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# Are deep-sea ecosystems surrounding Madagascar threatened by land-use or climate change?

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ABSTRACT

In this short communication, we present a multidisciplinary study of sedimentary records collected from a deep-sea interfluve proximal to the mouths of major northwestern Madagascan rivers. For the last 60 years, the seafloor has been repeatedly disturbed by the deposition of organic rich, tropical, terrestrial sediments causing marked reductions in benthic biodiversity. Increased soil erosion due to local land-use, deforestation and intensifying tropical cyclones are potential causes for this sedimentary budget and biodiversity shift. Our marine sedimentary records indicate that until now, these conditions have not occurred within the region for at least 20,000 years.

## 1. Introduction

The rich ecosystem of Madagascar, one of Earth's biodiversity hotspots, is endangered due to historical changes in land-use and related deforestation (Green and Sussman, 1990; Gade, 1996; Myers et al., 2000; Harper et al., 2007; Waeber et al., 2015). The clearing of tropical forests for extensive logging and agricultural exploitation by early 20th century colonies (Jarosz, 1993) is considered to have exacerbated soil erosion during torrential rains (e.g., Saboureau, 1959; Gade, 1996). That being said, the exclusive causality between anthropogenic land-use and increased erosion has been thoroughly debated for the last two decades (Kull, 2000; Klein, 2002). Erosional gullies (i.e. lavakas) are more abundant in seismically active areas, which suggests a complex relationship between tectonics and regional erosional processes (Cox et al., 2010). During rainy seasons, weathered red lateritic soils are washed into rivers which then drain into coastal watersheds. From space, astronauts describe Madagascar as 'bleeding into the ocean' (Fig. 1) (Helfert and Wood, 1986).

Despite identifying the impact of modern, human-induced deforestation and subsequent soil erosion on coral reefs (Maina et al., 2013; Grove et al., 2013), no investigation has ever assessed the potential and combined impact of modern land-use and extreme meteorological events (i.e., tropical cyclones) on deep-sea ecosystems. To further explore these issues, we analysed marine sediment cores recovered from ~ 780 m depth in the Mozambique Channel, off the Betsiboka and Mahavavy Sud Rivers (Fig. 1). Both major rivers drain from the highlands of central Madagascar. Cores MOZ1-MTB6 and MOZ1-MTB7 (each 50 cm long) were recovered from a steep interfluve and provide a 1000-yr record of sediment discharge from northwest (NW) Madagascar (Fig. 1) (Olu, 2014). For comparison, an additional 10 m-core (MOZ1-KSF-10) was collected at the same location covering the last ~ 20,000 years.

## 2. Material and methods

Cores MOZ1-MTB-6 and MOZ1-MTB-7 were collected with a Barnett-type multi-corer equipped with 8 PCPE tubes (96 mm internal diameter). Core MOZ1-MTB-6 was dedicated to sedimentary organic

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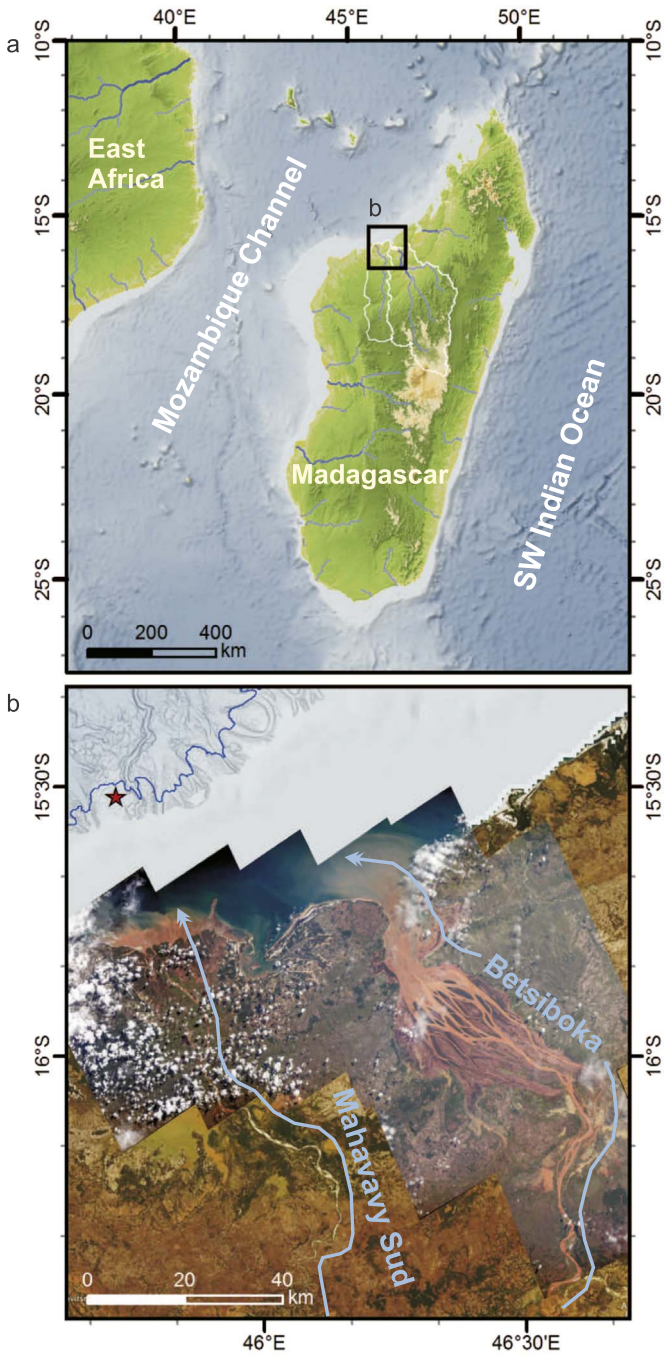
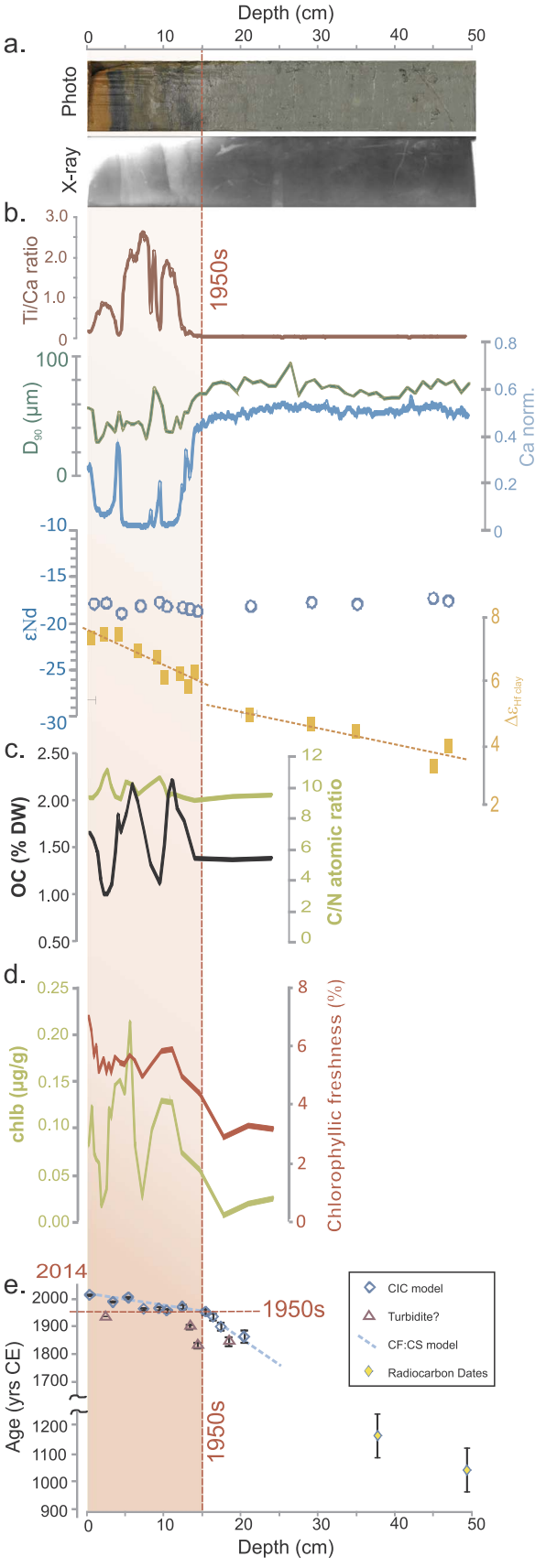



**Fig. 1. Study area off NW Madagascar. a:** General location of Madagascar. The Mahavavy Sud and Betsiboka watersheds are outlined in white and main Madagascan and East African rivers in blue. Bathymetry is extracted from Gebco (General Bathymetric Chart of the Oceans). River pathways are extracted from FAO archives. **b:** Location of multicorer deployments (MOZ1-MTB-6 and MOZ1-MTB-7) and MOZ1-KSF-10 core are indicated by the red star (− 15°31.15′ N; 45°42.94′ E; ~ 780 m; Olu, 2014). Bathymetry was mapped during the PTOLEMEE cruise using a EM302 multibeam echosounder (Jorry, 2014). The 1000-m isobath is outlined in dark blue. The paths of both Mahavay Sud and Betsiboka rivers were photographed from the International Space Station on March 21st, 2016. Image courtesy of the Earth Science and Remote Sensing Unit, NASA Johnson Space Center (http://eol.jsc.nasa.gov/Collections/Composites/). Terrestrial backgrounds were extracted from MapBox satellite data. Projection: World Mercator. Geodetic system: WGS84. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

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