Comparing highly resolved analogous Eularian/Lagrangian model setups of calanoid copepods for the study of aggregation patterns

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Motivation

Challenges in harvesting plankton in the sea:

- The ressource is widely spread throughout the ocean
- the potential energy density per individual is high
- The energy density of swarms at different spatial scales is highly variable
- The size of organisms is typically around the mm scale
- Implies operations at low reynolds numbers $Re = \frac{\rho\, u\, L}{v}$
- Increased drag forces $F_d = \frac{1}{2}\, \rho A\, u^2 f(Re)$

Knowledge on aggregation patterns of plankton is important for several reasons:

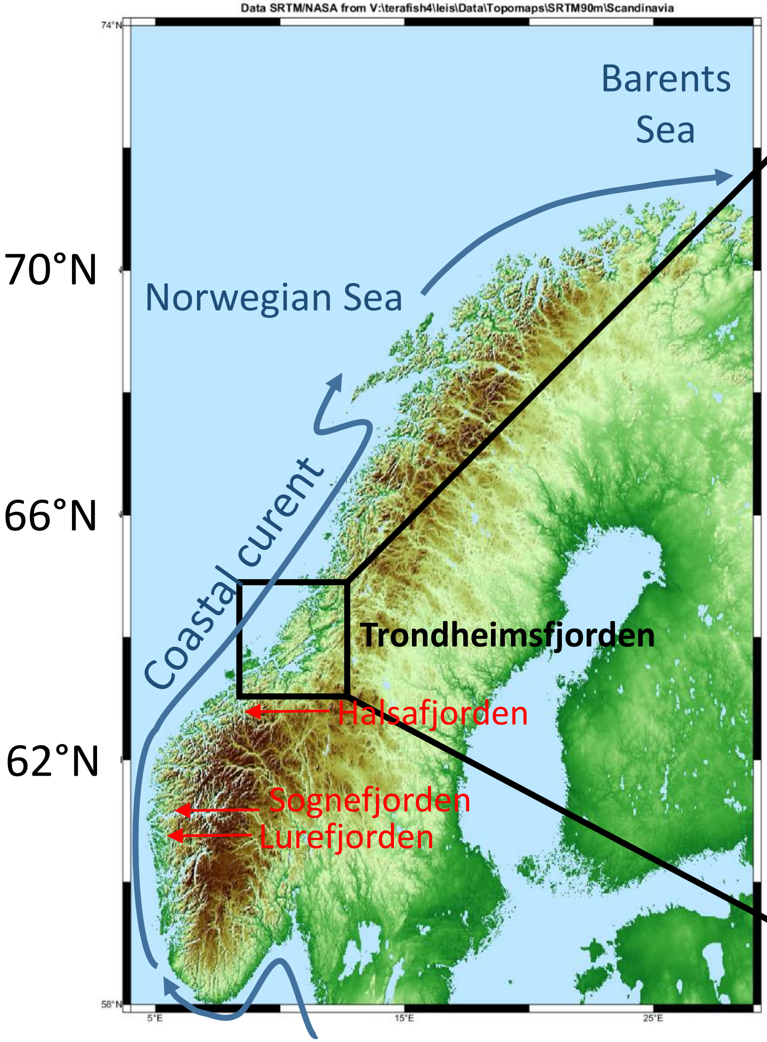
- Obvious from an economic point of view (harvesting yield)

- Ressource management to ensure a bearable and durable harvesting of the plankton stocks

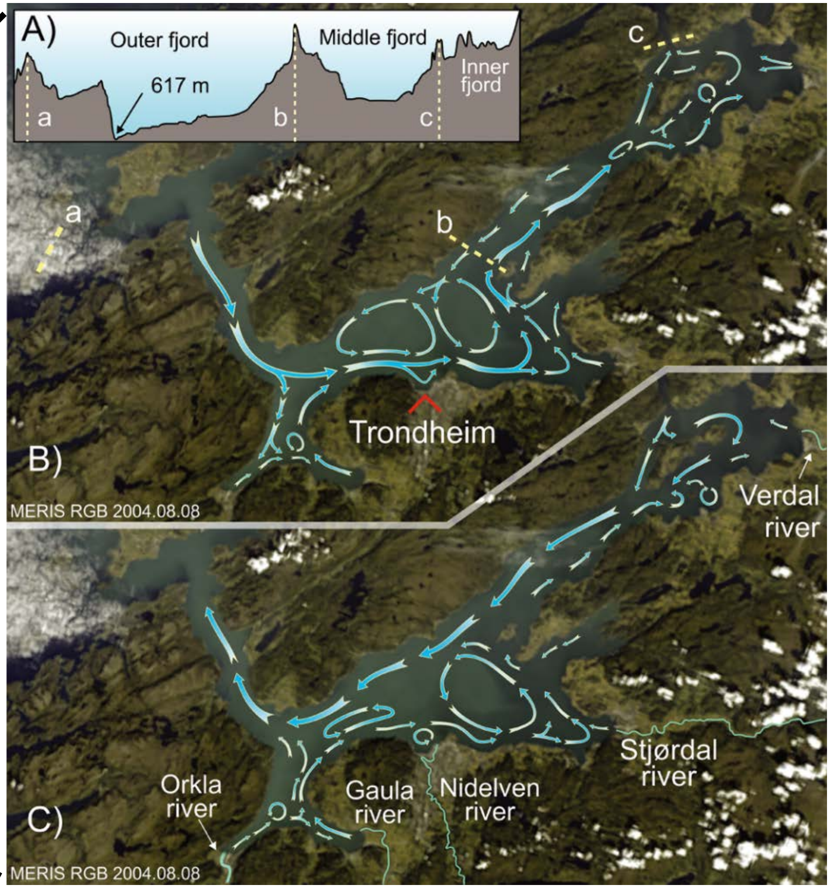
- Interactions (bycatch) between harvesting operations and potential predator species attracked to these areas such planktivorous fishes (herring, sprat, sardine, anchovy), other fish larvae (gadoids, tunas, etc.) and marine mammals

The model domain – case study area

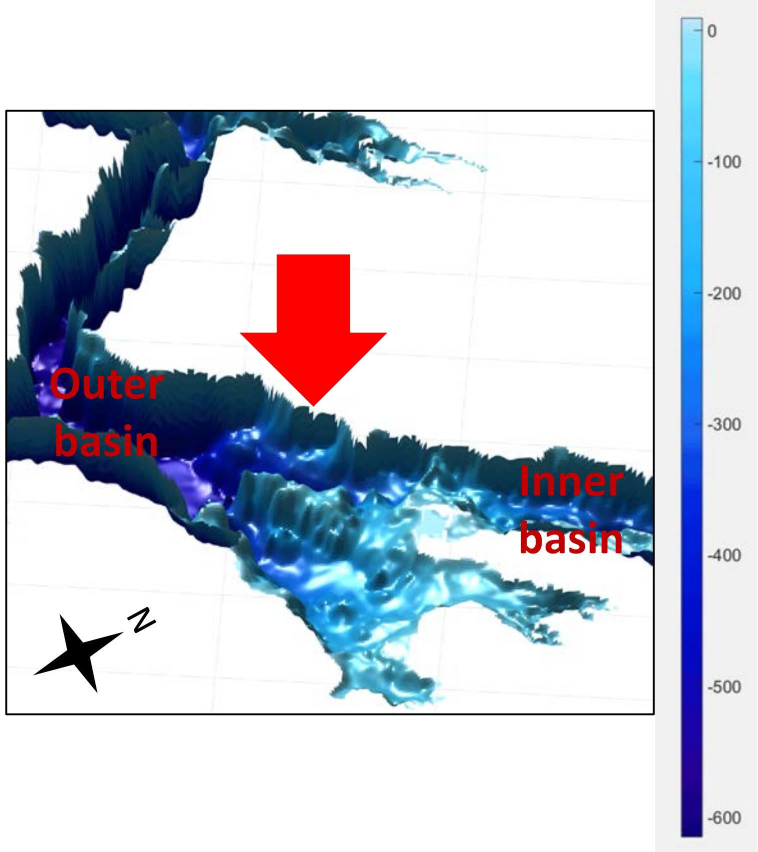
Norwegian Coastline



Trondheim fjord



From Volent et al. (2011)



Model setups

Hydrodynamic forcing

- SINMOD 160m horizontal resolution
- vertical z-layring
- Time step of 40 sec. / 1.3 sec.
- Wind forcing: downscaled ECMWF fields
- Tidal forcing

Eulerian model

- Passive concentration/density field
- Advection within a fixed layer

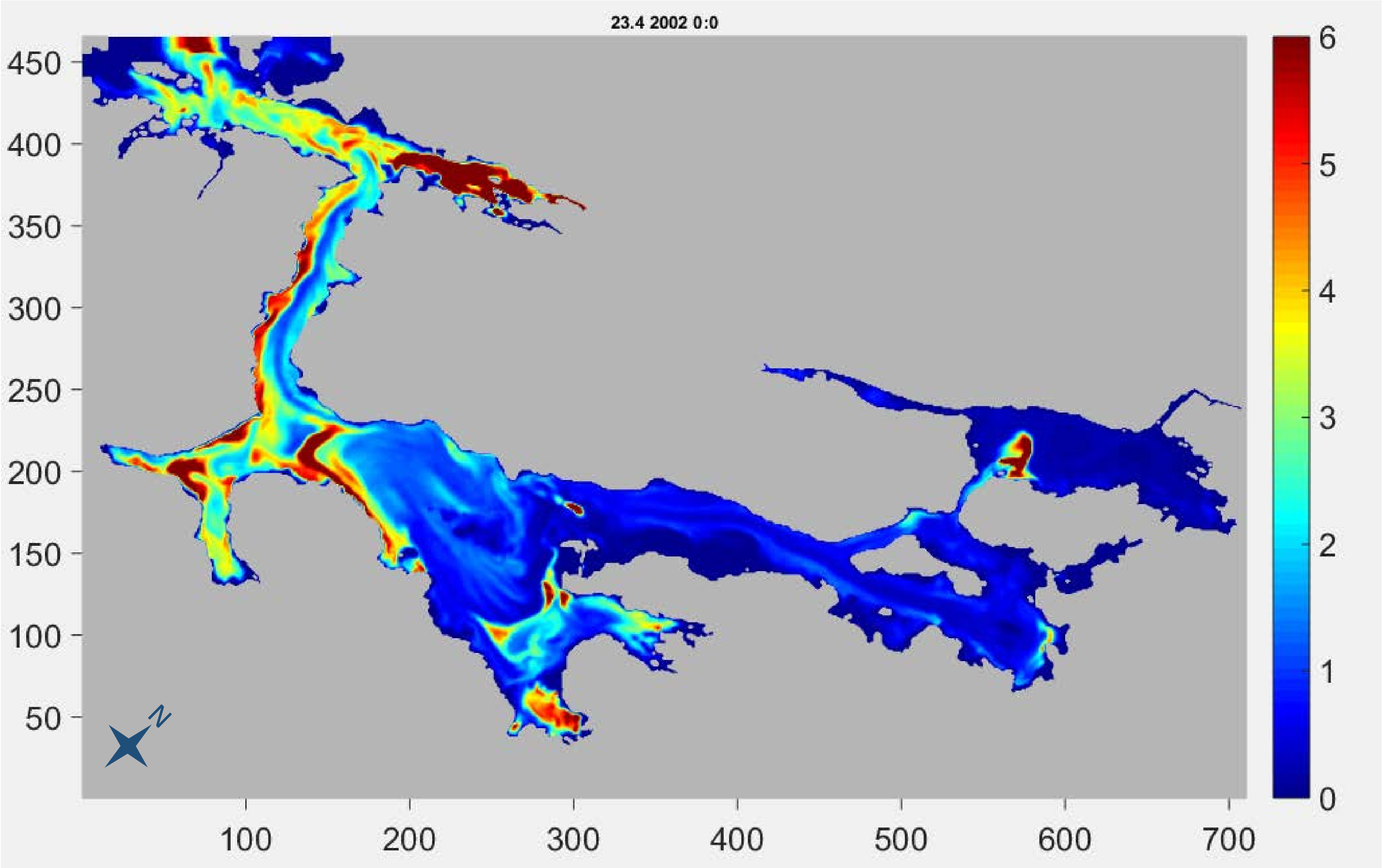
Lagrangian model

- Discrete particles
- Advection

Achieved through vertical re-positionning of individuals advected outside the pre-defined advection layer

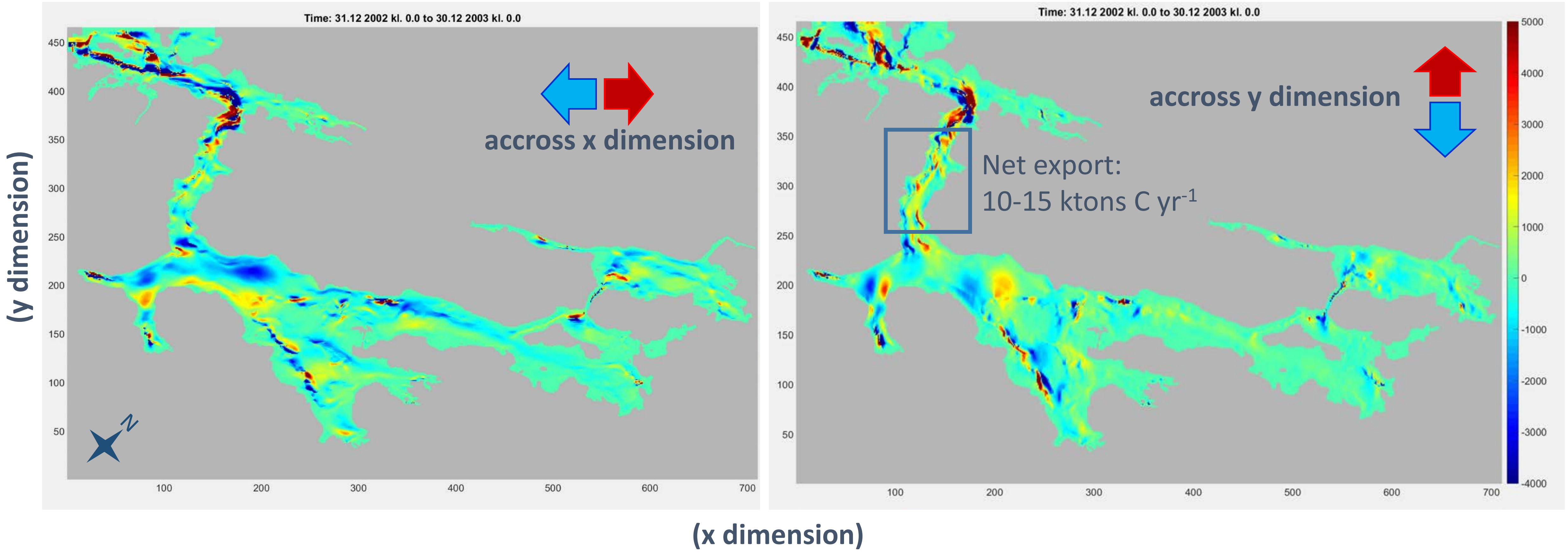
Eulerian production model *C. finmarchicus*

Biomass fields for *C. finmarchicus* (g C m^{-2}) from the SINMOD Ecosystem model



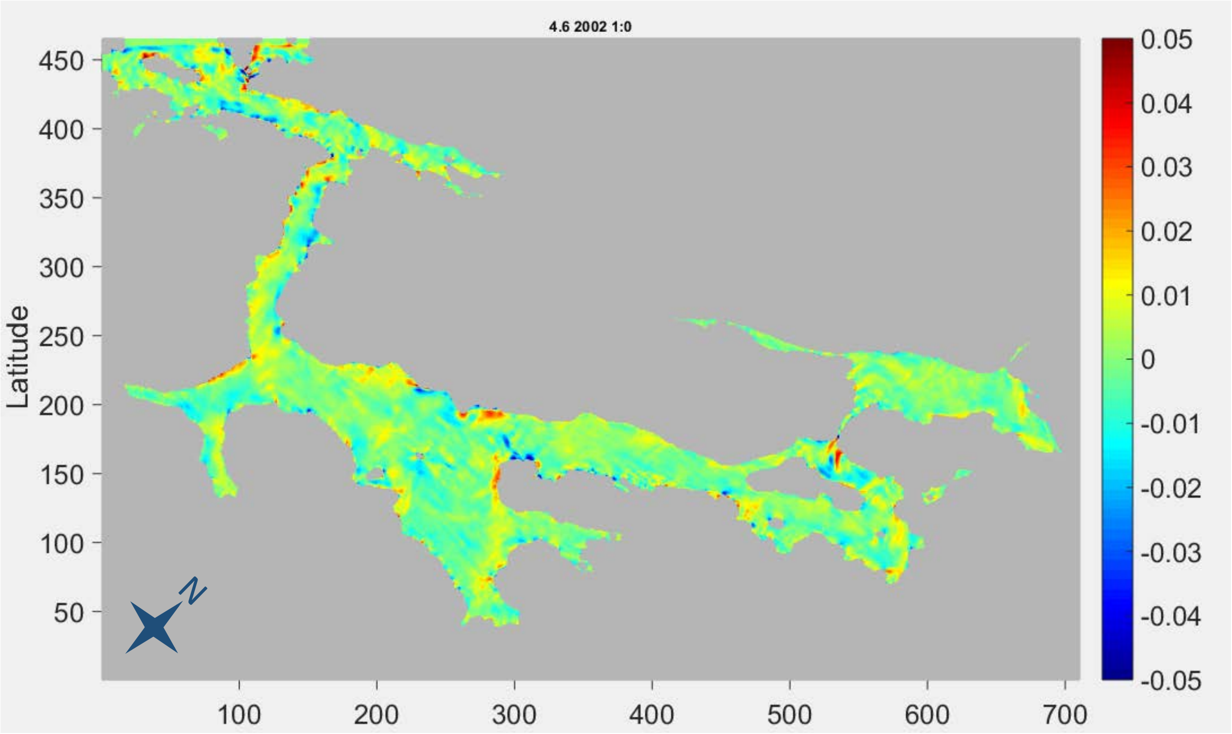
Transport of *C. finmarchicus*

Vertically integrated biomass flux (tons of carbon km^{-1} yr^{-1})

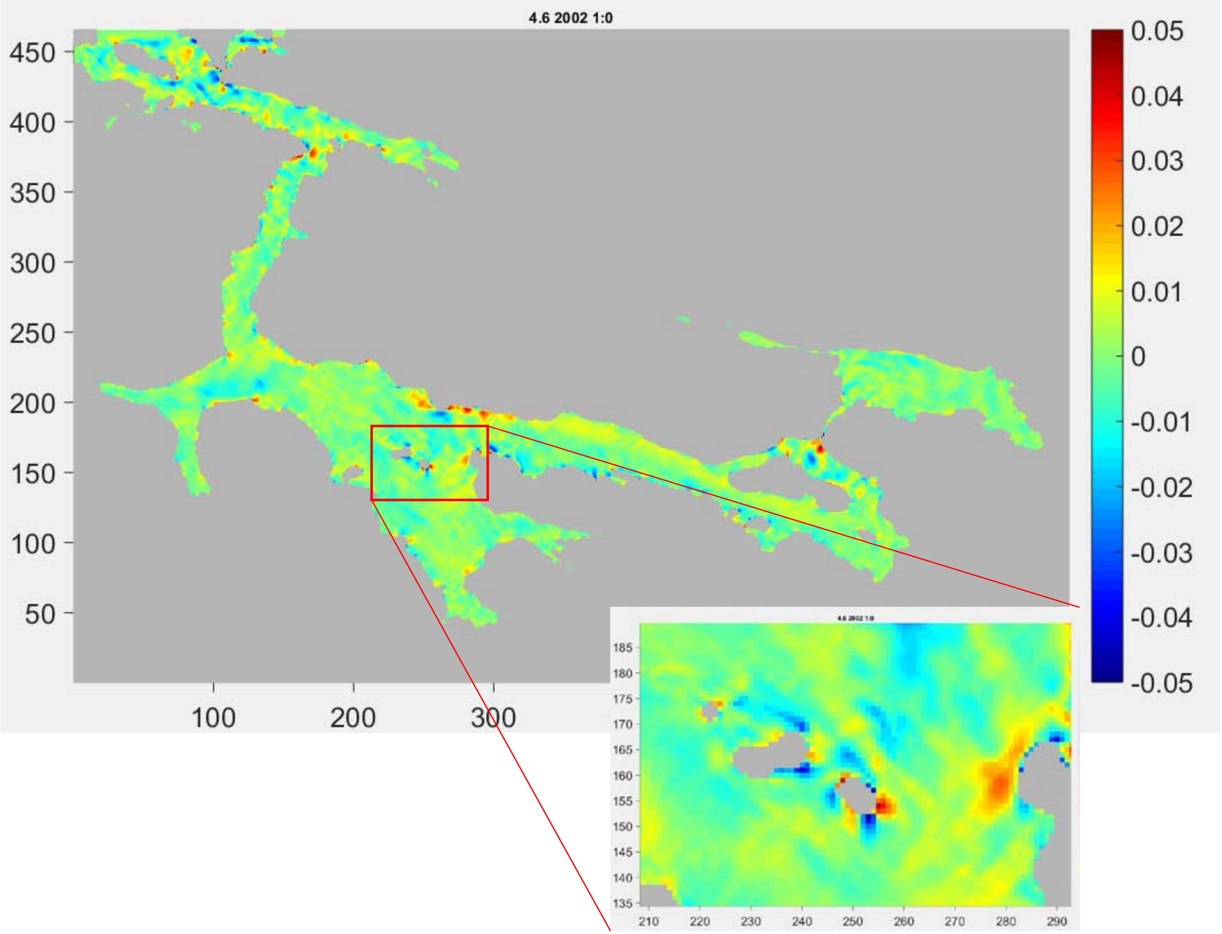


Up- and downwelling locations

Up- and downwelling locations at 15m depth (divergence of horizontal velocity u,v)

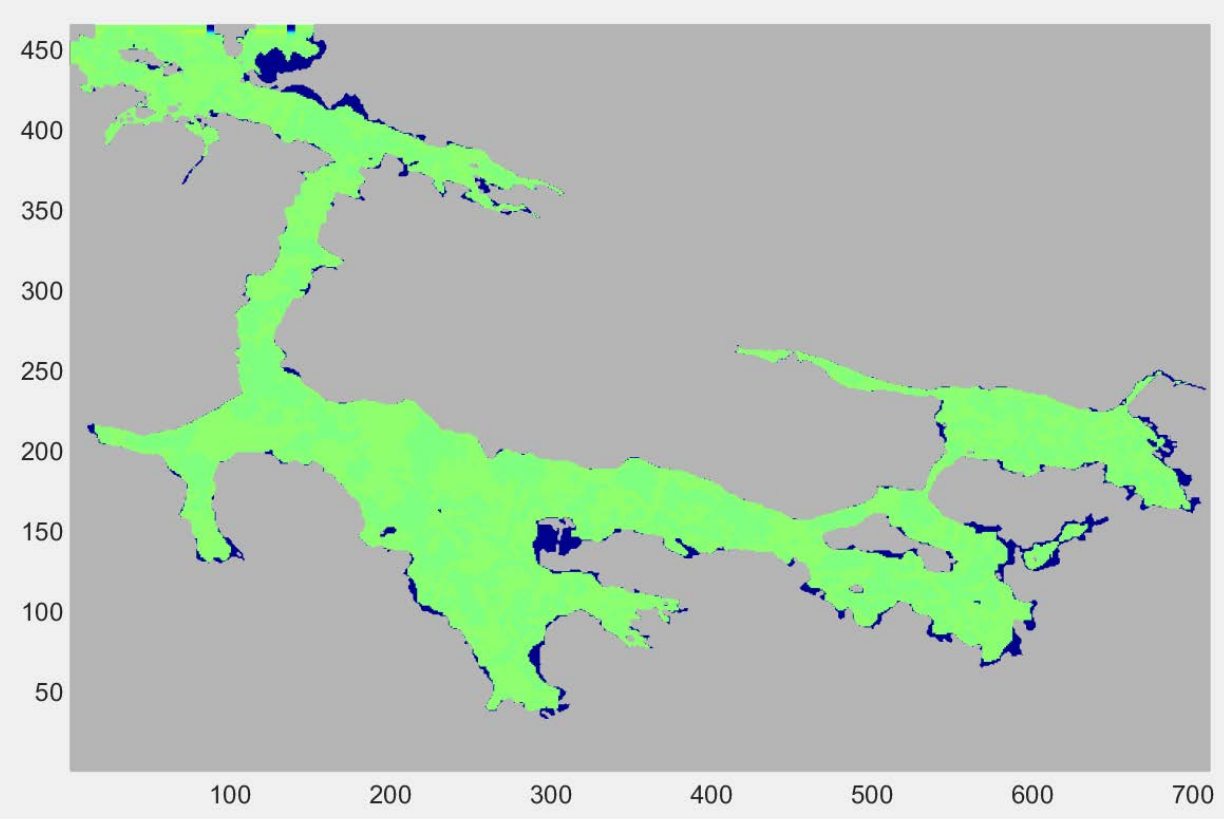


Up- and downwelling locations at 30m depth (divergence of horizontal velocity u,v)



Biomass distributions: Initial conditions

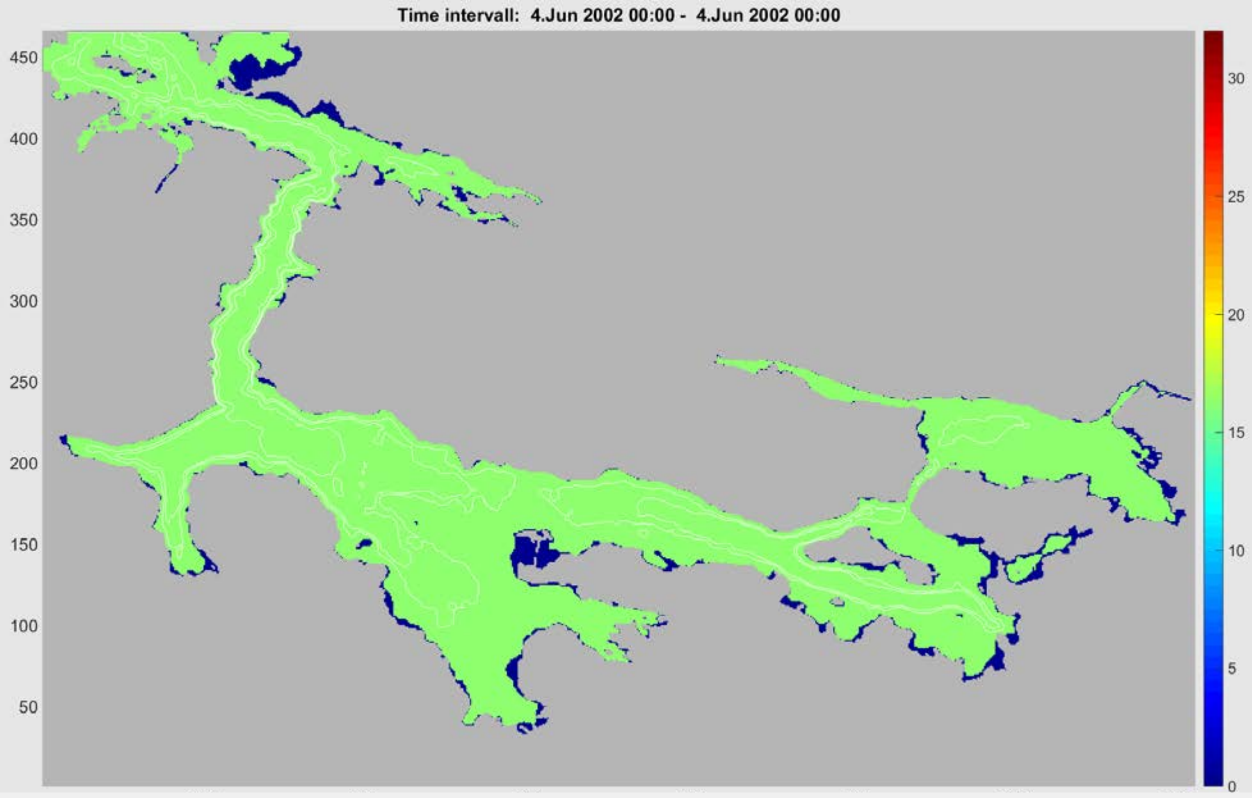
Eulerian model

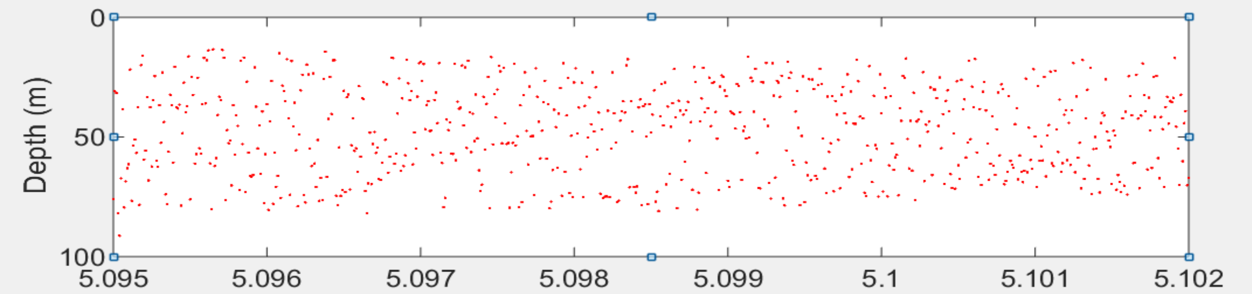


Homogeneous concentration of 16 ind per m^2

Uniform vertical distribution within a defined layer (13-84m)

Lagrangian model (interpolated field)



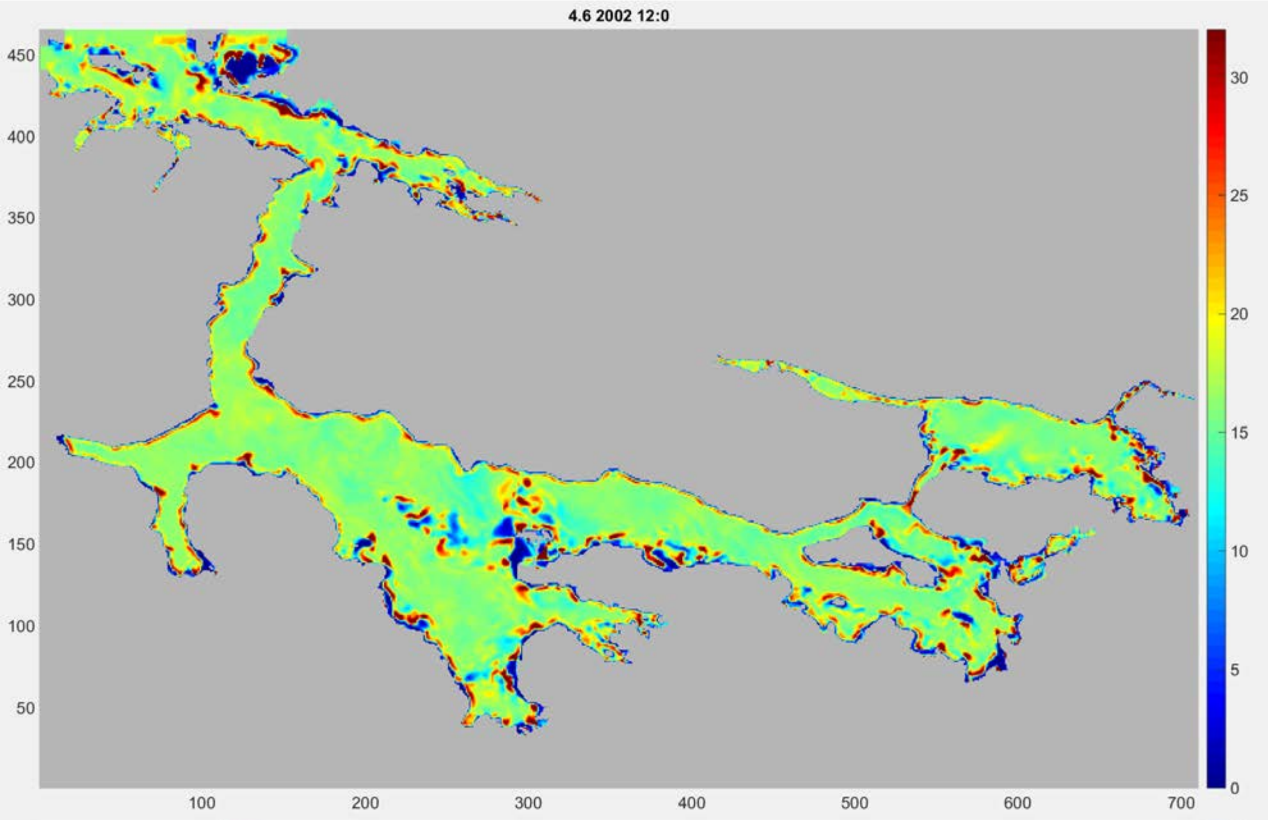


16 particles per 160m x 160 m grid cell

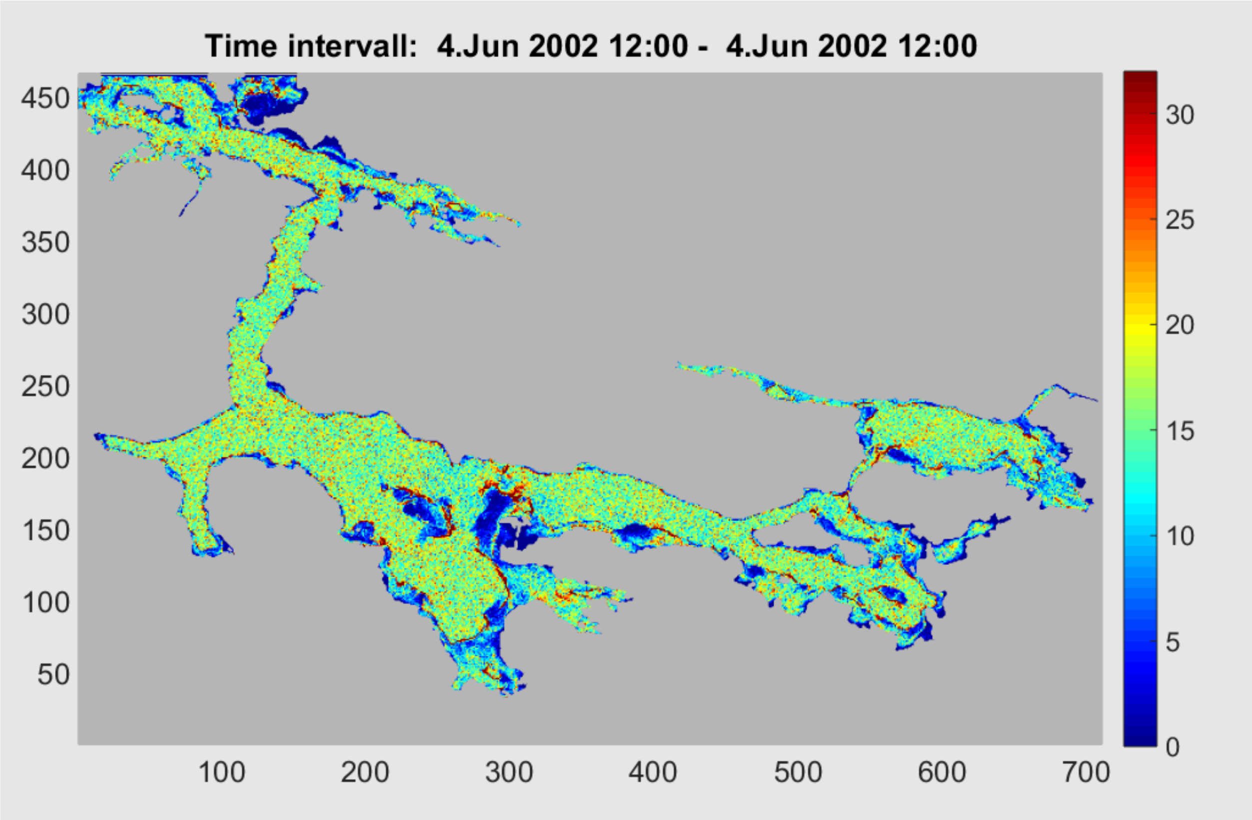
Random vertical distribution within a defined vertical layer

Biomass distributions: After 12h

Eulerian model

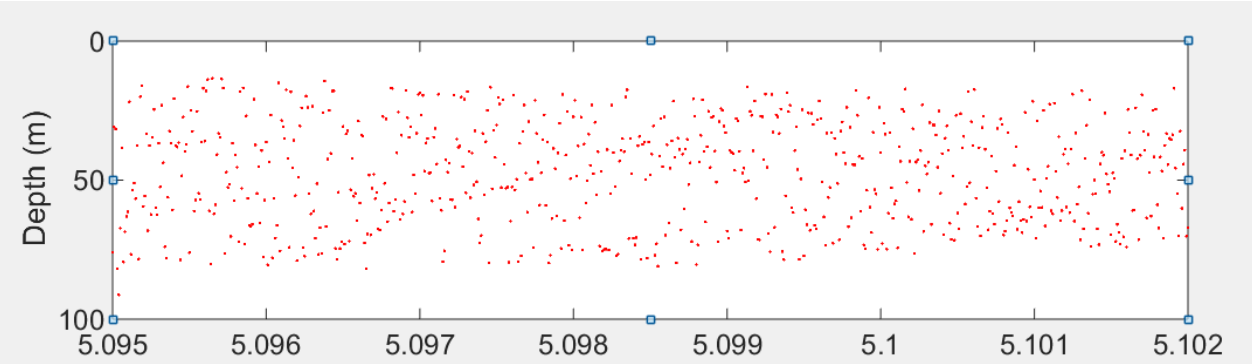


Lagrangian model



Perspectives

Ongoing focus on the diagnostic aspect of interplay between vertical migration patterns and advection



Further applications:
Take realistic biological production simulations from 3D eulerian calanoid copepod fields as initial conditions for simulating highly resolved (time and space) aggregation for different situations:

- Stage differenciated simulations
- Seasonal variations of the stock
- Locations (upwelling – downwelling)
- Wind situations (further exploring wind-induced)
- Internal waves
- Light conditions (irradiance) in coastal areas
- Interactions (time and space) with larval fish migration and foraging

Thank you for your attention!

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