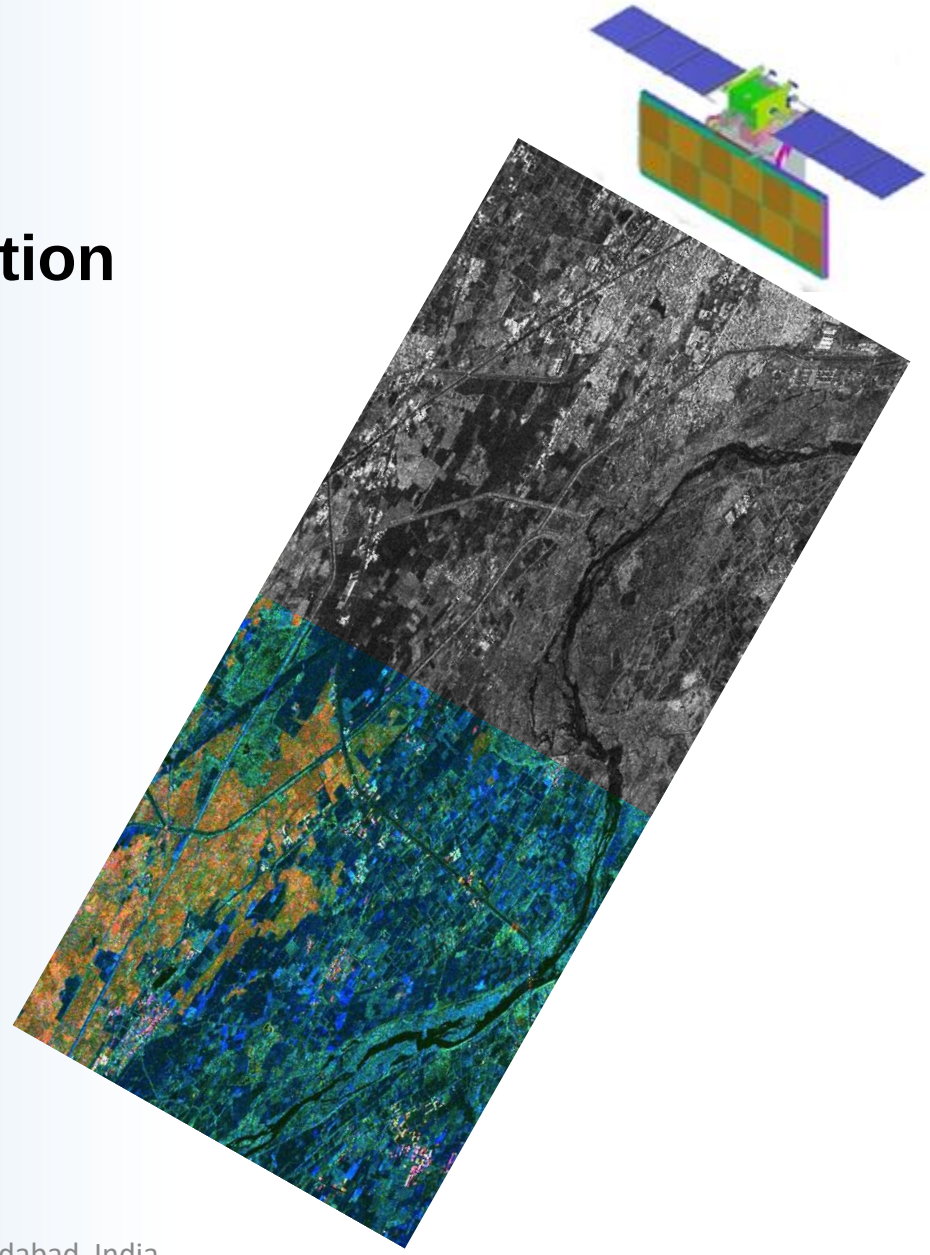
Australian activities in SAR calibration and validation



Matt Garthwaite, Zheng-Shu Zhou, Laura Brindle, CSIRO

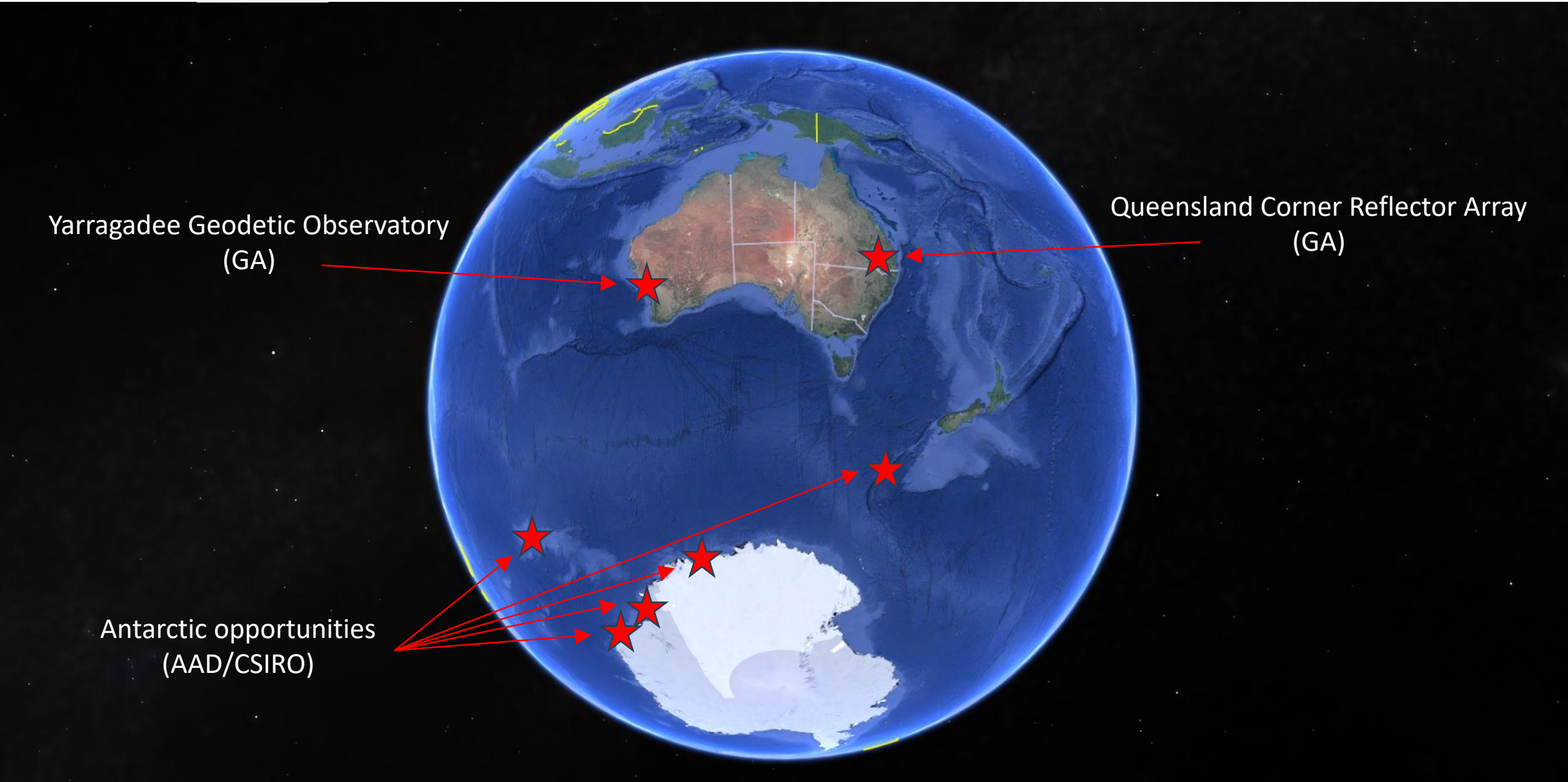
Medhavy Thankappan, Geoscience Australia

Melissa Fedrigo, Australian Antarctic Division

Outline:

1. Australian calibration targets
2. Antarctic opportunities
3. NovaSAR-1 ARD

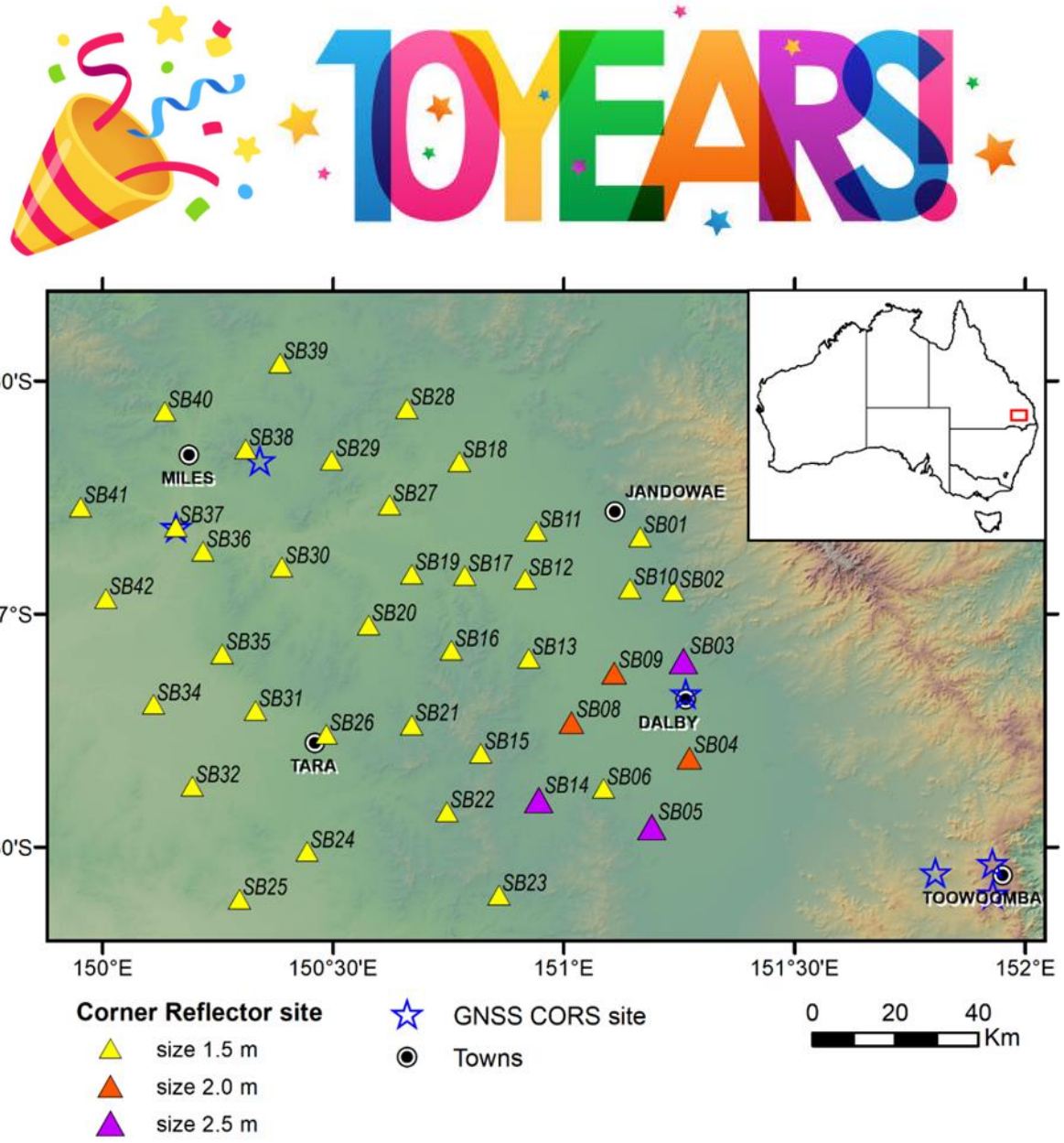
Australian SAR calibration targets



Queensland Corner Reflector Array

- QCRA established by GA in November 2014
- Unique array with 40 sites each with triangular CR spread across 130x130 km area
- Orientations have been constant since establishment, supporting tasking on ascending-passes
- Sporadic maintenance campaigns, last undertaken in May 2023

SB41 before/after maintenance in May 2023



Queensland Corner Reflector Array

- Last geodetic survey was undertaken in 2018, with positions and orientations published in 2020 →

Name	Latitude	Longitude	Height	X	Y	Z	veloX	veloY	veloZ	Azimuth	Elevation
SB01-CRApex	-26.834709869	151.165603925	409.4544	-4989394.0436	2746844.3890	-2862070.0899	-0.0325	-0.0083	0.0487	257.10	53.32
SB02-CRApex	-26.951633122	151.237612692	432.7094	-4987723.0920	2737761.6619	-2873635.5867	-0.0325	-0.0082	0.0486	256.21	53.33
SB03-CRApex	-27.100731842	151.258808903	391.8599	-4982121.1136	2732288.8068	-2888334.6208	-0.0326	-0.0081	0.0485	258.46	54.34
SB04-CRApex	-27.308871392	151.271959147	385.2420	-4973496.3076	2726074.1767	-2908844.8033	-0.0326	-0.0079	0.0484	258.51	54.67
SB05-CRApex	-27.456930253	151.190829581	403.0057	-4963032.7802	2729484.8820	-2923421.9268	-0.0327	-0.0077	0.0484	258.20	55.36
SB06-CRApex	-27.374738525	151.085922853	387.6754	-4961686.0170	2740588.5882	-2915329.5912	-0.0328	-0.0078	0.0484	255.28	54.60
SB08-CRApex	-27.232789689	151.016766186	373.0977	-4964674.9910	2750065.4225	-2901345.3849	-0.0327	-0.0079	0.0485	256.53	56.45
SB09-CRApex	-27.125995450	151.109203186	370.6178	-4973836.1805	2744662.7879	-2890816.8016	-0.0326	-0.0080	0.0485	258.28	55.60
SB10-CRApex	-26.946511436	151.143877897	390.5168	-4983429.8223	2746023.7924	-2873110.5601	-0.0326	-0.0082	0.0486	255.93	53.53
SB11-CRApex	-26.822684986	150.939507744	368.4832	-4979009.5403	2766786.0572	-2860862.5749	-0.0326	-0.0083	0.0487	257.05	54.23
SB12-CRApex	-26.926123142	150.916377294	358.7910	-4973356.7711	2766273.1942	-2871082.0808	-0.0327	-0.0082	0.0487	256.18	54.59
SB13-CRApex	-27.095306708	150.923620117	395.4661	-4966293.7922	2761522.6712	-2887801.0851	-0.0327	-0.0080	0.0486	256.42	55.11
SB14-CRApex	-27.399835706	150.944822797	387.9695	-4953803.7199	2752178.0222	-2917799.1845	-0.0328	-0.0077	0.0485	258.58	57.20
SB15-CRApex	-27.299077906	150.820193736	426.7689	-4952314.2625	2765464.7305	-2907899.4977	-0.0329	-0.0078	0.0486	255.85	55.84
SB16-CRApex	-27.078145481	150.756415219	381.4304	-4958958.4102	2776420.8158	-2886101.6076	-0.0328	-0.0080	0.0487	256.95	55.98
SB17-CRApex	-26.917645661	150.784720272	353.8773	-4967354.5677	2777899.3618	-2870242.2844	-0.0327	-0.0081	0.0488	255.78	55.40
SB18-CRApex	-26.673727158	150.773020519	361.1622	-4977426.1161	2784866.0882	-2846120.0659	-0.0326	-0.0084	0.0489	257.49	54.87
SB19-CRApex	-26.914870692	150.670436758	359.7925	-4961929.7791	2787872.5986	-2869970.7827	-0.0328	-0.0081	0.0488	256.56	56.07
SB20-CRApex	-27.023911789	150.576833939	357.7502	-4952594.1799	2793282.2333	-2880738.6086	-0.0329	-0.0080	0.0488	256.50	56.93
SB21-CRApex	-27.237809878	150.670032397	388.7727	-4947731.9551	2779941.4574	-2901847.1898	-0.0329	-0.0078	0.0487	256.61	56.26
SB22-CRApex	-27.424348239	150.746291272	413.0829	-4943165.9721	2768726.2931	-2920222.1494	-0.0330	-0.0076	0.0485	256.28	56.17
SB23-CRApex	-27.603355556	150.859533225	381.6017	-4940599.9636	2754474.9134	-2937801.3187	-0.0330	-0.0075	0.0484	256.67	56.44
SB24-CRApex	-27.509688500	150.443214533	337.3080	-4924598.3305	2792650.3507	-2928578.3415	-0.0331	-0.0075	0.0486	257.66	57.02
SB25-CRApex	-27.611298086	150.296827667	316.2926	-4912905.6949	2802632.4604	-2938551.0250	-0.0333	-0.0073	0.0486	256.52	57.72
SB26-CRApex	-27.258831019	150.485119703	355.3122	-4937780.3918	2795354.8632	-2903902.8093	-0.0330	-0.0077	0.0487	256.71	56.27
SB27-CRApex	-26.766765008	150.621767764	353.2136	-4966011.7183	2795718.6233	-2855324.7027	-0.0327	-0.0082	0.0489	256.66	56.25
SB28-CRApex	-26.559895989	150.659249961	370.9227	-4976820.0647	2797517.3361	-2834848.1859	-0.0326	-0.0085	0.0490	254.67	55.44
SB29-CRApex	-26.670527386	150.497016319	382.3580	-4964108.2091	2808898.5564	-2845812.7580	-0.0328	-0.0083	0.0490	256.63	56.06
SB30-CRApex	-26.900130550	150.388478883	338.8747	-4948776.7814	2812612.8792	-2868504.8151	-0.0329	-0.0080	0.0489	257.64	55.87
SB31-CRApex	-27.207300692	150.331555681	333.3380	-4932524.0922	2809862.7820	-2898815.4792	-0.0331	-0.0077	0.0488	256.97	56.71
SB32-CRApex	-27.369818422	150.194663150	322.1841	-4918623.5122	2817530.6952	-2914815.3006	-0.0332	-0.0075	0.0488	256.44	58.18
SB34-CRApex	-27.194269531	150.110867200	316.9538	-4922224.3108	2829162.3631	-2897523.6695	-0.0332	-0.0077	0.0489	256.72	58.01
SB35-CRApex	-27.085635667	150.259633119	371.1494	-4934363.3583	2819120.4921	-2886835.9213	-0.0331	-0.0078	0.0489	256.92	57.22
SB36-CRApex	-26.865806883	150.217619406	337.1187	-4941858.6484	2828211.3354	-2865111.7164	-0.0330	-0.0080	0.0490	257.48	57.09
SB37-CRApex	-26.813256386	150.158932542	343.3239	-4941244.4236	2834582.6408	-2859918.8393	-0.0330	-0.0081	0.0490	256.52	57.43
SB38-CRApex	-26.647021089	150.310322464	388.4128	-4955949.2062	2825640.2821	-2843487.7462	-0.0329	-0.0083	0.0490	256.86	56.27
SB39-CRApex	-26.462084544	150.384487339	374.2237	-4967555.5822	2823743.5891	-2825151.5218	-0.0327	-0.0085	0.0491	257.38	57.18
SB40-CRApex	-26.565935628	150.134804969	350.7873	-4950730.3110	2842795.8086	-2835437.7525	-0.0329	-0.0083	0.0491	256.13	56.74
SB41-CRApex	-26.770861503	149.952525394	387.4865	-4932867.8771	2853444.9610	-2855745.4107	-0.0331	-0.0080	0.0491	256.77	58.68
SB42-CRApex	-26.966789519	150.007075042	318.3996	-4927030.9345	2843811.4897	-2875080.7264	-0.0331	-0.0079	0.0490	255.85	58.67

http://dx.doi.org/10.11636/Record.2020.034

SARCalNet submission

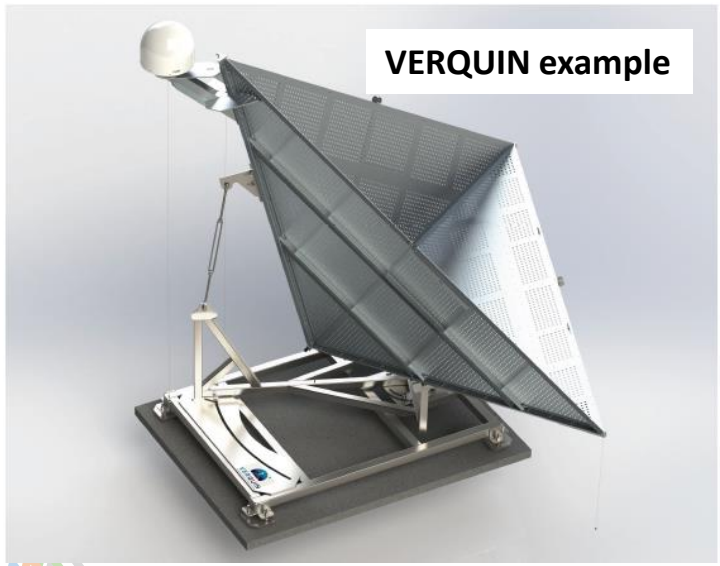
- GA and CSIRO are highly supportive of the SARCalNet initiative.
- We still intend to submit both the QCRA and Yarragadee targets for inclusion in SARCalNet

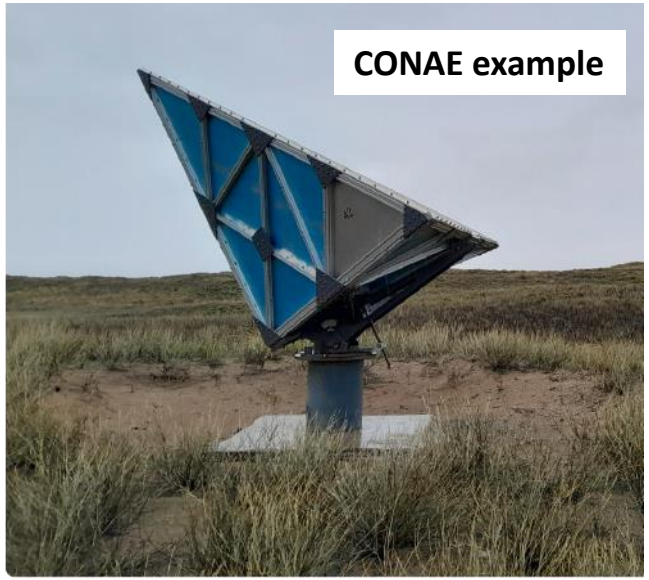
CR at GA's Yarragadee Geodetic Observatory

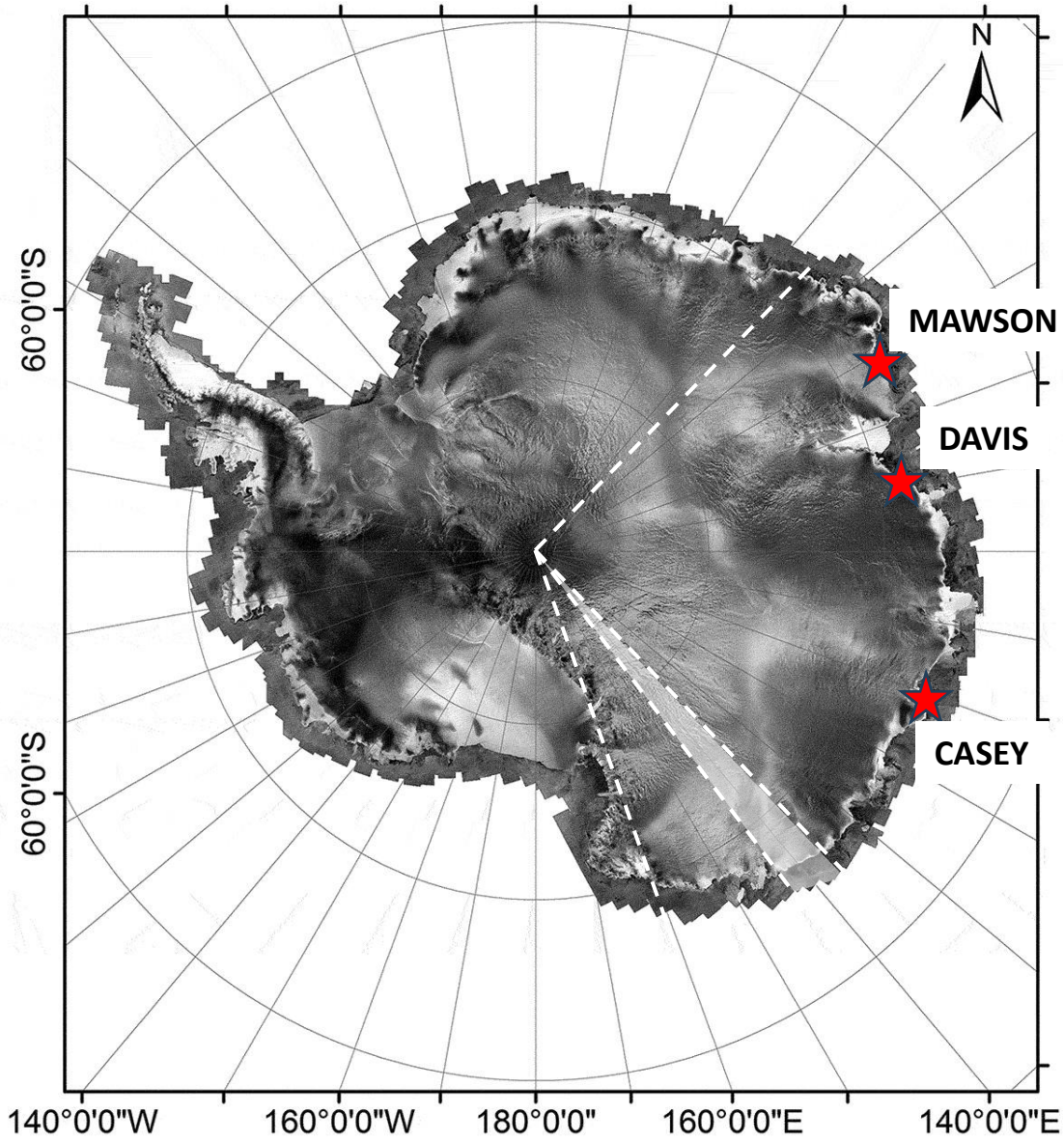
https://www.sarcalnet.org/

Antarctic corner reflectors

- AAD is exploring the procurement of new corner reflector targets
- Potential permanent installs at 3 Antarctic bases plus the Macquarie Island base at 54ºS
- Intent to support L-band radiometric calibration
- Issues: target robustness, radome, longevity





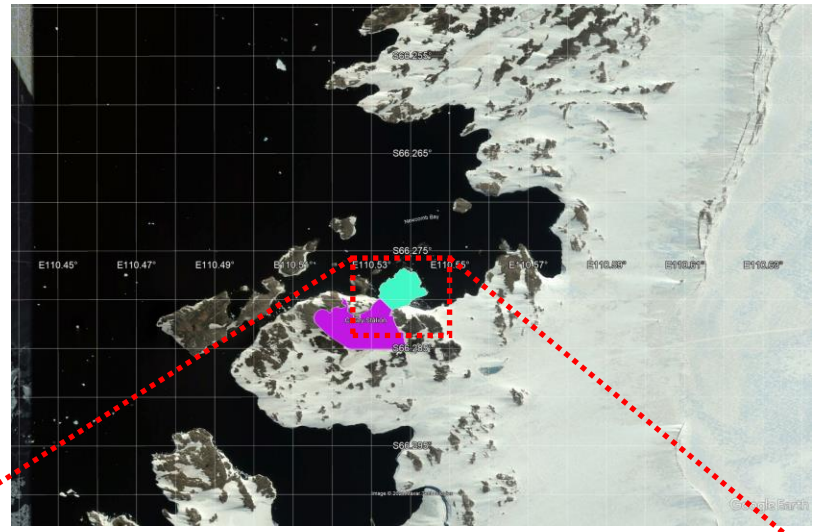


RADARSAT-1 1997 mosaic, Patel et. al 2019

Case study: Casey Station

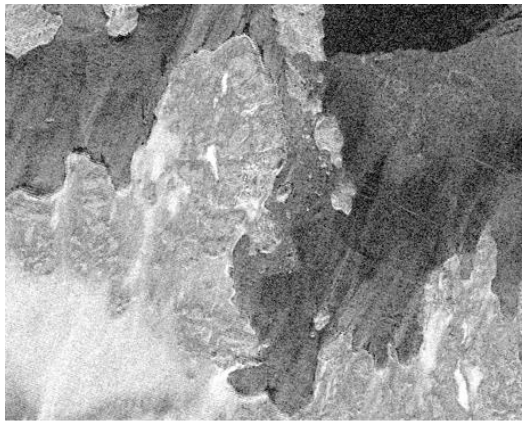
- AAD were keen to redeploy a CR (that was sent to Casey for a Danish experiment in 2024) to support NISAR post-launch calibration
- CSIRO assisted in finding deployment locations

Casey Research Station – Image Credit: Justin Chambers

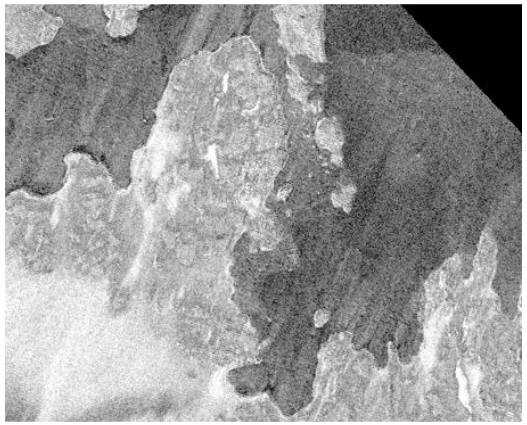


Case study: Casey Station

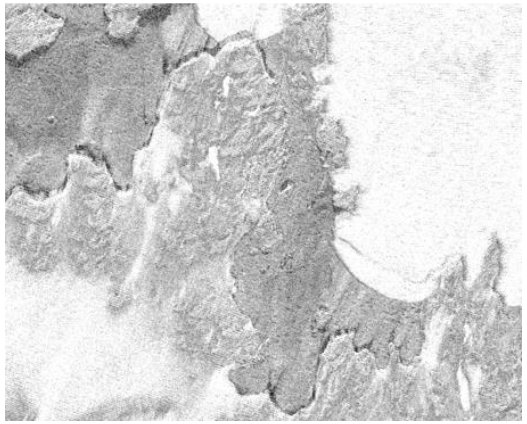
- We tasked NovaSAR-1 (S-band) images over Casey station in Stripmap mode with various viewing geometries



21/05/2023



23/05/2023

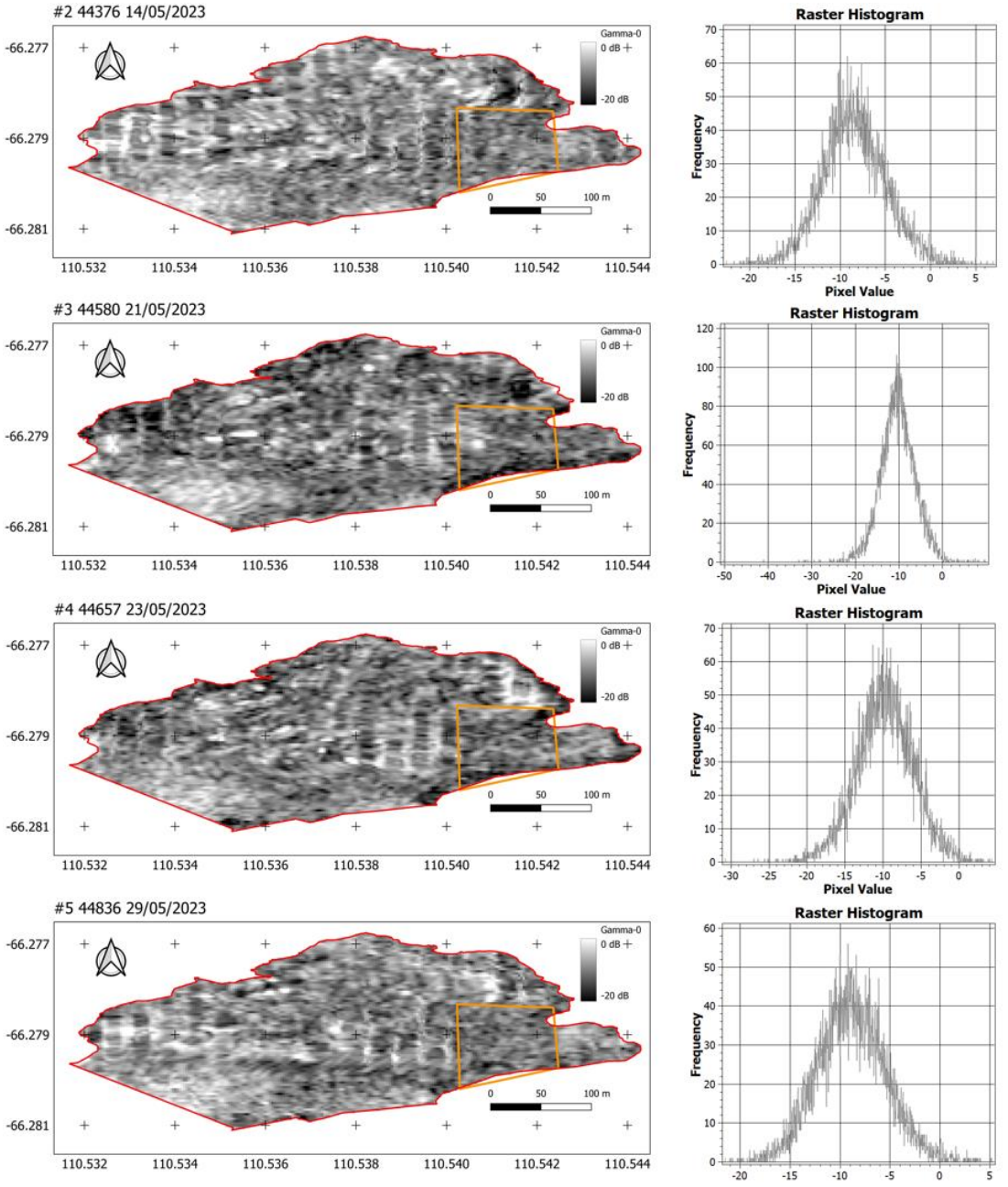


29/05/2023

Case study: Casey Station

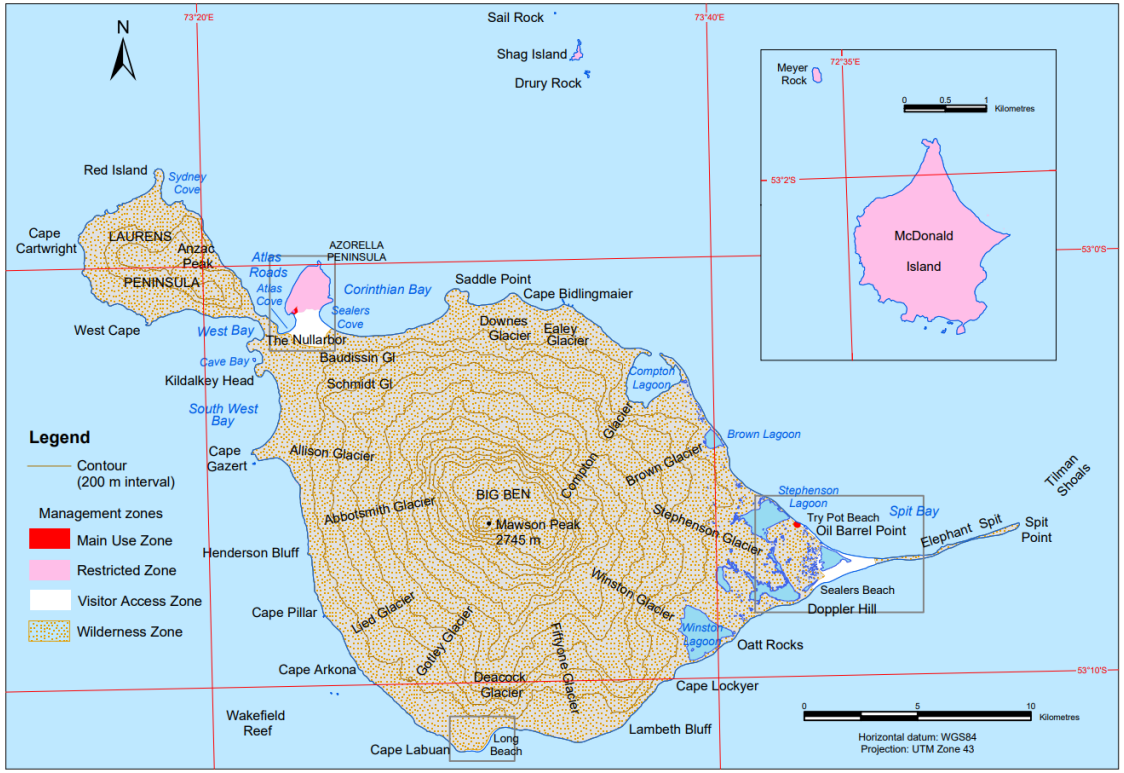
- We undertook desktop analysis of the images (first processed to NRB ARD spec) in Jan 2024
- Backscatter statistics are gaussian in the Extended Station Limits area with means from -8 to -10 dB across 4 images
- We found a smaller area (100m x 100m) with lower backscatter (mean -10 to -11 dB) that we recommended to AAD for further investigation

#	Acquisition date	Extended station limits					Subset area				
		Max (dB)	Mean (dB)	Min (dB)	Std Dev (dB)	Num samples	Max (dB)	Mean (dB)	Min (dB)	Std Dev (dB)	Num samples
2	14/05/2023	6.94	-8.39	-22.58	3.54	12867	-2.19	-10.15	-17.72	2.57	1284
3	21/05/2023	9.95	-10.19	-50.33	4.00	12869	0.82	-11.36	-23.67	3.66	1286
4	23/05/2023	4.38	-9.70	-30.79	3.72	12873	0.97	-11.39	-22.49	3.42	1286
5	29/05/2023	5.26	-8.81	-21.53	3.43	12867	-5.22	-10.79	-20.74	2.41	1284



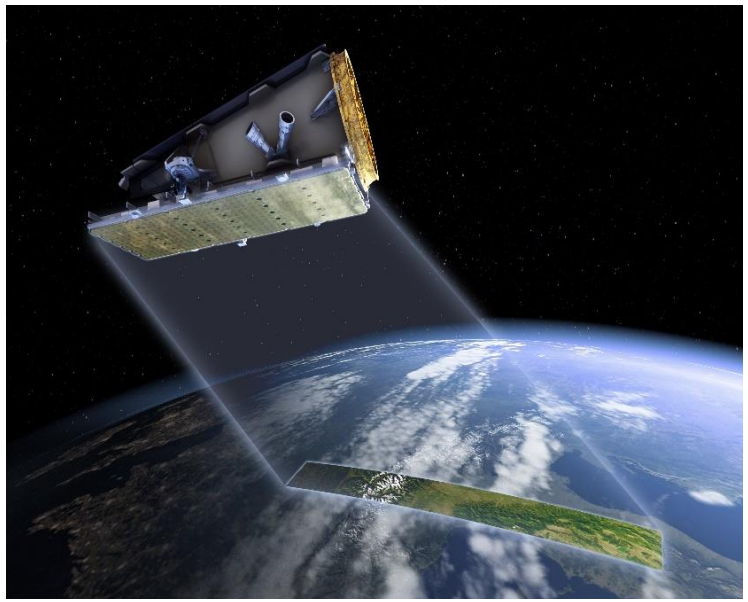
Heard Island corner reflectors

- AAD hoping to establish a geometric calibration network on Heard Island to support remote management using SAR and optical sensors.
- AAD last visited Heard Island in 2003/4!
- Considering different target designs including DBST and Top Hats – any thoughts?!



NovaSAR-1

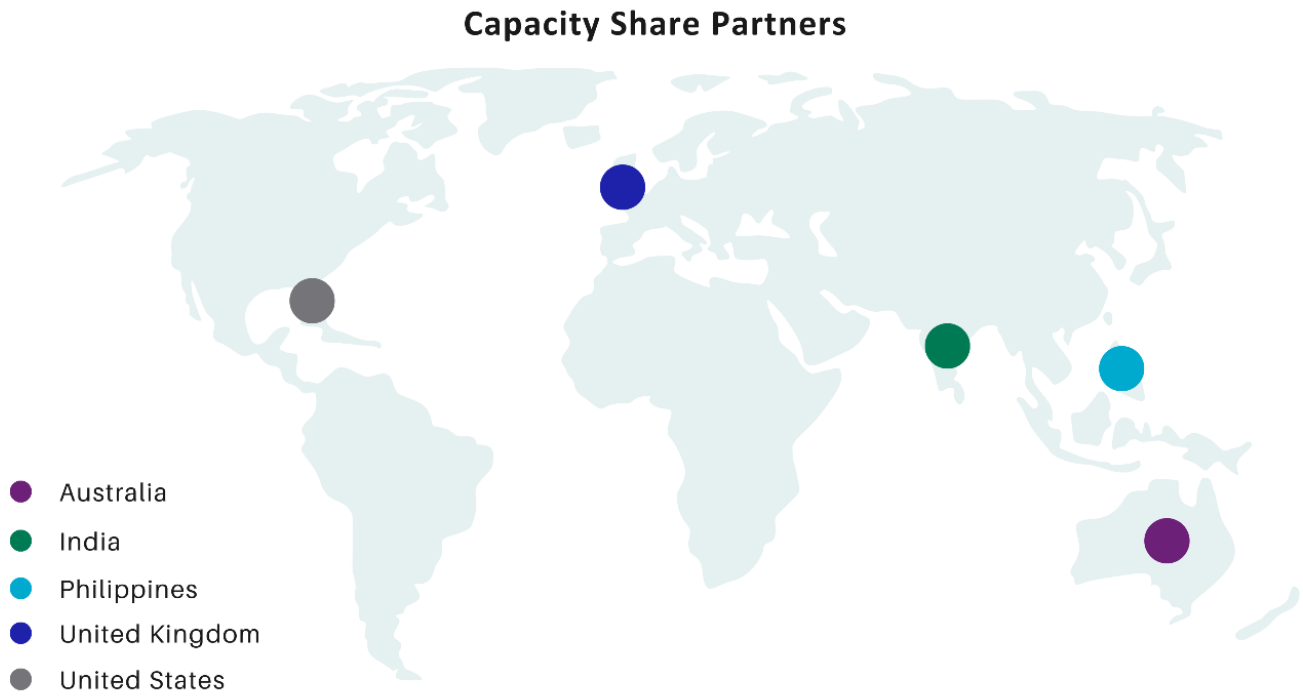
- Developed as a low-cost SAR technology demonstrator by SSTL and Airbus funded by UK Space Agency, launched in 2018
- In 2017, CSIRO acquired a 10% share in acquisition and tasking capacity for 7 years
- This is Australia's first-ever sovereign civilian EO satellite capability

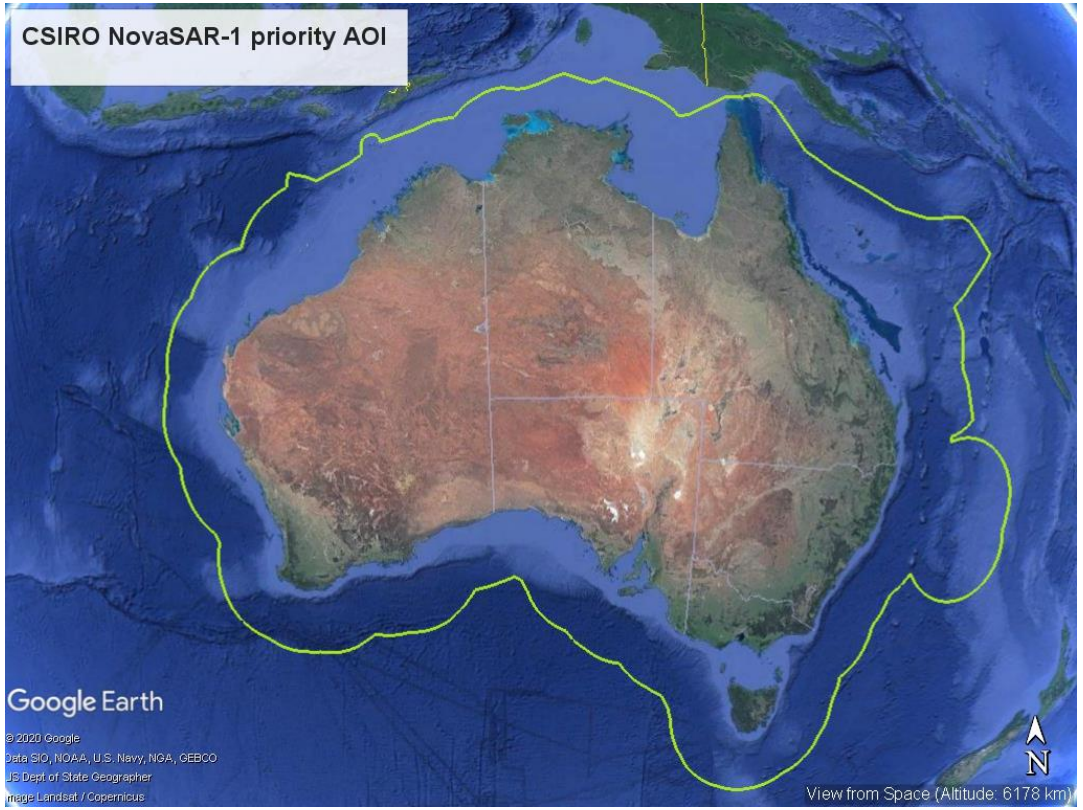


Parameter	Value
Imaging frequency band	3.1-3.3GHz (S-band)
Antenna	Microstrip patch phased array (3m x 1m)
No. of phase centers	18
Peak RF power	1.8kW
Polarisations	HH, HV, VV
Imaging polarization	Single, dual, tri- or quad polar
Design life	**7 years**
Mass	**<400kg**
Optimum orbit	583km
Propulsion system	Xenon
Payload duty cycle	**2-4min per orbit**
Payload data memory	**Up to 544GBytes**
Downlink rate	400Mbps
TTC frequency band	S-band (2025-2110MHz, 2200-2290MHz)
Downlink frequency band	X-band (8.025-8.4GHz)

NovaSAR-1

- CSIRO has priority tasking over Australia and its near-shore waters.
- But can task anywhere globally





NovaSAR-1 Tasking Requests

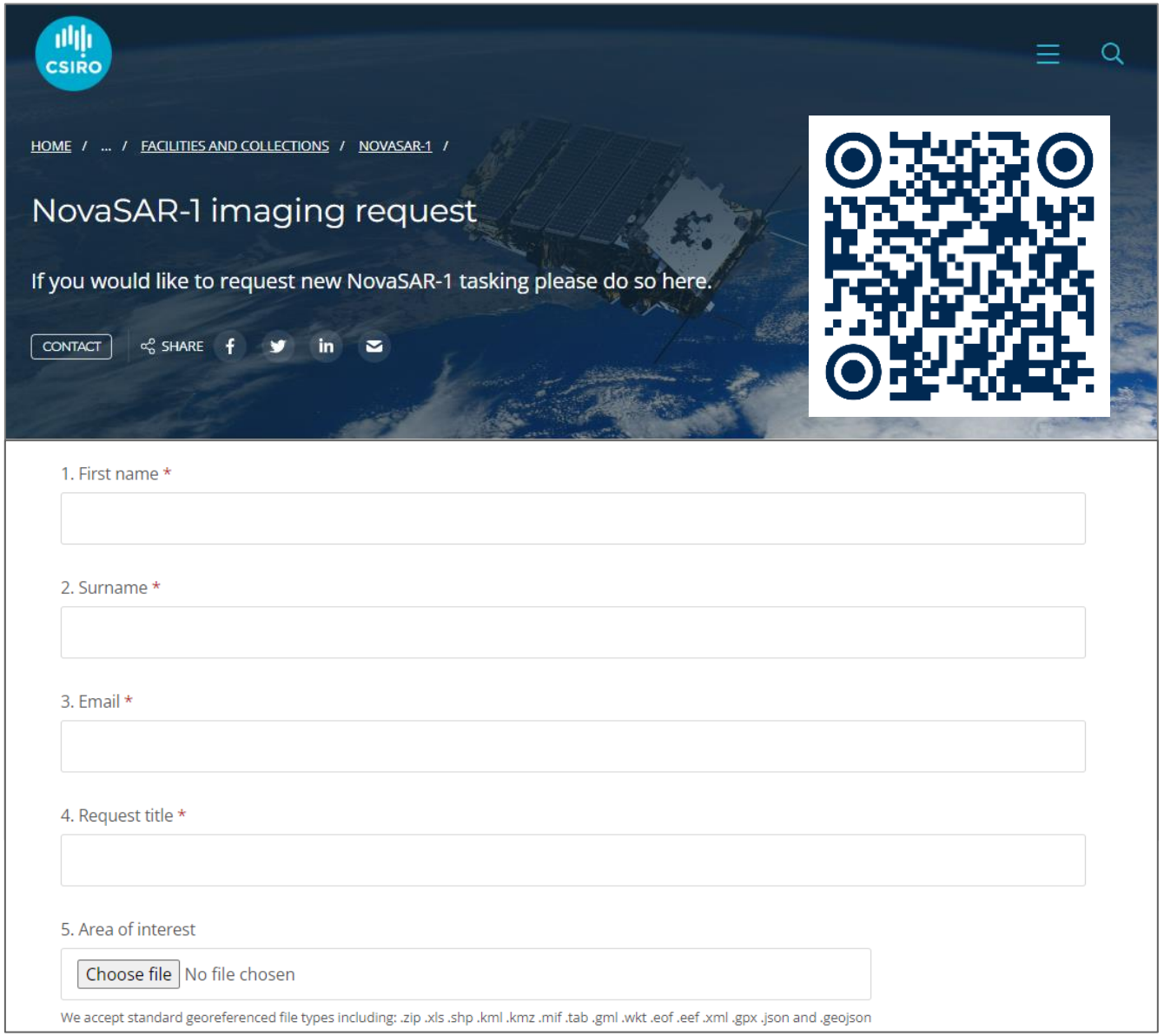
New NovaSAR-1 image tasking can be requested at any time using our simple online form

Requests are assessed on:

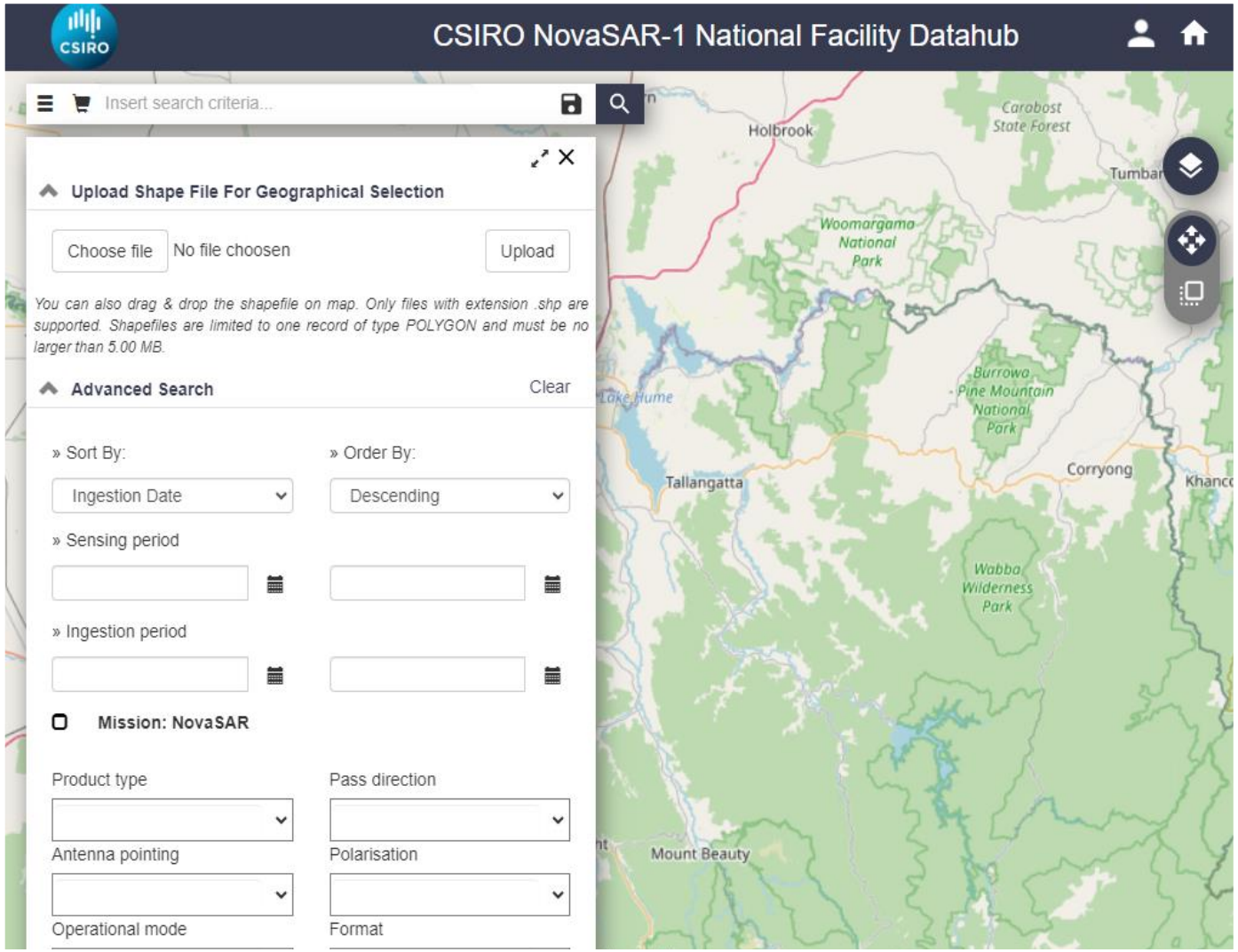
- Scope & Feasibility (AOI size, timeframes and selected mode)

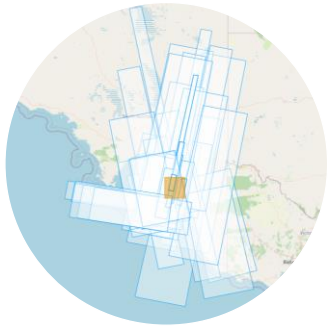
- Clashes with capacity share partners or existing projects

https://www.csiro.au/en/about/facilities-collections/NovaSAR-1/image-request



NovaSAR-1 Data Hub





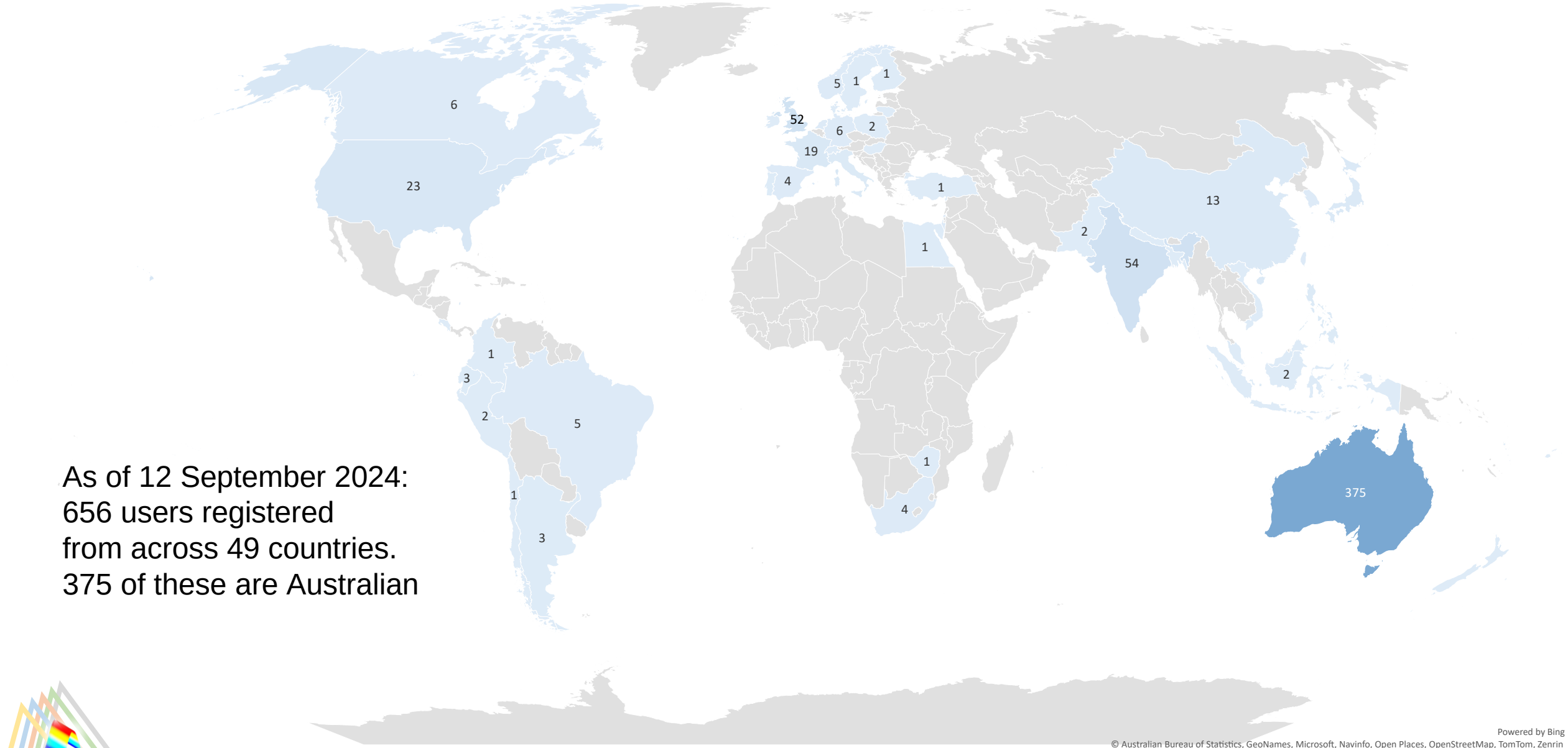
5300+ L1 products

FREE

2800+ CEOS-ARD NRB products

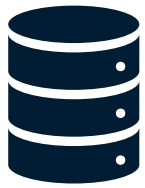
https://data.novasar.csiro.au/#/home

NovaSAR-1 Data Hub



As of 12 September 2024:
656 users registered
from across 49 countries.
375 of these are Australian

NovaSAR-1 CEOS ARD



All archive NovaSAR-1 SCD (excluding Maritime mode) and GRD data acquired in Australian region have been processed into ARD

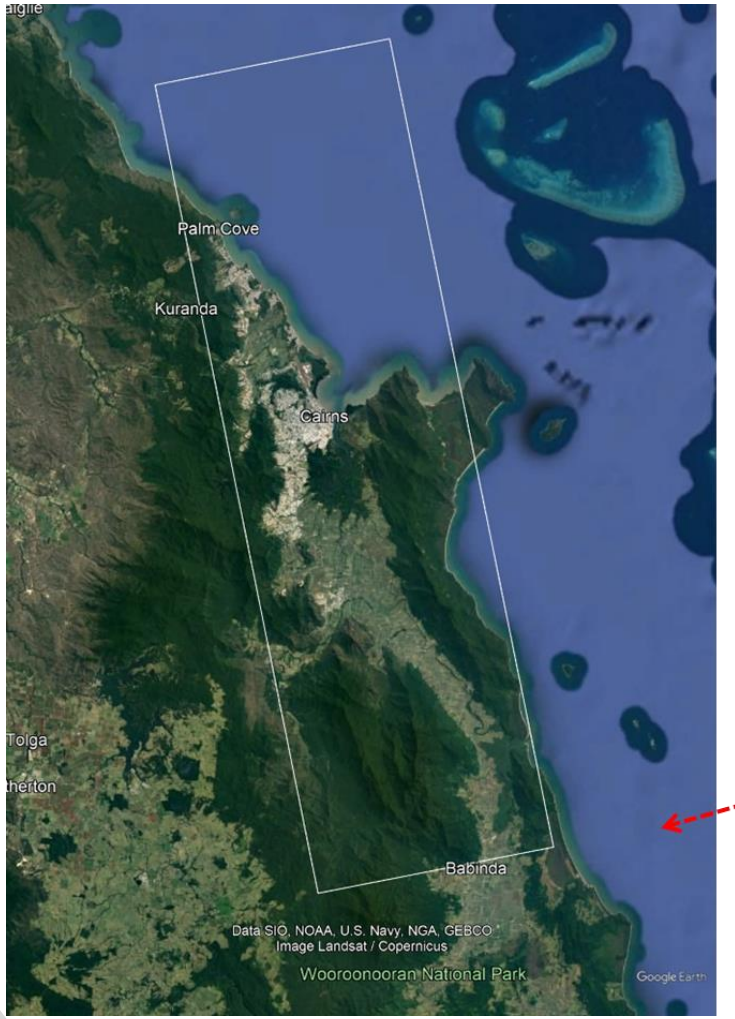
Submitted CSIRO self-assessment for CEOS-ARD NRB PFS v5.5 compliance review to CEOS in August 2023

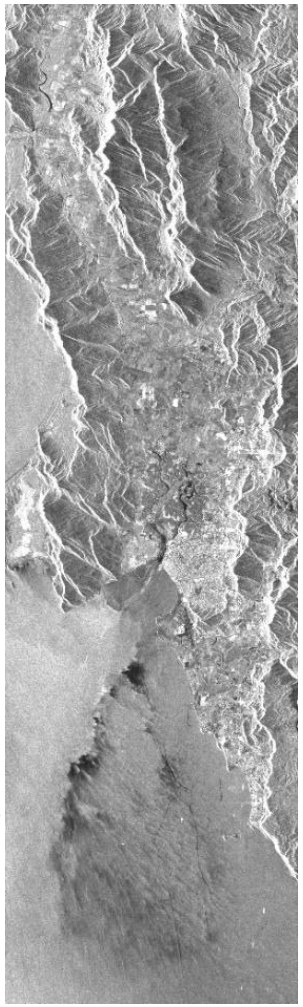
CEOS Review results were released on 5 October 2023: 14 CSIRO NovaSAR-1 NRB products have been evaluated as CEOS-ARD compliant at the threshold level

On 21 March 2024, the processed archive completed ingestion to the data hub and the AWS processing was integrated into the NovaSAR-1 image processing chain

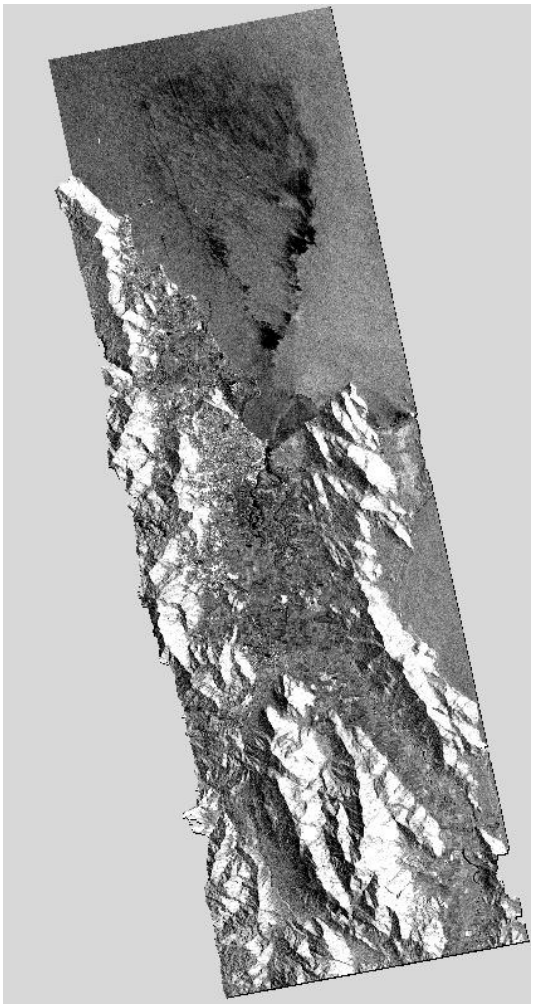
NovaSAR-1 CEOS ARD

- Sample of NovaSAR-1 ARD Processing for Acquisition 39919:

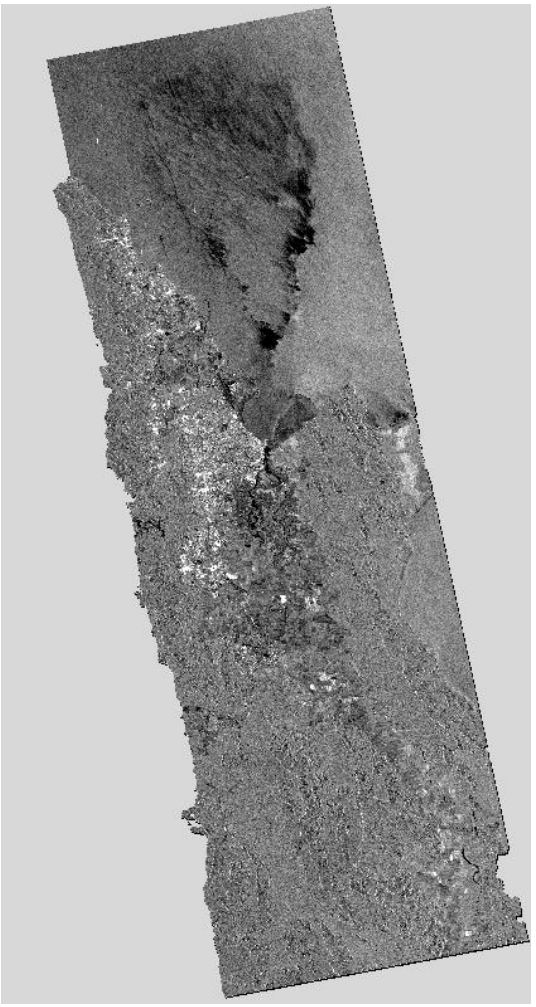




HH Source



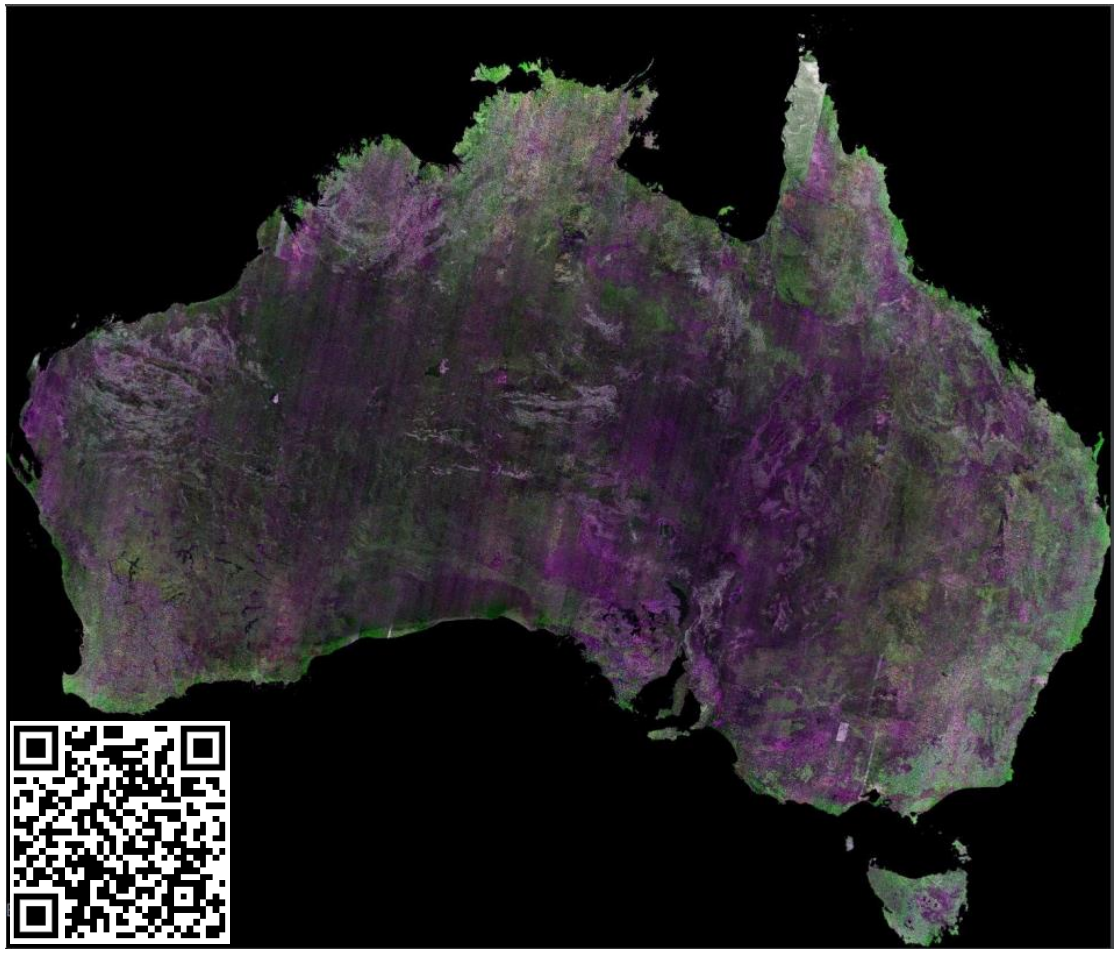
Beta0

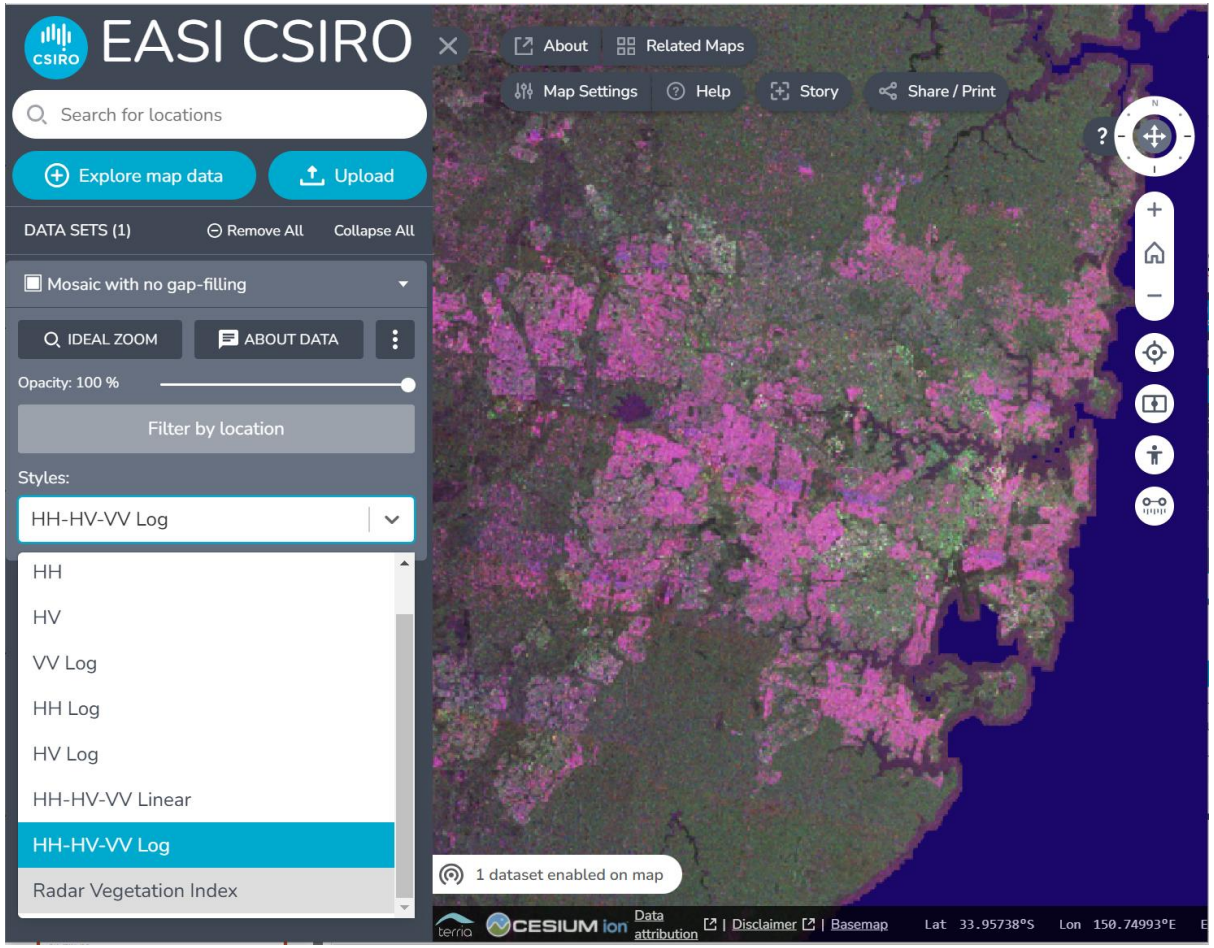


Gamma0-RTC

National Mosaic and EASI

- We completely mapped Australia with NovaSAR-1 tri-pol data between 2020 and 2023





https://map.csiro.easi-eo.solutions/

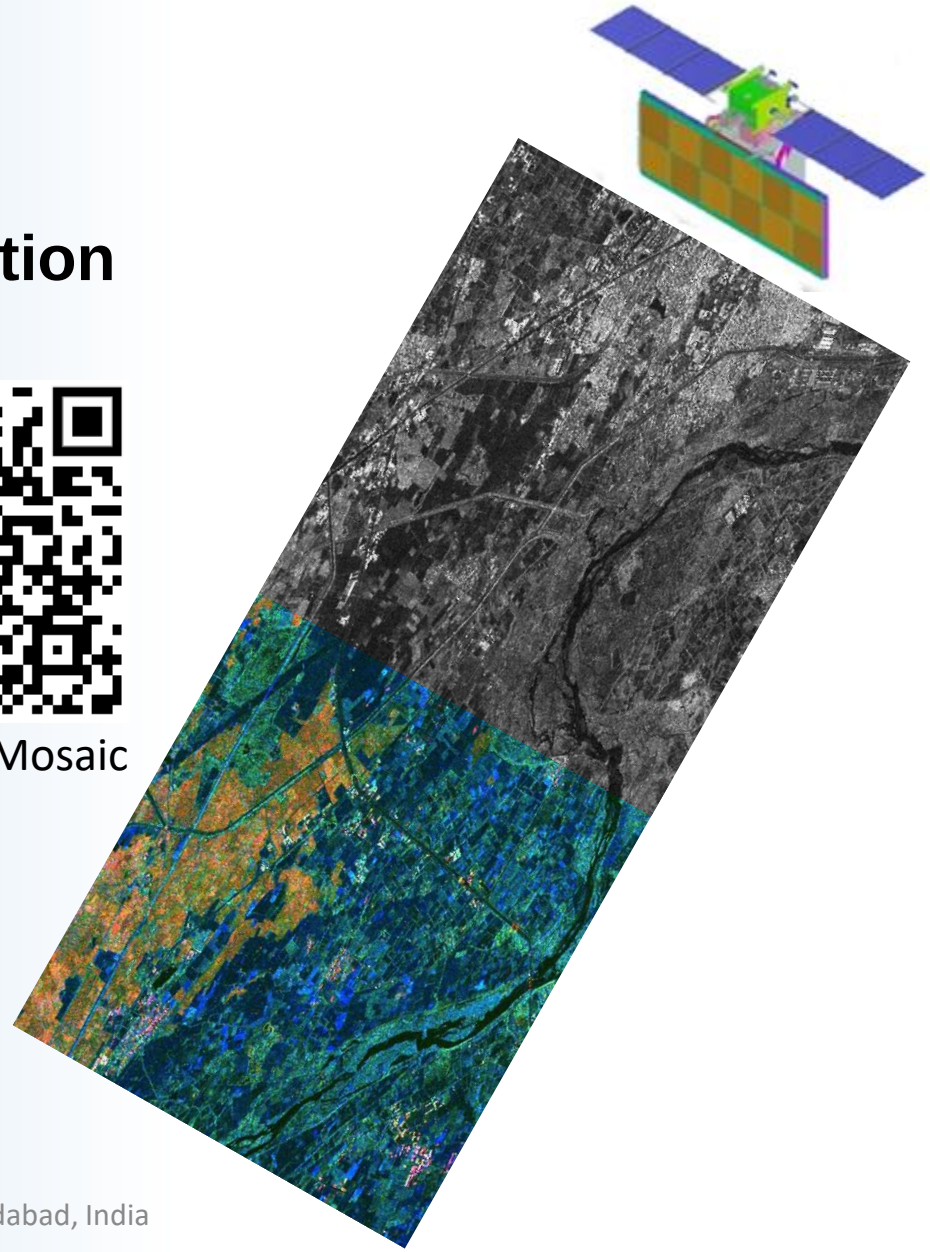
Australian activities in SAR calibration and validation

Queensland Corner Reflector Array

NovaSAR-1 Tasking

NovaSAR Data hub

NovaSAR Mosaic



Matt.Garthwaite@csiro.au