

Global marine geophysical-biological environment timeseries observed by satellites

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Satellite remote sensing is a useful tool for estimating geophysical-biological variables, their temporal change and relation with environmental conditions in the global scale even though the ecosystem is complex and hard to be measured directly. For example, the satellite ocean color just measures spectral reflectance as the radiative transfer, but their distribution and variation can give information about large-scale phytoplankton amount and variation since they have information on light absorption at each wavelength by phytoplankton pigments. In addition, the satellite data can be used to estimate related environmental variables, such as sea surface temperature (SST), sea wind speed, heat flux, precipitation, ocean current and so on, that can affect the ecosystems.

In order to monitor the long-term environmental change under the undergoing global warming, it is necessary to continue observations for several decades or more. In the recent 20-25 years, multi-channel optical and microwave satellite sensors such as SGLI[1], MODIS and AMSR-E and AMSR-2[2] have been in operation, and data on various global environmental changes have been accumulated. Here we made about 25 years combined timeseries by simply correcting their biases at the data grids using the overlap with reference MODIS data having the longest continuity among the datasets for optical sensor measurements. The advantage of the combined data is not only to show long-term trend, but also improve the reliability of the fluctuations shown by the data. For example, the global (60N-60S) chlorophyll-a concentration (Chl) timeseries showed different fluctuations among the sensors in some cases (MODIS and SeaWiFS in 2005-2008, MODIS and VIIRS in 2012, and MODIS and others in 2023), and that can be inferred to be due to sensor specific calibration errors, algorithms characteristics, shift of observation local time and so on. Conversely, the large peak of Chl in early 2020 appears in all of sensors, and it was assumed that Chl actually increased (the increase areas were in the southern mid-high latitude oceans, and it may be induced by the heavy wildfire aerosols in the southeast of Australia from the end of 2019 to the beginning of 2020 (reported by [3][4]).

From the overview of the 25-year monthly anomaly timeseries, we can see a large increase in SST (from both AMSRs and thermal infrared sensors) corresponding to the periods of the strong El Nino in 1997-1998, 2015-2016, and 2023-2024. In particular, the SST anomaly in 2023 became the highest in the 25 years. The timeseries data seems to indicate that the highest temperature was caused by the overlap of the temperature trend (about +0.02K/year) with the short-term SST increase associated with the El Nino (about +0.3K). On the other, Chl may show slight decrease in the decades and negative correlation with SST in the global average, however, we need to carefully investigate the results because there are differences among sensors caused from the higher sensitivity to the sensor calibration and estimation procedures.

Although the remote sensing has the difficulties and limitations especially for the biological observations, it is a valuable way for scale up to the global scale. In order to monitor and understand the current and future changes in the biological and physical environment on a global scale, by making use of the merits of the satellite observations, we need to continue the development and analysis of long-term time series about the marine biological and the physical environment on a global scale more than the coming decades.

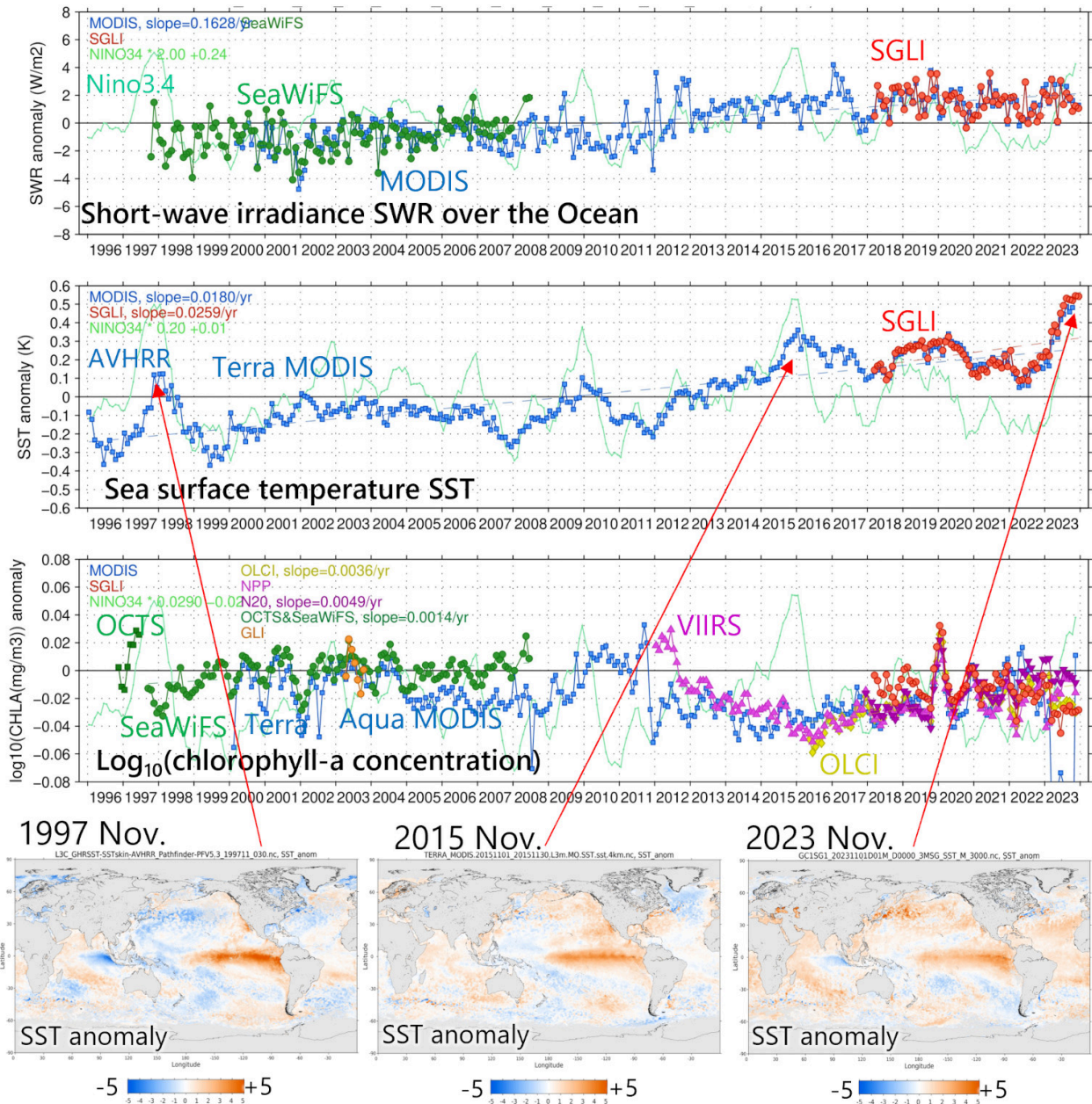
[1] GOCM-C homepage: https://suzaku.eorc.jaxa.jp/GCOM_C/data/product_std.html.

[2] AMSRs homepage: https://www.eorc.jaxa.jp/AMSR/index_en.html

[3] Tang et al., 2021, Widespread phytoplankton blooms triggered by 2019-2020 Australian wildfires.

[4] Li et al., 2021, 2019-2020 Australian bushfire air particulate pollution and impact on the South Pacific Ocean.

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Monthly anomaly of shortwave radiation (SWR), sea-surface temperature (SST), and Chlorophyll-a concentration (Chl) in 60°N~60°S, 180°W~180°E estimated by satellite optical imagers. Lower three panels show monthly SST anomaly in the strong El Niño events.