Sea-surface temperatures from the MODerate-resolution Imaging Spectroradiometer (MODIS)

Peter J. Minnett, Robert H Evans and Otis B. Brown.
Meteorology and Physical Oceanography
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149-1098, USA

Tel: +1 (305) 421-4104 Fax: +1 (305) 421-4622
email: pminnett@rsmas.miami.edu

Sea-surface temperature (SST) is a geophysical variable that is both highly important to a wide range of studies and applications, and is also accessible to measurement to useful accuracy from spacecraft radiometers, including MODIS.

At the accuracy required for many applications, such as Numerical Weather Predictions, ocean forecasting and climate monitoring, the meaning of "sea-surface temperature" is not as straightforward as one might first suppose. Because of the ocean is nearly always warmer than the atmosphere above, heat generally flows from the ocean to the atmosphere. The heat flux on the aqueous side of the ocean-atmosphere interface is accomplished by molecular conduction through the so-called skin-layer, and this results in the temperature of the skin layer being a few tenths of a degree cooler than the water just beneath. But it is the skin layer that is in contact with the atmosphere above, and it is the skin layer that gives rise to the thermal infrared emission that propagates through the atmosphere to be detected by the spacecraft radiometer. To establish the accuracy of the MODIS SST retrievals, it in necessary to use instruments capable of measuring the skin SST from ships, and it is important that these have absolute accuracies of 0.1K or better. With funding from the MODIS project, the Marine-Atmospheric Emitted radiance Interferometer (M-AERI) was developed to provide the baseline validation measurements for the MODIS SST retrievals, and for SSTs derived from the measurements of other spacecraft radiometers.

MODIS is a very complex instrument that incorporates several innovative developments compared to heritage instruments. For the measurement of SST the MODIS design includes spectral bands in the mid-infrared and thermal infrared atmospheric transmission windows that have been used by other spacecraft radiometers (such as the Advanced Very High Resolution Radiometers, AVHRRs) but MODIS also has two additional, very narrow bands in the mid-infrared window that have reduced sensitivity to variability in atmospheric water vapor distribution, and thus have the potential for increasing the accuracy of the SST retrievals. The mid-infrared measurements, close to wavelengths of 4 μm, are contaminated during the sunlit part of each orbit by reflected and scattered solar radiation, and so these SST retrievals are limited to measurements taken during the night-time part of each orbit. Further design innovations include an excellent internal black-body thermal reference target for the accurate calibration of the infrared measurements, and multiple detectors per spectral band and a dual sided paddle-wheel scan mirror, both of which allow a longer integration time for each measurement, thereby improving the signal-to-noise ratio of the data stream. The added complexity of the instrument comes at the cost of the need for additional corrections for instrumental artifacts that would be missing in a simpler device, such as the correction for the reflectivity of the scan mirror that changes with angle of incidence as well as wavelength in the thermal infrared. Several of the corrections were developed from the pre-launch characterization of the instruments while others have been derived by exhaustive and meticulous analysis of the on-orbit data. After several iterations of improved instrumental corrections, the SST accuracies from MODIS are comparable to those of other spacecraft radiometers, and therefore make a contribution to the long-term SST Climate Data Record.

In this presentation we discuss the forms of the algorithms used to derive SSTs from the MODIS on-orbit data and detail the approach to validation with a summary of the current best estimates of MODIS SST retrievals. The continuing contributions of the MODIS project to improving our understanding of the upper ocean and its role in the climate system will be outlined.