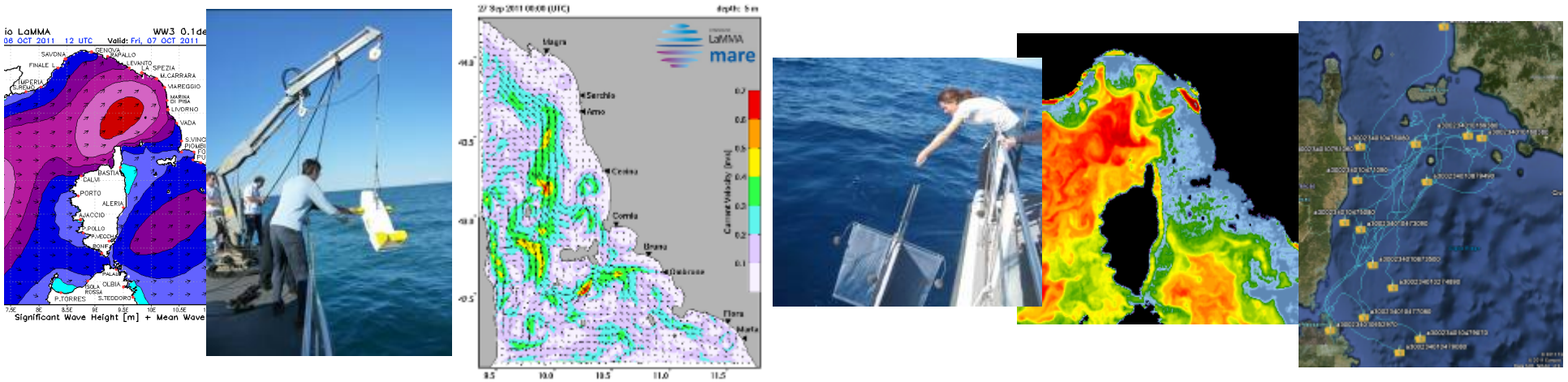
Sistemi osservativi e modelli di previsione costiera: verso un sistema di monitoraggio integrato per l'arcipelago e la costa toscana



Carlo Brandini
C.N.R. Ibimet - Consorzio LaMMA

Genova, 22 Maggio 2013

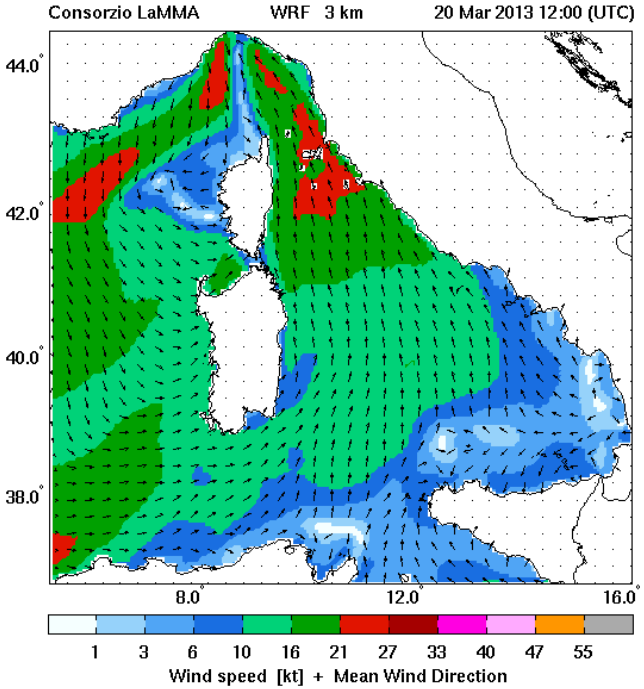
REGIONE TOSCANA

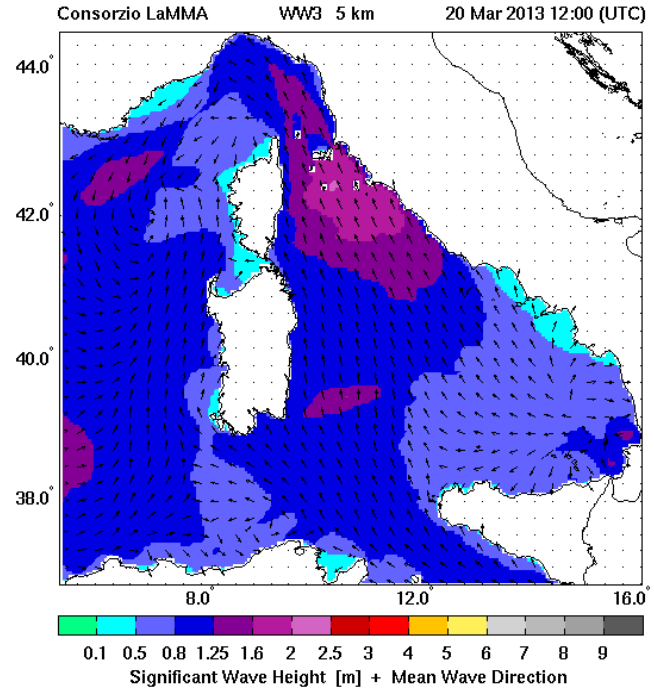
CONSORZIO LaMMA

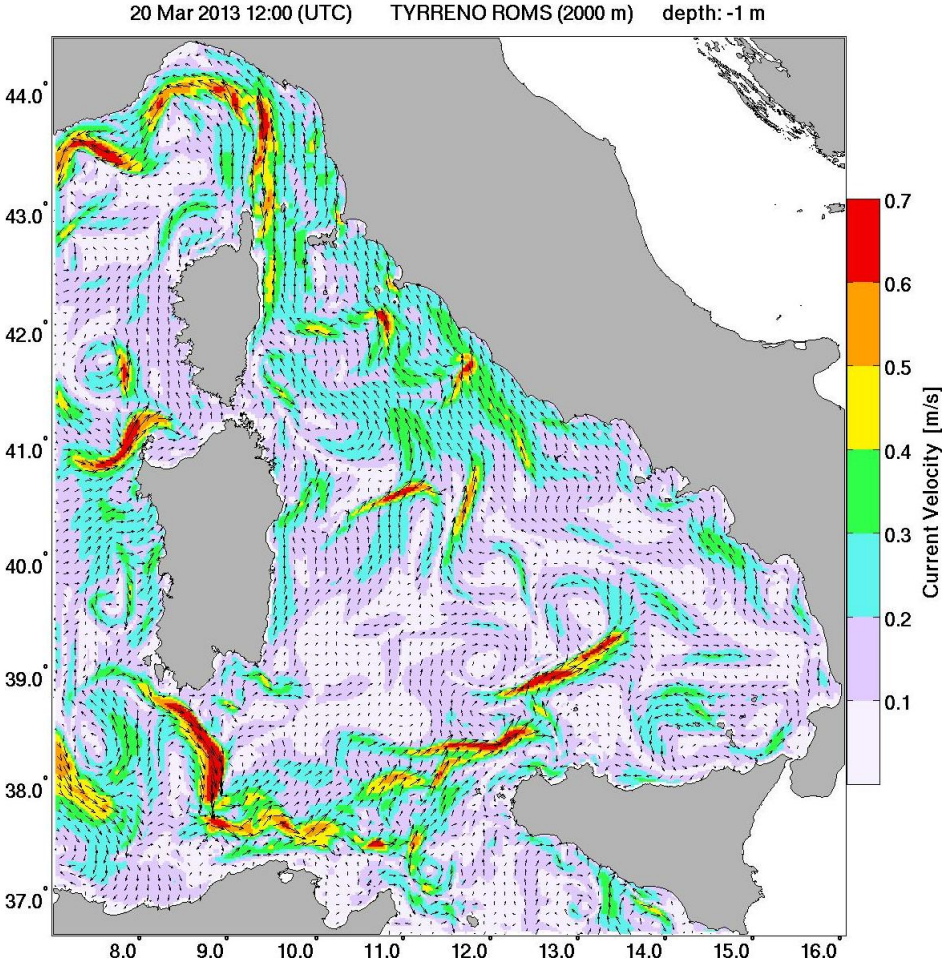
Fare dell'oceanografia operativa: osservare, ricostruire, prevedere.

- Mettere in campo un sistema per **ricostruire** lo stato del mare, sia in superficie che su tutta la colonna d'acqua, con elevata risoluzione spaziale e temporale, in modo operativo.
- Utilizzare il sistema di ricostruzione per **prevedere** cosa avverrà.
- Disporre di un sistema di **osservazioni**, disponibili in tempo reale, coerente con il sistema di ricostruzione/previsione adottato.
- Costruire intorno al sistema di **osservazione/ricostruzione/previsione** applicazioni e servizi ad alto valore aggiunto, con forti implicazioni per settori economici di grande importanza.

Vento, onde, correnti

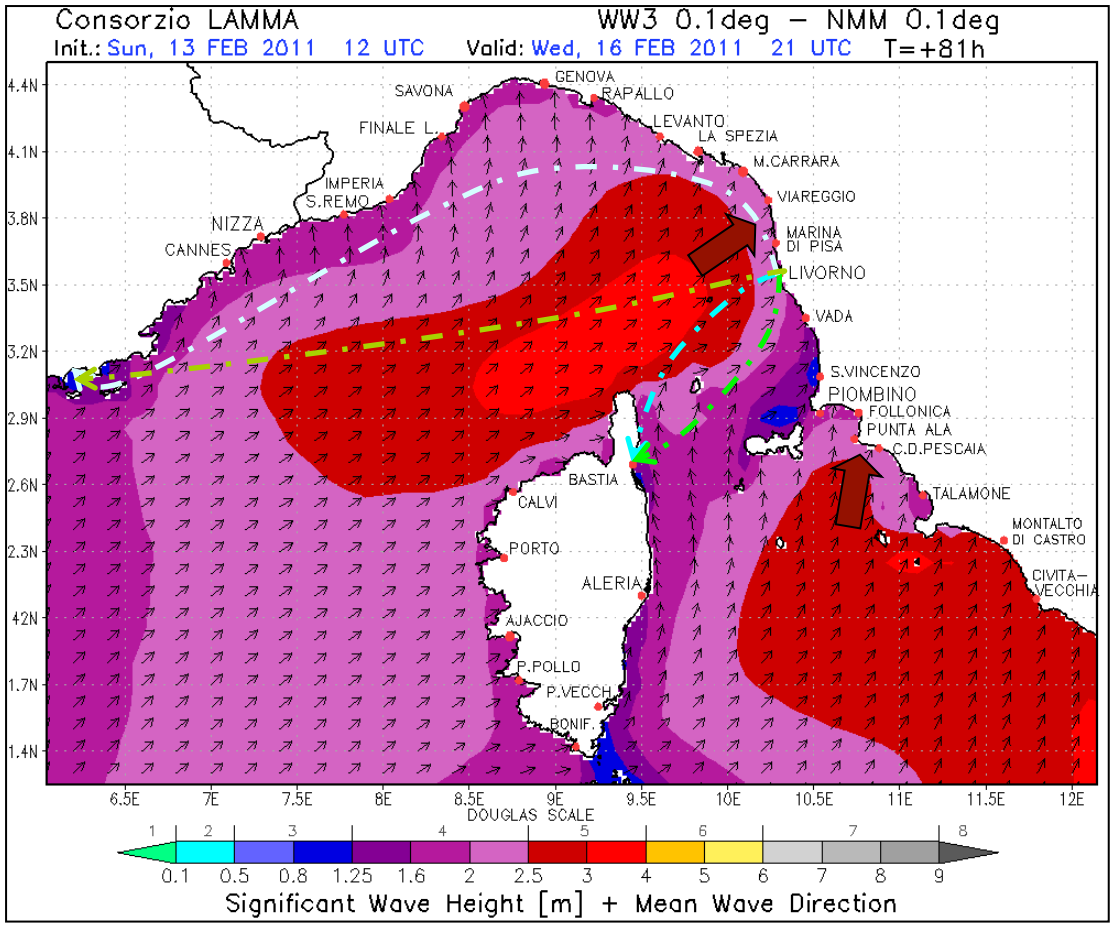






In 100 parole

Prevedere quello che avviene sulla superficie del mare



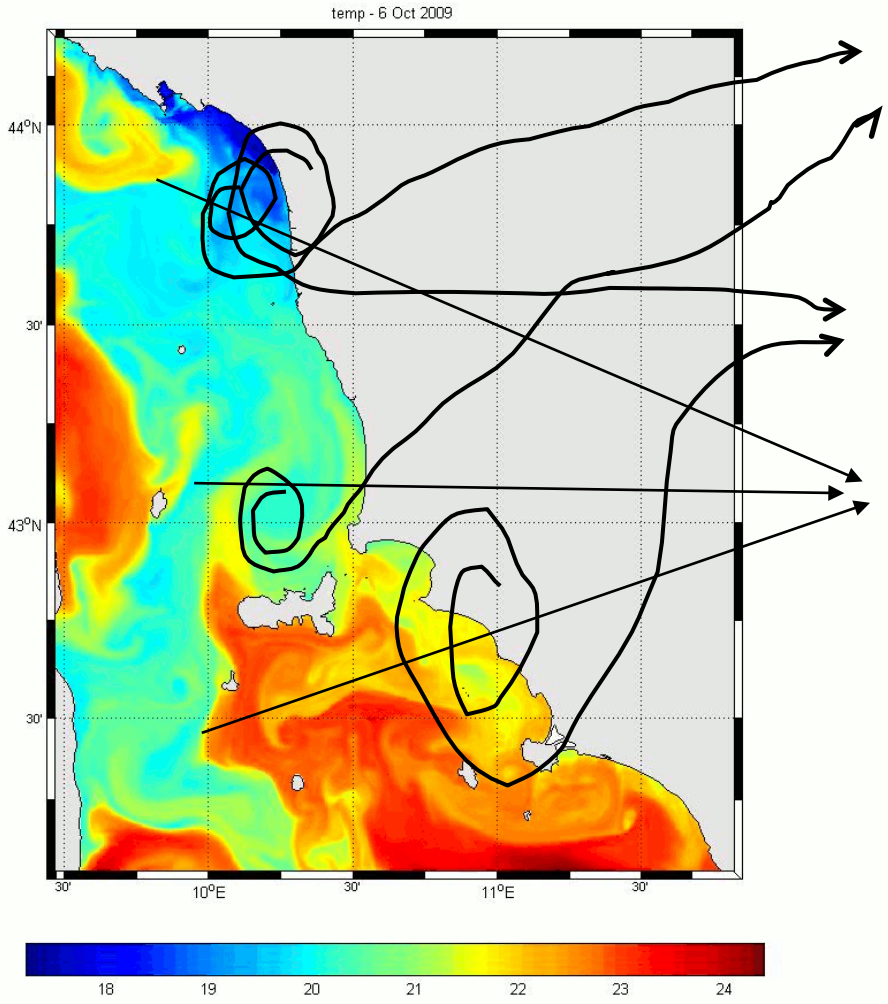
Migliorare la navigazione:

- ottimizzare le rotte delle navi
- individuare le zone di rada

Comprendere quanta energia investe la costa, per:

- prevedere gli effetti delle mareggiate
- individuare migliori criteri di progettazione delle opere di difesa
- individuare migliori criteri di sicurezza
- catturare l'energia delle onde

Capire come si muovono le masse d'acqua



Comprendere come si diffondono gli inquinanti lungo la costa, o come evolvono gli oil spills

Comprendere come si distribuiscono i sedimenti lungo la costa

Individuare parametri e mappe utili per la pesca

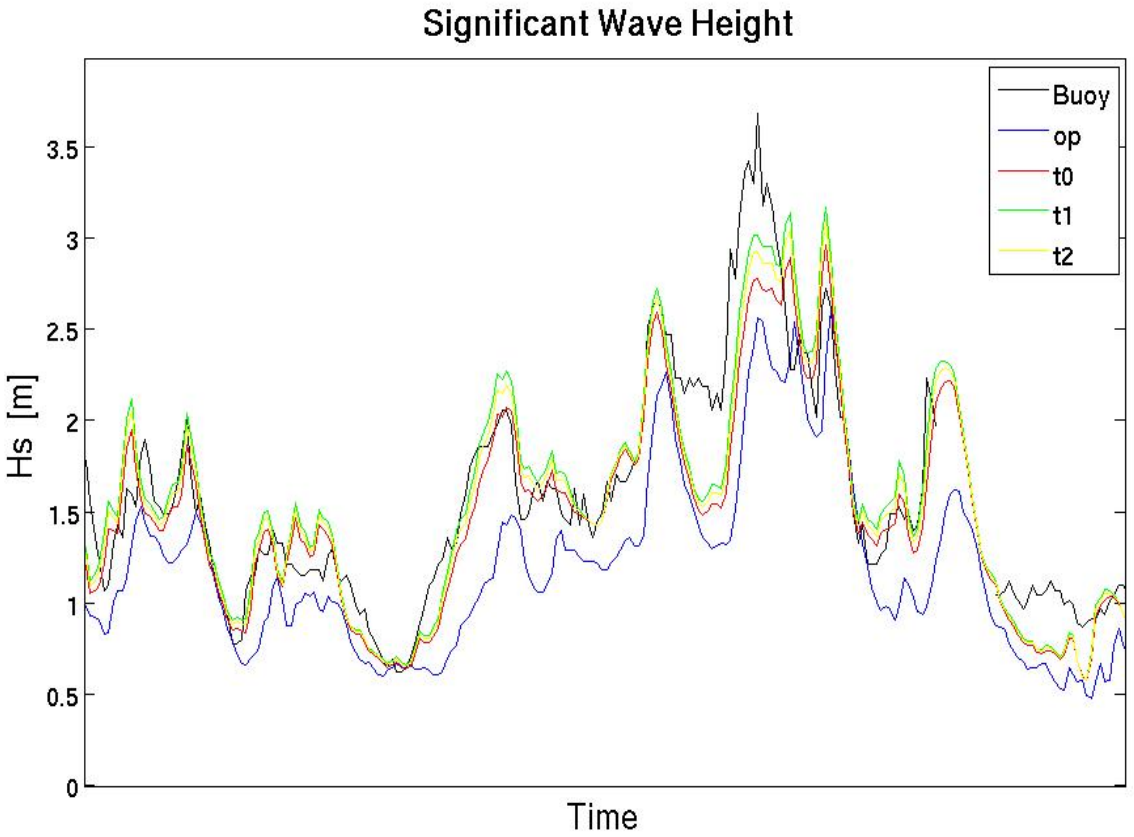
Costruire sistemi di supporto alla ricerca e soccorso in mare

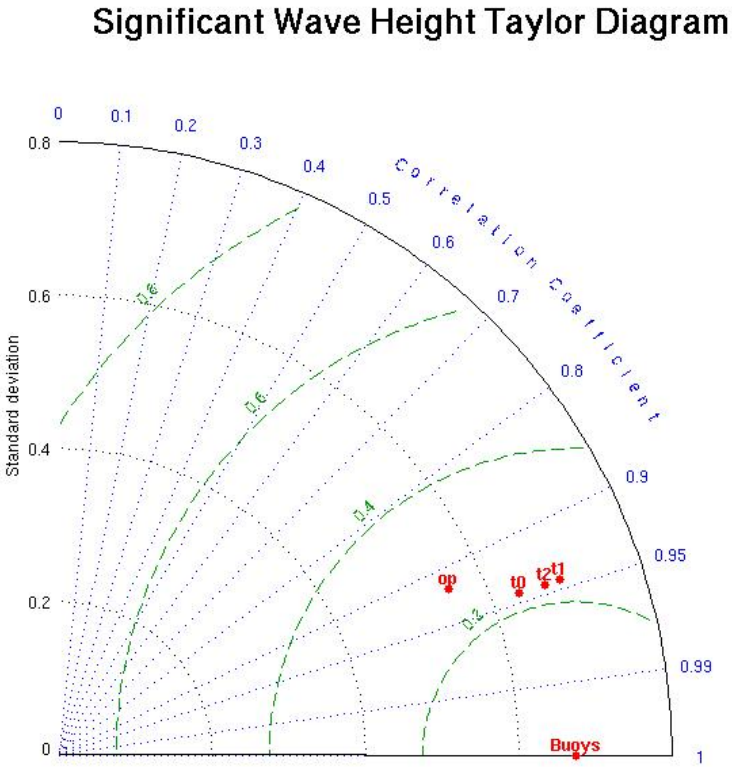
Studiare l'impatto sull'ambiente marino legato alla realizzazione di impianti industriali e di acquacoltura, scarichi a mare, ecc.

Molti modelli, molte verità (parziali)…

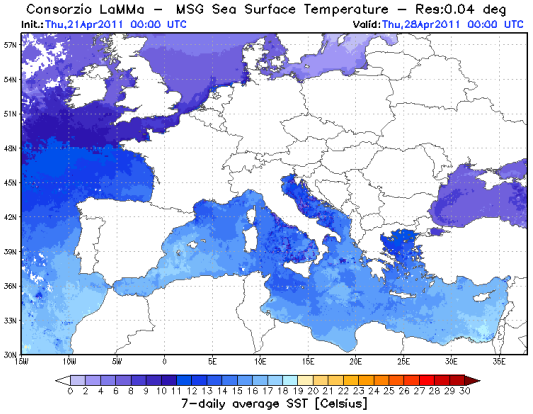
MODELLI GLOBALI			
GFS_0.5	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
ECMWF_0.12	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
ECMWF_0.25	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
MODELLI AD AREA LIMITATA			
ARW_GFS_12km	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
ARW_ECM_9km	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
ARW_ECM_3km	Tue, 21-05-2013 12 UTC	LASTRUN	00 12
ALL_ECM_3km	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
LAMI_7km	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
NMM_GFS_12km	Wed, 22-05-2013 00 UTC	LASTRUN	00 06 12 18
CONFIG. 1			00 12
CONFIG. 2			00 12
MODELLI MARE			
WAM_0.25	Tue, 21-05-2013 12 UTC	LASTRUN	
WW3_10km	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
WW3_HIWIN	Tue, 21-05-2013 12 UTC	LASTRUN	00 12
WW3_NEW_10km	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
WW3_NEW_HIWIN	Tue, 21-05-2013 12 UTC	LASTRUN	00 12
WW3_US_0.2	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
WW3_LIVORNO_5km	Tue, 21-05-2013 12 UTC	LASTRUN	00 12
	SPETTRI WW3 LR	SPETTRI WW3 HIWIN	SPETTRI WW3 HR
ENSEMBLE			
ECM_ENS_0.5	Wed, 22-05-2013 00 UTC	LASTRUN	00 12
GFS_ENS_1.0	Wed, 22-05-2013 00 UTC	LASTRUN	
ECM_MONTH	Thu, 16-05-2013 00 UTC	LASTRUN	

Calibrare (e validare) i modelli,





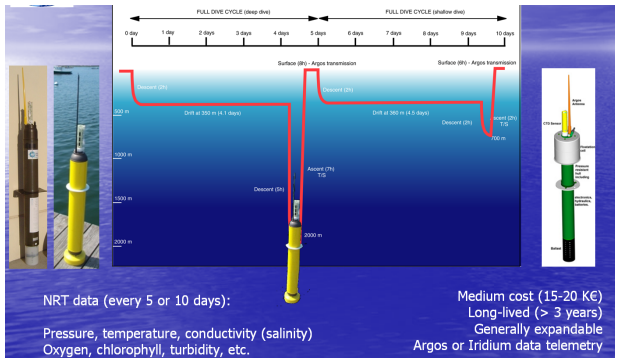
Integrare le informazioni disponibili



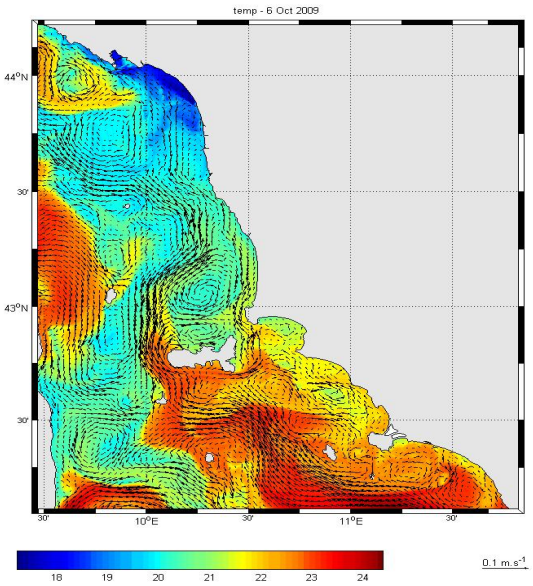
Misure in-situ

Misure satellitari

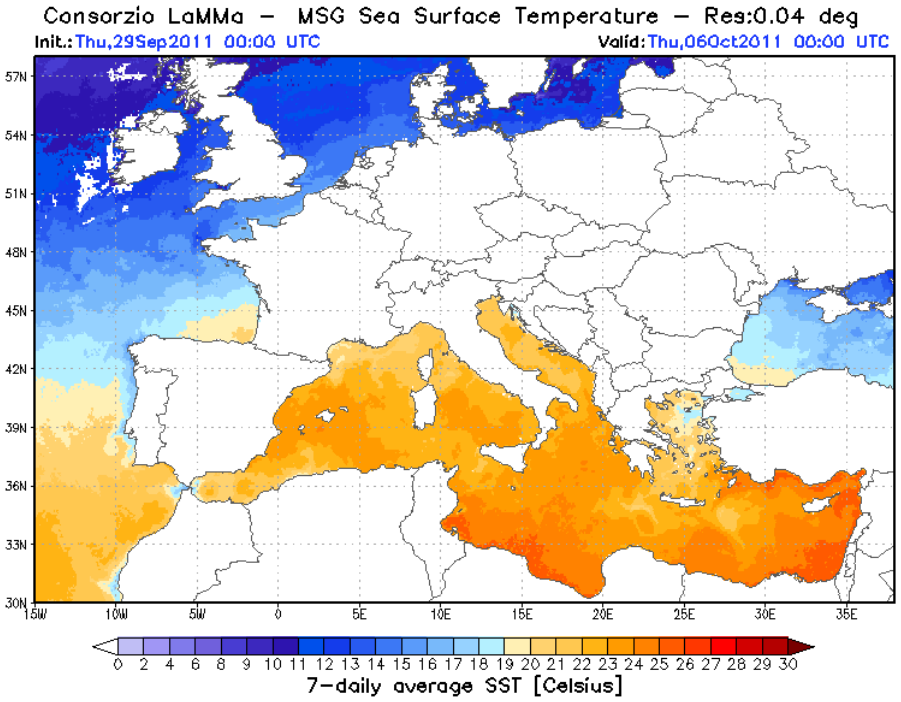
Sistemi Collaborativi e Condivisi



Modellistica



Osservazione remota, prodotti operativi



Mappa di SST (media su 7 giorni precedenti)

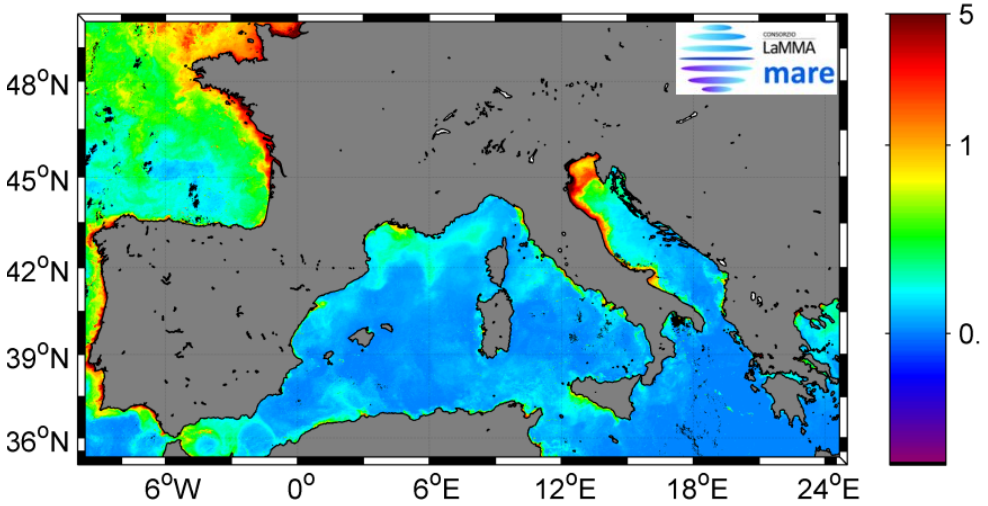
- METEOSAT second generation (MSG)
- Canali spettrali dell'infrarosso termico.
- Risoluzione temporale: 15 minuti
- Risoluzione spaziale: circa 4-5 km.

Mappa di Chla (media su 7 giorni)

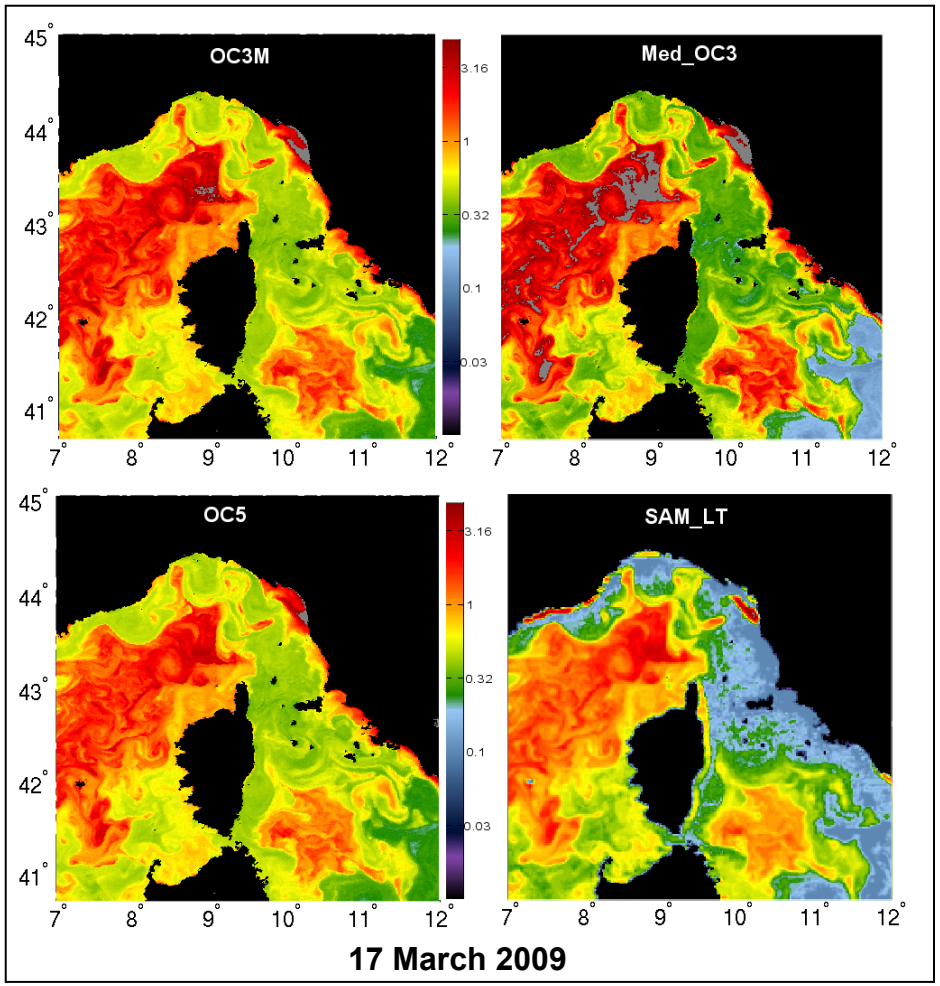
- Sensore MODIS-Aqua
- Risoluzione temporale: circa 1 giorno
- Risoluzione spaziale: circa 1 km.

OC5 Chlorophyll a mg/m^3

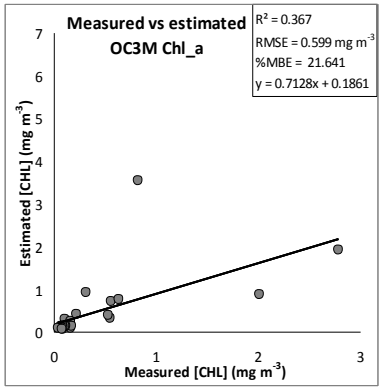
22 – 29 Settembre 2011

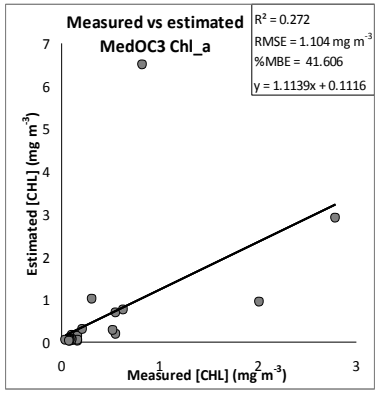


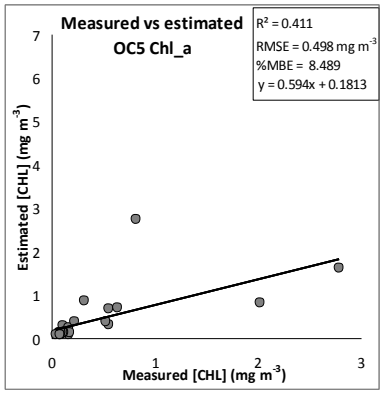
Chlorophyll_a algorithms (MODIS, MERIS)

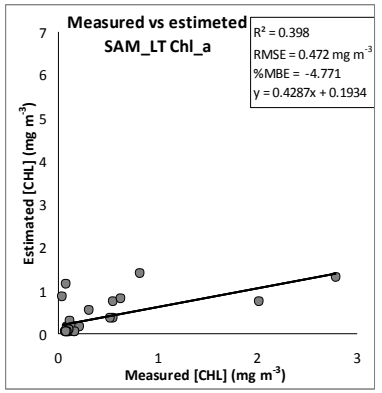


Campaign	Period	Number of stations	Institution
MOMAR	April 2010 July 2011	28	CIBM
MELBA	May 2011	11	LaMMA, Ifremer, CIBM
MILONGA	September October 2011	18	LaMMA, Ifremer, CIBM, ARPAT

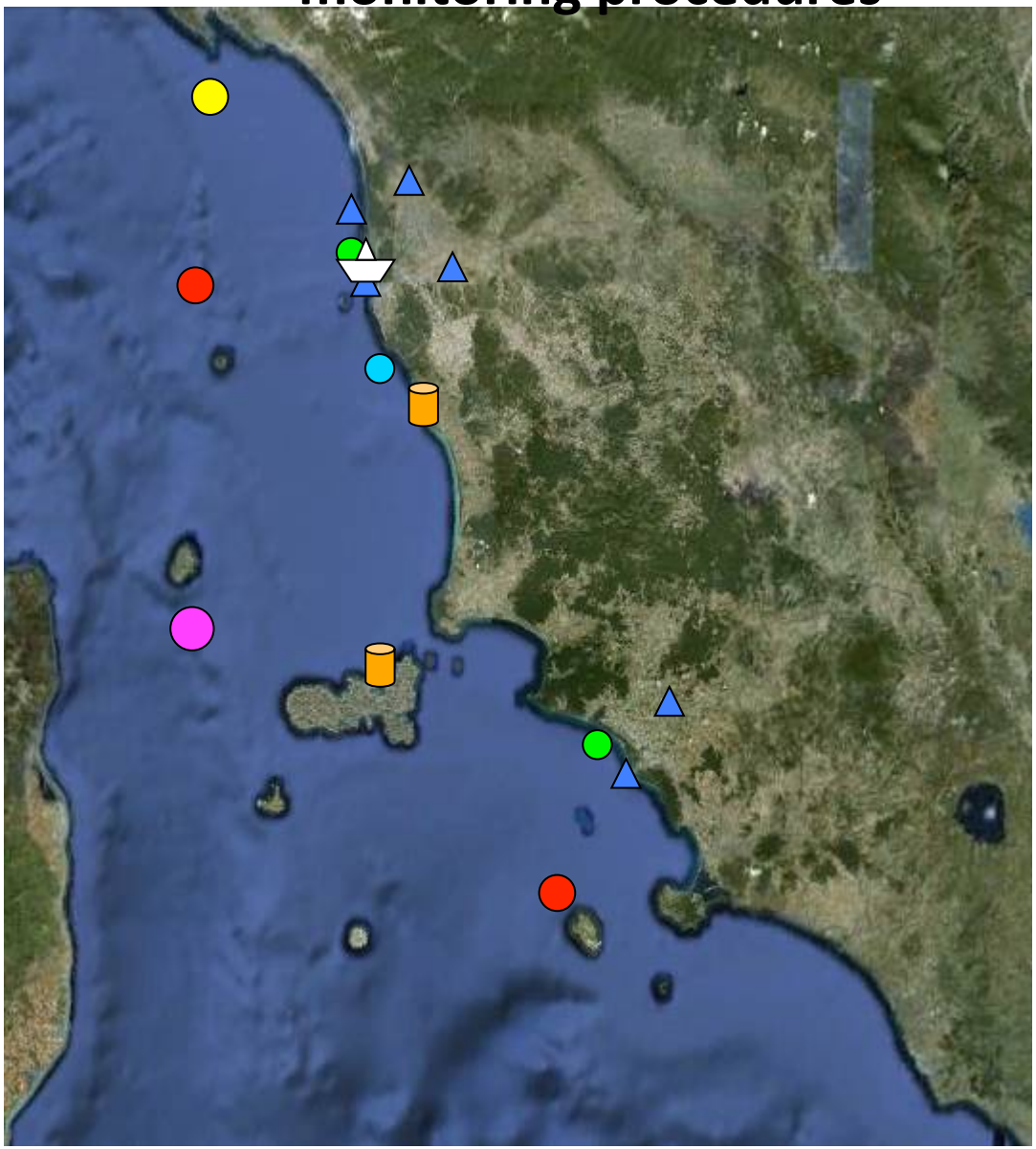








Need for improving sea monitoring procedures



The Tuscany Region marine measurement network

Oceanographic vessel

Wave buoys

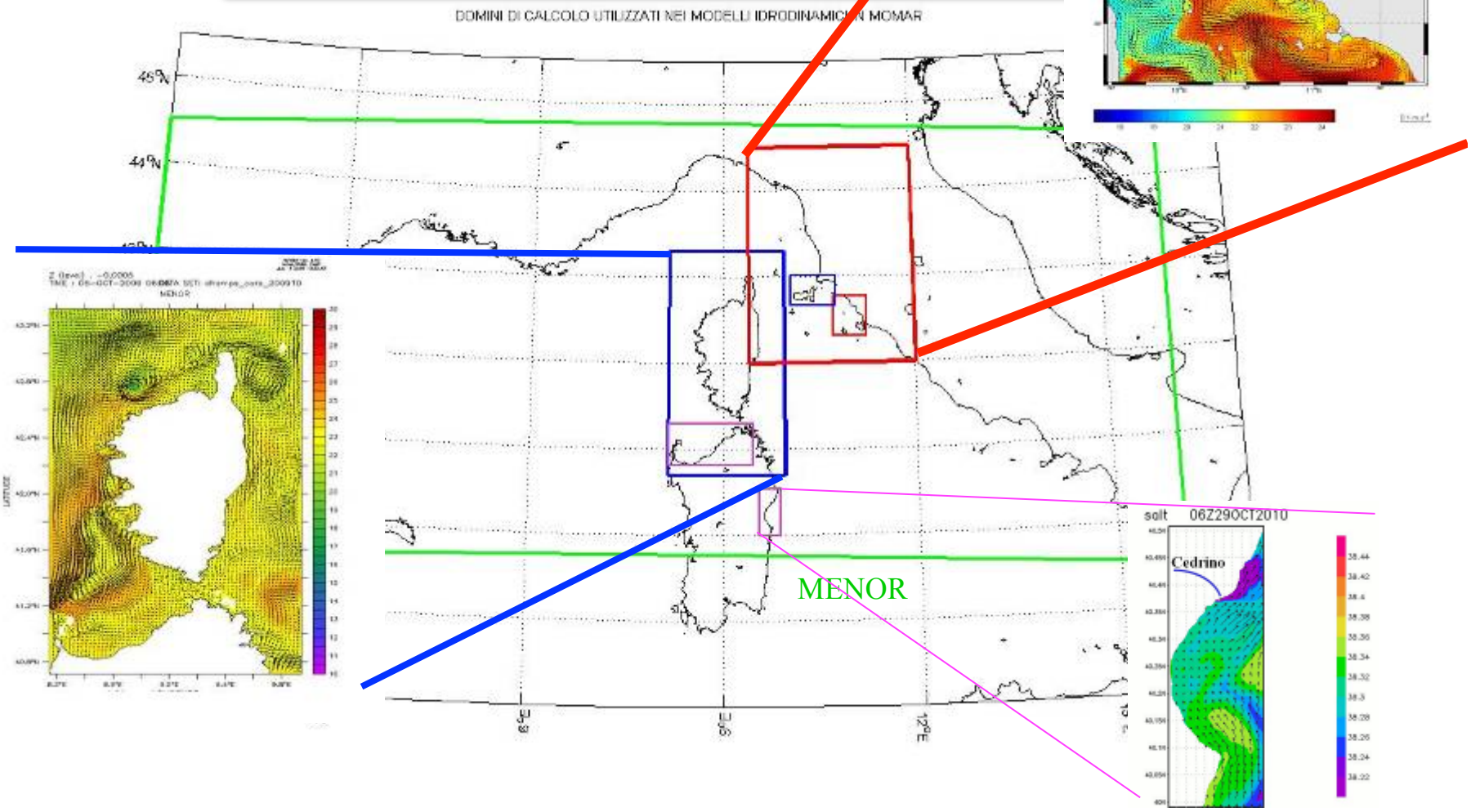
ADCPs

Oceanographic buoy

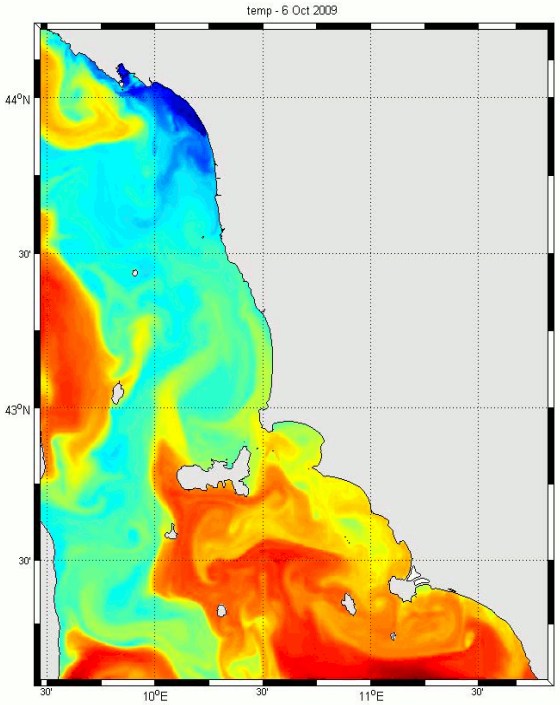
Tide gauge

Hydrometer

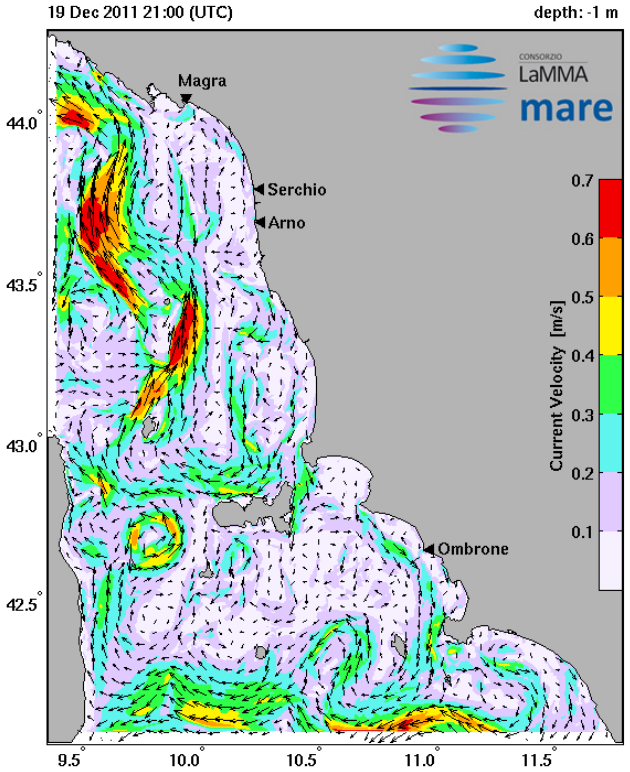
Sub-regional and coastal scale mode
model intercomparison



The Tuscan Archipelago coastal model

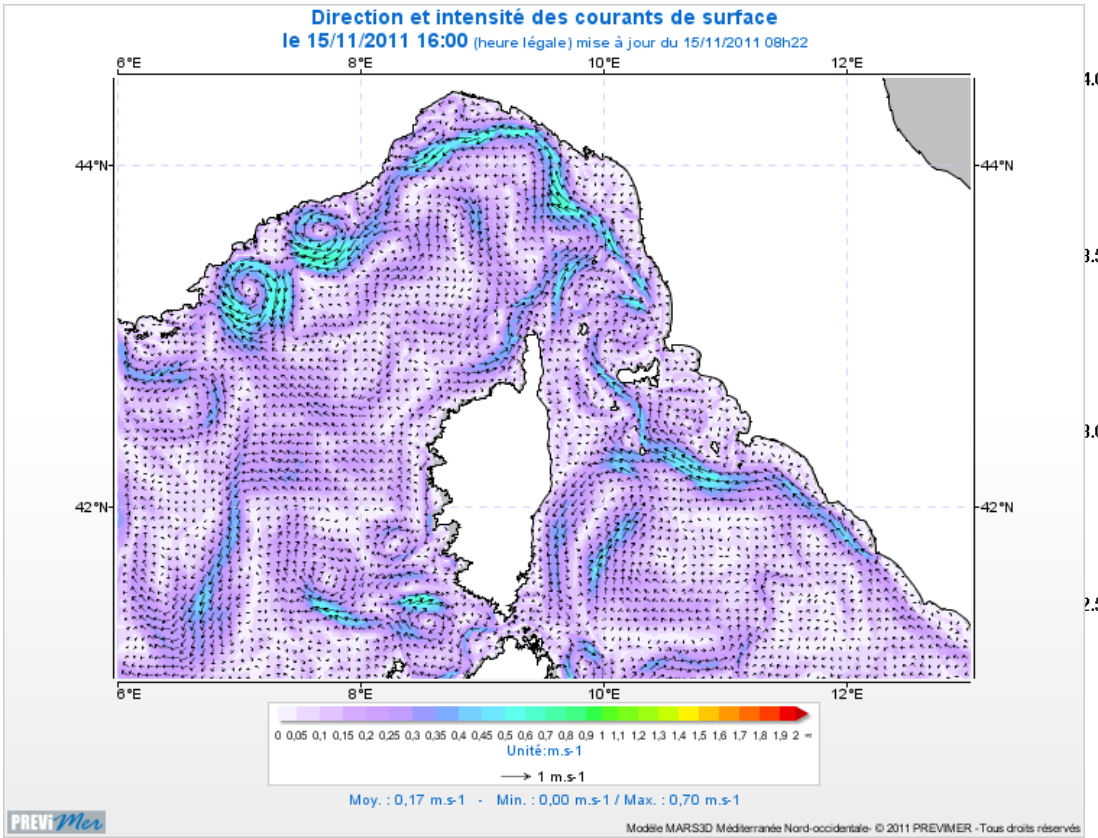


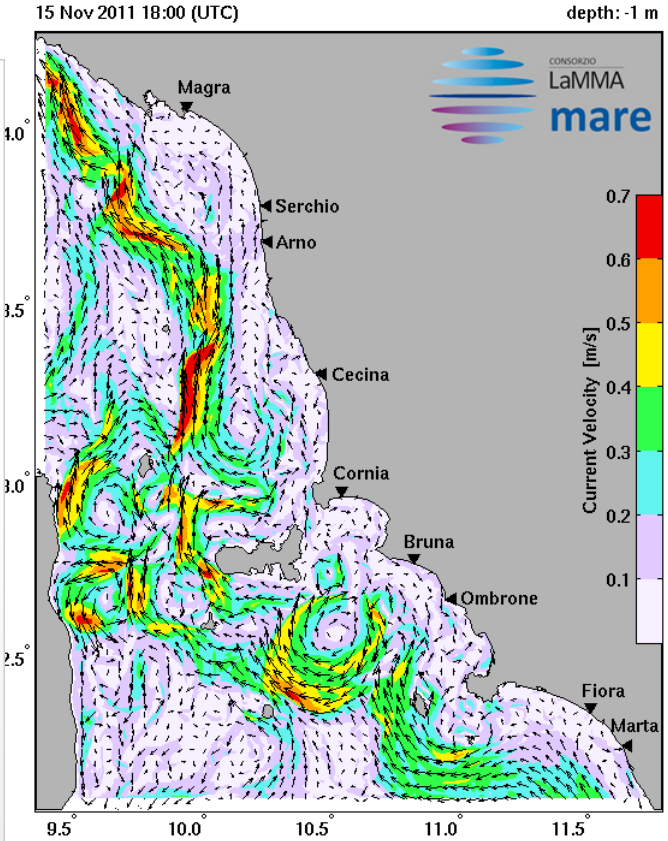
Temperature



Currents

MENOR vs ROMS





Campagne oceanografiche di misura

Ifremer

MELBA

ARPAT
Agenzia regionale per la protezione ambientale della Toscana

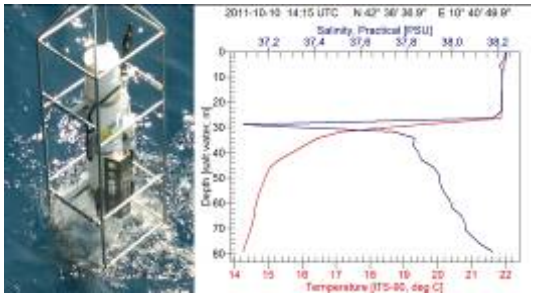
MILONGA

MIsure Lagrangiane OceaNoGrafiche al largo dell'Arcipelago toscano

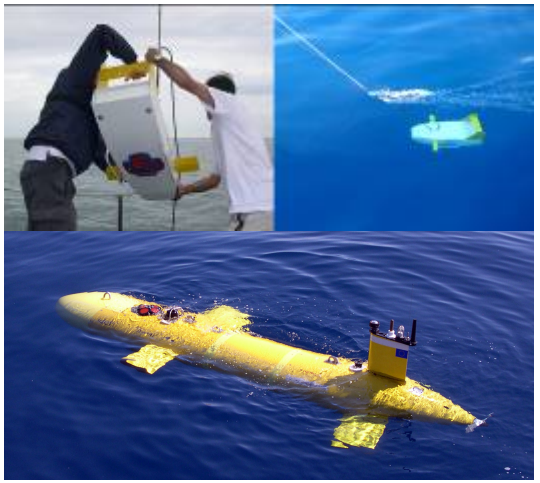
Misure in-situ

Water sampling/analysis

Temperature and salinity (CTD/floats)

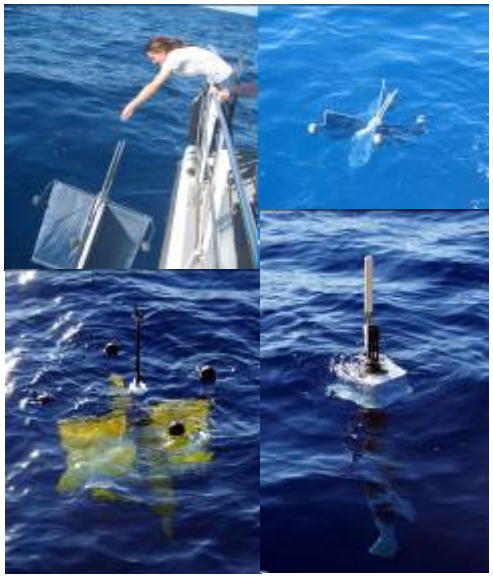


Currents (ADCP)

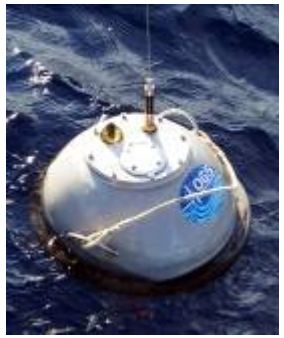


Sediments

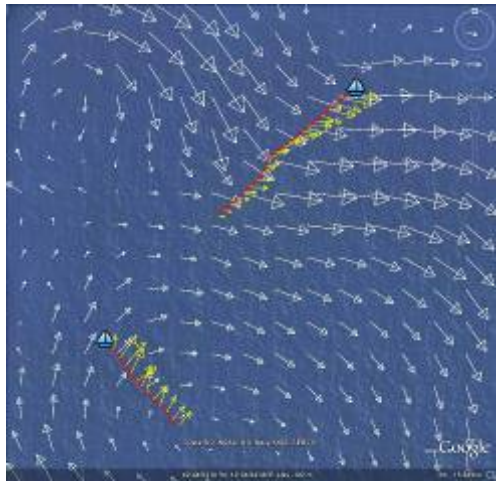
Currents (drifters/floats)



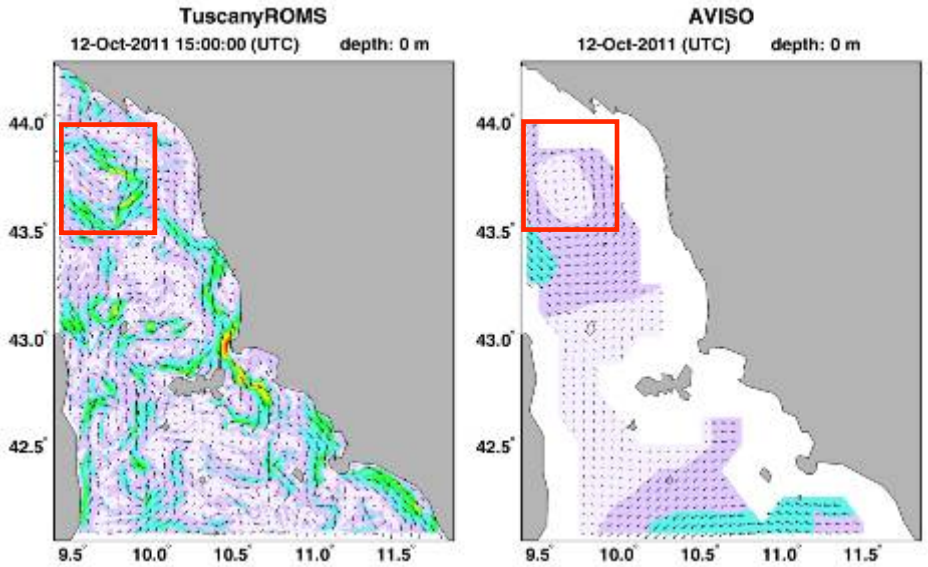
Waves (Buoy)



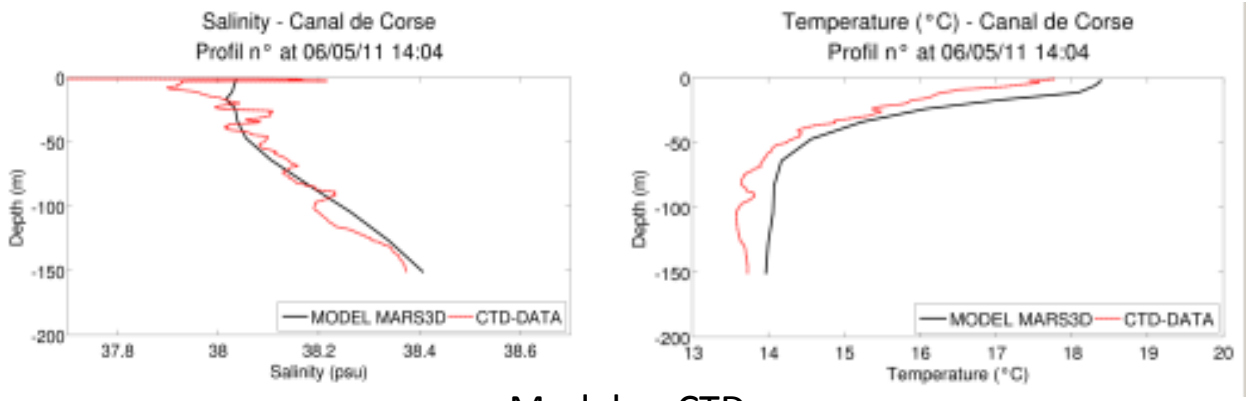
Verifica e calibrazione dei modelli



Model vs ADCP



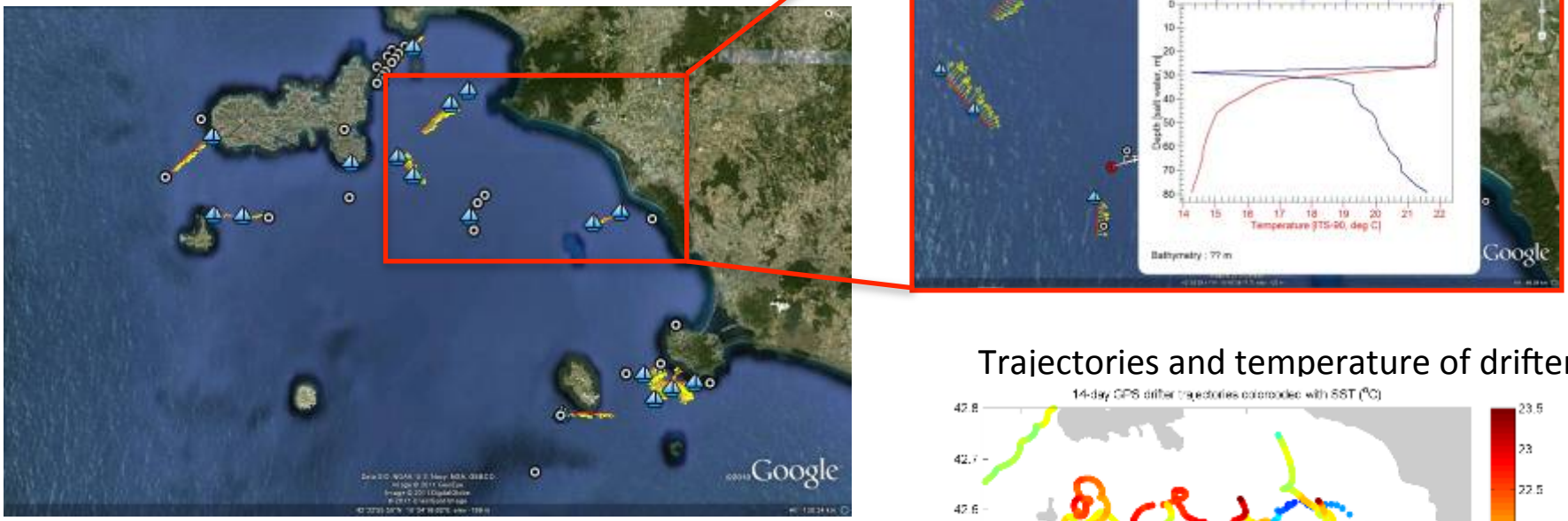
Model vs Satellite



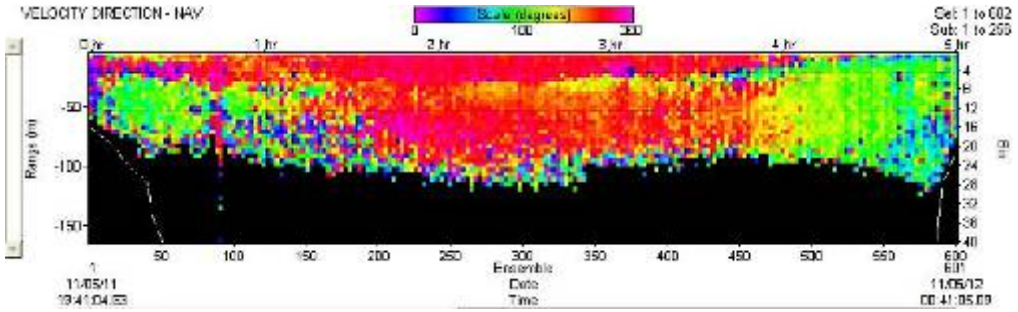
Model vs CTD

Misure in-situ

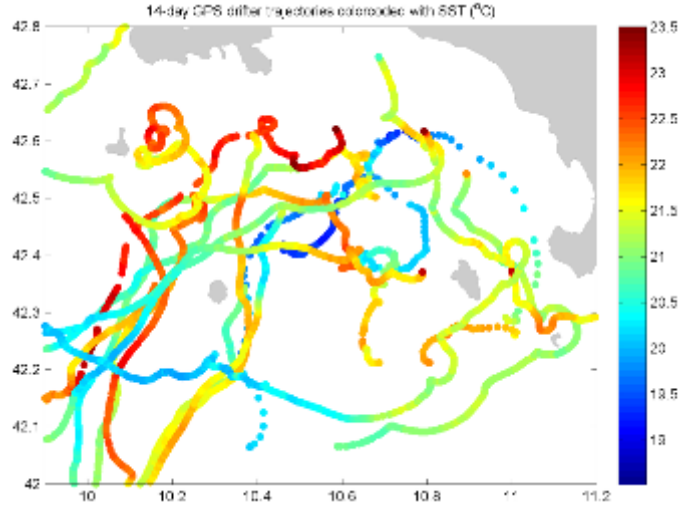
ADCP and CTD, MILONGA



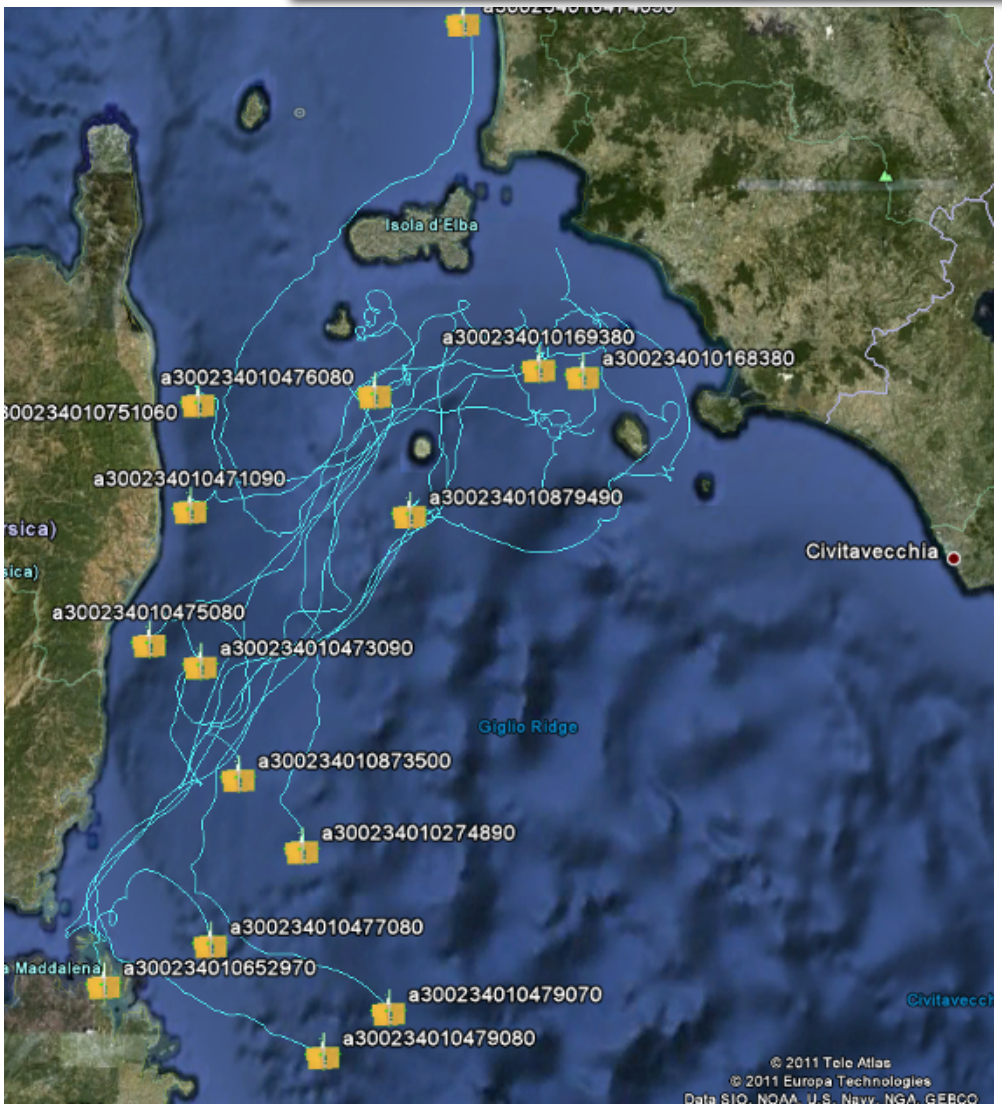
ADCP Current profile (MELBA)

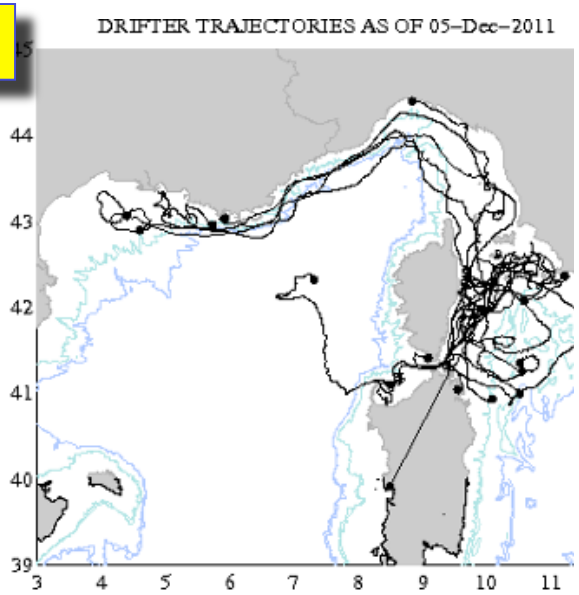


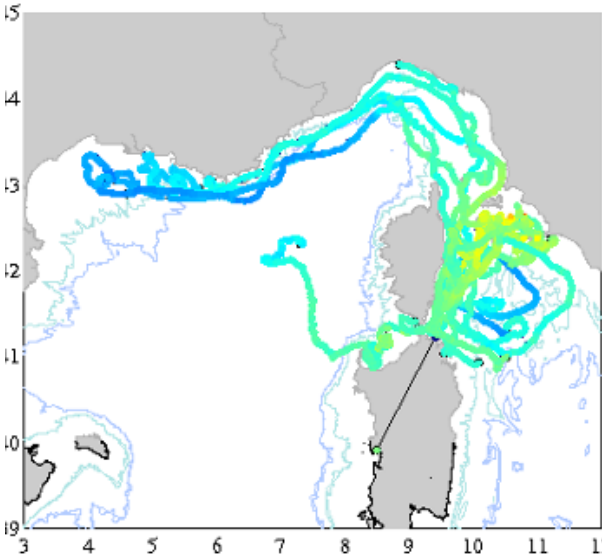
Trajectories and temperature of drifters

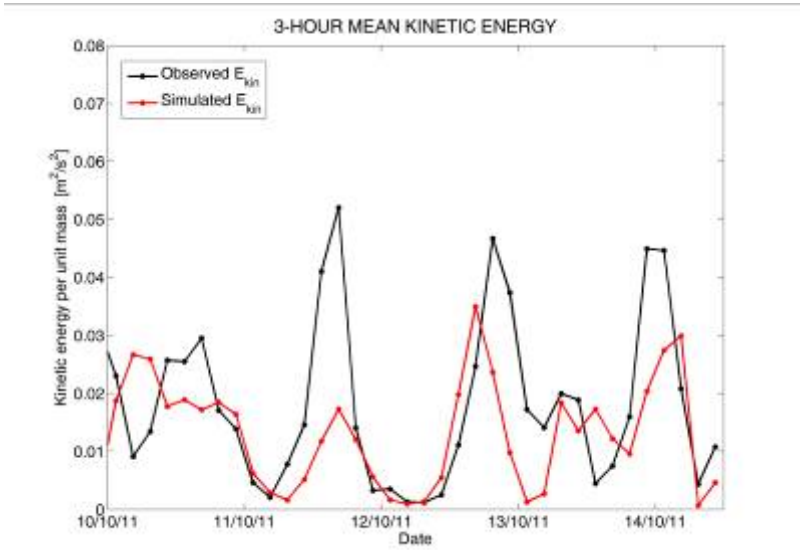


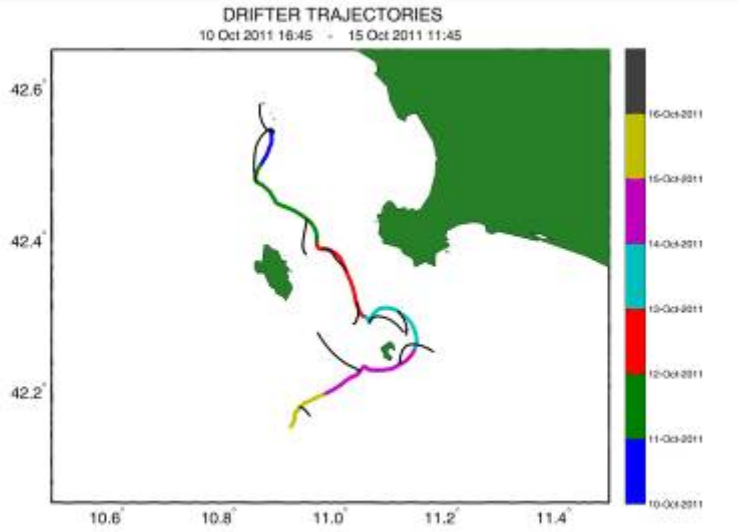
Misure lagrangiane

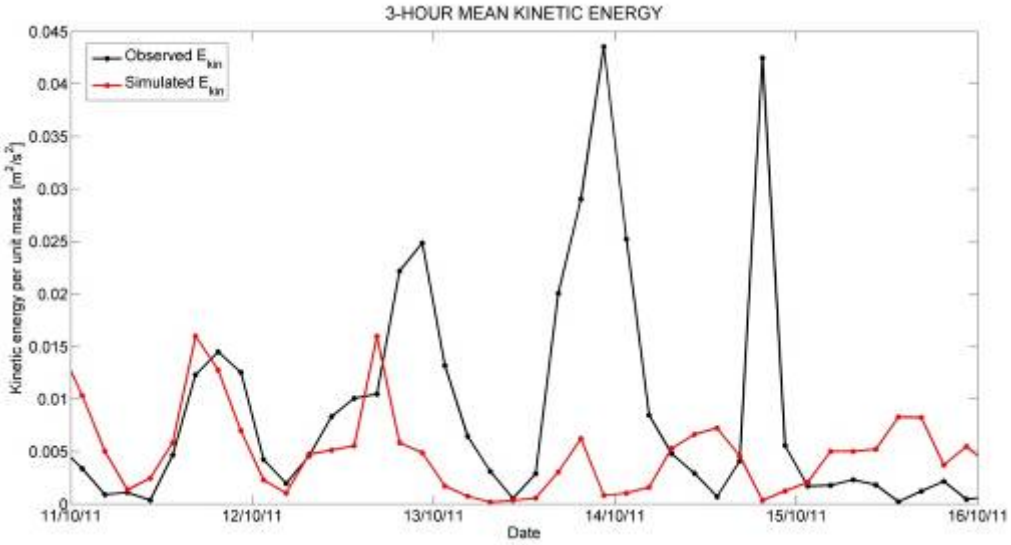


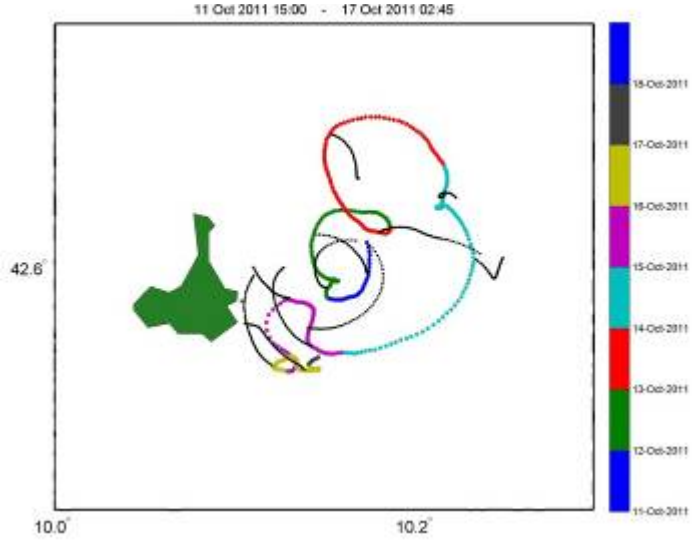





3-HOUR MEAN KINETIC ENERGY
Observed E_kin
Simulated E_kin
Kinetic energy per unit mass [m²/s²]
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
10/10/11
11/10/11
12/10/11
13/10/11
14/10/11
Date

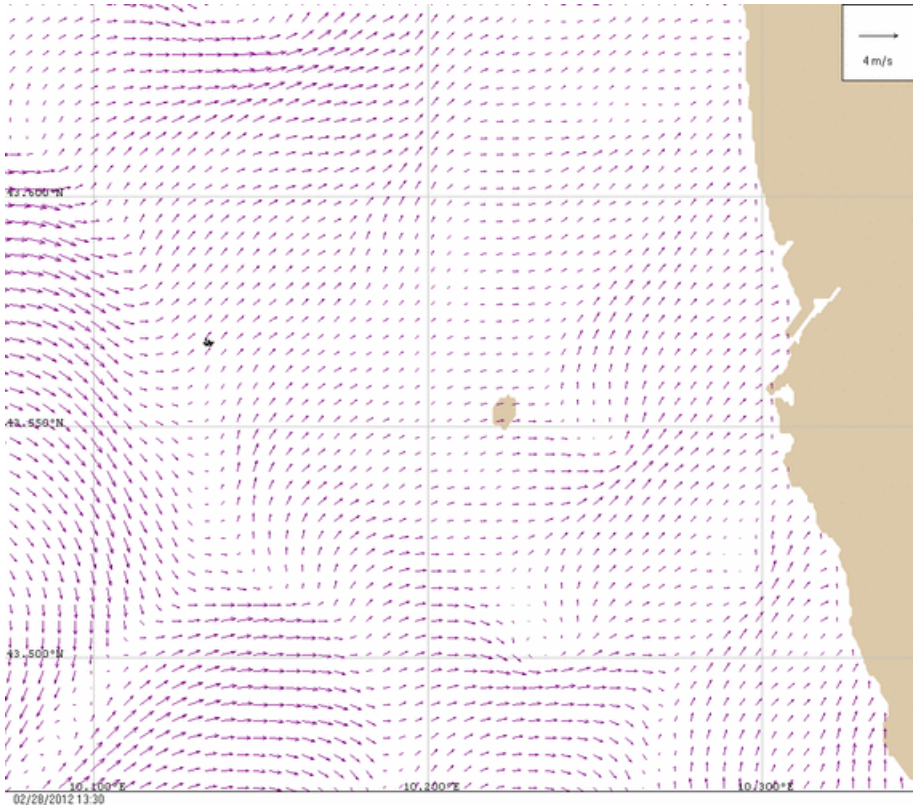

DRIFTER TRAJECTORIES
10 Oct 2011 16:45 - 15 Oct 2011 11:45
42.6°
42.4°
42.2°
10.6°
10.8°
11.0°
11.2°
11.4°
16-Oct-2011
15-Oct-2011
14-Oct-2011
13-Oct-2011
12-Oct-2011
11-Oct-2011
10-Oct-2011


3-HOUR MEAN KINETIC ENERGY
Observed E_kin
Simulated E_kin
Kinetic energy per unit mass [m²/s²]
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
11/10/11
12/10/11
13/10/11
14/10/11
15/10/11
16/10/11
Date


11 Oct 2011 15:00 - 17 Oct 2011 02:45
42.6°
10.0°
10.2°
18-Oct-2011
17-Oct-2011
16-Oct-2011
15-Oct-2011
14-Oct-2011
13-Oct-2011
12-Oct-2011
11-Oct-2011

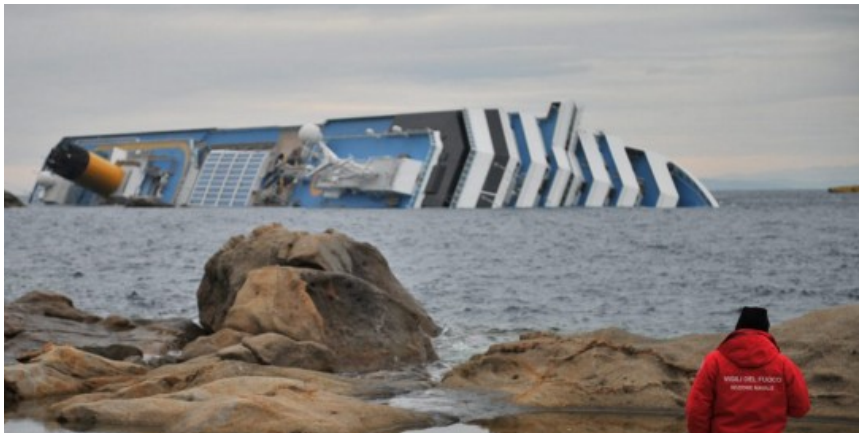
Applications and case studies

Polluttant dispersion at sea: paraffin dispersed offshore Livorno towards Livorno.



Simulation of paraffin spill (Livorno, 28/02/2012)

Applicazioni e casi studio



Risposta alle emergenze: il caso della Costa Concordia.

-Rapida installazione di un mareografo, e di stazioni meteorologiche

- Rapida ricostruzione e analisi di dati di stato del mare, per valutare la stabilità del relitto, e la pianificazione delle attività in mare

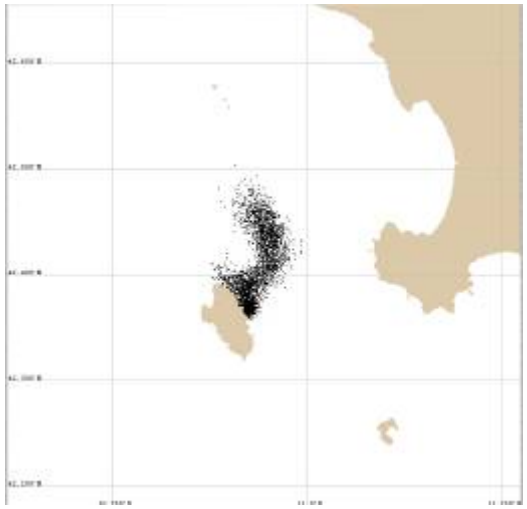
- Misure continue di idrocarburi tramite una sonda dedicata

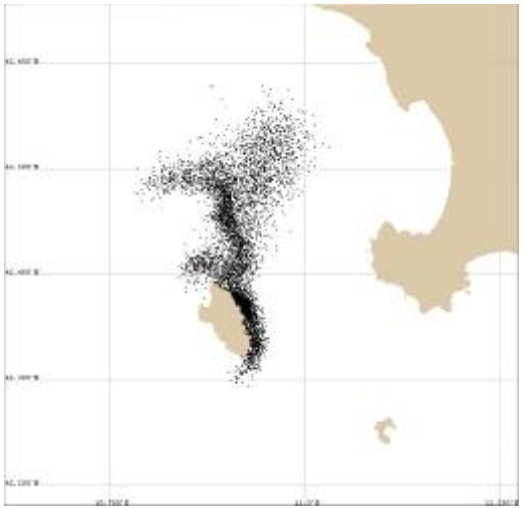
- Supporto al monitoraggio marino (ottimizzazione dei punti di campionamento)

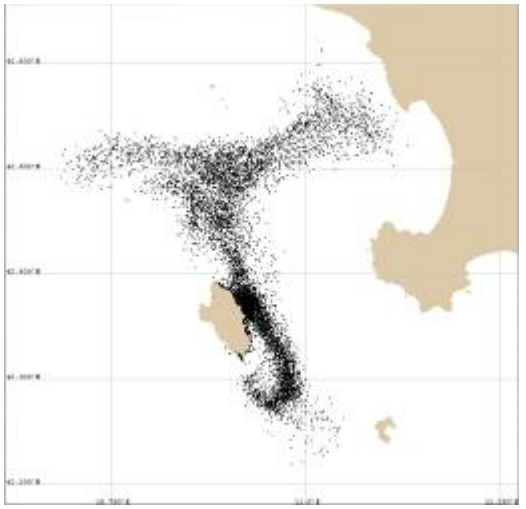
- Installazione di un radar marino in banda X(per onde, correnti, identificazione di eventuali sversamenti, ecc.)

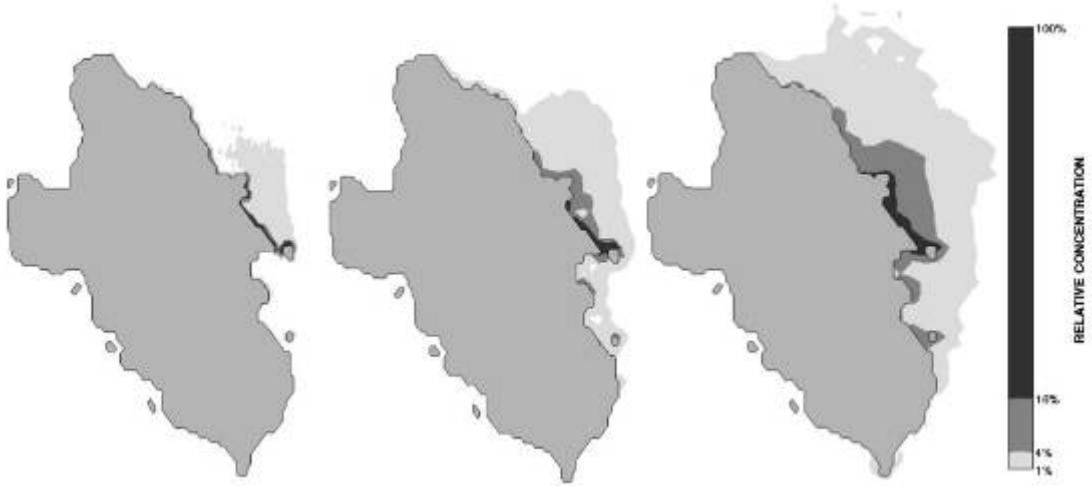
http://www.lamma.rete.toscana.it/meteo/previsioni-giglio

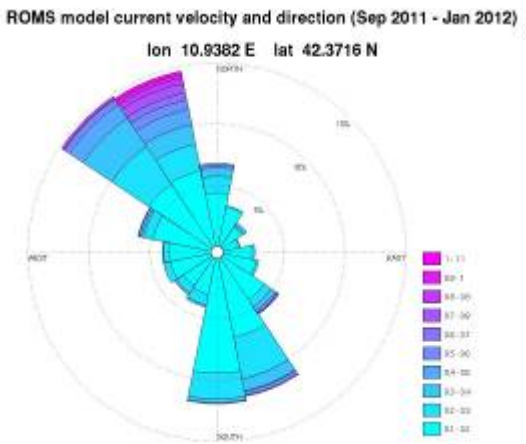
Optimize sampling point positions around Giglio







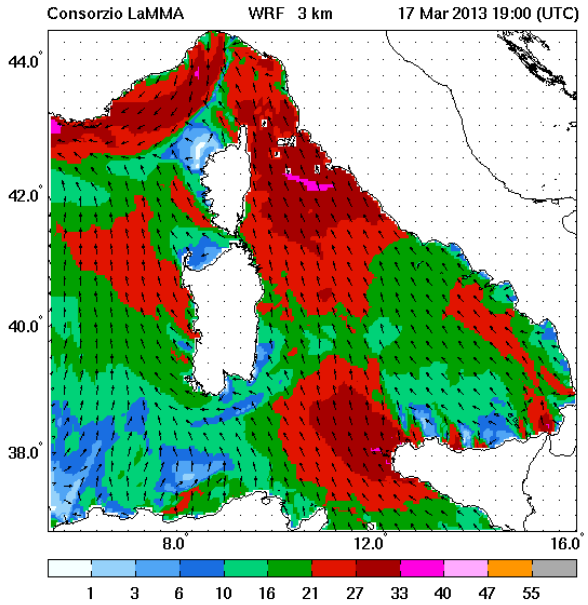


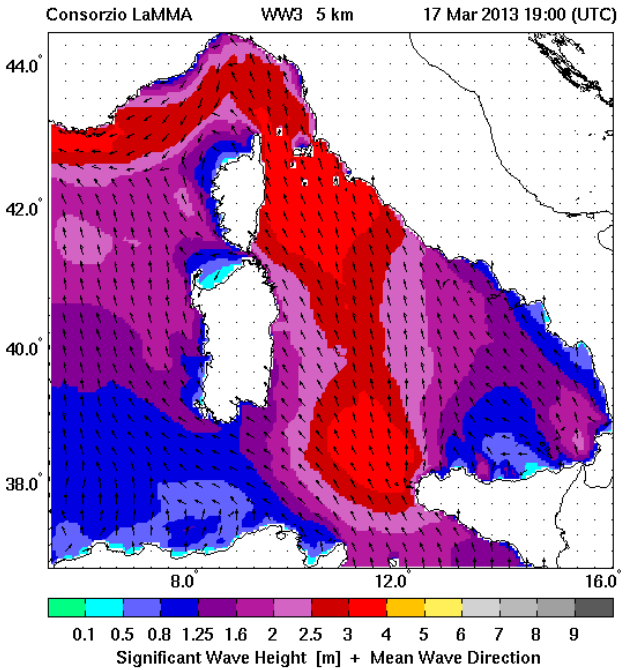


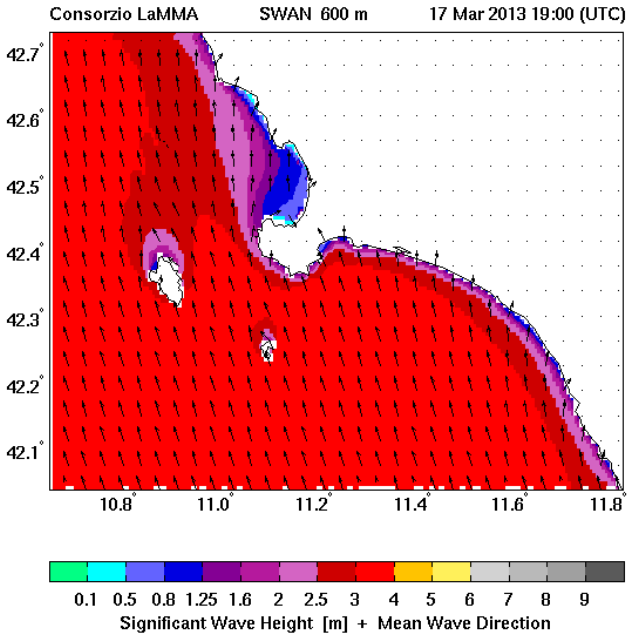
Emergency management at sea: products needed

Meteomarine forecating products

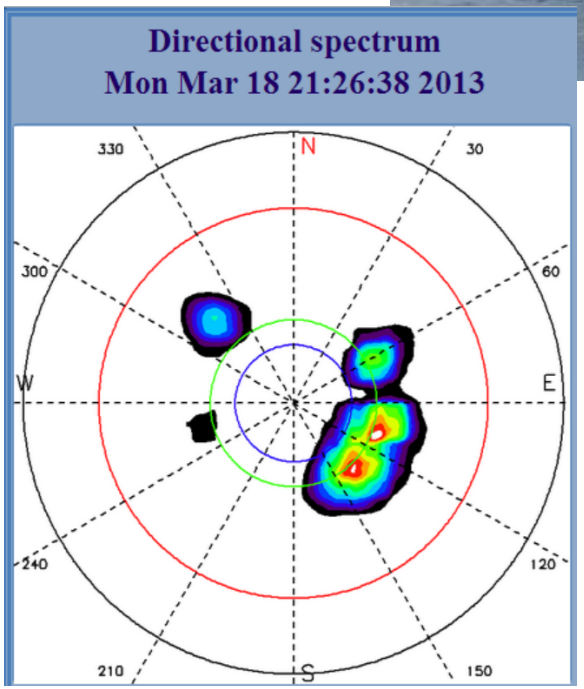
Meteorological information to support and make an optimized planning of operations at sea (i.e. for wreck removal works) is mainly given by meteorological and wave forecasting models. A modelling chain is build that include an atmospheric model (WRF) and some nested wave forecasting models based on WW3 and SWAN codes.

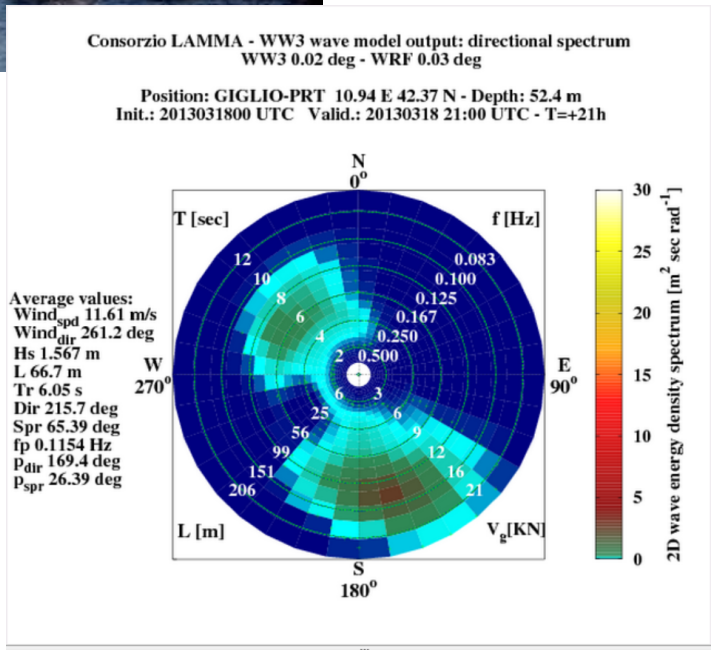




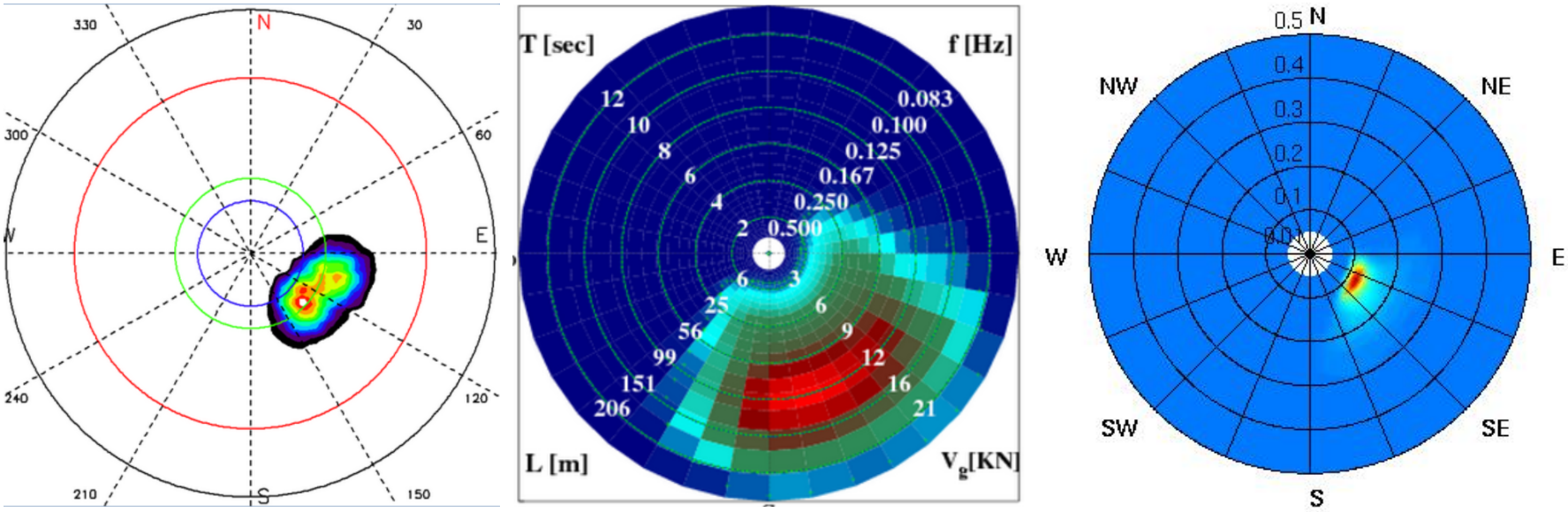


The Giglio wave radar, a tool for emergency support and work planning.





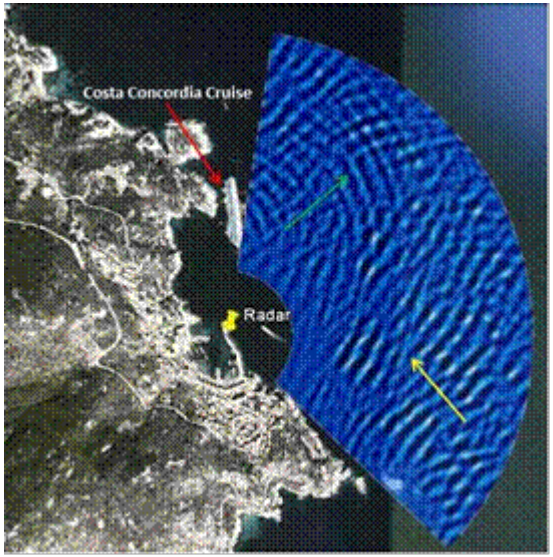
Wave spectra



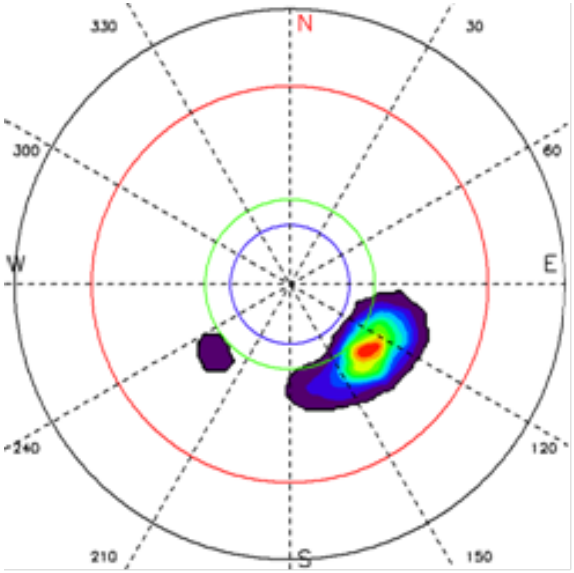
Measured wave spectra are compared with corresponding wave spectra from an operational WW3 model at 3 km resolution and a SWAN model at 600 m resolution. Storms from SE (*scirocco*) are a major cause of stress on the coast where the wreck of the Costa Concordia is, and this greatly affects the removal operations. The presence of double peaked spectra is quite common (see next slide).

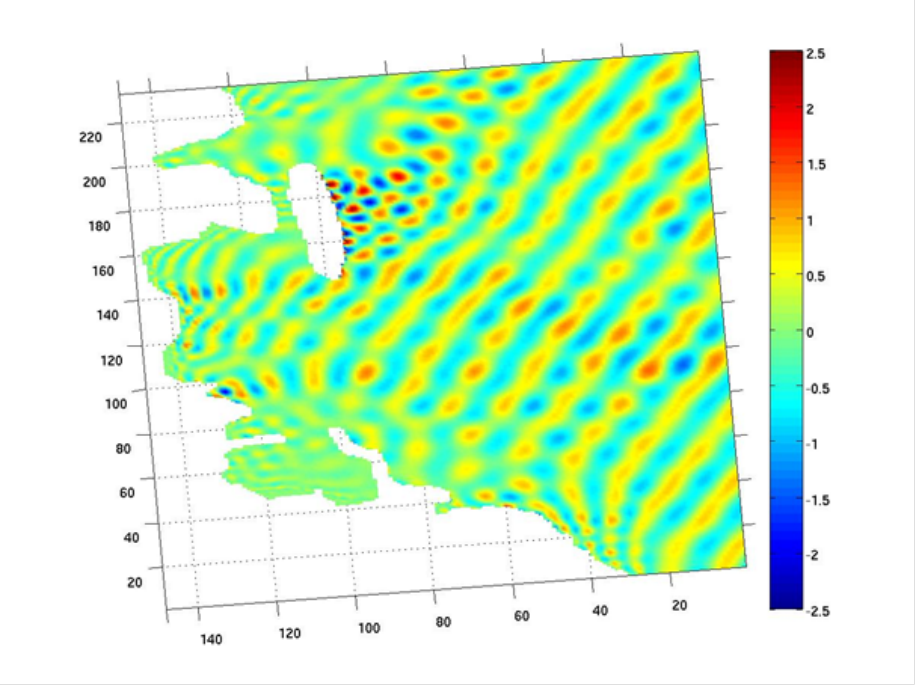
In all cases we observe similar spectrum shapes

Evaluation of wave reflection on the coast



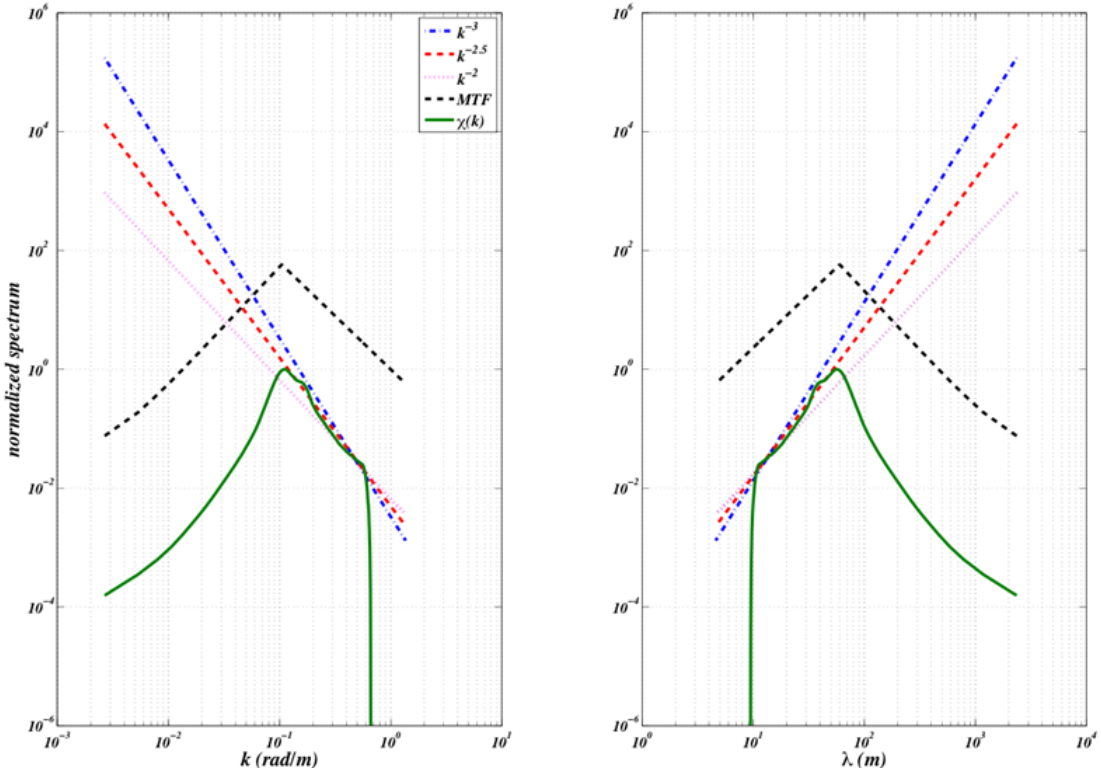
The waves coming from SE impinge on the wreck structure and arise a pattern of short crested waves, due to the superposition of the incident (partially refracted) waves and waves reflected from the wreck and the surrounding coast. These effects are clearly visible in the spatial reconstruction of the wave height.





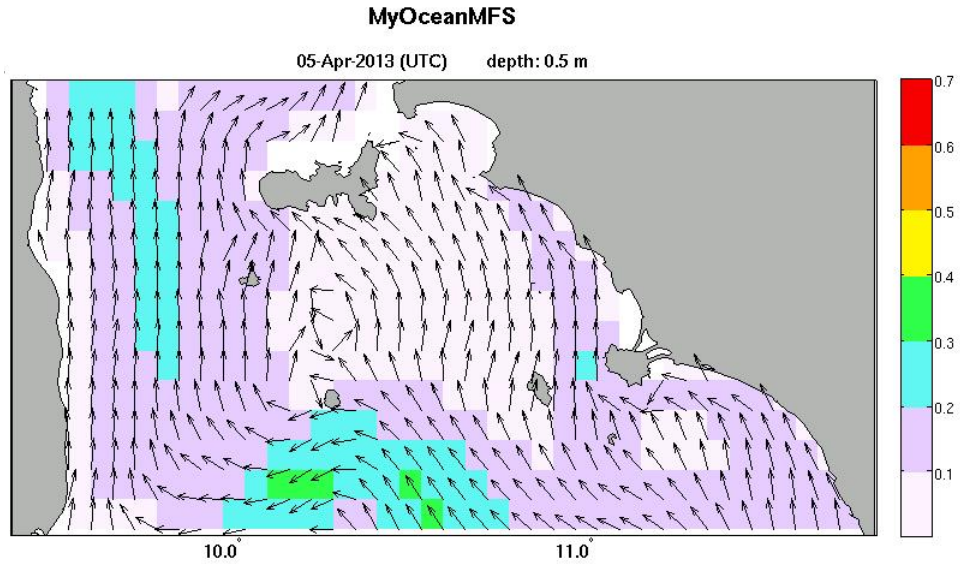
Spectral slope, validation of X-band wave radar

The wave spectrum depends on several parameters that need to be fitted in the spectrum, among them: fetch, duration of wind blowing, existence of a swell. Full scale measurements of the ocean waves demonstrated as the exponent of the frequency power law of the wave amplitude spectrum is strongly varying, although most of them confirmed a ω^{-4} scaling

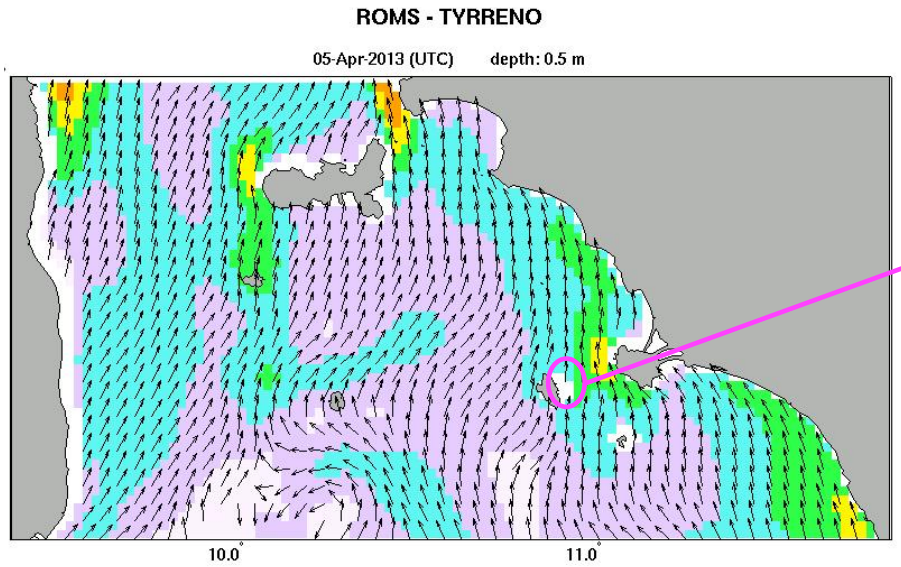


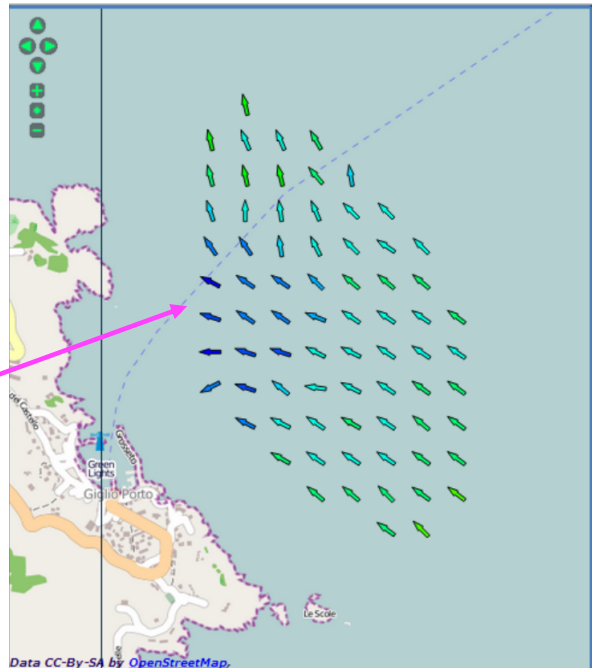
Log-log normalized 1D-spectrum as function of the wavenumber *k* and of the wavelength is shown in the left and right panel, respectively. On each panel the power law curves k^{-3}, $k^{-2.5}$, k^{-2} are also reported to reproduce the weak turbulence behavior in the equilibrium range . These result in the spectral domain show that measured wave spectra by X-band wave radar are consistent with hydrodynamics laws.

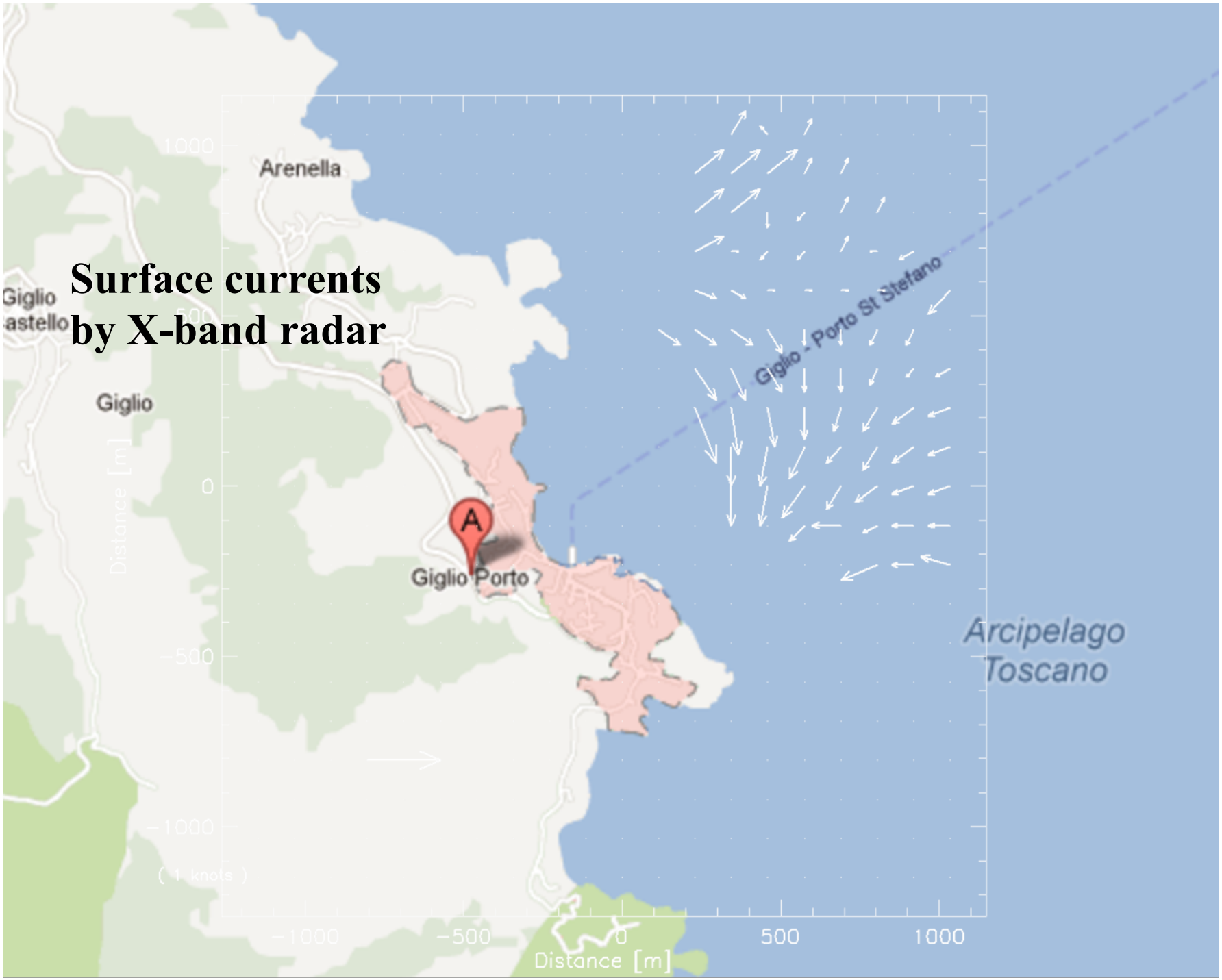
Verification of surface currents



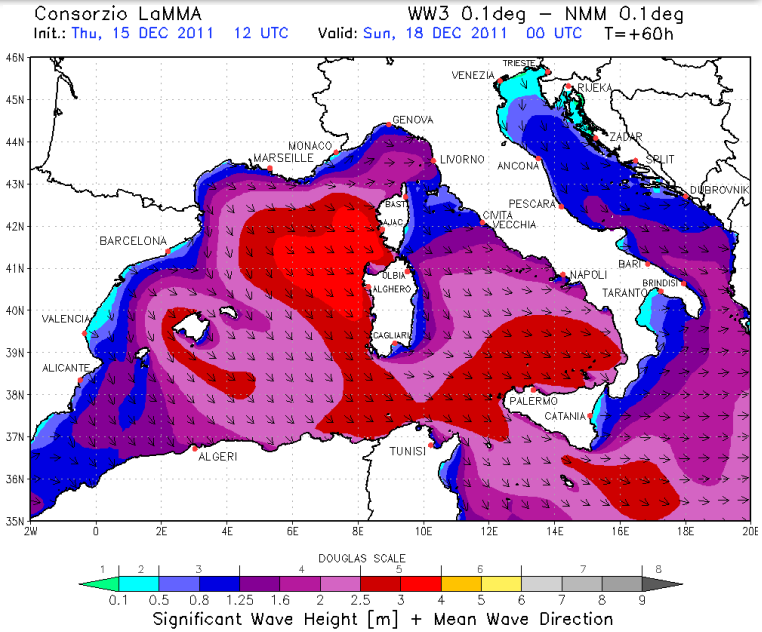
The coastline shape and bathymetry greatly influence the observed currents, with observation of sub-mesoscale patterns that are challenging to reproduce by hydrodynamic models. The impact of this observation/forecasting system on the activities of wreck removal and marine monitoring is very significant.

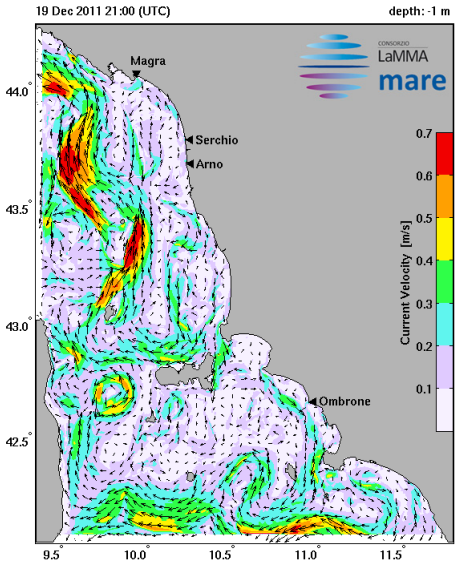




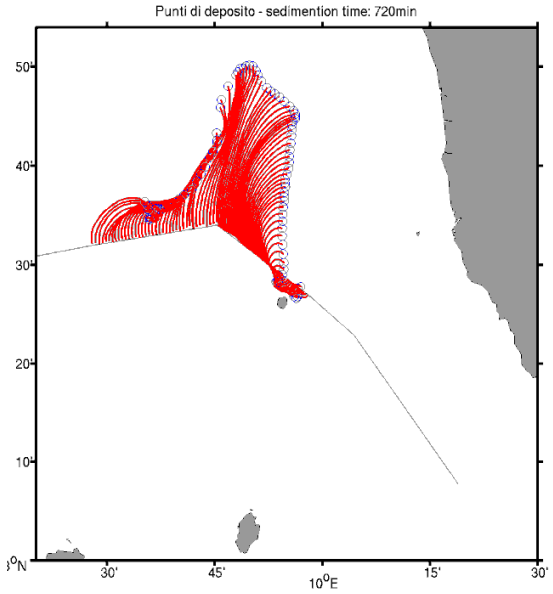

Surface currents
by X-band radar
Arenella
Giglio
Giglio Porto
A
Giglio - Porto St Stefano
Arcipelago
Toscano
1000
0
−500
−1000
(1 knots)
Distance [m]
−1000
−500
0
500
1000
Distance [m]

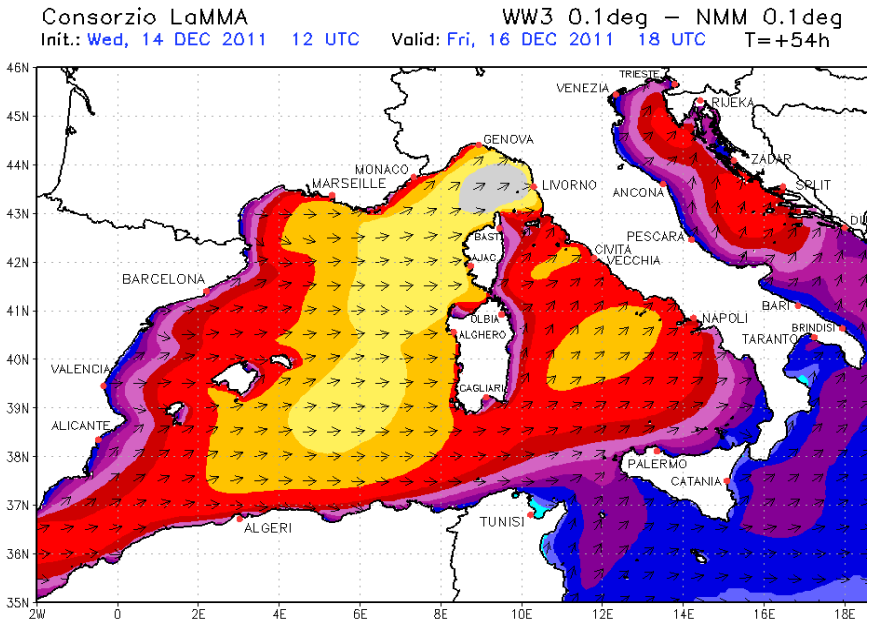
Applicazioni e casi studio

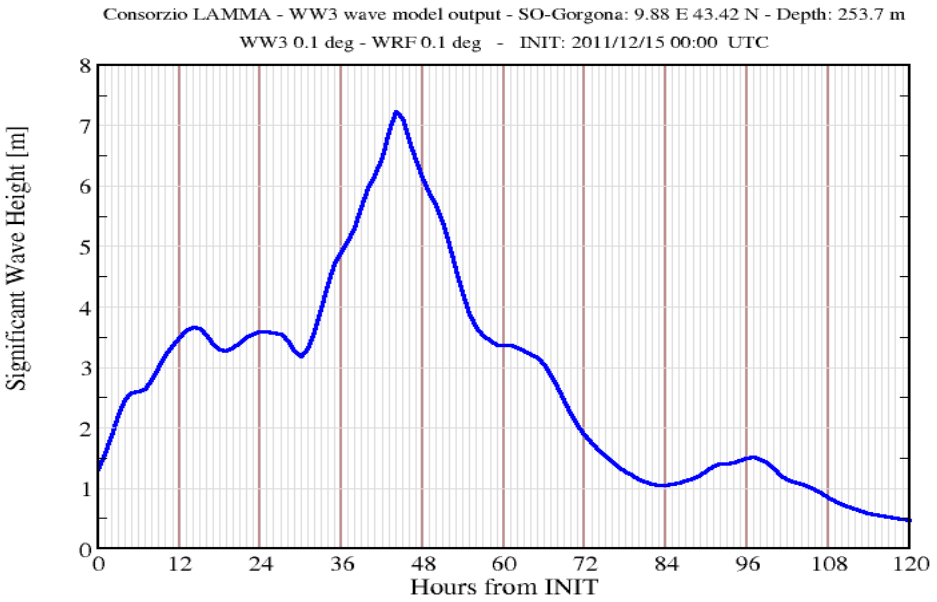


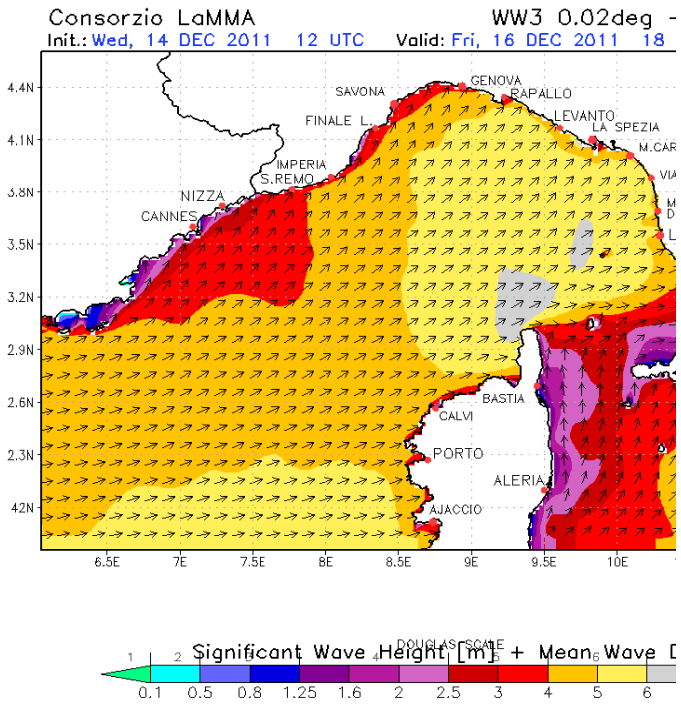


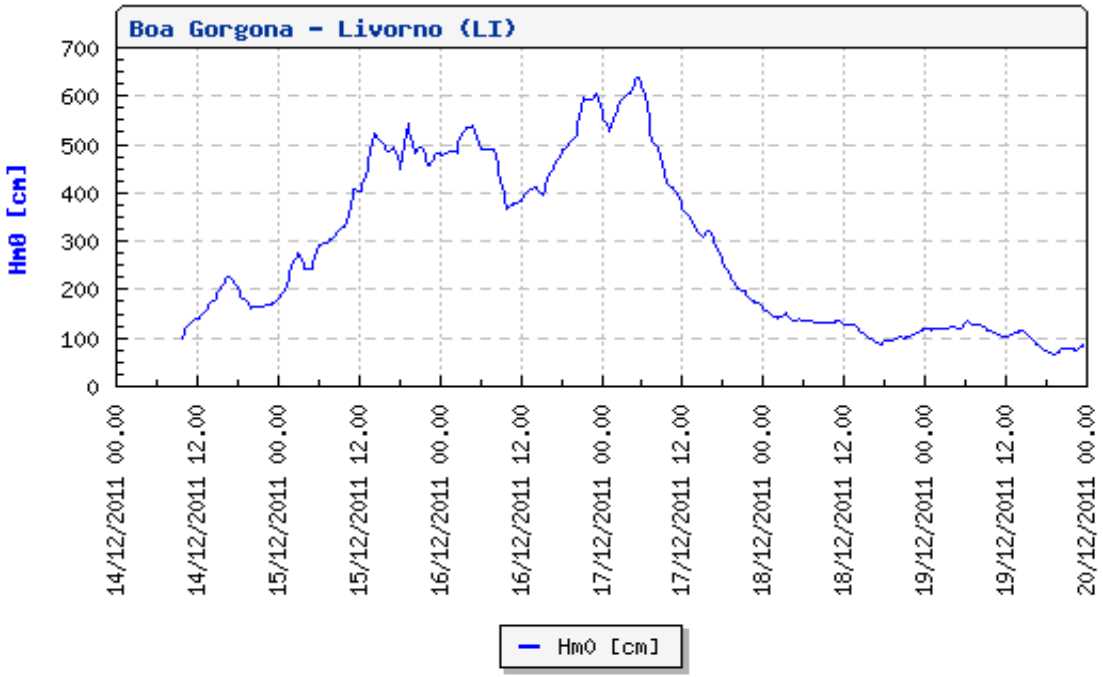
I fusti tossici alla Gorgona.




Consorzio LaMMA
WW3 0.1deg – NMM 0.1deg
Init.: Wed, 14 DEC 2011 12 UTC Valid: Fri, 16 DEC 2011 18 UTC T=+54h
TRIESTE
VENEZIA
RIJEKA
GENOVA
MONACO
MARSEILLE
LIVORNO
ANCONA
ZADAR
SPLIT
PESCARA
CIVITA VECCHIA
BARCELONA
BARI
NAPOLI
BRINDISI
TARANTO
VALENCIA
CAGLIARI
ALICANTE
PALERMO
CATANIA
ALGERI
TUNISI
DOUGLAS SCALE
0.1 0.5 0.8 1.25 1.6 2 2.5 3 4 5 6
Significant Wave Height [m] + Mean Wave D


Consorzio LAMMA - WW3 wave model output - SO-Gorgona: 9.88 E 43.42 N - Depth: 253.7 m
WW3 0.1 deg - WRF 0.1 deg - INIT: 2011/12/15 00:00 UTC
Significant Wave Height [m]
Hours from INIT

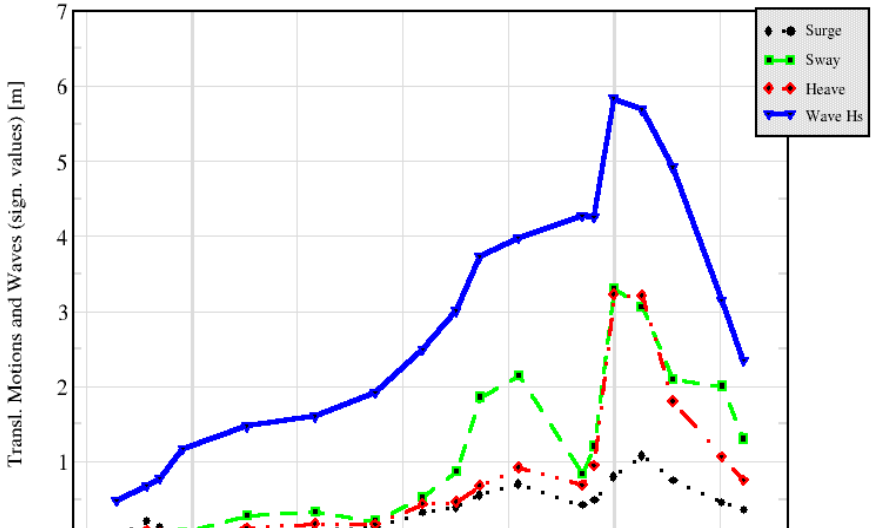

Consorzio LaMMA
WW3 0.02deg -
Init.: Wed, 14 DEC 2011 12 UTC Valid: Fri, 16 DEC 2011 18
SAVONA
GENOVA
RAPALLO
FINALE L.
LEVANTO
LA SPEZIA
IMPERIA
S.REMO
NIZZA
CANNES
BASTIA
CALVI
PORTO
ALERIA
AJACCIO
DOUGLAS SCALE
0.1 0.5 0.8 1.25 1.6 2 2.5 3 4 5 6
Significant Wave Height [m] + Mean Wave D


Boa Gorgona - Livorno (LI)
Hm0 [cm]
Hm0 [cm]

ROUTE: RouteBCG - SHIP: S175 ldcnd01 MxSpd: 18 KT - TOD: 20111215 20:00 TOA: 20111217 07:35

Route Time of Transit: 35.7 h - Route Lenght: 1029 Km

Metocean data from LaMMa - Atm: Global GFS, LAM WRF 0.2 deg - Waves: WW3 0.1 deg - Area: Mediterraneo



ROUTE: RouteBCG - SHIP: S175 ldcnd01 MxSpd: 18 KT - TOD: 20111215 20:00 TOA: 20111217 07:35

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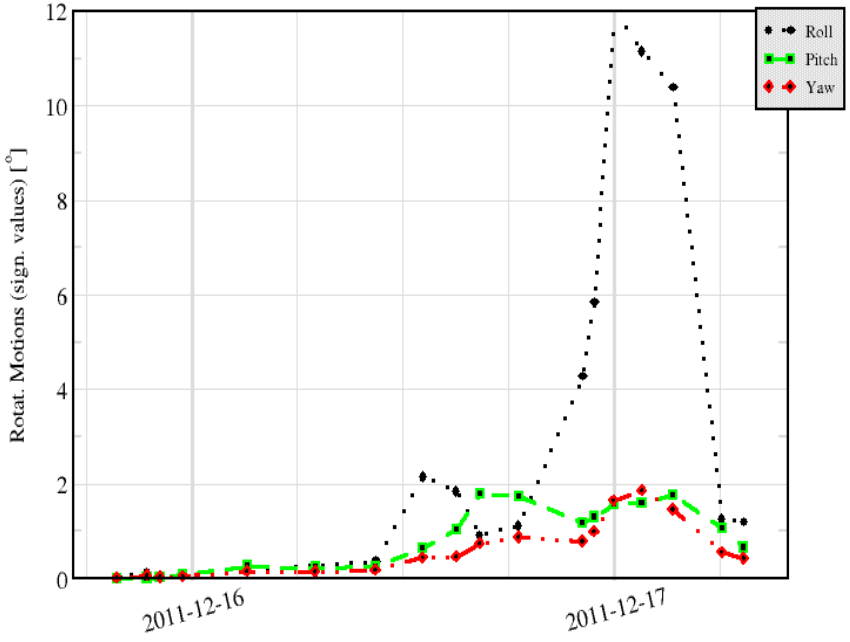
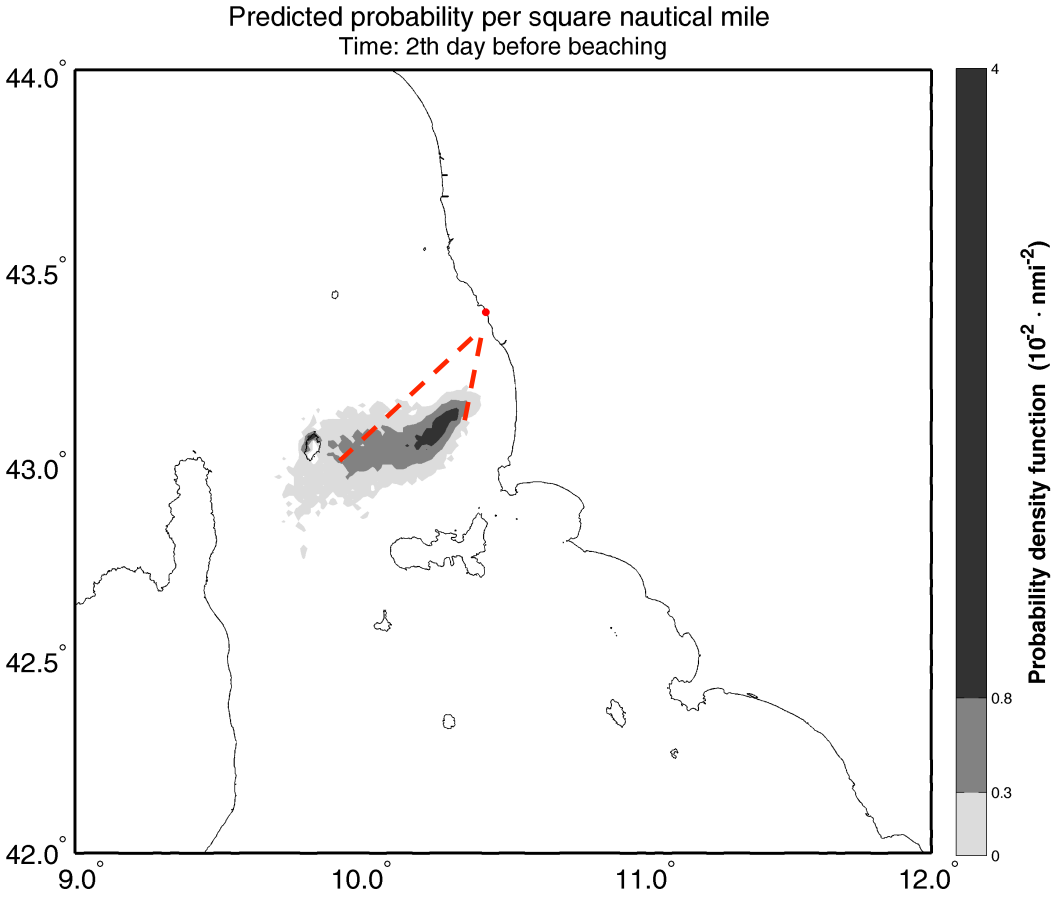


Weather routing for safety purposes

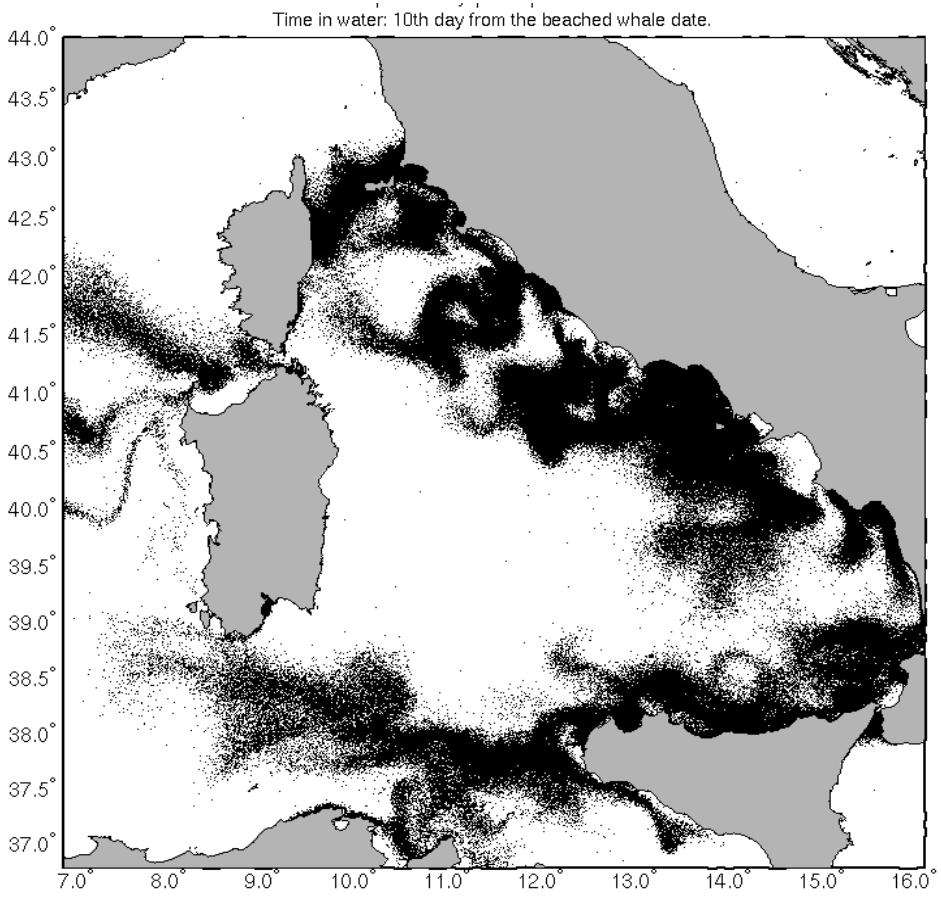
Applicazioni e casi studio

Mappa relativa alla probabilità che la carcassa della balenottera spiaggiata a Rosignano si trovasse in una certa area di mare 2 giorni prima dello spiaggiamento.

Nella mappa più l'area è scura maggiore è la probabilità.

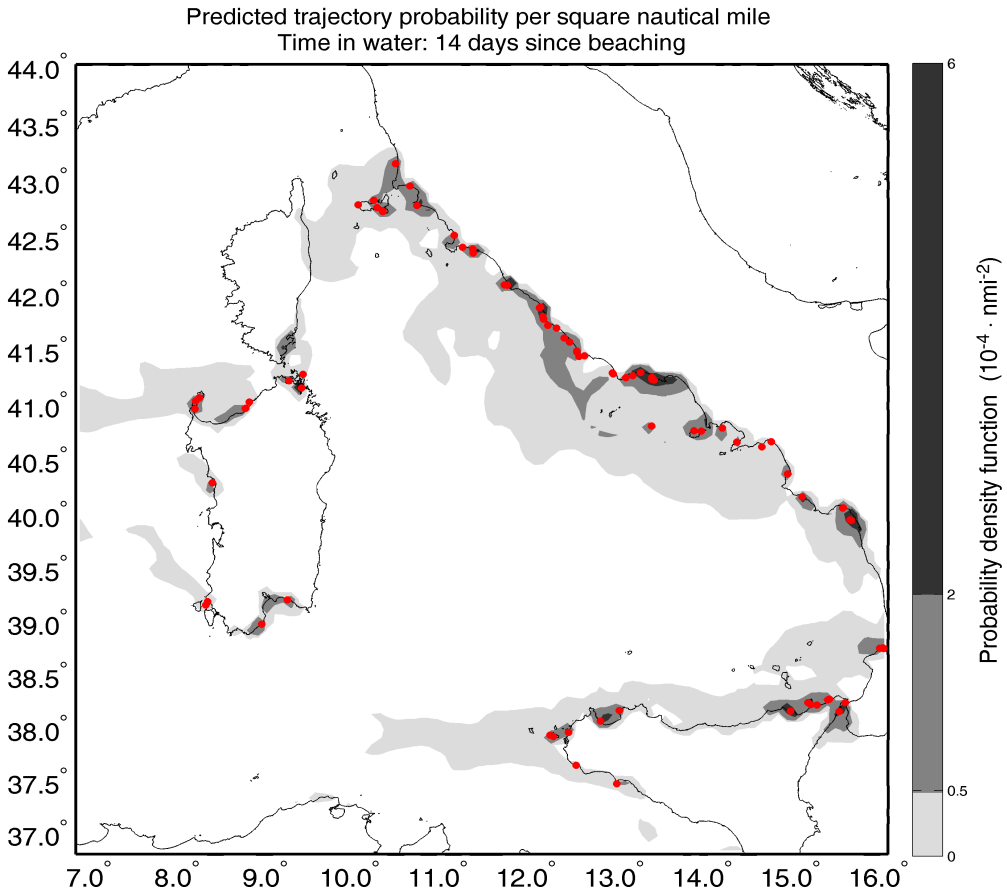


Back-trajectories, cumulo delle possibili traiettorie.



Mappa relative alla probabilità che le carcasse di cetacei si siano trovate in una certa area di mare nell'arco di 14 giorni prima dello spiaggiamento (densità di probabilità delle traiettorie).

Nella mappa più l'area è scura maggiore è la probabilità.



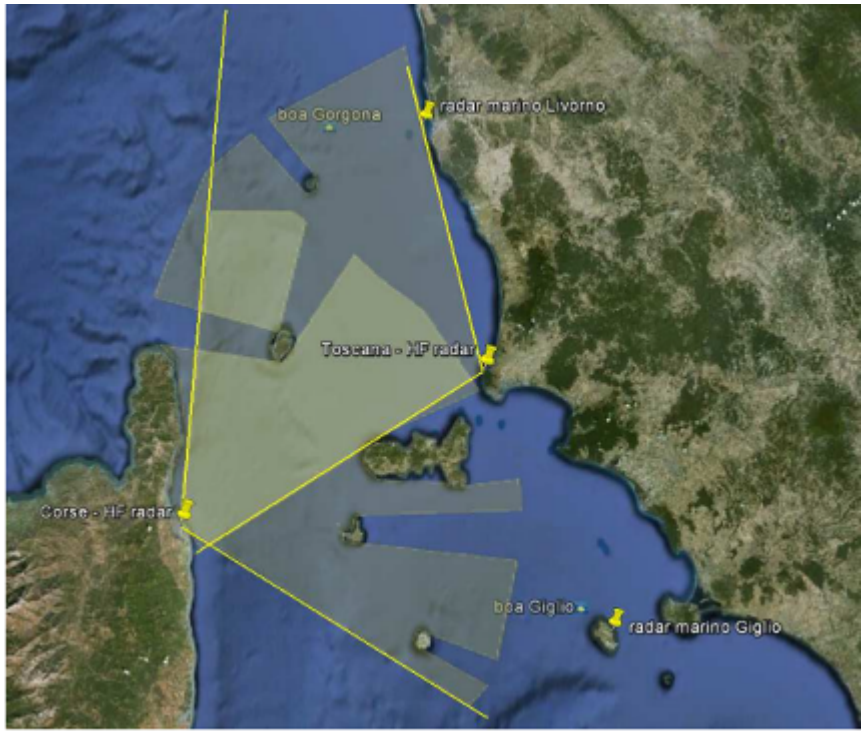
The MSFD → impact on cross-border initiatives

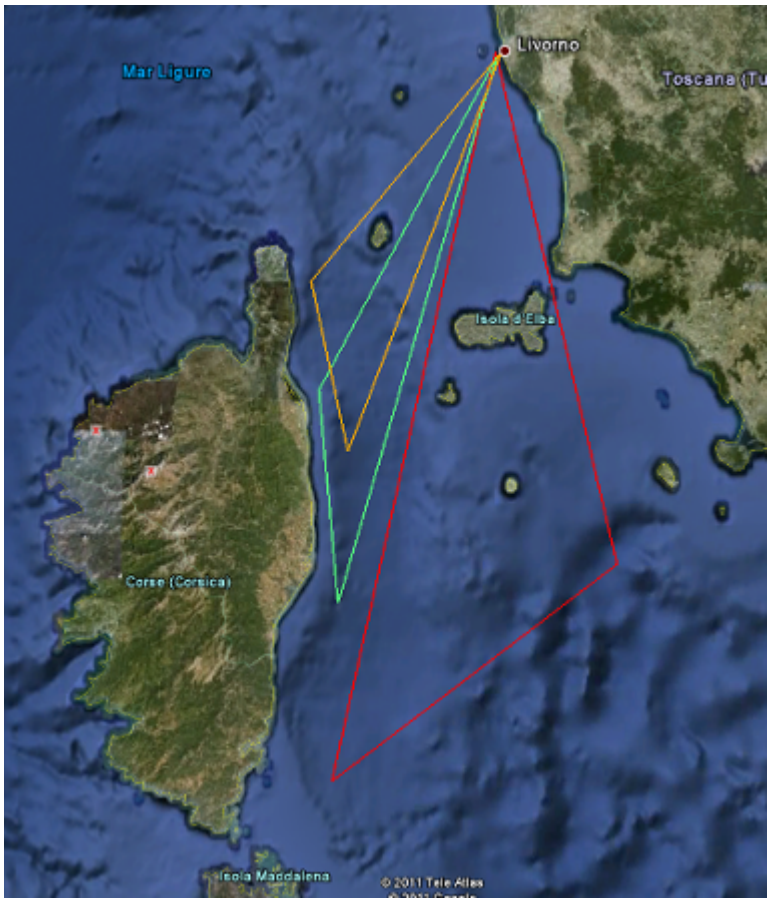
The Directive 2008/56/EC recognizes the sea monitoring as a fundamental tool for environmental protection and for contributing to the definition of common policies through the use of integrated control systems for the transnational marine space.

Maritime emergencies

Objective: define a common path for the creation of an integrated system for monitoring marine and coastal environment in the regions bordering the North Tyrrhenian / Ligurian sea area

MOMAR → SICOMAR





Simulare conviene...!

REGIONE TOSCANA

CONSORZIO LaMMA

Consiglio Nazionale delle Ricerche