

A satellite image of Earth's ocean from space, showing a vast expanse of blue water with white clouds and a thin white line representing the Earth's horizon. The image is taken from a high angle, looking down at the ocean.

NASA

Physical-biological oceanic processes: from scale interaction to the rise of the living ocean



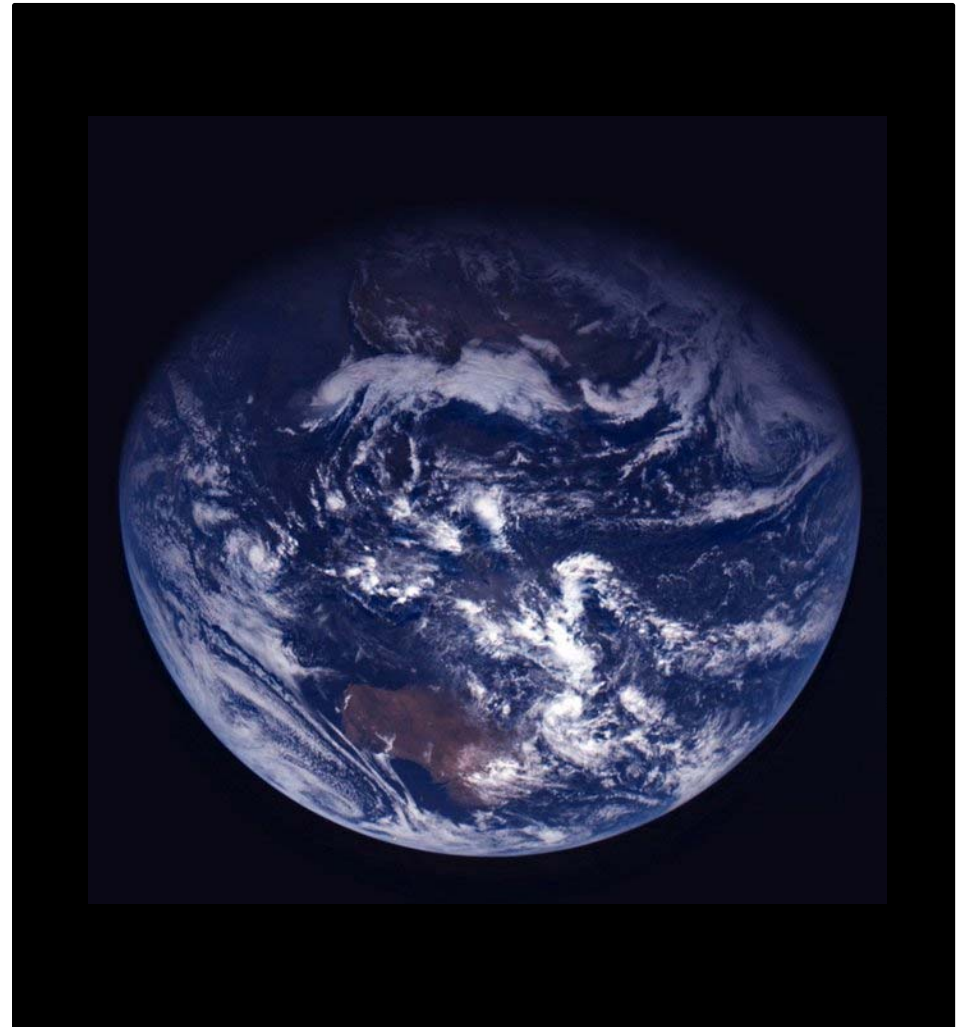
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Motivation

1. Focusing our research?
2. Several examples on establishing connections
3. Aim for 10 days of full consciousness



1. Focusing our research?

What do we mean by doing **research**?

We have always been told that doing research implies focusing...

And by so, people usually means to **identify the hole in the wall off knowledge**, sort of exploring concrete well-defined processes or situations.

But how do we focus when looking at the living ocean?

Should we focus or perhaps get out of focus?

It is not easy, as we may start just wondering what is a living being?

What is the living ocean?

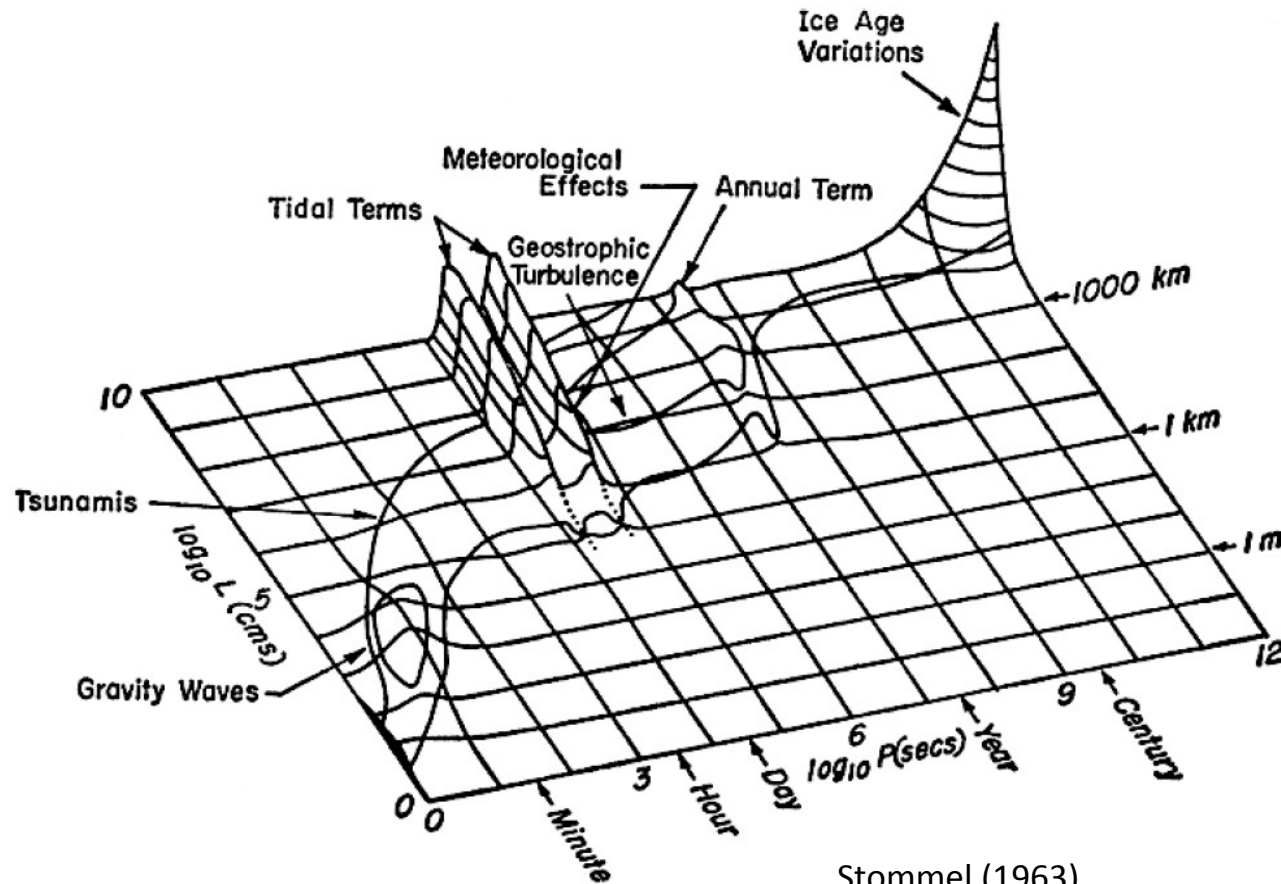
What are we? We are here and now, but we are connected with *elsewhere* and *elsewhen*.

Not being afraid of getting away of our *comfort zone*.

2. Several examples on establishing connections

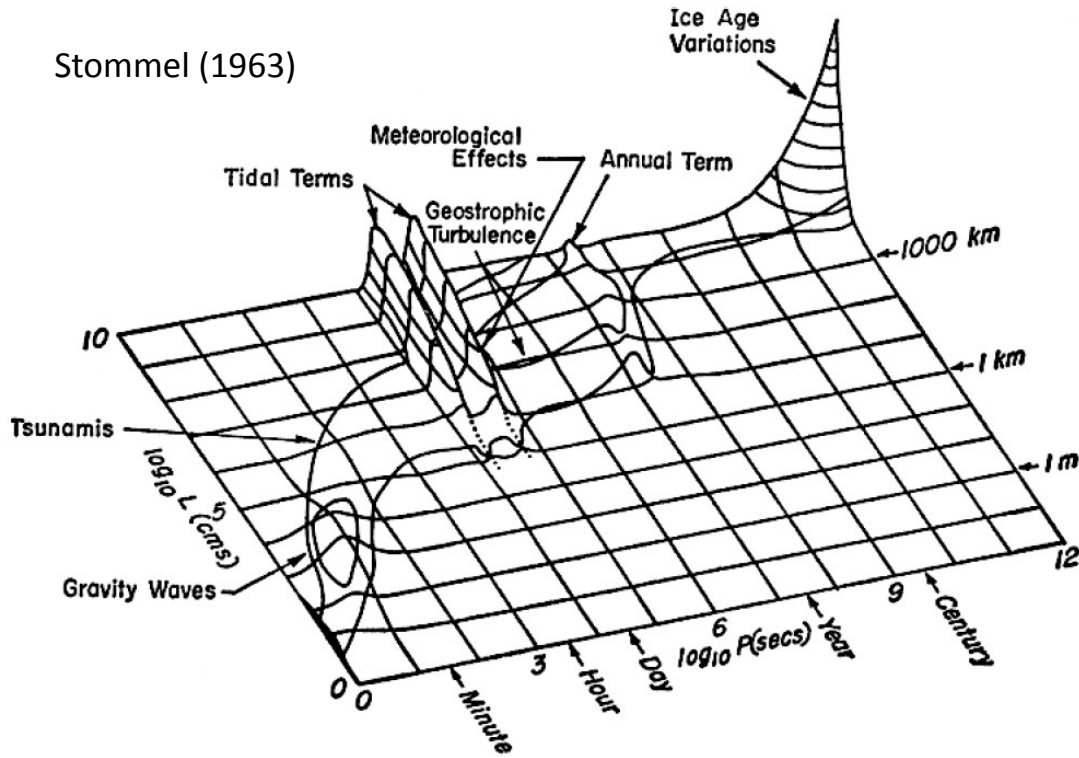
Example 1: Time-space spectrum of energy

The perception that there is continuous of scales contrasts with the classical image (since Stommel 1963) that ocean energy takes place at certain spatio-temporal scales, where energy input takes place.

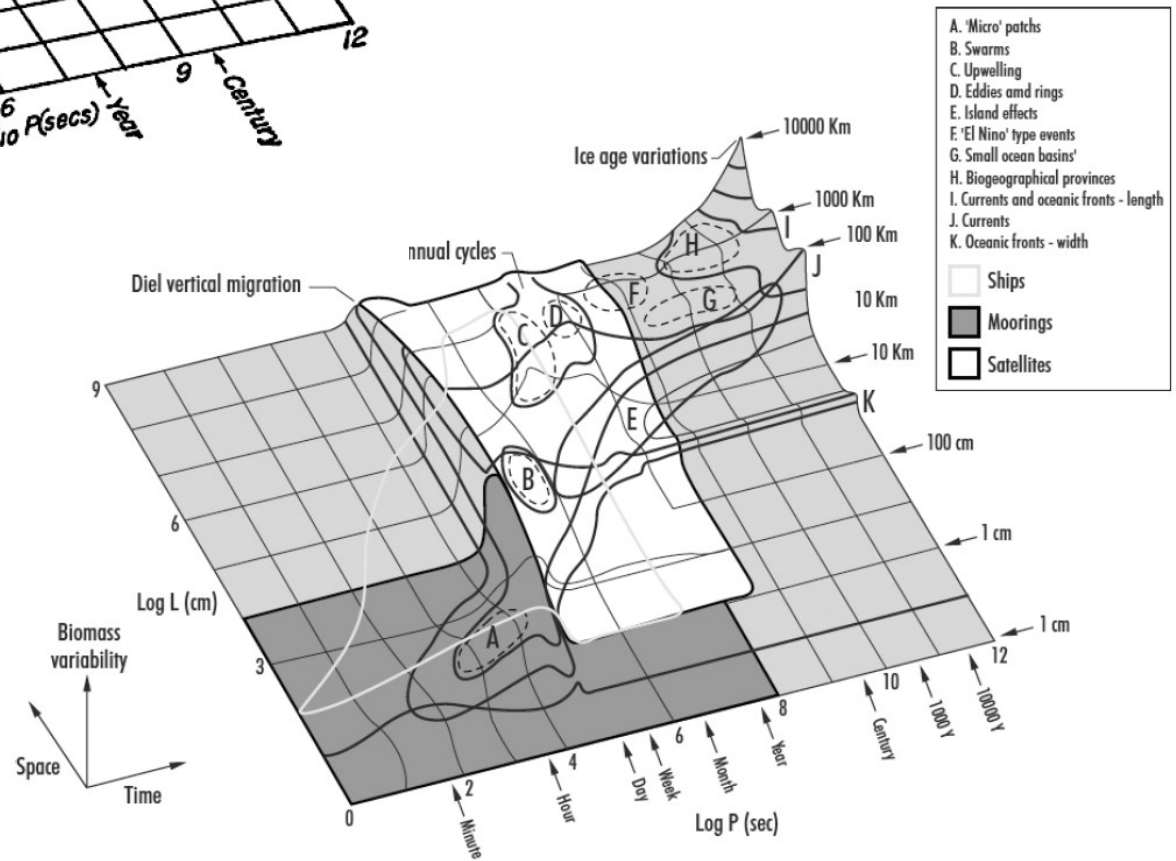


Stommel (1963)

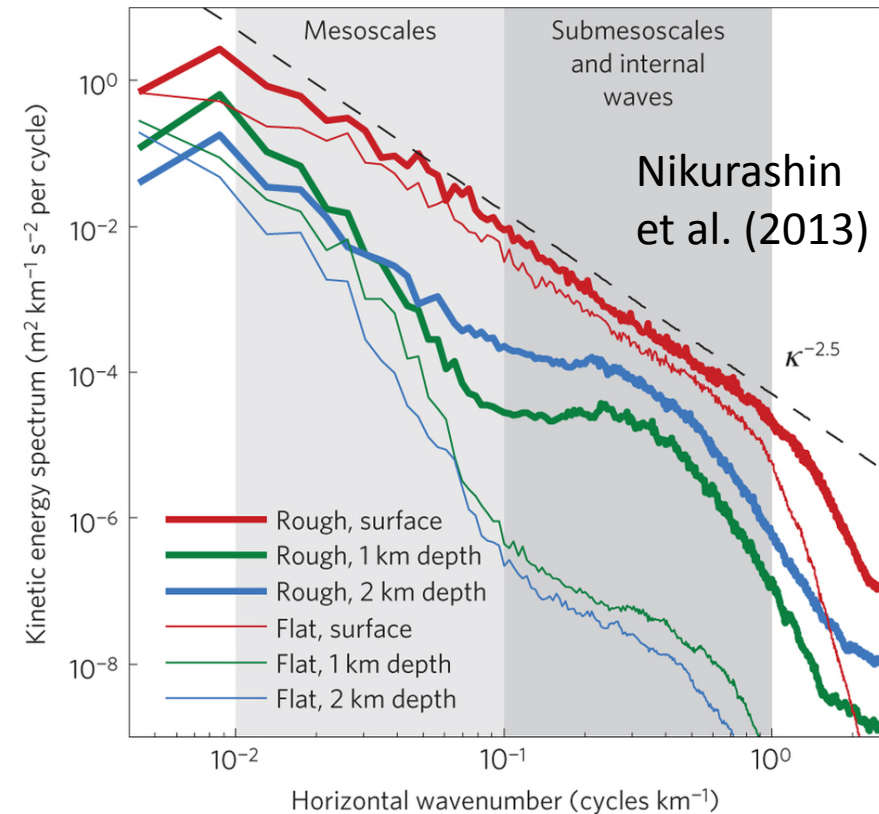
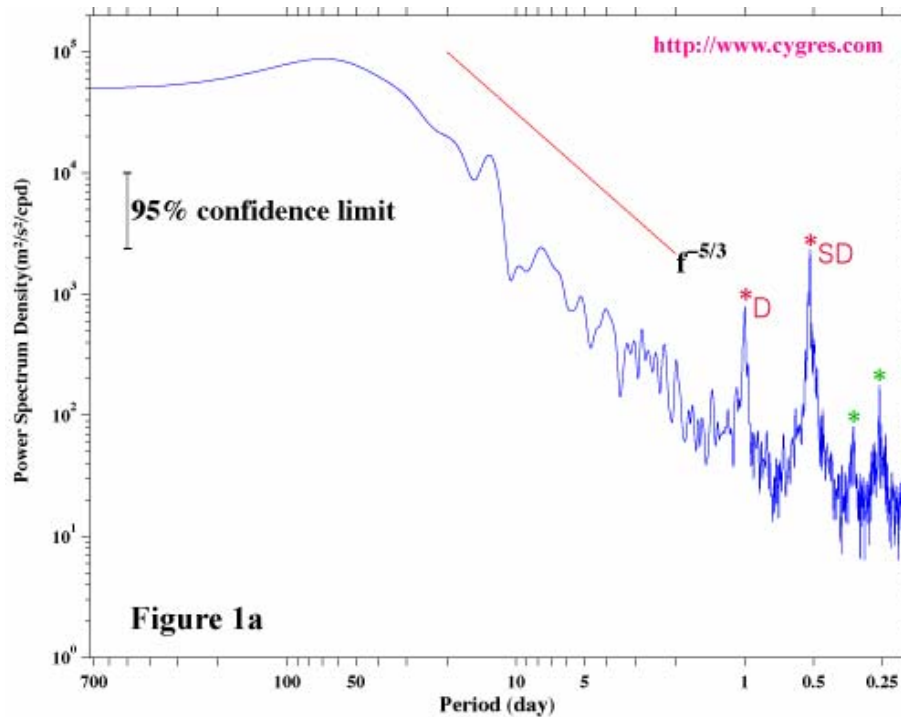
Stommel (1963)



Kaiser et al. (2005),
adapted from Haury et al. (1978)

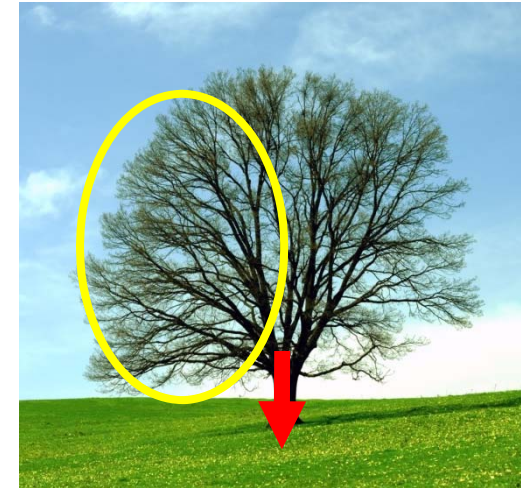
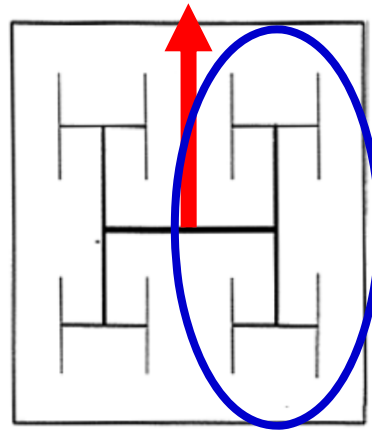
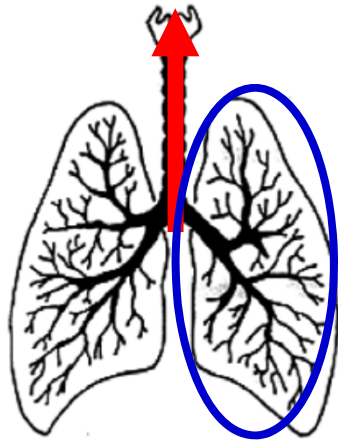


This discretization has been extended to biological processes, expressed in terms of biomass variability.



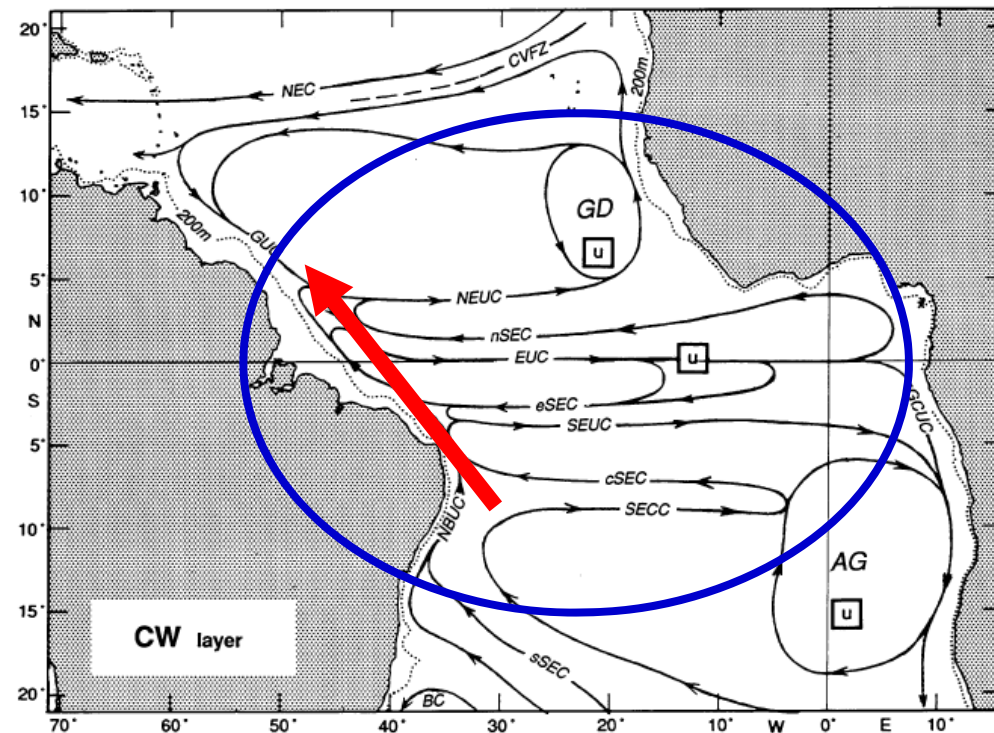
But ocean energy spectra, in either distance or time domains, show a continuous of processes.

Energy enters the ocean at regional or global scales and gets directly transferred to mesoscale structures, its spatio-temporal scale changing from basin to basin. Energy is transferred from the mesoscale to progressively shorter scales, until the Kolmogorov scale where dissipation is more effective than non-linear energy transfer.

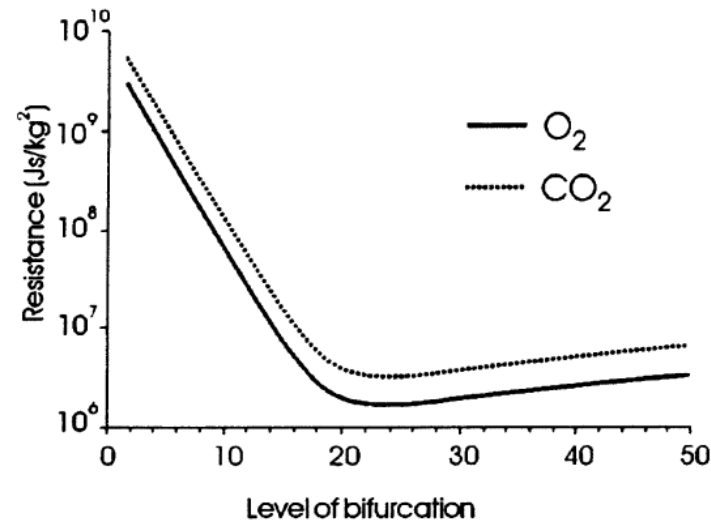
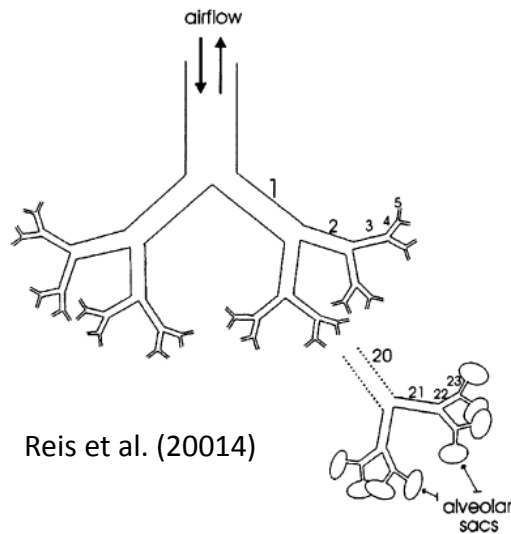


Example 2: Constructal theory
(Adrian Bejan et al.)

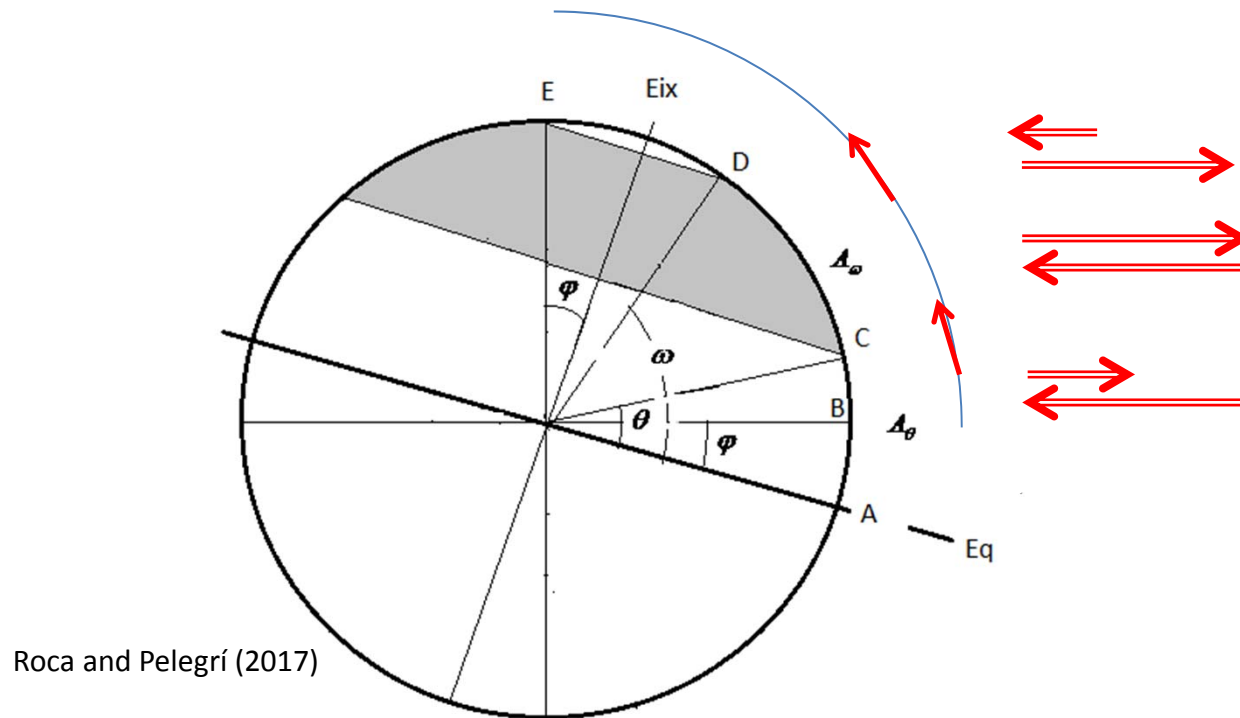
All living (and optimized non-living) systems hold spatial and temporal patterns that maximize the flow of energy, down to certain scales where diffusion is more effective.



Schott et al. (2001)



There is a certain number of bifurcation that minimizes the global resistance to air flow in mammalian airways and lungs.



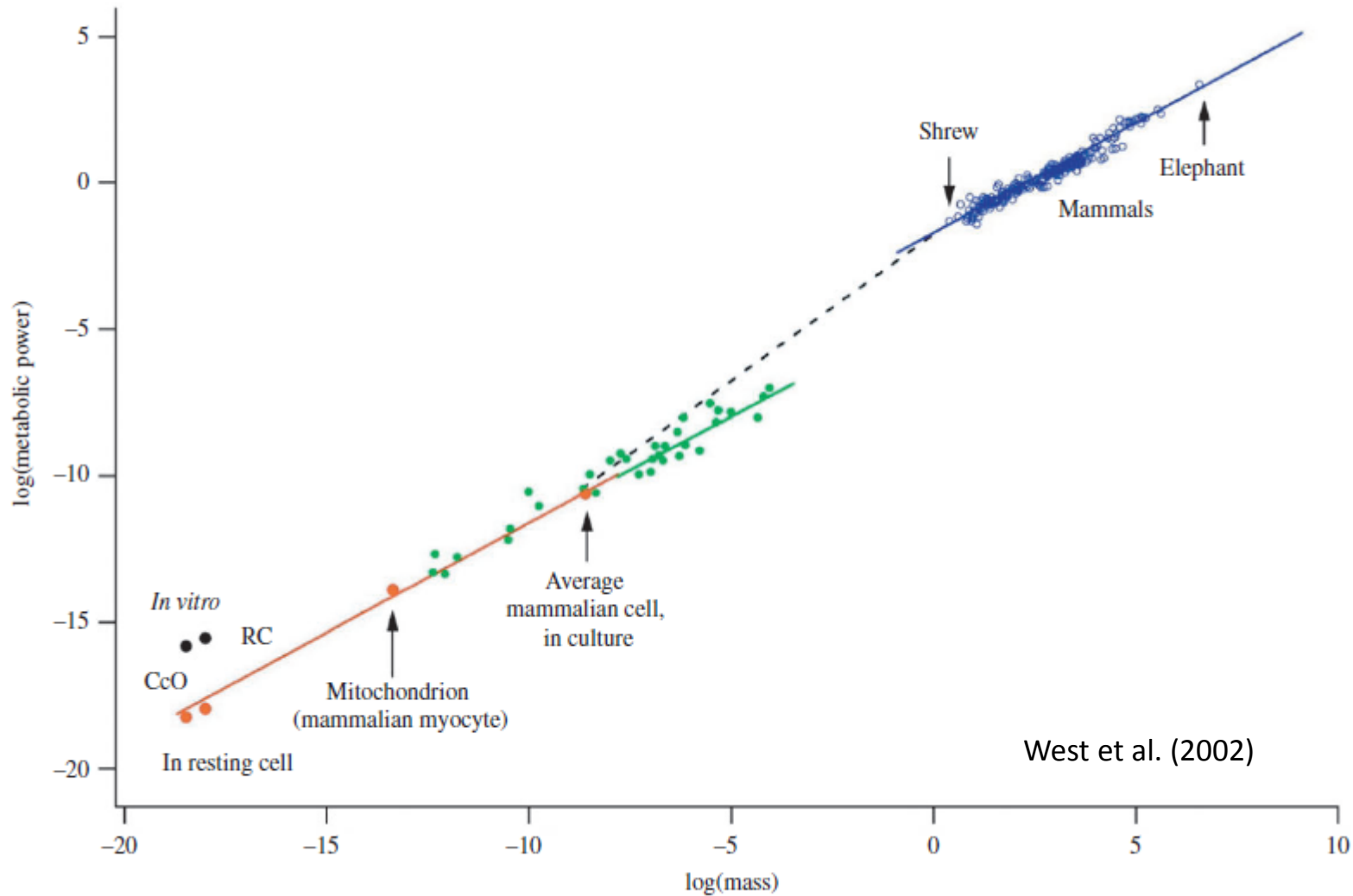
A realistic latitudinal distribution of temperatures is obtained by requiring the latitudinal energy flow to be maximal.

Example 3: Allometric relations

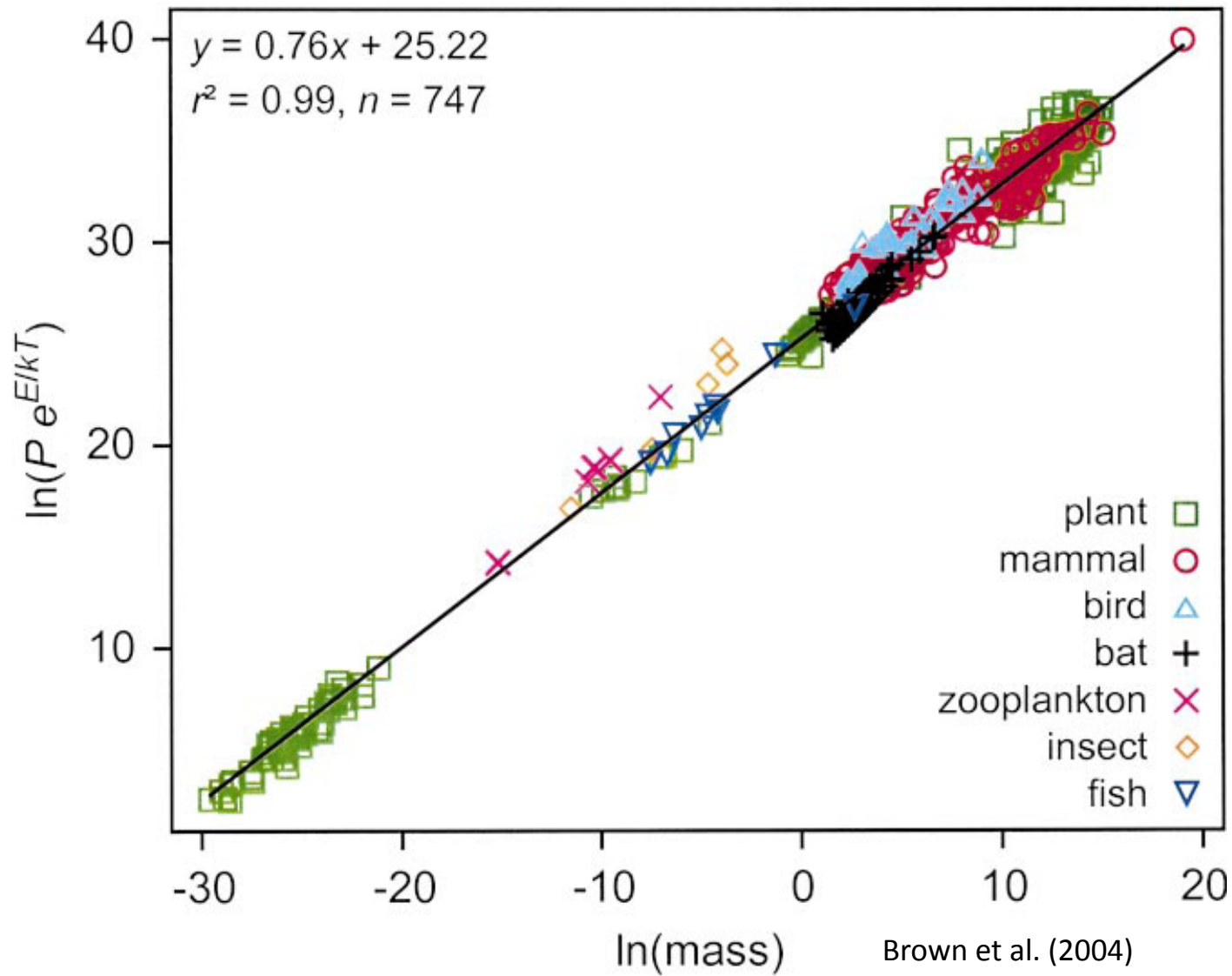
Isometry: length (L), area (L^2), volume (L^3) \rightarrow metabolic problems

In **allometry** the metabolism is based on mass \rightarrow

length ($V^{1/3}$), area ($V^{2/3}$), volume (V). In general: property = $a M^b$

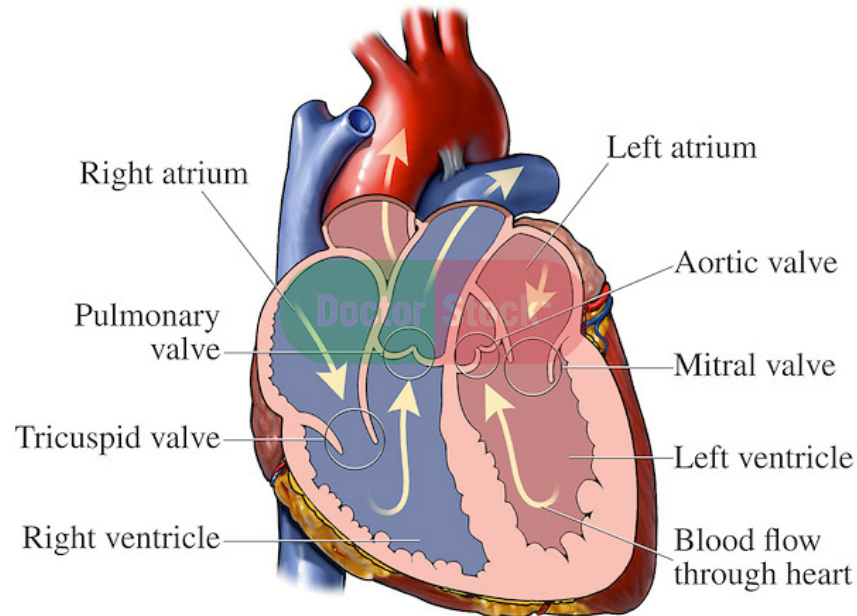


Biomass production (grams per individual and year)

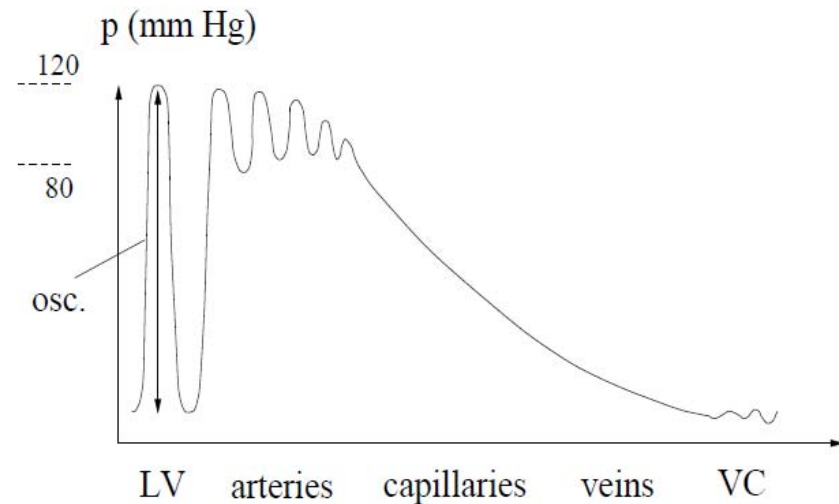
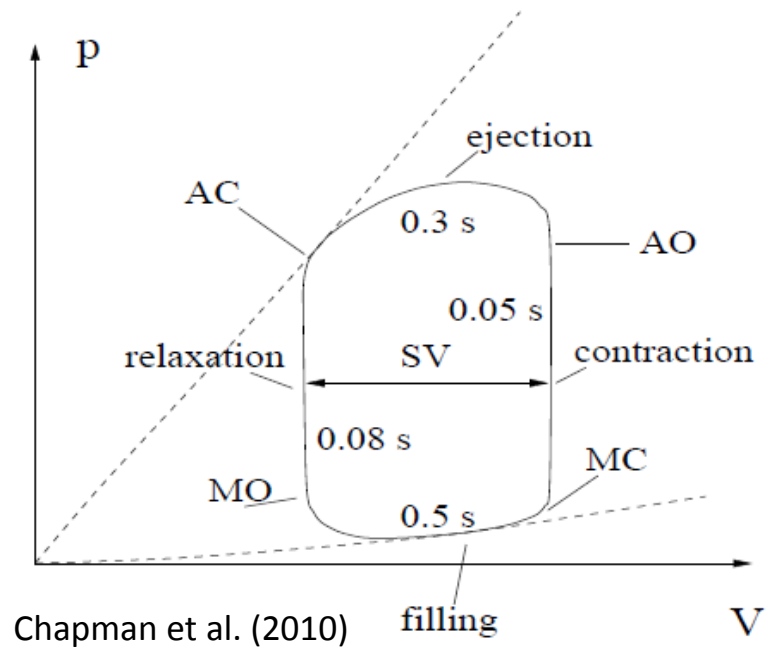


Example 4: Analogous physiological cycles

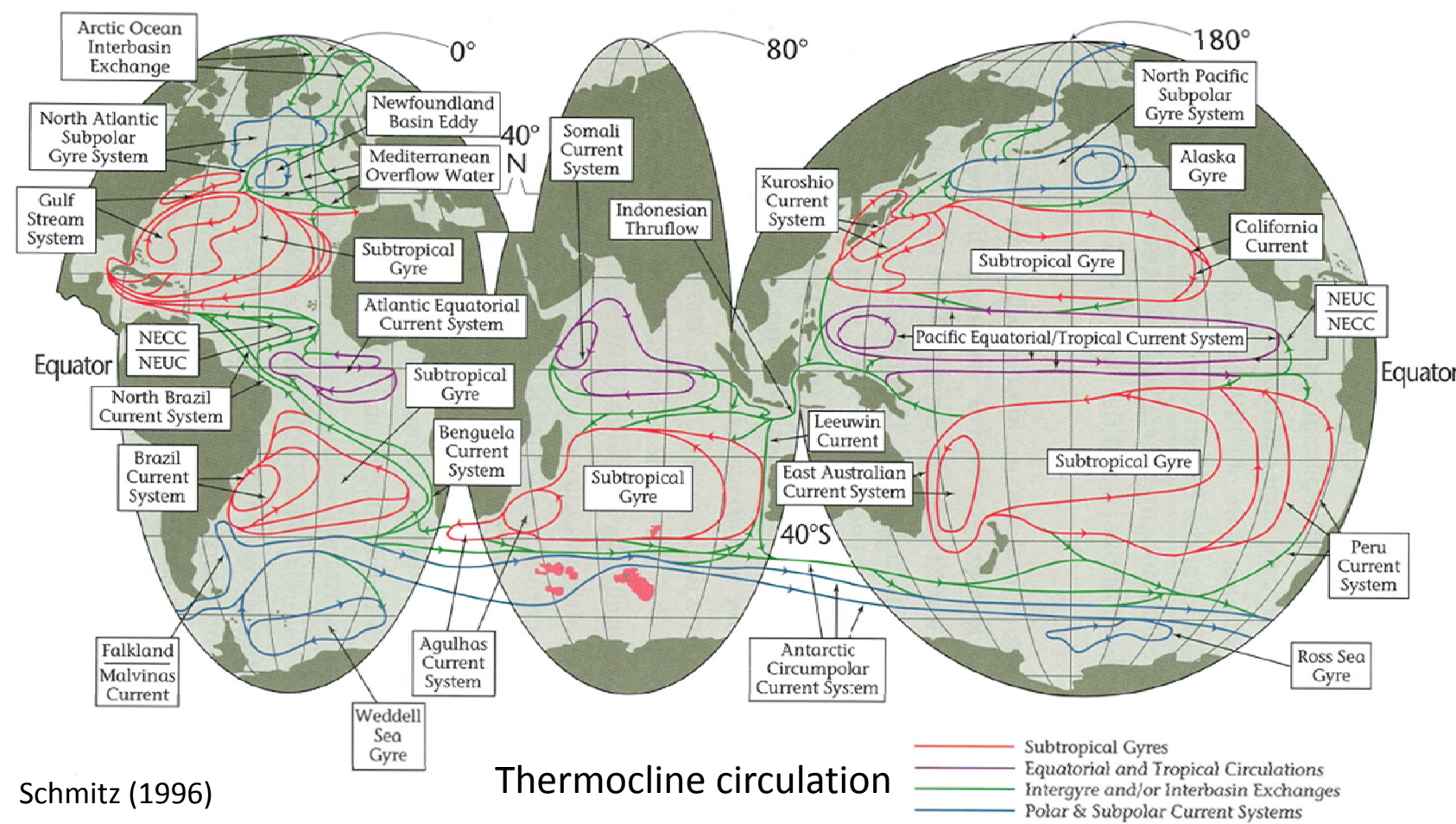
The heart is a good example of a relaxation-oscillator system.



But the heart wouldn't be able to make the blood go round the entire body and return to the atrium. To do so, it requires systems such as the body motion and the muscles acting over arteries and veins.



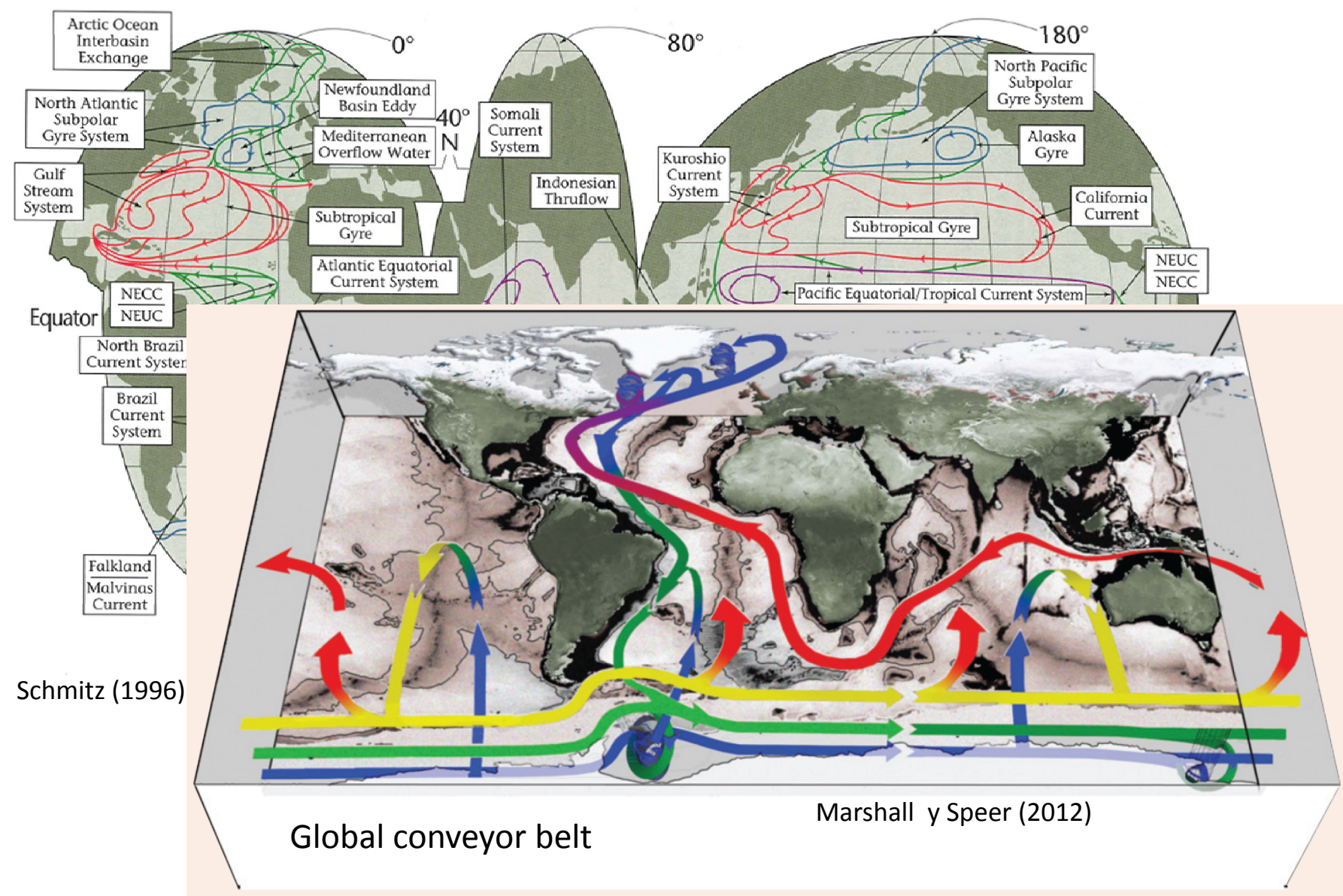
In the ocean we also have a circulatory system, with a short-fast pulmonary circuit and a slow-long systemic circuit. Water is pumped down each circuit during a short winter period.



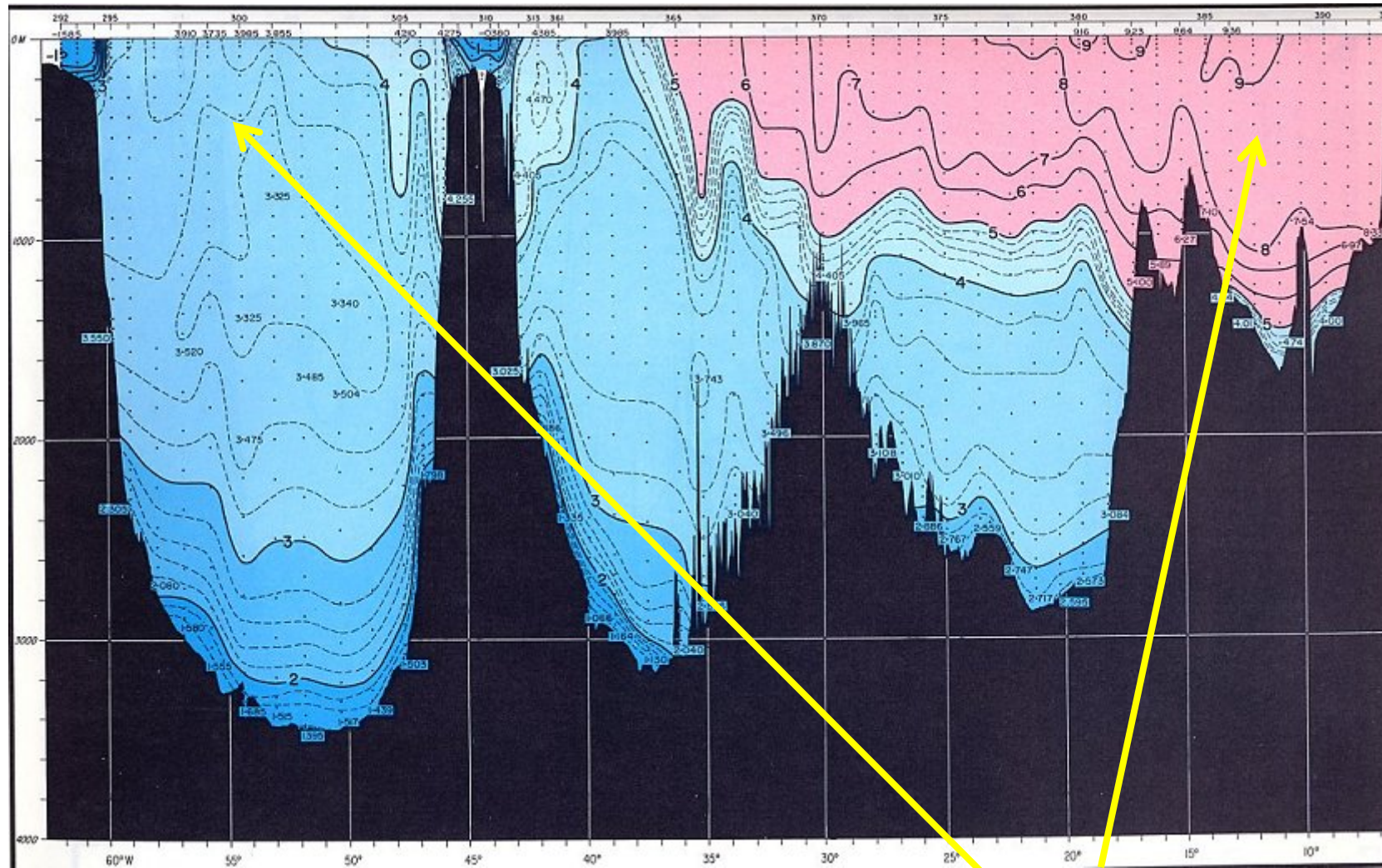
Schmitz (1996)

Thermocline circulation

In the ocean we also have a circulatory system, with a short-fast pulmonary circuit and a slow-long systemic circuit. Water is pumped down each circuit during a short winter period.



Erika Dan temperature section, 60°N, Labrador-Greenland-Rockall-Ireland

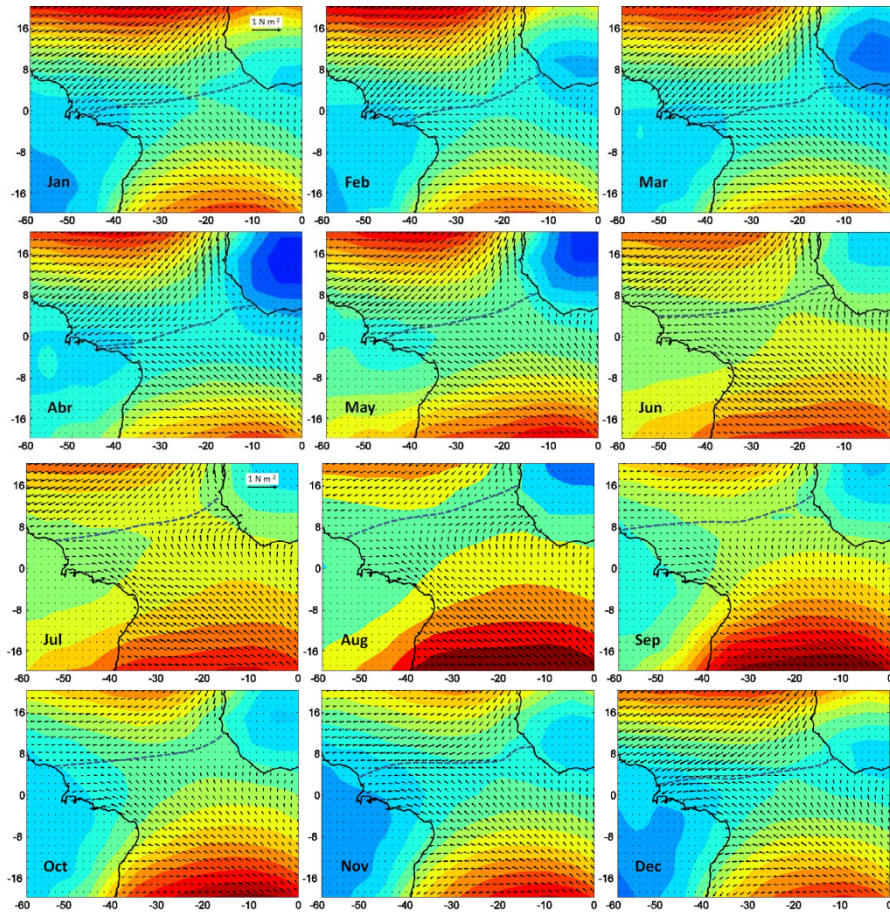


Worthington and Wright (1970)

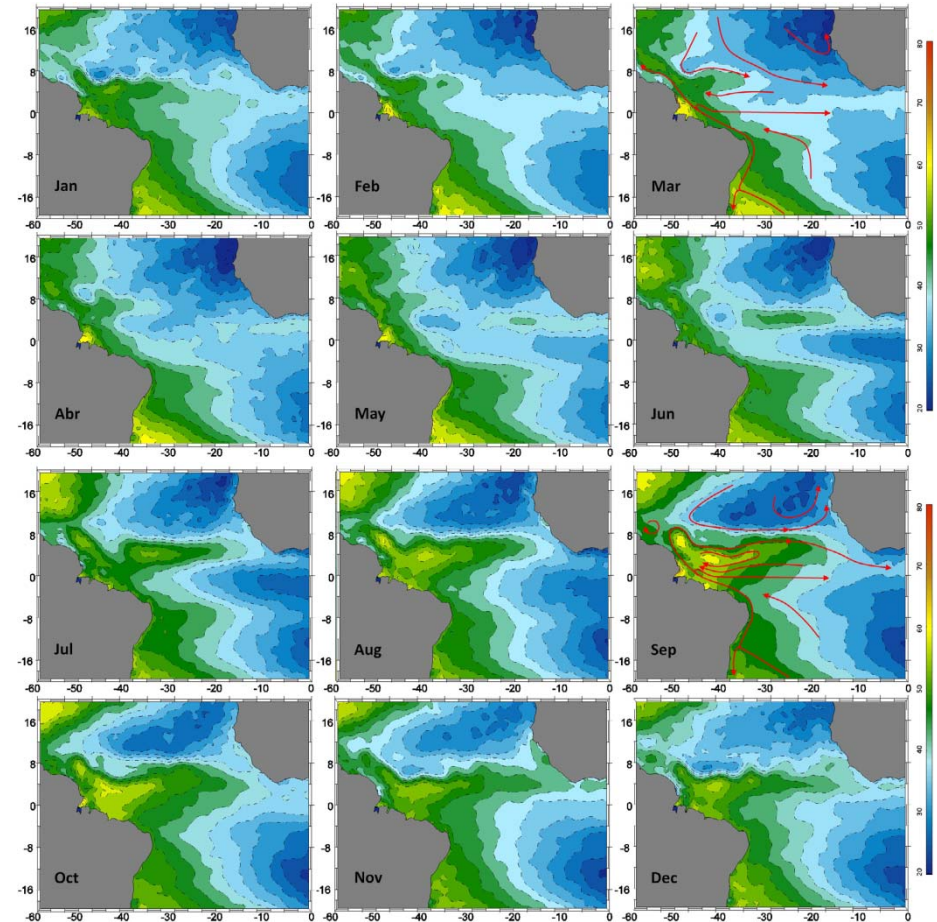
Winter deep convection

As it happens with the circulatory system of most living beings, the winter pressure anomaly at high latitudes is unable to bring the waters back to the deep-water formation regions. It does so with the help of winds.

Castellanos et al. (2015)

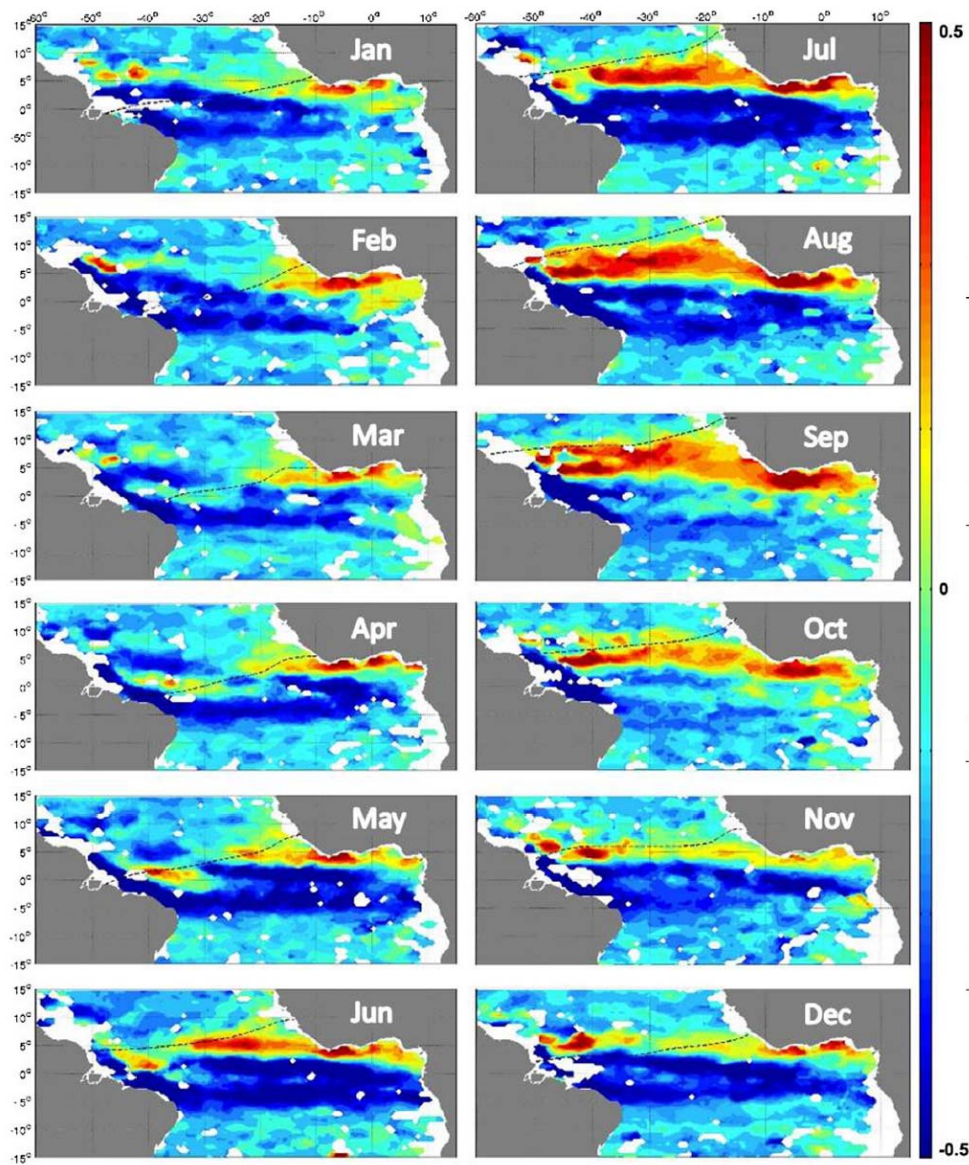


Pressure and surface winds



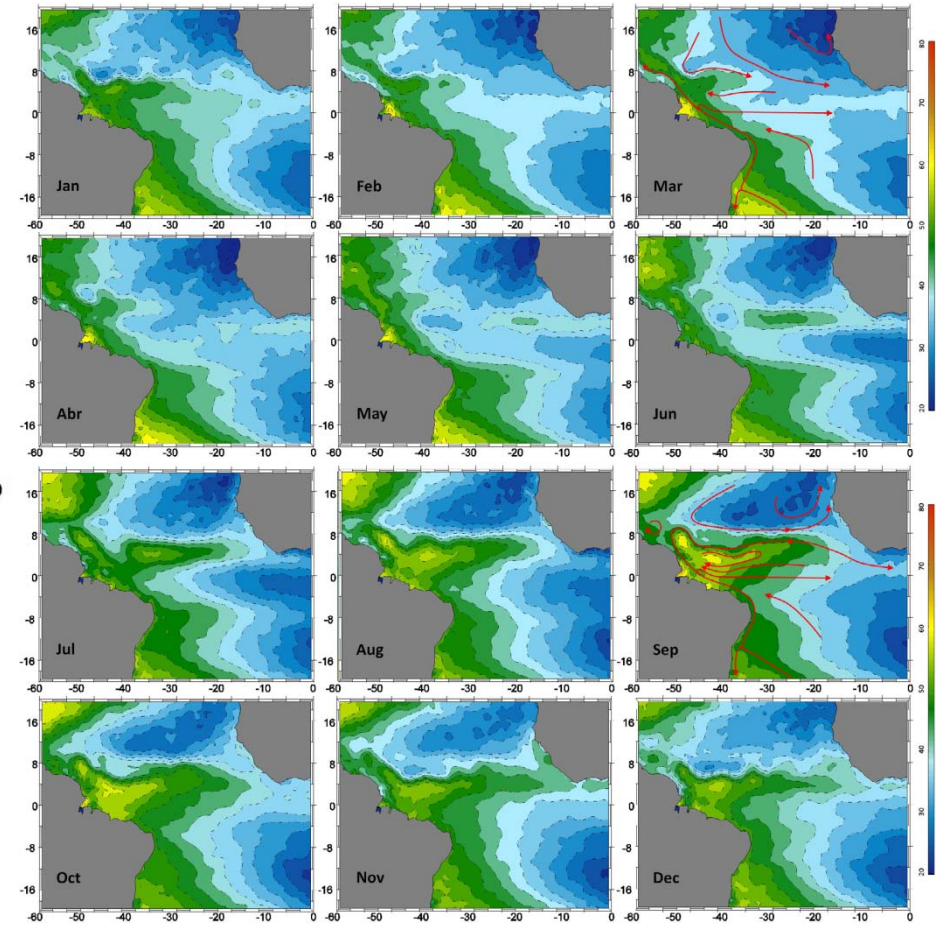
Absolute dynamic topography

Rosell-Fieschi et al. (2015)

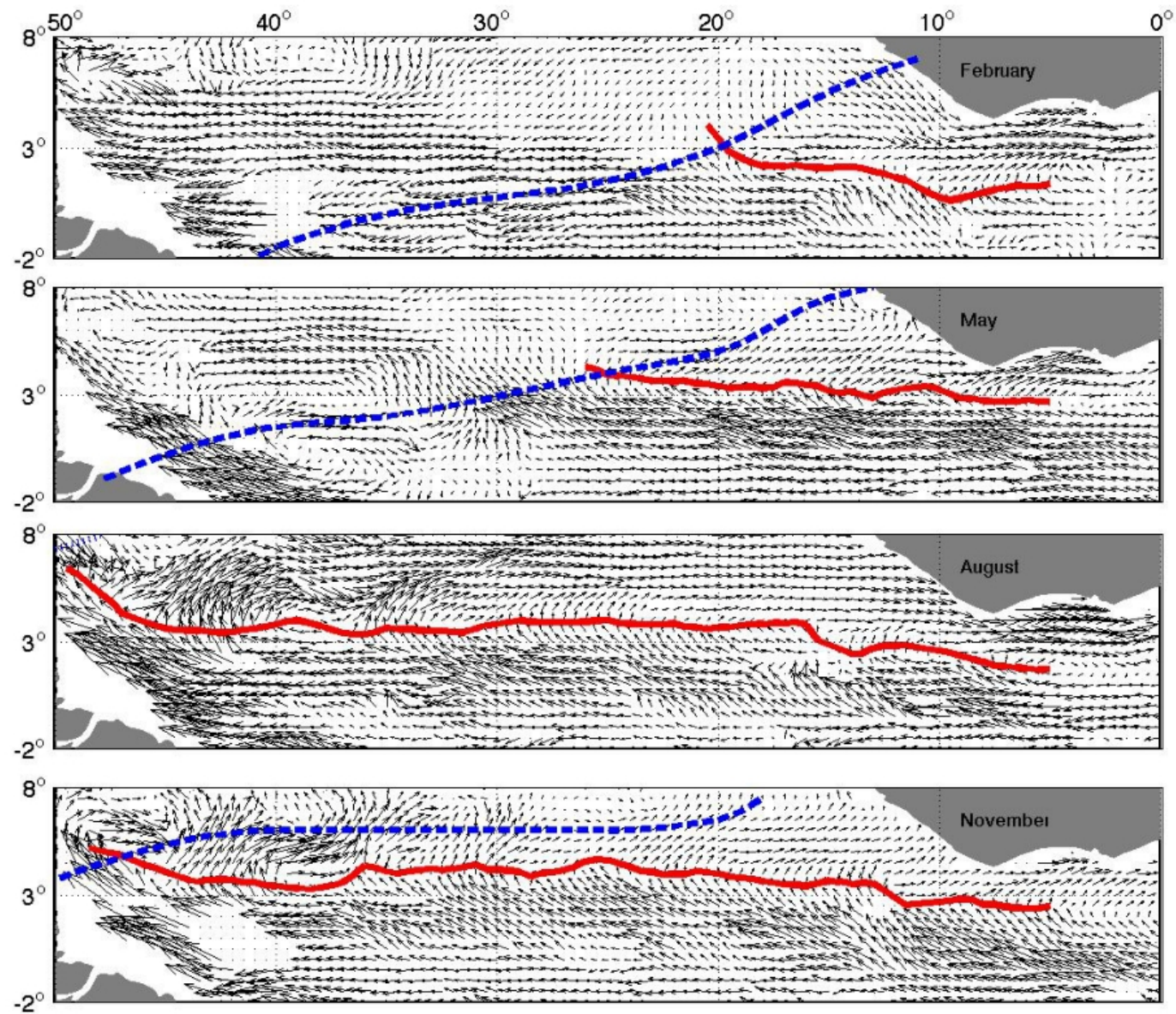
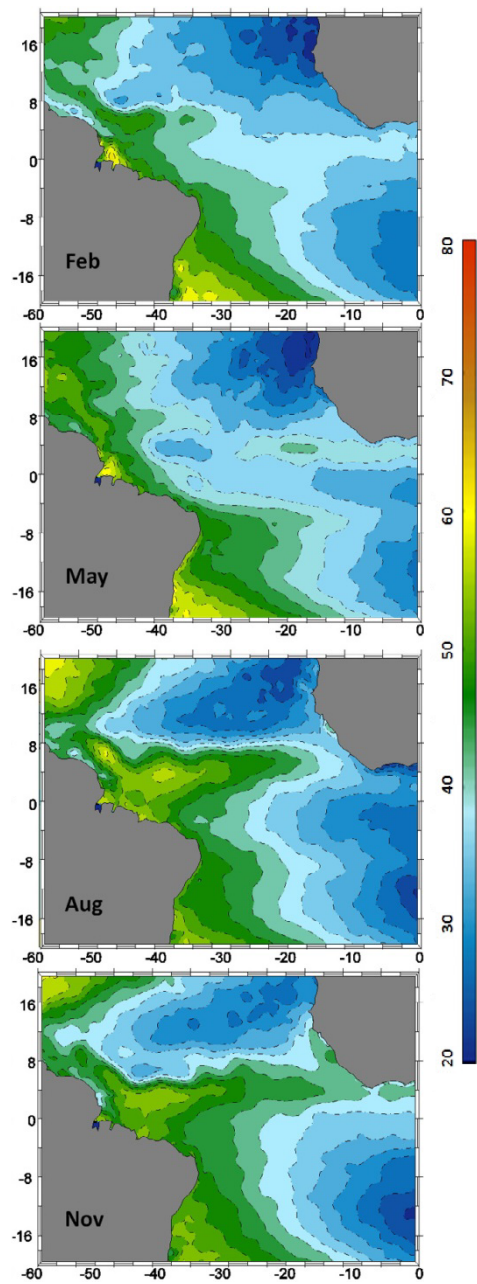


Surface zonal currents

Castellanos et al. (2015)



Absolute dynamic topography



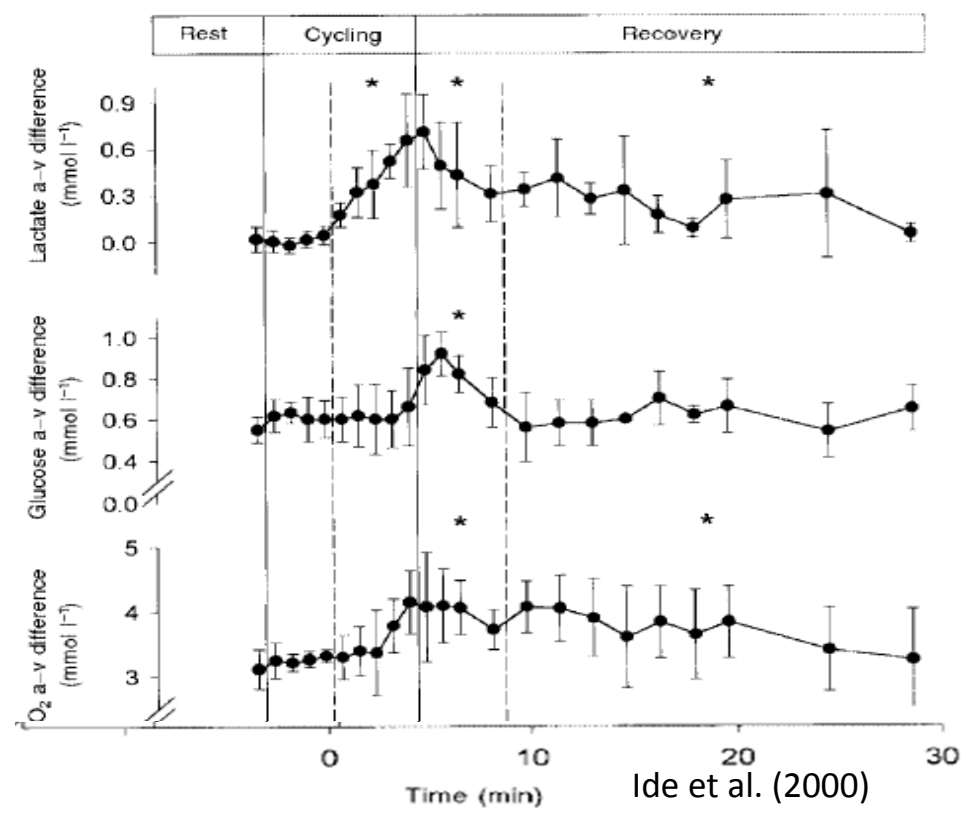
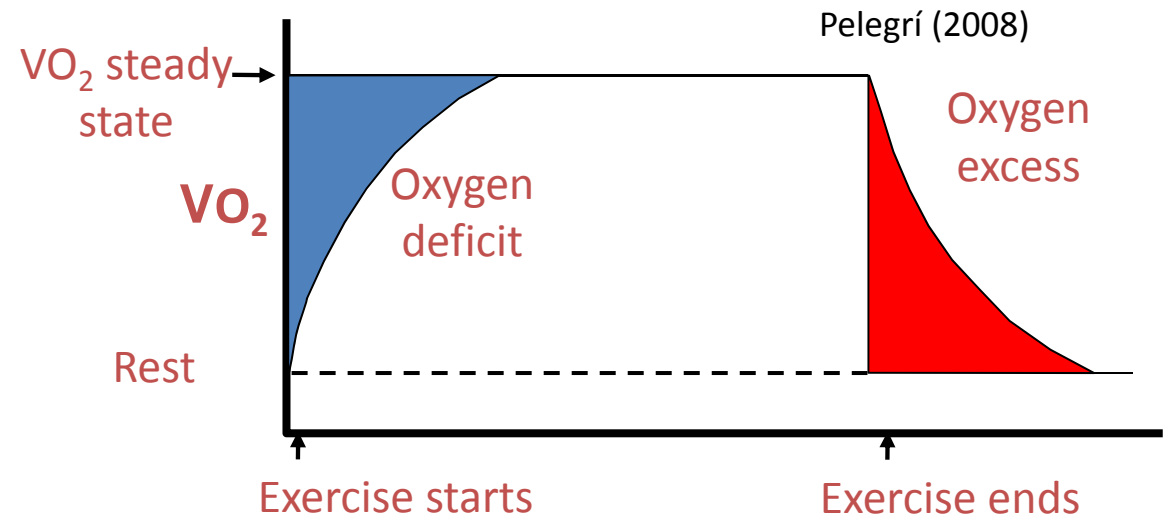
Castellanos et al. (2015)

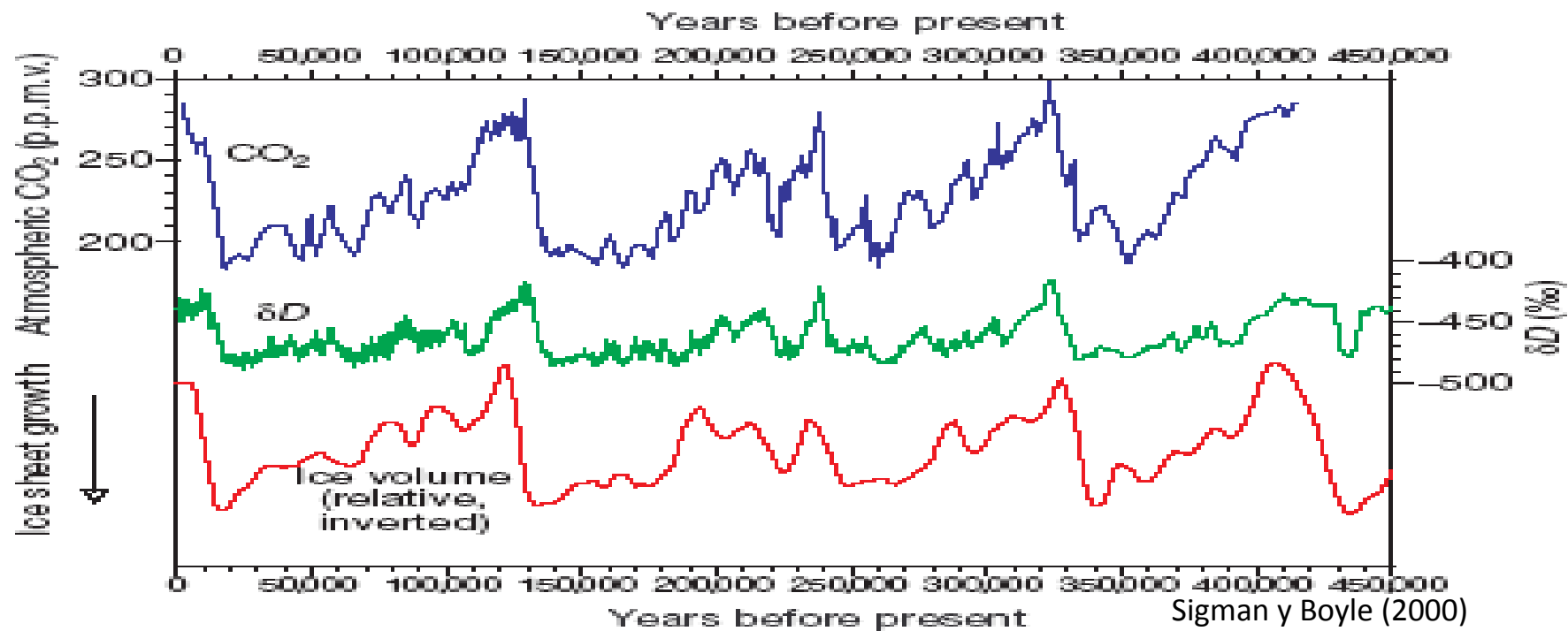
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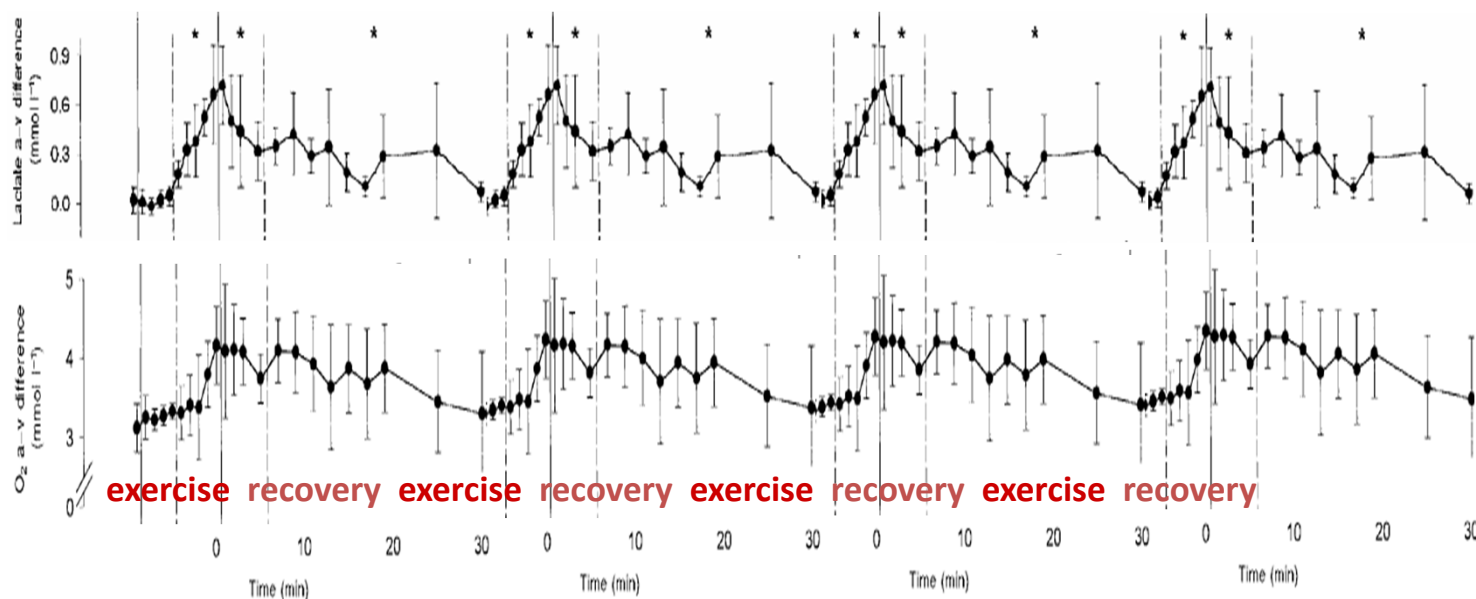
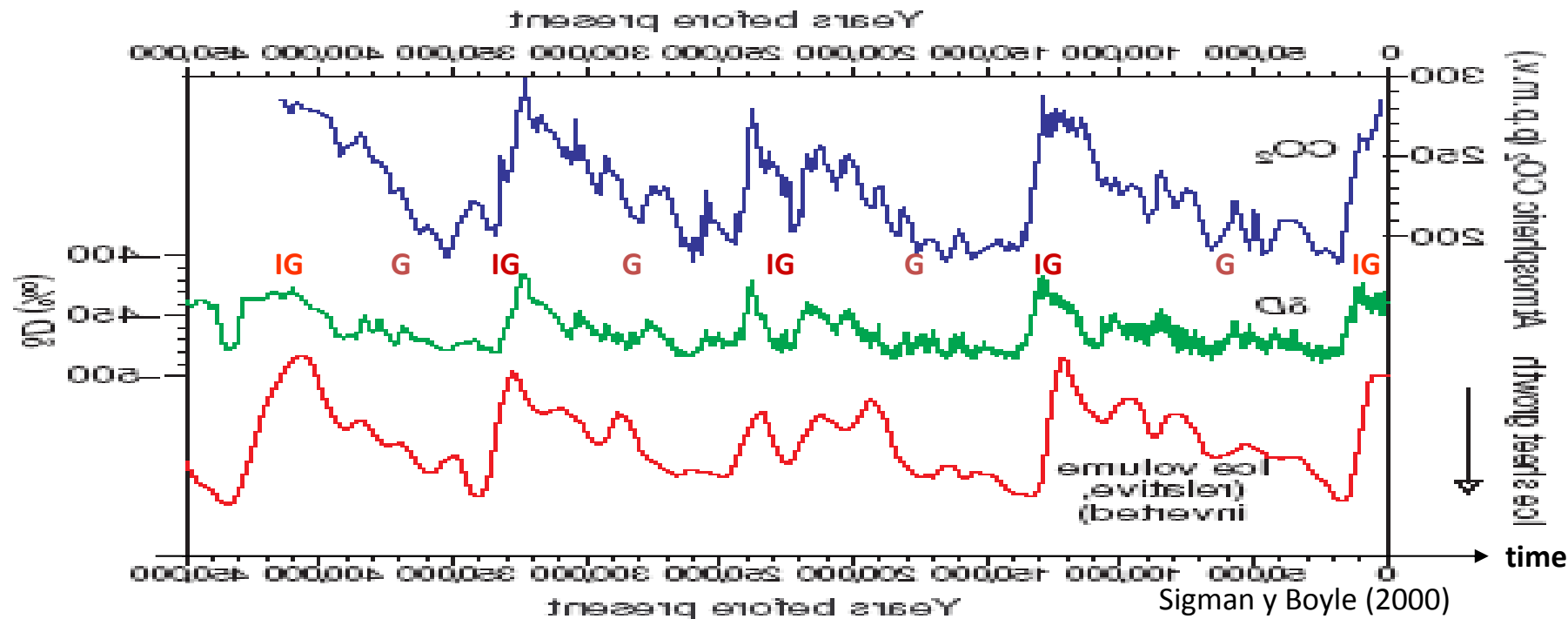
Another example is the exercise-recovery cycle. In mammals, for example, the system switches between two states with different rates of oxygen utilization. As the system goes from a state of rest (basal) to a state of exercise (enhanced), there is a short period of oxygen deficit; as it moves back to the rest state, the system has an oxygen excess.

Oxygen deficit: temporal delay in producing aerobic ATP, the body uses anaerobic ATP

Oxygen excess: resynthesis of ATP that is stored in cells







Earth's
physiology

Human
physiology

3. Aim for 10 days of full consciousness

We will be 10 days together discussing five key processes that define any living being:

- Spatial patterns
- Temporal patterns
- Recycling
- Structure
- External factors

And we will do so considering four spatial scales:

- Microstructure
- Fine structure in the vertical, or submesoscale in the horizontal
- Mesoscale
- Regional and global

For any of us, the easiest would be to focus on those topics that fall within our your expertise. But we ask you to escape from your comfort zone. We ask you to stay alert during 10 full days, in full consciousness, searching the horizon with the widest possible perspective.

Our objective is to go **from the parts to the whole**, searching for those connections and couplings that give rise to the complexity of the connected system. Use the pieces to build the impressionist collage.

Thanks for being with us, we do hope you find this colloquium useful and enjoy your stay in Catalonia.