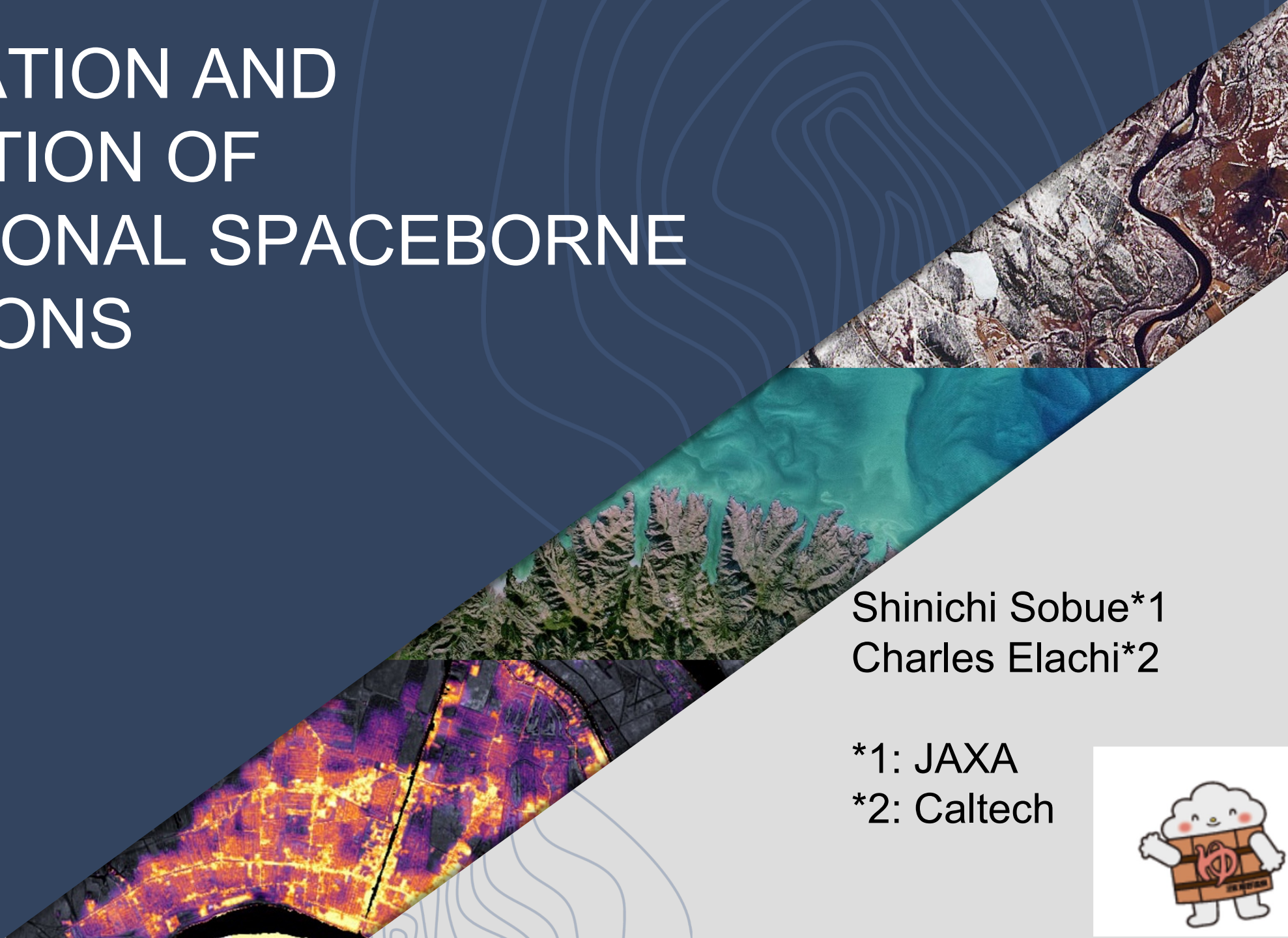
COORDINATION AND COOPERATION OF INTERNATIONAL SPACEBORNE SAR MISSIONS



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*1: JAXA
*2: Caltech

ICGS-SAR Workshop Objectives

- Identify new trends in spaceborne SAR missions (e.g. bistatic, constellations of SAR's, micro-SAR's).
- Identify areas where coordination of data acquisitions can lead to improved science processing efficiency (i.e., common areas targeted for campaigns or disjoint areas where multiple coverage would be redundant.
- Explore ways to facilitate search of available data and requests for future data acquisition particularly for immediate need due to natural hazards (earthquakes, volcanic eruptions, floods, landslides, tsunamis, etc.) and for future field campaigns and utilization planning, and for other applications. Identify best practices and lessons learned related to SAR data acquisition coordination initiatives like the WMO Polar Space Task group SAR Coordination Working Group (a very successful SAR mission coordination body for polar regions) and Charter on Space and Major Disasters.
- Identify areas where standards or common developments for data processing including data format standardization or Analysis Ready Data (ARD), product quality assurance (e.g. cross validation) and for data manipulation/fusion would be beneficial.
- Identify computational efficiencies and challenges in achieving the mission objectives.
- Identify challenges and opportunities in leveraging defense, civilian, commercial, and science systems to achieve users' objectives (science and applications).
- Identify organizational challenges in achieving coordination among agencies.
- Identify recommendations needed to acquire spatially and temporally dense SAR data sets.
- Discuss interest and value in having common test sites, both distributed and with corner reflectors, to calibrate all SAR systems with common references.
- Discuss how to maximize scientific/user exploitation of present and planned SAR missions (open data for scientific research, expanded ground receiving stations, …). Identify any regulatory challenges.
- Discuss the desirability of coordinating future missions and the role of the commercial sector to achieve future scientific and user objectives.
- Develop a roadmap for addressing the above challenges and development areas.

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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



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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.

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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.

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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

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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.

Organization Structure

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

First Workshop led by Charles, Caltech

Second Workshop led by Maurice, ESA

Third Workshop led by Sobue, JAXA

Fourth Workshop led by DLR

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WG-1' Accomplishment and Recommendation for Further Work

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.
- 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?

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

- Workplan:
  - Identify a set of global science measurements of interest to many/most countries with space agencies, which can be addressed by SAR (possibilities depicted at right)
  - Consider specific inter Agency coordination scenarios
    - *e.g.* multi-lateral partnerships, federations, CEOS/GEO-centric initiatives
    - Identify potential opportunities and roadblocks
    - Factor in the role commercial SAR



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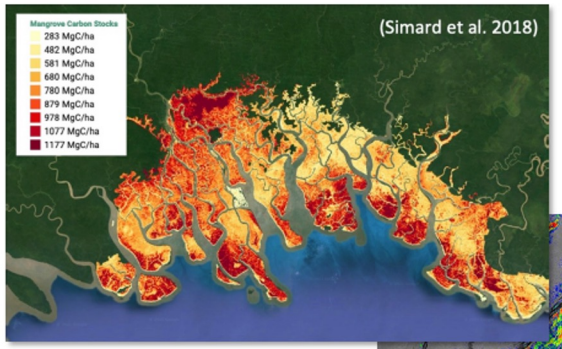
TA-1: Polarimetric and multi-frequency SAR applications

Key application areas

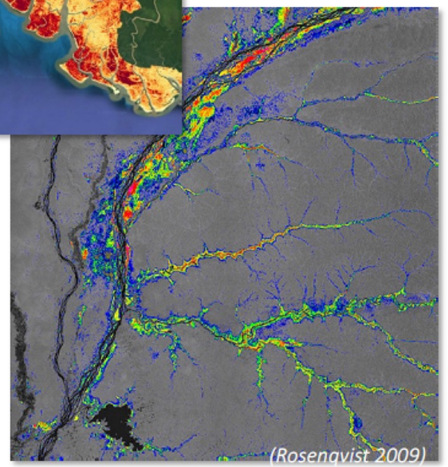
- Forest & Land Cover
- Vegetation structure & Above-Ground Biomass
- Wetlands extent and inundation
- Agriculture & Soil Moisture
- Ocean & Sea Ice

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]



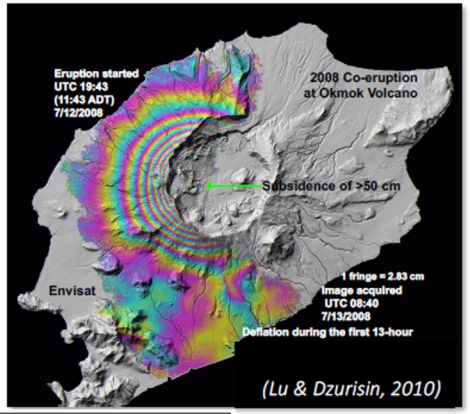
Wetland inundation [ALOS PALSAR]

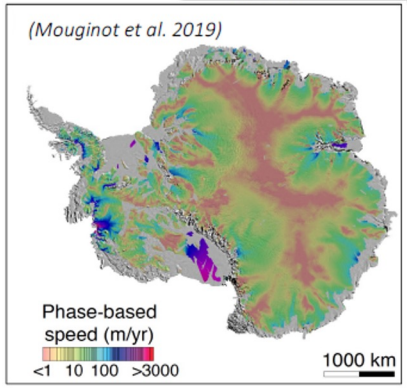
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TA-2: Interferometric SAR applications

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

Second Workshop in ESA/ESRIN

- On September 28 and 30, 2022, Second Workshop on International Coordination for Spaceborne Synthetic Aperture Radar was held in ESA/ESRIN, Italy
- 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

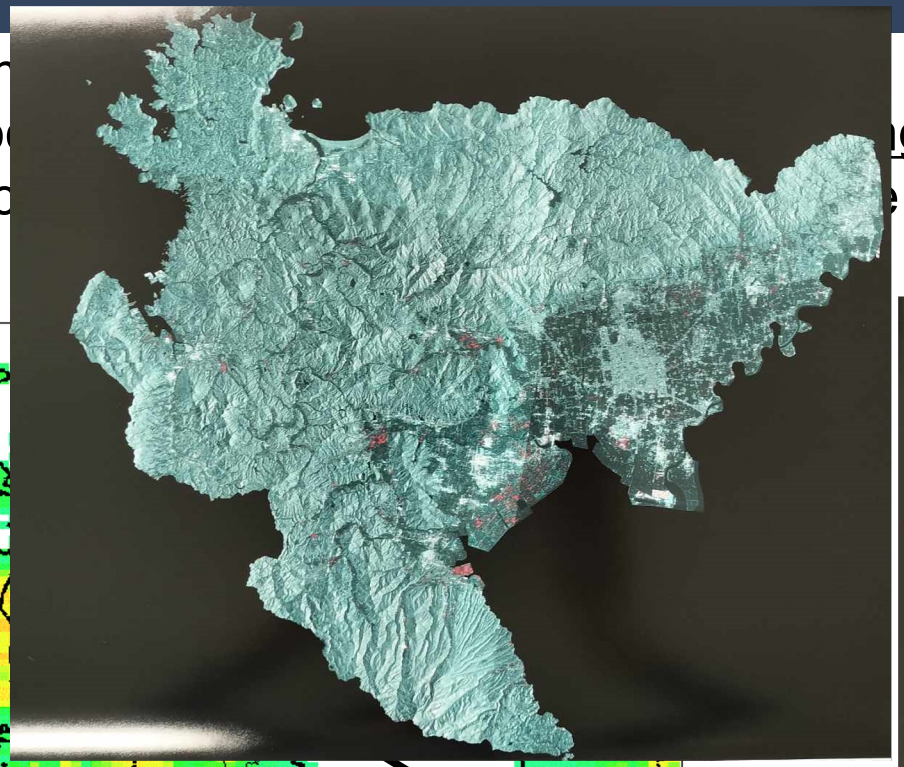
- WG's and TA' put in place to address these topics
- Strong desire from space agencies to work together in order to offer the best synergy among
- SAR missions to the users community
- Wish to include commercial SAR data providers in the overall approach

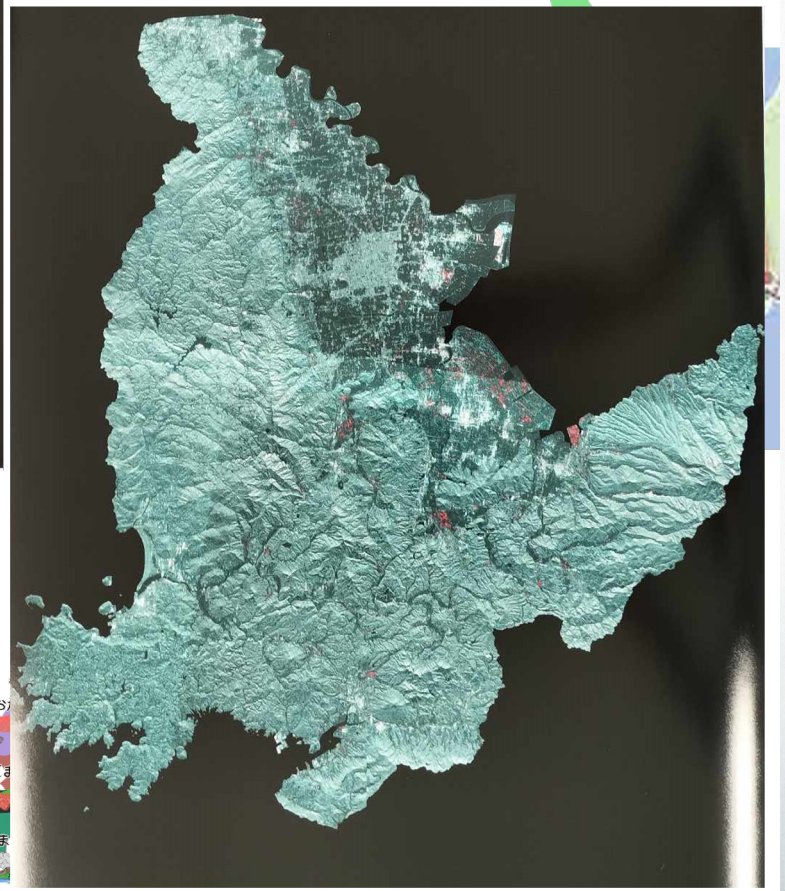
Second Workshop in ESA/ESRIN

- The main purpose of these activities is to bring together members of the community (agencies, stakeholders, users, researchers, ...), to exchange information and discuss ways to facilitate coordination, and collaboration that maximizes the benefit of present and future spaceborne SAR systems. We believe that a fully optimised & coordinated international SAR constellation, based on existing and planned missions among the space agencies, could bring substantial enhanced science and societal benefit that would not have been possible from a single Agency. Such a vision would need to be addressed by specifically addressing issues of:
  - Improving the discovery of the existing data through common metadata format
  - fostering an open, full and free data policy by inviting all space agencies to follow that policy whenever possible
  - coordinating observation requirements for future SAR missions during the planning/formulation phase
  - fostering R&D for Earth sciences studies and the development of new applications
  - promoting the use of SAR data for operational applications
  - exploiting synergies and cooperation potential in the scope of new SAR missions leading to enhanced information benefiting science and applications

Third Workshop in Saga, Japan

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Inc e agencies and new space







Third Workshop in Saga, Japan

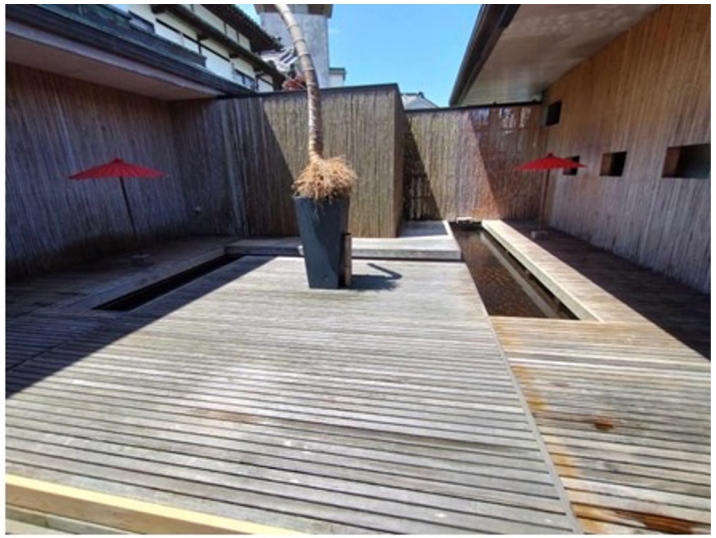
Saga Pref/JAXA coordinate with venue and will finalize venue before the middle of June.
Now, we plan to have it at Wataya besso (https://wataya.co.jp/en/)
Main conference room up to 100 participants (former wedding party room)
Three splinter meetings (2 groups in main conference room and one group in different room (up to 30 participants)).



Outlook of Wataya



Main Conference Room



Foot Onsen is available for a break (Need your own towel)

Third Workshop in Saga, Japan

	Wednesday 6th Nov	Thursday 7th Nov	Friday 8th Nov	Saturday 9th Nov
Morning	Opening Session Status of WGs and TAs Keynote addresses	Commercial discussions TA1 Session	WG Break out sessions Reports by WGs & TAs Discussions, way forward, and closing	10:00 - 11:30 Lecture at the Saga Prefecture Space & Science Museum
Afternoon	Keynote addresses Agency Updates	TA2 Session WG Break out sessions	13:00 - 18:00 Cultural Excursion (Optional, 2,000 yen)	
Evening	Cocktail Reception	Workshop Dinner with Saga Culture		

Third Workshop in Saga, Japan

Key Note Speakers

Prof. Seiko Shirasaka, Keio University,

Research and education interests: Space systems engineering, system development methodology, and system safety
Member of National Counsel of Space policy in cabinet office

Prof. Shunsuke Managi, Kyushu University

Wealth, Inclusive Growth and Sustainability

Dr. Thuy Le Toan, CESBIO

Radar remote sensing for land applications, with a focus on climate change and the global carbon budget

- WG/TA reports:
- Agency report: ASI, CONAE, CSA, DLR, ESA, ISRO, JAXA, NASA, VNSC, TASA

Specific Topics

- CEOS engagements:
- WG2 L-band Constellation Performance Analysis Results

  CSA Analysis Results
- **Session 5: Commercial partnerships with** QPS, SYNSPECTIVE, MELCO, NEC, ICEYE, MDA,

Specific topics to discuss:

- *<u>Smart tasking:</u> For MDA and disaster monitoring (such as flood monitoring), wide area observations are needed to identify target areas, which can then be targeted by high resolution satellites. Has your company considered this kind of smart tasking, in cooperation with space agencies?*
- *<u>Integrated data use:</u> X-band is very powerful with high spatial resolution and good technology for small and cost-effective satellites. Space agencies have demonstrated the value of using multiple band observations for specific applications. Does your company have any vision to promote this kind of integrated use of multiple frequency SARs in cooperation with governmental agencies?*