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The Nonconservation of Potential Vorticity by a Dynamical Core

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Numerical models of the atmosphere combine a dynamical core, which approximates solutions to the adiabatic, frictionless governing equations for fluid dynamics, with tendencies arising from the parametrization of other physical processes. Since potential vorticity (PV) is conserved following fluid flow in adiabatic, frictionless circumstances, it is possible to isolate the effects of non-conservative processes by accumulating PV changes in an air-mass relative framework. This "PV tracer technique" is used to accumulate separately the effects on PV of each of the different non-conservative processes represented in a numerical model of the atmosphere. Dynamical cores are not exactly conservative because they introduce, explicitly or implicitly, some level of dissipation and adjustment of prognostic model variables which acts to modify PV. Here, the PV tracers technique is extended to diagnose the cumulative effect of the non-conservation of PV by a dynamical core and its characteristics relative to the PV modification by parametrized physical processes.

Quantification using the Met Office Unified Model reveals that the magnitude of the non-conservation of PV by the dynamical core is comparable to those from physical processes. Moreover, the residual of the PV budget, when tracing the effects of the dynamical core and physical processes, is at least an order of magnitude smaller than the PV tracers associated with the most active physical processes. The implication of this work is that the non-conservation of PV by a dynamical core can be assessed in case studies with a full suite of physics parametrizations and directly compared with the PV modification by parametrized physical processes.