Weather

Physical Geography Lecture - GEOG B1
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Introduction

Weather is the short-term, day-to-day condition of the atmosphere.
Climate - the long-term average (over decades) of weather conditions and extremes in a region.
Meteorology*- the scientific study of the atmosphere with its complex linkages. Meteorologists study the atmosphere's physical characteristics and processes.

Air Masses

Each area of Earth's surface imparts its temperature and moisture characteristics to the overlying air.
Air mass - a body of air with a homogenous mix of temperature, humidity, and stability that may extend through the lower half of the atmosphere.
Air masses interact to produce weather patterns.

Air Mass Classification

Air masses are classified by the general moisture and temperature characteristics of their source regions.

Moisture (first letter):

Maritime (wet) - **m**

Continental (dry) - **c**

Temperature (second letter) - directly related to latitude:

Arctic - **A** Antarctic - **AA**

Polar – **P** Tropical – **T** Equatorial - **E**

Fig. 8.1*

Air Masses Affecting North America - I

Continental polar (**cP**)

Fig. 8.1

Cold, stable air / clear skies / high pressure

Major player in middle- and high-latitude weather

Can displace warm moist air upwards causing condensation

Maritime polar (**mP**)

Cold, moist unstable conditions prevail throughout the year

Air Masses Affecting North America - II

Maritime tropical (**mT**)

Fig. 8.1 >>Two affect N. America the most:

- ***mT Gulf/Atlantic*** - brings humidity to East and Midwest / very unstable and active from spring to fall
- ***mT Pacific*** - stable to conditionally unstable / generally has lower moisture content, so western U.S. receives lower average of precipitation than rest of the country

Air Mass Modification

As air masses migrate, their temperature and moisture slowly change to the surface over which they pass.
mT air masses lose moisture and warmth when heading over the continent.
cP air masses warm up when they head south.

EXAMPLE: When a cP air mass moves over the Great Lakes, it absorbs heat energy and moisture from the water and becomes humidified. This is called the *lake effect*, and it can produce heavy snowfall downwind of those lakes.

Fig. 8.2 *

Atmospheric Lifting Mechanisms

When an air mass is lifted, it cools adiabatically (by expansion). *
Four lifting mechanisms:

- Convergent lifting
- Convectional lifting
- Orographic lifting
- Frontal lifting

Convergent and Convectional Lifting

Convergent lifting - when air flows from different directions into the same low pressure areas, in converges and displaces air upward. * **Fig. 8.3 a**

Convectional lifting - when a maritime air mass moves to a warmer continental region, heating from the warmer land surface causes lifting and convection in the air mass. **Fig. 8.3 b**
Fig. 8.5 **

Orographic Lifting

*When an air mass is forced upslope as it is pushed against a mountain, the lifting air cools adiabatically, reaches saturation, moisture condenses, and clouds form.
Fig. 8.3 c
Precipitation often results on the windward side of the mountain.
On the leeward slope, the air descends and heats adiabatically, becoming hot and dry.** **Fig. 8.6**
>>The leeward side of the mountains is in the **rain shadow**.
Fig. 8.7 - Orographic patterns in WA state (2 mountain chains)

Frontal Lifting

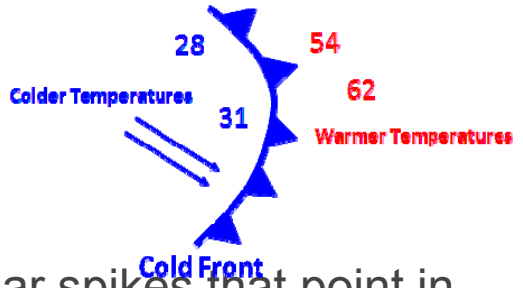
The leading edge of an advancing air mass is called a front.

Cold front - leading edge of a cold air mass

Warm front - leading edge of a warm air mass

A front is a narrow zone forming a line of conflict between two air masses with different temperatures, pressures, humidity levels, wind directions, and speed. *

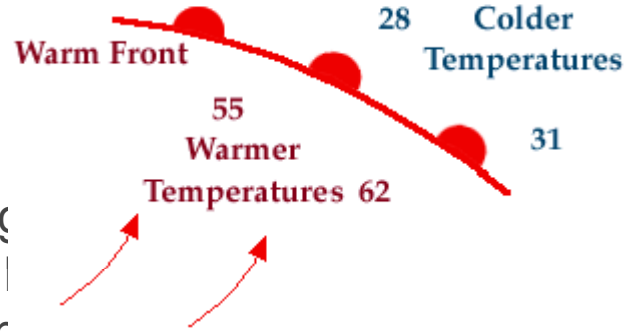
Cold Front



Cold fronts hug the ground and have a steep “face.”
As it passes, temperatures drop, and the pressure rises.
On weather maps, it is depicted as a solid line with triangular spikes that point in the directions of movement.
Warm, moist air will be lifted upward and displaced by a cold front, often creating clouds and storms. **Fig. 8.8**

A fast advancing cold front can cause violent lifting, creating a **squall line** with strong winds and heavy precipitation.

Warm Front



A warm air mass can be carried by the jet stream into reg
Warm air can also advance during monsoonal flow over l
Advancing warm fronts are generally too unstable to disp
push the cool air into a wedge, and then ride up over it. Fig. 8.9
On a weather map, a warm front is a solid line with semi-circles facing the direction of the frontal movement.

Midlatitude Cyclonic Storms

Midlatitude Cyclone - a migrating low-pressure weather system that occurs in the middle latitudes.

- Develops from conflict between contrasting air masses (cP and mT).
- Has a low-pressure center with converging, ascending air spiraling inward *
- Can be 1,600 km (1,000 mi) wide
- Guided by the jet streams
- Generally follow storm tracks that shift in latitude with the Sun and seasons

Fig. 8.10 **

Life Cycle of a Midlatitude Cyclone

P. 202, 8.1 Stages 1-4, and **8.3** *

Cyclogenesis - the first stage when the polar front meets a warm air mass
A cold front often moves faster and overtakes a warm front, wedging beneath it - producing an **occluded front**. **
This usually produces heavy precipitation.

When the air flow on either side moves almost parallel to the front, but it opposite directions, it is called a **stationary front**.

Weather Maps and Forecasting

*The atmosphere is a nonlinear system, so developing numerical models is difficult.
Technology is improving. **
Data is generated by: environmental satellites, surface stations, aircraft, and orbital platforms.

Data Interpreters

U.S. - National Weather Service (NWS) *
Canada - Meteorological Service of Canada
International - World Meteorological Organization

Essential element to collecting data: **Doppler radar**
Uses a backscatter from two radar pulses to detect the direction of moisture droplets toward or away from the radar source - indicates wind direction and speed.

Violent Weather

Weather related destruction has risen over 500% over the past three decades as populations have increased in areas prone to violent weather.
Climate change is only going to intensify violent weather.
Who is watching out for us?

- National Oceanographic and Atmospheric Association (NOAA)
- National Severe Storms Laboratory and Storm Prediction Center

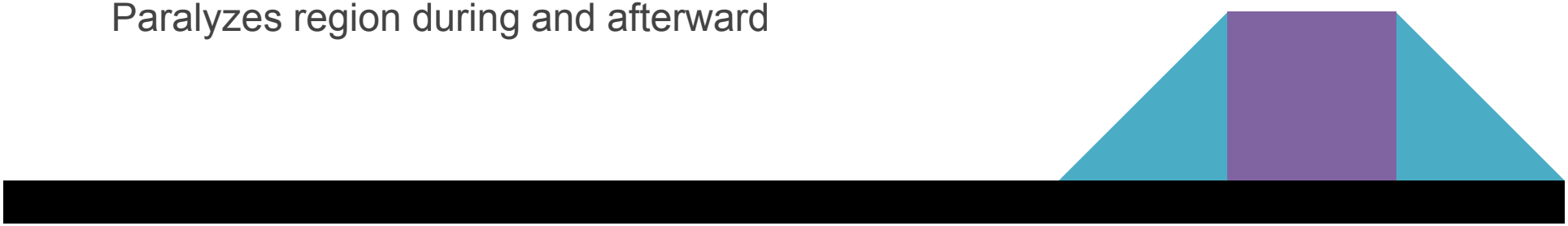
Ice Storms and Blizzards *

Ice storm - winter storm in which at least 6.4 mm (0.25 in) of ice accumulates on exposed surfaces

- Caused by a layer of warm air between two layers of cold air
- Precipitation falls and freezes into **sleet**, freezing rain, ice glaze, and ice pellets **

Blizzard - snowstorm with gusts / sustained winds at greater than 56 km (35 mph)

- Lasts longer than 3 hours
- Large snowfall
- Paralyzes region during and afterward



Thunderstorms

Turbulent weather characterized by giant cumulonimbus clouds and accompanied by lightning and thunder **Fig. 8.12**

Associated with squall lines of heavy rain (and sleet), gusting winds, hail, and tornadoes *

Most frequently experienced along equatorial regions and along the Intertropical Convergence Zone (ITZC) **

Turbulence and Wind Shear

Turbulence - created by mixing air with different densities, or by air layers moving at different speeds and directions.
Wind shear - the variation of wind speed and direction with altitude
>>needed to produce hail and tornadoes
Downbursts - severe turbulence that causes strong winds near the ground

Supercells

Strongest thunderstorms *
Contain a deep, persistently rotating updraft called a **mesocyclone** - a spinning column of rising air associated with a convective storm **
Produces heavy rain, large hail, high winds, lightning, and sometimes tornadoes.
Fig. 8.16
Supercell time lapse

Lightning and Thunder

Lightning - flashes of light caused by enormous electrical discharges *

Caused by a buildup of electrical-energy polarity between areas within cumulonimbus clouds, or between the cloud and ground

Fig. 8.13

Thunder - the sonic bang of the shock waves through the atmosphere as the lightning-heated air violently and abruptly expands

Hail

Hail or **hailstones** - ice pellets larger than 0.5 cm (0.20 in) that form within a cumulonimbus cloud

- Formed by raindrops repeatedly circulating above and below the freezing level in the cloud
- Each circulation adds another layer of ice until their weight can no longer be supported *
- Pea-sized is common, but hailstones can range from the size of quarters to softballs
- **Fig. 8.14** **

Tornadoes

Tornado - a violently rotating column of air in contact with the surface *

Fig. 8.16

Forms as moist air is drawn into a mesocyclone

energy is liberated by condensation, and rotating air increases speed

The spin of the converging parcels may form a smaller, dark grey **funnel cloud**

That funnel may lower to the surface

When it happens over water, it's called a **water spout** **

Tornado Measurement

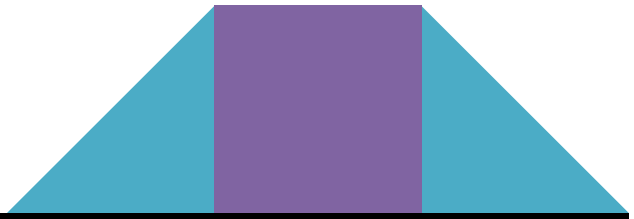
The pressure inside a tornado is usually 10% less than the surrounding air

Inrushing convergence is created by the horizontal pressure gradient causes high wind speeds

p. 210, Table 8.1- Enhanced Fujita Scale - Based on:

- 3-second-gust wind speed
- Damage

With current technology, 12-30 minute warnings are possible in areas with higher frequency *



Tornado Frequency

North America experience more tornadoes than anywhere else because of latitudinal position and our topography is conducive to contrasting air masses colliding. **Fig. 8.18 a**

Tornadoes have hit all 50 states, and all Canadian provinces and territories. Tornado season is April-August, but peak months are May-June * **Fig. 818 b**

Tropical Cyclones

Tropical cyclones - originate within tropical air masses and can be powerful *
Classified by wind speed **
Most powerful have different regional names - but all have the same genesis and destructive power
Hurricanes - around North America
Typhoons - western Pacific (mainly Japan and Philippines)
Cyclones - occur around Indonesia, Bangladesh, and India ***

Tropical Cyclone Development

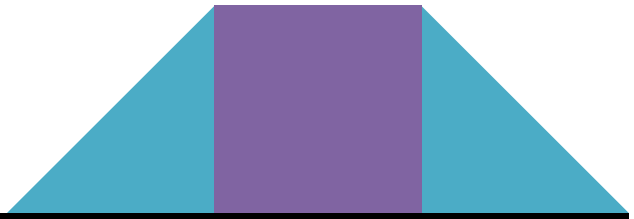
Convert heat energy from ocean into mechanical energy in the form of wind *

Triggered by slow-moving easterly waves **Fig. 8.19**

If sea-surface temp. exceeds 26°C (79°F) - tropical cyclone may develop

Surface airflow converges into low-pressure area, ascends, and flows outward aloft **

System will continue to develop as long as no wind shear blocks the vertical airflow



Physical Structure

Tropical cyclones have steep pressure gradients that generate inward-spiraling winds toward the center of low pressure * **Fig. 8.20 b**
Winds rush toward center then turn upward, forming walls of dense rain bands, and finally the eyewall - where the most intense precipitation occurs **Fig. 8.20 c**
Center of the is called the eye of the storm - where wind and rain subside **
Range in diameter from 160 - 1,000 km (100 - 600 mi) **Fig. 8.20 a**
Can dominate the full height of the Troposphere
Land fall - when the eye moves ashore

Damage Potential

Hurricane categories - **p. 213, Table 8.3 - Saffir-Simpson Hurricane Wind Scale**

Based on: wind speed / types of damage

Winds don't do all the damage…..

Storm surge - seawater pushed inland during a hurricane

>>when combined with a high tide - can create a storm tide

Rising sea levels will make storm surges more of a problem. *

Formation Areas / Storm Tracks

Fig. 8.21 - Seven primary formation areas & months they tend to form

Formations in the Atlantic Basin:

- Tropical depressions tend to intensify into storms as they cross Atlantic towards North and Central America
- Mature early (before reaching approximately 40°W) - tend to curve northward and miss the U.S.
- Mature later (after reaching 70°W) - has higher chance of hitting U.S. *

Coastal Flooding from Hurricane Katrina

Flooding in New Orleans was more a result of human engineering than the storm.* Katrina made landfall just south of the city with high rainfall and storm surges that moved through the canals.

As the level of Lake Pontchartrain rose from the rainfall and the storm surges, four levees broke, and there were at least four dozen levee breaches.

Some neighborhoods were under 6.1 m (20 ft) - the polluted water remained for weeks. **Fig. 8.22**

Repair and recovery is ongoing - over $12 billion

An Avoidable Cycle

Risk of human death is decreasing *
Damage is increasing. **
Recurrent cycle: construction → devastation → reconstruction → devastation → etc. ***
Governments need to create and implement better hazard zoning and development restrictions