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The International MODIS/AIRS Processing Package (IMAPP) for EOS Direct Broadcast Data

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Objectives

1. To develop a software package for international distribution which allows any ground station capable of receiving EOS direct broadcast data to produce a suite of geophysical products in near real-time (within 1 hour of satellite overpass).
2. By providing a software package to process MODIS and AIRS data, to directly involve the international community in the use and validation of EOS data sets.
3. Using data from the UW/SSEC X-band antenna, generate near real time MODIS/AIRS products over the central and eastern United States for distribution via the World Wide Web.
4. Implement synergistic retrieval algorithms that combine high spatial resolution MODIS data with high spectral resolution AIRS data.

Highlights

IMAPP v1.0 was released to the international EOS direct broadcast (DB) community in May 2000 under the GNU General Public License. Since that time, IMAPP has been adopted in more than 10 countries as the standard package for processing Terra MODIS DB data. For example, the University of Dundee in the United Kingdom used IMAPP to process their first Terra MODIS pass collected on May 8th, 2000 (Dundee served as a beta test site for IMAPP v1.0). Updated versions of IMAPP (v1.1 and v1.2) have followed in 2000 and 2001, bringing the latest calibration and geolocation updates to IMAPP users around the world.

Under separate NASA funding, the UW Space Science and Engineering Center (SSEC) installed a SeaSpace TeraScan SX-EOS groundstation in August 2000 in order to receive direct broadcast from Terra and Aqua. The system was declared operational on January 1, 2001, and since then has routinely acquired every Terra pass above 5 degrees elevation. Using funding from the IMAPP grant, a near real-time processing facility was established to automatically process the MODIS DB data through Level-1B in IMAPP, and produce quicklooks for distribution on the World Wide Web.

A new cloud classification algorithm has been developed for implementation with MODIS direct broadcast data. A maximum likelihood algorithm is used to classify surfaces into land, water, snow/ice, desert, vegetation, and also to classify different cloud types. This classification procedure refines the cloud mask algorithm, and enables further applications such as clear atmospheric profile or cloud parameter retrievals from the combination of MODIS and other sounder systems such as the Atmospheric Infrared Sounder (AIRS). The advantages of this method are the automated surface and cloud classification independent of radiance or brightness temperature threshold criteria, and interpretation of each class based on the radiative spectral characteristics of different classes.

Details:

Specific details of IMAPP releases during the reporting period are as follows:

May 12th, 2000 (v1.0) Initial release including the following functionality for Terra MODIS:

- Reformatting from time-ordered CCSDS Level-0 packets to Level-1A
- Geolocation for every 1000 m pixel
- Calibration for every pixel in bands 1-2, 1-7, and 1-36 at 250, 500 and 1000 m resolution respectively

November 1st, 2000 (v1.1) First update for Terra MODIS:

- Calibration algorithm and lookup tables are updated to version 2.4.3. This includes many post-launch improvements and bug fixes from the MODIS Calibration Team at GSFC
- Added support for definitive ephemeris and attitude data
- Solarisx86 is now supported on Intel Pentium platforms

April 13th, 2001 (v1.2) Second update for Terra MODIS:

- Calibration algorithm and lookup tables are updated to versions 2.5.5 and 2.5.5.1 respectively, which includes calibration data for the B-side electronics on MODIS (the switch to B-side electronics occurred on 1 November 2000). The calibration in IMAPP v1.2 is date dependent, and may be used for all Terra MODIS data back to February 2000. This version also includes a bug fix for aggregation of the 250 m and 500 m spectral bands to higher spatial resolution.
- Geolocation is significantly improved when using only the Level-0 platform ephemeris and attitude information (i.e. in near-realtime). Terrain correction is now available as an option (requires that DEM data files be installed: see the installation instructions). Definitive Terra ephemeris and attitude data are now available via FTP for input to IMAPP.
- Level-1A algorithm is more resistant to Level-0 input file anomalies. Processing now terminates gracefully if a packet with an improper length is encountered in the Level-0 input file.

IMAPP v1.2 is supported on the following UNIX platforms and operating systems:

- SGI MIPS, IRIX 6.5
- Sun Ultra, SunOS 5.7
- IBM RS/6000, AIX 4.3
- HP PA-RISC, HP-UX B.10.20
- Intel Pentium, Linux 2.2.12-20 (with gcc)
- Intel Pentium, Solarisx86 2.5.1 (with gcc)

The automated Terra MODIS quicklook system implemented at SSEC produces remapped images over the continental US, Canada, and the Gulf of Mexico within 80 minutes of the end of each overpass. For nighttime passes, infrared window images are generated at a variety of map scales. For daytime passes, visible images created from single bands, and true color composites created from multiple bands, are produced at a variety of maps scales over the USA (see Figure 1a). A list of target geographic locations and band combinations is queried for every MODIS overpass, and if the location was seen by that pass, a quicklook image is created. The list may be edited to add regions of special interest. An example is the flooding in the US upper midwest during the Spring of 2001. When the city of Lacrosse WI was threatened by flooding, a target location was entered in the list, and images were created automatically (see Figure 1b). The most recent 7 days of remapped images are available online at http://terra.ssec.wisc.edu/terra/. A new site that is more user-friendly is under development, and will be released in the summer of 2001.

A new method for automated classification of surface and cloud types using MODIS radiance measurements has been developed. The MODIS cloud mask is used to define the training sets. Surface and cloud type classification is based on the maximum likelihood (ML) classification method. Classified results then define training sets for another iteration. Iterations end when the number of pixels switching classes becomes smaller than a predetermined number or when other criteria are

met. The final class mean gravity values in the spectral domain are used for class identification and a final 1 km resolution classification map is generated for a MODIS granules. This classification procedure refines the cloud mask algorithm, and enables further applications such as clear atmospheric profile or cloud parameter retrievals from MODIS radiance measurements or from the combination of MODIS and other sounder systems such as AIRS (see Figure 2). The advantages of this method are the automated surface and cloud classification independent of radiance or brightness temperature threshold criteria, and interpretation of each class based on the radiative spectral characteristics of different classes.

Future Work

During the next year of IMAPP funding (04/15/2001 to 04/15/2002), the following work is planned:

1. Release the first MODIS Level-2 geophysical product algorithms as part of IMAPP. Algorithms will include a MODIS cloud mask, scene classification, temperature and moisture profile retrieval, and cloud top pressure, temperature, and phase. It is worth noting that the MODIS Fire Group at NASA/GSFC plans to release an IMAPP-compatible fire detection algorithm in 2001.
2. Continue to refine the IMAPP Level-1 software for Terra MODIS, and prepare for Aqua MODIS Level-1 processing. Part of this effort will involve generating predicted ephemeris and attitude data for realtime use with Aqua data, since the Aqua platform does not transmit these data in realtime.
3. Cooperate with the Aqua AIRS team at JPL to implement the AIRS/AMSU/HSB Level-1 software in direct broadcast mode. The goal is to have a package which can become part of IMAPP for release to the international community.
4. Begin prototyping combined MODIS/AIRS/AMSU/HSB retrieval algorithms, for eventual release as part of IMAPP.

Websites

IMAPP source code distribution: http://cimss.ssec.wisc.edu/~gumley/IMAPP/
SSEC MODIS quicklooks: http://terra.ssec.wisc.edu/terra/
SSEC MODIS Level-1B data: ftp://terra.ssec.wisc.edu/pub/terra/modis/

Publications

"High spatial resolution surface and cloud type classification from MODIS multi-spectral band measurements" by Jun Li, Zhongdong Yang, Hung-Lung Huang, W. Paul Menzel, Richard A. Frey, and Steven A. Ackerman. Submitted to Journal of Geophysical Research, April 2001.

Conference Presentations

"International MODIS and AIRS Processing Package (IMAPP) - Science and Algorithm" by Allen Huang. Presented at 4th International Conference on Direct Broadcast of Earth Observation Data, University of Dundee, Scotland, June 27-30, 2000.

"Status of the UW-SSEC X-band groundstation and MODIS data processing software" by Liam Gumley. Presented at 4th International Conference on Direct Broadcast of Earth Observation Data, University of Dundee, Scotland, June 27-30, 2000.

"The International MODIS/AIRS Processing Package (IMAPP): The EOS ATOVS" by Allen Huang. Presented at International Radiation Symposium 2000, Saint Petersburg, Russia, July 23-28, 2000.

"EOS Direct Broadcast Reception and Processing at the University of Wisconsin-Madison" by Liam Gumley. Presented at IGARSS 2000, Honolulu, Hawaii, July 24-28, 2000.

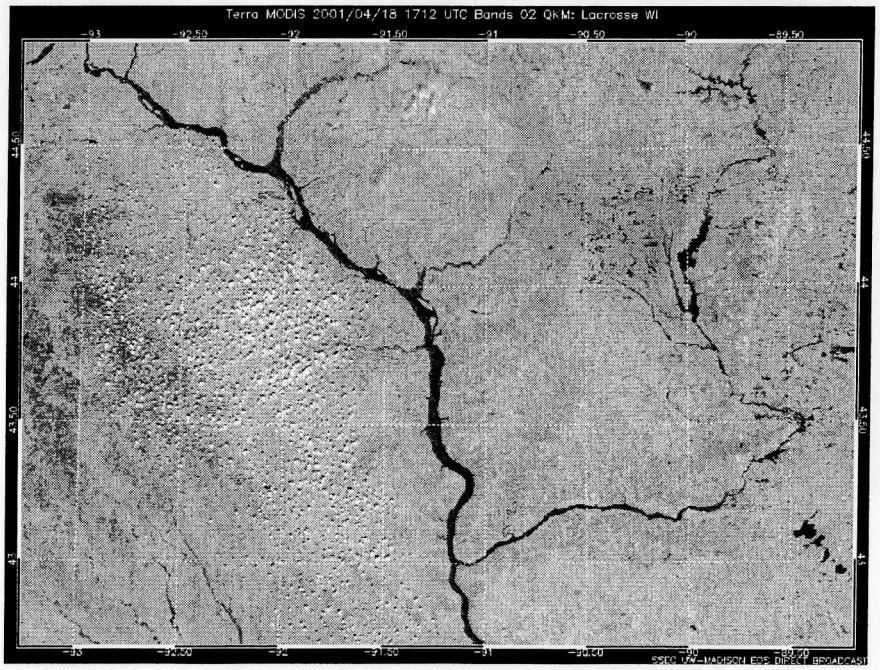
"International MODIS/AIRS Processing Package - Package Information and Science Objectives", by Allen Huang. Presented at 11th International TOVS Study Conference, Budapest, Hungary, September 22-29, 2000.

"Atmospheric Applications of Terra MODIS at the University of Wisconsin-Madison" by Liam Gumley. Presented at 10th TeraScan Users Conference, La Jolla, California, October 17-19, 2000.

"Atmospheric retrievals from MODIS measurements: A comparison with GOES sounder products" by Jun Li. Presented at Optical Remote Sensing of the Atmosphere, Coeur d'Alene, Idaho, February 5-8, 2001.

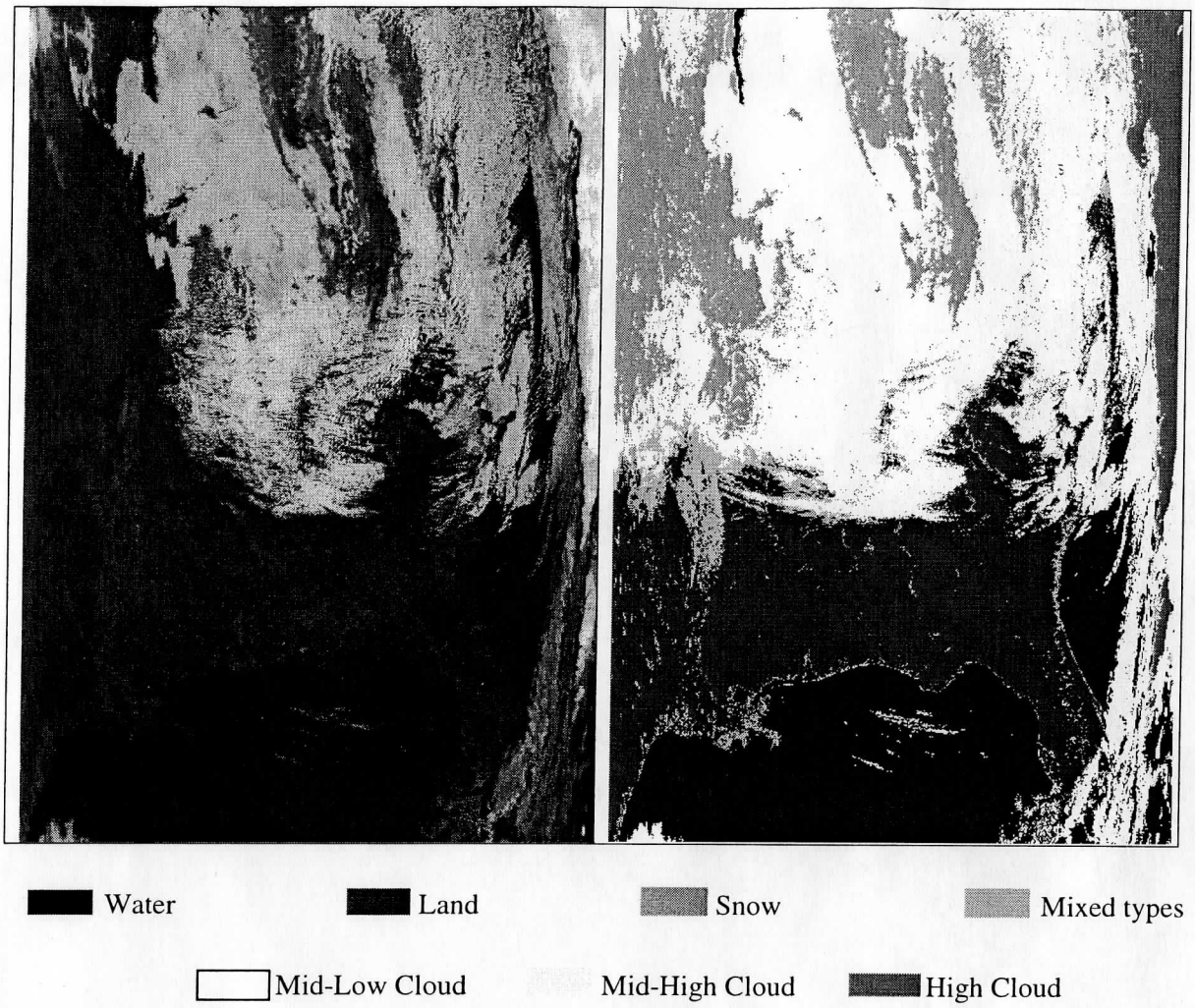
Figure 1a: Terra MODIS 2001-04-03 1613-1625 UTC: Bahamas and Cuba

Figure 1b: Terra MODIS 2001-04-18 1712 UTC: Lacrosse WI



Figures 1a and 1b show remapped MODIS images that were generated automatically by the SSEC direct broadcast processing facility. The MODIS data was unpacked, geolocated, and calibrated by IMAPP, and resampled to a map projection using custom IDL software.

Figure 2: MODIS Cloud Classification 2000-12-17 1640 UTC



The left panel of Figure 2 shows MODIS band 2 reflectance, and the right panel shows the classification map. The algorithm improves upon the scene classification from the MODIS cloud mask, and allows more robust discrimination of scene types such as snow versus cloud.