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| 13ESS AtmosphereExam Summary | **Q1** | **Q2** | **Q3** |
| **2013** | **Compare and Contrast**Climate vs Weather* West Coast vs Canterbury
* Heat Energy
 | **Discuss**Wind Belts (Ferrel Cell)* Westerlies (Nth and Sth)
* Heat
* Coriolis
 | **Compare and Contrast**Tropo vs Stratosphere* Atmosphere composition
* Temp/Density Gradients
* Aerosols
 |
| **2014** | **Compare and Contrast**Polar vs Hadley Cells* Convection
* Solar radiation
 | **Discuss\***Water cycle* Weather/climate
* equator vs poles
* Changes of state
* Energy changes (air temp)
 | **Compare and Contrast**Volcanic Aerosols* Tropo vs Stratosphere
* Transport
* Regional vs global Climate
 |
| **2015** | **Compare and Contrast**Wind Belts* Polar Easterlies vs Trades
* Temp and pressure gradients – winds
* Coriolis
 | **Discuss\***Climate Change* CO2 and H2O(g)
* Water vapour linked to increase in global temp
* Climate trends
 | **Describe and explain**Convection cells* All three cells
* Interactions
* Transporting energy
 |
| **2016** | **Explain with reasons**Climate vs Weather in NZ* All climate factors
* Landforms (mnts and coast)
* 2 named locations in NZ (own choice)
 | **Explain**Atmosphere layers* Use data given
* Differences in all 4 layers
* Temp/density/pressure
 | **Explain\***Clouds* Formation – vapour and aerosols
* Temp and air pressure
* Heat exchange
* High vs low clouds
 |
| **2017** | **Explain**Convection cells* All three
* (sim ’15 Q3)
 | **Explain**Volcanic Aerosols* Regional vs Global
* Size of eruption
* (sim ’14 Q3)
 | **Explain\***Climate feedbacks* Clouds/water; permafrost; desertification; sea ice; oceans.
* (sim ’15 Q2)
 |
| **2018** | **Explain**Cells (deserts)* Circulation cells forming deserts
* Solar radiation forming cells
 | **Explain**Atmosphere layers* Protecting Earth
* Ionosphere!
* UV, Gamma, IR, X-ray, meteors
* Troposphere prevents extreme surface temps
 | **Explain**Climate – Water Cycle* Increased temp effect on Water cycle
* Changes to water cycle that effect weather events
 |
| **2019** | **Explain**Atmosphere Layers* Temp Gradient in all layers
* Latitude and seasons effect on tropopause
 | **Explain**Wind Belts* Roaring 40’s formation
* Coriolis
* Wet West Coast, Alps
 | **Explain**Climate* Carbon and Water cycles
* Human activities influencing C and H2O
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 \* +/- feedbacks discussed

# Definitions or key ideas from Schedules:

## Climate and Weather:

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| Weather | Weather is the condition of the atmosphere at a particular place over a short period of time. [2013Q1]*or*Weather is a mix of events that happen over a day or series of days in a locality, including temperature changes, precipitation, wind, brightness, humidity, etc. [2016Q1] |
| Climate | Climate refers to the weather pattern of a place over a long period, long enough to gather and record meaningful averages of weather data. [2013Q1]*or*Climate is the average weather pattern in a place or region over many years, including averages of precipitation, temperature, humidity, sunshine, etc. [2016Q1] |
| Orographic Rainfall | As they [humid westerly winds] rise into lower pressure, the air expands and the temperature of the water-laden air drops, the water vapour condenses as very heavy rainfall. [2013Q1] |
| Low clouds on climate | Low level clouds tend to be thick and reflect much of the short-wavelength radiation coming from the Sun back into space. Also because of their low altitude, they will absorb long wave radiation from Earth’s surface, which may then be re-radiated back to Earth or into space. On balance more of this long wave radiation is re-radiated back into space creating a cooling effect. [2016Q3] |
| High clouds on climate | High clouds tend to be thin and virtually transparent. They reflect very little short-wavelength radiation from the Sun and emit only small amounts of long-wavelength radiation towards space, so most of the radiation reaches the Earth and increases its temperature, creating a warming effect. High clouds also will re-radiate some long wave radiation back to Earth enhancing their warming effect. [2016Q3] |
| Mountains | Mountains affect weather due to orographic lifting. As air moves up a mountain or ridge it is cooled. This happens due to the pressure difference. If the rising air gets cooled enough to reach the dew point, condensation begins, causing clouds and precipitation. The air descending on the other side of the mountain / ridge has lost its moisture, making it dry, and it warms as it descends, causing warm, dry air on the leeward side, forming a rain shadow. The air heats due to adiabatic heating. When the air mass descends in the atmosphere as it moves down the leeward side of the range, the air encounters increasing atmospheric pressure. The compression of the air mass causes the air mass to increase in temperature. [2016Q1] |
| Factors Effecting Climate [2016Q1] | • Latitude – sun heats the Earth unevenly, being greatest at the Equator and weakest at the poles.• Earth’s tilt – leads to different parts of Earth receiving more solar energy at different times of the year.• Altitude – decrease in air pressure leading to decrease in air temperature.• Wind formation – differences in solar heating cause temperature differences which form convection cells e.g. sea breeze, Hadley Cell.•Pressure differences – pressure differences caused by solar heating which create winds e.g. trade winds, equatorial heating.• Coriolis Effect – affects the rising and falling air masses, dragging them with the spin, causing air in the northern hemisphere to be deflected towards the right, and in the southern towards the left.• Ocean currents – movement of large bodies of warm or cold surface waters. e.g. Bay of Plenty, Gulf Stream.• Greenhouse gases – creating a warmer climate through heating of the atmosphere by reradiation of infra-red. |
| Greenhouse Effect | The Earth’s surface absorbs solar radiation, and then re-radiates infrared radiation back to the atmosphere, where it can be absorbed by clouds and greenhouse gases such as CO2, H2O, methane, CFCs, and nitrous oxide. The greenhouse gas molecules absorb the radiation, and as a result gain energy and speed up, leading to a rise in temperature. The gases eventually radiate some of this energy back to the Earth’s surface. [2017Q3] |
| Examples of **positive** **feedbacks** on the climate system | **Water vapour** – warm air can hold more water vapour than cool air can. Therefore, as the temperature increases, the amount of water vapour also increases, causing a greater absorption of solar (short wavelength) radiation, which then leads to a further increase in temperature.**Clouds** – An increase in cloud cover (due to increased levels of water vapour) causes more long wavelength (infrared / terrestrial) radiation to be absorbed, resulting in an increase in global temperature.**Melting permafrost** – when permafrost melts due to increased temperatures, it releases large amounts of methane gas, a type of greenhouse gas, into the atmosphere. By increasing the amount of greenhouse gases, the effect of global warming is increased.**Warming oceans** – cooler water can absorb more carbon dioxide than warm water. As temperatures of the ocean increase, less carbon dioxide will be absorbed by the ocean, leading to more carbon dioxide remaining in the atmosphere, amplifying the effect of global warming.**Melting sea ice** – as temperatures rise, sea ice melts. Sea ice has a high albedo; therefore, as it disappears, more solar radiation will be absorbed, causing the global temperatures to increase.**Desertification** – loss of carbon dioxide sink [2017Q3] |
| Examples of **negative feedbacks** on the climate system | **Clouds** – as cloud cover increases, more solar radiation is reflected backinto space away from the surface of the Earth, helping to cool the global climate.**Desertification** – as temperatures increase, more areas around the Earth will become deserts. Deserts have a high albedo, leading to more solar radiation being reflected away from the surface of the Earth back into space, helping to cool the Earth. [2017Q3] |

## Clouds, Water, and the Water Cycle

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| Cloud formation and Heat energyCloud formation and role of water vapourAerosols and Cloud Formation | Heat energy is released in condensation, but the air gets colder as it rises and expands, and it moves up over the Southern Alps. The air that is being lifted will expand and cool (approx.6°C per kilometre). This cooling of the rising moist air can lower its temperature to its dew point. This allows condensation, which releases energy to the atmosphere, of the water vapour contained within it, and hence the formation of a cloud. If enough water vapor condenses into[2013Q1]Clouds form when air containing water vapour rises and then cools to its dew point, the temperature at which air becomes saturated, and vapour condenses around small particles in the air called seeds. The moist air may originate over the ocean or inland e.g. evapotranspiration. [2016Q3]Aerosols are tiny particles such as dust, sulfates, sea salt and ammonium salts, that act as tiny seeds for the water vapour and are known as cloud condensation nuclei. The water vapour in the air condenses around these seeds. When the seed becomes too heavy, it will fall as precipitation. [2016Q3] |
| Evaporation | Evaporation is the process by which a substance changes from the liquid phase to the gas phase. On Earth, the most important substance is water. Energy is required for evaporation to occur (liquid water into water vapour). Energy can come from the Sun (radiation), the atmosphere (conduction) or the Earth (conduction). When energy is extracted from the atmosphere to evaporate liquid water, the atmosphere will cool. Evaporation is very important because it is how water vapour, which is needed for clouds and precipitation, enters the atmosphere. At the poles there is less evaporation than at equatorial regions. [2014Q2] |
| Condensation | Condensation is the process by which a substance changes from the gas phase to the liquid phase. As air containing water vapour rises into the atmosphere, it will expand and cool. If it cools to its dewpoint temperature, the air will become saturated and condensation will occur. Condensation can be observed in the atmosphere as clouds, fog, dew, or frost form. When condensation occurs, the heat required to originally evaporate the water is returned to the atmosphere, causing the atmosphere to warm. [2014Q2] |
| Precipitation | Clouds are composed of millions of water droplets that have condensed. These water droplets grow into larger droplets by colliding and coalescing with one another. Eventually, the droplets can grow large enough so they will not be able to stay suspended in the cloud. When this occurs, they fall out of the cloud as precipitation. If the cloud’s temperature is below freezing, it will contain ice crystals. Ice crystals collide and stick to other ice crystals and eventually fall from the cloud as snow. Precipitation is water, either liquid or solid, that falls from the atmosphere to the surface. [2014Q2] |
| Water Cycle (impacts of global **warming**) | * Warm air can hold more water vapour than cool air.
* As the lower atmosphere becomes warmer, evaporation rates increase, resulting in an increase in the amount of moisture circulating throughout the troposphere.
* Warmer temperatures have led to increased drying of the land surface in some areas, due to evaporation.
* Warmer temperatures have led to earlier snowmelts in some areas, causing changes to water runoff into rivers and streams.
* Warmer temperatures have melted polar ice caps and glaciers that would normally not melt for a long time, causing sea levels to increase.

Warmer temperatures lead to warmer oceans, which can lead to more cyclones / hurricanes forming (or stronger ones), resulting in more heavy rain and flooding. It can also cause the sea level to increase due to expansion, leading to coastal inundation due to storm surges. [2018Q3] |
| Water Cycle (impacts on specific **weather** events) | * The consequence of higher water vapour concentrations is an increase in the frequency of intense precipitation events, e.g. floods, mainly over land; a larger amount of water is falling in a shorter period of time.
* Warmer temperatures mean that more precipitation is falling as rain rather than snow, which can lead to flooding.
* Earlier arrival of spring-like temperatures is leading to earlier peaks in snowmelts, meaning a reduced availability of water during summer when it would normally be available.
* Desert areas of the world are experiencing greater evaporation and reduced precipitation, leading to severe drought conditions.
* Rising sea levels due to melting icecaps will lead to low-level areas being more prone to flooding, and some areas will be submerged.
* Intense rainstorms, as well as increasing the risk of flooding, lead to increased levels of water runoff, meaning soil moisture does not increase.

Increase in condensation leads to more clouds therefore more insulation, impacting the weather by increasing the temperature. [2018Q3] |

## Wind Belts

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| Westerlies | The Westerlies are prevailing (usual) strong winds in the middle latitudes between 30- and 60-degrees latitude. They blow from the high-pressure area in the horse latitudes (junction between Hadley and Ferrel cells) towards the poles. [2013Q2] |
| Wind | Wind is the movement of air caused by the uneven heating of the Earth by the Sun. Differences in atmospheric pressure generate winds. [2015Q1] |
| Coriolis | The Coriolis effect makes the trade winds appear to be curving to the west. If the Earth were not spinning the air mass would travel directly south to north, south of the equator and north to south, north of the equator. The Coriolis effect (Earth’s spinning west to east) appears to deflect the wind (air mass) movement to the left (anticlockwise) in the southern hemisphere. The opposite effect occurs for the trade winds north of the Equator. The Coriolis effect of the Earth’s rotation is greatest at the poles. (Conservation of angular momentum). [2015Q1] |
| Polar Easterlies | The polar easterlies form when the atmosphere/air mass over the poles cools. This cool air then sinks and spreads over the surface. As the air flows away from the poles, it is turned to the west (to the left or anticlockwise) by the Coriolis effect. Because these winds appear to begin in the east, they are called easterlies. [2015Q1] |

## Convection Cells

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| Convection in Troposphere | The atmosphere has a circulation because of convection. At the Equator, where more of the Sun’s heat is received, the air heats up, reducing its density. The hot air rises and at the top of the troposphere the air spreads towards the Poles in a convection cell. [2013Q2] |
| Convection Cell | The term used to describe the phenomenon that occurs when density differences exist within a body of liquid, e.g. ocean or gas, e.g. atmosphere. Heat is different at the extremes of the body of gas (or liquid). When a volume of fluid is heated, it expands and becomes less dense and, thus, more buoyant than the surrounding fluid. The colder, denser part of the fluid descends to settle below the warmer, less-dense fluid and this causes the warmer fluid to rise. Such movement is called convection, and the moving body of gas (or liquid) is referred to as a convection cell. [2014Q1]*or*A convection cell is a circulation caused by density differences within a body of air (liquid / gas) where warmer less dense air rises and cooler, denser air drops. [2017Q1] |
| Hadley Cell DescriptionHadley Cell convection and Trade WindsHayley Cell convection and pressure and energy flow | A tropical atmospheric circulation, which features rising motion caused by solar radiation creating low pressure near the Equator. This creates a poleward air (airmass) flow 15–17 kilometres above the surface. This airmass cools and descends in the subtropics (30° latitude), then flows back towards the equator near the surface. This circulation is intimately related to extreme weather/climate conditions (e.g. easterly trade winds, tropical rain belts, hurricanes, subtropical deserts, and the jet streams). Hot air rises at the Equator and falls at about 30° latitude. [2014Q1]The region of Earth receiving the Sun's direct rays is the Equator. Here, air is heated and rises, leaving low pressure areas behind. Moving to about thirty degrees north and south of the Equator, the warm air from the equator begins to cool and sink. Between thirty degrees latitude and the Equator, most of the cooling sinking air moves back to the Equator. The air movements toward the Equator are called trade winds – warm, steady breezes that blow almost continuously. [2015Q1]**Air rises at or near the Equator rapidly due to the intensity of the sun’s radiation on this part of the Earth’s surface. This creates a low-pressure zone around this region of the Earth’s surface, and certain extreme weather events (e.g. thunderstorms, cyclones). The rising air mass spreads and cools moving in higher altitudes until falling in the region of 30 degrees north or south of the Equator. This falling air mass creates an area of high pressure and subsequently moves across the Earth’s surface back toward the Equator or towards the higher latitudes (60 degrees North and South).** This is a closed cell. The rising air mass at the Equator contains large amounts of water vapour. The latent heat for the evaporation process originates from solar radiation. As it rises and cools, the water vapour condenses to release this heat into the atmosphere / air mass. The air mass carries the heat energy heat away from the Equator at high altitude. Polar cells lie between the Poles and 60 degrees North [2015Q3] and **[2017Q1]** |
| Ferrel Cell DescriptionFerrel Cell Explanation | The Ferrel cell fits in between these two closed loop convection cells [Polar and Hadley]. However, it is not a closed loop convection cell as it does not have the heat source of the equator (Hadley cell) or the cold heat sink of the Poles (Polar cell) to drive a convection current. It is known as a zone of mixing’ as the Westerlies winds are affected by passing weather systems such as the jet streams. [2013Q2]**The Ferrel Cell lies between the Hadley and Polar cells (30 to 60 degrees latitude). Some of sinking air mass at 30 degrees North continues travelling northwards along the Earth’s surface towards the Pole. This air is still warm as it has originated from the Equator, and at 60 degrees latitude, approaches cold air moving down from the Pole. This causes the warm air mass to rise with some mixing taking place between the two air masses. This is known as the Polar Front, where weather events can originate. At higher altitudes part of the air mass moves towards the Pole carrying heat energy with it. The heat energy is the result of condensing water vapour (latent heat) that originated from the equator. The remaining air mass moves back towards the Equator.** The Ferrel Cell is an open cell relying on the closed Polar and Hadley Cells. It is the link in the transportation of heat energy from regions of intense heating at the Equator (insolation) to regions of the Earth’s surface where the effects of solar radiation are far less intense, the Poles. [2015Q3] and **[2017Q1]** |
| Polar Cell | Cold dense air descends over the Poles, which creates high pressure, this cold air moves along the surface to lower latitudes. At around 60° latitude north and south, this air has been warmed up and rises upwards, creating a zone of low pressure. The pressure difference allows convection current to form. [2014Q1]**Polar cells lie between the Poles and 60 degrees North and South. These are closed cells. Cold, dense air descends over the Poles and the cold air is circulated towards the equator along the Earth’s surface. The air from the Poles rises at 60 degrees latitude and some of this air returns to the poles at altitude completing the Polar Cell.** [2015Q3] and **[2017Q1]** |

## Aerosols

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| AerosolsVolcanic Aerosols | Aerosols are minute particles suspended in the atmosphere. When these particles are sufficiently large, we notice their presence as they scatter and absorb sunlight. Their scattering of sunlight can reduce visibility (haze) and redden sunrises and sunsets. [2013Q3]*or*Aerosols are minute solid and liquid particles suspended in the atmosphere. {2017Q2]Aerosols are very small particles of solid or liquid in a gas medium. Volcanic aerosols are the small particles of gases and ash, which originate from the magma within a volcano, which have high energy during a volcanic eruption. [2014Q3] |

## Atmosphere Layers, Temperature, Pressure, and Density

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| DensityDensity with altitude | Atmospheric density is the mass of air molecules per unit of volume. [2016Q2]The atmosphere becomes thinner and thinner (gas particles further and further apart) and less dense – fewer gas particles per unit volume – with increasing altitude. This decrease in density continues through all layers of the atmosphere with increasing altitude, i.e. highest density at bottom of troposphere and decreases as you rise up through the troposphere, stratosphere and beyond to space. [2013Q3]Air density decreases with increasing altitude because there are fewer air particles the higher you go in the atmosphere. The highest density of gases in the atmosphere is at the surface of Earth at sea level, within the troposphere. [2016Q2] |
| Air Temperature*(related to the Thermosphere)* | Air temperature, however, is a measure of the kinetic energy of air molecules, not of the total energy stored by the air.*Therefore, since the air is so thin within the thermosphere, such temperature values are not comparable to those of the troposphere or stratosphere. Although the measured temperature is very hot, the thermosphere would feel very cold to us because the total energy of only a few air molecules residing there would not be enough to transfer any appreciable heat to our skin.* [2016Q2] |
| Air Pressure | Atmospheric pressure is the force per unit of area exerted on a surface by the weight of air above the surface. The force exerted on the air is due to gravity. Air pressure depends on the temperature and density of the air mass. Temperature affects air pressure by causing the air to either become more or less dense. Warm, less dense air has low pressure, while cold, more dense air has high pressure. The molecules that make up the atmosphere are pulled close to the Earth’s surface by gravity. This causes the atmosphere to be concentrated at the Earth’s surface and thin rapidly with height. Air pressure is a measure of the weight of the molecules above you. As you move up in the atmosphere, there are fewer molecules above you, so the air pressure is lower. [2016Q2] |
| TroposphereTroposphere HeatingTroposphere protection | The troposphere is mostly heated by energy transfer from the surface of the Earth, so the lowest part of the troposphere is where weather is found due to convection currents in the atmosphere there. As the altitude increases, the temperature drops as you go up through the troposphere. [2013Q3]The troposphere is mostly heated by infra-red energy transfer from the surface of the Earth, so temperature is highest at the lowest point and decreases with increasing altitude. [2016Q2]Without the troposphere, the Earth’s average surface temperature would be too cold for life. Natural greenhouse gases in the troposphere form a layer that acts like a blanket, helping to trap long wavelength infrared heat from the surface by stopping them from escaping out to space. Instead the gases absorb it and then re-radiate the heat back towards Earth… {2018Q2] |
| StratosphereStratosphere HeatingStratosphere protection | In the stratosphere, the presence of the ozone layer of gases, which absorbs ultraviolet radiation, heats the stratosphere to a temperature above that of the top of the troposphere. Temperature here increases with altitude. [2013Q3]The stratosphere defines a layer in which temperatures rise with increasing altitude. At the top of the stratosphere the thin air may attain temperatures close to 0°C or 270K. This rise in temperature is caused by the absorption of ultraviolet (UV) radiation from the Sun by the ozone layer. Such a temperature profile creates very stable atmospheric conditions. [2016Q2]The stratosphere contains the ozone layer, which is made up of ozone molecules. Ozone protects the Earth from damaging UV radiation and acts as a sort of sunscreen. Ozone molecules absorb UV radiation and re-radiate the energy as heat, warming the stratosphere. [2018Q2] |
| Mesosphere heatingMesosphere protection | The mesosphere has the coldest temperatures in the atmosphere because very little solar radiation is absorbed here and the air is very thin, with air particles far apart making it difficult for heat transfer. Temperatures in the mesosphere drop with increasing altitude to about –100°C or 180K. [2016Q2]Space debris, such as meteors and bits of asteroids, burn up as they enter the atmosphere due to friction between the gas particles in the atmosphere and the object. Most objects will completely burn up in the mesosphere, but some do penetrate further, depending on their original size. [2018Q2] |
| Thermosphere heatingThermosphere protection | Within the thermosphere temperatures rise continually to well beyond 1000°C. The few molecules that are present in the thermosphere receive extraordinary amounts of energy from the Sun, causing the layer to warm to such high temperatures. [2016Q2]The thermosphere is responsible for the absorption of X-rays and some gamma rays, and extreme UV from the Sun. [2018Q2] |
| Ionosphere (within the thermosphere) | High-energy solar photons rip electrons away from gas particles in the thermosphere, creating charged ions in a region called the ionosphere. Areas within the ionosphere absorb X-rays and extreme UV from the Sun, helping to protect the Earth. [2018Q2] |