



**The Abdus Salam
International Centre for Theoretical Physics**



2053-18

**Advanced Workshop on Evaluating, Monitoring and Communicating
Volcanic and Seismic Hazards in East Africa**

17 - 28 August 2009

**Eruptive Activity of Nyiragongo Volcano lessons learned: the scenarios of the
contingency plan of the city of Goma**

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**Eruptive Activity of Nyiragongo Volcano :
lessons learned for Natural Disasters in North
Kivu**

Activité avril 2009













Collaboration avec les Institutions Etrangères

- **Université de Naples 2 (I)**
- **Musée d'Afrique de Tervuren (B)**
- **Université de Luxembourg (L)**
- **Université de Florence (I)**
- **Inst. Nationale de Geophysique et Volcanologie (I)**
- **Université du Wisconsin (US)**
- **Université de Rochester (US)**
- **Columbia University (US)**
- **JPL/NASA (US)**
- **Université de Cambridge (UK)**
- **Société Volcanologique de Geneve (S)**

Identification of Possible Natural Hazards:

- **Volcanic Eruptions**
- **Earthquakes**
- **Acid Rains (up to pH 0)**
- **Deadly Soil CO₂ Gas Emissions**
- **Poor Water Quality (Endemic Fluorosis)**
- **Killer Lake**

Man Made Hazards

- **Lake Pollution**
- **Deforestation and Soil Avalanches/Landslides**

Eruptive Scenarios of Nyamulagira and Nyiragongo Volcanoes



Nyamulagira

Scenario 1

Scenario 2

Nyiragongo

- Scenario 1

- Scenario 2

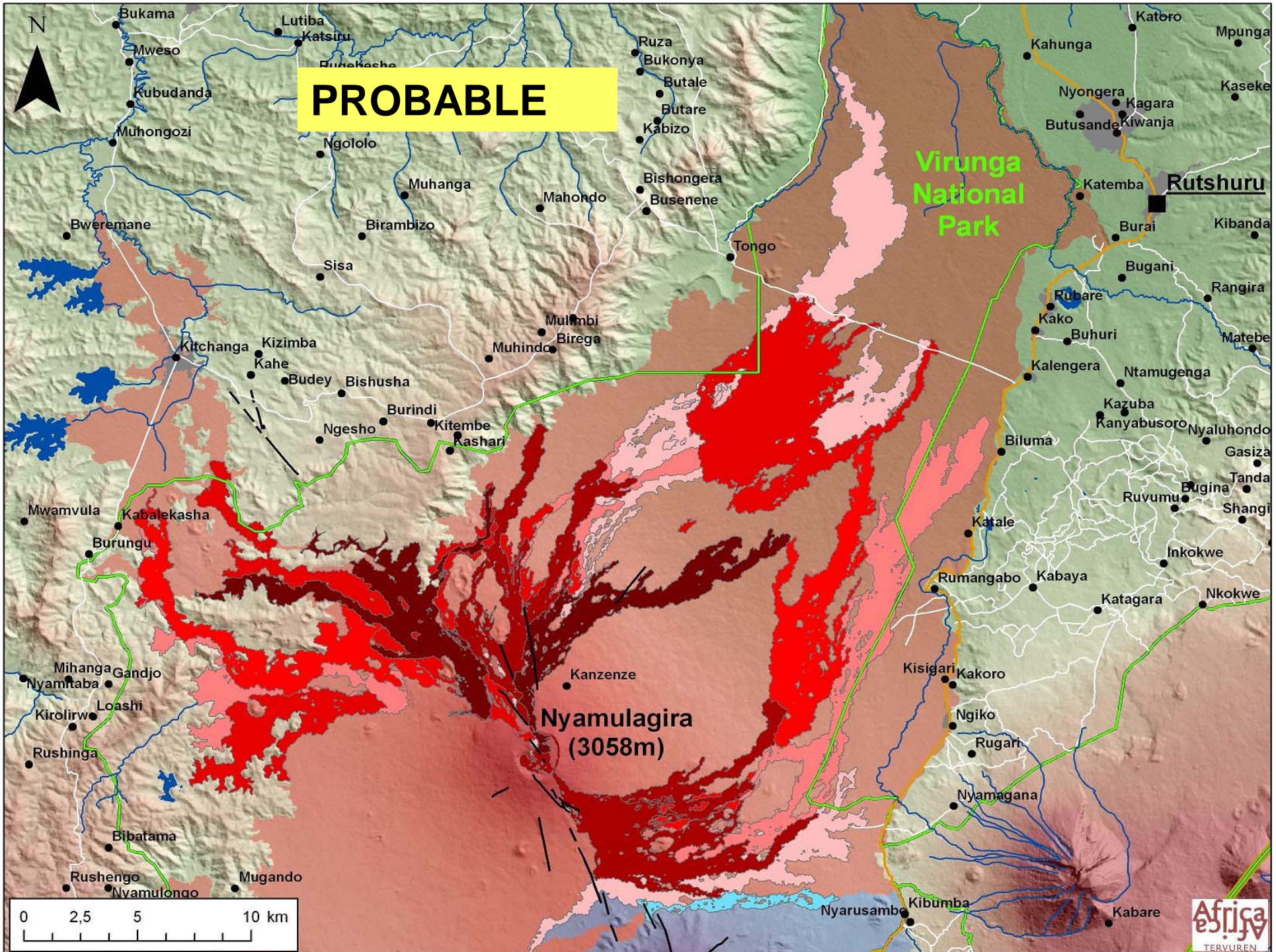
Current Activity

“Unité de Gestion des Risques Volcaniques”

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Benoît Smets – Royal Museum for Central Africa (Belgium)

Contact: dtedesco@unina.it

Echelle d'impact		Probabilité d'occurrence	
Négligeable	Pas de morts, blessés multiples. Impact minimal sur la qualité de vie. Arrêt des installations / services de base pour moins de 24 heures. Moins de 10% de dommages sévères sur les propriétés.	Très probable	Probabilité de près de 100% dans l'année ou 100% de probabilité sur le type d'éruption.
Limité	Quelques morts et blessés. Arrêt complet des installations/services de base pour moins d'une semaine. Plus de 10% de dommages sévères sur les propriétés.	Probable	Entre 10% et 100% de probabilité dans l'année, ou au moins une chance dans les dix prochaines années
Critique	Moins de 100 morts et blessés. Arrêt complet des installations/services de base pour au moins deux semaines. Plus de 25% de dommages sévères sur les propriétés.	Possible	Entre 1% et 10% de probabilité dans l'année, ou au moins une chance dans les cent prochaines années
Catastrophique	Nombreux morts et blessés. Arrêt complet des installations/services de base pour au moins un mois. Plus de 50% de dommages sévères sur les propriétés.	Peu Probable	Moins de 1% de probabilité dans l'année, ou moins d'une chance dans les cent prochaines années



Nyamulagira : scenario 1

PROBABLE

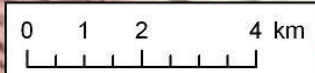
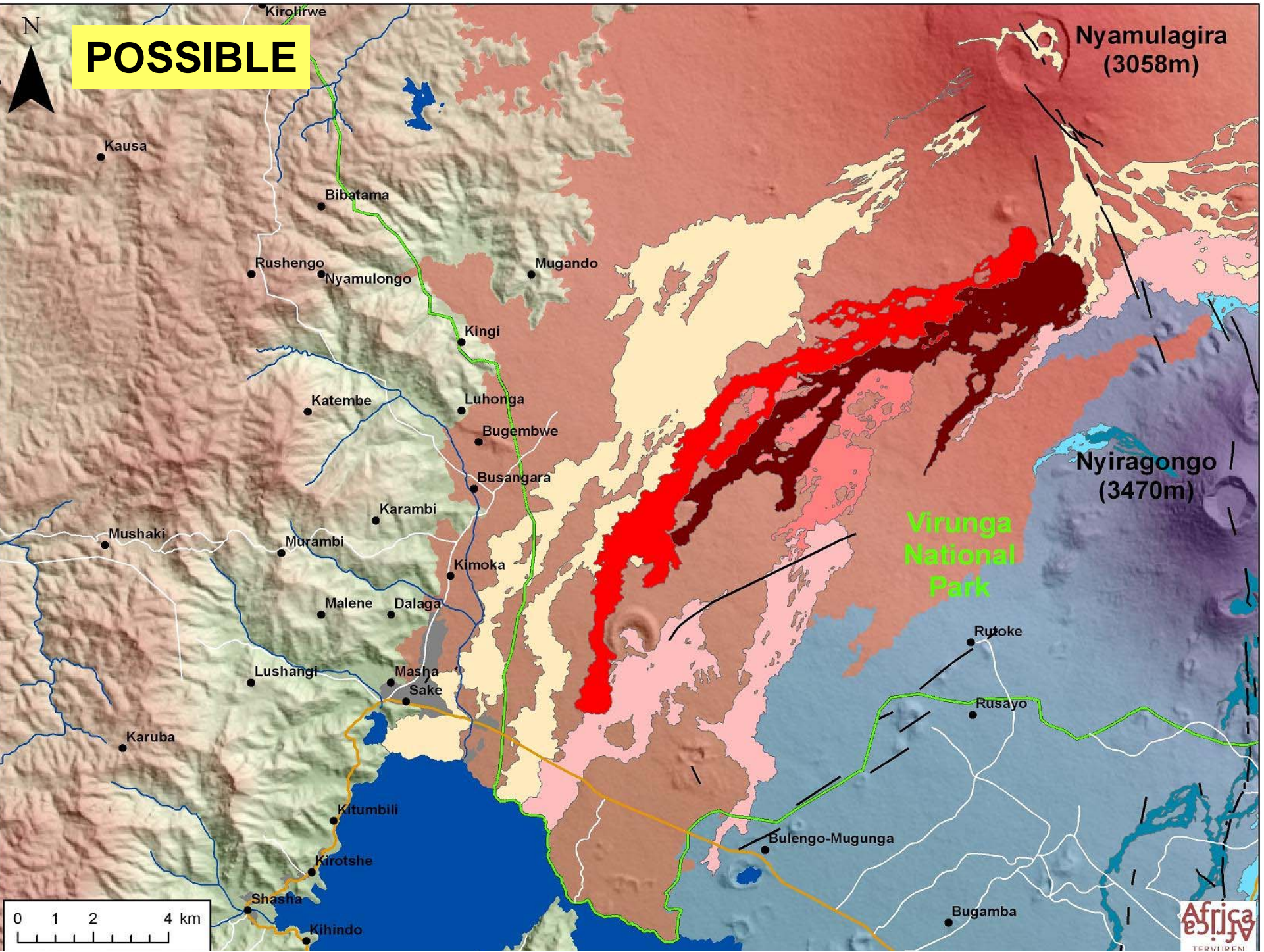
- **Event:** Fractures opening, important lava flows at west, north or east of the volcano, volcanic plume, scoria cones
- **Area affected:** Limited to the forest of Virunga National Park
- **Population affected by the volcanic plume:** Population in few kilometers around the eruptive site (mainly at west)
- **Duration (estimation)**
 - Crisis (emergency period): several weeks to several months (up to 2 years)
 - Post-emergency: ~3 months
 - Rehabilitation: ~3 months

POSSIBLE

Nyamulagira
(3058m)

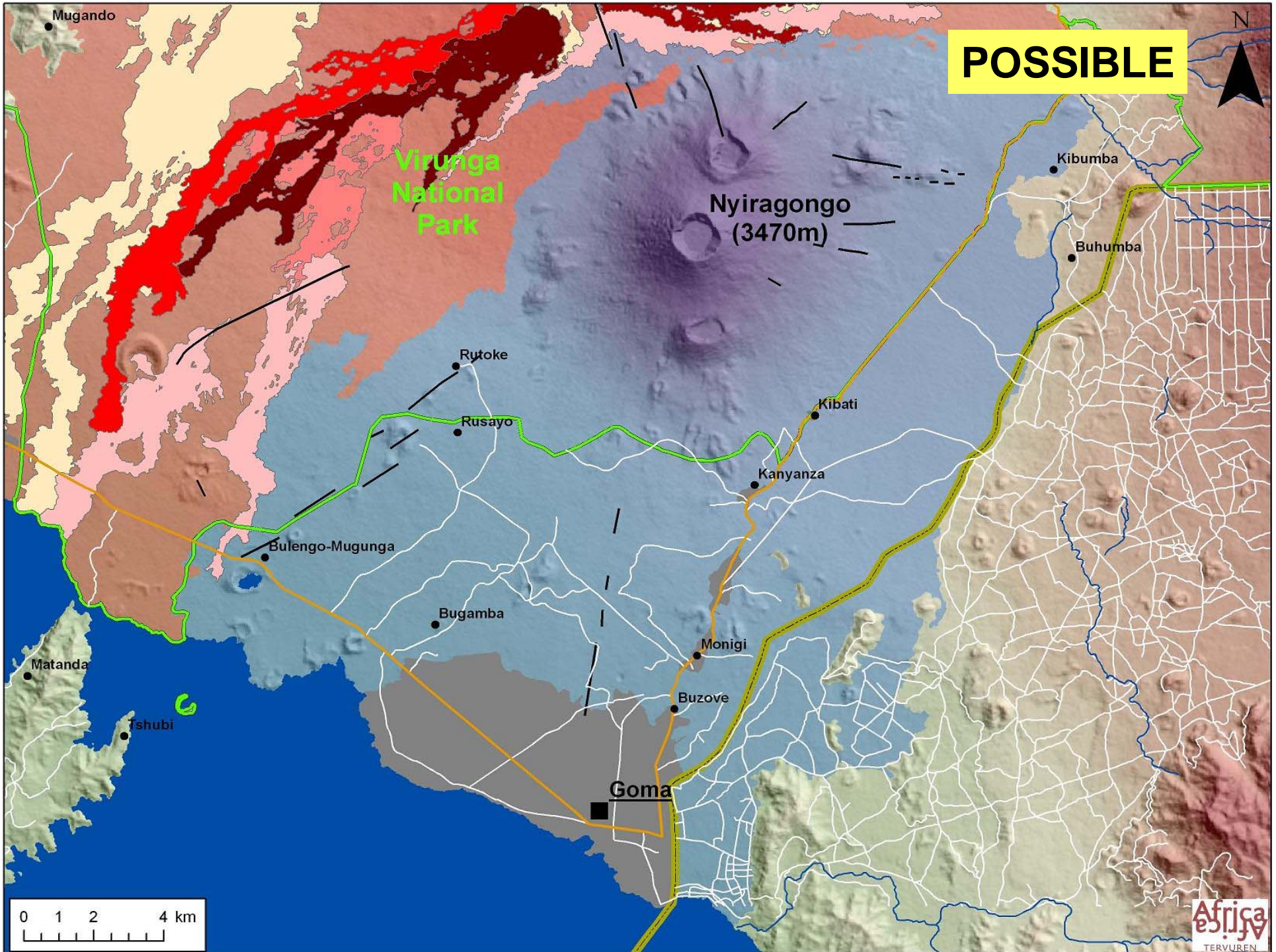
Nyiragongo
(3470m)

Virunga
National
Park

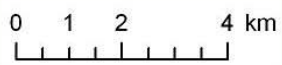


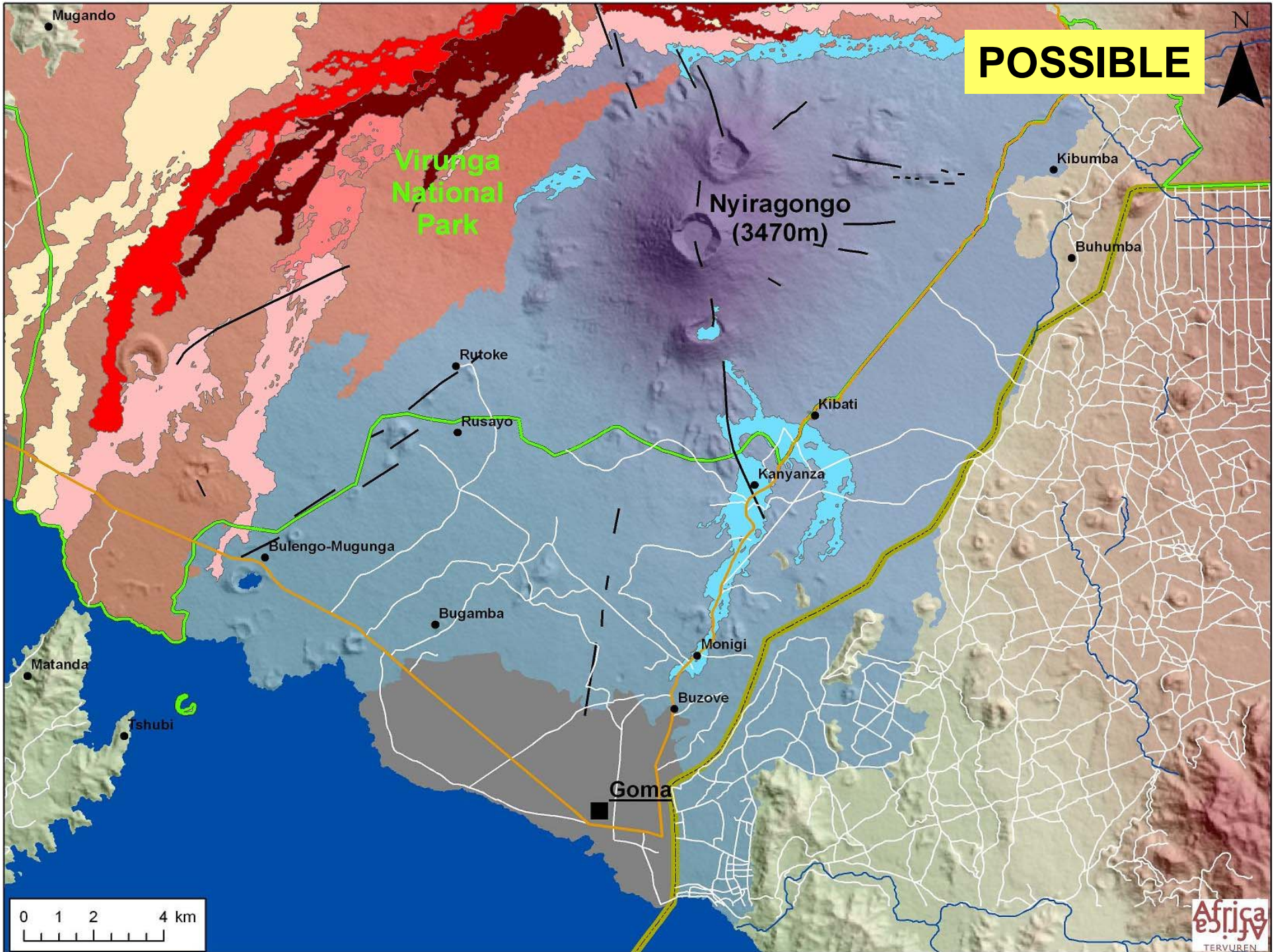
Nyamulagira : scenario 2 **POSSIBLE**

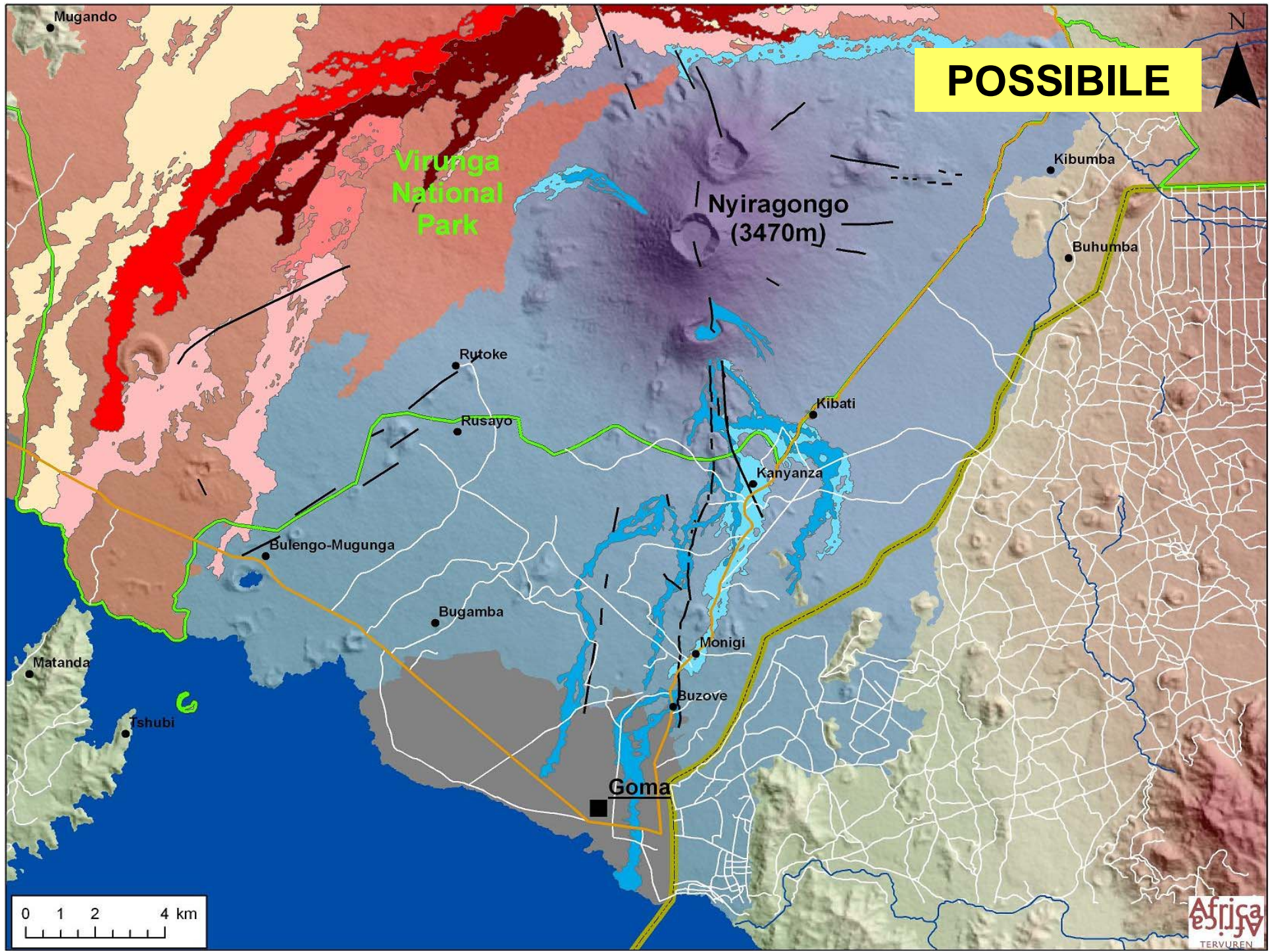
- **Event:** Fractures opening, important lava flows at south or west of the volcano, volcanic plume, scoria cones
- **Area affected:** Forest of the Virunga National Park, urban areas of Sake - Mubambiro, plus the Sake - Kitchanga & Goma - Sake road
- **Population affected by the volcanic plume:** Population few kilometers around the eruptive site (mainly on the south and south-western sides)
- **Population affected by the lava flows:** Sake - Mubambiro area (south) or less probably Kabalekasha - Kitchanga area (west)
- **Duration (estimation)**
Crisis (emergency period): several weeks to several months (up to 2 years). Post-emergency: ~3 months up to few years (depending on the M of the event)
Rehabilitation: ~1 year or more (as above)



POSSIBLE





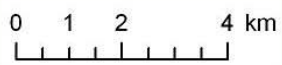


POSSIBLE

Nyiragongo
(3470m)

Virunga
National
Park

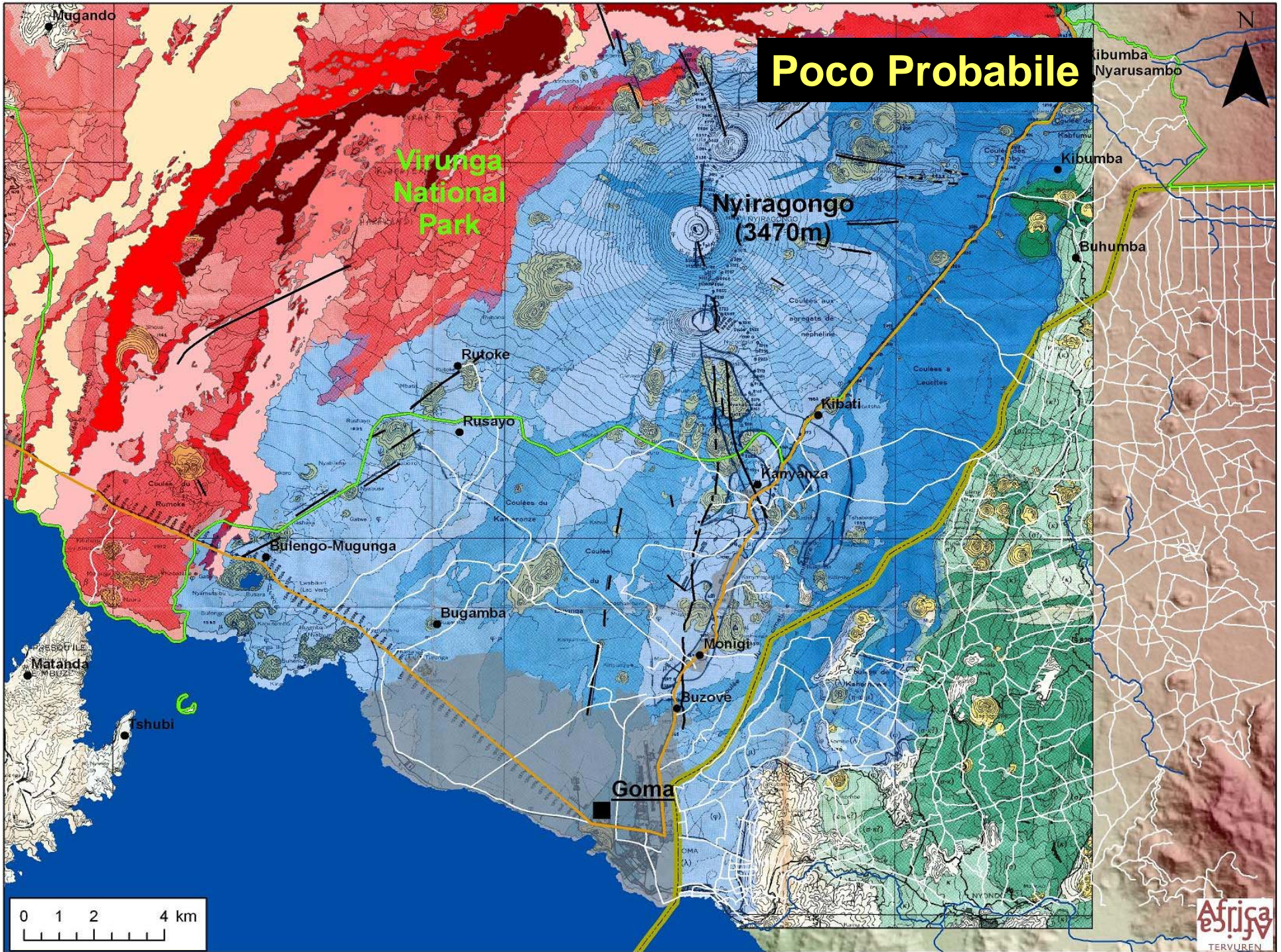
Goma



Nyiragongo : scenario 1

POSSIBLE

- **Event:** Opening fractures, lava flows, volcanic plume, scoria cones, phreato -magmatic explosion in case of fractures near the Lake Kivu
- **Area affected:** Area south of the volcano, Goma and vicinity, probably Gisenyi
- **Population affected (estimation)**
 - Dead: ~200
 - Injured: ~2.000
 - Displaced: ~250.000
- **Duration (estimation)**
 - Crisis (emergency period): ~1 week to months, depending on the M of the eruptive event
 - Post-emergency: ~3 months to years (as above)
 - Rehabilitation: ~1 year ~ x or ? years



Nyiragongo : scenario 2

PEU PROBABLE

- **Event:** Fractures opening, lava flows, volcanic plume, scoria cones, probable phreato-magmatic explosions (depending on available ground water), new fractures near or within Lake Kivu
- **Area affected:** Area from south-west to south-east of the volcano, Goma and vicinity, Gisenyi
- **Population affected (estimation)**
 - Dead: ~20.000 or more, depending on the forecast
 - Injured: ~100.000
 - Displaced: ~1.000.000 (the whole populations of the great Goma and Gisenyi)
- **Duration (estimation)**
 - Crisis (emergency period): several months to years
 - Post-emergency: ~6/12 months – ~several years or ?
 - Rehabilitation: ~several years ... may be impossible!



Current activity and international expertise

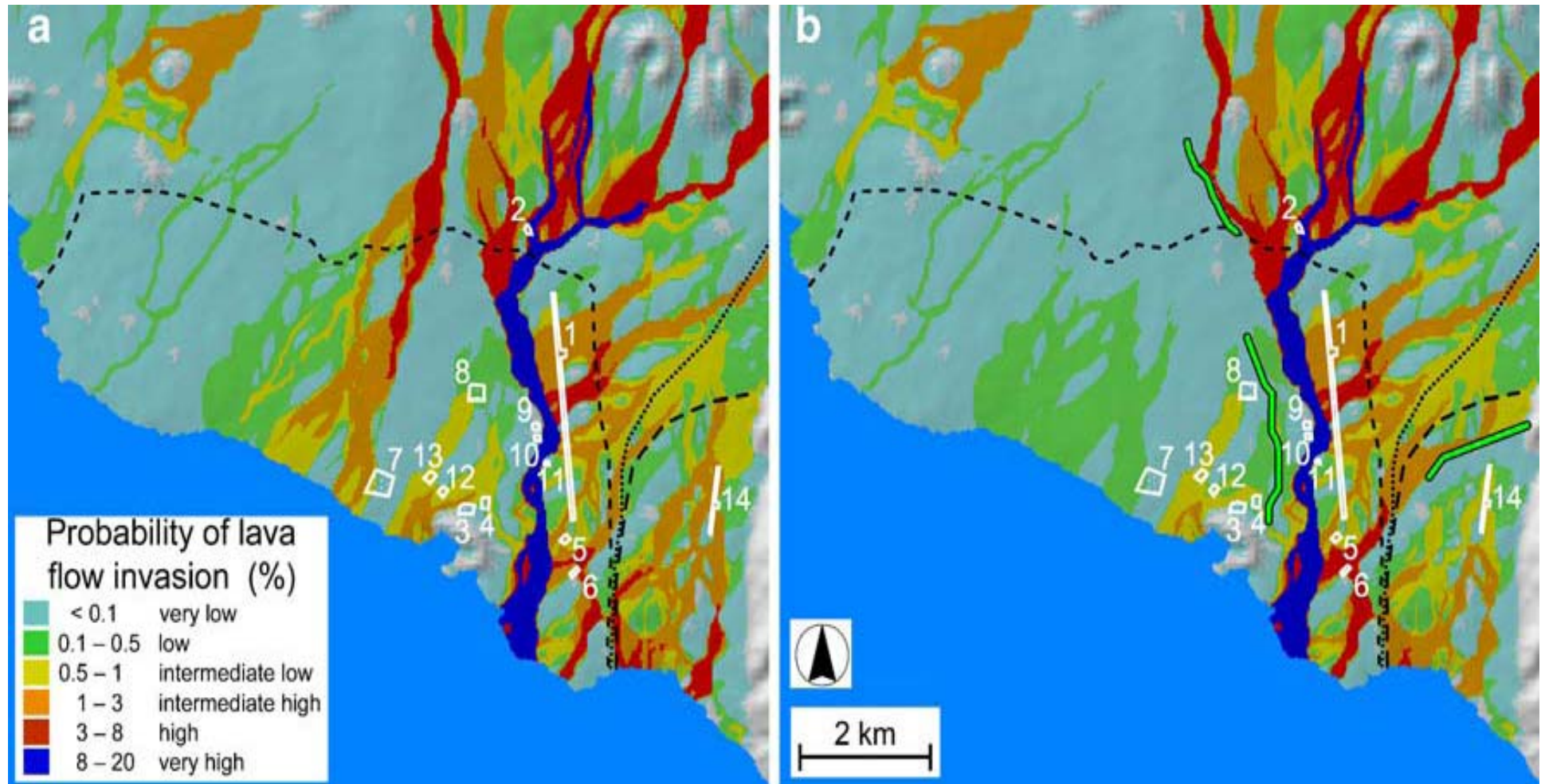
Nyiragongo: permanently active (steady state (active) lava lake, slightly decreasing volcanic plume), relatively stable

Nyamulagira: increasing fumarolic activity (disappeared in June) into the main crater, weak fumaroles in the 2006 eruptive site, increasing seismic activity but no yet real signs of a close event. Possible eruptive event in the next months may be more, one years.

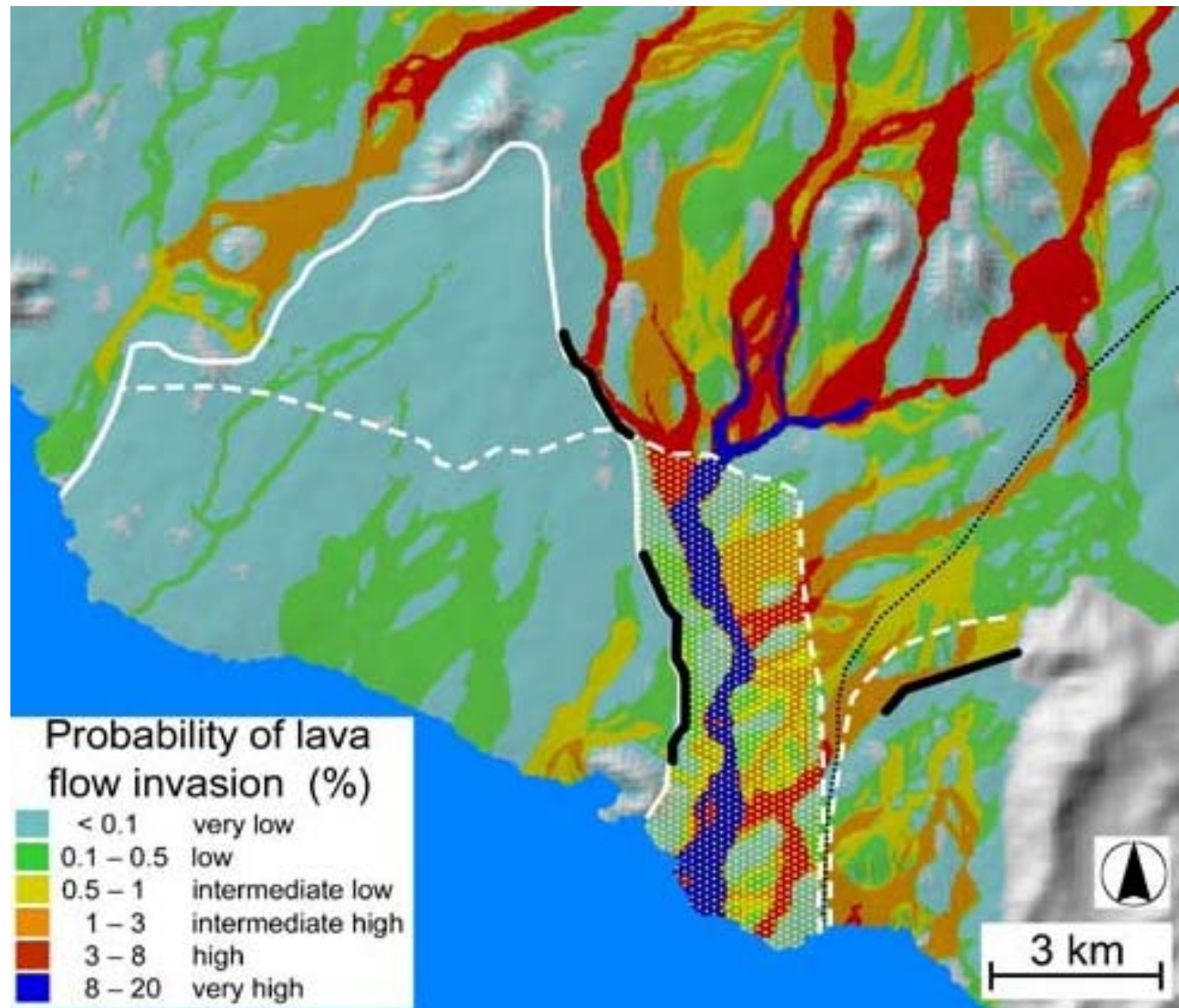
GVO (study and monitoring of volcanoes) and UGR (hazard and risk management) collaboration with international experts to help monitoring volcanoes, for training sessions, for scientific studies and for hazard assessment and mitigation. **An international scientific community of experts for Virunga volcanoes already exists and actively collaborate with GVO and UGR in their respective tasks.**

- Italy (Second University of Naples, University of Florence, INGV)
- Belgium (Royal Museum for Central Africa)
- Luxembourg (National Museum of Natural History, University of Luxembourg)
- USA (JPL/NASA, University of Wisconsin, Columbia University, Rochester University)
- UK (University of Cambridge)
- Switzerland (Société Volcanologique de Geneva).

Current activity



First attempt ... the real question is: from where the lava will start flowing next time? Specific monitoring systems are badly needed. Favalli et al., 2009; Chirico et al., 2009



The UGR and OVG also works in close collaborations with foreign Institutions :

- **Seismic data (GVO and INGV-Rome)**
- **GPS and tilt stations (ground deformation) Go-Risk**
- **Radar interferometry (ground deformation) Go-Risk**
- **Geochemical studies of water and gas (GVO –Naples and Florence Un, Lux. Un, USA)**
- **Distant crater CO₂ gas emanations (GVO – Na – USA)**
- **Study of plume impact on health (Na & Fi Univ.)**
- **Lake Kivu Hazard(s) (Naples, Florence, USA)**
- **Hazard mapping Go-Risk, Naples**
- **Remote sensing (plume) (INGV, Naples, Cambridge UK, USA)**
- **Satellite Imagery (Lux., JPL / NASA)**

ACTIVE FIRE DETECTION OVER NYIRAGONGO VOLCANO, NORTH KIVU, DRC

Thermal Anomaly Detection from MODIS Satellite Sensors, 10 April - 4 May 2009

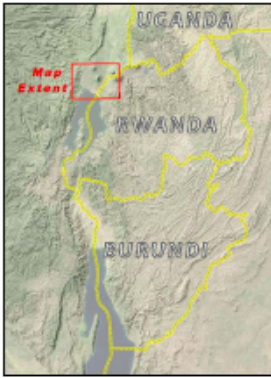
This map illustrates satellite-detected recorded all active fire/thermal anomalies (likely active fires and / or volcanic material) across the majority of the Nyiragongo volcano. These fire thus represent a minimum extent of the locations were detected by the MODIS volcanic activity. This is a preliminary assessment and has not yet been validated on the ground. It is likely that this product has not

Volcanic Activity
5 May 2009
Version 1.0
 Guide No: VO-2009-00076-COD



Analysis Summary:
 The satellite-detected thermal anomalies on the Nyiragongo volcano are centered over the main crater and extend up to 3km along the eastern and western slopes. These thermal anomalies are likely to represent active fires and / or volcanic material on the surface of the volcano, and have been identified on six separate days over the time period 10 April - 4 May 2009. The MODIS satellite image below recorded on 4 May shows an volcanic eruption in progress, with a primary westerly outflow direction. This is a preliminary assessment and has not yet been validated on the ground.

MODIS Terra 4 May 2009



Legend

- International Border
- National Road
- Provincial Capital
- Provincial road
- Town
- Track / Trail
- Village
- Drainage Line
- Volcano
- Elevation Contour (250m)
- Game Urban Extent
- Lake / Main River
- Parc National des Volcans

Active Fires by Location
 Active fire detected within 1km² area of MODIS satellite pixel

Map Scale for A3: 1:185,000

Fire Date: MODIS Aqua - Terra (NASA)
 Fire Processing: U of Maryland, NASA
 Fire Dates: 10 April - 5 May 2009
 Road GIS Data: Kavaya
 Other GIS Data: USGS, NGA, UNLCC, SALS
 Elevation: SRTM
 Satellite Imagery: Landsat 7
 Imagery Date: 11 December 2001
 Analysis: UNOSAT
 Map Production: UNOSAT (5 May 2009)
 Projection: UTM Zone 34 South
 Datum: WGS 1984

The depiction and use of boundaries, geographic names and related data shown here are not warranted to be error-free nor do they imply official endorsement or acceptance by the United Nations. UNOSAT is a program of the United Nations Institute for Training and Research (UNITAR), providing satellite imagery and related geographic information, research and analysis to UN humanitarian, development agencies & their implementing partners.

→ **Wrong alert !!!**

MODVOLC
Near-real-time thermal monitoring of global hot-spots

HIGP
University of Hawai'i

5/6/2009
29.20
E
-
1.50
N

display a different GMT date
previous 30. day(s) *No Subsequent alerts available*

Month summarize by

MM: DD: YYYY: This GMT Date

display a different area for the Date 5/6/2009 GMT

- 360 X 180
- 45 X 45
- 10 X 10
- 2 X 2
- .5 X .5
- .1 X .1

Zoom

(45° X 45°) Alaska go to region

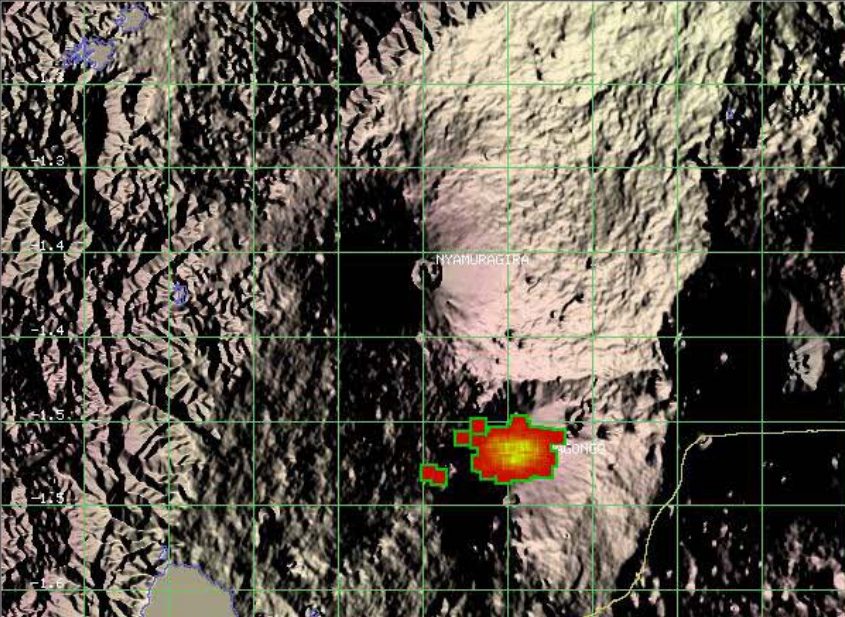
(15° X 15°) AntarcticaPen go to subregion

(2° X 2°) Acatenango go to target area

Lon: Lat: these coordinates

(360° X 180°) display globe

Number of Alerts



Thermal alerts linked to the active lava lake of Nyiragongo
(usual kind of alert for this volcano)