Sensitivity of reef-relevant ocean color phenomena to satellite data resolution

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Background

Satellite ocean color measurements are a valuable tool for evaluating water quality parameters relevant to coral reef habitats. However, low earth orbiting satellites offer a limited number of observations for detecting episodic, extreme events to which coral reefs are sensitive, and the spatial resolution of most sensors is too coarse for fine scale processes in optically shallow nearshore environments. Here, we assess whether high-resolution satellite ocean color measurements from the first geostationary satellite ocean color sensor (GOCI) can improve our understanding of coral reef habitat conditions and monitoring capabilities for potential reef changes. Using ten years (2011-2021) of GOCI ocean color measured eight times per day at a spatial resolution of 500 m around the Okinawa Prefecture region, we assess whether high-resolution grid configurations influence the retention of data in coastal areas where waters are otherwise masked at coarser resolutions to avoid optical reflectance in shallow waters. We further explore the detection of episodic, extreme chlorophyll blooms at increasing spatiotemporal resolution grids.

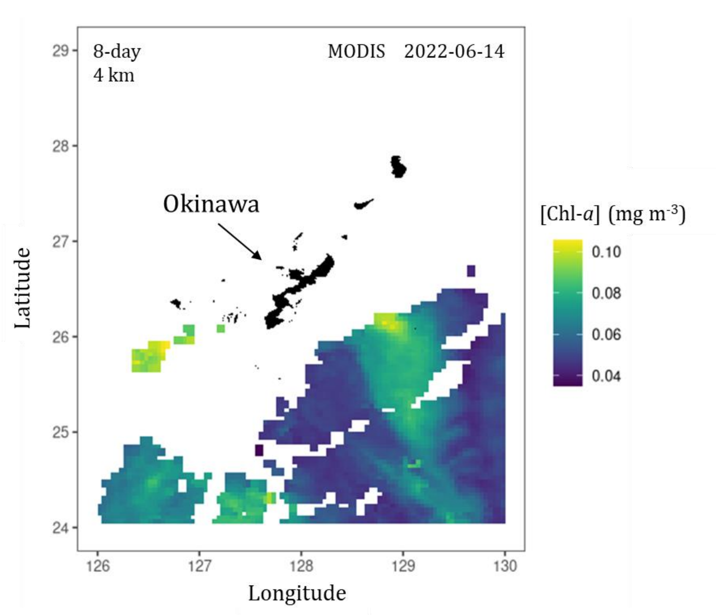

Figure 1. Chlorophyll-*a* coverage in the Okinawa Prefecture region from a low earth-orbiting satellite

Methods

- GOCI Level-3 ocean color data was provided by NOAA/NESDIS/STAR at 500 m and 8x per day around the Okinawa Prefecture region.
- Spatially coarsened grids were simulated to replicate existing satellite ocean color spatial resolutions at 750 m (e.g. VIIRS) and 4 km (e.g. SEAWIFS) using the daily estimates closest to noon:

Configuration	Spatial Resolution	Temporal Resolution
Coarse (e.g., SeaWIFS)	4 km	Daily
		8-day
		Monthly
Moderate (e.g., VIIRS)	750 m	Daily
		8-day
		Monthly
Full GOCI resolution	500 m	8x per day
		Daily
		8-day
		Monthly

- Temporally coarsened data were then simulated by averaging each grid cell across 8-day and monthly windows from the daily resolution at 500 m, 750 m, and 4 km
- Shallow water pixels were masked to remove any potential contamination of pixels by seafloor reflectance (30 m isobath plus an additional ½ diagonal pixel distance).
- Differences in the ability to detect episodic or extreme chlor-a events (> 2 SD above the monthly mean value at 4 km monthly grid) with increasing spatiotemporal resolution were evaluated.

Results

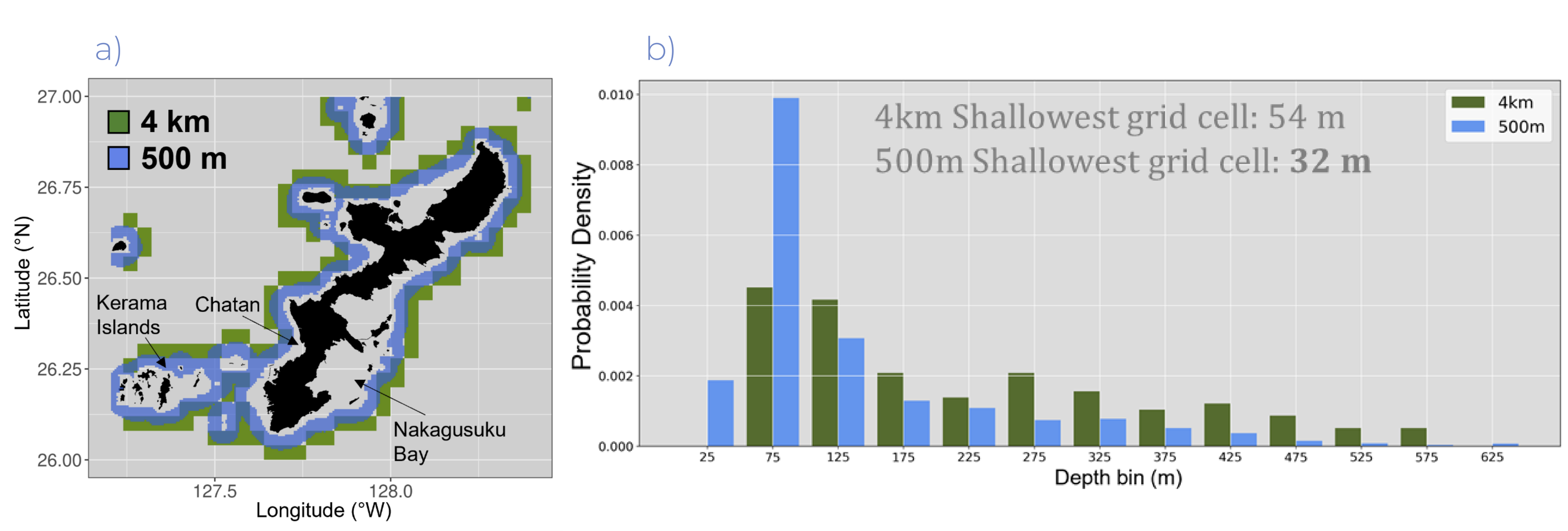

Figure 2. (a) Increased spatial coverage along Okinawa's coastal habitat from the 500 m GOCI ocean color grid (blue) in comparison to a 4 km grid (green). (b) Probability density of coastal ocean color grid cells across depth bins at 4 km (green) and 500 m (blue) resolution.

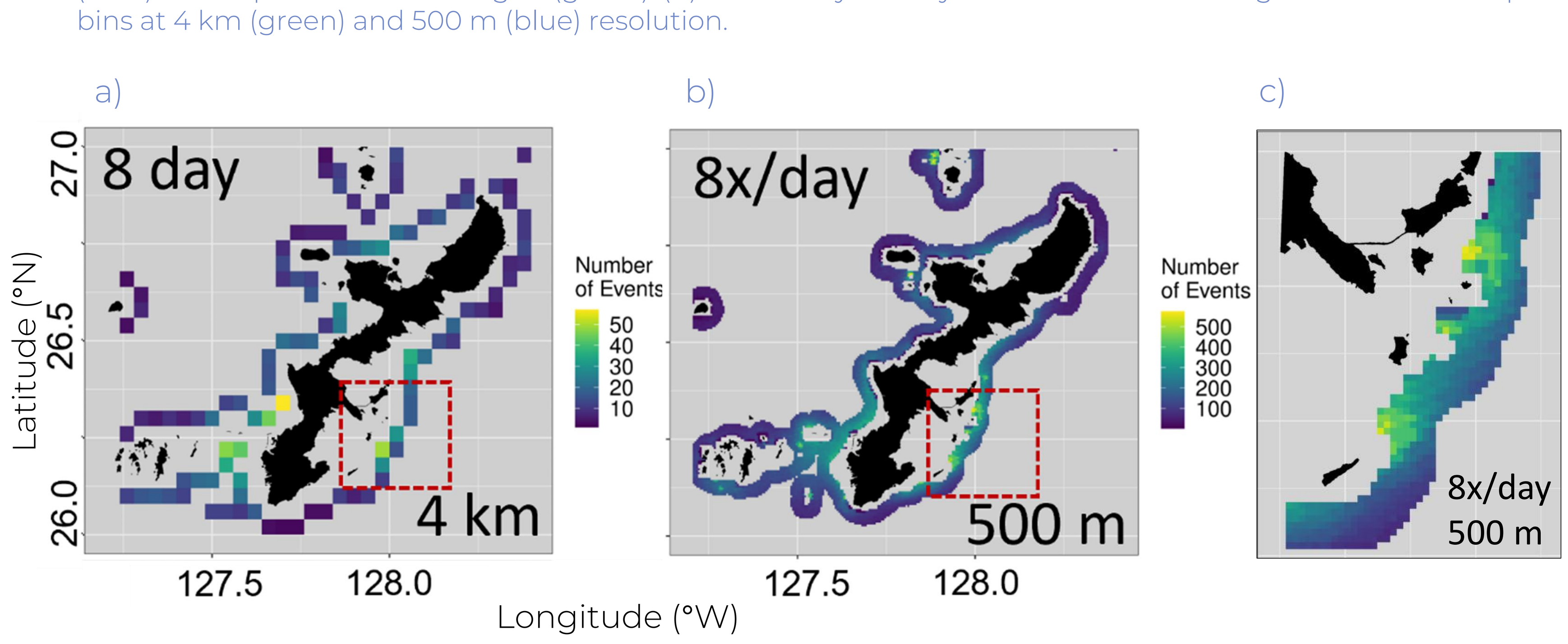

Figure 3. Number of episodic chlor-a events across the 10-year time series (2011-2021) within each grid cell mapped across coastal Okinawa at low **(a)** and high **(b)** spatiotemporal resolutions. Red boxes indicate zoomed in area around Nakagusuku Bay in **(c)**.

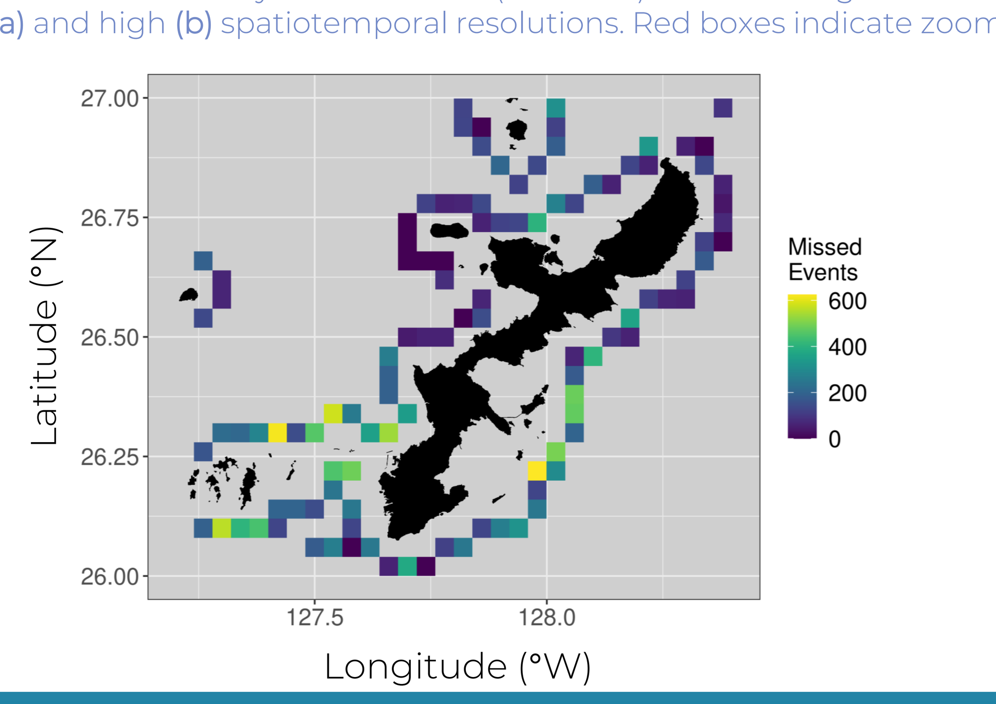

Figure 4. Number of episodic chlor-a events across the 10-year time series (2011-2021) that were not detected at the commonly used 8-day 4 km ocean color grid resolution but that were captured by the 8x/day 500 m full resolution GOCI grid configuration.

Conclusions

- High-resolution ocean color grids significantly increase retention of data in coastal areas where waters are otherwise masked at coarser resolutions to avoid optical reflectance in shallow waters.
- Geostationary data provides nearly 3x more days with ocean color observations around the coast by having measurements 8x-per-day as compared to once-daily measurements.
- The ability to detect episodic, extreme chlorophyll blooms increases significantly with increasing spatiotemporal resolution grids and the locations of these events becomes much more refined at higher resolutions.
- High-resolution ocean color data can enable us to assign more reliable risk to coral reef tracts that could be affected by frequent episodic events, and allows us to assess the persistence of such events in waters much closer to coastal habitat.
- Advancements in ocean color remote sensing technologies can improve our ability to more accurately describe water productivity and its relationship with the ecosystem, as well as to potentially help disentangle biological and water optical parameters.

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