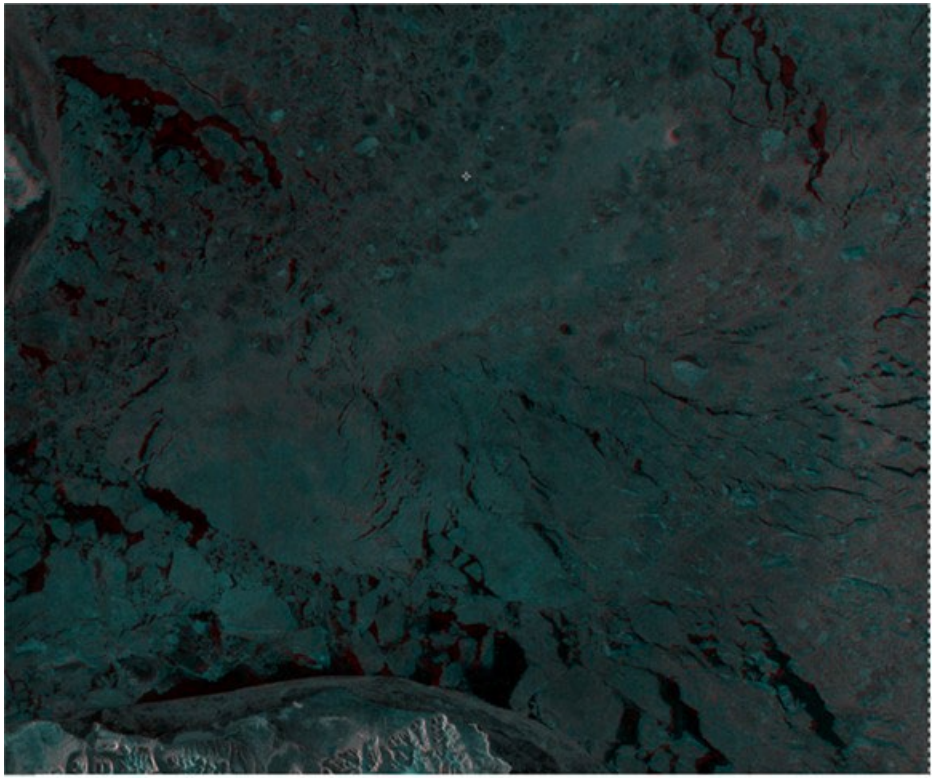
International Coordination Activity for Spaceborne Synthetic Aperture Radar to improve data visibility and accessibility



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Gerald W. Bawden*2,

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*1 Japan Aerospace Exploration Agency
*2 National Aeronautics and Space Administration
*3 Canadian Space Agency

Background of International SAR WS

- On May 30, 31 and June 1, 2018, a workshop on International Spaceborne SAR Missions Coordination and Collaboration was held at the California Institute of Technology
  - To explore the interest, advantage and the significance of a more coordinated approach between the different organizations to achieve higher value to the user community.
  - To improve data visibility and accessibility of spaceborne SAR under the international coordination.
- Working Group 1 (WG-1) was established to understand the issues related to data discovery and data access, as well as to discuss and coordinate this topic with good examples.

Accomplishment of WG-1

- 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.

Archive, Present and Future SAR Data

Archive	ERS	ENV	ALOS-1	R1	JERS	SEASAT
O&F	Y	Y	Y	N/Y by ASF	Y	Y
Proposal						

Prensent and Future adata	CSK	TSX	R2	S1	ALOS-2/4	RCM	NISAR	SAOCOM	RISAT
Discover present data	Yes	Y	Y	Y	Y	Y	Y	Y	Y
Discover furture data	No	No	No	Y	Y	Y	Y	?	-
Task	$(commercial)	$ and Propsal (science)	$ and P	Ad hoc (e.g. disaster)	Ad hoc, $ and P	Ad hoc	Ad hoc	P	$ and P
O&F	N	N	N	Y	Y for ScanSAR	Y?	Y	N	N
Science Proposal	Y	Y	Y for Canada	-	Y	-	-	Y	Y
$ (Commercial)	Y	Y	Y	-	Y	-	-	Y	Y

Need to survey of success story and beyond of international cooperation

1. Virtual Observation Constellation (purpose / scope, observation target, framework,

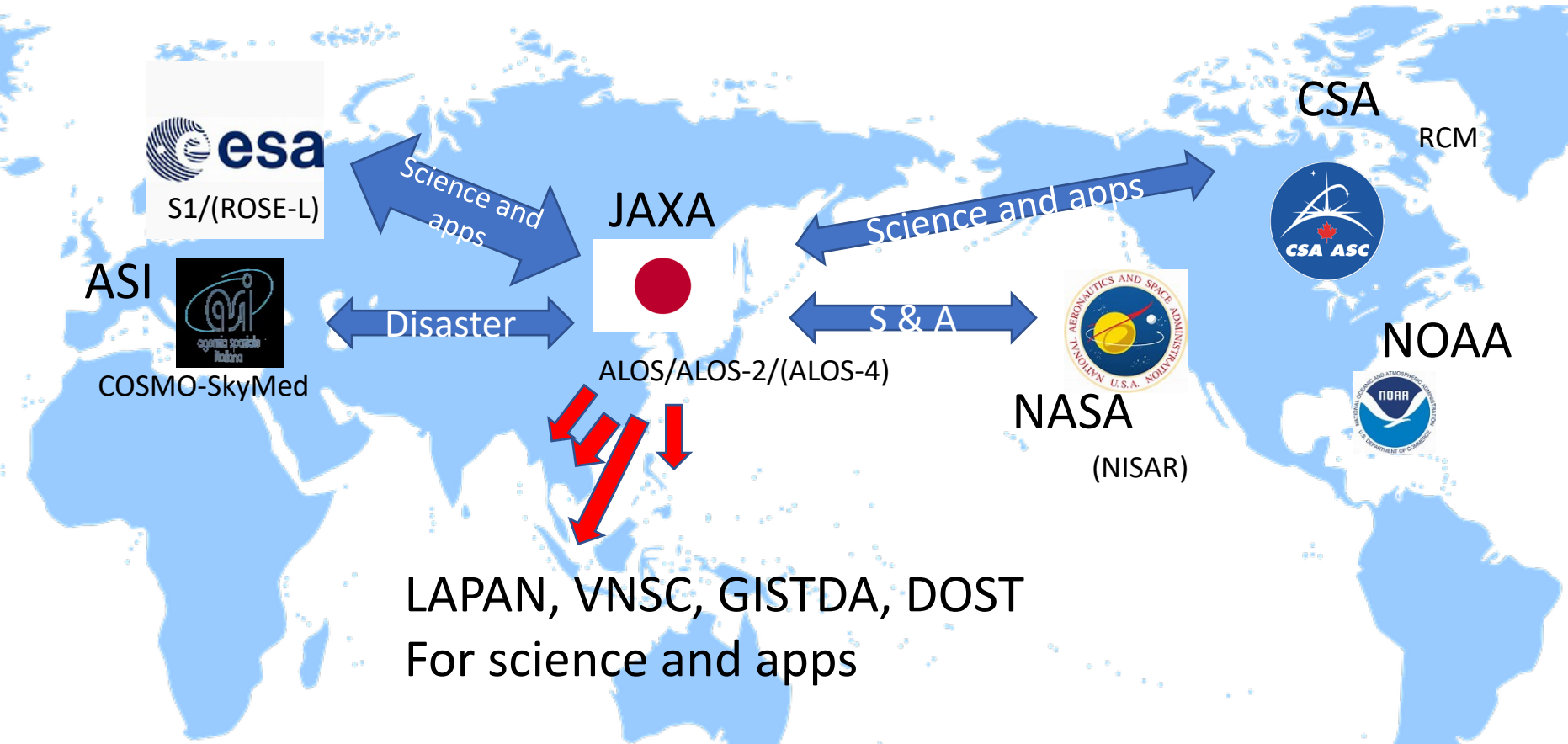
(1) Present – in operation satellites

- Sentinel-1 + RCM
- ALOS-2 + RCM (Sea Ice, Ship, …)
- ALOS-2 + Sentinel-1 (Sea Ice, Ship, oil spill, …)
- ALOS-2 + CSK/CSG (high temporal observation for disaster)
- SAOCOM + CSK/CSG
- Sentinel-1 + ICEYE
- For Specific project - MOSAiC project campaign (TDX, S1, R2, A2 …) – sea ice

(2) Near Future – Developing satellites

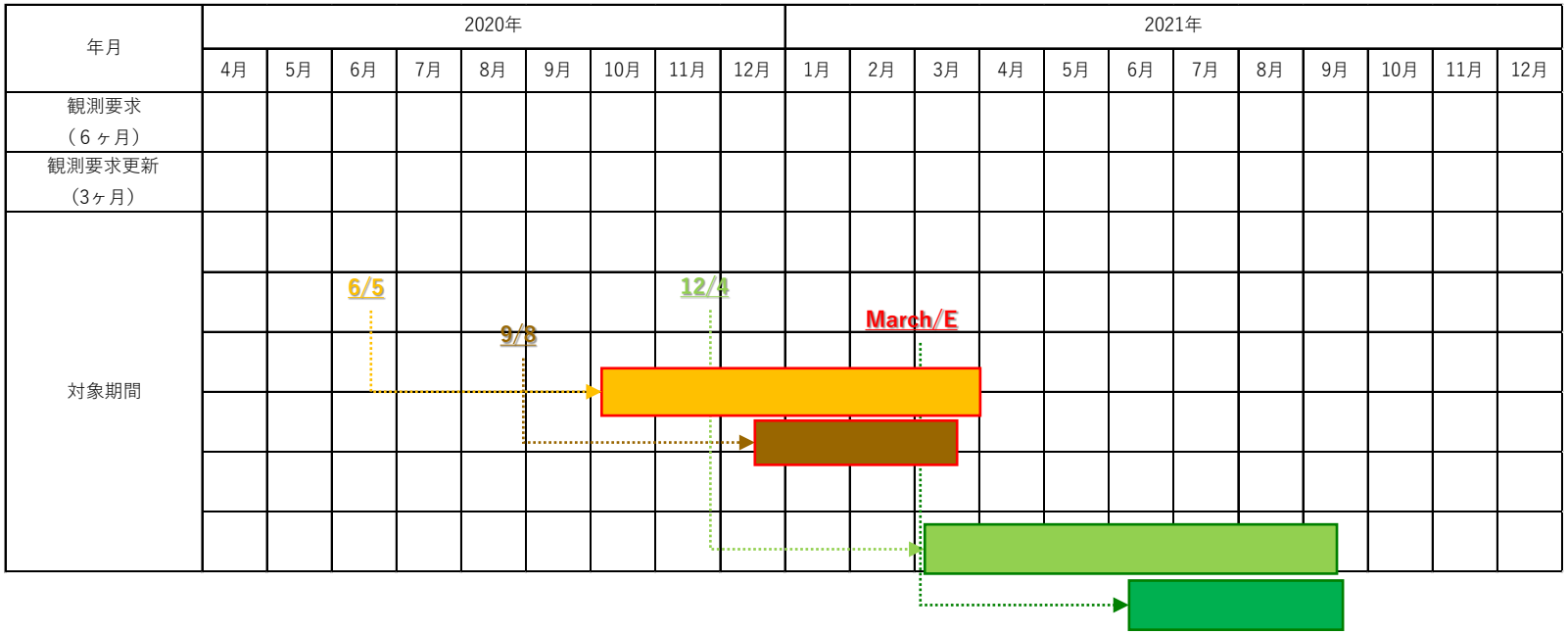
- ALOS-2 + ALOS-4
- ALOS-2/4 + STRIX (SYNSPECTIVE) or QPS (IQPS) satellite
- Sentinel-1 + NISAR + ALOS-2/4

Example by ALOS-2 SAR international cooperation



- Science and apps: Ocean (Sea Ice, ship, oil spill), Land use (agriculture, soil moisture, SWE, crustal deformation - volcano, subsidence, LULCC, forest) with disaster response
- FS for ALOS-4 DT in international partners

ALOS-2 Timeline to develop next 6 months basic observation scenario (BOS)



Timeline

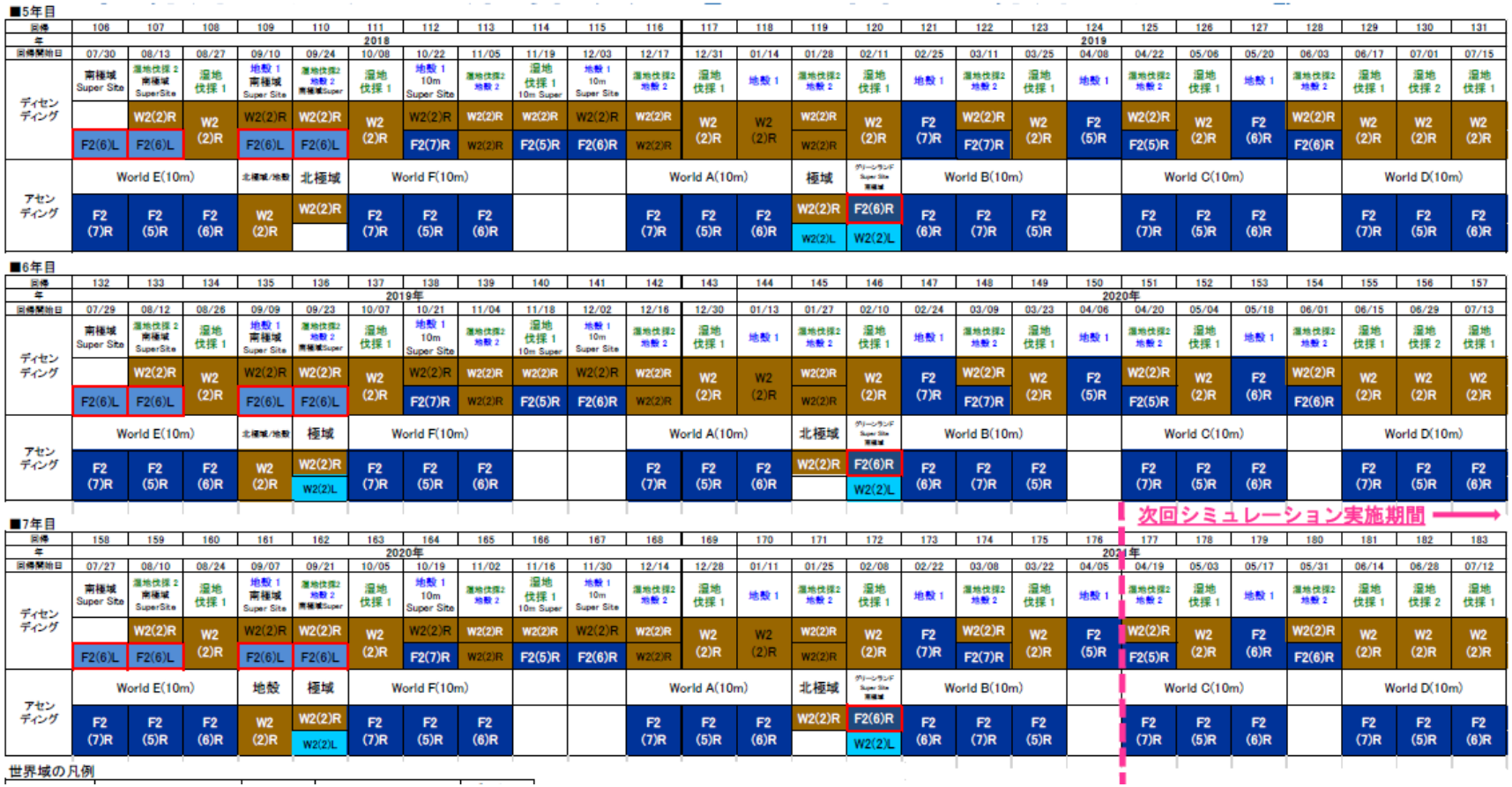
- September 2020 : Revision of later 3 months observation request (from January 2021 to April 2021)

- Priority of observation: Emergency > 6 months > 3 months revision > weekly (2 weeks before observation)

-> HOWEVER, to confirm the value of back-to-back observation by ALOS-2 and Sentinel-1 -> Deploy sea ice monitoring campaign observation with high priority weekly observation planning for **Belgica Bank for Ship Cruise from 26 April until 8 May**

ALOS-2 Basic Observation Scenario (BOS) world

4-7 years (global: SM3 and WD1 for JJ-FAST with intensive high temporal observation of SM1 and/or SM2 to selected area)



JAXA-ESA cooperation

Application	Location
Ship detection	Bornholm
Snow Water Equivalent	Upper Engadin(Swiss Alps)
	Sodankyla(Finland)
	Upper Engadin(Swiss Alps)
Soil moisture	Selhausen(Germany)
	Tavoliere(Southen Italy)
	Tibetan plateau
	SPAIN
Agriculture and GHG	SE Asia (Mekong delta)
Sea Ice /Polar	ArcticOcean (MOSAiC)
	BaffinBayWest
	BelgicaBank
	Greenland KapFarvel
	LabrodorSea
	Perennial
Permafrost	Norway
	Yukatan lake
iono and validation	Alaska
	Brazil
	California
	Canada(Churchill)
	Hawaii
	New Zealand
	North Europe(Kiruna)
	North Europe(Longyearbyen)
	North Europe(Tromso)
Volucano	Pitons Management Area
	Saar Area
	Etna
	Mayotte
Hurricane/Cyclone/Typhoon	
Urban and natural forests	Vienna
	Košice
Forest and Wetland and Inundation Mapping	West Tanzania (Mtendeli Refugee camp)
	Bangladesh (Kutupalong Rohingya)
Flooding and wetland inudation	State of Louisiana

JAXA-NASA cooperation

Application	Country	State
Geohazards	USA	California (North to South)
	USA	Unimak Island, AK
	USA	California (South to Mexico)
	USA	California (Central to South)
	USA	California (Central to South) => SF
	USA	California (Central to South)
	USA	Alaska
	USA	Denali, AK
	Guatemala	Queja, Guatemala
	Peru	Achoma, Peru
	Guatemala	San Pedro-Soloma, Guatemala
Soil Moisture	USA	South Fork, IA
	USA	Walnut Gulch, AZ
	USA	Little River, GA
Wetlands	India	Nanda Bet, India
	India	Nal Sarovar, India
	USA	Everglades, Florida
	USA	Yucatan Lake Louisiana
	USA	Franklin Bluffs, Alaska
	USA	Cottonwood Lake, North Dakota
	USA	Bonanza Creek, Alaska
	Panama	Panama Mangrove
	USA	Chesapeake Bay
	Peru	Pacaya Samiria, Peru
	USA	Carpenteria Salt Marsh, California
	USA	Lake St Clair
	Canada	Peace Athabasca Delta, Canada
	USA	Yukon Flats Alaska
	USA	Wax Lake Delta, Louisiana
	Brazil	Pantanal, Brazil
	Brazil	Mamiraua Reserve, Brazil
	Sudan	Sudd, South Sudan
Forests		DEJU
		BONA
		NIWO
		OSBS
		SJER
		LENO
		CLBJ
		UKFS
		Mondah
		TALL
Ionosphere		
Sea Ice	USA	Beaufort Sea
Polar	Antarctica	Amundsen Sea Embayment, Antarctica
Oil Spills	USA	Coal Oil Point
Ocean Winds	USA	Ocean Wind

JAXA-CSA cooperation

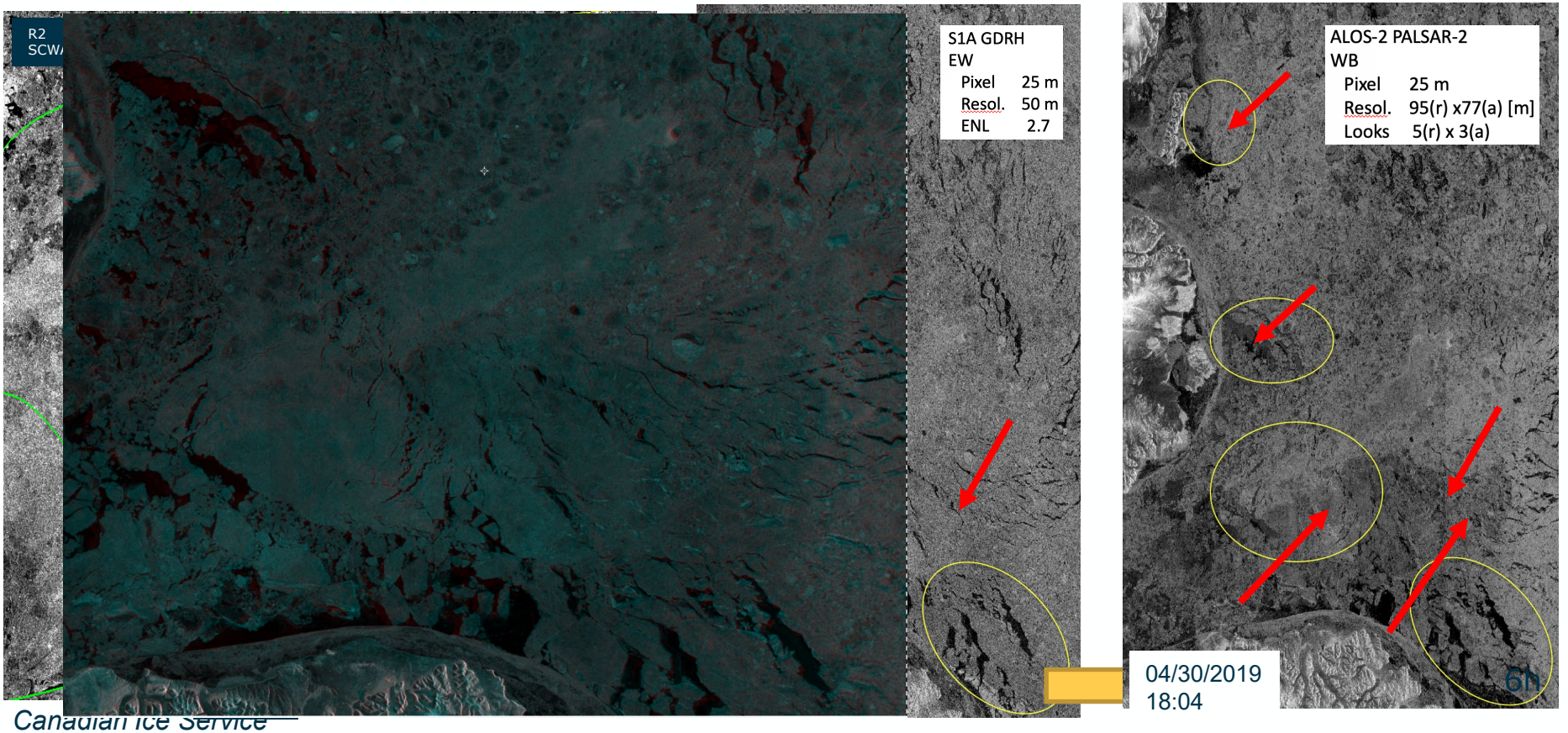
Agriculture	Manitoba	FP/CP
	Central Experimental Farm	FP/CP
	FortSimpson	SM3
	Newfoundland	SM1
	NWT-FortProvidence	SM3
	NWT-HayRiver	SM3
	Ontario	SM1/SM3
Sea Ice Monitoring	Baffin-Bay	W2
	Beaufort Sea	
	Pond-Inlet	SM3
	Nain(NL)	CP
Ice monitoring	Resolute_Bay	SM1
Cal/Val	Saskatchewan	SM1/FP
	Tuktoyuktuk	SM1
Permfrost	ZAMA	SM1/FP
Ocean	Whoale	SM1
Harricane	North Atlantic Ocean / Labrador Sea	

Coordination Topic

- Theme and area coordination scheme
  - LAND: Forest, wet land, agriculture (soil moisture),
  - Ocean: Sea ice, ice berg (Antarctic),
  - Cryosphere: Permafrost, SWE,
  - Disaster: Sea Wind, crustal deformation (volcano), …
  - Cal/Val: Ionosphere

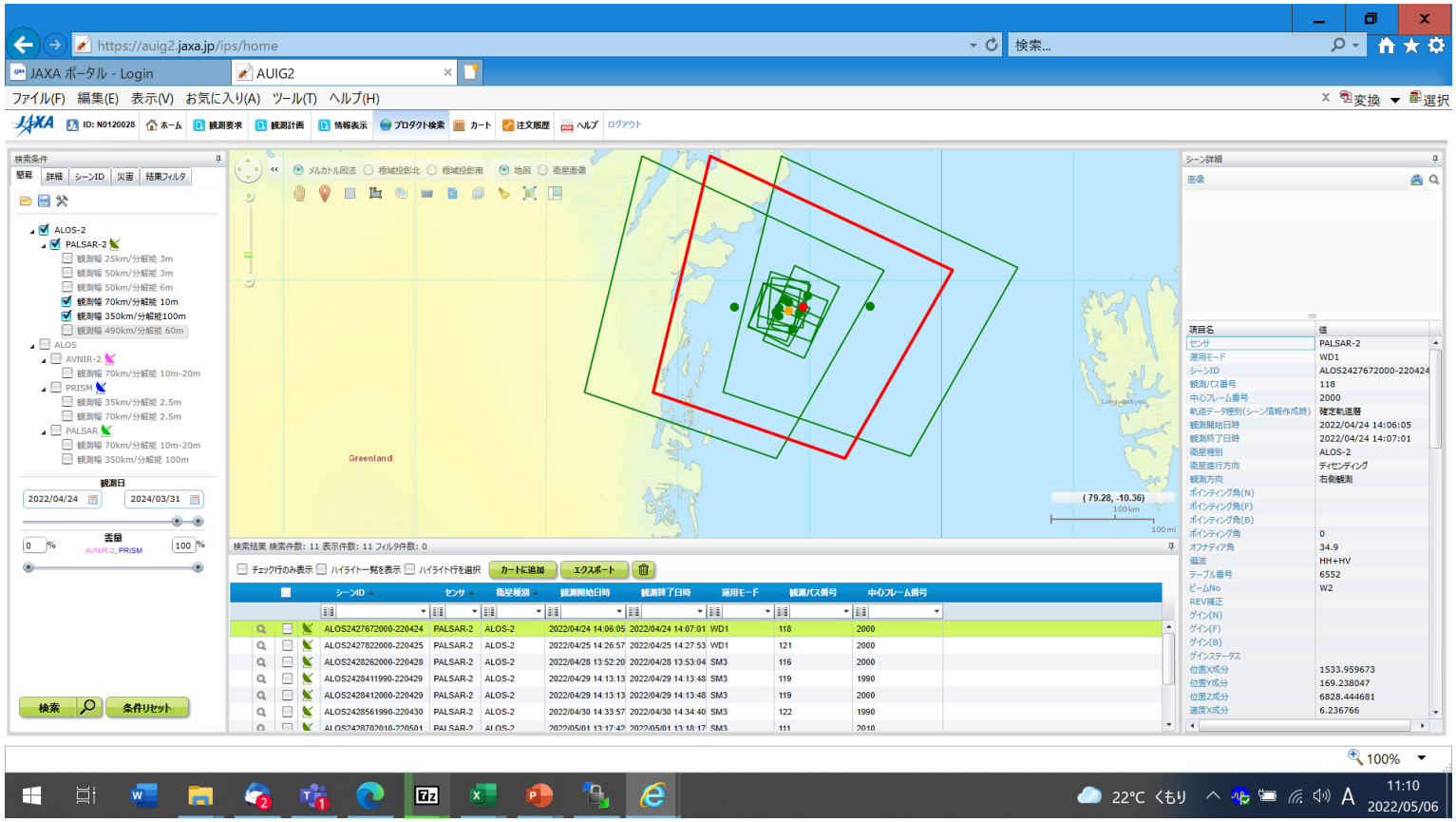
-> Priority area and theme selection process with set coordination team meeting by JAXA, ESA, NASA, CSA, … to maximize ALOS-2 6 months observation planning

Seaice of L- and C-band synergy (Baffin Bay)

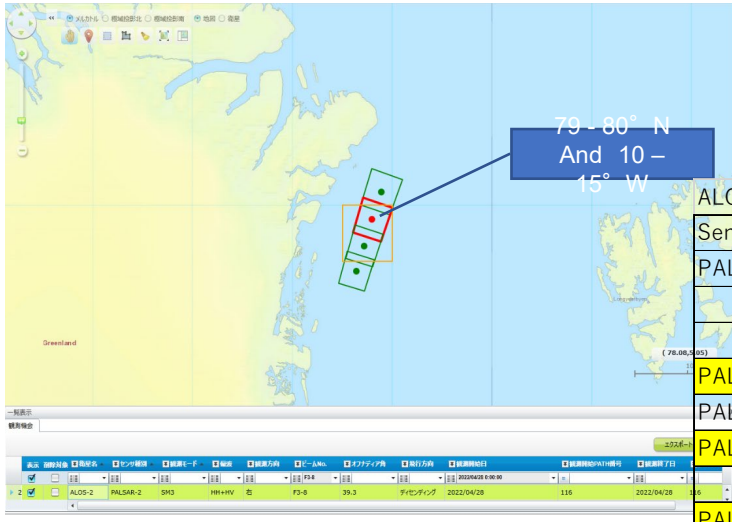


Canadian Ice Service

Challenge to joint campaign observation example
- Belgica Bank for Ship Cruise from 26 April until 8 May



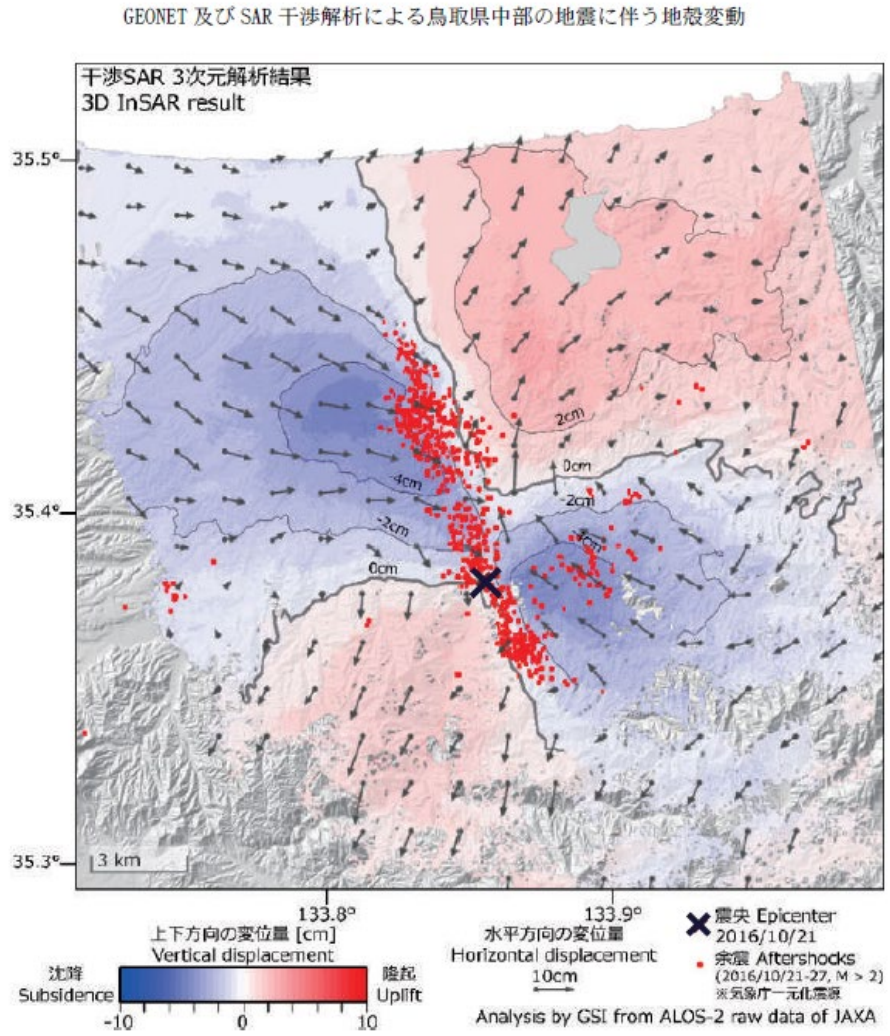
ALOS-2 and Sentinel-1 back-to-back Observation result



High temporal observation by ALOS-2 SM3 (10m) with Sentinel-1 EW (25m)

ALOS-2						Sentinel-1			
Sensor	Mode	Path	Frame	Obs date		Mode	Path	Frame	Obs date
PALSAR-2	WD1	118	2000	2022/4/24 14:06					
					17 hours	EW	240	155	2022-04-25T07:53:55
						EW	359	1709	2022-04-26T08:34:51
PALSAR-2	SM3	116	2000	2022/4/28 13:52	5 hours	EW	325	24	2022-04-28T08:18:14
PALSAR-2	SM3	119	1990	2022/4/29 14:13					
PALSAR-2	SM3	122	1990	2022/4/30 14:33	6 hours	EW	331	53	2022-04-30T08:01:51
					3hours	EW	194	59	2022-04-30T17:47:39
PALSAR-2	SM3	111	2010	2022/5/1 13:17	5 hours	EW	18	68	2022-05-01T08:43:19
					17 hours	EW	334	82	2022-05-02T07:45:31
PALSAR-2	SM3	117	2000	2022/5/3 13:59	5 hours	EW	332	97	2022-05-03T08:26:26
PALSAR-2	SM3	109	2010	2022/5/5 13:03	5 hours	EW	422	126	2022-05-05T08:10:24
PALSAR-2	WD1	115	2000	2022/5/7 13:45					
PALSAR-2	SM3	118	2000	2022/5/8 14:06					

Future observation coordination using Left and Right looking to interferometry using virtual constellation
- Improve along track deformation accuracy detection



Example of Totori earth quake using ALOS-2 observation left and right observation INSAR pair

L-SAR formation flights (virtual constellation)
-> ALOS-2+4
-> NISAR+ALOS-4
-> NISAR+ALOS-4+ROSE-L
-> ROSE-L+SDC+ALOS-4 F/O

Need to survey of success story and beyond of international cooperation

2. Emergency observation tasking and observation plan coordination

(1) Tasking mechanism

- International disaster charter (manual coordination?)
- Sentinel Asia (OPETIMS system)

(2) Observation plan process / procedure and observation plan provision scheme

Sentinel Asia Satellite Constellation

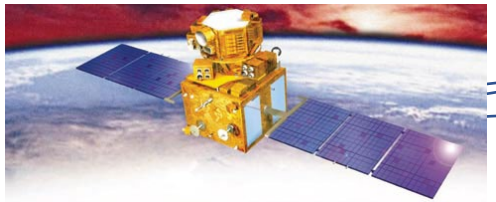
Sentinel Asia Constellation
contributing to Emergency Observations

International Charter

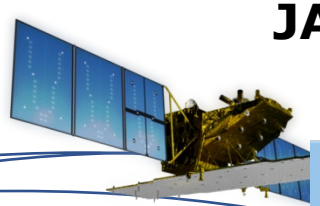
Escalation from Sentinel Asia

ISRO

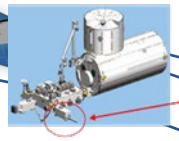
RESOURCESAT-2, OCEANSAT-2/OCM
IMS-1, CARTOSAT-1&2, RISAT-1



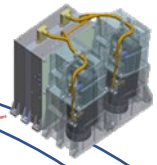
JAXA



ALOS-2

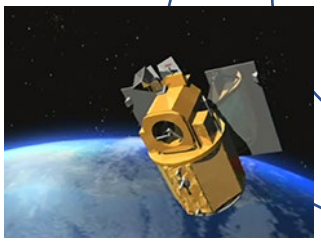


KIBO HDTV-EF2



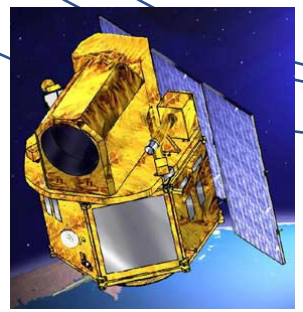
Sentinel Asia Constellation

NARLabs



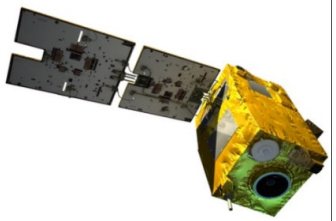
FORMOSAT-5

GISTDA



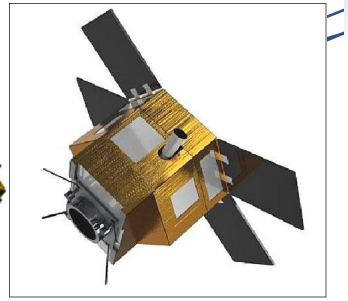
Taichote (THEOS)

STI/VAST



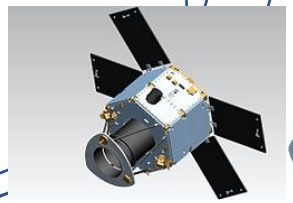
VNREDSat-1A

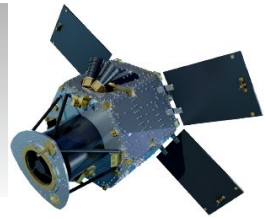
CRISP



TeLEOS-1

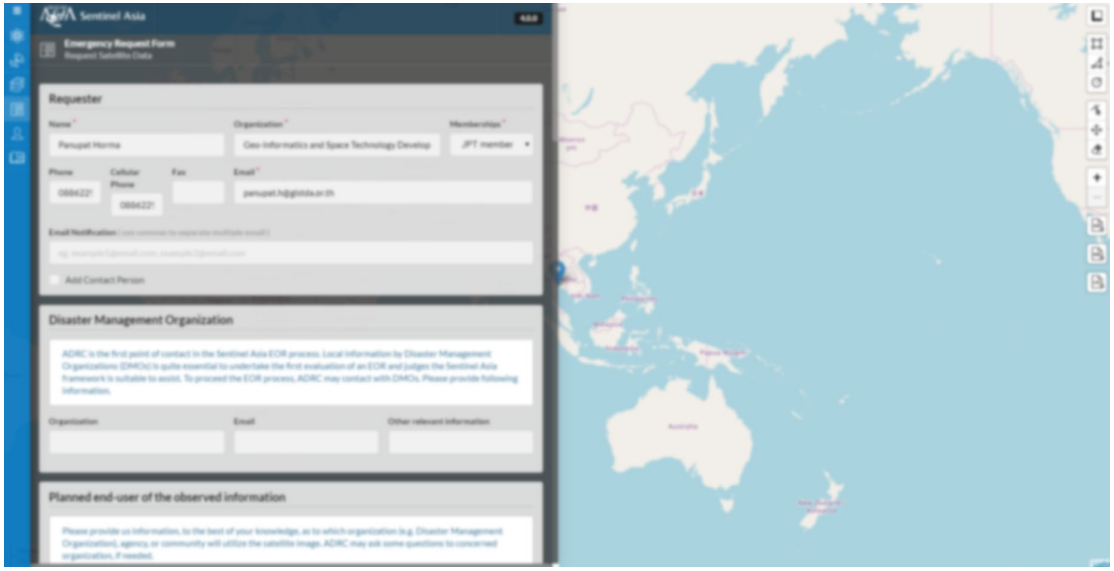
MBRSC





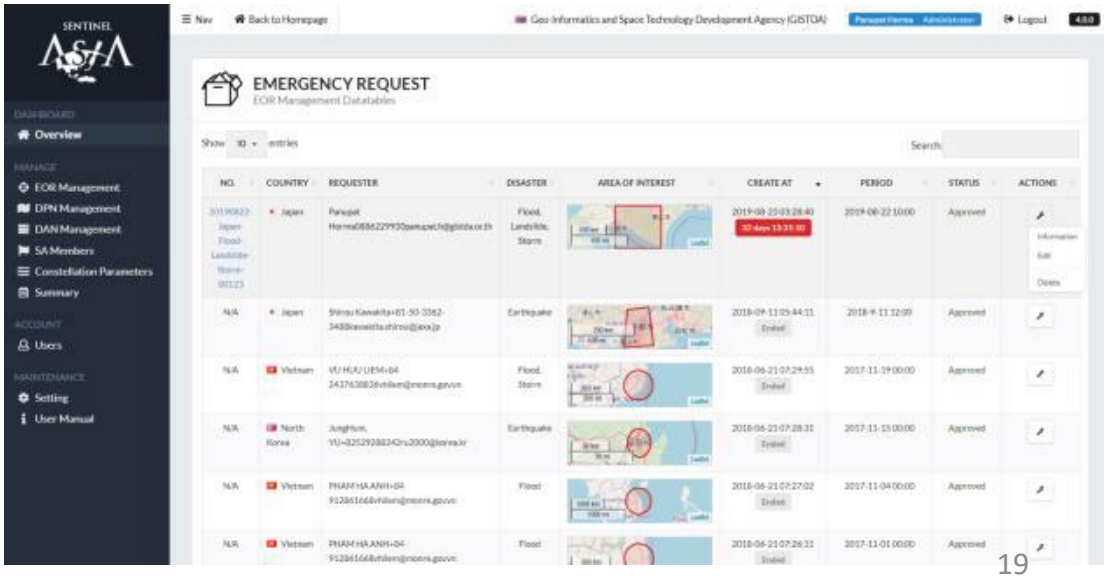
DubaiSat-2 and KhalifaSat

Disaster observation planning platform – OPTEMIS



(a) User terminal for EOR request

Synergize different information layers of users and operators to support disaster response timely and perform collaborative operations effectively,

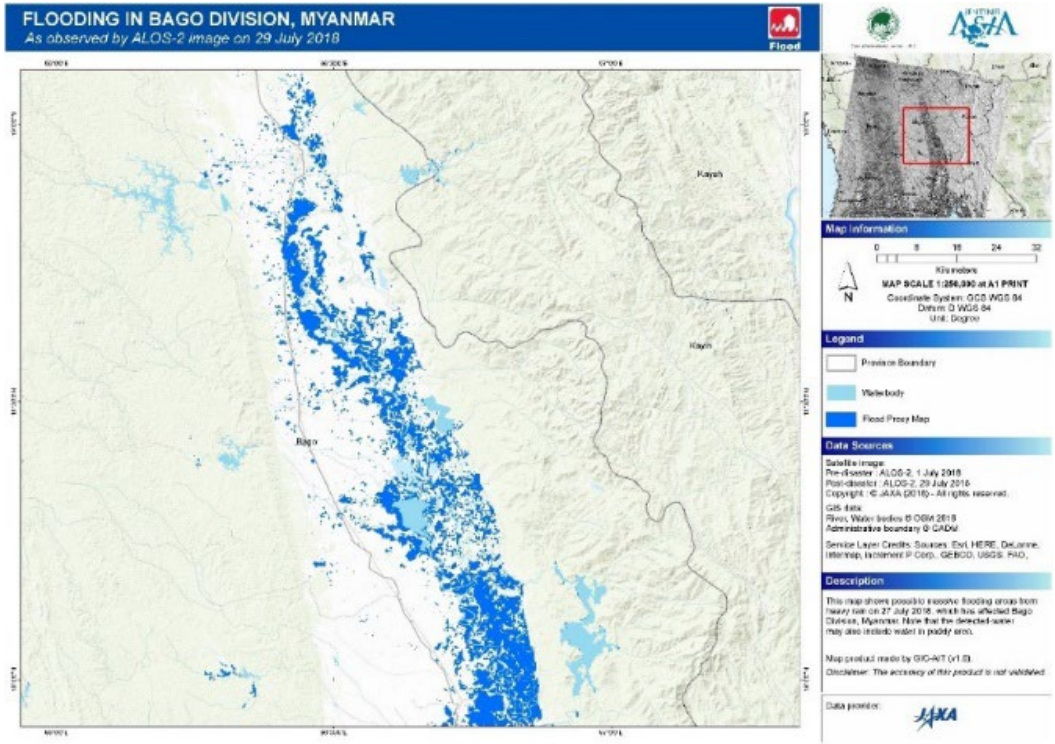


(b) EOR request dashboard for SA operators

Good practice through cooperation in Sentinel Asia

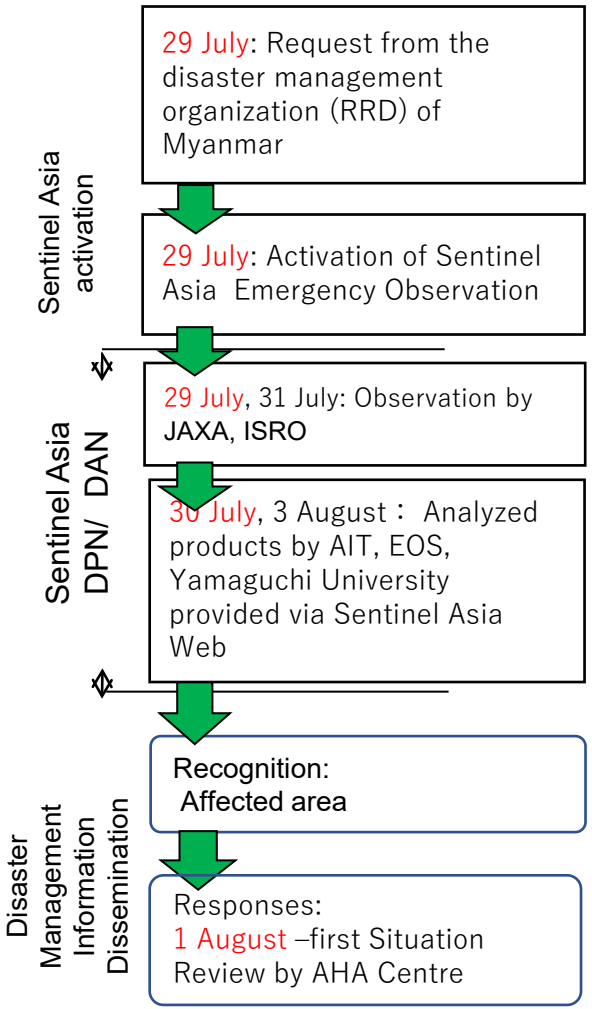
Floods in Myanmar, July 2018

Taninthayi Township, Myeik District in Taninthayi Region, was flooded as monsoon rains led the water level of the local river rise above the danger level, affecting many homes, lakes and wells in the villages and towns. Reportedly more than 100,000 were affected and more than 16,000 people were displaced.



The first analyzed product provided by AIT on 30 July

Courtesy: AIT



20

Need to survey of success story and beyond of international cooperation

3. Data and information access and sharing

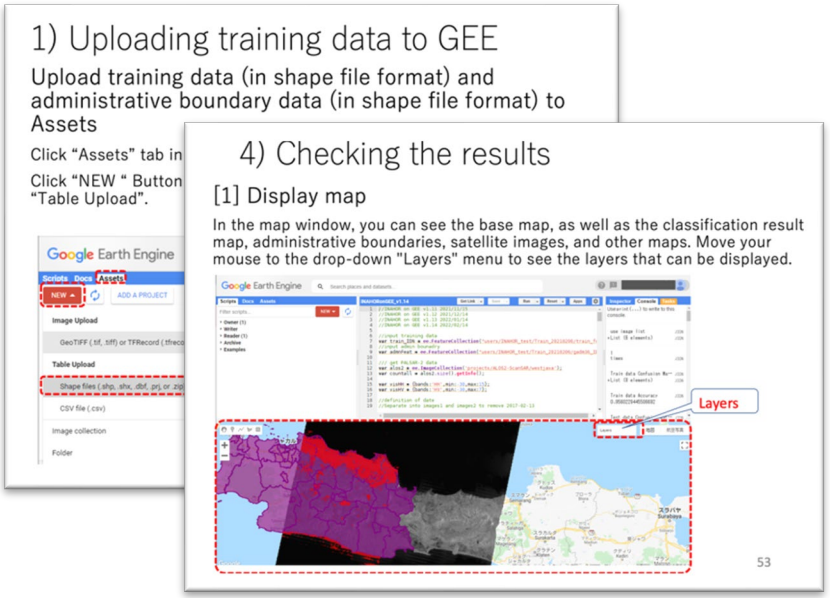
- List of Data products and distribution policy / method (WG1 table 1 / 2 update)
  Information provision: EO dashboard (covid-19, atmosphere, cryosphere, ocean,)
  - Technology - OGC
  - Platform - Cloud system - ODC (EAIL/Sandbox)
  - Data format standardization - CEOS ARD (CARD4L)

Data/Tool Sharing: Google Earth Engine with ALOS-2

- ALOS-2 ScanSAR data covering India, Bangladesh, Lower Mekong River region, have been ingested into GEE in collaboration with Google to facilitate rice monitoring related activities in the Asian region.
- At the AOGEO Task Group 5 (agriculture) held on 20th Oct 2021, joint study for rice mapping using S1+A2 etc. on GEE for Runtan irrigated area (JICA's irrigation project area) in West Java, Indonesia were proposed.
- JAXA's rice mapping tool (INAHOR) is available on Google Earth Engine (GEE) and tutorial material (document and video) is currently preparing (will be used training for the agricultural statistician).
- JAXA will process and plan to post all of ALOS-2 ScanSAR archived data (CEOS CARD4L ARD) in Asia in JAXA G-Portal as well as cloud platform such as TELLUS, VEDAS, GEE, etc. as well as national platform in cooperation with cooperative partners such as BRIN/LAPAN, DOST/PhilSA, GISTDA, VNSC from later this year (before coming GEO(TBD))

Visualization of ALOS-2 ScanSAR Imageries on GEE and detected rice planted area by INAHOR

Tutorial material



NASA-JAXA-ESA EO Dashboard Cooperation

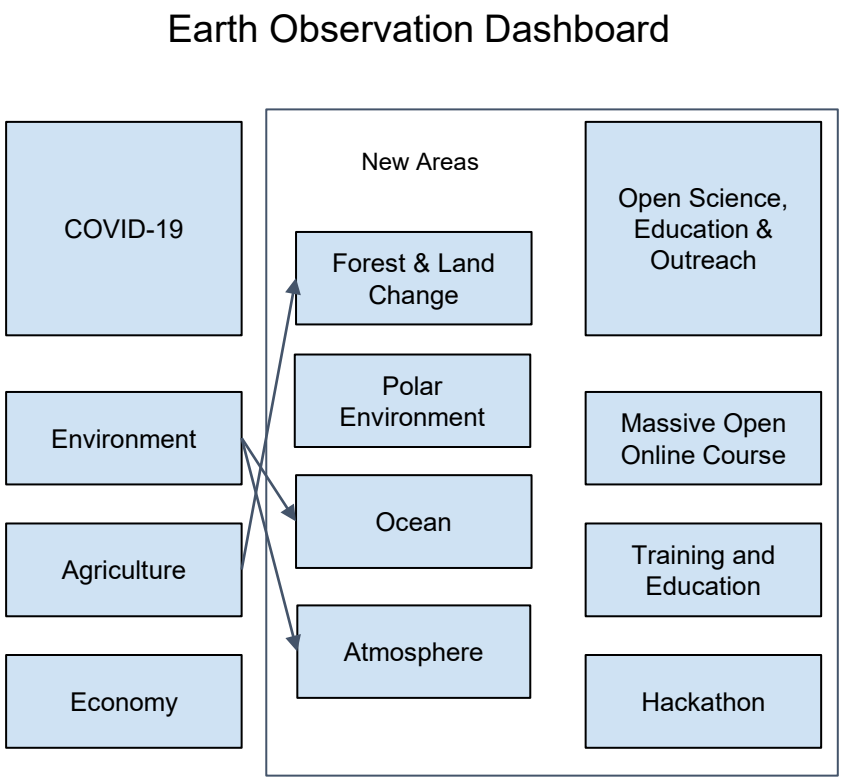
Understanding Global Changes with Satellite Observations

NASA, JAXA, ESA

Dashboard

1. **COVID Dashboard beyond June 2021**
   a. Maintain automated data flows
   b. Data and stories available for future studies
   c. Hackathon - incorporate novel ideas to dashboard

1. **EO Dashboard - Post-COVID Dashboard**
   a. Expanding upon COVID indicators to address environmental change with addition of Forest & Land change and Polar environment observation
   b. Open Science, Education, Outreach: overarching theme
   c. One year timeline for first version - include existing data products from all agencies



WG-1's recommendation for further works

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

- Not limited governmental cooperation but also invite commercial small SAR satellite constellation – what is observation target and value?
- Include survey of SAR + OPTICS constellation? (e.g. S1+S2?) – what is observation target and value?
- request information from CEOS WGISS, GEO/CEOS ODC community and OGC to improve data and information access?

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?