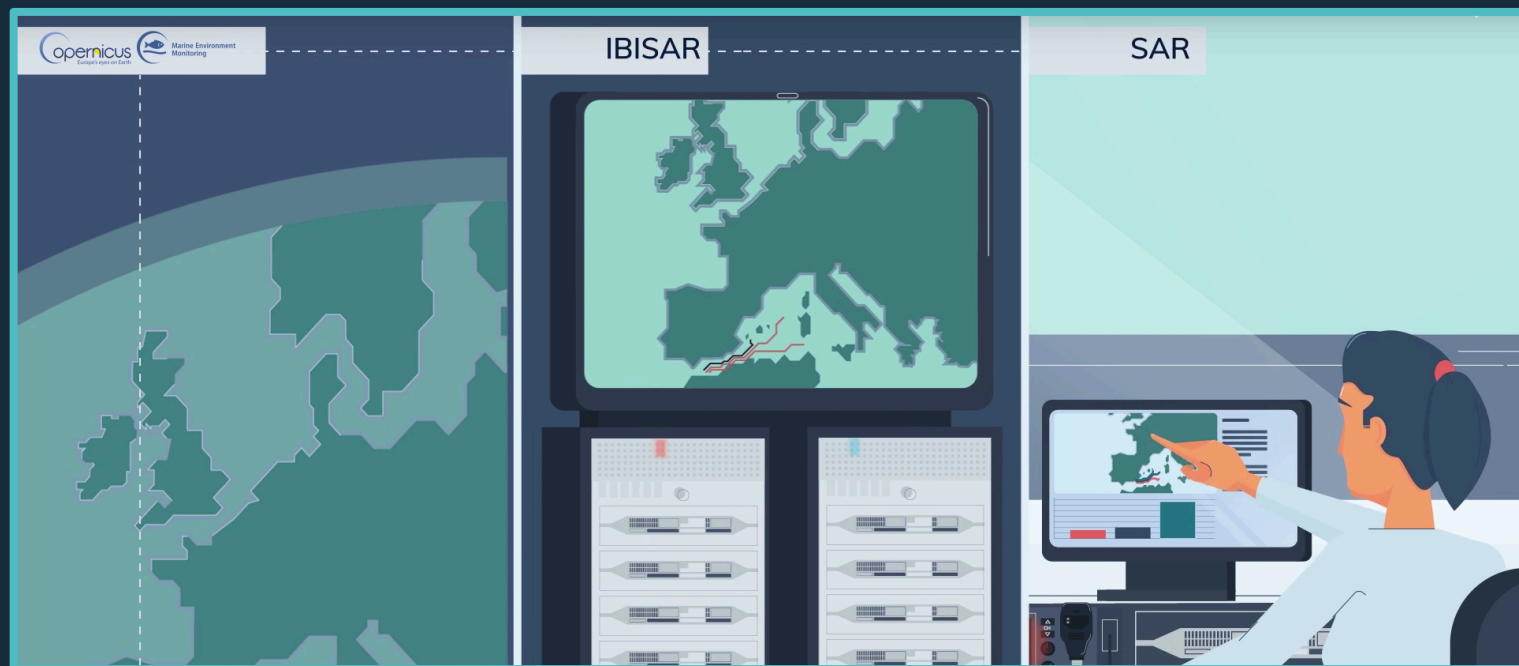


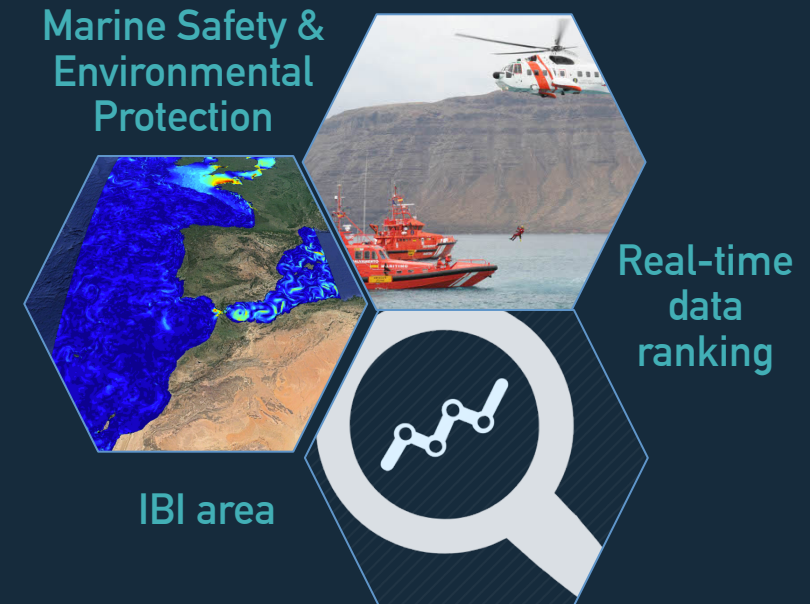
IBISAR downstream service:

Lagrangian assessment of CMEMS and regional model products supporting emergency decision-making at sea

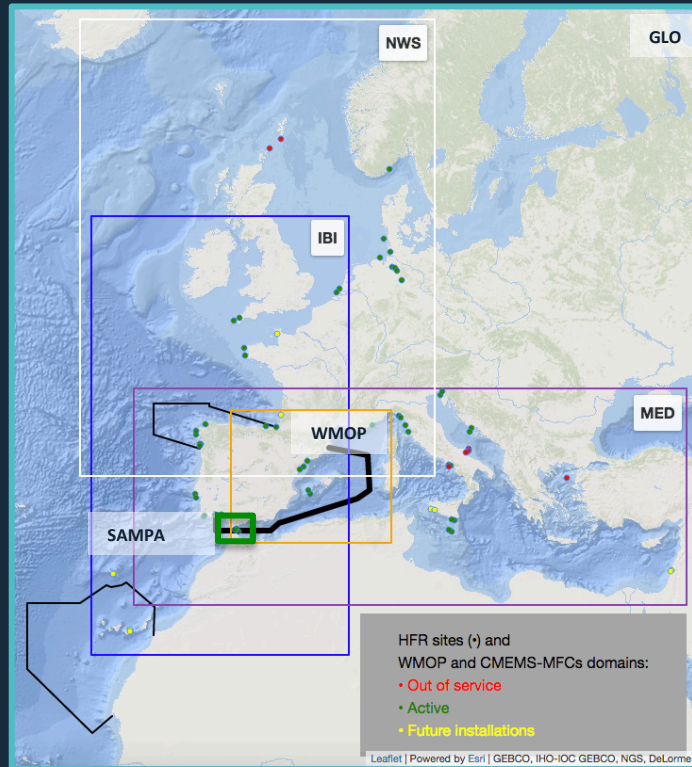


Emma Reyes, I. Hernández-Carrasco, A. Révelard, B. Mourre, P. Rotllán, E. Comerma,
T. Tajalli-Bakhsh, A. Rubio, J. Mader, L. Ferrer, C. de Lera Fernández, E. Álvarez-Fanjul, J. Tintoré

- 01 IBISAR: motivation
- 02 IBISAR: service overview
- 03 IBISAR: accurate data in 3 steps
- 04 IBISAR: skill assessment methodology
- 05 IBISAR: skill assessment results
- 06 IBISAR: skill assessment functionality
- 07 Conclusions



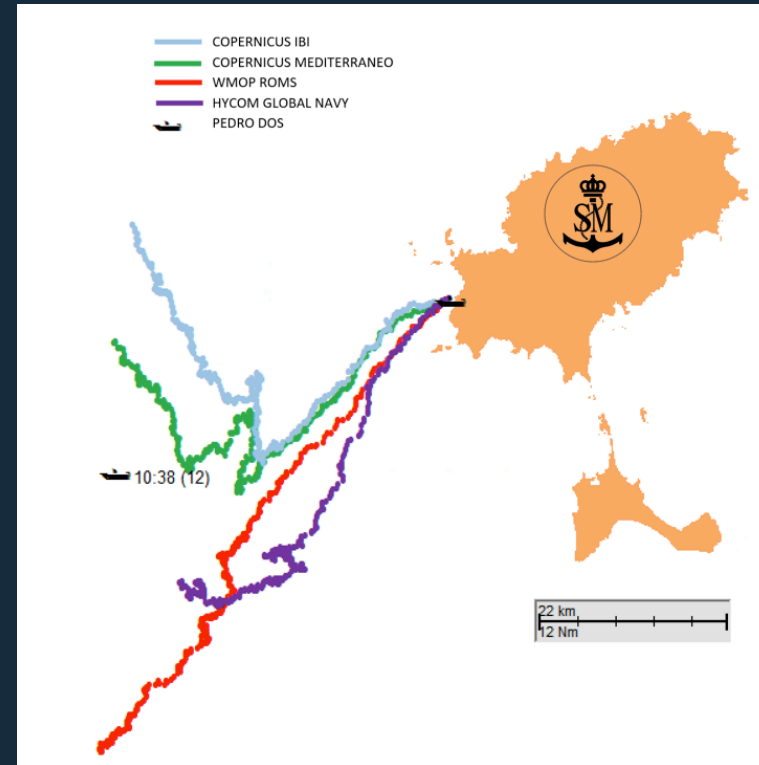
Copernicus Marine Service products are crucial...



Map showing CMEMS-MFC models overlapping in the IBI region and SAR areas

...to support Marine Safety & Environmental Protection

End-users overarching concern: Impact of inaccurate data on decision-making



Simulated trajectories from different models: drifting motorboat "Pedro II"

SAR operators need data confidence

How can we improve emergency response at sea?



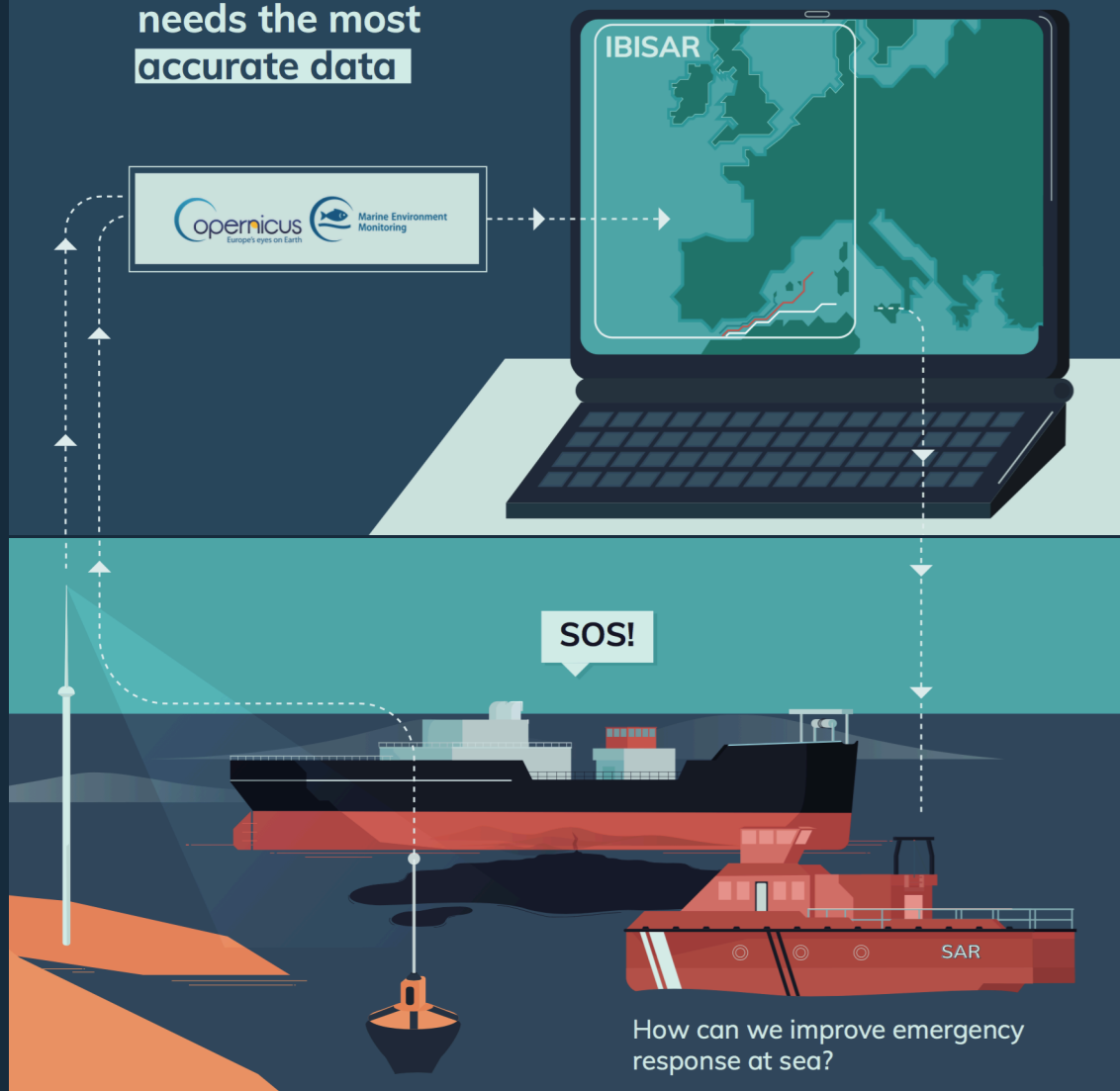
End-users needs

Reliable current observations and forecasting are essential

Easily interpretable metrics

User-friendly automated skill assessment

Effective response
needs the most
accurate data



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**

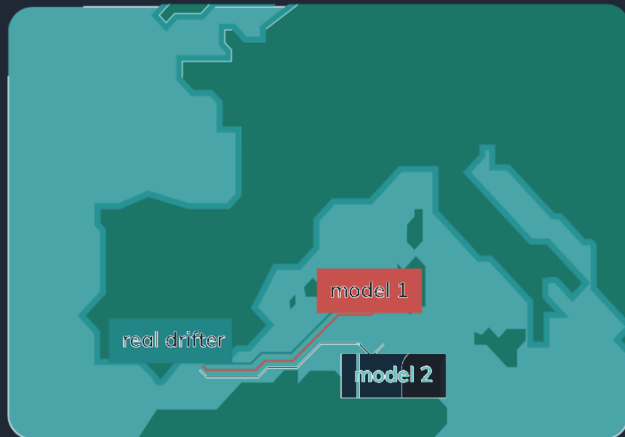
03 IBISAR: ACCURATE DATA IN 3 STEPS



1.- *Simulates* trajectories using available forecast models



03 IBISAR: ACCURATE DATA IN 3 STEPS



1.- Simulates trajectories using available forecast models



2.- Compares simulated trajectories vs. real drifters

03 IBISAR: ACCURATE DATA IN 3 STEPS

1.- Simulates trajectories using available forecast models



2.- Compares simulated trajectories vs. real drifters

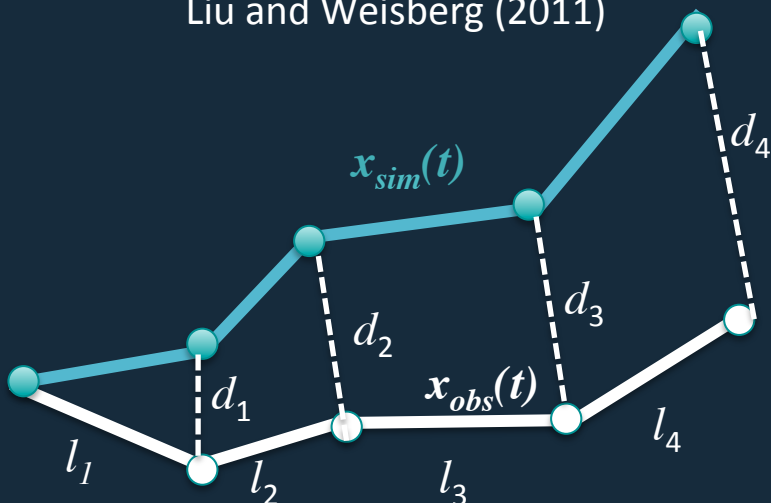
3.- Ranks models based on their performance



Skill Score definition

Normalized cumulative Lagrangian separation distances

Liu and Weisberg (2011)

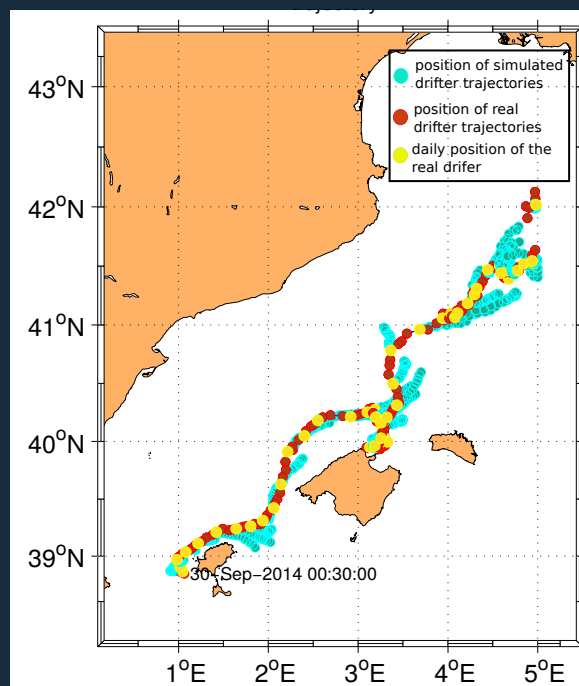


$$s = \frac{\sum_{i=1}^N d_i}{\sum_{i=1}^N l_i}; \quad SS = \begin{cases} 1 - \frac{s}{n} & (s \leq n) \\ 0, & (s > n) \end{cases}; n = 1$$

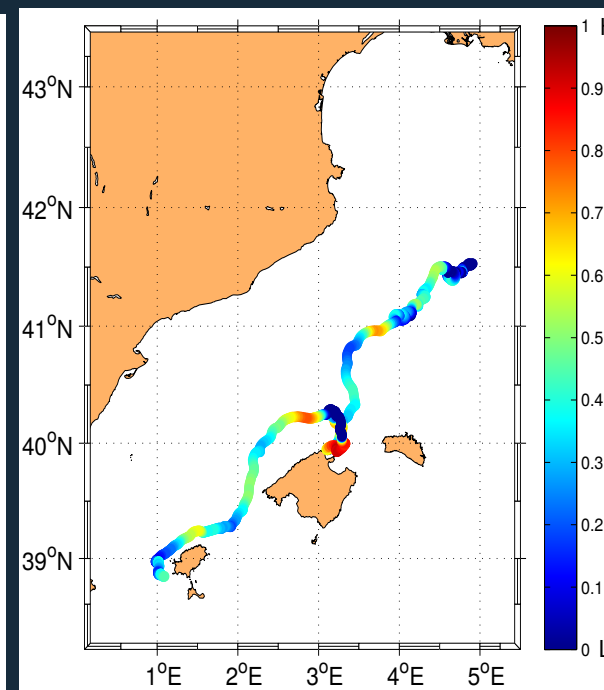
Lagrangian Trajectory-based
non-dimensional index

Trajectory model performance evaluation

CMEMS IBI MFC simulated vs. CODE drifter trajectories



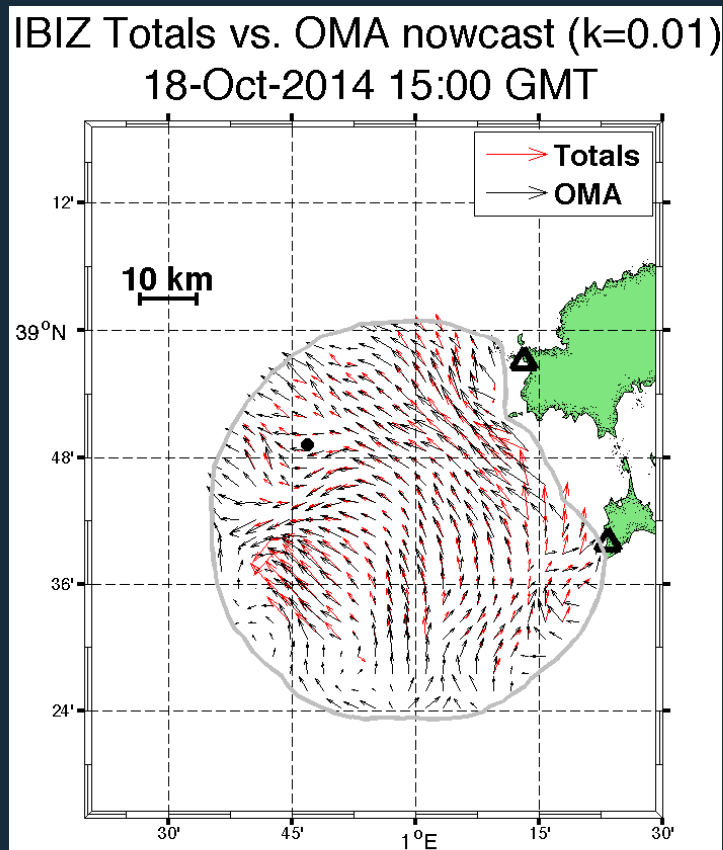
CMEMS IBI-MFC Skill Score (72 hours)



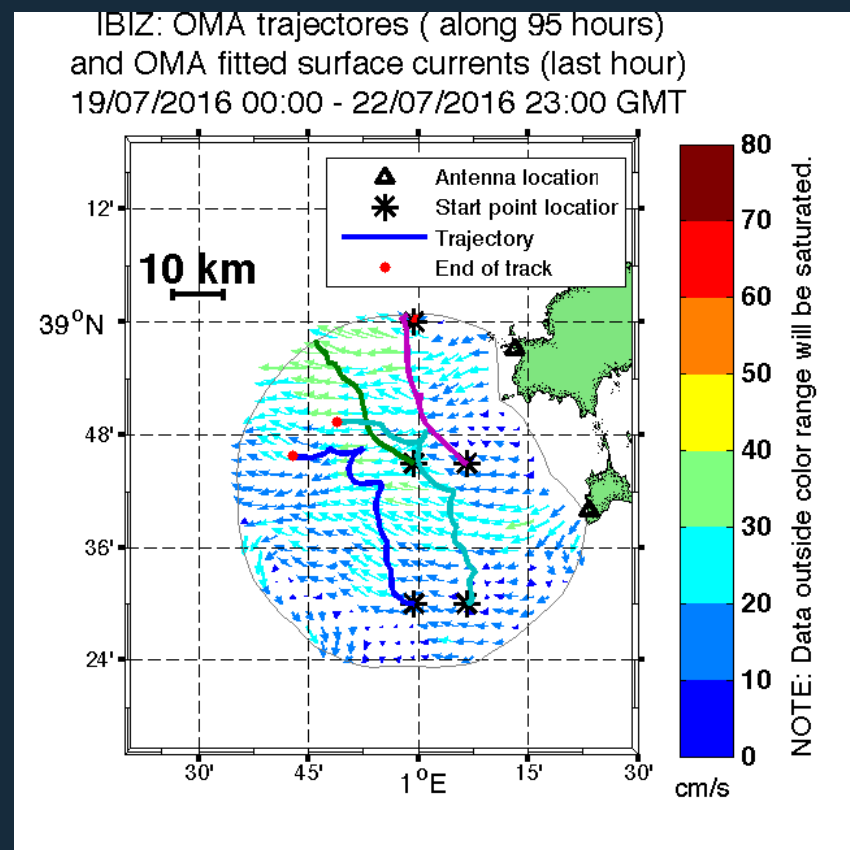
SS = 1 => perfect fit

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

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



▲ Gap-free 2D surface currents



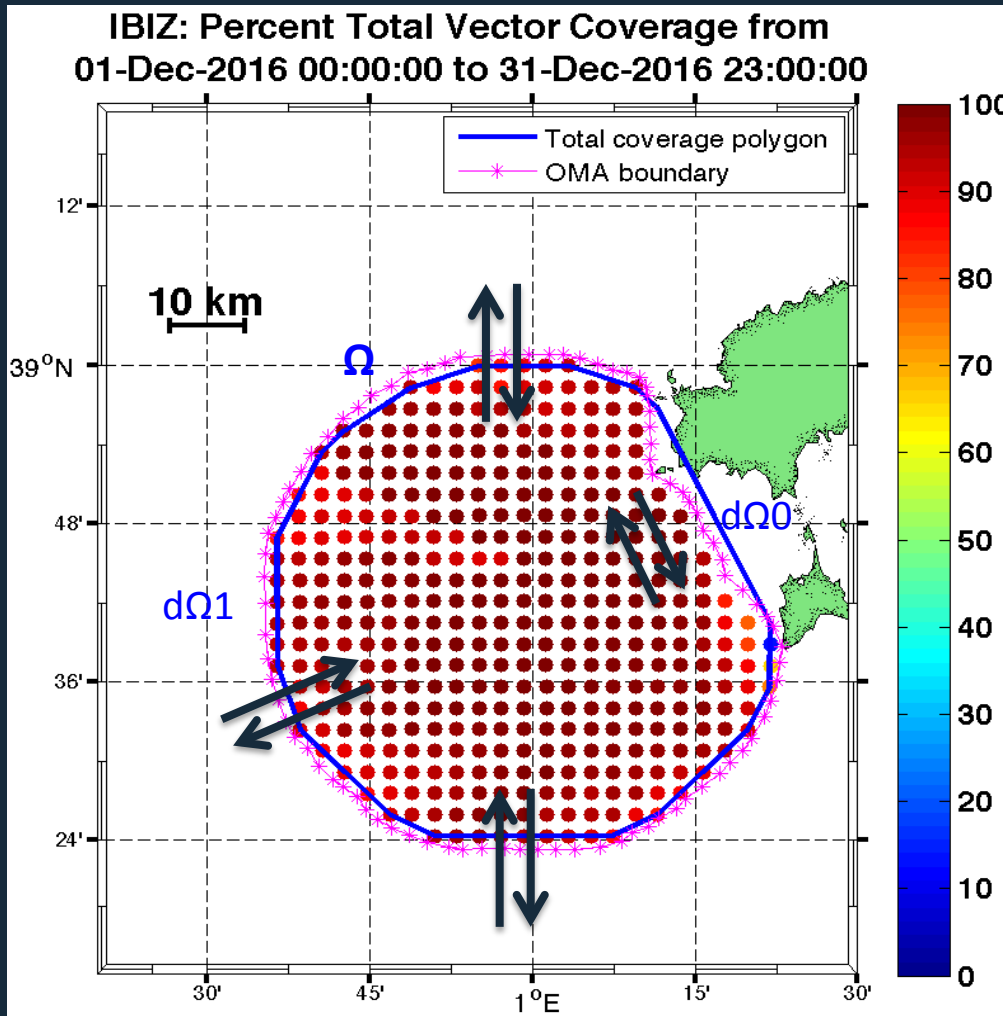
▲ Lagrangian trajectories

05

IBISAR: SA METHODOLOGY

PREVIOUS STEPS FOR HFR DATASETS

Data filled in the domain



Velocity OMA (Open-boundary Modal Analysis) nowcast

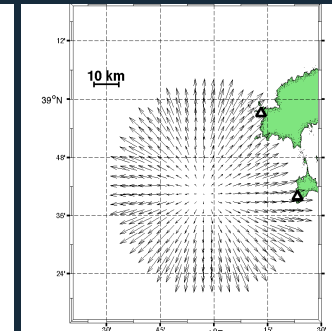
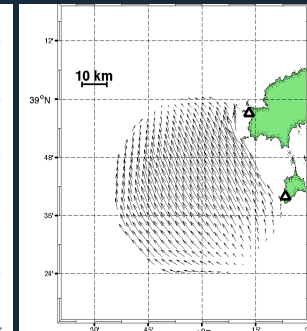
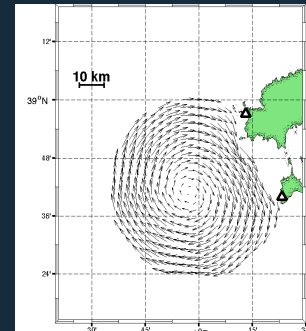
Incompressible
Divergence-free

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*



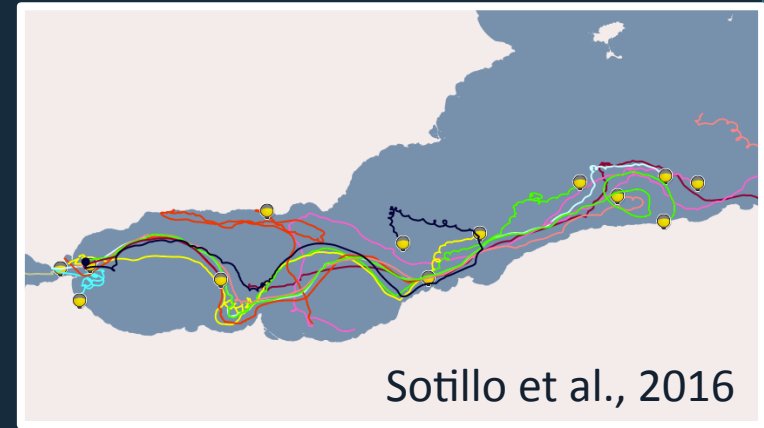
Velocity modes

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

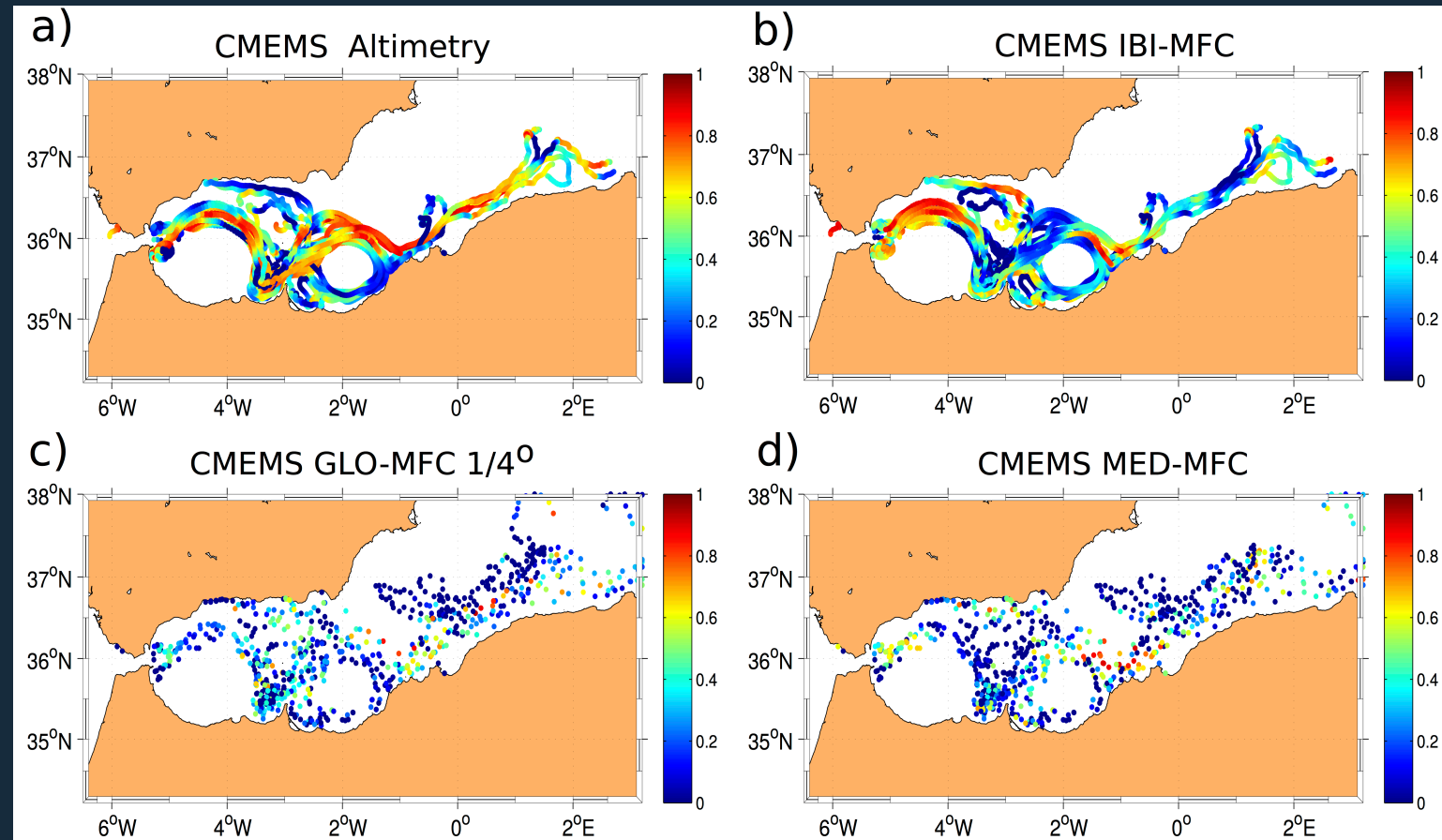
06 IBISAR: SA RESULTS - GIBST

MEDESS-GIB deployment plan: Sep-Oct 2014

- 35 drifters buoys: mostly CODE type
- Ocean models:
 - 3 CMEMS models: IBI, GLOBAL 1/4, MED
- Altimetry

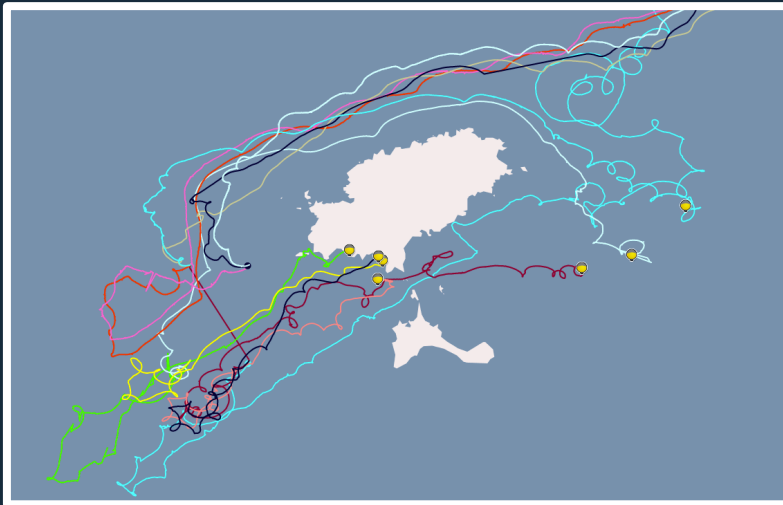


Spatial distribution of
Skill Scores in GIBST
(IBI sub-region)



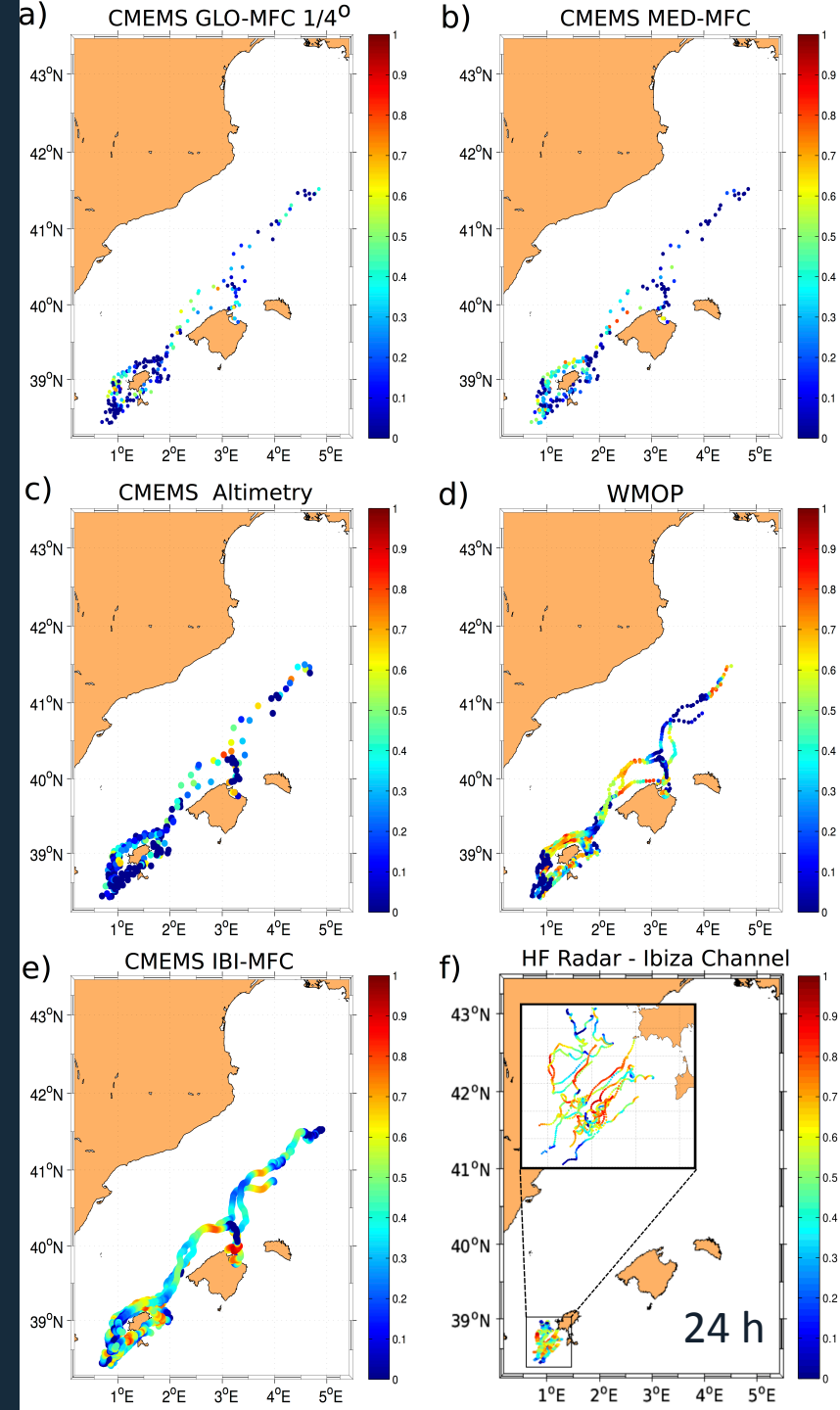
Sep-Dec 2014

- 13 drifter buoys: 4 CODE, 5 Iridium MD03i, 4 ODI
- Ocean models:
 - 3 CMEMS models (IBI, MED, GLOBAL)
 - 1 regional WMOP
- Altimetry and HFR



Lana et al. (2016)

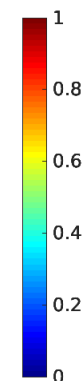
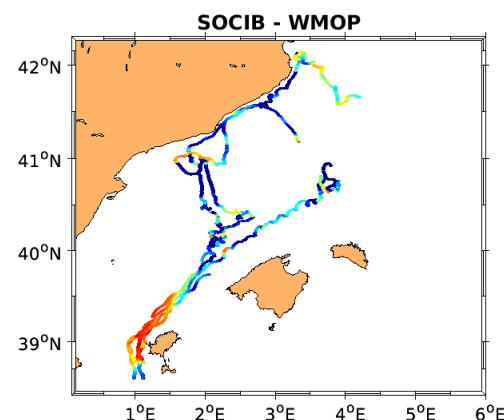
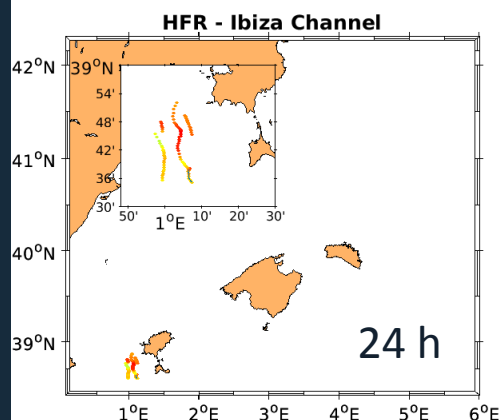
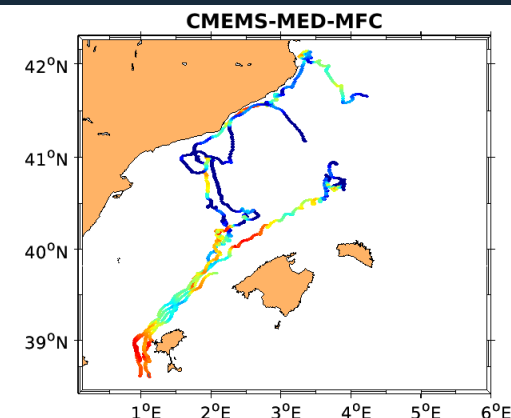
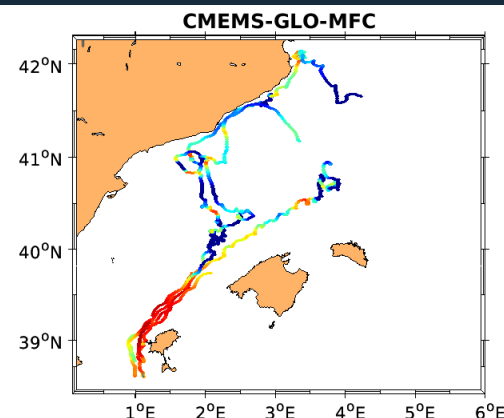
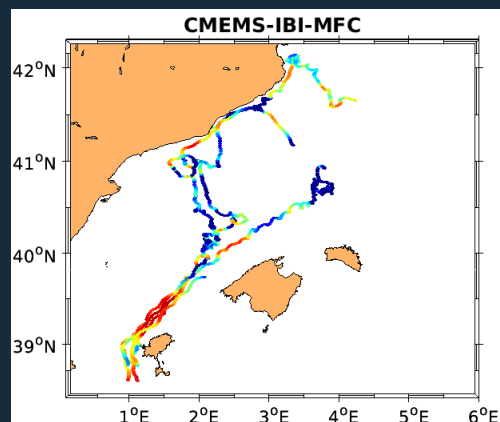
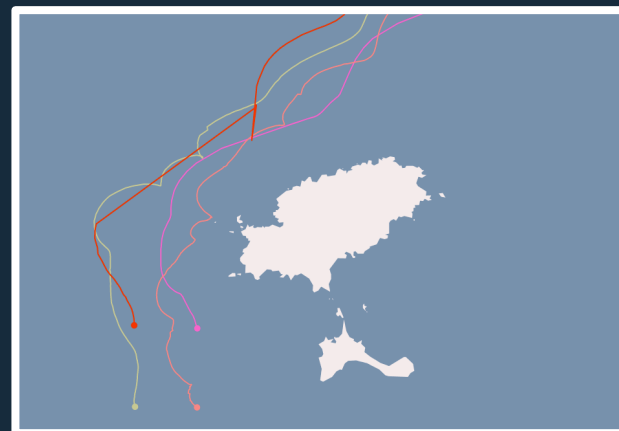
Spatial distribution of Skill Scores in WSMED (IBI sub-region)



06 IBISAR: SA RESULTS - WSMED

Jul-Sep 2016

- 4 drifter buoys: CODE
- Ocean models:
 - 3 CMEMS models
 - 1 regional WMOP
- HFR



**Skill Score after 72h
of simulation
(24h for HFR)**

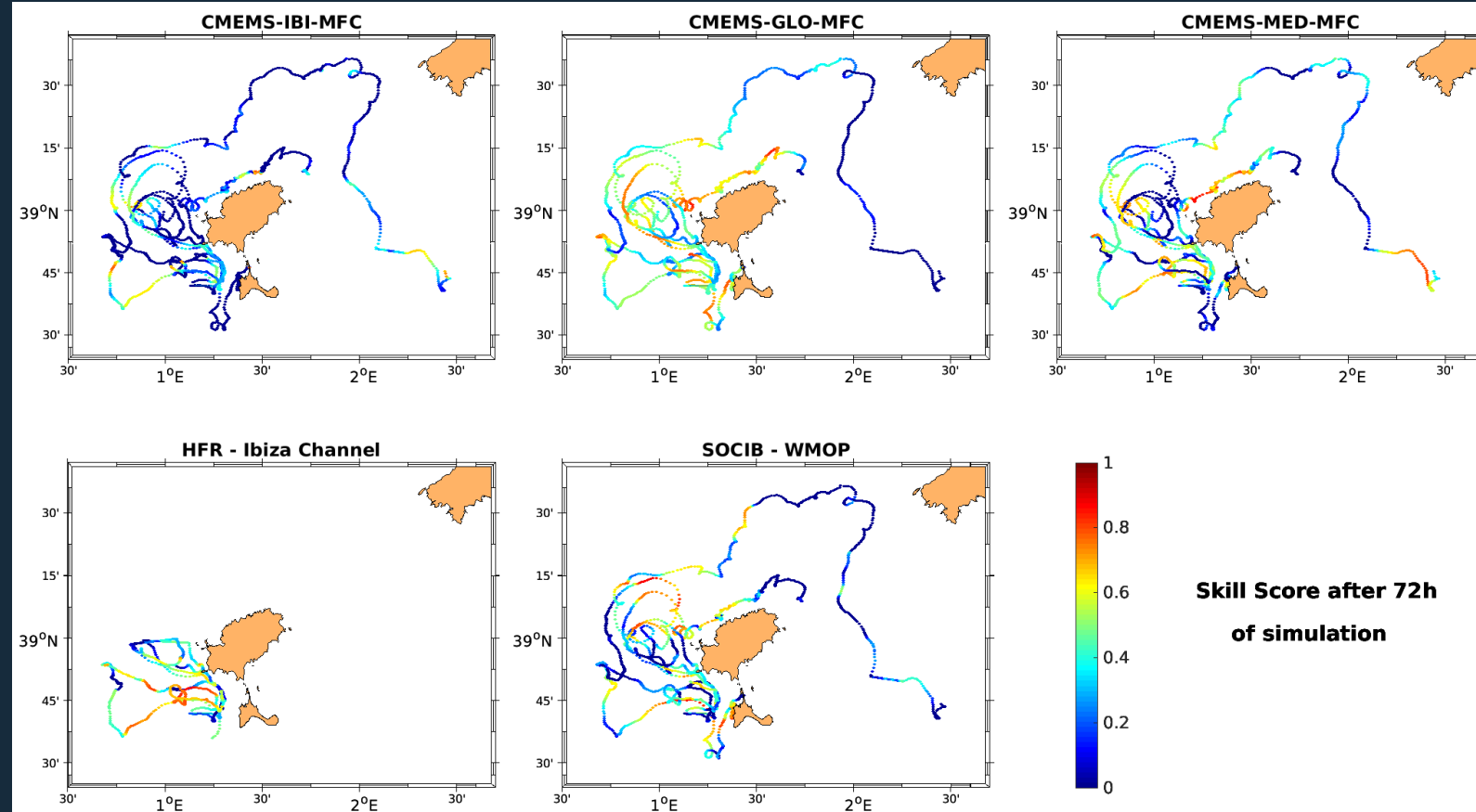
Spatial distribution of
Skill Scores in
WSMED
(IBI sub-region)



06 IBISAR: SA RESULTS - WSMED

Oct-Dec 2018

- 5 drifter buoys: CARTHE (eco-friendly)
- Ocean models:
 - 3 CMEMS models
 - 1 regional WMOP
- HFR



Spatial distribution of
Skill Scores in
WSMED
(IBI sub-region)

Skill Assessment IBISAR



MAKING COMPLEX EASY

Puertos del Estado



About

Inputs

Select Date Range:
(2016-07-24 / 2016-09-30)

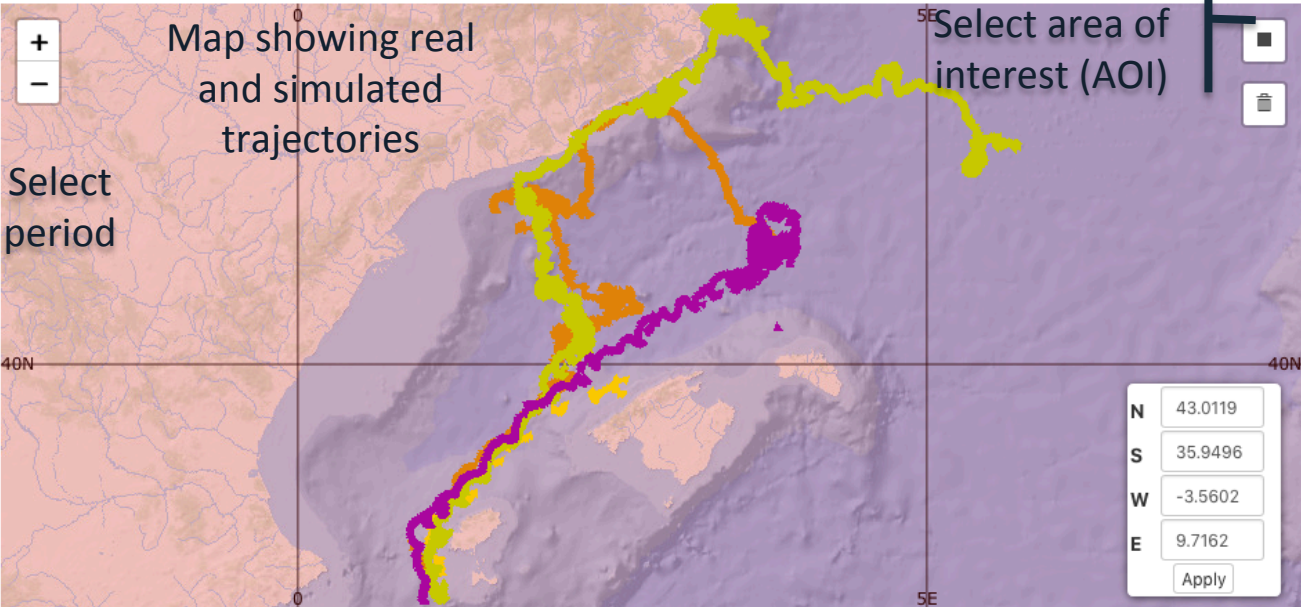
Fetch Skill Scores: AOI: (35.950, -3.560)
to (43.012, 9.716)

Display/Update Skill Scores

Legends

SLDMB Tracks

- odi013
- odi014
- odi015
- odi016



Average

Moored Buoys

SLDMBs

Reference sources

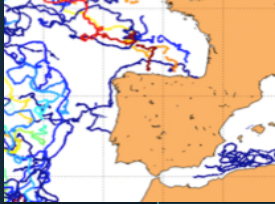
Target sources

Export to CSV

Download skill data

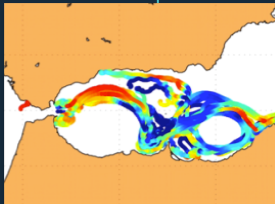
Display Skill Scores

Model	6 Month						Case					
	Skill Scor...	Num Buoy...	Num Obs...	Skill Scor...	Num Buoy...	Num Obs...	Skill Scor...	Num Buoy...	Num Obs...	Skill Scor...	Num Buoy...	Num Obs
HFRADAR_IB IZA	0	0	0	0	0	0	0.7063	4	25	0	0	0
WMOP	0.2615	6	8	0.1376	2	30	0.2261	4	507	0.1932	6	90
MEDITERRA NEAN_SEA	0.1671	9	20	0.0244	1	28	0.0991	1	15	0.3064	6	56



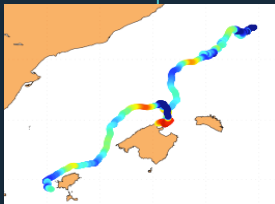
Intermediate-user requests

- * added-value **HFR gap-filled** products needed
- * satellite-tracked **drifters data ingestion** should be promoted



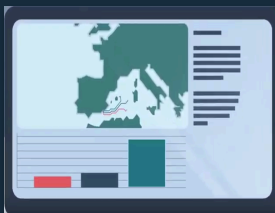
SA results in GIBST – Strait of Gibraltar

- * **altimetry** follows major **geostrophic circulation** features
- * **lower** models **performance**, particularly in the **EAG**
- * **IBI** yields the **highest skill** scores (tidal forcing included)



SA results in WSMED – Western Mediterranean

- * **downscaling needed** to reproduce the intense mesoscale activity
- * dynamically **different flow regimes** should be considered to evaluate model performance
- * **HFR** offers the **highest performance** in most scenarios



IBISAR complements the decision-support tools

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

ACKNOWLEDGEMENTS

Puertos del Estado



Spanish Port System



GOBIERNO
DE ESPAÑA

MINISTERIO
DE FOMENTO



Salvamento Marítimo

Spanish Maritime Safety and Rescue Agency

euskoos



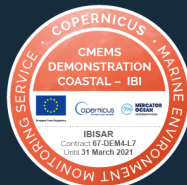
Operational Oceanography System of the Basque Country



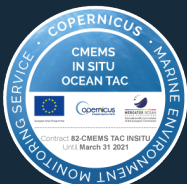
COSMO Project (CSIC-ICM)



INCREASE (Copernicus Marine Service – Service Evolution)



IBISAR (Copernicus Marine Service – User Uptake)



Copernicus Marine Service – INSTAC –phase2



SOCIB

Balearic Islands
Coastal Observing
and Forecasting
System

THANKS FOR YOUR ATTENTION



Visit www.ibisar.es

Effective response needs the most accurate data



@socib_icts #IBISAR