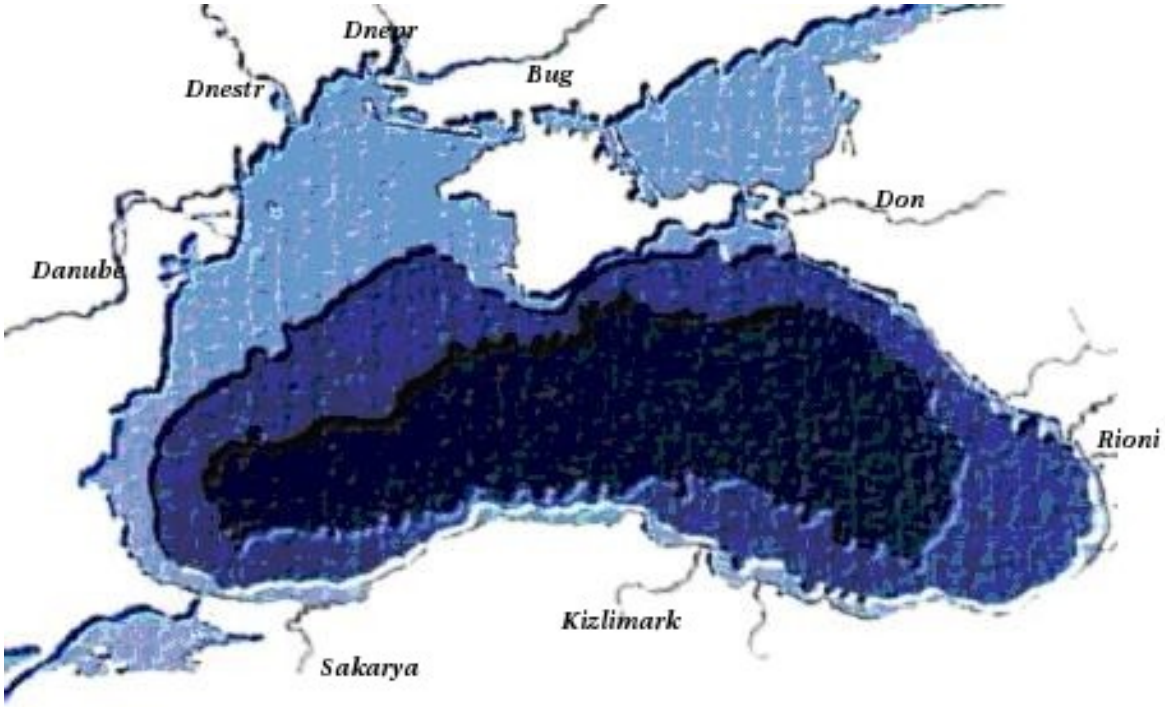
3D modelling of Black Sea North western shelf



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Université de Liège

MARE
INTERFACULTARY CENTER FOR MARINE RESEARCH - LIEGE UNIVERSITY

PERSEUS
POLICY-ORIENTED MARINE ENVIRONMENTAL RESEARCH IN THE SOUTHERN EUROPEAN SEAS

SESAME
rn European Seas: Assessing and Modelling Ecosystem chan

GHER
GeoHydrodynamics and Environment Research

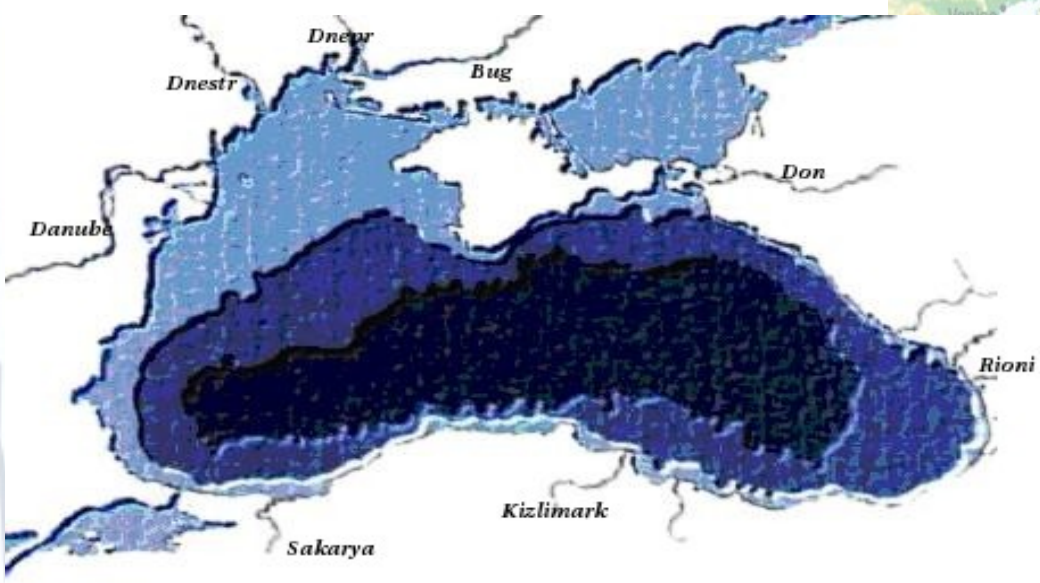
FNRS

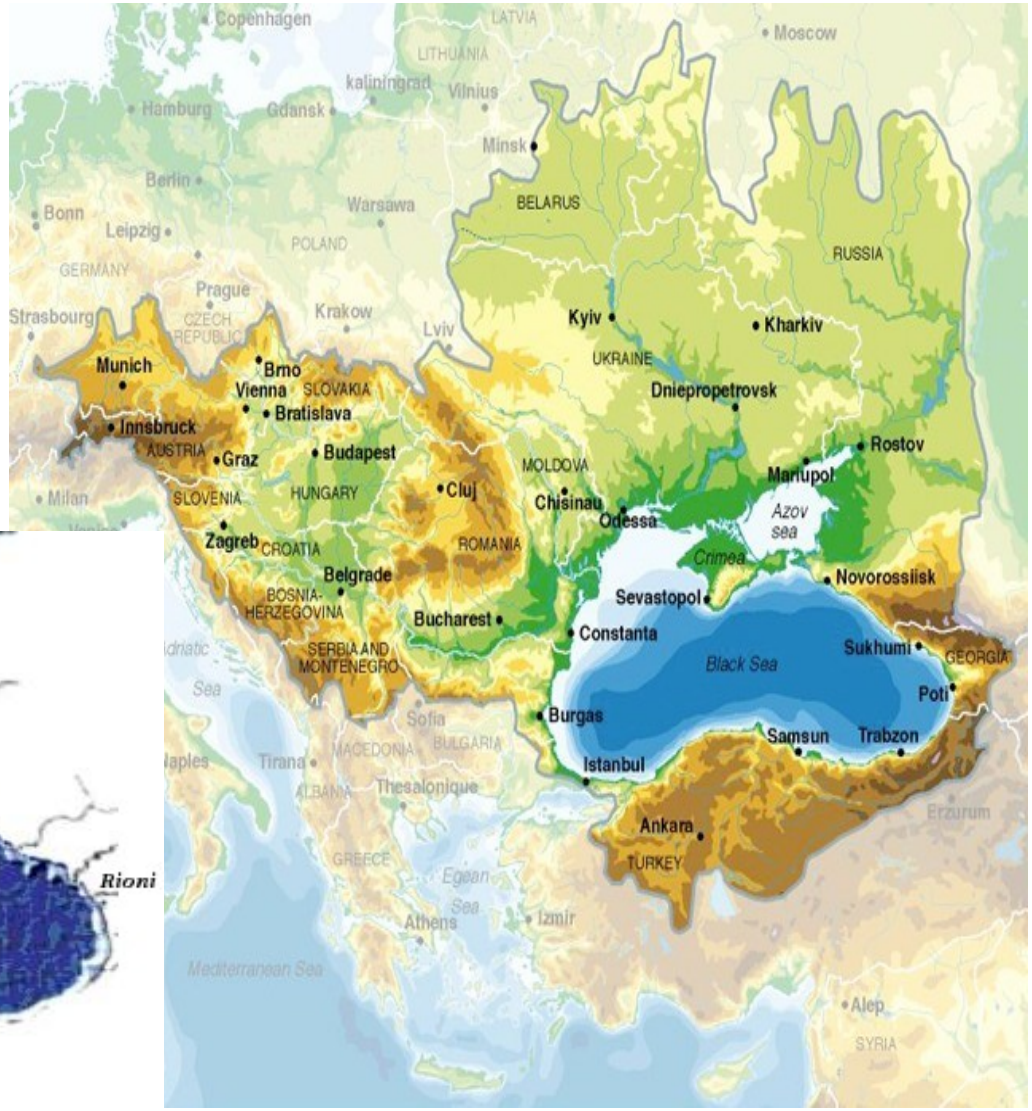
Outline

- Context.
- Physical model and ouputs.
- Biogeochemical model and outputs.
- Questions related to LTL – HTL coupling.

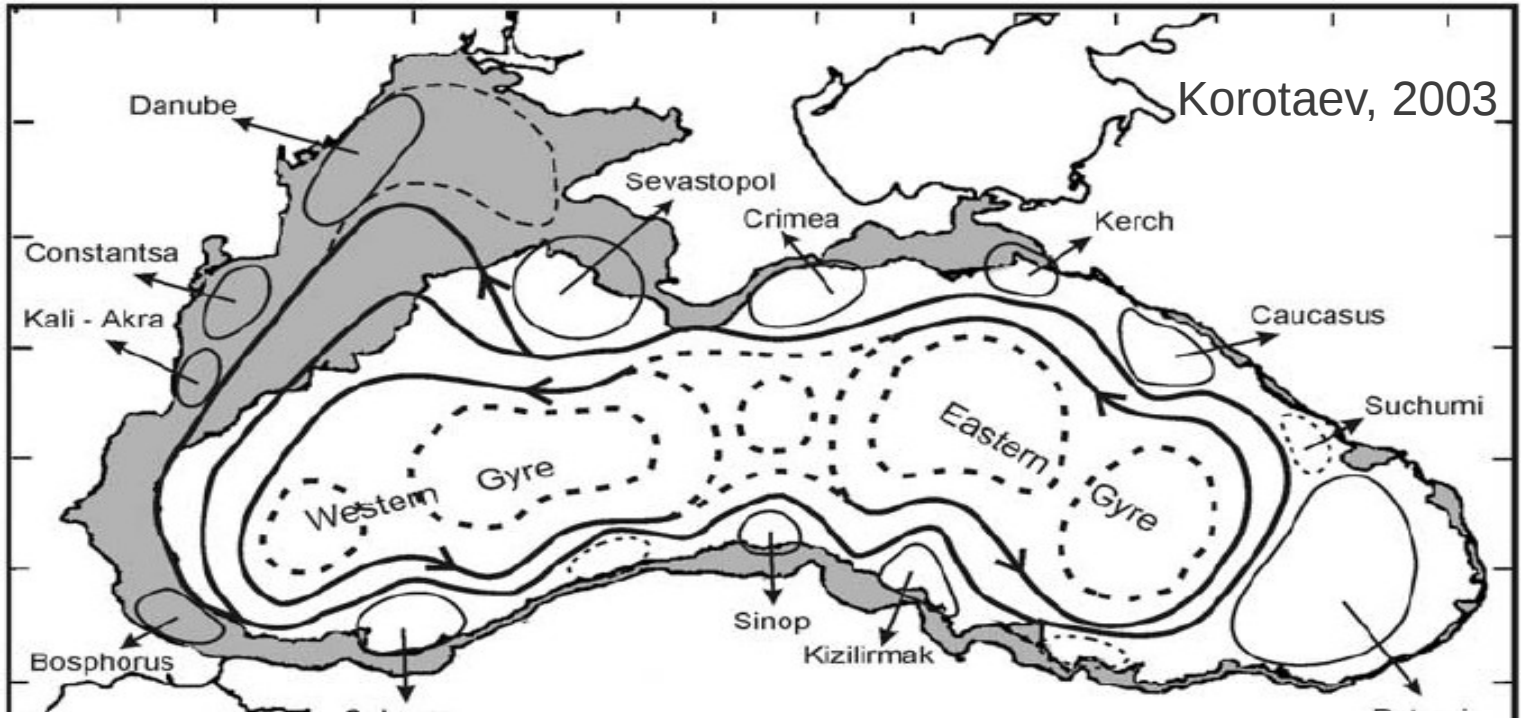
Context

- Quasi-enclosed basin.
- Strong stratification.
  - >Highly sensitive
    to external forcings.





Context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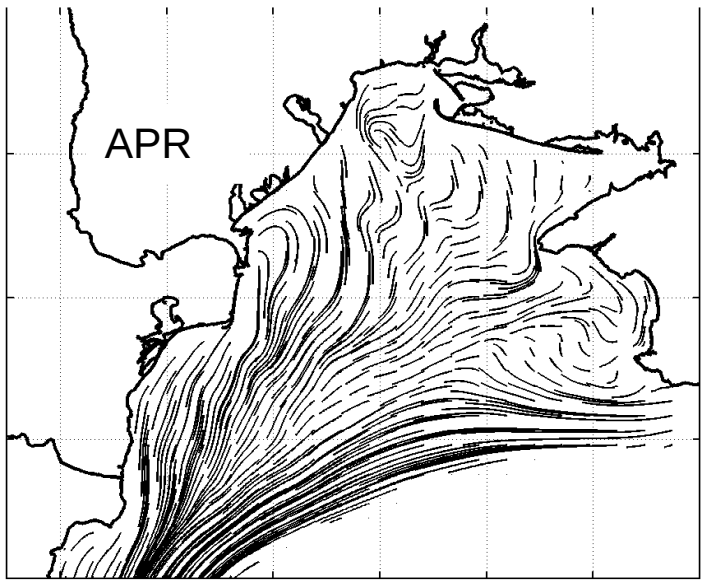
Danube
Sevastopol
Crimea
Kerch
Constantsa
Kali - Akra
Caucasus
Suchumi
Western Gyre
Eastern Gyre
Sinop
Kizilirmak
Bosphorus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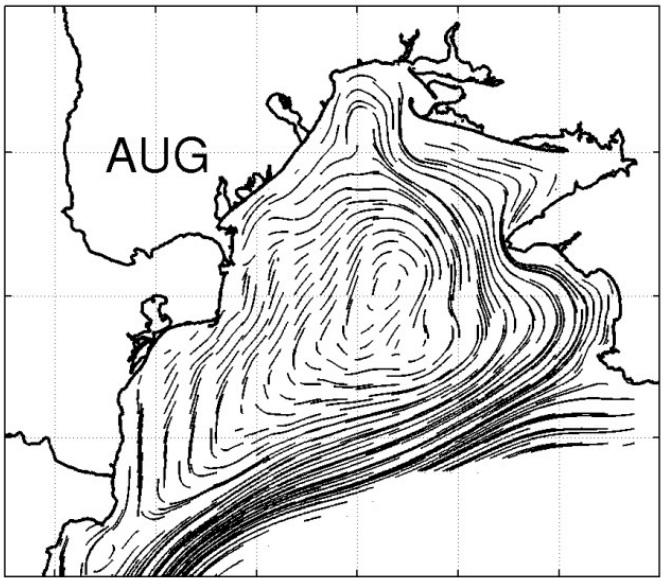
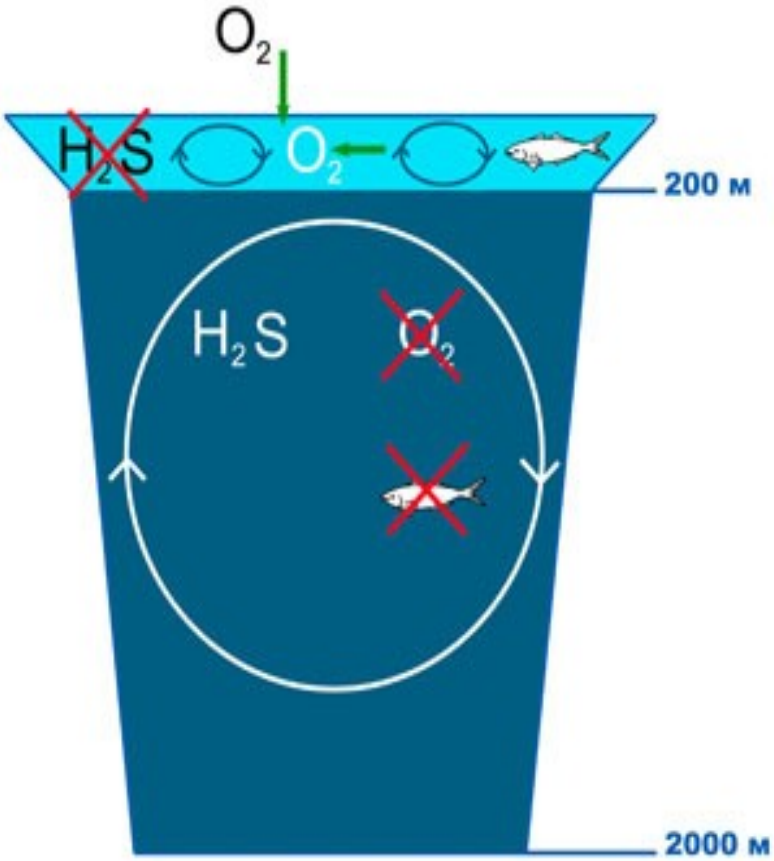
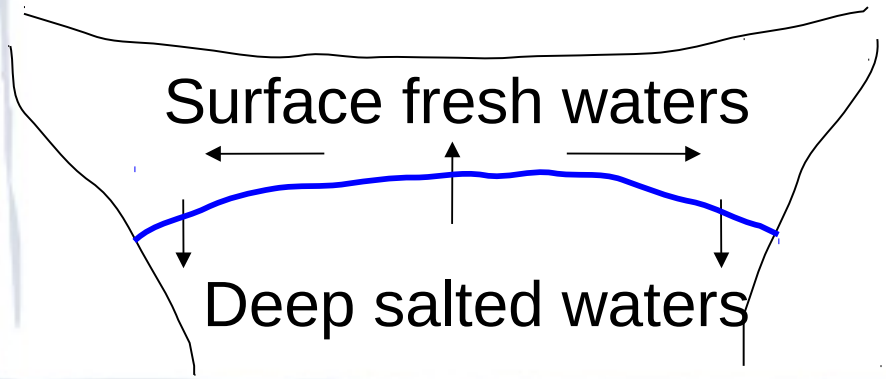
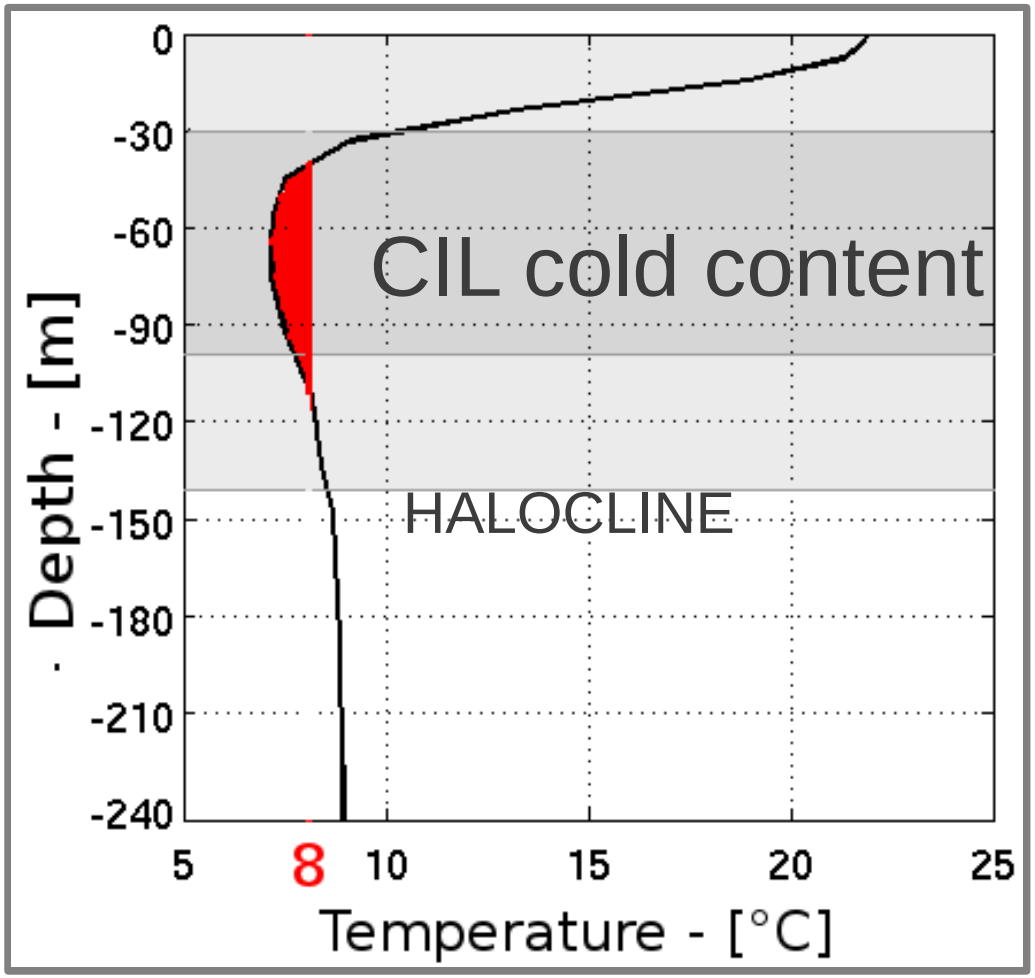

AUG

Context

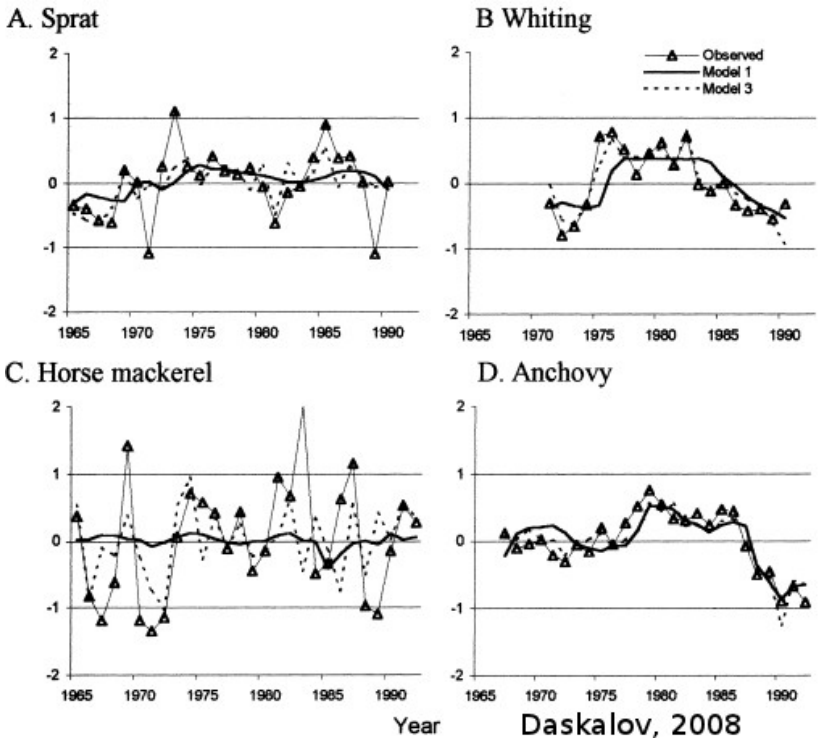

O2
H2S
O2
200 м
H2S
O2
2000 м


Surface fresh waters
Deep salted waters


0
-30
-60
-90
-120
-150
-180
-210
-240
Depth - [m]
CIL cold content
HALOCLINE
5
8
10
15
20
25
Temperature - [°C]

Context

- Severe environmental shifts occurs in late 80s
- Combination of pressure on ecosystem and hydrodynamic changes.



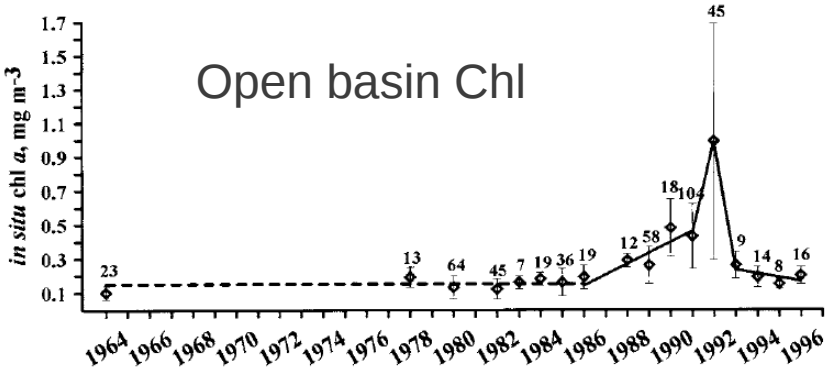
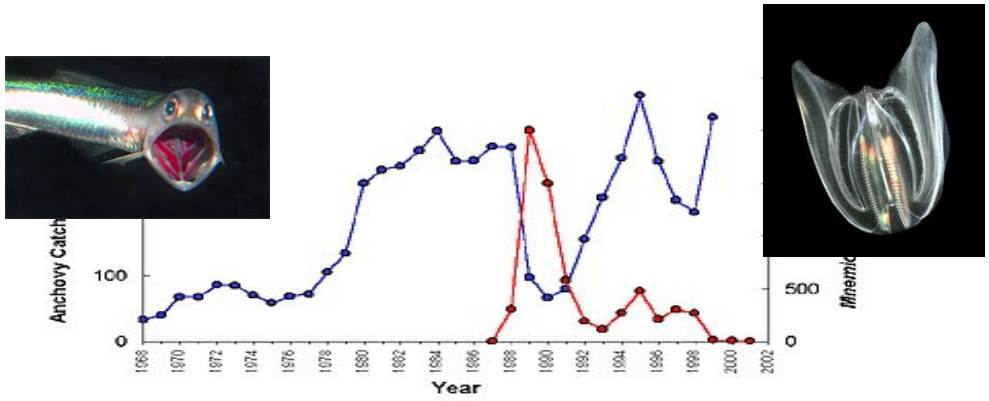


Figure 1 Long-term variability in surface chl *a* in the open Black Sea during May to September. Number of measurements and standard deviations are shown.



Context

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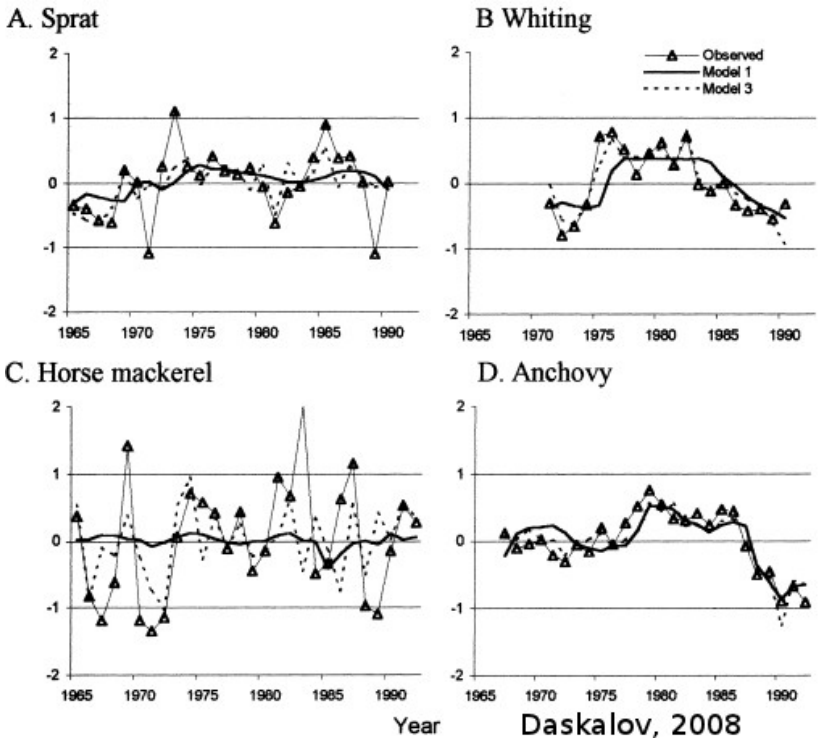

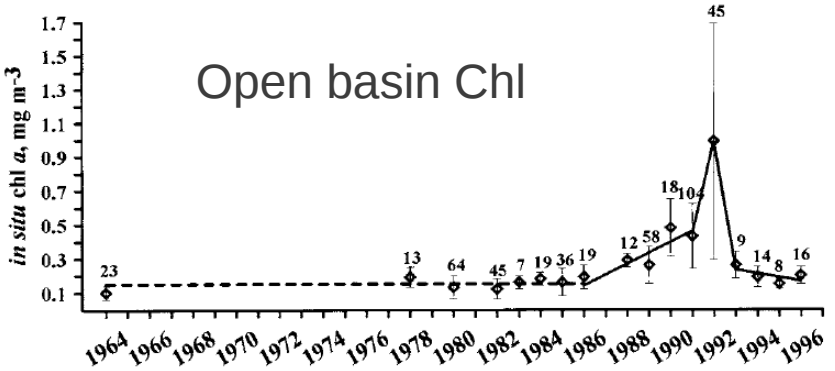

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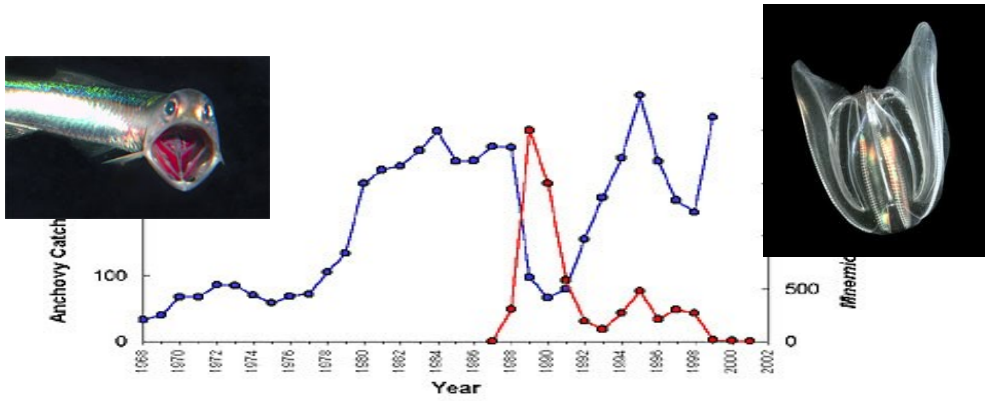
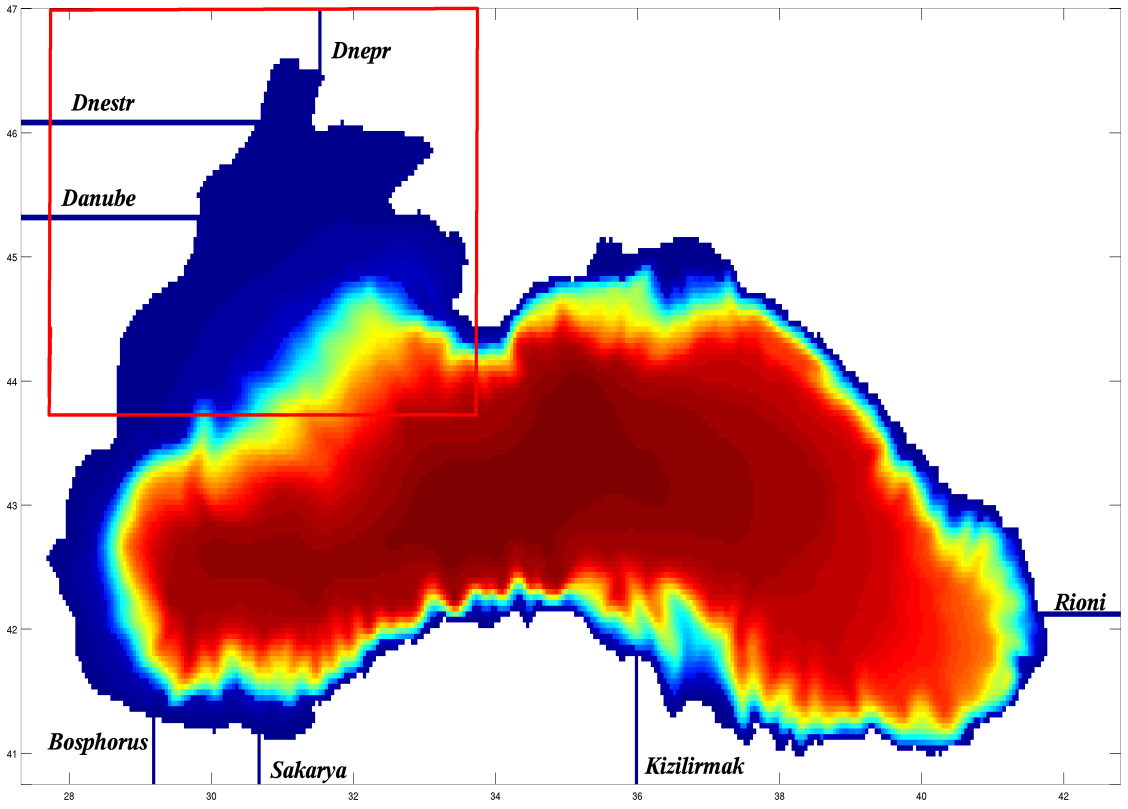
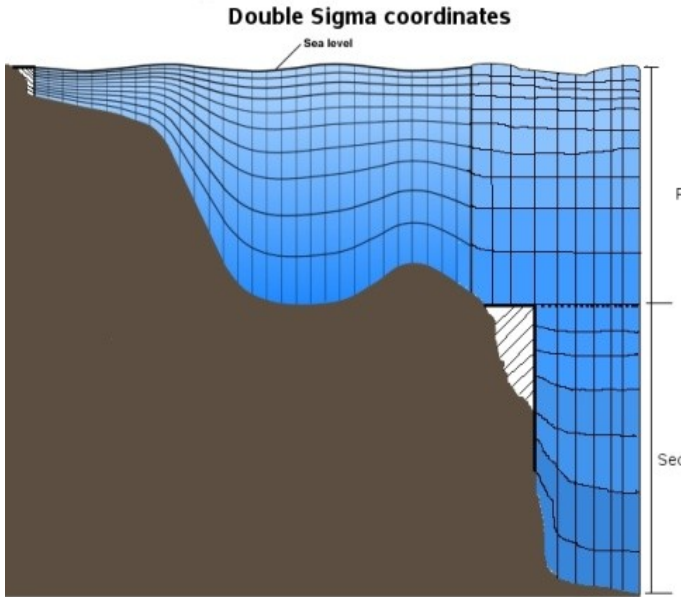


The GHER 3D physical model

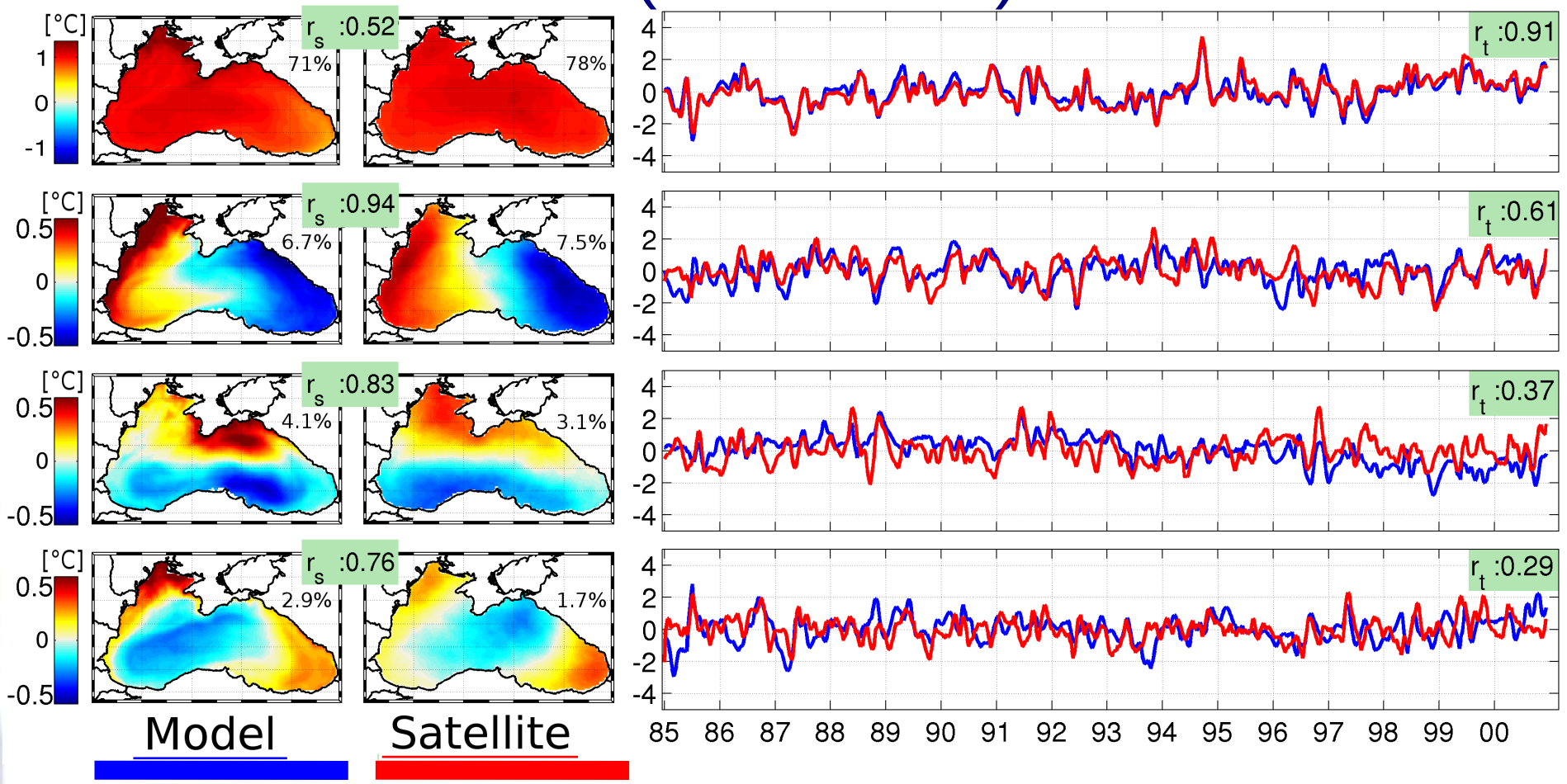
- Double-sigma vertical coordinates.
- Atmospheric conditions from ERA40. → Long term run 1962-2000
- No data assimilation and no relaxation.





SST anomalies

EOFs intercomparison : Model VS AVHRR (1985-2000)

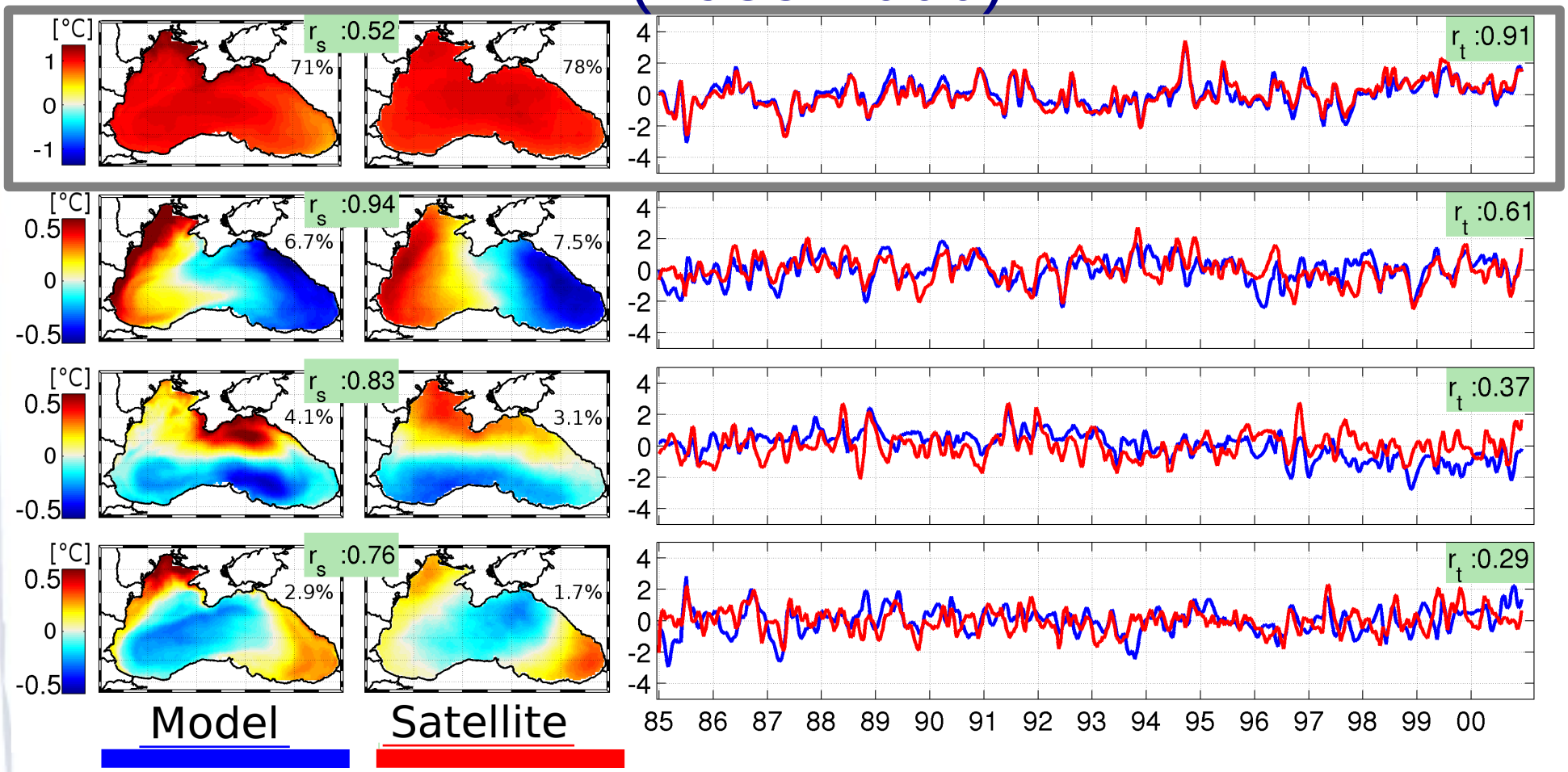


(Gridded AVHRR products provided by Nardelli et al, 2010)

SST anomalies

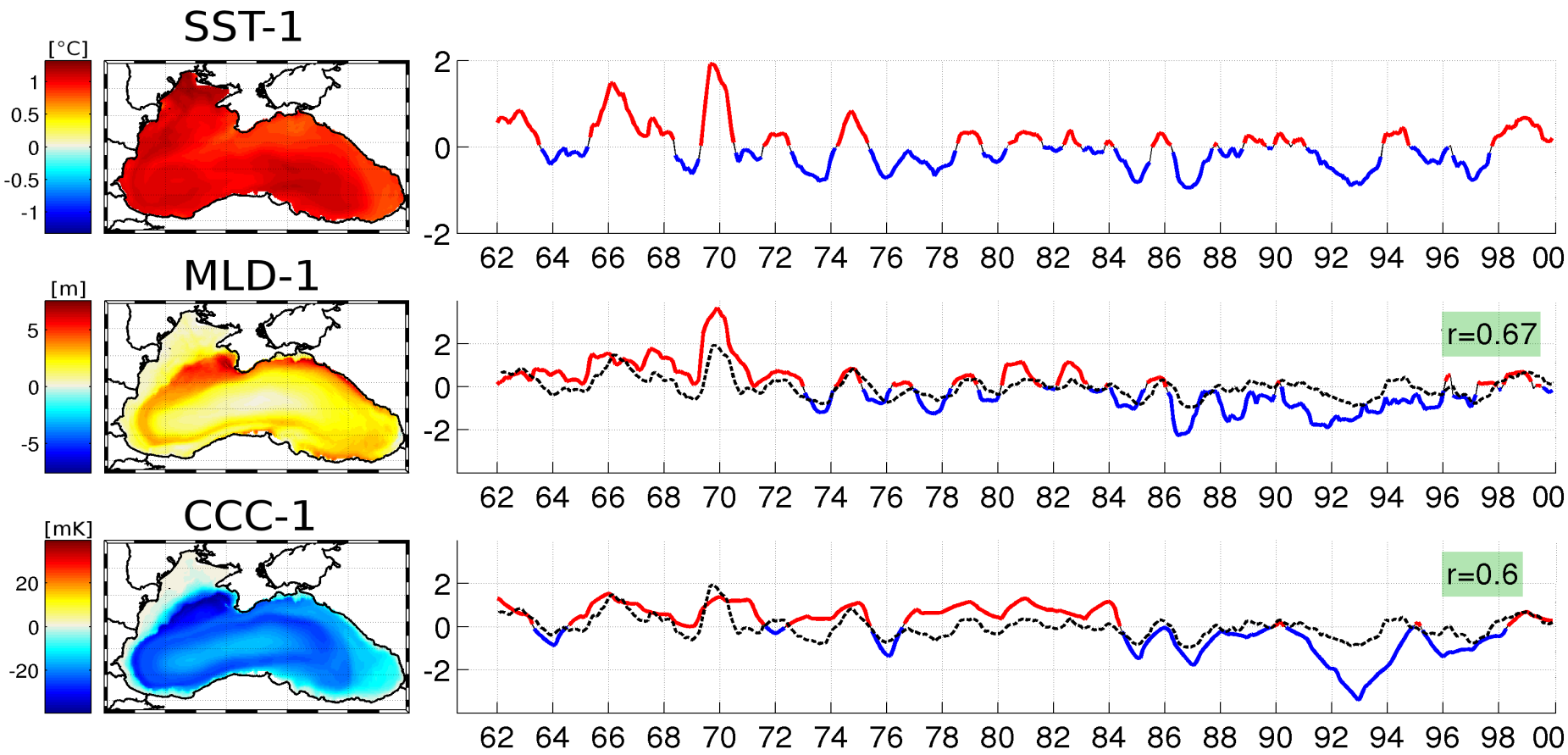
EOFs intercomparison : Model VS AVHRR (1985-2000)

SST-1

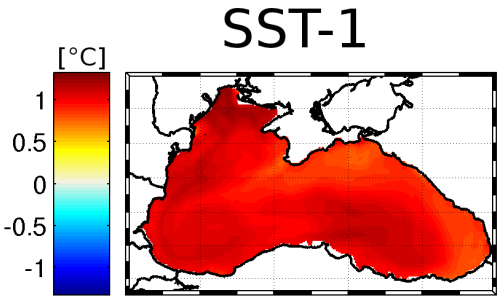


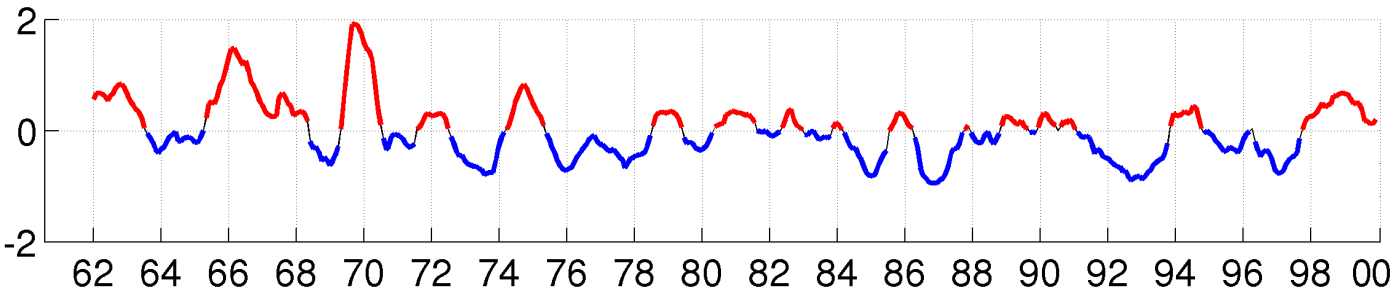
(Gridded AVHRR products provided by Nardelli et al, 2010)

SST-1 : relation to other variables

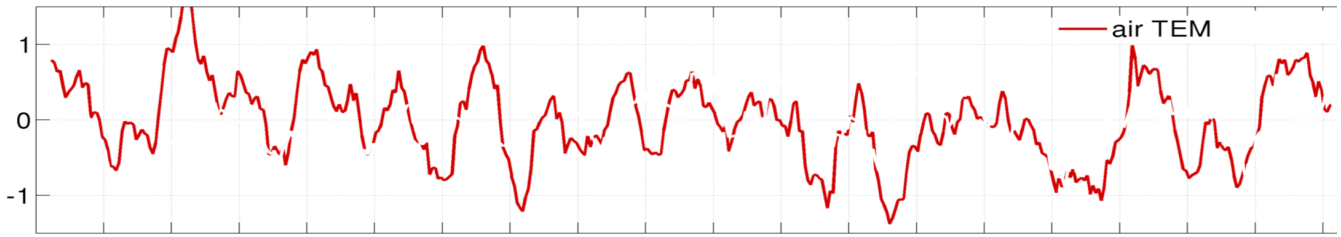


SST-1 : Atmopsheric drivers





Air Temperature
Basin average



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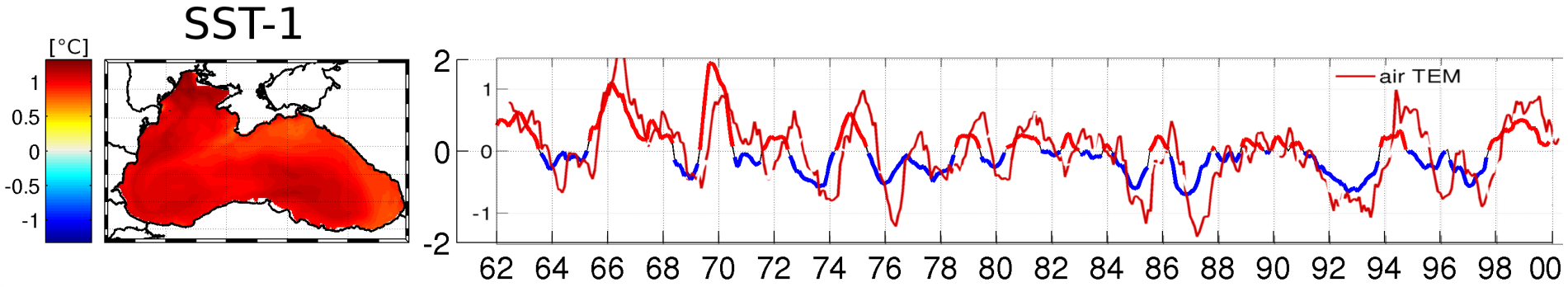

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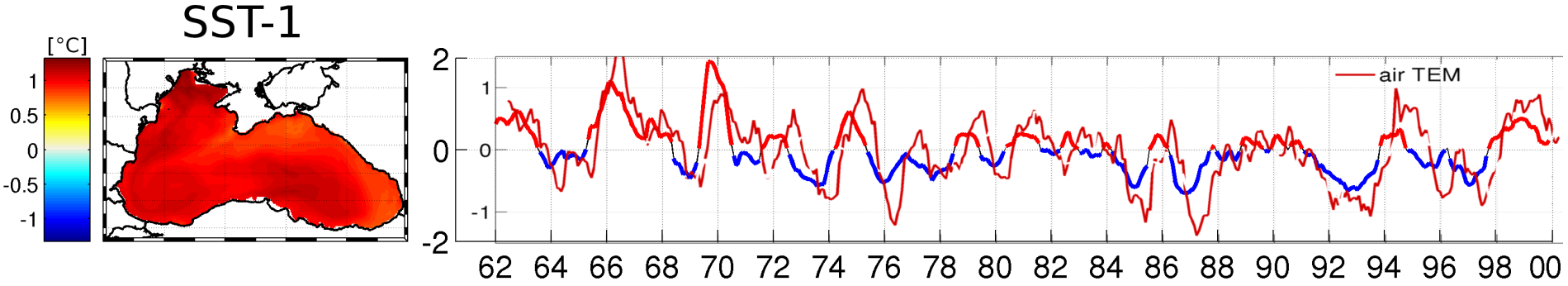
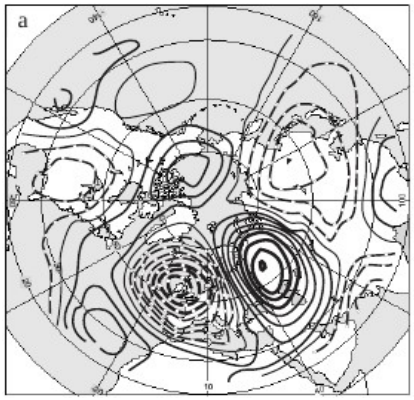
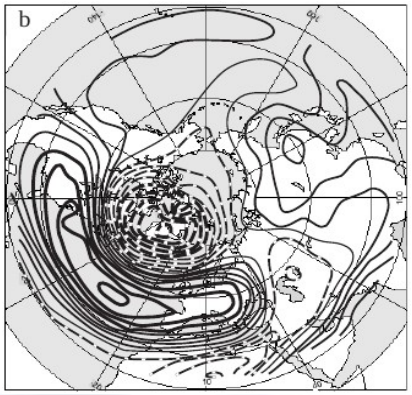


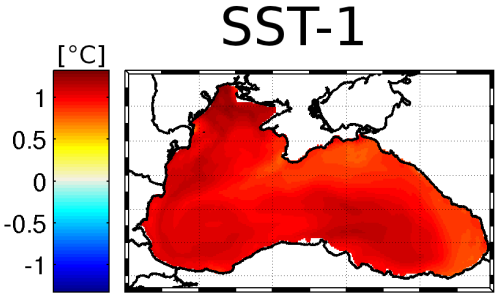


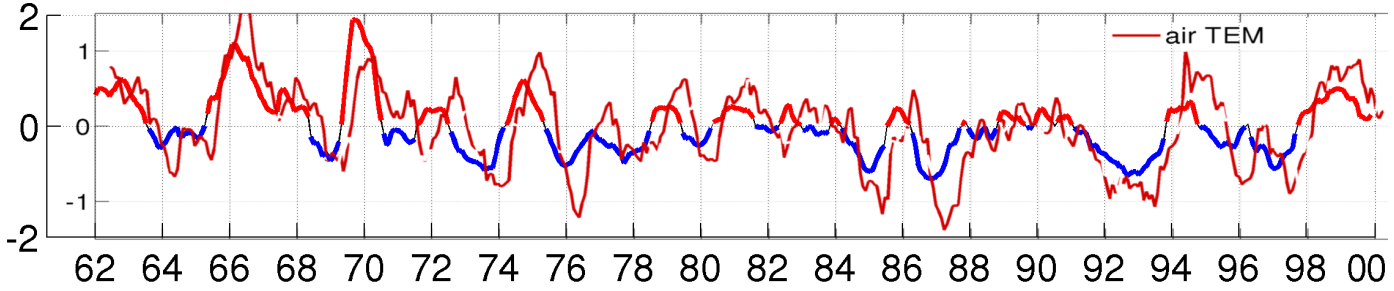
East Atlantic / West Russia

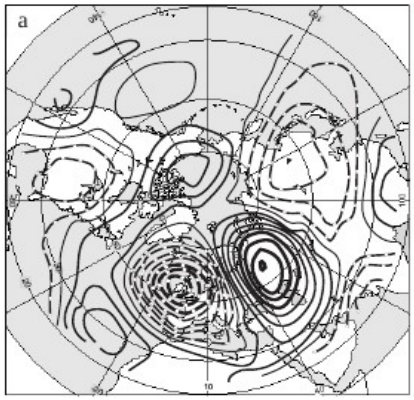


North Atlantic Oscillation

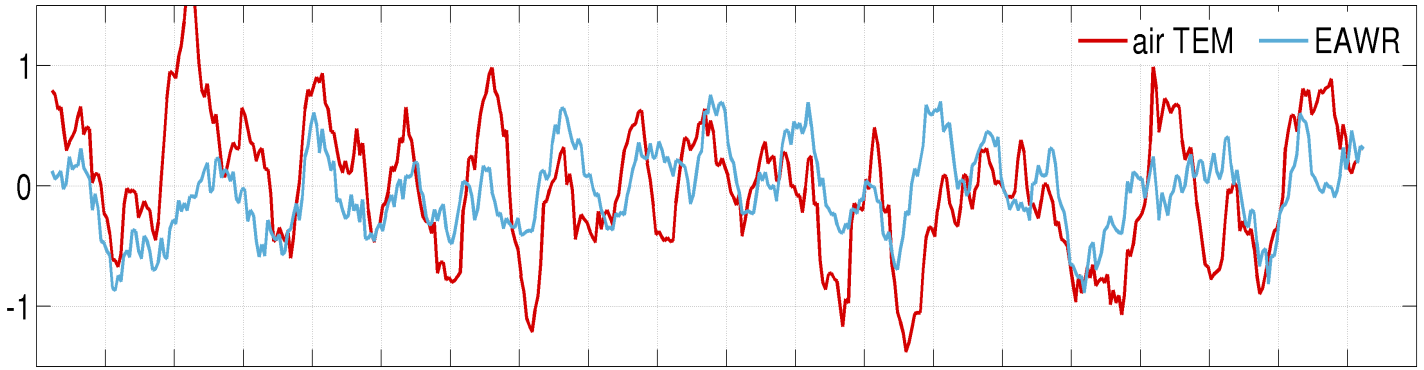
SST-1 : Atmopsheric drivers

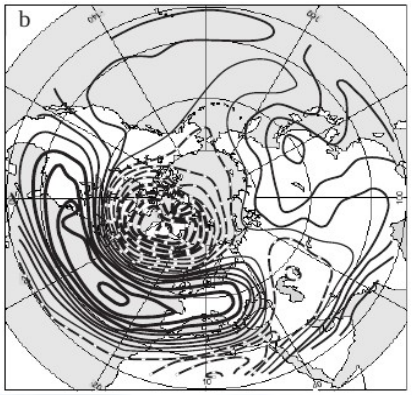






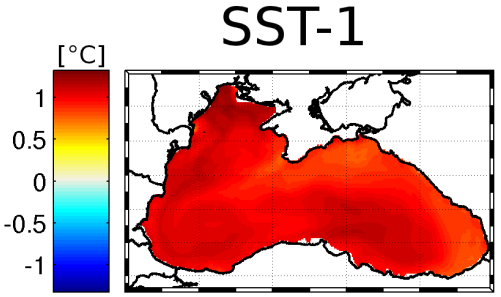
East Atlantic / West Russia

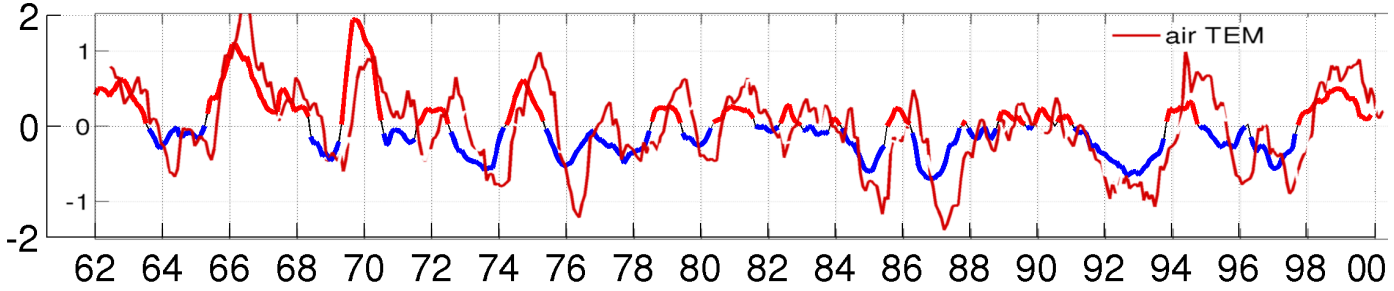


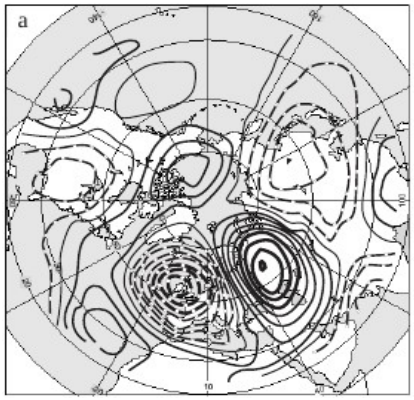


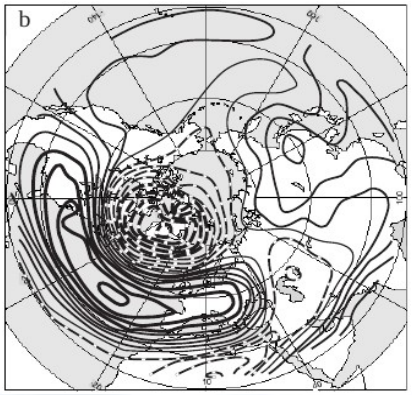
North Atlantic Oscillation

SST-1 : Atmopsheric drivers









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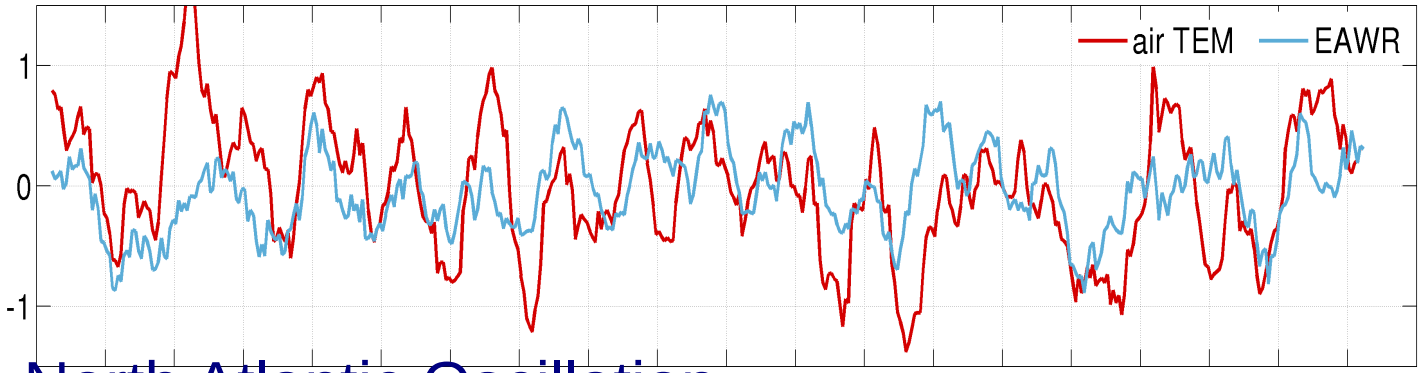
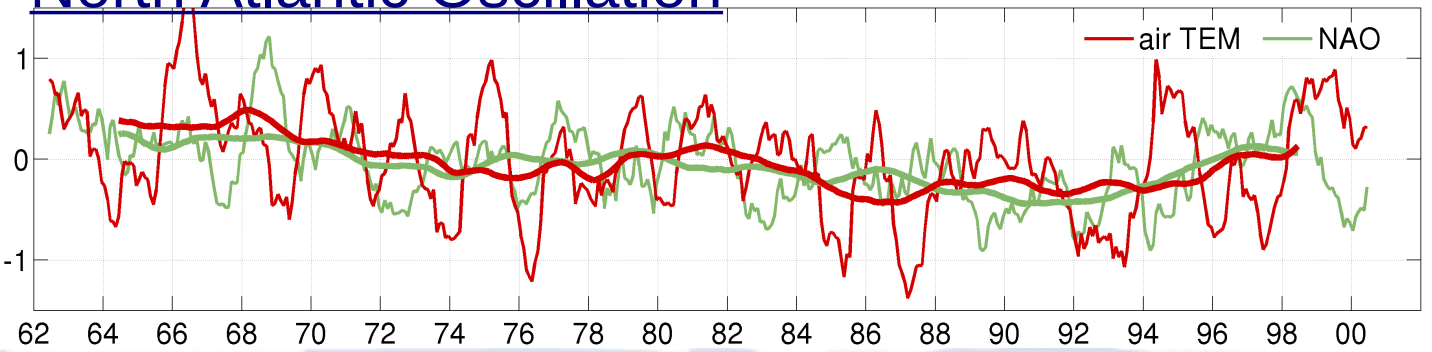
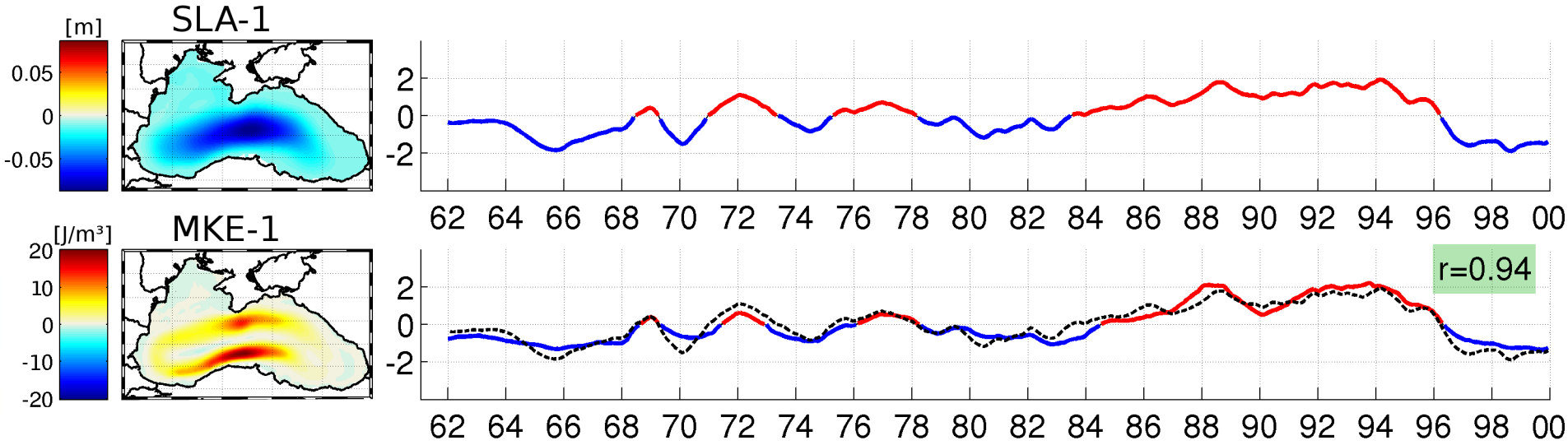


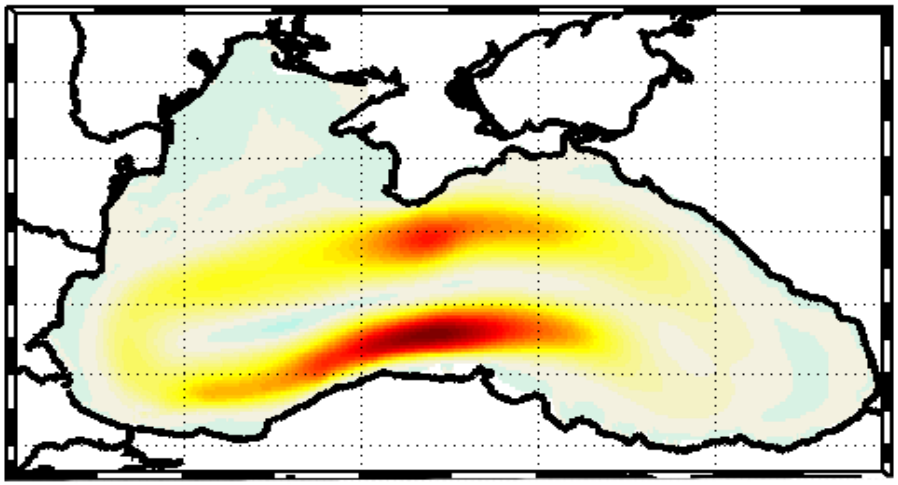
North Atlantic Oscillation

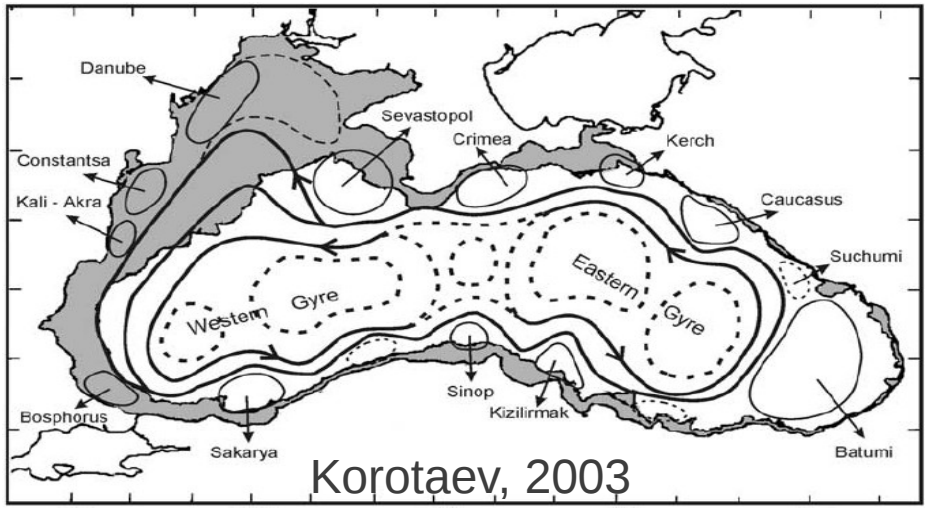


SLA-1 : Long term

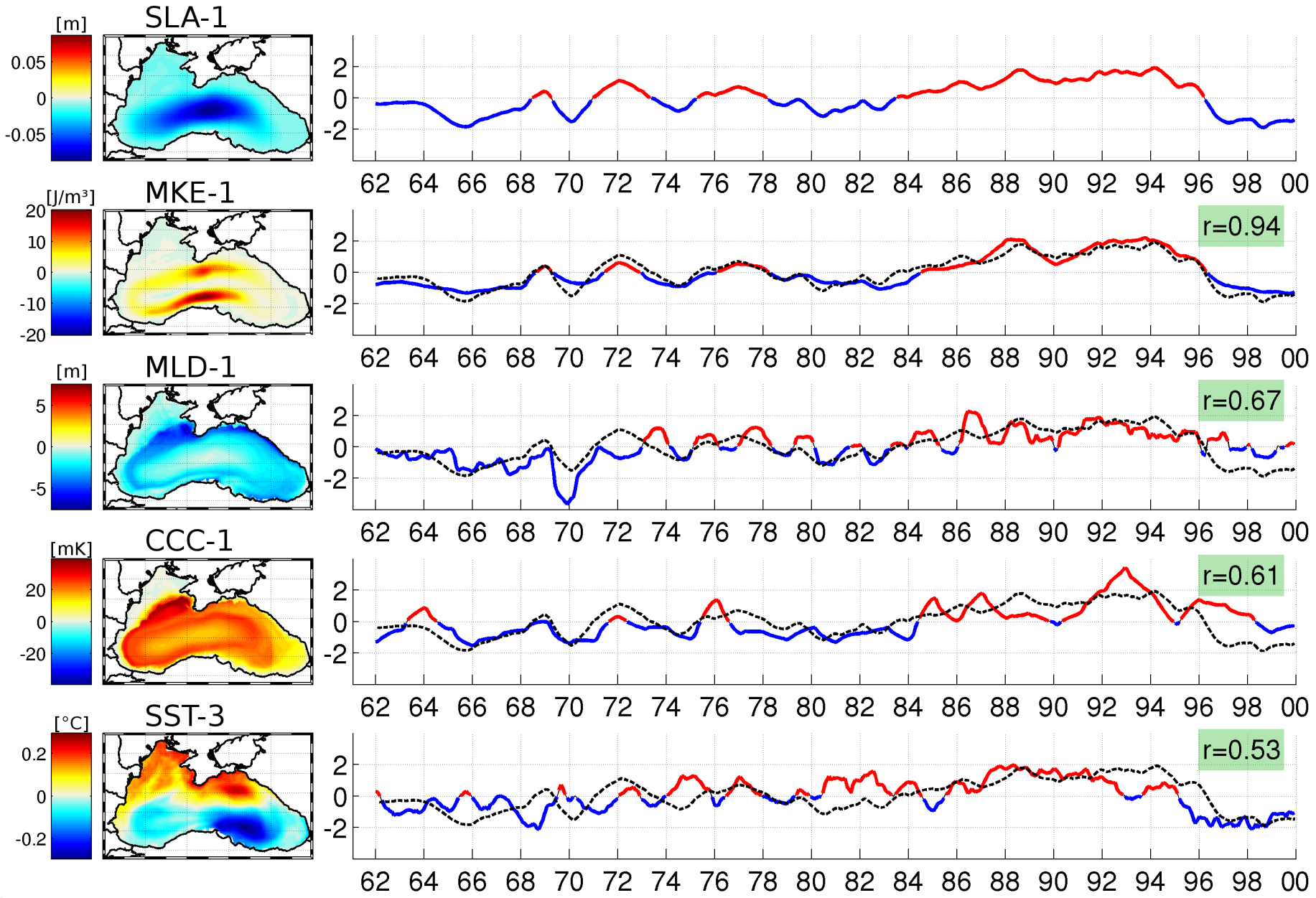


MKE-1 = The Rim current

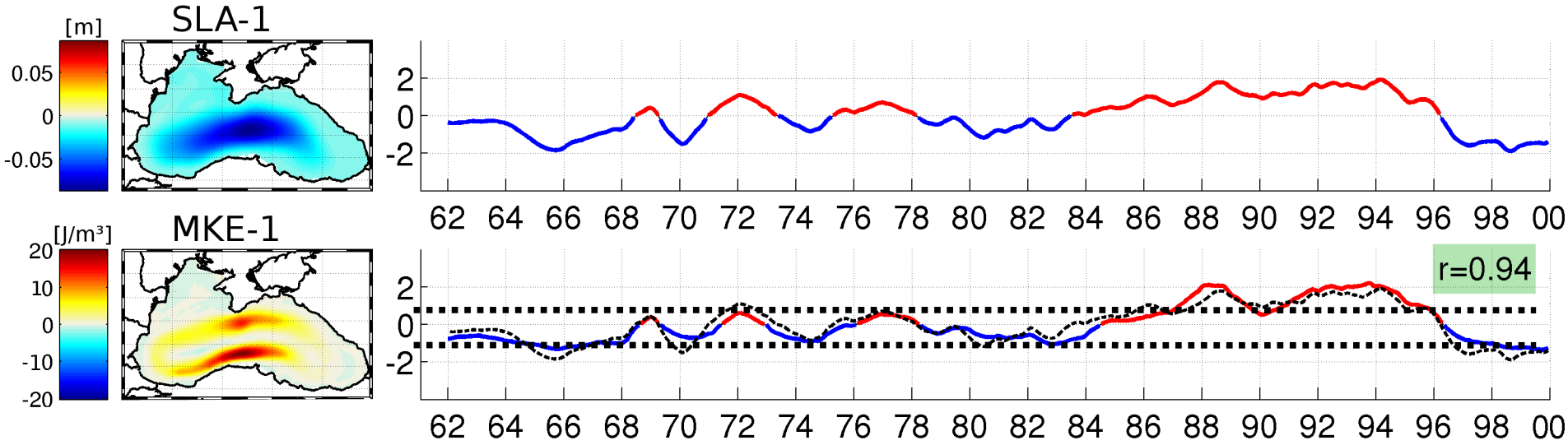




Rim current & other variables



SLA-1 : Long term



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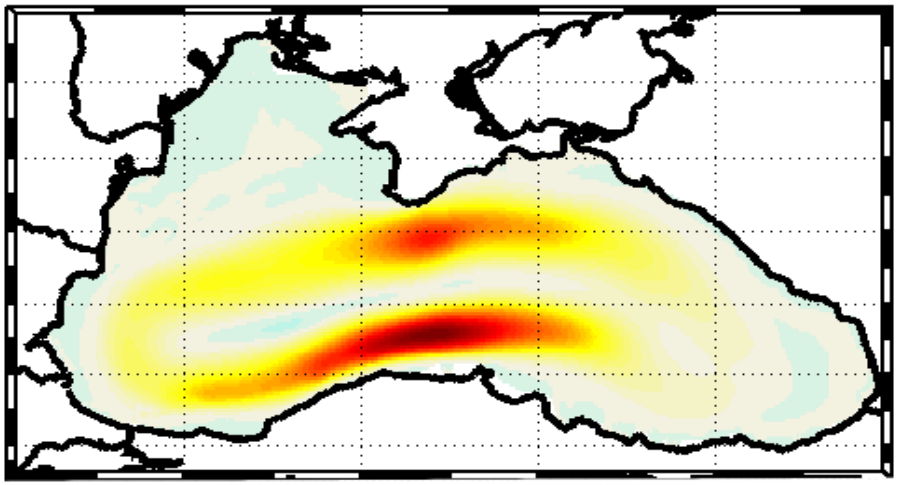
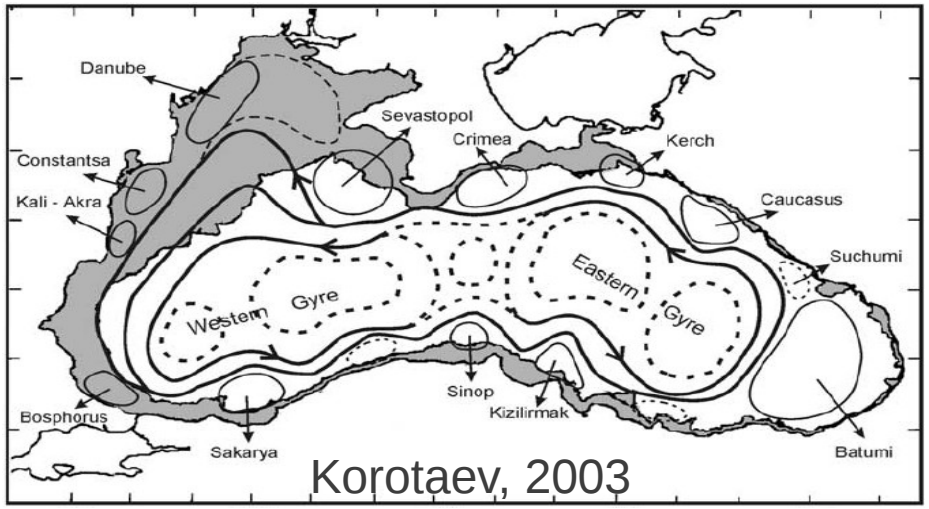
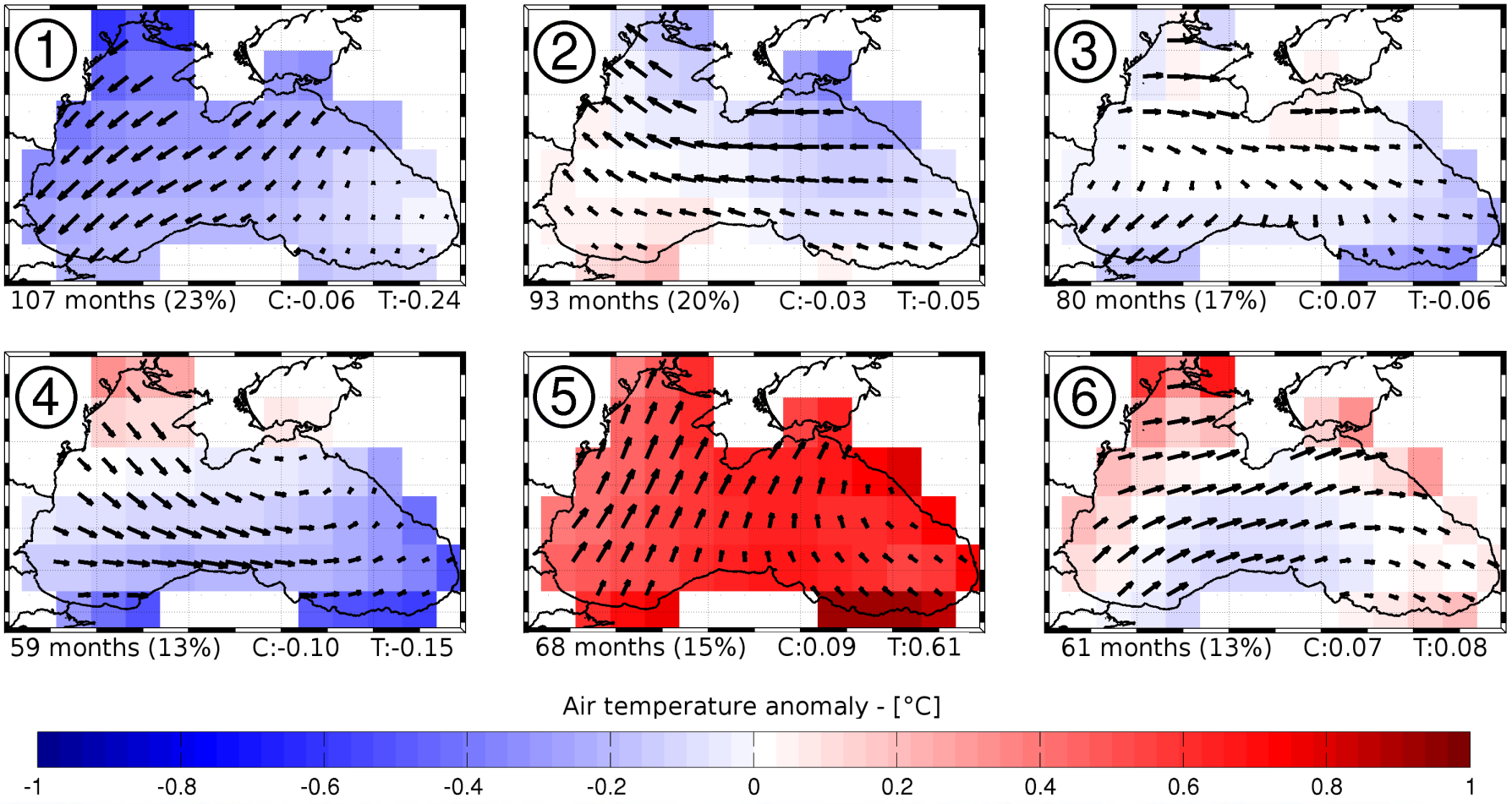




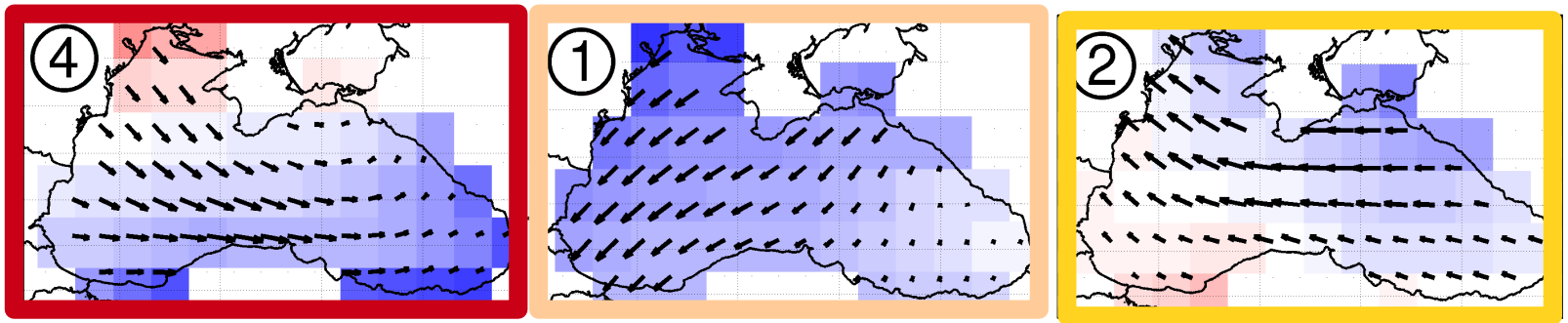
Winds regimes

38 years = 468 monthly anomalies distributed among 6 patterns identified trough SOM analysis

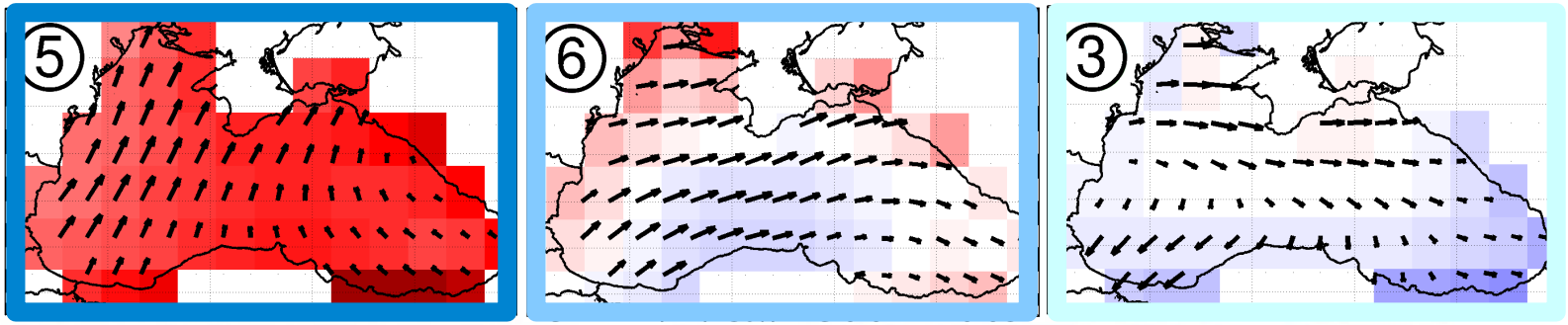


Rim current & winds regime

Cyclonic patterns



Anti-Cyclonic patterns



Rim current & winds regime

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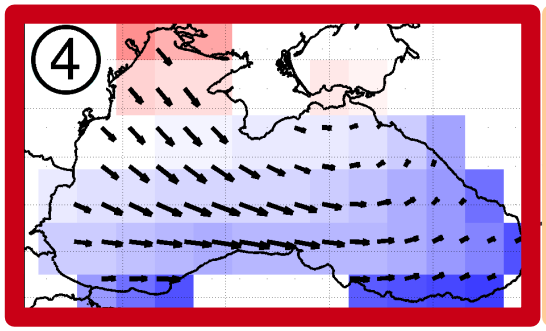
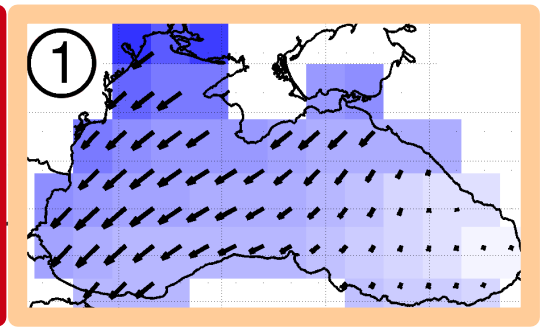
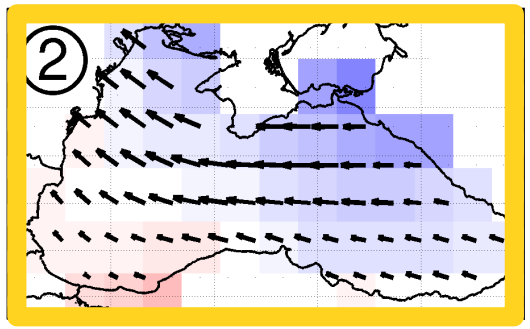
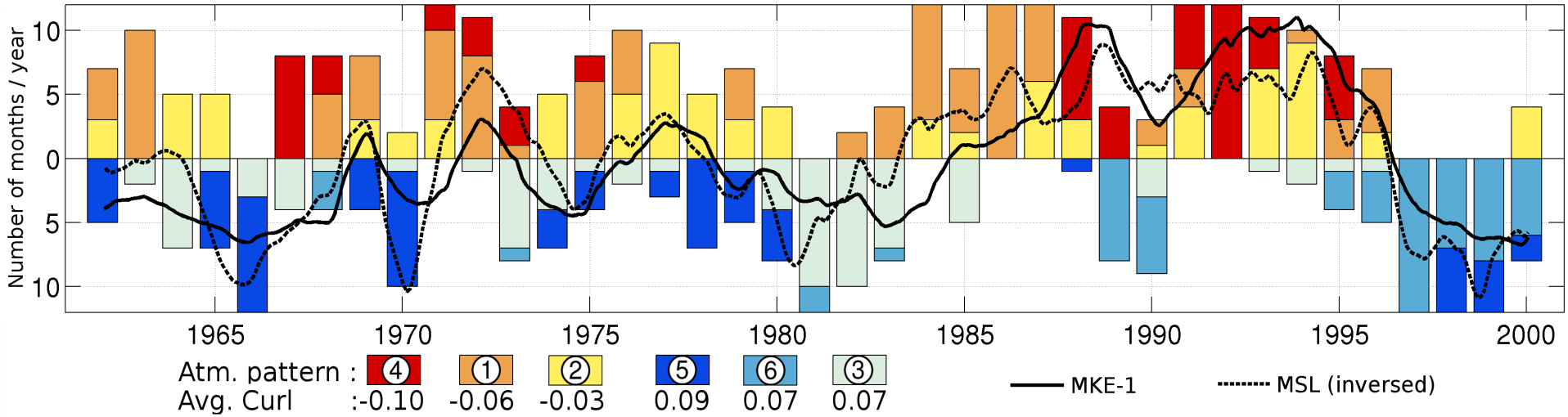
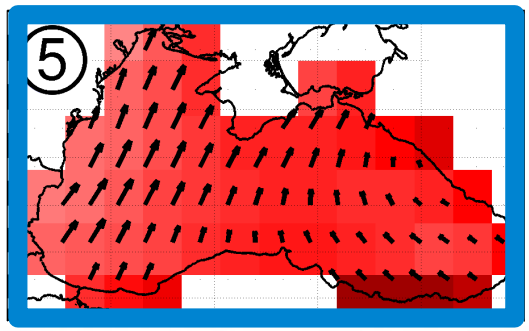


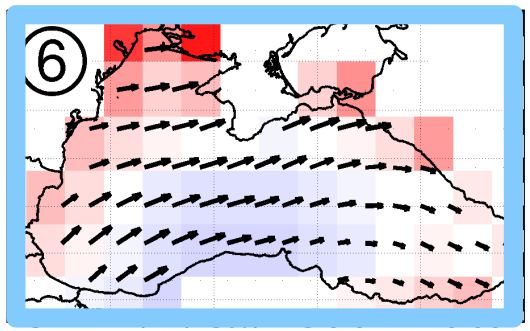


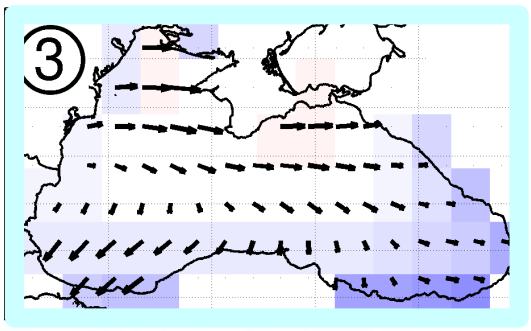




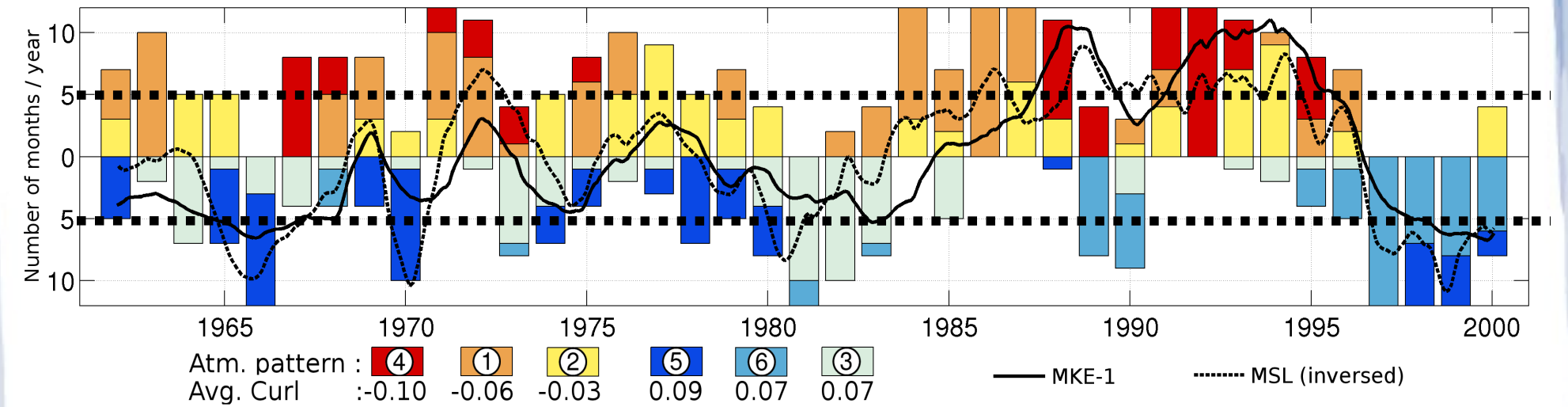
Anti-Cyclonic patterns

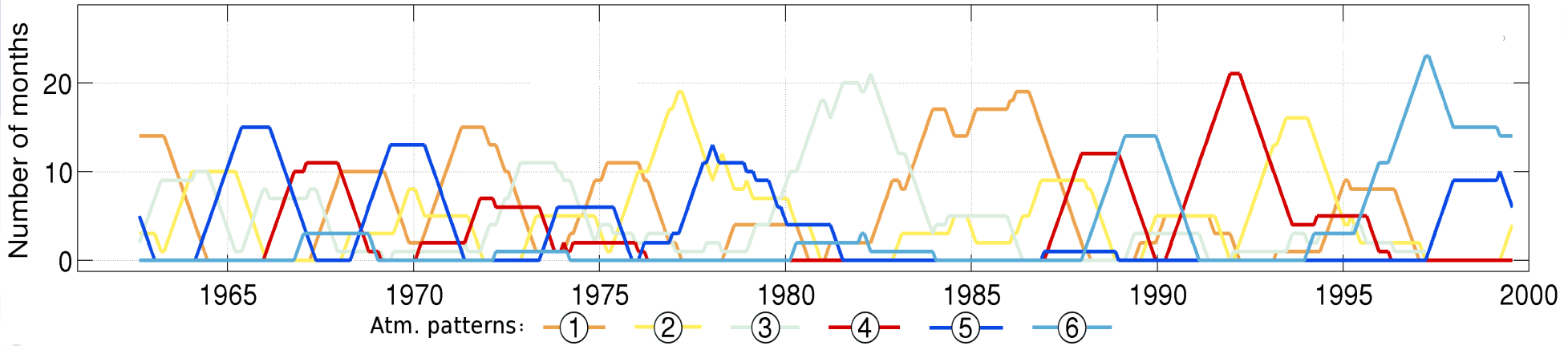




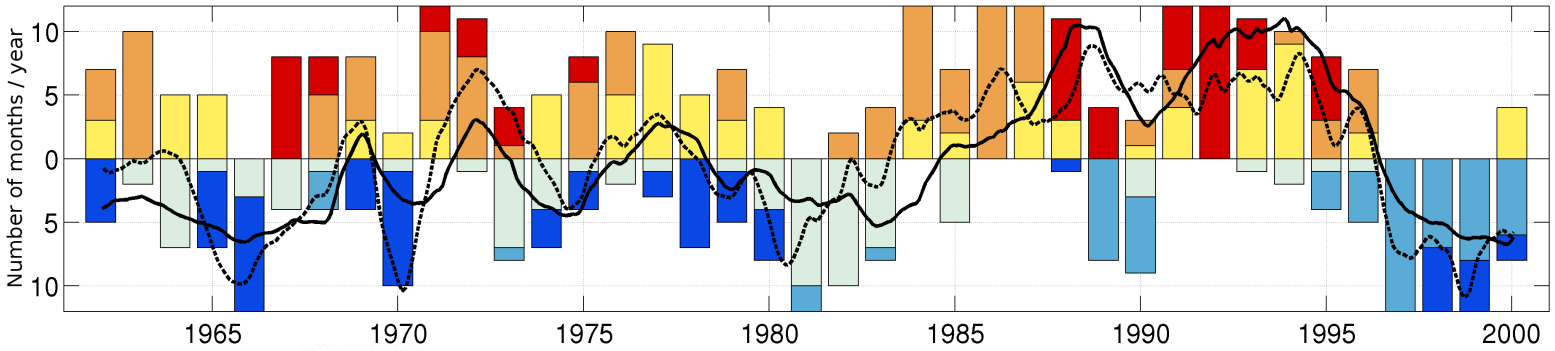


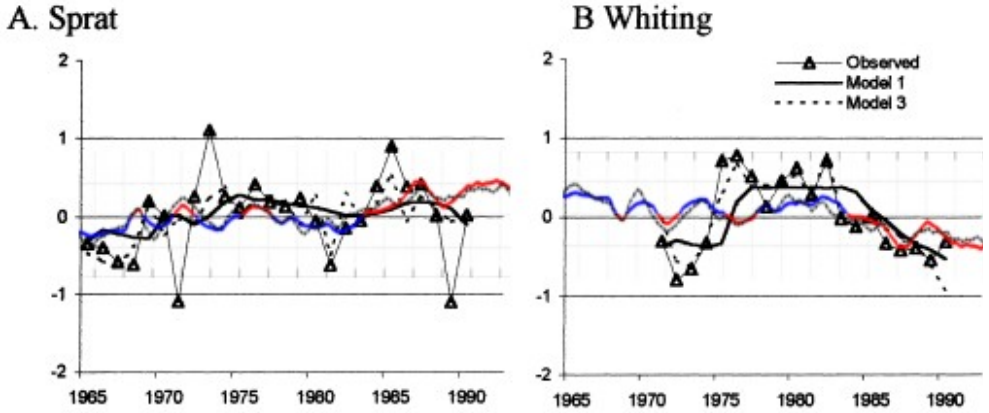
Rim current & winds regime





Environmental Implications





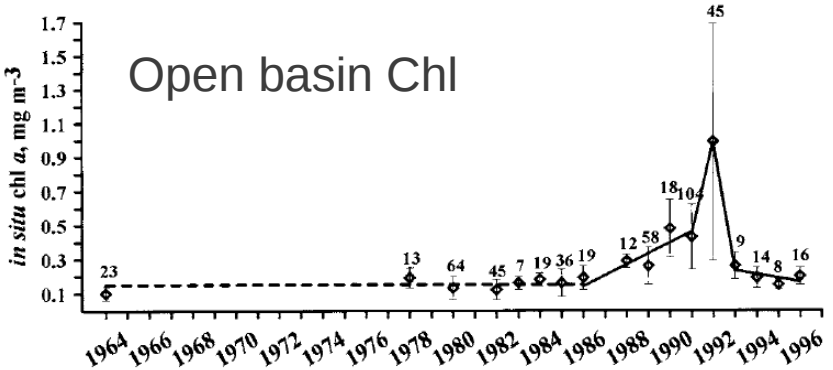
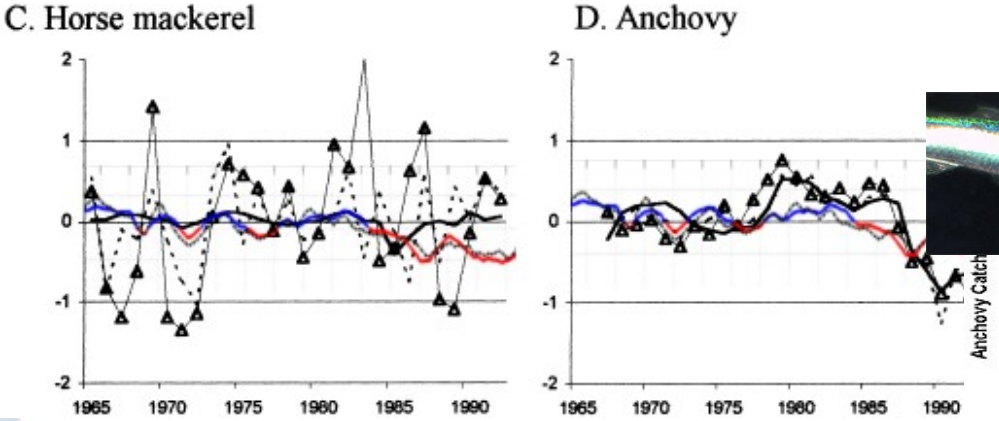
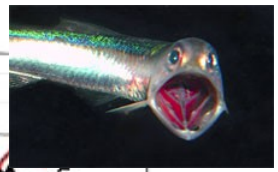


Figure 1 Long-term variability in surface chl *a* in the open Black Sea during May to September. Number of measurements and standard deviations are shown.

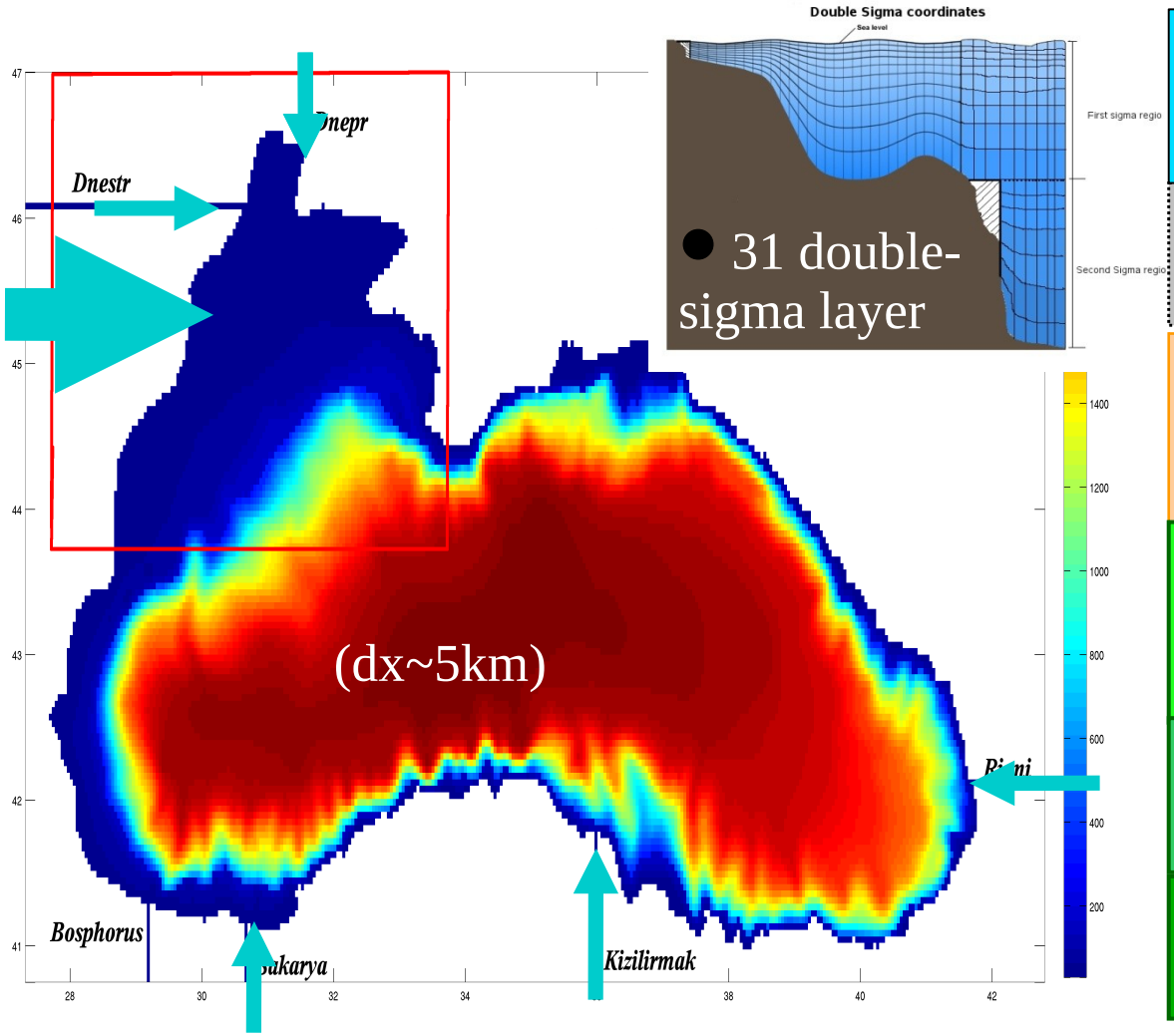
Yunev, 2003





Daskalov et al., 1998.

The biogeochemical Model : GHER-ECO



Monthly RIVERS fluxes and nutrients flows (from L. Wolfgang & A. Cociasu)

6h-atmospheric forcings from ECMWF (1.125°). (from ERA40)

36 States variables

Physics (5)
Currents, T°, Salinity,
Surface elevation, Turbulence

Oxygen and Dissolved Inorganic Carbon (2)

Inorganic nutrients (5)
SiO,NO3,NH4,PO4,"Reducers"

3 Phytoplankton (6) (free C/N)
Diatoms,Flagellates, Small Flagellates

Zooplankton (2)
Micro-, Meso-.

Gelatinous zooplankton(2)
Omnivorous , Carnivorous

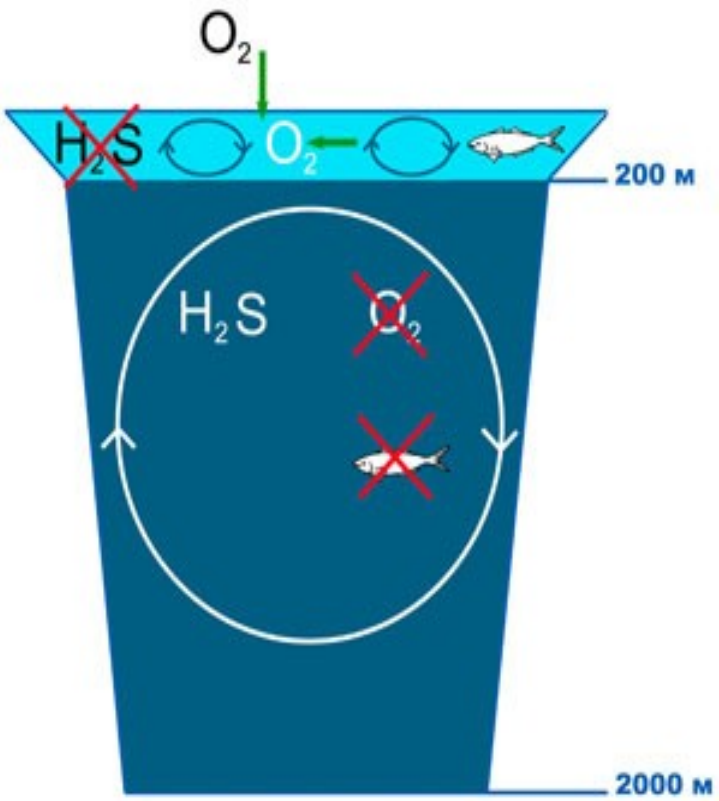
Detrital matter (8)
Particulate, Semi-labile and Labile forms
Silicious Detritus, Aggregates

Bacteria(1)

Model's Specificity

- No data assimilation : Necessity to construct specific Bosphorus representation to ensure conservation of volume and total salt content.

- Anoxic waters : The biological model explicitely includes anoxic chemistry trough the use of a variable 'Oxygen demanding Units', as a proxy for reducers acting in the anoxic zone.



- Sediments compartiment

- Light absorption scheme

Benthic Model

sedimenting variables
(POM, Diatoms)

W_{POC} is given by aggregation model

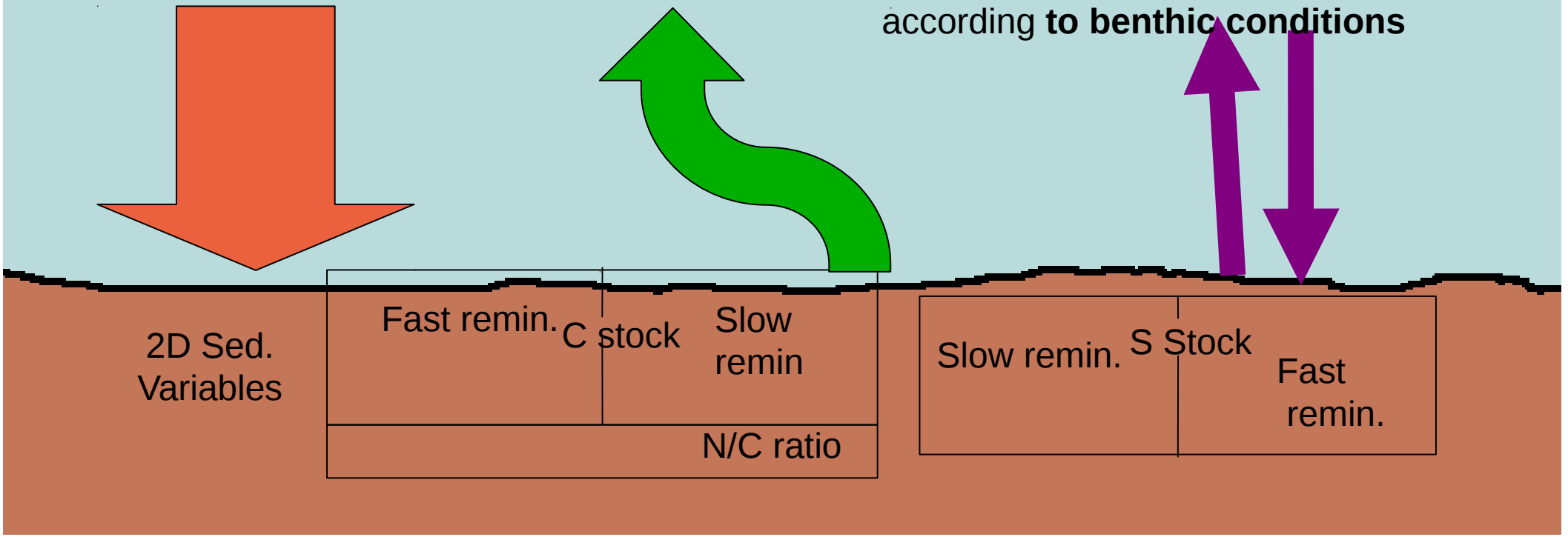
Resuspension
in particulate form

due to bottom stress from **currents** and (mainly) **waves**.

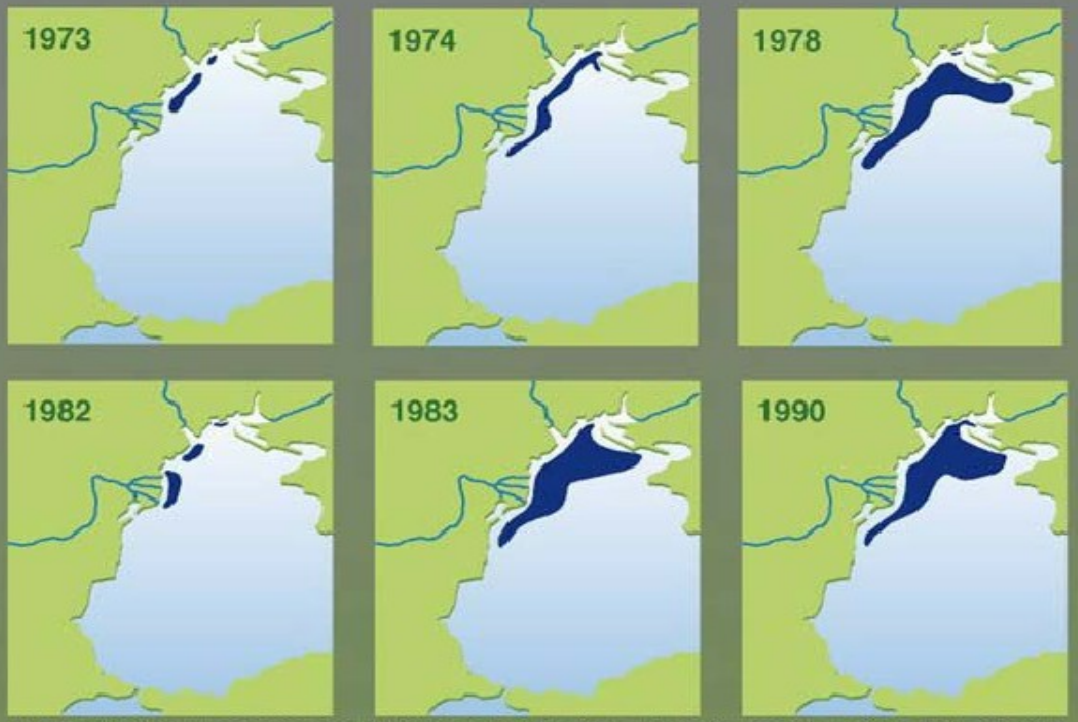
Benthic remineralisation

Remineralised content (in mmolC/m²/s)
= [fast C stock] . K_{fC} . f(T°)
+ [slow C stock] . K_{sC} . f(T°)

Calibrated functions compute from Cmin and Nmin, the fluxes of **Oxygen**, **ODU, DIC, Ammonium**, **Nitrate, Silicate,** according **to benthic conditions**



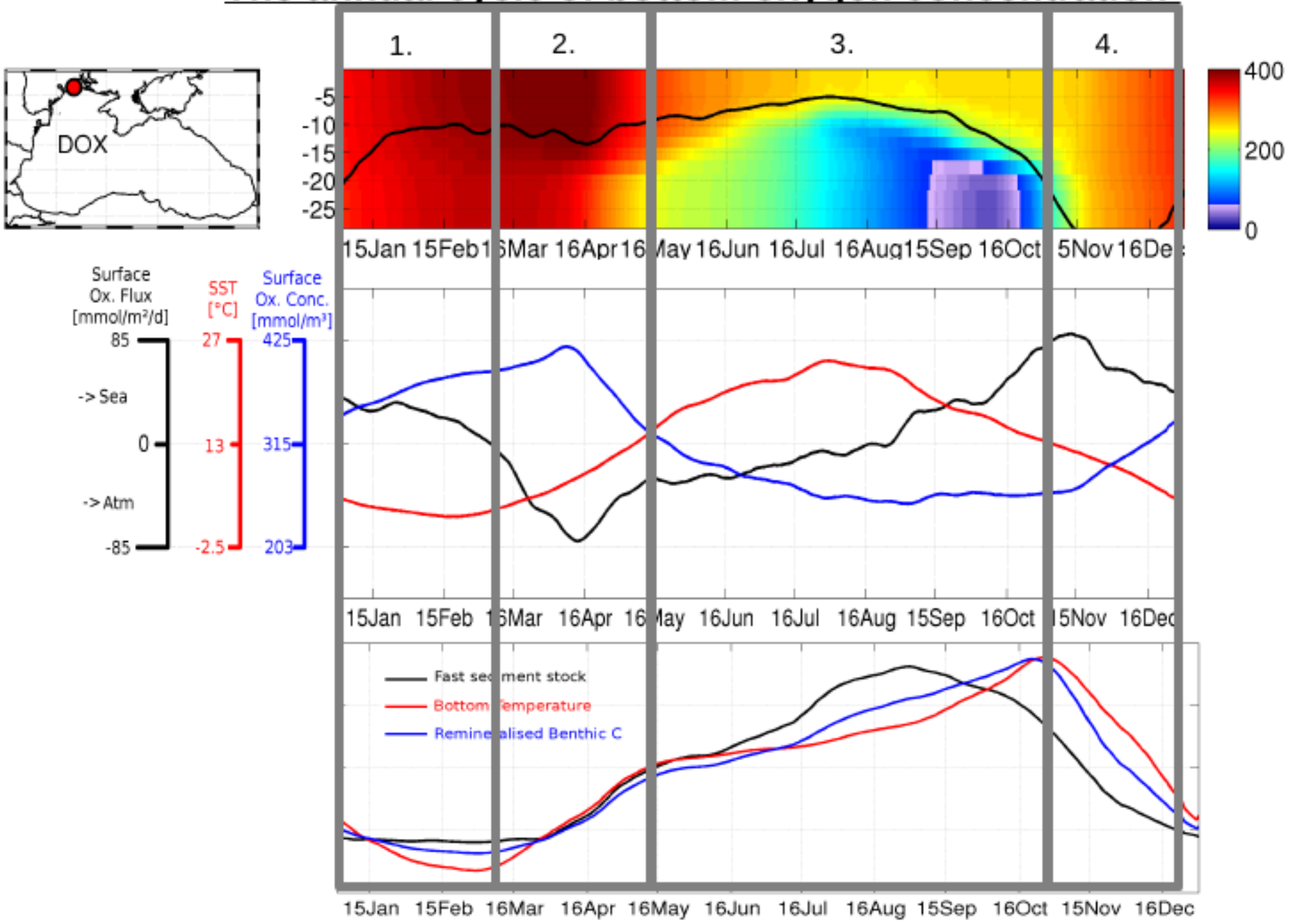
Expansion of hypoxia and anoxia zones in the northwest of the Black Sea

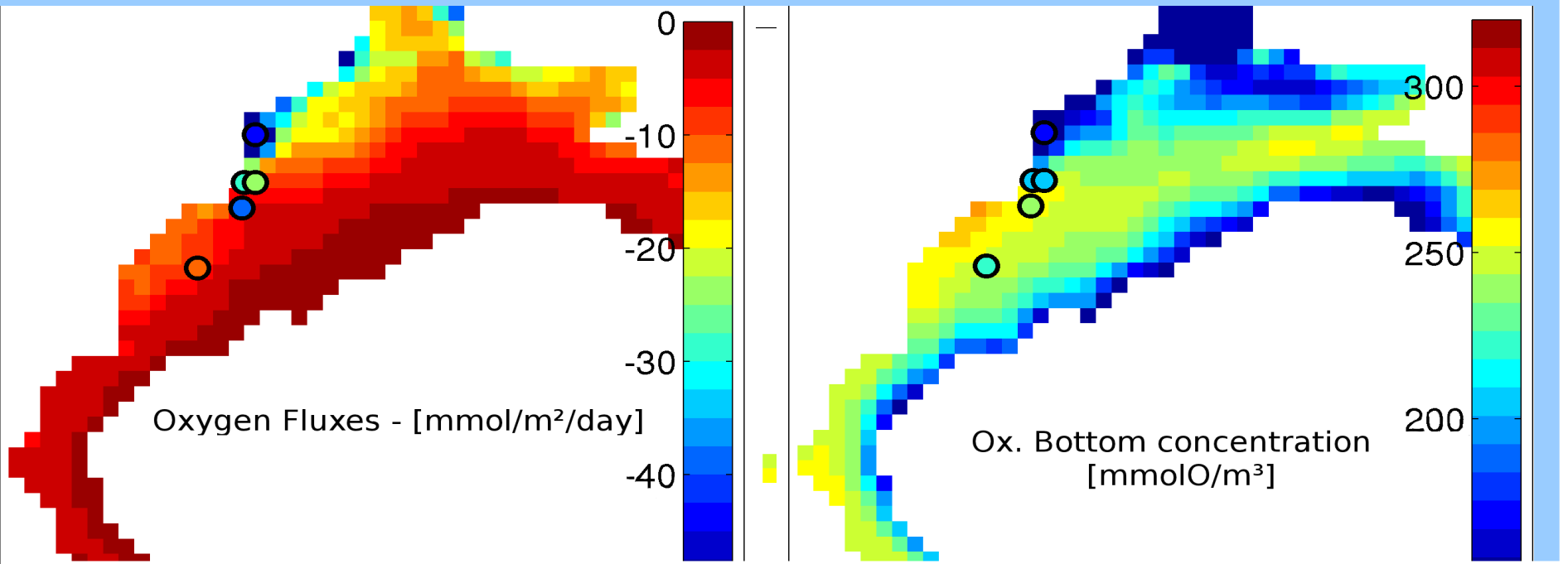


Note: Eutrophication was so strong that it caused temporary hypoxia events on the sea bottom that resulted to the mass mortality of benthic animals in the relatively shallow northeastern Black Sea.

Source: Y. Zaitsev and V. Mamaev, *Marine biological diversity in the Black Sea: A study of change and decline*, United Nations Publications, New York, 1997.

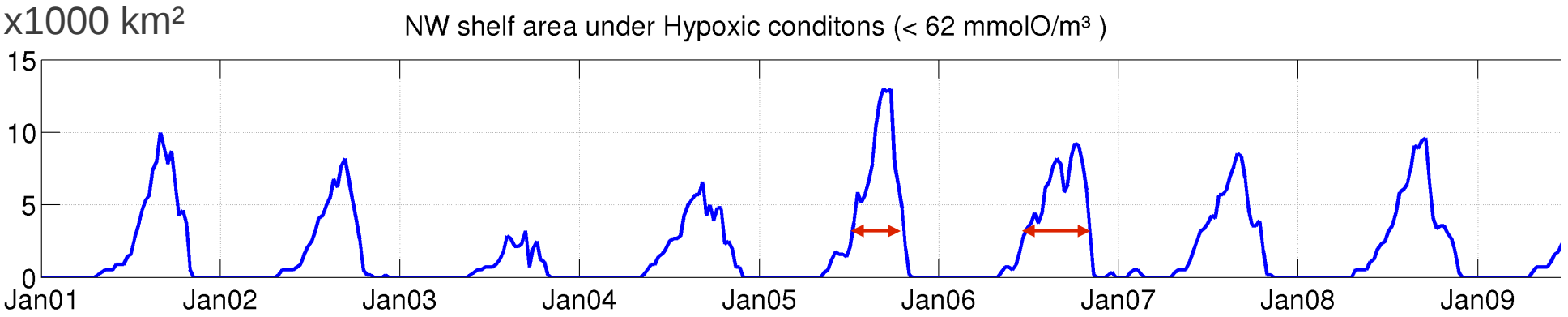
The annual cycle of bottom oxygen concentration



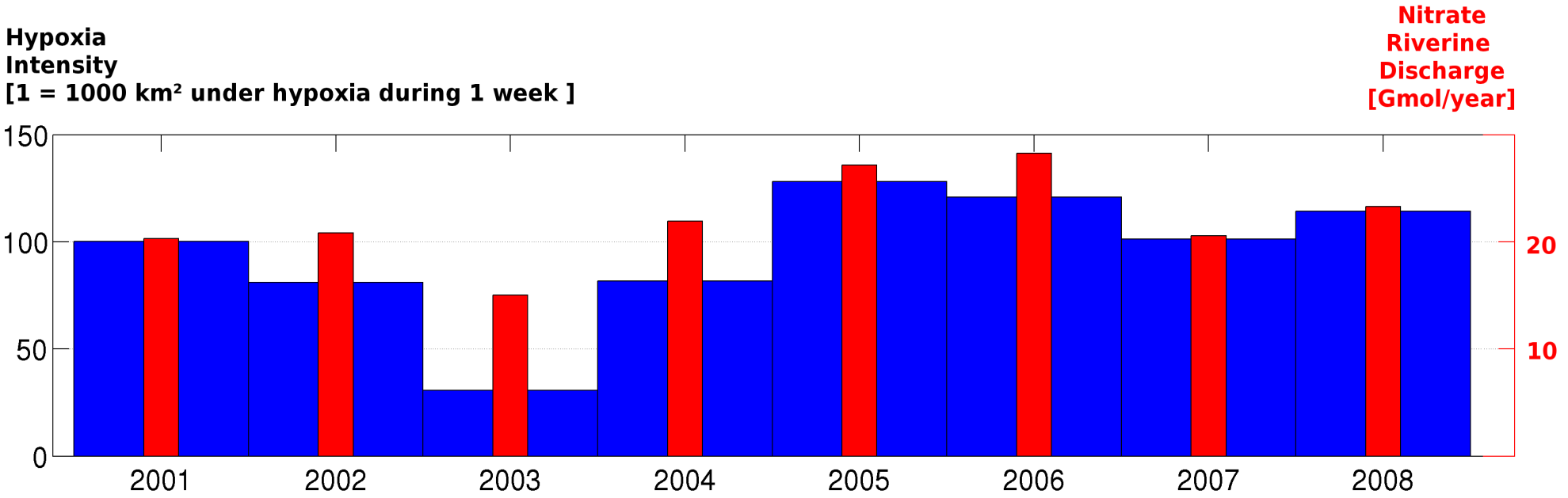


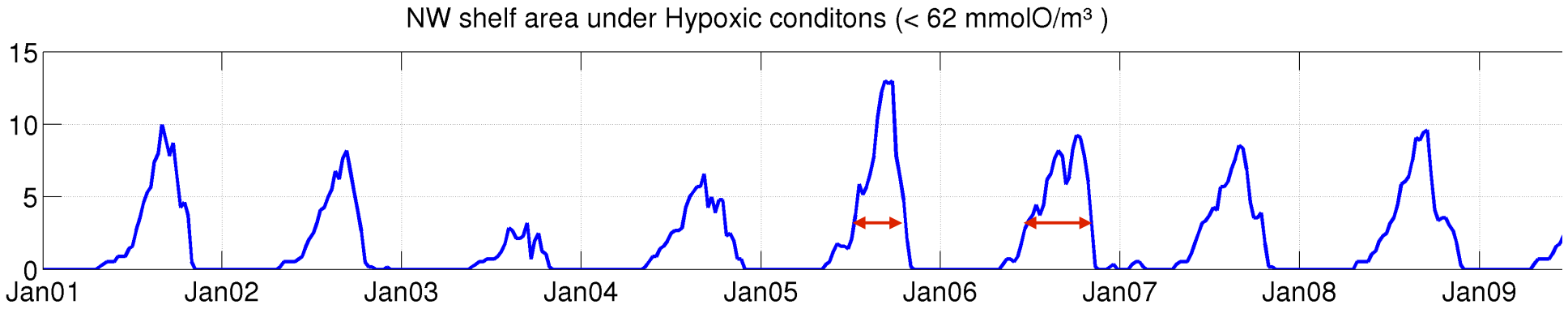
Capet A., et al, *Spatial variability of benthic remineralisation processes in the Black Sea North western Shelf*, *in prep*.

Hypoxia interannual variability



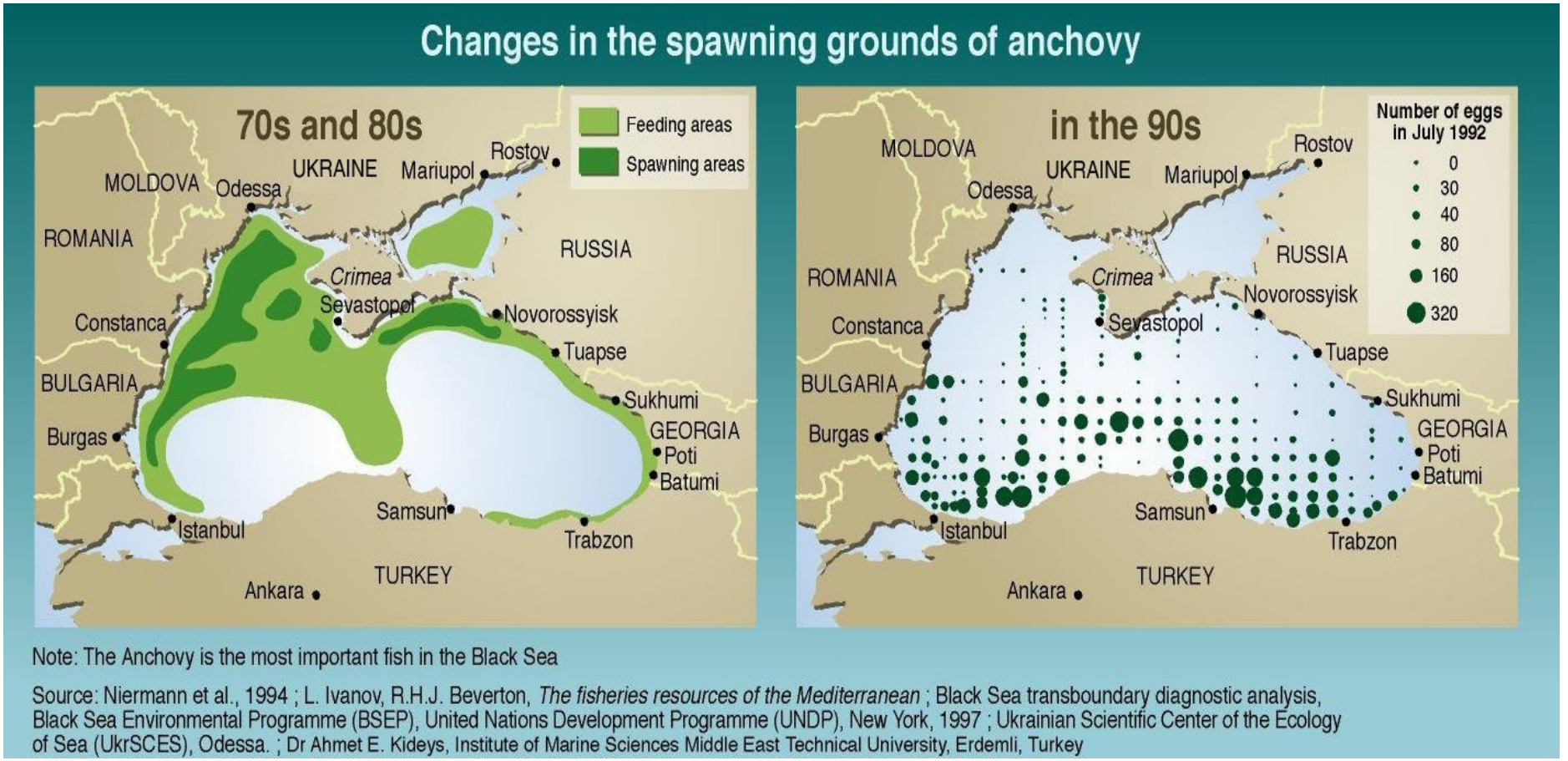
Hypoxia interannual variability





Questions

- Spatial variability : distinguishing NWS from open basin in the EwE inputs data.



Questions

- BS-NWS specificity : accounting for the influence of hypoxia → inclusion of benthic species ?

Questions

- 1-way
  - OK for hydrodynamical variables (SST, Rim current intensity ..)
- .. or 2-way
  - Represent the effect of trophic cascade on the zooplankton control (from bottom-up to top-down) (gelatinous variables in the LTL, inclusion of additional mortality by fish plankton consumption).
  - Direct interactions of HTL with detrital and inorganic stocks.

Context

- Quasi-enclosed basin.
- Strong stratification.
  - >Highly sensitive
    to external forcings.