MODIS Semi-Annual Report, June 2002

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This report 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 AND OCEAN

1. Validation and statistics of MODIS aerosol optical depth derived over land and ocean from 2000 to 2001 *(Remer, Levy, Kaufman, Ichoku, Chu*)
2. Validation and improvement of MODIS Aerosol Retrieval of dust using PRIDE and other dust data (*Remer, Levy, Kaufman*)
3. Validation of MODIS-derived aerosol optical depths during CLAMS experiment (*Levy, Martins, Remer, Kaufman*)
4. Analysis of glint angle dependence of MODIS-derived aerosol optical depth over ocean (*Levy, Kaufman*)
5. Validation of MODIS-derived aerosol optical depths in SAFARI 2000 (*Ichoku,Kaufman,Remer, Levy, Chu, Li, Mattoo)*
6. Validation of MODIS-derived aerosol optical depths in Beijing, China (*Chu, Kaufman*)
7. Seasonal variation and frequency of MODIS-derived aerosol optical depths from December 2001 – November 2002 *(Chu, Kaufman)*

ALGORITHM ENHANCEMENT & DEVELOPMENT

8. Summary of algorithm modifications
9. Extension of aerosol retrieval to 2.1 μm reflectance to 0.4 at nadir (*Chu, Kaufman, Vermote*)
10. Cirrus cloud screening scheme over ocean (*Li, Kaufman, Mattoo*)
11. River sediment screening in the coastal area (*Li, Kaufman, Mattoo*)
12. Improvements of cloud mask using spatial variability approach (*Martins, Mattoo, Kaufman, Remer, Li*)
13. Retrieval of heavy dust over ocean sunglint (*Martins, Kaufman, Mattoo*)

OTHER TOPICS

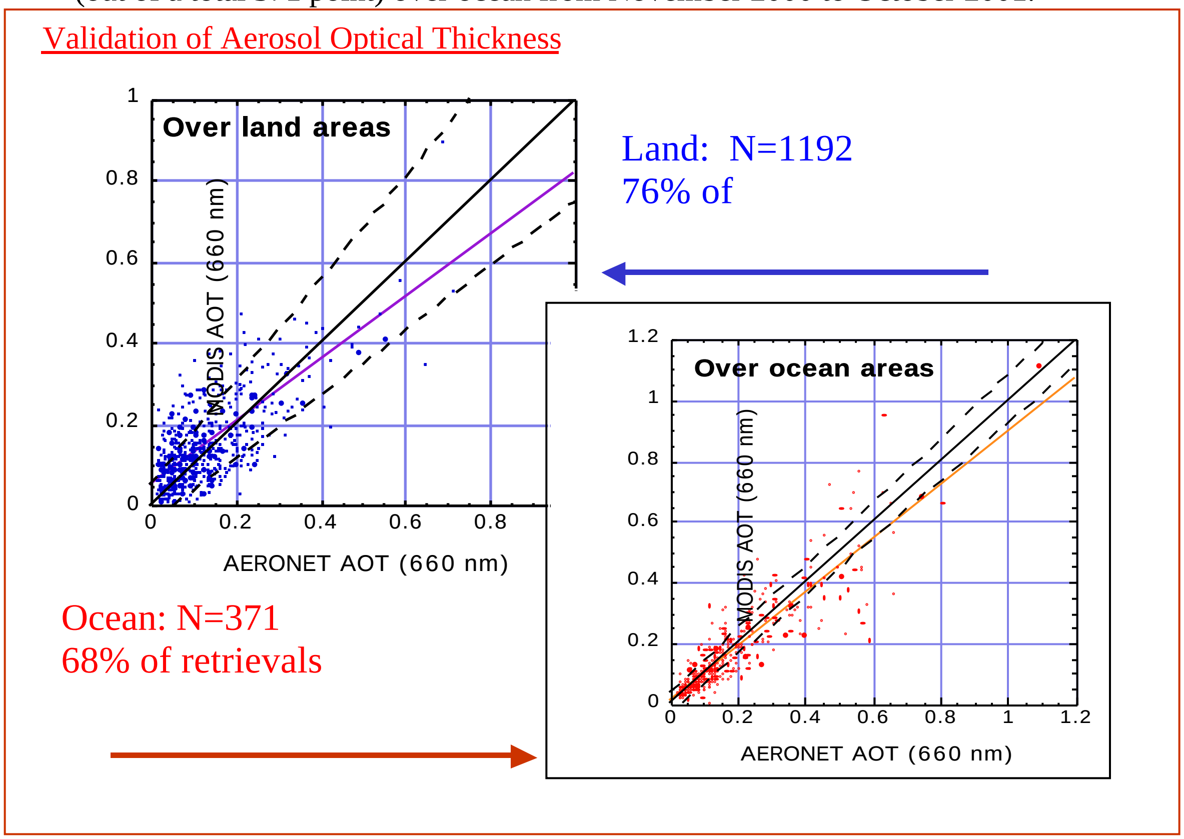
14. Absorption MODIS Lookup table and Combination Aeronet/MODIS retrievals of aerosol over the glint (*Mattoo, Kaufman, Martins*)
15. Statistics/comparison of MODIS and GOCART aerosol properties (*Kaufman, Mattoo*)
16. Empirical derivation of nonspherical phase functions (*Remer, Kaufman, Levy, Dubovik*)
17. Enhancement/maintenance of the automated daily process of the generation of the MAPSS database from MODIS and AERONET aerosol and water vapor products (*Ichoku, Kaufman, Remer, Chu)*
18. Calibration and analysis of Microtops sunphotometer measurements (*Ichoku, Martins, Fattori, Kaufman*)
19. Development of aerosol transport model (*Lapyonok, Dubovik, Kaufman,*)
20. Paper acceptance/submission/preparation (*Kaufman, Remer, Chu, Ichoku, Martins, Kleidman)*

21. Meeting and workshop (*Kaufman, Remer, Chu, Martins, Mattoo, Li, Kleidman, levy, Ichoku*)

1. Validation and statistics of MODIS aerosol optical depth derived over land and ocean during "consistent year" production

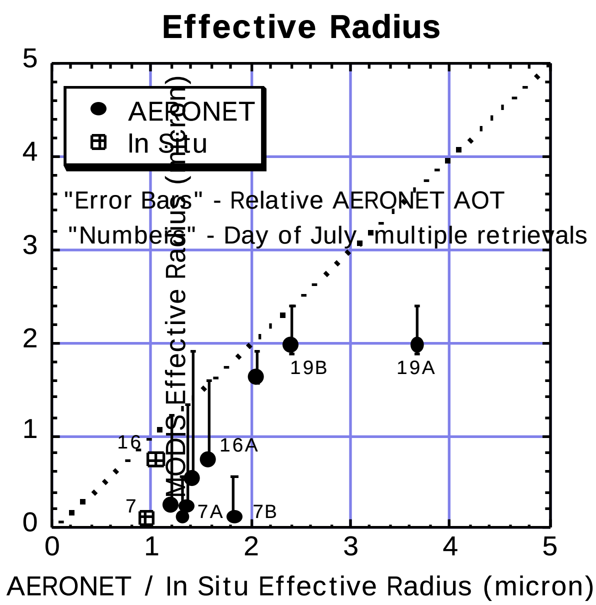
MODIS aerosol products have been routinely generated and the operational algorithm has been periodically updated. What we try to answer is:

1) whether there is any obvious change in retrieval quality caused by algorithm change,
2) whether the retrieval quality remain within the expected ranges. Based upon the comparisons between MODIS and AERONET, 76% (out of a total of 1192 points) of MODIS-derived aerosol optical depths fall within the retrieval error over land and 68% (out of a total 371 point) over ocean from November 2000 to October 2001.



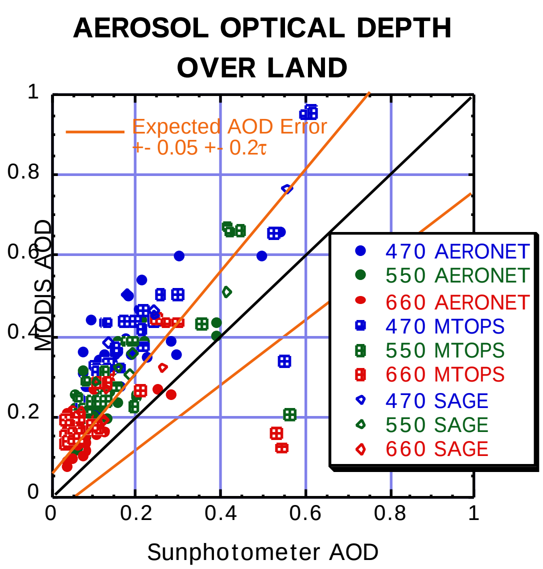
2. Validation and improvement of MODIS Aerosol Retrieval of dust using PRIDE and other dust data

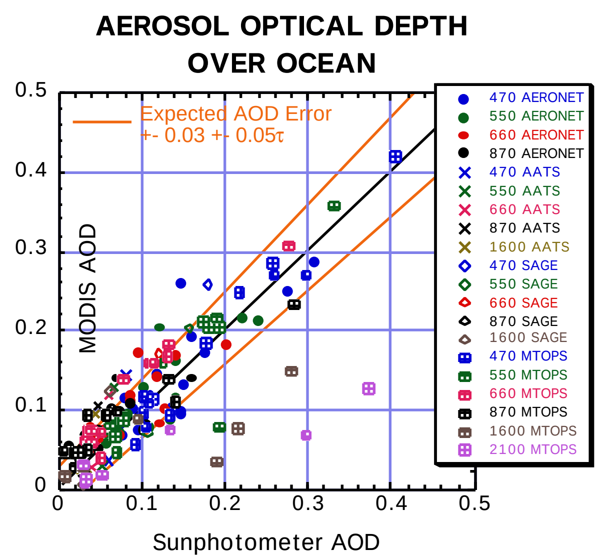
The Puerto Rico Dust Experiment (PRIDE) data are used to evaluate and improve MODIS aerosol retrievals over ocean under dusty condition. The MODIS-derived optical depths at 0.66 μm are found within retrieval errors. At longer wavelengths aerosol optical depths are not as good and show some kind spectral dependence. This spectral dependence, in turn, forces the retrieved effective radius to be too small. We believe that the spectral optical depth and size discrepancies are primarily caused by assuming spherical particle. We are working on introducing non-sphericity into the algorithm



3. Validation of MODIS-derived aerosol optical depths during CLAMS experiment

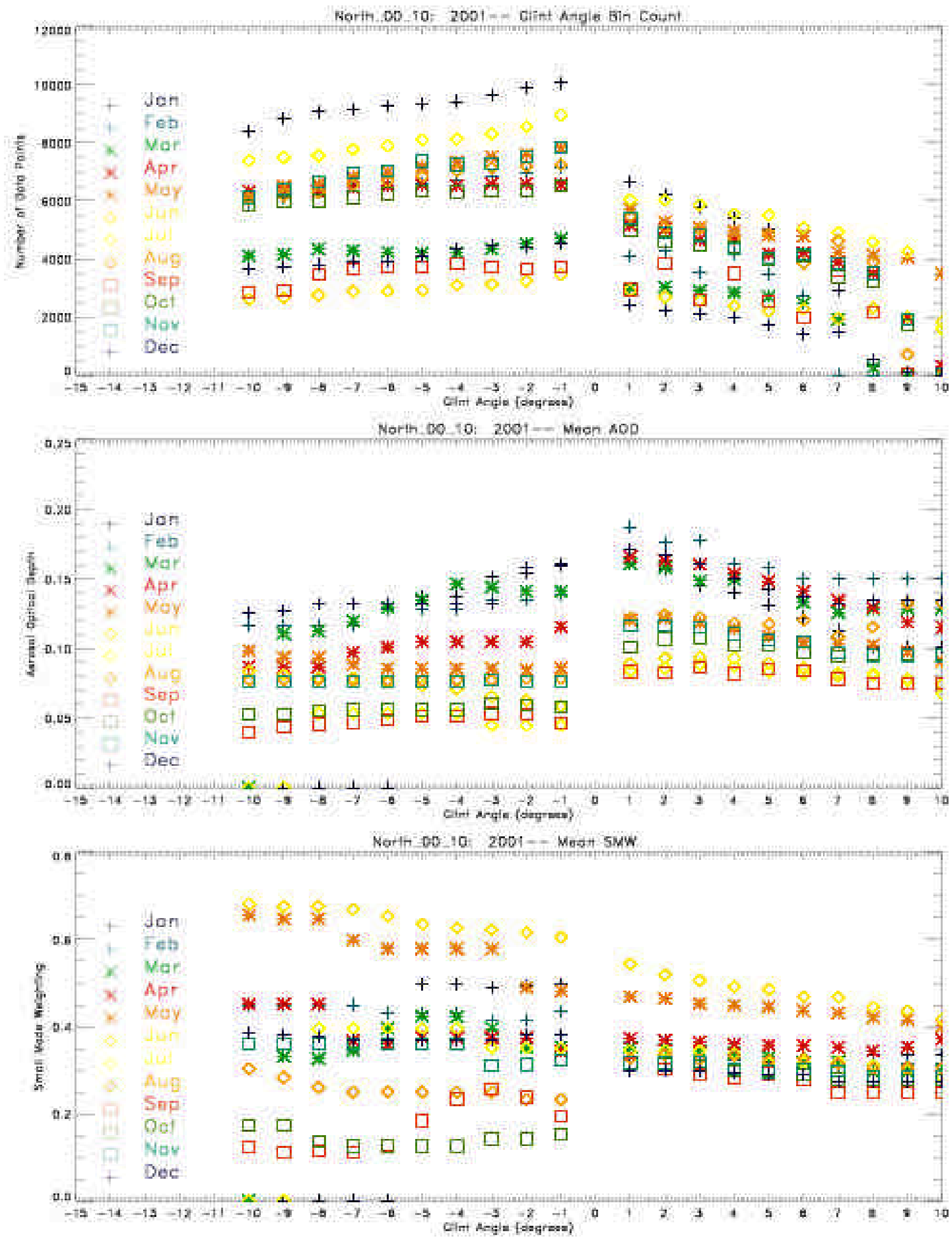
The MODIS-derived aerosol optical depths are compared to five different sunphotometers during CLAMS experiment, including the AERONET Cimel and Microtops sunphotometers with spectral channels in the visible wavelengths but also the new Microtops, the AATS (Ames Airborne Tracking Sunphotomter) and new NASA-Langley sunphotometers with spectral channels extending up to 2.1 microns. These new sunphotometers give us information to validation and improve the MODIS aerosol retrievals over ocean from near to mid-infrared wavelengths. Over ocean the MODIS retrievals show close to 1 to 1 comparison with sunphotometer measurements, whereas over land (coastal zone) MODIS-derived aerosol optical depths are consistently higher than the sunphotometer measurements, which is consistent with previous findings as shown by *Chu et al.* [2002] Reasons for the persistent discrepancy are under investigation. In the mid-infrared wavelengths (e.g., 1.6 and 2.1 µm), improvements in Microtops and "Langley" sunphotometer calibrations are needed in order to have meaningful conclusions.





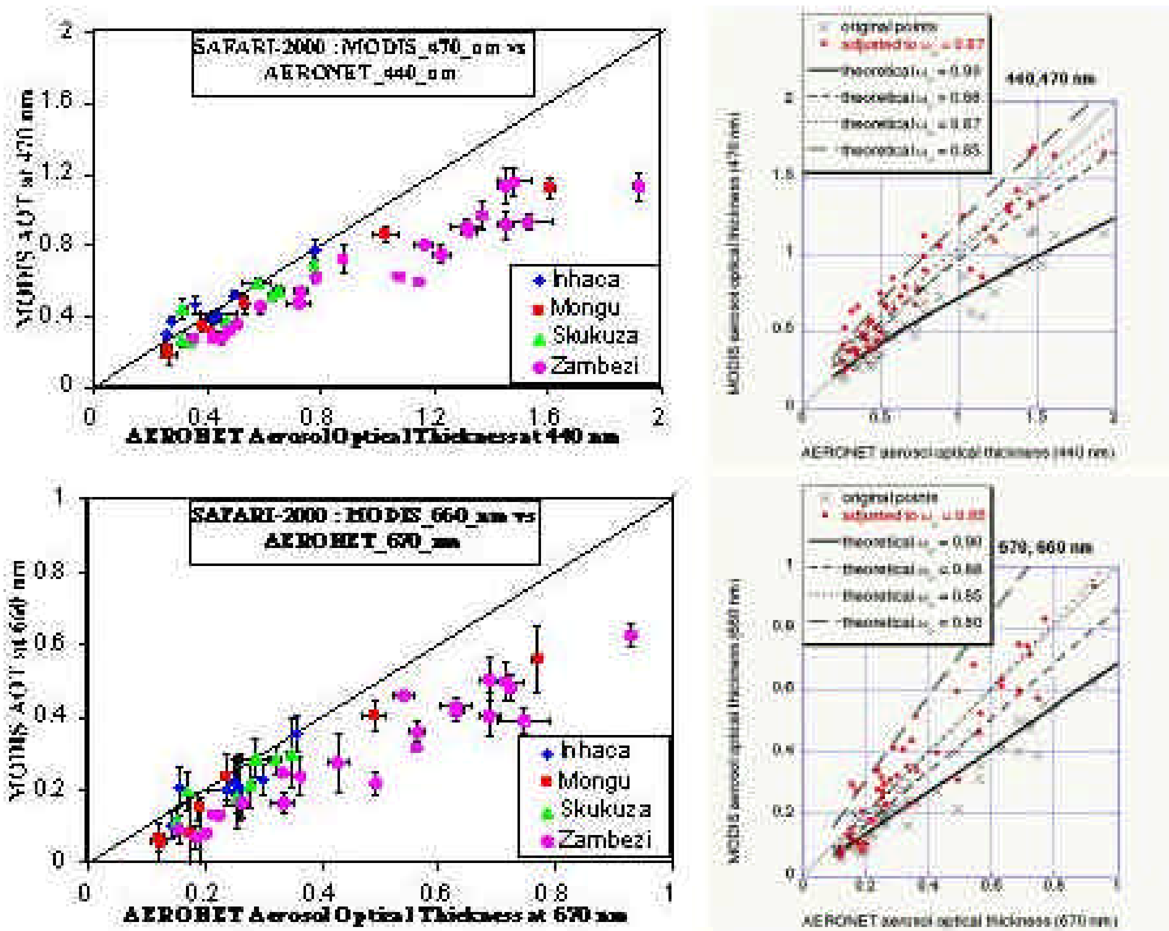
4. Analysis of glint angle dependence of MODIS-derived aerosol optical depth over ocean

MODIS retrievals over the ocean are analyzed as a function of MODIS glint angle for a selected latitude band between 0 and 10°N. Three panels represented number of retrievals, retrieved AOD at 0.55 μm, and small-mode fraction (at 0.55 mm). "Bins" of glint angle are shown by the x-axes. For example, -1 is glint angle between –40 and –42 degrees (the left side of glint mask), while +1 is glint angle between +40 and +42 degrees (the right side of the glint mask). Note, that there are no operational MODIS retrievals inside 40°glint angle. The retrieved aerosol properties are then calculated into monthly means. Seasonal variation can be seen between MODIS-derived aerosol properties and glint angle. A discontinuity across the center of the MODIS glint mask, which may relate to other angles, for example, scattering angle, or phase function.



5. Validation of MODIS-derived aerosol optical depths in SAFARI 2000

MODIS and AERONET data were analyzed together in an effort to gain a better understanding of aerosol spatial and temporal distribution as well as the physical properties and radiative forcing over southern Africa during the SAFARI-2000 field campaign. During that process, it was found that MODIS underestimated aerosol optical thickness (AOT) with respect to AERONET, especially in situations of high aerosol concentration. This was because the constant single scattering albedo (SSA) value of 0.9 used for MODIS smoke aerosol retrieval globally is not so suitable for southern African smoke due to its relatively higher absorption property relative to Brazilian smoke. The figure illustrates the relationships between MODIS and AERONET AOT during SAFARI-2000 based on MODIS retrieval with the original SSA=0.9, as well as those based on alternative SSA values. Another major accomplishment in the study was the calculation of aerosol radiative forcing for September 2000 over the southeastern Atlantic Ocean adjacent to the southern African region. The study and the detailed results are reported in a manuscript submitted (and already revised) for publication in the SAFARI-2000 special issue of the Journal of Geophysical Research (JGR).



6. Validation of MODIS aerosol optical depths in Beijing, China

Non-AERONET sunphotometer measurements acquired at Beijing, China has been used for validating MODIS retrievals in the region where AERONET measurements were not available. The sunphotometers made by Peking University have 10 spectral channels in the wavelength from 0.44 to 0.91 μm to measure aerosol optical depth and water vapor with calibration accuracy nearly within 1%. The validation results shown below depict that for MODIS-derived aerosol optical depths are slightly higher than those from sunphotometer measurements for aerosol optical depth < 0.4 and reversed for aerosol optical depth > 0.4. It reflects two issues (1) underestimation of surface reflectance and (2) underestimation of aerosol absorption. Work to fix these two problems are underway.

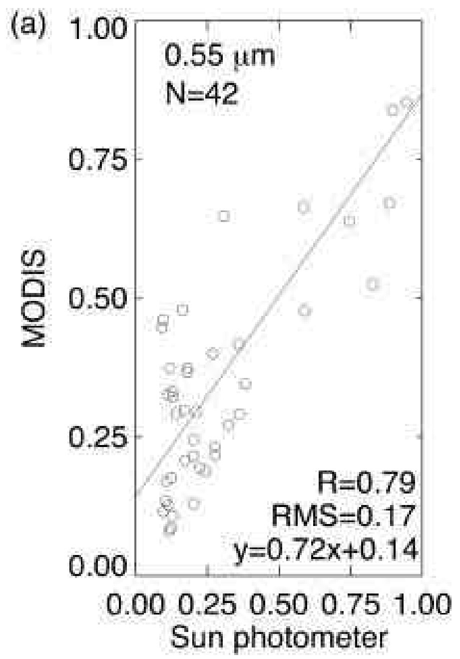


Figure 6 Comparisons of τ_a derived from MODIS and the sun photometer at Peking University (SPU) from May to November 2001 (a) all data (b) τ_a (SPU) within ± 1 hour of MODIS overpasses.

7. Seasonal variation and frequency of MODIS-derived aerosol optical depths from December 2001 – November 2002—consistent-year results

The MODIS-derived aerosol optical depths show clearly a strong seasonal variation from spring (e.g., Asian dust outbreak), summer (e.g., E. US and W. Europe summertime haze and S. Africa biomass burning), autumn (e.g., S. America biomass burning) to winter (e.g., central Africa biomass burning). Other aerosol events include springtime biomass burning in central America and Austrilia (S. Hemisphere). The biomass burning events in South America depicts a time lag of 1-2 months when compared to that in Southern Africa. The biomass burning in S. America didn't start until September-October 2001.

The frequency maps illustrate the frequency of MODIS aerosol retrievals in percentage corresponding to each season. Areas in black without aerosol retrievals are due to clouds, bright surface (deserts and snow/ice covered regions), or beyond the limits of sun-satellite geometry (solar zenith angle > 72°). More retrievals are seen in high latitudes (>40°) because of overlapping orbits. The so-called "warm pool" associated with summer monsoon in Southeast Asia shows much less aerosol retrievals in the summer when compared to other seasons.

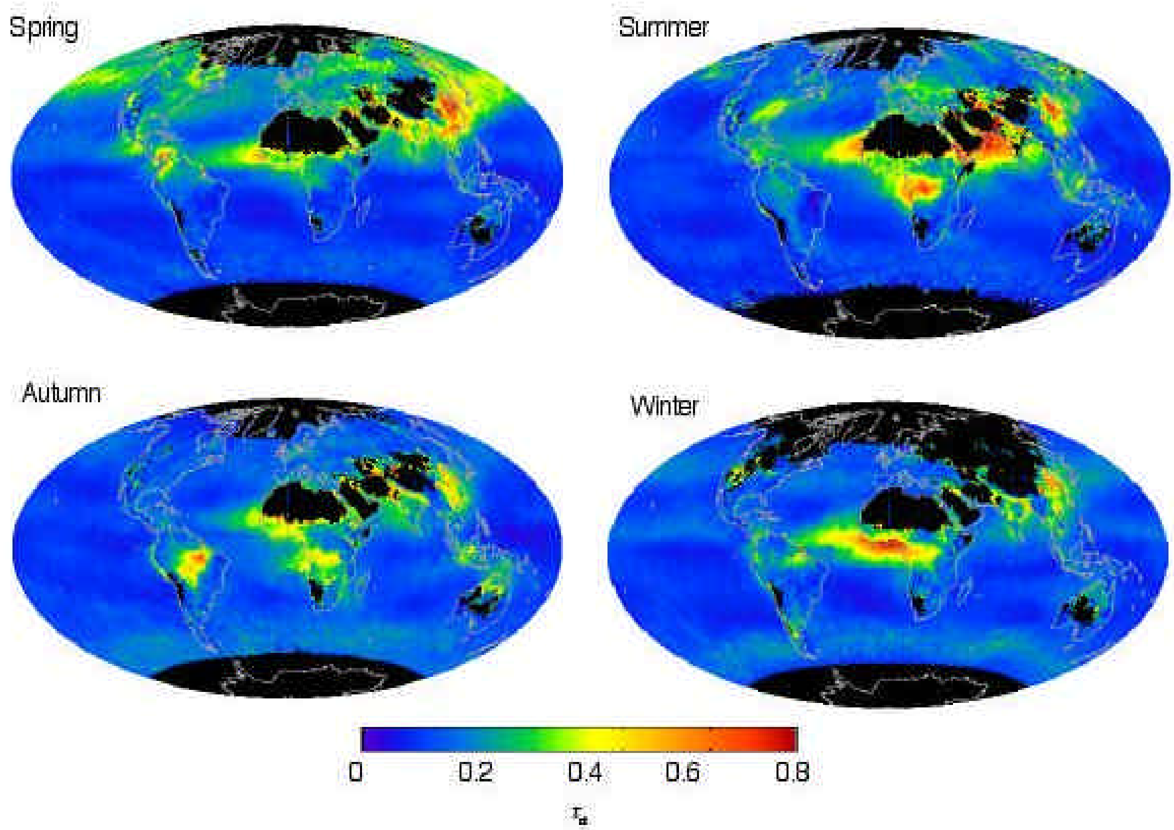


Figure 3(b) Images of seasonal means of MODIS-derived τ_a for spring (March - May 2001), summer (June - August 2001), and autumn (September - November 2001), and winter (December 2000 - February 2001).

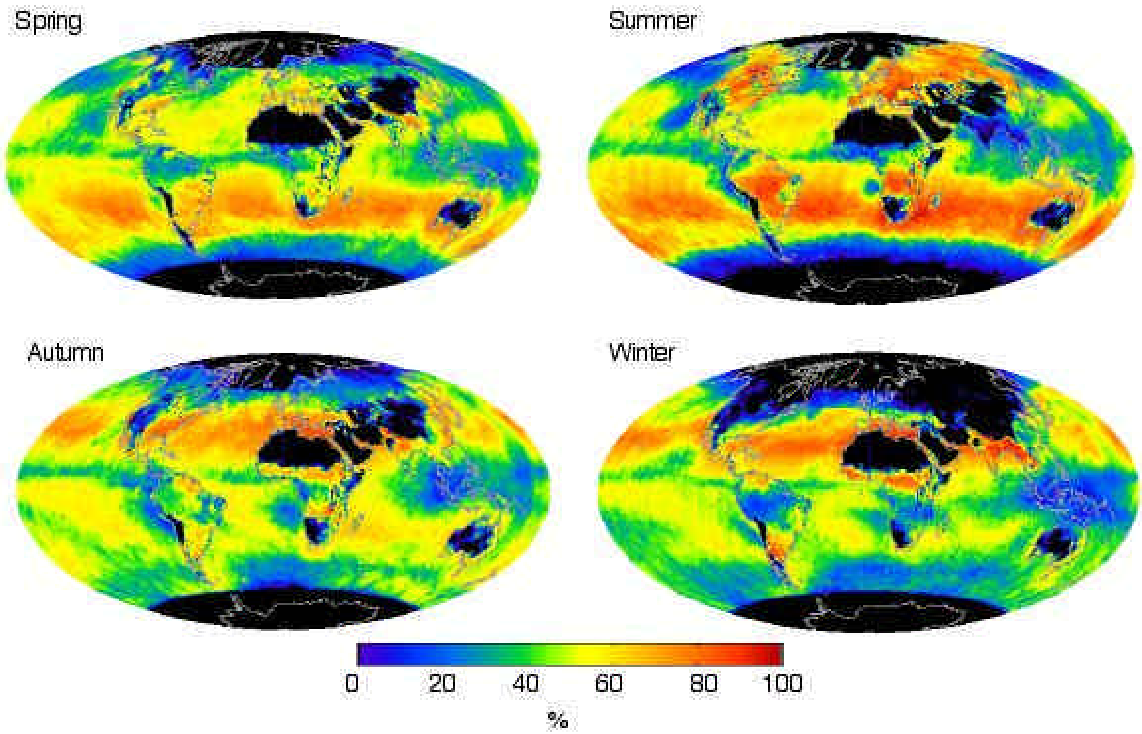


Figure 3 (a) Frequency maps of aerosol retrievals over land for spring (March - May 2001), summer (June - August 2001), autumn (September - November 2001), and winter (December 2000 - January 2001). Frequency in percentage is calculated using the MODIS level-3 daily products as the total number of days with non-filled values in a 1° ∞ 1° grid box divided by the total of calendar days in the season. Note that 19 days from June 16 to July 3, 2001 were without data because of MODIS malfunction.

8. Summary of algorithm modifications

Below is a summary of major science changes to the code. The date is the date of algorithm delivery, not the date of implementation which follows several weeks later. Version is the code version. Collection describes in which collection the modification first appears. All modifications will continue into all higher number versions. Algorithm designates whether the modification affected the land or ocean portion of the algorithm. The most recent modifications are described in greater detail within this semiannual report. The item numbers from this report are indicated.

The modifications in this table are restricted to major algorithm innovations. They do not include updates to the metadata, which will not affect the product, or small threshold adjustments, which may have a small effect on the product. We refer the interested reader to the full history modification file available from Shana Mattoo.

date	Version	collection	algorithm	Modification
08/01/02	4.1.0	4	ocean	- spatial variability cloud mask advances pixel by pixel. (item 12 below) - ρ0.47 test in cloud mask (item 12 below) - dust call back when ρ0.47/ ρ0.66 < 0.75 (item 12 of the report) - heavy dust retrieval over glint. (item 13) - river sediment mask (item 11 below)
08/01/02	4.1.0	4	land	- land aerosol models changed to increase aerosol absorption.
05/10/02	4.0.1	3	ocean	- τ > 5. Set to fill value
01/22/02	3.1.0	3	ocean	- cirrus mask using ρ1.38/ρ1.24 (item 10) - τ > 5. Set = 5. - Added and removed SDS's
01/22/02	3.1.0	3	land	- extending land retrievals at 0.47 to brighter surfaces (item 9 below) - shift land percentile filter to 20-50% - Added and removed SDS's
05/01/01	2.5.0	3	land	- ρ2.1 thresholds for dust retrieval shifted to darker surfaces. - path radiance and critical reflectance added as experimental products.
03/29/01	2.4.0	1	land	- snow mask extended to contiguous pixels - water screening threshold lowered.
11/16/00	2.3.2	1	ocean	- IR tests in cloud mask adjusted
10/20/00	2.3.1	1	ocean	- new LUT implemented (different dust models and removal of one coarse mode).
7/10/00	2.2.0	1	ocean	- spatial variability cloud mask implemented

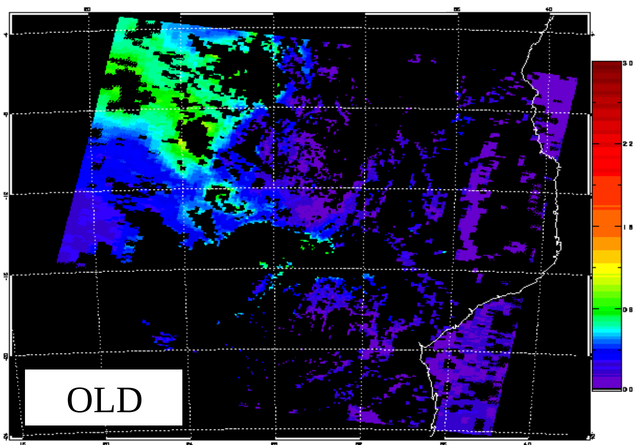
At launch	2.1.0	1		

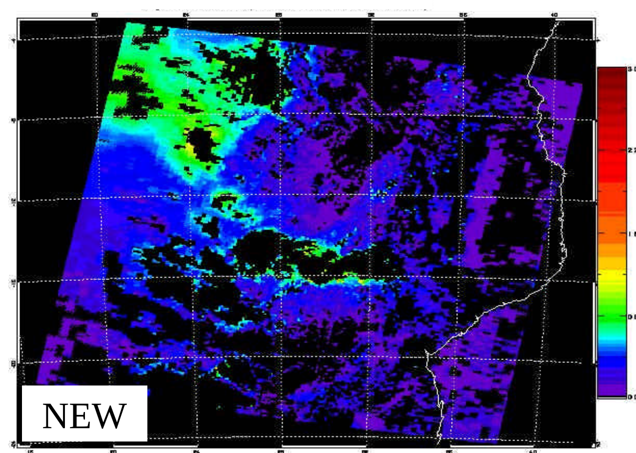
9. Extension of aerosol retrieval to 2.1 μm reflectance to 0.4 at nadir for 0.47 μm channel

Extension of 2.1 μm reflectance threshold from 0.25 to 0.4 at nadir with the inclusion of sun-satellite sensor geometrical factor

The 0.25 threshold → $0.25*[0.5*(1/\mu + 1/\mathrm{sqrt}(\mu_0))]$

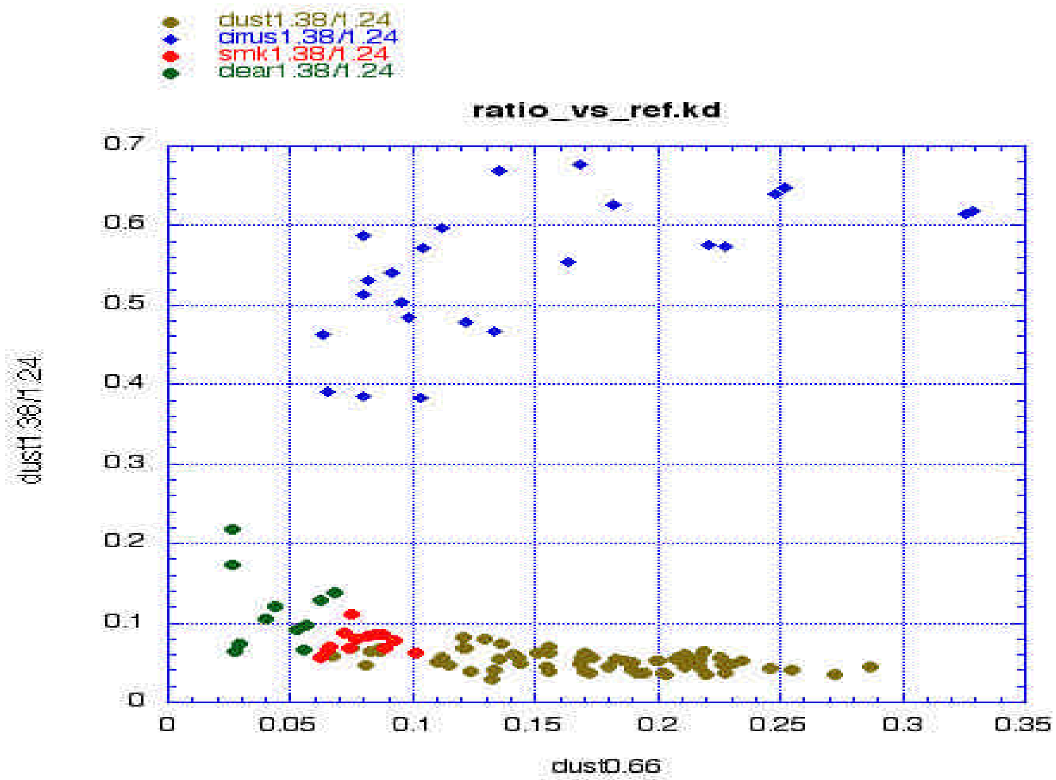
at off-nadir viewing (μ: cosine of satellite viewing angle; μ_0: cosine of solar zenith angle) for aerosol retrievals at 0.47 μm channel. In theory, the ratio (0.25) of the reflectance of 0.47 and 2.1 μm reflectance can be extended further to higher reflectance of 2.1 μm reflectance (e.g., 0.4), while the ratio (0.5) between 0.66 and 2.1 μm reflectance begins to deviate after 0.25. Continental aerosol model is only used to derive aerosol optical depth at 0.47 μm and extrapolated to 0.55 μm. Shown below is an example of Julian Day 233 UTC 0835, 2000 at east coast of Southern Africa. The left panel is the image of using 2.1 μm reflectance < 0.25 and the right panel is the use of 2.1 μm reflectance extending to 0.40 as described above.

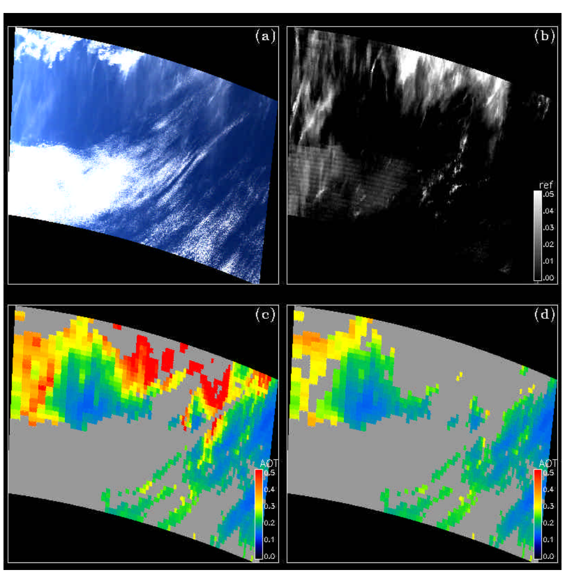


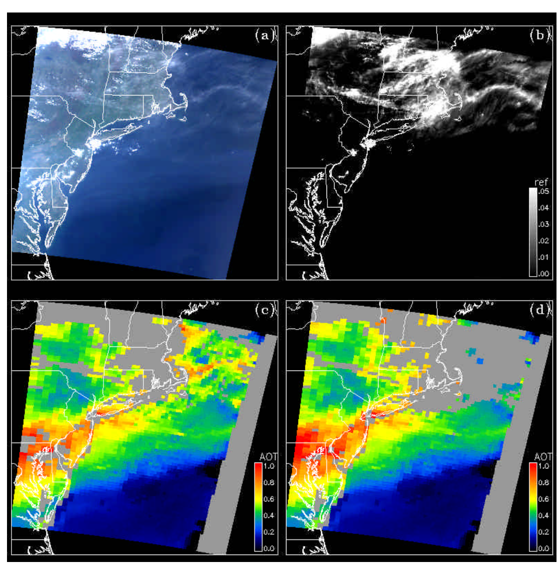


10. Cirrus cloud screening scheme over ocean

The ratio of reflectance at 1.38 μm and 1.24 μm show clear separation between cirrus clouds and aerosols (smoke, sulfate, and dust) using the threshold ~ 0.3. Cirrus contamination has been significantly reduced in the MODIS aerosol retrieval over ocean. Shown below are two examples in the coast of Alaska and US mid-Atlantic states. The threshold, distinguishes the cirrus clouds (blue) from the clear and aerosol (colored).

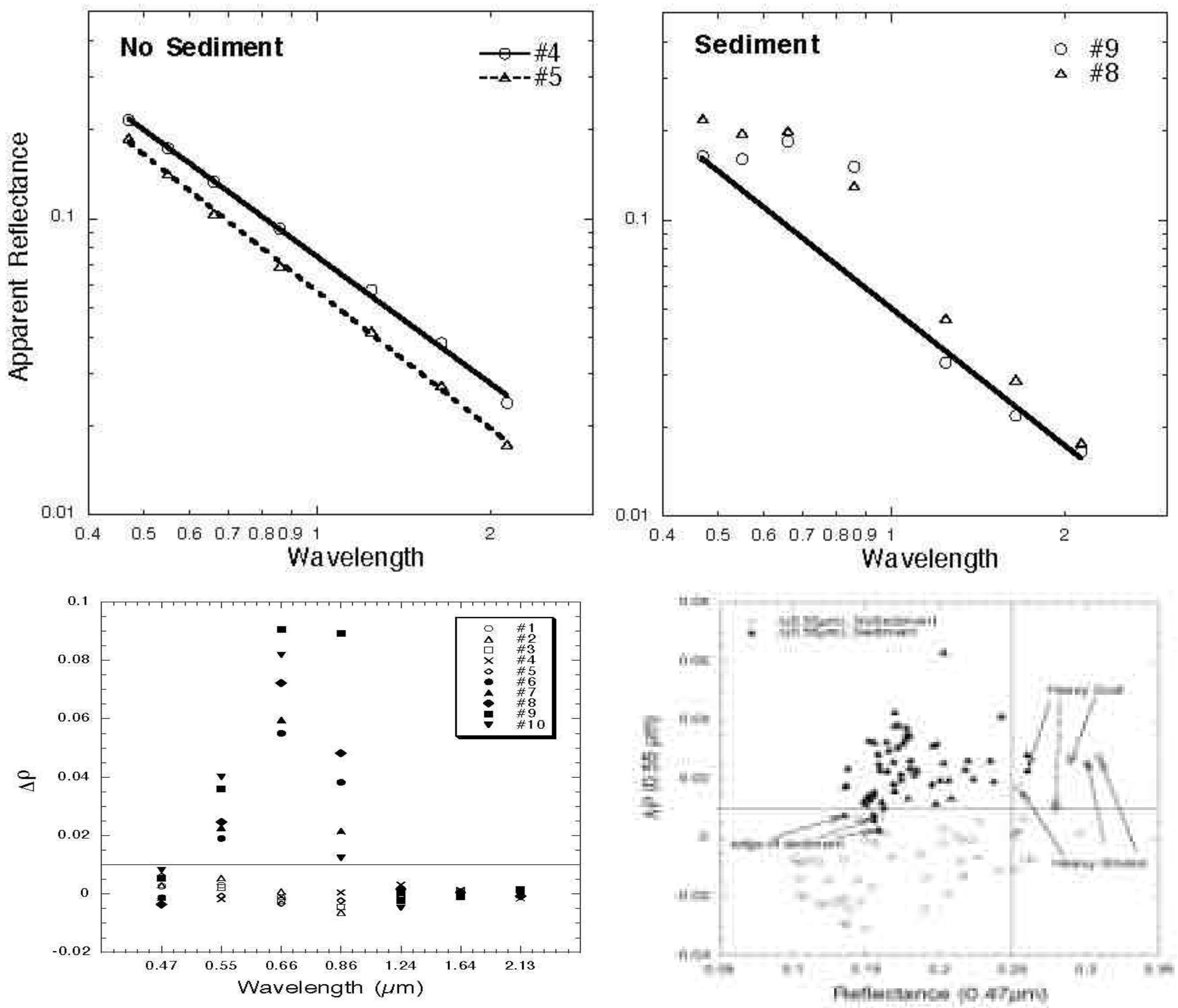


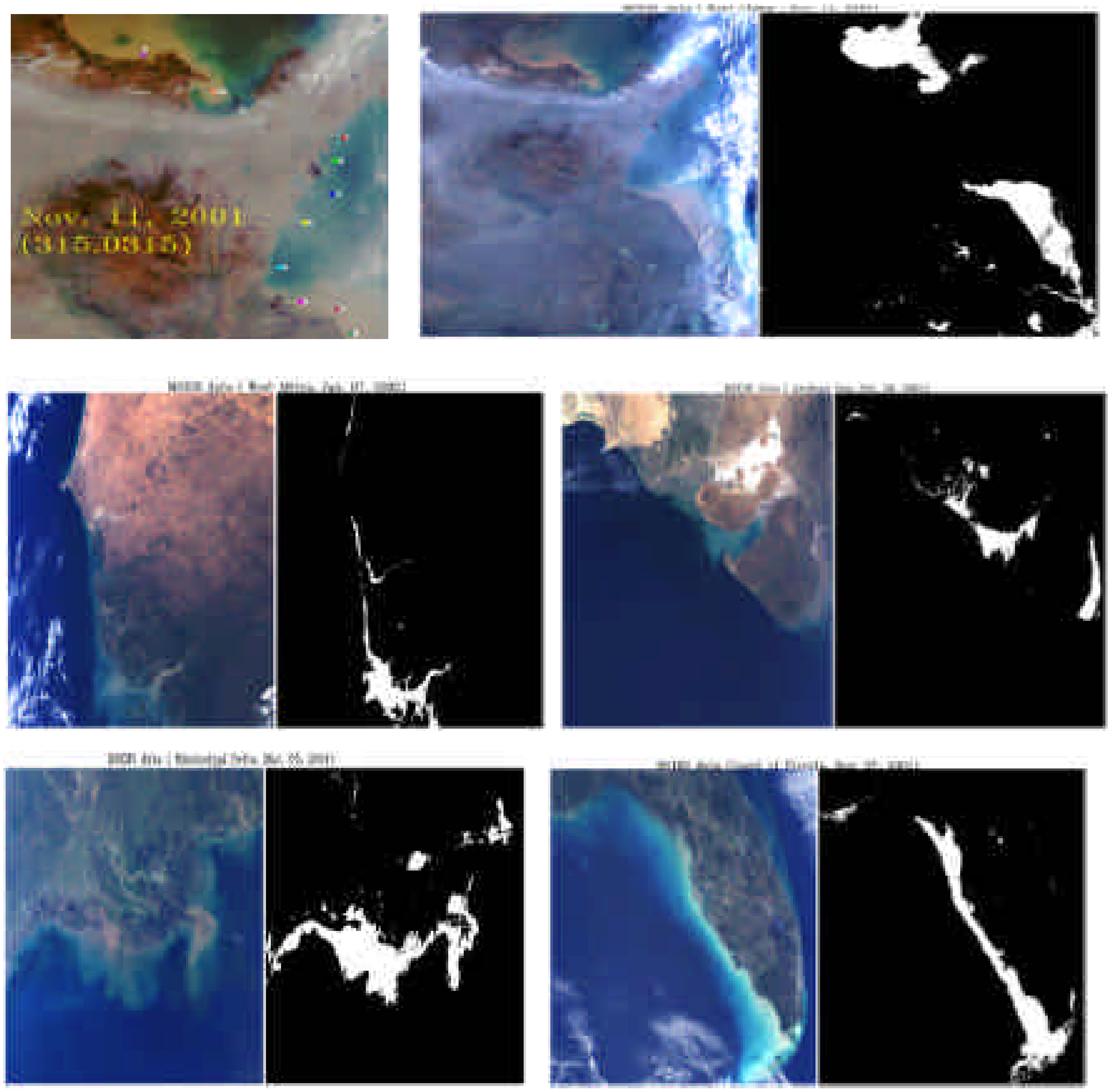




11. Removal of river sediment in coastal zones

River sediment has caused significantly high values in MODIS aerosol retrieval around river mouths because the existence of sediment reflects more sunlight back to space, which has been mistakenly treated as signal from aerosol backward scattering. Therefore, high aerosol optical depths are derived. Shallow water behaves similarly but with less intensity. The use of IR channels has shown good conditions to detect coastal turbid water and shallow water without masking out heavy aerosols. The sediment mask currently implemented into MODIS aerosol algorithm for testing. Shown below are the spectral reflectance, difference of spectral reflectance, and scatter plot between 0.55 and 0.47 μm for conditions with and without sediments, followed by the example case studies of sediment mask

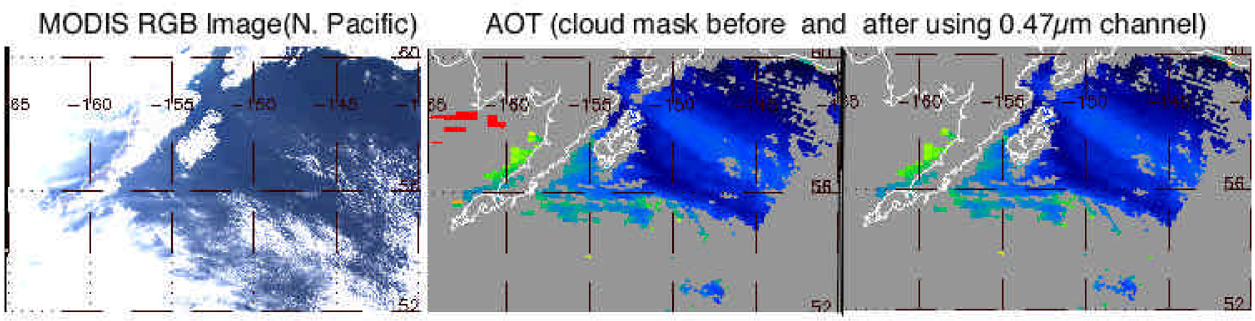




Color images and the corresponding black and white masks of the sediments. The sediment is shown by white.

12. Improvements of cloud mask using spatial variability approach

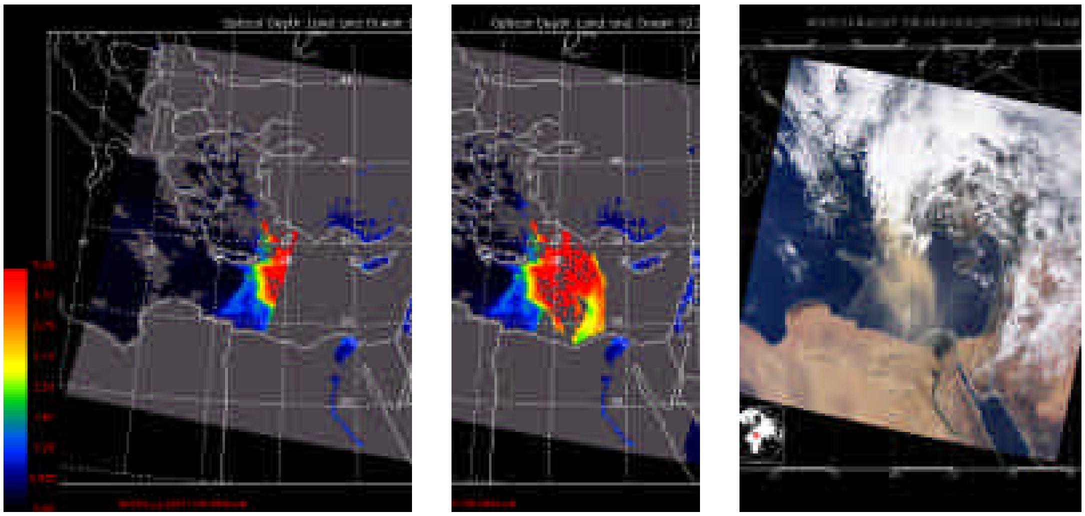
The cloud mask using spatial variability approach applied to aerosol retrieval over ocean experienced difficulty in screening (smooth) clouds around Alaska coast and in screening clouds with smoke on top in the west coast of southern Africa. Extra criteria are added, for example, the reflectance at 0.47 µm < 0.4. An example is shown before and after adopting this criterion. This condition is to remove the low homogeneous clouds. Tests with this threshold and spatial variability scheme are applied to the regions for clouds with smoke above. Note that the new mask gets rid of the high AOT (red) contamination.



The moving window of spatial variability test is changed from every 3 pixels (or every 1500m) to a single pixel (or every 500m). As a result, it produces a more consistent cloud masking procedure especially at cloud edge. Dust is consistently darker than clouds at 0.47µm. Another visible test was added to recover thick dust plumes screened out by spatial variability cloud mask. Pixels of heavy dust scenarios mistakenly identified as clouds are recovered by the visible ratio test, ref_0.47/ref_0.66 < 0.75, because dust is more absorbing at 0.47 than 0.66 µm wavelength.

13. Retrieval of heavy dust over ocean sun glint

Pixels of thick dust plumes that passed the ratio ref_0.47/ref_0.66 < 0.95 over ocean sunglint are allowed to enter the retrieval scheme since under this condition (aerosol optical depth > 2) sun glint effect does not change significantly the reflectance at top of the atmosphere. The figures (from left to right) show the improvement of dust retrieval using this threshold. In order not to affect aerosol statistics, the quality control in this case is set to zero.



14. Increase absorption in land aerosol models.

Following analysis in item 5 above, and analysis of subsequent AERONET data (Dubovik et al. 2002), we determined that the land aerosol models were underpredicting the degree of aerosol absorption in many places in the world. A new 'heavy' absorbing model is introduced that uses the same size parameters as the original biomass burning model, but has lower single scattering albedos. We also re-analyzed the assignment of the world to different models.

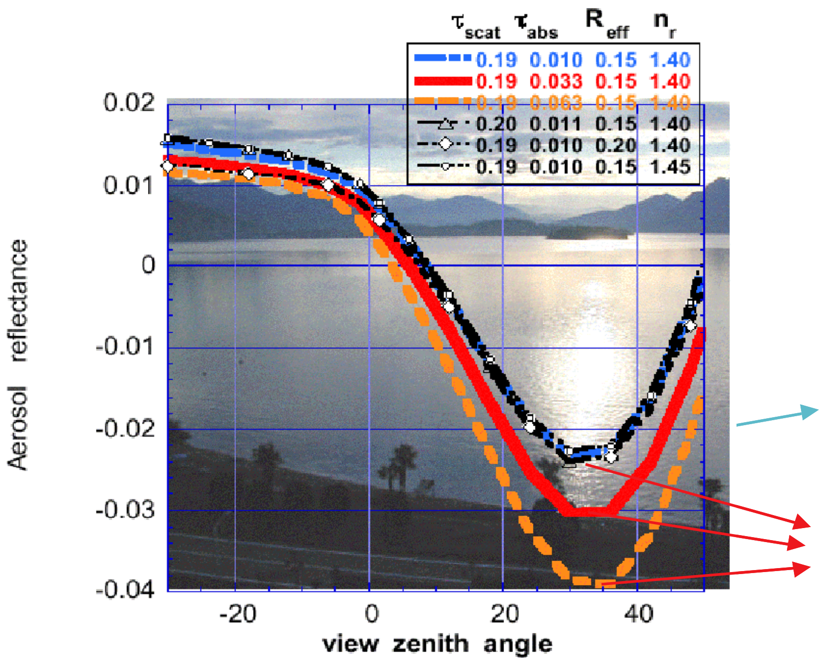
	OLD			NEW		
Model	Size param	ω_o 470	ω_o660	Size param	ω_o 470	ω_o660
Urban/industrial	Urban/indus	0.96	0.96	Urban/indus	0.96	0.96
Bio-burn moderate	Bio-burn	0.90	0.90	Bio-burn	0.91	0.89
Bio-burn heavy				Bio-burn	0.86	0.85

In terms of geographical re-arrangement, the changes include:

- Changing the model used for China from urban/industrial to Bio-burn moderate, all year.
- Keeping the Bio-burn moderate model for South and Central America all year. Previously, the urban/industrial model was used during the non-biomass burning season.
- Using the Bio-burn heavy model for Africa's biomass burning season, both north and south of the equator. In the non-burning season, north of the equator reverts to the Bio-burn moderate, while south of the equator reverts to urban/industrial.
- Shifting the line separating Europe from Asia westward, thus using the Bio-burn moderate model for most of eastern Europe, and the less absorbing urban/industrial model only for western Europe.

RS of Aerosol absorption over ocean glint – test with a combination AERONET/MODIS retrievals

To test the hypothesis that aerosol absorption can be derived over the ocean glint from satellites, a combination of MODIS and AERONET measurements are used. MODIS algorithms use radiative-transfer model generated look-up tables to derive aerosol properties from space. A set of MODIS-like look-up tables were generated given a range of single scattering albedos for an attempt to retrieve the quantity of aerosol absorption over the glint. These look-up tables will be used in combination with AERONET data to experimentally prove the concept as described in recent paper (Kaufman et al., GRL 2002). For the same purpose, the MODIS algorithm was modified in order to invert AERONET sunphotometer data and to combine it with MODIS measurements for the retrieval of the aerosol absorption properties. The modifications in the algorithm included the capability of inverting multi-angle sky radiance data available from the sunphotometers. The next step is to match the MODIS reflectances over sun glint with the multiple look-up tables in order to find optical thickness due to absorption. A similar approach is planned in future NASA satellites mission with multi-angle sensors from space instead of the AERONET sunphotometers from the ground.



Aerosol effect on sun-glint reflectance is weakly dependent on aerosol effective radius and refractive index but strongly dependent on the absorption and scattering optical thickness

Varying effective radius and refractive index

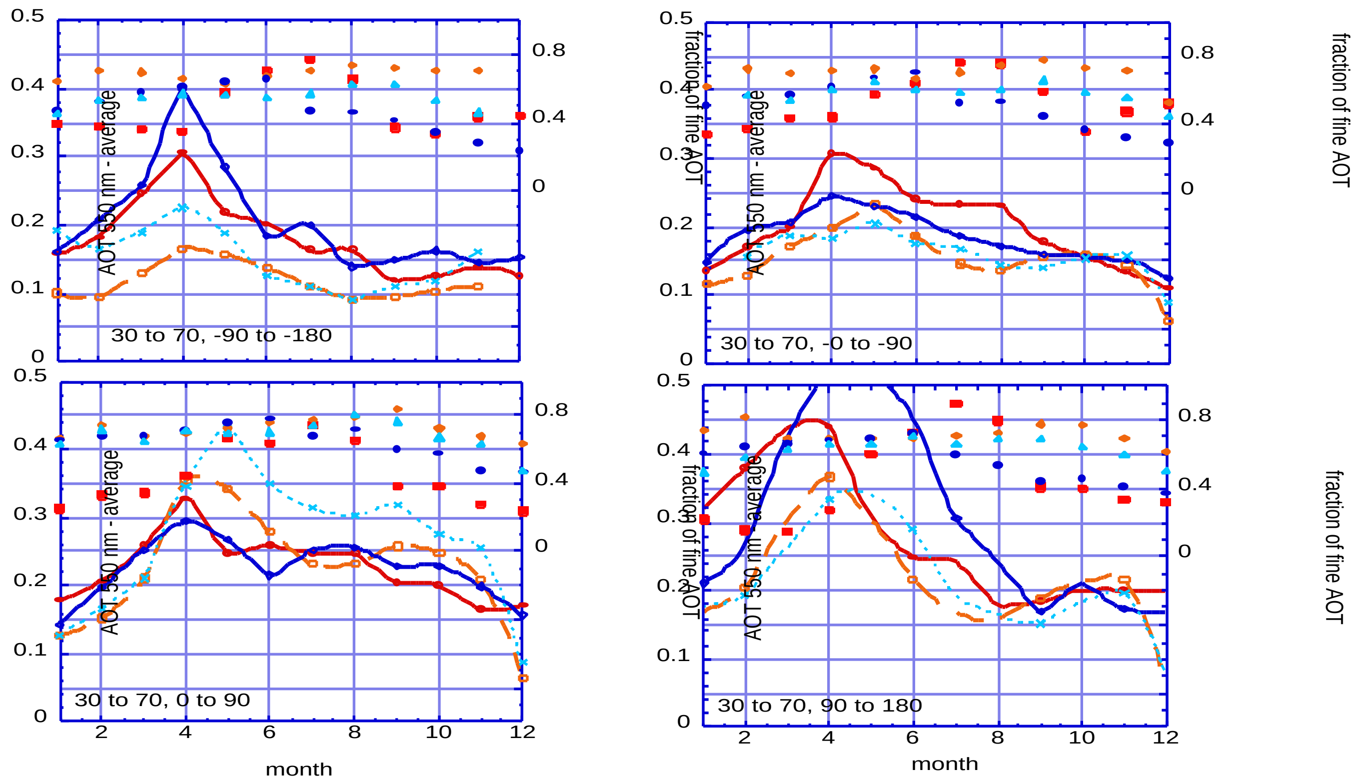
Varying Absorption Optical Thickness

15. Statistics/comparison of MODIS and GOCART aerosol properties

Daily L3 MODIS aerosol data in 1°×1° resolution are compared with GOCART model results in 2.5° × 2°. The optical thickness and the fraction of fine particles are compared. The global comparison is summarized in the following table:

Global results	AOT 550 Average AOT 550	std	average 10-90%	AOT Weigh-ted by (1-cloud fraction)	Contribution of fine aerosol (< 1μm diameter) TO AOT
MODIS – Land	**0.197**	**0.13**	**0.179**	**0.177**	**0.62**
MODIS - ocean	**0.175**	**0.20**	**0.146**	**0.132**	**0.49**
GOCART – land	0.135	0.08	0.123		0.67
GOCART – ocean	0.124	0.07	0.113		0.54

The GOCART results are lower then MODIS over land and ocean and with lower standard deviation. Detailed comparison for a given latitude band as a function of the month for 2001 is shown in the following figure. The analysis is part of the effort to use MODIS data to describe the global aerosol system.

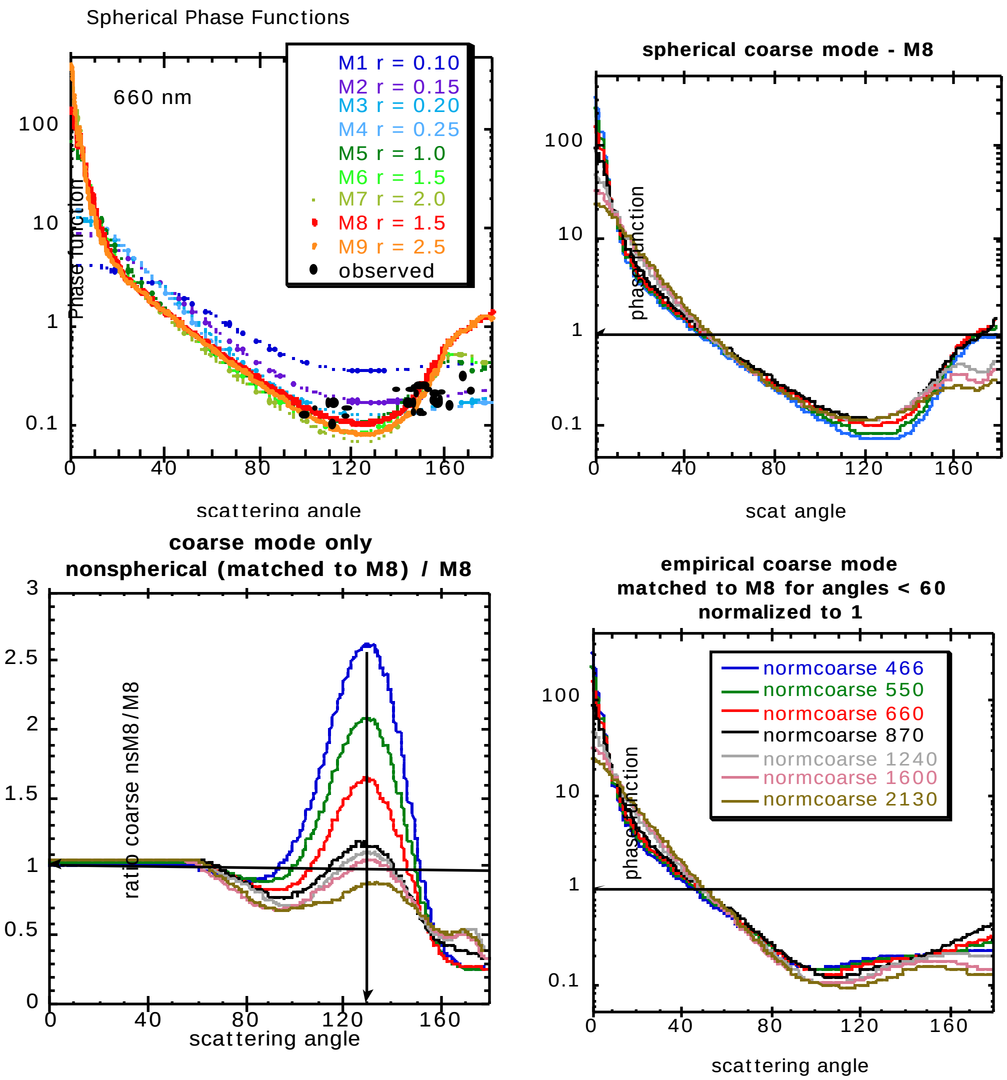


Plots of the aerosol optical thickness over land (red) and ocean (blue) for MODIS (solid dark lines) and GOCART model (light dashed lines) as a function of month for 2001. All plots are monthly averages for latitude range of 30-70N and for 4 longitude regions from west to east (90-180W), (0-90W), 0-90E), and 90-180E). The dots are the measured and modeled fraction of fine aerosol in the optical thickness, using the same color scale. Note the similarity in trends and location of maxima and minima between the MODIS data and the GOCART calculations.

16. Empirical derivation of nonspherical phase functions

As noted in item 2, above, retrievals of spectral optical thickness and size parameters for dust aerosol do not agree well with ground-based validation. We attribute these difficulties to the assumption of sphericity in the retrieval process. In order to correct this problem, we will need to introduce nonspherical phase functions into the algorithm. We use MODIS retrievals, co-located with AERONET observations, to derive empirical phase functions of airborne Saharan dust, with NO assumptions of particle shape.

Upper left (below). "Observed" represent phase functions needed by the algorithm to retrieve the same AOT as measured by co-located AERONET instruments at 660 nm. In some situations the algorithm requires a phase function far from the possible 'dust' phase functions shown in orange and red. Upper right: Spherical phase functions for the seven wavelengths of the retrieval algorithm. Lower right: Empirical phase functions for the seven wavelengths derived from the "observed" points in the first panel and similar observations for all seven wavelengths. Lower left: Ratio between nonspherical and spherical phase functions for the seven wavelengths.



17. Enhancement/maintenance of the automated daily process of the generation of the MAPSS database from MODIS and AERONET aerosol

The MODIS Aerosol and associated Parameters Spatio-temporal Statistics (MAPSS) software/database system, which is the main data structure used for MODIS aerosol validation, needs continuous maintenance, especially necessitated by increasing data volume and changes due to product updates. During the period under review, the problem of monotonic increase in memory usage in PERL when large data sets are processed in loops was resolved. This was achieved by modifying the relevant scripts and breaking them down to smaller components, which enabled even distribution of the computer memory usage. Also, previously, only the AERONET level 1.5 aerosol optical thickness (AOT) data were included in the MAPSS system because of near real-time data availability. The AERONET level 2.0 AOT data were added to the MAPSS database to improve the standard of MODIS validation.

18. Calibration and analysis of Microtops II Sun Photometer measurements

Microtops II sun photometers are handheld instruments, a few of which have been acquired by the group for the spot checking of aerosol optical depth and water vapor at sites of interest, primarily for MODIS aerosol retrieval validation. For some time, we have undertaken to do a detailed analysis of the quality and reliability of the instruments, so as to evaluate objectively their suitability for use in measuring AOT (aerosol optical thickness) and *W* (columnar water vapor) for MODIS retrieval validation. It was found that, the internal algorithm of the Microtops retrieves *W* and AOT at 936 nm incorrectly because of wrong parameterization (*k*-parameter). This is why the calibration coefficient V_0 at 936 nm shows significant dependence on water vapor (see figure). This dependence is rectified when the coefficient is recalculated with a more accurate value of the *k*-parameter (Vo(936)_newK). This is being corrected in the data acquired in many parts of the world with the Microtops sun photometers. However, it was found that when the Microtops is well calibrated and well cleaned, its AOT retrievals can be of comparable accuracy to those of CIMEL sun photometers used in the AERONET network, with uncertainties in the range of 0.01 to 0.02. A paper describing the performance characteristics of the Microtops II sun photometers was published in the Journal of Geophysical Research (JGR) for publicaiton. Two Microtops sun photometers were shipped back (from Israel and Egypt) and calibrated alongside the AERONET master sun photometer here at GSFC during several days/weeks (depending on the frequency of occurrence of clear days). This is a necessary activity for the periodic monitoring of the reliability of the Microtops.

Recently, we acquired custom-made Microtops outfitted with filters at 1.6 and 2.1 µm. Calibration of the longer wavelengths cannot be accomplished by intercomparing with with an AERONET master instrument because the standard AERONET instrument's spectral range ends at 1.02 µm. Two instruments were, therefore, sent to Mauna Loa with a representative from Solar Light Inc. in order to obtain a stand alone calibration from Langley plots. Furthermore, calibration of these longer wavelength channels requires developing corrections for water vapor and temperature dependence. We have learned that these corrections must be made individually for each instrument. The temperature correction is relatively small, but the water vapor correction will be significant and is not yet completed.

19. Development of aerosol assimilation model

Aerosol assimilation model is under development via fitting satellite and ground-based aerosol remote sensing data based upon a core of aerosol transport model developed by Paul Ginoux. The development of the aerosol assimilation model in the last six months include mainly the completion of the retrieval method and computer code for the retrieval desert dust sources from global aerosol observations (i.e., adopting original GOCART program for inversion purposes and combining it with the rigorous multi-parametric numerical inversion procedure). The good performance has been demonstrated in the series of numerical tests, where the desert dust sources were retrieved with high accuracy from GOCART modeled aerosol global fields. Significant efforts were put into adjusting the code to "real life" situation such as inverting the aerosol observations by MODIS, AERONET, etc. Specifically, the code was changed for inverting global distribution of the spectral optical thickness of desert dust (instead initially used aerosol mass). The code was modified for allowing time and spatial discontinuity of the input data (since the real data set do not provide the continuous data in each geographical greed box). The admissible desert dust aerosol sources where reduced to the land surface only. The efficiency of the retrieval code performance was checked by numerical tests after each major modification. The final series of the test have confirmed that desert dust sources (and correspondent global aerosol distribution) can be successfully retrieved from the modeled global observations of desert dust by MODIS and AERONET).
During the last few weeks the efforts were focused on closing up the global aerosol retrievals from the real MODIS observation of the atmospheric aerosol during the period April 7-14, 2001. A number of the issues (in using real date instead of modeled) were identified and expected to be resolved shortly.

20. Papers published/accepted/submitted

MODIS validation

1. **Remer, L. A., D. Tanré, Y. J. Kaufman, C. Ichoku, S. Mattoo, R. Levy, D. A. Chu,** B. N. Holben, **J. V. Martins, and R.-R. Li** and Z. Ahmad, Validation of MODIS Aerosol Retrieval Over Ocean, *Geophys. Res. Lett.*, 29(12), MOD 3, 1-4, 2002.
2. **Chu, D. A., Y. J. Kaufman, C. Ichoku, L. A. Remer, D. Tanre,** and B. N Holben: Validation of MODIS aerosol optical depth retrieval over land, *Geophys. Res. Lett.*, MOD 2, 1-4, 2002
3. **Martins, J. V., D. Tanré, L.A. Remer, Y. J. Kaufman, S. Mattoo, R. Levy**, MODIS Cloud screening for remote sensing of aerosol over oceans using spatial variability, *Geophys. Res. Lett.*, MOD 4,1-4, 2002.
4. **Ichoku, C., D. A. Chu, S. Mattoo, Y. J. Kaufman, L. A. Remer, D. Tanré,** I. Slutsker and B. N. Holben A Spatio-Temporal Approach for the Validation of MODIS Aerosol Products, *Geophys. Res. Lett*., MOD 1, 1-4, 2002.
5. **Levy, R.C., L. A. Remer, D. Tanré, Y. J. Kaufman, C. Ichoku**, B. N Holben, J. Livingston, P. Russell, H. Maring, Evaluation of the MODIS retrievals of dust aerosol over the ocean during PRIDE, submitted to….
6. Hao, W. M., R. E. Babbitt, R.A. Susott, D. E. Ward, B. L. Nordgren, **Y. J. Kaufman**, B. N. Holben and D. M. Giles, Comparison of aerosol optical thickness measurements by MODIS, sun photometers and hazemeters in Southern Africa during the SAFARI 2000 campaign, IJRS April 2002

7. **Ichoku, C., L. A. Remer, Y. J. Kaufman, R. Levy, D. A. Chu, D. Tanré,** and B. N. Holben MODIS observation of aerosols over Southern Africa during SAFARI 2000: data, validation, and estimation of aerosol radiative forcing, IJRS March 2002

MODIS algorithms

1. **Li, R.-R., Y. J. Kaufman,** B.-C. Gao, and C. O. Davis A Remote Sensing Technique To Detect Suspended Sediments And Shallow Coastal Water submitted to GRLJune 2002
2. Gao B.-C., **Y.J. Kaufman, D. Tanré and R.-R. Li**, Distinguishing tropospheric aerosol from thin cirrus clouds for improved aerosol retrievals using the ratio of 1.37 µm and 1.24 µm channels. GRL june 2002
3. **Kaufman**, Y.J., N. Gobron, B. Pinty, J.-L. Widlowski and M. M. Verstraete, Relationship between surface reflectance in the visible and mid-IR used in MODIS aerosol algorithm - theory accepted to GRL. April 2002
4. **Kaufman, Y.J., D. Tanré,** J.-F. Léon and J. Pelon, Retrievals of profiles of fine and coarse aerosols using lidar and radiometric space measurements submitted to IEEE TGRS submitted
5. Léon, J.-F., **D. Tanré**, J. Pelon and **Y. J. Kaufman**, Characterization of tropospheric aerosols based on active and passive remote sensing synergy, submitted to JGR

Application and preparation for application of MODIS data

1. **Kaufman, Y.J., B. N. Holben, S. Mattoo, D. Tanré, L.A. Remer,** T. Eck and J. Vaughn: Aerosol radiative impact on spectral solar flux reaching the surface, derived from AERONET principal plane measurements, J. Atmos. Scie., **59**, 633-644, 2002.
2. Smirnov, A., B.N.Holben, **Y.J.Kaufman,** O.Dubovik, T.F.Eck, I.Slutsker, C.Pietras, and R.N. Halthore, Optical properties of atmospheric aerosol in maritime environments. *J. Atmos. Sci*, **59**, 501-523, 2002
3. **Remer, L.A., Y.J. Kaufman,** Z. Levin, S. Ghan, 2001: Strategy to estimate uncertainties in spaceborne measurements of aerosol direct radiative forcing, *J. Atmos. Sci*, **59**, 657-667, 2002
4. Dubovik, O., B.N. Holben, T. F. Eck, A. Smirnov, **Y. J. Kaufman**, M. D. King, **D. Tanré** and I. Slutsker: Climatology of aerosol absorption and optical properties in key worldwide locations, *J. Atmos. Sci*, **59**, 590-608, 2002
5. **Kaufman, Y.J. , R. G. Kleidman**, D. K. Hall, **V. J. Martins** Remote sensing of subpixel snow cover using 0.66 and 2.1 µm channels, submitted to GRL
6. **Kaufman, Y. J. , C. Ichoku**, L. Giglio and S. Korontzi, **D. A. Chu**, W. M. Hao, **R.-R. Li**, C. O. Justice, Fires and smoke observed from the Earth Observing System MODIS instrument –physics, data and operational use. accepted Rem. Sens Environ.
7. **Kaufman, Y. J., D. Tanré** and O. Boucher, New satellites and ground-based aerosol measurements: implications to aerosol-climate research, Review invited by Nature, accepted.
8. **D. A. Chu, Y. J. Kaufman,** J. D. Chern, G. Zibordi, Jietai Mao, Chengcai Li, B. N. Holben, ready to submit to Atmospheric Environment, 2002.
9. **Kaufman**, Y.J., O. Dubovik, A. Smirnov and B. N. Holben Remote sensing of non aerosol absorption in cloud free atmosphere accepted to GRL, April 2002
10. **Kaufman, Y.J., J. V. Martins, L. A. Remer,** M. R. Schoeberl and M. A. Yamasoe, Satellite retrieval of aerosol absorption over the oceans using sunglint, accepted to GRL, 2002
11. King, M.D., S. Platnick, W. P. Menzel, **Y. J. Kaufman**, S. A. Ackerman, **D. Tanré, L. A. Remer** and B.-C. Gao, Cloud, Aerosol and Water Vapor Properties from MODIS: Preliminary Results from Terra, submitted IEEE TGARS

20. Conference/workshop

PRIDE science team meeting, Miami, Feb. 12-14, 2002
CLAMS science team meeting, Greenbelt, Feb. 27-28, 2002
AGU spring conference, Washington DC, May 28 – June 1 , 2002
IGARSS conference, Toronto, June 22 – 26, 2002