Seafloor subsidence and mantle dynamics

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The subsidence of seafloor is generally considered as a passive phenomenon related to the conductive cooling of the lithosphere since its creation at mid-oceanic ridges. Recent alternative theories suggest that the mantle dynamics plays an important role in the structure and depth of the oceanic lithosphere. However, the link between mantle dynamics and seafloor subsidence has still to be quantitatively assessed. Here we provide a statistic study of the subsidence parameters (subsidence rate and ridge depth) for all the oceans. These parameters are retrieved through the positive outliers method, a classical method used in signal processing. We also model the mantle convection pattern from the S40RTS tomography model. The density anomalies derived from this model are used to compute the instantaneous flow in a global 3D spherical geometry, and the induced dynamic topography.
The variations of the mid-oceanic ridge depths are well recovered by the modeled dynamic topography. The systematic fit of the bathymetry allows the recovery of the subsidence rate, from which we derive the effective thermal conductivity, k_{eff}. This parameter ranges between 1 and 7 $Wm^{-1}K^{-1}$. We show that departures from the k_{eff}=3 $Wm^{-1}K^{-1}$ standard value are systematically related to mantle convection and not to the lithospheric structure. Regions characterized by k_{eff}>3 $Wm^{-1}K^{-1}$ are associated with the uplift of mantle plumes. Regions characterized by k_{eff}<3 $Wm^{-1}K^{-1}$ are related to large scale mantle downwellings such as the Australia-Antarctic Discordance (ADD) or the return flow from the South Pacific Superswell to the East Pacific rise. This demonstrates that the mantle dynamics plays a major role in the shaping of the oceanic seafloor. In particular, the parameters generally considered to quantify the lithosphere structure, such as the thermal conductivity, are not only representative of this structure but also incorporate signals from the mantle convection occurring beneath the lithosphere.

