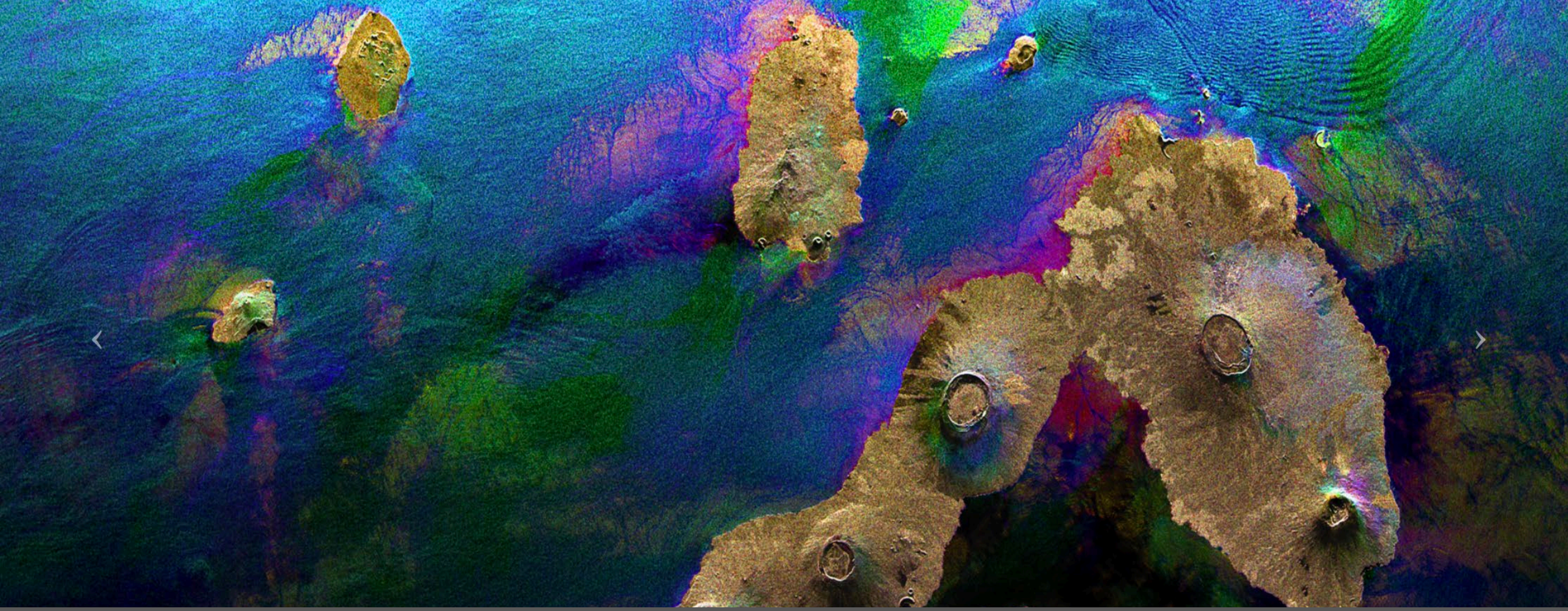
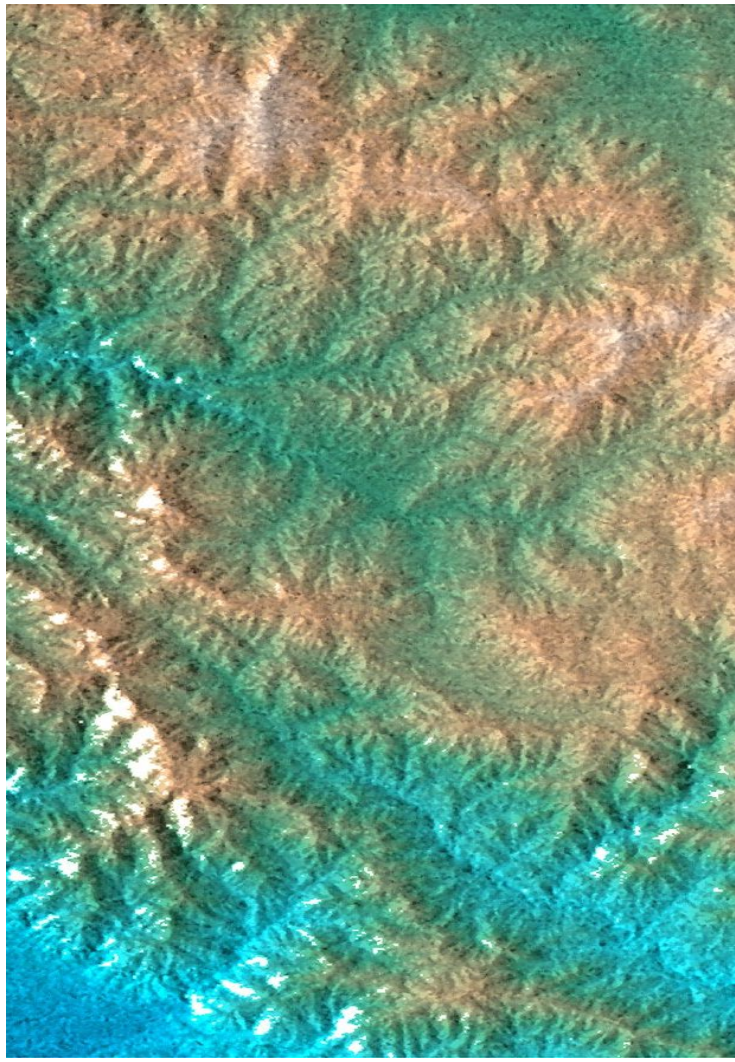


International Coordination of Future SAR Missions – An Overview

Dr. Maurice Borgeaud – ESA
Prof. Charles Elachi – Caltech

LPS'22, Bonn, Germany
25 May 2022

International Coordination for Spaceborne Synthetic Aperture Radar Data Acquisition, Processing and Analysis for Earth Science and Applications

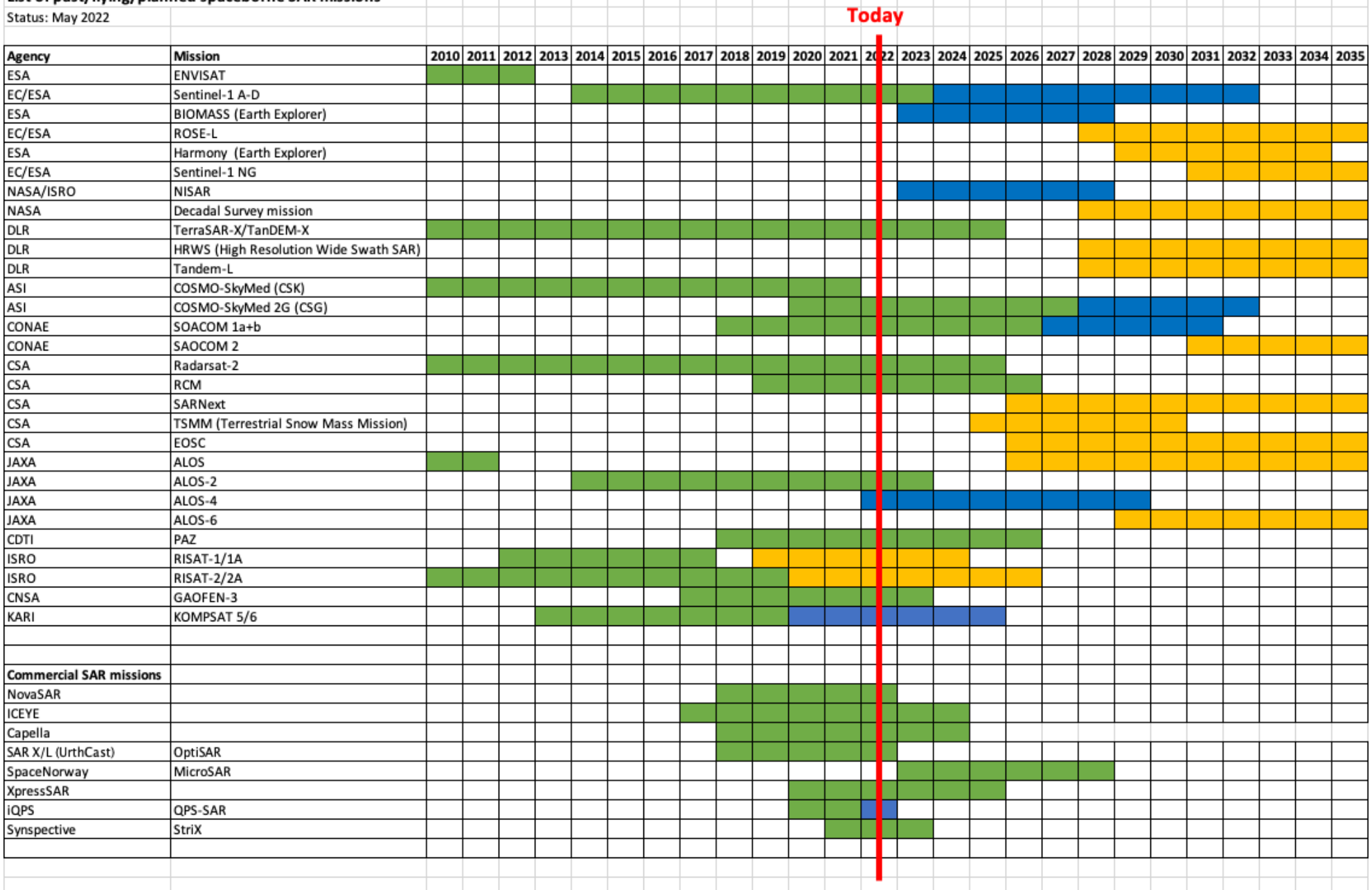


- Original idea proposed by Charles Elachi
- First workshop held on 30 May – 1 June 2018 at Caltech, USA
- Explore the interest in and value of a more coordinated approach among the different organizations flying or planning spaceborne SAR missions to achieve higher value for the science and application user community
- Workshop was attended by 60 scientists and engineers from almost all the agencies/countries flying spaceborne SAR's and from the commercial sector

2018 Workshop Attendees

List of past/flying/planned spaceborne SAR missions

Status: May 2022



Recommendation 1: Archival, present and future data should be easily and electronically accessible with a standard and common format, at little or no cost.

- All agencies flying spaceborne SAR systems either provide all of the data free of cost, or subsets of data for specific purposes and to support interagency agreements.
- While a single format may not be suitable for all SAR data, there is a strong consensus that a good degree of harmonization is warranted and possible, through the clear and common definition of metadata quantities, and creation of standard lookup tables to serve as Rosetta Stones translating among legacy formats.

Recommendation 2: Develop a mechanism to coordinate future data acquisition and coverage by present and planned systems, as well as ground reception and processing approaches for mutual benefit.

- Coordination among systems has led to significant benefit, particularly for polar ice studies (Polar Space Task Group) and rapid characterization of natural hazards (International Disaster Charter and Sentinel Asia). Expanded coordination will greatly benefit applications that rely on expanded coverage, shorter repeat time, long term monitoring and multiple frequency/polarized observations.
- Information on acquisition plans for each mission should be available to all to facilitate better coordinated between the agencies.

Recommendation 3: Take an optimized systems approach to the overall constellation of planned and proposed missions to explore the possible mutual benefit of the total constellation coverage and capabilities.

- Each organization, *understandably*, optimizes its system for its needs within its limitations. By evaluating the global constellation of missions as a coordinated system, there are opportunities for enhanced or new capabilities, while meeting individual agency requirements. Some examples:
  - Better filling of gaps and higher repeat coverage by slight adjustment of orbit, node crossings or local crossing time.
  - Quick response for time critical applications.
  - Better continuity of observations over a long period of time (multi decadal).
  - Enable new multiple system capabilities such as bistatic observations and multi interferometric observations.
  - Left / right imaging coordination to overcome shadowing

Recommendation 4: Coordinate and share common test sites and sites for calibration and validation.

- Calibration and validation sites are essential to be able to use the radar data for most applications. Each mission team establishes such sites to serve individual systems, with a few cases of common site utilization.
- Mutually agreed on common test sites and “Supersites” for calibration and validation of all currently flying and planned systems would provide great value. *This would significantly enhance the value of the data from multiple systems, save significant financial resources and encourage international collaboration.*
- Given the large number of SAR missions and the diversity of mission architectures (e.g. frequency, antenna, pattern, resolution, polarization, etc...), there is a recognized benefit to calibrating/validating all SAR missions over a number of “Super-Sites”.
- Public availability of data from all missions and associated ground based observations would facilitate inter-mission comparisons and fusion. These sites should be defined, developed, and supported by international teams, under multi-agency agreements.
- The validation and thematic sites should involve relevant user agencies, so that validated data are easily understood and used, and that data products can be widely applied by non-experts.

2018-2022 Activities

Since the 2018 First Workshop:

- Session at LPS'19 in Milano (more than 250 attendees)
- Coordination meeting in Milano in May 2019
- Second workshop should have taken place at ESA/ESRIN in May 2020
- Unfortunately, due to COVID-19, it was postponed first to May 2021 then to October 2021, then again to October 0222
- Several meetings of the Organisation Committee to prepare the Second Workshop
- Session at IGARSS'21, LPS'22, IGARSS'22
- New date for the Second Workshop: 28-30 October 2022, ESA-ESRIN, Frascati, Italy

Working Groups (WG)

In order to implement the 2018 recommendations, three working teams that include radar systems experts, users, and scientists from all the involved organizations have started their activities:

- WG-1 Present and future data – Visibility and access (LO-L2) working team to address recommendations 1 & 2
- WG-2 Future imaging systems – Goals, plans, challenges and opportunities working team to address recommendation 3
- WG-3 Data exploration – Cal/ Val, fusion and assimilation (L3-L4) working team to address recommendation 4

Thematic Areas (TA)

In the preparation of the Second Workshop, three thematic areas (TA) have been added to further deepen the collaboration across the WG topics and cover the following across-domains:

- TA-1: **Polarimetric and multi-frequency SAR applications** (polarimetric or multi-frequency backscatter intensity and/or polarimetric phase the main measurements. InSAR often useful, but not the main driver). TA-1 covers applications such as Forestry, Agriculture, Wetland and Other Land Uses (i.e. the IPCC "AFOLU" themes), plus such relating to Ocean and Sea Ice.
- TA-2: **Interferometric SAR applications** (interferometric phase the main measurement). TA-2 covers the traditional InSAR driven applications such as Solid Earth (incl. crustal deformation, volcanoes), Glaciers/Ice Caps, Geo-hazards, and PS.
- TA-3: **Programme coordination**

WG-1's accomplishment and recommendation for further works

1. Compile survey results of three main target area (virtual observation constellation, tasking and data sharing)

- Compiled information about number of satellite systems into two tables.
  - Table 1 illustrates discovery and accessibility of archived data
  - Table 2 summarized the discovery, tasking, and access to present and future data.
- Found that all agencies flying spaceborne SAR systems either provide all the data free of cost, or subsets of them for specific purpose or by entering into inter agency agreements.
- Found that their value will be significantly enhanced If all the data has standard geometric and radiometric formats.

2. Discuss and coordinate way forward to enhance the current cooperative framework for virtual observation constellation, tasking and data sharing.

a) Virtual constellation

- Need to establish a scheme to have multi-agencies / organization virtual constellations? (A-Train type framework, GPM or ACCP?) for what?

b) Tasking and observation planning

- Do we need enhance emergency observation tasking beyond international disaster charter or sentinel Asia (what is a value / advantage of SAR emergency observation? Night / bad weather? And other reason?
- Mechanism of observation plan sharing (just KML?)

c) data sharing

- How to enhance / improve data and information sharing and for what? Need to have a pilot / demonstration projects (- cooperation with CEOS and/or GEO to specific theme?) to provide valuable outcome (e.g. Carbon STK – Biomass, sea ice monitoring, etc.)
- Data format standardization with CEOS WGISS or WGCV?

WG -2 : Future imaging systems - Goals, plans, challenges and opportunities

- Membership list is being consolidated
- Workplan established:
  - Select a set of global science measurements we believe are of interest to many/most countries with space agencies, which can be addressed by SAR
  - Consider specific inter Agency coordination scenarios and identify potential opportunities and roadblocks
  - Discussion on role of commercial SAR
- Monthly meetings scheduled in preparation of the 2nd workshop

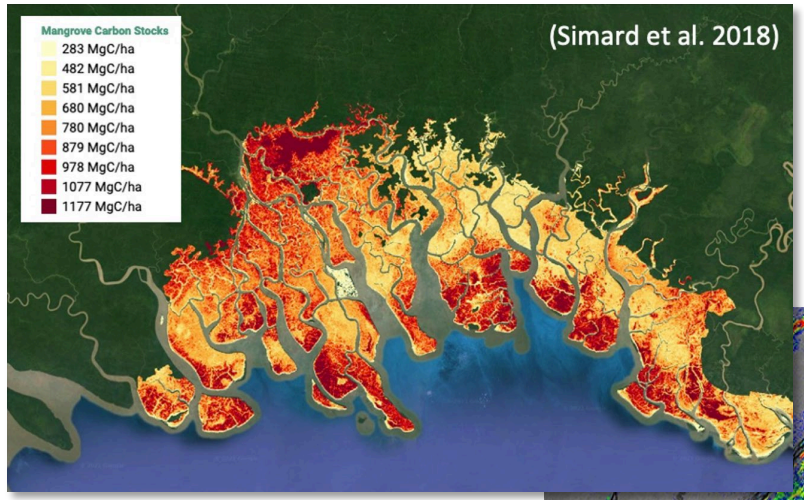
TA-1: Polarimetric and multi-frequency SAR applications

Key application areas

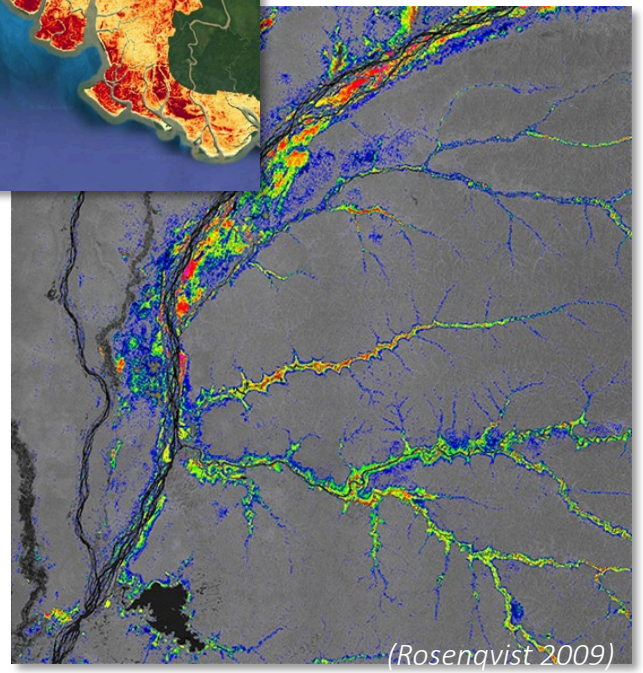
- Forest & Land Cover
- Vegetation structure & Above-Ground Biomass
- Wetlands extent and inundation
- Agriculture & Soil Moisture
- Ocean & Sea Ice

Challenges

- Ionospheric and tropospheric effects
- Lack of consistent data at regional-global scales:
  - Time-series data at several radar frequencies
  - Coincident multi-frequency datasets
  - Polarimetric time series
  - Bi-static data for R&D
- Temporal noise & Signal saturation



Mangrove carbon stocks [SRTM]

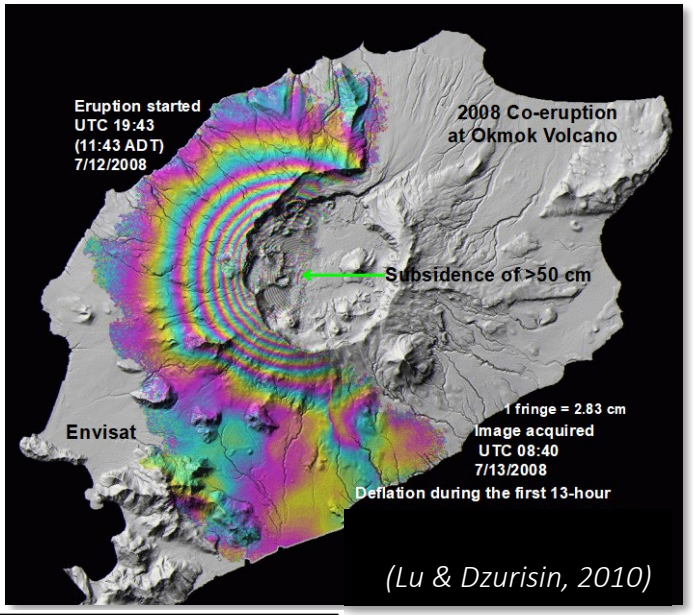


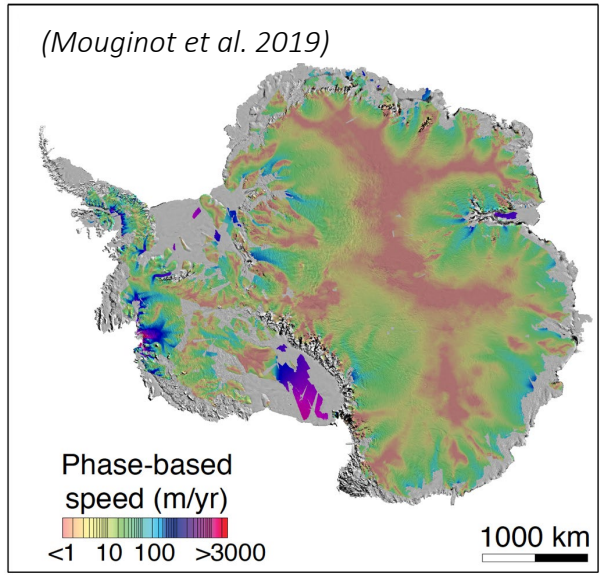
Wetland inundation [ALOS PALSAR]

TA-2: Interferometric SAR applications

Key application areas

- Crustal deformation, subsurface magma migration, aquifers
- Earthquakes, volcano eruptions, landslides, subsidence
- Velocity of glaciers, ice caps, and ice sheets
- Glacier grounding line mapping
- Applications related to Climate Change, e.g., relative sea level rise, increased occurrence of natural disasters





Challenges

- Temporal revisit
- Temporal decorrelation
- Ionospheric and tropospheric delay
- Spatial resolution
- Line-of-Sight (LOS) diversity
- Accessibility & latency in data delivery

Working Groups (WG)

WG1 Present and future data-Visibility and access (L0-L2)	**WG2** Future imaging systems- Goals, plans, challenges and opportunities	**WG3** Data exploration-Cal/Val, fusion and assimilation (L3-L4)
Co-Chair's Sobue, Kumar, Bawden, Kroupnik, Potin	**Co-Chair's** Suess, Zink, Rosen	**Co-Chair's** Schmullius, Chapman, McNairn, Frulla, Engdahl

Thematic Areas (TA)

TA1 Polarimetric and multi-frequency SAR applications	**TA2** Interferometric SAR applications	**TA3** Program and mission coordination
Co-Chair Rosenqvist, Scipal	**Co-Chair** Jones, Rommen	**Co-Chair** Bawden, Davidson

Summary and Way Forward

- With more than 25 spaceborne SAR systems currently flying and an additional 25+ being built or planned, tremendous opportunity to cooperate and coordinate among space agencies and industry actors:
  - Data harmonisation and standard
  - Coordinate future data acquisition and coverage
  - Optimized systems approach to the overall constellation of planned and proposed missions
  - Coordinate and share common test sites and sites for calibration and validation
- WG's and TA' put in place to address these topics
- Strong desire from space agencies to work together in order to offer the best synergy among SAR missions to the users community
- Wish to include commercial SAR data providers in the overall approach
- *Second Workshop on 28-30 Sept 2022 at ESA/ESRIN*

CSA ASC agenzia spaziale italiana DLR इसरो isro CONAE esa JAXA NASA

Due to the ongoing situation related to the COVID-19, many of you informed us that they would not be able to physically participate on site. We have considered a Hybrid or Virtual meeting but, unfortunately, this has proved to be impossible due to the varied time zone involved.
Therefore, we would like to kindly inform you that we have decided to postpone the **Second Workshop on International Coordination for Spaceborne Synthetic Aperture Radar** by one year to **28-30 September 2022**. Please pencil down these new dates in your agenda!

Second Workshop on International Coordination for Spaceborne Synthetic Aperture Radar

28-30 September 2022

ESRIN, Italy

Participation based on invitation only
Feel free to contact us if you think you can contribute:
sar.workshop@esa.int

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- Charles Elachi (Caltech)

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- Gerald Bawden (NASA)
- Gordon Campbell (ESA)
- Bruce Chapman (NASA/JPL)
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