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## **COSMO-SkyMed an existing opportunity for observing the Earth**

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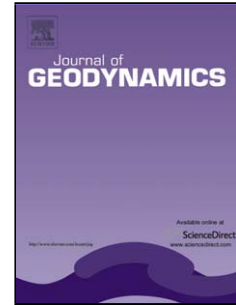
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# COSMO-SkyMed an existing opportunity for observing the Earth

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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 8<sup>th</sup> of June, the 9<sup>th</sup> of December 2007 and the 25<sup>th</sup> 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 1<sup>st</sup> of August 2008 both satellites are in the

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21 operational phase. The third satellite is still performing its commissioning and it is expected to enter  
22 in operation in the second half of 2009. The results of the commissioning phase of COSMO-SkyMed  
23 1 and 2 are presented together with the Scientific Mission Exploitation strategy (i.e.: Announcement  
24 of Opportunity, Background Mission).

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

27

## 28 1. INTRODUCTION

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

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

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

40 The results coming from the utilisation of the two operative satellites reveal the significant  
41 achievement of the X-band SAR and the importance of fast response time in a wide variety of

42 applications. In this paper ASI will be presented some analysis and results related to a set of X-band  
43 SAR applications conducted during 2008. Moreover it will be given an overview of the mission  
44 exploitation strategy.

45

## 46 **2. BRIEF MISSION NOTES**

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

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

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

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

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

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

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

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

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

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

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

## 84   **2.1 Operative Modes**

85   COSMO-SkyMed can operate in three different operative modes:

- 86   • Routine,  
87   • Crisis,  
88   • Very Urgent.

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

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

## 93   **2.2 Time Performance**

94   Four definitions apply to the time performances:

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

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

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

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

108

### 109 **3. THE SPACE SEGMENT**

#### 110 **3.1 Orbital Configuration**

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

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

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



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

127 In the Tandem-like configuration, two satellites are on the same orbit plane at a distance of  $67,5^\circ$ .  
128 This configuration allows to revisit any place on the earth with the same geometrical conditions (i.e.  
129 incident angle, etc.) after one day. The current configuration of the constellation is shown in Fig. 3:  
130 COSMO-SkyMed 1 and 2 are positioned at  $180^\circ$  each other, meanwhile COSMO-SkyMed 3 and 2 at  
131  $67,5^\circ$  in tandem-like configuration (also called "one-day interferometry configuration").

### 132 **3.2 Platform**

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

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

### 141 3.3 SAR Antenna

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

146 The nominal incidence angles (where the system grants the image quality requested) vary between  
147  $25^\circ$  and  $50^\circ$ . The extended incidence angles vary between  $20^\circ$ - $25^\circ$  and  $50^\circ$ - $59^\circ$  but also in this case  
148 the image quality is very close to the nominal condition.

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

150

## 151 4. THE GROUND SEGMENT

### 152 4.1 Overview

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

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

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

## 161 **4.2 Ground Segment Components**

162 The main components of the Common Ground Segment are:

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

## 174 **4.3 Integrated Logistics and Operations Segment**

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

179

## 5. LEOP AND COMMISSIONING PHASES

### 180 5.1 Overview

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

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

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

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

### 193 5.2 LEOP

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

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

### 199 **5.3 Commissioning Phase**

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

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

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

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

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

## 226 **6. OPERATIONAL PHASE**

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

## 229 **7. ACQUISITIONS DURING THE COMMISSIONING PHASE**

### 230 **7.1 Overview**

231 **7.1 Overview**  
232 During the Commissioning Phase the first two satellites have begun to acquire thousands of images  
233 all over the globe, showing the full potentiality of the System.

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

## 238 **7.2 Ocean And Ice Applications (February-March 2008)**

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

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

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

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

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

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

## 255 **7.3 Myanmar Flood (May 2008)**

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

- 258 • ScanSAR Huge Region: May 6th

259 • ScanSAR Wide Region: May 7th

260 • StripMap HIMAGE: May 8th

261 • Spotlight-2: May 10th

262 • Spotlight-2: May 11th

263 • StripMap HIMAGE: May 14<sup>th</sup>

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

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

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

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

#### 275 **7.4 China Earthquake (May 2008)**

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



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

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

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

### 291 **7.5 Agriculture Multi-Temporal Acquisition (May-July 2008)**

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

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

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

## 302 **7.6 Remarks**

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

306

## 307 **8. COSMO-SKYMED SYSTEM ACCESS**

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

310 1. *Institutional Users*

311 2. *Commercial Users*

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

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

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

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

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

323

## 324 **9. SCIENTIFIC MISSION EXPLOITATION STRATEGY**

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

- 326 • The COSMO-SkyMed Announcement of Opportunity;
- 327 • The Background Mission.

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

### 331 **9.1 The First Cosmo-SkyMed Announcement Of Opportunity**

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

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

338 • new ideas for system exploitation.

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

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

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

347 • Requested observation areas are focused mainly on global coverage, Italy and Europe, as  
348 shown in Fig. 14.

349 • Research project proposals cover wide thematic areas specified in the announcement. A  
350 strong interest can be noted on land use monitoring, ocean and ice and landslides phenomena  
351 observation as shown in Fig. 15:

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

## 354 **9.2 Background Mission**

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

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

359 • Risk Management Applications (guideline field)

360 • Cartography and planning applications

361 • Agriculture

362 • Forest

363 • Hydrology

364 • Geology

365 • Marine domain

366 • Archaeology

367 Inputs to the Background Mission come from:

368 • Scientific indications specified in the projects of the first CSK Announcement of Opportunity

369 • Institutional Users

370 • Commercial users

371

## 372 **10. CONCLUSIONS**

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

375 At present COSMO-SkyMed constellation allows to reach high performance in terms of Revisit and  
376 Response Time, number of images, image quality, short gap for interferometric acquisitions, these

377 performances will be further enhanced when the third and the fourth satellite will complete the  
378 constellation (end of 2010).

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

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

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

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

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

394

## REFERENCES

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Fig. 1. COSMO-SkyMed constellation in nominal configuration

Fig. 2. Tandem Interferometric Configuration in different orbit planes

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

Fig. 4. COSMO-SkyMed satellite (“stowed” and deployed configurations)

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

Fig. 6. Stripmap HIMAGE collected on the 9th of February over the Caspian Sea (zoom)

Fig. 7. Stripmap HIMAGE collected on the 31st of March: disintegration of the Wilkins Ice Shelf, Antarctica.

Fig. 8. ScanSAR Huge Region collected on the 6th of May over Rangoon Area, Myanmar.

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

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

Fig. 11. Spotlight collected on the 13th of May 2008 over Guan-Xian city, China.

Fig. 12. Spotlight collected on the 13th of May 2008 over Guan-Xian city, China (zoom).

These are two buildings whose walls in nominal condition should appear as two parallel bright straight lines; debris produce an high backscattered energy due to their irregular shape and the wall of one building is no more evident (see red arrows).

Fig. 13. Spotlight collected on the 25th of May, 26th of June and 28th of July 2008 over Kumagaya area, Japan.

Fig. 14. Requested observation areas.

Fig. 15. Research thematic areas.

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Table. 1. COSMO-SkyMed acquisition modes characteristics.

	<b>SPOTLIGHT</b>	<b>STRIPMAP</b>	<b>PING-PONG</b>	<b>SCANSAR WR</b>	<b>SCANSAR HR</b>
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.

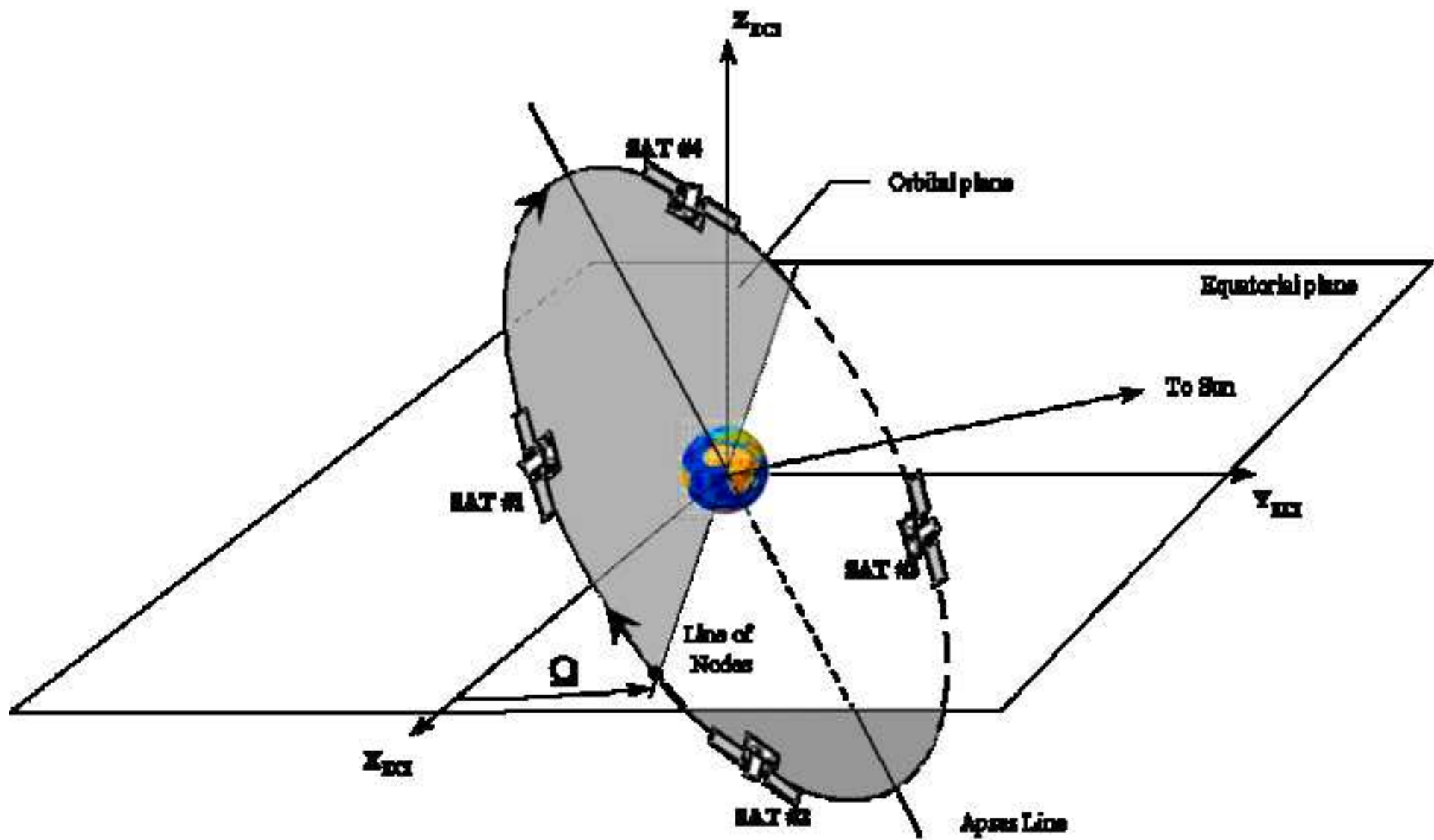
	2 sat.	3 sat.	Full Constellation
Response Time	40 h	38 h	37.5 h
Revisit time	5 h	3 h	2 h

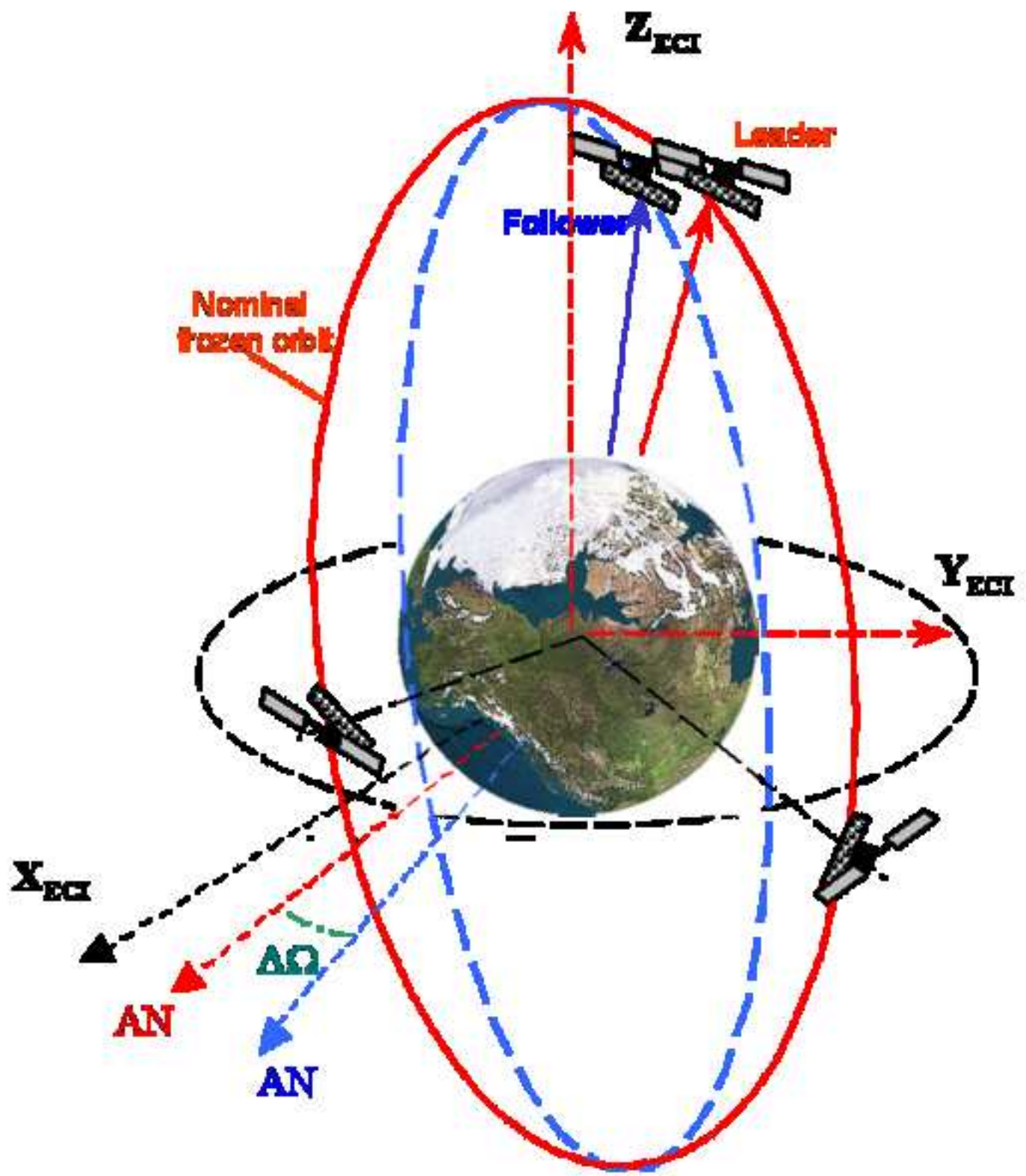
Table. 4. Performances of the CSK constellation – Measured values.

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

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Fig. 1. COSMO-SkyMed constellation in nominal configuration





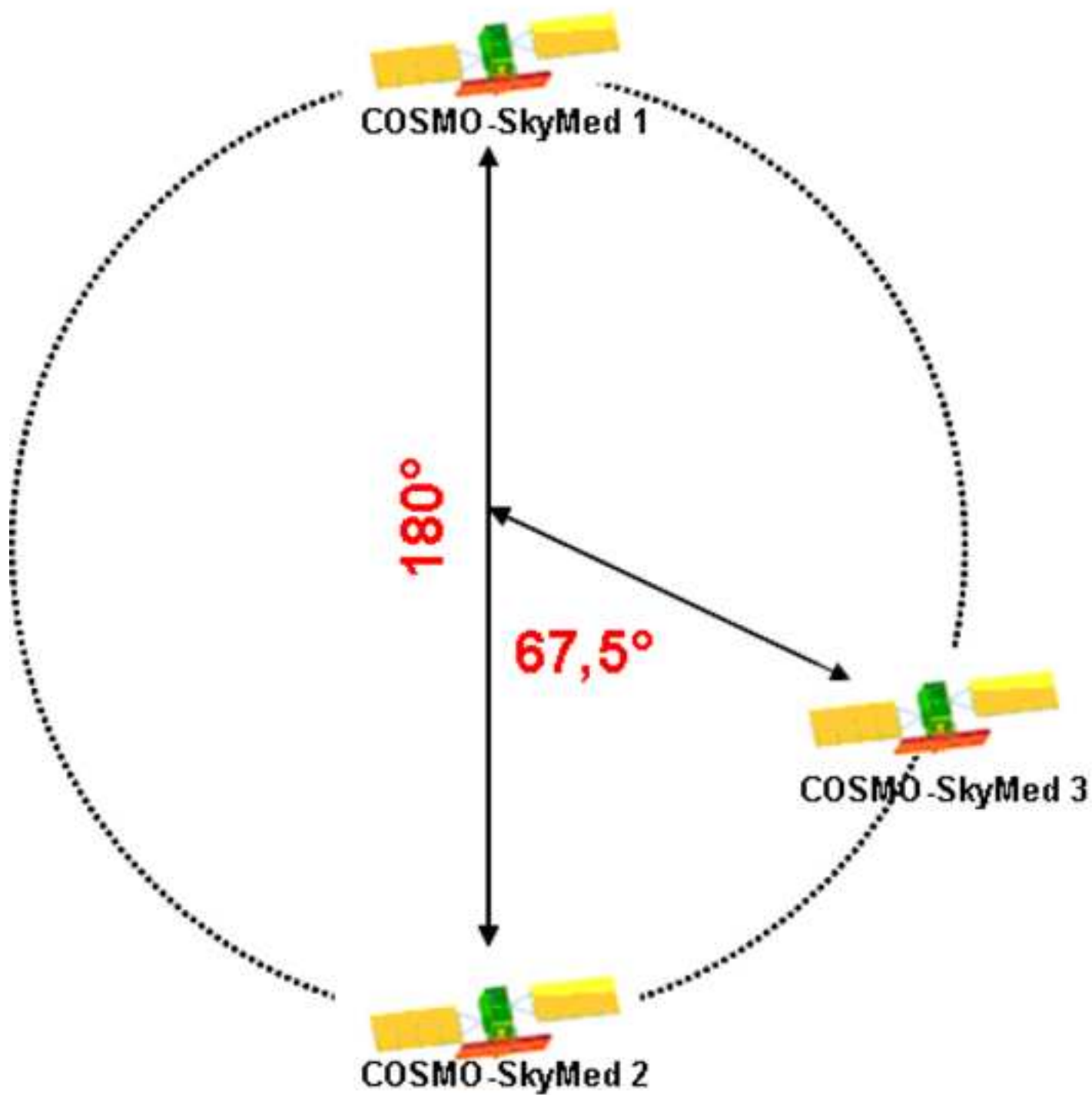


Fig. 4. COSMO-SkyMed satellite ("stowed" and deployed configurat

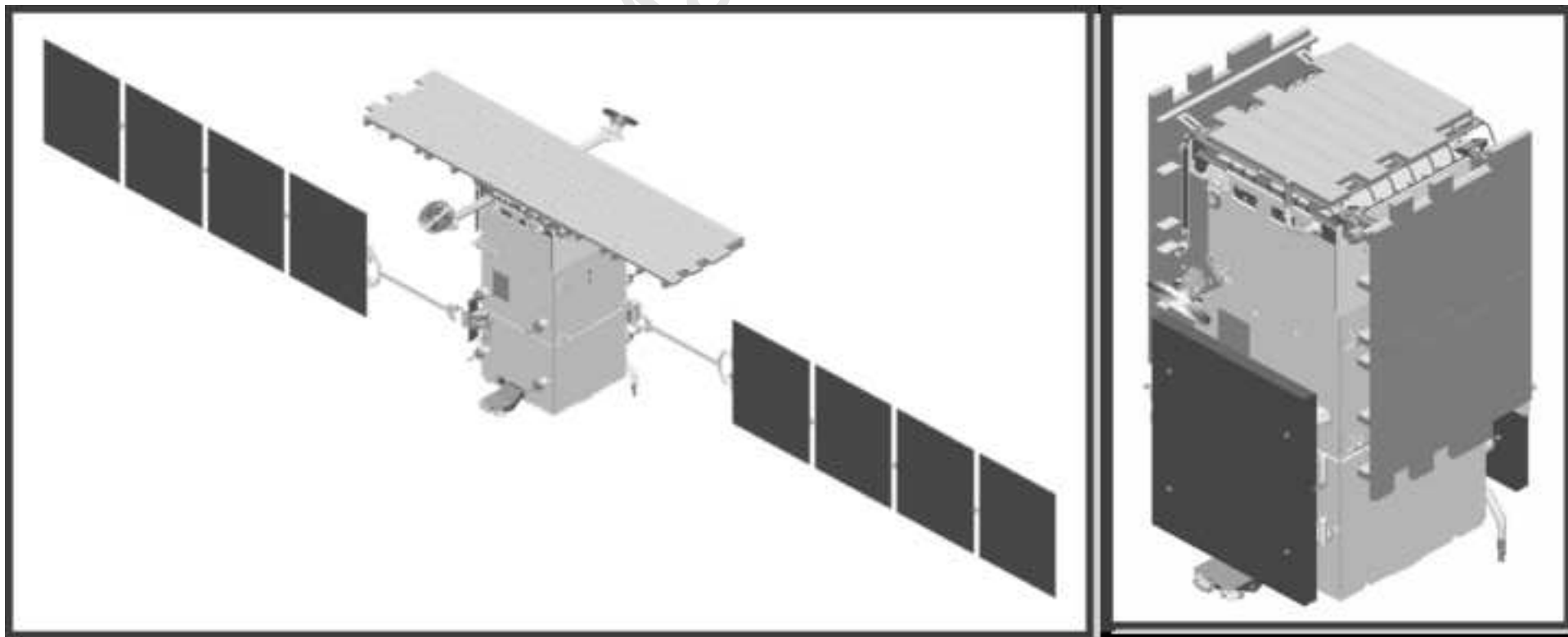




Fig. 5. Stripmap HIMAGE collected on the 9th of February over th

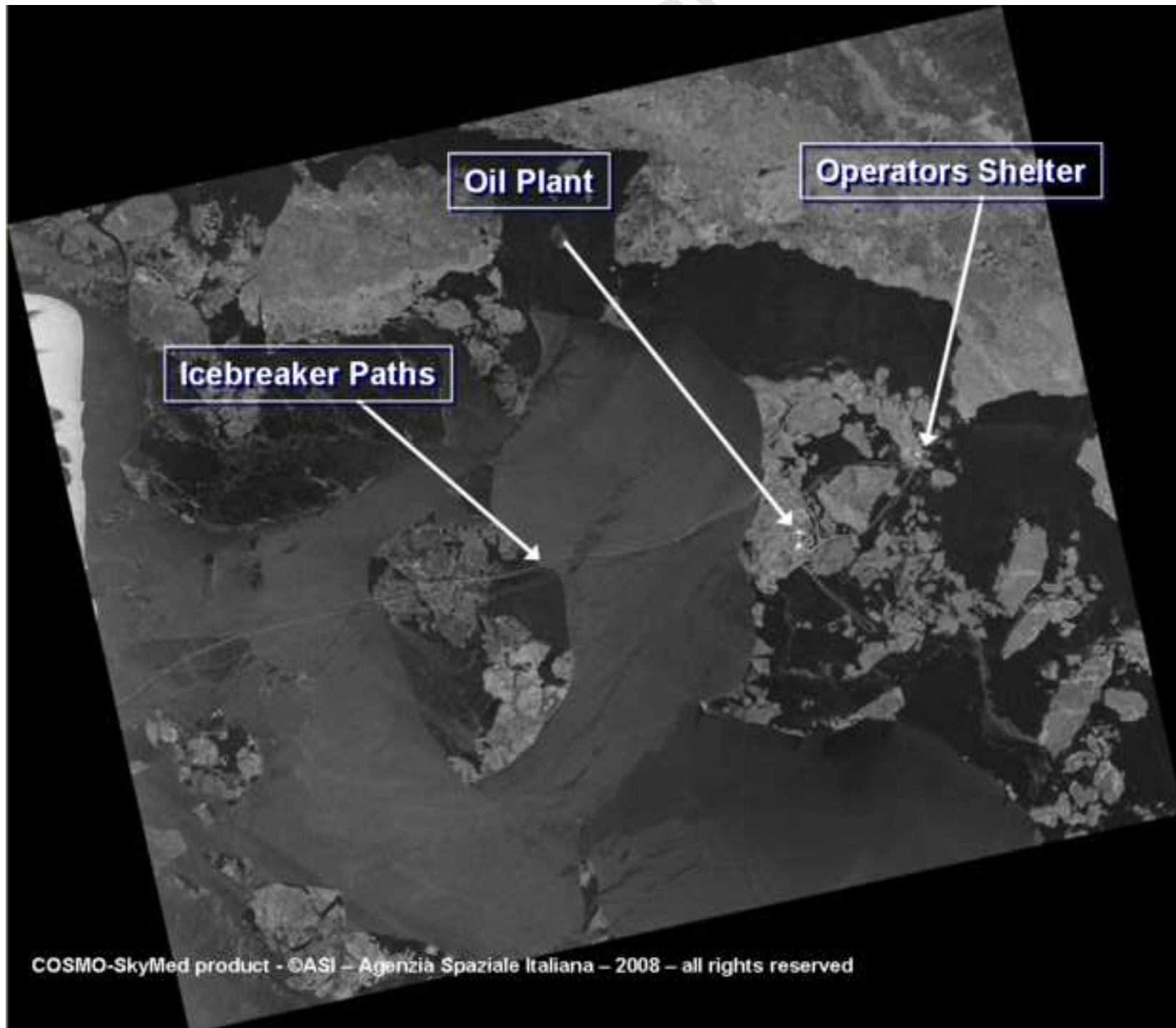


Fig. 6. Stripmap HIMAGE collected on the 9th of February over th

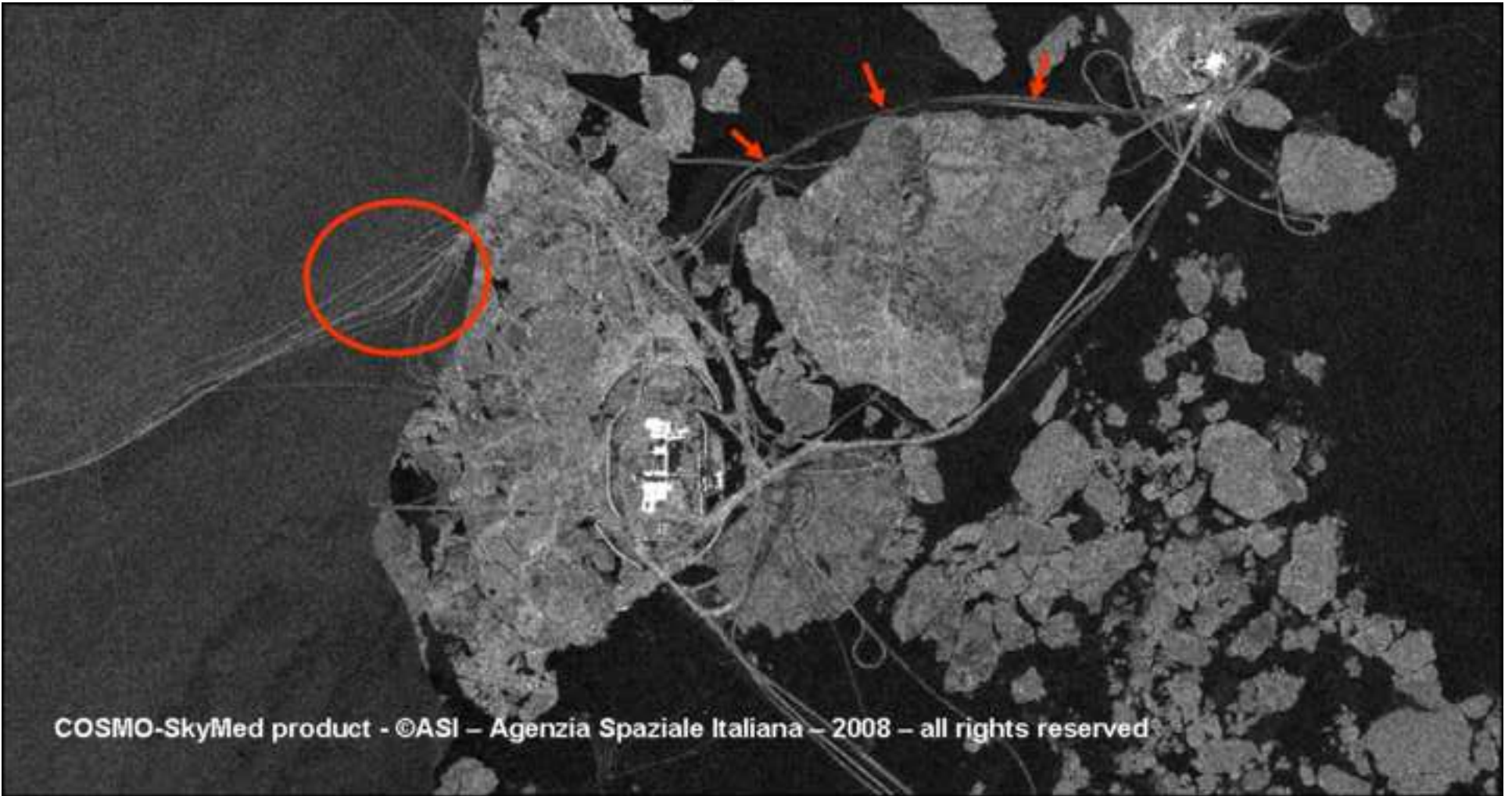


Fig. 7. Stripmap HIMAGE collected on the 31st of March: disinteg





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

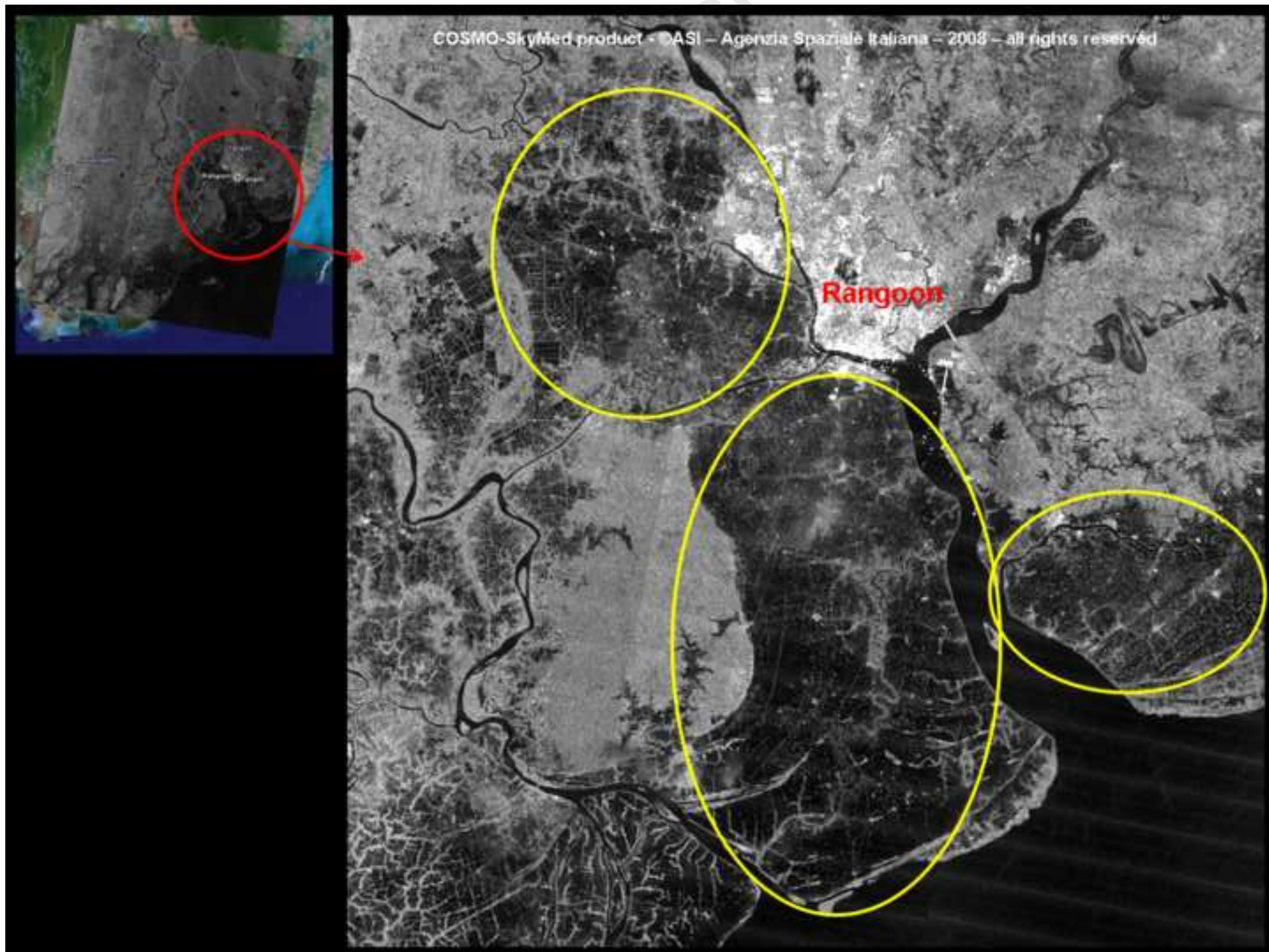




Fig. 9. Stripmap collected on the 8th of May over Rangoon Area,

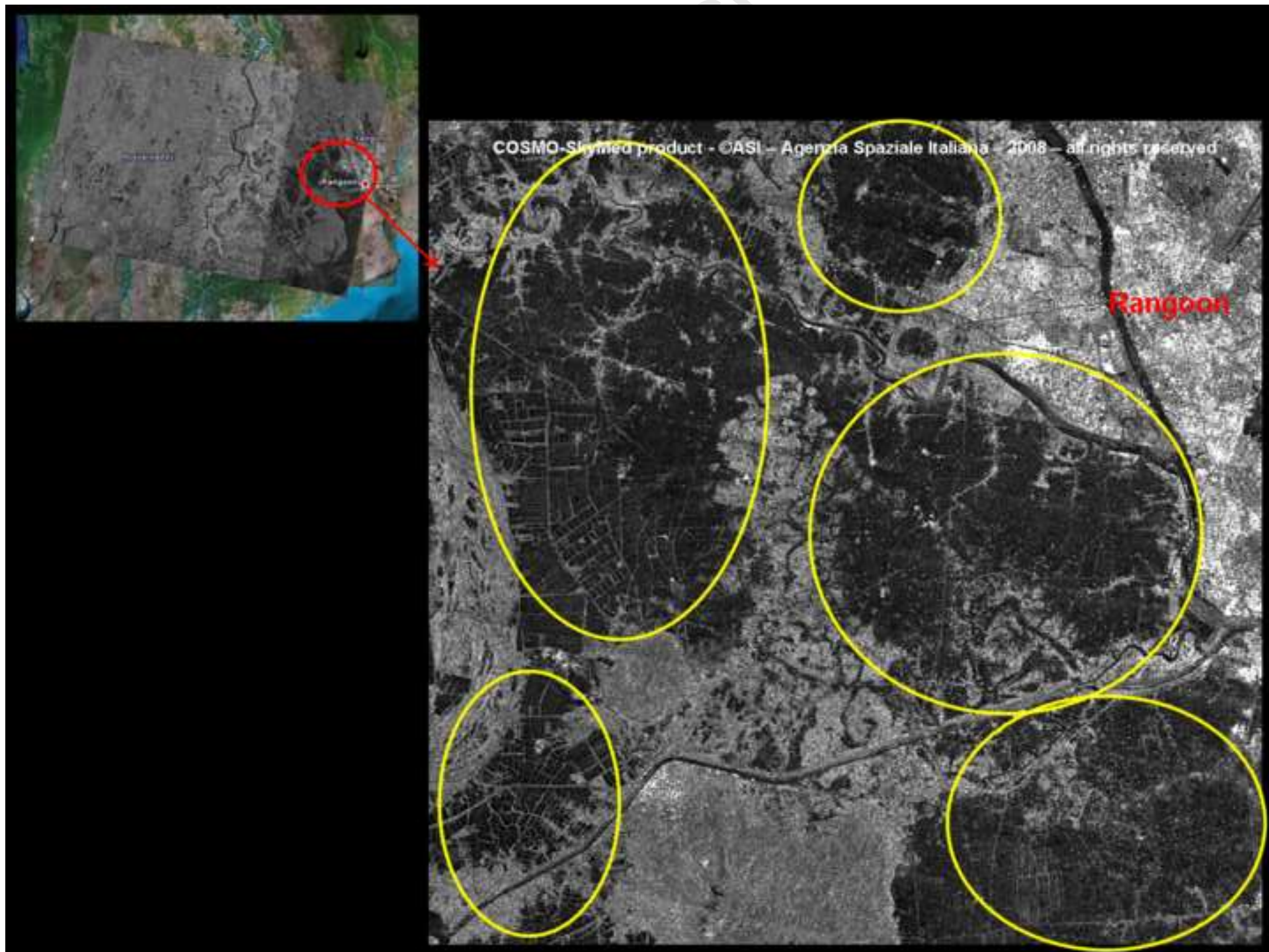




Fig. 10. Flood evolution Map [Credits to WFP].

# MYANMAR - Flood evolution (May, 6th and 8th 2008) COSMO-SkyMED and TerraSAR-X satellite image analysis

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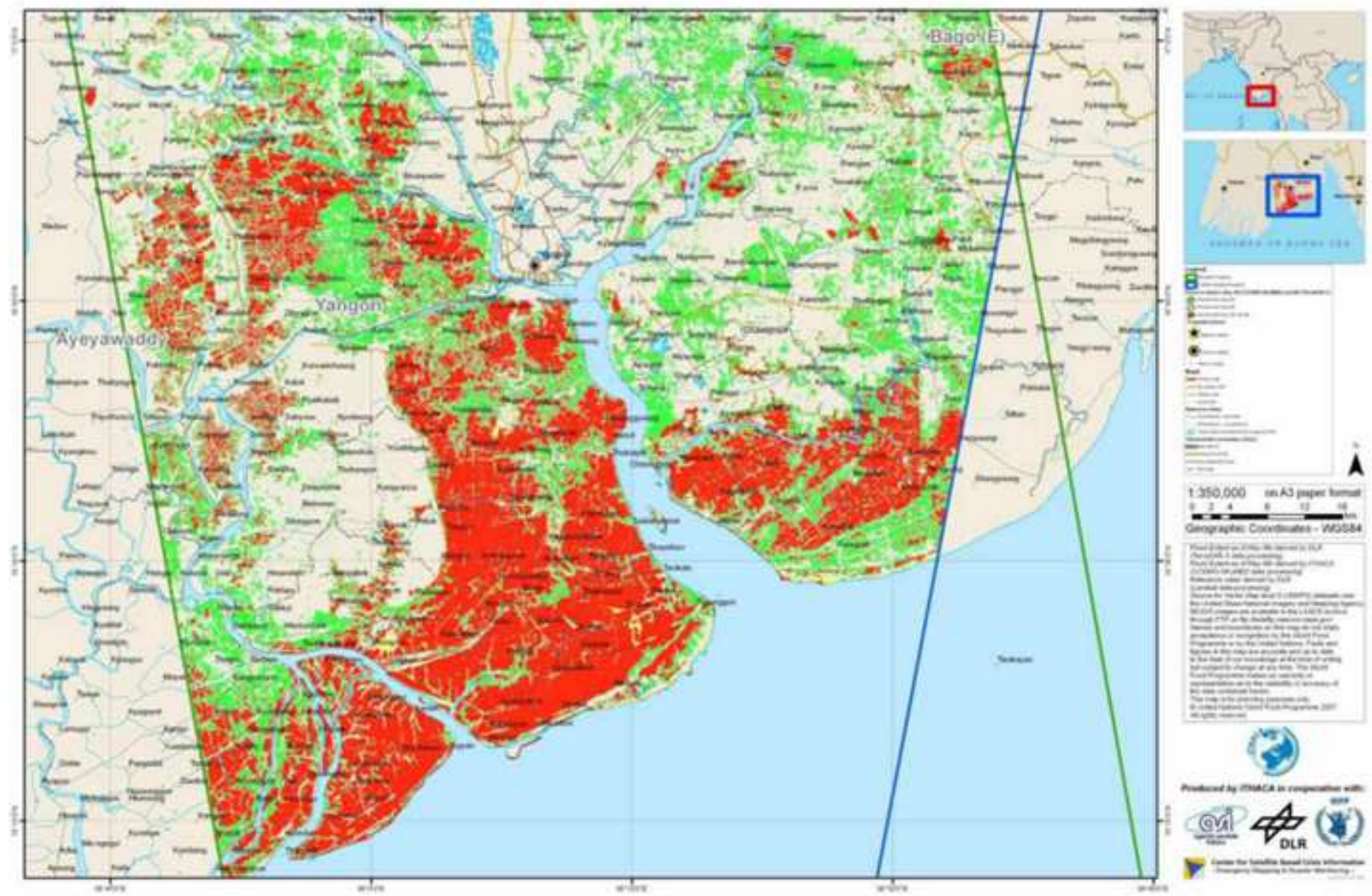
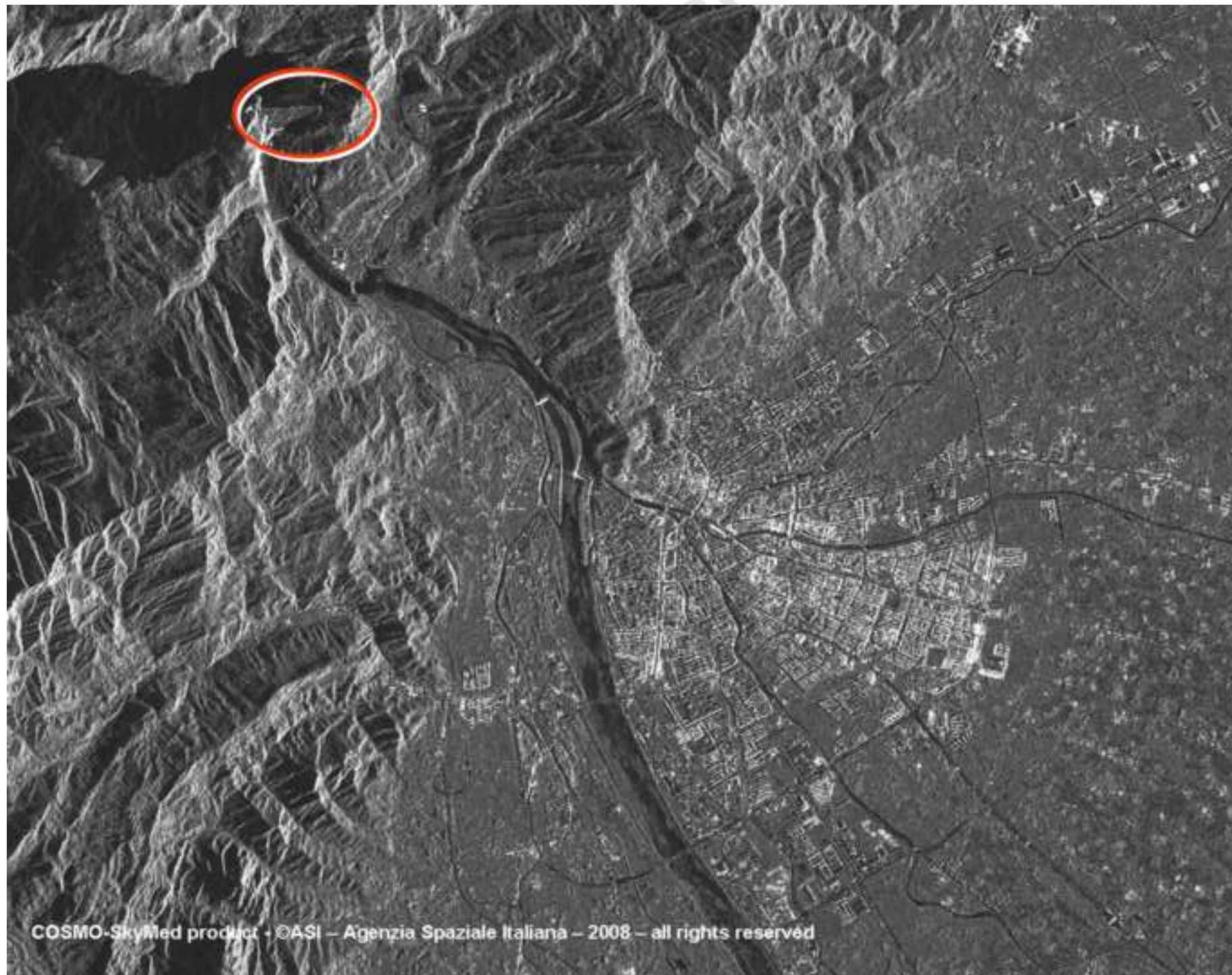


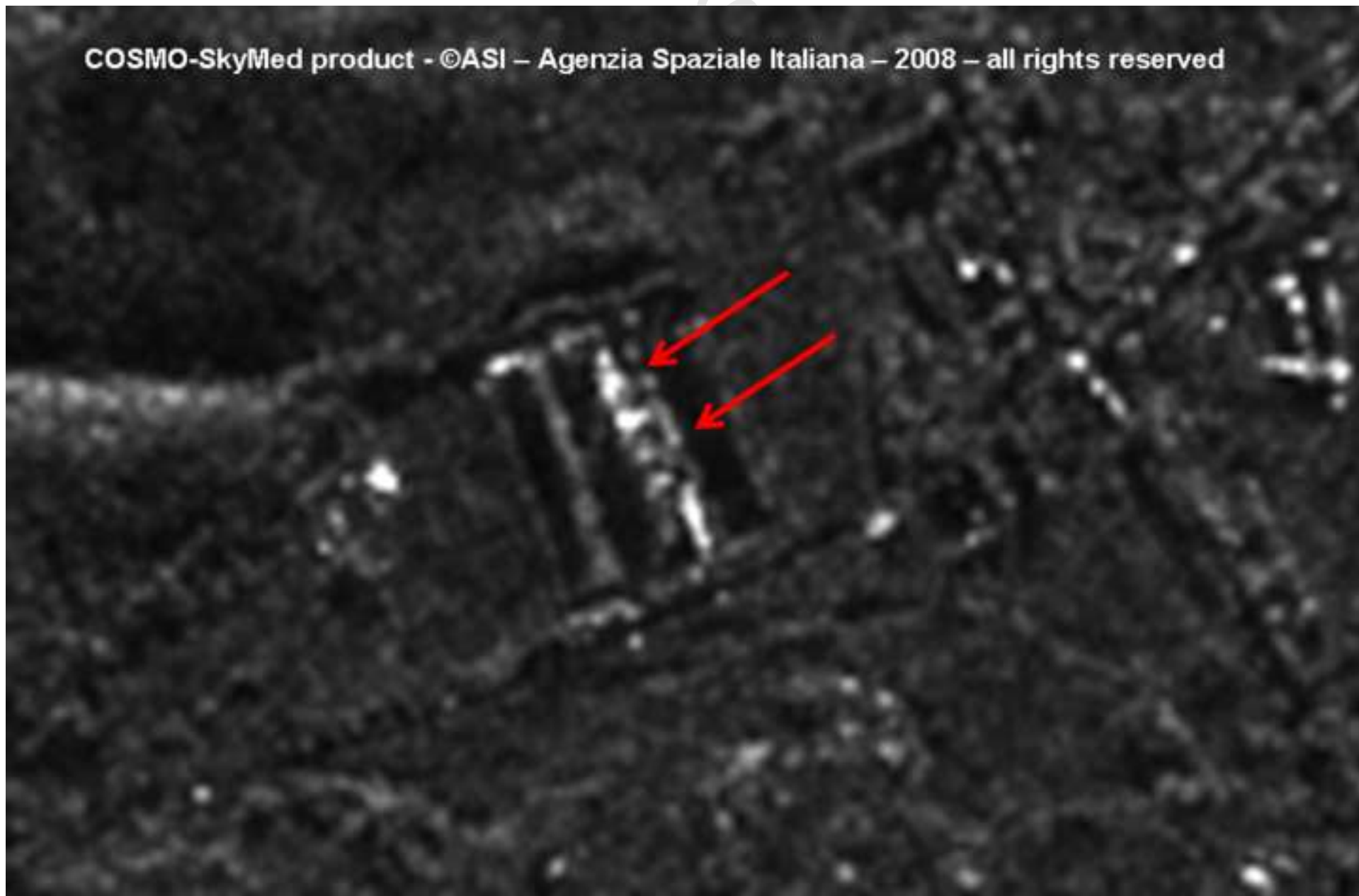


Fig. 11. Spotlight collected on the 13th of May 2008 over Guan-X



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





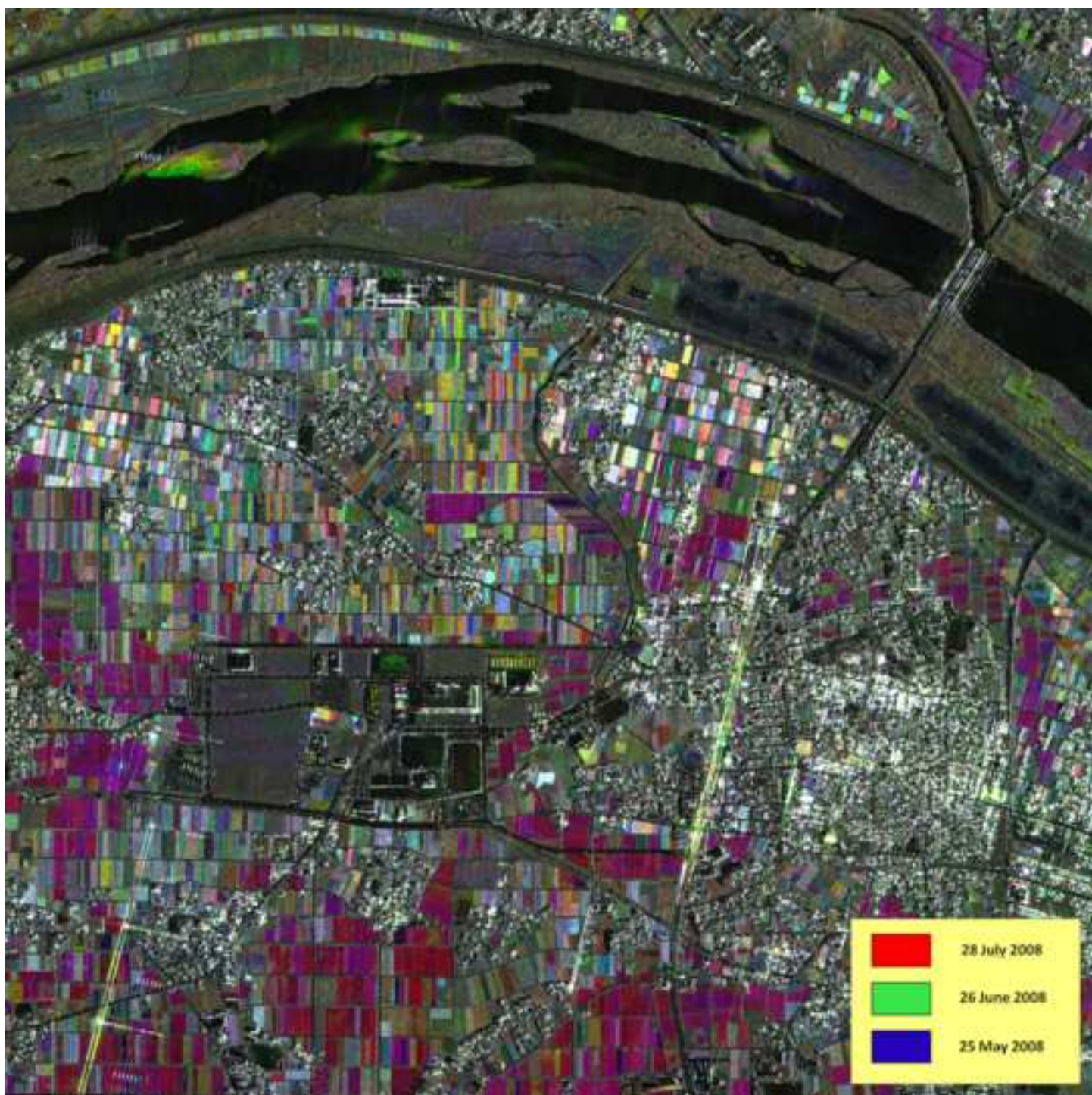


Fig. 14. Requested observation areas.

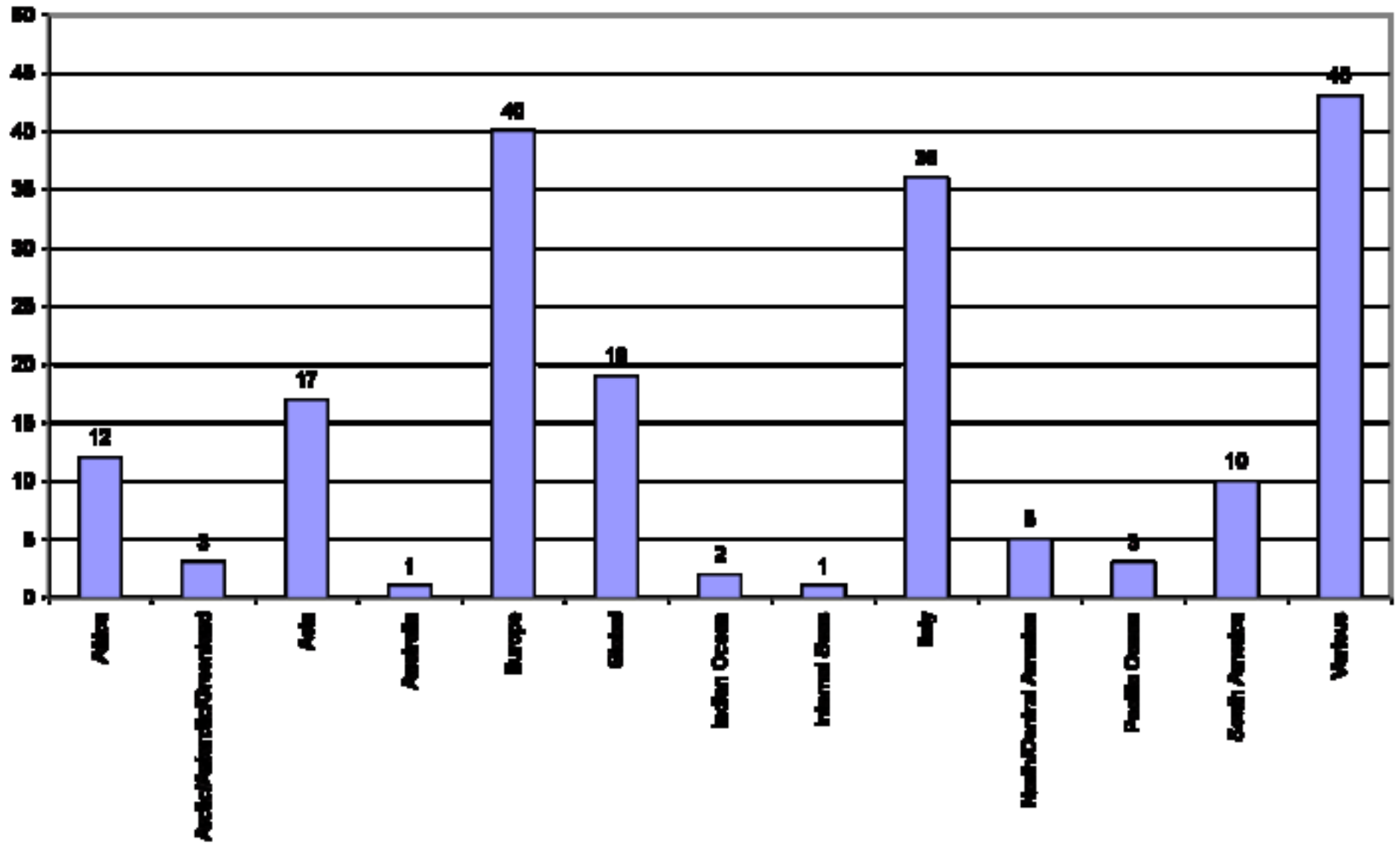


Fig. 15. Research thematic areas.

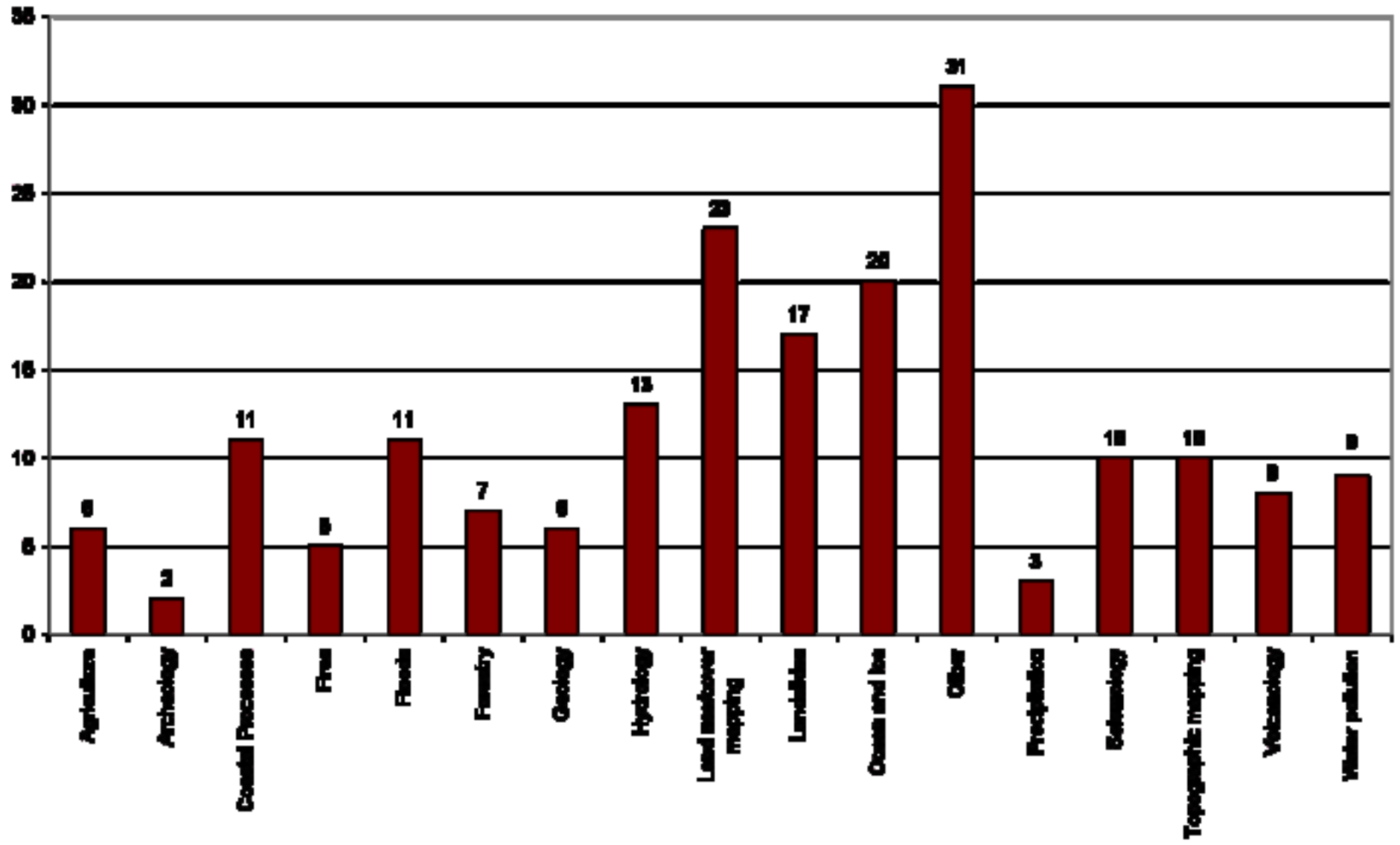


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