Machine learning based augmentation for LISS-4

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Resourcesat-2/2A

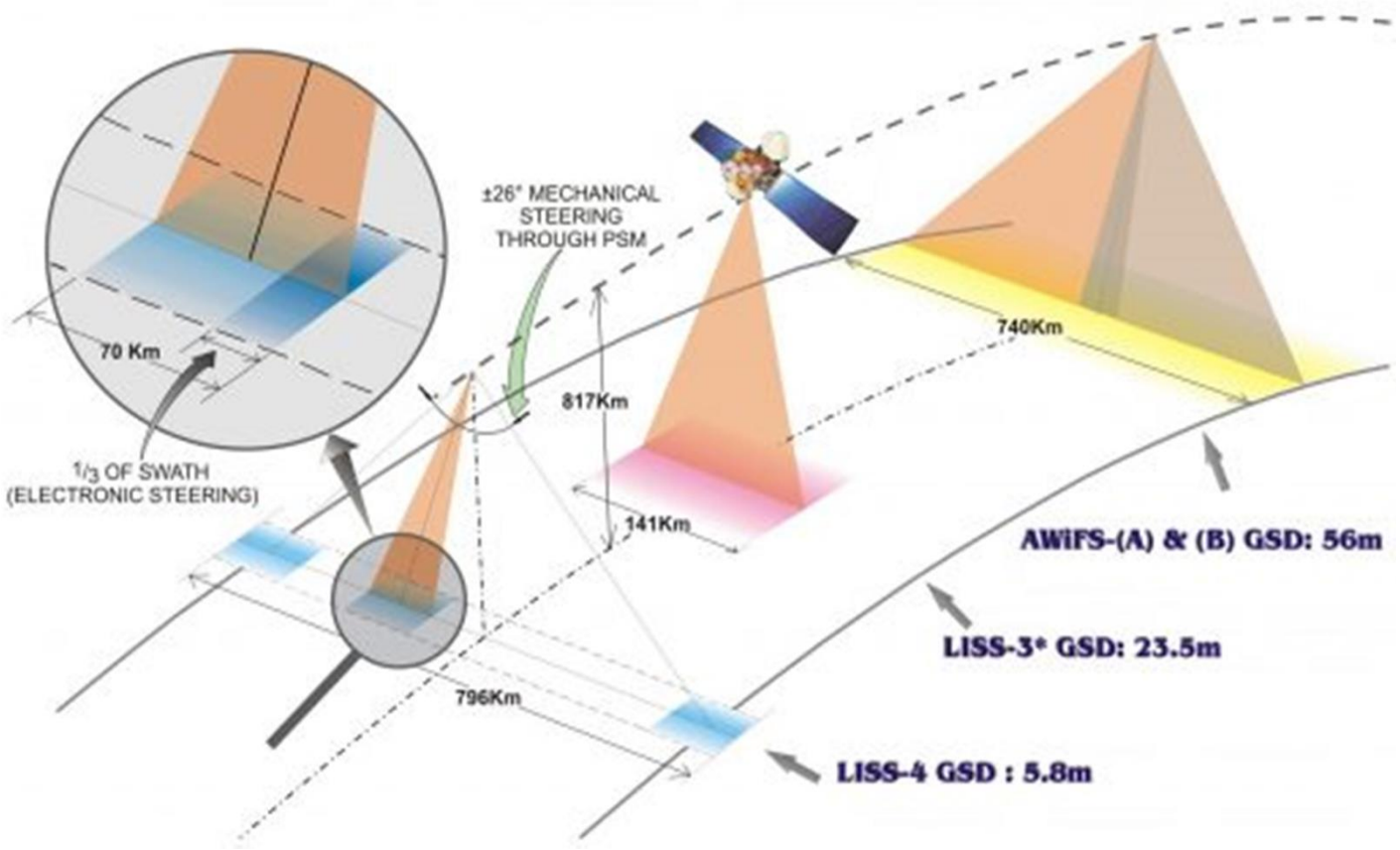


Fig: Resourcesat 2/2A 3-tier imaging

Resourcesat-2/2A

- LISS-4, LISS-3 and AWiFS sensors image the scene simultaneously.
- LISS-4 at 5.0 m resolution has 3 bands – Green, Red and NIR ; no SWIR band
- LISS-3 at 24.0 m resolution has 4 bands – Green, Red, NIR and SWIR

Objective:

- To augment LISS-4 by generating SWIR band data at 5.0 m spatial resolution

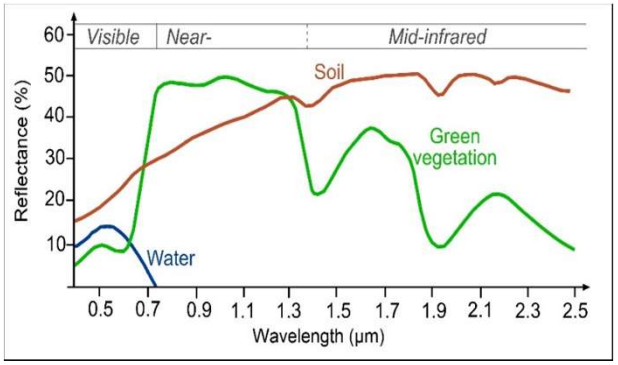
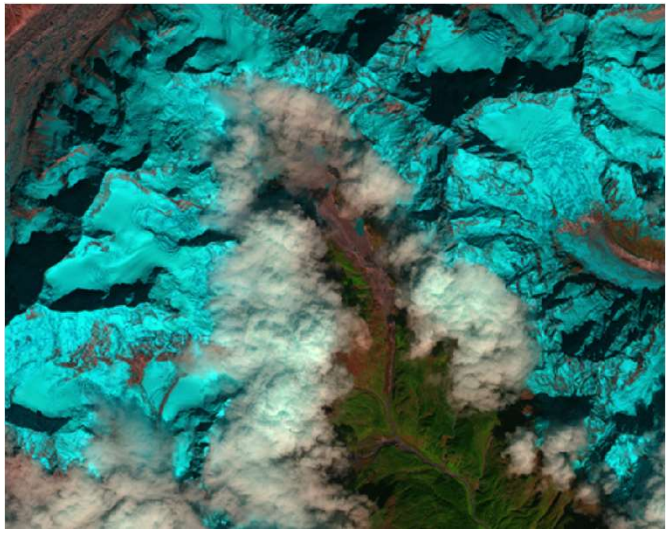


Fig: Typical Surface reflectance curve

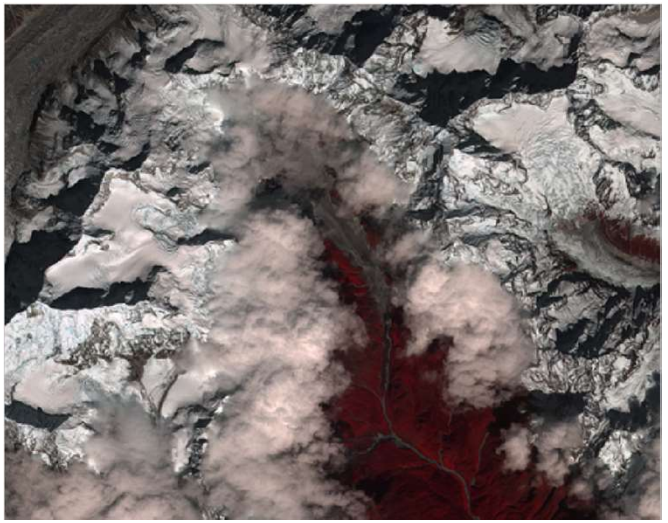
	LISS-4 Bands (5.0 m)	LISS-3 Bands (24.0 m)	AWiFS Bands (56.0 m)
Spectral Bands	Spectral Wavelength (nm)	Spectral Wavelength (nm)	Spectral Wavelength (nm)
B2 (G)	520-590	520-590	520-590
B3 (R)	620-680	620-680	620-680
B4 (NIR)	770-860	770-860	770-860
B5 (SWIR)	**Not present**	1550-1700	1550-1700
Swath	70 km	140 km	740 km

SWIR band data

- Can penetrate smoke and thin clouds
- Can differentiate between snow and cloud
- Helpful for proper delineation of water bodies
- Applications in mineral exploration, wildfire response, soil moisture studies..



R2A-L3-107-052-29OCT2023 (SWIR,NIR,R)

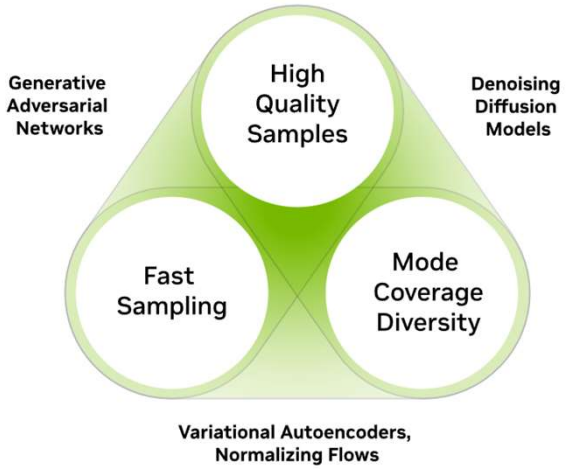


R2A-L3-107-052-29OCT2023 (NIR,R,G)

Generative AI

- Buzz word of recent times…
- Large language models… Chat GPT…..Dall E…

- How to generate SWIR band data ?
  - ➢Make use of Generative AI techniques…
  - ➢Generate by super-resolution techniques



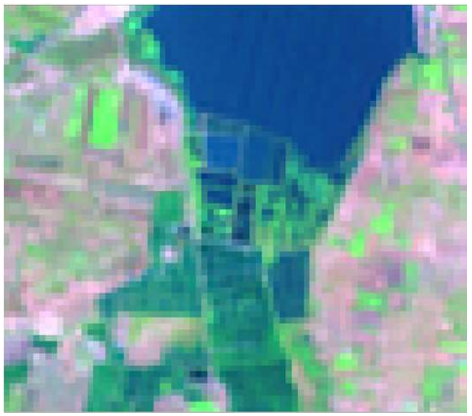
Super-resolution

- Enhancing the resolution of an image from low resolution to high resolution

- In remote sensing, typical approaches are:
  - Pan-sharpening
  - Inverting an explicit imaging model
  - Machine learning based methods

- Machine learning based methods:
  - Relation between the low resolution and high resolution data is not explicitly specified
  - Learns from data
  - Can capture complex relationships in data

- Different types:
  - Single image super-resolution
  - Multi-image super-resolution



R2A-L3-098-061-10FEB2023(SWIR,NIR,R)

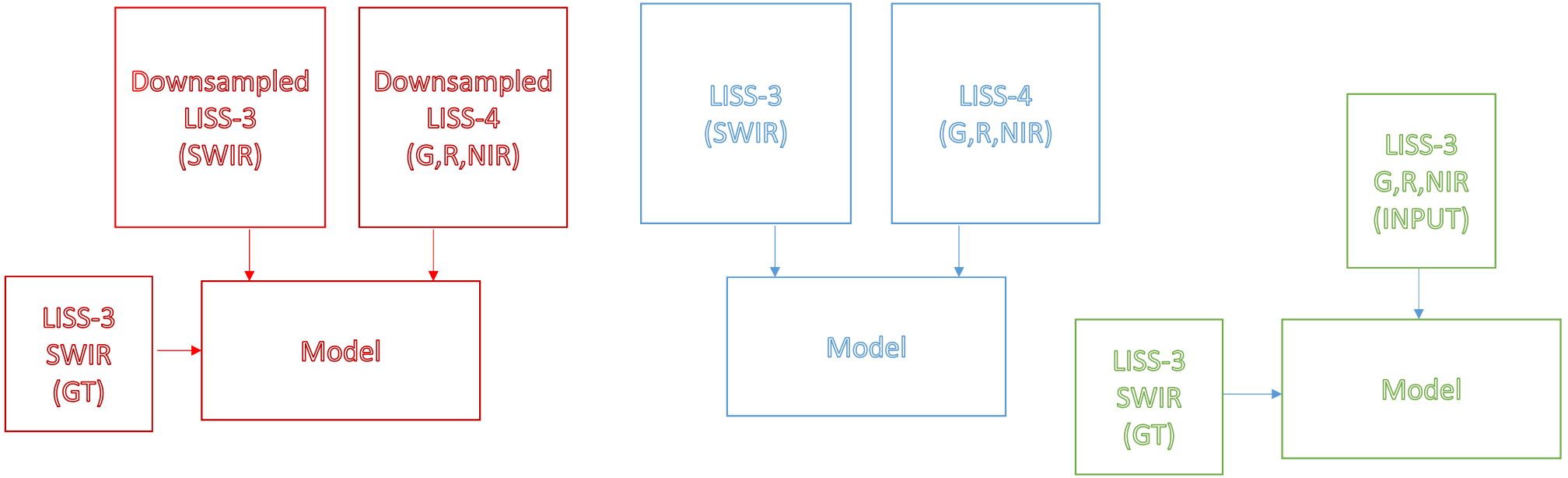
R2A-L4-098-061-D-10FEB2023(SWIR,NIR,R)

Low resolution

High resolution

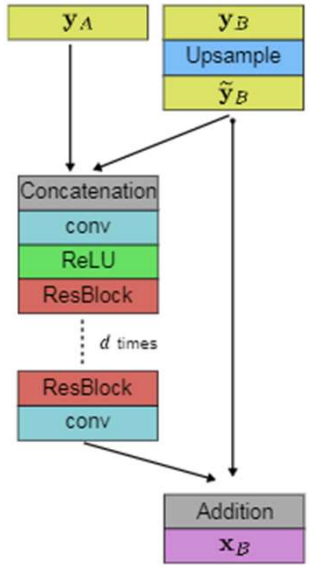
Super-resolution for LISS-4

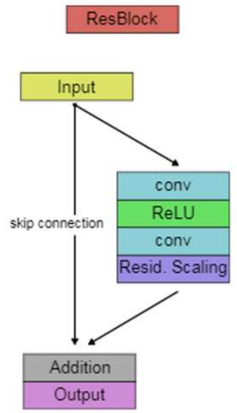
- LISS-3 and LISS-4 are acquired simultaneously
- Make use of LISS-3 SWIR at 24.0 m to generate SWIR at 5.0 m
- Different approaches:



Supervised approach

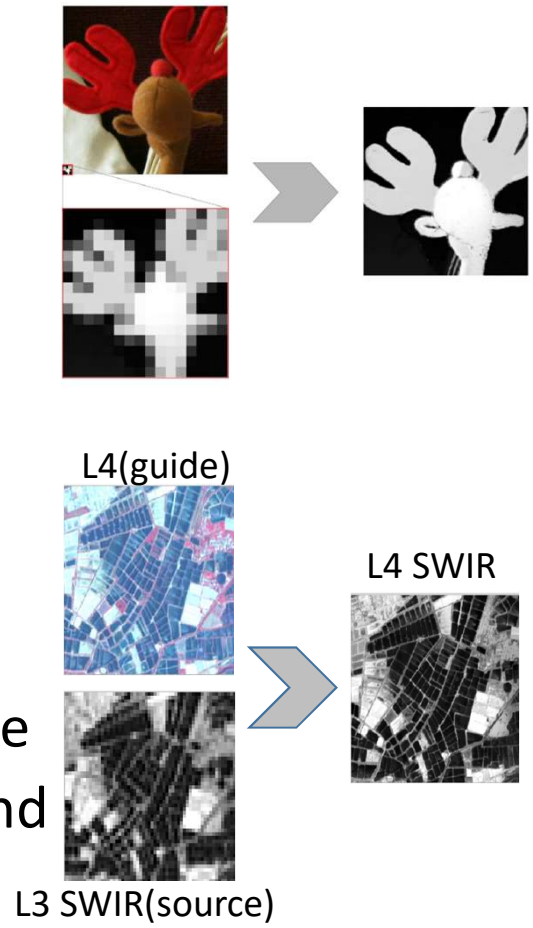
- Super-resolve SWIR at 24.0 m to 5.0 m
- Assumption - spectral correlation of image texture is self-similar over a (limited) range of scales
- Training data – downsampled images of LISS-4 and LISS-3 SWIR
- Preserve spectral information of SWIR band
- An end-to-end mapping from low resolution to high resolution
- Texture transferred from LISS-4 bands
- Learns a prior on the high resolution structure of SWIR, conditioned on known high resolution structure of LISS-4 data
- Loss function – L1
- Trained weight used to super-resolve LISS-3 SWIR, guided by LISS-4 data



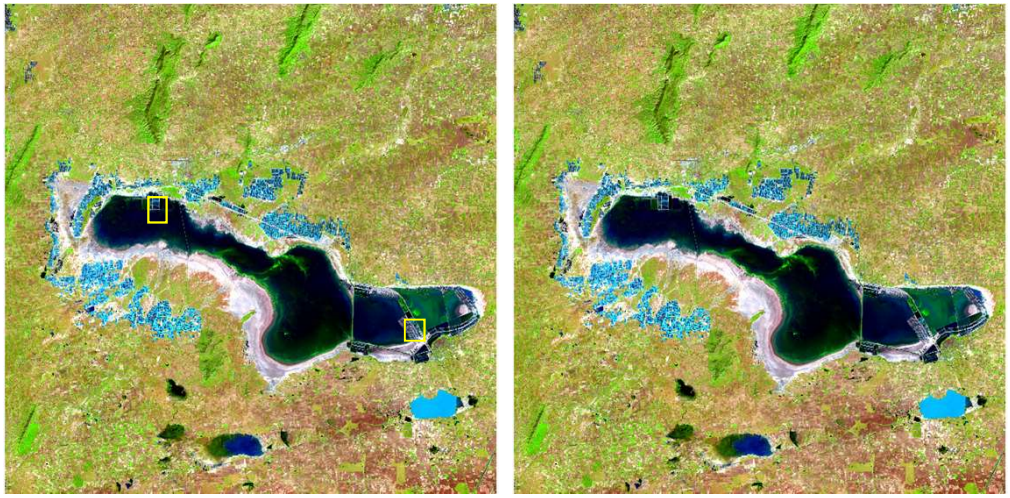


Guided Super-resolution

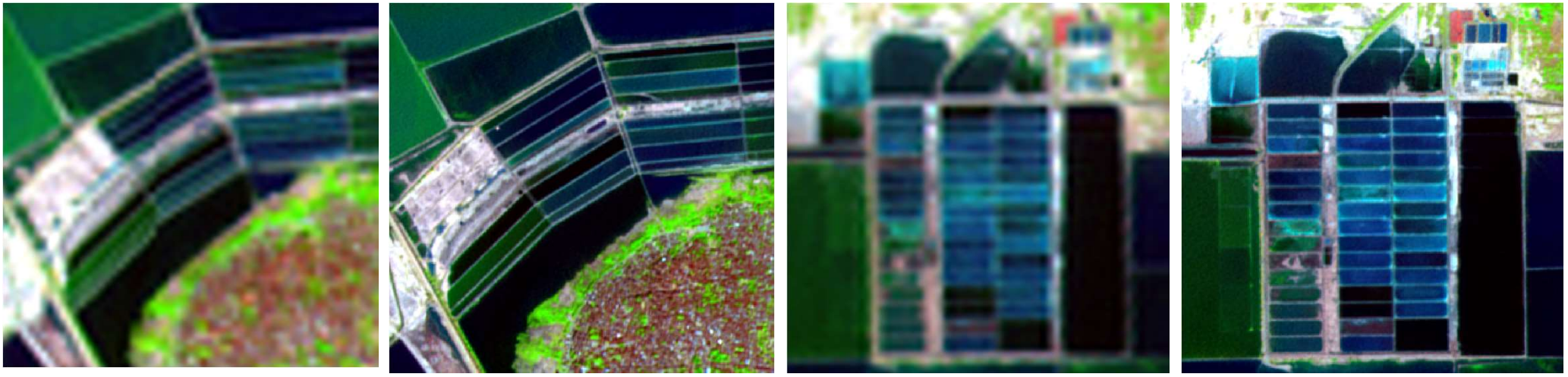
- A unifying framework where
- the inputs are low resolution source image and high resolution guide image from different domain and the target is the high resolution version of the source.
- Formulate as a pixel-to-pixel mapping of guide image(LISS-4) to the domain of source image(LISS-3 SWIR)
- Pixel-wise mapping as a machine learning model.
- Weights learned by minimizing the discrepancy between source image and down-sampled target image
- Unsupervised method, using only the specific source and guide images to fit the mapping



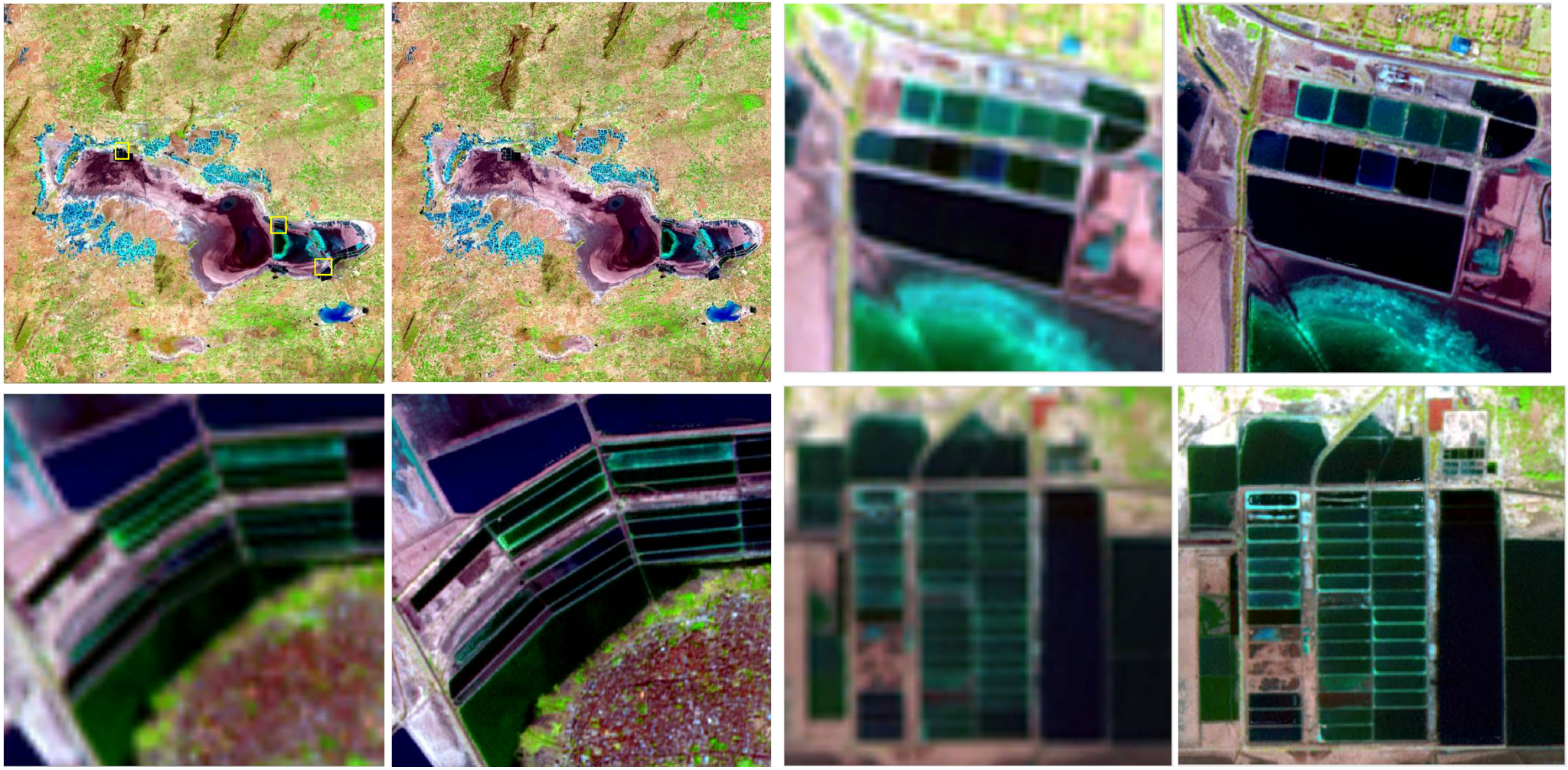
Sambhar lake (RS2A-94-52d-17Oct2022)



	B2	B3	B4	B5
RMSE	5.63	10.05	7.85	8.33
NMSE	0.0488	0.0828	0.040	0.0432
SSIM	0.959	0.946	0.9655	0.968
SAM	2.205	3.230	1.765	2.438

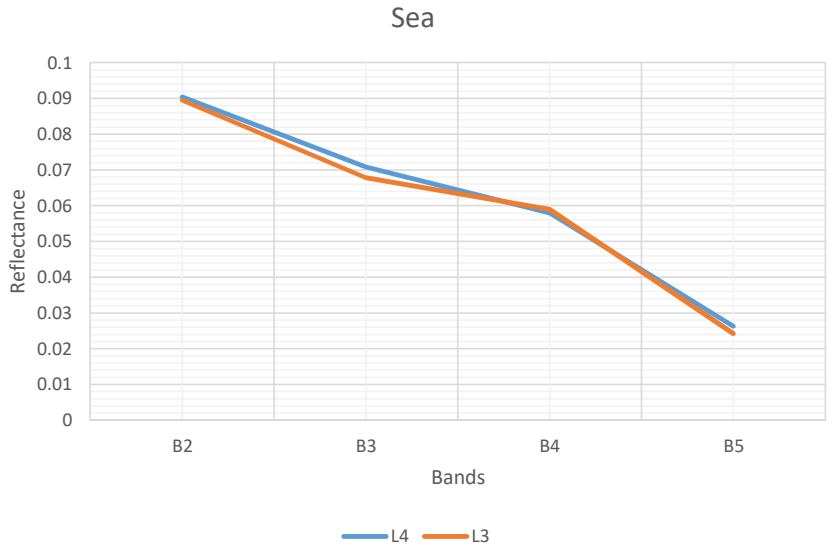


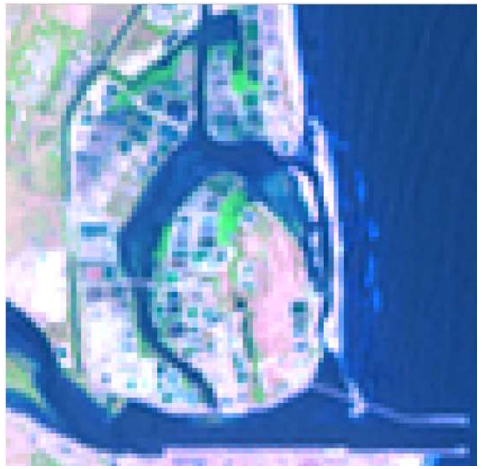
Sambhar lake (RS2A-94-52d-10Mar2023)



R2A-102-63-A-19APR2023

L3

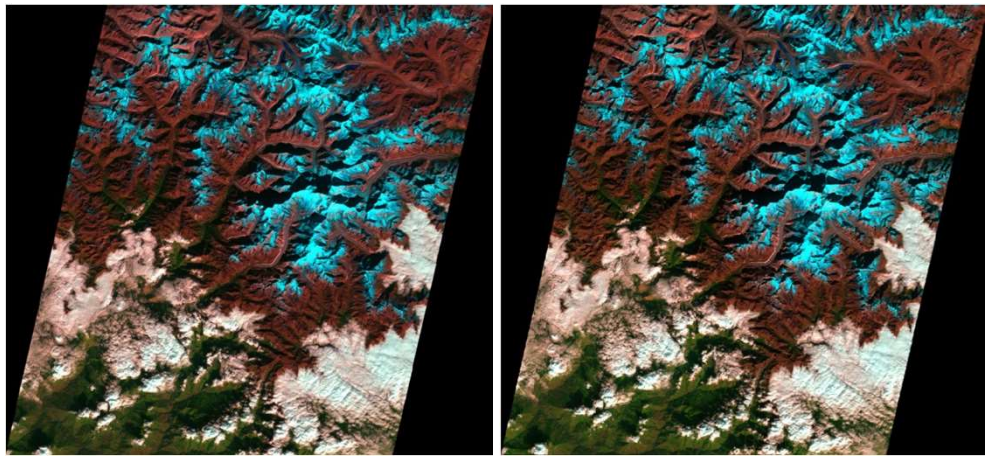


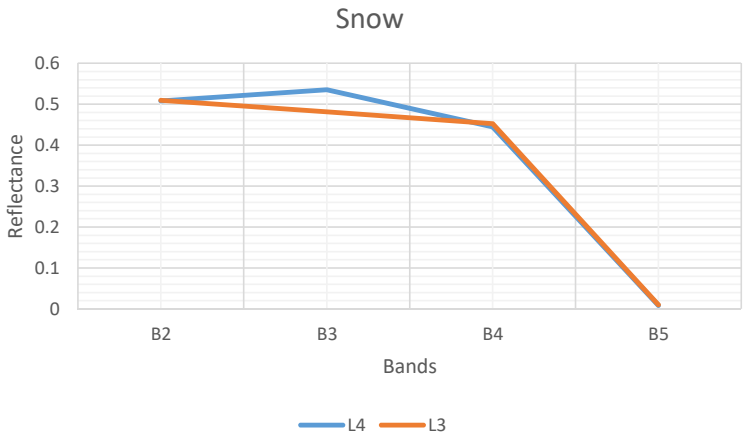


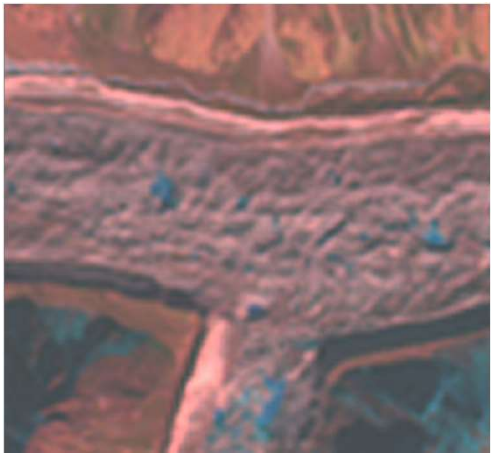
Part of Penna river (L3)

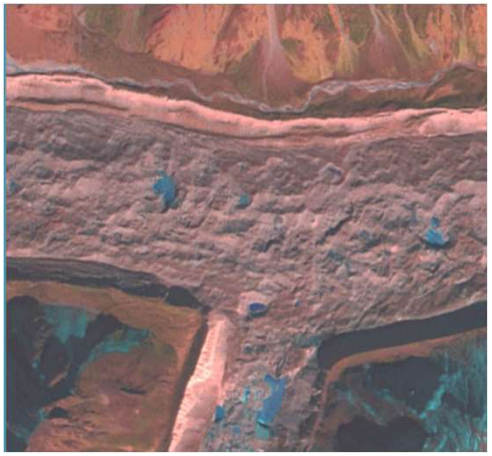
Part of Penna river (L4)

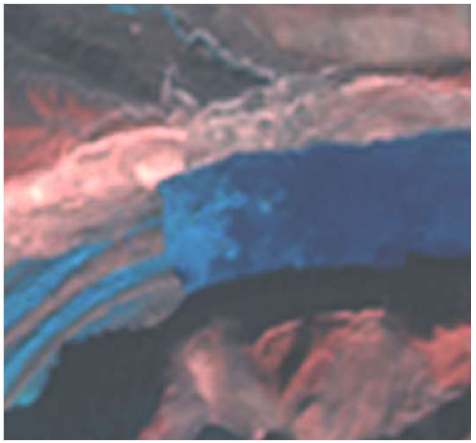
106-52-B-16dec2022 (Parts of Sikkim)



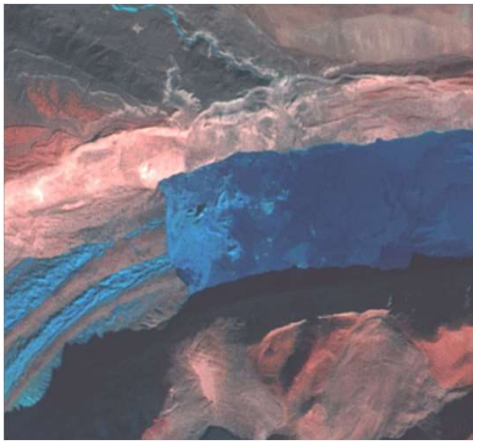






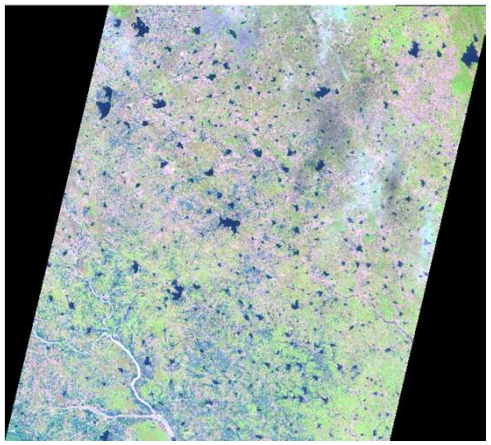


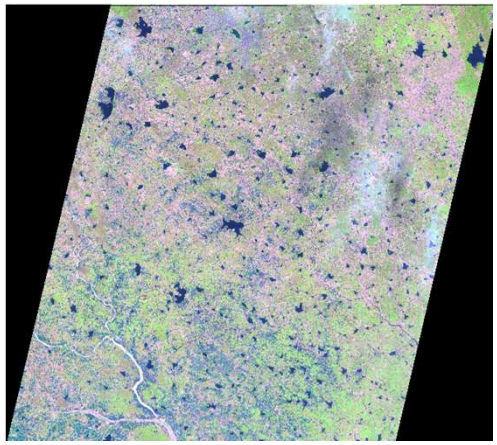
Part of Lhonak lake(L3)

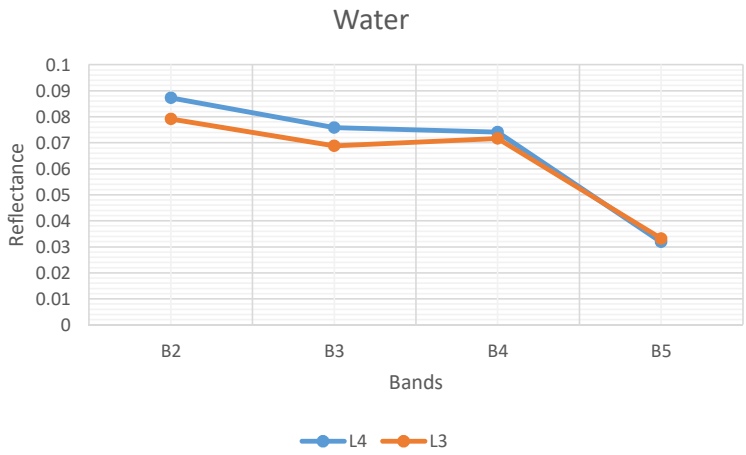


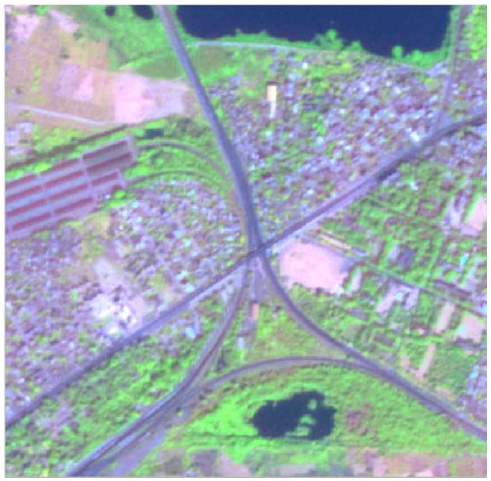
Part of Lhonak lake(L4)

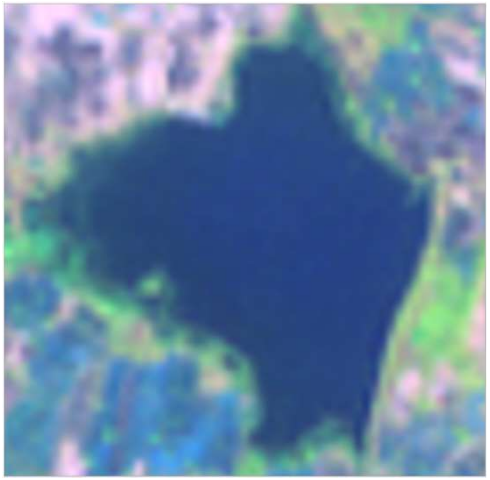
R2-101-060-C-22DEC2023

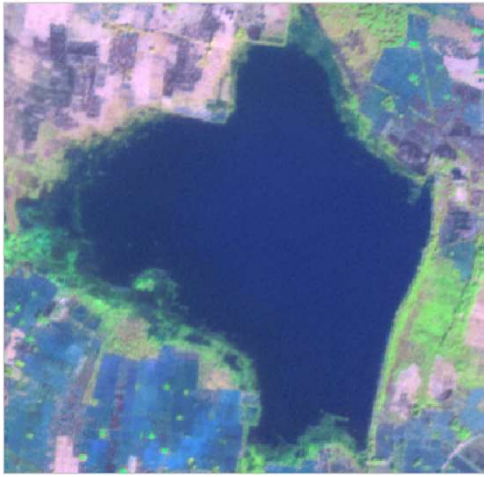












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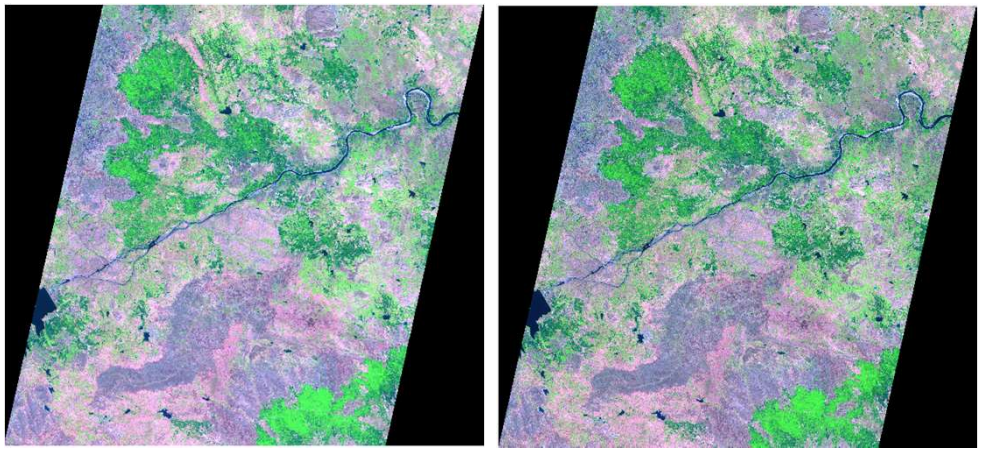

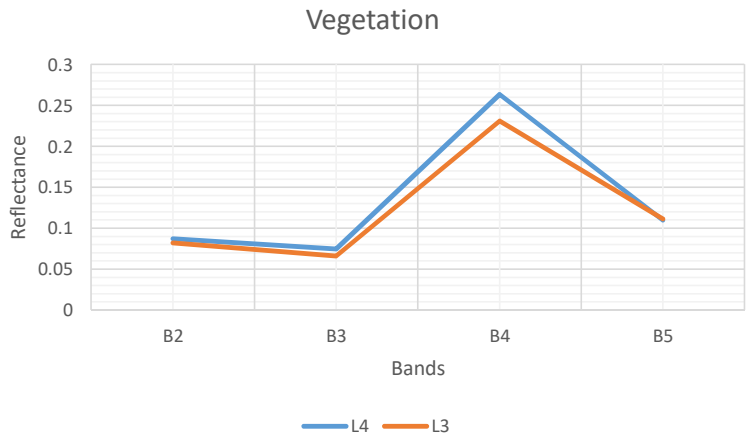

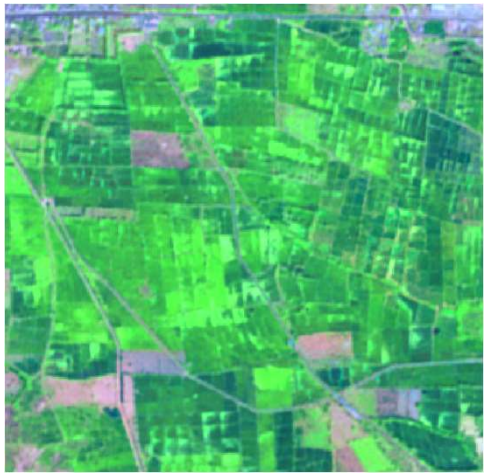

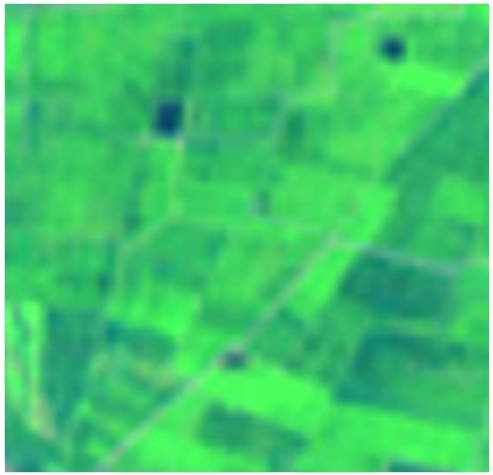

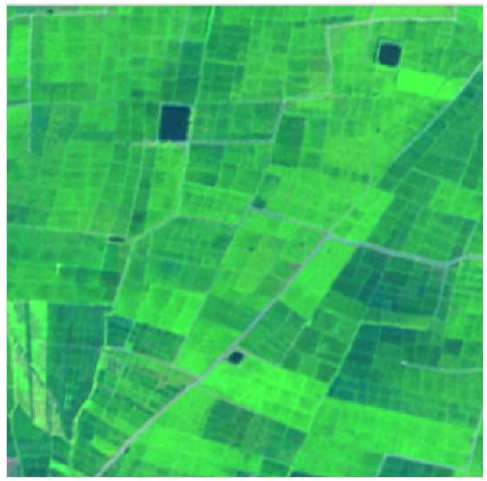

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(R2-099-061-B-27FEB2023)

Conclusion

- A method to super-resolve LISS-3 SWIR band to generate SWIR band data at 5.0 m resolution is developed
- State of the art quantitative measures such RMSE, NMSE, SSIM and SAM are used to evaluate the generated data and shows the effectiveness of the method.
- Scatter plots for different features such as water, ocean, vegetation and show close match with LISS-3 data.
- Visual analysis also shows high spectral fidelity.
- A new product with simulated SWIR band is realized. Soon it will be released to the users.

Thank you