Biologically-Induced Ocean Radiant Heating

Modelling the impact of water constituents on the radiative heat transfer in the Western Baltic Sea

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In Short

- Heating rates induced by optically active water constituents (OACs) contribute to the seasonal modulation of energy fluxes across the ocean-atmosphere interface.
- Attenuation of underwater light is especially complex in shelf and coastal seas due to absorption and scattering of highly variable optically active water constituents (OACs), i.e. phytoplankton, coloured dissolved organic matter (CDOM) and detritus.
- Seasonal changes in OACs will impact radiative heating in surface waters.

In coastal areas, the ocean can respond to the atmosphere rapidly and is highly variable over short spatial scales. In these cases, significant feedbacks between the ocean and atmosphere occur regularly. This project explores the contribution of optically active water constituents (OACs) to energy fluxes in the upper ocean using a coupled bio-optical-ocean-atmosphere model. Our aim is to understand how heterogeneity in OACs in shelf seas affects the characteristics of sub-mesoscale vertical mixing and advective fluxes, through feedbacks with upper ocean heating rates and water density. Our approach involves quantifying the contribution of optically active water constituents to heating rates in a shelf sea region, the Western Baltic Sea 1 , where different freshwater and nutrient regimes, and complex bio-optical and hydrodynamic processes take place.

Using a coupled bio-optical-ocean-atmosphere circulation model 2 , we spectrally resolve the underwater light field in a dynamic ocean and model the inherent optical properties (IOPs) of the different water constituents under varying environmental conditions. The explicit calculation of in-water spectrally-resolved absorption, scattering and backscattering coefficients, as well as the attenuation coefficient, and upward, downward and scalar irradiance fields, means that the optically active water constituents' contribution to the divergence of the heat flux can be calculated [1] and accounted for within the full hydrodynamic solution. Knowing the relative contributions of water constituents to the divergence of the heat flux and heating rates will provide insight into the relationship between ocean state, variability

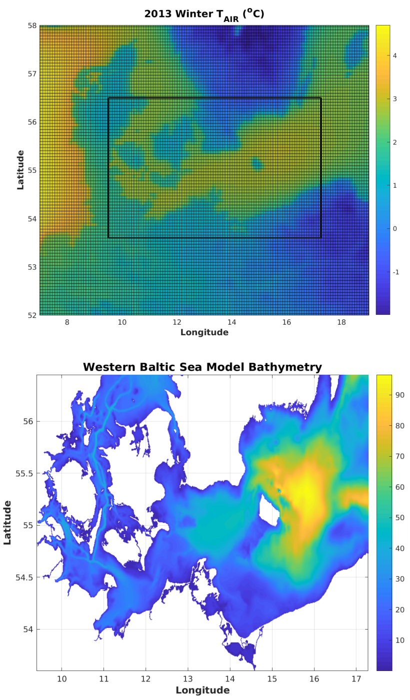

Figure 1: *Atmospheric (WRF) model domain (top), ocean (ROMS) model domain (bottom).*

in IOPs, phytoplankton community structure and air-sea energy fluxes. The impact these heating rates have on the ocean SST is fed back to the atmospheric component of the modelling system, so that we can evaluate the importance of considering a coupled ocean-atmosphere system for our purpose.

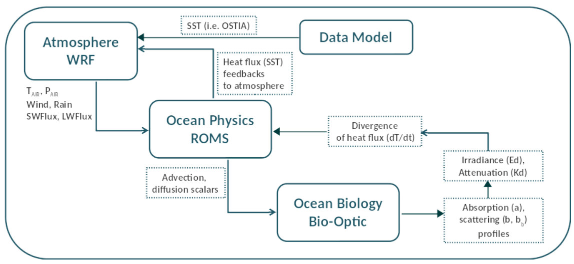

Figure 2: *Overview of the coupled modelling system, interaction between components and data streams.*

Preliminary results from a quasi-1D set up of the model system (6 x 6 horizontal grid, 30 vertical sigma layers with increased resolution in the top 20m, and periodic boundary conditions), tuned for the Western Baltic Sea (Arkona Basin) with four phytoplankton

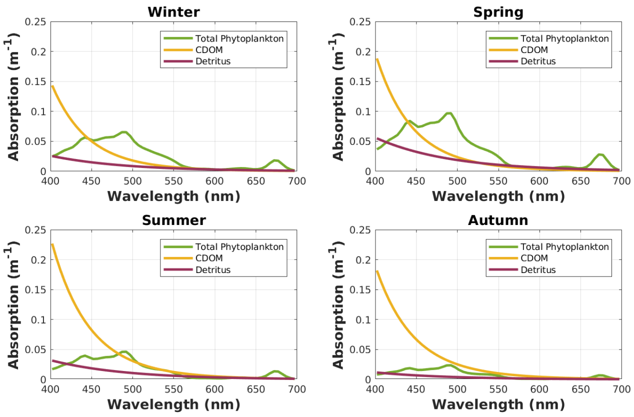

Figure 3: *Seasonal estimates of surface water constitutent spectral absorption (Phytoplankton, CDOM and detritus).*

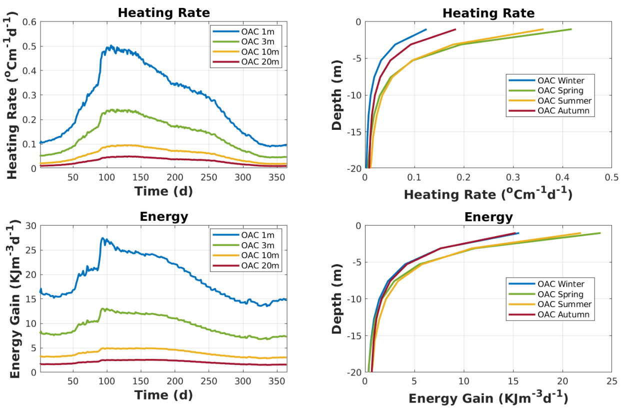

Figure 4: *Seasonal estimates of heating rates and energy gained.*

groups are shown in 3 4. These demonstrate that we can capture a seasonal cycle of the water constituent absorption characteristics, and associated heating rates and energy gained. These results indicate that the seasonal variability and vertical distribution of heating and energy gained from water constituents is greatest in the surface layer, with an increase in surface heating on the order of 0.5C in the upper 1m in spring and summer periods. CDOM absorption plays a significant role in surface heating, especially in summer and autumn. Ongoing work is the deployment of this model system in the full 3D Western Baltic Sea model domain shown in 1.

WWW

http://userpage.fu-berlin.de/geoiss/en/home.html

More Information

[1] Morel, A. (1988). *J. Geophys. Res.* **93**, 10749-10768.

Project Partners

(2) Leibniz-Institut for Baltic Sea Research (IOW), Warnemuende

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