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NSI Cal/Val Site

New Space Intelligence Inc.

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The first “Start-up” to conduct Calibration as a service

Main problems for EO data utilization

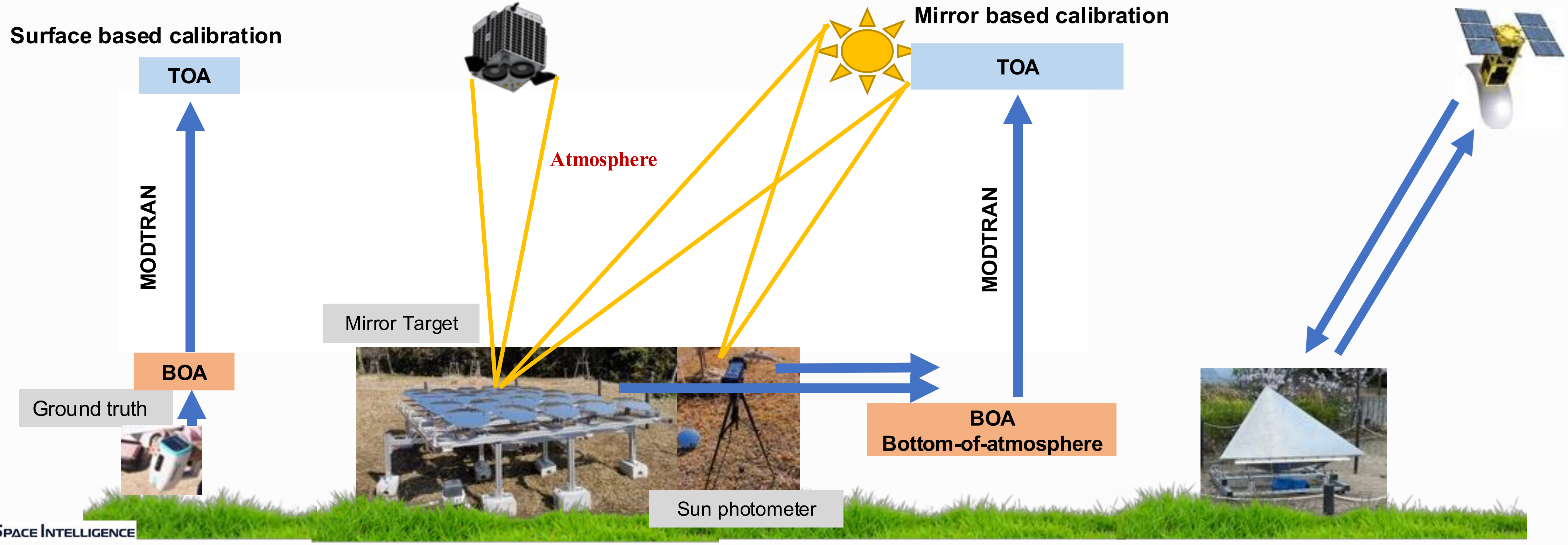
- Variation in spatial, spectral, radiometric properties in inter-constellation or intra-constellation satellites.
- Lower frequency (revisit time is high)
- Requirement of sudden event capture before and after the disaster quickly by the same sensor
- Getting cloud-free images (revisit time is high and if miss the capture due to cloudy condition then next chance will come after long time)
- Creating the common training data from existing public data and use of transfer learning

To solve these problems, we need to start thinking about
Calibration & Data Harmonization

Conceptual framework of NSI Cal/Val Site

- **Optical** satellite data calibration sites based on
  - Surface reflectance measurements
  - Ground point source-mirror reflectors
- **SAR** satellite data calibration based on
  - Corner reflector

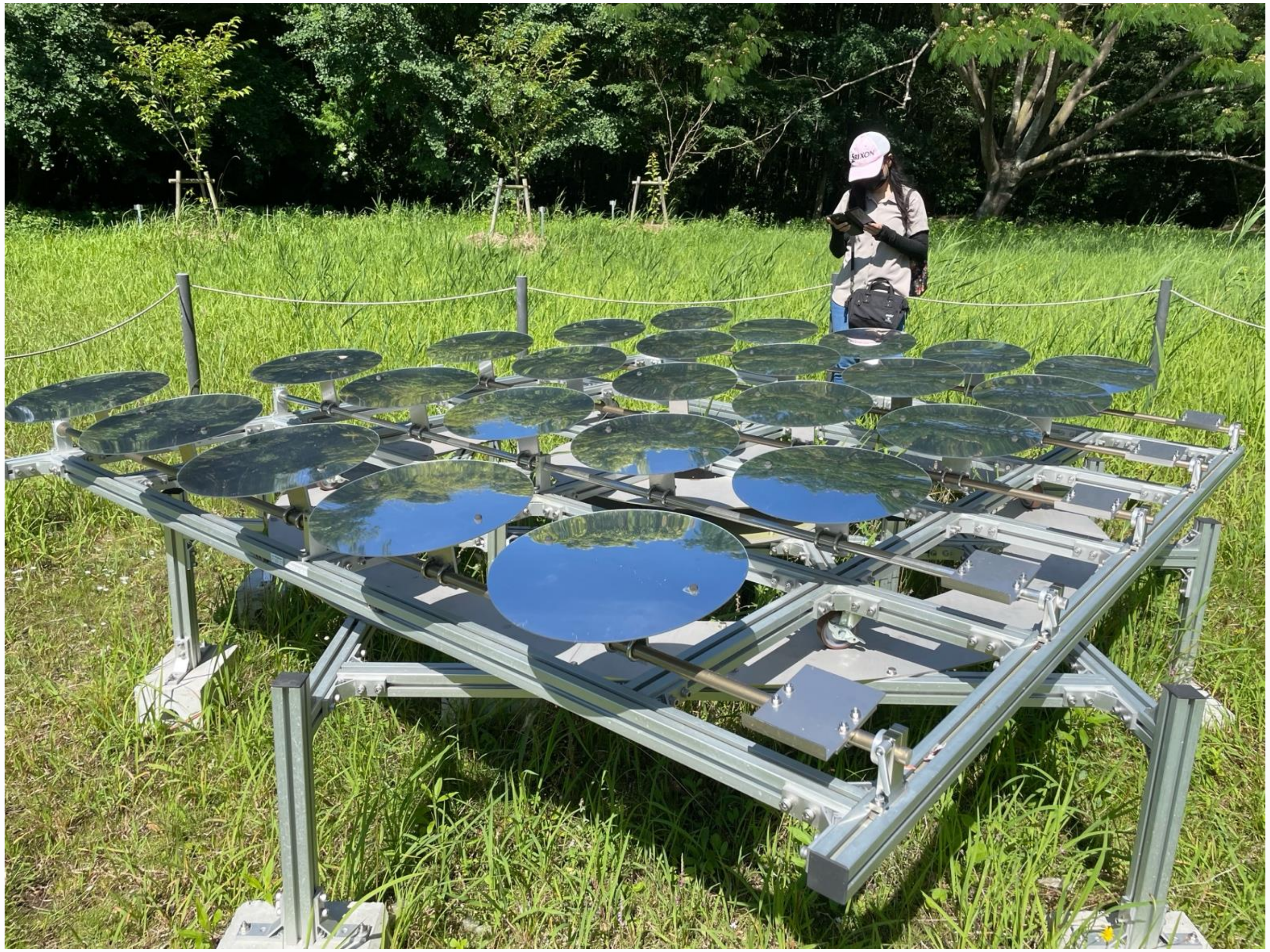
Data calibration
Harmonization
Multi-data utilization



1 Optical Data

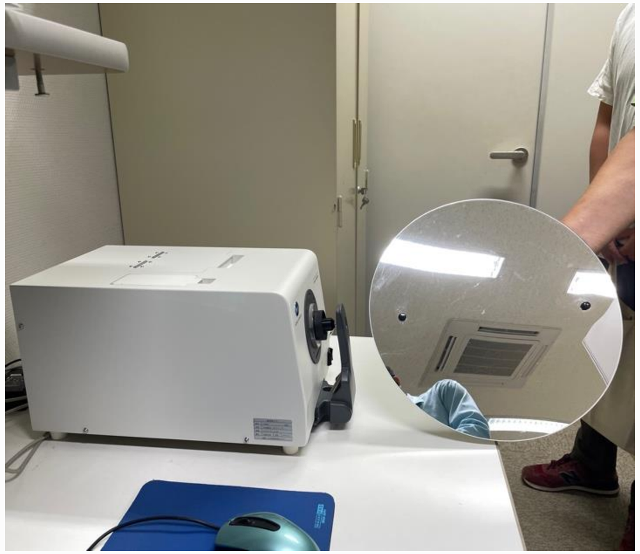
Large fixed Mirror Array (Tokiwa site)

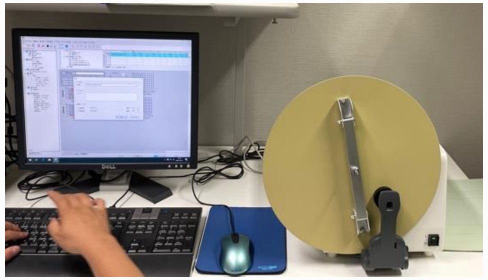
- Established in March 2021.
- With an aim to use this site as add-on to the vicarious calibration site. Requires less man power, due to the known surface reflectance with less BRDF effect.
- The total Lambertian Equivalent Reflectance (LER) can be controlled by keeping some mirror in different offset.

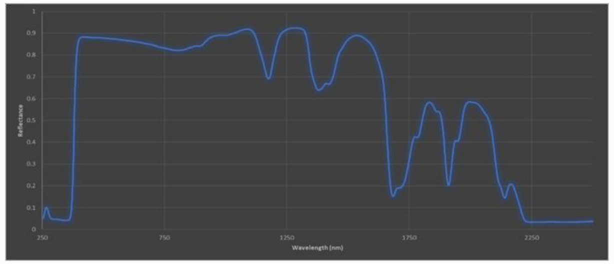


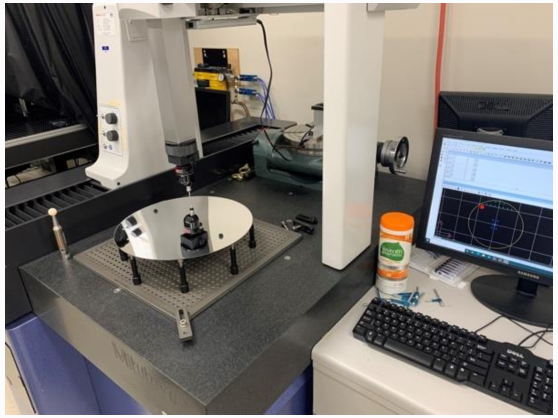
Mirror reflectance measurement in the lab

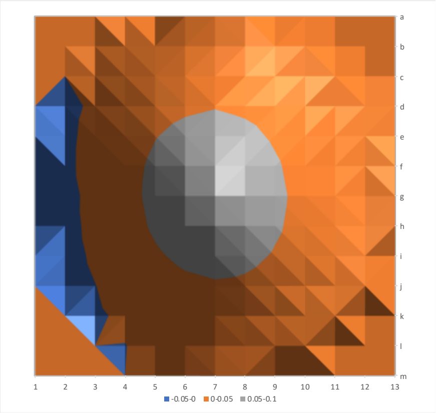
- Mirror reflectivity measured in the lab in Japan and USA.
- The measured range was in between the visual range i.e. 350 to 750 nm in Japan and in USA the range was till 2000 nm.
- We have reconfirmed the condition of the mirrors' reflectivity after use of three years and found that the reflectivity changes are still within 2% range.











NSI Mirror Site

1st installation for calibration **outside the U.S.**

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Mirror Array in Satellite Imagery (True Color Image)

New Space Intelligence

**Joint research with Yamaguchi University, Japan*

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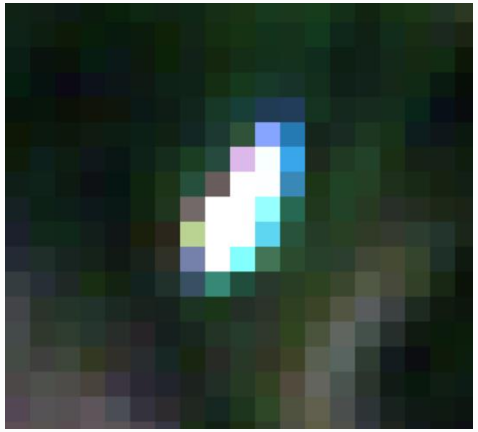
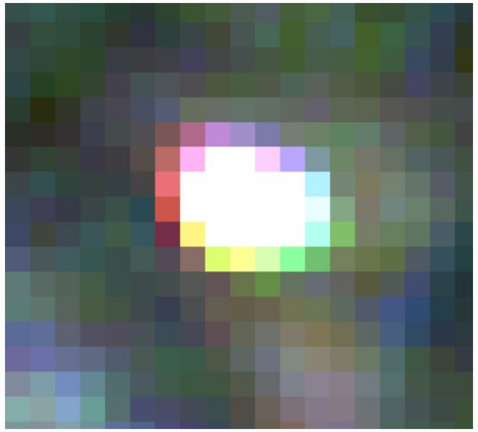
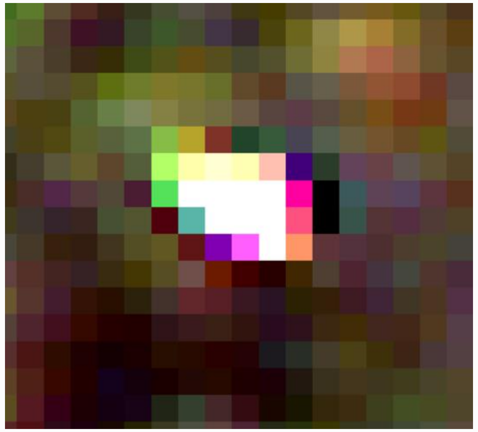
Mirror Array in Satellite Imagery (True Color Image)



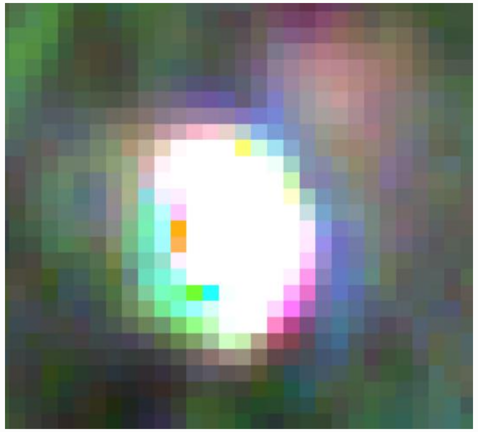
GRUS-1A 2021-08-05



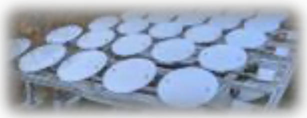
GRUS-1E 2022-11-12



GRUS-1D 2024-12-19

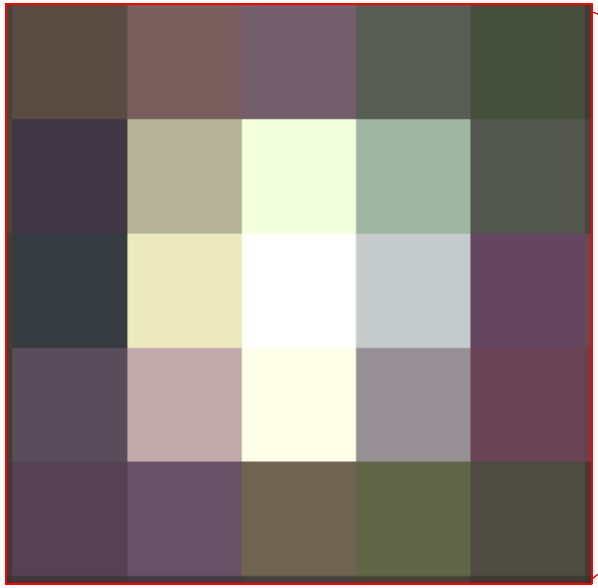


*PSB.SD 2024-12-19

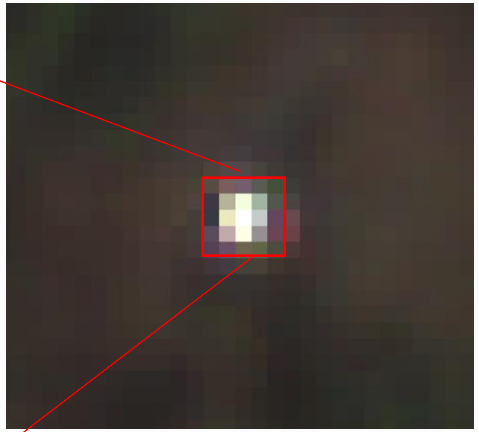


*PSB.SD 2022-11-12

Fixed Mirror Array



5x5 pixel



*PSB.SD 2025-02-26

Automated Mirror Array

*Joint research with Yamaguchi University, Japan

Atmospheric Measurements

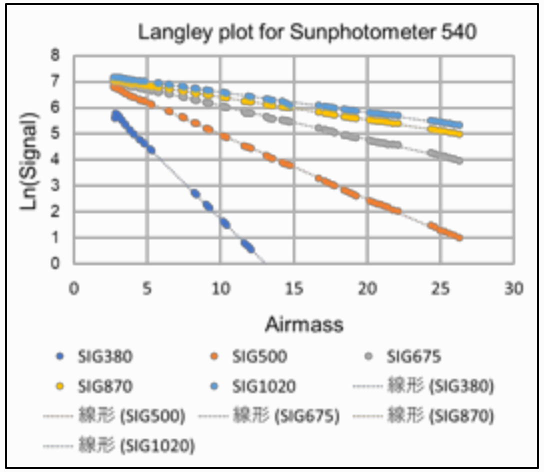
- Atmospheric measurements by Sunphotometer and Ozonemeter
  - MICROTOPS II 540 and MICROTOPS II 521 (Solar light Corp. USA)

a)

b)

c)

Microtops II for atmospheric measurement
a) Model 521, b) Model 540, c) Measurement for aerosol, ozone and water vapor depth at calibration site “Kirara” of Yamaguchi



Langley plot. for Model 521 and 540 Microtops measurement

Band name	Langley plot line	The extraterrestrial constant Vo
380nm	y = -0.5593x + 7.3151	7.3151
500nm	y = -0.2476x + 7.4444	7.4444
675nm	y = -0.1289x + 7.3609	7.3609
870nm	y = -0.0871x + 7.2867	7.2867
1020nm	y = -0.0775x + 7.3733	7.3733

Table of the estimated extraterrestrial constant Vo for Model 521’s bands.

Estimation of the extraterrestrial constant Vo through Langley method

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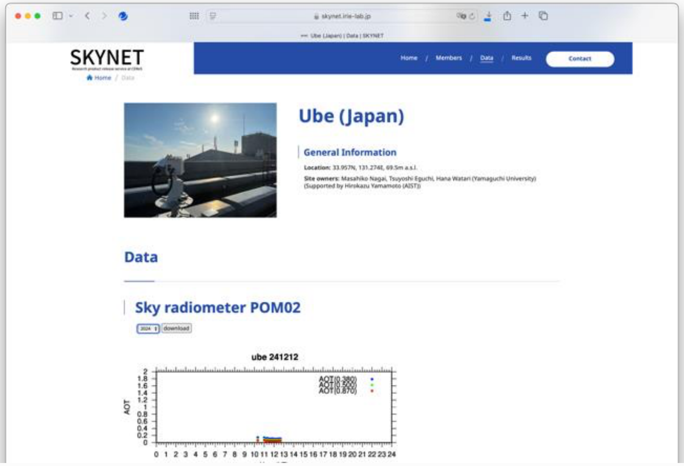
Atmospheric Measurements

Skyradiometer POM-02

Sky camera



Azimuth scan (aerosol observation)
Observes the amount of scattered solar radiation in the surrounding area. Observations are made once every 10 minutes.

Direct light observation
Observes the amount of direct solar radiation from the sun. Observations are made once every 3 minutes.

Estimation of TOA radiance using MODTRAN

Surface reflectance at ground by Spectroradiometer

Atmospheric data measured by Sun photometer

Spectral Sciences, Inc. and Air Force Research Laboratory (USA)

MODTRAN 6

Satellite radiance

	Band 1	Band 2	Band 3	Band 4	Band 5
Satellite pixel	6.354	5.991	3.395	7.686	11.659
Modtran simulation	6.349	5.912	3.746	7.811	11.793
Difference (Satellite - Modtran)	0.005	0.079	-0.351	-0.125	-0.134
Difference (%) (Difference/ Modtran)	0.077%	1.338%	-9.372%	-1.604%	-1.133%

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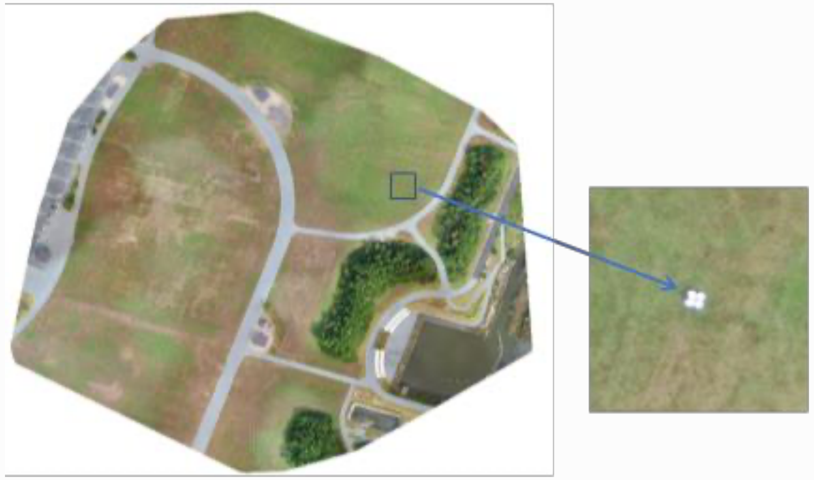
Calibration field campaigns

ASD HandHeld 2

ASD FieldSpec 4

SVC HR-1012i

Microtops II 540, 521



UAV Observation

International Partners

Agreement with
Labsphere inc.

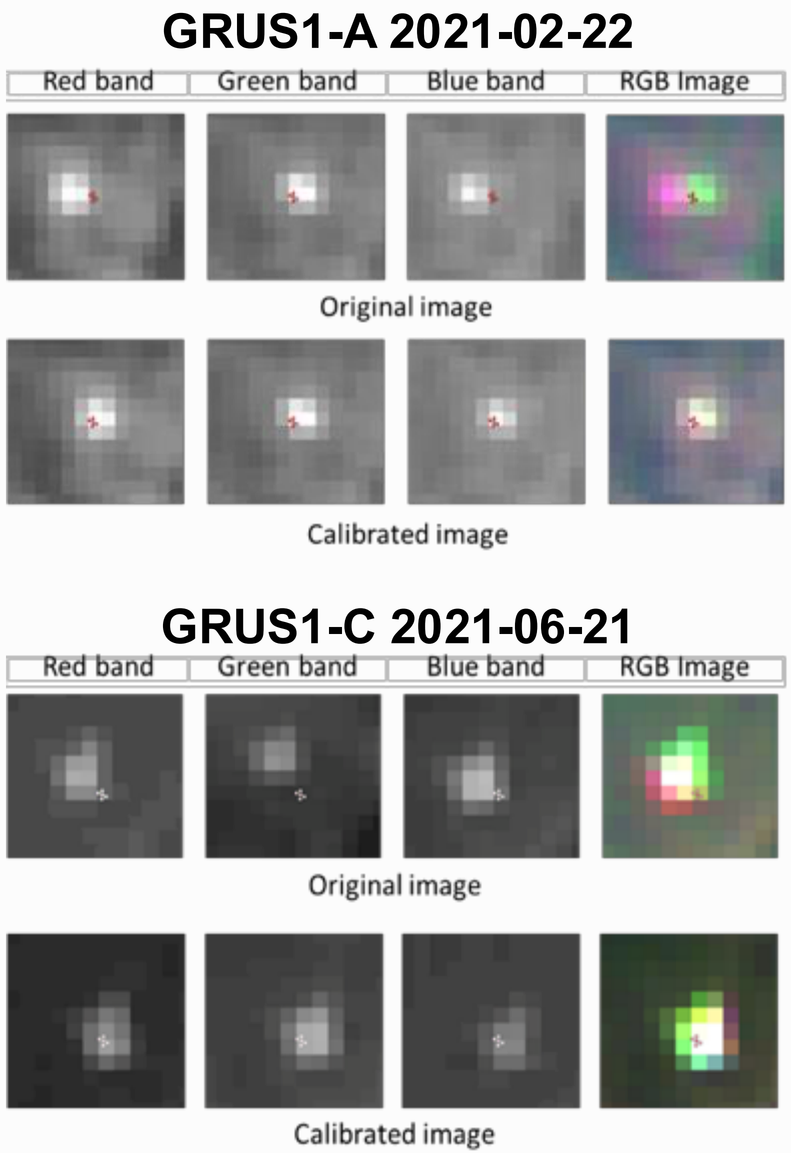
SDSU, Image Processing Lab
USGS ECCOE Cal/Val

Railroad Valley (NASA Test Site)

ISRO

Improvement in Sub-pixel geometric accuracy

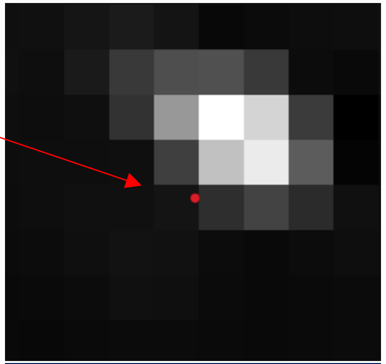
- Ground mirror reflector station allows precise estimation of positional accuracy of the mirror pixel at sub-pixel level.
- The mirror-array shows that the single band has different locational accuracy with 2.5m -12.5m.
- The difference in pixel location in the RGB bands tells us band registration accuracy and it makes an image blurring effect in color composite.



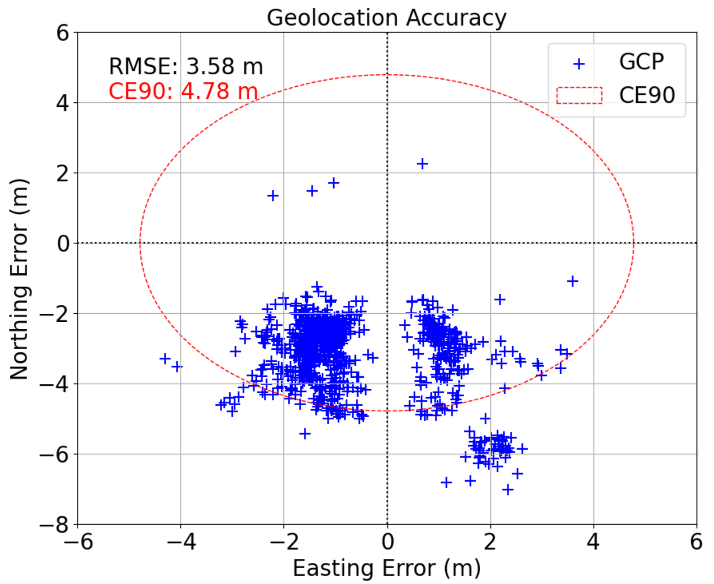
Enhanced geolocation accuracy

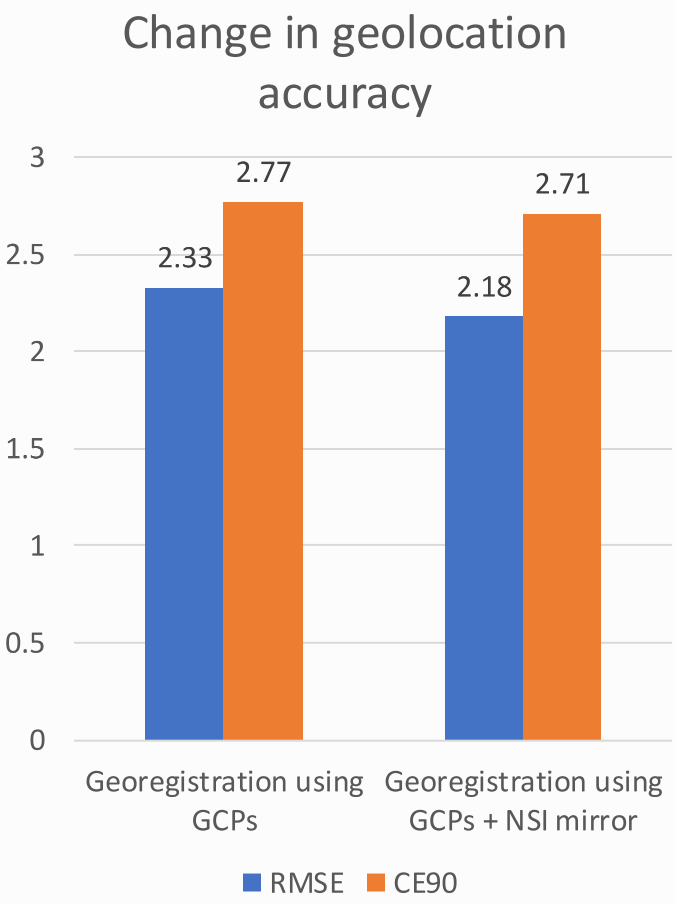
GRUS-1D 2024-12-19 (red band)

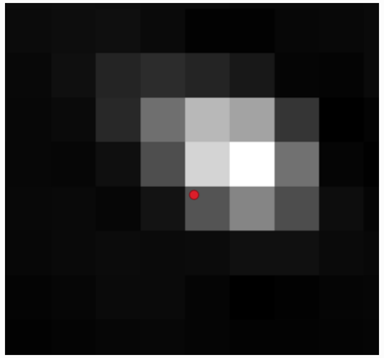
Location of mirror



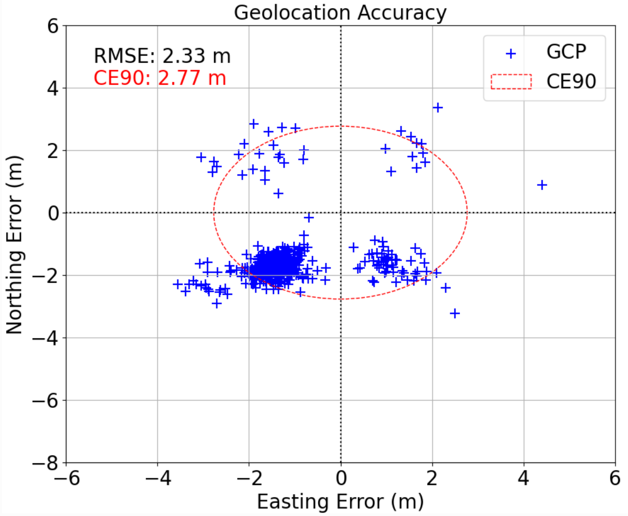
Before

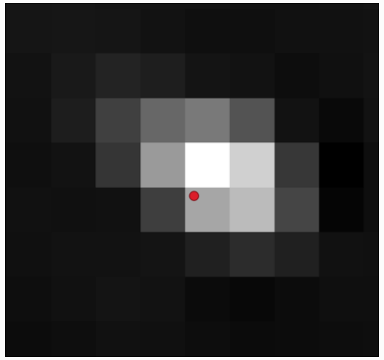




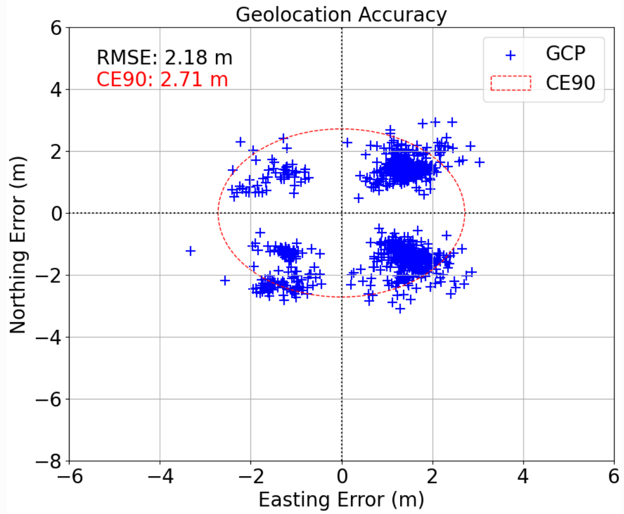


Using GCPs





Using GCPs + NSI mirror



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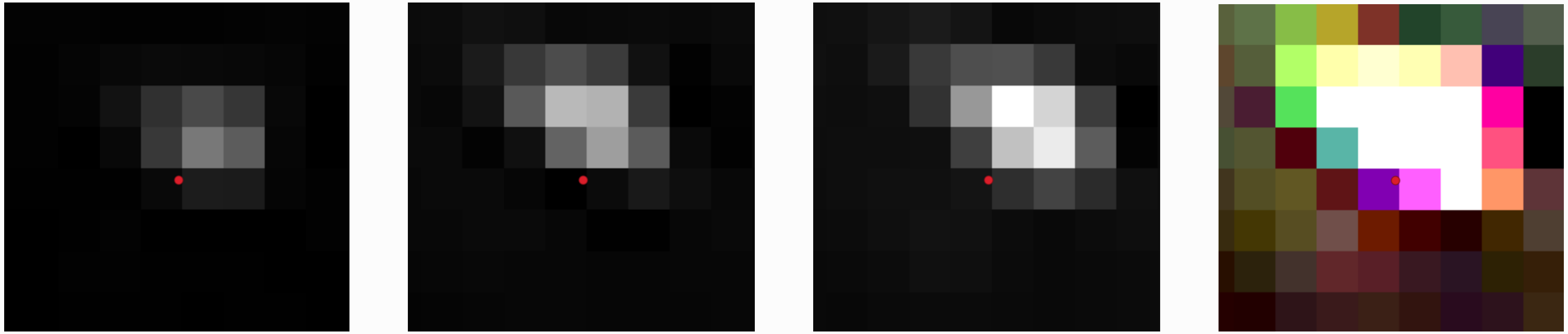
Improved band-to-band accuracy

BEFORE

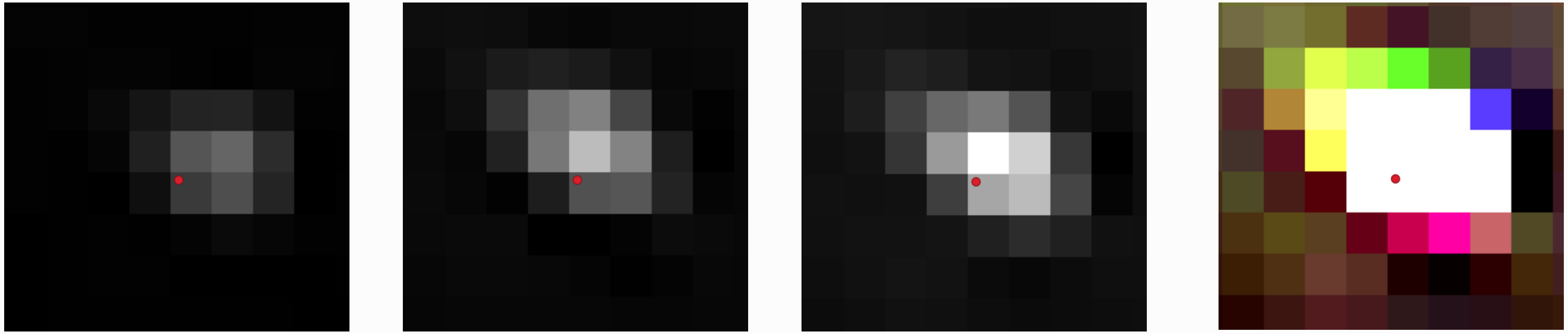
< 0.8 pixel



Blue band | Green band | Red band | RGB image

AFTER

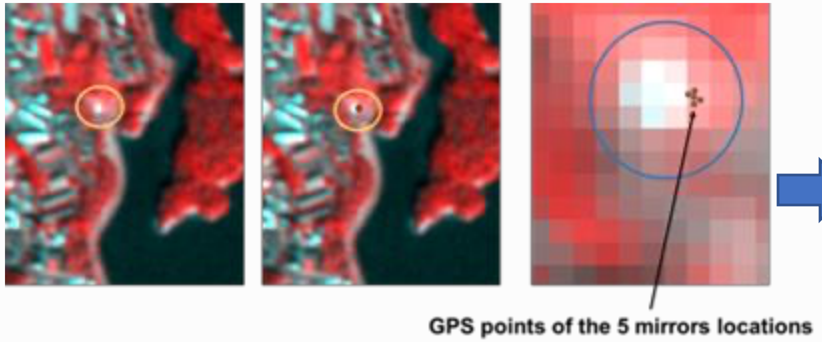
< 0.5 pixel



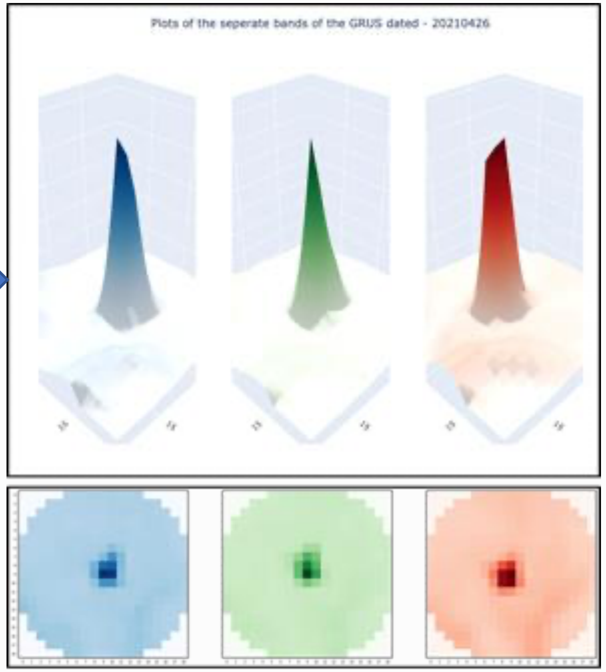
Measuring the spread of the reflected energy from the mirrors at Tokiwa for generating IPSF

- The distribution and spread of light energy reflected from the mirrors show that NSI has a potential to construct a point spread function from in-flight image. Here oversampling will be important.

- **Point Spread Function (PSF):** is the response of the optical system to the point light source. It is a direct measuring by the optical system and determination of the function for light spectrum spread around the point source.
- **In-flight Point Spread Function (IPSF):** is the PSF which is constructed from satellite image pixel. IPSF can be constructed on the base of light spectrum spread around the image pixel.



GRUS image of NSI mirrors

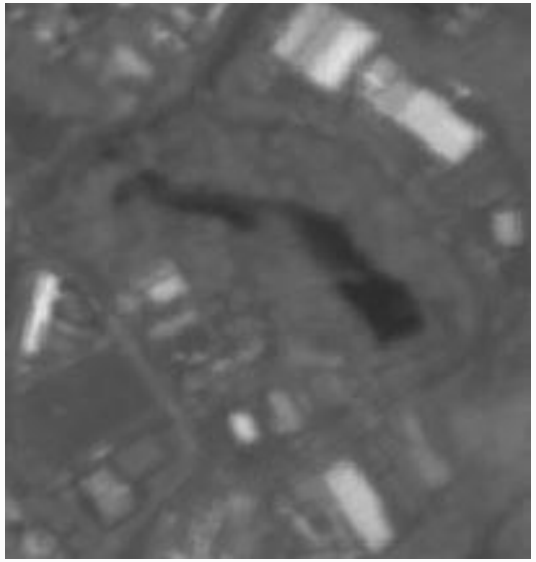


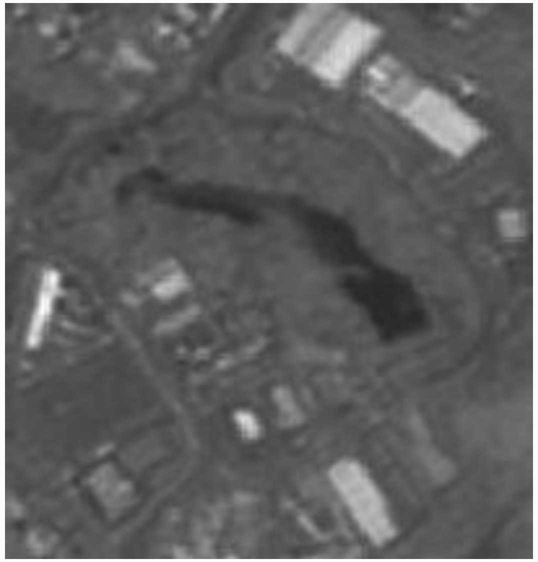
GRUS1-A 2021-04-26

Use of IPSF for image quality enhancement

The construction of the calibration site based on mirror reflector contributes following significant achievement for satellite remote sensing technology:

1. A spread of light spectrum of satellite image pixel has been analyzed for IPSF
2. IPSF's parameters as FWHM and sigma for GRUS1 image have been determined
3. Satellite image processing in spatial and frequency domain has been adopted for GRUS1 images
4. The IPSF has been applied to image reconstruction to remove blurring effects from the satellite image.


Original image


Improved image

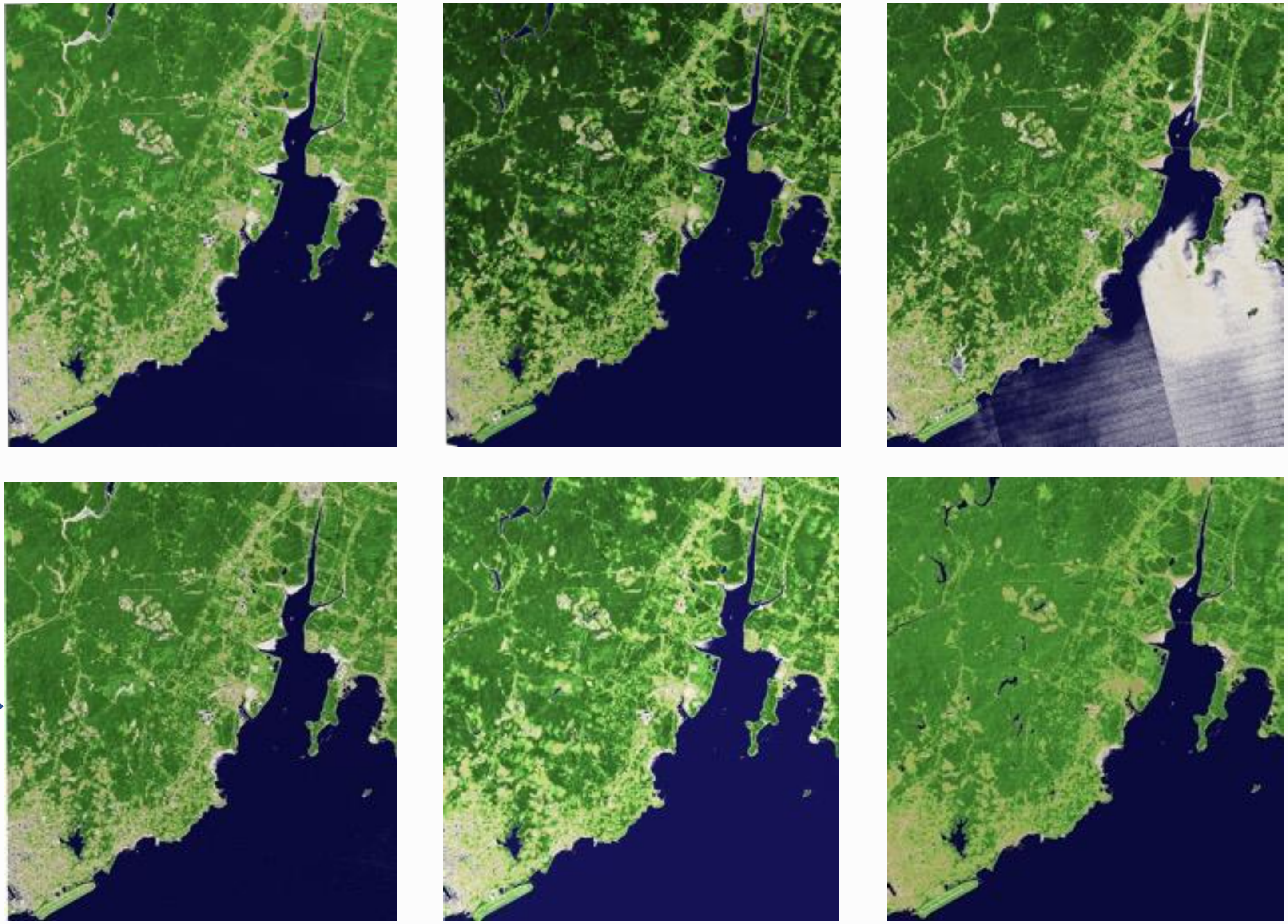

Original image

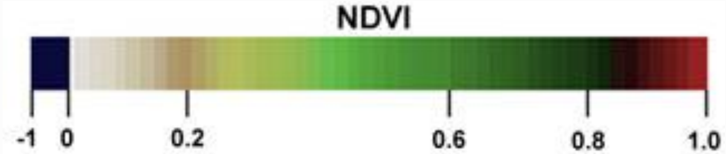

Improved image

Effect of calibration on NDVI

Before calibration

After calibration





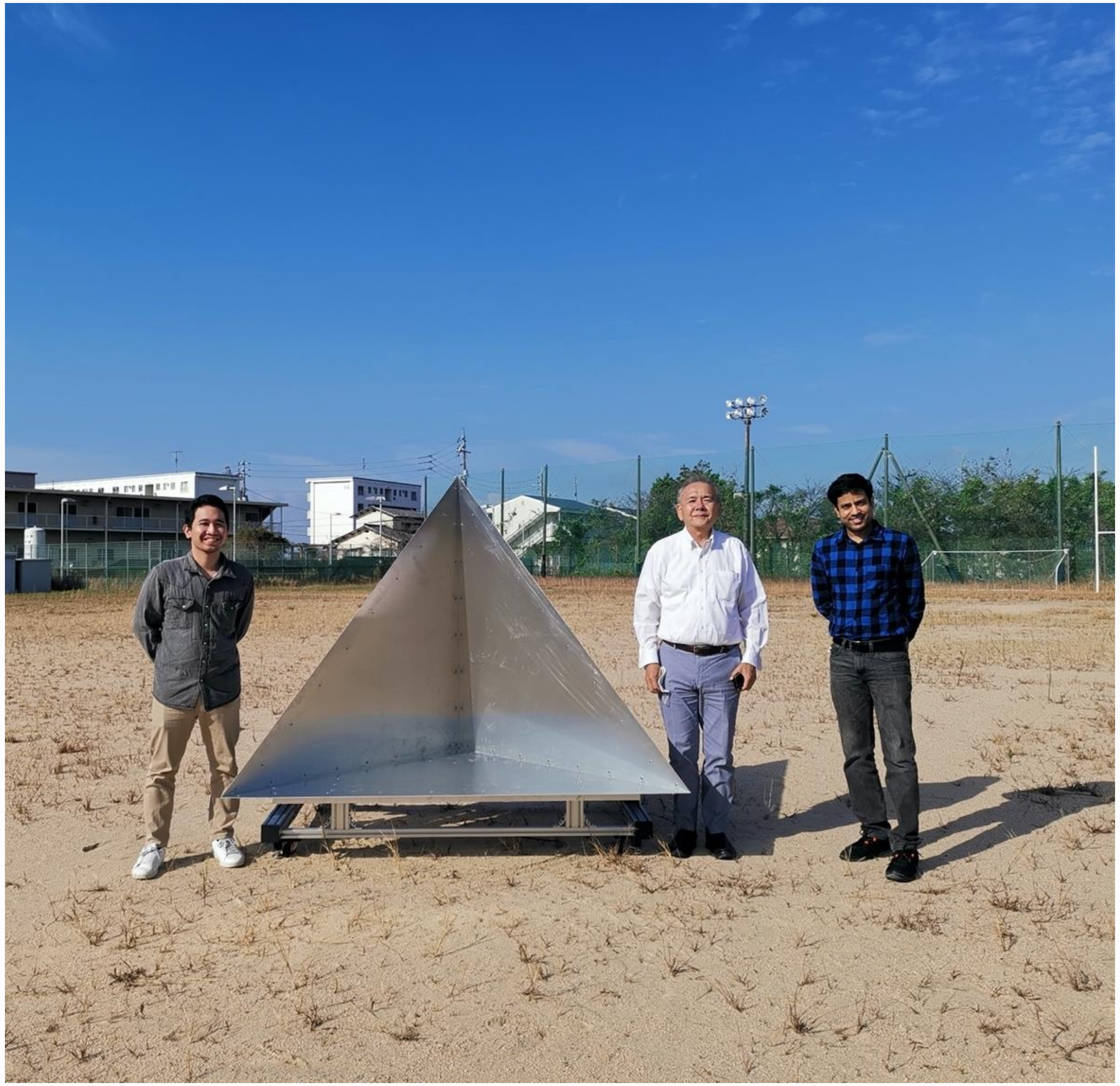
	PlanetScope PS2	PlanetScope PSB.SD	GRUS1
Date:	2022-08-05	2022-08-05	2022-08-05
Local Time:	10:34 am	10:11 am	10:47 am

2

SAR Data

CR details

- Shape: Triangular-trihedral CR
- Slant edge length: 141.4 cm
- Height: 100 cm
- Material: Aluminium
- Azimuth angle range: by whole CR rotation using attached wheels, 0~360^{o}
- Tilt angle range: 0~40^{o}



Experiments with Corner reflector



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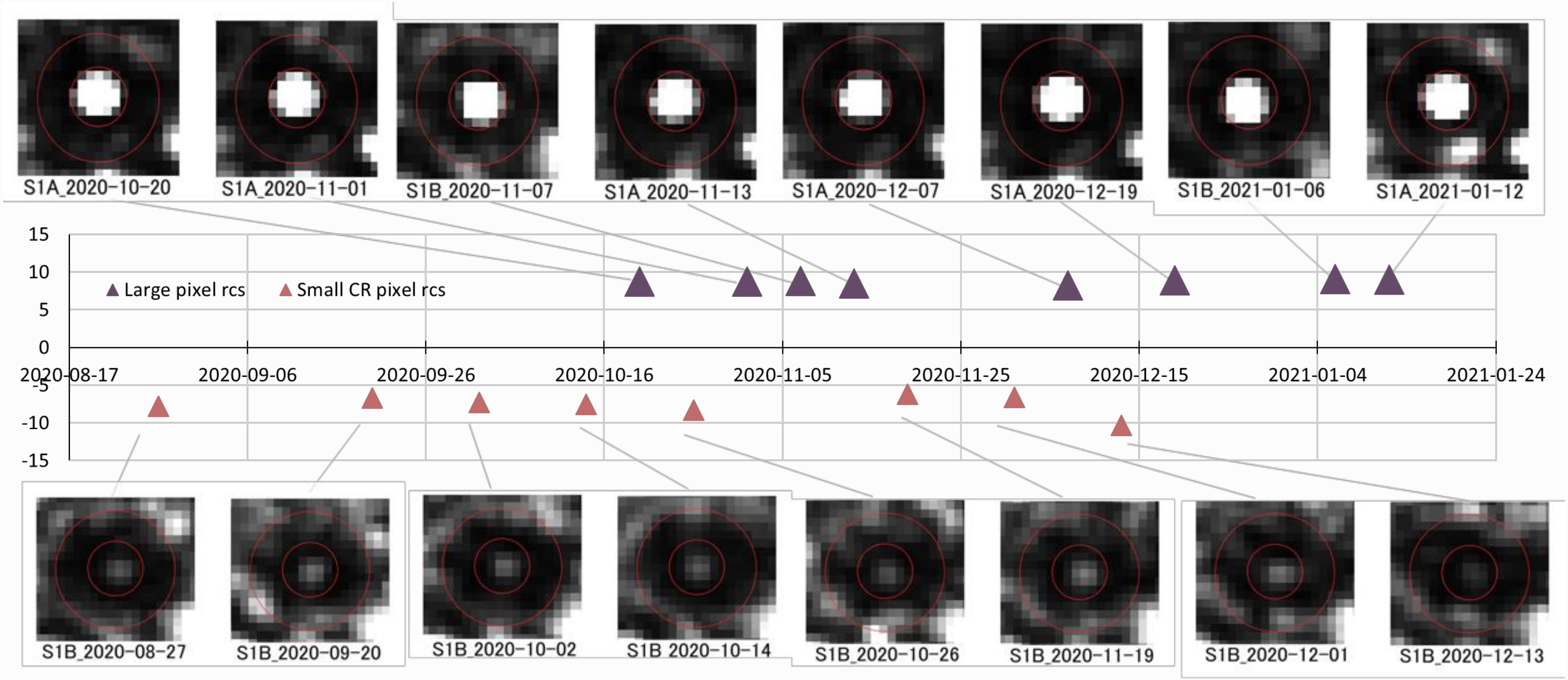
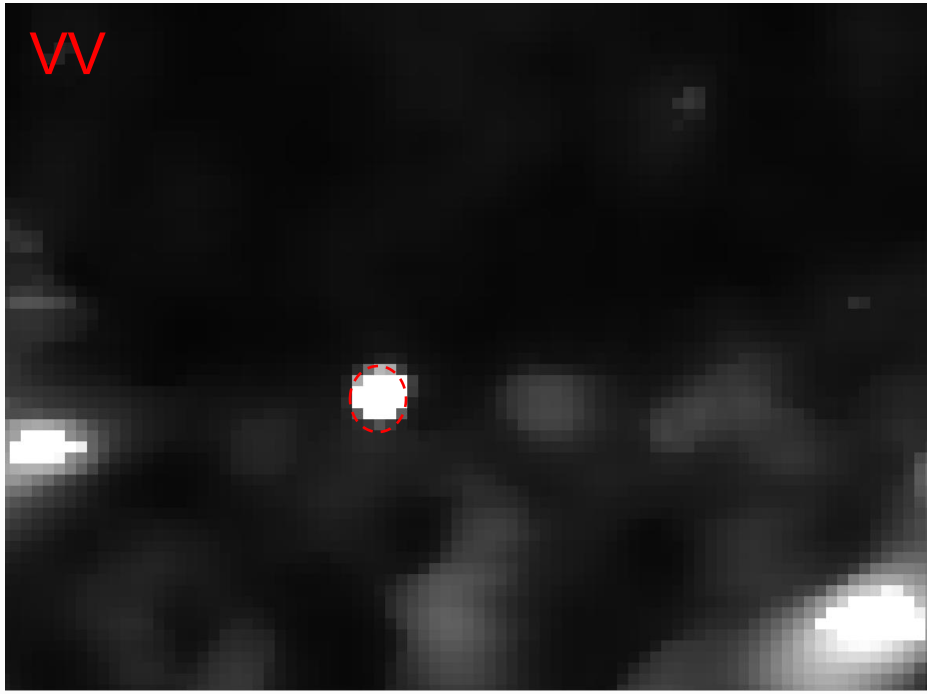
CR visibility on Sentinel-1A/B images



Pixel RCS of small CR and clutter intensity were presented in dB scale. Small CR gave average of the peak value at -7.582 dB. Large CR provided significant high energy at 8.760 dB. Large CR showed more stability than small CR with high backscattering value and lower standard deviation in multitemporal series analysis.]

CR in different polarization bands



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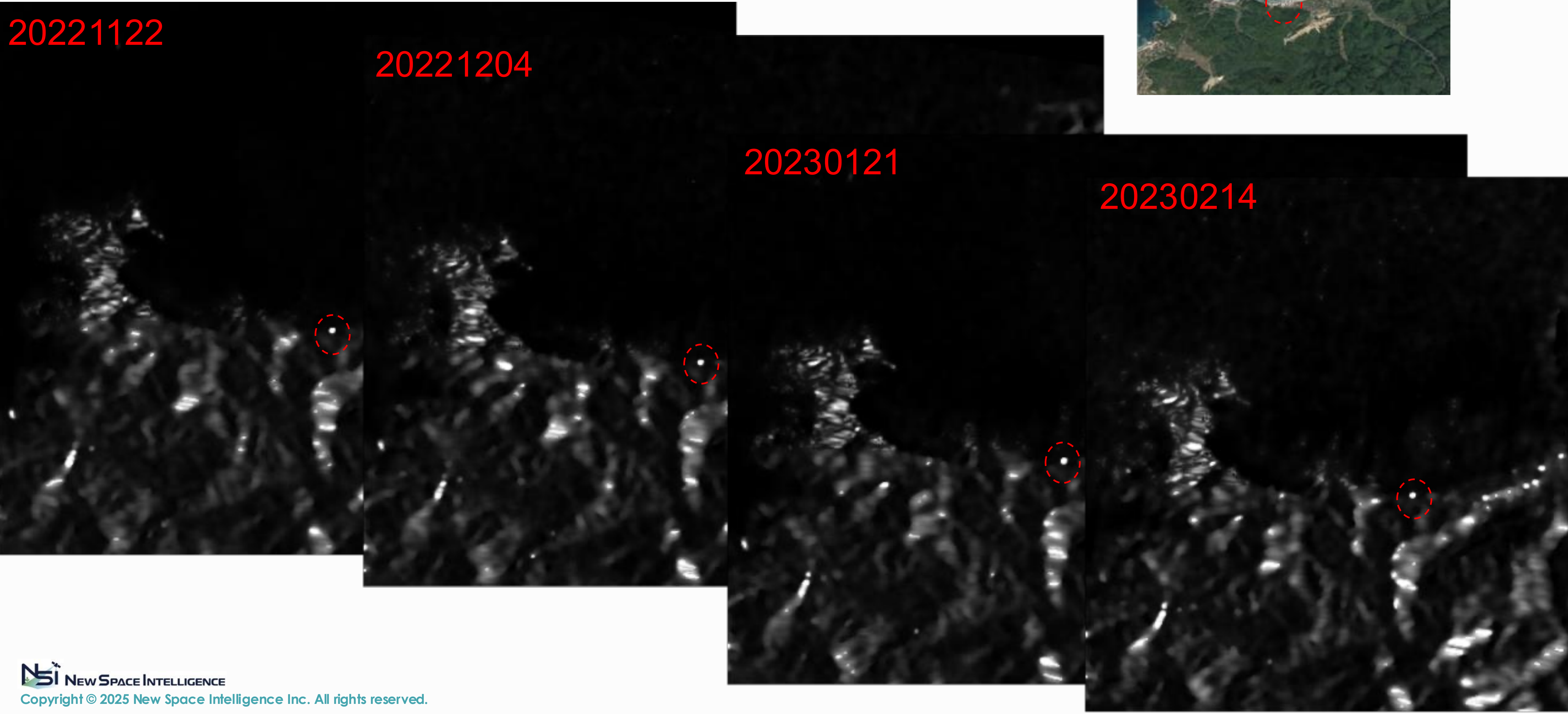
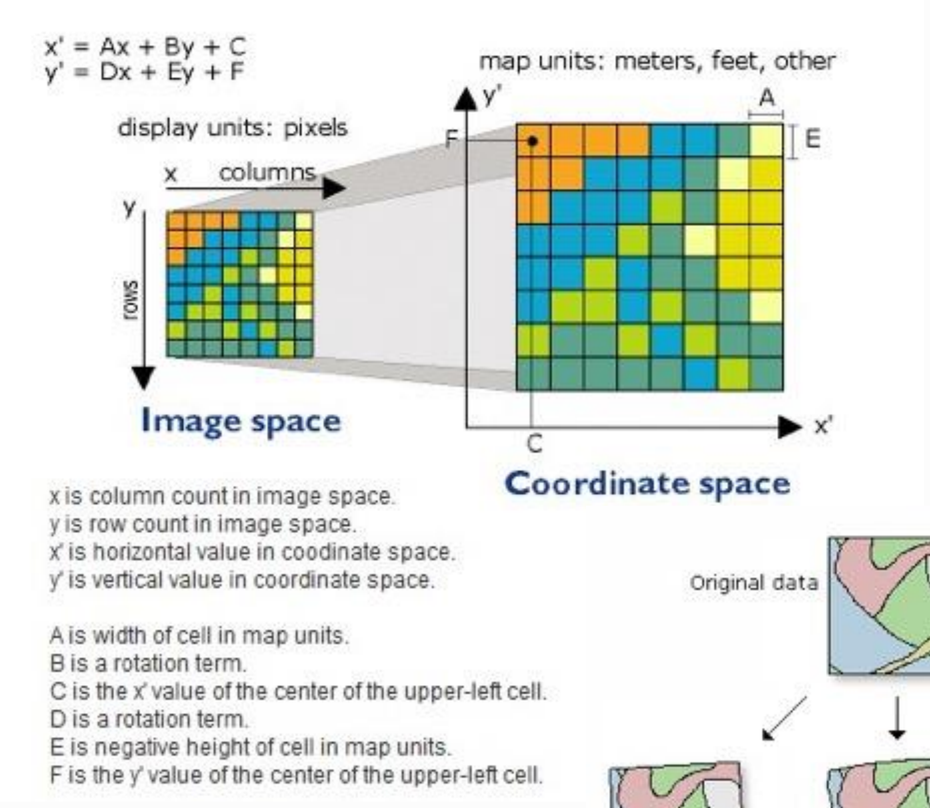
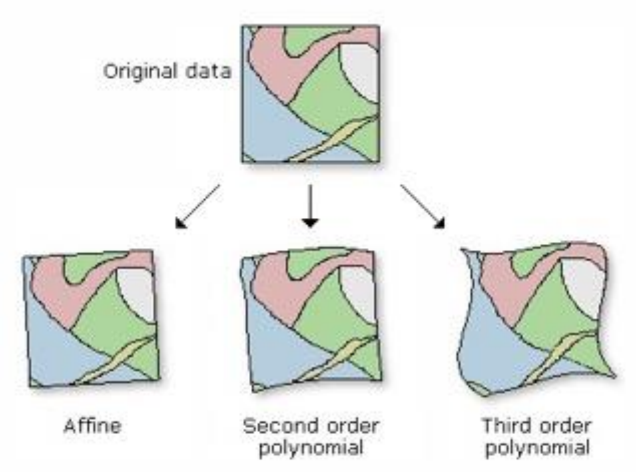
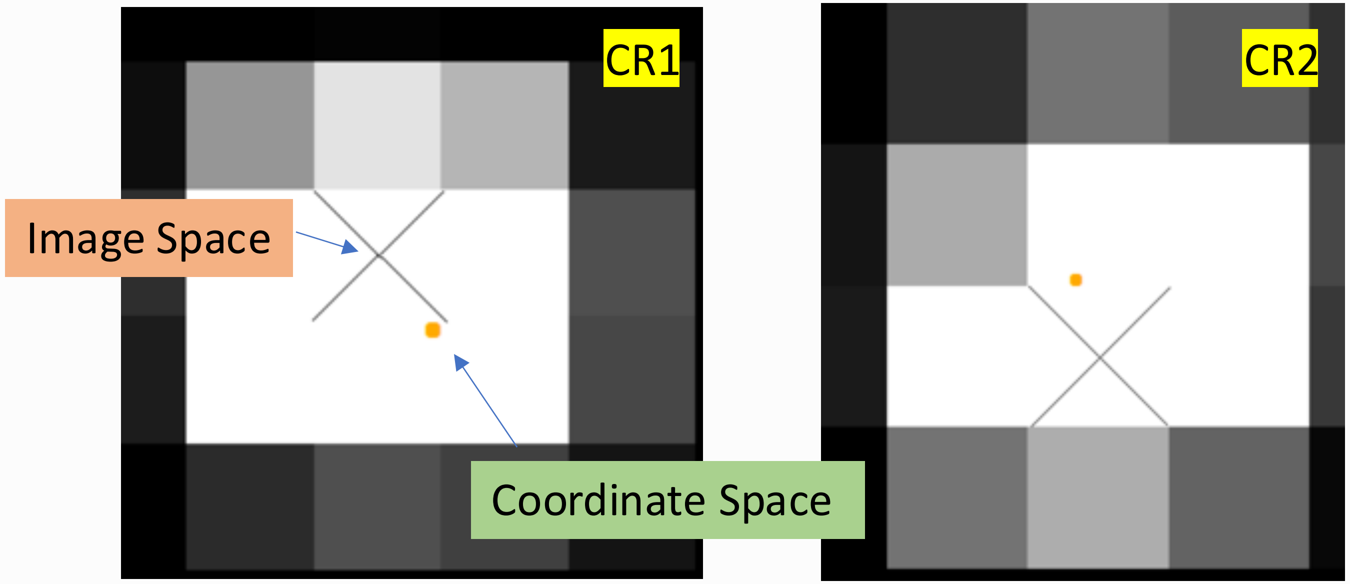
CR in time-series data



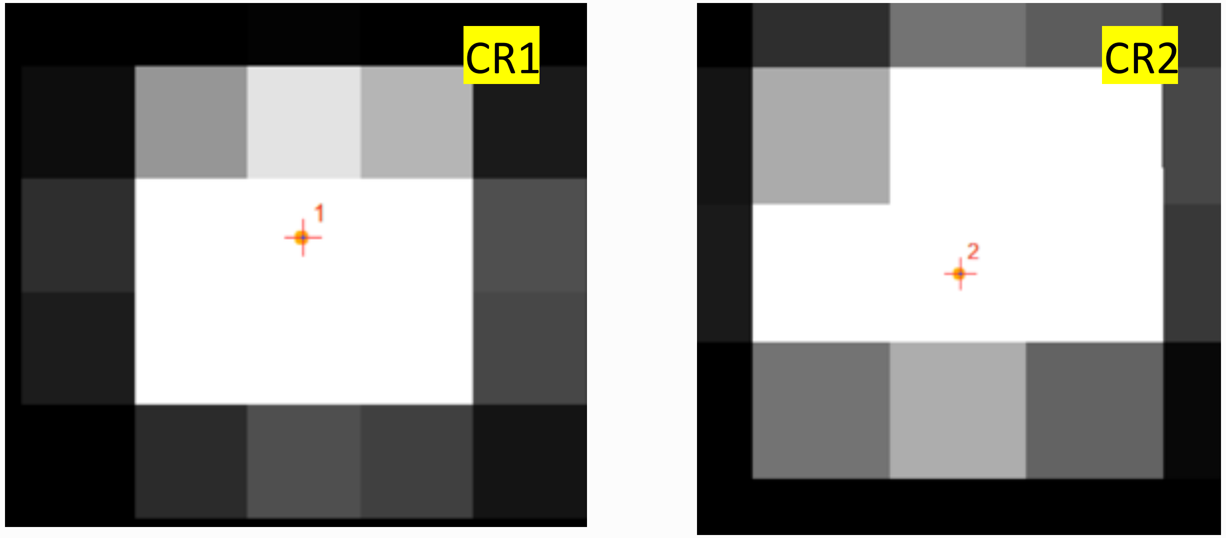
Georectification







Before Georectification



After Georectification

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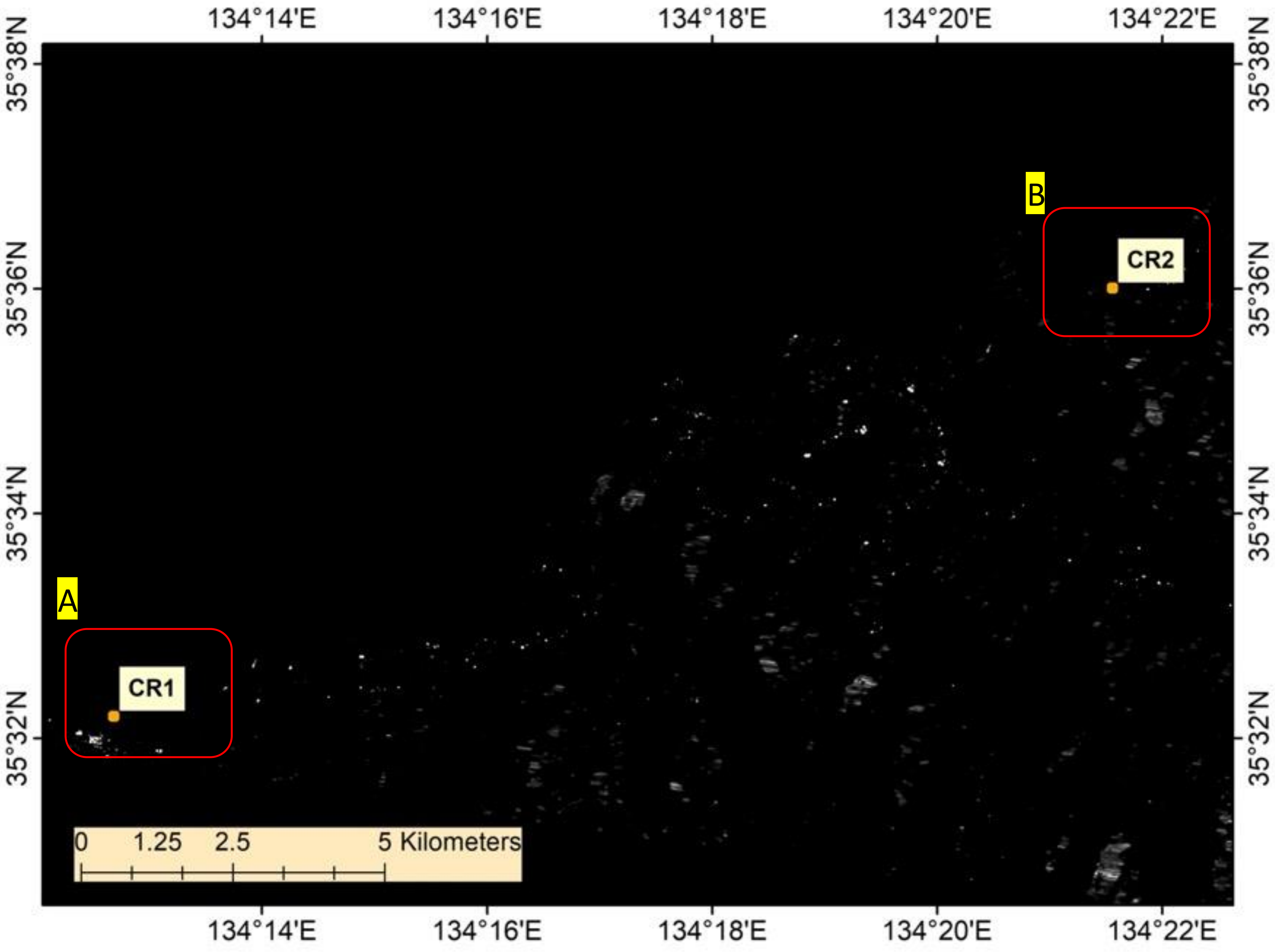
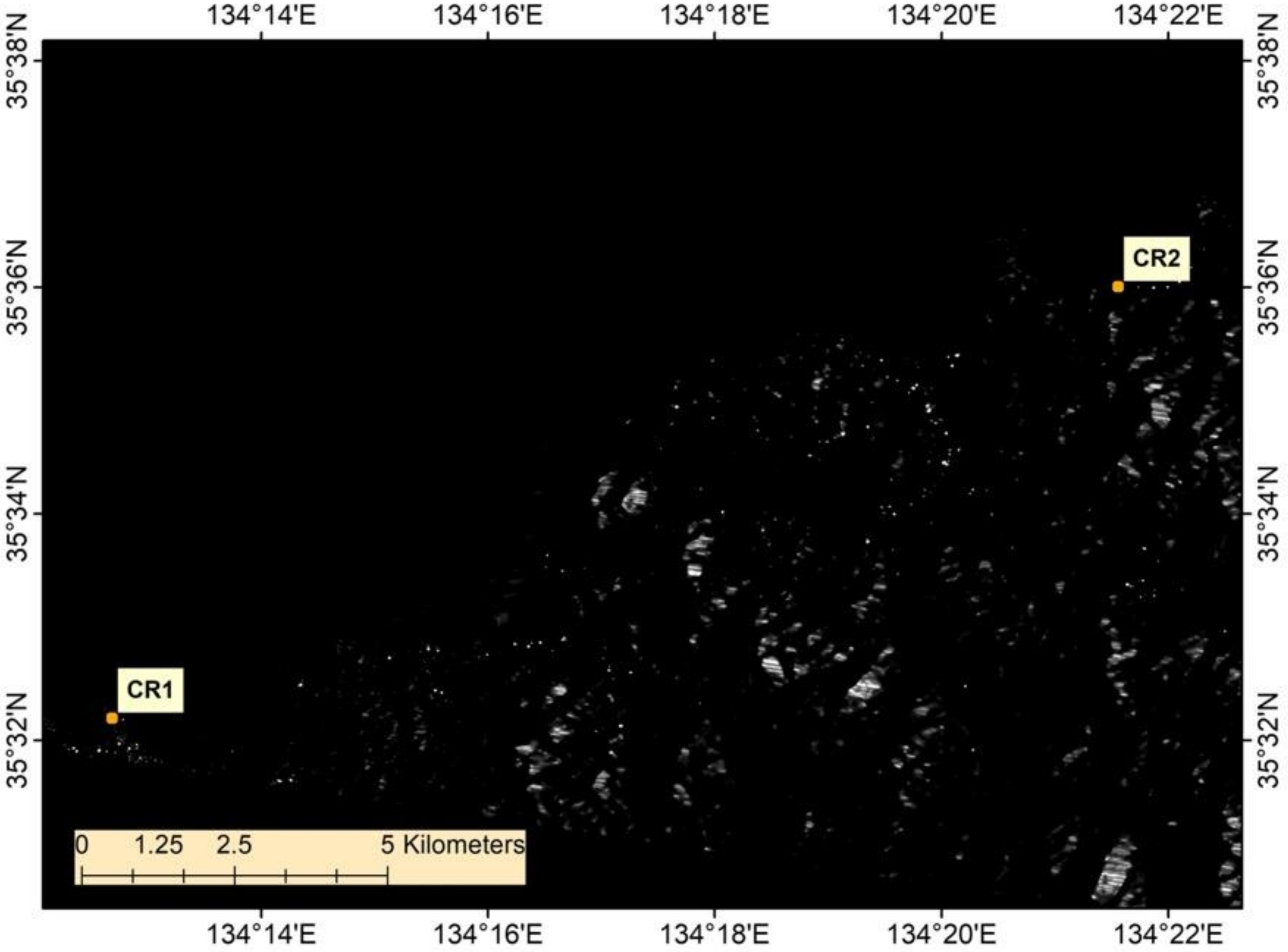
22 Nov. 2022 (Sentinel-1, VV) Before Georectification



22 Nov. 2022 (Sentinel-1, VV) After Georectification



3

Data Standardization

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Data Standardization Efforts

- Will follow **CEOS Product Family Specifications - Surface Reflectance (CEOS-ARD-SR)**
- Detail specific '**Threshold**' and '**Goal**' requirements for
  - General Metadata
  - Per-pixel Metadata
  - Radiometric and Atmospheric Corrections
  - Geometric Corrections

1. General Metadata
1.1 Traceability
1.2 Metadata Machine Readability
1.3 Data Collection Time
1.4 Geographical Area
1.5 Coordinate Reference System
1.6 Map Projection
1.7 Geometric Correction Methods
1.8 Geometric Accuracy of the Data
1.9 Instrument
1.10 Spectral Bands
1.11 Sensor Calibration
1.12 Radiometric Accuracy
1.13 Algorithms
1.14 Auxiliary Data
1.15 Processing Chain Provenance
1.16 Data Access
1.17 Overall Data Quality
2. Per-Pixel Metadata
2.1 Metadata Machine Readability
2.2 No Data
2.3 Incomplete Testing
2.4 Saturation
2.5 Cloud
2.6 Cloud Shadow
2.7 Land/Water Mask
2.8 Snow/Ice Mask
2.9 Terrain Shadow Mask
2.10 Terrain Occlusion
2.11 Solar and Viewing Geometry
2.12 Terrain Illumination Correction
2.13 Aerosol Optical Depth Parameters
3. Radiometric and Atmospheric Corrections
3.1 Measurement
3.2 Measurement Uncertainty
3.3 Measurement Normalisation
3.4 Directional Atmospheric Scattering
3.5 Water Vapour Corrections
3.6 Ozone Corrections
4. Geometric Corrections
4.1 Geometric Correction

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Thank you for your kind attention

Please feel free to reach out!

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