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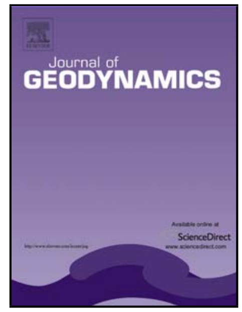

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COSMO-SkyMed an existing opportunity for observing the Earth

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ABSTRACT

COnstellation of small Satellites for Mediterranean basin Observation (COSMO-SkyMed) is the largest Italian investment in Space Systems for Earth Observation, commissioned and funded by Italian Space Agency (ASI) and Italian Ministry of Defence (MoD). COSMO-SkyMed is a Dual-Use (Civilian and Defence) end-to-end Earth Observation System aimed at establishing a global service supplying provision of data, products and services compliant with well-established international standards and relevant to a wide range of applications, such as Risk Management, Scientific and Commercial Applications and Defence Applications. The system consists of a constellation of four LEO mid-sized satellites, each equipped with a multi-mode high-resolution SAR operating at X-band. Three out of four COSMO-SkyMed satellites have been successfully launched the 8th of June, the 9th of December 2007 and the 25th of October 2008 respectively, while the remaining satellite will be deployed within 2010. COSMO-SkyMed 1 and 2 completed their Commissioning phase to test, verify and qualify the overall System and from the 1st of August 2008 both satellites are in the

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operational phase. The third satellite is still performing its commissioning and it is expected to enter in operation in the second half of 2009. The results of the commissioning phase of COSMO-SkyMed 1 and 2 are presented together with the Scientific Mission Exploitation strategy (i.e.: Announcement of Opportunity, Background Mission).

Keywords: **Keywords:** COSMO-SkyMed, Satellite Constellation, Synthetic Aperture Radar, Dual-Use, X-Band

1. INTRODUCTION

COSMO-SkyMed is the first italian dual Space System dedicated to the Earth Observation. COSMO-SkyMed is the largest Italian investment in Space Systems for Earth Observation, commissioned and funded by Italian Space Agency (ASI) and Italian Ministry of Defence (MoD). It is a Dual-Use (Civilian and Defence) end-to-end Earth Observation System aimed at establishing a global service supplying provision of data, products and services compliant with well-established international standards and relevant to a wide range of applications, such as Risk Management, Scientific and Commercial Applications and Defence Applications.

The system consists of a constellation of four LEO mid-sized satellites, each equipped with a multi-mode high-resolution SAR operating at X-band.

ASI in cooperation with MoD manages the contract assigned to an Italian industrial team, that is in charge of the project development. Thales Alenia Space Italia (TAS-I) is the Prime Contractor.

The results coming from the utilisation of the two operative satellites reveal the significant achievement of the X-band SAR and the importance of fast response time in a wide variety of applications. In this paper ASI will be presented some analysis and results related to a set of X-band SAR applications conducted during 2008. Moreover it will be given an overview of the mission exploitation strategy.

2. BRIEF MISSION NOTES

The object of the COSMO-SkyMed Program is to develop an End-to-End, turn-key system for "dual use" for both civilian and Defense purposes.

Primary Mission objective is thus to meet Customer's needs, under economical, schedule and political constraints, for a spaceborne Earth Observation System capable to provide:

- Environmental Risk Management for both civilian Institutional and Defence needs, through monitoring and surveillance applications assessing exogenous, endogenous, and anthropogenic risks.
- Provision of commercial products and services (e.g. for agriculture, territory management) to world-wide civilian user community

In order to reach these objectives the system has been conceived with the following main features:

- It is able to acquire images all over the world in every atmospheric condition during night and day,
- It is able to produce a large number of images with high resolution, accuracy (geolocation, radiometry etc) and quality,
- It is able to produce images for polarimetric and interferometric applications,

- It is able to acquire images with very short revisit and response times according to a specific product order.

Indeed COSMO-SkyMed Space Segment, at fully deployed constellation (4 satellites), will be capable to collect up to 1800 images per day; while the Ground Segment is currently downgraded in order to archive up to 560 images per day and to process 200 level 1C/1D products per day. Obviously the Ground Segment capacity can be scaled in order to fully exploit the constellation capacity when needed.

In order to supply data for a wide variety of application that range from cartography to emergency response the SAR payload has been designed to acquire a scene in various modes (see Table. 1) according to the image area and the resolution that is requested.

The Ground Segment can process this data in order to obtain product at the following standard processing level:

- Level 0 (RAW): containing for each sensor acquisition mode the unpacked echo data in complex in-phase and quadrature signal (I and Q) format.
- Level 1A (SCS), whose processing is aimed at generating Single-look Complex Slant (SCS) products.
- Level 1B (MDG), whose processing is aimed at generating Detected Ground Multi-look (MDG) products.
- Level 1C Products (GEC), whose processing is aimed at generating Geocoded Ellipsoid Corrected (GEC) products.

- Level 1D Products (GTC), whose processing is aimed at generating Geocoded Terrain Corrected (GTC) products.

2.1 Operative Modes

COSMO-SkyMed can operate in three different operative modes:

- Routine,
- Crisis,
- Very Urgent.

Each operative mode allows to satisfy different needs in terms of timeliness:

- ***Routine mode***: The image order can be satisfied in less than 72 hours.
- ***Crisis mode***: The image order can be satisfied in less than 36 hours on a specific crisis area.
- ***Very Urgent mode***: The image order can be satisfied in less than 18 hours.

2.2 Time Performance

Four definitions apply to the time performances:

- ***Reaction time***: time between the deposit and the acceptance of the user request at the User Ground Segment (UGS) until the SAR image on-board acquisition;
- ***Information age***: from the SAR image on-board acquisition to the product availability at UGS;
- ***Response time***: sum of Reaction time and Information age (The time needed for the delivery is not considered in the Response Time);
- ***Revisit time***: period between two successive acquisitions over the same target.

The time performance values depend by the target coordinates, the active Ground Segment, the constellation configuration and the operative mode.

The following tables (Table. 2 and Table. 3) report the values of the revisit time and the response time, scaled from the current configuration (2 satellites) to 4 satellites in orbit, in the average and worst cases. These values are referred to the nominal operative mode (Routine mode).

At the time being these time performances are the best that can be obtained among civilian SAR Systems.

3. THE SPACE SEGMENT

3.1 Orbital Configuration

In the nominal configuration, satellites are equi-phased in the same orbital plane, as shown in Fig. 1.

The nominal orbital configuration is conceived to grant access all over the globe in few hours, with at least two access opportunities per day with different incidence angles.

The mutual position of the satellites can be modified in order to make it more suitable for interferometric acquisition. Indeed the system can produce interferometric and DEM products, combining two radar acquisitions of the same target area detected by two satellites of the constellation with the same geometry. Obviously for some applications the more the two acquisition are close each other the more the decorrelation between the two images is low resulting in a better quality of the product. In COSMO SkyMed two interferometric configuration are foreseen: Tandem and Tandem-like (one-day interferometry).

In Fig. 2 is depicted the interferometric Tandem configuration. The two satellites are separated both in phase and in LTAN, with two different orbital planes with slightly different nodes (0.08 degrees of separation), such to obtain the "same" ground-track. This corresponds to a mutual distance of 151 km along track and allows to acquire the same scene with the same geometry with a delay of 20 seconds. The interval of the normal baseline can vary in a range of [100 m, 3500 m] (with 20% of accuracy) according to the acquisition mode.

In the Tandem-like configuration, two satellites are on the same orbit plane at a distance of 67,5°. This configuration allows to revisit any place on the earth with the same geometrical conditions (i.e. incident angle, etc.) after one day. The current configuration of the constellation is shown in Fig. 3: COSMO-SkyMed 1 and 2 are positioned at 180° each other, meanwhile COSMO-SkyMed 3 and 2 at 67,5° in tandem-like configuration (also called “one-day interferometry configuration”).

3.2 Platform

The following Fig. 4 shows the COSMO-SkyMed satellite in “stowed” configuration, i.e. when it is mounted in the launcher, and in fully deployed configuration. The platform architecture has been conceived to monitor each on-board equipment, to collect and distribute data to al the satellite unit, to receive and decrypt telecommands sent from the ground, to control the attitude and the orbit manoeuvres and for the transmission of satellite telemetries and the images to the ground stations.

One of the main characteristics of the platform is its agility since it makes possible acquisitions in left and right looking allowing to extend the access area of the System. This can be obtained by an attitude manoeuvre. The nominal side looking mode is the right looking.

3.3 SAR Antenna

The SAR antenna operates in X-band, with various resolutions (from 1 to 100 meters) and a number of polarizations over a large access region. It is equipped with a fixed antenna, having electronic scanning capabilities and it can manage a number of operative modes for the image acquisition but also for internal calibrations.

The nominal incidence angles (where the system grants the image quality requested) vary between 25° and 50°. The extended incidence angles vary between 20°-25° and 50°-59° but also in this case the image quality is very close to the nominal condition.

The access area, using the extended incidence angles, can reach 630 km.

4. THE GROUND SEGMENT

4.1 Overview

The COSMO-SkyMed system is dual, hence the applications are for civilian and defence users, assuring at the same time the data confidentiality and the integrity in each operative configuration.

The principles of a dual system are obtained through a specific architecture based on the innovative concept and the implementation of:

- the Ground Segment elements, with the aim to satisfy the civilian and defence user needs at the same time;
- the common centres, where the information are melted and processed together, adequately protected in terms of security.

4.2 Ground Segment Components

The main components of the Common Ground Segment are:

- Centro Pianificazione e Controllo Missione (Mission Planning and Control Centre, CPCM), in charge of coordinating the on-board and on ground operations through the generation of the acquisition plan and the management of all the activities including the resources sharing and the acquisition requests conflict solving;
- Core Ground Segment (CGS), composed of Centro di Controllo Satellite (Satellite Control Centre - CCS), Flight Dynamic System (FDS) and TT&C stations;
- User Ground Segment (UGS) whose aim is to receive and process the user requests, to acquire, archive, process and deliver the data received from the satellites of the constellation;
- Communication Network;
- GPS Fiducial Network: a support service to give the GPS ephemeris and the necessary data to increase the products geolocalisation.

4.3 Integrated Logistics and Operations Segment

Given the complexity and heterogeneity of the system, a big emphasis has been given since the design stage to Integrated Logistics and Operations Segment (ILS&OPS), that include the design and development of all the necessary resources processes and services needed to grant the availability and sustainability needed to operate the overall system.

5. LEOP AND COMMISSIONING PHASES

5.1 Overview

The first three satellites have been successfully launched from Vandenberg Air Force Base in California (US) by BOEING DELTA II Rocket. The outstanding performance of the Rocket allowed the satellites to be in the expected orbit and to preserve important amount of propellant.

At the current time the system with two satellites is in the operational phase and the civilian institutional and commercial users, as well as the defence users, are ordering images over a wide variety of areas.

The third COSMO-SkyMed satellite has been launched on October 28th 2008, and after the successful completion of LEOP, is entering its commissioning phase. The satellite has been positioned in Tandem-like configuration allowing, when operational, to perform 1-day interferometry.

The entire constellation will be completed by the end of 2010 and it will be fully operative by the end of 2010.

5.2 LEOP

During this phase the launch completion, the correctness of the orbital parameters and the start-up of the satellite have been verified.

All satellites have been placed in a stable orbital configuration showing nominal parameters in terms of thermal and power stabilisation, telecommands and control correctness and nominal deployment of the satellite appendices.

5.3 Commissioning Phase

The Commissioning Phase has been performed at the same time for COSMO-SkyMed 1 and COSMO-SkyMed 2, at the end of this phase both satellites entered in the Operational Phase. COSMO-3 successfully performed the commissioning first two stages (LEOP and In Orbit Test) devoted to performance requirements verification. Current activities are dedicated to check the system capability to maintain such performances in a quasi-operational context [12]. It is worth of mention that, though not yet formally commissioned, COSMO-3 has been used for Abruzzo earthquake acquisition campaign on April 2009, and it is expected to enter in operation in the second half of 2009.

During the Commissioning Phase the verification of the functionality, the performance and the operations of both satellites and of the overall System have been completed.

All the payloads, subsystems and elements of the satellites have been verified in orbit through the utilisation of the Ground Segment. All the calibration activities have been completed testing and verifying the SAR antenna of each satellite. The verification and validation of the whole System (satellites, sites and support System) have been completed.

The results coming from the Commissioning Phase confirm the high nominal performances of the constellation in terms of quality of product, system capacity and time performances already mentioned in the previous sections and scaled to the constellation with two satellites (see Table. 1, Table. 2 and Table. 3). In Table. 4 are reported some results obtained with a stripmap image during the calibration campaign performed in this phase, also in this case COSMO-Skemed confirm the expected results concerning the geometric resolution and a substantial overperformace concerning the geolocation accuracy.

It is important to highlight that COSMO-SkyMed guarantees this performances within the very tight time constraints shown in 2.2. Indeed the localization error can be improved gathering and integrating GPS measure of the site over a long time (weeks) but this is not applicable when the response time is of the essence as shown in 7.3 and 7.4. Therefore these characteristics make COSMO-Skymed very well suited for disaster management application .

6. OPERATIONAL PHASE

The System with two satellites entered in the operational phase on the 1st of August and is currently used by both civilian and defence users.

7. ACQUISITIONS DURING THE COMMISSIONING PHASE

7.1 Overview

During the Commissioning Phase the first two satellites have begun to acquire thousands of images all over the globe, showing the full potentiality of the System.

In the following there are some examples of applications realised using the images of COSMO-SkyMed 1 and 2 during the Commissioning Phase, to give an idea of the capability of the System and also to highlight the activities already performed to help rescue actions in emergency and natural disaster situations (Myanmar Flood and China Earthquake).

7.2 Ocean And Ice Applications (February-March 2008)

The images acquired by the COSMO-SkyMed satellites during February and March over the Northern Caspian Sea and the Antarctic Region show the great potentiality of the X-band SAR data in Ocean and Ice applications.

The penetration of the X-band electromagnetic waves allows volumetric analyses of the ice, as shown in Fig. 5 (Stripmap HIMAGE collected on the 9th of February 2008).

The same image acquired by an optical sensor should show the sea surface completely covered by ice.

Furthermore the next image (Fig. 6) makes even more evident as the X-band can show the internal difference of the ice sheets, for example the rescue ways, traced by icebreakers in the previous months (that are not visible in the optical spectral range), are clearly shown in the X-band image (circle and arrows highlight the rescue ways).

At the end of March after the alert based on the images collected by ENVISAT satellite of the European Space Agency (ESA), COSMO-SkyMed acquired some images of the disintegration of the Wilkins Ice Shelf as reported in Fig. 7 (Stripmap HIMAGE of the 31st of March 2008).

COSMO-SkyMed constellation makes possible the monitoring of these fenomena with a fast revisit time and the identification of large and small ice pieces thanks to its high resolution.

7.3 Myanmar Flood (May 2008)

Devastating Cyclone Nargis hit the Yangon region (southern Myanmar) on May 3rd 2008. The following acquisitions have been done by COSMO-SkyMed 1 after the flood:

- ScanSAR Huge Region: May 6th

- ScanSAR Wide Region: May 7th
- StripMap HIMAGE: May 8th
- Spotlight-2: May 10th
- Spotlight-2: May 11th
- StripMap HIMAGE: May 14th

On the 6th of May over Rangoon area COSMO-SkyMed 1 acquired an image (SCANSAR - Huge Region) with a fast Response Time equal to 20 hours, allowing to know in a short time the situation of the areas affected by the flood and to identify the main zones where the rescue actions had to take part.

The COSMO-SkyMed acquisition (ScanSAR Huge Region collected on the 6th of May) is reported in Fig. 8.

The flood areas are recognisable in the dark areas (highlighted by the circles). Another COSMO-SkyMed image of the disaster is reported in Fig. 9.

The World Food Programme (WFP) used COSMO-SkyMed images to create maps to be used for rescue actions. The flood evolution (between 6th and 8th of May) has been represented in the following picture (Fig. 10) elaborated by the WFP (red areas are affected by the flood):

7.4 China Earthquake (May 2008)

A powerful earthquake has killed at least 10,000 people in China's south-western Sichuan province, up to 5,000 of them in just one county. Many more have been killed and injured in other parts of

China after the 7.8 magnitude quake struck on the 12th of May. COSMO-SkyMed processed the first image with a Response Time of 16 hours from the alarm.

In Fig. 11 is reported an image of the Guan-Xian area (in Sichuan province). The image was relevant for monitoring the damage and the general situation of Guan-Xian area and the potential damage of the dike (see top left of the image). The image in Fig. 12 clearly shows the damage of a building after the quake. Indeed the pictures shows two buildings that in nominal condition should appear as two parallel bright straight lines; the collapsed walls of one of them are evident because the line is no more straight (see red arrows) and the debris produce an high backscattered energy due to their irregular shape.

The images acquired by COSMO-SkyMed, in the days immediately after the earthquake, were of a great importance to help the rescue actions. This event showed the huge contribution of the COSMO-SkyMed space constellation in monitoring and observation of natural disasters of this relevance.

7.5 Agriculture Multi-Temporal Acquisition (May-July 2008)

A multi-temporal acquisition over agricultural fields have been performed on the 25th of May, 26th of June and 28th of July 2008 over Kumagaya (Japan) area, near Tokyo city (Fig. 13). The area of acquisition is essentially composed of agricultural fields. The three COSMO-SkyMed images are acquired in the Spotlight mode and the multi-temporal acquisition is a Co-registered product obtained using the three Spotlight images.

The multi-temporal acquisition highlights a strong signal on the 28th of July (red-violet colour) that should be due to the presence of the rice fields (confirmed by observations in situ).

On May the rice fields are just at the beginning of the cultivation status and on May-June the presence of the water becomes quite relevant (in such cases the radar signal is weak), on July the first rice plants begin to grow up and their presence makes stronger the SAR signal.

7.6 Remarks

These are just examples of the capability of the COSMO-SkyMed constellation. Now with the beginning of the operational phase, COSMO-SkyMed becomes an important vehicle for the study of the Planet.

8. COSMO-SKYMED SYSTEM ACCESS

The access to the COSMO-SkyMed products for civilian use is ruled by the COSMO-SkyMed data Policy. According to this policy there are two main classes of Civilian users:

1. ***Institutional Users***
2. ***Commercial Users***

The institutional users are “entities” that pursue institutional, scientific (no profit oriented) and public objectives.

The access to COSMO-SkyMed civilian institutional user is granted through a web site: www.cosmo-skymed.it. On this site the potential user will find all the information about COSMO-SkyMed available products and services and the general terms and condition of the service.

The Institutional Use status needs to be assessed via a process managed by ASI under the data policy regulation.

A specific agreement will be settled identifying the user class and the relative quota of the COSMO-SkyMed System resources (including data and products) to be assigned to the end-user.

At the end of the process the user will get the information (user-name and password) necessary to log-in the system allowing to request data through a relevant web-form.

9. SCIENTIFIC MISSION EXPLOITATION STRATEGY

The Scientific Mission Exploitation Strategy is focused mainly on two projects:

- The COSMO-SkyMed Announcement of Opportunity;
- The Background Mission.

The main scopes of the Scientific Mission Exploitation Strategy is to grant the access to the System to the Scientific community, supporting them with the provision of COSMO-SkyMed data to conduct scientific projects in several thematic areas.

9.1 The First Cosmo-Skymed Announcement Of Opportunity

In May 2007 ASI issued the Announcement of Opportunity (AO) through the web pages of the Agency, to stimulate the use of COSMO SkyMEd system for civilian research purposes and Earth Observation application development, using the products of the Mission for:

- development of scientific applications;
- development and validation of Level 2 geophysics products algorithms;
- demonstration of the capabilities of COSMO-SkyMed in the thematic areas of GMES and GEO;

- new ideas for system exploitation.

The first Announcement of Opportunity has been a success since the CSK AO has attracted a great interest from over 600 scientists in more than 40 nations. In response to the CSK AO these scientists have proposed around 200 complex and interdisciplinary projects covering a wide spectrum of applications.

The Italian scientific community answered strongly but it must be highlighted that great part of the projects are conceived by international scientific teams, demonstrating an excellent cohesion and interest of the scientists at world wide level.

Some statistics on the first Announcement of Opportunity are reported in the following:

- Requested observation areas are focused mainly on global coverage, Italy and Europe, as shown in Fig. 14.
- Research project proposals cover wide thematic areas specified in the announcement. A strong interest can be noted on land use monitoring, ocean and ice and landslides phenomena observation as shown in Fig. 15:

Selected projects will start in the first half of 2010 and will last two years providing the opportunity to exploit at least the data collected by three satellites of the constellation.

9.2 Background Mission

The Background Mission has been conceived by ASI with the aim to collect images all over the world for the catalogue fulfilling. The Background Mission implements the lowest level of priority plan, i.e. when no further activity (so called foreground activity) is defined.

The Background Mission is based on the COSMO-SkyMed primary mission objectives:

- Risk Management Applications (guideline field)
- Cartography and planning applications
- Agriculture
- Forest
- Hydrology
- Geology
- Marine domain
- Archaeology

Inputs to the Background Mission come from:

- Scientific indications specified in the projects of the first CSK Announcement of Opportunity
- Institutional Users
- Commercial users

10. CONCLUSIONS

At worldwide level COSMO-SkyMed is the only SAR constellation currently operative dedicated to the civilian and defence use.

At present COSMO-SkyMed constellation allows to reach high performance in terms of Revisit and Response Time, number of images, image quality, short gap for interferometric acquisitions, these performances will be further enhanced when the third and the fourth satellite will complete the constellation (end of 2010).

The Commissioning Phase confirms that the system meets the performance required showing, for instance, that in the worst case the resolution stays below the threshold shown in Table. 1 and time performaces are better than those in Table. 2 and Table. 3. .

The constellation has been successfully used in various applications in the field of risk and emergency management such as China's earthquake, Myanmar and Haiti flood, Abruzzo earthquake, ice monitoring (reduction of the glaciers, Wilkins Ice Shelf disintegration), multi-temporal acquisition for agriculture monitoring, interferometry, landslides monitoring, maritime surveillance and security, rapid mapping. The results reveal the strong contribution of the X-band SAR and the importance of satellite constellation to get fast response and short revisit time.. A preview of the images acquired as from August 2008 is available on the COSMO-SkyMed web site.

For the scientific community the main project dedicated to the exploitation of the COSMO-SkyMed data is the Announcement of Opportunity.

In response to the first COSMO-SkyMed AO more than 600 scientists, coming from more than 40 nations, have proposed around 200 complex, interdisciplinary and international projects.

Selected projects will be activated by mid 2010 and they will last two years.

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Fig. 15. Research thematic areas.

Table. 1. COSMO-SkyMed acquisition modes characteristics.

	SPOTLIGHT	STRIPMAP	PING-PONG	SCANSAR WR	SCANSAR HR
Resolution [m]	1 x 1	3 x 3 – 5 x 5	15 x 15	30 x 30	100 x 100
Swath [km]	10 x 10	40 x 40	30 x 30	100 x 100	200 x 200
Possible Polarisation [T/R]	Single. Selectable among HH or HV or VH or VV	Single. Selectable among HH or HV or VH or VV	Alternating polarisation: 2 polarisations selectable among HH, VV, VH and HV	Single. Selectable among HH or HV or VH or VV	Single. Selectable among HH or HV or VH or VV
Incidence Angles [deg]	25-50 (nominal) - 20-59,5 (extended)				

Table. 2. Time performances of the CSK constellation – Worst Case.

	2 sat.	3 sat.	Full Constellation
Response Time	90 h	85 h	72 h
Revisit time	37 h	35.5 h	12 h

Table. 3. Time performances of the CSK constellation – Average values.

	2 sat.	3 sat.	Full Constellation
Response Time	40 h	38 h	37.5 h
Revisit time	5 h	3 h	2 h

Table. 4. Performances of the CSK constellation – Measured values.

RESOLUTION	
Ground Range resolution/DIM [m/ground]	4.677
Azimuth resolution/DIM [m]	4.912
LOCALIZATION MEASURE	
Azimuth Localization error [m]	3.5036454
Ground Range Localization error [m]	-4.4107693

Fig. 1. COSMO-SkyMed constellation in nominal configuration

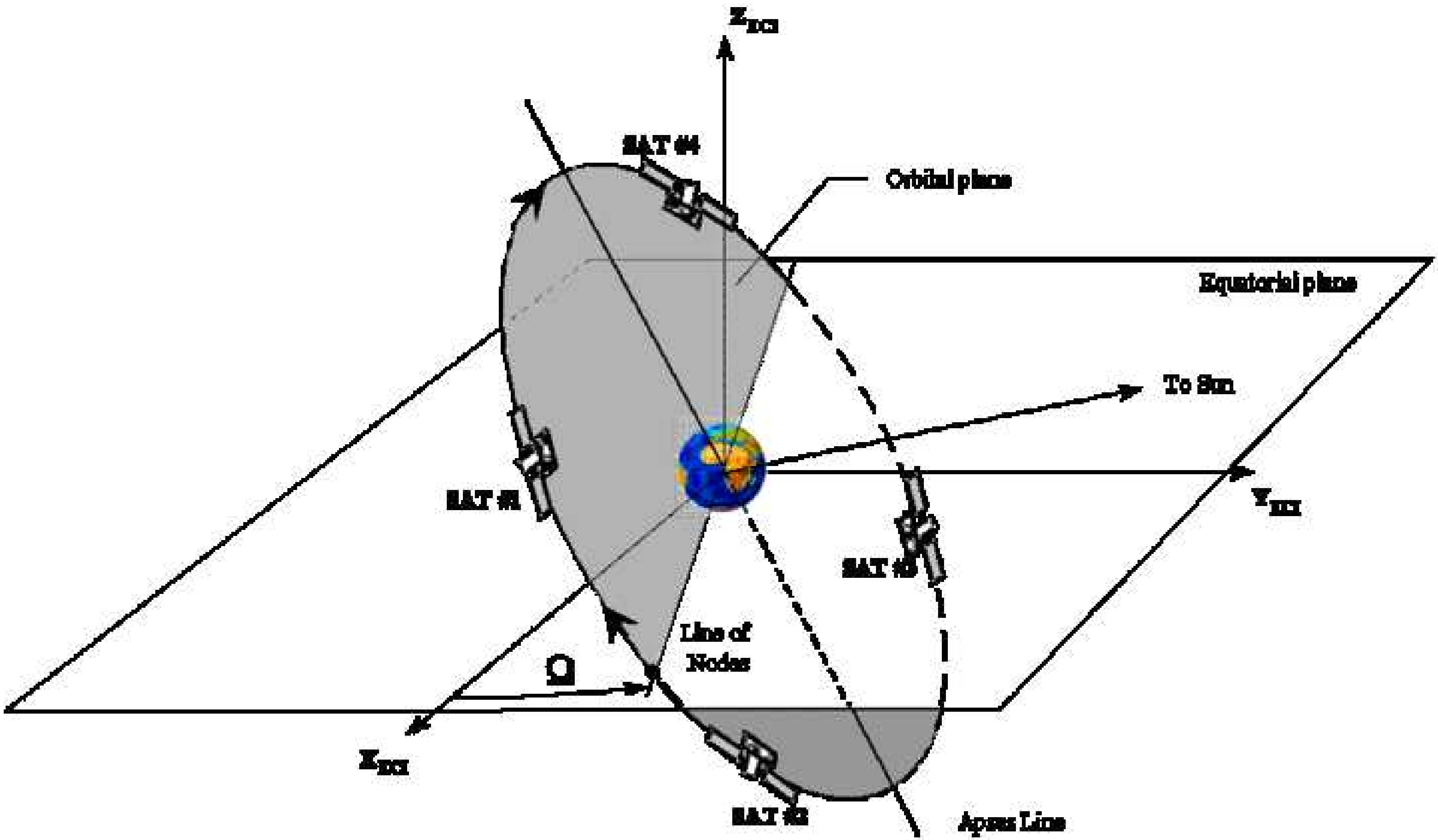


Fig. 2. Tandem Interferometric Configuration in different orbit

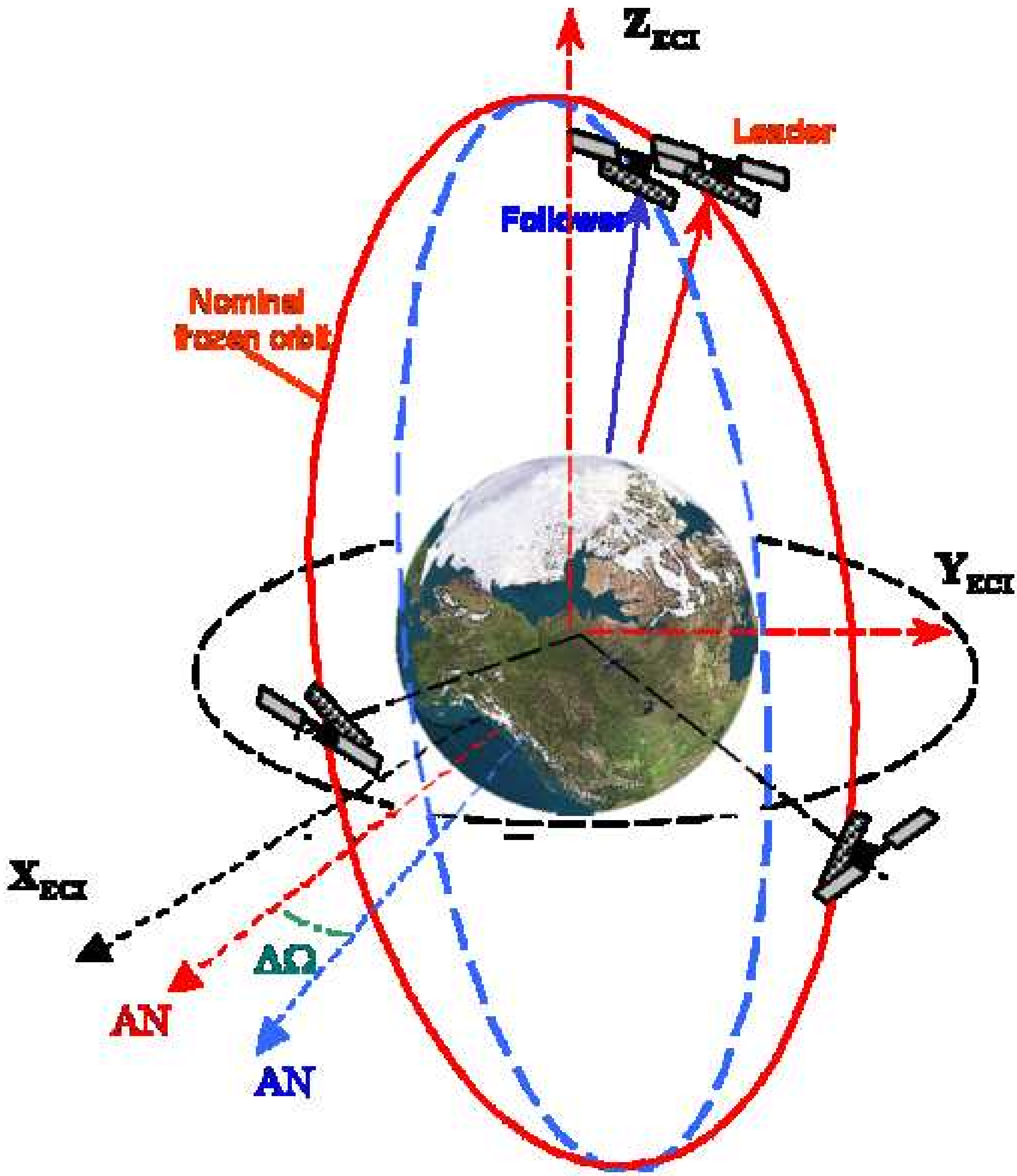


Fig. 3. COSMO-SkyMed constellation in current configuration.

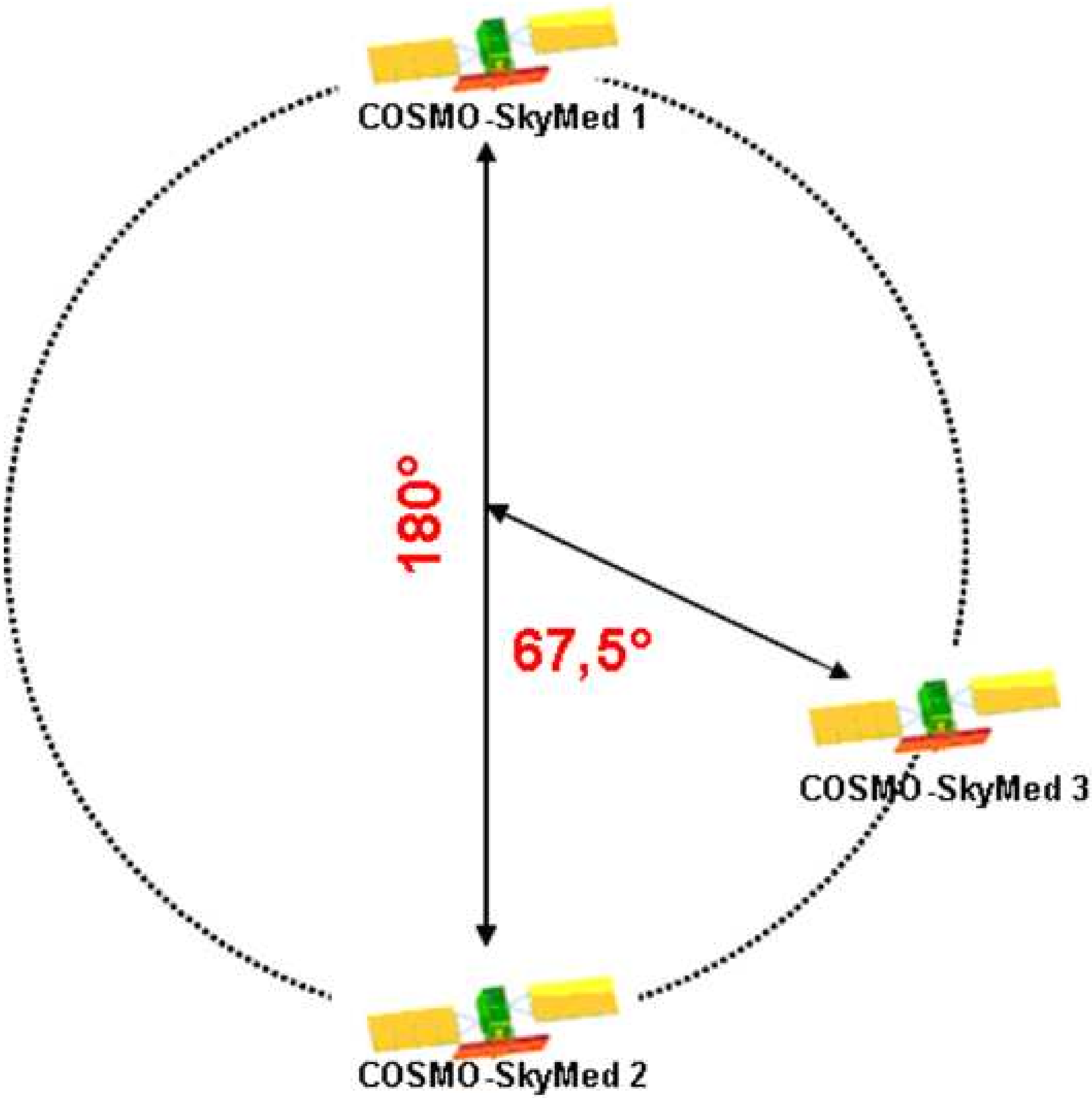


Fig. 4. COSMO-SkyMed satellite ("stowed" and deployed configurat

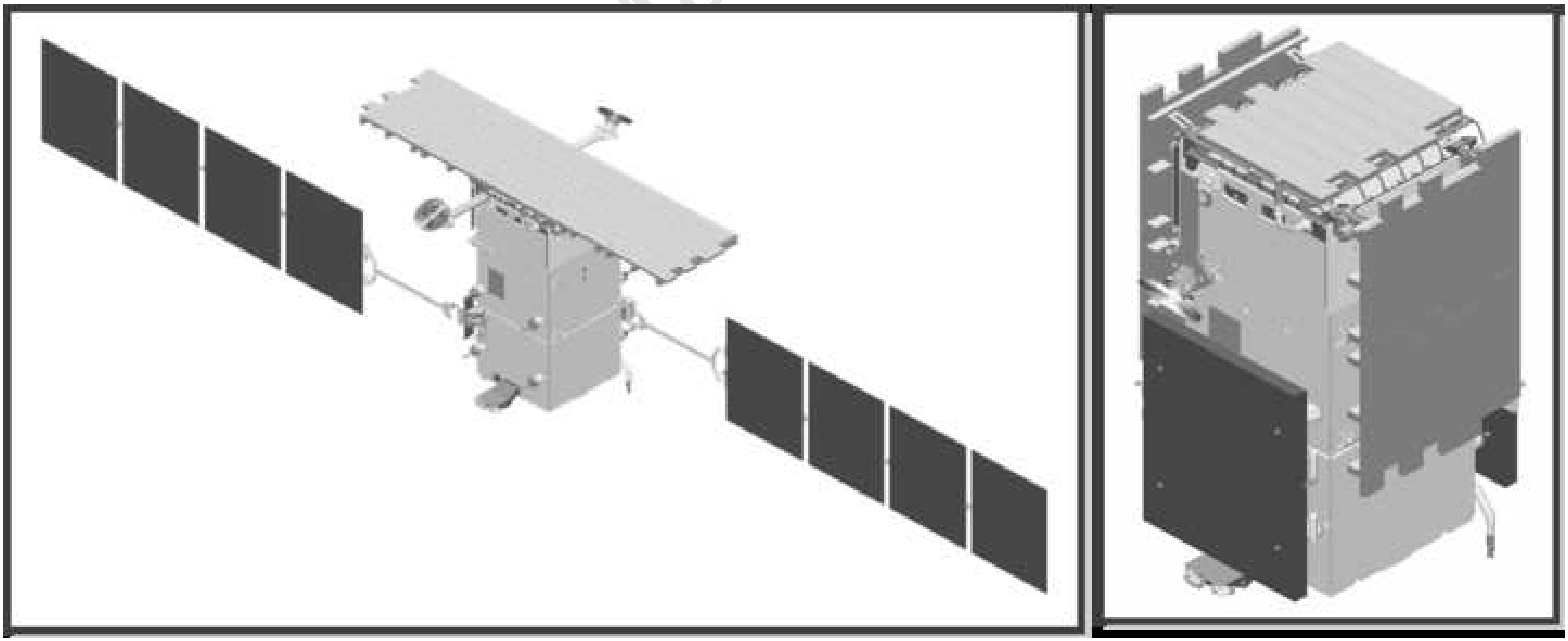


Fig. 5. Stripmap HIMAGE collected on the 9th of February over th

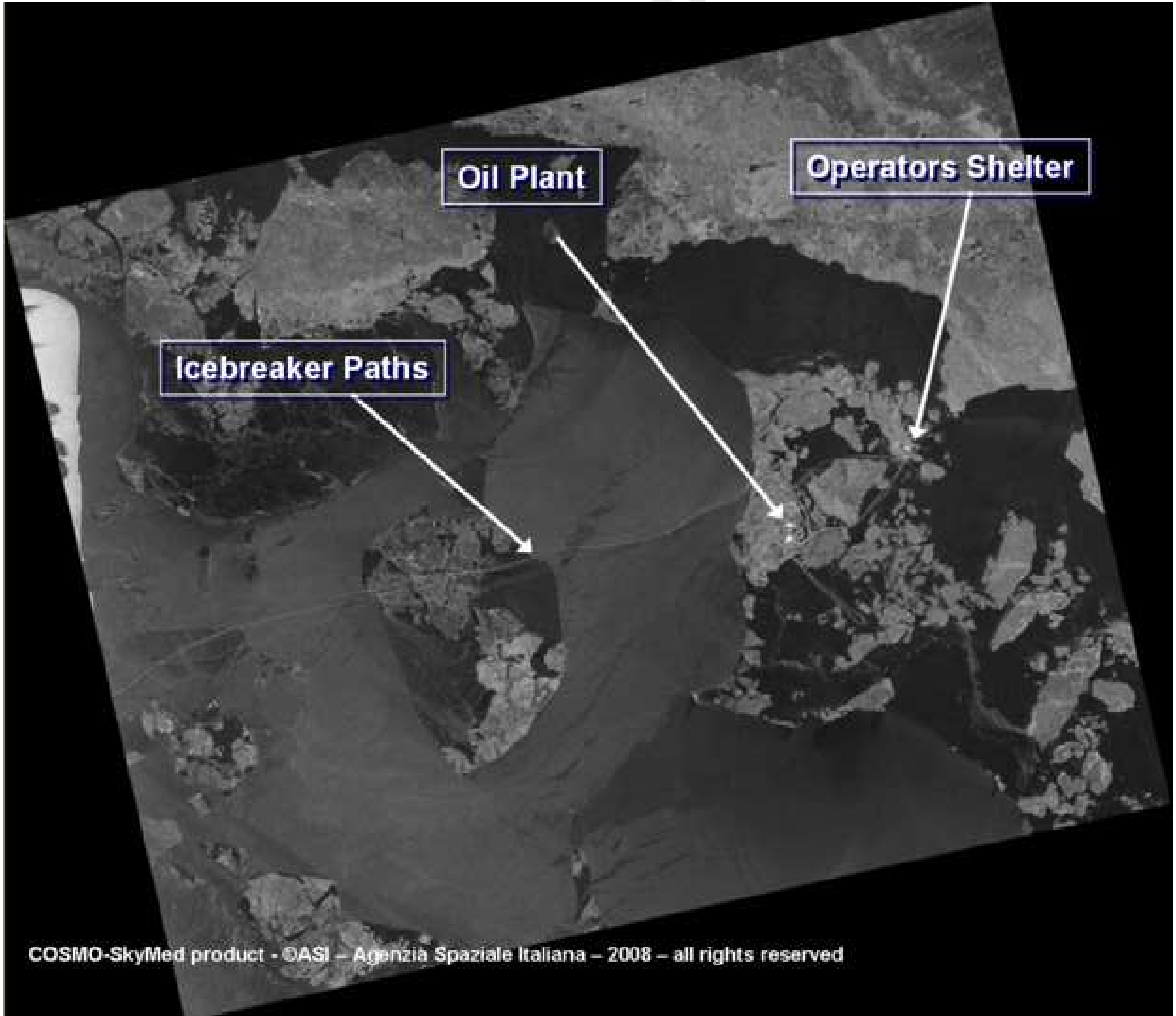


Fig. 6. Stripmap HIMAGE collected on the 9th of February over th

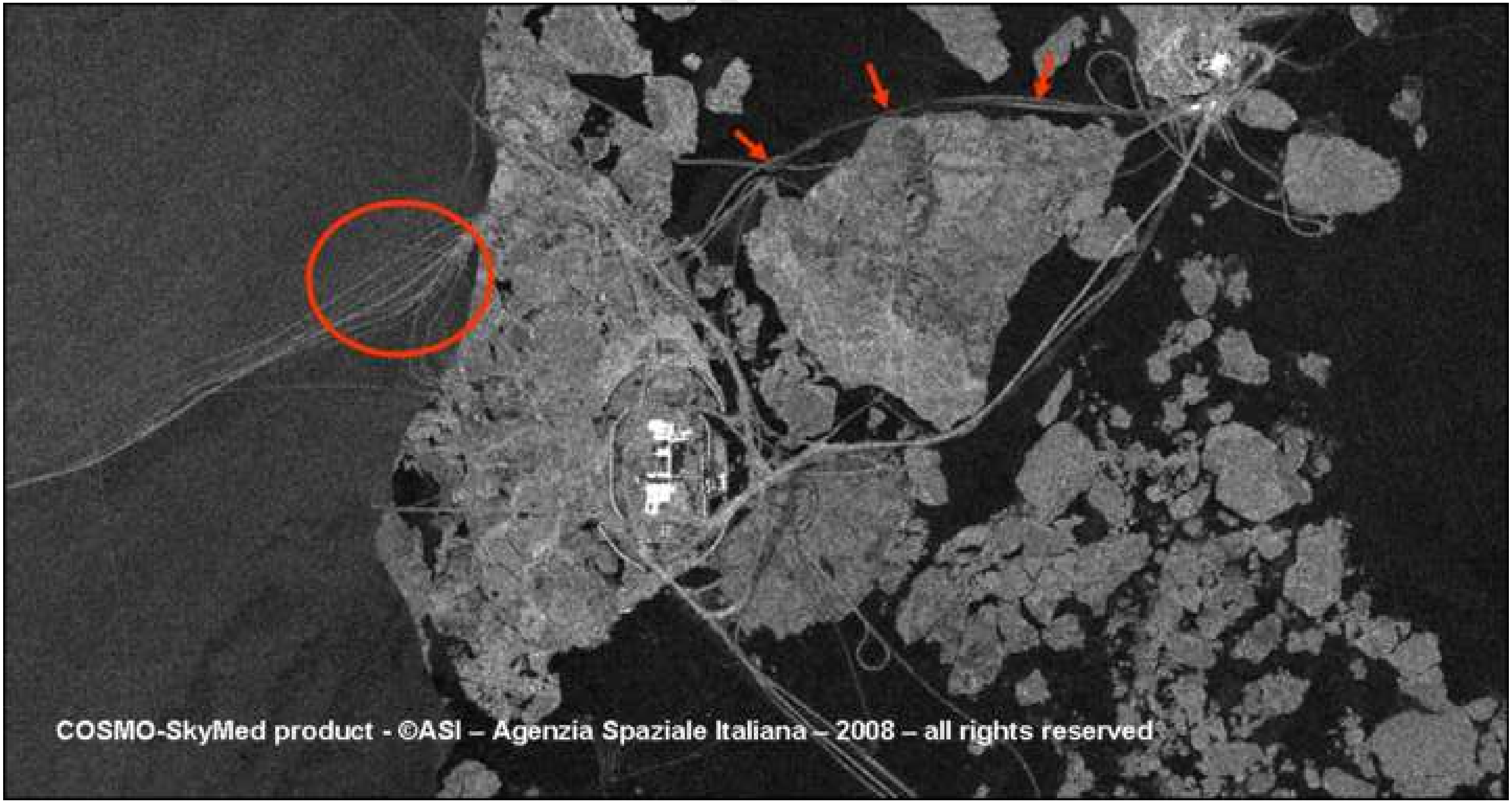


Fig. 7. Stripmap HIMAGE collected on the 31st of March: disinteg

Fig. 8. ScanSAR Huge Region collected on the 6th of May over Ran

Fig. 9. Stripmap collected on the 8th of May over Rangoon Area,

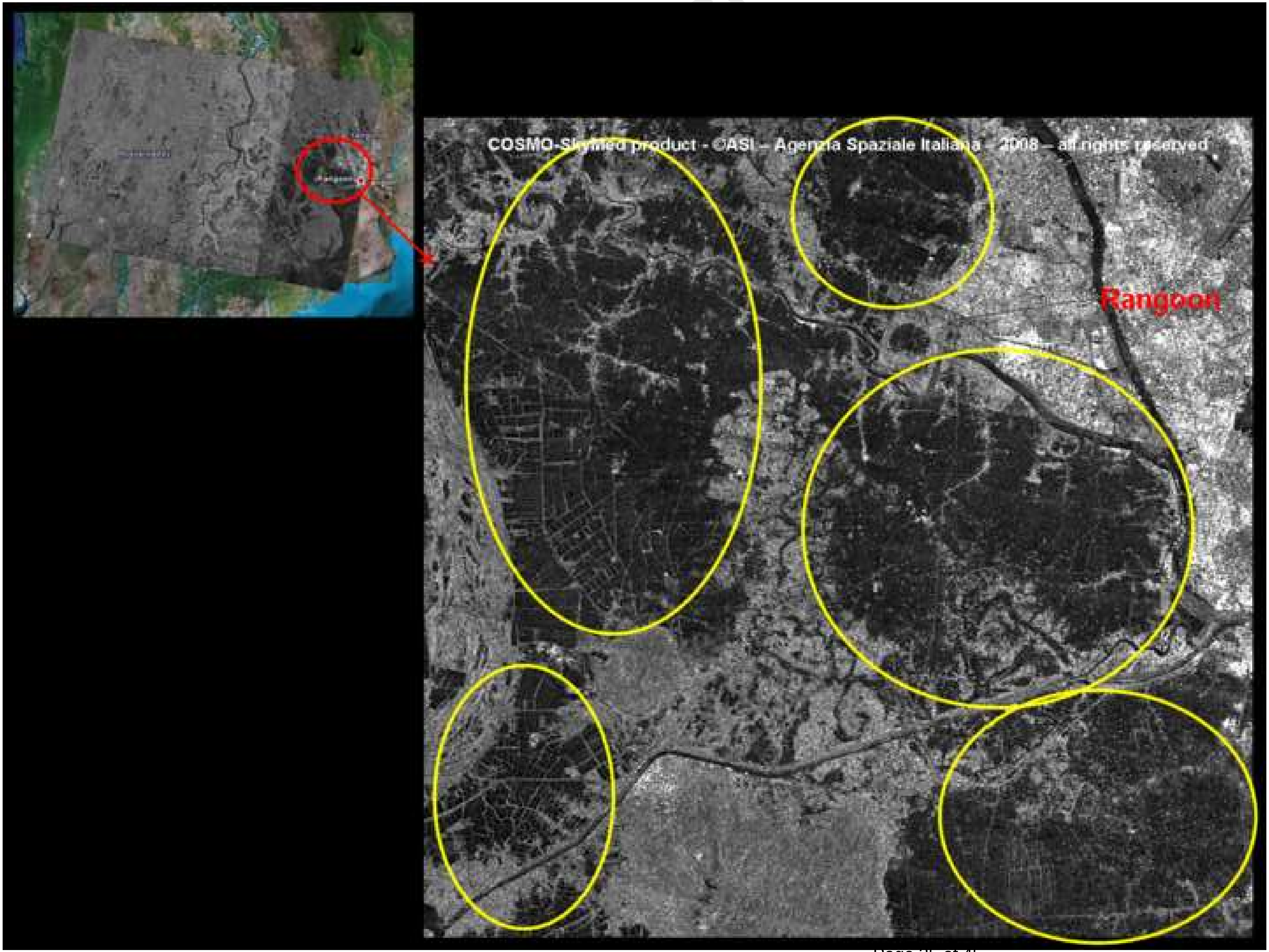


Fig. 10. Flood evolution Map [Credits to WFP].

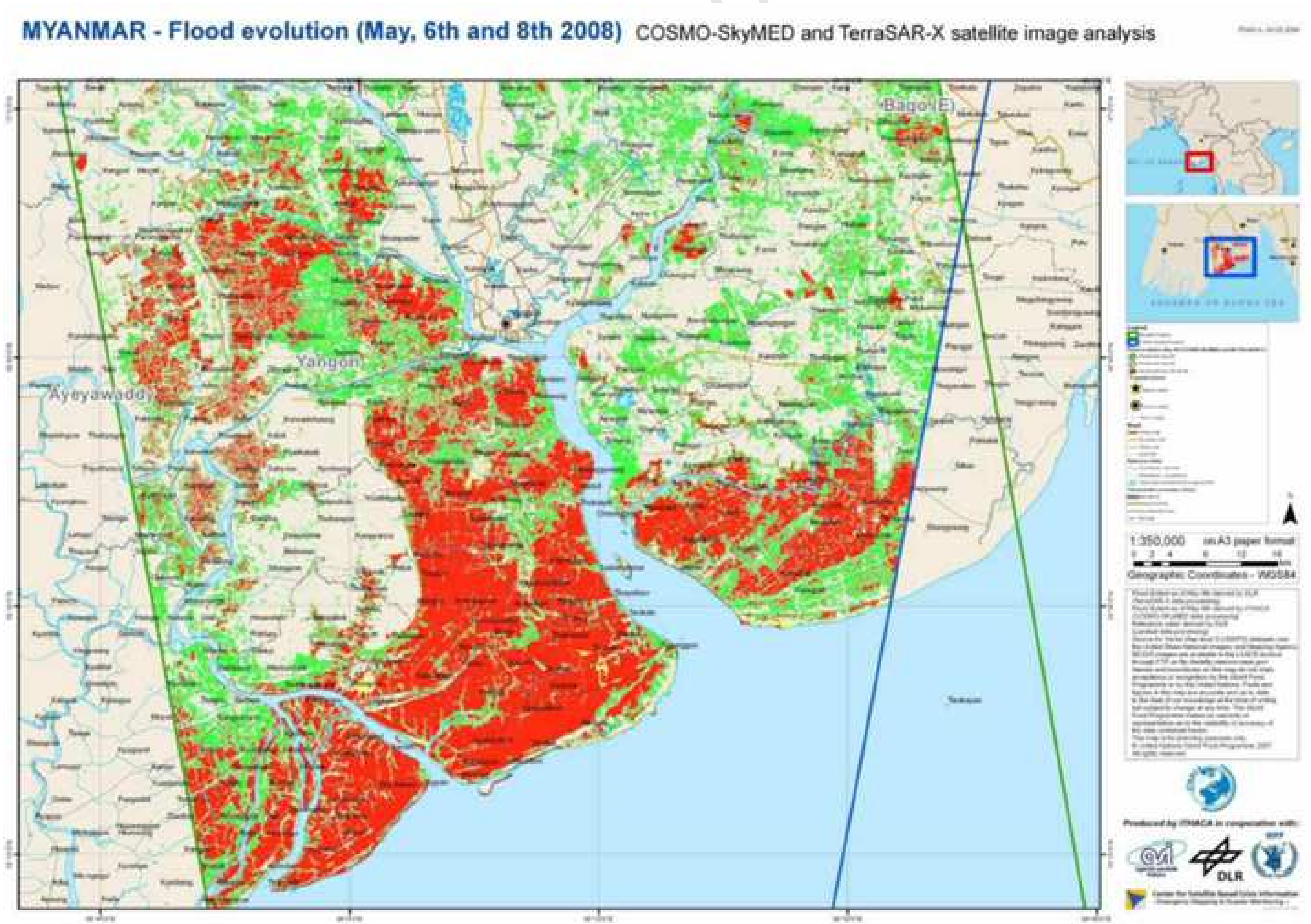


Fig. 11. Spotlight collected on the 13th of May 2008 over Guan-X

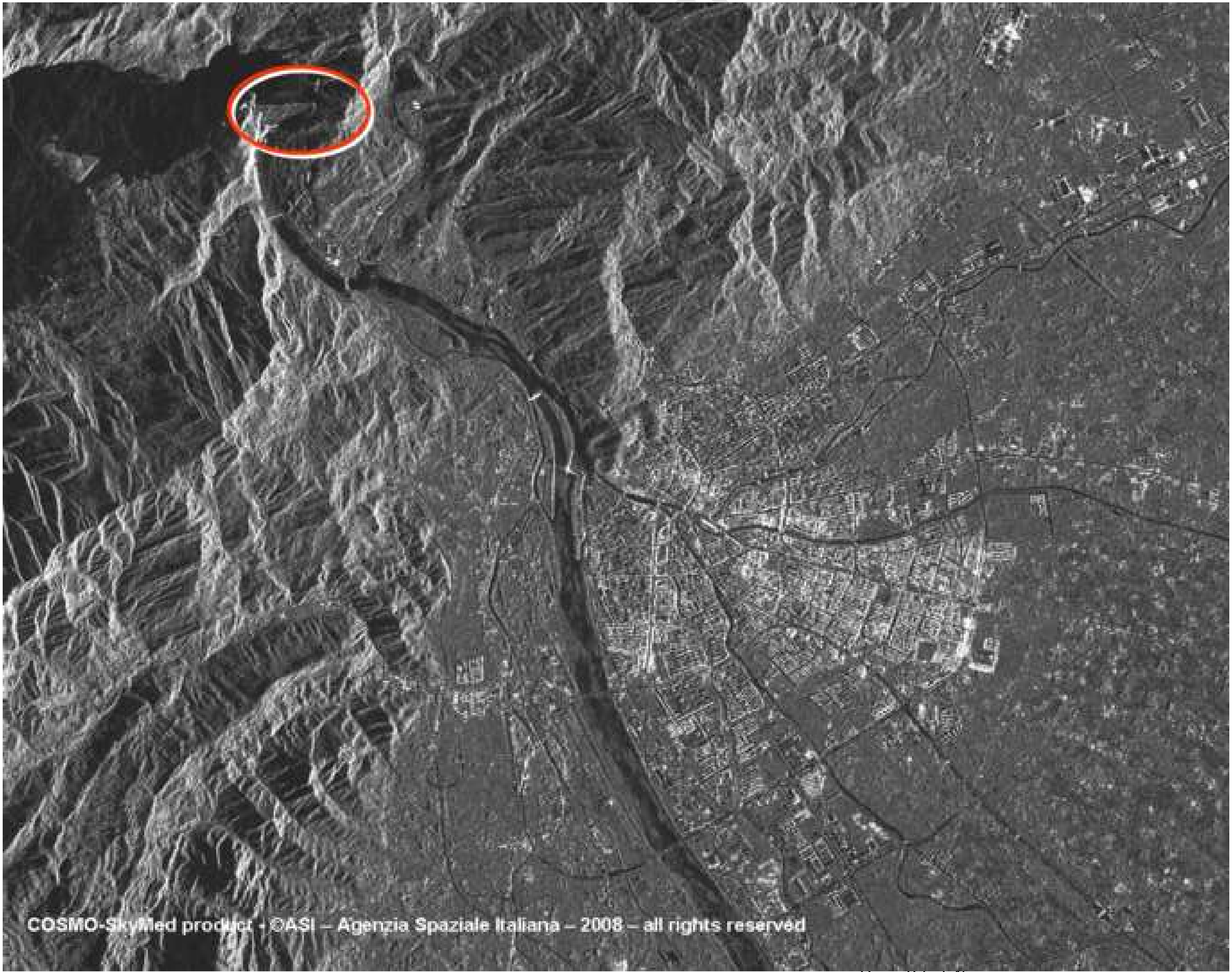
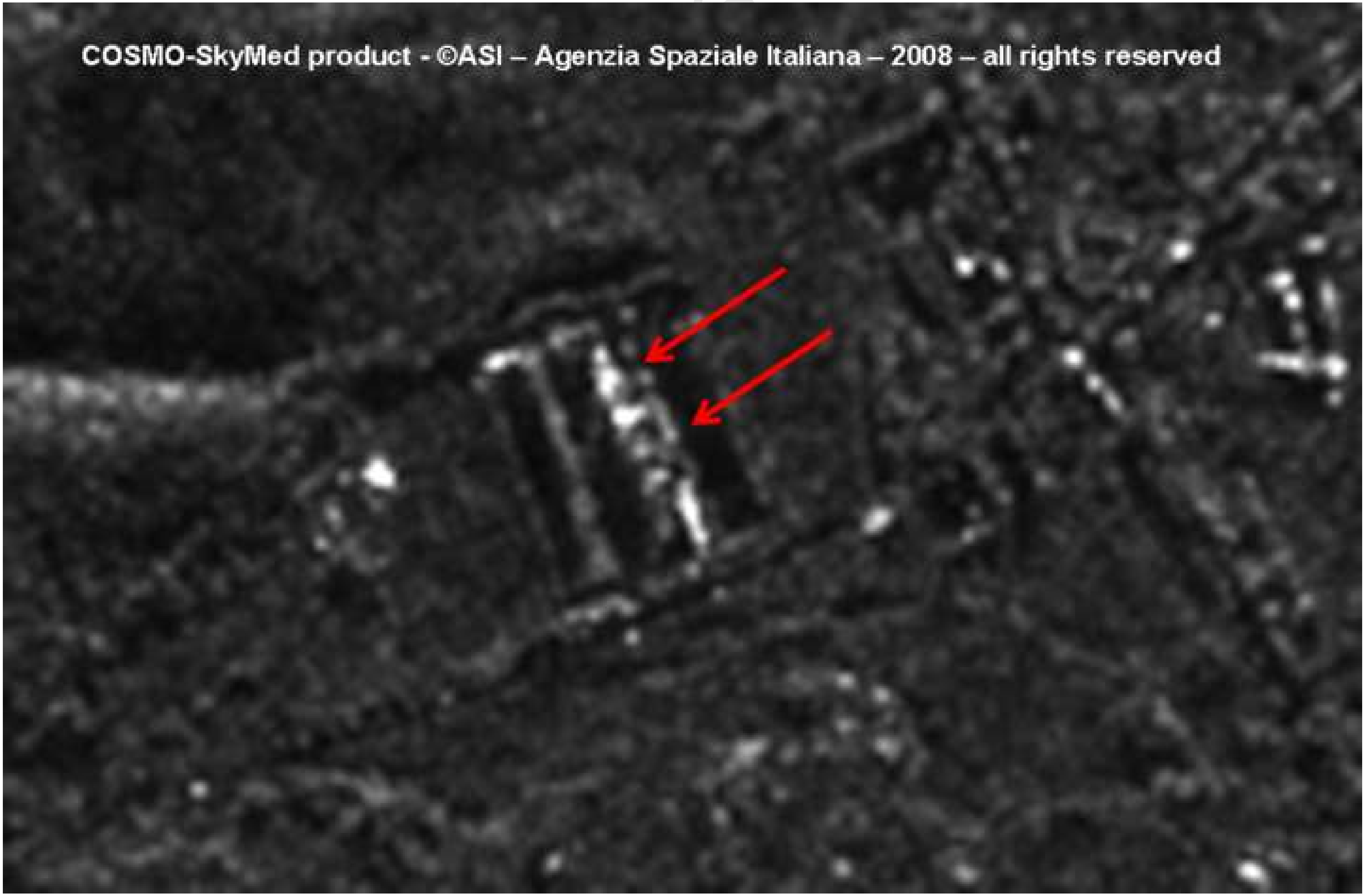


Fig. 12. Spotlight collected on the 13th of May 2008 over Guan-X



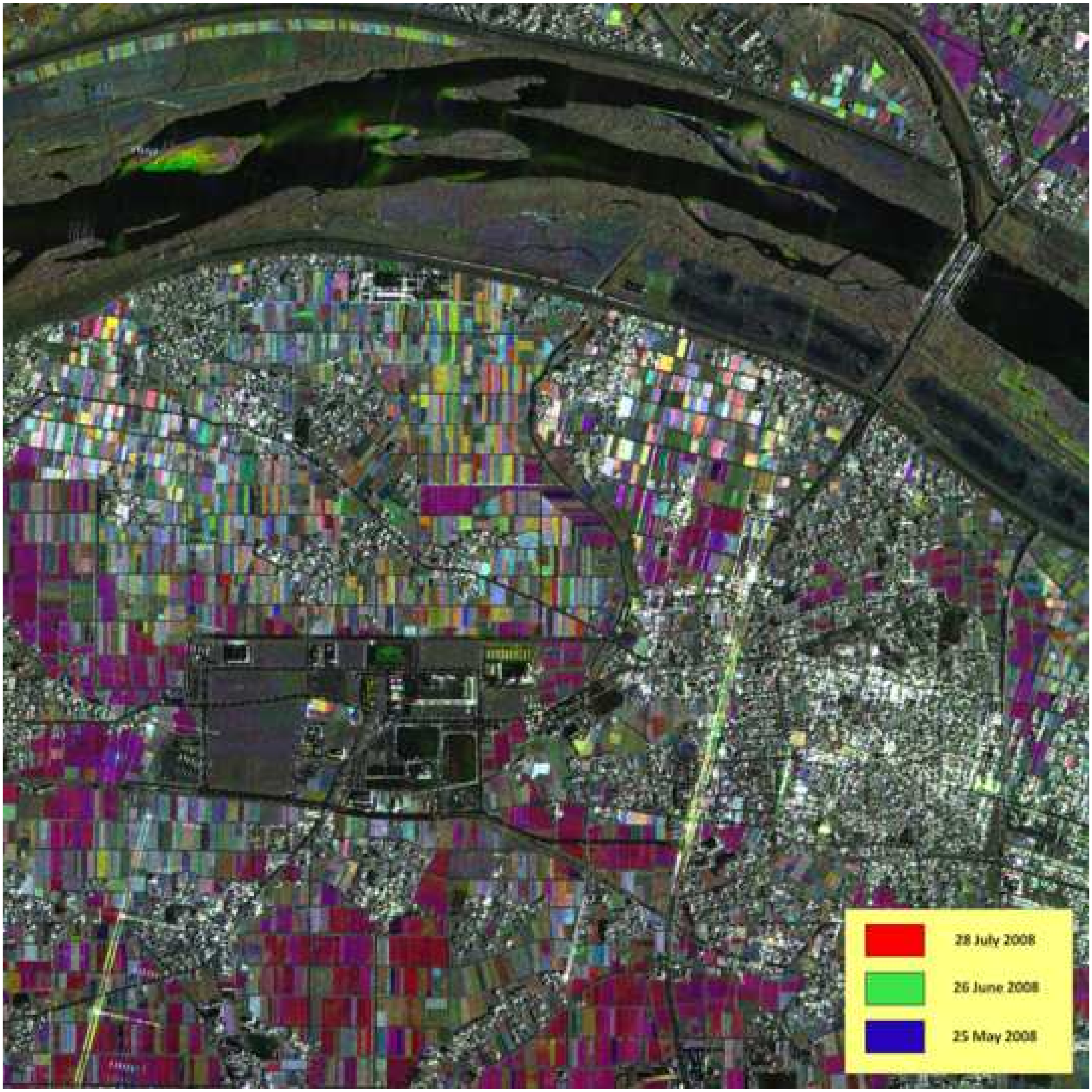

28 July 2008
26 June 2008
25 May 2008

Fig. 14. Requested observation areas.

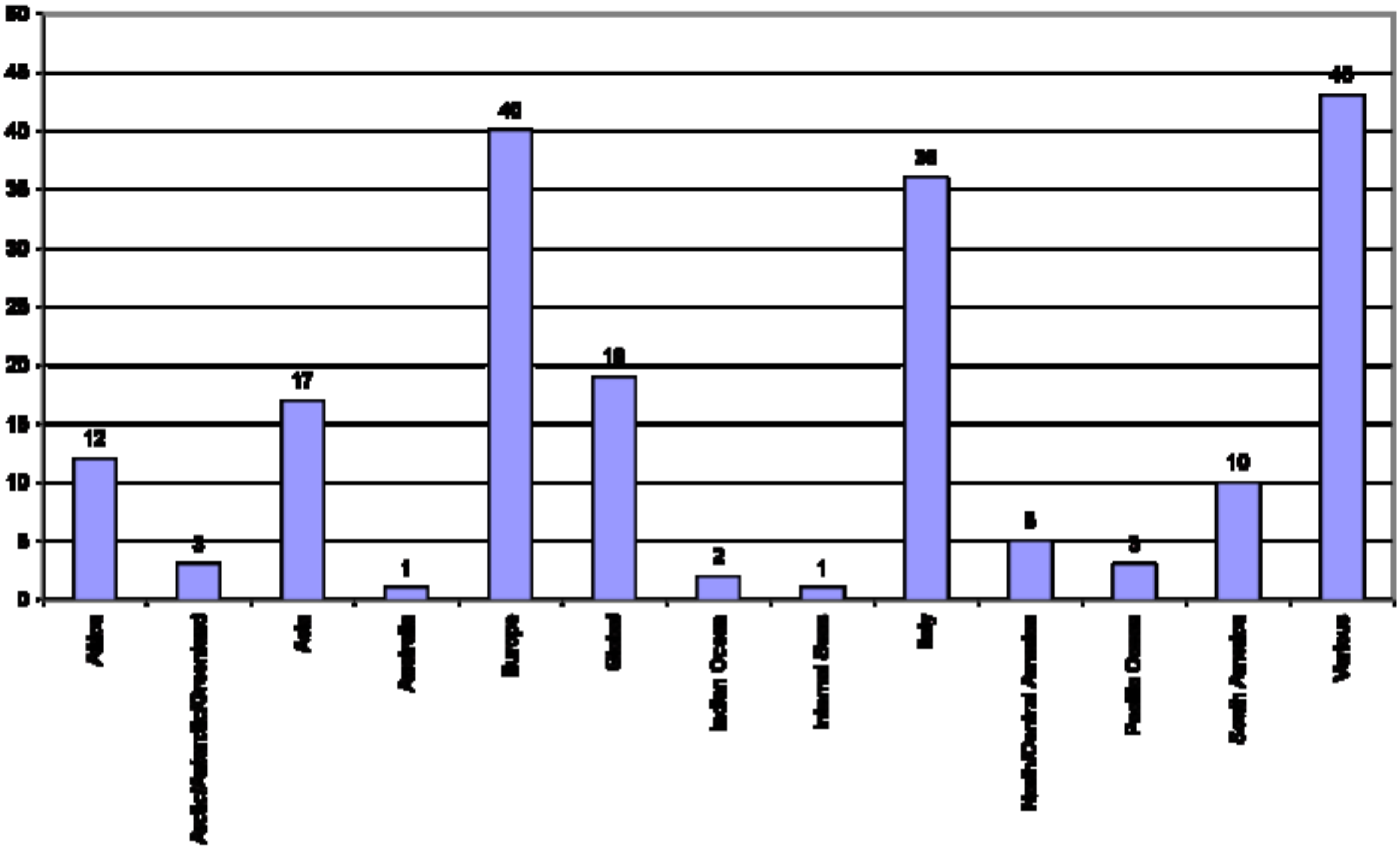


Fig. 15. Research thematic areas.

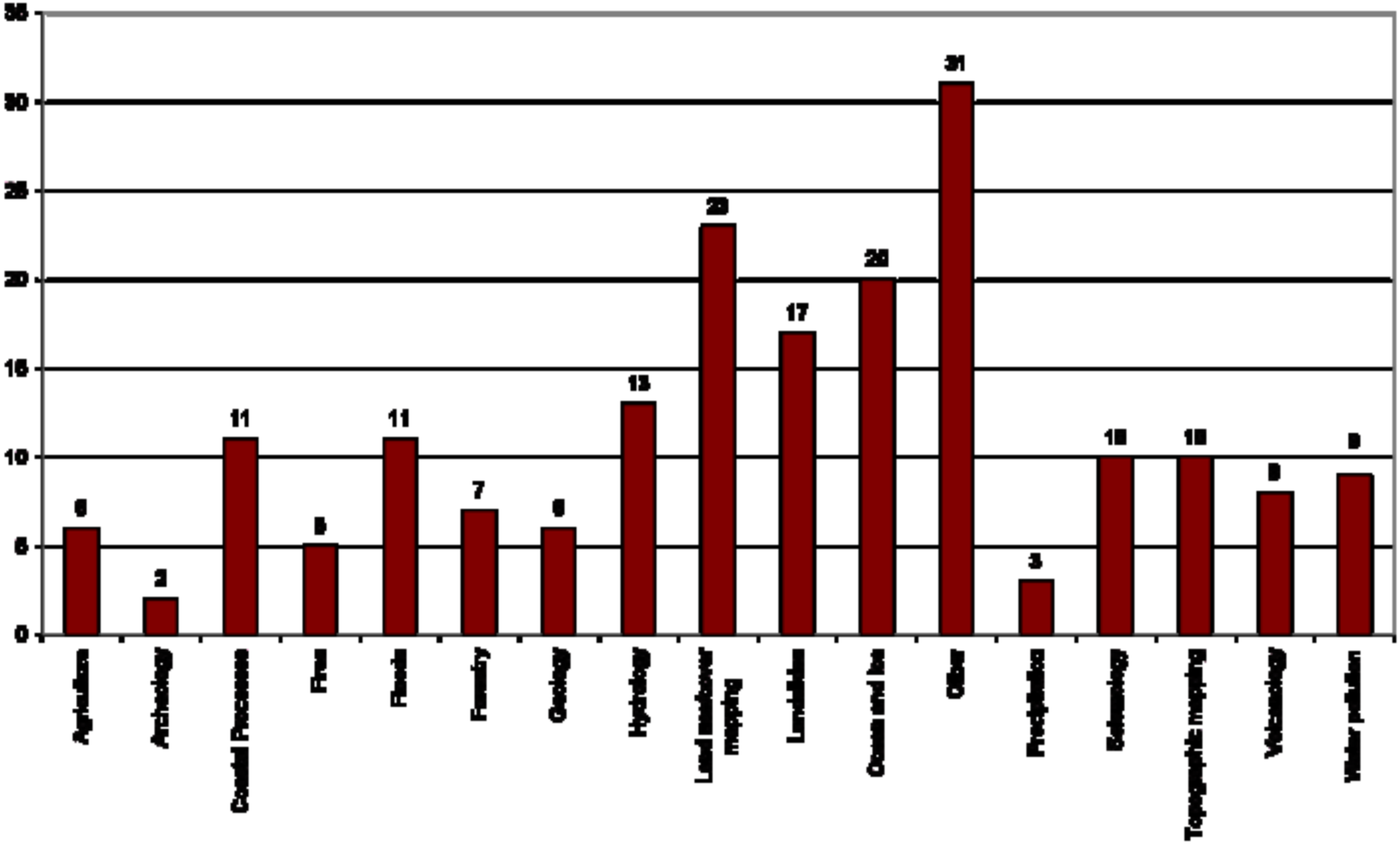


Table. 1. COSMO-SkyMed acquisition modes characteristics.

	SPOTLIGHT	STRIPMAP	PING-PONG	SCANSAR WR	SCANSAR HR
Resolution [m]	1 x 1	3 x 3 – 5 x 5	15 x 15	30 x 30	100 x 100
Swath [km]	10 x 10	40 x 40	30 x 30	100 x 100	200 x 200
Possible Polarisation [T/R]	Single. Selectable among HH or HV or VH or VV	Single. Selectable among HH or HV or VH or VV	Alternating polarisation: 2 polarisations selectable among HH, VV, VH and HV	Single. Selectable among HH or HV or VH or VV	Single. Selectable among HH or HV or VH or VV
Incidence Angles [deg]	25-50 (nominal) - 20-59,5 (extended)				

Table. 2. Time performances of the CSK constellation – Worst Case.

	2 sat.	3 sat.	Full Constellation
Response Time	90 h	85 h	72 h
Revisit time	37 h	35.5 h	12 h

Table. 3. Time performances of the CSK constellation – Average values.

	2 sat.	3 sat.	Full Constellation
Response Time	40 h	38 h	37.5 h
Revisit time	5 h	3 h	2 h

Table. 4. Performances of the CSK constellation – Measured values.

RESOLUTION	
Ground Range resolution/DIM [m/ground]	4.677
Azimuth resolution/DIM [m]	4.912
LOCALIZATION MEASURE	
Azimuth Localization error [m]	3.5036454
Ground Range Localization error [m]	-4.4107693