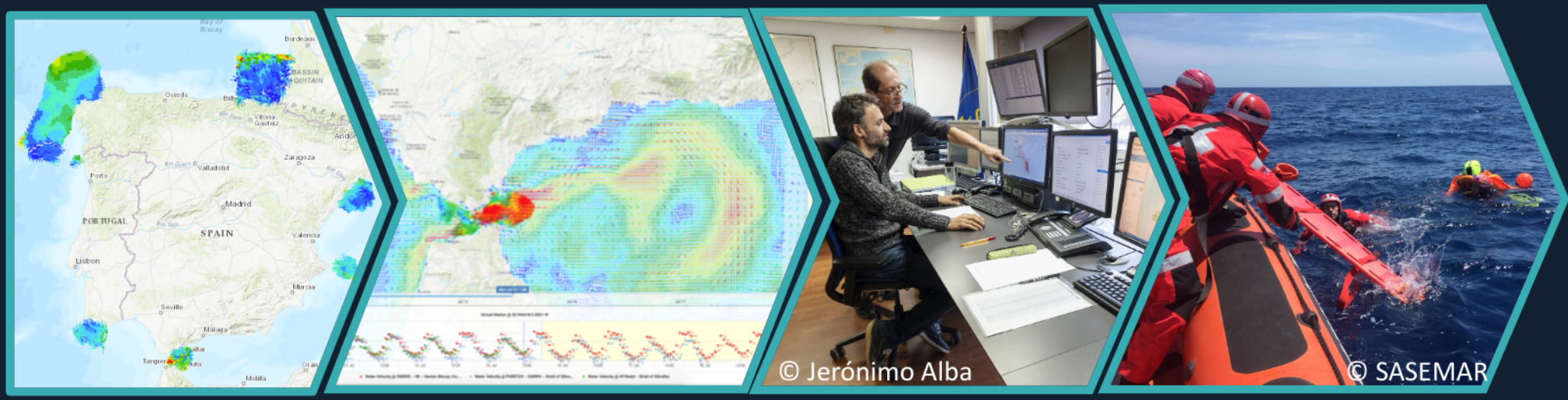
SOCIB Balearic Islands Coastal Observing and Forecasting System

IBISAR: helping SAR operators and emergency responders to select the most accurate ocean forecast



Emma Reyes

(on behalf of the IBISAR team)

ereyes@socib.es
ibisar@socib.es

SICOMAR-PLUS HF RADARS SUMMER SCHOOL
26-28.MAY. 2021

www.socib.es

SOCIB

OUTLINE

01 Why IBISAR service?

02 IBISAR: Service overview

03 IBISAR: Main elements

04 IBISAR: Data used

05 HF radar current gap-filling

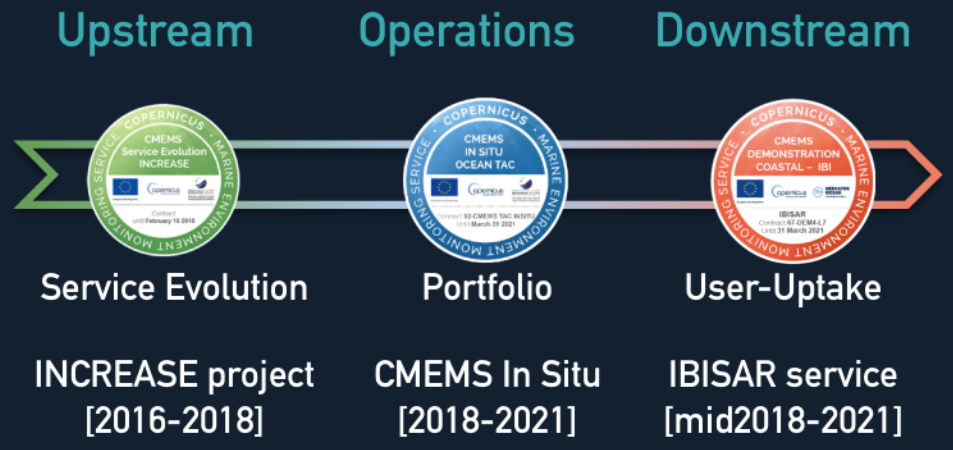
06 IBISAR: How it works?

07 IBISAR: Validation results

08 IBISAR: Recent case studies

09 IBISAR: Audience metrics

10 Conclusions



Timeline of HFR data development, ingestion and use (CMEMS news)

SOCIB

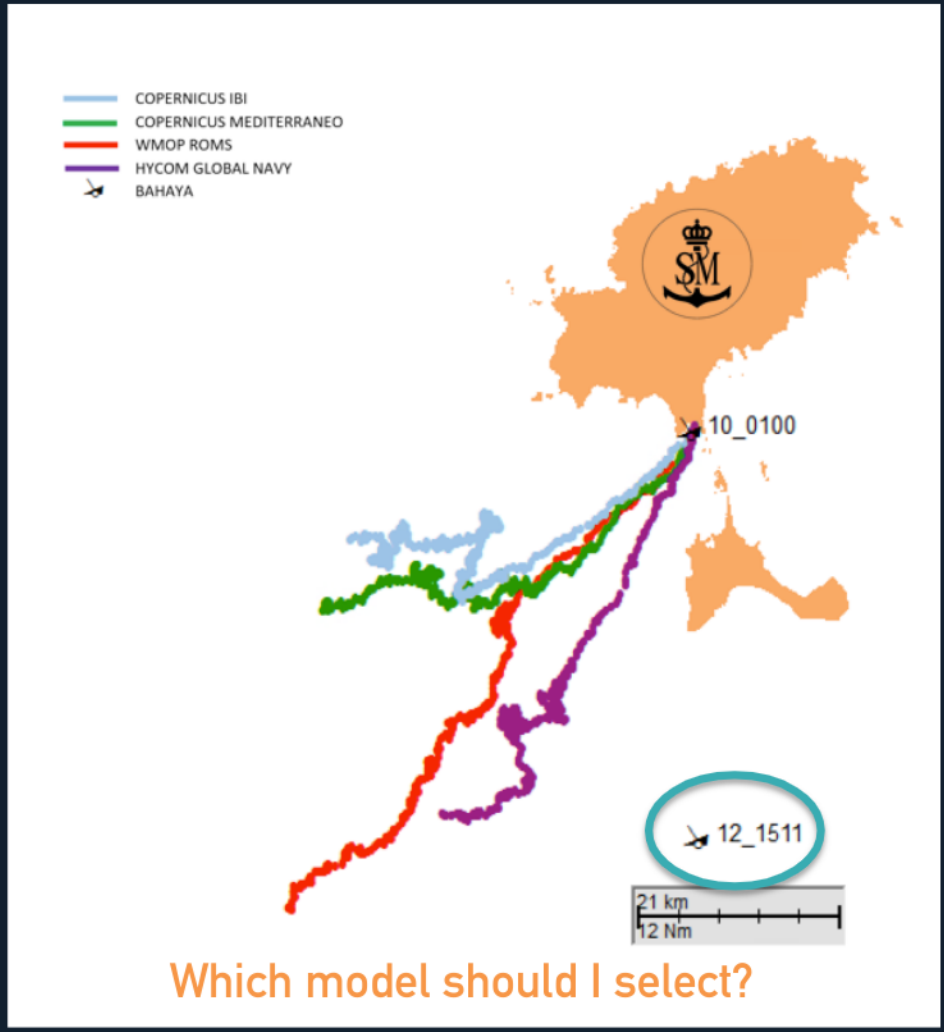
01 WHY IBISAR SERVICE?

SAR CASE HISTORY: DRIFTING SAILING VESSEL "BAHAYA"

SARMAP – scenario simulation:

- Time step: 10 min
- Number of particles: 5000
- Wind: AEMET HIRLAM HR (5 km)
- Drifting for 62 hours
- Currents: different models

Windy storm at Pitiusas Islands
10/08/2017



Which model should I select?

SARMAP: Simulated trajectories and vessel initial/final location

SOCIB

02 IBISAR SERVICE OVERVIEW

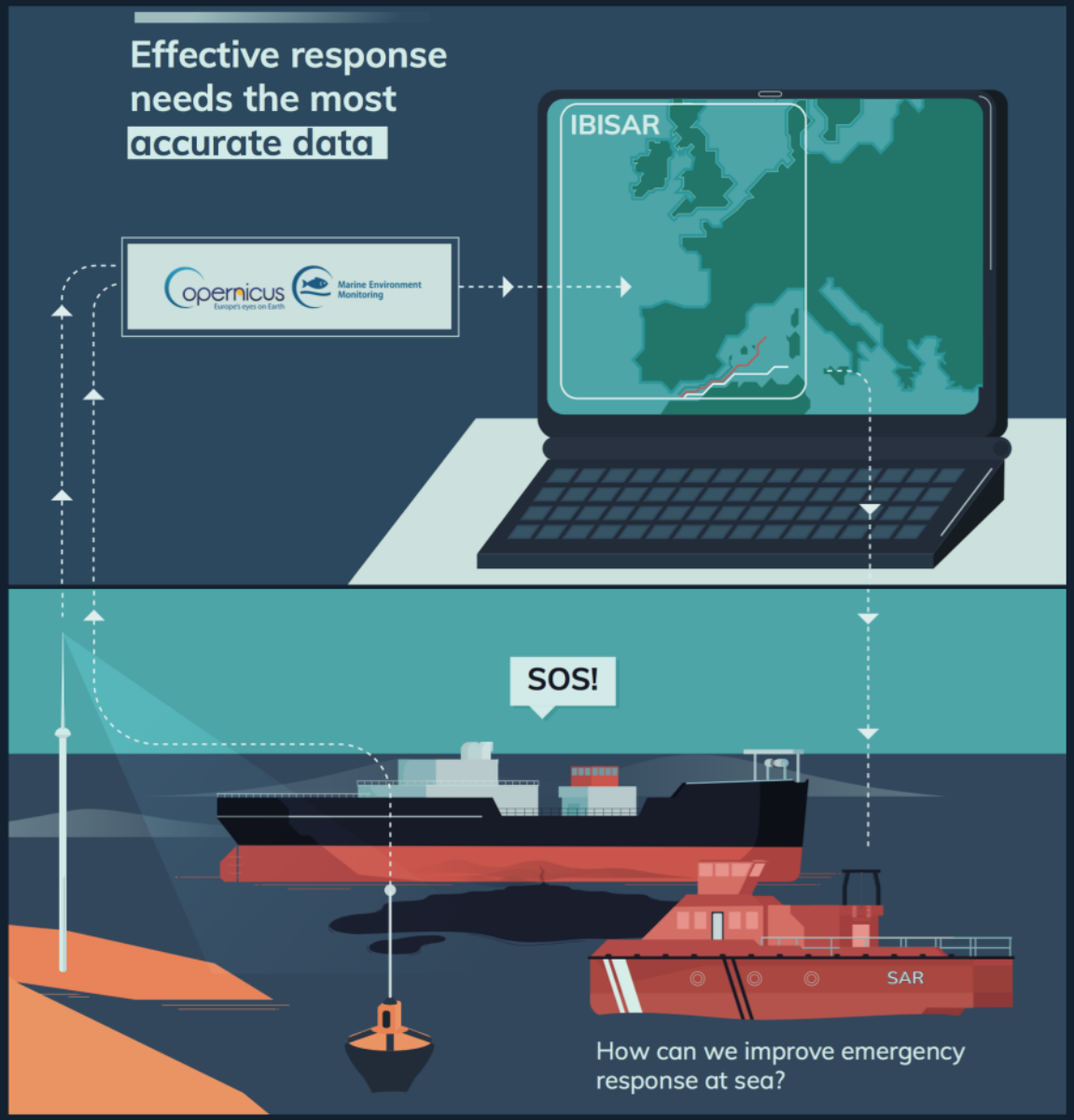
How can we improve emergency response at sea?

End-users needs

- Reliable current observations and forecasting are essential
- Easily interpretable metrics
- User-friendly automated skill assessment

SOCIB

02 IBISAR SERVICE OVERVIEW



IBISAR service

Provides real-time information of the most accurate ocean current forecast in the IBI area

Facilitates decision-making to SAR operators and emergency responders

End-users needs

Reliable current observations and forecasting are essential

Easily interpretable metrics

User-friendly automated skill assessment

SOCIB

03 IBISAR: MAIN ELEMENTS

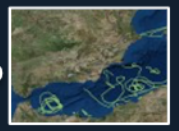
IBISAR downstream service

Updated database
[Data catalogue]

OceansMap viewer
[Visualization & Comparison]

Skill Assessment
[Skill score computation]

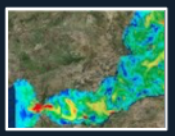
In-Situ



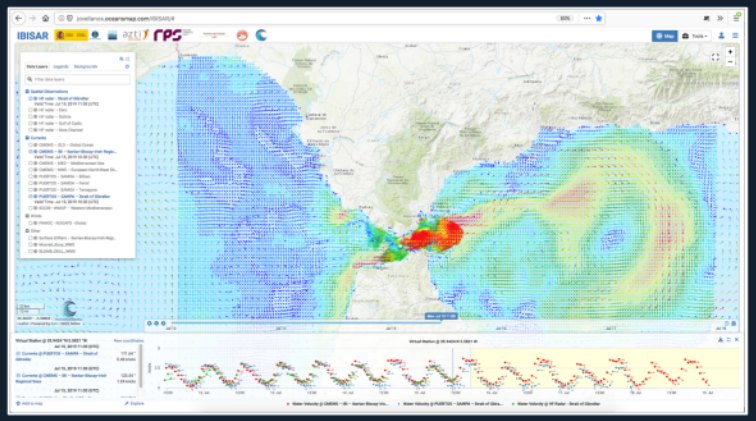
Drifters [IBI]

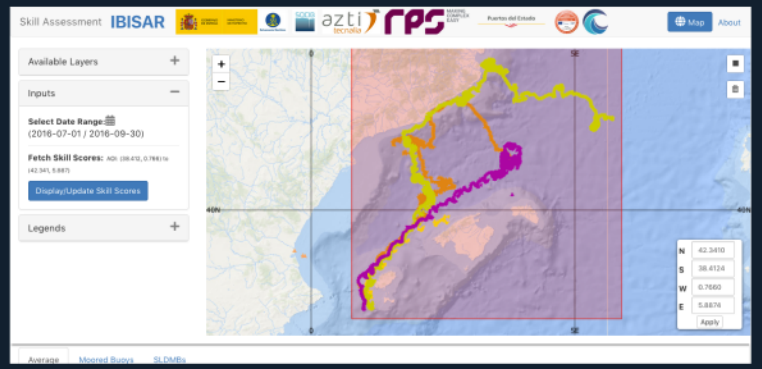
6 HF radars

8 Models



Surface current forecast





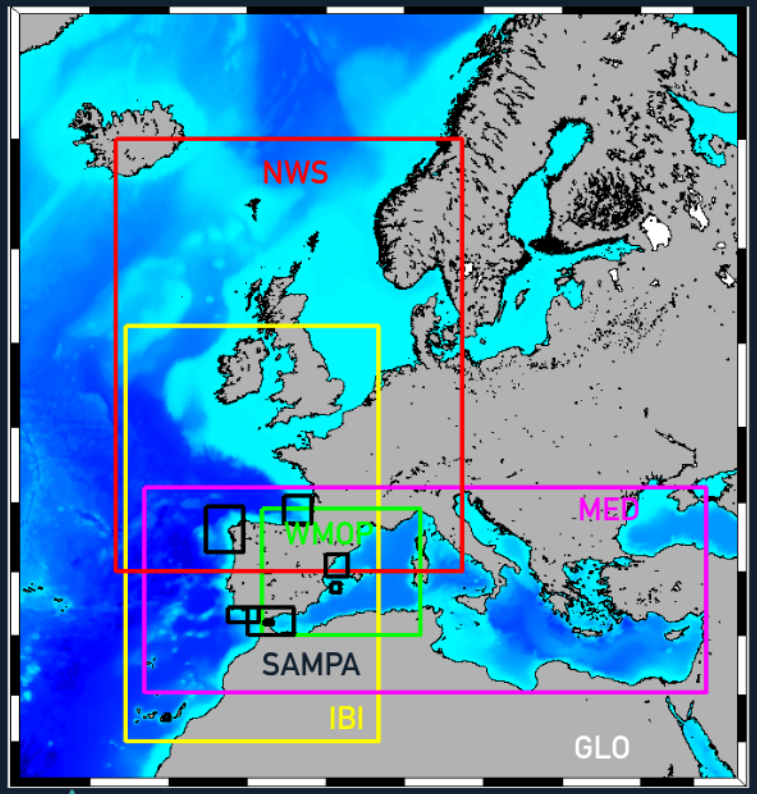
SOCIB

04 IBISAR: DATA USED

Ocean models

What? Current forecast

How? Target sources

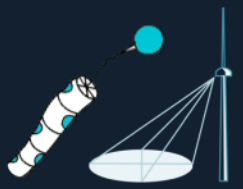


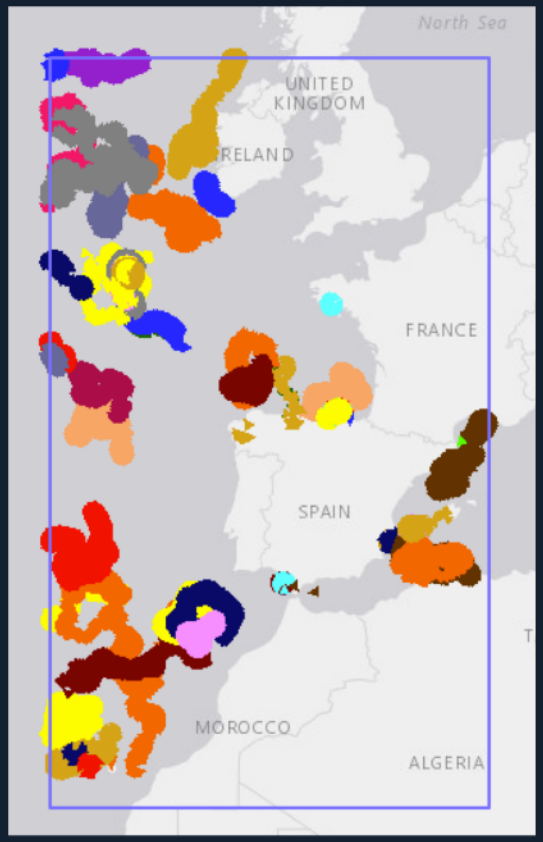
Ocean current forecast

In-Situ Data

What? Current surface observations

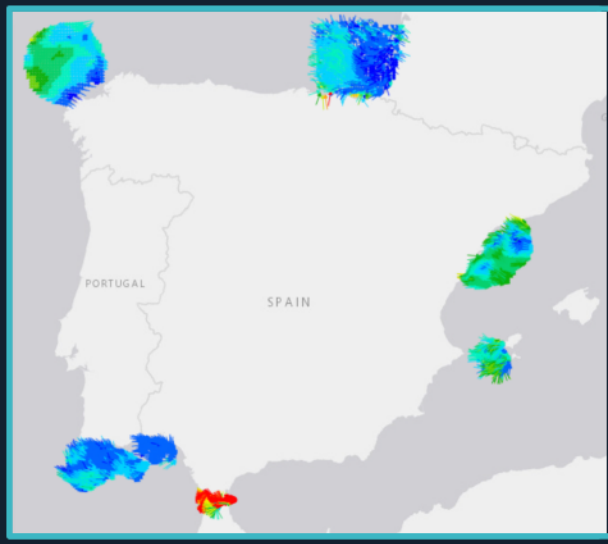
How? Reference source





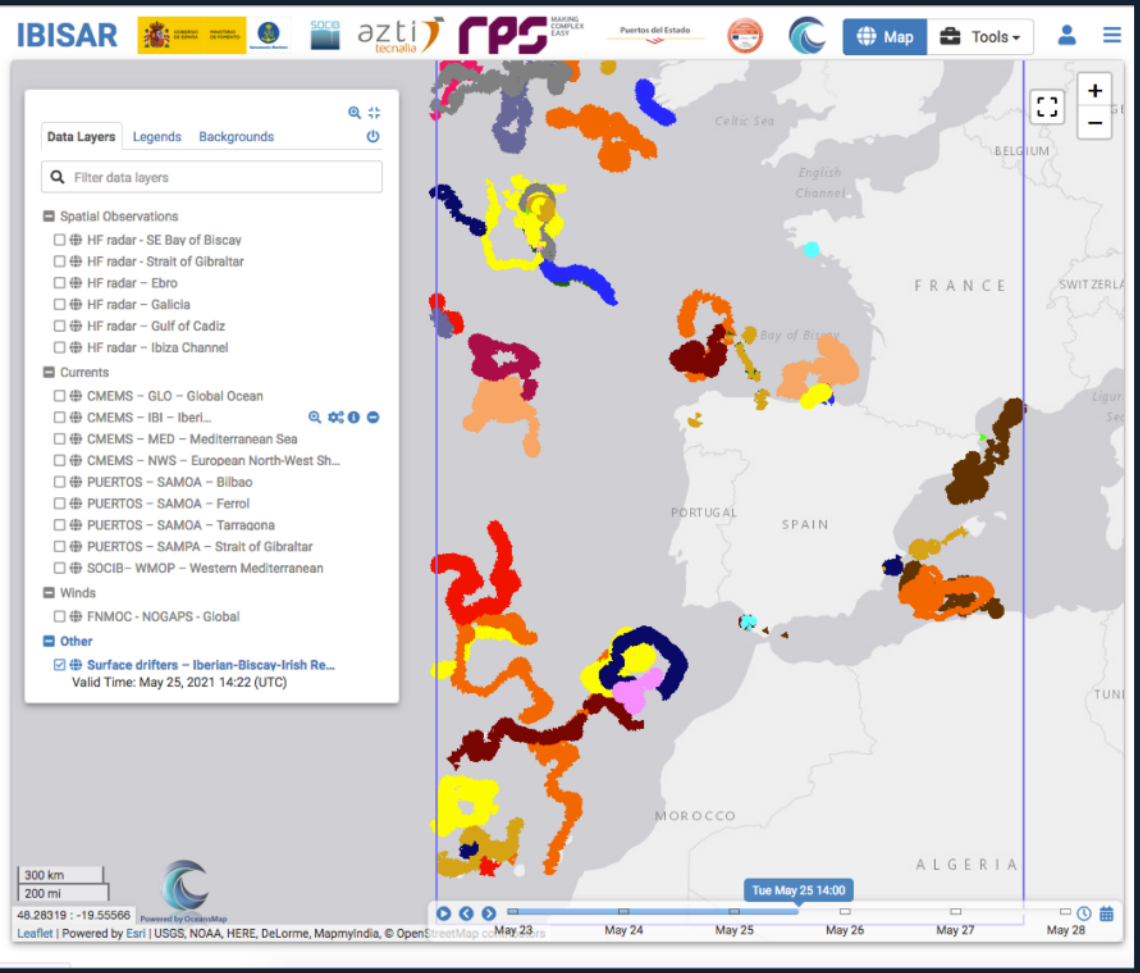
Drifter trajectories

HFR surface currents



04 IBISAR: DATA USED

Lack of drifters in coastal areas



IBISAR: drifters trajectories available (25/05/21)

CMEMS – IBI: number of drifters
www.marineinsitu.eu/monitoring/

04 IBISAR: DATA USED

Use of HFR-derived trajectories

frontiers in Marine Science

ORIGINAL RESEARCH
published: 29 March 2021
doi: 10.3389/fmars.2021.630388

Sensitivity of Skill Score Metric to Validate Lagrangian Simulations in Coastal Areas: Recommendations for Search and Rescue Applications

Adèle Révelard[1], Emma Reyes[1], Baptiste Mourre[1], Ismael Hernández-Carrasco[2], Anna Rubio[3], Pablo Lorente[4,5], Christian De Lera Fernández[6], Julien Mader[3], Enrique Álvarez-Fanjul[5] and Joaquin Tintoré[1,2]*

[1] SOCIB – Balearic Islands Coastal Ocean Observing and Forecasting System, Palma, Spain, [2] Instituto Mediterráneo de Estudios Avanzados, IMEDEA (CSIC-UIB), Esporles, Spain, [3] AZTI, Marine Research, Basque Research and Technology Alliance, Pasaia, Spain, [4] Nologin Consulting S.L., Zaragoza, Spain, [5] Puertos del Estado, Madrid, Spain, [6] Centro de Seguridad Marítima Integral Jovellanos, Salvamento Marítimo, Gijón, Spain

OPEN ACCESS

Edited by:
Hervé Claustre, Centre National de la Recherche Scientifique, France

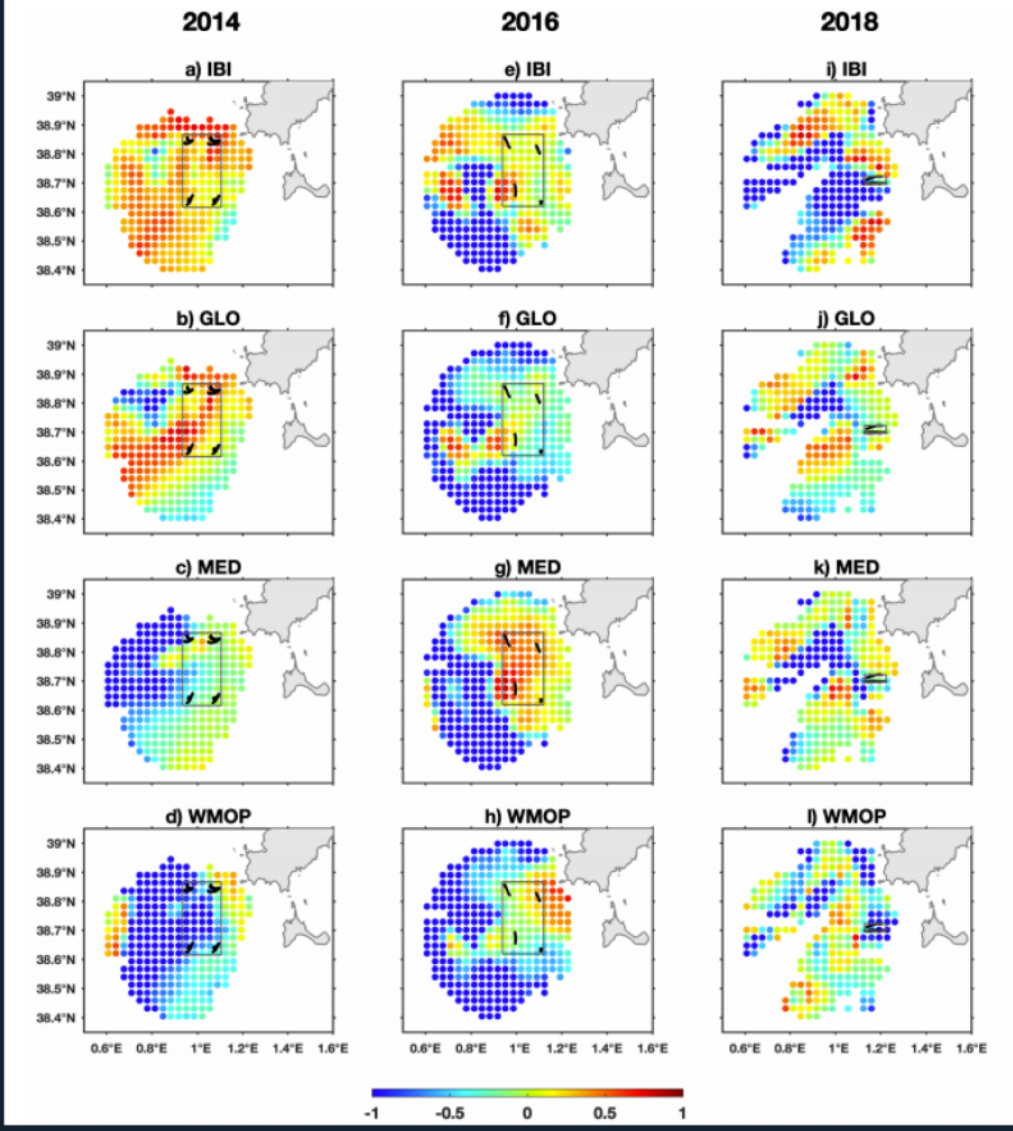
Reviewed by:
Erik Van Sebille, Utrecht University, Netherlands
Shane Elipot, University of Miami, United States
Tamay Ozgokmen, University of Miami, United States

***Correspondence:**
Adèle Révelard
arevelard@socib.es

Specialty section:
This article was submitted to Ocean Observation, a section of the journal Frontiers in Marine Science

Received: *17 November 2020*
Accepted: *15 February 2021*
Published: *29 March 2021*

Search and rescue (SAR) modeling applications, mostly based on Lagrangian tracking particle algorithms, rely on the accuracy of met-ocean forecast models. Skill assessment methods are therefore required to evaluate the performance of ocean models in predicting particle trajectories. The Skill Score (*SS*), based on the Normalized Cumulative Lagrangian Separation (NCLS) distance between simulated and satellite-tracked drifter trajectories, is a commonly used metric. However, its applicability in coastal areas, where most of the SAR incidents occur, is difficult and sometimes unfeasible, because of the high variability that characterizes the coastal dynamics and the lack of drifter observations. In this study, we assess the performance of four models available in the Ibiza Channel (Western Mediterranean Sea) and evaluate the applicability of the *SS* in such coastal risk-prone regions seeking for a functional implementation in the context of SAR operations. We analyze the *SS* sensitivity to different forecast horizons and examine the best way to quantify the average model performance, to avoid biased conclusions. Our results show that the *SS* increases with forecast time in most cases. At short forecast times (i.e., 6 h), the *SS* exhibits a much higher variability due to the short trajectory lengths observed compared to the separation distance obtained at



Révelard et al., 2021. Front. Mar. Sci.

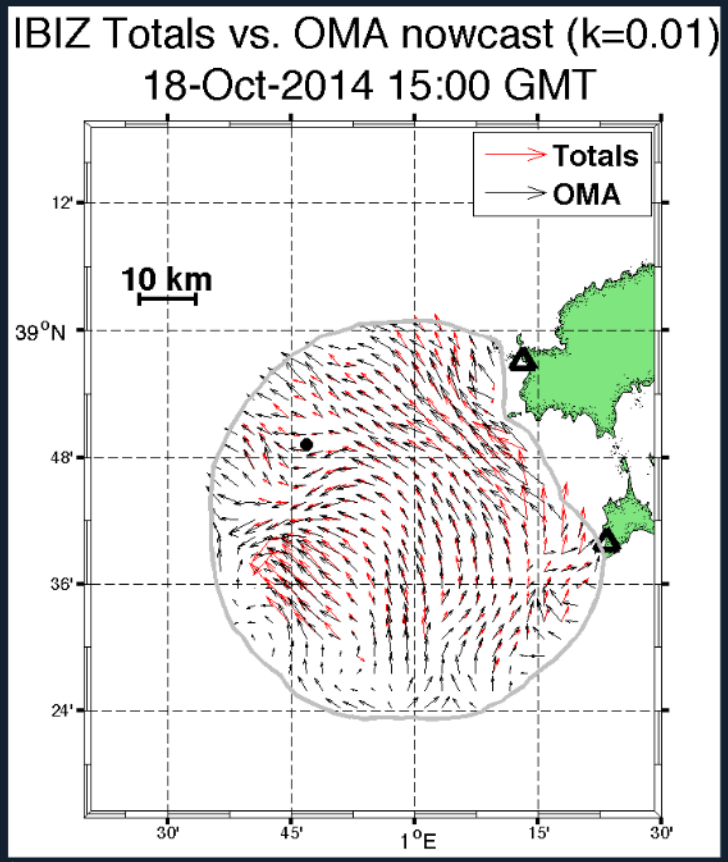
Model skill score (vs. HFR-derived trajectories)

SOCIB

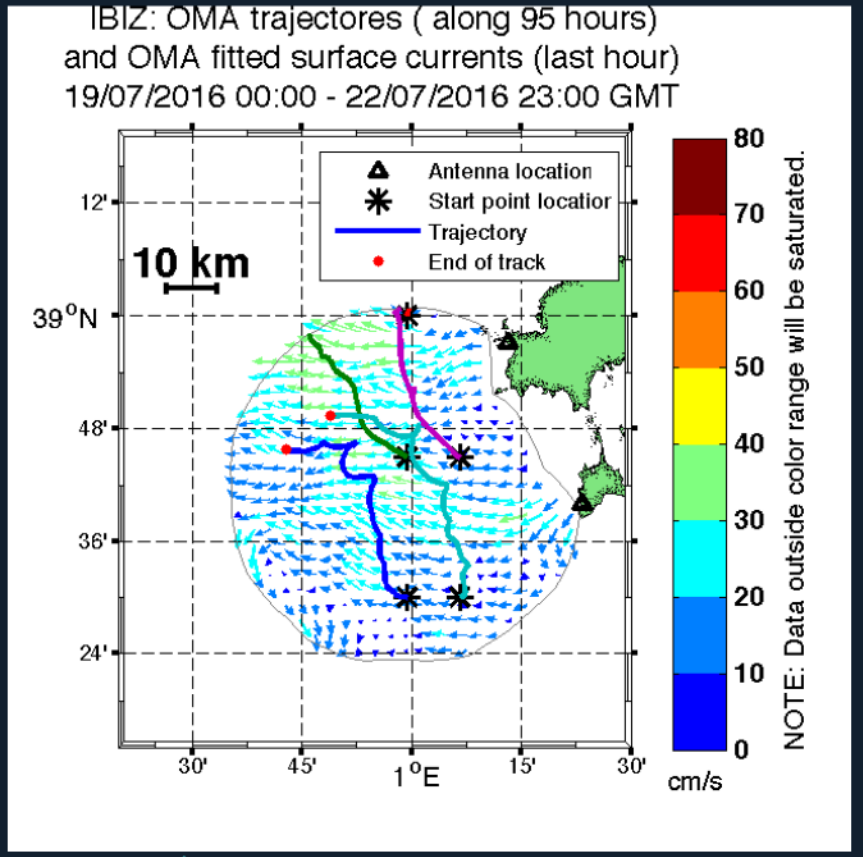
05 HF RADAR CURRENT GAP-FILLING

Open-boundary Modal Analysis (OMA) [Kaplan & Lekien, 2007]

- Obtain gap-free 2D surface currents from radials
- Gap-free needed for Lagrangian applications



Gap-free 2D surface currents

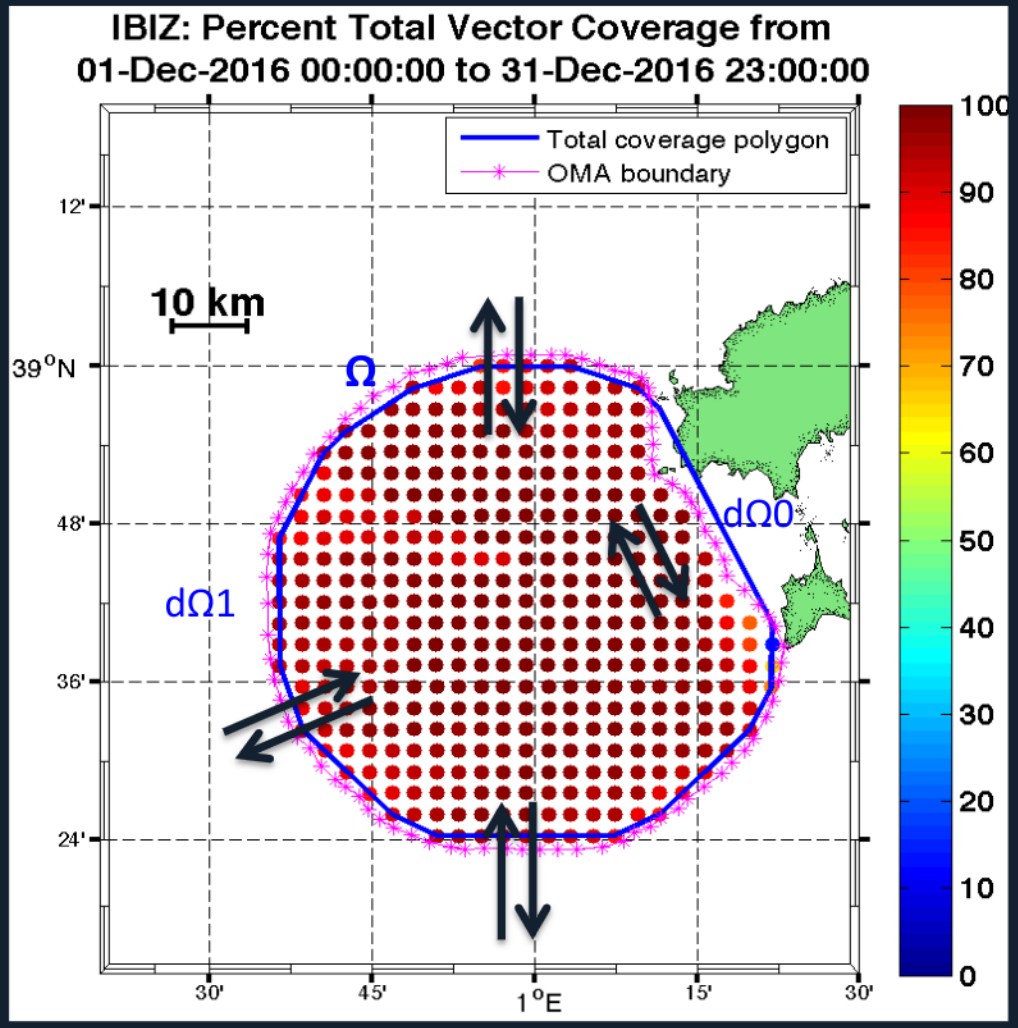


Lagrangian trajectories

SOCIB

05 HF RADAR CURRENT GAP-FILLING

OMA domain for spatial mode calculation



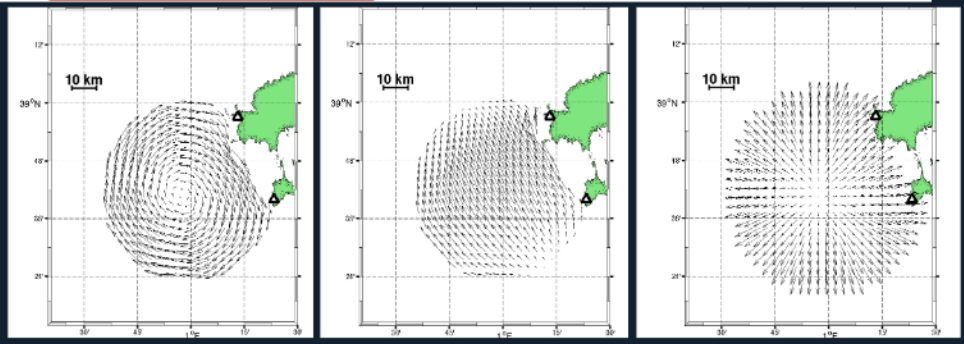
https://github.com/rowg/hfrprogs

Velocity OMA (Open-boundary Modal Analysis) nowcast

Incompressible Divergence-free	Irrotational Vorticity-free	Boundary

$$\bar{u} = \sum_{i=1}^{\infty} \alpha_i^{\psi} \nabla \times \psi_i \bar{k} + \sum_{i=1}^{\infty} \alpha_i^{\phi} \nabla \phi_i + \sum_{i=1}^{\infty} \alpha_i^{b} \nabla \phi_i^{b}.$$

Dirichlet *Neumann*

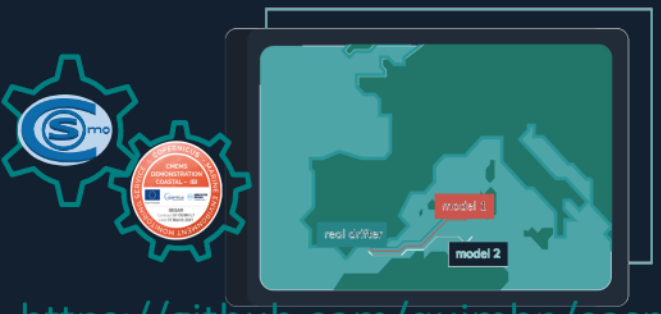


Velocity modes

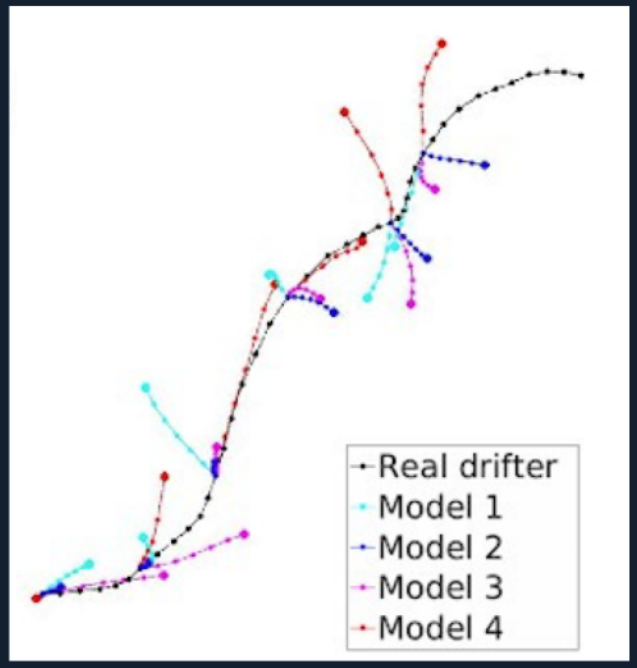
- Describe all possible patterns
- Only depend on the geometry
- Can be computed once
- Can be stored for real-time applications

06 IBISAR: HOW IT WORKS?

1.- Trajectory simulation



https://github.com/quimbp/cosmo.git



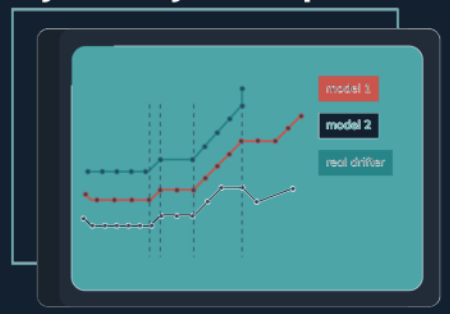
- Simulated trajectories

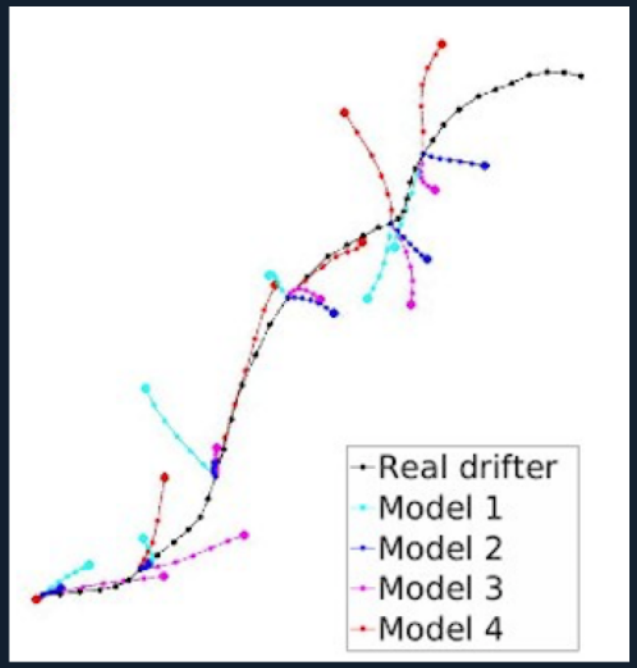
SOCIB

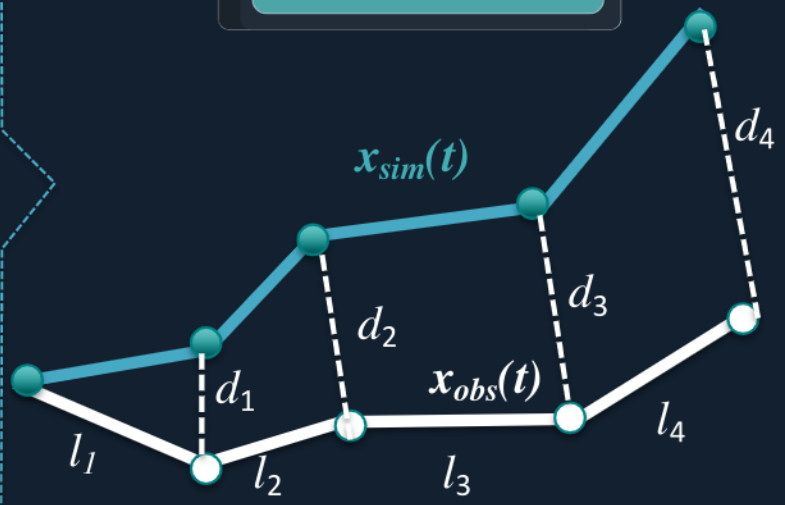
06 IBISAR: HOW IT WORKS?

1.- Trajectory simulation

2.- Trajectory comparison







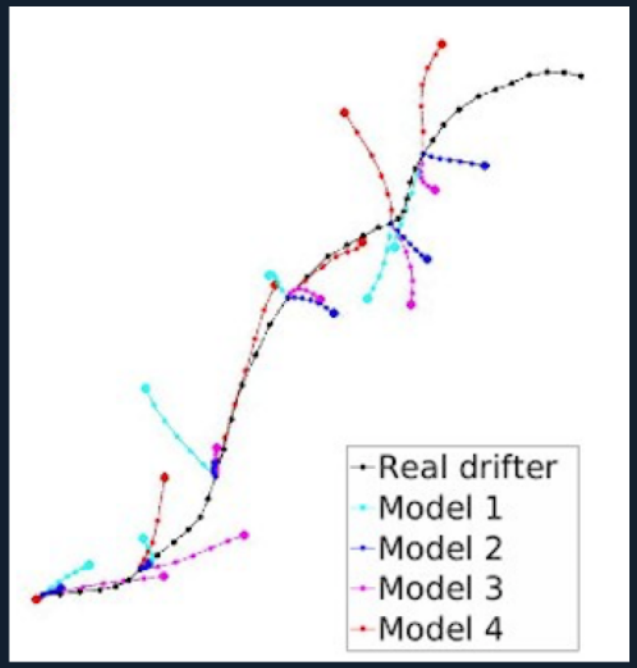
$$s = \frac{\sum_{i=1}^{N} d_i}{\sum_{i=1}^{N} l_i}; \qquad ss = \left\{ \begin{array}{ll} 1 - \frac{s}{n} & (s \le n) \\ 0, & (s > n) \end{array} \right\}; n = 1$$

- Simulated trajectories
- NCLS distance (Liu & Weisberg, 2011)

SOCIB

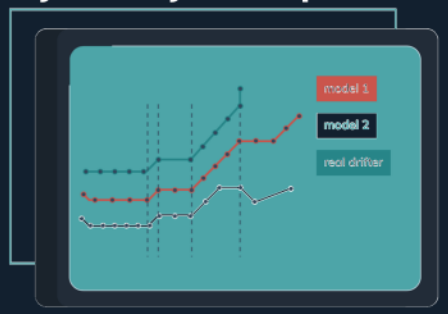
06 IBISAR: HOW IT WORKS?

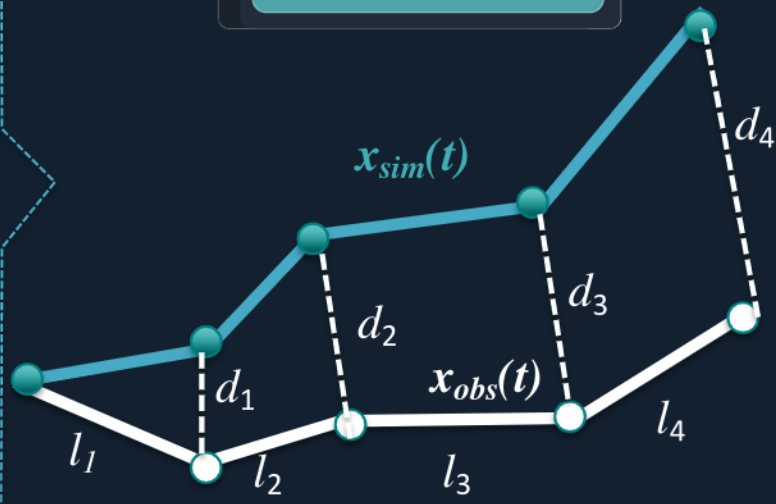
1.- Trajectory simulation



Simulated trajectories

2.- Trajectory comparison





$$s = \frac{\sum_{i=1}^{N} d_i}{\sum_{i=1}^{N} l_i}; \quad ss = \begin{cases} 1 - \frac{s}{n} & (s \le n) \\ 0, & (s > n) \end{cases}; n = 1$$

NCLS distance (Liu & Weisberg, 2011)

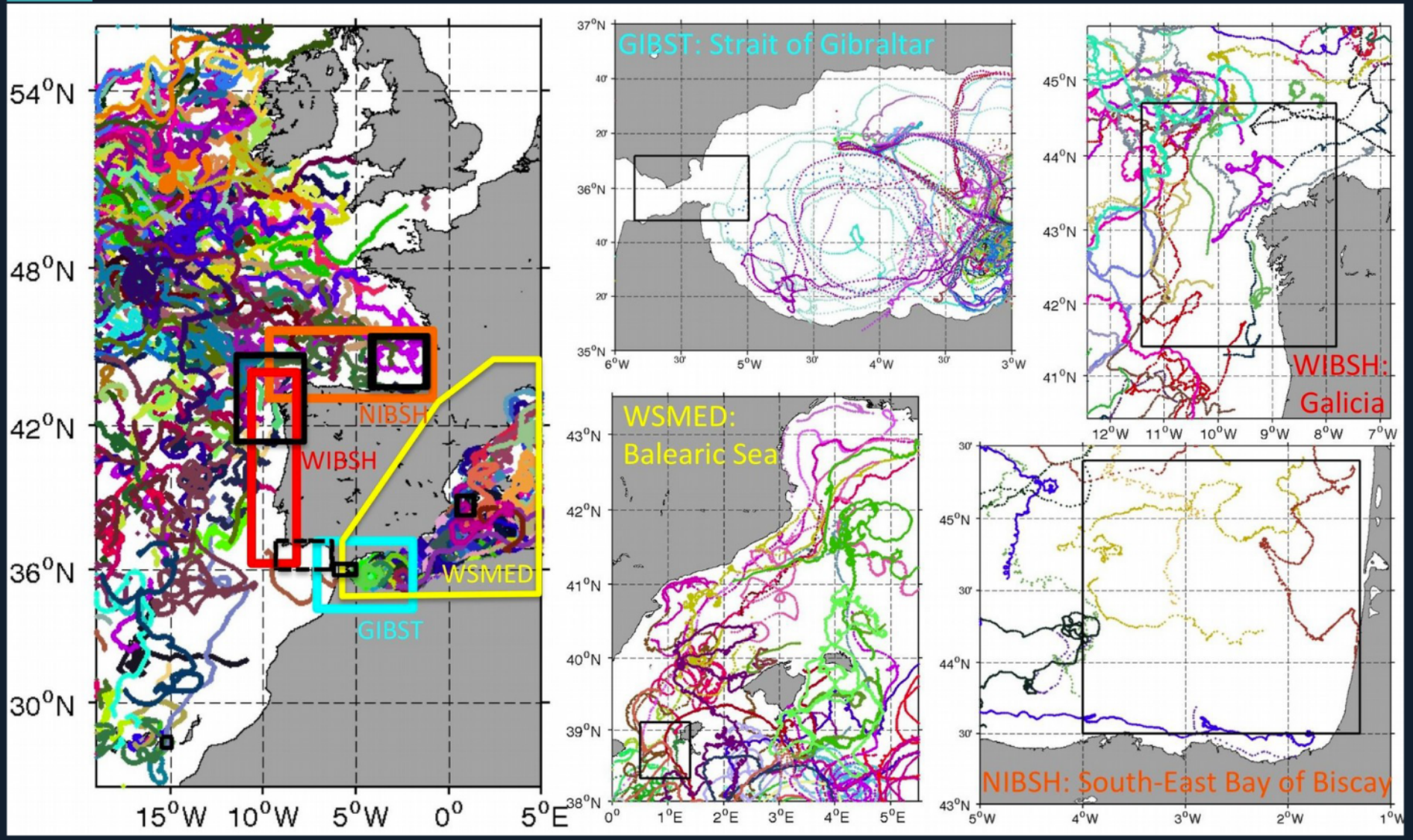
3.- Model ranking

User: Select area & period

Display/Update Skill Scores

Models	Skill Score
Model 3	0.74
Model 1	0.52
Model 2	0.28

07 IBISAR: VALIDATION RESULTS



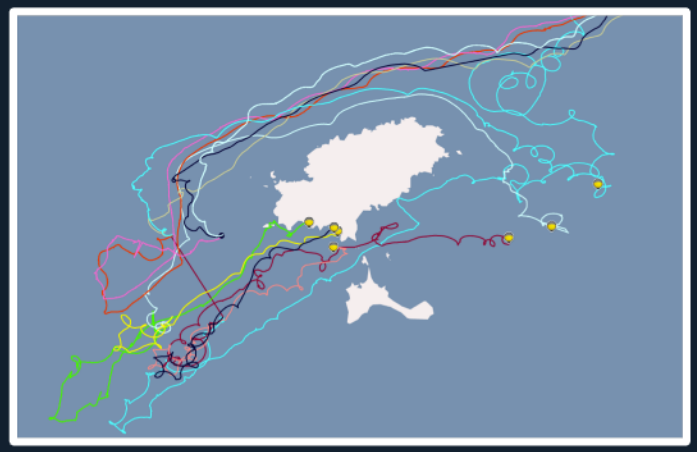
IBISAR methodology has been validated in 4 pilot areas using 144 drifters

SOCIB

07 RESULTS: IBIZA CHANNEL

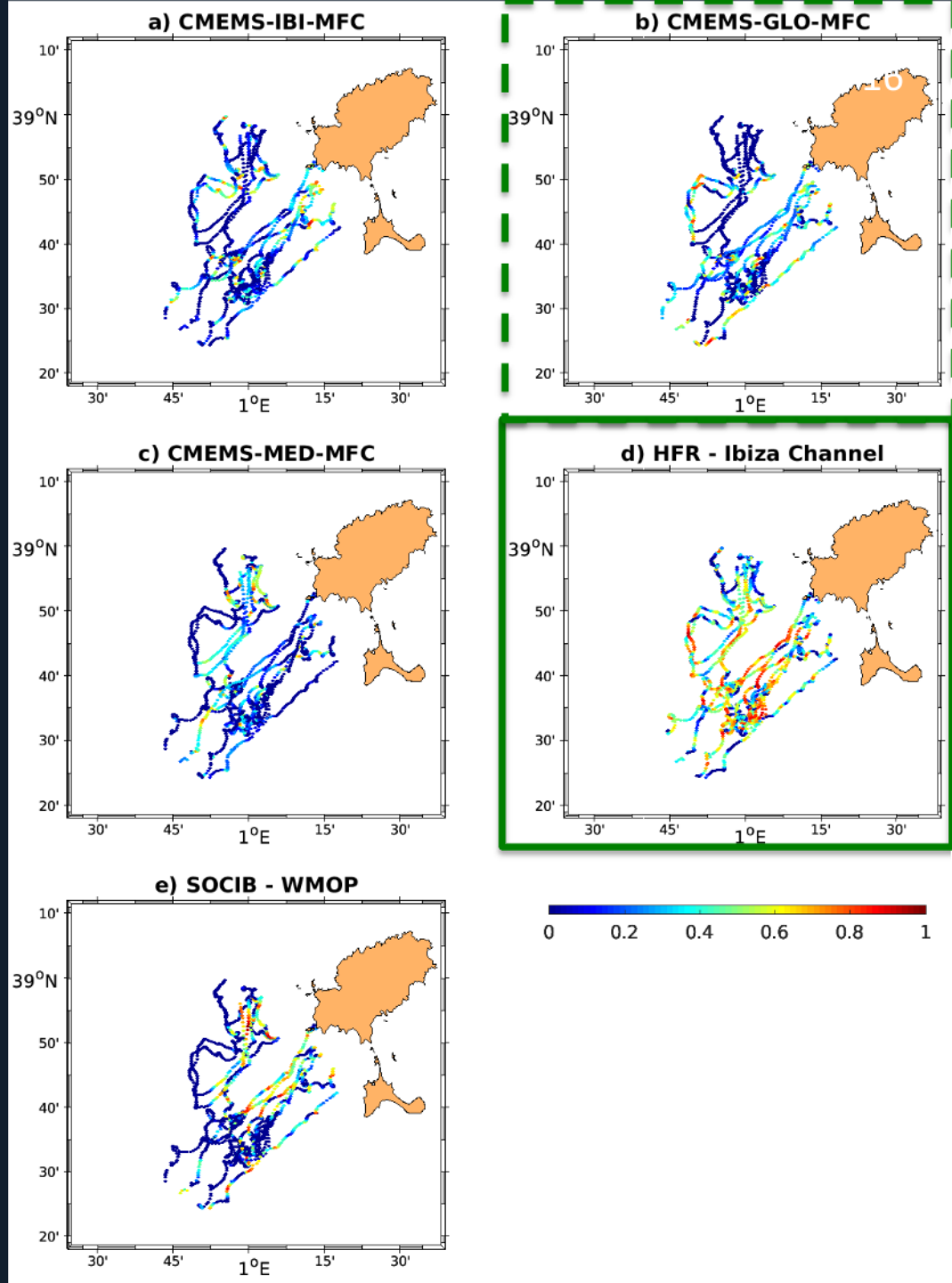
30 Sep-10 Oct 2014

- 13 drifter buoys
- 4 Ocean models:
  - 3 CMEMS models (IBI, MED, GLOBAL)
  - 1 regional model (WMOP)
- HFR Ibiza Channel



Dataset: https://doi.org/10.25704/MHBG-Q265

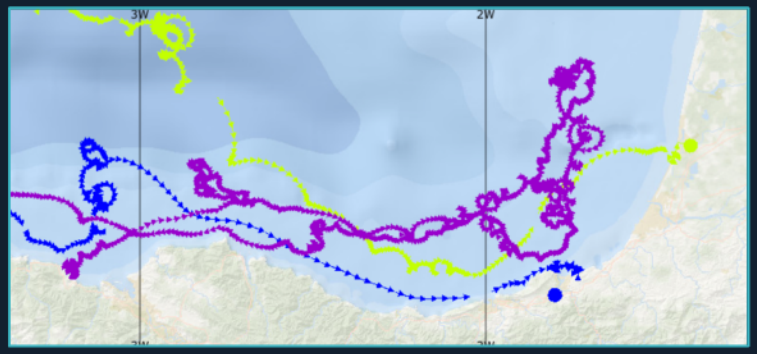
Spatial distribution of Skill Scores of models and HFR in the Ibiza Channel



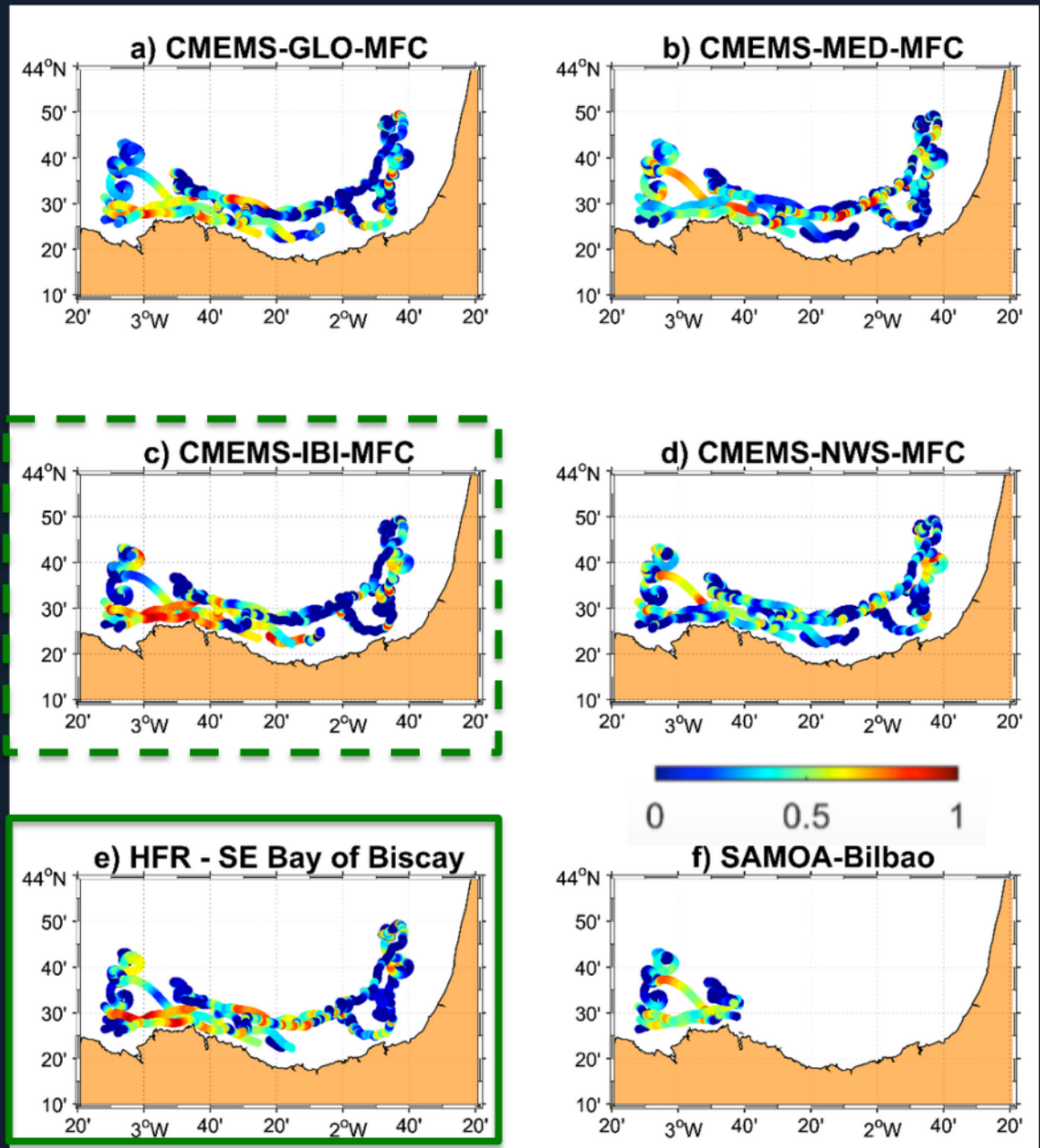
07 RESULTS: BAY OF BISCAY

17-19 Sep 2018
12-14 Feb 2019

- 5 drifter buoys: CMEMS & SASEMAR
- 5 Ocean models:
  - 4 CMEMS models (IBI, MED, GLOBAL, NWS)
  - 1 regional model (SAMOA-BIL)
- HFR Bay of Biscay (BoB)



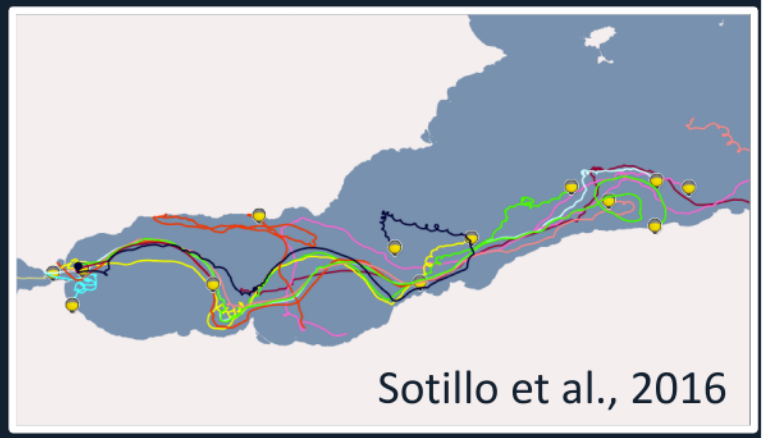
Spatial distribution of Skill Scores of models and HFR in the BoB



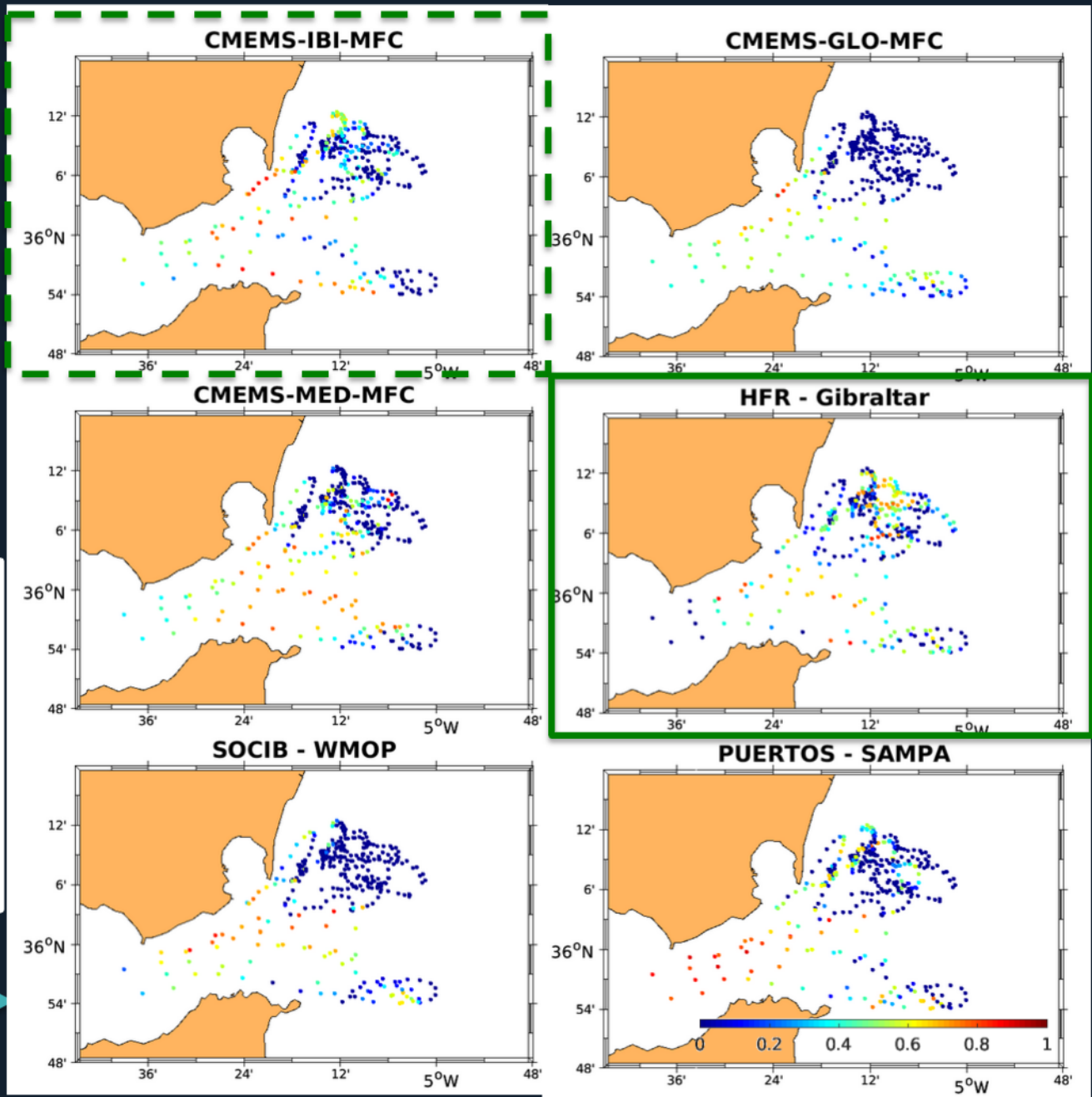
07 RESULTS: GIBRALTAR

9-13 Sep 2014

- 20 drifter buoys: MEDESS-GIB
- 5 Ocean models:
  - 3 CMEMS models (IBI, MED, GLOBAL)
  - 2 regional models (SOCIB-WMOP, PUERTOS-SAMPA)
- HFR Strait of Gibraltar (SoG)



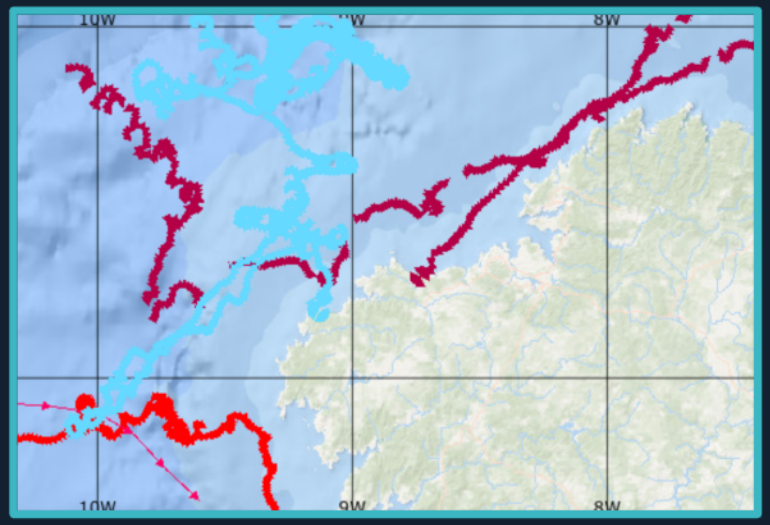
Spatial distribution of Skill Scores of models and HFR in the SoG



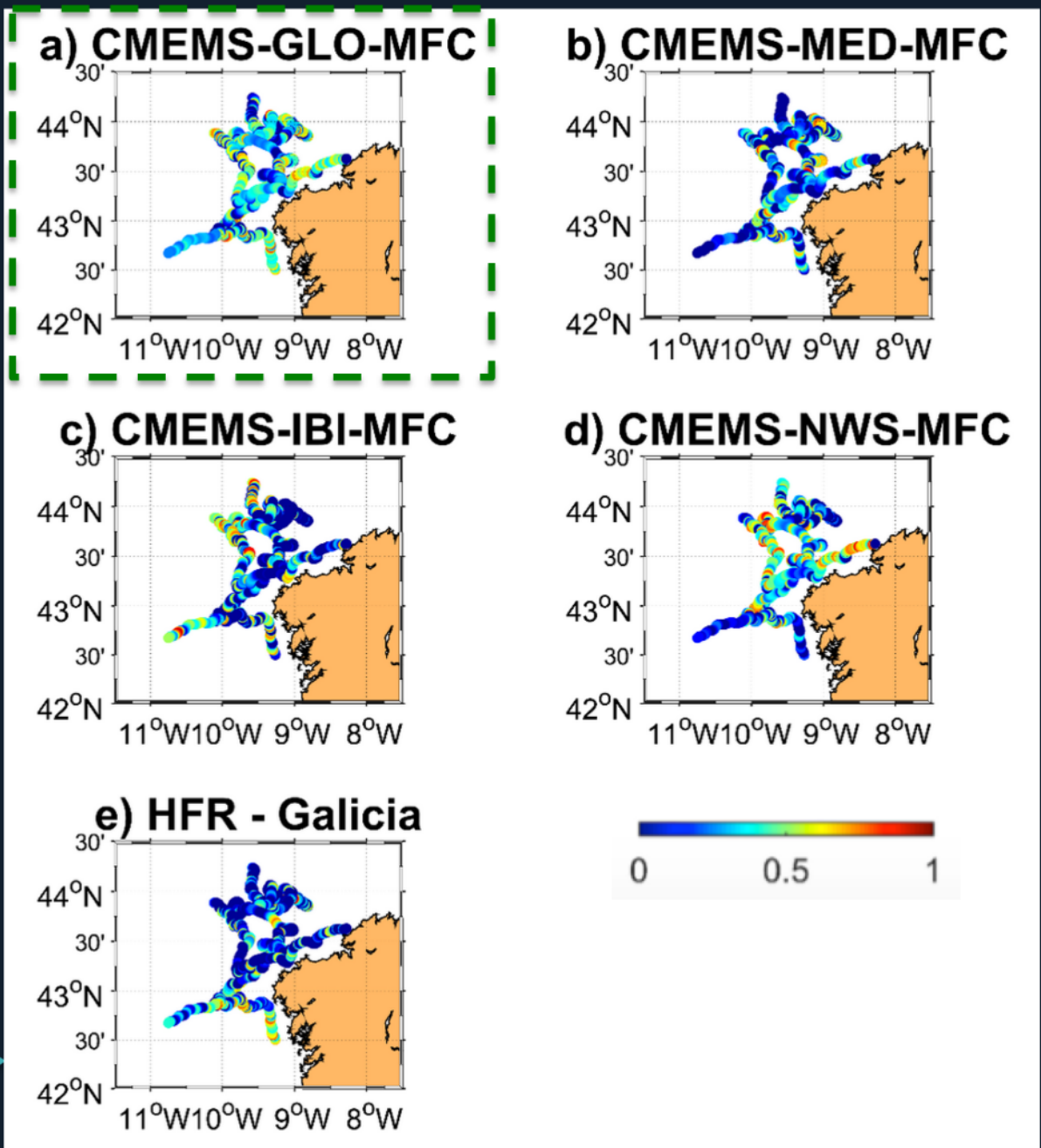
07 RESULTS: GALICIA

2018 and 2019

- 3 drifter buoys: CMEMS
- 5 Ocean models:
  - 4 CMEMS models (IBI, MED, GLOBAL, NWS)
- HFR Galicia

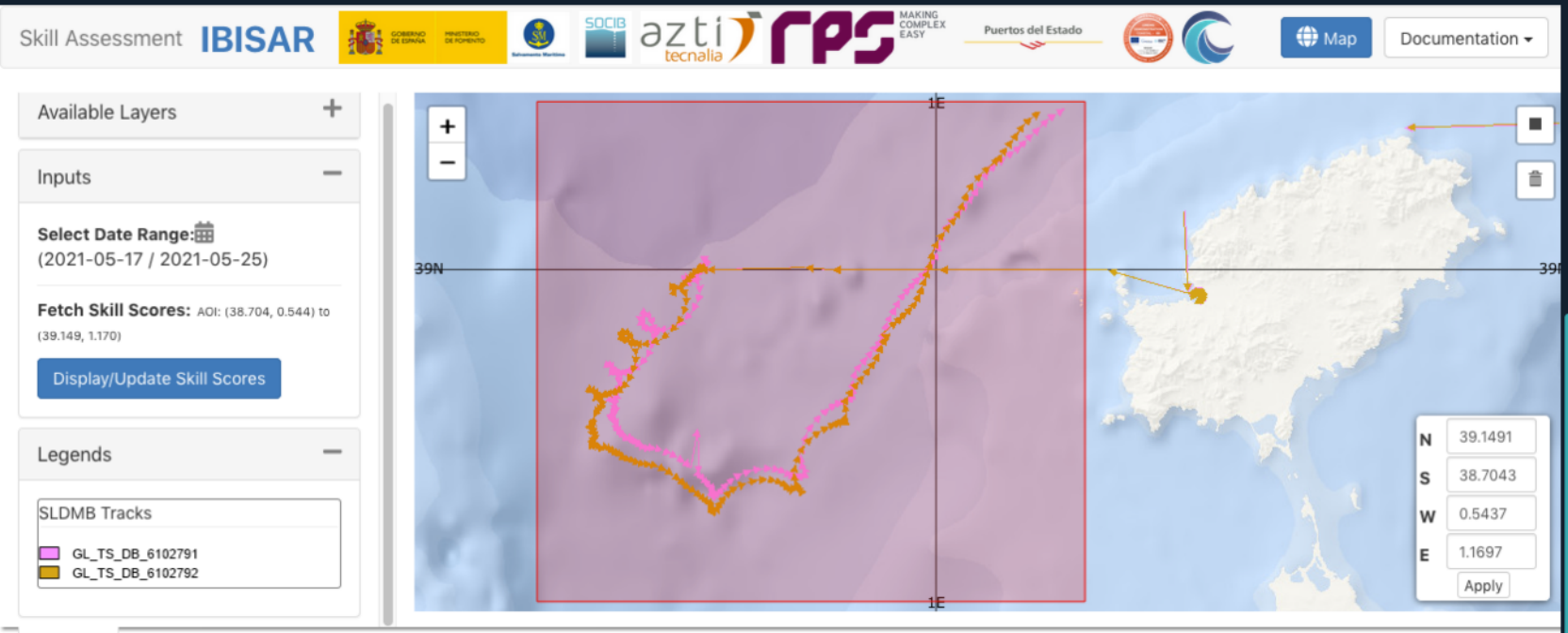


Spatial distribution of Skill Scores of models and HFR in Galicia



08 IBISAR: RECENT CASE STUDY

Drifters deployment during SOCIB's CANALES-SPRING 2021 oceanographic cruise



IBISAR skill assessment output

Export to CSV

Data from: **2021/05/17** to **2021/05/25**

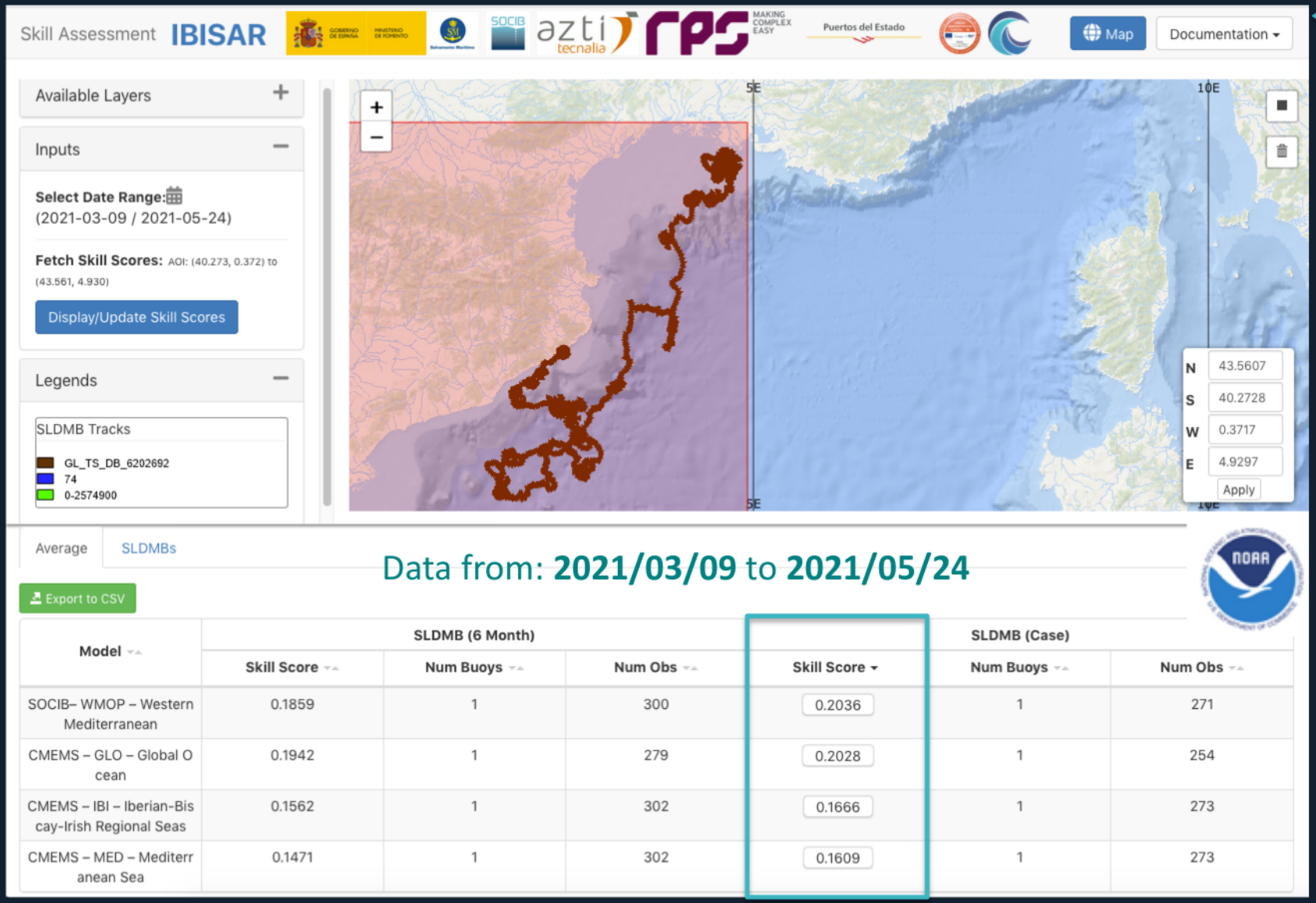
Model	SLDMB (6 Month)			SLDMB (Case)		
	Skill Score	Num Buoys	Num Obs	Skill Score	Num Buoys	Num Obs
HF radar – Ibiza Channel	0.1742	2	26	0.1742	2	26
CMEMS – GLO – Global Ocean	0.1139	2	44	0.1139	2	44
CMEMS – MED – Mediterranean Sea	0.0645	2	45	0.0645	2	45
CMEMS – IBI – Iberian-Biscay-Irish Regional Seas	0.0519	2	45	0.0519	2	45
SOCIB– WMOP – Western Mediterranean	0.0353	2	45	0.0353	2	45

Launching of 2 SVP-B drifters from the NOAA's Global Drifter Program

08 IBISAR: RECENT CASE STUDY

Drifter deployment in the Gulf of Lion

IBISAR skill assessment output



Model	SLDMB (6 Month)			SLDMB (Case)		
	Skill Score	Num Buoys	Num Obs	Skill Score	Num Buoys	Num Obs
SOCIB– WMOP – Western Mediterranean	0.1859	1	300	0.2036	1	271
CMEMS – GLO – Global Ocean	0.1942	1	279	0.2028	1	254
CMEMS – IBI – Iberian-Biscay-Irish Regional Seas	0.1562	1	302	0.1666	1	273
CMEMS – MED – Mediterranean Sea	0.1471	1	302	0.1609	1	273

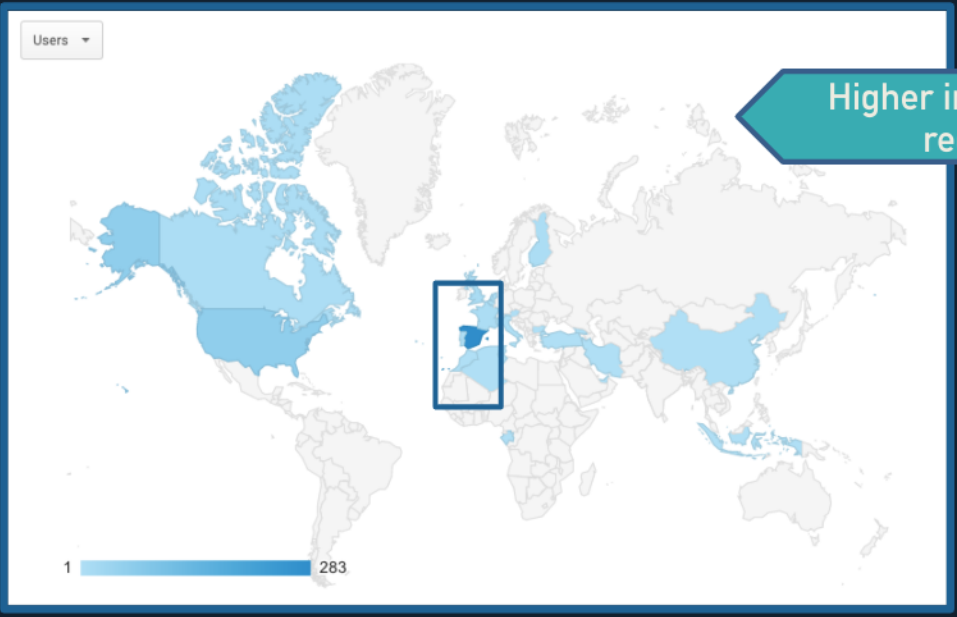
09 IBISAR: AUDIENCE METRICS – GEO LOCATION

Period (MAR19-MAY21)

IBISAR website

Global interest

IBISAR service

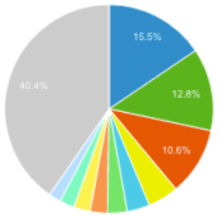


Higher in IBI region

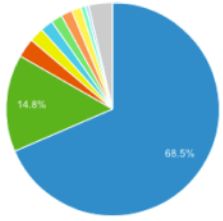
Spain on 3rd position

% users per country

		2,480 % of Total: 100.00% (2,480)	2,480 % of Total: 100.00% (2,480)
1.	United States	386	15.55%
2.	China	318	12.81%
3.	Spain	263	10.59%
4.	France	118	4.75%
5.	India	87	3.50%
6.	United Kingdom	76	3.06%
7.	(not set)	66	2.66%
8.	Germany	63	2.54%
9.	Japan	57	2.30%
10.	Nigeria	47	1.89%



		407 % of Total: 100.00% (407)	407 % of Total: 100.00% (407)
1.	Spain	283	68.52%
2.	United States	61	14.77%
3.	United Kingdom	12	2.91%
4.	Netherlands	9	2.18%
5.	France	8	1.94%
6.	Canada	7	1.69%
7.	Finland	7	1.69%
8.	Belgium	6	1.45%
9.	Austria	3	0.73%
10.	Georgia	2	0.48%

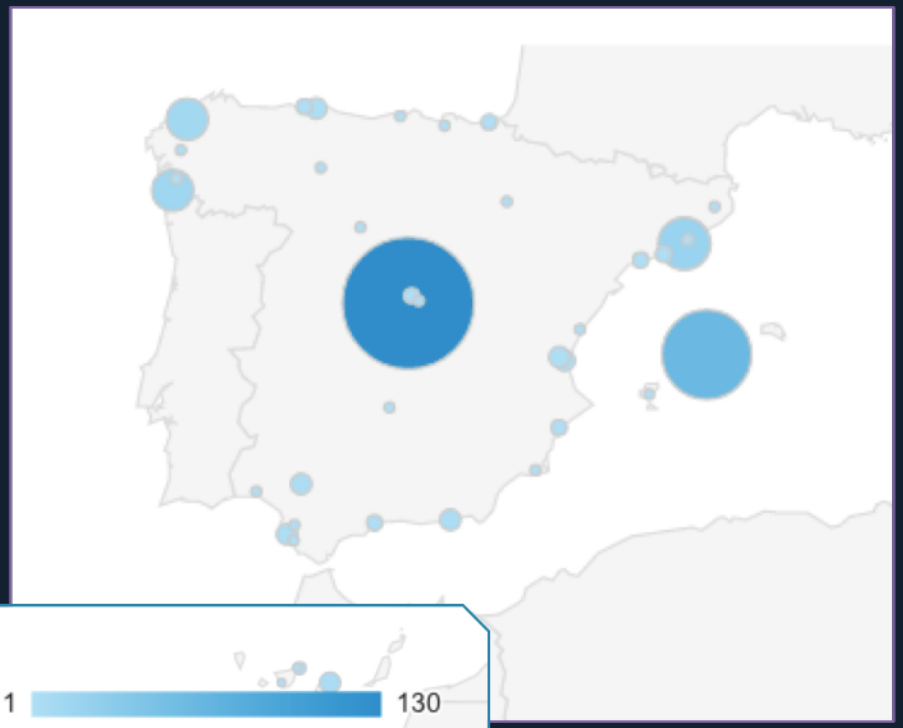


Highest audience from Spain

09 IBISAR: AUDIENCE METRICS – GEO LOCATION IN SPAIN

Perfect match between the geographic distribution of the:

IBISAR service users in Spain



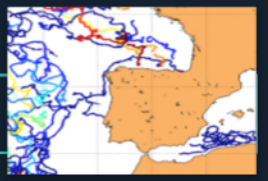
19 + 1 national MRCCs from SASEMAR

MRCC = Maritime Rescue Coordination Centres

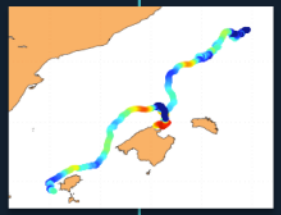
SOCIB

10 CONCLUSIONS

SAR Operators needs data confidence



Lack of drifters in coastal prone-risk areas



SA results in the pilot areas

- GLO model is able to reproduce the intense mesoscale activity
- Downscaling in needed to reproduce submesoscale patterns
- Skill Score is strongly region-dependant and scenario-specific
- HFR offers the highest performance in most scenarios
- HFR performance decreases in the baseline and domain outer-edges

HFR simulated trajectories for backtracking and forecast

- operational gap-filled HFR currents needed
- short-term predictions needed

IBISAR complements the decision-support tools

* User-friendly service
* Improve SAR and pollution control operations

SOCIB

ACKNOWLEDGEMENTS

Puertos del Estado

Spanish Port System

GOBIERNO DE ESPAÑA · MINISTERIO DE FOMENTO · Salvamento Marítimo

Spanish Maritime Safety and Rescue Agency

COSMO Project (CSIC-ICM)

INCREASE (Copernicus Marine Service – Service Evolution)

IBISAR (Copernicus Marine Service – User Uptake)

Copernicus Marine Service – INSTAC –phase2

THANKS FOR YOUR ATTENTION

SOCIB Balearic Islands Coastal Observing and Forecasting System