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Characterization of the Gravity Wave Climatology in the Middle Atmosphere with the Nasa Ames Mars Global Climate Model

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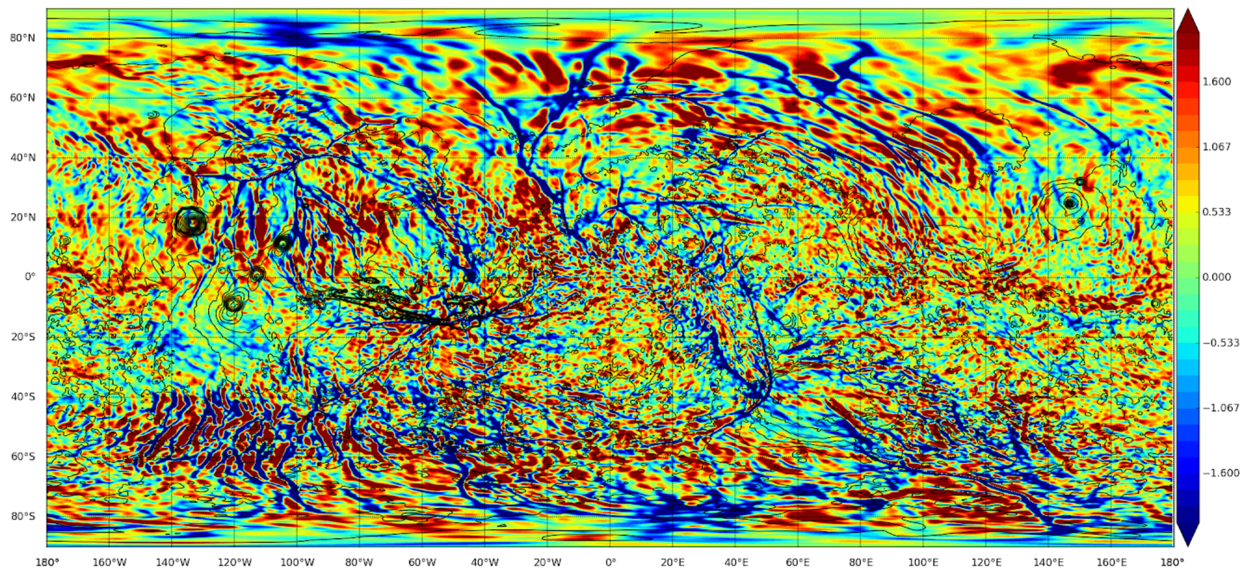

Figure 1: Vertical winds [m/s] at 80 km used as a proxy for waves activity from a Ames MGCM simulation at ¼ x ¼ de-gree using 100 vertical layers. The solar longitude is Ls 100. Note the prominent wave activity around the 45-65 southern latitude band.

Abstract

We characterize the climatology of orographic gravity waves in the middle atmosphere of Mars using the NASA Ames Global Climate Model (MGCM) with sub-degree horizontal resolution and a large (>100) number of vertical layers.

1. Introduction

Gravity waves are atmospheric waves that propagate vertically over tens of kilometers, break, and deposit momentum that can change the mean atmospheric flow at high altitudes. Different phenomena are known to produce such waves on Mars: A first category consist in the waves excited by the topography (orographic) as the near-surface atmospheric flow encounters an obstacle, such as a mountain range. The upward deflection of the flow induces a perturbation that can propagate upward and grow in amplitude if the stability conditions of the atmosphere are appropriate. On Mars, gravity waves, are known to have a significant influence on the Hadley circulation and to dynamically alter the thermal structure of the atmosphere in the polar regions. [1] [2] One challenge associated with modeling gravity waves with Global Climate Models (GCM), is that the horizontal scale of the topographic features that are exciting orographic gravity waves are typically much smaller than the grid spacing of the model. Therefore, these waves cannot be adequately resolved within a numerical simulation and must be parameterized as a sub-grid scale process. This work aims to characterize the climatology of orographic gravity waves in the middle atmosphere of Mars.

2. Method

We ported the implementation of the Palmer et al. [3] orographic gravity wave drag scheme with wavelength-dependent thermal damping rates from Eckermann et al. [4] into the Ames MGCM using the Geophysical Fluid Dynamics Laboratory's FV3 dynamical core. Multi-annual simulations were performed using a baseline resolution of 3.75 x 3.75 degree with 36 vertical layers and extending to an altitude of ~ 100 km. The horizontal resolution is then increased from 3.75x3.75 to ¼ x ¼ degree with 50-150 additional layers added to the vertical grid (while maintaining the model's top at a well-tested altitude of 100 km) in order to investigate the sensitivity of the thermal structure to the spatial discretization.

3. Results and future work

The sub-grid scale orographic gravity wave drag scheme allowed to alleviate part (but not all) of the systemic cold bias in polar temperature when comparing seasonal MGCM predictions to MRO-Mars Climate Sounder (MCS) observations. The high-resolution simulations are now being used to track the presence of waves with high vertical wavenumber and to characterize the sources for gravity waves, as well as the atmospheric conditions that are favorable to their propagation, growth, and breaking, particularly during the southern hemisphere winter where orographic gravity wave activity is prominent. The analysis is extended to some of non-orographic sources that are explicitly resolved with the MGCM.

References

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