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Insights on the Subduction Process from High-Resolution 3D Models

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This is an exciting time in geodynamics as the use of unprecedented high-resolution 3D modeling allows us to ask new questions that were previously unattainable. It is now relatively straightforward to run 3D numerical simulations, with local mesh refinement to $\sim$1 km, input data mapped onto over 100 million finite element nodes, and using tens of thousands of compute hours per model, e.g. Jadamec et al. [2012]. With the additional computational resources, comes a new approach to modeling the tectonic problem. For example, mapping tectonic plates onto a high-resolution 3D geodynamic model grid forces the modeler to ask questions much as a field geologist would ask when constructing a geologic map. In this process of moving from textbook models of subduction to using models based on observation, the modeler is forced to explain the more complicated geometries and features in the Earth, allowing for the new computational approaches to be powerful tools for scientific discovery. Subduction modeling of this kind has expanded the classical view of two-dimensional corner flow, e.g. McKenzie [1969], to a slab driven flow that can be quite complex with predictions for upper mantle flow rates that can be over ten times surface plate motions, e.g. Jadamec et al. [2010] and others. In this talk, I will investigate the role of the third-dimension and non-linearity in plate boundary deformation. I will present high-resolution 3D numerical models that examine the effect of observationally based slab geometry, multiple subducting plates, non-linear rheology, and variations in overriding plate thickness on the subduction related deformation of plate margins. Specific examples include the Alaska and Central America subduction systems. In addition, I will highlight future directions in subduction modeling, and how these can be advanced by the increased incorporation of observational data, high-performance computing, focused numerical algorithms, and 3D interactive data visualization.