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The effect of temperature-dependent thermal parameters in thermal models of subduction zones

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The thermal structure of subduction zones plays an important role in the seismicity that occurs there with e.g., the downdip limit of the seismogenic zone associated with particular isotherms (350 °C - 450 °C) and intermediate-depth seismicity linked to dehydration reactions that occur at specific temperatures and pressures. Therefore, accurate thermal models of subduction zones that include the complexities found in laboratory studies are necessary. One of the often-ignored effects in models is the temperature-dependence of the thermal parameters such as the thermal conductivity, heat capacity, and density.

Here, we build upon the model setup presented by Van Keken et al., 2008 by including temperature-dependent thermal parameters to an otherwise clearly constrained, simple model setup of a subducting plate. We consider a fixed kinematic slab dipping at 45° and a stationary overriding plate with a dynamic mantle wedge. Such a simple setup allows us to isolate the effect of temperature-dependent thermal parameters. We add a more complex plate cooling model for the oceanic plate for consistency with the thermal parameters.

We test the effect of temperature-dependent thermal parameters on models with different rheologies, such as an isoviscous wedge, diffusion and dislocation creep. We find that slab temperatures can change by up to 65 °C which affects the location of isotherm depths. The downdip limit of the seismogenic zone defined by e.g., the 350 °C isotherm shifts by approximately 4 km, thereby increasing the maximum possible rupture area of the seismogenic zone. Similarly, the 600 °C isotherm is shifted approximately 30 km deeper, affecting the depth at which dehydration reactions and hence intermediate-depth seismicity occurs. Our results therefore show that temperature-dependent thermal parameters in thermal models of subduction zones cannot be ignored when studying subduction-related seismicity.