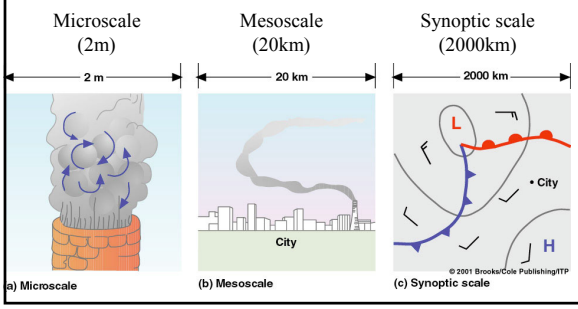
Chapter 10, Part 1

Small Scale Winds

Scales of Motion

- Wirls or eddies exist at all length scales in the atmosphere.



Examples of Wind at Different Scales

- Microscale (2m) – small turbulent eddies
- Mesoscale (20km) – thunderstorms, tornadoes, land/sea breeze
- Synoptic scale (2000km) – hurricanes, weather map features like highs and lows
- Global scale (5000 km) – long waves in the westerlies

Speed Skating

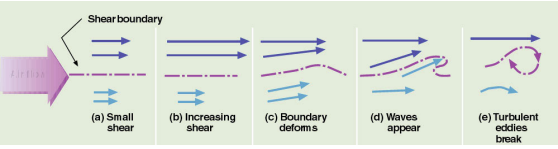
Jerry Lampen/Reuters

- Why do speed skaters crouch down and put their hands behind them?

Viscosity

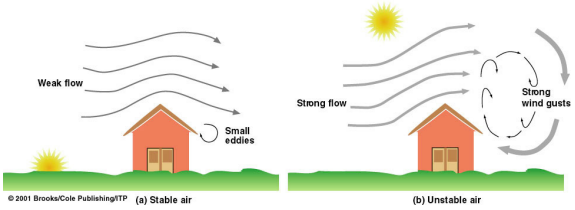
- The friction of fluid flow is called viscosity.
- Molecular viscosity is due to the random motion of air molecules.
- Eddy viscosity is due to turbulent whirling eddies.

Development of Turbulent Flow



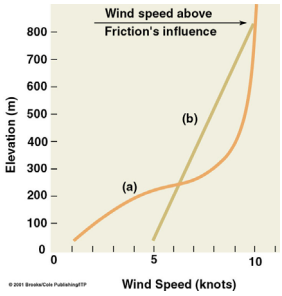
- As long as the relative speed between the two air layers is small (small shear), there is no turbulence (laminar flow).
- As the relative wind speed increases, the boundary deforms and then waves and eddies appear.
- This leads to clear air turbulence.

Development of Turbulence



- The size of the eddies increases as the wind speed increases and as the atmosphere becomes unstable by, for example, the solar heating of the ground.
- Shown: mechanical turbulence and thermal turbulence.

Planetary Boundary Layer



Because of friction the air near the ground moves slower than the air above.

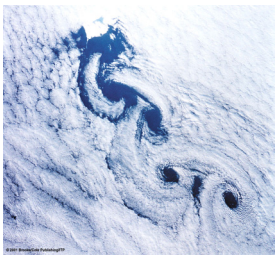
- Friction layer
- Planetary boundary layer

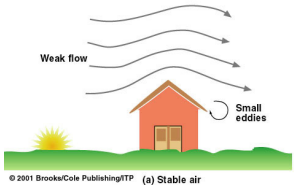
With more vertical mixing of the air (e.g. unstable atmosphere) the difference in speed is smaller.

Factors which Increase Turbulence

- Surface heating – air rises producing strong thermal turbulence
- High wind speeds – produces strong mechanical turbulence
- Rough or hilly landscape – produces strong mechanical turbulence

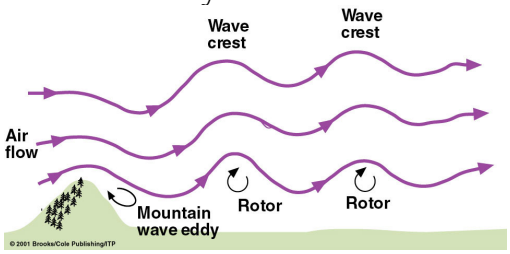
Large and Small Eddies





- Eddies form when air encounters an obstacle.
- They occur on both large scales (mountains) and small scales (house).

Eddy Formation

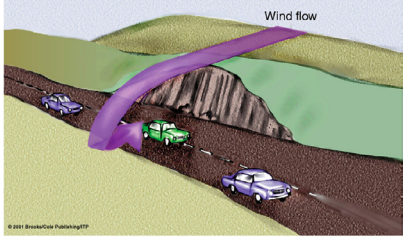


- Eddies form on an objects leeward side.
- Roll eddies or rotors can occur further downwind of the obstacle.

Clear Air Turbulence

- Wind layers moving at difference speeds (wind sheer) can lead to clear air turbulence, which is dangerous for flying.

Force of the Wind



- Wind exerts force on objects.
- This can move small particles like sand and dirt and for stronger winds large objects (e.g. in hurricances).

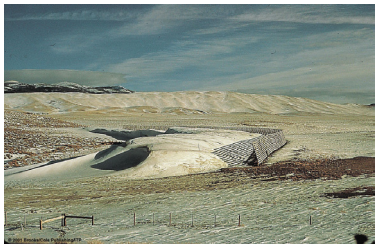
Wind and Exposed Soil

- Wind picks up tiny, loose particles (e.g. sand).
- Removal of these particles, leaving only larger gravel and pebbles can lead to "desert pavement."
- Constant sand blasting of rocks causes a flattened and pitted windward surface.
- Blowing sand comes to rest behind obstacles and eventually becomes a sand dune.
- On a dune's surface sand rolls and slides producing sand ripples.

Wind and Snow Surfaces

- Wind blowing over snow can produce snow dunes and snow ripples.
- For a strong enough wind clumps of snow can be rolled along (snow rollers).

Snow Fences

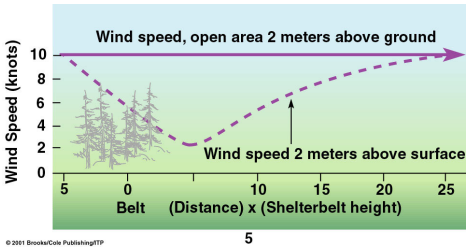


- Behind snow fences the wind speed is reduced allowing the snow to settle to the ground.
- This keeps a blanket of snow on crops and keeps large drifts away from towns.

Wind and Vegetation

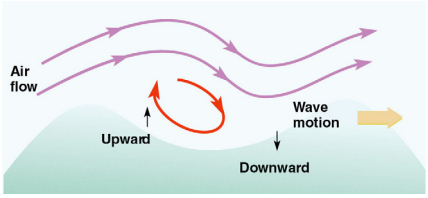
- Wind can bend and break branches.
- Wind also causes plants to loose water more rapidly.

Shelter Belts



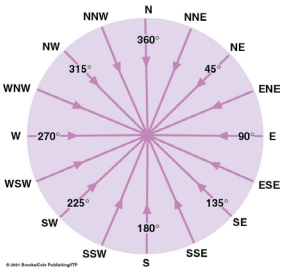
- Rows of trees decrease the surface wind speed and hence reduce erosion.

Wind and Waves



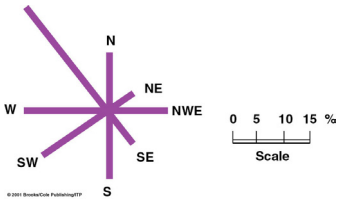
- Waves forming by wind blowing over a water surface are called wind waves.
- They depend on wind speed, the length of time the wind blows, and fetch (distance of deep water over which the wind blows).
- Above: microscale winds help waves grow taller.

Wind Direction



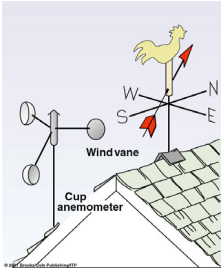
- Wind direction by characterized by N, E, … or by an angle.
- Other common terms are:
  - Onshore wind
  - Offshore wind
  - Upslope wind
  - Downslope wind.

Prevailing Wind



- The wind direction most often observed is called the prevailing wind.
- A wind rose represents the percent of the time that wind blew in a given direction.

Measuring Wind Speed and Direction



Wind Vane
Cup Anemometer

Aerovane

Summary

- Viscosity is the friction of air flow.
- There are two sources: molecular and eddy.
- Turbulence can be created by obstacles (mechanical) or air rising (thermal).
- Near the surface the wind moves slower.
- The wind strongly influences the surface of the earth (dunes, waves, …).