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# Revisiting the island mass effect: a systematic study in the tropical Pacific

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## Overview

- The **island mass effect (IME)** is defined as a chlorophyll concentration (Chl) increase in the vicinity of islands (e.g., Doty and Oguri, 1956). This may be a near-ubiquitous process according to a 35-island study (Gove et al., 2016), but basin-scale impacts on Chl and phytoplankton community composition are unknown.
- Here we systematically investigate all islands and atolls in the tropical Pacific by using an **algorithm automatically detecting the IME zone from satellite Chl**. We contrast physical and biological variables within climatological IME and background (BG) zones for each island.
- Goals: (1) **quantify** the IME impact on phytoplankton biomass and diversity; (2) **classify** the islands as a function of enrichment processes and phytoplankon response.

## Methods

### ISLAND DATASET

Islands = closed contours in the GSHHS full resolution coastline
Reefs = ETOPO1 pixels shallower than 30m (submerged or matched with islands)

all Pacific islands and reefs ("islands") N = 12293 → remove islands within 100 km of continents N = 8735 → combine islands within MODIS NaN patches **N = 658**

(456 emerged islands and 202 submerged reefs)

### IME AND BACKGROUND ZONE DETECTION

**1)** Sort islands by Chl_max = highest nearby Chl[(*)]

**2)** For each islands, iteratively lower the IME contour cChl starting at Chl_max, until one of the 4 criteria below is met. **IME zone** = inside the cChl contour.

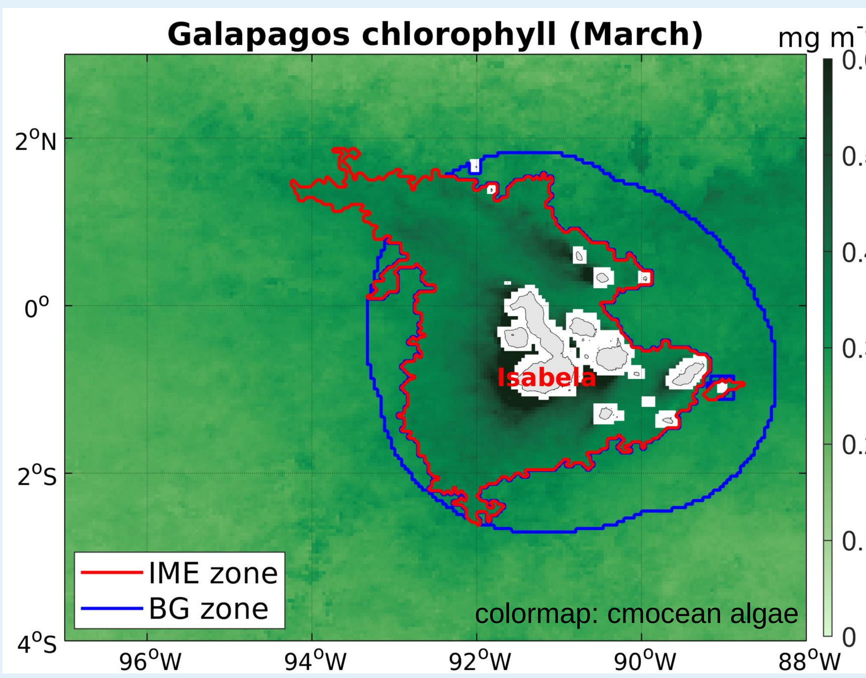
**3)** Define the background area **BG** as the first nIME pixels closest to the island outside of the IME zone (nIME = # of IME pixels). Chl_bg = mean Chl in BG area.

IME strength = Chl_max - Chl_bg

4 criteria to stop iterations:

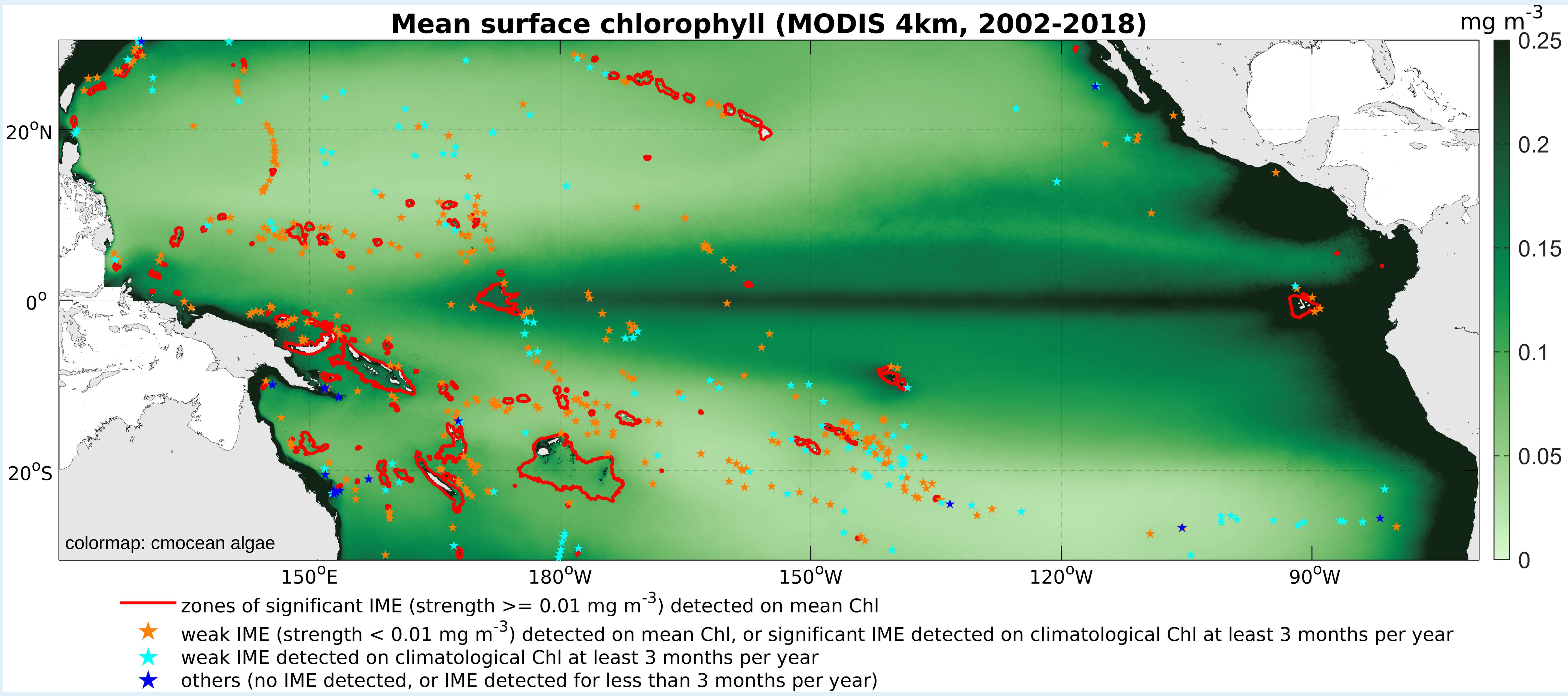
(i) cChl lower than the min nearby Chl
(ii) the IME zone is too large (exiting an arbitrary circle or touching continents)
(iii) the IME zone intersects a previously detected IME
(iv) zones of high Chl are found within the IME zone, not connected to the island.

(*)Ocean color data removed in pixels < 30 m depth to avoid bottom contamination (Gove et al., 2016).




*Example of IME and background zones detected for the Galapagos islands. Here the Isabela IME is merged with IMEs from smaller islands.*

## Results




### GLOBAL IMPACT

⇨ **32% of islands have significant IMEs** on a seasonal basis at least 3 months / year (59% including shared IMEs, 98% also including weak IMEs).

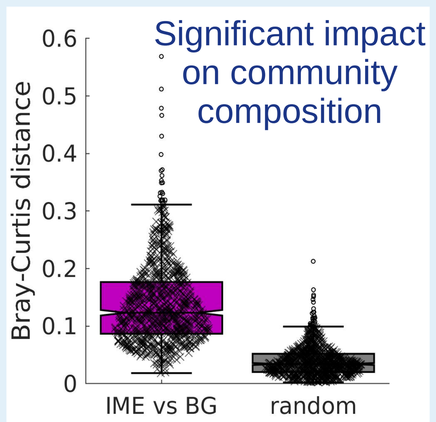
⇨ On average, IMEs represent **2% of the tropical Pacific area**

⇨ **16% Chl increase** on average for significant IMEs (9.5% mean Chl increase near islands)

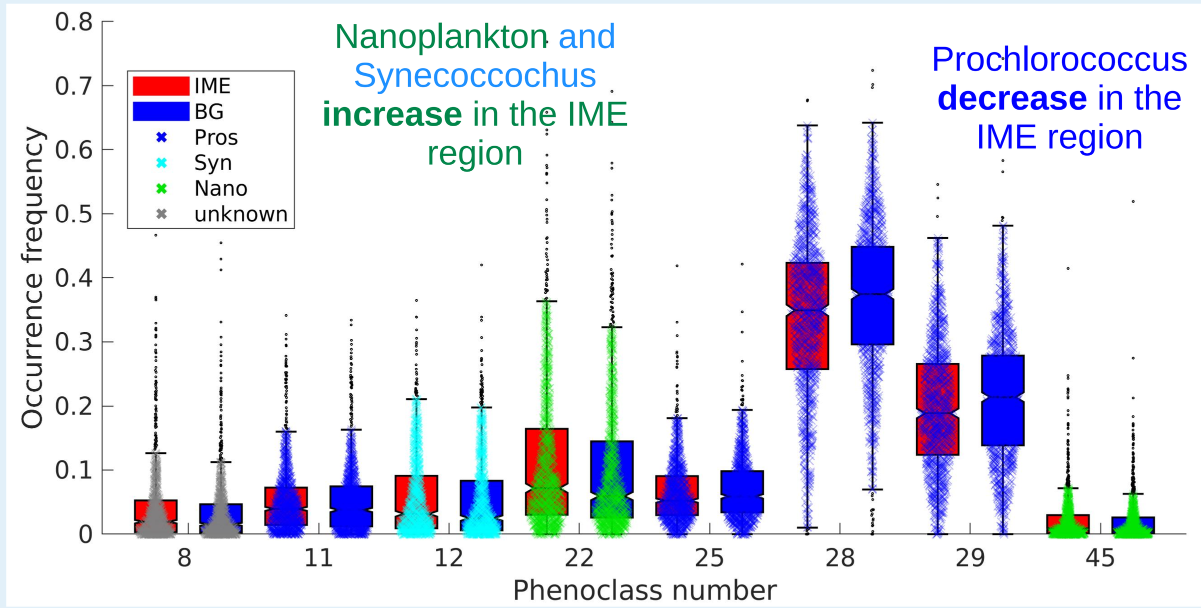
⇨ Represents **~ 580 tons of Chl** over a 10 m surface layer.

### IMPACT ON PHYTOPLANKTON COMMUNITY

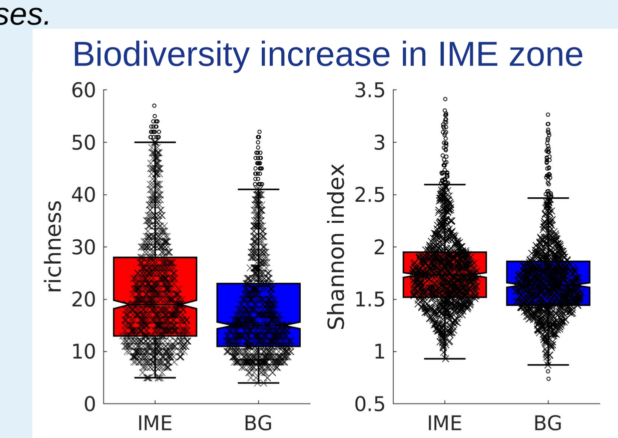
**PHYSAT** = ocean color radiance anomalies clustered into "**phenological classes**" and labelled using HPLC data (Alvain et al., 2008; Rêve-Lamarche et al., 2017). Climatological frequency of occurrence computed for each pixel and each class.




Statistics in climatological IME vs BG zones with >100 PHYSAT data pixels, excluding weak and shared IMEs (N = 852).

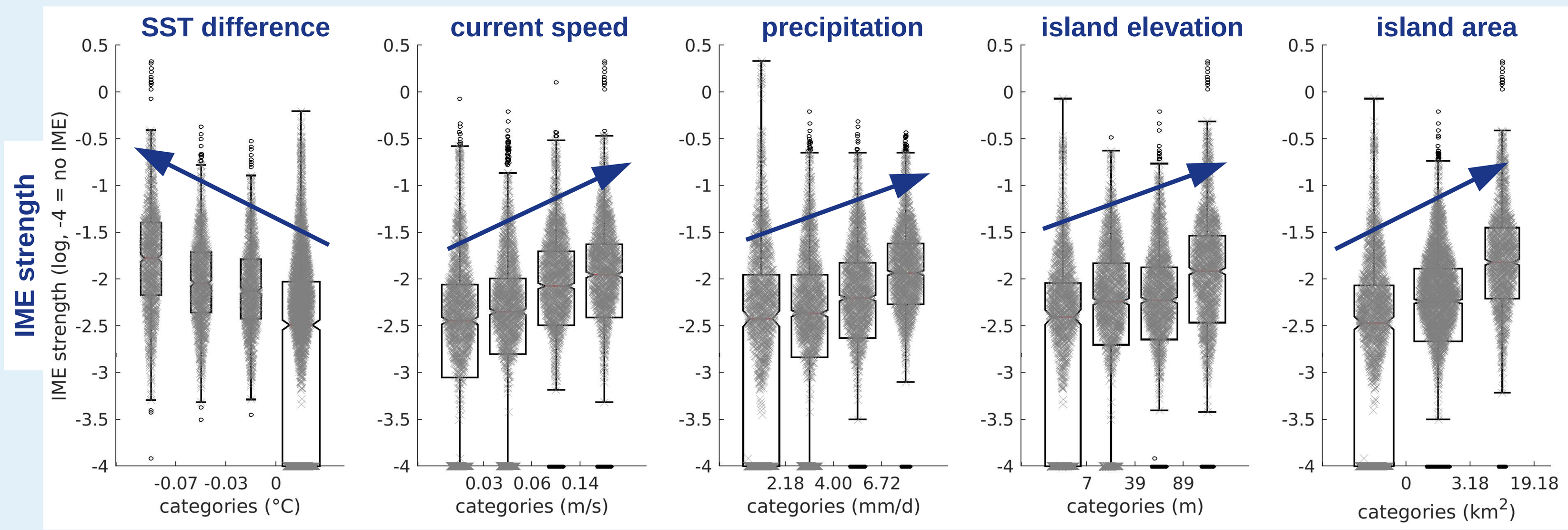



***Above:*** *Bray-Curtis dissimilarity between IME and BG communities, compared with random pixel drawings.*
***Right:*** *frequency distribution in IME and BG zones for dominant phenoclasses.*
***Bottom:*** *comparison of biodiversity indices in IME and BG zones.*




⇨ **IMEs increase biodiversity and impact the phytoplankton community composition**

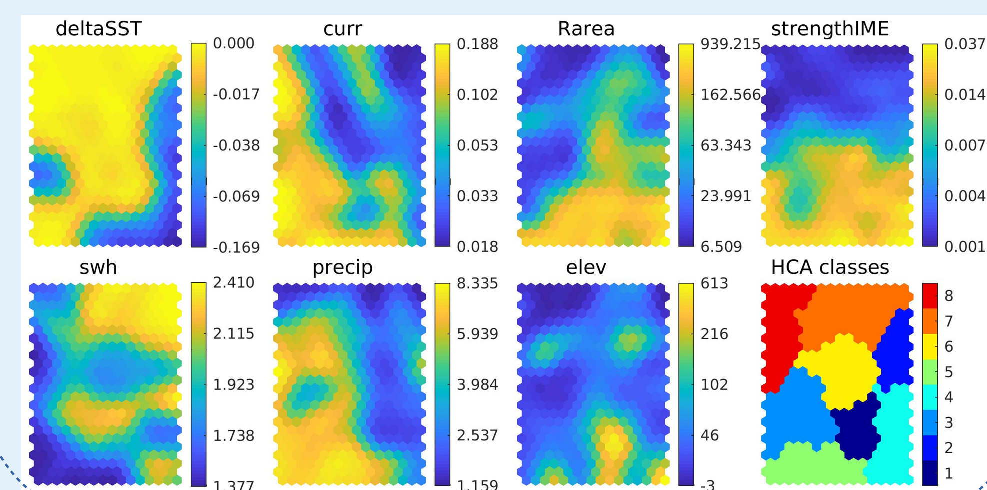
### PHYSICAL FORCING




***Above:*** *IME strength as a function of predictor categories (defined based on quantiles).*
***Predictors =*** *SST difference between IME and BG zones, currents, precipitation, maximum island elevation, island area / reef area, significant wave height. (Climatological analysis, shared IMEs excluded).*

⇨ **IME strength increases with SST cooling, current speed, precipitation, island elevation and island area.**

***In progress:*** *unsupervised machine learning using Self-Organizing Maps (SOM). Open for discussion!*

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Datasets include MODIS 4km chlorophyll and SST, PHYSAT phenological classes, OSCAR surface currents, GPCP precipitation, AVISO sea wave height, ETOPO1 bathymetry, and GSHHS full resolution coastline.
Matlab toolboxes Alternative box plot (https://mathworks.com/matlabcentral/fileexchange/46545-alternative-box-plot), cmocean (https://matplotlib.org/cmocean/) and SOM (https://github.com/ilarinieminen/SOM-Toolbox) were used.

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