2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

PROJECT ID. 57979

MONITORING HARSH COASTAL ENVIRONMENTS AND OCEAN SURVEILLANCE USING RADAR REMOTE SENSING

Dragon 5 Mid-term Results Project

OCTOBER 17, 2022

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PROJECT TITLE: MONITORING HARSH COASTAL ENVIRONMENTS AND OCEAN SURVEILLANCE USING RADAR REMOTE SENSING

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PRESENTED BY: F. NUNZIATA

Objectives

- Ocean & coastal zone thematic area
  - Marine dynamic environment
  - Sea surface characteristics

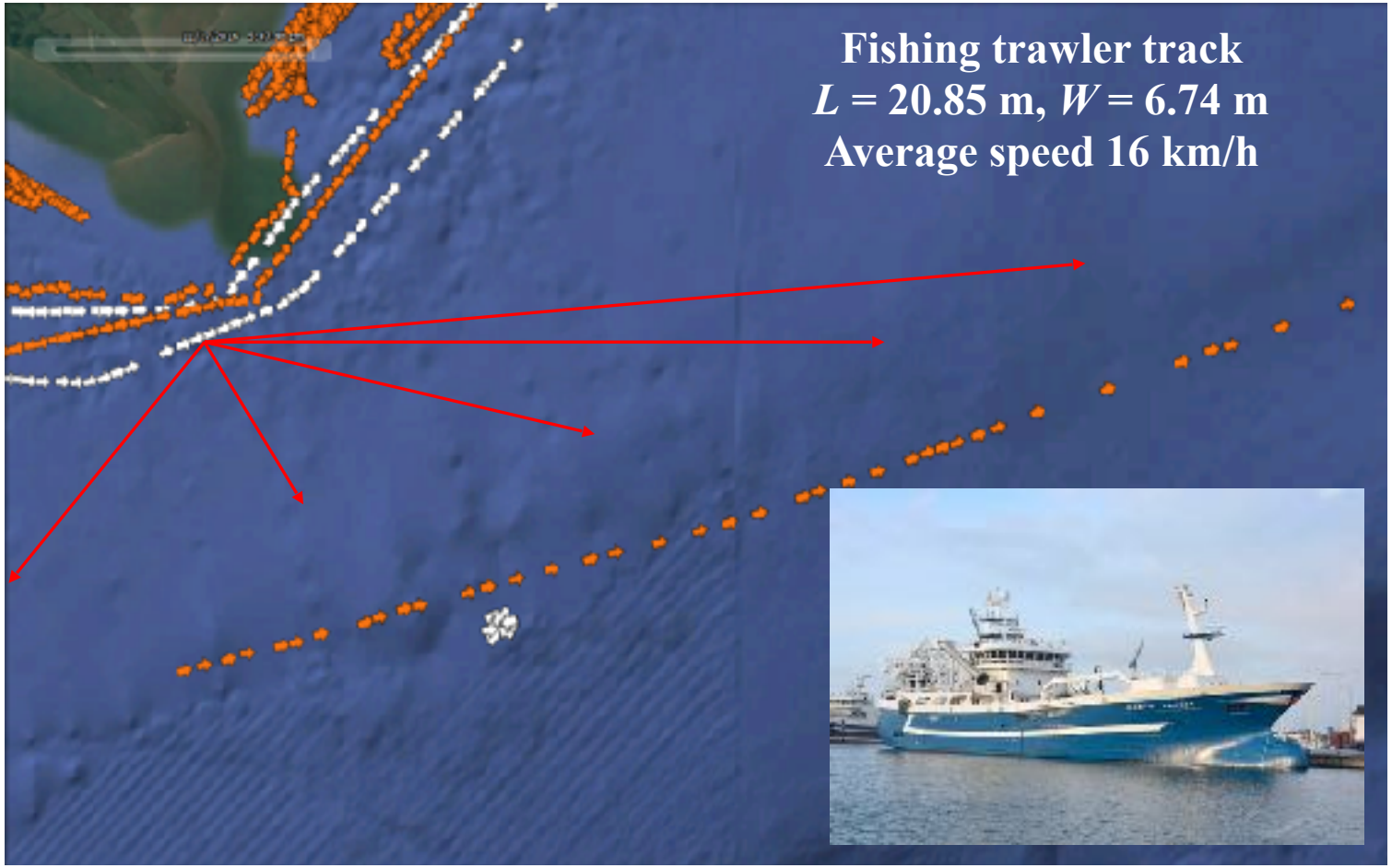
<u>The project aims at exploiting Synthetic Aperture Radar satellite measurements to generate innovative added-value products to observe coastal areas characterised by harsh environments, even under extreme weather conditions.</u>

Dragon 5 Mid-term Results Reporting

- Ship backscattering vs incidence angles
- Backscattering from offshore wind farms
- Backscattering from oil emulsions
- Bistatic scattering from oil-covered sea surface
- Backscattering under wave breaking conditions

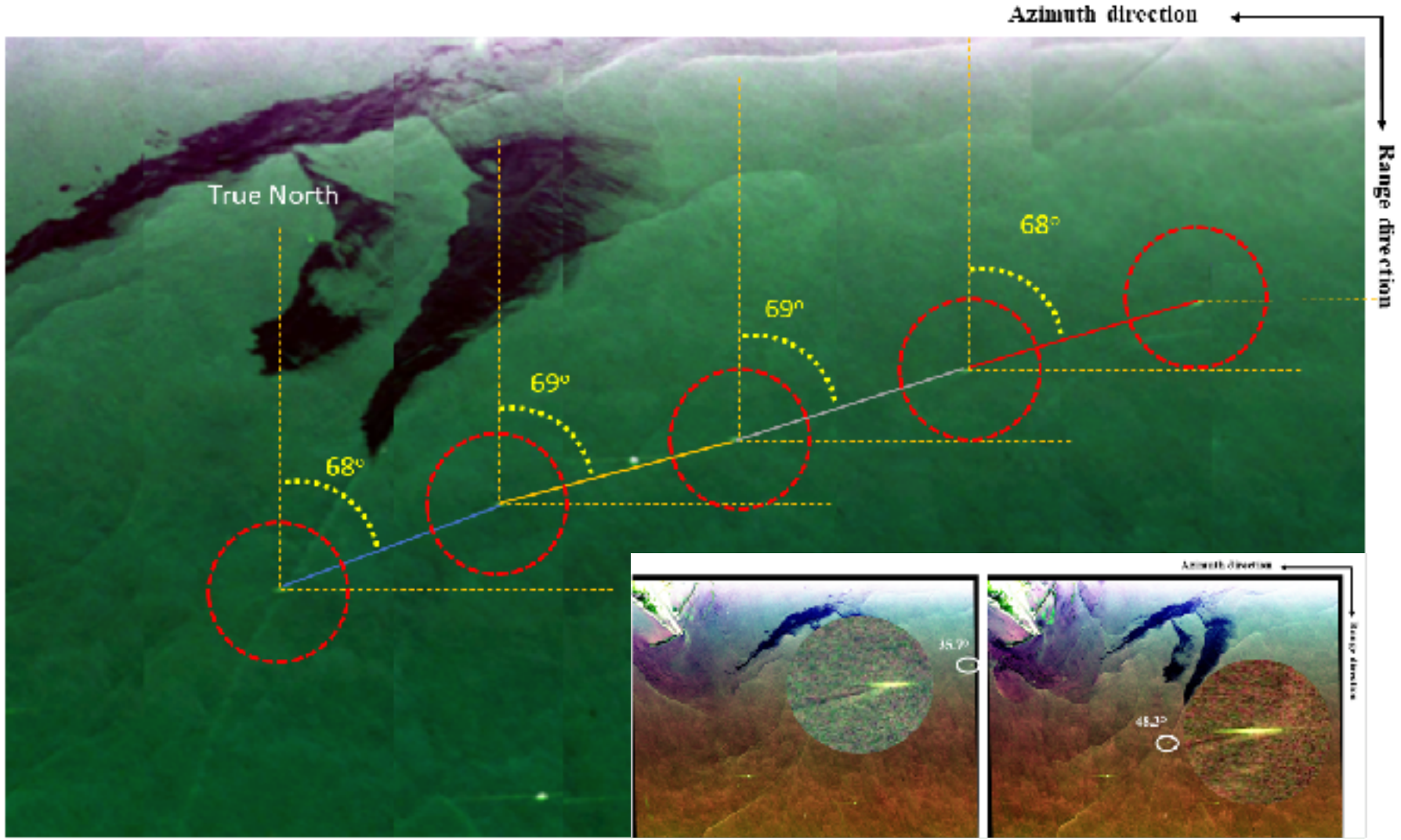
Ship backscattering vs incidence angles

- **Gulf of Mexico on 17/11/2016.**
- **Time series of UAVSAR imagery.**
- **Five SAR scenes collected over the target spanning two hours acquisitions.**
- **Wide incidence angle range, 35° - 49°.**
- **Low-to-moderate sea state conditions, wind speed in the range 1 m/s - 5 m/s.**



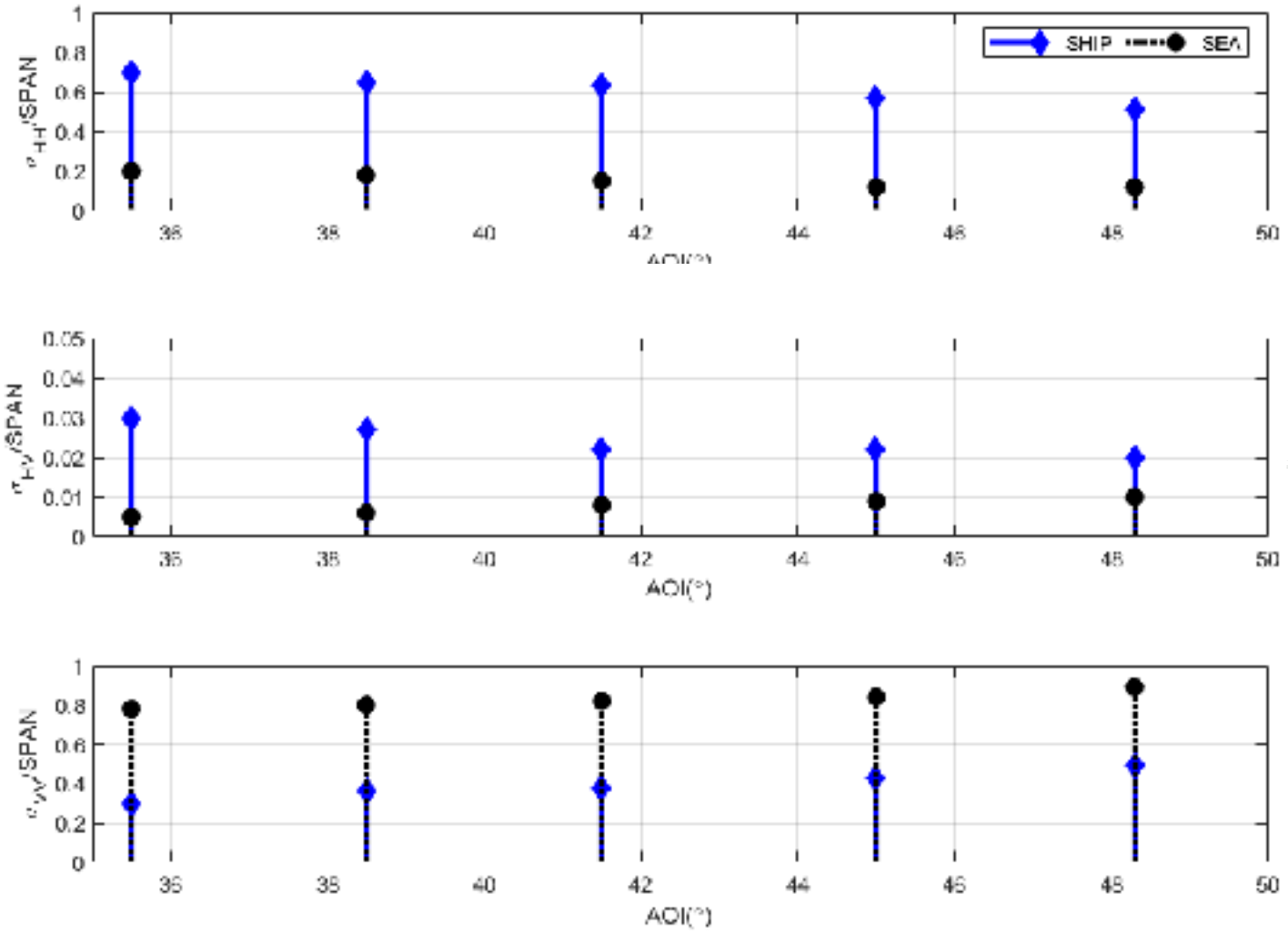
Ship backscattering vs incidence angles

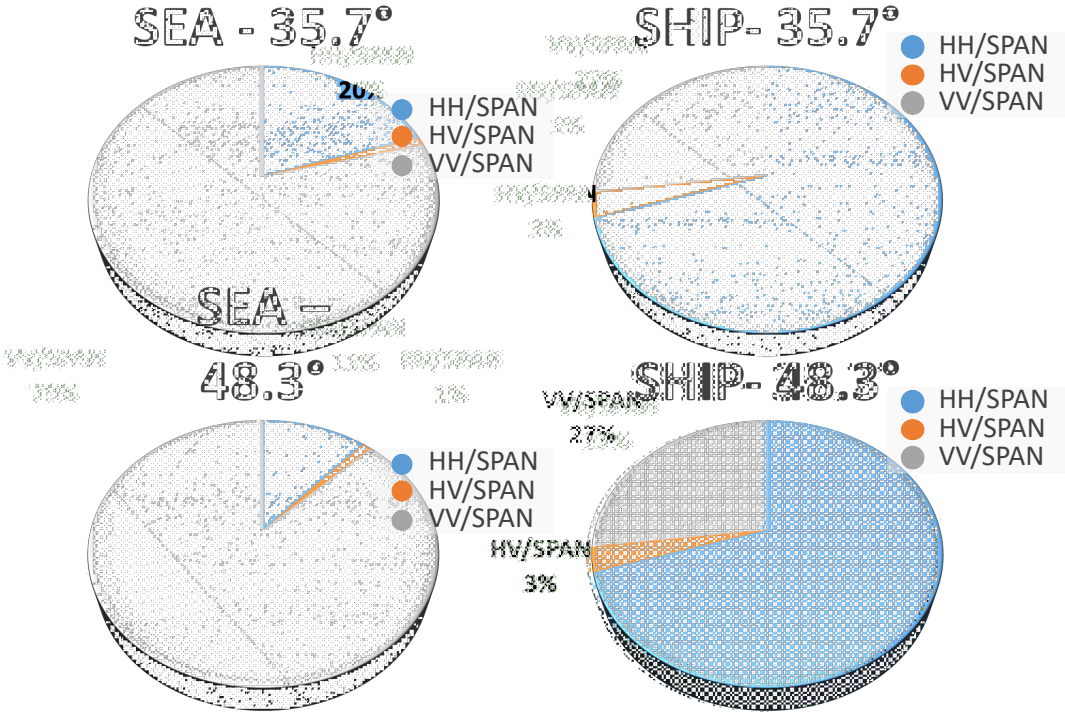
UAVSAR polSAR data set



Ship backscattering vs incidence angles

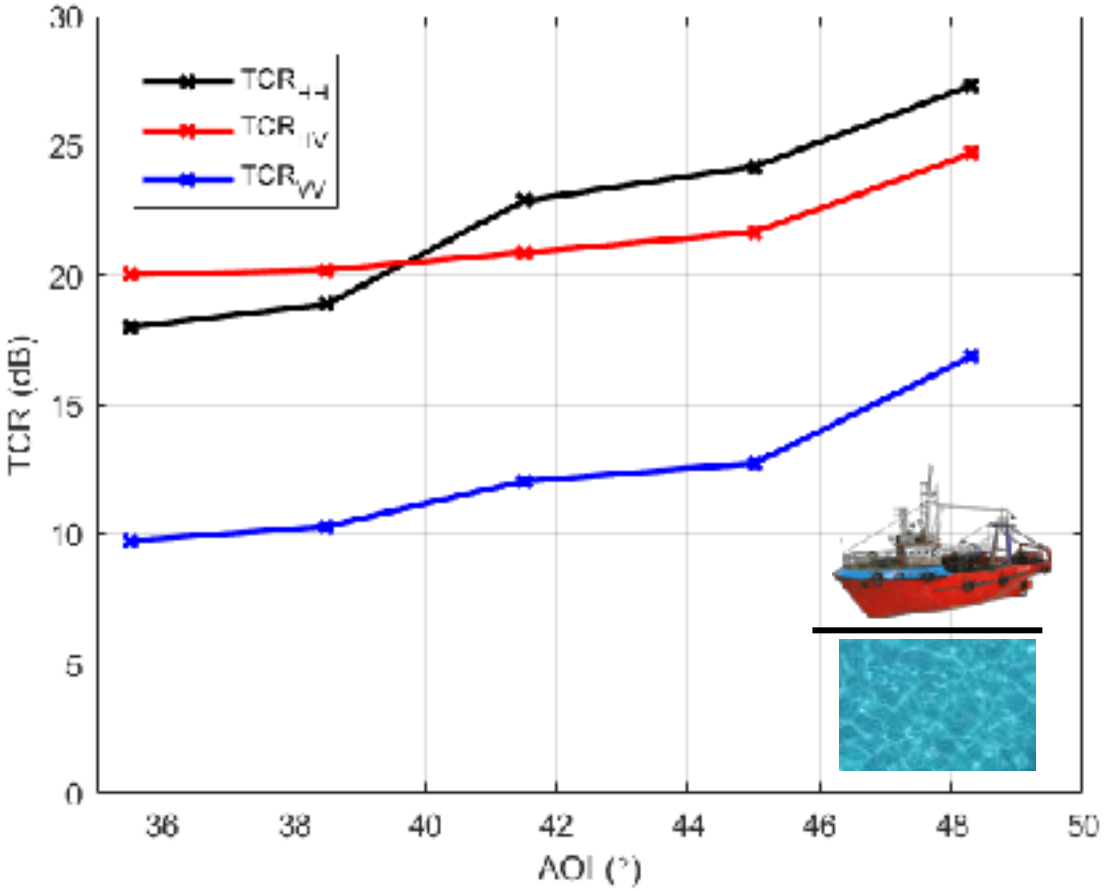
Multi-pol NRCS contribution relative to the SPAN



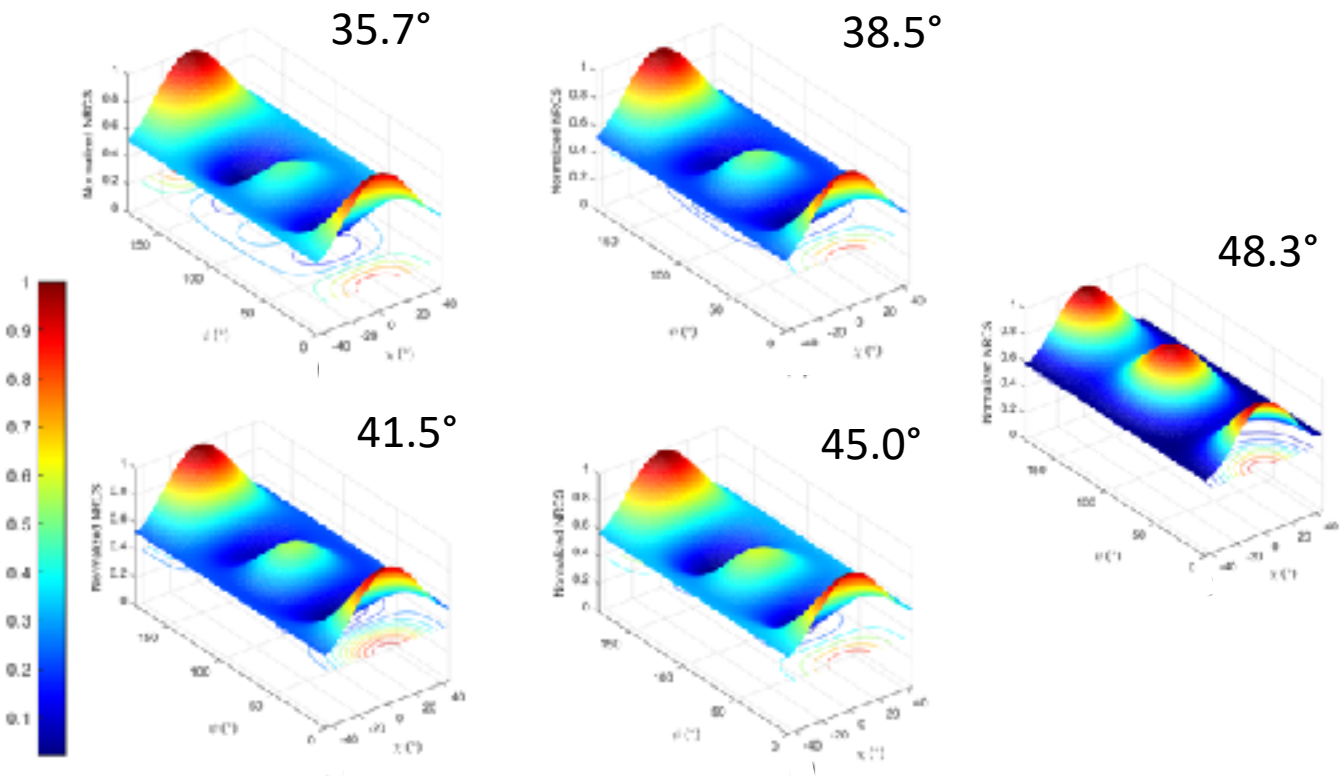


Ship backscattering vs incidence angles

Multi-pol Target-to-Clutter Ratio



Co-polarisation signature of the ship



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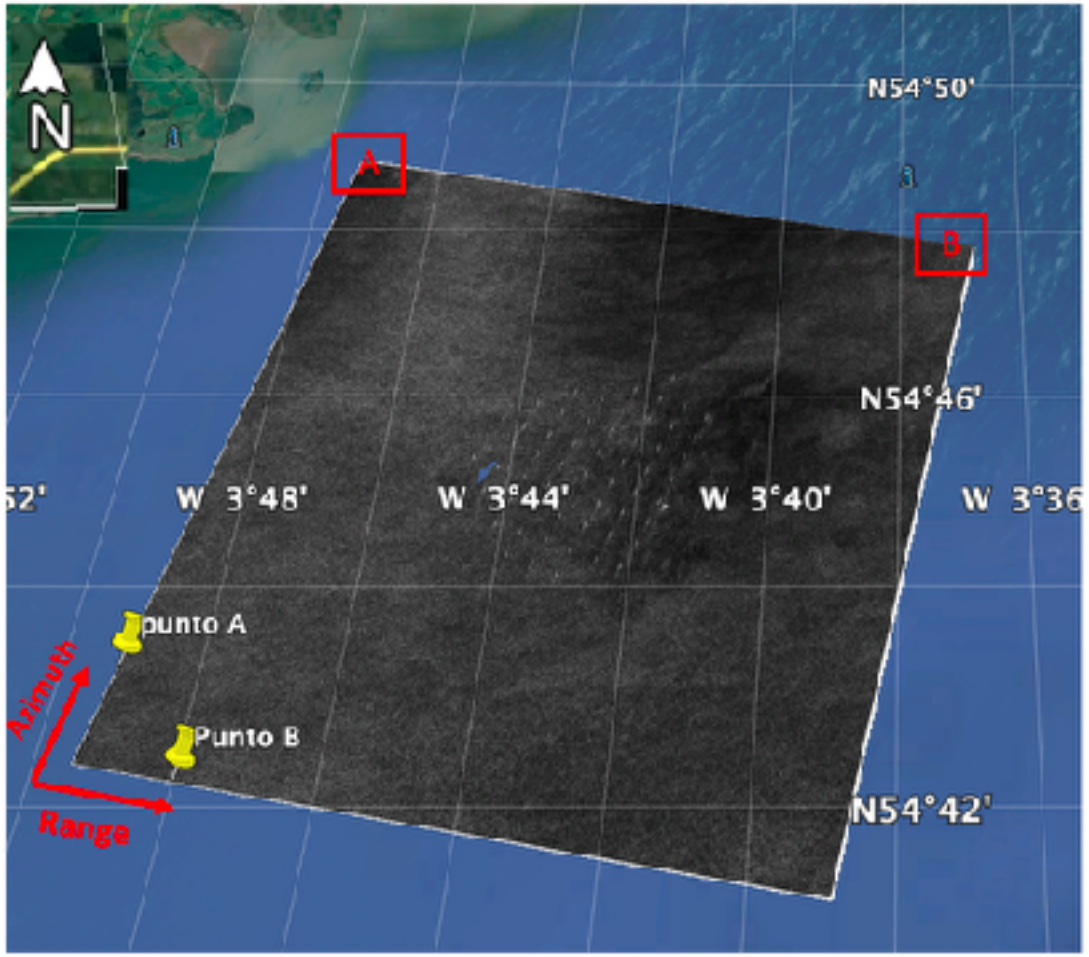
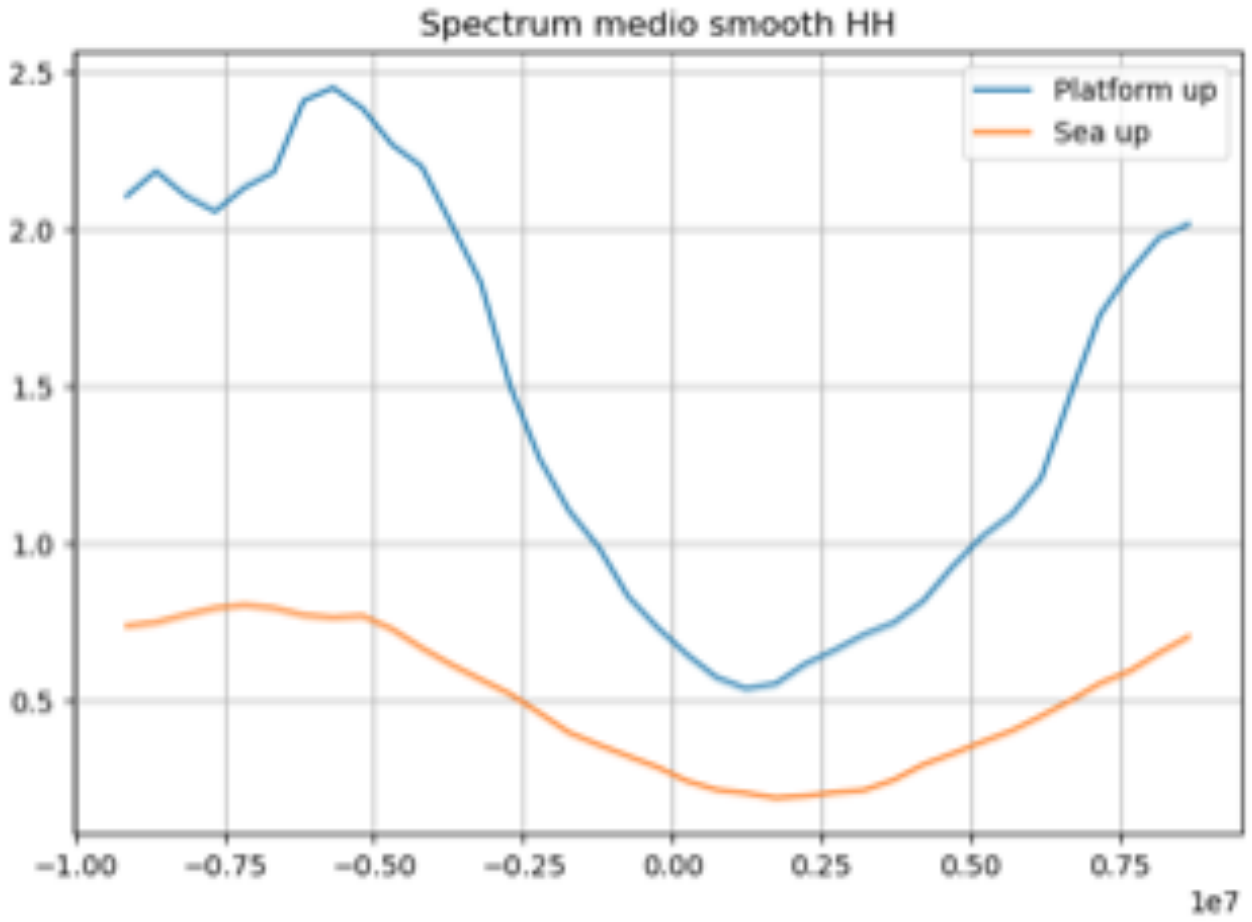
Backscattering from off-shore wind farms

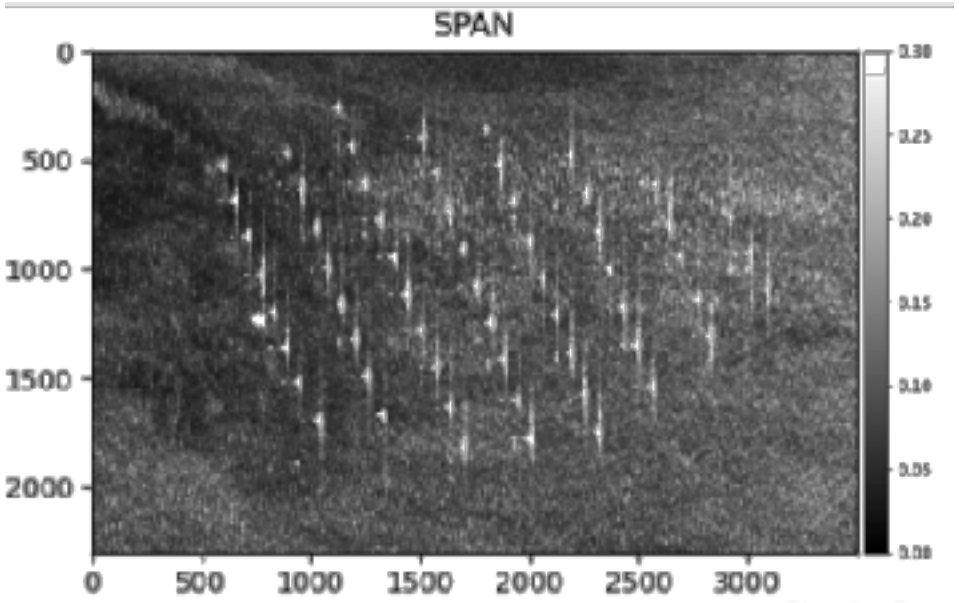
Robin Rigg OWF (Solway Firth, UK): PAZ X-band polSAR measurement

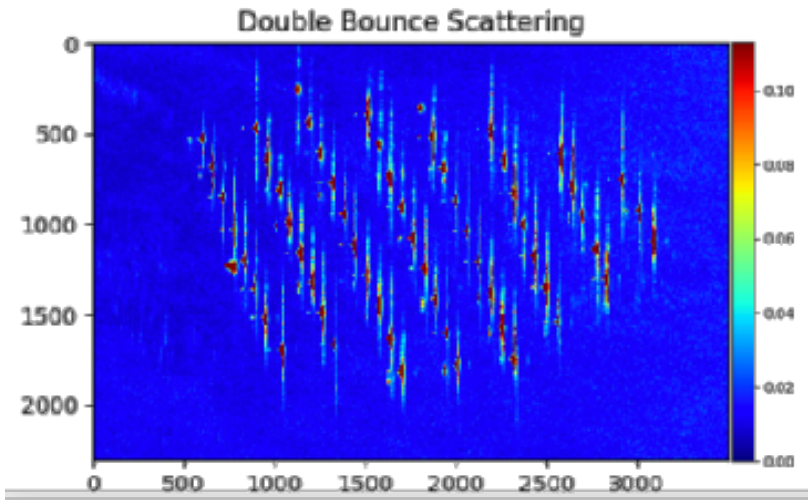


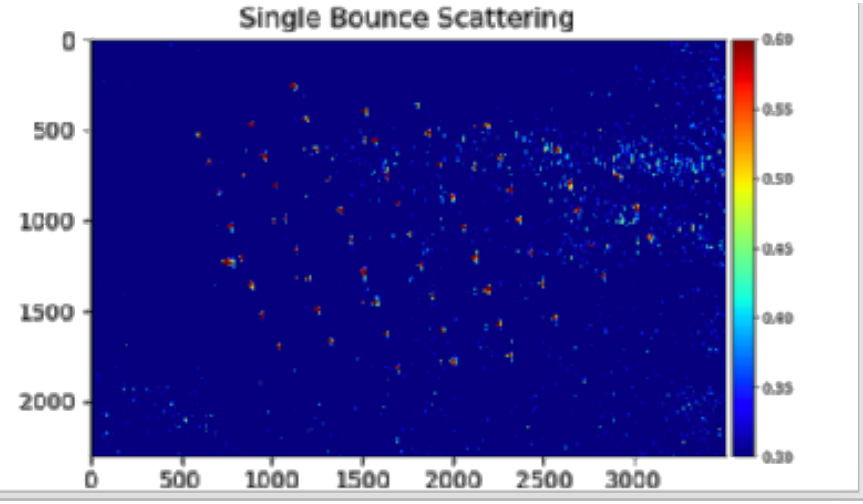


Backscattering from off-shore wind farms

Wind turbine backscattering decomposition







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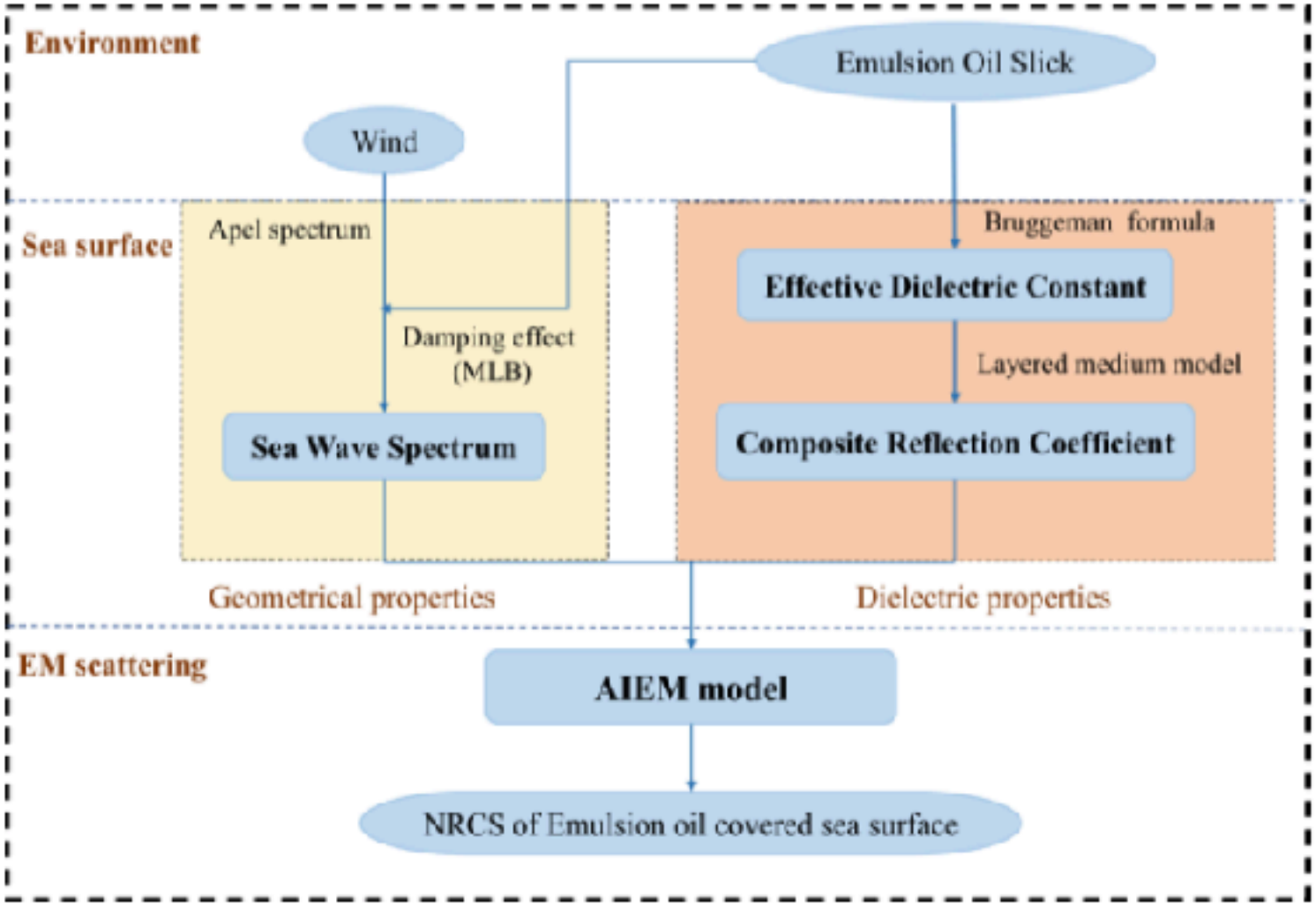
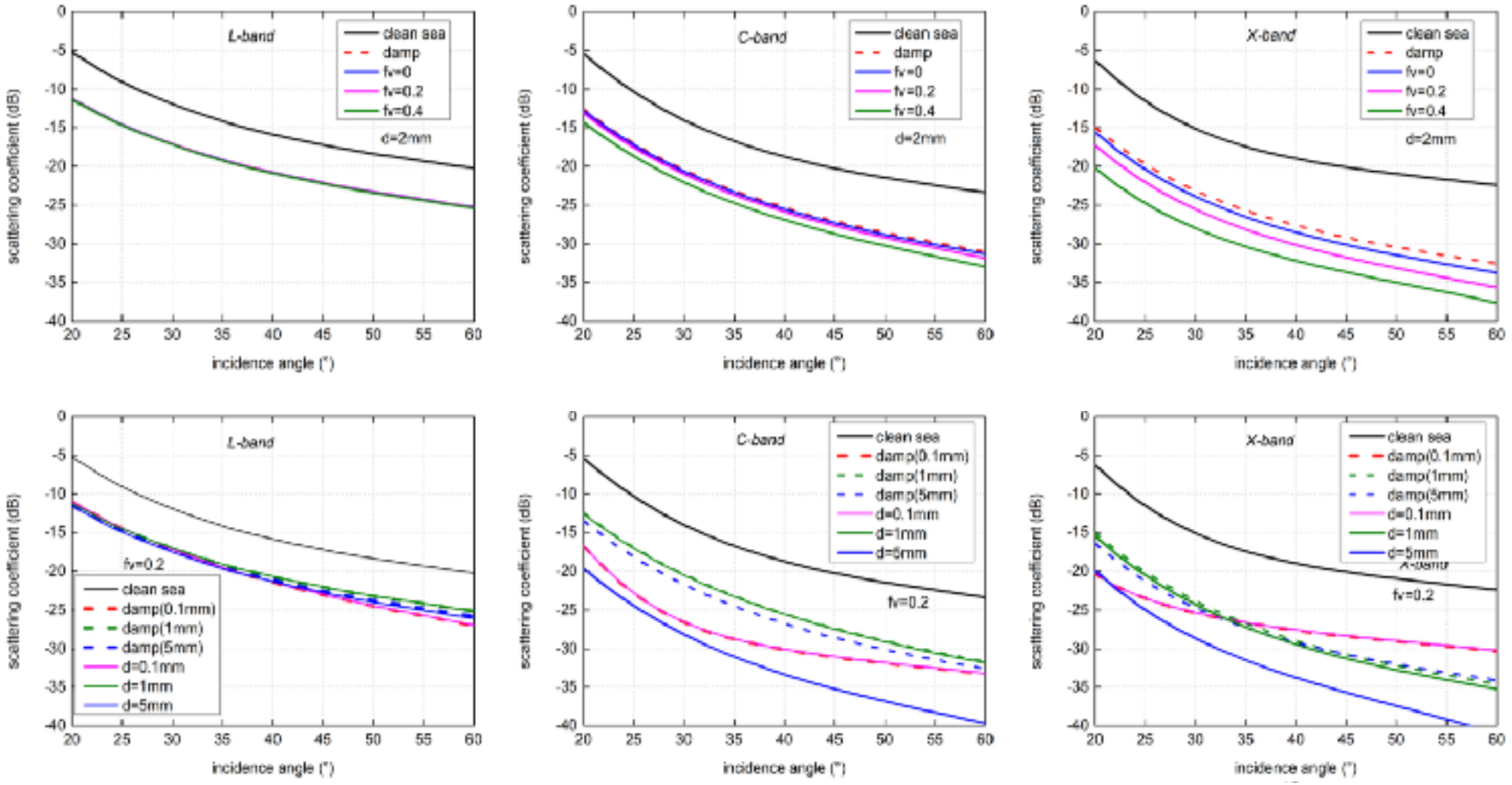
Backscattering from oil emulsions

Multi-frequency simulation of scattering from marine oil emulsion



Backscattering from oil emulsions

Backscattering coefficient versus incidence angle at L-, C- and X-band



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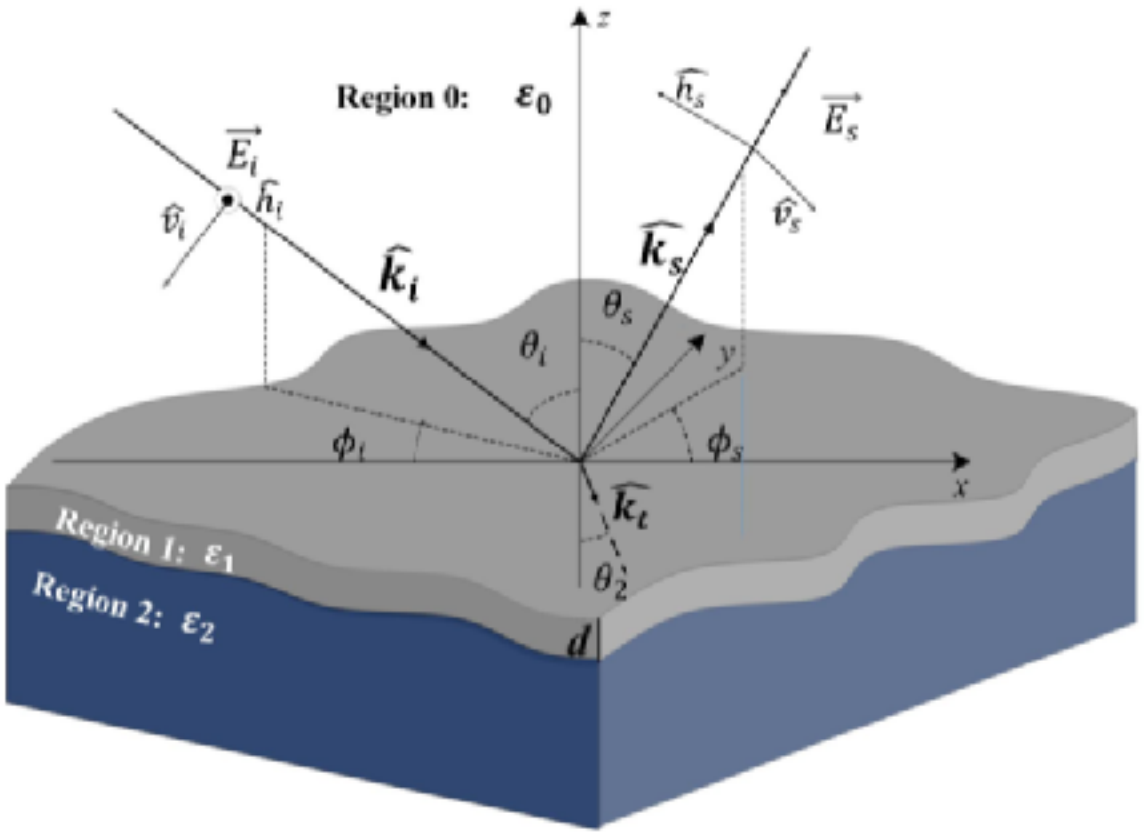
Bistatic scattering from oil-covered sea surface

Bistatic scattering geometry of oil-covered sea surface

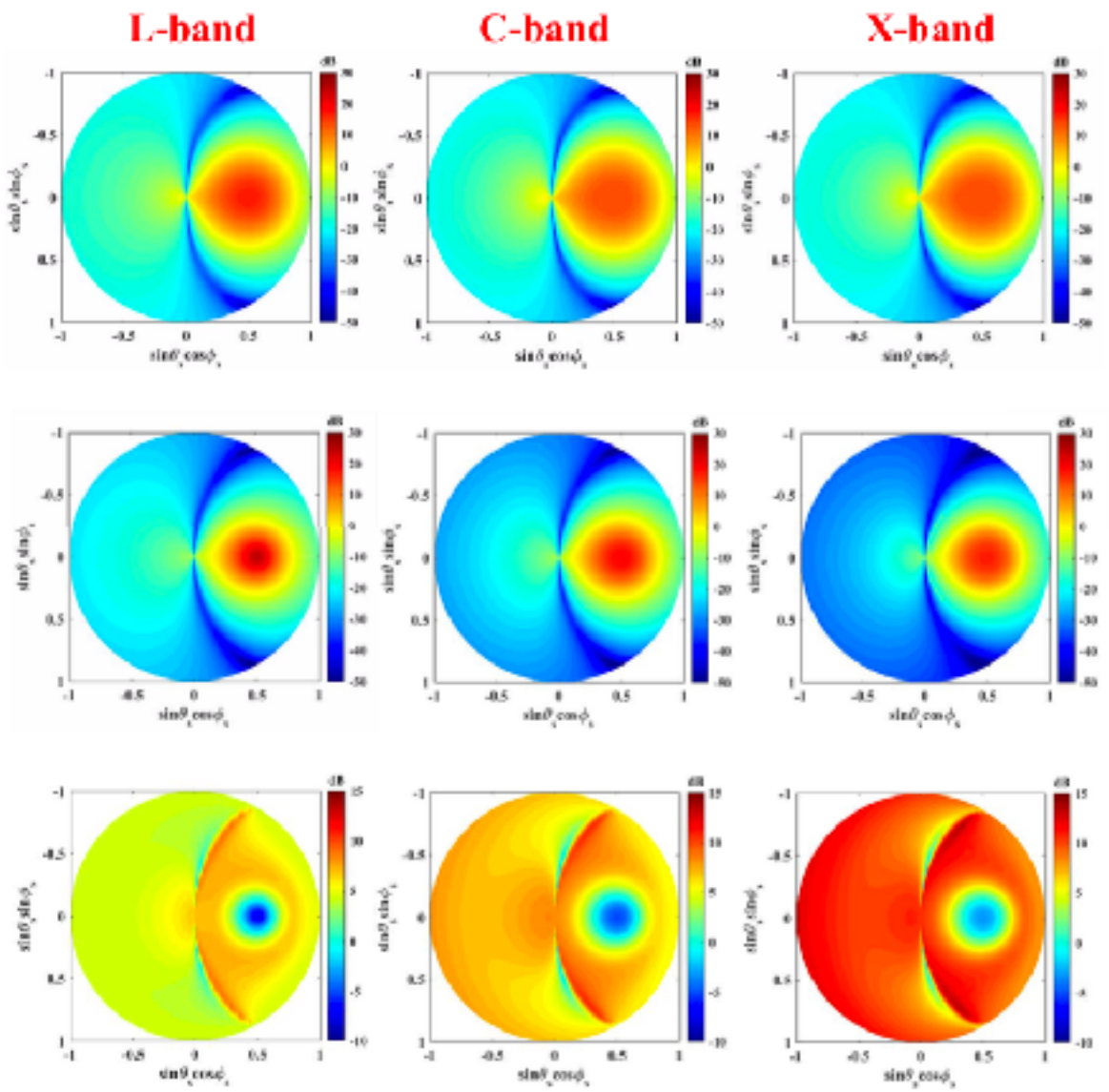


The bistatic radar scattering coefficients related to an oil-covered sea surface are predicted by modeling:

- **The oil damping effect on surface roughness**
- **The oil modification on the dielectric properties of the scattering surface**

The bistatic scattering is predicted using the AIEM.

Bistatic scattering from oil-covered sea surface



Multi-frequency bistatic scattering analysis

Bistatic scattering is depicted in the form of the unit circle:

- **Left semicircle → backscattering**
- **Right semicircle → forward scattering**

- **Horizontal axis crossing the origin of the circle → plane of incidence (ϕ_s = 0° or 180°)**
- **Vertical axis crossing the origin → cross-plane (ϕ_s = 90° or 270°);**

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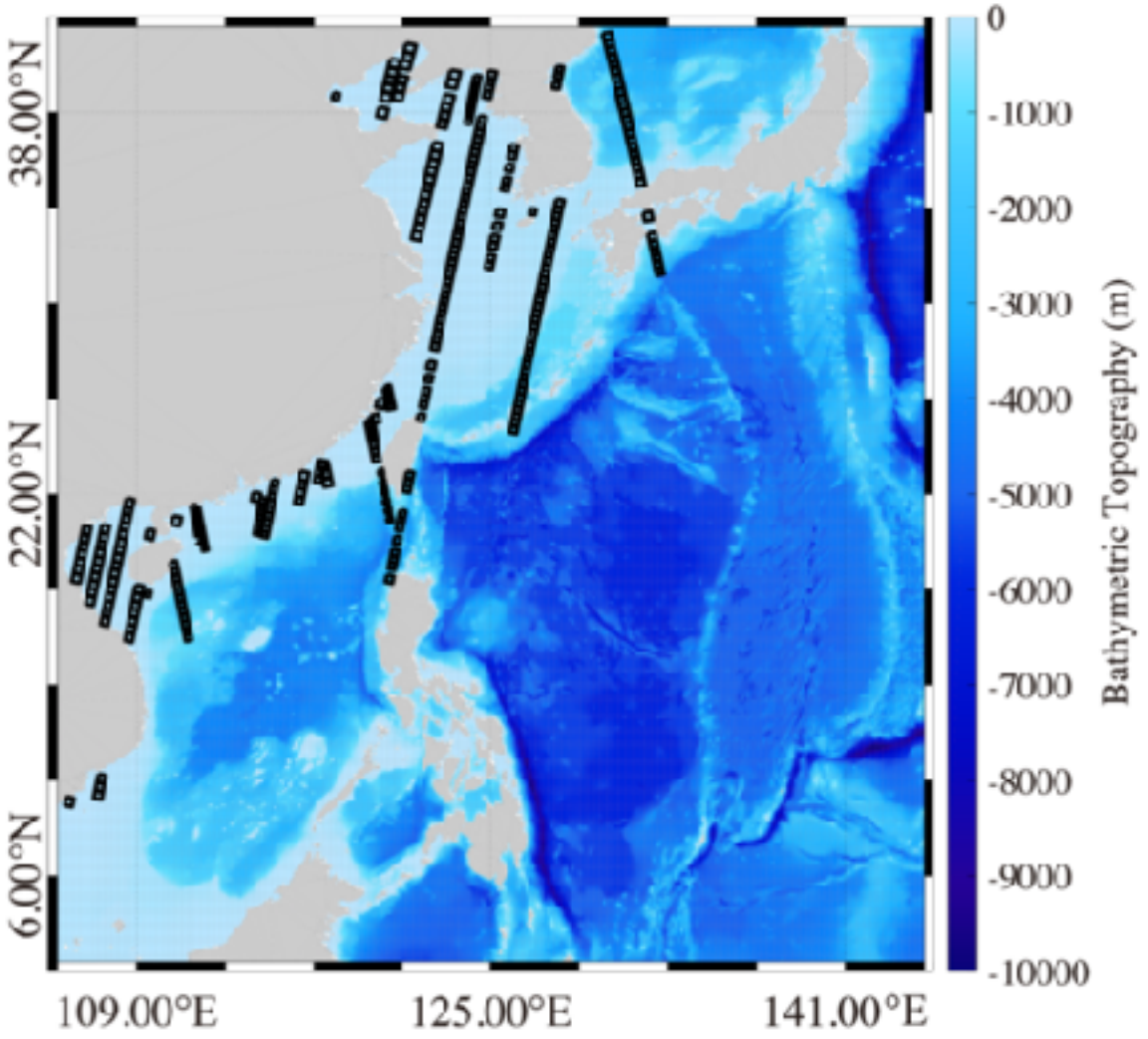
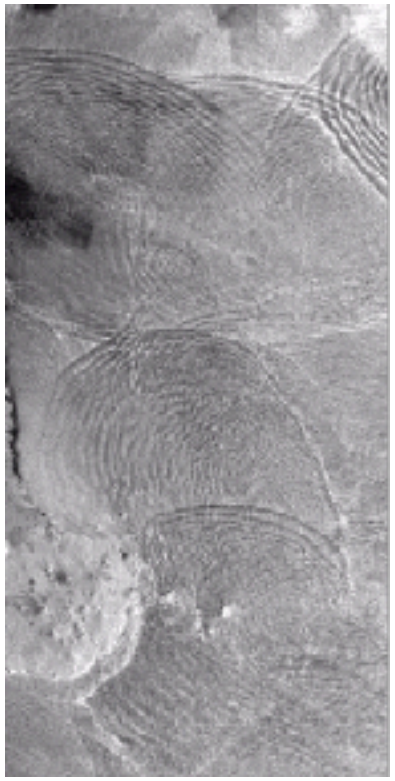
Backscattering under wave-breaking conditions





Gaofen-3 C-band SAR measurements

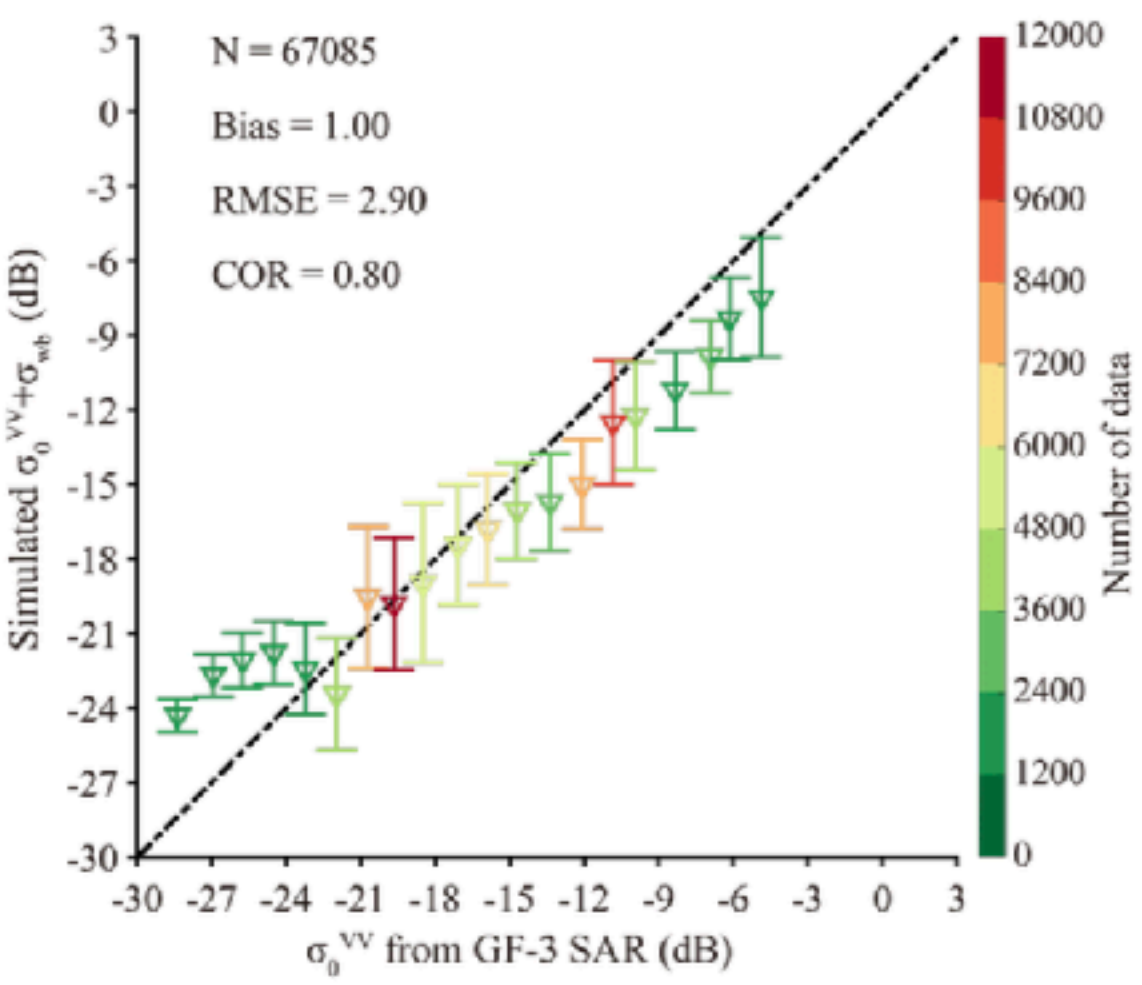
$$\sigma^0_{qq} = \sigma^0_b + \sigma^0_{wb}$$

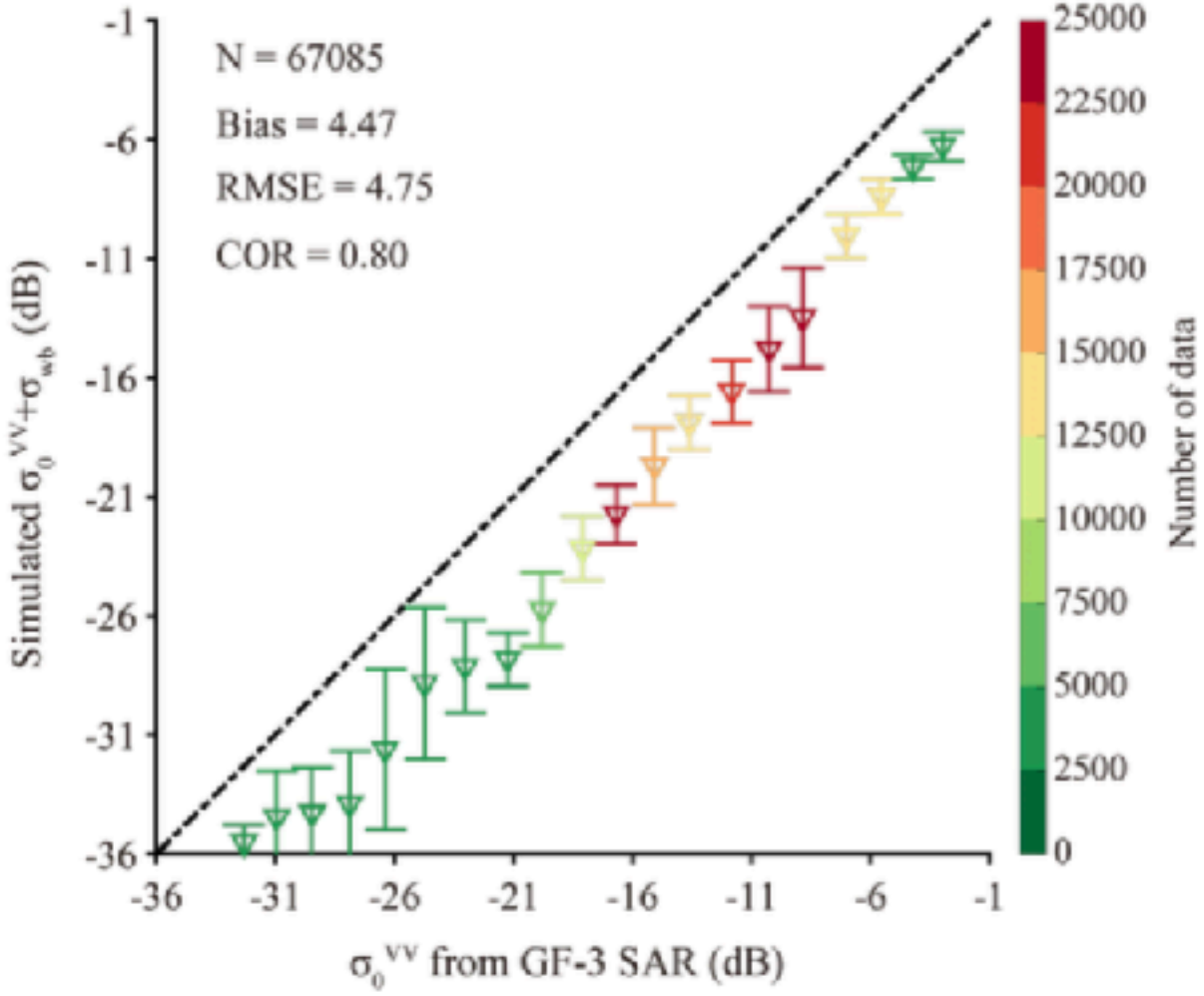
$$\sigma^0_{wb} = \sigma^0_{vv} - \frac{PD}{(1 - PR)}$$

1. **Two-scale surface scattering model**
2. **Simplified approach**

Backscattering under wave-breaking conditions

Predicted versus actual VV-pol NRCS





EO Data Delivery

ESA Third Party Missions	No. Scenes
1.RadarSAT-2	10
2.Alos-2	10
3.UAVSAR	6
4.CSK	400
5.CSG	2
6.PAZ	4
Total:	432
Issues:	

ESA, Explorers & Sentinels data	No. Scenes
1.Sentinel-1	500
2.	
3.	
4.	
5.	
6.	
Total:	500
Issues:	

Chinese EO data	No. Scenes
1.Gaofen-3	500
2.	
3.	
4.	
5.	
6.	
Total:	500
Issues:	

European Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
M. Alparone	Università di Napoli Parthenope	Monitoring harsh coastal environments using SAR multifrequency polarimetric scattering	Development of models and methods to classify intertidal flat areas using full-polarimetric SAR scenes
G. Inserra	Università di Napoli Parthenope	Sentinel-1 IW DP measurements to extract the coastline in Terra Nova Bay, Antarctica	Extraction of time series of coastlines over the Drygalski ice tongue, Antarctica to evaluate its dynamics

Chinese Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
T. Meng	Chinese Academy of Sciences	Simulation of X-band Co-polarized backscattering from Oil-covered sea surfaces	Prediction of the X-band signal backscattered off a slick-free and slick-covered sea surface using different scattering and damping models

Future activities

- **Backscattering from offshore wind farms**
- **Comparison of microwave backscattering from slick-covered sea surface predicted using different scattering and damping models**
- **Retrieval of oil thickness**
- **Classification of harsh coastal environments using polSAR multi-frequency measurements**

Training

Academic exchanges, cooperation, contribution to Dragon 5 training

1. Zoom meetings monthly
2. Visiting scientists exchanges: we hosted a Chinese PhD student working on scattering from oil emulsions for 1y

Publications

T. Meng, K.-S. Chen, X. Yang, F. Nunziata, D. Xie and **A. Buono**, "Simulation and Analysis of Bistatic Radar Scattering from Oil-Covered Sea Surface," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 60, pp. 1-15, 2022.

T. Meng, X. Yang, K.-S. Chen, F. Nunziata, D. Xie and **A. Buono**, "Radar Backscattering Over Sea Surface Oil Emulsions: Simulation and Observation," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 60, pp. 1-14, 2022.

F. Nunziata, X. Li, A. Marino, W. Shao, M. Portabella, X. Yang and **A. Buono**, "Microwave satellite measurements for coastal area and extreme weather monitoring," *MDPI Remote Sensing*, vol. 13, pp. 3126, 2021.

E. Ferrentino, **A. Buono**, F. Nunziata, A. Marino and M. Migliaccio, "On the use of multi-polarization satellite SAR data for coastline extraction in harsh coastal environments: the case of Solway Firth," *IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing*, vol. 14, pp. 249-257, 2021.

F. Nunziata, **A. Buono**, G. Inserra, M. Alparone, and M. Migliaccio. "On the multi-frequency polarimetric scattering of harsh coastal environments," *Proceedings of IEEE IGARSS 2022*, Kuala Lumpur, Malaysia, July 17 - 22, 2022.

G. Inserra, M. Migliaccio, F. Nunziata and **A. Buono**, "A multi-polarization analysis of Terra Nova Bay polynya." *Proceedings of the EUSAR Conference*, Leipzig, Germany, July 25-27, 2022.

M. , Zahribanhesari, **A. Buono**, F. Nunziata, G. Aulicino and M. Migliaccio, "Analysis of fine-scale dynamics of the Drygalski ice tongue in Antarctica using satellite SAR data," *International Journal of Remote Sensing*, vol. 43, no. 7, pp. 12602-2619, 2022.

F. Nunziata, **A. Buono**, A. Muhammad, D. Velotto and M. Migliaccio, "Analysis of the effect of the incidence angle on polSAR ship scattering," *Proceedings of IEEE IGARSS 2021*, Brussels, Belgium, July 12 - 16, 2021.

W. Shao, Z. Lai, F. Nunziata, A. Buono, X. Jiang and J. Zuo, Wind Field Retrieval with Rain Correction from Dual-polarized 2 Sentinel-1 SAR Imagery Collected During Tropical Cyclones, MDPI Remote Sensing, in print.

Publications under revision

Under review:
MDPI Remote Sensing
•M. Adil, A. Buono, F. Nunziata, E. Ferrentino, D. Velotto and M. Migliaccio, On the effects of the incidence angle on the L-band multi-polarisation scattering of a small ship, under review
•M. Z. Hesari, A. Buono, F. Nunziata, G. Aulicino and M. Migliaccio, Multi-polarisation C-band SAR imagery to estimate recent dynamics of the d'Iberville glacier, under review
IEEE TGR
•G. Inserra, F. Nunziata, A. Buono, G. Aulicino and M. Migliaccio, C-band SAR multi-polarisation scattering signatures of ice-free and ice-infested coastal polynyas, in print.
IEEE JOE
•A. Buono, G. Inserra, F. Nunziata, M. Migliaccio, F. Parmiggiani and G. Aulicino, Characterization of the Terra Nova Bay polynya using dual-polarimetric C-band SAR measurements, minor revision

Conclusions

The project aims at demonstrating the benefits of radar products for coastal area monitoring and, therefore, it is framed into the “Ocean & coastal zone” Dragon-5 thematic area.

- The co-operation was successful in all the topics
- A Chinese PhD student spent a 1y period @ Uniparthenope
- Pandemic restrictions that still aply in PR China limited the exchange of students
- The activities scheduled for the next year are already ongoing