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Eclipse-induced changes of Titan's meteorology at equinox

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Abstract

The impact of equinoctial eclipses on Titan's meteorology is investigated by a global climate model. Eclipses are simulated by globally turning off the solar heating at the right time. The surface temperature on the subsaturnian side suddenly drops during an eclipse by a small amount. This in turn affects the temperature and wind in the planetary boundary layer due to slightly reduced convective heating transfer from the surface. The impact of eclipses is not entirely negligible for Titan's meteorology.

1. Introduction

An eclipse of Titan by Saturn occurs when the Sun passes through Titan's orbital plane, so that Saturn can periodically put Titan into its own shadow. This repeatedly (~20 times) occurs within a period of ~1 year around the vernal and autumnal equinox for up to ~6 hours. Due to synchronous rotation of Titan only the subsaturnian side is directly affected by an eclipse. Titan's eclipses are excellent opportunities to observe Titan's airglow in darkness [1]. On the other hand, an eclipse is also known to cause small meteorological changes on Earth [2]. This study explicitly investigates whether similar meteorological effects may also be expected on Titan.

2. Methods

The impact of the eclipse on Titan's meteorology is investigated by comparing the results of simulations with a Titan global climate model (GCM) carried out with and without implementing eclipses. The most recent version of the Cologne Titan GCM [3] is used. The thermal inertia of the surface has been tuned such as to approximately fit the observed diurnal cycle of the surface temperature at low latitudes [4]. An eclipse is simulated by globally turning off the solar heating for the duration of an eclipse. The eclipse duration and timing are calculated as a function of the season, i.e. the Saturn-centric longitude of the Sun (L_S), and local time at Titan's subsaturnian meridian.

3. Results

During an eclipse the surface temperature on the subsaturnian side decreases for up to 6 hours by 0.1 K or so. The diurnal maximum temperature is thus systematically lower on the subsaturnian side than on the antisaturnian side on 20 consecutive Titan days. The impact of eclipses on the atmosphere is less clear-cut but not negligible. The mean atmospheric temperature near the surface is slightly lower if eclipses are taken into account. This is not caused by in situ radiative cooling of the air during the eclipse but due to slightly reduced convective heat transfer from the surface. The perturbation of the surface air temperature has an influence on the surface winds. This study investigates the significance of the response of the atmosphere (temperature, wind and pressure) to eclipses dependent on longitude, latitude and altitude.

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