Multi-Instrument Data Analysis and Synthesis (MIDAS) project to develop neural network-based data fusion techniques

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Project Description

Current uncertainties in the role of aerosols and clouds limit our ability to accurately model the Earth's climate system and to predict climate change. These limitations are due primarily to difficulties in adequately measuring aerosols and clouds on a global scale. NASA's A-Train satellites provide an unprecedented opportunity to address these uncertainties. The various active and passive sensors aboard the A-Train use a variety of measurement techniques to provide in-depth observations of the multi-dimensional properties of clouds and aerosols. However, to fully achieve the potential of this ensemble requires a robust data fusion framework that can optimally and efficiently map this disparate collection of measurements into a comprehensive set of cloud and aerosol physical properties.

Over the past three years, researchers at Goddard Space Flight Center (GSFC), Langley Research Center (LaRC), and the University of Wisconsin CIMSS have worked together under the auspices of the Multi-Instrument Data Analysis and Synthesis (MIDAS) project to develop a data fusion framework using collocated airborne data sets as proxies for A-Train measurements. With the successful launch of the Cloud-Aerosol Lidar Infrared Pathfinder Spaceborne Observations (CALIPSO) satellite, the algorithms developed and tested on the airborne data can now, in principal, be applied to the satellite measurements and used to investigate relevant scientific questions. Specific science questions being addressed include:

- Investigating dust-cloud interactions: A specific research goal is to use the MIDAS architecture to quantify the impact of the Saharan and Taklimakan dust on suppression or enhancement of cloud development. We will also use the MIDAS framework to verify and/or improve the cloud-aerosol discrimination algorithm used to process data from the Moderate Resolution Imaging Spectroradiometer (MODIS).
- Using active remote sensing data to improve passive remote sensing retrievals: We will investigate using the vertical profile information available from CALIPSO measurements to generate new column-averaged microphysical retrievals from passive remote sensing instruments. An important aspect of this research element is to develop a new parameterization that uses the lidar-derived extinction profile to permit accurate passive infrared retrievals in cirrus clouds.
- Developing a realistic assessment of measurement errors to constrain climate prediction models: The advantage of the MIDAS data fusion technique is its ability to accurately identify the 3D structure of clouds and aerosols along the nadir track, and then to extend that knowledge to off-nadir pixels using similarity analyses. This phase of the proposal will (a) validate the off-nadir scene classification results; (b) apply the improved scene classifications to reduce the uncertainties in estimating radiative forcing of complex cloud and aerosol objects (e.g., multi-layer cloud and/or aerosols, and dust-contaminated clouds); and (c) provide a quantitative assessment of the impact that these reductions in observational uncertainties will have in reducing climate prediction uncertainties through an innovative perturbed physics ensemble approach.

Accomplishments

- Developed both aircraft and satellite collocation algorithms to collocated both imager and sounder (MODIS/AIRS) and nadir active remote sensed measurements with the imager and sounder (CALIPSO/AIRS and CALIPSO/MODIS)
- Using the collocation we compared one month of global cloud retrievals between the active and passive sensors.
- Developed cluster algorithms using aircraft data as a proxy of satellite retrievals
- Applied the aircraft algorithms to MODIS and CALIPSO as presented in Figure 1
- Investigated MODIS cirrus height sensitivity to uncertainties in the instrument Spectral Response Function (SRF) with results presented in Figure 2.

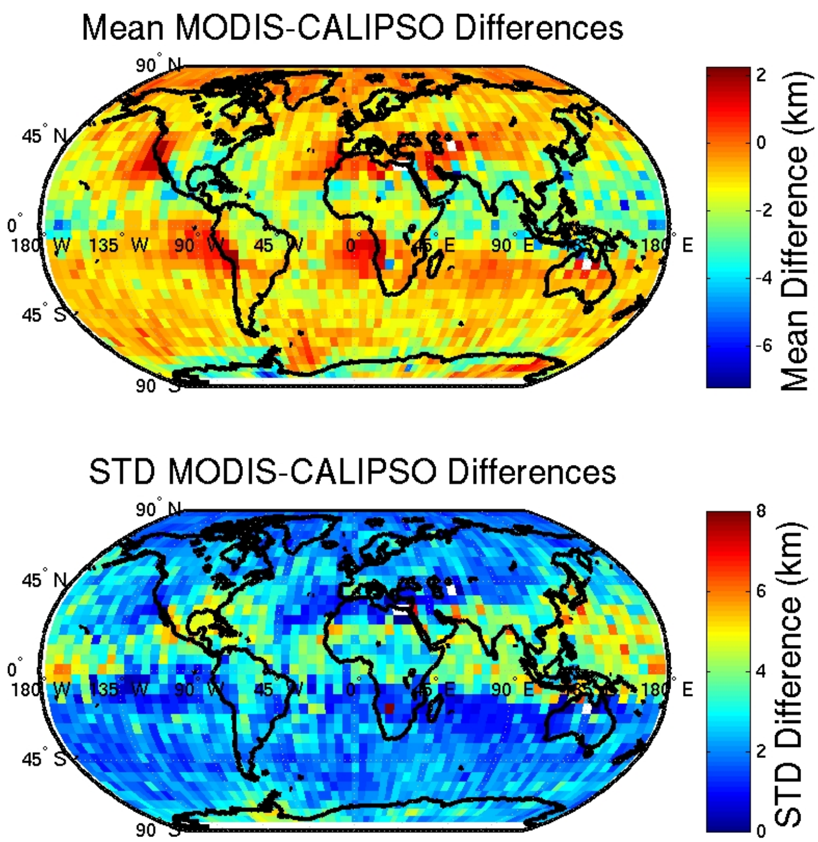

Figure 1 ***The mean cloud top height differences are presented in the top image. For each 5-degree grid box the mean cloud height difference (MODIS – CALIPSO) is calculated. A negative difference (blue) results when mean MODIS cloud height is below the CALIPSO. The bottom image presents the standard deviation of the MODIS – CALIPSO cloud height differences for each 5-degree region.***

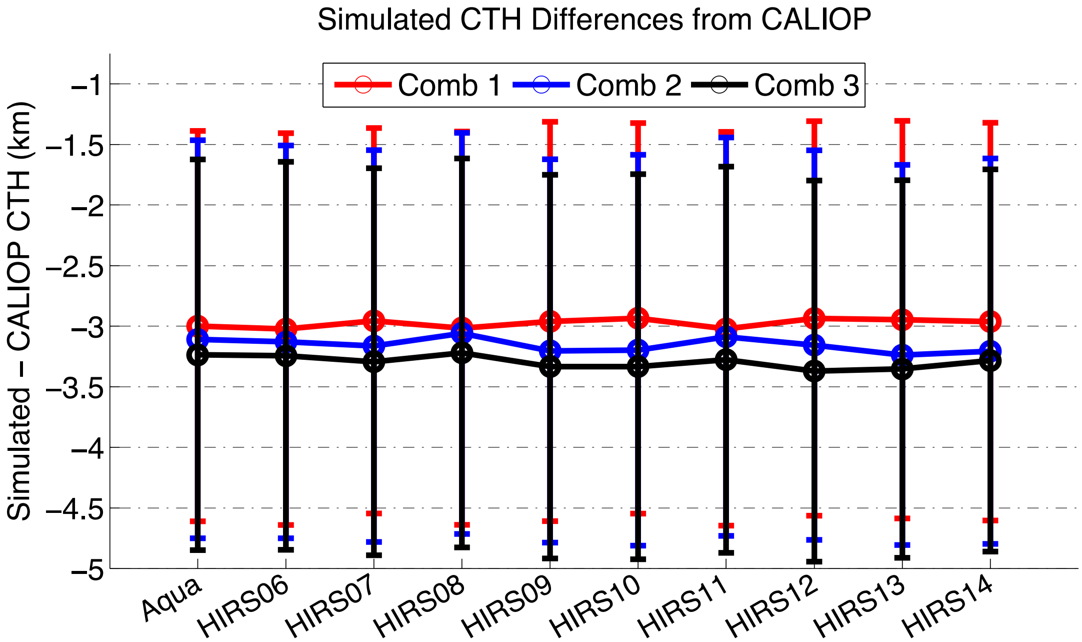

Figure 2 Simulated cloud heights as differences from the CALIOP lidar. Distribution means are again plotted as circles with 1 standard deviation designated by the bar ends

Publications:

Nagle, FW., & Holz, RE. (2009). Computationally efficient methods of collocating satellite, aircraft, and ground observations. *Journal of the Atmospheric and Oceanic Technology*, *26*(8), 1585-1595.

Holz, R. E., S. A. Ackerman, F. W. Nagle, R. Frey, S. Dutcher, R. E. Kuehn, M. Vaughan, and **B. A. Baum**: Global MODIS cloud detection and height evaluation using CALIOP. *J. Geophys. Res*. ., 113, D00A19, doi:10.1029/2008JD009837