

Comparative global energy budgets for Earth, Mars and Venus

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Abstract

We analyse the global transfers of energy within the climate systems of Mars and Venus, as simulated by relatively comprehensive numerical circulation models of both planets. These results will then be presented in schematic form for comparison with the 'classical' global energy budget analysis of Trenberth et al. [1] for the Earth, highlighting the important similarities and differences. We also consider how to extend this approach towards other Solar System planets, notably Titan and the gas giants.

1. Introduction

The weather and climate on Earth are generally determined by the amount and distribution of incoming solar radiation. This must be balanced in equilibrium by the emission of thermal radiation from the surface and atmosphere, but the precise routes by which incoming energy is transferred from the surface and within the atmosphere and back out to space are important features that characterize the current climate.

This has been analysed in the past by several groups over the years, based on combinations of numerical model simulations and direct observations of the Earth's climate system. The results are often presented in schematic form [1], as graphically illustrated below in Figure 1, to show the main routes for the transfer of energy into, out of and within the climate system. Although relatively simple in concept, such diagrams convey a great deal of information about the climate system in a compact form.

Such an approach has not so far been adopted in any systematic way for other planets of the Solar System, although quite detailed climate models of several planets are now available, constrained by many new observations and measurements. This approach is

therefore quite timely and potentially useful for comparing the climates of different planets.

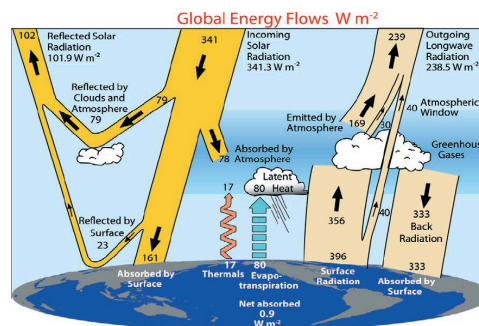


Figure 1: Schematic global energy budget for the Earth, as produced by Trenberth et al. [1].

2. Data sources

In this study we focus on Mars and Venus for comparison with the Earth. For Mars we analyse simulations of the atmospheric circulation using the UK version of the LMD-UK Mars GCM [2], covering the complete annual and diurnal cycles of the Martian year, supplemented by data from the UK Mars reanalysis dataset MACDA [3], to compute the main routes of energy flow.

For Venus, we analyse results from a new version of the Oxford Planetary Unified Model System (OPUS) adapted to Venus conditions[4], that now includes a detailed representation of radiative exchanges of energy within the Venus atmosphere, including the effects of H_2SO_4 cloud decks [5]. The results will be analysed from a long simulation that is approaching equilibrium.

3. Discussion

The results will be presented in diagrammatic form, for direct comparison with the Trenberth et al. analysis for the Earth. A number of uncertainties remain concerning several aspects of the resulting energy budgets, and will be discussed in the presentation. We will also consider how this approach may be extended to other Solar System planets, including both gas giants as well as other terrestrial planets.

References

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