal and AVHRR data over the adjacent Atlantic obtained and are being compared.

4. Analysis of spectral properties of land across a transition from desert to vegetation

Representative target spectra selection based on video imagery have been chosen. Some preliminary data analysis for MODIS column water vapor and aerosol optical depth completed. Some calibration problems due to dark current drift and atmospheric correction addressed.

5. Generation of dust look-up table assuming a mixture of spherical and non-spherical particles

New dust look-up is generated using a hybrid phase function (misture of both non-spherical and spherical phase functions). The hybrid phase function is constructed assuming 80% spherical and 20% non-spherical particles based upon the ratios of non-spherical and spherical phase functions from M. Mishchenko et al. (1997) but assuming a different refractive index and size distribution. It is believed that the realistic dust particle is not 100% spherical nor non-spherical. The percentage ratio is estimated based upon the comparison of radiative transfer model calculations, Landsat TM reflectance data and AERONET measurements of sky radiance at 120° scattering angle.

6. Analysis of effect of heavy smoke on aerosol radiative forcing using SCAR-C AVIRIS data

Several heavy smoke scenarios in SCAR-C AVIRIS database were further analyzed for different solar zenith angles, in order to test the sensitivity of solar fluxes reflected by the smoke to space to illumination conditions. The data set is used to estimate the abiliy of MODIS to estimate directly the smoke direct forcing of climate.

7. Analysis of data from Mexican smoke event

Our measurements of the smoke from the Southern Mexico and Central American biomass burning episode were mostly made after the wind shift carried the fresh smoke westward over the Pacific Ocean. This gave us the opportunity to observe the aging of the older residual smoke over a wide regional area. The smoke particles of the older Mexican smoke tended to be a larger size than the average smoke particles observed in previous campaigns in South America and Africa. The effect on the phase function is relatively small, introducing manageable errors to the MODIS retrieval algorithms and increasing the aerosol radiative forcing by only 10%.

8. Analysis of TARFOX data over ocean

A complete set of TARFOX images has been analyzed to test the MODIS aerosol algorithm over ocean. The retrievals shows good comparison with in-situ measurements, in particular, for effective particle size. The test of glint angle indicate the current limit of glint angle should be changed from 30° to 40° to improve the retrieval. QA flag of glint angle between 40 and 50 is added to indicate the range. A few shortcomings of subroutines were also corrected. A paper was accepted for publication.

9. Sensitivity study of aerosol retrieval over ocean using TARFOX data

MODIS ocean algorithm showed significant sensitivity to the change of solar zenith angle and azimuth angle for the retrieval of aerosol properties. Discontinuities were found in the retrieved aerosol parameters field especially in locations adjacent to cloudy pixels, which were possibly due to deficiency in cloud mask algorithm. Other discontinuities were found due to the variations of the solutions derived. The average of selected solutions showed much stable results. This information will be used to improve the algorithm.

10. Validation of total precipitable water in SCAR-B using MODIS total precipitable water algorithm

For total precipitable water derived from AVIRIS data, agreement is found between AVIRIS-derived column water vapor and sunphotometer observation as well as the radiosonde results. Surface reflectance plays a key role in the derivation of total precipitable water. The linear interpolation of surface reflectance values from two adjacent window channels to water vapor absorption channel overestimates the column water vapor up to 50% over red soil. Further investigation is planned to solve this issue.

11. Study of 0.94 and 0.86 μm channel ratio for total precipitable water and cloud height

The use of the reflectance ratio of 0.94 and 0.86 μm wavelength for retrieving total precipitable water showed great sensitivity to cloud height. Feasible study were performed using SCAR-B MAS measurements and radiosonde data. These two channels were proposed to use by Triana instrument. Using the same pair of wavelengths, good agreement was also found in the relationship of the reflectance ratio at 0.94 and 0.86 μm and total water column derived from LASE measurements over ocean glint region collected during TARFOX experiment. It indicates that we can derive total precipitable water not only over land but also over ocean glint region.

12. Application of MODIS aerosol, water vapor and cloud mask algorithms on TARFOX and SCAR-B MAS data

The application of MODIS cloud mask algorithm to TARFOX and SCAR-B MAS data showed errors in several cloud mask flags, such as cirrus flag, shadow flag, and glint flag. These errors have been reported to University of Wisconsin for further evaluation of the cloud mask algorithm whether they are due to instrument calibration or algorithm deficiency. The MODIS aerosol and water vapor algorithms were also applied to SCAR-B MAS data to generate a suite of aerosol optical thickness and total precipitable water results. This is an effort to fully evaluate the MODIS algorithms and will continue until the launch of MODIS on EOS-AM1 satellite.

13. Application of cirrus cloud detection/correction algorithm

Promising results of cirrus cloud detection/correction were shown for AVIRIS images over water and land using 1.38 μm cirrus detection channel. The cirrus correction is important, for example, to improve vegetation index and water-leaving radiance and the retrieval of aerosol optical thickness. By removing cirrus cloud, low clouds can also be seen, which is also useful for aerosol-cloud interaction study.

14. Calibration of hand-held sunphotometers (Microtop II)

Three hand-held sunphotometers (Microtop II) are continuously performed by taking measurements of various conditions of aerosol optical thicknesses for calibration and intercomparison. For the preliminary calibration, except 0.34 μm ultraviolet and 0.94 μm water vapor absorbing channels, the other 3 channels (from 0.44 to 0.86 μm) showed expected and stable results. Long term calibration is planned for all 5 sunphotometers.

15. Development of MODIS aerosol visualization software

The after-launch visualization software is planned to develop for both visualization and validation purposes. Aerosol properties retrieved from MODIS measurements and AERONET ground-based sunphotometer aerosol optical thickness data are grouped into a user-friendly database. Global maps and statistical results are going to be produced daily, weekly and monthly.

16. Using global transport models to estimate the limitations of MODIS estimates of aerosol forcing

We intend to combine the results of global transport models with AERONET data and MODIS data in order to make the best estimate of global aerosol

radiative forcing both the direct and indirect effects. As a pilot study, we asked the question of how much of the global radiative forcing occurs in regions where the aerosol optical thickness is large enough to be retrieved from MODIS with sufficient accuracy. To do this study we used the model results of Tegen et al. (1997) and ISCCP climatology. The model data severely underestimated aerosol optical thickness in smoke regions close to the sources when validated by AERONET data. The model data was then adjusted to agree with AERONET. The results show that MODIS will be able to see most of the direct forcing, but perhaps only 50% of the indirect forcing. An interesting byproduct of this analysis indicates that on a global basis cloud fraction is inversely correlated with aerosol, which suggests that estimates of indirect forcing may be too high. Further studies using this model and others are planned.

17. Submission of updated aerosol ATBD

MODIS aerosol ATBD has been updated and submitted to EOS project office.

18. Papers published in JGR SCAR-B and EOS-AM1 special issue (December 27, 1998)

1. **Kaufman, Y. J.,** P. V. Hobbs, V. W. J. H. Kirchhoff, P. Artzxo, **L. A. Remer**, B. N. Holben, M. D. King, D. E. Ward, E. M. Prins, K. M. Longo, L. F. Mattos, C. A. Nobre, J. D. Spinhirne, Q. Ji, A. M. Thompson, J. F. Gleason, S. A. Christopher, and S.-C. Tsay, Smoke, Clouds, and Radiation-Brazil (SCAR-B) experiment, J. Geophys. Res., 103, 31,783 - 31,808, 1998.
2. **Kaufman, Y. J.**, **R. G. Kleidman**, and Michael D. King, SCAR-B fires in the tropics: Properties and remote sensing from EOS-MODIS, J. Geophys. Res., 103, 31,955 - 31,968, 1998.
3. **Kaufman, Y. J.**, C. O. Justice, L. P. Flynn, J. D. Kendall, E. M. Prins, L. Giglio, D. E. Ward, W. P. Menzel, and A. W. Setzer, Potential global fire monitoring from EOS-MODIS, J. Geophys. Res., 103, 31,955 - 32,215 - 32,238, 1998.
4. Yamaso M. A., **Y. J. Kaufman**, O. Dubovik, **L. A. Remer**, B. N. Holben and P. Artaxo, Retrieval of real part of the refractive index of smoke particles from Sun/sky measurements during SCAR-B, J. Geophys. Res., 103, 31,955 - 32,215 - 32,238, 1998.
5. Duvovik, O., B. N. Holben, **Y. J. Kaufman**, M. Yamasoe, A. Smirnov, **D. Tanre**, and I. Slutsker, Single scattering albedo of smoke retrieved from sky radiance and solar transmittance measured from ground, J. Geophys. Res., 103, 31,783 - 31,808, 1998.
6. Gao, Bo-Cai, **Y. J. Kaufman**, W. Han, and W. J. Wiscombe, Correction of thin cirrus path radiances in the 0.4-1.0 μm spectral region using the sensitive 1.375 μm cirrus detecting channel, J. Geophys. Res., 103, 32,169 - 32,176, 1998.
7 Martins, Y. J., P. Artaxo, C. Liousse, J. S. Reid, P. V. Hobbs, and **Y. J. Kaufman**, Effects of black carbon content, particle size, and mixing on light absorption by

aerosols from biomass burning in Brazil, J. Geophys. Res., 103, 32,041 - 32,050, 1998

8. **Remer, L. A., Y. J. Kaufman**, B. N. Holben, A. M. Thompson, and D. McNamara, Biomass burning aerosol size distribution and modeled optical properties, J. Geophys. Res, 103, 31,879 - 31,892, 1998.
9. **Chu, D. A., Y. J. Kaufman, L. A. Remer**, and B. N. Holben, Remote sensing of smoke from MODIS Airborne Simulator during SCAR-B experiment, J. Geophys. Res, 103, 31,979 - 31,988, 1998.
10. **Wald A. E., Y. J. Kaufman, D. Tanre**, and B.-C. Gao, Daytime and nighttime detection of mineral dust over desert using infrared spectral contrast, J. Geophys. Res, 103, 32,307 -32,313, 1998.

Other publications:

11. **Remer, L.A.** and **Y.J. Kaufman**, Dynamical aerosol model: Urban/industrial aerosol., J.Geophys. Res., 103, 13,859-13,871, 1998.

12. Hegg, D.A., Y. J. **Kaufman,** 1998: Measurements of the relationship between submicron aerosol number and volume concentrations. *J. Geophys. Res.*, **103**, 5671-5678.

13**. Kaufman**, Y. J., D. D. Herring, K. J. Ranson, and G. J. Collatz, 1998: Earth Observing System AM mission to Earth", *IEEE IGARS special issue on EOS,* **36,** 1045-1055.

14. Ferrare, R. A., S. H. Melfi, D. N. Whiteman, K. D. Evans, M. Poellot, and Y. J. **Kaufman**, 1998: Raman Lidar Measurements of Aerosol Extinction and Backscattering - Part 2: Derivation of Aerosol Real Refractive Index, Single Scattering Albedo, and Humidification Factor. *J. Geophys. Res.*, 103, 19,673-19,689, 1998.

15. Alpert, P., Y. J. **Kaufman**, Y. Shay-El, D. **Tanre**, A. da Silva, S. Schubert, Y. H. Joseph, 1998; Quantification of Dust-Forced heating of the Lower Troposphere. ***Nature***, 395, 367-370.

16. Holben, B. N., T. F. Eck, I. Slutsker, D. **Tanré**, J. P. Buis, A. Setzer, E. Vermote, J. A. Reagan, Y. J. **Kaufman**, T. Nakajima, F. Lavenu, I. Jankowiak and A. Smirnov, 1998: AERONET-A federated instrument network and data archive for aerosol characterization, Rem. Sens. Environ., 66, 1-16.

Submitted papers:

17. Alpert, P., J. Herman, Y. J. **Kaufman**, I. Carmona, 1998: Dust forcing of climate inferred from correlation between TOMS aerosol index and atmospheric model errors. *Atmospheric Res*. **submitted**.

18. **Kaufman** Y. J., and V. Ramanathan, 1998: State of the art check-up of planet Earth at the turn of the millennium. *Bull. of Meteor. Soc*.. Submitted, *1998.*

19. **Kaufman**, Y. J., A. Karnieli and D. Tanré, 1998: Detection of dust over the desert by EOS-MODIS. *IEEE TGARS* **submitted.**

20. Shay-El, Y., Alpert, P., Y. J. **Kaufman**, D. **Tanre**, A. da Silva, S. Schubert, Y. H. Joseph, 1998; Lower tropospheric Response to Dust as inferred from correlations between dust frequencies and analysis updates of NASA/GEOS.***Tellus,*** **submitted.**

21. **Tanré**, D., L.R. **Remer**, Y.J. **Kaufman**, P.V. Hobbs, J.M. Livingston, P.B. Russel, A. Smirnov, Retrieval of Aerosol Optical Thickness and Size Distribution Over Ocean from the MODIS Airborne Simulator during Tarfox, *J. Geophys. Res.* **submitted.**

22. King, M. D., Y. J. **Kaufman**, D. **Tanré**, and T. Nakajima, 1998: Remote sensing of tropospheric aerosols from space: past, present and future. *Bull. of Meteor. Soc*.. Submitted to BAMS. November 1998

23. **Kaufman**, Y. J., D. **Tanré**, A. Karnieli, and L.A. **Remer**, 1998: Dust absorption and radiative forcing derived from measured solar radiation. *Science.* **submitted.**

19 Meetings attended

1. MODIS Atmosphere meeting at St. Michaels, November 4-6, 1998 (*Kaufman, Remer, Chu, Mattoo Kleidman, Levy, Ichoku*)
2. DAO/EOS-AM1 instrument team workshop, NASA Goddard Space Flight Center, November 30 - December 1, 1998. (*Chu*)
3. MODIS Science team meeting, University of Maryland, College Park, December 14-15, 1998 (*Kaufman, Remer, Chu, Mattoo, Li, Levy, Ichoku*)
4. MODIS PI data processing meeting, NASA Goddard Space Flight Center, November 20, 1998 (*Ichoku, Chu*)
5. NASA First Aerosol Radiative Forcing Science Team Meeting, NASA/GISS in New York, November 1998 (*Kaufman, Remer*).
6. IGAC Joint International Symposium on Global Atmospheric Chemistry, Seattle, August 1998 (*Kaufman, Remer*).