

Sustainable presence in the Ocean: Yes, we can!

So why don't we make it happen?

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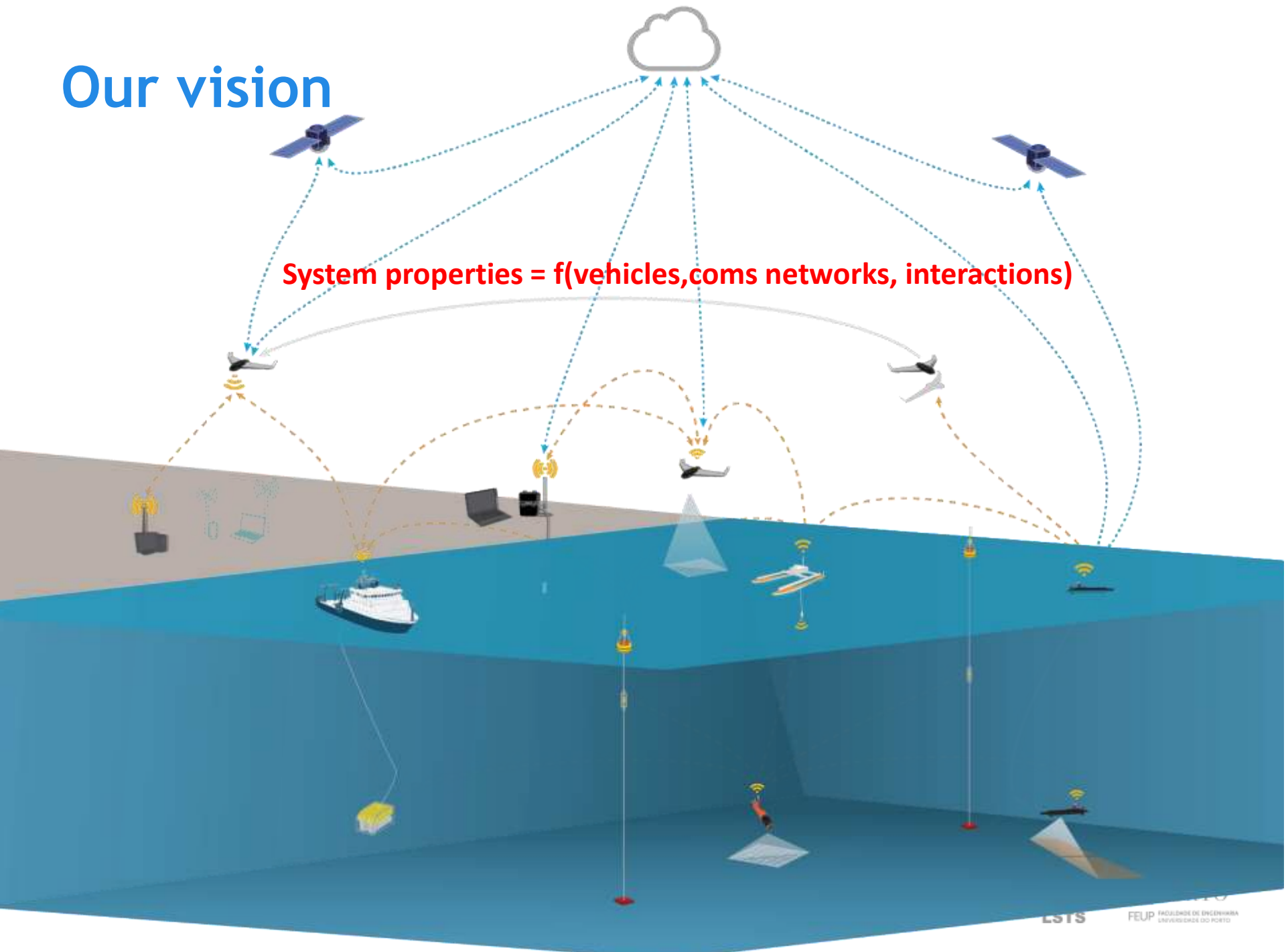


LAB OVERVIEW



Our vision

System properties = $f(\text{vehicles, coms networks, interactions})$



Vehicle systems



Low cost modular vehicles
Long endurance
Common software and hardware
Inter-operable



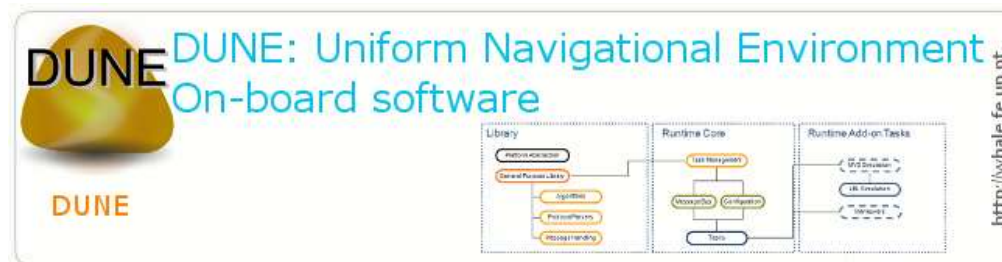
Open source LSTS software tool chain



Off-board command, control and communications



Communication protocols for command and control of heterogeneous systems



Onboard software (vehicles, buoys, data loggers)

J. Pinto, P. Sousa Dias, R. Martins, J. Fortuna, E. R. B. Marques, and J. Borges de Sousa, *The LSTS tool chain for networked vehicle systems*, Proceedings of the IEEE/MTS OCEANS'13, Bergen, June, 2013.

Powered by LSTS software



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WHAT WE DO

[ATLAS ELEKTRONIK](#) » [What we do](#) » [Unmanned Vehicles](#) » [SeaCat](#)

[Submarine Systems](#)

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[Mine Warfare Systems](#)

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SEACAT HYBRID AUV SYSTEM



Spin-off - Oceanscan MST



Operation areas



Large scale exercises

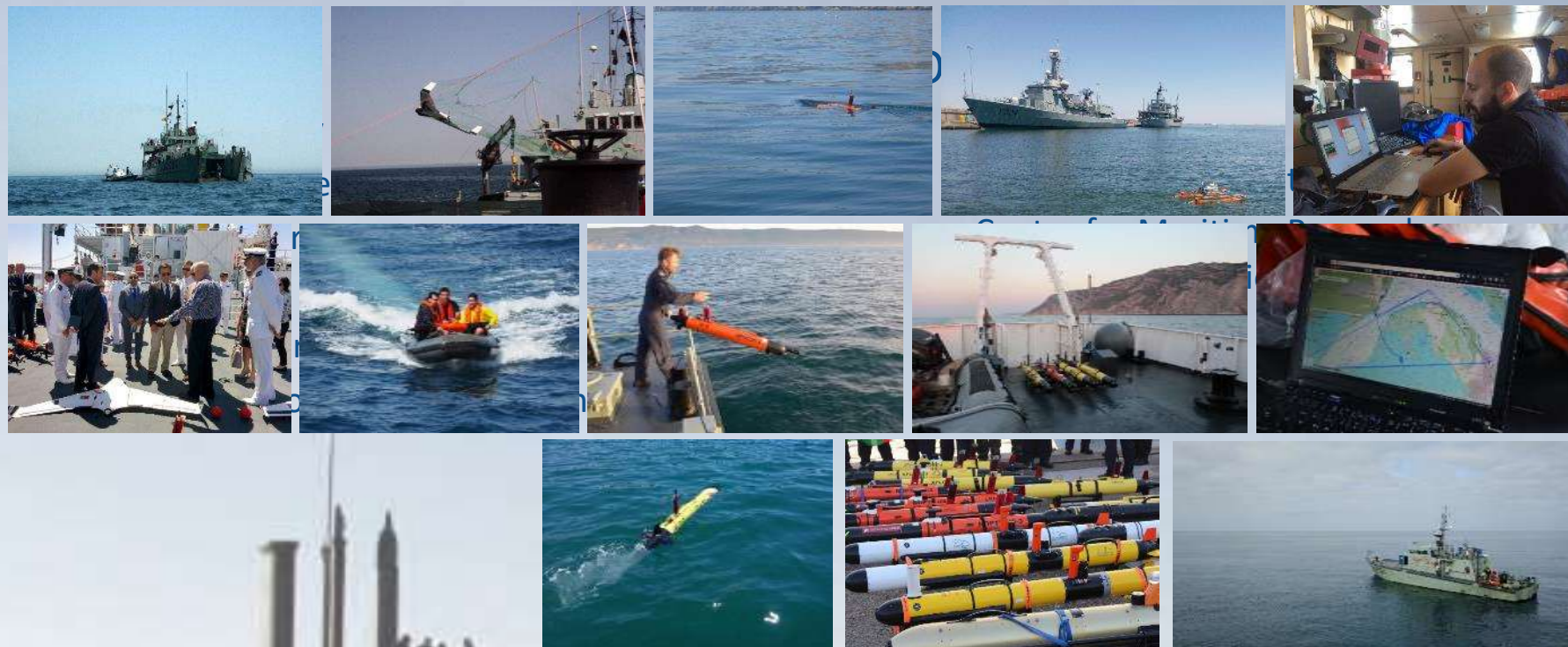
Deployments from shore or from ship/submarine

Over 100 days of ops per year

2018

- 4000 Km underwater
- 200 flights

Rapid Environmental Picture MUS exercise



2015 edition - Azores

- Eco systems mapping
- Tracking whales
- Mapping

NTNU SmallSat Program



NTNU
Norwegian University of
Science and Technology



Norsk Romsenter
NORWEGIAN SPACE CENTER



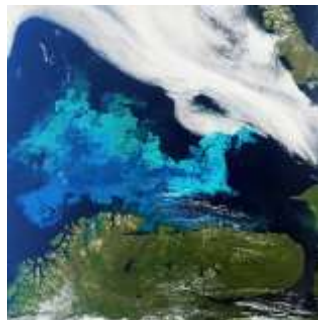
nano
avionics



UNIS
University of North-South

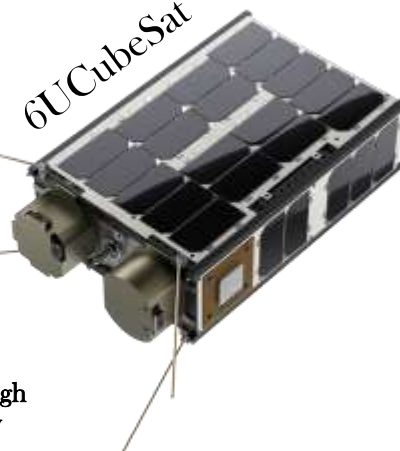


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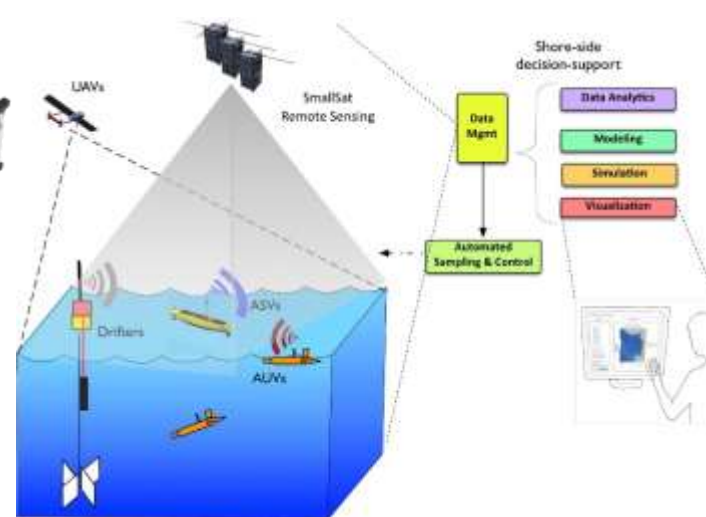


Subject: Ocean Color

6UCubeSat



Coordinated observations



Payload: HSI

Objective:

Provide and support ocean color mapping and monitoring through a Hyperspectral Imaging (HSI) CubeSat in SSO with intelligently processed data and on-demand flexible communications

Impact:

- Better understand and predict transient biological events, improve ocean model and identify Harmful Algal Blooms
- Low-cost and rapid prototyping of hyperspectral camera
- Proof-of-concept in a multi-agent system architecture
- Pipeline of nanosatellites dedicated to oceanography
- Open data products to the ocean color community



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Spectrogram

Courtesy of Kanna Rajan and Mariusz E. Grøtte, NTNU

Underwater archeology

- “Belinho” shipwreck (15xx) “discovered” in 2014 with detailed mapping 2017
 - Multi-disciplinary team (TAMU, UNL, CME)
 - Cooperation with the University of Texas AM&M
 - AUVs equipped with side-scan sonars and magnetometers

REPORTAGEM

Há um navio quinhentista “praticamente intocado” na costa de Esposende

Arqueólogos chegaram primeiro que os caçadores de tesouros a um navio do século XVI, que será um dos mais importantes achados a nível mundial, pelas condições em que se encontra.

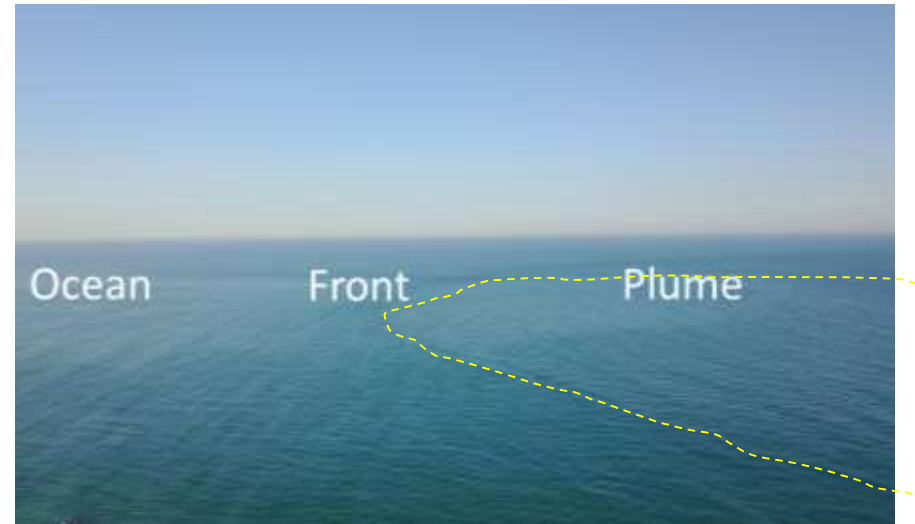
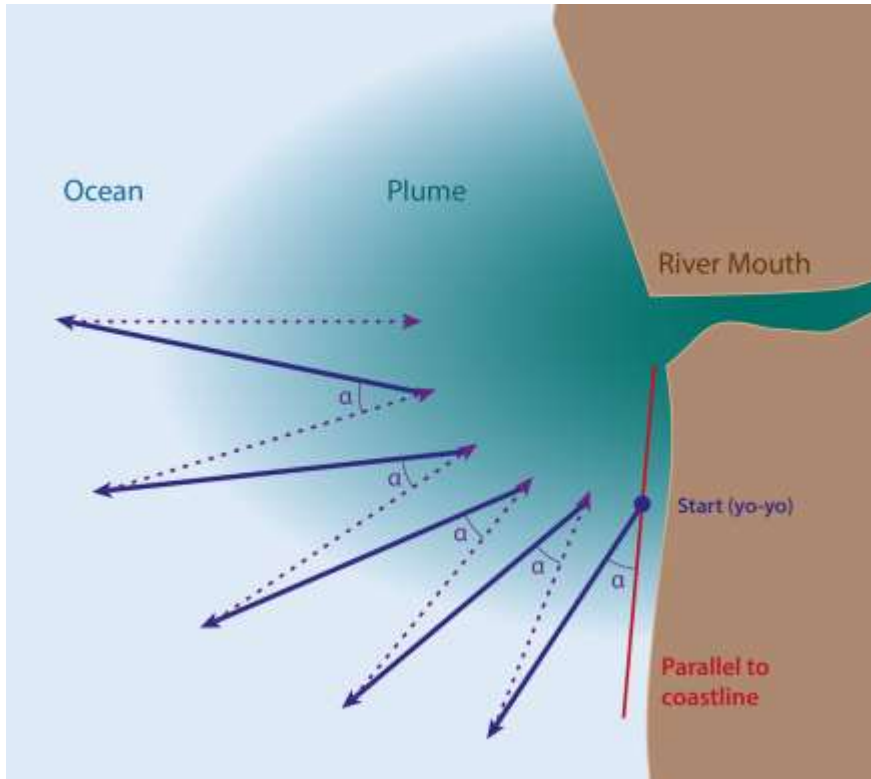
ABEL COENTRÃO 6 de Agosto de 2017, 7:25



(c) John Sexton



Douro river plume mapping



AUVs autonomously tracking edge of the plume
Edge of the plume is visible from the air

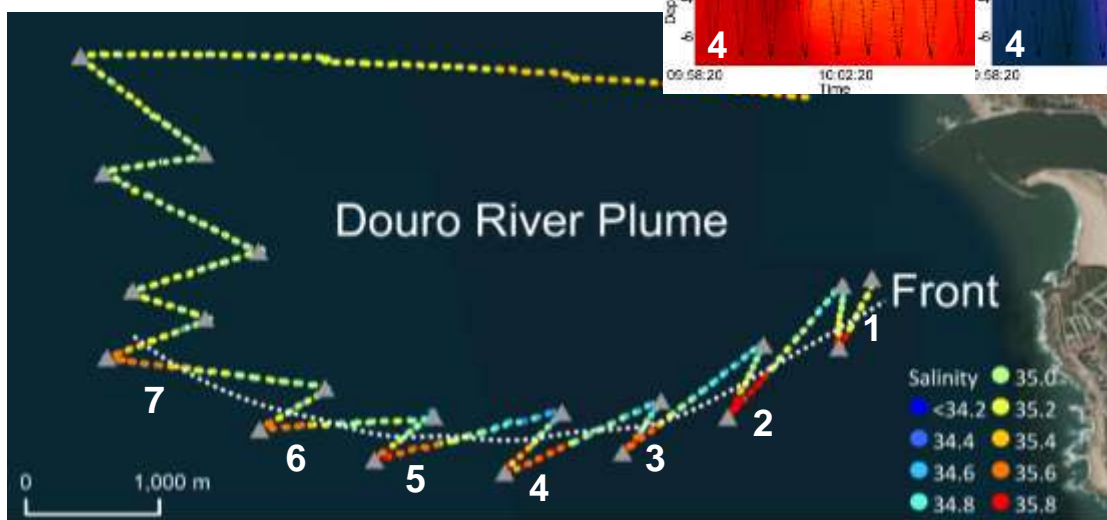
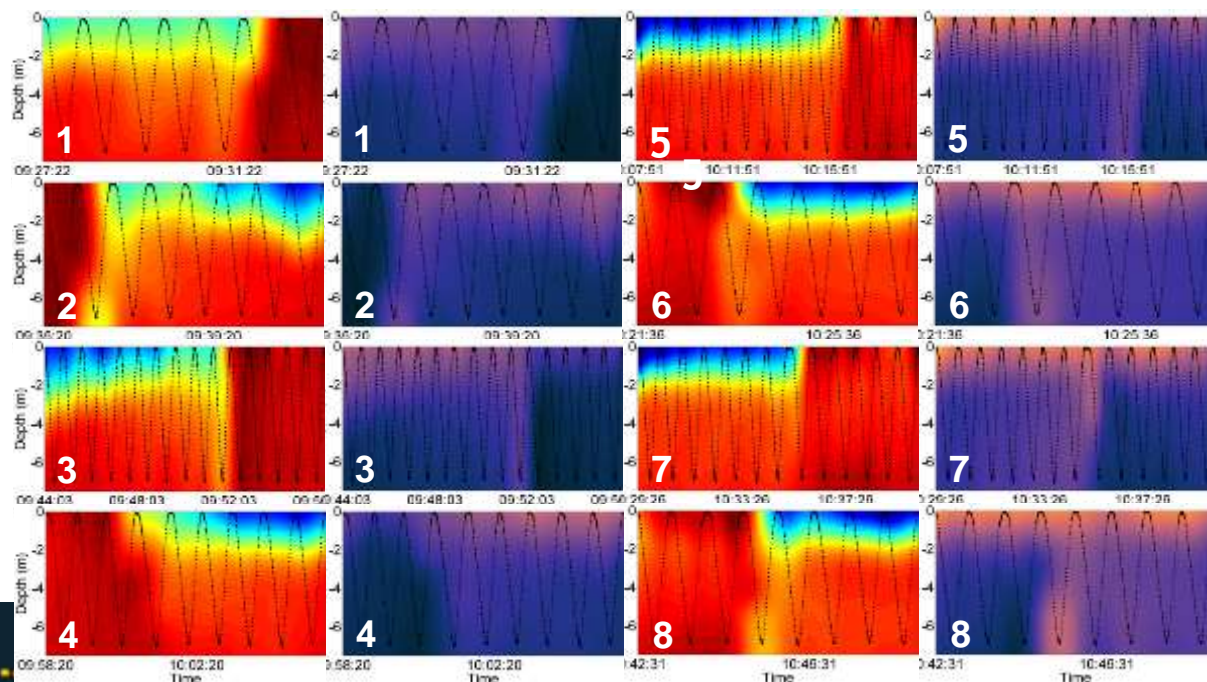
- Results



Salinity



Temperature



Mendes, R., Pinto, J., da Silva, J. C., Dias, J. M., & de Sousa, J. B. (2018, May). Using a Autonomous Underwater Vehicle to track the frontal region of a river plume. In Oceans Science Meeting 2018, Portland, USA.

Pinto, J., Mendes, R., da Silva, J. C., Dias, J. M., & de Sousa, J. B. (2018, May). Multiple Autonomous Vehicles Applied to Plume Detection and Tracking. In 2018 OCEANS-MTS/IEEE Kobe Techno-Oceans (OTO) (pp. 1-6). IEEE.

Small satellite coms with UxV



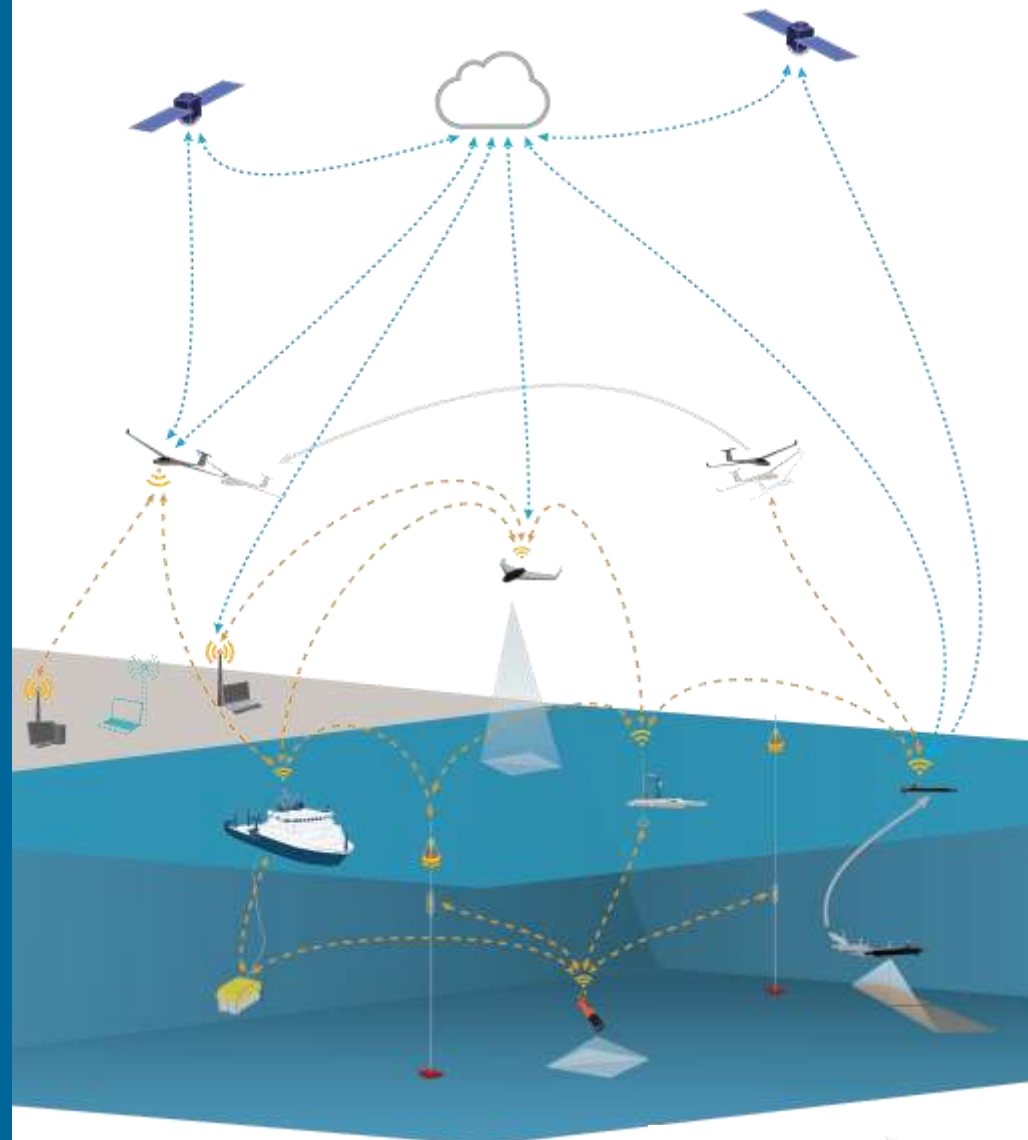
Exploring the STF front with multiple robots



May 28–June 17, 2018



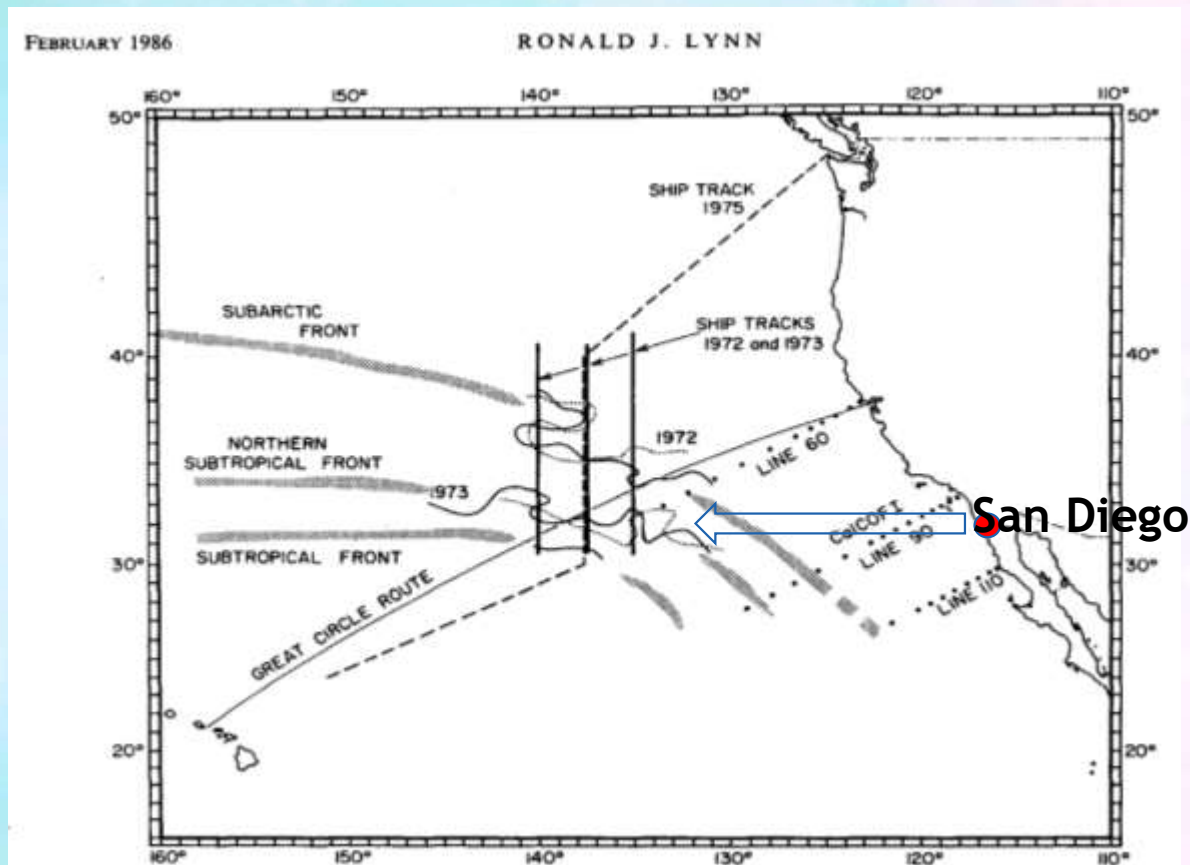
https://schmidt-ocean.org/cruise/exploring_fronts_with_multiple_aerial-surface-underwater-vehicles/



Main goal of the cruise

To demonstrate a novel multi-vehicle system capable of finding, tracking and sampling features of the ocean with adaptive spatial-temporal resolution

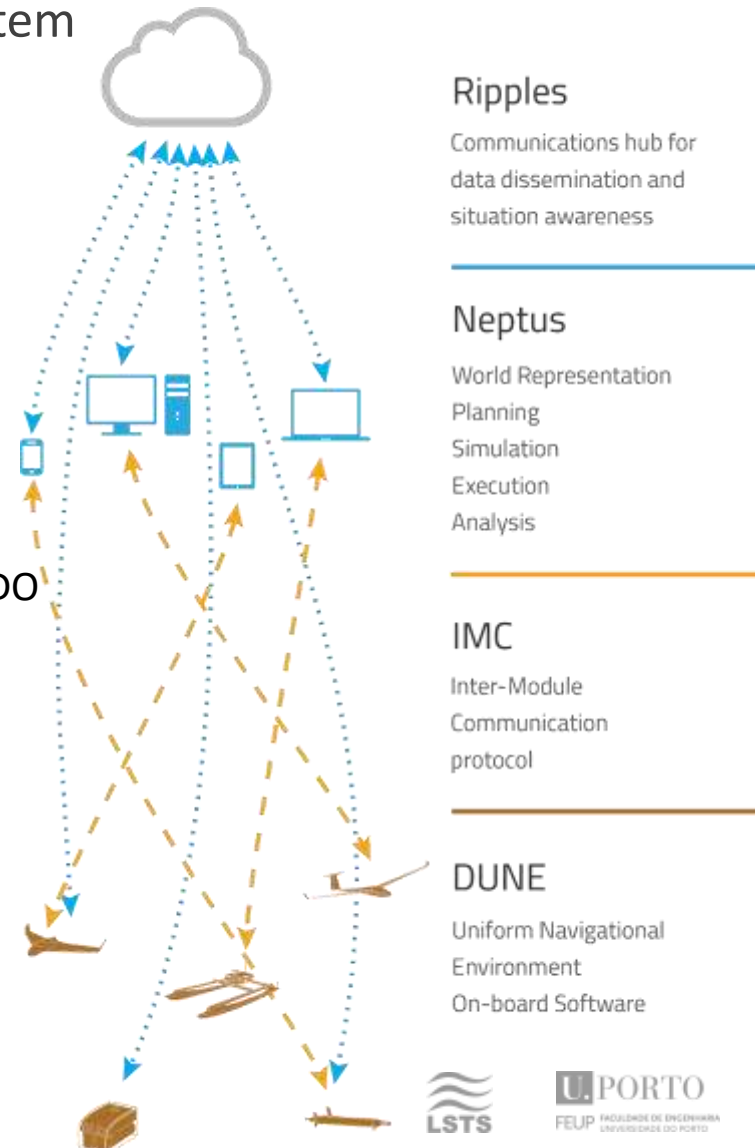
Target: North Pacific Subtropical Front



Ronald J. Lynn, The Subarctic and Northern Subtropical Fronts in the Eastern North Pacific Ocean in Spring, *Journal of Physical Oceanography*, Volume 16 No. 2, February 1986, pp.209-222.

System

- R/V Falkor based networked multi-vehicle system
 - 3 VTOL UAVS (IR/multispectral cameras, DSM)
 - 2 Quadcopters
 - 1 Wave glider / 2 Saildrones
 - SIL Camera/ ALF sensor
 - 1 **Eco-Mapper** AUV
 - 1 **Lauv-xplore-1**: CTD, pH and DO2
 - 1 **Lauv-xplore-2**: CTD, Chlorophyll-a and Turbidity
 - 3 **Lauv-xplore-3-5**: CTD (50h+ endurance)
 - 1 **Lauv-harald**: CTD, Chlorophyll-a, Organic Matter/DO

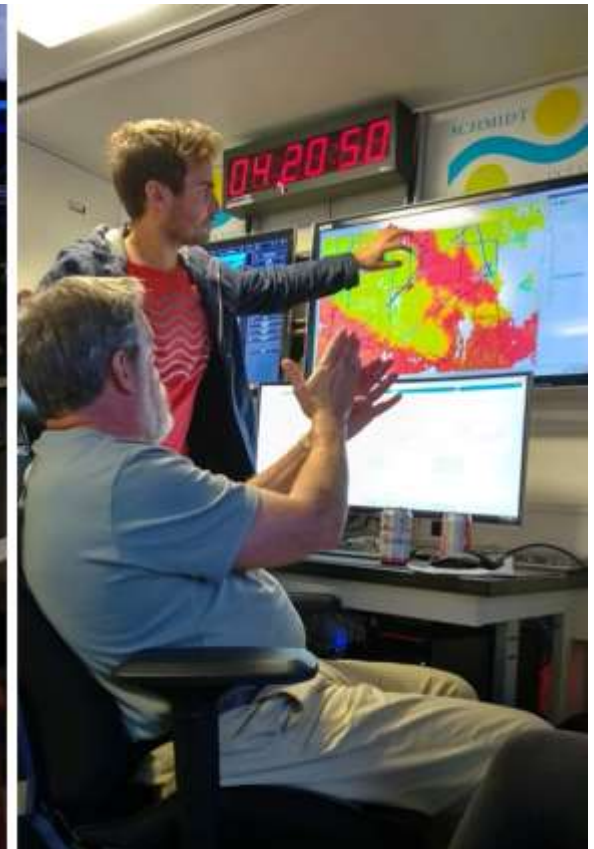


Web-based mission control center (24/15)

- 4 shifts per day / operators in Porto and onboard the R/V Falkor

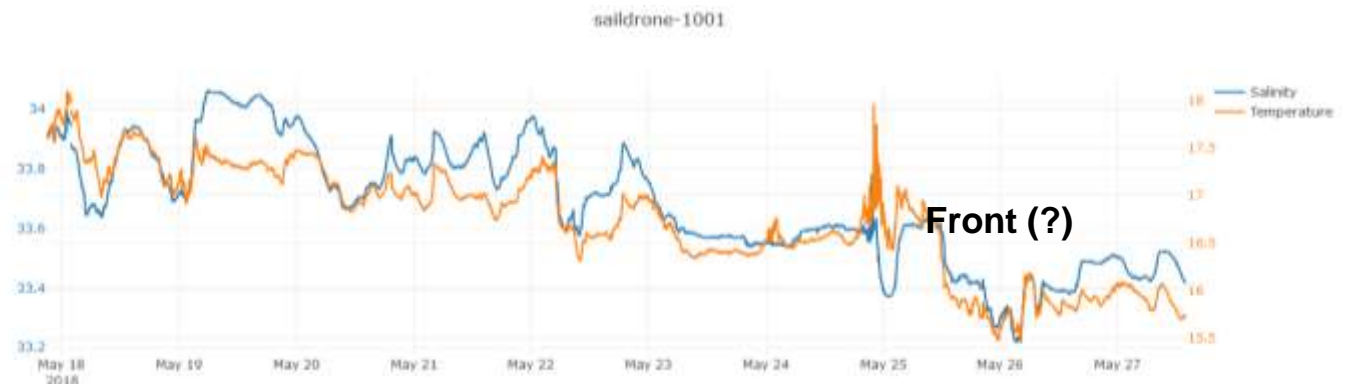
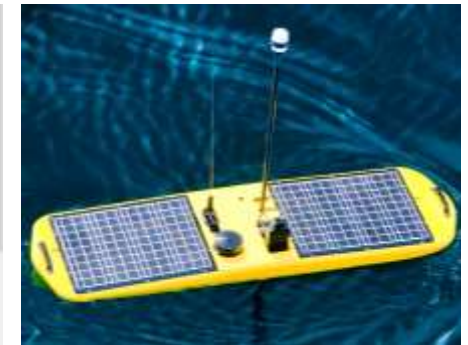
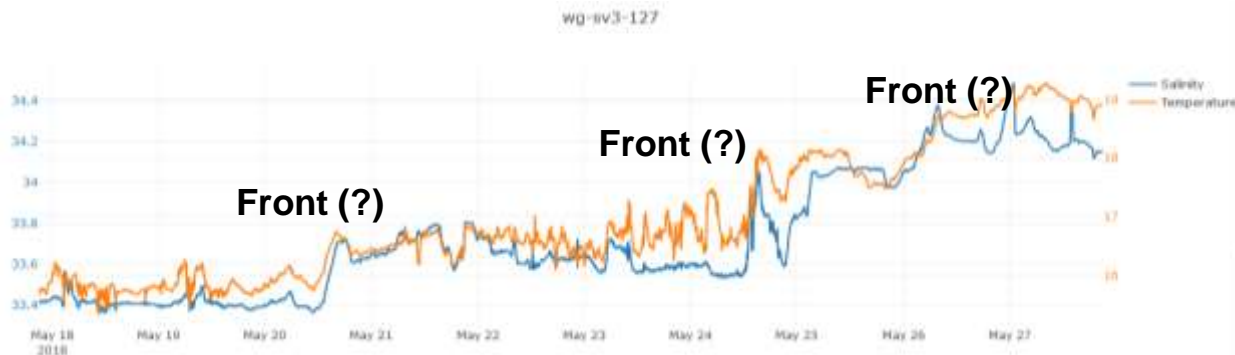
Mission control center (R/V Falkor)

AUVs did over 2000 Km
ASVs did over 10000 Km



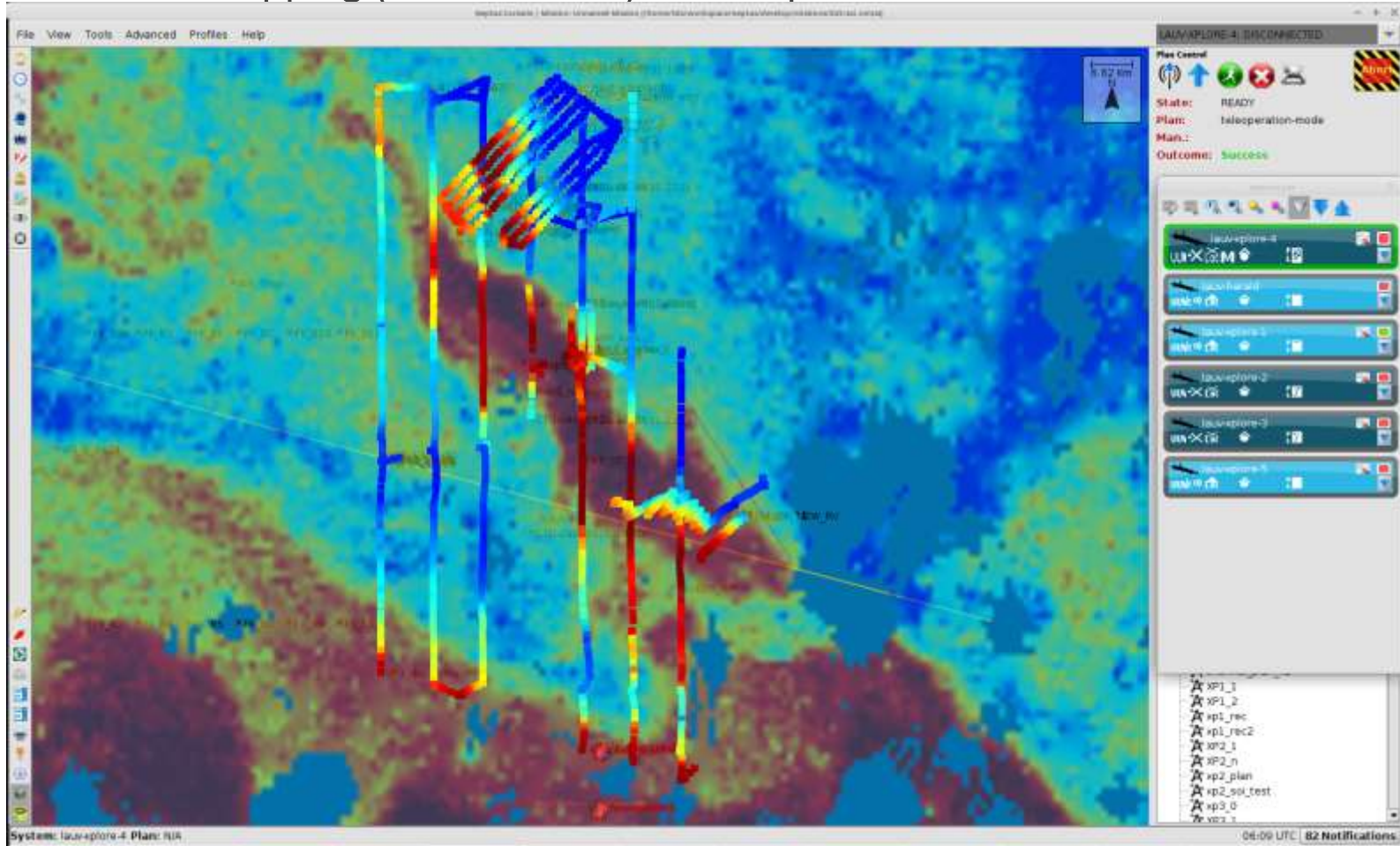
Finding the front

- One WaveGlider (WG) and two Saildrones (SD) deployed into the target research area ahead of the ship's arrival



Mapping the front (AUV data + SST data)

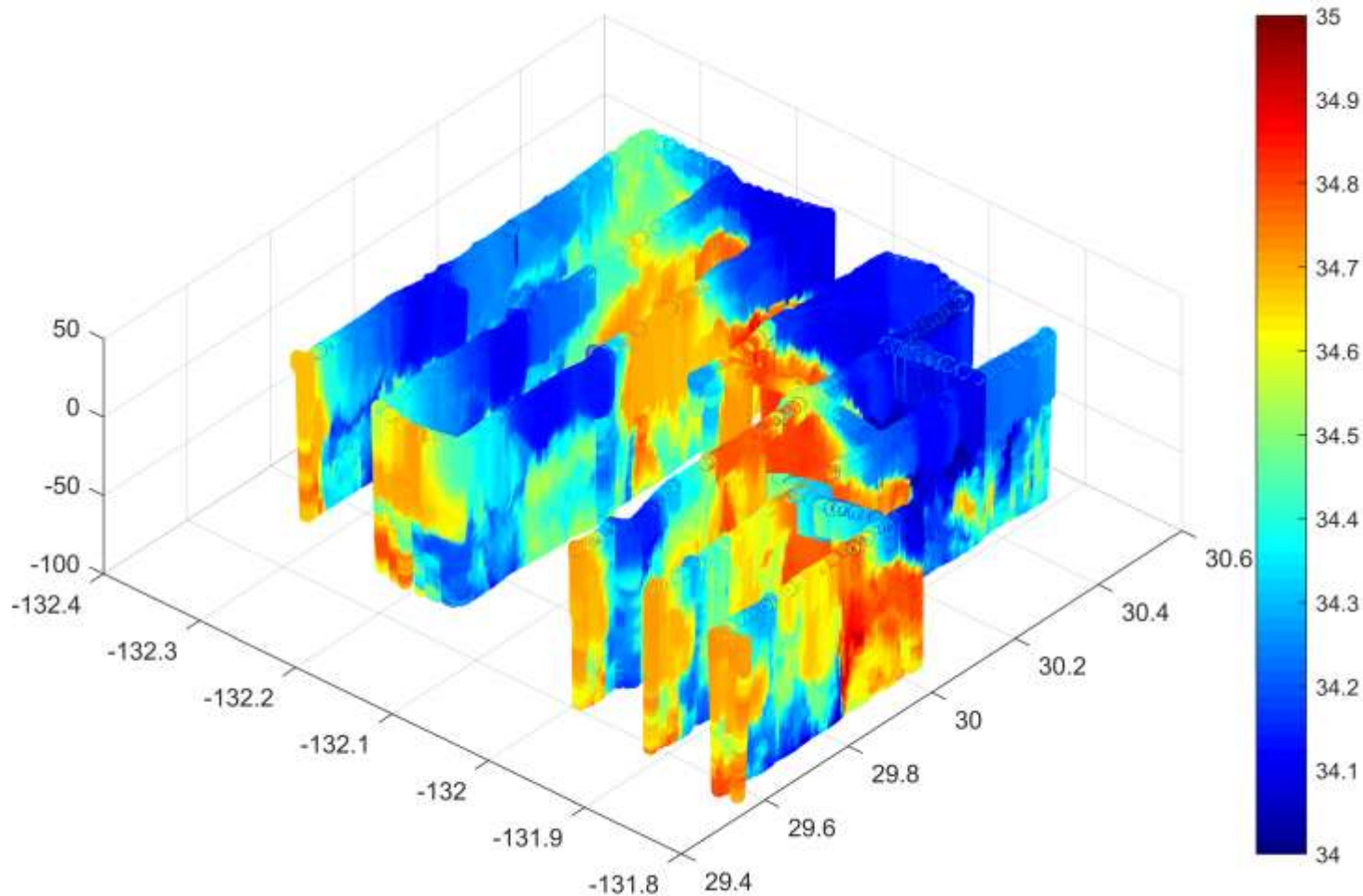
- Mesoscale mapping (50Nm x 40Nm) with unprecedented sub-mesoscale resolution



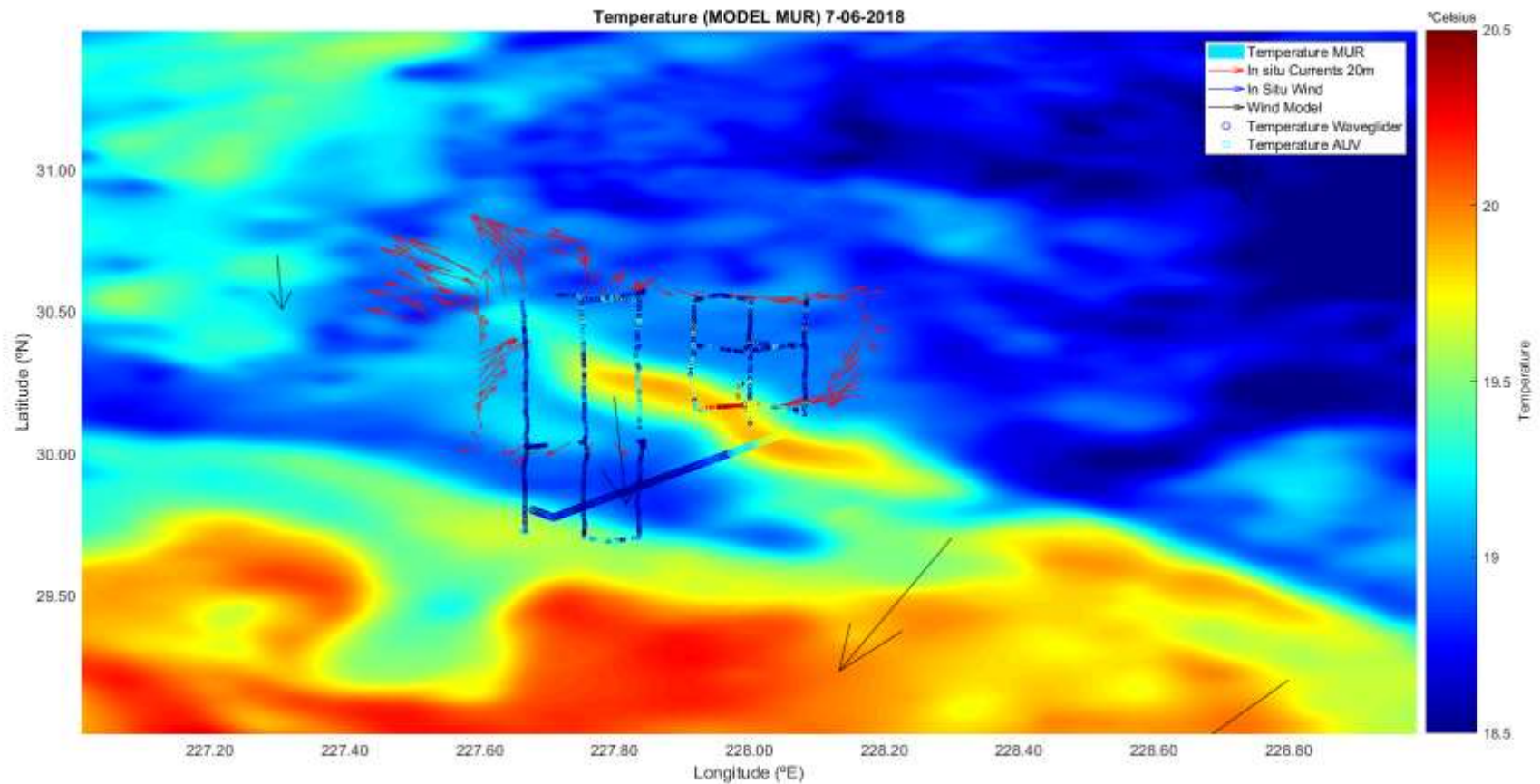
- Observed a filament detaching from the front

3D view of the front

- Measurements taken by AUVs (mowing the lawn yo-yo motion pattern)

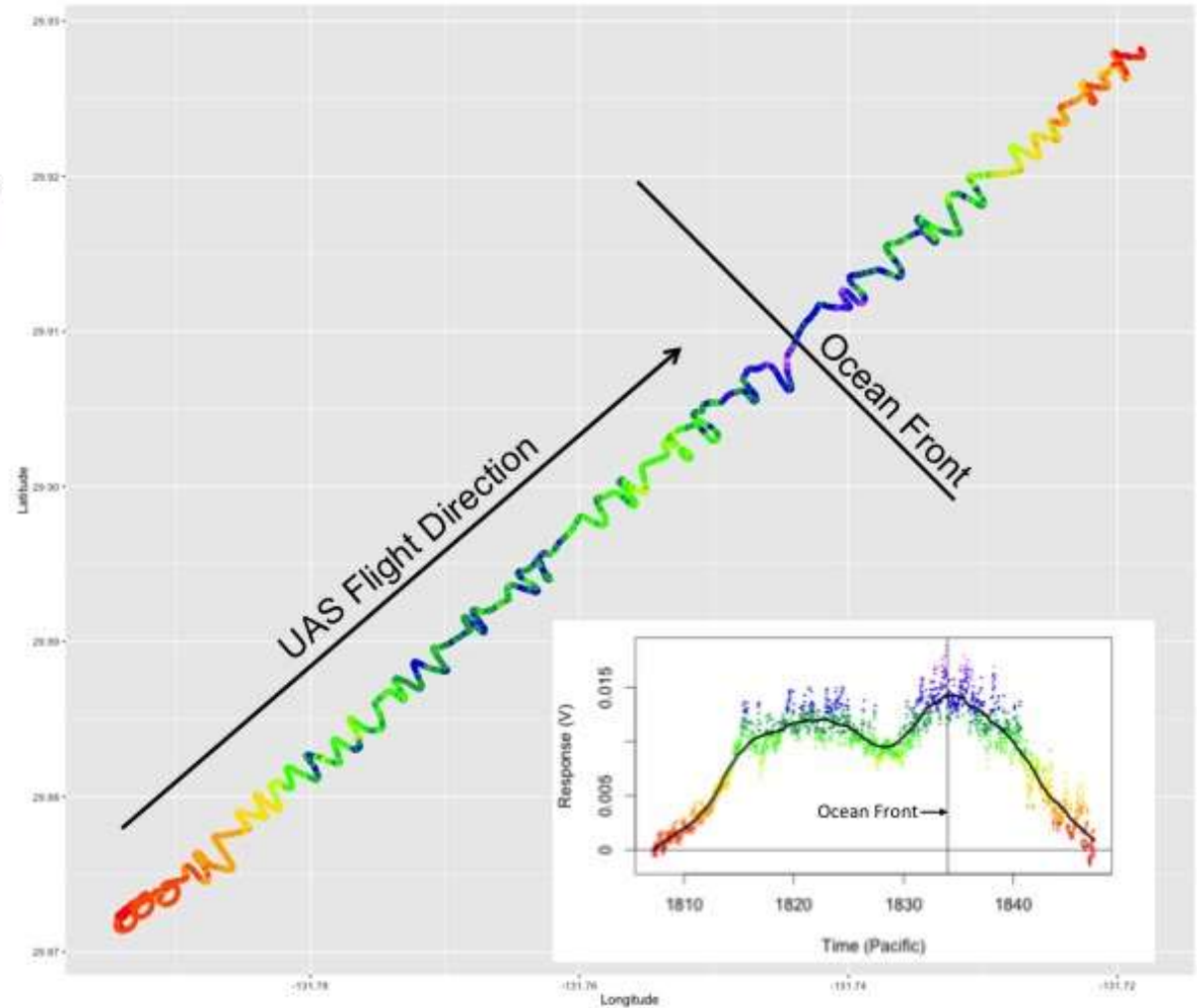
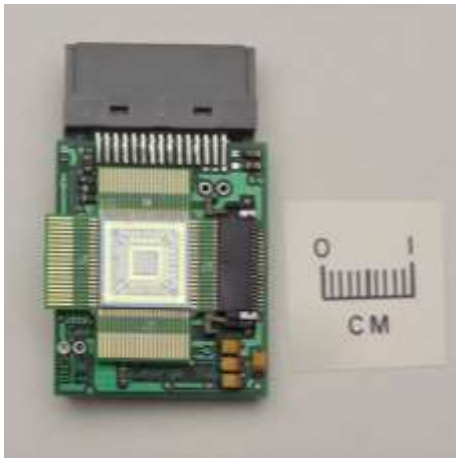


Finite-size Lyapunov exponents (FSLE)



Courtesy of José da Silva, FCUP

DMS sensor data

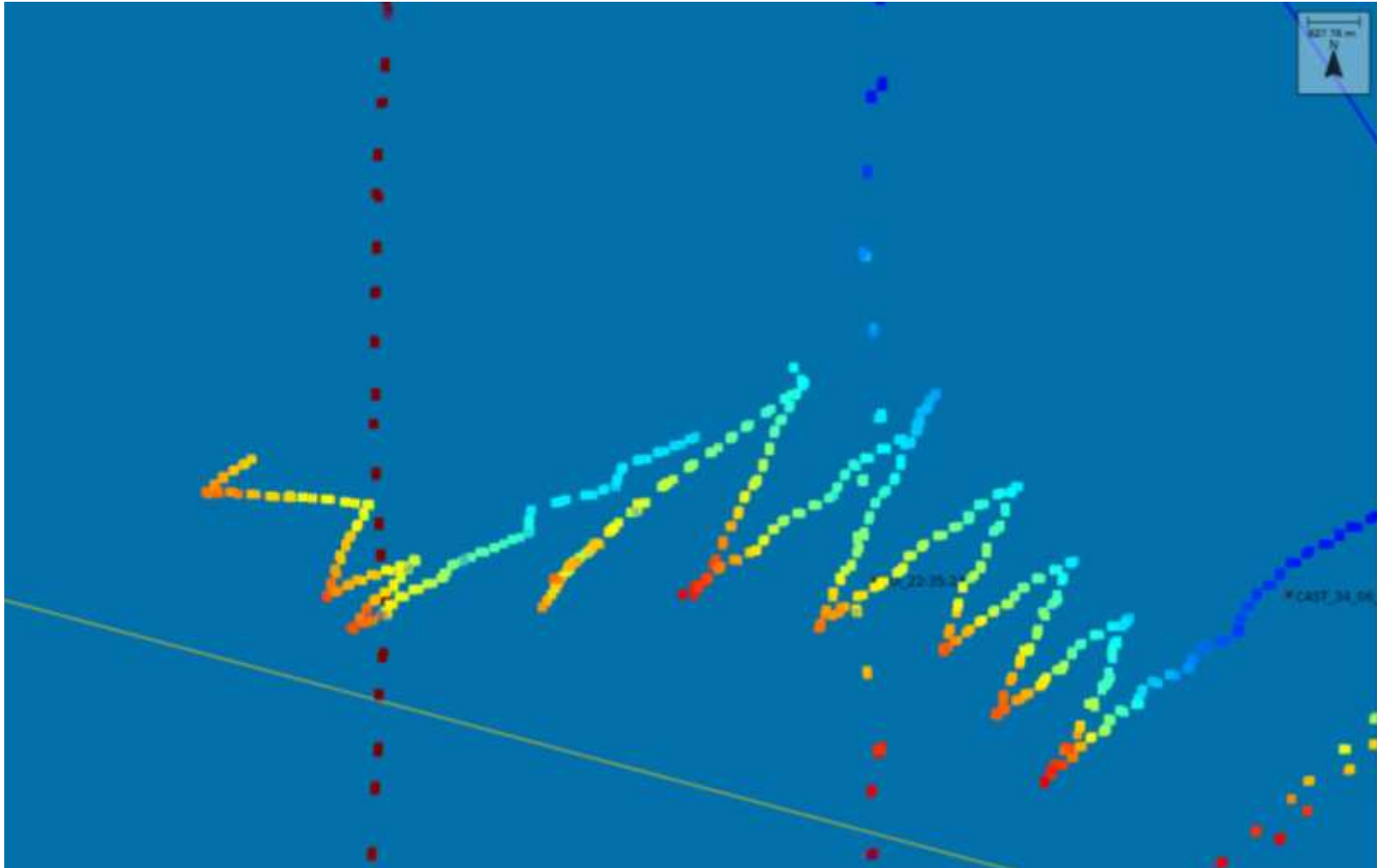


Courtesy of Ian Brosnan, NASA-Ames

J. Borges de Sousa

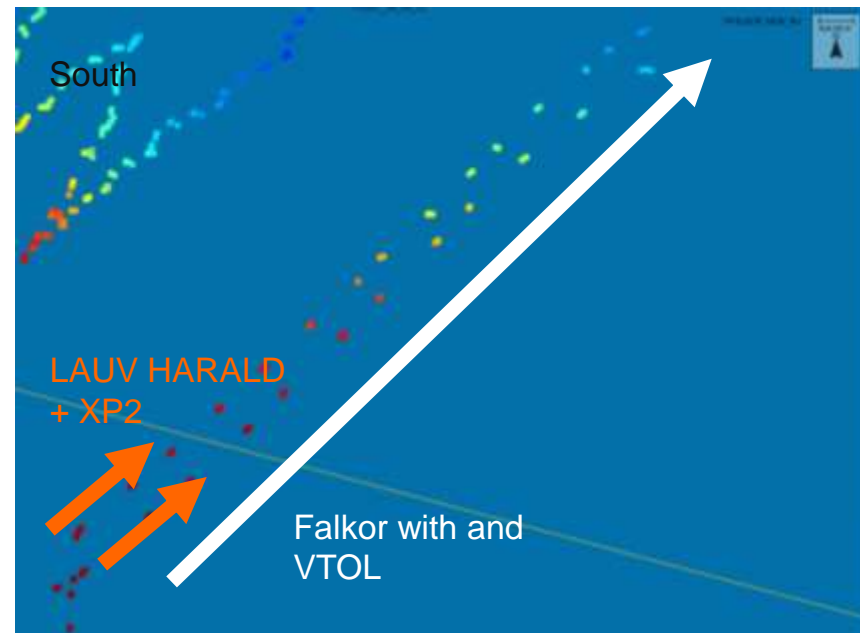
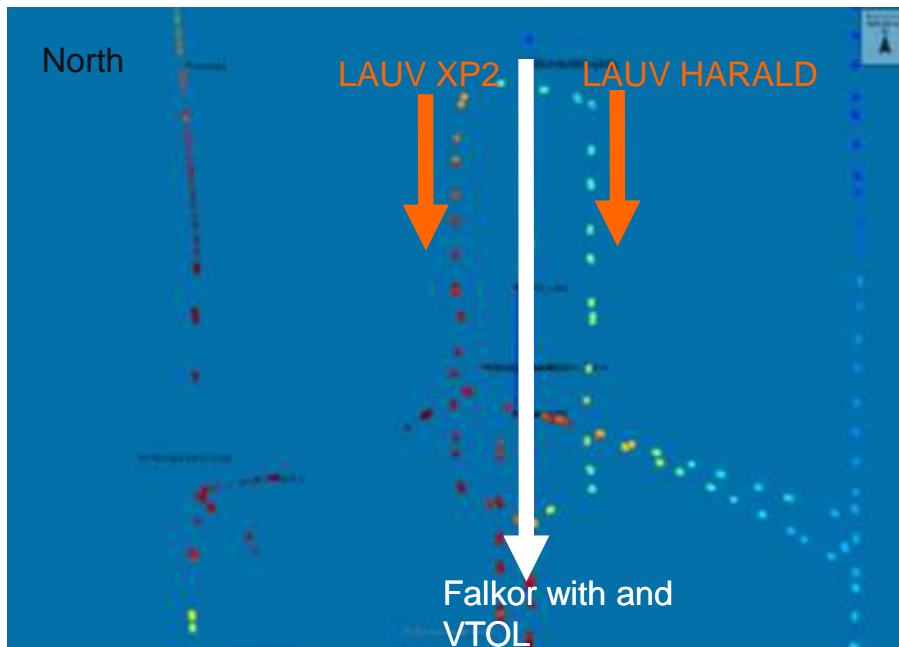
Automated front detection and tracking

- Performed with Wave Glider, R/V Falkor and AUVs



Hi-res coordinated sampling

- Hi-res data sampling using AUVs with biochemical sensors coordinated with *Falkor* (ADCP, ALF, etc) and UAVs (camera and DMS sensor)



On future oceanographic field operations



“Technology first: new technology should drive the SOI science program.”

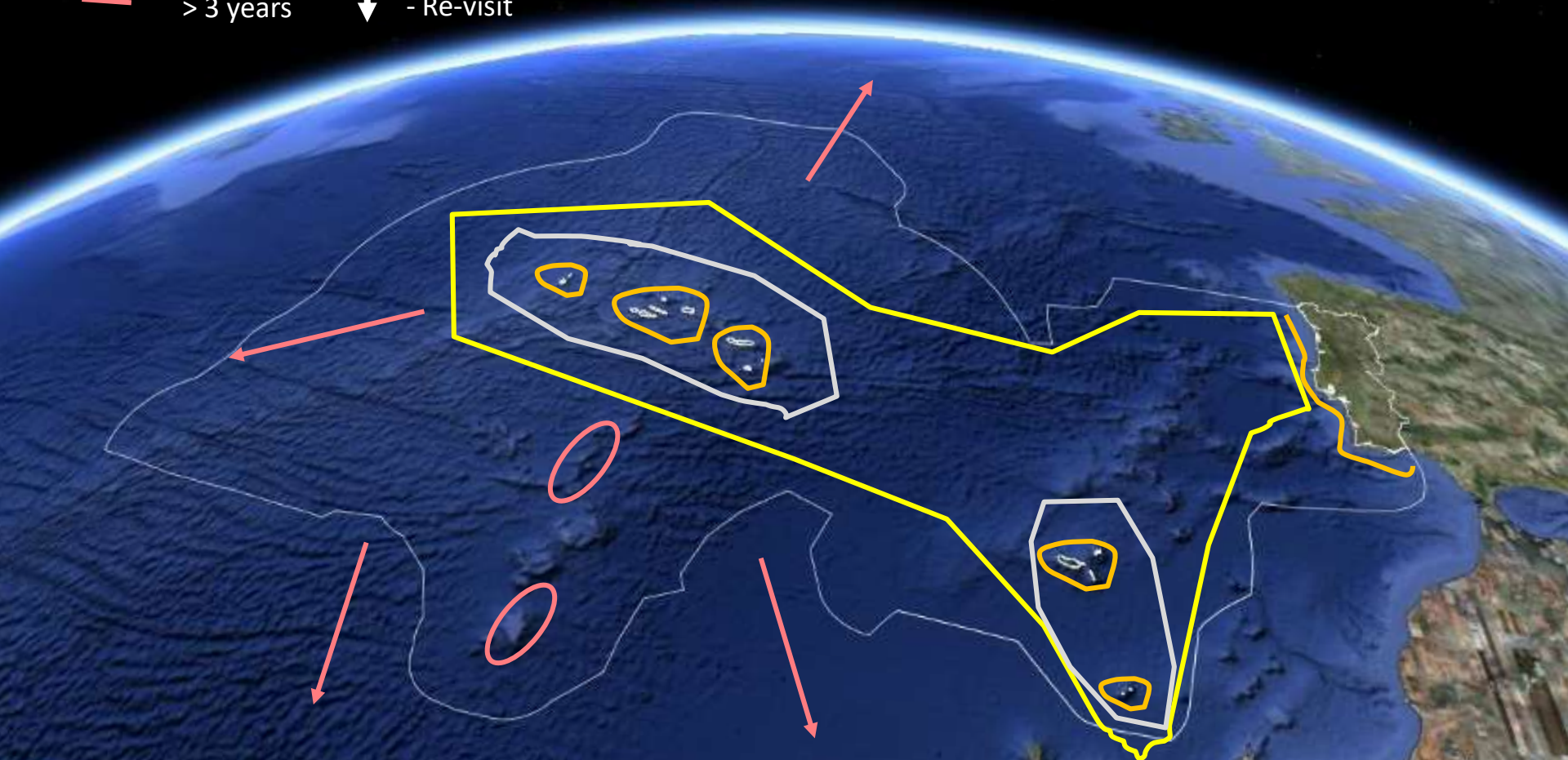
Eric Schmidt • Founder and President

Sustainable presence in the Ocean: Yes, we can!

- | | | | |
|---|-------------|---|---|
| — | Now | ↓ | Increasing complexity <ul style="list-style-type: none">- # of assets / # institutions- Coordinated ship-robotic surveys- Diversity of sensors- Re-visit |
| — | 1 – 2 years | | |
| — | 2 – 3 years | | |
| — | > 3 years | | |

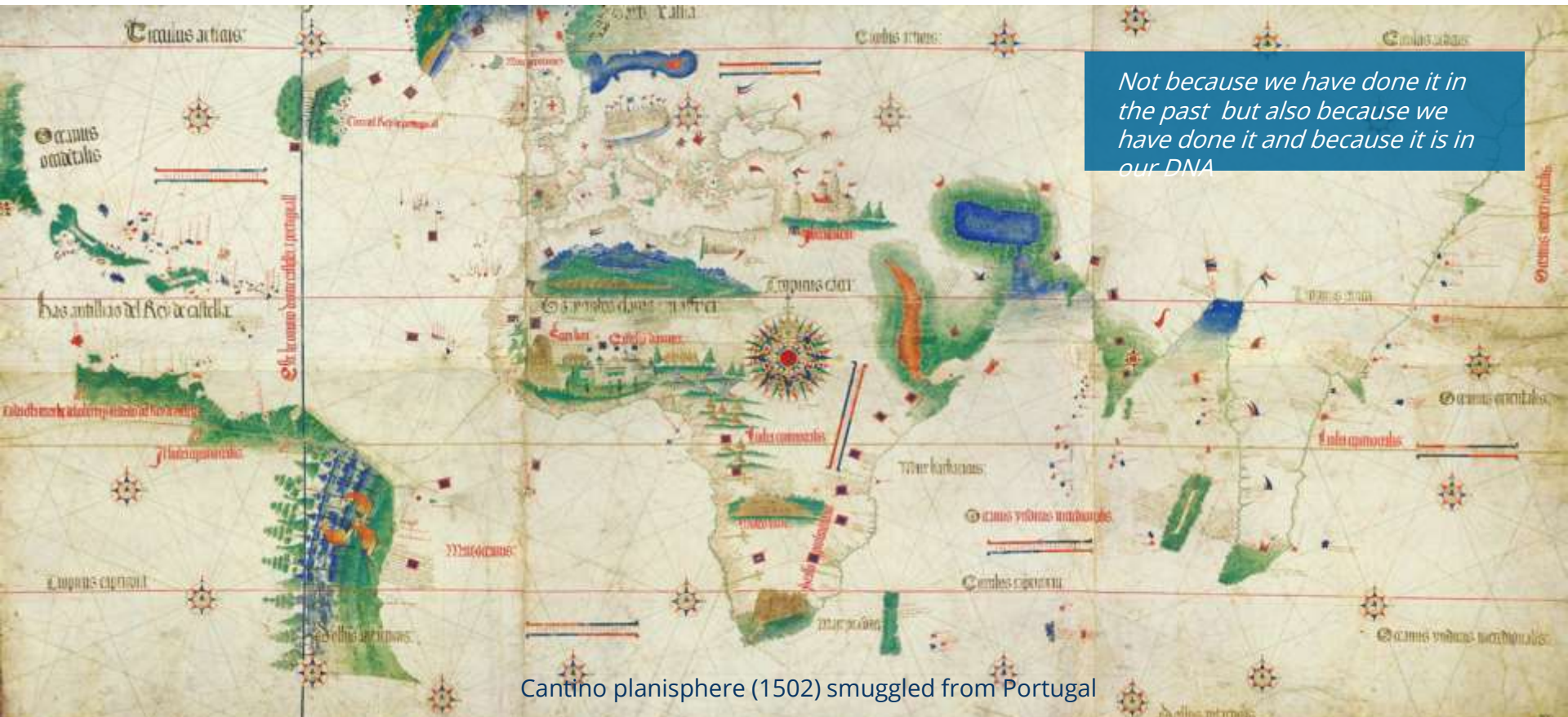
"The voyage of discovery is not in seeking new landscapes but in having new eyes"

Marcel Proust



Why don't we make it happen?

- New organizational and funding models, as well as new cooperative mind-set
 - Infra-structures development and coordination programs
 - Inclusive ocean observation programs bridging science and technology
 - Phased technology development programs – start small, grow healthy
 - Think Atlantic in the triple helix framework (Government, Academia and Industry)





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EUMarineRobots

Marine robotics research infrastructure network

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<https://www.oceansconference.org/porto-2021/>