BioREaCH :Biodiversity-Remote sensing for Estuarine and Coastal Habitat research

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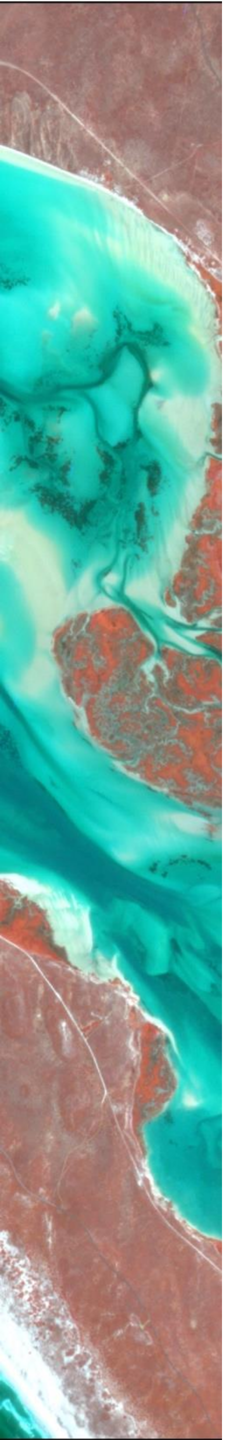
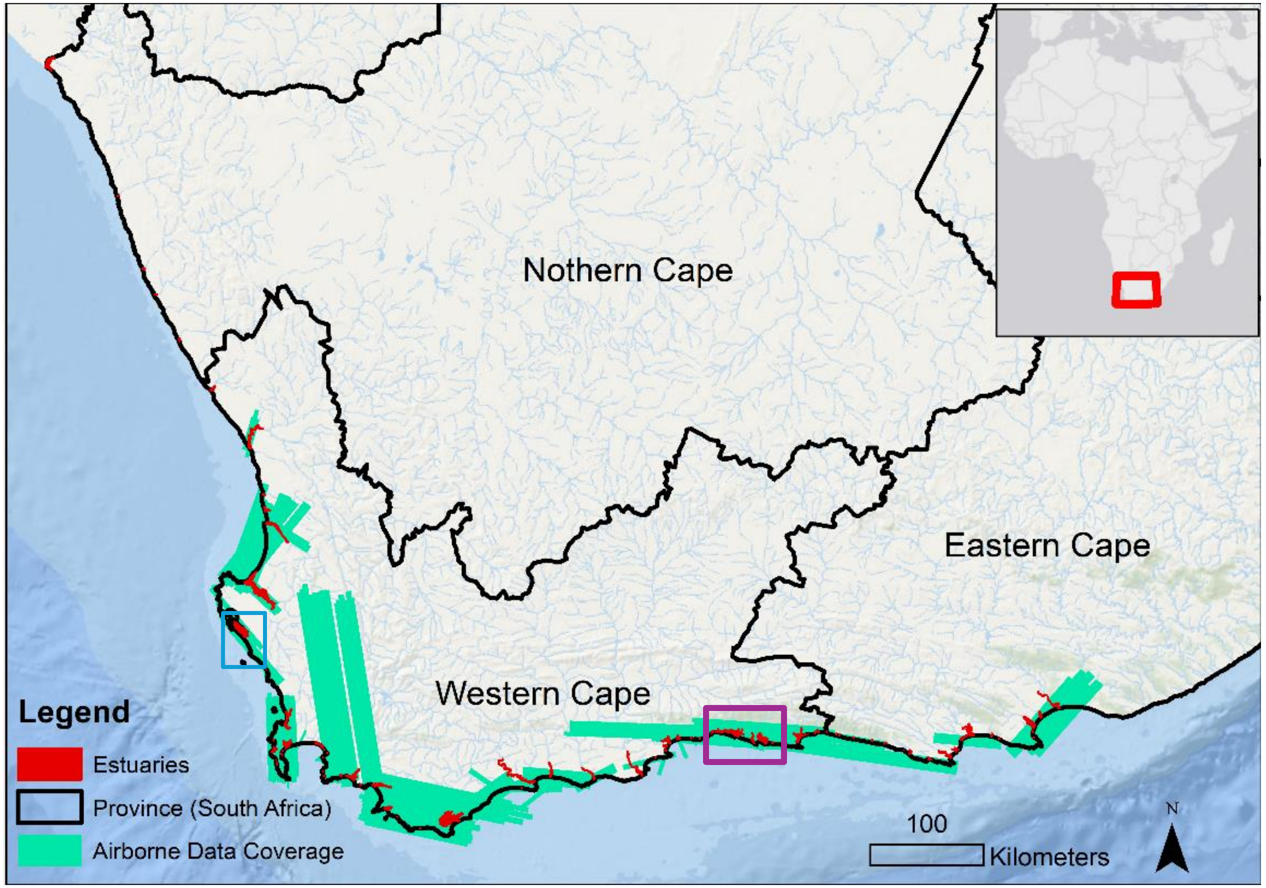
Biodiversity and Ecological Conservation Program Meeting

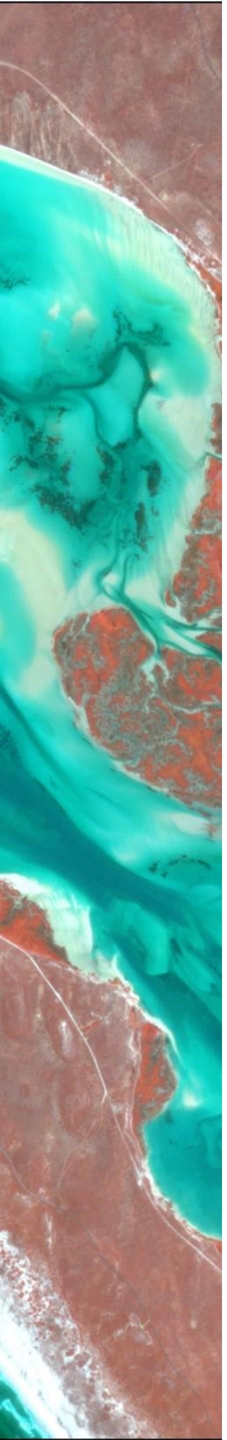
5/28/2025



Project Background: BioREaCH

- Biodiversity-Remote sensing for Estuarine and Coastal Habitat research(BioREaCH)is focused on understanding the biodiversity of coastal wetlands across the Greater Cape Floristic Region of South Africa using imaging spectroscopy, LiDAR, and multispectral satellite data.
- Recent efforts by collaborators to map change across coastal wetlands in South Africa found that medium resolution satellites overpredicted both seagrass and salt marsh habitats (Van Deventer et al. 2025)

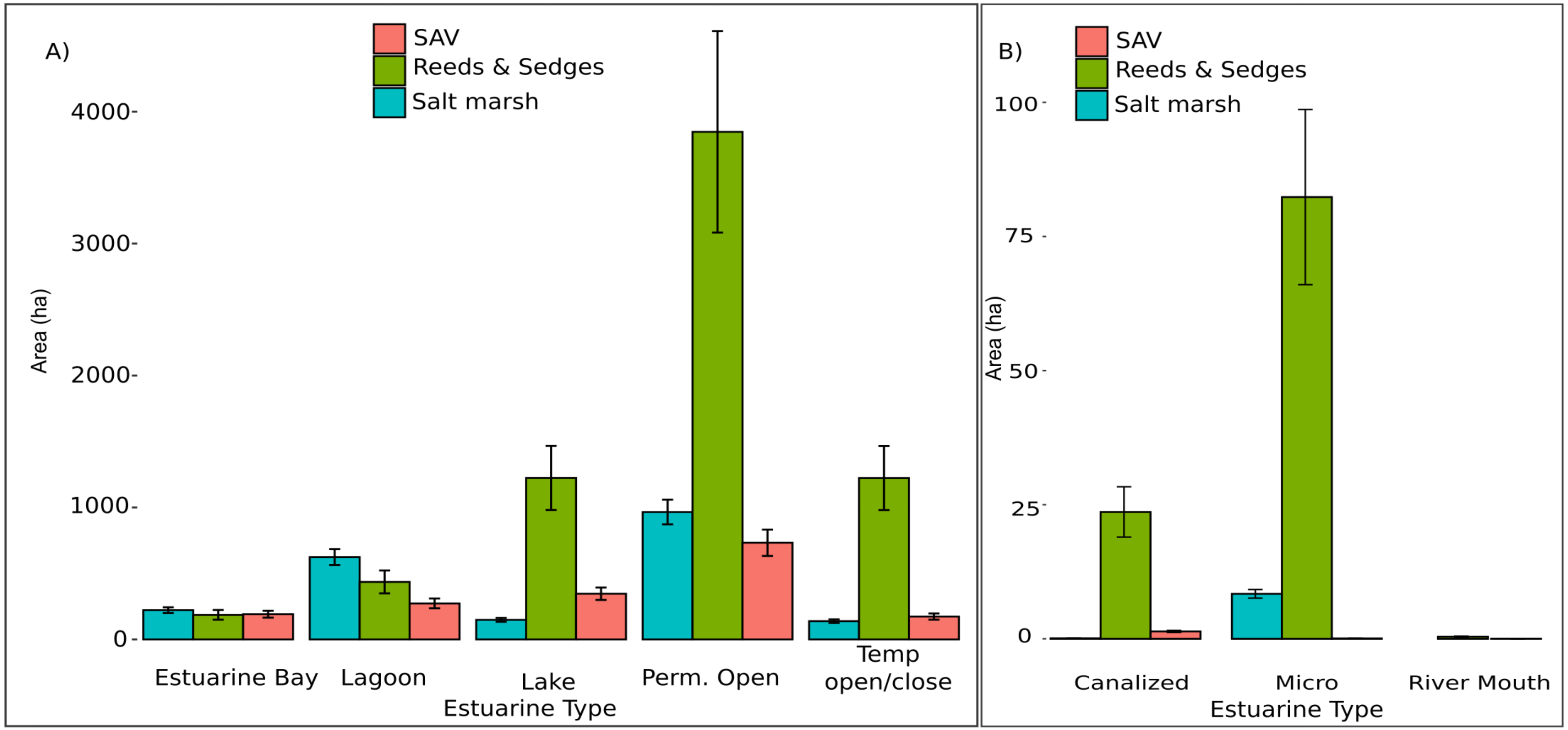




Satellite data baseline

- We mapped 10,848.9 ha ± 1830.9 of coastal wetlands (16% of total extent of the estuaries)
  - Reeds and Sedges: 7,022.7 ±1,392.8 ha (64.7%)
  - Salt marsh: 2,107.6 ± 203.9 ha (19.4%)
  - SAV: 1,718.6 ± 234.25 ha (15.8%)

We mapped 9,066.35 ±2,154.6 ha of tidal marsh slightly higher than the global tidal marsh layer's estimate of 8,026.34 ha for the same 83 estuaries.

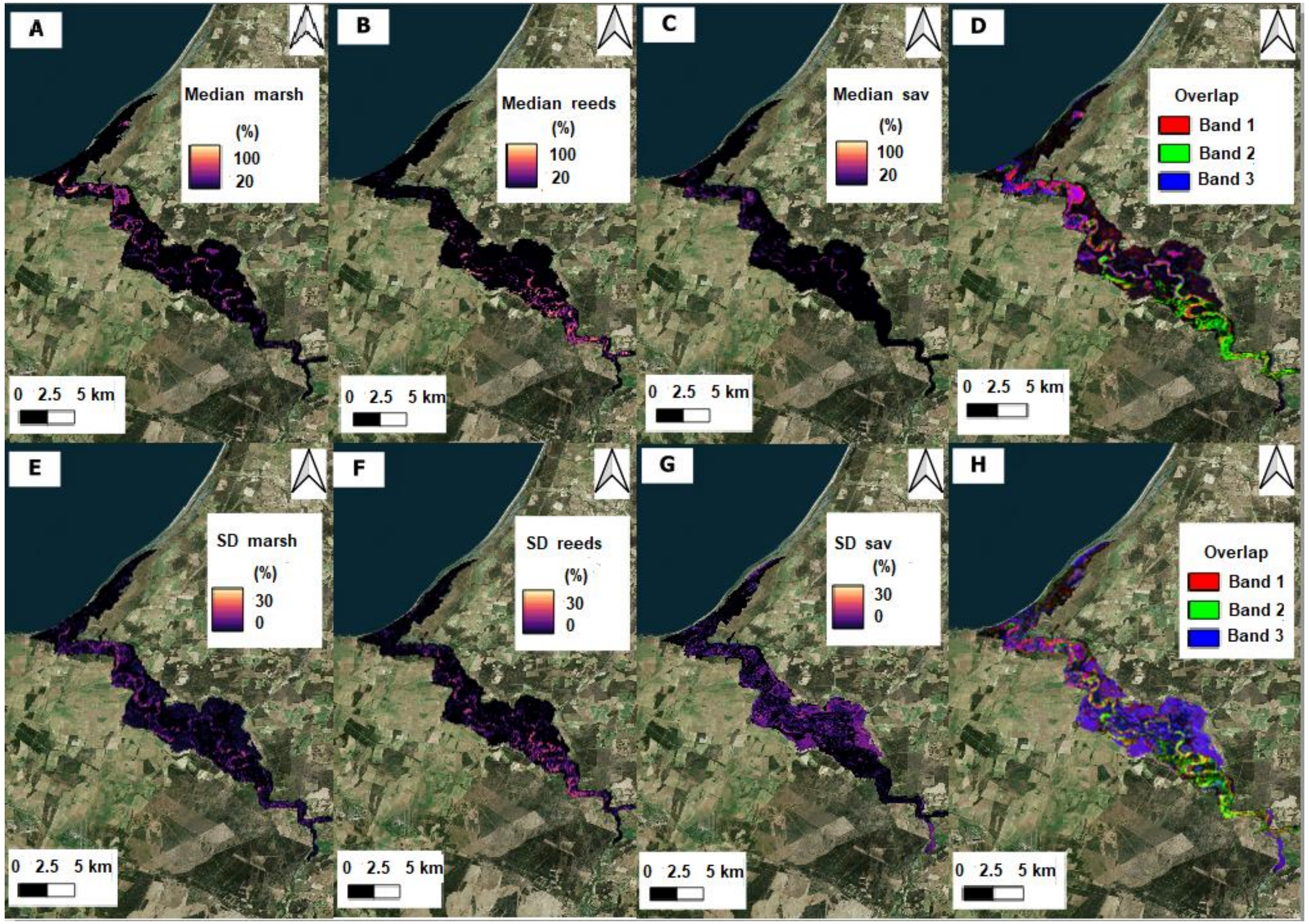


Campbell et al. in revision

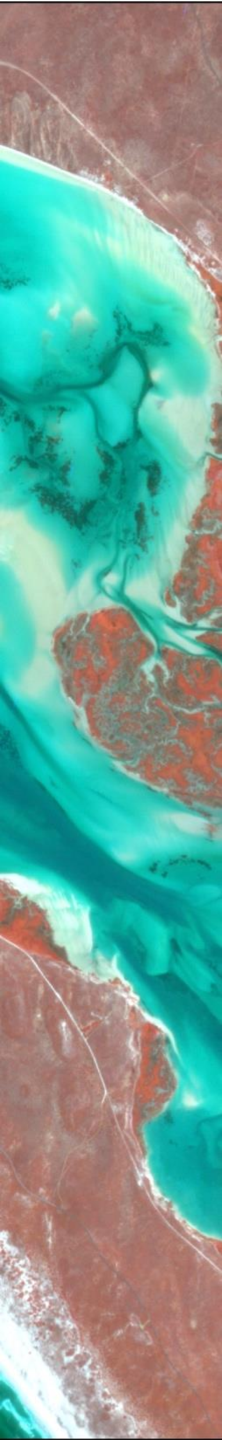
EMIT

Assessed the NASA Earth Surface Mineral Dust Source Investigation (EMIT) sensor for utility in mapping coastal wetland extent.

- Evaluated three wetland habitats at the sub-pixel scale
- Best performance was for low tidal stage images during the growing season.

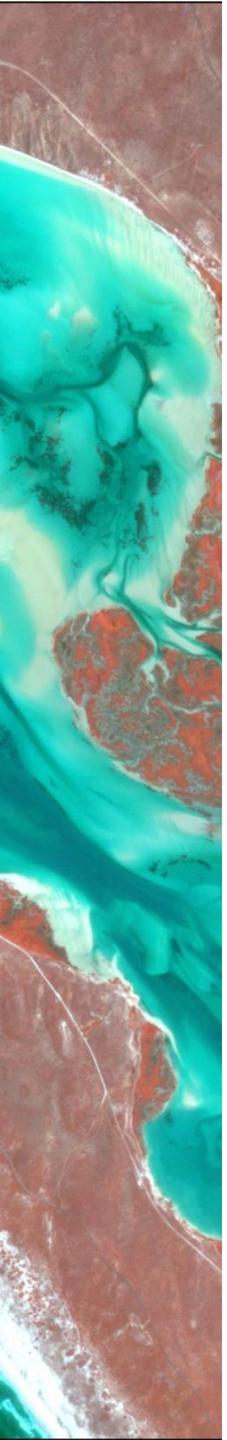


Thakali, Campbell and Adam, in Revision



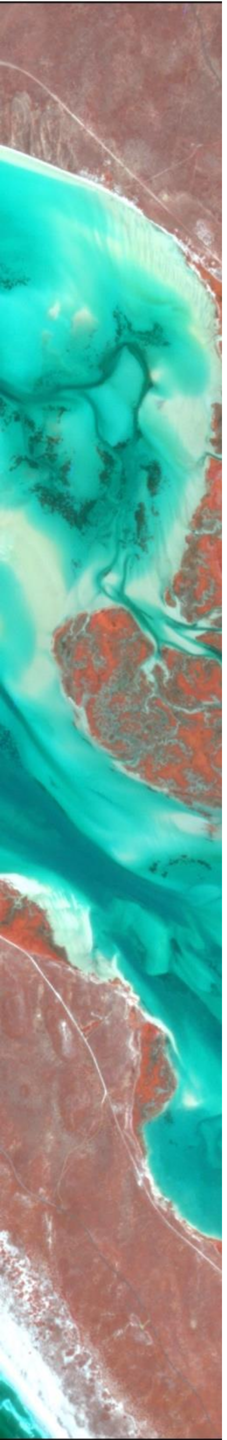
Fieldwork

- 64 – 10 m vegetation plots
  - Identified species
  - % cover
  - Vegetation height
- Species and plot level spectral data
- 19 soil cores
- Collected within 2 weeks of airborne acquisitions
- >500 GPS vegetation community locations



BioREaCH updates

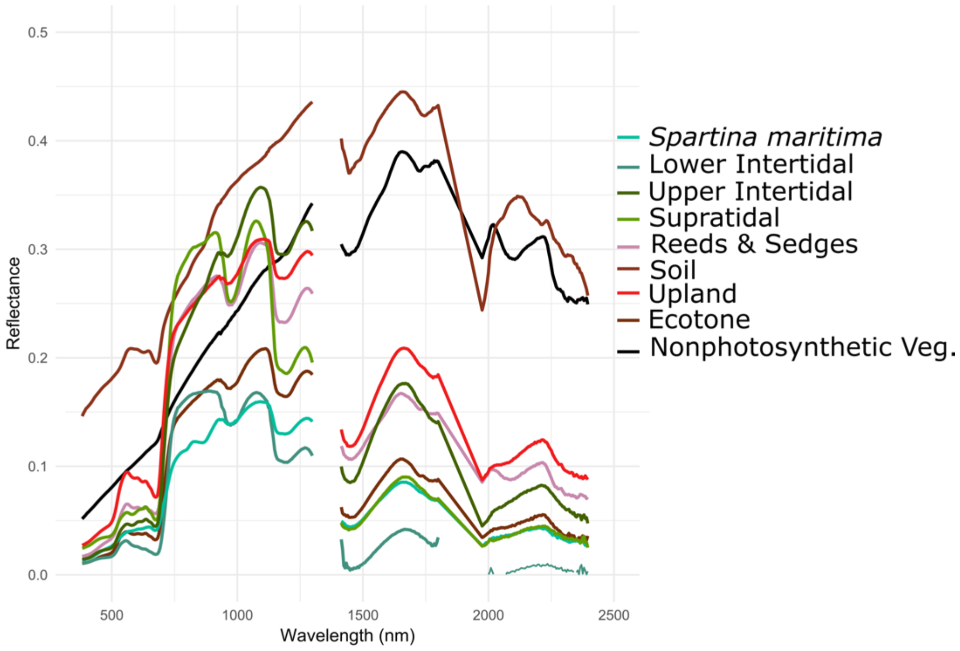
1. Spectral library development and application for Plant Functional Type mapping
2. Estuarine EBVs - salinity
3. Hydrological modeling

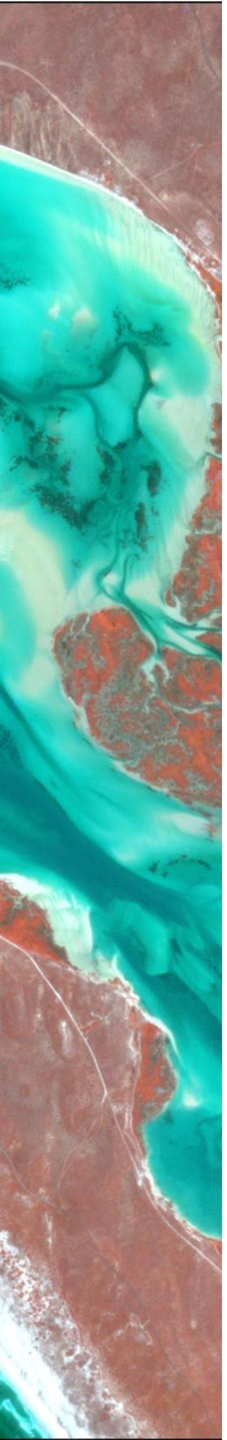


Spectral libraries

- We used three hundred and ten *in situ* ASD FieldSpec measurements to create our spectral library
- Develop a spectral library and apply to airborne data for plant functional community classification

1. Broad
   Water, Wetland, Upland, Soil
2. Tidal marsh community
   Water, Supratidal marsh, Upper intertidal marsh, Intertidal marsh, Upland, Reeds and Sedges, Soil



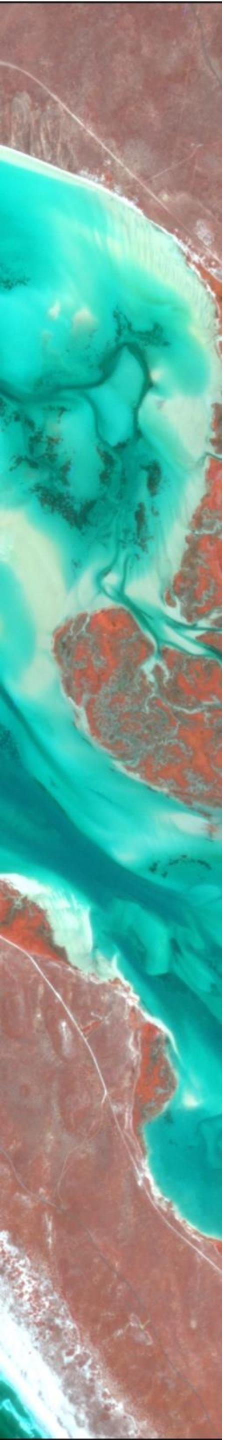


MESMA

Multiple Endmember Spectral Mixture Analysis (MESMA; Ochoa et al. 2025) was used to apply the spectral signatures to AVIRIS-NG data collected during the BioSCape campaign.

MESMA assumes each pixel is composed of a combination of pure spectra or endmembers.

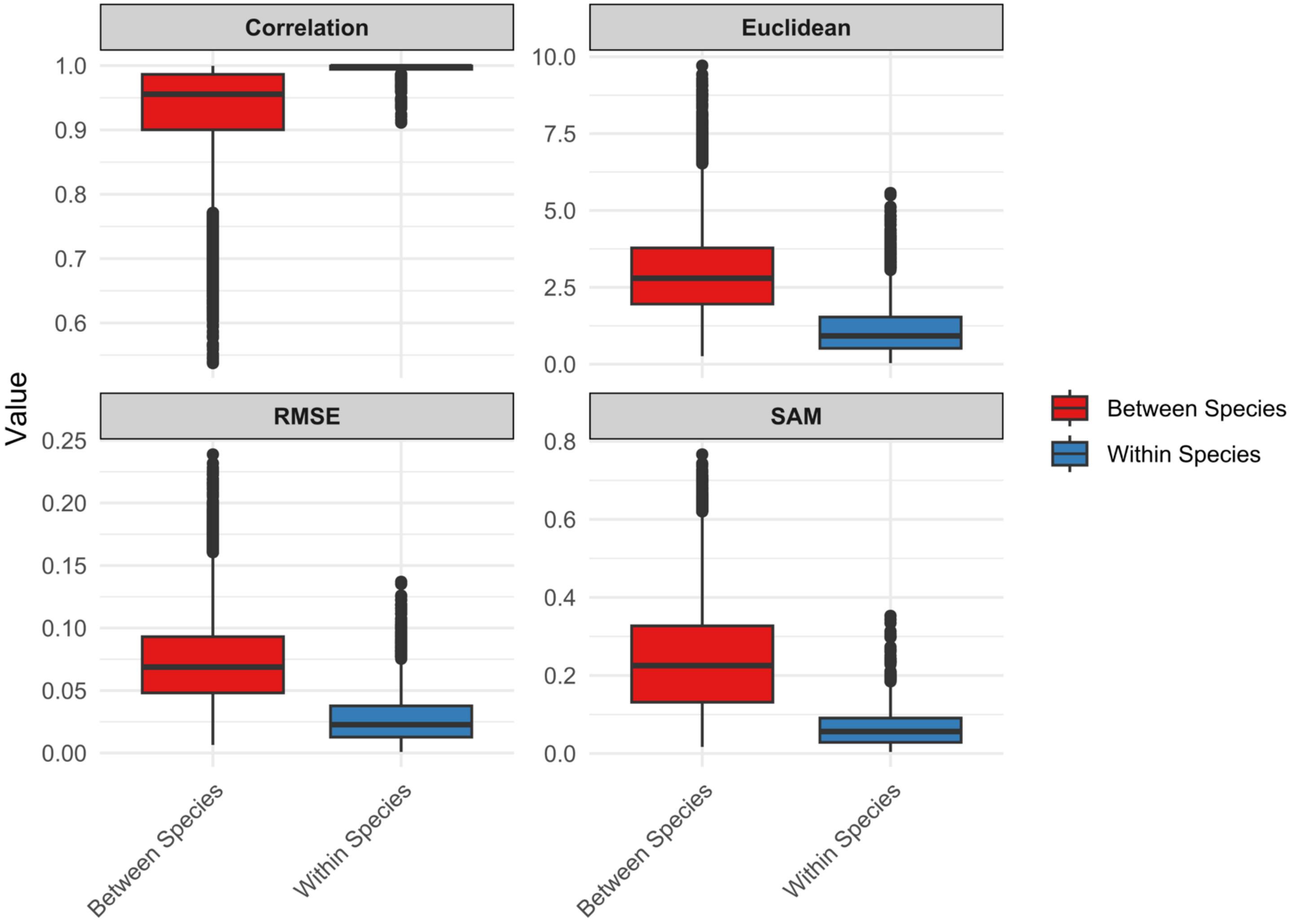
In our study, the spectral library is composed of pure spectra collected in the field in Langebaan Lagoon coincident with airborne image acquisitions.

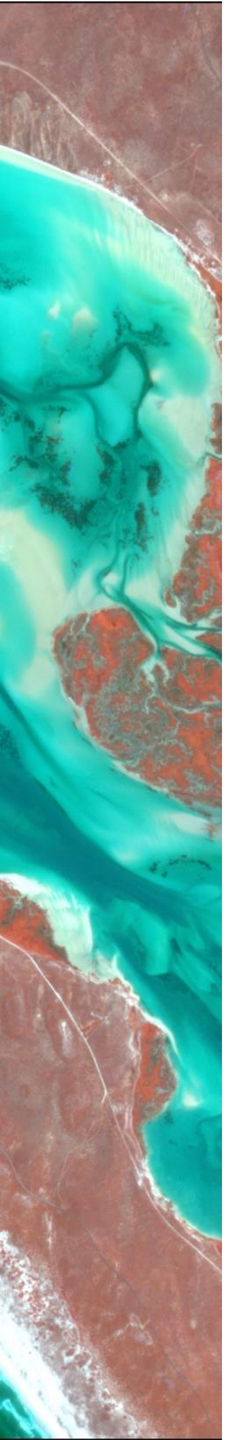


Evaluating *in situ* spectra

Compare metrics of similarity to identify spectra that were inconsistent with those from the same species.

Metrics: Euclidean distance, RMSE, Spectral Angle Mapping, and correlation



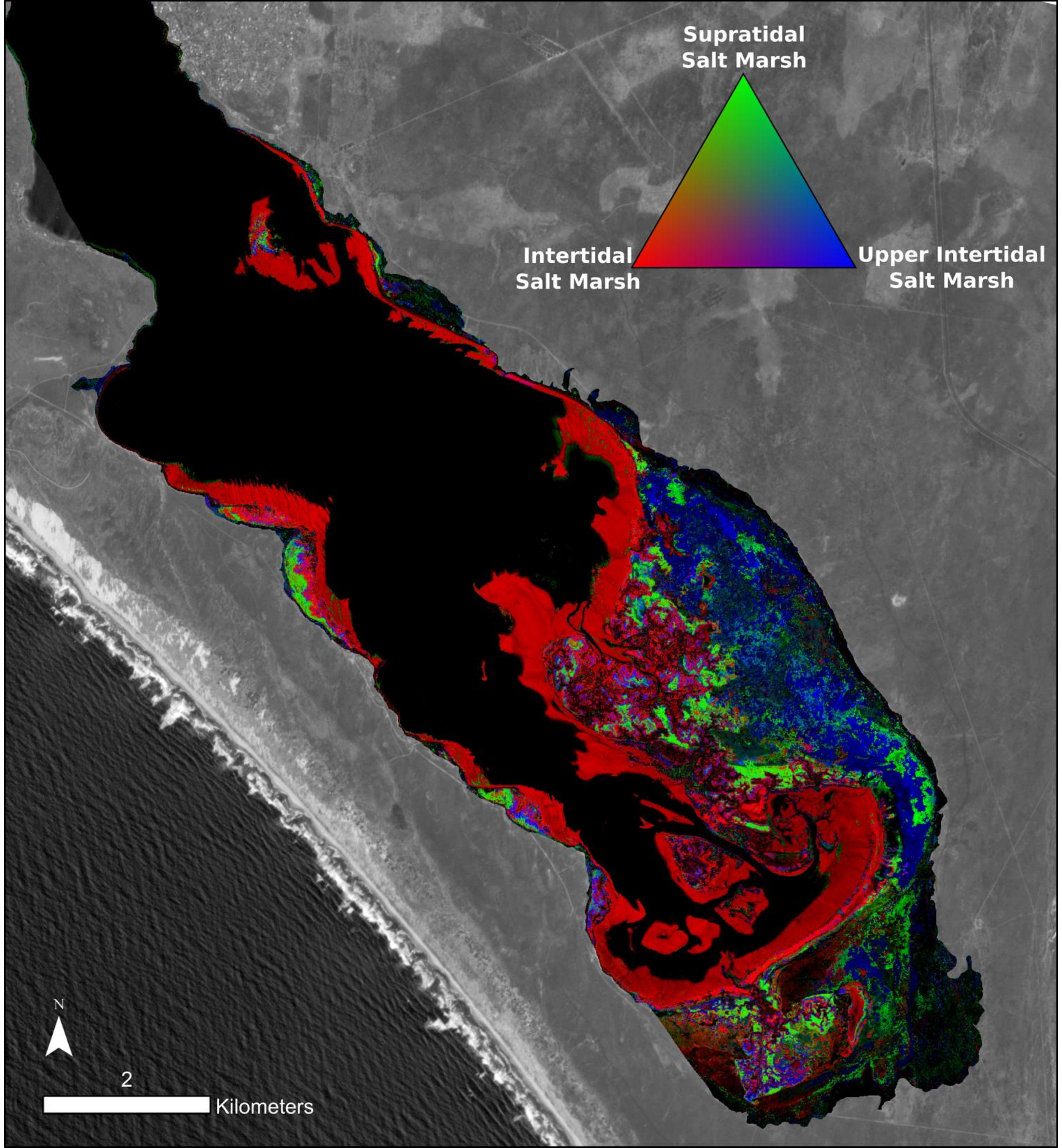


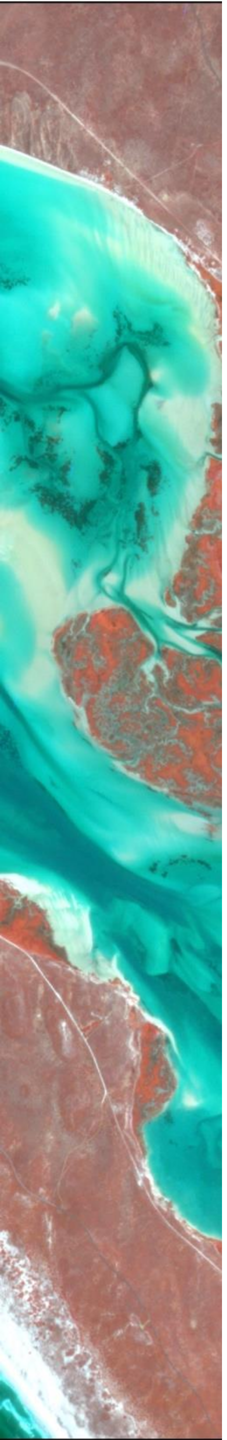
MESMA-Results

Langebaan Lagoon – 10/29/2023 (0.077 m above MSL)

Salt marsh habitats

- Intertidal is over predicted



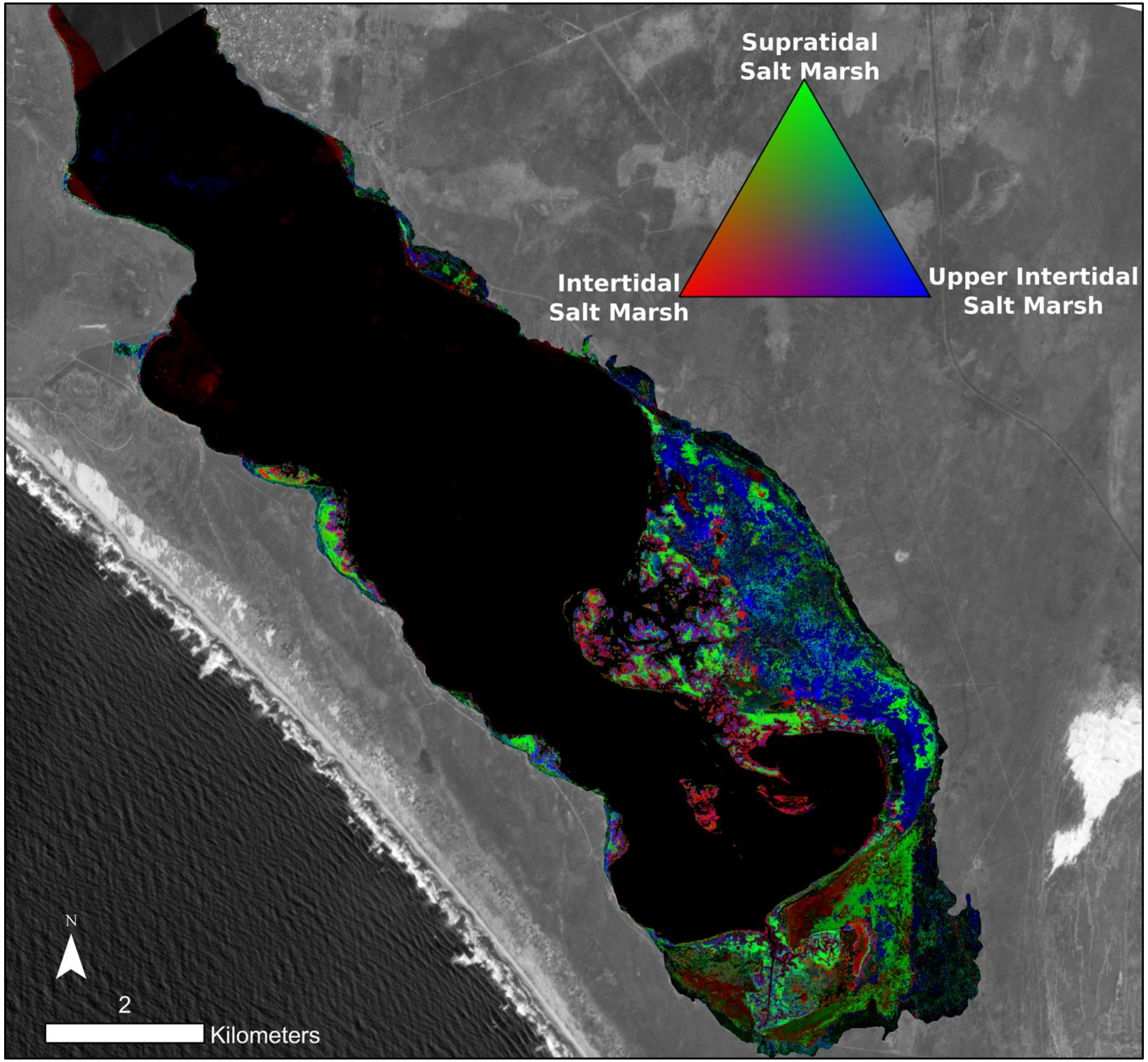


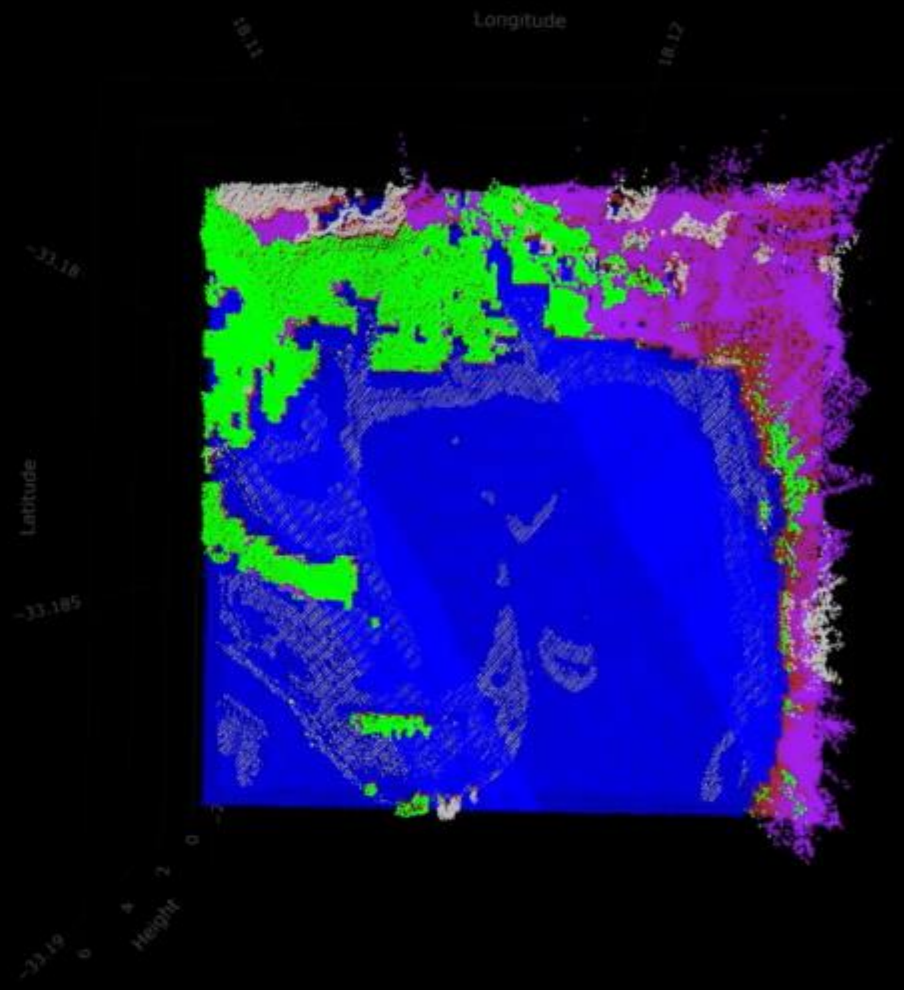
MESMA-Results

Langebaan Lagoon – 10/26/2023 (0.708 m above MSL)

Salt marsh habitats

- Intertidal extent reduced due to higher water levels and no submerged spectra in the spectral library





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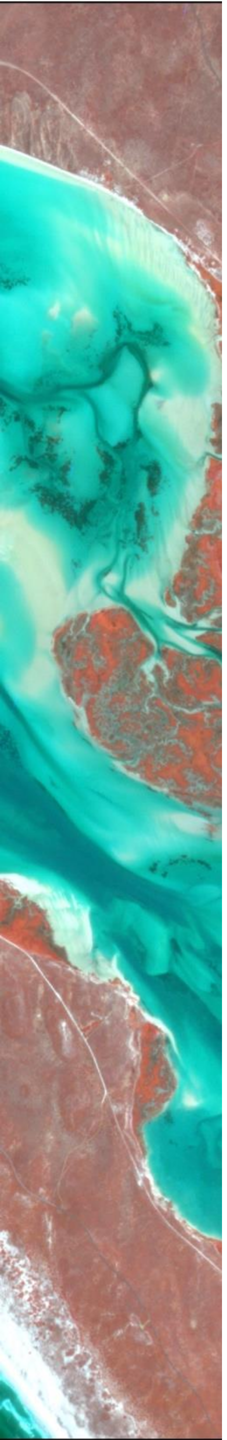
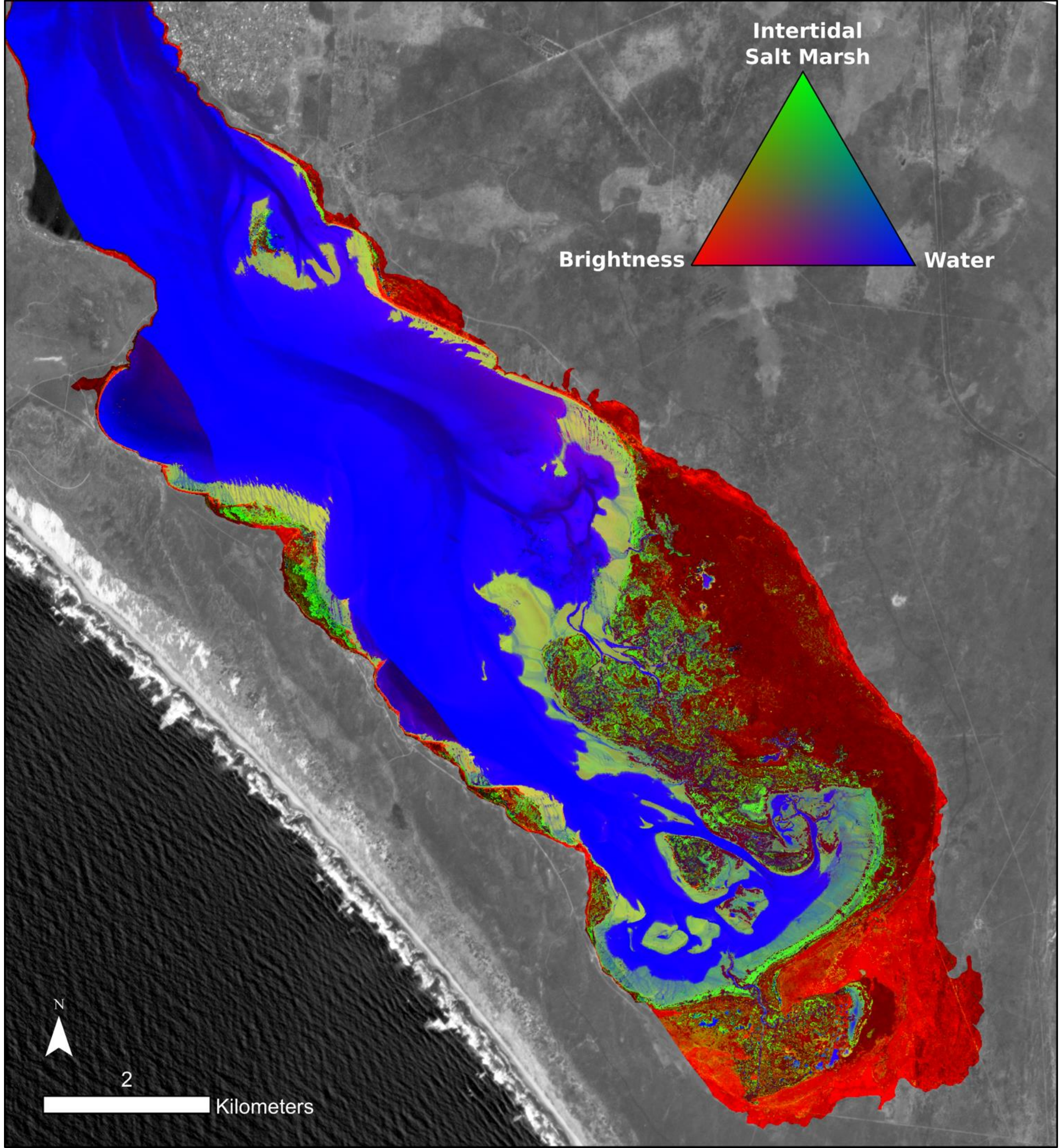
18.12
-33.18
Latitude
-33.185
-33.19
Height
0
2
4
6



MESMA- Results

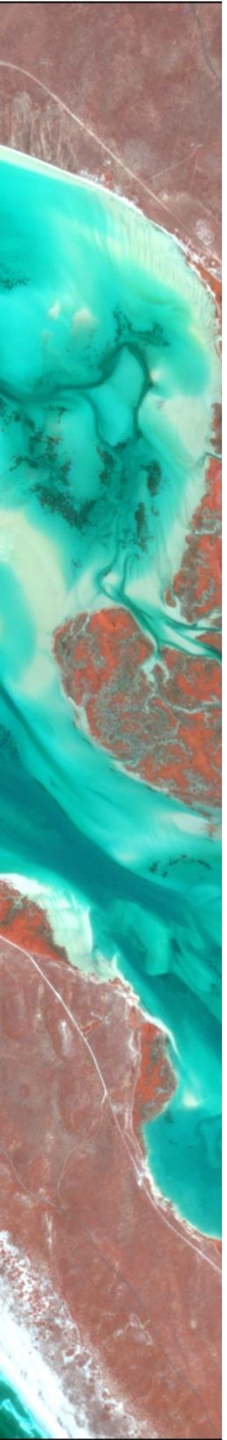
Langebaan Lagoon – 10/29/2023 (0.077 m above MSL)

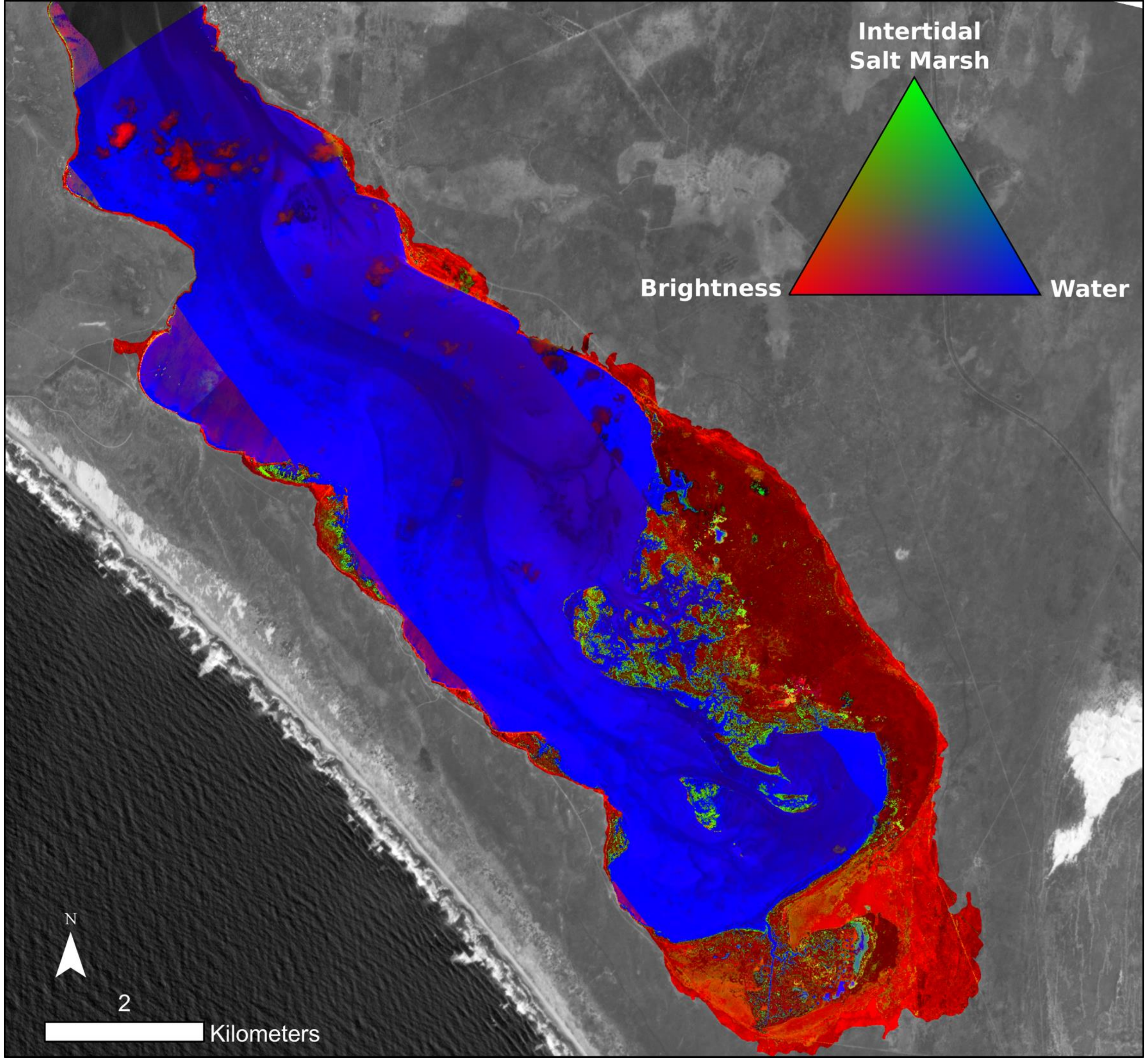
- Brightness is used to normalize the MESMA results
- Tidal height difference derived from LVIS – 1.46 m



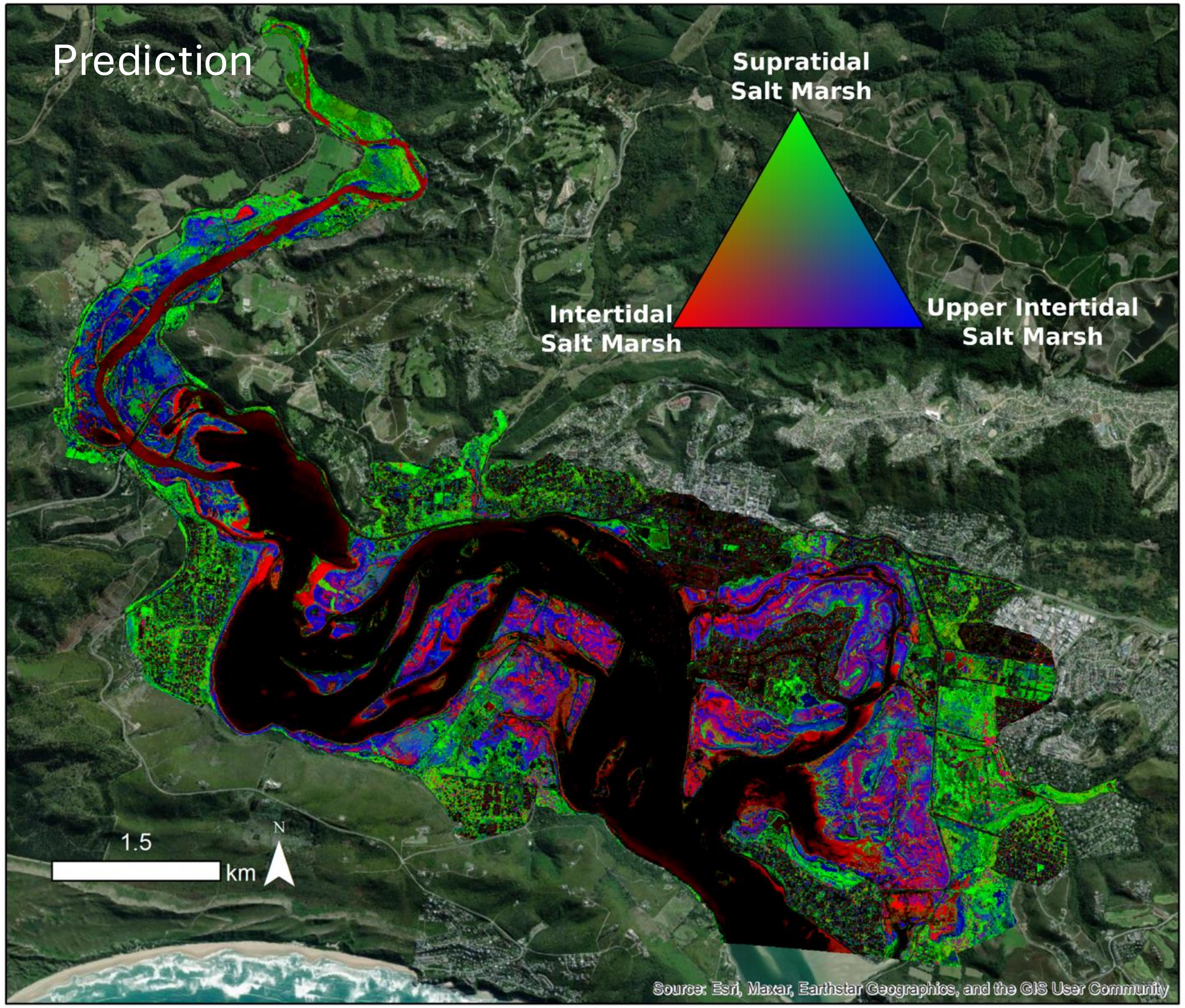
MESMA- Results

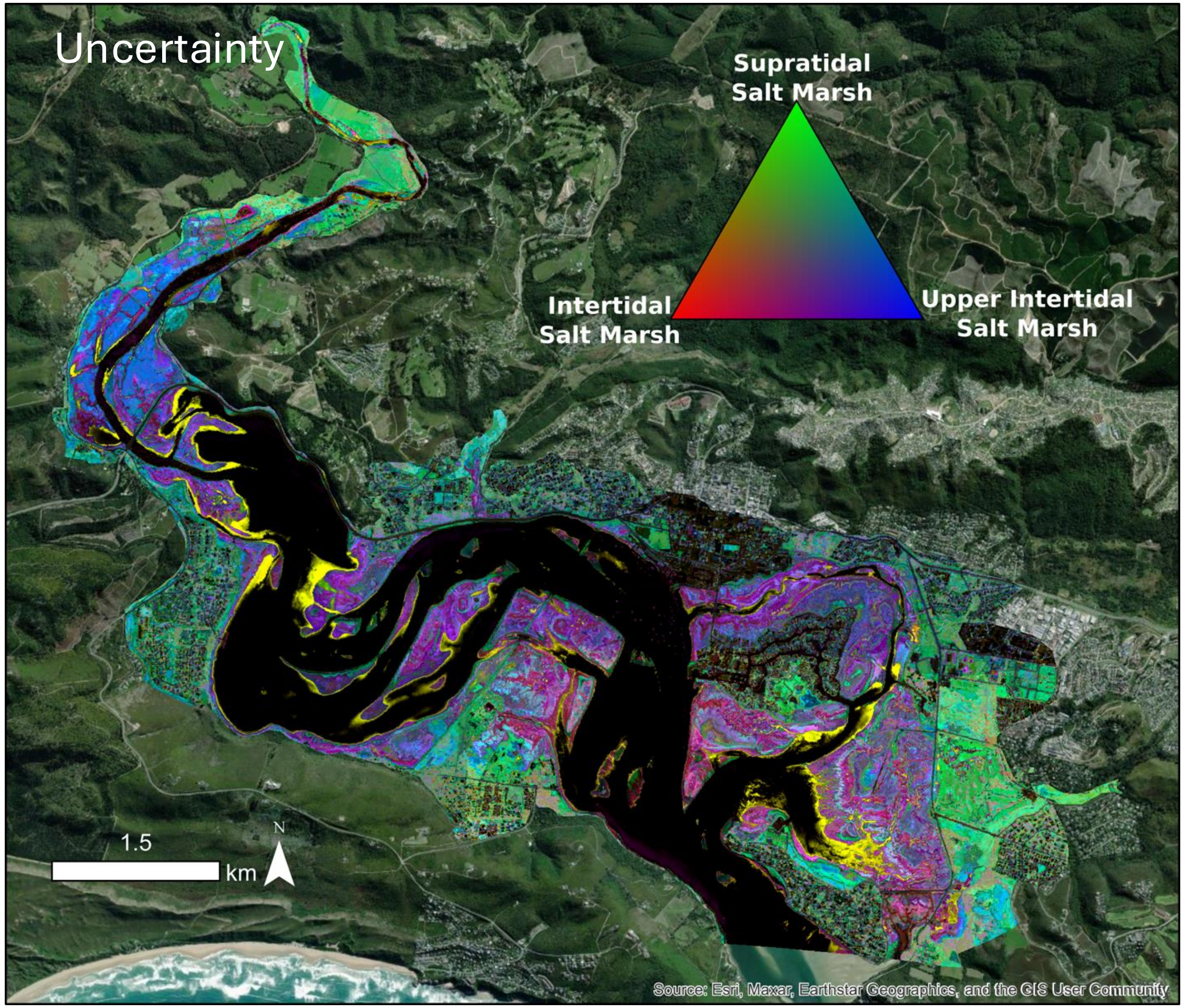
Co-associated habitat and materials.

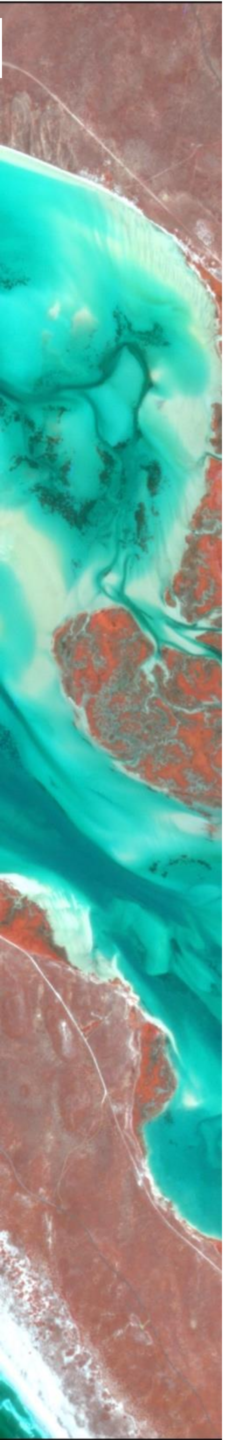




Knysna – MESMA result

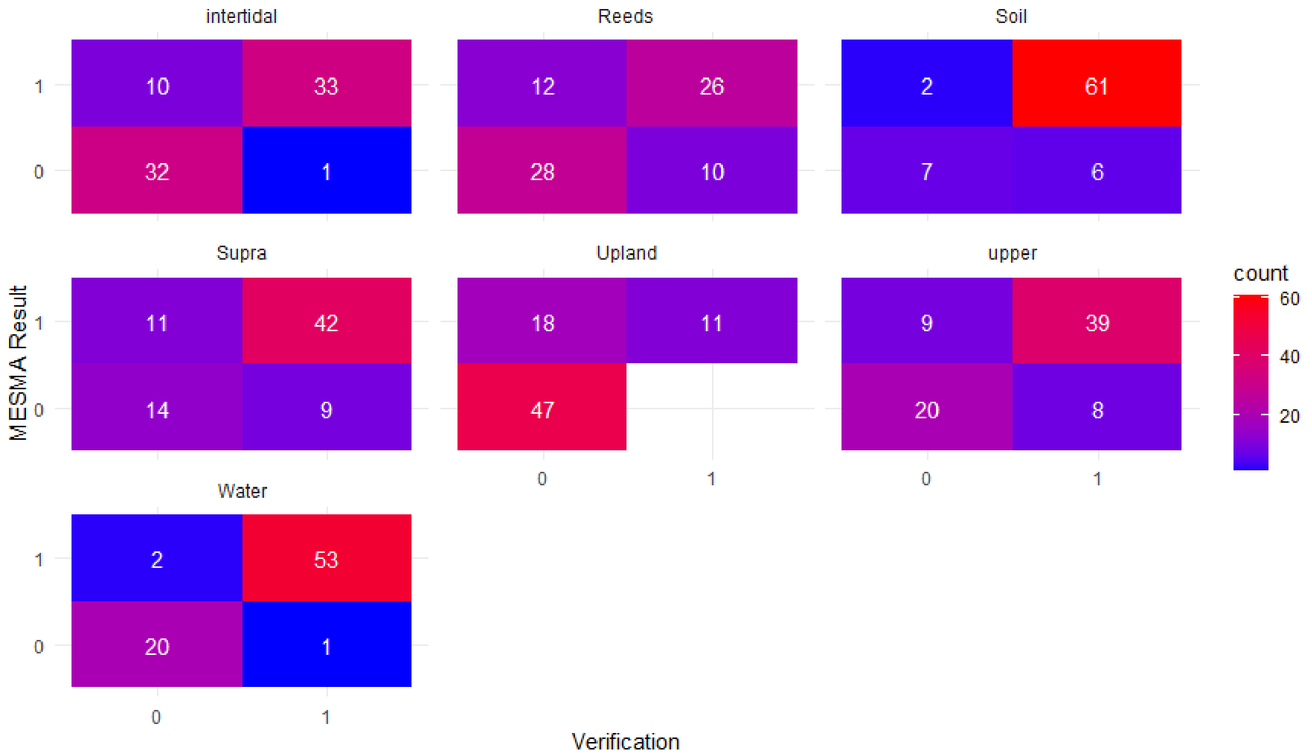


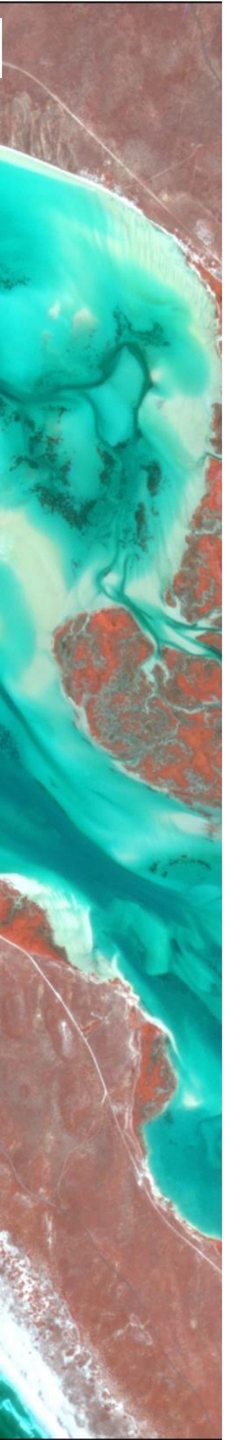




MESMA-Plot verification

- MESMA result was extracted to plot locations and associated vegetation surveys were used to verify the absence or occurrence of each endmember.
- Of our 64 plots – 1 plot was removed as it was outside of the estuarine functional zone and several plots had multiple MESMA results due to overlapping flight lines (n =76).
- Plots evaluated for each of our 8 classes.
- Overall accuracy: 81.4% (n=532)

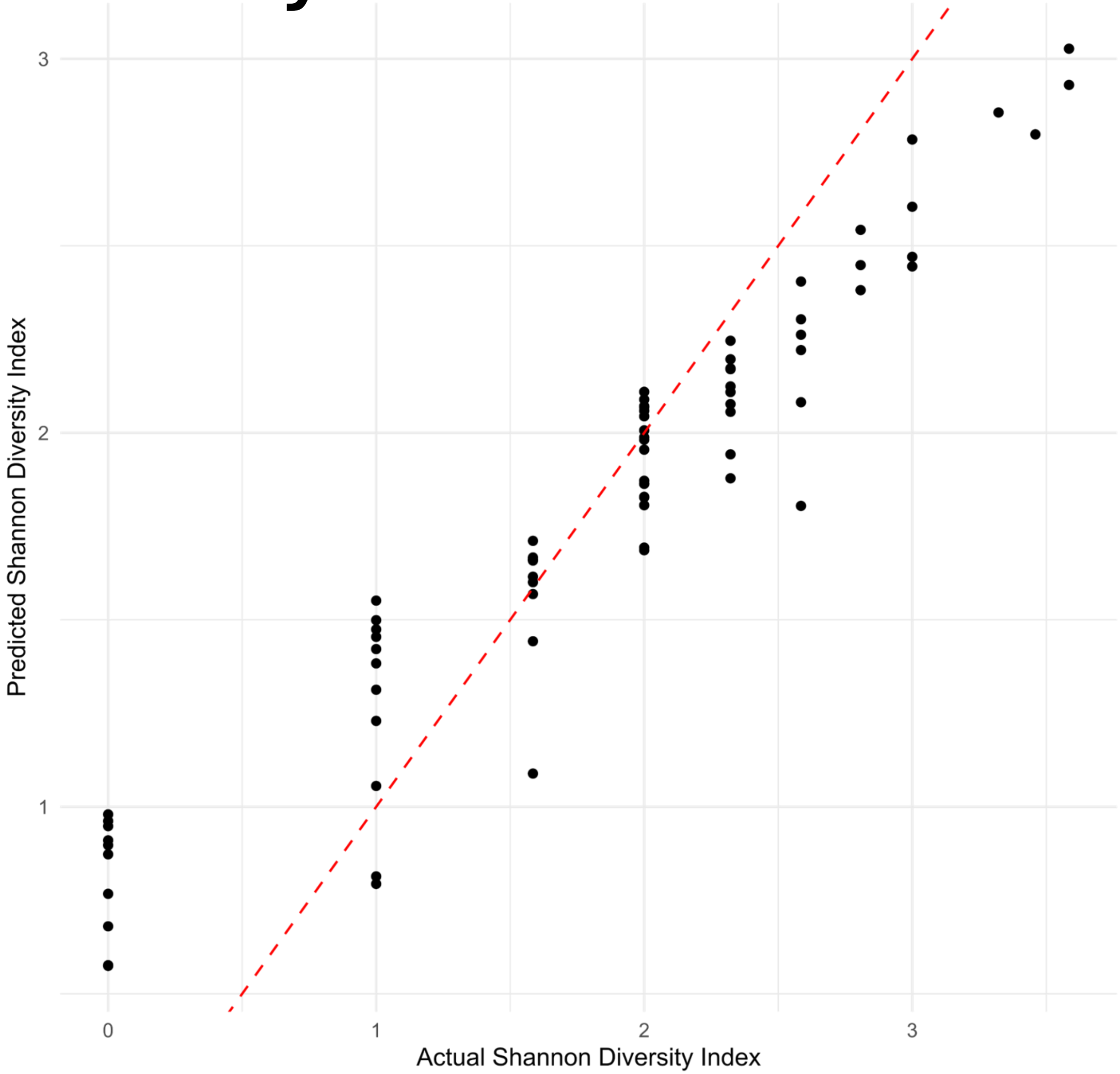


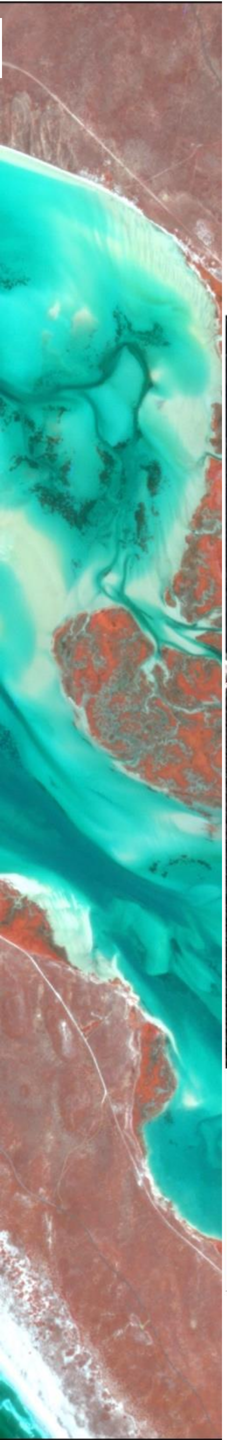


Predicting Shannon Diversity Index

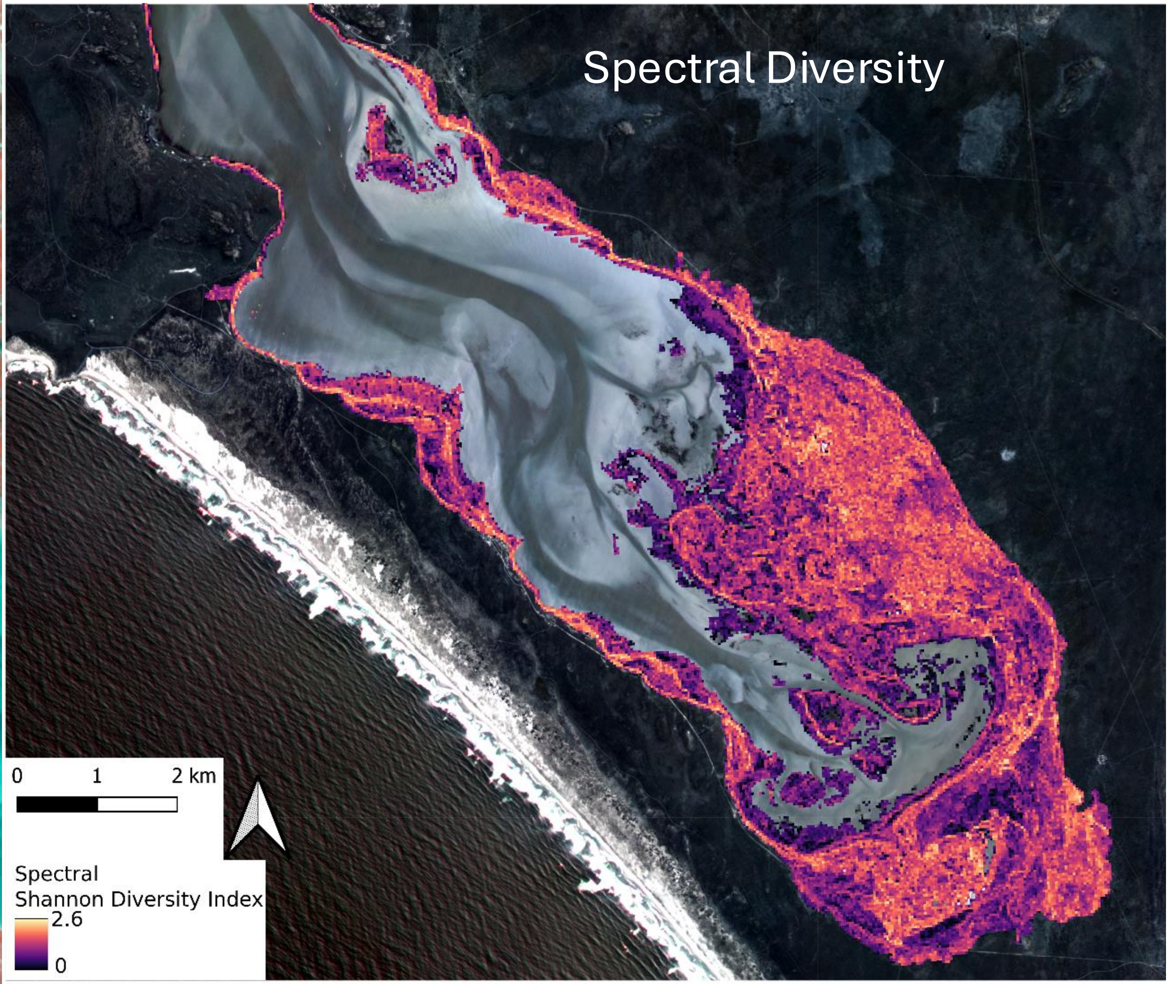
- Spectral diversity (Féret and Asner, 2014) alone did not capture the trend in Shannon diversity index seen in our plots
- ML algorithms did a good job but XGBoost overfit

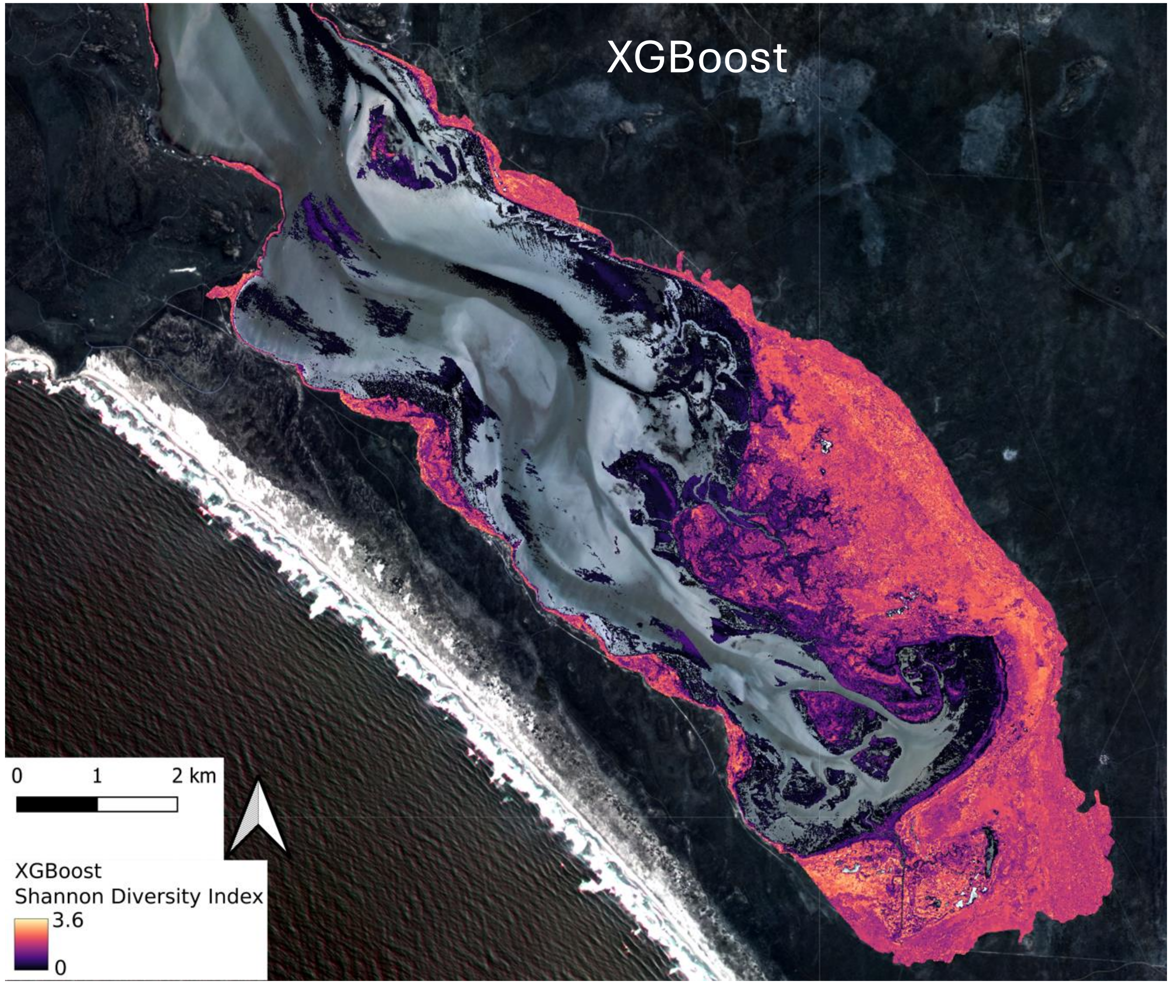
Model	RMSE	R^2	MAE
Spectral Diversity	1.14	0.0015	0.97
Random forest	0.42	0.91	0.32
Mean by Habitat (Salt marsh, SAV, Reeds & Sedges)	0.87	0.35	0.62
Multiple linear regression	0.78	0.30	0.617
XGBoost	**0.12**	**0.99**	**0.098**

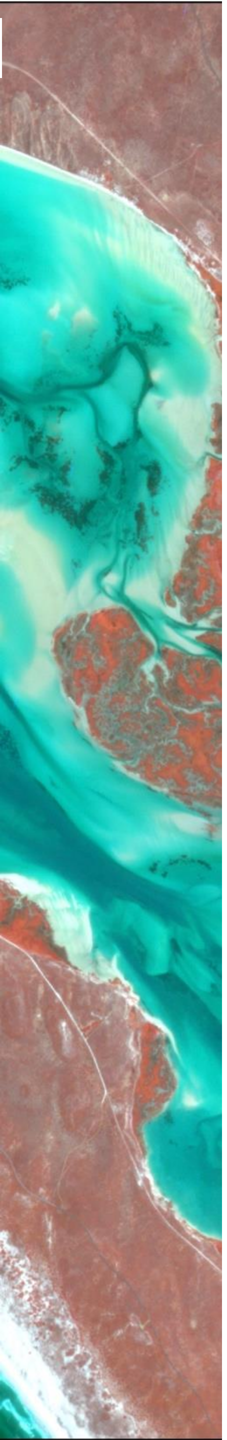




Shannon Diversity Index (Machine Learning vs Spectral)

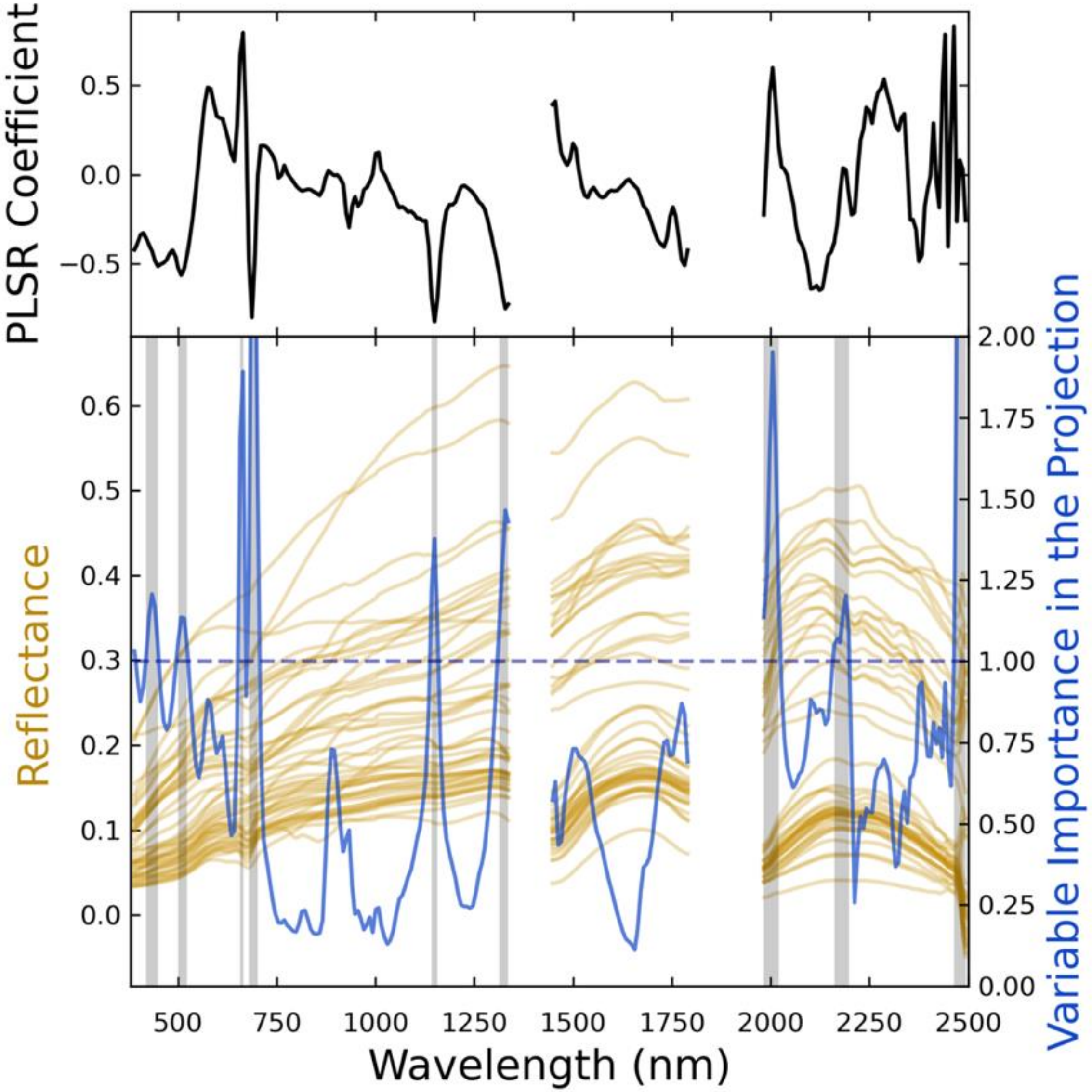




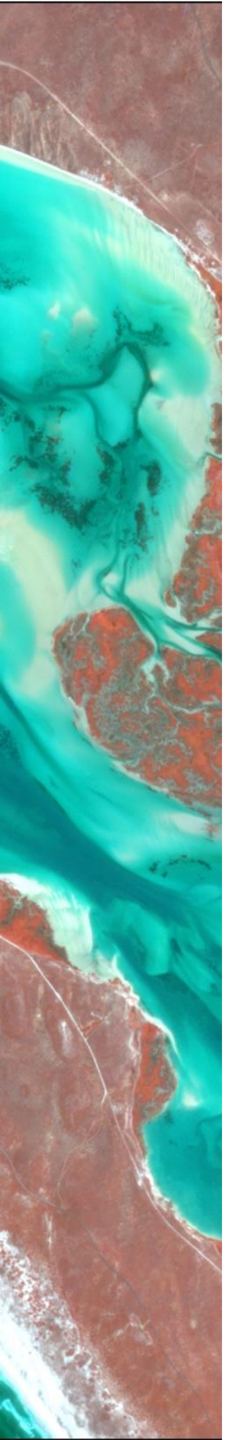


Salinity

- Data collected in Carpenteria, CA, salt marsh was used to train a partial least squared regression of spectra to salinity.
- Langebaan Lagoon data collected as part of our fieldwork was used to validate the salinity prediction.



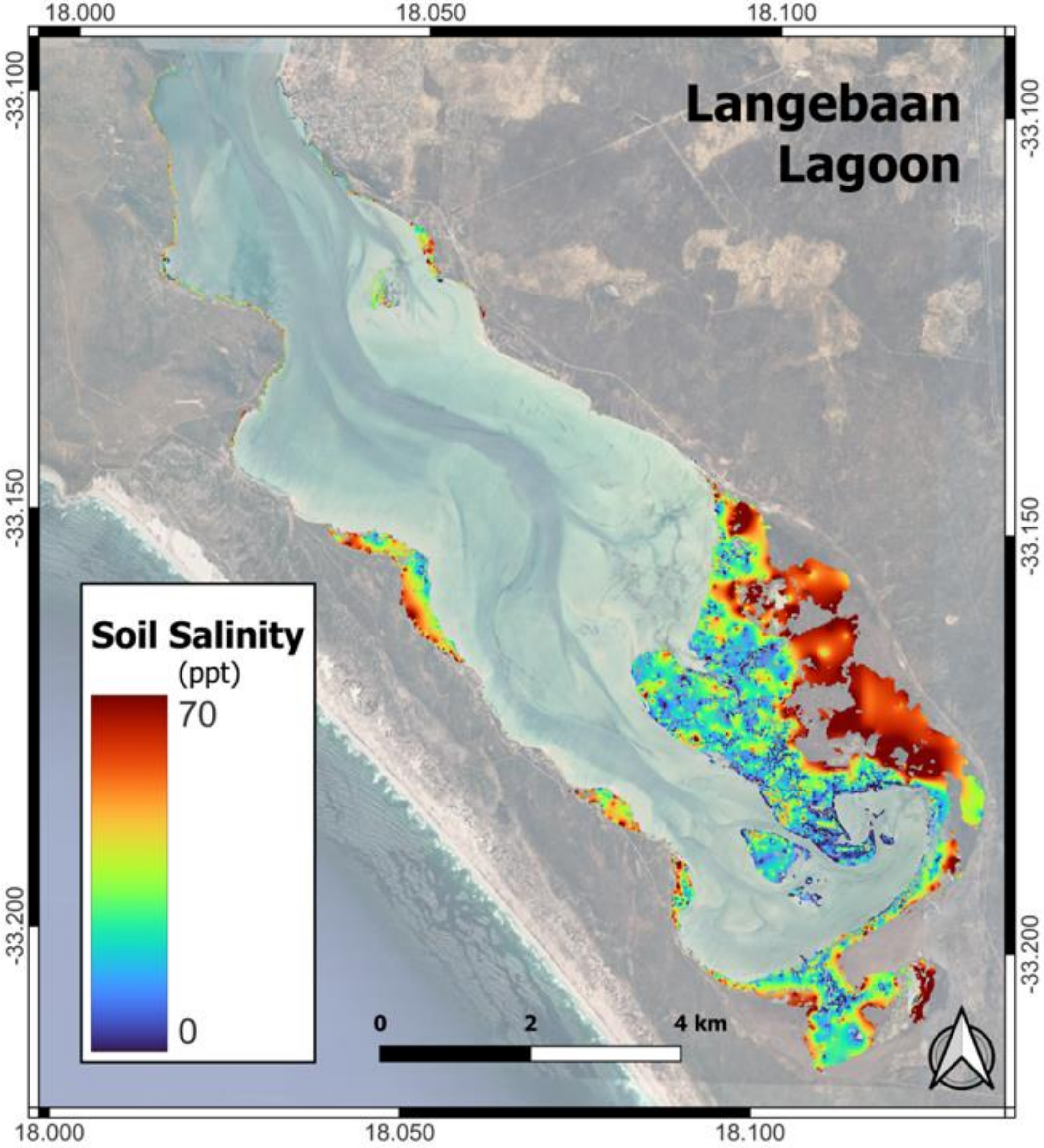
Jensen et al. *in prep*



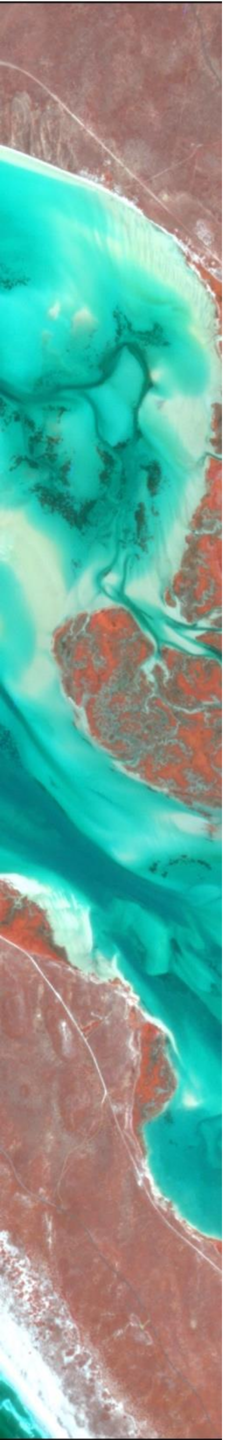
Salinity

Soil salinity (parts per thousand) derived from AVIRIS-NG across the Langebaan Lagoon.

- Predicted for locations with a soil fraction > 0.8.
- bilinear interpolation was used to estimate soil in vegetated regions of the salt marsh.



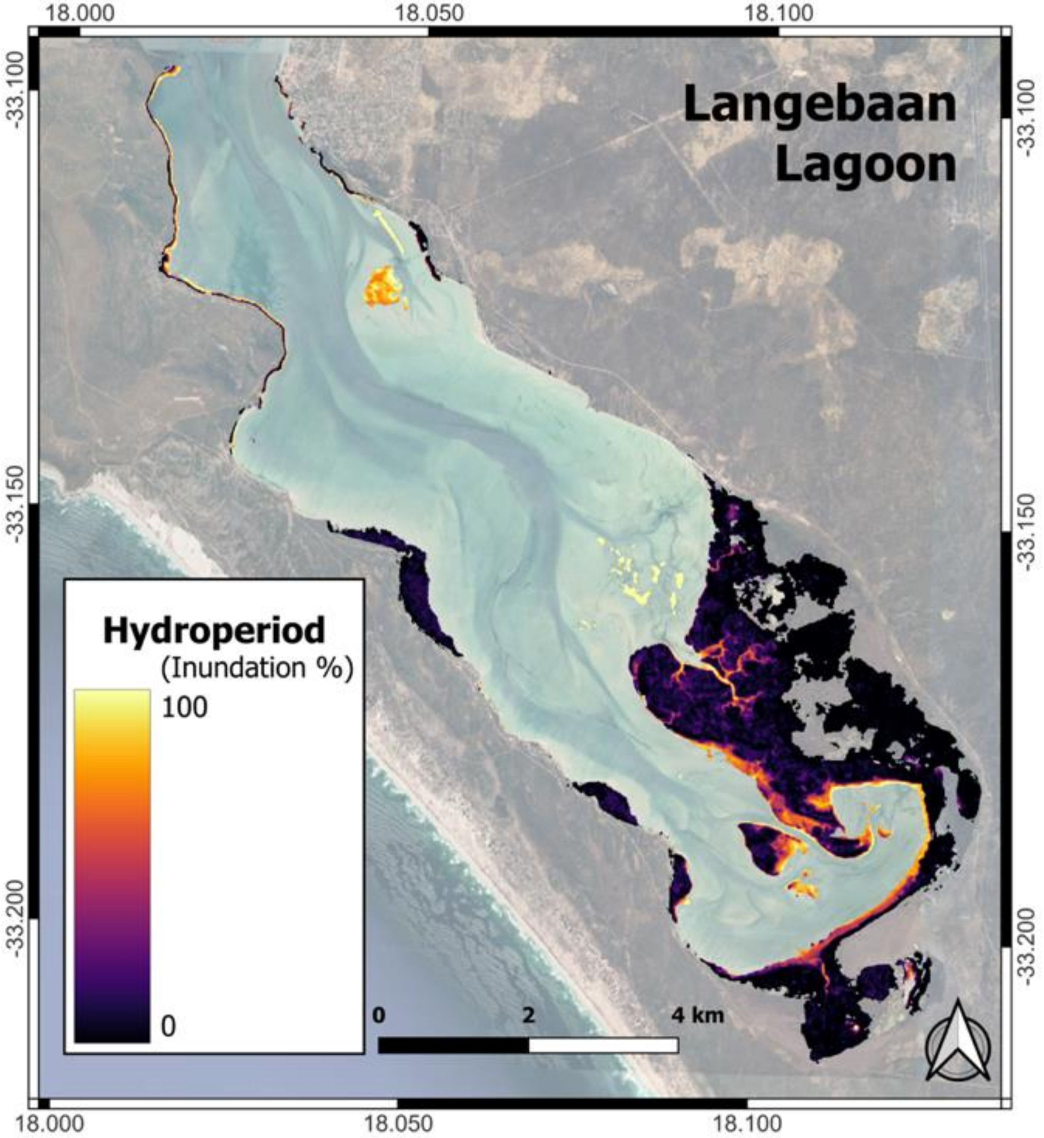
Jensen et al. *in prep*



Hydrological parameters

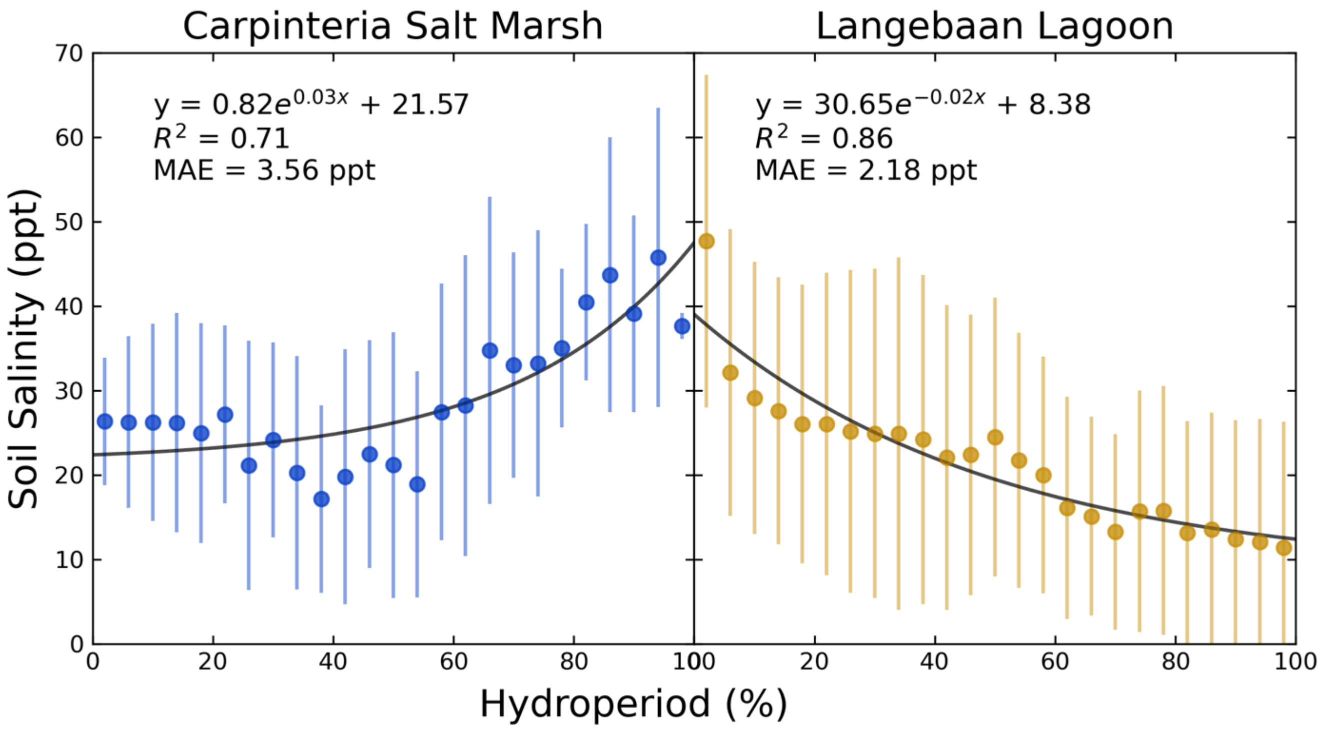
- Hydroperiod- Sentinel-1 Synthetic Aperture Radar archive used to determine % of observations with inundation.
- Hydrological modeling – integrating gauge data with bathymetry models to estimate the hydrological dynamics of Knysna estuary.

Jensen et al. *in prep*



Salinity by hydroperiod

- Hydroperiod (% time spent inundated) derived from Sentinel-1 across (a) the Carpinteria Salt Marsh Reserve and (b) the Langebaan Lagoon. Each point represents the mean salinity value for the given bin, with the bars representing the bin's standard deviation.



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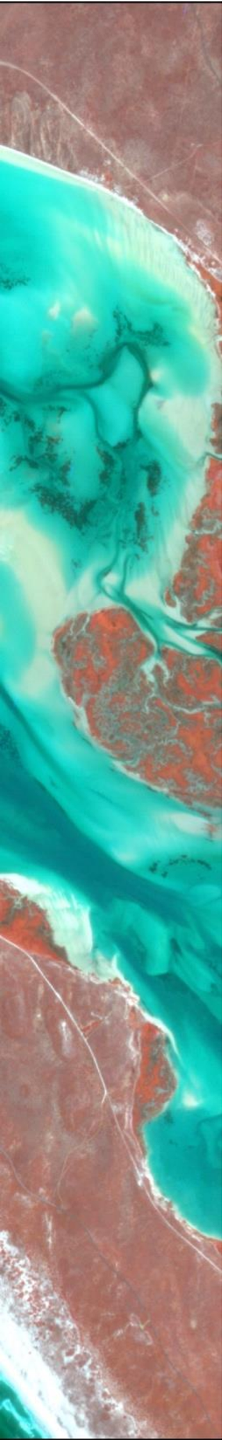
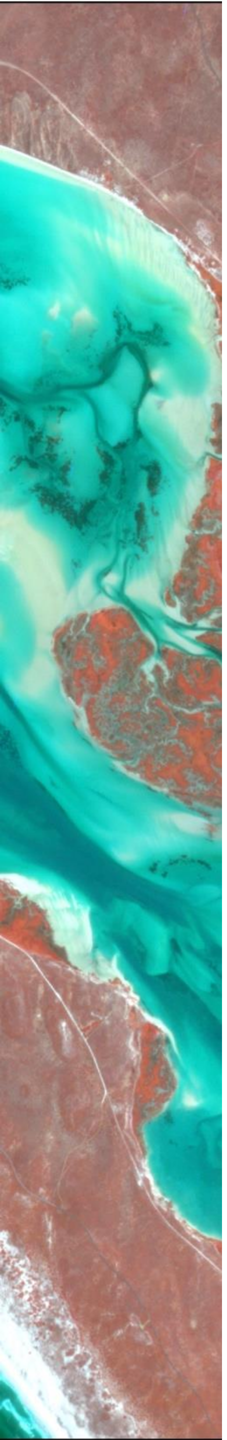
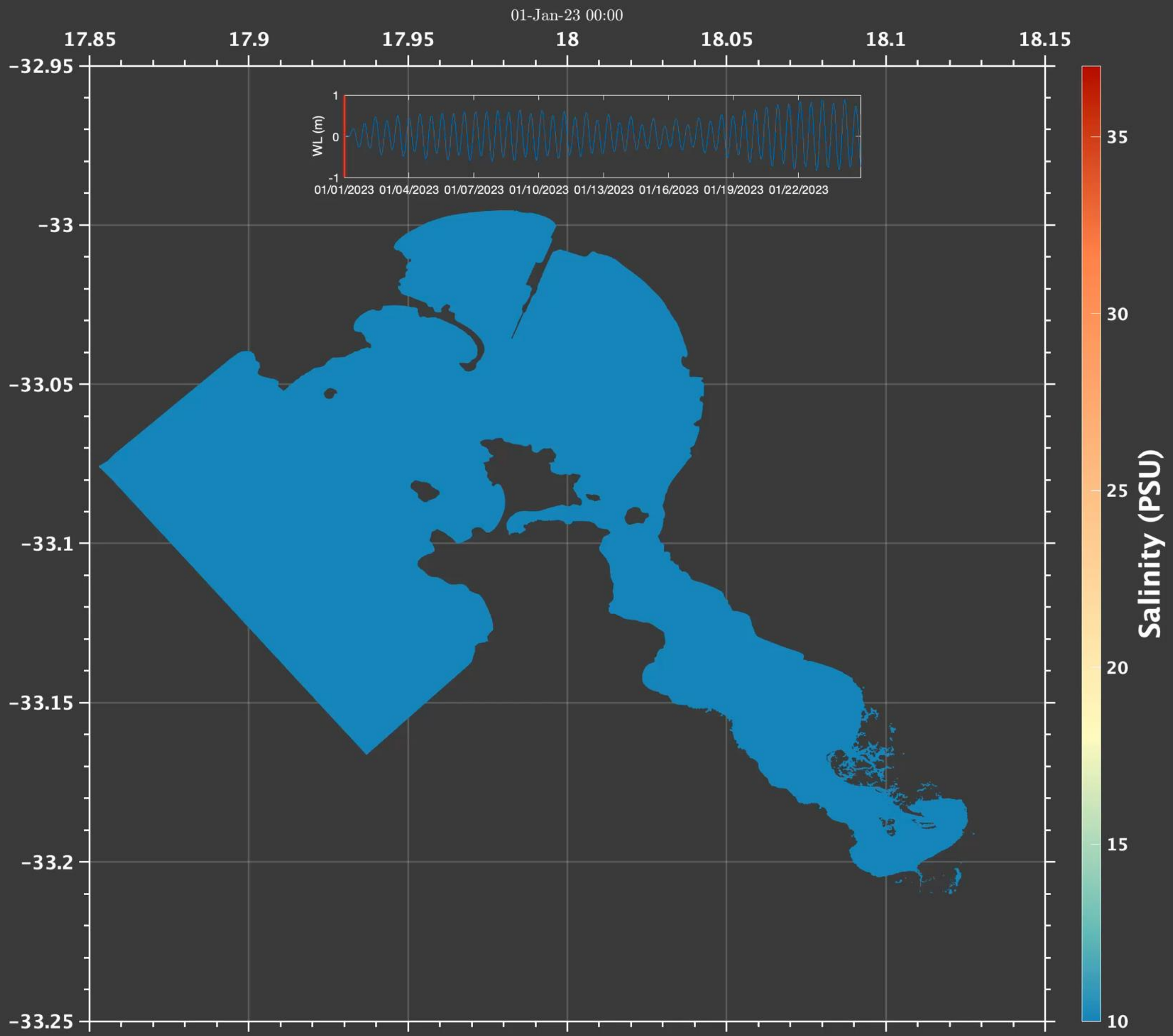


Bathymetry- Langebaan Lagoon



Hydrodynamic Mesh



01-Jan-23 00:00
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18
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-32.95
-33
-33.05
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-33.2
-33.25
WL (m)
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-1
01/01/2023
01/04/2023
01/07/2023
01/10/2023
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01/16/2023
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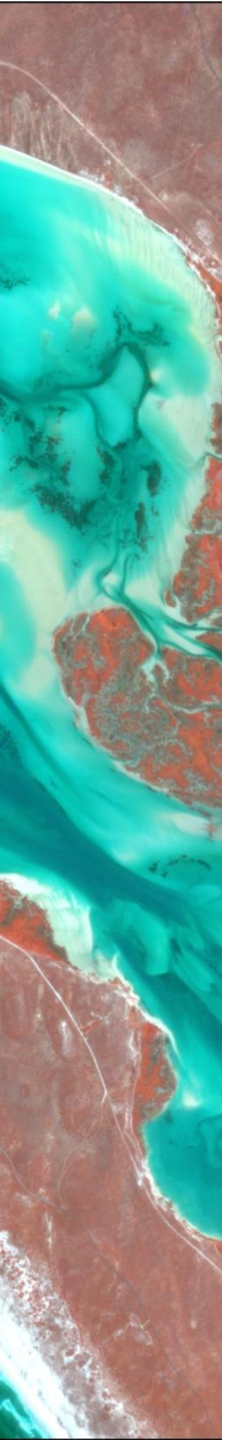
01/22/2023
Salinity (PSU)
35
30
25
20
15
10



Conclusions and next steps

- Salinity prediction method performed well from California to South Africa
- MESMA class prediction are informative for calculate a spatial high resolution shannon diversity index that improved on Spectral Diversity metrics in our study estuaries.
- Next steps
  - Apply MESMA to all estuaries
  - Analyze estuarine drivers (salinity, elevation and hydroperiod) relative to Shannon diversity index

Acknowledgements

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UNIVERSITY OF THE
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UNIVERSITY OF MARYLAND 1856

UMBC

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Touching lives through innovation

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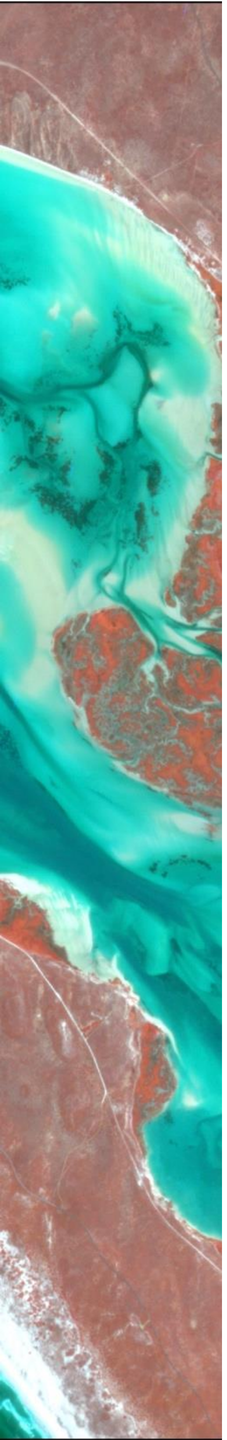

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