Tropospheric response to downward propagating tide from the stratosphere

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Recently it has been recognized that dynamical variations in the stratosphere may have a significant impact on the tropical troposphere (e.g., convection) at various time scales. In a modeling perspective, these "remote" effects can provide a unique diagnosis of dynamical and physical processes in the troposphere. Here we discuss investigation of two aspects of tropospheric behavior via analysis of the 12 h dynamical wave (semidiurnal tide) that is remotely excited in the stratosphere and propagates downward to the troposphere. We simulate this type of wave by running an atmospheric model with the diurnal cycle of solar heating artificially suppressed below the stratosphere (hereafter referred to as "Remote-F" experiment). It is found that the tropical troposphere still exhibits a semidiurnal variation associated with this downward propagating dynamical wave (e.g., surface pressure is ~50% of amplitude compared to the control run).

The first aspect involves diagnosis of the tropical rainfall. We found that the Remote-F experiment simulated a strong coherent semidiurnal rainfall variation in the tropics (~50% of that seen in the control run). This finding demonstrates that stratospherically forced atmospheric tide propagates downward to the troposphere and contributes to the organization of large-scale convection. Notably the results varied somewhat depending on the cumulus schemes used for the model, indicating that such experiments could be used for evaluation of physical processes in models. In the real atmosphere the lunar semidiurnal tide is a close analog of the semidiurnal wave in the Remote-F experiment since both are quasi-adiabatic mechanically forced waves with similar space and time scales. Recent satellite determinations of the lunar semidiurnal variation in tropical rainfall can thus provide a benchmark for evaluating the cumulus schemes used in the model.

The second aspect involves diagnosis of the thermal coupling between air and sea. Since there is no direct thermal forcing of the semidiurnal tide near the surface in the Remote-F experiment, the surface air temperature (T) and pressure (P) variations should be to first order in adiabatic relation. Any deviations from purely adiabatic behavior are a measure of diabatic effects – found to be dominated by damping processes (notably heat exchange with the ocean). Again the observed lunar tide can provide a real world benchmark to evaluate the Remote-F result. In fact, by using data from buoy measurements across the Pacific and Atlantic, we detected significant lunar tidal T and P variations over the ocean. We will demonstrate that this observed T-P relation in the lunar tide can be used to constrain the air-sea thermal exchange parameter used in models.

Key words: solar tides, lunar tides, tropical rainfall, air-sea coupling

References

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