SWESARR

Snow Water Equivalent Synthetic Aperture Radar and Radiometer

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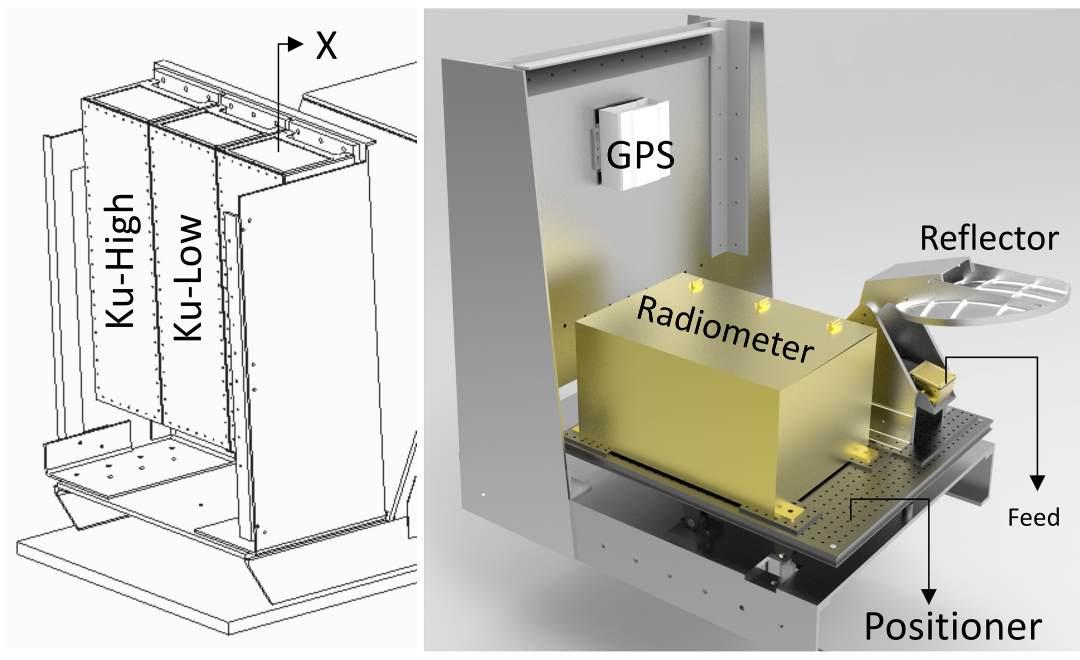
Snow Water Equivalent (SWE) is a challenging quantity to estimate using remote sensing techniques, due to snow spatial variability and the influence of substrate, vegetation, and atmospheric properties. Even though snow covered area can be estimated based on optical or microwave remote sensing, and snow depth can be estimated from surface height differencing snow free and snow on conditions using lidar and radar altimetry data reliably, remote sensing of SWE remains a challenge. At NASA Goddard Space Flight Center, a new dual microwave instrument has been designed and built to remotely observe microwave radiation relevant for SWE retrievals. SWE Synthetic Aperture Radar and Radiometer (SWESARR) is a new instrument which flew SnowEx 2020 snow-off science flights between November 4th and 6th 2019, and snow-on science flights between February 8th and 12th.

SWESARR flies inside a Twin Otter looking through a radome with a 45-degree incidence angle to the ground. a) Twin otter, b) SWESARR instrument, and c) aircraft installation.

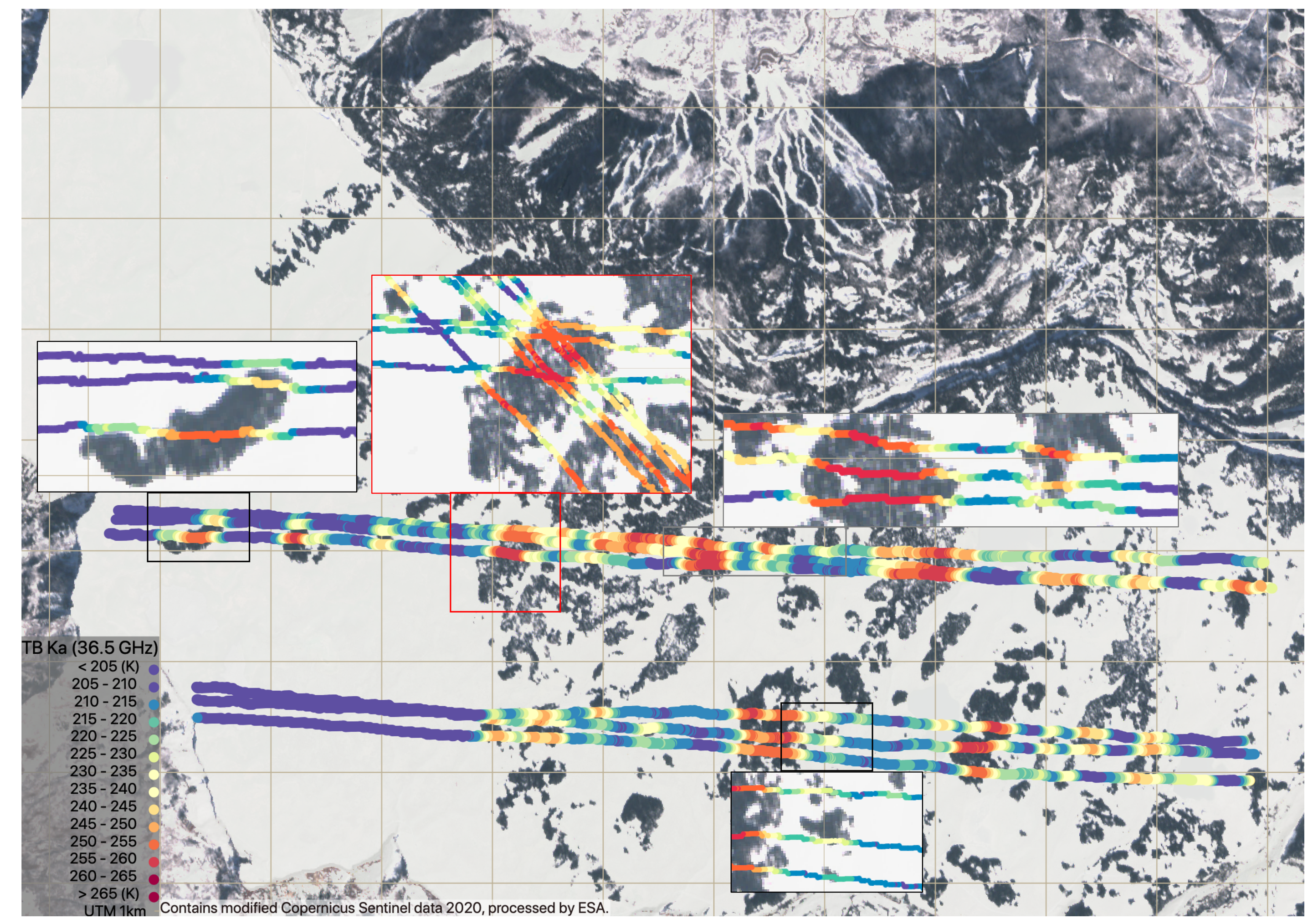
SWESARR Hardware

Recently, the SWESARR radiometer has been upgraded to increase the signal-to-noise ratio. In contrast, The radar was designed from scratch leveraging Goddard's airborne radars.

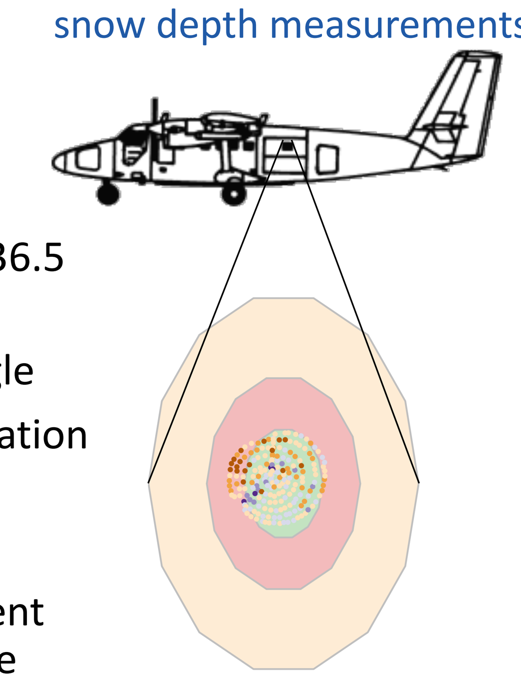


SWESARR utilizes a single feed to assure collocated radar and radiometer observations on the ground. The feed uses a current sheet array, providing frequency coverage between 9.6 to 36.5 GHz.

Instrument	Band	Freq. (GHz)	BW (MHz)	Pol.
Radar	X	9.65	200	VV,VH
Radiometer	X	10.65	200	H
Radar	Ku-Lo	13.60	200	VV, VH
Radar	Ku-Hi	17.25	100	VV, VH
Radiometer	K	18.70	200	H
Radiometer	Ka	36.50	1000	H



radiometer footprints & snow depth measurements



Simultaneous observations at:

. 10.65, 18.7, and 36.5 GHz

. 45° incidence angle

. horizontal polarization

. Meaningful TB variations, consistent with features at the surface

. Large dynamic range

. Repeatability

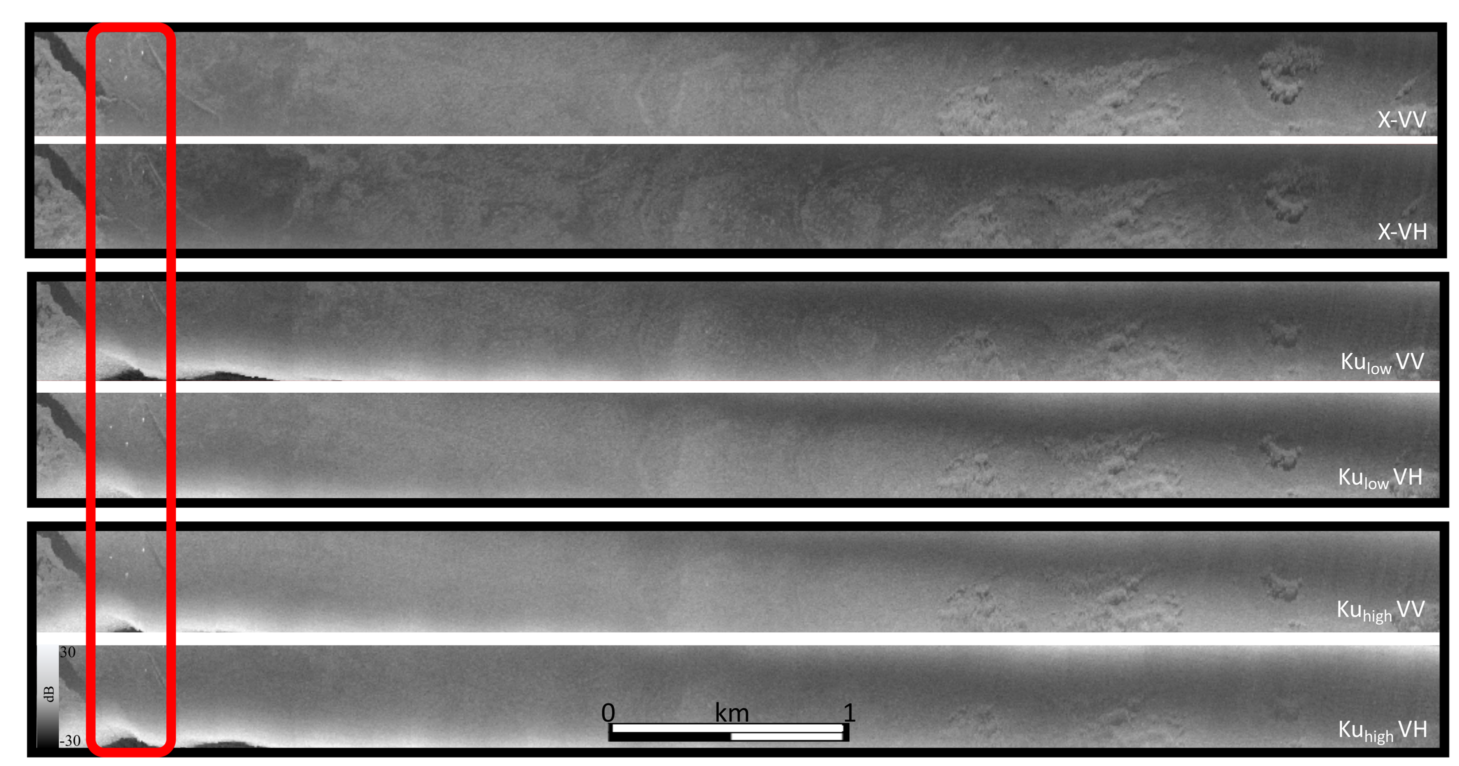
X 496 m x 352 m

Ku 282 m x 200 m

Ka 144 m x 102 m

Calibration

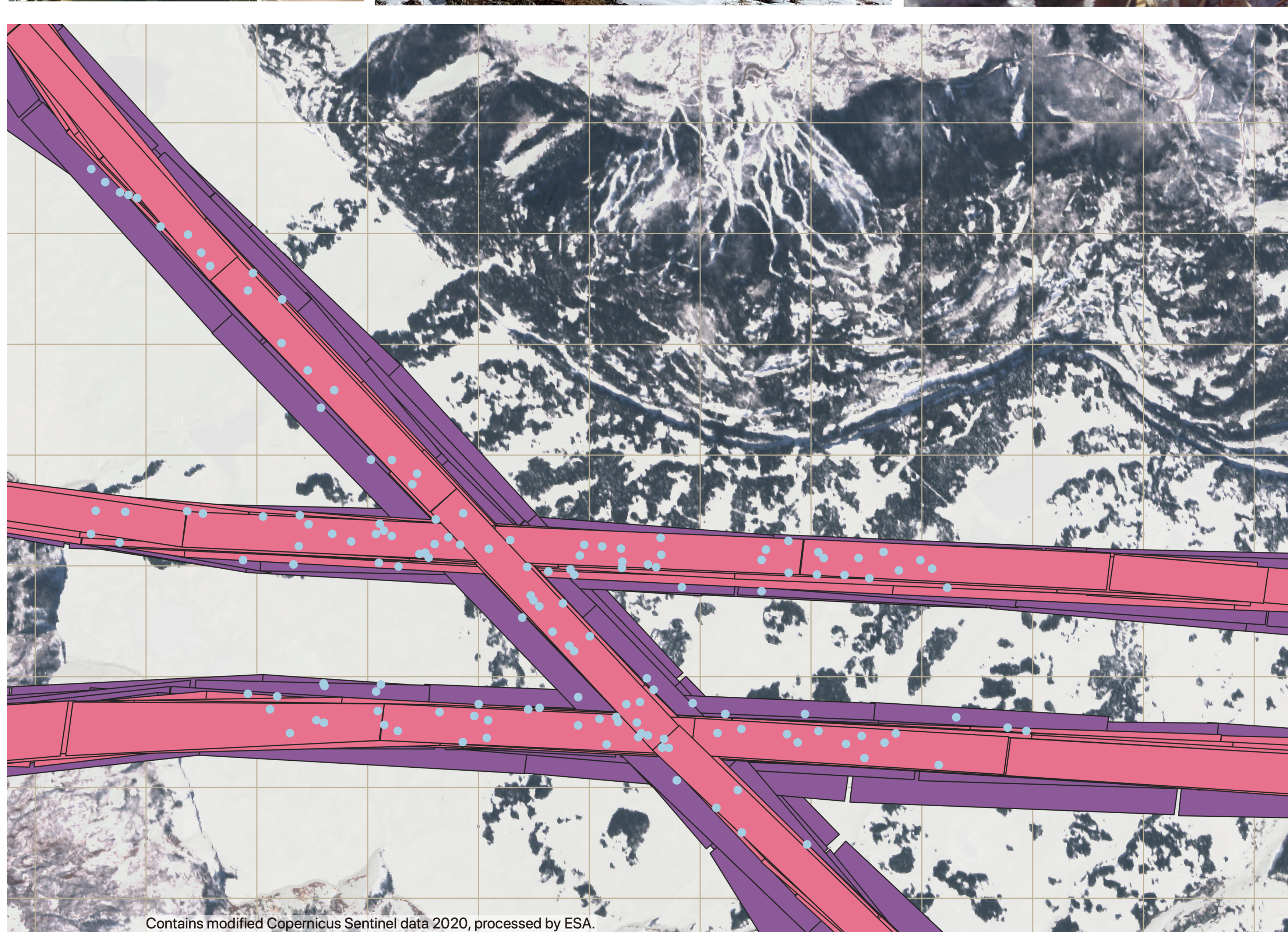
In order to obtain high quality observations using SWESARR, different calibration data was collected throughout the project. The instrument characteristics were measured in the anechoic chamber, and corner reflectors are installed in flight paths to calibrate backscatter values. Snow measurements are also taken over the Grand Mesa around the time of the over passes to validate the retrievals.



Example SWESARR data collected on 2020-02-11 between 17:26:24 and 17:28:04 imaging the South Ground Line.

Corner reflectors for radar calibration were installed on the west end of the Grand Mesa (red box). Trees are visible on the opposite end of the image.

The dark patch to the left of the red-box is the radar-shadow due to the nearly 3000ft elevation change at the edge of the Grand Mesa.



Snow-off flights in Nov. 2019

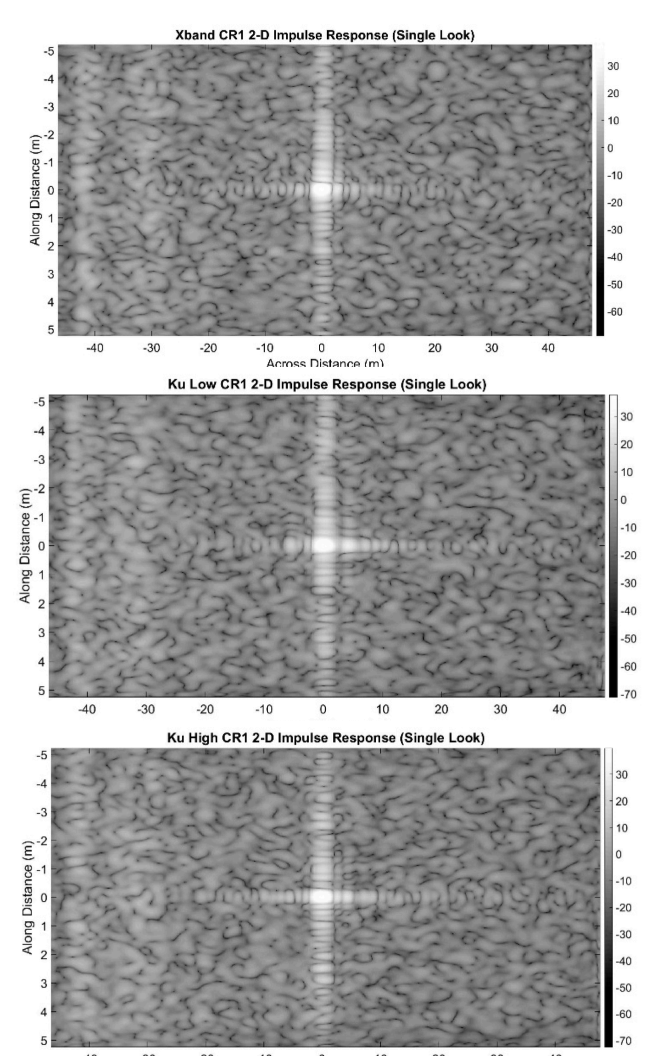
- 3 science flight days / 3 flights
- North (8 passes),
- South (8 passes), and
- Cross-West (6 passes)

Snow-on flights in Feb.2020

- 4 science flight days / 5 flights
- North (8 passes),
- South (7 passes),
- Cross-West (6 passes), and
- Cross-East (8 passes)

- Co-flown with UW-IR
  PI: Jessica Lundquist
  POC:Chris Chickadel

• Snow pit locations



Corner reflector observations from December 2018 with all radar bands are shown on the left and instrument performance are summarized in the table below. Geocoded products will be distributed with square pixels for ease of use and increased signal power as a result of multi-looking. In the table below:
Exp: Expected, Opt: Manually optimized processing,
Prod: Automated production code (preliminary values)

	X-VV (VH)	Ku-L VV (VH)	Ku-H VV (VH)
Native Res. (m)	1.1 x 0.2	1.1 x 0.2	1.1 x 0.2
Filtered Res. (m)	1.8 x 0.2	1.8 x 0.2	1.8 x 0.2
GeoTiff Res. (m)	2x2	2x2	2x2
NESO (dB) (Exp/Opt./Prod.)	-33/-34/-30	-32/-29/-24.2	-30/-33/-31
Dynamic Range (dB) (Exp/Opt./Prod.)	66/62/66 (55)	66/62/66 (58)	66/53*/66 (56)
Cross-Pol Isolation (Exp./Opt./Prod.)	25/21/18	27/24/21	28/29/22
Peak Sidelobe Ratio (Exp./Opt./Prod.)	-20/-17/-17	-20/-15*/-18	-20/-18/-20
Integrated Sidelobe Ratio (Exp./Opt.)	-17/-16	-20/-15	-20/-18
3dB Swath Width @1500m AGL (m)	439	311	246
Abs. Sigma Std. (dB) (Prod.)	0.9	1.3	2.9
Geocoding Err. (m) (Prod.)	Abs.:<300m Rel.:<6m		

*Preliminary analysis

Interested in SWESARR?

Ask us questions!

Batu Ludo

Acknowledgements

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