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Integrating Remote Sensing and Machine Learning for Ocean Plastic Litter Detection and Monitoring in South African Coastal Waters

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TECHNICAL SESSION 1

Integrating Remote Sensing and Machine Learning for Ocean Plastic Litter Detection and Monitoring in South African Coastal Waters

SHORT BIO

Tamuka is a Doctor of Engineering candidate at Cape Peninsula University of Technology. His research focuses on integrating satellite remote sensing and machine learning to detect and monitor ocean plastic litter, with the aim to contributing to environmental sustainability, marine policy, and South Africa's national Earth observation capabilities

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Presentation Outline

- Introduction, Problem Statement, & Research Aim
- Why Remote Sensing + Machine Learning?
- Workflow
- Spectral Signature Analysis of Plastics vs Environment
- Examples
- Spectral Indices for Floating Plastic Detection
- Expected Outcomes
- Contribution to National Space Dialogue
- Conclusion
- References

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Introduction, Problem Statement, & Research Aim

Problem:

- Plastic pollution in the ocean is a growing environmental issue.
- Millions of tonnes of plastic enter oceans yearly [1,2].

Challenge:

- Traditional detection methods lack accuracy and efficiency.

Aim:

- Remote sensing with machine learning for improved detection.

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Why Remote Sensing + Machine Learning?

- Large-Scale Surveillance
- High-Frequency Monitoring
- High Resolution Data options (Sentinel, PRISMA)
- Automated Detection via ML

IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received 17 October 2024, accepted 28 October 2024, date of publication 11 November 2024, date of current version 19 November 2024.

Digital Object Identifier 10.1109/ACCESS.2024.3494660

SURVEY

Comparative Review of Remote Sensing Methods for Ocean Plastic Litter Detection

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This work was supported in part by French-South African Institute of Technology (F'SATI) and African Space Innovation Centre (ASIC), Cape Peninsula University of Technology, South Africa.

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Workflow

Model Development and Evaluation 4

Train ML models (RF, SVM, CNN) using the selected features. Split Training / Validation data and use metrics

Feature Extraction & Selection 3

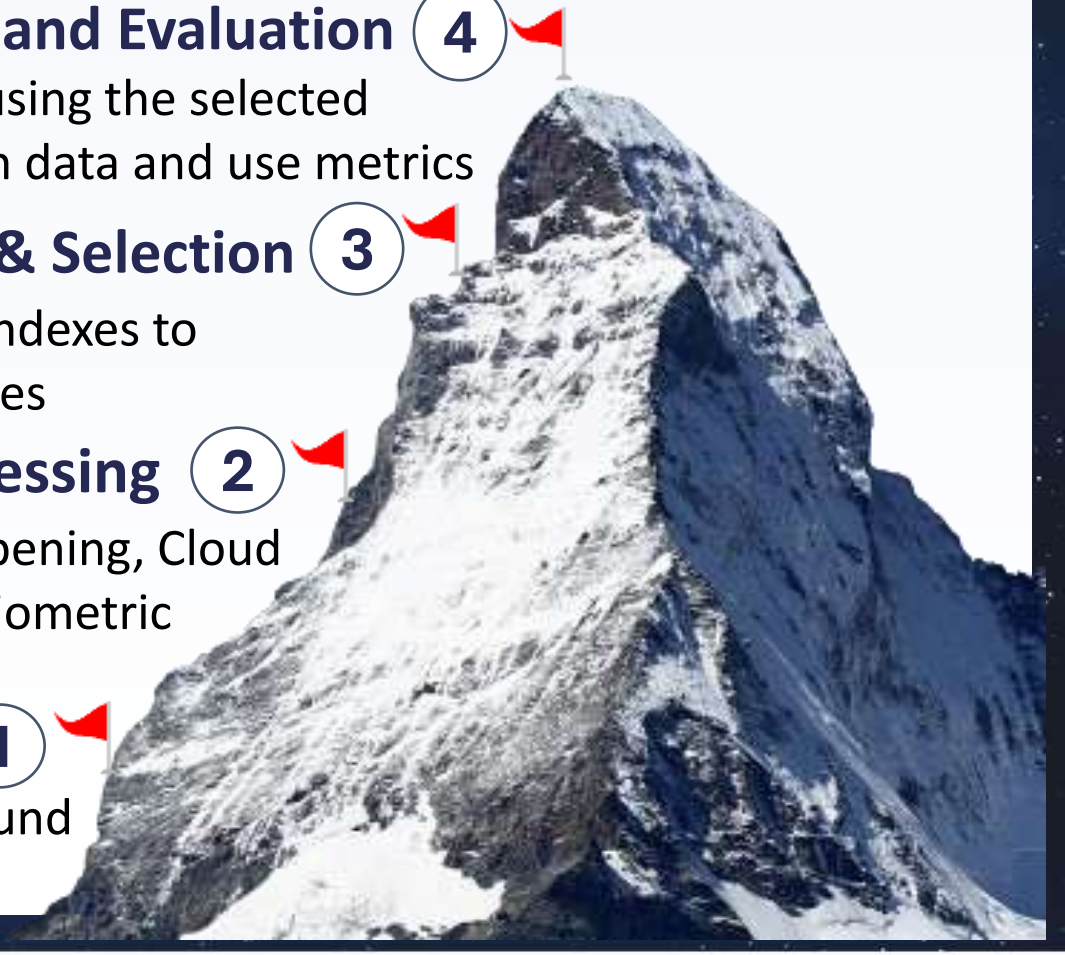
From spectral bands, generating indexes to choosing the most relevant features

Preprocessing 2

Atmospheric Correction, Pansharpening, Cloud masking, Sunglint correction, Radiometric calibration [4, 5, 6]

Data Collection 1

Satellite Sources + Ground Truth Data



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Spectral Signature Analysis of Plastics vs Environment

- Unique Polymer Signatures
- Water vs Plastic
- Plastic vs Vegetation
- Refs: [3, 4, 5, 7]

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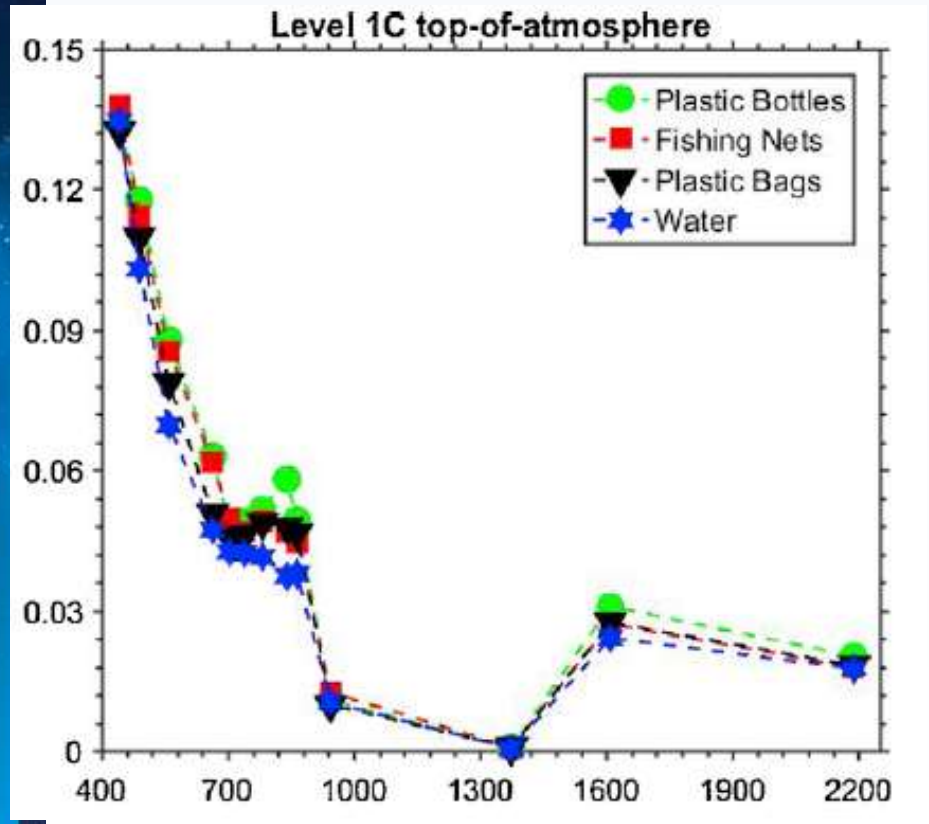
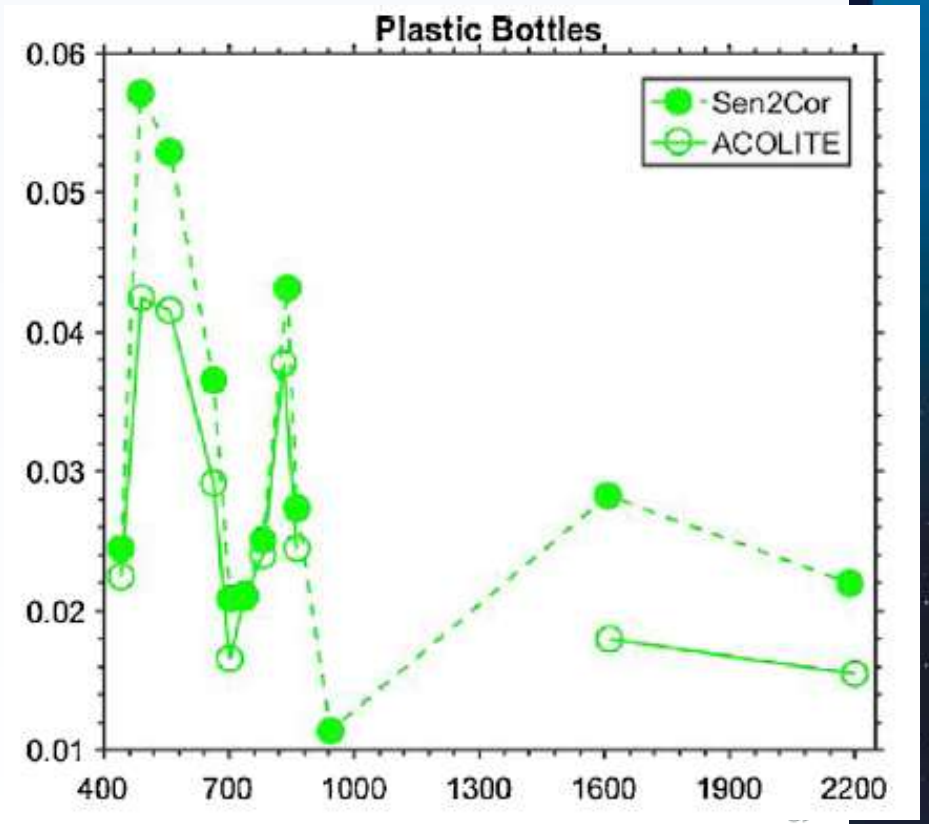
Example: Copernicus Sentinel [3]





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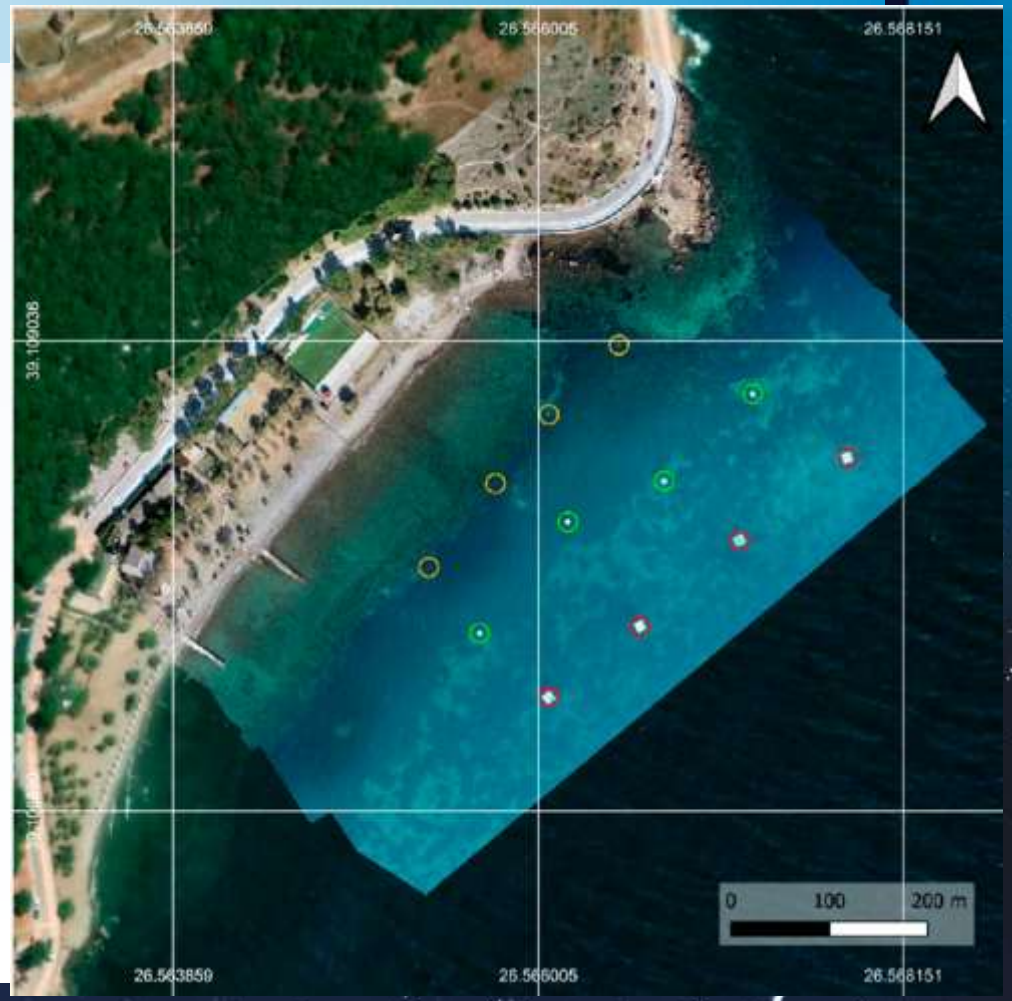
Example: PRISMA

Location:
Tsamakia Beach, Lesvos, Greece.

Targets:
12 Artificial floating plastics (HDPE, PET, PS, mixture; sizes 0.6m–5.1m).

Focus:
Largest targets (5.1m) to minimize pixel-mixing effects [4].



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Spectral Indices for Floating Plastic Detection

- Floating Debris Index (FDI) [8]
- Plastic Index (PI) [5]
- Normalized Difference Vegetation Index (NDVI) [8]
- Index Application Workflow: Compute indices on preprocessed images => Apply thresholds
- These indexed images can feed into ML classifiers as additional feature layers, significantly improving classification accuracy

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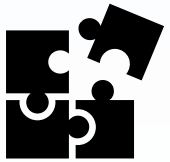
Expected Outcomes

- Improved detection accuracy of mesoplastics & macroplastics
- Enhanced distinction of plastics from natural debris
- Real-time monitoring potential using satellite revisit times
- GIS maps of plastic hotspots along SA coastlines



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Contribution to National Space Dialogue

Demonstrates earth observation for environmental sustainability

Supports marine policy & conservation strategies

Framework scalable to other African coastlines

Potential for real-time cleanup response

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Conclusion

- Integration of RS + ML can significantly improve detection & monitoring
- Scalable, automated framework is feasible for South African coastlines
- Bridges science, technology, and policy for ocean health
- Need for data or generate data for South African studies

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