MODIS Quarterly Report (January 1997 - March 1997)

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This reports covers the MODIS **cirrus characterization and correction** algorithm and part of the MODIS **near-IR water vapor algorithm.**

Main topics addressed in this time period:

1. **Level 2 and Level 3 file specifications for MODIS near-IR water vapor and thin cirrus products**: The Level 2 and Level 3 file specifications for MODIS near-IR water vapor and thin cirrus products have been defined and revised several times with the help from Allen Chu. It now appears that another minor change is necessary in order to satisfy the requirement from the MODIS Project. The Level 2 thin cirrus product contains mainly two images - cirrus reflectance image and aircraft contrail index image. The cirrus reflectance image can be used by other MODIS investigators to remove cirrus path radiance effects from MODIS data. The contrail index image plus the cirrus reflectance image can be used to assess the radiative effects of aircraft contrails.

2. **Issues related to MODIS Ch. 18 and Ch. 26**: During a MODIS PFM Reflectance Bands Workshop held at Goddard in early February, problems related to Ch. 18 and Ch. 26 surfaced. The digital number of Ch. 18 is typically only 43. Digitization noise will likely be introduced in calibrated MODIS data for this channel. Ch. 18, the very narrow water vapor absorption channel, was originally proposed by Dr. Al. Arking. The filter for this channel has far more layers of coating in comparison with other “broader” channels. The peak transmission for filter 18 is only about 0.3. As a result, little energy will be transmitted to the detectors. Gao proposed to increase the gain factor for this channel. After a number of E-mail exchanges, it is still not clear how the problem will be solved.

   Ch. 26 is located near the center of the 1.38-μm water vapor band. Laboratory measurement of system response function for this channel encountered the water vapor absorption problem. Both SBRS and University of Wisconsin proposed methods of modeling the water vapor absorption effects. Gao has also investigated the issue and found out that the present line parameters for the 1.38-μm water vapor band on the HITRAN96 AFGL database have not been updated. These line parameters were based mostly on theoretical calculations. The shapes of calculated transmittance spectra using these line parameters are not quite “correct”. New high resolution laboratory-measurements of transmittances for this water vapor bands have been made at AFGL. Improved line parameters will be available in the near future. Therefore, we need to defer the modeling efforts on removing the water vapor absorption effects from SBRS laboratory-measured Ch. 26 data.

3. **Algorithm Development** (*Han, Gao,, Chu, and Ridgway*) -

a. I/O interface routines - Allen Chu has made good progress with writing the I/O interface routines for both the MODIS near-IR water vapor algorithm and the thin cirrus algorithm.

b. Thin cirrus algorithm - The 1.375-µm channel is affected by absorption from water vapor above and within cirrus clouds. The magnitude of the absorption depends on the amount of the water vapor, the solar and view zenith angles. A lookup table has been produced for correction of angular dependencies. An empirical approach, similar to the one outlined in our MODIS cirrus proposal, will be implemented in our algorithm for estimating cirrus reflectances in the 0.4 - 1.0 µm region from the 1.375-µm channel.

Aircraft contrails resulted from commercial aircraft emissions may have radiative effects on the Earth's radiation budget. Detection of contrails from AVHRR and GOES data are practically difficult. Images of the 1.375-µm MODIS channel, which usually do not have surface and low level cloud contaminations, will be very useful for contrail detections during the day time. Bill Ridgway has made progress with the contrail detection algorithm. The central part of the algorithm is to find "ridges" from "gradient" images, and then to find "linear" features using the Hough Transform technique. Now Bill Ridgway is testing the contrail algorithm using MAS data acquired during FIRE II and SUCCESS missions. Additional contrail images are needed to further test the algorithm so that "threshold" values can be set up properly.

c. Near-IR water vapor algorithm - Our V1 MODIS near-IR water vapor algorithm assumed a two-way transmission model during the derivation of water vapor values from MODIS data. However, under hazy conditions and over dark surfaces, correction of aerosol effects is needed. Currently, a module using aerosol optical depths from Yoram Kaufman's MOD04 algorithm is being developed for correction of aerosol effects in our retrieved water vapor values. A lookup table consists of several parameters, including aerosol optical depth, apparent reflectance at 0.86-µm, solar zenith angle, view zenith angle, relative azimuth angle, and column water vapor amount, is being produced using a radiative transfer algorithm based on DISORT.

4. **Ice particle phase function calculations** - There are two scientific groups performing theoretical calculations of ice particle phase functions - Professor Liou's group at University of Utah, and Drs. Michael Mishchenko and Andrew Macke at NASA/GISS. The two groups do not necessarily agree with each other. Gao has made arrangements to provide partial support to both groups for their

help in simulating ice particle phase functions. Both groups have already provided back some simulation results. Michael Mishchenko modified the standard geometric ray optics technique to include Fraunhofer diffraction effects. After the modification, the delta-function transmission peaks in phase functions are reduced.

5. **Radiative transfer modeling** (*Wei Han, Gao, and Ridgway)* -

Our previous report has described progress with expansion of ice particle phase functions and improving DISORT. Further progress has been made during this quarter. Now we can perform radiance simulations using DISORT with realistic ice particle phase functions for MODIS channels. This set of codes will be useful for sensitivity studies on our empirical approach for correction/removing thin cirrus effects from MODIS data.

The framework for the radiative transfer modeling of inhomogeneous thin cirrus cloud fields was also developed during this quarter by Bill Ridgway. The centerpiece is a Monte Carlo simulation of scattered solar radiance based on (1) sun angle, (2) detector wavelength, position, orientation, and resolution, (3) spatially varying surface albedo and bi-directional reflectance function, (4) conservative Rayleigh scattering and non-conservative aerosol and cirrus scattering, and (5) absorption by atmospheric gases (primarily water vapor). The Monte Carlo algorithm is functional, but each of the components such as, for instance, the ice particle phase function or K-distributions representing single channel water vapor absorption are still under development. A FORTRAN code with simplified components was created as a starting point for the development.

6. **Data Analysis** (*Wei Han, Gao,*) - We have made additional analysis of AVIRIS and MAS data collected during the ARMCAS experiment conducted in June, 1995. Although surface features are seen in water vapor channels near 1.38 and 1.88 µm under the very dry arctic conditions, we found from AVIRIS and MAS data that the 1.38 and 1.88 µm channels are still the best channels to detect thin clouds over arctic tundra (because of absorption by water vapor between clouds and the surface), while the IR emission channels and visible channels fail completely in detecting any clouds. We also found that cirrus clouds can be separated from water clouds based on the differences between the 1.66- and 1.73-µm images. The shapes of reflectance spectra for water clouds and ice clouds are different in this spectral region because of differences in water and ice refractive indices. An abstract on this subject was submitted to the AGU Spring Meeting to be held in Baltimore in May, 1997.

Plans for the next 3 month:

We will make every efforts to make sure that the V2 MODIS near-IR water vapor and cirrus cloud algorithms be delivered to MODIS SDST before the end of June, 1997. It was frustrating with development of operational algorithms under the evolving MODIS standard environment (HDF-EOS and MAPI).