











Portraying the dynamics of a tropical deep-seated landslide

Natural and anthropic controls

A. Dille^{1,2}, F. Kervyn¹, A. Handwerger³, D. Derauw⁴, B. Smets¹, E. Monsieurs¹, M. Kervyn², N. d'Oreye^{6,7}, O. Dewitte¹

- ¹ Royal Museum for Central Africa, Belgium
- ² Vrije Universiteit Brussel, Belgium
- ³ JPL, California Institute of Technology, USA
- ⁴ Centre Spatial de Liège, Belgium
- ⁵ ECGS, Luxembourg
- ⁶ National Museum for Natural History, Luxembourg

context

City of Bukavu - Kivu Rift

East African Rift

- steep topography
- intense seismicity

Tropics

- intense rainfall events
- deep weathering

Africa

- high population pressure
- context of data scarcity

- Insar MSBAS
- 590 Sentinel 1 & CSK
- 4.5 years time series

Courtesy of N. d'Oreye

East-West surface displacements

	mm/yr							
-75	-50	-35	-10	0	10	35	50	75

CIS-MaSTER - MSBAS v3 [March 2015 - Aug. 2019] Sensors: COSMO-SkyMed & Sentinel 1

GNSS reference station

- InSAR MSBAS
- 590 Sentinel 1 & CSK
- 4.5 years time series

GNSS reference station

East-West surface displacements

mm/yr

-75 -50 -35 -10 0 10 35 50 75

MSBAS processing chain Samsonov and d'Oreye 2012, 2017

ain

MSBAS 3D, Samsonov et al., under review

-75 -50 -35 -10 0 10 35 50 75

CIS-MaSTER - MSBAS v3 | 03 2015 - 08 2019 Sensors: COSMO-SkyMed & Sentinel 1

mm/yr

-30 -25 -15 -10 0 10 15 25 30

[Jan. 2018 - Jan. 2019] Sensor: COSMO-SkyMed

-75 -50 -35 -10 0 10 35 50 75

CIS-MaSTER - MSBAS v3 | 03 2015 - 08 2019 Sensors: COSMO-SkyMed & Sentinel 1 -30 -25 -15 -10 0 10 15 25 30

[Jan. 2018 - Jan. 2019] Sensor: COSMO-SkyMed

- different landslide units with contrasting velocities
- E-W ~ 3 8 cm/yr
- Vertical ~1 2 cm/yr

TS 1

TS 3

TS 4 TS 6

TS 7

TS 9

Handwerger et al., 2013, 2019

- Quantifying pore pressure changes within the landslide
- Kinematics:
 - Variation closely tied to rainfall pattern
 - Strong acceleration with onset of rainy season
 - Deceleration with dry season

Pore pressure diffusion model *Handwerger et al., 2013, 2019*

Handwerger et al., 2013, 2019

Handwerger et al., 2013, 2019

Funu landslide

Funu landslide

Funu landslide

Limits of InSAR / dGNSS

displacements rates

dGNSS >>> InSAR

>> 100 mm/yr < 100 mm/yr

Limits of InSAR / Digital Image Correlation

 Measure of surface deformation using Pléiades (2013) and UAV-SfM orthomosaic (2018)

Limits of InSAR / Digital Image Correlation

 Measure of surface deformation on succeeding (1 year) UAV-SfM orthomosaics

Limits of InSAR / Digital Image Correlation

 Measure of surface deformation on succeeding (1 year) UAV-SfM orthomosaics

- Strong relationship between change in porewater pressure and slide movement
- Short time lag considering inferred depth
- Different units, different kinematic behaviour

 \rightarrow Urban growth and landsliding?

WY 2015 | Dry season

EW displacement rate [mm/yr] -100 -50 -25 0 25 50 100

AF R C Museum

museum

1974

AF R C Museum

museum

2018

Funu - landslide kinematics & urban footprint

museum

Funu - landslide kinematics & urban footprint

Influence on baseflow hydrology?

- infiltration
- runoff
- recharge
- runoff redirection
- gullying
- weight (?)
- pipe leakage

take home messages

- landslide kinematic behaviour strongly influenced by seasonality of the precipitation pattern
- combining remote sensing key to unravel mechanisms that control displacements associated with landslides in such data scarce context
- urbanisation induced destabilisation of previously stable landslide units – influencing a thousand years old deep-seated landslide
- What's next?

