Status Update of IMAPP and IPOPP
The End-to-End Processing Package for EOS and future Polar Orbiting Satellite Systems

Allen Huang, Liam Gumley, Kathleen Strabala, Jun Li, Jun Huang, Elisabeth Weisz, Hal Woolf, Paolo Antonelli, and Tom Achtor

Cooperative Institute for Meteorological Satellite Studies
Space Science and Engineering Center
University of Wisconsin-Madison

ITSC 15, Maratea, Italy
5 Oct., 2006
Status Update of IMAPP and IPOPP

IMAPP provides users with an EOS satellite Terra and Aqua direct broadcast system the capability to calibrate and navigate locally received satellite data and, from these data, to create environmental data products of significant regional interest. So far, more than 150 direct broadcast stations are using IMAPP for their daily routine direct broadcast processing from the raw data to the generation of end products and information.

CIMSS is currently funded by NASA to maintain and update IMAPP and to continue to support direct broadcast users, development for the NPOESS and its Preparatory Project (NPP) support by IPO/NASA is well underway. The processing package for NPP/NPOESS will be built on the foundation laid by IMAPP and the data processing element provided by the NPOESS prime contractor, working closely with NASA’s Direct Readout Laboratory (DRL). In addition, International Polar Orbiter Processing Package (IPOPP) will also be extended to include the processing of METOP data. The IPOPP METOP component effort is to leverage EUMETSAT NWP Satellite Application Facility (SAF) located at UK Met office and its Meteo France partner. These SAF team members are jointly developing a new version of AAPP (ATOVS and AVHRR Pre-Processing Package) to perform level 1 processing on AMSU, MHS, HIRS, AVHRR and IASI (i.e. generate calibrated, geolocated radiances). Within IPOPP, specified level 2 retrieval algorithms to individually and/or synergistically process AMSU, MHS, AVHRR and IASI data to produce atmospheric products will also be developed and distributed.

This presentation is to highlight the current status and future prospects for IMAPP and its successor, IPOPP.
Overview of CIMSS Direct Broadcast (DB) Activities

- Real time data processing and distribution
- Software development and distribution
- Remote sensing workshops
Overview of CIMSS DB Activities

- **Real time data processing and distribution**
  - Real time direct broadcast web page
    - Archive of quick look data
    - Instrument data and products staged on anonymous ftp site, and available through McIDAS ADDE servers
  - Support of environmental monitoring and weather forecasting where quality and timeliness of data are vital
    - Images of events of public interest (Stoughton Tornado, Tire Fire, Dust Storm, Hurricanes)
    - Images for Great Lakes Coast watch, sea ice, marine animal migrations
    - High Resolution SST’s for local NWP initialization
    - Polar Winds
    - PAW – PDA Animated Weather
    - IDEA – Infusing Satellite Data into Environmental Applications
    - NWS - AWIPS
Overview of Activities (cont.)

• **Software development and distribution**
  – IMAPP allows other users the ability to support their own real time data and processing systems
  – Testbed for MODIS/AIRS products
  – Support of our own research (total control of system from end to end)
    • AIRS data for ABI simulations
    • MODIS/AIRS combined products
    • MOD07 TPW / near-infrared validations

• **Remote sensing workshops**
  – Global outreach
    • Now that we have data and products, what do we do with them?
International MODIS/AIRS Processing Package (IMAPP)

Builds upon our previous experience with
• ITPP (International TOVS Processing Package) since 1985
• IAPP (International ATOVS Processing Package) since 1998

Purpose:
• The intention in developing IMAPP for processing direct broadcast MODIS and AIRS data is to help foster the rapid improvement of retrieval algorithms and other applications of EOS data in a variety of global weather, process studies, and climate applications, just as the ITPP and IAPP have done for TOVS and ATOVS data.

Available from:
http://cimss.ssec.wisc.edu/~gumley/IMAPP/
Current IMAPP Status

**MODIS products – Level 1B and Geolocation**
- cloud mask (MOD35), cloud properties (MOD06CT) - height, temperature, emissivity, phase
- atmospheric profiles (MOD07) T, q, tpw, total ozone, stability
- aerosol optical depth (MOD04)
- sea surface temperatures (Jim Davies)
- near-infrared water vapor (Peter Albert, Ralf Bennartz)

**MODIS utilities**
- creating true color images tutorial

**AIRS products**
- AIRS/AMSU/HSB Level 1 (with JPL)
- AIRS Level 2 profiles (both single pixel and 3x3)

**AMSR-E products – RSS L1B software**
- Rain rate, rain type (B05 algorithm)
- Soil Moisture (B03 algorithm)
IMAPP AIRS Clear Sky Retrieval at CIMSS

- Principal Component Regression Retrieval performed for every AIRS FOV
- Retrieved Parameters: T, Q, O3 at 101 p levels, TPW, Total Ozone, Surface Emissivity and Reflectivity
- Training set: SEEBOR_V5 (July 2006), 15704 profiles, 10 emiss points
- Number of PCs used: 30
- SARTA version: V106 (sarta_apr05)

**Version 1.2 (July 2006)**

- Number of Channels: 1688 pristine channels (“p1688.txt”)
- Separate Coefficients for 6 BT classes and 11 scanning angles

**Version 1.3 (Sept 2006)**

- Number of Channels: 1450 pristine channels (channels below 2400 cm$^{-1}$)
- Separate Coefficients for 6 BT classes and 11 scanning angles and for land and ocean cases.
- Additional Predictors: surface pressure, solar zenith angle
- In retrieval using NCEP gdas1 surface pressure and AIRS L1B solar zenith information
132 selected Prepqc Matchup profiles: RMS and Stdev of RAOB minus RTV

IMAPP RTV v1.2

IMAPP RTV v1.3
Selected Prepqc Matchup profiles: Temperature Profiles (day)
Selected Prepqc Matchup profiles: Temperature Profiles (night)
Selected Prepqc Matchup profiles: Humidity Profiles (day)
Selected Prepqc Matchup profiles: Humidity Profiles (night)
Granule 192, Sept-02, 2003 (daytime, ascending)

BT [K] at 920 cm$^{-1}$
Surface Skin Temperature

IMAPP AIRS RTV v1.2

IMAPP AIRS RTV v1.3

RTV v1.2 minus RTV v1.3
Temperature at 700 mbar

IMAPP AIRS RTV v1.2

IMAPP AIRS RTV v1.3

RTV v1.2 minus RTV v1.3

Temperature [K] at 706.565 mbar
Humidity at 850 mbar

IMAPP AIRS RTV v1.2

IMAPP AIRS RTV v1.3

RTV v1.2 minus RTV v1.3

Humidity [g/kg] at 852.788 mbar
Total Precipitable Water

IMAPP AIRS RTV

v1.2

IMAPP AIRS RTV

v1.3

RTV v1.2 minus RTV v1.3

TPW [cm]
Surface Emissivity at 1204 cm$^{-1}$

IMAPP AIRS RTV v1.2

IMAPP AIRS RTV v1.3

RTV v1.2 minus RTV v1.3
Surface Reflectivity at 2325 cm\(^{-1}\)

IMAPP AIRS RTV v1.2

IMAPP AIRS RTV v1.3

RTV v1.2 minus v1.3
Granule 11, Sept-08, 2004 (nighttime, descending)

BT [K] at 1217 cm\(^{-1}\)

Clear and partially cloudy pixels

Clear pixels
Surface Skin Temperature

IMAPP AIRS RTV v1.2

IMAPP AIRS RTV v1.3

RTV v1.2 minus v1.3

Surface Skin Temperature [K]
Surface Skin Temperature

IMAPP AIRS RTV v1.2: G011, 09-08-2004
Surface Skin Temperature [K]

IMAPP AIRS RTV v1.3: G011, 09-08-2004
Surface Skin Temperature [K]

ECMWF Analysis:
Surface Skin Temperature [K]

Standard Physical Retrieval:
Surface Temperature [K]
Surface Emissivity at 1204 cm\(^{-1}\)

IMAPP AIRS RTV v1.2

Operational Standard Physical Retrieval Product

IMAPP AIRS RTV v1.3
Surface Reflectivity at 2325 cm\(^{-1}\)

IMAPP AIRS RTV v1.2
Operational Standard Physical Retrieval Product

IMAPP AIRS RTV v1.3
Real Time Data Processing and Distribution
### Terra - September 19, 2005

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<th>End UTC</th>
<th>Quicklook</th>
<th>Browse Images</th>
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<td></td>
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<td>18:03:40</td>
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Information current as of September 20, 2005 15:37:33 UTC
Latest Terra MODIS University of Wisconsin Direct Broadcast Daytime Products

Other Product Pages:

Terra Daytime | Terra Nighttime | Aqua Daytime | Aqua Nighttime | Archive

- **Natural Color** (R: 0.65 micron, G: 0.55 micron, B: 0.45 micron)
- **Band 26** (1.38 micron)
- **Band 20** (3.7 micron)
- **Band 31** (11 micron)
- **Cloud Mask Product**
- **Cloud Top Pressure**
- **Cloud Phase**
- **Total Precipitable Water Vapor**
- **Aerosol Optical Depth**
- **Sea Surface Temperatures**
Hurricane Rita  19:20 UTC  21 September 2005 UW/SSEC
AMSR-E Rain Rate Product
28 August 2005  0722 UTC

Hurricane Katrina
# MODIS True Color Images Requests

Averages ~2 per month (Jen O’Leary and Terri Gregory)

Diverse requests

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<tr>
<th>Image Description</th>
<th>Date</th>
<th>Purpose (if applicable)</th>
<th>Organization/Person</th>
<th>Website (if applicable)</th>
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<td>4/15/2003</td>
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<td>Earth Observatory</td>
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<td>Autumn in WI and MI</td>
<td>6/10 October 2003</td>
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<td><a href="http://earthobservatory.nasa.gov/">http://earthobservatory.nasa.gov/</a></td>
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<td>Clouds in color by altitude</td>
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<td>for an article about &quot;new generation of satellites zooms in on a familiar planet&quot;</td>
<td>Wisconsin State Journal</td>
<td><a href="http://www.madison.com/">http://www.madison.com/</a></td>
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<td>SeaSpace</td>
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<td>article about detrimental effects of fire</td>
<td>Wisconsin State Journal</td>
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<td>Hurricane Katrina</td>
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<td>to illustrate a movie honoring hurricane rescue workers</td>
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<td>July 2002</td>
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<td><a href="http://www.ssec.wisc.edu/">http://www.ssec.wisc.edu/</a></td>
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<td>Tropical Storm Isidore</td>
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<td>Southwestern dust in midwest</td>
<td>16 December 2003</td>
<td>for a story about the dust from New Mexico that was carried by the wind to Wisconsin</td>
<td>WISCTV</td>
<td><a href="http://www.channel3000.com/">http://www.channel3000.com/</a></td>
</tr>
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</table>
Canadian Ice Service integrates MODIS into operational data stream for ice monitoring

CIS data suite includes RadarSat and Envisat (SAR); AMSR, QuikScat and SSM/I (microwave); MODIS, OLS, NOAA and GOES (visible images).

• MODIS supplements SAR data in clear sky conditions.

• 250 meter resolution true color GeoTIFF images are obtained daily from SSEC for Great Lakes, Hudson Bay, Labrador coast, and Gulf of St. Lawrence.

MODIS helps to define ice boundary along southern Prince Edward Island
Real Time Sea Surface Temperatures SST’s
Steve Ackerman, Tom Whittaker, Jim Davies

• Supports Turtle Migration Studies in Delaware Bay
  – http://whale.wheelock.edu/whalenet-stuff/stop_cover
• Roll over values through web site (Java Applet)
• http://cimss.ssec.wisc.edu/db_products/SST/
MODIS Polar Wind Vectors can be derived automatically
Jeff Key, Chris Velden, Dave Santek

Wind vectors are generated using automatic feature tracking software developed for GOES.

6.7 µm heights are assigned based on forecast atmospheric profile.

11.0 µm heights are assigned based on window brightness temperature or CO2 cloud height.

Winds are automatically quality controlled.

Terra MODIS 6.7 µm (band 27) 2003/03/13
Positive impact on forecast demonstrated by ECMWF

NWP Centers using MODIS Polar Winds Operationally:

ECMWF, GMAO, JMA, CMC, FNMOC, UKMO, DWD, NCEP/EMC
Bratseth analysis combining the RTG-SST and MODIS data.
MODIS Real-Time Images for PDAs (Russ Dengel)

Satellite images, radar loops, forecasts, road conditions are reformatted for PDA size displays and made available in real-time.

MODIS True Color images are created from every daytime pass in PDA format; latest image is always available.

Users: Firefighters, Police, Pilots, Commuters…

www.ssec.wisc.edu/data/paw/
Infusing Satellite Data into Environmental Applications (IDEA)
Tony Wimmers, Brad Pierce, Chieko Kittaka, Liam Gumley, Scott Bachmeir, Scott Lindstrom, Jerry Robaidek, Bill Bellon

- Direct Broadcast MODIS data used to initialize aerosols for trajectory forecasts to improve air quality assessment, management and prediction
- Moved processing to CIMSS due to real-time availability of MODIS data and central location of antenna providing CONUS coverage
- http://idea.ssec.wisc.edu/
IDEA features a 48-hour trajectory forecast of boundary-layer aerosols. In this example, heavily aerosol-laden air is forecast to move to the north. Trajectories are color-coded to distinguish which aerosols affect the surface. The trajectories in this example are free of forecast precipitation (yellow patches) which shows areas where aerosols will “wash out” in the near future.
Support of SPORT (Short-term Prediction Research and Transition) Center at NASA MSFC
- Aim is to improve short term (0-24hr) weather forecasts
- SSEC DB MODIS and AMSR-E Products distributed to 6 NWS sites in the Southern Region

CIMSS began routine insertion into AWIPS central region data feed on 30 June 2006
- Current feed consists of
  - MODIS L1B Bands 1 (.86 micron), 7 (2.1 micron), 26 (1.38 micron), 20 (4.0 micron), 27 (6.7 micron) and 31 (11 micron)
  - Products – Cloud Phase, TPW, Cloud Top Temperatures, Fog, SST
- Keys to success
  - Provide something better or new to forecasters (ie, higher spatial resolution)
  - Must be placed in format that can be accepted by AWIPS
  - Must have a person at the forecast offices to champion the data (SOO – Dan Baumgardt – ARX  Jordan Gerth – MKX)
Software Development and Distribution
EOS Direct Broadcast Sites

More than 150 ground stations around the world
(not all are shown on this map from Nov. 2003)
Current Products at McMurdo
Jeff Key, Willian Straka
(all MODIS):
  Winds
  Cloud mask*
  Cloud pressure*
  Cloud phase*
  Total precipitable water*
  Inversion strength
  Inversion depth
  Ice/snow surface temperature
  Ice/snow albedo

Planned products:
  Ice motion (MODIS + AMSR-E)
  Ice age
  Cloud optical properties

*IMAPP/MODIS Science Team products

http://stratus.ssec.wisc.edu/db/mcmurdo
Remote Sensing Workshops

Paul Menzel, Allen Huang, Liam Gumley, Paolo Antonelli, Tom Rink, Jeff Key, Steve Dutcher and Kevin Baggett

2004 – Nanjing, China
2004 – Perth, Australia
2005 – Taipei, Taiwan
2005 – Beijing, China
2006 – Andenes, Norway
2006 – Pretoria, South Africa
2007 – India & South America
• Teach Principles of Environmental Remote Sensing
  - building on the work of Paul Menzel
• Promote use of Aqua and Terra Data and Products
  - Lectures On Topics Determined by Student Interest
  - Labs (Practical hands on use – learn strengths and weaknesses of algorithms)
• Foster collaborations and international relations (We learn a great deal)
Hydra Visualization Tool

http://www.ssec.wisc.edu/hydra/

Tom Rink, Kevin Baggett, Paul Menzel
Future IMAPP applications

**AIRS Sounding System Software:**
- Cloud Detection
- Cloud Properties (Height, Emissivity)
- Cloud Liquid Water
- AMSU Precipitation
- Combined MODIS/AIRS products

**MODIS L2 products:**
- Surface Reflectance
- Suspended Sediment Concentration
- Cloud Optical Properties
- Scene Classification
- Snow Cover/Lake Ice
Future IMAPP applications (Continued)

**AMSR-E:**
- Ocean Products (SST and Wind Speed)
- Snow/Water Equivalent

**Utilities:**
- Utility to visualize L1B and L2 IMAPP products
  - Hydra / IDV
  - McIDAS binaries (supplement to McLITE)
  - Utilities to share data with other users
    - DODS server
    - ADDE server
- Utilities to collocate MODIS/AIRS pixels

**Workshops:**
- More IMAPP remote sensing workshops planned
  - India 2007, Russia?
Summary

• Aqua and Terra Direct Broadcast support a wide range of activities at CIMSS

• Real time generation of images and products is vital to the support of environmental monitoring

• Support for global DB users will continue in the form of:
  • Production Software (L1b and L2 products)
  • Processing Scripts (Including cluster processing – Steve Dutcher)
  • Visualization Tools
  • Tutorials
  • Workshops

• We intend to follow on from Terra and Aqua to NPP and NPOESS via the International Polar Orbiter Processing Package (IPOPP)
Other related Presentations/Posters

5.5 Paolo Antonelli - Training Workshop

A13 Tom Achtor - IAPP
A14 Tom Achtor - NPP PEATE

A15 Kathleen Strabala – Direct Broadcast