Upper Ocean Circulation

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MAR 555

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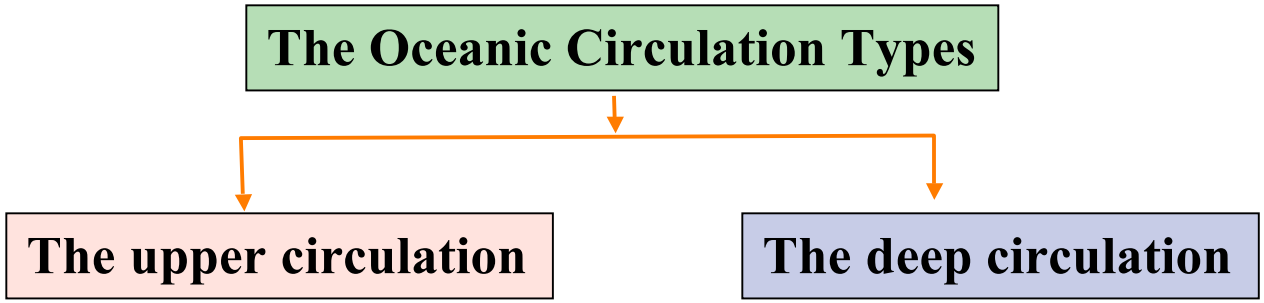
MAR555 Lecture 4: The Upper Oceanic Circulation



The upper circulation→The thermocline circulation (temperature)
or the wind-driven circulation

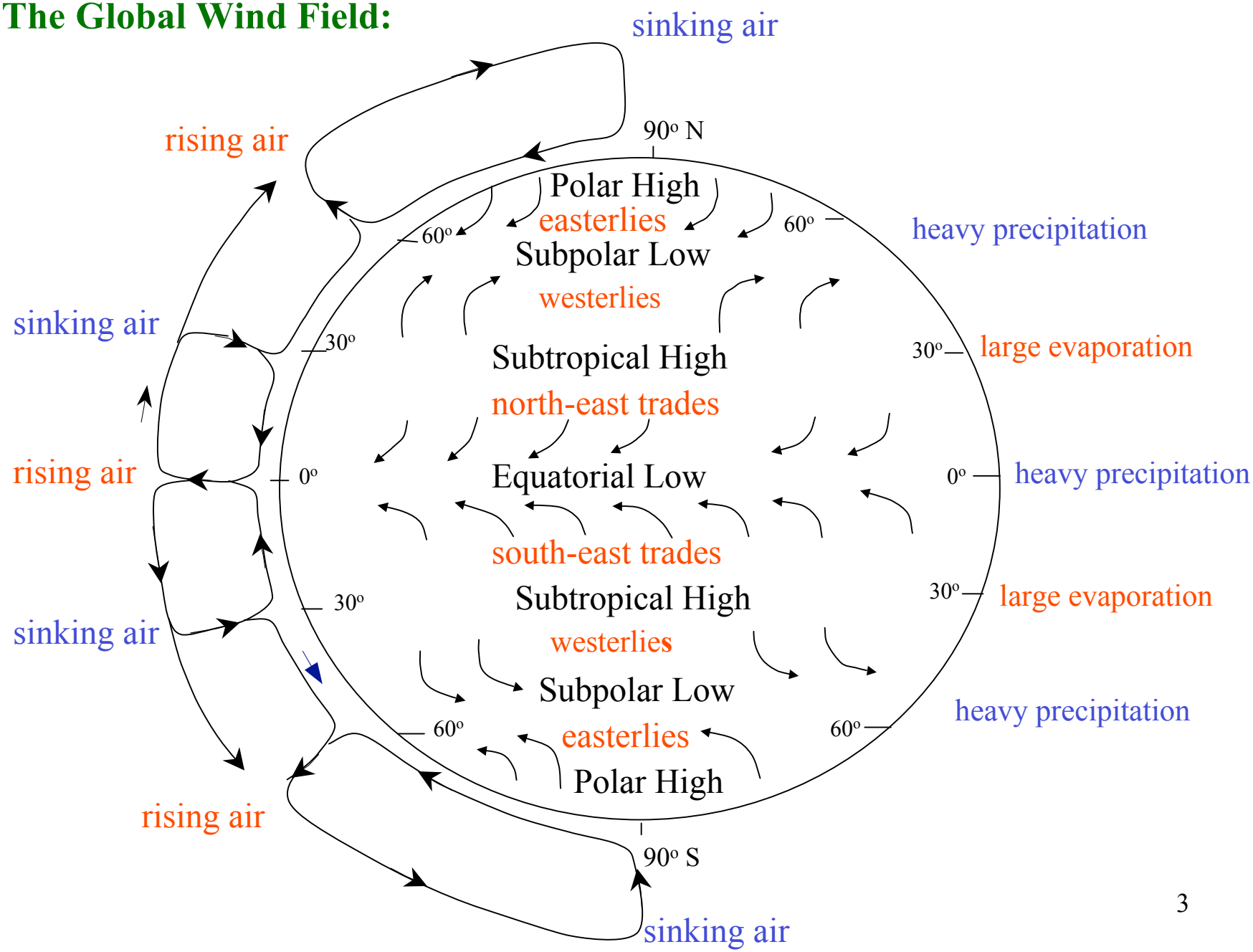
It principally exists in the upper few hundreds of meters and mainly driven by surface wind stress.

The deep circulation→The thermohaline circulation (salinity)

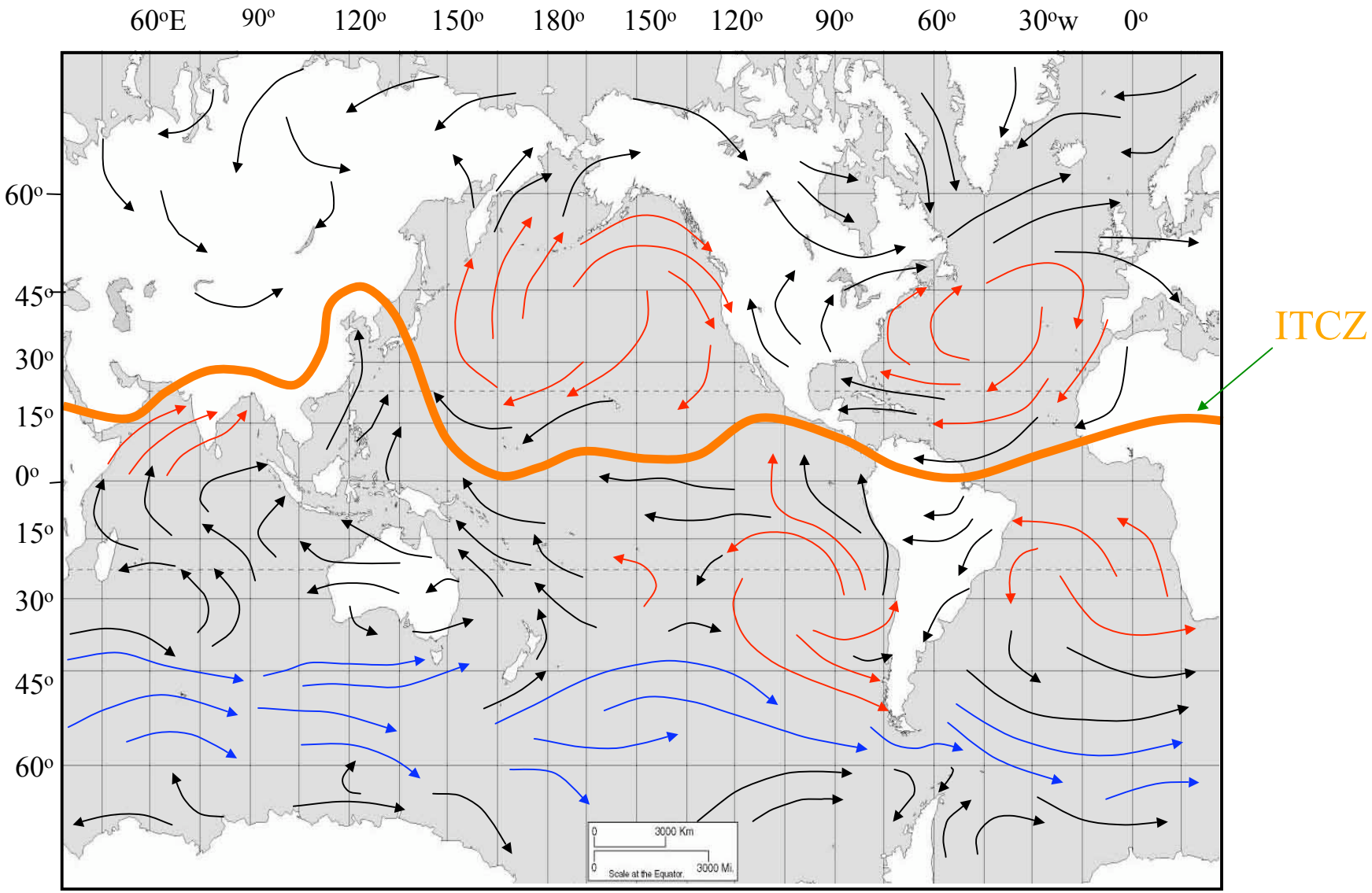
prevails in the deep ocean and mainly driven by the buoyancy forcing associated with cooling (heated) by the cold (warm) air, and modified by sources and sinks of the fresh water.

Observed currents: a result of the combined effects of wind- and buoyancy-driven forcings.

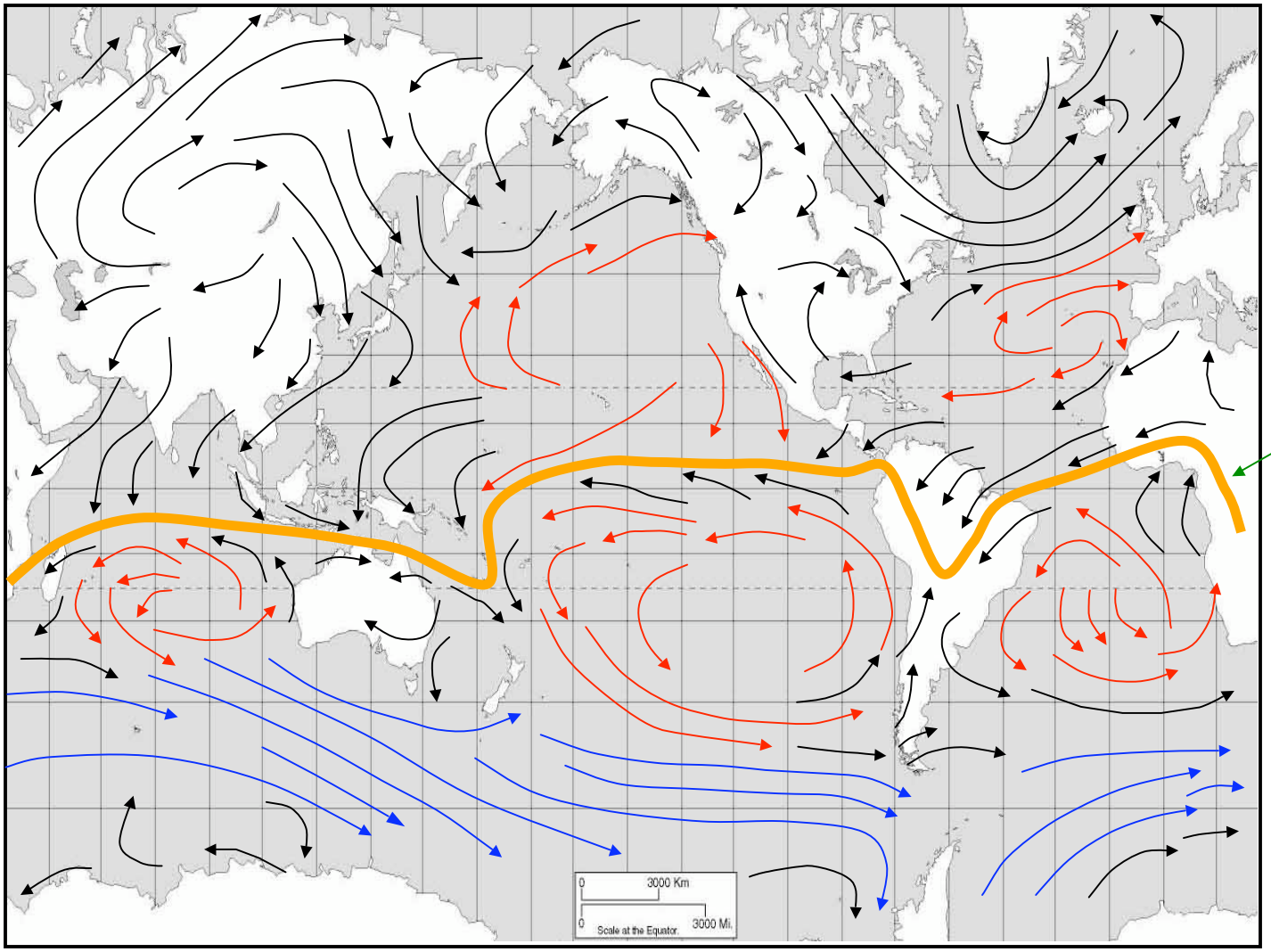
The Global Wind Field:



ITCZ: Inter-tropical convergence zone

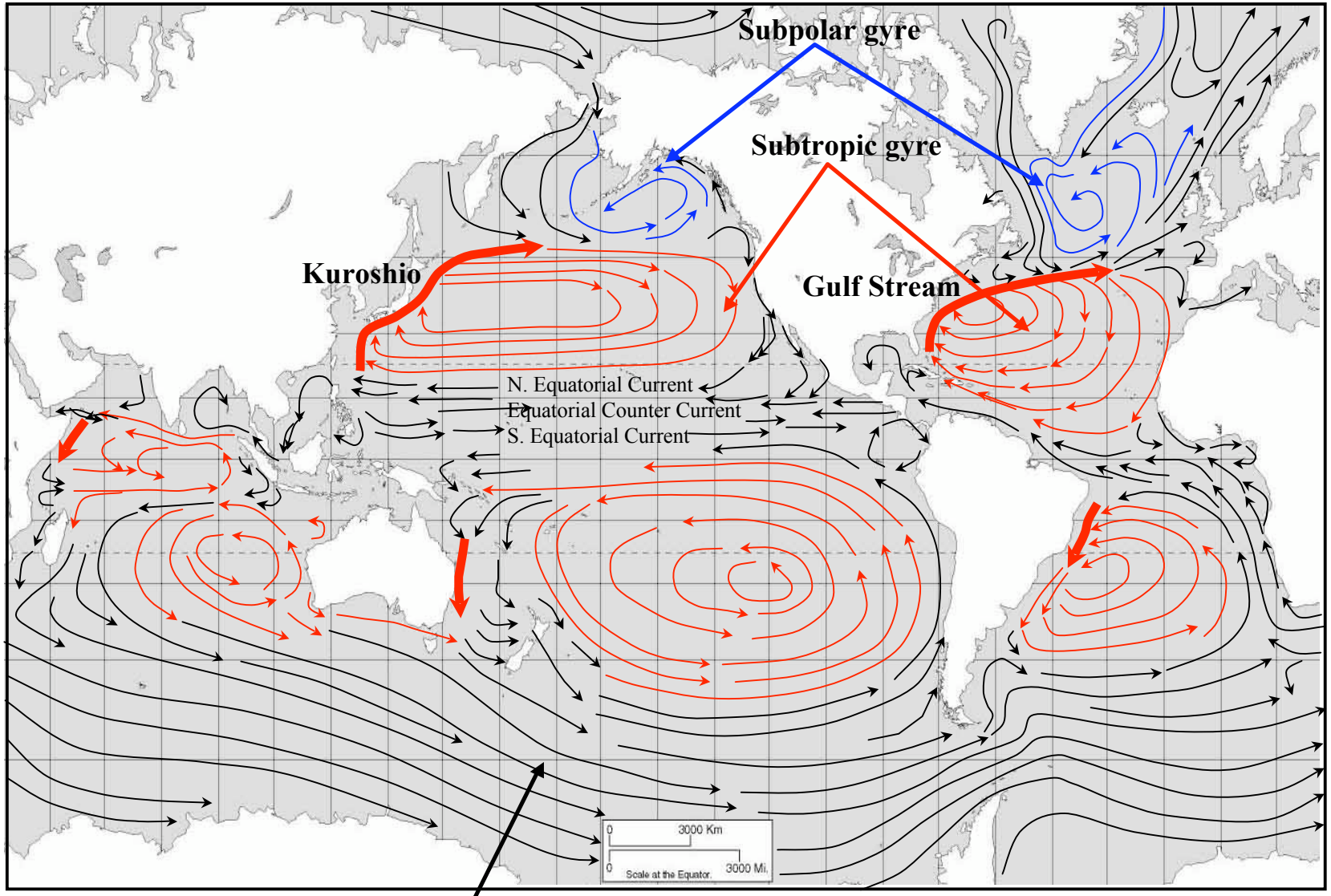


Wind Field on the northern hemisphere July



Wind field on the northern hemisphere January

Wintertime upper layer circulation



The Antarctic circumpolar current

1. The Atlantic Circulation System

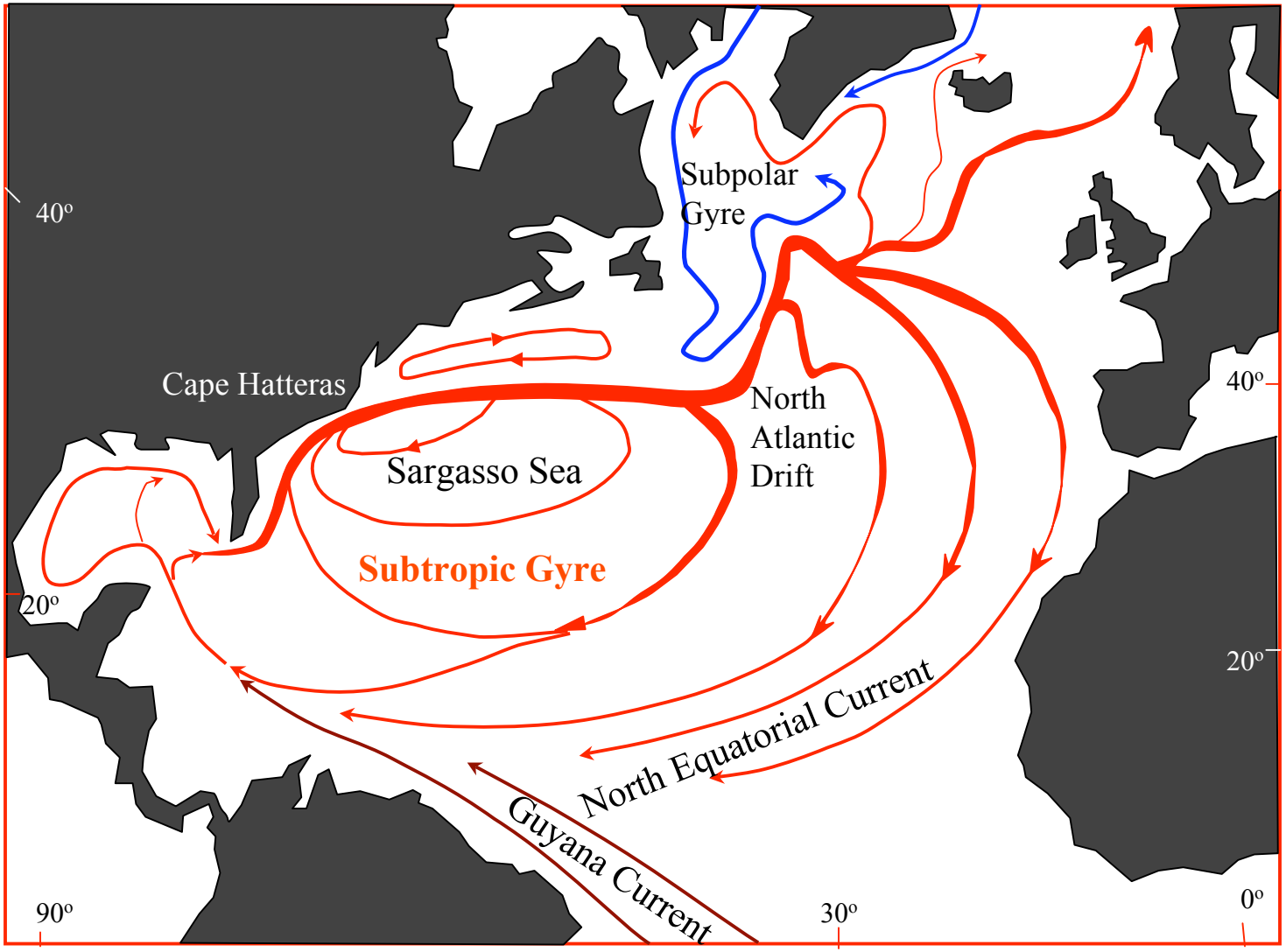
In the northern hemisphere:

- Subtropic Gyre
- The Gulf Stream and Rings
- Subpolar Gyre

In the southern hemisphere:

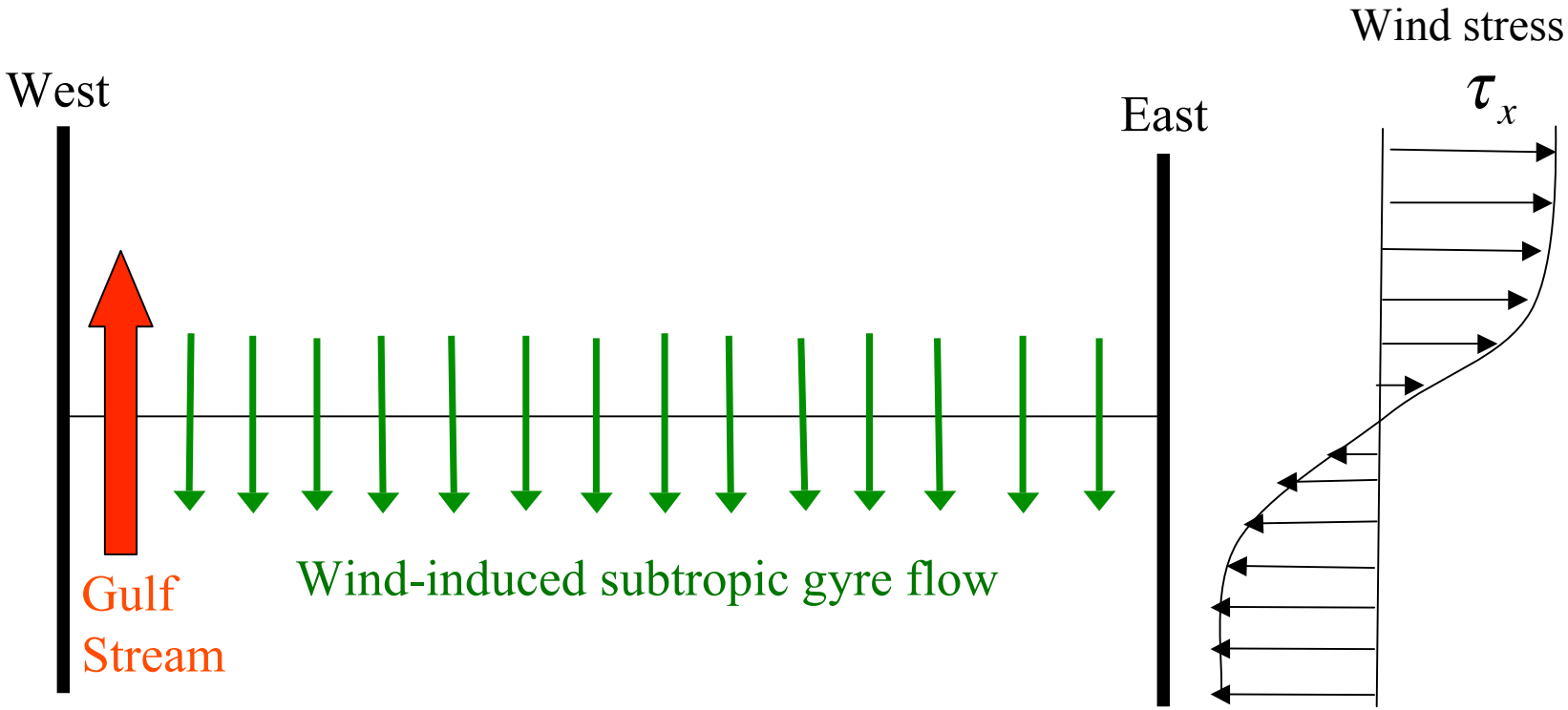
- Subtropic Gyre
- The Atlantic circumpolar circulation

Equatorial current patterns are very similar in the Atlantic and Pacific Oceans, which will be described later.

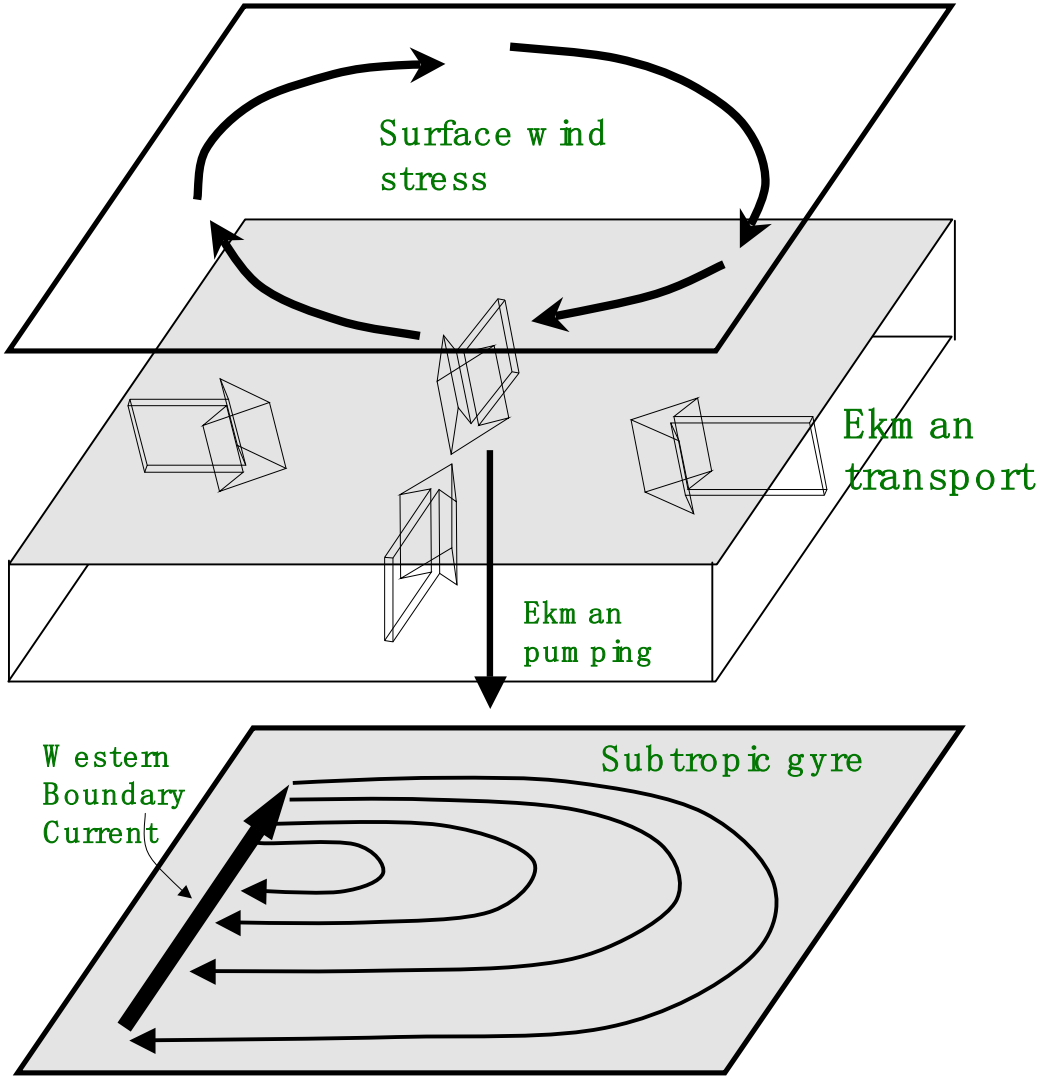


The Gulf Stream: A strong narrow current flowing northward along the continental slope through the Florida Strait and leaves to the interior of the North Atlantic Ocean at Cape Hatteras. Bowing to popular usage, oceanographers also include its extension part between Cape Hatteras and Grand Banks as continuous flow of the Gulf Stream.

Total wind-induced southward volume transport in the interior of the ocean is balanced by the a narrow northward flow on the western boundary



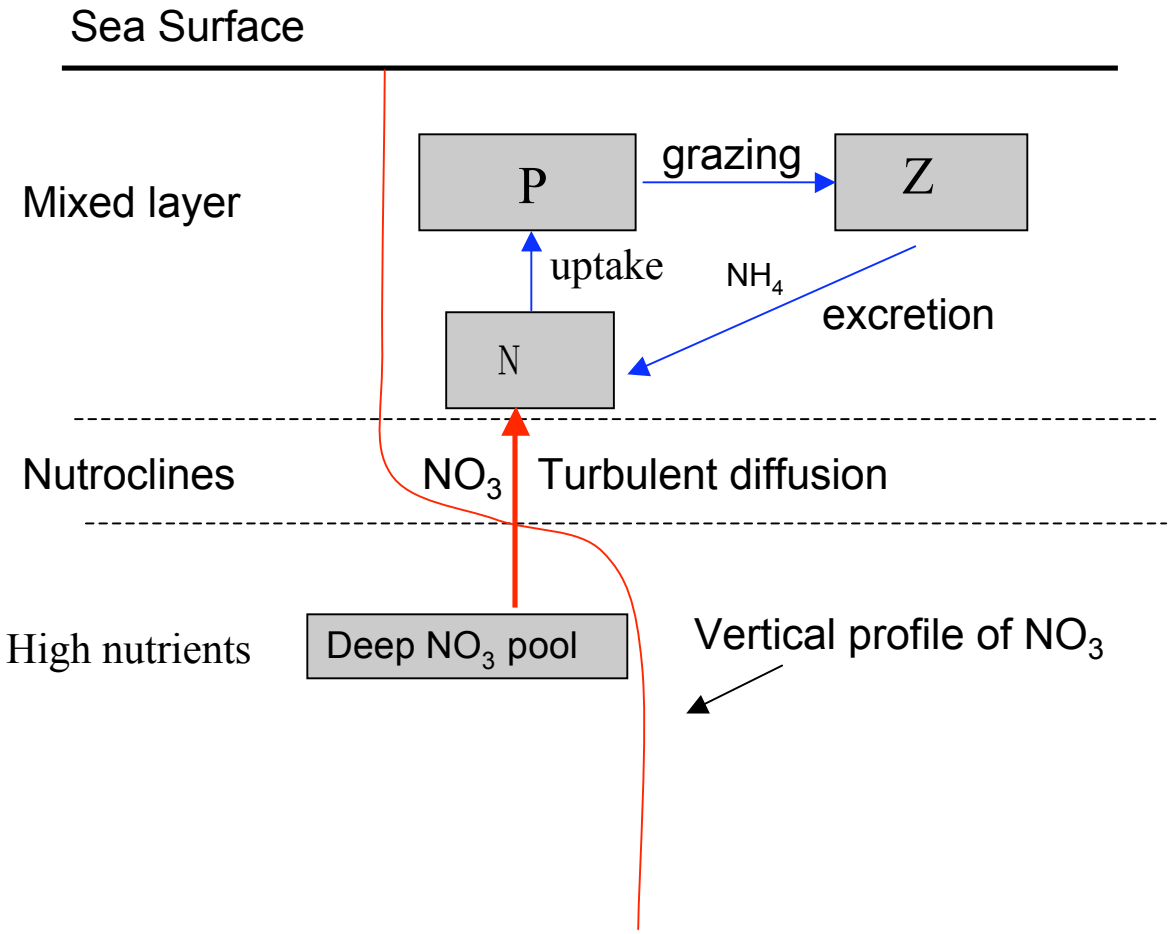
Good light condition, mixed layer depth: 100-200 m in summer, 400 m in winter



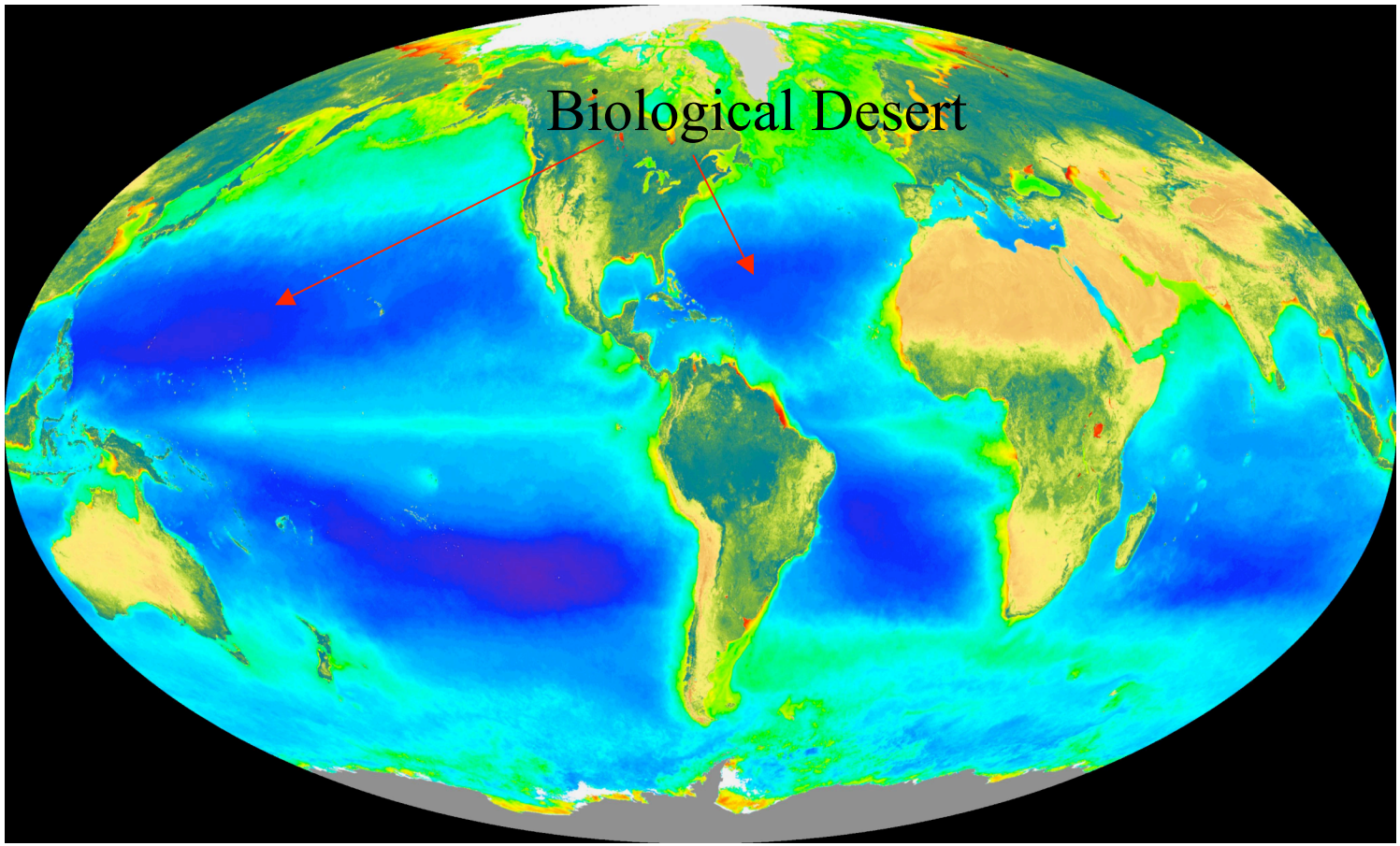
Limit the upward nutrient flux from the deep ocean to the euphotic layer

Main Sources of nutrients' supply in the mixed layer:

1) Nutrient recycling among the food web— a nutrients-phytoplankton-zooplankton system;
2) Upward flux through the thermoclines—turbulent diffusion and meso-or small scale eddy interaction.



Global Distribution of Chl-a Concentration



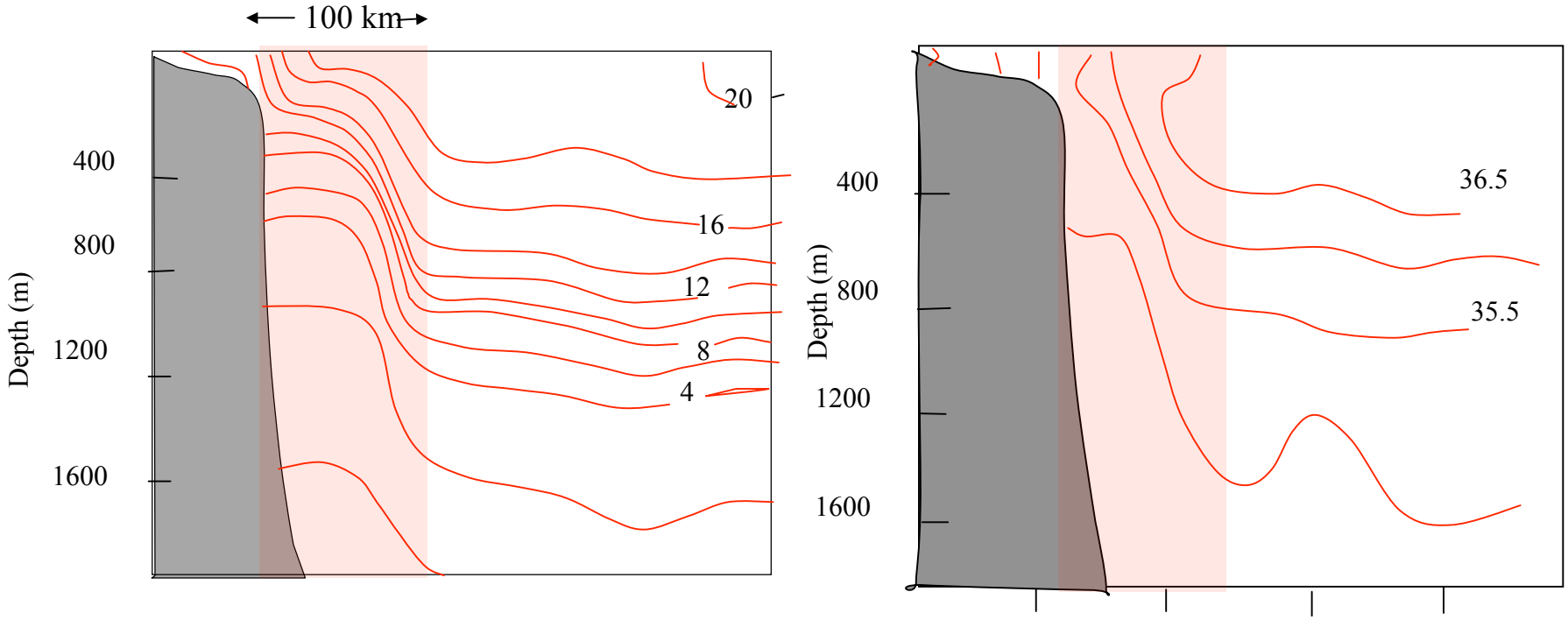
Subpolar gyre: 15-150 mg/m^2

In the divergence zone near the equator: 15-30 mg/m^2

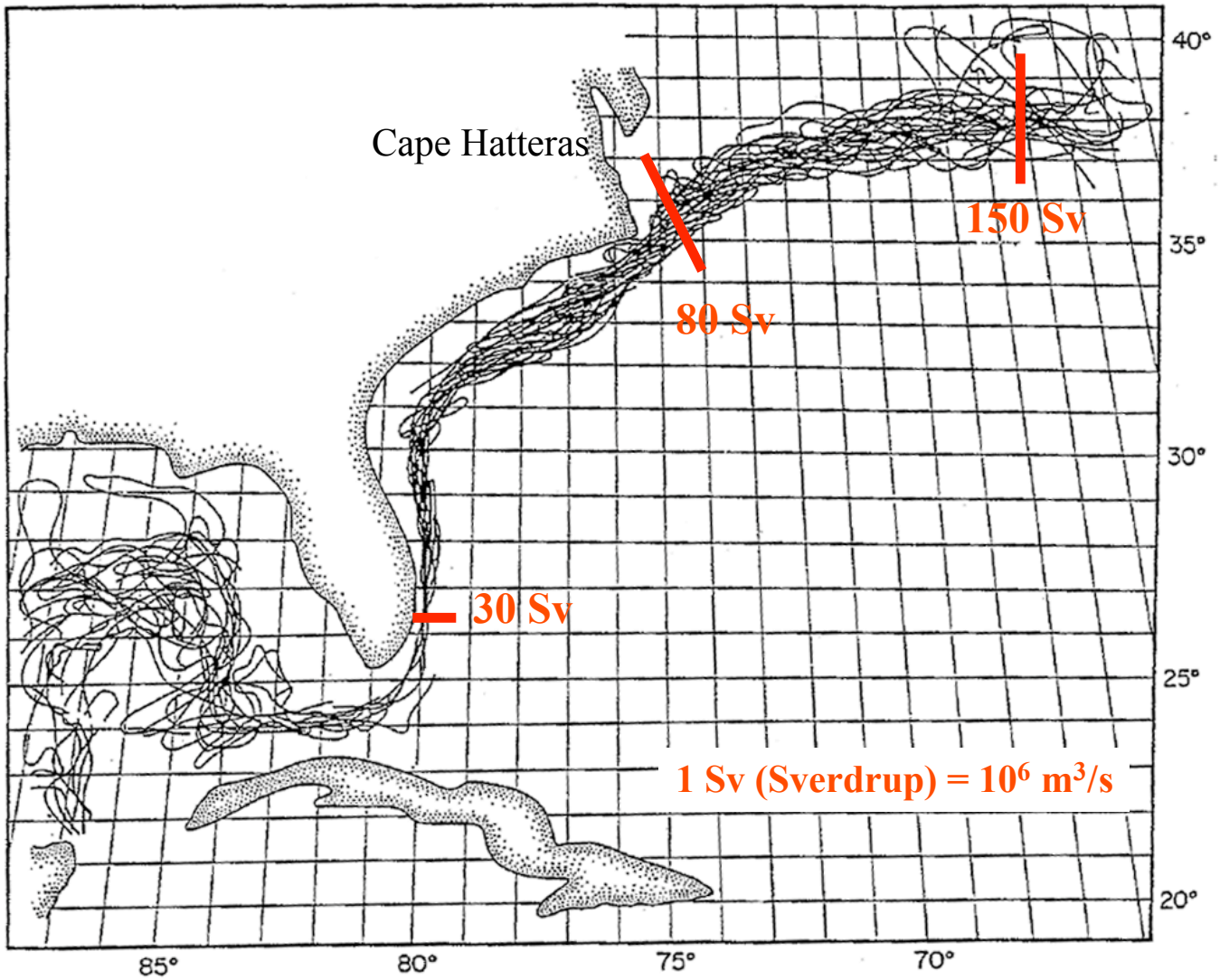
Subtropic gyre: 5-25 mg/m^2

The Gulf Stream:

- **The warm and saline water;**
- **Steeply sloping isotherms (temperature) and isohalines (salinity);**
- **Cross-shelf~ 100 km;**
- **A vertical scale of ~ 1000 m;**
- **The surface current ~ 100 cm/s**

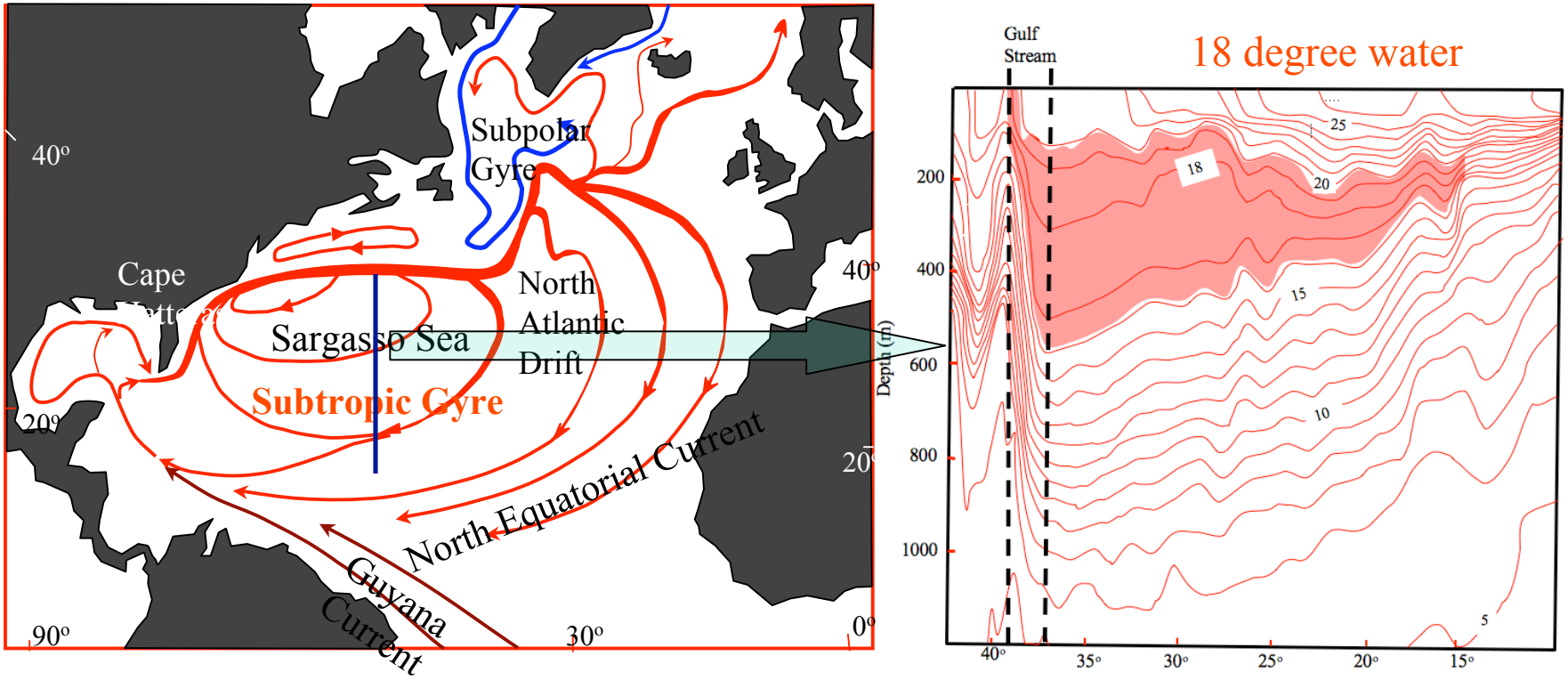


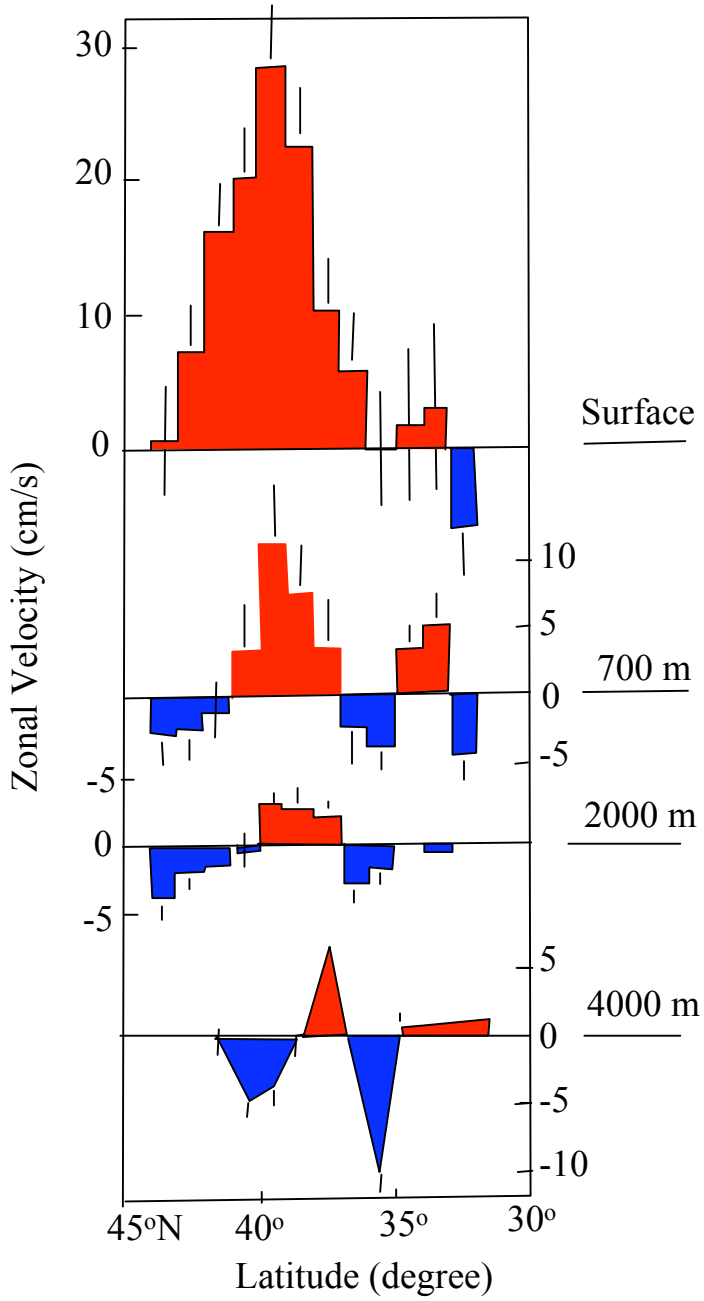
The position of thermal front of the Gulf Stream taken from the satellite images and surface tracking drifters



QS: Why does the Gulf Stream transport increase when it move northward along the slope and after it enters the interior North Atlantic Ocean?

Recirculation and rings !





A direct current measurement on a north-south section of 55° W (Hogg et al. 1986)

Blue: The recirculation flow

Red: The eastward flow

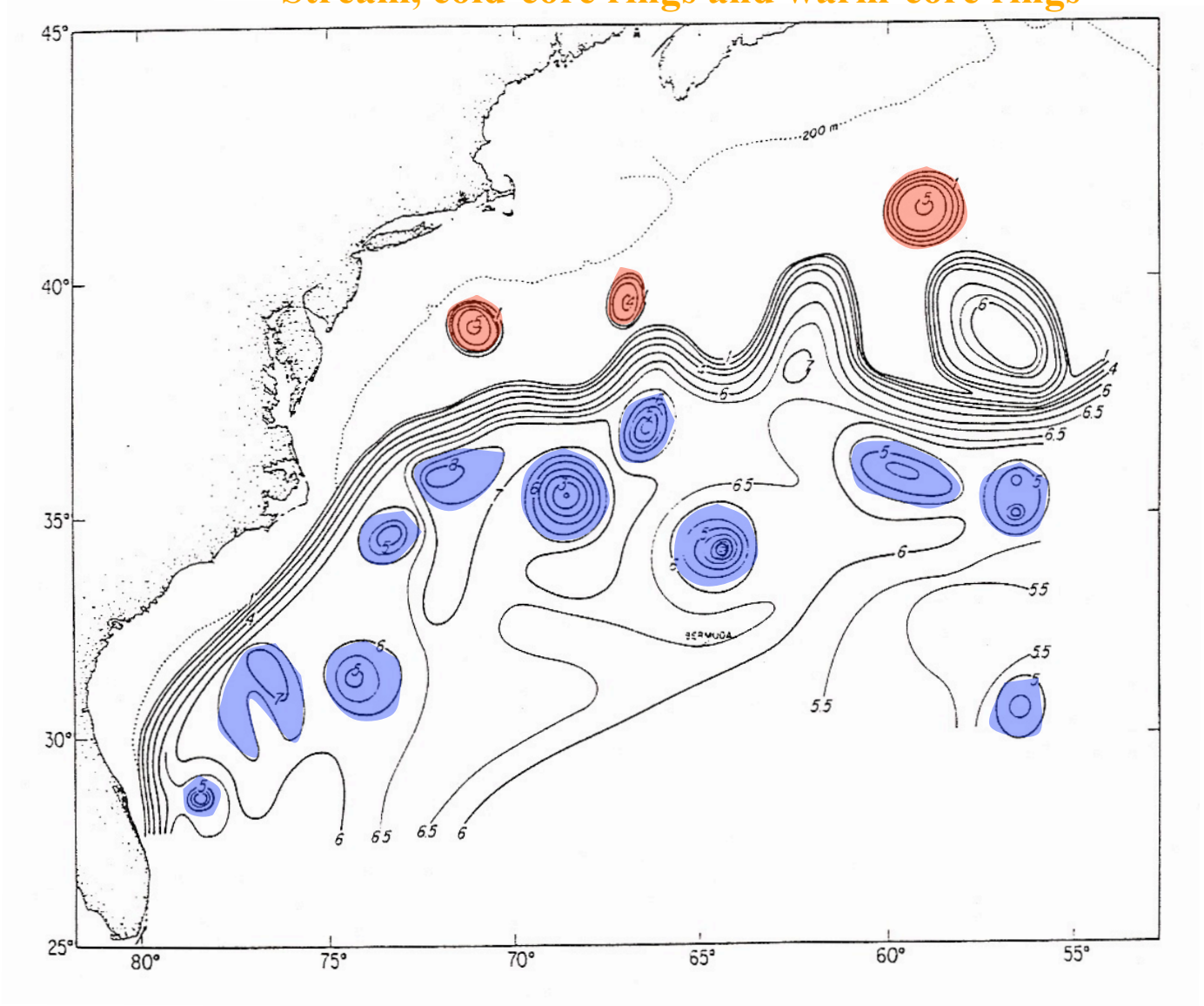
Solid black line: Measurement uncertainty

Recirculation increases with depth.

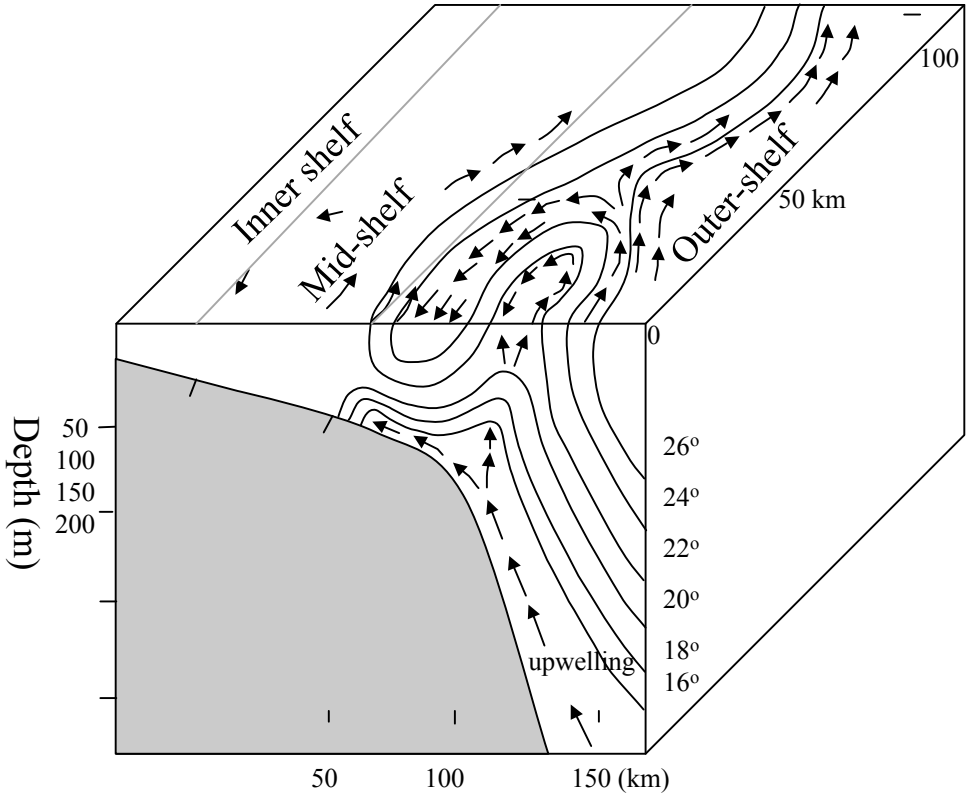
At ~4000 m,

it can reach ~10 cm/s

A chart of the topography of the 150 isothermal surface showing the Gulf Stream, cold-core rings and warm-core rings



Instability of the Gulf Stream front: eddy formation at the shelf break.



Eddy scale:

L ~ 50-60 km

Upwelling advects nutrients upward to the euphotic layer: producing a near-surface phytoplankton bloom. The euphotic layer depth: > 20 m in the outer shelf.