

Session “Displacements and deformations 4”

Synergies and results on X- & L-band SAR research and institutional support during emergencies in the framework of the ASI – JAXA cooperation for disaster management

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Long-standing ASI-JAXA cooperation

The Italian Space Agency (ASI) and the Japan Aerospace Exploration Agency (JAXA) have partnered to advance the understanding of the Earth's surface and atmosphere from space through the use of Synthetic Aperture Radar (SAR) satellites in the fields of Earth sciences and Earth observation applications.

18 September 2009 – Memorandum of Understanding concerning the Feasibility Study and Joint Research Activities for the Anticipated Mutual Cooperation in the Satellite Disaster Monitoring signed

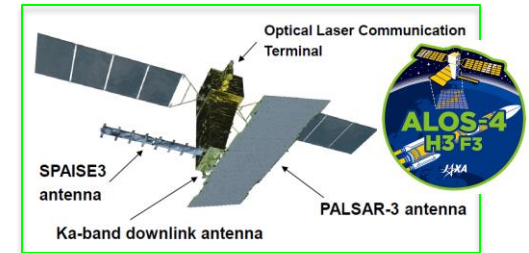
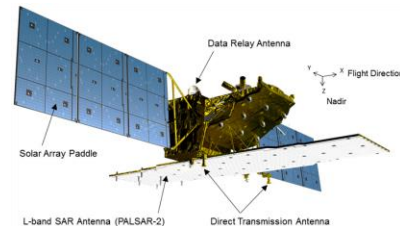
25 November 2016 – Signature of the Implementing Arrangement concerning Mutual Cooperation for Satellite Support to Disaster Risk Management (IA)

September 2019, November 2022, March 2024 & March 2026 – IA extended, also accounting for the evolution of the respective satellite assets

ASI-JAXA IA purpose

The IA encompasses and defines T&Cs governing the cooperation as to:

1. Acquisition by COSMO-SkyMed First Generation, COSMO-SkyMed Second Generation, ALOS-2, and ALOS-4 in response to emergency requests made by the other ASI or JAXA;
2. SAR research activities exploiting the synergy between COSMO-SkyMed and ALOS to address Disaster Risk Management and Earth Observation topics;
3. Establishment of COSMO-SkyMed First Generation and COSMO-SkyMed Second Generation archive over Japan and ALOS-2 and ALOS-4 archive over Italy for Disasters Risk Management and Earth Observation Research and Application development activities.

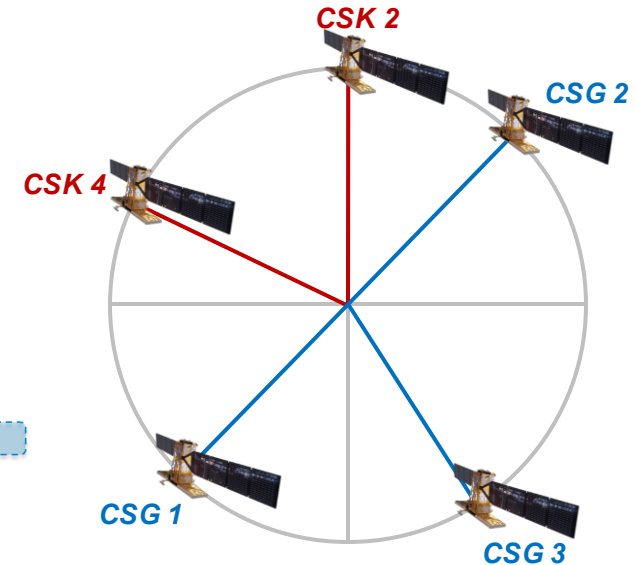
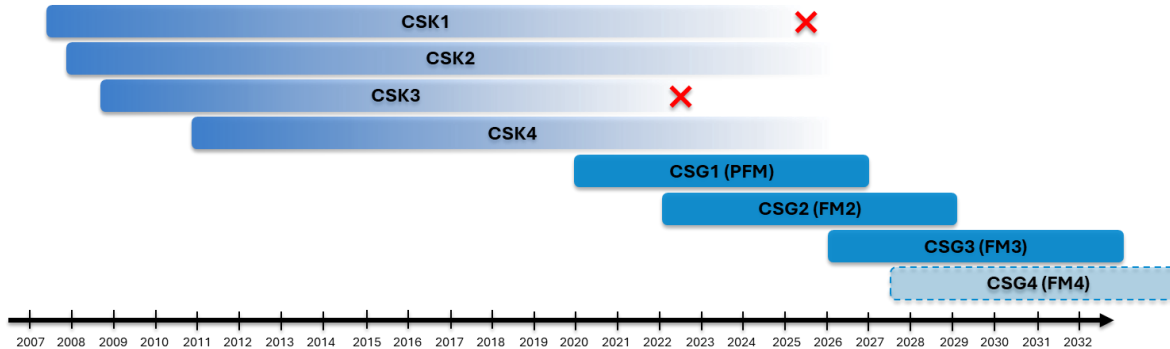


COSMO-SkyMed Mission Evolution

- Italian flagship SAR Earth Observation program
- Dual-use civilian and defence system
- From First Generation (CSK) to Second Generation (CSG) constellation
- Service continuity and enhanced capabilities



MINISTERO
DELLA DIFESA

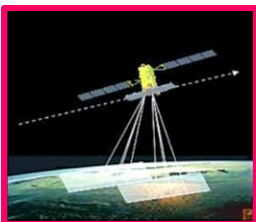
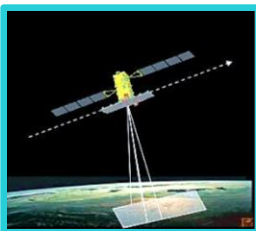
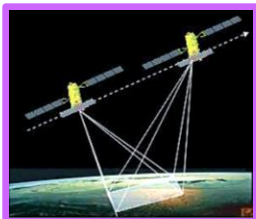


Key Technical Enhancements of CSG

- Enhanced image quality and platform performance
- Improved flexibility and tasking capabilities
- Faster operational service including near real-time delivery
- Enhanced polarimetric capabilities
- New acquisition modes



COSMO-SkyMed Acquisition modes



Scansar	CSK			CSG		
	Max resolution (Azimuth x Range)	Polarization	Scene size (Azimuth x Range)	Max resolution (Azimuth x Range)	Polarization	Scene size (Azimuth x Range)
Wide	23 x 13.5 m	Single	100 x 100 Km			
Huge	38 x 13.5 m	Single	200 x 200 Km			
ScanSAR-1				20 x 4 m	Single / Dual	100 x 100 Km
ScanSAR-2				40 x 6 m	Single / Dual	200 x 200 Km
Stripmap	CSK			CSG		
	Max resolution (Azimuth x Range)	Polarization	Scene size (Azimuth x Range)	Max resolution (Azimuth x Range)	Polarization	Scene size (Azimuth x Range)
HIMAGE	3 x 3 m	Single	40 x 40 Km	3 x 3 m	Single / Dual	40 x 40 Km
Ping Pong	15 x 15 m	Alternating	30 x 30 Km	12 x 5 m	Alternating	30 x 30 Km
Quad Pol				3 x 3 m	Quad	40 x 15 Km
Spotlight	CSK			CSG		
	Max resolution (Azimuth x Range)	Polarization	Scene size (Azimuth x Range)	Max resolution (Azimuth x Range)	Polarization	Scene size (Azimuth x Range)
Spotlight-2	1 x 1 m	Single	10 x 10 Km			
Spotlight-2A				0.4 x 0.5 m	Single / Dual	3,5 x 7 Km
Spotlight-2B				0.6 x 0.6 m	Single / Dual	10 x 10 Km
Spotlight-2C				0.8 x 0.8 m	Single / Dual	5 x 10 Km

Standard Acquisition Modes Product Quality and Feature Summary at processing level L1A

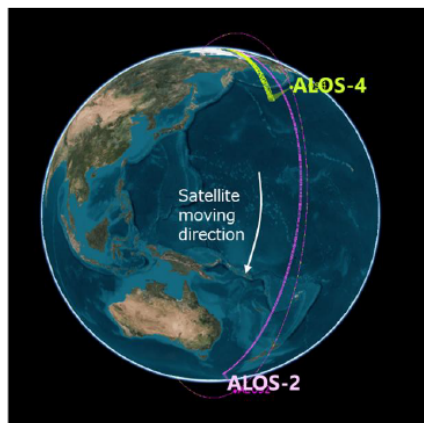
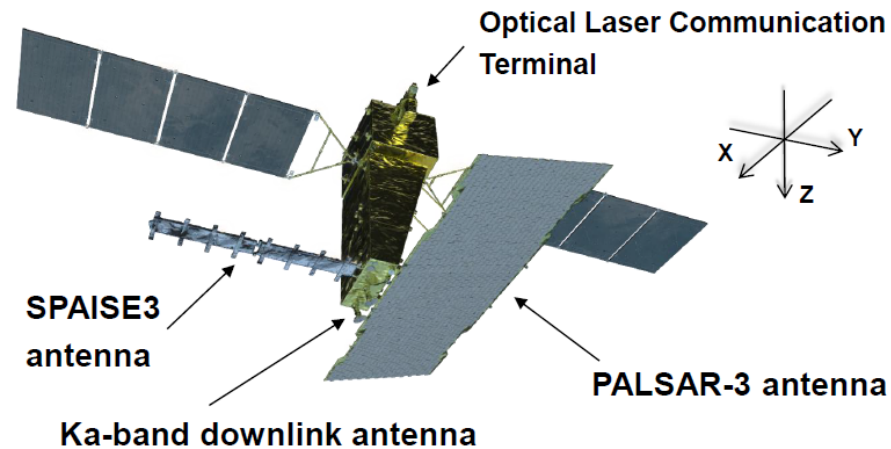
ALOS-4 Launch of ALOS-4 aboard H3 F3



- ALOS-4 was launched aboard the third H3 Launch Vehicle at 12:06:42 (JST) on July 1, 2024, from the Tanegashima Space Center.



ALOS-4 Overview of ALOS-4



ALOS-4 flies on the same reference orbit as ALOS-2, enabling combined observations and data analysis by both.

Lifetime		7 years
Mission Instruments		PALSAR-3 SPAISE3
Size (X, Y, Z)		10.0 m × 20.0 m × 6.4 m
Satellite Mass		Approx. 3,000 kg
Electrical Power	Solar cells	Approx. 7,000 W
	Battery	380 Ah
Data recorder		Approx. 1 Tbyte
Downlink		3.6 Gbps (Ka-band) 1.8 Gbps (optical data relay)
Orbit (Same as ALOS-2)	Type of orbits	Sun-synchronous sub-recurrent orbit
	Altitude	628 km
	Local sun time at descending	12:00 ± 15 min
	Revisit time	14 day
	Inclination angle	97.9 deg.

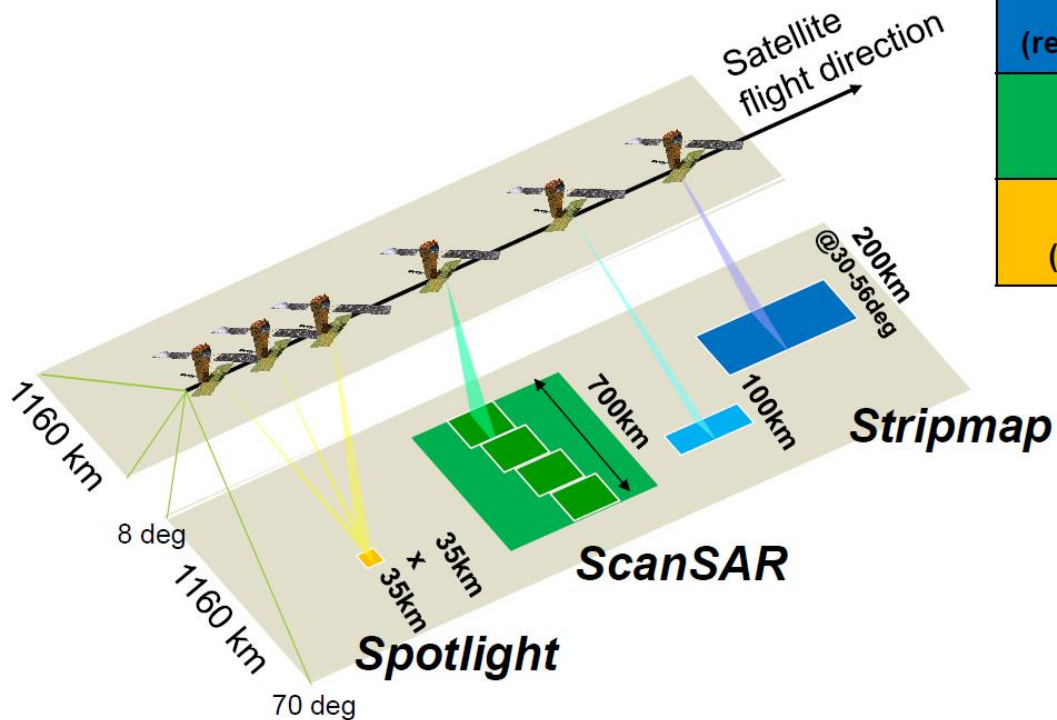


ALOS-4 Observation Mode



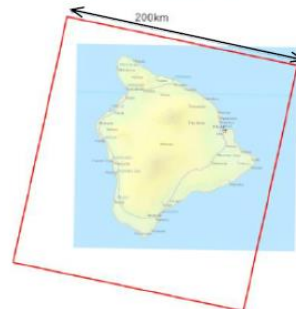
SAR mode	Spotlight	Stripmap						ScanSAR
Code name	SB	UW	UB	HW	HB	FW	FB	XB
Resolution [m]	3 x 1 (Rg x Az)	3		6		10		25 (1 look)
Swath width [km]	35 x 35	200	100	200	100	200	100	700 (4 scan)
Center freq. [MHz]	1257.5	1257.5		1236.5 (or 1257.5/1278.5)				
Bandwidth [MHz]	84	84		42		28		28
Polarization*	S, D	S, D	S, D, Q	S, D	S, D, Q	S, D	S, D, Q	S, D
Available Incidence angle range	8-70	30-56	8-70	30-56	8-70	29-56	8-70	8-70
NESZ	< -20 dB	< -20 dB		< -24 dB		< -28 dB		< -20 dB
Rg. S/A	> 15 dB	> 15 dB		> 15 dB		> 20 dB		> 15 dB
Az. S/A	> 15 dB	> 15 dB		> 15 dB		> 20 dB		> 15 dB
Pol. X-talk	< -30 dB							
Split-band option	N/A	N/A	N/A	N/A	N/A	28+10 MHz	N/A	N/A

*Polarization: S = HH or HV or VV or VH, D = HH+HV or VV+VH, Q = HH+HV+VH+VV

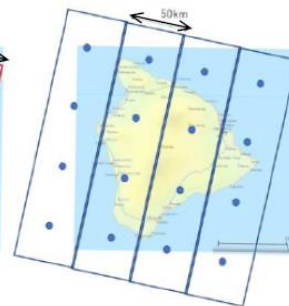


Obs. mode	ALOS-4 (PALSAR-3)	ALOS-2 (PALSAR-2)
Stripmap (res. 3 m/6 m/10 m)	100 or 200 km	30-70 km
ScanSAR (res. 25 m)	700 km	350 or 490 km
Spotlight (res. 3 m x 1 m)	35 km x 35 km	25 km x 25 km

ALOS-4/PALSAR-3
Stripmap mode
200 km swath



ALOS-2/PALSAR-2
Stripmap mode
50 km swath

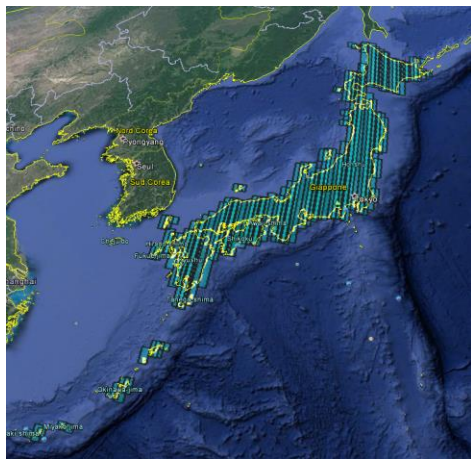


Island of Hawaii

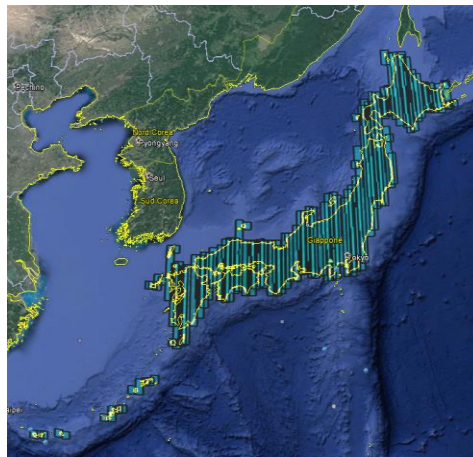
Activity 1: Building X- & L-band national archives

COSMO-SkyMed observations over Japan in Stripmap Himage HH mode (40x40 km) 3 m resolution, right looking. One coverage a year in ascending orbit from May to November, and one coverage a year in descending orbit from May to November. In order to avoid snow seasons, such acquisitions for the northern part of Japan were collected between the beginning of June and the end of October.

As of June 2026, ASI delivered a total of 12,552 standard frames, of which 10,686 since 2016.



Descending coverage

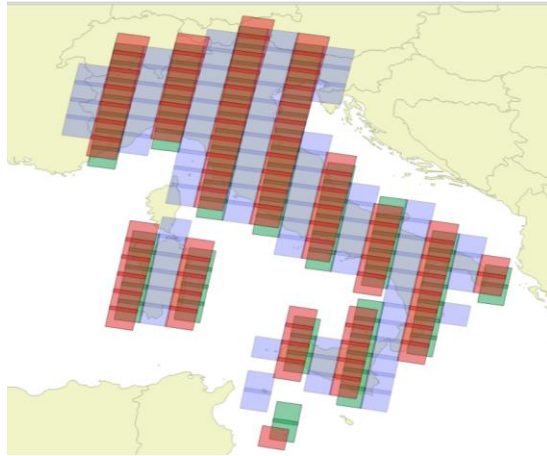


Ascending coverage

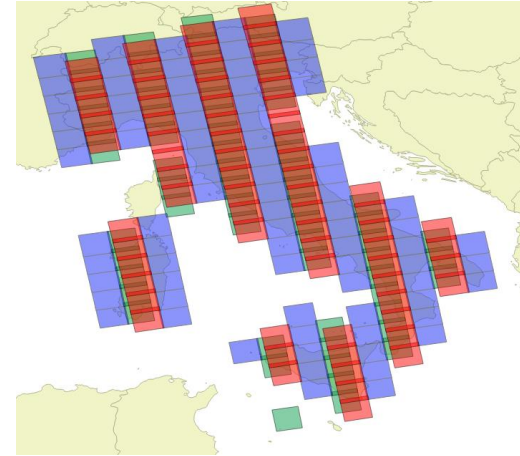
Activity 1: Building X- & L-band national archives

ALOS-2 observations over Italy in Stripmap 10 m resolution, dual pol. (HH+HV) mode, right looking, with incidence angles ranging from 30 to 49°, along both ascending and descending orbits. On average per annum, **four coverages using the two orbit directions** with the same looking (no blind spot in mountainous areas).

JAXA provided a total number of about 4,700 products between 2017 and 2025



Descending coverage



Ascending coverage

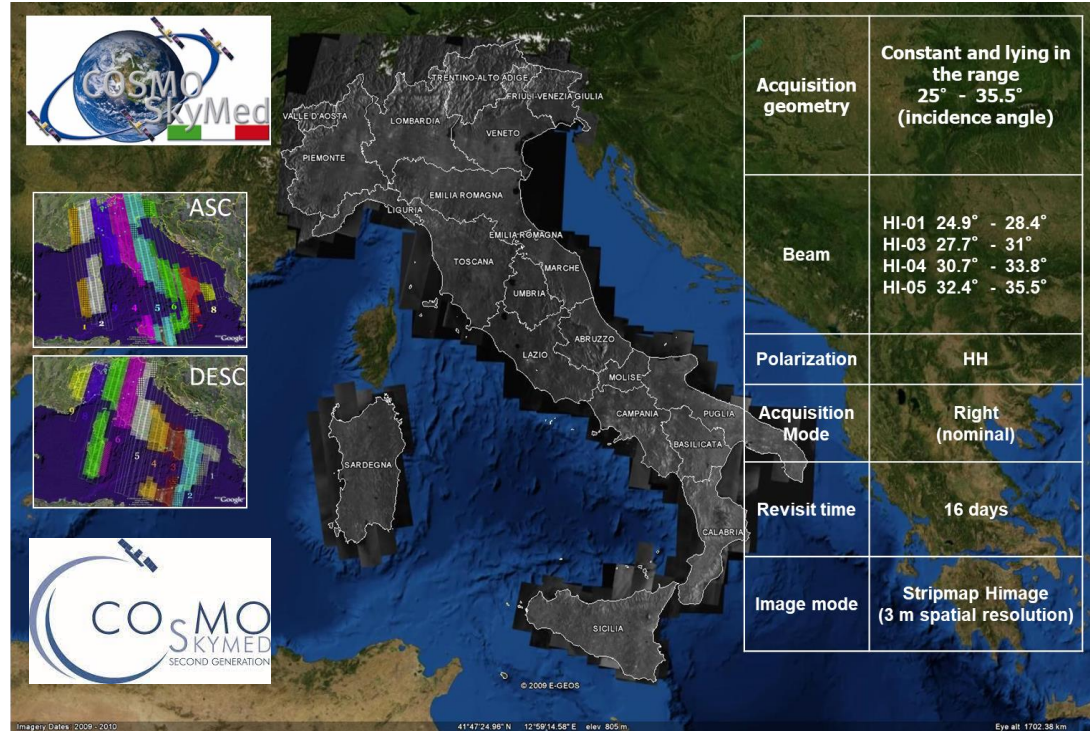
Activity 1: Building X- & L-band national archives

The major advantage of building and mutually exchanging X- and L-band SAR archives consists in:

- the creation of **the basis for disaster response**
- **regular observation plans of the whole territory** of both the countries

to complement respective nationwide acquisition programs

e.g. the MapItaly project since 2009

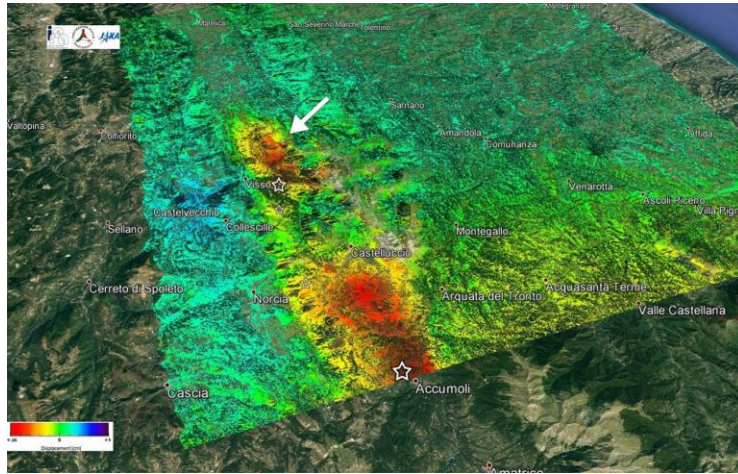


Activity 2: Emergency response (in Italy)

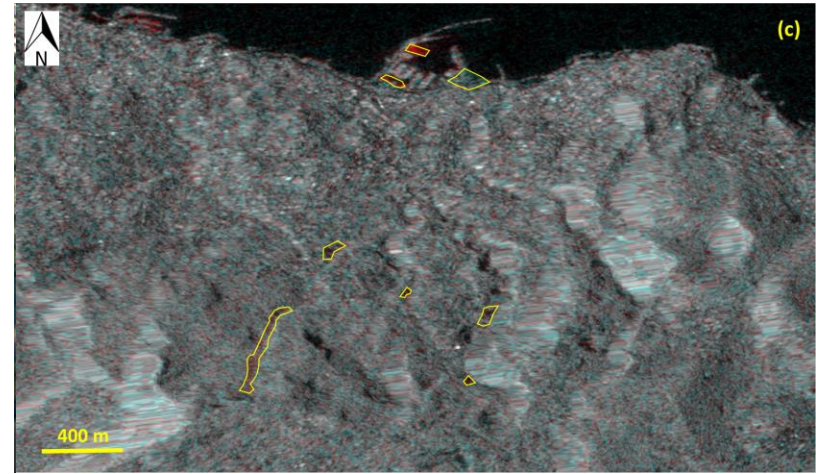
Collection of bespoke SAR images in emergency mode (thus with the highest priority) in response to disaster events that may occur in both the countries

**Several occasions across years when ALOS-2 data proved very useful
& complemented COSMO-SkyMed & Sentinel-1**

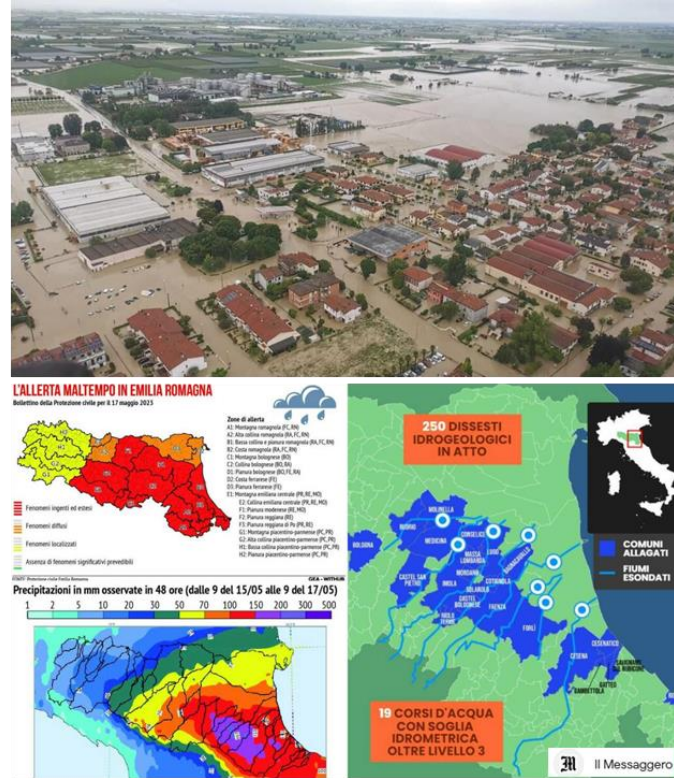
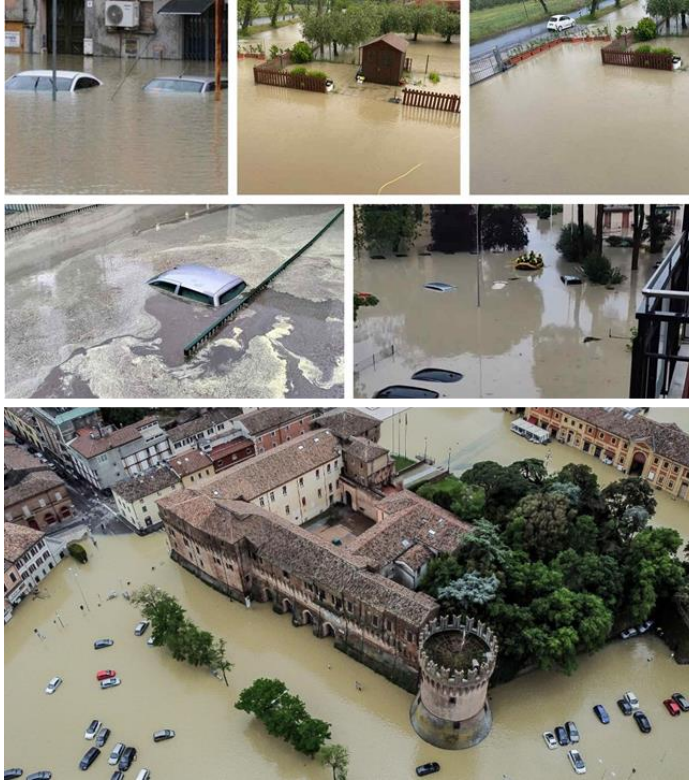
Central Italy Earthquake 2016-2017



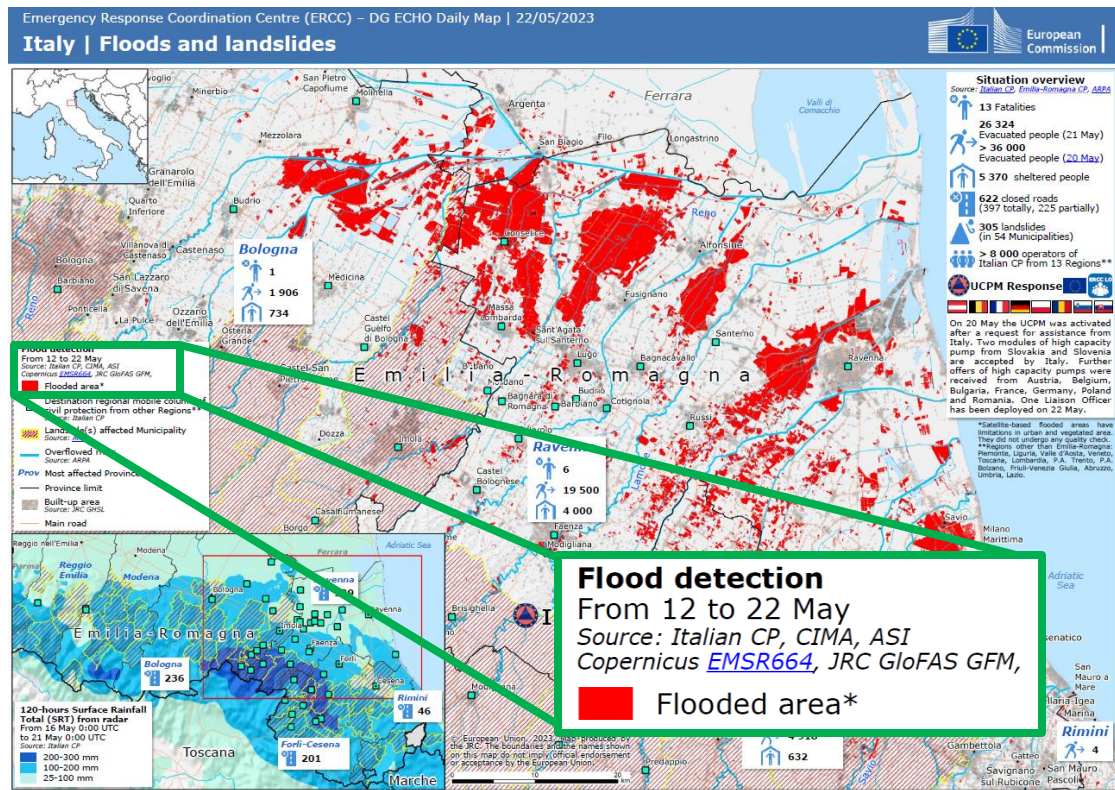
2022 Casamicciola mudflow



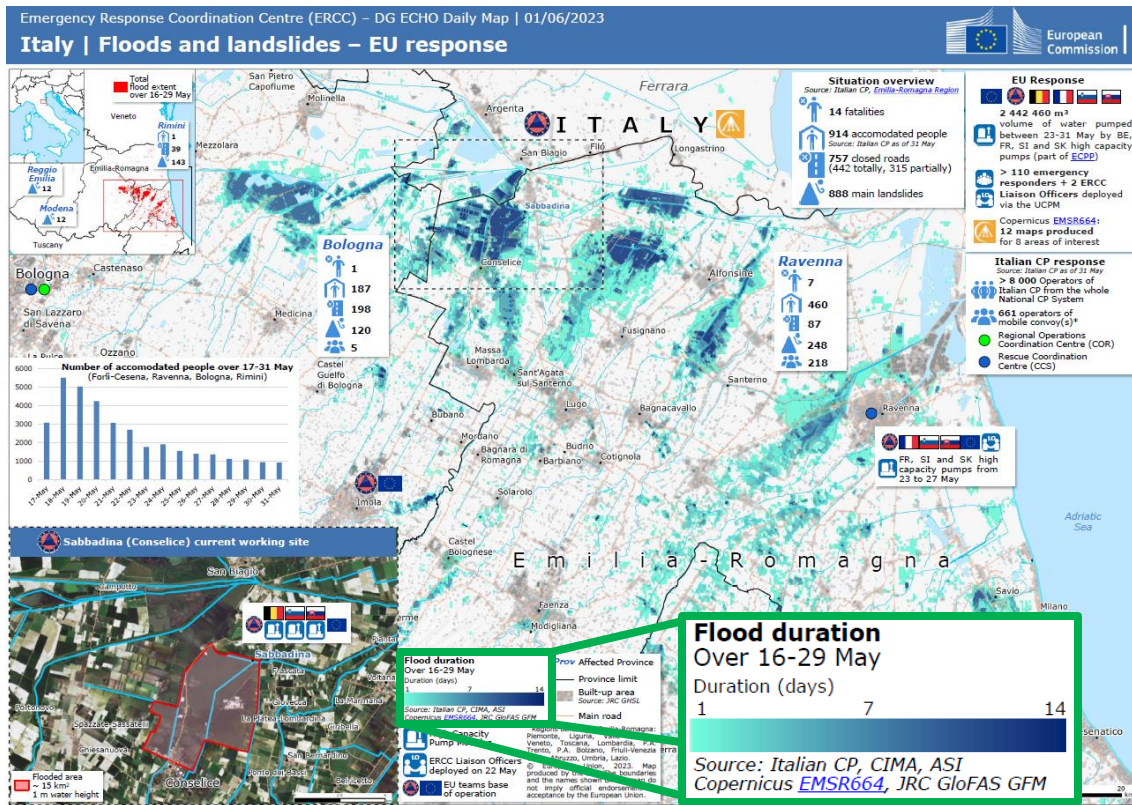
Catastrophic floods in Emilia-Romagna region in 2023



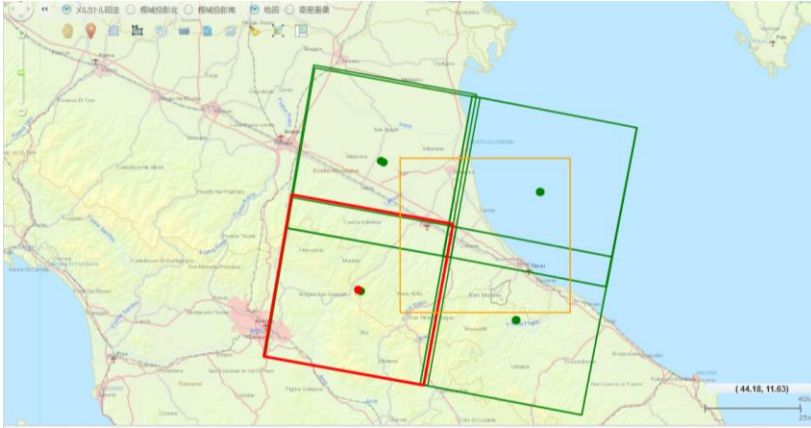
Catastrophic floods in Emilia-Romagna region in 2023



Catastrophic floods in Emilia-Romagna region in 2023



Catastrophic floods in Emilia-Romagna region in 2023



Noto Peninsula Earthquake (2024)

Earth observation related to the Noto Peninsula Earthquake (1 week after the disaster) for high temporal and different looking observation under domestic and international cooperation

16:10(JST)
Earthquake

1/1 ▼ 1/2 1/3 1/4 1/5 1/6 1/7 1/8



○ 23:10 ○ 12:37 ○ 23:51 ○ 11:42 ○ 12:30 23:58 ○

AXELSPACE

○ 10:04

○ 9:57



○ 13:19

○ 1:10

○ 13:58

○ 0:31

○ 13:17

Synspective

○ 9:33



○ 10:27
(Pre-disaster)

○ 17:52
(CSG)

○ 5:32
(CSG)

○ 5:02
(CSG)
○ 5:31
(CSK)

○ 5:32
(CSK)

○ 17:40
(CSK)

○ 4:50
(CSG)
○ 5:38
(CSG)

○ 17:28
(CSG)

○ 17:46
(CSG)

○ 5:26
(CSG)
○ 5:38
(CSK)



○ 10:40

Sentinel-2A (ESA)

○ 17:51

Sentinel-1(ESA)

Noto Peninsula Earthquake (2024)

Major earthquake occurred in Noto Peninsula, Japan (Jan 1, 2024)

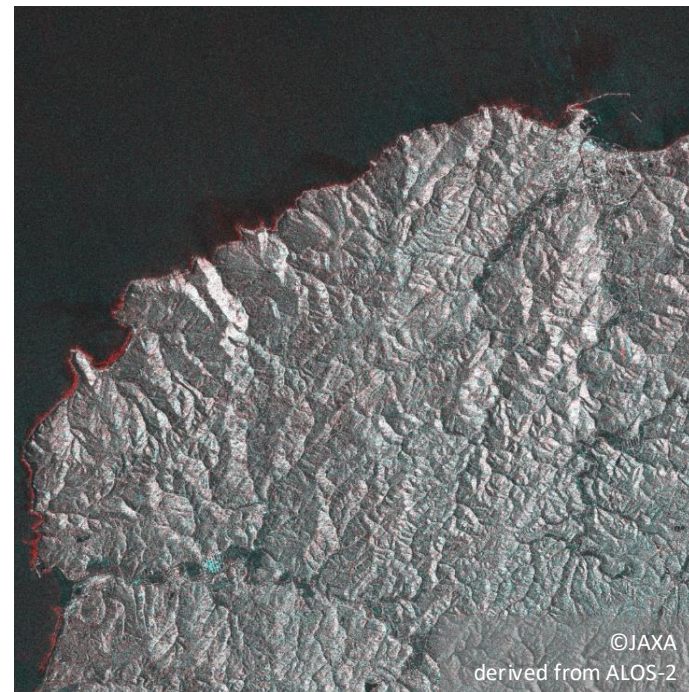
- ASI provided 17 CSK scenes and 28 CSG scenes
- ALOS-2: Ascending, left-looking, CSG: Ascending, right-looking
 - Different viewing geometries enable interpretation of areas not visible in a single image



CSK: 17 scenes
(6 with archives)



CSG: 28 scenes
(8 with archives)



Earthquake-induced coastline changes
Newly exposed land areas (in red)

Activity 3: Join Research

X- and L-band SAR acquisitions are also an asset to support **scientific studies** aiming to improve the **understanding of natural hazards**.

Until early 2023, the cooperation focused on the following thematic areas:

- Volcanoes
- Earthquakes
- Floods
- Landslides
- Coastal and Marine disasters (e.g. Tsunami high tide, oil spill)
- Deterioration of Infrastructure

From the Japanese side, research projects involving the Japanese science community were approved and supported by ASI. Research topics: water related disaster, Volcanoes, Earthquakes, Landslides, Marine disaster, crustal deformation and agricultural damage assessment in cooperation with researchers in Japan.

From the Italian side, ALOS-2 emergency acquisitions were also valuable datasets to investigate the Earth's processes causing the disasters

Activity 3: Join Research (evolution)

Since April 2023, wider scope and topics portfolio have been encompassed:

- Application development for Disaster Risk Management (DRM)
- Understanding and addressing all the phases that compose **the whole DRM cycle** (i.e. Mitigation, Preparation, Response, Recovery)

Thematic areas:

- Volcanoes
- Earthquakes
- Floods
- Landslides
- Coastal and Marine disasters (e.g. Tsunami high tide, oil spill)
- Deterioration of Infrastructure
- Climate Change, extreme weather events and drought (incl. water balance, soil moisture)
- Land cover land use (e.g. urbanization, agriculture)
- Reconstruction and recovery after disasters

Interest not only in change detection, but also on **time series analysis**

Activity 3: Join Research – Hot spot areas for time series



Asc				
③A20 Jolanda di Savoia	F2-6	197	44.25	44.75
②A21 Tavoliere Pugliese	F2-5	195	40.75	41.25
A25 Calabria region rural areas1	F2-5	195	39.25	39.75
A26 Calabria region rural areas2	F2-5	195	38.25	39.25
A27 Basilica region rural areas	F2-5	195	39.75	40.25
①A22 Rome's rural hinterland	U2-9	198	40.75	41.25
⑤A24 Stromboli volcano	F2-6	196	37.75	38.75
A23 Campi Flegrei caldera	F2-5	196	40.25	40.75
Etna C02 Path196 • Right	F2-5	196	36.75	37.75
Etna C02 Path196 • Right	F2-6	196	36.75	37.75
Etna C02 Path191 • Left	F2-5	191	38.25	39.25
Etna C02 Path191 • Left	F2-6	191	38.25	39.25

Dsc				
③A20 Jolanda di Savoia	F2-6	93	135.25	135.75
②A21 Tavoliere Pugliese	F2-5	91	138.75	139.25
A23 Campi Flegrei caldera	F2-6	91	139.25	140.25
①A22 Rome's rural hinterland	U2-8	92	138.25	139.25
⑤A24 Stromboli volcano	F2-7	90	141.25	142.25
A25 Calabria region rural areas1	F2-6	90	140.25	141.25
A26 Calabria region rural areas2	F2-6	90	140.75	141.75
A27 Basilica region rural areas	F2-6	90	139.75	140.25
Etna C02 Path90 • Right	F2-6	90	142.25	143.25
Etna C02 Path90 • Right	F2-7	90	142.25	143.25
Etna C02 Path96 • Left	F2-6	96	140.75	141.25
Etna C02 Path96 • Left	F2-7	96	140.75	141.25

Multi-mission SAR data & research context in Italy

ASI's interest & investments in promoting multi-mission/multi-frequency SAR data collection and development of image processing algorithms and prototype product development



Innovation in InSAR Processing and Analysis of C-, X- and L-Band SAR Data for Natural Hazards, Agriculture, Marine and Coastal Applications in the framework of ASI's "Multi-Mission and Multi-Frequency SAR" Program

Deodato Tapete, Antonio Montuori, Fabrizio Lenti, Patrizia Sacco, Maria Virelli, Simona Zoffoli, Alessandro Coletta

Italian Space Agency (ASI)

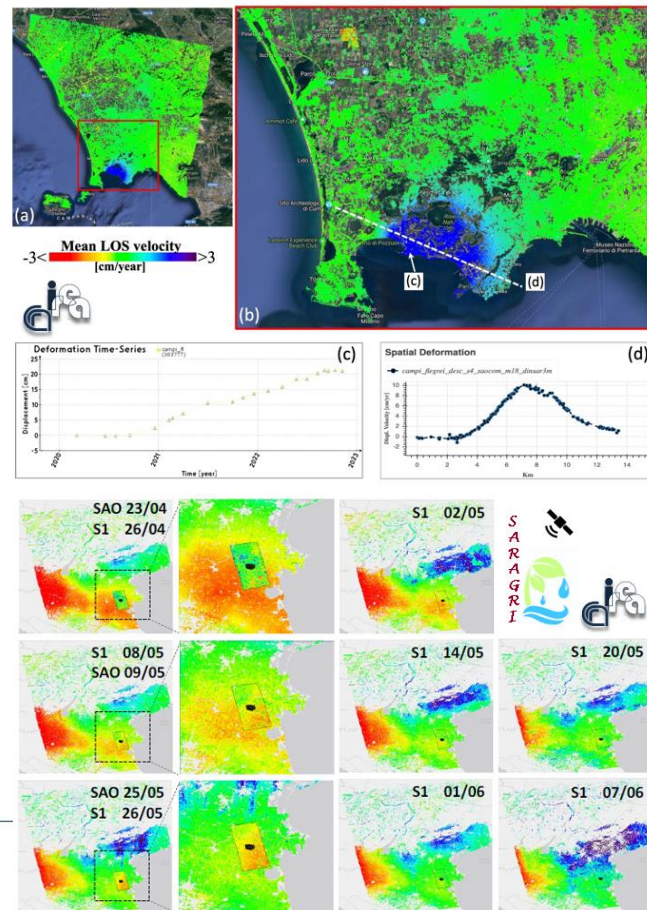
FRINGE 2023
University of Leeds, UK | 11 - 15 September 2023

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ASI Agenzia Spaziale Italiana

THE EUROPEAN SPACE AGENCY

Further progress since ASI's ppt at FRINGE 2023!

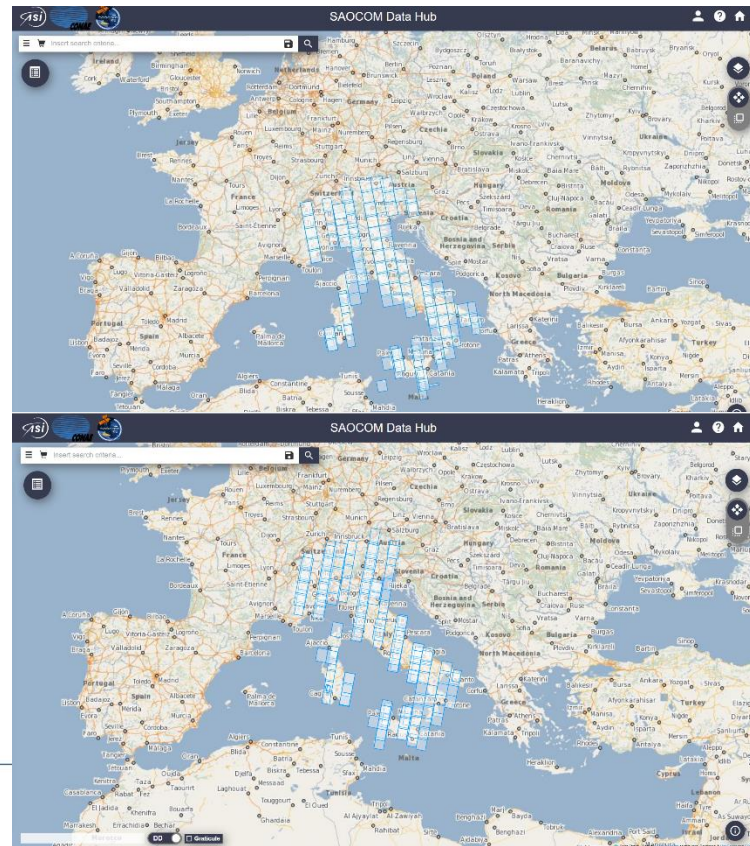
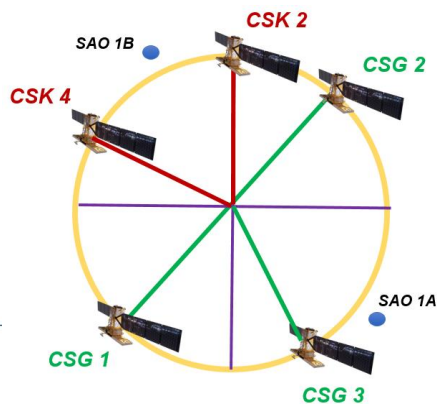


Multi-mission SAR data & research context in Italy

SAOCOM acquisition plan over Italy (since July 2022)

- High priority acquisition plan (Foreground mission)
- Global Italy coverage
- Stripmap
- Dual pol vh-vv
- Beams S3, S4, S5
- Asc. & Desc
- SAO1A & SAO1B
- Two acquisitions every 48 days (3 SAOCOM cycles) not equally distributed

Access through the ASI
SAOCOM Portal:
<https://saocom.asi.it>



Achievements of ASI – JAXA cooperation in DRM

- Exemplar long-standing partnership between space agencies that bring to the common benefit the SAR missions that the two space agencies have developed and are operating in different radar bands
- SAR data from COSMO-SkyMed (1st & 2nd Generations) and ALOS-2 missions have proved to complement each other during not only several disaster events whenever one agency asked the other for emergency observations, but also to address scientific research questions on the Earth's causative processes
- Now ALOS-4 is also included
- For both the emergency and joint research activities, the X- and L-band archives being built over Italy and Japan represent effective basemaps to provide pre-disaster observations
- Opportunities from multi-mission/frequency SAR data-based research to be fully investigated

**Thank you
for your attention!**

