International MODIS/AIRS Processing Package - Package Information and Science Objectives

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ABSTRACT

The Space Science and Engineering Center at the University of Wisconsin-Madison with support from NASA has installed an X-band ground station to receive direct broadcast from the EOS Terra and Aqua satellites in near realtime. Image data from MODIS (MODerate resolution Imaging Spectro-radiometer) are received and processed to Level-1B within 60 minutes of reception. The system includes commercially available antenna hardware; a data receiving front end; ingest software; and reformatting, calibration, navigation, image processing, and atmospheric product generation software.

An International MODIS/AIRS Processing Package (IMAPP) has been developed for processing of EOS MODIS data for weather, climate, nowcasting, NWP, cloud property, and radiation budget studies. Future system capabilities will encompass EOS Aqua AIRS (Atmospheric Infrared Sounder) data receiving and processing. This paper will address the details of system configuration, MODIS product requirements, and expectations of the International TOVS community.

Keywords
EOS Terra, EOS Aqua, X-band direct broadcast system, MODIS, AIRS, calibration, navigation, Level-1, Level-2 products.

INTRODUCTION

The MODIS and AIRS instruments onboard the EOS Terra and EOS Aqua platforms will provide greatly enhanced remote sensing capabilities for the observation of planet Earth. The improved imaging capability from MODIS and the atmospheric sounding capability from AIRS will provide new and exciting opportunities for scientists of many disciplines to study the earth and its atmosphere. The ability to receive the data stream in a timely manner and accomplish fundamental processing to transform sensor measurements to radiances and geophysical products will be key to utilizing these data. For this purpose, the Space Science and Engineering Center (SSEC) at the University of Wisconsin-Madison and others in the United States, along with international groups around the globe, are installing X-band ground stations to receive the direct broadcast data stream from the EOS Terra and EOS Aqua platforms (Barton and Dodge, 1999).

Once the direct broadcast data stream is received, it must be processed to derive calibrated, geo-located MODIS and AIRS radiances (Level-1B data). In order to conduct interdisciplinary studies with MODIS and AIRS data, the international EOS direct broadcast community has expressed a strong desire for a software package which uses well-established algorithms to process MODIS and AIRS data to Level-1 (Griersmith, 1998). In addition, there are also several geophysical products (e.g. cloud mask, temperature and moisture profiles) that would directly facilitate the use of MODIS and AIRS direct broadcast data in the international science community, such as in the field of numerical weather prediction.

The IMAPP software provides the international multi-disciplinary science community with the capability to process direct broadcast MODIS and AIRS data into calibrated, geo-located radiances and to create derived products utilizing the capabilities of both instruments. The specific goals of IMAPP are:

1. To develop a software package for international distribution which allows any X-band ground station capable of receiving direct broadcast data from the EOS Terra and Aqua platforms to produce calibrated and geo-located MODIS and AIRS radiances, and selected geophysical products, in near real-time (within 1 hour of satellite overpass).
2. By providing a freely available software package to process MODIS and AIRS direct broadcast data, to promote and support the worldwide use of EOS data, and to directly involve the international community in the validation of EOS data sets.
3. To develop and implement a synergistic MODIS/AIRS algorithm for direct broadcast data that utilizes the high spatial resolution of MODIS data and the high spectral resolution of AIRS data.
4. Using the SSEC X-band ground station and IMAPP, to routinely receive EOS direct broadcast data over the central and Eastern United States and generate a suite of MODIS and AIRS products within one hour of overpass. The Level-1 and Level-2 near real time regional data can be shared with international TOVS community users to broaden the scopes of EOS earth science initiative.

PACKAGE INFORMATION

IMAPP is freely available at the web address:

http://cimss.ssec.wisc.edu/~gumley/IMAPP/IMAPP.html

IMAPP implementation details can be briefly summarized as follows:

Differences between IMAPP and GSFC/DAAC Operational Software:

- Ported to a range of UNIX platforms,
- Only tool kit required is NCSA HDF 4.1r3,
- Processing environment is greatly simplified,
- Downlinked or definitive ephemeris/attitude data,
- Passes of arbitrary size may be processed.

Language, Data Format

ANSI standard C, HDF.

Supported Platforms: IRIX, SunOS (Ultra), AIX, HP-UX, Linux (x86), Solarisx86.

IMAPP Functions for MODIS are:

1. Reformatting (Level-1A):

Unpack earth view and engineering data from Level-0 data stream (time-ordered MODIS CCSDS packets with duplicates removed).

2. Geolocation:

Compute earth location/elevation and sensor/sun viewing geometry for every 1000-m pixel.

3. Calibration (Level-1B):

Transform earth view image counts to radiance units for every pixel in bands 1–2, 1–7, and 1–36 at 250-, 500- and 1000-m resolution respectively.

Level-1A File Contents are:

1. Global metadata (e.g. date, no. of scans, Orbit No.)

2. Scan-level metadata (e.g. mirror side, scan start time)

3. Pixel quality data (missing or discarded packet, bad CRC)

4. Scan data (e.g. Earth view, space view, OBC view)

5. Discarded packets

6. Engineering data (e.g. S/C attitude, OBC temperature)

Geolocation File Contents are:

1. Geodetic position (latitude, longitude, and height above ellipsoid) for center of each 1000-m pixel

2. Sun and satellite bearings (zenith and azimuth) for center of each 1000-m pixel

3. Land/sea mask for center of each 1000-m pixel

4. Sun and Moon positions with respect to MODIS for each scan

5. Instrument information sufficient to permit geolocation for specific bands and sub-pixel ground location.

Level-1B File Contents are:

1. Earth view image data (radiance/reflectance units)

250-m resolution file contains bands 1–2

500-m resolution file contains bands 1–7

1000-m resolution file contains bands 1–36

2. Geolocation data for every 5th 1000-m pixel on every 5th line (3, 8, 13, ...)

3. Global metadata (e.g. date, time, number of scans, day/night mode, LUT serial numbers)

SCIENCE OBJECTIVES

1. Cloud Mask

Figure 1 demonstrates the cloud detection product which will be produced by IMAPP (Ackerman et al. 1998).

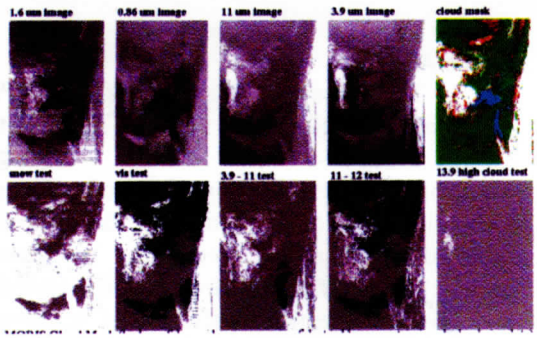

Figure 1. (a) Upper Panel: 1.6, 0.86, 11, and 3.9 μm images, together with the MODIS cloud mask (far upper right) where high confidence clear is green, confident is blue, uncertain is red, and cloudy is white). (b) Lower Panel: snow; visible; 3.9–11; 11–12; and 13.9 μm high cloud threshold test result images.

2. Total Precipitable Water (TPW)

An example IMAPP MODIS TPW product is shown in Figure 2 (upper panel) together with band 29 (8.55 μm) water vapor band brightness temperatures (lower panel). As in all following images, the images were obtained on 2 September 2000.

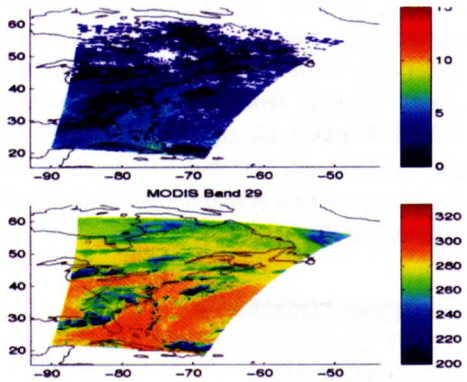

Figure 2. MODIS TPW and 8.55 μm water

3. Sea Surface Temperature (SST) and Land Surface Temperature (LST)

An example IMAPP MODIS SST/LST image is displayed with 11 μm band brightness temperatures in Figure 3. SST and LST are represented by surface skin temperature retrieved over ocean and land area, respectively.

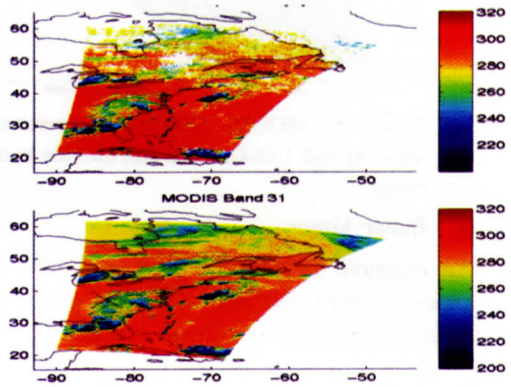

Figure 3. MODIS SST/LST and 11 μm atmospheric window channel brightness temperatures.

4. Total Column Ozone

An example of an IMAPP MODIS-derived total column ozone product is shown with the 9.73 μm ozone band brightness temperatures in Figure 4.

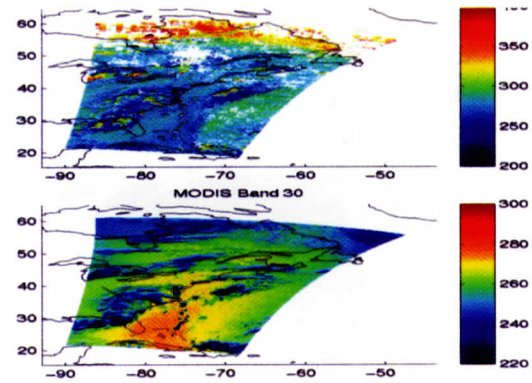

Figure 4. MODIS Total Column Ozone and 9.73 μm ozone band brightness temperatures.

5. Temperature Profile

Figure 5 shows an example IMAPP MODIS 500 hPa temperature retrieval (Jun, et al., 2000) is shown with the 13.64 μm band brightness temperatures.

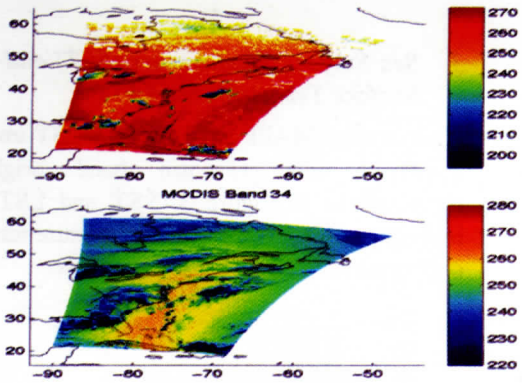

Figure 5. MODIS 500 hPa temperature retrieval and 13.64 μm carbon dioxide band image.

6. *Water Vapor*

An example IMAPP MODIS 700 hPa water vapor is displayed with 7.33 μm water vapor band brightness temperatures in Figure 6.

7. *Surface Emissivity*

Example IMAPP MODIS shortwave infrared surface emissivity is displayed with 4.05 μm surface band brightness temperatures in Figure 7.

8. *Future MODIS/AIRS Synergistic Products*

Synergistic Level-2 products will also be derived when both MODIS and AIRS data are available through direct broadcast of the Aqua satellite.

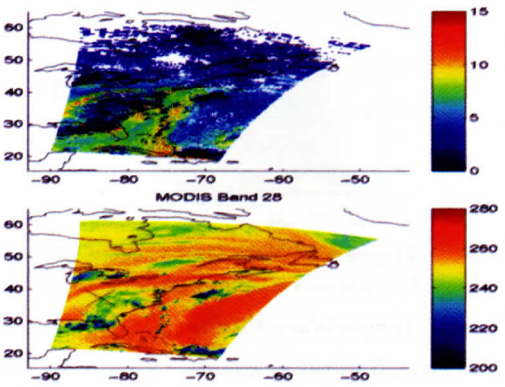

Figure 6. MODIS 700 hPa water vapor retrieval and 7.33 μm water vapor band brightness temperatures.

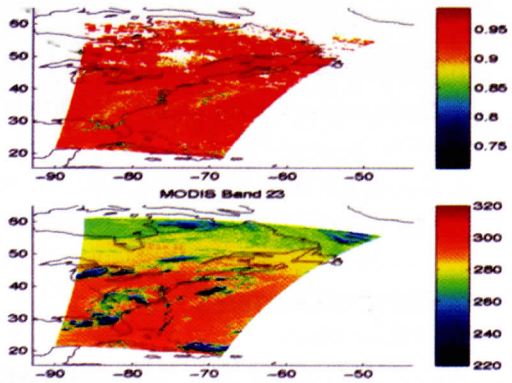

Figure 7. MODIS surface infrared emissivity and 4.05 μm surface band brightness temperatures.

SUMMARY

This paper summarizes IMAPP processing capabilities in terms of Level-0 to Level-1, Level-1 to Level-2. Package information is described in areas of software compatibility, program language, data format tool kit, calibration accuracy, navigation accuracy and efficiency, internal file contents and format. Scientific objectives of achieving Level-2 products are also outlined. Example Level-2 products such as cloud mask, TPW, SST/LST, total ozone column concentration, shortwave infrared surface emissivity, and sounding profiles of temperature and water vapor are demonstrated with comparisons made to the Level-1 calibrated infrared images.

A new release of IMAPP in March 2001 will include an enhanced Level-1 calibration procedure using B-side electronics and an improved navigation scheme. New cloud and surface type classification algorithm without using the statistic threshold approach is also developing and further improvement in cloud mask products is expected. Comparisons of IMAPP MODIS Level-2 products with other operational satellite retrieval products are also underway. With all these ongoing efforts and the strong support from NASA and International TOVS Working Group (ITWG), it is expected that IMAPP will continue to revive itself for the challenges of new research and operational polar orbiting satellite systems.

ACKNOWLEDGMENTS

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