THE PHOTOMETRIC LIGHT CURVES OF EARTH AS A PLANET ALONG ITS HISTORY

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ABSTRACT

By making use of both geographical information of our own planet and satellite-based estimations of the distribution of Earth's cloud cover from the International Satellite Cloud Climatology Project (ISCCP), we have studied the large-scale cloud patterns according to their location on Earth's surface depending on latitude and surface types (ice, water, vegetation and desert). These empirical relationships are used here to reconstruct the possible cloud climatology during historical epochs of the Earth, such us the Late Cretaceous (90 Ma ago), the Late Triassic (230 Ma ago), the Mississippian (340 Ma ago), and the Late Cambrian (500 Ma ago). With this information, we here attempt to reconstruct and understand the 24-hour globally-integrated photometric variability of these epochs according to their different geographic and cloud distribution. This work is a first attempt to study Earth-like planet state of geological evolution according to their photometric albedo.

1. CLOUD DATA & SEMI-EMPIRICAL MODEL FOR CLOUDS

We have used fractional cloud cover data from the ISCCP to calculate the 1984-2006 climatology with the aim of classifying the amount of clouds according to different surface types. With this classification we have obtained empirical relationships between cloud distributions and latitudes (Fig. 1).

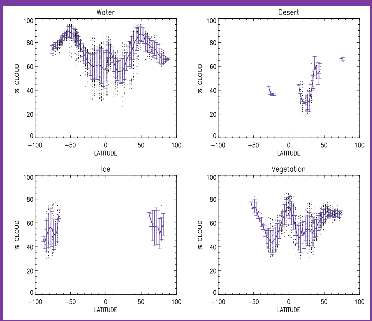

Figure 1. Empirical relationships between the amount of clouds, surface types and latitude. Cloud fraction as a function of latitude (dots) for each surface type: water (top left), desert (top right), ice (bottom left) and vegetation (bottom right). Solid lines represent the mean cloudiness at each latitude, and bars represent the standard deviation of the mean (1 sigma).

2. RECONSTRUCTING CLOUDS & LIGHT CURVES OF PRESENT EARTH

In order to reconstruct the global mean cloudiness of the present Earth, we have used a surface map and assigned to each map's point a cloudiness fraction by using the information of the relationships previously derived in section 1, taking into account both surface type and latitude (Fig. 2 top). Once these cloud maps were calculated, we used them to simulate the photometric variability of the Earth as seen from a distant observer (Fig. 2 bottom).

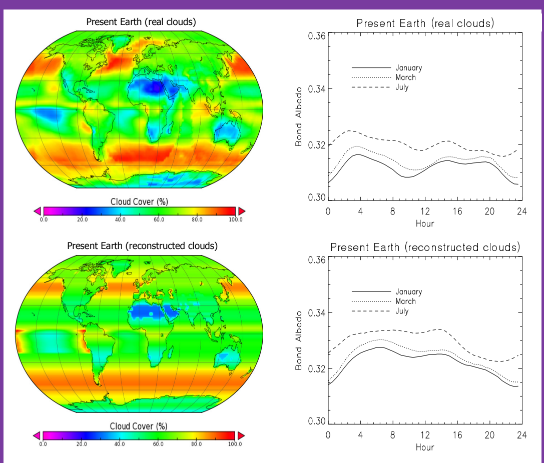

Figure 2. Cloud distribution and light curves of the present Earth. Left panels: global distribution of real (top) and reconstructed (bottom) cloud cover. Right panels: corresponding simulations of Bond Albedo 24 hour variability for three different months.

3. THE PLANET EARTH ALONG ITS HISTORY

As we did with the present Earth, we used the aforementioned empirical relationships and geographical distribution maps to reconstruct the possible cloud distribution of the Earth 90, 230, 340 and 500 Ma ago (Fig. 3 left). Then, we used these maps to simulate the 24-hour Bond Albedo variation of such epochs (Fig. 3 right).

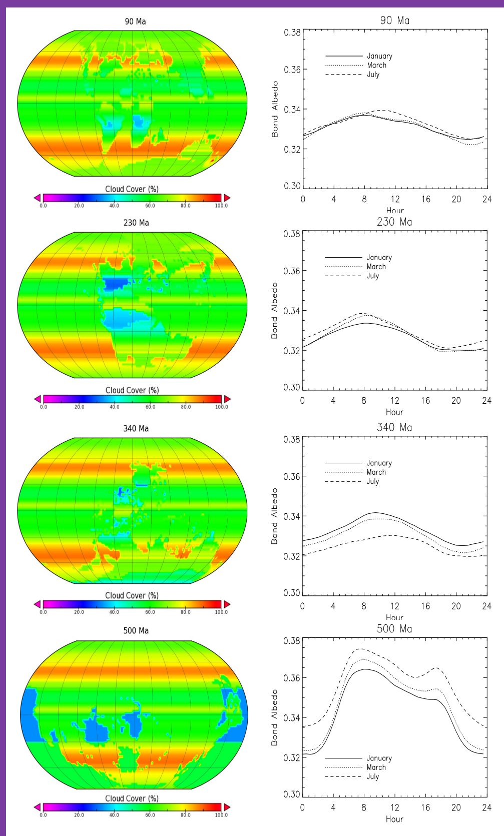

Figure 3. Cloud distribution and light curves of the Earth 90, 230, 340 and 500 Ma ago (from top to bottom) Left panels: global distribution of reconstructed cloud cover. Right panels: corresponding simulations of Bond Albedo 24 hour variability for three different months.

4. SUMMARY

- We have used information about the surface properties and continental distribution of the Earth to study the behavior of the large-scale cloud patterns
- We have obtained empirical relationships between clouds, latitude and surface type
- We have reconstruct the cloud distribution and photometric light curves for different past epochs of the Earth
- Past epochs present similar mean albedo to present day's but with larger amplitude variability, which should have profound influences on the global climate
- This increased variability could help in the determination of the rotational period of the planet, the identification of the presence of continents, and eventually a liquid ocean

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