Assessment of an oxygen prognosis model for the North Sea - Baltic Sea transition zone

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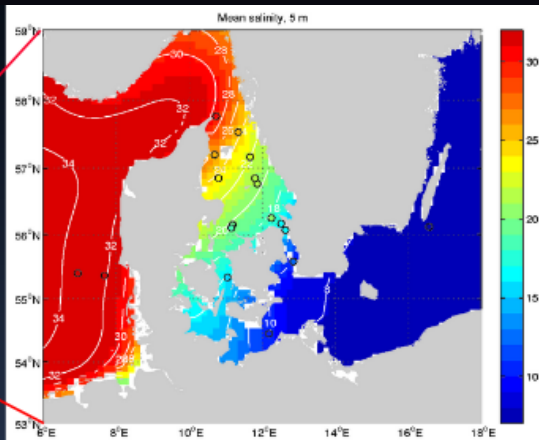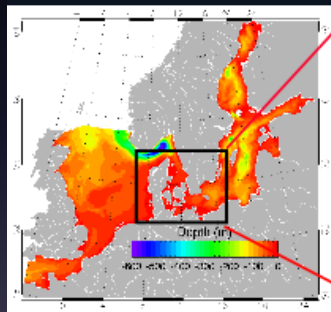# Table of contents

Introduction

Figure from Kristine S. Madsen PhD thesis

Oxygen depletion in the North Sea - Baltic Sea transition zone

Oxygen depletion:
$o_2 < 63 \ mmol/m^3$

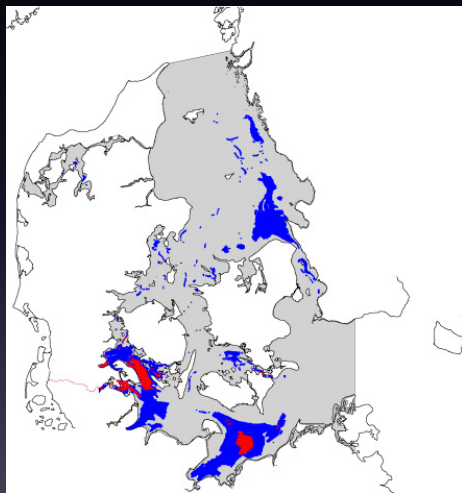**Oxygen deficiency:**
$o_2 < 126 \ mmol/m^3$

Figure from NERI homepage

Challenges in oxygen modelling

- We need an accurate description of the physical processes, ie. vertical mixing and advection
- A good estimate of the biological production
- The link between production, export production and oxygen consumption is not completely understood

We are modelling the uncertain biogeiochemical processes as simple as possible while a state-of-the-art model is used for the physical processes

Model description

The physical model: DMI-cmod
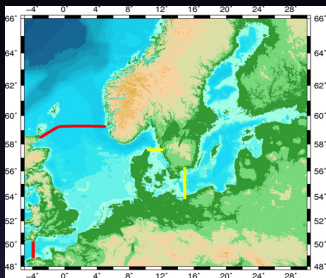
Outer boundary of the coarse domain:
6nm hor. resolution, 50 vertical layers

Nested fine domain
1nm hor. resolution, 52 vertical layers

- Hourly met forcing from the atmospheric model DMI-HIRLAM
- Climatological field of S & T and sea level elevation at outer lateral B.C
- River run off at inner lateral boundaries
- Included sea ice model
- k-ω turbulence model

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Oxygen model

Parameterization

- Oxygen flux through sea surface
- Pelagic sink
- Benthic and sediment sink applied at the bottom layer
- $R_i = \mu_i Q_{10}^{\frac{T - T_{ref}}{10}} \frac{O_2}{k_i + O_2}$

Domain

- Oxygen module only runs in the fine domain and BS
- Prescribed boundary condition for O_2 in Northern Kattegat

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Model assessment

Model requirement

In order to assess a model we must define a target definition or model requirement, otherwise the model can not be validated nor invalidated

$\Longrightarrow$ Validation is subjective!

- The purpose of the model is to simulate oxygen depletion events in the NS-BS transition zone
- A model requirement should be that the errors is not larger than the definition of oxygen depletion
- Ideally the model should be assessed at the time and place that oxygen depletion occurs, that is the autumn and in the bottom

Assessment method

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Visual comparison

- Model output is compared against maps of oxygen depletion areas
- No quantitative results

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Time series analysis

- Model results are compared against observation for 2 stations
- Easy to visualize errors but...
- Gives no information about spatial distribution of the error

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Spatial validation

- All available data in the region is collected for the years 2002-2006
- Model-observation pars are collected for the bottom water
- Statistical measures are computed for the autumn month and gathered into a grid

Model observation comparison for Great Belt
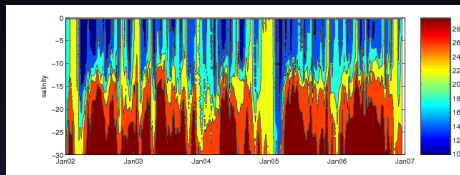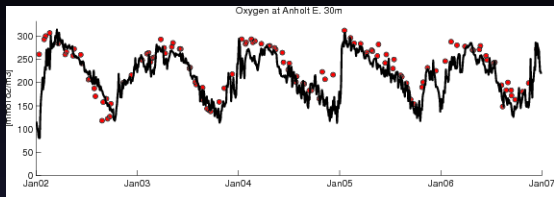

(a) observed salt.
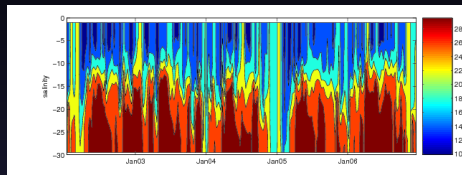
(b) modelled salt.
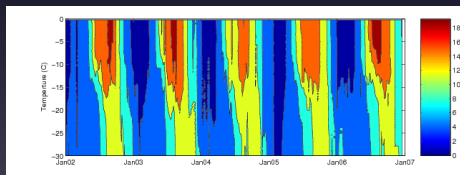
(c) observed temp.

(d) modelled temp.

(e)

(f)

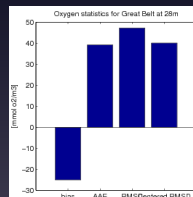(g)

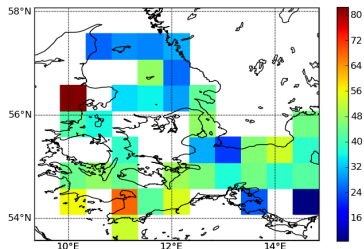

(h)
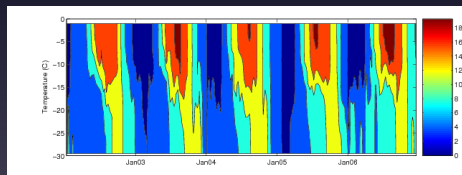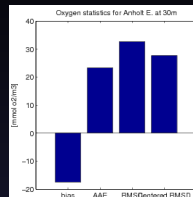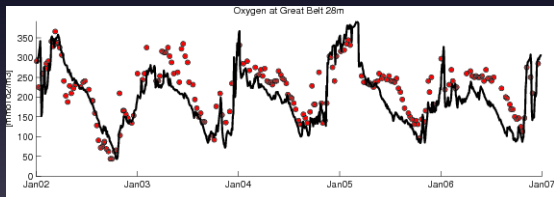
Validation during aug-oct 2002-2006 at depth below 15m

AAE

Units in **[mmol O2/m3]**

$$n : 3149$$
$$AAE : 38$$
$$bias : -8$$
$$RMSD : 53$$
$$corr : 0.74$$

Oxygen depleted area
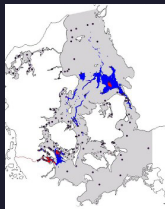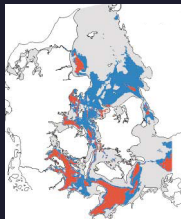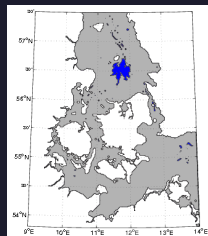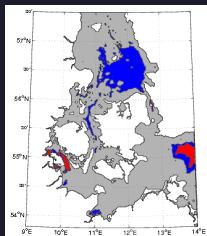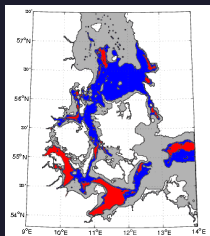
Process studies

- Interannual variations in autumn wind vs oxygen conditions
- Impacts of advected North Sea water on oxygen concentrations
- Influence of topography on oxygen consumption

Conclusions

- The North Sea - Baltic Sea transition zone suffers from seasonal hypoxia because of a highly stratified water column and increased nutrient inputs

- Presented here is a simple oxygen consumption parameterization coupled to a 3d circulation model

- A quantitative assessment of the model shows that it is able to predict the oxygen depletion events

- The interannual variations in oxygen conditions in this region is to a large extent governed by physical processes

Thank you