Application of Multisensory Remote Sensing for Controlling Illegal, Unreported, and Unregulated (IUU) Fishing Activities: Project Overview

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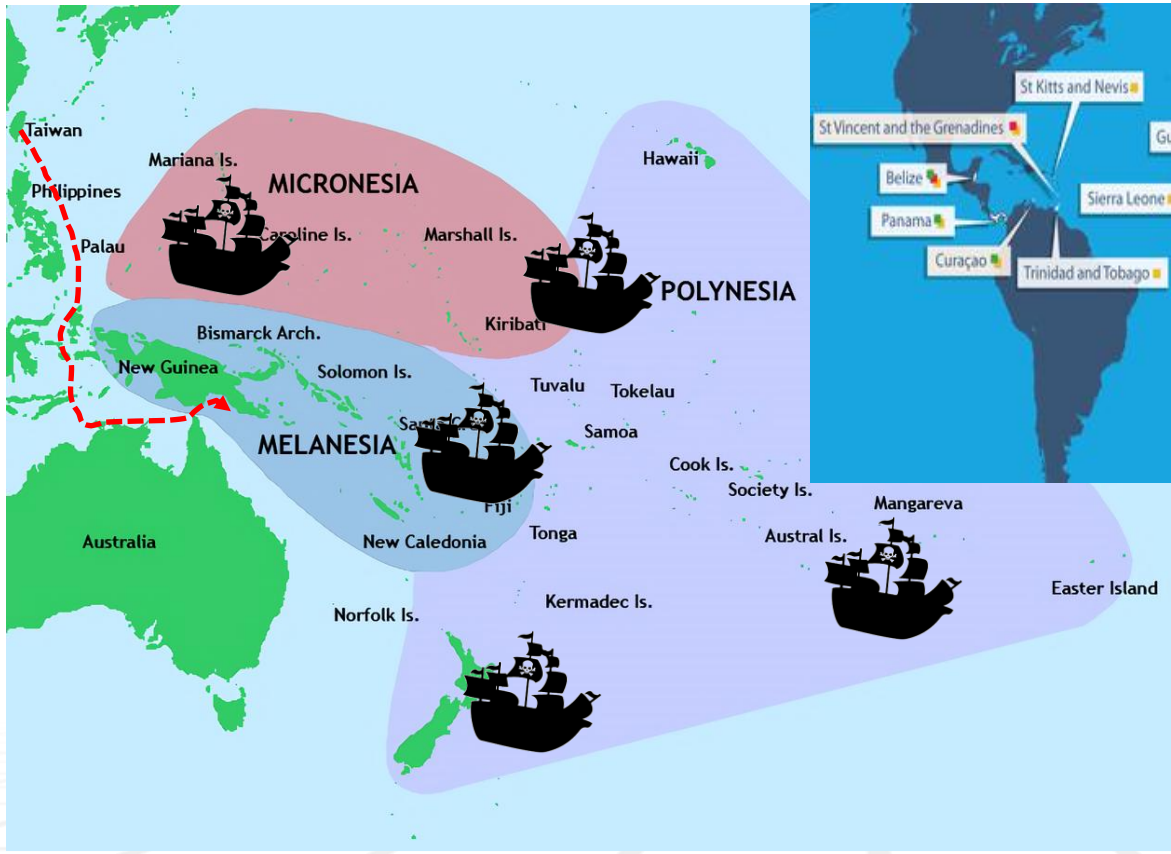
Illegal, Unreported, and Unregulated Fishing (IUU)

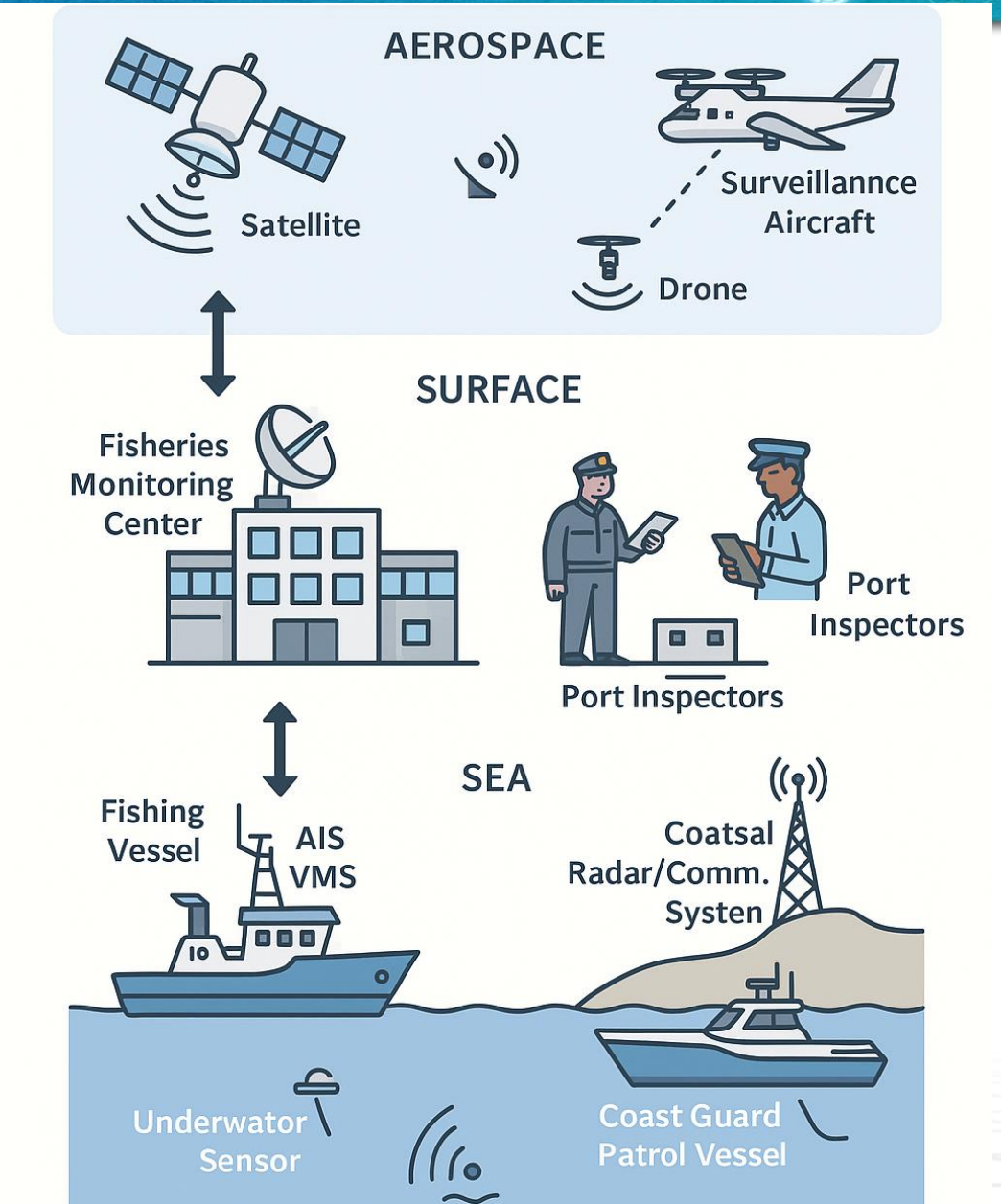
- An issue that has been **globally concerned and accounts for up to 30% of total catches** (US National Intelligence, 2016)
- Regarding the IUU, this issue has **recorded critical damage on a global scale**. The most crucial issue that has come to the surface is financial loss. Approximately, 11 billion USD (10 billion EUR) has been recorded globally on an annual basis which turned out to be an estimate of 19% of the world's reported value of catches (European Commission, 2020). This problem will not only results in financial issues but even damage the marine environment as well as the socio-economic society around it (MRAG, 2020).



FISHERY Monitoring, Control & Surveillance (MCS)

(Food and Agriculture Organization (FAO), UN)

- **Fisheries Monitoring, Control, and Surveillance (MCS) systems** are integral to sustainable fisheries management, encompassing sea, land, and aerospace components. A comprehensive diagram illustrating these interconnected elements can enhance understanding of their collaborative functions.
  - Sea Component: depicts fishing vessels equipped with Vessel Monitoring Systems (VMS), Automatic Identification Systems (AIS), and onboard observers.
  - Land Component: illustrates Fisheries Monitoring Centers (FMCs), port inspections, and data analysis units.
  - Aerospace Component: includes satellites and aerial surveillance systems monitoring fishing activities and transmitting data to FMCs.



Application of Multisensory Remote Sensing for Controlling Illegal, Unreported, and Unregulated (IUU) Fishing Activities

- **Under the ROK-PIF Cooperation Fund**
- **Donor:** Ministry of Foreign Affairs (MOFA) KOREA
- **Implementing Agencies:** KIOST and FFA
- Period: 2021 ~ 2025, US$ 2.4M

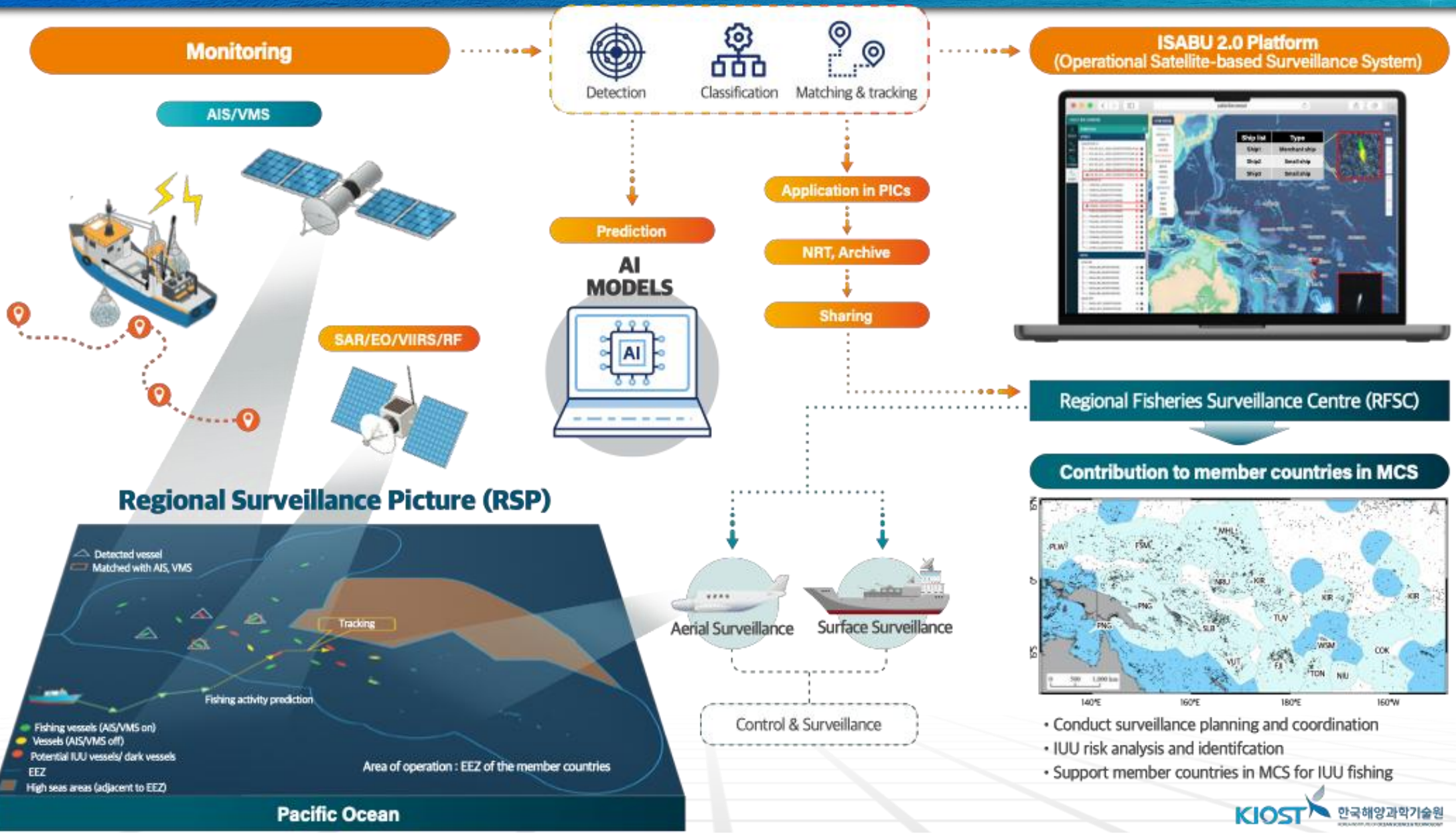
Ministry of Foreign Affairs

PACIFIC ISLANDS FORUM

KIOST 한국해양과학기술원 KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY

FFA

MCS for IUU Fishing by Multisensory RS and VMS



Role and Responsibilities (R&R) of KIOST

Objective

Outcome

Algorithms for SAR/EO satellites

- S-1/2 based small vessel detection module ★
- Automatic satellite data collection module
- Algorithms: High-resolution SAR/EO, and RF-based identification

Night-time monitoring techniques

- (NRT Algorithm) fishing vessel monitoring: VIIRS
- (Archive) Long-term analysis of fishing activity: VBD

Algorithms for ship classification

- Fishing activity prediction: AIS, V-pass, (VBD)
- Algorithms: Ship type classification from AIS or EO

Contribution

Service: sharing outcomes

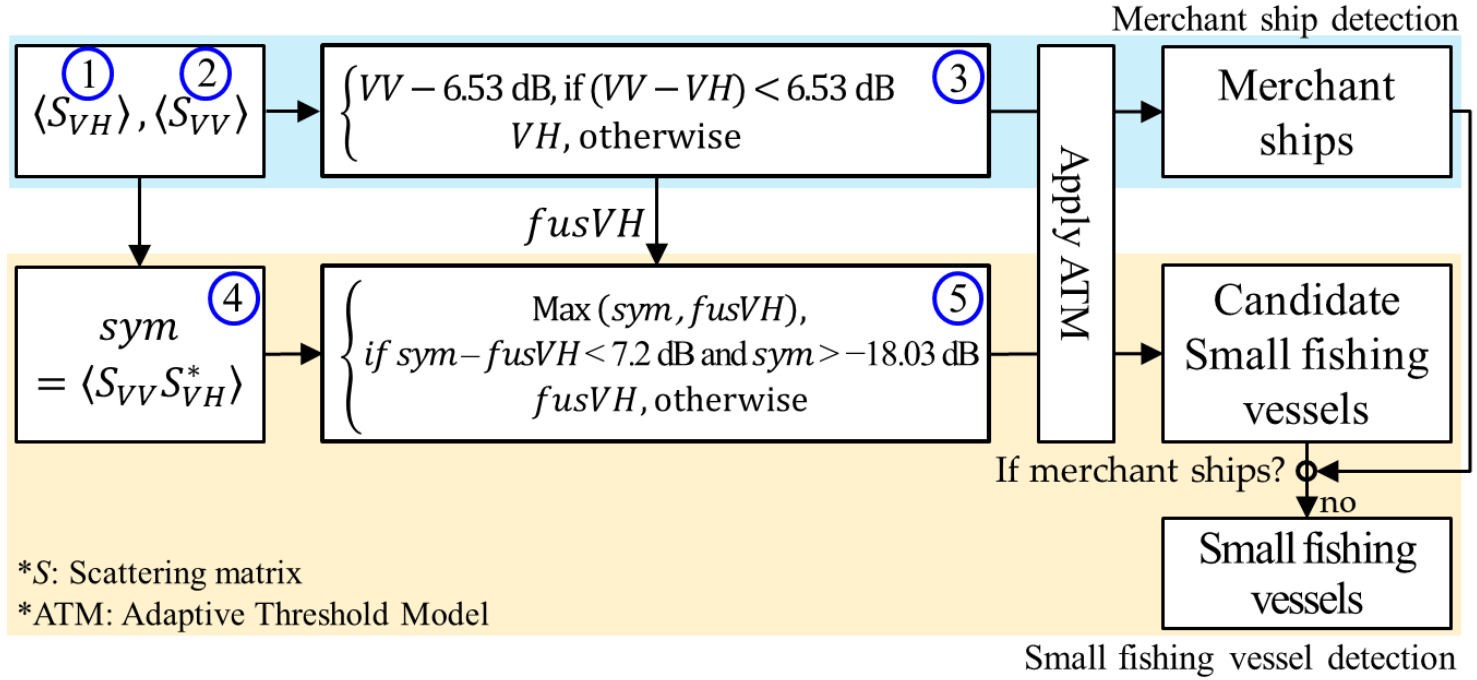
- Near Real Time ★
- Archive
- Platform

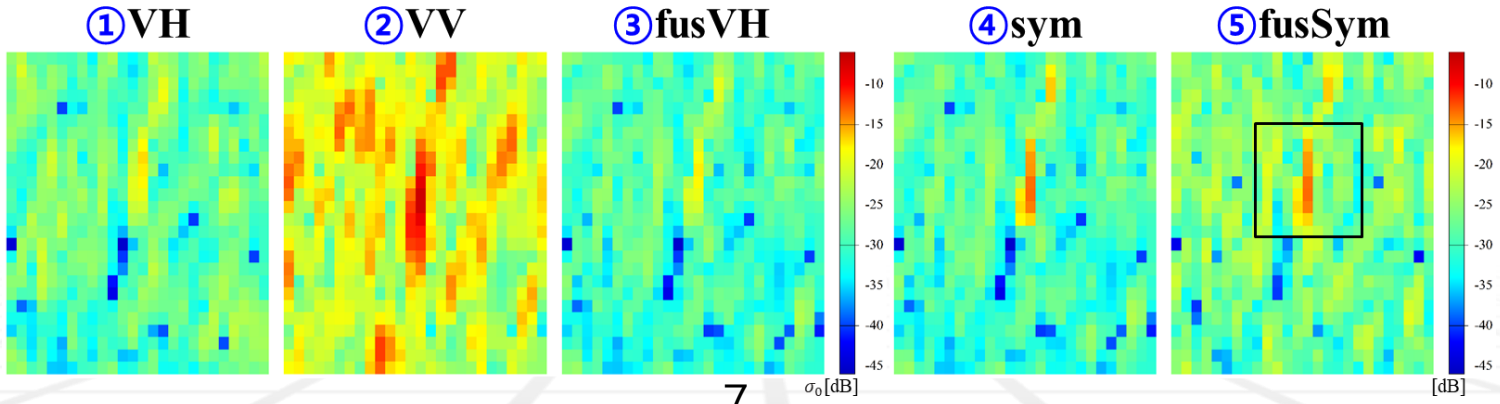
★ The output has been prepared for delivery to FFA (test sharing conducted). Currently, the sharing is on hold until integration with RFSC's regional surveillance operation.

- Additionally, AIS/V-pass data is used to predict fishing activity and classify ship type, which was tested in Korean waters (published articles). This approach can be applied in the EEZ of the Pacific countries with the help of FFA, and the fishing activity prediction map can be generated.

1. S-1 based small vessel detection

Polarimetric combination

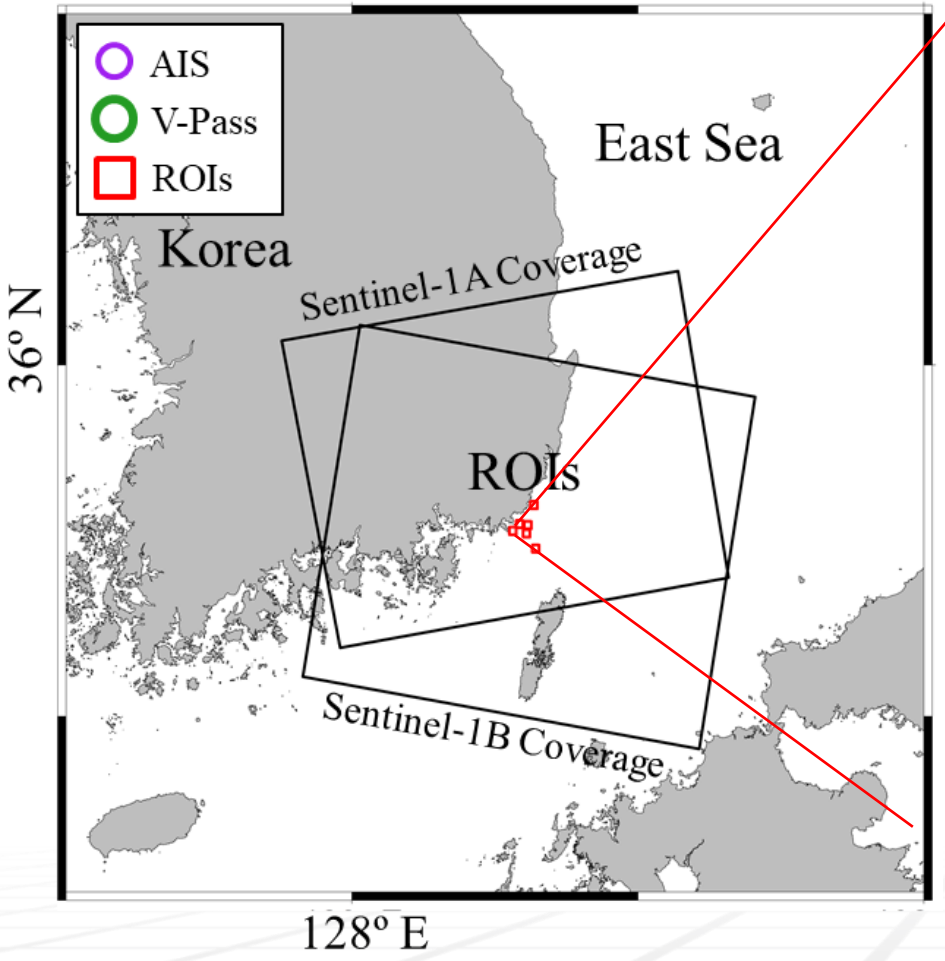


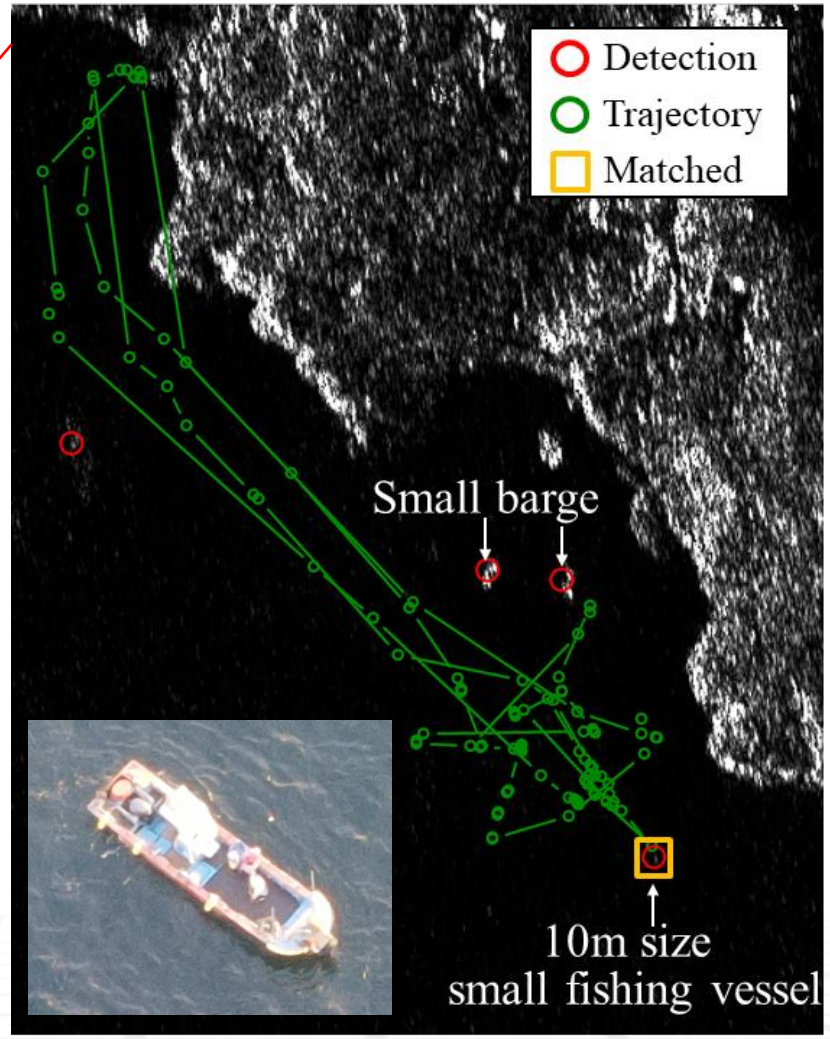


IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (DOI: https://doi.org/10.1109/jstars.2025.3624445)

1. S-1 based small vessel detection

Polarimetric combination





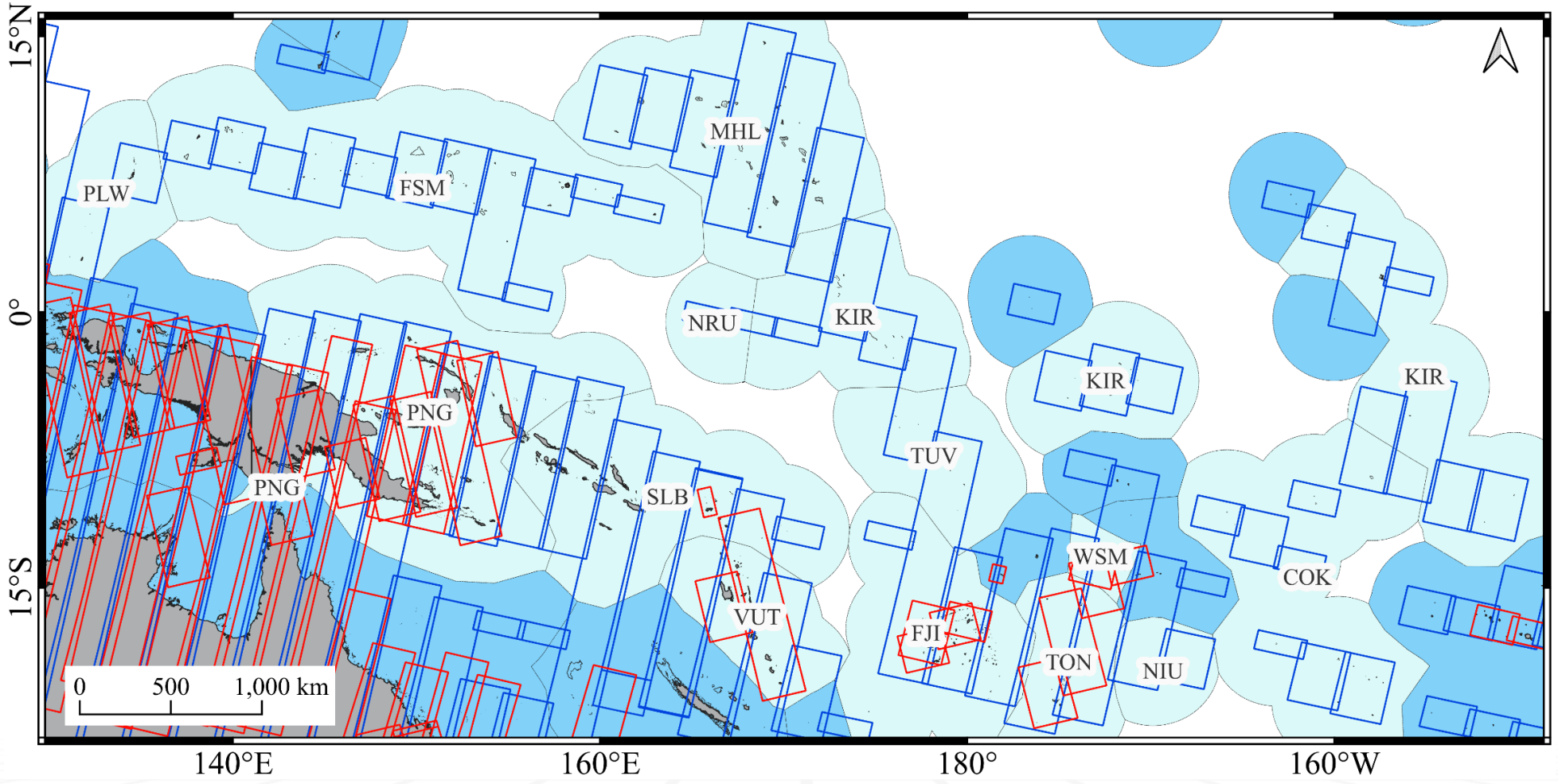
Validation with 10 m size small fishing vessel

Accuracy: Small fishing vessels - 84% from 14 images

Application

1. S-1&2 based small vessel detection

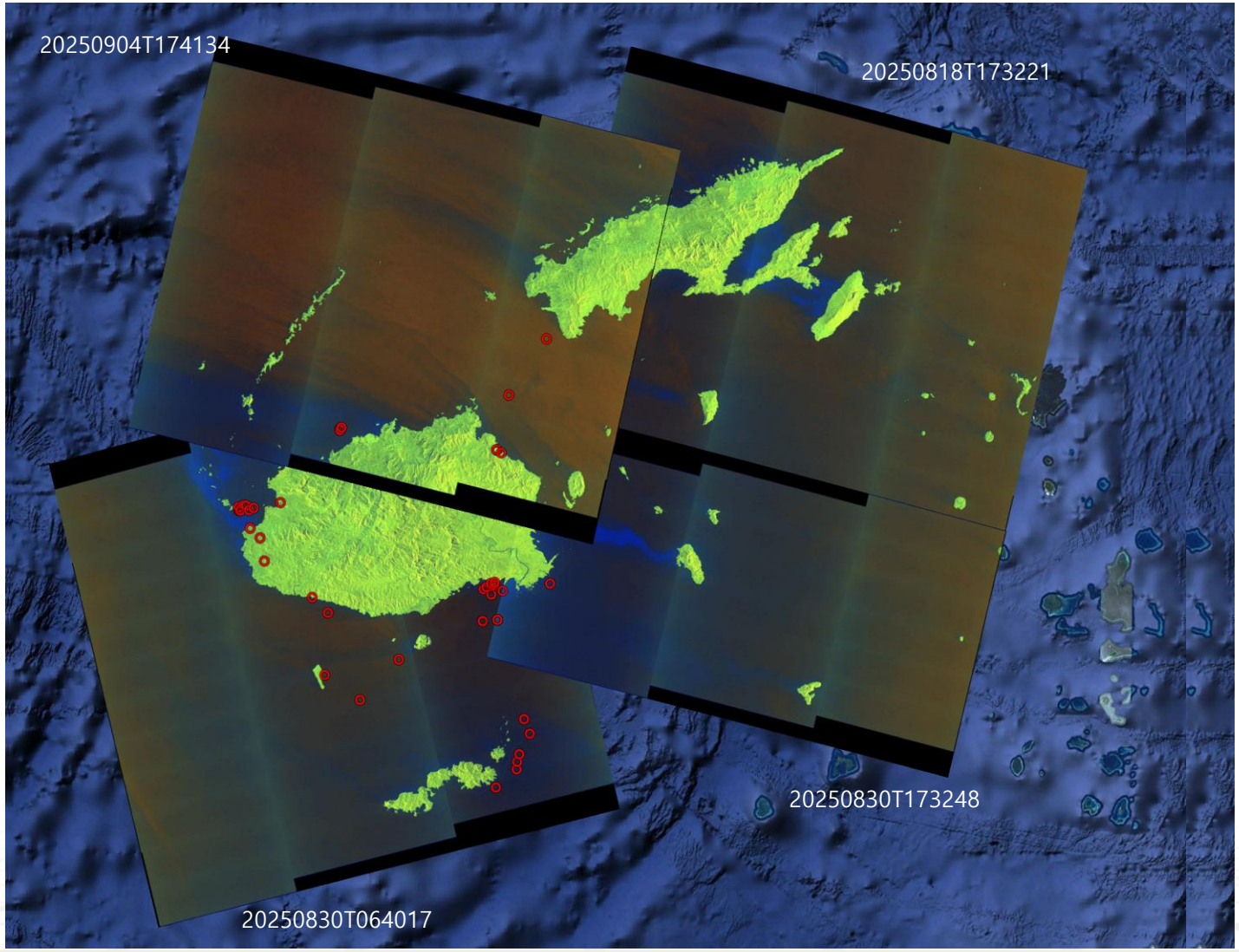
Satellite Observation: Sentinel-1 and Sentinel-2



Period: June 2025

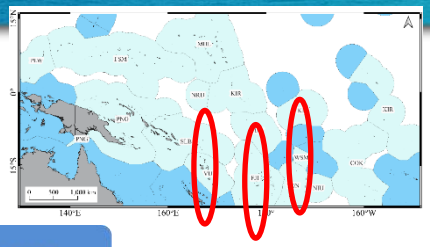
1. S-1 based small vessel detection

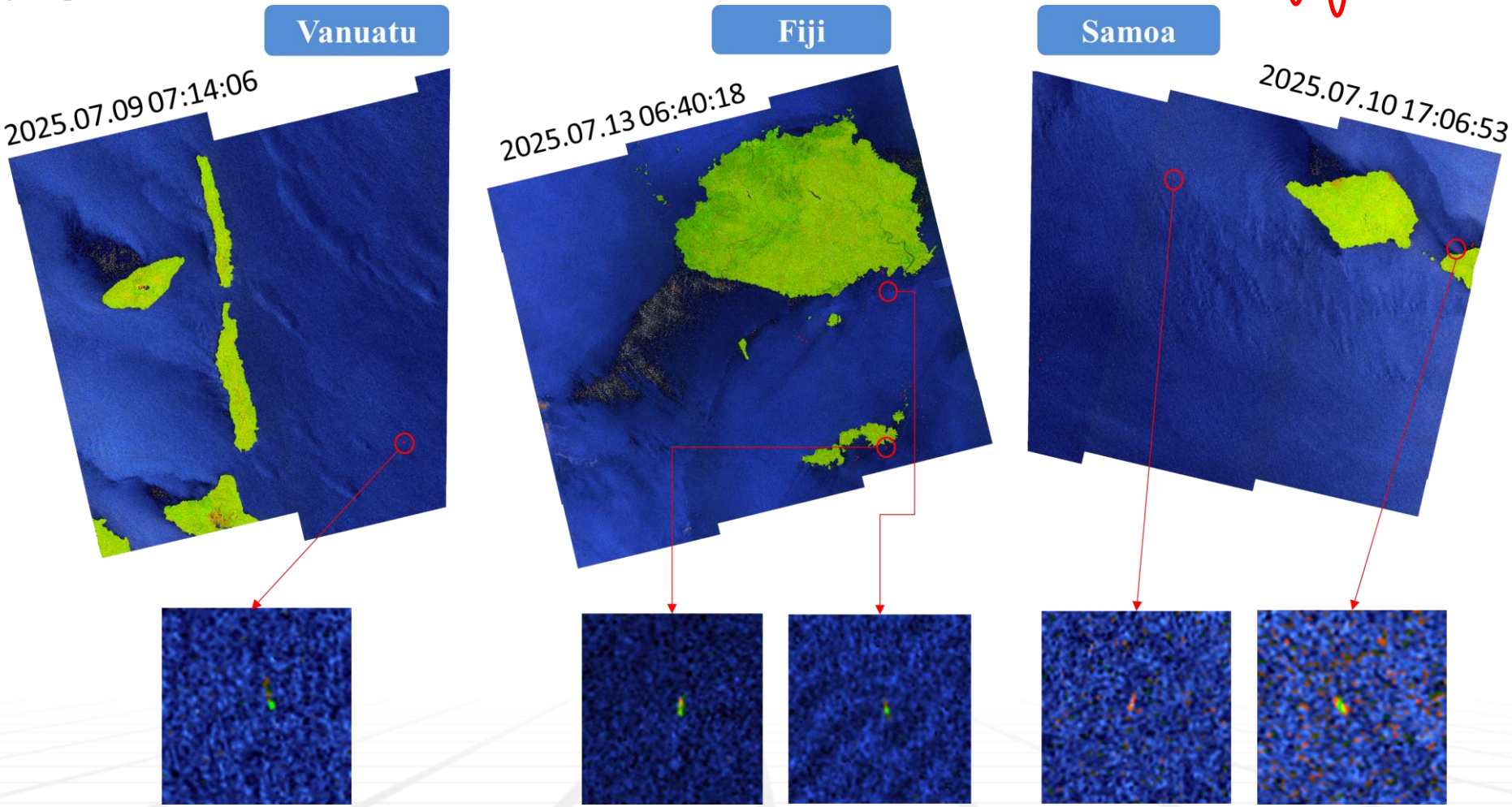
Satellite Observation: Sentinel-1



1. S-1 based small vessel detection

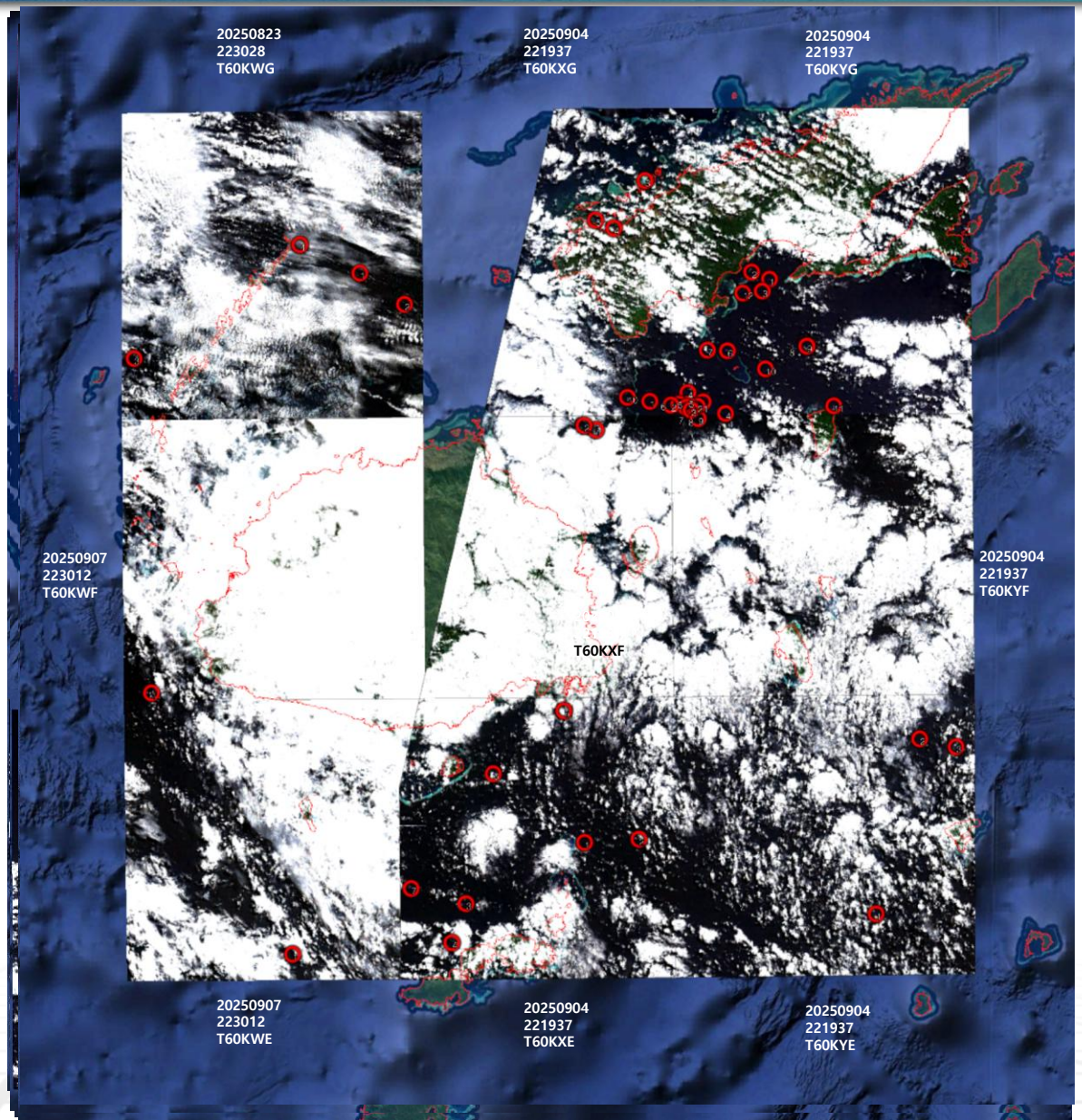
- Application period: 2025.06.01 - 2025.08.18
- Satellite platform: Sentinel-1 and Sentinel-2
- Test area: Samoa, Fiji, Tonga, Tuvalu, Vanuatu
- Sharing output data to FFA: 2025.08.18 ~ 2025.09.19





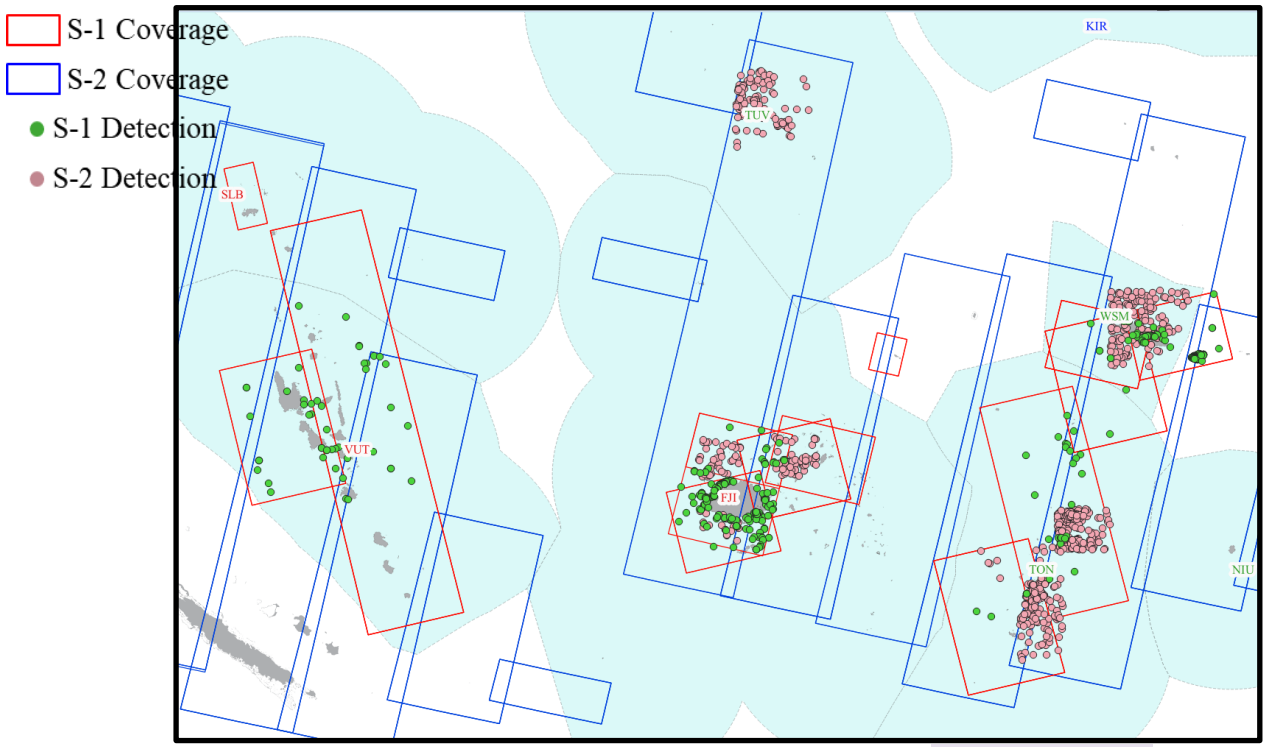
1. S-2 based small vessel detection

Satellite Observation: Sentinel-2



1. Sharing of S-1/2 Vessel Detection

Total ship detection result from 2025.06.01 to 2025.08.18

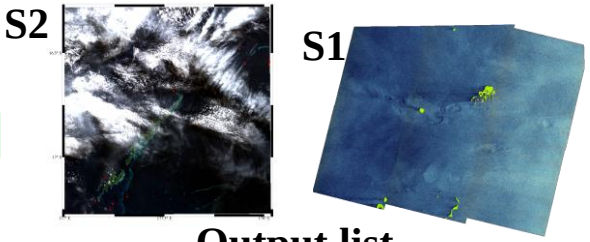


Number of ship detection by PIC

Platform	WSM	FJI	VUT	TON	TUV
Sentinel-1	53	226	48	30	-
Sentinel-2	175	137	-	373	106

Mailing System

NRT



Web Platform

Output list

No.	Outcomes
1	Ship position
2	Ship image
3	Satellite image

Archive

Sharing

- Application period: 2025.06.01 - Current
- Satellite platform: Sentinel-1 and Sentinel-2
- Test area: Samoa, Fiji, Tonga, Tuvalu, Vanuatu
- Sharing output data to FFA: 2025.08.18 ~ 2025.09.19

2. Automatic satellite data collection module

http://10.30.0.201:40000/
ISABU1 (10.30.0.201)

Docker: moonareum/kiost_sigs

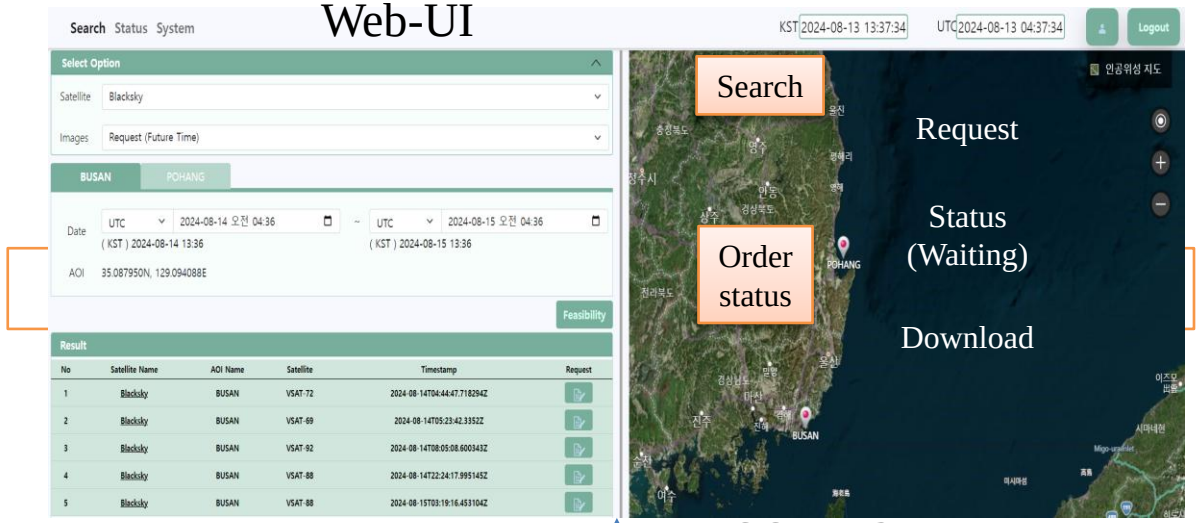
BlackSky
Capella
PlanetScope
ICEYE

Satellites

API

Order, Download

Web-UI



SQLite3 DB

db.sqlite3

~CORRECTION.json

Check every 10 min

crontab

Polling.sh

../New/

If file exist,

Docker: docker.isabu.cloud/rbase_torch

Applications

Ship Detection (Docker: docker.isabu.cloud/rbase_torch)

Oil Detection (Docker)

MAB…

~ANALYSYS_SHIP_DETECTION.json

Anlysis status

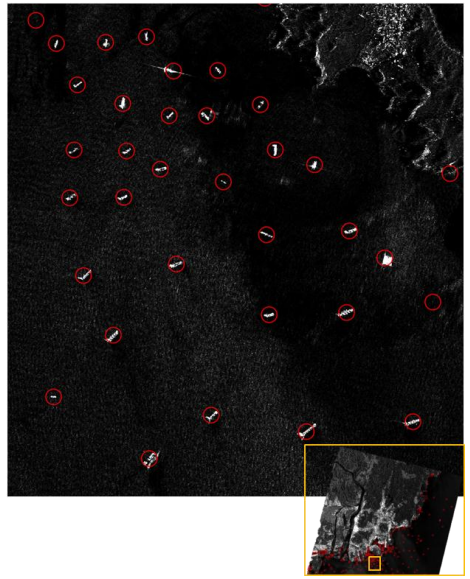
- Path: /data1/shared-data/hs_set

3. High-resolution SAR/EO

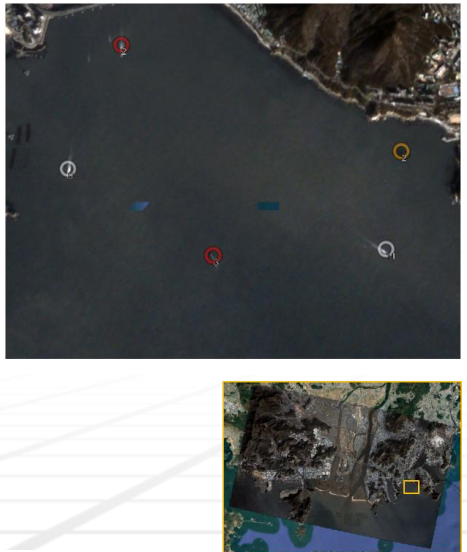
Area: Busan, South Korea, Method: CFAR and Deep learning model

Capella (1 m res)

ICEYE (1m res)



PlanetScope (3.5m res)

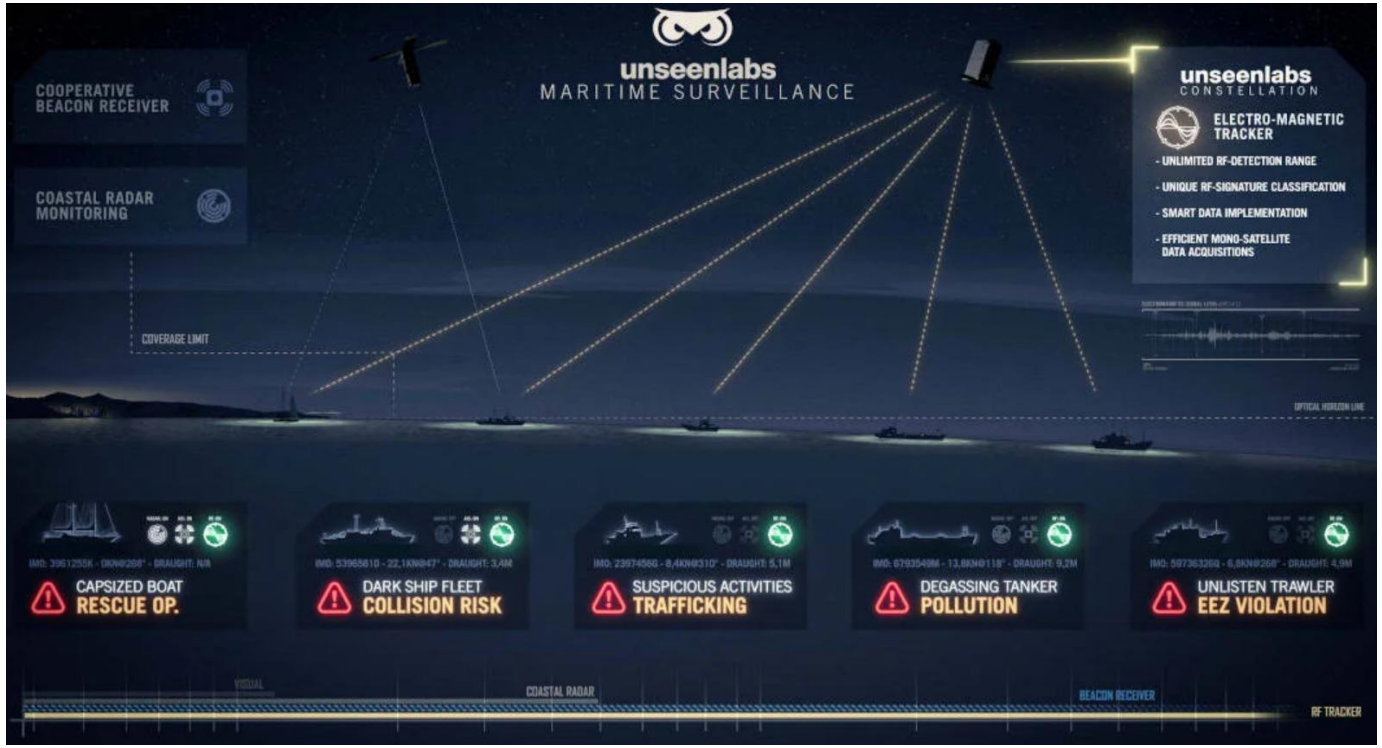


Blacksky (1m res)

3. RF

- Radio frequency (RF) data encompasses the observation of the electromagnetic radiation spectrum
- It emits a frequency that can be gauged within the range of 300 GHz to 9 kHz

- RF strategy offers a reliable means of observing ship operations at sea
  - While AIS may be subjected to manipulation
  - Irrespective of weather conditions
  - Time of day



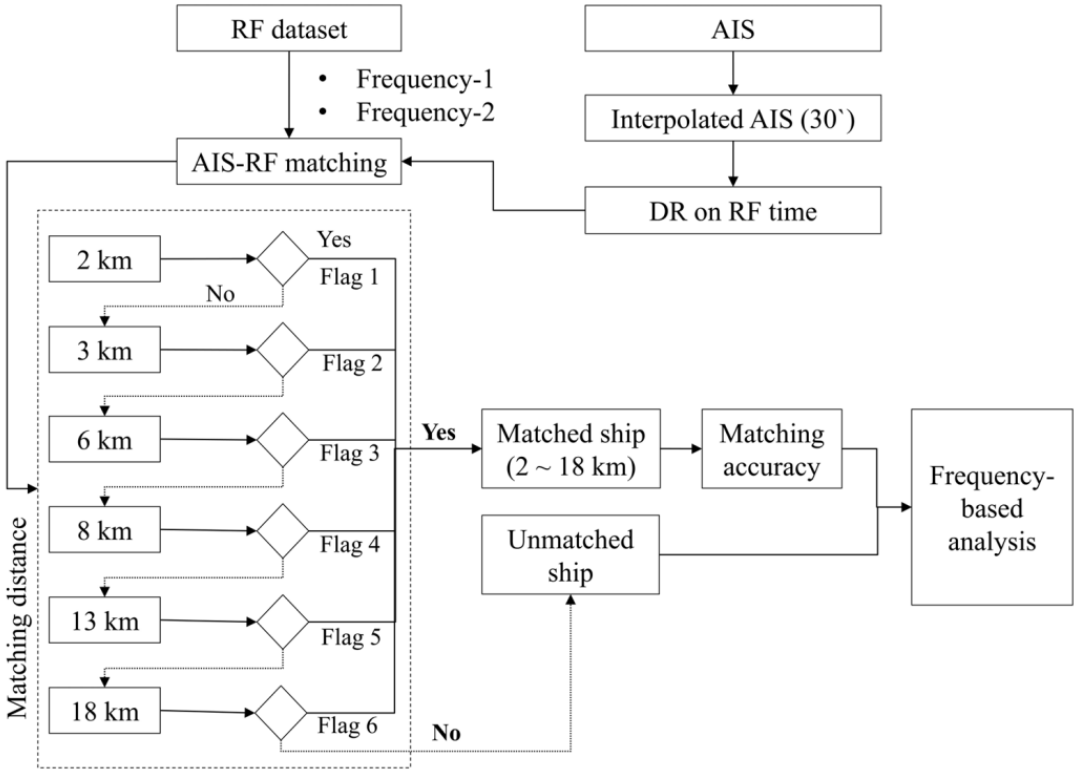
https://digit.site36.net/2022/06/26/maritime-surveillance-spy-satellites-in-frontex-operation/

- A case study was performed by Unseenlabs where a fishing fleet was monitored in the north Arabian Sea by utilizing the RF data collection → 35% of the vessels were operating without AIS visibility

3. RF

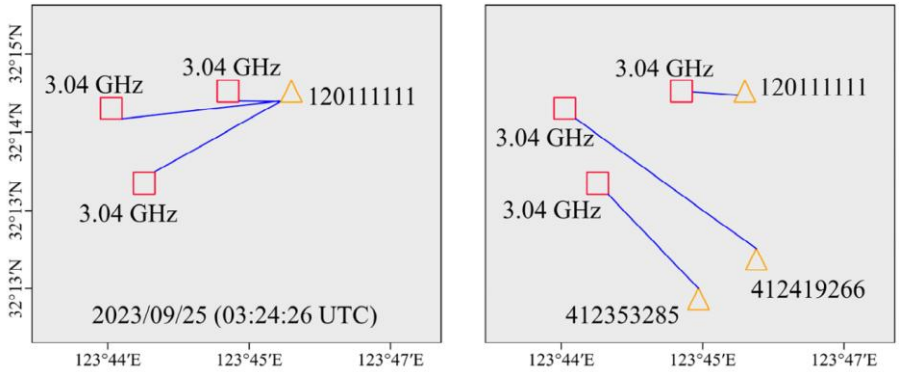
Purpose: Ship identification through RF and AIS data matching

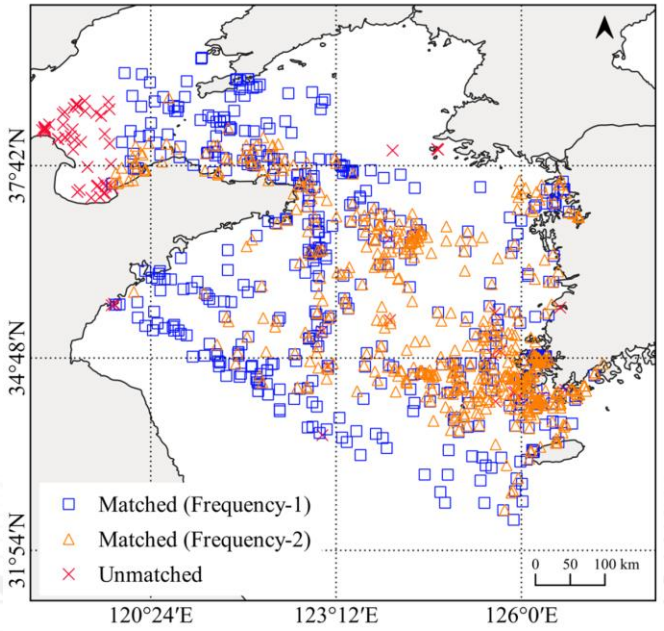
Method: Distance-based matching between RF and AIS



Frequency-1 and frequency-2 represent the RF data with frequency ranges from 3.024 to 3.077 GHz and 9.3734 to 9.4249 GHz, respectively.

Example of matching between RF & AIS

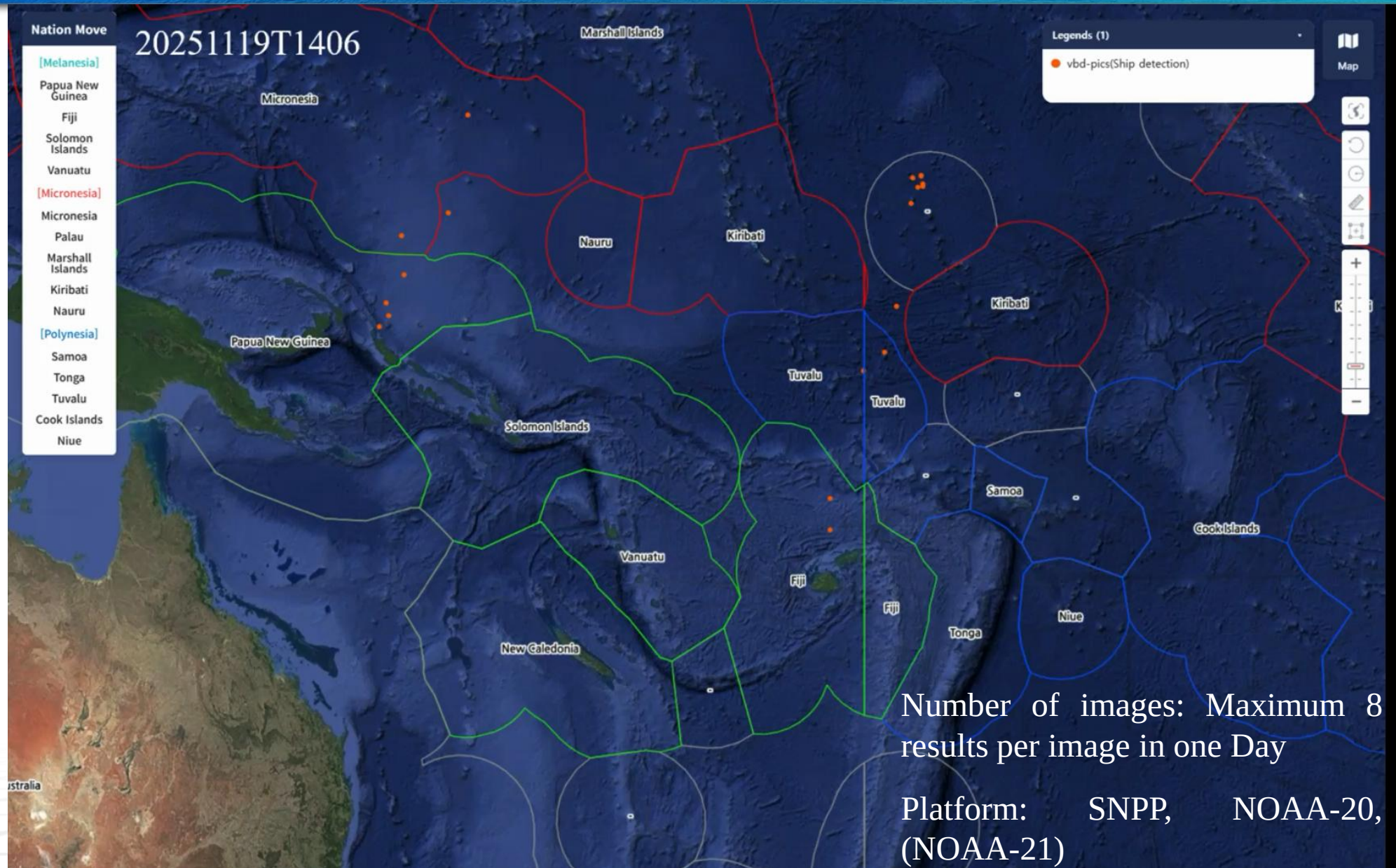




Identification of ships after comparing RF & AIS data in the Korean water

Journal of Marine Science and Engineering (DOI: https://doi.org/10.3390/jmse13020191)

1. NRT Nighttime fishing vessel monitoring

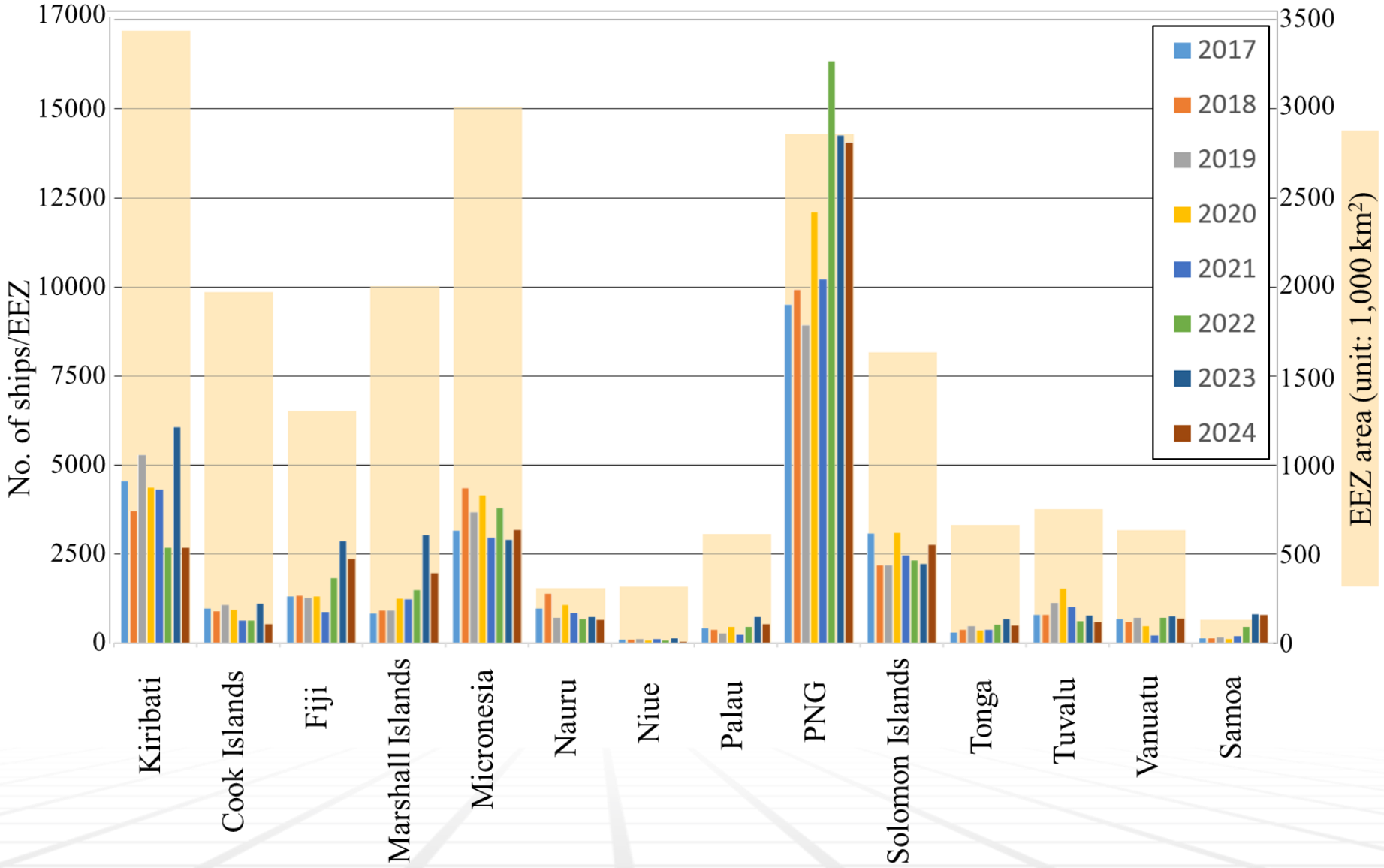


Number of images: Maximum 8 results per image in one Day

Platform: SNPP, NOAA-20, (NOAA-21)

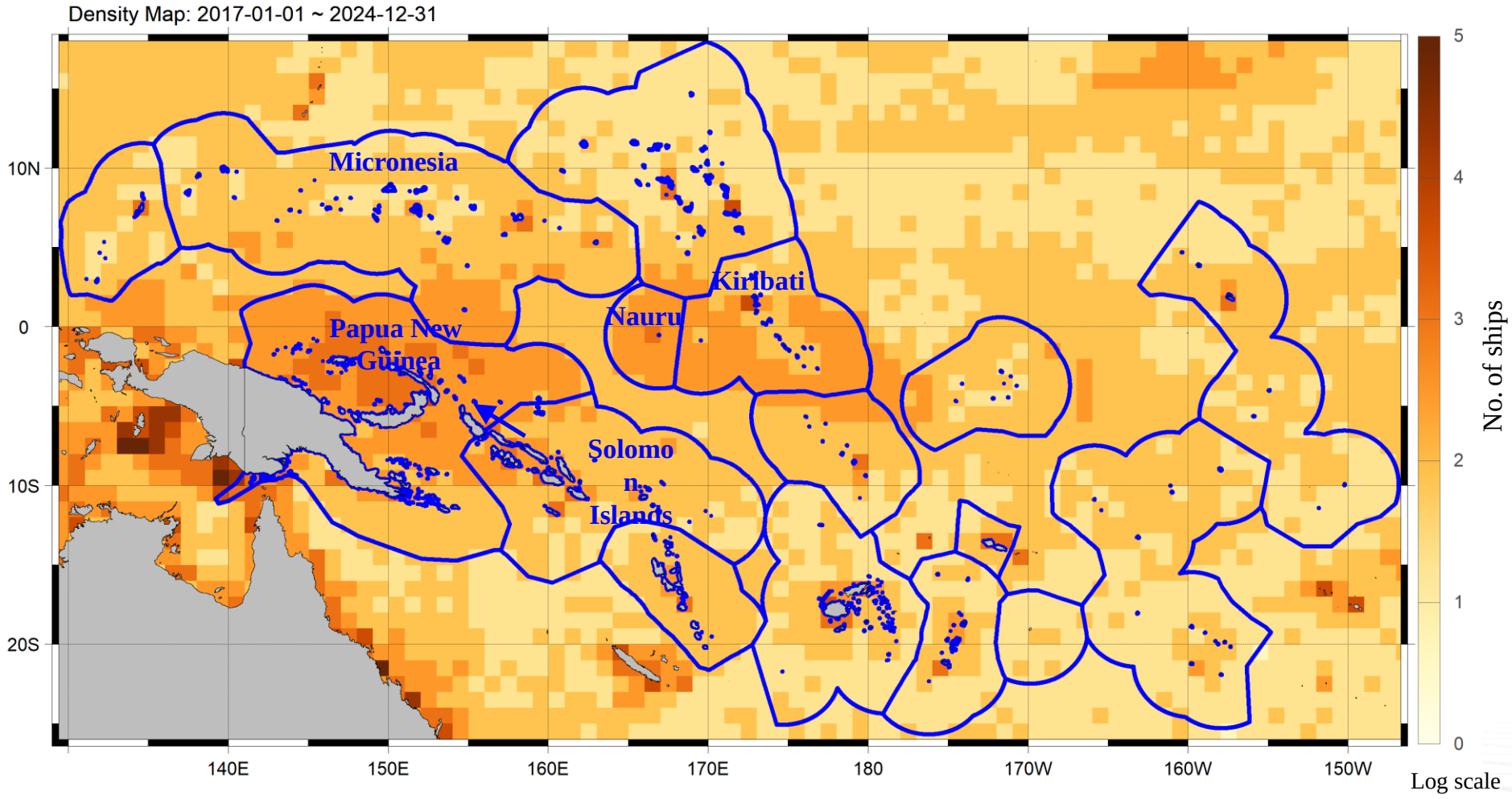
2. NRT Nighttime fishing vessel monitoring

Annual number of fishing vessel activities histogram by EEZ area



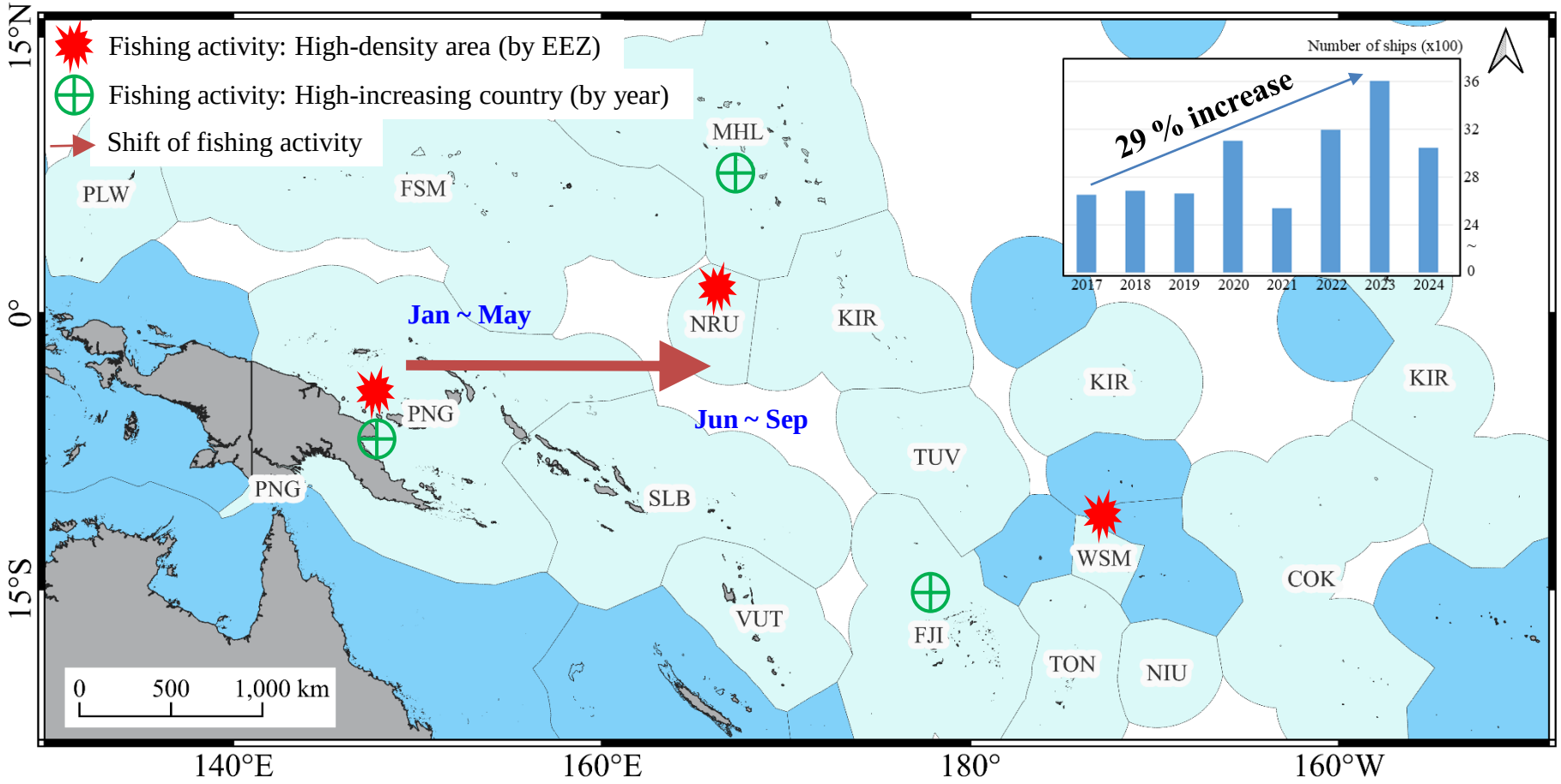
2. NRT Nighttime fishing vessel monitoring

- **2017 – 2024.** Papua New Guinea, Nauru, and Kiribati showed a widespread distribution of fishing vessels, whereas Solomon Islands and Micronesia were found to have vessels concentrated in EEZ border waters



2. NRT Nighttime fishing vessel monitoring

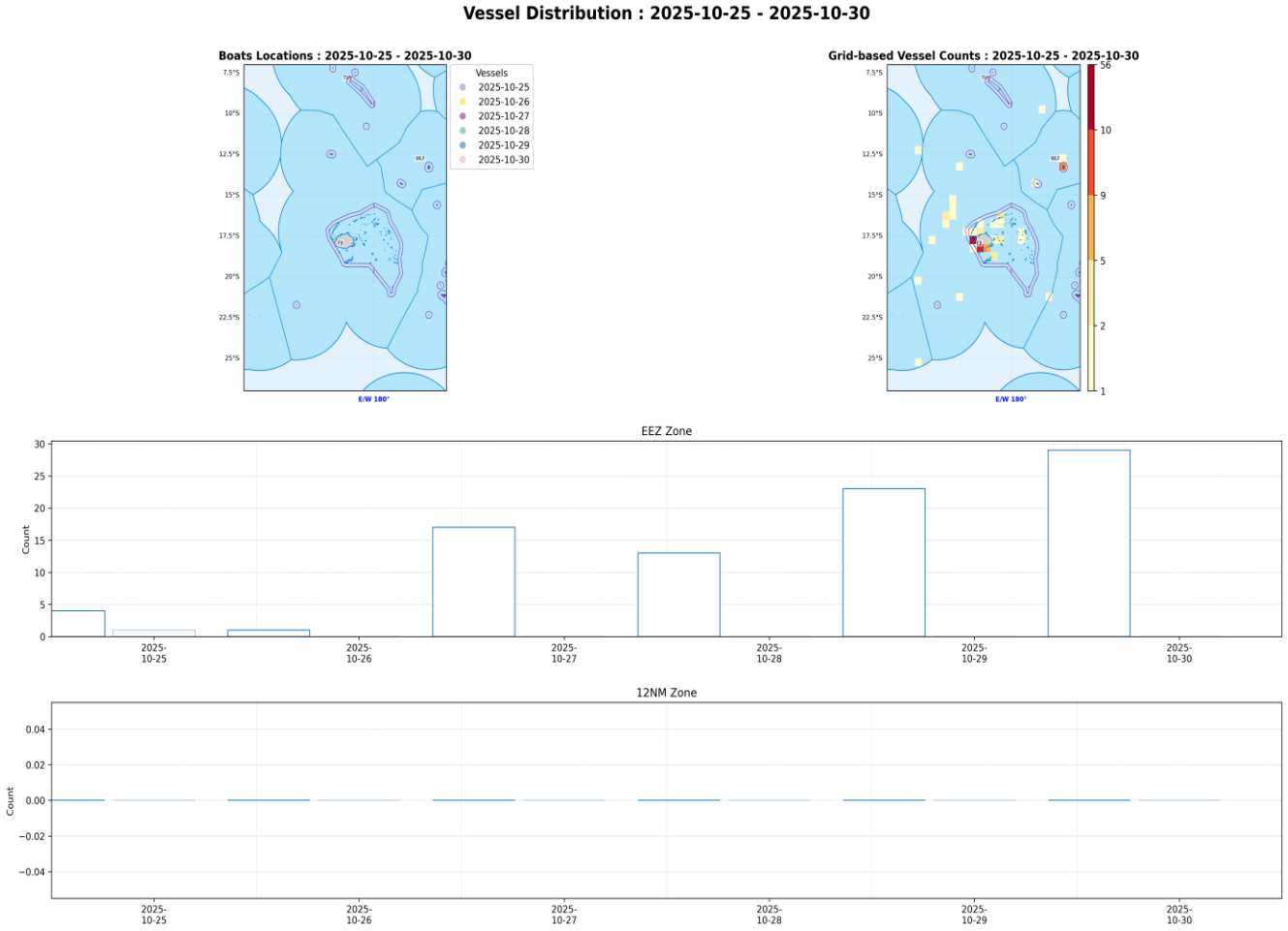
Long-term analysis of fishing activity (VBD)

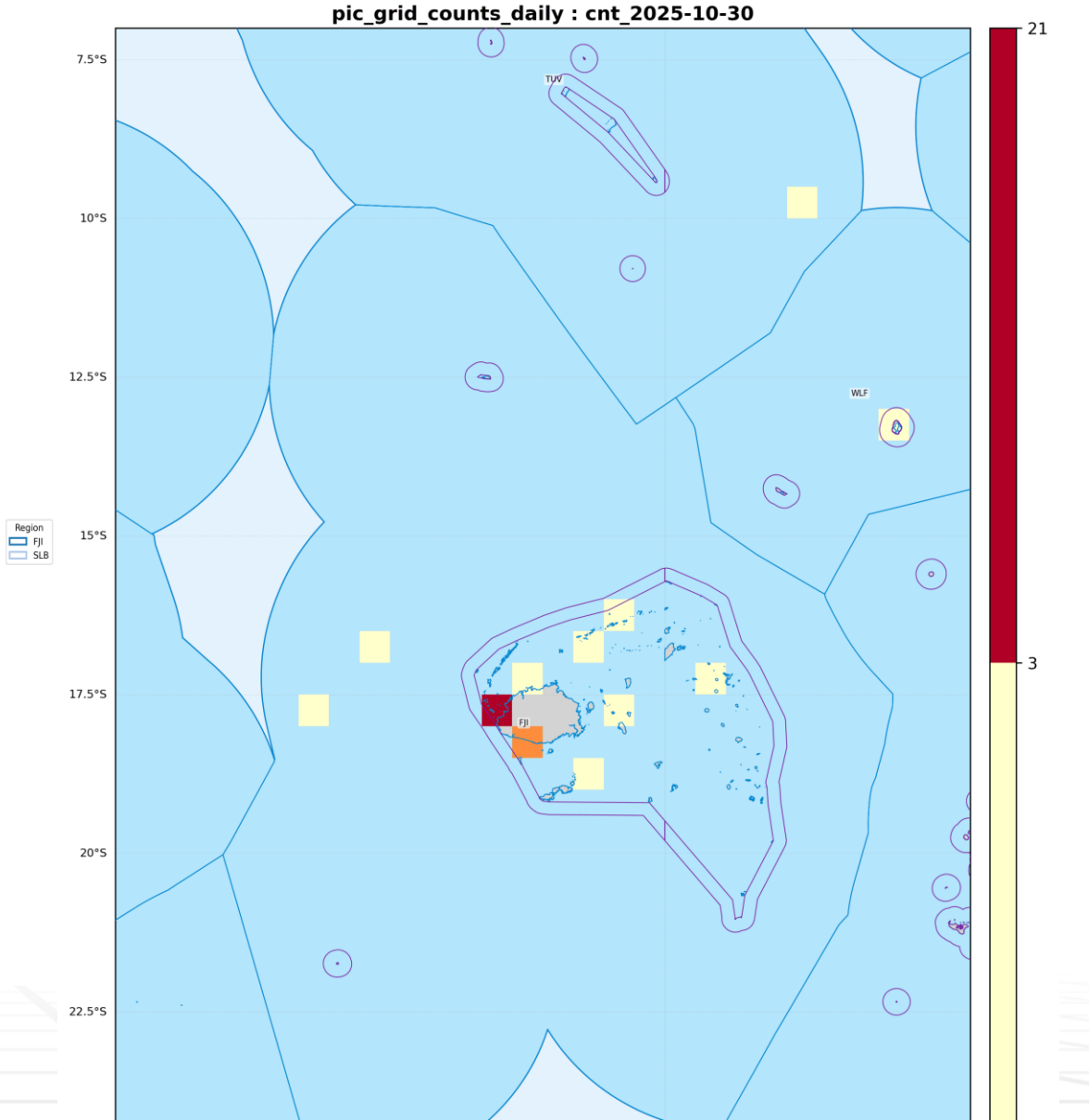


- From January to May: Western EEZs of Papua New Guinea and Solomon Islands
- From June to September: Shifted toward the central EEZs, specifically Kiribati and Nauru.
- In most countries, fishing activity was relatively low at the beginning of the month, increasing toward the middle and late phases.

2. NRT Nighttime fishing vessel monitoring

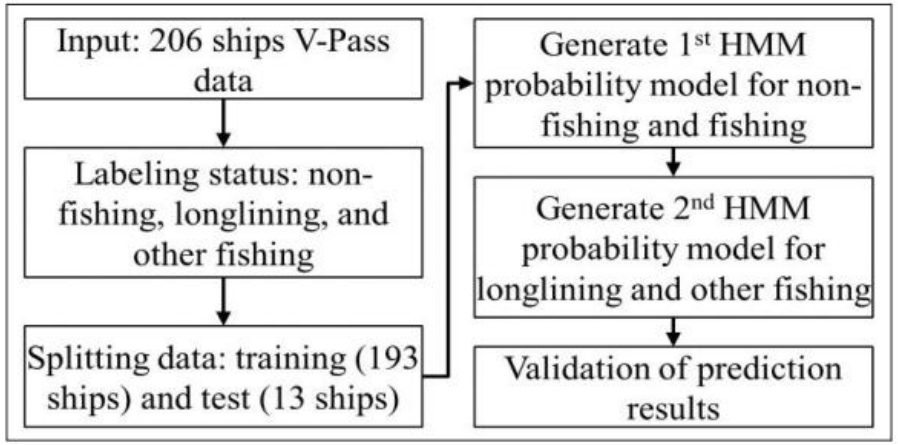
Daily Report

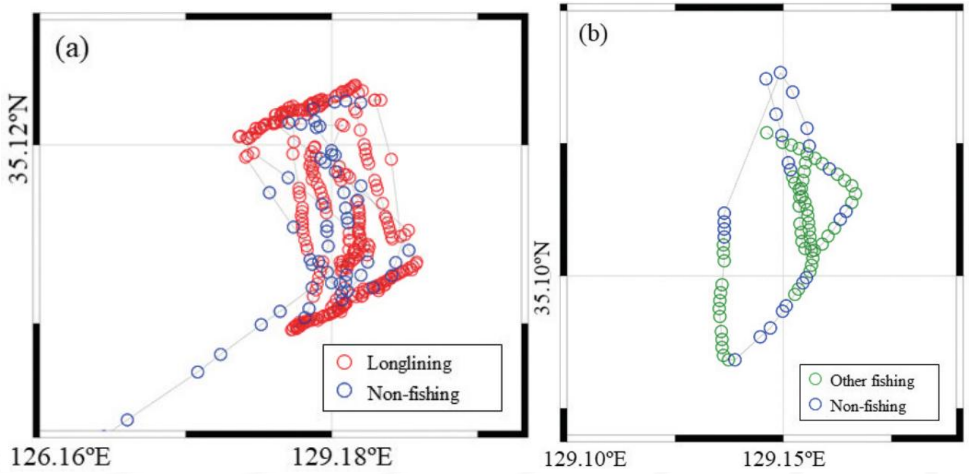




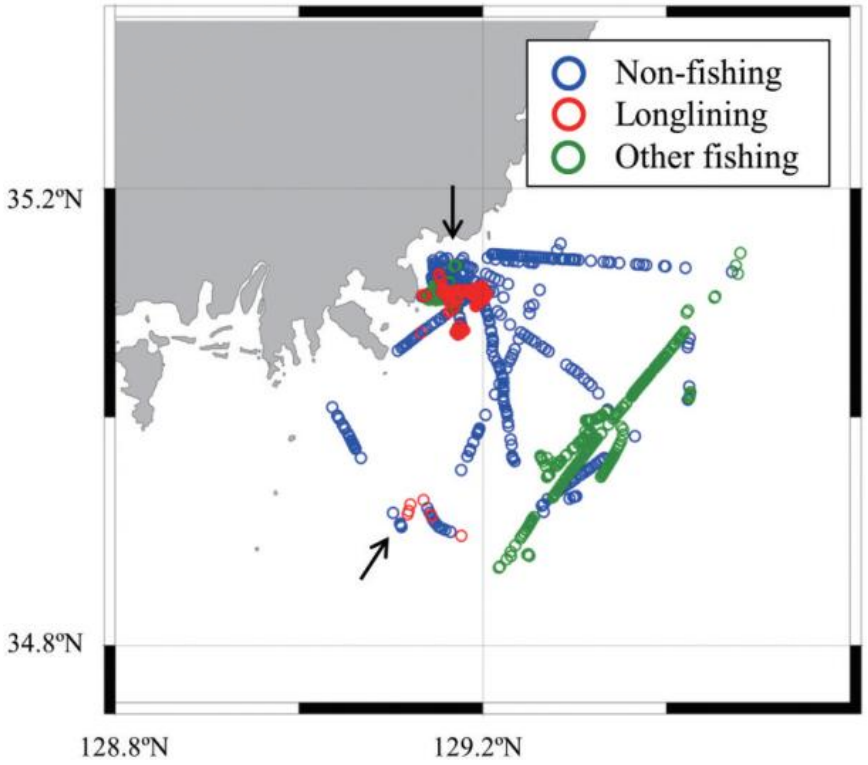
1. Prediction of fishing activity

Predicted the fishing activity through the HMM based on the speed and behavior of each fishing vessel





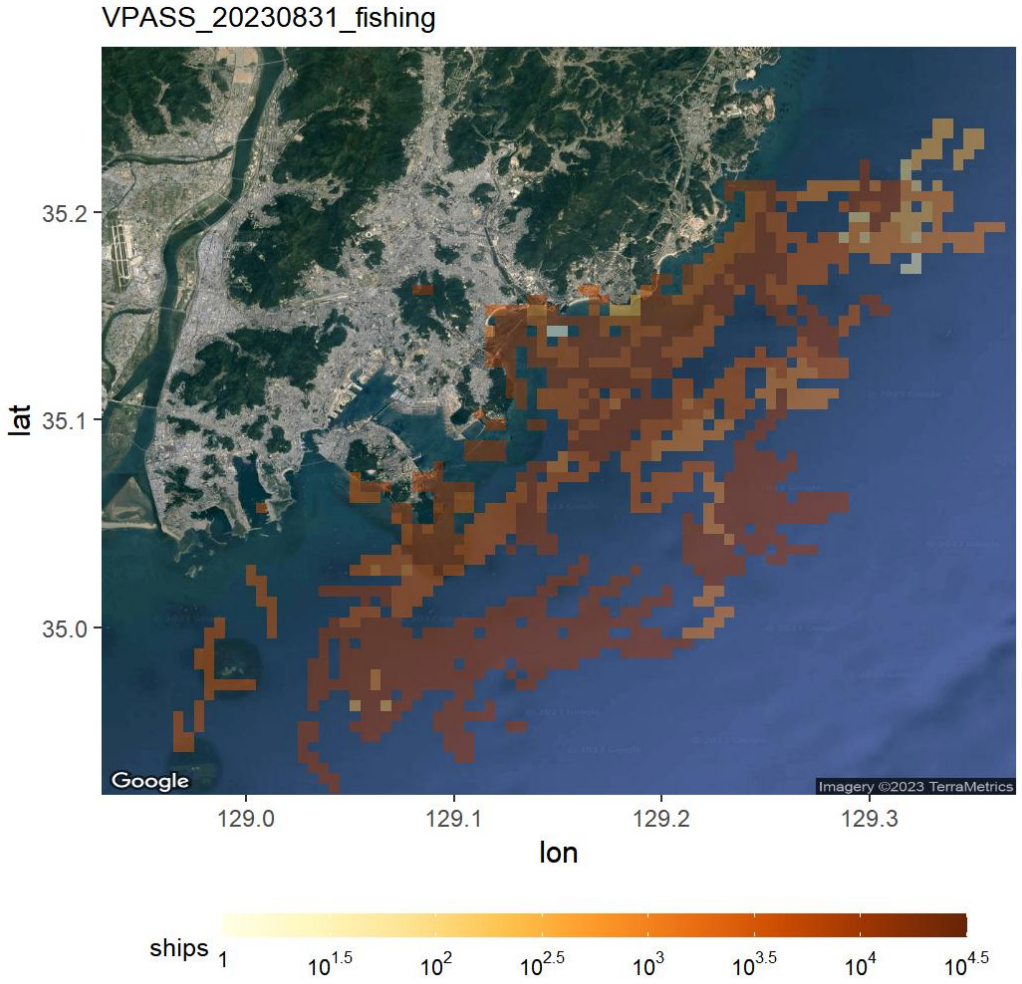
Example of movement patterns of fishing vessels

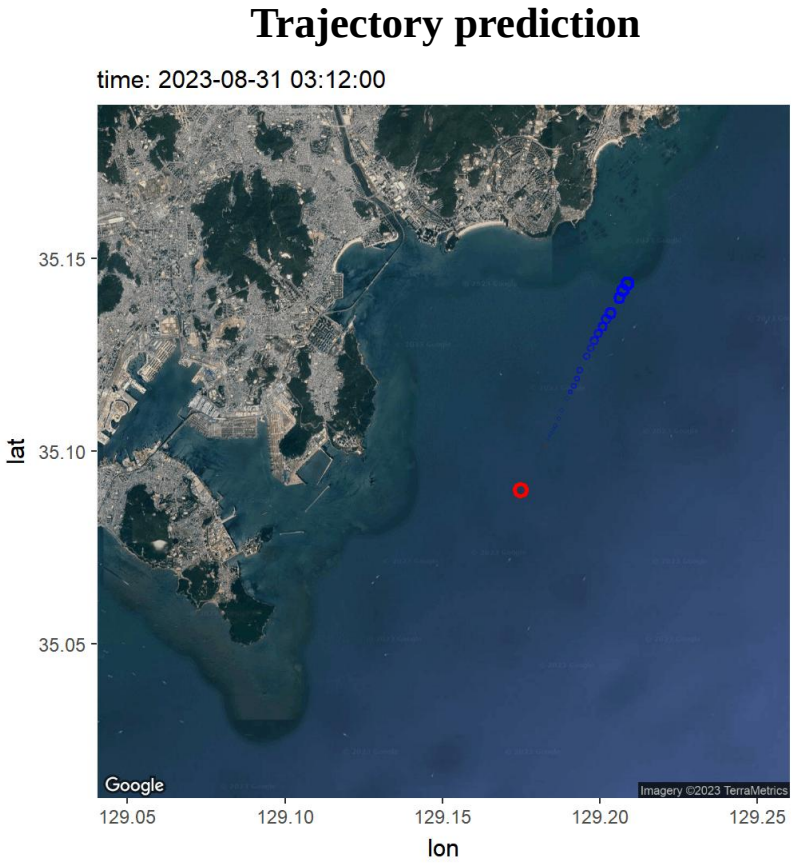


Classification of fishing activity:
Longlining, Non-fishing & Other fishing

Korean Journal of Remote Sensing (DOI: https://doi.org/10.7780/kjrs.2022.38.1.6)

1. Prediction of fishing activity



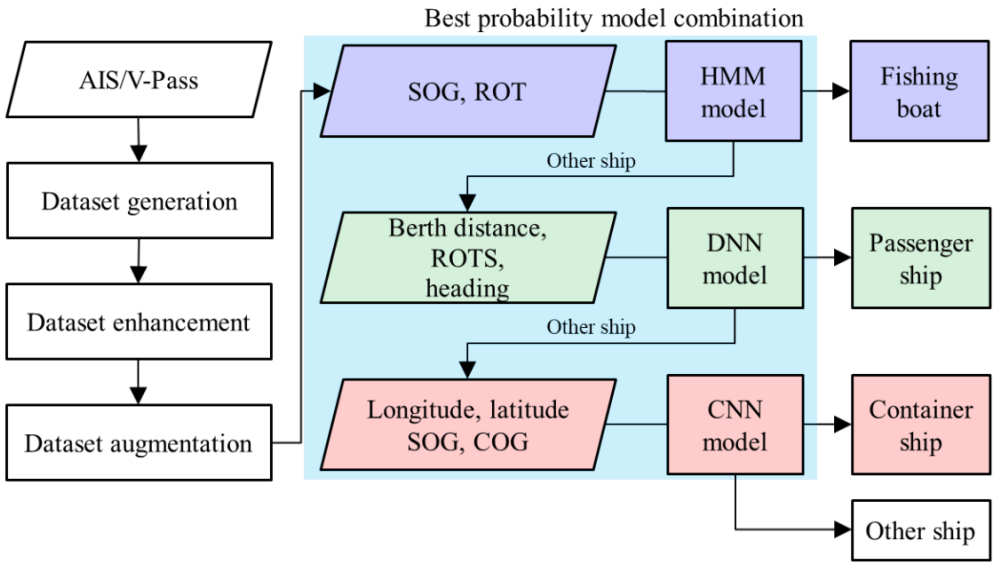


Korean Journal of Remote Sensing (DOI: https://doi.org/10.7780/kjrs.2022.38.1.6)

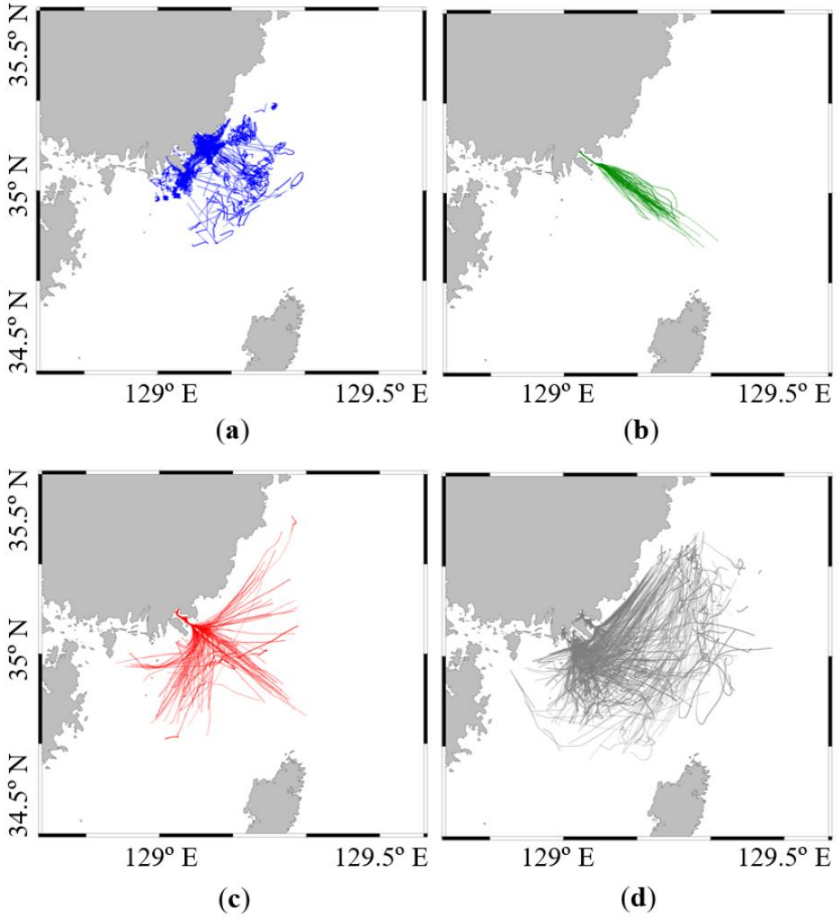
2. Ship type classification

Area: Busan, South Korea

Method: HMM-DNN-CNN model



Overall workflow for ship type classification through combining of multiple models. Here, SOG = speed over ground, ROT = rate of turn, ROTS = rate of turn in speed, and COG = course over ground.



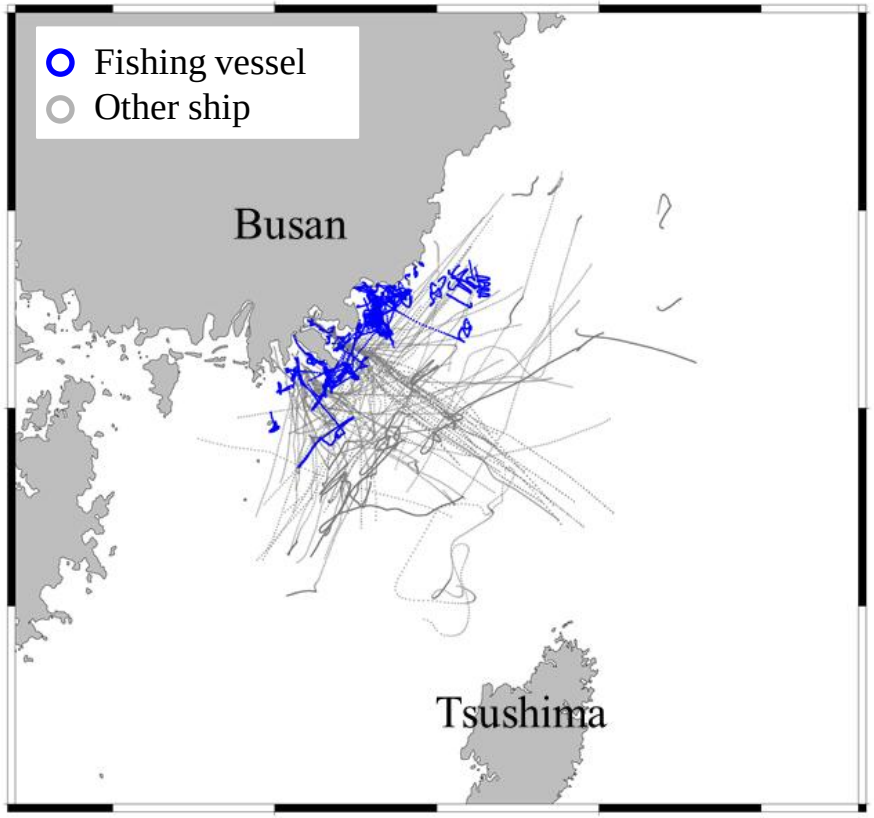
Trajectories of different ship types from the training dataset

Remote Sensing (DOI: https://doi.org/10.3390/rs16224245)

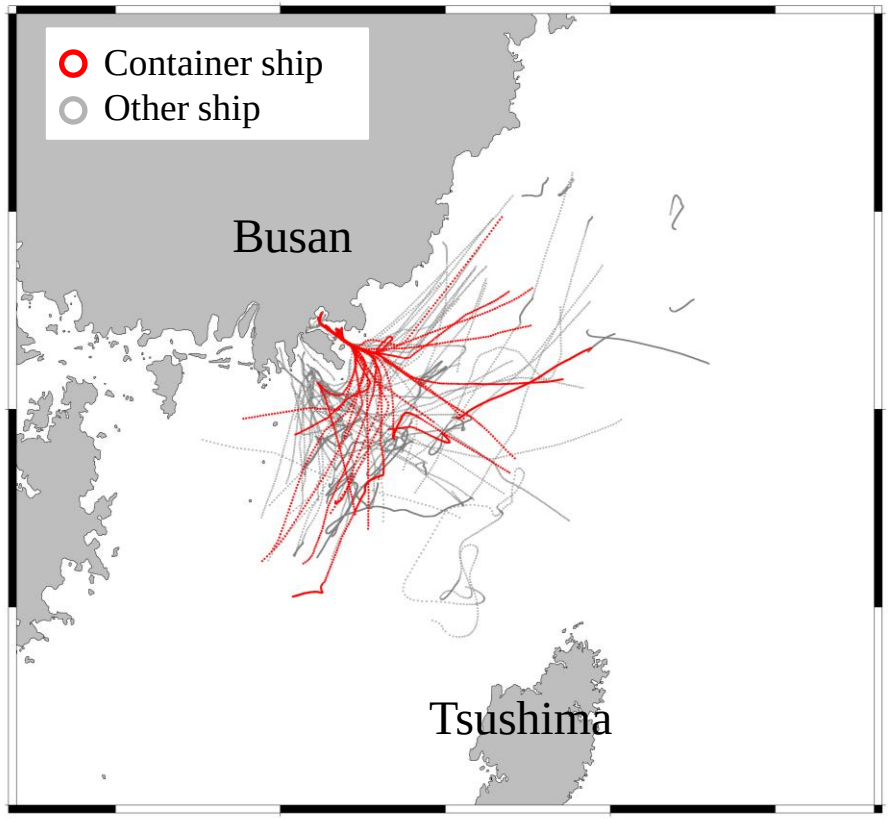
2. Ship type classification

Accuracy: Fishing vessel - 99.33%, Container ship - 95.83%

Fishing vessel classification using AIS



Container ship classification using AIS



Remote Sensing(DOI: https://doi.org/10.3390/rs16224245)

List of Publications (IUU)

1. Prediction of Longline Fishing Activity from V-Pass Data Using Hidden Markov Model. Korean Journal of Remote Sensing, 2022.
2. Detection of maritime traffic anomalies using Satellite-AIS and multisensory satellite imageries: Application to the 2021 Suez Canal obstruction. Journal of Navigation, 2022.
3. Enhancement of Small Ship Detection Using Polarimetric Combination from Sentinel−1 Imagery. Remote Sensing, 2024.
4. Matching Method for Ship Identification Using Satellite-Based Radio Frequency Sensing Data. Korean Journal of Remote Sensing, 2024.
5. Classification of Ship Type from Combination of HMM–DNN–CNN Models Based on Ship Trajectory Features. Remote Sensing, 2024.
6. Frequency-Based Analysis of Matching Accuracy Between Satellite Radio Frequency and AIS Data for Ship Identification. Journal of Marine Science and Engineering, 2025.

Newsletter

As part of promoting activities, several editions of the newsletter have been published and distributed to personnel in Pacific Island countries

Summary

- KIOST has **developed an algorithm** to extract the coastline from a Sentinel-2 image and applied it to the Funafuti, Tuvalu.
- The coastline of **Funafuti**, extracted from **2019 to 2023**, **will be shared with SPC** and contribute to the DEP (Digital Earth Pacific) platform for demonstration.

- Moreover, an **algorithm** has been developed to estimate the **wave properties**, including wave direction and wavelength, from Sentinel-2 and Landsat data, which has been **applied** in **Funafuti**.
- It will provide insight into the wave properties around the island and help to understand its impact on the coastal changes. **After validation**, this **outcome** will be shared with **SPC** for **demonstration** on the **DEP** platform.

- The **land use map** of the **eastern** side (2023) and the **southeastern** side of **Funafuti**, Tuvalu, was generated (2025). The land use information will be shared with SPC, which can be added to the DEP platform. It will highlight the land use properties of Funafuti and aid in understanding these properties.

✓ Additionally, KIOST has analyzed the long-term changes of the coastal areas of Tuvalu, which depict the circumstances of previous coastal changes.

✓ Besides, a long-term analysis of tropical cyclone occurrences in the vicinity of Tuvalu and its possible impact on Tuvalu has been conducted. The output of these analyses will be helpful in understanding the pattern of coastal changes resulting from natural or anthropogenic occurrences.

Next Project Summary

Application of Multisensory Remote Sensing for Controlling IUU Fishing Activities (II)

- MCS for IUU Fishing by Multisensory Remote Sensing and VMS -

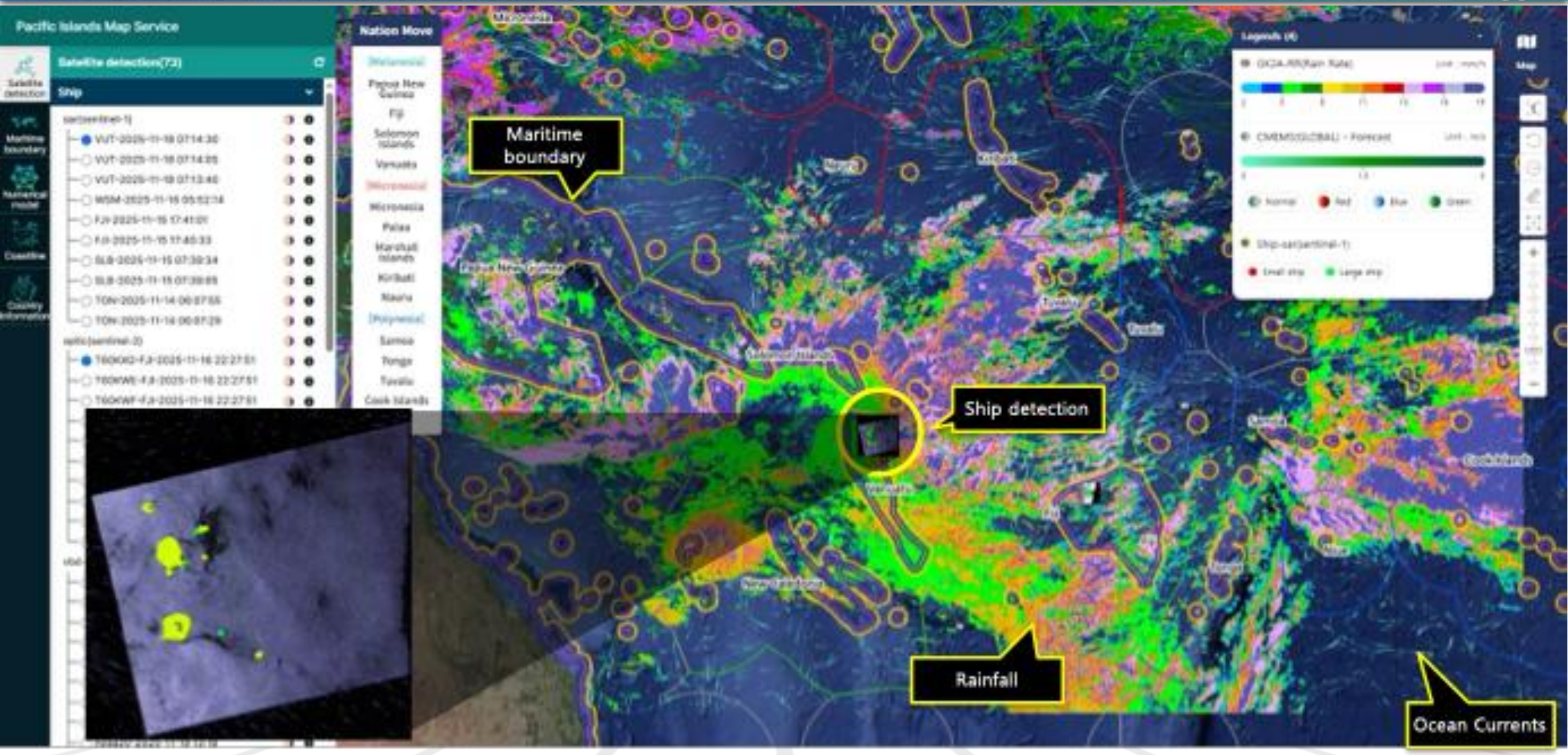
Project Goal: "Enhance Tools and Skills necessary to implement efficient, effective and targeted MCS systems for PICs".

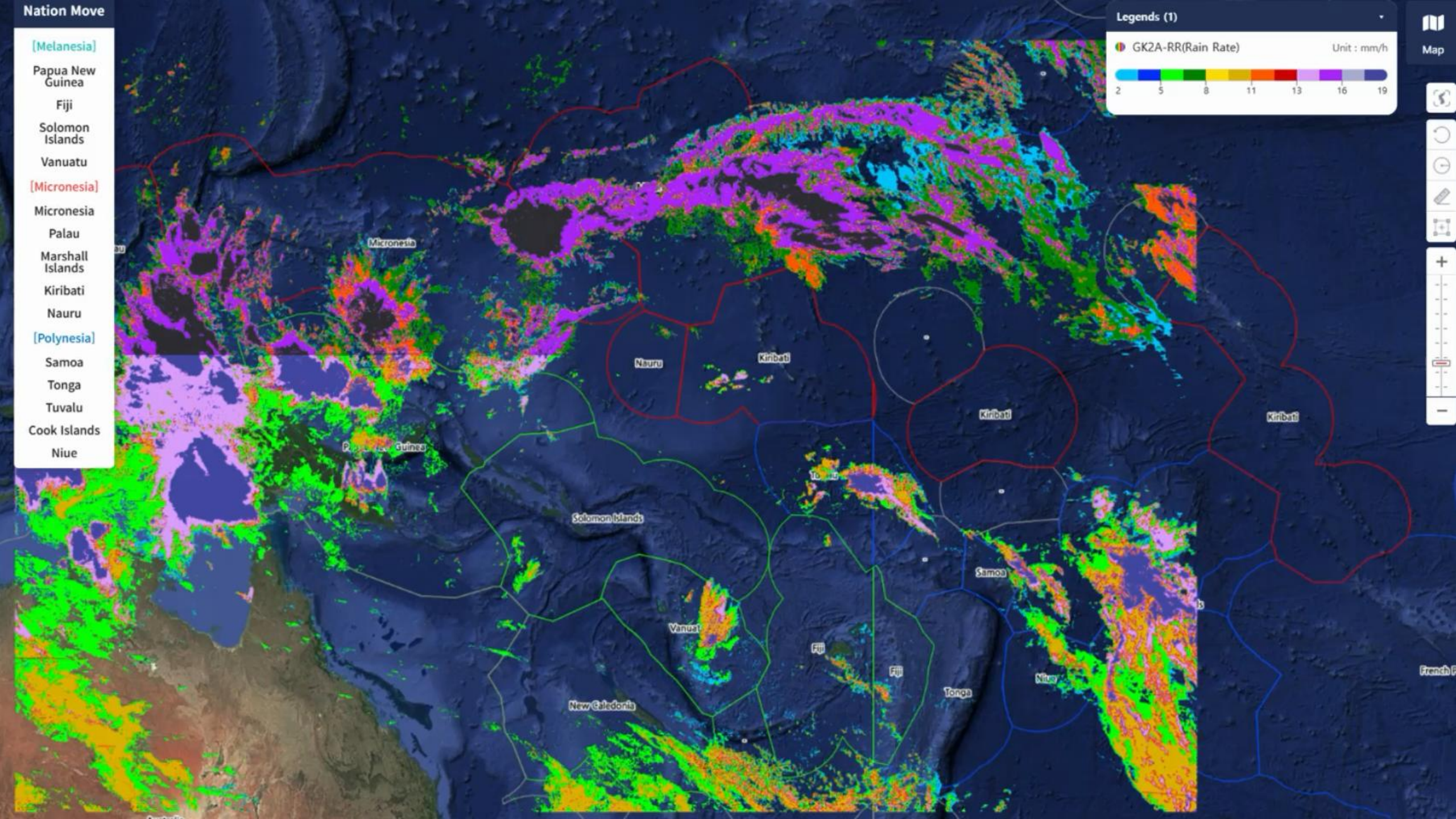
- **Donor:** Ministry of Foreign Affairs (MOFA) KOREA.
- **Implementing Agencies:** FFA and KIOST

1. Remote Sensing Techniques: ship detection, classification & identification using Radio frequency (RF), SAR and EO satellites
2. Data Analysis Units
   - Matching and Tracking
   - AI Prediction Models for MCS
3. Capacity building

1. Operational usage of developed algorithm
2. Capacity building
3. MDA development through RSP & RIMF
4. Use of MCS data to conduct Risk Assessment and Intelligence Analysis

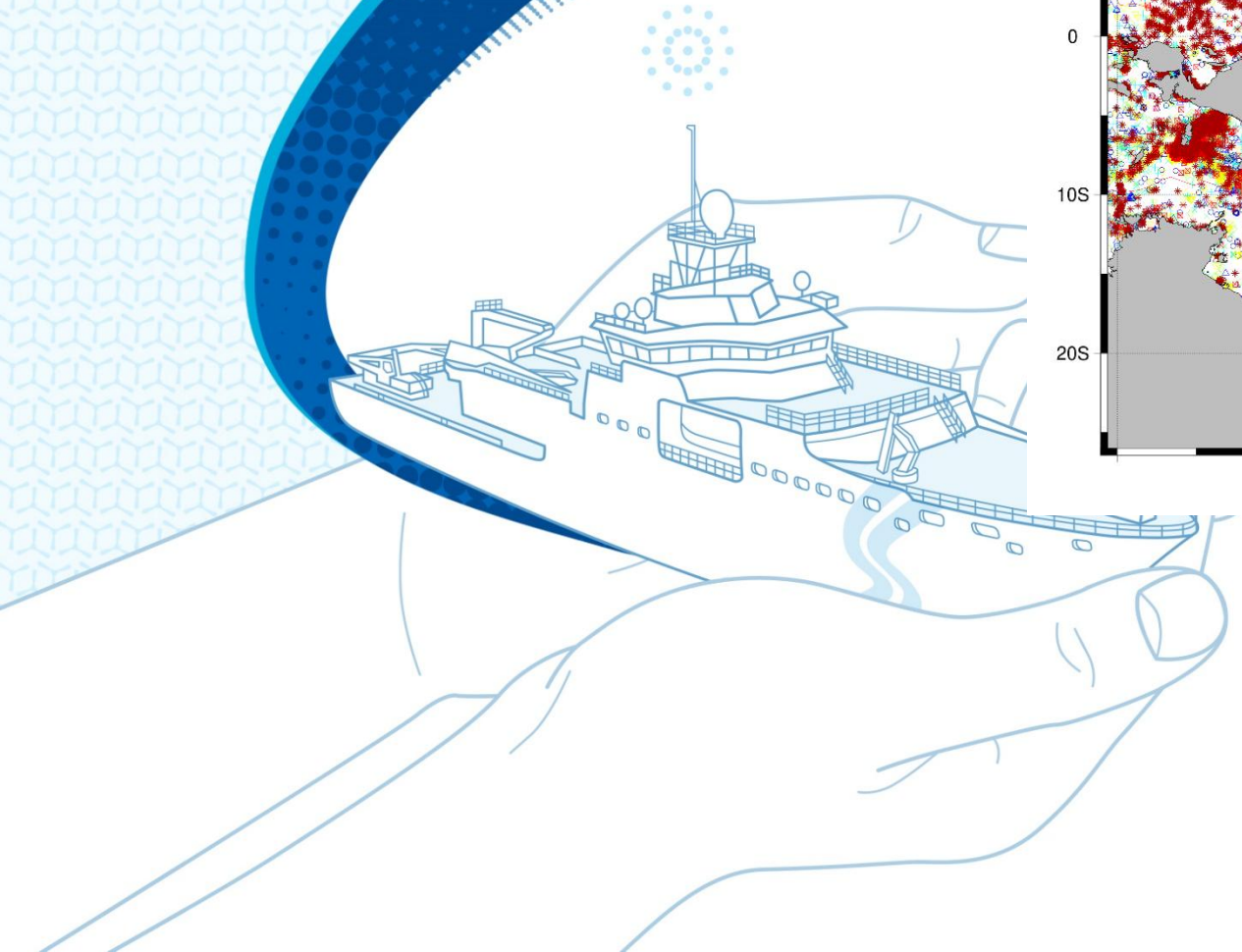
Pacific Data Platform: Map Service

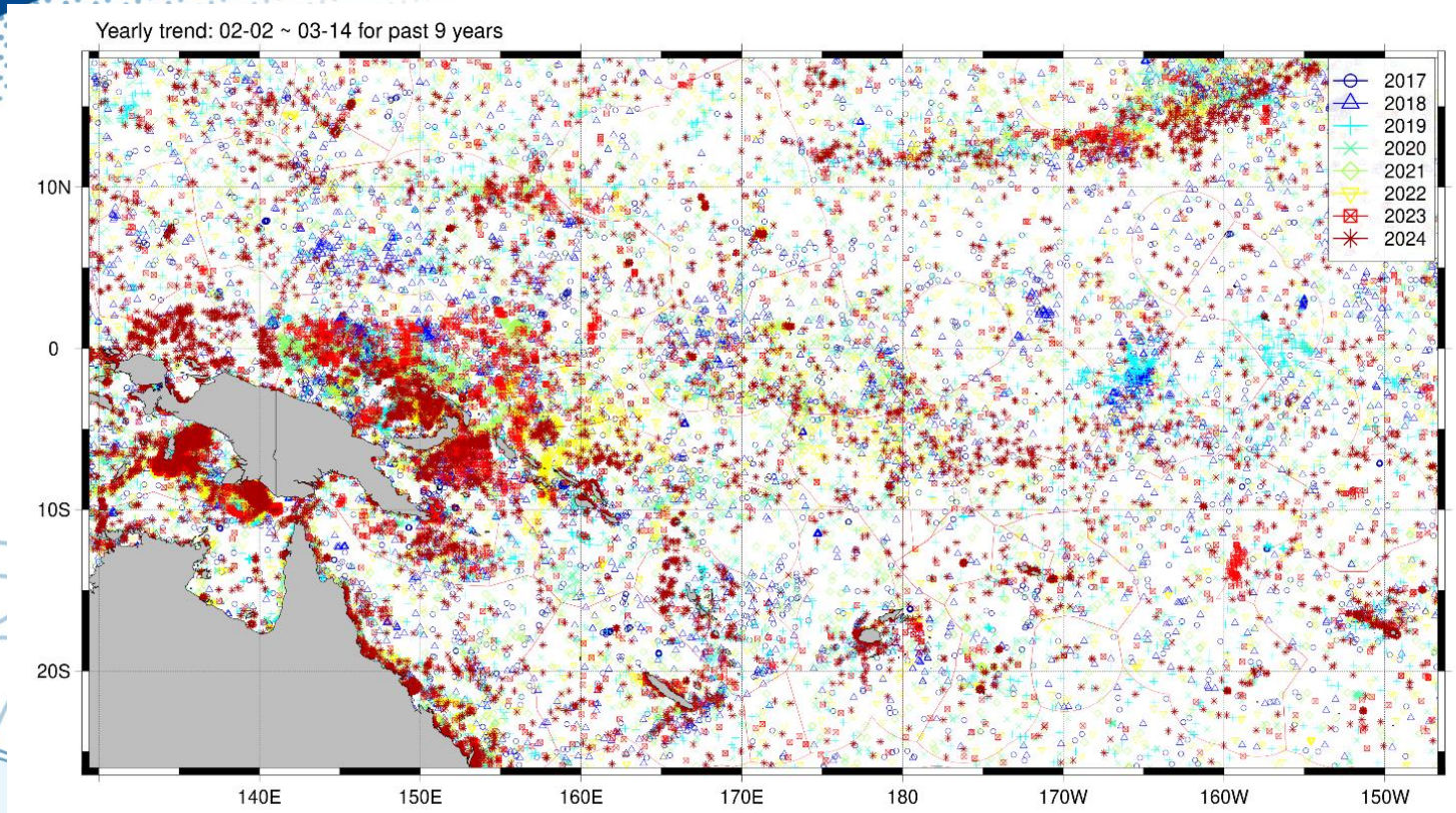



Nation Move
[Melanesia]
Papua New Guinea
Fiji
Solomon Islands
Vanuatu
[Micronesia]
Micronesia
Palau
Marshall Islands
Kiribati
Nauru
[Polynesia]
Samoa
Tonga
Tuvalu
Cook Islands
Niue
Legends (1)
GK2A-RR(Rain Rate)
Unit : mm/h
2
5
8
11
13
16
19
Map
Micronesia
Nauru
Kiribati
Kiribati
Kiribati
Solomon Islands
Samoa
Vanuat
Fiji
Fiji
Tonga
Niue
New Caledonia

Finding the People's Happiness in the Sea,
Ocean Science & Technology Contributing
to the Humankind

바다에서 찾는 국민의 행복, 인류에 공헌하는 해양과학기술





THANKYOU

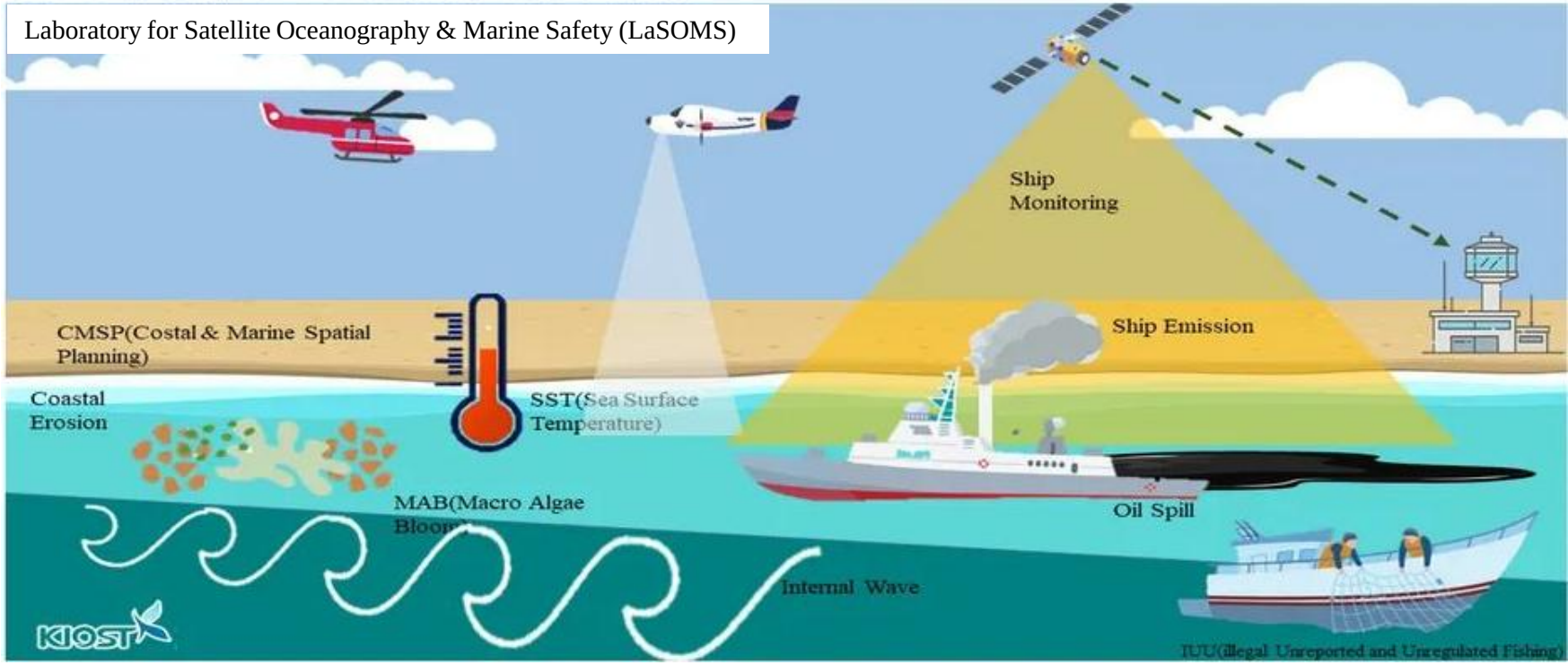
50 해양을 과학하다
Ocean Specialist KIOST
KIOST

KIOST
한국해양과학기술원

Come join the Laboratory for Satellite Oceanography & Maritime Safety (LaSOMS)

We are looking for students (Master's/PhD) to start Spring and Fall 2026 & 2027

Contact: Dr. Chan-Su Yang
(yangcs@kiost.ac.kr)



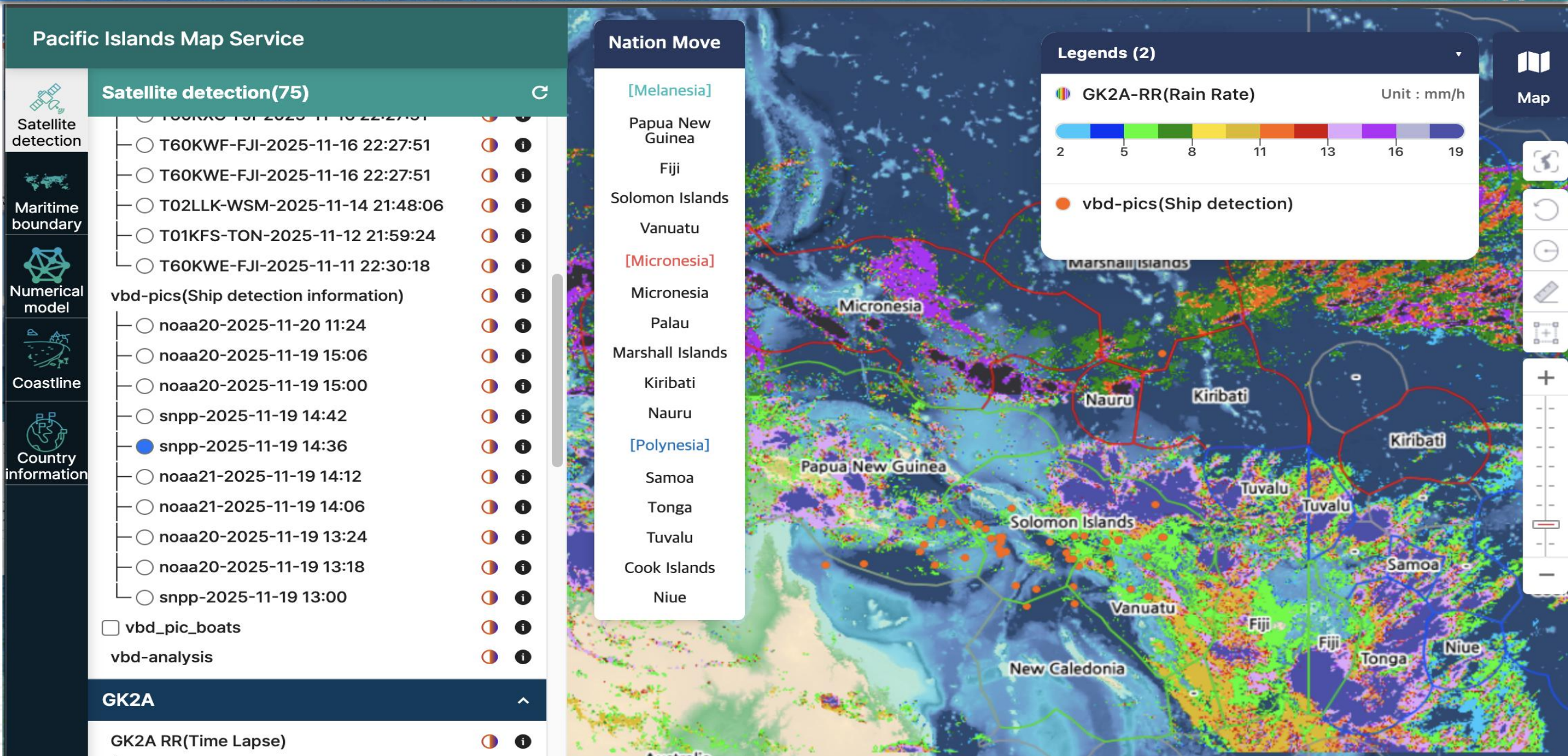
Application belongs to:

1) University of Science & Technology (UST), Republic of Korea Link: https://www.ust.ac.kr/eng/

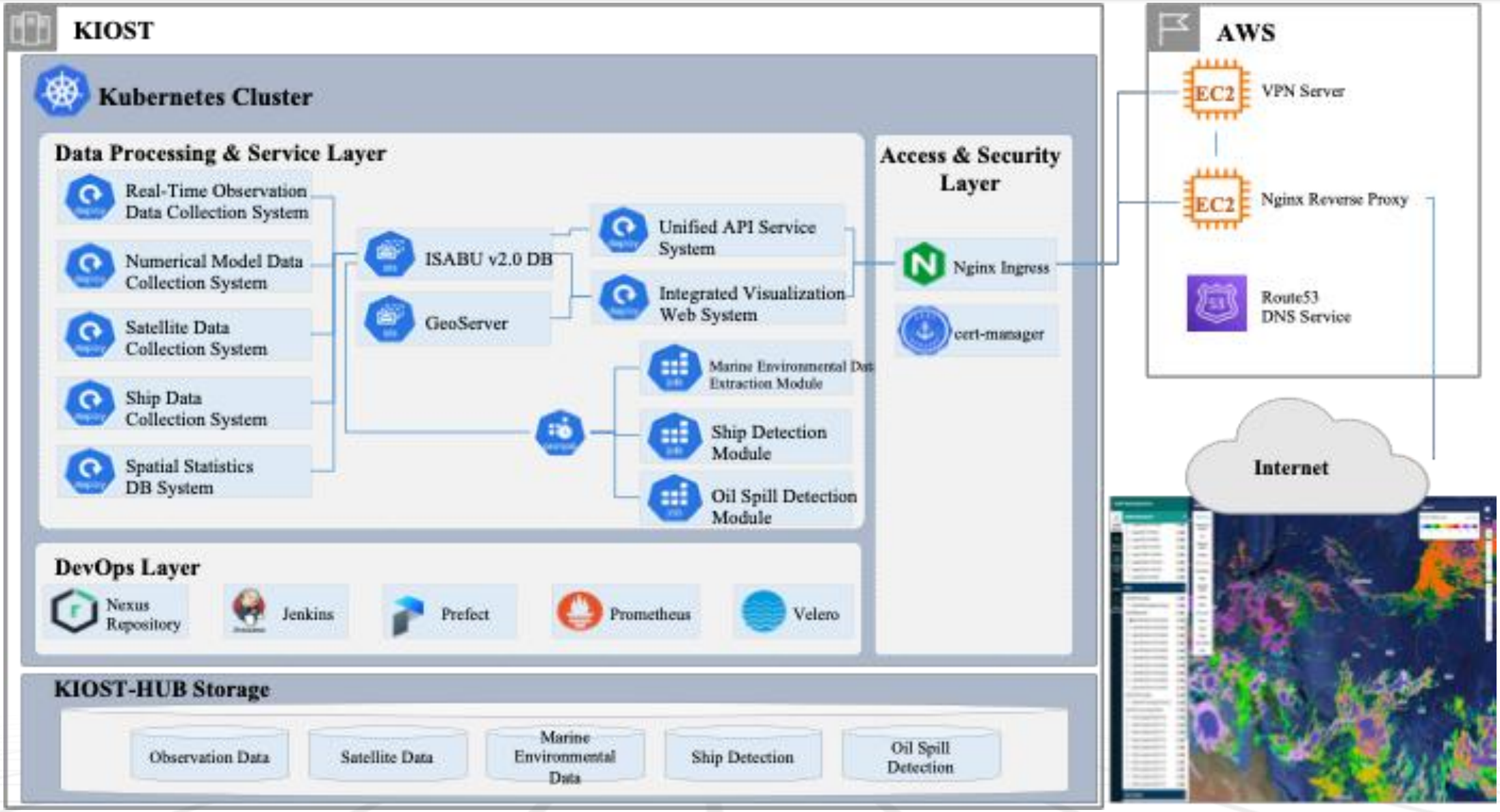
2) Ocean Science and Technology School, Korea Maritime & Ocean University, Republic of Korea
Link: https://www.kmou.ac.kr/english/main.do

** Tuition fee, living and other expenses will be covered by scholarship
(1100 US$ for M. course and about 1300 US$ for Ph.D candidates)

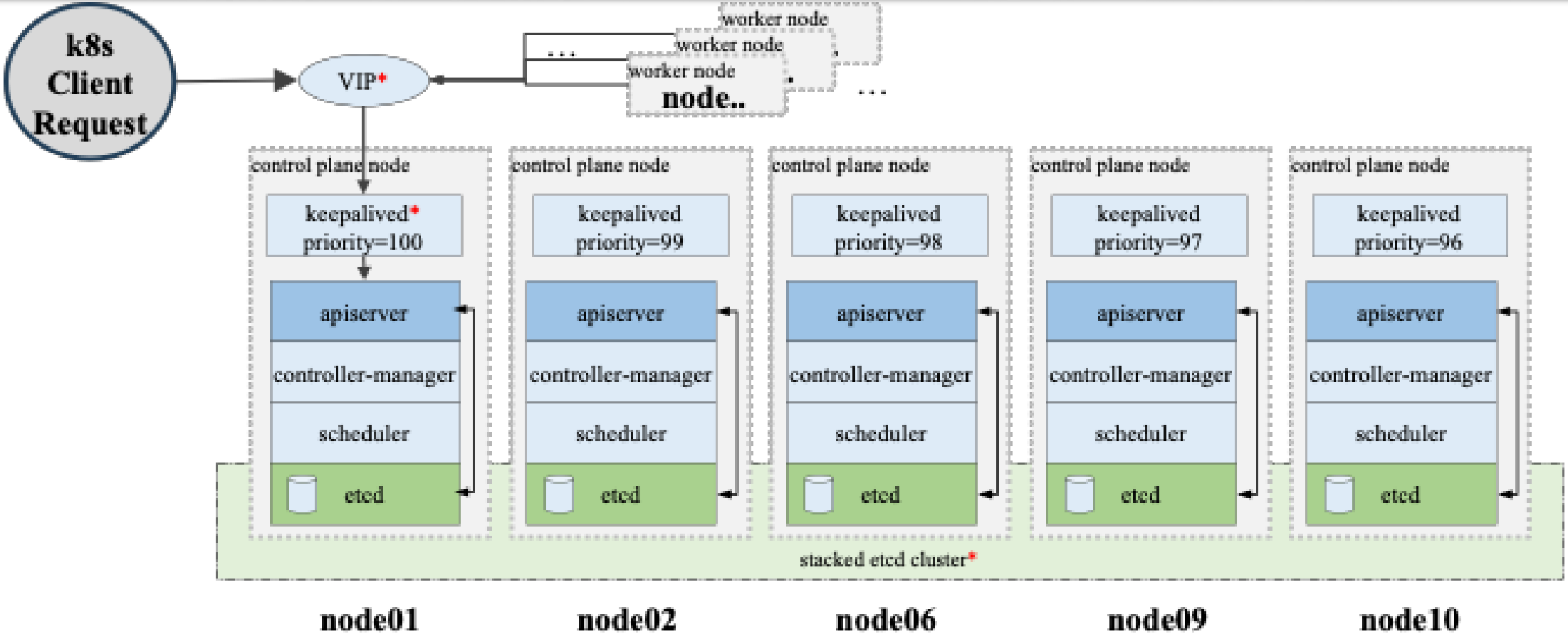
Pacific Data Platform



Pacific Data Platform: ISABU2.0



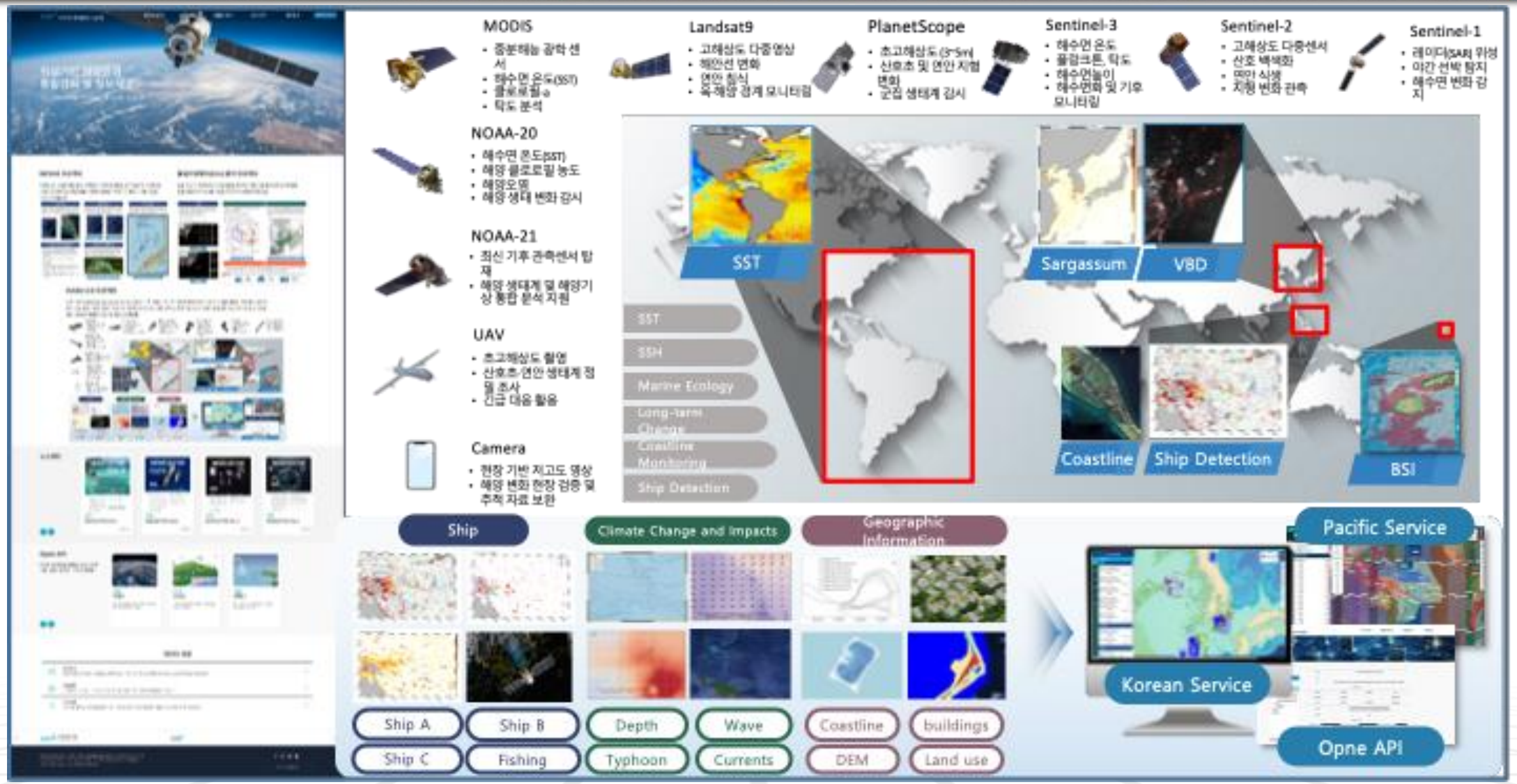
Pacific Data Platform: ISABU2.0



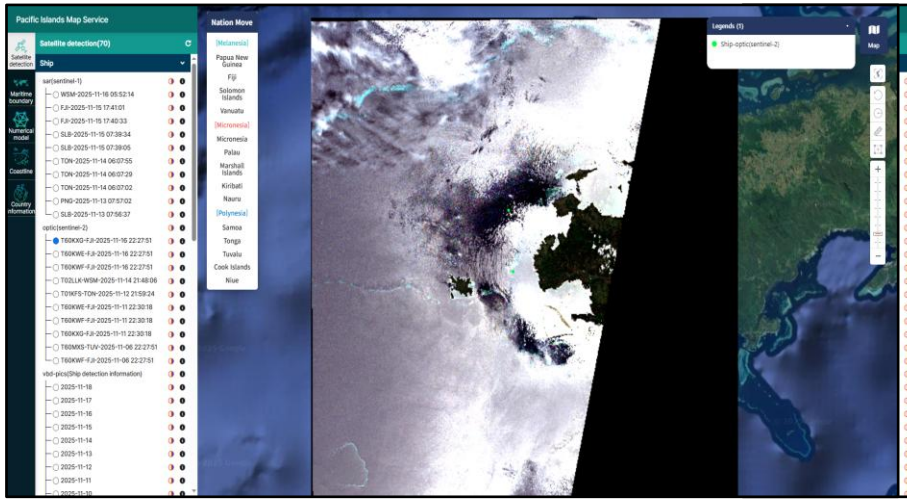
Kubernetes clustering provides high availability by automatically recovering from node failures.

- VIP: Virtual IP used as the primary access point for the Kubernetes API server
- keepalived: Assigns the VIP to the node with the highest priority value
- Stacked etcd cluster: Five master nodes running etcd in a clustered, synchronized configuration

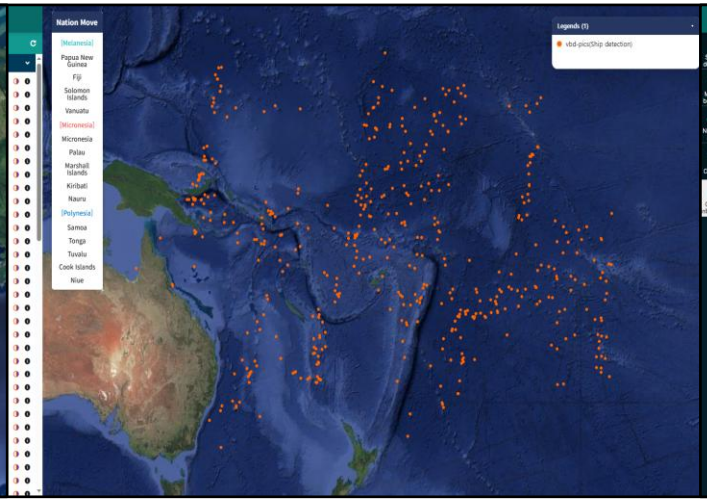
Pacific Data Platform



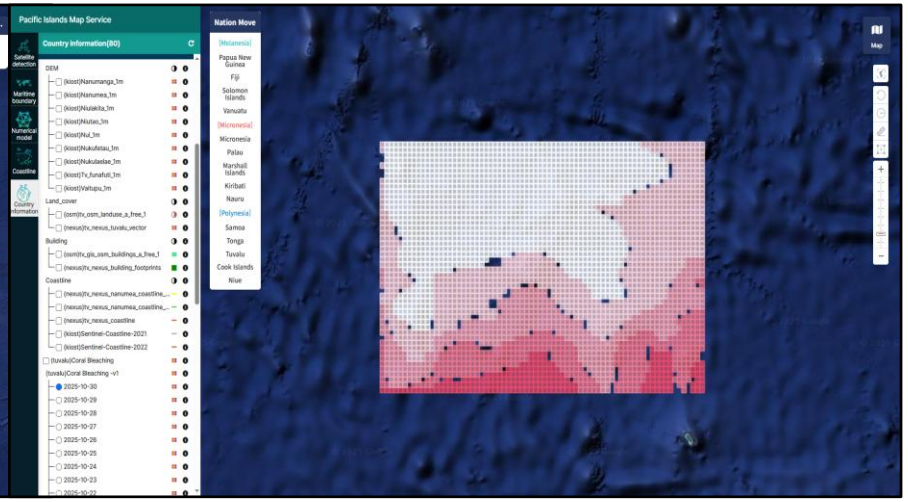
Pacific Data Platform: NRT



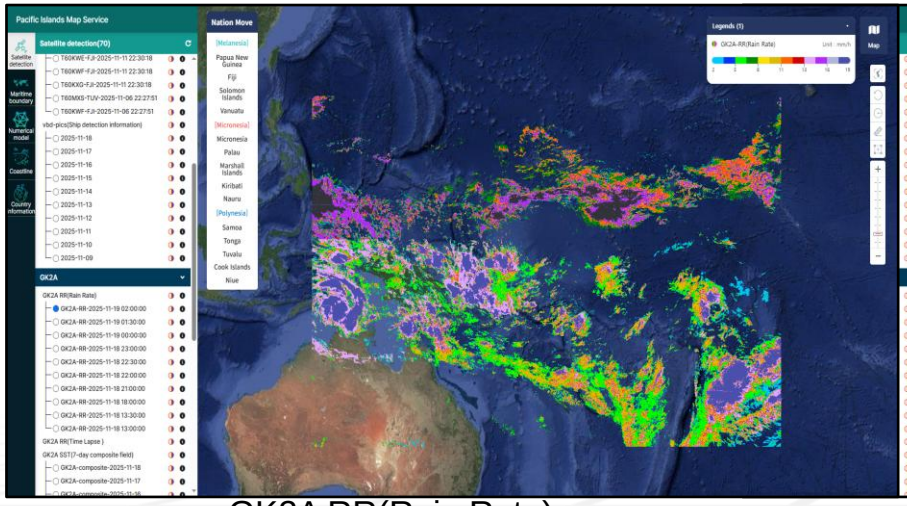
sar(sentinel-1)



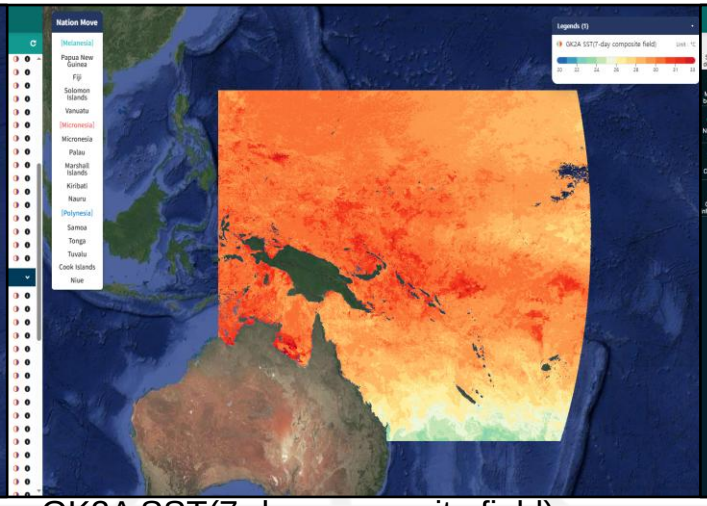
vbd-pics(Ship detection information)



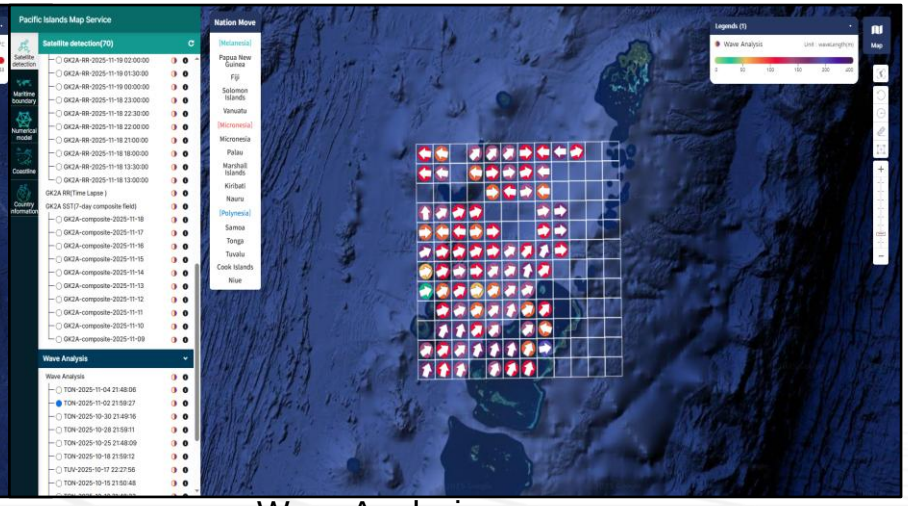
Tuvalu_BSI –v1



GK2A RR(Rain Rate)



GK2A SST(7-day composite field)



Wave Analysis