Gaspard-Gustave Coriolis (1792–1843)

- French mathematician, mechanical engineer
- Coined term “work” (= force acting through a distance)
- One of the first to formulate correct expression for kinetic energy (½mv^2)

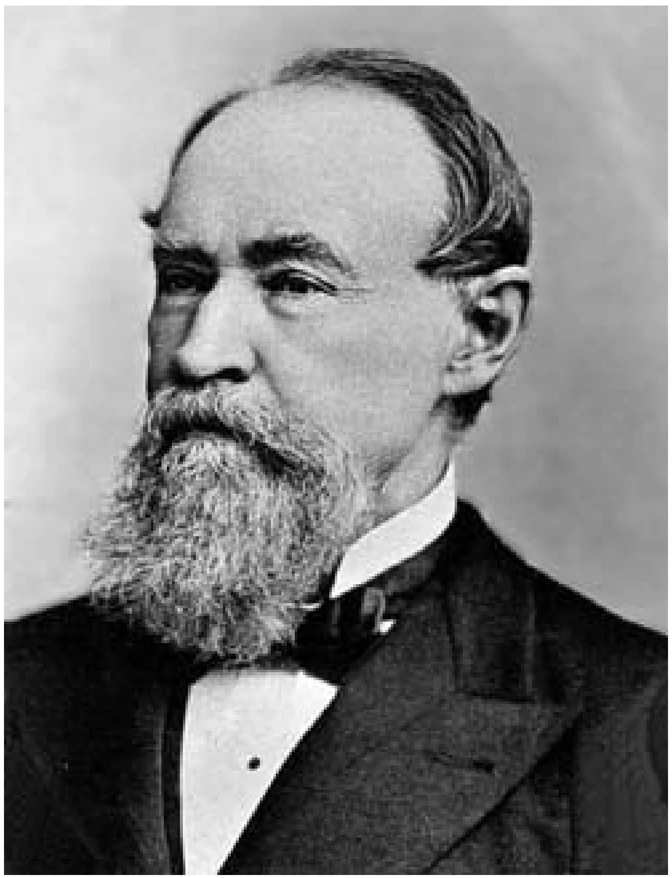
- His work on (apparent) forces in rotating systems did not address any atmospheric science problems
- Contemporary scientists working on atmospheric problems were not aware of his work on rotating systems

<u>Jean Bernard Léon Foucault (1819–1868)</u>

Foucault Pendulum in the Panthéon, Paris

William Ferrel

(1817–1891)
An essay on the winds and the currents of the ocean. Nashville Journal of Medicine and Surgery (1856).



Ferrel, 1858:

THE
ASTRONOMICAL JOURNAL.

No. 109.

VOL. V. ALBANY, 1858, JANUARY 20. NO. 13.

THE INFLUENCE OF THE EARTH'S ROTATION UPON THE RELATIVE MOTION OF BODIES NEAR ITS SURFACE.

BY W. FERREL.

If a body upon or near the earth's surface receive a motion relatively to the earth, either by means of a single impulse or by a continually acting force, this motion, combined with the rotatory motion of the earth, gives rise to a deflecting force relatively to the earth, which causes a different relative motion from that of a body acted upon in a similar manner upon the earth at rest. It is proposed, in this paper, to examine a few of the effects produced by this deflecting force.

Let x, y and z be three rectangular coördinates having their origin at the center of the earth, x corresponding with the axis; and P, Q and R be the forces which act respectively in the directions of these ordinates. We shall then have

$$\frac{ddx}{dt^2} = P\,; \quad \frac{ddy}{dt^2} = Q\,; \quad \frac{ddz}{dt^2} = R. \qquad [1]$$

Let r = the distance of the body from the earth's center
θ = its polar distance
ϖ = its longitude [printed π in the fractions]
nt = the rotatory motion of the earth.

We shall then have

$$x = r\cos\theta\,; \quad y = r\sin\theta\cos(nt+\varpi)\,; \quad z = r\sin\theta\sin(nt+\varpi) \qquad [2]$$

Substituting the second differential of the value of x in the first of equations [1], we get

$$\cos\theta\frac{ddr}{dt^2} - 2\sin\theta\frac{dr}{dt}\cdot\frac{d\theta}{dt} - r\cos\theta\frac{d\theta^2}{dt^2} - r\sin\theta\frac{dd\theta}{dt^2} = P \qquad [3]$$

Substituting in like manner the second differentials of y and z in the last two of equations [2], and multiplying the former by $\cos(nt+\varpi)$ and the latter by $\sin(nt+\varpi)$, and adding, we get

$$\sin\theta\frac{ddr}{dt^2} + 2\cos\theta\frac{dr}{dt}\cdot\frac{d\theta}{dt} - r\sin\theta\frac{d\theta^2}{dt^2} + r\cos\theta\frac{dd\theta}{dt^2} - r\sin\theta\left(n+\frac{d\pi}{dt}\right)^2 = \cos(nt+\varpi)\,Q + \sin(nt+\varpi)\,R \qquad [4]$$

Multiplying equation [3] by $\cos\theta$ and equation [4] by $\sin\theta$, and adding, we get the first of equations [5]. Multiplying the former by $\sin\theta$ and the latter by $\cos\theta$, and subtracting, we get the second of equations [5]. Again, after substituting the second differentials of y and z, as stated above, in the last two of equations [1], if we multiply the former by $\sin(nt+\varpi)$ and the latter by $\cos(nt+\varpi)$, and subtract, we get the last one of the following equations.

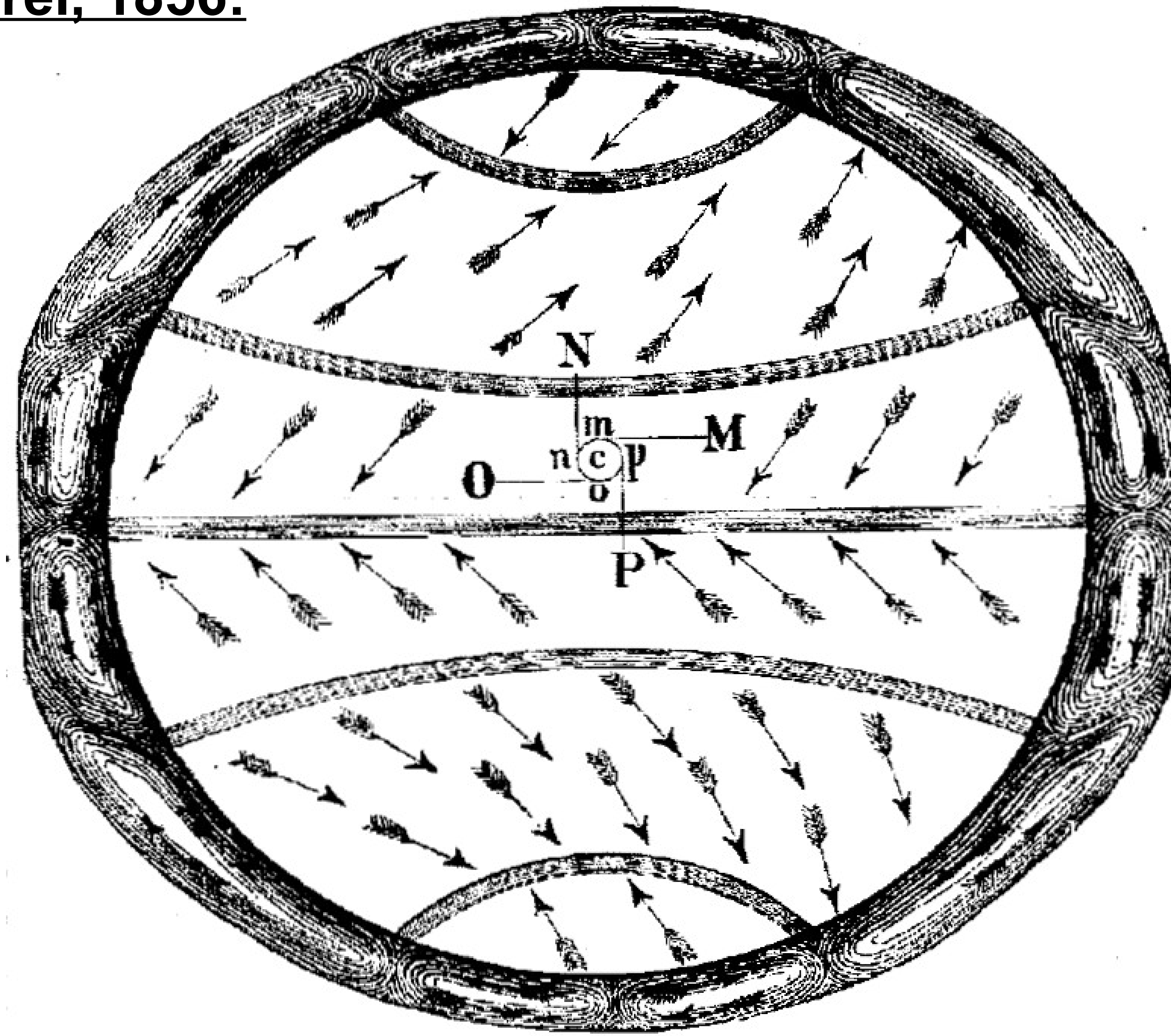
$$\frac{ddr}{dt^2} - r\frac{d\theta^2}{dt^2} - r\sin^2\theta\left(n+\frac{d\pi}{dt}\right)^2 = \cos\theta\,P + \sin\theta\cos(nt+\varpi)\,Q + \sin\theta\sin(nt+\varpi)\,R\,;$$

$$-r\frac{dd\theta}{dt^2} - 2\frac{dr}{dt}\cdot\frac{d\theta}{dt} + r\sin\theta\cos\theta\left(n+\frac{d\pi}{dt}\right)^2 = \sin\theta\,P - \cos\theta\cos(nt+\varpi)\,Q - \cos\theta\sin(nt+\varpi)\,R\,; \qquad [5]$$

$$-r\sin\theta\frac{dd\pi}{dt^2} - 2\sin\theta\left(n+\frac{d\pi}{dt}\right)\frac{dr}{dt} - 2r\cos\theta\left(n+\frac{d\pi}{dt}\right)\frac{d\theta}{dt} = (\sin nt+\varpi)\,Q - \cos(nt+\varpi)\,R.$$

"If a body is moving in any direction, there is a force arising from the Earth's rotation, which always deflects it to the right in the northern hemisphere, and to the left in the southern hemisphere."

Ferrel, 1856:



From Hann-Süring (Lehrbuch der Meteorologie - “Textbook of Meteorology”, 1926): (loosely translated)

“Ferrel's Theory … was first published at places and in such a form, that hampered its distribution and recognition. The mathematical form, in which it appeared, was not very comprehensible to most readers and likewise appeared uninviting to others, due to its lack of elegance.”