PÓS-GRADUAÇÃO Oceanografia
Física Química Geológica

PPGOGQG
TE: Oceanos e Clima

Aula 3 – Circulação Oceânica

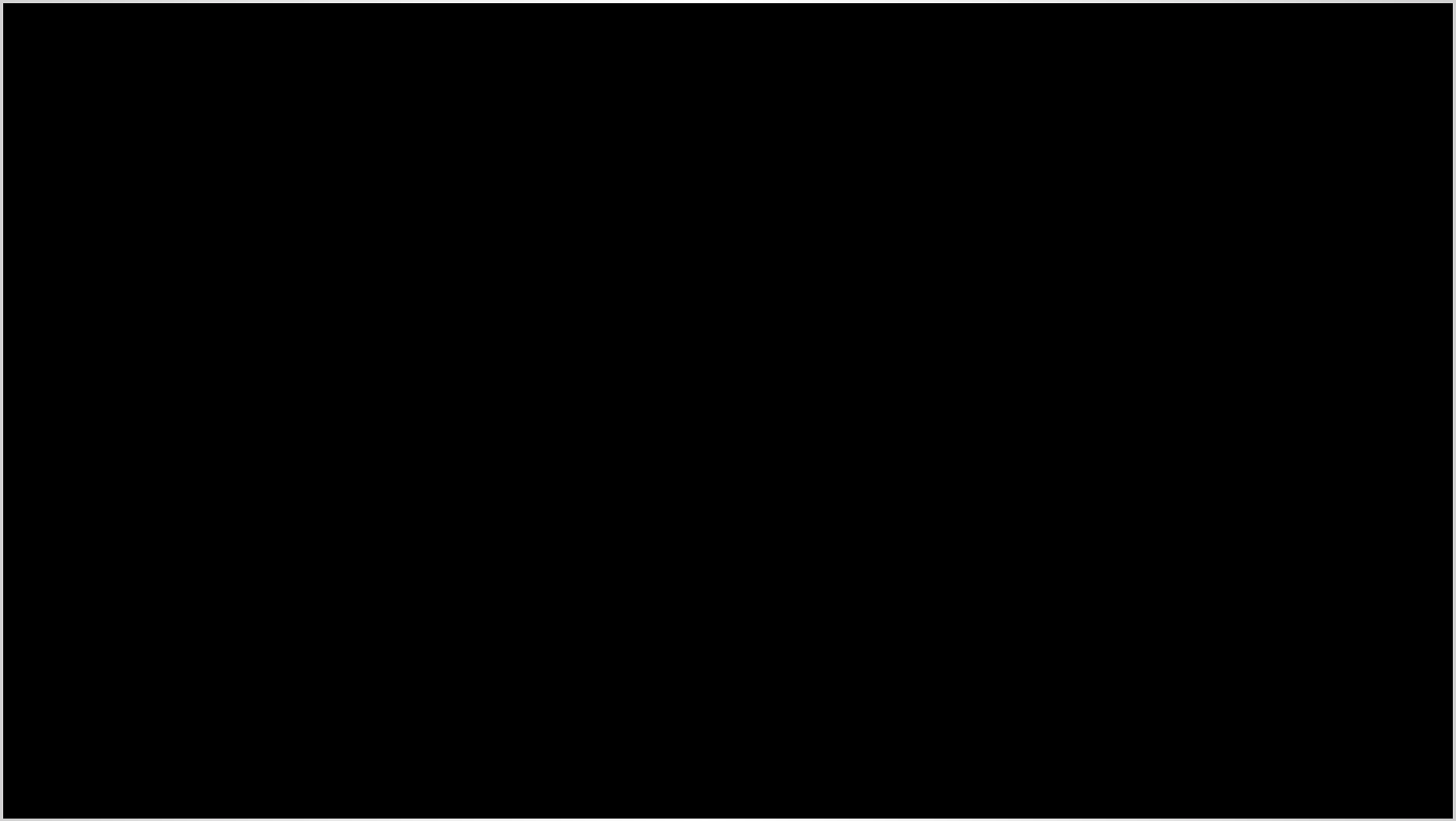
Prof. Dr. ***Mauricio M. Mata***

Laboratório de Estudos dos Oceanos e Clima (LEOC)

1º SEM. 2016
Terça-feira – 14:00/16:00h, sala 2119

FURG

O Oceano em movimento...

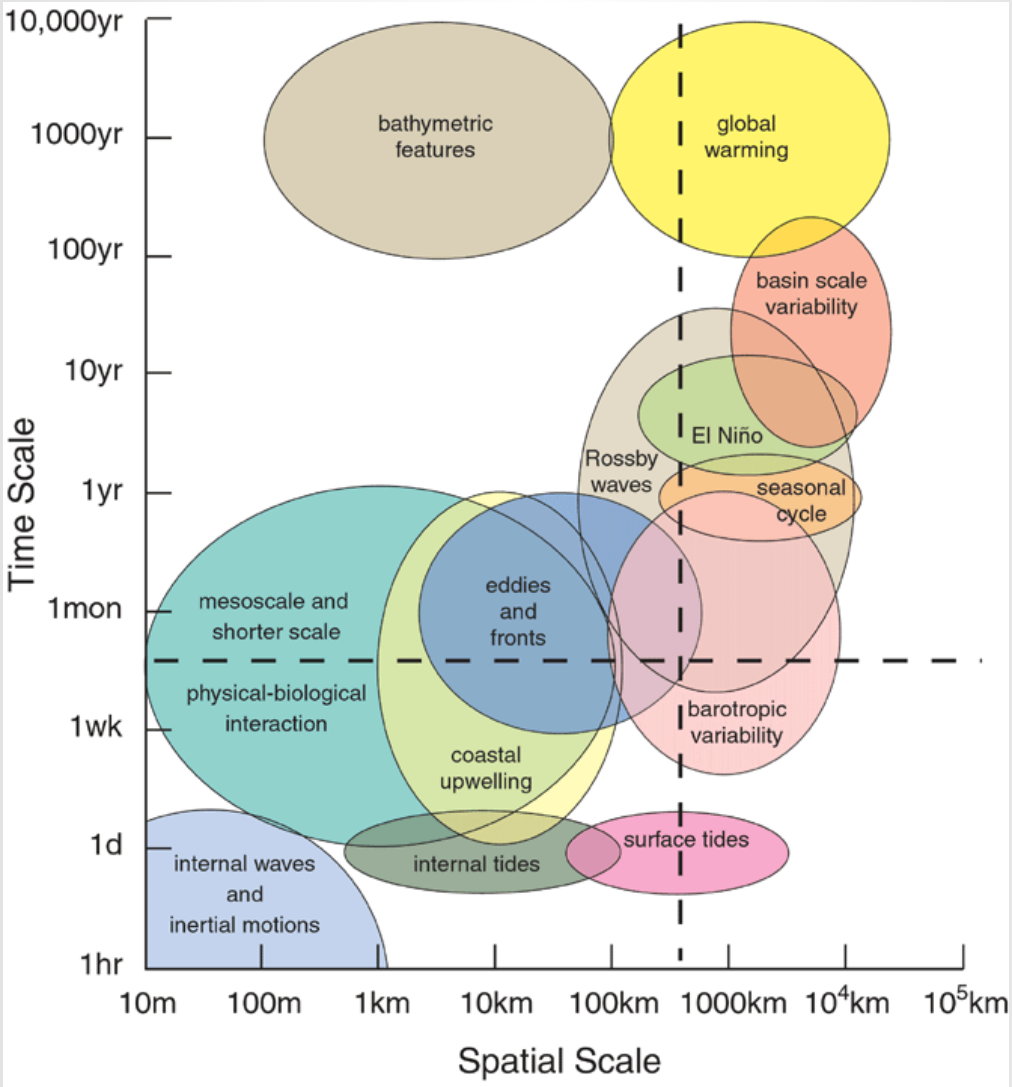


Introdução

- Os primeiros três metros dos oceanos armazenam a mesma quantidade de calor que toda a atmosfera. Este calor é liberado e reabsorvido regularmente em um ciclo do oceano para atmosfera e vice-versa. Conseqüentemente, é fundamental o conhecimento da circulação oceânica para o para que o regime climático dos nosso planeta (e suas mudanças) possa ser compreendido em escalas temporais da ordem de décadas. Em escalas menores, padrões atípicos na taxa e tamanho desta interação oceano-atmosfera pode causar eventos meteorológicos extremos (furacões, enchentes, secas, etc).

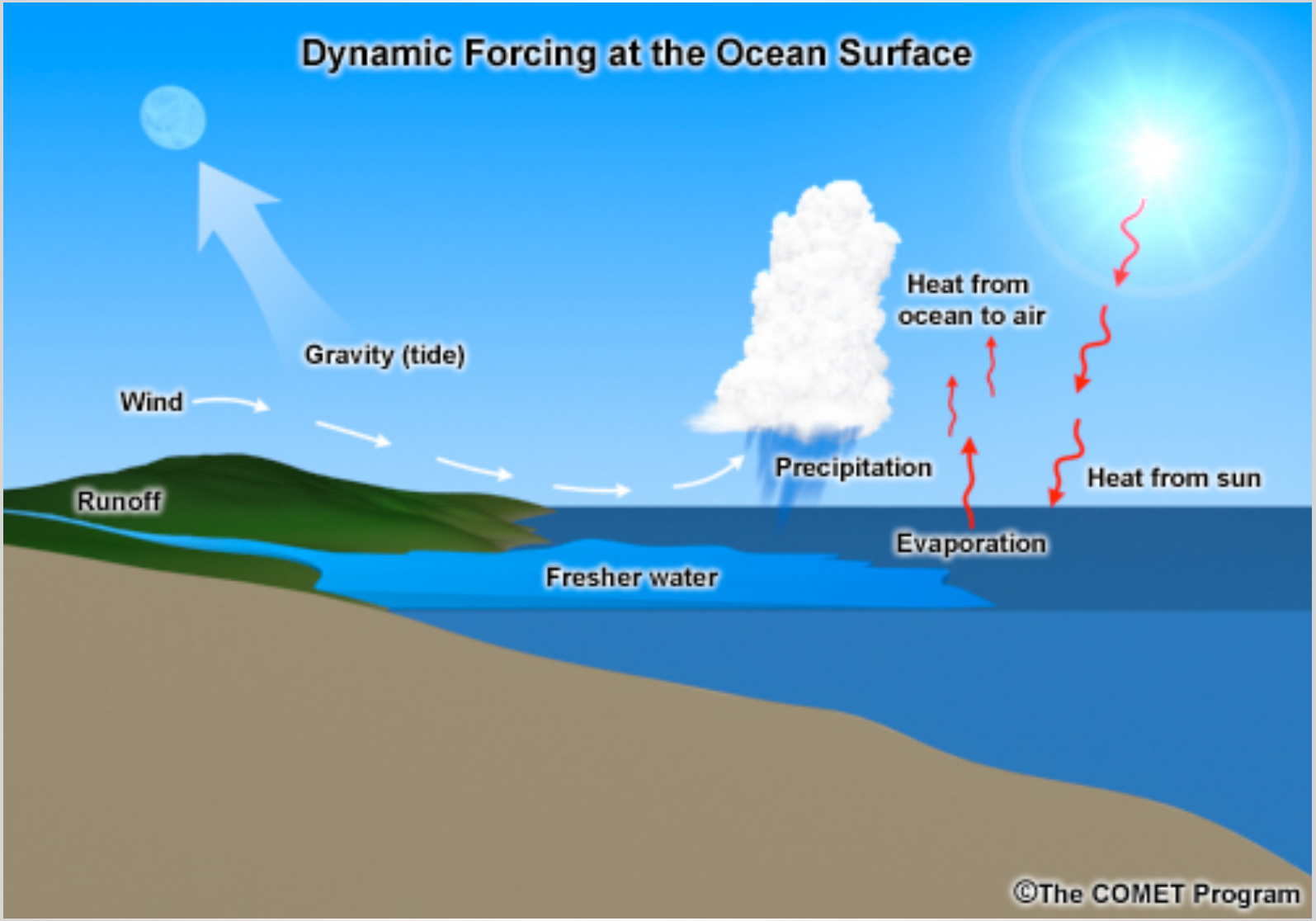
Figure 13.1 The oceanic conveyor belt carying heatnorthward into the North Atlantic. Note that this is a cartoon, and it does not accurately describe the ocean's circulation. (from Broecker and Peng, 1982).

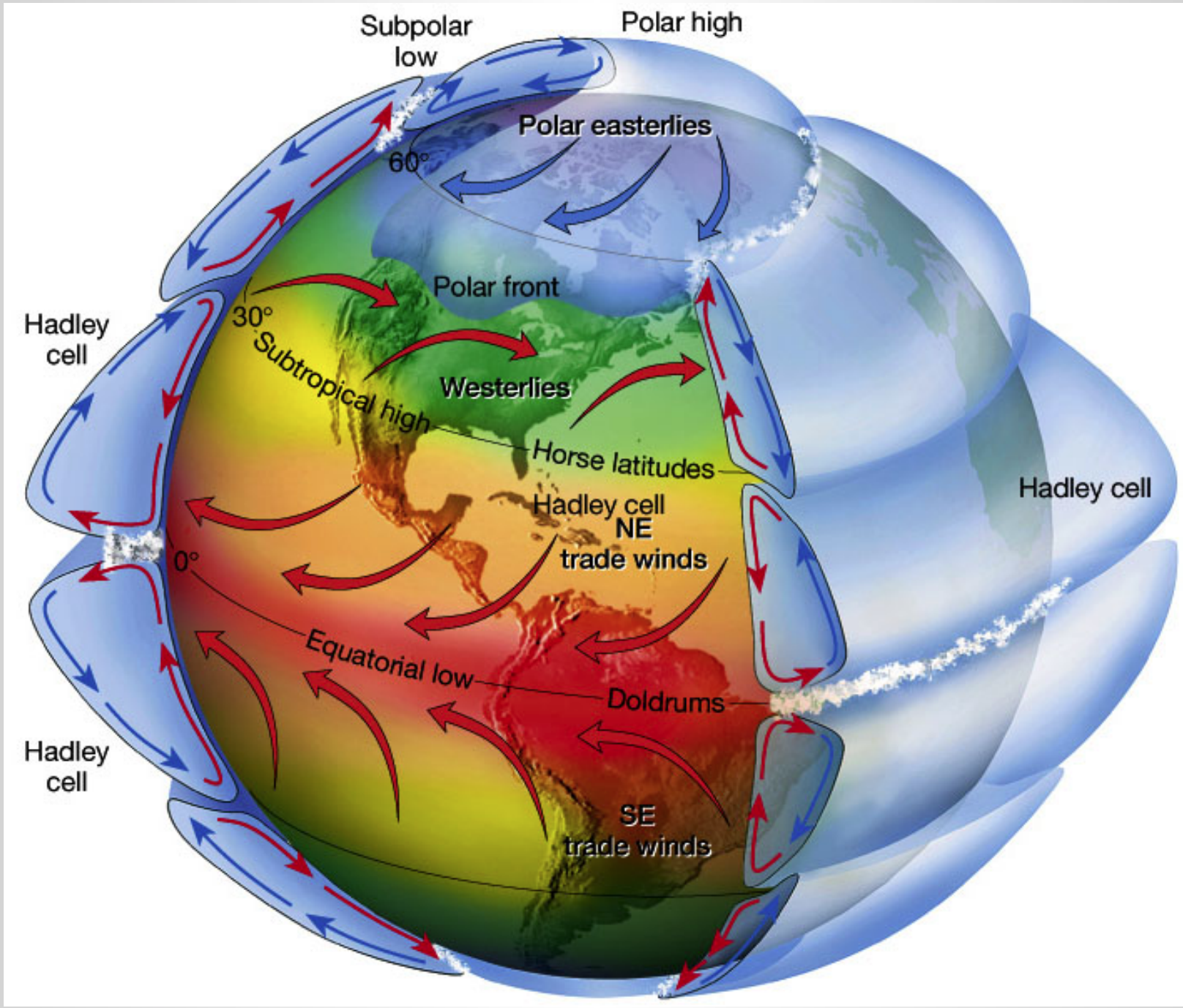
Escalas x Movimentos Oceânicos



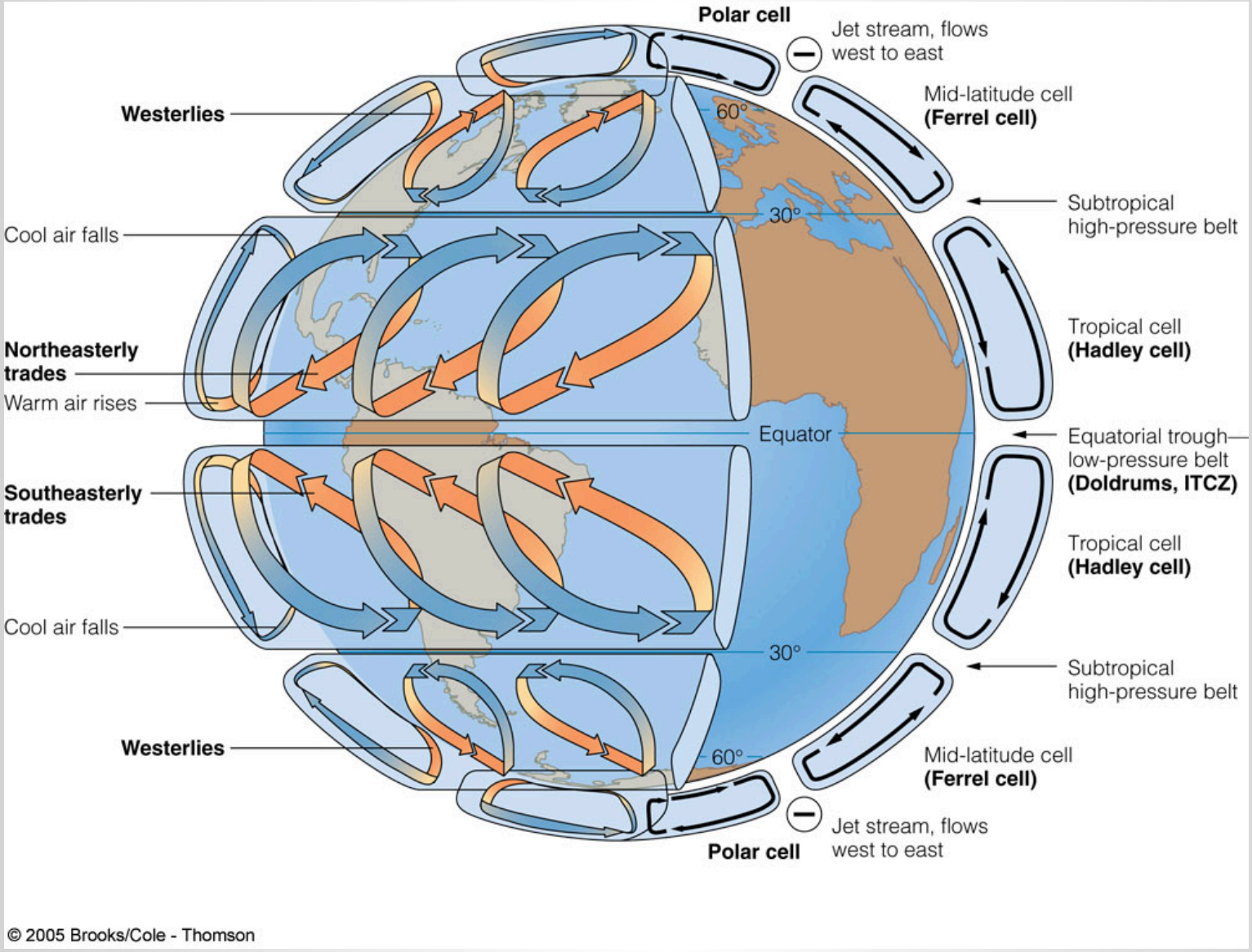
Forças que atuam nos oceanos

- PRIMÁRIAS
- Cisalhamento do Vento (wind stress)
- Gradiente de Pressão / Densidade
- Gravidade
- SECUNDÁRIAS
- Coriolis
- Atrito / Fricção

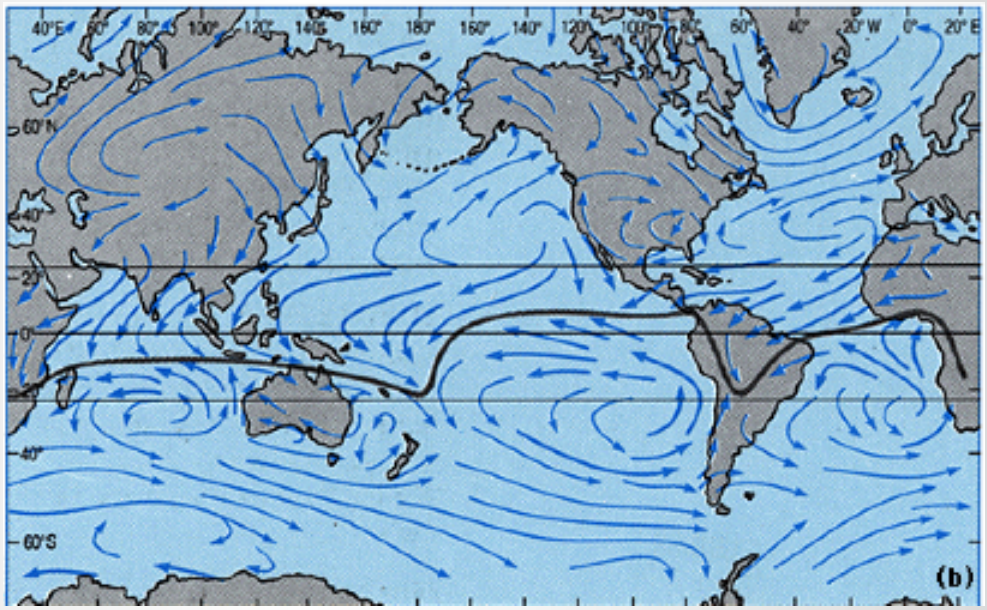

Dynamic Forcing at the Ocean Surface
Heat from ocean to air
Gravity (tide)
Wind
Precipitation
Heat from sun
Runoff
Evaporation
Fresher water
©The COMET Program


Subpolar low
Polar high
Polar easterlies
60°
Polar front
Hadley cell
30°
Subtropical high
Westerlies
Horse latitudes
Hadley cell
NE trade winds
Hadley cell
0°
Equatorial low
Doldrums
Hadley cell
SE trade winds

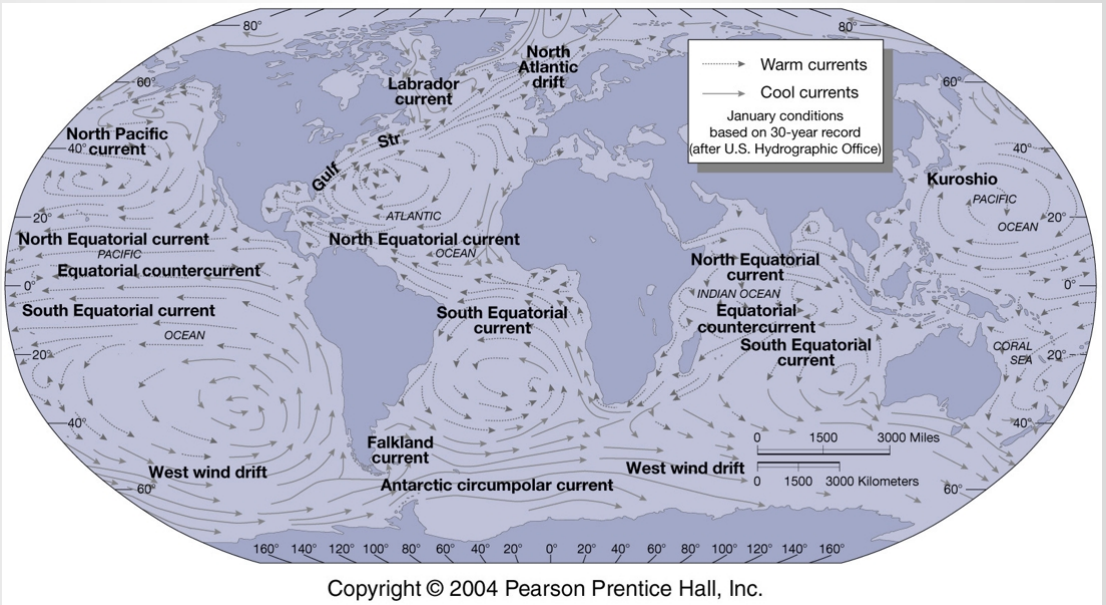
Circulação Atmosférica



Padrão superficial de ventos - Janeiro



Correntes Oceânicas Superficiais



Giros Oceânicos

- Giros Subtropicais
  - Centrados aprox. 30º N / S
- Sistema Equatorial de Correntes
- Corrente de Contorno Oeste
- Correntes Oceânicas em Latitudes Médias
- Correntes de Contorno Leste

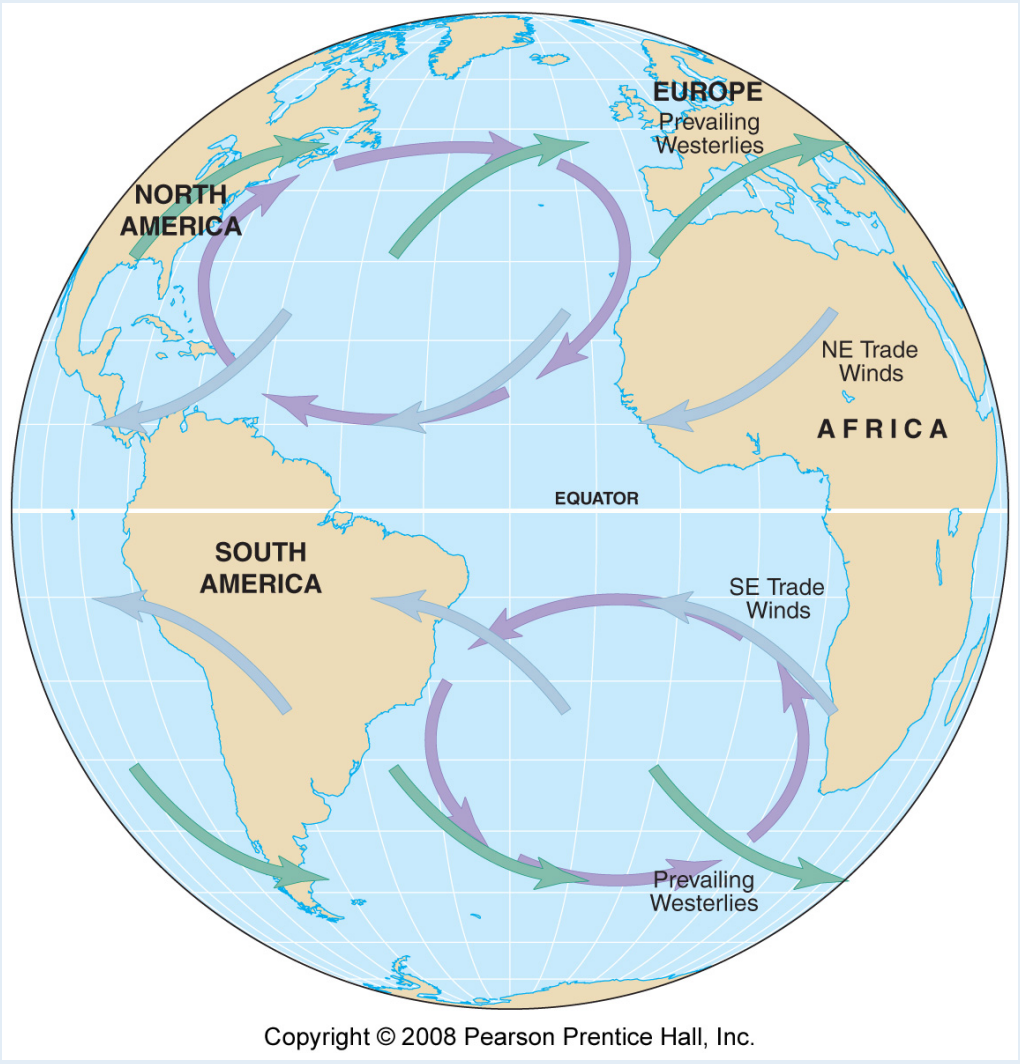
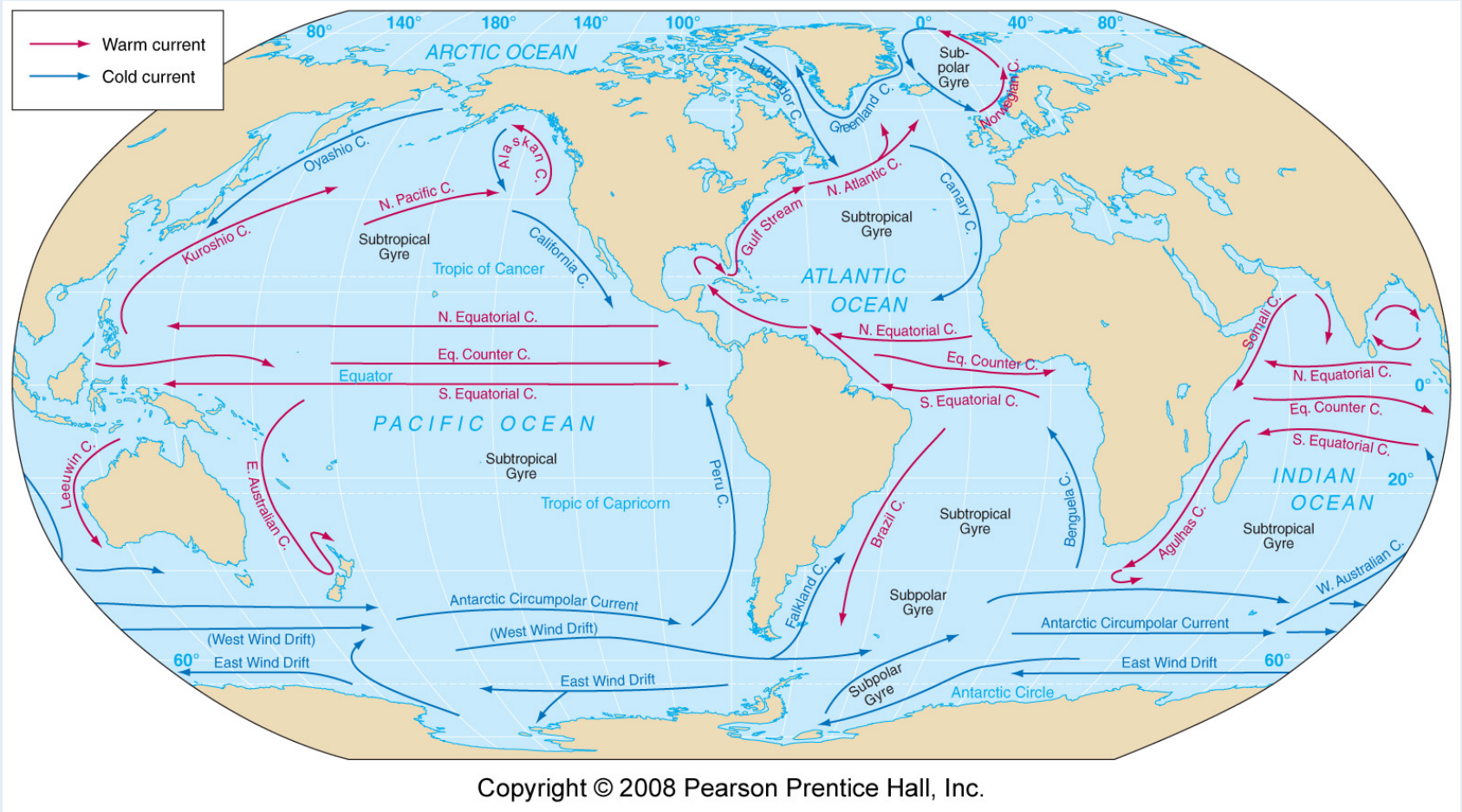


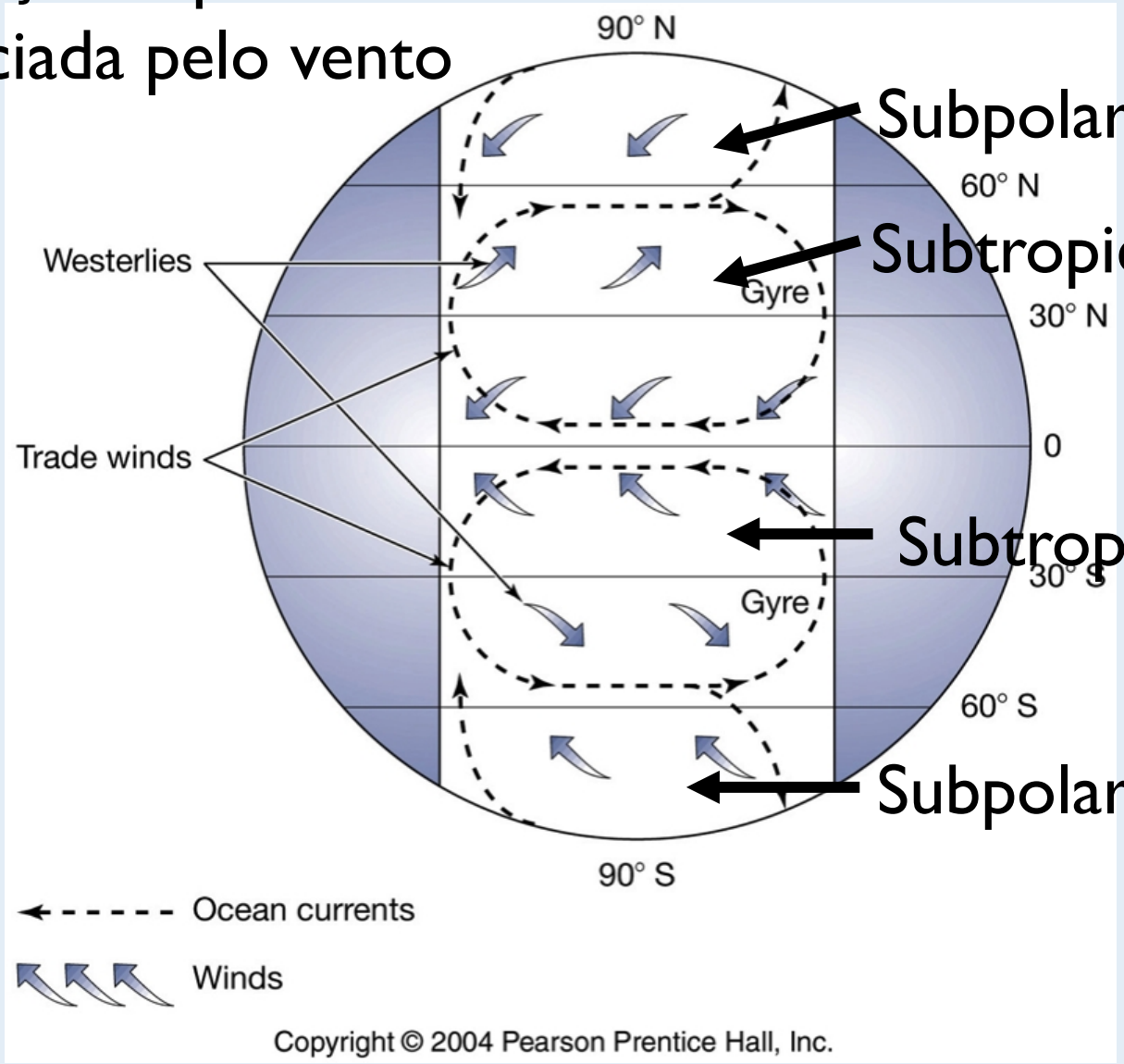
Fig. 7.4

Outras Correntes de Superfície

- Contra-Correntes Equatoriais
- Giros Subpolares



Esquema simplificado da Circulação superficial influenciada pelo vento

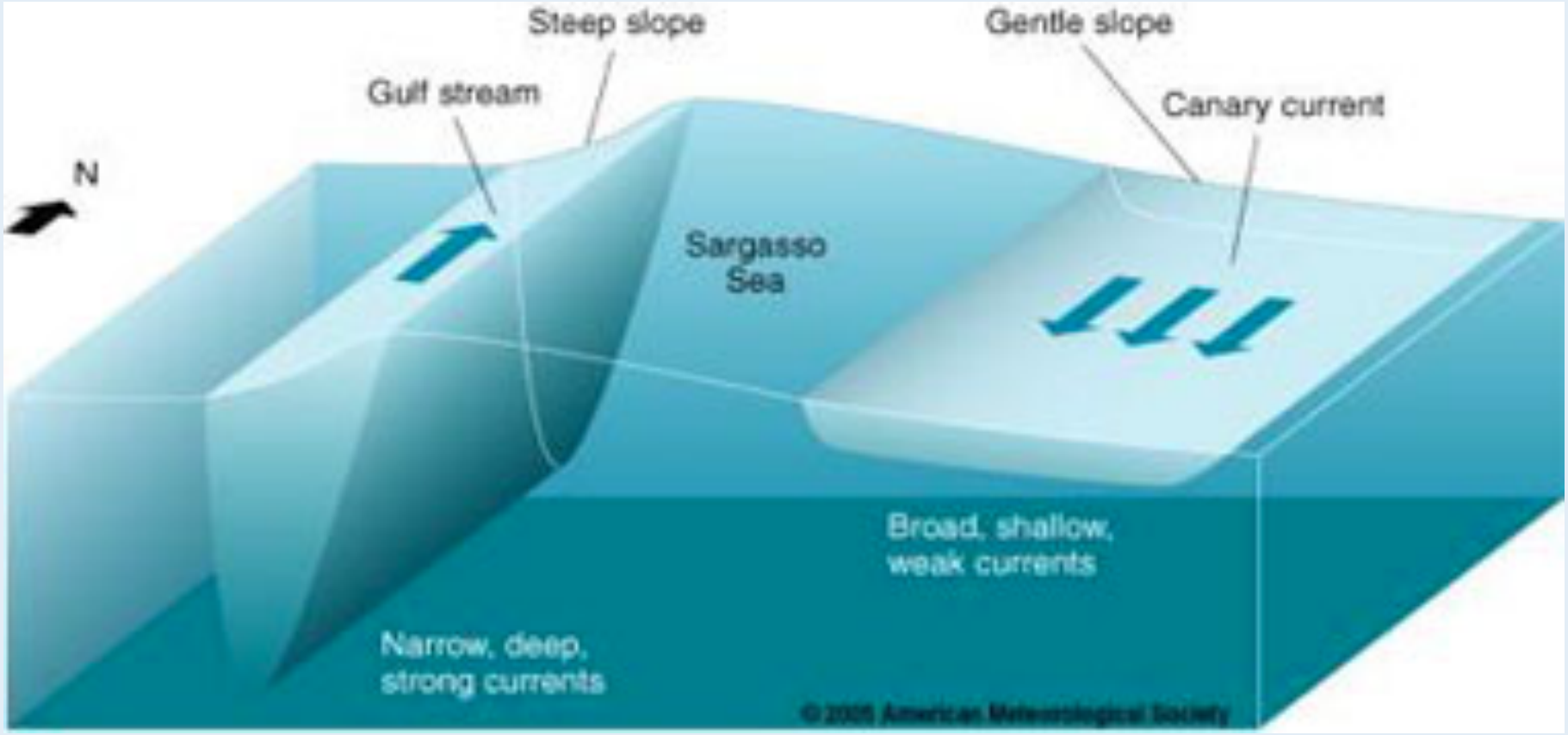


Intensificação das Correntes de Contorno Oeste

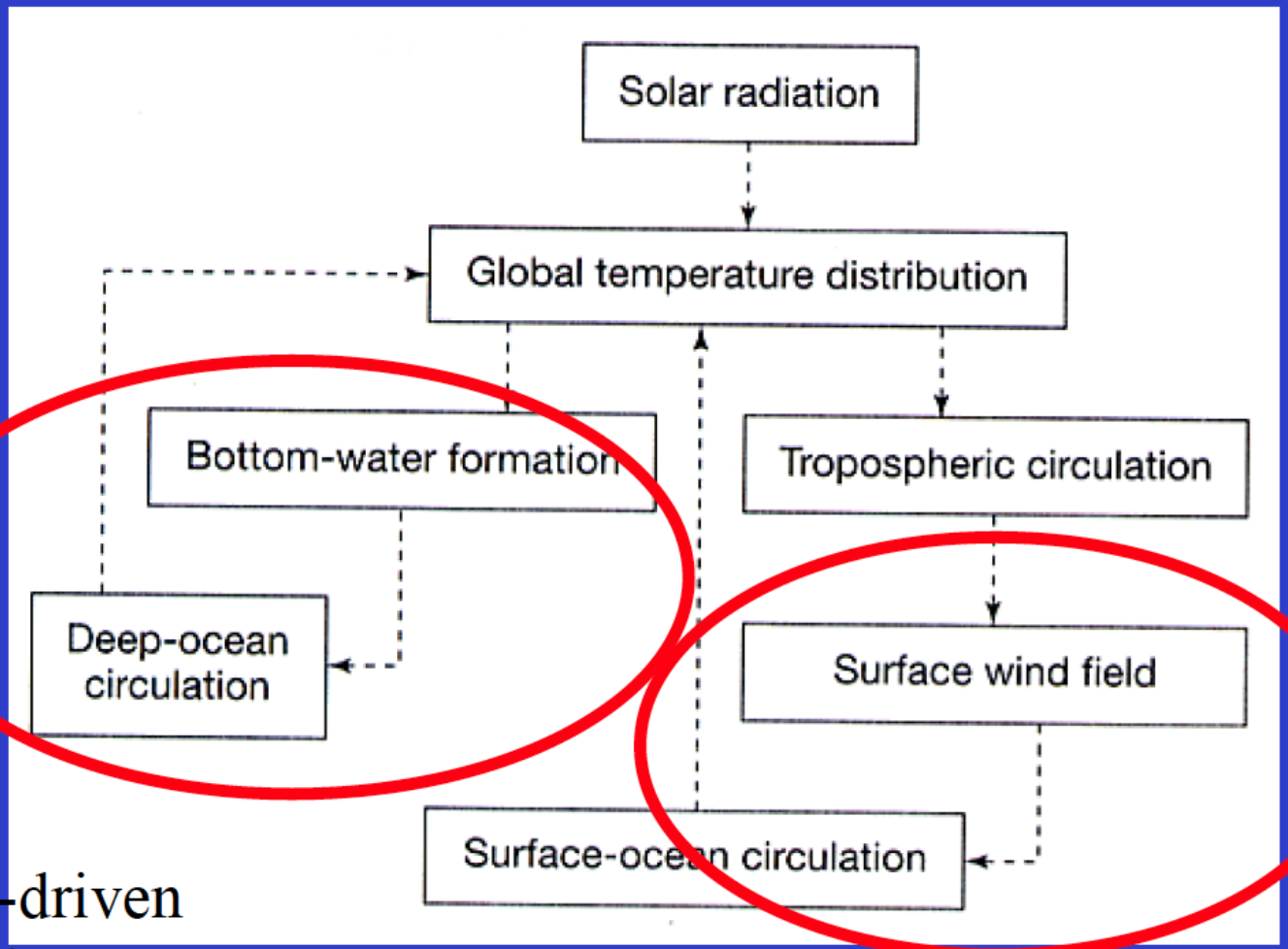
- Centro dos Giros Subtropicais deslocado para OESTE devido à influência da rotação da Terra;
- Como consequência as CCOeste são intensificadas:
  - Mais velozes;
  - Mais estreitas
  - Mais profundas
  - Mais quentes

Correntes de Contorno Leste

- Lado oriental das bacias oceânicas (com propriedades opostas as CCOs):
  - Frias
  - Mais lentas
  - Mais rasas
  - Mais largas


Steep slope
Gentle slope
Gulf stream
Canary current
N
Sargasso
Sea
Broad, shallow,
weak currents
Narrow, deep,
strong currents
© 2005 American Meteorological Society

Two Circulation Systems

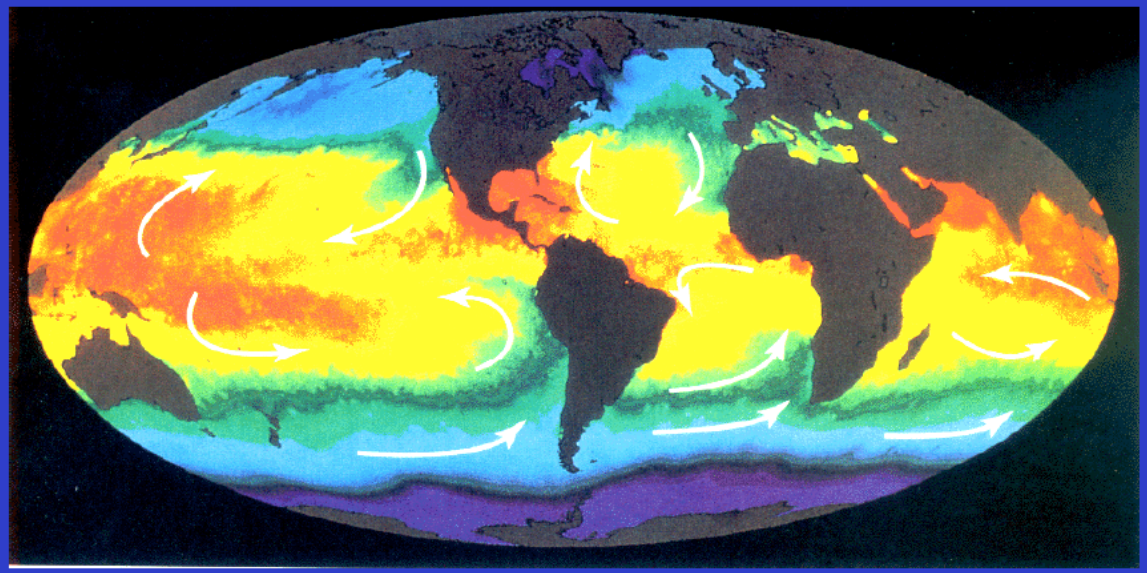


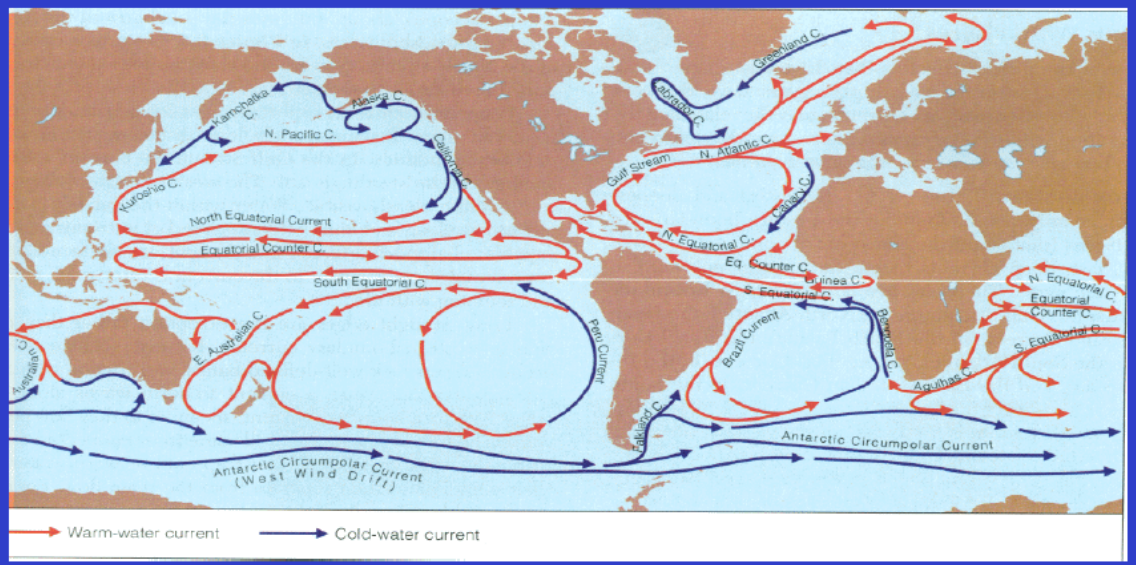
density-driven circulation

wind-driven circulation

(Figure from *The Earth System*)

Six Great Current Circuits in the World Ocean





- **5 of them are geostrophic gyres:**
  - North Pacific Gyre
  - South Pacific Gyre
  - North Atlantic Gyre
  - South Atlantic Gyre
  - Indian Ocean Gyre

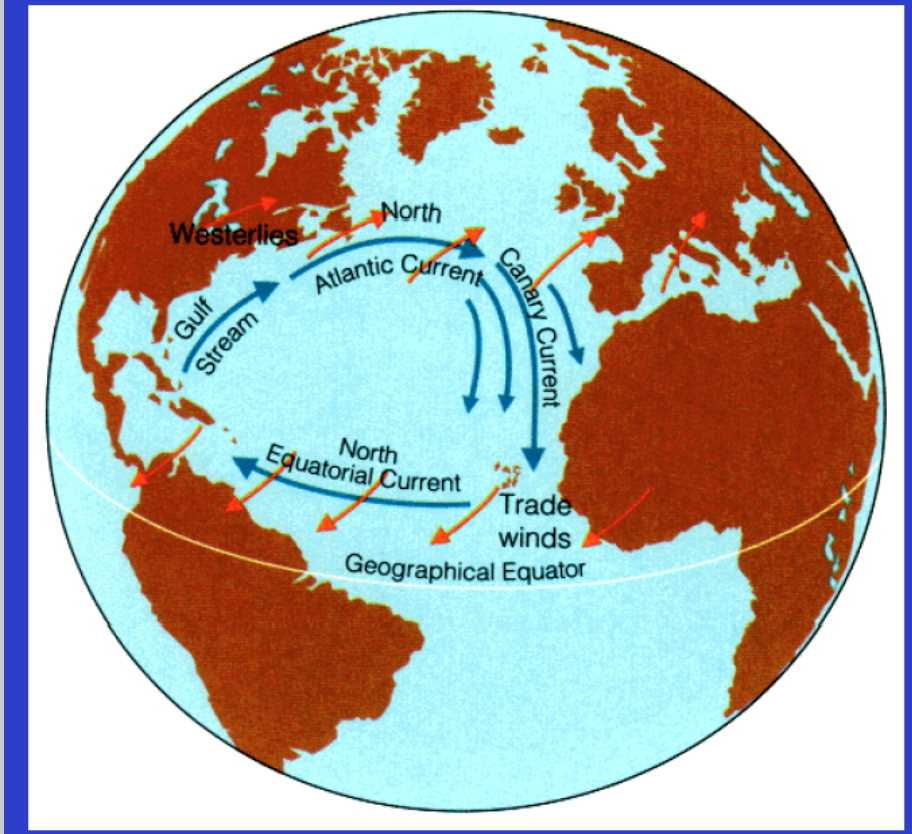
- **The 6th and the largest current:**
  - Antarctic Circumpolr Current
  - (also called West Wind Drift)

(Figure from *Oceanography* by Tom Garrison)

ESS228
Prof. Jin-Yi Yu

Characteristics of the Gyres

(Figure from *Oceanography* by Tom Garrison)



Volume transport unit:

1 sv = 1 Sverdrup = 1 million m^3/sec

(the Amazon river has a transport of ~0.17 Sv)

- **Currents are in geostropic balance**
- **Each gyre includes 4 current components:**

two boundary currents: western and eastern

two transverse currents: easteward and westward

Western boundary current (jet stream of ocean)

the fast, deep, and narrow current moves **warm** water polarward (transport ~50 Sv or greater)

Eastern boundary current

the slow, shallow, and broad current moves cold water equatorward (transport ~ 10-15 Sv)

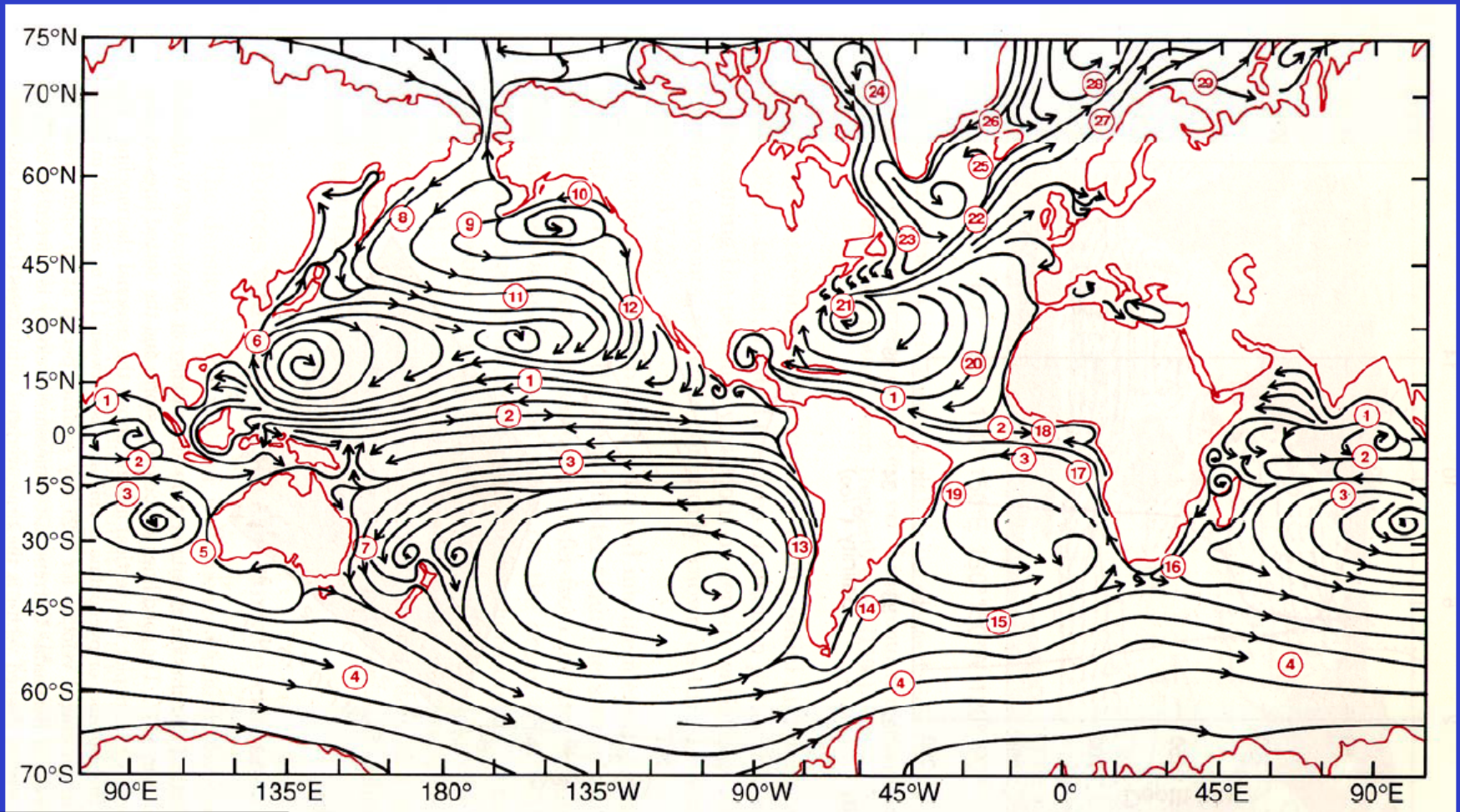
Trade wind-driven current

the moderately shallow and broad westward current (transport ~ 30 Sv)

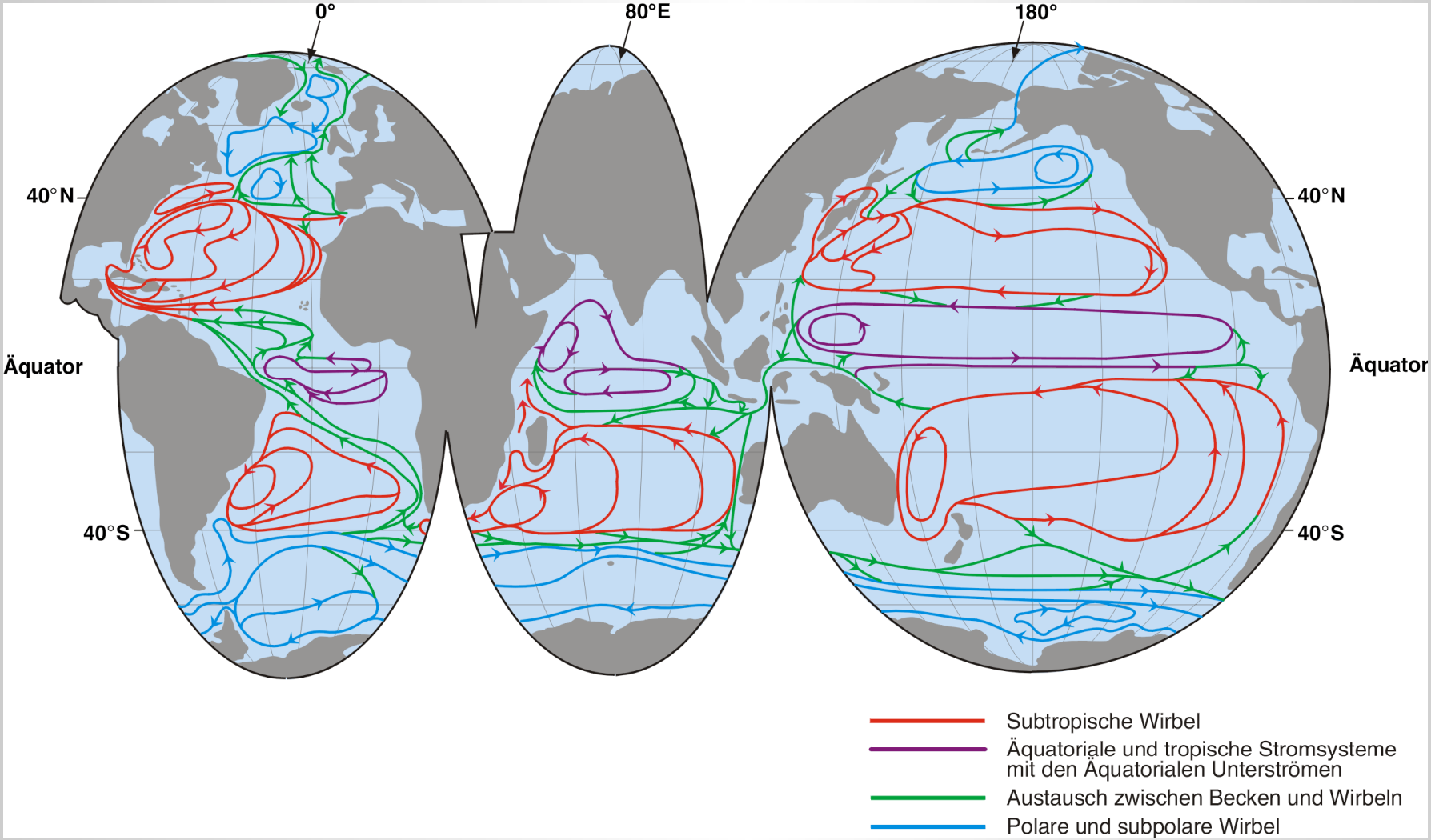
Westerly-driven current

the wider and slower (than the trade wind-driven current) eastward current

Global Surface Currents



Circulação Superficial



A Circulação Profunda

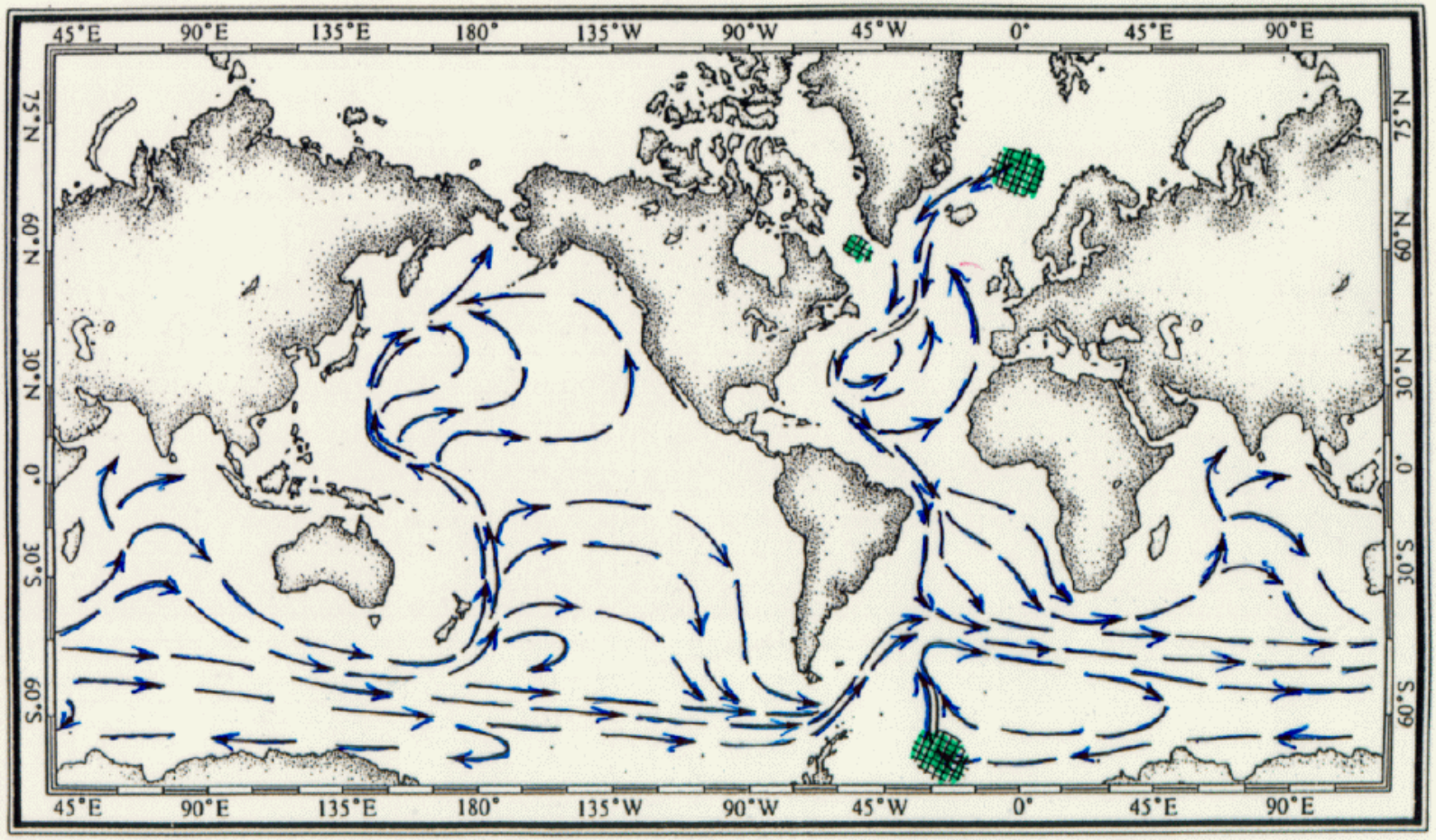
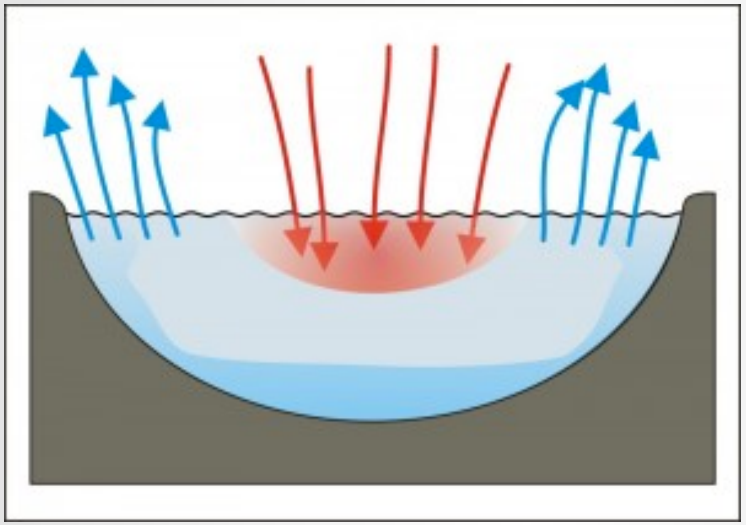
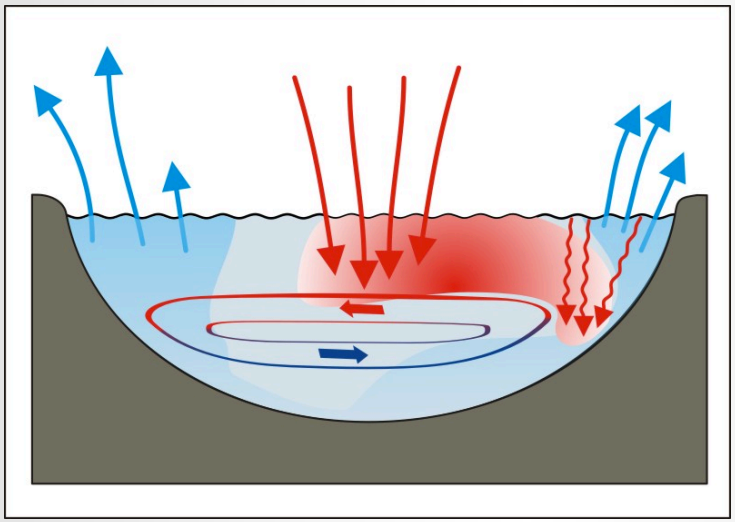


Fig. 2.23 Schematic flow lines for abyssal circulation. The cross-hatched areas indicate regions of production of bottom water. [Adapted from Stommel, H., *Deep Sea Research* (1958).]

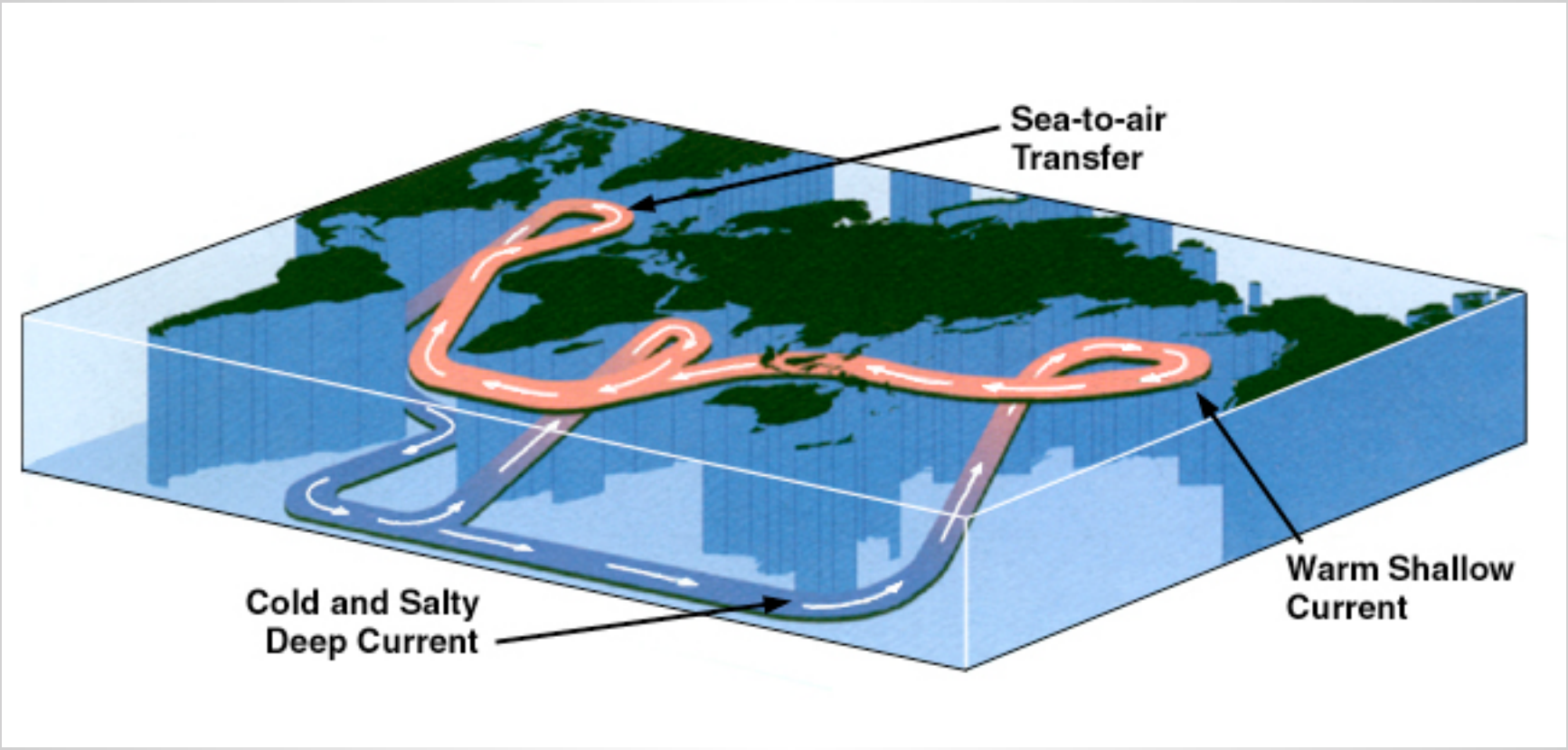
A forçante termohalina da Circulação Profunda

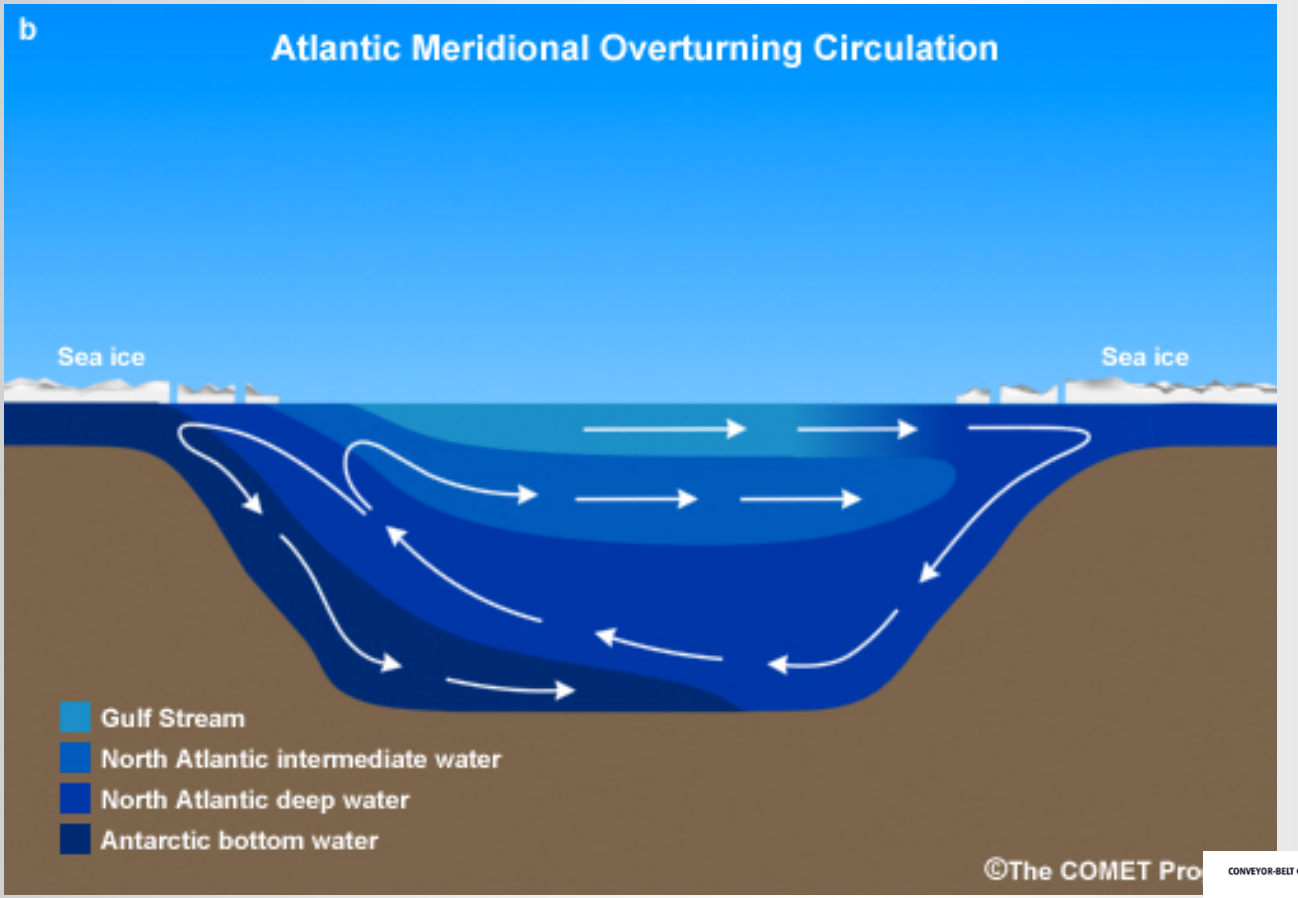


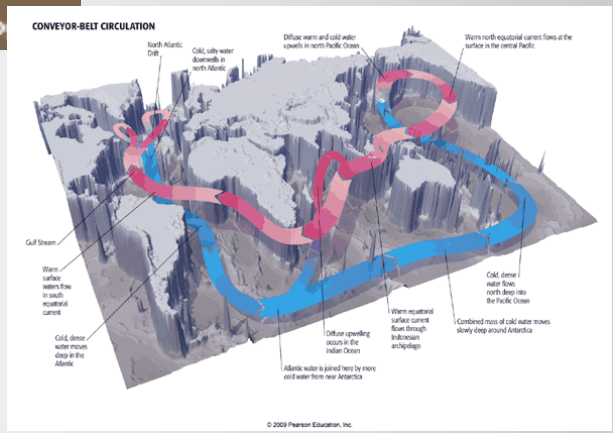
THC – Modelo 1



THC – Modelo 2


Sea-to-air
Transfer
Warm Shallow
Current
Cold and Salty
Deep Current


b
Atlantic Meridional Overturning Circulation
Sea ice
Sea ice
Gulf Stream
North Atlantic intermediate water
North Atlantic deep water
Antarctic bottom water
©The COMET Pro


CONVEYOR-BELT CIRCULATION
North Atlantic Drift
Cold, salty water downwells in north Atlantic
Diffuse warm and cold water upwells in north Pacific Ocean
Warm north equatorial current flows at the surface in the central Pacific
Gulf Stream
Warm surface waters flow in south equatorial current
Cold, dense water moves deep in the Atlantic
Diffuse upwelling occurs in the Indian Ocean
Warm equatorial surface current flows through Indonesian archipelago
Cold, dense water flows north deep into the Pacific Ocean
Combined mass of cold water moves slowly deep around Antarctica
Atlantic water is joined here by more cold water from near Antarctica
© 2009 Pearson Education, Inc.