Earth & Environmental Science 2019 v1.3

IA3 high-level annotated sample response

August 2018

Research investigation (20%)

This sample has been compiled by the QCAA to assist and support teachers to match evidence in student responses to the characteristics described in the instrument-specific marking guide (ISMG).

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

2. apply understanding of the cause and impact of Earth hazards or global climate change to develop research questions
3. analyse research evidence about the cause and impact of Earth hazards or global climate change
4. interpret research evidence about the cause and impact of Earth hazards or global climate change
5. investigate phenomena associated with the cause and impact of Earth hazards or global climate change through research
6. evaluate research processes, claims and conclusions about the cause and impact of Earth hazards or global climate change
7. communicate understandings and research findings, arguments and conclusions about the cause and impact of Earth hazards or global climate change.

Note: Objective 1 is not assessed in this instrument.

Queensland Government
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For all Queensland schools
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Instrument-specific marking guide (ISMG)

Criterion: Research and planning

Assessment objectives

2. apply understanding of the cause and impact of Earth hazards or global climate change to develop research questions
5. investigate phenomena associated with the cause and impact of Earth hazards or global climate change through research

The student work has the following characteristics:	Marks
• informed application of understanding of the cause and impact of Earth hazards or global climate change demonstrated by a considered rationale identifying clear development of the research question from the claim • effective and efficient investigation of phenomena associated with the cause and impact of Earth hazards or global climate change demonstrated by – a specific and relevant research question – selection of sufficient and relevant sources.	5–6
• adequate application of understanding of the cause and impact of Earth hazards or global climate change demonstrated by a reasonable rationale that links the research question and the claim • effective investigation of phenomena associated with the cause and impact of Earth hazards or global climate change demonstrated by – a relevant research question – selection of relevant sources.	3–4
• rudimentary application of understanding of the cause and impact of Earth hazards or global climate change demonstrated by a vague or irrelevant rationale for the investigation • ineffective investigation of phenomena associated with the cause and impact of Earth hazards or global climate change demonstrated by – an inappropriate research question – selection of insufficient and irrelevant sources.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Analysis and interpretation

Assessment objectives

3. analyse research evidence about the cause and impact of Earth hazards or global climate change
4. interpret research evidence about the cause and impact of Earth hazards or global climate change

The student work has the following characteristics:	Marks
• systematic and effective analysis of qualitative data and/or quantitative data within the sources about the cause and impact of Earth hazards or global climate change demonstrated by – the identification of sufficient and relevant evidence – thorough identification of relevant trends, patterns or relationships – thorough and appropriate identification of limitations of evidence • insightful interpretation of research evidence about the cause and impact of Earth hazards or global climate change demonstrated by justified scientific argument/s.	5–6
• effective analysis of qualitative data and/or quantitative data within the sources about the cause and impact of Earth hazards or global climate change demonstrated by – the identification of relevant evidence – identification of obvious trends, patterns or relationships – basic identification of limitations of evidence • adequate interpretation of research evidence about the cause and impact of Earth hazards or global climate change demonstrated by reasonable scientific argument/s.	3–4
• rudimentary analysis of qualitative data and/or quantitative data within the sources about the cause and impact of Earth hazards or global climate change demonstrated by – the identification of insufficient and irrelevant evidence – identification of incorrect or irrelevant trends, patterns or relationships – incorrect or insufficient identification of limitations of evidence • invalid interpretation of research evidence about the cause and impact of Earth hazards or global climate change demonstrated by inappropriate or irrelevant argument/s.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Conclusion and evaluation

Assessment objectives

4. interpret research evidence about the cause and impact of Earth hazards or global climate change

6. evaluate research processes, claims and conclusions about the cause and impact of Earth hazards or global climate change

The student work has the following characteristics:	Marks
• insightful interpretation of research evidence about the cause and impact of Earth hazards or global climate change demonstrated by justified conclusion/s linked to the research question • critical evaluation of the research processes, claims and conclusions about the cause and impact of Earth hazards or global climate change demonstrated by – insightful discussion of the quality of evidence – extrapolation of credible findings of the research to the claim – suggested improvements and extensions to the investigation that are considered and relevant to the claim.	5–6
• adequate interpretation of research evidence about the cause and impact of Earth hazards or global climate change demonstrated by reasonable conclusion/s relevant to the research question • basic evaluation of the research processes, claims and conclusions about the cause and impact of Earth hazards or global climate change demonstrated by – reasonable description of the quality of evidence – application of relevant findings of the research to the claim – suggested improvements and extensions to the investigation that are relevant to the claim.	3–4
• invalid interpretation of research evidence about the cause and impact of Earth hazards or global climate change demonstrated by inappropriate or irrelevant conclusion/s • superficial evaluation of the research processes, claims and conclusions about the cause and impact of Earth hazards or global climate change demonstrated by – cursory or simplistic statements about the quality of evidence – application of insufficient or inappropriate findings of the research to the claim – ineffective or irrelevant suggestions.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Communication

Assessment objective

7. communicate understandings and research findings, arguments and conclusions about the cause and impact of Earth hazards or global climate change

The student work has the following characteristics:	Marks
• effective communication of understandings and research findings, arguments and conclusions about the cause and impact of Earth hazards or global climate change demonstrated by – fluent and concise use of scientific language and representations – appropriate use of genre conventions – acknowledgment of sources of information through appropriate use of referencing conventions.	2
• adequate communication of understandings and research findings, arguments and conclusions about the cause and impact of Earth hazards or global climate change demonstrated by – competent use of scientific language and representations – use of basic genre conventions – use of basic referencing conventions.	1
• does not satisfy any of the descriptors above.	0

Task

Context
Investigate one of the following claims: • Earthquake early warning systems save lives. • Volcanic eruptions can be predicted. • Tsunami early warning systems save lives. • An increase in extreme weather events will kill the Great Barrier Reef. • Poor urban planning can destroy lives and property. • Excessive urbanisation of coastal shorelines will cause destruction of coastal ecosystems. • Prolonged drought causes the extinction of endangered animal species. • Burning fossil fuels is causing the Earth to get warmer. • Climate change will make extreme weather events more frequent. • Climate change will cause sea levels to rise. • Climate change will change species distribution across Australia. You may identify an alternative claim in consultation with your teacher. This claim must be related to Unit 4 subject matter.
Task
Gather secondary evidence related to a research question in order to evaluate the claim. Develop your research question based on a number of possible claims provided by your teacher. Obtain evidence by researching scientifically credible sources, such as scientific journals, books by well-credentialed scientists, and websites of governments, universities, independent research bodies or science and technology manufacturers. You must adhere to research conventions.

Sample response

Criterion	Marks allocated	Result
Research and planning Assessment objectives 2, 5	6	6
Analysis and interpretation Assessment objectives 3, 4	6	5
Conclusion and evaluation Assessment objectives 4, 6	6	5
Communication Assessment objective 7	2	2
Total	**20**	**18**

The annotations show the match to the instrument-specific marking guide (ISMG) performance-level descriptors.

Key: Research and planning | Analysis and interpretation | Conclusion and evaluation | Communication

Note: Colour shadings show the characteristics evident in the response for each criterion.

Research and planning [5–6]

a considered rationale identifying clear development of the research question from the claim

The rationale shows evidence of careful, deliberate thought. The sequence of ideas involved in the development of the research question from the claim is easily seen.

selection of sufficient and relevant sources

Sources are scientific and provide enough evidence for the development of a scientific argument that responds to the research question.

Research investigation

To what extent has average temperature increase across the continent correlated with the frequency or severity of cyclones around Australia?

Claim

The claim chosen is “Climate change will make cyclones worse.”

Rationale

The above claim represents people’s belief or fear, that climate change will make the impact of cyclones on our lives worse. An assumption that climate change is occurring will be linked to evidence that average temperature change in Australia has occurred over the past 100 years. To investigate this claim, the term ‘worse’ must be redefined by criteria that can be linked to quantifiable evidence. In relation to cyclones, information on the frequency and severity is available. ‘Worse’ cyclones fall under the category of ‘severe’. The severity of a cyclone can be measured by factors such as central pressure, radius, wind speed or classification number for warnings. These factors are easily quantifiable and scientifically valid as data is regularly collected by the Australian Bureau of Meteorology. High standards are set by the bureau for data collection instrumentation and much of this data is available for analysis so that a decision on the validity of the claim can be based on unbiased evidence rather than speculation. Economic impact could also be considered but is outside the scope of this investigation.

Originally the investigation was going to be limited to cyclones that crossed the coast of Queensland as these are the events that have the most impact on our lives in this state. However, data availability from the Australian Bureau of Meteorology has made consideration of continental Australia and its surrounding oceans a more feasible option.

Research and planning [5–6]

a specific and relevant research question

The research question identifies the phenomenon to be investigated and allows for the collection of sufficient and relevant data.

The research question has been developed from the claim and is connected to the topics covered in the unit.

Research question

To what extent has average temperature increase across the continent correlated with the frequency and severity of cyclones around Australia?

Justified arguments and evidence

The main evidence in relation to this argument has been obtained from the Australian Bureau of Meteorology or BOM. Data recorded as part of the Australian Climate Observations Reference Network and displayed by the BOM (Long term temperature record, 2016) establishes that there has been an increase in the average temperatures recorded in Australia since 1910.

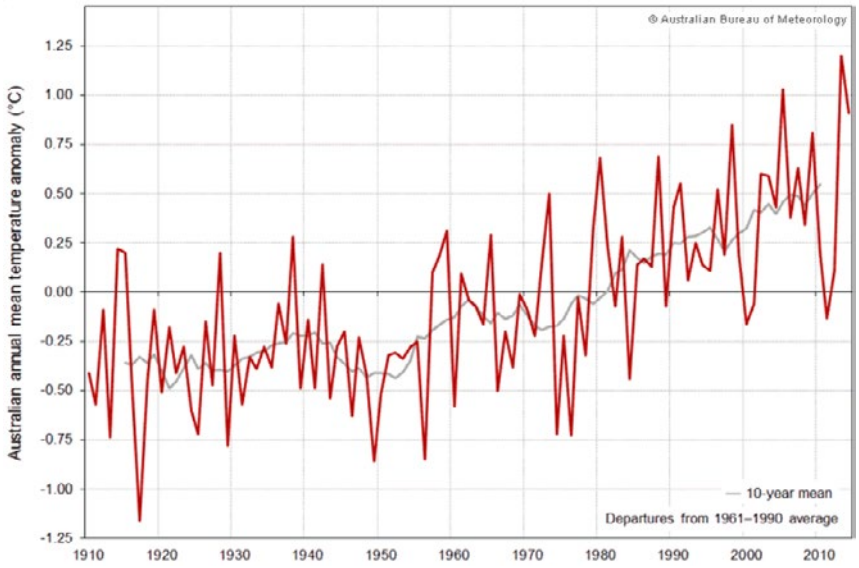

Figure 1. Annual mean temperature anomalies for Australia (red) with 10-year mean (light grey). Departures are from the 1960–1990 average.

Analysis and interpretation [5–6]

thorough identification of relevant trends, patterns or relationships

The response identifies relationships in a way that is not superficial or partial. Identified relationships are applicable and directly connected to the formation of the scientific argument.

identification of sufficient and relevant evidence

The evidence is adequate for the purpose of responding to the research question and can support a valid conclusion. The evidence is applicable to the formation of the scientific argument.

Figure 1 shows mean temperature anomalies in Australia since 1910 based around the average temperature for 1960 to 1990. It can be seen that the 10-year temperature mean was at a minimum of -0.5 °C in the early 1920's and has steadily climbed to reach a maximum value of 0.5°C in 2010 an increase of 1°C. While it took approximately 63 years to reach mean temperature levels in 1983 it has taken only 27 years to rise another 0.5°C.

Analysis and interpretation [5–6]

identification of sufficient and relevant evidence

The evidence responds to the research question in terms of the frequency and severity of cyclones and can support a valid conclusion. The evidence is applicable to the formation of the scientific argument.

thorough identification of relevant trends, patterns or relationships

The response identifies trends, patterns or relationships that are not superficial or partial. The trends, patterns, or relationships have direct bearing upon and are applicable to the formation of the scientific argument.

justified scientific argument/s

The scientific argument uses a process of sound reasoning and draws upon valid and reliable evidence.

On their page which discusses tropical cyclone trends (Tropical cyclone trends, 2017) the following graph is displayed:

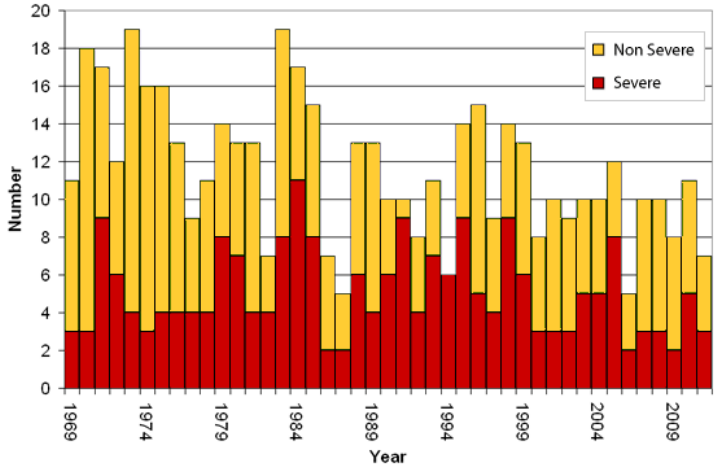

Figure 2: Severe and non-severe tropical cyclones recorded in the Australian region from 1969 – 2011. Severe tropical cyclones are those which show a minimum central pressure of less than 970 hPa.

The obvious trend seen in this data is a general reduction in the total number of recorded cyclones since 1969. The trend in severe cyclones however is not so clear. To further analyse the data above a table has been constructed using the data above and spreadsheet data from the BOM titled “Database of past tropical cyclone tracks” (Database of past tropical cyclones, 2017). To obtain the most recent data recorded, cyclone tracks from 2012 to 2017 were analysed to determine if their central pressure dropped below 970 hPa at any time.

Figure 3

Time period	Total number of cyclones recorded.	Average number of cyclones per year.	Average number of severe cyclones per year.	Percentage of severe cyclones per year.
1969/1978	142	14.2	4.4	30.9%
1979/1988	123	12.3	6.0	48.8%
1989/1998	110	11.0	6.3	57.3%
1999/2008	98	9.8	4.1	41.8%
2009/2017 (Feb)	67	8.7	3.4	40.3%

The evidence in Figure 3 shows a dramatic drop in cyclone numbers each decade since 1969. The number of cyclones recorded in the years between 1999 and 2008 was only 98, 31% less than the 142 recorded between 1969 and 1978.

Analysis and interpretation [5–6]

thorough identification of relevant trends, patterns or relationships

The response identifies trends, patterns or relationships that are not superficial or partial. The trends, patterns, or relationships have direct bearing upon and are applicable to the formation of the scientific argument.

identification of sufficient and relevant evidence

The evidence is appropriate for the purpose of responding to the research question. It is applicable and directly connected to the formation of the scientific argument.

Conclusion and evaluation [5–6]

justified conclusion/s linked to the research question

The response uses sound reasoning and valid and reliable evidence to support conclusions that directly respond to the research question.

extrapolation of credible findings of the research to the claim

The response identifies believable outcomes of the research and then applies them to the claim.

The average number of cyclones per year is also down from over 14 per year in the 1970's to less than 10 in the first decade of the new millennium.

The evidence relating to severe cyclones is less clear. If considering the 3 decades from 1969 to 1999 there appears to a dramatic increase in the number of severe cyclones and also the percentage of cyclones that are severe. From 1969 to 1978 there was an average of 4.4 severe cyclones per year which represented 30.9% or just under a third of the total cyclones per year. By the decade between 1989 and 1999, Australia was averaging 6.3 severe cyclones per year which now represented over half of all cyclones at 57.3%. Since 1999 however the number of severe cyclones has reduced to values close to those in the 1970's however the percentage of all cyclones that are severe is still quite high at over 40%.

Analysis of this raw data is supported by published scientific articles. The journal Nature features an article by Haig, Nott and Reichart (2014), that states Australian tropical cyclone activity is lower than at any time over the past 500 – 1500 years. Their statements come from use of a Climate Activity Index (CAI) that compares modern data to oxygen isotope values in geological sediments. Their evidence indicates the presence of a regular multi-centennial cycle of activity which has undergone a sharp decrease since the 1960's. This correlates with the temperature data of figure 1 showing a more rapid temperature rise since approximately 1954.

An article published in Nature Geoscience by Thomas (Tropical cyclones and climate change, 2010) indicates that modelling studies project global averages of cyclonic frequency will decrease by 6 – 34%. However, it also indicates that the frequency of severe cyclones may increase by 20%. This is due to increases in oceanic temperature creating cyclones with higher wind speeds (Nott, 2015).

Conclusion

The conclusion that can be made from the data is that while the number of cyclones is reducing, the general severity of cyclones is increasing. The evidence supports the existence of a negative correlation between increases in average temperature across the Australian continent with the frequency of cyclones occurring around Australia. It also supports the existence of a correlation between increases in average temperature with the percentage of severe cyclones that occur.

On balance, the evidence supports the claim that climate change will make cyclones worse. It is true that the number of cyclones has decreased between 1969 and today. However, the cyclones that do occur today are more severe on average (e.g. 40.3% severe in 2017 compared to 30.9% severe in 1969, Figure 3) and, according to Thomas (2010), likely to become even more severe. This means that they are likely to have a greater impact on our lives by causing greater property damage, destruction of agricultural production and loss of human life.

Analysis and interpretation [3–4]

basic identification of limitations of evidence

The response recognises some fundamental limitations of evidence. However, the response has not identified limitations of the evidence that affect how well it can be used to develop a response to the research question.

Conclusion and evaluation [5–6]

insightful discussion of the quality of evidence

The discussion shows understanding of the features of the evidence that affect its ability to be used to respond to the research question.

Conclusion and evaluation [3–4]

suggested improvements and extensions to the investigation that are relevant to the claim

The improvements and extensions to the investigation are applicable to the claim but do not show evidence of careful or deliberate thought.

Communication [2]

fluent and concise use of scientific language and representations

The response is easily understood, avoids unnecessary repetition and meets the required length.

acknowledgment of sources of information through appropriate use of referencing conventions

Sources of information are acknowledged using a referencing style that is suitable for the purpose of the essay.

Evaluation of the claim and recommendations

The inability to definitively support or reject this claim revolves about data availability and time scales. The cyclone track data available from the BOM is easy to validate scientifically but offers data from only 1969 when satellite tracking commenced. Therefore, there is no reliable evidence to show the existence of a correlation between rising air temperature and frequency and severity of cyclones between 1910 and 1969. In contrast, temperature data has been reliably compiled since 1910. The need to use predictive models such as CAI is necessary since the collection of most types of scientific data used today did not occur until the second half of last century. These models rely on the high degree of correlation between current measurements and paleontological data. However, this evidence is only as valid as the assumptions on which these models are based. Another issue with measurement of cyclonic frequency is its variant nature from year to year. 1983 saw a total of 19 cyclones recorded but 4 years later in 1987 only 5 cyclones were recorded. This investigation has also not considered the impact of El Nino and La Nina which further impact the variability of yearly cyclonic frequency. It is recommended that monitoring of both cyclone frequency and intensity be continued as the progress of time will help resolve this issue. Also, there are other ways to rate the severity of cyclones that do not refer to air pressure, e.g. wind speed. It might be useful to data based on these measures. With temperature records indicating an increasing rate of temperature change this issue may become clearer sooner rather than later.

Word count: 1526

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