P6.27 CLOUDSAT AND MODIS DATA MERGING: THE FIRST STEP TOWARD THE IMPLEMENTATION OF THE NASA A-TRAIN DATA DEPOT

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1. INTRODUCTION

The A-Train is a succession of six U.S. and international sun-synchronous orbit satellites seconds to minutes apart across the 1:30 p.m. local afternoon equator crossing time according to the sequence: Orbiting Carbon Observatory (OCO), EOS Aqua, CloudSat, Polarization & Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar (PARASOL), CALIPSO, and EOS Aura, Figure 1. Flying in such a formation increases the number of observations and enables coordination between science observations, resulting in a more complete "virtual science platform." The A-Train formation will allow for synergistic measurements where data from several different satellites can be used together to obtain comprehensive information about various key atmospheric components or processes. This combined information from several sources will give a more complete answer to many questions than would be possible from any single satellite.

In order to take advantage of this unique opportunity, the NASA Goddard Space Flight Center (GSFC) Earth Sciences (GES), Data and Information Services Center (DISC) is building an A-Train Data Depot (ATDD) to process, archive, access, visualize, analyze and correlate distributed atmosphere measurements from various instruments along A-Train tracks. The ATDD will enable the seamless access to remotely located A-Train data, so that they can be combined to create a consolidated vertical view of the Earth's Atmosphere along the flying tracks. Once the infrastructure of the ATDD is in place, it can be easily evolved to serve data from all A-Train data measurements as a one-stop shopping that will save time and improve efficiency. Users interested in Atmospheric Chemistry, and Water and Energy Science will have a clear connection with their data of interest by being able to access the specific subset (parameter, spatial, and temporal) of interest.

This paper describes the initial efforts at the GES/DISC in the development of the ATDD portal starting with a comparison among MODIS, AIRS and Aura/MLS temperature vertical profiles along a hypothetical CloudSat orbital track provided by the CloudSat data processing facility at the Cooperative Institute for Research in the Atmosphere (CIRA).

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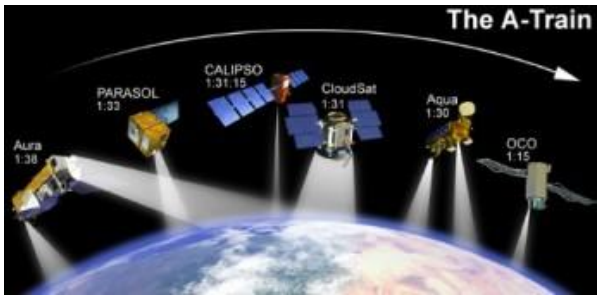

Figure 1. The A-Train constellation.

2. THE A-TRAIN GES-DISC INSTRUMENTS

2.1 Aqua – MODIS

The A-Train Moderate Resolution Imaging Spectro-radiometer (MODIS) is flying on the EOS Aqua satellite launched in May 2002, figure 2. It provides images of land, ocean and atmosphere in 36 spectral bands (0.4μm - 14.5μm) with spatial resolutions of 250m (bands 1-2), 500m (bands 3-7) and 1000m (bands 8-36).

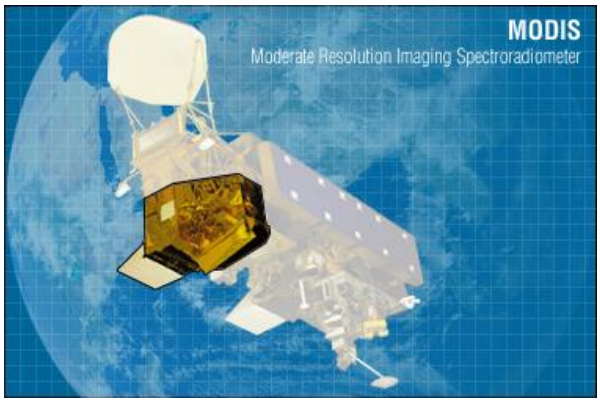

Figure 2. Aqua – MODIS instrument.
Acknowledgments: http://thorpex-data.ssec.wisc.edu

The MODIS/Aqua data products archived at the GES-DISC consist of calibrated and geolocated Level 1A and 1B radiances and Level 2 and Level 3 atmospheric products including aerosols, precipitable water, cloud parameters, total ozone and atmospheric profiles. The following data/product sets have been identified as highest priority data to be subsetted for the ATDD system integration:

GES-DISC MODIS Data/Products Group 1:

- MYD02_1KM_L1B, 1 km resolution, radiances bands 1-7, 17-20, 26-36.
- MYD02_QKM_L1B, 0.25 km resolution, radiances band 1.
- MYD03 1 km resolution, geo-location data.
- MYD035_L2, cloud Mask data.
- MYD07_L2, 5 km res., atmospheric profile data.

GES-DISC MODIS Data/Products Group 2:

- MYD04_L2, level_2 10 km resolution, aerosol products.
- MYD05_L2, level_2 1 km resolution, column water vapor.
- MYD06_L2, level_2 5 km resolution, cloud products.

2.2 Aqua – AIRS

AIRS is a high spectral resolution spectrometer with 2378 bands in the thermal infrared (3.7 - 15.4 μm) and 4 bands in the visible (0.4 - 1.0 μm) flying aboard the EOS Aqua satellite, figure 3. These ranges have been specifically selected to allow determination of atmospheric temperature with an accuracy of 1°C in layers 1 km thick, and humidity with an accuracy of 20% in layers 2 km thick in the troposphere. In the cross-track direction, a ±49.5 degree swath centered on the nadir is scanned in 2 seconds, followed by a rapid scan in 2/3 second taking routine calibration related data that consist of four independent Cold Space Views, one view of the Onboard Blackbody Calibrator, one view of the Onboard Spectral Reference Source, and one view of a photometric calibrator for the VIS/NIR photometer. Each scan line contains 90 IR footprints, with a resolution of 13.5 km at nadir and 41km x 21.4 km at the scan extremes from nominal 705.3 km orbit. The Vis/NIR spatial resolution is approximately 2.3 km at nadir. The GES-DISC provides AIRS calibrated and geolocated Level 1 and Level 2 radiances and data/products.

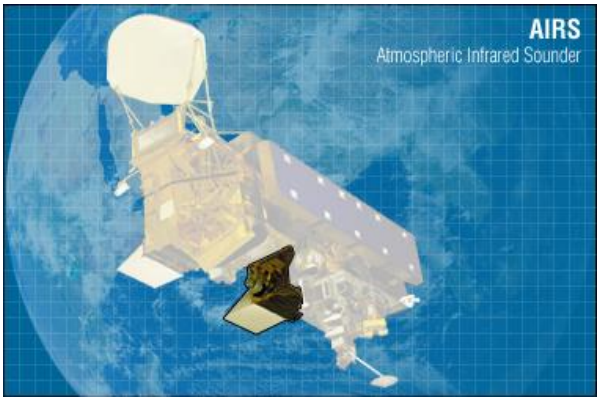

Figure 3. Aqua – AIRS instrument. Acknowledgments: http://thorpex-data.ssec.wisc.edu

2.3 Aura – MLS

The Microwave Limb Sounder (MLS) is one of the four instruments aboard the Aura spacecraft operating in a 705 km sun-synchronous polar orbit, with an ascending equator crossing at 1:45 PM. The instrument scans the Earth's limb in the forward direction of flight, viewing microwave emissions at the 118, 190, 240 and 640 GHz, and 2.5 THz spectral regions from the stratosphere into the upper troposphere. These measurements are used to derive vertical profiles of O3, H2O, BrO, ClO, HCl, HOCl, OH, HO2, HCN, CO, HNO3, N2O, and SO2 mixing ratios, as well as relative humidity with respect to ice, cloud water/ice content, geopotential height and temperature, figure 4. The vertical resolution of these data is about 3 km, and the spatial coverage is near-global (-82° to +82° latitude), with each profile spaced 1.5° (about 165 km) along the orbit track (roughly 15 orbits per day).

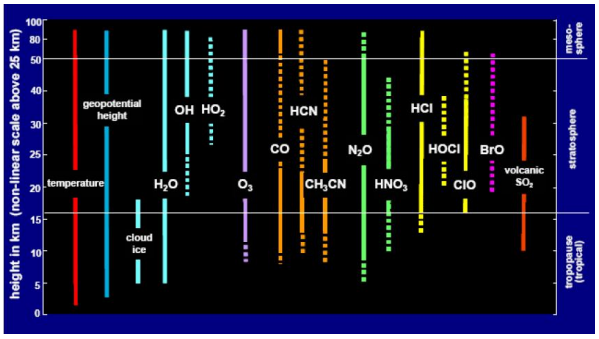

Figure 4. EOS Aura MLS Measurements

The GES DAAC archives level 0 (raw), 1 (geolocated and calibrated radiances), 2 (geolocated geophysical parameters) and 3 (gridded geophysical parameters) data products from Aura MLS.

2.3 CloudSat

Cloudsat is a satellite experiment designed to measure the vertical structure of clouds from space. The spacecraft will produce detailed, three-dimensional images of cloud structures by measuring their vertical profiles using active remote sensing (94-GHz radar), figure 5. It will advance understanding of the cloud-climate feedback problem, improve and validate cloud and aerosol information from other satellite systems, and improve understanding of the indirect effect of aerosols on clouds.

CloudSat Standard Data Products will be distributed by the CIRA CloudSat Data Processing Center (CDPC), located at Colorado State University in Fort Collins.

For further information check the CIRA CDPC site http://cloudsat.atmos.colostate.edu/.

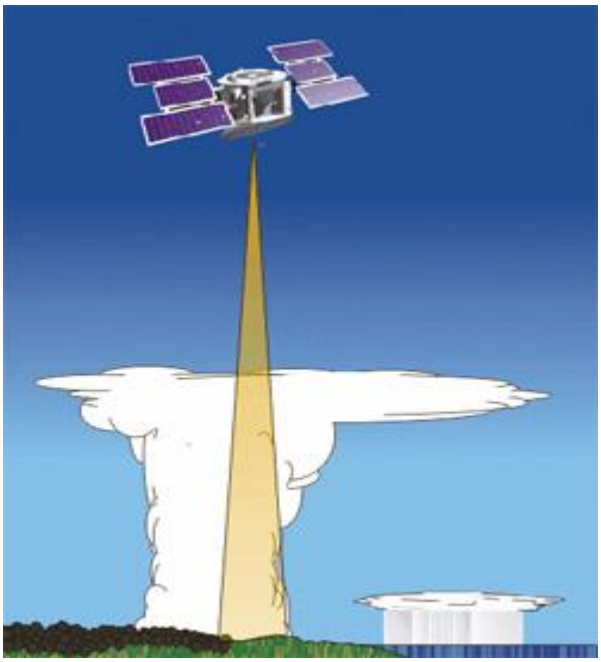

Figure 5. CloudSat 94-GHz nadir-looking radar.

3. THE ATDD IMPLEMENTATION

The initial implementation of the ATDD consists in the a comparison among MODIS, AIRS and Aura/MLS temperature vertical profiles along a hypothetical CloudSat orbital track provided by the CloudSat data processing facility at CIRA resulting in the following efforts:

- Select and display MODIS data/products swaths subsetted to narrower strips along the A-Train track, at +/-3 km and +/- 30 km from nadir for products with resolution equal or better than 1 km, figure 6.
- Use the CloudSat time and ephemeris as the baseline date/time counter.
- Visualization of MODIS, AIRS and MLS "curtains" or vertical slices through the atmosphere along the A-Train tracks.

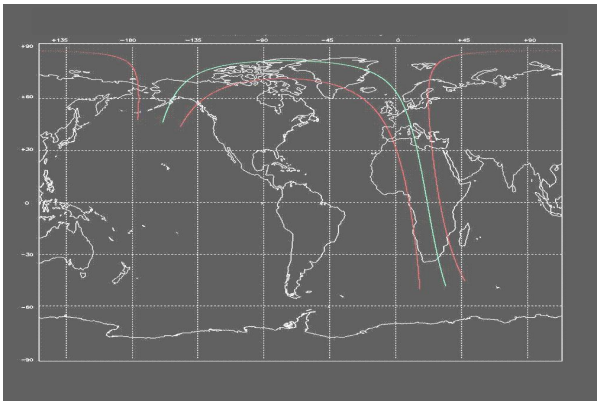

Figure 6. Simulated CloudSat Ground Track (Green) within the Aqua MODIS Swath (Red) June 21, 2005, 12:00 – 13:00 GMT

3.1 MODIS-AIRS-MLS-CloudSat Inter-comparison

AQUA MODIS, Aura MLS and AIRS temperature profiles colocated with the simulated CloudSat sub-track are displayed for June 21st, 12:00 -13:00 GMT in two images set. Set 1 profiles the three instruments from 300.0mb to 5.0 mb, figure 7, and Set 2 profiles AIRS and MLS from 1000.0 to 0.1 mb, figure 8. Ten MODIS 5-min granules where used corresponding to 4060 scans. The MODIS MOD07 profile pixel selected from each scan line was the one closest to the CloudSat sub-track. For the most part the MOD07 temperature retrieval seems to be well correlated with this cloud mask classification, i.e., no retrievals when cloudy.

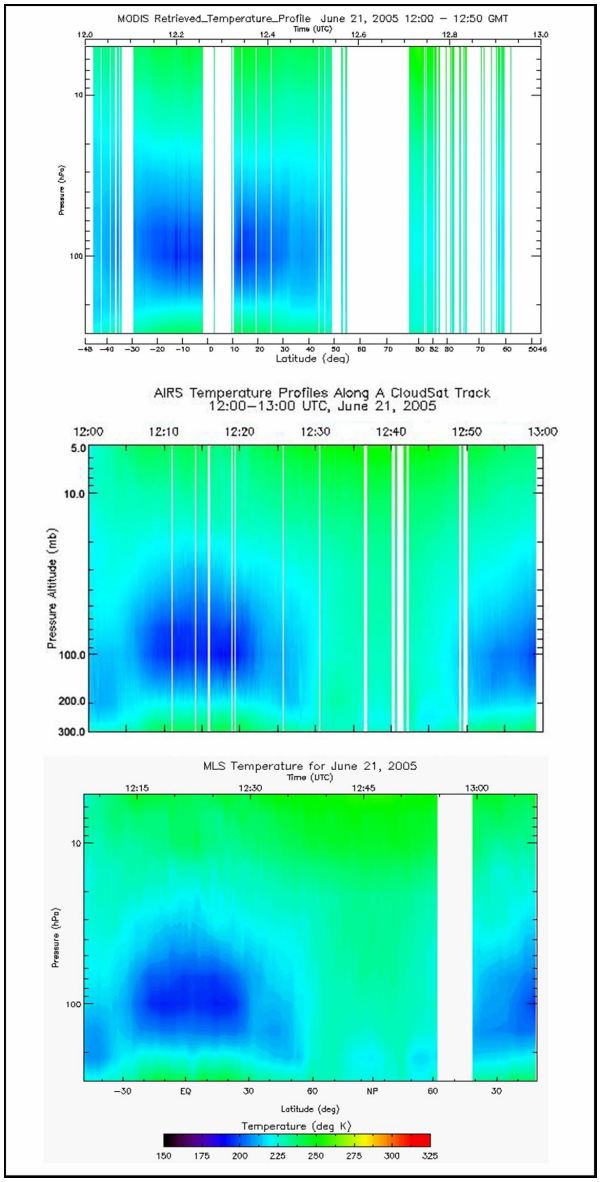

Figure 7. AIRS-MODIS-MLS temperature vertical profile from 300.0 to 5.0 mb, June 21, 2005, 12:00 – 13:00 GMT.

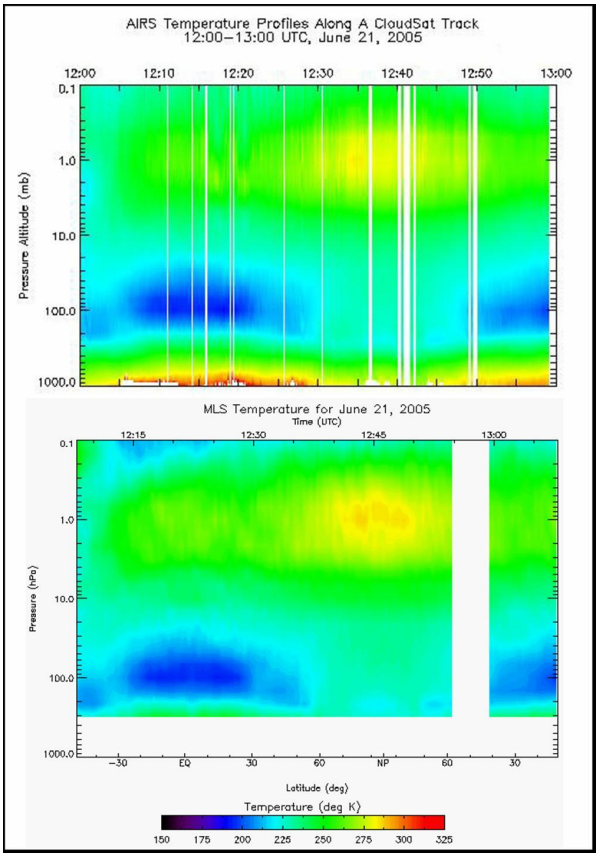

Figure 8. AIRS-MLS temperature vertical profile from 1000.0 to 0.1 mb, June 21, 2005, 12:00 – 13:00 GMT.

4.0 NEAR FUTURE ATDD FEATURES

This GES-DISC ATDD service will be further integrated into the GES-DISC Interactive Online Visualization and Analysis Infrastructure (**Giovanni**) system, the GES-DISC web-based visualization and analysis tool - http://disc.sci.gsfc.nasa.gov/techlab/giovanni/. Further it will provide data quality summary for each product, clearly labeling preliminary data as Beta quality product and provide registration option for users.

Besides the Aqua-MODIS/AIRS and Aura-MLS instruments, the following have been defined as priorities for the near future A-Train data subsets:

Aqua Earth's Radiant Energy System (CERES): Three-channel radiometer measuring reflected solar radiation in the 0.3-5 μm wavelength band, emitted terrestrial radiation in the 8-12 μm band, and total radiation from 0.3 μm to beyond 100 μm.

Aura Ozone Mapping Instrument (OMI): Hyper-spectral imager that employs a push-broom mode to observe solar backscatter radiation in the visible and ultraviolet. The hyper-spectral capabilities improves the accuracy and precision of the total ozone amounts and will also allow for accurate radiometric and wavelength self calibration over the long term.

Aqua - Advanced Microwave Scanning Radiometer (AMSR-E): Dual polarization 12-channel, 6-frequency, total power passive-microwave radiometer system that measures brightness temperatures at 6.925, 10.65, 18.7, 23.8, 36.5, and 89.0 GHz.

5.0 CONCLUSION

This article describes the GES-DISC preliminary work in the implementation of the A-Train Data Depot (ATDD) to process, archive, access, visualize, analyze and correlate distributed atmosphere measurements from various instruments along A-Train tracks.

Further information is available in the GES-DISC ATDD web site: http://disc.sci.gsfc.nasa.gov/atdd.