Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

Inter-basin exchange in the Azov-Black-Marmara-Mediterranean Seas system: unstructured-grid modeling

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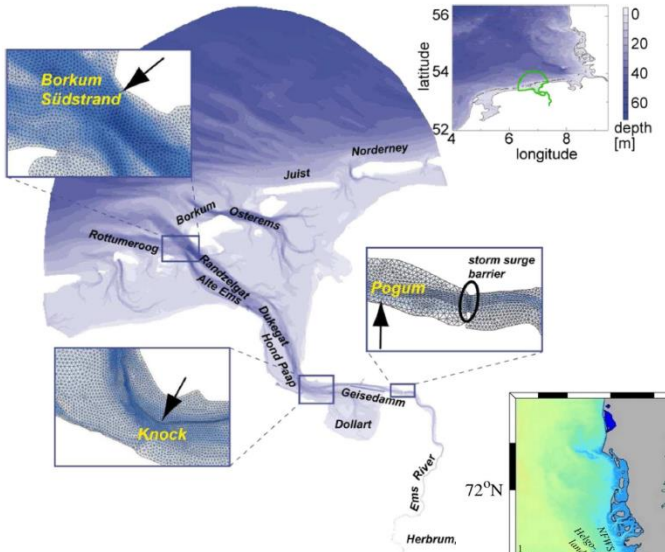
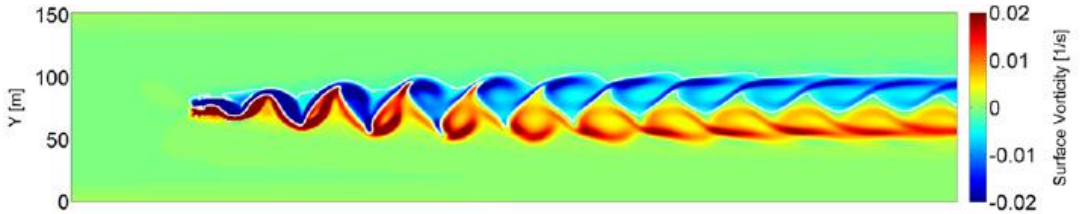
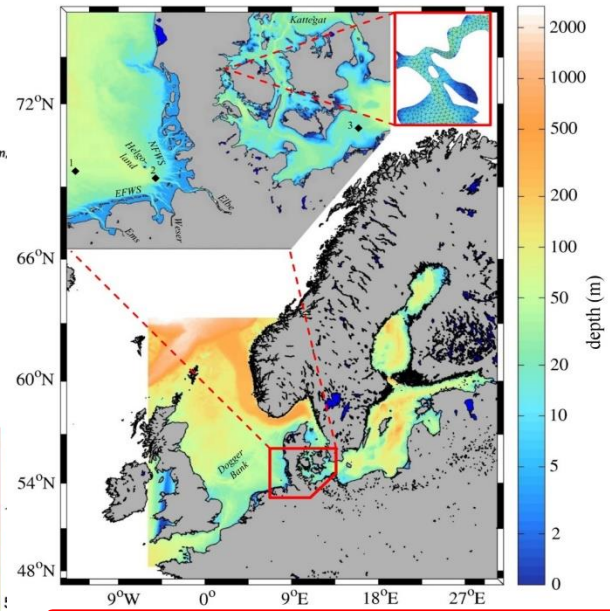
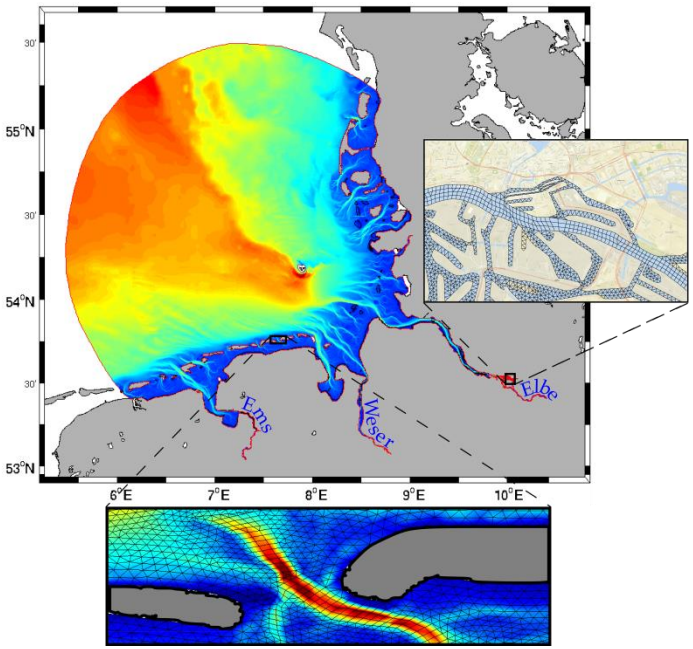
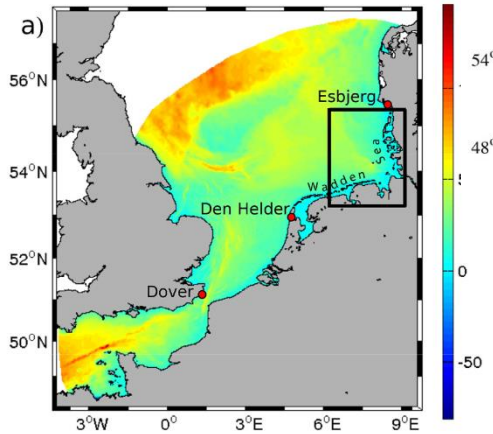
Seamless modelling (our model areas) … and the model is SCHISM

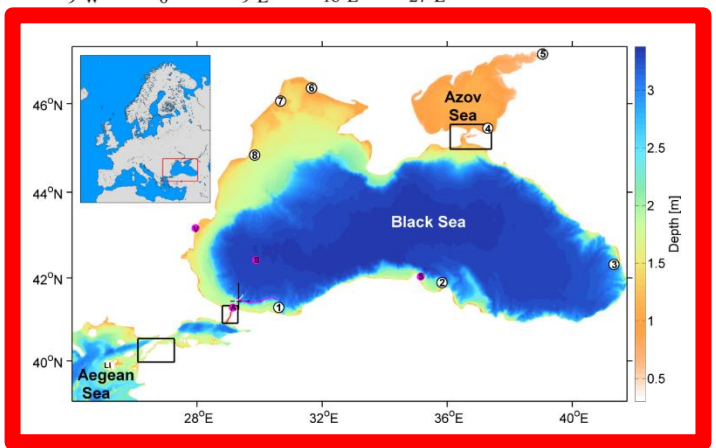












Grashorn, S. and E.V. Stanev (2016)
Pein et al. (2014;2016)
Jacob, B., E. V. Stanev, Y.J. Zhang (2016)
Zhang, Y.J., E.V. Stanev, S. Grashorn (2016a, b)
Jacob and Stanev (2016)
Schloen, J., E. V. Stanev, S. Grashorn (2017)
Stanev, Grashorn and Zhang (2017)

The model

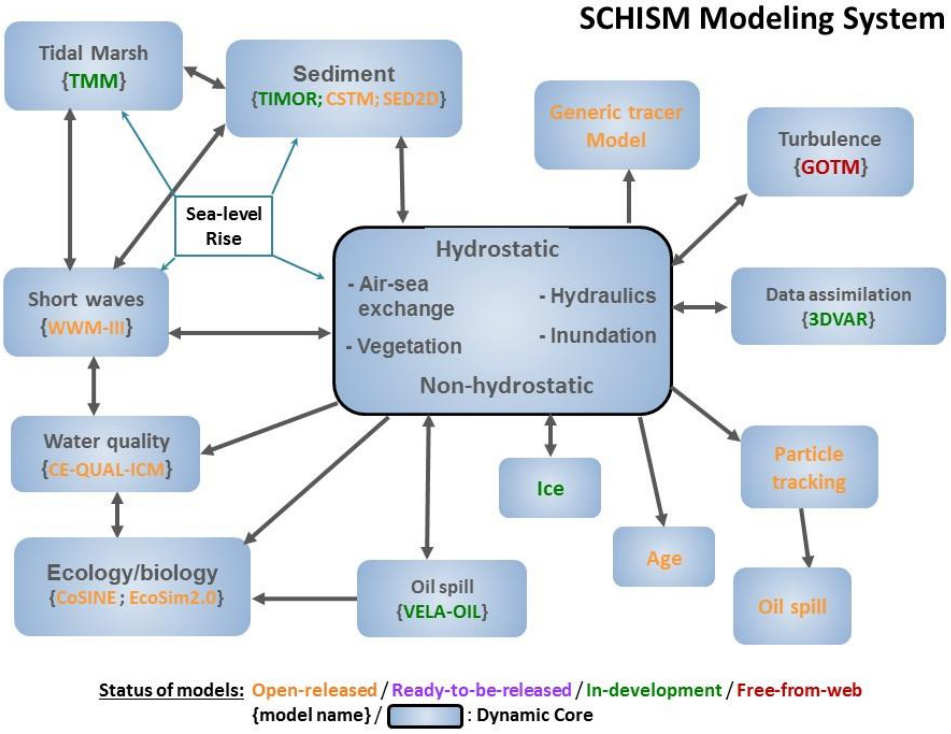
Semi-implicit Cross-scale Hydroscience Integrated System Model; www.schism.wiki

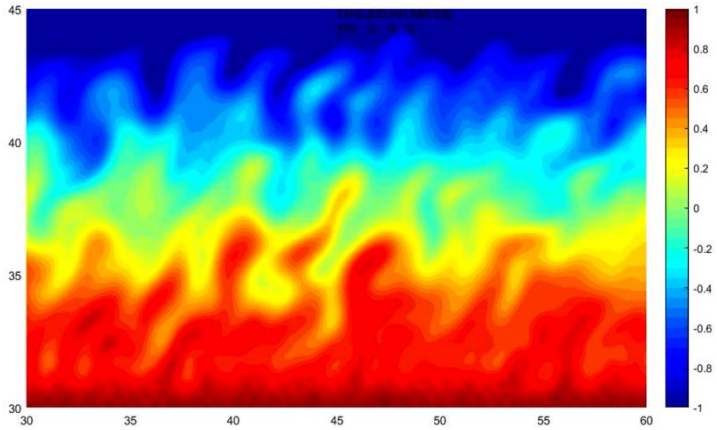
3D, primitive equations, unstructured-grid.

- Upgrade from an existing model (SELFE, A Semi-implicit Eulerian-Lagrangian Finite Element model for cross-scale ocean circulation).

- Uses hybrid finite element and finite volume approach.

- New viscosity formulation (effectively filters out spurious modes without introducing excessive dissipation).





- New higher-order implicit advection scheme for transport (TVD^2) is proposed to effectively handle a wide range of Courant numbers

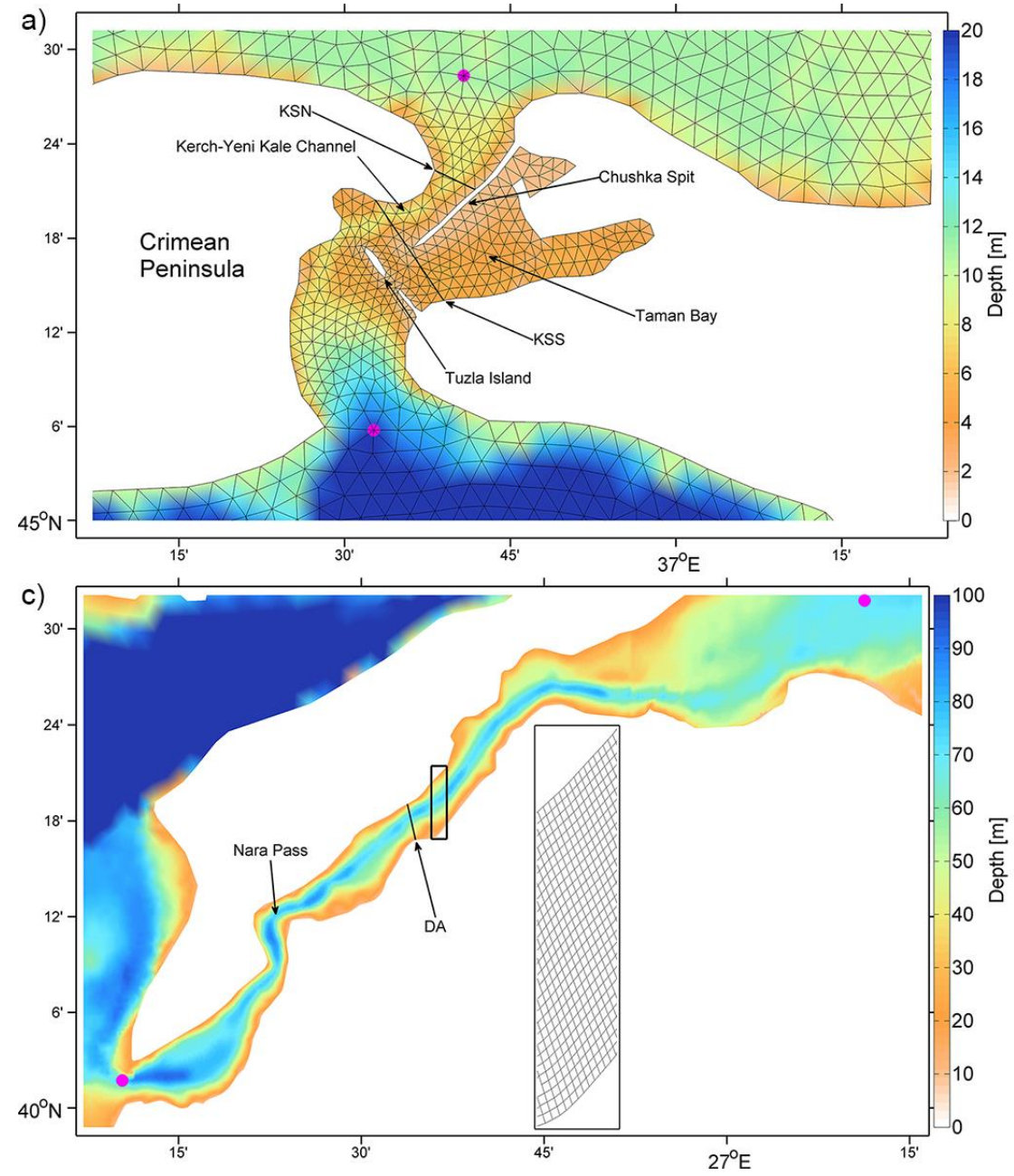
- Addition of quadrangular elements into the model

- Flexible vertical grid system (Zhang et al. 2015, OM)

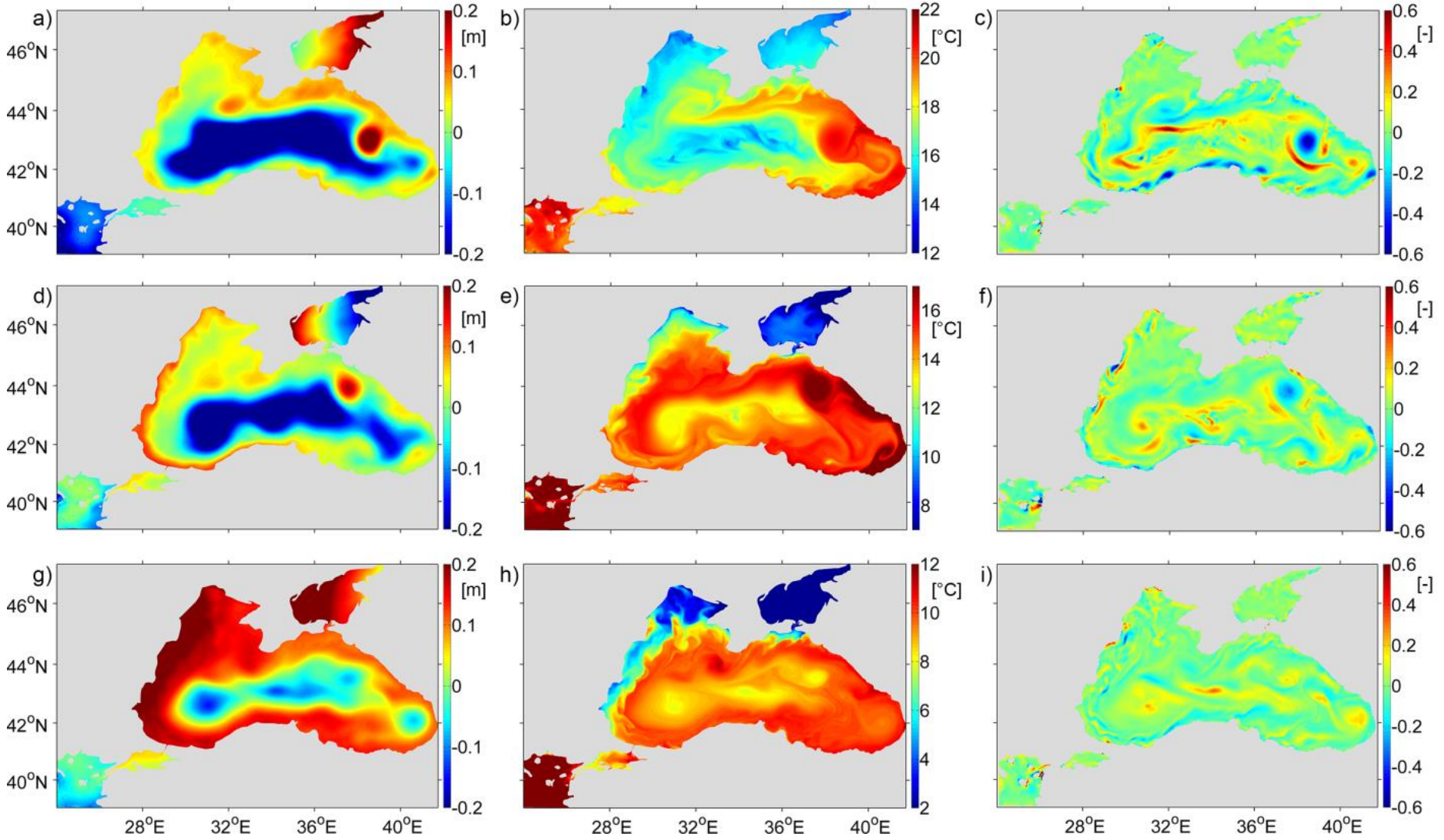
- Model polymorphism that unifies 1D/2DH/2DV/3D cells in a single model grid.

Zhang Y.J., F. Ye, E. V. Stanev, and S. Grashorn (2016a): Ocean Modelling.

The Black Sea Straits



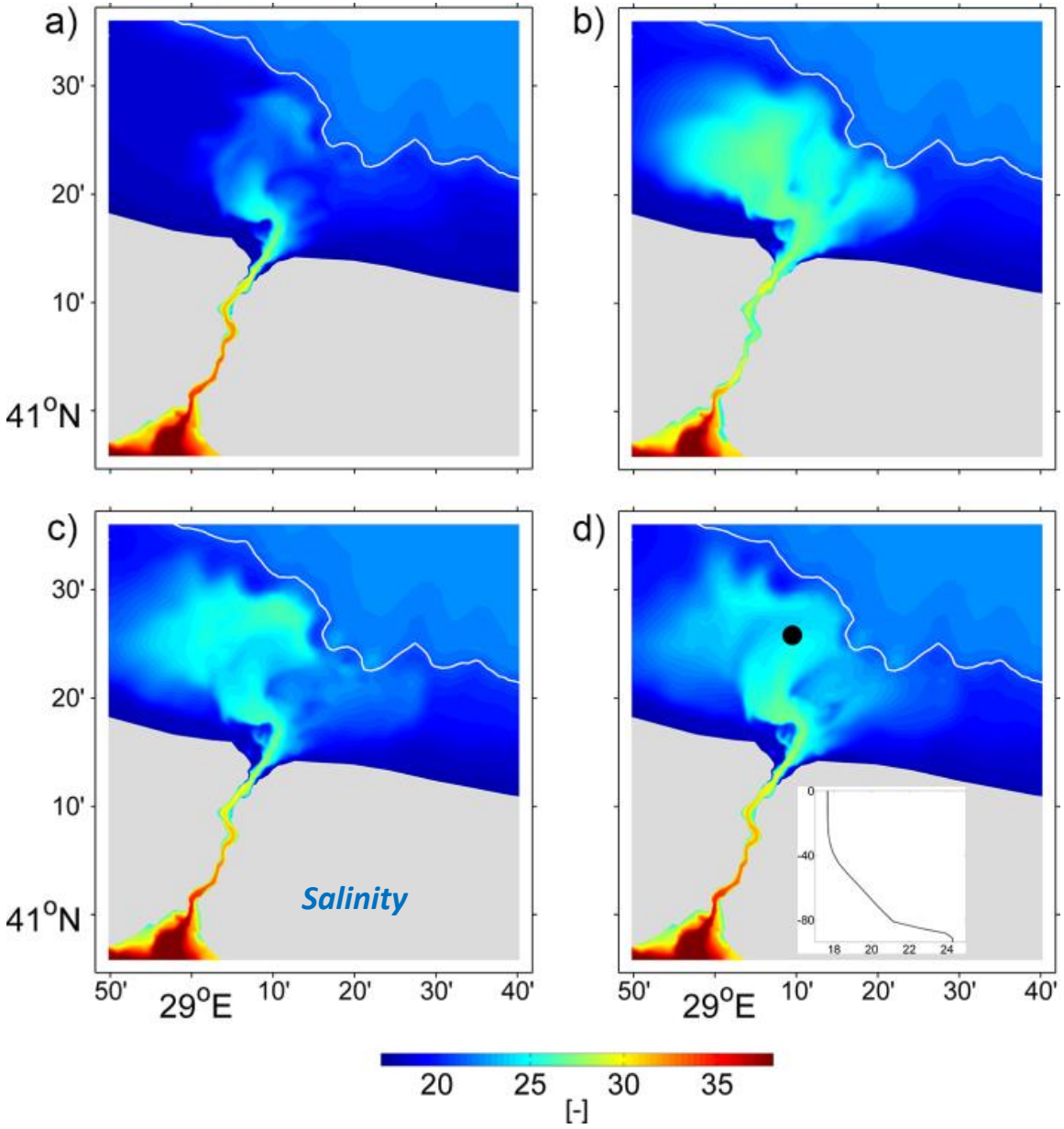
The Black Sea model:
~104K nodes and ~178K triangles/quadrangles with a minimum grid side length of ~80m, coarsest resolution ~3km, 53 levels in the deepest parts of the Black Sea



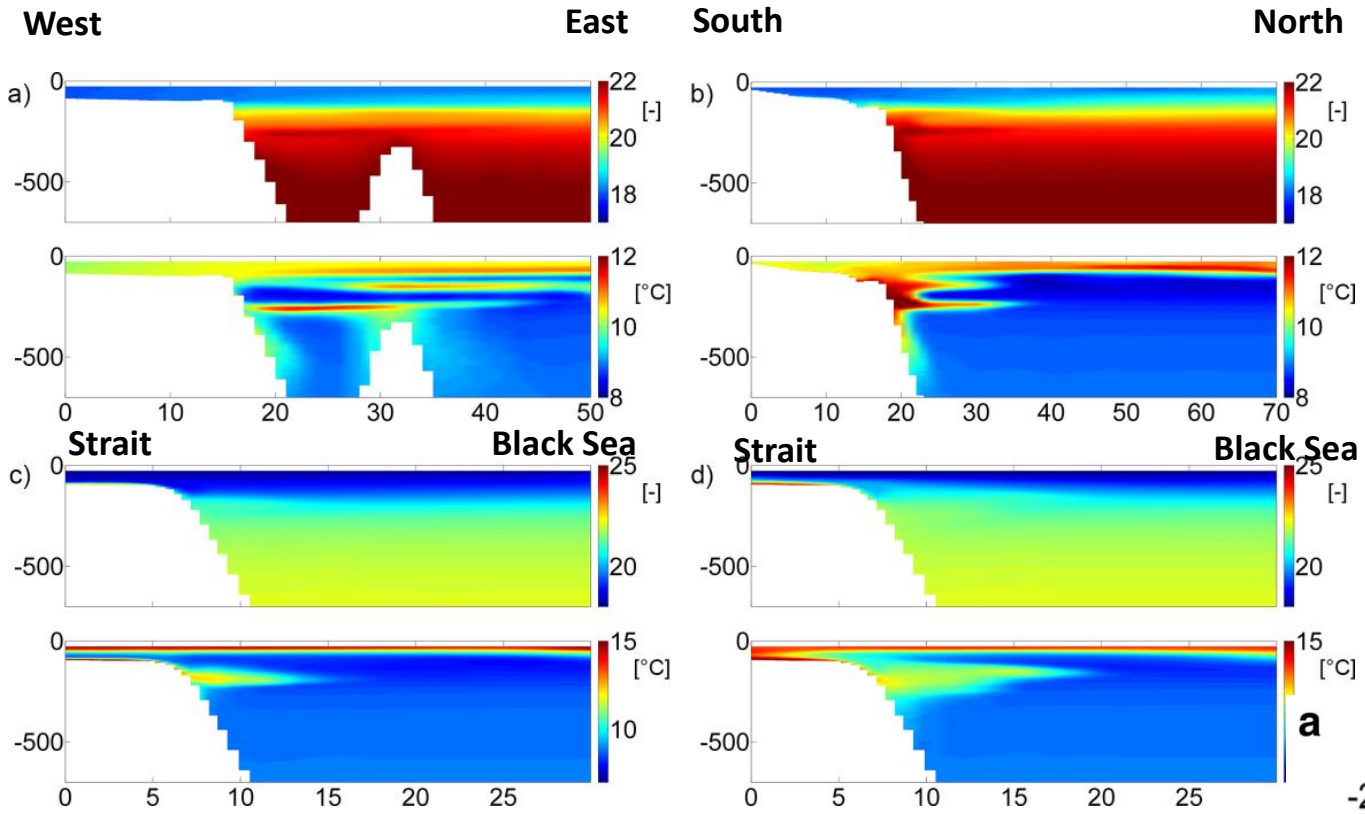
Sea level (a, d, g), SST (b, e, h) and relative vorticity at sea surface normalized by the Coriolis parameter (c, f, i). (a, b, c) corresponds to 08-Oct-2008, (d, e, f) to 12-Nov-2008, and (g, h, i,) to 22-Jan-2009. Note that the SST colorbars have different ranges.

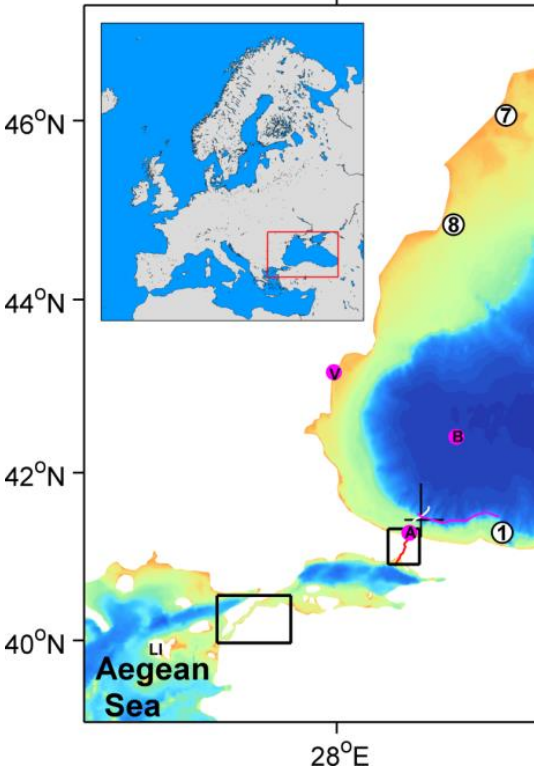
Bosporus Strait

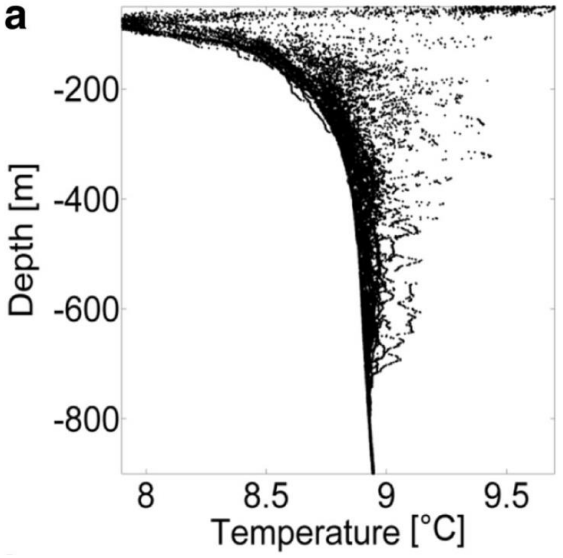
Bottom arrested plume



Salinity during the inflow event in November 2008. White isoline is the 250m isobath. The individual frames correspond to 00:00 GMT on(a) Nov. 21, 2008, (b) Nov. 23, 2008, (c) Nov. 25, 2008 and (d) Nov. 27, 2008.

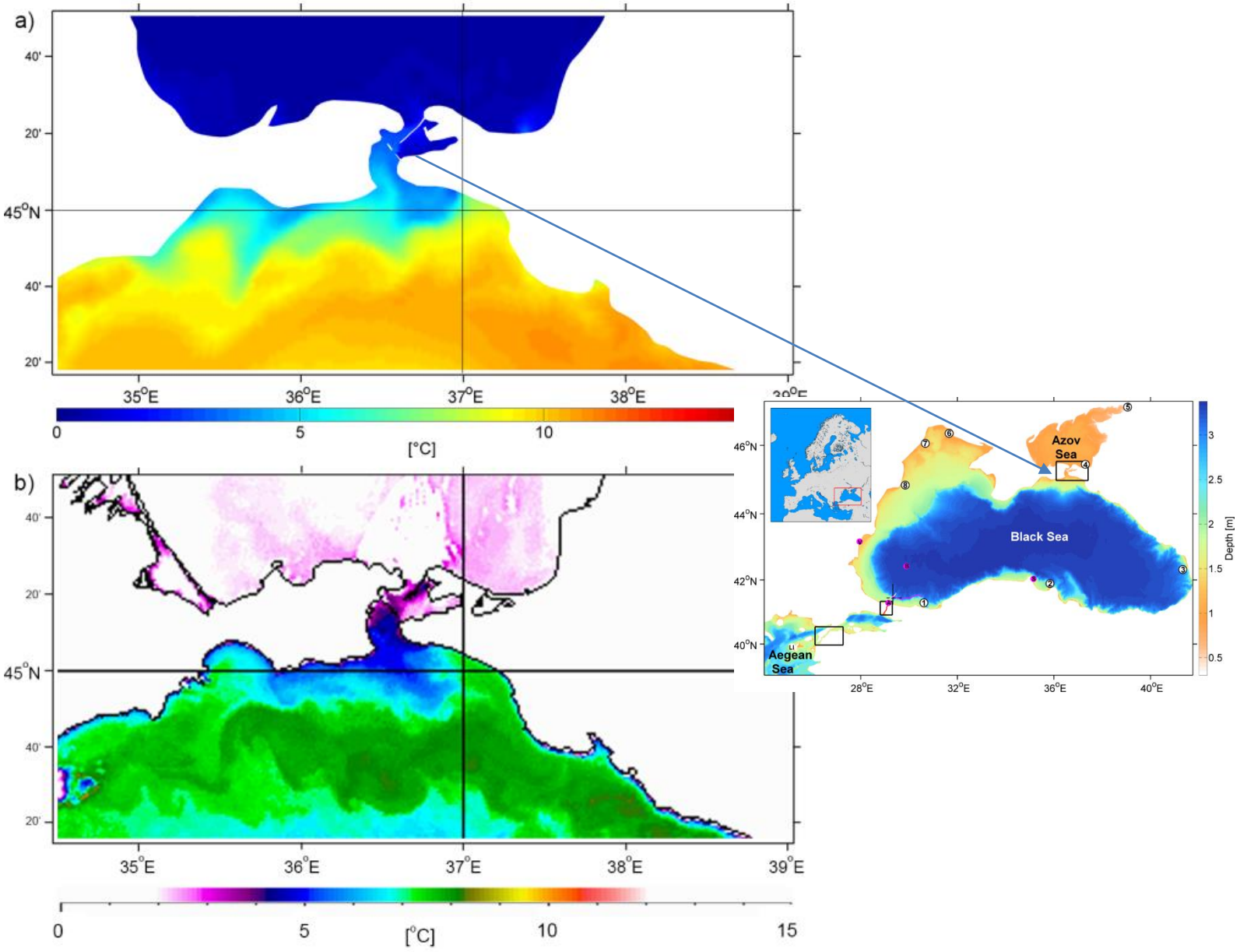




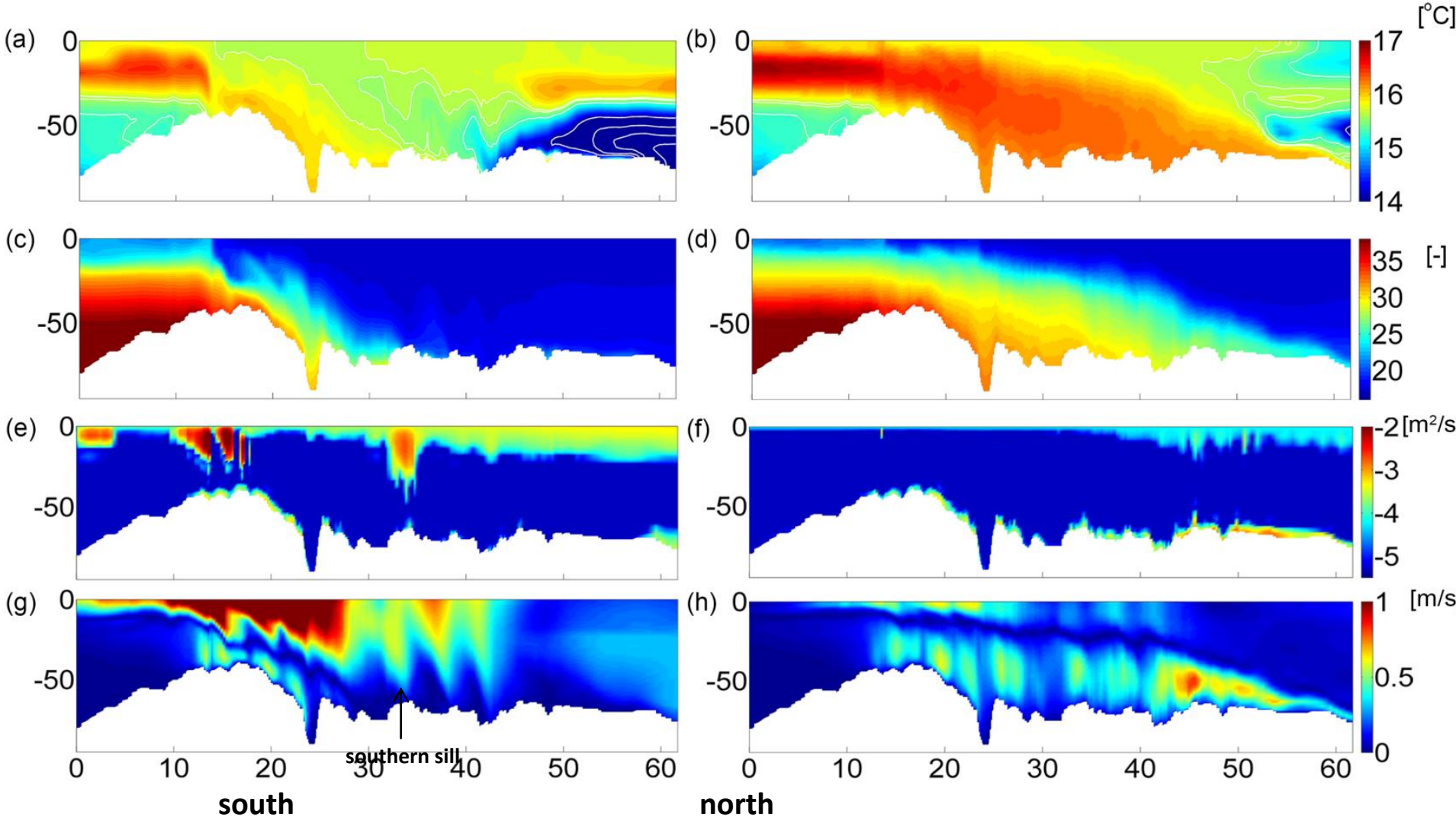


a) zonal salinity and temperature cross-sections on January 9, 2009;
b) is the same but for a meridional section on January 4, 2009;
(c and d) are plotted along the red line in Fig. 1 near the exit of the Strait on November 8, 2008 and November 26, 2008

Surface Plume

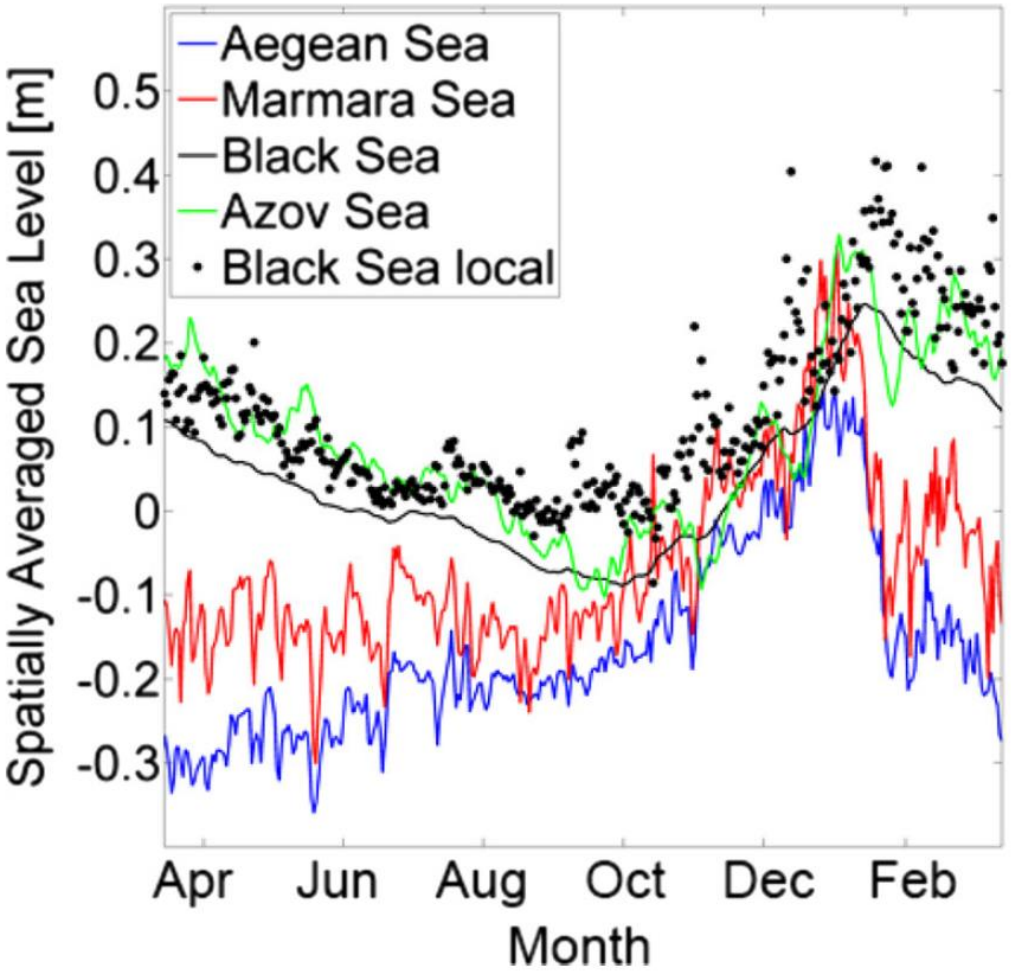


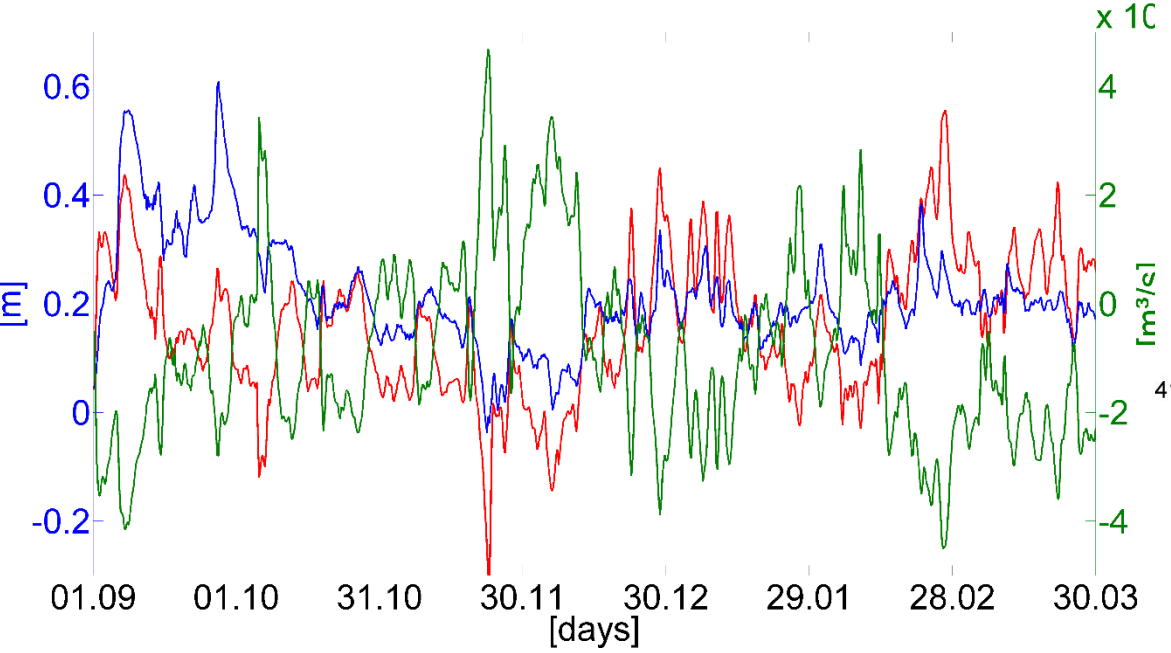
SST, Kerch Strait (model versus AVHRR)

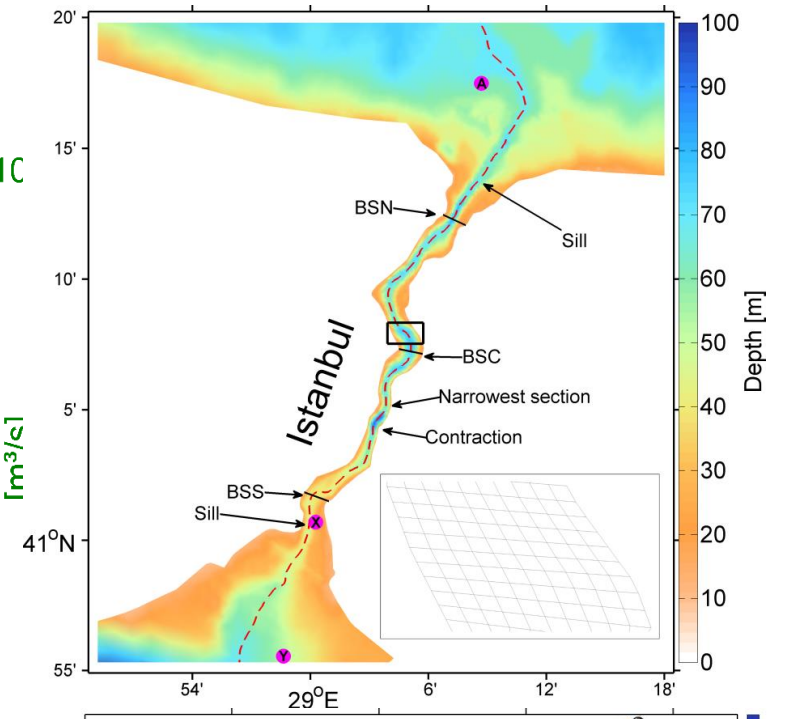


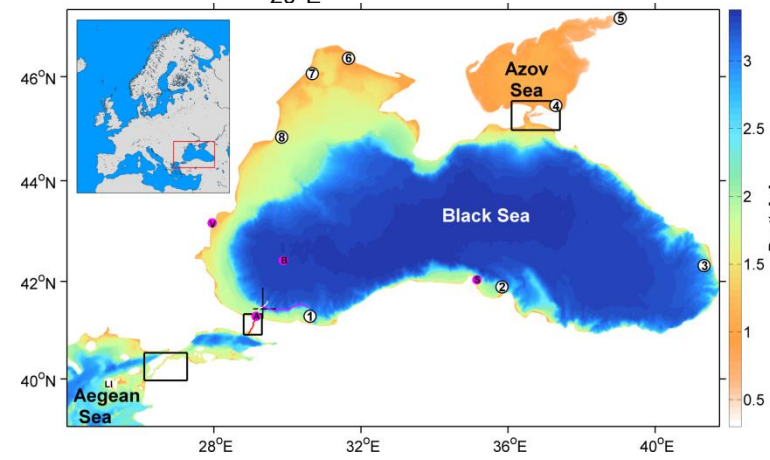
Along-Bosphorus-Strait transects at 12:00, 2008-10-26 (a, c, e, g) and at 00:00, 2008-11-02 (b), (d), (f), (h).

The following isolines are plotted in (a) and (b) to better represent the mixing of cold intermediate water in the strait: 11, 12, 13, 14, 15.30, 15.57 and 15.65 °C.


Aegean Sea
Marmara Sea
Black Sea
Azov Sea
Black Sea local
Spatially Averaged Sea Level [m]
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
Apr
Jun
Aug
Oct
Dec
Feb
Month



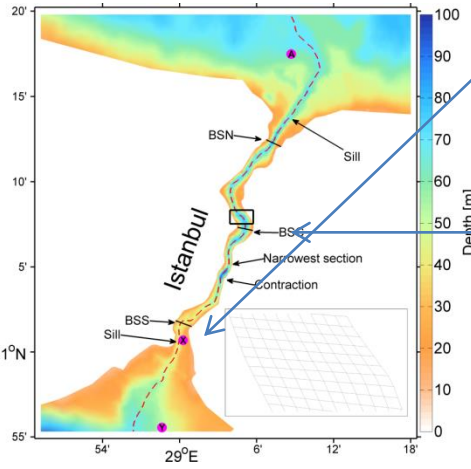


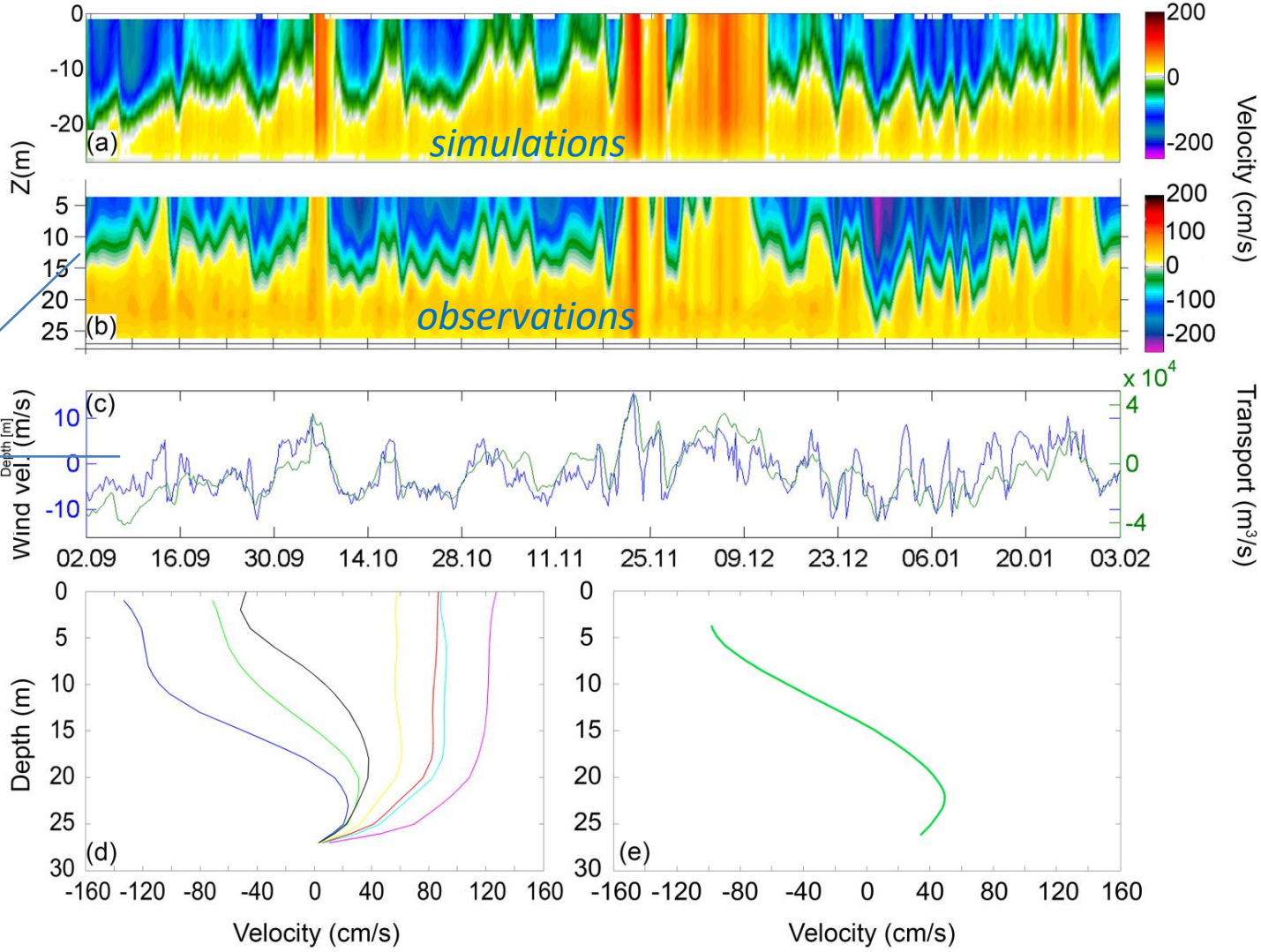


green: the total transport across the section BSC.
blue: the difference between surface elevations at locations A and B (in the open sea)
red: the difference between sea levels at locations A and Y (at the two ends of the strait)

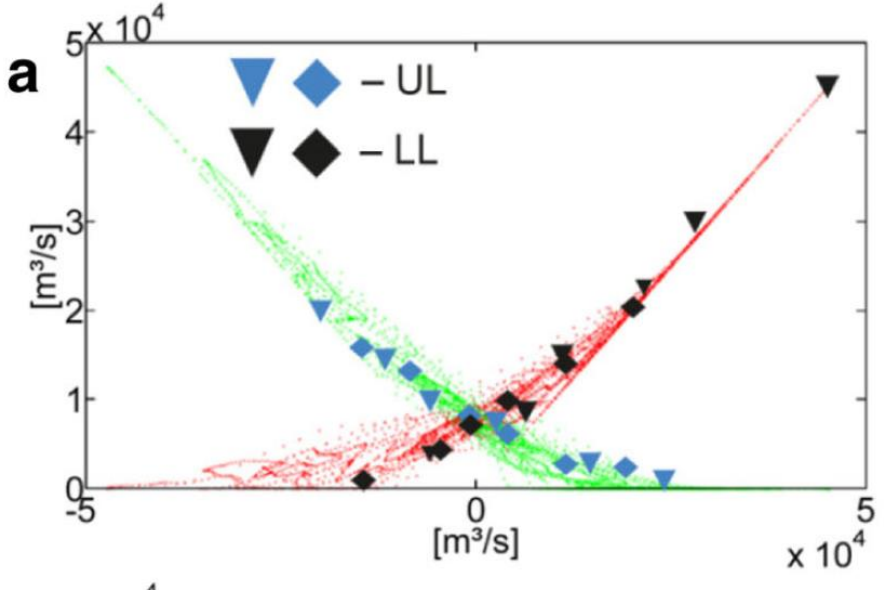
Bosporus Strait

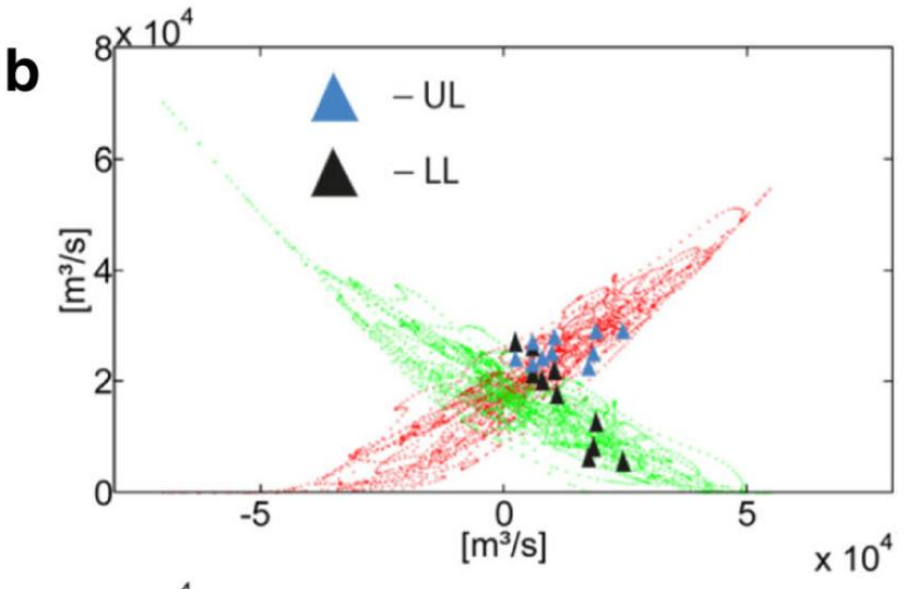
positive towards the Black Sea



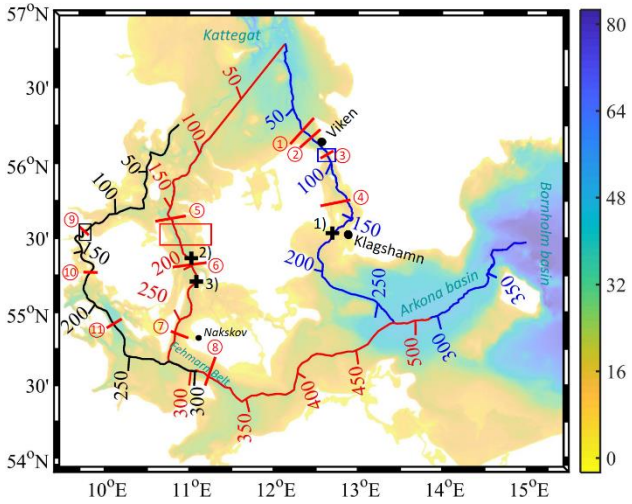


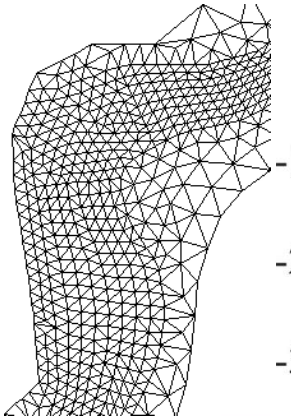
The individual lines in (d) correspond to: red: 06.10.08 00:00, blue: 26.10.08 12:00, black: 02.11.08 00:00, magenta: 22.11.08 18:00, cyan: 06.12.08 00:00, yellow: 21.01.09 00:00. The green lines in (d) and (e) show time averaged profiles for the period in (a-b).

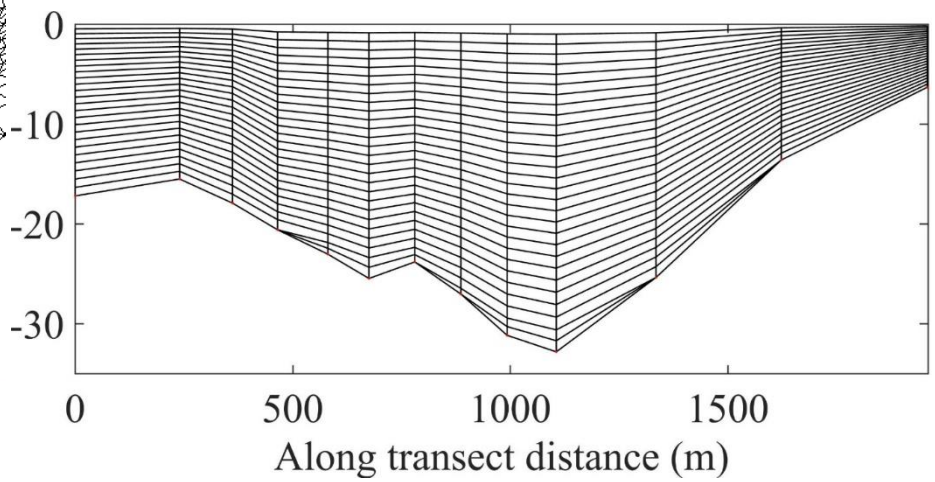

a
x 10^4
5
4
3
2
1
0
– UL
– LL
[m³/s]
-5
0
5
[m³/s]
x 10^4

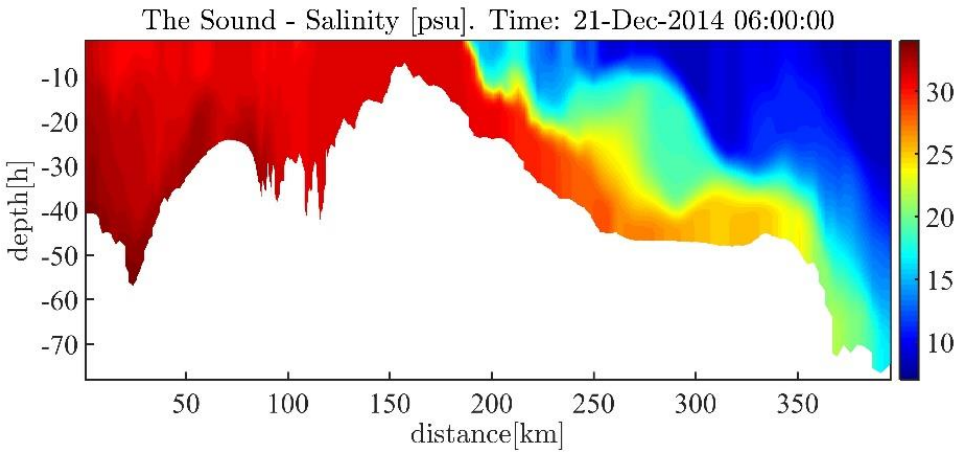

b
x 10^4
8
6
4
2
0
– UL
– LL
[m³/s]
-5
0
5
[m³/s]
x 10^4

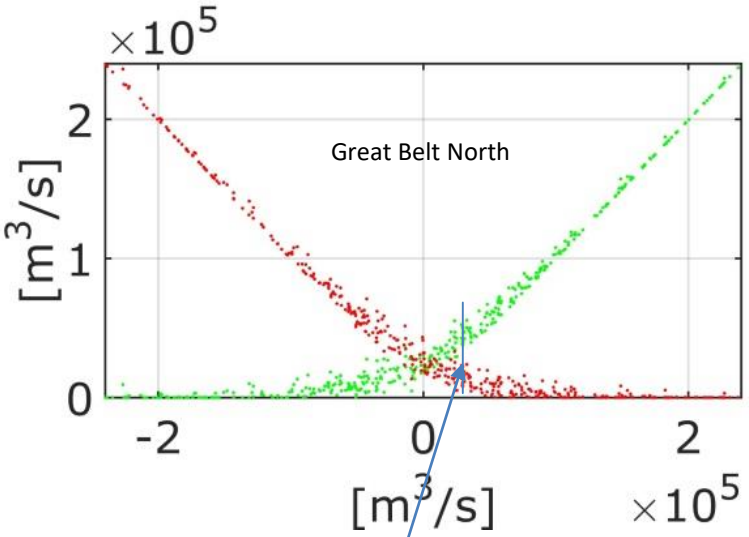
Other similar ocean cases: The Baltic Sea











Multiple States&non/unique bahavior

Conclusions:

Think about seamless forecasting

for

process studies

- *interbasin exchange*
- *climate*

and operational use

- *improving skills of ocean forecasting*
- *downstream services*
- *coastal and estuarine predictions (interfaces).*