
气象□□ 英□5

New words:

- ◆ Vector: 向量
- ◆ Zonal 纬向的 latitude 纬度
- ◆ Meridional: 经向的 longitude: 经度
- ◆ Subpolar: 副极地的 subgrid
- ◆ Jetstream 急流
- ◆ Reversal 颠倒, 反转
- ◆ Westerly 西风 easterly 东风
- ◆ Westerlies 西风带 easterlies 东风带
- ◆ Retreat : 复原, 恢复; 撤退 withdraw
- ◆ Equator 赤道 ribbon 带状物, strip ; belt
- ◆ Coriolis 科里奥利力
- ◆ Oceanographic 海洋学的 kinetic 运动的

大气环流：一般是指具有世界规模的、大范围的大气运行现象，既包括平均状态，也包括瞬时现象，其水平尺度在数千公里以上，垂直尺度在10km以上，时间尺度在数天以上。

大气大范围运动的状态。

某一大范围的地区（如欧亚地区、半球、全球），某一大气层次（如对流层、平流层、中层、整个大气圈）在一个长时期（如月、季、年、多年）的大气运动的平均状态或某一个时段（如一周、梅雨期间）的大气运动的变化过程都可以称为大气环流。

◆ 大气环流通常包含平均纬向环流、平均水平环流和平均经圈环流3部分。

①**平均纬向环流**。指大气盛行的以极地为中心并绕其旋转的纬向气流，这是大气环流的最基本的状态，就对流层平均纬向环流而言，低纬度地区盛行东风，称为东风带（由于地球的旋转，北半球多为东北信风，南半球多为东南信风，故又称为信风带）；中高纬度地区盛行西风，称为西风带（其强度随高度增大，在对流层顶附近达到极大值，称为西风急流）；极地还有浅薄的弱东风，称为极地东风带。

②**平均水平环流**。指在中高纬度的水平面上盛行的叠加在平均纬向环流上的波状气流（又称平均槽脊），通常北半球冬季为3个波，夏季为4个波，三波与四波之间的转换表征季节变化。

③**平均经圈环流**。指在南北-垂直方向的剖面上，由大气经向运动和垂直运动所构成的运动状态。通常，对流层的经圈环流存在3个圈：低纬度是正环流或直接环流（气流在赤道上升，高空向北，中低纬下沉，低空向南），又称为哈得来环流；中纬度是反环流或间接环流（中低纬气流下沉，低空向北，中高纬上升，高空向南），又称为费雷尔环流；极地是弱的正环流（极地下沉，低空向南，高纬上升，高空向北）。

◆ 控制大气环流状态的基本因子

- ① 大气本身的特殊尺度（准水平）
- ② 太阳辐射随纬度分布的不均匀性（三圈环流）
- ③ 地球自转（准地转）
- ④ 地球表面的不均匀性（海陆分布、陆地起伏）
- ⑤ 地面摩擦（东西风维持）

General Circulation of the Atmosphere

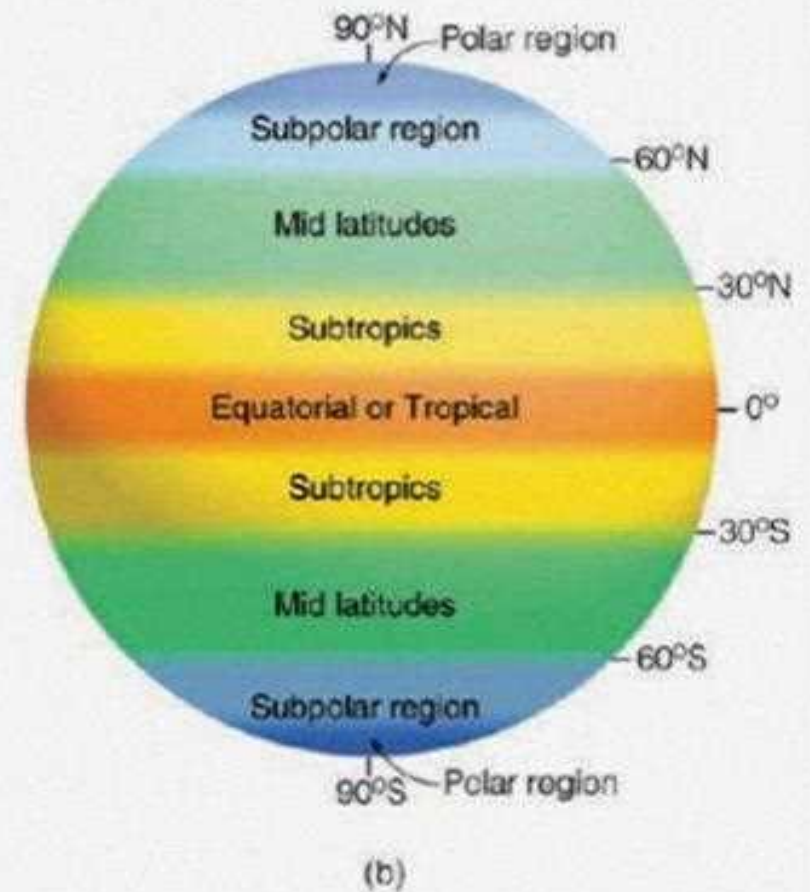
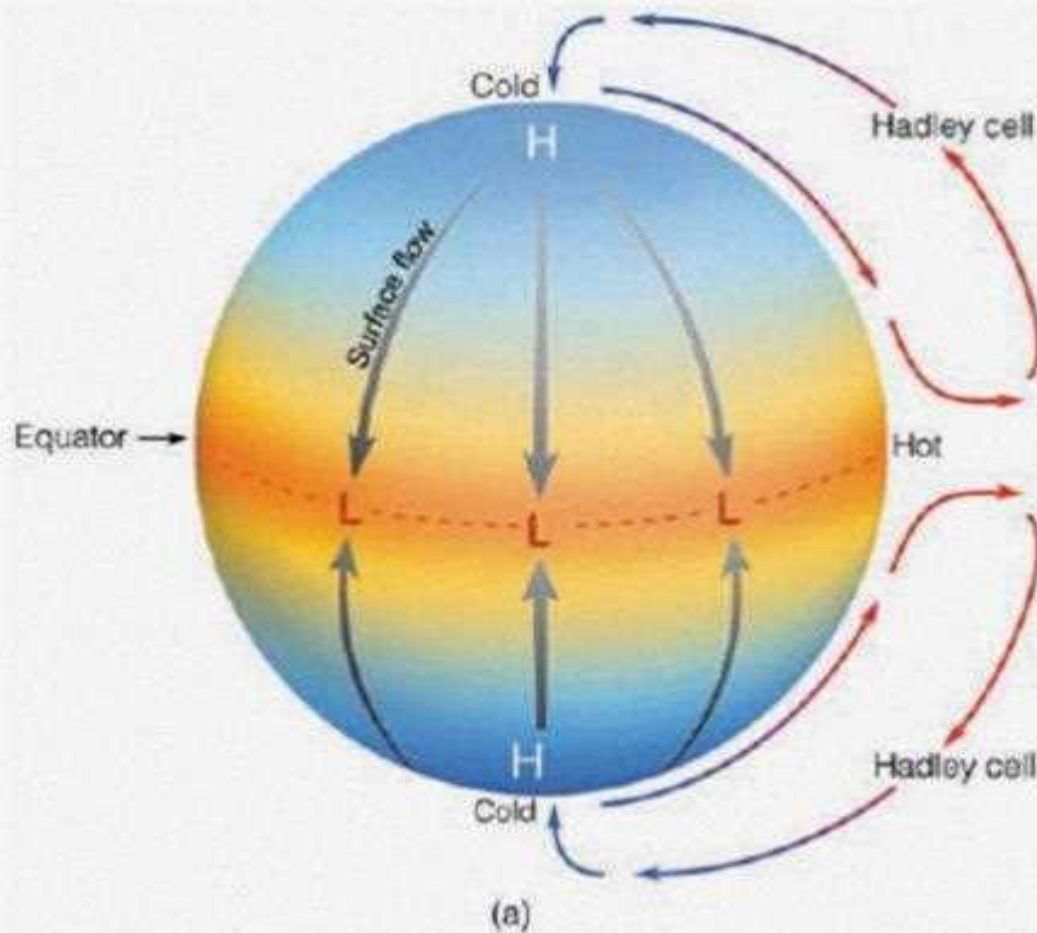
Before we study the general circulation, we must remember that it only represents the *average* air flow around the world. Actual winds at any one place and at any given time may vary considerably from this average. Nevertheless, the average can answer why and how the winds blow around the world the way they do — why, for example, prevailing surface winds are northeasterly in Honolulu, Hawaii, and westerly in New York City. The average can also give a picture of the driving mechanism behind these winds, as well as a model of how heat and momentum are transported from equatorial regions poleward, keeping the climate in middle latitudes tolerable.

The underlying cause of the general circulation is the unequal heating of the earth's surface. We learned in Chapter 2 that, averaged over the entire earth, incoming solar radiation is roughly equal to outgoing earth radiation. However, we also know that this energy balance is not maintained for each latitude, since the tropics experience a net gain in energy, while polar regions suffer a net loss. To balance these inequities, the atmosphere transports warm air poleward and cool air equatorward. Although seemingly simple, the actual flow of air is complex; certainly not everything is known about it. In order to better understand it, we will first look at some models (that is, artificially constructed simulations) that eliminate some of the complexities of the general circulation.

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SINGLE-CELL MODEL The first model is the single-cell model, in which we assume that:

1. The earth's surface is uniformly covered with water (so that differential heating between land and water does not come into play).
2. The sun is always directly over the equator (so that the winds will not shift seasonally).
3. The earth does not rotate (so that the only force we need to deal with is the pressure gradient force).



● **FIGURE 10.1** Diagram (a) shows the general circulation of air on a nonrotating earth uniformly covered with water and with the sun directly above the equator. (Vertical air motions are highly exaggerated in the vertical.) Diagram (b) shows the names that apply to the different regions of the world and their approximate latitudes.

THREE-CELL MODEL If we allow the earth to spin, the simple convection system breaks into a series of cells as shown in ● Fig. 10.2. Although this model is considerably more complex than the single-cell model, there are some similarities. The tropical regions still receive an excess of heat and the poles a deficit. In each hemisphere, three cells instead of one have the task of energy redistribution. A surface high-pressure area is located at the poles, and a broad trough of surface low pressure still exists at the equator. From the equator to latitude 30° , the circulation is the *Hadley cell*. Let's look at this model more closely by examining what happens to the air above the equator. (Refer to Fig. 10.2, as you read the following section.)

Over equatorial waters, the air is warm, horizontal pressure gradients are weak, and winds are light. This region is

referred to as the **doldrums**. (The monotony of the weather in this area has given rise to the expression “down in the doldrums.”) Here, warm air rises, often condensing into huge

赤道无风带是指赤道附近南、北纬 5° 之间的地带。这里太阳终年近乎直射，是地表年平均气温最高地带。由于温度的水平分布比较均匀，水平气压梯度很小，气流以辐合上升为主，风速微弱，故称为赤道无风带。它控制下的天气特点是气压低、湿度大、多云、多雷暴，是海上航行时要避开的区域。

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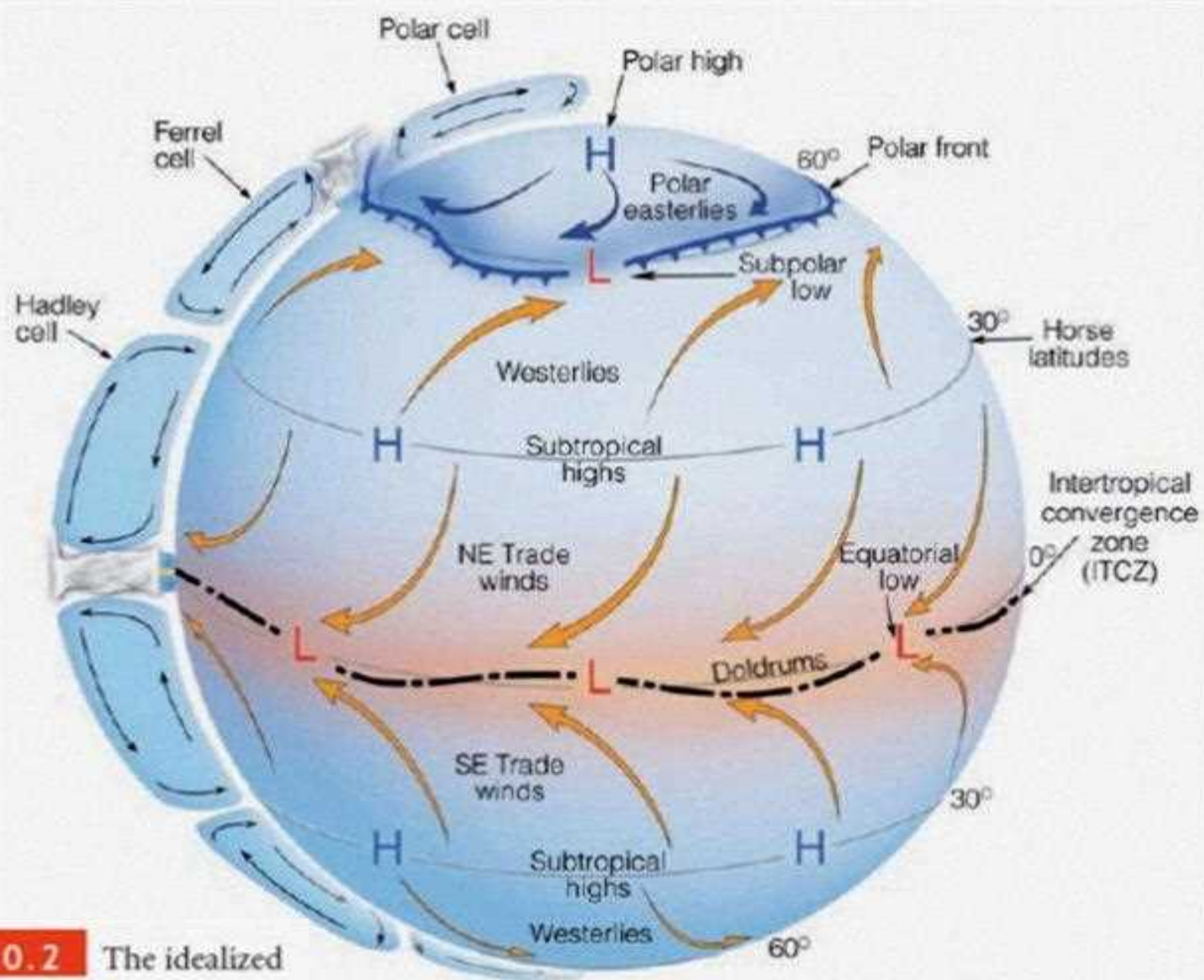
tropopause, which acts like a barrier, causing the air to move laterally toward the poles. The Coriolis force deflects this poleward flow toward the right in the Northern Hemisphere and to the left in the Southern Hemisphere, providing westerly winds aloft in both hemispheres. (We will see later that these westerly winds reach maximum velocity and produce jet streams near 30° and 60° latitudes.)

As air moves poleward from the tropics, it constantly cools by giving up infrared radiation, and at the same time it also begins to converge, especially as it approaches the middle latitudes.* This convergence (piling up) of air aloft increases the mass of air above the surface, which in turn causes the air pressure at the surface to increase. Hence, at latitudes near 30° , the convergence of air aloft produces belts of high pressure called **subtropical highs** (or anticyclones). As the converging, relatively dry air above the highs slowly descends, it warms by compression. This subsiding air produces generally clear skies and warm surface temperatures; hence, it is here that we find the major deserts of the world, such as the Sahara. Over the ocean, the weak pressure gradients in the center of the high produce only weak winds. According to legend, sailing ships traveling to the New World were frequently becalmed in this region, and, as food and supplies dwindled, horses were either thrown overboard or eaten. As a consequence, this region is sometimes called the **horse latitudes**.

From the horse latitudes, some of the surface air moves back toward the equator. It does not flow straight back, however, because the Coriolis force deflects the air, causing it to blow from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. These steady winds provided sailing ships with an ocean route to the New World; hence, these winds are called the **trade winds**. Near the equator, the *northeast trades* converge with the *southeast trades* along a boundary called the **intertropical convergence zone (ITCZ)**. In this region of surface convergence, air rises and continues its cellular journey.

Meanwhile, at latitude 30° , not all of the surface air moves equatorward. Some air moves toward the poles and deflects toward the east, resulting in a more or less westerly air flow—called the *prevailing westerlies*, or, simply, **westerlies**—in both hemispheres. Consequently, from Texas northward into Canada, it is much more common to experience winds blowing out of the west than from the east. The westerly flow in the real world is not constant as migrating areas of high and low pressure break up the surface flow pattern from time to time. In the middle latitudes of the Southern Hemisphere, where the surface is mostly water, winds blow more steadily from the west.

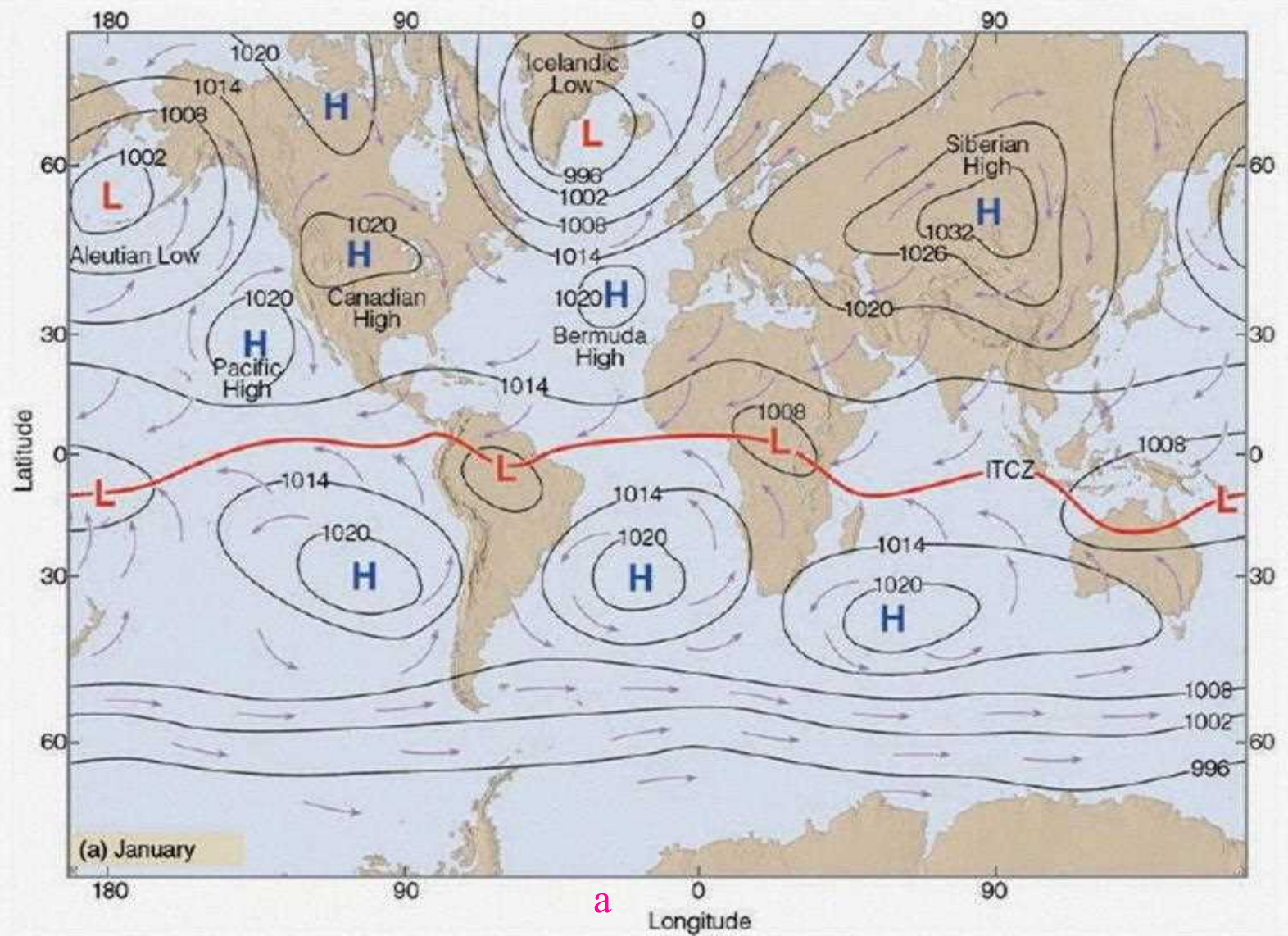
We can summarize all of this by referring back to Fig. 10.2 and noting that, at the surface, there are two major areas of high pressure and two major areas of low pressure. Areas of high pressure exist near latitude 30° and the poles; areas of low pressure exist over the equator and near 60° latitude in the vicinity of the polar front. By knowing the way the winds blow around these systems, we have a generalized picture of surface winds throughout the world. The trade winds extend from the subtropical high to the equator, the westerlies from the subtropical high to the polar front, and the polar easterlies from the poles to the polar front.



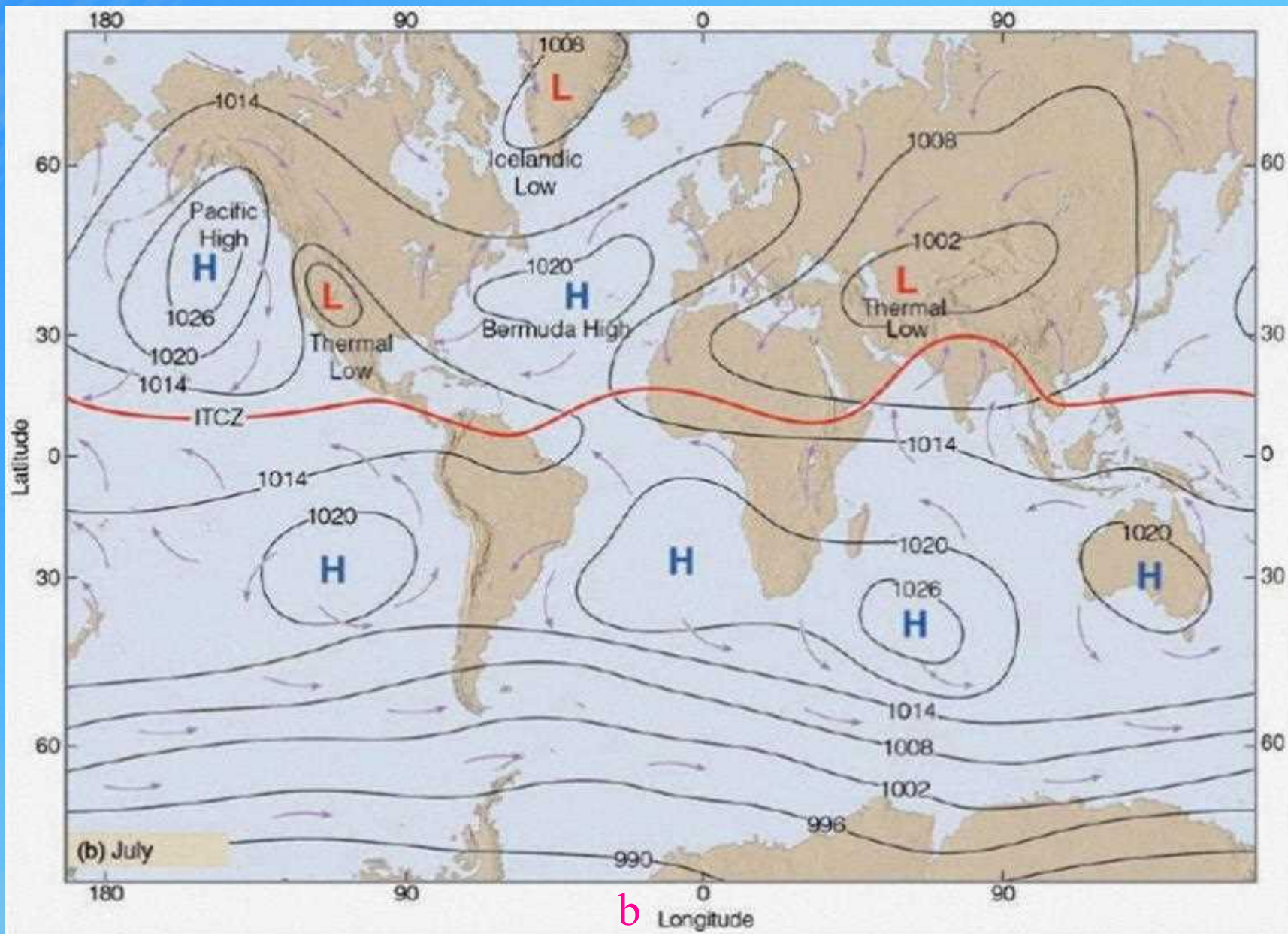
ACTIVE FIGURE 10.2 The idealized wind and surface-pressure distribution over a uniformly water-covered rotating earth. Visit the Meteorology Resource Center to view this and other active figures at academic.cengage.com/login

AVERAGE SURFACE WINDS AND PRESSURE: THE REAL WORLD When we examine the real world with its continents and oceans, mountains and ice fields, we obtain an average distribution of sea-level pressure and winds for January and July, as shown in ● Fig. 10.3a and 10.3b. Look closely at both maps and observe that there are regions where pressure systems appear to persist throughout the year. These systems are referred to as **semipermanent highs and lows** because they move only slightly during the course of a year.

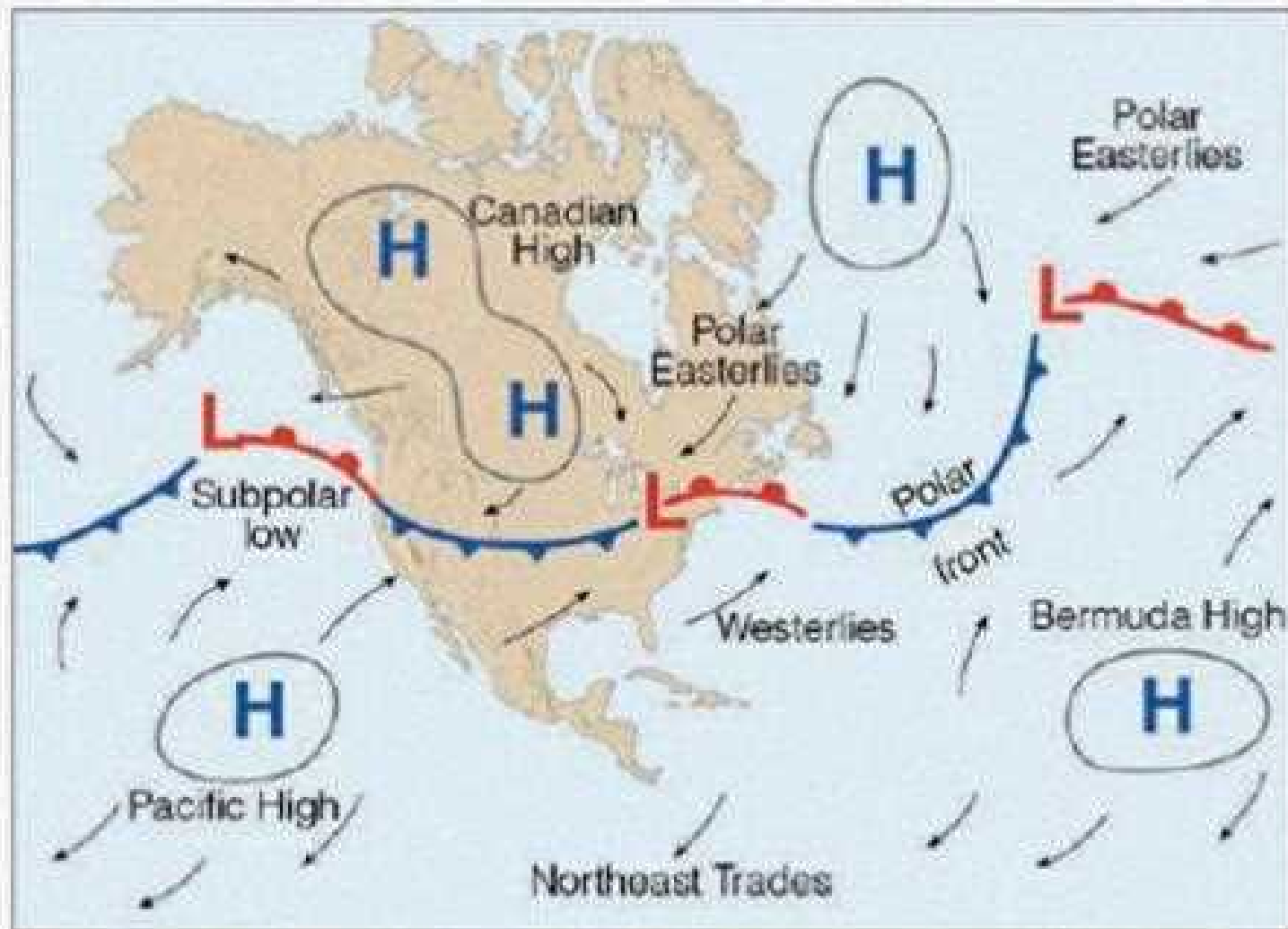
In Fig. 10.3a, we can see that there are four semipermanent pressure systems in the Northern Hemisphere during January. In the eastern Atlantic, between latitudes 25° and 35°N is the *Bermuda–Azores high*, often called the **Bermuda high**, and, in the Pacific Ocean, its counterpart, the **Pacific high**. These are the subtropical anticyclones that develop in response to the convergence of air aloft near an upper-level



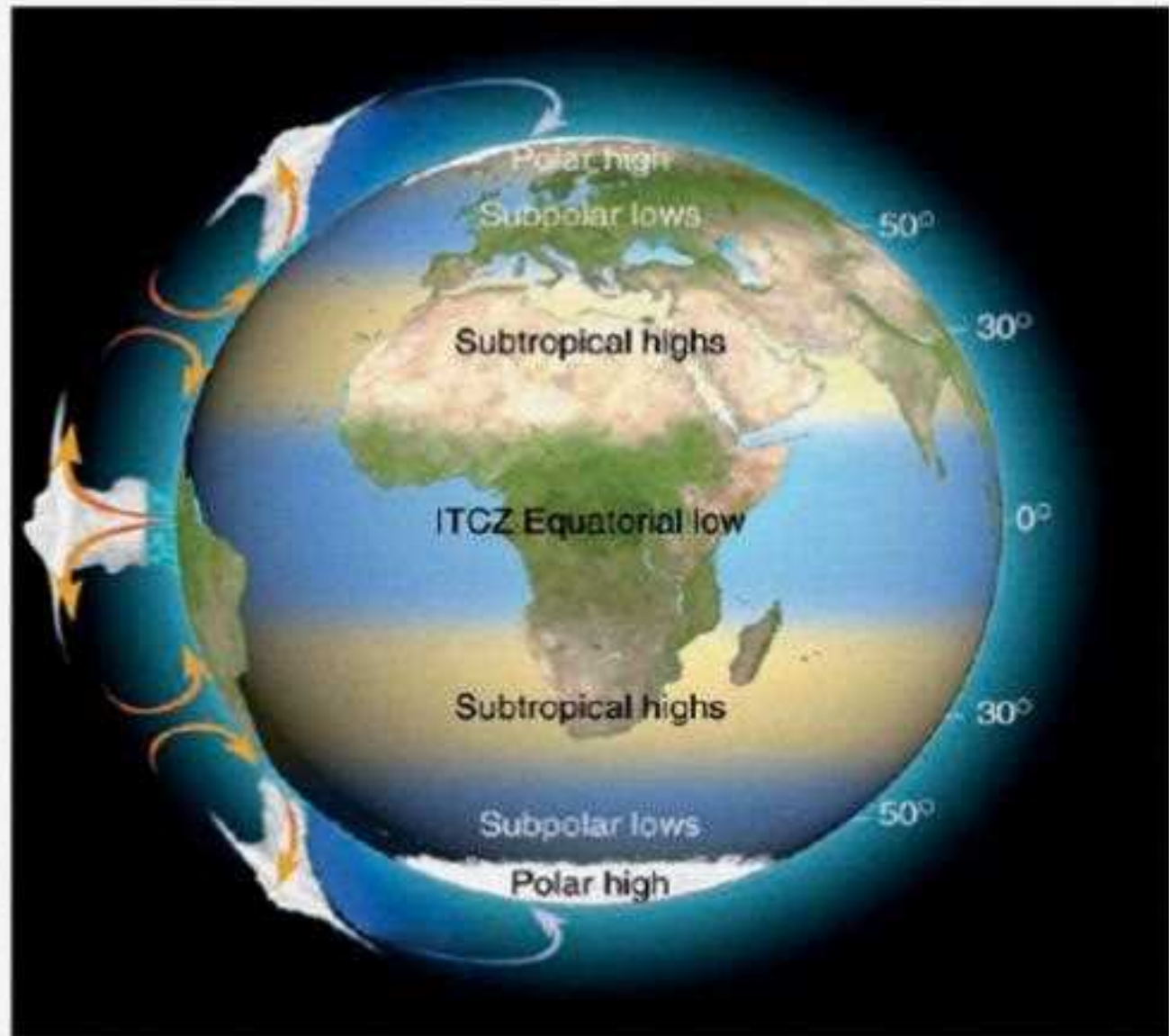
● **FIGURE 10.3** Average sea-level pressure distribution and surface wind-flow patterns for January (a) and for July (b). The solid red line represents the position of the ITCZ.



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● **FIGURE 10.4** A winter weather map depicting the main features of the general circulation over North America. Notice that the Canadian high, polar front, and subpolar lows have all moved southward into the United States, and that the prevailing westerlies exist south of the polar front. The arrows on the map illustrate wind direction.



● **FIGURE 10.5** Rising and sinking air associated with the major pressure systems of the earth's general circulation. Where the air rises, precipitation tends to be abundant (blue shade); where the air sinks, drier regions prevail (tan shade). Note that the sinking air of the subtropical highs produces the major desert regions of the world.



● **FIGURE 10.6** During the summer, the Pacific high moves northward. Sinking air along its eastern margin (over California) produces a strong subsidence inversion, which causes relatively dry weather to prevail. Along the western margin of the Bermuda high, southerly winds bring in humid air, which rises, condenses, and produces abundant rainfall.

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