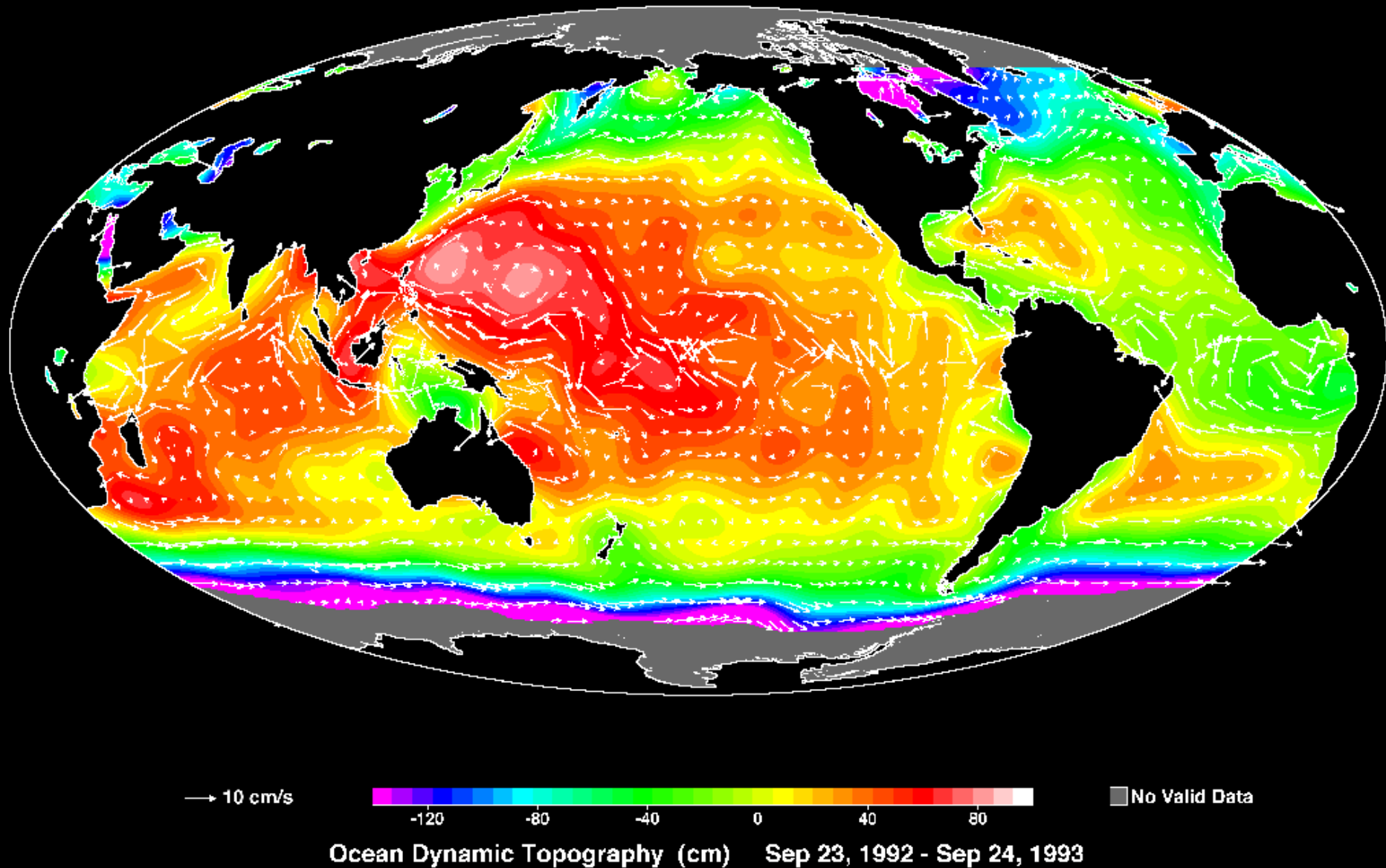
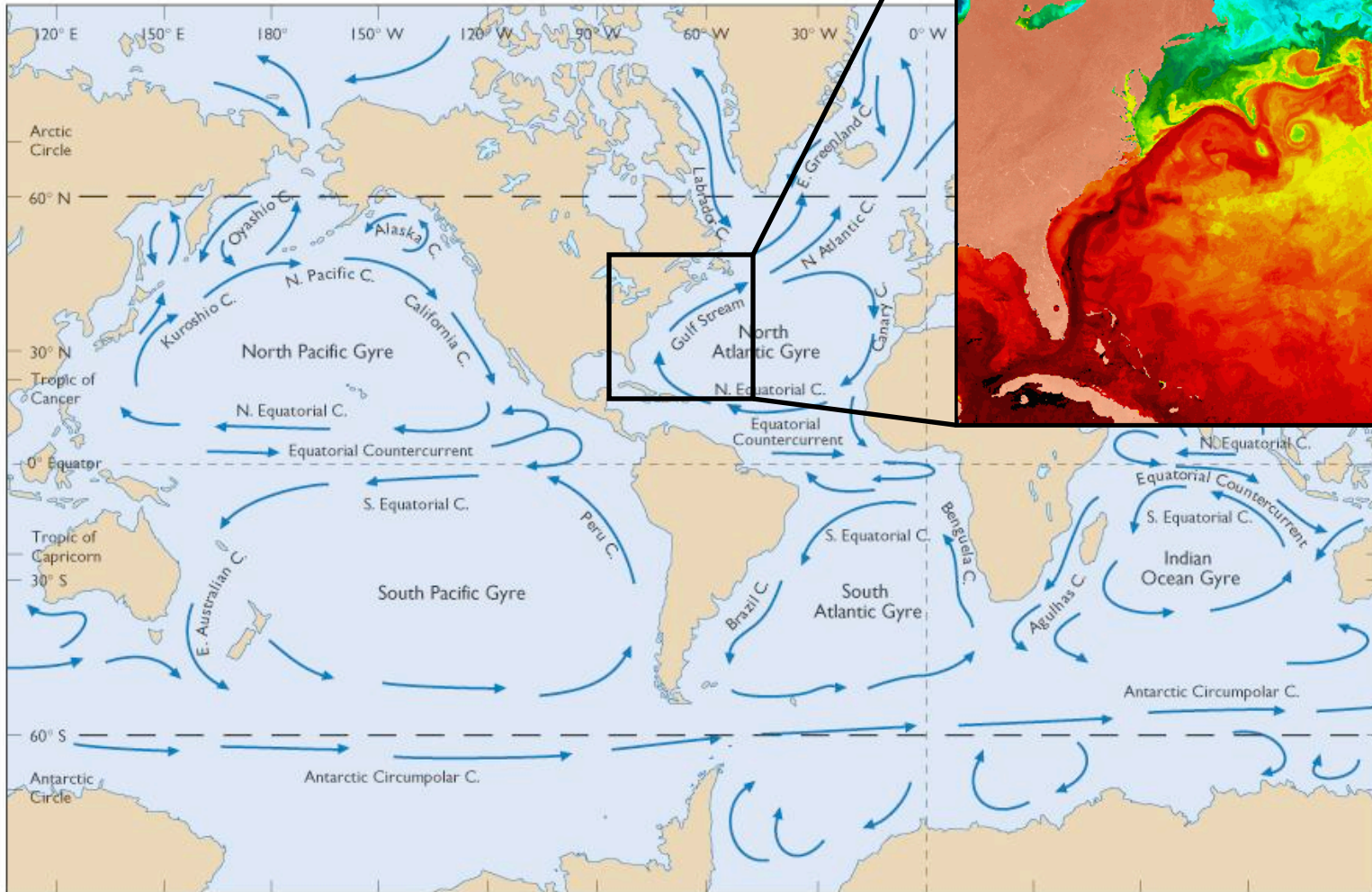


The Ocean General Circulation



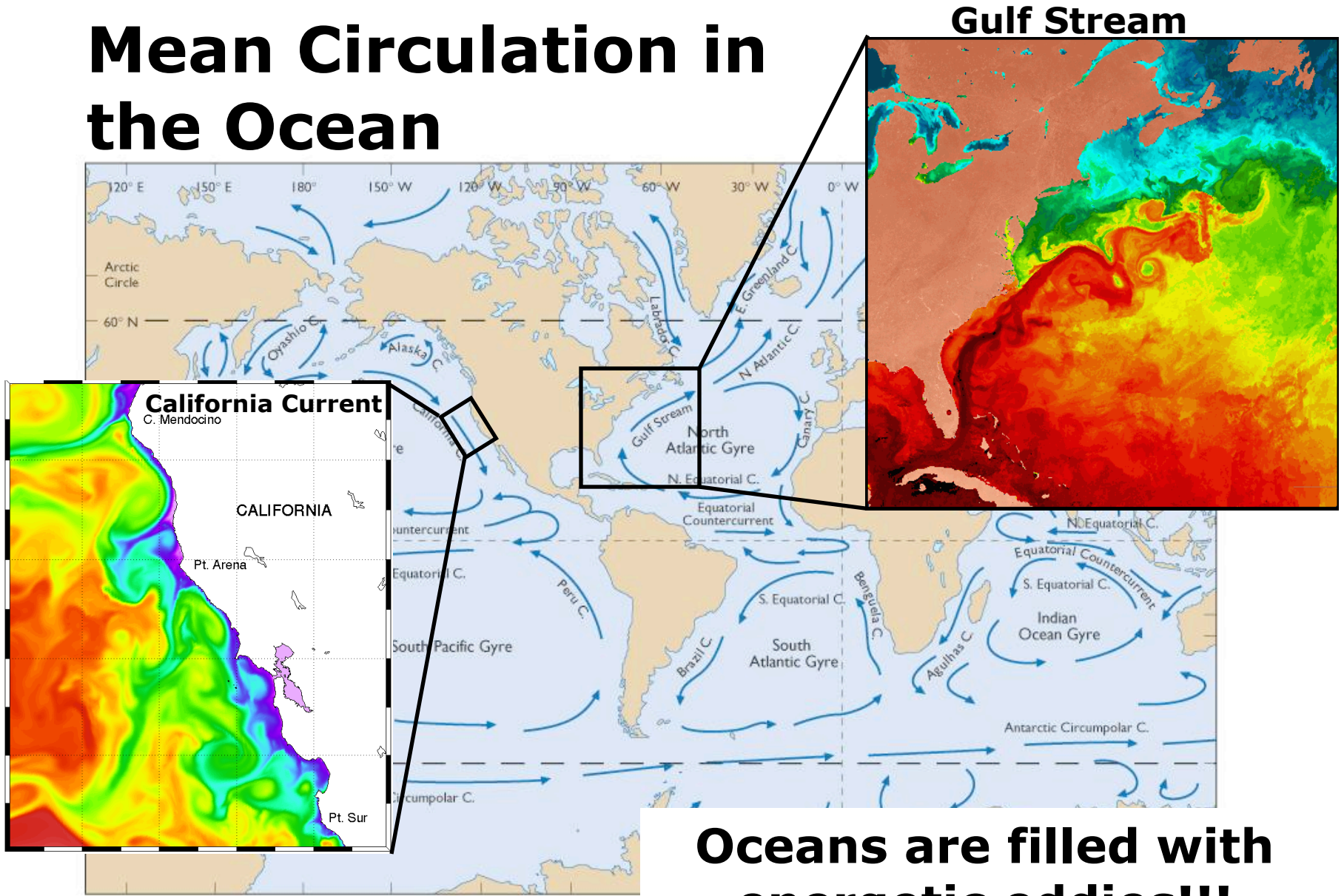
Mean Circulation in the Ocean

Gulf Stream



(b) GLOBAL SURFACE-WATER CURRENT PATTERN

Mean Circulation in the Ocean



(b) GLOBAL SURFACE-WATER CURRENT PATTERN

Oceans are filled with energetic eddies!!!

Gulf Stream, Plankton Bloom



Gulf Stream Spiral Eddies



Mediterranean Sea, Shear Wall Spiral Eddies



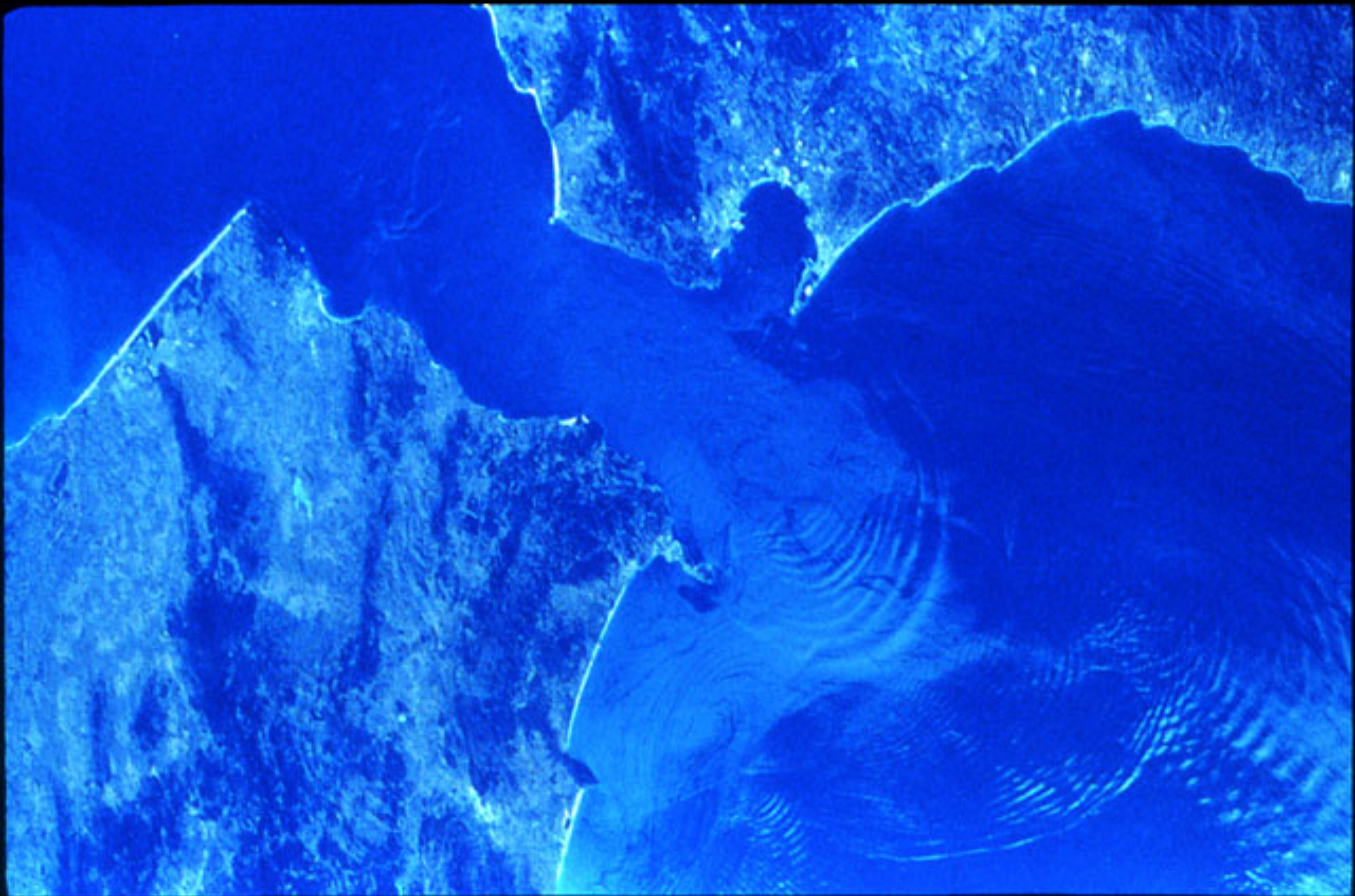
Tropical Atlantic, Spiral Eddy



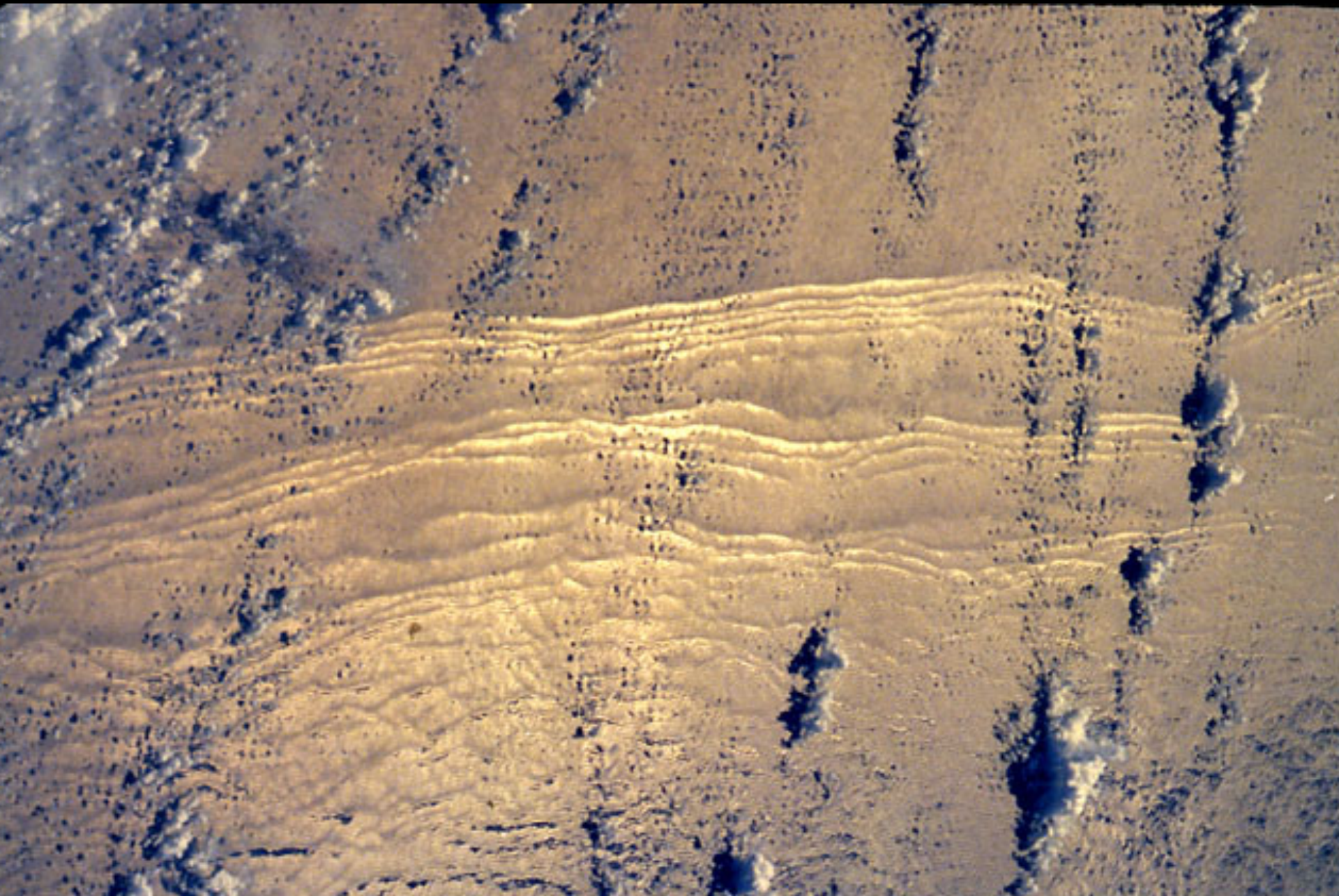
Greek Island, Spiral Eddies and Wakes



Strait of Gibraltar, Solitons



Eastern Pacific Internal Waves



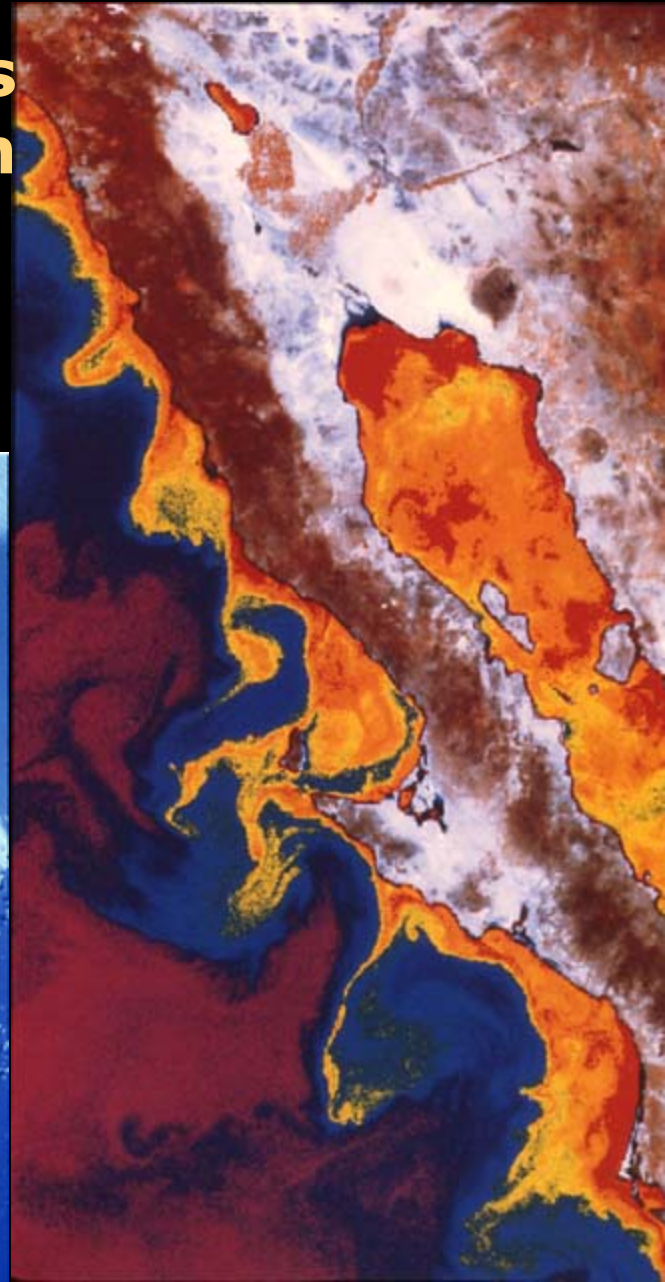
Kelvin Wakes, from Ships



Coastal Dynamics

California Filaments and Phytoplankton

Hawaiian Island Wakes



Ocean wind driven circulation

Key questions:

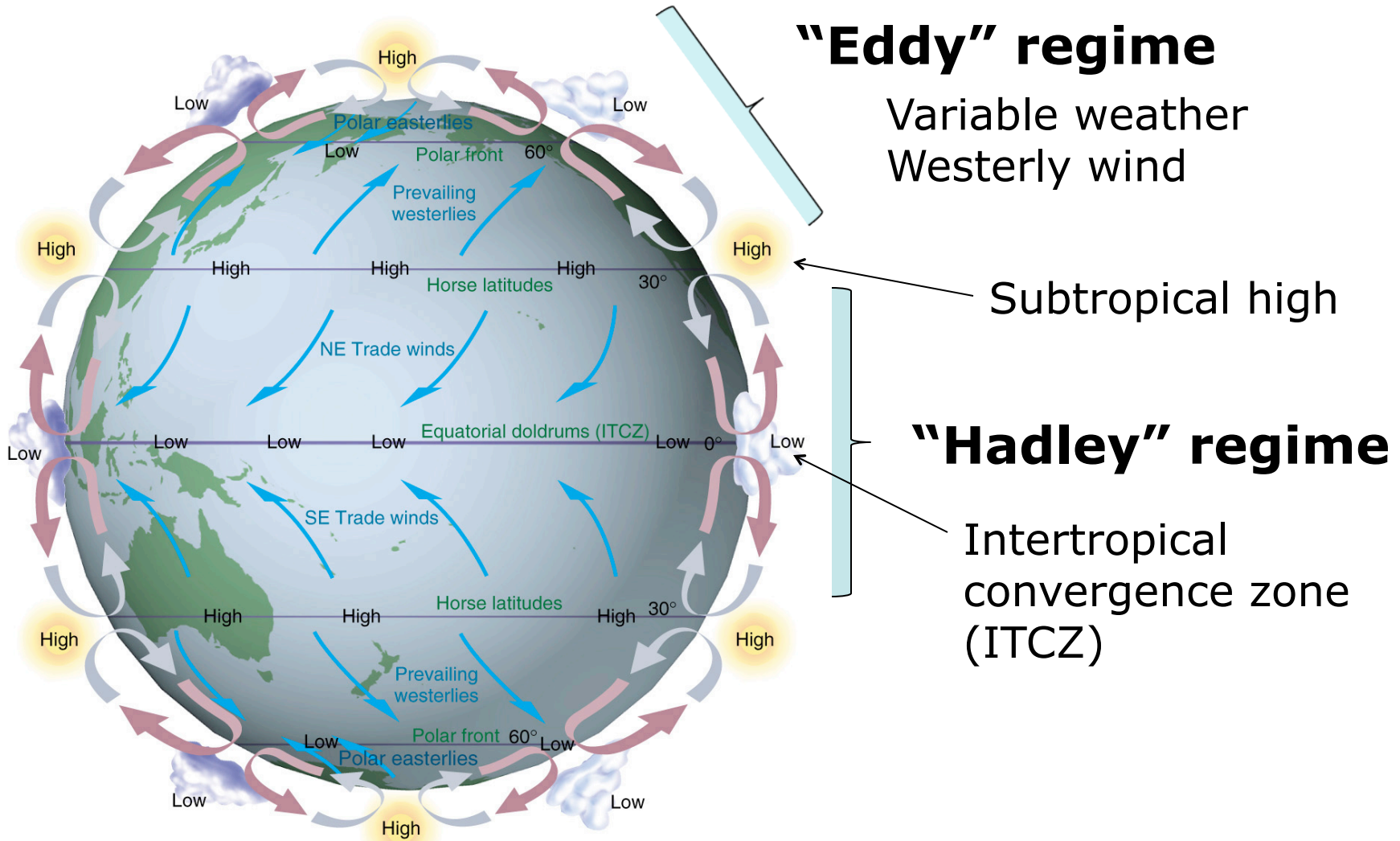
How does the wind drive surface currents?

What drives oceanic gyres?

What is Ekman transport?

What drives upwelling and downwelling?

Atmospheric winds



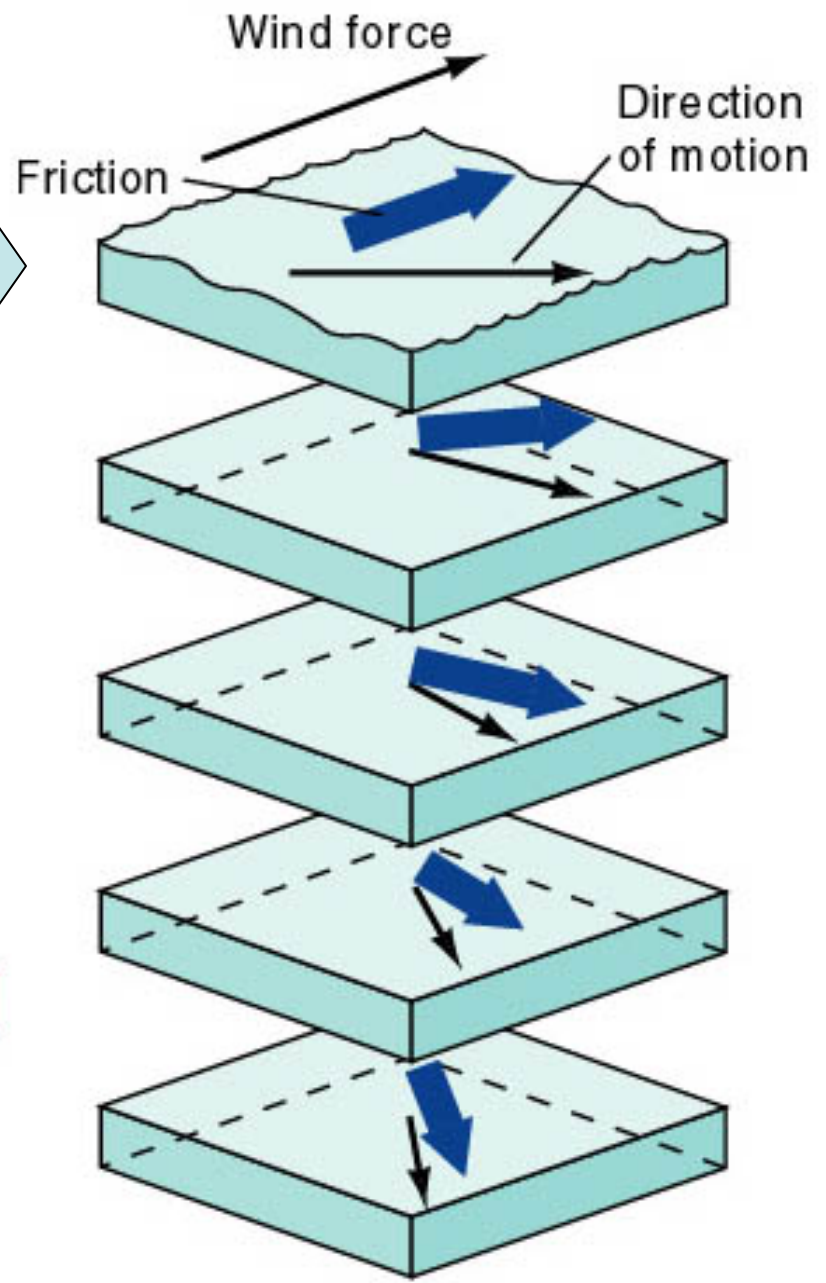
How is the energy of the winds transferred to the ocean?

Ekman Theory ...

How does wind force propagate in the ocean?

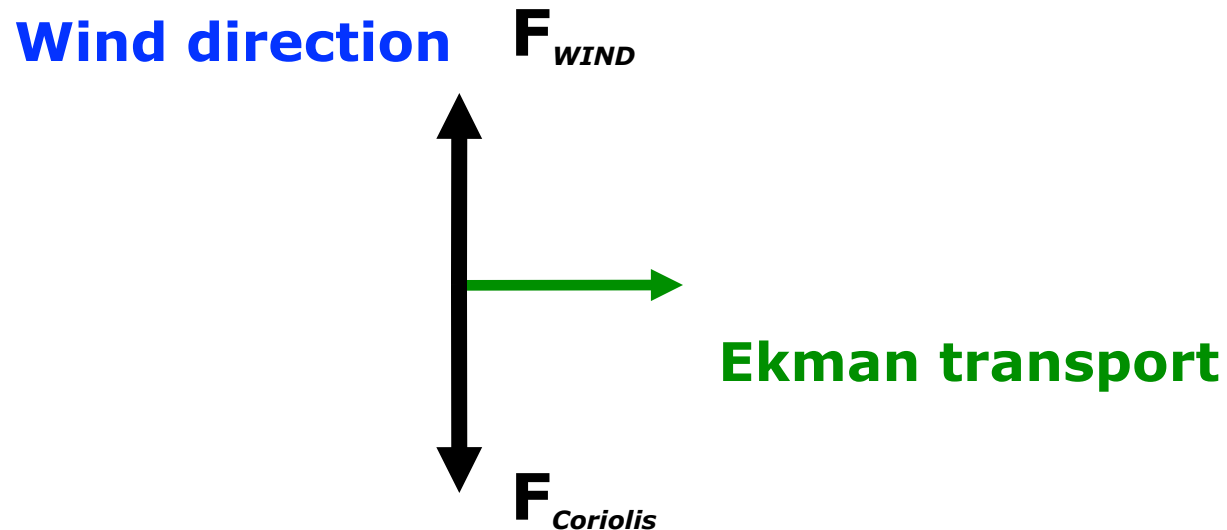
surface →

balance between friction and rotation



b

Ekman transport: Balance between wind and Coriolis force

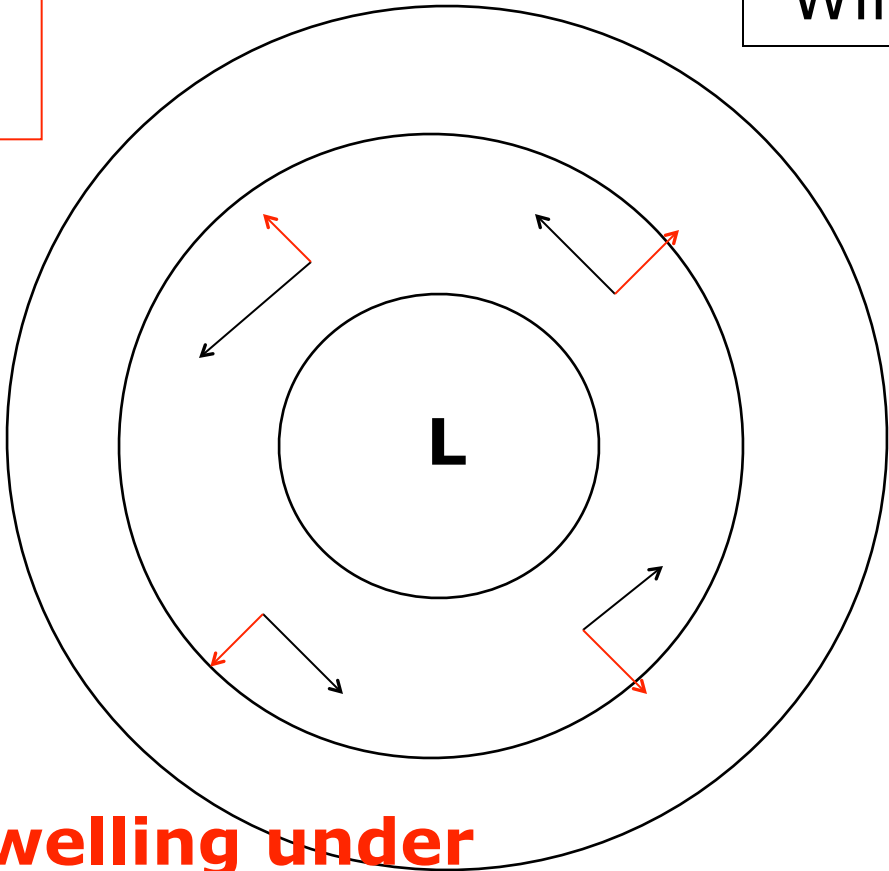


- 1) Surface water is pushed by the atmospheric wind
- 2) Coriolis force acting on surface current balances the wind stress
- 3) Surface current (averaged over tens of meters) points to the right of the direction of the wind

What would happen to the Ekman transport under the cyclonic atmospheric circulation?

Ekman transport

Wind stress

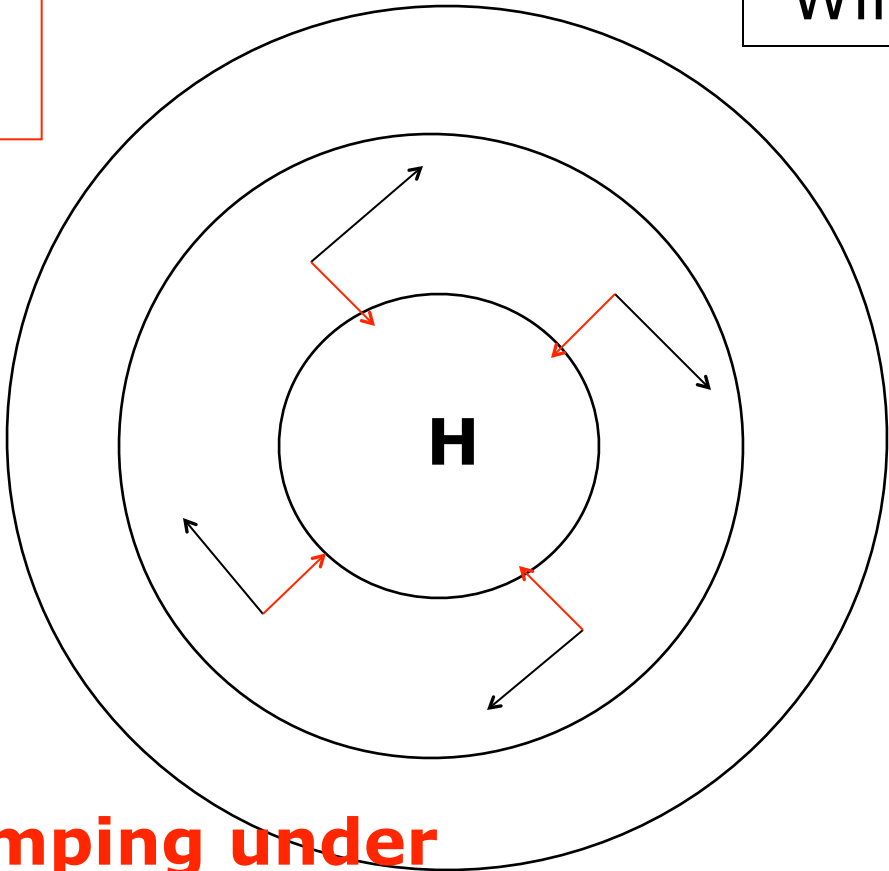


Ekman upwelling under cyclonic circulation

What would happen to the Ekman transport under the anti-cyclonic atmospheric circulation?

Ekman transport

Wind stress



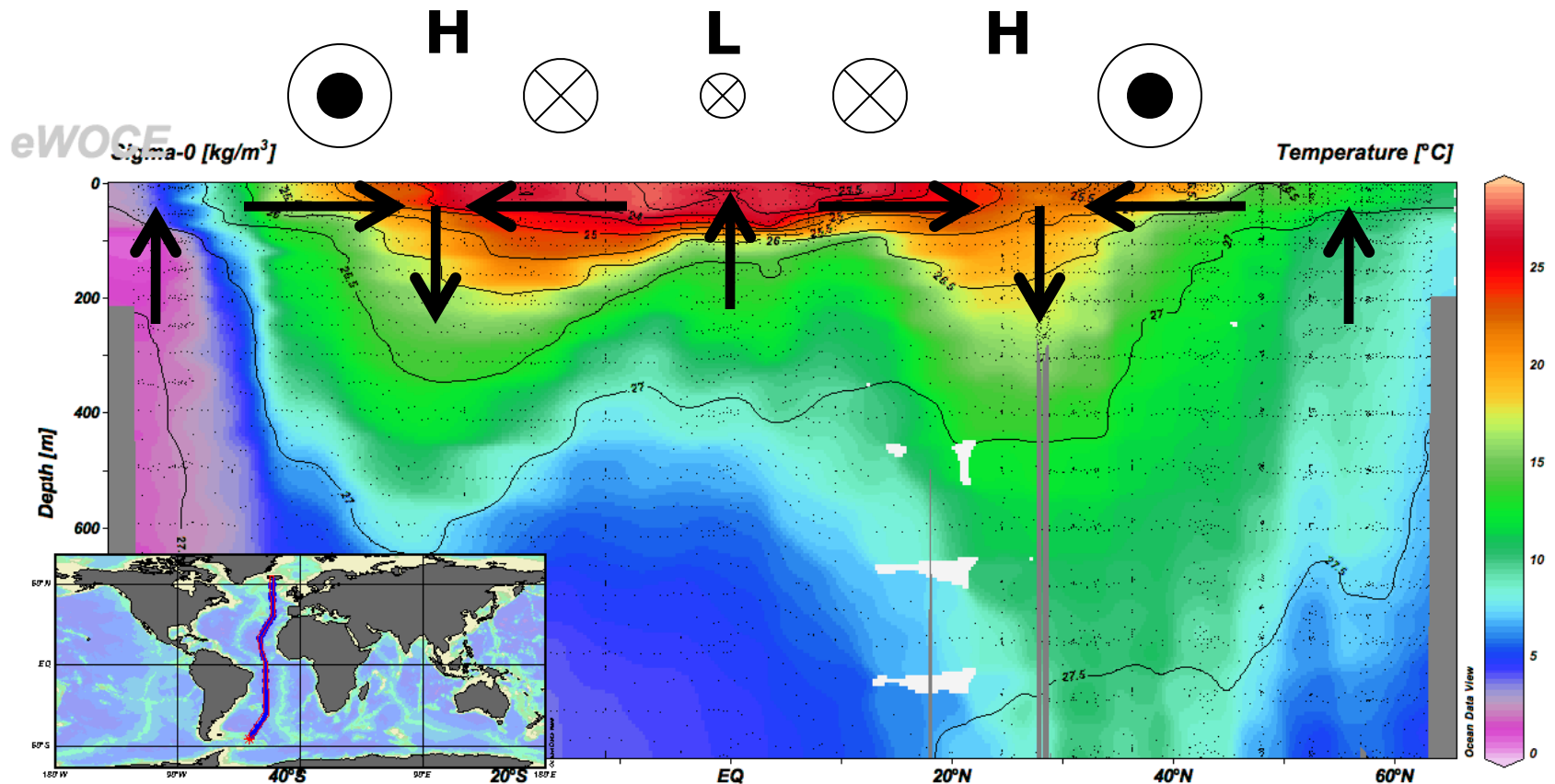
Ekman pumping under anti-cyclonic circulation

Ocean temperature structure

Atlantic Ocean

Temperature structure in the top 1,000m

What controls this structure?



Ekman Theory ...and vertical advection in the ocean

COASTAL UPWELLING and DOWNWELLING

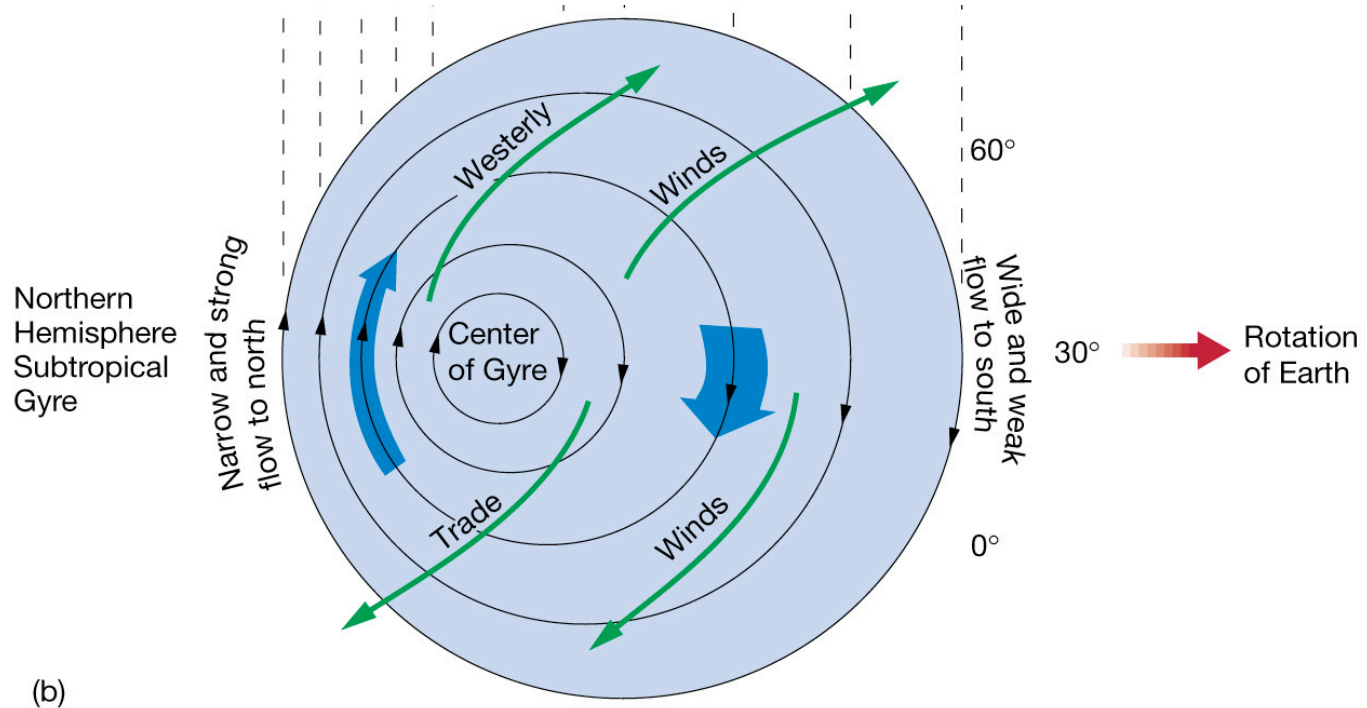
OPEN OCEAN EKMAN PUMPING

Subtropical “ocean gyre” is a geostrophic circulation

1) Atmospheric high pressure → Anti-cyclonic wind stress

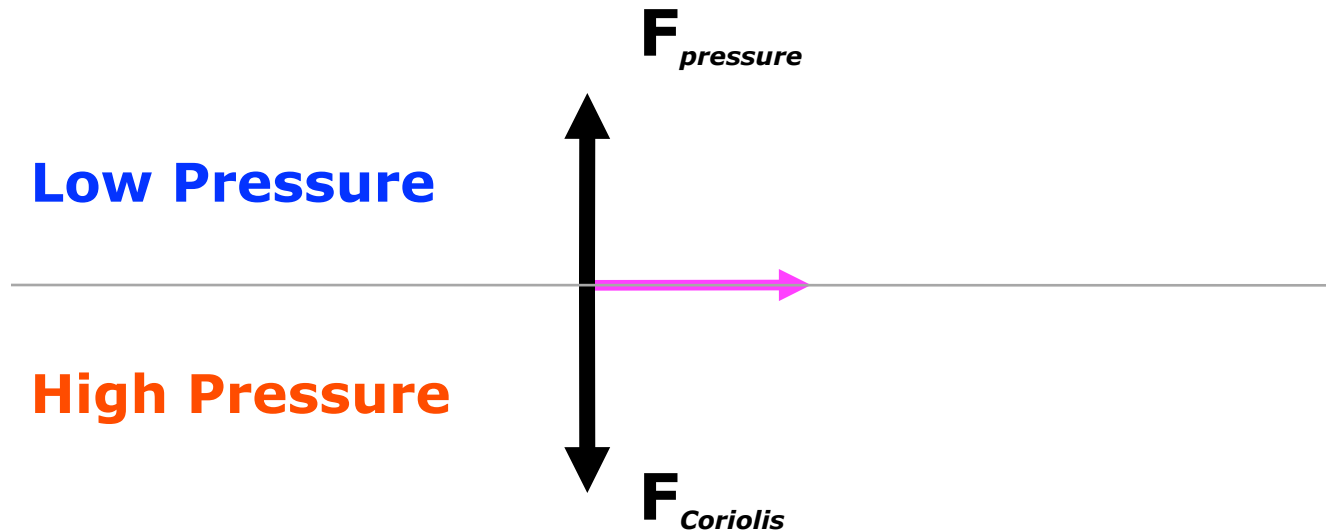
1) Ekman transport converges toward the middle, raising up the sea surface slightly

2) Pressure force drives the geostrophic gyre circulation



Balance of forces: geostrophic balance

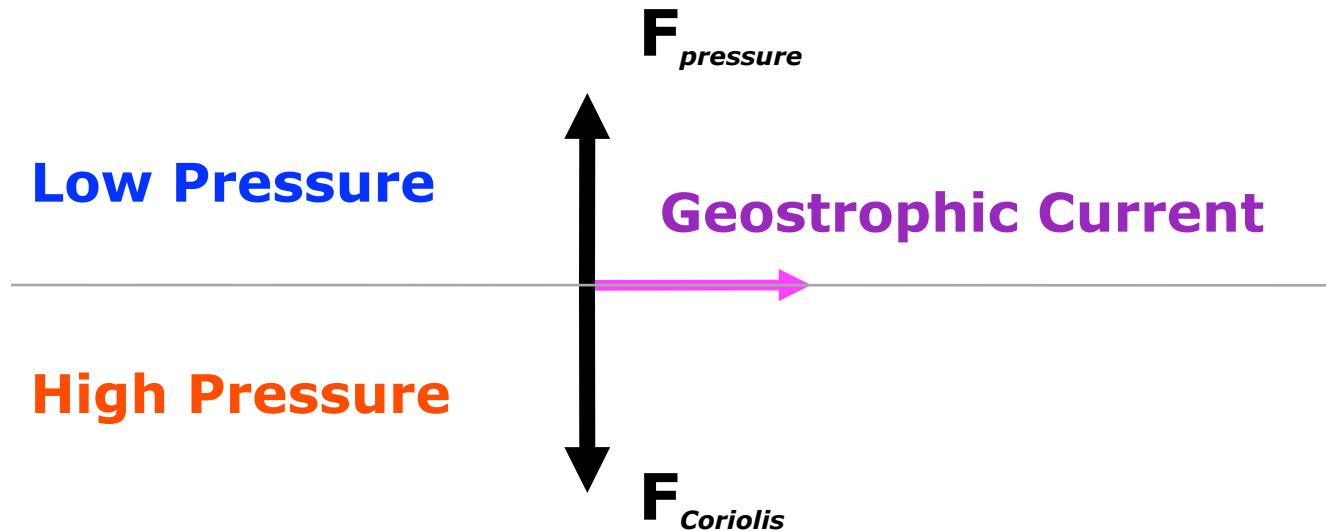
Applies to the Ocean same as Atmosphere!



- 1) Particle will have the Coriolis force 90 degrees to the right
- 2) Particles will tend to move along line of constant pressure
- 3) Particles will have the high pressure on their right (same as Coriolis)

Balance of forces: geostrophic balance

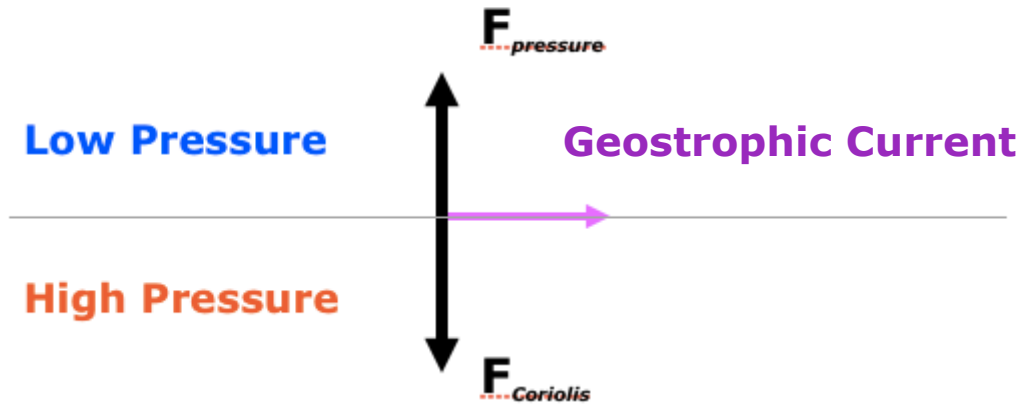
Applies to the Ocean same as Atmosphere!



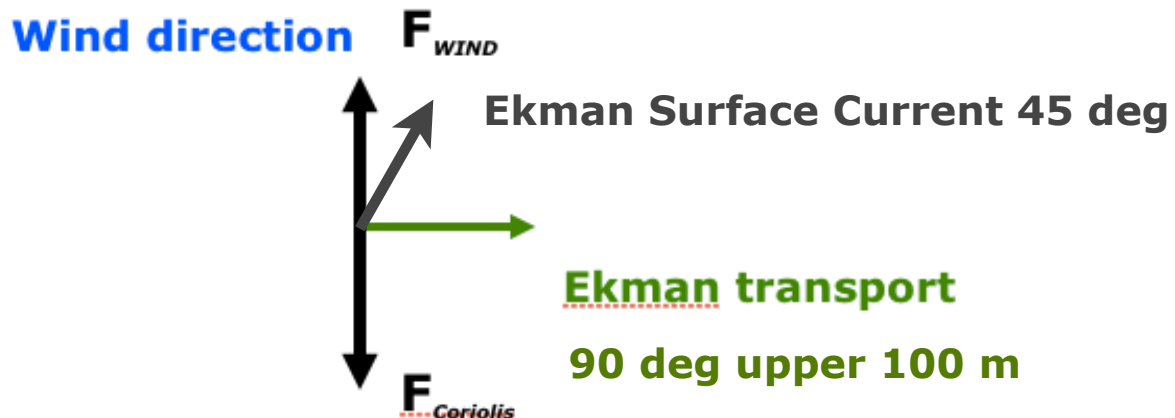
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Balance of forces: geostrophic balance

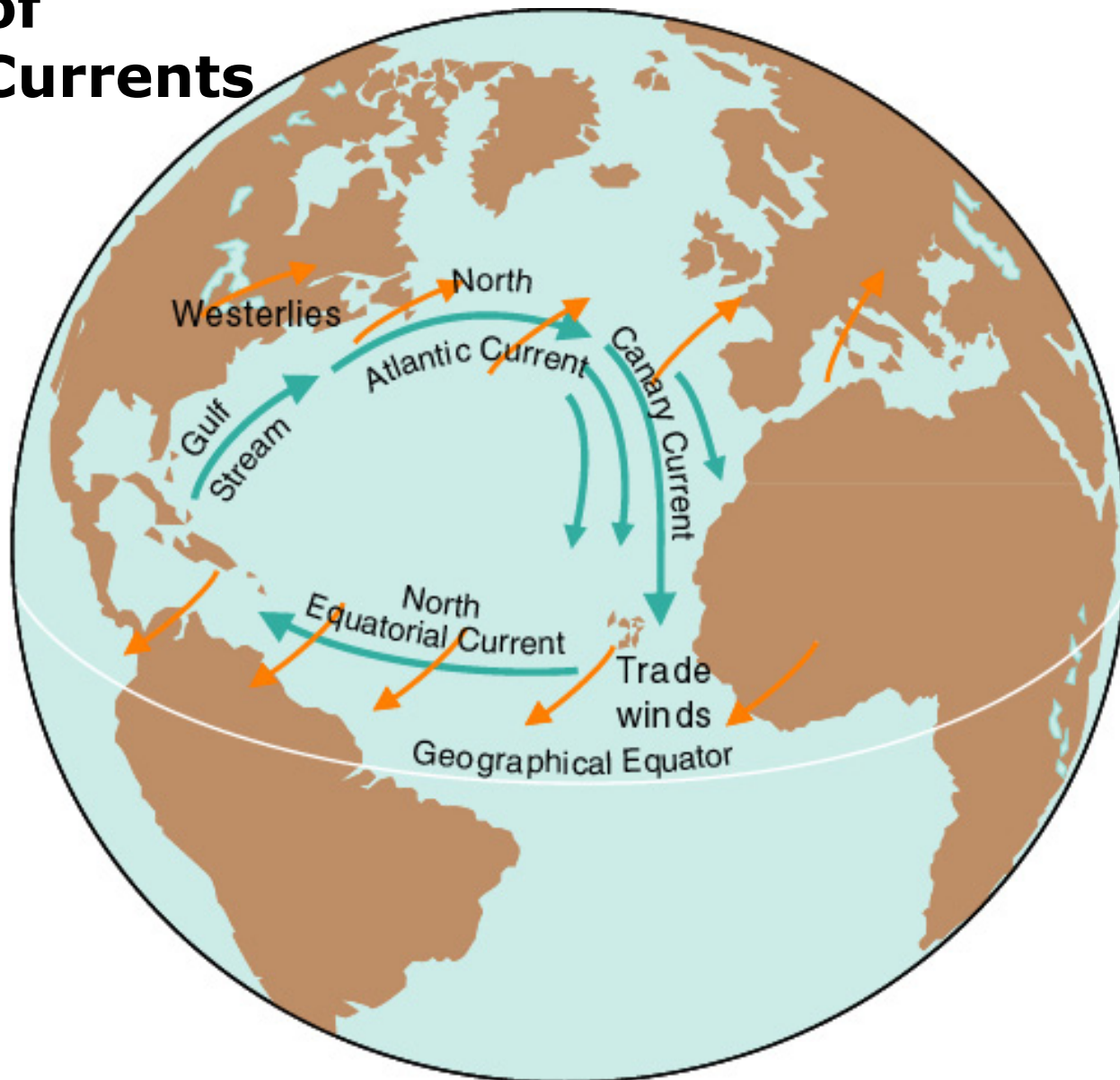
Applies to the Ocean same as Atmosphere!



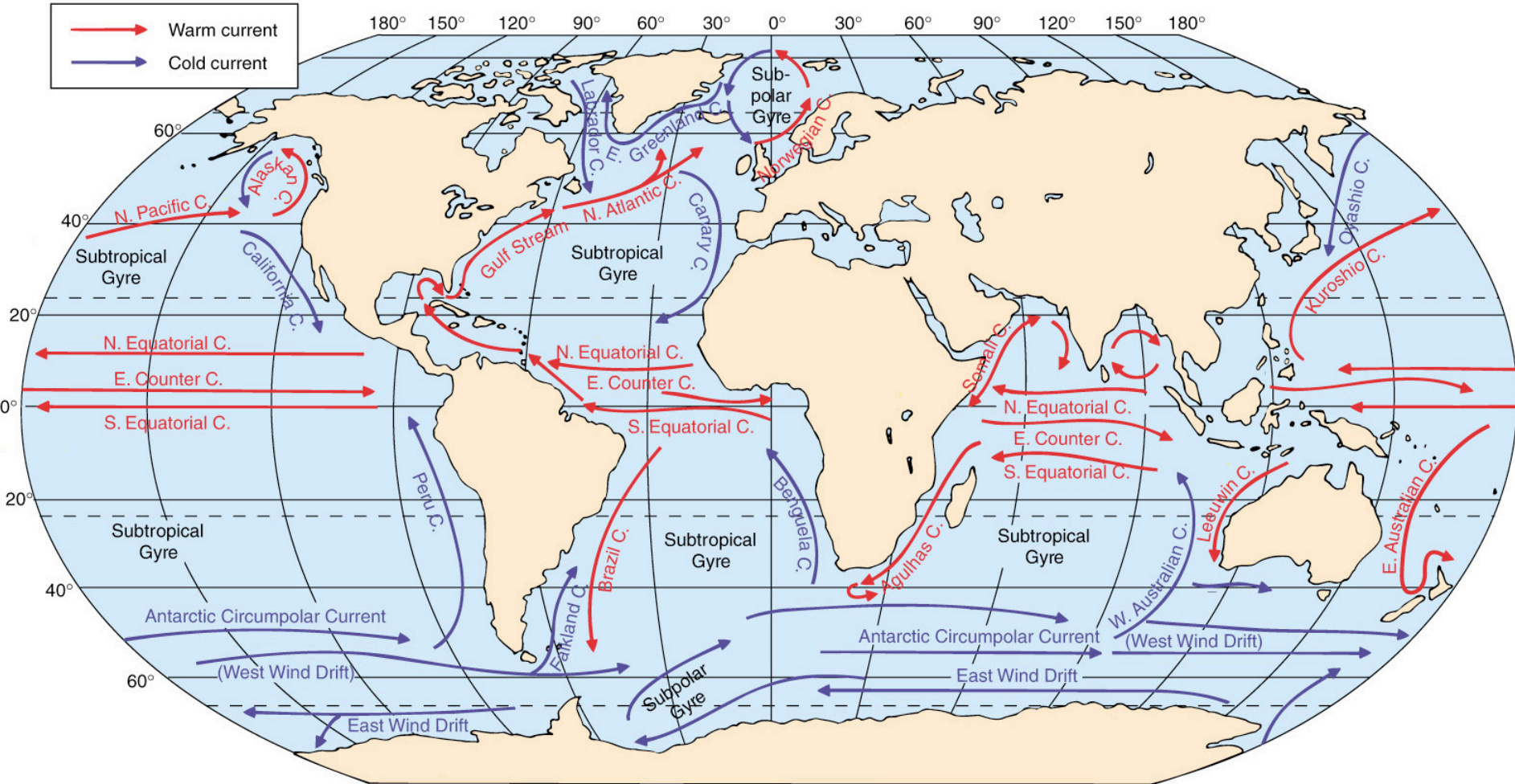
Ekman transport: Balance between wind and Coriolis force



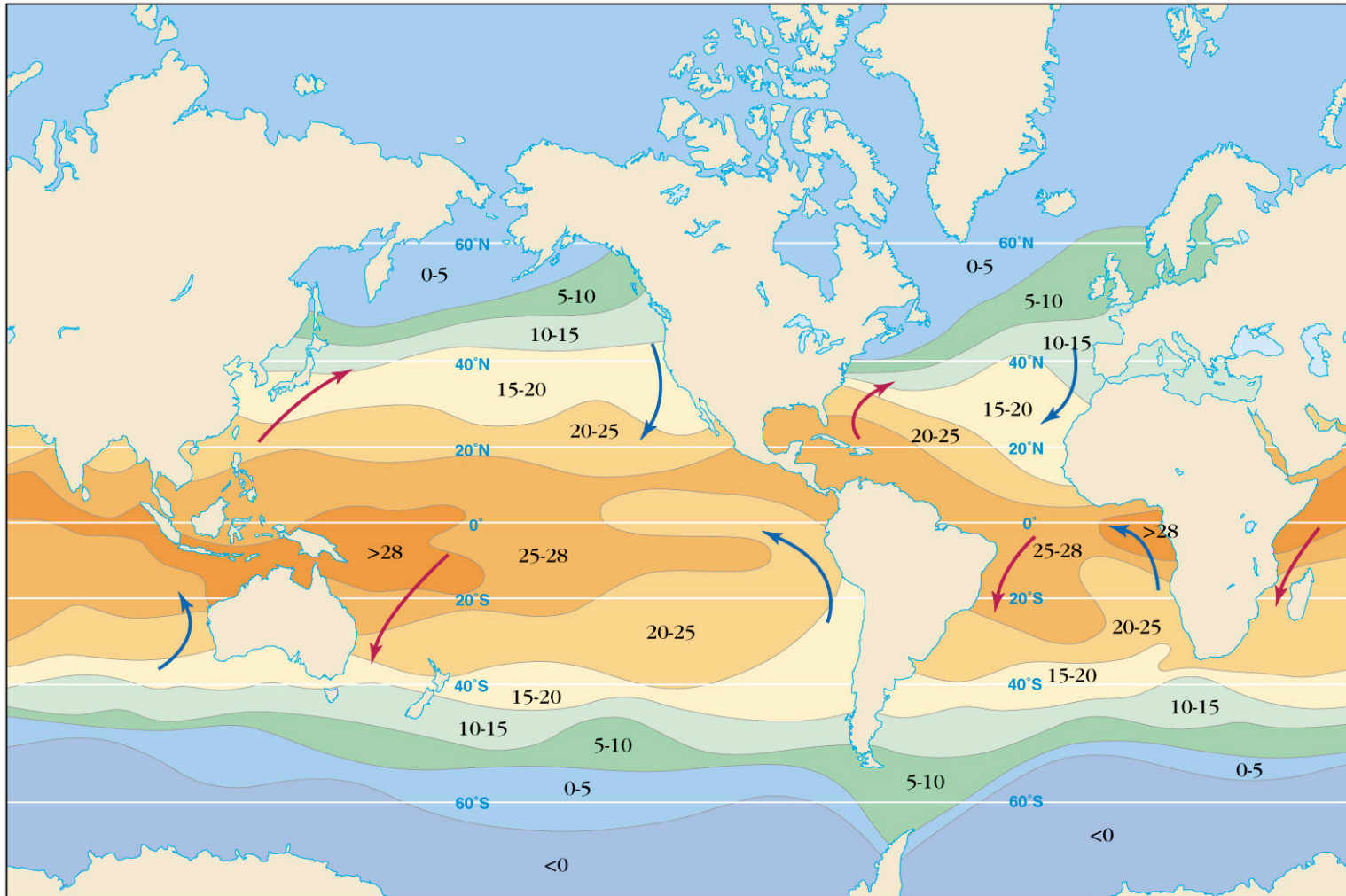
Effects of Ekman Currents



Ocean general circulation



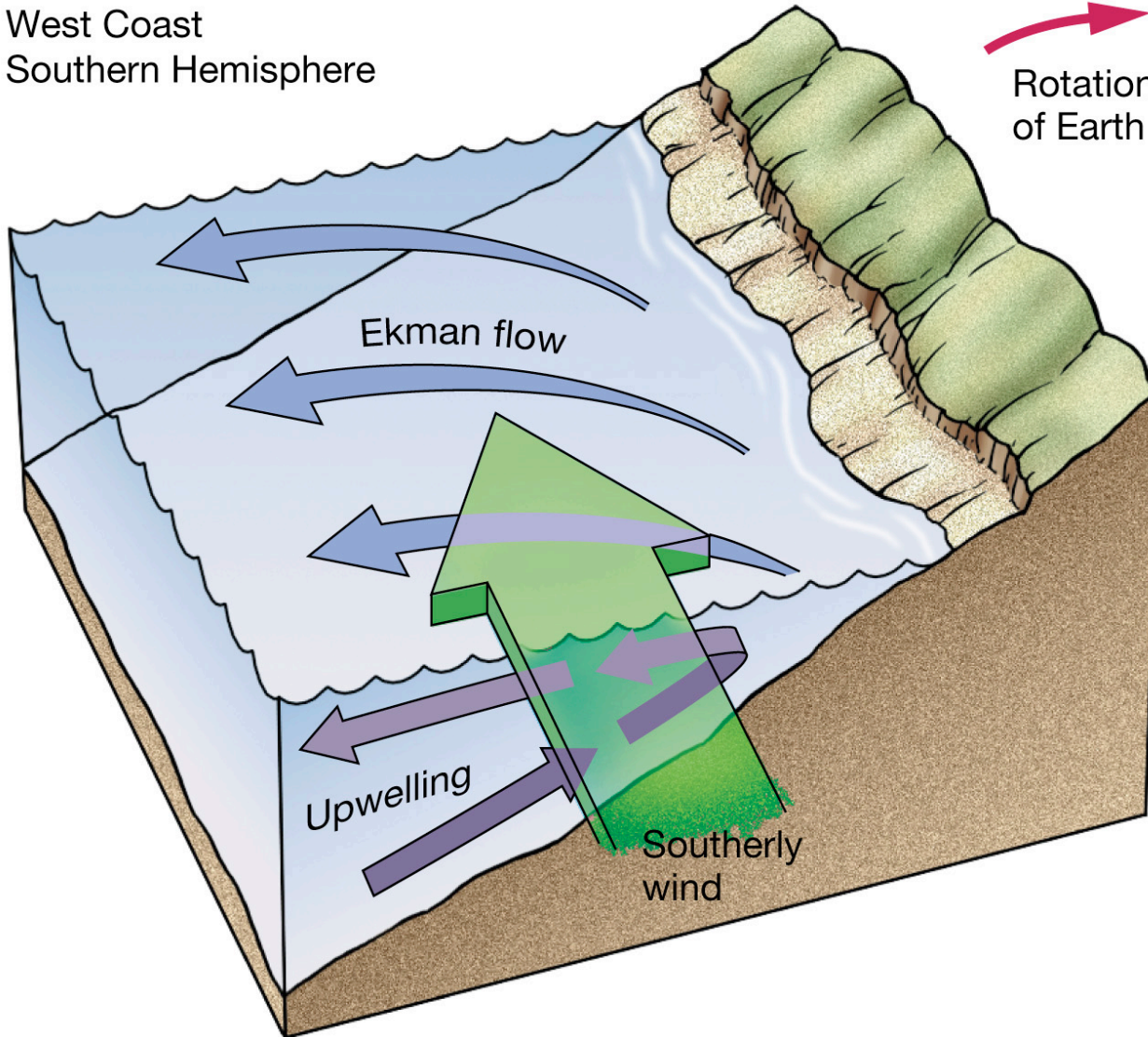
Heat transport by the ocean circulation



Regional circulation: Coastal upwelling

West Coast
Southern Hemisphere

Rotation of Earth



Equatorial upwelling

