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Cinematic and geomorphological study of the Mare a Poule d'Eau landslide (Hell-bourg, La Reunion island) using satellite (SPOT5) and aerial images



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Introduction

La Réunion is a volcanic island located in the Indian Ocean. Its climate is tropical. This island is characterized by pluviometric records with an annual cumulative rainfall locally exceeding 7m/year. The main precipitations occur during intense rainfalls often linked to cyclones in the winter season. These extreme events, combined to steep slopes, lead to an intense erosion.

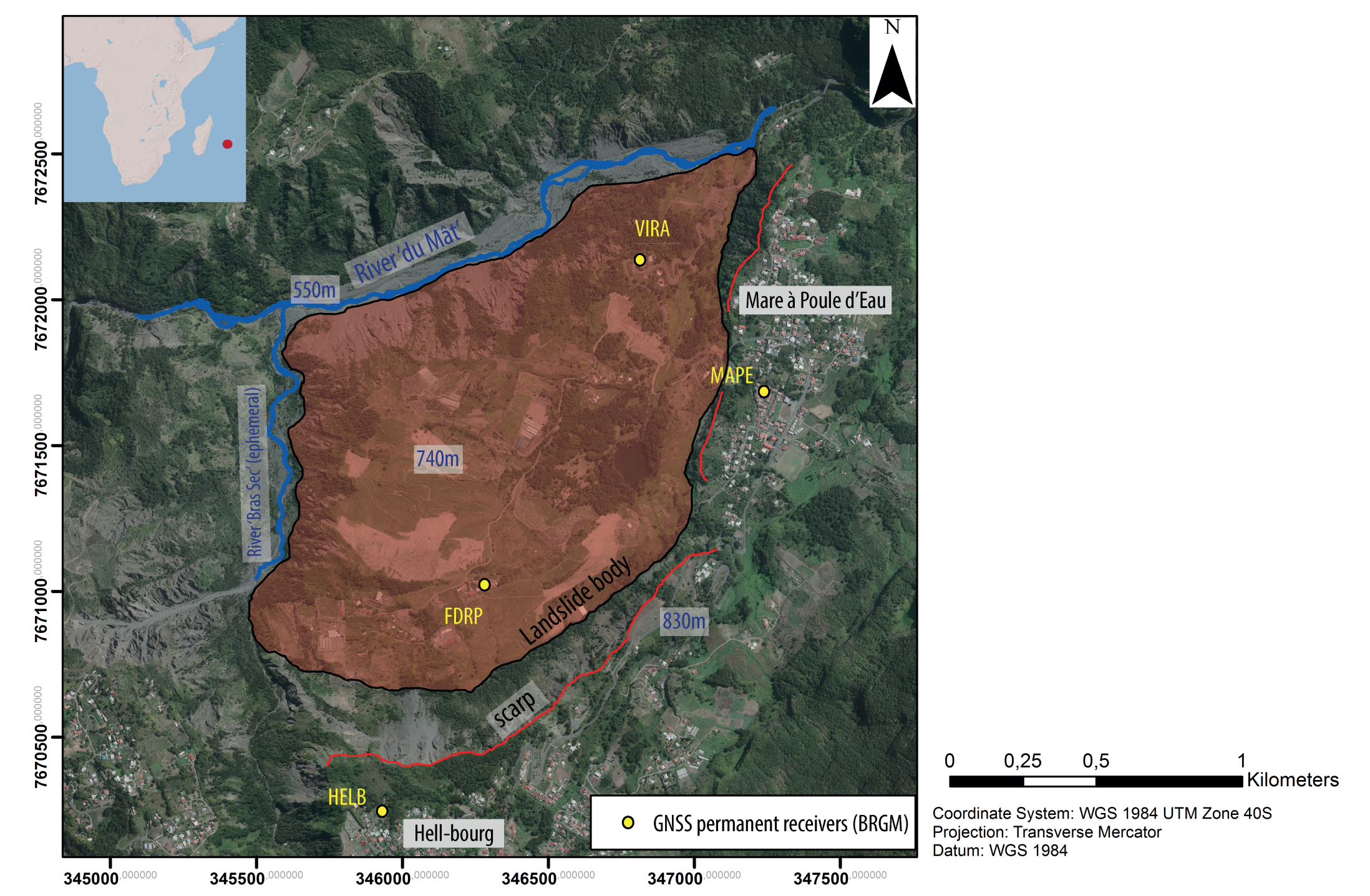
Context of the study

The slow-moving landslide of Mare à Poule d'Eau (MAPE) located in the Salazie watershed is the result of a massive debris avalanche due to the dismantling of the extinct volcano (Piton des Neiges) 955 000 years ago (Arnaud, 2005).

The permanent GNSS receivers network (BRGM-French Geological Surveys) shows a maximum velocity of 1,7 m/year for the 2010-2013 period.

The Northern limit of the landslide is the River du Mât, a permanent river which mean annual flow is 3m³/s and can reach 145 m³/s during cyclones.

The aim of this study is to improve the knowledge of this landslide combining :
 - a cinematic study of the landslide from SPOT5 images correlation and IGN images observation
 - a geomorphological study to combine those results to the morphology of the landslide and improve our knowledge on the landslide/river interface

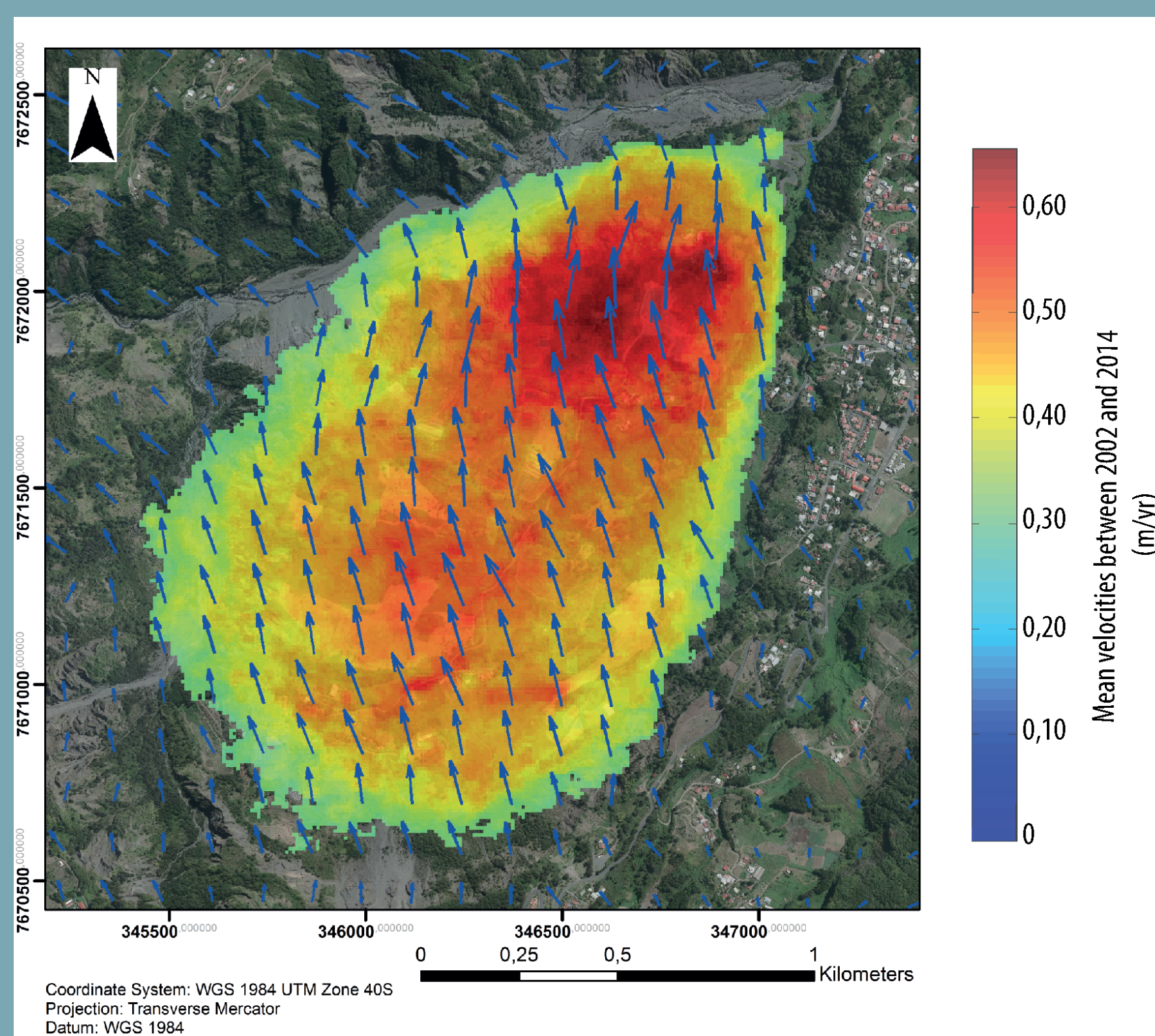


Location of the study site : the Mare à Poule d'Eau landslide in La Reunion island (Indian Ocean)

I. Cinematic study of the landslide using SPOT5 images correlation (2002-2014)

In order to derive surface displacement maps, correlation of SPOT5 images has been applied on images pairs using the MicMac software (Deseilligny et al., 2013). This correlation is challenging on tropical areas due to high seasonal vegetation changes. Due to high relief only images acquired with a similar phase angle have been processed.

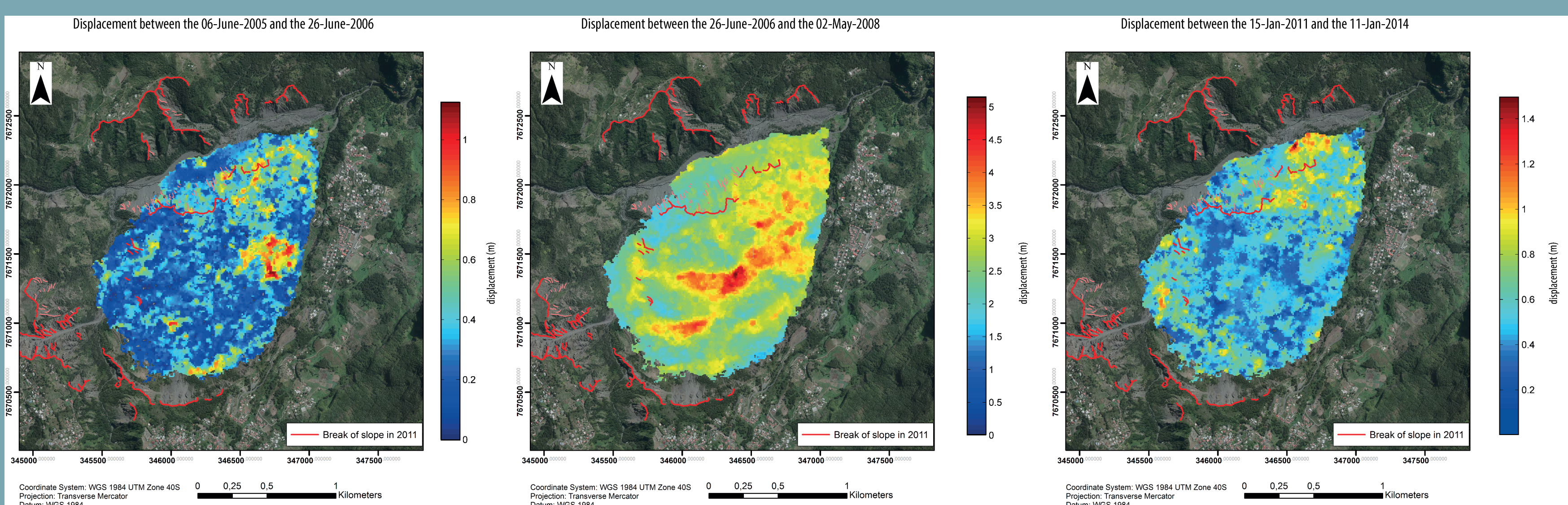
I. 1. Main slip surface : spatial variability of the horizontal displacement



Mean velocities and directions of the slip surface calculated from 27 pairs of SPOT5 images using correlation techniques.

General velocities are over-estimated (compared to the velocity measured using the permanent GNSS receivers network) :
 - Uncertainties of the correlation method : 1/10 pixel (which is equal to an error of 0.35m/year);
 - Rapid changes in vegetation may induce errors.

I. 2. Temporal evolution of the landslide horizontal velocity (2003-2012)

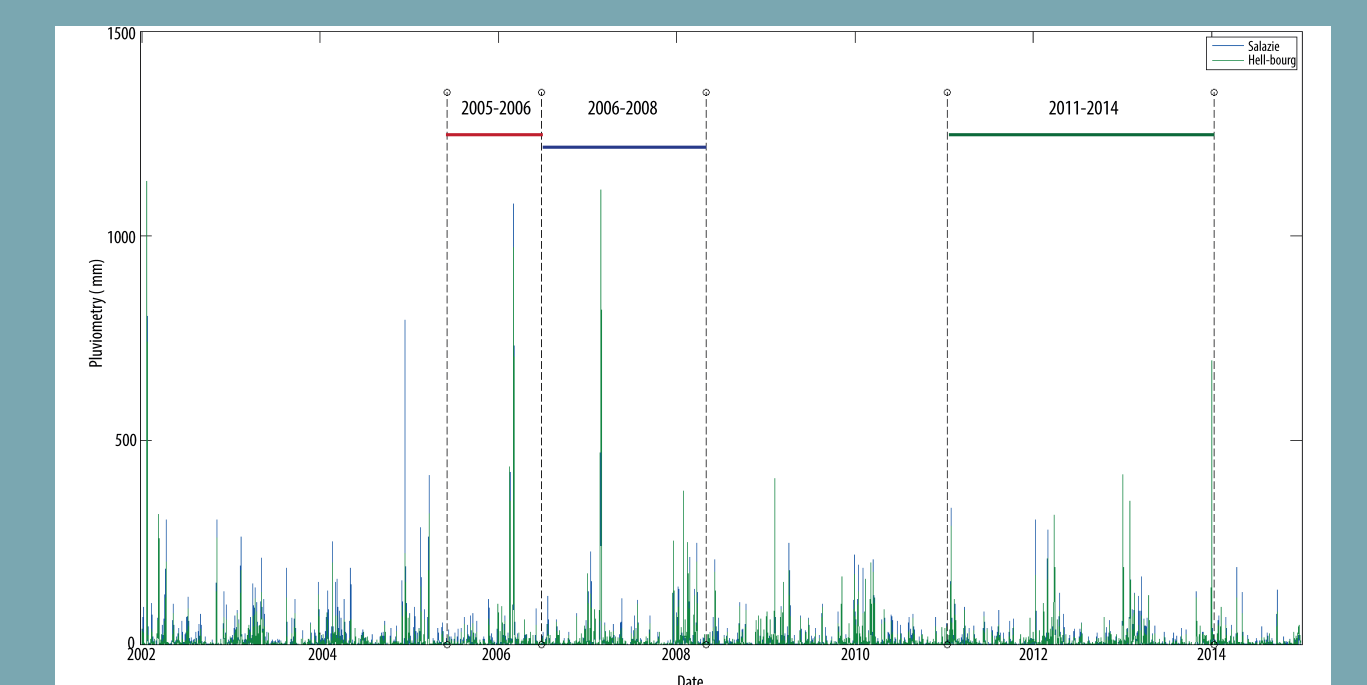


Displacement between two images acquisitions : 2005-2006, 2006-2008 and 2011-2014 illustrating the temporal variability of the horizontal displacement (notice that the colorbar is specific to each image)

General tendencies :

- the interval 2006-2008 is a period of intense horizontal displacement, probably due to the cyclone Gamede in 2007;
- the best results are obtained correlating images acquired during the same season;
- higher velocities are calculated on the North-Eastern part of the landslide.

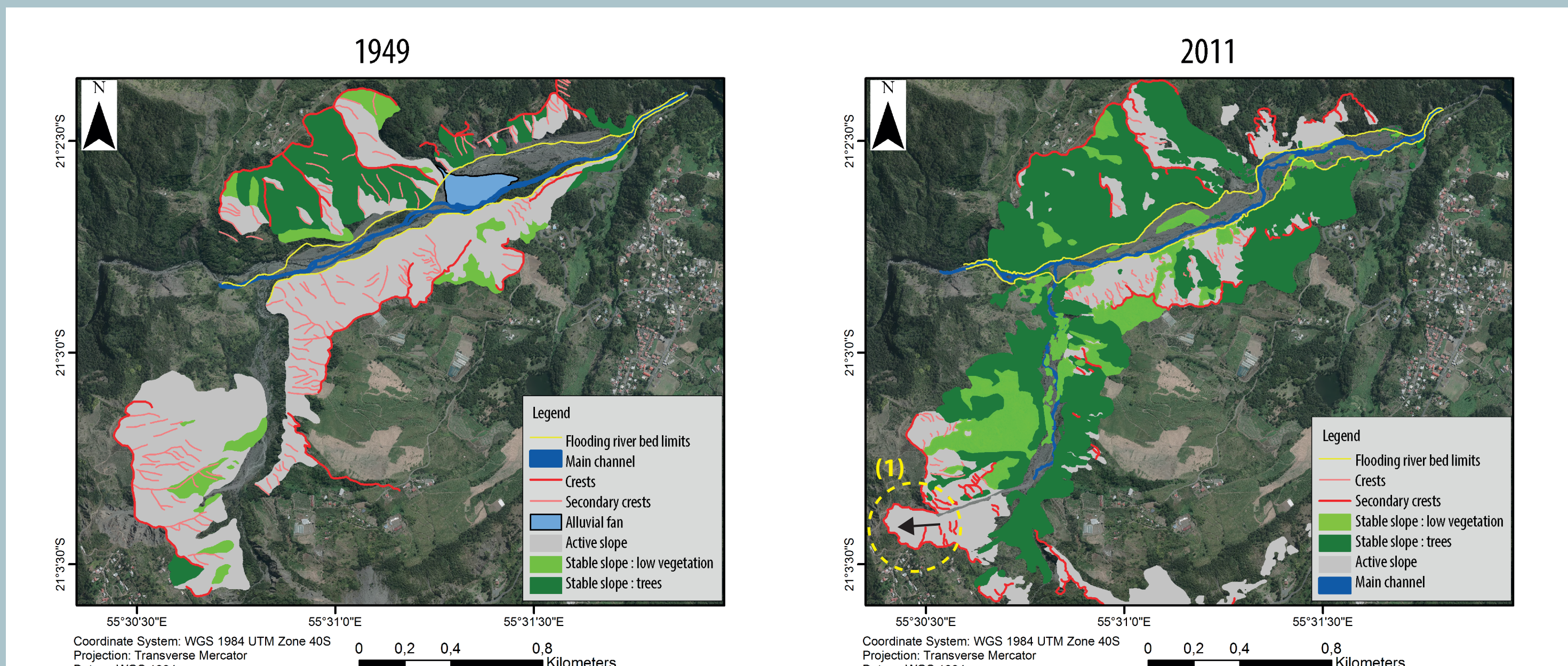
Relation between horizontal displacement and pluviometry : high cumulated rainfalls lead to a more important displacement than the intensity of the rainfall event itself.



Monthly rainfalls recorded in Hell-bourg and Salazie stations from 2002 to 2014.

II. Geomorphological study of the landslide (1949-2011)

II. 1. Geomorphology of the limits of the landslide from aerial images

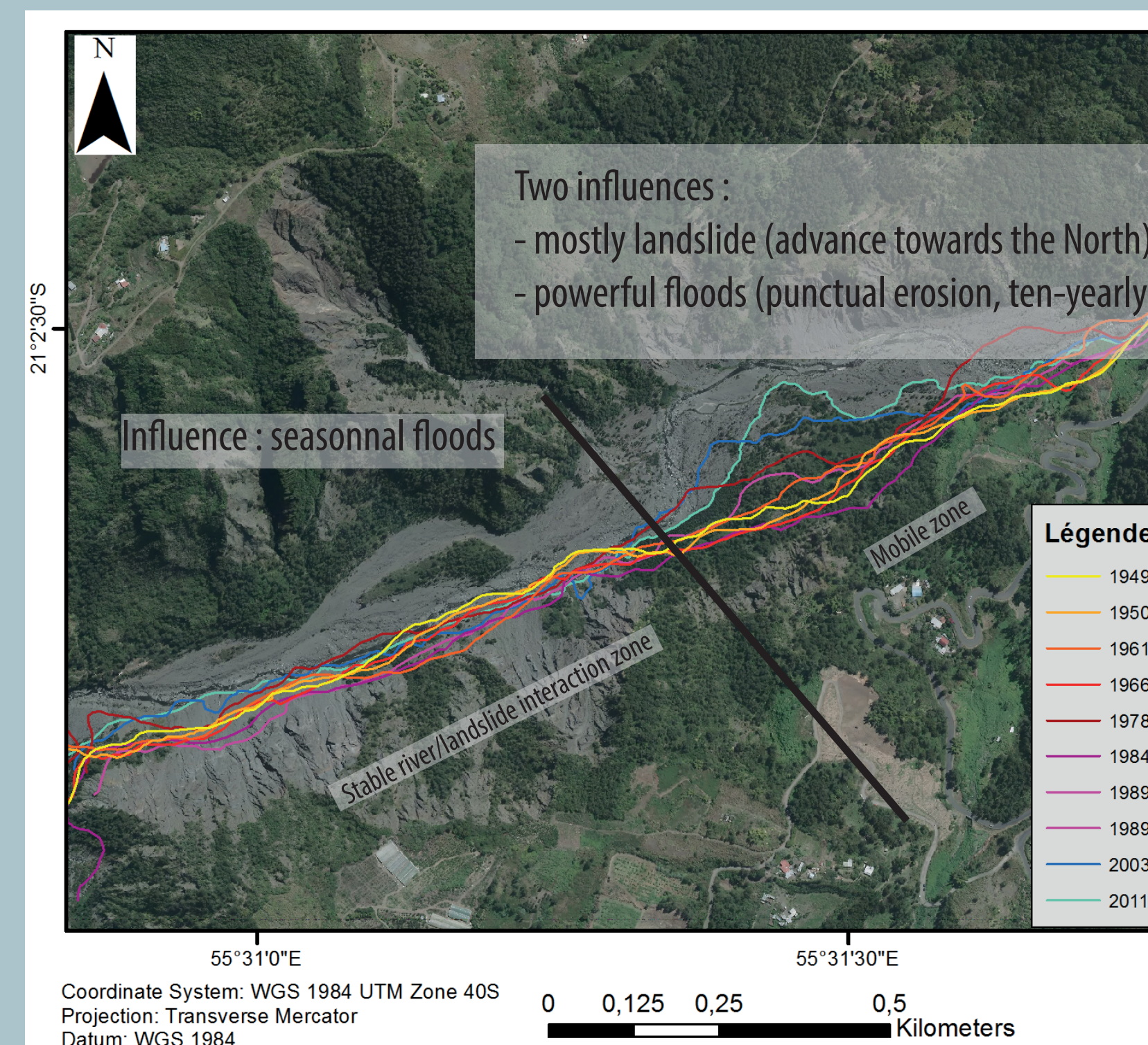


Evolution of the crests and increase of the vegetation from 1949 to 2011 due to a revegetation policy

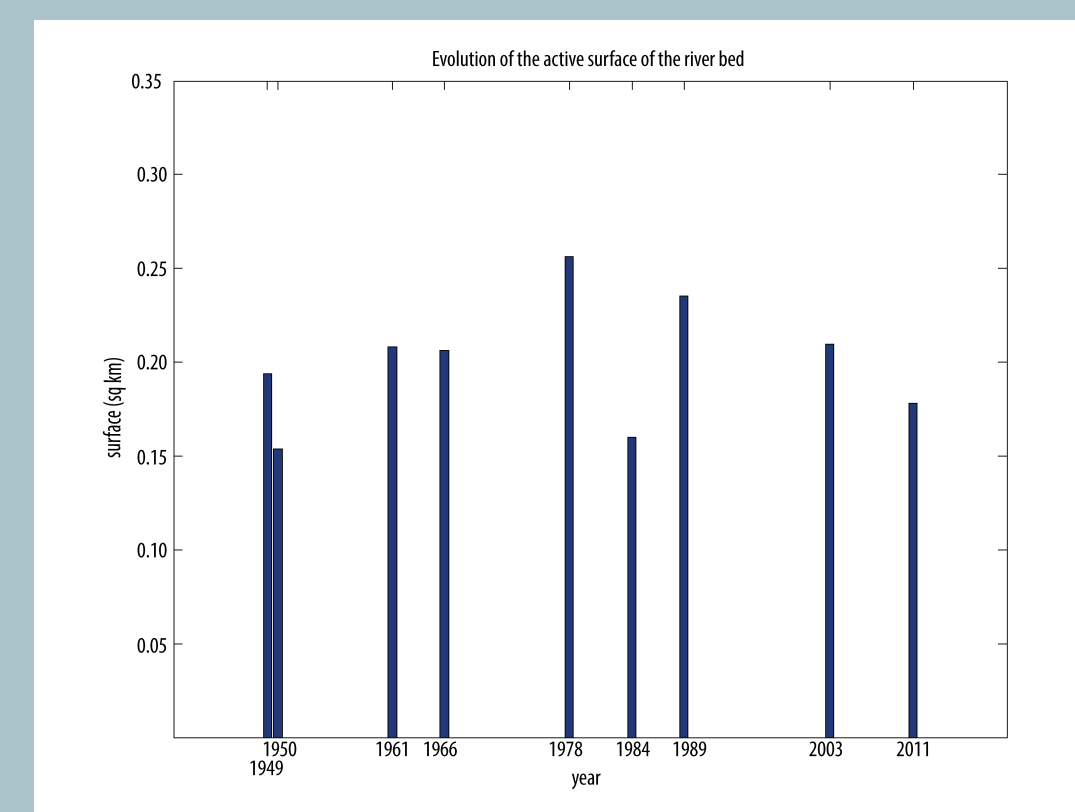
Stability of the landslide limits:

- no retrogressive erosion at the landslide' limits
- retrogressive erosion of 120m : the main source of sediments for the river

II. 2. River/landslide interactions : evolution of the active river bed



River/landslide interface observed from aerial images from 1949 to 2011



Surface of the active river bed from aerial images, from 1949 to 2011

Stability of the river bed :

quick return of the river to its equilibrium state after a flood.

Bibliography and acknowledgements

Arnaud, N., 2005. Les processus de démantèlement des volcans, le cas d'un volcan bouclier en milieu océanique : le Piton des Neiges (île de la Réunion). PhD, Univ. de la Réunion.
 Deseilligny, M.-P., Belveaux, J., Choqueux, G., Deveau, M., Girod, L., 2013. MicMac, Apero and Other Beverages in a Nutshell, ENSG — Marne-la-Vallée. p. 275.
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