

# Monitoring of volcanic activity in the Virunga Province (N-Kivu, DRC): Experience of the GORISK project and illustration with the Nyamulagira January 2010 eruption"

## *STEREO II – Products and Services*

Royal Museum for Central Africa – Cartog & Rem. Sens.  
National Museum of Natural History of Luxembourg  
University of Luxembourg – Lab. Of Radiation Physics  
2<sup>nd</sup> University of Napoli – Dept. of Env. Sc.

Goma Volcanological Observatory

UNOPS – UGR/RMU  
CEMUBAC

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P. Mitangala



- Introduction
- GORISK structure
- Project location
- Goma: eruption means
- Output Deformation
- Output Geochemistry
- Health
- Goma map update
- GIS
- Training
- Conclusion



# GORISK: Who?

**Funding**

**BELSPO**  
Belgium

**National Research Fund**  
Luxembourg

**Coordination**

**Royal Museum for Central Africa**

**Operations**

**Scientific Partners**

**Royal Museum for Central Africa (Belgium)**

**2<sup>nd</sup> University of Napoli (Italia)**

**National Museum of Natural History Luxembourg**

**University of Luxembourg Luxembourg**

*Cartography/ InSAR Deformation modeling Data integration Training*

*Gas and water Instrumentation. Training*

*InSAR processing Ground based deformation systems Training*

*Permanent gas measurement Instrumentation Training*

**End users**

**Goma Volcanologic Observatory (RDC)**

*Deformation & geochemistry*  

- Measurements
- Maintenance
- Interpretation

**CEMUBAC (B) (NGO health)**

*Health:*  

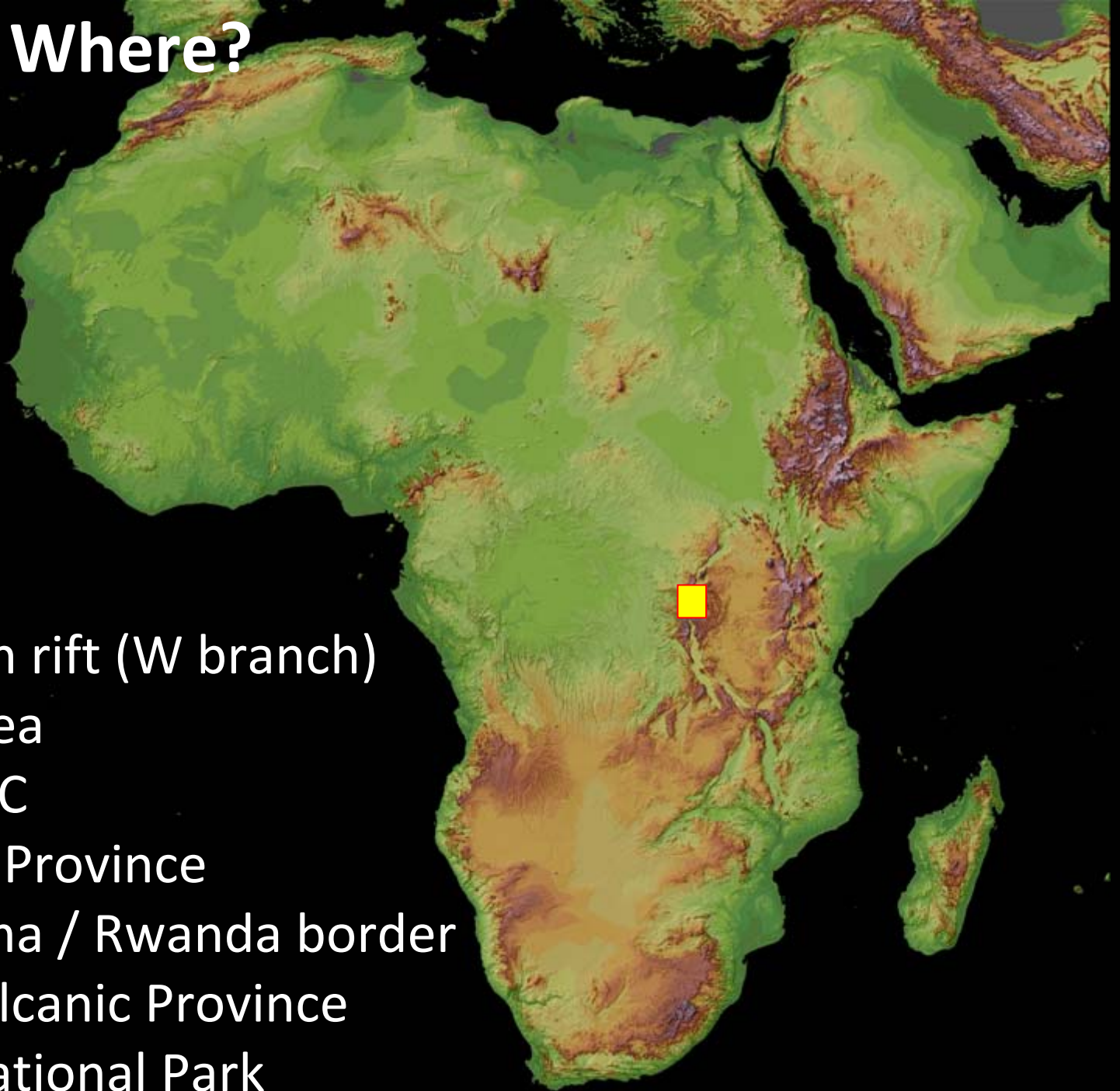
- Data collection
- Health data analysis

**UNOPS (UN) Risk Management Unit**

*Data integration for risk management purposes*

# GORISK: Where?

- Introduction
- GORISK organigram
- Project location
  - Geographical
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East African rift (W branch)

Tropical area

Eastern DRC

North Kivu Province

City of Goma / Rwanda border

Virunga Volcanic Province

Virunga National Park

# GORISK:

## Where?

- Introduction
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- Project location  
    Volcanological
- Goma: eruption means
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## Nyamulagira and Nyiragongo:

→ the two most active volcanoes of Africa

### Nyamulagira:

- many historic eruptions > 30 since 1900
- no major direct threat on populations
- impact on crops
- impact on vegetation, cattle, population health...

### Nyiragongo:

- Two historic eruptions: 1977 / 2002
- Direct and major threat for Goma
- Rapid lava flow (slope: 100Km/h, plain: 20-40 Km/h)
- Short distance / fractures
- Only volcano with direct casualties from lava flow
- 2002: ~15% of the city was destroyed
- long term socio-economic impact



# GORISK: Where?

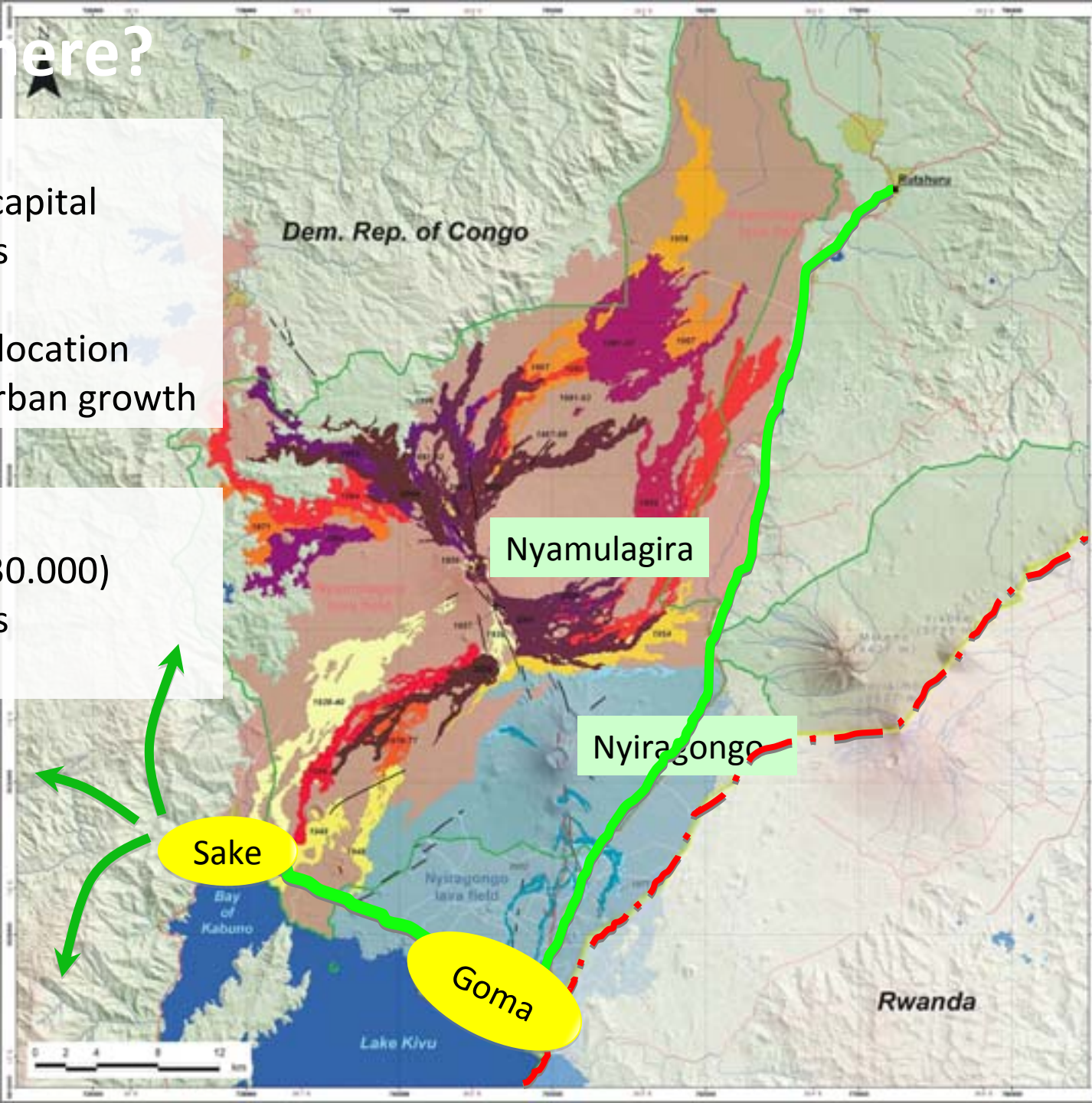
## Goma:

North Kivu Province capital  
~ 800.000 Inhabitants  
Border with Rwanda  
Economic / strategic location  
Uncontrolled rapid urban growth

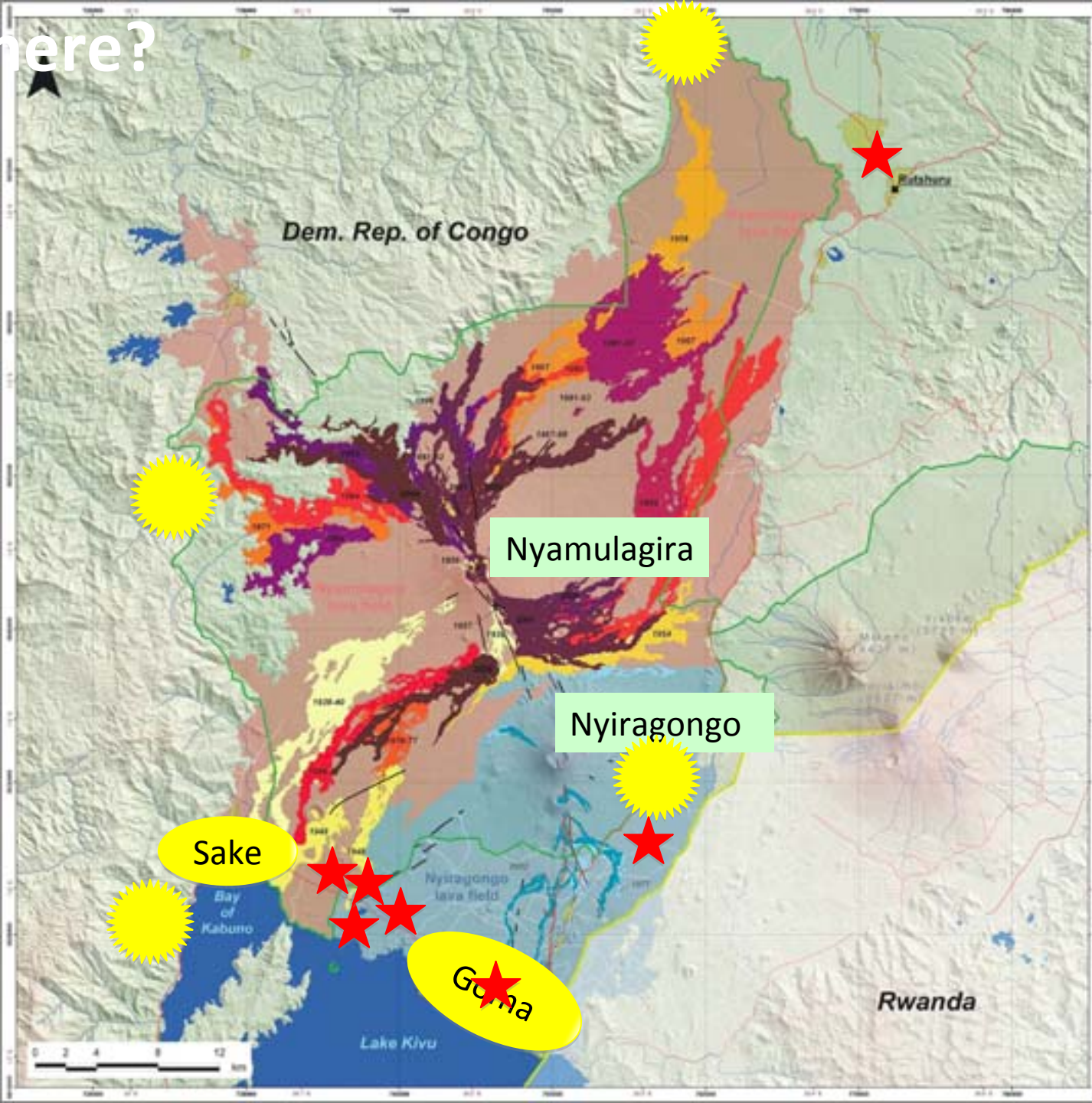
## Sake:

Important centre (~ 30.000)  
Junction of major axis  
Sensitive location

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**•Goma: eruption means**

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Goma main market, April 15<sup>th</sup> 2008.



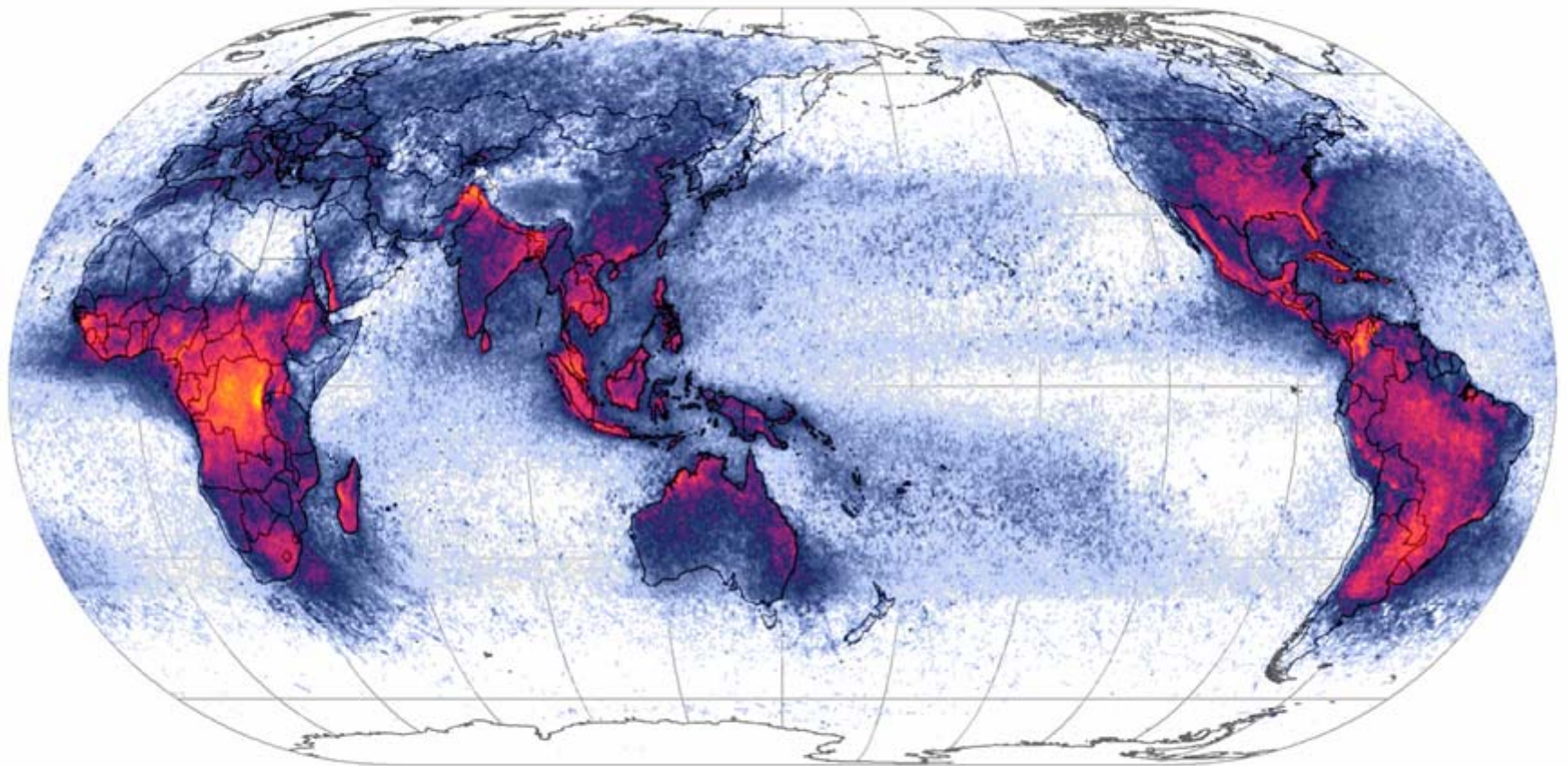
November 19<sup>th</sup> 2009.

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# Frequency of Lightning Strikes



colors show number of strikes per square kilometer per year:

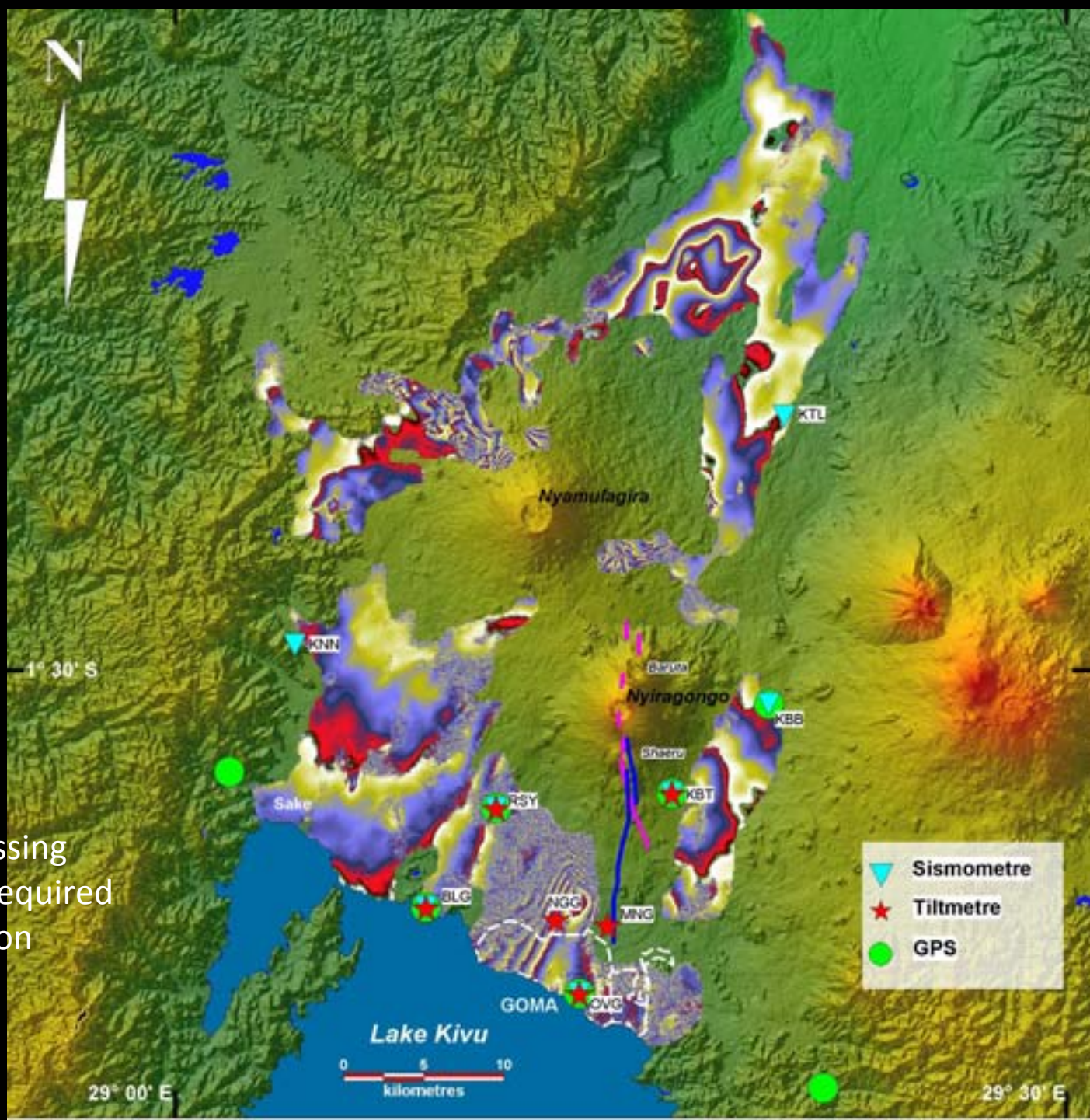


Source: NOAA

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Challenge:  
 > 600 scenes  
 > 6000 interferograms

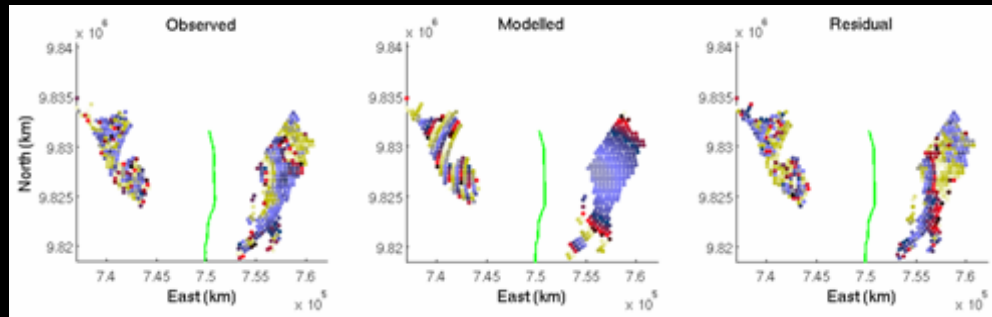
- Automated mass processing
- Manual refining when required
- Web tool implementation



# Nyiragongo 2002:

## Modeling of InSAR data, close to known eruptive fissure

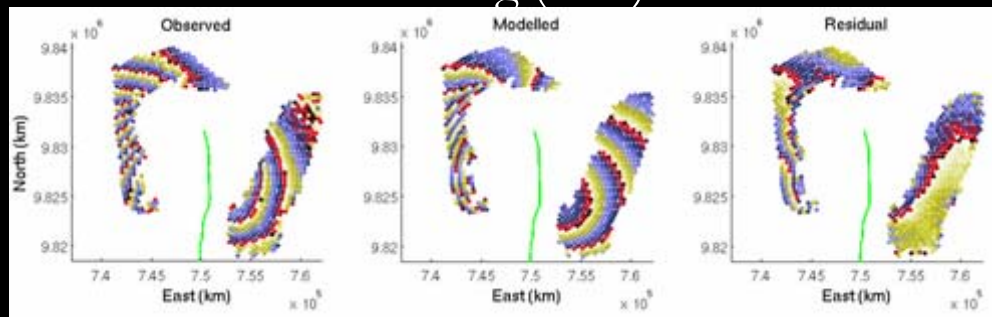
### ERS data



### Best fit model:

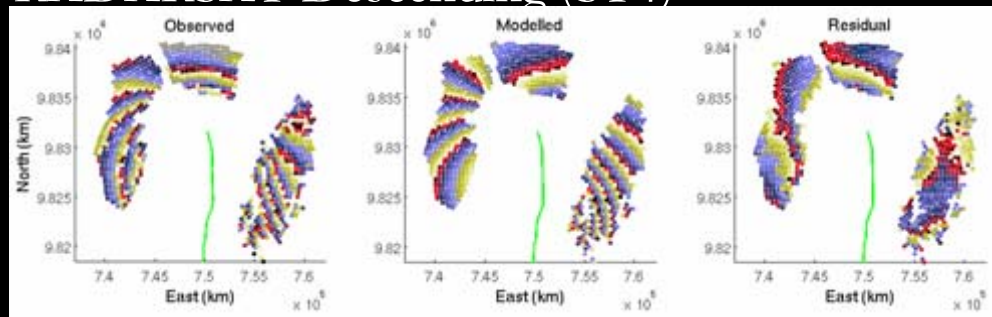
- Subvertical dyke
- Small overpressure

### RADARSAT Ascending (ST6)



-> consistent with the extensional rift system

### RADARSAT Descending (ST4)

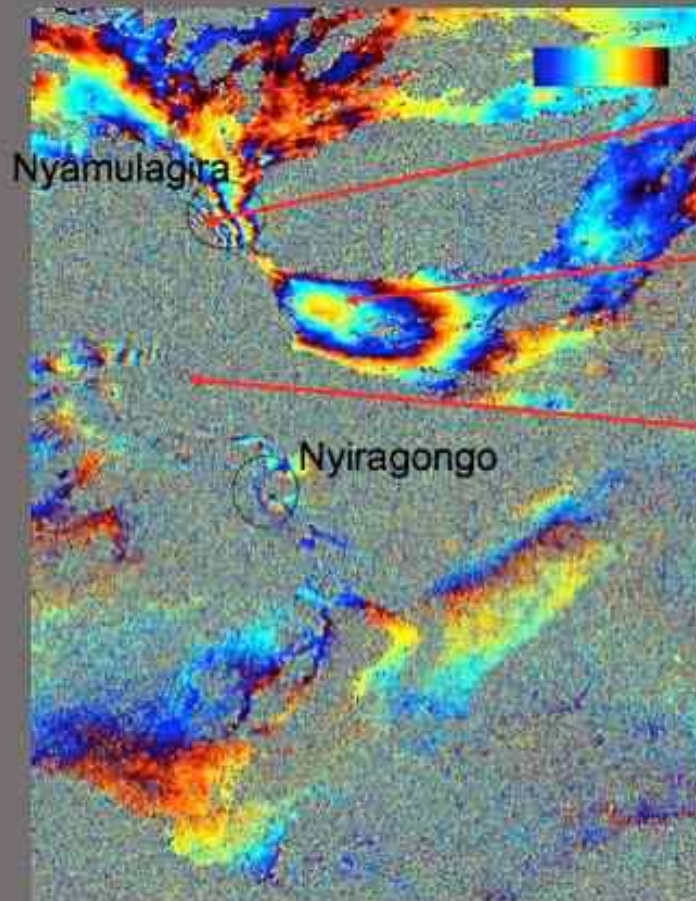


In green: eruptive fissure

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## The Nyamulagira Nov. 2006 eruption

ENVISAT ascending Swath I7: Oct 06- Dec 06 (35 days)  
 $B_{\text{perp}} = -200 \text{ m}$ ,  $h_s = 99 \text{ m}$



**Inflation:** 8 to 10 fringes with positive range change (i.e. ~ 22 to 28 cm)

**Deflation:** 1.75 fringes with negative range change (i.e. ~5 cm)

**Inflation:** positive range change of 7 fringes (i.e. ~ 20 cm)

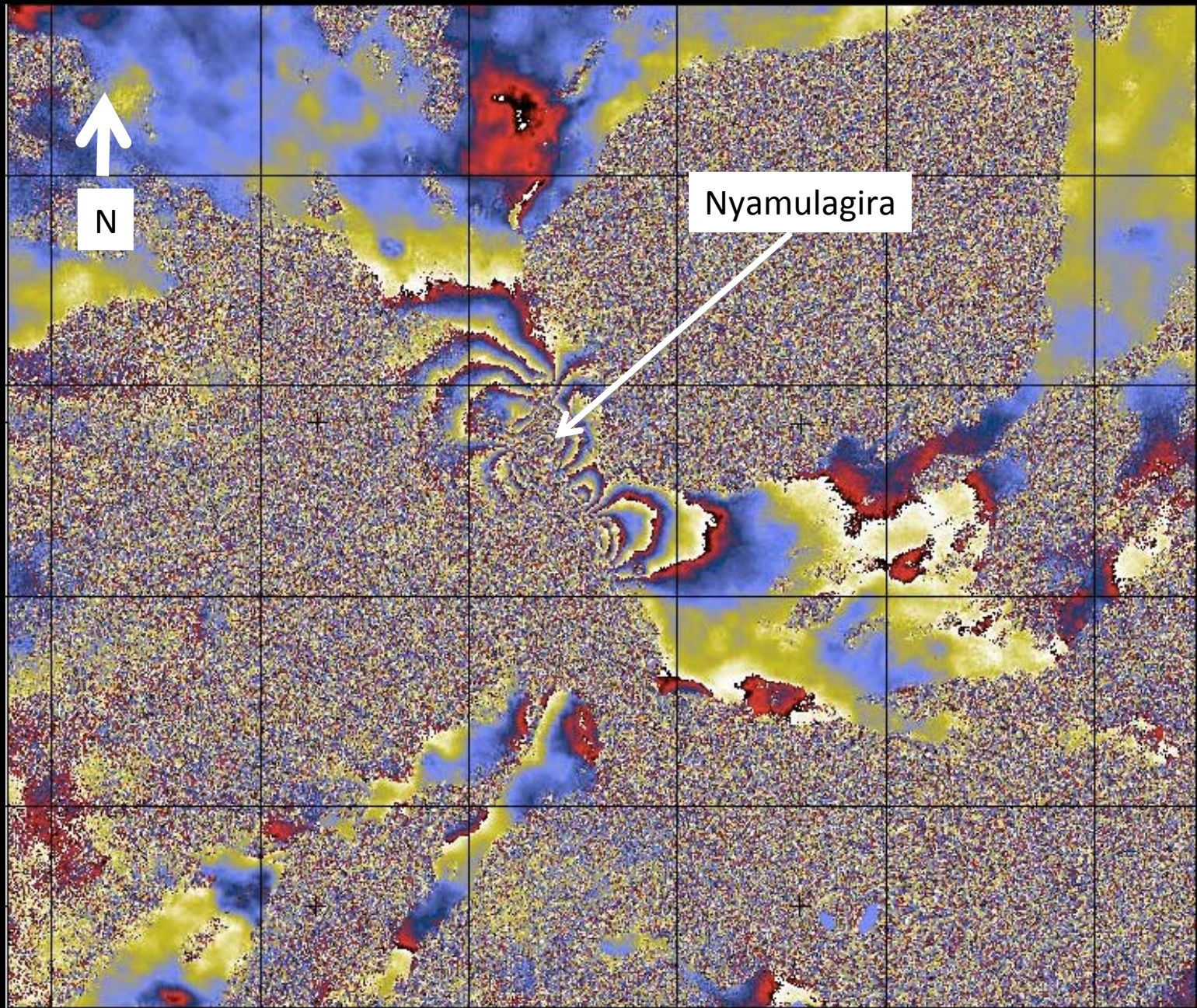
Deformation captured on only one « good » interferogram because :

- Artemis failure
- spatial or temporal baseline

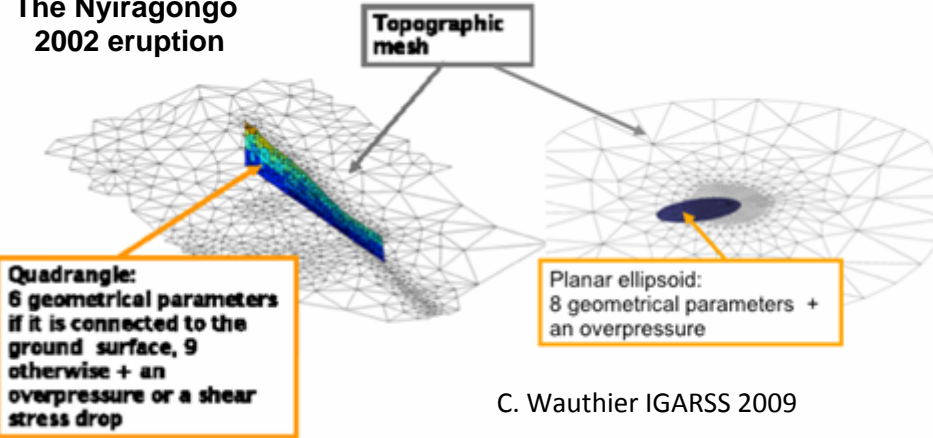


# Nyamulagira January 2010

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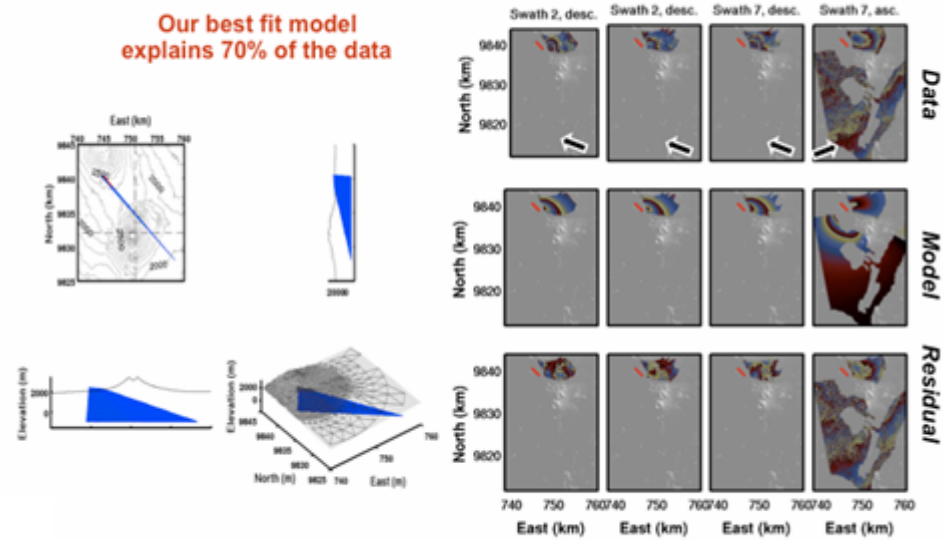


## The Nyiragongo 2002 eruption

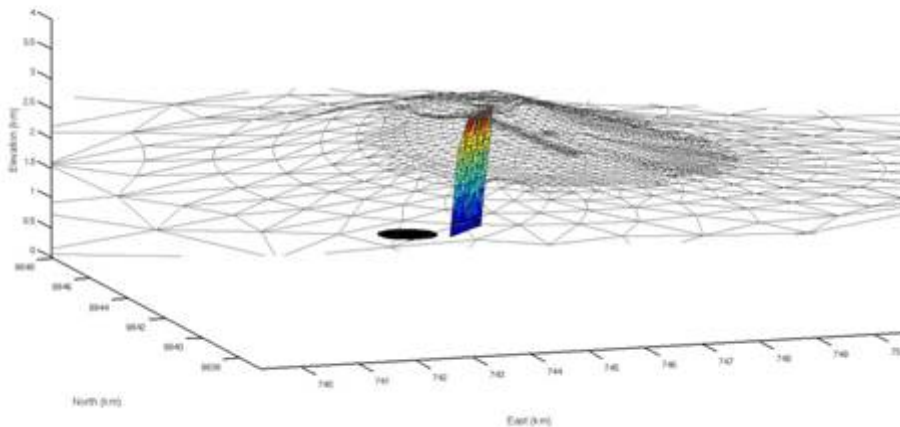


## The Nyamulagira 2006 eruption

Our best fit model explains 70% of the data



## The Nyamulagira 2010 eruption



- Dike along the Nyiragongo – Nyamulagira axis, below Nyiragongo !

# The web-based tool :

ESA InSAR Orbits Table

http://terra.ecgs.lu/insar/index.php?volcanoID=Lengai\_ENV\_desc\_9212&type=mix

ESA InSAR image processor

Available Volcanoes

Customize (Advanced)

ASC\_2670  
DESC\_1790

Flags (Advanced)

ASC\_188\_01  
ASC\_460\_02  
DESC\_2120

Slave (Advanced)

DESC\_2120

Master (Advanced)

DESC\_3210  
DESC\_616  
DESC\_9202

Hydrographical (Advanced)

ASC\_5147  
ASC\_4201  
DESC\_2216  
DESC\_3210  
DESC\_3210

Volcano-ID: Lengai\_ENV\_desc\_9212

Choose one of the following available image-types:

Phase Images Mixed Images Coherence Images

ESA-InSAR Mixed images for volcano Lengai\_ENV\_desc\_9212

Version 0.9.2, date 2008-07-10

Mixed Images for volcano Lengai\_ENV\_desc\_9212 at a glance

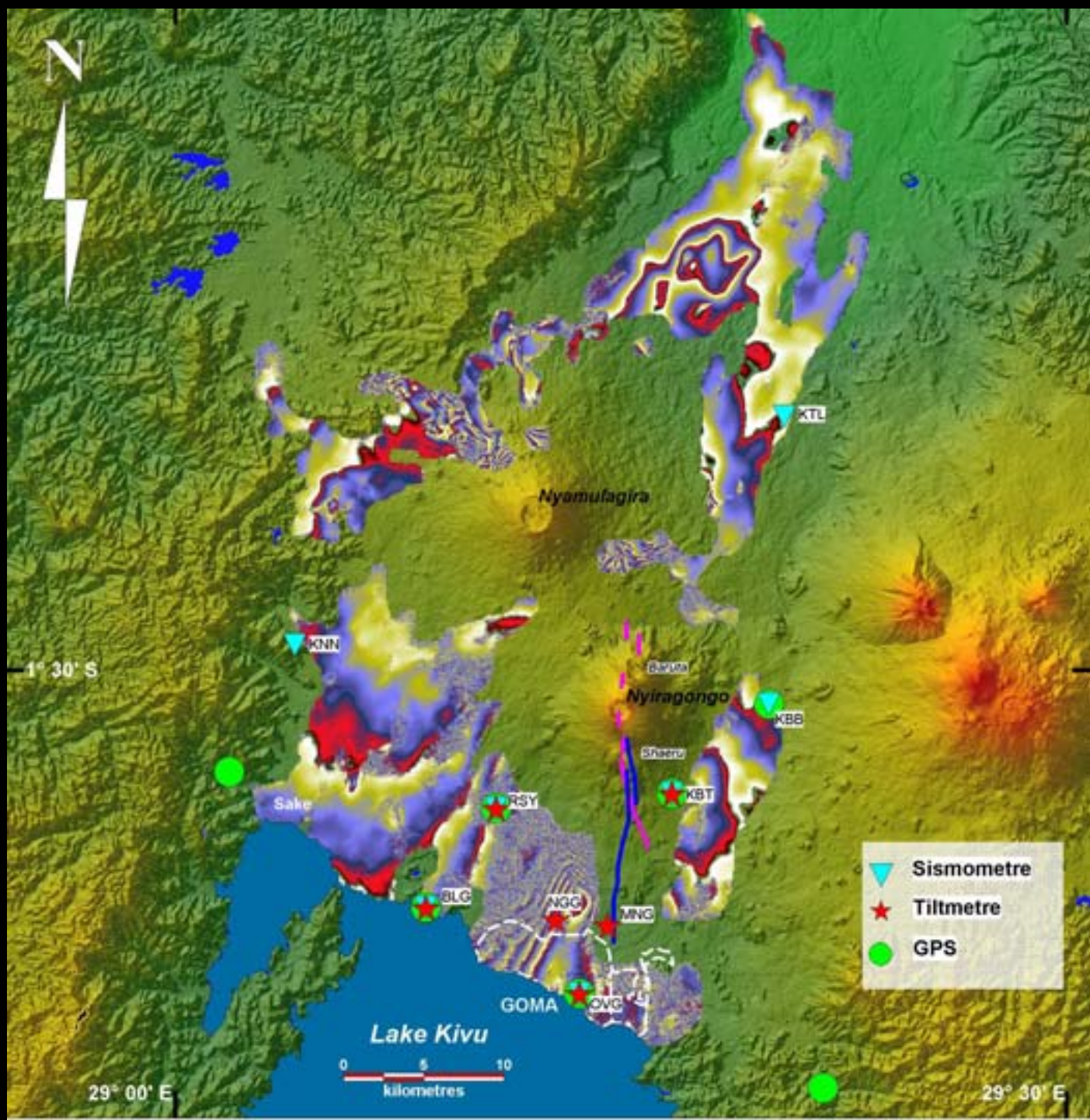
Date/Orb. Nr of master

Date/Orb. Nr of slave

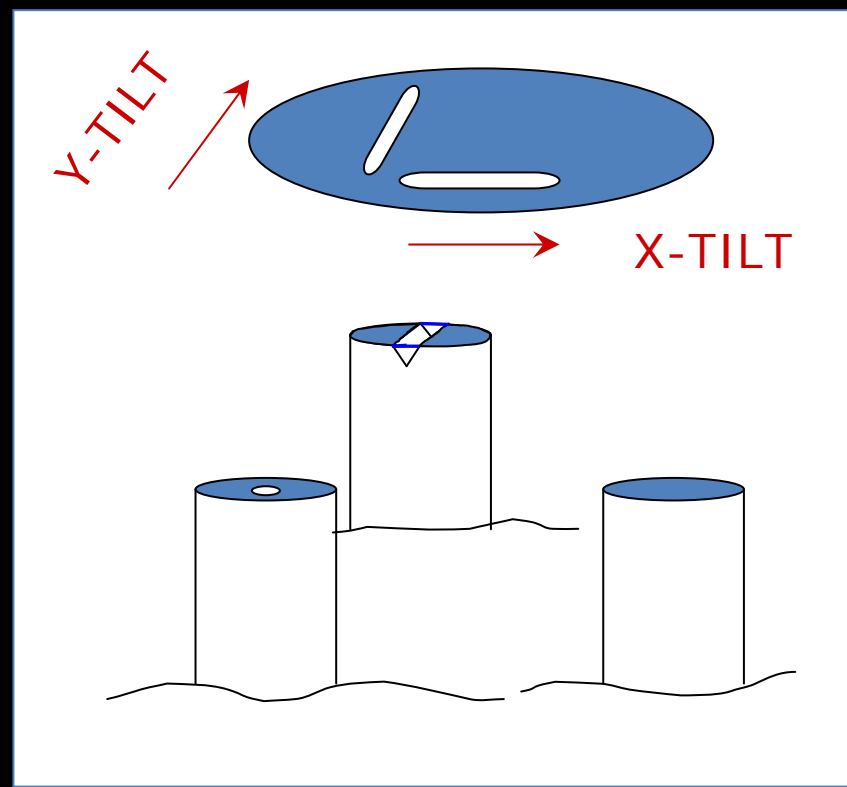
	27-OCT-2003 9853	01-DEC-2003 9794	19-APR-2004 11188	31-OCT-2005 19184	13-FEB-2006 20087	25-MAR-2006 21188	28-MAY-2006 22190	03-JUL-2006 22681	07-AUG-2006 23192	25-DEC-2006 25196	29-JAN-2007 26697	08-MAR-2007 26198	23-JUL-2007 28202	27-AUG-2007 28703	01-OCT-2007 29204	16-NOV-2007 29705	10-DEC-2007 30206	14-JAN-2008 30707	19-FEB-2008 31208	26-APR-2008 32210	02-JUN-2008 32711	07-JUL-2008 33212	11-AUG-2008 33713	19-SEP-2008 34214	23-OCT-2008 34715	28-DEC-2008 35217		
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19-APR-2004 11188		■																										
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13-FEB-2006 20087				■																								
25-MAR-2006 21188					■																							
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01-OCT-2007 29204														■														
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07-JUL-2008 33212																					■							
11-AUG-2008 33713																						■						
19-SEP-2008 34214																							■					
23-OCT-2008																								■				

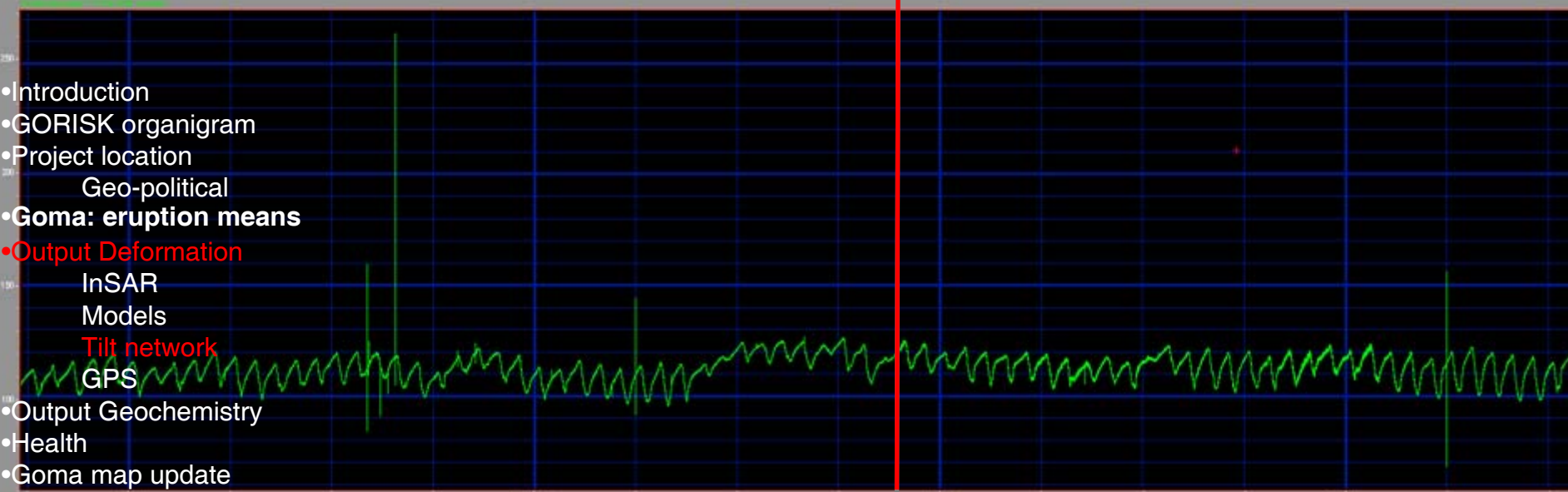
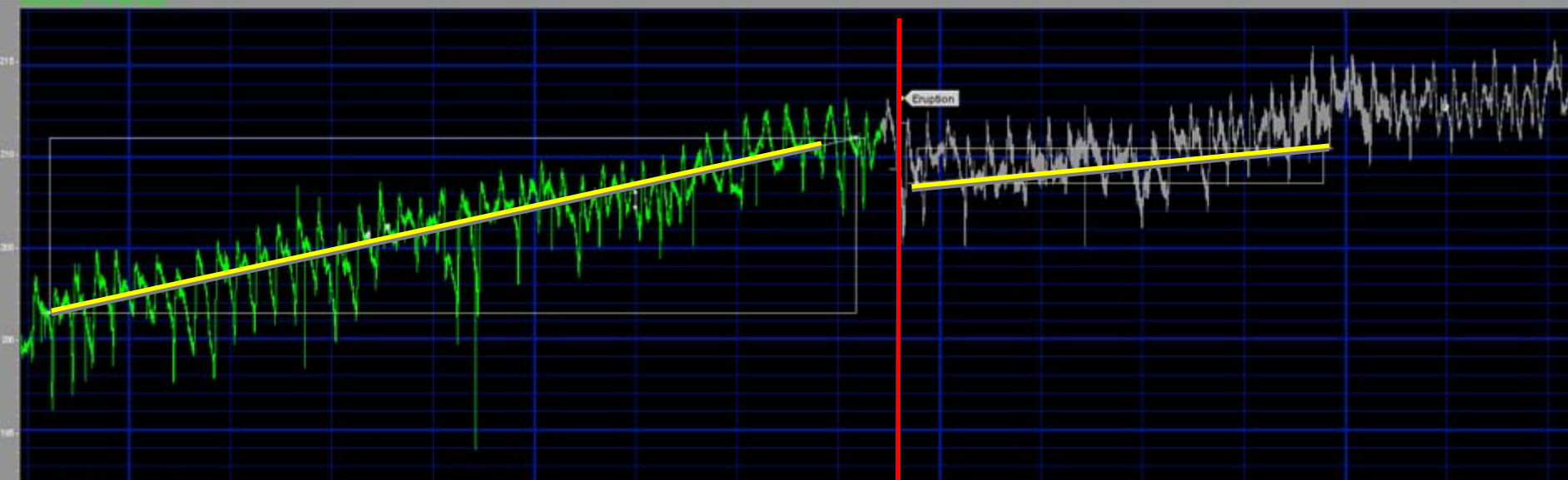
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**6 stations**  
**Regular download**  
**FTP**



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25-11-08

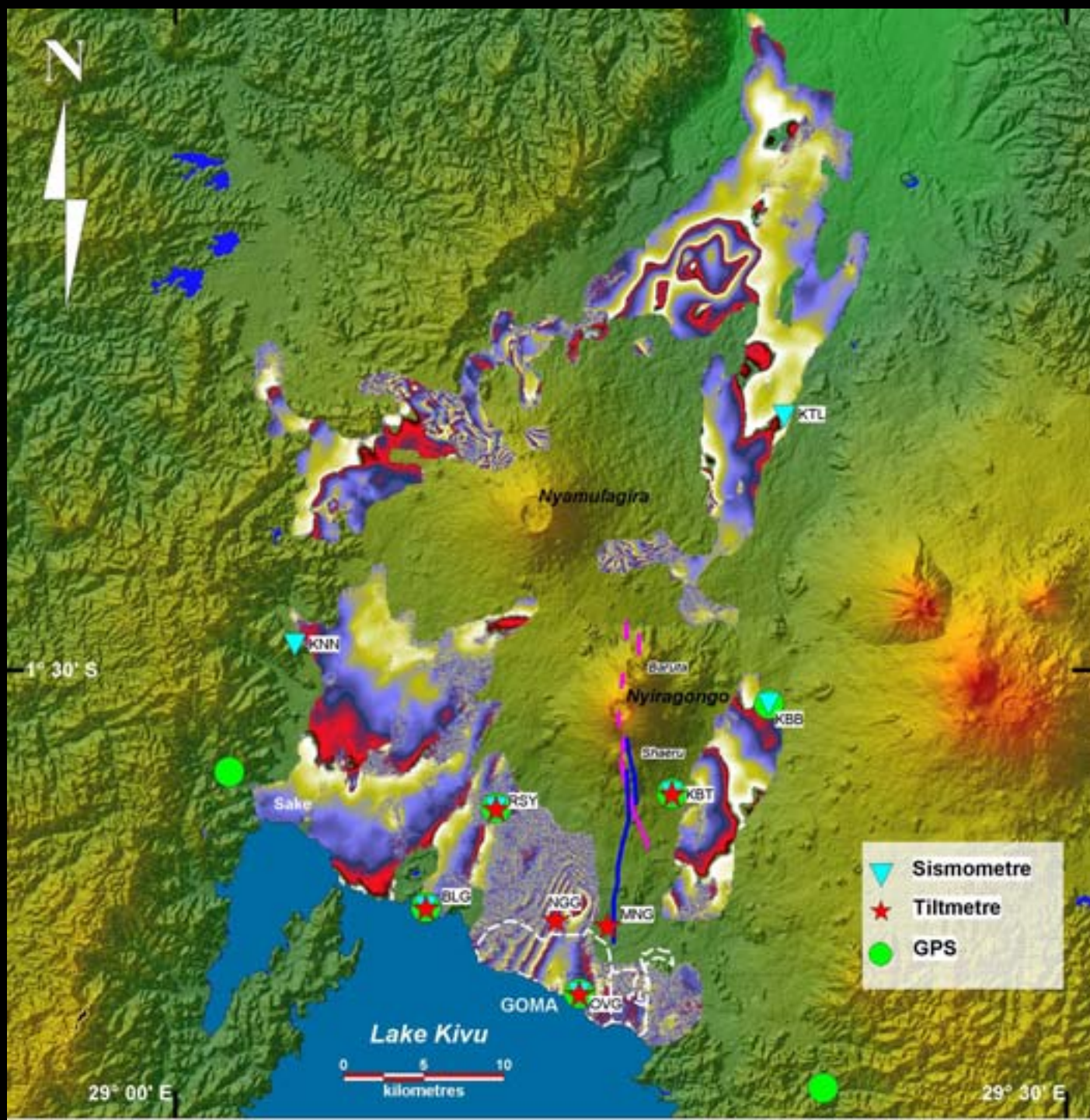
15-12-08

04-05-08

24-01-09

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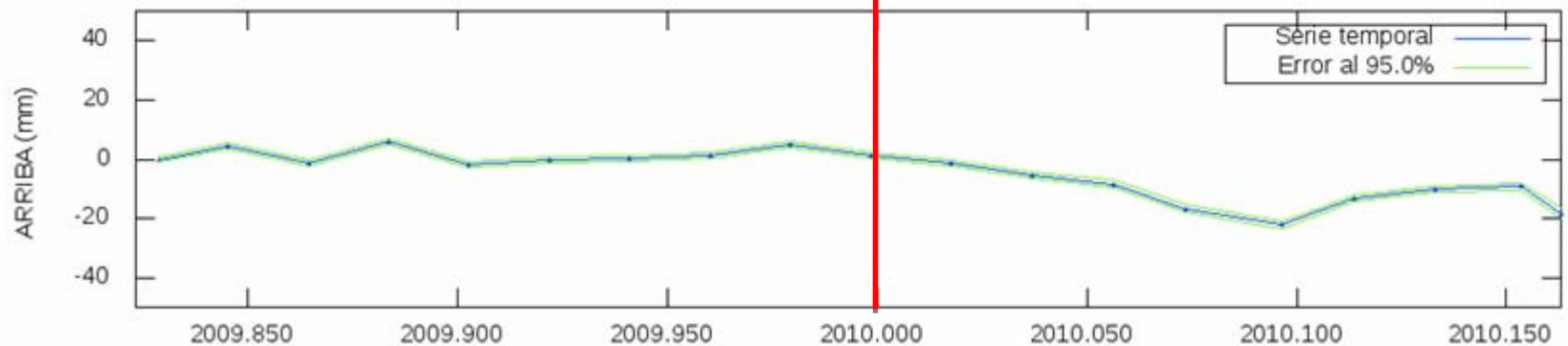
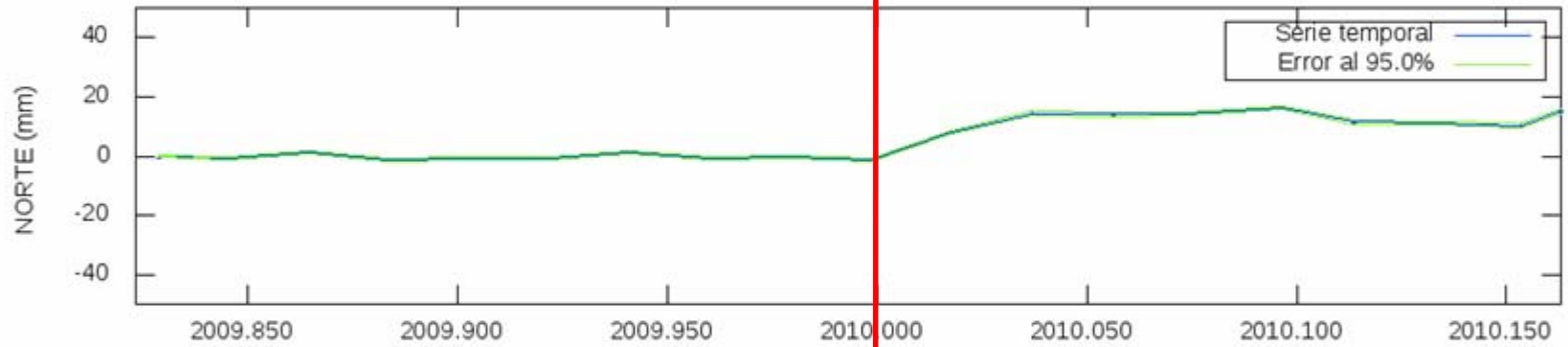
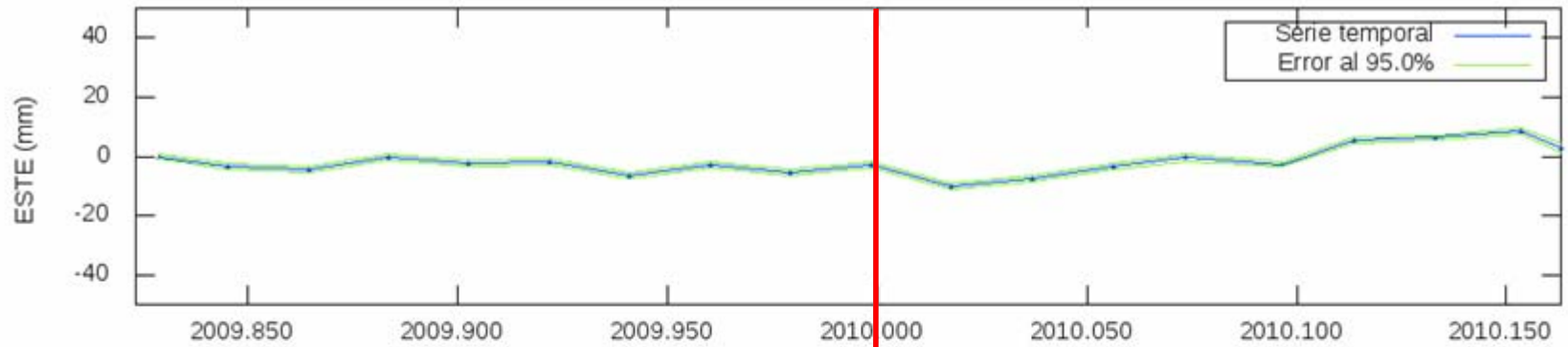
**7 stations  
Telemetred  
FTP**





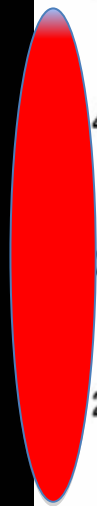


RSY

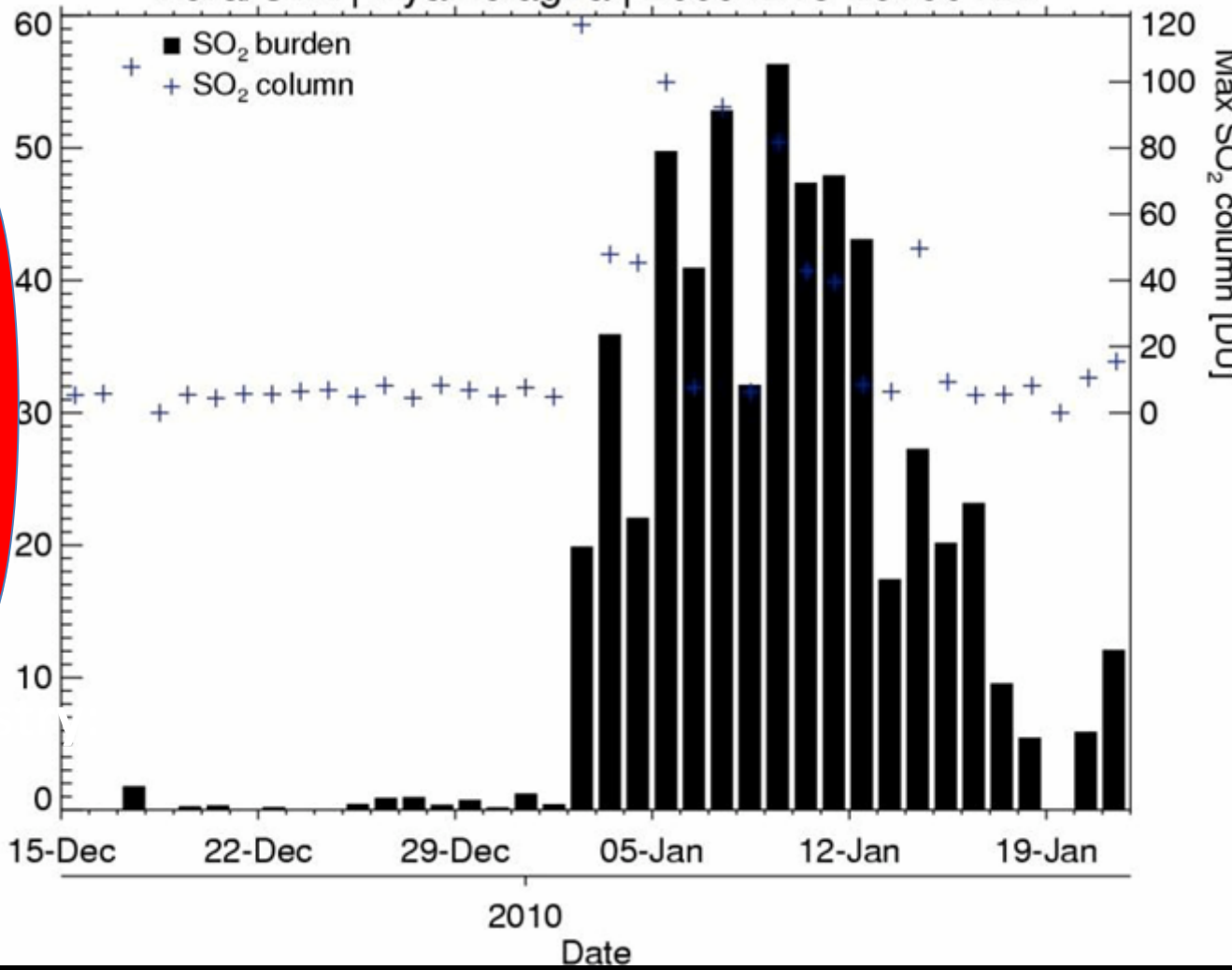


TIEMPO (años)

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- Plume**
- Water
- Gas - Mazukus
- Gas - perm. meas.
- Health
- Goma map update
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Aura/OMI | Nyamulagira | 20091215-20100121



**Geochem**

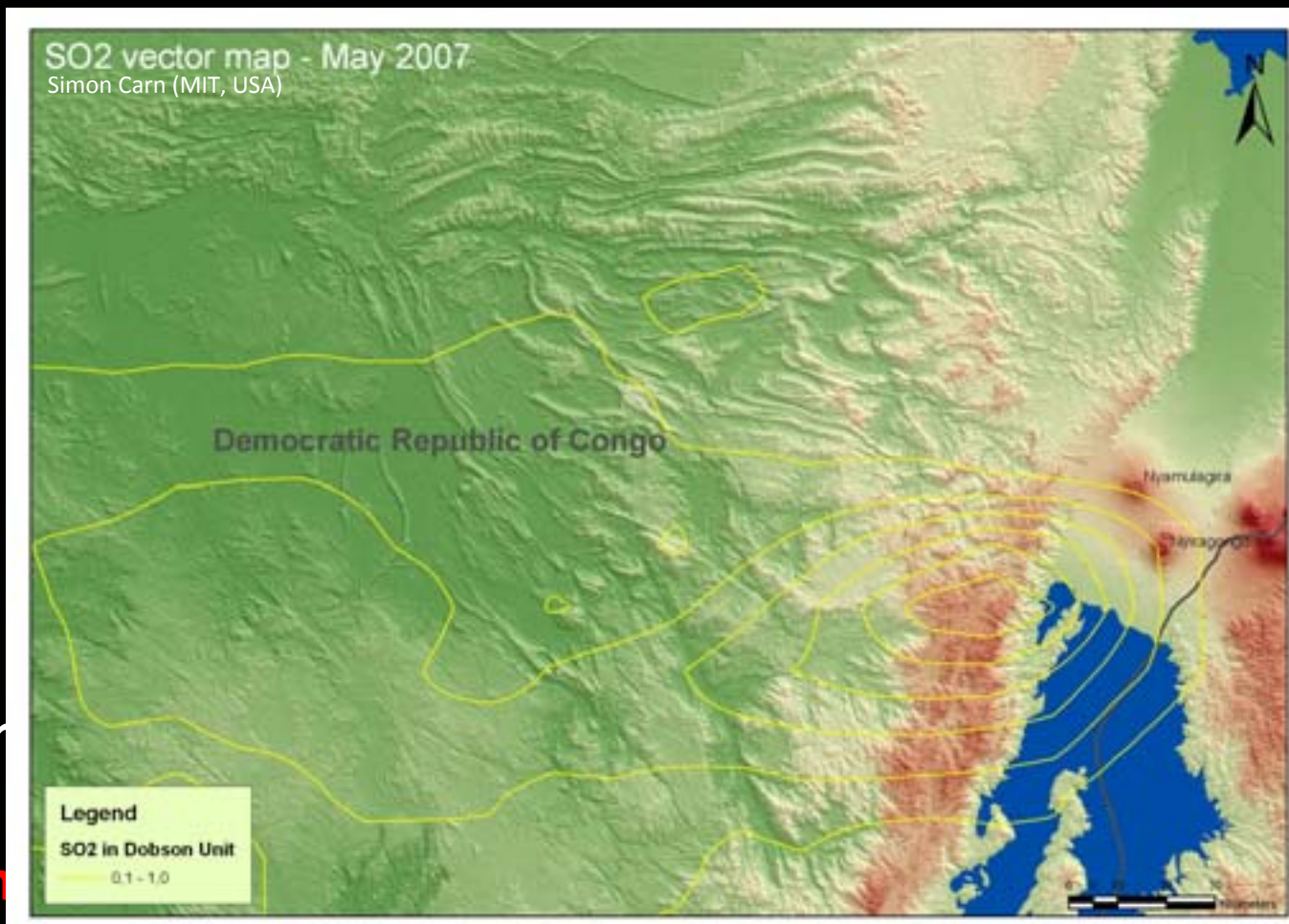
**Plume**

**Water**

**Gas - Mazukus**

**Gas - permanent measurements**

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**Geochem**

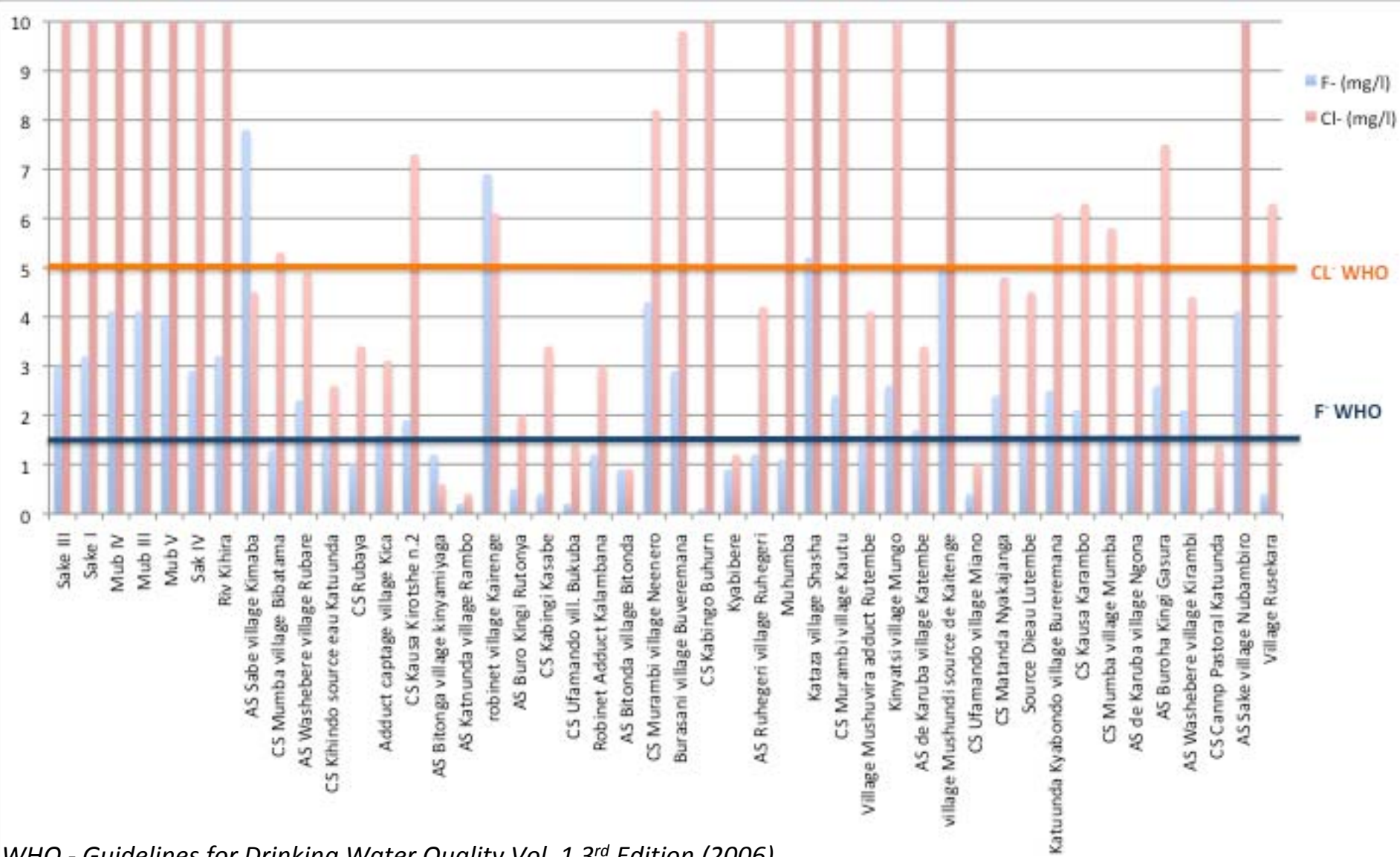
**Plum**  
**Water**

**Gas - Mazukus**

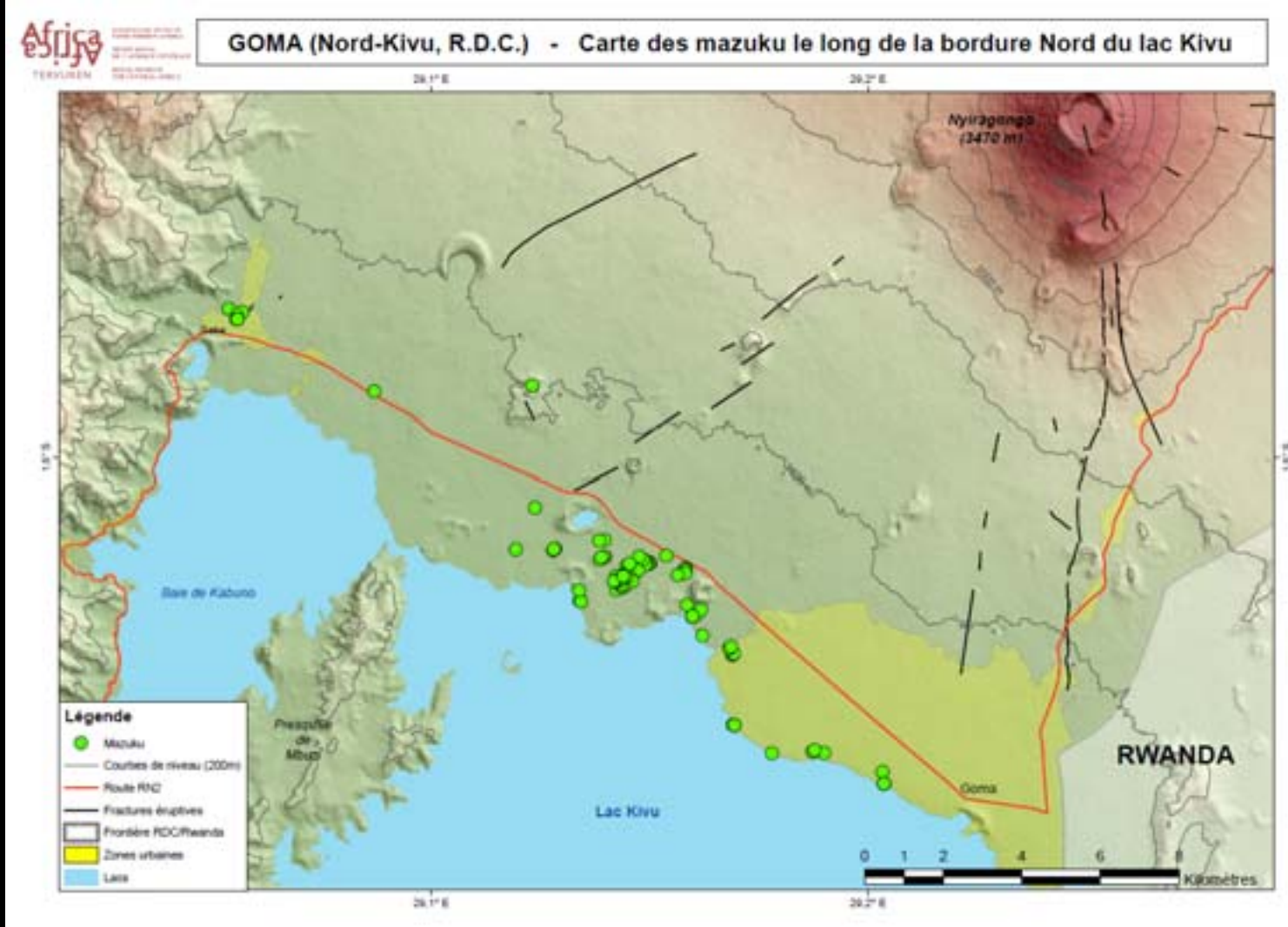
**Gas - permanent measurements**

# Output Geochemistry

Plume  
**Water**  
 Gas - Mazukus  
 Gas - perm. Meas.



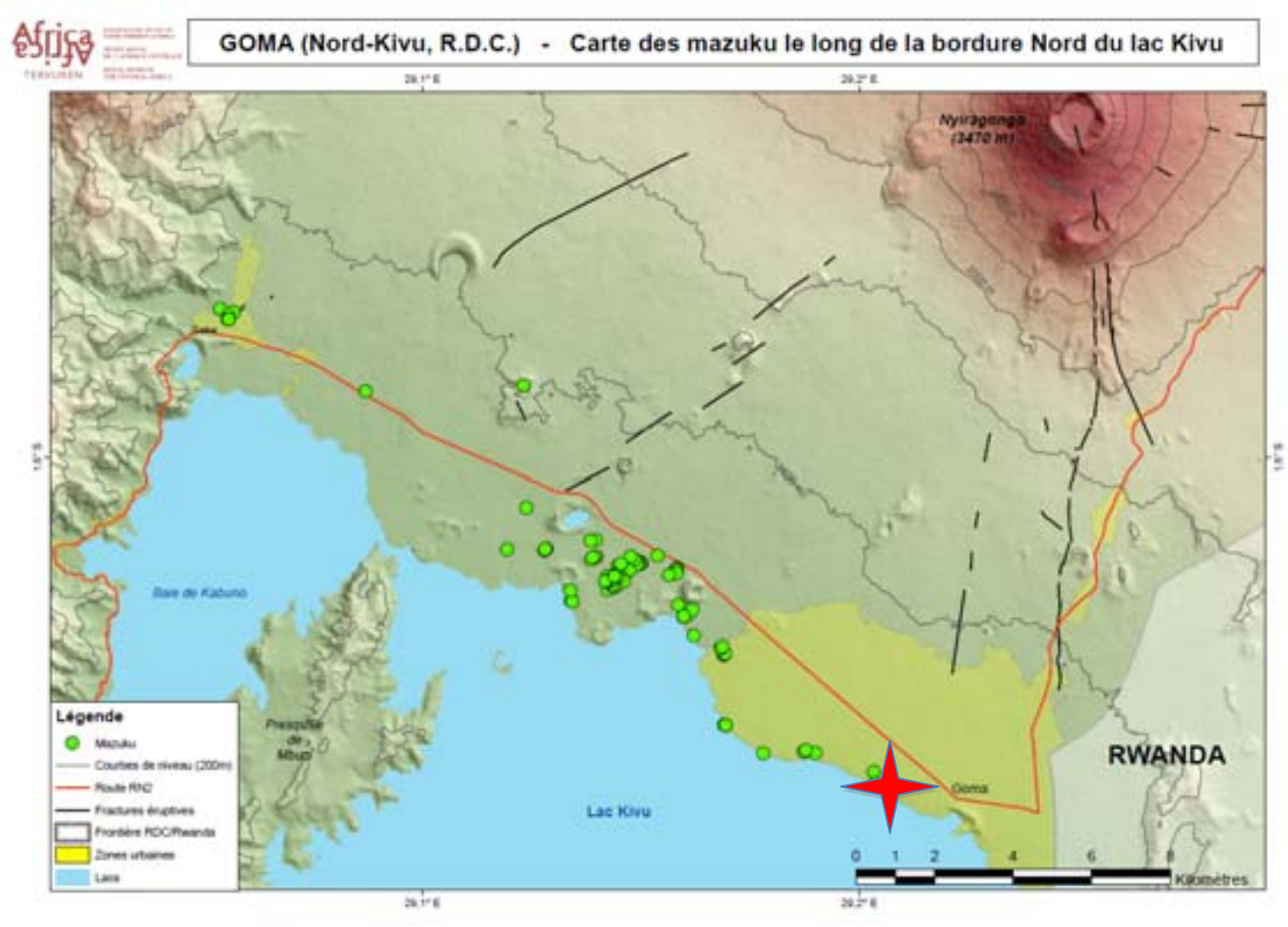
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**Geochemistry:**

- Plume
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- Gas - Mazukus**
- Gas - permanent measurements

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**Geochemistry:**

- Plume
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- Gas - permanent measurements**

# CO<sub>2</sub> – Rn continuous measuring station in “Le Chalet”

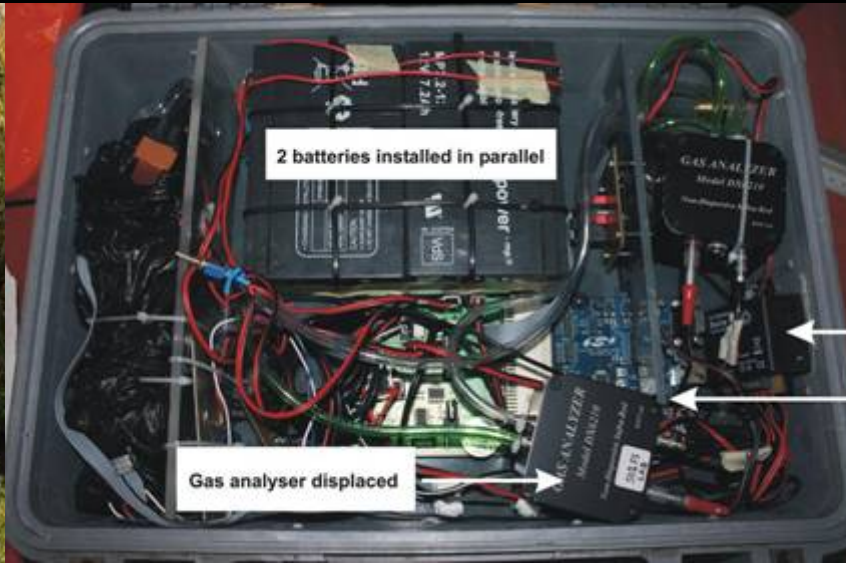
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**Output Geochemistry**

Plume  
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**Gas - perm. meas.**

Health  
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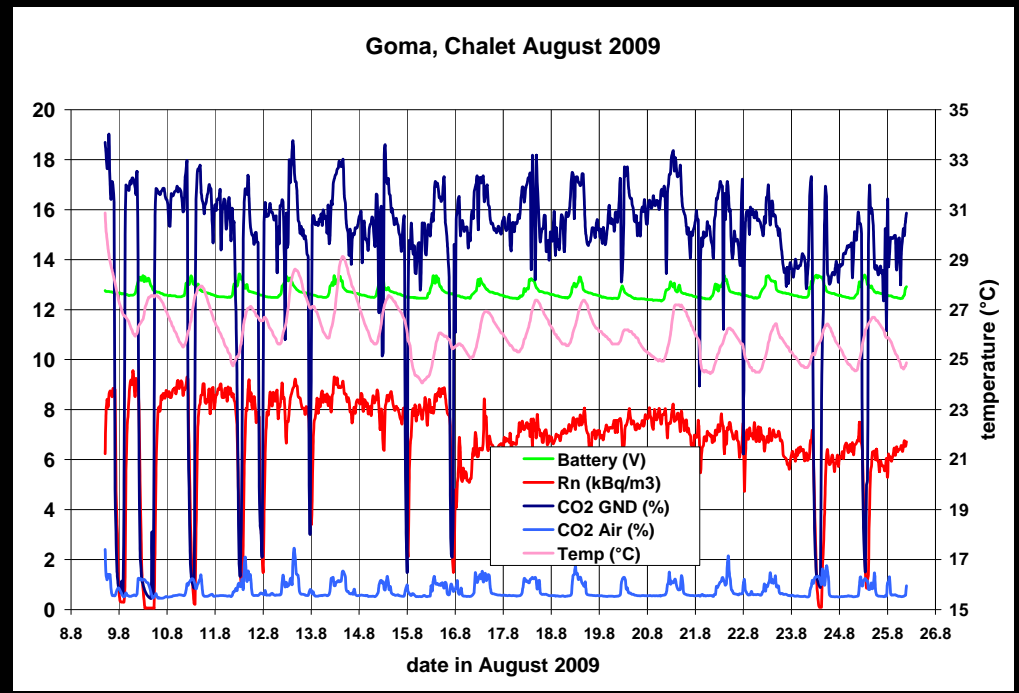


Photos by B. Smets



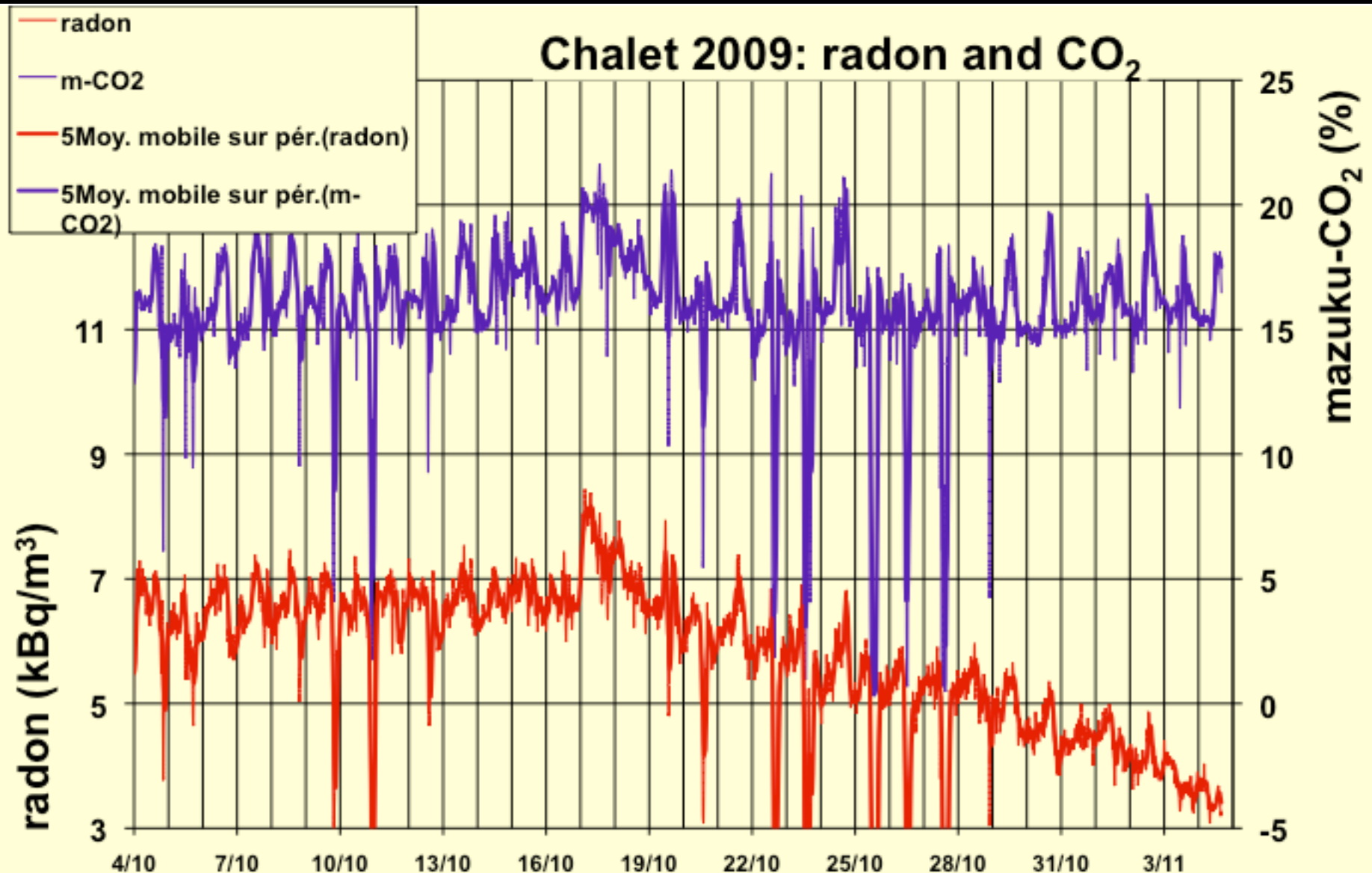
New tension regulator  
 ajusted to 12V

Narrow wall to install the gas  
 analyser in its new place



# Output Geochemistry

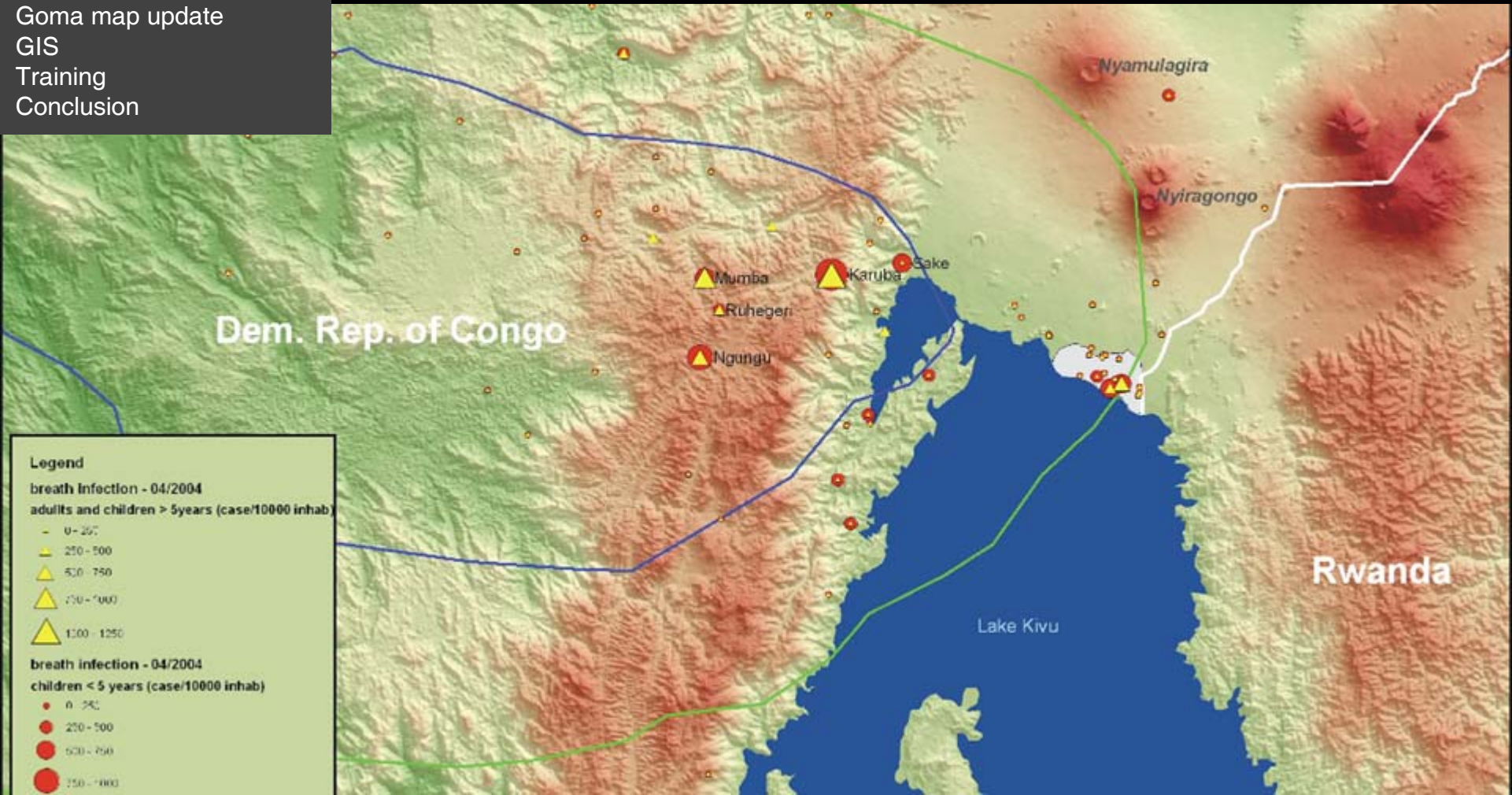
- Plume
- Water
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**Health**  
Goma map update  
GIS  
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	Site ▼	Site_Code	Longitude	Latitude	Altitude
19	Muja	OVG020	29.2	-1.7	0
20	Munigi 1	OVG021	29.24588	-1.63744	0
21	Munigi 2	OVG022	29.2426	-1.64276	0
22	Ngangi	OVG023	29.2133	-1.63937	0
23	Nyiragongo	OVG024	29.25135	-1.528017	3411
24	OVG	OVG025	29.2267	-1.6812	0

T° moy					
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T°C fracture immediate	ThCouple/Hg	CO2 % vol. dans frac	Vent N=nul Fa=faible M=moyen F=fort	Météo S=soleil P=pluie Nu=nuage	Moyenne mesures
------------------------	-------------	----------------------	-------------------------------------	---------------------------------	-----------------

Site	Date	Heure	T°	%Humid.	Force Vent	Dir
------	------	-------	----	---------	------------	-----

<b>Défo / Tilt</b>						
Site	Charge batterie	Température extérieure	Température instrument	Tilt X et Tilt Y		

<b>Défo / GPS</b>						
Site	Date	Heure	Ligne de base	DX	DY	

<b>Géoch / CO2</b>			
Site	Date	%CO2	PA (pression atm.)

<b>Géoch / SO2</b>		
Site	Date	flux

<b>Géoch / Eau</b>						
Date	Lieu de récolte	Date d'analyse	App. Utilisé	pH	Conduct.	T

<b>Géoch / CO2-Rn</b>				
Site	Date	Heure	%CO2	%Rn

<b>Géoch / SO2-DOAS</b>						
Site	Downloaded	Pre-evaluated	Archived	Post evaluated	Flux	Co

<b>Sismo</b>						
Date	Heure	Type	Latitude	Longitude	Profondeur	M

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# Dissemination

- Peer reviewed paper (submitted/accepted): 5
- Proceedings: 20
- Presentation at meetings and congresses: 26
  
- WWW links:
  - GORISK
    - [www.africamuseum.be](http://www.africamuseum.be)
    - [www.ecgs.lu](http://www.ecgs.lu)
  - Eruption January 2010
    - <http://terra.ecgs.lu/rnvt>

# Conclusions

GORISK main objectives have been achieved

- Deformation monitoring:
  - New methods have been developed and adapted to that very specific context
  - Remote sensing techniques are essentials
  - Validation through the last January eruption
- Geochemical monitoring:
  - First continuous gas monitoring in the area: promising
  - Gas – Mazuku mapping revealed wide concerned areas
  - Water sampling confirmed high content of critical elements
- Health:
  - Preliminary results are requiring more systematic monitoring

# Conclusions

## → Risk assessment

has been highly improved, new geodynamic models

## → Risk Management

has been provided high valuable informations and products

## → Health impact

has been assessed

→ Project was **achieved in very adverse conditions** (political, institutionnal, security

→ The volcanic **risk remains** and continuous efforts are required

→ Future **eruptions will occur** and the 2002 scenario could have been **worse**



A photograph of a volcanic eruption. A large, billowing plume of orange and yellow smoke or ash rises from a rocky crater. The foreground shows the dark, jagged edges of the crater rim. The background is dark, making the bright colors of the smoke stand out.

**Thank you**