http://www.youtube.com/watch?v=_R7L5DNvgfU

http://www.youtube.com/watch?v=mcPs_OdQOYU&feature=related

http://www.youtube.com/watch?v=_36MiCUS1ro&NR=1

The Coriolis Effect

From the perspective of a viewer in a Fixed Frame of Reference, the Earth appears flat and motionless

Because the Earth is rotating, objects that move freely across the planet (such as ocean currents and weather systems) must be viewed in a Rotating Frame of Reference

Coriolis Effect is an “artificial force” included in the equations of fluid motion on a rotating sphere, to compensate for motions in a rotating frame that are viewed from a fixed frame

Gaspard Gustave Coriolis (1792–1843)

famous paper (1935) - ‘On the equations of relative motion of a system of bodies’

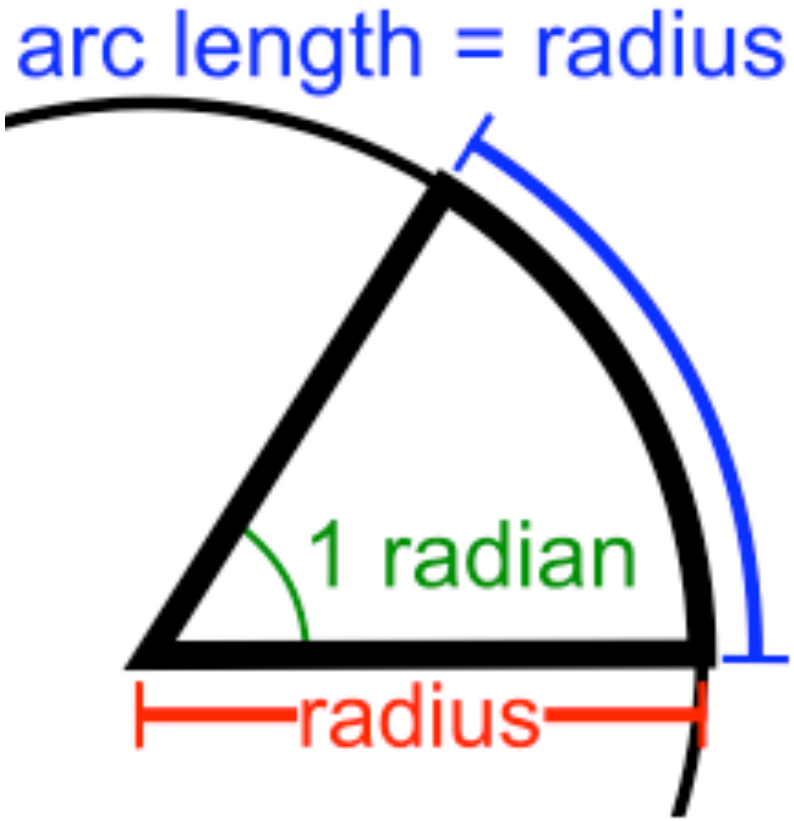
Bull Amer. Met. Soc., Persson, 79, 7, 1998,1377-1385

Earth's Rotation

- Earth's rotation gives rise to a fictitious force called the Coriolis force
- Coriolis force accounts for the apparent deflection of motions in a rotating frame
- Analogy
  - throwing a ball from a merry-go-round

radians

radian – angle subtended by arc equal in length to radius



θ = 1 rad when s / r = 1

θ is the angle in radians
s is arc length
r is radius

2πr radians / r = 360°
or
1 radian = 180/π °

Earth's Rotation

- Earth rotates about its axis wrt sun (2π rad/day)
- Earth rotates about the sun (2π rad/365.25 day)
- Earth rotates relative the "distant stars" (2π rad/86164 s)

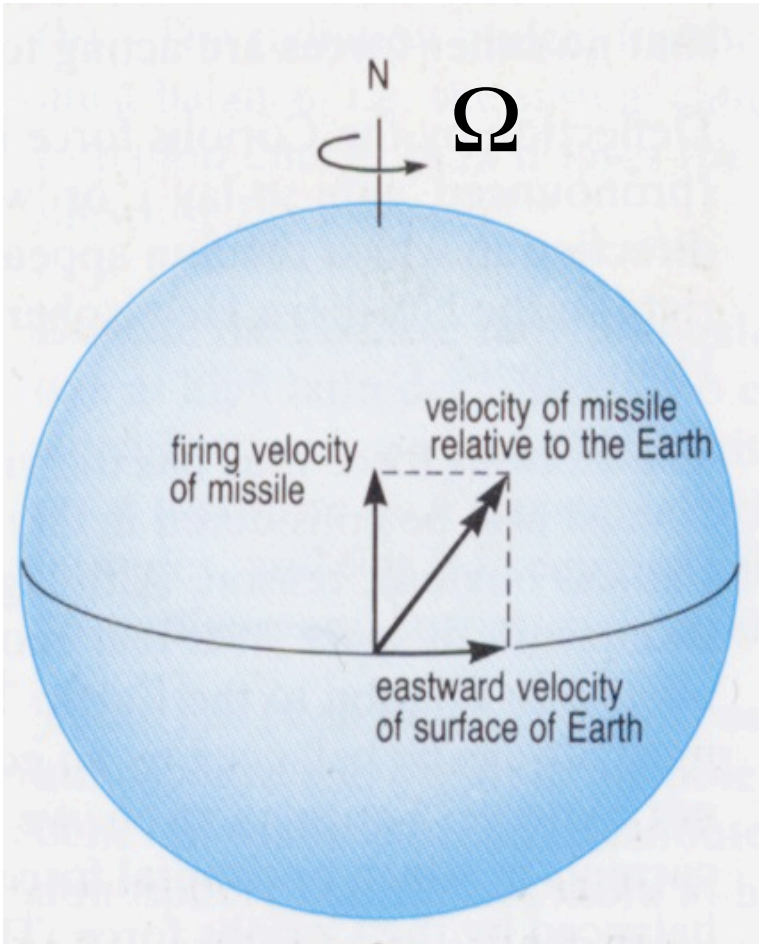
  Sidereal day = 86164 sec = ~23 hrs 56 min

  (Note: 24 h = 86400 sec)
- Thus, Earth's rotation frequency, Ω

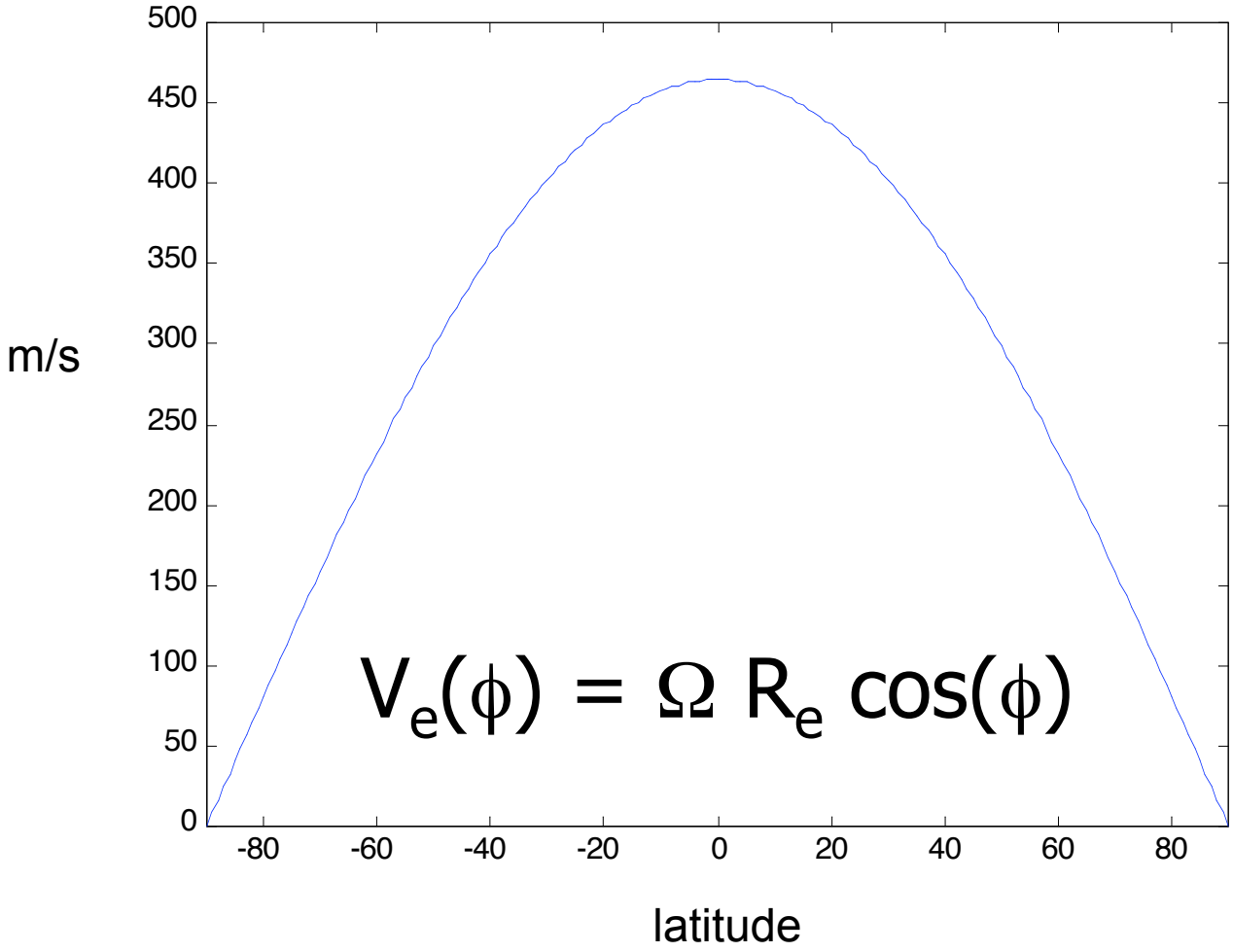
  $\Omega = 7.29 \times 10^{-5}\ s^{-1}$ (radians per sec)

Earth's Rotation

- Velocity of Earth's surface
- $V_e(Eq) = R_e \Omega$
  R_e = radius Earth (6371 km)
  $V_e(Eq)$ = 464 m/s
- as latitude, ϕ, increases,
  $V_e(\phi)$ will decrease
- $V_e(\phi) = \Omega R_e \cos(\phi)$



velocity of Earth's surface as a function of latitude



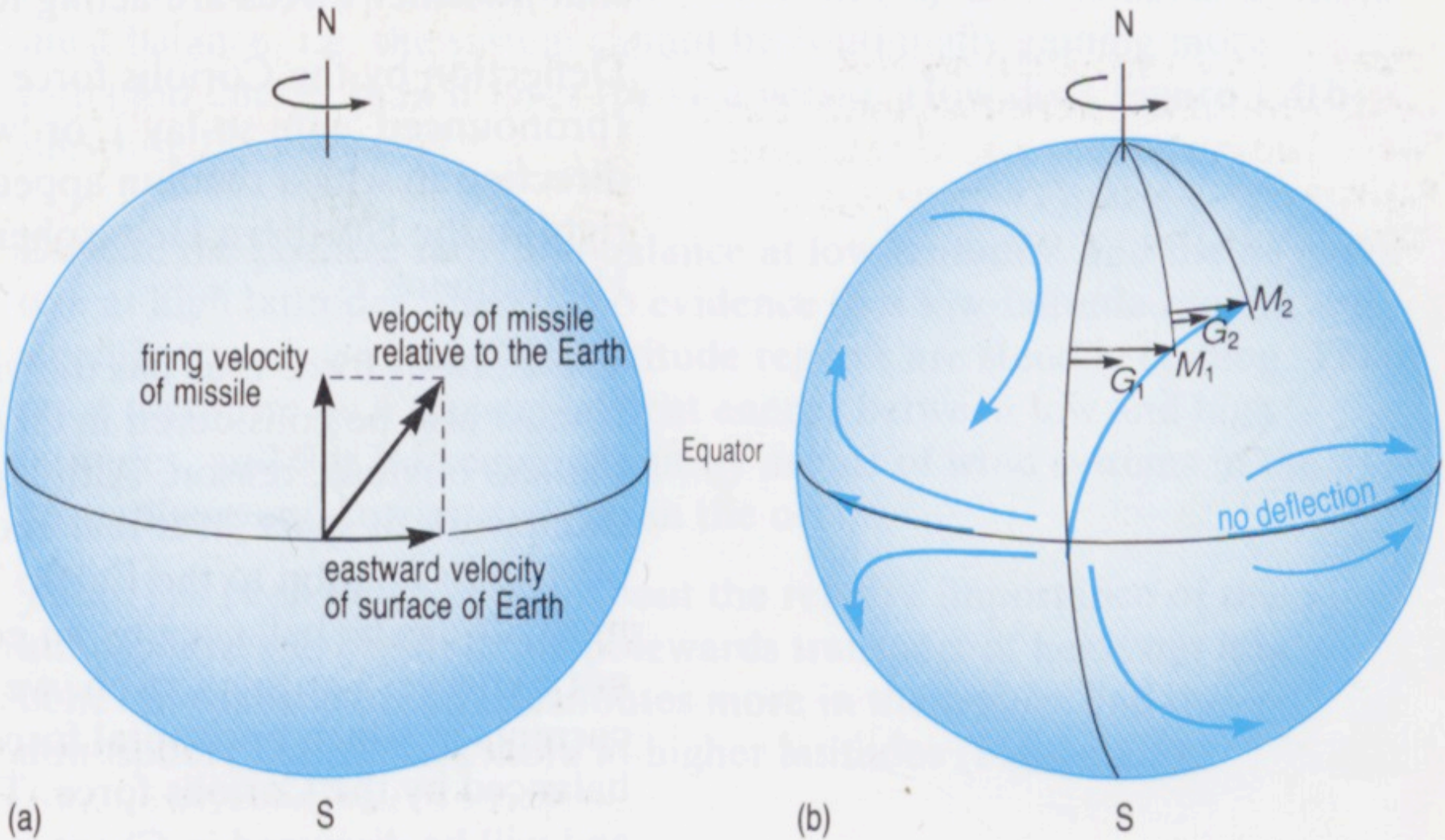


Figure 1.2 (a) A missile launched from the Equator has not only its northward firing velocity but also the same eastward velocity as the surface of the Earth at the Equator. The resultant velocity of the missile is therefore a combination of these two, as shown by the double arrow.

Earth's Rotation

- Moving objects on Earth move with the rotating frame ($V_e(\phi)$) & relative to it (v_{rel})
- The absolute velocity is $v_{abs} = v_{rel} + V_e(\phi)$
- Objects moving north from Equator will have a larger V_e than that under them
- If "real" forces sum to 0, v_{abs} will not change, but the $V_e(\phi)$ at that latitude will

Earth's Rotation

- Frictionless object moving north
  v_{abs} = const., but $V_e(\phi)$ is decreasing
  v_{rel} must increase (pushing the object east)

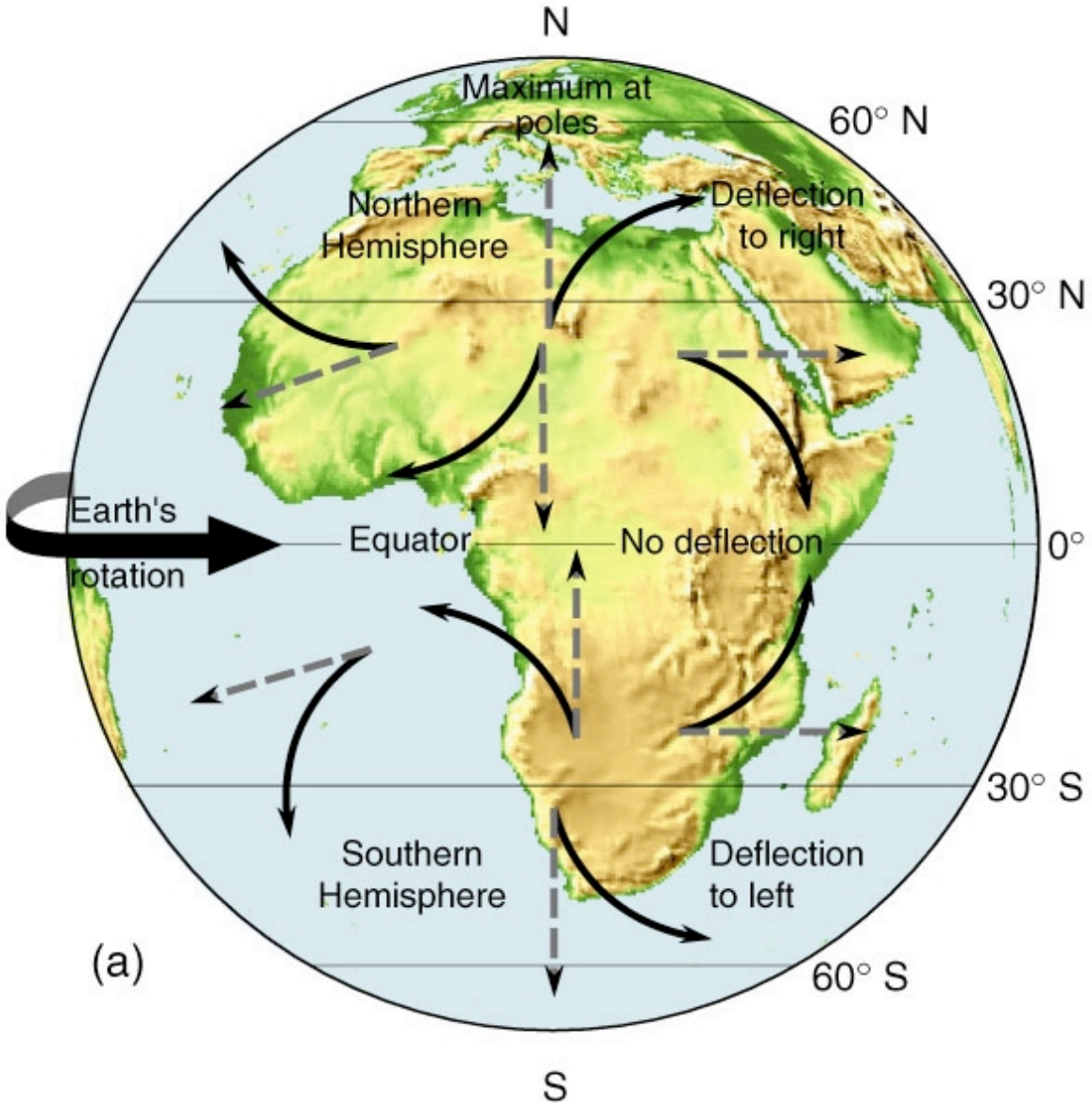
- When viewed in the rotating frame, moving objects appear deflected to right in northern hemisphere (left in SH)

- Coriolis force accounts for this by proving a "force" acting to the right of motion

Coriolis Force

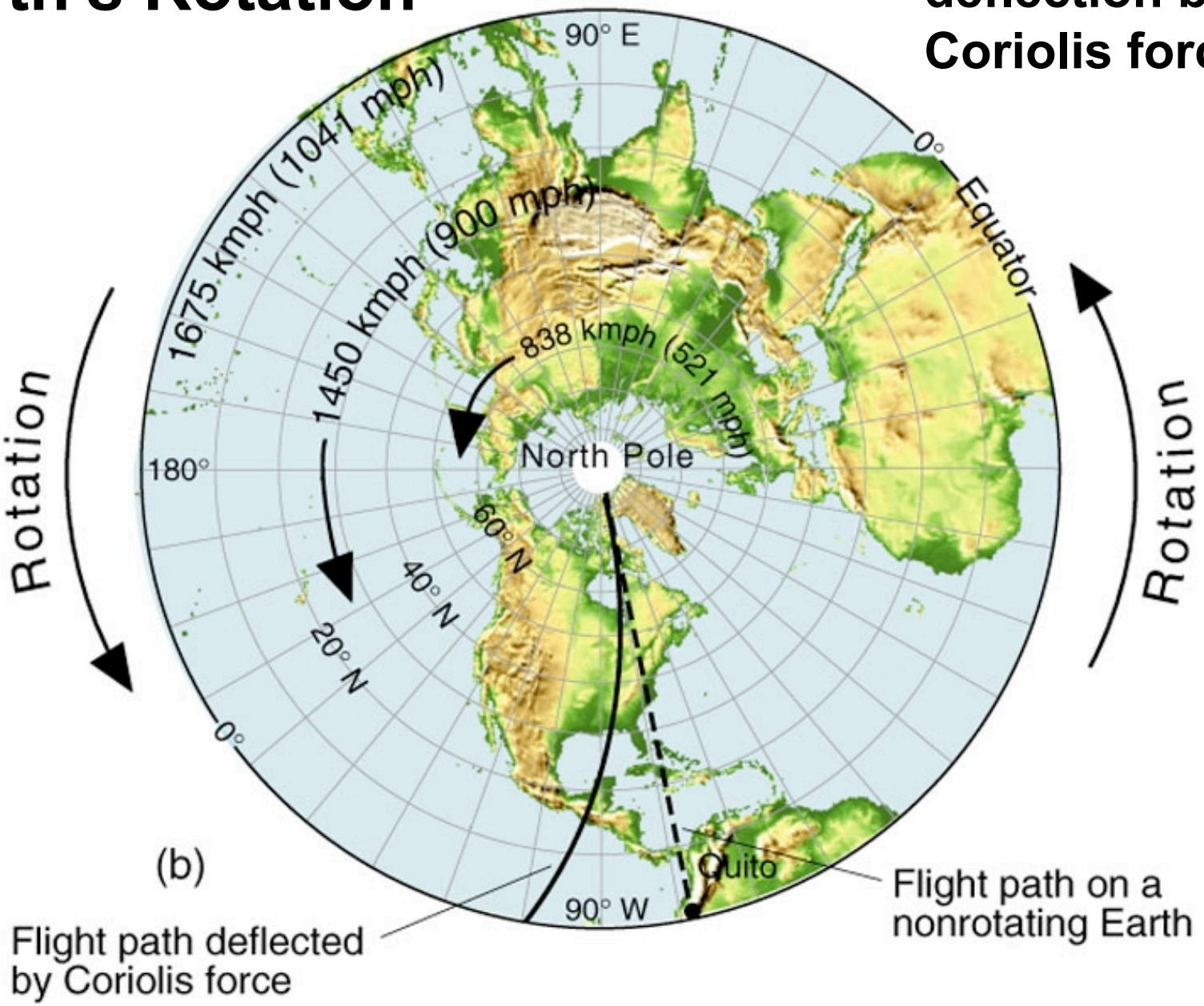
An object with an initial east-west velocity will maintain that velocity, even as it passes over surfaces with different velocities.

As a result, it appears to be deflected over that surface (right in NH, left in SH).



Earth's Rotation

deflection by Coriolis force



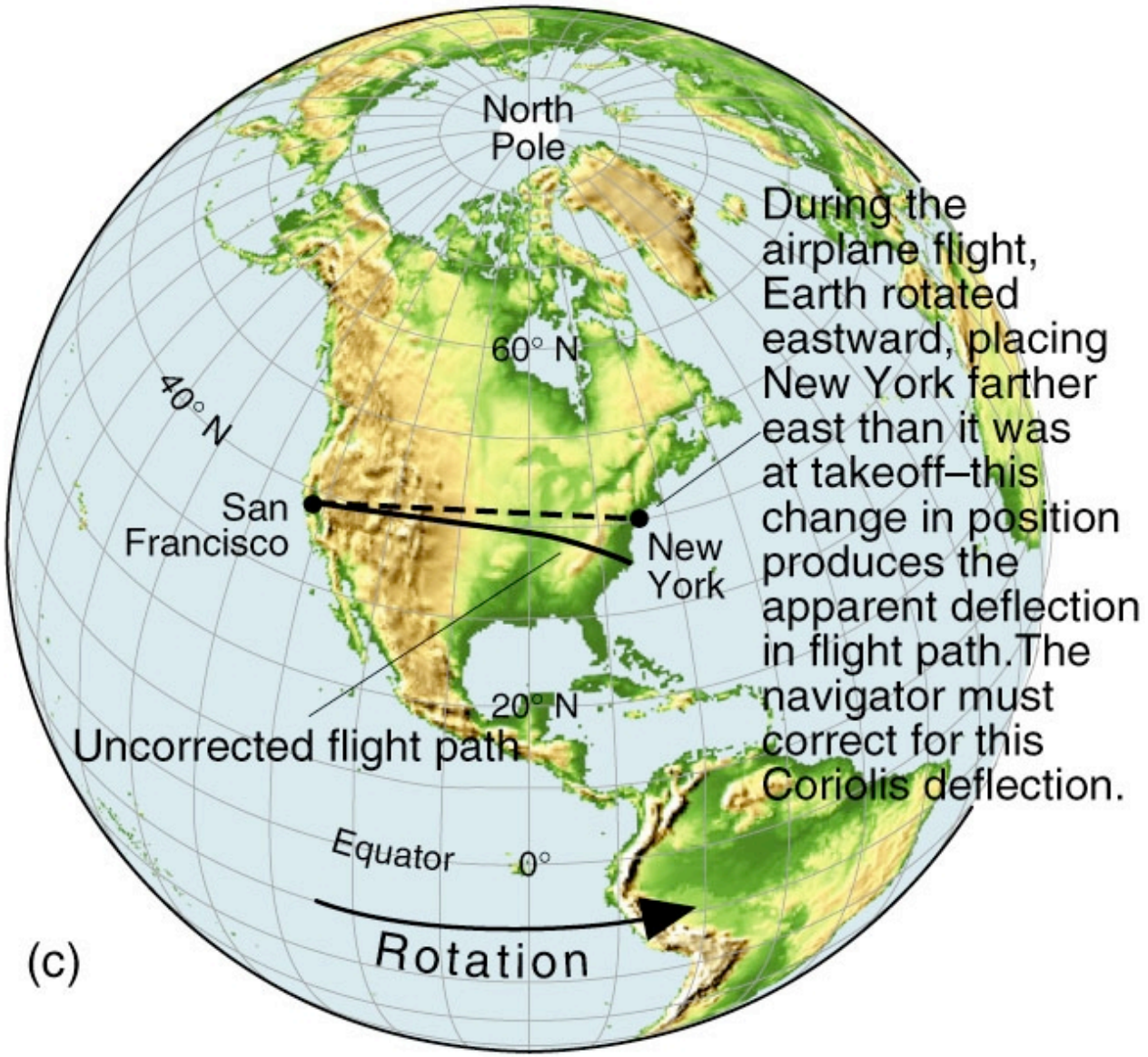

North Pole
60° N
40° N
San Francisco
New York
20° N
Uncorrected flight path
Equator
0°
Rotation
(c)
During the airplane flight, Earth rotated eastward, placing New York farther east than it was at takeoff–this change in position produces the apparent deflection in flight path. The navigator must correct for this Coriolis deflection.

TABLE 8.3 Summary of the Coriolis Effect and Its Mathematics

1. The Coriolis effect accounts for the motion of a rotating sphere (i.e., the rotational effects and sphericity of the Earth) to explain and quantify the motion of objects from the perspective of a fixed frame of reference (i.e., on the surface of the Earth).
2. From our fixed frame of reference, moving objects such as winds and currents deflect to the right of their trajectories in the Northern Hemisphere and to the left of their trajectories in the Southern Hemisphere (Figure 8-12).
3. The Coriolis effect increases with latitude. (Formally, it is proportional to the Coriolis parameter, f, which is given by $f = 2\ \Omega \sin \phi$, where ω is the rotation rate of the Earth and ϕ is latitude.)
4. The Coriolis effect for horizontal motion is zero at the equator. (At the equator, $\phi = 0$ and thus $\sin \phi$ and $f = 0$.)
5. The Coriolis effect is proportional to the velocity of the parcel of seawater or air; faster-moving objects experience greater deflections due to the Coriolis effect.
6. The Coriolis effect is most important for large-scale motions, that is, over scales greater than tens of kilometers (tens of miles), such as the circulation of the ocean and atmosphere.

Earth's Rotation (summary)

- Motions in a rotating frame will appear deflected to the right in the northern hemisphere
- Motions in a rotating frame will appear deflected to the left in the southern hemisphere
- Motions are not deflected on the equator, greatest deflection at poles, varies with latitude
- Coriolis parameter is f; $f = 2 \Omega \sin(\phi)$
  $\Omega = 7.29 \times 10^{-5}\ s^{-1}$; ϕ is latitude
- It is a matter of <u>frame of reference</u>, there is NO Coriolis "force"

Readings (Ocean and Atmosphere):

Text Chapter 8 (pgs 138 – 151)

Reader pgs. 51 – 61

HW #2 assigned; Due Friday 31 Oct 2008

Midterm on Wednesday 5 Nov 2008