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Atmosphere dynamics of our planet is quite well described by traditional primitive equations based on the so-called shallow-atmosphere approximation. Thus, the model is dynamically consistent (*in the sense that it possesses conservation principles for mass, energy, potential vorticity and angular momentum*) when certain metric terms and the $\cos\phi$ Coriolis terms are neglected (Phillips, 1966). Nevertheless, to simulate planetary atmospheres, the shallow-atmosphere approximation should be relaxed because of the low planet radius (such as Titan) or the depth of their atmospheres (such as Jupiter or Saturne).

Non-traditional terms have some dynamical effects (Gerkema and al., 2008) but they are little-known and rarely integrated into general circulation dynamical cores (Wood and Staniforth, 2002). As an example, the french GCM of the Laboratoire Météorologique Dynamique (LMD-Z) integrates the traditional primitive equations discretized from their curl (vector-invariant) form based on a finite different scheme whose conserves exactly potential vorticity (Sadourny, 1975a,b).

We considered an orthogonal curvilinear system and we first derived a curl form of global, deep-atmosphere quasi-hydrostatic model in which prognostic variable is absolute axial momentum instead of relative velocity vector. Given the close relationship between the curl form and Hamiltonian formulation of the previous equations, we generalized Sadourny's energy-conserving formulation by discretizing the Poisson bracket and the energy themselves (Salmon, 1983; Gassmann, 2013). The substantial computing infrastructure of the dynamical core is the same but the modification of the hydrostatic balance requires a mass-based vertical coordinate (Wood and Staniforth, 2003).

The new discretization has been implemented into LMD-Z on a longitude-latitude horizontal grid and test cases (Held and Suarez, 1994; Ullrich et al., 2013) have been performed considering an idealized deep atmosphere (small like-Earth). They validate the accuracy and the numerical stability of the new dynamical core.