ABSTRACT

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Combining Satellite and in Situ Data with Models to Support Climate Data Records in Ocean Biology

The satellite ocean color data record spans multiple decades and, like most long-term satellite observations of the Earth, comes from many sensors. Unfortunately, global and regional chlorophyll estimates from the overlapping missions show substantial biases, limiting their use in combination to construct consistent data records. SeaWiFS and MODIS-Aqua differed by 13% globally in overlapping time segments, 2003-2007. For perspective, the maximum change in annual means over the entire SeaWiFS mission era was about 3%, and this included an El Niño-La Niña transition. These discrepancies lead to different estimates of trends depending upon whether one uses SeaWiFS alone for the 1998-2007 (no significant change), or whether MODIS is substituted for the 2003-2007 period (18% decline, $P<0.05$). Understanding the effects of climate change on the global oceans is difficult if different satellite data sets cannot be brought into conformity.

The differences arise from two causes: 1) different sensors see chlorophyll differently, and 2) different sensors see different chlorophyll. In the first case, differences in sensor band locations, bandwidths, sensitivity, and time of observation lead to different estimates of chlorophyll even from the same location and day. In the second, differences in orbit and sensitivities to aerosols lead to sampling differences.

A new approach to ocean color using in situ data from the public archives forces different satellite data to agree to within interannual variability. The global difference between SeaWiFS and MODIS is 0.6% for 2003-2007 using this approach. It also produces a trend using the combination of SeaWiFS and MODIS that agrees with SeaWiFS alone for 1998-2007. This is a major step to reducing errors produced by the first cause, sensor-related discrepancies.

For differences that arise from sampling, data assimilation is applied. The underlying geographically complete fields derived from a free-running model is unaffected by solar zenith angle requirements and obscuration from clouds and aerosols. Combined with in situ data-enhanced satellite data, the model is forced into consistency using data assimilation. This approach eliminates sampling discrepancies from satellites.

Combining the reduced differences of satellite data sets using in situ data, and the removal of sampling biases using data assimilation, we generate consistent data records of ocean color. These data records can support investigations of long-term effects of climate change on ocean biology over multiple satellites, and can improve the consistency of future satellite data sets.