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Editorial

Predicted Planetary Temperatures

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ABSTRACT

In order for a planet to maintain a constant average temperature, the amount of energy it radiates must equal the amount of solar energy radiation it absorbs, as shown schematically in the diagram. In our discussion of Energy from the Sun, we found that the radiative energy flux reaching the atmosphere of the inner, rocky planets of our solar system can be calculated. However, not all this radiation is absorbed by the planet's atmosphere and surface, because part of it gets reflected back into space by clouds and surface features. The ratio of the amount of radiation reflected from a surface compared to the amount of radiation that strikes it is called the surface albedo. The word "albedo" is derived from the Latin word for "white," and indicates the "whiteness" of the surface doing the reflecting. A pure white surface, approximated on Earth by freshly fallen snow, has an 100%), indicating that all the incident radiation is reflected. A black body has an albedo of zero (or 0%), since albedo of unity (or the entire incident radiation is absorbed. Different features on a planet will have different albedos and they change over time. For example, the clouds in this photograph have a relatively high albedo as they are white and reflective and the sea below them has a rather low albedo because water is a good absorber of radiation. Later the clouds may disappear so their reflectivity will be lost.

INTRODUCTION

The albedo of a planet is an average over time and accounts for the various planetary features. The table below gives the average albedos, α, for the inner planets of the solar system. To calculate the actual amount of the solar energy flux that is absorbed by the atmosphere and surface of a planet, we have to account for the albedo by reducing the incoming flux by a factor of 1 – α. For a low albedo, as on Mercury, the factor is near unity and most of the incoming energy is absorbed. For a high albedo, as on Venus, the factor is closer to zero and a good deal of the incoming energy is reflected away.

The rocky, inner planets of our solar system vary in sizes, atmospheres, and temperatures. Mercury, the smallest and closest to the sun has no atmosphere and extremes of temperature that average to about that predicted by our simple black body model. Mars, the next largest and farthest from the sun, has a very tenuous atmosphere that is mostly CO2 and an average temperature close to or just a bit above that predicted by the simple black body model. Venus is closest in size to Earth, but has an atmosphere that is much denser than Earth's.

Venus is continuously shrouded in clouds that make it impossible to observe its surface at visible wavelengths from outside the atmosphere and are responsible for the planet's very high albedo. This table provides a comparison of the observed and predicted surface temperatures of the planets and the compositions of their atmospheres. The table provides evidence that an atmosphere has a pronounced effect on the temperature at the planetary surface, causing it to be warmer than predicted by the simple black body model. Venus, with a thick atmosphere, has a surface temperature about 500 K above the prediction. The Earth, with a thinner atmosphere, has a mild 33 K warming. However, this warming of the Earth above the freezing point of water (273 K) has profound consequences, because life, as we know it, would not be possible on a planet where the water is permanently frozen—the snowball Earth instead of the "blue marble"

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