The Italian COSMO-SkyMed constellation support for Disaster Management and Emergency Response

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Outlines

- **COSMO-SkyMed system features**
- Application domains
- Emergency management:
  - ✓ Oklahoma tornado
  - ✓ Super Typhoon Haiyan
  - ✓ Humanitarian crisis
  - ✓ CEOS - Bardarbunga volcano
  - ✓ CEOS - Cephalonia earthquake
- Open Call
- Conclusions

COSMO-SkyMed features

8 JUN. - 2007
COSMO-1

5 NOV. - 2010
COSMO-4

SINCE M
SATEL

The Largest Italian investment in Space System for Earth Observation

JR SAR
ONAL

9 DE
CO

NO OTHER 4 SAR SATELLITES CONSTELLATION TODAY ON THE EO OPERATIONAL SCENE

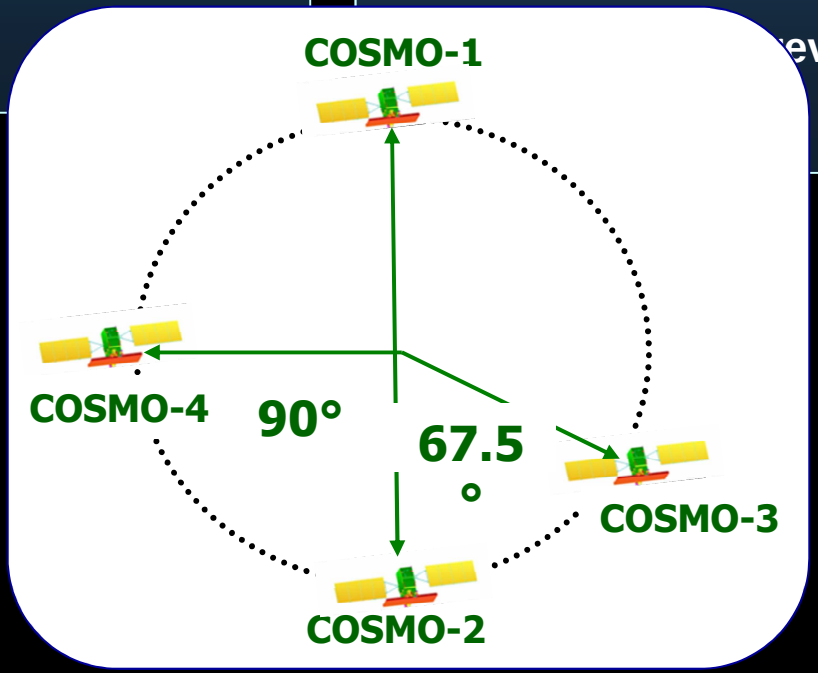
25 OCT. - 2008
COSMO-3

COSMO-SkyMed features

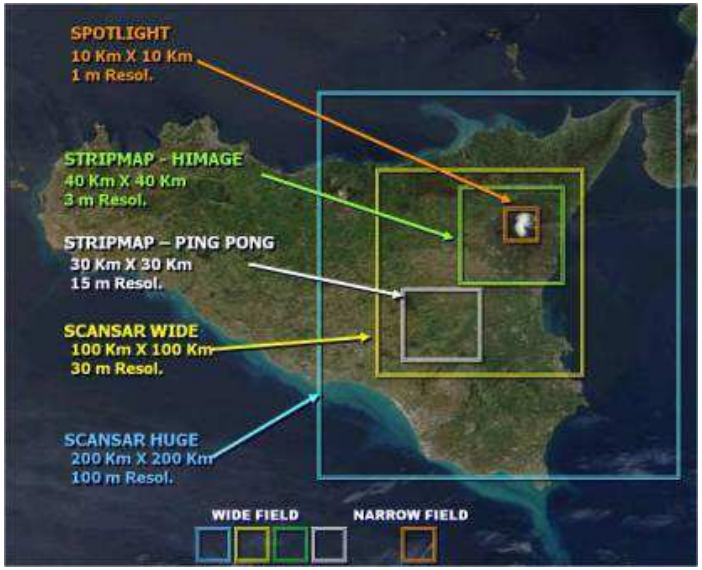
- SENSOR X-BAND SAR (9.6 GHz)
- BANDWIDTH 400 MHz
- HEIGHT 619.6 Km
- ORBIT SSO
- INCLINATION 97.8°
- ORBITAL PERIOD

4 SAR SATELLITES CONSTELLATION

- Worldwide global coverage
- All weather night/day acquisitions
- Fast response time
- Fast large/long area mapping
- Accurate information frequently updated
- evisit (1 day)



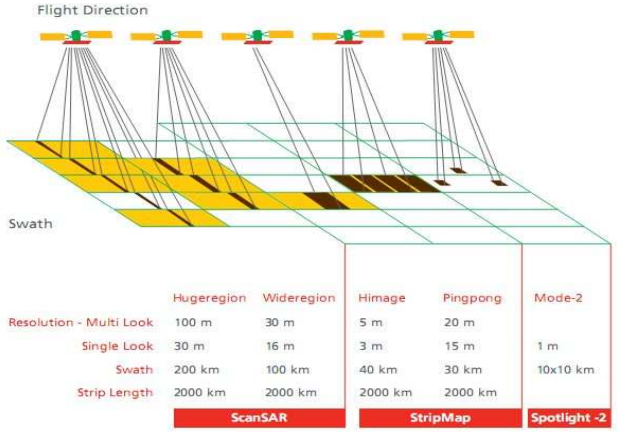
COSMO-SkyMed features



75 Narrow Field
+
375 Wide Field
Images per day
per satellite

1800 images
per day

MULTI-MODE ACQUISITION CAPABILITY



	Hugeregion	Wideregion	Himage	Pingpong	Mode-2
Resolution - Multi Look	100 m	30 m	5 m	20 m	
Single Look	30 m	16 m	3 m	15 m	1 m
Swath	200 km	100 km	40 km	30 km	10x10 km
Strip Length	2000 km	2000 km	2000 km	2000 km	
	ScanSAR		StripMap		Spotlight -2

RESPONSE TIME

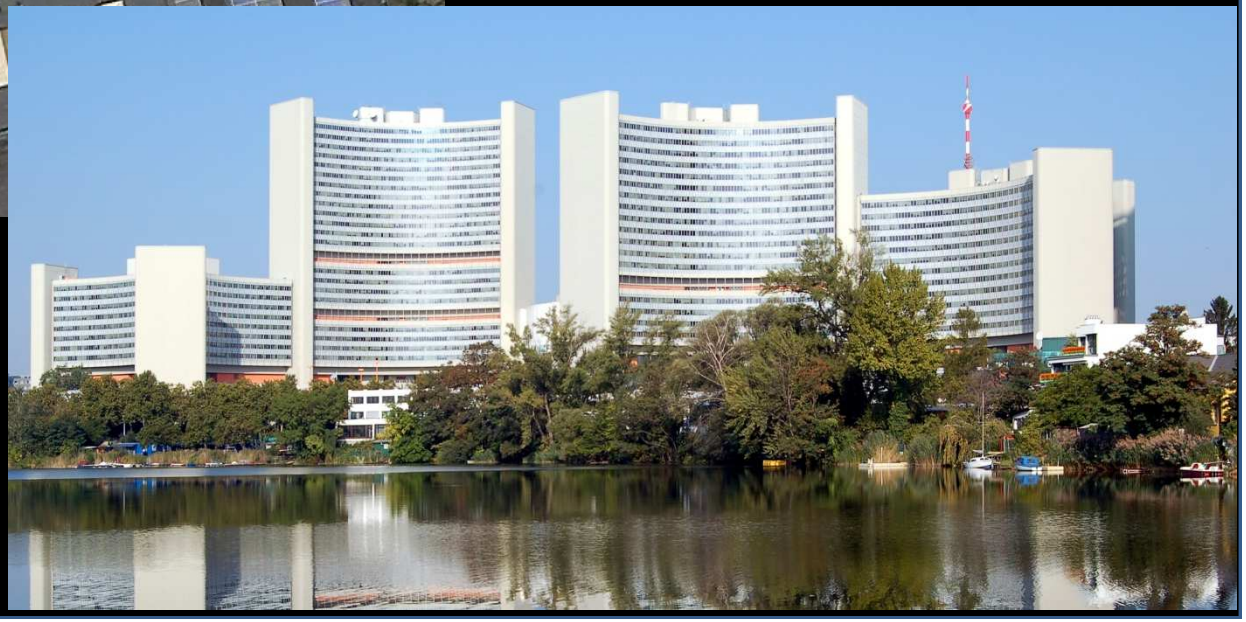
4 SATELLITES (real cases)

VERY URGENT	**6-18 h**
CRISIS	**12-36 h**
ROUTINE	**24-72 h**

COSMO-SkyMed features

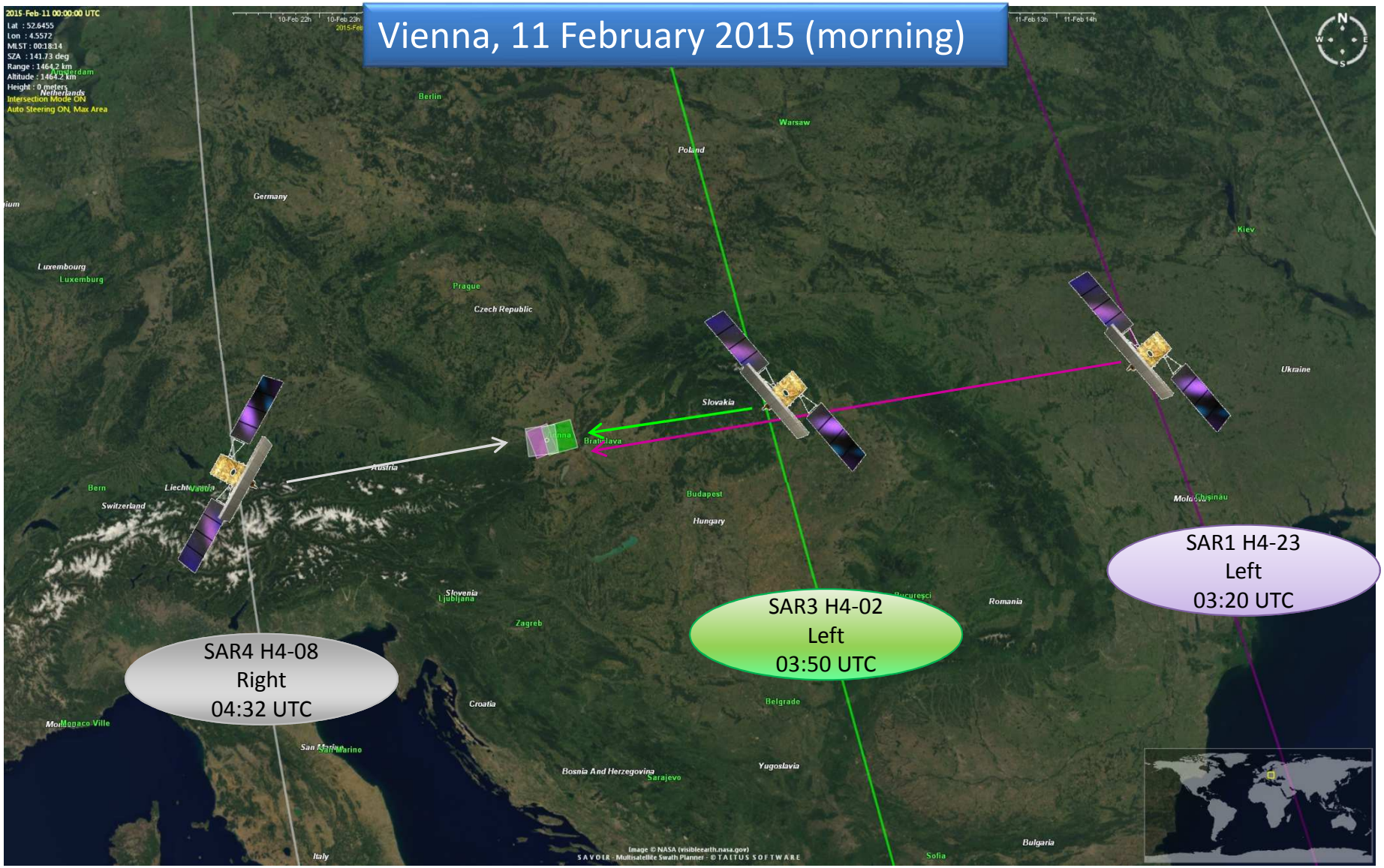
ASI HEADQUARTERS

Constellation Unique Capabilities

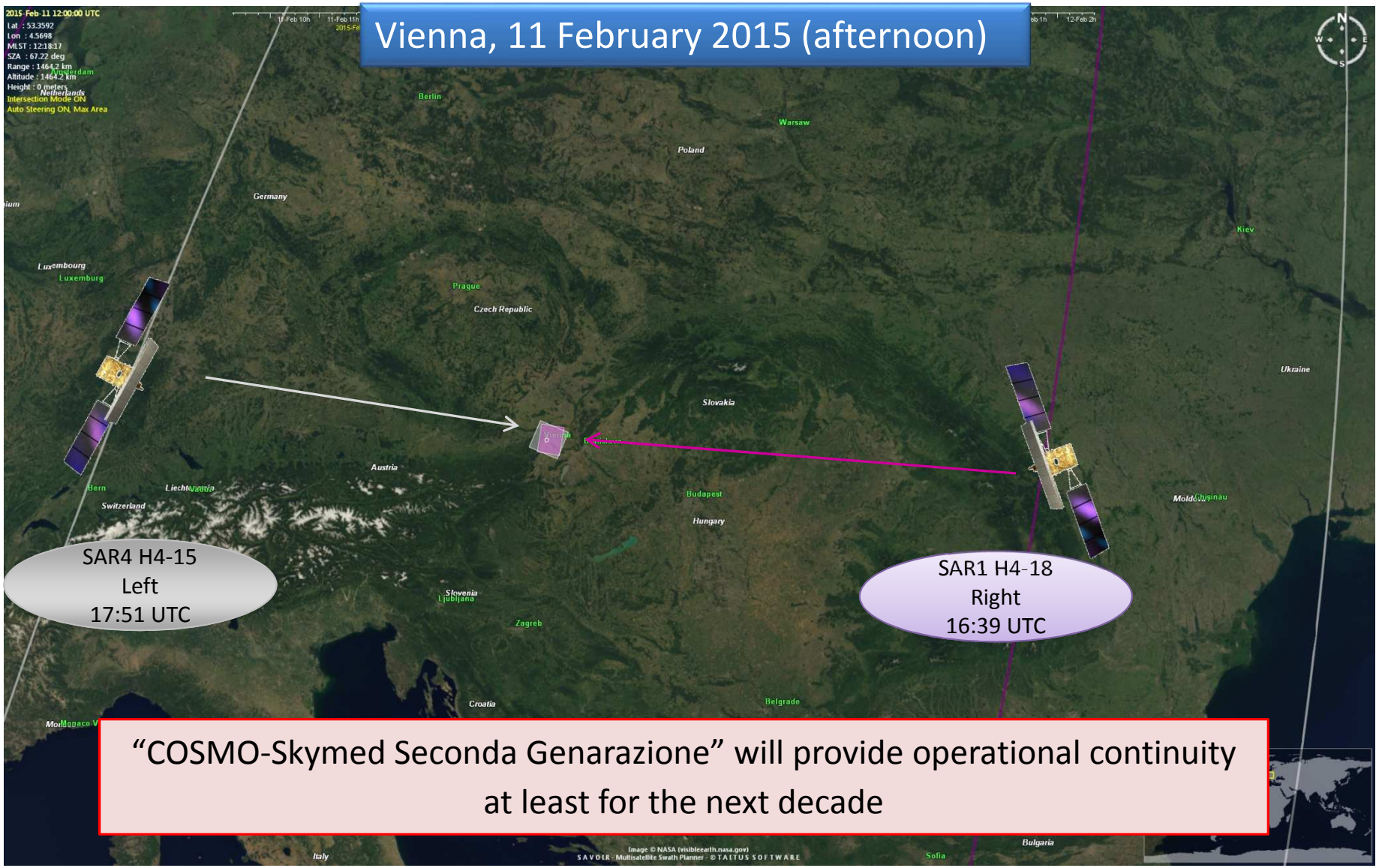


VIENNA INTERNATIONAL CENTRE

COSMO-SkyMed features



COSMO-SkyMed features



"COSMO-Skymed Seconda Genarazione" will provide operational continuity at least for the next decade

Application domains

RISK MONITORING AND MANAGEMENT OF EMERGENCIES

OCEAN AND ICE MONITORING

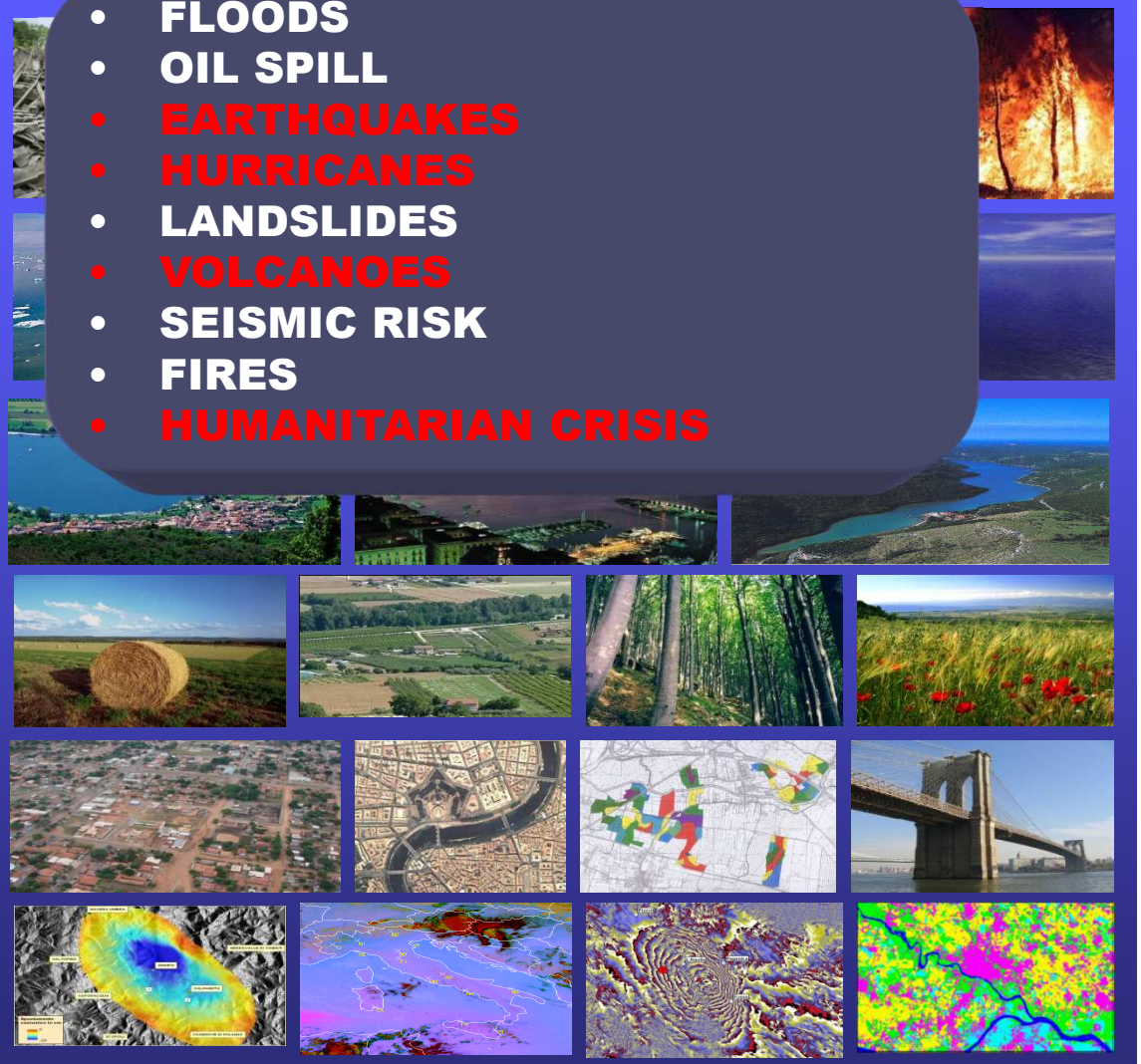
MONITORING AND MANAGEMENT OF COASTALIINES AND INLAND WATERS

MONITORING AND MANAGEMENT OF FORESTRY AND AGRICULTURAL RESOURCES

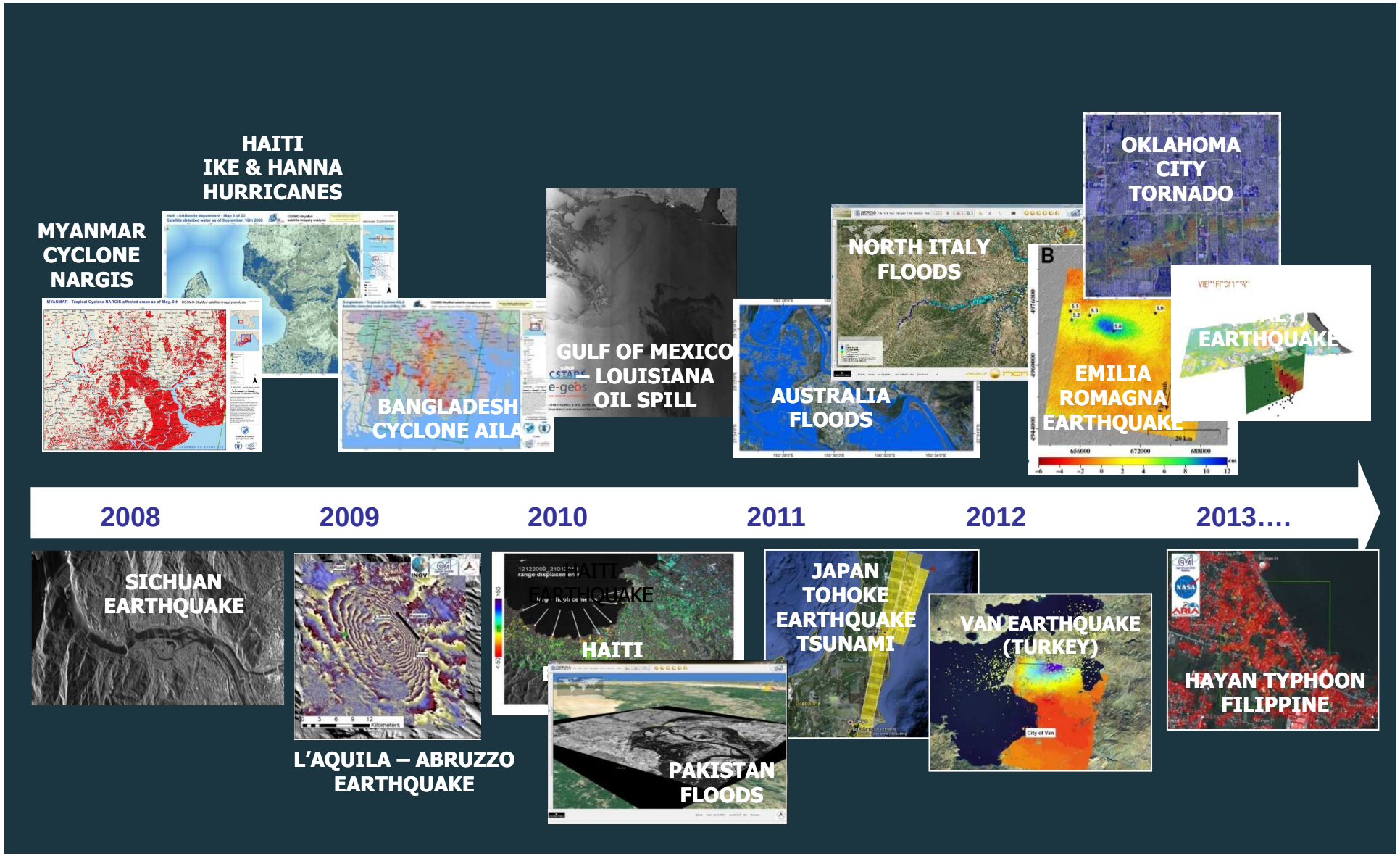
TECHNICAL CARTOGRAPHY – URBAN PLANNING

SCIENTIFIC APPLICATIONS

- FLOODS
- OIL SPILL
- EARTHQUAKES
- HURRICANES
- LANDSLIDES
- VOLCANOES
- SEISMIC RISK
- FIRES
- HUMANITARIAN CRISIS



Application domains



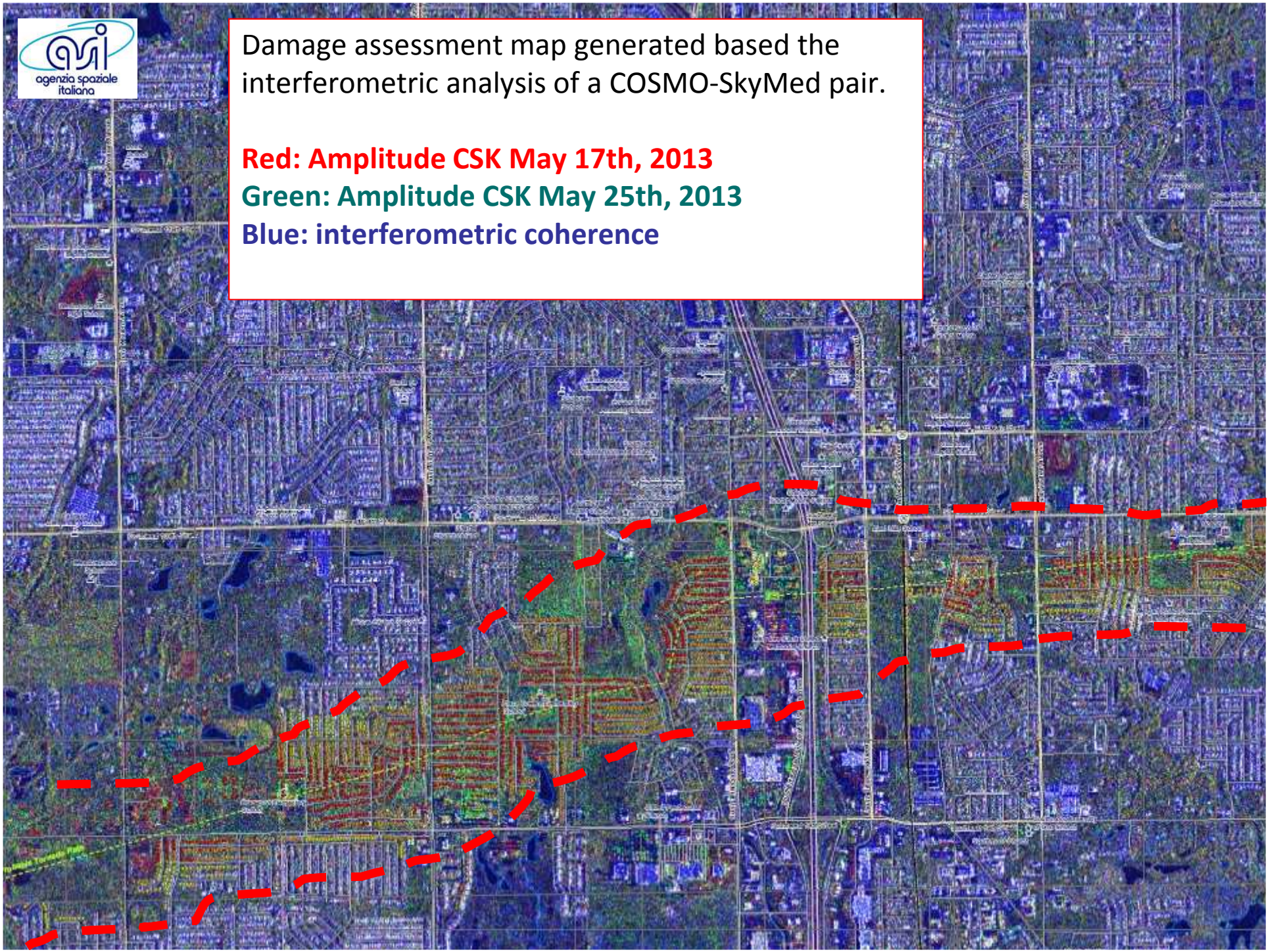
Oklahoma tornado(2013)

Event description:

- On the afternoon of May 20, a large, violent tornado touched down west of Newcastle, Oklahoma and impacted the town of Moore, causing severe damage to residential areas as well as Plaza Towers and Briarwood Elementary schools. The Oklahoma Office of the Chief Medical Examiner has confirmed several fatalities, at least 200 people injured.

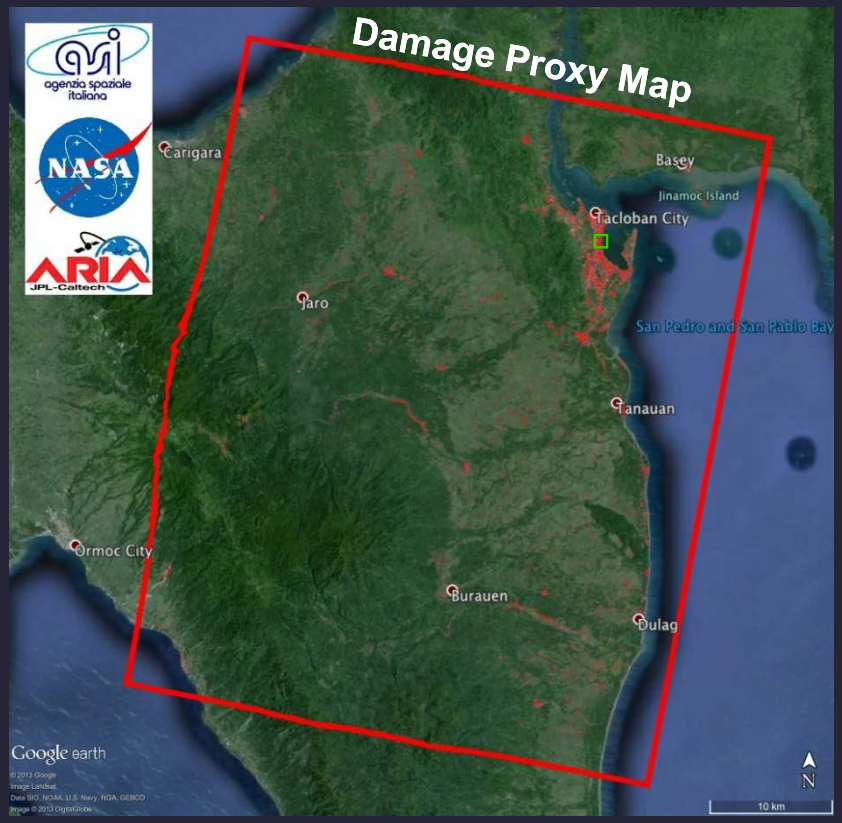
Triggering entity: e-GEOS Autoactivation

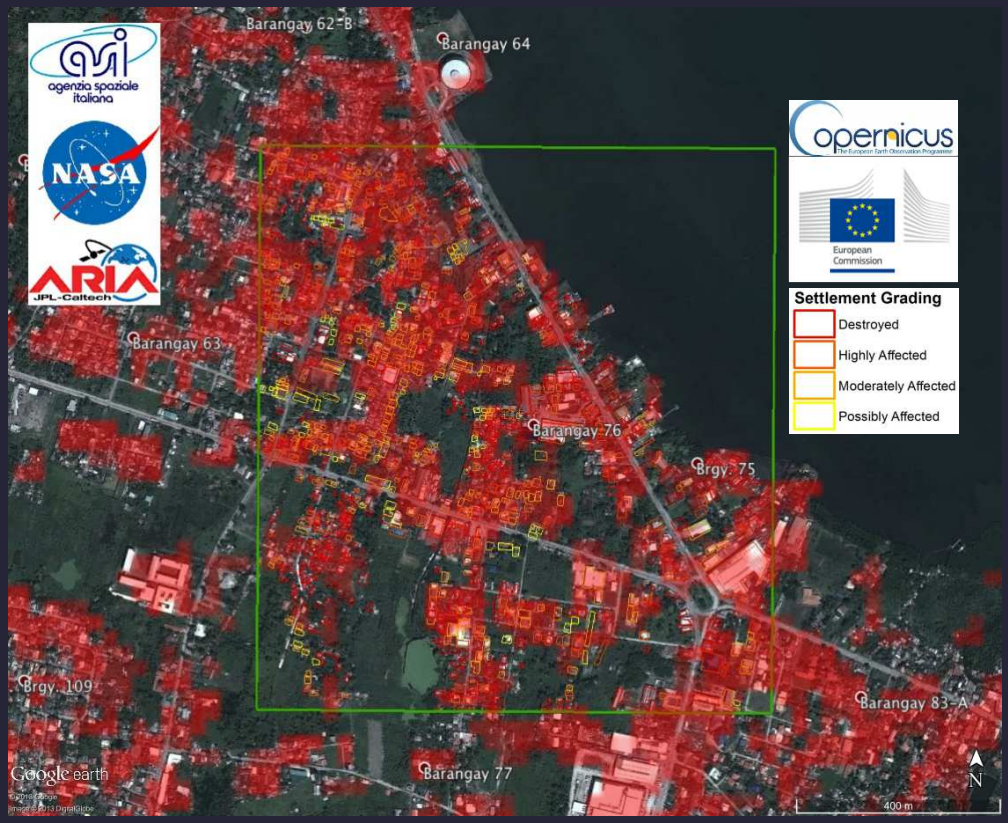
- e-GEOS has been proactively acquiring COSMO-SkyMed images before and after the event, generating damage assessment maps provided to US Government.
- e-GEOS has been regularly acquiring also optical data for optical-SAR combined analysis.


agenzia spaziale italiana
Damage assessment map generated based the interferometric analysis of a COSMO-SkyMed pair.
Red: Amplitude CSK May 17th, 2013
Green: Amplitude CSK May 25th, 2013
Blue: interferometric coherence

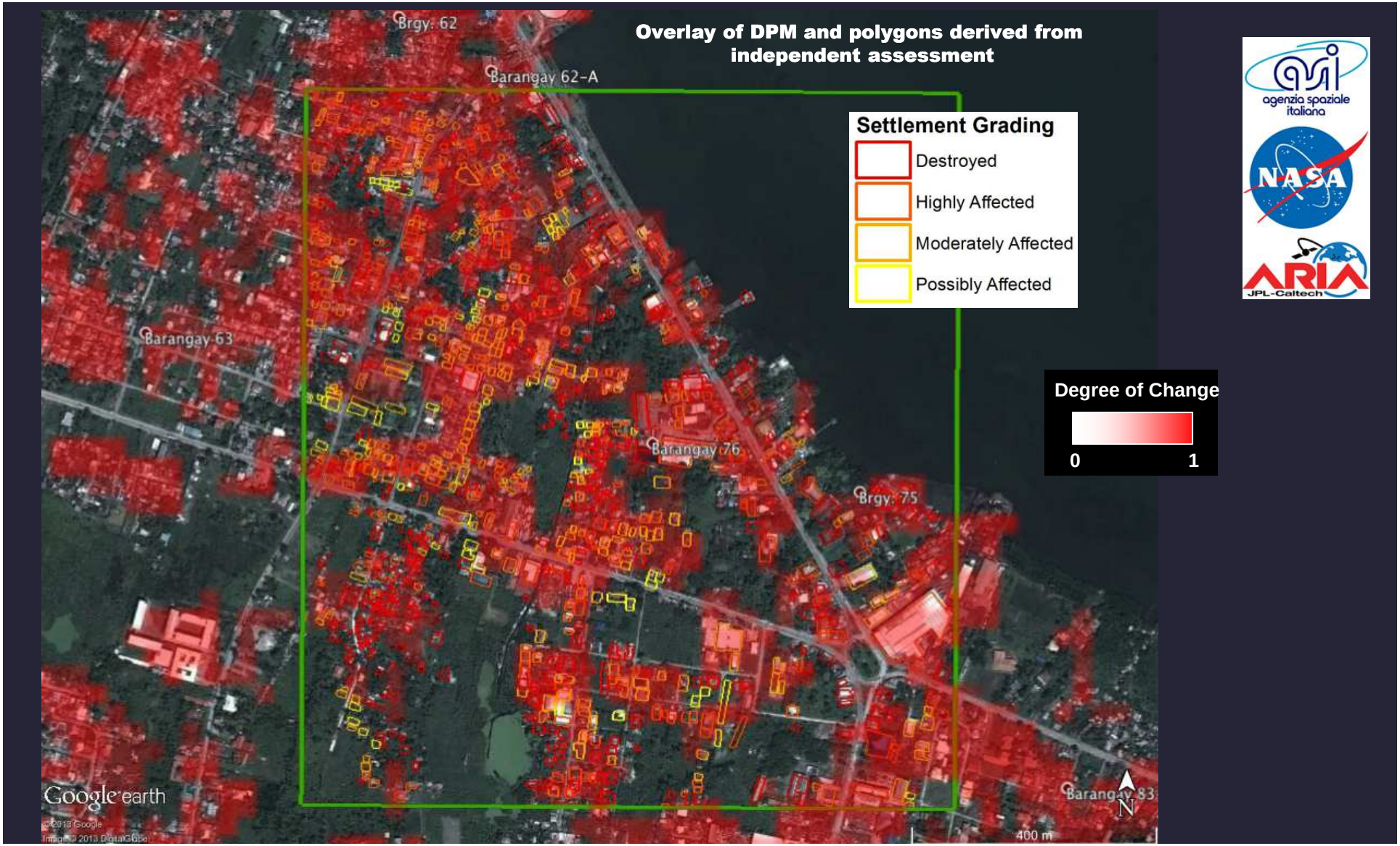
Super Typhoon Haiyan (2013)

- **2013-11-08 0:00AM (UTC): Haiyan struck Philippines**
- **2013-11-11 (Day 3): COSMO-SkyMed data acquisition**
- **2013-11-11 (Day 3): damage map delivery**





Super Typhoon Haiyan (2013)



IDP camp - Jordan (2013)

Event description:

- Since August 2012 the conflict in Syria has been forcing civil population to migrate towards the border with the nearby Jordan
- A IDP camp was set up by UNHCR in Al Mafraq area

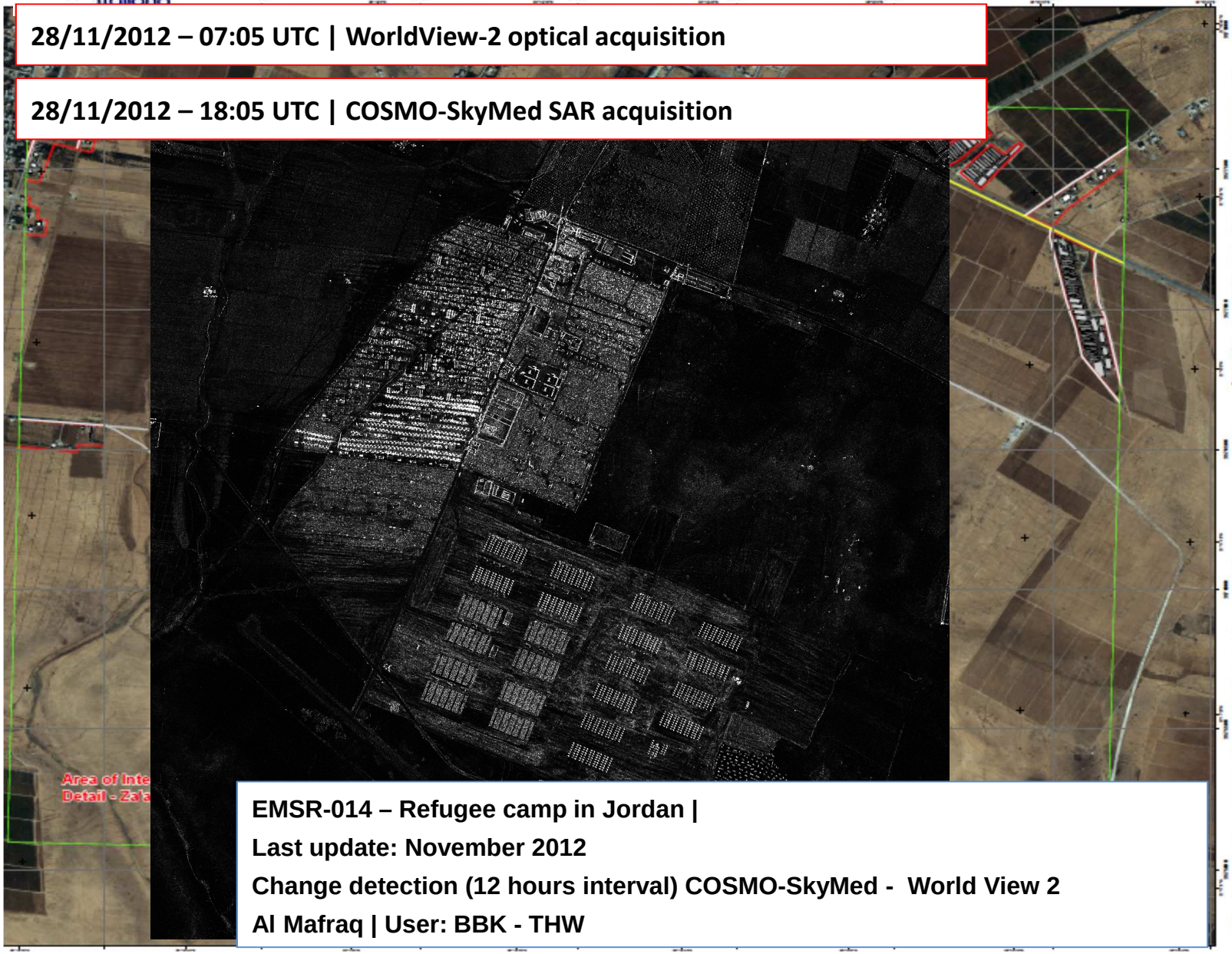
Triggering entity: German BBK on behalf of THW (through EC MIC)

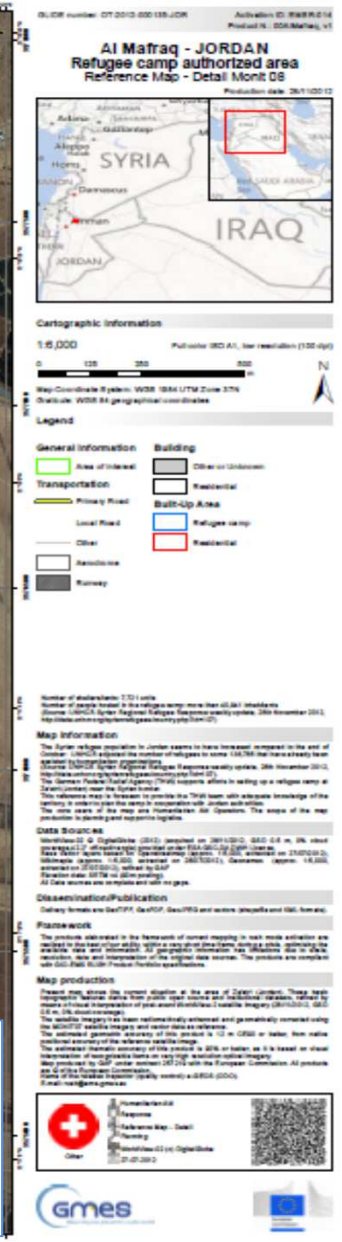
- e-GEOS has been activated by the German BBK on behalf of THW (German entity for humanitarian aid operations) to regularly monitor the evolution of Al Mafraq IDP camp.
- e-GEOS has been regularly acquiring both optical and SAR data over more than six months, providing constant updates to the relief operators involved.

Optical – SAR integration

28/11/2012 – 07:05 UTC | WorldView-2 optical acquisition

28/11/2012 – 18:05 UTC | COSMO-SkyMed SAR acquisition





EMSR-014 – Refugee camp in Jordan |

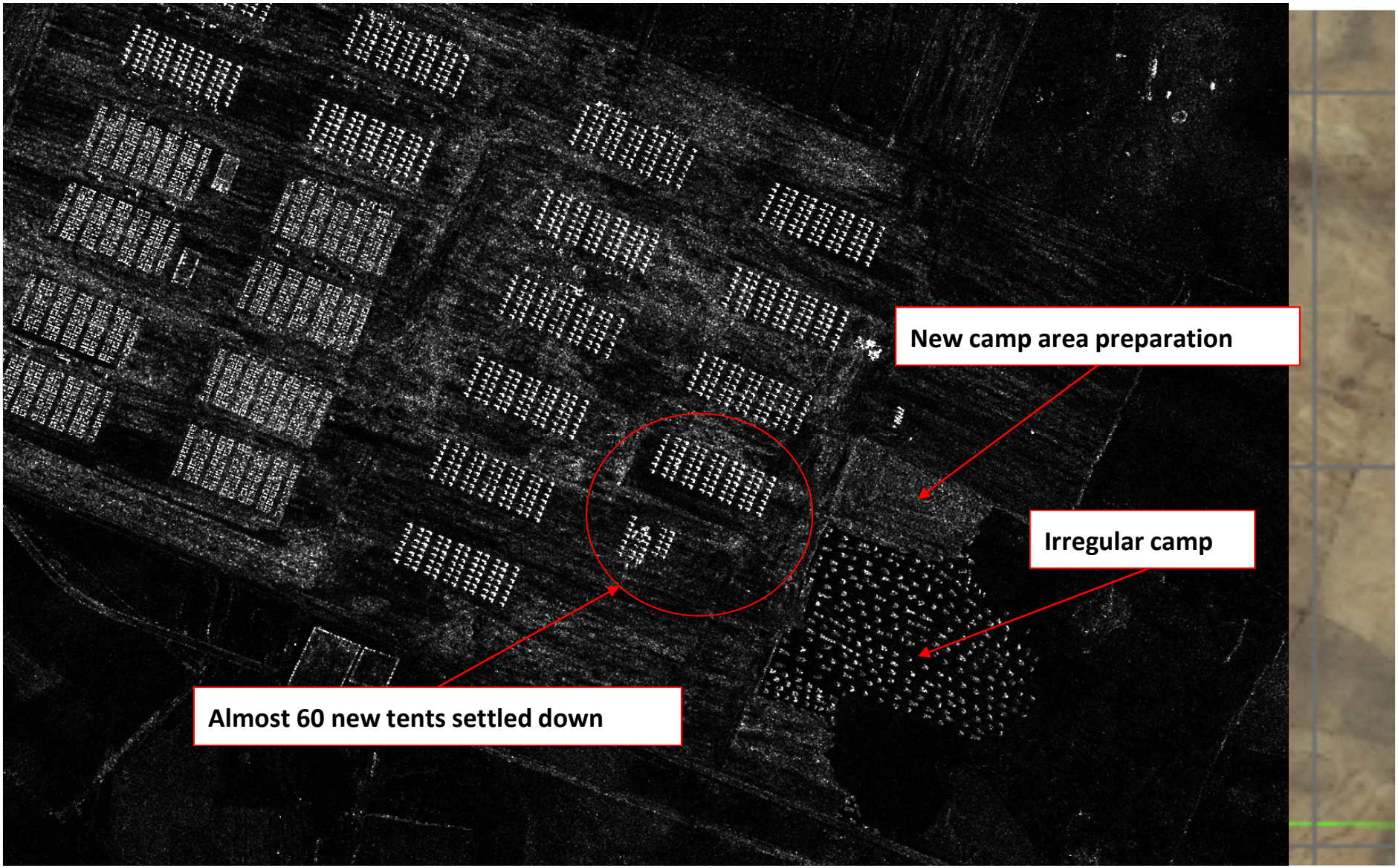
Last update: November 2012

Change detection (12 hours interval) COSMO-SkyMed - World View 2

Al Mafraq | User: BBK - THW

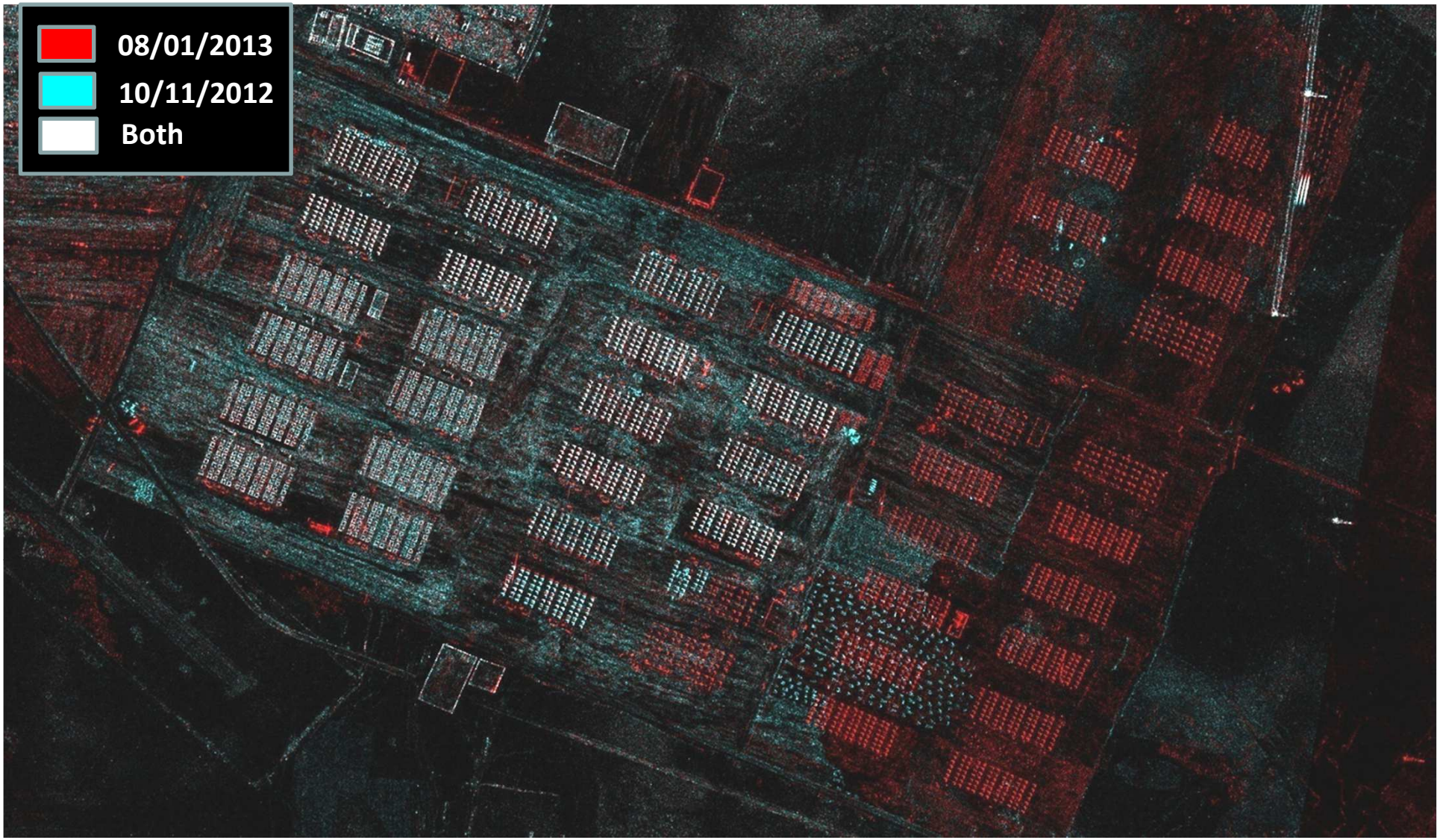
IDP camp - Jordan (2013)

What happened in 12 hours?

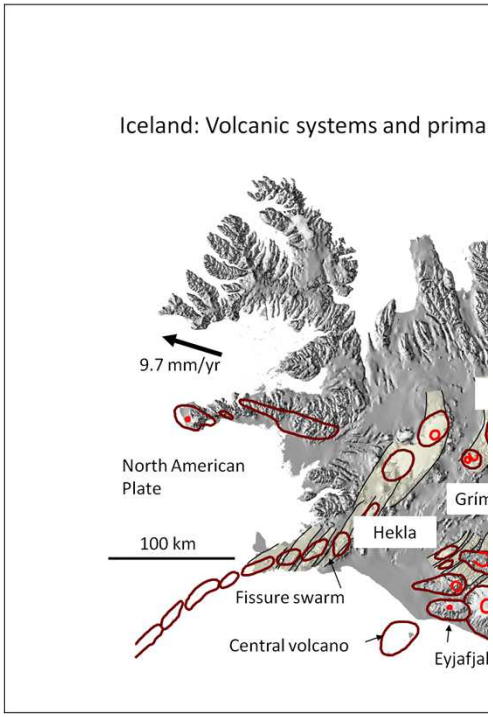


IDP camp - Jordan (2013)

Two months later…..



CEOS – Bardarbunga volcano



LETTER

doi:10.1038/nature14111

Segmented lateral dyke growth in a rifting event at Bárðarbunga volcanic system, Iceland

Freysteinn Sigmundsson[1], Andrew Hooper[2], Sigrún Hreinsdóttir[3], Kristín S. Vogfjörd[4], Benedikt G. Ófeigsson[4], Elias Rafn Heimisson[1], Stéphanie Dumont[1], Michelle Parks[1], Karsten Spaans[2], Gunnar B. Gudmundsson[4], Vincent Drouin[1], Thóra Árnadóttir[1], Kristín Jónsdóttir[4], Magnús T. Gudmundsson[1], Thórdís Högnadóttir[1], Hildur Maria Fridriksdóttir[1,4], Martin Hensch[4], Páll Einarsson[1], Eyjólfur Magnússon[1], Sergey Samsonov[5], Bryndís Brandsdóttir[1], Robert S. White[6], Thorbjörg Ágústsdóttir[6], Tim Greenfield[6], Robert G. Green[6], Ásta Rut Hjartardóttir[1], Rikke Pedersen[1], Richard A. Bennett[7], Halldór Geirsson[8], Peter C. La Femina[8], Helgi Björnsson[1], Finnur Pálsson[1], Erik Sturkell[9], Christopher J. Bean[10], Martin Möllhoff[10], Aoife K. Braiden[10] & Eva P. S. Eibl[10]

Crust at many divergent plate boundaries forms primarily by the injection of vertical sheet-like dykes, some tens of kilometres long[1]. Previous models of rifting events indicate either lateral dyke growth away from a feeding source, with propagation rates decreasing as the dyke lengthens[2–4], or magma flowing vertically into dykes from an underlying source[5,6], with the role of topography on the evolution of lateral dykes not clear. Here we show how a recent segmented dyke intrusion in the Bárðarbunga volcanic system grew laterally for more than 45 kilometres at a variable rate, with topography influencing the direction of propagation. Barriers at the ends of each segment were overcome by the build-up of pressure in the dyke end; then a new segment formed and dyke lengthening temporarily peaked. The dyke evolution, which occurred primarily over 14 days, was revealed by propagating seismicity, ground deformation mapped by Global Positioning System (GPS), interferometric analysis of satellite radar images (InSAR), and graben formation. The strike of the dyke segments varies from an initially radial direction away from the Bárðarbunga caldera, towards alignment with that expected from regional stress at the distal end. A model minimizing the combined strain and gravitational potential energy explains the propagation path. Dyke opening and seismicity focused at the most distal segment at any given time, and were simultaneous with magma source deflation and slow collapse at the Bárðarbunga caldera, accompanied by a series of magnitude $M > 5$ earthquakes. Dyke growth was slowed down by an effusive fissure eruption near the end of the dyke. Lateral dyke growth with segment barrier breaking by pressure build-up in the dyke distal end explains how focused upwelling of magma under central volcanoes is effectively redistributed over long distances to create new upper crust at divergent plate boundaries.

The formation of dykes is favourable at divergent plate boundaries, because plate movements stretch the crust and reduce the normal stress on potential dyke planes. Rifting events at divergent plate boundaries typically occur in episodes separated by hundreds of years of quiescence. Only a few such episodes have been monitored, as most divergent plate boundaries form mid-ocean ridges. In 1975–84 a rifting episode took place at Krafla volcanic system, Iceland, and from 2005 to 2010 in the Afar region of Ethiopia[1]. Limited geodetic and seismic data have been interpreted in terms of lateral flow of magma, with dyke propagation rates of up to 2–3 km per hour initially and then at a declining rate as magma propagates away from a central feeding source[2–4]. The propagation of such dykes has been modelled as inflation of magma filled cracks with uniform excess pressure[7,8]. The formation of regional dykes in Iceland has alternatively been attributed to the vertical rise of magma from major magma reservoirs underlying dyke swarms[5,6].

Bárðarbunga is a subglacial basaltic central volcano with a 70 km^2 caldera at the northwestern corner of Vatnajökull ice cap in Iceland[9,10] (Fig. 1, Extended Data Fig. 1). It has an associated fissure swarm[11] extending 115 km to the southwest and 55 km to the north-northeast. Activity in the last 2,000 years includes both subglacial eruptions and major effusive fissure eruptions, with 23 verified eruptions in the last 1,100 years[12]. Timings of the most recent effusive eruptions north of the Vatnajökull ice cap, originating from the Bárðarbunga system, are not well known, but they are inferred to have produced the Holuhraun lava field sometime in the period from AD 1794 to 1864[6]. The Holuhraun eruptive fissure was reactivated in 2014. In 1996, the Gjálp subglacial eruption was likely to have been triggered by the Bárðarbunga volcanic system[13,14]. Seismic activity at Bárðarbunga has been steadily increasing since 2005, mostly confined to the area northeast of its caldera.

On 16 August 2014 at 03:00 UTC, an intense seismic swarm began at Bárðarbunga. Initial seismic activity occurred in several clusters. One cluster was consistent with the formation of a radial dyke segment aligned in direction N127°E, outward from the Bárðarbunga caldera. Other clusters to the northeast of the caldera may also signify magma movements, or stress induced seismicity. GPS observations show simultaneous deflation of the caldera and displacements consistent with widening across the N127°E radial dyke, although deformation due to magma movements in the other clusters may also contribute. The seismic activity then focused on a lineament in direction N55°E, extending from the southern tip of the initial N127°E dyke segment (Extended Data Fig. 2). Lateral growth of this dyke is reflected in the migration of seismicity, along segments of variable strike; maximum widening of 1.3 m occurred between stations URHC and KVER spaced 25 km apart (Supplementary Fig. 1). Displacements of continuous GPS stations indicate the fastest rate of widening at any time in the most distal segment of the dyke throughout its evolution. The rate of dyke propagation varied considerably. A long halt in propagation, for 80 h, began on 19 August. Propagation rate exceeded 1 km h^{-1} on 23 August when a new segment initiated with a 90° left turn and advanced 4 km north-northwest over two short segments. Following this the dyke took a right turn onto a new lineament striking N47°E, and then onto a N25°E striking segment.

The lengthening of the dyke ended on 27 August, around 10 km north of Vatnajökull, and a minor fissure erupted in Holuhraun for about 4 h on 29 August. On 31 August, a new eruption began from the same fissure and is still ongoing at the time of writing. After 4 September the

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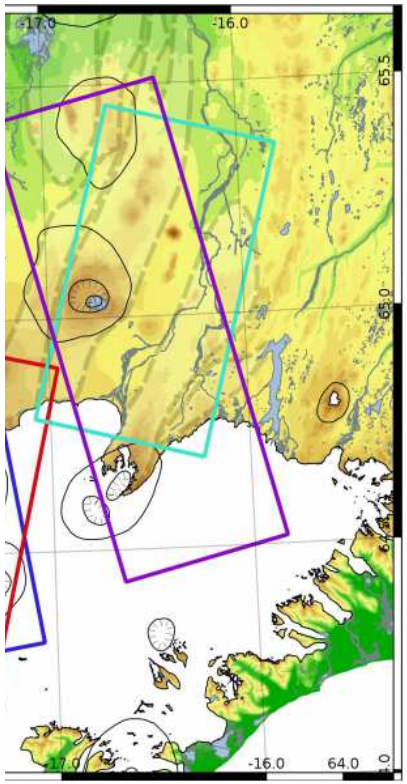

CSK 2631
28/06/2014
30/07/2014
01/09/2014
18/10/2014
19/10/2014
22/10/2014

CSK 2631
26/06/2014
28/07/2014
13/08/2014
29/08/2014
06/09/2014
22/09/2014
26/09/2014
30/09/2014
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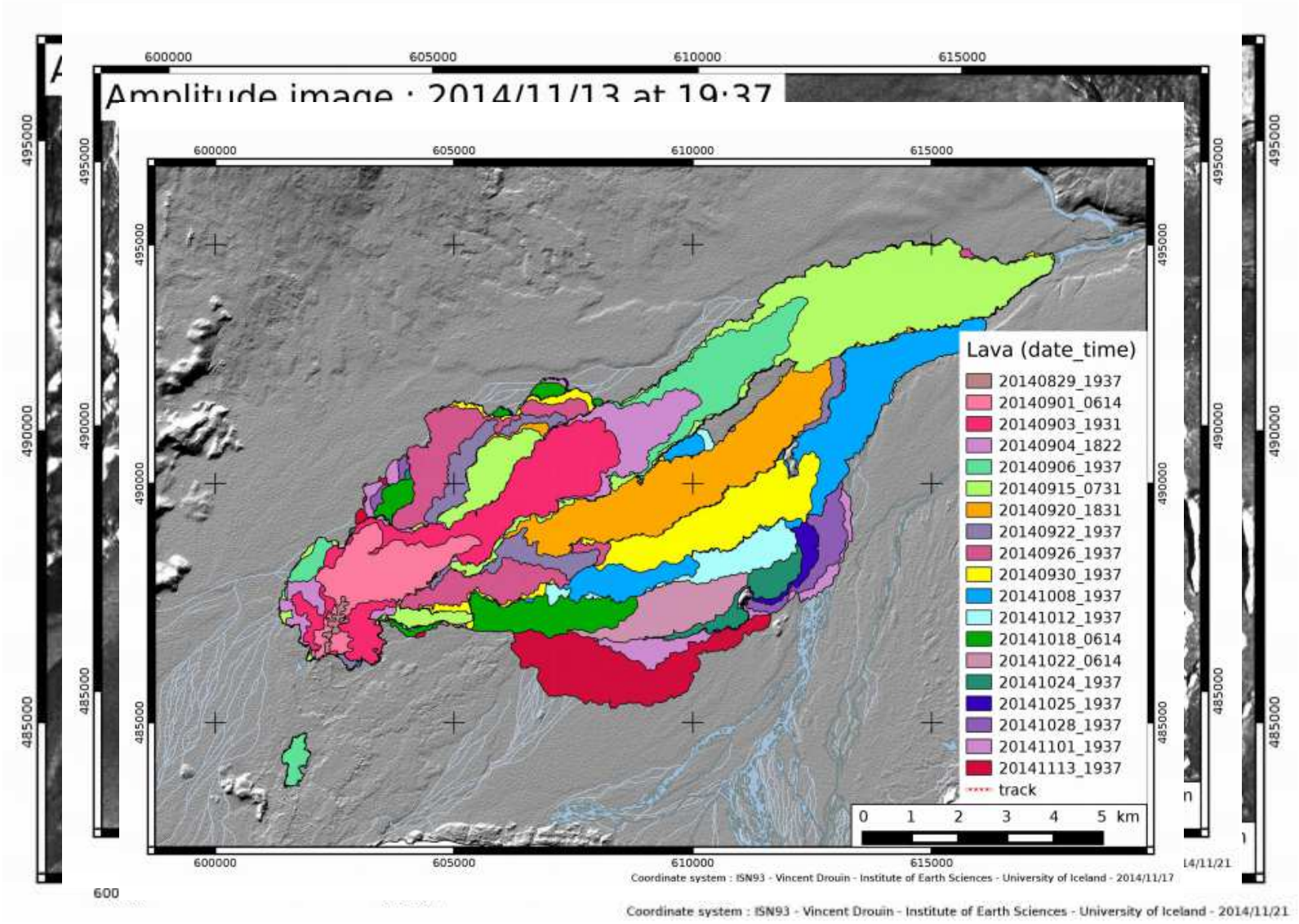
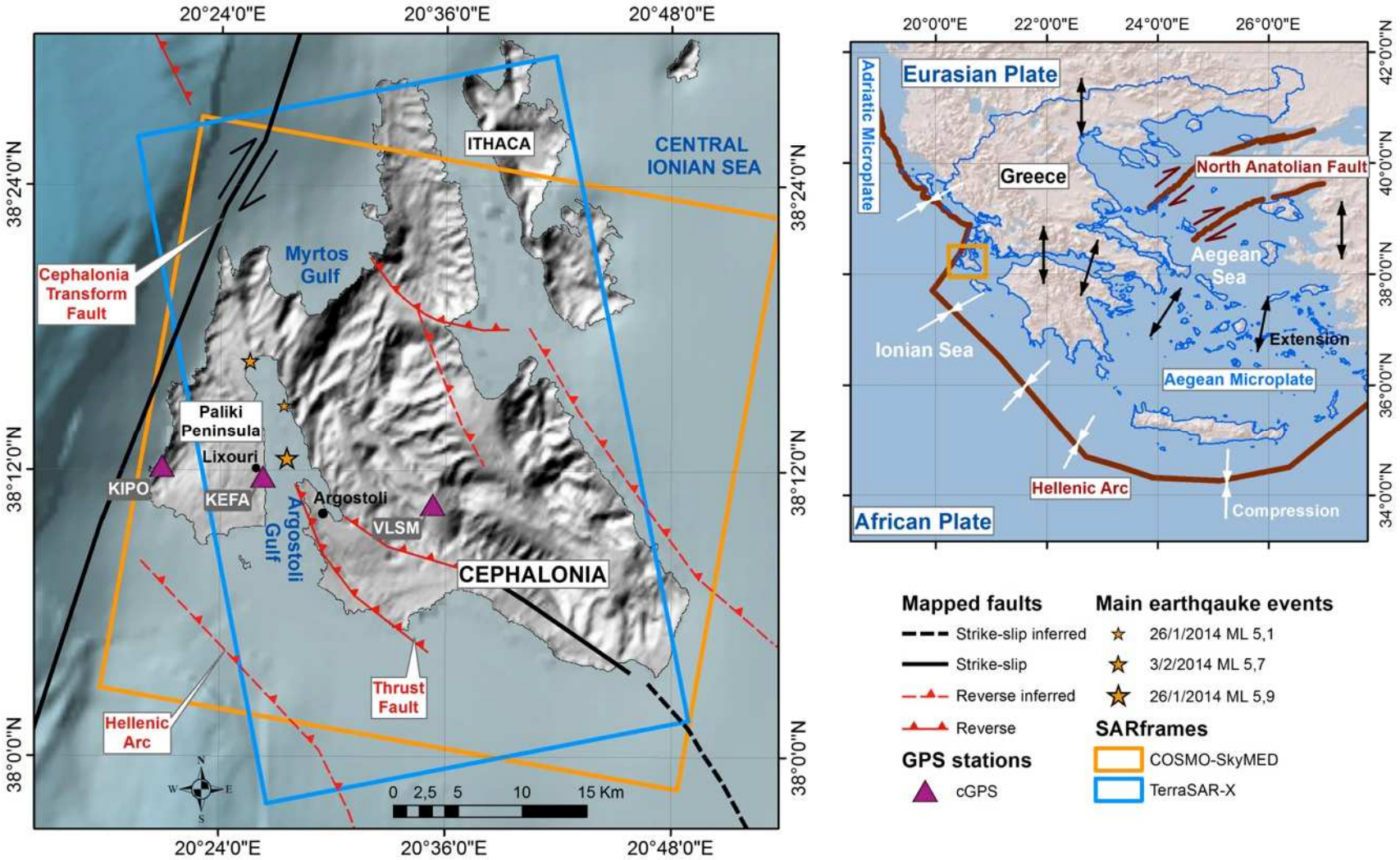
01/11/2014
13/11/2014

CEOS – Bardarbunga volcano

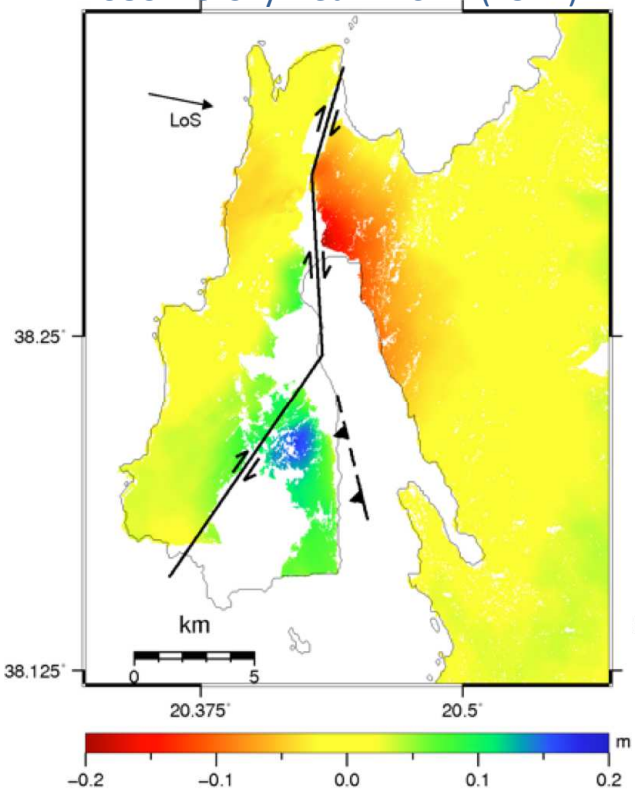


CEOS – Cephalonia earthquake

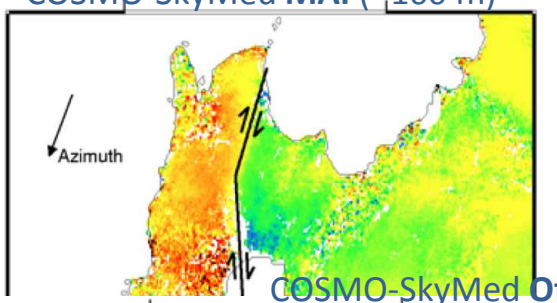


CEOS – Cephalonia earthquake

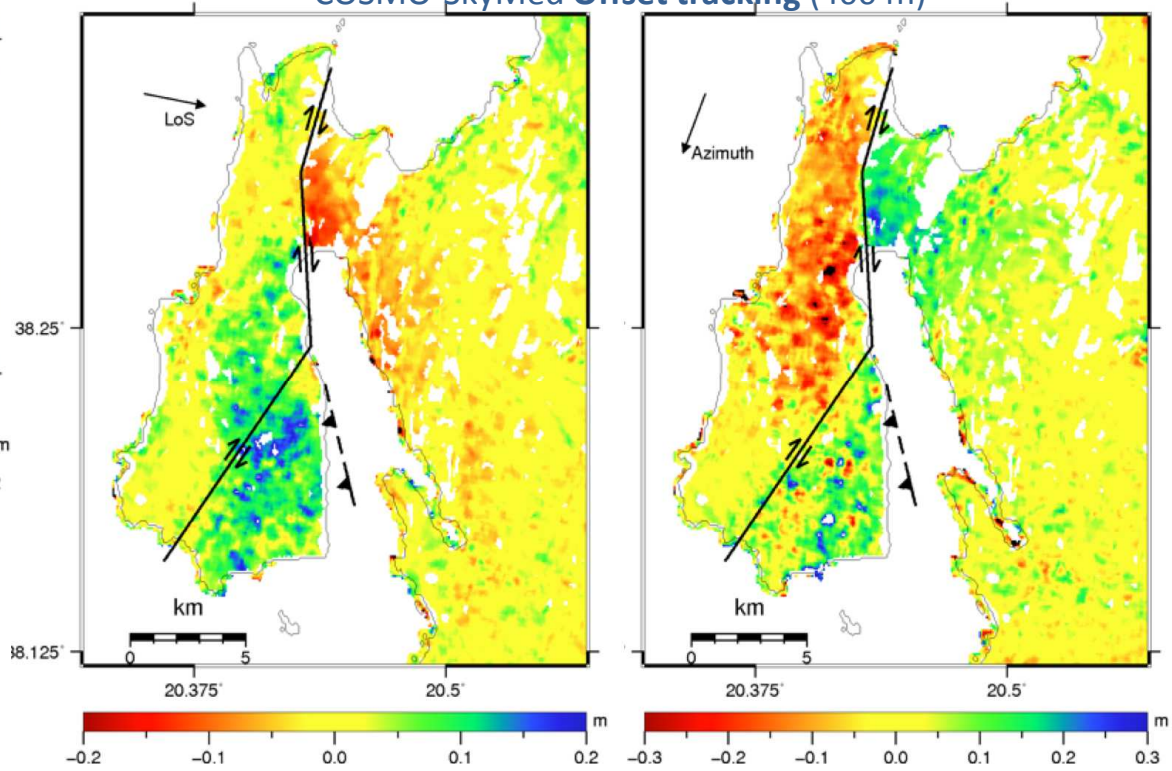
COSMO-SkyMed **DInSAR** (15 m)



COSMO-SkyMed **MAI** (~100 m)



COSMO-SkyMed **Offset tracking** (400 m)



OPEN CALL

COSMO-SkyMed Constellation

Open Call for Science

Italian Space Agency

The call is going to be published on ASI web site within February 2015

Conclusions

These not exhaustive examples I have just presented to you do not cover the incredibly numerous examples of the contribution provided worldwide by COSMO-SkyMed satellite constellation in supporting Emergency Management operations.

I am confident that these case studies gave you a good representation of the actual capabilities of the COSMO-SkyMed mission and its invaluable amount of data, showing as Italy plays a key role in the space-based technology for emergency management, providing its contribution in the national and international context.

Thanks for attention!