

Use of an Unmanned Surface Vehicle (Saildrone) to Study Natural Oil Seeps in the Gulf of Mexico

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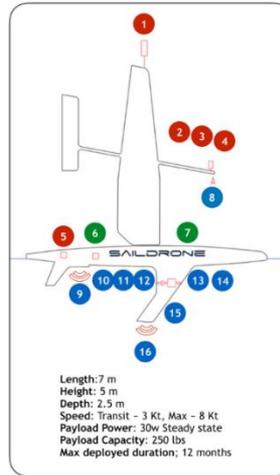
DATA CAPABILITIES

Atmospheric Measurements

- Wind Speed: 1 Anemometer @ +5 m
Gill Windmaster 3D ultrasonic 20Hz
- Wind Direction: 1 Anemometer @ +5 m
Gill Windmaster 3D ultrasonic 20Hz
- Radiation: 2 Sunshine Pyranometer @ +2.2 m
Delta-T Devices SPN1
- Air Temperature: 3 Pyranometer @ +2.2 m
Eppley PSP & PIR
- Relative Humidity: 4 Meteorological Probe @ +2.2 m
Rotronic HC2 - S3 with rad shield
- Pressure: 5 Digital Barometer @ +0.2 m
Vaisala BAROCAP PT8210

Physical Measurements

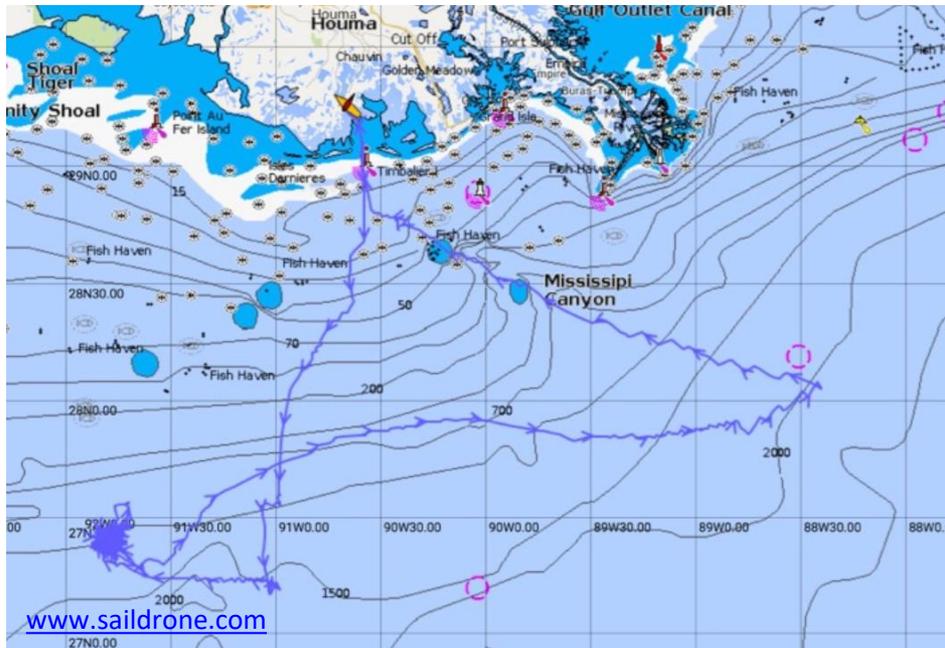
- Wave Height & Period: 6 Dual GPS aided IMU
- Magnetic Field: 7 Magnetometer @ 0 m
Barrington MAG 548
- Depth: 16 SIMRAD Echo Sounder @ -2.5 m
SIMRAD WST Mini (EK80)



Ocean Measurements

- Skin Temperature: 8 SST IR Pyrometer @ +2.2 m
Hetronics CT15.2
- Ocean Currents: 9 ADCP @ -0.2 m
Teledyne RDI Workhorse 300 kHz
- pH: 10 Honeywell Durafet @ -0.5 m
- Chl - a: 11 Fluorometer @ -0.2 m
Sea-bird Scientific WET labs Eco-Tripet
- Red Backscatter: 11 Fluorometer @ -0.2 m
Sea-bird Scientific WET labs Eco-Tripet
- Dissolved Oxygen: 12 Oxygen Optode @ -0.5 m
Aanderaa 4831
- pCO₂: 13 CO₂ System @ -0.5 m
PMEL mapCO₂
- Water Temperature: 14 Thermosalinograph @ -0.5 m
Teledyne RDI Citadel TS-NH / Sea-Bird Scientific Prawler / RBR CTD / FL / DO
- Salinity: 14 Thermosalinograph @ -0.5 m
Teledyne RDI Citadel TS-NH / Sea-Bird Scientific Prawler / RBR CTD / FL / DO
- Marine Mammal Acoustics: 15 Passive Acoustic Recorder
Acousonde
- Fish Biomass: 16 SIMRAD Echo Sounder @ -2.5 m
SIMRAD WST Mini (EK80)

www.saildrone.com



Track of SAILDRONE 125 during the 2015 Gulf of Mexico mission with ECOGIG.

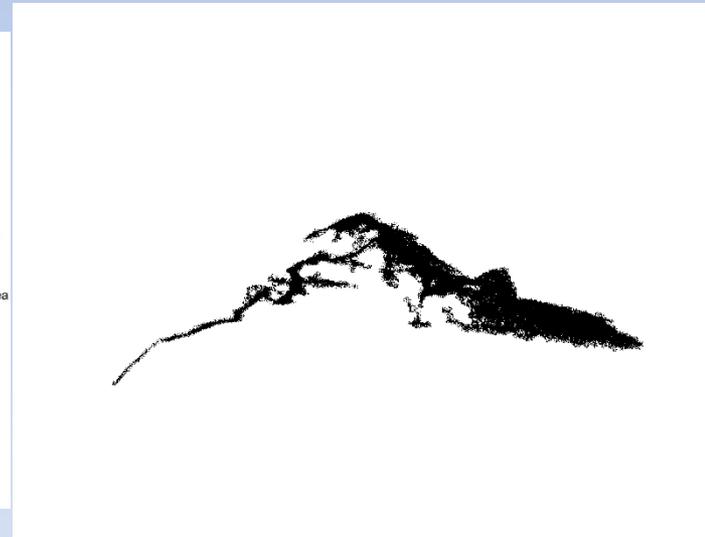
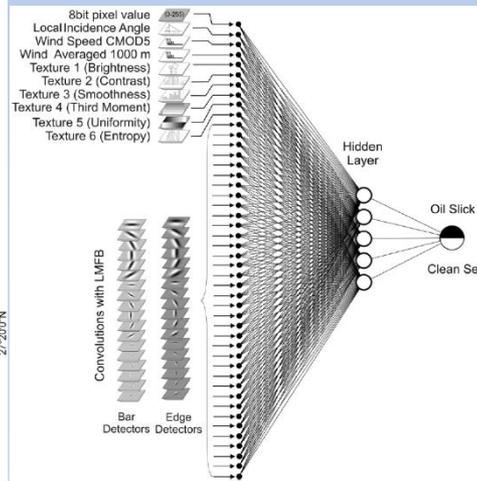
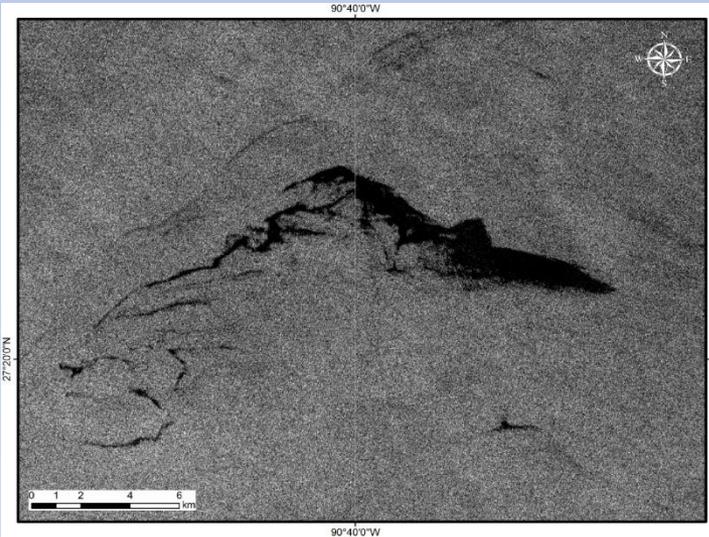
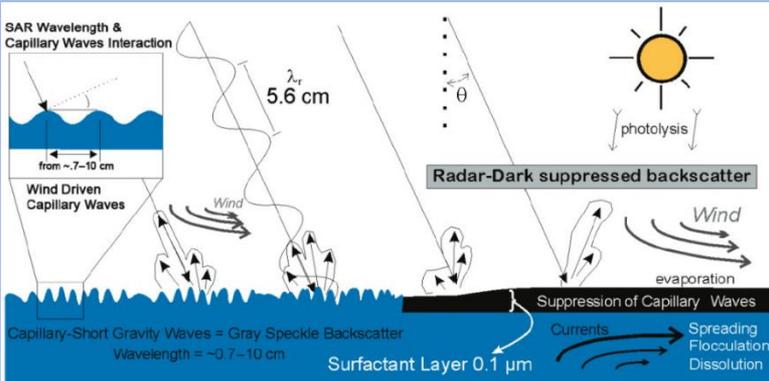
Saildrone 125 being deployed from Cocodrie LA, carrying the Remote Optical Watcher (ROW) device from Laser Diagnostic Instruments (LDI), that detects oil by using its natural fluorescence.



Credit: Caroline Johansen

Synthetic Aperture Radar (SAR)

SAR images are particularly useful in oil slick detection and monitoring because of their large coverage, cloud-penetrating, and 24-h per day capabilities.



Texture Classifying Neural Network Algorithm (TCNNA) is an FSU-developed algorithm which was used to delineate oil slicks in SAR images (Reference: [Garcia-Pineda, O., Zimmer, B., Howard, M., Pichel, W., Li, X., & MacDonald, I.R. \(2009\). Using SAR images to delineate ocean oil slicks with a texture-classifying neural network algorithm \(TCNNA\). *Canadian Journal of Remote Sensing*, 35, 411-421](#)).

90°40'0"W



- Oil drops rise from a fixed point on the seafloor to the ocean surface.
- The oil spreads out in a thin layer from the *oil slick origin* (OSO) and moves downstream with wind and current.
- The oil remains visible on the surface until it weathers and disperses—**Residence time**.



27°20'0"N

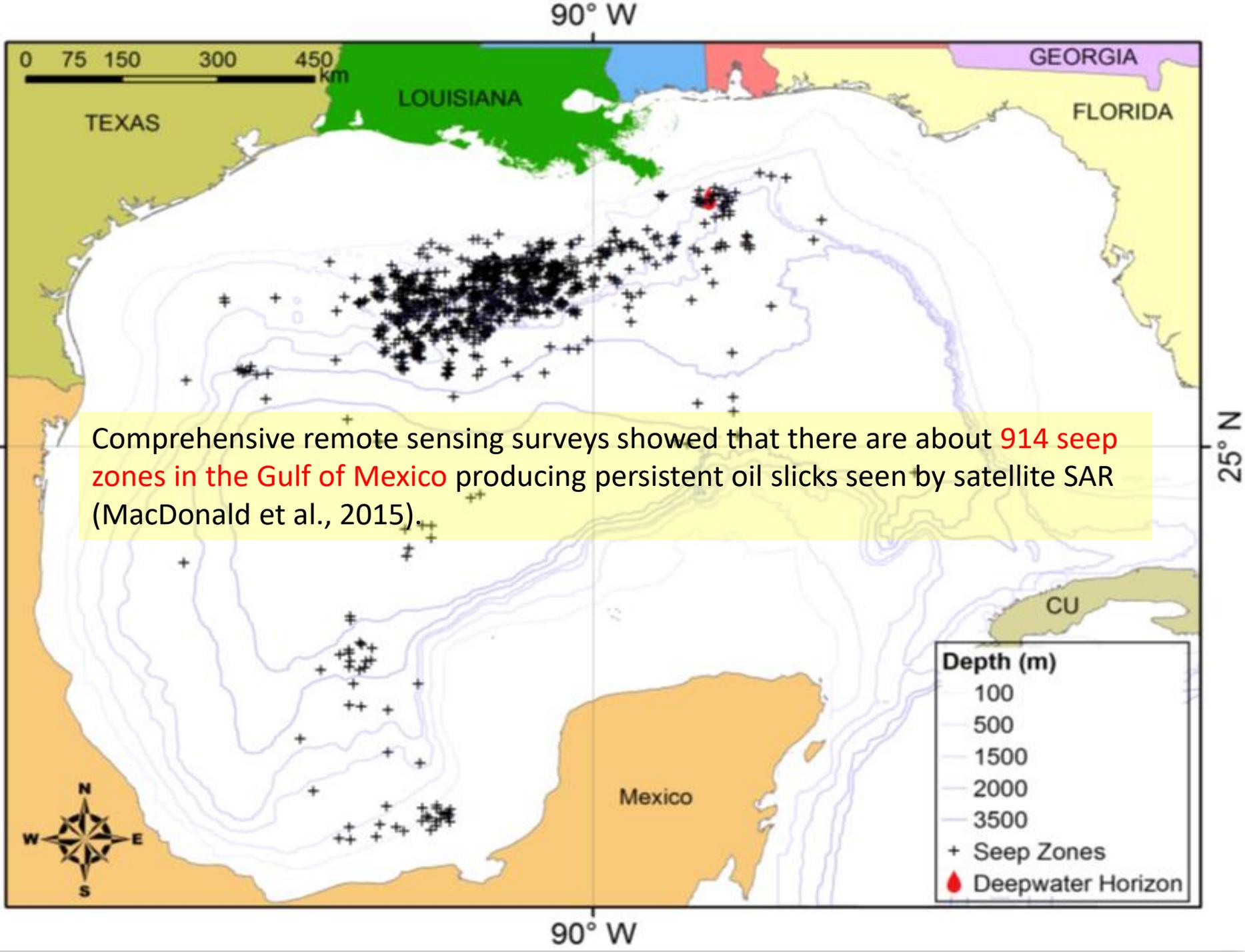
27°20'0"N



90°40'0"W



Credit: Caroline Johansen



Comprehensive remote sensing surveys showed that there are about **914 seep zones in the Gulf of Mexico** producing persistent oil slicks seen by satellite SAR (MacDonald et al., 2015).

90°40'0"W

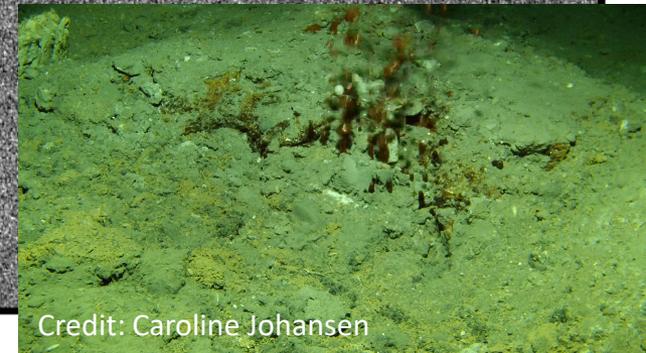


What can we learn from natural oil slicks?

- Analyzing natural oil slicks can show how oil moves with wind and currents.
- Better understanding of oil slicks movement and residence time can improve use of remote sensing during oil spills.
- The size and persistence of oil slicks is an indication of the flux of oil into the environment.

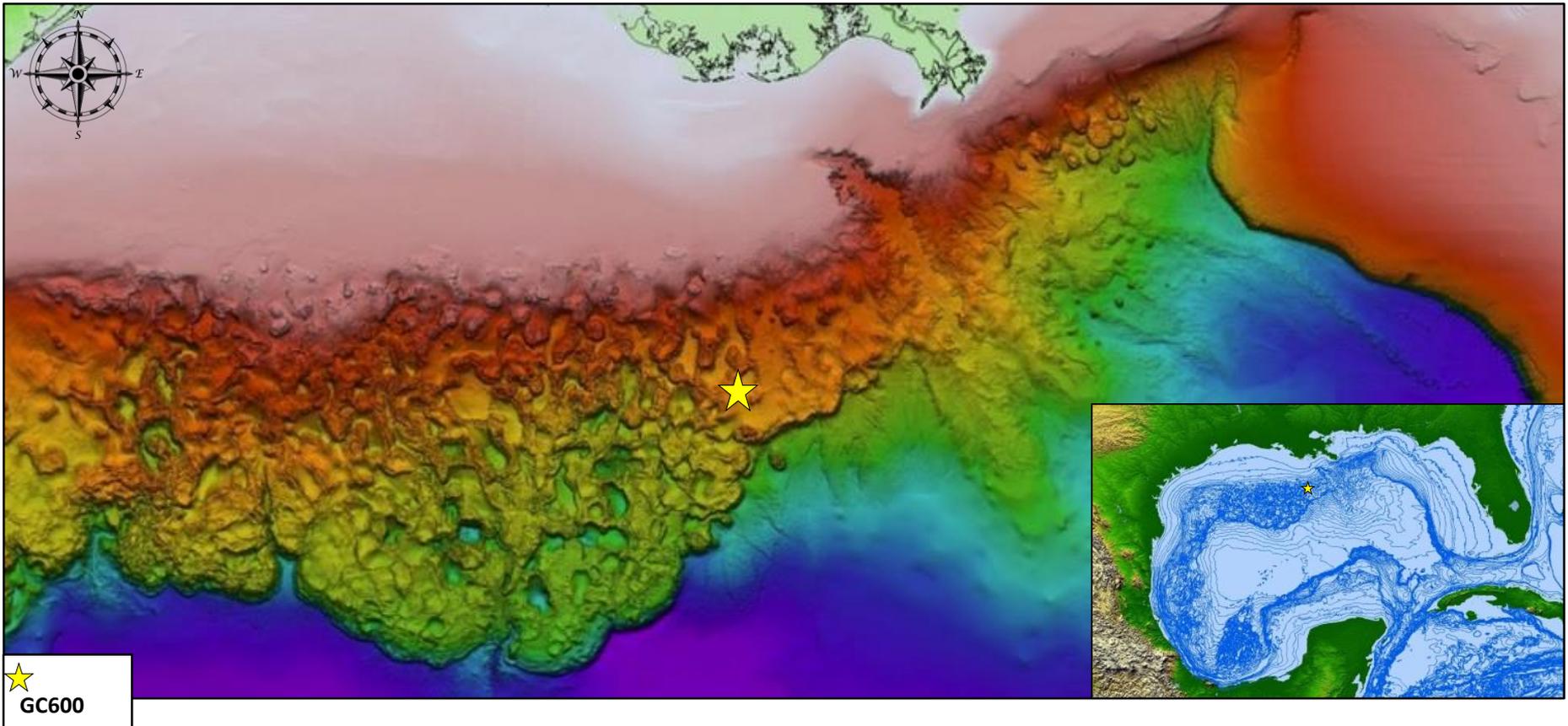
0 1 2 4 6 km

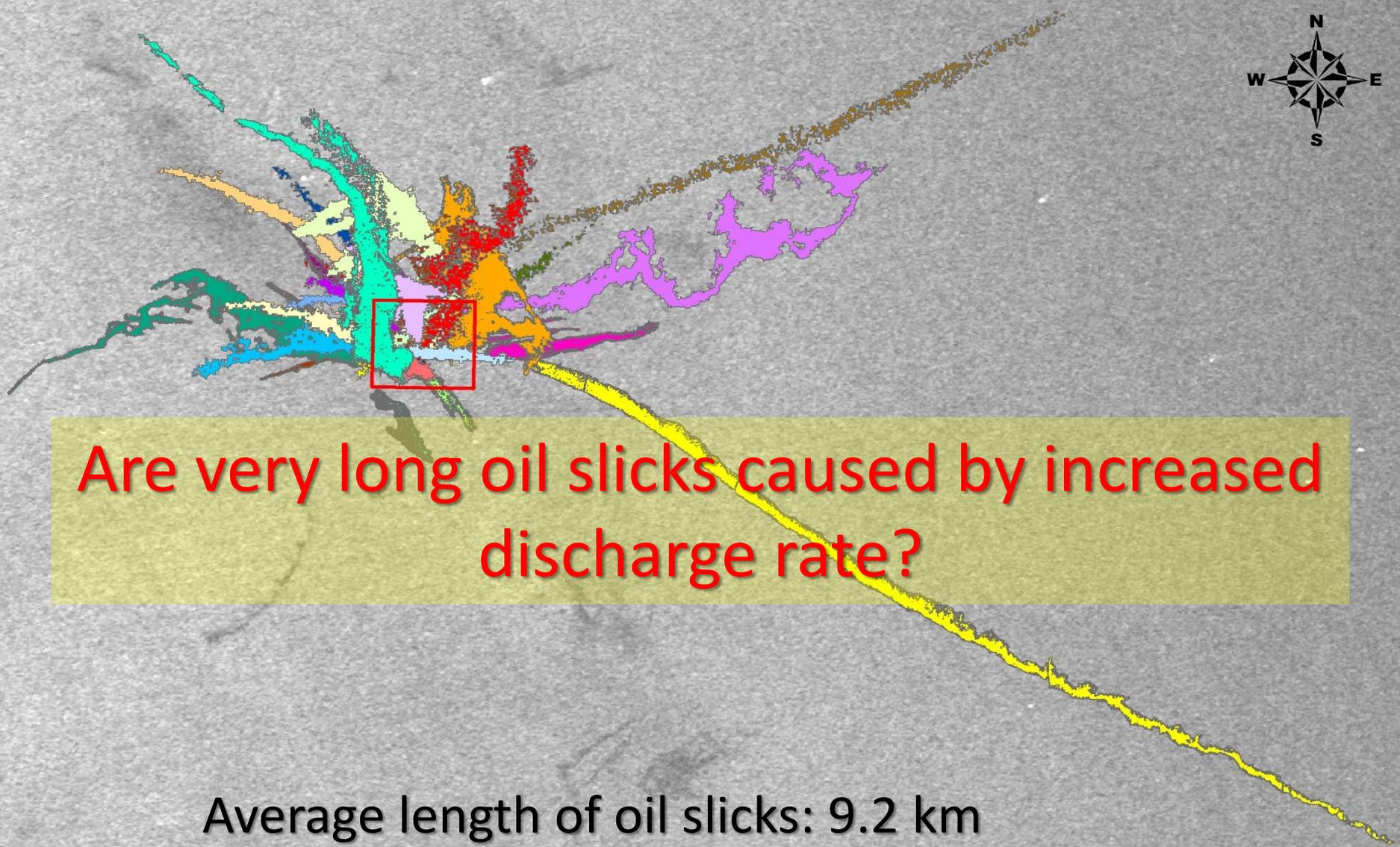
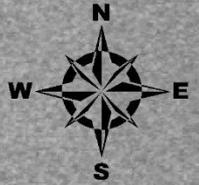
90°40'0"W



Credit: Caroline Johansen

Study Location: Northern Gulf of Mexico (GC600)

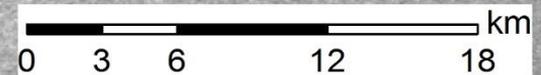




Are very long oil slicks caused by increased discharge rate?

Average length of oil slicks: 9.2 km

Symbology
[Red Box] GC600 Lease Block



90°40'0"W



Method

- We used a Lagrangian particle-tracking surface oil drift model which accounts for the advection by wind and surface currents.
- The wind scaling coefficient = 0.035
- The wind deflection angle = 20° to the right

27°20'0"N

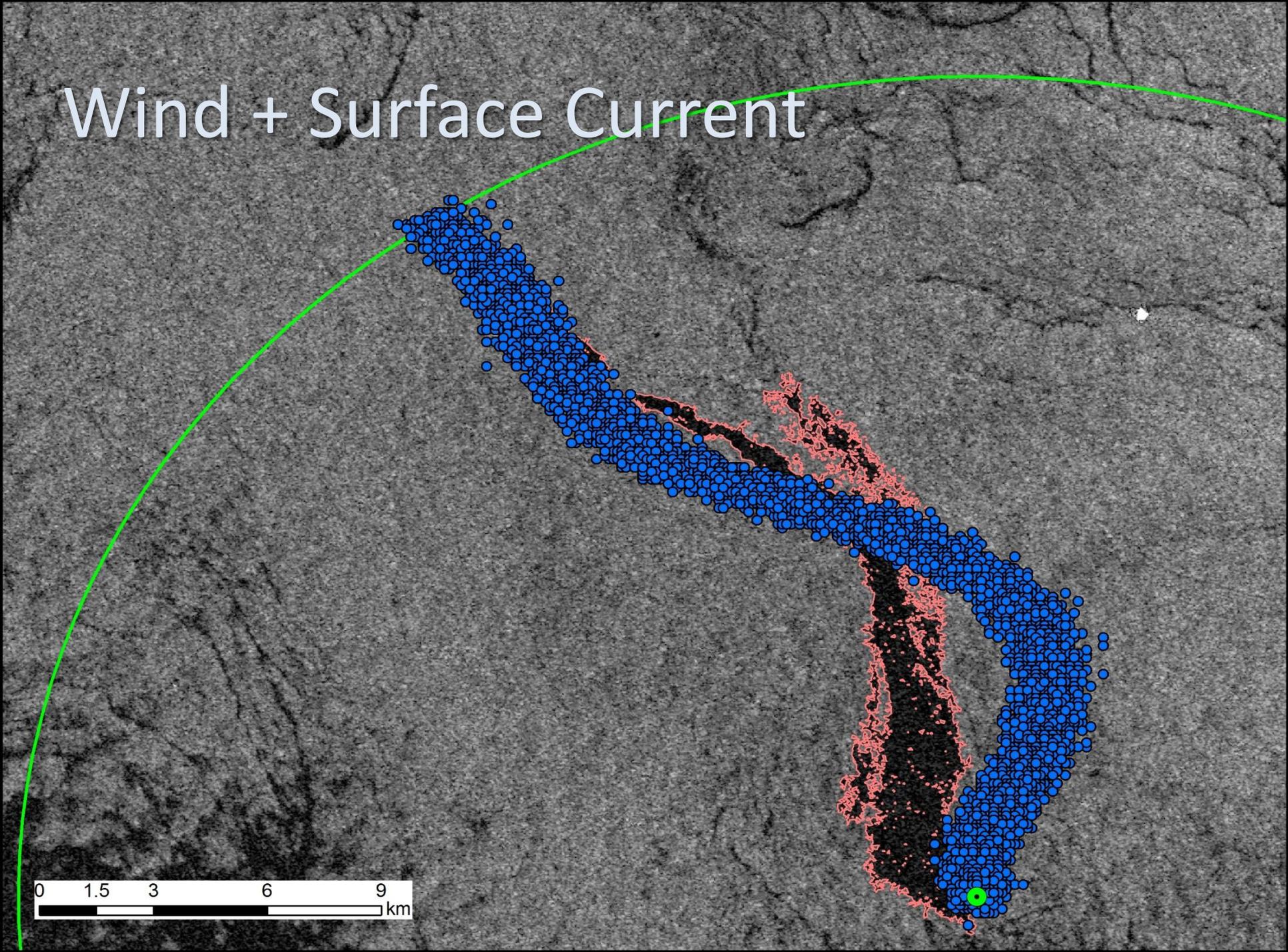
27°20'0"N



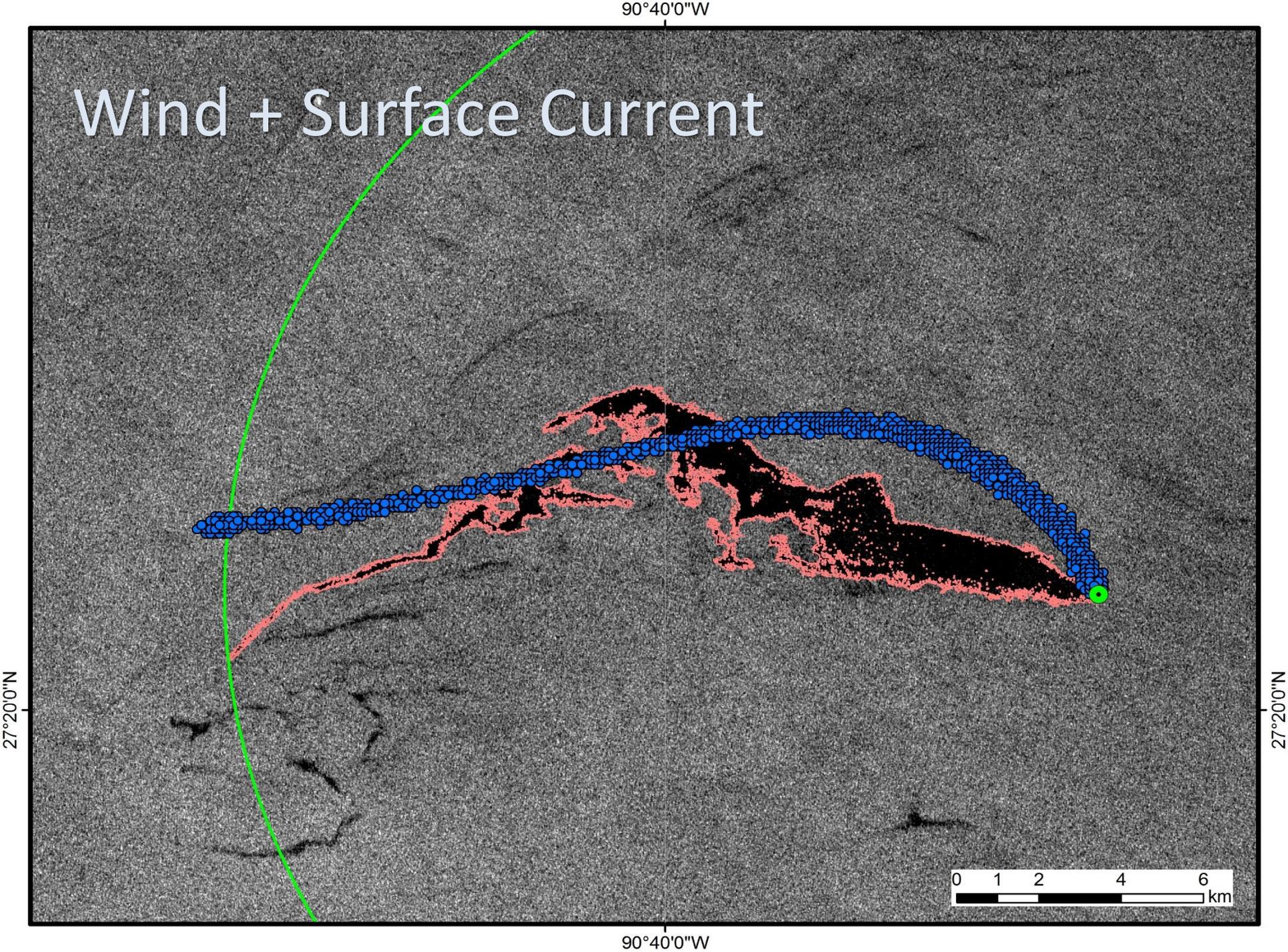
90°40'0"W

Wind + Surface Current

0 1.5 3 6 9 km



Wind + Surface Current



Average Length (km)	9.2	Average Wind Velocity (m s ⁻¹)	5.9
Average Surface Residence-Time (h)	6.4	Average Current Velocity (m s ⁻¹)	0.4

$$L = \alpha + \beta \times V_w + \gamma \times V_o + u \times V_w \times V_o \times \cos\theta + \varepsilon$$

The F-test demonstrates that the linear regression model fits the data set (the p -value 0.0006).

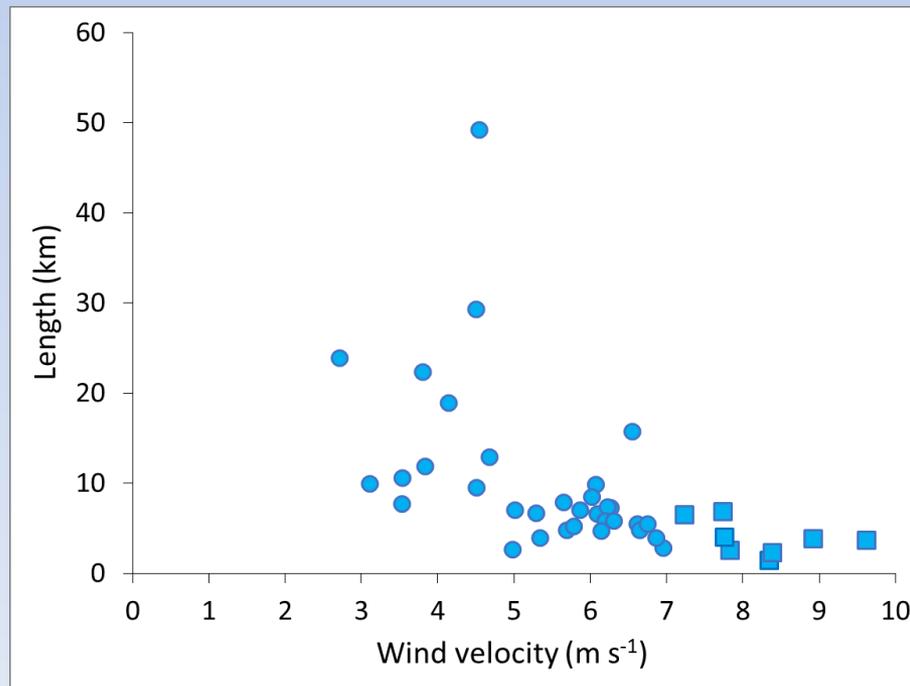
	Coefficients	Standard Error	<i>t</i>	<i>p</i>-value
α	21.21	5.1	4.17	0.0002
β	-2.93	0.7	-4.01	0.0003
γ	16.14	7.3	2.22	0.0329
u	-0.01	0.7	-0.01	0.9887

α : intercept

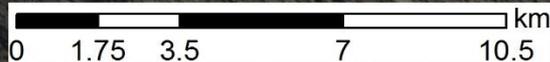
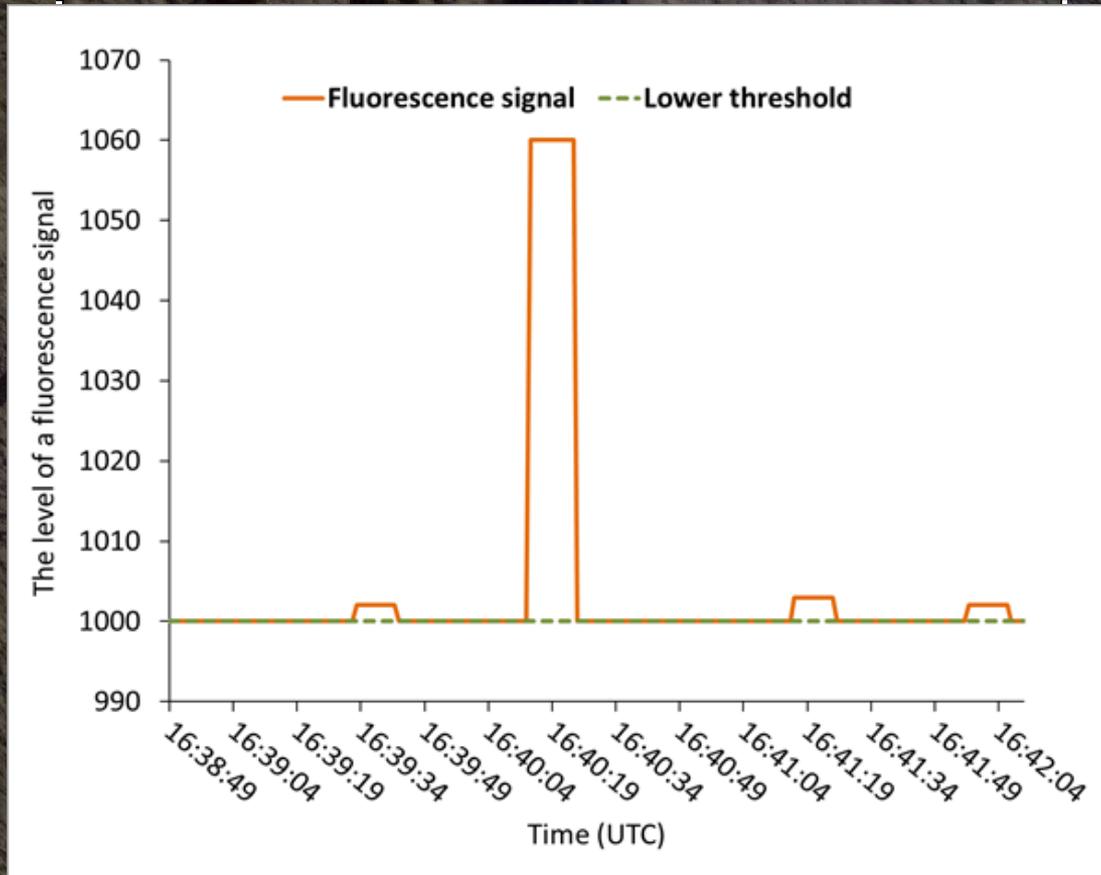
B : wind speeds coefficient

γ : surface current speeds coefficient

u : coefficient of the relative angles between the surface current and rotated wind vectors



Saildrone path (October 12, 2015)

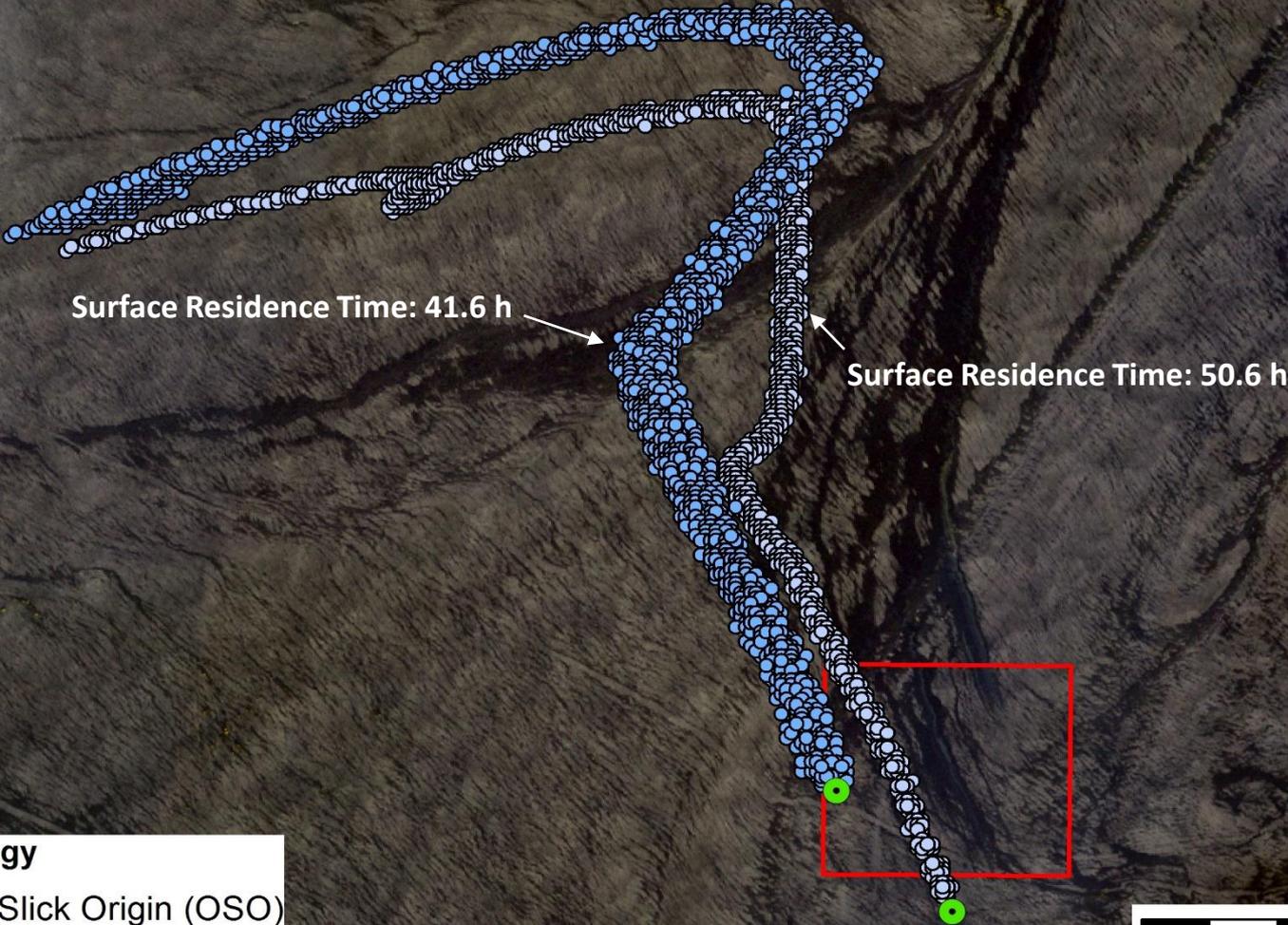


★ SailDrone location at 16:38:49 UTC

Symbology

- Seep Sites
- GC574 Lease Block

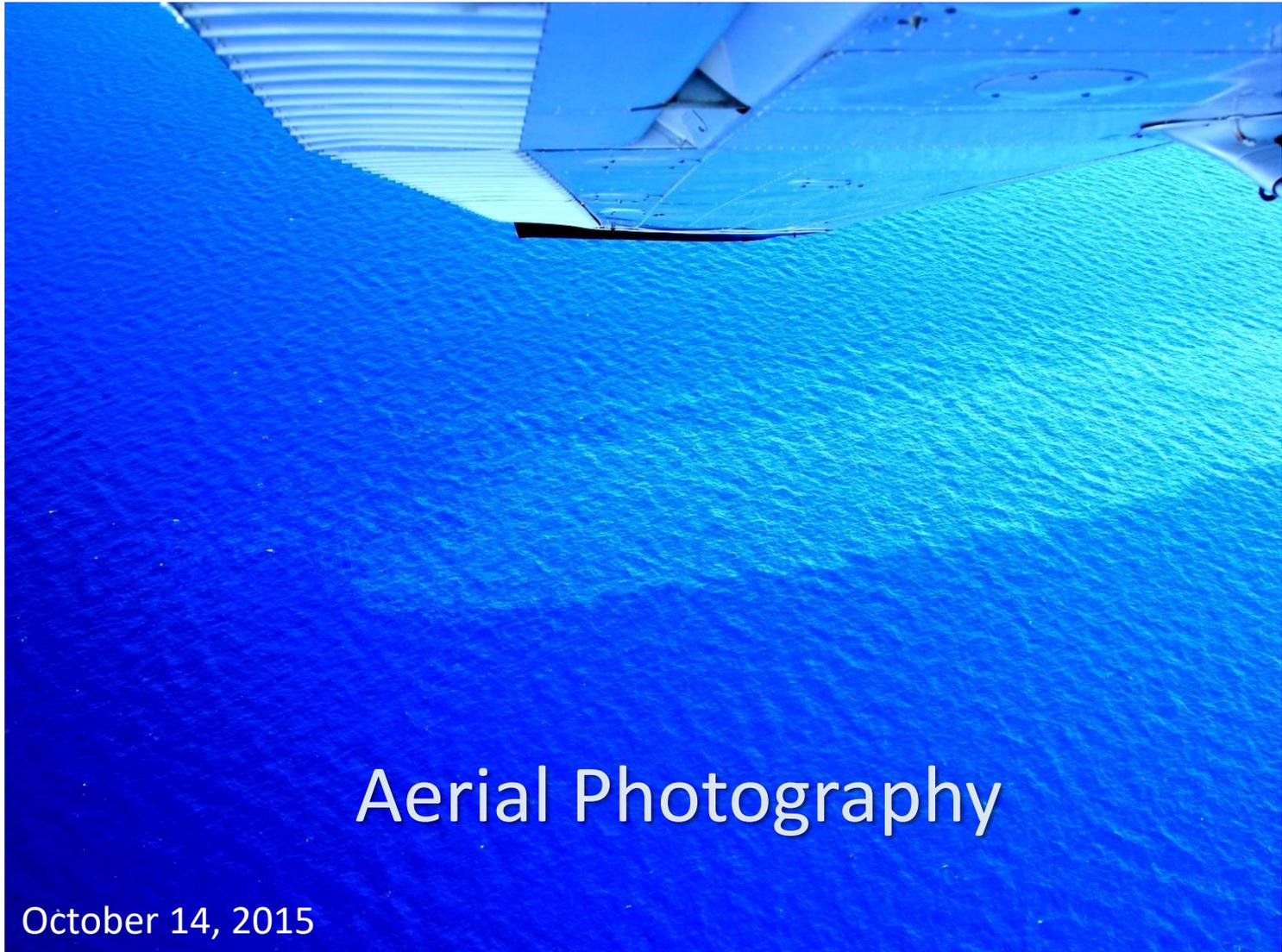
Average wind speed: 2.1 m/s



Symbology

- Oil Slick Origin (OSO)
- GC574 Lease Block





Aerial Photography

October 14, 2015

Summary

- An oil drift model, when combined with SAR images obtained from GC600 seep site, indicated an average surface residence-time of 6.4 h for natural oil slicks.
- Surface winds are largely responsible for disappearance of the oil slicks from the sea surface. Wind speeds $> 7 \text{ m s}^{-1}$ significantly reduced the length of the oil slicks to $< 10 \text{ km}$.
- The Saildrone proved to be an effective tool not only for measuring surface winds but also for detecting thin, narrow oil slicks under open ocean conditions.
- A Saildrone study and our analysis indicated that surface currents are responsible for extending oil slicks on the sea surface. Very large natural oil slick doesn't mean necessarily that there is been a change in the release of the natural oil.