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Solar wind influence on tropical cyclones mediated by atmospheric gravity waves

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Physical processes responsible for changes of tropical cyclone intensity are not well understood [1]. To improve the current understanding of tropical cyclone structure and intensity changes the future research needs to focus on response to all external forcing [2]. We examined rapid intensification of tropical storms in the context of solar wind coupling to the magnetosphere-ionosphere-atmosphere (MIA) system. Tropical cyclone "best tracks" in the southern and northern hemispheres are used in the superposed epoch analysis of time series of solar wind parameters. The results show that rapid intensification of tropical storms tends to follow arrivals of high-speed streams (HSS) from coronal holes or coronal mass ejections [3]. The ensuing auroral and polar cap activity including ionospheric currents and ionospheric convection generates atmospheric gravity waves (AGWs) that propagate from high-latitude lower thermosphere both upward and downward [4,5,6]. If ducted in the lower atmosphere, they can reach tropical troposphere. Cases of rapid intensification of tropical cyclones following arrivals of HSSs are shown to be preceded by AGWs generated by solar wind Alfvén waves coupling to the MIA system. The gravity waves are observed in the ionosphere as traveling ionospheric disturbances. Their propagation in the lower atmosphere is examined by ray tracing in a model atmosphere to show that they can reach tropical cyclones. Despite significantly reduced wave amplitude, but subject to amplification upon reflection in the upper troposphere, these gravity waves can trigger/release moist instabilities to initiate convective bursts. Convective bursts have been linked to rapid intensification of tropical cyclones. Spiral gravity waves produced in typhoons were observed and simulated to propagate radially outward from the typhoon core [7]. The spectra of waves in surface pressure and surface wind measured by the Impacts of Typhoons on the Ocean in the Pacific (ITOP) buoy during the nearby passages of intense typhoons are similar to those of incoming aurorally-generated AGWs. It is suggested that the interaction of aurorally-generated gravity waves with the tropical cyclone vortex and the inner primary eyewall could play a role in the intensification process. Assuming that quasi-periodic convective bursts lead to vortex waves, a two-dimensional barotropic approximation [8] is used to obtain asymptotic solutions representing propagation of vortex waves.

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