

A satellite image of the Black Sea, showing the surrounding landmasses of Europe and Asia, with clouds visible over the land. The sea itself is a deep blue color.

# A stochastic approach to identify and model uncertainties in the analysis and forecasting of Black Sea ecosystems

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# The Black Sea

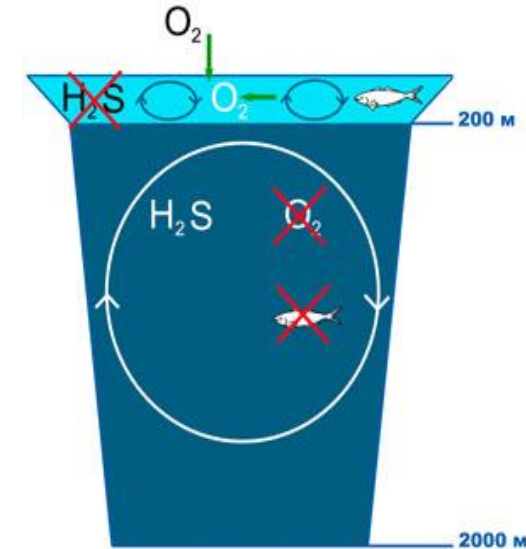
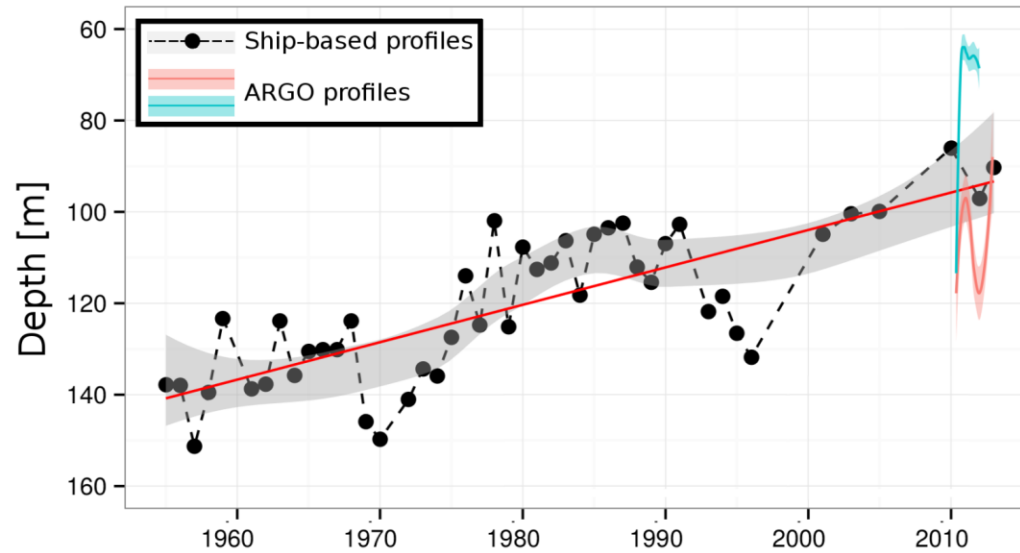
Large river discharges



Bosphorus strait

# Biogeochemistry in the Black Sea

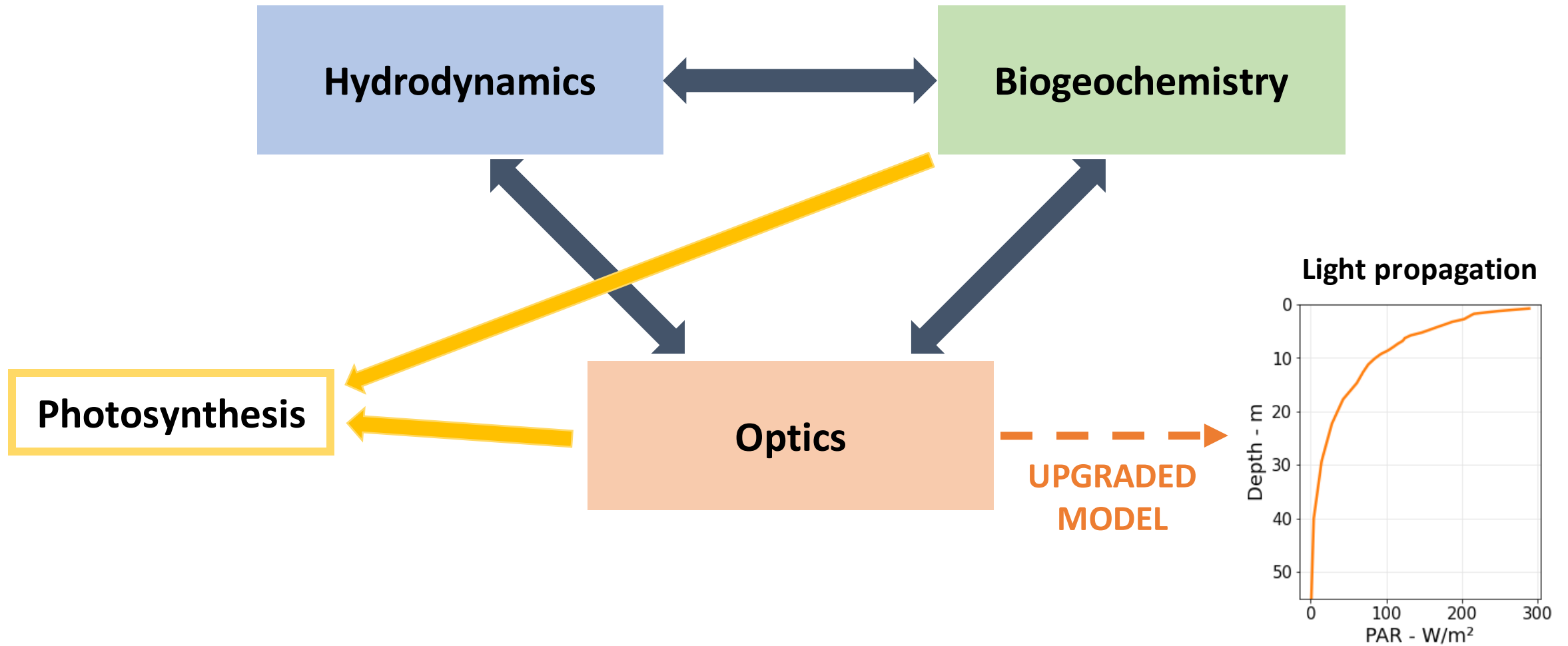
## Oxygen penetration depth



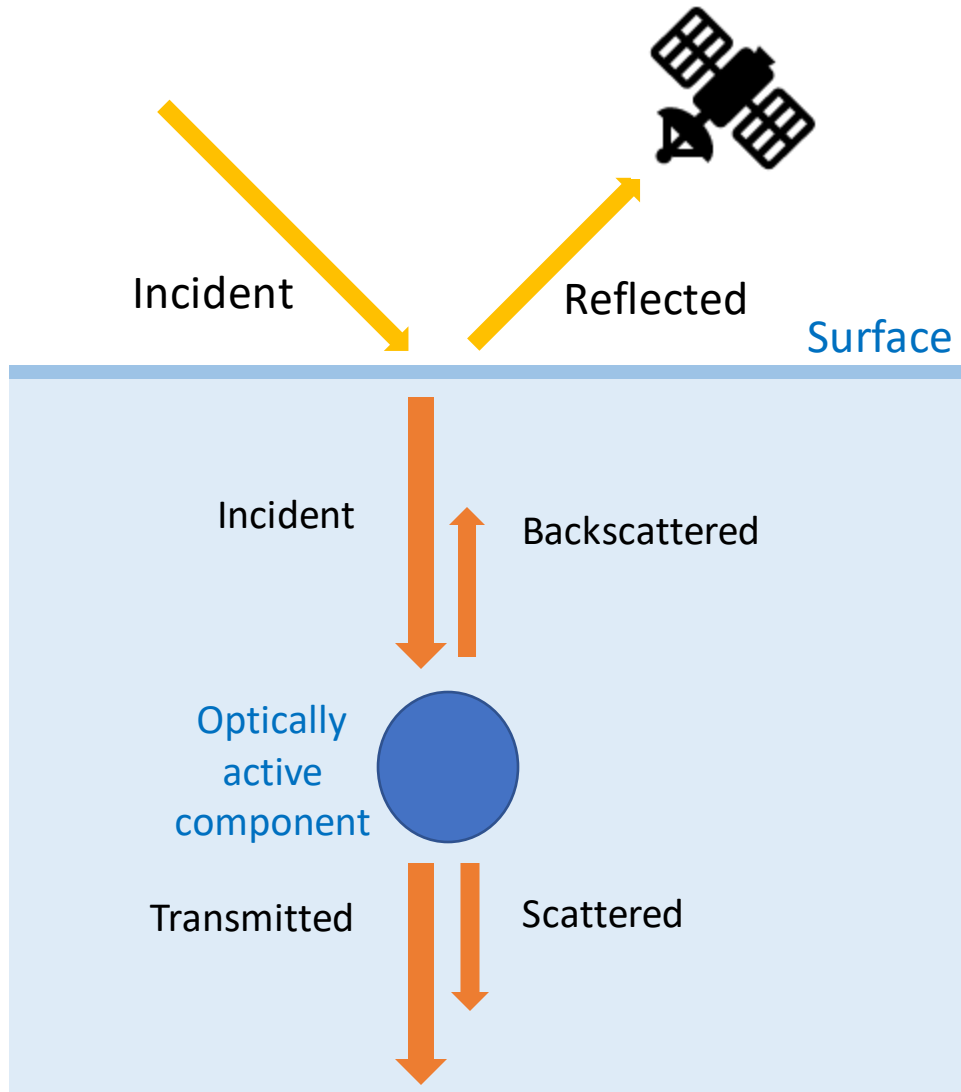
Consequences on:

- Habitat of aerobic species
- Nitrogen and sulfide cycling through coupling mechanisms

# Biogeochemical modelling



# Optics modelling



A new link to what is directly observed by the satellite:

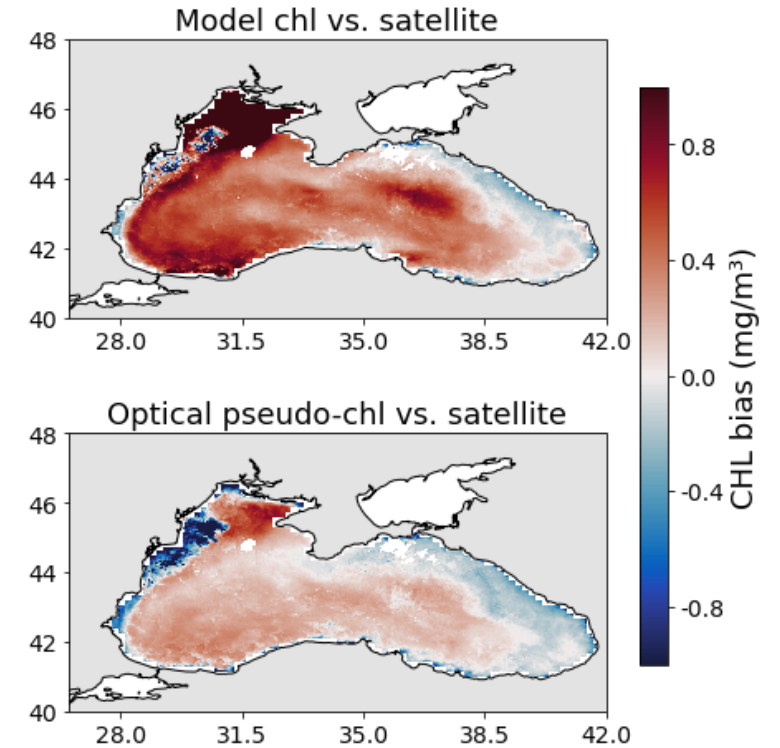
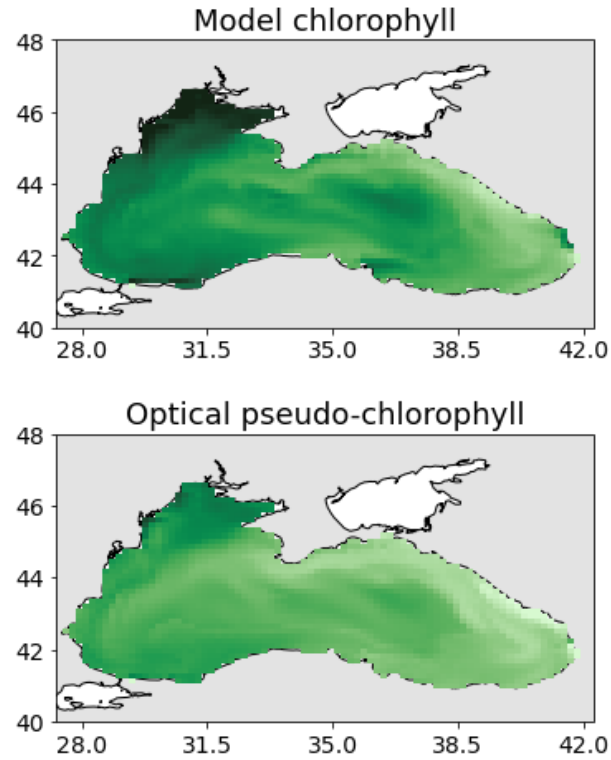
$$\text{Surface reflectance} = \frac{\text{Reflected}}{\text{Incident}}$$

# Chlorophyll and pseudo-chlorophyll

Biogeochemical variable  
 $= f(\text{phytoplankton})$

**Model**

Optics-derived variable  
 $= f(\text{surface reflectance})$



Optical variables are closer to satellite observations than biogeochemical variables

# Model uncertainty and ensemble runs

What is uncertain in the model?

Initial condition

Unresolved scales

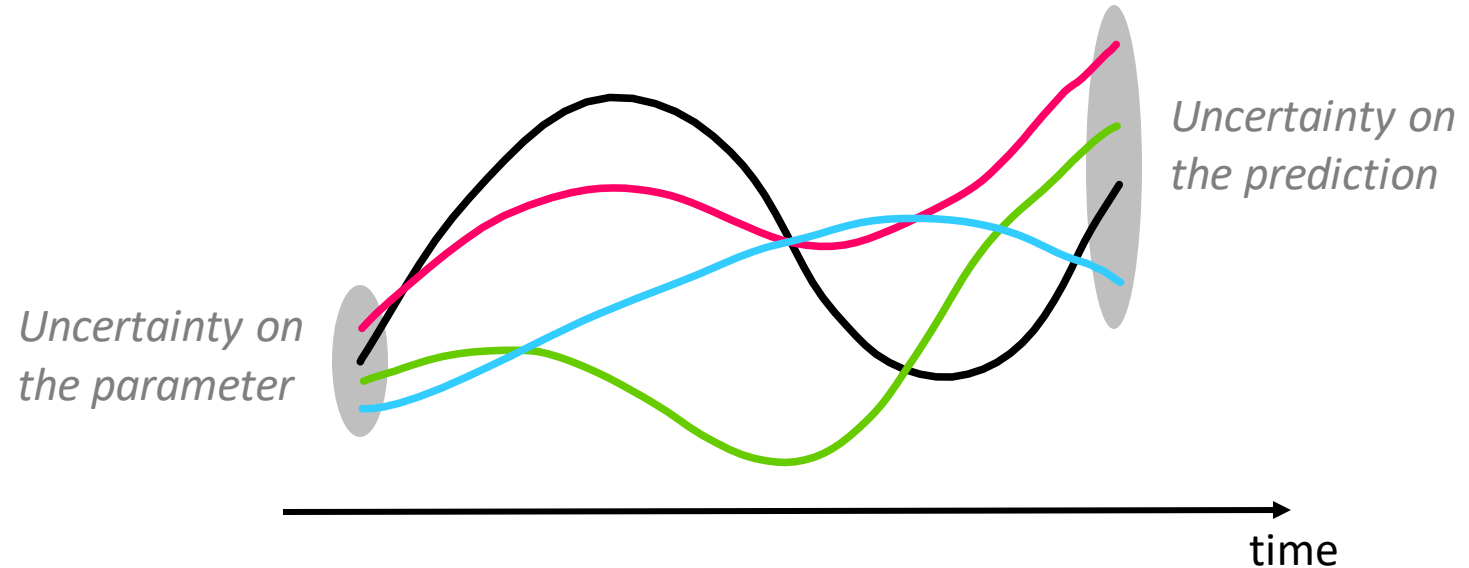
Wind

Phytoplankton growth/mortality

Nutrient discharge

Optical properties

Solar flux at the surface



Indicators for the Black Sea:

- Oxygen depth
- Basin-scale oxygen loss
- Nitrogen budget



**Make predictions while providing an uncertainty range!**