Ocean-color optical property data derived from the Japanese Ocean Color and Temperature Scanner and the French Polarization and Directionality of the Earth's Reflectances: a comparison study

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We describe our efforts to study and compare the ocean-color data derived from the Japanese Ocean Color and Temperature Scanner (OCTS) and the French Polarization and Directionality of the Earth's Reflectances (POLDER). OCTS and POLDER were both on board Japan's Sun-synchronous Advanced Earth Observing Satellite from August 1996 to June 1997, collecting approximately 10 months of global ocean-color data. This operation provided a unique opportunity for the development of methods and strategies for the merging of ocean-color data from multiple ocean-color sensors. We describe our approach to the development of consistent data-processing algorithms for both OCTS and POLDER and the use of a common *in situ* data set to calibrate vicariously the two sensors. Therefore the OCTS- and POLDER-measured radiances are bridged effectively through common *in situ* measurements. With this approach to the processing of data from two different sensors, the only differences in the derived products from OCTS and POLDER are the differences that are inherited from the instrument characteristics. Results show that there are no obvious bias differences between the OCTS- and POLDER-derived ocean-color products, whereas the differences due to noise, which stem from variations in sensor characteristics, are difficult to correct at the pixel level. The ocean-color data from OCTS and POLDER therefore can be compared and merged in the sense that there is no significant bias between two.

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1. Introduction

The Japanese Ocean Color and Temperature Scanner (OCTS)[1] and French Polarization and Directionality of the Earth's Reflectances (POLDER)[2] were both flown on the Japanese Sun-synchronous Advanced Earth Observing Satellite (ADEOS) from August 1996 to June 1997, collecting about 10 months of global ocean color data. ADEOS was on a polar orbit at an altitude of 800 km with local crossing time (descending node) at around 10:40 am. This was the first time in history that two ocean-color sensors were on board the same platform and viewed the global ocean with the same temporal and similar global spatial coverages. Therefore the operation provides an ideal case for studying and comparing ocean-color data that is derived from two different sensors, hence allowing the development of a strategy for a ocean-color data merger from multiple ocean-color sensors. The primary goal of the National Aeronautics and Space Administration Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies (SIMBIOS) project is to develop methods for the meaningful comparison and merging of data products from multiple ocean-color missions.[3] In a recent study, Wang and Franz[4] show that, using a vicarious intercalibration approach between the modular optoelectronic scanner (MOS)[5] and the Sea-viewing Wide Field-of-View Sensor (SeaWiFS)[6,7] (SeaWiFS ocean color data were used as "truth"), one can meaningfully compare the ocean optical property data derived from two sensors. The bias differences

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are reduced significantly between the two products. In the Wang–Franz study,[4] measurements from the two sensors had a temporal difference of about 90 min. In this paper, we compare the ocean-color data derived from OCTS and POLDER measurements using consistent data-processing algorithms for both sensors and vicarious calibrations based on a common *in situ* data set from the Marine Optical Bouy (MOBY)[8] in the waters off Hawaii. Therefore differences in the derived ocean-color products from OCTS and POLDER are associated primarily with differences in instrument characteristics. We first give a brief overview of the sensor characteristics of the OCTS and the POLDER and their differences. Detailed algorithm descriptions for processing OCTS and POLDER data are then presented. Next we outline the vicarious calibration scheme in which the OCTS- and POLDER-measured radiances are calibrated with a common *in situ* MOBY data set. Finally, we provide results that compare OCTS and POLDER ocean-color data with global *in situ* measurements and compare a series of OCTS measurements with those of POLDER over the Sargasso Sea and the Bermuda area.

6. Conclusion

We describe a procedure to calibrate vicariously OCTS and POLDER Level-1B data using the MOBY *in situ* measurements. This procedure effectively bridges the OCTS and POLDER Level-1B data through the use of a common set of MOBY *in situ* measurements. The vicarious calibration assumes the band 865-nm gain coefficients are not changed, while the visible bands are adjusted such that the derived normalized water-leaving radiances are forced to be equivalent to the MOBY *in situ* measurements. Using the derived gain coefficients, we can use a consistent atmospheric-correction algorithm to process OCTS and POLDER data from Level-1B to Level-2 products. Therefore the differences in the OCTS and POLDER-derived ocean-color products are mainly from the differences of the sensor characteristics, i.e., with this approach, the retrieved products would be identical if the two sensors were identical.

We demonstrate the efficacy of vicariously recalibrating OCTS and POLDER with a common *in situ* data set and using a consistent atmospheric-correction algorithm for data processing. Both the OCTS- and POLDER-derived normalized water-leaving radiances compare reasonably well with independent *in situ* data. Over the Sargasso Sea and the Bermuda area, the ocean-color products derived from OCTS have a good agreement with data from POLDER measurements. It is particularly important that there are no obvious bias differences between the OCTS- and POLDER-derived ocean-color data, i.e., the overall ratio values between the OCTS- and POLDER-derived normalized water-leaving radiances at 443, 490, and 565 nm are 1.0004, 1.0103, and 0.9840, while the ratio value in the derived chlorophyll-a concentration is 0.9907. However, the noise differences, which are usually inherited from sensor characteristics, are difficult to remove at the pixel level. These noise differences possibly can be reduced with data-averaging schemes (e.g., averaging Level-2 data to Level-3 products). To resolve the noise problem, however, one will generally need improved instruments, e.g., high sensor signal-to-noise performance, good sensor linearity response, and high radiometric stability. It is found that the POLDER-derived $[L_w(\lambda)]_N$ are usually more noisy than those of OCTS, in particular, for the 443-nm band products. This most likely results from the POLDER sensor nonlinearity response problem.[37] On the other hand, effects of the subpixel cloud contamination around cloud edge lead to high sparkling values in the POLDER-retrieved ocean color products.

The OCTS and POLDER data-processing procedures and algorithms are scheduled to be implemented in MSL12 within the SeaDAS software,[12] which is freely available. Therefore interested scientists can process OCTS and POLDER data with the widely distributed SeaDAS software package.

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