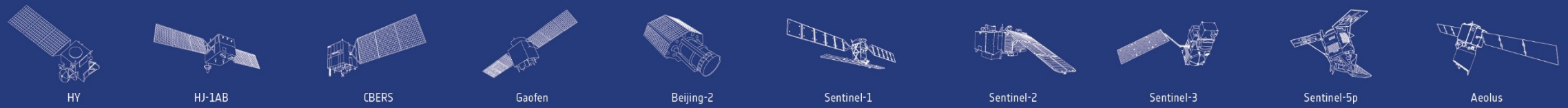


2023 DRAGON 5 SYMPOSIUM

3rd YEAR RESULTS REPORTING

11-15 SEPTEMBER 2023

PROJECT ID. 57192

REMOTE SENSING OF CHANGING COASTAL MARINE ENVIRONMENTS (RESCCOME)

WEDNESDAY, 12 SEPTEMBER 2023, S.2.1: COASTAL ZONES AND OCEANS

ID. 57192

PROJECT TITLE: REMOTE SENSING OF CHANGING COASTAL MARINE ENVIRONMENTS (RESCCOME)

PRINCIPAL INVESTIGATORS: MARTIN GADE & LI XIAO-MING

CO-AUTHORS: MERETE BADGER, CHARLOTTE HASAGER, ABDALMENEM OWDA, SEBASTIAN PETERS, SIMON SCHÄFERS, WANG WENSHENG, ZHANG DI, ZI NANNAN

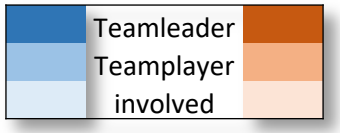
PRESENTED BY: MARTIN GADE

Objectives:

- Exploitation of Copernicus Sentinels, ESA, ESA TPM and Chinese EO data:
  better understanding of the ways, in which coastal ecosystems are exposed to, and react on, various anthropogenic impacts
- Scientific exchange:
  bi- or multi-lateral research or educational activities, joint Sino-European research packages
- Publication of co-authored results:
  joint publications at the Midterm and Final Dragon 5 Symposia, and in leading peer-reviewed scientific journals
- Training to young European and Chinese scientists:
  webinars, excursions, educational courses, and summer schools

Contribution of the Partners:

	European partners					Chinese partners				
Research Packages:	UHH	UoA	UoB	UiT	DTU	AIRCAS	OUC	NSOAS	HNTOU	TJU
57192-1: Intertidal regions										
57192-2: Offshore wind farms										
57192-3: Offshore oil pollution										
57192-4: Coastal pollution										
57192-5: Coastline changes										
Cross-Cutting Themes:										
Synergism of RS data										
Processing of Big Data										
Coastal stress factors										
Education of Young Scientists										
Dissemination and outreach										



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ReSCCoME: EO Data Delivery

ESA /Copernicus Missions	No. Scenes
1. Sentinel-1	>1000
2.	
3.	
4.	
5.	
6.	
Total:	

Issues:

Through ESA's Sentinel Hub and from local archives at UHH and DTU.

ESA Third Party Missions	No. Scenes
1. TerraSAR-X	>10
2. ALOS	5
3. Radarsat-2	2
4.	
5.	
6.	
Total:	>17

Issues:

From local archives at UHH.

Chinese EO data	No. Scenes
1. GF-1	400 PMS 400 WFV Cam
2. Gf-3	12 Strip Dual
3. GF-6	400 WFV Multi
4. SDGSAT-1	>500 GLI >2600 TIS
Total:	>4300

Issues:

SDGSAT-1 (launched Nov 2021) freely available: https://www.sdgsat.ac.cn/

GF-1, GF-3, and GF-6 data available: https://data.cresda.cn/

European Young scientists contributions in ReSCCoME

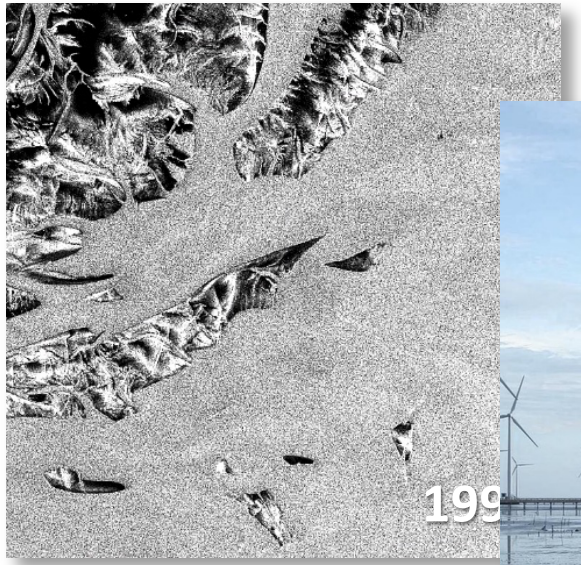
Name	Institution	Poster title	Contribution including period of research
Simon Schäfers	UHH	A Neural Network for the Detection of Water Lines	MSc student, since 2022
Sebastian Peters	UHH	N/A	BSc student, since 2021
Abdalmenem Owda	DTU	N/A	PhD student, since 2021

Chinese Young scientists contributions in ReSCCoME

Name	Institution	Poster title	Contribution including period of research
Zhang Di	UHH	Classification of Intertidal Flat Surfaces by Means of Deep Learning	PhD student, 2020-2022
Zi Nannan	AIRCAS	Oceanic Eddy Detection from SAR Imagery Based on Deep Learning Network	PhD student, since 2021
Qiu Yujia	AIRCAS	Retrieval of Sea Ice Drift in the Arctic Based on Sequential Sentinel-1 SAR Data	PhD student, since 2020
Huang Bingqing	AIRCAS	N/A	PhD student, 2019-2023
Jia Tong	AIRCAS	N/A	PhD student, 2018-2022

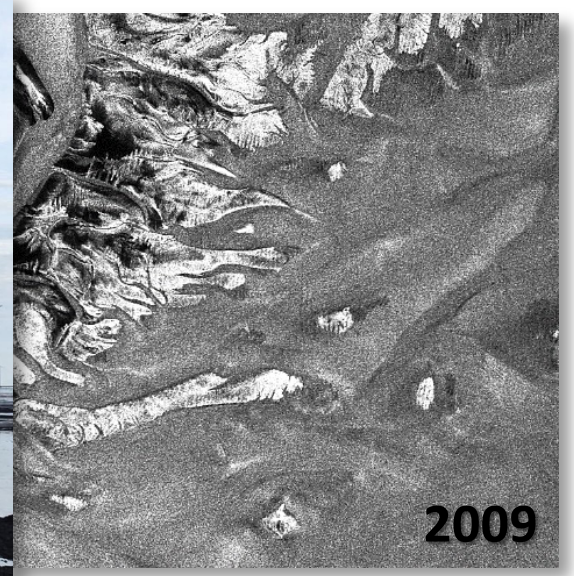
ReSCCoME: Remote Sensing of Changing Coastal Marine Environments

Longterm changes – example: Chinese coast:



ERS-1, 10 Jun 93, 0234 UTC

2011: Jiangsu Rudong intertidal offshore wind farm



NVISAT, 11 May 09, 1345 UTC

25 km × 25 km

Sentinel-1A, 11 Mar 17, 0954 UTC

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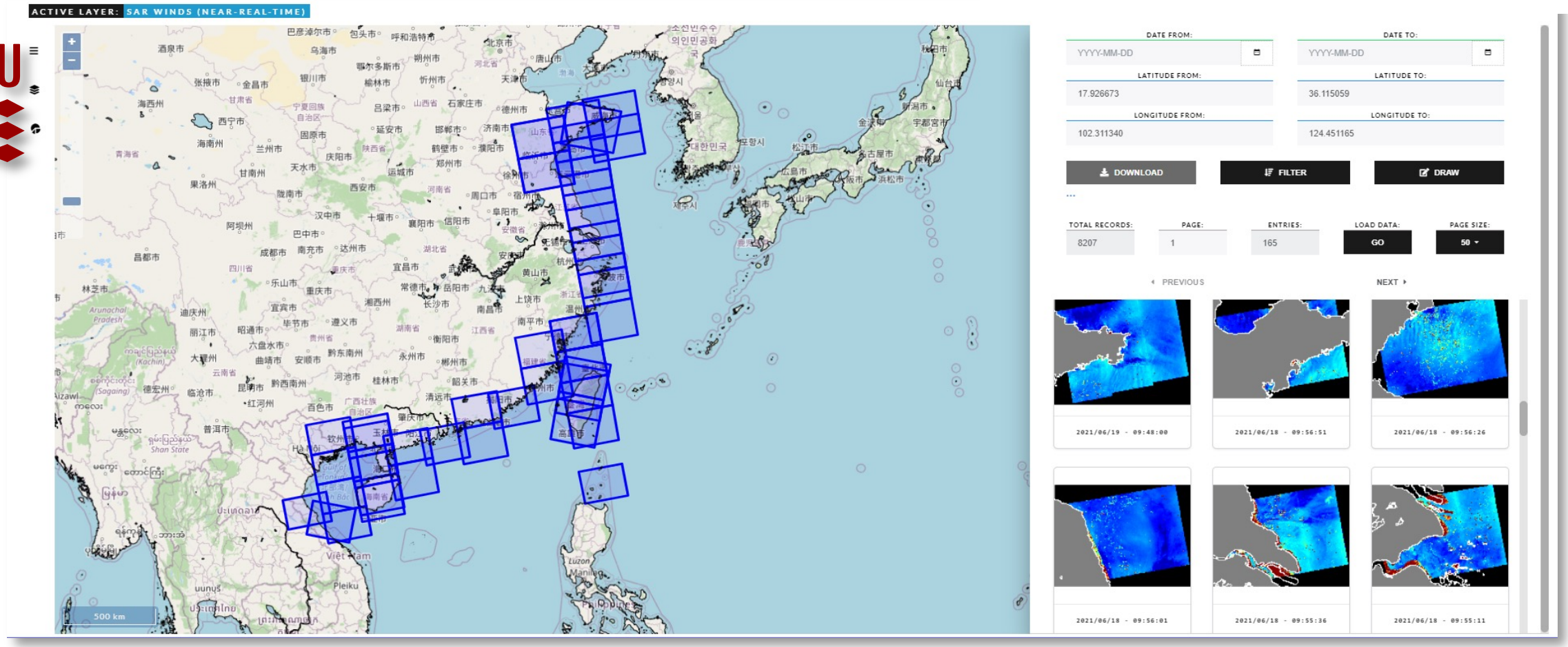
ReSCCoME: Remote Sensing of Changing Coastal Marine Environments

Full archive of wind maps from DTU:

https://science.globalwindatlas.info/ (select 'Offshore wind fields in near-real-time')



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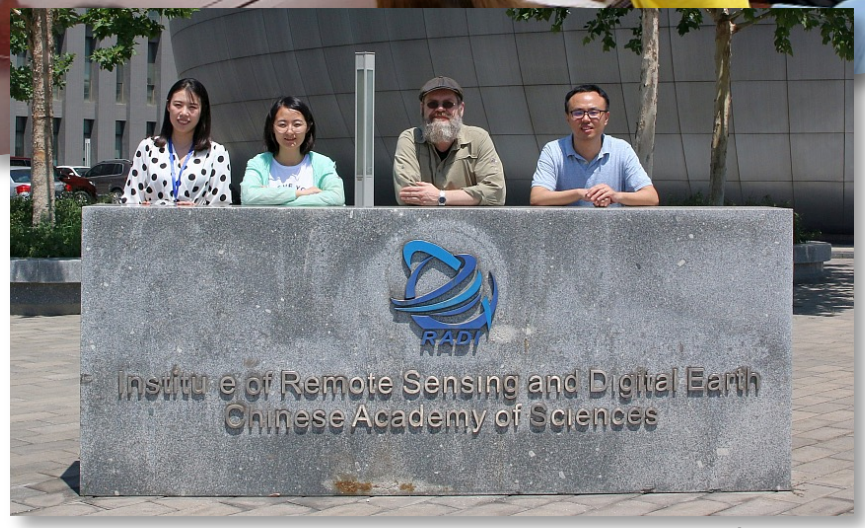
ReSCCoME: Field Data Collection

In-situ Data Measurements and Requirements:

- Intertidal Flats: surface roughness, sediments, moisture, habitats
- Offshore Wind Farms: atmospheric and oceanic parameters
- Offshore Oil Pollution: surface films, environmental conditions
- Coastal Pollution: plastic debris, waves & currents, bathymetry
- Coastline Changes: waterlines, water level, bathymetry

ReSCCoME: Level & Training of Young Scientists

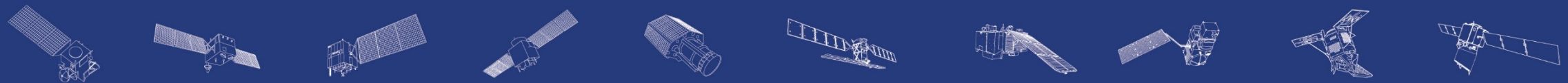
Training Classes at AIRCAS, Bejing, and TJU, Tianjin



Field Data Collection Campaigns and Periods:

- UHH student excursions on the German North Sea coast

57192 - ReSCCoME



OFFSHORE WIND FARMS

SAR Wind Retrieval and Wakes for Offshore Wind Energy Applications in East China

Credit: Abdalmenem Owda

57192 – ReSCCoME – Offshore Wind Farms

Wind wakes:

- Defined as wind-speed reduction at downwind side of offshore wind farms (OWFs)
- Decrease efficiency of OWFs
  - reduce wind-power generation
  - increase load effects on wind turbines

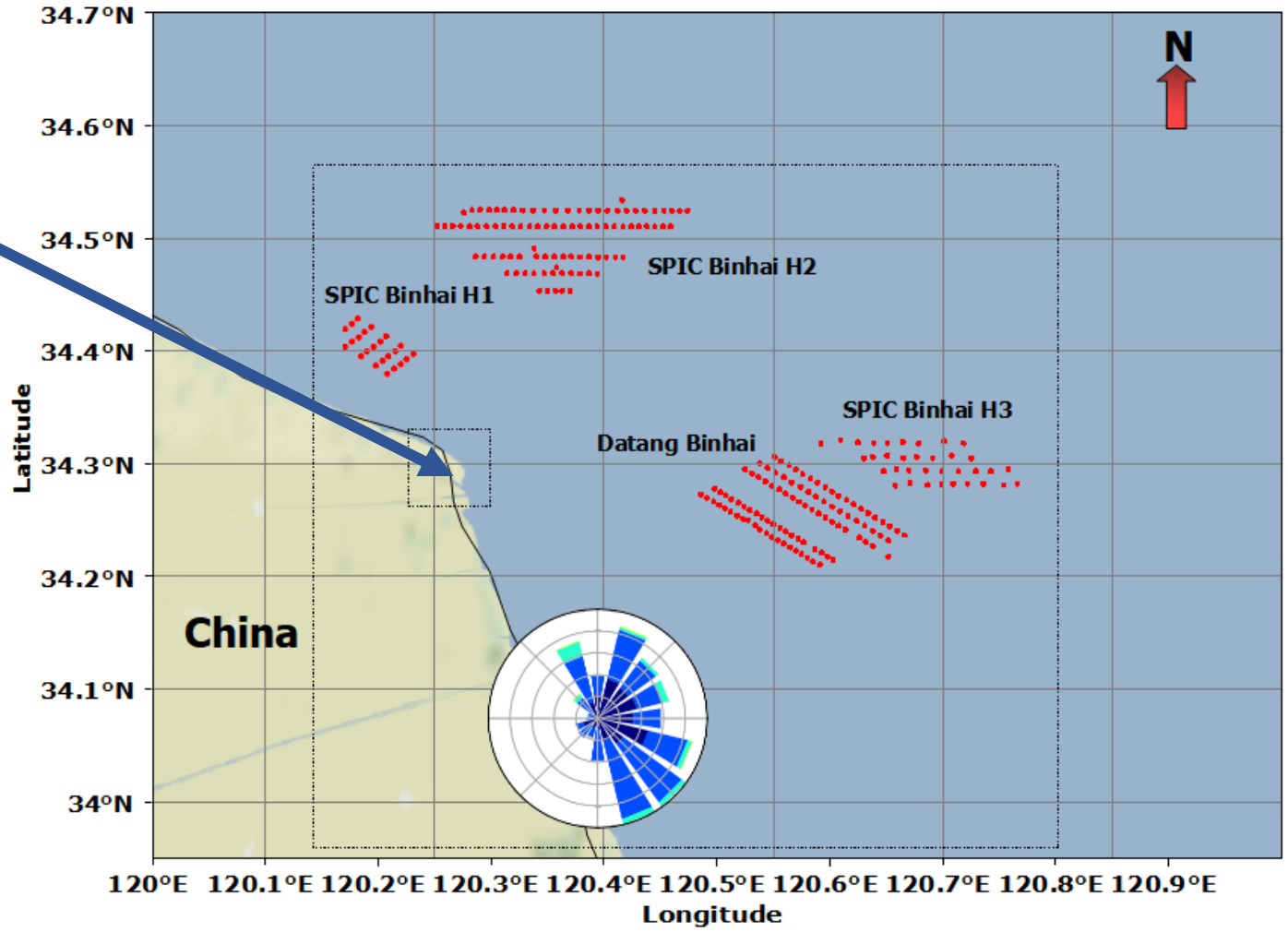
SAR:

- Provide wind speed (10 m) and wakes deficit at high spatial resolution (min. 500 m)
- Wind wakes cause high local radar contrast at downwind sides of OWFs

Study area on the Chinese coast

land expension into the sea

may increase local std dev of wind speed derived from SAR data



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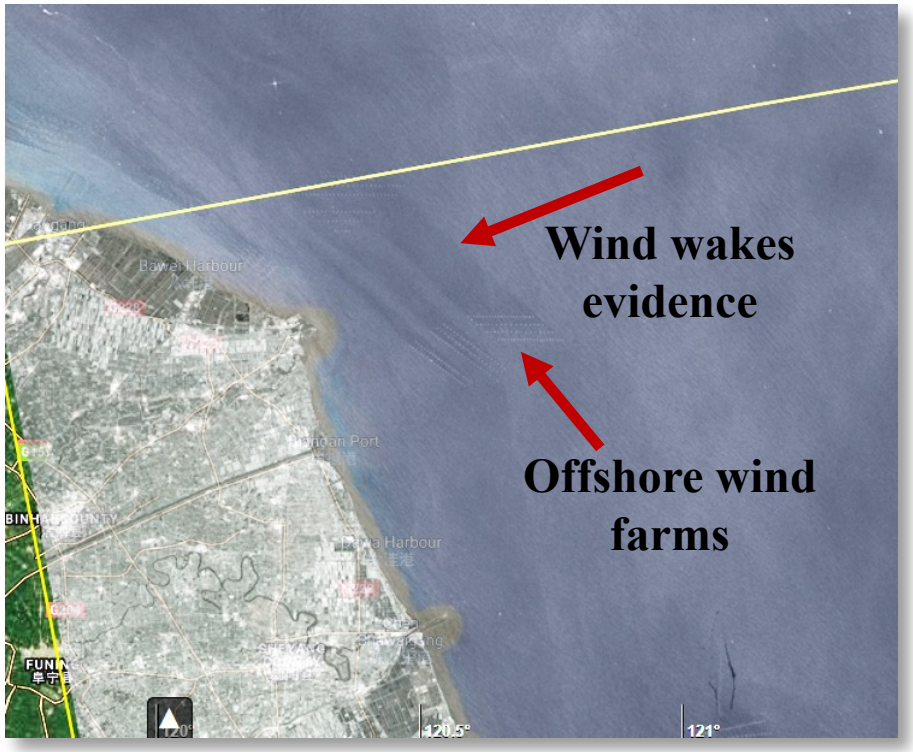
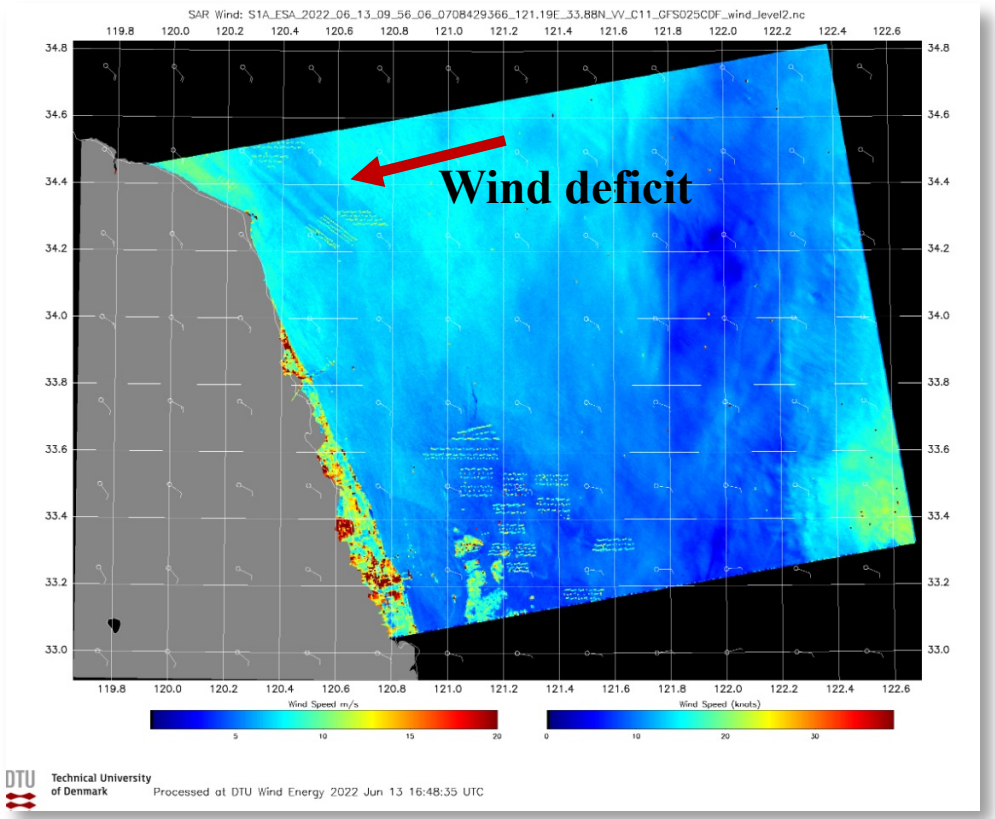
SAR Wind retrieval for offshore wind energy applications in E China



Sentinel 1A-level 1-GRDH was taken at 13h June 2022 13:09:55

https://ovl.oceandatalab.com/

CMOD5.N

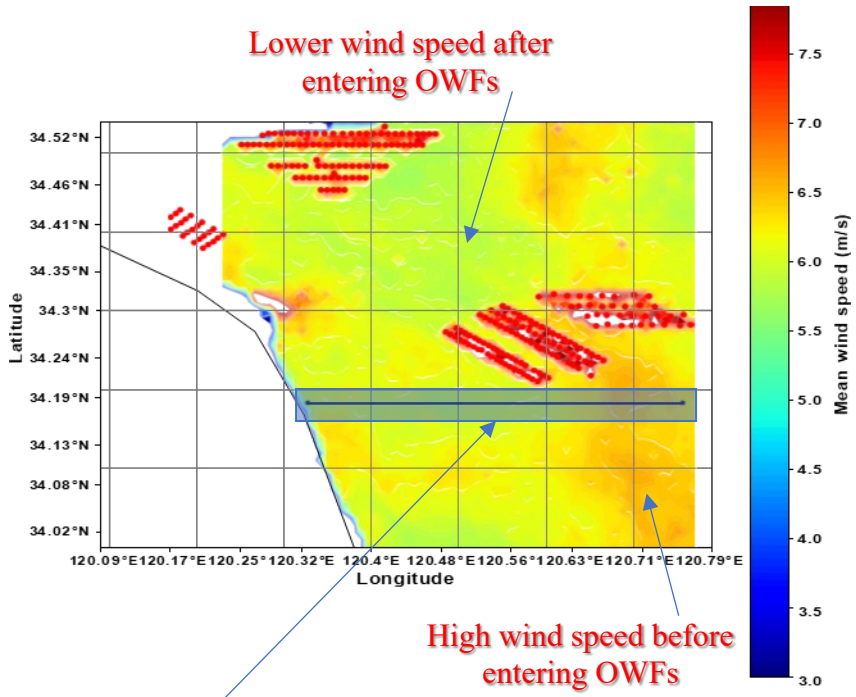


SAR wind map for the same Sentinel scene

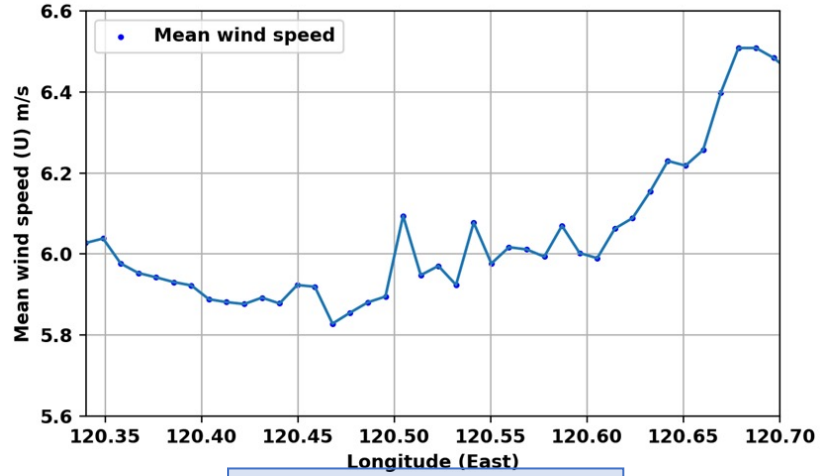
https://science.globalwindatlas.info/

Wind speed and power variation near coast

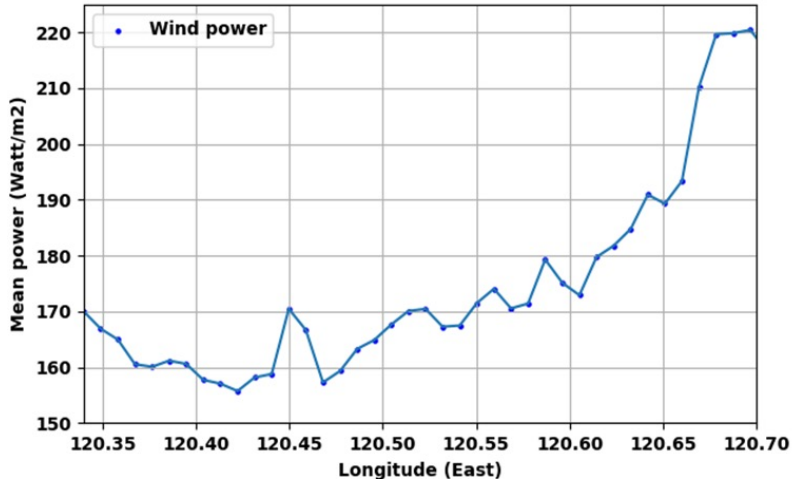
Average wind speed map from a group of SAR scenes



Wind speed and power variation along the black line (left). More wind speed reduction and power losses getting closer to the coast



$$P_{mean} = \frac{1}{2} \times \rho \times U^3$$



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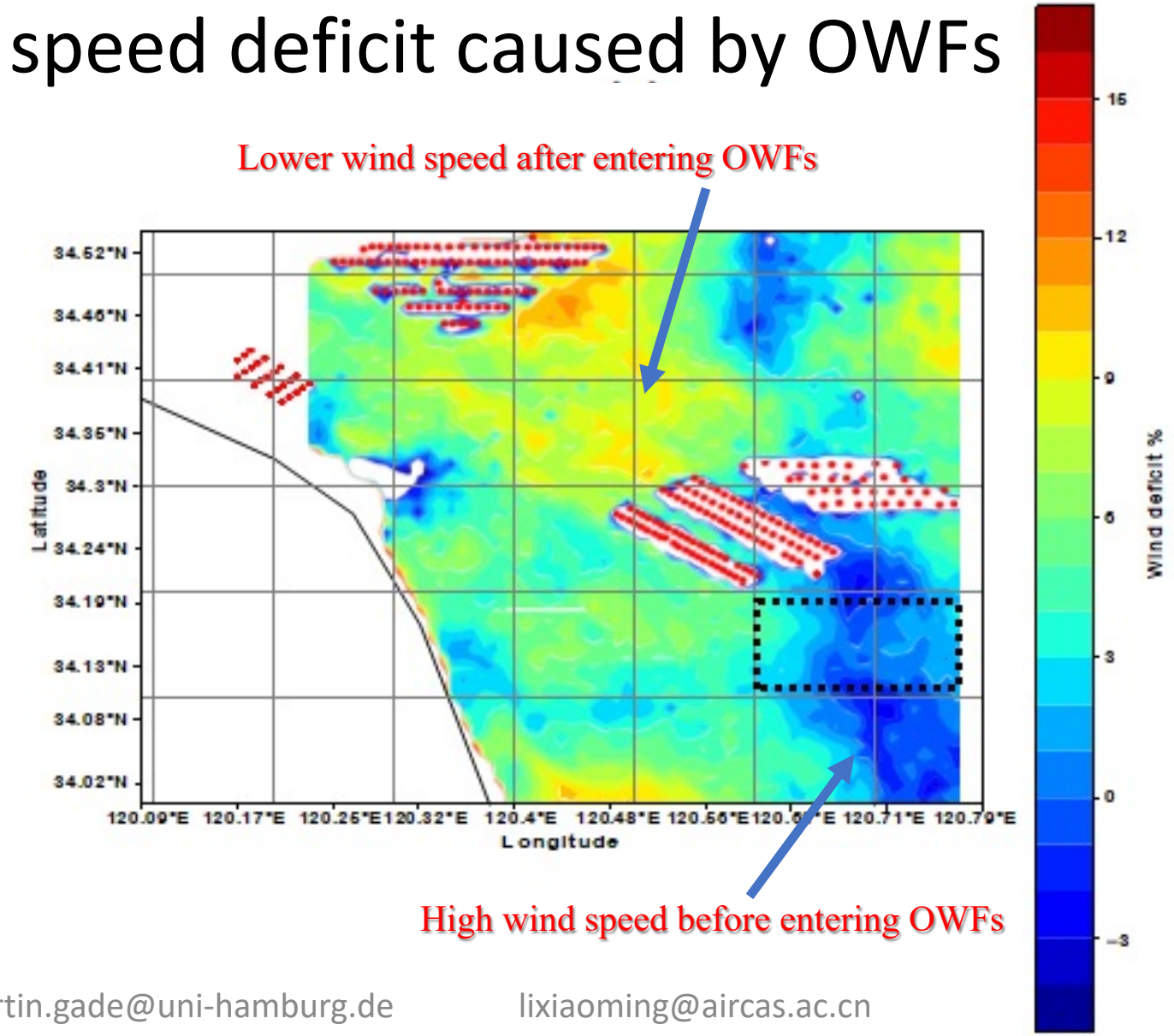
Wind speed deficit caused by OWFs



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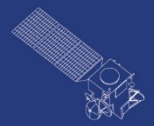
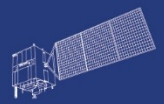
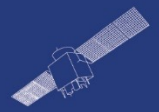
57192 - ReSCCoME


HY


HJ-1AB


CBERS


Gaofen


Beijing-2


Sentinel-1


Sentinel-2


Sentinel-3


Sentinel-5p


Aeolus

INTERTIDAL FLATS

Classification of Intertidal Flat Surfaces by Means of Multi-Sensor Data

Credit: Zhang Di, Wang Wensheng

Wadden Sea: intertidal flats on the European North Sea coast

Intertidal flats:

- ~ 10 km offshore, exposed during low tide
- Danish-German-Dutch North Sea coast
- Fine sediments, partly vegetated, habitats
- Strong morphodynamics
- Invasive species: Pacific Oyster (*Crassostrea gigas*)
- National Parks, UNESCO World Heritage (2009)
- Frequent monitoring mandatory
- SAR, because of usually high cloud cover

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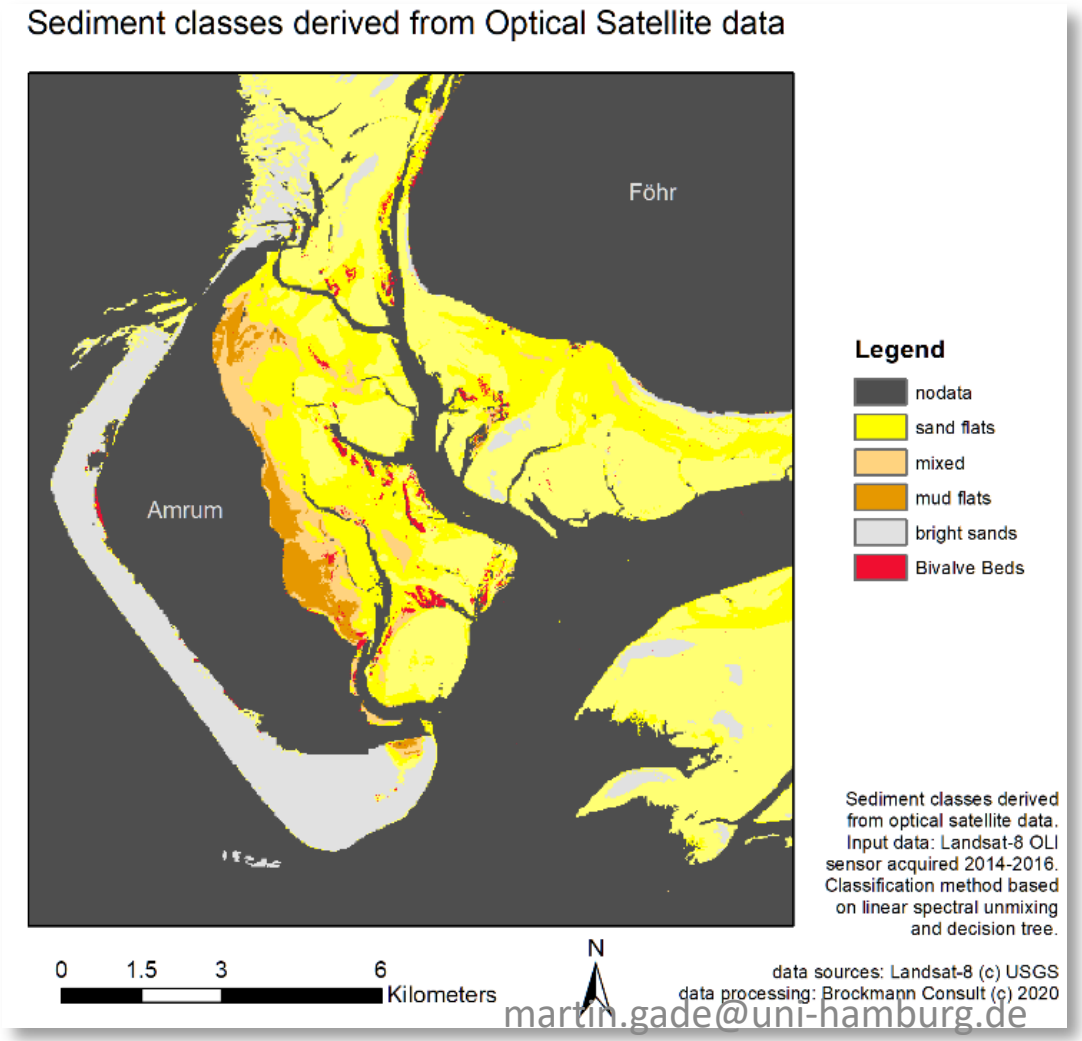
Traditional classification based on optical data



5 surface classes:

- sand
- mixed sand/mud
- mud
- bivalves
- bright sand

- Linear spectral unmixing
- Decision tree

Data source:
Landsat-8

Classification:
© Brockmann Consult

6 km × 6 km

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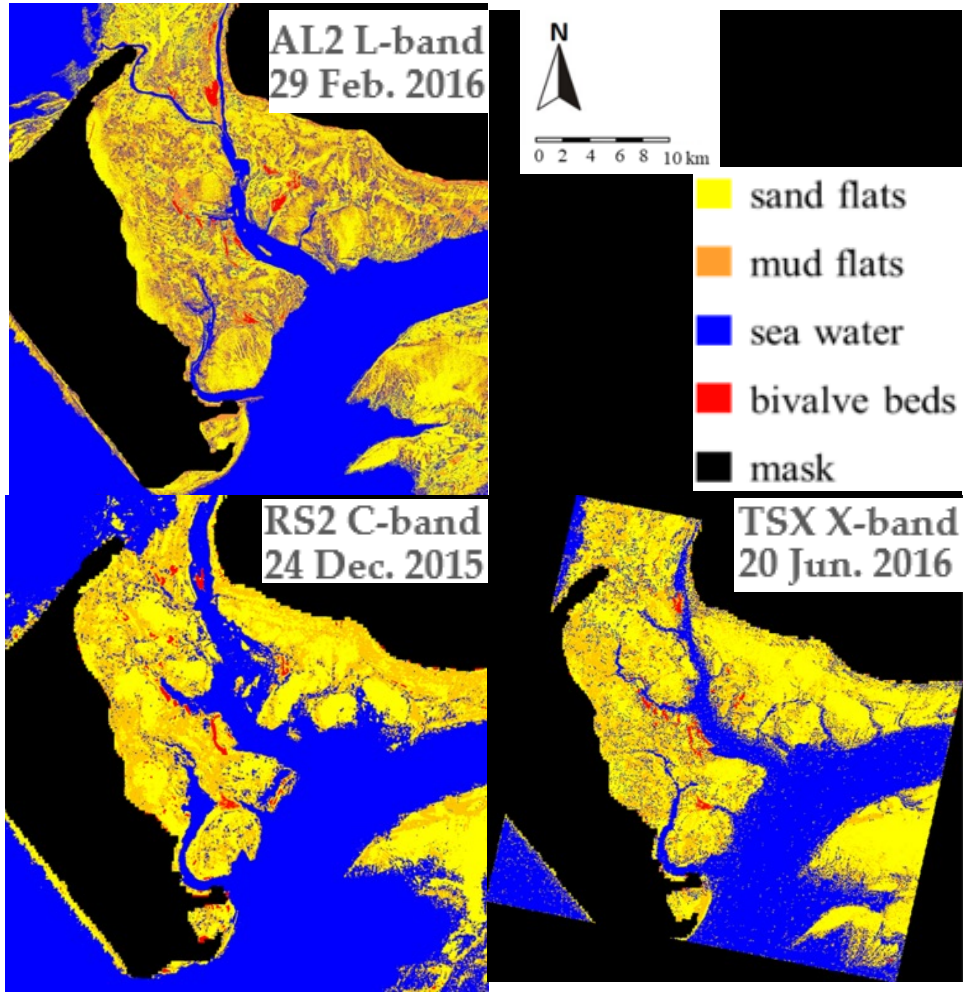
Discrimination of Surface Types — FCDK-RF Algorithm



FCDK-RF

- Freeman-Durden:
  - FD_odd, FD_vol, FD_dbl;
- Cloude-Pottier:
  - Entropy H, alpha angle α, Anisotropy A;
- Double-Bounce Eigenvalue Relative Difference (DERD);
- Kennaugh Elements (D3 and P)
- Classification according to Random Forest (RF) theory.

EXTENSION

- Partly Polarimetric Mode (HH with VV);
- Sediments, Habitats, Bivalve (oysters and mussels) beds.

	AL2 (L-Band)		RS2 (C-Band)		TSX (X-Band)	
	PA (%)	UA (%)	PA (%)	UA (%)	PA (%)	UA (%)
Sandy sediments	86.7	85.6	89.1	86.2	81.7	79.8
Mixed sediments	86.8	87.2	88.0	86.7	81.0	80.9
Open water	86.5	88.5	88.9	87.6	86.2	87.0
Bivalve beds	89.0	91.8	90.9	91.3	91.6	92.7
OA (%)	86.2		88.7		85.9	

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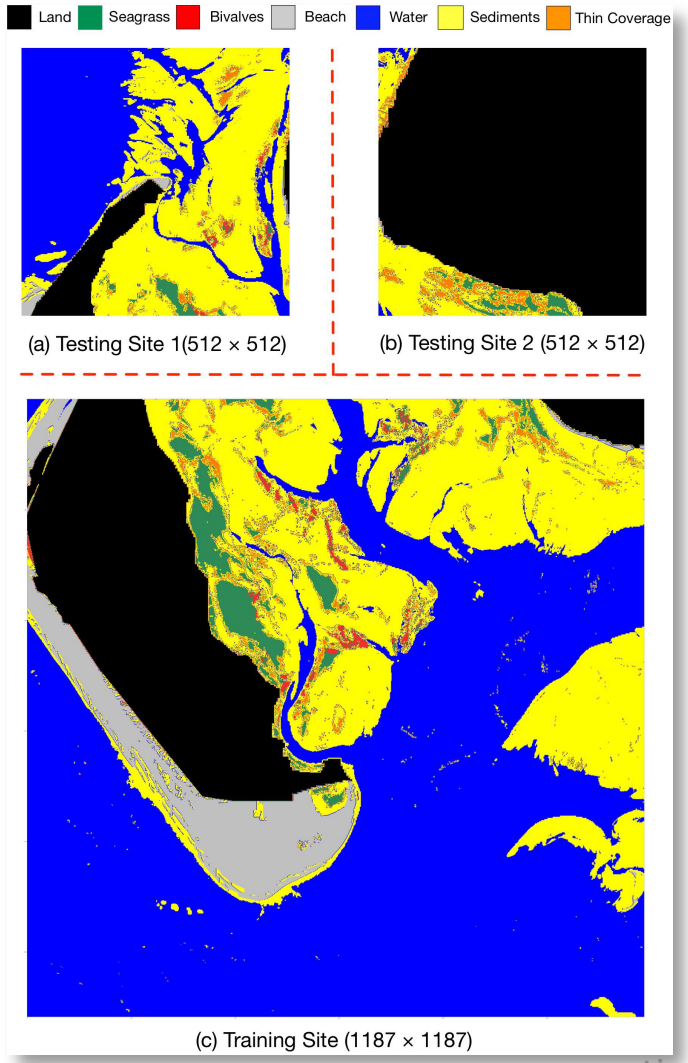
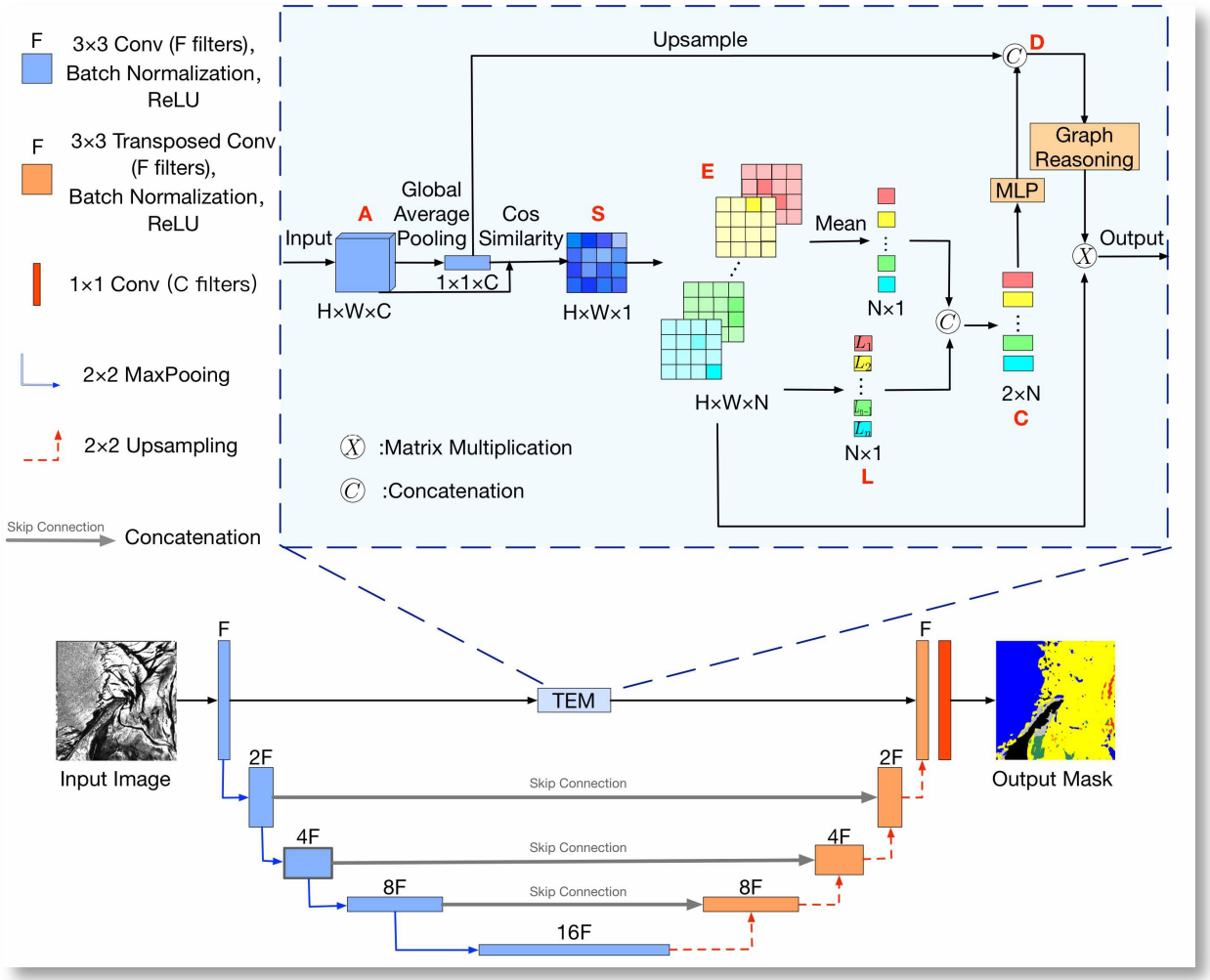
TE-UNet: Texture Enhancement UNet

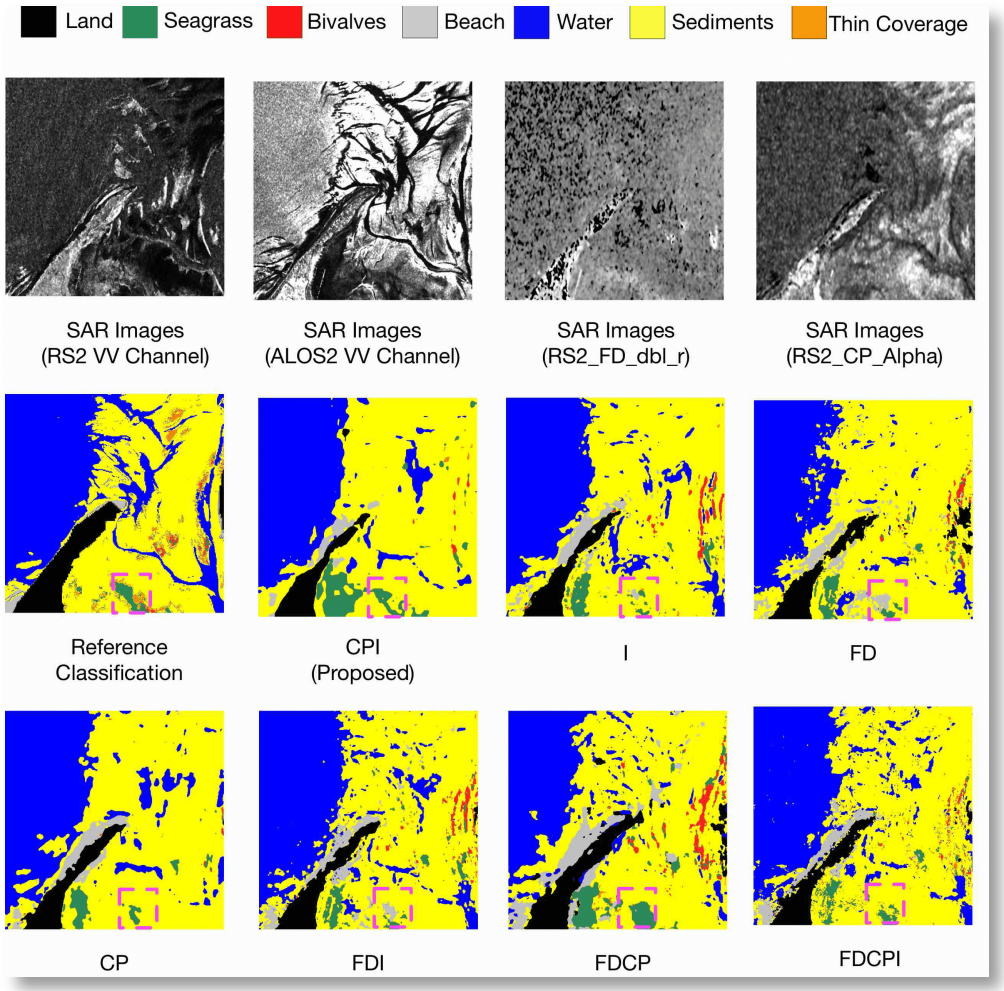




6 km × 6 km

[Zhang 2022]

Classification Based on Deep Learning Using SAR and Optical Data

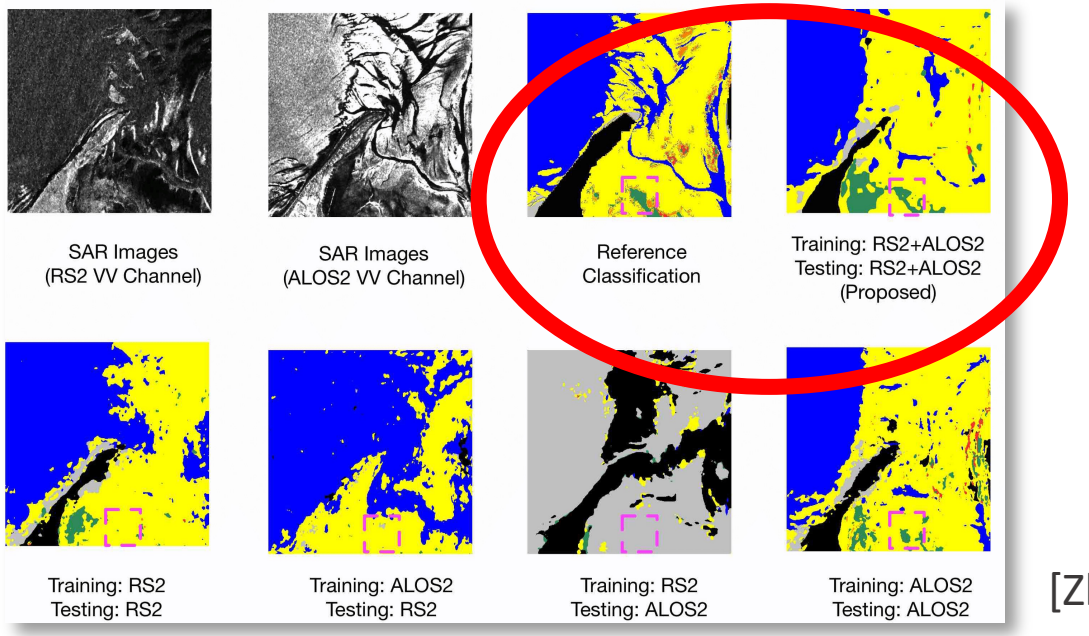


Radarsat-2
24 Dec 2015, 0543 UTC

ALOS-2
29 Feb 2016, 2257 UTC

Reference:
Landsat-8, SPOT-4, © Brockmann Consult

6 km × 6 km



[Zhang 2022]

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On the Use of SAR Data to Monitor Coastal Erosion and Morphodynamics in Intertidal Areas

Credit: Sebastian Peters, Simon Schäfers

Coastal erosion caused by storm surges

Norderney 2022

Langeoog 2022

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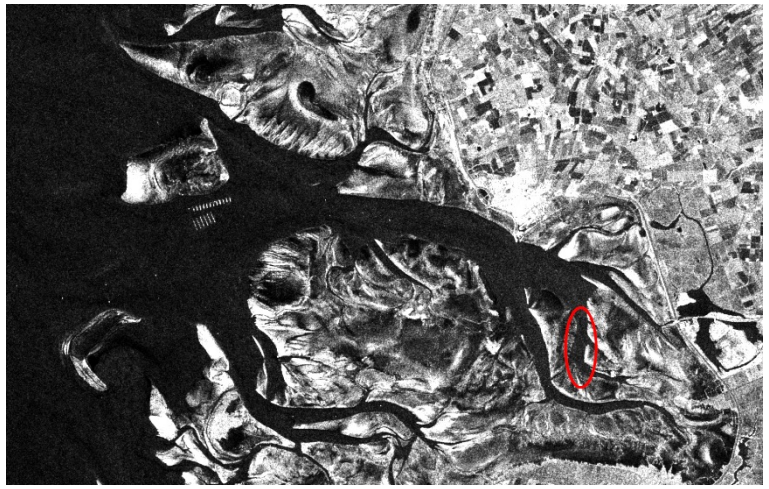
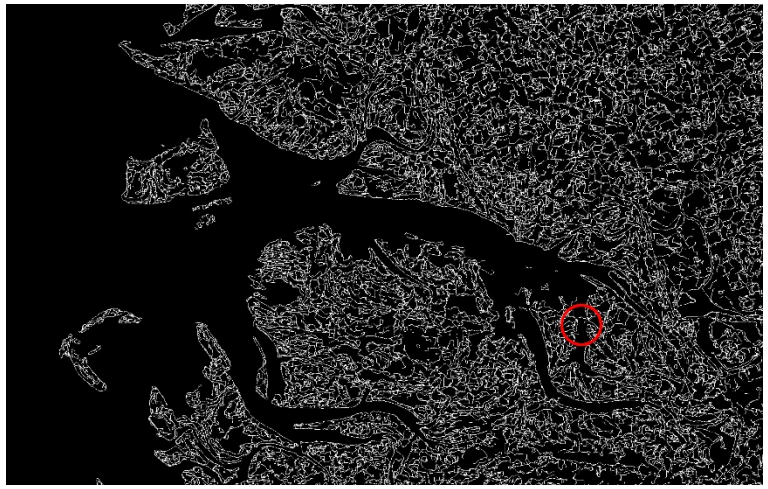
Wadden Sea waterlines from Sentinel-1 SAR data



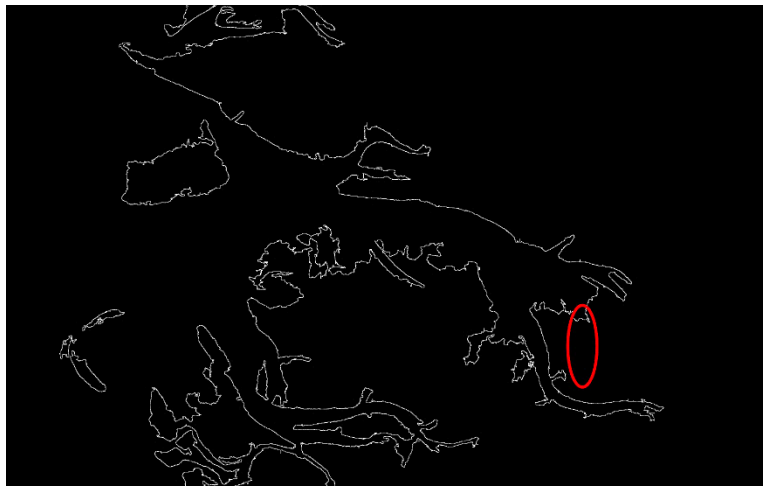
original SAR image

detected edges



binary land-water map

final waterlines



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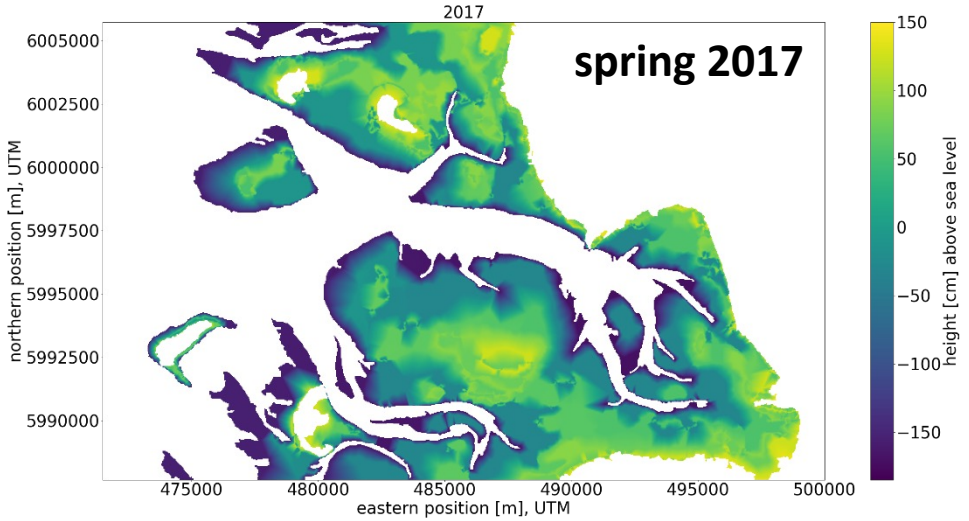
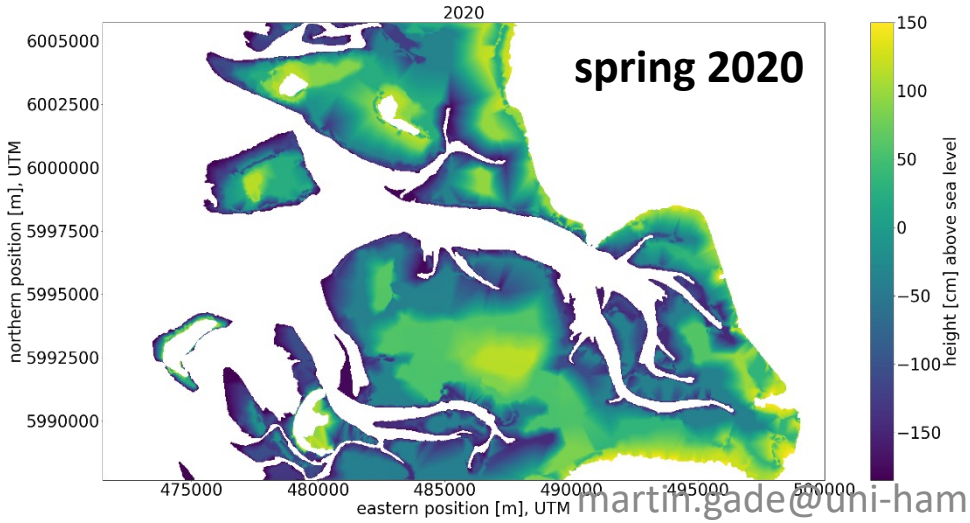
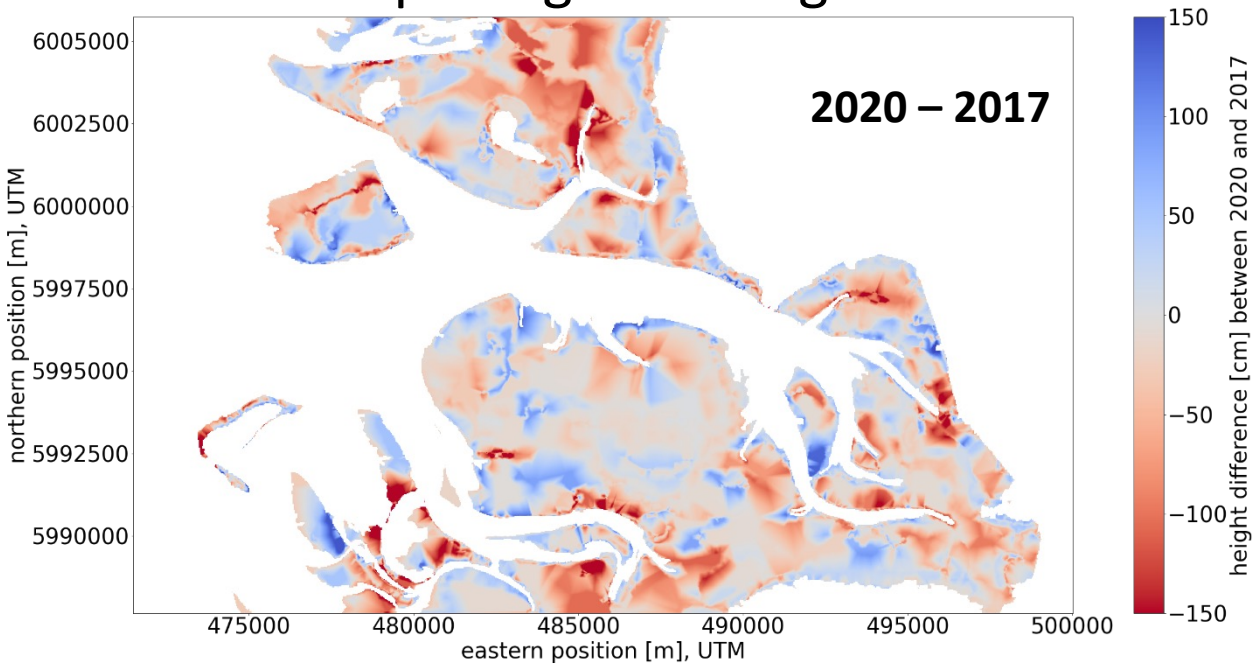
Wadden Sea topography from waterlines





Morphological change



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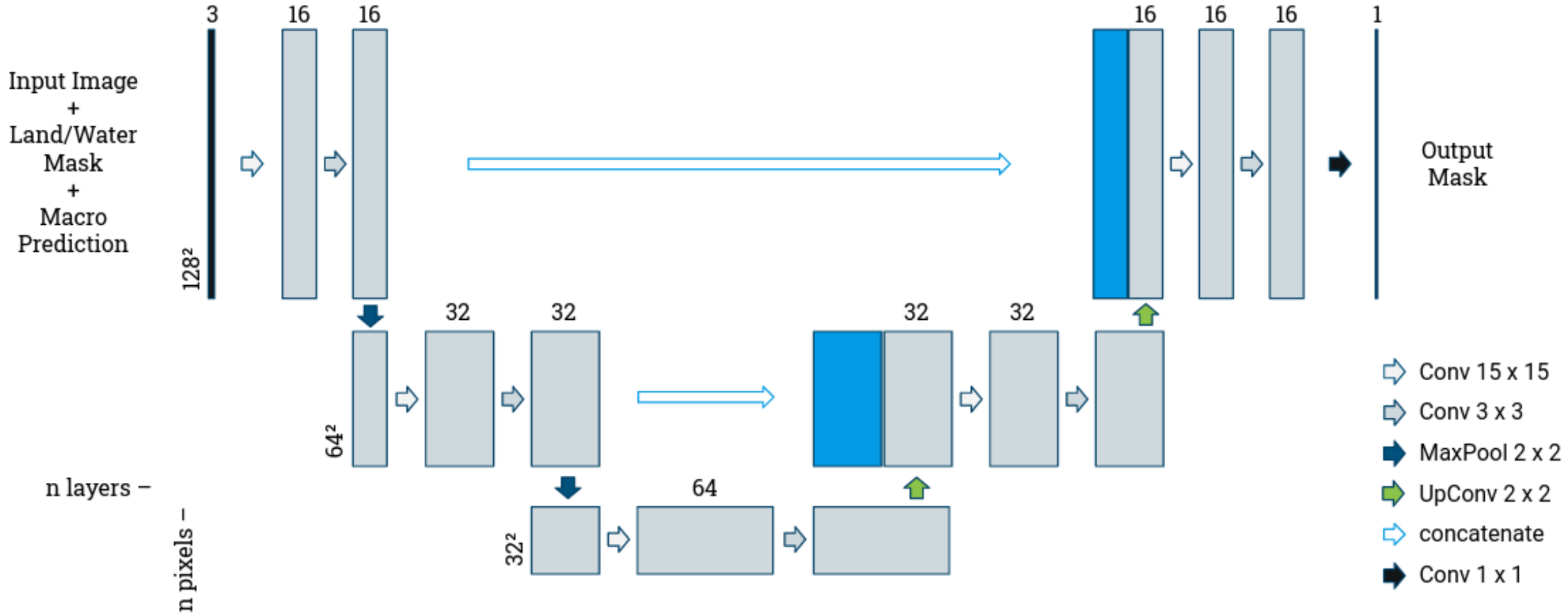
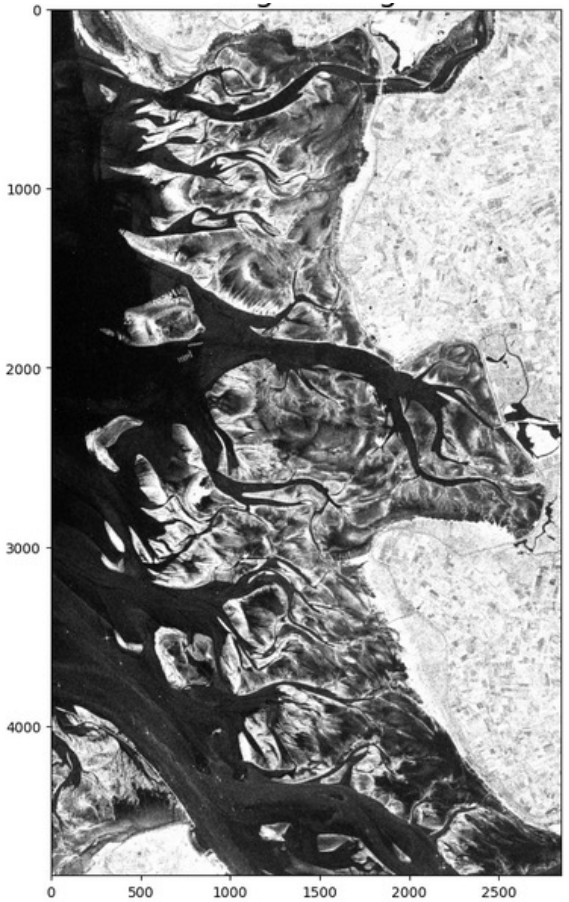
Classification aided by a neural network

Convolutional Neural Network (CNN) : U-Net

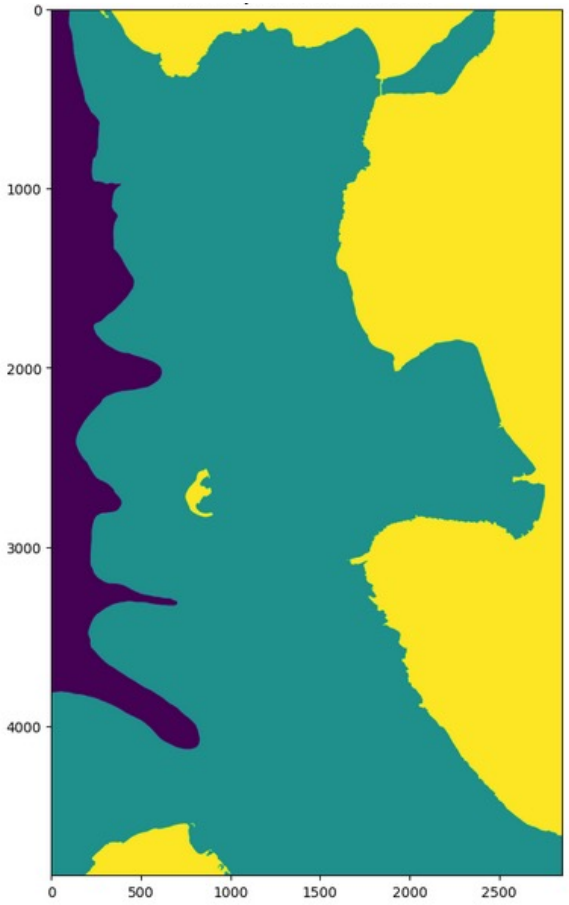


Classification aided by a neural network

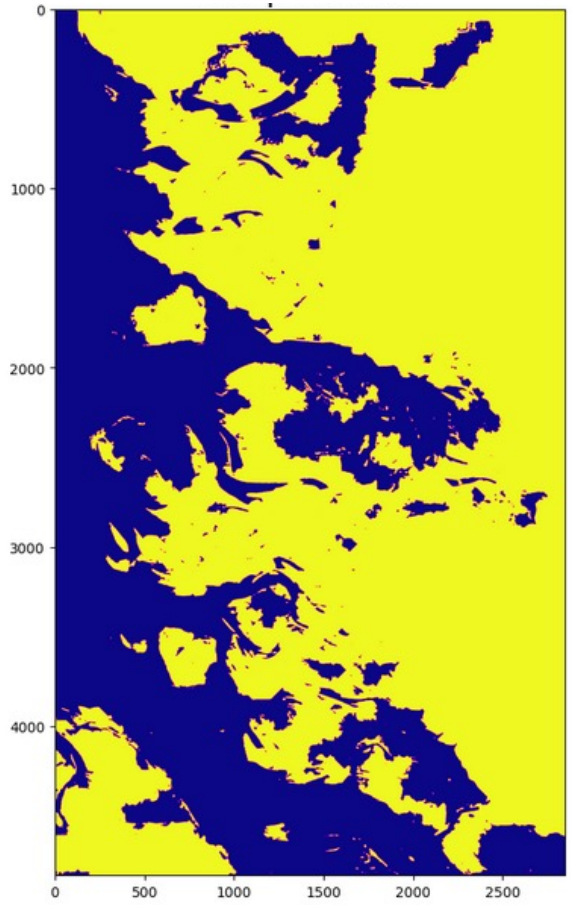
Sentinel-1A SAR image
19 May 2020



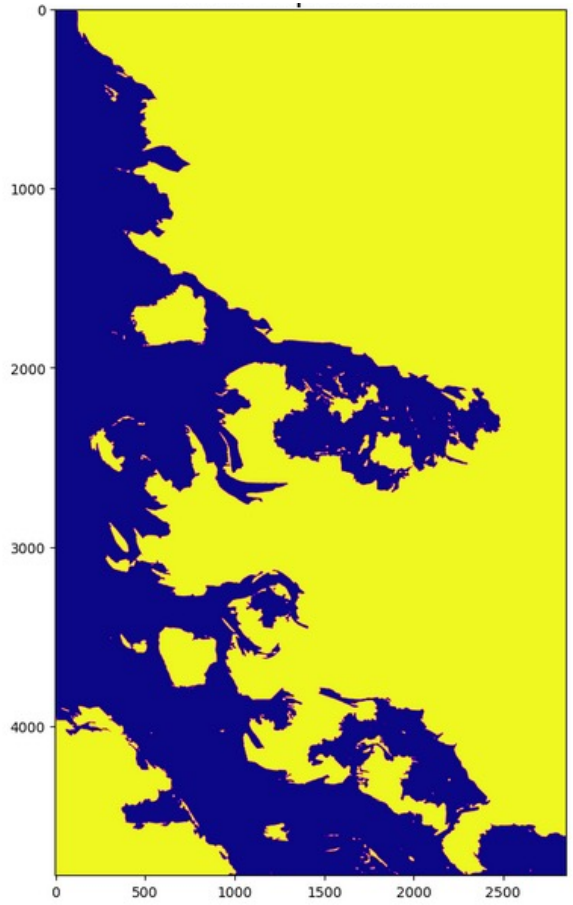
additional input
water – **transition** – **land**



classification output
land / water mask



refined output
after floodfilling



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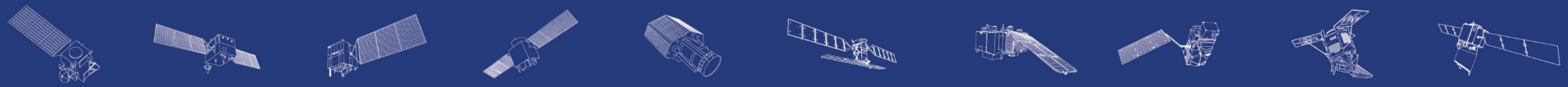
57192 - ReSCCoME



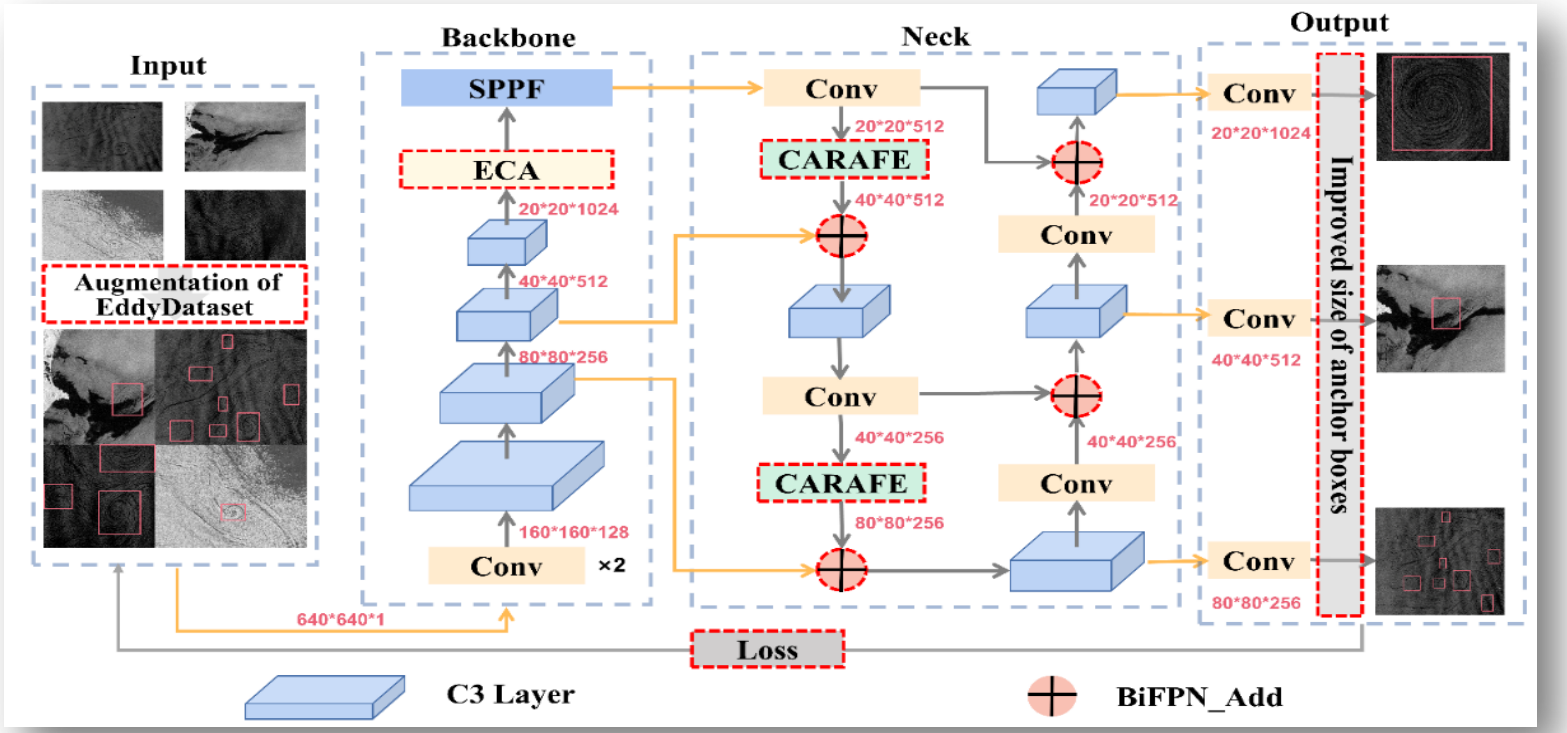
SUB-MESOSCALE OCEANIC EDDIES

Oceanic Eddy Detection from SAR Imagery Based on Deep Learning Network

Credit: Zi Nannan

Overall architecture of EOLO

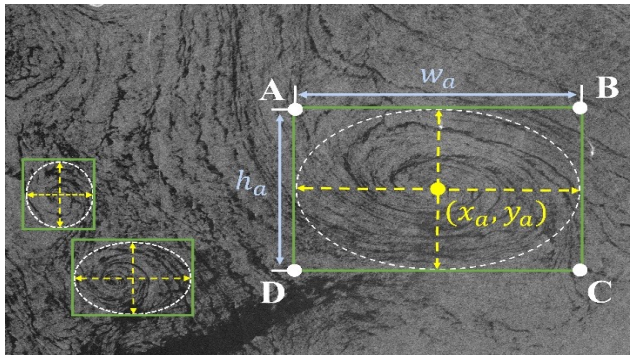
◆ The automatic detection network of EOLO



Eddy automatic detection network structure based on YOLO model (EOLO)

EOLO outputs detected eddies with their center and width-height information

◆ Geographic information extraction of detected eddies



Eddy center: (x_a, y_a)

Diameter: $\frac{AB + AD}{2}$

Geographic Affine Transformation model

Convert to row and column numbers to the corresponding geographic coordinates

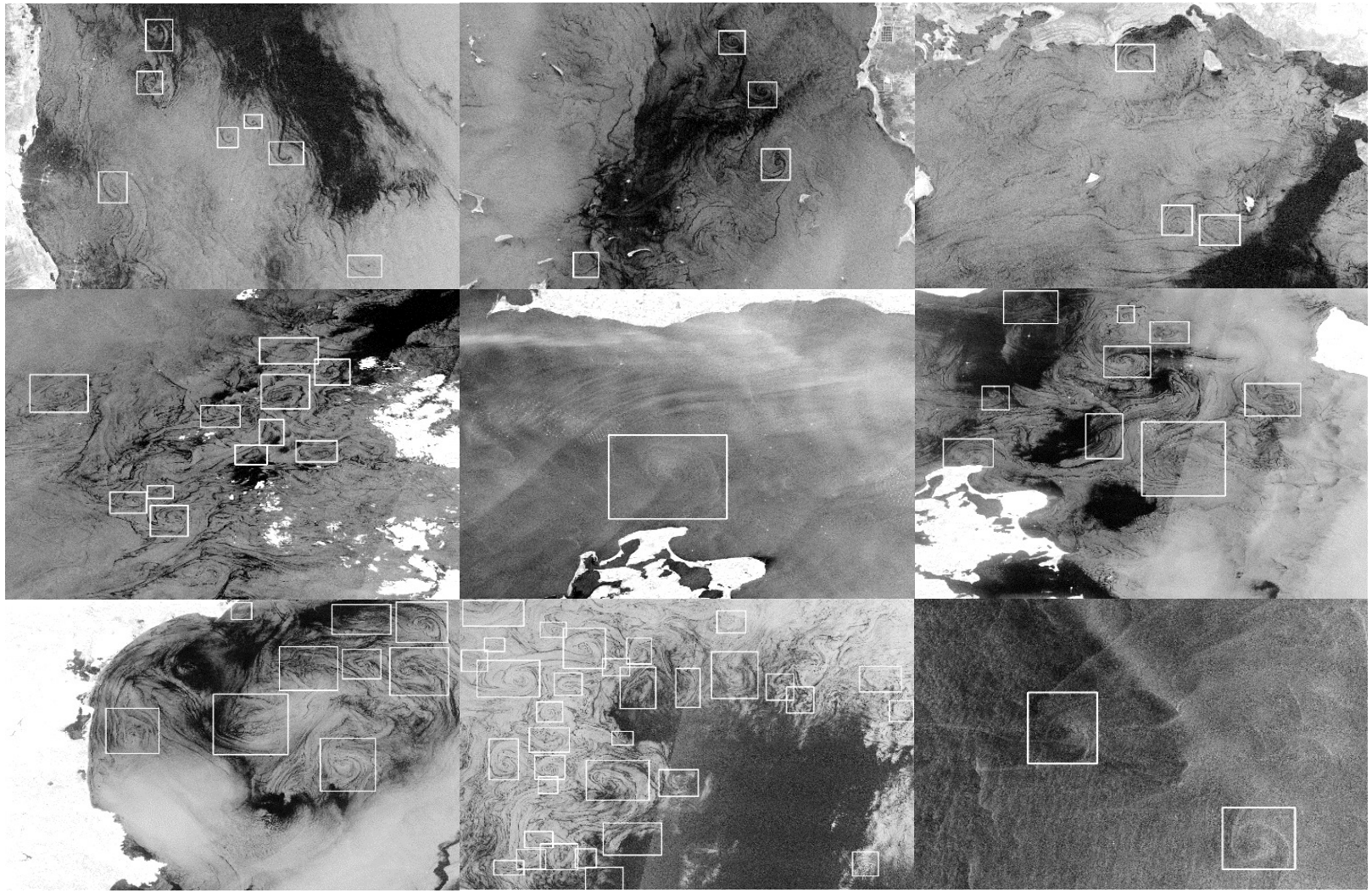
$(x_a, y_a, w_a, h_a) \rightarrow$ **longitude and latitude of eddy center and eddy diameter**

Adaptability of EOLO in different marginal seas

Red Sea
(Precision = 0.968)

Baltic Sea
(Precision = 0.957)

Western Mediterranean Sea
(Precision = 0.965)



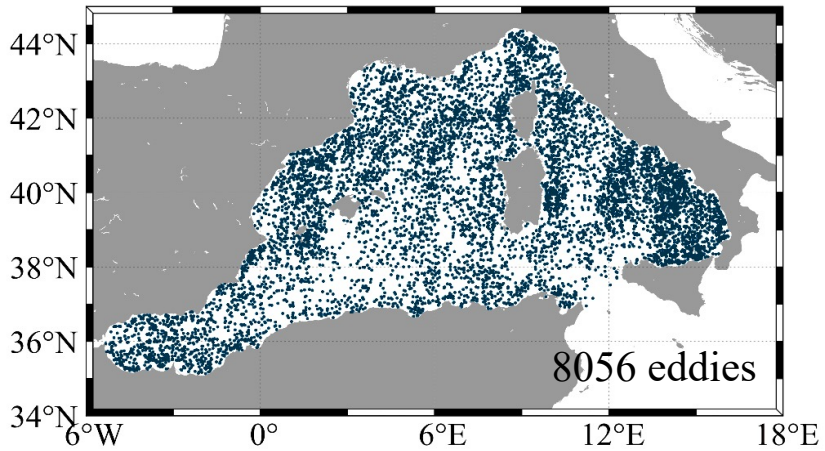
Spatial characteristics of ocean eddies in the Western Med

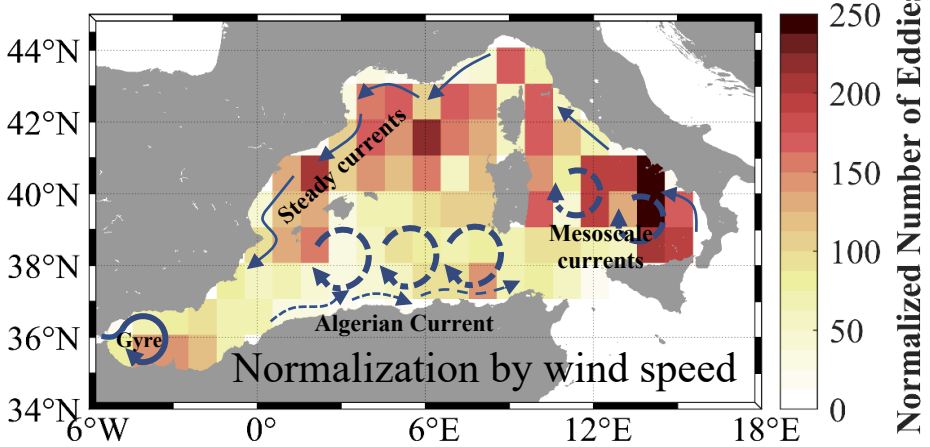
Data Source

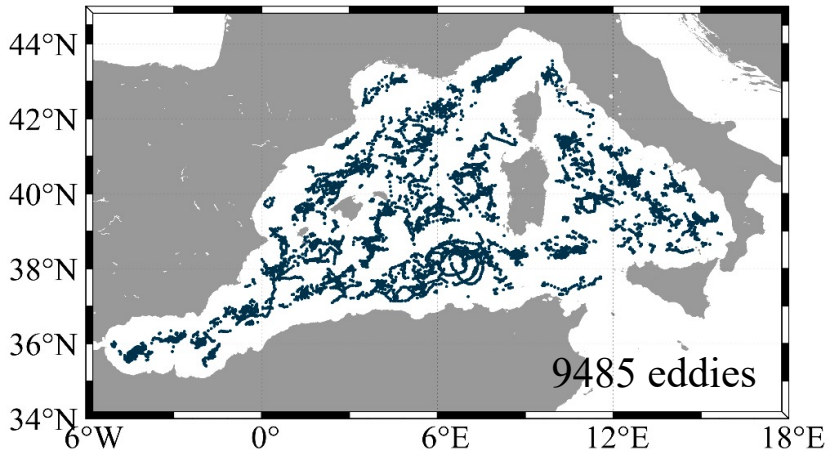
In 2021

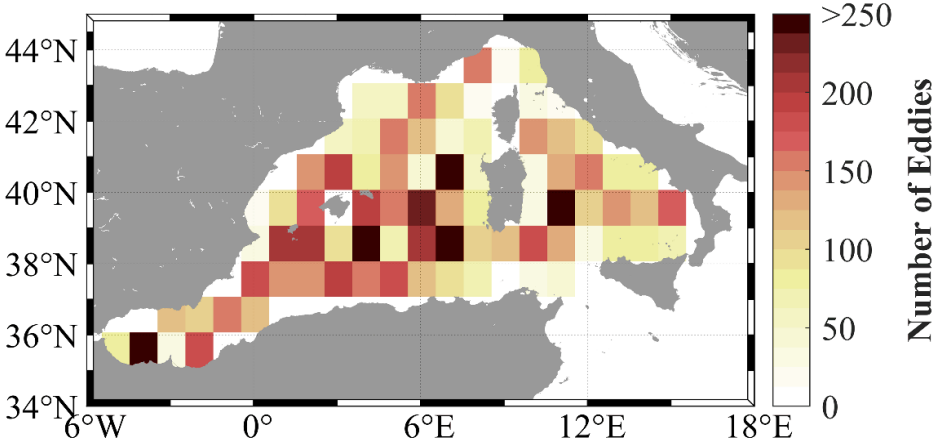
SAR:
Sentinel-1 A/B

RA:
Global altimeter eddy product provided by AVISO (META3.2 DT)



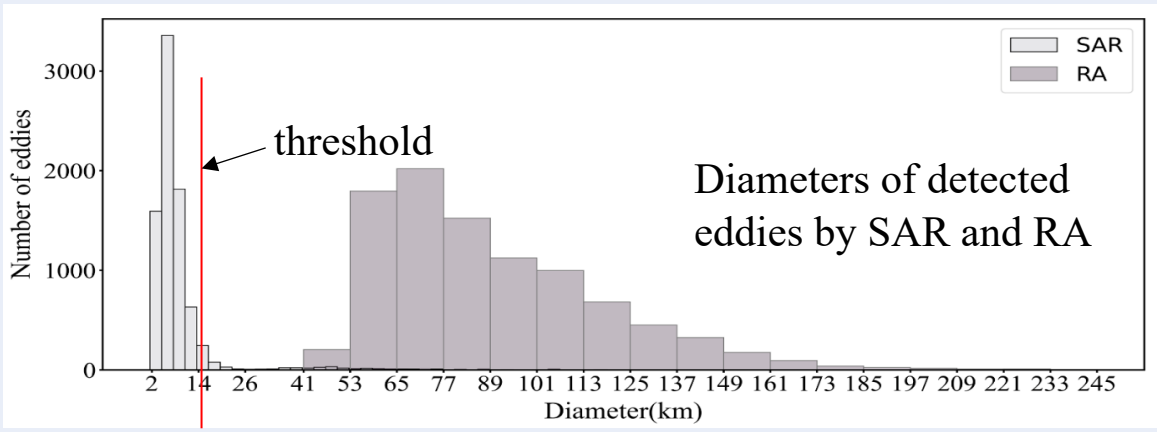






Notable differences in the spatial distributions of ocean eddies detected by SAR and RA.

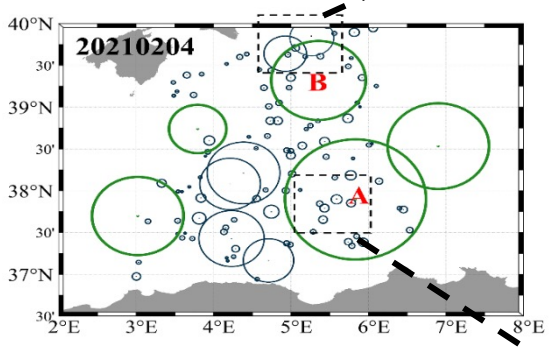
Spatial characteristics of ocean eddies in the Western Med

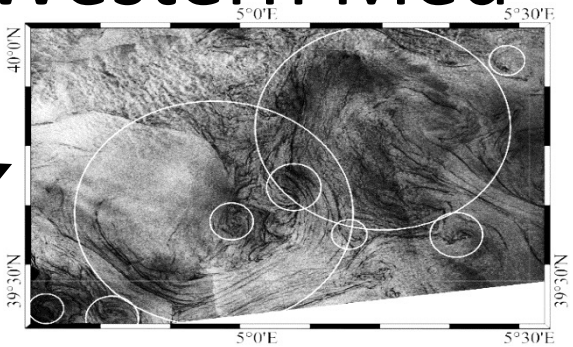


Diameters of detected eddies by SAR and RA

SAR: mostly in sub-mesoscale
RA: all in mesoscale scale

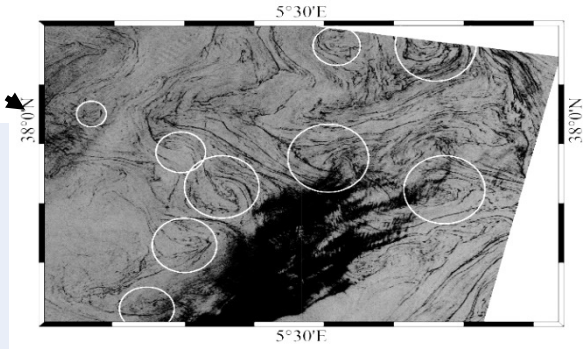
Cases of small eddies merging into large eddies



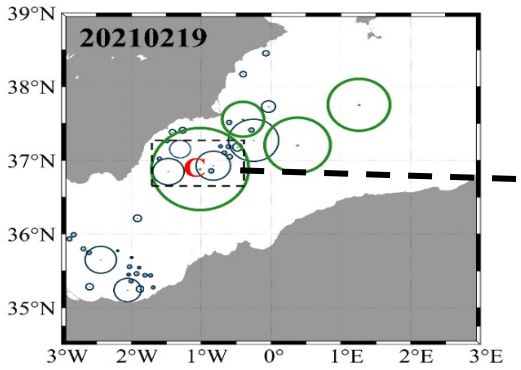


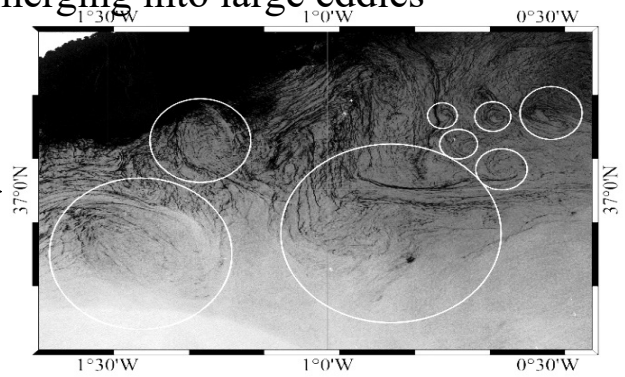
RA eddy

SAR eddy



Cases of small eddies merging into large eddies





The reason of the spatial distribution discrepancy:

- Due to the limitation of spatial resolution, their sizes are remarkably different;
- Also due to the limitation of spatial resolution, the eddies detected by gridded map merging of multi-RA along-track data may be the results of small-scale ones merging into larger ones.

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ReSCCoME Peer-Reviewed Publications

- Gade, M., M. Badger, K. Dimitriadou, X. Li, A. Owda, S. Peters, S. Schäfers, D. Zhang, 2023: “Remote Sensing of Changing Coastal Marine Environments – a Midterm Report”, *Trans. Geospatial. Inform. Serv.,* to be resubmitted.
- Zi, N., X.-M. Li, M. Gade, H. Fu, 2023: “Ocean Eddy detection based on YOLO deep learning algorithm by Synthetic Aperture Radar data”, *Remote Sens. Environ.,* under review.
- Zhang, D., M. Gade, W. Wang, H. Zhou, 2023: “EddyDet: A Deep Framework for Oceanic Eddy Detection in Synthetic Aperture Radar Images”, *MDPI Remote Sens,* revised.
- Zhang, D., W. Wang, M. Gade, 2023: “TENet: A Texture-Enhanced Network for Intertidal Sediments and Habitats Classification in Multi-band PolSAR Images”, *IEEE Trans. Geosci. Remote Sens.,* under review.
- Gade, M., S. Peters, S. Schäfers, 2023: “On the Use of SAR Data to Monitor Coastal Erosion and Morphodynamics in Intertidal Areas”, *MDPI Coasts,* in preparation.

ReSCCoME Outlook for Year 4

- Continuation of presented work
- Intensify field work, where needed
- Initiate new / foster existing collaborations
- Summer School together with partner project

HY HJ-1AB CBERS Gaofen Beijing-2 Sentinel-1 Sentinel-2 Sentinel-3 Sentinel-5p Aeolus

谢谢！