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Scale-to-Scale Energy and Enstrophy Fluxes of Atmospheric Motions via CFOSAT

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Turbulence theory essentially describes energy and enstrophy flows crossing scales or a balance between input and output. A famous example is the Richardson-Kolmogorov forward energy cascade picture for three-dimensional homogeneous and isotropic turbulence. However, due to the complexity of turbulent systems, and the lack of an efficient method to describe the cascade quantitatively, the factual cascade features for most fluids are still unknown. In this work, an improved Filter-Space-Technique (FST) is proposed to extract the energy flux Π_E, and enstrophy flux Π_Ω between different scales for the ocean surface wind field which was remotely sensed by the China-France Oceanography Satellite (CFOSAT). With the improved FST method, Π_E and Π_Ω can be calculated for databases which contain gaps or with irregular boundary conditions. Moreover, the local information of the fluxes are preserved. A case study of the typhoon Maysak (2020) shows both inverse and forward cascades for the energy and enstrophy around the center of the typhoon, indicating a rich dynamical pattern. The global views of Π_E and Π_Ω for the wind field are studied for scales from 12.5 to 500 km. The results show that both Π_E and Π_Ω are hemispherically symmetric, with evident spatial and temporal variations for all the scales. More precisely, positive and negative Π_E are found for the scales less and above 60 km, respectively. As for Π_Ω, the transition scale is around 150 km, forward and backward cascades are corresponding to the scales below and above this scale. In the physical space, stronger fluxes are occurring in midlatitudes than the ones in tropical regions, excepts for a narrow region around 10^{o}N, where strong fluxes are observed. In the temporal space, the fluxes in winter are stronger than the ones in summer. Our study provides an improved approach to derive the local energy and enstrophy fluxes with complex field observed data. The results presented in this work contribute to the fundamental understanding of ocean surface atmospheric motions in their multiscale dynamics, and also provide a benchmark for atmospheric models.

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