Journal of Geography

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/rjog20>

The General Circulation of the Atmosphere

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Published online: 20 May 2008.

To cite this article: Annie L. Weller (1911) The General Circulation of the Atmosphere, Journal of Geography, 10:4, 114-119, DOI: [10.1080/00221341108985661](https://doi.org/10.1080/00221341108985661)

To link to this article: <http://dx.doi.org/10.1080/00221341108985661>

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First—The primitive inhabitants of the region.

Second—The earliest settlers in the region, their heroism and the courses they followed—probably rivers—in entering the locality.

Third—The development, chartering, and naming of the towns.

Fourth—The earliest industrial life of the region and why?

Fifth—Later and present day industrial life.

Sixth—Biography of past and present day leaders in exploration, settlement, industry, education, politics and religion. Each biography should tell who the man was, what he did, and how he did it.

THE GENERAL CIRCULATION OF THE ATMOSPHERE

By ANNIE L. WELLER,
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AIR MOVEMENT AND ITS CAUSES.—Wind is air in motion. Were the earth everywhere at the same temperature the air would be practically motionless, but let one small portion be heated more than its surroundings and motion begins. Being heated, the air expands—that is, the molecules push farther apart and since the direction of least resistance is upward, the greatest expansion is up. Air, of course, is not in layers but for the purpose of analysis let us imagine it so arranged. In figure 1 let lines a, b, c, d, e, represent the dividing surfaces between layers, and the dotted

Fig 1

lines the dividing surfaces after expansion has taken place, calling the dotted lines a', b', c', d', e'. Since a cubic inch of air p is below the surface d', while m and n are above it, p has more air pressing down upon it and it will therefore press outward toward m and n and will tend to move outward. As soon as this movement begins the pressure at z is relieved and that at x and y is increased and the air from x and y will move in toward z, pushing the air at z up. The circulation is now started and will con-

tinue as in fig. 2 so long as the air about z is heated more than that around it.

Fig 2

THE MOVEMENT OF AIR ON THE EARTH WITHOUT THE INFLUENCE OF ROTATION

Since the temperature near the equator is higher than that near the poles, the process explained above is continually going on. The air over the equatorial region pushes out to the north and south, relieving the pressure at the equator and increasing it to the north and south. The air near the earth's surface now pushes toward the equator, causing rising currents at that place. The circulation is now established with winds toward the equator in the lower air, upward currents at the equator and winds toward the poles in the upper air.

Since the 30° parallel divides the surface of each hemisphere approximately into halves, there must always be half of the air of the hemisphere on either side of this parallel and some air will begin to rise from the lower atmosphere as soon as it passes 30° , while some will sink from the upper atmosphere as soon as it passes 30° in going toward the poles. Since the meridians, poleward of 30° , approach each other more rapidly than they diverge in the lower latitudes the downward movement would

Fig 3

be stronger and more noticeable. Figure 3 illustrates this general hemispherical movement of the air.

Influence of Rotation. Ferrel's Law.—Should a body be started mov-

ing in space in a definite direction, it would keep that direction unless some force from outside itself were brought to bear upon it to cause a change; so air, moving along any meridian near the earth would tend to keep in line with that meridian, if the earth were motionless, but if the earth rotates the meridian changes its direction relative to space while the air tends to keep its direction; the result is that the air moves to the right of the meridian in the northern hemisphere and to the left in the southern. This change may be easily seen by using a globe and a pencil pointed to represent wind direction; it is stated in Ferrel's law as follows: *All freely moving matter on or near the surface of the earth, is deflected, by a force arising from the rotation of the earth, to the right of its course in the northern hemisphere and to the left in the southern.*

The Trade Winds—Northern Hemisphere.—We have already seen that because of differences of temperature between the poles and the equator the lower air moves toward the equator. Beginning, then from 30° latitude to the equator the air should all be moving either south or upward, but because of the deflective force of rotation it is turned to the right of its course and becomes a northeast wind.

Southern Hemisphere.—In the southern hemisphere the wind comes from the south, is turned to the left and becomes a southeast wind. In

Fig 4

figure 4 the dotted arrows represent the winds directed by temperature differences alone, while the solid arrows show the winds as they are deflected by rotation.

The Upper Air Movement.—As the air approaches the equator, moving toward the west, it begins to rise and in rising keeps its westward motion. In the upper atmosphere as the air moves away from the equator it is deflected, and when it reaches about 30° latitude it is moving due north in the northern hemisphere and due south in the southern, and from that latitude on it is turned to the east and becomes a westerly wind.

The Belt of Westerlies.—As the air approaches the poles it begins to sink, keeping its easterly course till it nears the earth's surface, where it is gradually turned again toward the equator, since it is deflected by rotation. It now becomes what is termed the prevailing westerly wind, not

being turned enough to come from the east till after it has passed latitude 30° and has again joined with the trades.

Several factors tend to keep this air turned toward the east notwithstanding the deflective force of rotation. First: The sinking currents tend to retard its velocity and the less the velocity the less the deflective force. Second: These sinking currents tend to keep the direction of motion of the upper air which is toward the north-east. Third: Since everywhere between the poles and 30° latitude the air is moving toward the east there is a whirl formed with the pole as its center and centrifugal force tends to pile up the air at the outside of the whirl, that is, at 30° latitude, thus causing high pressure at that place. From this belt of high pressure the air flows off to the north and south. That going toward the equator joins the trades, while that going toward the poles strengthens the westerlies since it is deflected from its straight course by rotation and becomes a southwest wind in the northern hemisphere and a northwest wind in the southern.

The Horse Latitudes or Tropical Calms and the Doldrums.—Since there is a belt of high pressure at 30° latitude we find the air pressing down and out. This sinking air forms the calms called the horse latitudes. At the equator the rising air forms the equatorial calms or doldrums.

Fig 5

The Ideal Circulation.—The winds of the general circulation, then, are as follows: (1) at the equator the doldrums or calms with rising currents;

(2) from this belt north and south to 30° latitude, the trade winds with their directions northeast in the northern and southeast in the southern hemisphere;

(3) at 30° latitude there are the horse latitudes or tropical calms with sinking air currents;

(4) from the belt of tropical calms toward the poles are the belts of prevailing westerlies with wind from the southwest in the northern hemisphere and from the northwest in the southern;

(5) in the upper air the general direction of winds is southwest in the northern and northwest in the southern hemisphere.

Variations from the Ideal Circulation.

A. Periodical winds

1. Land and water distribution

Since land absorbs heat more easily than water and gives it off more easily after absorption, than water, a land surface in summer is warmer and in winter is colder than a water surface; therefore there is a tendency for air to move from the water to the land in summer and from the land to the water in winter, forming the monsoon winds. The differences in temperature between day and night give the same conditions, resulting in land and sea breezes.

2. Shifting of the heat equator.

As the vertical rays of the sun shift to the north and south of the mathematical equator, the belt of greatest heat follows, causing the doldrum belt to shift also. When the doldrum belt lies to the north of the equator the southeast trades cross into the northern hemisphere, are deflected to the right and become southwest winds. When this belt of greatest heat lies south of the equator the northeast trades similarly cross to the southern hemisphere and are turned to the left, becoming northwest winds. Such variations are most noticeable in places like India where these winds join with and intensify the monsoons.

As the belts of trades are shifted to the north or south, the horse latitudes are pushed out of their ideal position, passing in some places far north or south of latitude 30°.

B. Variable winds

1. Cyclonic and anticyclonic winds

In middle latitudes there is a series of high and low pressure areas, often large enough in horizontal extent to cover a large part of the United States, which are constantly passing to the east, keeping in general the direction of the prevailing winds. In the cyclones or "low" areas, which move on the average about 30 miles an hour, the winds blow in toward the center from all directions, shifted slightly by the rotation of the earth. In the anticyclones or "high" areas the conditions are the opposite, the winds blowing out from the center. In so much as these areas pass over us every few days in middle latitudes giving to each place the winds of the different parts of the area, the winds of the middle latitudes are extremely variable. Large "high" and "low" areas are more or less constant over the large land and water masses, varying their location only with the season. These, however, tend to give periodical changes of winds.

2. Surface features

Where prevailing winds strike mountain ranges they are turned more or less in a direction parallel with the range. The amount they are turned from their course depending somewhat upon their force.

Summary.—The general circulation of the atmosphere, then, comprises the prevailing westerlies, the tropical calms, the trade winds and the equatorial calms with the upper air moving toward the poles. This is interfered with by (1) land and water distribution; (2) the shifting of the region of greatest heat; (3) the cyclonic and anticyclonic areas and (4) the surface features of the earth.

THE WORLD'S GREAT RIVERS—THE ST. LAWRENCE

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IN the gulf and estuary of the St. Lawrence River, North America has an open gate turned invitingly toward Europe. It is not surprising, therefore, that but a few years elapsed after the discovery of the western continents before the enterprising Cartier came upon this entrance and turned his ships in to explore. Inside a most remarkable water lane led to the very heart of a great continent.

The St. Lawrence River, in its most limited bounds, begins at the foot of Lake Ontario, opposite the city of Kingston, and extends about 775 miles in a northeasterly direction to the Point des Monts which is generally conceded to mark, however poorly, the inward limit of the gulf. The river is seldom less than two miles in width and at several points expands to lake-like proportions. At the Point des Monts it is about eighty miles wide.

Scattered at intervals throughout the course of this great stream are numerous islands. At the very outset, near the foot of Lake Ontario, a group commonly known as the Thousand Islands contains in reality more nearly two thousand isolated points of very ancient and contorted rock. Projecting above the stream, gray sided and forest covered, they break the monotony of the water surface and create in that placid body the mystery of countless winding channels.

In the clearness of its waters and the constancy of its volume the St. Lawrence is of all great rivers peculiar. The cause for this is found in the fact that the stream has its source in the greatest body of fresh water in the world, which acts as a settling tank to remove sediment and as a storage reservoir to regulate its flow. It is the only river of great size whose volume is not sensibly affected by seasonal changes. From flood-