Deformation in the Northern Volcanic Zone of Iceland 2008-2014: an interplay of tectonic, magmatic, and glacial isostatic deformation

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Using campaign and continuous GPS measurements spanning 2008 to 2014, we derive the surface velocity field across the Northern Volcanic Zone (NVZ) of Iceland, a subaerial part of the divergent boundary between the North-American and Eurasian plates. No volcanic activity nor magmatic intrusions were detected in the zone during the time period. We infer an extensional rate of $17.4 \pm 0.2 \text{ mm/yr}$ in direction $292.0 \pm 0.5^\circ$, consistent with the results of previous studies and current plate motion models including MORVEL2010 and GEODVEL2010. The horizontal velocity field reveals about 50-km wide stretching zone caused by the divergent plate movements. Glacial isostatic adjustment (GIA) induces uplift of over 20 mm/yr at the northern edge of Vatnajökull ice cap with 3-4 mm/yr horizontal motion directed away from the ice cap. Deformation in the NVZ between 2008 and 2014 can be explained by a combination of models: i) Mogi sources for volcanic and geothermal deformation at Askja and Krafla volcanoes, ii) scaled version of a velocity field derived from a glacial isostatic model, and iii) simple arctangent-based model for secular plate spreading. Through inversion of this spreading model, we find the approximate location of the plate boundary axis as well as its locking depth (brittle-ductile boundary). The plate boundary axis lies through each of the main central volcanoes in the NVZ with exception of Kverkfjöll: Theistareykir, Krafla, Fremrinámar, and Askja. It also does not appear to follow the general direction of each fissure swarm but rather to change direction at the central volcanoes. The locking depth is on average within the 7-9 km range, consistent with detailed seismicity studies in the Askja volcanic system.
Horizontal velocities for A) Mogi sources, B) GIA models, C) plate spreading, D) GPS measurements, E) all model components (A,B,C), and D) residuals. Model items shown include plate spreading segments (green lines) and Mogi sources (blue circles). In F), the grid in the Kverkfjöll fissure swarm shows the approximate location of the 2007-2008 intrusion as inferred by Hooper et al. (2011).