

**Decline of the Black Sea Oxygen Inventory:** Foreseeing future evolution and consequences

Arthur Capet<sup>1</sup>, Luc Vandenbulcke<sup>2</sup>, Marilaure Grégoire<sup>1</sup> <sup>1</sup>MAST, ULg, Liège, Belgium



### The world's largest anoxic basin



accumulates organic matter in sediments,

and is now sustained by global warming that :

(3) restricts the spring ventilation,

tion that :

(2)

(4)

HE Black Sea is quasi-enclosed and permanently stratified basin. Exposed to large external pressures, its ecosystem is highly sensitive and prone to large and quick response.

Oxygen conditions are challenged by the combination of two main drivers

- Eutrophication, peaking in the 80's.
- Warming, starting from the 2000's.

# **Societal Challenges**

 $\mathbf{X}$  S deoxygenation threathens marine resources and services, foreseeing its evolution is a strategic challenge. Policy-makers should be informed about:

- How will oxygen distribution evolve in the **short**, **mid and long term future** ?
- May **habitat compression** jeopardizes the survival of fishery stocks ?
- May hydrogen sulphide excursions threatens marine and coastal populations ?

## **Models**

AMHBI (BiogeochemicAl Model for Hypoxic and Benthic-Influenced area) is a "quite-complex" model ( $\sim$  30 State Variables), focusing on benthic-pelagic ex-

# **Seasonal hypoxia**

changes and suboxic biogeochemical processes. It is coupled with 3D circulation models for operational (NEMO, CMEMS) and process-oriented studies (GHER). In addition, a 1D set-up has recently been implemented for development, sensitivity, calibration, and MCMC studies (R framework, FME).

Gelatinous G1 G2 EASONAL hypoxia appeared on the northwest-Bacteria Zooplankto Organic Group Past years (1981-2009) Composition 20 ern shelf in the 80's following eutrophica-Free Stoich. ratio ----Fixed Stoich. ratio <sup>N</sup> 15 Aineralizatior ອີ10 enhances organic matter rain to bottom waters espiration Dissolved inorganic ----- 1981-2009 Lysis Labile Oxidation ----- 2015-2020 Phytoplankton . P2 Ρ3 Trophic Interactions С 60 80 Nitrogen Riverine Discharge - [Gmol] Р Mortality Chemical reactions Nitrif Excretion Oxidation ODL NP  $NO_{x}$   $NH_{4}^{+}$   $PO_{4}^{3}$  DIC  $SiO_{4}^{3+}$ Particulate N<sub>2</sub> loss Benthic/Pelagic Fluxes Deposition Anammo> -----Dissolved Diagenesis ( Bulk Parameterization Benthic/Pelagic N P -Burial Fluxes Labile Semi-Labile



WATER

COLUMN

DOM

Resuspension

SEDIMENTS

<u>N</u> P

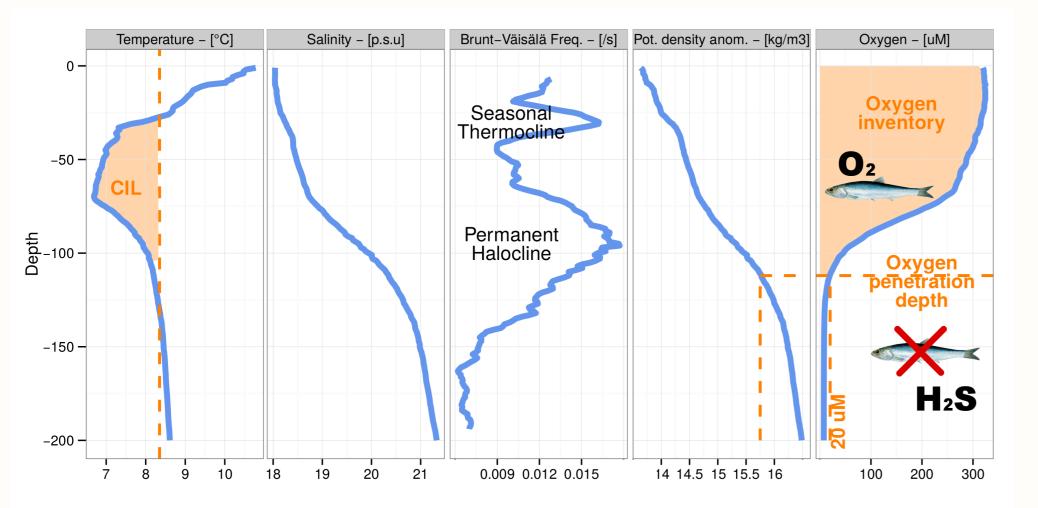
elongates the stratification period. Oxygen exchange with Atmosphere -5 3 Depth -15 (1)Oxygen Consumption -20 Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

#### **Observations**

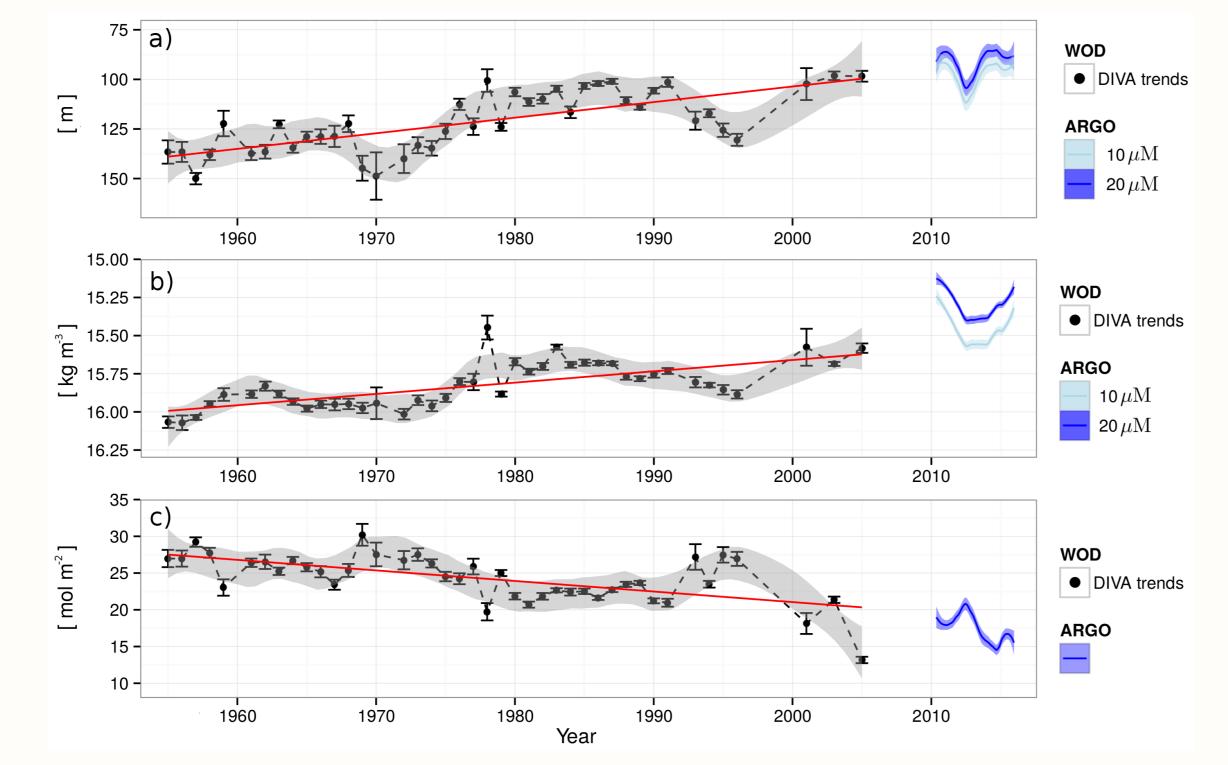


### Shoaling of the oxycline

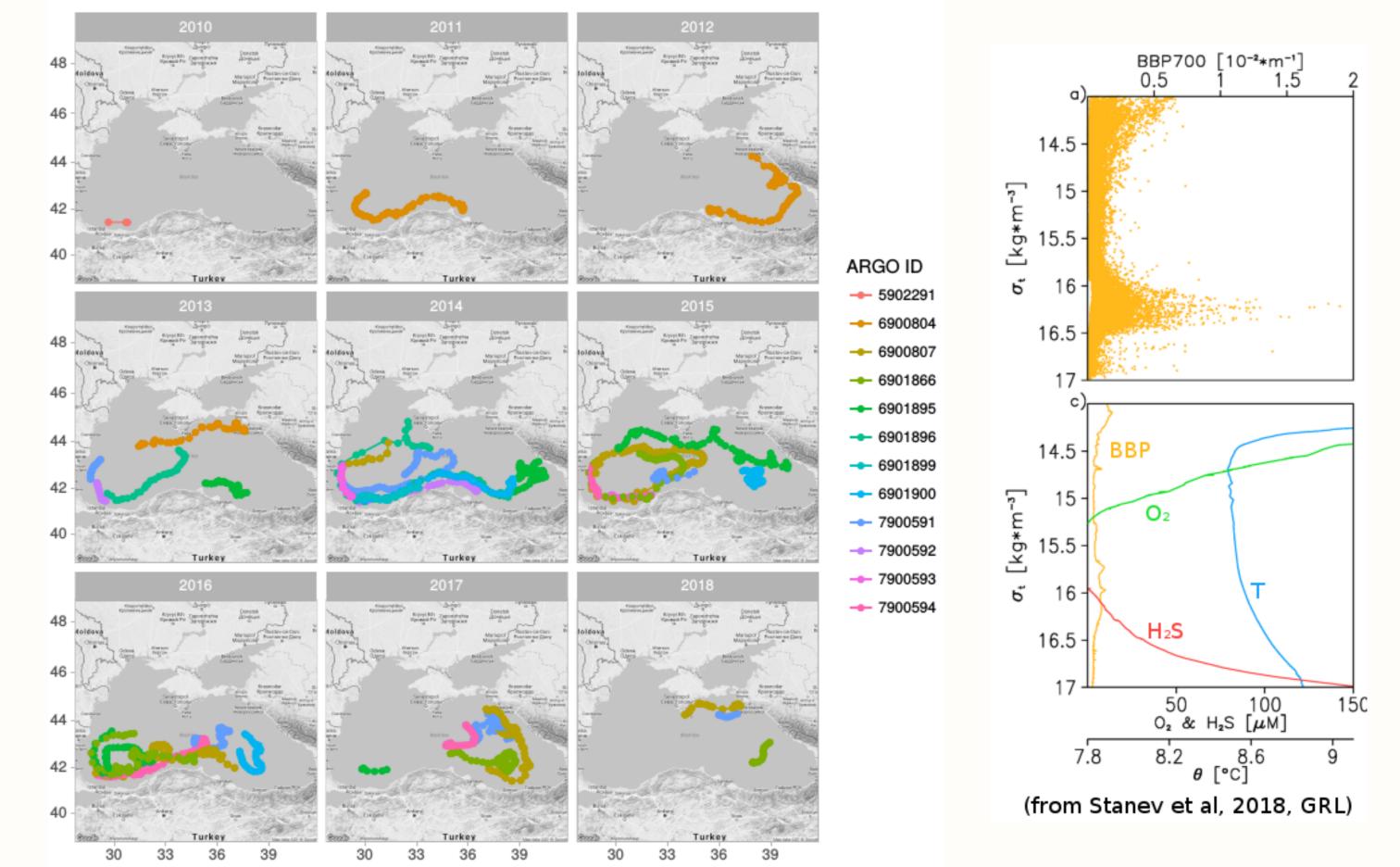
the open sea, where permanent anoxia prevails, the limit between oxic and anoxic waters migrated upward during the last decades.



Three diagnostics derived from vertical profiles: oxygen inventory  $[mol m^{-2}]$ , oxygen penetration depth [m], oxygen penetration depth on a density scale [kg m<sup>-3</sup>].



GC-Argo Floats presents an opportunity to better constrain the oxygen cycle worldwide. In particular the **detrital loop**, **light penetration** and **suboxic biogeo**chemistry are all key sub-surface elements of the basin-scale oxygen dynamics which are poorly constrained by current data set.



Deoxygenation trends in the Black Sea basin. The volume of oxygenated water has decreased by 44% from 1955 to 2015.

#### **Data assimilation challenges**

- E target a general biogeochemical data assimilation methodology that
  - incorporates sub-surface BGC-Argo observations.
  - allows to recognize the uncertainty stemming from the inherent diversity of BGC mediators (plankton, bacteria)
  - enhances the reliability of scenario simulations by improving models rather than model results,
  - ensures dynamical consistency and conservation in order to keep track of BGC fluxes (eg. C, N, O 2), in terms of transport and transfer among various pools.

Modelling for Aquatic SysTems: http://labos.ulg.ac.be/mast/

acapet@uliege.be