Understanding the Stratospheric Influence on the Troposphere through Finite-Amplitude Wave Activity Theory

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Stratospheric variability, e.g. associated with stratospheric vortex weakening events (SVW) including sudden stratospheric warmings (SSWs), can have substantial effects on surface weather and climate, especially at middle to high latitudes. Some progress has been made to elucidate such coupling, but it is often discussed in the framework of the transformed Eulerian mean (TEM) formalism tailored for small-amplitude eddies, wherein the role of wave activity at arbitrary amplitude and the noncoservative processes including mixing and diabatic source/sink of wave activity remains elusive. Here we introduce a novel approach, based on the theory of finite-amplitude wave activity, for quantifying the amount of the mean-flow modification by eddies and by nonconservative processes in isolation. Through the application of this theory, we conclude that; (1) the indirect effect of tropospheric wave activity through residual displacements is needed to amplify and maintain the tropospheric responses (Lubis et al., 2018a), (2) the latitude-height structure of the tropospheric response is determined by the local structure of the tropospheric wave activity (Lubis et al., 2018a), and (3) the nonconservative effect associated with 'irreversible mixing' contribute to maintaining the downward migrating signals in the aftermath of the event within the stratosphere (Lubis et al., 2018b, in review).

While the tropospheric wave feedback is certainly playing a central role in amplifying the tropospheric response, it is nonetheless unclear how exactly wave activity between the stratosphere and troposphere communicates. One possibility is that this influence is the direct, in which the lifecycle of synoptic-scale transient eddies are dictated by the stationary wave forcing or influenced by the exchange of wave activity with the stationary eddies. A second possibility is that the anomalous stratospheric state is directly influencing the synoptic-scale eddies through modifying their growth rates. We will test these hypotheses by analyzing a local wave activity budget evolution in each layer of the atmosphere using both observation and idealized GCM simulations (Lubis et al. 2018c, in prep).

Key words: finite-amplitude wave theory, nonconservative process, stratosphere-troposphere coupling.

References

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