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Accurate Quantification of Seamount Volcanism in Abyssal Sediments Using Gaussian Process Regression

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Seamounts are isolated, underwater volcanoes with more than 100 m in relief. This kind of volcanism arises from the lithosphere or asthenosphere through fractional melt and is a direct manifestation of the tectonic-magmatic activity of the interior of the earth. While previous studies have quantified the global distribution of seamounts by their physical properties (e.g., height, semimajor axis, angle, etc.), these studies usually (1) assume an elliptical cone to model seamount shape, and (2) neglect the sediment coverage on the seamount, which results in significant uncertainties when comparing properties of seamounts near the continents covered with thick sediments to those in the open ocean covered with thin sediments.

We apply a large-scale Gaussian Process regression to recover the seamount topography covered by sediments for an accurate distribution of volcanism in the South China Sea basin (with an average thickness of 1.5 km sediments) and the entire Pacific Ocean (with < 300 m thick sediments). Specifically, we first use Tophat filtering to isolate short-spatial-wavelength seamount topography above long-wavelength seafloor. Subsequently, we apply Gaussian Process regression to learn the seamount structure above the seafloor in order to extrapolate the structure beneath the sediment. Lastly, we compute the seamount volume above the sedimentary basement (i.e., top boundary of the oceanic crust) and compare it to the volume above the seafloor. Our results show that for the South China Sea, there is a significant increase in estimated seamount volume above the basement as compared to above the seafloor. For the Pacific Ocean, due to the thin sediment coverage, we observe negligible differences between the two volume estimates. Thus, analysis of seamount properties in marginal basins in the West Pacific with thick sediment coverage can lead to significant underestimation of volcanism intensity if sub-seafloor topography is not accounted for. For these marginal basins, without massive hotspots or apparent evidence of mantle plumes, normal plate tectonic processes are likely responsible for the intensive oceanic volcanism.