Lagrangian Spatiotemporal Fingerprints of Dissolved Inorganic Carbon in Eighteen Degree Water

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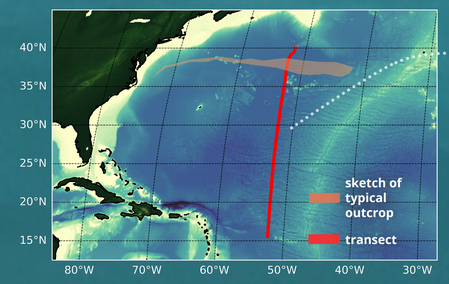
This is work in progress. Your perspectives are appreciated!

Introduction

Eighteen Degree Water (EDW) is a mode water found in the North Atlantic which outcrops in late winter, allowing for atmospheric exchange of heat and CO_2. This makes EDW an important buffer for heat and carbon anomalies, as well as a pathway for (anthropogenic) carbon to penetrate from the ocean surface into deeper layers, from which it can eventually be sequestered.



Previous studies have mainly focused on physical aspects of EDW formation and destruction. Studies that focus on dissolved inorganic carbon (DIC) in EDW are based on transect and station observations only.

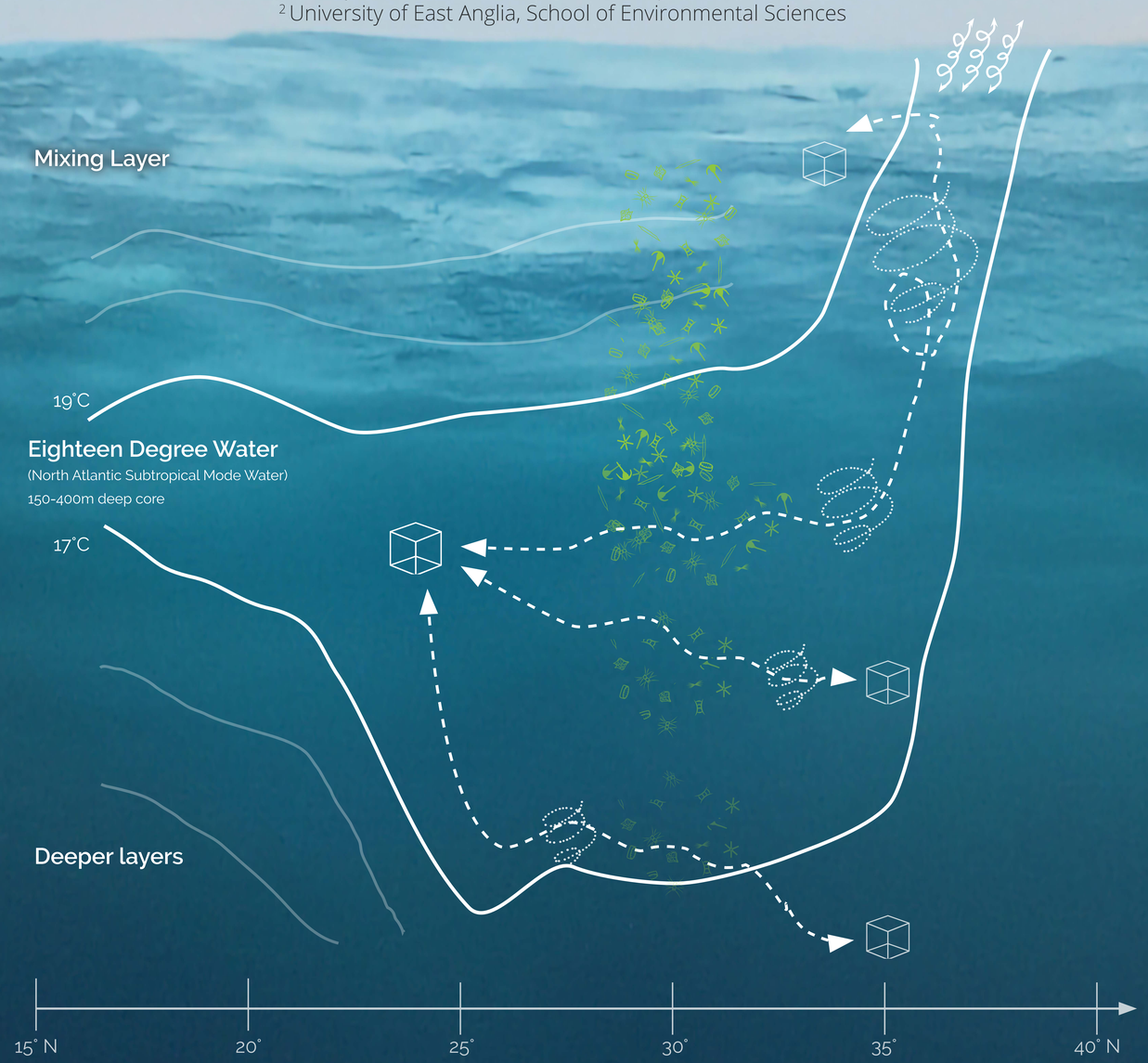
Aim

At which spatiotemporal scales do physical and biogeochemical processes alter DIC concentrations along water parcel trajectories before and during EDW reventilation at the surface and export to deeper layers?

We differentiate the contributions of vertical diffusion, soft-tissue and carbonate processes.

Data and simulation

- Unassimilated reanalysis (FREEGLORYS2V4) with an eddy-permitting (1/4th degree) ocean model (NEMO) coupled with biogeochemistry (PISCES)
- Daily data available between 1992 and 2019
- Advection of Lagrangian particles, initialized on EDW in different years and seasons (March and September)
- Recording state (in or out of EDW)
- Sampling key biogeochemical properties (DIC, Alkalinity, Nitrate, Phosphate).



Physical and biogeochemical processes influence the concentration of Dissolved Inorganic Carbon while water parcels move within Eighteen Degree Water and while they get exported to deeper layers or reventilated back at the surface.

Lagrangian analysis reveals the associated timescales and spatial patterns.

Air-sea exchange

Turbulent diffusion

Photosynthesis/respiration

$CaCO_3$ precipitation/dissolution

Disentangling processes

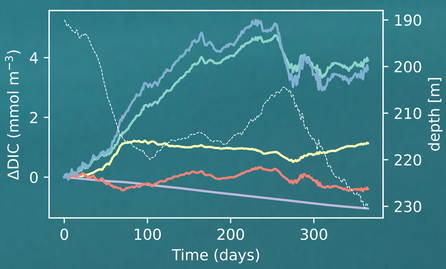
$$\frac{\mathrm{D[DIC]}}{\mathrm{D}t} = \frac{\partial \mathrm{[DIC]}}{\partial t}_{\text{diffusion}} + \frac{\mathrm{D[DIC]}}{\mathrm{D}t}_{\text{biology}} + \frac{\partial \mathrm{[DIC]}}{\partial t}_{\text{surface/air-sea}} + \frac{\partial \mathrm{[DIC]}}{\partial t}_{\text{residual}}$$

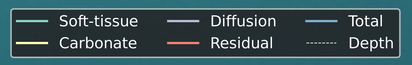
$$\frac{\mathrm{D[DIC]}}{\mathrm{D}t}_{\text{biology}} = r_{c:p}\frac{\mathrm{D}[PO_4^{3-}]}{\mathrm{D}t} + \frac{1}{2}\left(\frac{\mathrm{D[TA]}}{\mathrm{D}t} + \frac{\mathrm{D}[NO_3^-]}{\mathrm{D}t}\right)$$

soft-tissue

carbonate

Attribution of DIC changes for an example trajectory





Temporal and spatial analysis

We identify DIC enrichment and depletion events based on changepoint detection in the Lagrangian time series. From this we compute a distribution of timescales associated to different strengths of DIC changes per process.

Based on this, we can differentiate DIC enrichtment and depletion regimes in space and across years, in the context of a changing climate and ocean.

Contact

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abstract

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