INVESTIGATION OF CLOUD PROPERTIES AND ATMOSPHERIC STABILITY WITH MODIS

QUARTERLY Report for JUL - SEP 1994

Paul Menzel
NOAA/NESDIS at the University of Wisconsin

Contract NAS5-31367

ABSTRACT

In the last quarter several milestones were accomplished. Benchmark data and software to test cloud properties algorithms were delivered to and successfully implemented by SDST. Considerable progress was made toward a benchmark data set and software for the cloud mask. In an August meeting of the MODIS cloud mask team, the algorithm was simplified, validation strategies were considered, and ATBD rewriting was begun. Two new members of the UW MODIS team were hired, Liam Gumley, who will work on atmospheric profiles, and Dan LaPorte, who will assist with the infrared calibration.

TASK OBJECTIVES

Software Delivery. Cloud Properties (temperature, amount, and phase) software has been prepared with benchmark data sets (from HIRS and MAS) and delivered to SDST third quarter of 1994. Cloud Mask software and benchmark data (from AHVRR and HIRS) will be sent fourth quarter of 1994. Atmospheric Profiles software will be sent first quarter of 1995.

Revised ATBDs. Based on the peer review of May 1994 and continuing MAS, AVHRR, HIRS, and GOES cloud investigations, the MODIS Cloud Mask ATBD (version 1) will be revised. The revised ATBD will be redrafted and submitted in the fourth quarter of 1994. The Cloud Properties and Atmospheric Profiles ATBDs will also be strengthened with more on validation.

Algorithm Definition. Processing and testing of the cloud parameter algorithms (mask, temperature, phase, height, and amount) will continue using the MAS (MODIS Airborne Simulator) data already at UW. Algorithms for atmospheric total column amount (ozone, precipitable water vapor, and stability) and profiles (temperature and moisture) will be developed using the HIRS (High resolution Infrared Radiation Sounder) data from these field experiments and beyond.

Global Cloud Study. Pre-MODIS cloud studies will continue via the global cloud census with HIRS data now in its sixth year.

MODIS Infrared Calibration. The approach of validating MODIS radiances using the MAS and HIS (High-resolution Interferometer Sounder) instruments will be tested this coming January on GOES-8. The calibration of the MODIS infrared channels requires adequate testing before launch to characterize detector non-linear

response, stray radiation, and angle dependence of background radiation.

WORK ACCOMPLISHED

Software Transfer. The cloud top properties beta software and HIRS benchmark data set were delivered to the SDST and successfully implemented on the TLCF.

Data Issues. A significant effort was put forth in the last quarter in determining ancillary data set requirements and estimating computer processing and data volume requirements for UW MODIS products, in making the input scan cube MODIS data compatible with Wisconsin Toolkit routines and gauging user concerns regarding our MODIS level 2 products. The ancillary data sets were submitted at the MODIS Test Data Workshop at Flathead Lake, Montana. The computer processing and data volume estimates and product abstract descriptions were delivered to the SDST. Work has begun to incorporate scan cube data as a format that can be manipulated by the Wisconsin Toolkit. This will allow Wisconsin Toolkit routines to be used in science data production software. The issue of final user products versus investigator products has been raised. It is likely that an investigator may wish to save supporting product information for research or validation purposes that a user would not need or want. A proposal to create a new file type that would be archived, available only to investigators and include this supporting data has been made to the SDST. The final product file available to the public would include only the MODIS parameters defined in the product abstracts.

Cloud Mask. The Cloud Mask Team met in Madison, WI on August 30 and discussed modifications in response to the peer review. This included the spectral channels, the output format, the algorithms, the ancillary data, and the validation activities. The mask at 500 meter resolution was waived; it was felt that the 250 meter mask would alleviate the need for a 500 meter mask. The spatial coherence tests were placed last in the processing chain of the algorithm; they will be used infrequently due to the large inherent processing load. Validation with ER-2 campaigns, ground campaigns with all sky cameras, and comparison with ASTER were discussed. Quality control was also discussed; monitoring consistency of cloud detection with various tests, performing regional statistics, keeping cloud detection independent of satellite view angle, and correlating with SST and OLR determinations. A revised ATBD will be distributed in November.

The CERES team installed the Satellite Image Visualization System (SIVIS) at the UW SCF. This cloud mask tool has been used to generate masked images from MAS and AVHRR data sets using combinations of visible and infrared threshold tests. This tool will be extremely valuable in defining and testing many of the MODIS cloud mask algorithms.

Global Cloud Studies. An automated method of monitoring various climate parameters has been developed. The CHAPS (Collocated HIRS and AVHRR Products) algorithm was implemented during the months of July 1993, January 1994, and July 1994. Radiance measurements from the AVHRR and HIRS/2 instruments aboard NOAA-12 were used in conjunction with forecast model output from the National Meteorological Center (NMC) to produce global distributions of cloud altitude and amount, the spectral greenhouse effect of atmospheric water vapor, and spectral cloud radiative forcing. By collocating the high spatial resolution AVHRR (GAC) data within HIRS/2 footprints, scene homogeneity may be assured while preserving the high spectral information of the HIRS/2 instrument. Steve Ackerman and Rich Frey are the leading this effort.

Tri-spectral Cloud Phase Algorithm. Kathy Strabala continued investigation of the effectiveness of the 8-11 micron versus the 11-12 micron brightness temperature difference technique for discerning cloud phase. This effort is now focused on gathering coincident data for validation purposes.

MAS cloud parameters. The CO_2 slicing algorithm is being adapted to MAS data for testing MODIS cloud height and effective emissivity products. The software has been applied to MAS data and the results are under analysis. 5 km by 5 km boxes of MAS data are being used to emulate the application to MODIS data. Early tests show that the results are vulnerable to weak 13.3 micron signal to noise. Results were improved by expanding the domain (essentially a spatial average) for the warm and cold temperature determination such that 13.3 micron and 11.0 micron signal to noise were roughly equivalent. However, expansion of the domain has the effect of reducing the natural variability in the data and thus the signal for the CO_2 height and emissivity determination as well. This issue must be investigated further. An adjustment of the domain size as a function of the total variability of the target box may be a useful approach for isolating the natural variability from instrument noise. When the MAS 50 channel digitizer comes on line, MAS 13.8 micron data will also be incorporated into the height/emissivity determination. This channel is desirable because surface radiance, a source of significant variability, is obscured by strong CO_2 absorption. Signal to noise improvement in this channel will also be required.

SCAR Activities. MAS SCAR-C (California) flights and activities were supported by Chris Moeller, Elaine Prins, and Kathy Strabala from September 21 through October 7, 1994. Satellite imagery interpretation and weather forecast information was provided for all days of the experiment. This included analysis of MAS data collection conditions and wildfire identification (using GOES-8 imager data) in support of mission planning. MAS SCAR-C missions were flown on Sept. 21, 22, 27, 30, Oct. 5 and 7. Data scenes included controlled burns, wildfires, smoke plumes, smoldering and post-burn areas. Several flights were coordinated with the University of Washington C-131A (smoke plume in situ, CAR

radiometer, etc.). On MAS flight days, GOES-7 and GOES-8 data were archived at CIMSS, University of Wisconsin.

RISC6000 Workstation. An Exabyte 8505 external tape drive has been added to the workstation. This drive is being used to read MAS data sets directly into the workstation, saving cost and time of reading the data sets through the IBM mainframe. With this addition, the workstation is now self contained for MAS data processing (in McIDAS format), product generation, and analysis. In the future, all new MAS products will be developed on this workstation and it will serve as a template for setting up additional MODIS project workstations at CIMSS.

MAS FY95 Flights. Plans have been developed for combined MAS and HIS instrument underflights of GOES-8 in January 1995. The inter comparison of these three instruments will test techniques in preparation for post-launch validation of MODIS infrared calibration. Other objectives with the data set include cloud properties (height, emissivity, particle size, and thermodynamic phase) and cirrus detection (MAS 1.88 micron channel). In preparation for these flights, MAS is being integrated with a 50 channel 12 bit digitizing system, replacing the old 12 channel 8 bit system. Data collection will include clear and cloudy scenes in both warm and cold sector atmospheres. Additional fiscal 1995 MAS flights (cloud properties, masking) are tentatively scheduled for summer 1995.

Aerosol Detection. The manuscript entitled "Satellite remote sensing of H2SO4 aerosol detection using the 8 to 12 micron window region: applications to Mount Pinatubo" by Ackerman and Strabala was published in the September issue of the Journal of Geophysical Research. Original investigations of the 8-11 micron brightness temperature difference aerosol signal were developed using HIRS March through November 1991 data sets. This processing is being expanded to include 2 years of data for comparison with optical depth measurements from analyses of solar beam observations from Mauna Loa, Hawaii by Elsworth Dutton.

Infrared Calibration. A technique to calibrate one sensor with the blackbody from another was successfully tested with GOES and Meteosat data (as part of another program at UW). By matching empirical distribution functions of the raw counts from collocated data, the distribution of Meteosat counts is matched to the distribution of GOES counts (assuming there is sufficient variation in the scene so that as much of the range of possible counts is involved). Then with M-3 counts matching G-7 counts, M-3 counts are correlated with G-7 radiances (via linear fit). G-7 radiances are converted to M-3 radiances by correlating clear sky forward calculations for the given atmospheric state and the respective spectral response functions. Then M-3 radiances calibrated with the G-7 blackbody can be compared with the operationally calibrated radiances. For several different cases, the mean difference for the temperature range was 0.5 C and the standard deviation about that mean was about 0.5 C.

PROBLEMS

Too much work, too little time.

MEETINGS

UW hosted the cloud mask team meeting in Madison, WI in Aug 1994 attended by scientists from LaRC and South Dakota School of Mines and Technology.

Paul Menzel presented the Cloud Mask ATBD to the assembled MODIS scientists at the meeting in Flathead Lake, MT in Sep 1994.

Paul Menzel presented at the Calibration Team Meeting in October 1994 the technique for inter calibration of satellite sensors mentioned above and also expressed some concerns on vacuum test characterization of background radiation and stray light.

Paul Menzel, Chris Moeller, Kathy Strabala, and Dan LaPorte attended the MODIS Science Team Meeting in October 1994. The initial version of the MODIS cloud mask was presented by Paul Menzel at the plenary. Kathy Strabala presented the tri-spectral cloud phase technique to the Atmospheres Group.