Filament and eddy contribution to the offshore transport of organic carbon

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Rationale

The **lateral redistribution of organic carbon** from highly productive coastal regions to the open waters fuels excess rates of remineralization offshore [1,2]. Mesoscale (20-200 km wide) structures such as upwelling **filaments and eddies are expected to drive a significant fraction of this total offshore flux**, but their contribution must be constrained [3].

We quantify the mesoscale flux of organic carbon from the coast of the Canary Upwelling System using **high-resolution model simulations**.

Modeling setup

Coupled model: **ROMS** (3D ocean's flow [4])+ **NPZD** (biogeochemistry [5])

Atlantic telescopic grid: covers full basin and resolves mesoscale flow in the region of study

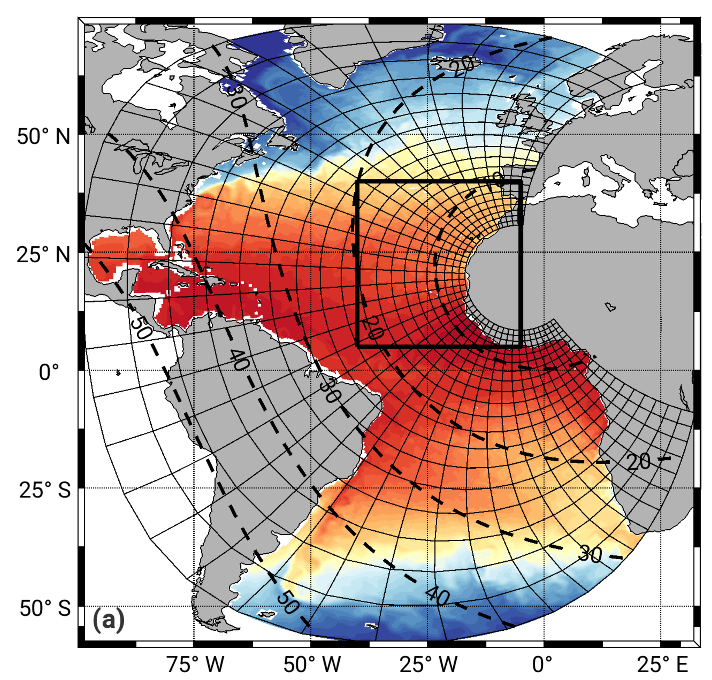


Fig 1. Atlantic Telescopic Grid on instantaneous sea surface temperature, showing every 20th grid line. Region of study (Canary Upwelling System) highlighted with a black square.

Mesoscale flux calculation

Mesoscale structures are identified with **automated algorithms** [6,7] at each time step. The associated flux is calculated as the product of velocities and organic carbon concentrations within the surface of the structures.

Results

Percent of total offshore flux

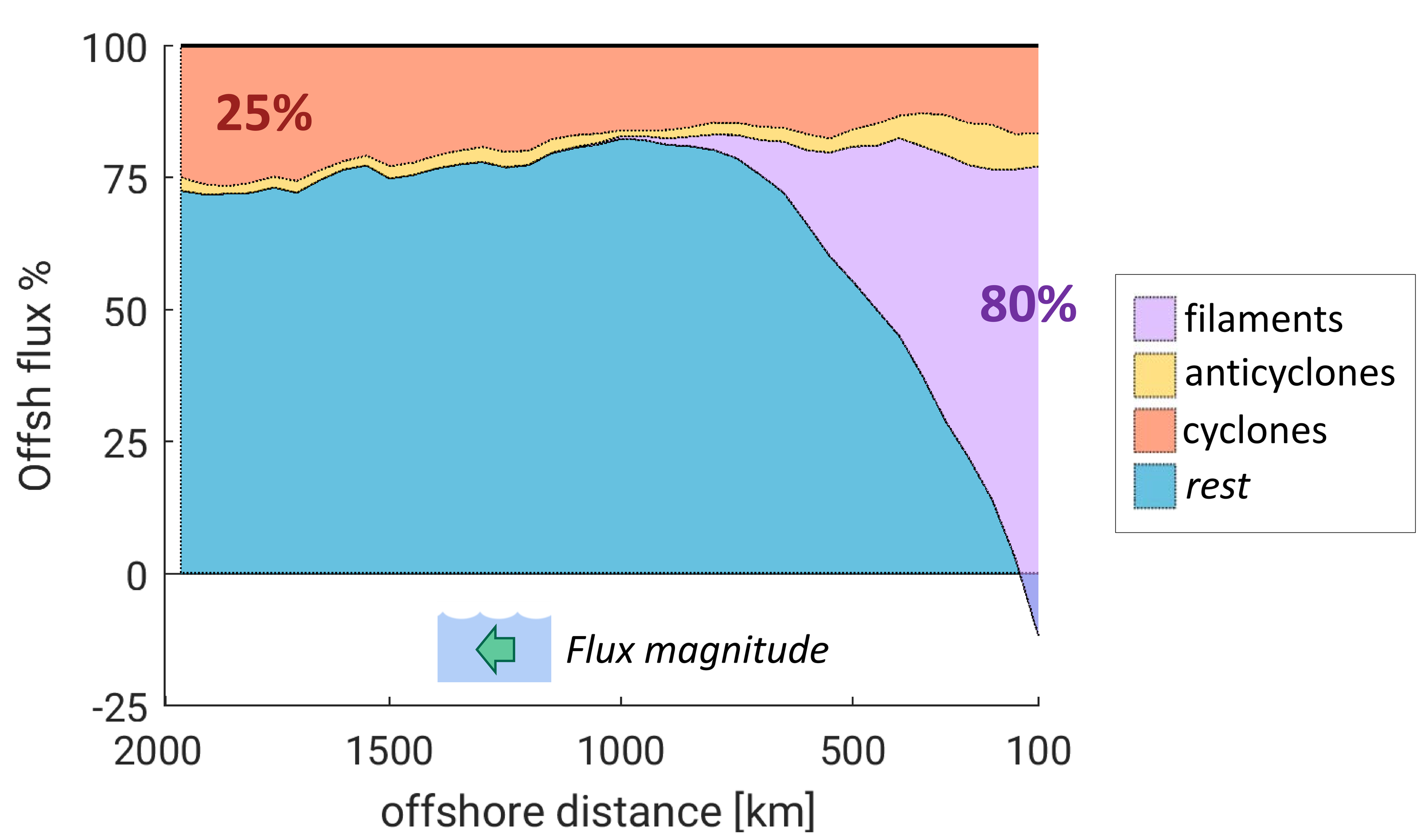


Fig 2. Mesoscale contribution to the offshore flux of organic carbon at different distances from the north-western African coast

Percent of offshore flux divergence

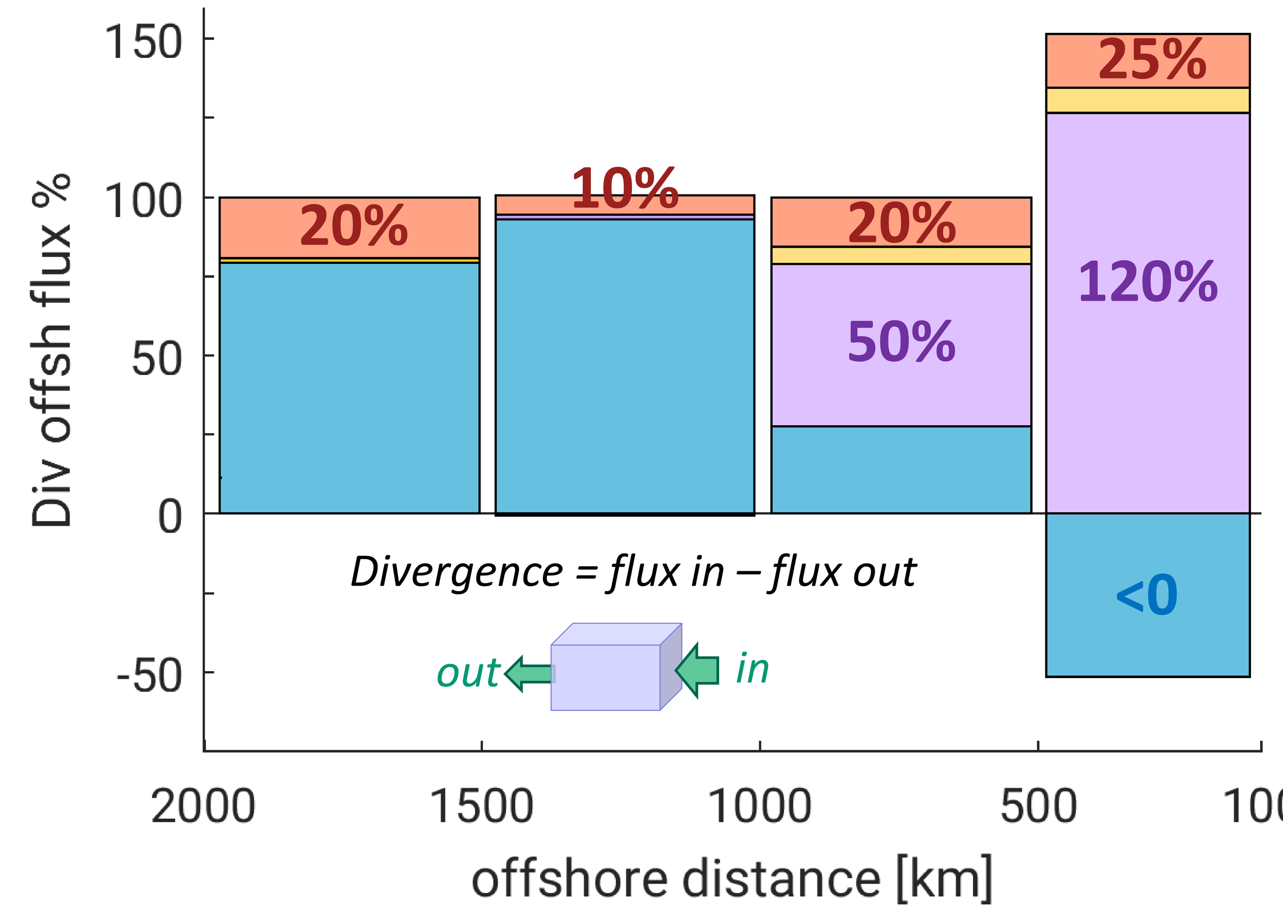


Fig 3. Mesoscale contribution to the flux divergence at different distances from the coast, for 4 large scale domains

Percent of tracer

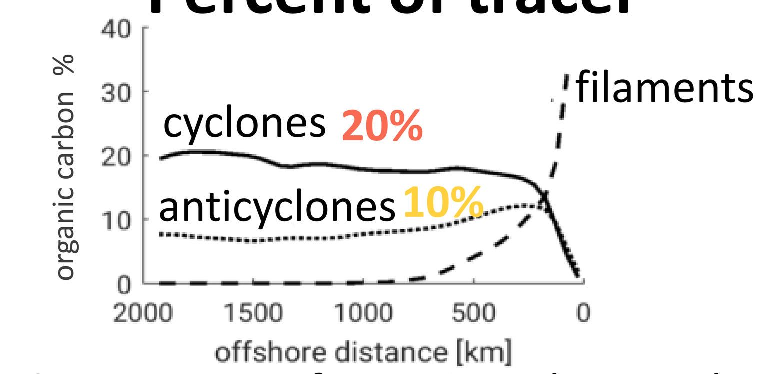


Fig 4. Percent of organic carbon stock in each structure by offshore distance

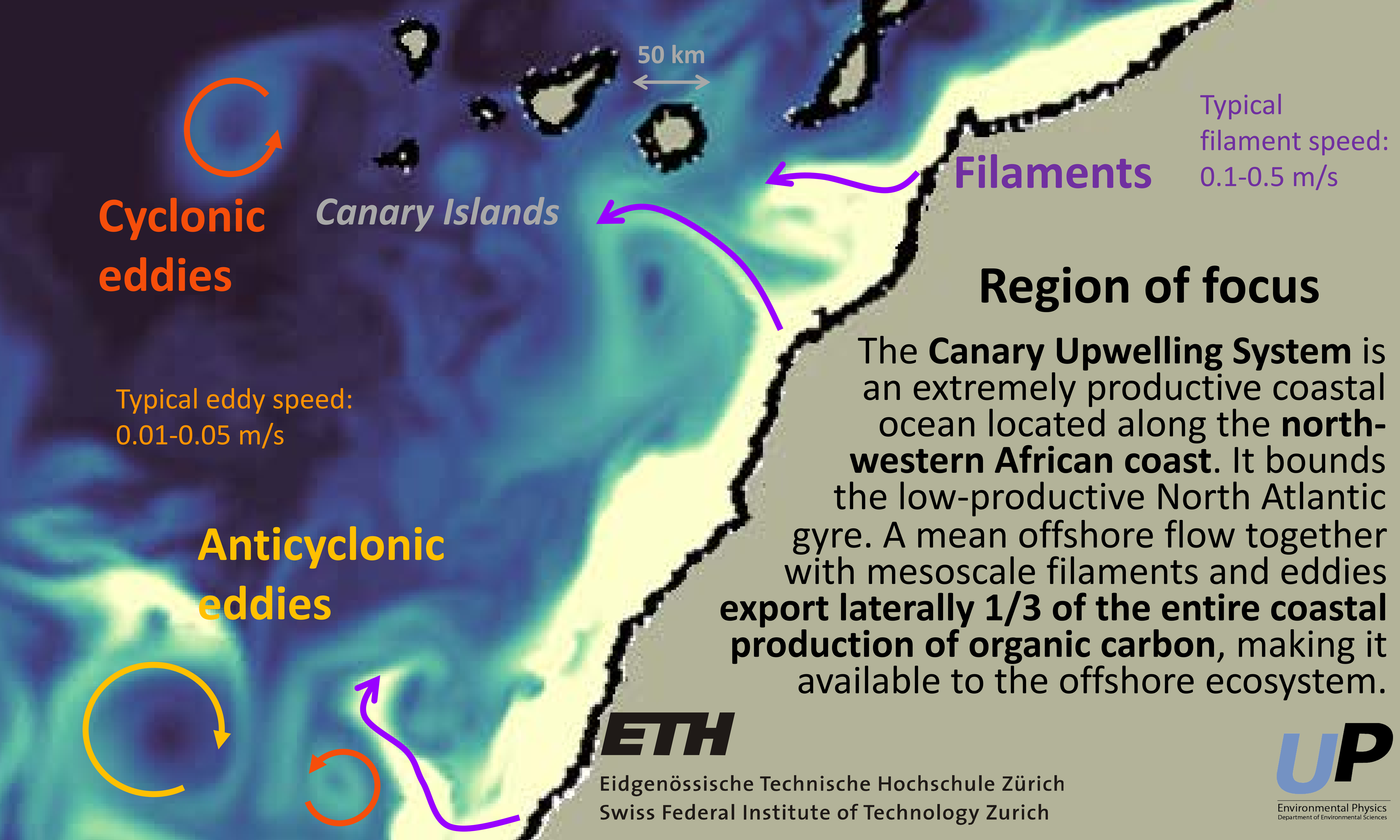
- Narrow **filaments** are responsible for **most of the flux** (80%) at 100 km offshore and are the **main source of coastal organic carbon** (divergence) up to 1000 km from the coast.
- The **eddy flux** is relatively small (~20%) but **far reaching** and is **driven by cyclones**; eddies are 10 times slower than filaments but contain **30% of the organic carbon** offshore.

Implications

1) The coastal-open ocean exchange of organic carbon is **driven by small scales**: coarse global models must include a parameterization

2) Observation-based estimates of the organic carbon flux must deal with **substantial variability**

3) Far reaching eddies represent a reservoir of organic carbon for the open ocean and **fuel offshore remineralization discontinuously**



Region of focus

The **Canary Upwelling System** is an extremely productive coastal ocean located along the **north-western African coast**. It bounds the low-productive North Atlantic gyre. A mean offshore flow together with mesoscale filaments and eddies **export laterally 1/3 of the entire coastal production of organic carbon**, making it available to the offshore ecosystem.

Literature
[1] Lovecchio et al., Biogeosciences (2017)
[2] Burd et al., Deep Sea Res .II (2010)
[3] Nagai et al., Jour. Geophys. Res (2015)
[4] Shchepetkin and McWilliams, Ocean Modeling (2005)
[5] Gruber et al., Deep Sea Res. I (2006)
[6] Faghmous et al., Scientific Data (2015)
[7] Lovecchio et al., Biogeosciences Discussions (2018)

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