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Spatiotemporal diagnoses of irreversible mixing and Stratosphere-Troposphere exchange in baroclinic wave life cycles in idealised models of the mid-latitude atmospheric jet stream

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In order to improve our understanding of irreversible mixing along the atmospheric jet stream, a series of numerical experiments have been performed to simulate a range of baroclinic wave cycles under a variety of idealised initial conditions in a dry non-hydrostatic model. All experiments have been performed from zonally uniform flows that cover simple yet realistic initial states of the jet stream, vertically covering the troposphere and lower stratosphere. Baroclinic waves develop naturally out of numerical noise at the synoptic scale and tropopause folding develops in all cases. We employ quantitative measures of irreversible mixing, based on energetics and entropy considerations and illustrate the spatiotemporal development of irreversible mixing at the meso-scale. We find that the degree of irreversible mixing becomes most intense in the saturation stage of the baroclinic wave as intuitively expected. We also find the totaal irreverisble mixing remains modest for all cases, in the sense that the irreversible change of potential energy remains substantially smaller than that of the total available potential energy. We then illustrate the meso-scale structure of irreversible mixing in terms of the change of entropy and find that the irreversible mixing occurs primarily along the surface fronts rather than in the vicinity of tropopause. The irreversible mixing activity has a complex structure with periodic and spiral patterns at the meso-scale. We also quantify the degree of stratosphere-troposphere exchange for mass and enthalpy and found a non-monotonic response of the net exchange as a function of the strength of stratification of the stratosphere.