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Improving aerosol vertical retrieval for NWP application: Studying the impact of IR-sensed aerosol on data assimilation systems.

Mayra Oyola (1), Jared Marquis (2), Benjamin Ruston (1), James Campbell (1), Nancy Baker (1), Douglas Westphal (1), Jianglong Zhang (2), and Edward Hyer (1)

(1) Naval Research Lab, Monterey, CA, United States (mayra.oyola.ctr@nrlmry.navy.mil), (2) University of North Dakota, North Dakota, USA

Radiometric measurements from passive infrared (IR) sensors are important in numerical weather prediction (NWP) because they are sensitive to surface temperatures and atmospheric temperature profiles. However, these measurements are also sensitive to absorbing and scattering constituents in the atmosphere. Dust aerosols absorb in the IR and are found over many global regions with irregular spatial and temporal frequency. Retrievals of temperature using IR data are thus vulnerable to dust-IR radiance biases, most notably over tropical oceans where accurate surface and atmospheric temperatures are critical to accurate prediction of tropical cyclone development. Previous studies have shown that dust aerosols can bias retrieved brightness temperatures (BT) by up to 10K in some IR channels that are assimilated to constrain atmospheric temperature and water vapor profiles. Other BT-derived parameters such as sea surface temperatures (SSTs) are susceptible to negative biases of at least 1K or higher, which conflicts with the accuracy requirement for most research and operational applications (i.e. +/- 0.3 K).

This problem is not limited to just satellite retrievals. BT bias also impacts the incorporation of background fields from NWP analyses in data assimilation (DA) systems. The effect of aerosols on IR fluxes at the ocean surface is a function of both aerosol loading and vertical profile. Therefore, knowledge of the aerosol vertical distribution, and understanding of how well this distribution is captured by NWP models, is necessary to ensuring proper treatment of aerosol-affected radiances in both retrieval and data assimilation. This understanding can be achieved by conducting modeling studies and by the exploitation of a robust observational dataset, such as satellite-based lidar profiling, which can be used to characterize aerosol type and distribution.

In this talk, we describe such an application using the Navy Aerosol Analysis Prediction System (NAAPS) and Naval Research Laboratory (NRL) Atmospheric Variational Data Assimilation System (NAVDAS). We describe the impact of aerosol-biased radiances on operational DA, and thus the quantitative impact of dust on model profiles of temperature and water vapor mixing ratio before and after data assimilation, using collocated hyperspectral Cross-track Infrared Sounder (CrIs) and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) observations over the Tropical Atlantic. We then describe how the NAVDAS radiance assimilation system responds when coupled with NAAPS dust concentration fields, and thus how the model representation of dust compares with observations.. The result is a conceptual description of how IR-absorbing dust impacts radiance DA for operational weather modeling, and a first-order description of how adept current aerosol transport models are for providing compulsory corrections.