Lecture 9

Ocean Circulation -- Part II

TEMPERATURE, SALINITY, AND DENSITY

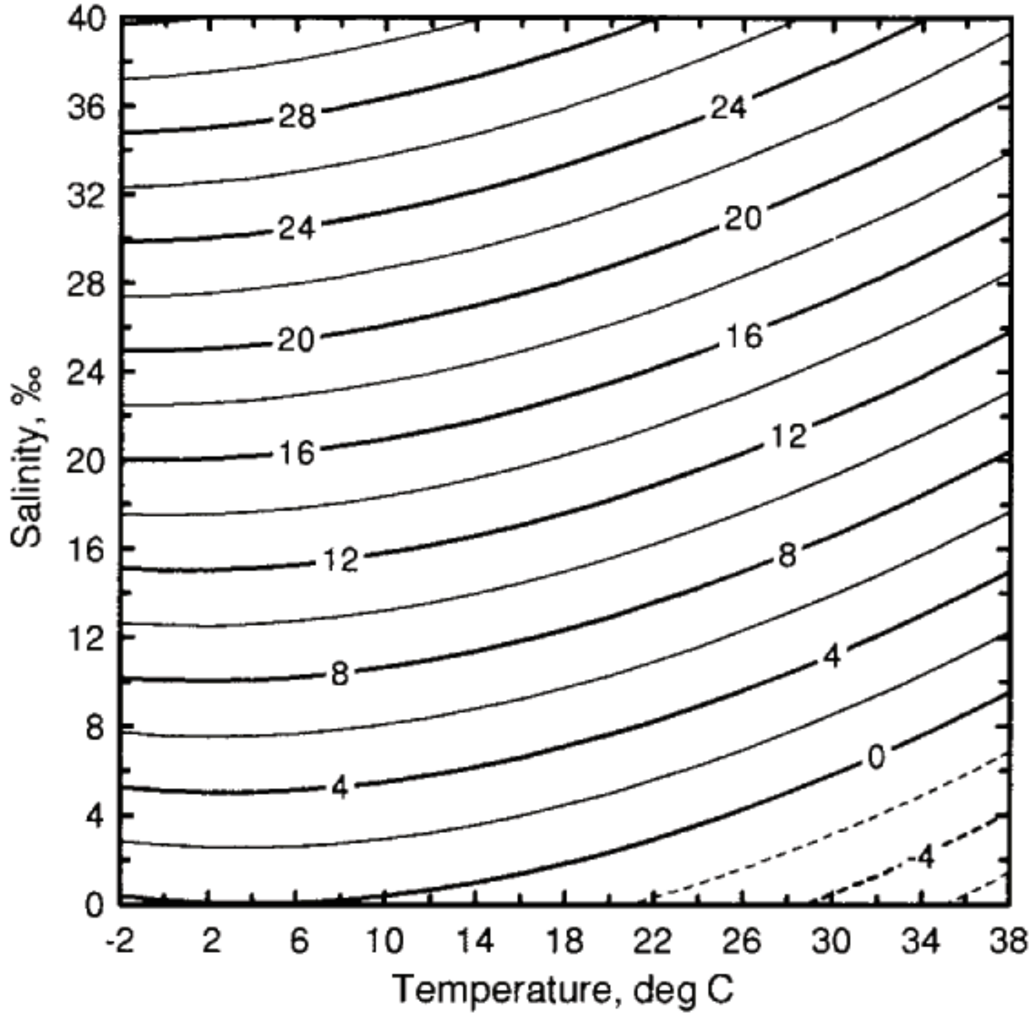
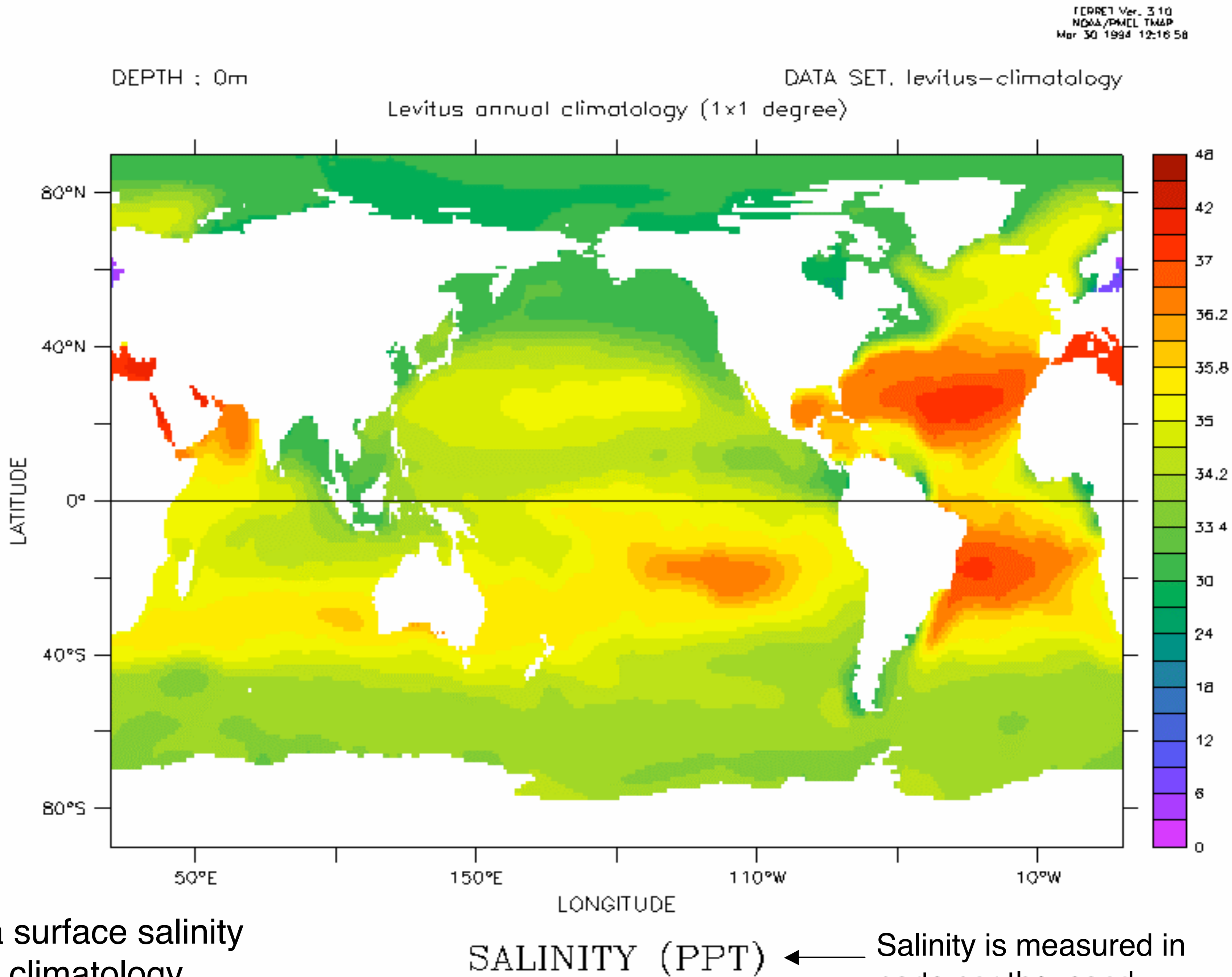
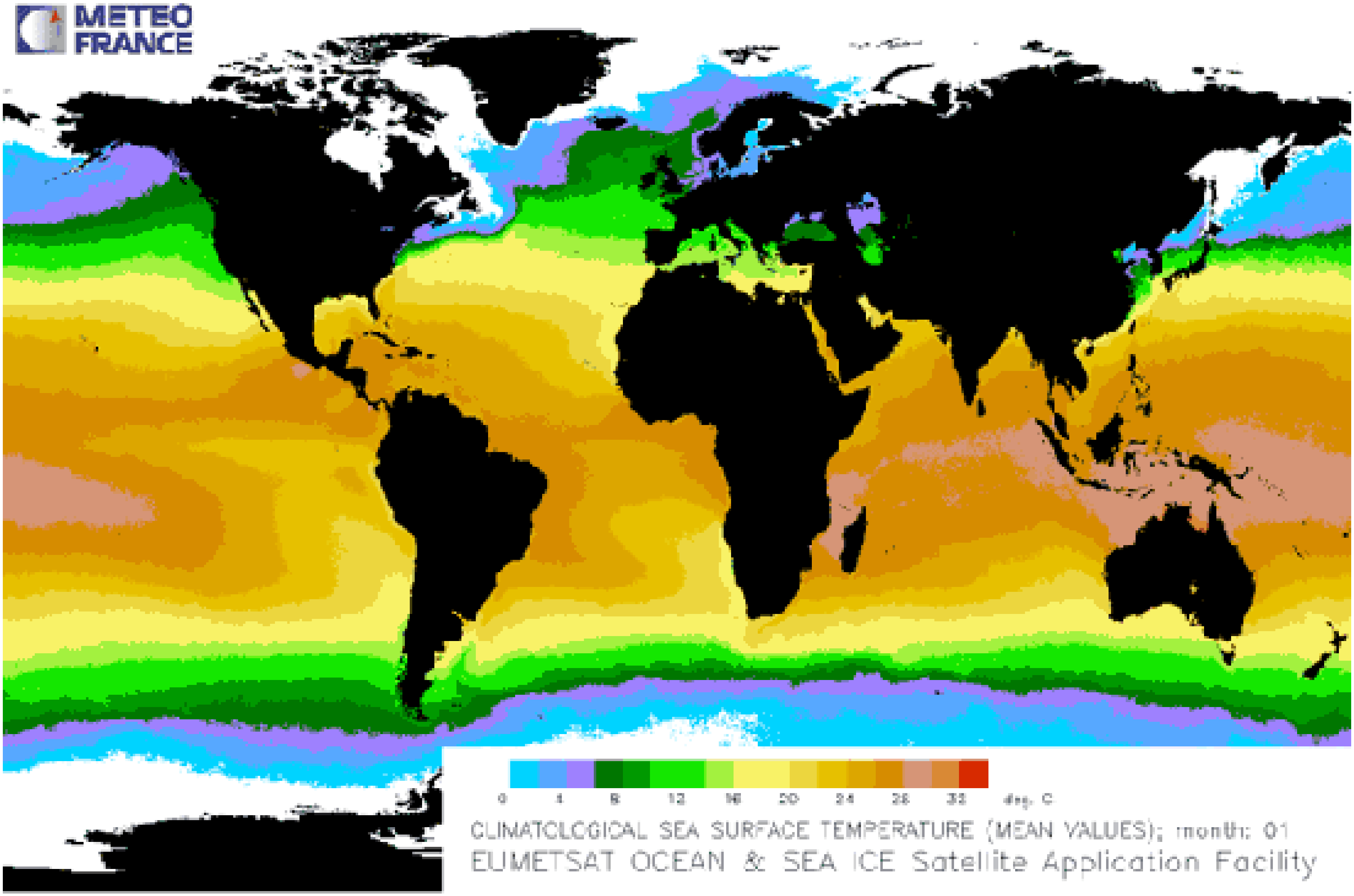


Fig. 7.2 Contours of seawater density anomalies ($\rho_t - 1000$, kg m^{-3}) plotted against salinity and temperature.

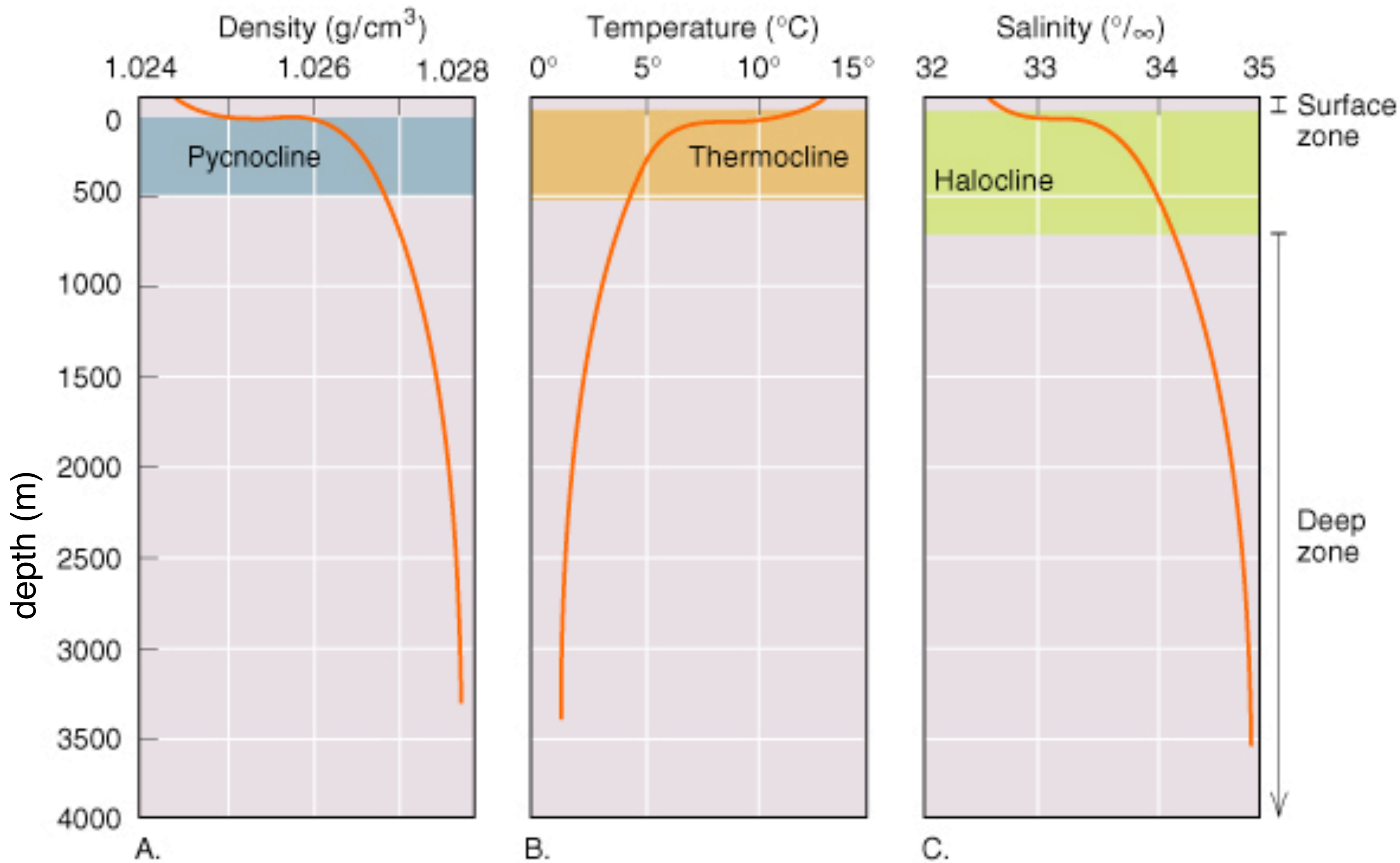


sea surface salinity climatology

Salinity is measured in parts per thousand


METEO
FRANCE
0
4
8
12
16
20
24
28
32
deg. C
CLIMATOLOGICAL SEA SURFACE TEMPERATURE (MEAN VALUES); month: 01
EUMETSAT OCEAN & SEA ICE Satellite Application Facility

Vertical distribution of temperature, salinity, and density



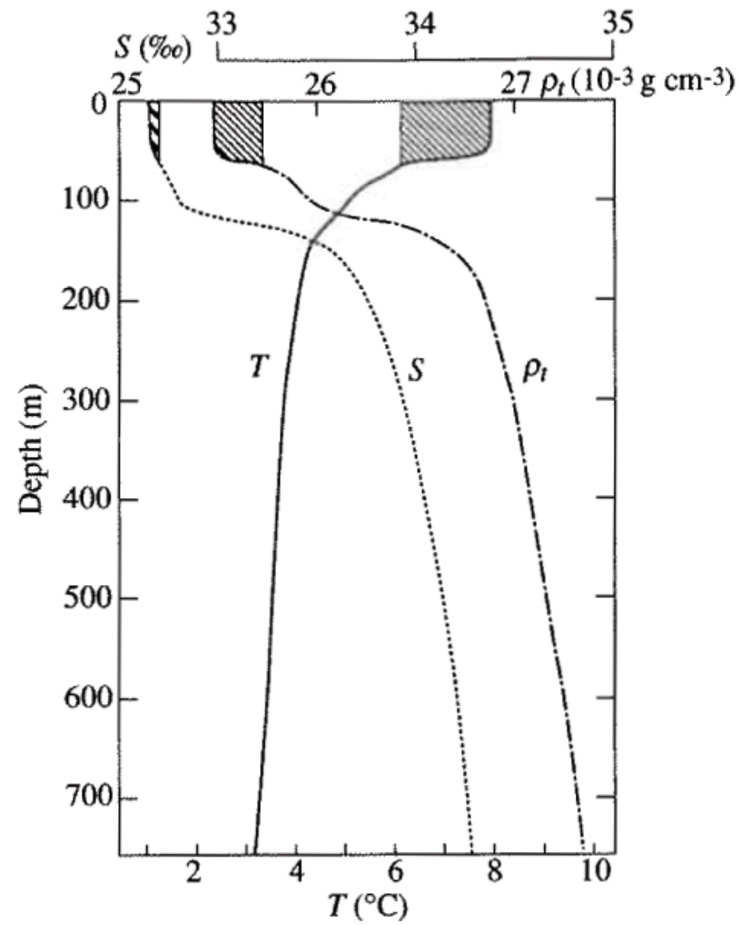


Fig. 7.4 Vertical profiles of temperature (T, °C), salinity (S, ‰), and potential density ($\rho_t - 1000$, kg m^{-3}) at Ocean Station P, 50°N, 145°W, on June 23, 1970 showing the mixed layer in the top 50 m. The hatched area shows the change since May 19, 1970 and indicates the springtime warming and thinning of the mixed layer. [From Denman and Miyake (1973). Reprinted with permission from the American Meteorological Society.]

Zonal-mean potential temperature in the global ocean

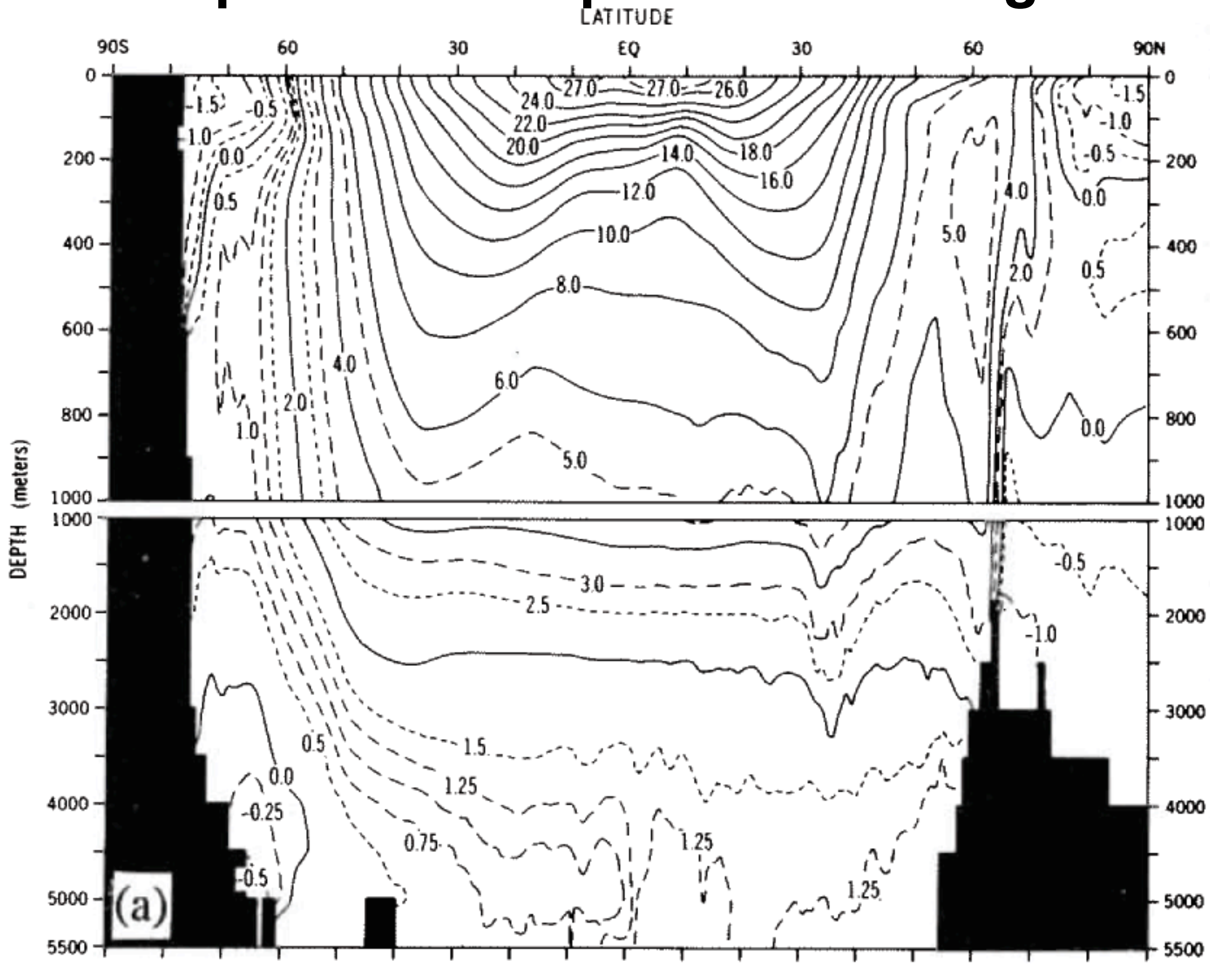
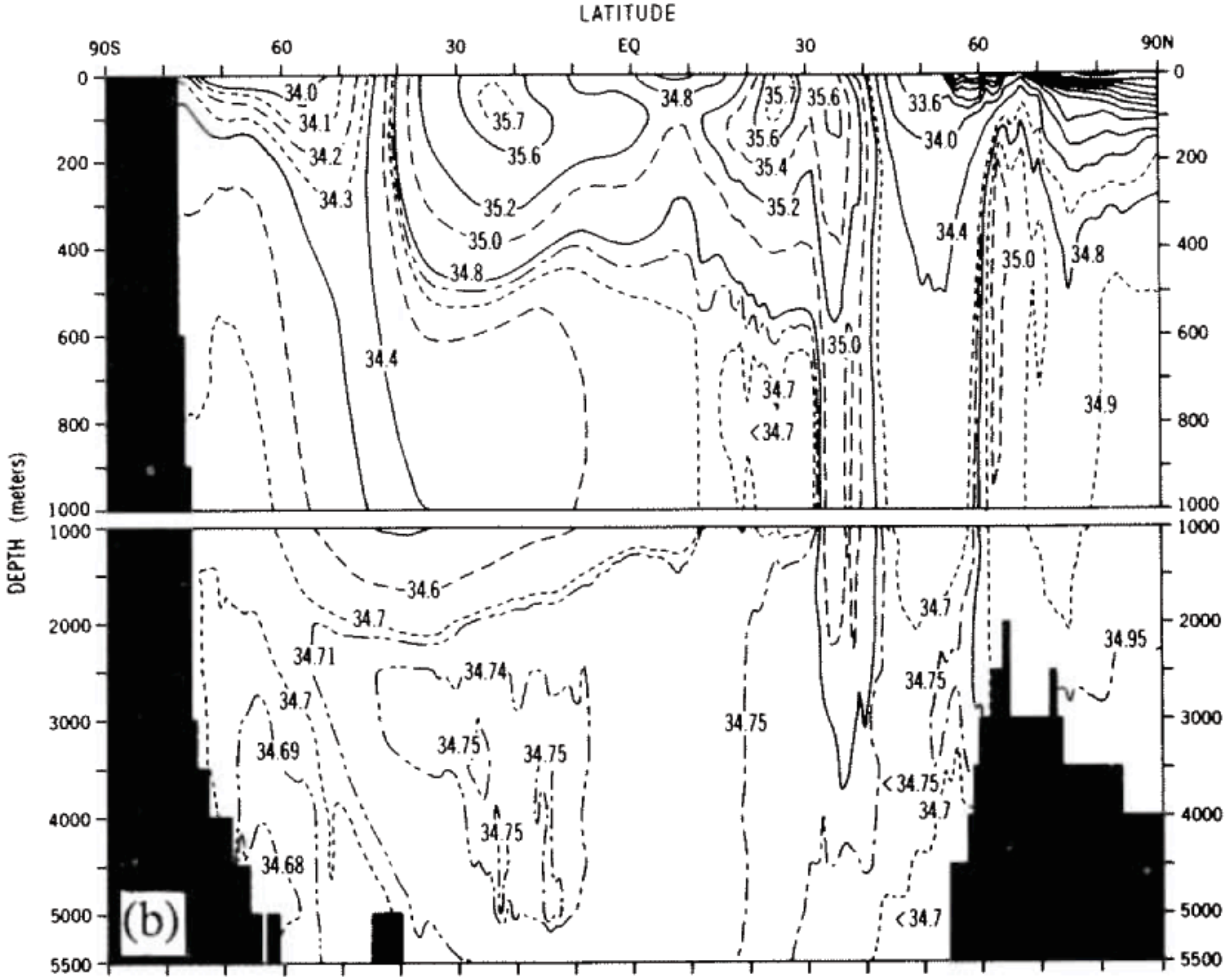


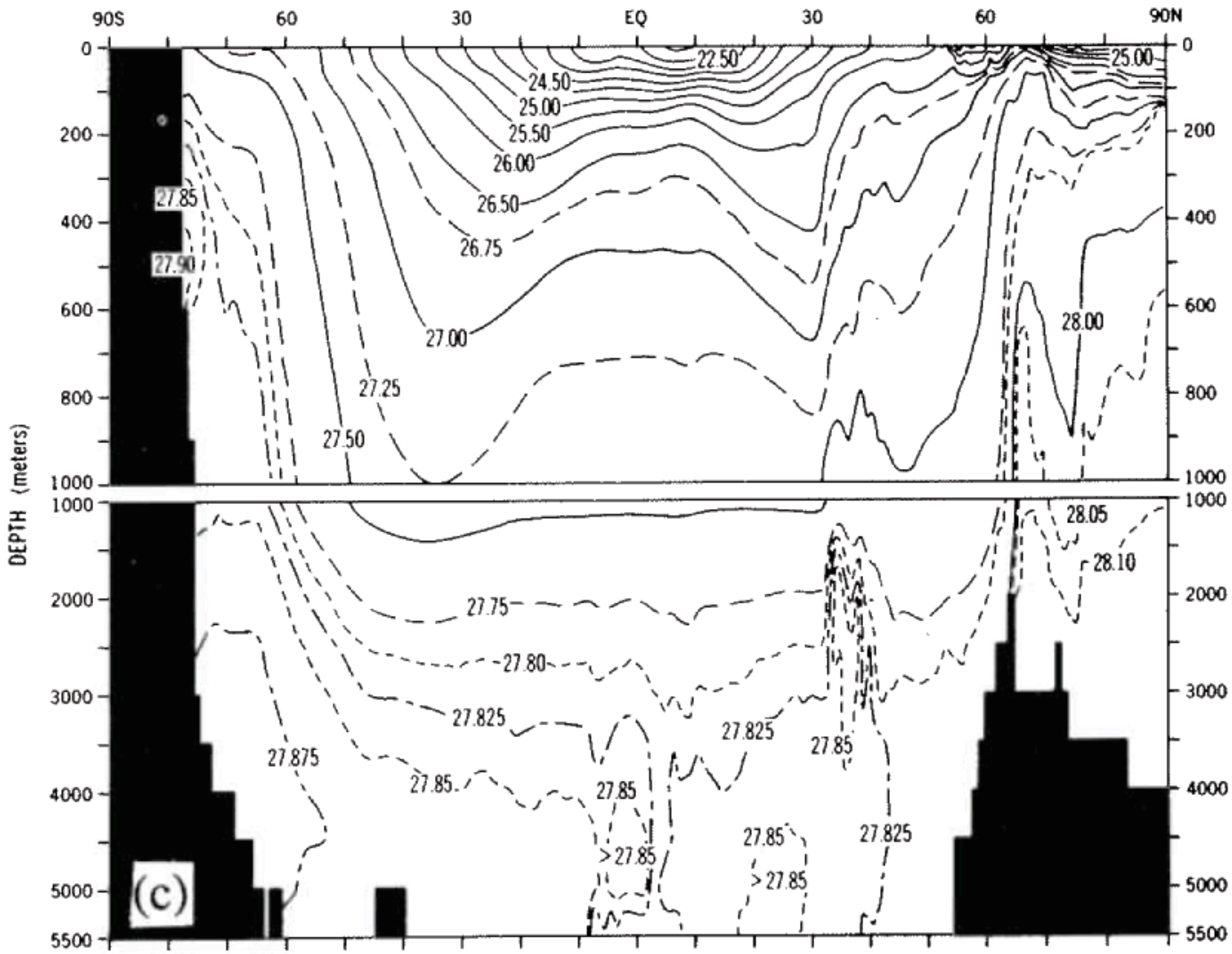
Fig. 7.1 Annual-mean zonal average for the global ocean of (a) potential temperature (°C), and (b) salinity [‰ (‰ = parts per thousand)], and (c) potential density ($\rho_t - 1000$, kg m^{-3}). [From Levitus (1982).]

The *thermocline* is the zone of rapidly decreasing temperature with depth in the upper 200 m

Zonal-mean salinity in the global ocean

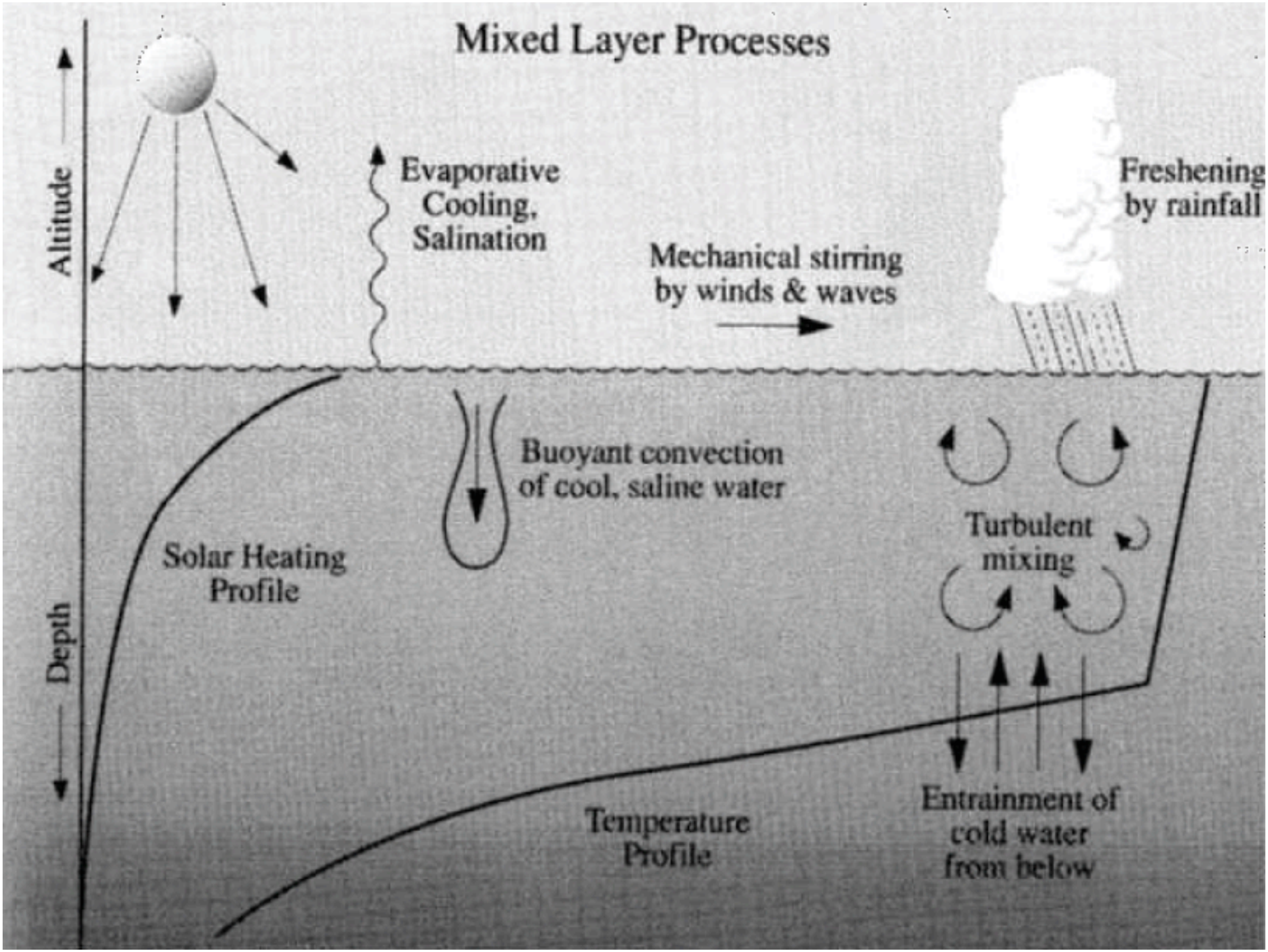


Zonal-mean potential density in the global ocean



Where is the ocean the most stratified?

THE MIXED LAYER


Mixed Layer Processes
Altitude
Depth
Evaporative
Cooling,
Salination
Freshening
by rainfall
Mechanical stirring
by winds & waves
Buoyant convection
of cool, saline water
Turbulent
mixing
Solar Heating
Profile
Temperature
Profile
Entrainment of
cold water
from below

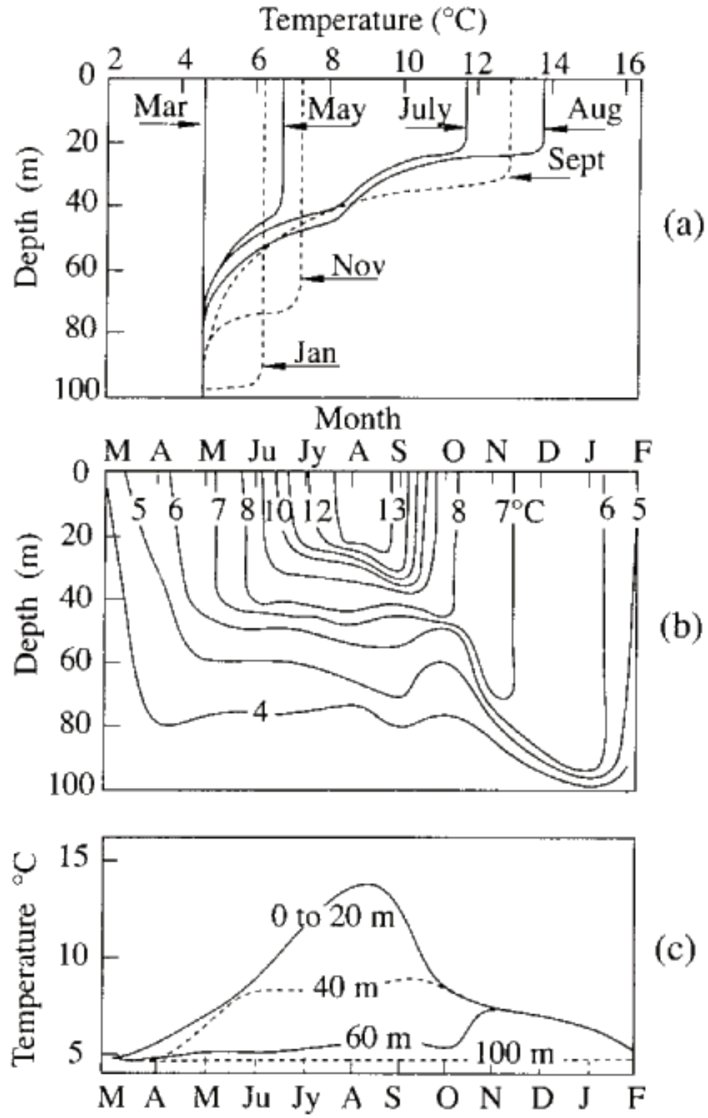
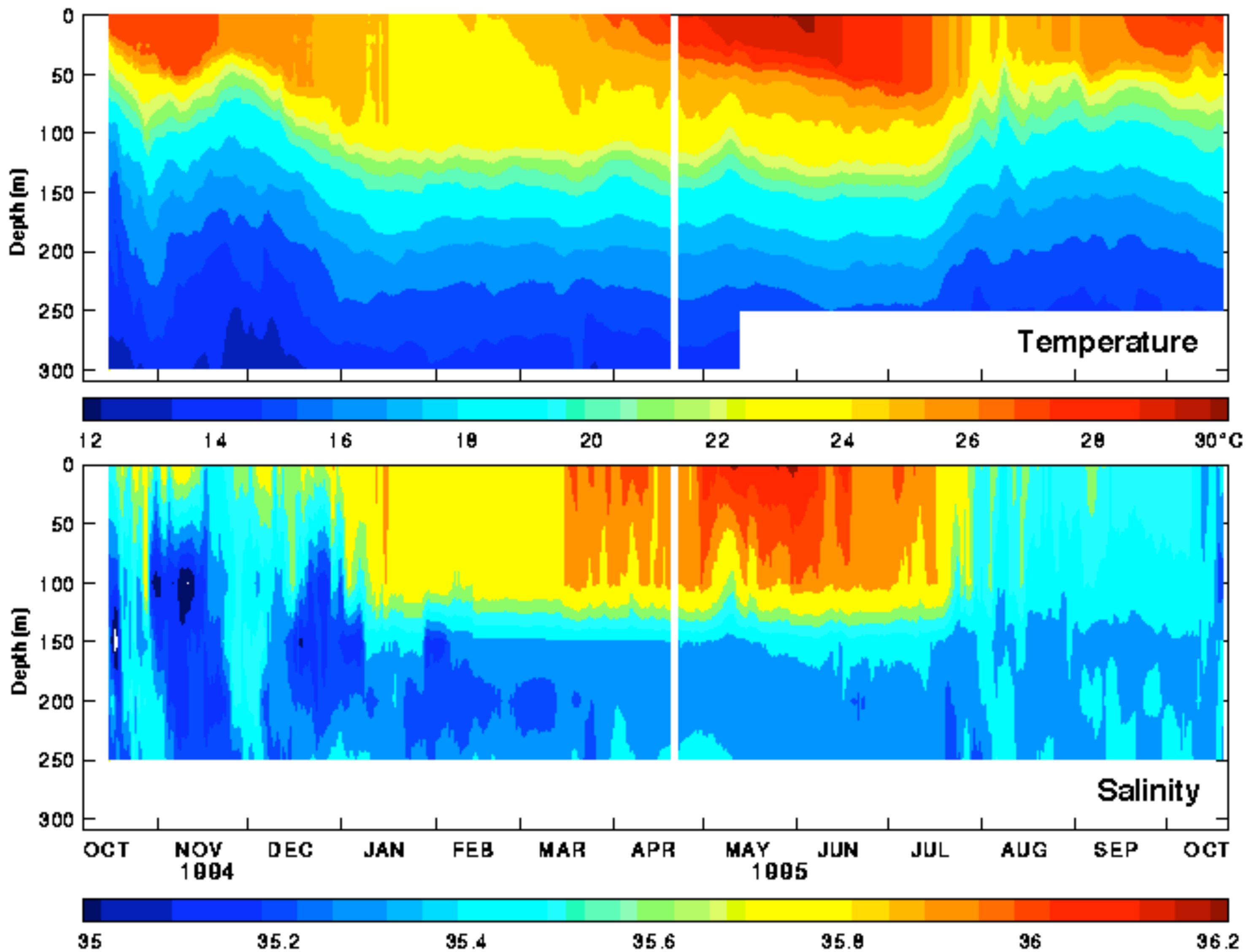


Fig. 7.6 Seasonal variation of temperature in the upper ocean at 50°N, 145°W in the eastern north Pacific. (a) Vertical profiles of temperature by months, (b) temperature contours, and (c) temperatures at various depths versus time of year. [From Pickard and Emery (1990). Reprinted with permission from Pergamon Press, Ltd., Oxford, England.]

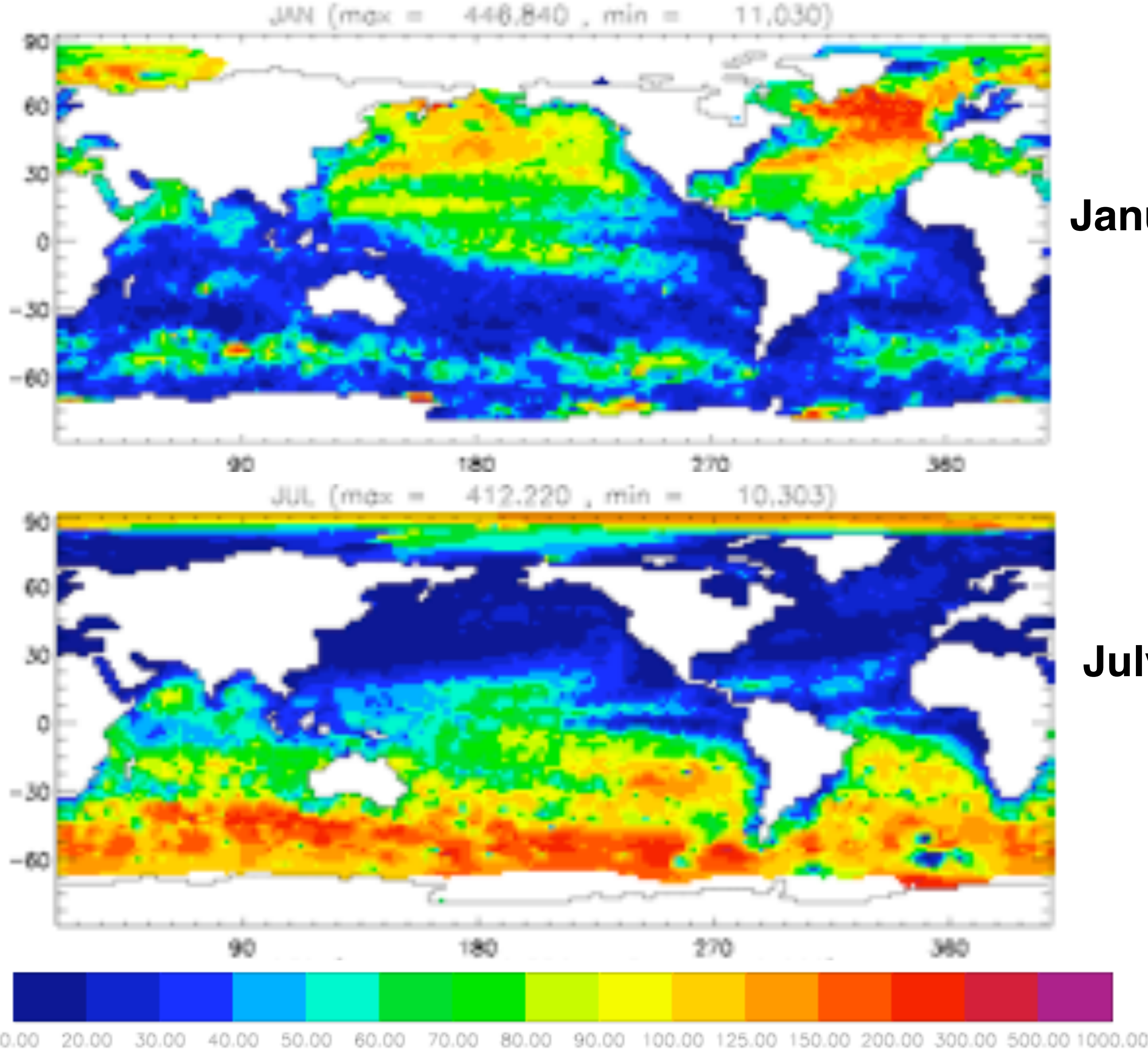
The seasonal variation in the mixed layer at weather station Papa in the northeast Pacific

THE MIXED LAYER IN THE TROPICS

Temporal Variability of Temperature and Salinity at 15.5 °N, 61.5 °E



Climatological Mixed Layer Depths as Captured by *in situ* Profiles



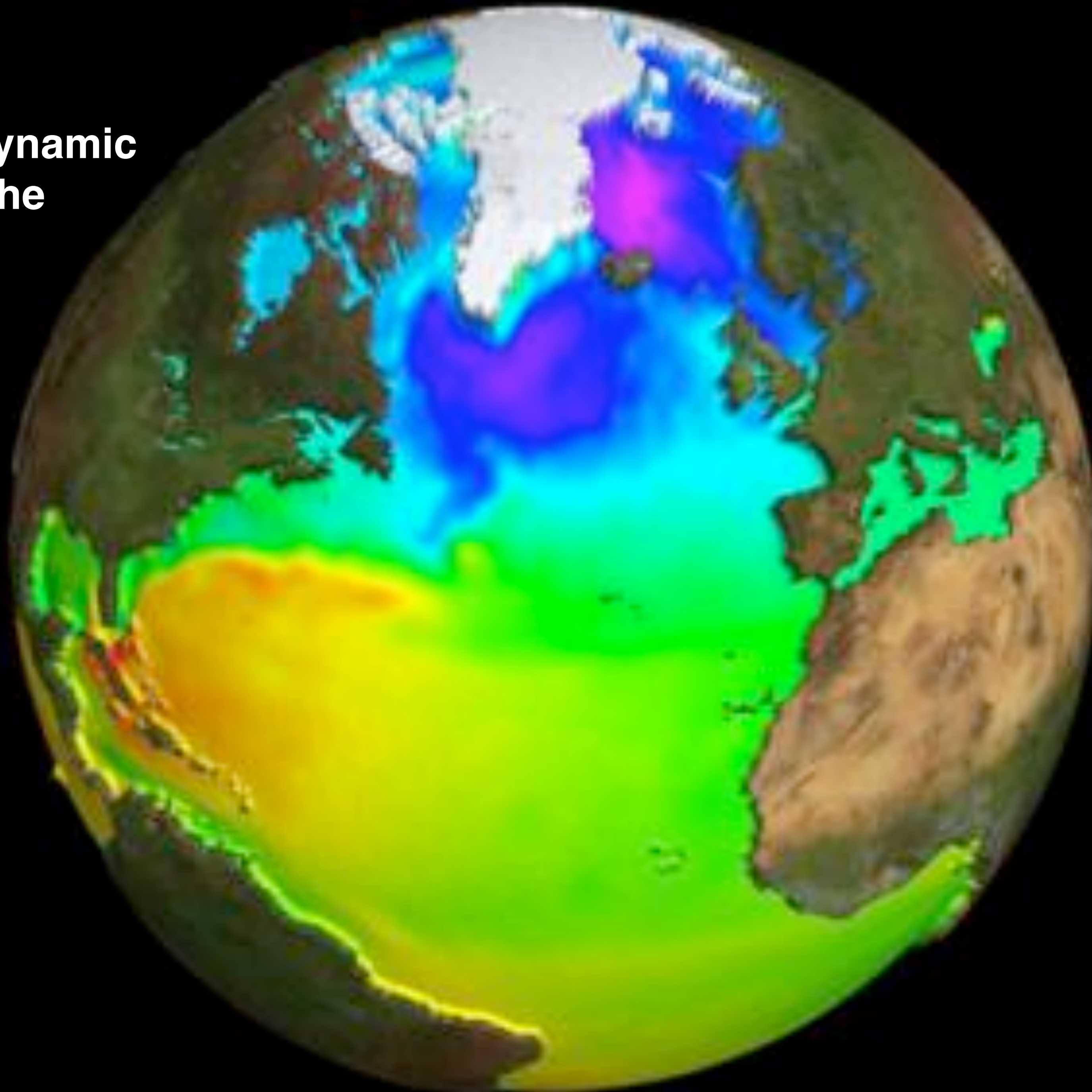
January

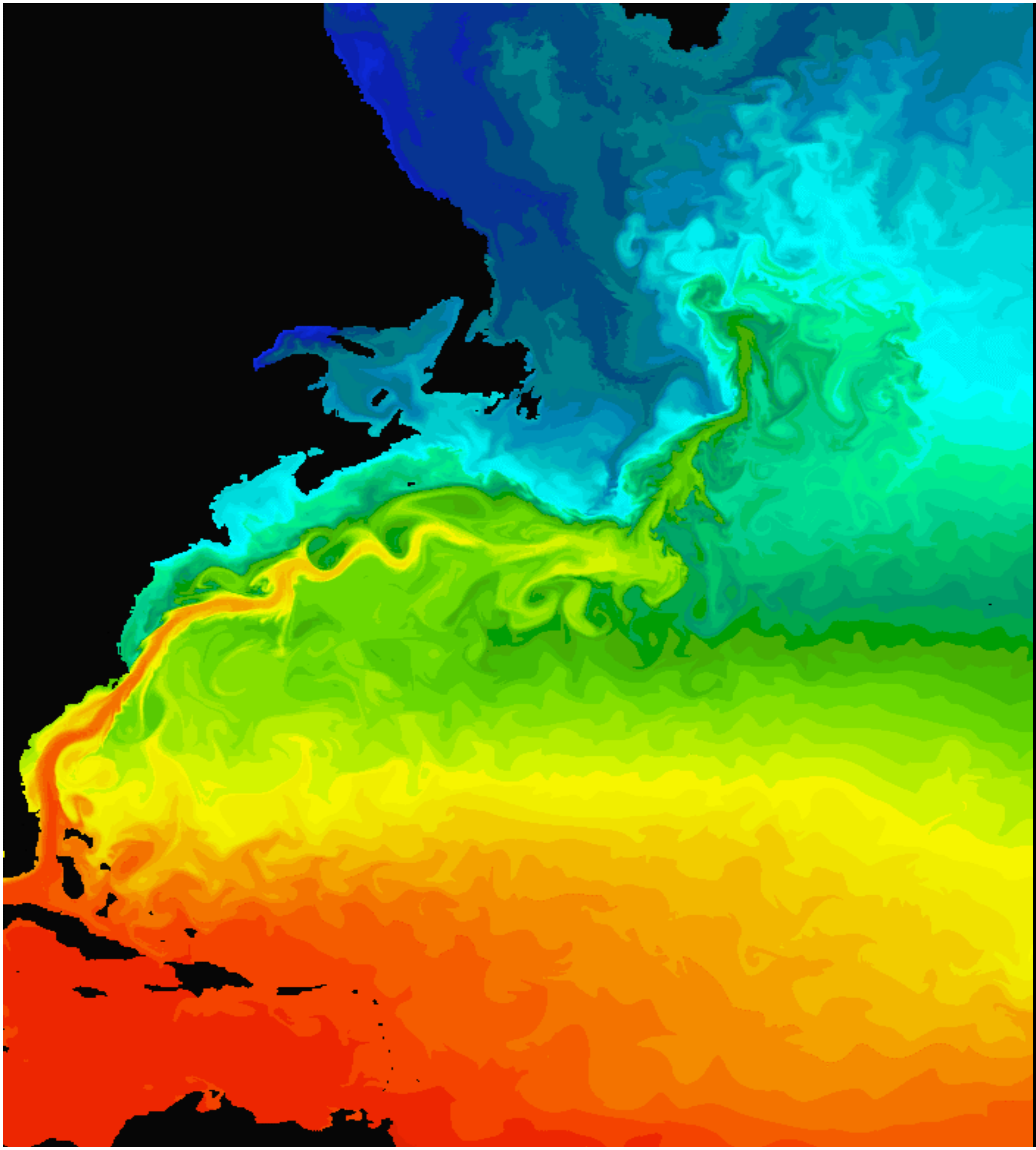
July

deBoyer
2004

TURBULENCE AND EDDIES

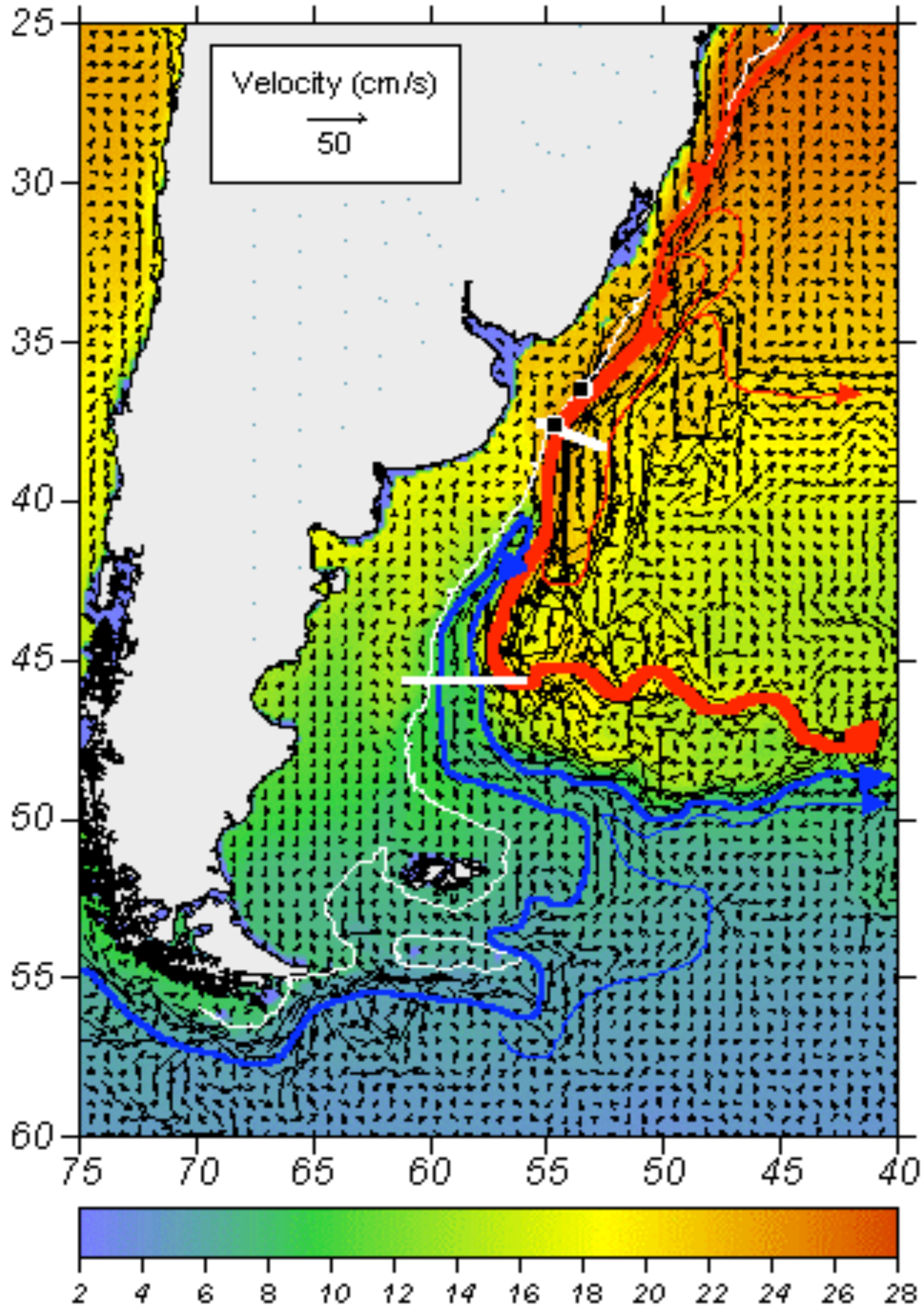
A close up of dynamic topography in the North Atlantic





An example of gyre flow at the western boundary of the Atlantic: The Gulf Stream

image from NASA

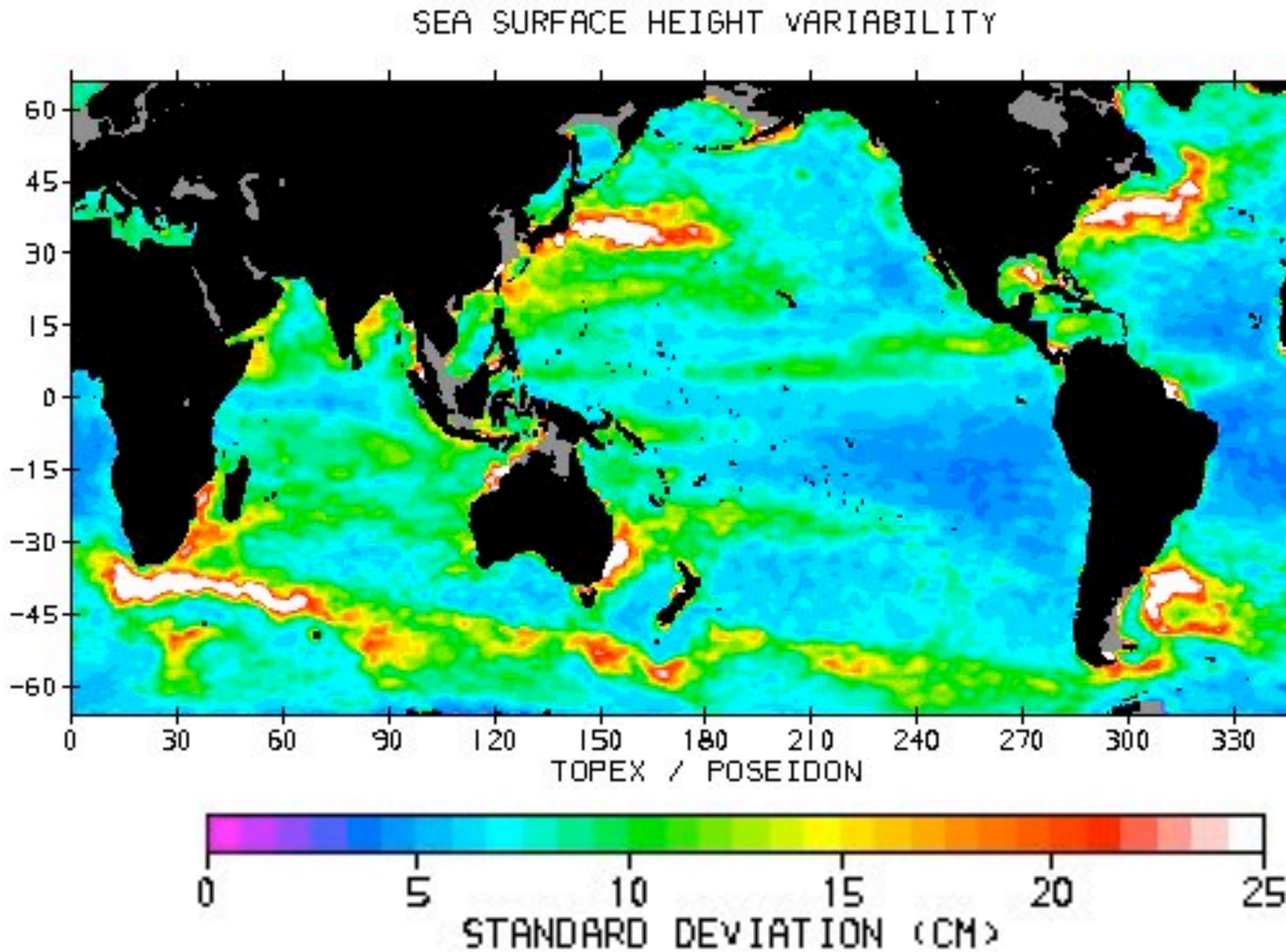


OTHER WESTERN BOUNDARY CURRENTS -- THE BRAZIL CURRENT

January snapshot of the upper layer horizontal velocity and temperature fields derived from the Miami Isopycnal Coordinate Model (Micom). The red and blue lines show schematically the regions of higher velocity and where the flow is relatively well organized. The thick blue line represents the Malvinas Current and the Malvinas Return and the thick red line represents the Brazil Current.

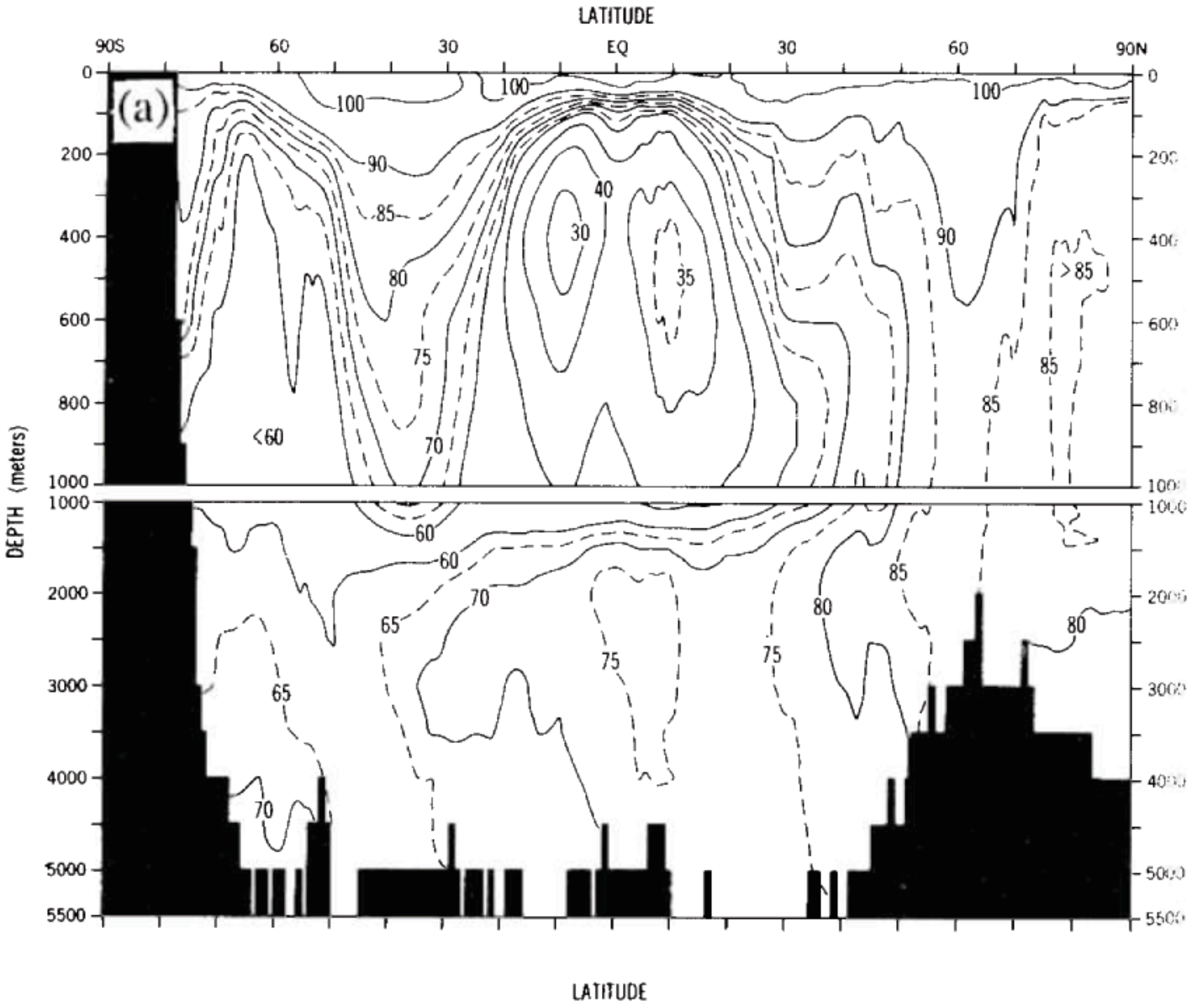
(Piola et al. 2006)

Eddy activity can be measured roughly by the variability of sea surface height.

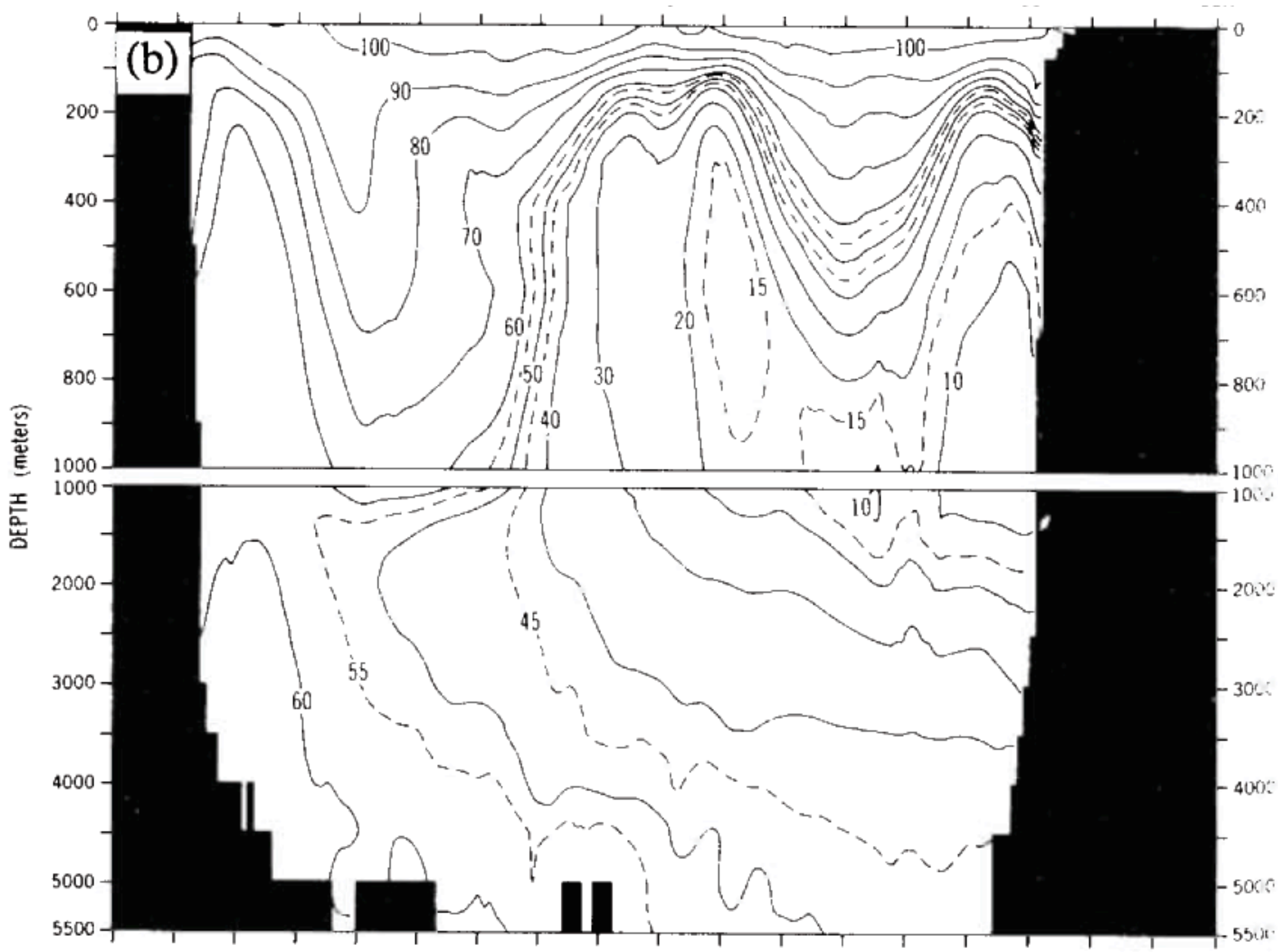


DEEP WATER FORMATION AND THE THERMOHALINE CIRCULATION

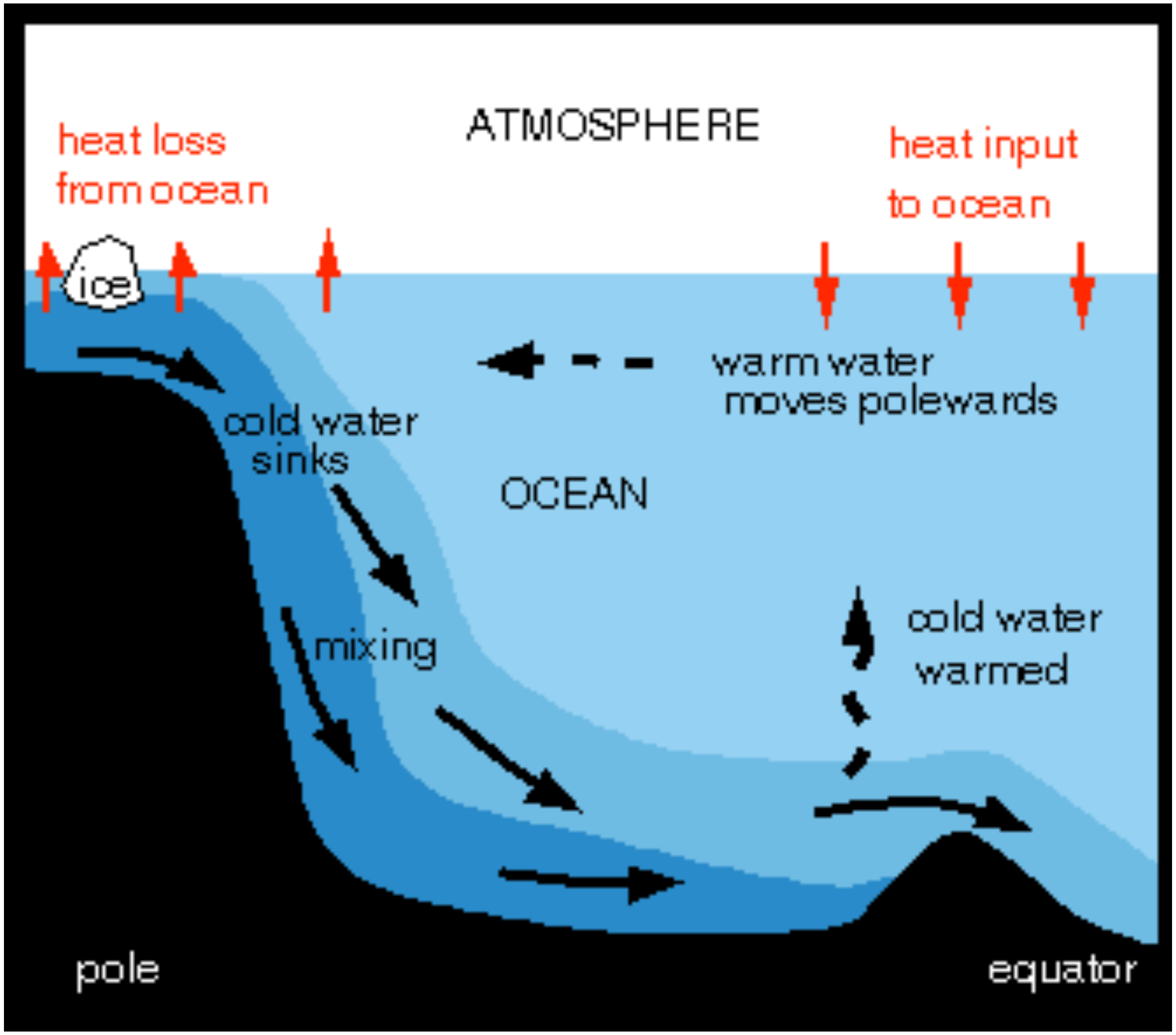
Zonally-averaged Oxygen saturation in the Atlantic Ocean (%)

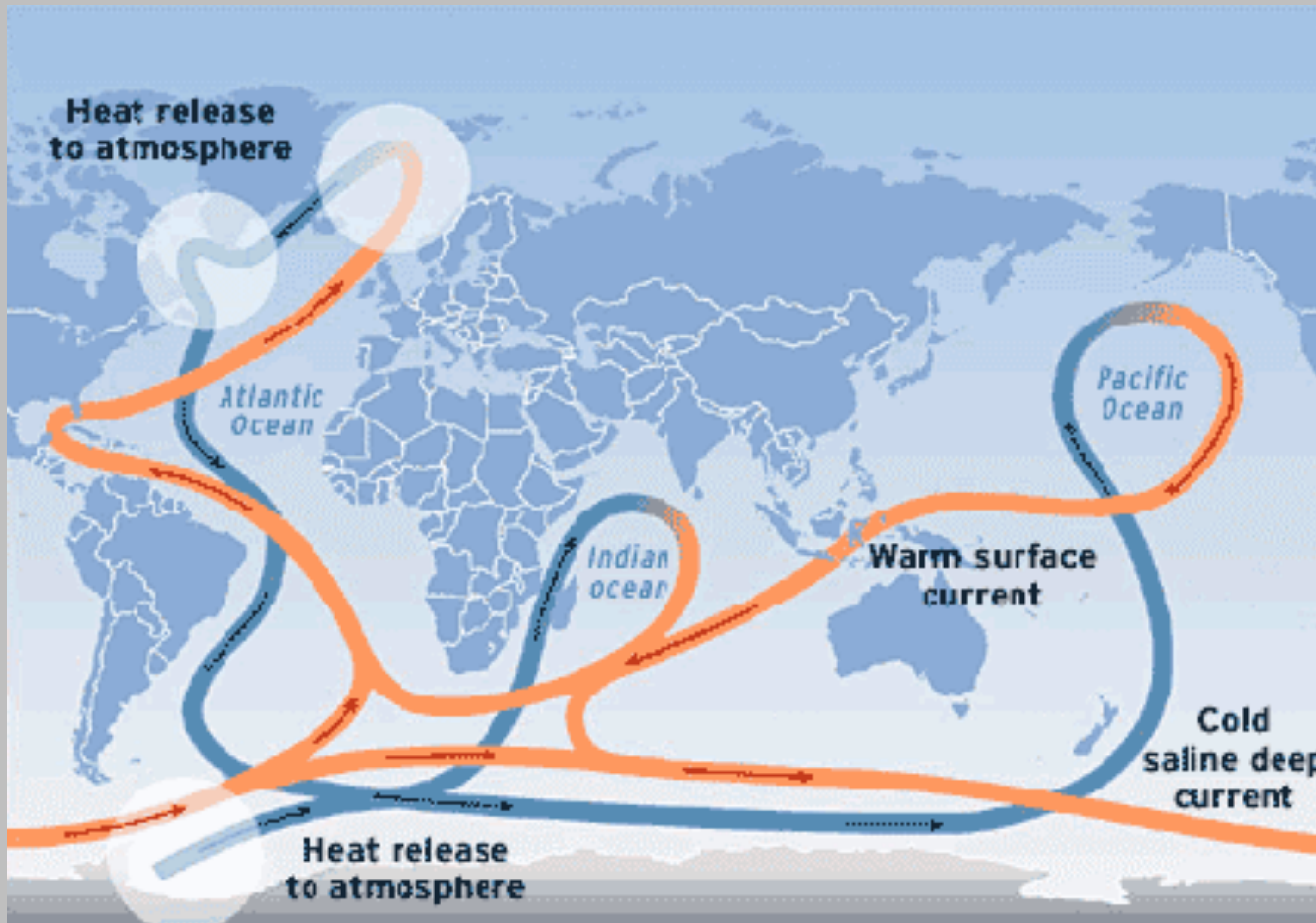


Zonally-averaged Oxygen saturation in the Pacific Ocean (%)



The Thermohaline Circulation -- time scale is ~1000 years





Because of its high salinity, North Atlantic water is more susceptible to sinking than other waters with the same temperature. This is therefore a major sinking region of the global thermohaline circulation. The Southern Ocean is also a site of deep convection. All of the deep water of the entire ocean originates in one of these two regions.