OceanGliders

Water Transformation

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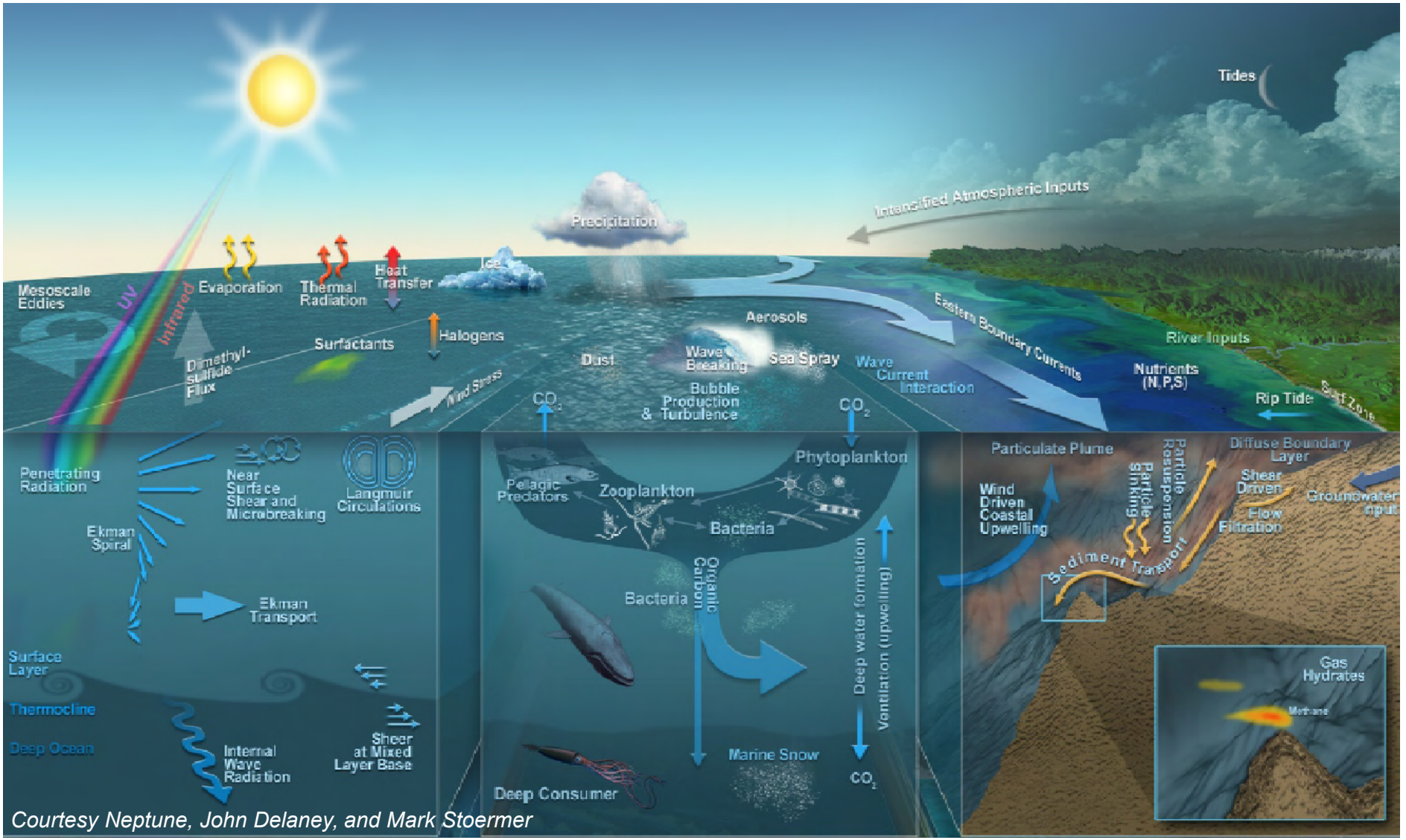
Water Mass Transformation



Courtesy Neptune, John Delaney, and Mark Stoermer

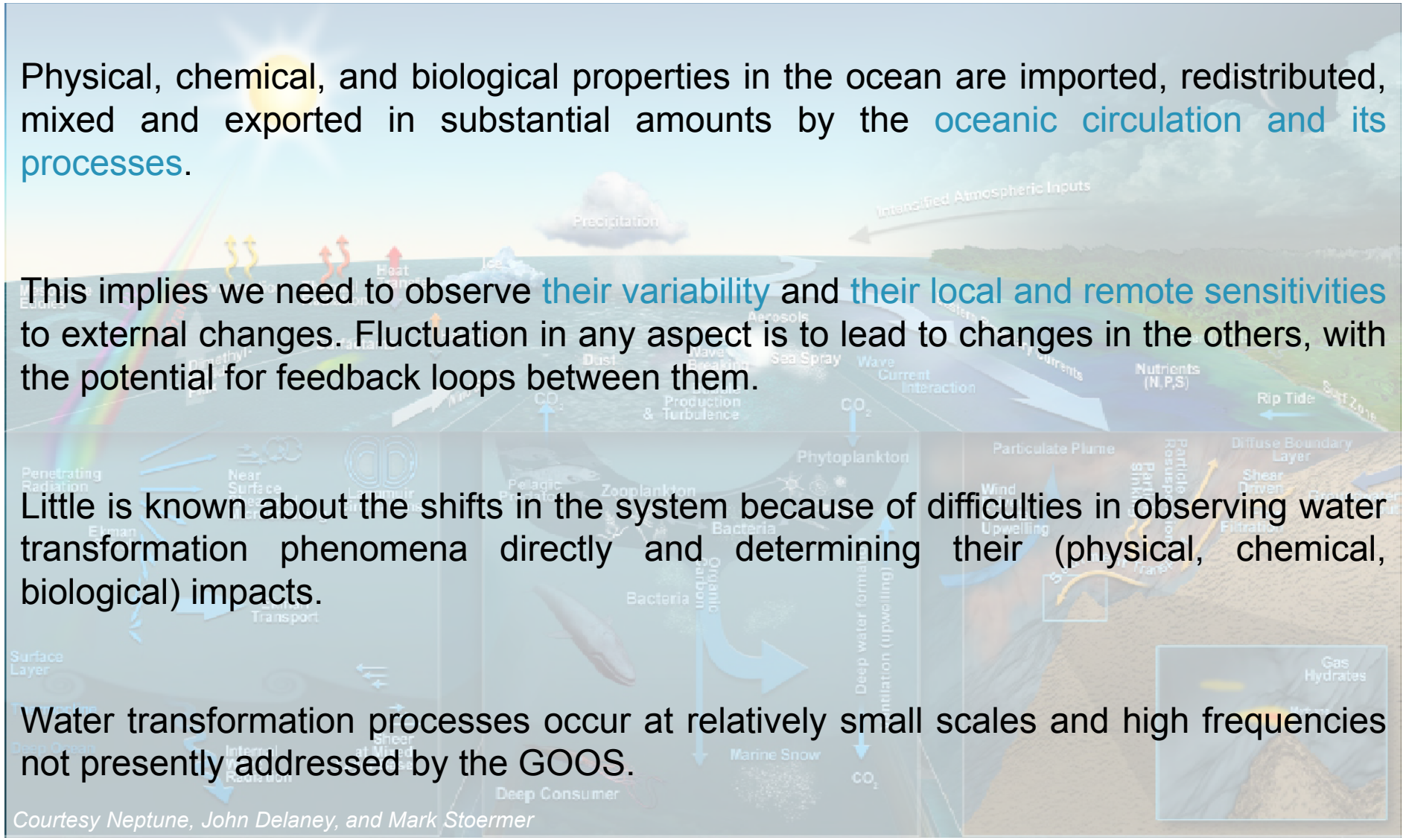
Water Mass Transformation

Physical, chemical, and biological properties in the ocean are imported, redistributed, mixed and exported in substantial amounts by the oceanic circulation and its processes.

This implies we need to observe their variability and their local and remote sensitivities to external changes. Fluctuation in any aspect is to lead to changes in the others, with the potential for feedback loops between them.

Little is known about the shifts in the system because of difficulties in observing water transformation phenomena directly and determining their (physical, chemical, biological) impacts.

Water transformation processes occur at relatively small scales and high frequencies not presently addressed by the GOOS.



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Water Mass Transformation

They are critical phenomena, however, that need to be assessed to better understand and model the evolution of the global/regional oceans, and in particular their deep reservoirs of heat, salt, nutrients, etc.

We do not know how these ocean processes influence change in these water properties.

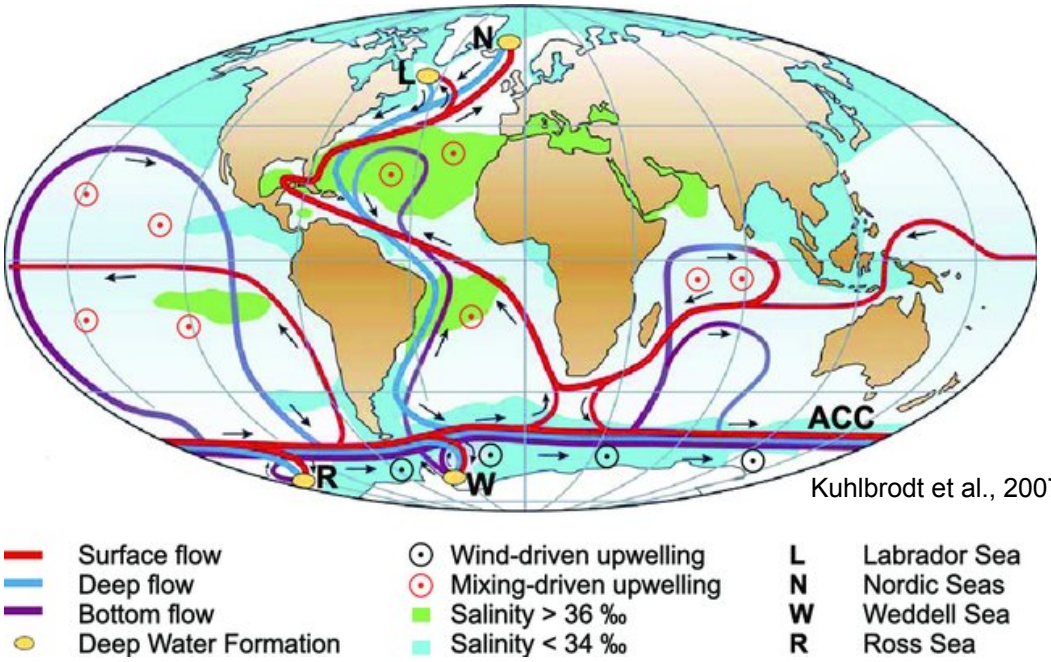
To fill this gap, the **OceanGliders** program proposes the long term and sustained observation of these phenomena with gliders whose unique capabilities (including under ice operations) and versatility allow them monitoring of such processes, in combination with other observing techniques, with sufficient accuracy.

OceanGliders aims to first address the two following global needs in ocean observations, by considering several key regions where water transformation processes that are important for the global (physical, chemical and biological) ocean occur.

1) Open sea and shelf water mass formation (vertical-horizontal mixing)

2) Mesoscale and submesoscale phenomena (horizontal-vertical mixing)

1) Open sea and shelf water formation



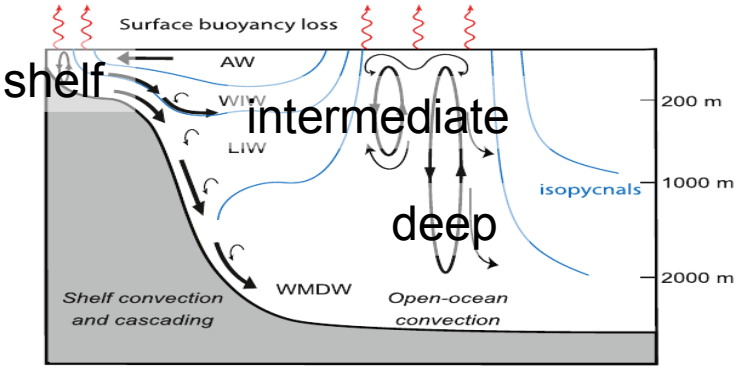
Kuhlbrodt et al., 2007

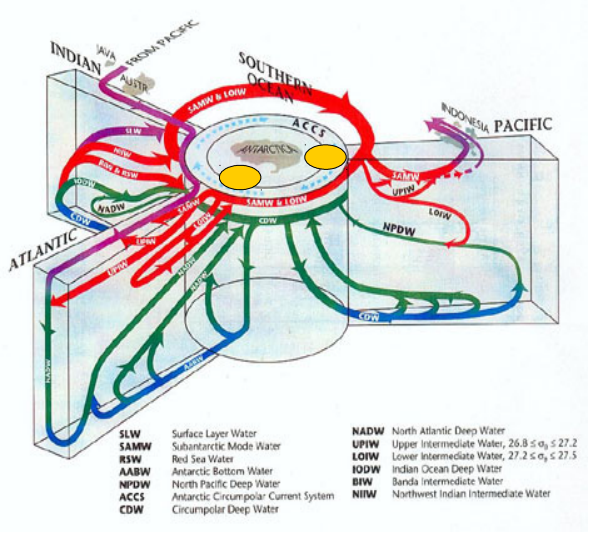
Winter strong air sea fluxes imply the vertical mixing can reach great depths at some locations.

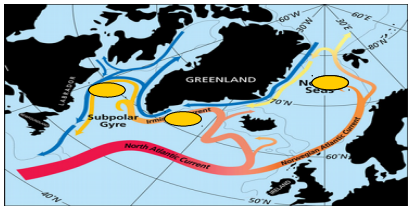
This Deep Water Formation phenomenon sets up the properties of water masses that will spread on great distances O(1000 km)

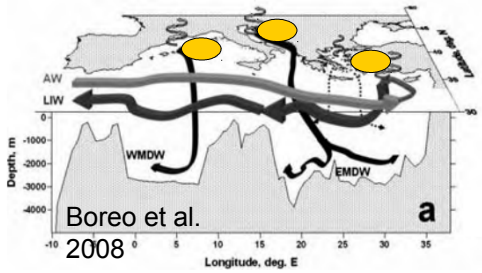
And in mid-latitudes and subpolar areas:

- Intermediate water formation
- Shelf water formation





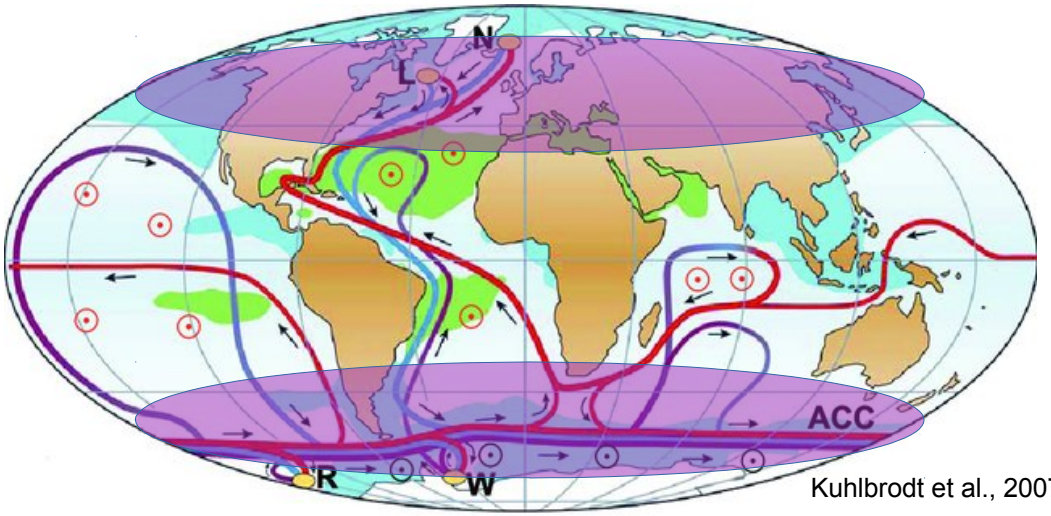




Boreo et al. 2008

The newly-formed waters interact with older ones and between each other, when subducted and disconnected from the surface.

1) Open sea and shelf water formation

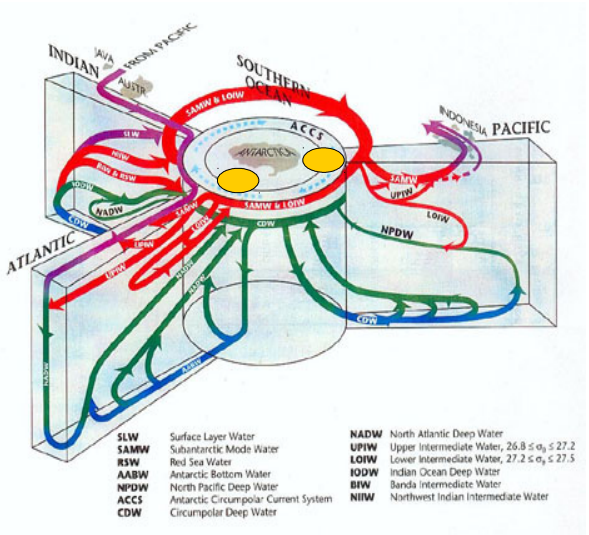


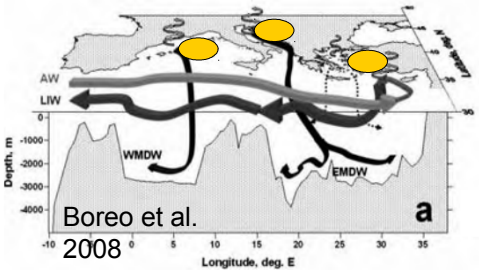
Kuhlbrodt et al., 2007

Surface flow
Deep flow
Bottom flow
Deep Water Formation

Wind-driven upwelling
Mixing-driven upwelling
Salinity > 36 ‰
Salinity < 34 ‰

L Labrador Sea
N Nordic Seas
W Weddell Sea
R Ross Sea





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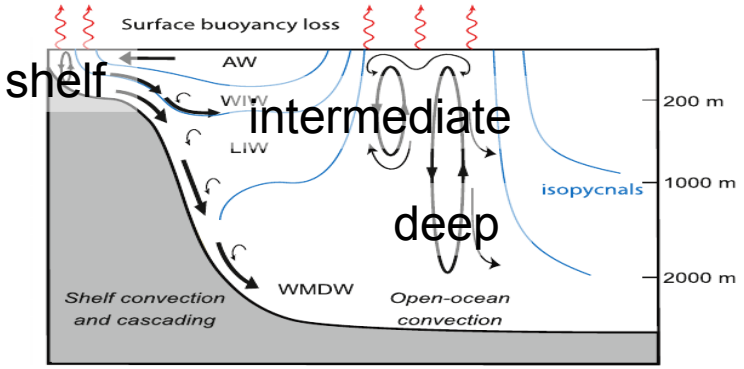


The newly-formed waters interact with older ones and between each other, when subducted and disconnected from the surface.

1) Open sea and shelf water formation

The observation of such phenomena remained a challenge until the use of autonomous underwater gliders in combination with more classical ocean observing techniques.

Water formations

- occur on an “intermittent” basis and often very local patches (~100km) during relatively short episodes of strong air-sea fluxes (some days)

- result from different oceanic and atmospheric factors that must be considered at least on a period starting the previous summer/fall due to preconditionning effects.

This implies:

- sustained in-situ observing efforts on relatively large areas,

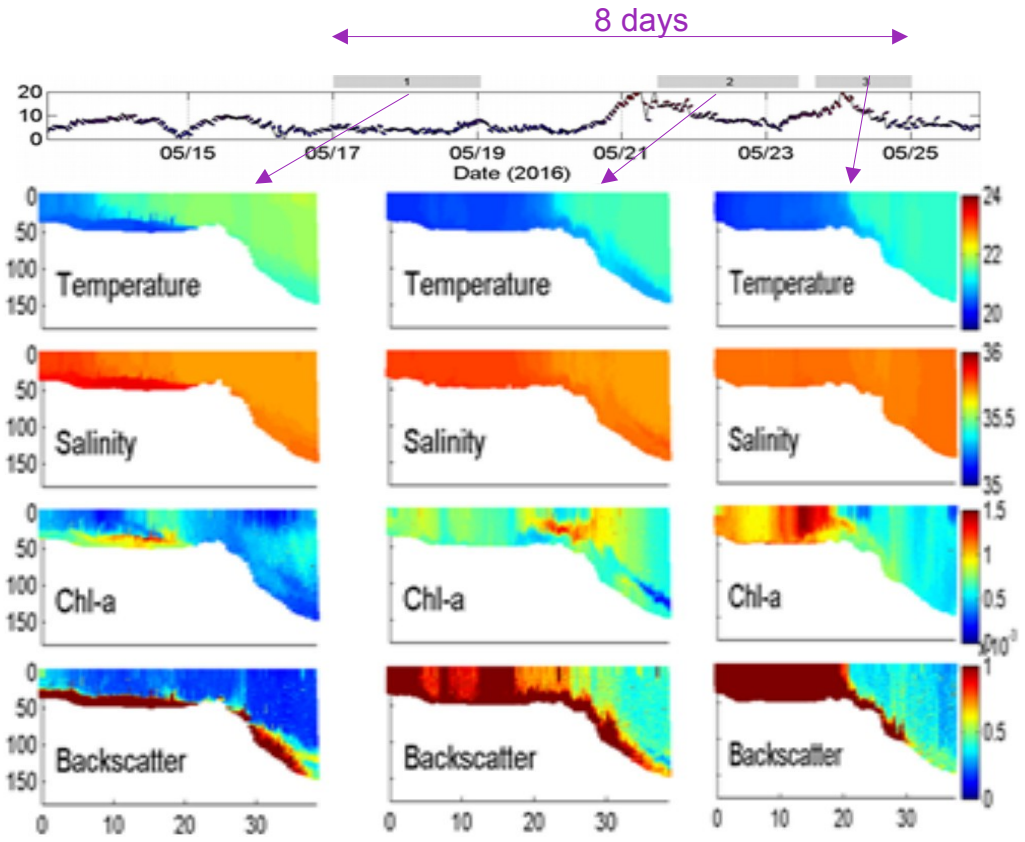
- high horizontal resolution because of the involved small scale circulation features

- almost throughout the year, and moreover in winter/spring, when it is very difficult to carry out in-situ measurements due to severe conditions at sea.

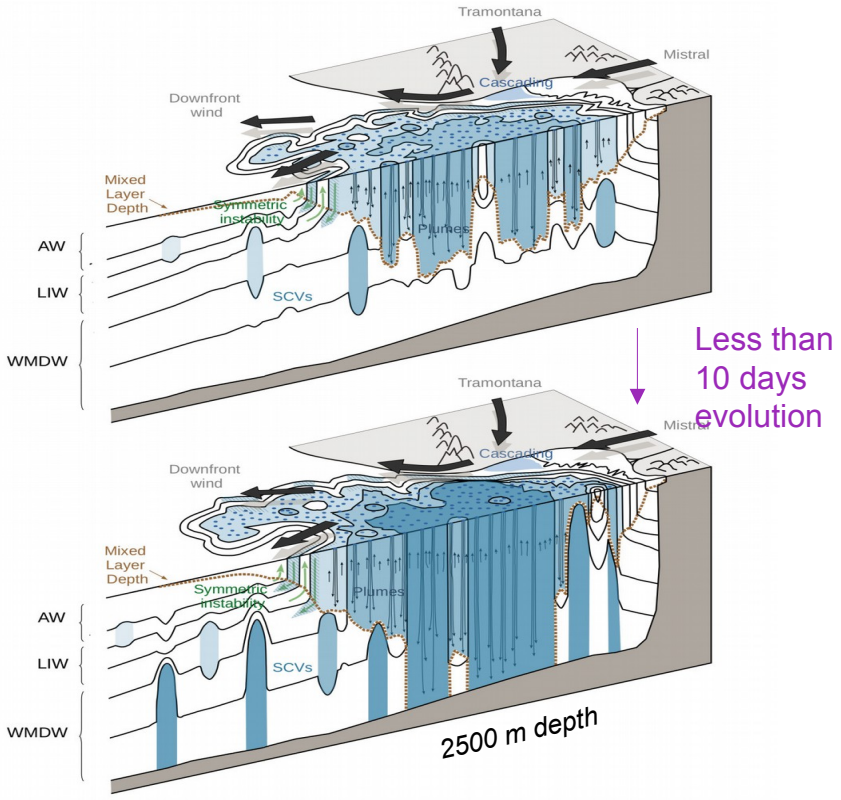
1) Open sea and shelf water formation

Gliders:
→ allow to capture most of the oceanic (physical/biogeochemical) variability of the upper ocean layer (~1 km) with high resolution measurements (1 km horiz.);
→ are able to operate even during severe conditions at sea;
→ can repeat observations along e.g. a ~300 km section at a ~10 days repeat-rate.

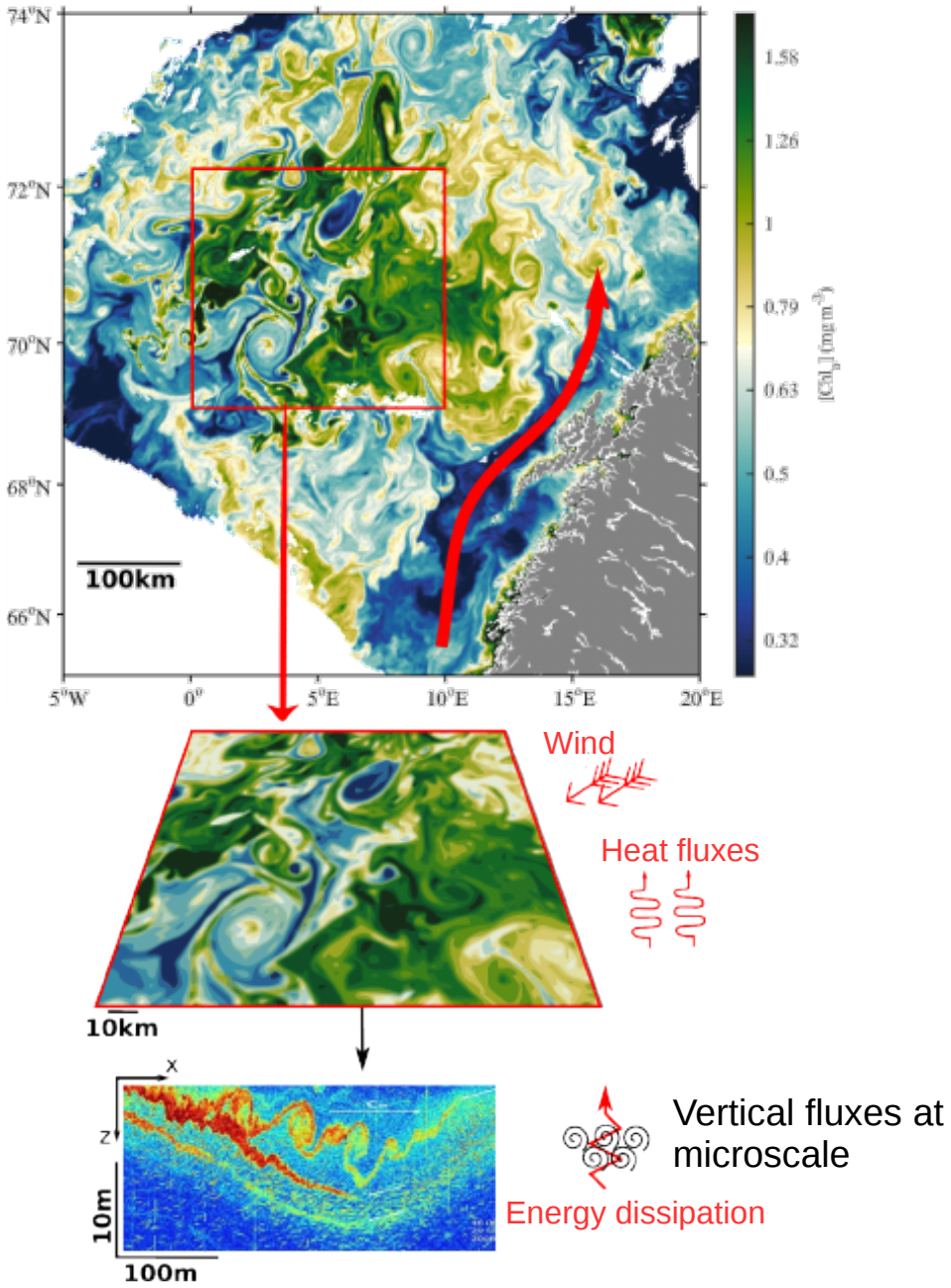
Gliders can provide synoptic views of the different newly-formed water masses



Australia shelf



2) Mesoscale and submesoscale phenomena



Ocean/Atmosphere/Land coupling
Energy cascade (direct/inverse)

Large scale circulation
O(100-1000 km & 10-10^5 days)

↕

Mesoscale eddies
O(10-100 km & 1-10 days)

↕

Submesoscale fronts, filaments and eddies
O(1-10 km & 0.1-1 day)

↕

Microstructure turbulence
O(0.01-100 m & 1-10^3 s)

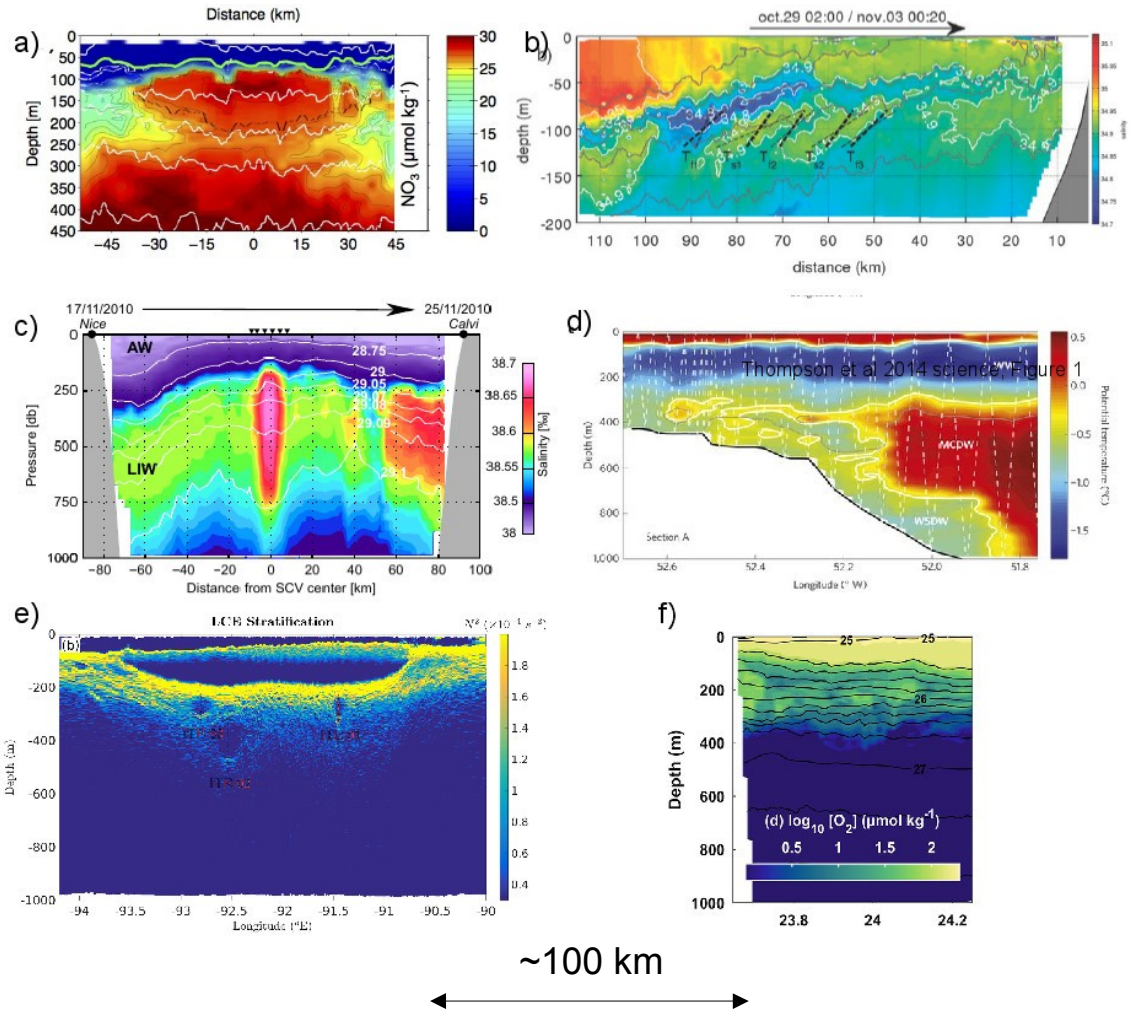
Small scale processes impact the fluxes of energy and matter that determine the physical and biogeochemical evolution of the ocean

2) Mesoscale and submesoscale phenomena

Many glider observations reveal ‘new’ (sub)mesoscale oceanic processes that are crucial for the functioning of the physical, chemical and biological regional and global ocean: Eddies, SCVs, fronts, plumes, filaments, microstructure turbulence patches...

The extent and variability of their impact over long periods of time still needs to be assessed.

Gliders offer a new high-resolution lens for observing the full seasonal cycle, in their ability to observe the physical-biological coupling at sub-seasonal and sub-mesoscale.



a) Vertical section across a Dead Zone Eddy (DZE) showing its lens-like structure in nitrate concentrations (from Figure 7 of Karstensen et al. 2017); **b)** Vertical section of salinity across the upwelling front off Peru (from Figure 7 of Pietri et al. 2013); **c)** Vertical section across a SCV “Suddy” (from Figure 2 of Bosse et al 2015) **d)** Vertical section across the shelf of Antarctica peninsula (from Figure 1 of Thompson et al 2014) **e)** Vertical section across a LCE showing intrathermocline eddies (ITE) within (from Figure 11 of Meunier et al 2018b) **f)** Vertical section of dissolved oxygen in the Persian Gulf (from Figure 2 of Queste et al 2018)

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Ocean Gliders

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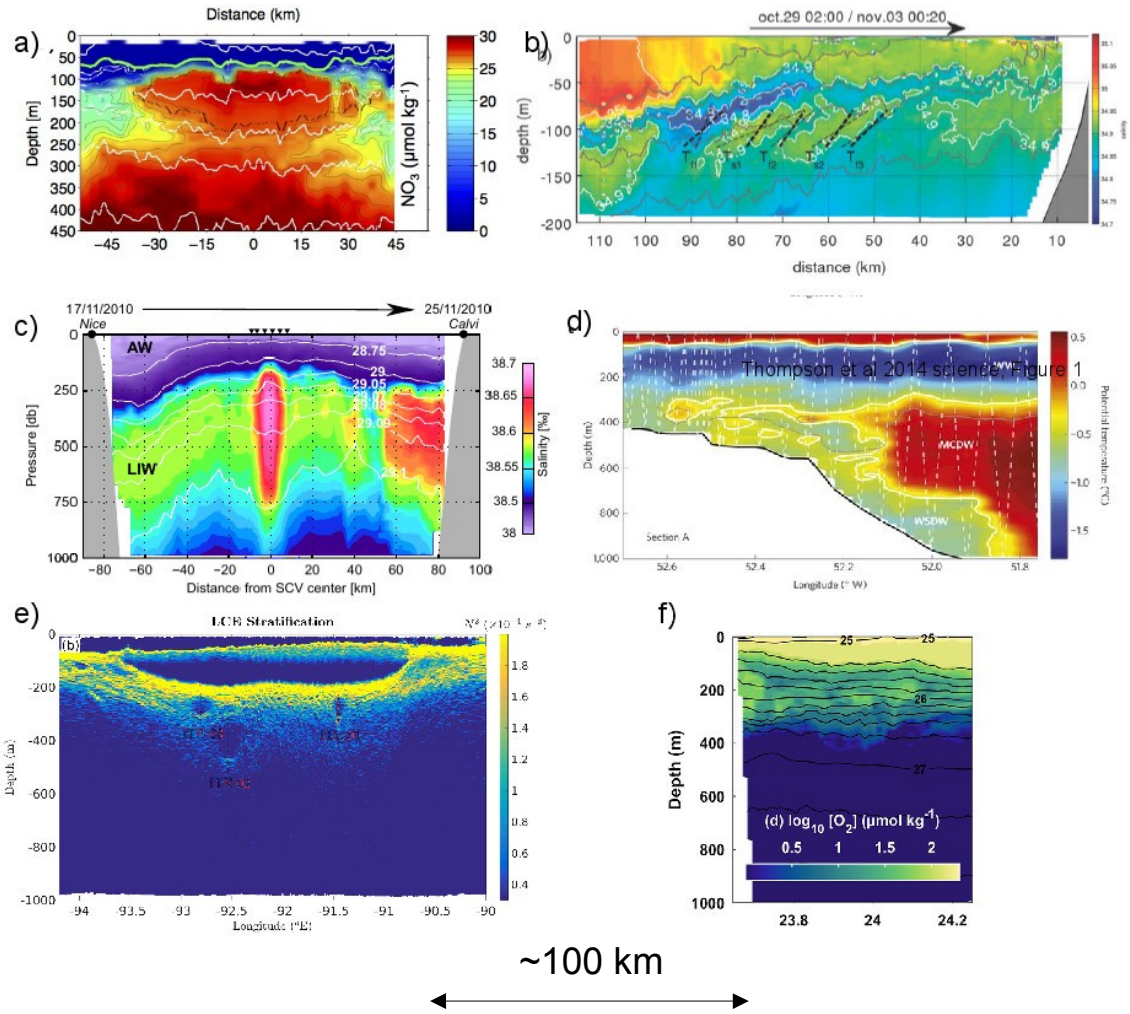

The anomalies caused by the (sub)mesoscale variability exceed by one order of magnitude those attributed to changes in large scale circulation and marine ecosystem (IPCC, Bates et al. 2018). They must be considered seriously to further our understanding and observation of the physical, biogeochemical and biological ocean.

dissolved oxygen in the Persian Gulf (from Figure 2 of Queste et al 2018)

Water Mass Transformation (WMT) Task Team

Objectives:

- to provide coordination and linkage for developing a global observing program on water transformation phenomena together with the other components of the GOOS;
- assist other teams in engaging in the glider technology on this topic.

Tools:

- methodologies to estimate the variability of water transformation phenomna (e.g. water formation rates and eddy fluxes);
- best practices in glider mission design, glider operations and data analysis.

Expected benefits:

- have a better knowledge of the water transformation phenomena, and of the links between them;
- improve the GOOS (and its applications) with key (physical and biogeochemical) constraints, and in particular on numerical models.

Setting up a common framework to study WMT

Before proposing glider sections for the design of **OceanGliders** in the GOOS, several questions need to be answered such as:

1) What key regions need to be monitored;
2) What variables need to be measured;
3) What are the important indices/metrics for the monitoring of WMT
4) What is the temporal resolution needed for the monitoring of such areas? (repeat-rate of 10 days? all year long? only in winter/summer?);
5) What will be the complementarity with the other GOOS components (satellites and in situ: OceanSITES, Argo, …) .

Please fill the google form available at https://forms.gle/wi7xuKDZFSWBRYtk8
so we can produce a synthesis of the answers to be disseminated and discussed.


Thank
you!