MODIS Semi-annual Report
January–June 2000

Michael D. KiNg[1] and Steven Platnick[1,2]
[1] Goddard Space Flight Center, Greenbelt, MD
[2] University of Maryland Baltimore County, Baltimore, MD

Abstract

Major efforts over the past six months included: (i) continued development of MODIS level 2 and 3 (L2, L3) visualization software for use by the atmosphere group, (ii) in-depth analysis of the MODIS L2 cloud retrieval algorithm and ancillary data sources for selected golden granules, (iii) modifications to the L2 code based on golden granule analysis, (iv) continued analysis of MAS and CAR data from various Arctic experiments; and (v) participation in planning and organizational efforts, and instrument activities in support of the SAFARI 2000 dry season campaign in southern Africa.

I. Task Objectives

With the use of related airborne instrumentation, such as the MODIS Airborne Simulator (MAS) and Cloud Absorption Radiometer (CAR), our primary objective is to extend and expand algorithms for retrieving the optical thickness, effective radius, and water path of liquid and ice clouds using radiation measurements from the Moderate Resolution Imaging Spectroradiometer (MODIS). The secondary objective is to obtain an enhanced knowledge of surface angular and spectral properties that can be inferred from airborne directional radiance measurements.

II. Work Accomplished

a. MODIS Data Analysis, Code and Related Software Development

MOD06 Level-2 cloud retrieval code

With the availability of MODIS data, Mark Gray, Steven Platnick, and Michael King have focused on examining MODIS Level 2 cloud optical thickness and effective radius retrievals. Initial visualization by Mark Gray of level-2 results processed by MODAPS revealed some problems in the processing of cloud over land, though ocean cloud results were encouraging. Examination of stratus cloud scenes near the western coastlines of California, Namibia (see Fig. 1, 2) and Chile gave results physically realistic and consistent with our understanding of these systems. Processing problems for clouds over land were corrected by Jason Li with modifications to the cloud mask "decision tree" that uses individual cloud mask tests at each pixel to determine whether to perform a retrieval.

Further work has depended on the visualization of Quality Assurance (QA) processing path information in the Level-2 output. Comparing these parameters to the Level 1B input radiances and the retrieved cloud parameters allows for an internal consistency check and to check that retrievals are physically realistic. Eric Moody has been working on the following visualization tools for this effort:

1. Developed an IDL tool to visualize Ancillary Ecosystem information in three formats, as a global map, a geolocated box, or a single/multiple granule plot.
2. Developed IDL bit extraction and mapping software to visualize cloud mask flags (see Fig. 3) and QA flags (see Fig. 4) as single or multiple granule plots.
3. Developed IDL software to visualize ancillary inputs into the code.

Eric Moody has been working on the following Quality Assurance/Assessment code for an anticipated code delivery to SDST at the end of July:

1. Added second byte to the 1 km Cloud Mask output array, to include Heavy Aerosol, Thin Cirrus, and Shadow Found flags.
2. Adjusted the Ancillary data source categories in the MODIS QA Plan, and corrected the code implementation of this Ancillary QA plan.
3. Adjusted the Optical Thickness out-of-bounds categories in the MODIS QA Plan, and corrected the code implementation.
4. Corrected code implementation of the Cloud Phase used in retrieval processing path flag, so that Undetermined cloud phase pixels are no longer being incorrectly set as Mixed cloud phase.
5. Rayleigh Correction Flag implemented in the code.
6. Added a Retrieval Outcome flag to clarify if the pixel's retrieval failed or succeeded.
7. Created a mechanism to set QA flags to reflect how the code actually performs, which is and will continue to be used in code development and correction efforts.

MOD08 Level-3 atmosphere code

Paul Hubanks completed delivery of the MOD08_TL (Tiling), MOD08_D3 (Daily), MOD08_E3 (Eight-Day), MOD08_M3 (Monthly) packages. Specifically, several bugs were noted in the MOD08_TL (tile) code and corrected. In addition, several bugs were also corrected in the Daily, Eight-Day, and Monthly software packages. Problems noted in L2 inputs were referred back to the appropriate team member. This also eliminated these erroneous values from propagating into Level 3 statistics. When necessary, the Common Data Language (CDL) file specifications were corrected for the tile, daily, eight-day, and monthly products. Prepared and delivered 39 updated HDF structure files; and the new Common Data Language (CDL) file specs for each product. Updated and delivered the History.txt files detailing the changes made to the HDF structure files. Ran several test cases for each product. All elements were redelivered to SDST for integration into MODAPS.

Eric Moody adjusted the L2 file spec to correct errors in computing Cirrus and Contrail Reflectance and Fraction SWIR products. In addition, he fixed a problem in the L2 code with fill values being incorrectly set to –999.0 and propagating incorrectly to the L3.

MODIS Atmosphere web site development

Paul Hubanks worked on the following MODIS Atmosphere web site items:

a. A redesign of the "Publications" and "Images" sections of the MODIS Atmosphere web site has been completed.

b. A MODIS-Atmosphere image archive, containing the best images produced within the MODIS-Atmosphere group, has been created (http://modis-atmos.gsfc.nasa.gov/IMAGES).

c. Completed the web interface for the high-resolution L3 images produced by Eric Moody (see Fig. 5). Developed an image file directory tree convention. Added a menu interface for easy navigation of the images.

d. An improved interface for low-resolution (MOD08_D3) images, as well as the L1B RGB granule and global images has been developed.

e. Six new MODIS product analysis and visualization tools have been added to the Tools section on the MODIS Atmosphere web site. Created a MODIS Tools email list-server to keep interested parties informed of new tools and (corrected) versions of existing tools.

Paul Hubanks updated the Cloud Retrieval Group web site to include publication and staff listings. A new software section was created with several linked pages detailing software available for download.

Mark Gray web-based work focused on developing an automated system for the generation and display of quicklook Level 1B (and eventually Level 2) imagery on the MODIS Atmosphere Discipline homepage. This consists of a set of Perl and IDL scripts for the automatic generation of imagery and HTML documents for individual granules and global scenes. The system updates the Level 1B granule scenes daily at http://modis-atmos.gsfc.nasa.gov/IMAGES/, but is not yet fully automated. Full automation of this package and the automation of global quicklook web page generation is an on-going

Eric Moody, Mark Gray, and Paul Hubanks worked on adding visualization and data processing tools to the site's Tools page. Eric Moody and Paul Hubanks worked on placing daily High Resolution (10 km) Level 3 images on the site's

Images page.

MODIS product visualizations and other software tools

Eric Moody has developed the following codes:

1. Continued subsetting tool development to support spatial and data set subsetting of Level 1B data and all Atmosphere Level 2 data. The subsetting process was automated to aid in processing daily standing orders.

2. Developed a code which produces High Resolution (10 km) Level 3 products. Automated the daily production of a defined number of products, and to produce images of the products to be displayed on the MODIS Atmosphere web site (see Fig. 5).

Visualization packages were developed by Mark Gray using IDL for viewing Level 1B data (multigranuleplot) and Level 2 data (level2_viewer). The package multigranuleplot takes a string array containing MODIS Level 1-B filenames and an output filename and generates a single RGB image of the scene plotted on a map projection. Granules with resolutions of 1 km or 500 m can be used. If the world keyword is set then the data will be plotted on a world map using an appropriate map projection (Fig. 6).

A Level 2 visualization package is also in development by Mark Gray. The capabilities of level2_plot are similar to multigranuleplot (multiple projections, image formats, etc.) with the additional ability to specify a particular SDS for visualization (Figs. 2 and 3). These above tools have been used extensively by other atmosphere team members.

Using these tools, Eric Moody and Mark Gray visualized MODIS data for various press conferences, meetings, and proposals.

Paul Hubanks has worked on daily MOD08 browse imagery visualizations, including:

1. Enhancement of MOD08 Web-Based Browse Image Display System. Completed Java-based browse image display scripts for both the Equal-Area and Equal-Angle grid projection for all the MOD08_D3 product groups. The scripts display primary statistical parameters (simple, QA-weighted, fraction, and pixel counts) for each SDS in MOD08_D3 through the modis-atmos web site (http://modis-atmos.gsfc.nasa.gov/MOD08_D3/browse.html).

2. A complete set of browse images (over 600 images per day) for each MOD08_D3 (MOD08 Daily Global) product file are generated and uploaded to the MODIS Atmosphere web site. Images are projected onto 2 grids: equal-angle and equal-area. Work has continued on a daily basis.

3. Developed a standardized directory and filename convention to be used for

all QA and browse images created on the Windhoek platform for the MODIS-Atmosphere group.

4. Completed the logic-flowchart required to develop Unix scripts to automate the browse creation process for the MOD08_D3 (L3 daily product). Logic document was delivered to Dave Makofski for implementation on Windhoek; however Dave was unable to complete this task before he left the position. This work is on hold until a new system administrator for Windhoek is hired.

b. MODIS-related Instrument Research

Cloud Absorption Radiometer (CAR) modification

CAR modifications by Code 553 have been coordinated by Charles Gatebe. Along with Gatebe, Tom Arnold, and Jason Li were involved in ongoing discussions and meetings over the last half-year concerning the redesign of the CAR data system and raw data format. Tom Arnold and Jason Li helped procure and set up the new CAR ground station computer.

CAR modifications include:

1. Upgrade/replace instrument electronics and data storage: Update digitization from 10 bits to 16 bits; build new data storage system to replace existing exabyte drive; implement new commercial LabView software control (with features such as data analysis, visualization, instrument control, etc.); improve data acquisition system; increase the SNR by digitizing the signal at the source, replace old cabling, etc.

2. Spectral modifications: Install two interference filters to correspond to the TOMS UVA channels at 340 and 380 nm. This involves modifying the optical train of the CAR with a new mechanical/optical package. These new spectral channels will allow CAR UV measurements for comparison with the TOMS aerosol index and ground-based sunphotometers.

CAR Data processing

The CAR instrument has undergone extensive upgrade during the first half of this year. Before diving into the new instrument and new data, it is a good time to summarize research findings derived from data collected during past field experiments. Jason Li prepared a giant poster just for this purpose. It summarizes all the BRDF data that we have collected in the last decade: BRDF over cloud, ocean, ice/snow surfaces, vegetated surfaces, including tundra, and finally the desert.

In an attempt to achieve the best quality of our CAR data sets, Jason Li reprocessed CAR data for the FIRE/ACE experiment and implemented a pitch angle correction algorithm. Although the outcome was not as good as he had hoped for, due to unreliable input navigation data, the implementation is in place that will be extremely useful for future datasets where we anticipate having more accurate navigation data.

Working with Steve Platnick, Jason Li sought better ways of visualizing BRDF images in both polar coordinates and in BRDF space. He figured out geometric transformation relationships between the two spaces. To simplify the matter, he created a color wheel and then displayed it in both polar and BRDF space. By tracking the location of various colors in two spaces, it is clear that the center portion of the color wheel (or real world measurement for that matter) is inverted in BRDF space.

MODIS Airborne Simulator (MAS)

Several MAS upgrades were implemented by NASA Ames Research Center in collaboration with NASA Goddard Space Flight Center and NOAA/CIMSS at the University of Wisconsin. These include: new blackbodies with Nextel paint, replacement of exabyte tape drives with hard disks, 16 bit data processing, replacement of old dichroics as well as primary and secondary mirrors, redesign of port 4 dewar mounts and pressure release valve, and rewriting the L1B processing code. This was completed prior to deploying the MAS on the ER-2 for SAFARI 2000.

c. MODIS-related Field Campaign and Validation Efforts

Several members of the group (King, Platnick, Tsay) participated in a planning meeting for the Southern Africa Regional Science Initiative year 2000 experiment (*SAFARI 2000*) in Pietersburg, South Africa in April 2000. This experiment, to be conducted during several periods in southern Africa, including both wet and dry seasons, will study biomass burning, industrial pollution, land surface-atmosphere processes, cloud and precipitation processes, and their effects on the southern Africa ecosystem. An intensive observational period will be conducted during the dry season (August and September 2000) and include remote sensing observations from the Terra spacecraft and the NASA ER-2 (with airborne versions of MOPITT, MISR, and MODIS, as well as other instruments). The remote sensing retrievals will be validated against in situ meteorological, aerosol, and cloud data from the University of Washington CV-580 aircraft and two South Africa Weather Bureau Aerocommander 690A aircraft, as well as numerous instrumented ground sites. A cloud mask for the SAFARI region was processed by S. Ackerman and R. Frey at the University of Wisconsin using an AVHRR algorithm and used by S. Platnick in designing ER-2 flight plans to the Namibian coast. Results of the cloud mask for September 1999 are shown in Fig. 7.

Tom Arnold modified and updated MODIS validation plan posters that were presented at MODIS validation workshop.

d. MODIS-related Services

Meetings

1. Michael King attended *Science Executive Committee* meeting in Chicago on 2 February 2000.

2. Michael King, Steven Platnick, Charles Gatebe, and Si-Chee Tsay participated in the *ISRSE Symposium*, Cape Town, South Africa, 27-31 March 2000.

3. Michael King, Steven Platnick, Charles Gatebe, and Si-Chee Tsay participated in the *SAFARI 2000 Dry Season Campaign Planning Meeting*, Pietersburg, South Africa, 3-7 April 2000.

4. Michael King organized, chaired, and attended the *EOS Investigators Working Group* meeting, Tucson, Arizona, 11-13 April 2000.

5. Steven Platnick, S. C. Tsay, M. Gray, and E. Moody attended the *MODIS Science Team Meeting*, 7-8 June 2000, Greenbelt, MD.

6. Steven Platnick, Si-Chee Tsay, Mark Gray, Eric Moody, Jason Li, and Tom Arnold attended the *MODIS Atmosphere Discipline Team Meeting*, 9 June 2000, Greenbelt, MD.

7. Michael King regularly attended weekly *MODIS Technical Team meetings*.

8. Mark Gray, Eric Moody, and Paul Hubanks attend the weekly *MODIS Atmosphere Data Processing meetings*.

9. Michael King and Steve Platnick attended the *Gordon Conference on Solar Radiation and Climate* in New London, Connecticut on 25-29 June 2000.

Presentations

1. King, M. D., and A. F. Hasler, 2000: NASA's Earth observation program: Past, present, and future. *Proc. 28th International Symposium on Remote Sensing of Environment,* Somerset West, Western Cape, South Africa, 27-31 March 2000.

2. King, M. D., 2000: Electronic Theater 2000. Linder Auditorium, Johannesburg College of Education, Johannesburg, South Africa, 30 March 2000 (two showings @ 1100 people each).

3. King, M. D., 2000: Electronic Theater 2000. Pietersburg Airport, Pietersburg, South Africa, 3 April 2000.

4. King, M. D., 2000: Electronic Theater 2000. CSIR Auditorium, Pretoria, South Africa, 6 April 2000 (two showings @ 600 people each).

5. Platnick, S., S. A. Ackerman, R. A. Frey and M. D. King, 2000: Remote sensing of Namibian marine stratocumulus clouds. *Proc. 28th International Symposium on Remote Sensing of Environment*, Somerset West, Western Cape, South Africa, 27-31 March 2000.

6. Gatebe, C. K., M. D. King, S. C. Tsay, Q. Li and G. T. Arnold, 2000: Sensitivity of MODIS 2.1 µm channel for off-nadir view angles for use in remote sensing of aerosol. *Proc. 28th International Symposium on Remote Sensing of Environment*, Somerset West, Western Cape, South Africa, 27-31 March 2000.

7. Platnick, S., 2000: Ship tracks and MODIS, *Goddard Summer Student Symposium*, 5 June 2000, Greenbelt, MD.

8. Platnick, S., M. D. King, M. Gray, E. Moody, J. Li, G. T. Arnold, S. C. Tsay, 2000: MOD06 cloud retrievals, *MODIS Science Team Meeting*, 7 June 2000, Greenbelt, MD.

9. Platnick, S., 2000: Early MODIS imagery and products, *JCET Meeting*, 10 May 2000, Baltimore, MD.

10. King, M. D., S. Platnick, S. C. Tsay, S. A. Ackerman, M. A. Gray, E. G. Moody, J. Y. Li, and G. T. Arnold,, 2000: New multispectral cloud retrievals from MODIS, *Gordon Conference on Solar Radiation and Climate*, New London, Connecticut, 25-29 June 2000.

III. Data/Analysis/Interpretation

a. FIRE-ACE

MAS FIRE-ACE cloud retrievals

A technique for cloud retrievals over snow and ice surfaces (Platnick et al.) was accepted for publication in the JGR FIRE-ACE special issue.

MAS FIRE-ACE cloud mask processing

The MAS FIREACE field experiment dataset was used as a testbed for the MAS cloud mask code and the subsequent "decision tree" particle phase determination algorithm. This effort by Tom Arnold involved reprocessing MAS data through both code sets several times as changes and improvement were made. The majority of the effort was spent reviewing the cloud mask code to better understand implications for the particle phase determination. The "decision tree" aspect of this code went through several significant revisions. After each revision output plots were reviewed by the CRG group and used as basis for suggesting additional improvement as the output data was reviewed. To facilitate the reprocessing of the data and to more easily process future datasets, scripts have been generated to automate the processing.

b. CAR Analysis

CAR Bidirectional Reflectance (BRDF) analysis

Charles Gatebe has continued his work on CAR BRDF patterns in the MODIS 2.1 µm band relative to the 0.47 and 0.68 µm bands, obtained during the Smoke, Clouds and Radiation-Brazil (SCAR-B) experiment. The ratio of these bands is used in the MODIS aerosol remote sensing algorithm over land. Results, showing substantial differences in ratios between the forward and backward scattered directions, were submitted for publication to *JGR* (Gatebe et al. 2000).

c. Namibian stratocumulus

New AVHRR investigation

The final couple of weeks of the SAFARI 2000 dry season campaign (10-23 September) will focus on Namibian marine stratocumulus clouds, as part of MODIS cloud retrieval validation activities. The validation effort will include the University of Washington Convair-580 *in situ* aircraft, as well as the MAS on the ER-2. Only two *in situ* and remote sensing efforts have apparently been reported (Platnick and Twomey 1994, Watts et al. 1997), only one of these being in the peer-reviewed literature. This is in stark contrast to the relatively numerous California and Arctic Ocean stratus studies. Interestingly, results from the two Namibian stratus studies show droplet effective radii to be significantly less than these other marine stratocumulus regimes. In an effort gain more knowledge of these clouds before the SAFARI experiment, Steven Platnick analyzed high resolution (1 km) AVHRR imagery collected in September 1999. His retrievals from three scenes showed a substantial range of droplet effective radii, including very small sizes comparable to the Platnick and Twomey study. Retrieval results for optical thickness and effective radius are shown in Fig. 8. A comparison of these size retrievals with previous studies is shown in Fig. 9.

These Namibian studies clearly do not constitute a meaningful sample, however this regime certainly warrants further study. The SAFARI validation work will provide the first opportunity for a comprehensive investigation of Namibian stratus.

IV. Anticipated Future Actions

1. Further analysis of cloud retrieval algorithm results and performance from MODIS Terra data.

2. Refine Level-2 and Level-3 algorithms subject to MODIS Terra results.

3. Participate in the SAFARI 2000 dry season campaign (August-September 2000).

4. Continue analysis of FIRE-ACE MAS data sets.

V. Problems/Corrective Actions

The main MODIS emphasis during the next reporting period is to implement atmospheric correction (k-distribution method for water vapor above cloud) and to further examine the ice cloud look-up tables for use in the MOD06 cloud retrieval code. In addition, the radiative transfer look up libraries for ice and water clouds will be regenerated, and further tests of the software access of these libraries for cloud optical thickness and effective radius retrievals over various ecosystems will be conducted.

VI. Publications

a. Published

1. Curry, J. A. P. V. Hobbs, M. D. King, D. A. Randall, P. Minnis, G. A. Isaac, J. O. Pinto, T. Uttal, A. Bucholtz, D. G. Cripe, H. Gerber, C. W. Fairall, T. J. Garrett, J. Hudson, J. M. Intrieri, C. Jakob, T. Jensen, P. Lawson, D. Marcotte, L. Nguyen, P. Pilewskie, A. Rangno, D. C. Rodgers, K. B. Strawbridge, F. P. J. Valero, A. G. Williams, and D. Wylie, 2000: FIRE Arctic Clouds Experiment. *Bull. Amer. Meteor. Soc.*, **81**, 5-30.

2. King, M. D., and D. D. Herring, 2000: Monitoring Earth's vital signs. *Sci. Amer.*, **282**, 72-77.

3. Dubovik, O., A. Smirnov, B. N. Holben, M. D. King, Y. J. Kaufman, T. F. Eck and I. Slutsker, 2000: Accuracy assessments of aerosol optical properties retrieved from AERONET sun and sky-radiance measurements. *J. Geophys. Res.*, **105**, 9791-9806.

4. Soulen, P. F., M. D. King, S. C. Tsay, G. T. Arnold and J. Y. Li, 2000: Airborne spectral measurements of surface-atmosphere anisotropy during the SCAR-A, Kuwait oil fire, and TARFOX experiments. *J. Geophys. Res.*, **105**, 10203-10218.

5. Rolland, P., K. N. Liou, M. D. King, S. C. Tsay and G. M. McFarquhar, 2000: Remote sensing of optical and microphysical properties of cirrus clouds using MODIS channels: Methodology and sensitivity to assumptions. *J. Geophys. Res.*, **105**, 11721-11738.

6. Baum, B. A., D. P. Kratz, P. Yang, S. C. Ou, Y. Hu, P. F. Soulen and S. C. Tsay, 2000: Remote sensing of cloud properties using MODIS Airborne Simulator imagery during SUCCESS. I: Data and models. *J. Geophys. Res.*, **105**, 11767-11780.

7. Baum, B. A., P. F. Soulen, K. I. Strabala, M. D. King, S. A. Ackerman, and W.

P. Menzel, 2000: Remote sensing of cloud properties using MODIS Airborne Simulator imagery during SUCCESS. II: Cloud thermodynamic phase. *J. Geophys. Res.*, **105**, 11781-11792.

8. Ji, Q., and S. C. Tsay, 2000: On the dome effect of Eppley pyrgeometers and Eppley pyranometers. *Geophys. Res. Lett.*, **27**, 971-974.

9. Wen, G., S. C. Tsay, R. Cahalan and L. Oreopoulos, 1999: Path radiance technique for retrieving aerosol optical thickness over land. *J. Geophys. Res.*, **104**, 31321-31332.

b. Accepted

10. Platnick, S., J. Y. Li, M. D. King, H. Gerber, P. V. Hobbs: A solar reflectance method for retrieving cloud optical thickness and droplet size over snow and ice surfaces. *J. Geophys. Res.*, in press.

11. Platnick, S.: Vertical photon transport in cloud remote sensing problems. *J. Geophys. Res.*, in press.

12. Platnick, S.: Approximations for horizontal transport in cloud remote sensing problems. *JQSRT*, in press.

13. Platnick, S.: A superposition technique for deriving mean photon scattering statistics in plane-parallel cloudy atmospheres, *JQSRT*, in press.

14. Platnick, S., P. A. Durkee, K. Nielson, J. P. Taylor, S. C. Tsay, M. D. King, R. J. Ferek, P. V. Hobbs and J. W. Rottman, 1999: The role of background cloud microphysics in the radiative formation of ship tracks. *J. Atmos. Sci.*, in press.

15. Durkee, P. A., R. E. Chartier, A. Brown, E. J. Trehubenko, S. D. Rogerson, C. Skupniewicz, K. E. Nielson, S. Platnick and M. D. King, 1999: Composite ship track characteristics. *J. Atmos. Sci.*, in press.

16. Dubovik, O., and M. D. King, 2000: A flexible inversion algorithm for retrieval of aerosol optical properties from sun and sky radiance measurements. *J. Geophys. Res.*, in press.

17. Marchand, R. T., T. P. Ackerman, M. D. King, C. Moroney and J. P. Muller, 2000: Multiangle observations of arctic stratus clouds. *J. Geophys. Res.*, in press.

18. Herring, D. D., and M. D. King, 2000: Space-based observations of the Earth. *Encyclopedia of Astronomy and Astrophysics*, Macmillan Press, in press.

19. Rottman, J. W., S. Platnick and M. D. King, 2000: Airborne observations of stratus clouds during the southerly surge event of 10-11 June 1994. *Mon. Wea. Rev.*, in press.

c. Submitted

20. Arnold, G. T., S. C. Tsay, M. D. King, J. Y. Li and P. F. Soulen, 1999: Airborne spectral measurements of surface anisotropy for Arctic sea ice and tundra. *Int. J. Remote Sens.*, submitted.

21. Gatebe, C. K., P. D. Tyson, H. J. Annegarn, G. Helas, A. M. Kinyua and S. Piketh, 1999: Characterization of aerosols at a remote high altitude site over equatorial Africa. *J. Geophys. Res.*, submitted.

22. Gatebe, C. K., P. D. Tyson, H. J. Annegarn, G. Helas, A. M. Kinyua and S. Piketh, 1999: Inter-Hemispheric transport of aerosols over continental Africa. *Atmos. Environ.*, submitted.

23. Gatebe, C. K., M. D. King, S. C. Tsay, Q. Ji, G. T. Arnold and J. Y. Li, 2000: Sensitivity of off-nadir zenith angles to correlation between visible and infrared reflectance for use in remote sensing of aerosol over land. *IEEE Tran. Geosci. Remote Sens.*, submitted.

VII. References

Gatebe, C. K., M. D. King, S. C. Tsay, Q. Ji, G. T. Arnold and J. Y. Li, 2000: Sensitivity of off-nadir zenith angles to correlation between visible and infrared reflectance for use in remote sensing of aerosol over land. *IEEE Tran. Geosci. Remote Sens.*, submitted.

Platnick, S., and S. Twomey, 1994: Determining the susceptibility of cloud albedo to changes in droplet concentration with the Advanced Very High Resolution Radiometer. *J. Appl. Meteor.*, **33**, 334–347.

Watts, P. D., P. N. Francis, M. D. Glew, P. Hignett, J. P. Taylor, and B. Hawden, 1997: Validation of ATSR-2 visible channel reflectances and cloud parameter retrievals using Meteorological Research Flight SATE 2 data. *Proc. SPIE EUROPTO*, **3220**, 258–269.

Cloud Retrieval Group, MODIS Atmosphere, MAS, and CAR web sites can be found at:

http://ltpwww.gsfc.nasa.gov/crg
http://modis-atmos.gsfc.nasa.gov
http://ltpwww.gsfc.nasa.gov/MAS
http://ltpwww.gsfc.nasa.gov/CAR

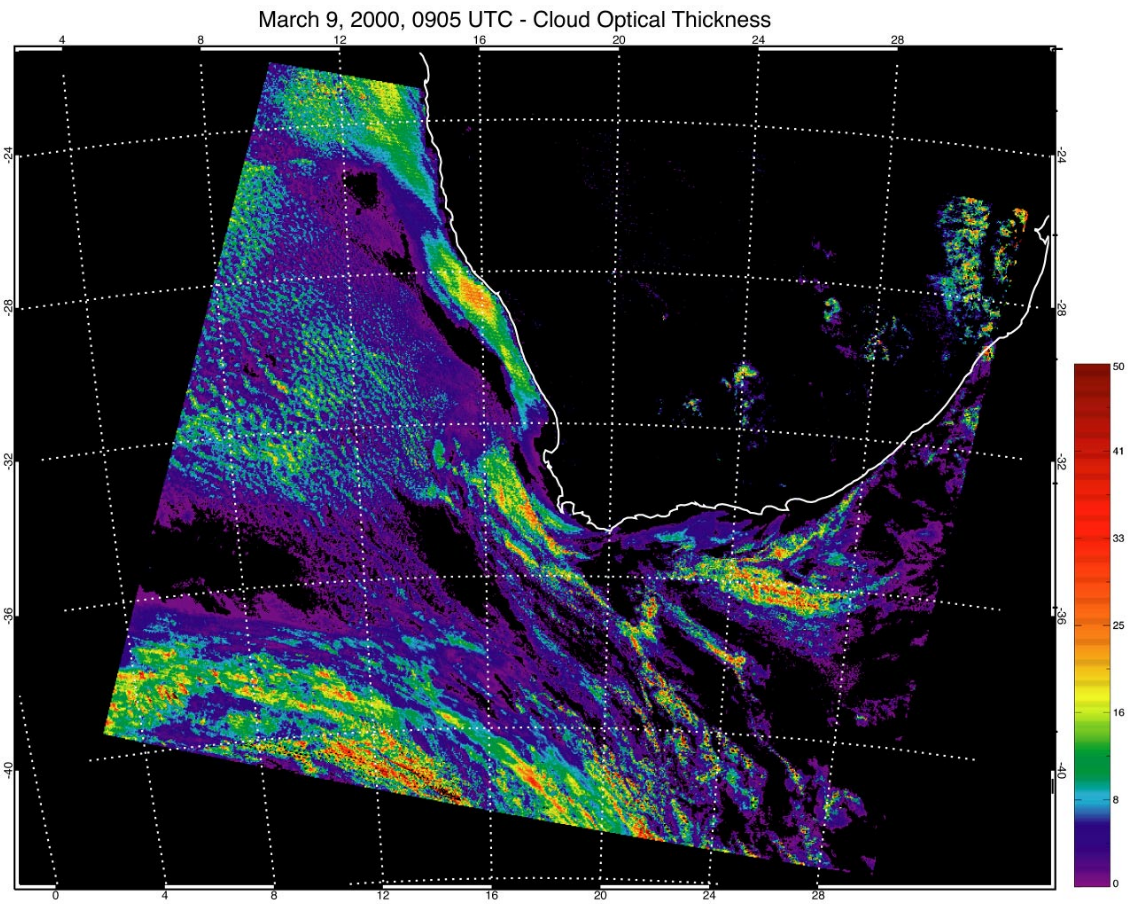


Fig. 1. Cloud optical thickness retrieval.

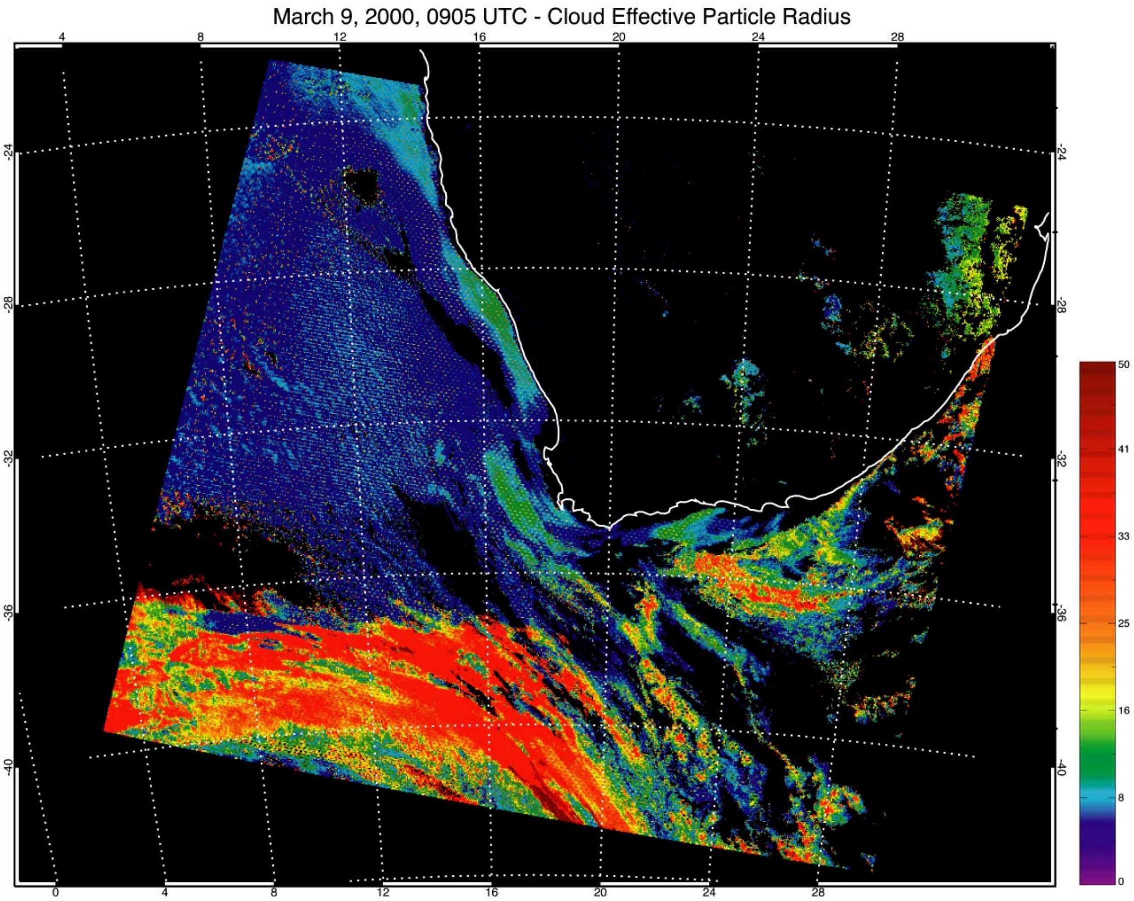


Fig. 2. Cloud effective radius retrieval.

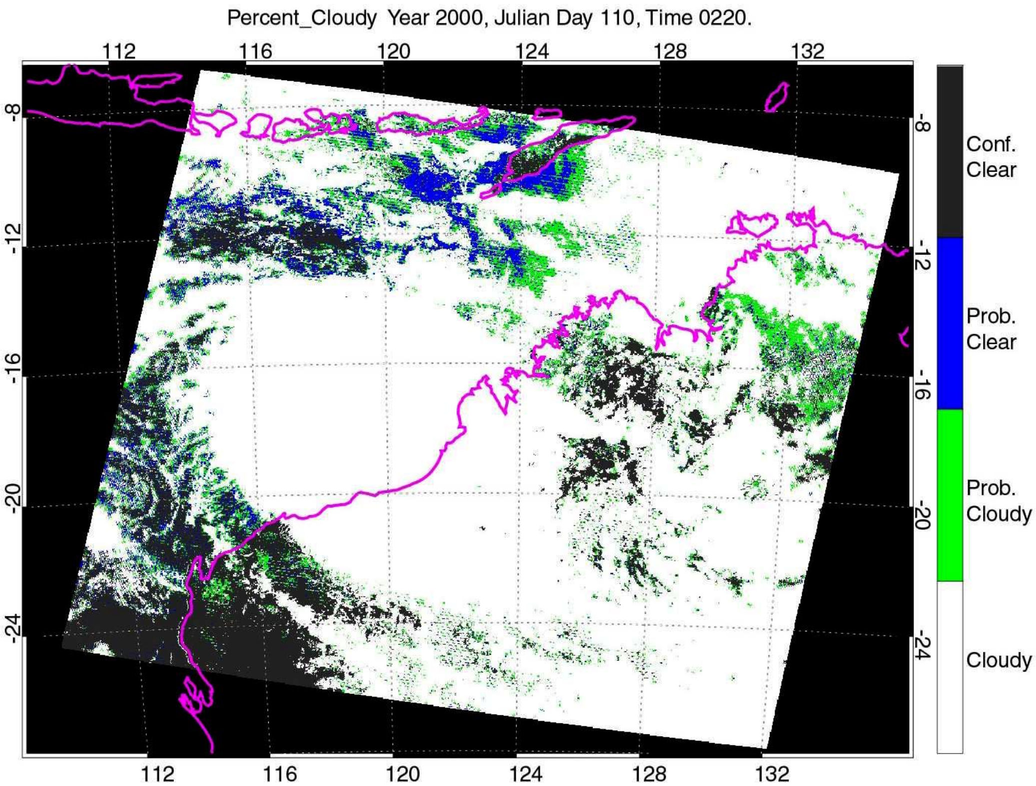


Fig. 3. Sample MODIS Cloud Mask bit flag visualization. Percent Cloudy, over Western Australia from April 19th, 2000.

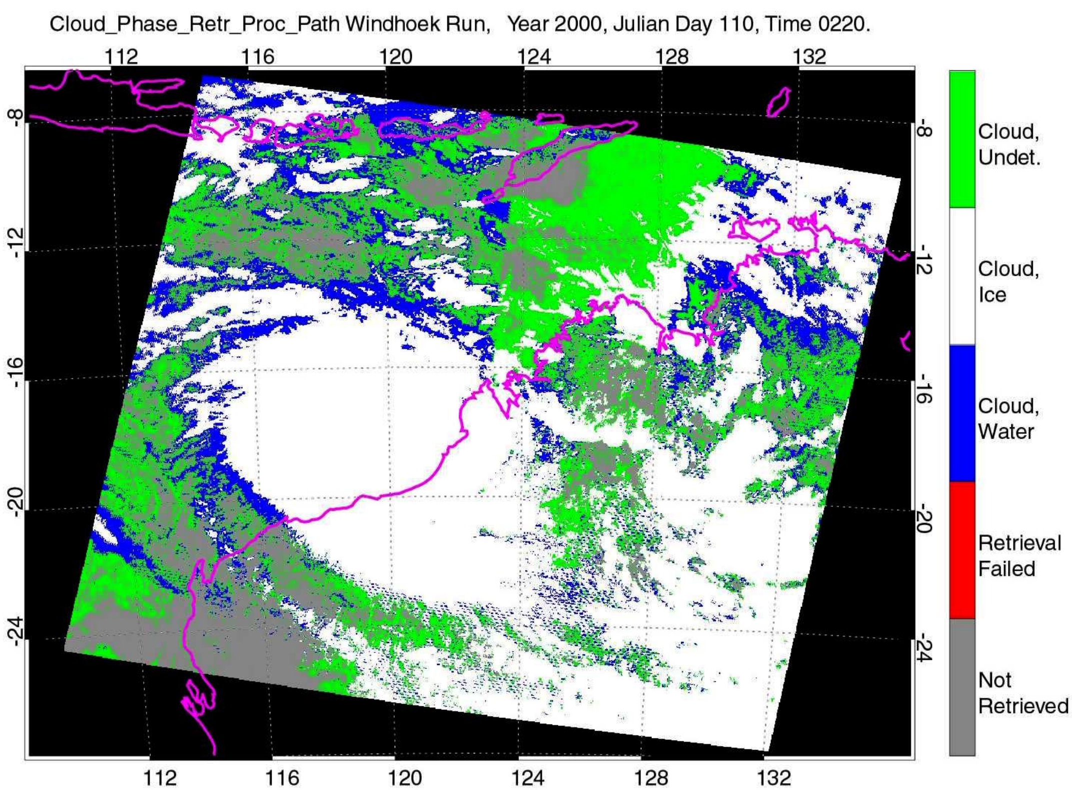


Fig. 4. Sample MODIS QA bit flag visualization. Cloud Phase used in retrieval processing path, over Western Australia from April 19th, 2000.

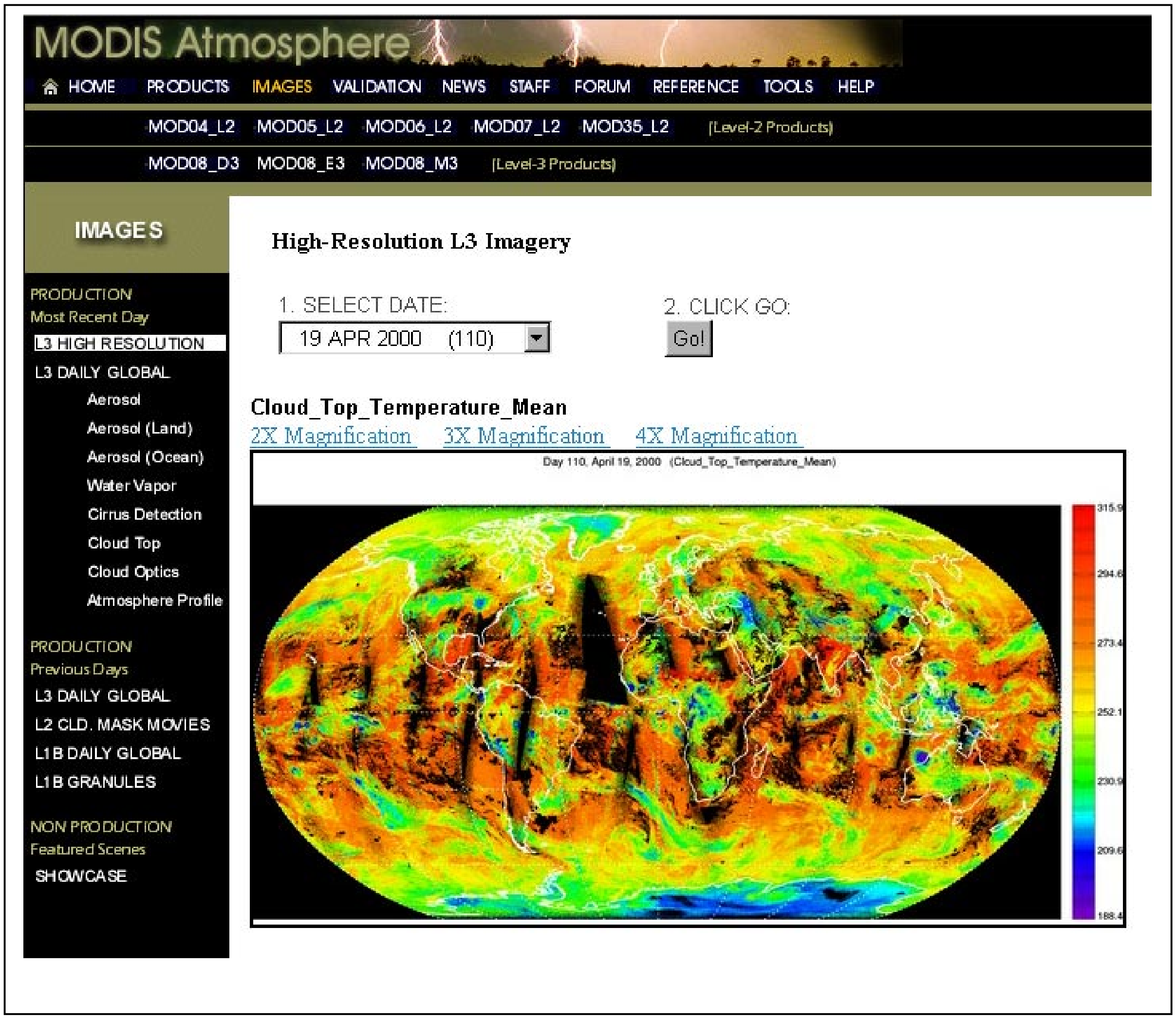


Fig. 5. An example high resolution L3 browse image captured from the MODIS Atmosphere web site.

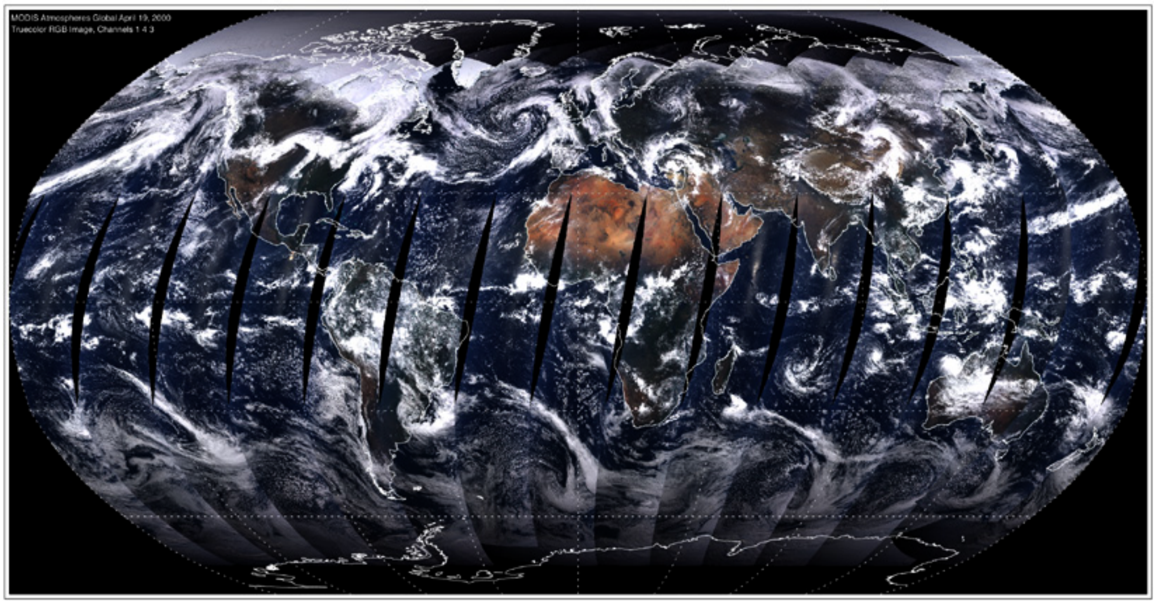


Fig. 6. Example global level-1B quicklook.

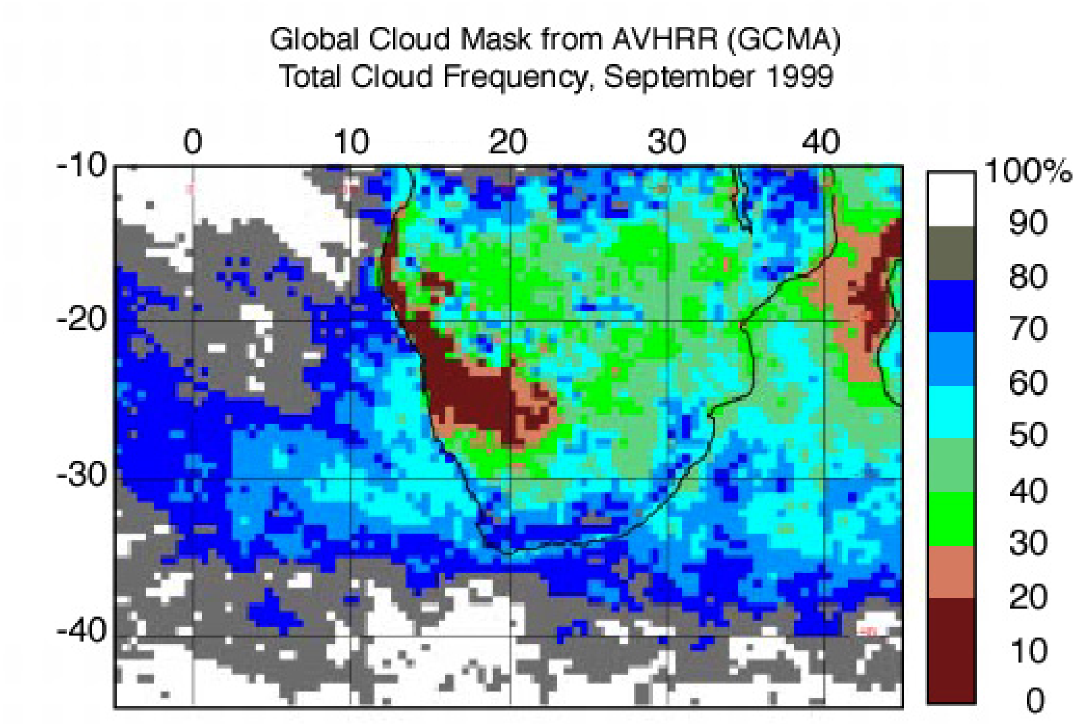
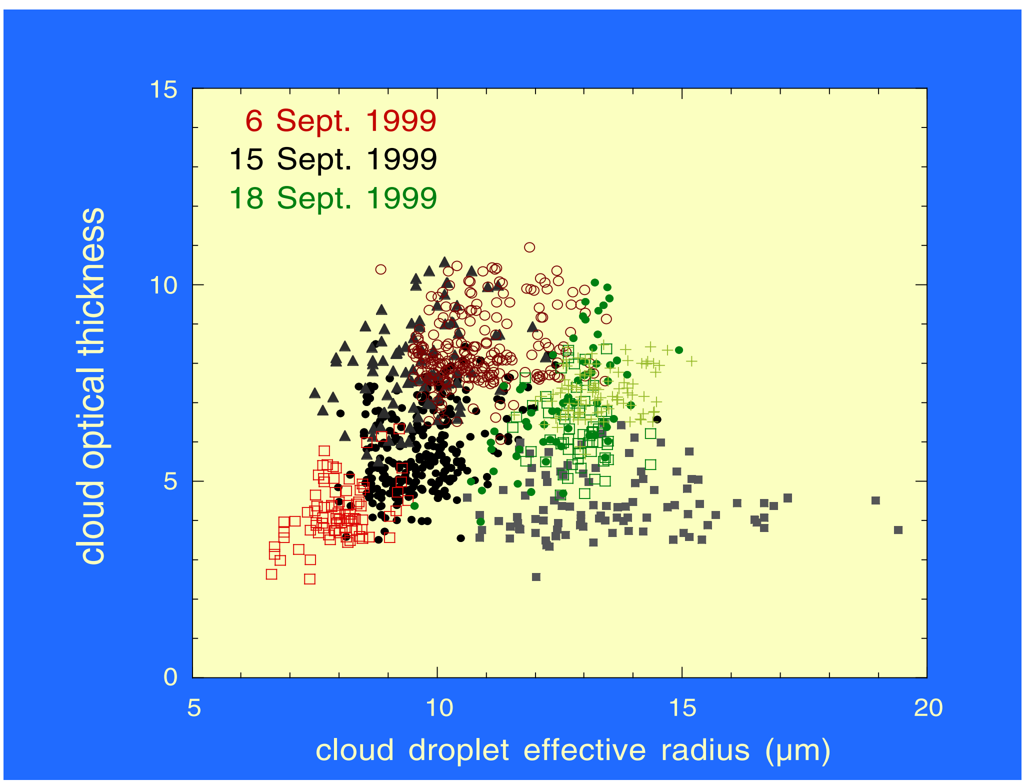


Fig. 7. AVHRR cloud frequency results from the SAFARI 2000 region. (from S. Ackerman). Note the high frequencies in the Namibian stratocumulus regime.



lus clouds from three September 1999 scenes.

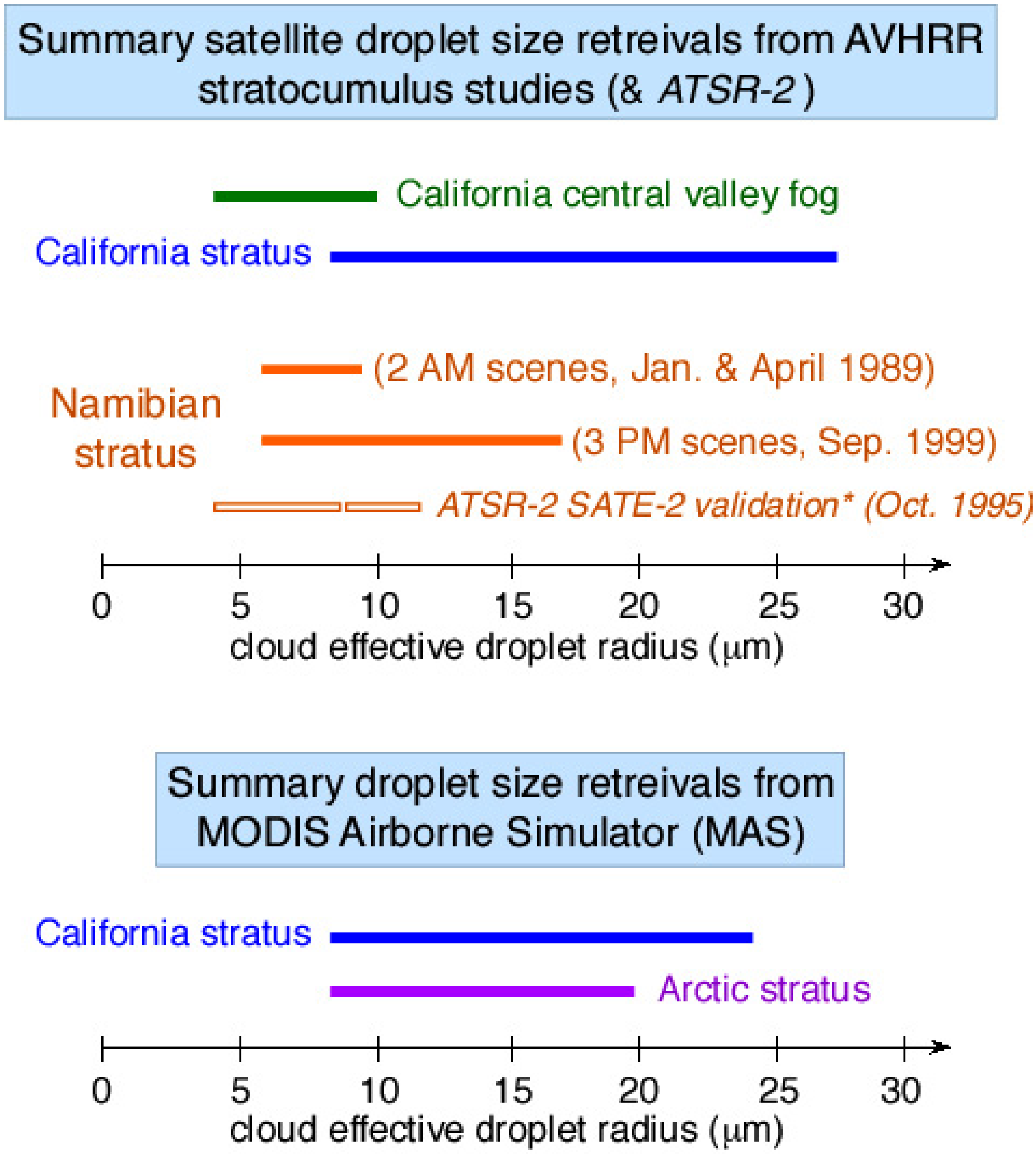


Fig. 9. Summary of recent satellite (AVHRR) retrievals of Namibian stratocumulus. Previous AVHRR and airborne (MAS) droplet size retrievals from three marine stratocumulus regimes, and an ATSR-2 validation campaign with Namibian stratus are also shown. Though limited investigations have been made on Namibian stratus, these clouds often have significantly smaller droplets than the other regimes. This intriguing result suggests further study (such as will be possible during *SAFARI 2000* dry season campaign).