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Full-vector Holocene records from Réunion and Bali constrain the origin of the South Atlantic Anomaly

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The South Atlantic Anomaly (SAA) is the most prominent low-intensity feature of the modern geomagnetic field. Its origin is debated between hypotheses invoking (i) a deep-mantle controlled flux system beneath southern Africa at the edge of the African Large Low-Shear Velocity Province (LLSVP), and (ii) models proposing an eastward origin in the Indian Ocean followed by westward migration into the South Atlantic. Discriminating between these scenarios requires well-dated Southern Hemisphere paleomagnetic records, which remain sparse.

Here, we present new full-vector paleomagnetic data from volcanic products on Réunion Island and Bali (Indonesia), providing constraints on Holocene field behavior on both sides of the Indian Ocean. At Réunion, Bayesian paleosecular-variation curves based on our new data reveal a pronounced intensity maximum around ~1400 CE followed by a sharp decline to ~29 μT at ~1550 CE. This high-to-low transition indicates that Réunion did not experience persistent low fields prior to the devolpment of the SAA. This is inconsistent with models proposing an origin under the Indian Ocean and an east-to-west migration from there. Instead, the Réunion record documents the onset of low-field behavior only after ~1400 CE, in agreement with the hypothesis that the SAA originated below, or slightly to the east of the African continent and is probably linked to the presence of the African LLSVP.

The Indonesian paleointensity records from Bali reveal earlier low-intensity episodes (~1000–1300 CE), but these are temporally disconnected from the Réunion minimum and are best interpreted as expressions of independent or recurrent (West) Pacific or Indian Ocean anomalies rather than precursors of the SAA. Together, the data indicate that while low-field patches may likely recur in the Indian Ocean realm, the modern SAA originated beneath southern Africa and moved westwards from its point of inception. These results support a top-down control on the geodynamo driving the occurence of the SAA and provide new data to create the next-generation geomagnetic field models optimized to track the origin, and. evolution of the South Atlantic Anomaly through time.