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Compressible viscoelastodynamics: the Longman (1963) paradox and the long period tangential flux.

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The compressible viscoelastodynamics and the fluid behaviour of the Earth occupy an important position in the study of glacial isostatic adjustments (GIA). There, our understanding of these issues is incomplete and we still have to solve the Longman (1963) paradox concerning compressible inviscid solids, in order to describe correctly viscoelastic solids at large time scales or the fluid outer core. For compositional stratifications (the density increase with depth deviates from what should be expected from self-compression) static perturbations cannot involve volume changes. Thus the incremental pressure vanishes and loads could not be sustained, at least from a mathematical point of view. This conclusion is not physically sound and, obviously, load are sustained isostatically. For compressional stratifications instead, incremental pressure is allowed. However the differential system describing conservation of momentum and self-gravitation is not well posed and thus it is not completely solved. Smylie & Manshina (1971) and Chinnery (1975) proposed a way to avoid the Longman (1963) paradox in order to define core-mantle boundary (CMB) conditions. For compressional stratifications, we set up the system of differential equations controlling the perturbations of the inviscid fluid and we propose a new way to derive the CMB conditions able to determine also spatial and gravitational perturbations. Furthermore, we derive a new analytical solution for compressible Maxwell Earth models characterized both by stable and unstable compositional stratifications, as well as by compressional stratifications. This allows us to discover a new class of relaxation modes, the compositional C-modes, of which the unstable Rayleigh-Taylor modes are a subclass. If the stratification is unstable these modes describe the well known gravitational overturning, while, for stable stratification, they describe a long period tangential flux, which diverges in the fluid limit. Our findings make a step ahead in the solution of the Longman (1963) paradox and shed new light on material compressibility and buoyancy forces.