On the backscattering of offshore platforms via single and dual-polarization TerraSAR-X data

A. Marino[(1)], D. Velotto[(2)], and F. Nunziata[(3)]

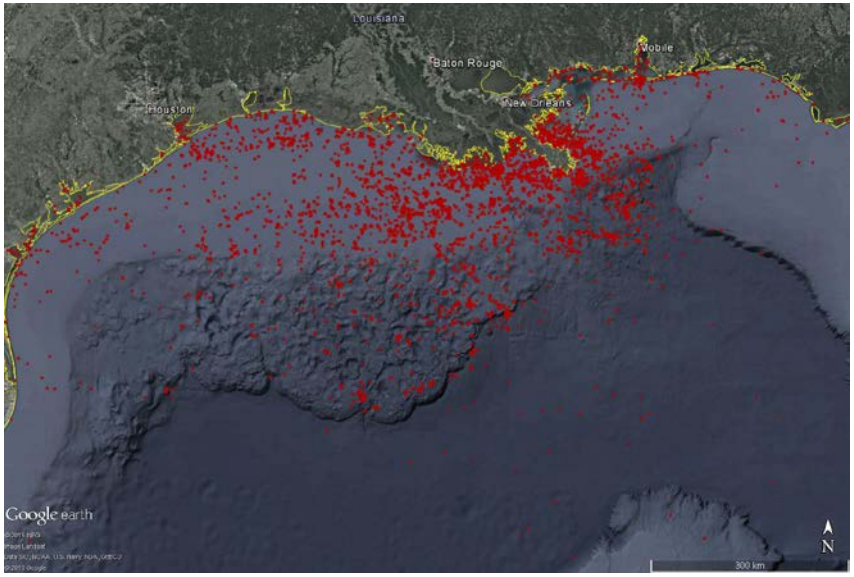
(1)Open University, School of Engineering and Innovation, Milton Keynes, U.K.
[(2)]German Aerospace Center (DLR), IMF-SAR BF Bremen Flughafen, Germany
[(3)]Università di Napoli Parthenope, Dipartimento Ingegneria, Napoli, Italy

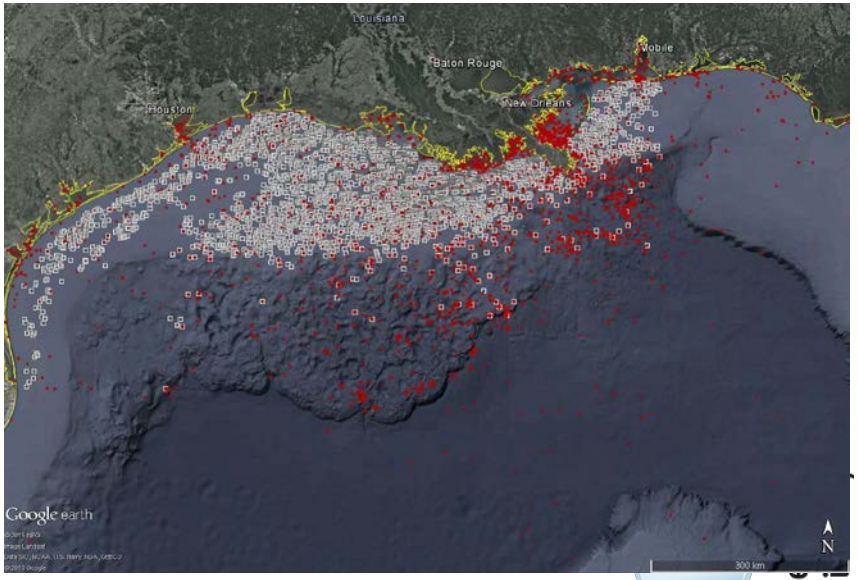
Email: *Armando.marino@open.ac.uk*

The Open University

Motivations

- ~10k accident reports (2010-2015)[1]
  - ~7000 involve oil spill
  - ~4500 caused by platform
- ~4000 offshore platforms (2013)[2]
  - High correlation with accident



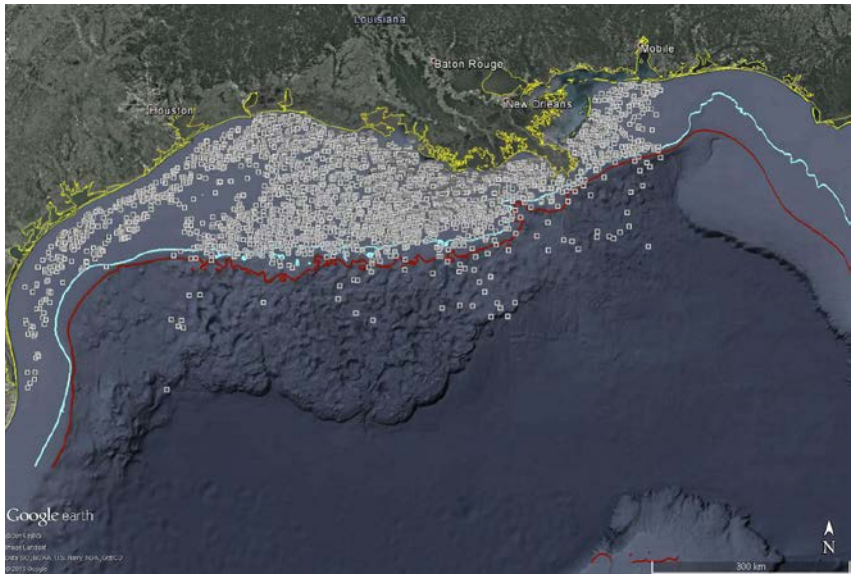


- **Environmental treats !**

[1] U.S Coast Guard – National Response Center (NRC)
[2] Bureau of Ocean Energy Management (BOEM)

Motivations

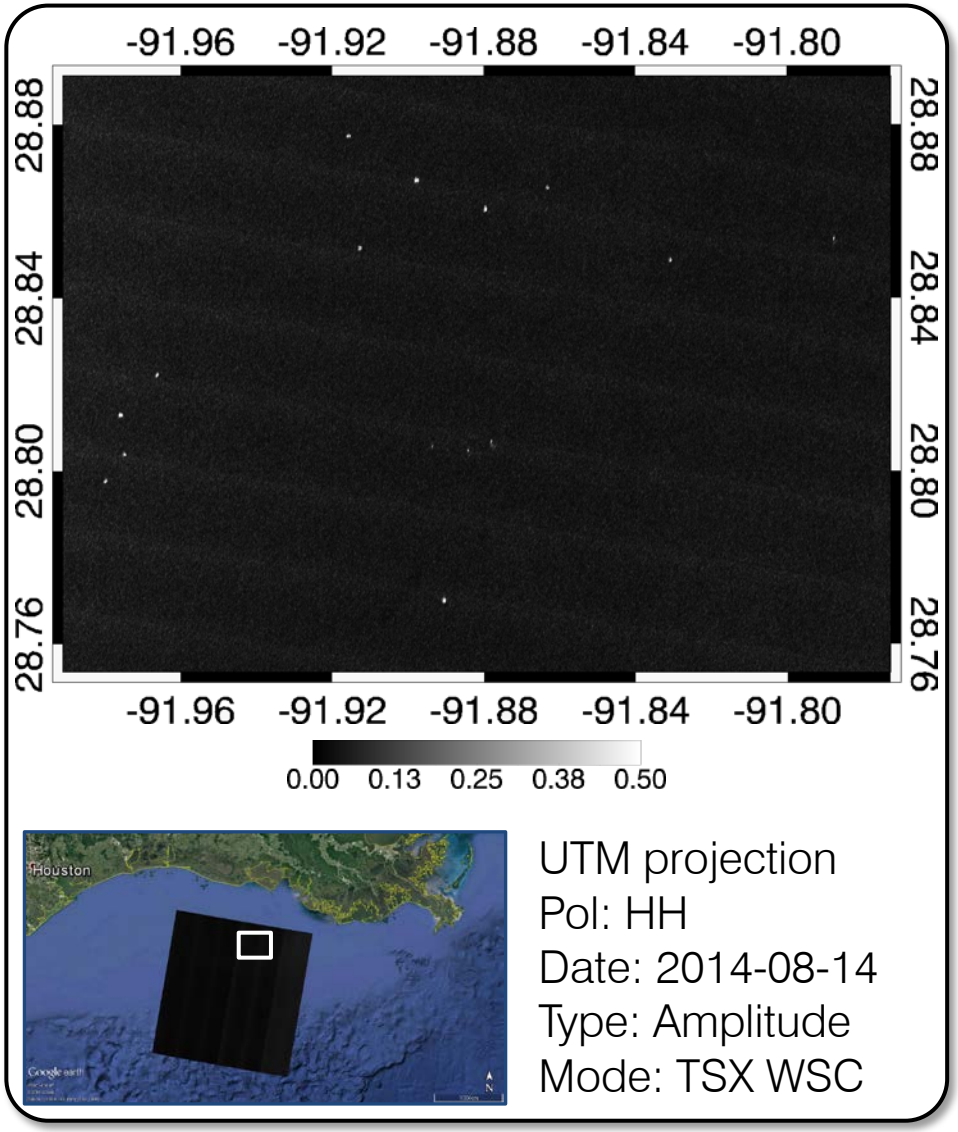
- Deep water technology
  - Increased number at water depth >300m
  - Highly subject to stormy weather
- Change detection (existence/position)
  - Unknown positions, e.g. Africa, Brazil
  - Machine failures and tropical events
- Obstacles for maritime traffic



- Safety and Security !

The Open University

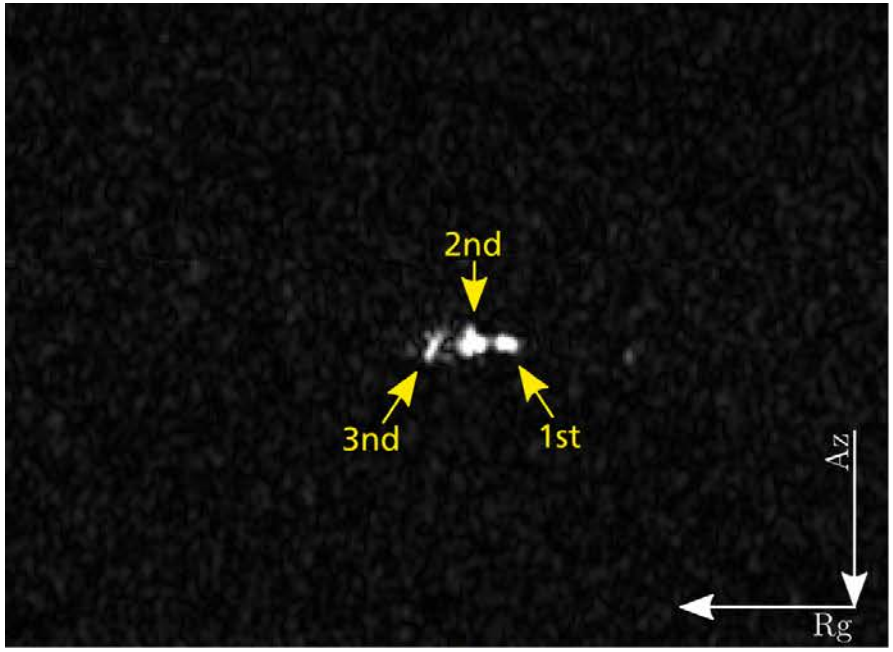
Monitoring via medium resolution imagery

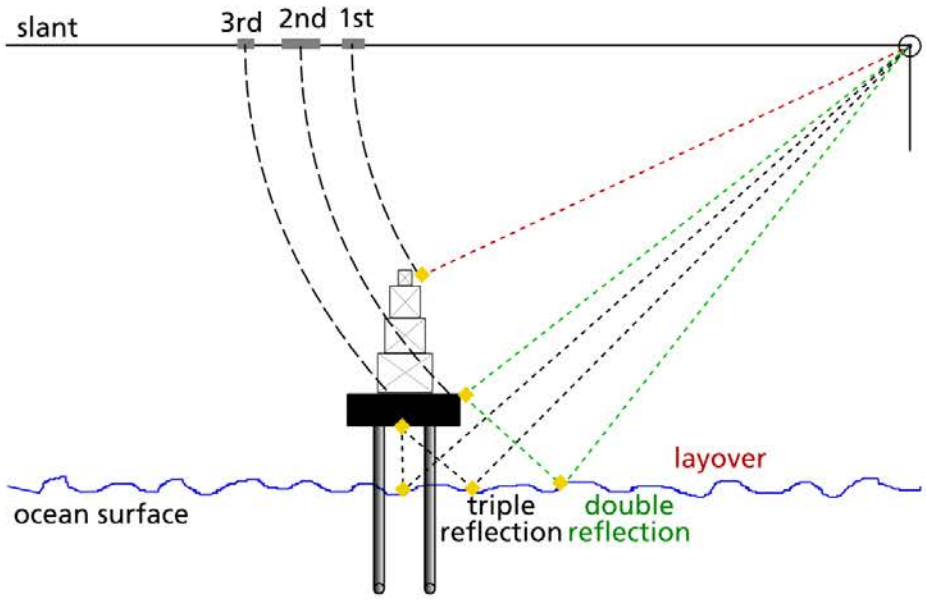


- TerraSAR-X WideScanSAR
- 200km swath @ 1.8m x 40m (SLC)
- all weather/day&night
- Target of interest >30m

The Open University

Platform backscattering



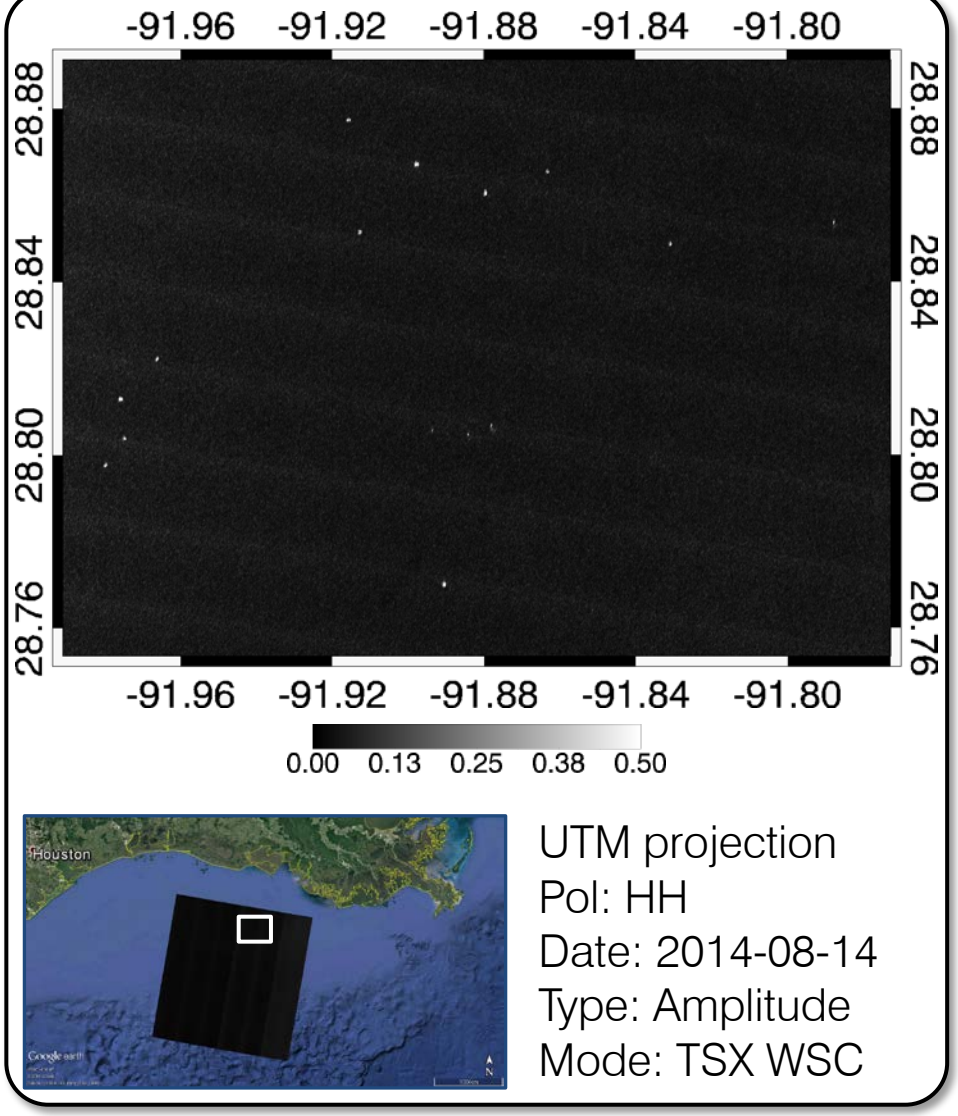


The three main backscatter signatures are given by

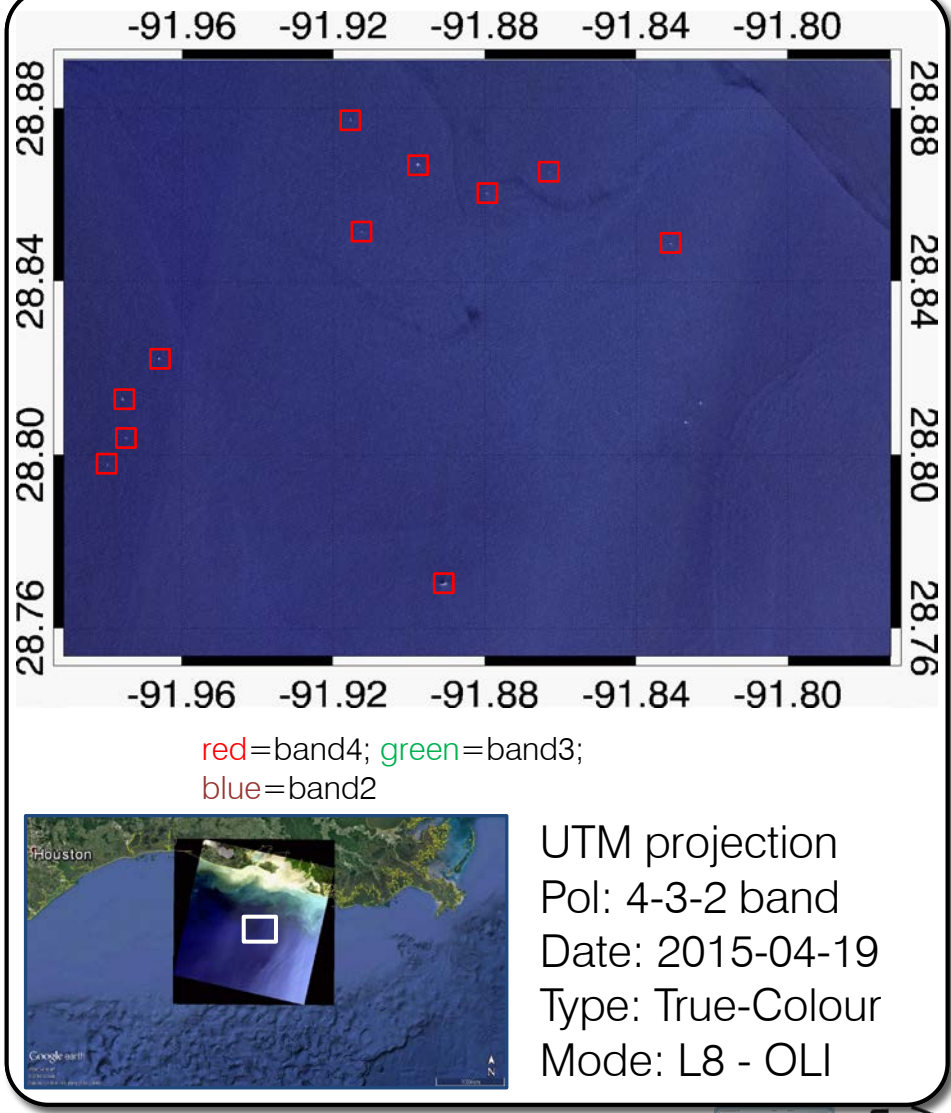
- layover
- double reflection
- triple reflection

The Open University

Monitoring via medium resolution imagery



UTM projection
Pol: HH
Date: 2014-08-14
Type: Amplitude
Mode: TSX WSC



red=band4; green=band3;
blue=band2

UTM projection
Pol: 4-3-2 band
Date: 2015-04-19
Type: True-Colour
Mode: L8 - OLI

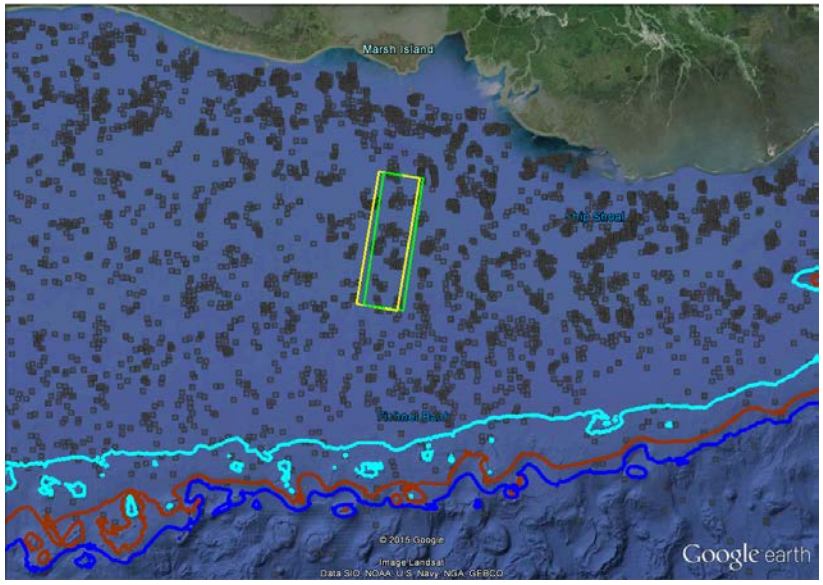
☐ Offshore platform location extracted from BOEM database

The Open University

Multi-temporal dataset

Possible causes:

- ~~Viewing direction~~
- ~~Met-ocean conditions~~
- Polarization
- Resolution
- Incidence angle



3x { case *low*, case *high* }

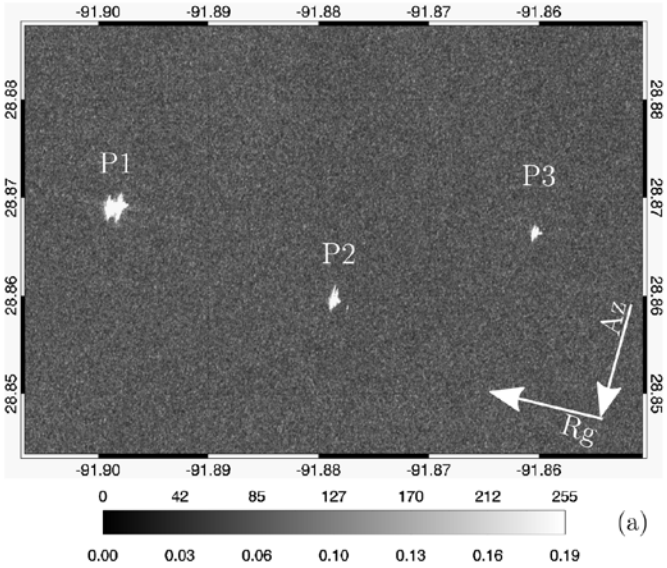
OVERVIEW OF THE DUAL-POLARIMETRIC TS-X/TD-X SM ACQUISITIONS IN GOM

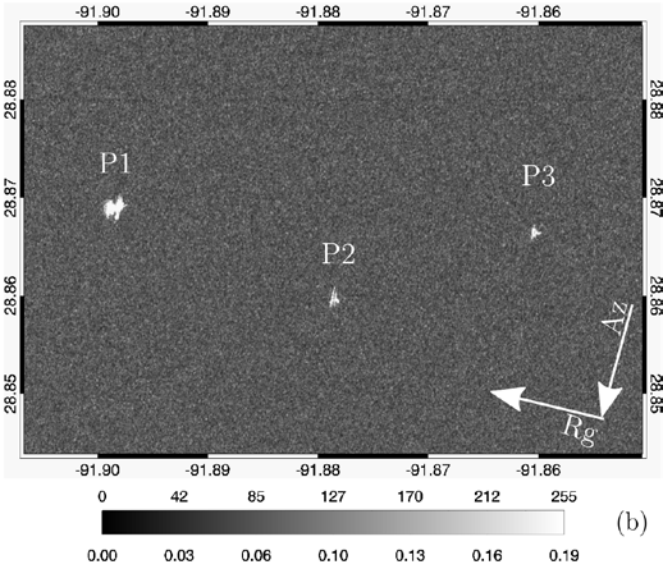
Acquisition ID	Data Time	Resolution* Rg-Az	Incidence Angle ϑ	Polarization	Wind Speed m/s
GoM1	2014/10/13 12:17 UTC	1.2m x 6.6m	19.8° - 21.7°	HH-VV	7-12
GoM2	2014/03/24 12:08 UTC	1.2m x 6.6m	39.0° - 40.3°	HH-VV	6-11
GoM3	2012/10/28 12:17 UTC	1.2m x 6.6m	19.8° - 21.7°	HH-HV	8-12
GoM4	2014/03/02 12:08 UTC	1.2m x 6.6m	39.0° - 40.3°	HH-HV	5-10
GoM5	2012/11/08 12:17 UTC	1.2m x 6.6m	19.8° - 21.7°	VH-VV	5-10
GoM6	2014/03/13 12:08 UTC	1.2m x 6.6m	39.0° - 40.3°	VH-VV	4-9

**Nominal values. The resolution in range depends on incidence angle and increases with it.*

Analysis – case *high*

HH



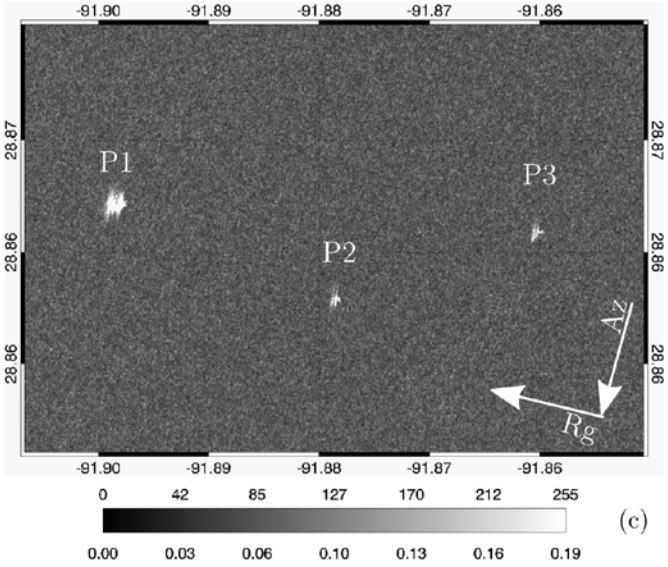


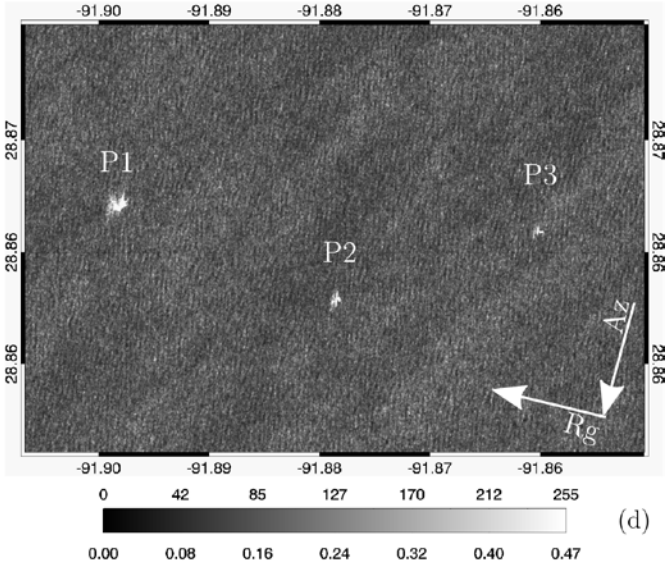
HV

GoM4

GoM6

VH



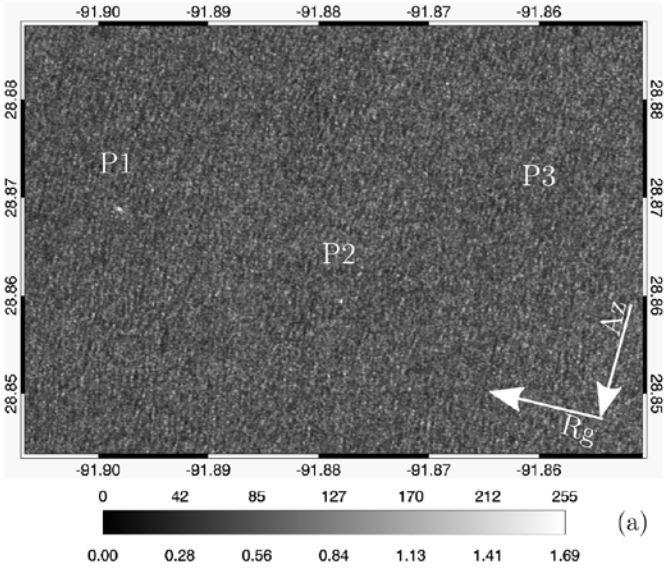


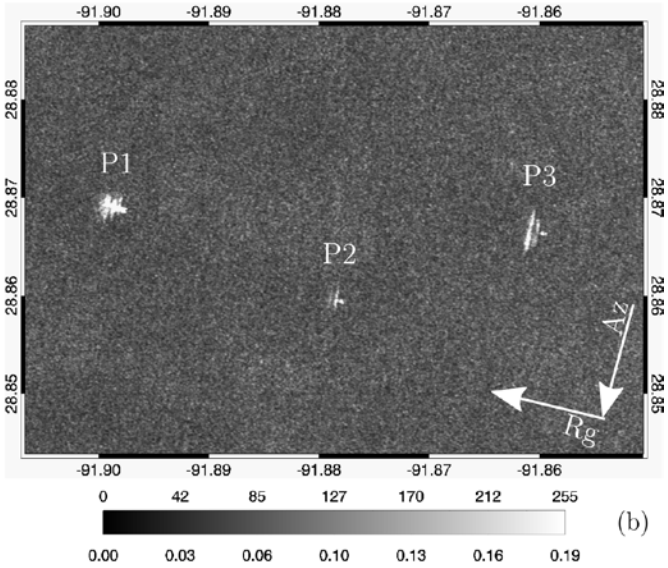
VV

The Open University

Analysis – case *low*

HH



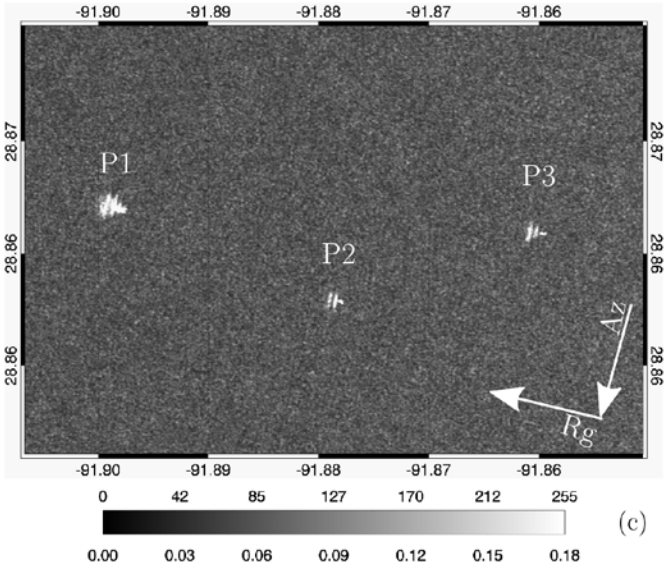


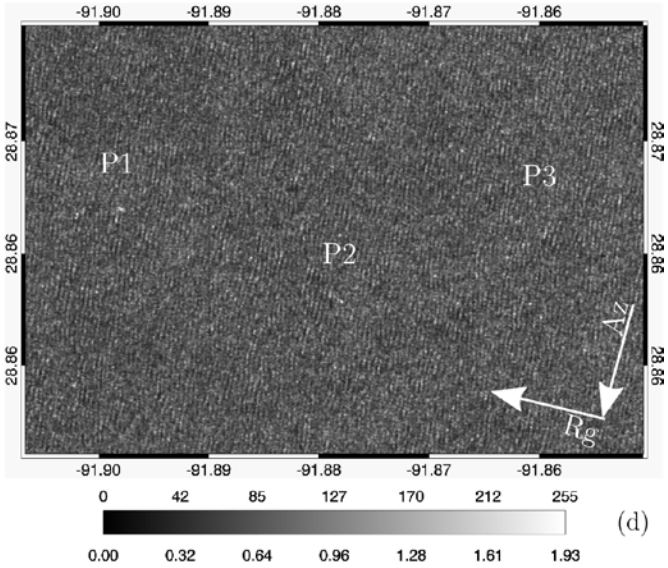
HV

GoM3

GoM5

VH



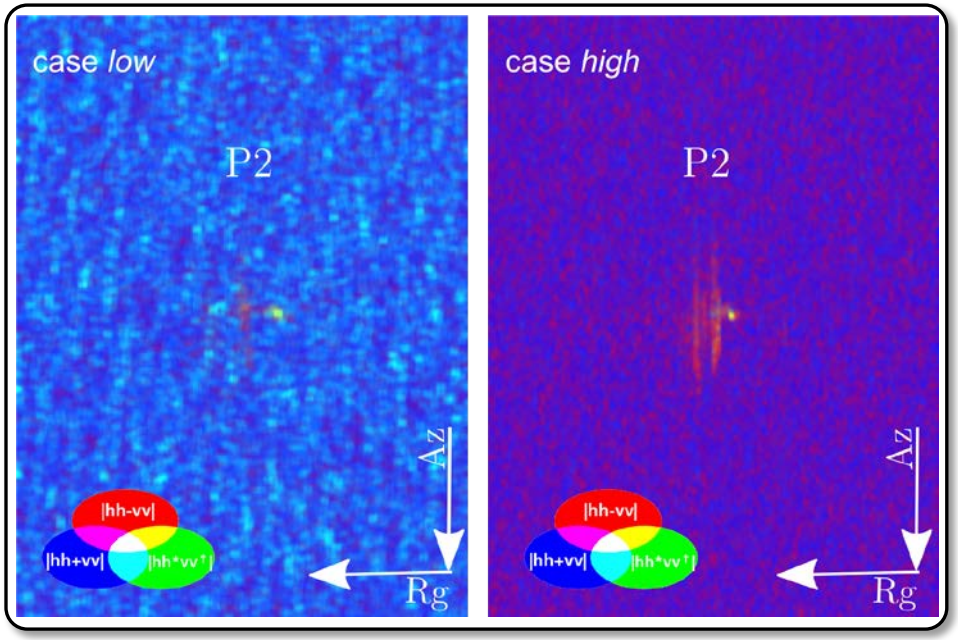


VV

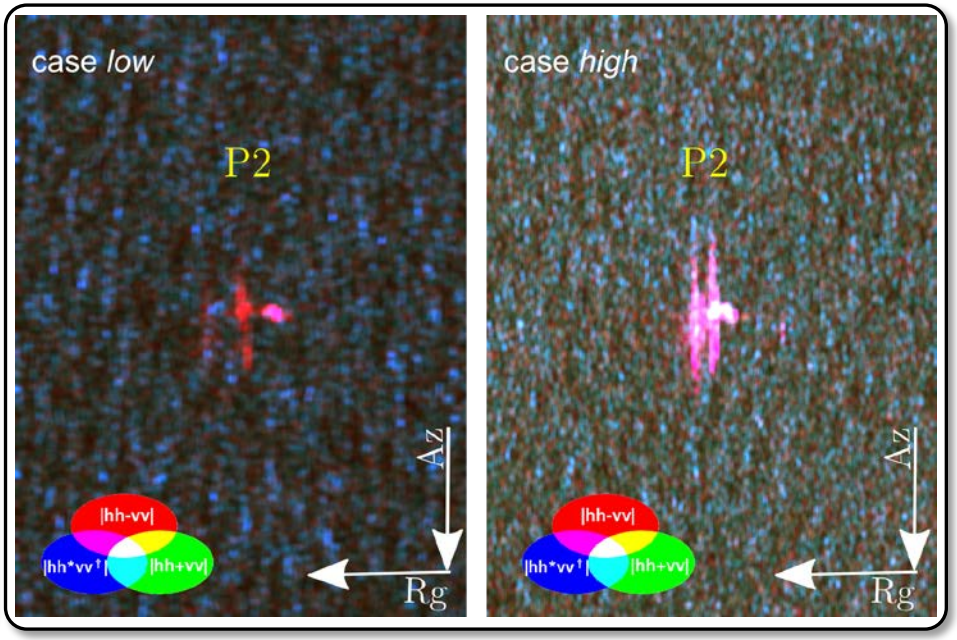
The Open University

Scattering mechanism analysis

Platform P2 scattering mechanisms identification using the most informative polarization combination, i.e. HH-VV, for cases *low* and *high*



RGB channels normalized → highlight the polarimetric content: double reflection, correlation and single reflection



RGB channels scaled individually → highlight the power: double reflection, correlation and single reflection

The Open University

Polarimetric observables

Coherent observables:

$$\mathrm{DoD} = 1 - \frac{\sqrt{(|HH|^2 - |VV|^2)^2 + [2\langle \Re(HH * VV^\dagger)\rangle]^2 + [2\langle \Im(HH * VV^\dagger)\rangle]^2}}{\langle |HH|^2 + |VV|^2 \rangle}$$

$$\mathrm{PNF} = \frac{1}{\sqrt{1 + \frac{RedR}{P_{tot} - P_{sea}}}} \quad [1]$$

Incoherent observables:

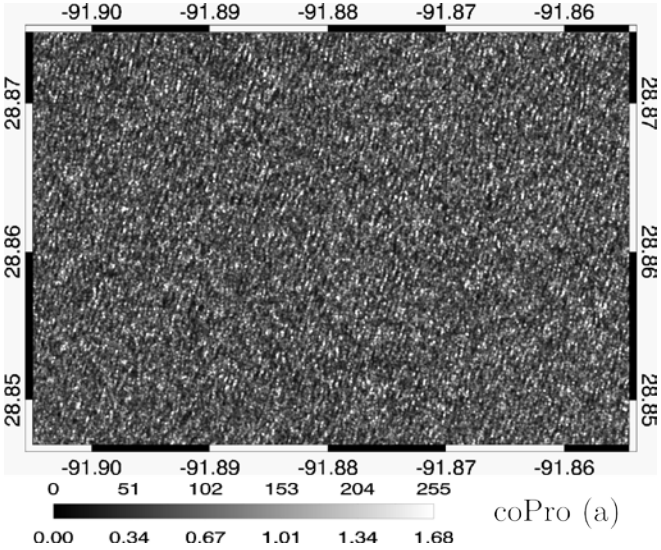
$$\mathrm{coProd} = |HH| * |VV|$$

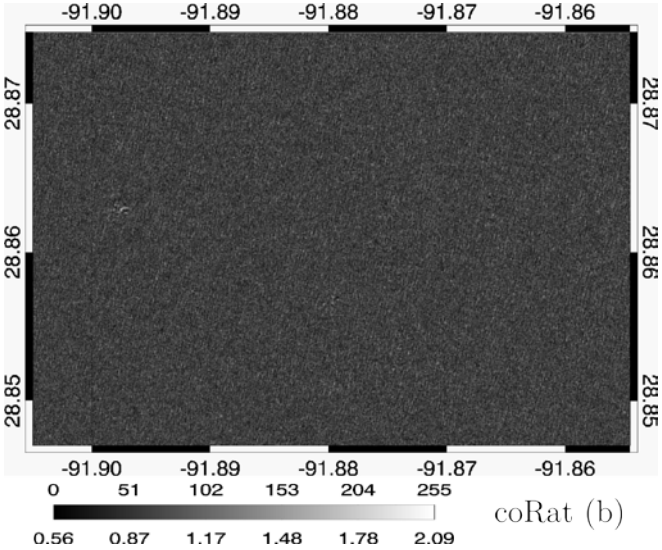
$$\mathrm{coRat} = |HH|/|VV|$$

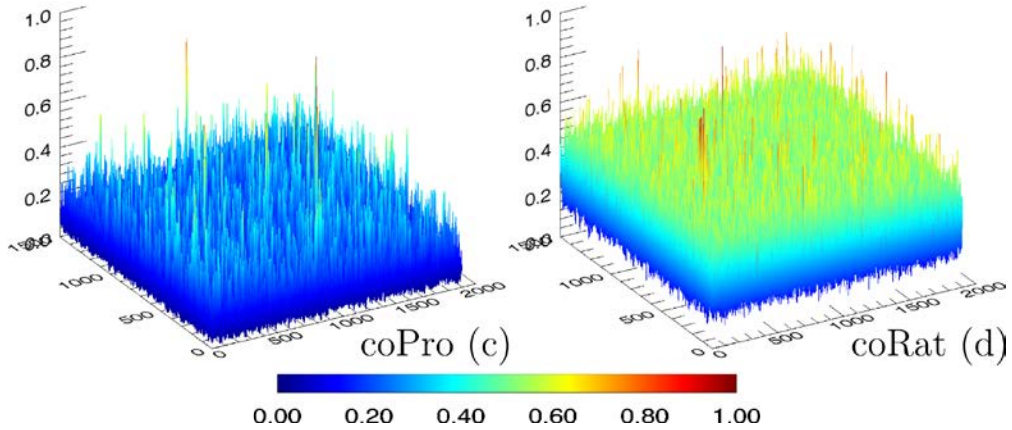
[1] A. Marino, "A Notch Filter for Ship Detection With Polarimetric SAR Data," *IEEE J. Sel. Top. Appl. Earth Obs. Remote Sens.*, vol. 6, no. 3,pp. 1219–1232, Jun. 2013.

Polarimetric observables

Challenging case: HH-VV case *low* – incoherent detectors



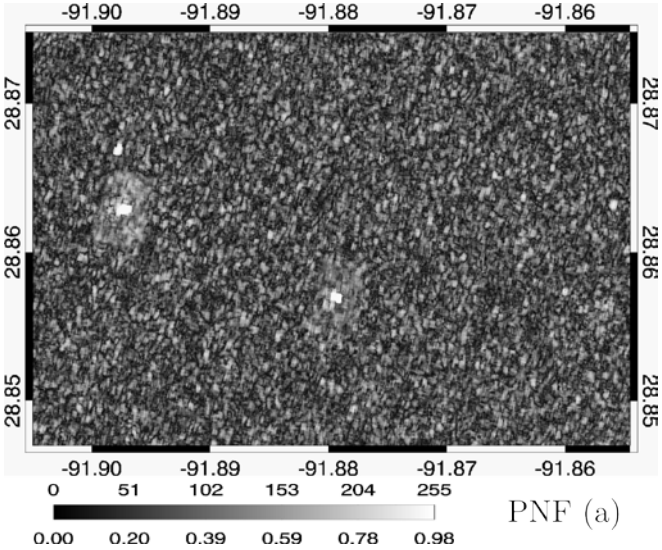


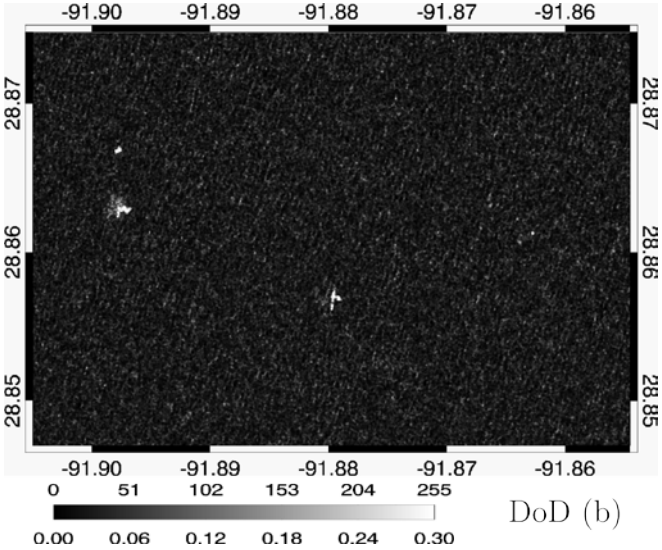


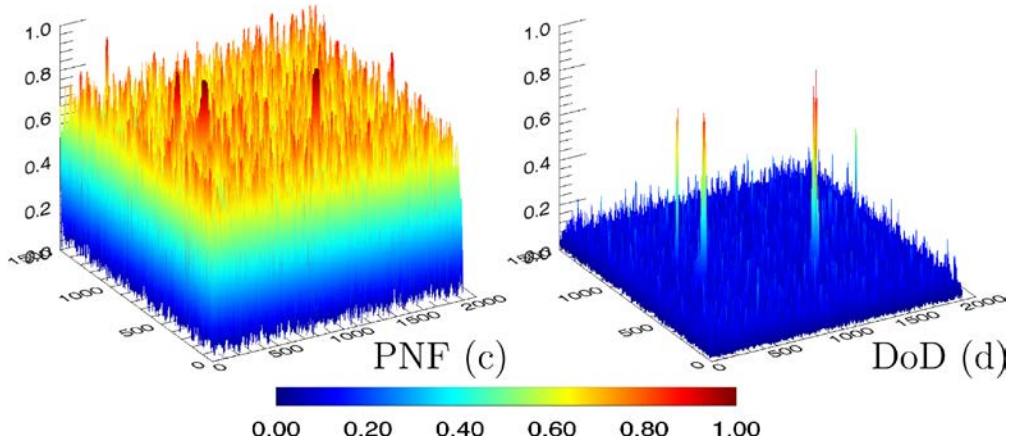
The Open University

Polarimetric observables

Challenging case: HH-VV case *low* – coherent detectors







The Open University

Conclusions and future work

- ✔ Offshore platform detection in SAR imagery can be challenging under certain circumstances
- ✔ The backscattering contributions is investigated depending on radar parameters
- ✔ Coherent and incoherent detectors in co-pol/co-pol dataset are considered to increase the detectability for challenging cases
- ❑ Extend the study to bistatic quad-pol, e.g. TanDEM-X DRA mode.
- ❑ Evaluate other polarimetric detectors and compare the performances under a common metrics.

The Open University

Questions?

The Open University