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Mountain torque and its influence on the atmospheric angular momentum on Titan

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Previously, the large angular momentum of Titan's superrotating atmosphere was simulated and discussed by global climate models that assumed a globally flat surface. This assumption is no longer valid since Titan lacks a global ocean on the surface and instead possesses a diverse surface with topography of various scales. This study investigates how Titan's atmospheric angular momentum behaves in the presence of global-scale topography constrained by Cassini. The atmospheric circulation is simulated by the Cologne Titan general circulation with an implemented topography map and the angular momentum fluxes across the surface are analysed in detail. On seasonal timescales the angular momentum exchange is dominated by the friction torque, which oscillates semi-annually. Topography barely modifies the friction torque, but introduces a mountain torque, which has a characteristic pattern on diurnal and seasonal timescales. Tidally induced surface pressure variations cause a large diurnally oscillating mountain torque, although it is not relevant for the atmospheric angular momentum budget. Additionally the mountain torque undergoes a small semi-annual cycle associated with the seasonal variations in the surface zonal wind direction. The annual-mean mountain torque does not disappear and causes a net transfer of angular momentum from the surface to the atmosphere. A non-zero annual-mean mountain torque arises because the surface pressure on the east side of low-latitude mountains is higher due to equatorial surface easterlies and high mountain ranges are scarce in mid latitudes, where surface westerlies prevail. In the steady state the atmospheric angular momentum is larger in the presence of topography due to the mountain torque.