An Efficient and Flexible Framework for Real-time Satellite Inter-calibration

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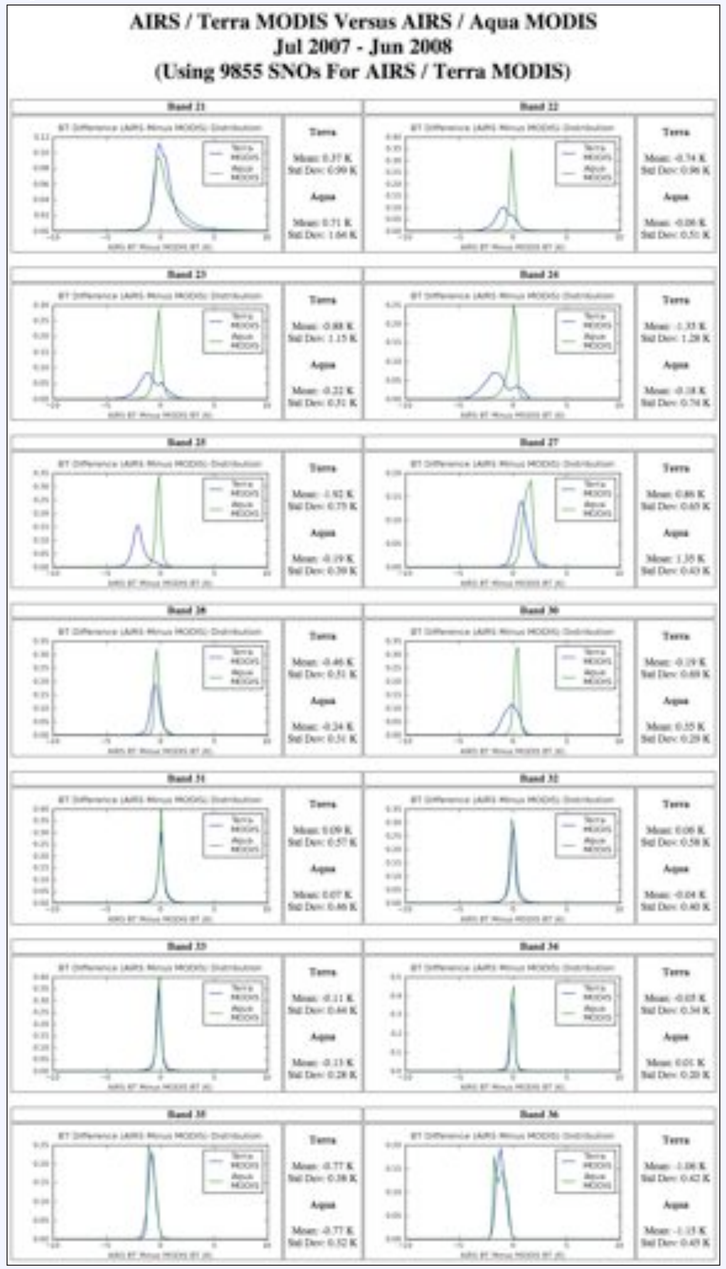
Comparing Aqua And Terra MODIS

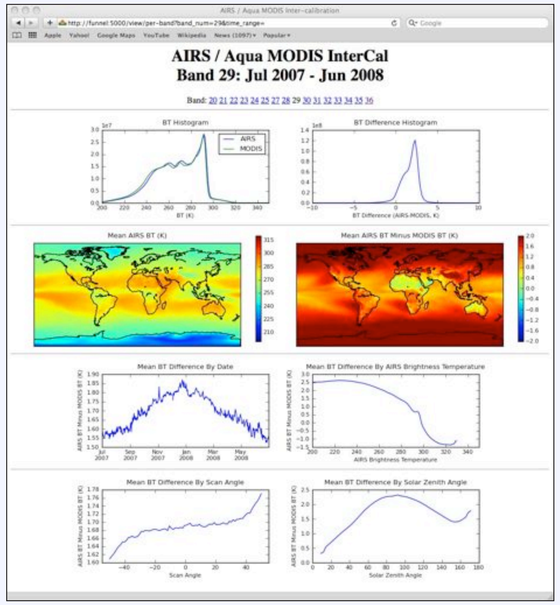
An advantage of a multi-sensor framework is the ability to easily combine results from multiple inter-calibration comparisons. Here, the framework has been used to gain a look at differences between Aqua and Terra MODIS by seeing how each compares to AIRS.



The methods for comparing each of Aqua and Terra MODIS to AIRS are described to the right. For this comparison, the Aqua MODIS / AIRS comparisons were filtered to the same conditions under which SNO-based AIRS / Terra MODIS comparisons are available: latitudes between 68 and 69 degrees and scan angles under 10 degrees.

Introduction

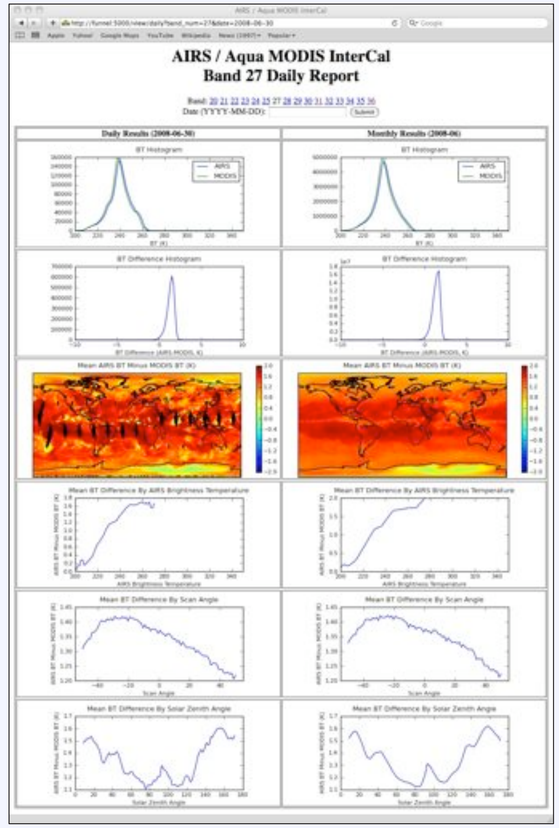
Past studies have routinely demonstrated the utility of high-spectral resolution radiometric observations (AIRS, IASI) in assessing the calibration of other sensors such as imagers (MODIS). Building on these previous efforts, in collaboration with the GOES-R Algorithm Working Group (AWG), we are developing an inter-calibration system that leverages computationally efficient collocation and simultaneous nadir overpass (SNO) methods to compare satellite observations (both GEO and LEO) in near real-time. This new capability enables both monitoring of current instrument calibration and analysis of long-term radiometric trends between observations on different satellites. As new platforms are launched this system will be capable of providing near real-time comparisons between NPP (CrIS, VIIRS), GOES-R (ABI), and existing observations from systems such as AIRS, IASI, and MODIS.



1-Year AIRS / Aqua MODIS Inter-calibration Results

AIRS and Aqua MODIS are aboard the same spacecraft, yielding a wealth of data for inter-calibration. Still, previous work has only provided comparisons for a small number of hand-picked days. The new framework allows comparisons over larger time scales, as indicated by the year-long view on the left.

- Data sets can be quickly inter-calibrated as soon as they are made available. At right, a view is shown that compares a day's results to cumulative results for that month. This tool can help to identify whether a sensor is behaving consistently.
- Biases can be characterized and viewed as a function of any variable that can be retrieved from the underlying data sets (Earth location, scan angle, etc.) or the inter-calibration results themselves (scene brightness temperature (BT), standard deviation of BT within the scene).
- Results can be filtered on a variety of conditions. For example, a user may want to only look at uniform scenes (e.g., BT standard deviation less than 1K within the scene).
- Note the plot of BT difference over time. This new capability allows for easy identification of anomalies and for tracking of trends in biases over time.



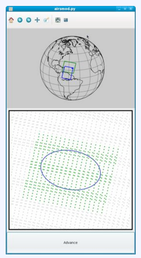
Daily Report View of Inter-calibration Results

Methodology

AIRS / Aqua MODIS

With AIRS and MODIS sensors both on the Aqua spacecraft, accurate inter-calibration can be done on a pixel-by-pixel basis. To compare hyper-spectral AIRS data with MODIS imager bands, each band's spectral response function is applied to the AIRS radiances. To analyze MODIS radiances in terms of the larger AIRS spatial footprint, the observations must be collocated.

A toolkit to support efficient collocation for many types of sensors is under development. This figure shows a snapshot of the collocation process for AIRS and MODIS. By analyzing satellite navigation data, the collocation algorithm only needs to search a small subset of all MODIS pixels for overlap with the AIRS footprint. The search space is denoted by the green-shaded pixels, the AIRS footprint by the blue oval.



This style of same-orbit, per-pixel inter-calibration is particularly demanding computationally. Cluster-based processing and efficient algorithms make it tractable. A similar technique will be applied to inter-calibrate CrIS and VIIRS upon launch of the NPP spacecraft.

A variety of inter-calibration techniques are supported. These will continue to be added and adapted as support for new sensors is made available.

AIRS / Terra MODIS

To inter-calibrate AIRS on Aqua and MODIS on Terra, a SNO-based method must be used. Aqua and Terra pass over the same ground point twice per orbit, but such passes typically happen about 16 minutes apart. It is therefore necessary to mitigate temporal effects by averaging radiance values over a large area. For this work, each Aqua / Terra SNO is treated as a single sample for inter-calibration. For the Aqua versus Terra MODIS study presented here, all MODIS pixels with an associated scan angle under 10 degrees and within 100km of the SNO ground location were averaged. AIRS pixels were first multiplied by each MODIS band's spectral response function, then selected and averaged by the same criteria.

System Components

PEATE Data Archive

- As part of the University of Wisconsin Atmospheric Product Evaluation and Test Element (PEATE), the inter-calibration framework has access to terabytes (144 TB, currently) of satellite data products over high-speed network links.
- Data archive servers also function as storage for intermediate inter-calibration outputs.

Front End Node

- Results produced on the cluster and stored in the archive are further aggregated, then made available to users via a Pylons web application.
- The front end also manages cluster tasks and gridding/filtering configuration by interacting with the database.

PEATE Cluster

- Parallelizable inter-calibration tasks are spread across a 252-core cluster. This includes collocation, spatial and spectral aggregation, and preliminary gridding.
- Provides quick turnaround for processing data sets once available.

Database

- Contains metadata for all satellite data sets and inter-calibration results.
- Used as a coordination point for cluster jobs to throttle connections to data archive servers and to distribute processing tasks.