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Coral skeletal luminescence records changes in terrigenous dissolved organic matter (tDOM) parameters in tropical coastal waters

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The flux of terrigenous dissolved organic carbon (tDOC) from land to the coastal ocean is an important component of the global carbon cycle, and can impact coastal marine ecosystems. A potentially large fraction of this tDOC flux can be oxidised to CO_2, resulting in coastal ocean acidification and ultimately degassing to the atmosphere. tDOC is also rich in chromophoric dissolved organic matter (CDOM) which is the fraction of dissolved organic matter that absorbs light. CDOM plays an important role in aquatic systems by absorbing sunlight and reducing its transmission through the water column. This is a partially beneficial effect since photodegradation reactions release nutrients and protect biota from harmful UV radiation. However, CDOM light absorption also reduces the light available for primary producers. Long running tDOC and CDOM measurements from North America and Europe show that tDOC fluxes have been increasing in the 20th century in response to climate and land-use change. However, despite the biogeochemical and ecological significance of tDOC, there are few long-term records of tDOC, and none at all from tropical shelf sea environments. This severely limits our understanding of its drivers and processes.

Here, we show that luminescence green-to-blue (G/B) ratios in coral skeleton cores are an accurate proxy for tDOC concentration in seawater. Coral luminescence is generated by humic-like substances, which are highly fluorescing compounds that are incorporated by corals into their skeletons during growth, forming sub-annual growth layers that luminesce under UV light. These humic-like substances are an integral component of tDOC and are an important constituent of the CDOM pool. We used solution fluorescence excitation emission matrix (EEM) measurements of

dissolved powders of coral skeletons collected from multiple locations on the Sunda Sea Shelf along with abiogenic aragonite growth experiments to show that coral luminescence G/B is quantitatively related to the fluorescence intensity of terrestrial humic substances. We then combined a satellite-retrieved time series of CDOM with an analysis of a coral core section from an area of Borneo affected by run-off from tropical peatlands. We show that coral G/B ratio is a quantitative proxy for CDOM concentration at monthly resolution over a period of 12 years at this site (R^2 = 0.57). Furthermore, we examine data from a multi-year biogeochemical time series in Singapore combined with recently collected coral cores from the monitoring site. These results show that coral luminescence G/B ratios are highly correlated with terrestrial CDOM absorption across the ultraviolet and visible wavelength spectrum, as well as with the tDOC concentration as estimated from stable isotopes of dissolved organic carbon. Taken together, our results show that coral G/B ratios can be a powerful proxy to reconstruct bio-optical and biogeochemical variability resulting from tDOC input. Corals can therefore allow us to potentially reconstruct tDOC flux variability across tropical seas over past centuries, and therefore to investigate seasonal to inter-annual drivers of tDOC dynamics.