Heat Budget of Earth

Indian Geography Notes for UPSC Exams

The **heat budget of Earth** is an ideal balance between the incoming heat absorbed by the Earth and the outgoing heat escaping from the Earth in the form of radiation. This justifies why the Earth , neither heats up, nor cools down in spite of the huge transfer of heat that takes place. If this balance is disturbed, the Earth will get more and more warmer or cooler as time passes. In other words, the heat budget of Earth is simply the gain and loss of heat, as well as the balance of heat that is received and radiated.

In this article, let us look at the heat budget of Earth, the Albedo of Earth, the calculation of heat budget of Earth, its importance and variations and the effects of heat budget of Earth on the climate system of Earth for the UPSC IAS Examination since the topic is important from the context of Indian Geography section which is a part of UPSC mains GS 2 paper.

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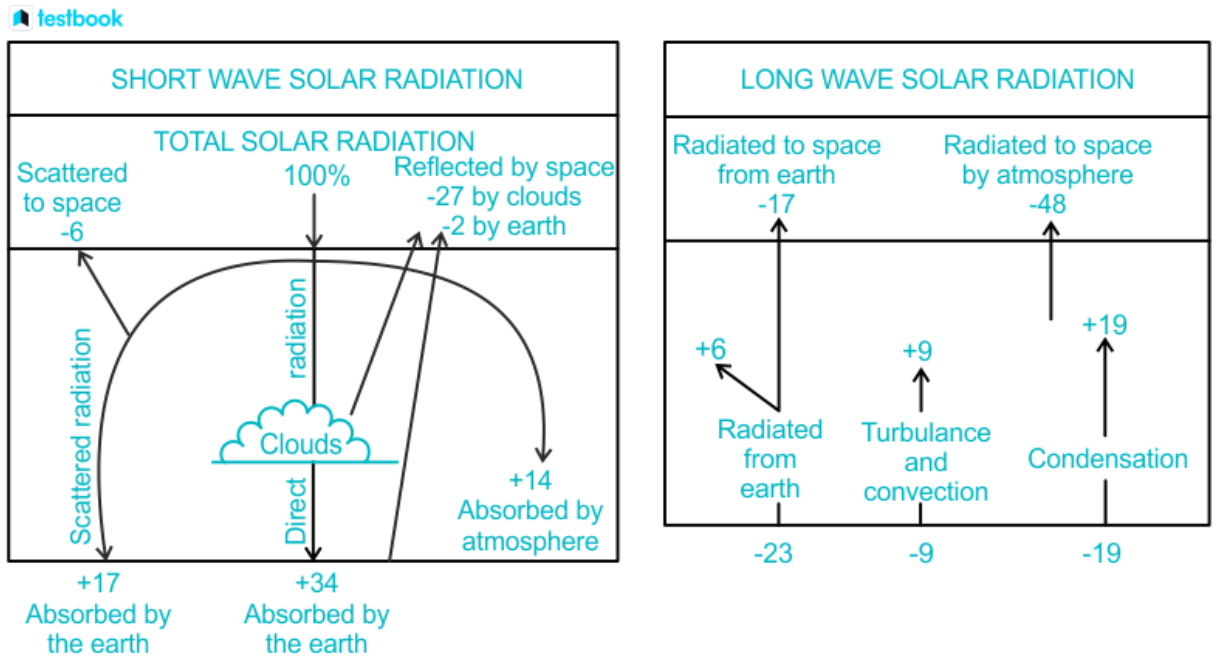
What is the Heat Budget of Earth?



The sun doesn't heat the Earth uniformly. Since the Earth is a sphere, the sun heats the equatorial regions more when compared to the polar regions. The atmosphere and the oceans work non-stop to counter the solar heating imbalances through vaporization of surface water, convection, rainfall, winds and ocean circulation.
This coupled atmosphere and ocean circulation preserve the temperature of the Earth in the following ways:

- The climate's heat engine should not only redistribute solar heat from the equator toward the poles, but also from the surface of the Earth and lower atmosphere back to space.
- Earth is in radiative equilibrium and the global temperature is comparatively stable when the flow of incoming solar energy is balanced out by an equal flow of heat to space.
- Regions situated within the equator and 40° N and S latitudes obtain ample sunlight and hence are known as energy surplus regions. Regions over and above 40° N and S latitudes lose more heat than that obtained from sunlight and thus they are called energy deficit regions.
- The atmosphere (planetary winds) and the oceans (ocean currents) carry surplus heat from the tropics (energy surplus regions) towards the poles (energy deficit regions) making up for loss of heat at higher latitudes.
- Most of the heat transfer takes place across the mid-latitudes (30° to 50°) and therefore much of the stormy weather is linked with this region.
- Hence, the transfer of excess energy from the lower latitudes to the deficit energy regions of the higher latitudes maintains an overall balance over the Earth 's surface.

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Heat Budget of Earth and Atmosphere

- The total solar radiation that reaches a horizontal surface on the ground is known as **global radiation**. It includes the direct shortwave radiation from the sun and the diffuse radiation scattered by the atmosphere.

- It may be stated that the solar energy obtained at the Earth ’s surface is transformed into heat energy which heats the outer surface of the Earth. Therefore, the Earth after getting heated up also emits energy in the form of **long-wave radiation**.
- The radiation coming from the sun towards the Earth's surface is called **incoming shortwave solar radiation** and the radiation emitted from the Earth towards the atmosphere is called **outgoing longwave terrestrial radiation.**

Calculation

Assume incoming solar insolation to be 100 units. The amount lost through scattering and reflection -

1. through clouds be 27 units
2. by dust particles be 6 units
3. by ice caps and glaciers be 2 units

The above sums up to a total of 35 units that are reflected back into space (albedo of the Earth). Now, the units obtained by Earth and its atmosphere is
100 – 35 = 65 units.

Heat Budget Of Earth

51 units of solar insolation are obtained by the Earth as direct radiation, which can be divided as follows:

1. Obtained through direct radiation = 34 units
2. Obtained as diffused daylight = 17 units

which turns out to a total of 51 units.

Heat Budget of Atmosphere

1. Absorption by the atmospheric gasses present in different vertical zones of the atmosphere = 14 units
2. Now 51 units + 14 units= 65 units (total solar insolation obtained by Earth and atmosphere)
3. Out of the solar radiation obtained directly by Earth, i.e. 51 units, 17 units are emitted back into outer space and the remaining 34 units (51-17) is absorbed by the atmosphere in the form of outgoing terrestrial radiation.

This turns out to a total of 48 units (14+ 34 = 48).

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What is the Albedo of Earth?

The Earth does not obtain or lose heat as a whole. It maintains a constant temperature. This is only possible if the amount of heat absorbed as insolation is equal to the amount lost by the Earth as a consequence of terrestrial radiation.

- Albedo is a measure of the amount of light that hits a surface and reflects back without being absorbed.
- It possesses a value less than one and is a reflection coefficient.
- Some amount of solar radiation is reflected, scattered or dispersed and absorbed as it passes through the atmosphere.
- The albedo of the Earth is the amount of radiation that gets reflected.
- Different surfaces will possess different albedo values.
- The "Urban heat island influence" takes place when highly developed areas, such as cities, have higher average temperatures than neighboring suburban or rural areas due to the effect of albedo.
- Lower vegetation, greater people density and increased infrastructure with dark surfaces (asphalt roads, brick structures, etc.) are all to blame for the higher average temperature.

Urban Heat Island Influence

An Urban Heat Island (UHI) is that area of an urban or a metropolitan region that is marked by considerably high temperatures in comparison to its rural counterpart due to excessive human activity. The difference in temperature is seen generally during the night and when winds are weak. The UHI is seen when both the summer and winter seasons are at their peak. The term heat island is also used to denote this effect.

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How is the Heat Budget of Earth Analyzed and Calculated?

- Consider that the insolation acquired at the top of the atmosphere is 100 percent. While it passes through the atmosphere, some amount of energy is reflected, scattered, and absorbed. Only the leftover part reaches the surface of the Earth.
- Approximately 35 units are reflected back to space, even before striking the Earth's surface. Out of this, 27 units are reflected back from the top of the clouds and 2 units from the areas of the Earth that are covered by snow and ice. The amount of radiation that is reflected is termed the albedo of the Earth.
- The remaining 65 units are absorbed, 14 units within the atmosphere and 51 units by the surface of the Earth. The Earth emits back 51 units in the form of terrestrial radiation. Out of this, 17 units are emitted to space straight away and the remaining 34 units are absorbed by the atmosphere (where 6 units are directly absorbed by the atmosphere, 9 units via convection and turbulence, and 19 units via latent heat of condensation).
- The 48 units that are absorbed by the atmosphere (14 units from insolation and 34 units from terrestrial radiation) are also emitted back into space.
- Therefore, the total radiation returning from the Earth and the atmosphere is 17 and 48 respectively, which sums to 65 units, thereby balancing the total of 65 units obtained from the sun.

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Variation in the Heat Budget of Earth

- Even though the Earth as a whole retains a balance between insolation and terrestrial radiation, we do not find this at all latitudes.
- The amount of insolation in the tropical zone is larger than the amount of terrestrial radiation. As a result, it is a location that has excess heat.
- The heat gain in the polar zone is lesser than the heat loss. As a result, it is a region with a heat deficit.
- Therefore, insolation causes an imbalance of heat at different latitudes.
- Winds and ocean currents, which carry heat from zones of surplus heat to heat deficit zones, aid in the mitigation of this imbalance to some extent.

- This process of redistribution and balancing of latitudinal heat is termed latitudinal heat balance.

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Effects of Heat Budget of Earth on the Climate System of Earth

- The heat budget of the Earth is significant in establishing the Earth's climate. When the heat budget balances, the temperature on the Earth remains comparatively constant, with no overall increase or decrease in average temperature.
- The global weather and climate variations are basically caused by the uneven heating of Earth and its atmosphere. This uneven heating occurs as a consequence of latitudinal and seasonal variations in insolation.
- The energy that comes to the Earth and the energy that is emitted from the Earth does not actually balance. This imbalance is partly caused by the energy received from the sun, which changes with the seasons and changes in the composition of the Earth's atmosphere. Variations in the composition of Earth's atmosphere alter the amount of energy absorbed and reflected by the atmosphere. Changing factors such as these result in a very low, but substantial energy imbalance on the Earth.
- As human activities increase the quantity of carbon dioxide in the atmosphere, the energy imbalance continues to build up. To account for this imbalance, the Earth's temperature will rise in response. As well, since the amounts of carbon dioxide and other greenhouse gasses in our atmosphere are rising, this value is anticipated to increase at a rate per decade, contributing even more to rising temperatures.
- It is this imbalance in the heat budget of the Earth that results in rising temperatures on the Earth, one of the most substantial effects of climate change.

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Importance of Heat Budget of Earth

- The heat balance of the Earth is a crucial component of what makes it livable and this is attained by the heat budget of Earth.
- It keeps the planet warm.
- It is essential for enhancing the manufacturing of solar panels that capture and convert this energy.
- It is accountable for the change in temperature from the equator to the poles.
- It aids in the process of photosynthesis and hence the growth of plants.
- It is also responsible for the variation in the rain patterns from the equator to the poles.

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Conclusion

The sun is the ultimate source of heat. The differential heat obtained from the sun is distributed differently across the globe, which is the ultimate reason behind all climatic traits. Hence, understanding the Heat Budget of the Earth and distribution of temperature in different seasons is crucial for understanding other climatic features such as wind systems, pressure systems, precipitation and so on.

We hope that all your doubts regarding the topic Heat Budget of Earth have been addressed after going through this article. Testbook offers standard quality study notes for various competitive exams. Be successful in your UPSC exam preparations by downloading and using the Testbook App now!