

# **ATOC 1060-002**

## **OUR CHANGING ENVIRONMENT**

### **Class 15 (Chp 5)**

#### **Objectives of Today's Class:**

- 1. Surface winds and ocean circulation;**
- 2. Ocean circulation and sea surface temperature (SST);**
- 3. Observed western boundary currents.**

# 1. Ocean Circulation

## Observations

**Tropical Atmosphere  
Ocean Array (TAO):  
Western Pacific**

**Moorings**

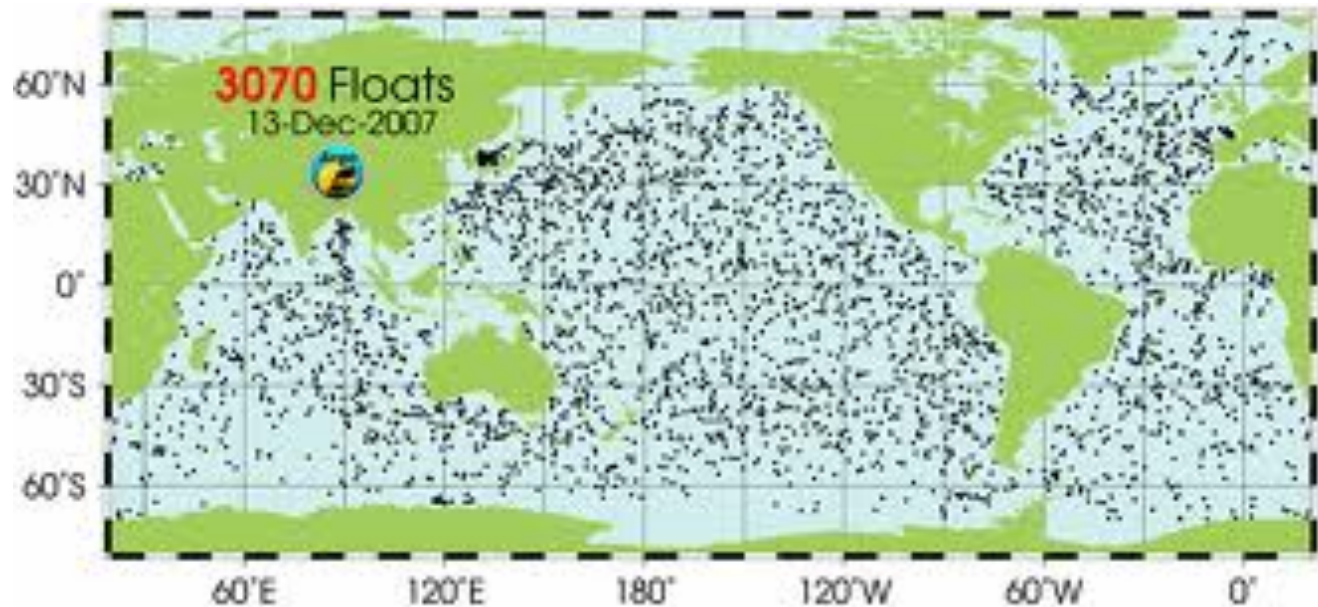
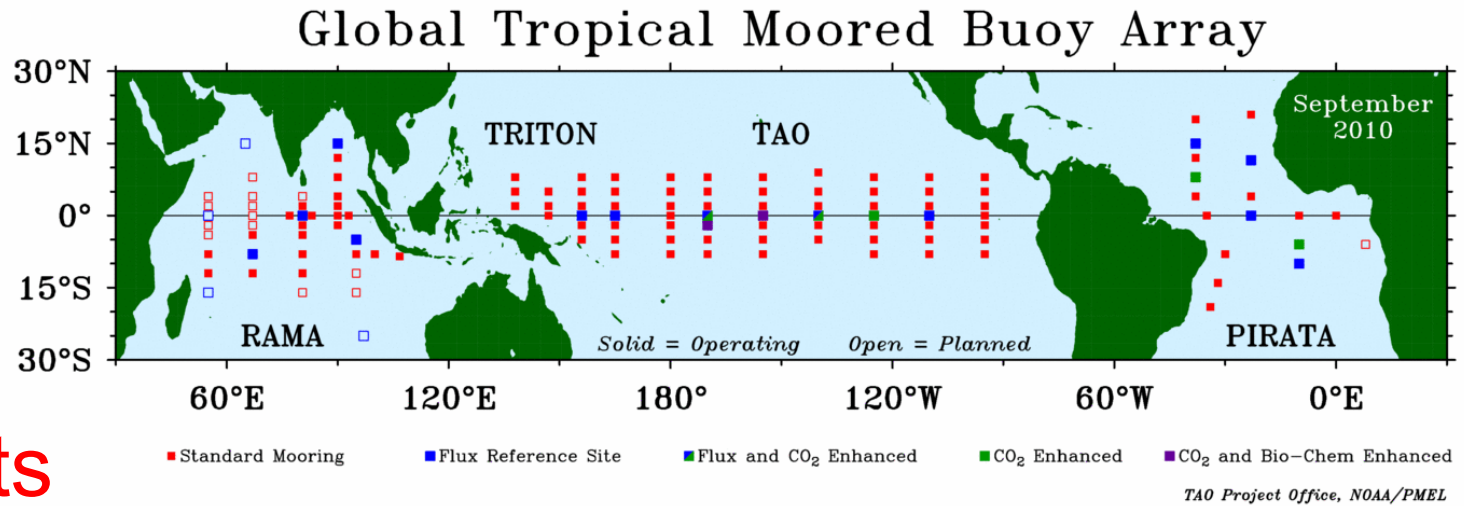
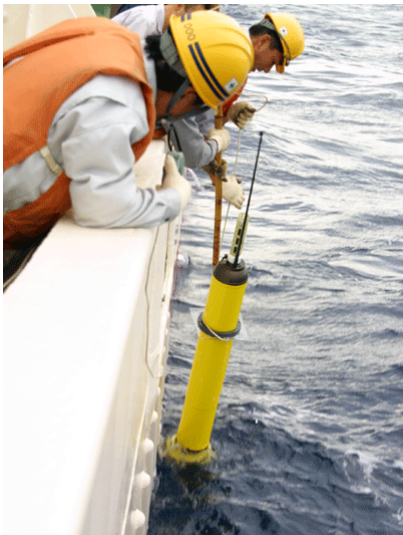


Figure 1

# Ocean observations at present

Moorings  
data

Argo floats  
data





**Cruises:** Atlantic: Measuring Cross-Equatorial Western boundary flow  
boundary flow **CTD bottle: C-conductivity (measure salinity);  
T-temperature; D-depth.**



Figure 2

# Surface winds and currents

Solar heating:  
 Atmosphere circulation-  
 Oceanic circulation

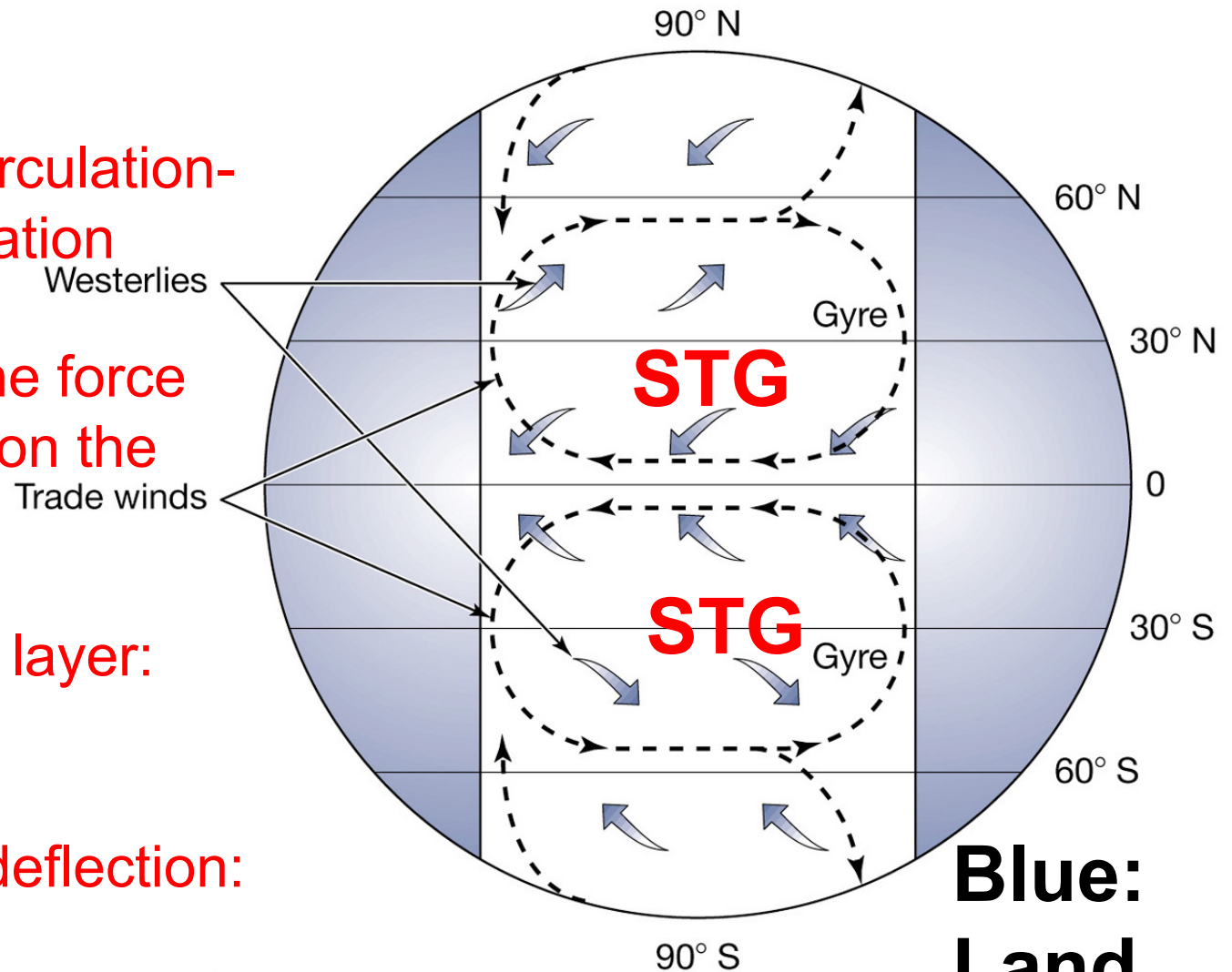
Wind stress: the force  
 of wind acting on the  
 surface

Surface mixed layer:  
 50m~100m

Coriolis force deflection:  
 20-40°

Why not 90° ?

**STG: SubTropical Gyre**



← - - - - Ocean currents

← ← ← Winds

**Blue:  
 Land  
 mass**

Fig. 5-1

# Observed surface circulation and major currents

North Indian Ocean: Monsoon; mean winds weak

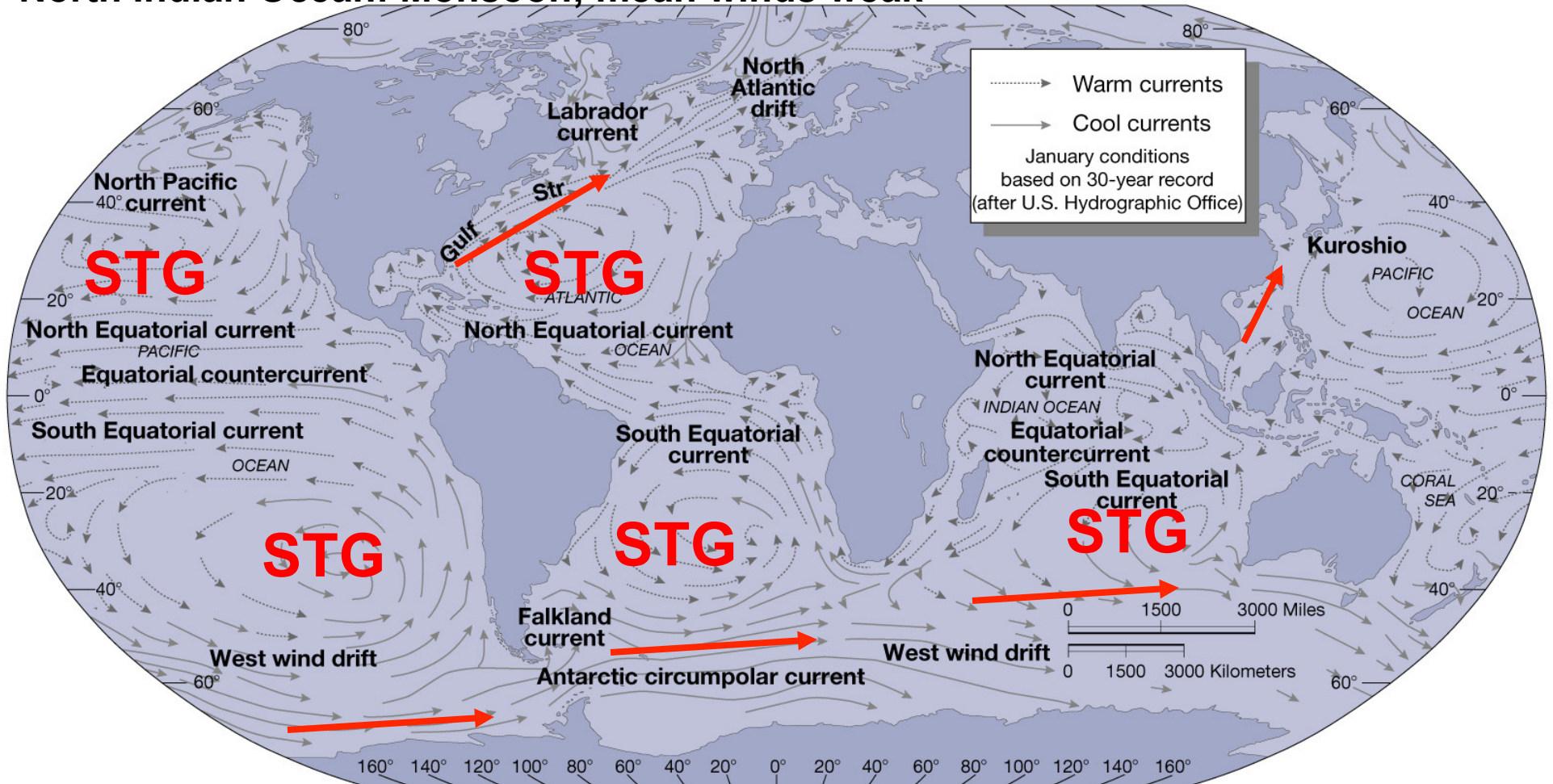


Fig. 5-2

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# How is the STG formed?

a) Ekman convergence; b) Geostrophic component.

**Observations: Norwegian explorer Nansen -  
ship+ice drift at 20-40°angle with  
the winds;**

**Swedish physicist: Ekman - connect the  
wind-driven currents with Earth's rotation -  
mathematical explanation for Nansen's observation.**

# Ekman spiral

**Coupled layers:**

**Friction drag=>**

**Energy**

**Dissipated=>**

**slower motion  
below;**

**Coriolis effect:**

**deflection=>**

**Ekman spiral**

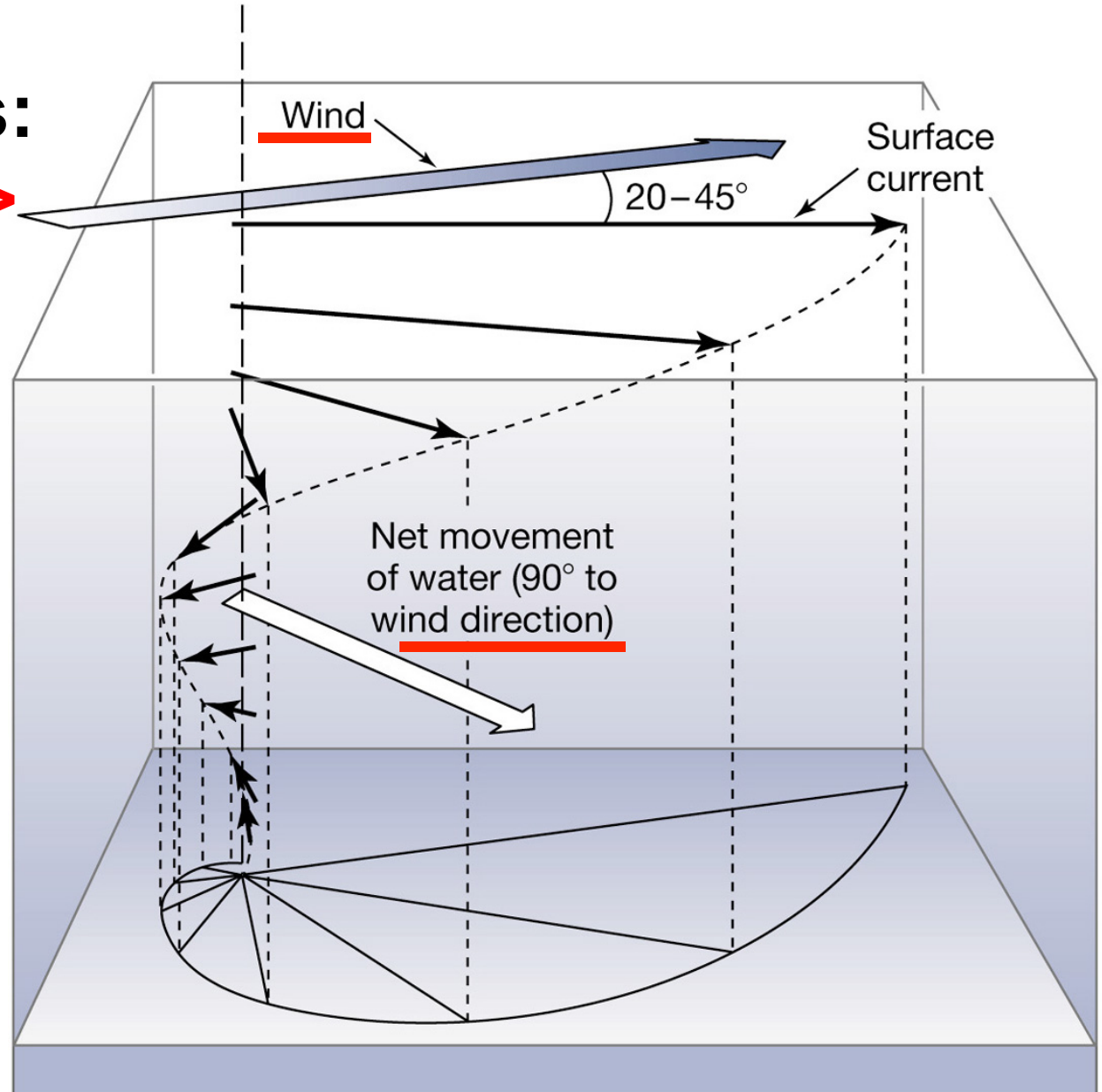


Figure 5-3a

(a)



# Ekman's theory

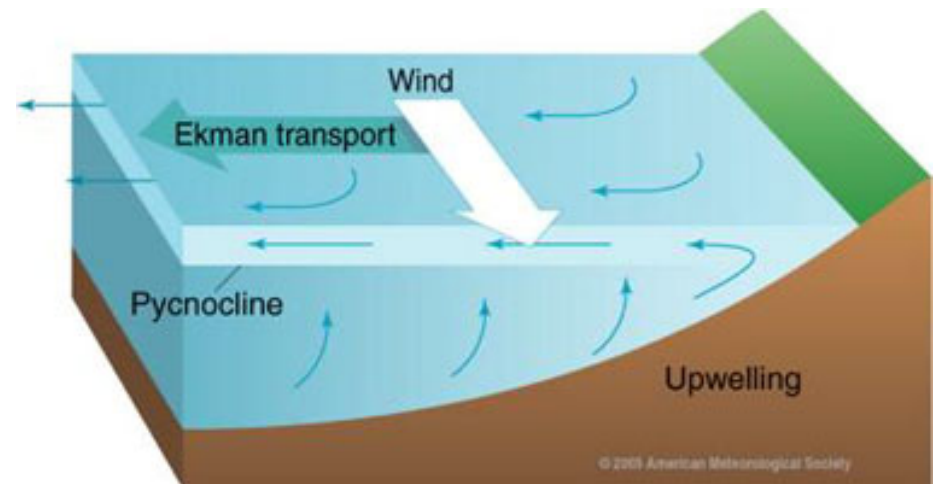
**Reality: Ekman spiral difficult to observe due to turbulence (Ekman spiral assumes laminar, organized flow);**

**we do observe surface currents are in about 45° angle or less**

# Ekman transport

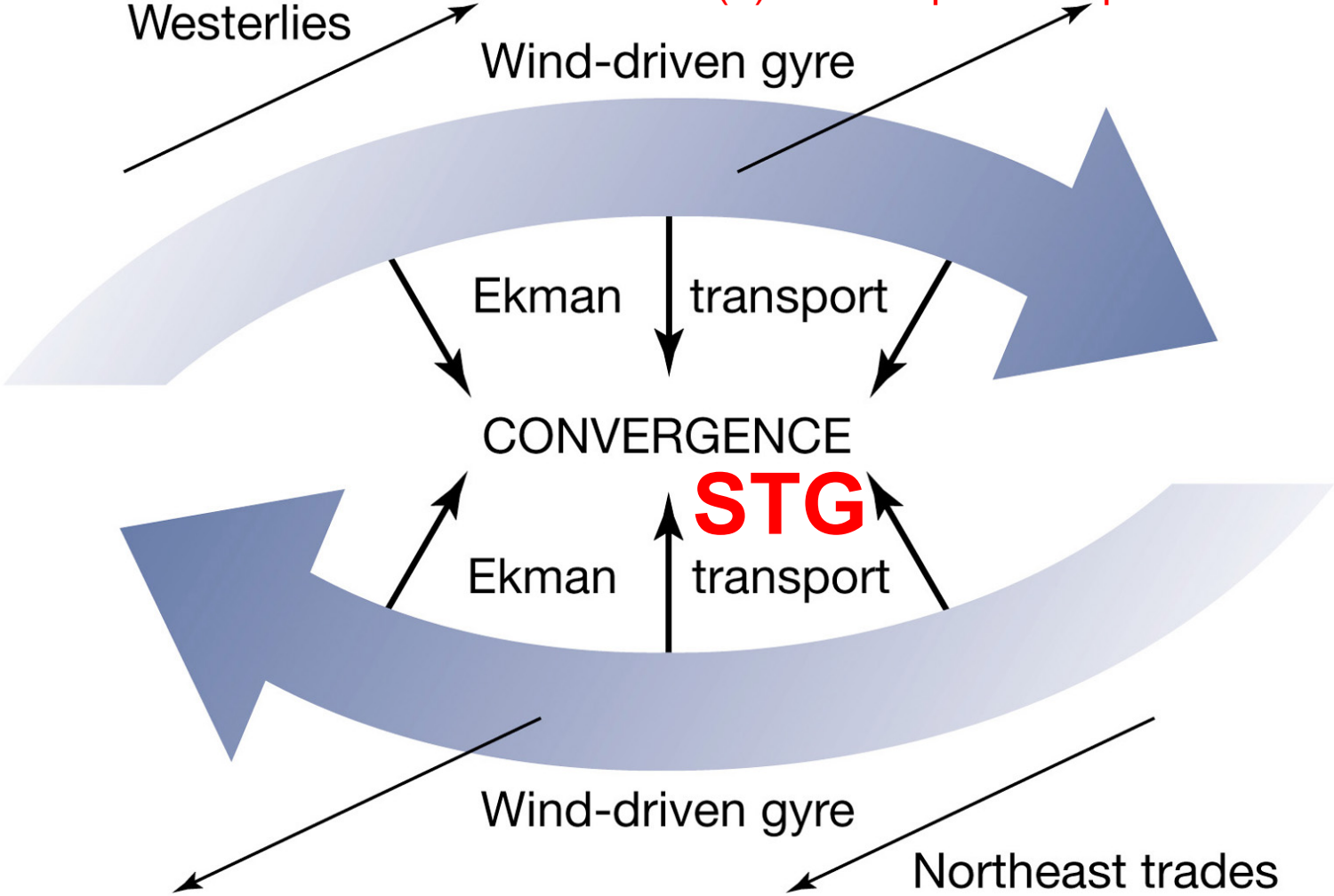
**Ekman transport** - the net movement of water in the entire layer - is at the right angle ( $90^\circ$ ) to the wind direction. Northern Hemisphere to the right and southern Hemisphere to the left.

When add up all layers in the spiral, the net direction of transport within the water column is at right angle to the wind direction.



Northern Hemisphere

Formation of the STG: (a) Surface Ekman convergence;  
(b) Geostrophic component.



(b)

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Figure 5-3b

# 2. Sea surface temperature (SST)

ANNUAL MEAN

GLOBAL SEA SURFACE TEMPERATURES

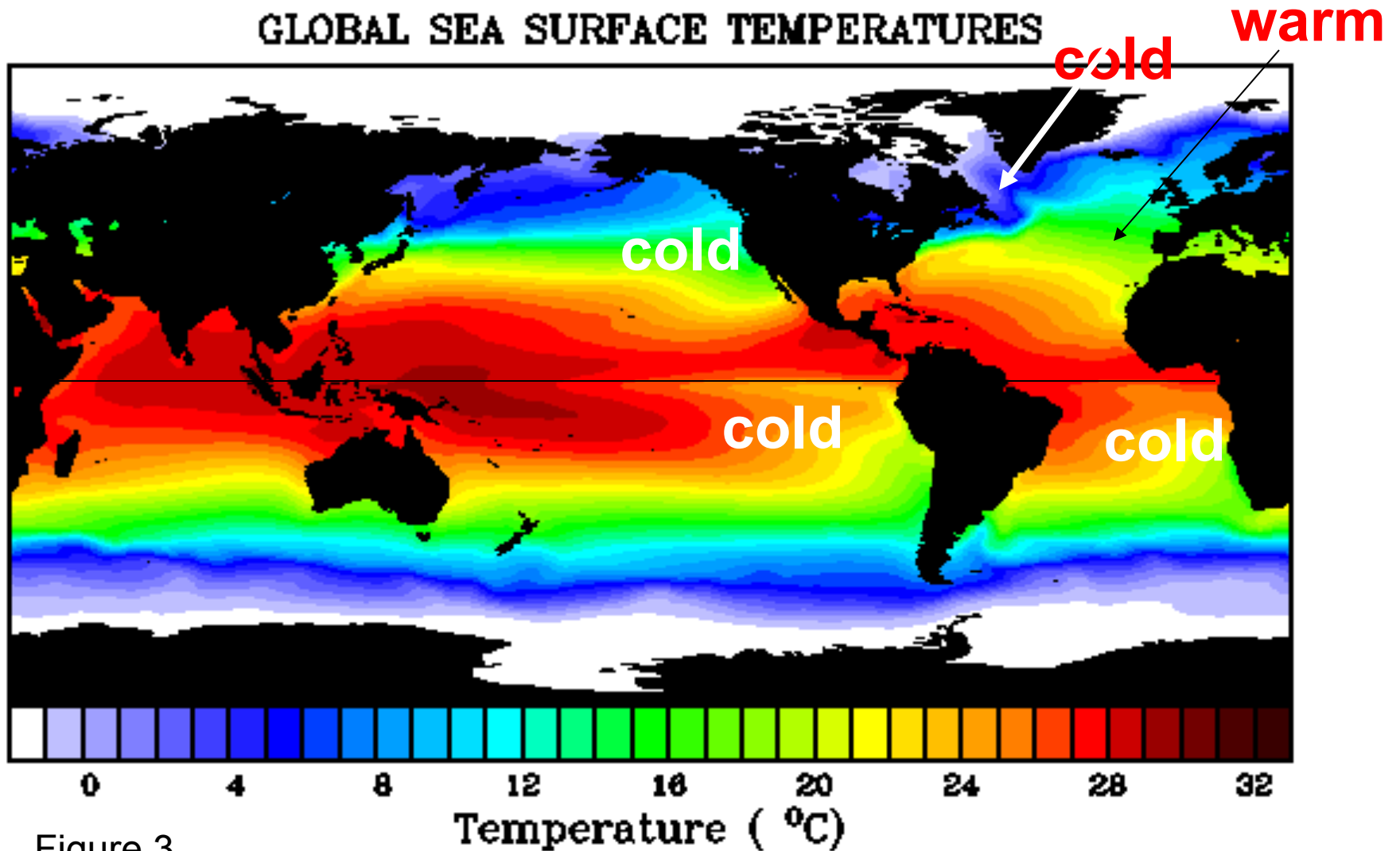
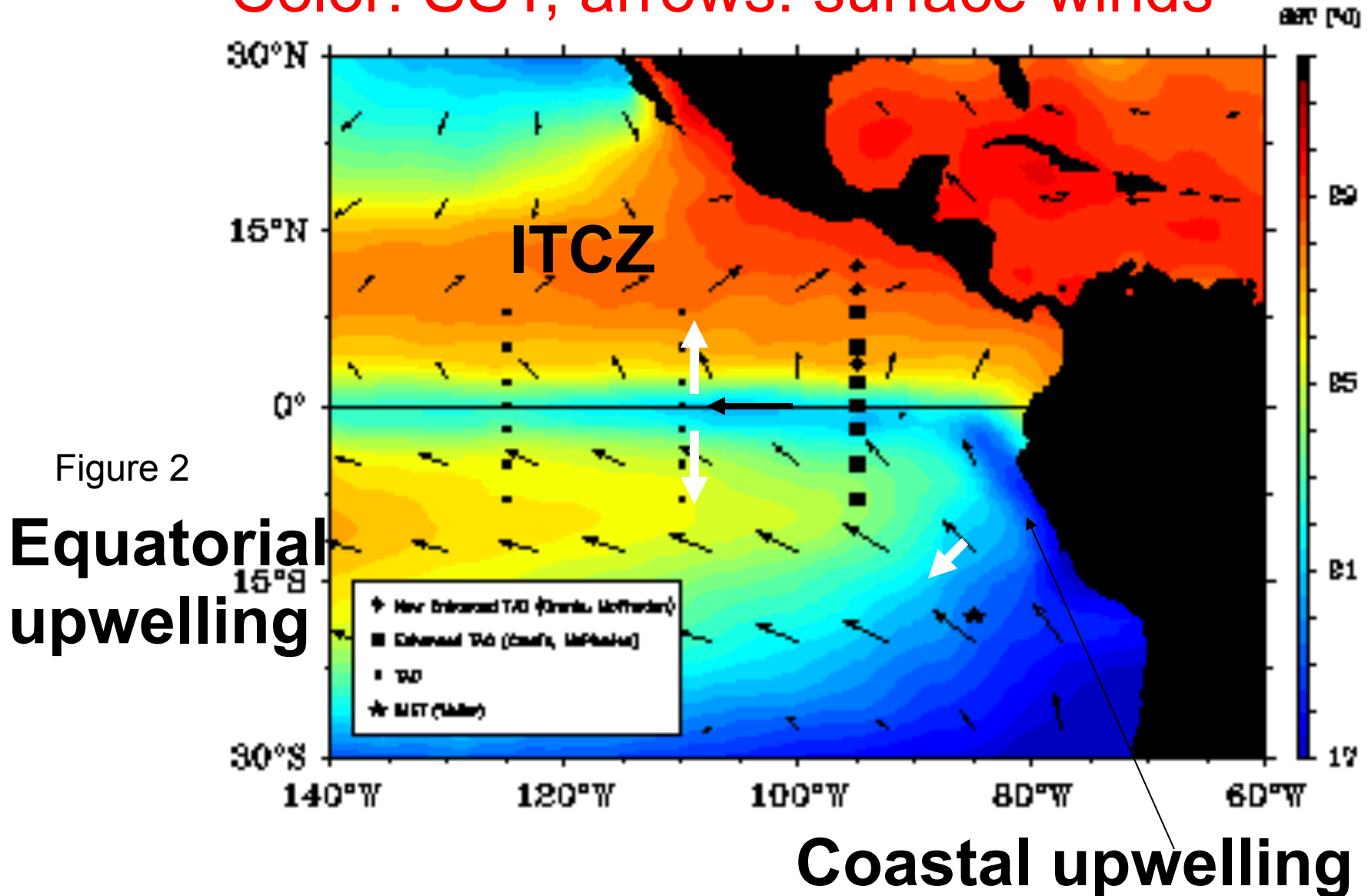


Figure 3



# Observations: Eastern Pacific

Color: SST; arrows: surface winds



# Ekman Divergence: equatorial Pacific or Atlantic

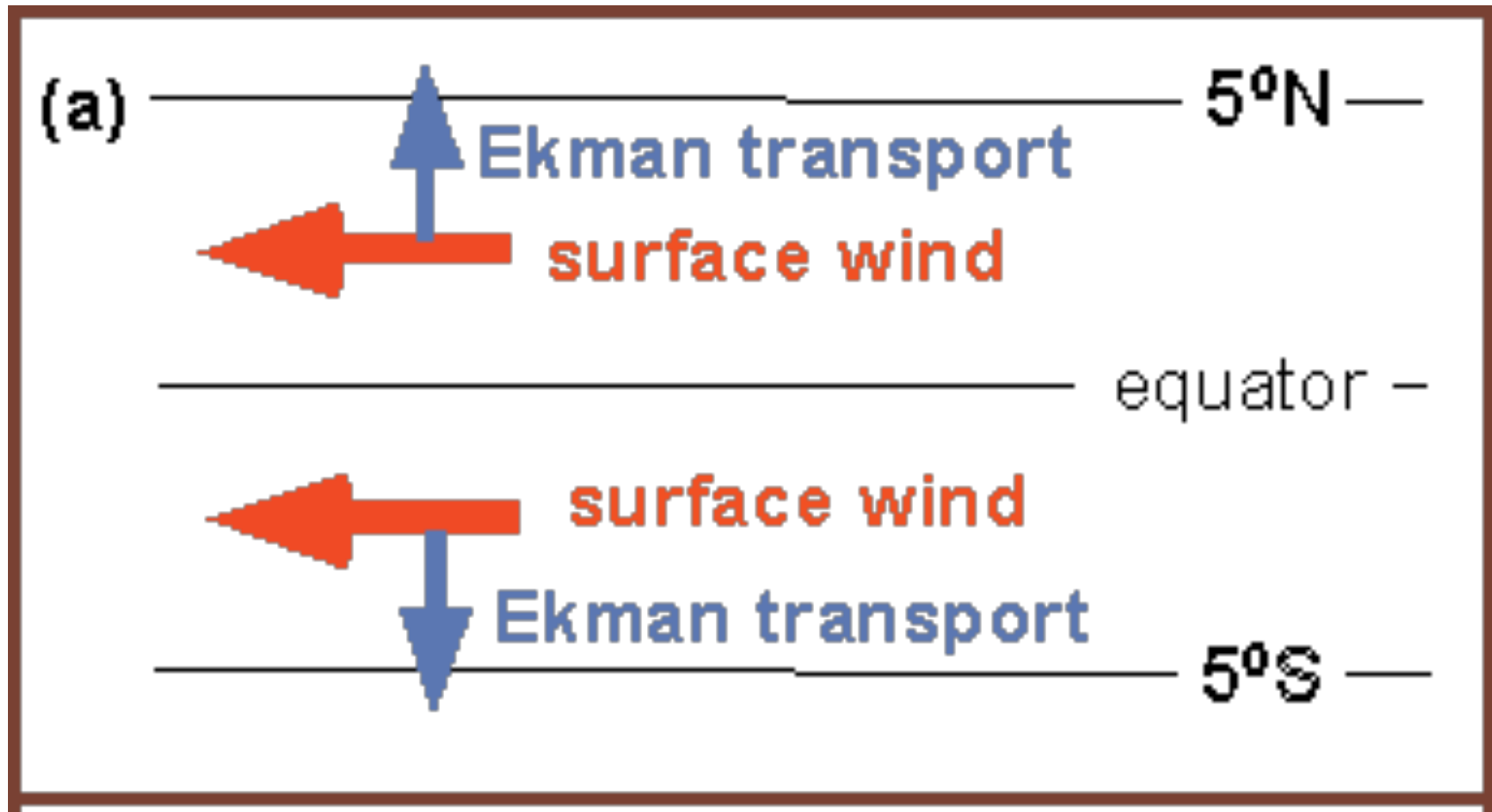
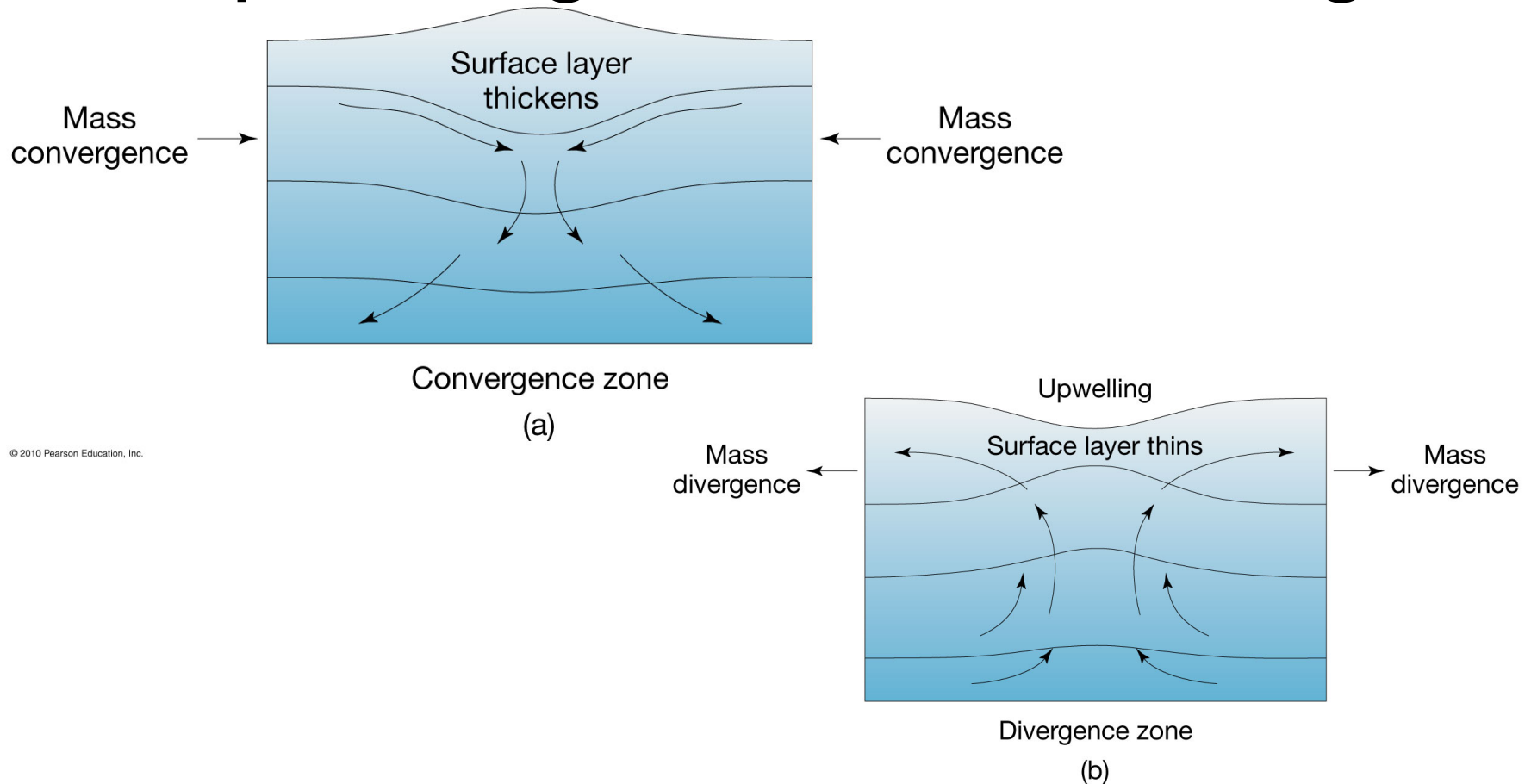


Figure 3

**Surface**

# Upwelling and downwelling



**Upwelling: colder deeper water moves up to the surface; supply nutrients - marine life**

Figure 5-4

# 3. Boundary currents

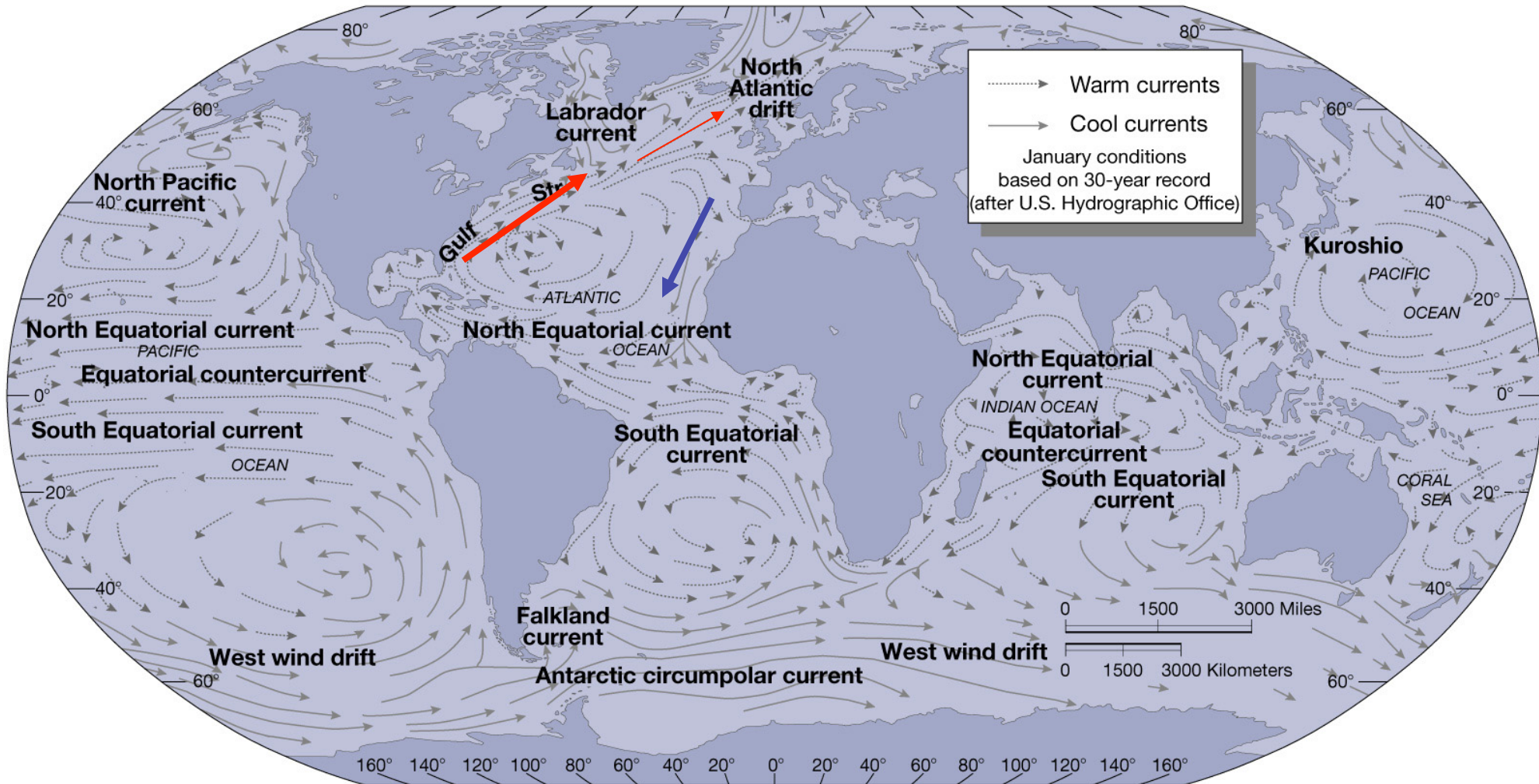


Fig. 5-2

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# North Atlantic: western boundary current

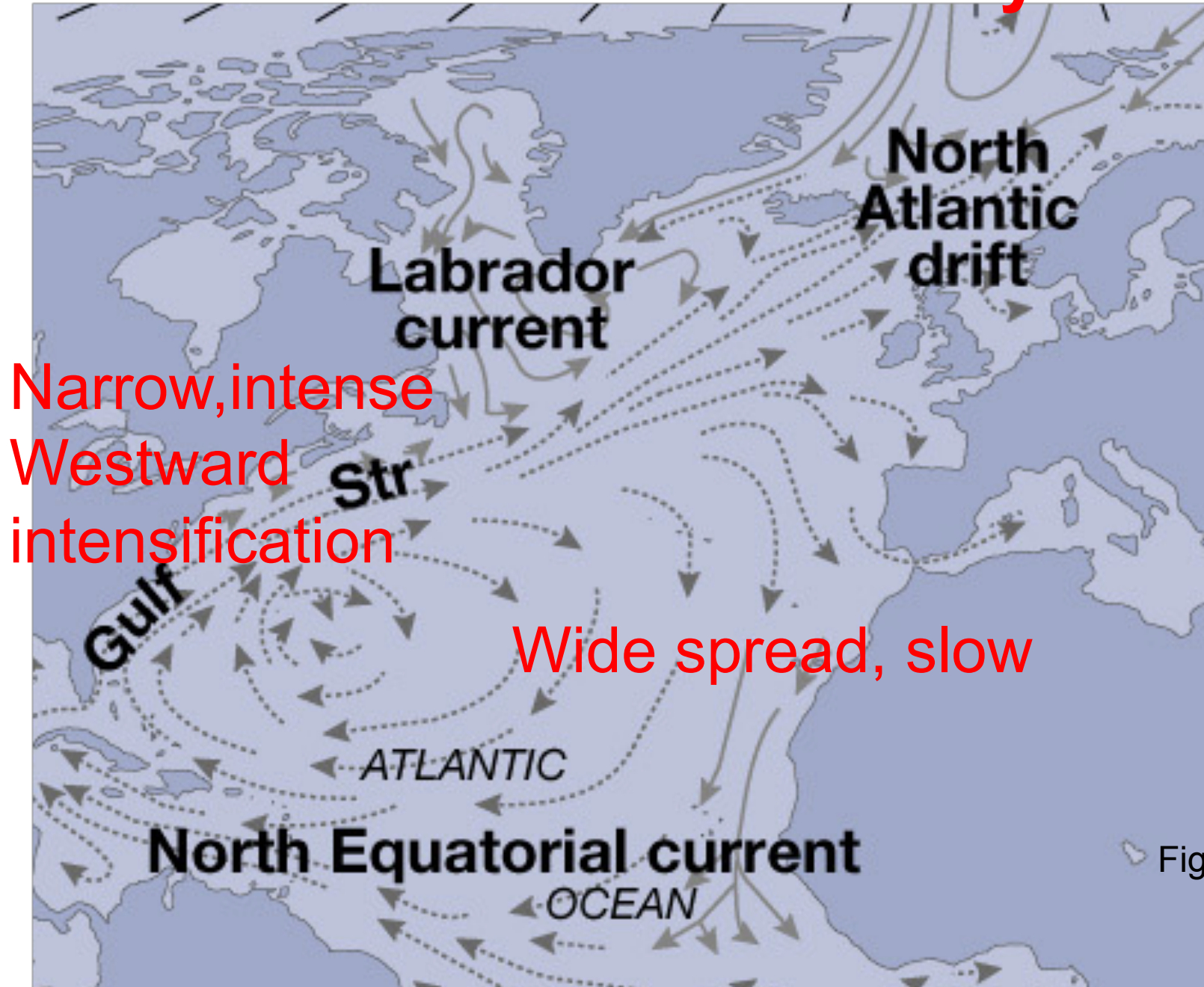


Fig. 5-2

# Westward intensification: western boundary current (WBC)

**a) Asymmetry between east and west:**

**Western boundary: intensification;**

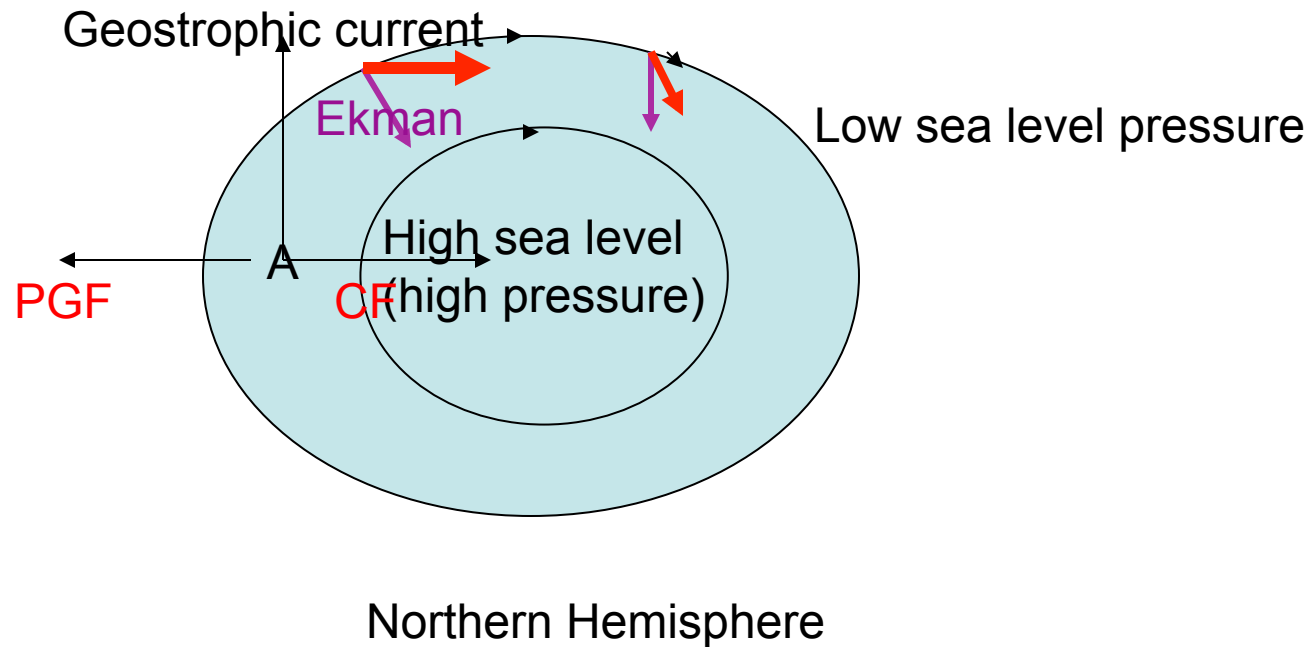
**Gulf stream: 50-75km wide; as fast as 1-2m/s; 1-2km deep;**

**Eastern boundary: 1000km, slow; 500m deep;**

**2) Exist in Atlantic, Pacific, and Indian Oceans;**

**3) Dynamics: due to changes of Coriolis force with latitude - westward propagating Rossby waves.**

# Geostrophic component



Red arrows: Total flow that forms the STG.