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The improvement of GRAPES global extratropical singular vectors and experimental research

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The singular vectors (SVs) based on total-energy norm have been used generally for representing the initial uncertainty in the ensemble forecasting. The GRAEPE SVs based on the total-energy norm using the GRAPES dynamical core model was developed. The impacts and importance of linearized physical processes on the SVs have been widely studied in the literatures. To improve the GRAPES SVs, in this study based on the recently developed GRAPES tangent linear model (TLM) and ajoint model (ADM) version 2.0, the implementation of linearized planetary boundary layer (PBL) parameterization on the calculation of extratropical SVs is conducted. The characteristics of SVs and their linear evolution are measured by energy partition, energy spectra and spatial distribution through one–month experiments. The unreasonable quick energy growth near surface that was observed in the structure of SVs without linearized physical has been greatly improved, furthermore, the structures of upgraded SVs are more consistent with those of previous studies , showing the characteristics of typical total-energy based SVs: the energy maximum is located in the middle troposphere, with obvious westward tilt with height in the spatial structure of SVs at initial time; during their growth, there are upward energy transfer to upper troposphere and downward energy transfer to surface, and an upscale energy transfer is shown in the energy spectra. The results show the upgraded SVs are capable to capture the baroclinic instability in the troposphere. In order to improve the computation efficiency of GRAPES SVs, the ADM that is most time consuming is optimized by reducing the use of GCR (Generalized Conjugate-Residual) in the ADM and increasing computational memory, which decrease the total computation time of GRAPES SVs up to 25%. Therefore, the upgraded GRAPES SVs is satisfactory to meet the expectation for constructing the initial perturbation for GRAPES global ensemble prediction.