Balearic Islands Coastal Observing and Forecasting System



HIGH FREQUENCY RADARS: IMPORTANT ASSETS OF COASTAL OCEAN OBSERVING SYSTEMS



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VI JORNADAS DOCTORALES EIDEMAR 1-2 DECEMBER, 2020, ONLINE www.socib.es

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OUTLINE









Plays a critical role in our climate system. We need to characterize the ocean state and variability











Characterization of state and variability at the 'right' scale







Multiplatform, integrated ocean observation and forecasting in response to Science & Society needs: from Events to Climate



03 TWO-FOLD PARADIGM SHIFT

Ocean Observation

1

FROM: ship-based observation

To: multi-platform observing systems

Increase in human potential for analysis:

open science, open for society

Data availability

2

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FROM: delayed-mode data (12-24 months)

To: near real-time quality controlled data





04 HOW DO WE DO THAT? multi-platform integrated observing and forecasting systems





05 THE HIGH-FREQUENCY RADAR

Radar HF: Land-based remote sensing technology of coastal basins

- <u>Radio detection and ranging</u> (US Navy, 1940) \bullet
- High Frequency, between AM and TV •



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05 THE HIGH-FREQUENCY RADAR: OPERATION PRINCIPLE

Bragg principle: the radar signal returns directly to the antenna when it scatters off a wave M2

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05 THE HIGH-FREQUENCY RADAR: OPERATION PRINCIPLE





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Bragg Waves traveling towards the antenna

- Surface currents
- Wind direction

Second-order peaks

- Waves
- Wind speed



Typical HF (high-frequency) ocean surface Doppler Spectrum

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05 THE HIGH-FREQUENCY RADAR: HF RADAR OF THE IBIZA CHANNEL

2 CODAR SeaSonde HF radarstations

- Central frequency= 13.5 MHz
- Bandwidth= 90 kHz





The radial vector maps from multiple radar stations are merged to create a total velocity vector current map.

Reference:

 Mantovani et al. (2020). Best Practices on High Frequency Radar Deployment and Operation for Ocean Current Measurement. Frontiers in Marine Science, 7:210. https://doi.org/10.3389/fmars.2020.00210

05 THE HIGH-FREQUENCY RADAR: SURFACE OCEAN CURRENTS MEASUREMENTS

Radial velocities from the antennas GALF & FORM

Surface ocean currents from the HFR system of the Ibiza Channel

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05 THE HIGH-FREQUENCY RADAR: GAP-FILLING

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

- Obtain gap-free 2D surface currents from radials 0
- Gap-free needed for Lagrangian applications 0

HFR derived Lagrangian Trajectories

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05 THE HIGH-FREQUENCY RADAR: GAP-FILLING

Velocity OMA (Open-boundary Modal Analysis) nowcast

Velocity modes

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

2 HFR combined antennas vs.

Models

Satellites

Other HFR type (phase array)

CMEMS Drifters: 01/2016-08/2019

05

Models

Observation vs. forecast

Surface drifters

Continuous monitoring in wide coastal areas

Fixed stations

2D Surface current maps vs. Time series

Satellites

Higher temporal resolution (30 min-1 h)

Lower visual impact

Global

Network

05 THE HIGH-FREQUENCY RADAR: WORLDWIDE DISTRIBUTION

Growing at a rate of 6 new stations/yr. in EU

Global HF Radar network: http://global-hfradar.org/

06 SOCIB: DATA, SCIENCE & SOCIETY

Integrated ocean observing and forecasting system

1 mission

Focus on meso- & sub-mesoscale, From nearshore to open ocean

3 drivers

Science priorities Data & Technology Society Needs

3 topics

Operational Oceanography Ocean Health Climate

Integrated Data Management Approach

SOCIB Data Centre

Provides different tools for visualizing, downloading and accessing open and quality-controlled multidisciplinary data

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□ Anticyclonic eddy during fall 2017

Its intensification and persistence in time, greater than in previous years, could act as a barrier, diverting the Northern Current.

Anticyclonic eddy in the Balearic Sea during fall-winter 2017

SCIENCE

Sustainable fisheries and conservation

Linking ocean variability & species ecology to improve population stock assessment

Bl: one of the three main bluefin tuna spawning areas in the world

Larval Atlantic bluefin tuna abundances

Monitoring key biogeochemical parameters

C

(m) -100 -200

-300

0.3

Longitude

Continuous monitoring of biogeochemical EOVs in the Mallorca and Ibiza Channels

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2.0

1.5

1.0

0.5

0.0

23

Longitude

Seasonal variability of chlorophyll-a concentration in the Ibiza Channel

Oceanographic Turtles

Interactions between environmental factors, marine animals and human activities.

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Turtle and glider deployment (left) and turtle dives (black) towards higher productive depths (right)

Coastal HF Radar: extreme events monitoring

Impact of the last extreme Ebro river discharge event on the surface circulation.

Maps of HF radar surface currents and surface Chl-a concentration for reference conditions (left) and extreme discharge events (middle-right)

20/10/2018

Coastal HF Radar: extreme events monitoring

Daily averaged current

Response of sub-mesoscale structures to an extreme wind event in the Liguria Sea.

31/10/2018

Estimated vorticity/f

20/10/2018

31/10/2018

Maps of daily averaged HFR surface currents (left) and surface relative vorticity –normalized by f – (right) before (20/10/18) and after (31/10/18) the extreme wind event.

Coastal HF Radar: seasonal events monitoring

Winter intensification of the slope Iberian Poleward Current in the Bay of Biscay

Hovmöller diagrams of HFR along-slope surface current along two longitudinal transects at 2.7° W (a) and at 2° W (c). Low-pass filtered wind vectors (e).

-5.6 -5.5 -5.4 -5.3 -5.2 Longitude (deg E)

-5.1 -5 -4.9

WMOP Daily mean 14-Oct-2020 Total surface currents (m/s)

Daily HF radar surface current maps:

Ibiza Channel Delta Ebro **Gibraltar Strait**

Mourre et al., 2018 Aguiar et al., 2020

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Gliders

Time series of Temperature (left) and Salinity (right) at fixed mooring locations (Palma Bay)

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HF radars

Daily Sea Surface Temperature maps from satellite L4 SST product (left) and WMOP model (right)

Glider temperature and Salinity sections in the Ibiza Channel

38.4

38.2

38

37.8

37.6 37.4 37.2

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ARGO vertical temperature profiles

06 SOCIB: SCIENCE

□ WMOP model improvement

HF radar data assimilation improves the prediction of Lagrangian trajectories

IBIZ - Apr 8, 2015 07:00 (UTC) (±37.5 min

40.0 cm/s

Mean separation distance (km) over the time between real and simulated trajectories for different DA simulations. Validation performed with 14 drifters (10 days)

□ IBISAR: coastal downstream service

Evaluates the performance of ocean current forecasts available in the Iberian-Biscay-Irish (IBI) regional seas

06 SOCIB: SOCIETY - IBISAR: WHY?

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

Which model should I select?

SARMAP: Simulated trajectories and vessel initial/final location

SOCIB: SOCIETY – 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

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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

Average Manager Burnet St Did

1.- Trajectory simulation

SOCIB: SOCIETY – HOW IBISAR WORKS?

1.- Trajectory simulation

2.- Trajectory comparison

Simulated trajectories

NCLS distance (Liu & Weisberg, 2011)

SOCIB: SOCIETY – HOW IBISAR WORKS?

1.- Trajectory simulation

0

Puertos del Estado

<u>si</u>

Model 2

0.28

MEMBER OF BASQUE RESEARCH

GOBERNO DE ESPAÑA

MINISTERIO DE FOMENTO

Simulated trajectories

NCLS distance (Liu & Weisberg, 2011)

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05 THE HIGH-FREQUENCY RADAR: MARITIME SAFETY APPLICATIONS

- > 5800 incidents in 2019
- ~88% SAR
- ~12% pollution
- CCS Palma
- 10% missions (100% SAR)

Map showing the geographical distribution of the SAR and pollution incidents in 2019 (source: SASEMAR)

THE HIGH-FREQUENCY RADAR: MARITIME SAFETY APPLICATIONS

- 5183 SAR missions
- Coastal indicents < 20 km
- Offshore incidents (until 100 km)

Map showing the geographic distribution of the SAR incidents in 2019 coloured based on the mínimum distance to any closes coastal point.

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05 THE HIGH-FREQUENCY RADAR: MARITIME SAFETY APPLICATIONS

- 5183 SAR missions:
- 50% SAR < 3 km offshore
- All inside HFR coverage:
 <30 km <u>– short range</u>
 <60 km <u>– medium range</u>
 <200 km long range

Histogram of the SAR incidents percentage in 2019 based on their distance to any closes coastal point.

05 THE HIGH-FREQUENCY RADAR: MARITIME SAFETY APPLICATIONS

HFR Surface current forecast reduce the search area by 3, when compared vs. HYCOM

HYCOM

36,000 km²

12,000 km²

CODAR

s showing search area after 96 hours with the HYCOM model -left- and with the Short Term Predictions of HF radar – right- (source: MARACOOS)

06 SOCIB: SOCIETY – DATA VIEWERS

Viewer- coastal tourism sector: http://seaboard.socib.es/galfi; http://seaboard.socib.es/pitiuses

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information in near-real time.

SOCIB: SOCIETY – QUID REPORTS 06

←) → 🏠 🛛 🔏 www.socib.eu/?seccion=observingFacilities&facility=radar

Month 05

HF RADAR monthly reports

Year 2020

2013 2014 2015

2016 2017 2018

2019 ✓ 2020 HFR monthly quality assessment reports

Near-real time validation of the Ibiza Channel buoy and HF radar

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Download

- HF radar (0.9 m) - Buoy (1.5 m)

▲^S

Screenshot of the <u>Copernicus Marine Service Dashboard</u> showing the coverage of the different HF radar systems available

SocorristalB App

- Support tool for lifeguards
- 353 beaches from BI
- Meteo-ocean observation
 & forecasting
- Alarms & notifications

MEDCLIC Kids App

MEDCLIC KIDS

ICTS SOCIB

- Educational app for kids
- 3 languages (ES, EN, CA)
- 3 games
 - Puzzle
 - Find it!
 - Memory

Follow the Glider

• Glider – exploring tool for students and teachers

Ocean Literacy

- Broad catalogue of educational resources
- For students, teachers & general public
- SOCIB: founding member of EU40cean

POI

06 SOCIB: SCIENCE WITH AND FOR SOCIETY

SOCIB promotes ocean literacy with activities to discover, learn, generate awareness, inspire, enjoy and empower citizens with THE OCEAN

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We organize meetings Between citizens and researchers We design activities and materials Focused on the educational community

We communicate

Research results, products, data, services and activities

06 SOCIB: SOCIETY - ON SITE EVENTS

Open Days R/V SOCIB

Meetings with scientists

Science fairs

Exhibitions

Talks and conferences

Workshops

06

SOCIB: SOCIETY - EDUCATIONAL RESOURCES

Didactic units and flipped classroom

Workshops and education conferences

SOCIB: an integrated ocean observing and forecasting system contributing to a long term sustained EOOS

SOCIB Balearic Islands Coastal Observing and Forecasting System

2019-07-18 19:40:00 SCB-ETDCAM005

THANKS FOR YOUR ATTENTION!

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