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Compatibility Condition for the Kinematics of Subduction

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Plate kinematics on the surface of the Earth has been described successfully by the Eulerian rotation without intraplate deformation. It is, however, difficult to specify the kinematics of the lithosphere subduction. Connected with the surface plate velocity across the pivot axis, the trench, the velocity vector field of the subducted slab had been conventionally defined by simply rotating the surface Eulerian kinematics with respect to the local strike onto the slab surface. It usually results in unrealistic in-plane deformation rates within the slab surface. Alternatively, the flow field as well as the observed slab geometry can be shown to be natural consequences of attaining the kinematic field with the minimum dissipation power. The dependence of the deformation rates, associated with such flow field as defined following the minimization, upon the intrinsic geometry of the non-Euclidean surface is, however, implicit and opaque. We derive, in this study, the fundamental compatibility equation of the strain-rates tensor for the subduction flow field to highlight the fundamental dependency. There are two factors; one is associated with the variation of the Gaussian curvature along the stream lines. The other is the local compressibility amplified by the in situ Gaussian curvature. We discuss the implications of these factors and point out that to delineate the potential membrane deformation rates of the subducted slab, unambiguous information on the subduction kinematics is essential in addition to mapping the Gaussian curvature variation of the subducted slab.