

DIRECT BROADCAST PROCESSING PACKAGES FOR TERRA, AQUA, METOP, NPP, AND NPOESS: RECENT PROGRESS AND FUTURE PLANS

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ABSTRACT:

The global community of polar-orbiting direct broadcast reception and processing stations has continued to grow with the advent of new satellite systems and lower-cost technology for signal acquisition and computer hardware. In particular, an active network of more than 150 X-band ground stations have been deployed in the past 5 years to acquire data directly from the NASA Terra and Aqua spacecraft. The availability of software to process the data received from Terra and Aqua has played a major role in facilitating the adoption of the resulting remote sensing products by government agencies, universities, and other users around the world. In this paper, the current suite of software available for processing Terra and Aqua direct broadcast data is described. Plans for software packages for future missions including MetOp, NPP, and NPOESS are also described.

1. OVERVIEW

The remote sensing community has had access to software for processing polar orbiter direct broadcast data since the mid 1980s (Huang, 1986). The distribution of freely available software for processing data from the NOAA operational polar orbiters and the NASA Earth Observing system has enabled users around the world to obtain real-time information on local conditions and to develop region-specific products. The key features of these software packages are that they are (1) freely available, (2) portable to a variety of operating systems, and (3) well documented and tested. In this paper we summarize the various packages available at the time of writing, and also report on plans for future processing packages.

2. CURRENT SOFTWARE PACKAGES

2.1 Terra and Aqua Pre-processing Software

The purpose of the pre-processing software for the Terra and Aqua spacecraft is to unpack, error-correct, reformat, and inspect the raw telemetry streams acquired by direct broadcast. The pre-processing software is designed to output a format known as Level 0, defined as reconstructed time-ordered CCSDS packets with all communication artifacts (including duplicate packets) removed. This includes PN and Reed Solomon decoding as well as reassembly of the raw telemetry packets. Supported instruments on Terra include MODIS, and on Aqua, MODIS, AIRS/AMSU/HSB, and AMSR-E. The software packages available for pre-processing of Terra and Aqua data are as follows.

RT-STPS: Terra and Aqua telemetry preprocessing to Level 0
<http://directreadout.gsfc.nasa.gov/index.cfm?section=downloads&page=technology>

CCSDS Merge: Merge two or more CCSDS data streams
<http://www.sat.dundee.ac.uk/~arb/ccsdsmerge/>

EOSLZX: Extract MODIS images from Level 0 data
<http://www.sat.dundee.ac.uk/~arb/eoslx-free/>

2.2 MetOp Pre-processing, Geolocation, and Calibration Software

The purpose of the pre-processing software for the European MetOp satellites is to provide calibrated and geolocated HIRS, AVHRR, AMSU, MHS and IASI data.

AAPP: ATOVS and AVHRR Pre-Processing Package for MetOp and NOAA polar orbiters
<http://www.metoffice.gov.uk/research/interproj/nwpsaf/aapp/>

2.3 Terra and Aqua Geolocation and Calibration Software

For the Terra and Aqua MODIS instruments, geolocation and calibration software developed by the MODIS Science Team is available to convert Level 0 to Level 1B in HDF format. The most recent version of the software (MODISL1DB) uses the standard NASA HDF format and provides automated scripts for retrieving calibration lookup tables and other ancillary data.

MODISL1DB: Level 0 to Level 1 processing for Terra and Aqua MODIS
<http://oceancolor.gsfc.nasa.gov/seadas/modisl1db/>

For the Aqua AIRS/AMSU/HSB instruments, geolocation and calibration software developed by the AIRS Science Team is provided as part of the International MODIS/AIRS Processing Package (IMAPP; Huang 2004).

AIRS DB: Level 1 processing for AIRS/AMSU/HSB
<http://www.ssec.wisc.edu/~gumley/IMAPP/AIRS/>

For the Aqua AMSR-E instrument, geolocation and calibration software developed by Remote Sensing Systems is available as part of IMAPP.

AMSR-E DB: Level 1 processing for AMSR-E
<http://www.ssec.wisc.edu/~gumley/IMAPP/>

2.4 Terra and Aqua Geophysical Product Software

MODIS

Geophysical products for the Terra and Aqua MODIS instruments can be created using three different software packages. These packages read Level 1 data as input and

compute geophysical products such as sea surface temperature or cloud top pressure as output. The first package for Terra and Aqua MODIS is a compilation of several distinct processing algorithms from the MODIS Science Team, including cloud mask, wildfire detection, ice and snow mapping, and land surface reflectance (land based atmospheric correction). The algorithms in this package are the version designated "Collection 4" by the MODIS Science Team, which were released in 2004. An update to the current "Collection 5" version is expected soon.

DB_ALG: MODIS Science Algorithms for Direct Broadcast
<http://directreadout.gsfc.nasa.gov/index.cfm?section=downloads&page=technology>

The second package for Terra and Aqua MODIS is IMAPP, which includes the Collection 5 (i.e., current) versions of the MODIS Science Team algorithms for cloud mask, atmospheric temperature and moisture profiles, cloud top pressure and phase, aerosol optical depth, and sea surface temperature.

IMAPP: Level 2 Products for Terra and Aqua MODIS
<http://www.ssec.wisc.edu/~gumley/IMAPP/>

The third package for Terra and Aqua MODIS is SeaDAS, which generates a suite of ocean products, and is the official MODIS Science Team software for ocean processing. Products include water leaving radiances, chlorophyll-a, attenuation coefficient, and sea surface temperature. (**Note:** MODISL1DB is a subset of SeaDAS).

SeaDAS: Ocean Color product generation and visualization
<http://oceancolor.gsfc.nasa.gov/seadas/>

The NASA GSFC Rapid Response Group has also released standalone versions of the MODIS wildfire detection, vegetation index, and corrected reflectance algorithms.

MODIS Fire Detection and Vegetation Index:
<http://directreadout.gsfc.nasa.gov/index.cfm?section=downloads&page=technology>

AIRS

The AIRS DB package developed by the NASA AIRS Science Team also contains an implementation of the AIRS/AMSU Level 2 retrieval algorithm. Products include atmospheric temperature and moisture profiles, cloud top properties, and land surface temperature and emissivity.
<http://www.ssec.wisc.edu/~gumley/IMAPP/AIRS/>

AMSR-E

The AMSR-E package developed at the University of Wisconsin (based on algorithms from the AMSR-E Science Team) includes software for retrieving rain rate and soil moisture.
<http://www.ssec.wisc.edu/~gumley/IMAPP/>

2.5 VISUALIZATION AND REPROJECTION

Several free software packages are available for visualizing and reprojecting MODIS and AIRS data.

Hydra is an interactive Java application for display and analysis of MODIS and AIRS Level 1 and Level 2 Products:
<http://www.ssec.wisc.edu/hydra/>

HDFLook is a visualization and analysis application for MODIS and AIRS Level 1 and Level 2 products which runs in both interactive and batch (command line) modes:
http://www-loa.univ-lille1.fr/Hdflook/hdflook_gb.html

MRTSwath is an application for resampling MODIS data from sensor projection to standard map projections. Binary, HDF, and GeoTIFF output is supported:
<http://edcdaac.usgs.gov/landdaac/tools/mrtswath/>

3. FUTURE SOFTWARE PACKAGES

The NOAA Integrated Program Office (IPO) is partnering with the University of Wisconsin-Madison (UW) and the NASA GSFC Direct Readout Laboratory (DRL) in the development of the International Polar Orbiter Processing Package (IPOP). IPOP will support the NPP mission (to launch in 2010) and subsequent NPOESS missions. Algorithms developed by the NPP and NPOESS contractors will be adopted and extended into a user-friendly and value added software package. UW will work with DRL to provide standard products from VIIRS, CrIS, and ATMS. The IPOP software package will allow any ground station capable of receiving direct broadcast from NPP and NPOESS to produce calibrated and geolocated radiances (SDRs), along with a select group of value added key science products (EDRs). IPOP will be derived from the operational processing software obtained from NPOESS, and IPOP will be

- Freely available
- Portable to UNIX platforms including Linux (Intel), Solaris (SPARC), and OS X
- Efficient to run on modest hardware,
- Simple to install and easy to use,
- Able to ingest and process direct broadcast overpasses of arbitrary size,
- Able to produce core and regional value added EDR products.

VIIRS Products in IPOP

VIIRS EDRs to be included in IPOP are: Albedo (Surface); Cloud Cover/Layers; Cloud Effective Particle Size; Cloud Optical Thickness; Cloud Top Height; Cloud Top Pressure; Cloud Top Temperature; Suspended Matter; Vegetation Index; Cloud Base Height; Ice Surface Temperature; Visible/IR imagery; Land Surface Temperature; Sea Ice; Snow Cover; and Surface Type. In addition, a number of other products have been identified as useful to the direct broadcast community, including True Color atmospherically corrected images; Single FOV cloud mask and phase; Cloud Infrared Properties; and Cloud Classification. These VIIRS products will be added to the IPOP suite.

CrIS/ATMS Products in IPOP

CrIS/ATMS EDRs to be included in IPOP are: Atmospheric Vertical Temperature Profile, Atmospheric Vertical Moisture Profile, Pressure Vertical Profile, and Clear Column Radiances. In addition, CIMSS/SSEC will release a locally developed value added high-spatial resolution regional cloud clearing and sounding product. In the period prior to NPP launch, the AVHRR/IASI sensor suite onboard the EUMETSAT MetOp spacecraft will be used as a pathfinder for IPOP, since IASI is the closest analog to CrIS.

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5. REFERENCES

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