What causes weather and climate?

• Weather is probably the most difficult subject to understand in physical geography

• There are a lot of factors that come together to make up the forces for our weather and climate systems

• Once we can understand the basics, we can understand why some areas are desert, while some areas are jungles. We’ll understand why it’s raining in Victoria, but snowing up island
Weather vs Climate

- The difference between weather and climate is a measure of time
- Weather is the conditions over a short period of time
- Climate is how the atmosphere "behaves" over relatively long periods of time
- When we talk about climate change, we’re talking about changes in long-term averages of daily weather

Climate Controls

- Climate controls are the individual factors that come into play in the creation of weather trends that generate local climates
- The controls include...
Climate Controls cont.

1. Latitude
   - distance from the equator equates to angles from the sun.
   - Regions closer to the equator have more direct energy exposure from the sun.
   - Regions at the higher latitudes receive their energy on a much greater angle and therefore are able to absorb less, leading to cooler temperatures.
Climate Controls cont.

2. Proximity to large bodies of water (oceans).

- Regions closer to oceans have their temperatures moderated as the temperature of the water remains more or less consistent all year long leading to moderated weather.

- Water temperature regulates air temperature

- Regions further from oceans (inland) will have greater extremes in weather as the land cools and heats much faster than the water. Maritime climates vs Continental climates

- Can be seen by comparing seasonal temperatures between a coastal city and a continental city (Vancouver & Trail are both at 49 degrees north)

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vancouver, B.C.</td>
<td>-5°C</td>
<td>29°C</td>
</tr>
<tr>
<td>Trail, B.C.</td>
<td>-25°C</td>
<td>43°C</td>
</tr>
</tbody>
</table>
Climate Controls cont.

3. Oceanic currents

• Regions under the influence of large bodies of water will be influenced by the currents in the water.

• Oceans are made up of dominant currents – some are warmer currents, others are colder

• Water temperature warms or cools the air (wind) blowing across its surface.

• Warm air absorbs more moisture than cold air. This is why the west coast has wet moderated climate, the warm ocean air carries a great deal of moisture
Climate Controls cont.

4. Prevailing Winds

• All regions have prevailing wind directions. In our area, we’re dominated by westerlies (meaning the wind generally blows in from the west)

• Winds blowing off the oceans are moderated keeping our climate less extreme (Maritime Climate). Milder in the winters & cooler in the summers

• Winds blowing off the land impact the climate of a region by giving the extreme fluctuations (Continental Climate). Colder winters and hotter summers

• West coast communities are the only ones in Canada with temperatures typically above freezing due to the westerly winds coming off the Pacific Ocean. Most (all) of the remainder of Canada experience more of a Maritime type climate with colder winters and warmer summers
Climate Controls cont.

5. Altitude

- Regions closer to sea level have climate that are milder than regions at higher altitude.
- Generally speaking, for every 150m rise in altitude, the temp drops by approx. 1 degree Celsius.
- For example:

<table>
<thead>
<tr>
<th>Location</th>
<th>Altitude</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victoria, B.C.</td>
<td>25 m</td>
<td>Approx. 300 m difference = 2 degrees of variation</td>
</tr>
<tr>
<td>Kelowna, B.C.</td>
<td>344 m</td>
<td>Only part of the equation for differences in weather</td>
</tr>
</tbody>
</table>

What’s the mildest temp in Victoria we’d want to see when planning a trip to Mt Washington? When will we know that precipitation on Mt Washington will be rain, and not snow? 😊

<table>
<thead>
<tr>
<th>Location</th>
<th>Altitude</th>
<th>Elevation Difference</th>
<th>Daily Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victoria, B.C.</td>
<td>25 m</td>
<td>1068 m</td>
<td>0°C</td>
</tr>
<tr>
<td>Mt Washington base elevation</td>
<td>1083 m</td>
<td>~7°C of change</td>
<td>~7°C</td>
</tr>
</tbody>
</table>
3000 meters = 10.5°C
2000 meters = 17°C
1000 meters = 23.5°C
0 meters altitude (sea level) = 30°C
Climate Controls cont.

6. Proximity to mountains

• How close are the nearest mountains and in what direction are they?
• Mountains play a huge role in determining climate. There are always one side with heavy precipitation and the other side in a rain shadow.
• They block incoming wind storms, or funnel them in certain directions
• They can cool and/or moderate the air temperature (Chinook Winds & Calgary)
Climate Controls cont.

7. Precipitation

- The amount of precipitation (rainfall, snow, etc...) depends on the distance from larger bodies of water and the prevailing wind direction.
- The closer we are to water the more likely we are to have increased precipitation.
WEATHER ANOMALIES
Weather Complexities

• Due to the influence of global climate change, we’re experiencing greater extremes in weather patterns around the planet.

• From hotter drier summers which lead to droughts and wildfires, to intense storms bringing snowfall to regions that shouldn’t see snow – Mississippi and Texas
El Nino Southern Oscillation

• This weather phenomenon has become quite common in recent years in Pacific waters and definitely impacts us here in western Canada
  • At one time was thought to occur every 2 – 7 years at best, but recently has become quite regular
  • Some scientists believe it could become permanent with global warming
• El Nino forms off the coast of Peru in the southern Pacific. Under normal conditions, strong south-easterly winds push the warmer surface water in the ocean toward Australia allowing for cooler nutrient rich waters to come to the surface.
  • Because of this upwell off the west coast of South America, sea life is abundant! Fishing grounds off Chile and Peru are rich and continuous.
Warm rising air causes thunderstorms and floods.

Atmosphere

Trade winds blow westwards.

Dry sinking air causes droughts.

Australia

Warm surface water

Strong surface currents

Ocean

Upwelling of cold deep water

South America

Normal
How El Nino forms

• During an El Nino year, for some unknown reason, the strong prevailing trade winds weaken

• Waters off Peru gradually begin to warm as it’s no longer being pushed toward Australia

• The high pressures and tropical storms typically associated with the Fiji and Indonesia move back toward Peru and bring rain to an otherwise arid part of the world

• The nutrient rich cold water upwell disappears and the fishing industry and sea life abundance begin to suffer
El Niño Year

Increased convection

When trade winds drop, warm surface water may flow eastwards

Trade winds drop

Warm sea currents replace the cold water and establishes a deep layer of warm water along the coast.
Dry sinking air causes droughts.

Trade winds reverse direction.

Warm surface currents reverse.

Warm rising air causes thunderstorms and floods.

Cold upwelling ceases.

EL NIÑO
How El Nino impacts us in Canada

- El Nino changes the weather in North America
- Winters in our area are noticeably warmer and drier as the air current (Jet Stream) is pushed further north, bringing Victoria unseasonal mild dry conditions
- Terrible news for ski hills as snow packs can be critically low
- Has lead to ice storms in eastern Canada and caused major problems with downed power lines
  - For example, El Nino of 1998 brought freezing rain to Que, Ont & NB. The extreme weight broke thousands of tree branches that caused power lines to drop. Residents were without hydro for months in some places. At the time was the most expensive natural disaster in Canadian history
How El Nino impacts us in Canada con’t

• Reservoirs that store surface water can be far below capacity
• El Nino can bring intense violent storms leading to major coastal erosion and severe damage.
  • For example, the El Nino of ’98 brought wind storms to Oregon reaching 220 km/hr with waves reaching 48’. Repairs to roadways etc., cost millions of dollars to repair
La Nina

• The direct inverse of El Nino. Not as commonly experienced.
• Trade winds off Peru intensify, pushing warmer waters further to the west (Australia), and greater cool water upwelling occurs along the coast of Peru in the eastern Pacific
• This larger pool of cooler waters impacts the weather in North America
• Peaks between late December to early March
• The air currents (Jet Stream) is pulled further south in North America bringing cold arctic air deep into the southern US
• Victoria will experience much colder and greater snowfall during La Nina winters

• Climatologists are saying this winter is in fact setting up for La Nina year
EL NIÑO FOR CANADIAN BIRDS AND BEES:

EL NIÑO, I SEE, BUT WHAT CAN IT BE?

WARM AND SNOW-FREE—GREAT TIME FOR A BEE!

LA NIÑA, I HEAR, IS THE ONE TO FEAR!

BUT WITH SNOW SO DEEP, I’LL BE SOUND ASLEEP.
Off the waters of Uculet?!

While the ocean vessel ‘Dawn Raider’ was commercial fishing for dogfish, this Great White was hooked in the mouth but only resisted slightly for 15 minutes before it came up alongside the boat to have a look; long enough for one of the crew members to slip a rope around it’s tail. And that’s when the s**t hit the fan!! The Shark took off towing the 42 foot fishing boat backwards through the water at about 7 Knots. Just like in JAWS, the boat was taking on water over the stern and the crew watched in horror as the shark would actually jump completely out of the water at times. This went on for an hour before the shark finally drowned. She weighed in at 1035 LBS. It is suspected she followed an El Nino current into local waters in search of food.
El Nino Explained ~ 2 mins

El Nino Explained ~ 4½ mins
Seasons

- The four seasons of the year that regions in the mid & polar latitudes receive is solely due to the axis of the earth & our orbit of the sun.
- If the earth was straight upright with the poles being the top & bottom of the earth, we wouldn’t receive the seasonal variation.
- Because the earth is tipped at 23.5° we get variations in temp & daylight as we rotate around the sun.
Axis oriented away from the sun

23.5°

September 22-23
Autumnal Equinox

Axis oriented toward the sun

December 21-22
Winter Solstice

June 20-22
Summer Solstice

March 20-21
Vernal Equinox
Energy In – Energy Out

• June 21 is the longest daylight day of the year. The day where Victoria receives the greatest amount of energy from the sun in a 24 hour period

• Likewise, December 21 is the shortest daylight day of the year – the single day where we receive the least amount of energy from the sun – in the northern hemisphere

• Neither of these days represent the warmest day (June 21) nor the coolest day (Dec 21)

• Most of the heat we feel is from the earth absorbing & retaining it before slowly releasing it back

• After June 21, we continue to see good weather and the earth continues to absorb energy – more than it loses, giving us hotter weeks following the 21st

• Same principal applies to Dec 21. Weeks after the darkest day of the year, the earth continues to cool until early Feb before average temperatures begin to rise, and energy can be absorbed into the earth
Global & Local Wind and Airflow
Air Masses

- Massive bodies of air that have similar moisture and temperature conditions throughout.
- Can be large enough to cover much of North America (e.g., Polar front that often grips us in the winters for a week or so).
- Air masses are classified according to their source.
- Air masses formed over land are continental. Air masses formed over water are maritime.
- North America is generally impacted by:
  - Continental Polar
  - Maritime Polar
  - Maritime Tropical
  - Continental Tropical
Global Winds

- Polar easterlies
- Polar high
- Subpolar low
- Polar Easterlies
- Equator
- Doldrums
- 30° N
- 30° S
- Equatorial low (ITCZ)
- Subtropical high
- Trades
- Subtropical high
- Trades
- 60° S
- 60° N
- Westerlies
- Trade winds
- Westerlies
Global Air Circulation

The highest solar energy input is at the equator.

Solar energy

Equator 0°

30°N

60°N

Polar cap

Cold deserts

Evergreen coniferous forest

Temperate deciduous forest and grassland

Hot desert

Tropical deciduous forest

Tropical rain forest

Warm air rises and moves toward the poles.

Air cools and descends at lower latitudes.

Polar cap

Cold deserts

Tropical deciduous forest

Tropical rain forest

Warm air rises and moves toward the poles.

Air cools and descends at lower latitudes.

Southeast trades

Northeast trades

Westerlies

Westerlies

Moist air rises, cools, and releases moisture as rain.
Global Air Circulation Clip ~ 2½ mins
Jet Streams
- Rapid current of air
- Approx. 9 – 12 km up
- Reaches average speed of 175 kph
- Little friction to slow wind speed down
- Can be up to a few hundred km wide
- Definitely plays into flight patterns for air travel
- Huge part of weather patterns in all parts of the world – particularly in the upper latitudes
Chinook Winds

- Release of latent heat during condensation
- Compression heating
- Warmer drier

Ascending moist air cools

Chinook Winds
Atmospheric pressure increases & compressed air warms

The Rockies

Drier air warms

High Plains

Heat added

-12°C Chinook wall cloud

Moisture lost

10°C

Heat added

18°C

Strong wind

Chinook

Warm dry
Land Breeze
Happens during nights

Sea Breeze
aka – Thermals
Happens during sunny days

Land Breeze
Happens during nights
Created in large part due to the unequal heating of the earth from our sun. In northern hemisphere a low rotates clockwise & a High rotates counter clockwise. Opposites in the southern hemisphere.
Weather Disturbances
Cold front
Source: Lutgens and Tarbuck, 2004
• Thunderstorms & Hailstorms
• Hurricanes, Cyclones & Typhoons
• Tornadoes
• Fog

• Two types:

• Radiation Fog – forms during cloudless and windless nights. As the ground cools, the air closest to the ground cools quickest. As it cools the air condenses and air becomes saturated creating a visible low lying fog.

• If any wind is present, radiation fog will not develop as the wind mixes with the warmer air above

• Advection Fog -
Radiation Fog

Further radiational cooling at top of fog layer, deepens it

Heat radiating from the surface at night, cools the bottom air until it reaches saturation

Fog forms first at the surface, thickening as cooling continues
ADVECTION FOG

FOG

COOL SURFACE

WIND 5-15 KT

WARM, MOIST AIR

WARM SURFACE
Advection Fog

- Air is cooled to saturation by having warm moist air moving over a cold surface.
- San Francisco has a lot of advection fog since the surface water near the coast is much colder than the water farther off shore. Warm moist air from the Pacific Ocean is advected over the cold coastal waters, chilling the advected air from below.