Artificial Intelligence approach for ships detection from satellite imagery

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1. Introduction

SDGs with Ocean

How does Space Applications linked to SDGs

Asia-Pacific Plan of Action

on Space Applications for Sustainable Development (2018-2030)

(a) disaster risk reduction and resilience
(b) **natural resource management**
(c) connectivity
(d) social development
(e) energy
(f) climate change





[ncc.com]



[statista]

➔ **Space application enable resource management in wide ocean**

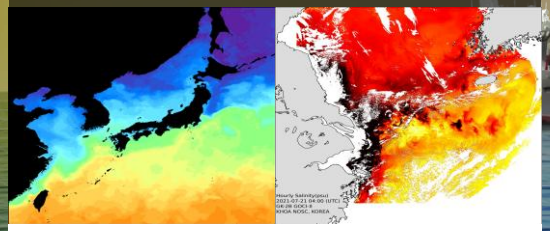
Requirement for ocean monitoring

What is required to implement Space Application on Ocean

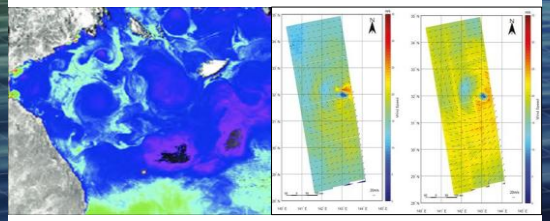




Ocean



Sea Temperature | Sea Salinity

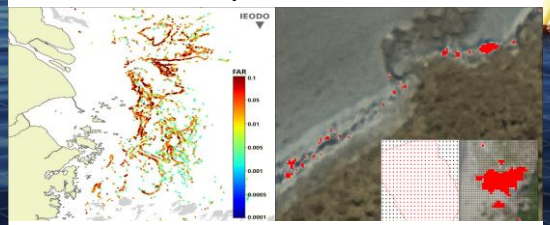


Chlorophyll-a | Sea Wind

Coast

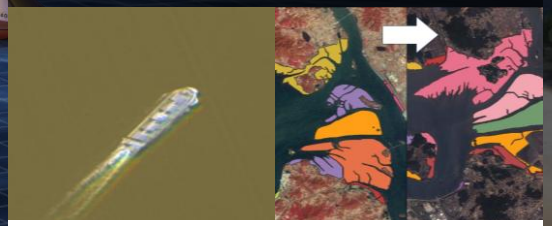


Aquaculture



Sargassum | Marine Debris

Port and Waterfront

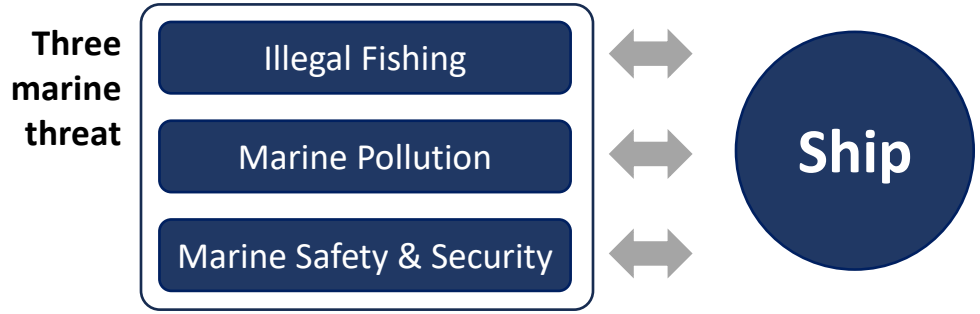


Ship Detection | Tidal flat

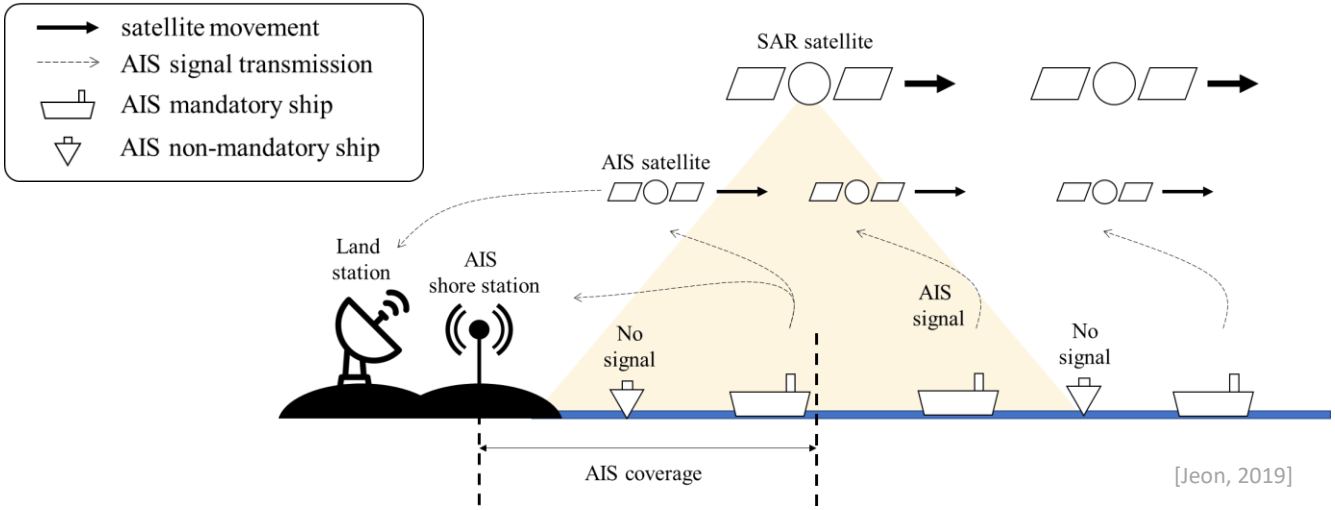
➔ The key is Digital Innovation with Satellite & AI

Reason of Ship Detection with Satellite

(why ship) the three marine threat issues are related to ship



(why satellite) limitation of current ship monitoring measurement



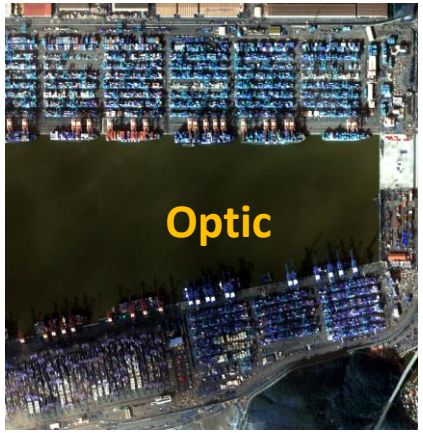
➔ Satellite based ship detection contribute to treating marine threat

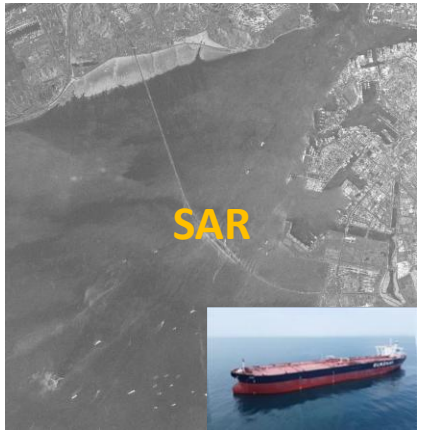


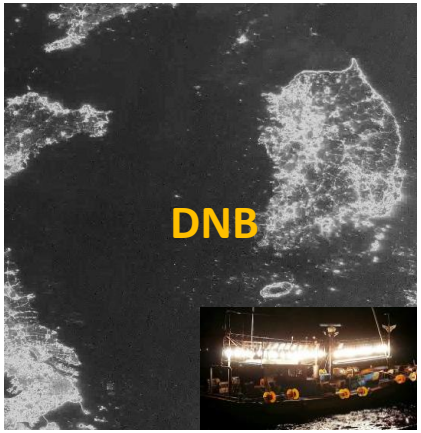
2. Satellite Data Type

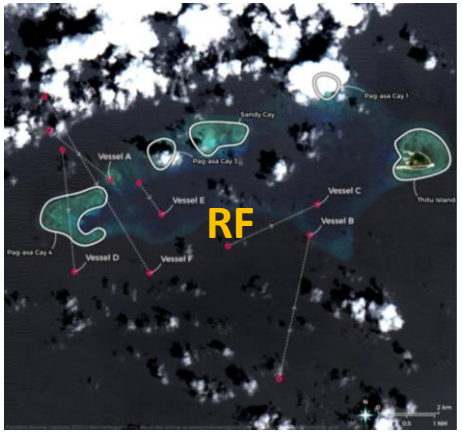
Satellite Data Type

What data are used in ship detection









- SAR : Synthetic Aperture Radar
- DNB : Day & Night Band
- RF : Radio Frequency

	Optic	SAR	DNB	RF
Resolution	High	High	Low	-
Night	Unavailable	Available	Available	Available
Cloud	Unavailable	Available	Unavailable	Available
Noise	Low	High	Low	-

➔ Feature of sensor & ship must be considered for effective detection



3. Ship Detection

with AI & statistics

Faster R-CNN

Ship Detection with Deep Learning × Optic

Result : Commercial Satellite Imagery (Sep. 27, 2023 by Black Sky)



➔ Fine resolution, but expensive to regular monitoring

Faster R-CNN

Ship Detection with Deep Learning × Optic

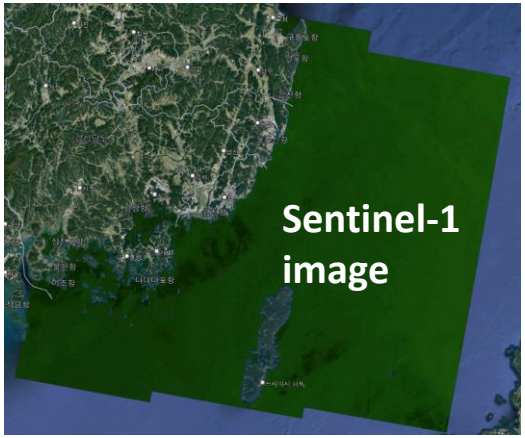
Result : Free Satellite Imagery (Dec. 30, 2023 by Sentinel-2)

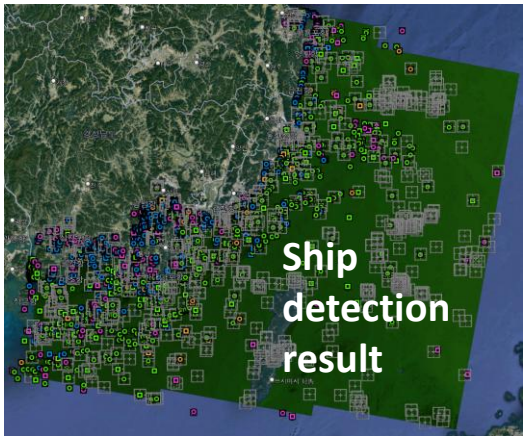


➔ Low resolution, but freely available ➔ Sustainable

Ship Detection with Statistics × SAR Threshold

Result : SAR & AIS convergence information





SAR information



AIS information



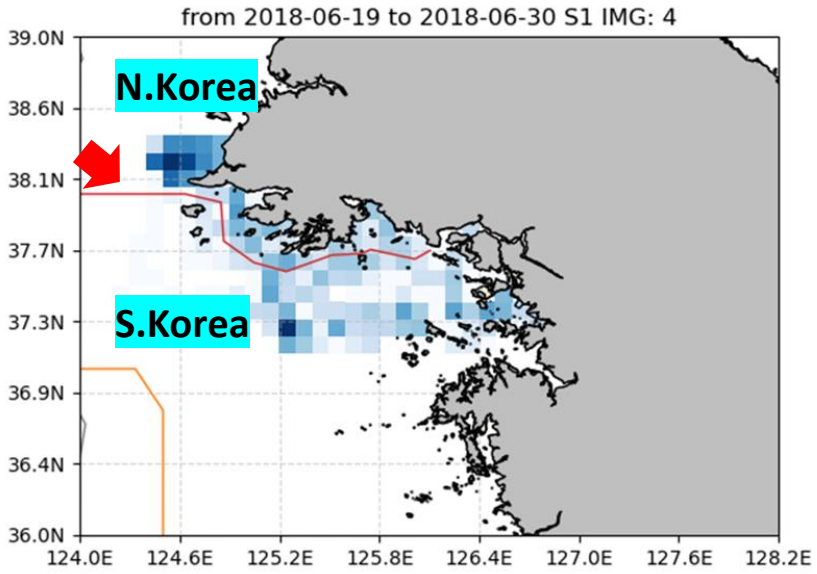
SAR AIS Dead Reckoning

➔ Convergence data provide detailed ship information

Ship Detection with Statistics (Threshold) × SAR

Result : Wider coverage for marine domain awareness

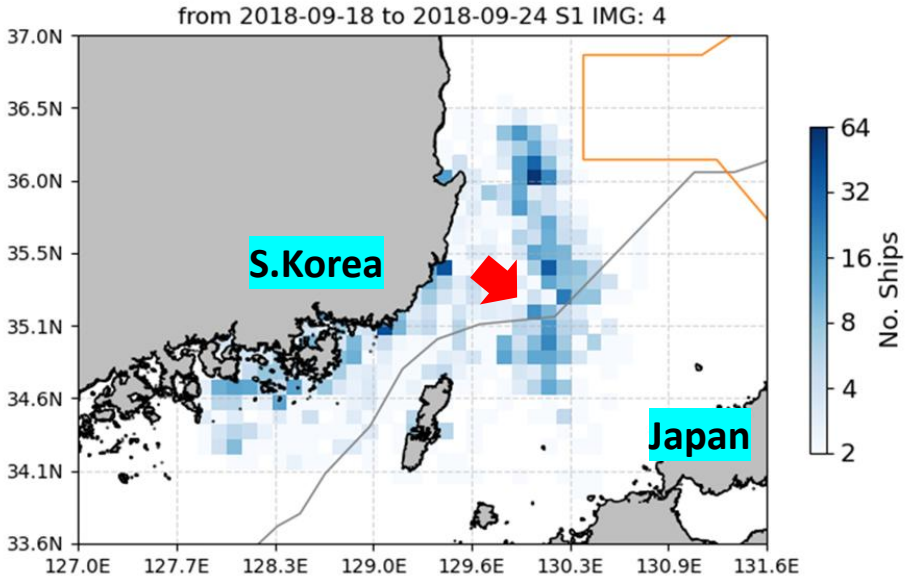
☐ **Border between South & North Korea**



Military demarcation line

Korea-China provisional measures water

☐ **Border between South Korea & Japan**



(virtual) EEZ

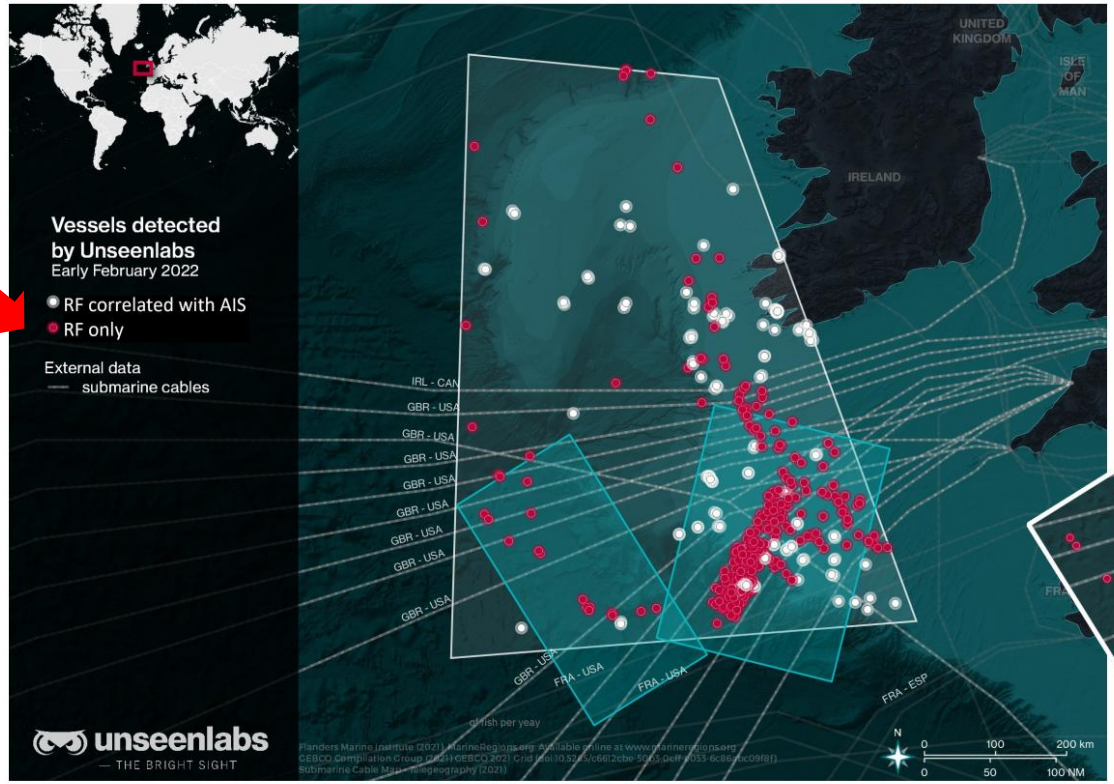
Korea-Japan intermediate water

➔ **Monitoring beyond border line release information gap**

Illegal Ship Detection with RF sensor

Result : Dark vessel detection with RF×AIS

☐ **Enlightening potential risk activity on Irish coast**



February 2022 | RF data collection - Celtic Sea
Single coverage: 338,121,236 km²

424 RF signals coming from ships were detected in this zone, but only 91 ships were officially emitting AIS signals.

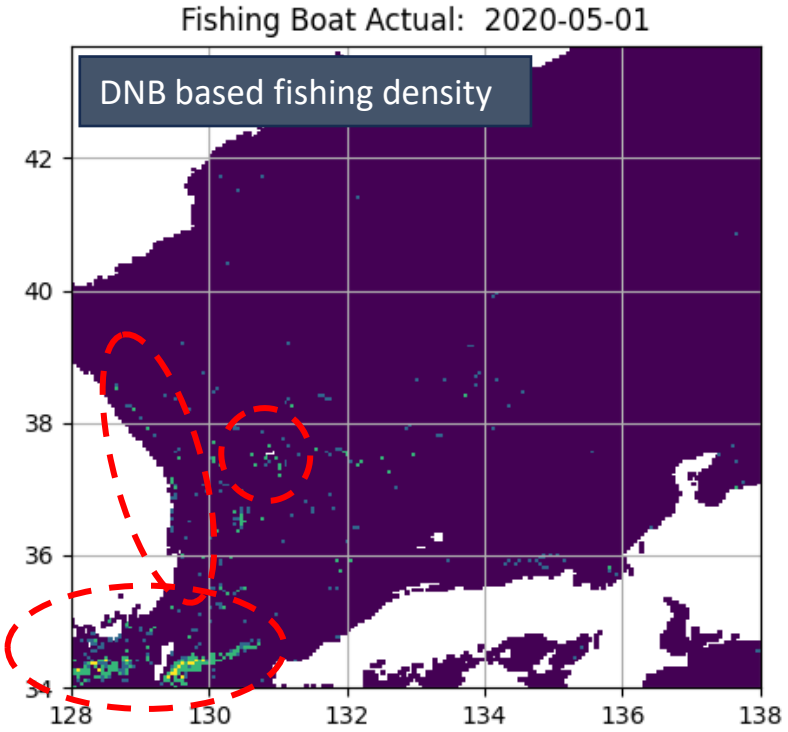


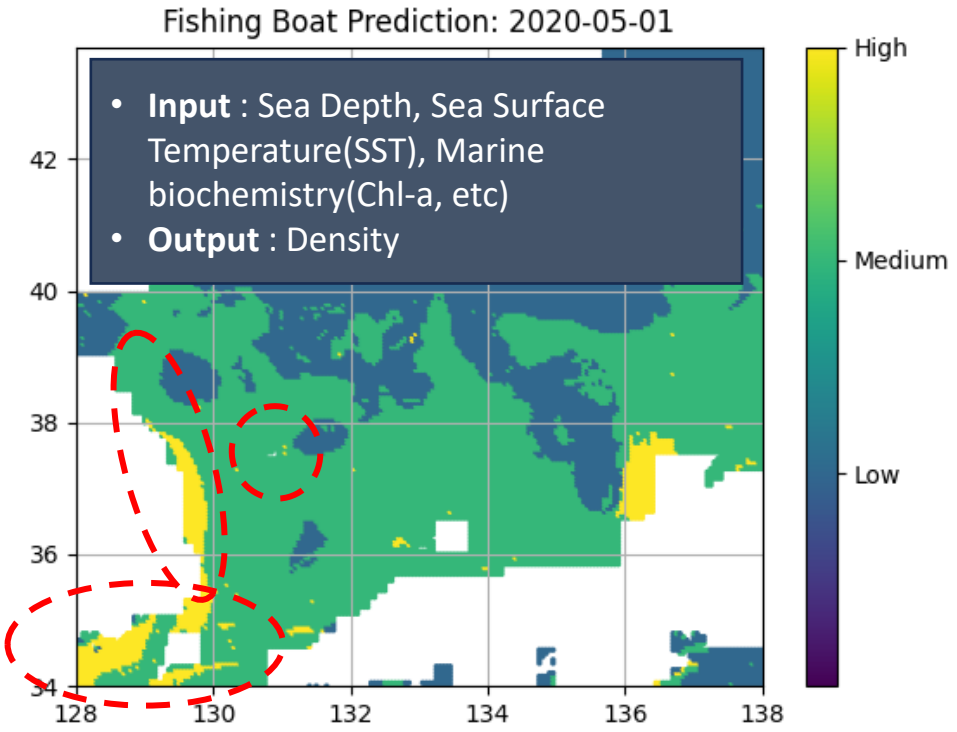
[Unseenlab white paper]

➔ Dark vessel is distinguished from innocent vessels

Fishing Density Estimation with Random Forest Machine Learning × DNB

Result : Fishing density of actual & model prediction





Density	High	Medium	Low
High	6	1	0
Medium	1	44	1
Low	0	0	17

Accuracy: 0.96
F-1 score: 0.93

➔ **Trained model shows potentiality to estimate fishing density**



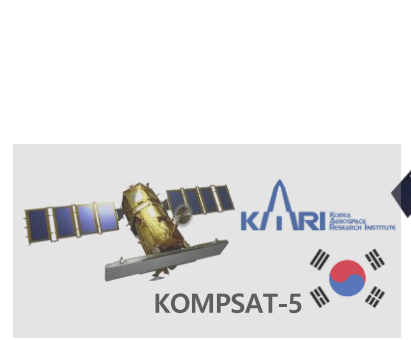
4. Application to Overseas

Tanzania ODA Project

SAR Ship Detection

☐ **Problems from ships**

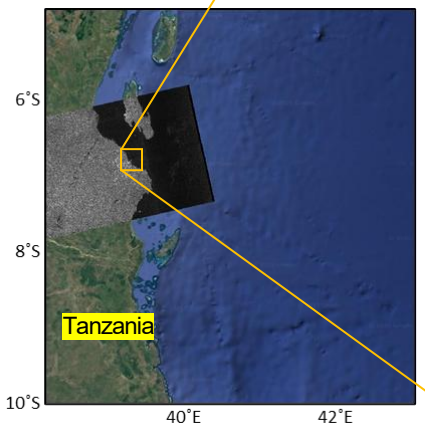
- Use of small mesh nets and dynamite fishing leads coral reef destruction and declining fish stocks
- Cargo ships emission leads air pollution

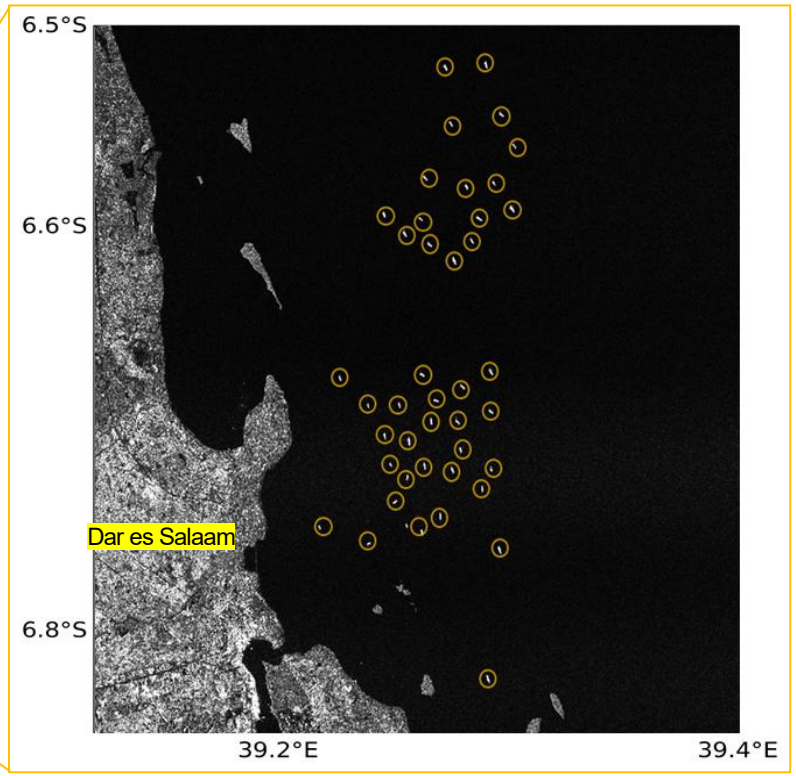






[National Geography]





➔ **SAR ship detection produce basic information for ship activities**

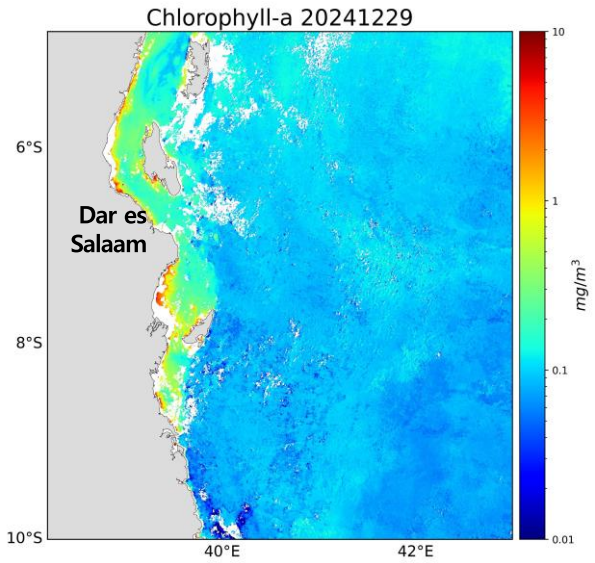
Tanzania ODA Project

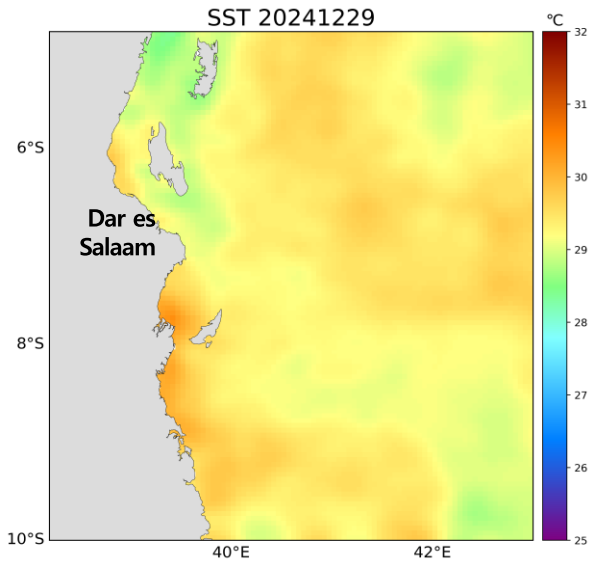
Chlorophyll-a & sea surface temperature production

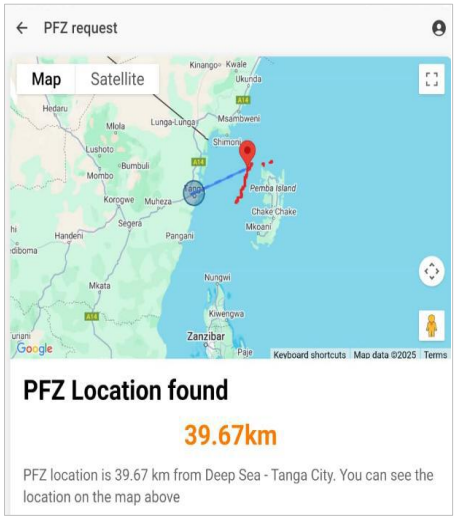
☐ **Potential Fishing Zone (PFZ)**

- Chlorophyll-a & sea surface temperature(SST) are essential to derive PFZ

NOAA-20 | NOAA Suomi-NPP | MODIS | Multi-Platform CubeSAT







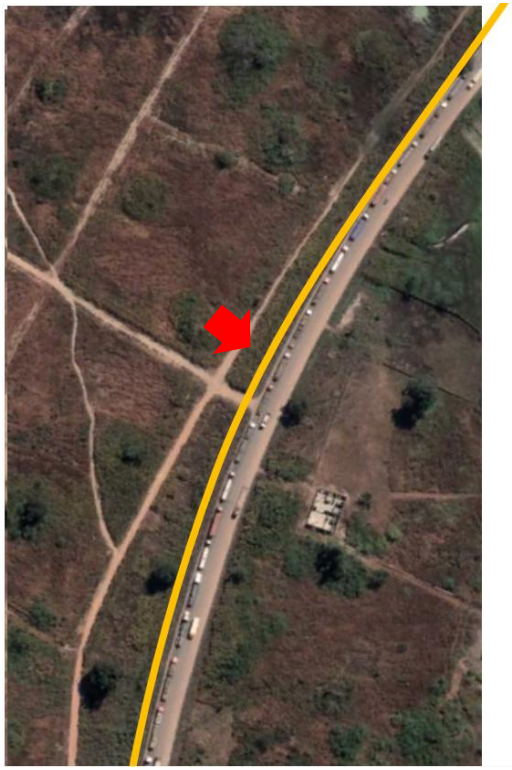
➔ Chl-a & SST production contribute to PFZ derivation

Supply Chain Monitoring

Truck congestion between Congo and Zambia

☐ **Truck congestion related to the expansion work of the border post parking lot**

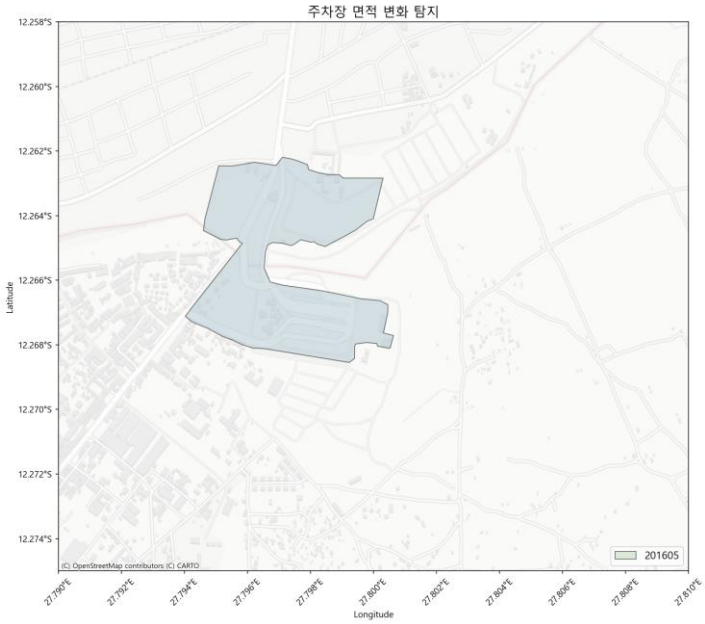
- Confirmation of truck in satellite imagery
- Time-series analysis on correlation between parking lot's expansion and congestion



Before expansion. Jun. 2018



After expansion. May. 2019



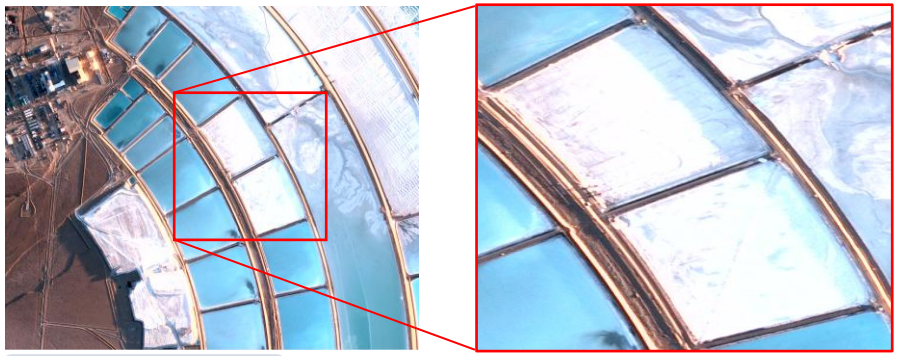
Parking lot expansion

➔ **Satellite imagery contribute to intuitive field confirmation**

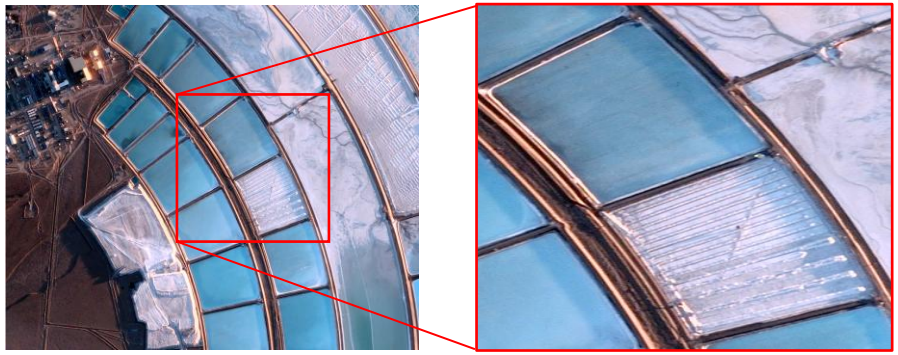
Supply Chain Monitoring

Lithium mine shipment forecast

May 11, 2023



May 24, 2023



[Time-series monitoring of brine lake in lithium mine]



특허증
CERTIFICATE OF PATENT

특 허 Patent Number 제 10-2656376 호

출원번호 Application Number 제 10-2023-0108115 호

출원일 Filing Date 2023년 08월 18일

등록일 Registration Date 2024년 04월 05일

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인공위성 영상 이미지 분석을 통한 리튬 광산 모니터링 시스템 및 그 방법

특허권자 Patentee
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인천광역시 연수구 갯벌로 129, 503호 (송도동,산업기술연구집적센터)

발명자 Inventor
등록사항란에 기재

위의 발명은 「특허법」에 따라 특허원부에 등록되었음을 증명합니다.
This is to certify that, in accordance with the Patent Act, a patent for the invention has been registered at the Korean Intellectual Property Office.

2024년 04월 05일

특허청
Korean Intellectual Property Office

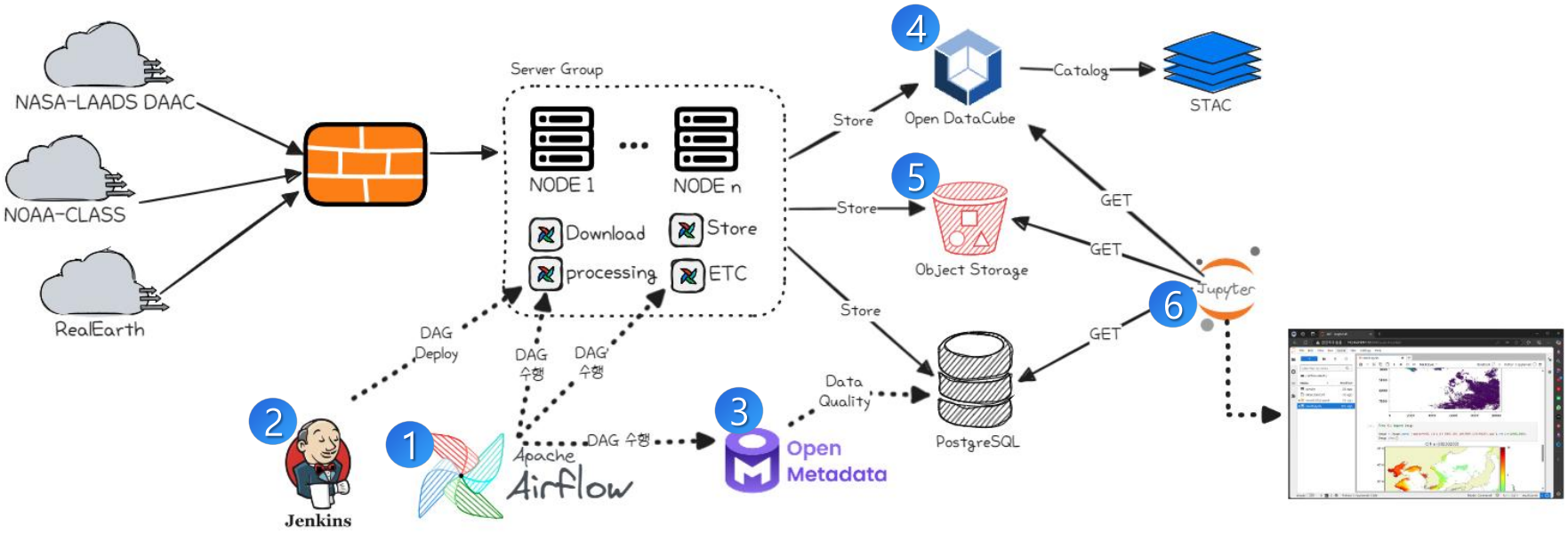
특허청장
COMMISSIONER,
KOREAN INTELLECTUAL PROPERTY OFFICE

[Patent in Korea]

➔ Satellite enable monitoring of production sites in supply chain

Data Management System

Life-Cycle Data Management



1	Pipeline management using Airflow
2	Automated DAG deployment using Jenkins
3	Data validation using OpenMetadata
4	GIS data management using Open Data Cube
5	Large file processing using MinIO
6	Data analysis using Jupyter Notebook

➔ Automated data management is required



5. Conclusion

Summary & Conclusion

SDGs & ship detection by satellite

- Marine resource management requires proper measurement
- Wide ocean area has ship related marine threats
- Satellite's active and wide feature is adequate to monitor ocean status

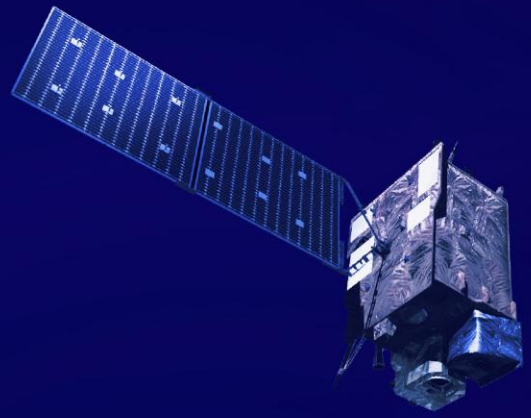
Ship detection method

- Ship detection needs consideration for feature of satellite sensors and ships
- Sustainable monitoring can be made when the cost of data & equipment are satisfied
- Ship detection result & marine biochemistry data can be utilized to estimate ship density

Application to overseas

- Ship detection results is the basic information for marine use
- Satellite based Chl-a & SST production contribute to deriving potential fishing zone in Tanzania
- Satellite also can be used for supply chain monitoring
- Automated data management system is required for sustainable use of satellite-based monitoring system

➔ Sustainable marine use is from satellite technical innovation



Thank you

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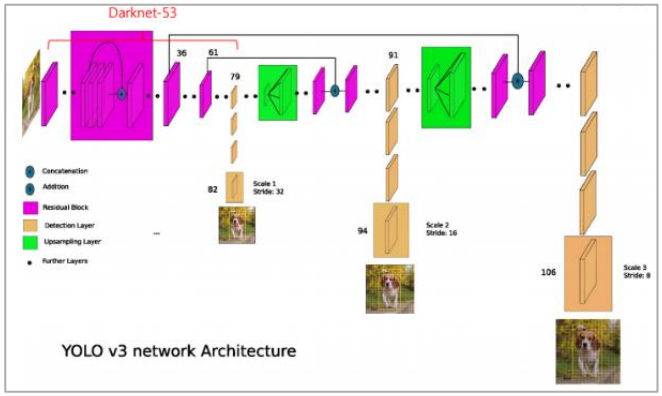




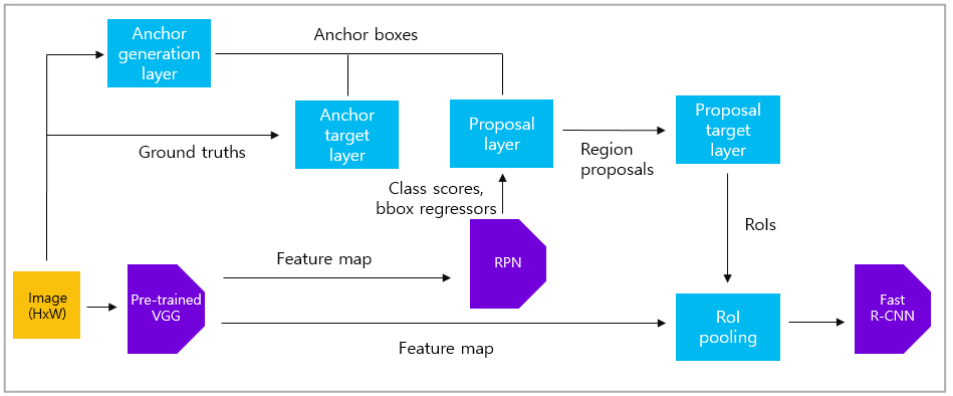
Ship Detection with Deep Learning × Optic

Method : Model comparison & Selection

YOLOv3



Faster R-CNN



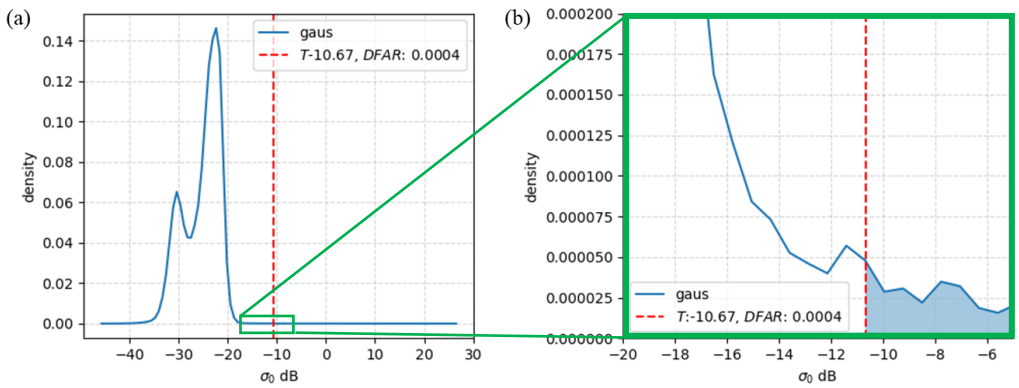
Model	YOLOv3	Faster R-CNN
Speed	Fast	Slow
Accuracy	Middle High	High
Complexity	Simple	Complex
Small Object Detection	Low	High
Recognition from background	Low	High
Feature	Low Accuracy but High Speed Detection ➔ Realtime Detection	Low Speed Detection but High Accuracy ➔ Satellite Image Detection

➔ Selected Faster R-CNN has higher accuracy than YOLOv3

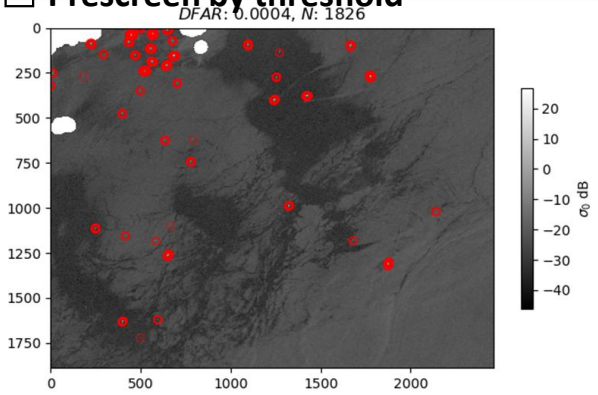
Ship Detection with Statistics × SAR

Method : Prescreening ship candidates

☐ **KDE based threshold derivation**

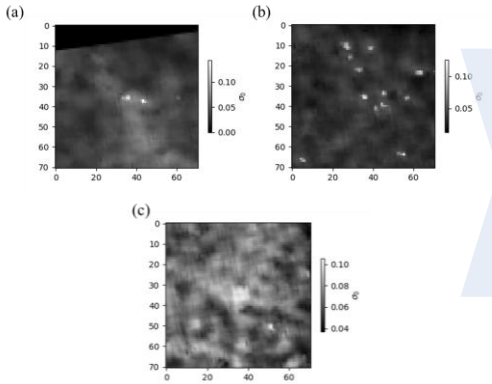


☐ **Prescreen by threshold**

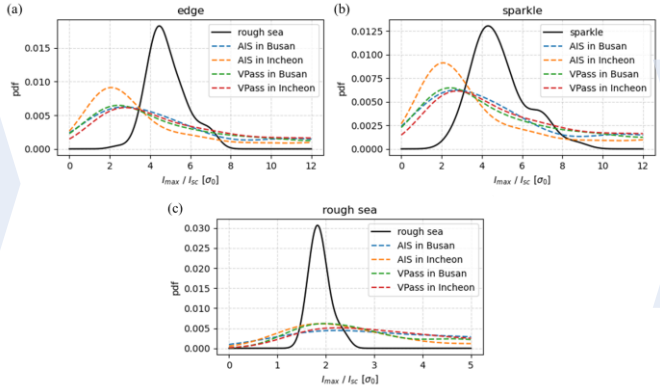


Method : Discrimination ship pixel from noise

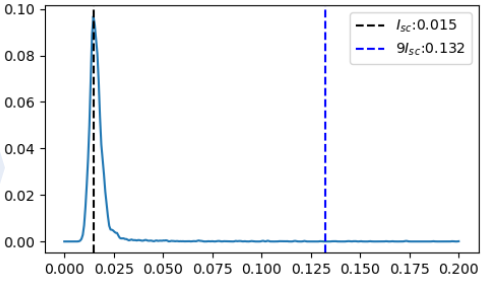
☐ **Noise type**



☐ **Statistical analysis for noise type**



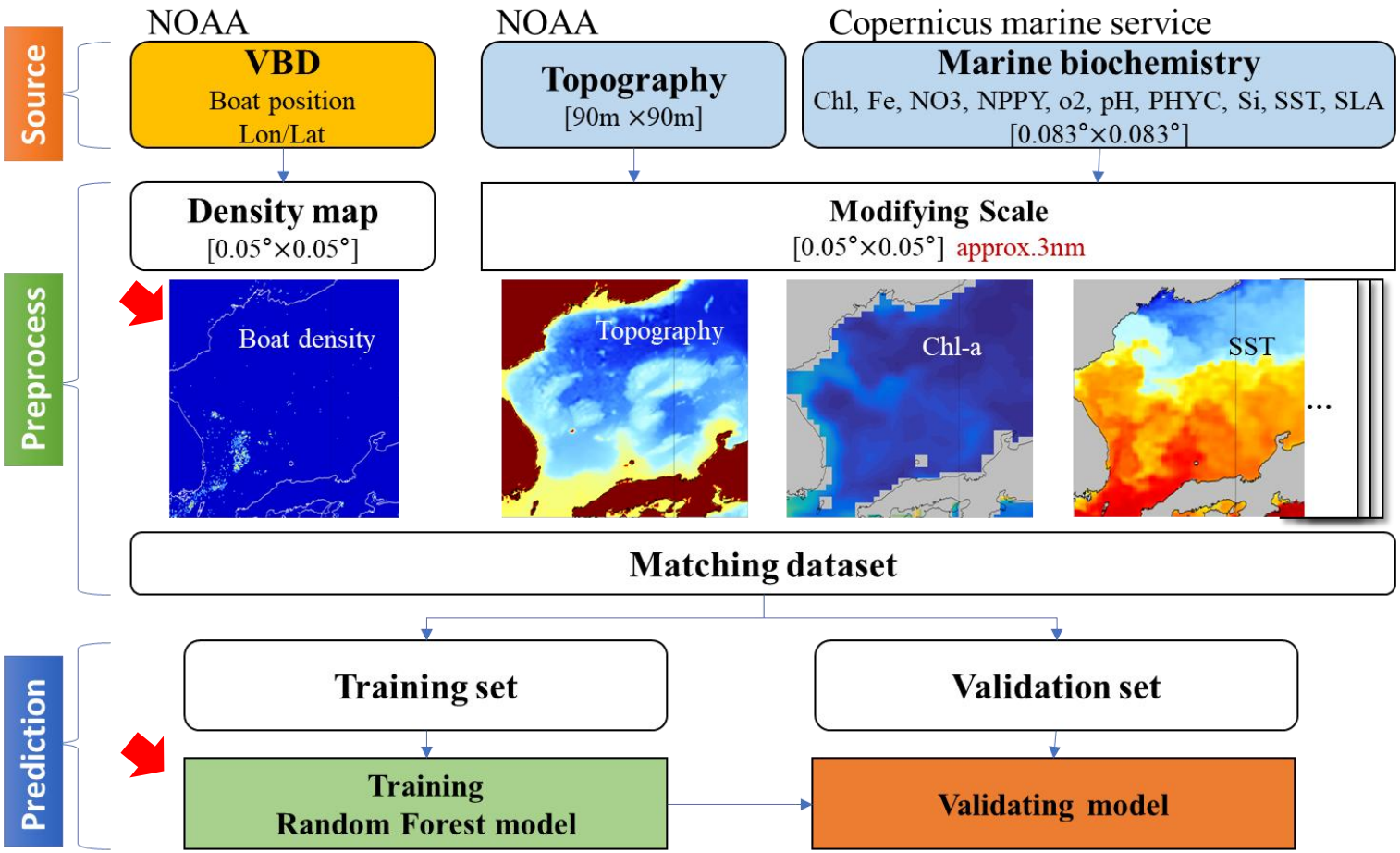
☐ **Threshold avoid noise**



➔ **Stepwise threshold method is time-efficient for ship detection**

Fishing Density Estimation with Machine Learning × DNB

Method : Data & model all about



➔ Various elements affect fishing density and require ensemble