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Optical remote sensing of ecological dynamics in the Red Sea

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Patterns of algal blooming, described by variations in the abundance of planktonic agents, are considered to be indicators of the ecological balance in coastal and marine environments. Remote sensing from Earth orbit can help assess these patterns over a range of space and time scales, monitoring at a glance the ecological dynamics of entire marginal and enclosed seas. In particular, optical remote sensing allows basin-wide, multi-annual monitoring of chlorophyll-like pigments concentration (or *chl*).

A time series of *chl* statistical maps and anomalies, comprising 9 consecutive full-year cycles, from January 1998 to December 2006, were considered to explore the space and time heterogeneity of algal blooming in the Red Sea. The data were collected by the Sea-viewing Wide Field-of-View Sensor (SeaWiFS), which started its mission in September 1997. Original top-of-the-atmosphere radiances were processed to correct atmospheric noise, to derive normalized water-leaving radiances and then to compute from these other derived parameters (*chl*). Single images were re-mapped on a common equal-area grid, and all valid pixels for a given time period and grid cell were averaged to compute monthly and yearly composites. Anomalies were derived by subtracting the climatological record from the composites.

The imagery details the diverse characteristics of the northern (oligotrophic) sub-basin and the southern (mesotrophic) sub-basin, between which a central, transitional sub-basin presents more variable environmental conditions. Hardly any subdivision between a strictly pelagic region and a costal zone appears anywhere in the Red Sea, with the exception of that occurring between the basin interior and the broad shelf

areas, dotted by numerous islands, of the south.

The observed seasonal pattern is essentially bimodal, with a *fall-winter* period of extended blooming, which progresses from south to north, followed by a *spring-summer* period of less intense blooming episodes, occurring in both the central sub-basin and the southern sub-basin. Overall, the annual bio-geo-chemical cycle seems to be governed by the climatic characteristics of the basin, the monsoon regime in particular, and by the ensuing thermohaline circulation.

The *chl* interannual variability is not very pronounced, but there are hints of a steady *fall-winter* maxima increase, for most of the data set considered. The *chl* anomalies show limited oscillations around zero over the greater part of the basin. In the south, however, negative anomalies characterize the first half of the period considered, while positive anomalies prevail in the second half. A series of odd blooming episodes are also highlighted by both anomaly record and trend of the *chl* large-scale average.