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Effects of a local deepening of slab-mantle decoupling depth on slab surface temperature

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In the subduction zone, we generally observe low seismic attenuation in the forearc mantle. In addition, surface heat flow shows low value in the forearc and a sudden transition to high value in the arc. These observations suggest that the forearc mantle is cold and is not involved in the corner flow in the mantle wedge. We can understand it in terms of slab-mantle decoupling depth (D_{dec}). Above D_{dec}, the mantle does not move with the slab just beneath it. Therefore, it becomes cold quickly due to the cooling from the overriding plate and the slab. Below D_{dec}, on the other hand, the mantle moves with the slab. It keeps this part of mantle warm by advection of hot material due to the corner flow. Thus, D_{dec} is a key parameter which strongly affects thermal structure in the subduction zone. Comparison of the observed surface heat flow and the one predicted with 2D numerical model suggests that D_{dec} does not vary much for each subduction zone and is 70-80km, but in each subduction zone D_{dec} may show some degree of along-arc variation. One such example is the junction between Japan and Kurile arcs, where the down-dip limit of thrust type earthquake is locally deepened by around 15km. In this presentation, we investigate the effects of a local deepening of D_{dec} on slab surface temperature.

Toward the goal, we use time-dependent 3D finite element models to compute mantle flow and temperature. Only mantle wedge is treated as a dynamic entity. We use a simple slab geometry and assume a local deepening of D_{dec} to see its effects. We find that the increase in slab surface temperature at D_{dec} is larger where we assume a deepening of D_{dec}, which produces a warmer region there. It is caused by 3D flow in the mantle wedge due to along-arc variation of D_{dec}. We also calculate surface heat flow from obtained thermal structure, but it does not show significant along-arc variation. These results do not change even when we use a realistic slab geometry which is similar to that of the junction between Japan and Kurile arcs. While the surface heat flow anomaly and deepening of the seismic belt in S. Hokkaido cannot be easily explained by these models, the temperature excursions at the slab surface are significant. These models predict potentially strong variations in the conditions that the fluids leave the slab, which may be visible by various new geothermometers, such as those based on the H_2O/Ce ratio.

Keywords: subduction zone, slab-mantle decoupling depth, slab surface temperature