MonGOOS

HFRadar
EuroGOOS Task Team

Coastal High-frequency radars in the Mediterranean Sea

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Puertos del Estado

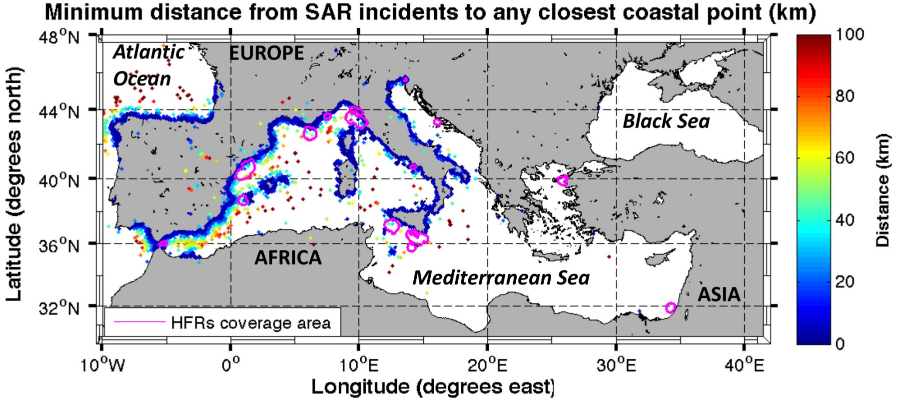
SOCIB Balearic Islands Coastal Observing and Forecasting System

THE MEDITERRANEAN COASTAL AREAS

01

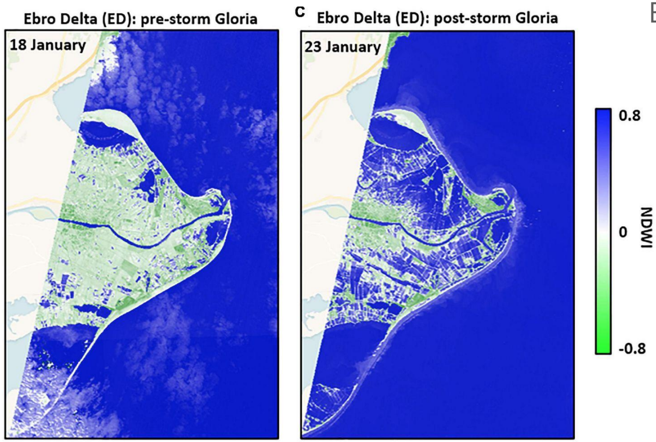
The Mediterranean coastal areas

Maritime Safety



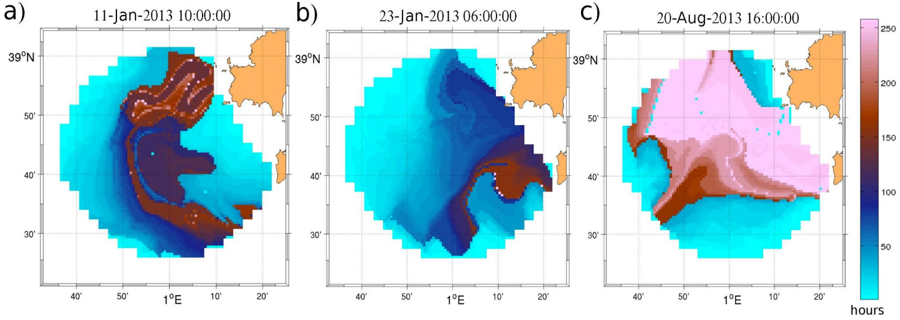
SAR incidents locations from France, Italy, Slovenia and Spain in 2019

Extreme Hazards



Ebro Delta before and after Gloria storm in January 2020 (Lorente et al., 2021)

Environmental Transport Processes



Particle residence times (hours) from HFR-Ibiza (Rubio et al., 2020)

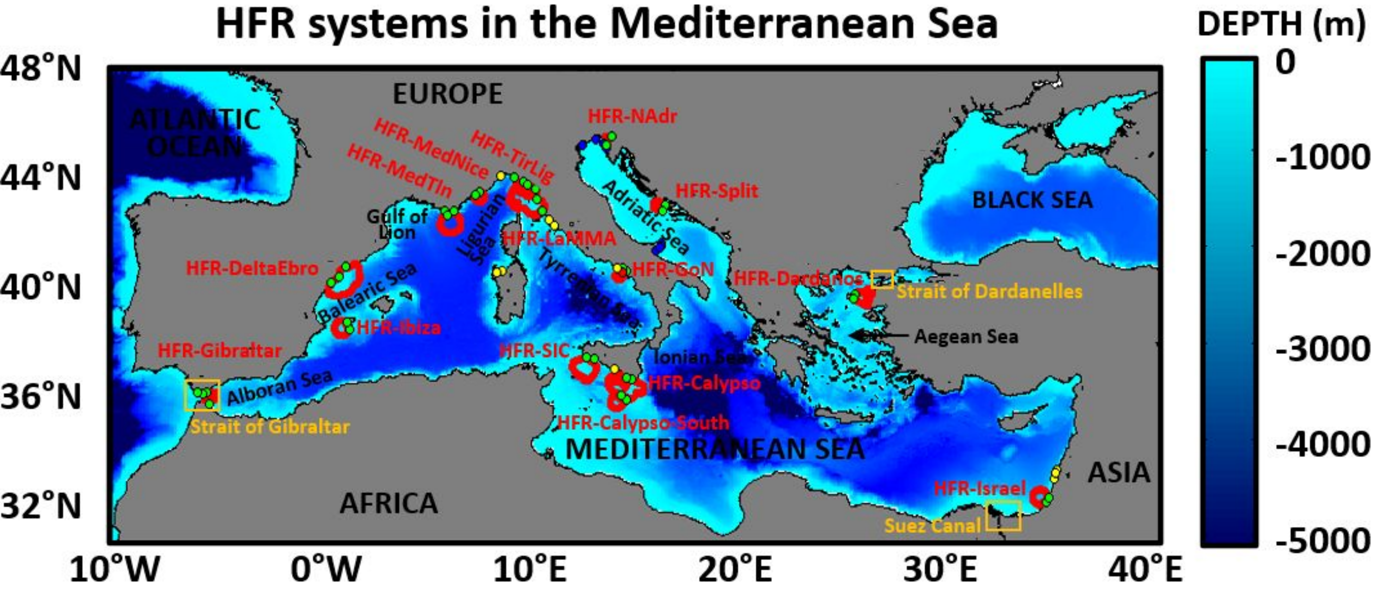
Integration of HFRs in the COOSs

- Cost-effective land-based technology
- Operation principle: Bragg's theory
- 2D surface currents maps, waves & wind
- High spatial resolution (0.2- 6 km)
- High temporal resolution (30'-1h)
- Wide coastal coverage (> 200 km)
- Complement coastal in-situ & satellite

THE MEDITERRANEAN HFR NETWORK

02

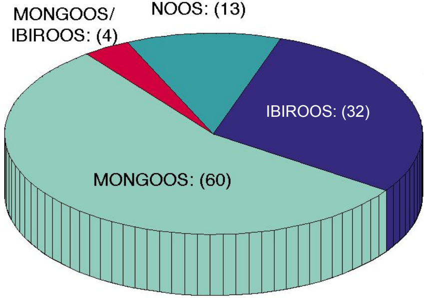
The Mediterranean HFR network: status



Map of HF radar systems (> 55% in EU) deployed in the Mediterranean
(Source: Lorente et al., 2022)

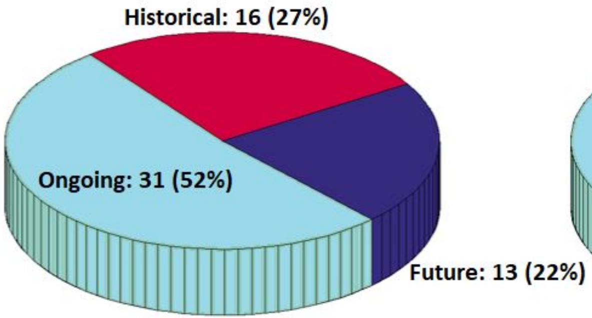
Going into detail...

- 21 networks (> 48.8% of EU)
- 60 HFR sites (55.04% of EU)
- 49 HFR permanent (81.6%)
- 31 HFR ongoing (51.7 %)
- 13 Future HFR (21.6 %)
- 33 medium-range (55%)
- 14 NRT connected (23.3%)
- 9 REP connected (15%)
- Unbalanced N/S and W/E

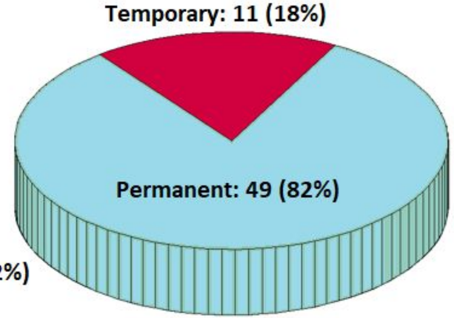


The Mediterranean HFR network: key numbers

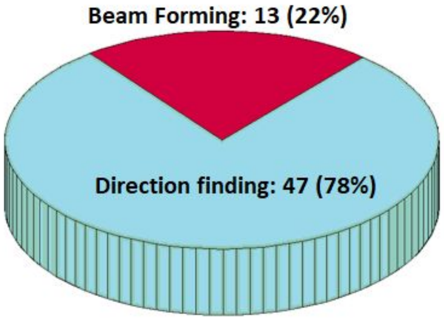
Status



Permanence



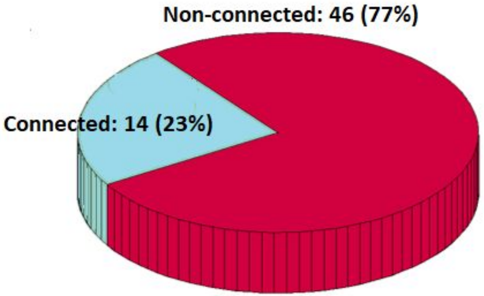
Type of System

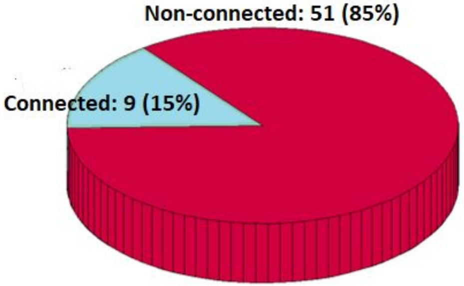


- ☑ Operational
- ☑ Permanent
- ☑ Direction Finding

Connection with the European HFR node

NRT Data

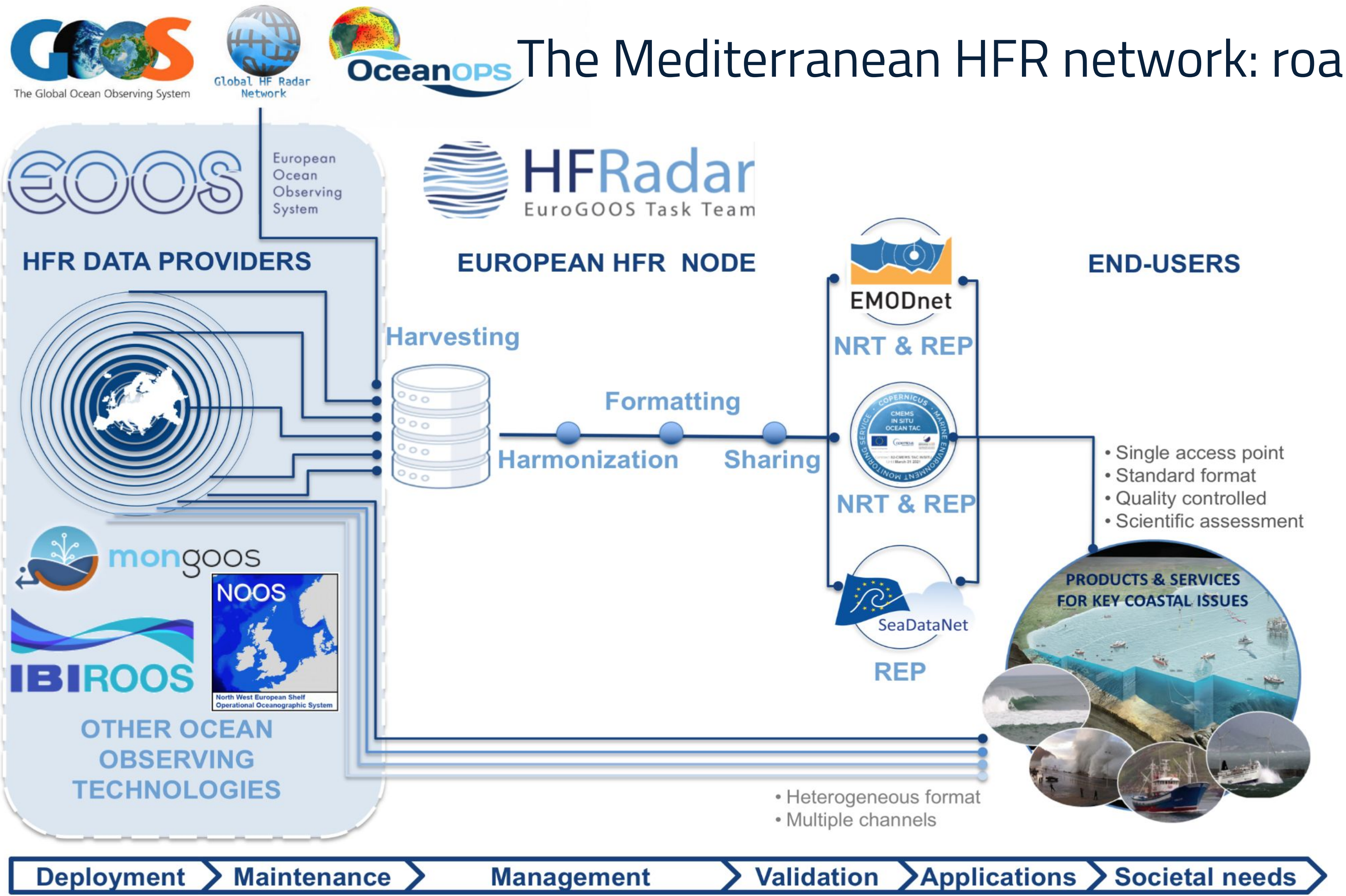




REP Data

(Source: Lorente et al., 2022)

The Mediterranean HFR network: roadmap



(Source: Rubio et al., 2022)

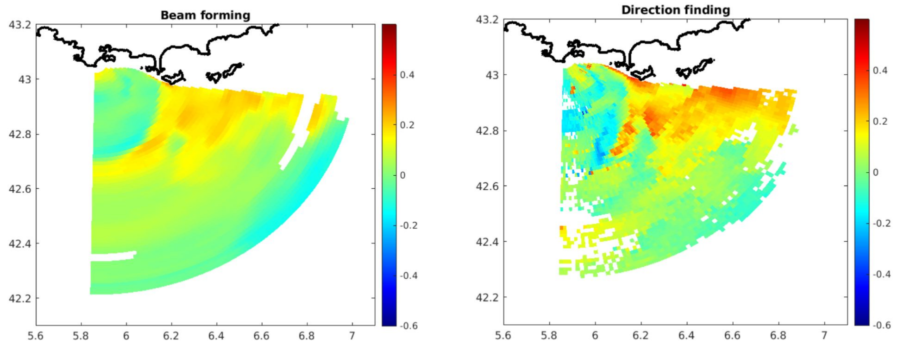
HFR BASIC PRODUCTS

03

HFRs Basic Products

Surface Currents

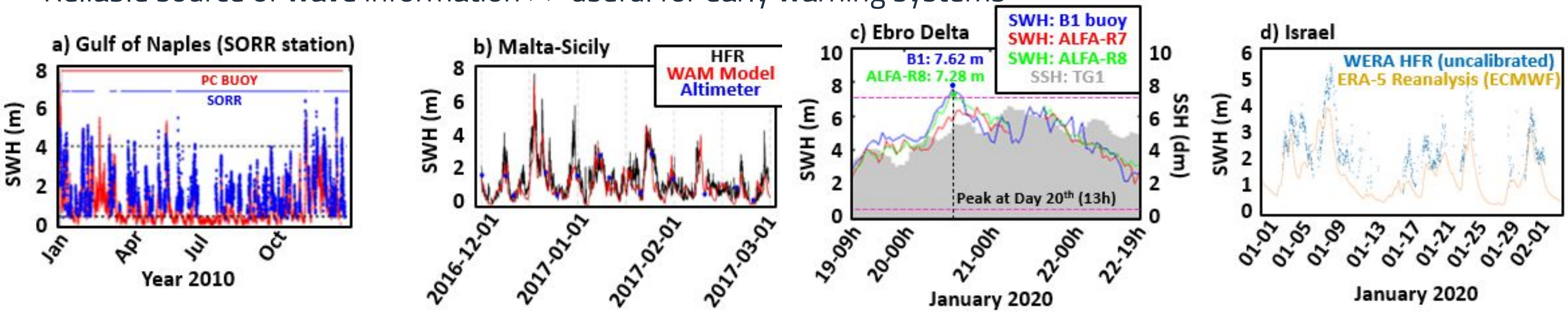
- Primary HFR measurement
- First-order Bragg peaks
- Different factors can affect the radial currents measurements
- New techniques to improve raw HFR signal processing quality



Hourly radial surface current maps provided by HFR in Fort Peyras (Toulon, France) with a 12-antenna receiving array. Dumas and Guérin, 2020

Wave height, period and direction

- Second-order Bragg peaks
- Reliable source of wave information >> useful for early warning systems



Time series of the validation of HFR derived Significant Wave Height (SWH) versus: a) PC buoy (in the GoN); b) WAM model and altimeter (in Malta-Sicily Channel); c) buoy (Ebro Delta); d) ERA-5 reanalysis (Israel)

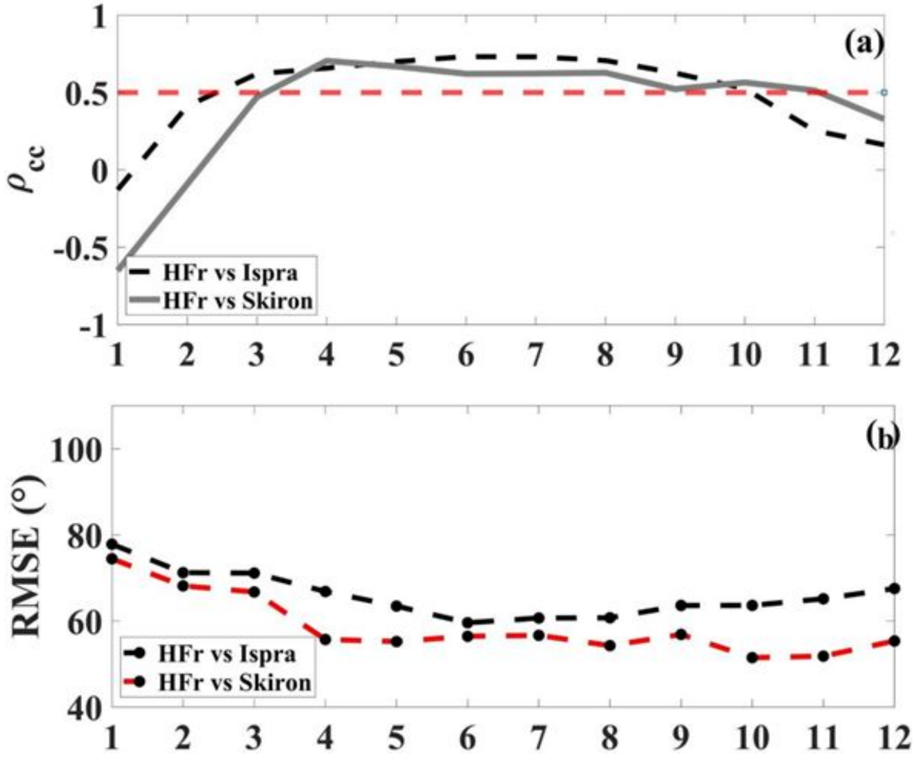
HFRs Basic Products

Winds

2 studies in the Mediterranean Sea

- Ligurian Sea: WERA radar, 12 MHz (Shen & Gurgel, 2018)
  - Wind direction accuracy depends on the HFR frequency
  - Inversion of wind direction improves with higher-wind conditions

- Gulf of Naples: CODAR SeaSonde HFR, 25 MHz (Saviano et al., 2021)
  - Validation vs. weather station and SKIRON/Eta model
  - Good statistical agreement, better between 4-10 km from the coast
  - Noise interference, wind duration and fetch should be evaluated.



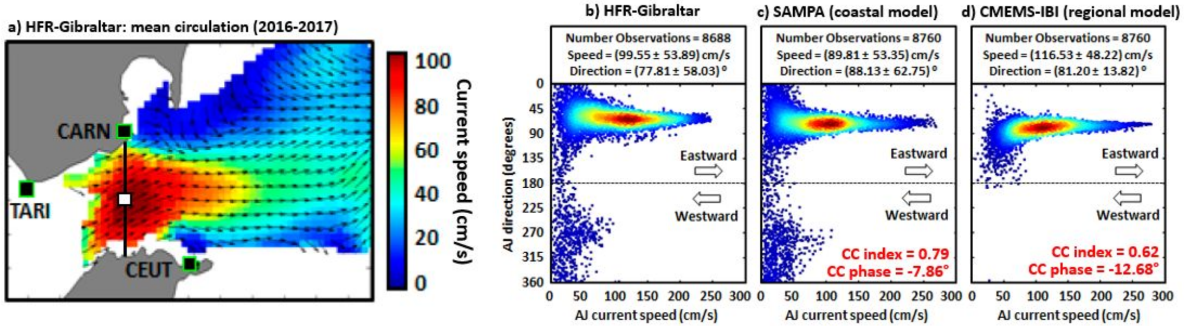
Variation of the (a) circular correlation coefficient and of the (b) RMSE on range cells between HF radar wind direction versus the weather station (located at Ispra) and the model SKIRON/Eta for February 2009 in the Gulf of Naples. Saviano et al., 2021

HFR APPLICATIONS

04

HFR Applications: Maritime Safety

Model assessment & improvement

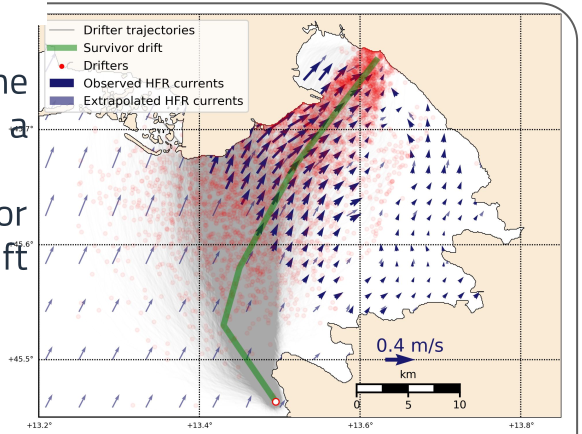


CMEMS-IBI and SAMPA coastal model assessment vs. HFR-Gibraltar in 2017 (Lorente et al., 2019)

- The assimilation of HFR currents helps to reduce the error in simulating trajectories up to 50% (Hernández-Lasheras et al., 2021)

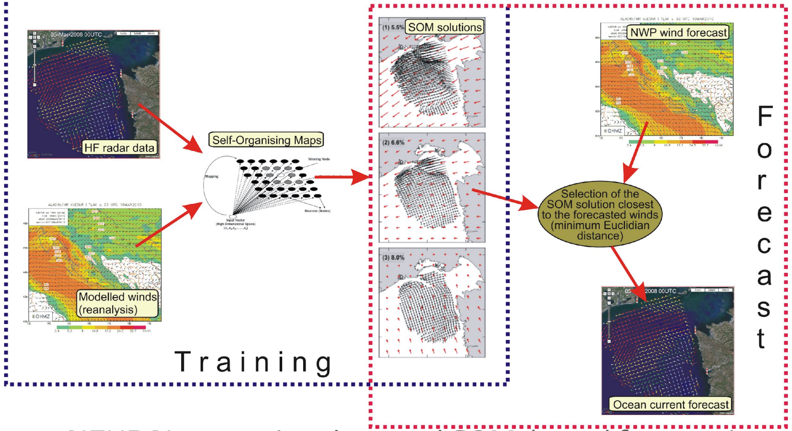
Lagrangian hindcasting

- SAR operation in the Northern Adriatic during a Scirocco storm.
- HFR-NAdr employed for hindcasting & survivor's drift trajectory verification.



HFR currents for Lagrangian hindcasting of an accident in October 2018 in the Gulf of Trieste (Ličer et al., 2020)

HFR Short-Term Predictions

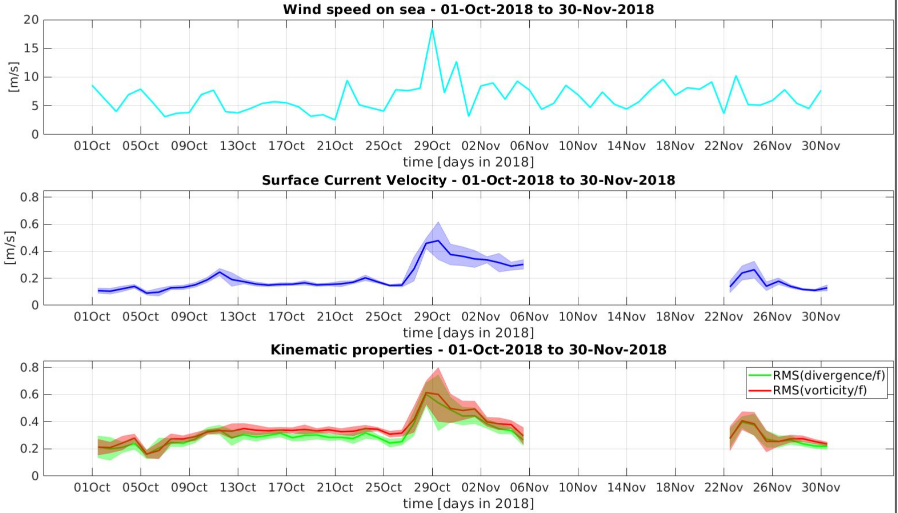


NEURAL operational coastal SOM-based forecasting system in the northern Adriatic (Vilibić et al., 2016)

HFR Applications: Extreme natural hazards

Extreme events

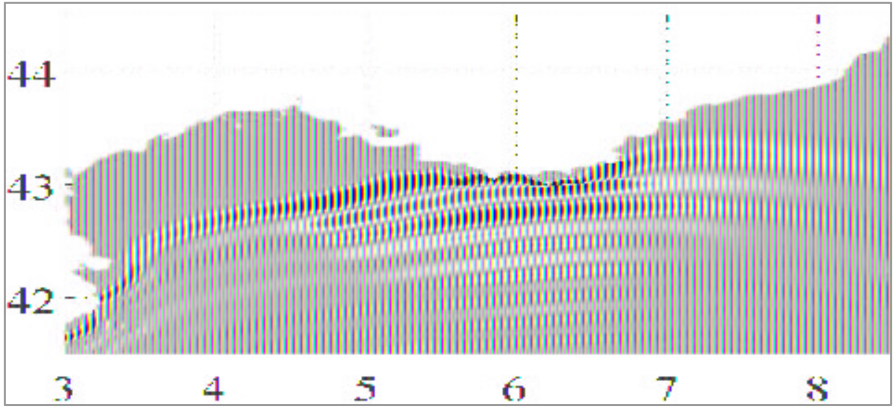
- Small-scale ocean response to extreme wind event.
- Extreme Ebro river freshwater discharge event.
- Sea state characterization during Gloria storm.
- Collapse of the Atlantic Jet in the Gibraltar strait.



Time series of wind speed, HFR currents and RMS of normalized vorticity & divergence during a extreme wind event in the Ligurian Sea in 2018 (Berta et al., 2020).

Tsunami detection

- HFR technology can detect tsunami-induced currents.
- Promising applications of HFRs.
- Integrated as complement tool to warning systems.
- Lower operational frequencies recommended.

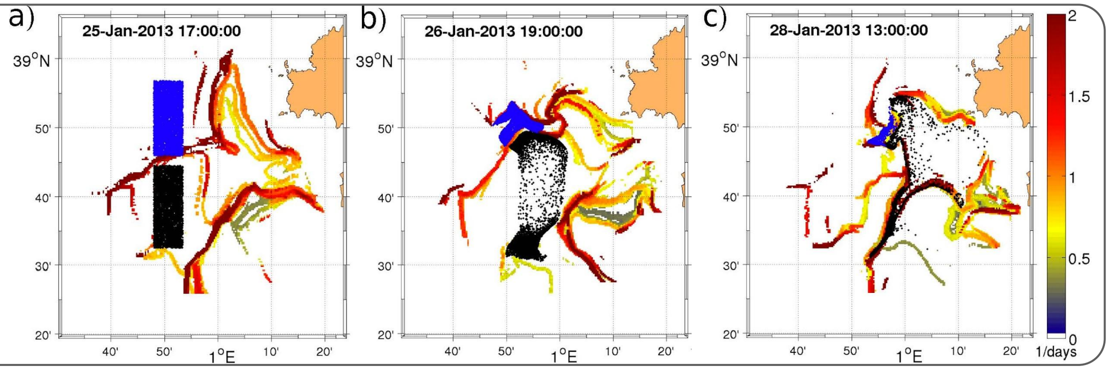


Simulated surface elevation (in meter) after 1h10 propagation for a tsunami generated by a M7.8 seismic source in the North of Algerian margin (courtesy of Stephan Grilli, Univ. of Rhode Island, USA).

HFR Applications: Ecological Transport Processes

Pollution and floatables tracking

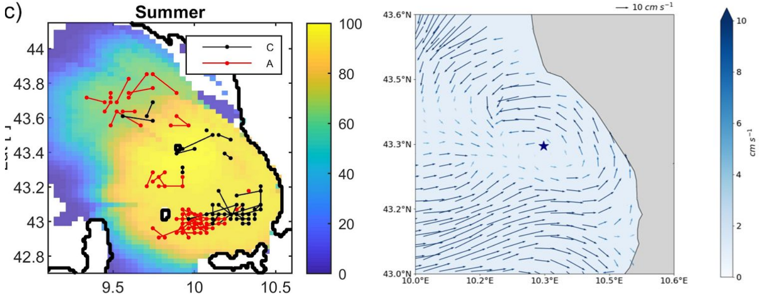
- HFR potential for tracking oil spills, ML
- To understand the phyto distribution.
- To identify scenarios that favour local retention.



Evolution of two sets of particles (black and blue) in the HFR-Ibiza footprint area superimposed on the backward FSLE (colorbar). Hernández-Carrasco et al., 2018

Eddy tracking

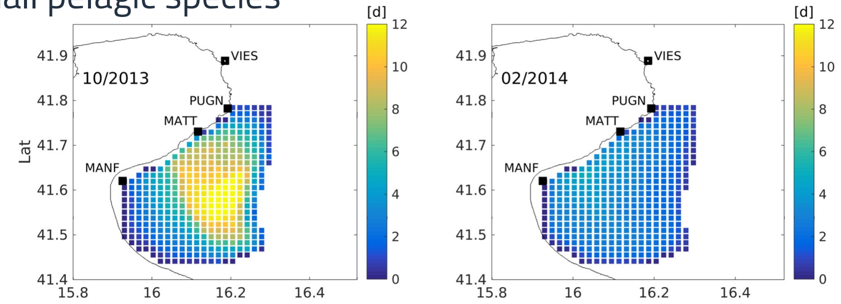
- 2 eddy algorithms tested in the Mediterranean
- To detect mesoscale eddies (Nencioli et al., 2010) and submesoscale eddies (Bagaglini et al., 2020)



Eddies detected with both algorithms with the HFR-LaMMA

Transport of biological quantities and connectivity

- HFR in support of the coastal zone management.
- To investigate oscillating plankton population dynamics, the role of coastal currents in the recruitment & abundance of small pelagic species

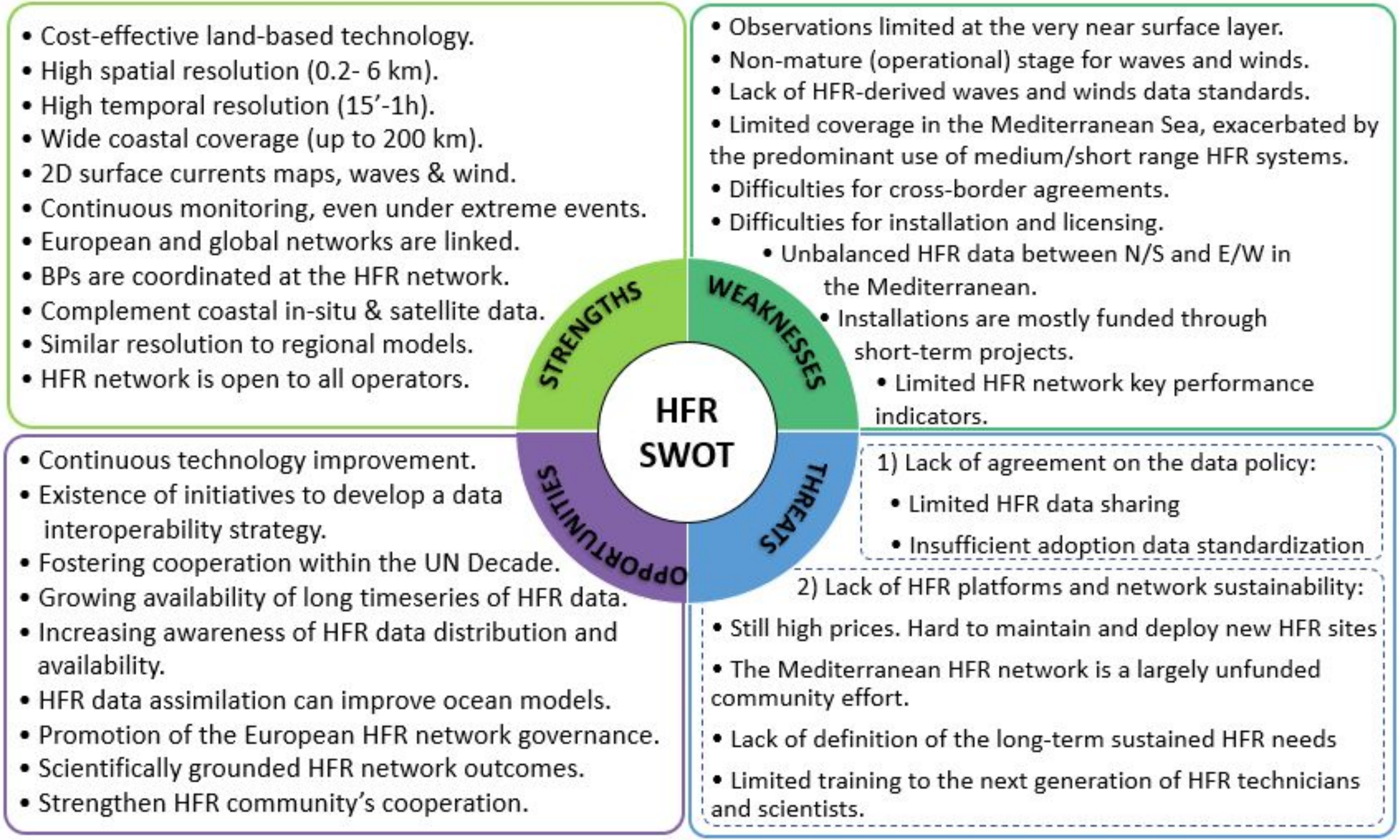


Average residence times (days) in the Gulf of Manfredonia.

CHALLENGES

05

Challenges to be faced by the Mediterranean HFR network (I)



Lorente et al., 2022 [DOI: 10.5194/os-18-761-2022]

Challenges to be faced by the Mediterranean HFR network (II)

- HFRs has boosted the research at the coastal areas.
- HFRs help to overcome the scarceness of observations and the ocean model limitations in coastal areas.
- HFRs are a great asset for NRT model operational assessment and model improvement.
- HFRs are very resilient platforms, even under extreme events.
- HFRs can detect tsunami-induced currents.
- HFRs can track oil spill and marine litter.
- HFRs can detect and track small-eddies.
- Increasingly capability to develop HFR Short Term Predictions.

a) Limited adoption of common data and metadata models for HFR surface currents.

b) Lack of HFR-derived waves and winds & added-value operational distribution in standardized format.

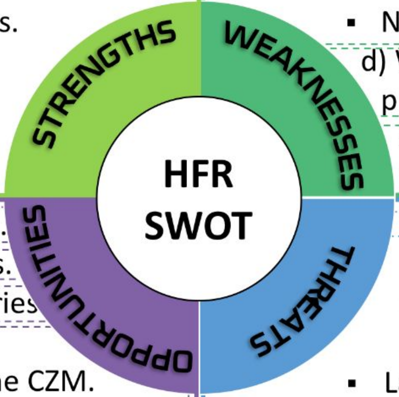
- Lack of consensus on the methodology to generate some basic and added value HFR data products.

c) Lack of consolidated user engagement strategy.

- Need to reinforce the user's loyalty.

d) Weak ties between the academia with the private sector and the policy-makers.

e) Limited development of methodologies for data combination and integration.



i) Steadily growing European HFR network.

j) Growing interest of HFR new capabilities.

k) Extending the coverage and the timeseries

l) UN's Decade raises ocean's awareness.

- Fostering of the HFR data in supporting the CZM.
- HFRs can greatly contribute in the achievement of the GES of the Mediterranean water.
- Existence of an European HFR stakeholder engagement strategy to facilitate co-production.
- Integration of HFRs in tsunami warning systems.
- HFR combination with other observing platforms.
- Key role of NGOs and citizen science in monitoring.

f) Limited HFR data assimilation in models.

- Lock of the interoperable data access.
- Limited user uptake, data use and value.
- Fail in addressing the user needs.
- Lack of HFR tsunami alert system available in the Mediterranean Sea, despite the existing risk.
- Long-range HFR are required for HFR-based tsunami early warning systems in the Mediterranean.

g) Different capabilities to resolve and characterize the processes for diverse observing platforms and models.

- Risk that the coordinated efforts needed will decrease.

h) Limited training to HFR technicians and scientists.

Reyes et al., 2022 [DOI: 10.5194/os-18-797-2022]

Recommendations

42 Co-authors

22 Institutions

15 HFR-systems

7 Countries

13 Recommendations

- Expansion of the Mediterranean HFR network
- Reinforcing the Mediterranean's leadership in HFR activities
- Keep promoting the HFR data interoperability and distribution
- Enhancing HFR data discoverability, access and usability
- Further development of emerging HFR applications
- Extension of the HFR time series
- Fostering the HFR data integration
- Boosting the HFR data assimilation
- Expansion of the pool of expertise
- Training of the new generations of HFR technicians and scientists
- Strengthening partnerships
- Seeking for funding
- Regional contribution to long-term major effort

Thank you very much for your attention