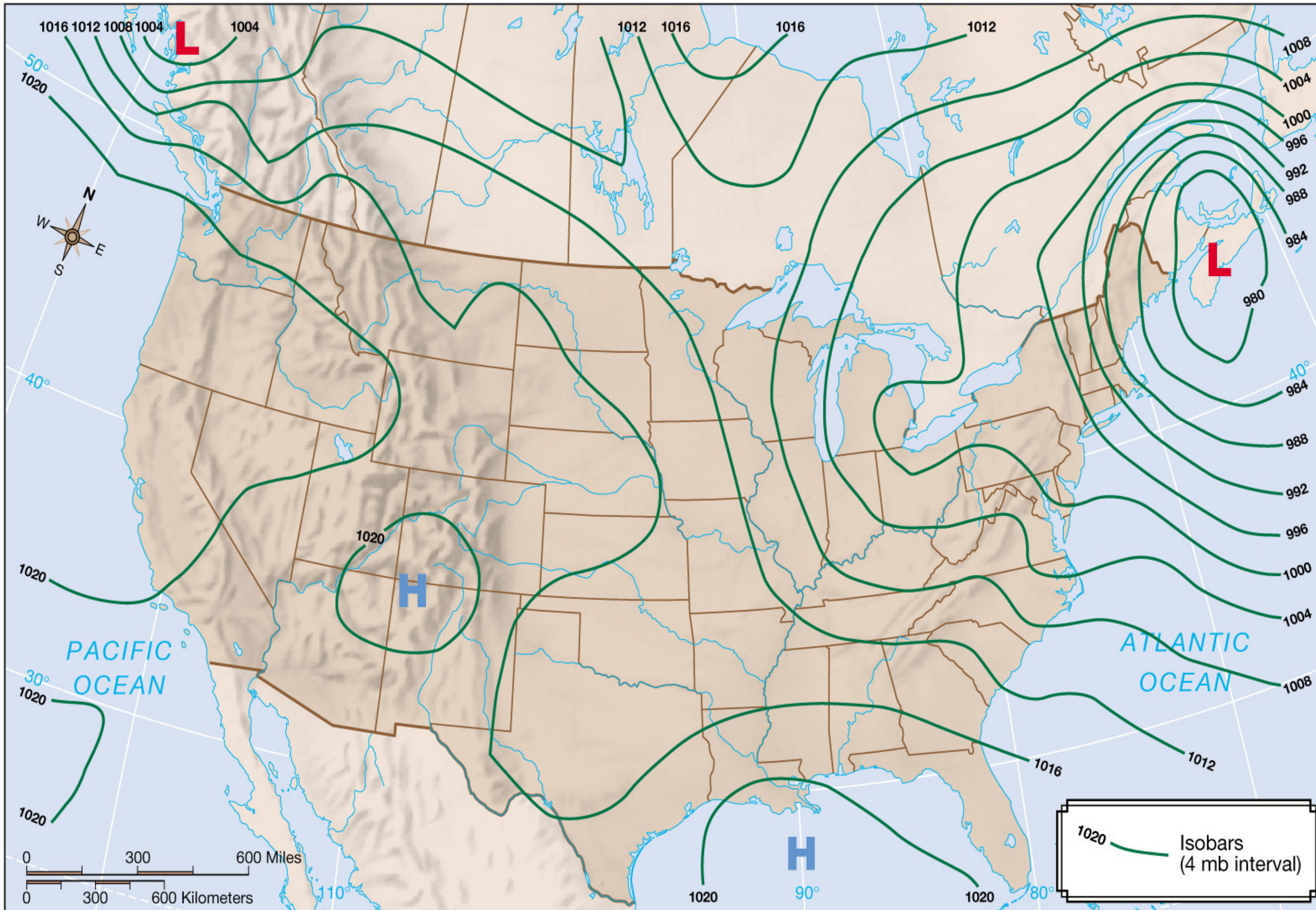
Forces and Winds

GEOG/ENST 2331 – Lecture 8
Ahrens et al., Chapter 8
Lab 3

Last lecture: Pressure gradients

- Pressure in the atmosphere
- Forces in the atmosphere
  - Pressure gradient force
  - Gravitational force
- Pressure in the upper atmosphere

Pressure Gradient – a rate of change in pressure

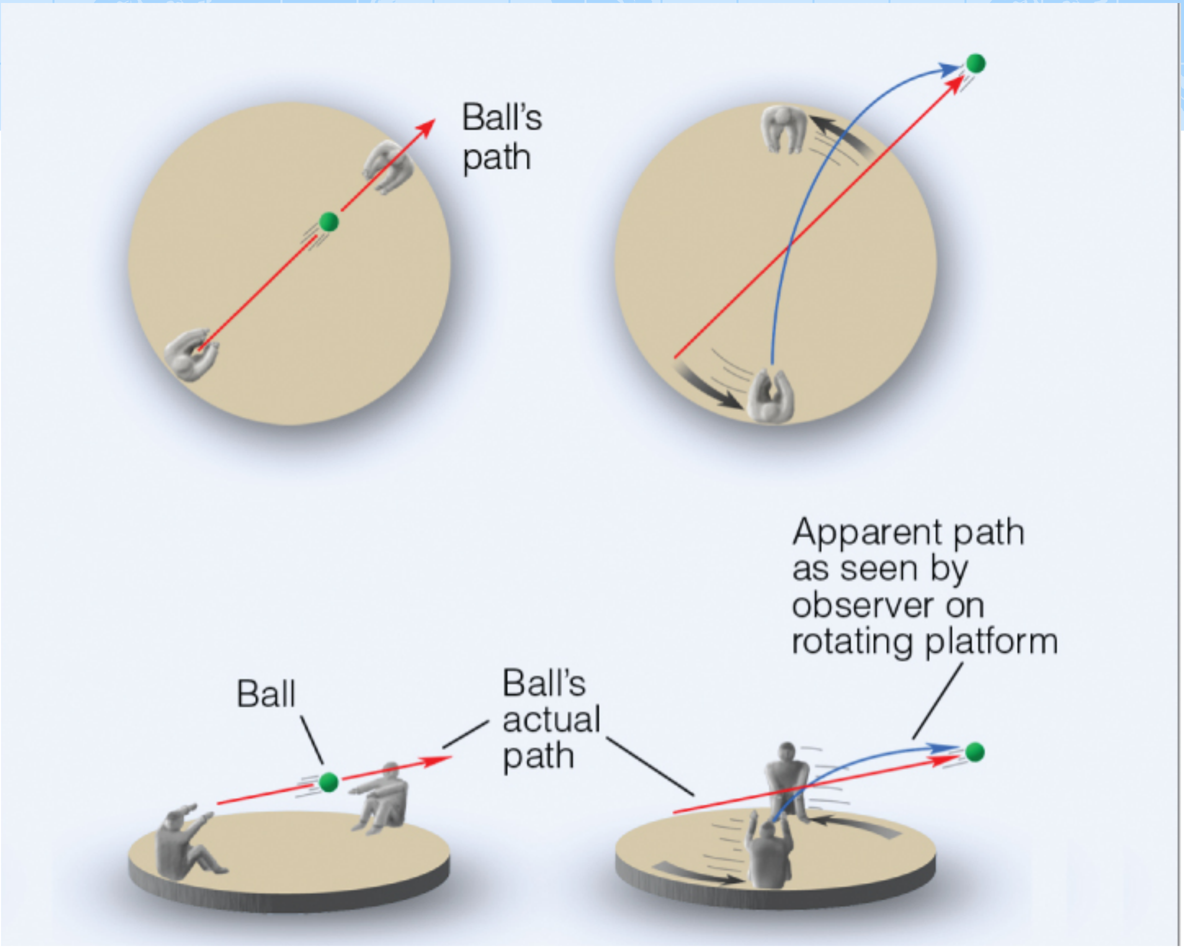


Forces and Winds

- **Coriolis force**
  - **Nature and description**
  - **Geostrophic winds**
- Frictional force
- Measuring wind

Coriolis effect

- “Fictitious” or “apparent” force due to rotation of the Earth.
- In the Northern Hemisphere (NH) moving objects are deflected to the **right**.
- In the Southern Hemisphere, the deflection is to the **left**.
- Only noticeable on large scales (hundreds of kilometres).

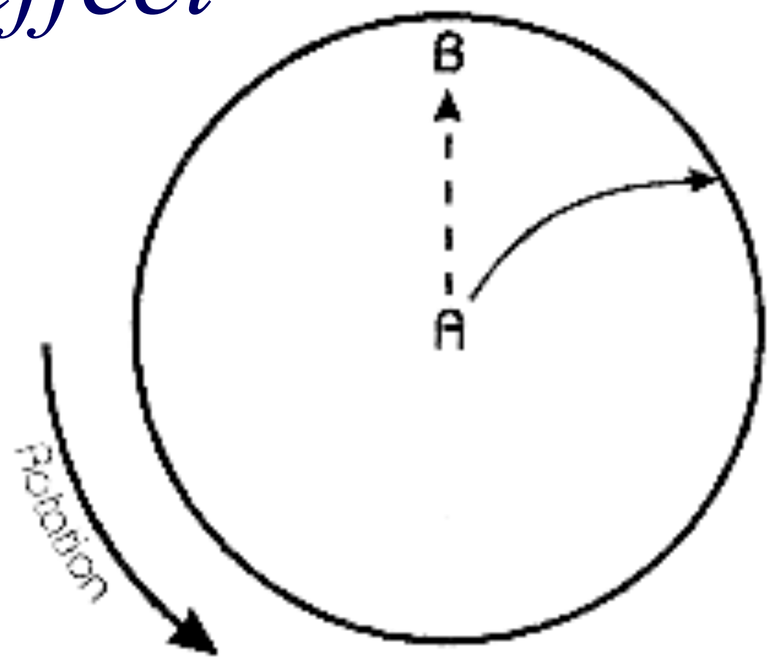


Coriolis effect

The ball is thrown straight at the target, but the target is moving.
The *apparent* trajectory of the ball is a bend to the right.

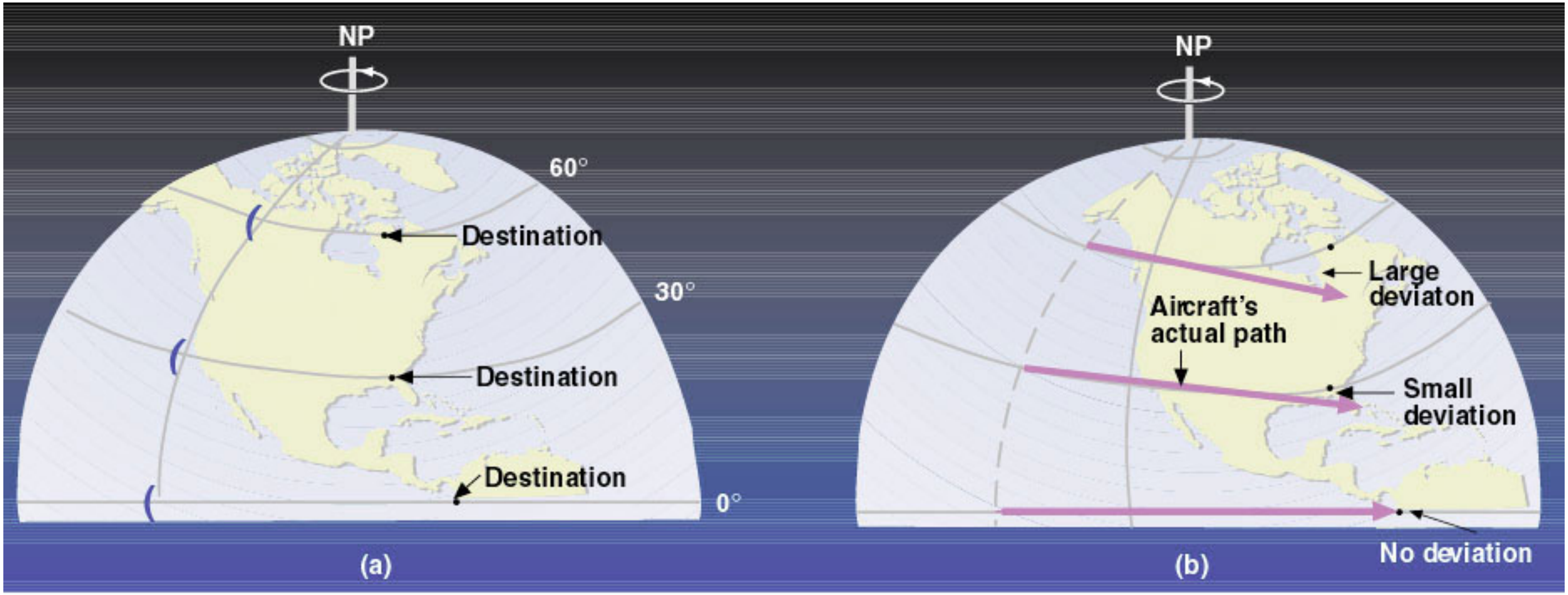
Ahrens: Fig. 8.21

Coriolis effect

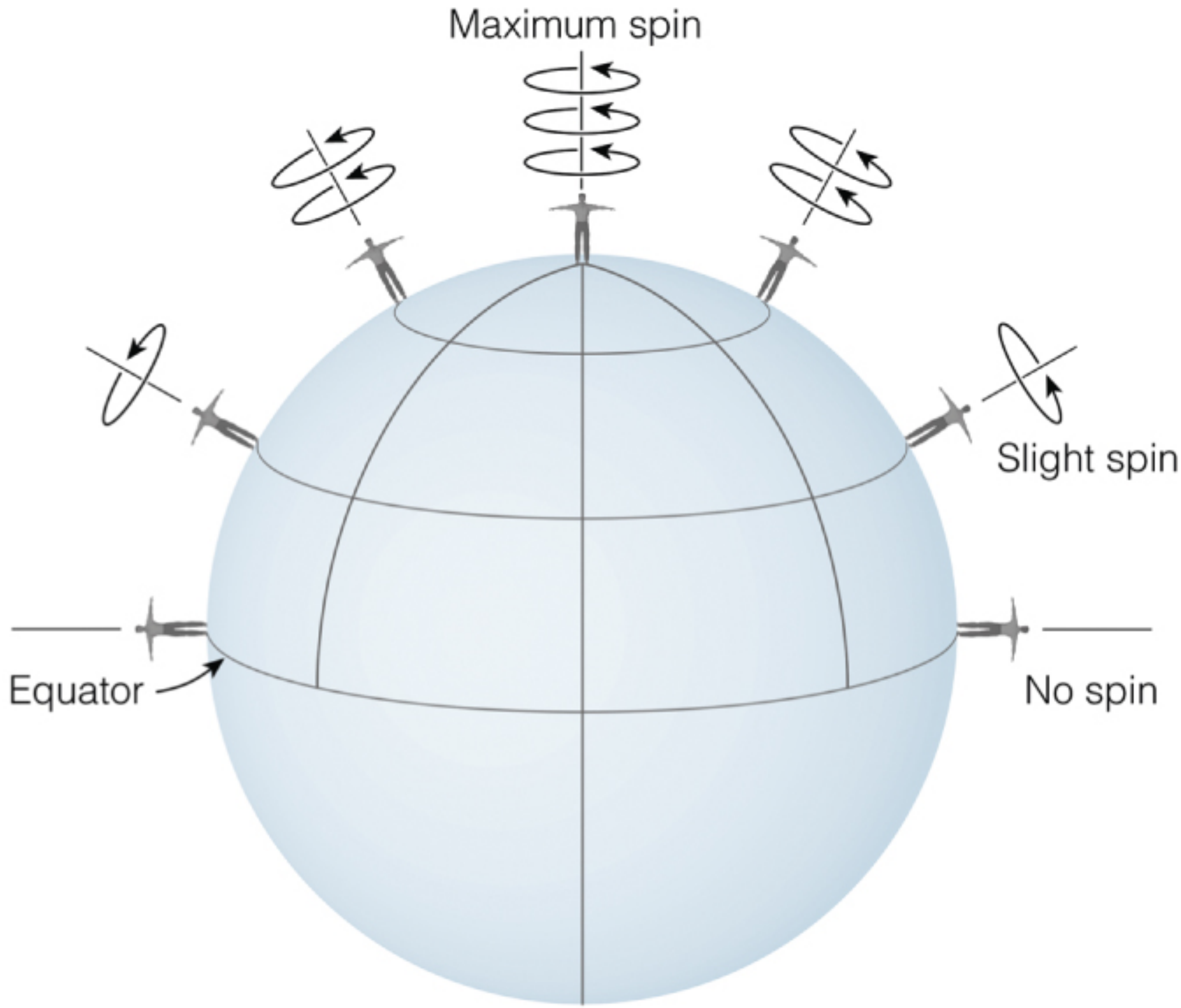


Thought exercise: Starting at North Pole, you aim your plane straight at Thunder Bay.
What city are you more likely to arrive at:
Thunder Bay, Toronto, or Regina?

A function of latitude

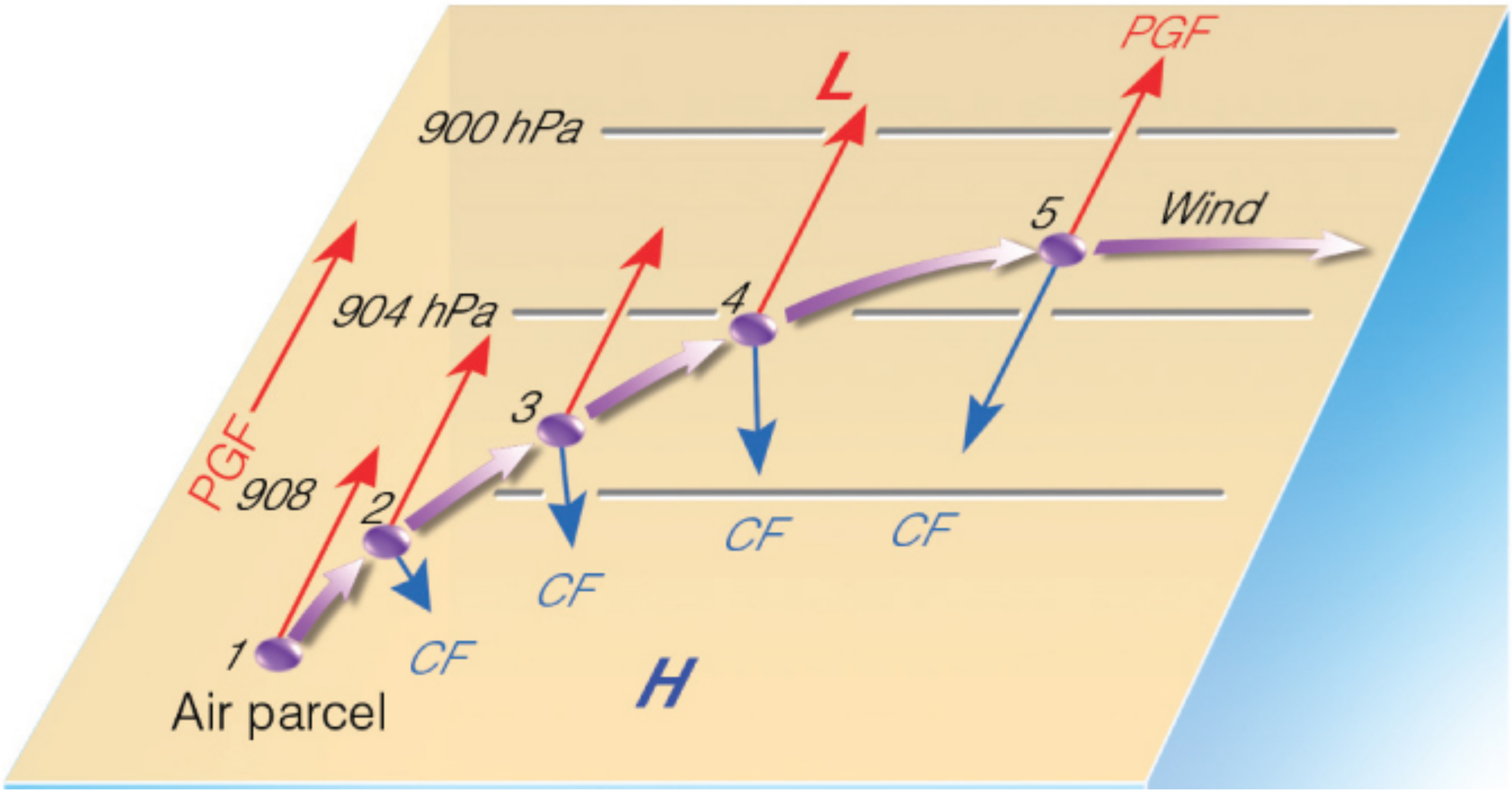


Latitude and spin



Ahrens: Fig. 12.20

Geostrophic Wind



Ahrens: Active Fig. 8.21

Geostrophic Wind

- Result of a horizontal balance of forces.
  - Pressure gradient force
  - Coriolis force
- Flow is always parallel to isobars
- Upper air flow over large distances always becomes geostrophic

North-South balance of forces

$$\text{PGF} = -\frac{1}{\rho}\frac{\Delta P}{\Delta y}$$

$$\text{CF} = -(2\Omega \sin\phi)u$$

If CF = - PGF,

$$u = -\frac{1}{(2\Omega \sin\phi)\rho}\frac{\Delta P}{\Delta y}$$

Geostrophic Wind – Lab 3

$$u = -\frac{1}{\left(2\Omega \sin\phi\right)\rho}\frac{\Delta P}{\Delta y}$$

$$v = \frac{1}{\left(2\Omega \sin\phi\right)\rho}\frac{\Delta P}{\Delta x}$$

Upper air winds

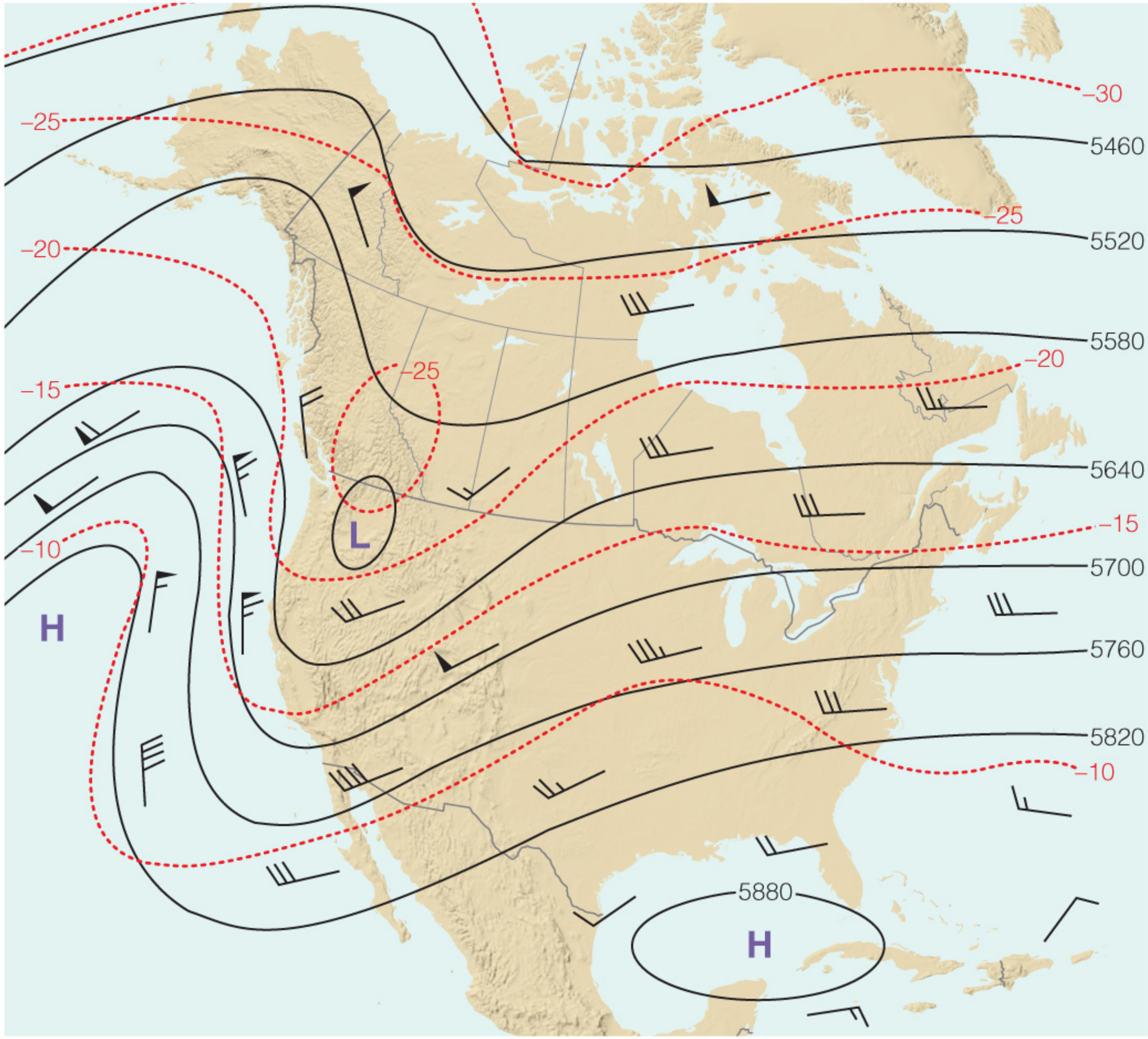
Upper atmosphere winds are typically *zonal*

Westerly winds in both hemispheres

Ahrens: Fig. 8.29

500 hPa

Isobaric Chart

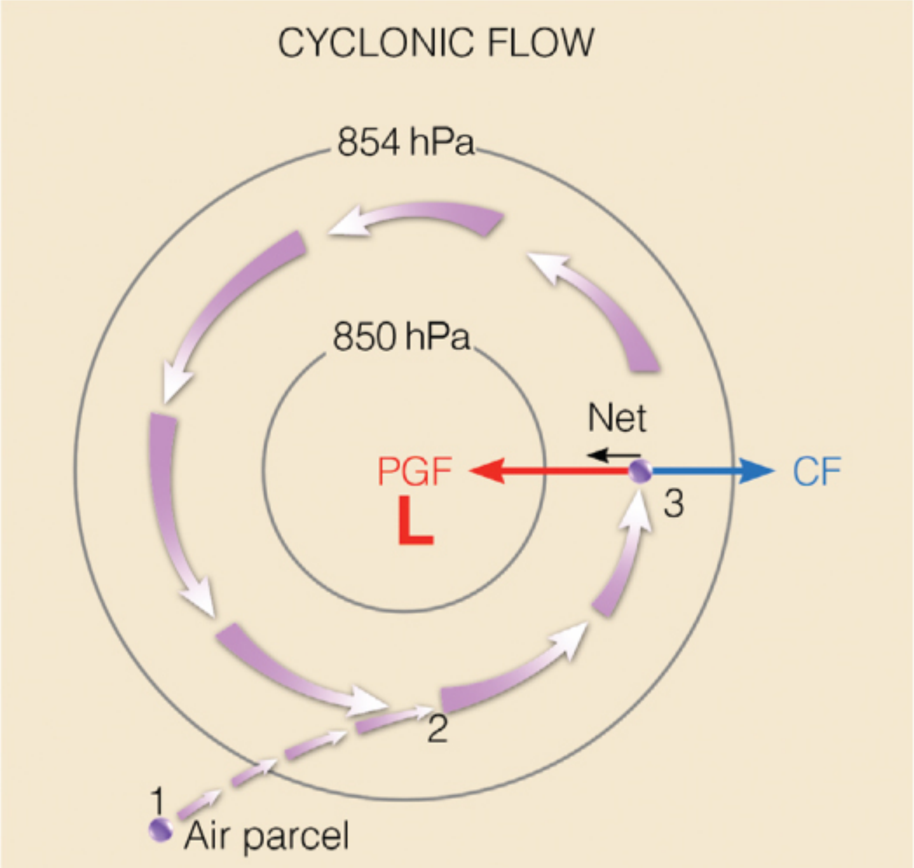


Gradient Wind

Circular motion involves constant acceleration toward a centre.

PGF > CF

Flow is at a constant speed parallel to curved isobars.



(a) Low - pressure area (cyclone) aloft

Ahrens: Fig. 8.27a

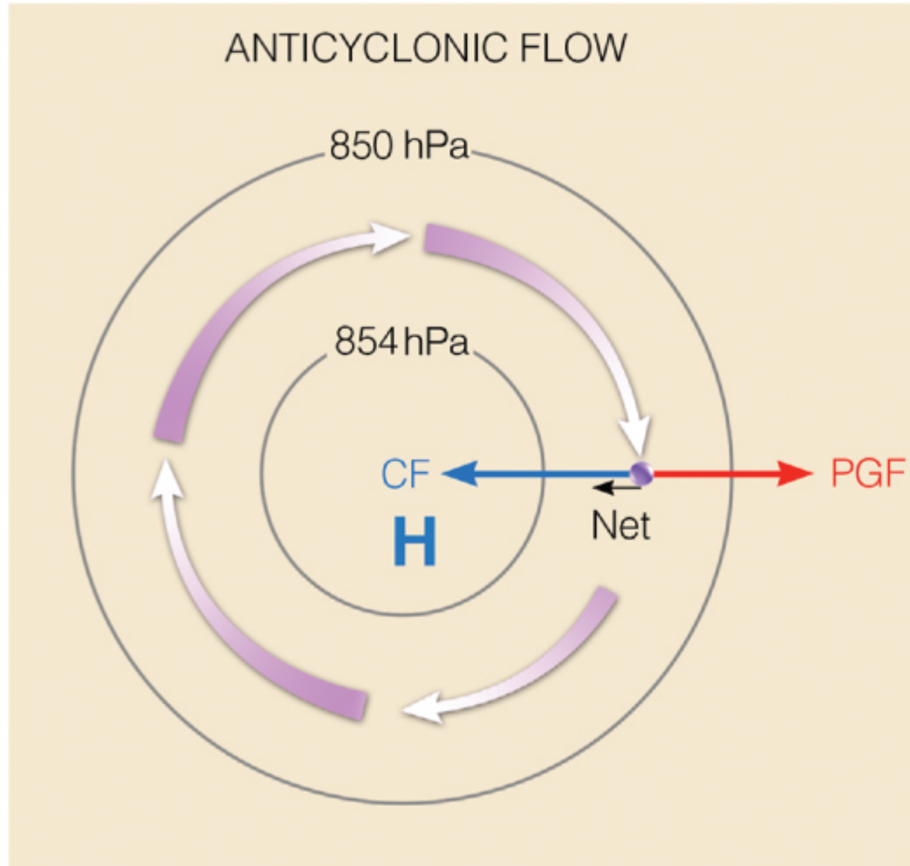
Gradient Wind

Circular motion involves constant acceleration toward a centre.

CF > PGF

Flow is at a constant speed parallel to curved isobars.

For an equal pressure gradient, gradient flow around highs is *faster* than flow around lows



(b) High - pressure area (anticyclone) aloft

Ahrens: Fig. 8.27b

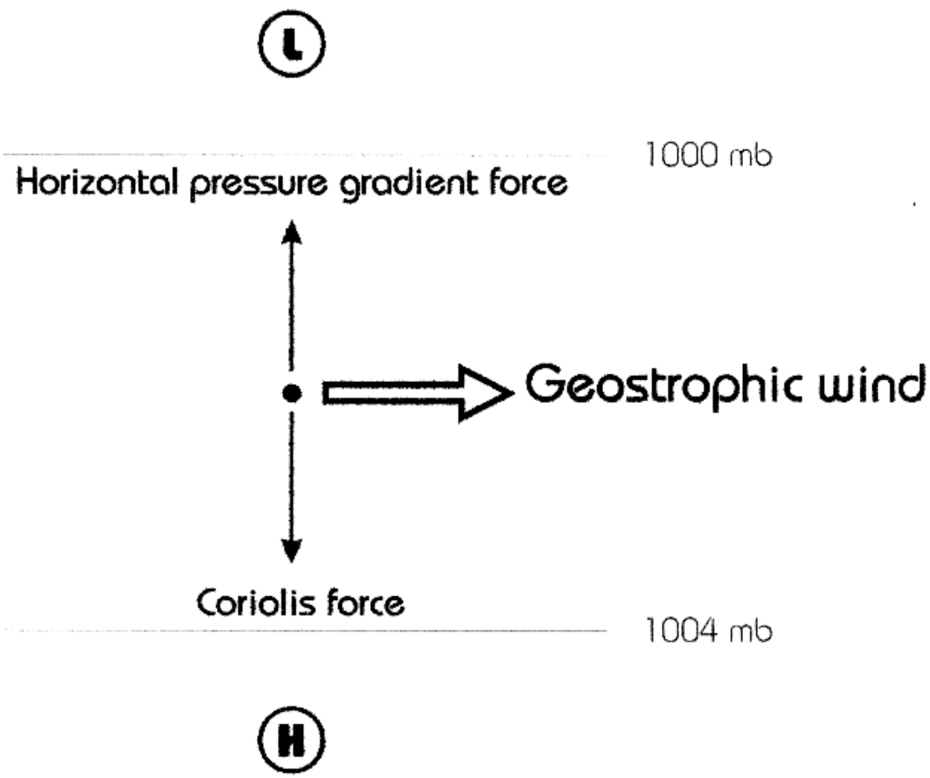
Frictional force

- Force at the contact of moving surfaces
- Like CF, friction is proportional to velocity, but always acts in the **opposite** direction

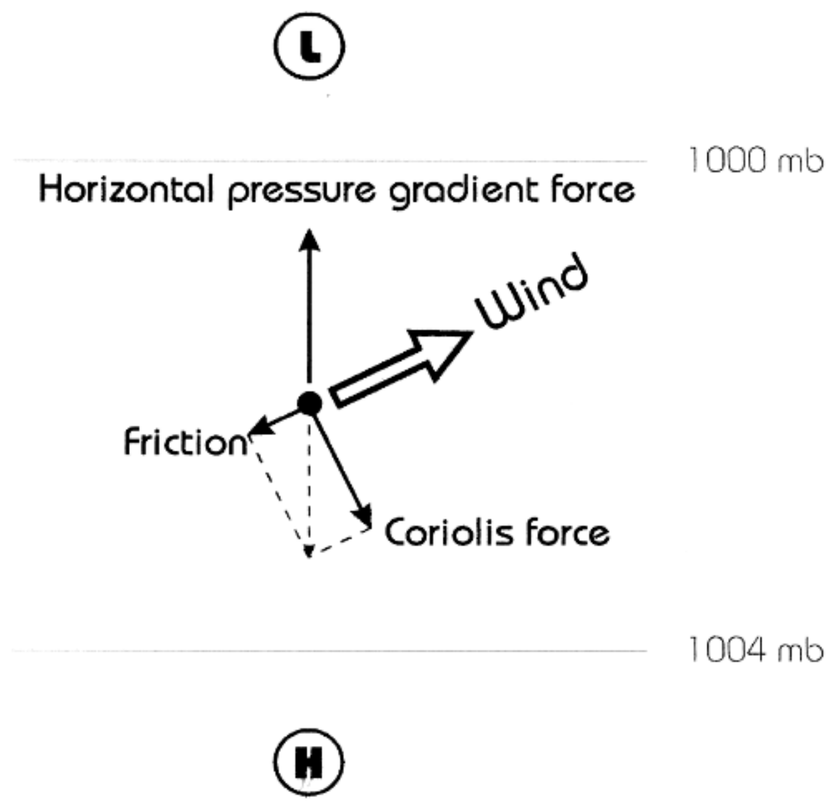
- Important for air within 1.5 km of the surface, the *planetary boundary layer*
  - Above 1.5 km is the *free atmosphere*

Balance of forces

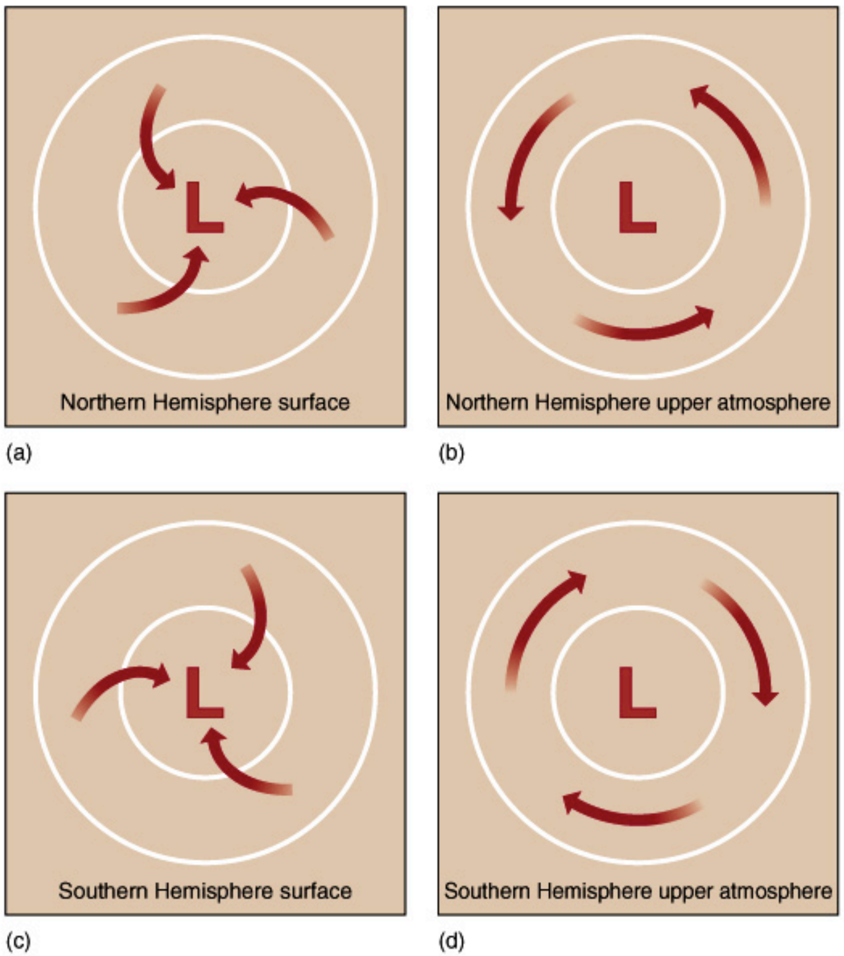
Free atmosphere



Boundary layer

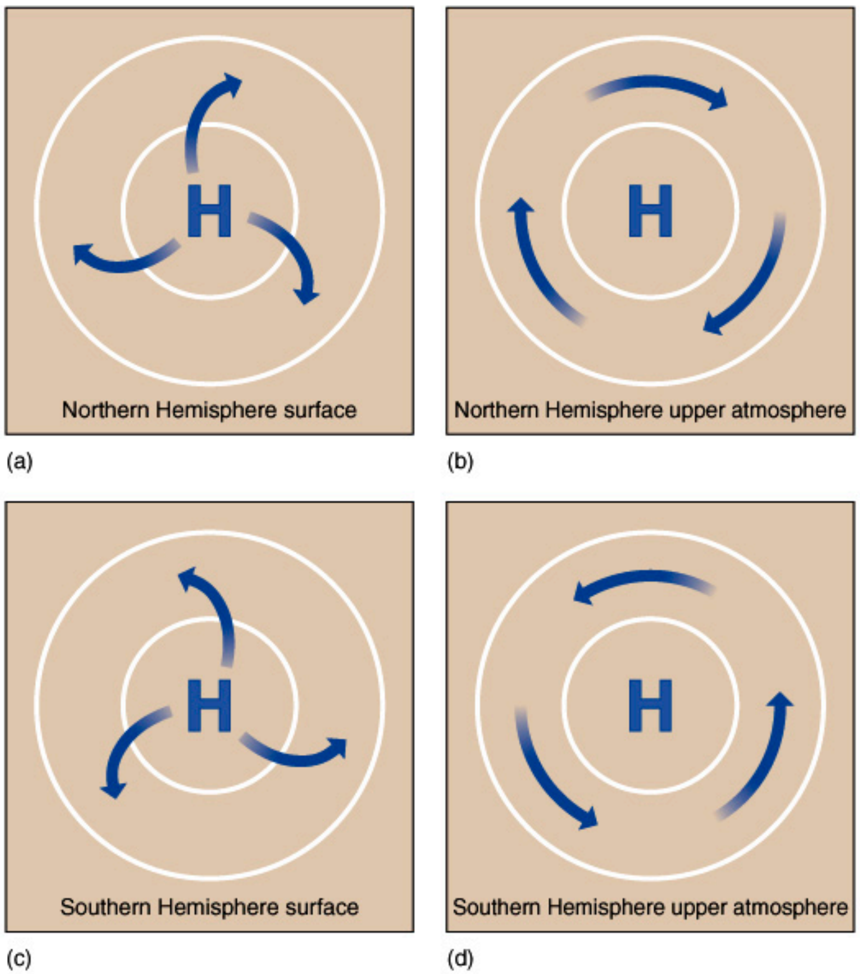


Cyclonic motion

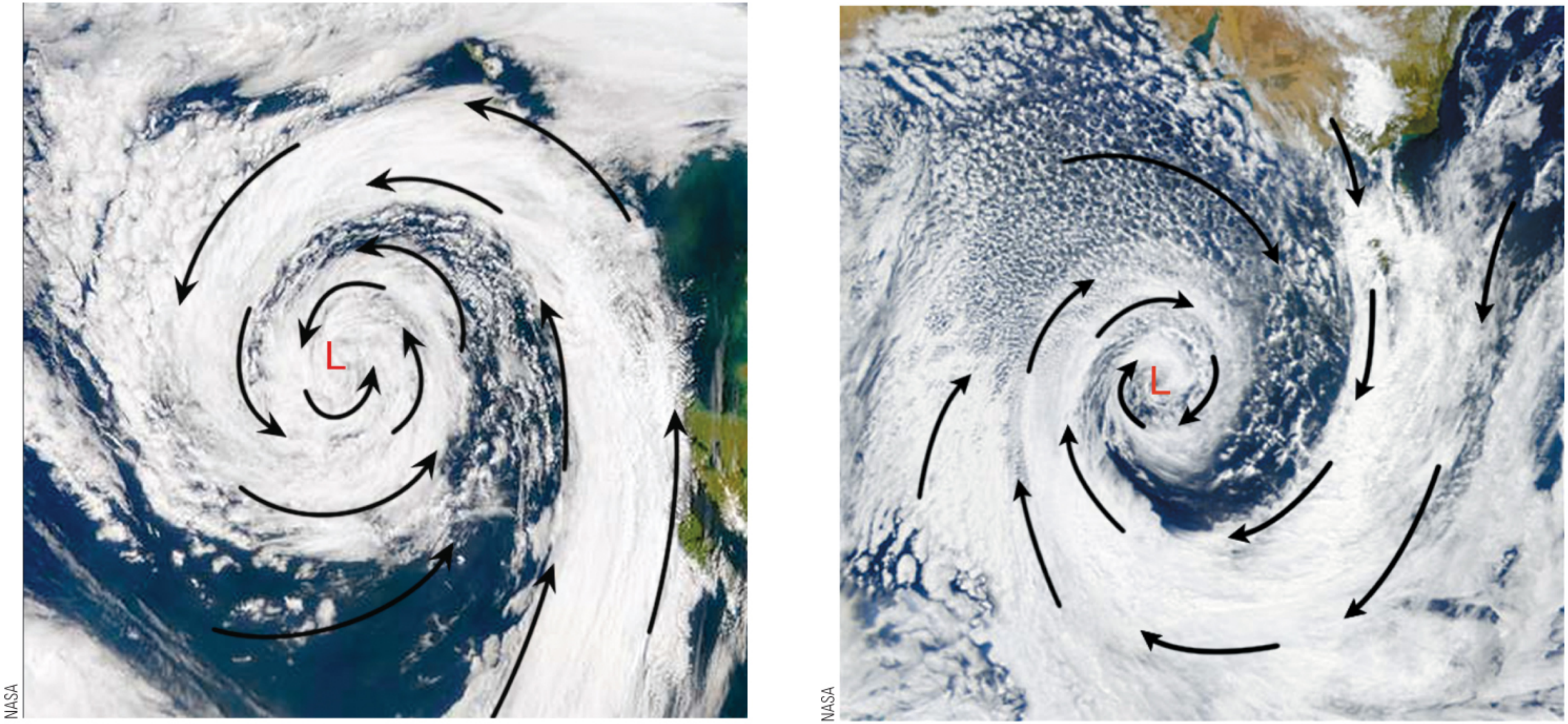


- Counterclockwise in NH
- Convergence of winds at the surface
- Clockwise in SH
- A&B: Figure 4-17

Anticyclonic motion



- Clockwise in NH
- Divergence of winds at the surface
- Counterclockwise in SH
- A&B: Figure 4-16



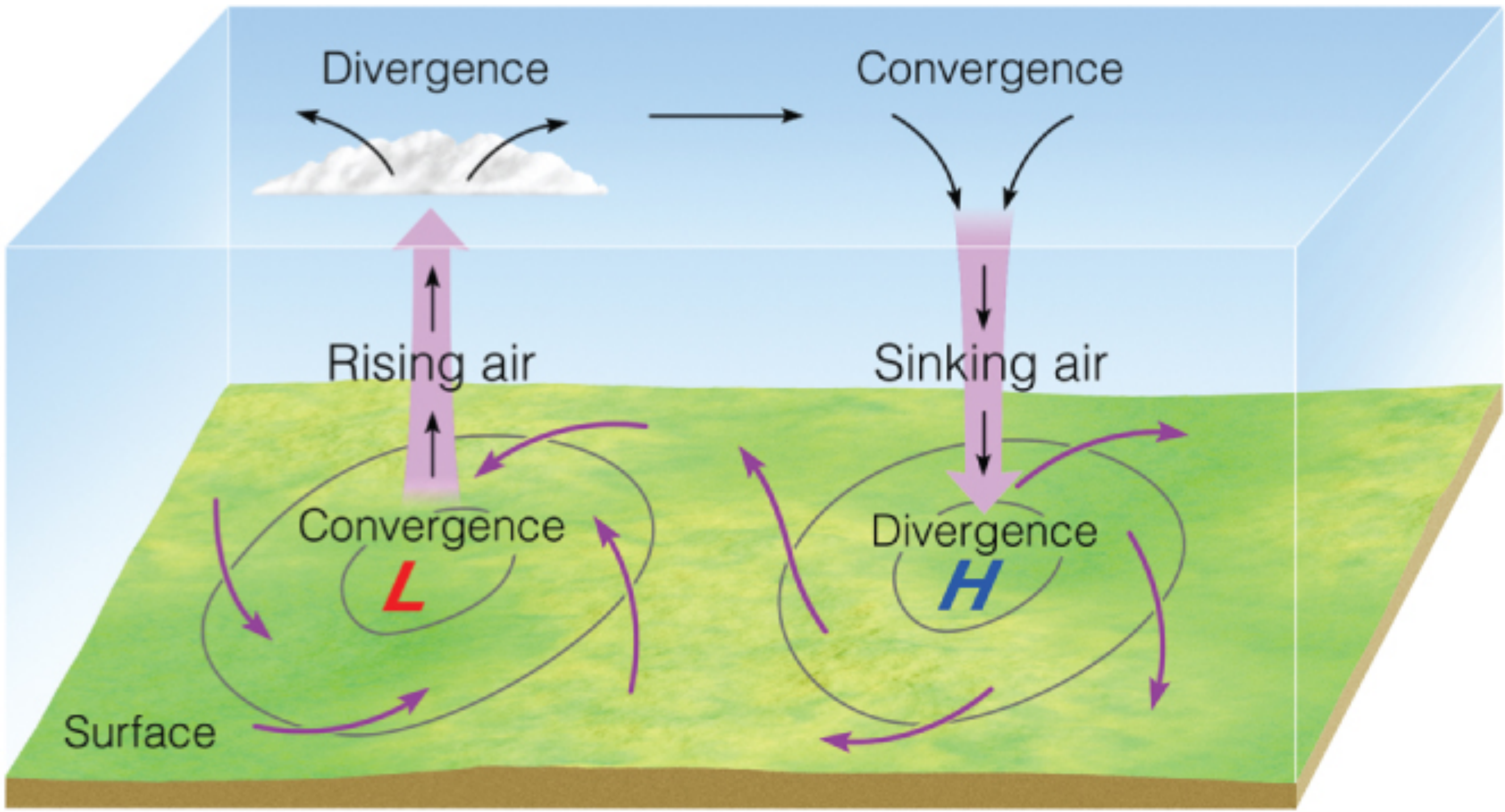
(a) Northern Hemisphere

(b) Southern Hemisphere

Wind flow patterns

Ahrens: Fig.: 8.28

Surface winds and vertical motion



Ahrens: Fig. 8.34

Measuring wind

- Wind vane
  - Direction
- Anemometer
  - Speed

Wind speed

- km/h
- m/s (1 m/s = 3.6 km/h)

- Knot: a nautical mile per hour
  - 1.9 km/h
  - Equal to one *minute* of latitude (one 60th of one degree) per hour
  - Originally measured by equally spaced knots in a rope dragged behind a ship

Wind direction

- Winds are always named after the location they blow **from:**
  - A wind that is travelling east is called a *west wind* or *westerly*
  - A wind travelling north to south is a *north wind*
  - A wind blowing in from the lake is called a *lake breeze*

Next week

- Moisture and humidity
- Atmospheric stability
- Ahrens et al., Chapters 4 and 6