

living planet symposium | BONN

23-27 May
2022

TAKING THE PULSE
OF OUR PLANET FROM SPACE



→ RADAR VISION FOR COPERNICUS



Sentinel-1 Overall Mission Status

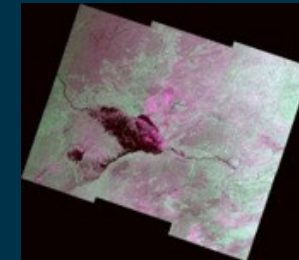
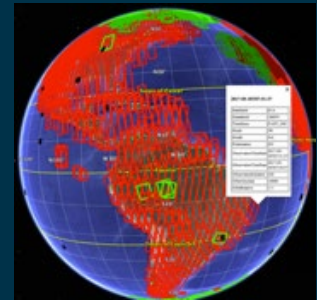
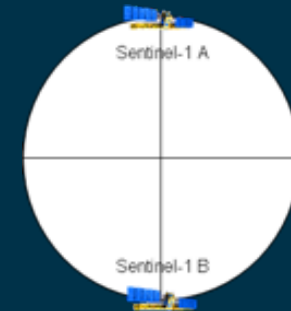
Pierre Potin, O. Colin, M. Pinheiro, B. Rosich, L. Martino, A. O'Connell, J.B. Gratadour, R. Torres, M. Davidson

European Space Agency (ESA)

25 May 2022

Sentinel-1 Constellation Mission Facts

- Constellation of two identical SAR C-band (5.405 GHz) satellites (A & B units)
- Sentinel-1A launched on 3 April, 2014 & Sentinel-1B on 25 April, 2016
- Near-Polar, sun-synchronous (dawn-dusk) orbit at 698 km
- Instrument duty cycle of 25 min/orbit in High Bit Rate modes and 75 min/orbit in Low Bit Rate mode (Wave)
- 12-day repeat cycle (each satellite), 6 days for the constellation
- Systematic SAR data acquisition using a predefined observation scenario
- 7 years lifetime, consumables for 12 years at least
- Operational use of the European Data Relay System (EDRS) service





- **Sentinel-1B major anomaly** occurred on 23 Dec 2021
- Sentinel-1A, launched in April 2014 (8 years ago), **has reached its design lifetime of 7 years of operations:**
https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-1/First_Copernicus_satellite_exceeds_design_working_life
- Sentinel-1A is fully operational and remains key for many Copernicus Services and users worldwide in the operational, scientific, commercial domains
- Sentinel-1 contribution to **emergency activations** continues to be very high (about once a week in average), for flood monitoring in particular
- Sentinel-1A is operated close to its **full mission capacity** (i.e. difficulty to accommodate additional observations)

Sentinel-1B anomaly status

Facts:

- The Sentinel-1B satellite unavailability started on 23 December 2021
- The problem is related to the **CAPS unit of the satellite power sub-system**, that supplies power to the radar
- The attempts performed so far for the reactivation of the related function have not been successful
- The satellite remains under control, the regular orbit control manoeuvres are routinely performed

Status of investigations:

- Out of the 18 potential failure scenarios identified by the CAPS supplier (Leonardo), one scenario has been qualified as “possible”, and is related to a leakage of a ceramic capacitor which is part of the main and redundant regulators of the 28V power regulated bus (the bus that supplies power to the SAR electronics subsystem)
- Other potential root causes were rated as “Low Probability” or “Negligible”
- System analyses were performed by ESA and TAS-I to assess possible recovery attempts, and special operations were developed for Sentinel-1B to perform in-flight tests and execute new recovery attempts

Last communication to users (22 April 2022):

<https://sentinels.copernicus.eu/web/sentinel/-/copernicus-sentinel-1b-anomaly-6th-update/1.1>

Sentinel-1B anomaly: recovery attempts & way forward

Status of recovery attempts:

- On 4 April 2022, in one of the many attempts to switch ON the prime regulator, the status of the regulator remained ON for 4.4 seconds and was then reverted autonomously to OFF. This was the first time this change of status was observed since the start of the recovery attempts. This behaviour could indicate that the prime regulator features a degradation, but not necessarily a permanent failure.
- However subsequent recovery attempts were unsuccessful, some of them were executed in varying the temperature of the CAPS unit. Further attempts are currently on-going.

Way forward:

- The work of the Anomaly Review Board (ARB) will be completed by end May 2022 and an ESA report, including the ARB conclusions, the status of the various parallel actions, as well as recommendations for further actions, will be issued.
- Three medium-term actions, to be completed indicatively by end 2022, will be conducted:
 1. Technological tests will be carried out by two main means:
 - Set up of a ground breadboard representative of the 28V bus, and execution of a series of tests
 - Further tests to be performed on Sentinel-1B
 2. Modifications of Sentinel-1C/D CAPS to increase its robustness
 3. Further support the lack of Sentinel-1B data with Copernicus Contributing Mission data
- Should the technological tests be inconclusive, Sentinel-1B will be declared failed, and a deorbiting plan will be implemented in 2023 (i.e. lowering Sentinel-1B orbit for space debris mitigation similarly to ERS-2)

Sentinel-1B anomaly: status of parallel actions

- **Prepare for a launch of Sentinel-1C at the earliest possible opportunity**

- a launch period is contractually fixed between 1 May 2023 and 31 October 2023. However, the contract foresees a priority for an earlier launch in case the spacecraft scheduled for launch in the first quarter of 2023 is delayed.
- Last agreement with Arianespace is 2nd half of April 2023

- **Adjustments of the Sentinel-1A observation scenario**

- See next slide

- **Substitute a fraction of Sentinel-1B data with Copernicus Contributing Mission (CCM) data**

- volume of **Radarsat-2** data has been largely increased to support CMEMS sea ice monitoring activities
- in agreement with CSA, in the frame of the Canada-EU agreement on Copernicus:
 - **Radarsat Constellation Mission (RCM)** observation frequency over sea ice areas was increased
 - The European Commission asked for RCM data coverage over specific areas to evaluate the suitability of the mission to support the monitoring of agricultural activities in the context of the EU Common Agricultural Policy (CAP)

Rationale

- Following the Sentinel-1B anomaly (unavailability of several months) a number of **adjustments have been performed** (exercise still on-going, to some extent) in order to reduce the impact of missing S1B data.
- This was based on **various needs expressed by key users / communities** (incl. Copernicus Services), as well as specific ad-hoc requests received at the Copernicus EO Support helpdesk

Notes:

- **Sentinel-1A was already operated close to its max. capacity** (mainly in terms of max. SAR duty cycle constraint per orbit), preventing the addition of substantial observations
- These adjustments are being performed **outside Europe and European waters**, as in Europe all potential Sentinel-1A passes are already part of the standard plan (cannot do better in Europe...)

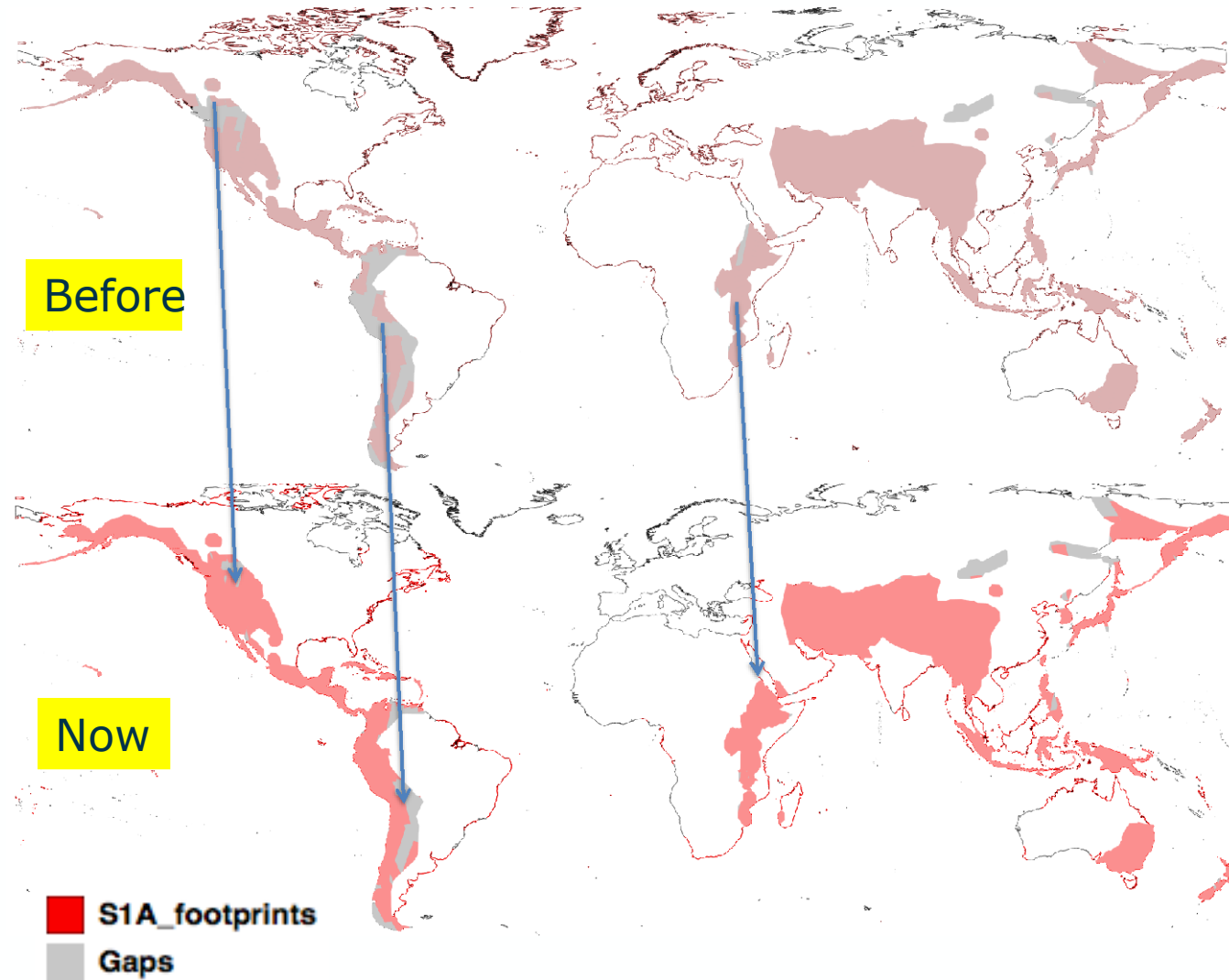
Main additions

- ⇒ **Tectonic areas and priority volcanoes**, in South America, Africa and New Zealand
- ⇒ **Ice sheet monitoring (Antarctica)**
- ⇒ **Various targets** of limited extent worldwide



Enhanced coverage of the tectonic mask as well as of the volcanic hot spots, with additional acquisitions permanently included in the S1A Long Term Plan over areas in Africa, Argentina, Australia, Bolivia, Colombia, La Reunion, Mongolia, New Zealand, Peru and Western part of Canada and USA

At least one acquisition every 12 days is ensured for all of the priority volcanoes identified as part of the Powell report



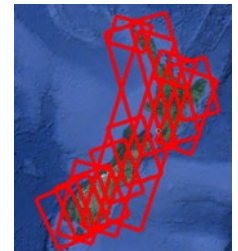
Remaining gaps on tectonic mask (~ 9%)

EXAMPLES



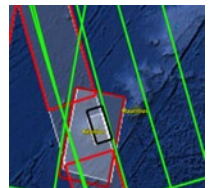
Afar

Ascending passes added



New Zealand

Ascending passes added



La Reunion

SM mode reinserted



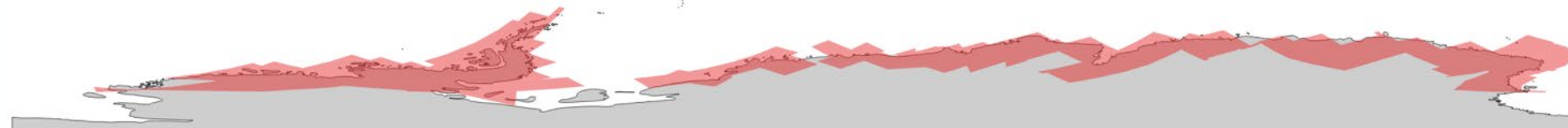
Sentinel-1A observation plan update

Antarctica ice sheet margins

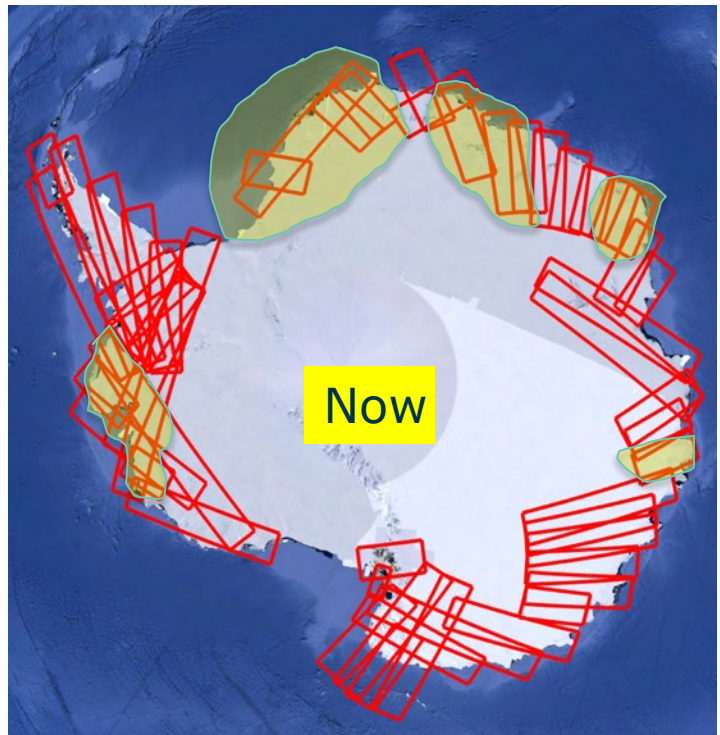
Reintroduce some key S1B IW orbit passes in Antarctica.

New S1A coverage was implemented as of 21 March 2022 on the following AOIs:

- a) Rayner Glacier: ascending orbits 14, 43, 58 added.
- b) East Peninsula: ascending orbits 2, 46, 164 and descending orbit 50 added.
- c) West Peninsula: priority was raised for descending orbits 68 and 54.
- d) Wilhem Glacier: ascending orbits 100, 129 added
- e) Kollisen Glacier: ascending orbit 74 added



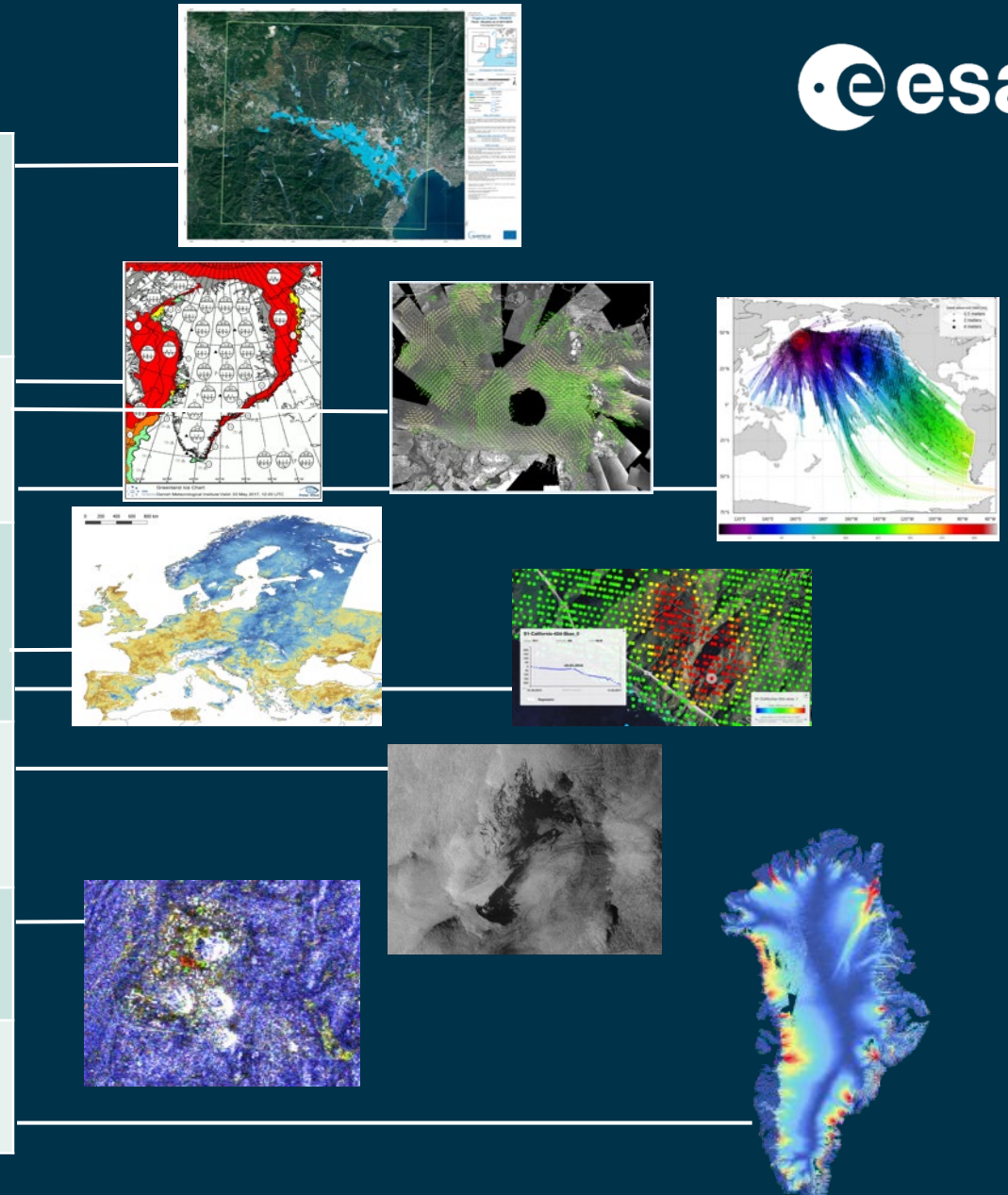
GIS map showing the new S1A IWS SH coverage in Antarctica



Sentinel-1 used in most Copernicus services...



<p>CEMS Copernicus Emergency Management Service</p>	<ul style="list-style-type: none"> - Emergency response to rapid mapping (flood mainly) - Risk recovery (e.g. ground deformation) - Validation (e.g. floods, landslides) - Automated global flood monitoring (in development)
<p>CMEMS Copernicus Marine Environment Monitoring Service</p>	<ul style="list-style-type: none"> - Sea-ice (incl. charting, concentration, thickness, drift) - Icebergs concentration - Wave / swell
<p>CLMS – Pan-European & Global Copernicus Land Monitoring Service Global Land Ground Motion Service</p>	<ul style="list-style-type: none"> - HRLs: Wetness and Water, Imperviousness, Tree cover & Forest, Grassland, Snow, River/Lake ice - Global: Soil moisture - European ground motion service
<p>CSS – CMS Copernicus Security Service Copernicus Maritime Surveillance Service European Maritime Safety Agency / CleanSeaNet</p>	<ul style="list-style-type: none"> - Oil spill detection and polluter identification (CleanSeaNet) - Maritime surveillance (e.g. ship detection, search and rescue, anti-piracy)
<p>CSS – SEA Copernicus Security Service Support to External Action</p>	<ul style="list-style-type: none"> - Change detection - Feature identification
<p>C3S Copernicus Climate Change Service</p>	<ul style="list-style-type: none"> - Ice sheets & ice shelves - Ice velocity - Glaciers



... as well as in national services, and the scientific and commercial domain



Use of Sentinel-1 in the Copernicus Marine Environment Monitoring Service (CMEMS)



Marine
Monitoring

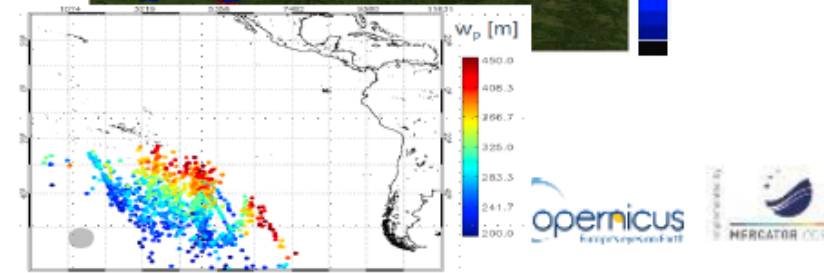
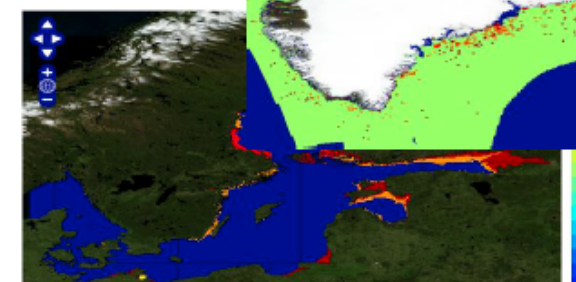
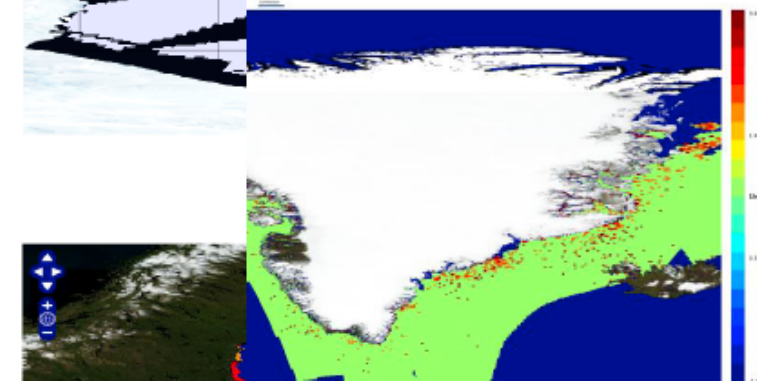
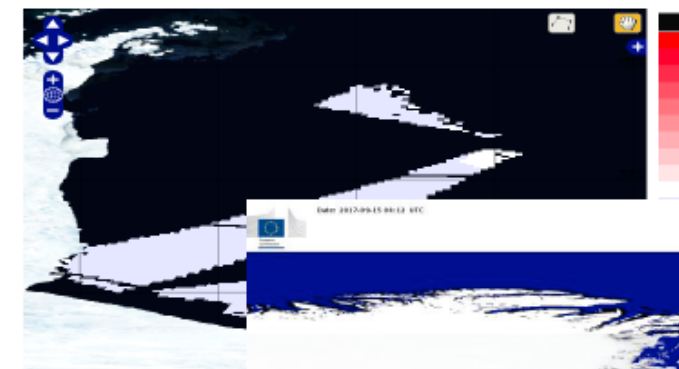
Sentinel-1 based products

Well established use of Sentinel-1 data in the Copernicus Marine Service

9 Products distributed:

- Antarctic Ocean - Sea Ice Edge from SAR
- Arctic Ocean – Sea Ice Charts – Svalbard and Greenland
- Baltic Sea - Sea Ice Concentration and Thickness Charts
- Baltic Sea - SAR Sea Ice Concentration, Edge, Thickness and Drift
- Global Ocean - High Resolution SAR Sea Ice Drift
- Arctic Ocean - SAR Sea Iceberg Concentration
- Sea Ice Concentration based on Sentinel-1 and AMSR2
- Noise corrected images
- Wave parameters

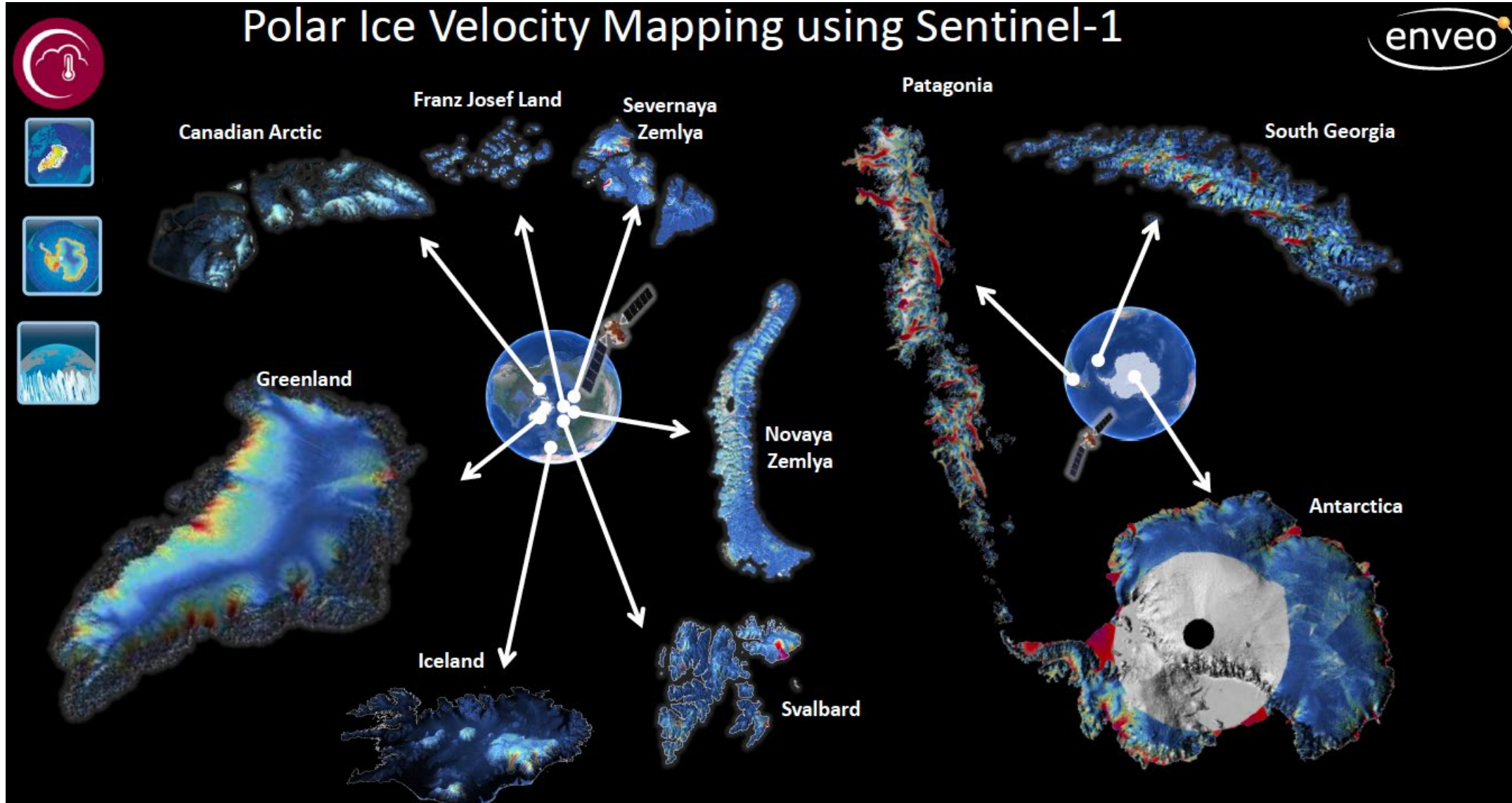
Systematic use for validation of model products



Courtesy CMEMS,
A. Reppucci,
Mercator Ocean

Use of Sentinel-1 in the Copernicus Climate Change Service (C3S)

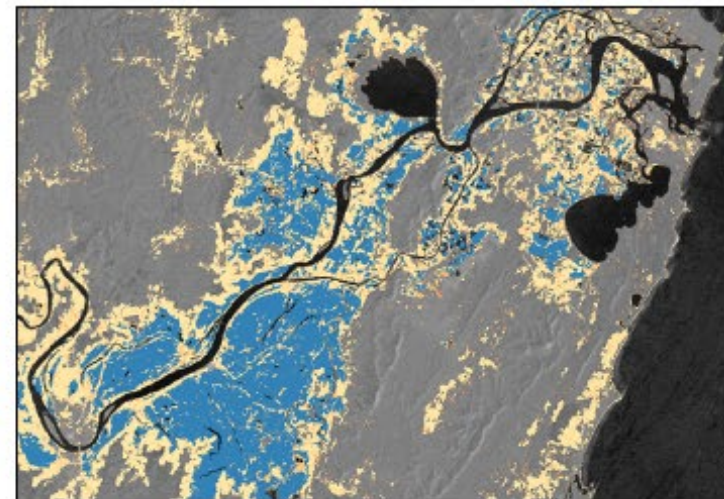
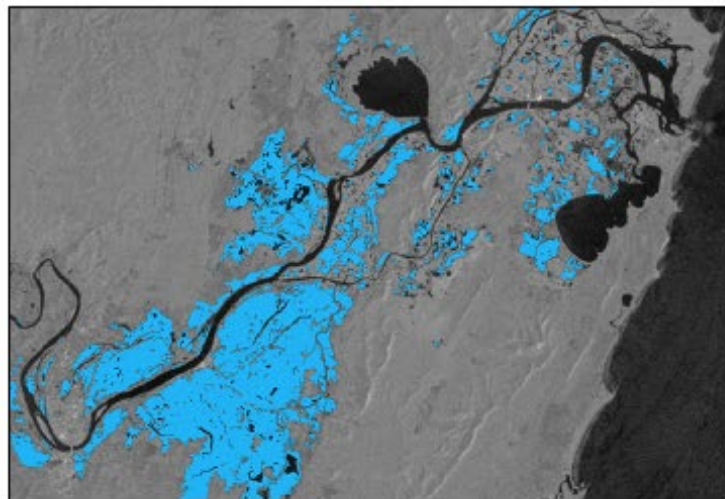
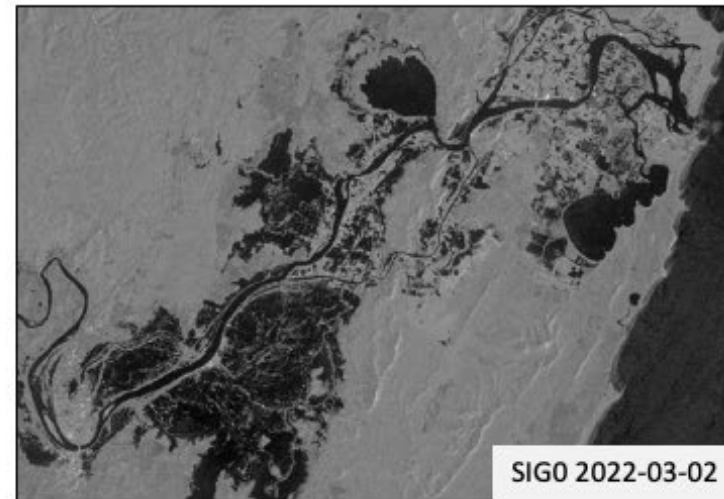
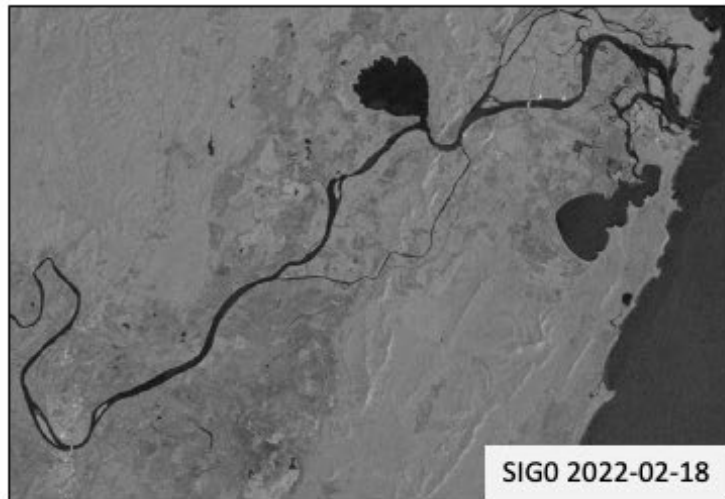
Polar Ice Velocity Mapping using Sentinel-1



Courtesy C3S,
T. Nagler,
ENVEO

Use of Sentinel-1 in the new Global Flood Monitoring service of the Copernicus Emergency Management Service (CEMS)

Courtesy CEMS,
Niall McCormick,
JRC




Ensemble flood

 Flood

Ensemble likelihood

 Certainly flood

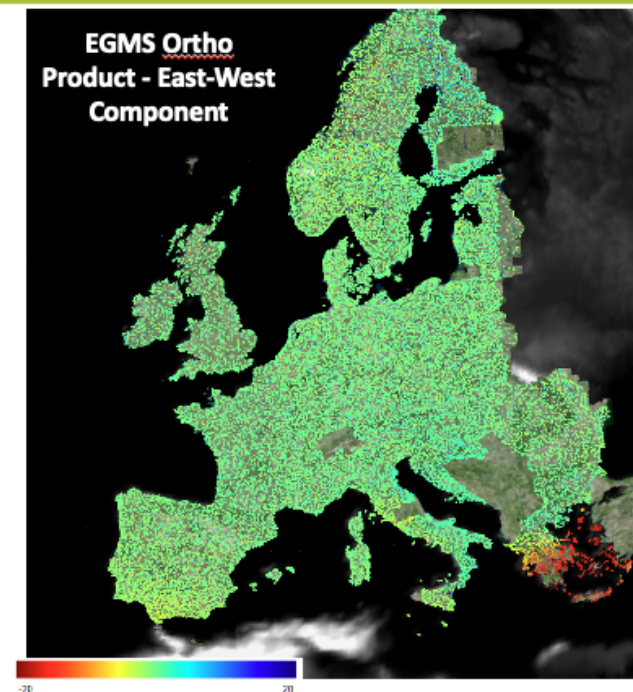
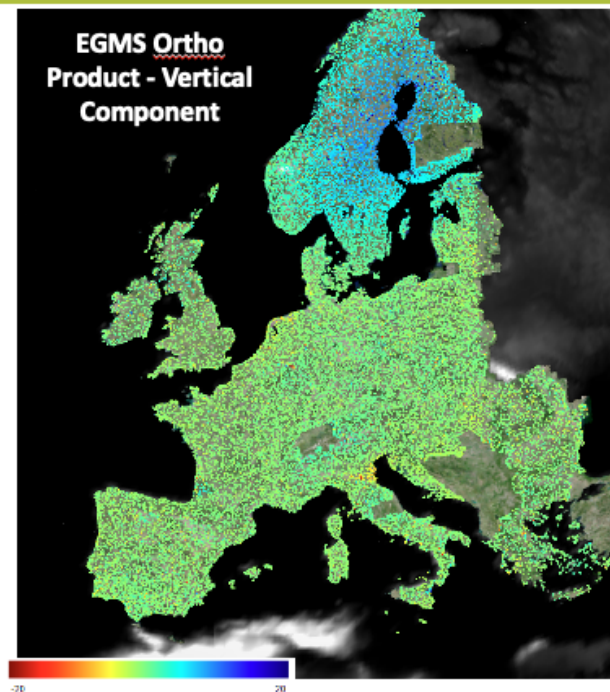
 Certainly non-flood

10 km

Use of Sentinel-1 in the Copernicus European Ground Motion Service



First product from the European Ground Motion Service (EGMS) released



EGMS, part of the Copernicus Land Monitoring Service, delivers millimetre-accuracy information on natural and anthropogenic ground motion phenomena (landslides, subsidence, volcanic phenomena, etc.).

For details please attend the presentation *"First look at the European Ground Motion Service products"*, Session *Satellite EO for Geohazard Risks-3*, Thursday, 3.40pm, room Addis Abeba.

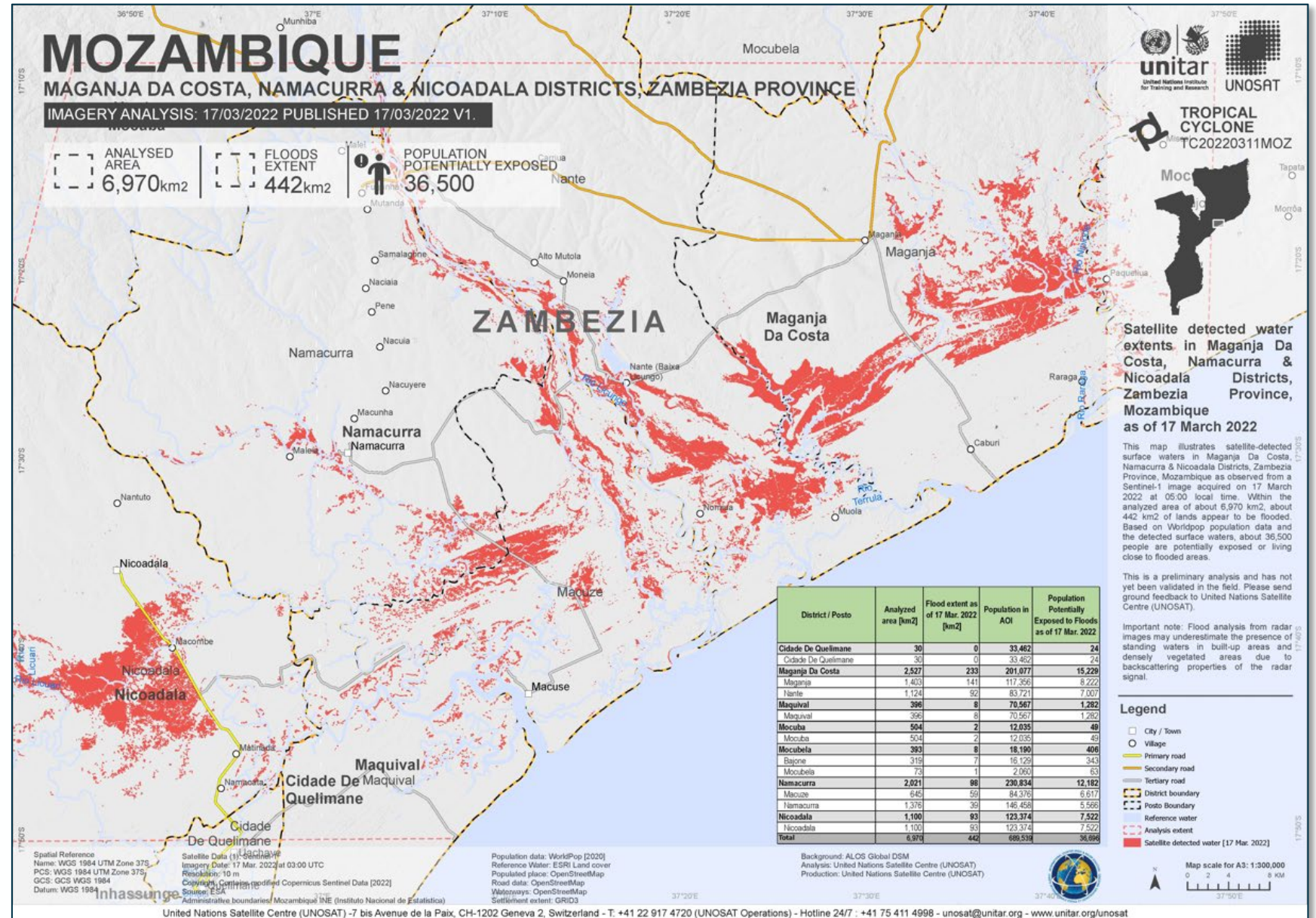
Courtesy EGMS,
Henrik Steen Andersen ,
EEA

Sentinel-1A
fully operational

Call 866 from the International Charter Space and Major Disasters related to **floods in Mozambique**, due to cyclone Gombe

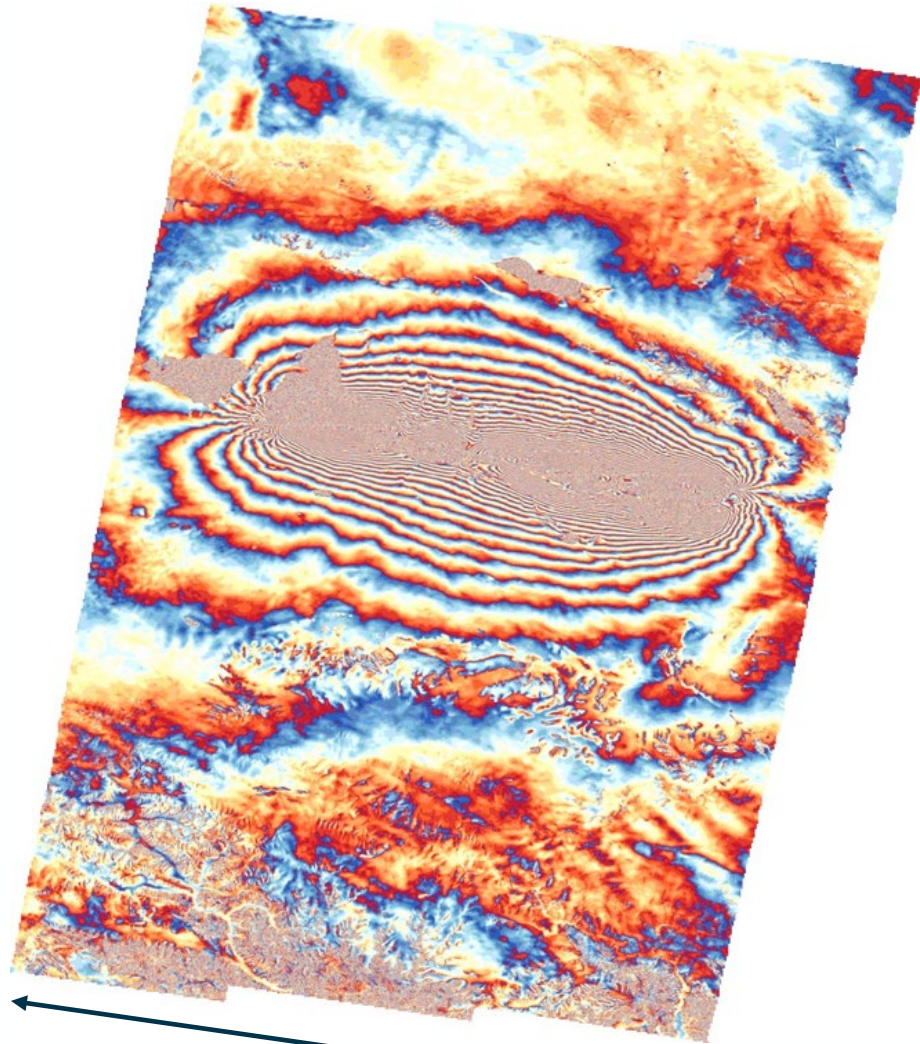
Flood delineation map based on Sentinel-1A data acquired on 17 March 2022

Copyright: Contains Copernicus Sentinel data (2022) / processed by UNOSAT

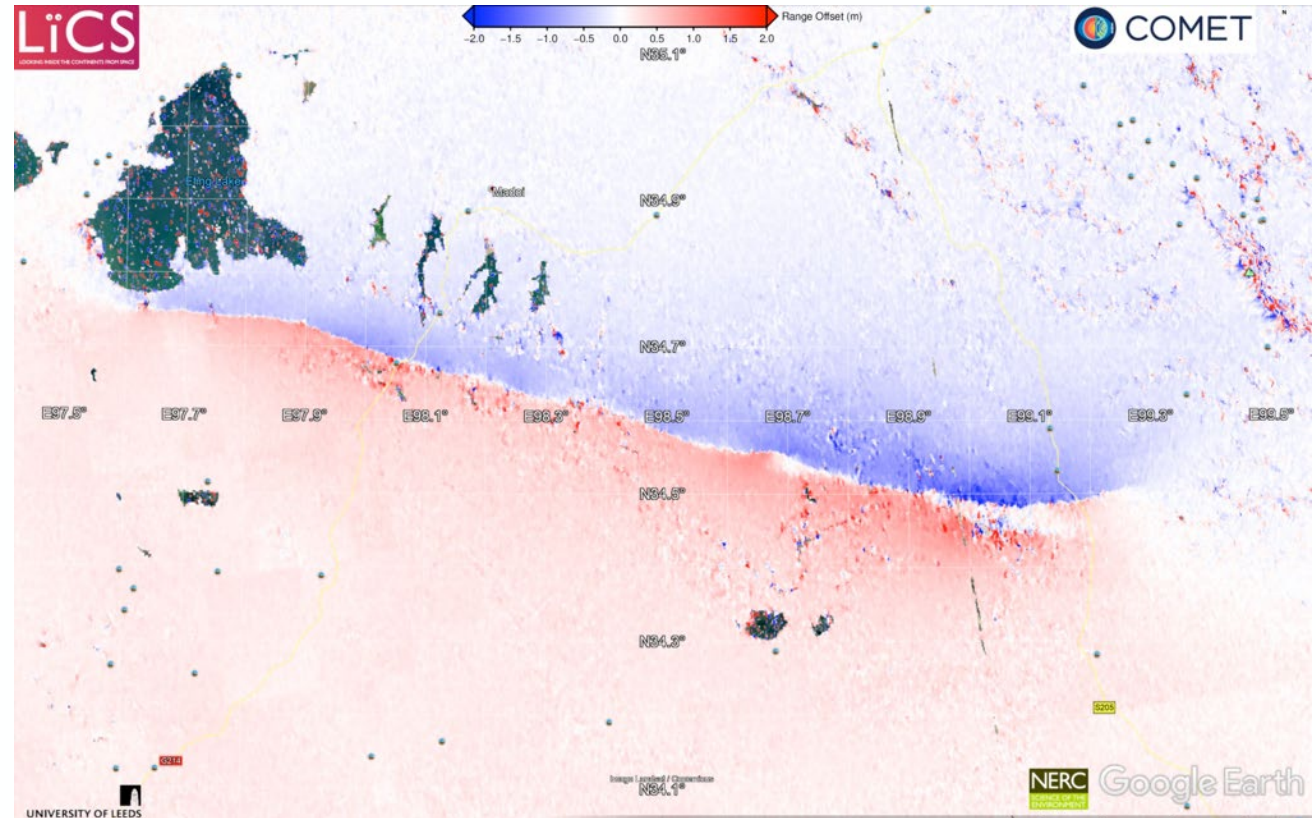


Mw7.4 earthquake, Southern Qinghai, China, 21 May 2021

Descending pass interferogram



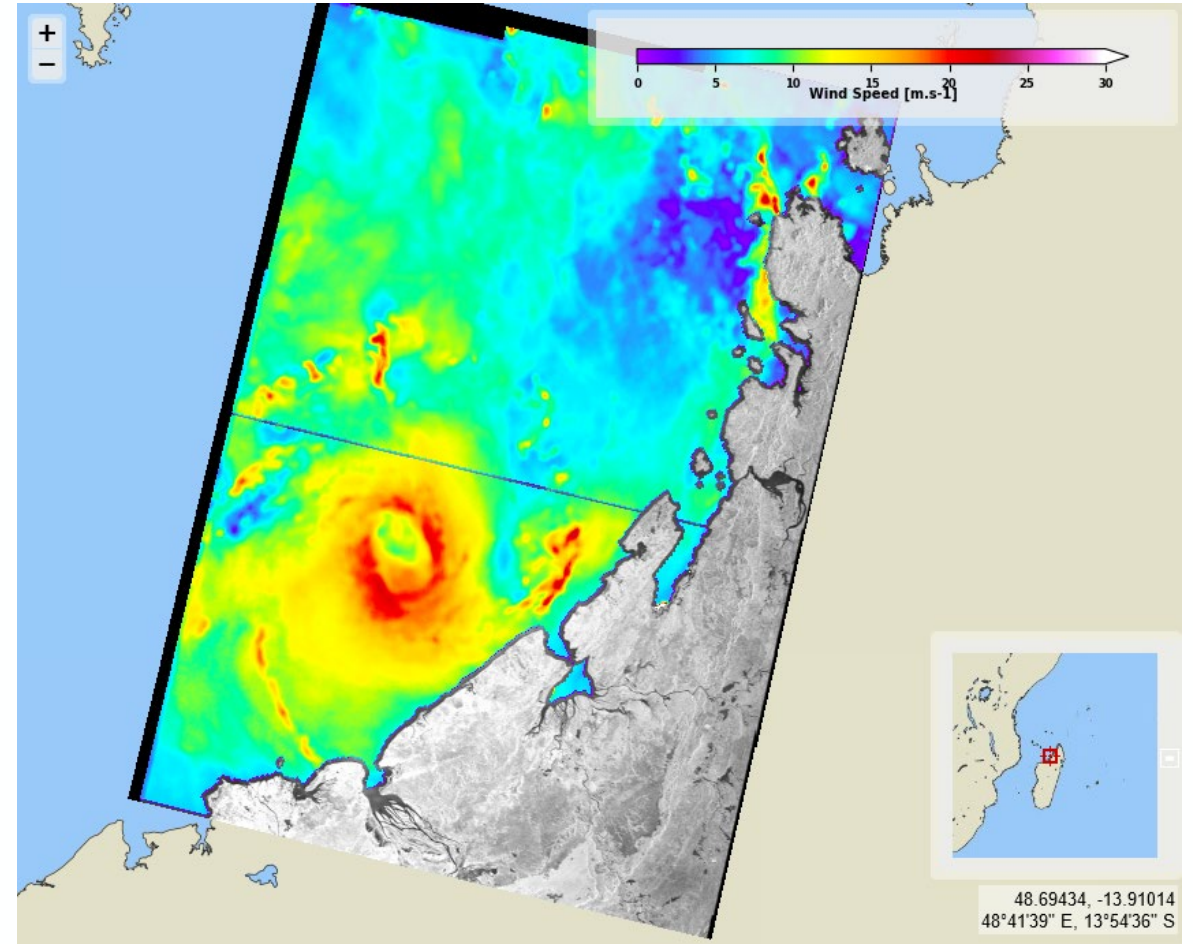
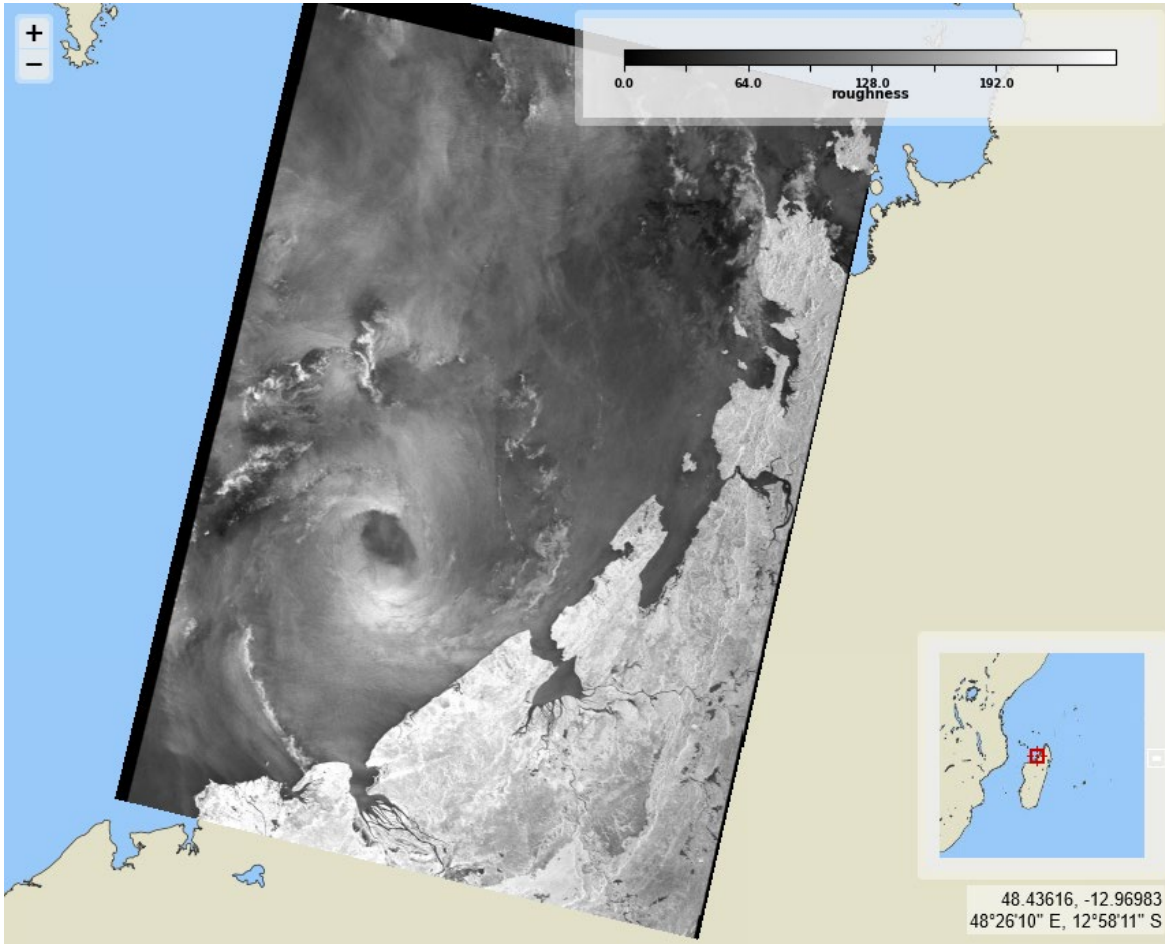
250 km swath



"SAR offsets (in range) indicate 156 km long rupture with single major trace rupture along most of length except in the east with a second splay" –

Courtesy John Elliott, University of Leeds / COMET

© Contains modified Copernicus Sentinel data (2021) / processed by COMET



From CYMS: Cyclone Monitoring Service by Sentinel-1 – Sentinel-1A acquisition of 9 March 2022

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- The **mission is today based on the operations of Sentinel-1A only**, similarly to the period Oct 2014 – Oct 2016, before the launch and commissioning of Sentinel-1B
- **Sentinel-1B operated nominally up to 23 Dec 2021**, when the major anomaly located in a unit of the power subsystem occurred
- The **Sentinel-1B anomaly ARB investigations will be concluded soon**, an ESA report will be released, with some recommendations for further actions
- **Sentinel-1A is fully operational and remains key for Copernicus Services** and users worldwide in the operational, scientific, commercial domains
- Looking forward to the **launch of Sentinel-1C** to come back to a mission based on a 2-satellite constellation => **April 2023**
- Actions will start with the European Commission to analyse a **potential anticipation of the launch of Sentinel-1D**, in order to ensure a robust planning for the 2-satellite constellation mission

Thank you for your attention !

Copernicus Programme: copernicus.eu

Sentinel Online: sentinels.copernicus.eu

CSC Data Access: spacedata.copernicus.eu

 **ESA Sentinel app: available for iOS and Android**



Suez Canal traffic jam and Ever Given ship seen by Sentinel-1, 25 March 2021

Copyright: Contains Copernicus Sentinel data (2021) / ESA

