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91193

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NZQA

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Level 2 Earth and Space Science, 2019

91193 Demonstrate understanding of physical principles related to the Earth System

9.30 a.m. Wednesday 27 November 2019
Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of physical principles related to the Earth System.	Demonstrate in-depth understanding of physical principles related to the Earth System.	Demonstrate comprehensive understanding of physical principles related to the Earth System.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Excellence

TOTAL 21

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QUESTION ONE: THE COLOUR OF CLOUDS

www.thoughtco.com/types-of-clouds-recognize-in-the-sky-4025569

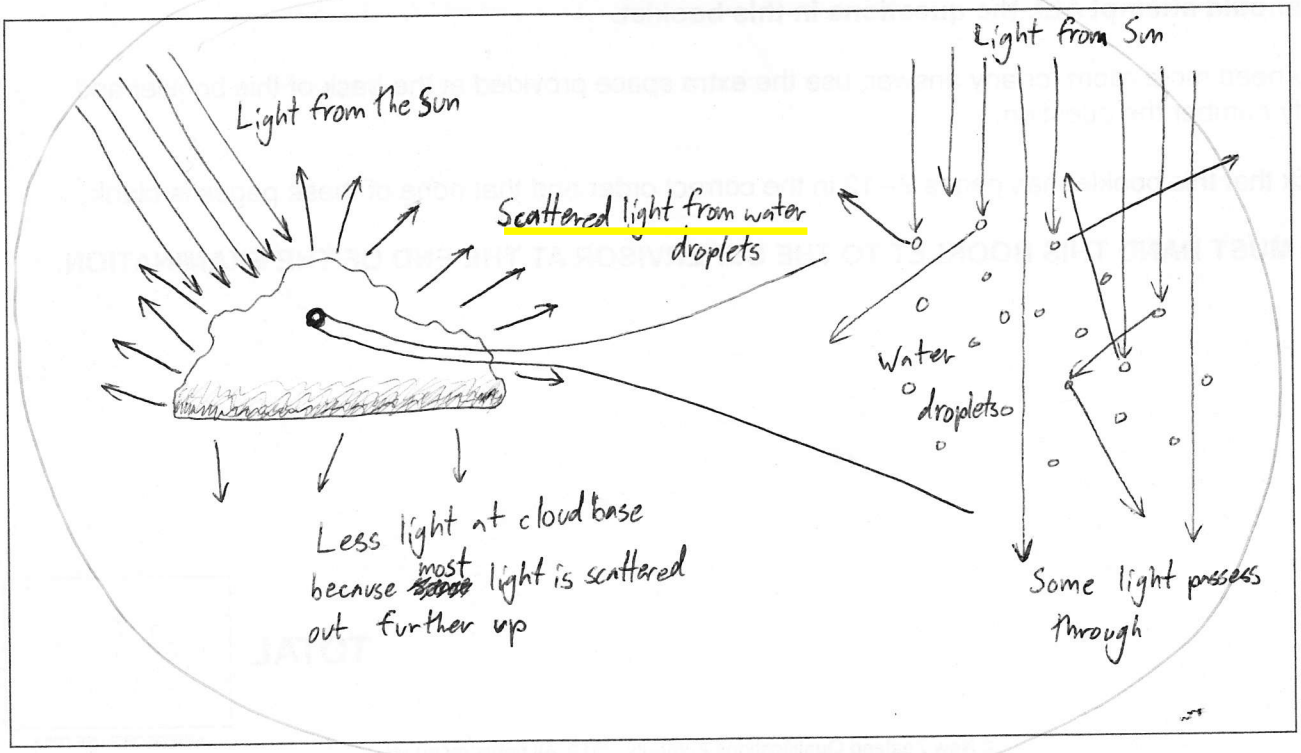
Clouds reduce the amount of sunlight reaching the surface of the Earth, but they do allow some light through.

Explain, in detail, why clouds often appear white.

In your answer, you should consider:

- how light travels through space to reach the Earth
- how colours of the light spectrum differ from each other
- what happens to the light as it travels through the clouds
- why the bases of clouds often look darker.

A diagram may assist your answer.



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Sunlight, as seen on Earth, consists of electromagnetic radiation emitted by the outer layers of the sun. Since electromagnetic radiation is a form of wave that does not require a medium to be transmitted through, it is able to transit the vacuum of space until it reaches Earth. The majority of the radiation emitted by the Sun is of visible and infrared frequencies, infrared radiation having lower frequencies and a combination of frequency of the wave increasing throughout the visual spectrum from red light having a low frequency, yellow-green light with a medium frequency and blue-violet light with a high frequency. The wave length of electromagnetic waves is also inversely proportional to frequency, so blue-violet light has the shortest wavelength of visible light and red light has the longest wave length. Infrared radiation has even longer wavelengths than red light. Since all the different frequencies of visible light emitted from the sun have approximately the same intensities, these are percelved by the human eye to combine into white light and the Sun (if directly observed) appears this colour. When white light from the sun enters the Earth's atmosphere and strikes clouds, the microscopic water droplets inside the cloud that have formed as a result of water vapour condensing scatter the light waves that interact with them through Mie scattering, where the scattering particles (water droplets) are similar to the size of the wavelength of the light they are scattering (from ~400nm across for blue-violet light to ~700nm across for red light). Mie scattering is predominantly forward-scattering so when light interacts with a water droplet it is more likely to continue travelling in a similar direction as it did before, but some light is scattered sideways outside the cloud to where the eye can see it. Cloud bases often appear darker than the outside of a cloud not only because the upper outside is often illuminated directly by the Sun and reflects light, but is primarily due to most of the light that enters the cloud eventually being scattered sideways by the water droplets and a lesser amount of light exits the cloud through the cloud base.

More space for this answer is available on the following page.

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QUESTION TWO: CLOUD EFFECTS ON EARTH'S RADIATION

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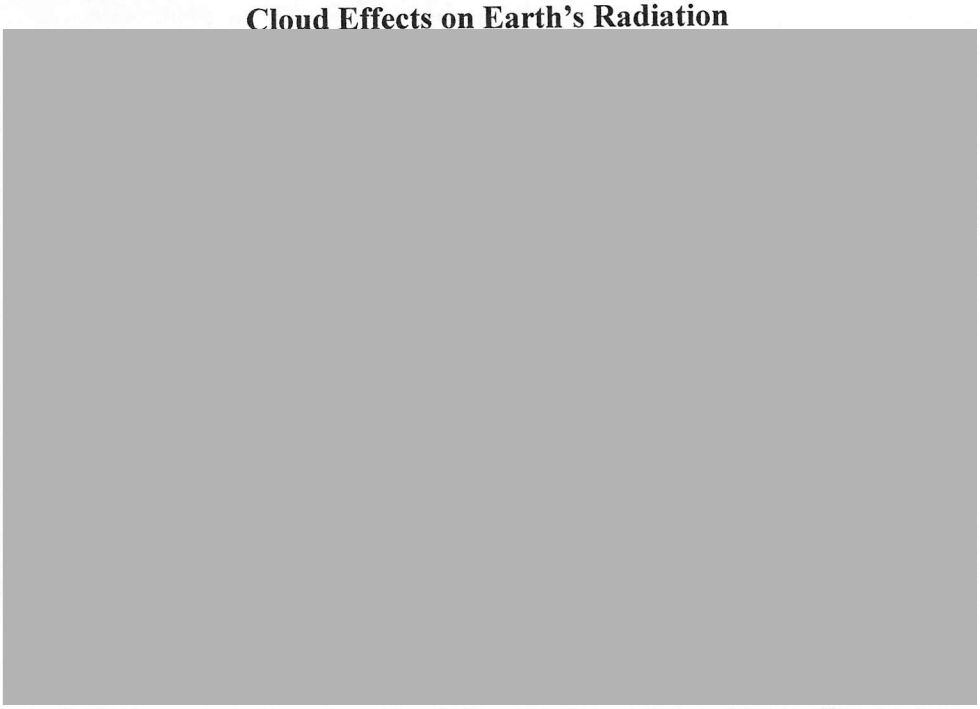
Cloud Effects on Earth's Radiation



https://eoimages.gsfc.nasa.gov/images/imagerecords/54000/54219/Clouds_effects.jpg

A NASA satellite is used to measure radiant energy from both the Sun and the Earth at the top of the atmosphere. This has helped scientists to understand the effects clouds have on the temperature of the Earth.

Use the diagram to help you explain in detail the different effects clouds may have on the movement of energy to and from the Earth.

In your answer, you should consider:

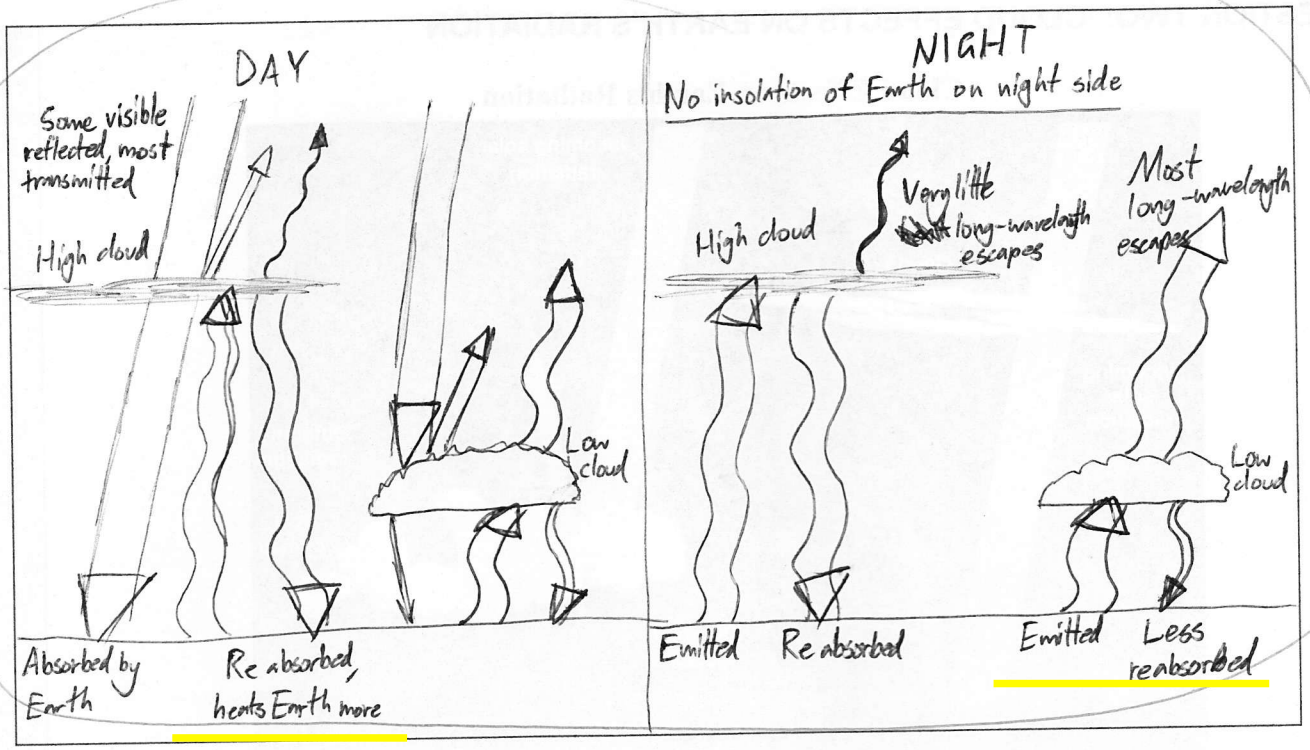
- where clouds may form and the effect the different locations may have on energy transfer to and from the Earth
- the difference between the energy from the Sun and the Earth
- whether the clouds may have a warming or cooling effect on the Earth at different times of day.

A diagram may assist your answer; there is space for this on the following page.

Clouds form through multiple different processes such as air convection, but the main factor is the air that forms a particular cloud becoming saturated with gaseous water vapour and condensing into liquid water droplets (or ice crystals if cold enough) due to either a decrease in temperature below the dew point where water vapour becomes saturated or an increase in humidity (amount of water vapour) to the point where the air is saturated.

Continued next page →

More space for this answer is available on the following pages.



Low clouds such as cumuliform clouds usually form as a result of radiation from the Sun heating the Earth's surface unevenly, causing some parts to be warmer than others. Air located next to these warmer parts of the surface then warm up through some conduction to the air and radiation emitted from the surface and absorbed by the air. As this air warms up it becomes less dense and ~~becomes buoyant, rising~~ experiences a buoyant force from the more dense air around it, convectively rising and slowly cooling as it expands in the lower pressure of increased height. Eventually it cools to the point where water vapour inside it can condense into water droplets and become a cloud. High clouds like cirrus form at high altitudes (>7km) where water vapour condenses into ice crystals due to the colder temperatures and are usually thin and wispy.

These clouds have different characteristics due to their differing compositions of water droplets and ice crystals. Low clouds are mostly opaque to shorter-wavelength visible light and reflect some of it back into space but absorb some visible light too, but reflects some too and transmits most longer-wavelength infrared light. High clouds are mostly transparent to visible, shorter-wavelength light and transmit the majority of this radiation but also reflects a small amount, whereas they are highly reflective to long-wavelength infra-red radiation and only transmits a small amount.

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The radiation energy emitted by the sun that is received on Earth is predominantly short-wavelength visible light, which when absorbed by the Earths atmosphere and surface is re-emitted as longer-wavelength infra-red light, which is absorbed and reflected differently to visible light.

~~At the day time, both types of clouds receive short wavelength light from the sun.~~

Low cloud will have a cooling effect since most of the ~~energy~~ radiation it transmits is long-wavelength infrared, allowing it to mostly escape the atmosphere. However most of the short-wavelength light that strikes it is reflected, causing the Earth below them during the day time to be cooler because less radiation is received there. At night the net effect will slightly reduce the rate of cooling as if it were clear skies, since some of the radiation striking them is reflected back to Earth.

High clouds will have a significant warming effect, since they reflect the majority of long-wavelength infra red emitted from Earth back towards it, keeping it warm. Adding to this is the transmission of most short-wavelength light from the sun, which results in more warming of the surface below that cannot be re radiated back into space since the high cloud only reflects it. At night, the loss of long-wave length infra-red is very slow due to the high reflection / low transmission and it has a larger insulating effect than low clouds.

QUESTION THREE: OCEAN CIRCULATION

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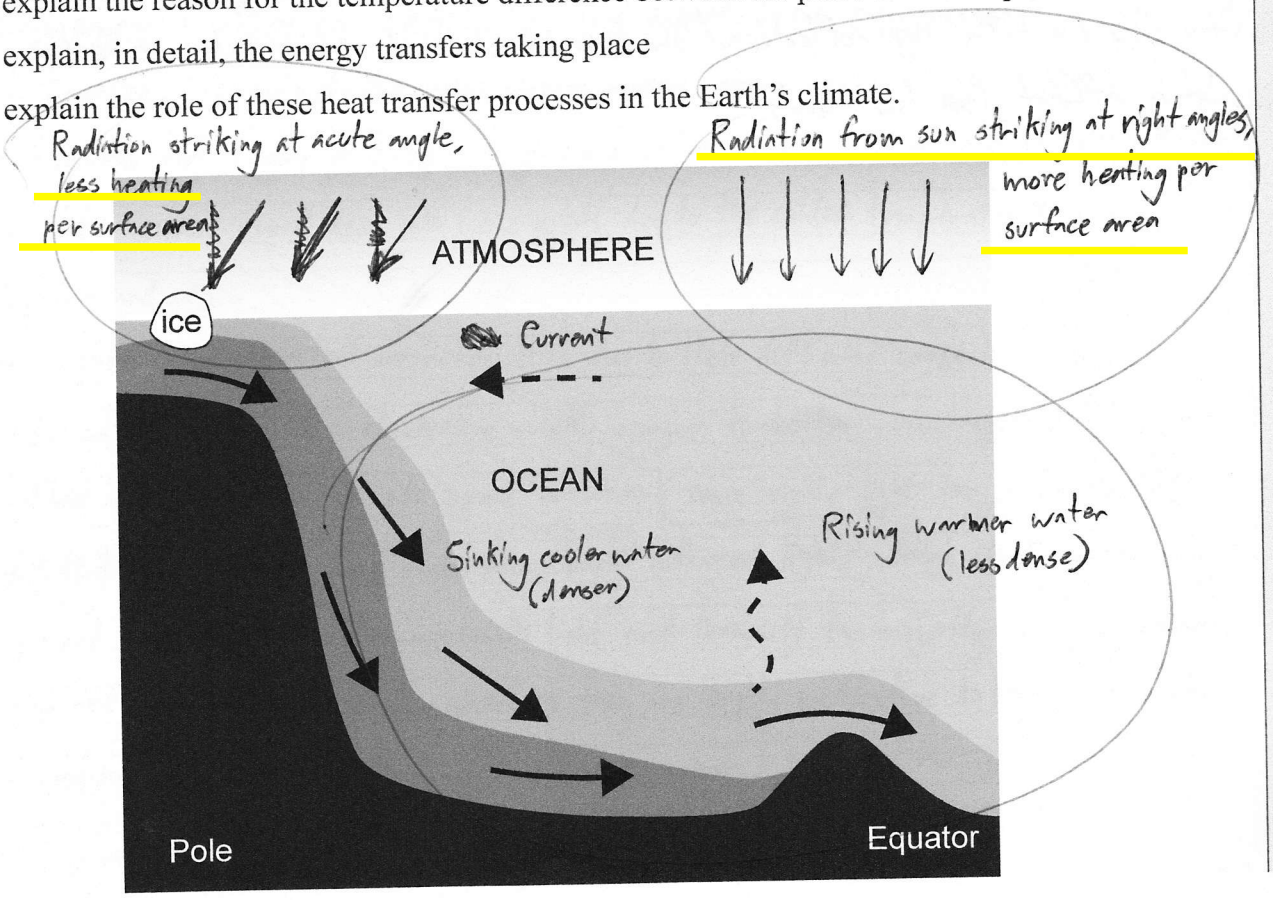
www.jpl.nasa.gov/images/earth/20100325/atlantic20100325-full.jpg

The global ocean conveyor belt is a series of ocean currents that transfer heat around the globe, driven by cold, dense water sinking at the poles. It has a major effect on the Earth's climate, accounting for a quarter of the Earth's heat transport.

Explain in detail the energy transfer processes involved in the global ocean conveyor belt.

In your answer, you should:

- label the diagram below, showing heat transfers taking place at different latitudes
- explain the reason for the temperature difference between the poles and the Equator
- explain, in detail, the energy transfers taking place
- explain the role of these heat transfer processes in the Earth's climate.



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The wide differences in temperature over the different latitudes on Earth is a result of the angle that the light from the Sun strikes the surface of Earth. At the hotter Equator, the Sun's radiation strikes the Earth at close to right angles and the heating effect per unit of surface area is higher than at the poles, where the radiation strikes at a more acute angle and the heating effect per unit of surface area is less, making the poles colder.
As short-wavelength radiation from the sun strikes the oceans, they warm up to a degree, more near the Equator than near the poles.

Convection current forms - warm, less dense water near equator rises, travels to poles, becomes colder/denser so sinks (releasing some heat to air where it sinks, making nearby atmosphere warmer eg. Near UK/Norway it is warmer than than average at that high latitude) - warmer atmosphere where convection current sinks is coastal factor, does not affect middle of continents eg. Russia where it is extremely cold compared to UK/Norway.

More space for this answer is available on the following page.

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M6

Excellence Exemplar 2019

Subject	L2 Earth and Space Science	Standard	91193	Total score	21

Q	Grade score	Annotation
1	E8	The candidate has provided a complete explanation relating the white appearance of clouds to the forward scattering of all wavelengths of visible light.
2	E7	The candidate discusses how short and long wave radiation interacts with cloud formations to either keep the surface of the Earth warm or cool.
3	M6	The candidate explains the difference in the heating of the ocean at the equator and the poles in terms of the radiation and surface area. The transfer of heat from ocean to the atmosphere via conduction and to the poles from the equator is explained.

Confirmation of check	Y / N
This exemplar has been checked for similarities with current online exemplars.	Y