The role of sediment resuspension in biogeochemical cycling across continental shelves
A modelling study of the Black Sea system

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Context
The Black Sea
Objectives

Model(s)

Diagenetic variability

The role of sediments resuspension

Conclusion
Northwestern shelf
- < 120 m
- Large freshwater and nutrient inputs

Central basin
- 120 - 2000 m
- Strong stratification

Objectives:
Resolve biogeochemical budgets across River-Shelf-Basin continuum.
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→ Importance of benthic-pelagic coupling to represent the shelf biogeochemistry
- Benthic-dissolved fluxes are expensive measurements.
- Few available data
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**Technical requirement:** set up a bentic-pelagic coupled model resolving the variability of benthic solutes fluxes
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GHER 3D Hydrodynamic Model

Hydrostatic model, Double Sigma coordinates, Real time forcings (ECMWF)
Provides: T, S, TKE, U, V, \( \eta \)
GHER 3D Biogeochemical Model

Provides: C, N, P, Si, O2 cycling through various forms.
Benthic-Pelagic coupling

Provides: Fluxes at the sediment water interface.
Benthic-Pelagic coupling

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Sedimentation (POM, Diatoms)

Variable sinking velocities

Bottom Stress Effects

$T < T_c \rightarrow$ Deposition

$T > T_c \rightarrow$ Resuspension

Early Diagenesis (Soetaert et al, 2000)

[mmol C/m²/s]

$D_c = [\text{fast C stock}] \cdot k_{tc} \cdot f(T^o)$

$+ [\text{slow C stock}] \cdot k_{sc} \cdot f(T^o)$

2D Sediments Variables

C stock

Fast

Slow

N/C ratio

Si Stock

Fast

Slow
Benthic-Pelagic coupling

\[ \tau = \tau_{\text{currents}} + \tau_{\text{waves}} \]

\( \tau_{\text{currents}} \leftarrow (\text{GHER model}) \)

\( \tau_{\text{waves}} \leftarrow (\text{WAM model, offline}) \)

Kandilarov and Stanev, 2012

\( \tau^f \): Critical stress for deposition and erosion of \( S^f \).

\( \tau^s \): Critical stress for erosion of \( S^s \).

<table>
<thead>
<tr>
<th></th>
<th>Deposition</th>
<th>Resusp. ( S^f )</th>
<th>Resusp. ( S^s )</th>
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<tbody>
<tr>
<td>( \tau &lt; \tau^f )</td>
<td>( \tau^f &lt; \tau )</td>
<td>( \tau^s &lt; \tau )</td>
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\[ P = (1 - \frac{\tau}{\tau^f}).w_{\text{POM}}.[\text{POM}] \]

\[ P^f = (\frac{\tau}{\tau^f} - 1).M_{\text{f}} \]

\[ P^s = (\frac{\tau}{\tau^s} - 1).M_{\text{s}} \]
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Fluxes Validation

Water

Benthic Fluxes

Sediments
Diagenetic variability

Region 1 (23.7 km² / 15-57 m)
- $D_C$: 9.1 molC/m²/yr
- Oxic: 18.3%
- Denit.: 5.9%
- Anox.: 76.0%

Region 2 (33.9 km² / 26-109 m)
- $D_C$: 3.6 molC/m²/yr
- Oxic: 41.8%
- Denit.: 6.3%
- Anox.: 51.9%

Region 3 (21.4 km² / 46-120 m)
- $D_C$: 1.6 molC/m²/yr
- Oxic: 68.8%
- Denit.: 5.1%
- Anox.: 26.1%
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Bottom stress effects impact on spatial variability
Bottom stress effects impact on spatial variability
Bottom stress effects impact on shelf budgets
Bottom stress effects impact on shelf budgets
Bottom stress effects impact on seasonal variability
Bottom stress effects impact on seasonal variability
Bottom stress effects impact on basin budgets

Relative increase: \( \tau_{dep} = 0.02 \) compared to \( \tau_{dep} = 0.05 \text{ N/m}^2 \)
Bottom stress effects impact on basin budgets

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- The calibration of bottom stress effects at shelf scale...
  - Is difficult AND bears large scale impacts,
  - Affects the biogeochemical “filtering” capacity of the shelf.
Conclusions

- Considering sediment resuspension is necessary to reproduce the variability of benthic dissolved fluxes.
- The calibration of bottom stress effects at shelf scale is difficult AND bears large scale impacts,
  - affects the biogeochemical “filtering” capacity of the shelf
  - and, consequently, basin scale budgets.
What’s next?

Big gaps in this study:
- Fixed roughness length
- Fixed critical resuspension threshold and erodability constant
Thank you for your attention