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Asymmetric dynamics at subduction zones: from plate kinematic constraints to global mantle convection

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The lithospheric sinking along subduction zones is part of the mantle convection. Therefore, computing the volume of lithosphere recycled within the mantle by subducting slabs quantifies the equivalent amount of mantle that should be displaced, for the mass conservation criterion. Starting from the analysis of the subduction hinge kinematics, that could either move towards (H-convergent) or away (H-divergent) with respect to the fixed upper plate, we compute the amount of lithosphere currently subducting below 31 subduction zones worldwide. Our results show that ~190 km^3/yr and ~88 km^3/yr of lithosphere are currently subducting below H-divergent and H-convergent subduction zones, respectively. This volume discrepancy is principally due to the difference in the two end-members subduction rate, that takes into account the hinge kinematics. We also propose supporting numerical models providing asymmetric volumes of subducted lithosphere, using the subduction rate, instead of plate convergence, as boundary condition. Subduction zones show a worldwide asymmetry from geological and geophysical observations, such as slab dip, structural elevation, gravity anomalies, heat flow, metamorphic evolution, subsidence and uplift rates or depth of the décollement planes. This asymmetry is expressed also in the behaviour of the subduction hinge, so that H-divergent subduction zones appears to be coincident with subduction zones having “westward”-directed slabs, whereas H-convergent are compatible with those that have “eastward-to-northeastward”-directed slabs. On the basis of this geographical polarity of subducting slabs, the obtained lithospheric volume estimation gives ~214 km^3/yr and ~88 km^3/yr of subducting lithosphere for subduction zones with W-directed and E-to-NE-directed slabs, respectively. This imply that W-directed subduction zones contribute more than twice in lithospheric sinking into the mantle with respect to E-to-NE-directed ones. In accordance with the conservation of mass principle, this volumetric asymmetry in the mantle suggests a displacement of ~120 km^3/yr of mantle material from the west to the east, providing a constrain for a global asymmetric mantle convection.