Title: Maxwell-type viscoelasticity in small and large deformations of planetary mantles

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Abstract: A present limitation of global-scale simulations of planetary interiors is that they assume a purely viscous or viscoplastic flow law for solid rock, i.e. elasticity is ignored. This is not a good assumption in the cold and strong outermost mantle layer known as the lithosphere, which seems to maintain its elastic properties even on time scales corresponding to the geological processes of subduction or sedimentation. Here we overcome such simplification and present a numerical tool for modelling visco-elasto-plastic mantle convection. The most promising new feature of the resulting models is related to the ability of viscoelastic materials to remember deformation experienced in the past. Thus, the growing viscoelastic lithosphere of a cooling planet, when subject to internal or surface loading, can store information about its thickness at the time of loading. This phenomena is consistent with datasets of the effective elastic thicknesses determined in flexure studies and we label it here as the "stress memory effect". Attention is also paid to the theoretical foundations of viscoelasticity. We review the approaches that are commonly used to formulate Maxwell-type constitutive equations and thoroughly analyze the condition of material objectivity in a search for objective stress rate that fits Maxwell's original idea the best. While the main focus of the thesis lies in the field of large deformations, small deformations of planetary mantles are addressed too. We solve the traditional problem of glacial isostatic adjustment on a rotating Earth and analyze the accompanying changes in the rotational, gravitational and elastic energy of the planet.

Keywords: Viscoelasticity, Maxwell fluid, Numerical modelling