The generation of plates from mantle convection:
using Euler poles to identify and analyze plate evolution

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Abstract

Determination of the system properties required for the self-consistent generation of plate-like surface motion on an infinite Prandtl number bi-modally heated convecting fluid has been an aspiration of geodynamicists since the early days of mantle convection modelling. During the past decade, modelling mantle convection in a full 3D spherical geometry has become commonplace and attaining milestones like producing models that include viscosity contrasts that exceed a factor of million while maintaining mobile surfaces and obtaining model output features that emulate the dichotomy in morphology between downwellings (slab subduction) and upwellings (mantle plumes) has prompted a new set of questions and goals. How do we recognize when plate-like surface motion has been obtained? Can global mantle convection models produce secondary but fundamental properties of plate tectonics like transform faults and one-sided subduction? The first of these questions recognizes problems that may not be immediately apparent. Unlike the Earth, numerical mantle convection models are not accompanied by seismic or paleomagnetic data. Consequently, the identification of candidate plate boundaries is the first problem that must be solved in order to analyze whether the surface motion in the intervening regions between the assumed boundaries is rigid, in agreement with the principal tenet of plate tectonics. We describe our findings from several mantle convection models where an automated detection tool has been used to find boundaries and then assess the candidate plates for rigidity by determination of the implied Euler poles. We also present findings from calculations that generate transform fault features along spreading boundaries as well as describing plate evolution based on Euler pole fitting of the surface motion. We conclude by describing plate reorganization events identified in a model showing extended periods of plate-like surface motion.