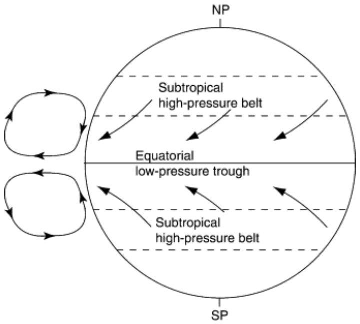
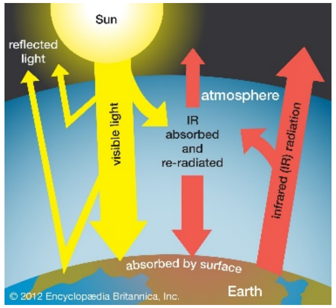
Assessment Schedule – 2024

Earth and Space Science: Demonstrate understanding of processes in the atmosphere system (91414)

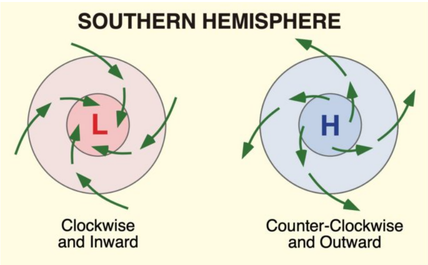
Evidence Statement

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
ONE	The ITCZ forms near the Equator and is characterised by rising warm air, cloud formation, higher rainfall, and weak surface winds. Differential heating due to Earth's curvature causes more direct insolation, intense heating, and higher temperatures and at the Equator. The Hadley cells form between the Equator / ITCZ and 30˚N / S. Warm surface air heated via radiation (and conduction) expands, becomes more byouant / less dense, and rises in the troposphere, leaving a low pressure zone at the surface. The large volume of rising air reaches the tropopause and diverts north and south. Air cools as it rises and density increases, due to contraction, causing it to sink back down at the 30° latitudes, leading to high pressure at the surface. The cold sinking air moves from high to low pressure, causing surface winds from 30° to the Equator. This air is heated by the surface as it returns to the Equator. This completes convection circulation of the Hadley cell. There is generally very little wind at the ITCZ, as wind converges and rises in this area, which sailors refer to as "the doldrums"..  Warm air rising at the ITCZ holds large volumes of water vapour, resulting from evaporation in the tropics, due to surface ocean heating by the solar radiation and trade winds converging. Rising humid air will cool adiabatically until it reaches dew point temperature, upon which water vapour will condense to form droplets. This is responsible for the formation of the cloud bank at the ITCZ. The phenomenon is permanent as Hadley cell circulation is continuous. The ITCZ moves north and south as the angle of insolation changes over the course of a year (apparent position of Sun shifts north and south), between different seasons. During summer, when the Southern Hemisphere is tilted towards the Sun, solar radiation is more concentrated over a small surface area. This causes a shift in Hadley cell formation towards the south and associated shift in the ITCZ. During the Southern Hemisphere winter, the ITCZ moves north, due to the Northern Hemisphere being tilted towards the Sun. During autumn and spring the, ITCZ is closer to the Equator.	Describes with understanding: • winds weak at ITCZ / most airflow up • high rainfall / cloud common in ITCZ • more intense heating / warmer near Equator • warm air rising AND cold air sinking / a convection cell • rising air leaves low pressure / sinking air → high pressure • surface wind from high to low pressure • more evaporation due to direct heating • warm rising air transports water vapour • vapour condenses to form water droplets / clouds • ITCZ moves north and south with Sun.	Explains in detail: • formation of ITCZ / Hadley cell due to the angle of solar insolation / atmosphere heating processes • circulation due to temperature OR pressure differences in the Hadley cell • formation of high and low pressure bands on surface causing wind from 30˚ to ITCZ • winds at ITCZ weak (doldrums) as converging and rising in Hadley cell • cloud formation processes at ITCZ (evaporation, cooling, and condensation) • changes in angle of insolation cause shift in ITCZ position.	Discusses comprehensively: • formation of Hadley cell and surface winds due to solar insolation, temperature and pressure gradients • formation of permanent cloud bank at ITCZ due to continuous Hadley cell updraught and water cycle processes • shift in ITCZ accurately linked to seasons AND shift of more direct insolation / angle.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	ONE point from Achievement.	TWO points from Achievement.	THREE points from Achievement.	FOUR points from Achievement.	ONE point from Merit.	TWO points from Merit.	ONE point from Excellence.	TWO points from Excellence.

Q	Evidence	Achievement	Achievement with Merit	Achievement with Excellence
TWO	The greenhouse effect originates when greenhouse gases (GHG) in the atmosphere trap heat, creating a layer that warms the atmosphere.  Earth's surface absorbs short-wave solar radiation and re-emits the energy as long-wave / IR radiation (heat). GHG absorb this heat and re-emit it back into the atmosphere, towards the surface, out to space, or towards other greenhouse gas molecules. GHGs cause an increase in atmospheric temperature and provide a comfortable temperature for life to exist on Earth. GHGs include CO_2 and CH_4. These occur naturally in the atmosphere, due to volcanic outgassing, wetlands and other natural processes, but human activities increase the emissions of these two gases. Fossil fuel combustion (coal / oil / gas) for energy production (transport and electricity) is responsible for carbon dioxide emissions, contributing 40% of NZ annual emissions, adding carbon. Agriculture accounts for 49% of carbon emissions in New Zealand. This includes methane, resulting from livestock farming, e.g. cattle and sheep releasing methane during digestion. (Agriculture also releases nitrous oxide from fertilisers and urine.) Methane is also released from landfill / waste processes. Methane is a more potent greenhouse gas than carbon dioxide, and leads to 28 times more warming of the atmosphere. Industrial processes release GHG, mainly via combustion. Decomposers break down organic waste and release carbon compounds into the atmosphere (CO_2 and methane). Increasing GHGs in the atmosphere causes additional heat to be trapped in the atmosphere, increasing global average temperatures. However, due to variations in climate, some areas may experience more extreme temperatures (hotter and / or colder than normal) as the global average temperature increases. Carbon dioxide remains in the atmosphere for a long time (300–1000 years), while methane only remains for 12 years, but is then broken down to CO_2, thus having a longer-term warming effect. Methane also has a greater warming potential than carbon dioxide, which means 1 kg of methane will warm the atmosphere as much as 28 kg of carbon dioxide. Nearly half of New Zealand's emissions are from agriculture, which is mainly methane, meaning our farming practices are responsible for more atmospheric warming than our combustion of fuels.	Describes with understanding: • greenhouse effect as warming of atmosphere • surface absorbs short-wave, but emits long-wave radiation (heat) • GHG absorb heat and re-emits it, trapping in the atmosphere • combustion of fossil fuels for energy releases CO_2 • livestock belching / agriculture releases mainly methane • increasing GHG cause increase in atmospheric temperature • CO_2 lasts longer • methane absorbs and releases more energy / heat • recognition that a significant portion (half) of NZ emissions are methane • another effect on climate (not temp).	Explains in detail: • GHG's absorb IR / long-wave radiation emitted by the surface • TWO carbon-addition processes explained, (incl. source and form of carbon) • increasing GHG trap and re-emit more heat, leading to increase in atmospheric temperature • two effects of increased GHG on climate • methane has greater (short-term) impact on atmospheric temperature / climate with reason • comparison between CO_2 (less impact, but longer term) and methane (greater impact over short term).	Discusses comprehensively: • interaction between radiation (from the Sun and Earth's surface) and GHGs cause greenhouse effect / atmospheric warming • sources and effect of emitted GHGs in New Zealand carbon cycle on climate / atmospheric processes • comparing lifetime and warming potential of CH_4 and CO_2 and links to agriculture and energy / combustion.

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	ONE point from Achievement.	TWO points from Achievement.	THREE points from Achievement.	FOUR points from Achievement.	ONE point from Merit.	TWO points from Merit.	ONE point from Excellence.	TWO points from Excellence.

Q	Evidence	Achievement	Merit	Excellence
THREE	High-pressure systems lead to clear sunny skies, but large variation in daily temperatures. Air flow brings colder upper troposphere air towards the surface. However, solar radiation is absorbed by the surface during the day, and heat is re-emitted, warming the lower troposphere. There are no clouds blocking, reflecting, or absorbing radiation. This causes higher day-time temperatures and colder night temperatures. Surface air circulation around a high-pressure system in the Southern Hemishere is anticlockwise, because the Coriolis effect causes deflection towards the left and wind flows along the isobars. As air is sinking, there is no rising humid air, preventing condensation and rainfall, causing dry conditions. This system has widely spaced isobars, so winds are very weak, because the pressure gradient is weak.  In contrast, low-pressure systems are centred on a rising column of warm air, likely to contain water vapour. As the humid air rises, it will cool and condense, forming clouds and precipitation. Air flow around these systems is clockwise at the surface (deflected left towards the centre). Wind directions follow the isobars and are strong, as the pressure gradient is strong (closer spaced isobars). As air flow is clockwise around the system, surface winds are from the west in the chart. Clouds (in low pressure systems) have a high albedo and reflect incoming solar radiation, causing less energy to reach the surface. This causes a decrease in surface atmospheric temperature. At night, heat radiated from Earth is absorbed and reflected by the cloud, retaining a higher temperature. This causes a smaller range in temperature. Additionally, there is a cold front approaching from the south-west present in the low-pressure system. There is a boundary between a cold incoming air mass and a warmer air mass. The cold denser air mass will force the warmer air mass to rise, causing precipitation and storms along the front. There is also a drop in temperature, associated with stronger wind gusts, but this lasts a short period as cold fronts move fast.	Describes with understanding: • high pressure associated with sunny, clear conditions • low pressure associated with cloud and precipitation • effect of cloud cover on solar insolation / temperatures • high pressure airflow anticlockwise • low-pressure airflow clockwise • identifies an accurate wind direction for the North Island (W) or South Island (SW) • wind stronger when isobars closer / P gradient greater • front is a boundary between two different air masses OR warm air mass rises over cold air mass at a front • Air rises in LP / sinks in HP • Cold front associated with drop in temp / stronger wind / heavy rain • Warm front associated with increasing temp / lighter rain	Explains in detail: • sinking air in high pressure prevents condensation, thus clear skies, while low pressure opposite • rising air in low pressure leads to warm moist air cooling and condensation / cloud formation • effect of cloud cover on solar insolation / temperatures with reason • wind around both pressure systems determined by Coriolis, deflecting air to left in Southern Hemisphere • wind direction follows isobars and strength depends on spacing / pressure gradient • cold front ahead of cold air mass will force warm air mass to rise, causing precipitation.	Discusses comprehensively: • variation in clouds, insolation, and temperature in both systems • circulation directions and wind strengths for both systems related to Coriolis isobars • modifications to weather conditions, due to cold OR warm fronts (cloud / precipitation, temperature, wind & air mass directions).

NØ	N1	N2	A3	A4	M5	M6	E7	E8
No response; no relevant evidence.	ONE point from Achievement.	TWO points from Achievement.	THREE points from Achievement.	FOUR points from Achievement.	ONE point from Merit.	TWO points from Merit.	ONE point from Excellence.	TWO points from Excellence.

Cut Scores

Not Achieved	Achievement	Achievement with Merit	Achievement with Excellence
0 – 7	8 – 13	14 – 18	19 – 24