

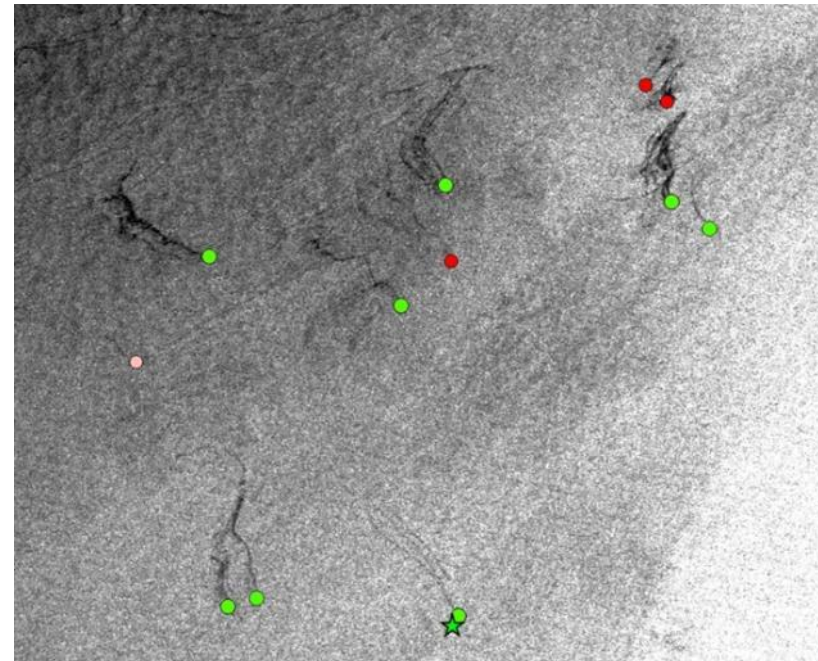
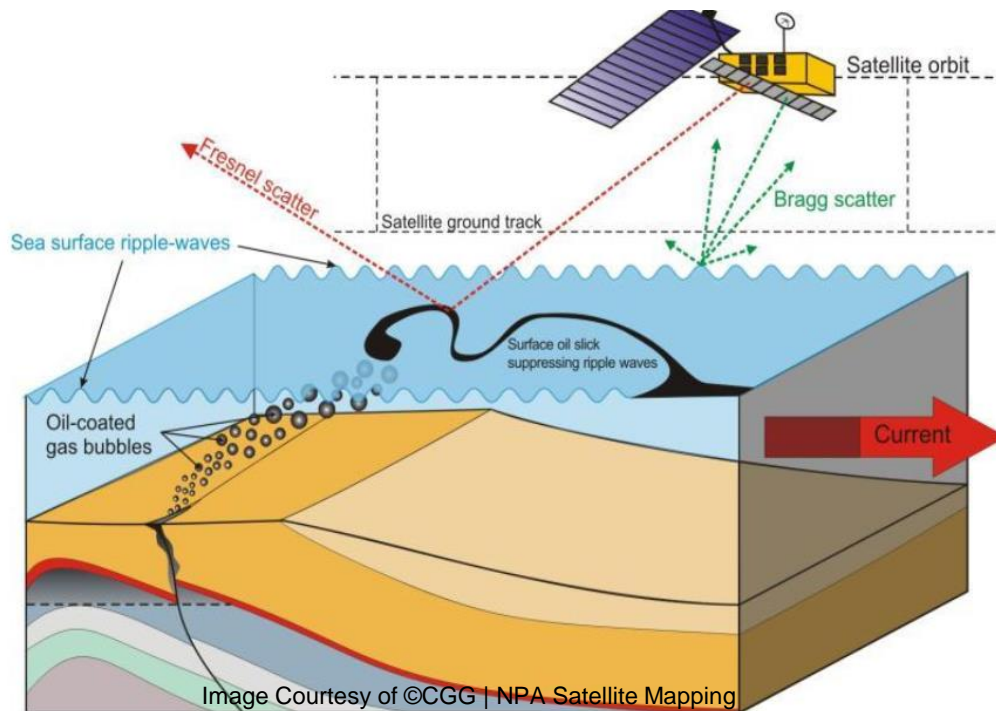
**Case studies for the Energy  
Sector in Mexico : Offshore**

**Natural Seepage Mapping**

# Case Study Offshore: Natural Seepage Mapping

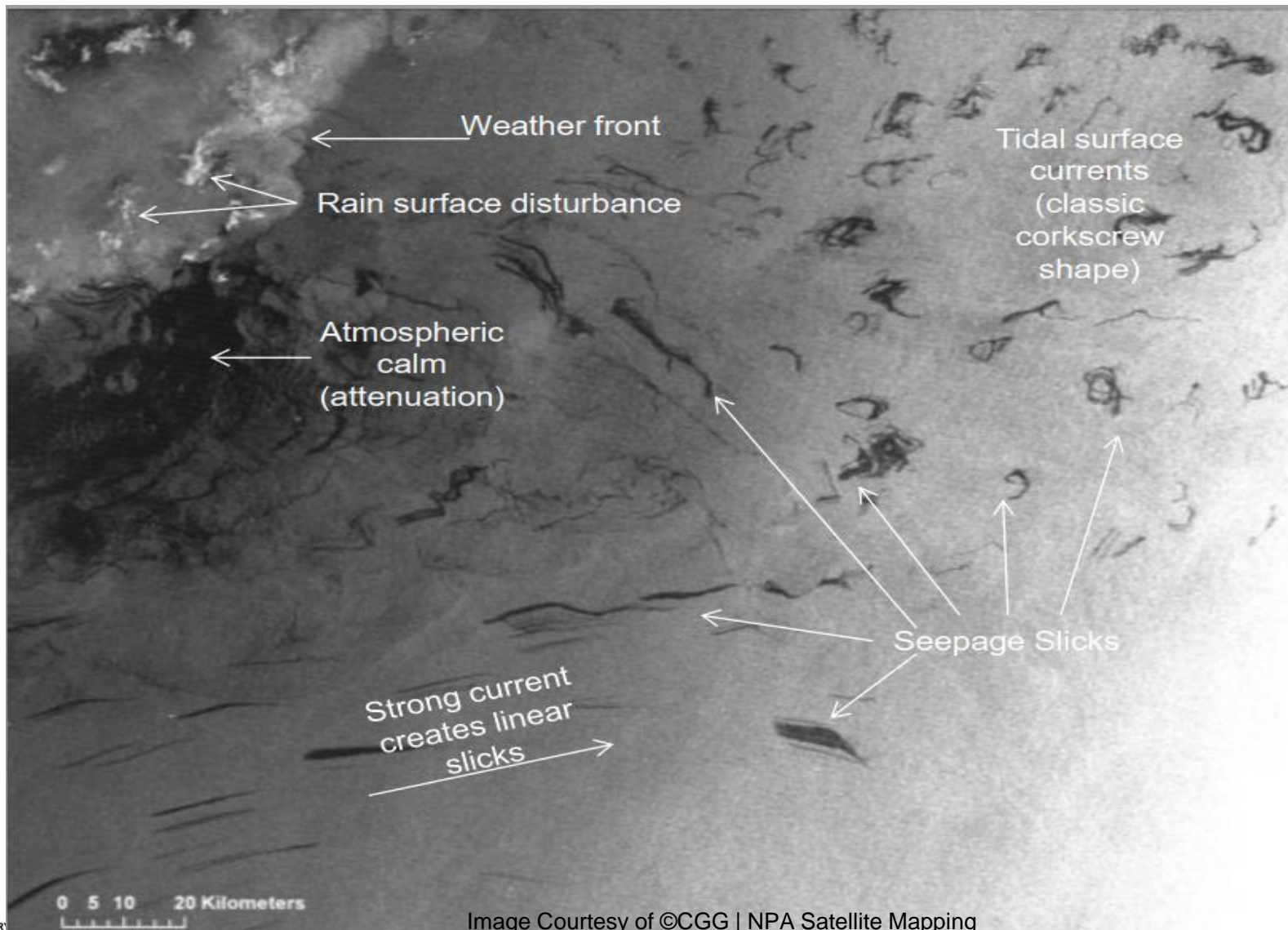
## High presence of natural hydrocarbon emanations in the Gulf

- Same principle as Oil Spill Detection
- Detects hydrocarbon that emanate from the sea bed
- Assess confidence of natural seepage based on morphology, location and occurrence.



# Case Study Offshore: Natural Seepage Mapping

## High presence of natural hydrocarbon emanations in the Gulf



# Case Study Offshore: Natural Seepage Mapping

## High presence of natural hydrocarbon emanations in the Gulf

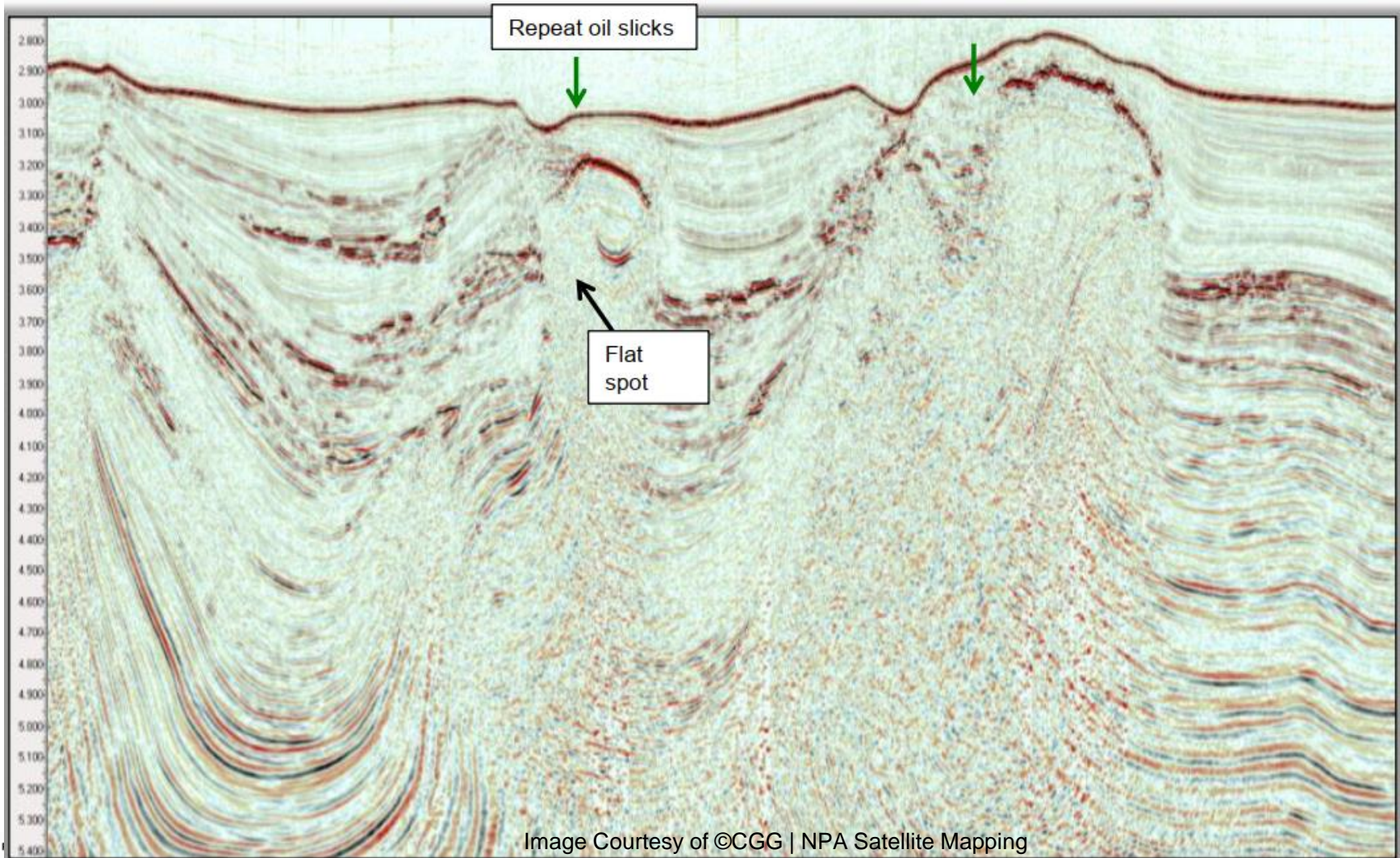
**Chapapotera de Cantarell – one of the biggest and more active seepage in the world**



# Case Study Offshore: Natural Seepage Mapping

## High presence of natural hydrocarbon emanations in the Gulf

- Can be used to find oil bearing structures
- Can be used to estimate type and quality of oil

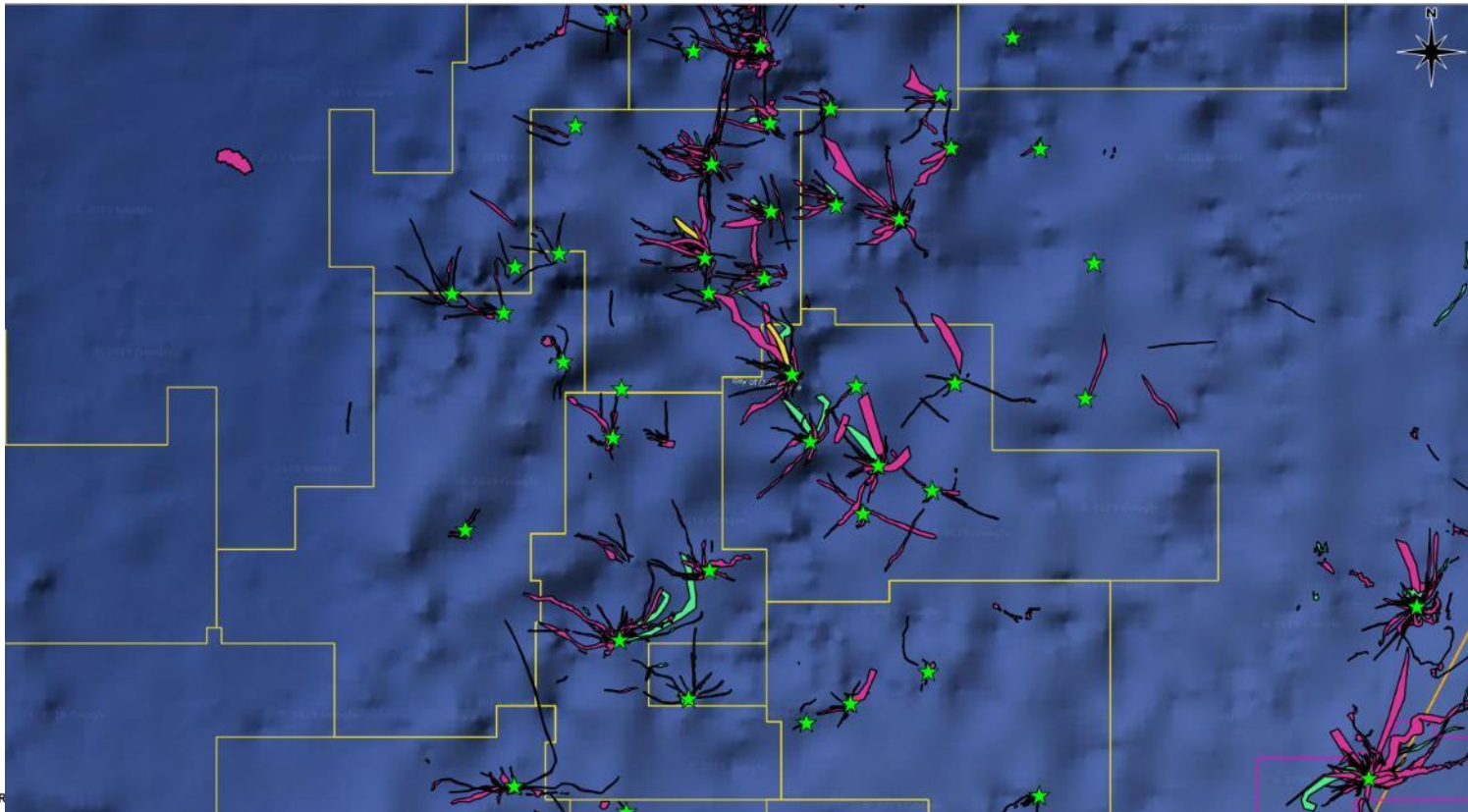


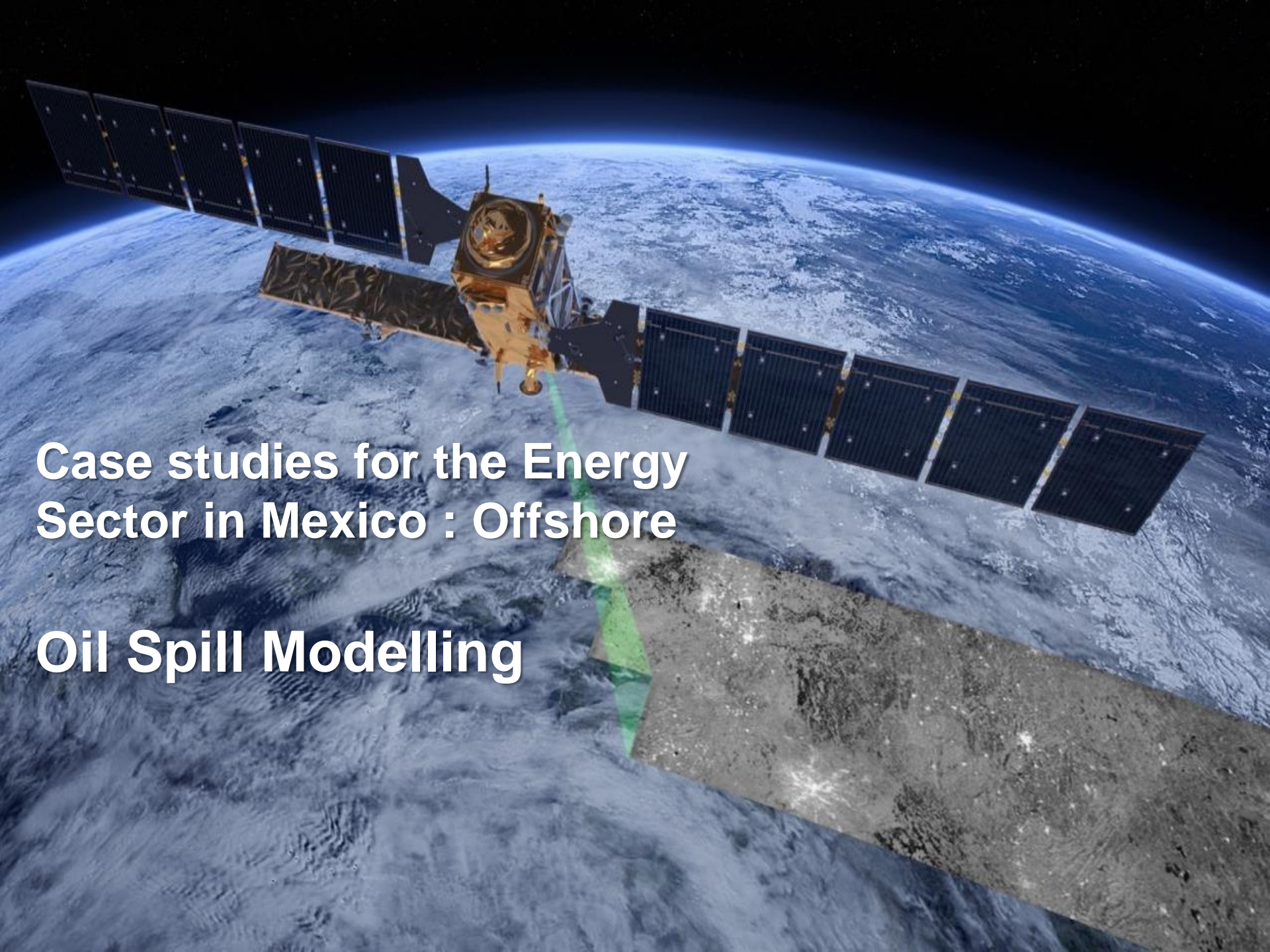
# Case Study Offshore: Natural Seepage Mapping

## High presence of natural hydrocarbon emanations in the Gulf

### Problem: natural seepage in future production areas

- Natural Seepage can be misinterpreted for Operational Spill
- Slicks entering and crossing different Blocks
- Oil & Gas operators can blame each other (liability)
- Not clear regulation? CNH / ASEA ?





**Case studies for the Energy  
Sector in Mexico : Offshore**

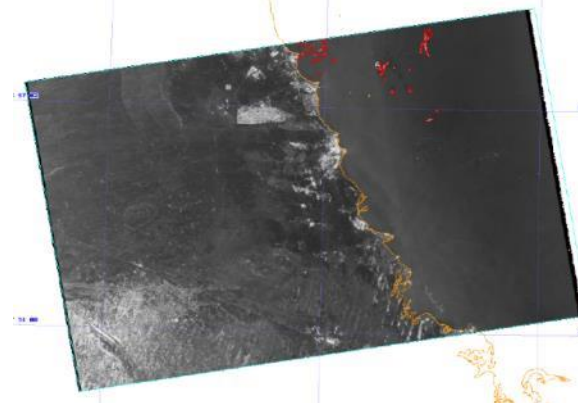
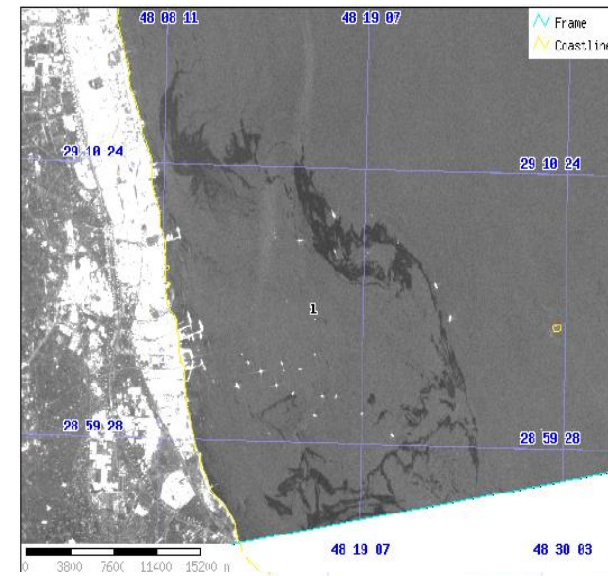
**Oil Spill Modelling**

# Case Study Offshore: Oil Spill Modelling

## Forensic study in the Persian Gulf

**Problem: big scale oil spill hits the coast**

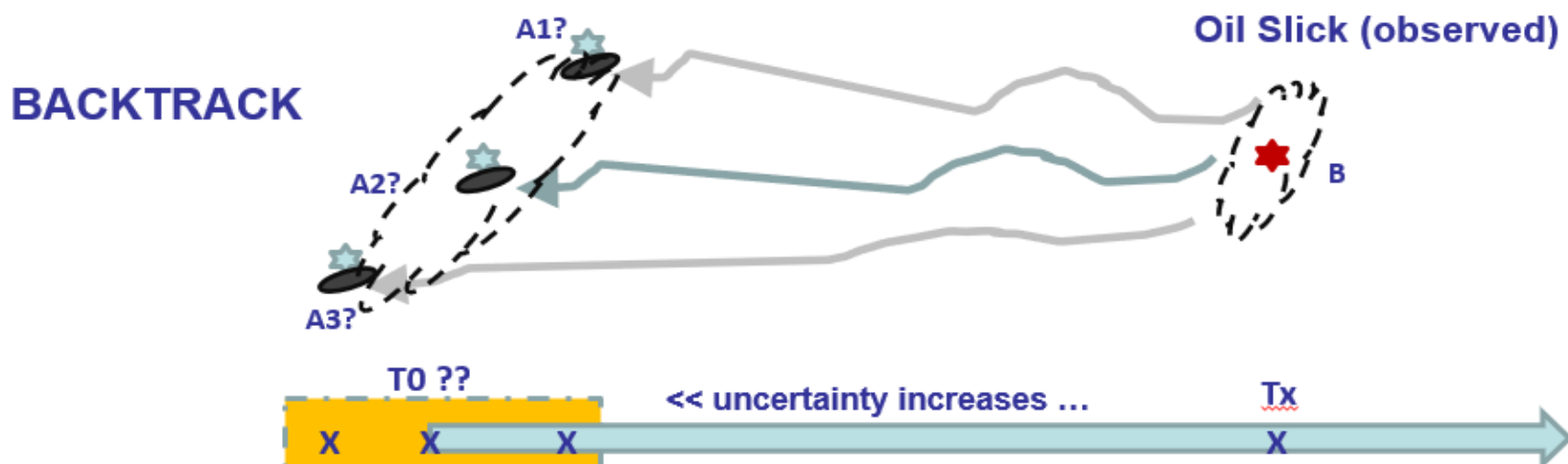
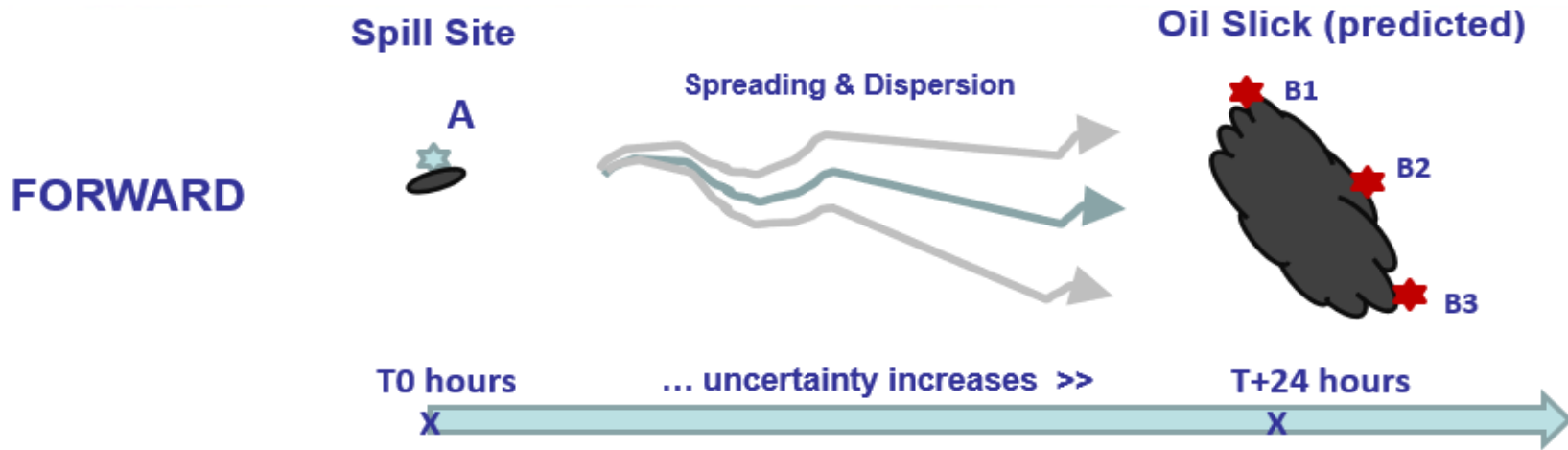
- Which operator is responsible for it?
- How much oil was released?



# Case Study Offshore: Oil Spill Modelling

## Forensic study in the Persian Gulf

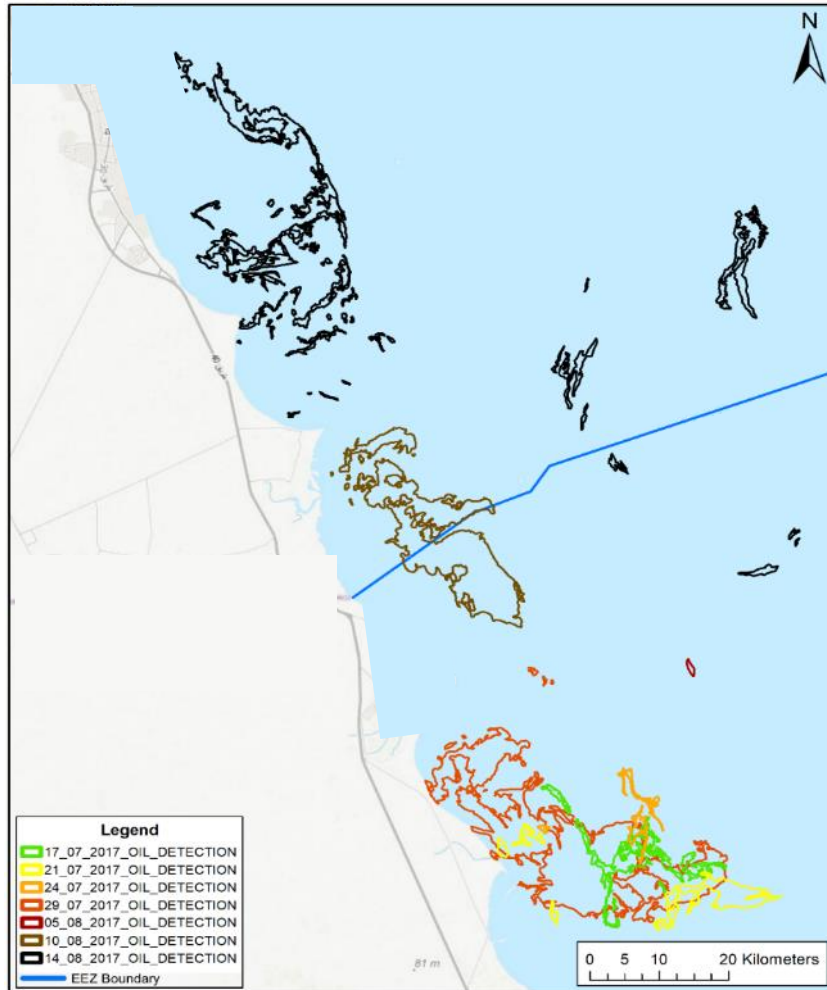
### Theory of Oil Spill Modelling



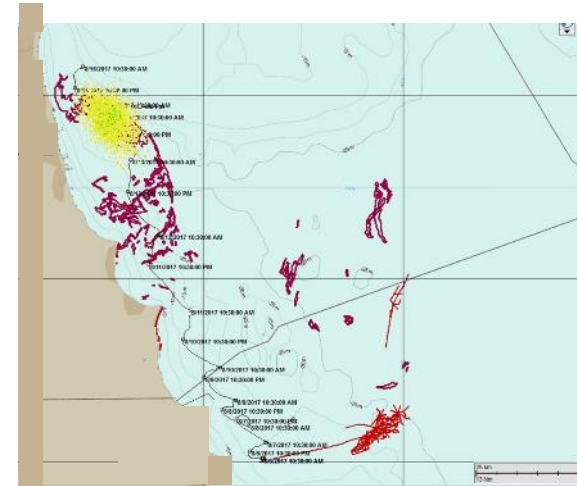
# Case Study Offshore: Oil Spill Modelling

## Forensic study in the Persian Gulf

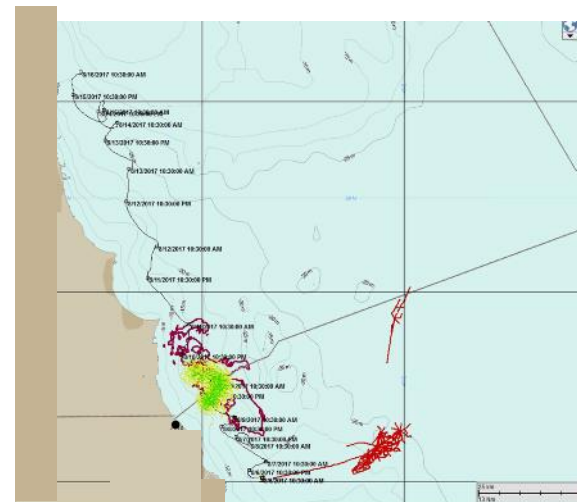
Exact origin of oil spill found – pipeline leakage



Oil Detection with RADAR images



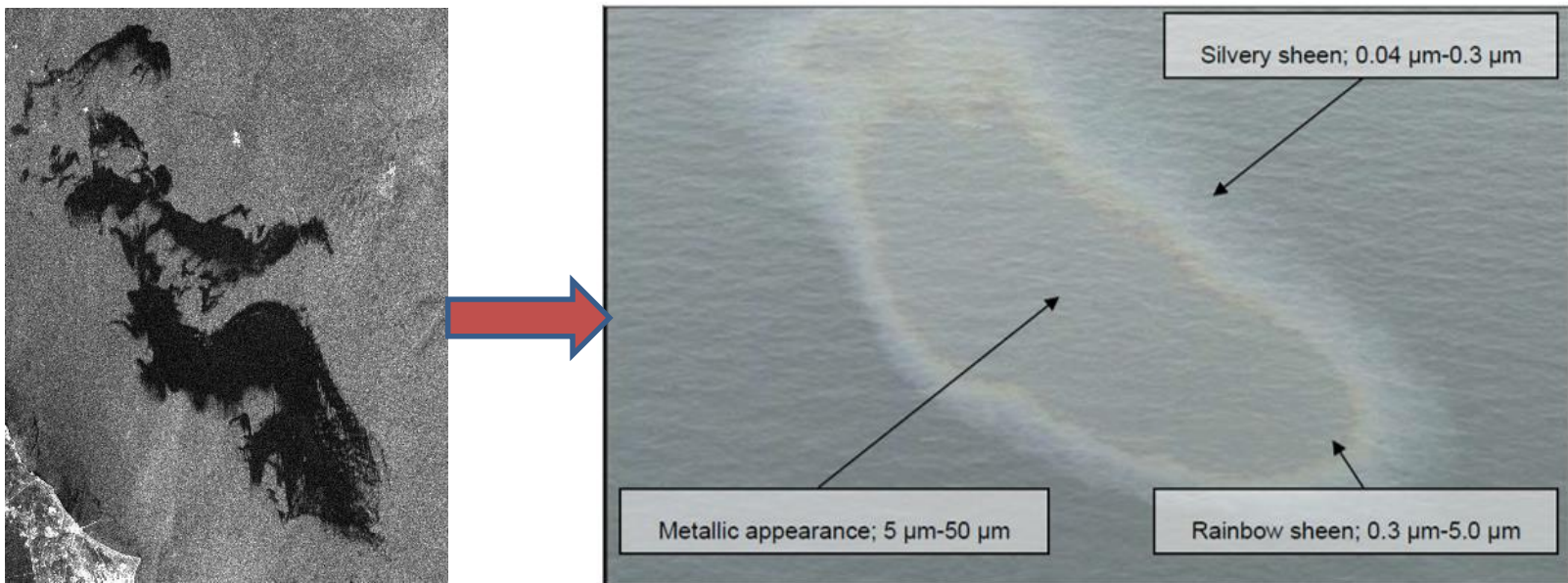
Modelling based on RADAR detections



# Case Study Offshore: Oil Spill Modelling

## Forensic study in the Persian Gulf

Estimated amount of oil leaked, following the Bonn convention, based on maximum extent of the event detected by RADAR image & insitu observation



**9000 Barrels of  
equivalent Oil**

Code	Description Appearance	Layer Thickness Interval ( $\mu\text{m}$ )	Litres per $\text{km}^2$
1	Sheen (silvery/grey)	0.04 to 0.30	40 – 300
2	Rainbow	0.30 to 5.0	300 – 5000
3	Metallic	5.0 to 50	5000 – 50,000
4	Discontinuous True Oil Colour	50 to 200	50,000 – 200,000
5	Continuous True Oil Colour	200 to More than 200	200,000 - More than 200,000

Table 1. The Bonn Agreement Oil Appearance Code



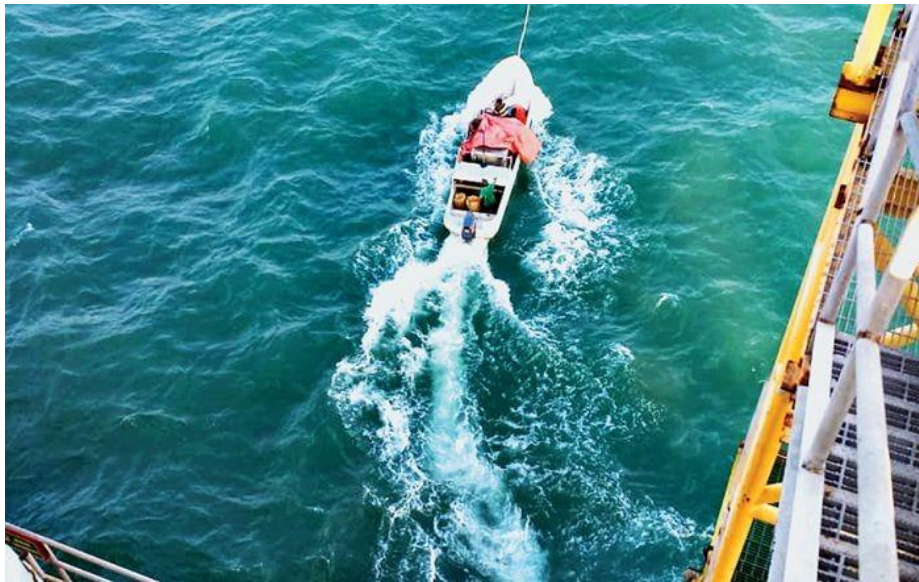
**Case studies for the Energy Sector  
in Mexico : Offshore**

**Exclusion Zones & Security**

# Case Study Offshore: Exclusion Zones & Security

## Theory of Vessel Detection with RADAR satellites

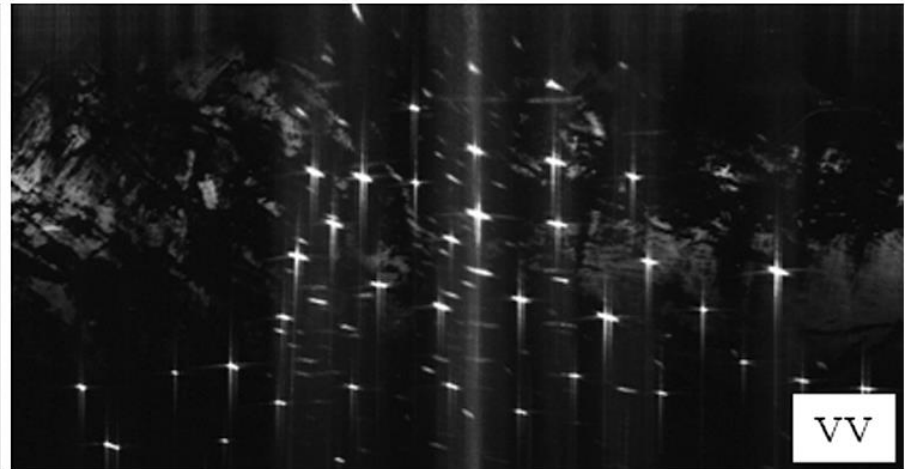
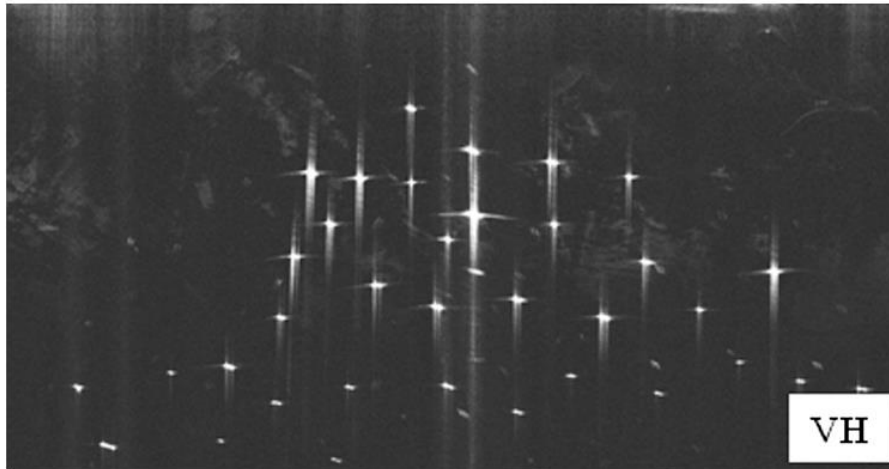
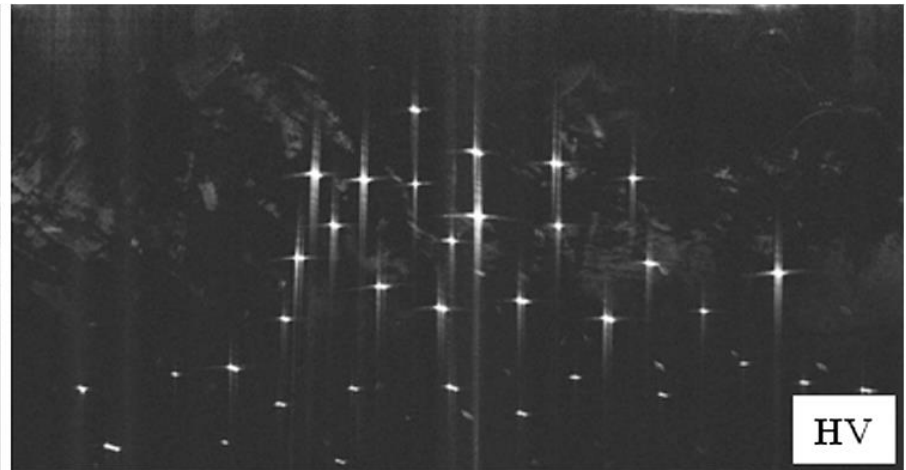
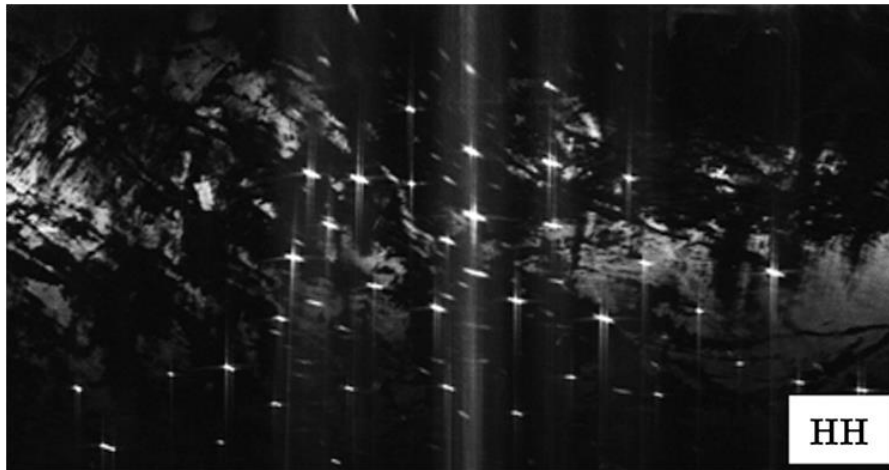
**Challenge – pirates attacking platforms to steal material**



# Case Study Offshore: Exclusion Zones & Security

## Theory of Vessel Detection with RADAR satellites

Opposite measurement to Oil Spill – bright targets



# Case Study Offshore: Exclusion Zones & Security

## Theory of Vessel Detection with RADAR satellites

Good vessels “normally” have AIS on – correlation is possible

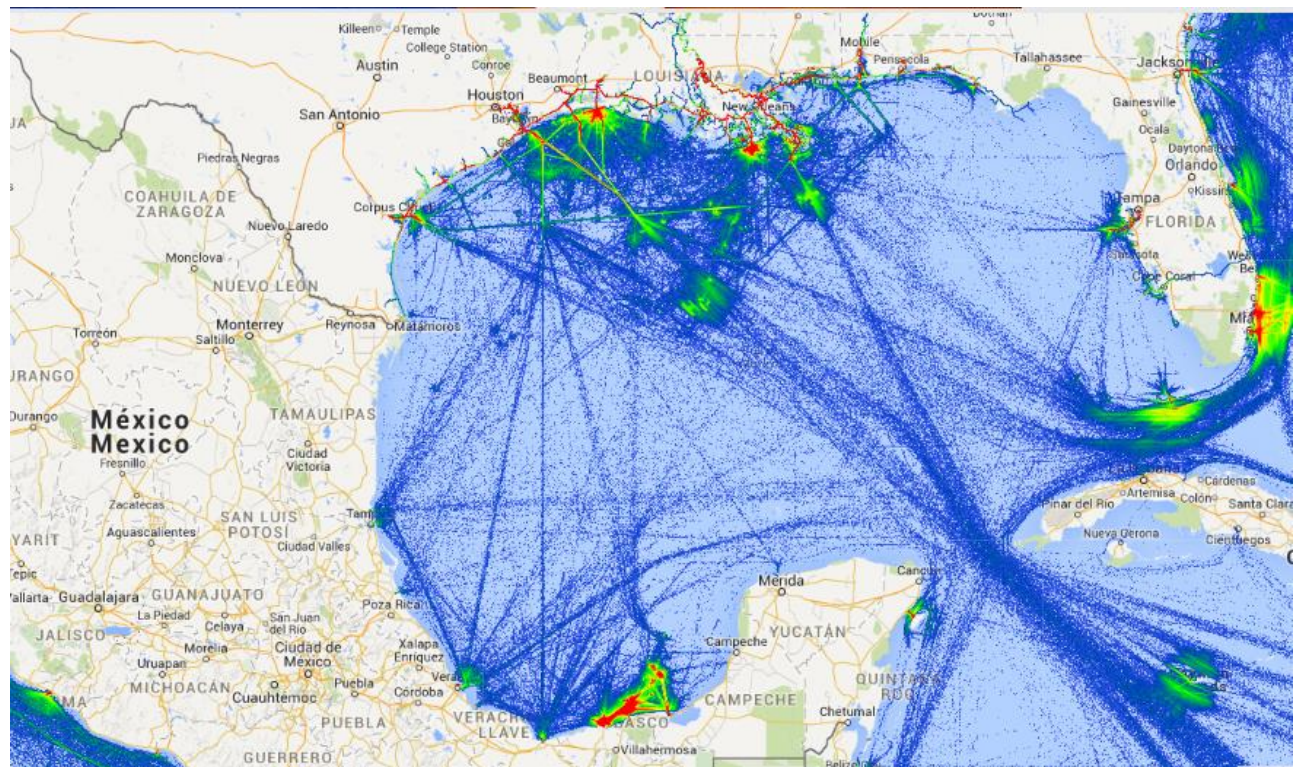
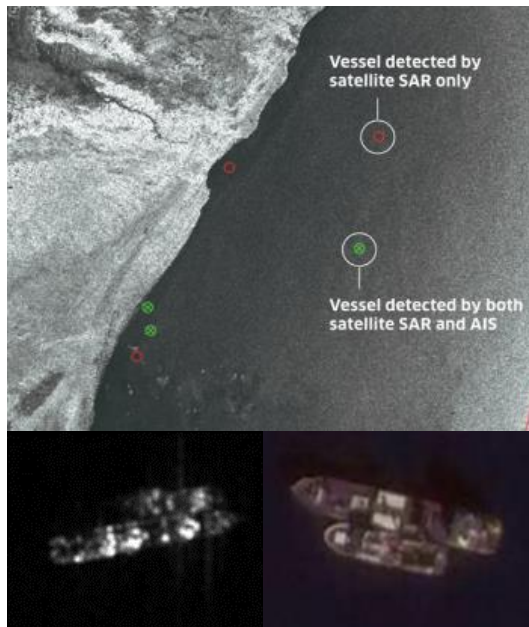


Image Courtesy of MarineTraffic.com

Top - SAR Image with Correlated AIS; Left - SAR vessel detection; Right - Optical

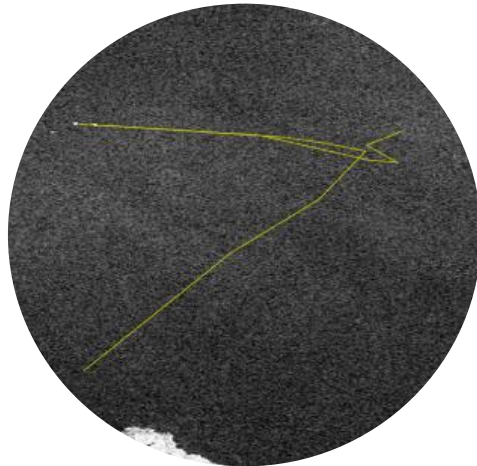


**Criminal vessels don't have AIS, or they switch it off**

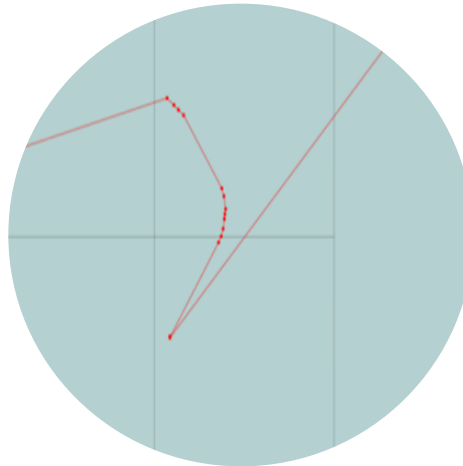
# Case Study Offshore: Exclusion Zones & Security

## Theory of Vessel Detection with RADAR satellites

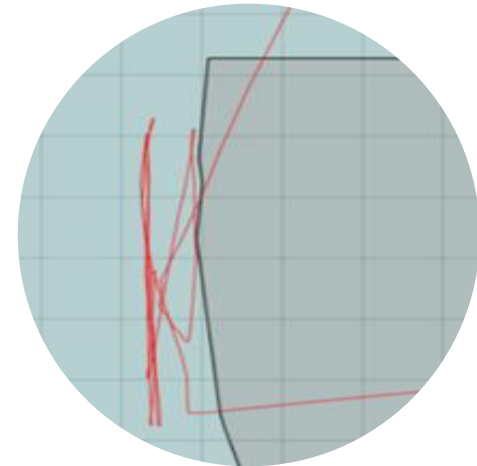
**Criminal vessels still can operate with AIS on!**



**SAR & AIS: Trans-Shipment**



**AIS "banana track": Trans-shipment (fuel)**



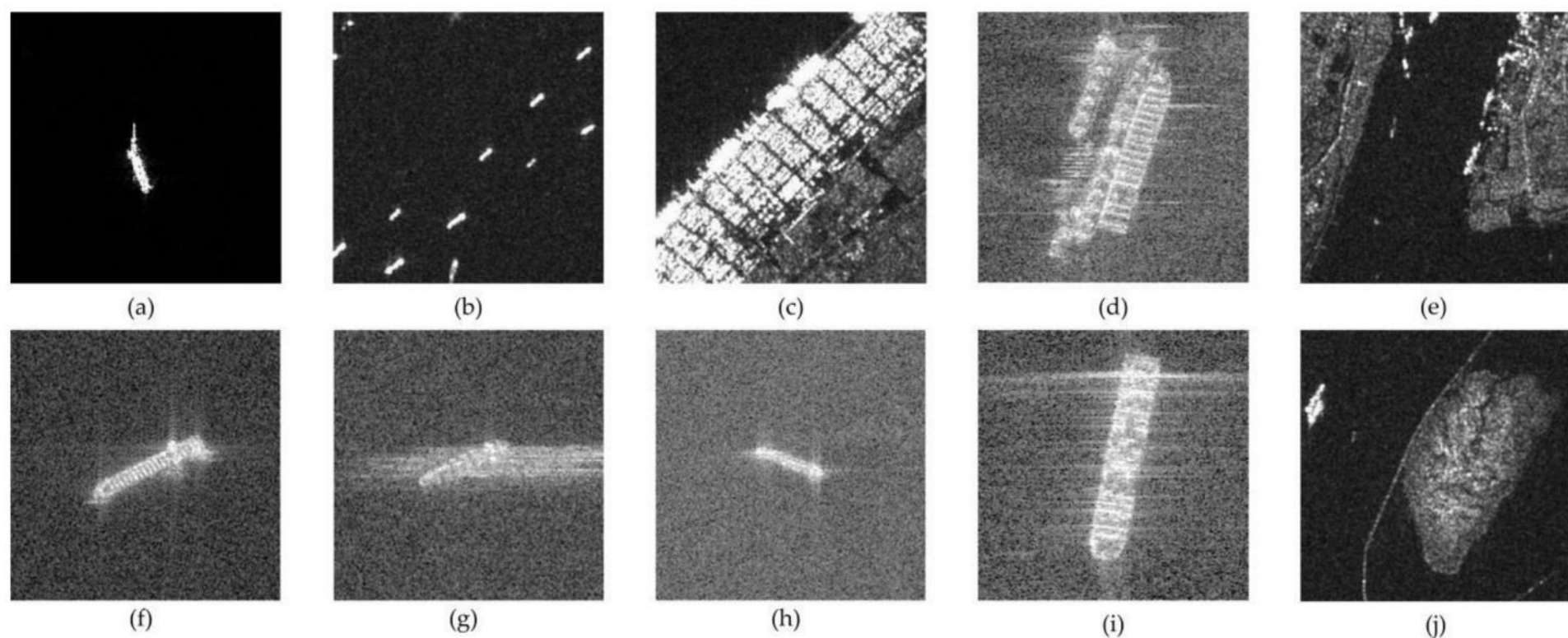
**Waiting to enter an exclusion zone**

# Case Study Offshore: Exclusion Zones & Security

## Practice – KSAT Vessel Detection with RADAR satellites

Detection capabilities depends on the resolution

General rule – we can detect vessels  $\frac{1}{2}$  pixel size



GAOFEN-3 different resolution modes: Image source <https://doi.org/10.3390/rs11070765>

# Case Study Offshore: Exclusion Zones & Security

## Practice – KSAT Vessel Detection with RADAR satellites

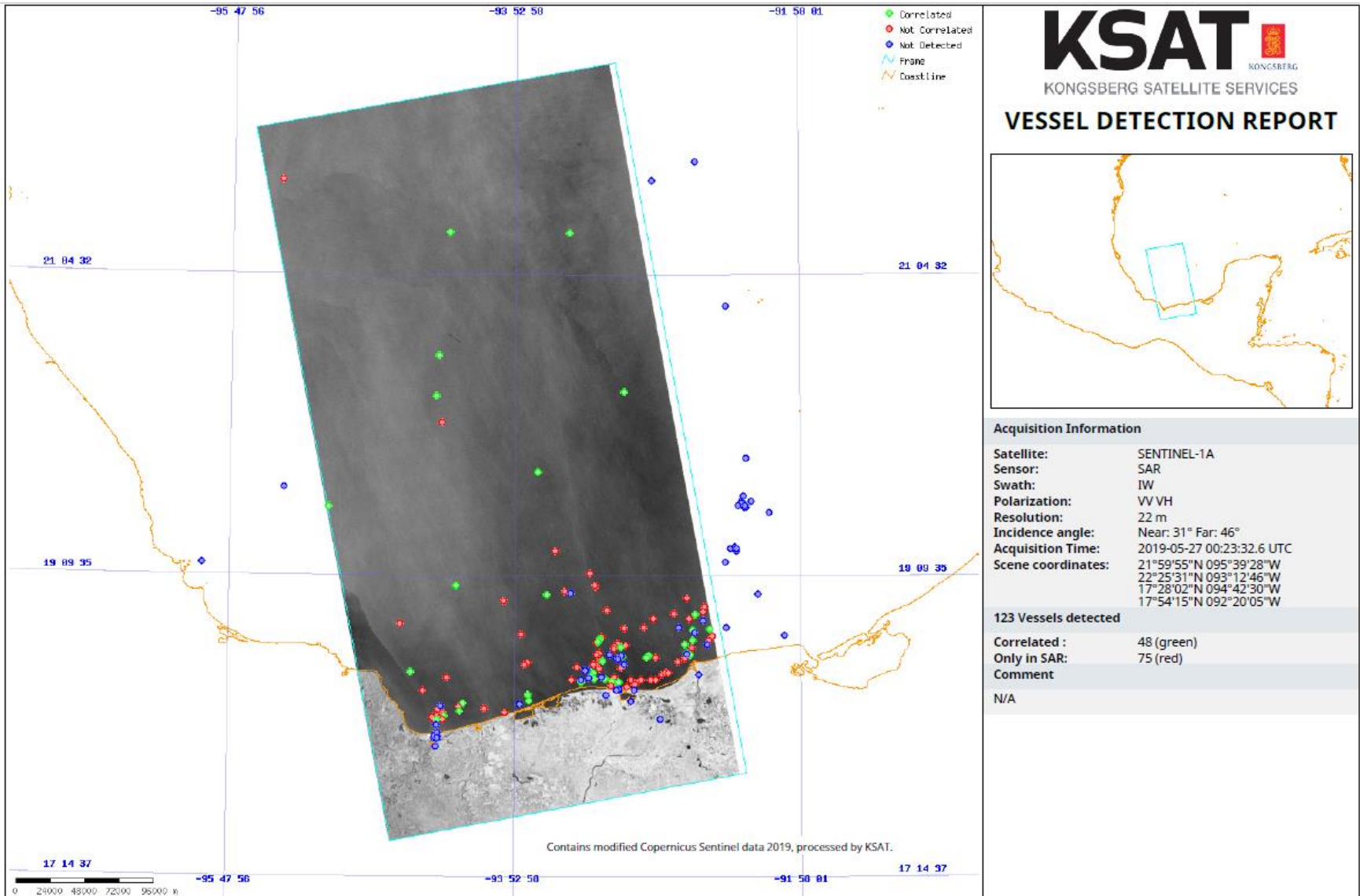
**Detection capabilities depends on the resolution**  
**General rule – we can detect vessels  $\frac{1}{2}$  pixel size**

Satellite	Beam Modes	Resolution (m)	Nominal scene size (Km)	Typical minimum detectable vessel size
RADARSAT-2	Wide Fine	10	150x150	>5 m
	Wide	25	150x150	>12 m
	Standard	20	100x100	>10m
	Fine	8	50x50	>4 m
GAOFEN-3	SS	25	150x150	>12m
	FSII	10	100x100	>5m
	FSI	5	50x50	>3m
TerraSAR-X / PAZ	ScanSAR	19	150x100	>9m
Cosmo-Skymed	ScanSAR Wide	30	100x100	>15m
Sentinel-1	IW	10	2	>5m

# Case Study Offshore: Exclusion Zones & Security

## Practice – KSAT Vessel Detection with RADAR satellites

### Pilot studies in the Gulf of Mexico – delivery time NRT





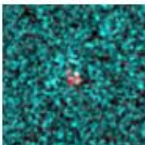


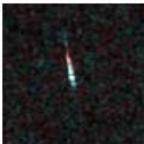
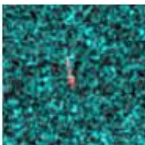
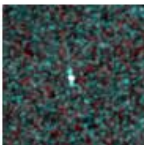
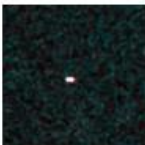
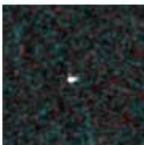
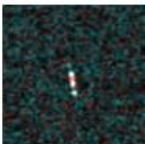

# Case Study Offshore: Exclusion Zones & Security

## Practice – KSAT Vessel Detection with RADAR satellites

### Pilot studies in the Gulf of Mexico

#### Detected vessels - Only in SAR

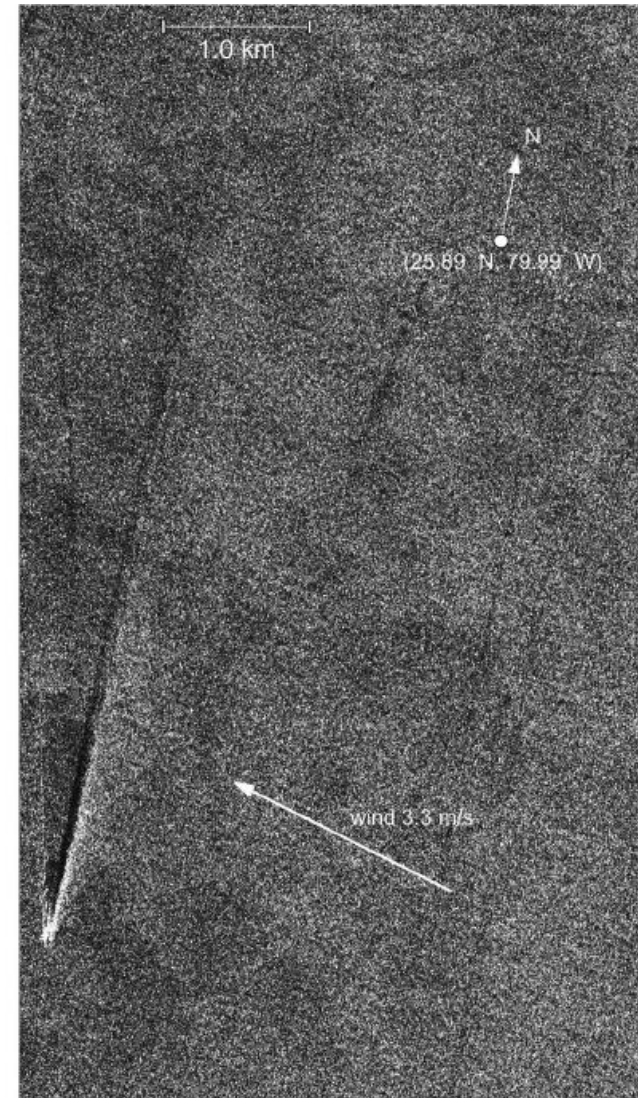
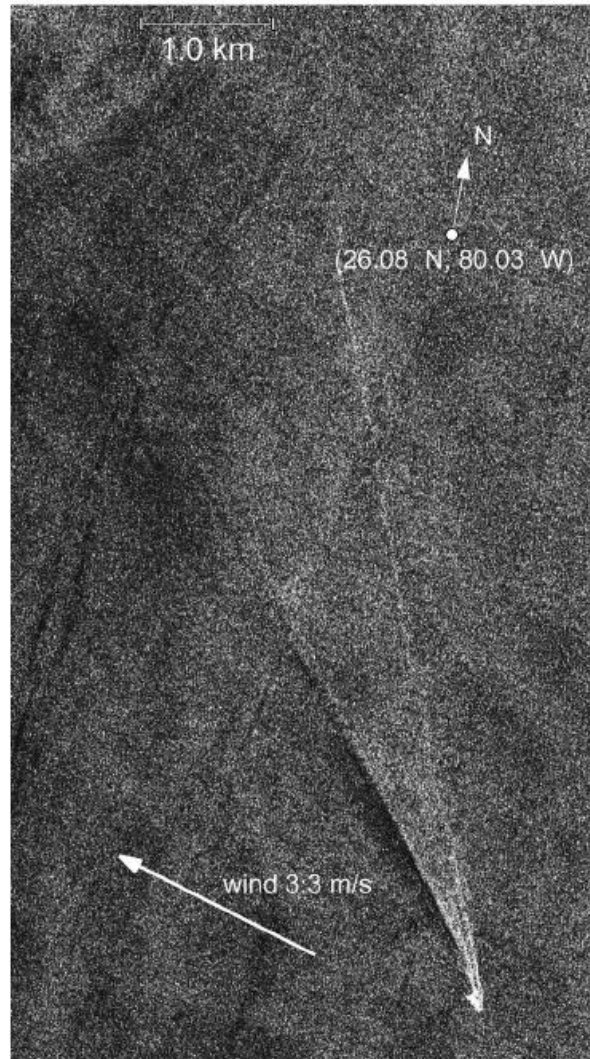
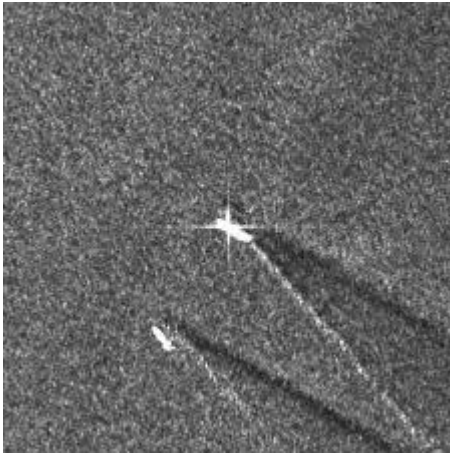
Detection thumbnail size 1000x1000 m

	<p><b>Position</b> 20°08'06"N 094°22'41"W</p> <p><b>Heading(SAR)</b> 093°</p> <p><b>Length(SAR)</b> 100 m</p> <p><b>Width(SAR)</b> 40 m</p>	<p><b>Confidence</b> HIGH</p>		<p><b>Position</b> 19°35'51"N 095°08'04"W</p> <p><b>Heading(SAR)</b> 160°</p> <p><b>Length(SAR)</b> 32 m</p> <p><b>Width(SAR)</b> 28 m</p>	<p><b>Confidence</b> MEDIUM</p>
	<p><b>Position</b> 19°19'07"N 093°36'37"W</p> <p><b>Heading(SAR)</b> 269°</p> <p><b>Length(SAR)</b> 30 m</p> <p><b>Width(SAR)</b> 10 m</p>	<p><b>Confidence</b> MEDIUM</p>		<p><b>Position</b> 18°37'58"N 092°44'35"W</p> <p><b>Heading(SAR)</b> 212°</p> <p><b>Length(SAR)</b> 44 m</p> <p><b>Width(SAR)</b> 28 m</p>	<p><b>Confidence</b> HIGH</p>
	<p><b>Position</b> 18°29'43"N 093°29'59"W</p> <p><b>Heading(SAR)</b> 101°</p> <p><b>Length(SAR)</b> 92 m</p> <p><b>Width(SAR)</b> 55 m</p>	<p><b>Confidence</b> HIGH</p>		<p><b>Position</b> 18°36'43"N 092°47'28"W</p> <p><b>Heading(SAR)</b> 261°</p> <p><b>Length(SAR)</b> 30 m</p> <p><b>Width(SAR)</b> 20 m</p>	<p><b>Confidence</b> MEDIUM</p>
	<p><b>Position</b> 19°03'39"N 093°32'47"W</p> <p><b>Heading(SAR)</b> 270°</p> <p><b>Length(SAR)</b> 50 m</p> <p><b>Width(SAR)</b> 20 m</p>	<p><b>Confidence</b> HIGH</p>		<p><b>Position</b> 19°01'08"N 092°43'44"W</p> <p><b>Heading(SAR)</b> 268°</p> <p><b>Length(SAR)</b> 20 m</p> <p><b>Width(SAR)</b> 10 m</p>	<p><b>Confidence</b> LOW</p>
	<p><b>Position</b> 18°57'41"N 092°36'43"W</p> <p><b>Heading(SAR)</b> 187°</p> <p><b>Length(SAR)</b> 10 m</p> <p><b>Width(SAR)</b> 10 m</p>	<p><b>Confidence</b> LOW</p>		<p><b>Position</b> 18°55'04"N 092°48'56"W</p> <p><b>Heading(SAR)</b> 252°</p> <p><b>Length(SAR)</b> 21 m</p> <p><b>Width(SAR)</b> 19 m</p>	<p><b>Confidence</b> LOW</p>
	<p><b>Position</b> 18°46'27"N 093°18'10"W</p> <p><b>Heading(SAR)</b> 093°</p> <p><b>Length(SAR)</b> 20 m</p> <p><b>Width(SAR)</b> 10 m</p>	<p><b>Confidence</b> LOW</p>		<p><b>Position</b> 18°38'26"N 093°00'12"W</p> <p><b>Heading(SAR)</b> 131°</p> <p><b>Length(SAR)</b> 53 m</p> <p><b>Width(SAR)</b> 30 m</p>	<p><b>Confidence</b> HIGH</p>

# Case Study Offshore: Exclusion Zones & Security

## Practice – KSAT Vessel Detection with RADAR satellites

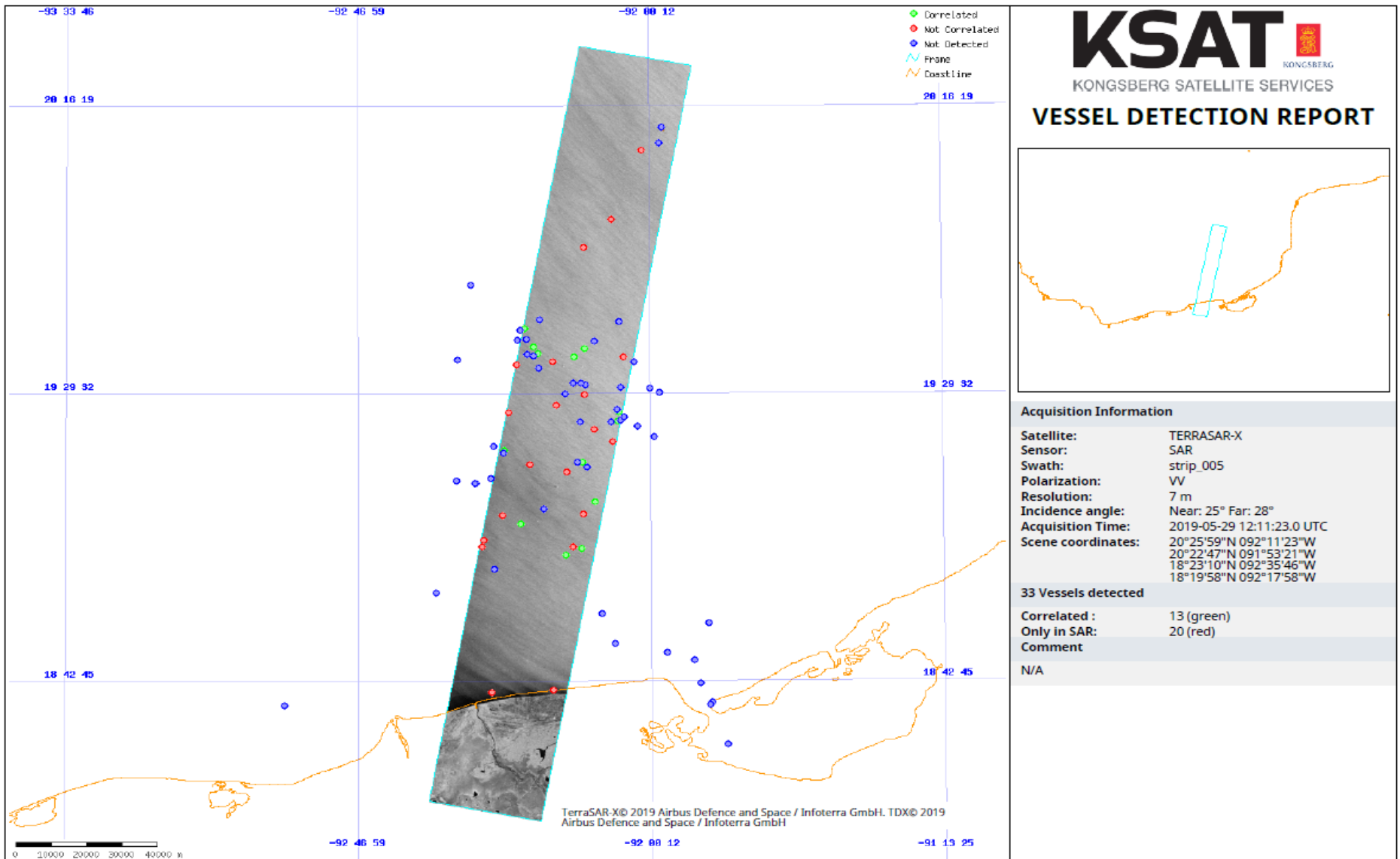
### Pilot studies in the Gulf of Mexico



# Case Study Offshore: Exclusion Zones & Security

## Practice – KSAT Vessel Detection with RADAR satellites

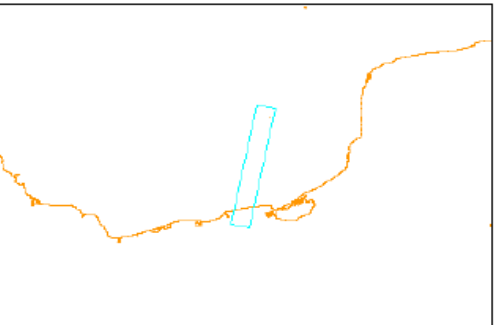
### Pilot studies in the Gulf of Mexico



# KSAT

KONGSBERG SATELLITE SERVICES

## VESSEL DETECTION REPORT



Acquisition Information	
Satellite:	TERRASAR-X
Sensor:	SAR
Swath:	strip_005
Polarization:	VV
Resolution:	7 m
Incidence angle:	Near: 25° Far: 28°
Acquisition Time:	2019-05-29 12:11:23.0 UTC
Scene coordinates:	20°25'59"N 092°11'23"W 20°22'47"N 091°53'21"W 18°23'10"N 092°35'46"W 18°19'58"N 092°17'58"W
33 Vessels detected	
Correlated :	13 (green)
Only in SAR:	20 (red)
Comment	
N/A	

TerraSAR-X © 2019 Airbus Defence and Space / Infoterra GmbH. TDX © 2019 Airbus Defence and Space / Infoterra GmbH


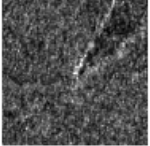

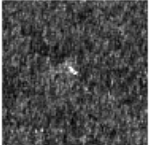
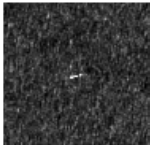
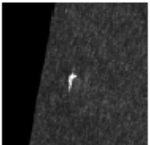
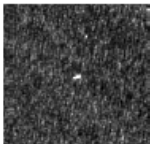


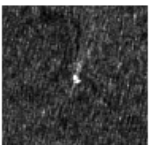
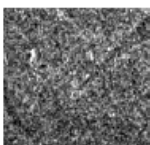

# Case Study Offshore: Exclusion Zones & Security

## Practice – KSAT Vessel Detection with RADAR satellites

### Pilot studies in the Gulf of Mexico

#### Detected vessels - Only in SAR

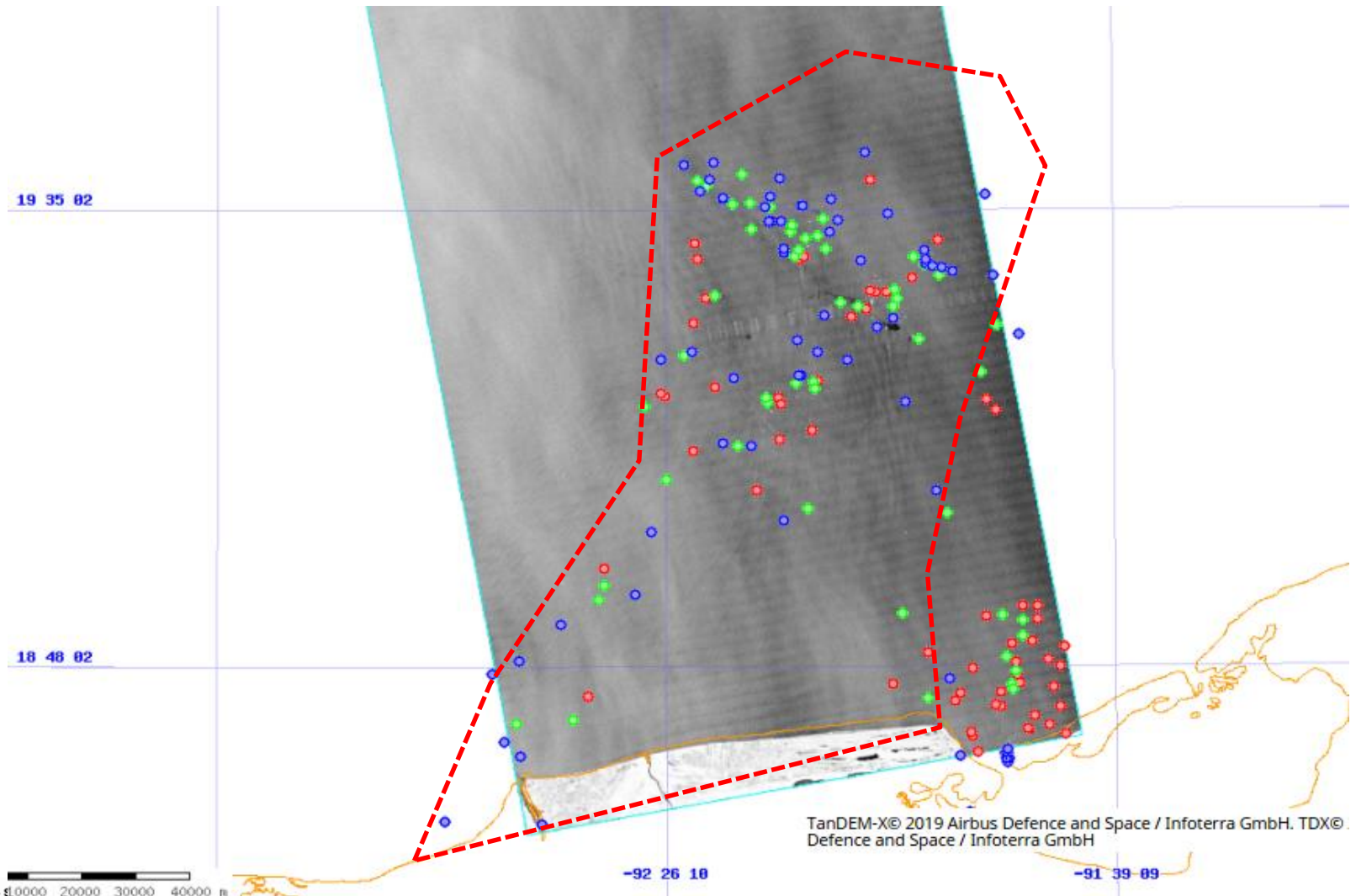
Detection thumbnail size 1000x1000 m

	<p><b>Position</b> 19°04'34"N 092°27'13"W</p> <p><b>Confidence</b> MEDIUM</p> <p><b>Heading(SAR)</b> 099°</p> <p><b>Length(SAR)</b> 9 m</p> <p><b>Width(SAR)</b> 3 m</p>		<p><b>Position</b> 19°05'42"N 092°26'59"W</p> <p><b>Confidence</b> LOW</p> <p><b>Heading(SAR)</b> 288°</p> <p><b>Length(SAR)</b> 6 m</p> <p><b>Width(SAR)</b> 6 m</p>
	<p><b>Position</b> 19°26'23"N 092°22'57"W</p> <p><b>Confidence</b> MEDIUM</p> <p><b>Heading(SAR)</b> 353°</p> <p><b>Length(SAR)</b> 31 m</p> <p><b>Width(SAR)</b> 11 m</p>		<p><b>Position</b> 19°27'33"N 092°15'15"W</p> <p><b>Confidence</b> HIGH</p> <p><b>Heading(SAR)</b> 065°</p> <p><b>Length(SAR)</b> 15 m</p> <p><b>Width(SAR)</b> 10 m</p>
	<p><b>Position</b> 19°29'16"N 092°10'41"W</p> <p><b>Confidence</b> HIGH</p> <p><b>Heading(SAR)</b> 069°</p> <p><b>Length(SAR)</b> 37 m</p> <p><b>Width(SAR)</b> 7 m</p>		<p><b>Position</b> 19°34'08"N 092°21'35"W</p> <p><b>Confidence</b> MEDIUM</p> <p><b>Heading(SAR)</b> 023°</p> <p><b>Length(SAR)</b> 9 m</p> <p><b>Width(SAR)</b> 6 m</p>
	<p><b>Position</b> 19°35'28"N 092°04'28"W</p> <p><b>Confidence</b> HIGH</p> <p><b>Heading(SAR)</b> 060°</p> <p><b>Length(SAR)</b> 16 m</p> <p><b>Width(SAR)</b> 9 m</p>		<p><b>Position</b> 19°53'23"N 092°10'46"W</p> <p><b>Confidence</b> LOW</p> <p><b>Heading(SAR)</b> 282°</p> <p><b>Length(SAR)</b> 9 m</p> <p><b>Width(SAR)</b> 9 m</p>
	<p><b>Position</b> 19°04'30"N 092°12'45"W</p> <p><b>Confidence</b> MEDIUM</p> <p><b>Heading(SAR)</b> 094°</p> <p><b>Length(SAR)</b> 12 m</p> <p><b>Width(SAR)</b> 15 m</p>		<p><b>Position</b> 19°57'51"N 092°06'18"W</p> <p><b>Confidence</b> HIGH</p> <p><b>Heading(SAR)</b> 310°</p> <p><b>Length(SAR)</b> 17 m</p> <p><b>Width(SAR)</b> 5 m</p>
	<p><b>Position</b> 18°40'51"N 092°25'43"W</p> <p><b>Confidence</b> HIGH</p> <p><b>Heading(SAR)</b> 054°</p> <p><b>Length(SAR)</b> 4 m</p> <p><b>Width(SAR)</b> 2 m</p>		<p><b>Position</b> 19°09'37"N 092°23'58"W</p> <p><b>Confidence</b> HIGH</p> <p><b>Heading(SAR)</b> 328°</p> <p><b>Length(SAR)</b> 17 m</p> <p><b>Width(SAR)</b> 13 m</p>

# Case Study Offshore: Exclusion Zones & Security

Practice – KSAT Vessel Detection with RADAR satellites

Pilot studies in the Gulf of Mexico – ideal technology to enforce exclusion zones



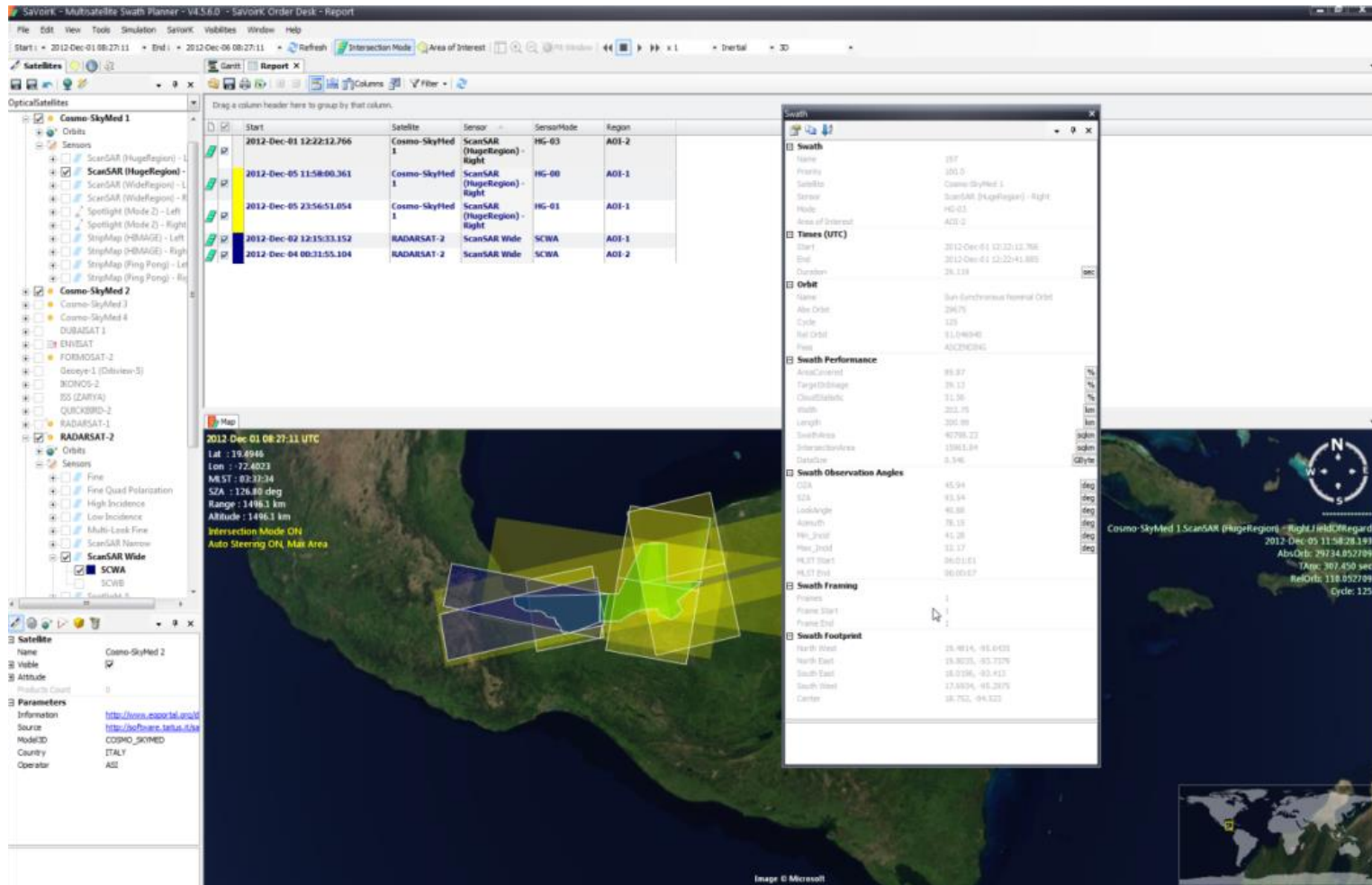


**Case studies for the Energy Sector in Mexico :  
Onshore & Offshore**

**Image ordering in emergency mode**

# Case Study Offshore and Onshore Image ordering in emergency mode

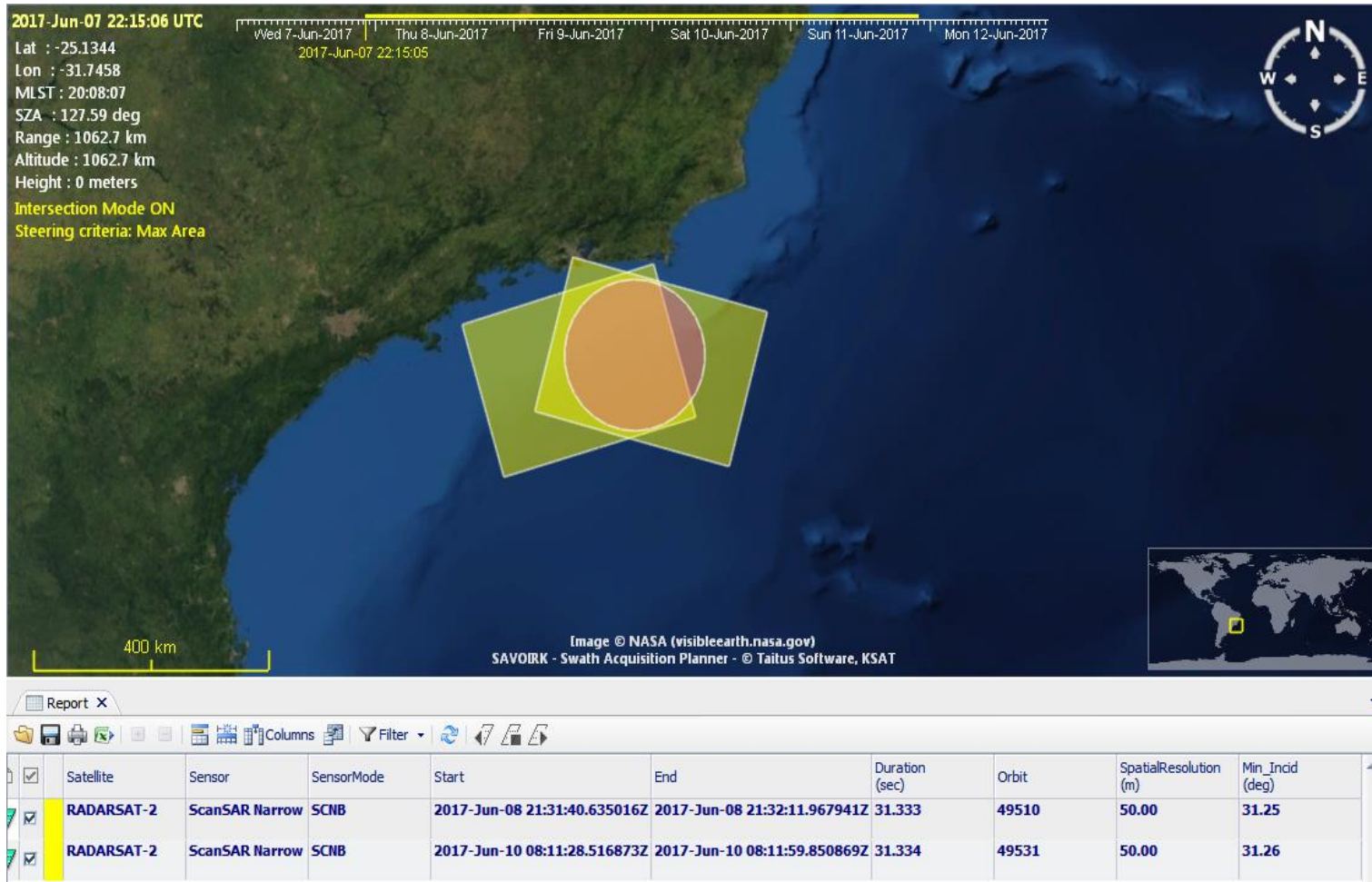
- Core KSAT capabilities
  - ORDERDESK personnel 24/7/365
  - Proprietary planning software tool



# Case Study Offshore and Onshore

## Image ordering in emergency mode

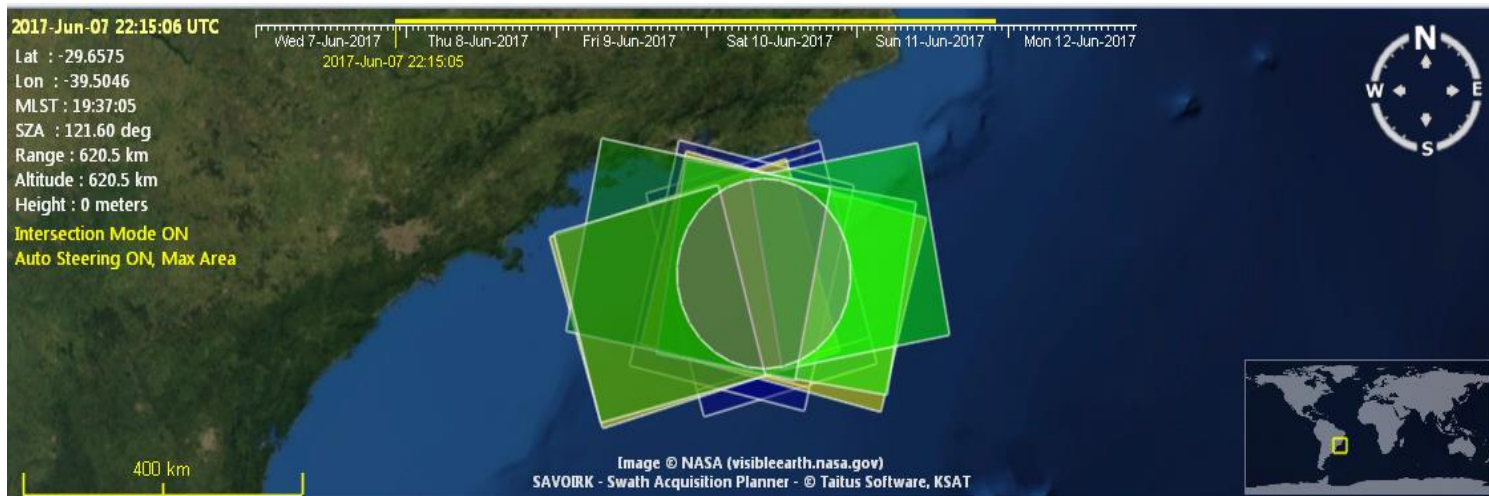
- Imaging opportunities with 1 SAR satellite next 3 days



# Case Study Offshore and Onshore

## Image ordering in emergency mode

- Imaging opportunities with 1 SAR satellite next 3 days



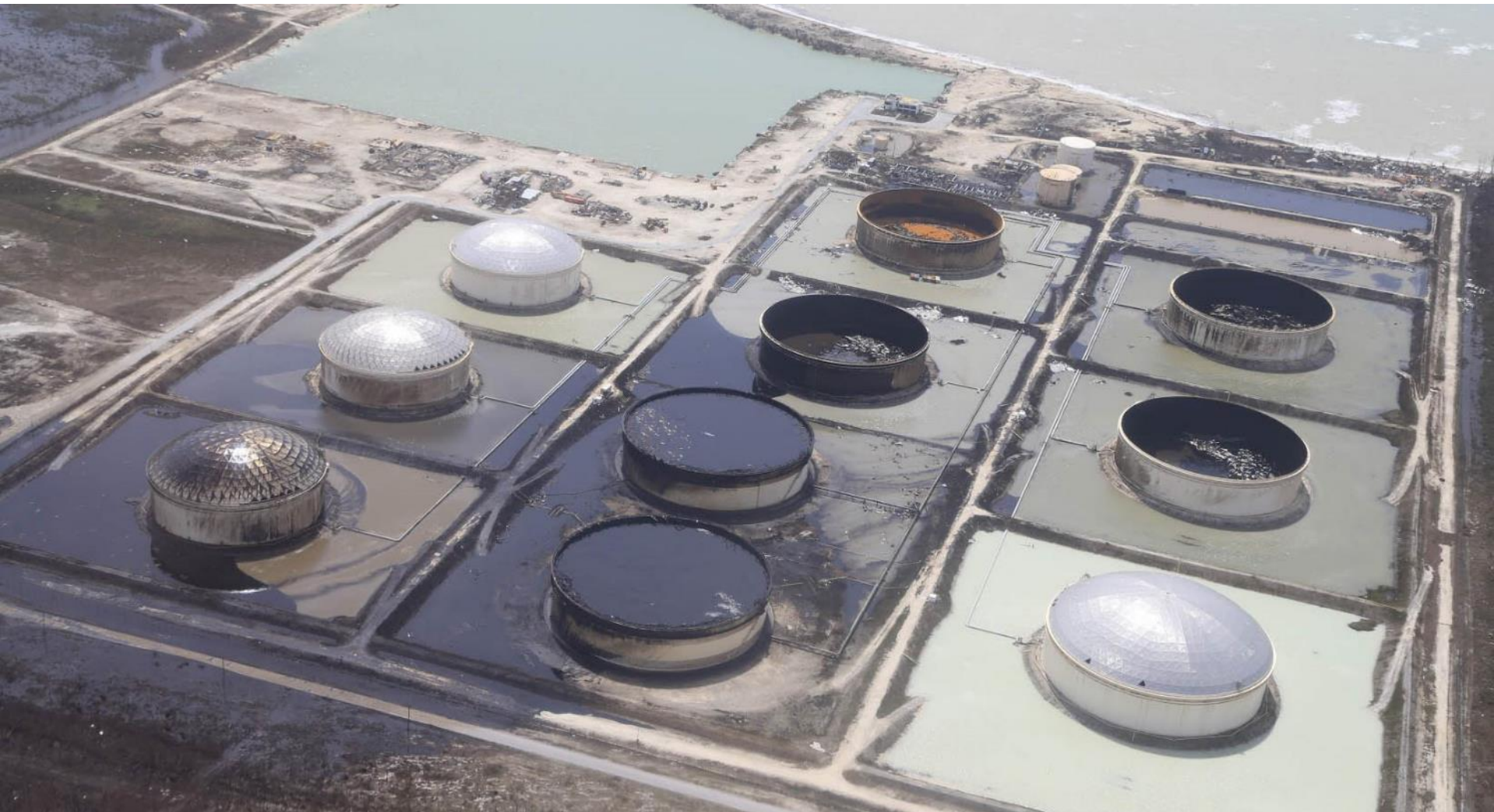
Report X

	Satellite	Sensor	SensorMode	Start	End	Duration (sec)	Orbit	SpatialResolution (m)	Min_Incid (deg)
	TerraSAR-X	WS Full Performance Left	wideBeam_005	2017-Jun-08 20:43:10.551365Z	2017-Jun-08 20:43:39.551366Z	29.000	55364	40.00	34.74
	RADARSAT-2	ScanSAR Narrow	SCNB	2017-Jun-08 21:31:40.635016Z	2017-Jun-08 21:32:11.967941Z	31.333	49510	50.00	31.25
	TerraSAR-X	WS Full Performance Left	wideBeam_001	2017-Jun-09 08:46:51.523703Z	2017-Jun-09 08:47:20.523703Z	29.000	55372	40.00	15.53
	RADARSAT-2	ScanSAR Narrow	SCNB	2017-Jun-10 08:11:28.516873Z	2017-Jun-10 08:11:59.850869Z	31.334	49531	50.00	31.26
	TerraSAR-X	WS Full Performance Right	wideBeam_001	2017-Jun-10 08:29:49.027341Z	2017-Jun-10 08:30:18.027341Z	29.000	55387	40.00	15.52
	Cosmo-SkyMed 2	ScanSAR (HugeRegion) - Right	HR-03	2017-Jun-10 09:12:35.057533Z	2017-Jun-10 09:13:10.057533Z	35.000	51417	100.00	41.21
	Cosmo-SkyMed 2	ScanSAR (HugeRegion) - Right	HR-03	2017-Jun-10 19:58:09.161650Z	2017-Jun-10 19:58:44.161650Z	35.000	51424	100.00	41.22
	TerraSAR-X	WS Full Performance Right	wideBeam_005	2017-Jun-11 21:25:46.328677Z	2017-Jun-11 21:26:15.328677Z	29.000	55410	40.00	34.73

# Case Study Offshore and Onshore

## Image ordering in emergency mode

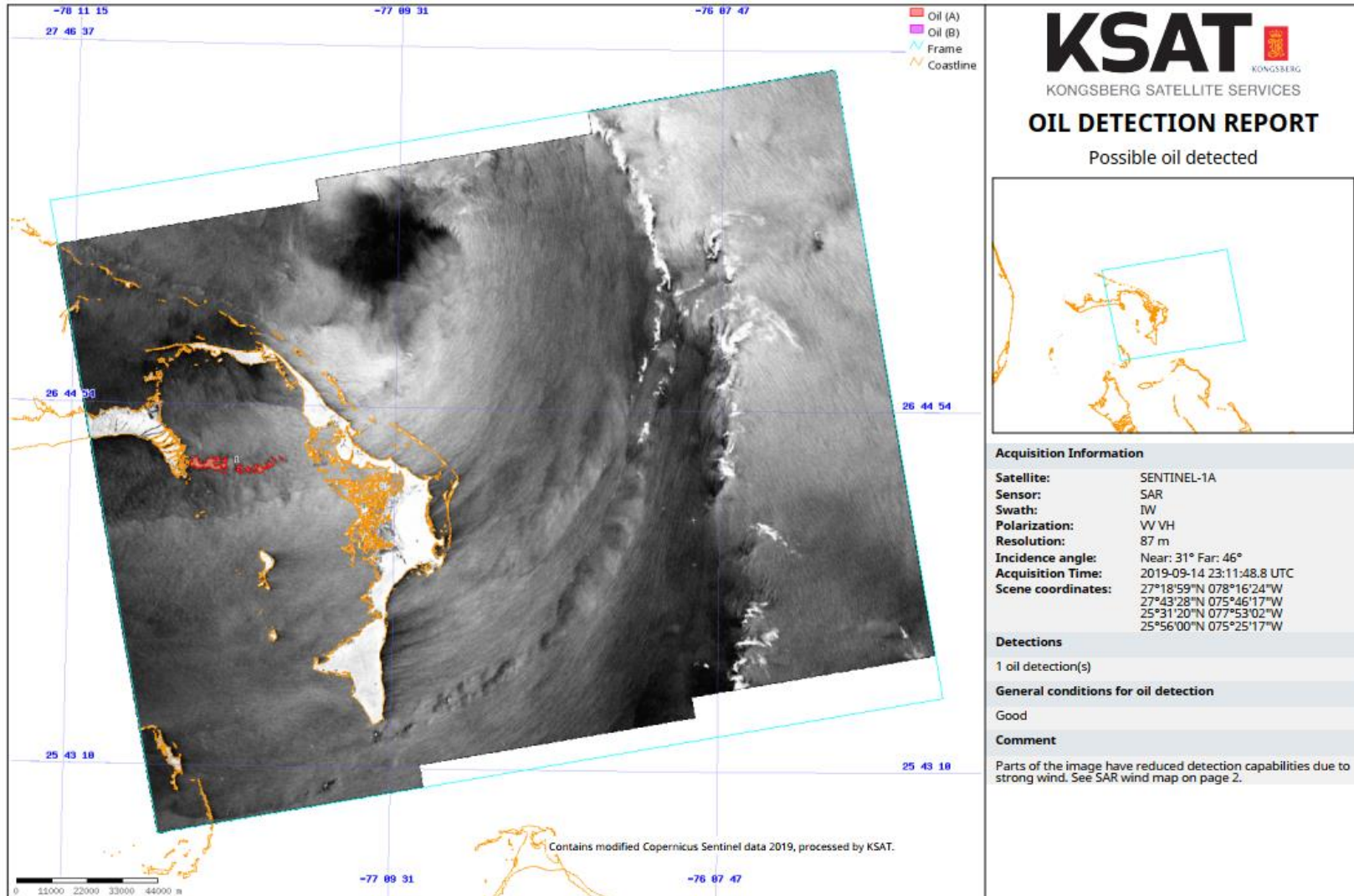
- Hurricane Dorian damage to EQUINOR storage facility in BAHAMAS
- No Environmental Law in BAHAMAS



# Case Study Offshore and Onshore

## Image ordering in emergency mode

- Hurricane Dorian damage to EQUINOR storage facility in BAHAMAS





**Case studies for the Energy Sector  
in Mexico : Onshore**

**Pipeline vandalism**

# Case Study Onshore - Pipeline vandalism

## Explosion pipeline Tuxpan-Tula / 17th January 2019



- **Illegal tapping of oil in a pipeline**
- **Steal of hydrocarbons**
- **Major environmental and social risk**

Demonstration capabilities persistent monitoring optical imagery (non-NRT) followed by NRT high optical resolution ordering.

Data from Planet Labs – 3m resolution



Time lapse and future possibilities

# Case Study Onshore - Pipeline vandalism

## Evolution of the area – could it had been detected?



# Explosion ducto Tuxpan-Tula

## Evolution / 25th September 2018



# Explosion ducto Tuxpan-Tula

## Evolution / 30th September 2018



# Explosion ducto Tuxpan-Tula Evolution / 5th October 2018



# Explosion ducto Tuxpan-Tula Evolution / 23th October 2018



# Explosion ducto Tuxpan-Tula Evolution / 5th November 2018



# Explosion ducto Tuxpan-Tula

## Evolution / 11th November 2018



# Explosion ducto Tuxpan-Tula

## Evolution / 16th November 2018



# Explosion ducto Tuxpan-Tula

## Evolution / 23th November 2018



# Explosion ducto Tuxpan-Tula Evolution / 1st December 2018



# Explosion ducto Tuxpan-Tula Evolution / 2nd December 2018



# Explosion ducto Tuxpan-Tula

## Evolution / 16th December 2018



# Explosion ducto Tuxpan-Tula

## Evolution / 18th December 2018



# Explosion ducto Tuxpan-Tula

## Evolution / 19th December 2018



# Explosion ducto Tuxpan-Tula Evolution / 15th January 2019



# Explosion ducto Tuxpan-Tula / 17<sup>th</sup> January 2019

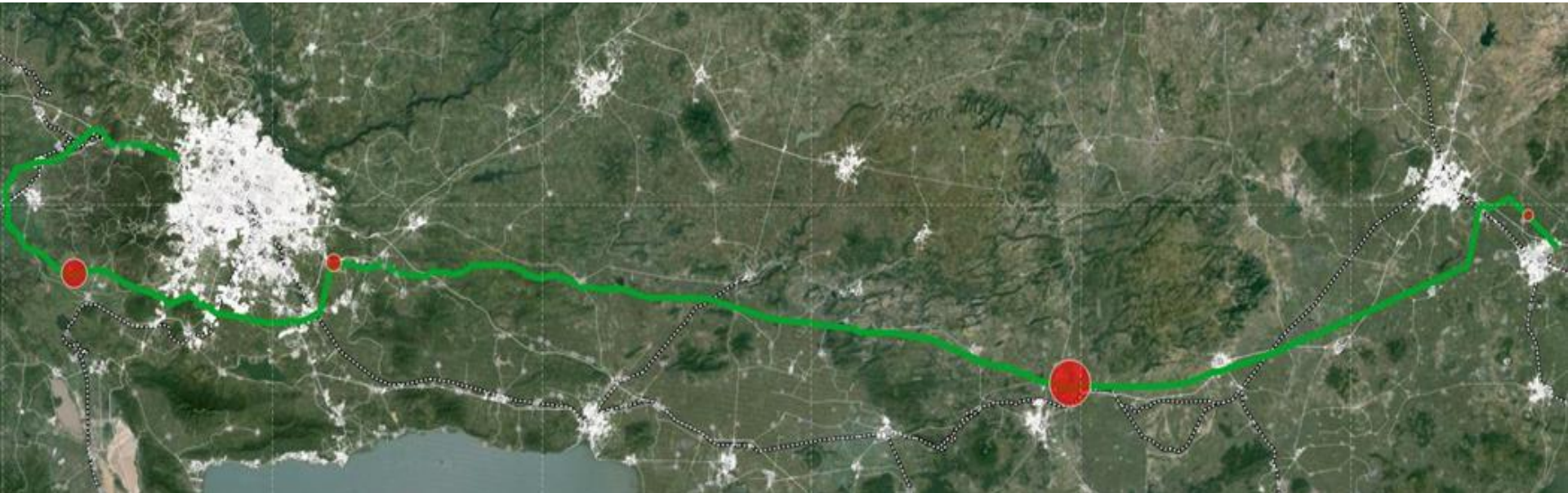
## Evolution / 21st January



# Potential Methodology

## Pipeline monitoring

- Baseline persistent monitoring with **mid-resolution** optical satellites
- Detection of suspicious events
- Pipeline operator can check, validate (or discard) the changes as potential risks.
- High risk threads can trigger **high-resolution Near Real Time** imagery from 4 satellites (Superview 1/2/3/4)



# Potential Methodology

Challenge – what to consider a high risk event?



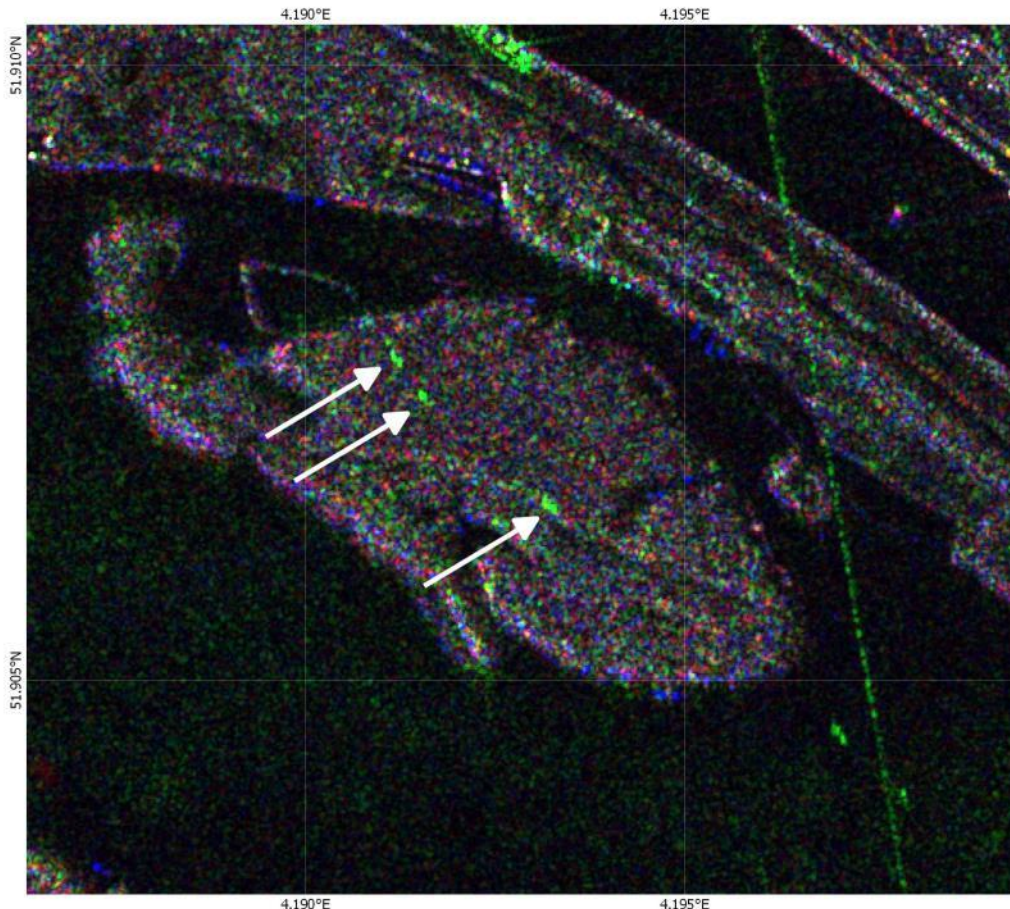
# Potential Methodology

## Challenge – how to deal with cloudy images?

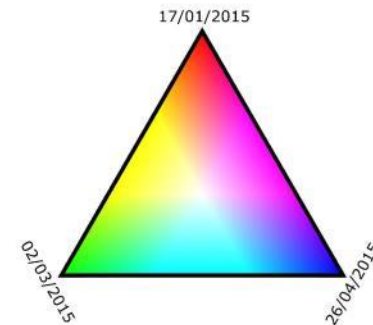
Also possible to detect changes with SAR imagery

### Visual analytics product

Change features over 17/01/2015, 02/03/2015 and 26/04/2015



### Legend



Color = feature present at corresponding date, eg.:

red = feature present only at 17/01,  
 yellow = feature present at 17/01 and 02/03,  
 magenta = feature present at 17/01, not present at 02/03 and present again at 26/04  
 white = stable feature over 3 dates

### Scenes

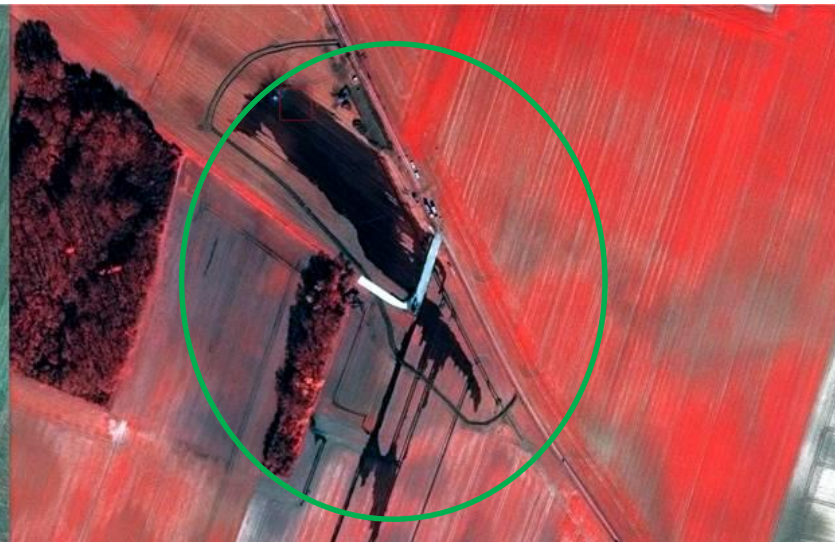
Mission	Mode	Date
TerraSAR-X	SM	17/01/2015
TerraSAR-X	SM	02/03/2015
TerraSAR-X	SM	26/04/2015

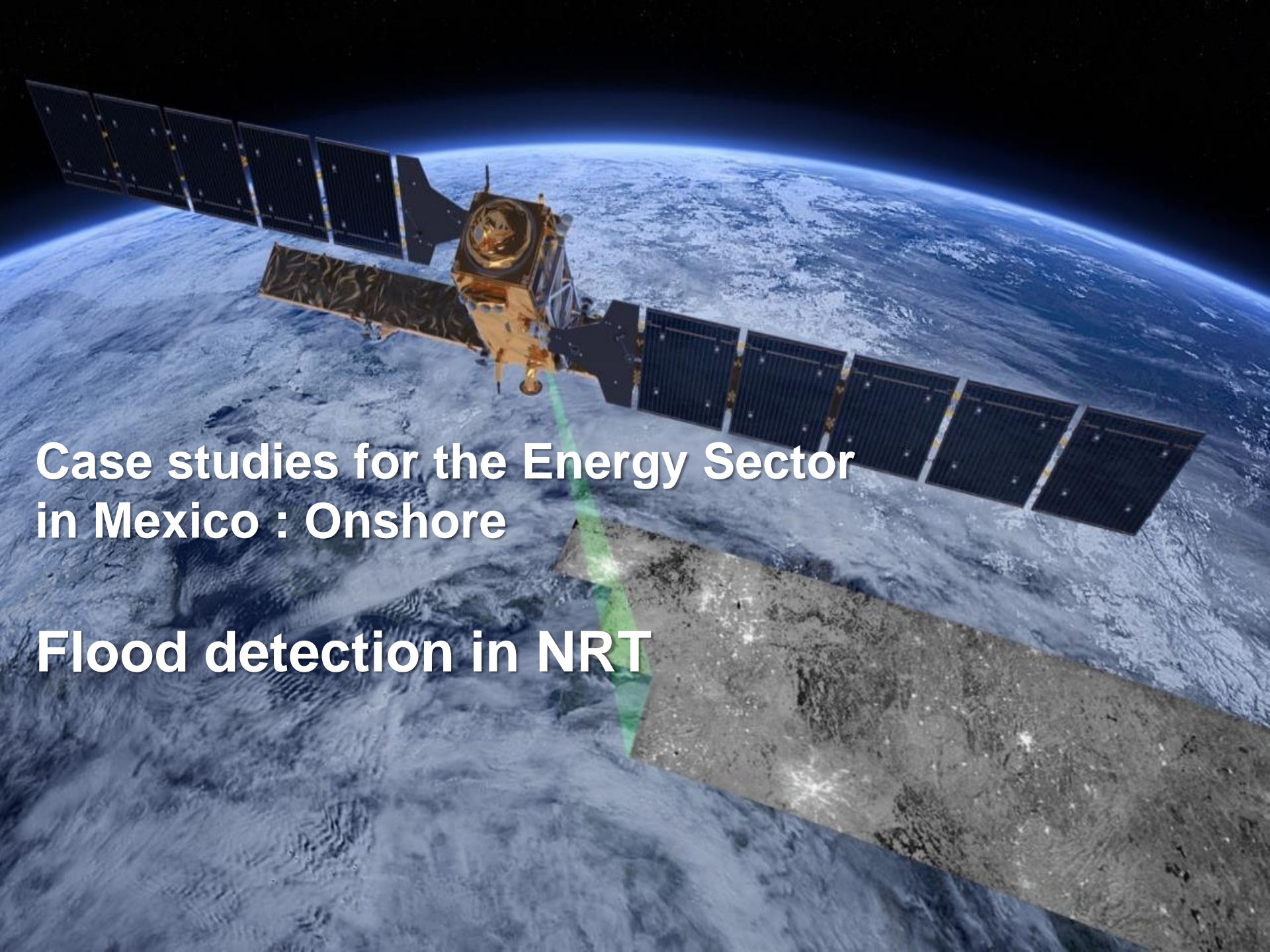
Coordinate system is EPSG:4626

# Case Study Onshore - Pipeline break

## Delivery of High Resolution image in emergency mode

- Operative oil spill from pipeline / International Oil&Gas operator / Europe
- Ordered using 24/7, objective: oil recovery, damage assessment





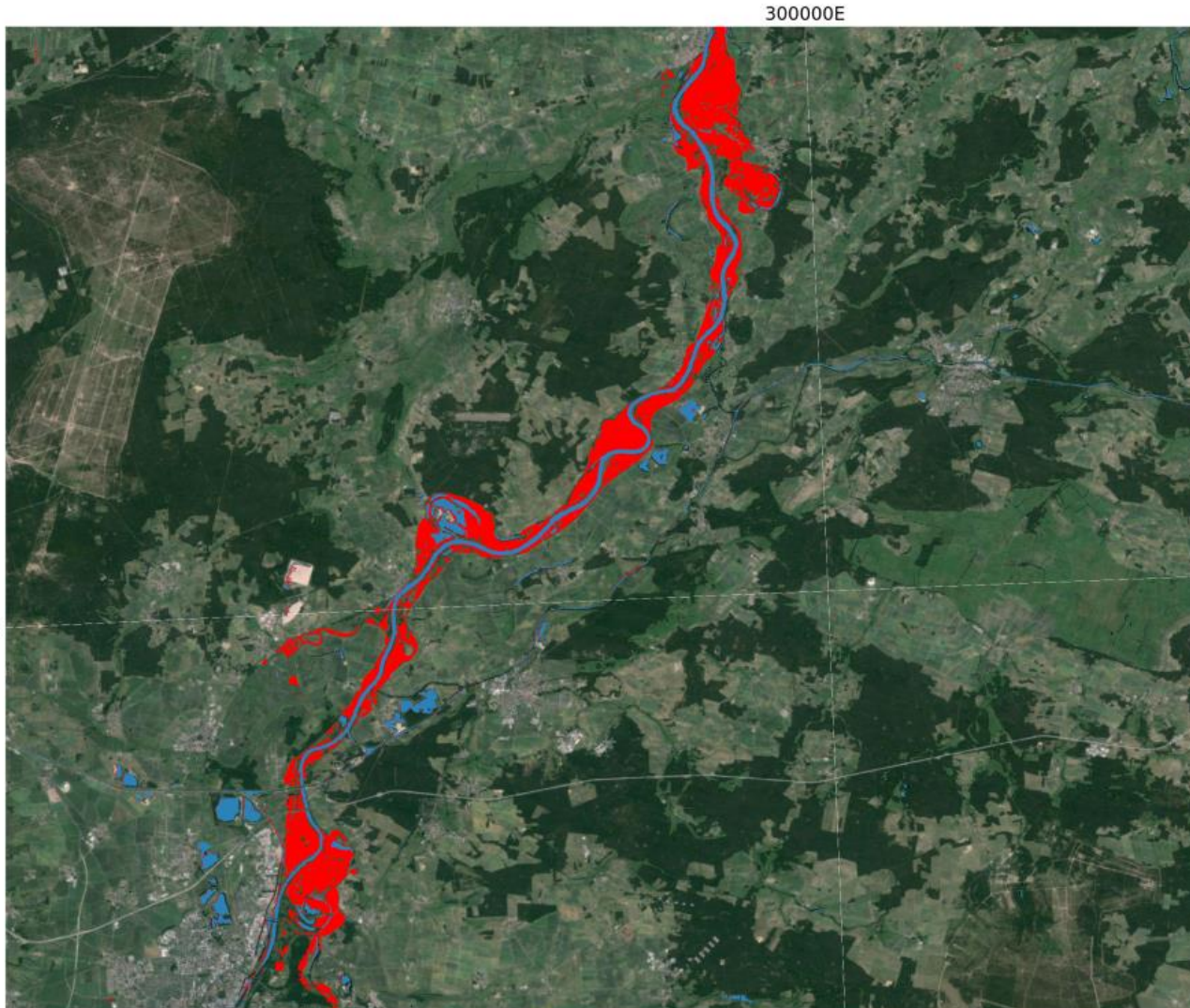
**Case studies for the Energy Sector  
in Mexico : Onshore**

**Flood detection in NRT**



# Case Study Onshore - Flood Monitoring

## Automatic detection of Flood in NRT

- Based on change detection between 2 images



### Legend

-  Water feature
-  Flood
- Backdrop = Google

### Scenes

Mission	Mode	Date
TerraSAR-X	SC HH	2016/03/25
TerraSAR-X	SC HH	2013/06/06

UTM Zone 33N Coordinates shown  
Projection system is Web Mercator



**End of the workshop, thanks for  
your attention!**

**carlesd@ksat.no**