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APPLICATIONS**

Radar remote sensing for detecting human activity in desert areas

Studying Migrations Routes: New data and Tools
Rome, June 16th , 2016

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- High resolution Earth Observing satellite mission play a big role in monitoring humanitarian crises and consequences on human life.

- Besides of the continuously increasing/ed spatial resolution the main objective of new mission is to guarantee persistency of monitoring along time

Persistent = very frequent and long lasting

Nigeria – Cameroon border Optical images for monitoring changes

Courtesy: urthecast deimosimaging

destroyed/burned buildings
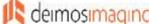
Very accurate damage assessment can be done starting from EO VHR data pairs (long term CD); changed targets can be mapped and identified.
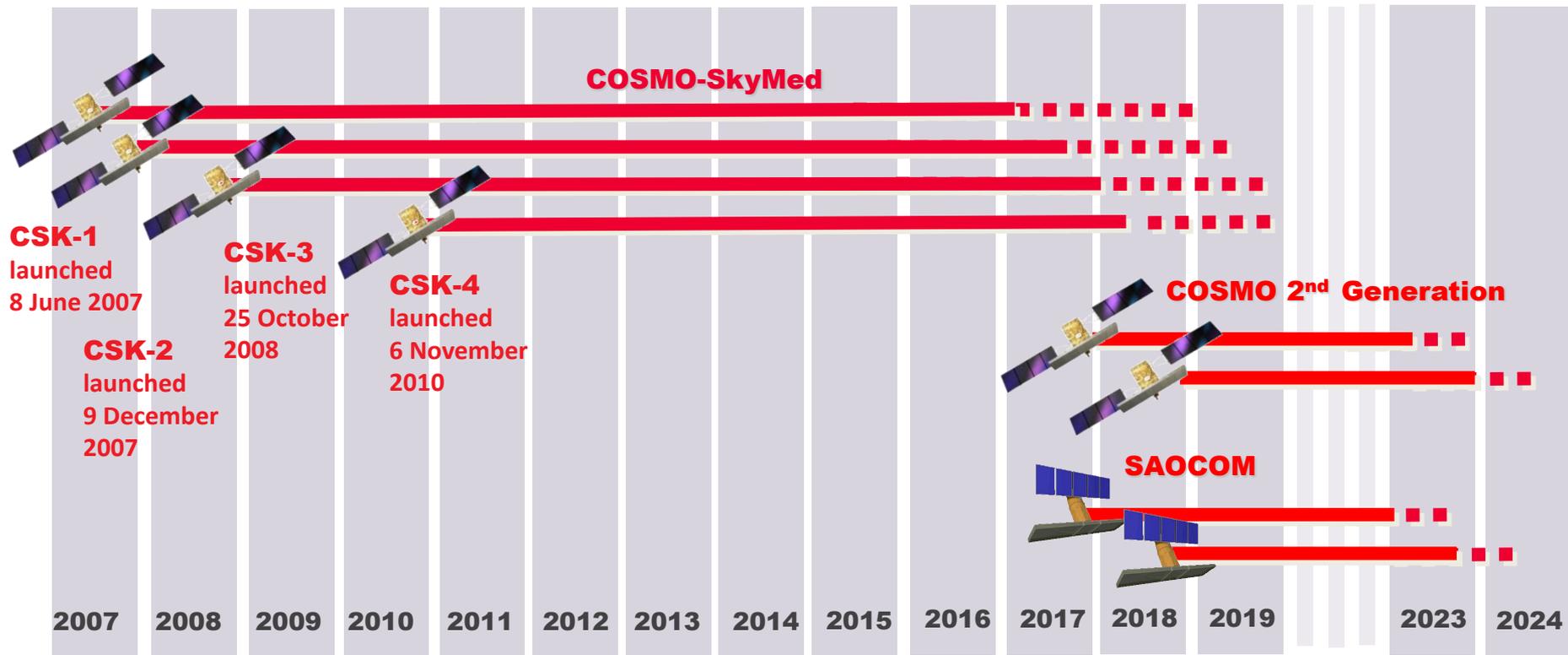
Full HD movie from ISS

Click in the image to activate the movie!

Courtesy: urthecast deimosimaging

New satellite sensor technologies can provide further support to activity analysis monitored from remote. This example portrays a full HD movie taken from the ISS (International Space station) and documenting even faint activities such as people walking or vehicles in motion

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Advanced solutions

- Constellations:
  - "swarms" of small satellites
  - Unique multi-sensor platform
  - Automated data analysis and signal extraction (even onboard)

- Advanced Sensors > Imaging Radar:
  - Cloud penetrating
  - Independent on lighting conditions
  - Ideal to detect "human artefacts"
  - Accurate and automated co-registration and geo-referencing
  - Coherent detection (Radar)

- Constellation of Imaging Radar > COSMO-SkyMed

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COSMO-SkyMed: a long living operational system

COSMO-SkyMed

CSK-1
launched
8 June 2007

CSK-2
launched
9 December
2007

CSK-3
launched
25 October
2008

CSK-4
launched
6 November
2010

COSMO 2nd Generation

SAOCOM

| 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2023 | 2024 |

- COSMO-SkyMed constellation is fully deployed and operational
- CSG satellites will replace the CSK satellites that reached the end of life
- With the launch of the first CSG satellite planned in 2017 and the second one year later, CSG will provide operational continuity at least until 2023
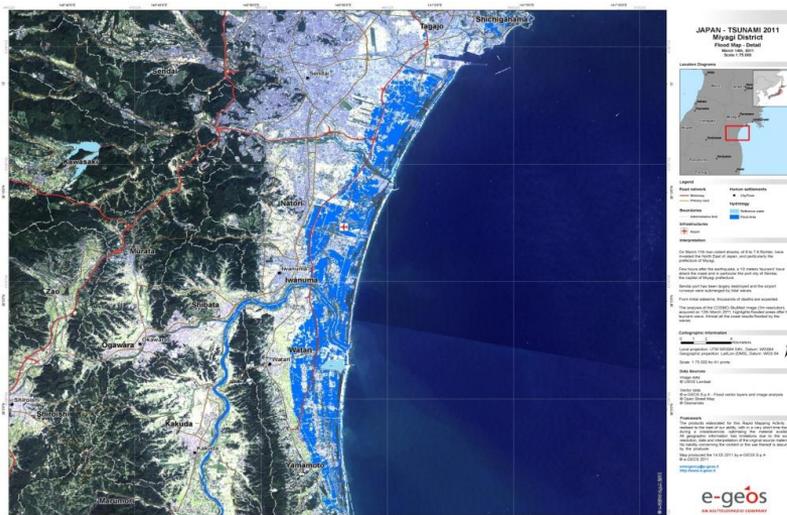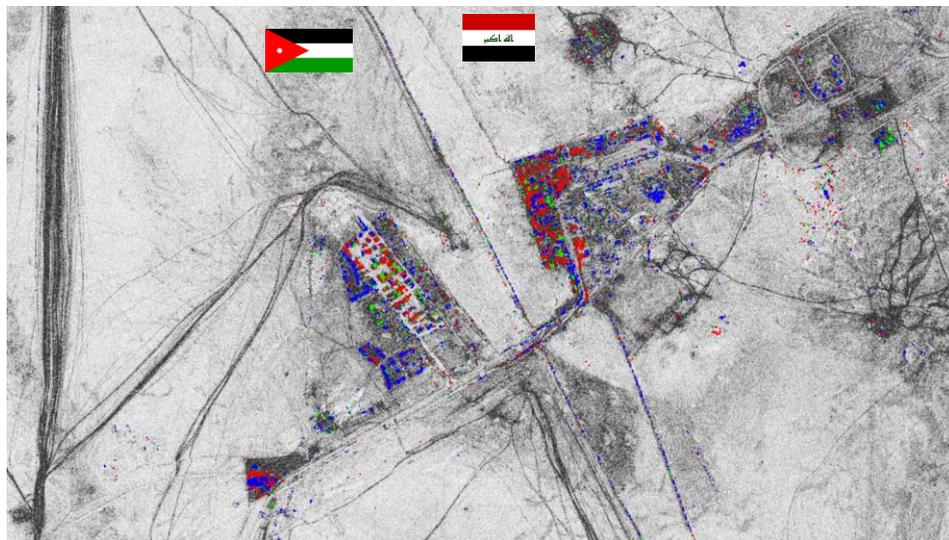
- COSMO-SkyMed constellation is designed to image any place on the earth several times per day

- > = 4 images per day can be collected by the constellation over a designated area

- Being the satellites on a sun-synchronous orbit data collection can occur in two time windows 12 hours apart, each day.

- In addition the constellation provides a very fast system response as illustrated in the figures: most of the north eastern coast of Japan was covered within 24 hours after the tsunami strike (upper image)

- These performances make COSMO-SkyMed the ideal tool to manage emergency situation and and any application requiring frequent monitoring (the example shows monitoring activity at a checkpoint between Iraq and Jordan)

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COSMO change detection
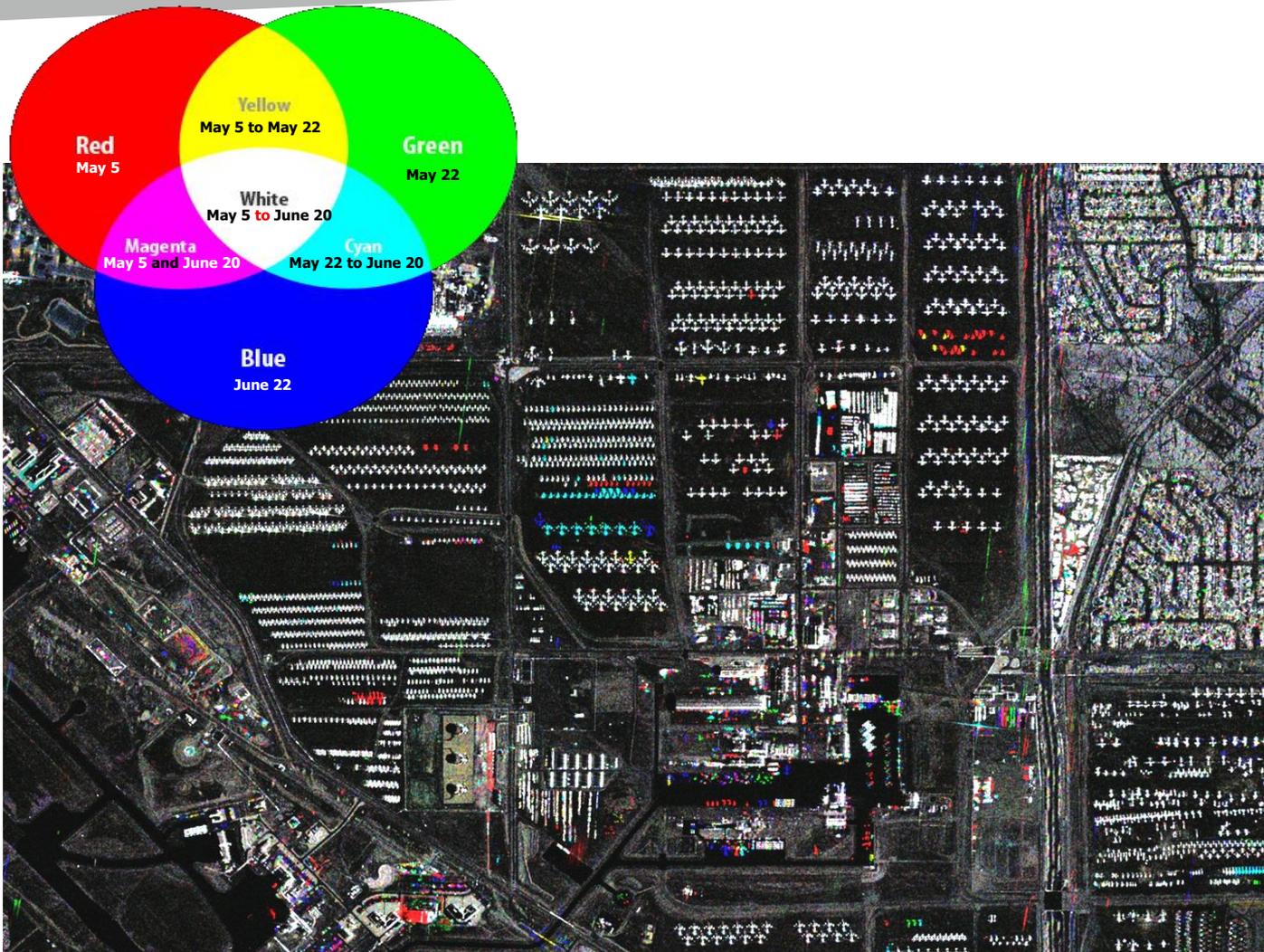

- SAR data provide perfect image matching without control points

- This allows to generate perfect change detection images

- Over a long time span these images provide information about the evolution of a target area
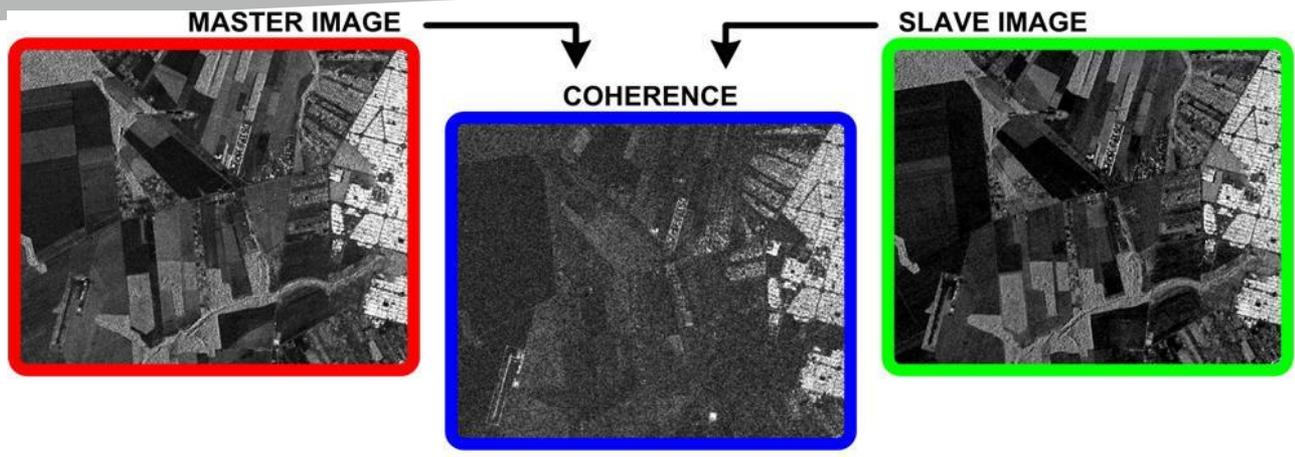
When the time interval is very short (a day or few days) change detection images provide information about activity

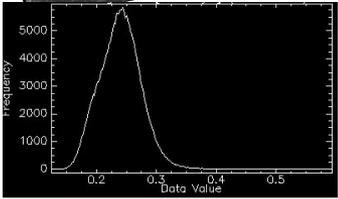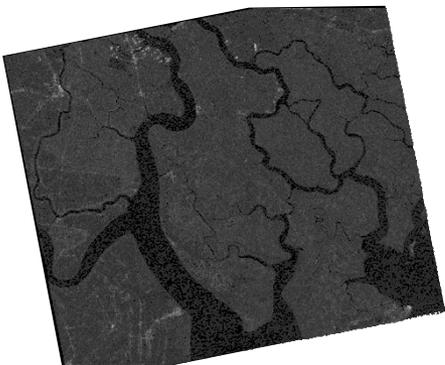## Color key

- 🟥 20110629
- 🟩 20110630
- 🟦 20110703
- 🟨 20110629 - 20110630
- 🟪 20110629 - 20110703
- 🟦 20110630 - 20110703
- ⬜ All dates
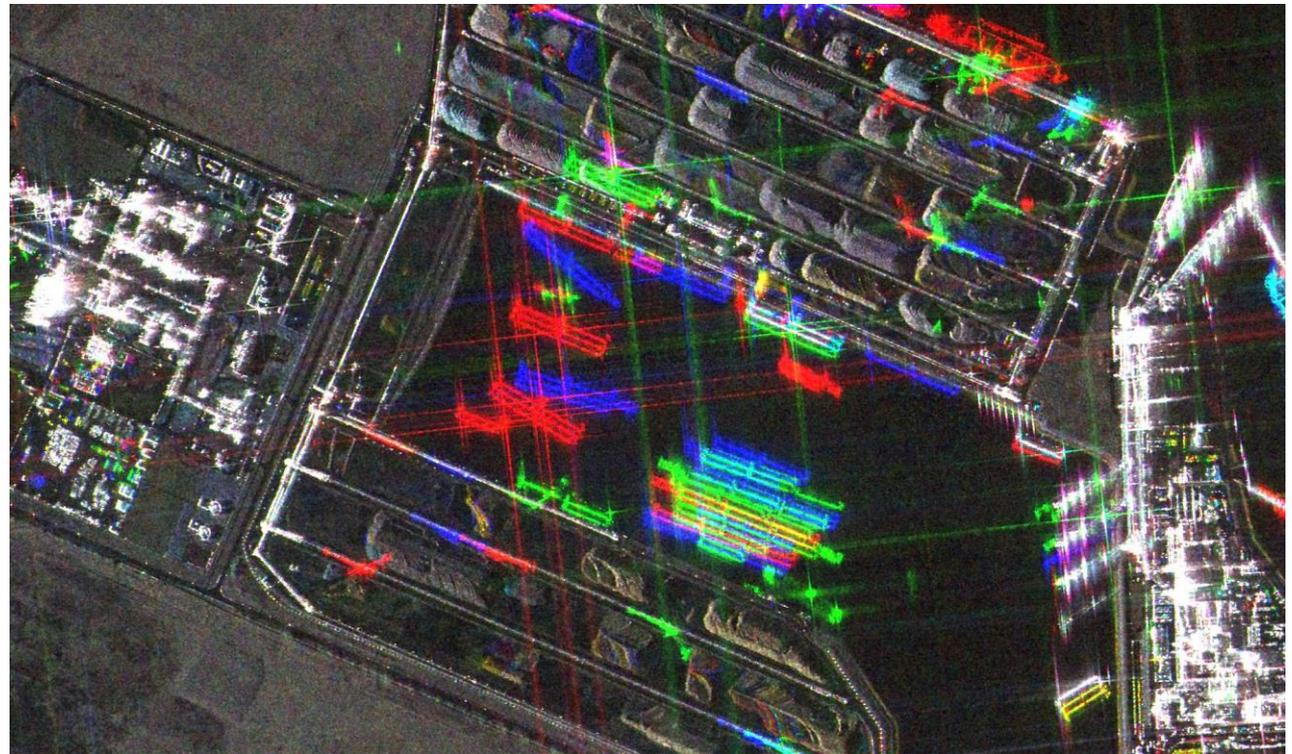
Definition and use of coherence
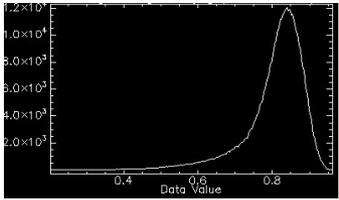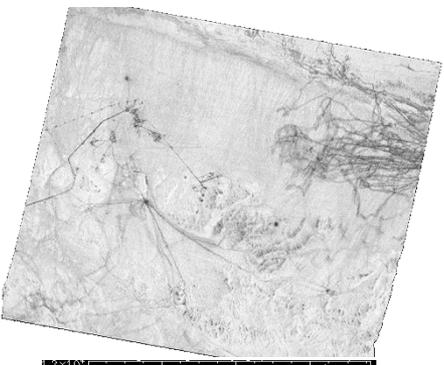

MASTER IMAGE → COHERENCE ← SLAVE IMAGE

Coherence map; 8 days, Mekong delta, Vietnam

Mean value 0.24; Max value 0.59

Coherence map; 8 days, Qom, Iran

Mean value 0.81; Max value 0.96

The coherence value - which ranges between 0 and 1, is influenced by the following factors:

- Systemic spatial de-correlation (baseline between orbits)
- Additive noise
- Temporal de-correlation between the two scenes
- Atmospheric effects
- **Human activity**

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Coherence:Disturbed terrain (tracks & more)

- Any disturbance on a flat and coherent terrain (i.e. without vegetation)

- Coherence temporary low values are related to human activity occurring in the time interval between two images

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Coherence analysis during coalition bombing

This map shows the areas stricken by bombing over the city of 'Ain el Arab space, in three subsequent time intervals

Multi coherence from CSK

🟥	2014, Oct 15-19
🟩	2014, Oct 19-23
🟦	2014, Oct 23 - Nov 08

Coherence is a product derived from two COSMO-SkyMed data collected in different times. Low values of coherence indicate areas/targets affected by changes (with respect to surrounding stable areas)

Kobane: WorldView-2, October 14

Border crossing #2 is very active during this week, many vehicles arrive, go away or change their position

CD (target) from CSK

● 2014, Oct 15

● 2014, Oct 19

● 2014, Oct 23
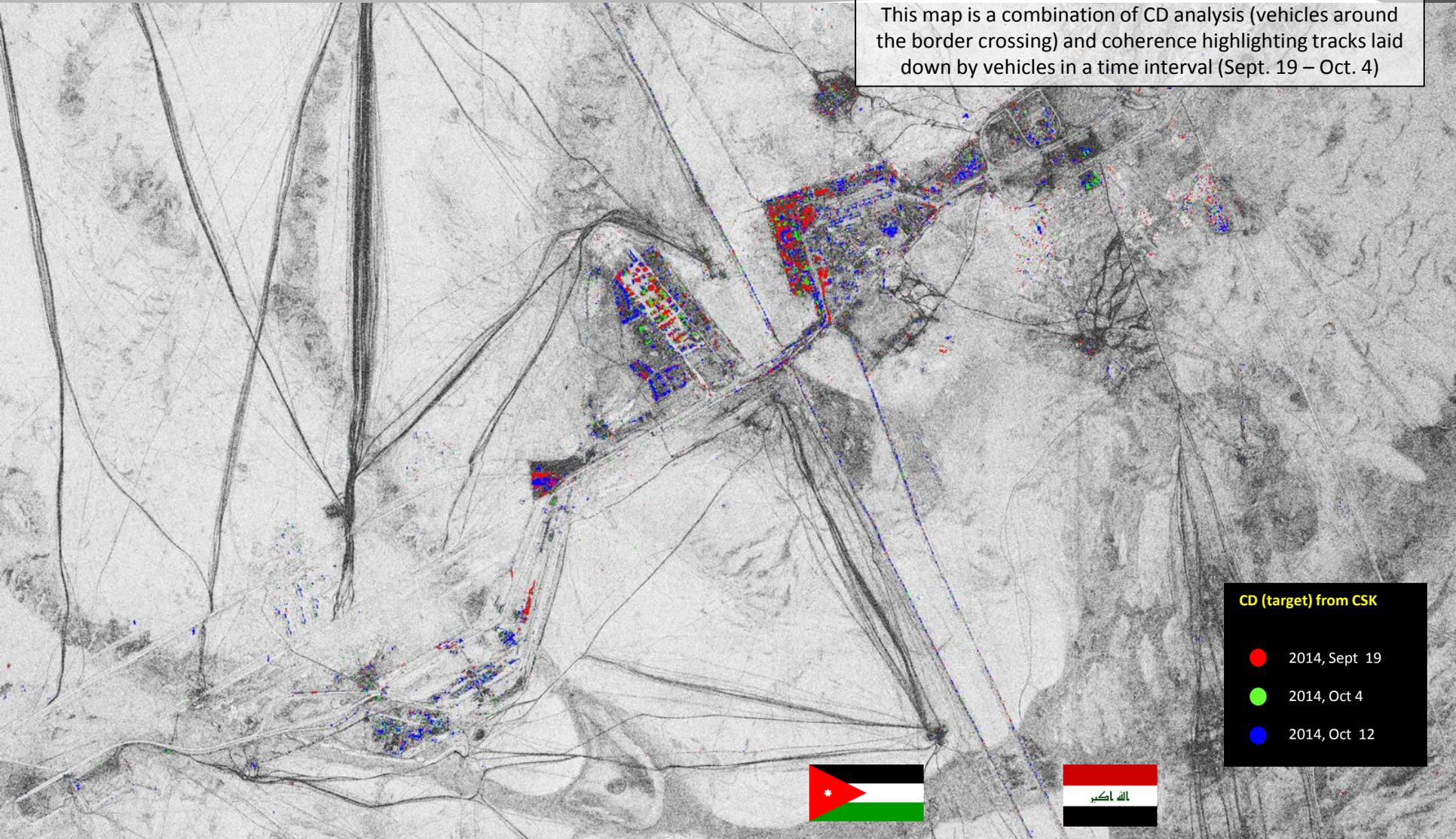
Border crossing (tracks with coherence)
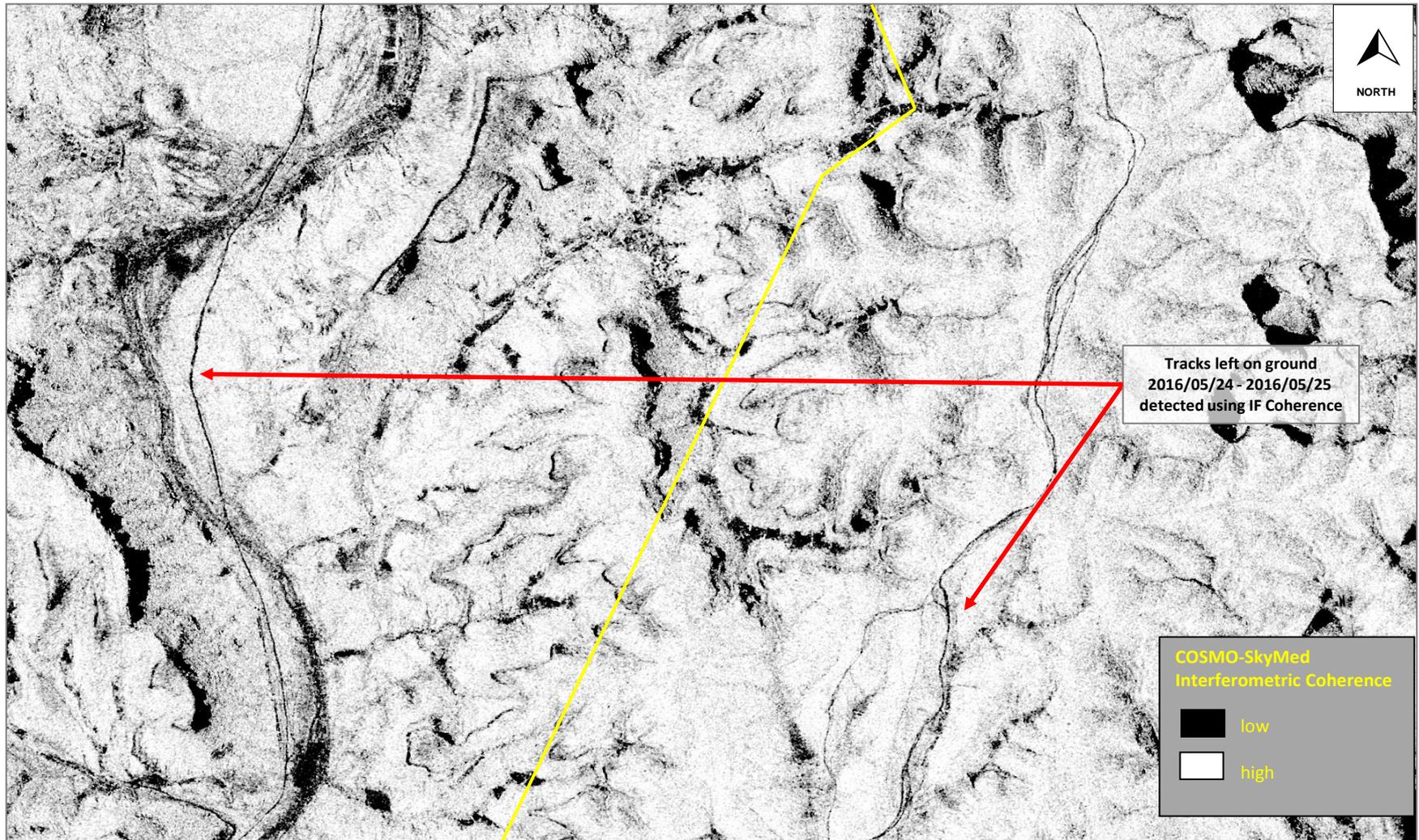

Coherence October 15 – 19

This map is a combination of CD analysis (vehicles around the border crossing) and coherence highlighting tracks laid down by vehicles in a time interval (Sept. 19 – Oct. 4)
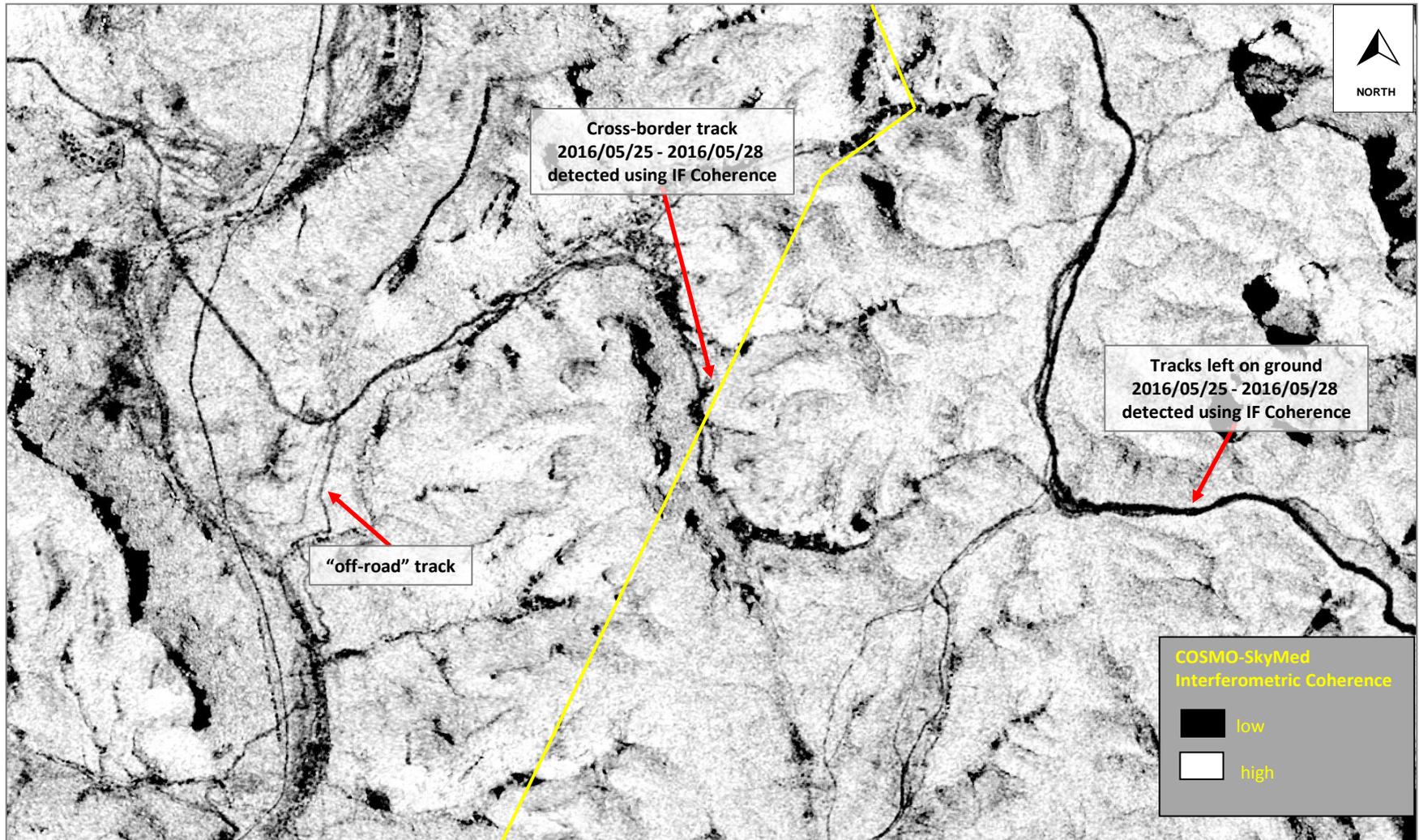
CD (target) from CSK

🔴 2014, Sept 19

🟢 2014, Oct 4

🔵 2014, Oct 12

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Border (source: Google Earth)

NORTH

Google Earth (2012/06/28)

Tracks along border

NORTH

Tracks left on ground
2016/05/24 - 2016/05/25
detected using IF Coherence

**COSMO-SkyMed
Interferometric Coherence**

low

high
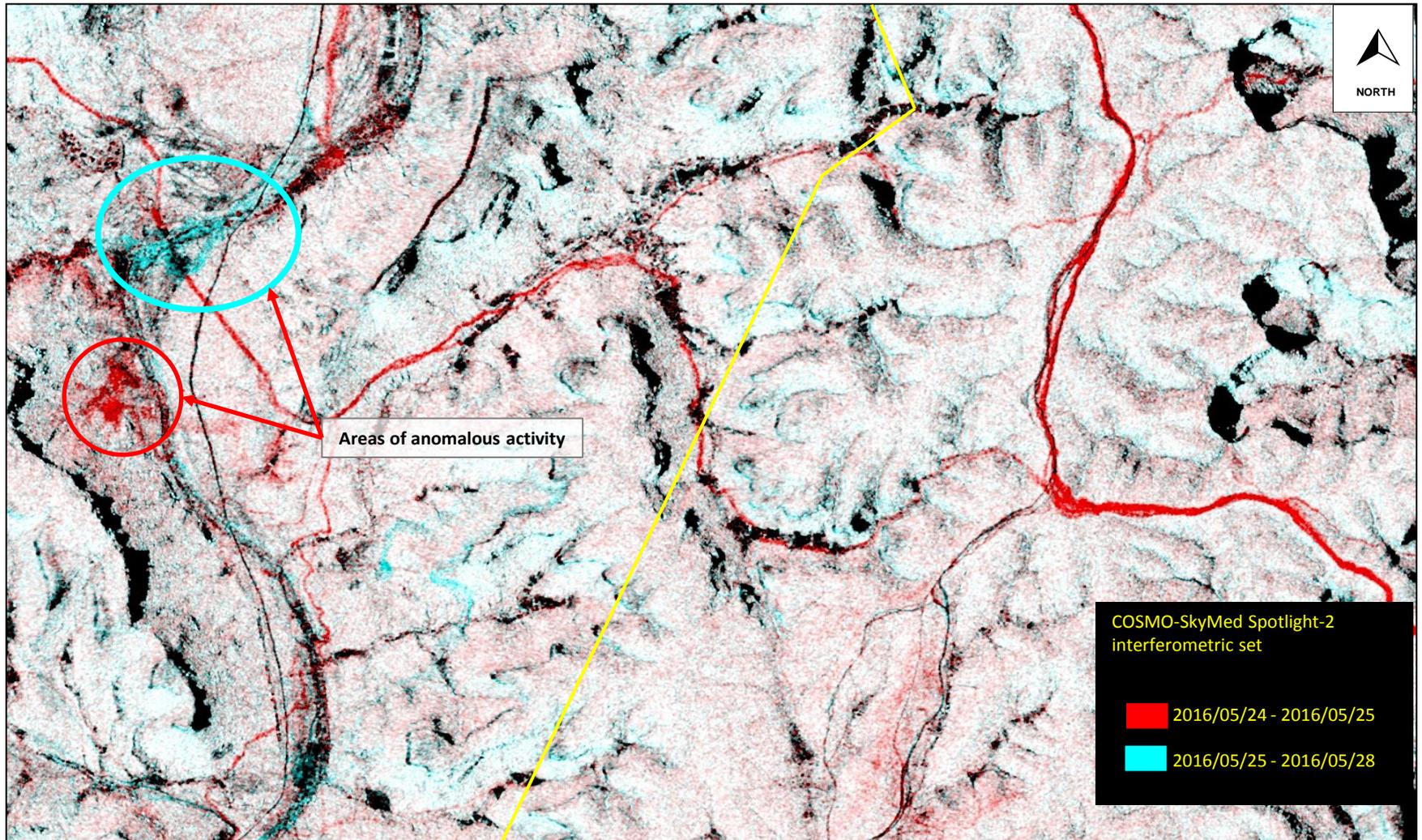
COSMO - SkyMed Spotlight IF Coherence image, 2m res.

Tracks along border

COSMO - SkyMed Spotlight IF Coherence image, 2m res.

Cross-border track
2016/05/25 - 2016/05/28
detected using IF Coherence

Tracks left on ground
2016/05/25 - 2016/05/28
detected using IF Coherence

"off-road" track

NORTH

COSMO-SkyMed
Interferometric Coherence

low

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19

NORTH

Areas of anomalous activity

COSMO-SkyMed Spotlight-2
interferometric set

🟥	2016/05/24 - 2016/05/25
🟦	2016/05/25 - 2016/05/28

COSMO - SkyMed Spotlight Multi Coherence(MC) image, 2m res.

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Activity maps: the Mali case

The following sequence of slides illustrate the concept of activity monitoring with a time sequence of Radar (SAR) data.

The area represent a lake approx. 40 km east of Timbouktou, south of the Niger river close to the village of Arlal. Some small villages are present south of the lake.

The sequence of SAR derived coherence maps (reference time interval on the bottom right) shows some darker features that represent:
- The lake (water is naturally un-coherent)
- The villages > due to the presence of people (terrain disturbance)
- Tracks joining the lake and the villages (again terrain disturbance, due to people from the villages going to the lake, very likely for fishing)

Starting from the beginning of March 2013, tracks to the lake disappear.

This can be due to "natural" reasons, the lake starts shrinking from the end of March.
But can also be due to **some "social" reasons related to stress conditions for the people of the village**.
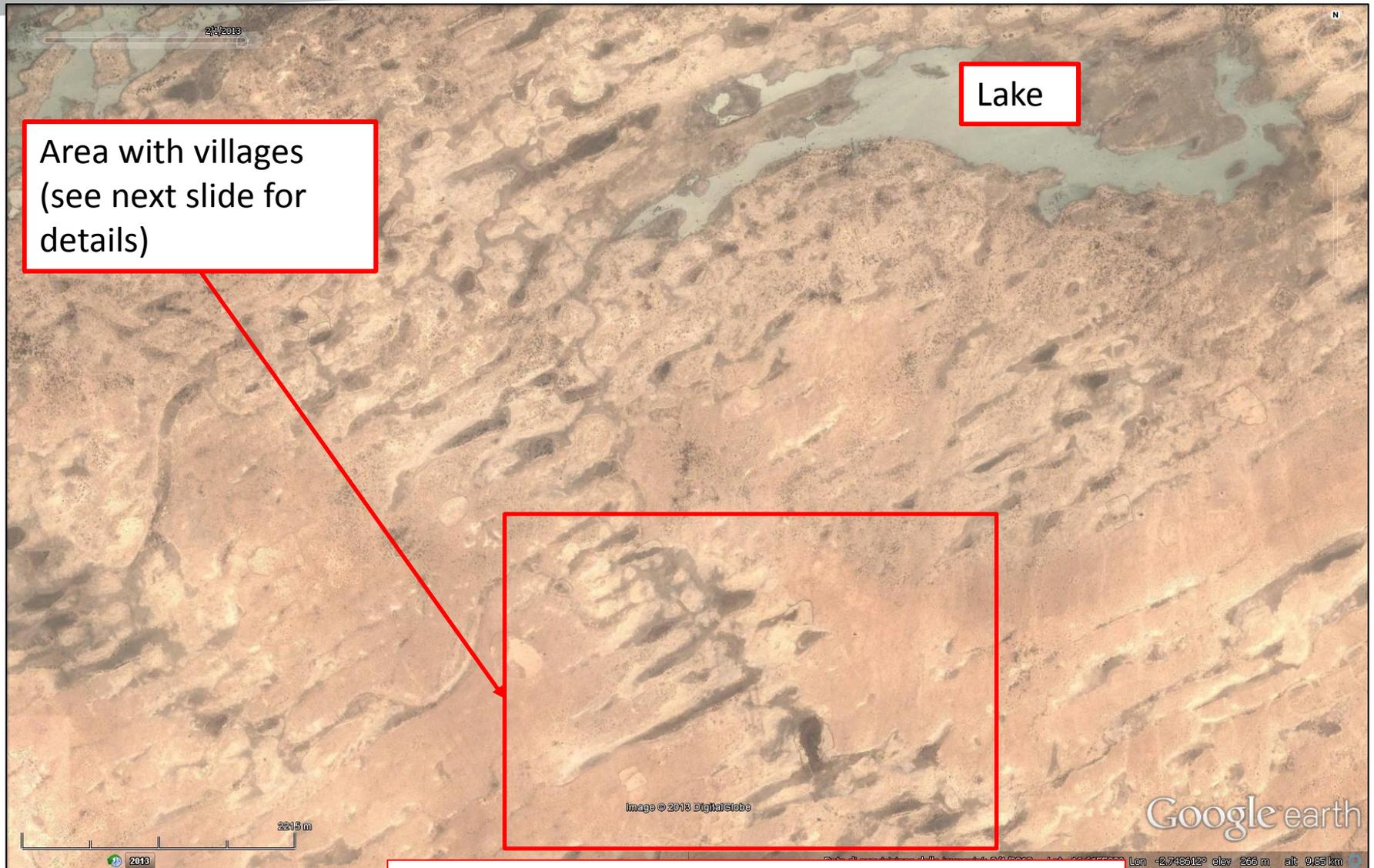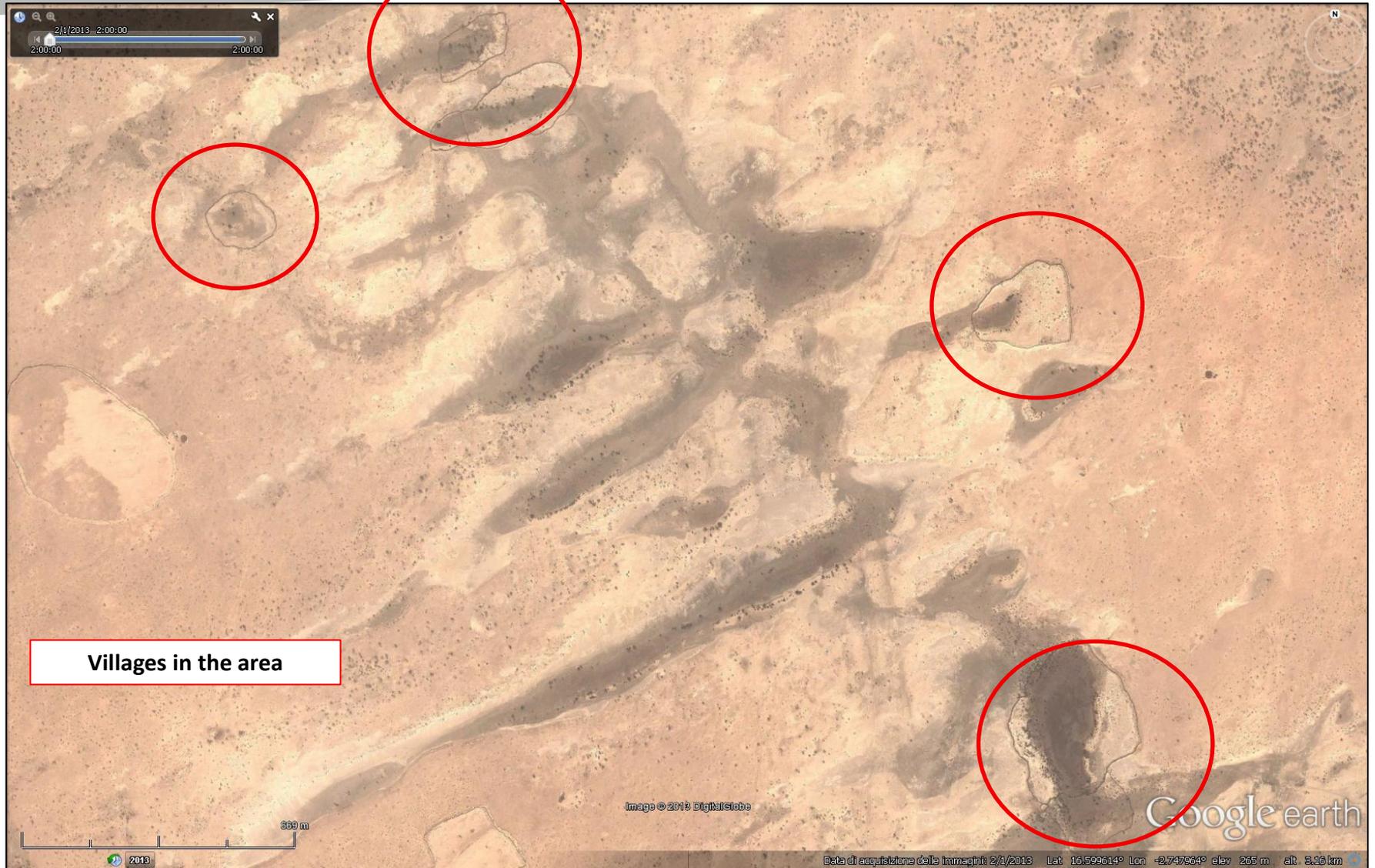
Lake

Area with villages (see next slide for details)

Google Earth Electro Optical image acquired on 2013-10-14

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Area east of Timbouktou - Villages

Villages in the area

2013-01-13 / 2013-01-25

A lot of tracks that link the villages to the lake (top right)

2013-01-25 / 2013-01-29

2013-01-29 / 2013-02-06

2013-02-06 / 2013-02-07

2013-02-07 / 2013-02-10

2013-02-10 / 2013-02-22

2013-02-22 / 2013-02-23

2013-02-23 / 2013-03-02

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Tracks to the lake seem to disappear from this date

2013-03-02 / 2013-03-10

Area east of Timbouktou - CSK coherence time series

2013-03-10 / 2013-03-11

2013-03-11 / 2013-03-18

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2013-03-18 / 2013-03-26

Area east of Timbouktou - CSK coherence time series

2013-03-26 / 2013-03-27

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2013-03-27 / 2013-03-30
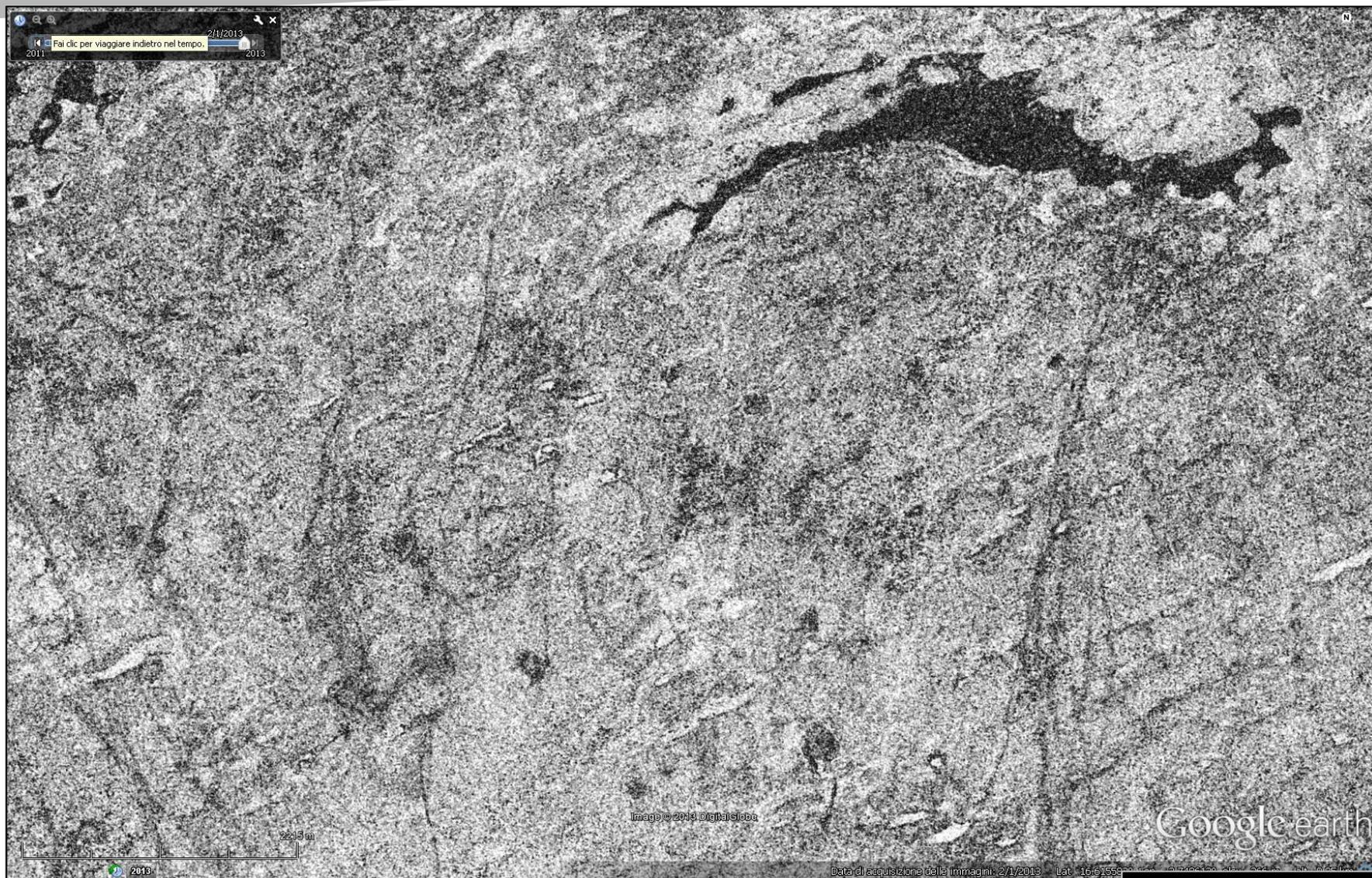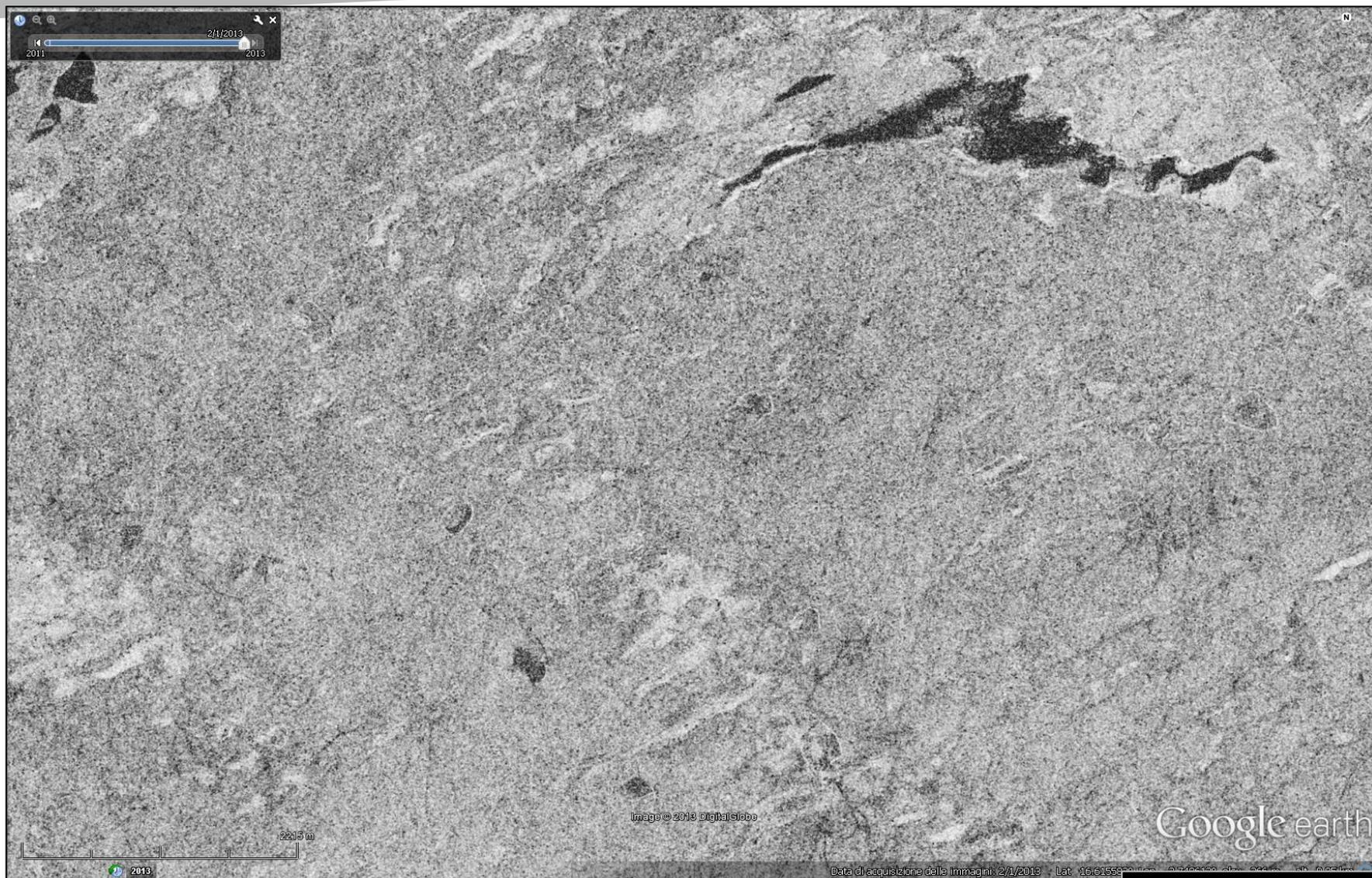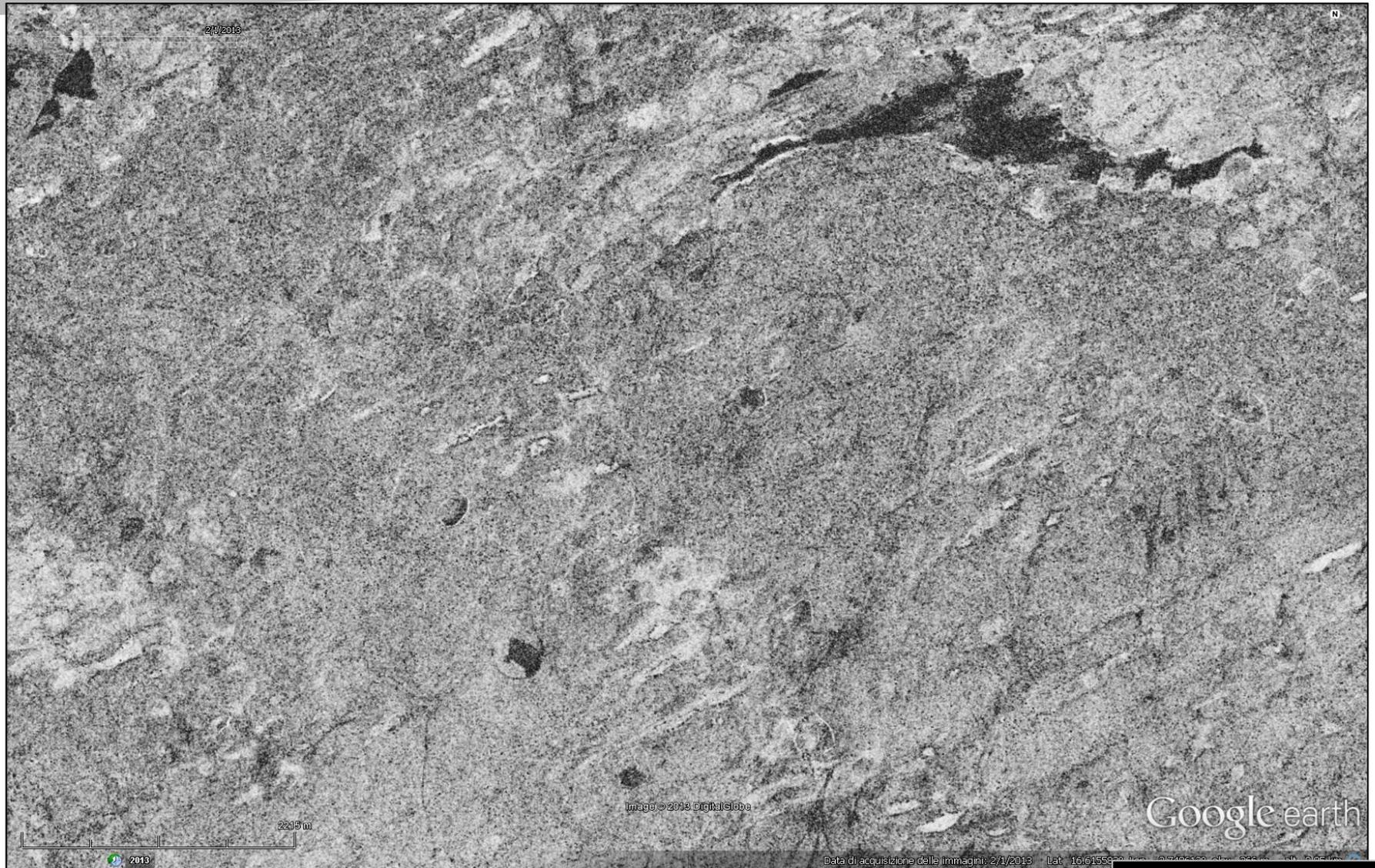
Automated derivation of Synthetic activity maps

Incoherence Values

🟥	**1.75 – 2.000**
🟧	**2.0001 – 3.000**
🟩	**3.0001 – 4.000**
🟩	**4.0001 – 999.0**
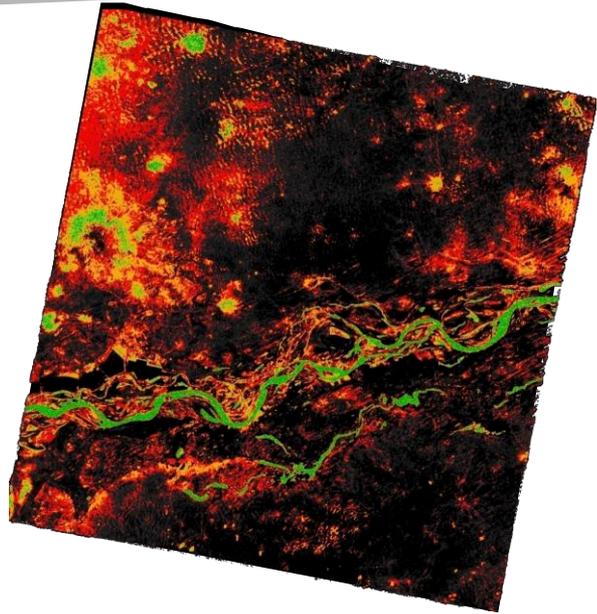
Product Resolution: 50 m
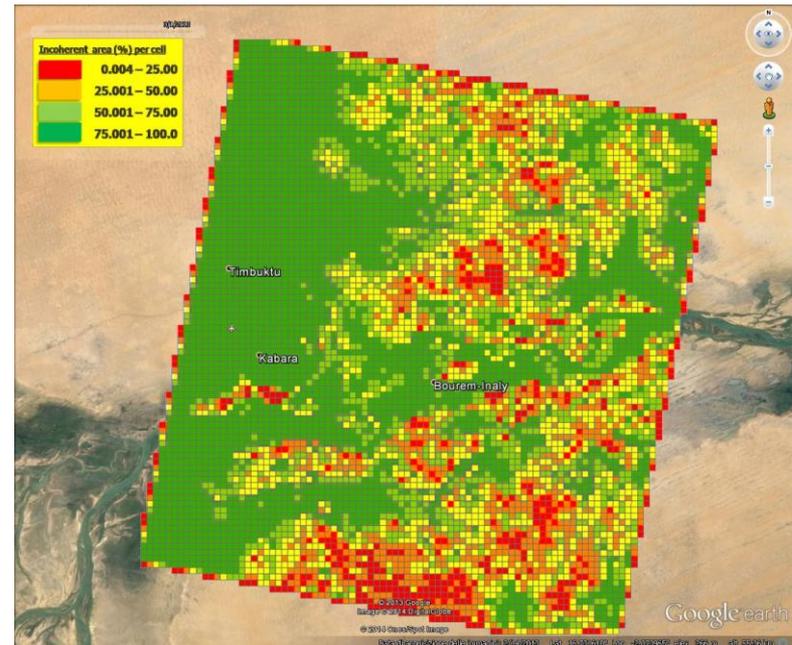
Conclusion

- Modern satellite missions based on advanced sensors can support persistent monitoring over wide areas.

- Imaging radar measurements can be exploited as indicator of human activity.

- Constellations of satellites equipped with Imaging Radar provide suitable "big data" for the application of analytic engines to derive signals and trends.

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Thank you

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