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Balance, PV inversion and velocity splitting: an update

M. E. McIntyre

DAMTP, University of Cambridge, UK (mem@damtp.cam.ac.uk)

Practically our entire understanding of large-scale atmosphere–ocean dynamics depends on the notions of balance and potential-vorticity (PV) inversion. These are essential, for instance, for a clear understanding of the basic Rossby-wave propagation mechanism, or quasi-elasticity, that underlies almost every large-scale fluid-dynamical phenomenon of meteorological and oceanographical interest. Examples include the global-scale transport of terrestrial greenhouse gases by the Rossby-wave-driven (gyroscopically-pumped) global-scale mean meridional circulation (e.g. tutorial at http://www.atm.damtp.cam.ac.uk/people/mem/papers/ECMWF/ecmwf05.html) as well as Rossby-wave-mediated global teleconnections, baroclinic and barotropic shear instability, vortex coherence, and vortex-core isolation. The ideas involved in understanding balance and PV inversion continue to hold special fascination because of their exquisite subtlety as well as their fundamental importance both for theory and for applications, such as data assimilation. In this talk I will focus on two recent and unexpected discoveries that improve our understanding. The first is the healing of non-Hamiltonian "velocity splitting" (work in collaboration with Dr Mohebalhojeh) and the second is the concept of "wave-vortex duality" (in collaboration with Professor Buehler), which repairs an "Einsteinian mismatch" between the way we view forces due to gravity waves and the way we view vortex dynamics.