

Climate of the Baltic Sea Region

Large scale ocean circulation

Prof. Dr. Markus Meier

Leibniz Institute for Baltic Sea Research Warnemünde
(IOW)

markus.meier@io-warnemuende.de

Oceans

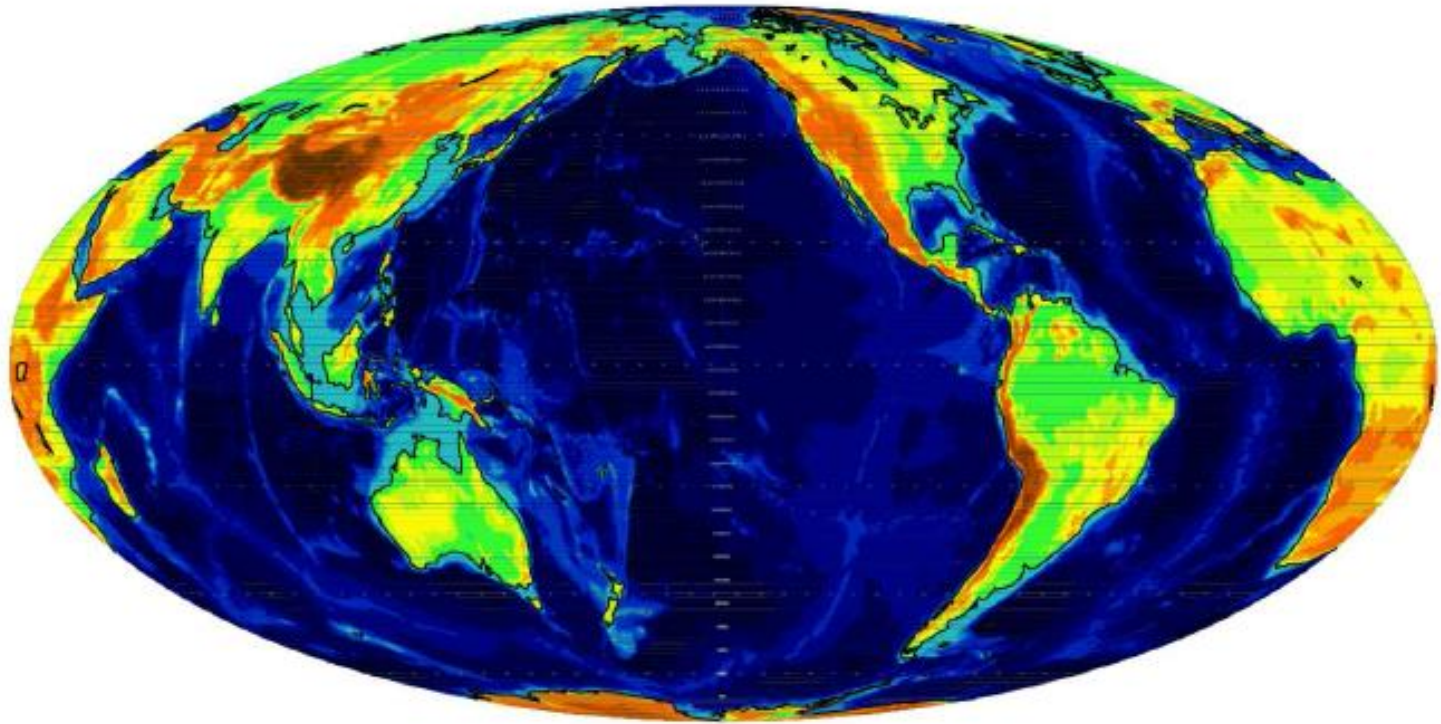


Figure 3.43: 2/3 of the globe is oceans

(Source: D. Dommenges)

Differences between the atmosphere and oceans

- Incompressible liquid – ideal gas
- Water is 1000 times denser than air
- Water has a 4 times larger specific heat capacity than air
- Oceans are forced from the top, atmosphere from below (implications for mixing)
- Ocean currents are mostly forced by atmospheric winds, atmospheric winds are initiated by temperature contrast

(Source: D. Dommenget)

Differences between the atmosphere and oceans

- The oceans have lateral boundaries with small gateways between the basins
- The oceans do not have latent heating by water phase transitions (e.g. liquid to water vapour and vice versa)
- Salinity in the oceans affects density
- The oceans have floating sea ice affecting air-sea exchange of heat, water vapour and momentum

(Source: D. Dommenges)

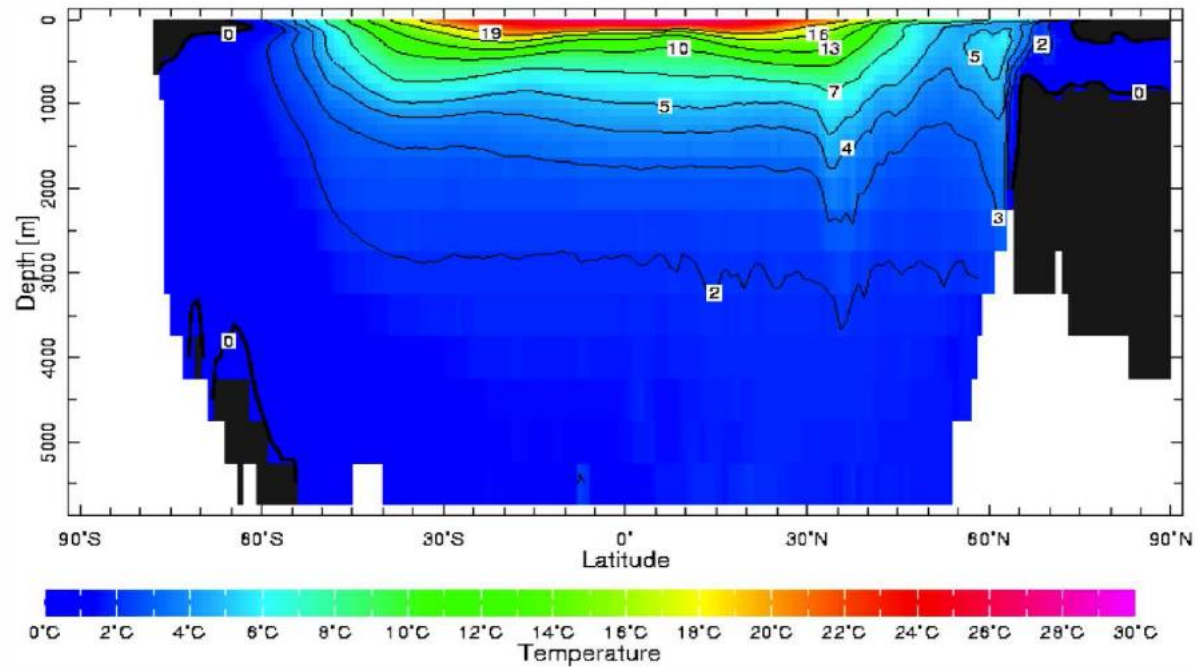
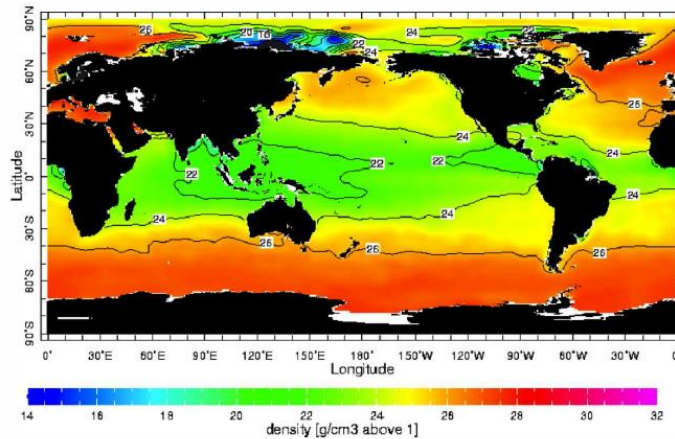
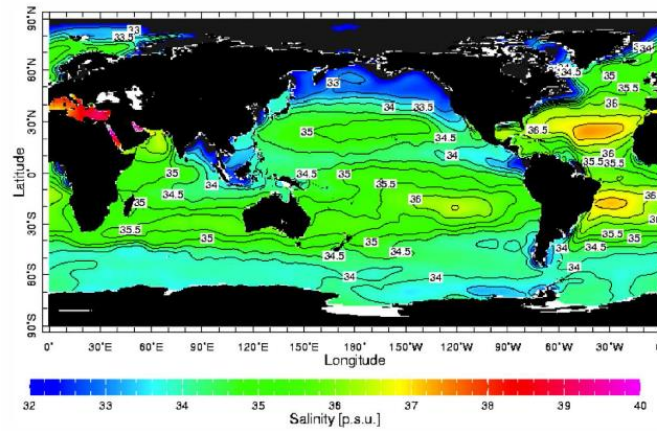
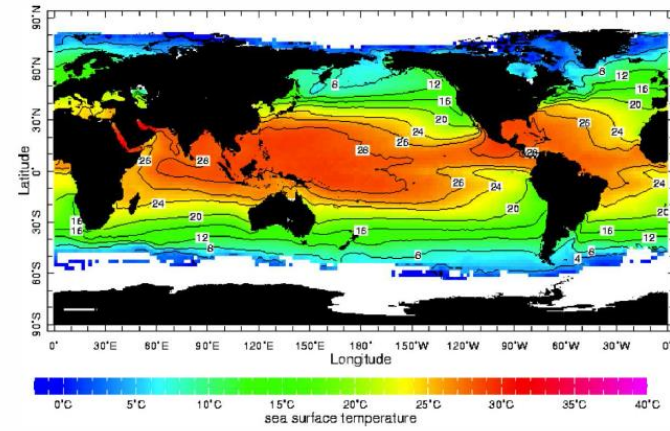


Figure 3.45: Annual-mean cross-section of zonal-average temperature [°C] in the world's oceans - the whole water column. Data from the Levitus World Ocean Atlas 1994.

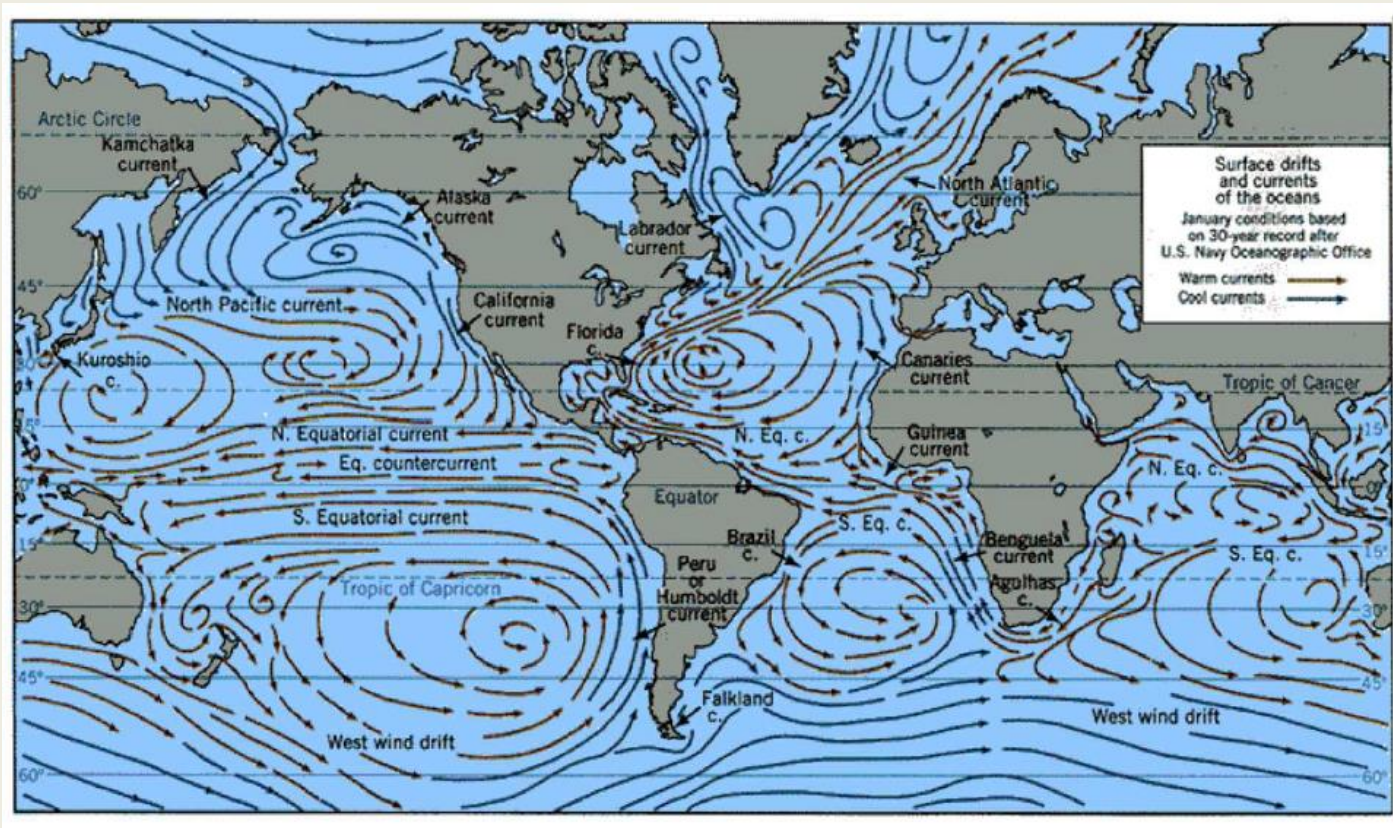
(Source: D. Dommenges)

Large scale ocean circulation



(Source: D. Dommenges)

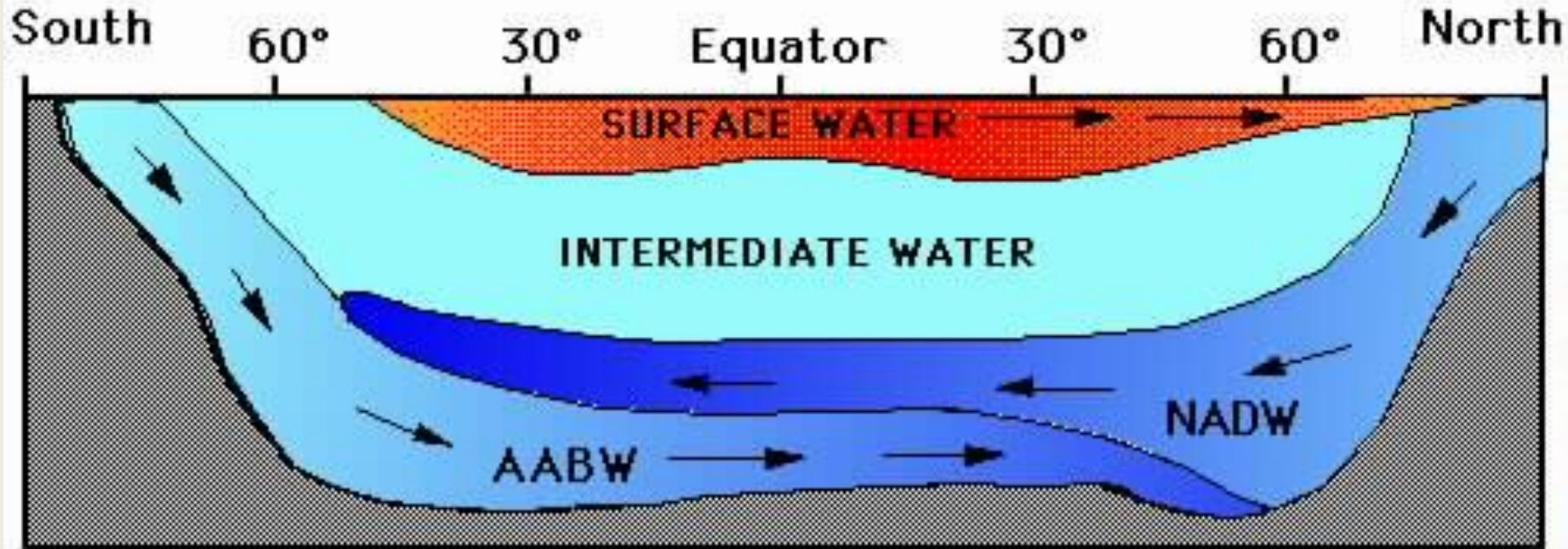
Wind driven (surface) circulation



(Source: D. Dommenges)

Deep water formation and the conveyor belt circulation

Atlantic Ocean Thermohaline Circulation



Increased nutrients & dissolved CO₂

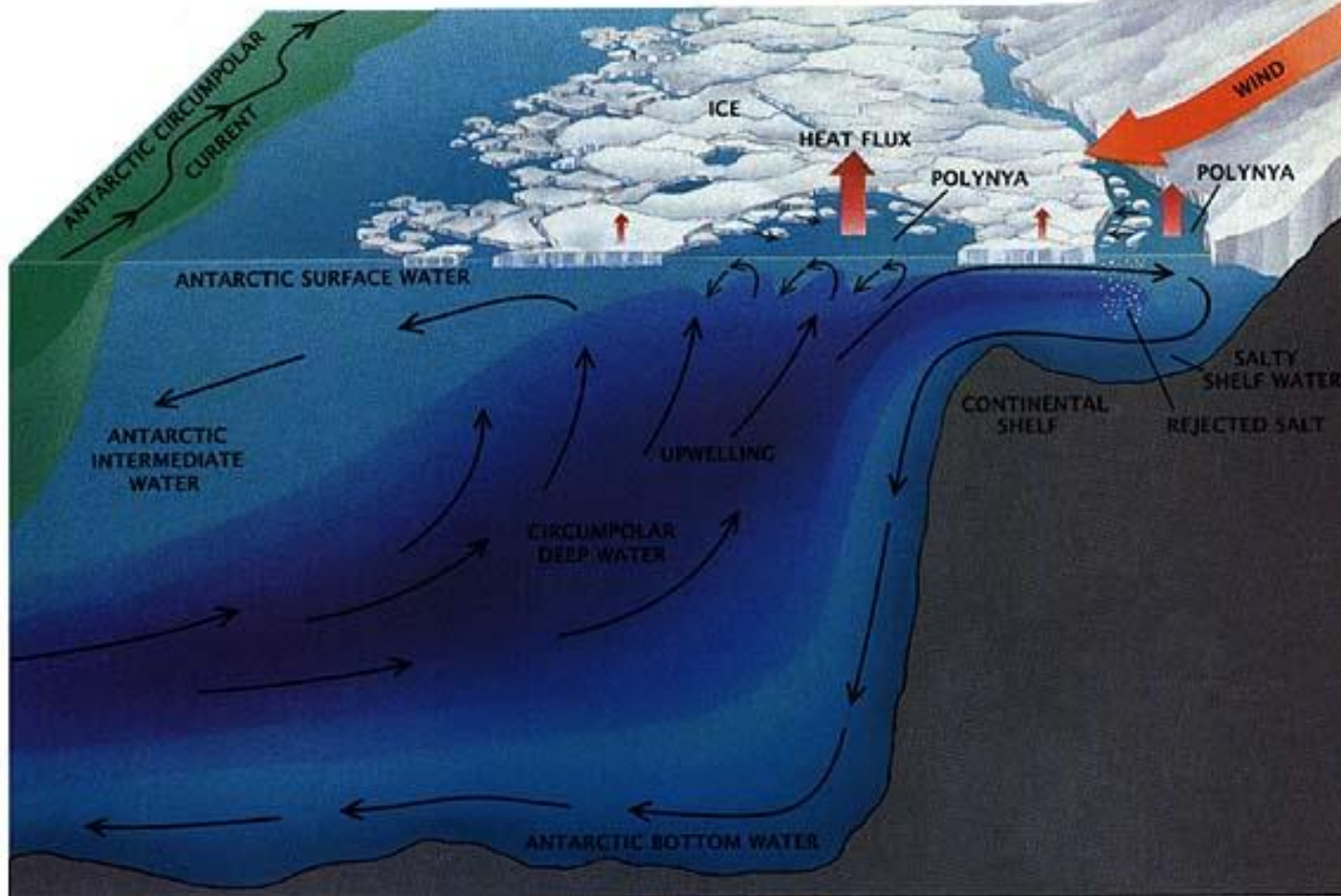


Warm, low nutrients, & oxygenated



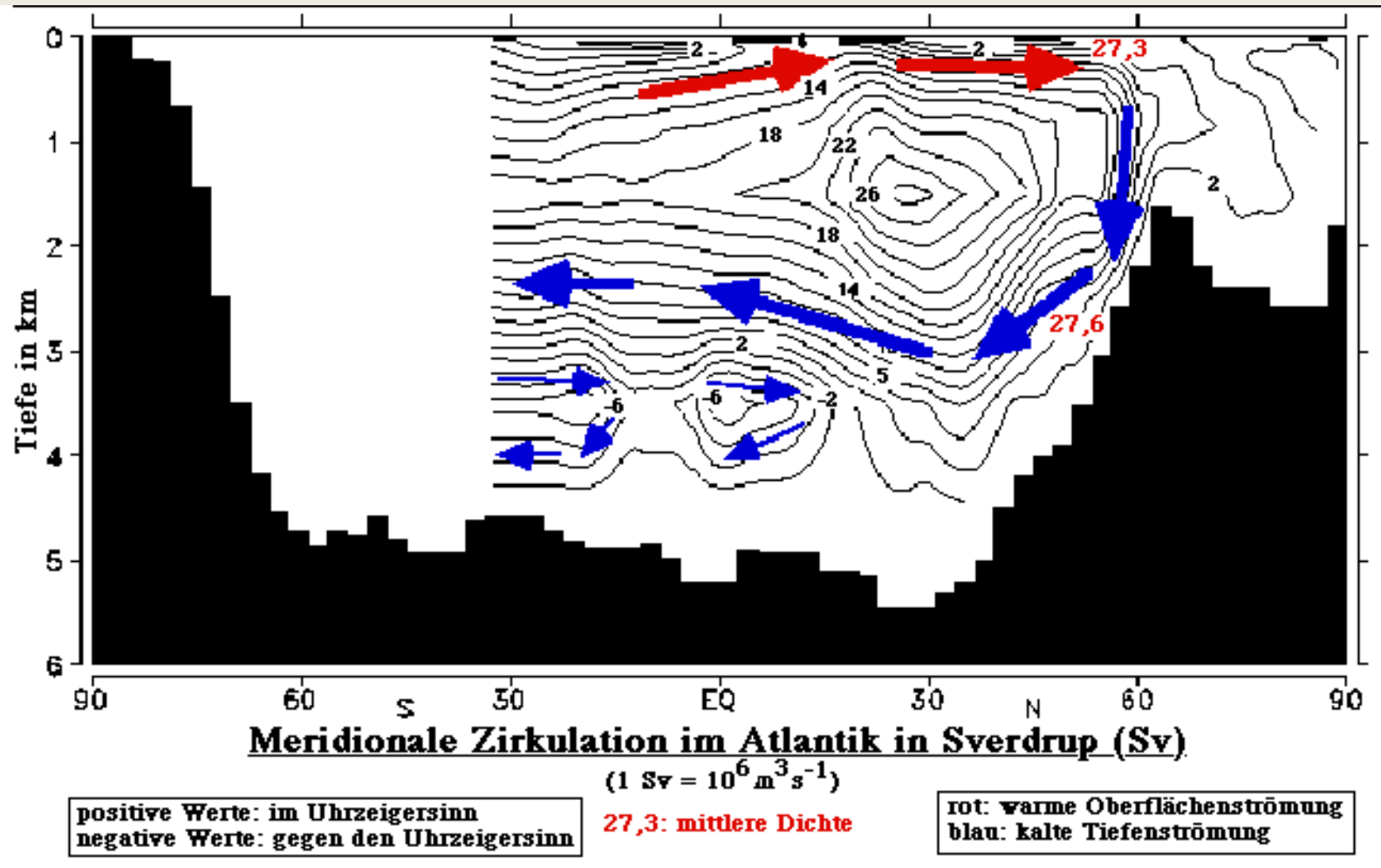
(Source: U. Cubasch)

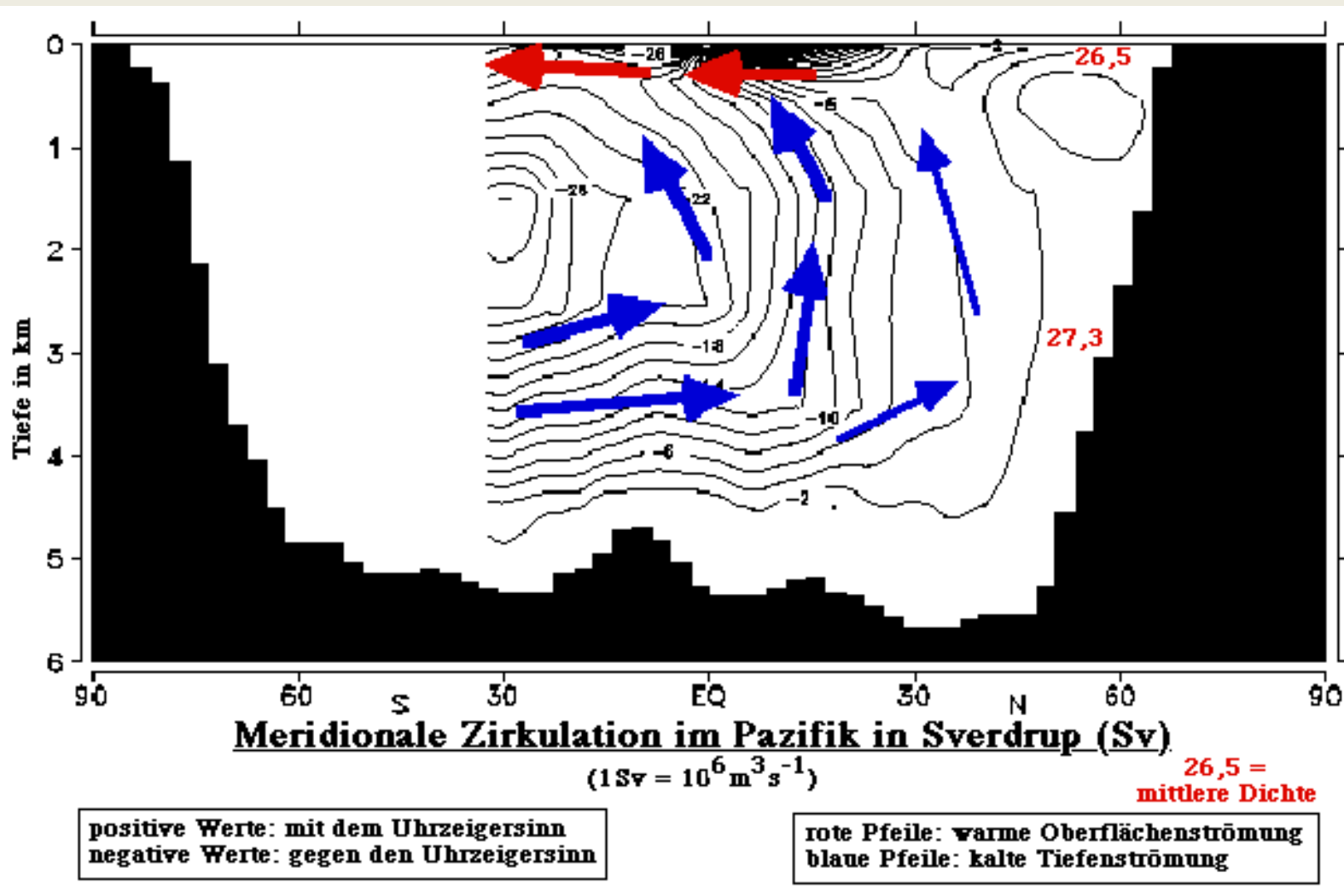
Source: Gordon, Arnold L. and Josefino, C. Comiso (1988) "Polynyas in the Southern Ocean." *Scientific American*, June 1988, Vol. 256, No. 6, p. 92.

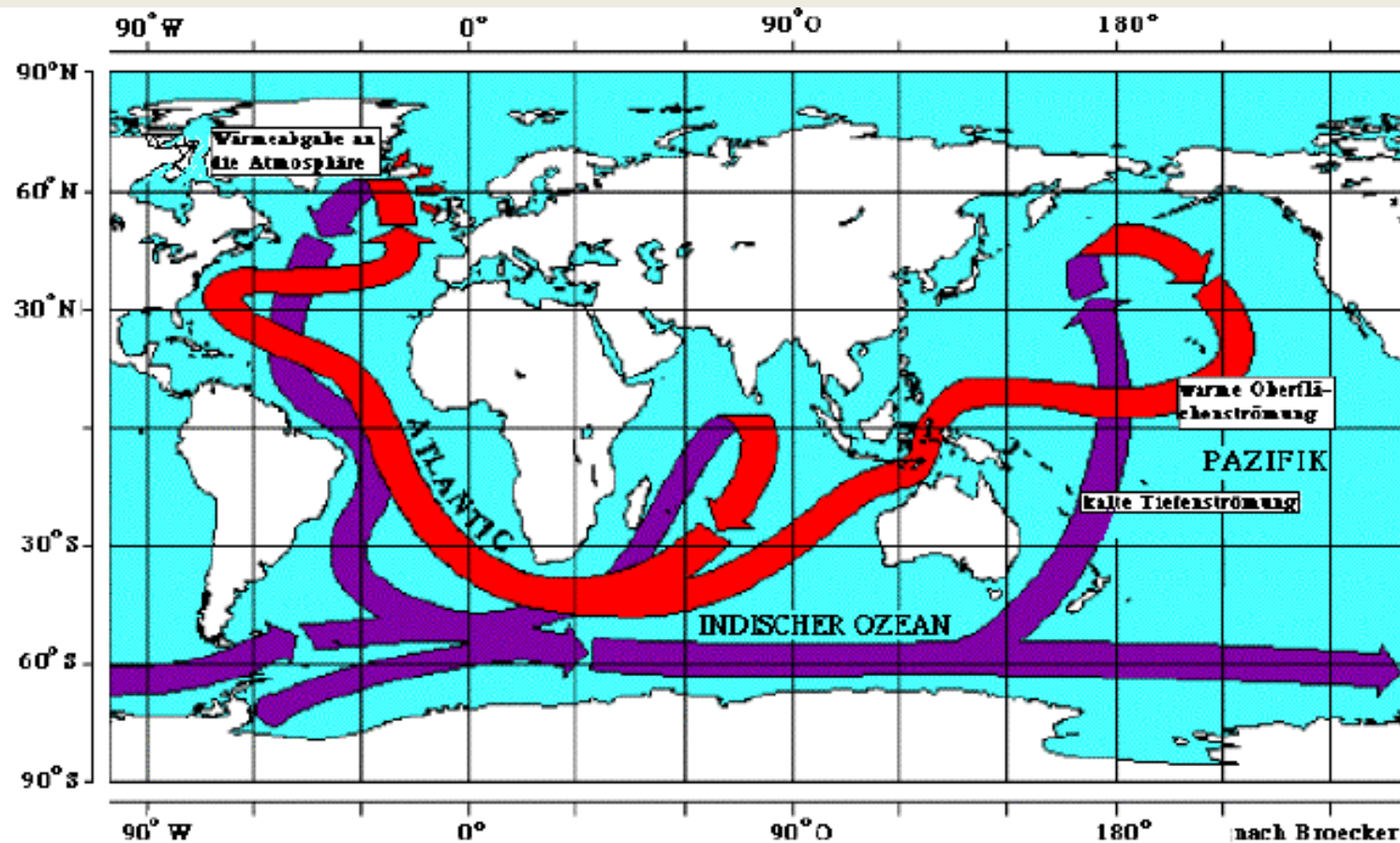


Meridional circulation pattern of the Southern Ocean (the ocean surrounding Antarctica) is dominated by the upwelling of a warm, salty water mass called the Circumpolar Deep Water and its transformation into Antarctic Surface Water, which ultimately sinks to become Antarctic Intermediate Water and Antarctic Bottom Water. The circulation is driven by wind and the exchange of heat and fresh water between the ocean and the atmosphere.

(Source: U. Cubasch)







Das große marine Förderband

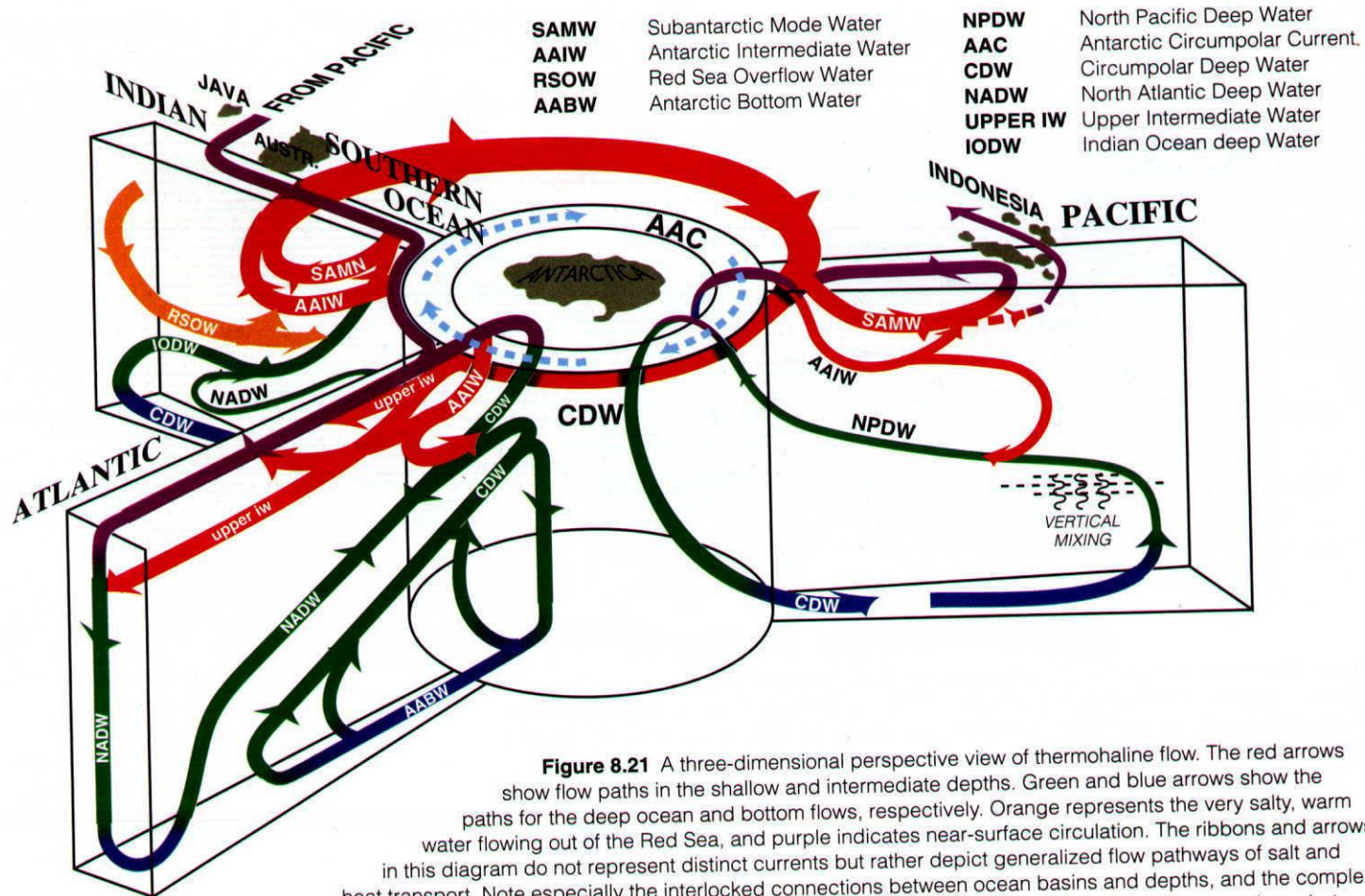


Figure 8.21 A three-dimensional perspective view of thermohaline flow. The red arrows show flow paths in the shallow and intermediate depths. Green and blue arrows show the paths for the deep ocean and bottom flows, respectively. Orange represents the very salty, warm water flowing out of the Red Sea, and purple indicates near-surface circulation. The ribbons and arrows in this diagram do not represent distinct currents but rather depict generalized flow pathways of salt and heat transport. Note especially the interlocked connections between ocean basins and depths, and the complex formation of Antarctic Bottom Water (AABW). This graphic represents decades of work by many researchers, but special mention should be made of the contributions of Wallace Broecker, William Schmitz, and Jack Cook.

Circulation of various oceans

(Source: U. Cubasch)

Northern Hemisphere

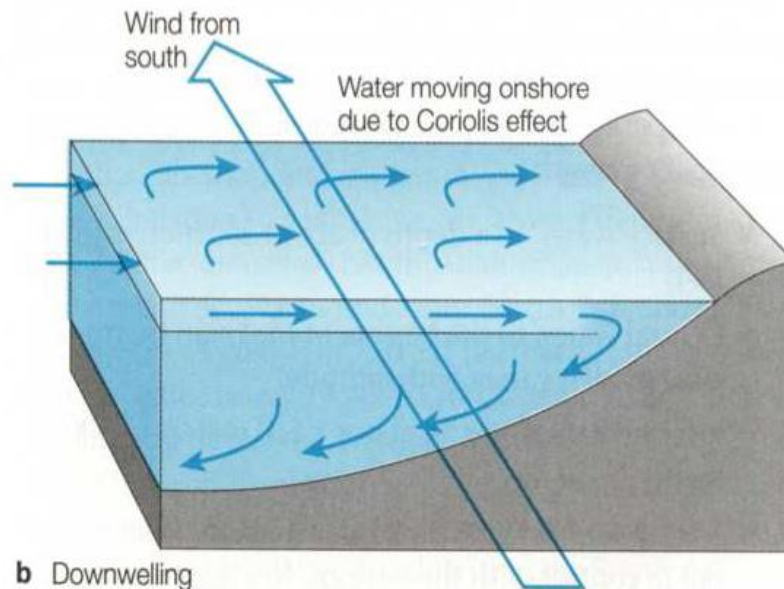
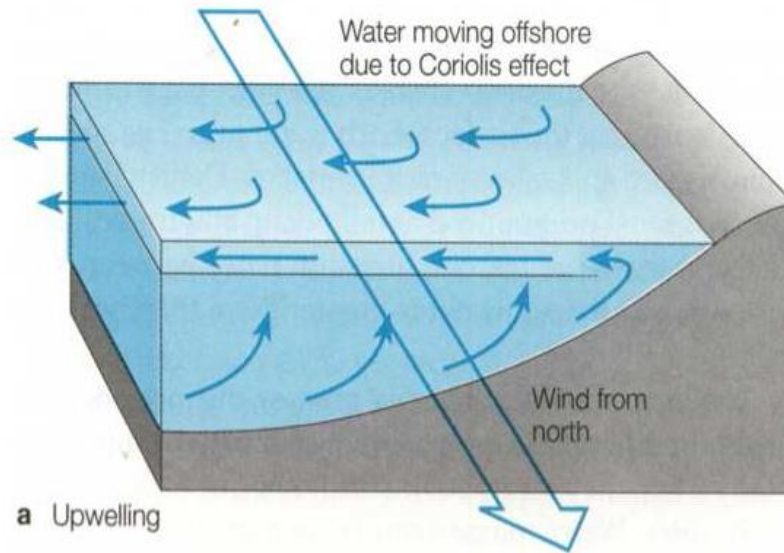


Figure 3.52: Upwelling in NH

(Source: D. Dommenges)

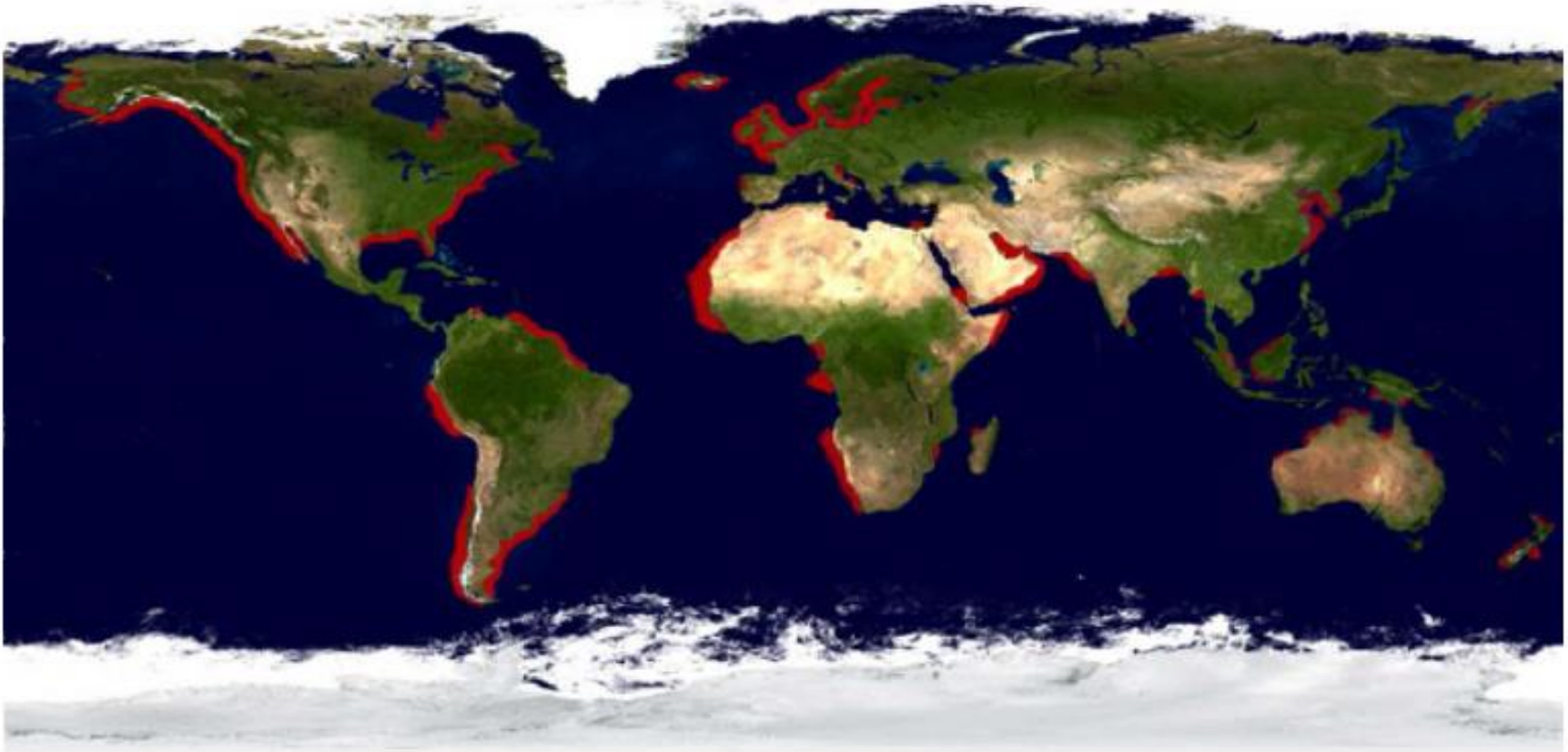


Figure 3.55: Coastal upwelling regions through out the global oceans.

(Source: D. Dommenges)

Deep convection

Main causes of upwelling:

Coastal winds

Coriolis force

Continuity

Main causes of deep convection:

Buoyancy

Cooling

Sea ice formation

(Source: D. Dommenges)

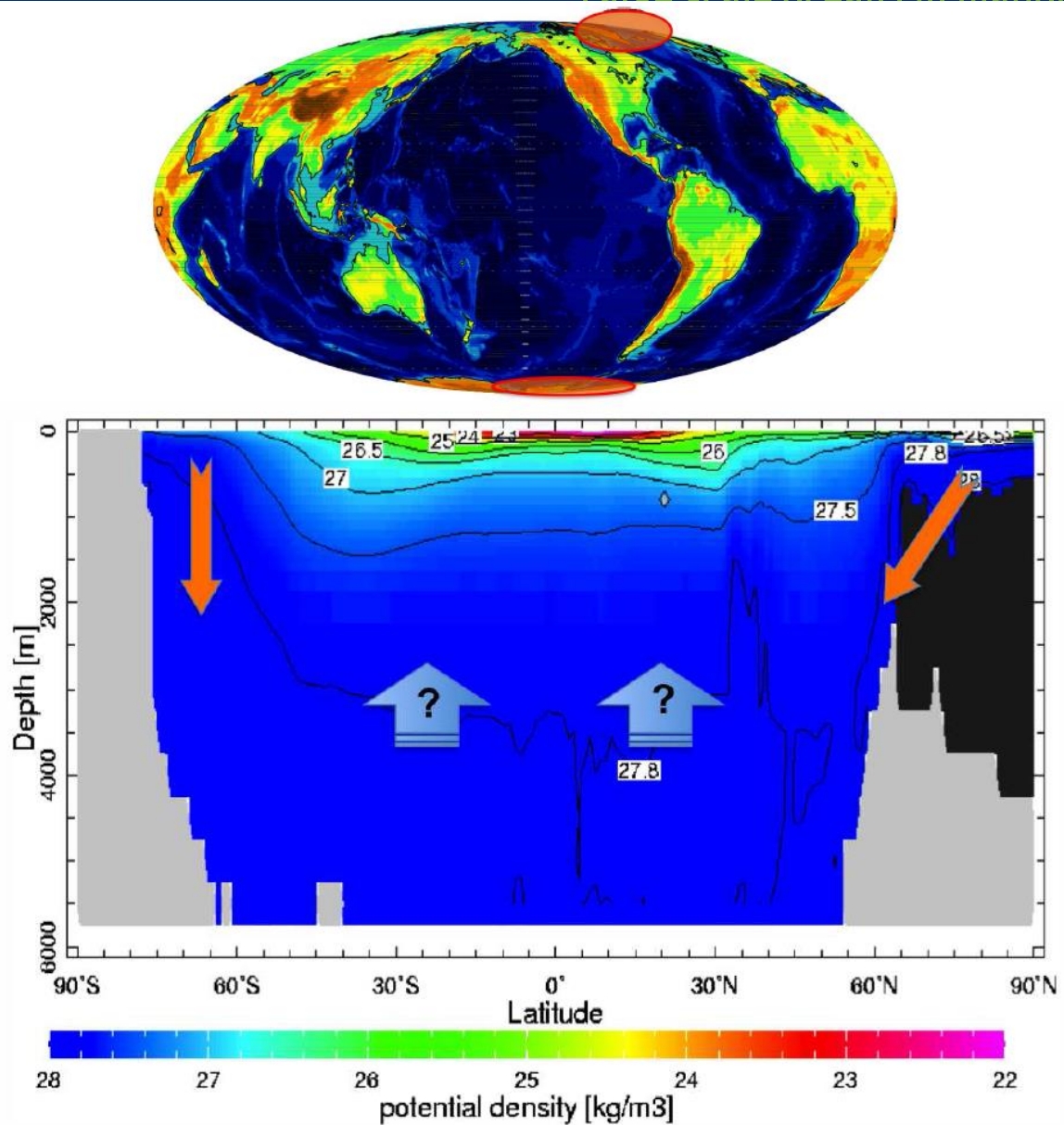
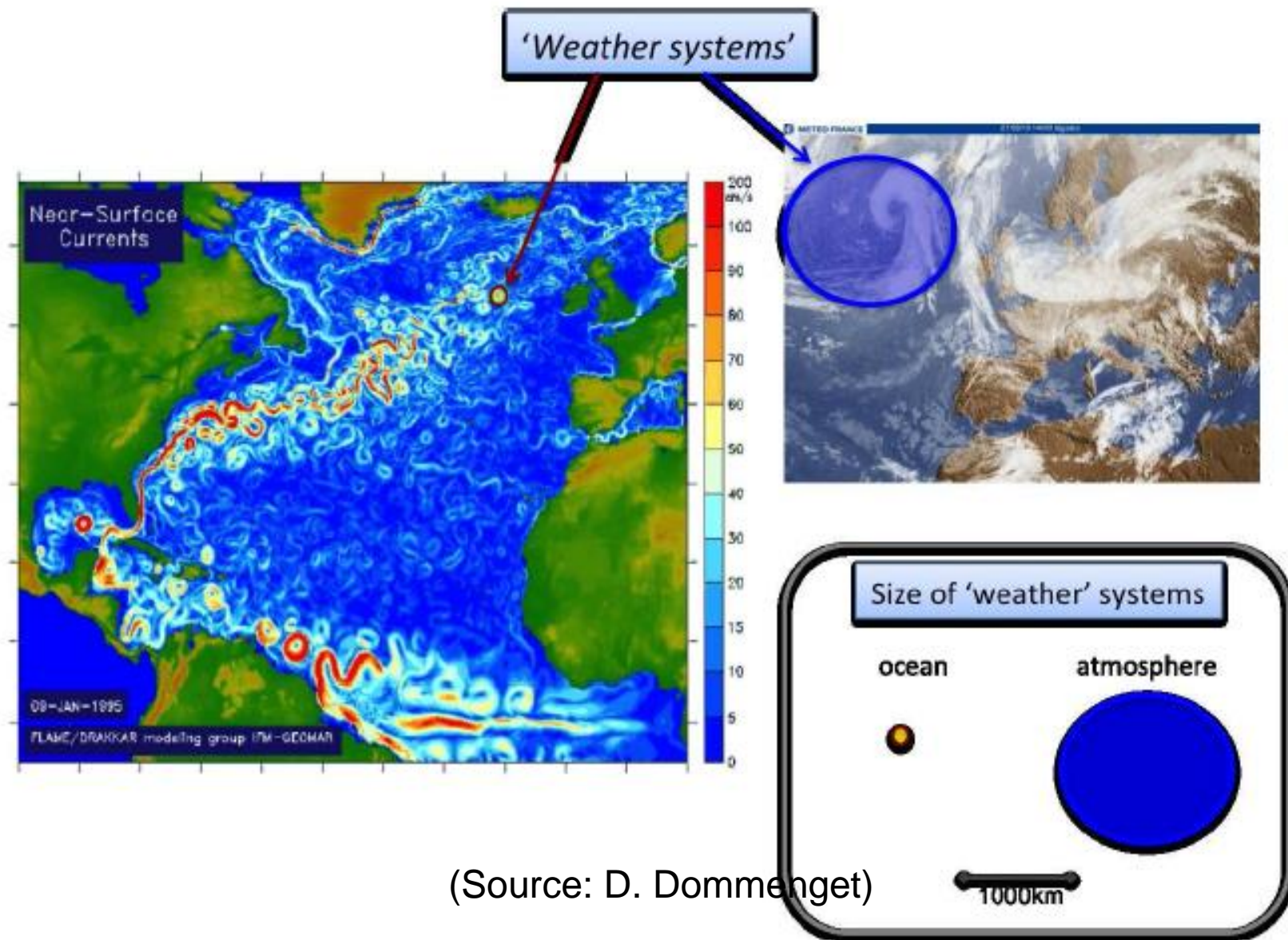


Figure 3.59: Deep ocean convection regions:



(Source: D. Dommenges)

Thank you very much for your attention!

