La dinamica costiera e la sua gestione attraverso l'utilizzo dei servizi Copernicus

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Workshop
LIFE+IMAGINE: Gestione integrata in area costiera, focus su eventi estremi e consumo del suolo
Roma, 21 settembre 2015
Sala UNICEF Via Palestro 14

Outline

DEFINITIONS:

- Framework for **Maritime Spatial Planning and integrated coastal management** (2013/0074 (COD)), Maritime Spatial Planning (MSP) framework Directive (2014/89/EU)
- **Monitoring** methods

CHALLENGES:

future needs in terms of **monitoring and development of indicators** to assess the impacts of climate change

IMPLICATIONS:

of climate change will regard **physical and biological features** of the marine and coastal environment

DEFINITIONS:

- REGULATION (EU) No 377/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 3 April 2014 establishing the **Copernicus Programme**
- **Monitoring** methods

CHALLENGES:

future needs in terms of **monitoring and development an autonomous, multi-level operational Earth observation capacity of EU worldwide**

IMPLICATIONS:

of climate change will regard hazard, **vulnerability, risk, climate change** of the marine and coastal environment (Emergency, Land, Climate, Marine environmental and Maritime **Core services**)

REGULATION (EU) No 377/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 3 April 2014 establishing the Copernicus Programme

The objective is to use multi-source data to get a timely and quality information, services and knowledge, and to provide **autonomous and independent** access to information in relation **to environment and security on a global level**. It will pull together all the information obtained by the Copernicus environmental satellites, air and ground stations **to provide a comprehensive picture of the "health" of Earth**. The geo-spatial information services offered by Copernicus can be grouped into six main interacting themes: **land, ocean, emergency response, atmosphere, security and climate change**.

Copernicus builds upon **3 components**:

the space component (observation satellites and associated ground segment with missions observing land, atmospheric and oceanographic parameters) This comprises two types of satellite missions, ESA's five families of dedicated Sentinel (space missions) and missions from other space agencies, called Contributing Missions.

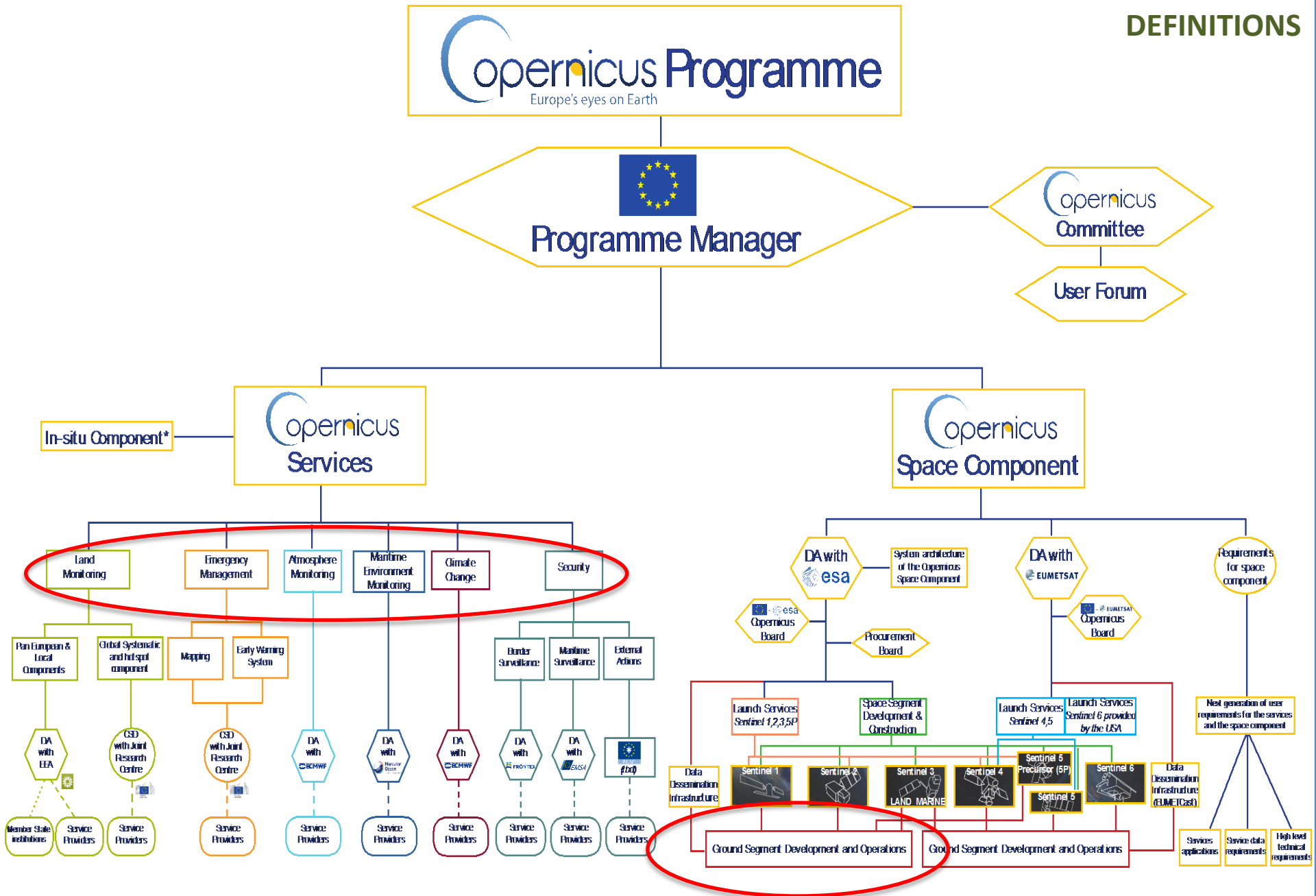
in-situ measurements (ground-based and airborne data gathering networks providing information on oceans, continental surface and atmosphere)

services to users.

- The Copernicus Sentinels satelites are a perfect name for a constant and commonly planned Earth monitoring;
- This will provide a double advantage to European tax payers since they are paying for the Copernicus programme, the contributing missions and the much needed in-situ data;
- The additional knowledge offered by Copernicus products and services complements the information and data needed to support MS policies, reporting, assessments under EU obligations and comparison of their implementations.

…& connections with Marine Strategy Framework Directive (2008/56/EC), Renewable Energy Directive (2009/28/EC), etc…

DEFINITIONS



DEFINITIONS

Maritime Spatial Planning (*MSP*) framework DIRECTIVE 2014/89/EU

•The Integrated Maritime Policy for the European Union (IMP) identifies Maritime Spatial Planning as a cross-cutting policy tool enabling public authorities and stakeholders to apply a coordinated, integrated and trans-boundary approach.
•The application of an ecosystem-based approach will contribute to promoting the sustainable development and growth of the maritime and coastal economies and the sustainable use of marine and coastal resources.

• *MPS* supports and facilitates the implementation of the Europe 2020 Strategy **for smart, sustainable and inclusive growth** ('the Europe 2020 Strategy') of the **coastal and maritime sectors.**

• *MPS* will contribute to the effective management of marine activities and the sustainable use of marine and coastal resources, by creating a framework for consistent, transparent, sustainable and evidence-based decision-making.

• In marine waters, ecosystems and marine resources are subject to significant pressures. Human activities, but also climate change effects, natural hazards and shoreline dynamics such as erosion and accretion, can have severe impacts on coastal economic development and growth, as well as on marine ecosystems, leading to deterioration of environmental status, loss of biodiversity and degradation of ecosystem services.(…)

•Moreover, **healthy marine ecosystems and their multiple services, if integrated in planning decisions, can deliver substantial benefits in terms of food production, recreation and tourism, climate change mitigation and adaptation, shoreline dynamics control and disaster prevention.**

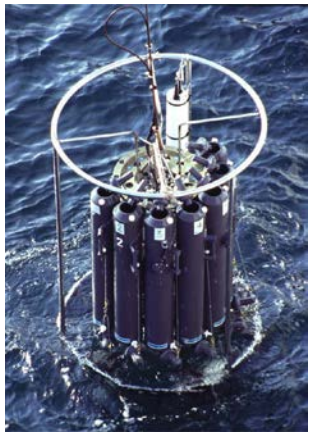
• Directive 2001/42/EC of the European Parliament and of the Council establishes environmental assessment as an important tool for integrating environmental considerations into the preparation and adoption of plans and programmes.

…& connections with Marine Strategy Framework Directive (2008/56/EC), Renewable Energy Directive (2009/28/EC), etc…

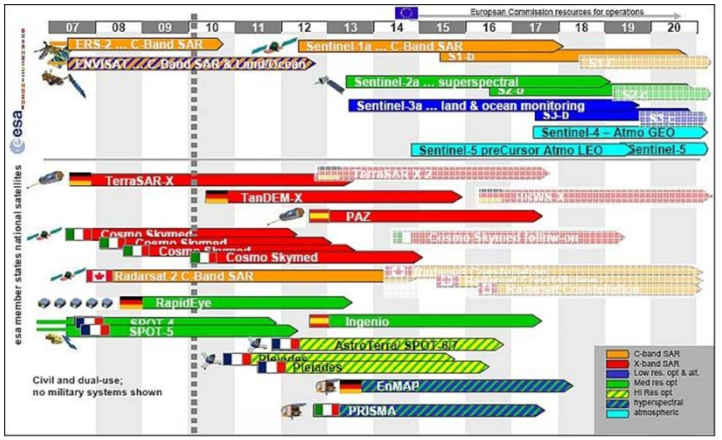
Monitoring methods are:

DEFINITIONS

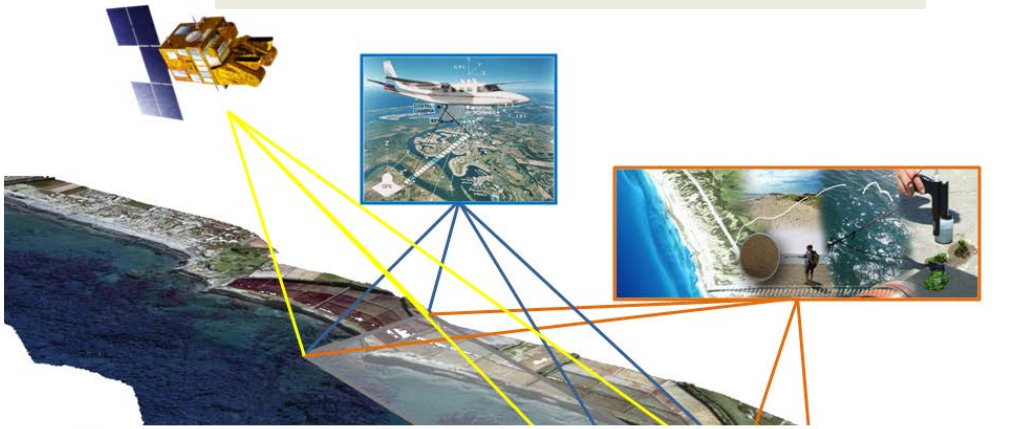
DIRECT



INDIRECT



or INTEGRATED



The strategy of combining high and very high resolution spectral measurements in a multisensory and multi resolution analysis. This includes different ways of data fusion to assimilate spectral and spatial variability in complex coastal mapping and modeling.

CHALLENGES

Identify the nature and rate of consequences of climate change in European marine and coastal waters using **new technologies to increase spatial and temporal resolution of the monitoring services**

Predict the consequences of climate change for our marine environment: this will require the **development and measurement of indicators** which are indicative of the underlying mechanisms of climate-induced changes

Predict the response and feedback of marine environments and ecosystems to climate change: this will require the improvement of regional climate models and **the development of biophysical models**

Scenario generation

The Wadden sea

- Habitats
- Wave, Wind, Surge
- Extreme events
- Geomorphology
- Ecology

River & delta
Freshwater, sediments and nutrients supply

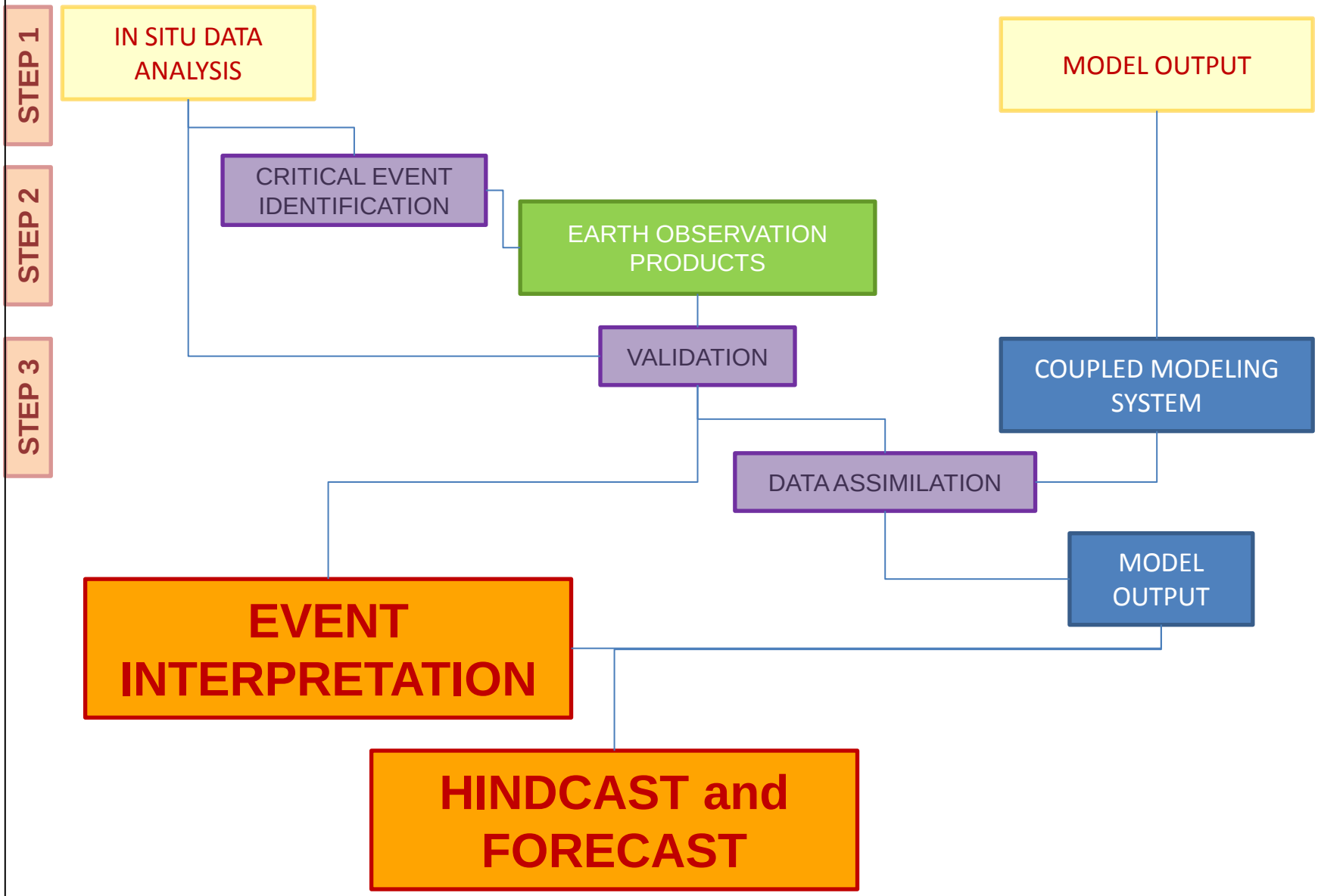
Sandy beaches & Wetlands
Floodings & Erosion

The Northern Adriatic sea

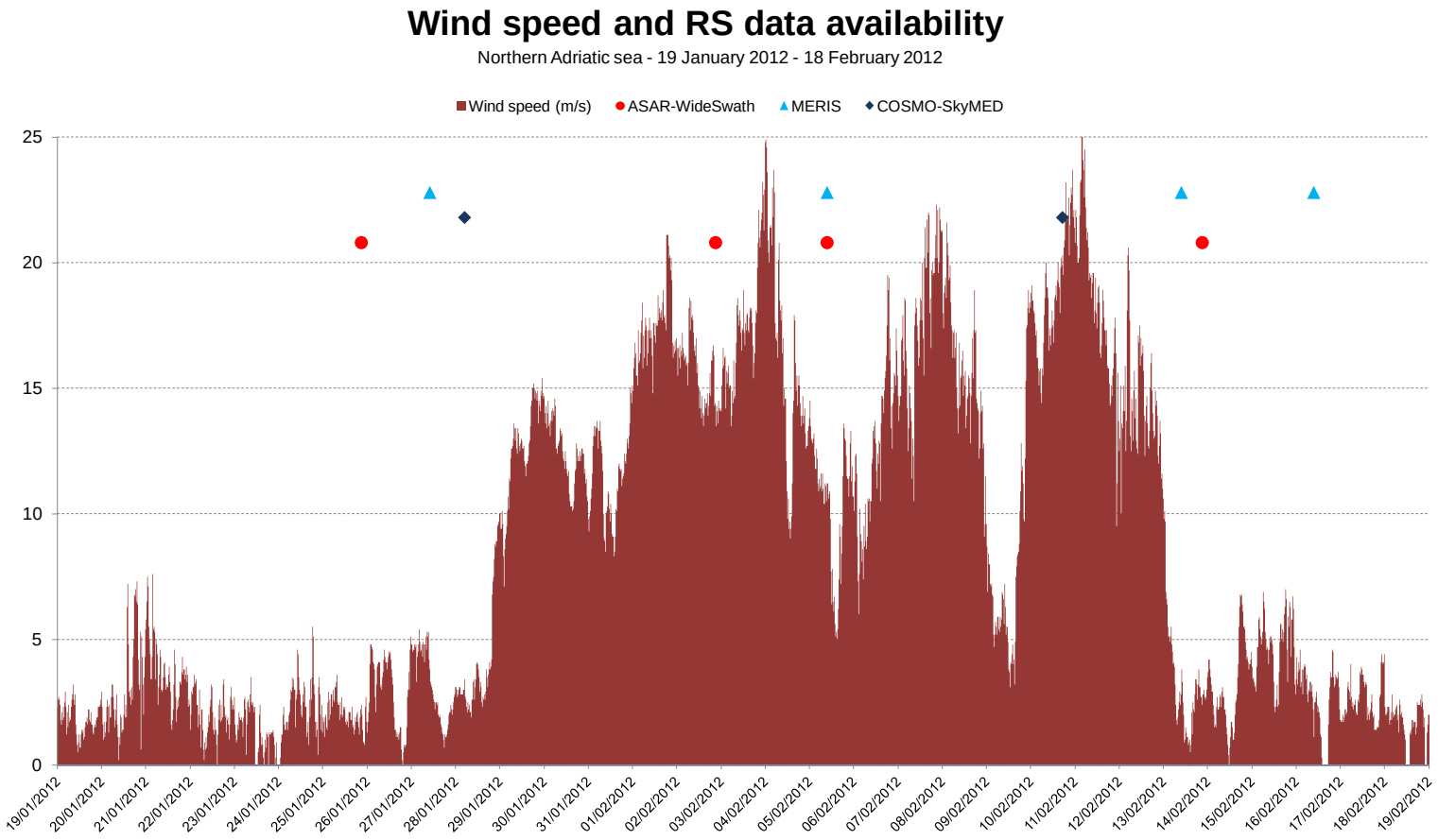
Assessment & Monitoring of critical events

In northern Adriatic Sea the main forcing of waves are the local winds. Two distinct wind regimes, Bora and Sirocco, dominate conditions in the area and influence basin-wide circulation

Assessment & Monitoring of wind extreme events



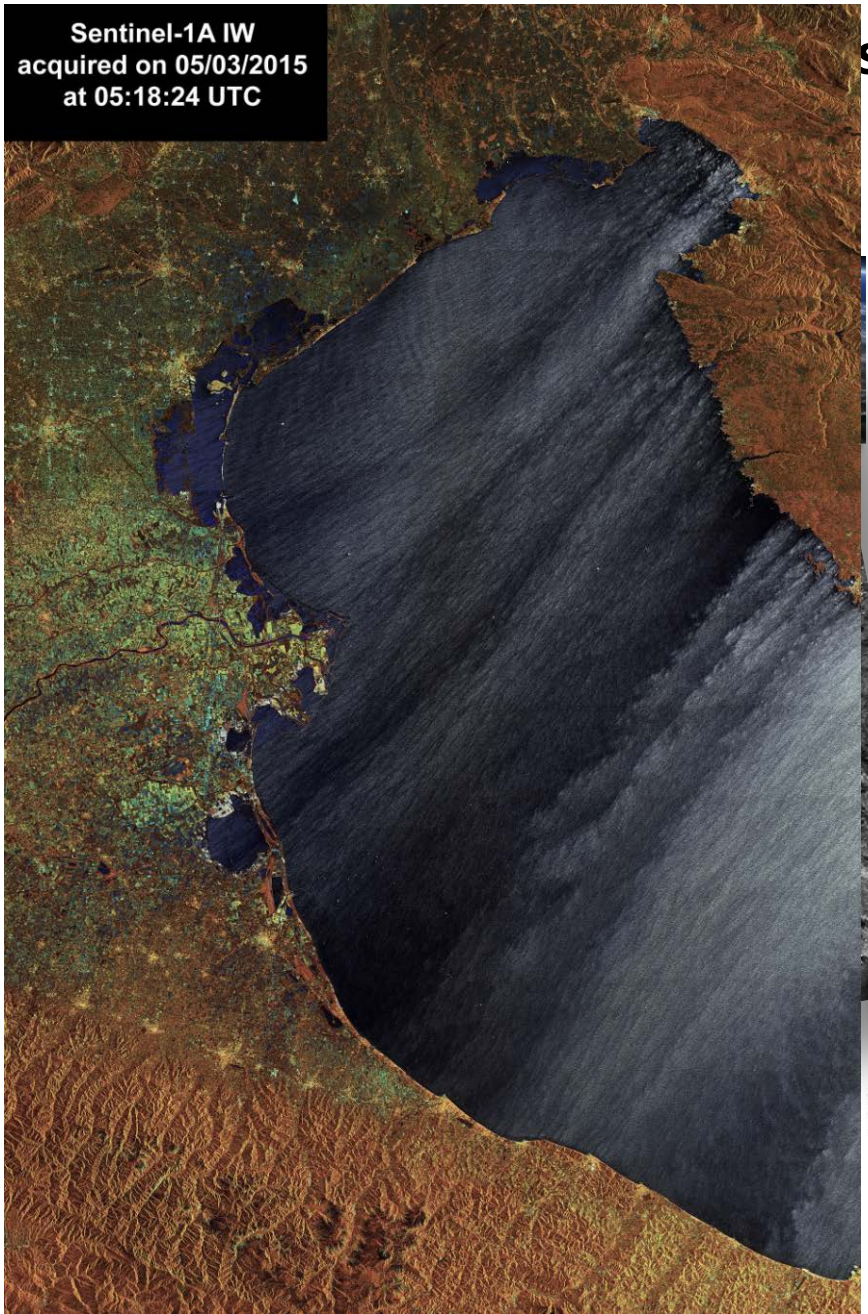
Evaluating Remote Sensed data availability during Bora events in winter 2012



***in situ* data analysis**

Met ocean parameters estimations and monitoring on the base of SAR satellite data

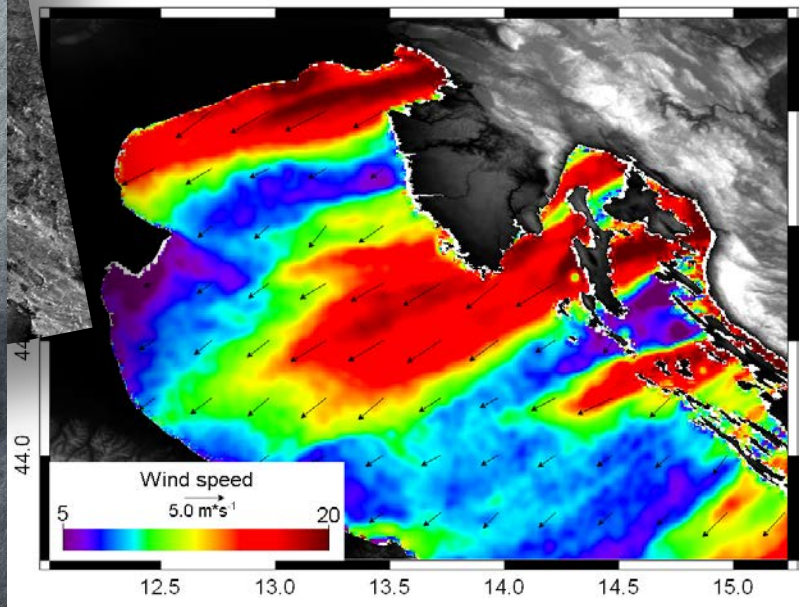
The ESA Sentinels constitute the first series of operational satellites responding to the Earth Observation needs of the EU-ESA COPERNICUS program. The COPERNICUS space component relies on existing and planned space assets as well as on new complementary developments by ESA



s from SAR

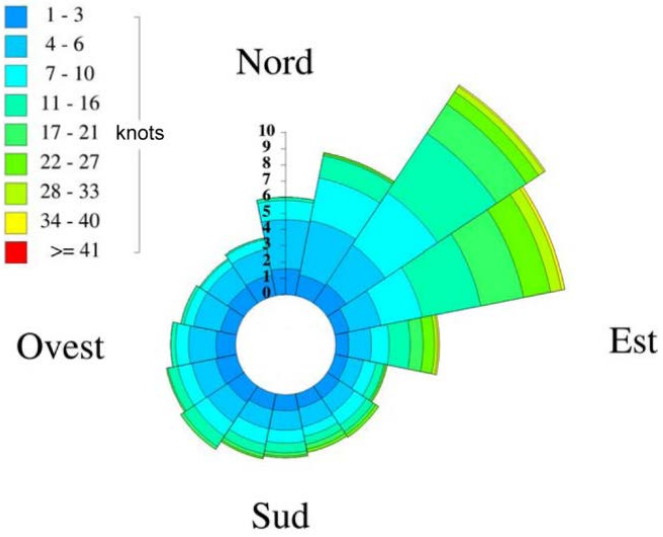
Remote Sensing Synthetic Aperture Radar (SAR) has the ability to detect sea surface signatures
Wind field (intensity and direction) can be estimated from SAR at high time frequency and high resolution (up to 300 m)

Wide swath SAR data represent an important source of information for wave reanalysis applications where knowledge of the wind field is crucial (wave downscaling, formation of wind wake patterns and jet structures)



Offshore Northern Adriatic Sea: met-ocean parameters

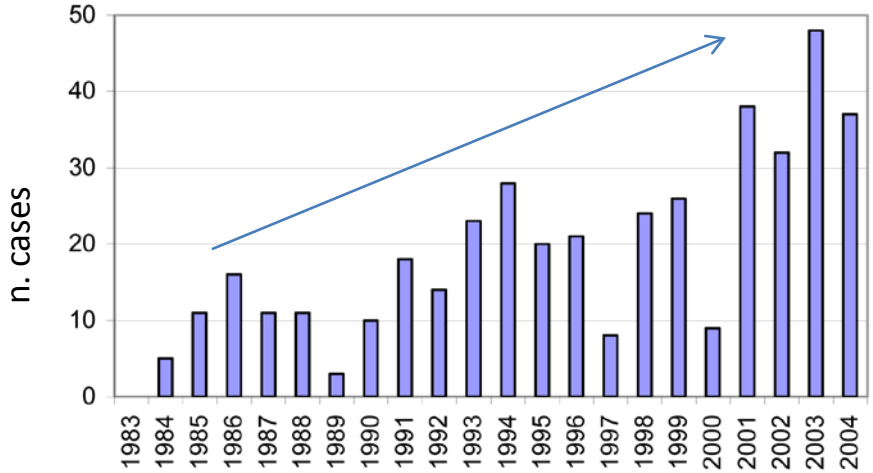
In situ data: Met-ocean and climatic analysis

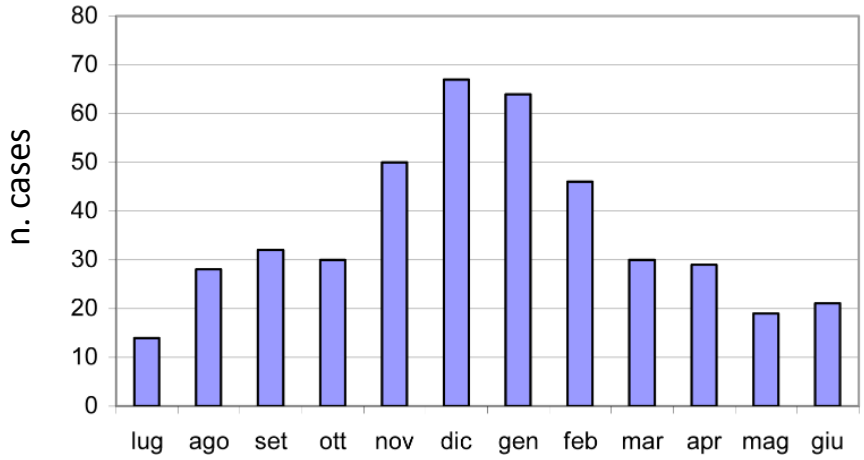


Wind analysis for the period 1983-2004

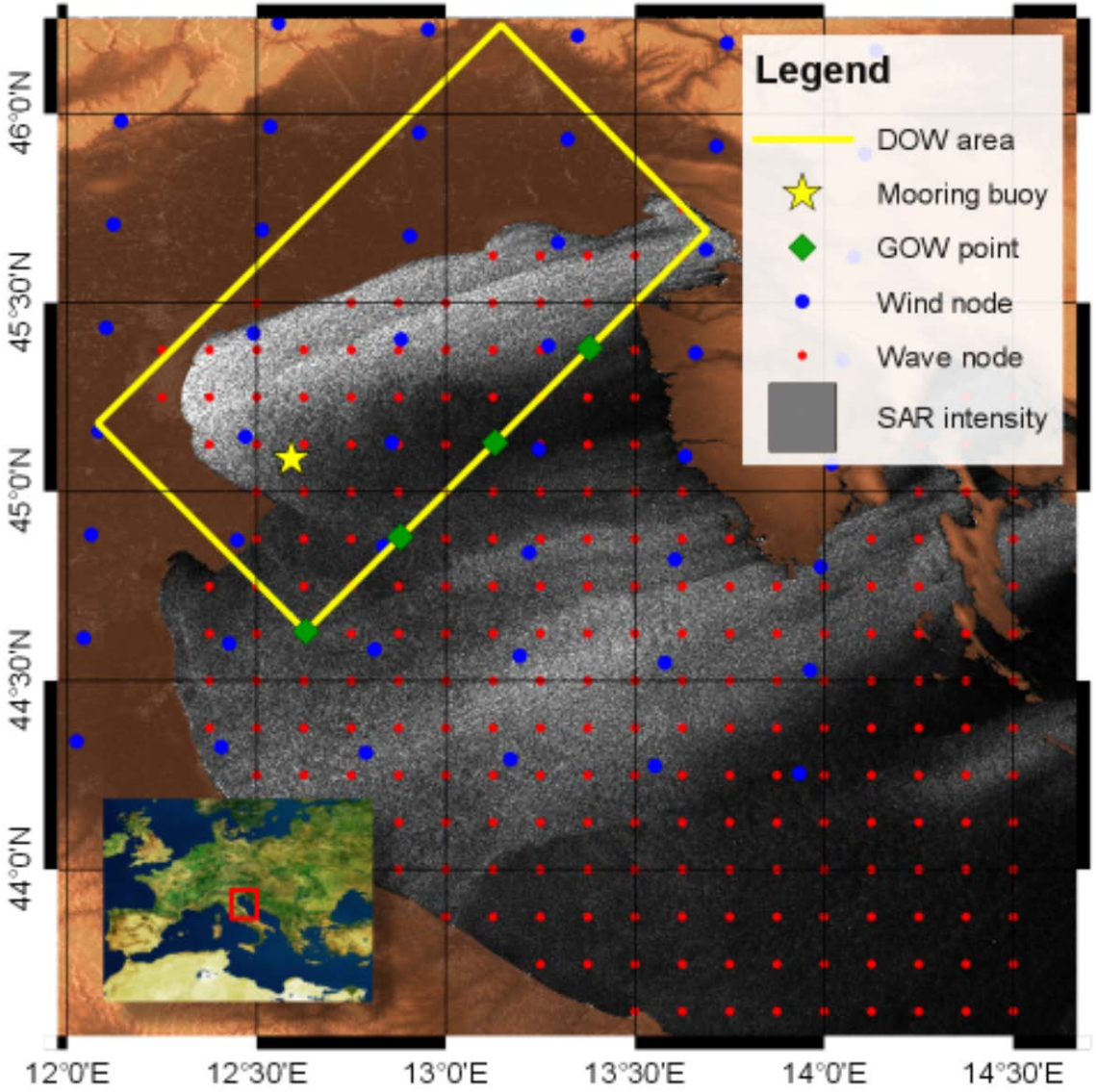
Dominant wind comes from ENE, mostly during winter period

Critical wind events (knots > 30)



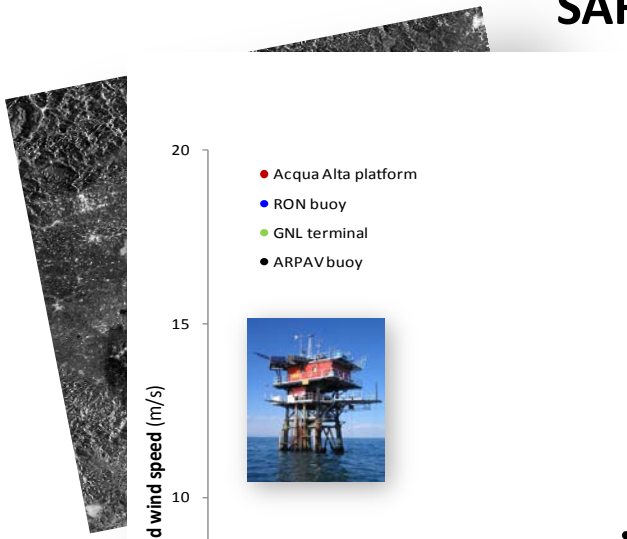


Estimated Wind field

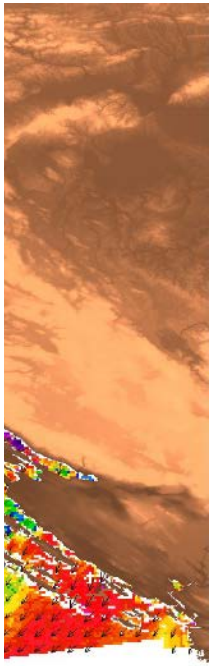


Estimated wind fields at fine scale from SAR satellite allow the observation of morphology, wake patterns, the formation of the barrier jet on the western Adriatic coast and, where present, dual-jet structure of the Bora wind

Estimated Wind field from medium resolution SAR ASAR Wide-Swath Mode



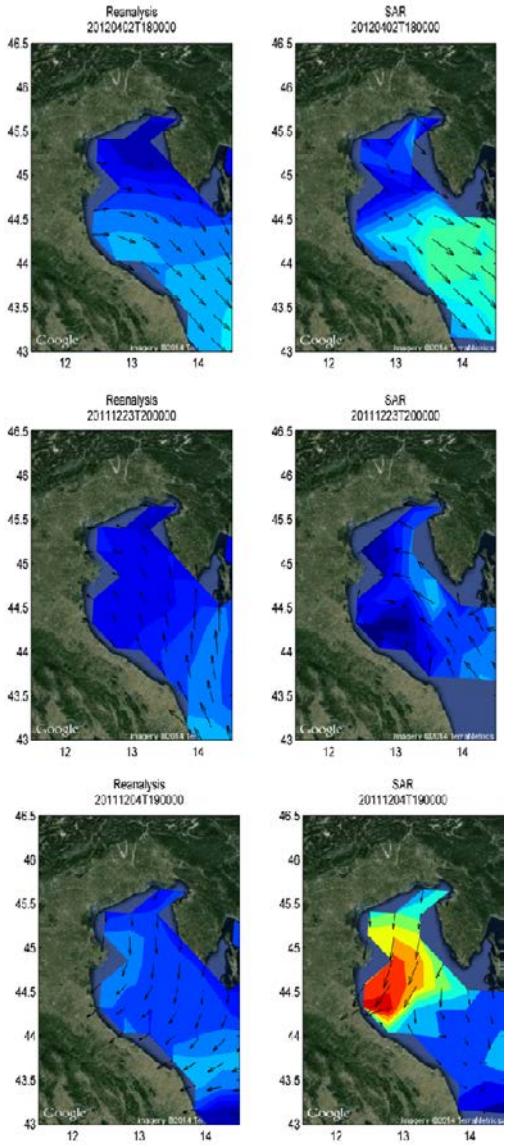
data (wind platform, buoy



ESA, Soprano CLS

Wind speed and direction (spatial resolution 800m) estimated using **CMOD5** algorithm from **ENVISAT ASAR** Wide Swath acquired on 02/02/2012

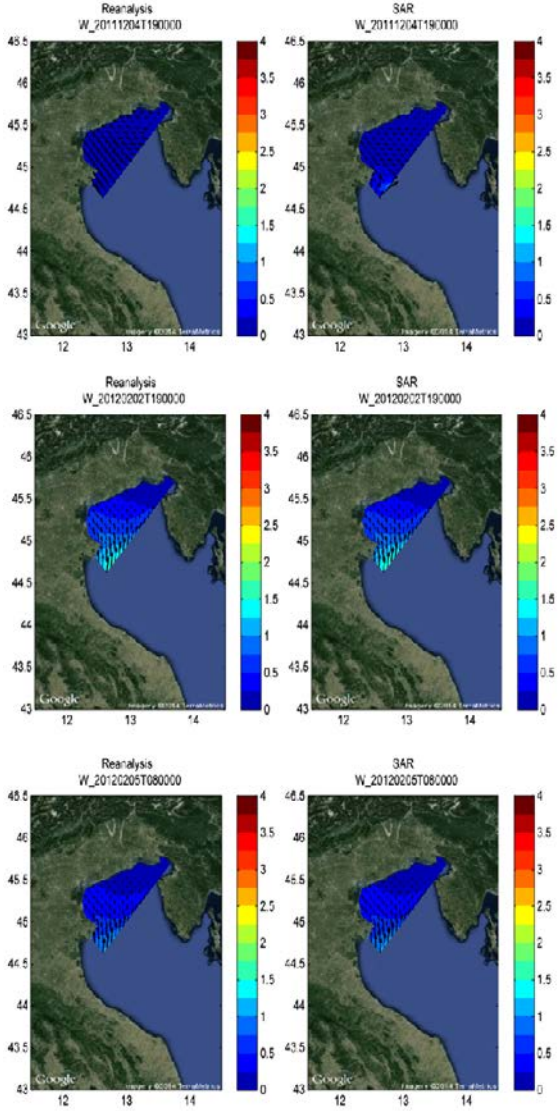
Wave simulations with SAR wind fields



Some cases of waves fields forced with Reanalysis winds (left) and SAR winds (right).

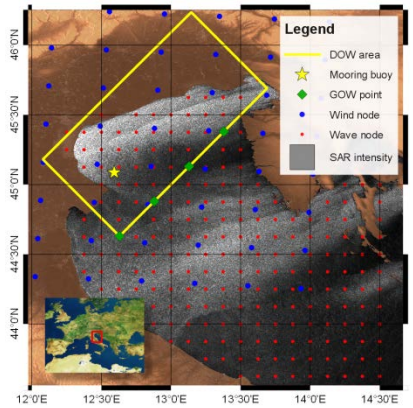
Analysis of wind SAR fields

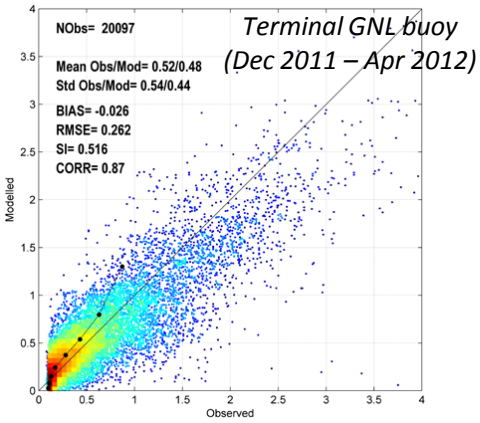
- SAR wind fields: instantaneous conditions of winds
- Reanalysis wind fields: mean conditions of the wind of 1 hour
- Comparison between SAR (Ws) and Atmospheric Reanalysis (Wm)
- Ws was interpolated to the Wm resolution



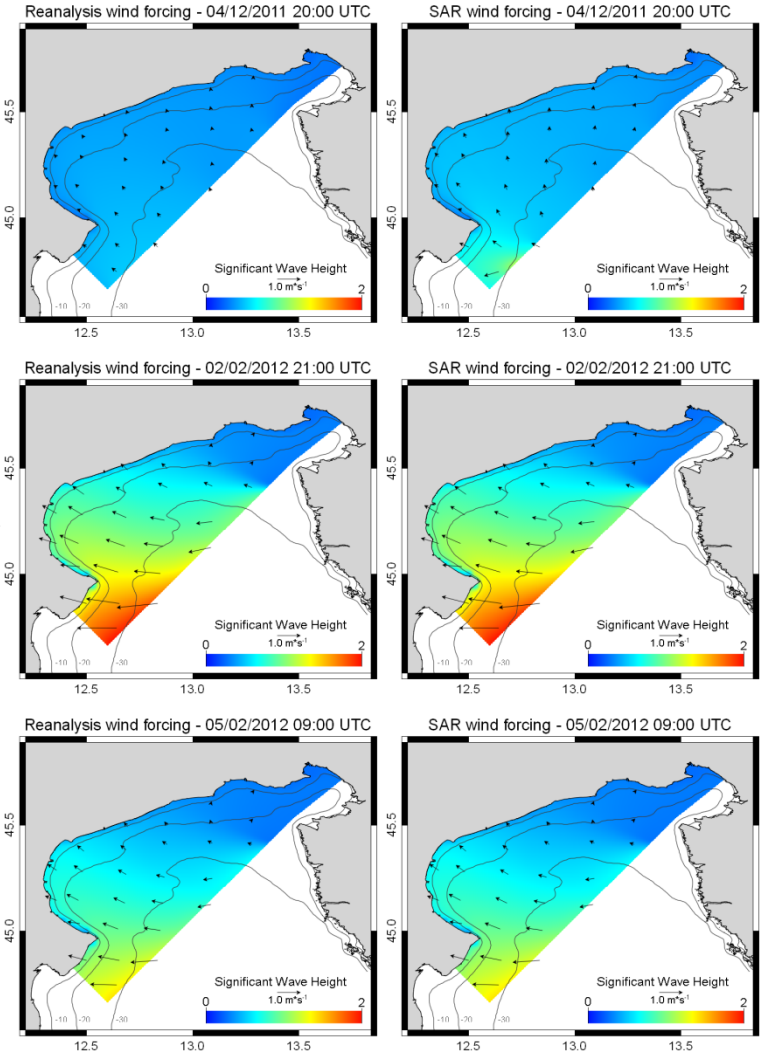
Examples of wind fields with similar patterns between SAR and Reanalysis.

Wave Downscaling of northern Adriatic Sea



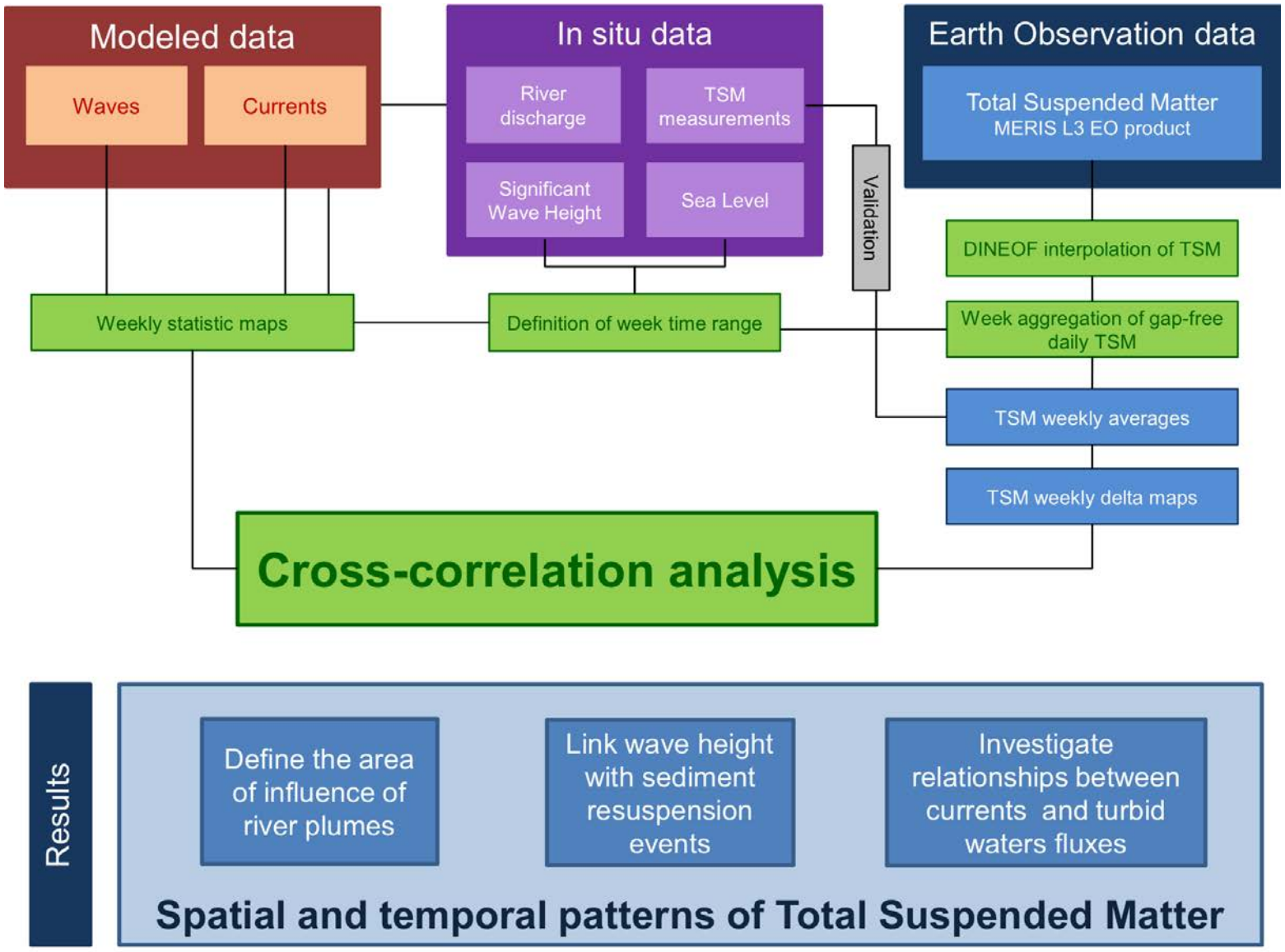


Terminal GNL buoy (Dec 2011 – Apr 2012)



- SAR wind fields (ASAR) used to force wind waves in shallow waters (simulation for the period Dec2011- Apr2012)
- Time series of wave fields have been reconstructed using radial basis functions (RBF) interpolation
- Comparison with reanalysis wind forcing (atmospheric model) and in situ instrumental data indicate the general good quality of the downscaled waves
- Results demonstrate how long-term SAR data archive (Level-2 – Ocean) can be successfully up-taken into oceanographic modeling, opening the way for new improvements on services for operational oceanography.

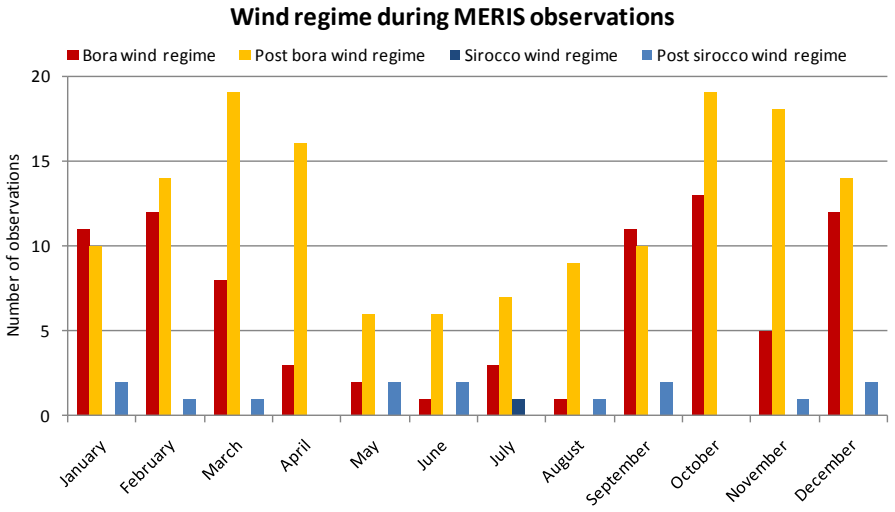
Gutierrez, O.Q., Filipponi, F., Taramelli, A., Valentini, E., Camus, P. & Mendez, F.J. (2015). On the feasibility of the use of wind SAR to downscale waves on shallow water. *Ocean Science Discussion*, in press.

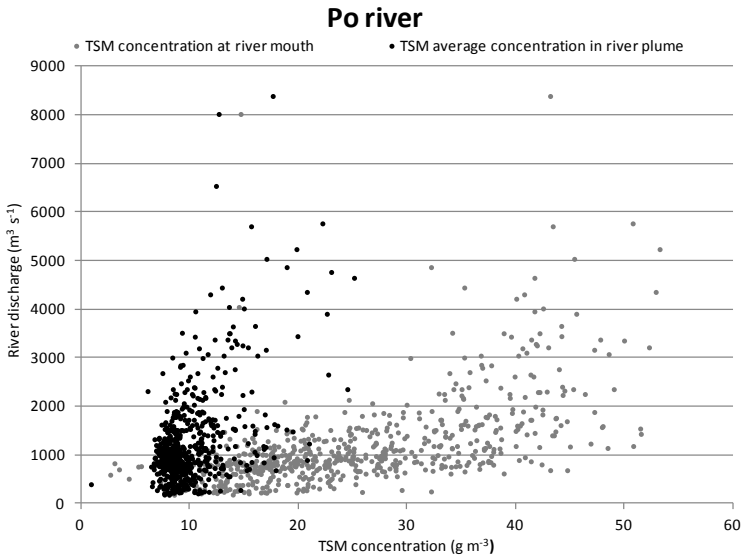

Modeled data
Waves
Currents
In situ data
River discharge
TSM measurements
Significant Wave Height
Sea Level
Validation
Earth Observation data
Total Suspended Matter
MERIS L3 EO product
DINEOF interpolation of TSM
Weekly statistic maps
Definition of week time range
Week aggregation of gap-free daily TSM
TSM weekly averages
TSM weekly delta maps
Cross-correlation analysis
Results
Define the area of influence of river plumes
Link wave height with sediment resuspension events
Investigate relationships between currents and turbid waters fluxes
Spatial and temporal patterns of Total Suspended Matter

Correspondance between TSM concentrations and physical forcings

Relationships between physical forcings and TSM concentration variability were first evaluated using geostatistical analysis on single observations.

While there is a correspondance among river discharge and TSM concentration in river plumes, a clear quantitative relation was not found

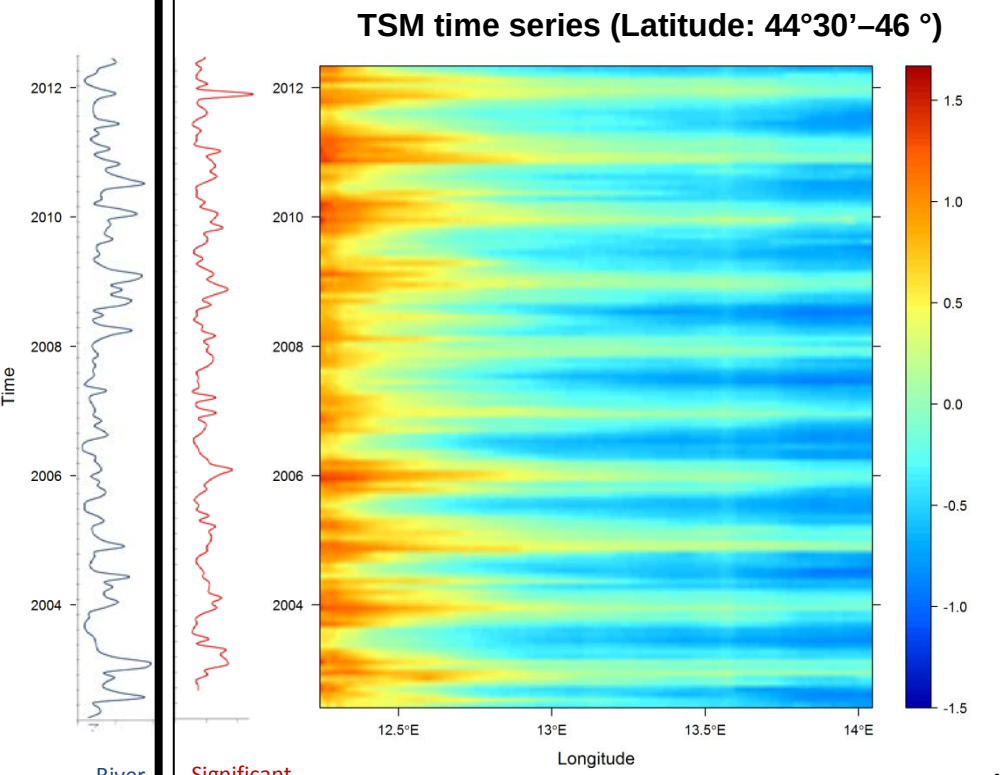




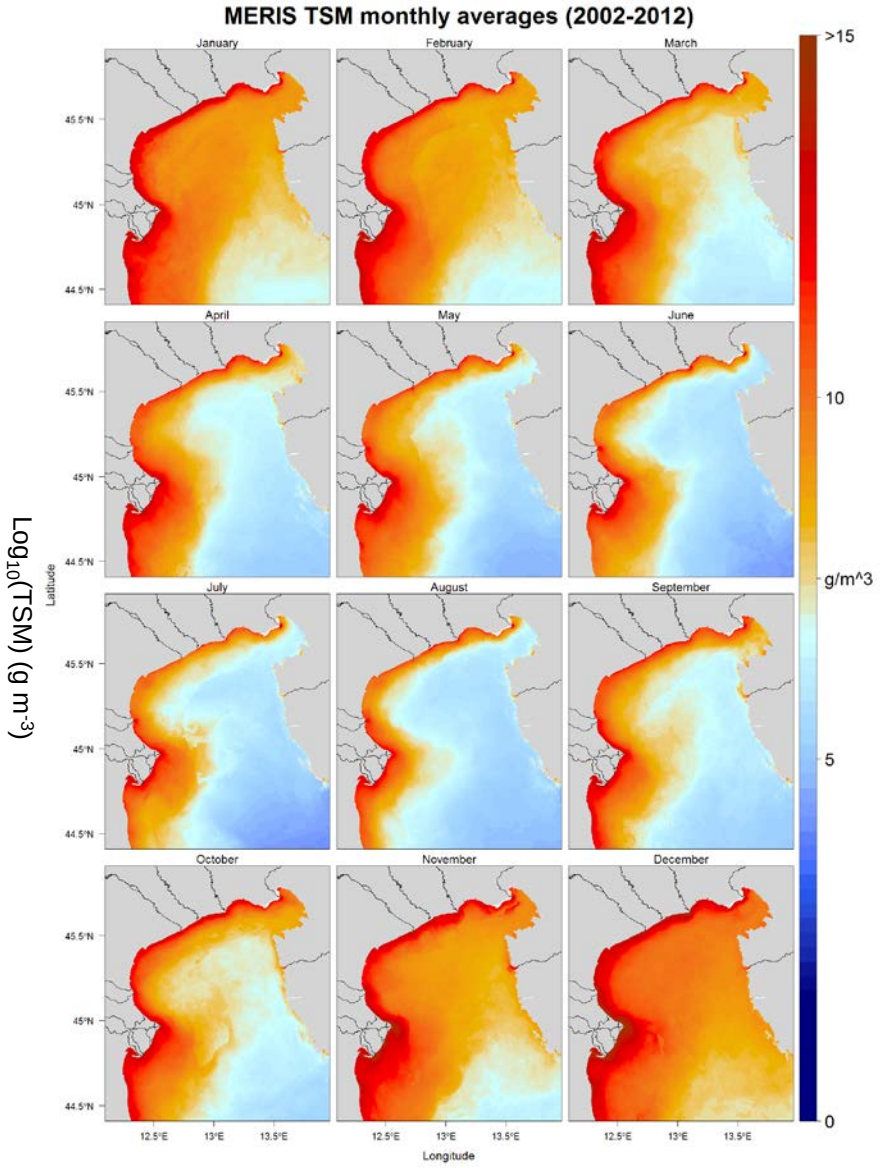
Optical multispectral sensors can not observe through clouds.
As a consequence, some events can never be observed, event in extended time series.

Analysis of inter-annual and intra-annual spatial variability

Monthly averages were used to assess
intra-annual variability of suspended sediment.



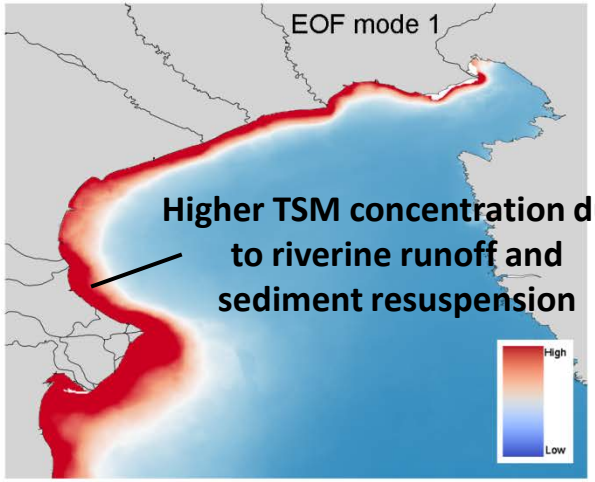
Hovmoller diagram provide a good representation of inter-annual variability!

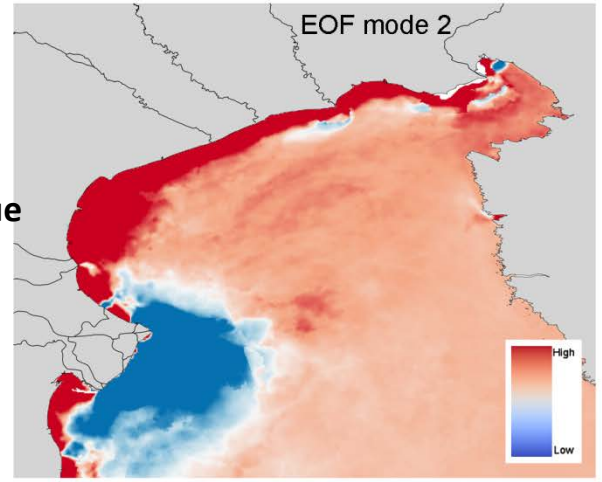


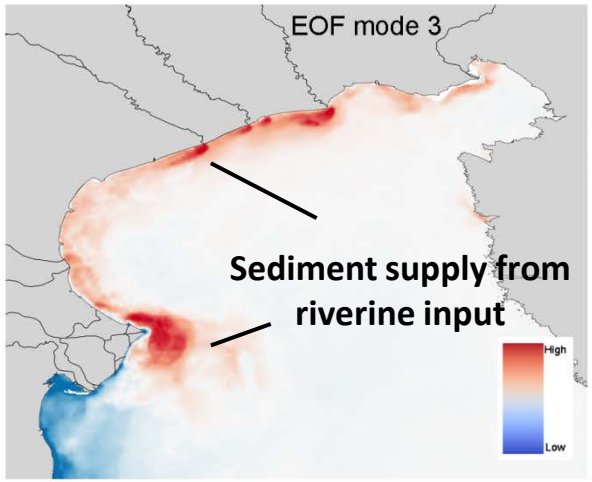
Empirical Orthogonal Function (EOF) analysis

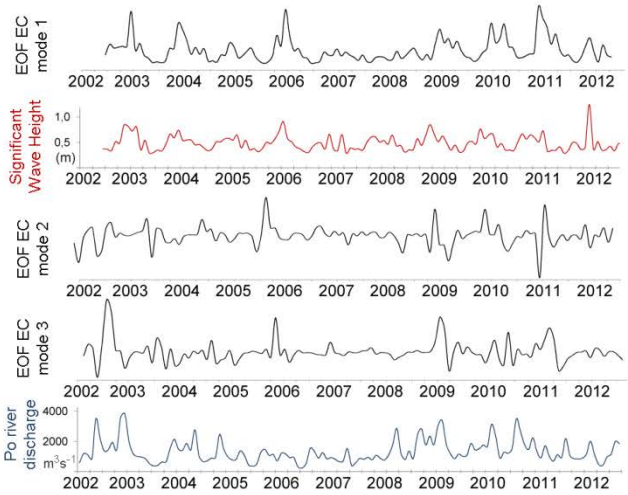
Resulting EOF modes represent both spatial dimension and temporal dimension, the latter is called Expansion Coefficient (EC) time series

Expert knowledge is needed to interpret EOF results and identify relations with environmental forcings, even if modes cannot always be interpreted in terms of real physical signal

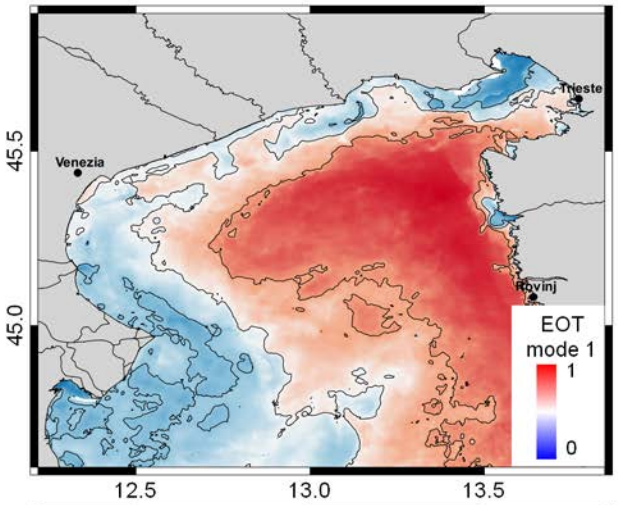


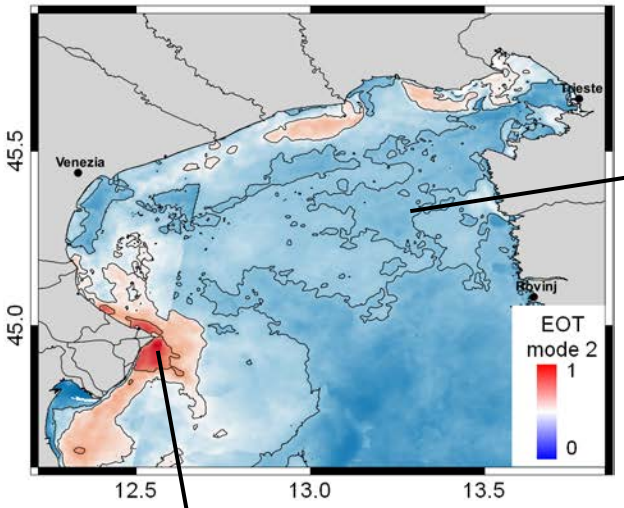


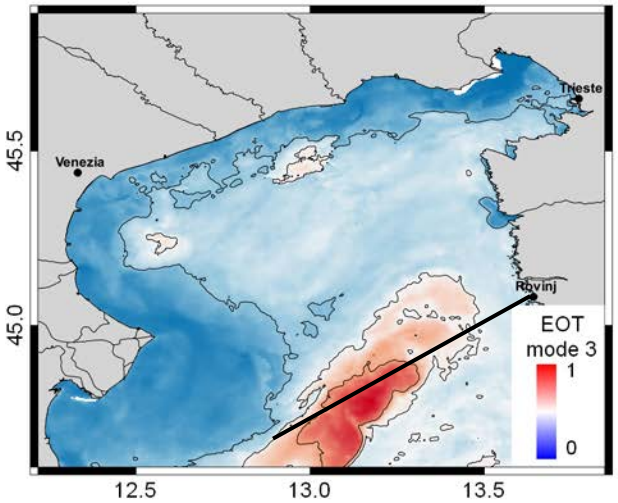




Empirical Orthogonal Teleconnection (EOT) analysis



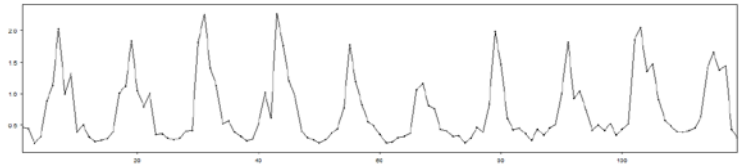




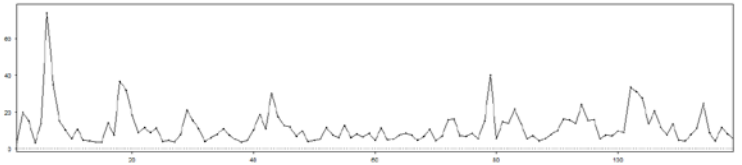
resulting modes not always represent real and clear patterns

Ability to detect small features

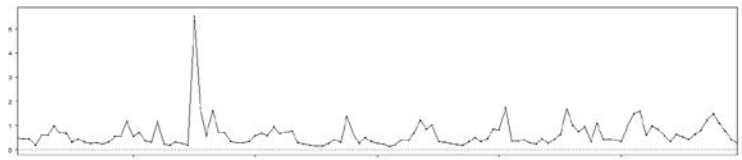
EOT mode 1



EOT mode 2



EOT mode 3



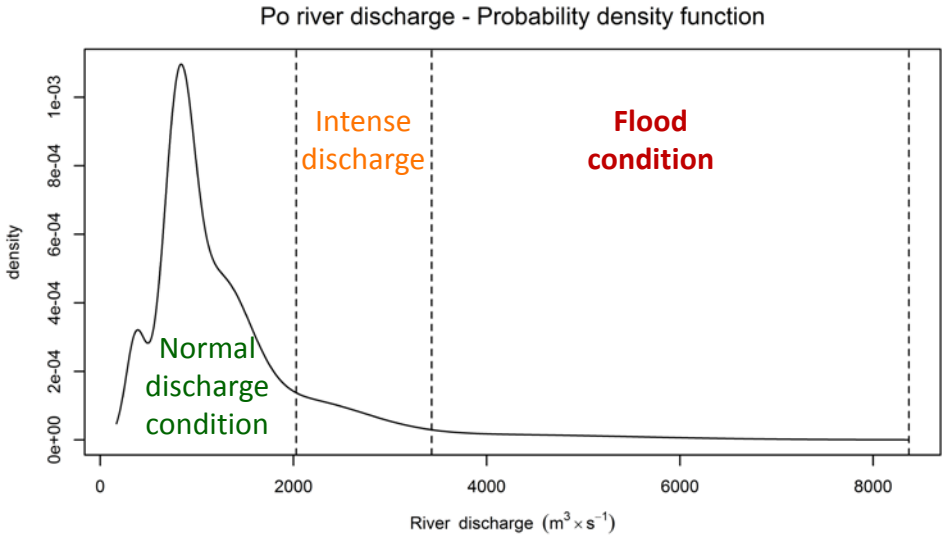
Hydro-climatic variables classification based on magnitude

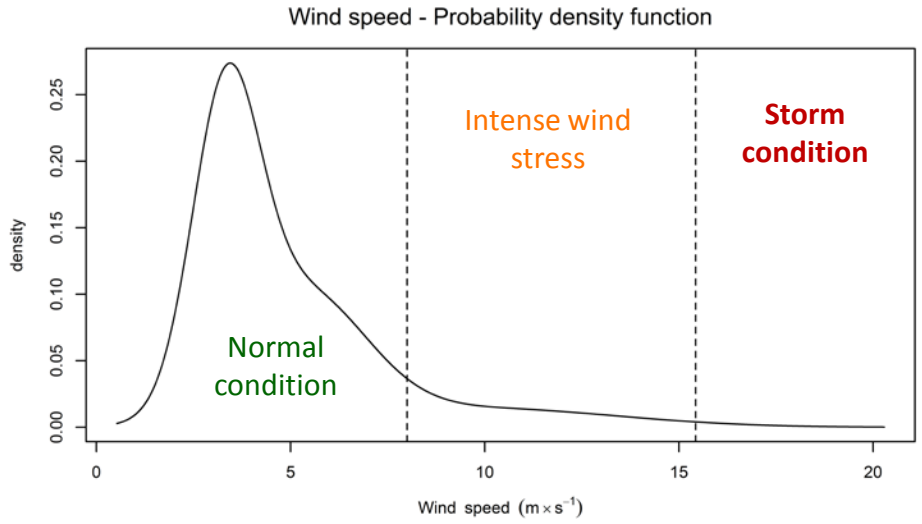
River plumes represent one of the major gain in sedimentary budget of littoral cells.

Wind stress and **hydro-climatic variables** pulses perturb sediment steady state.

Statistically speaking, density distribution represent of hydro-climatic variables is a **positively skewed distribution**. Occurrence of intense physical stress has to be find at the far end of the distribution tail.

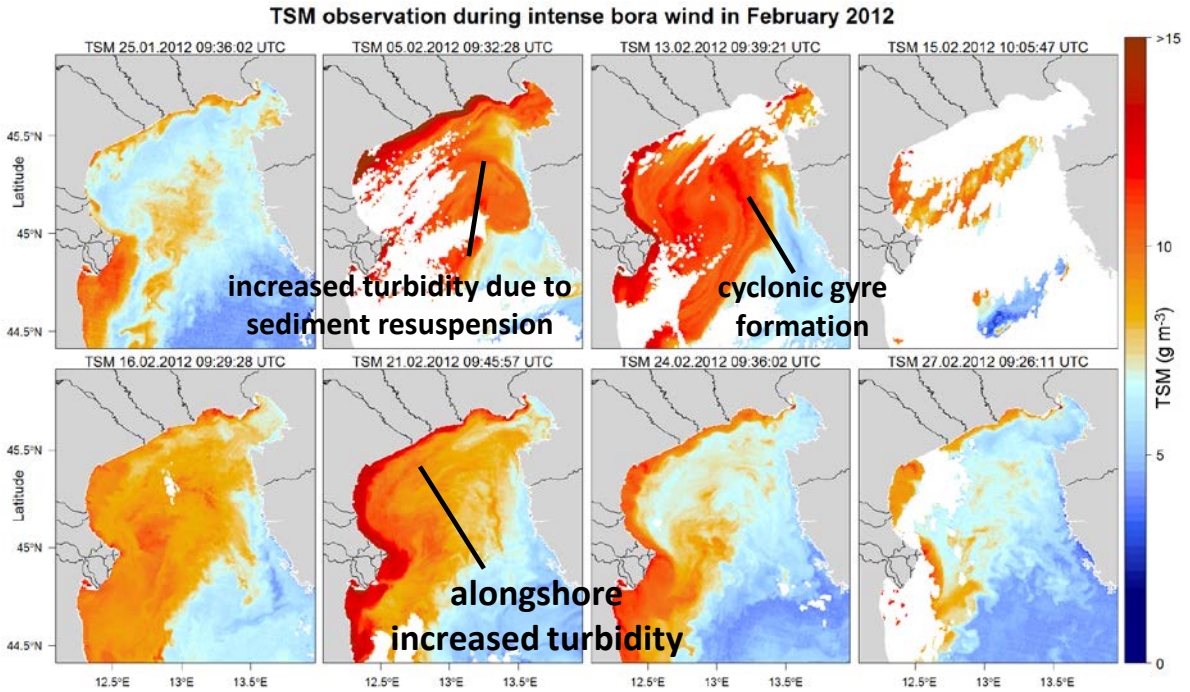
Identification of threshold values was done using hierarchical clustering approach, based on the Bayesian Information Criteria (BIC).

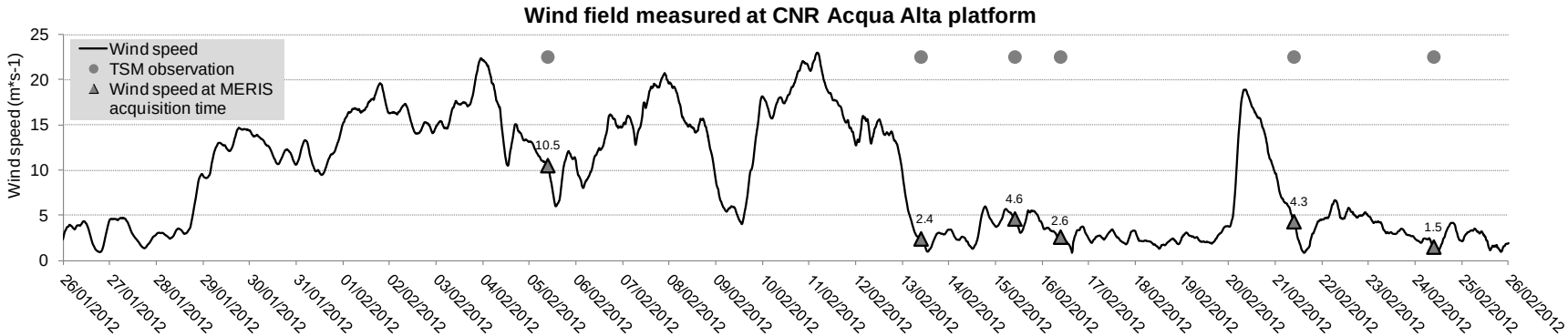




Monitoring of sediment resuspension event during intense wind stress

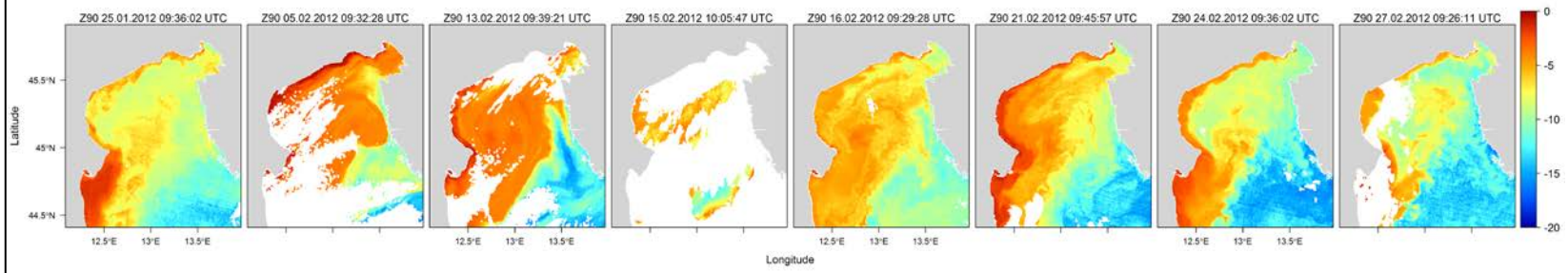
Evolution of sediment resuspension processes has been evaluated during storm condition events identified from in situ data analysis



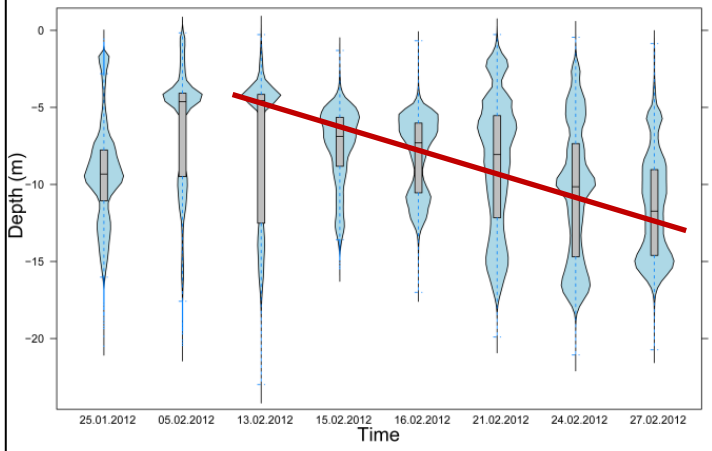


Filipponi, F., Zucca, F., Taramelli, A. & Valentini, E. (2015). Total Suspended Matter (TSM) and maximum signal depth (Z90_max) for monitoring the evolution of sediment resuspension processes in shallow coastal environments. Proc. of "Sentinel-3 for Science Workshop", Venice (Italy) 2-5 June 2015, ESA SP-734, in press.

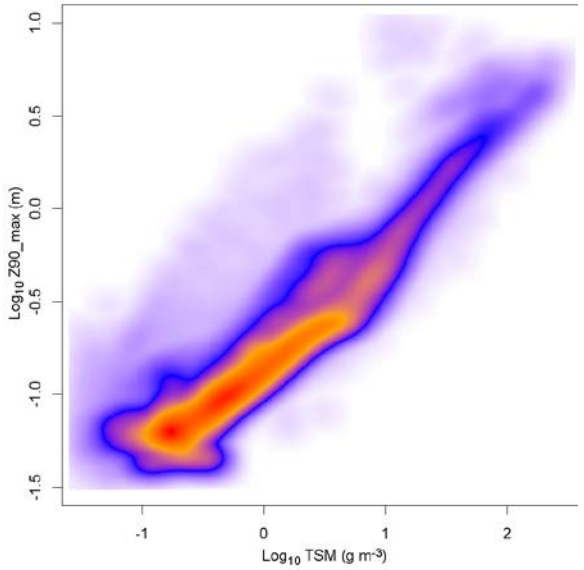
Monitoring of sediment resuspension event during intense wind stress



Evolution of particle settling has been investigated analyzing variations of maximum signal depth (Z90_max), hence describing the evolution of the vertical distribution of turbidity in the water column during the resuspension event

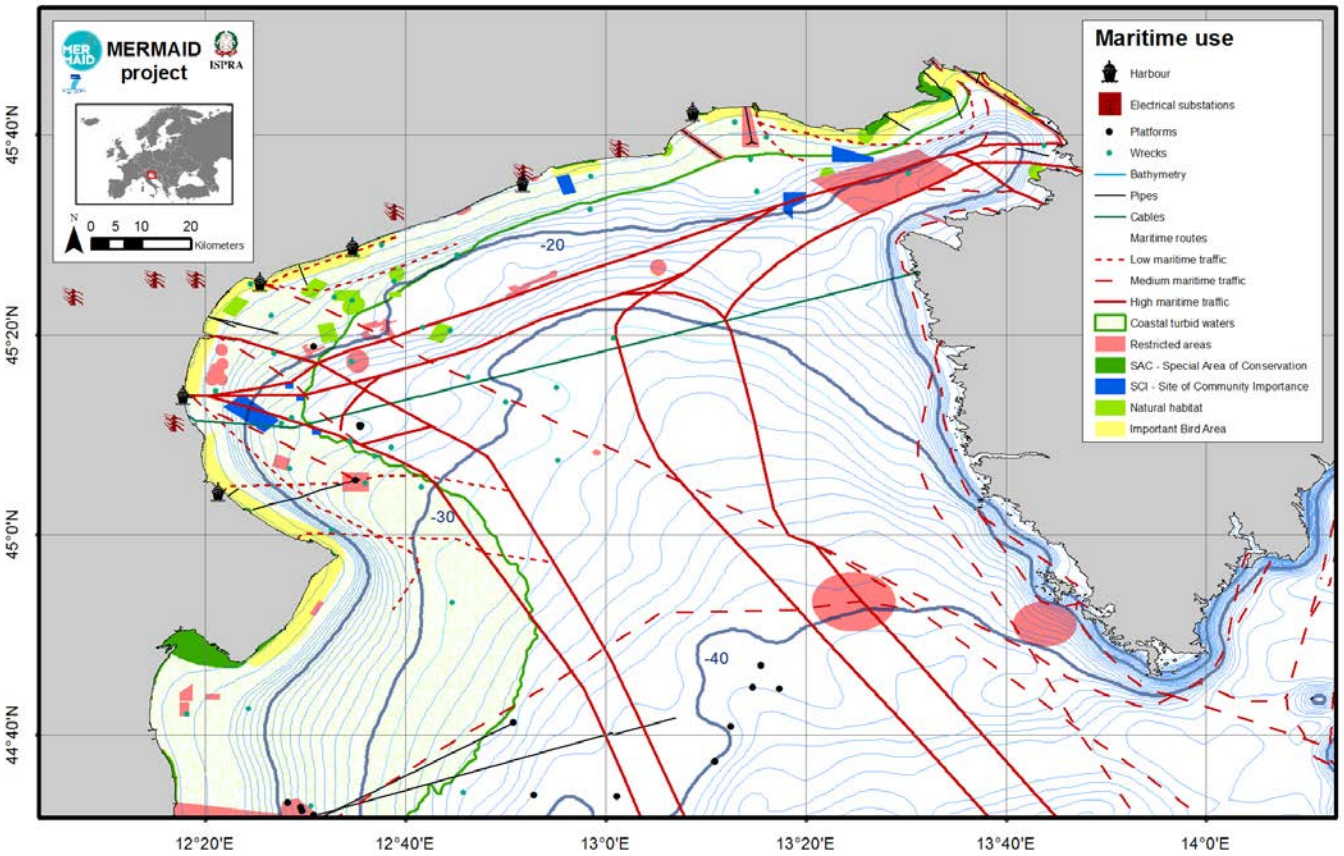


particle settling



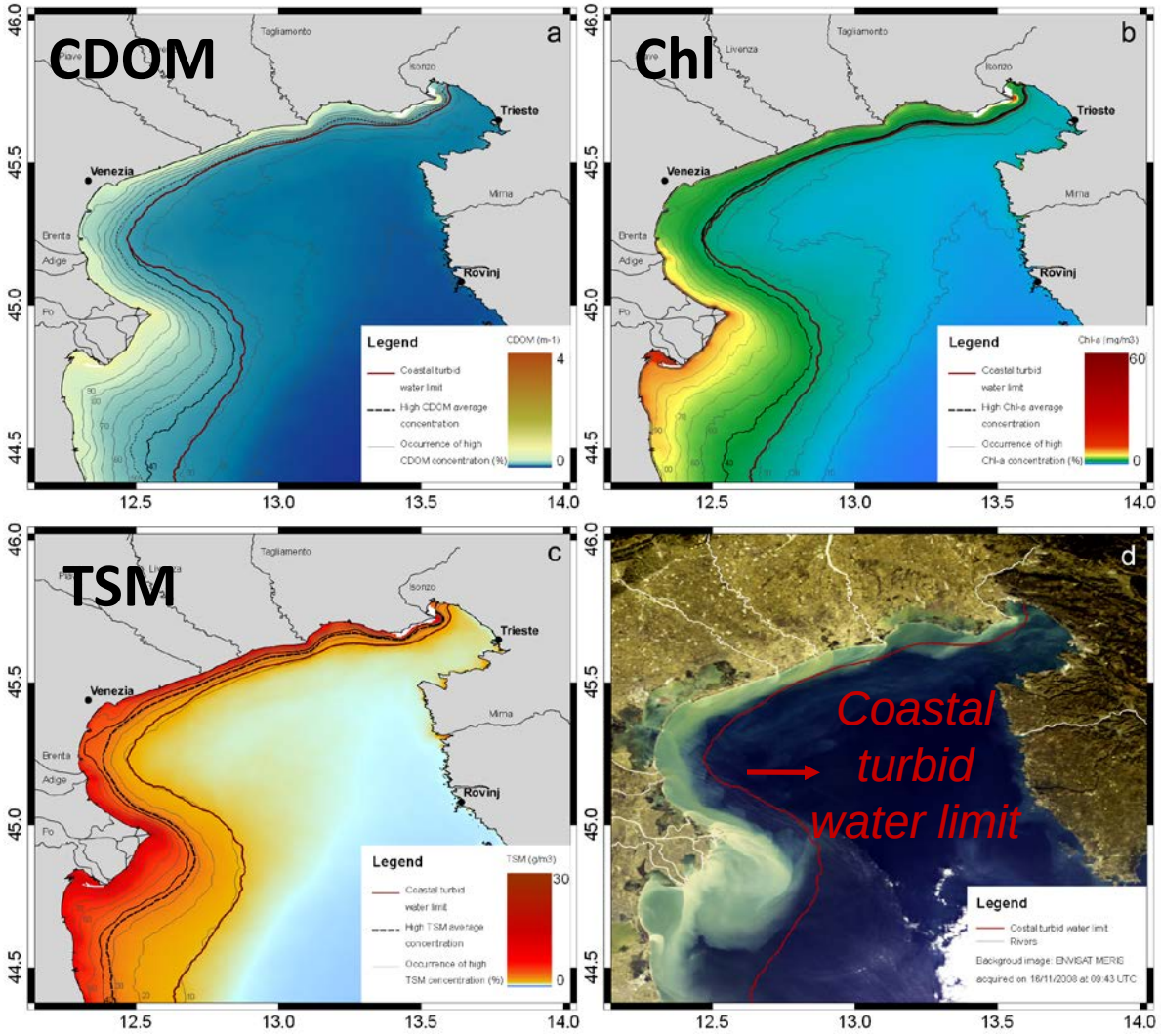
Z90_max parameter has been found to be quantitatively highly related with TSM concentrations

Mapping current spatial maritime use to support Maritime Spatial Planning directive



Mapping current spatial maritime use (existing maritime platform, main marine routes, protected and restricted area, thematic maps from EO, …) to identify potential confict of use of maritime space and support Maritime Spatial Planning directive

Earth Observation product analysis: water quality

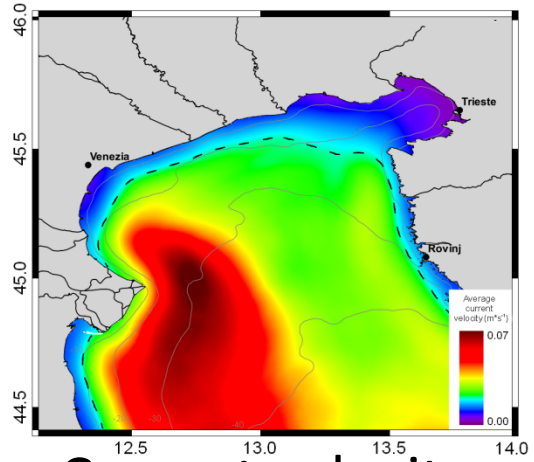


Decadal statistics (2002-2012) of Ocean Color products

ENVISAT MERIS acquired on 16/11/2006 at 09:43 UTC

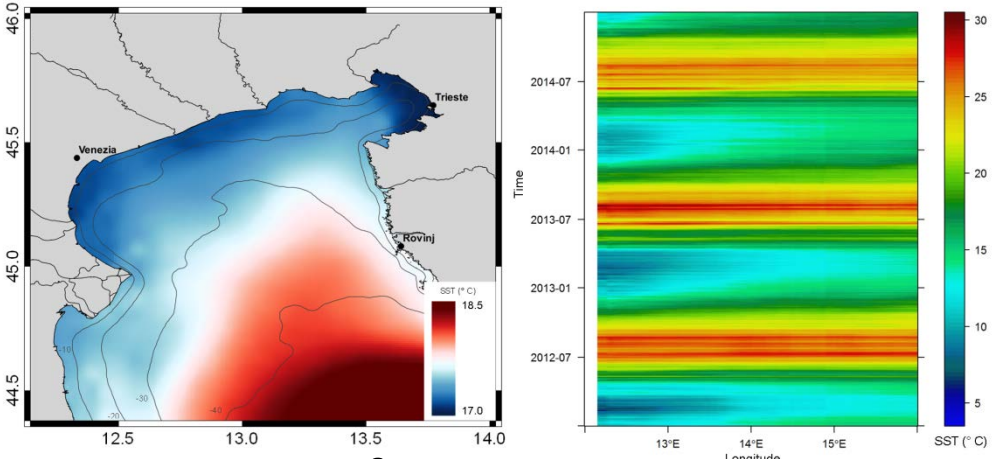
Long-term analysis on spatial distributed data of **Chlorophyll**, **CDOM** and **TSM** can be used to identify the area of influence of large river plumes, which represent the main external contribution of nutrients and sediments

MyOcean Copernicus Marine Service and EO products for environmental monitoring and sustainable coastal development



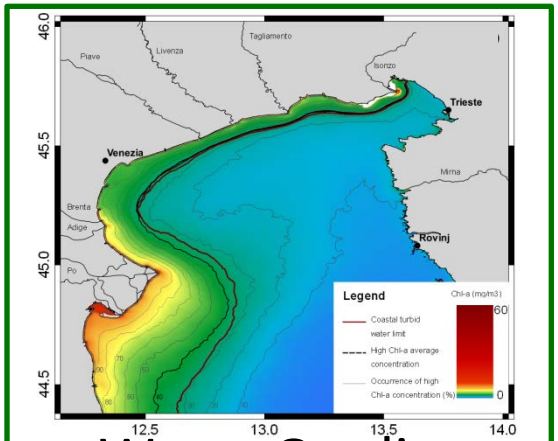
Current velocity

MyOcean product:
MEDSEA_REANALYSIS_PHYS_006_004



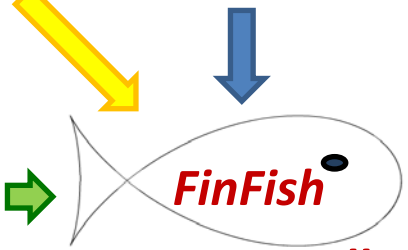
Sea Surface Temperature

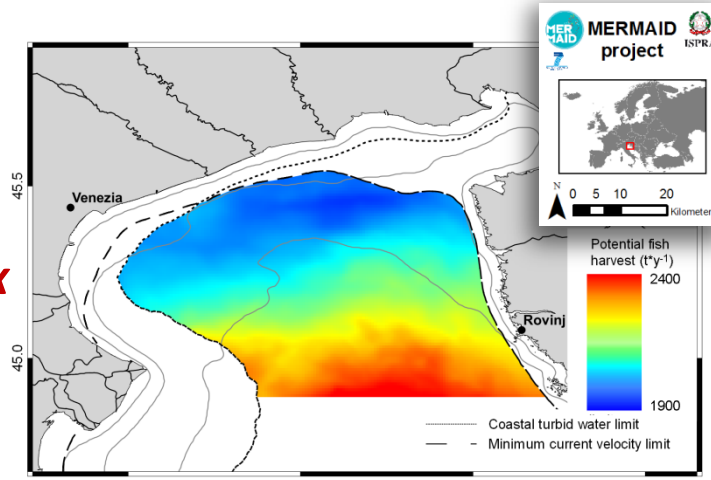
MyOcean product: SST_MED_SST_L4_NRT



Water Quality

ISPRA product





Aquaculture suitability

CHANGE IN COASTAL EXPOSURE AND VULNERABILITY: ECOSYSTEM SERVICES ROLE

OBJECTIVE

Assessing the role of ecosystems in terms of flood protection and thus vulnerability reduction by:

- testing a ready to use exposure and vulnerability assessment model (i.e. InVEST Coastal Vulnerability Model)
- proposing an alternative approach based on Fuzzy Logic

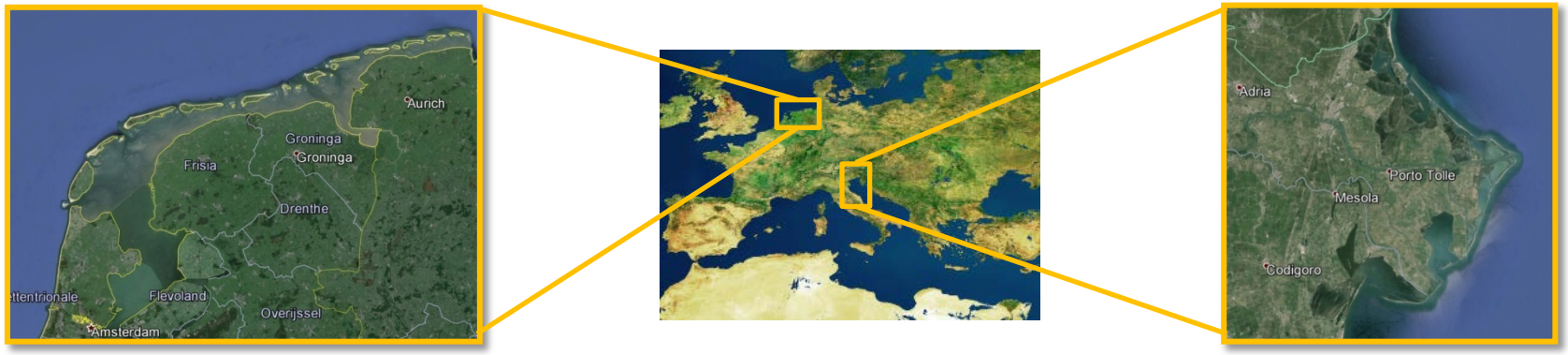
PRODUCTS

→ Current degree of coastal exposure and vulnerability

→ Generation of scenarios of coastal exposure and vulnerability by changing hazard and ecosystem characterization

AOI: Wadden Sea (The Netherlands) and Po Delta (Italy)

DATA: EO data a/o products, in situ data



REGULATING SERVICES: FLOOD PROTECTION

Variables used by the InVEST model and in Fuzzy Logic Approach

VARIABLES FOR ASSESMENT		InVEST model		Fuzzy Logic Approach		
				Fuzzy 'SUM'	Raster Calc 'SUM'	Raster Calc 'SUM'
		no habitat	habitat	no habitat	habitat	no habitat
		A	B	C	D	E
Physical forcing	Waves (Height - Direction - Intensity	X	X	X	X	X
Physical settings	Digital Terrain Model	X	X	X	X	X
	Geomorphology	X	X	X	X	X
	Erosion			X	X	
	Subsidence			X	X	
	Sea Level Rise	X	X			
Social component	Population	X	X	X	X	X
	Corine Land Cover 2007			X	X	X
Habitat	Dune presence		X		X	
	Lagoons/Saltmarshes presence		X			

Some of these variables **are OR could be part** of Copernicus CORE and DOWNSTREAMING SERVICES….

- Land cover/Land use map → IS part of **CORE SERVICE LAND**
- Detailed Habitat map → COULD be part of a **DOWNSTREAMING SERVICES**

InVEST Coastal Vulnerability model: computes the physical Exposure Index (EI: EI=1 low exposure, EI=5 very high exposure) to SURGE (WAVES)

RANK (R_i)	Very Low	Low	Moderate	High	Very High
VARIABLE	1	2	3	4	5
Geomorphology	Rocky, high cliffs, etc.	Medium cliff, indented coast	Low cliff, alluvial plain	Cobble beach, estuary, lagoon, bluff	Barrier beach, delta sand beach, mud flat,
Relief	> 90th Percentile	> 75th Percentile	Average value	< 25th Percentile	< 10th Percentile
Natural Habitats	Coral reef, mangrove, coastal forest	High dune, marsh	Low dune	Seagrass, kelp	No habitat
Sea Level Change	Net decrease < 20th Percentile	< 40th Percentile	±1 < 60th Percentile	< 80th Percentile	Net rise > 81th Percentile
Wind Exposure	< 10th Percentile	< 25th Percentile	Average value	> 75th Percentile	> 90th Percentile
Wave Exposure	< 10th Percentile	< 25th Percentile	Average value	> 75th Percentile	> 90th Percentile
Surge Potential	No exposure	< 25th Percentile	Average value	> 75th Percentile	> 90th Percentile

Expert knowledge ranking

Coastal Exposure Index (EI) with Habitat = $(R_{geomorph} * R_{relief} * R_{habitat} * R_{wave} * R_{surgepot} * R_{sealevel})^{\wedge} \frac{1}{6}$

Note: ALL RESULTS ARE EXTENT RELATED AS WELL AS RANKING VALUES

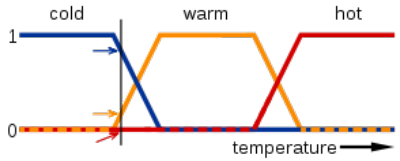
Coastal exposure Index without Habitat

Habitat: Dune & Wetlands

Coastal exposure Index with Habitat

Coastal Vulnerability : A FUZZY LOGIC APPROACH

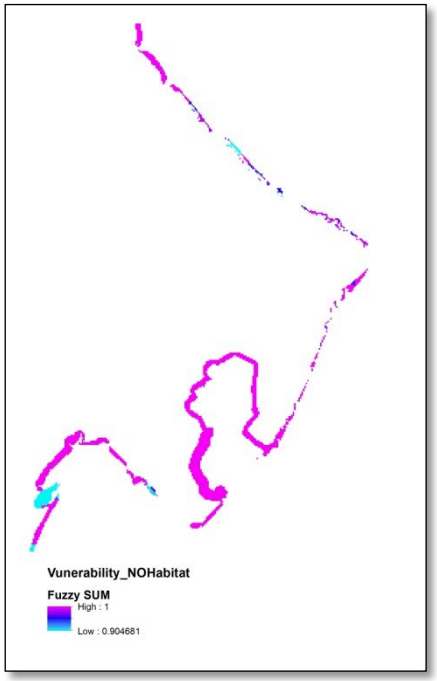
Applied to complex and imprecise problems enables to handle non-linearity, common in multi-criteria framework and vagueness, common in environmental issues and has the ability to model complex behaviors as a collection of simple ‘‘if–then’’ rules based on expert knowledge.



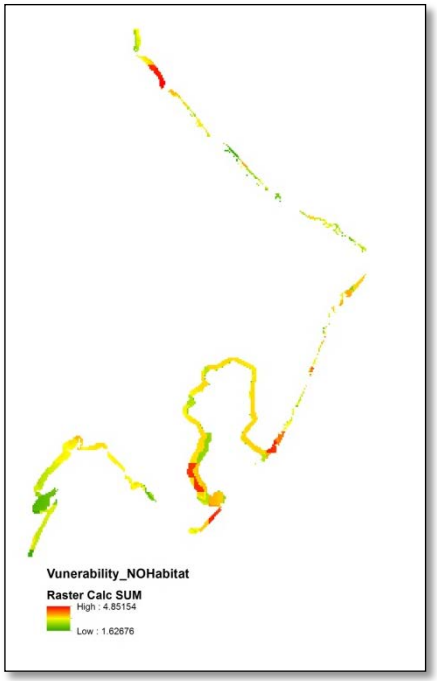
Example of membership function for Temperature

Data Rasterization → **Data Fuzzification** → **Operator: Fuzzy SUM and Raster Calc SUM**

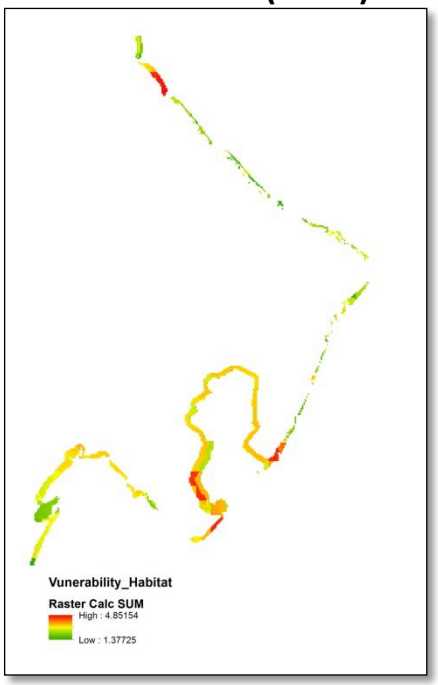
Fuzzy SUM



Raster Calc SUM without Habitat

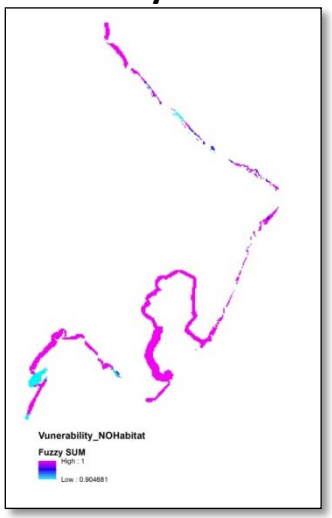


Raster Calc SUM with Habitat (Dune)



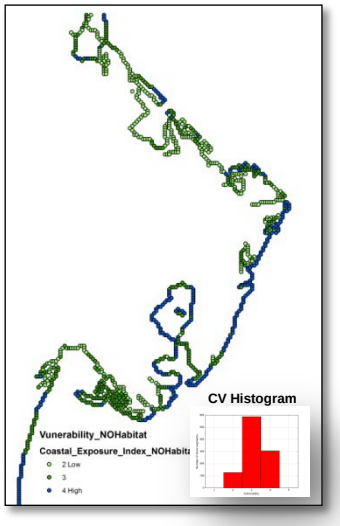
Coastal Vulnerability : InVEST CV model vs FUZZY LOGIC APPROACH

Fuzzy SUM

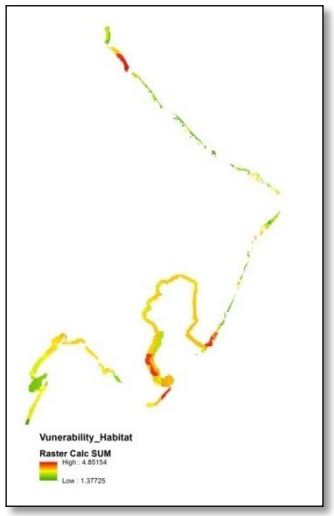


Raster Calc SUM without Habitat

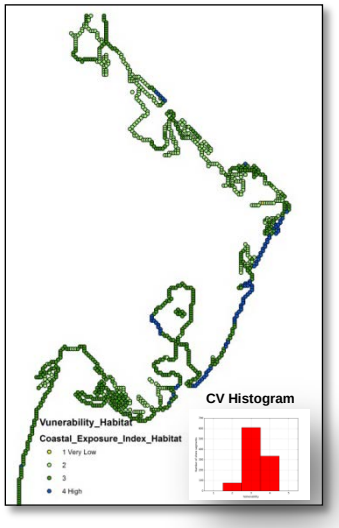
InVEST CV without Habitat



Raster Calc SUM with Habitat



InVEST CV without Habitat



InVEST model

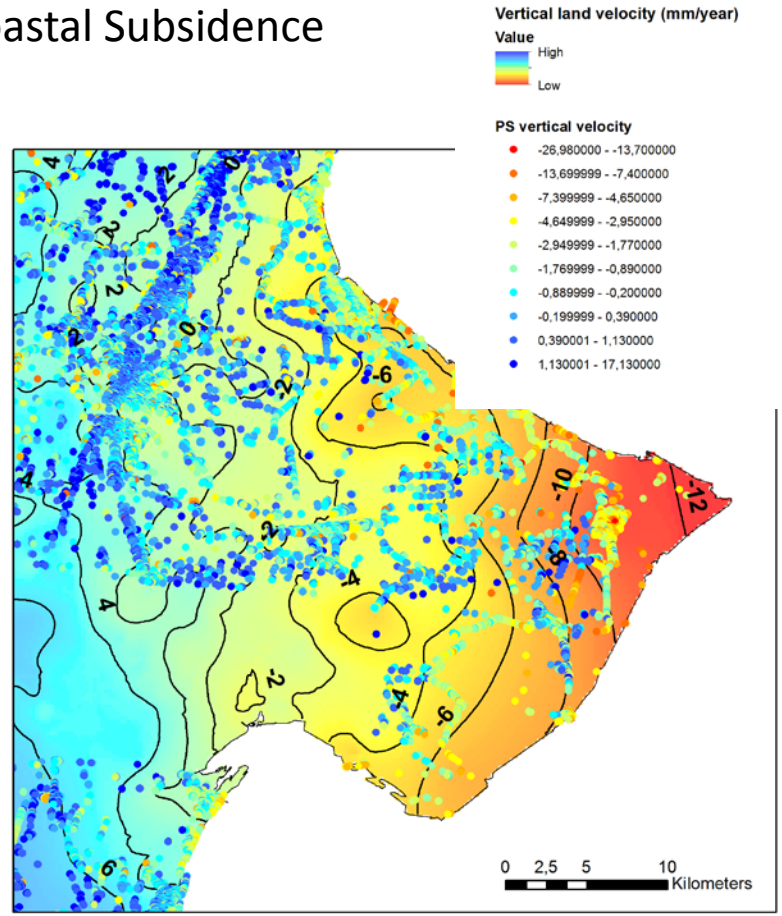
- ready to use but data compulsory
- “fair” qualitative description of CE (not CV)
- includes a storm surge and wave field model
- habitat protective action easy to manipulate
- doesn’t consider the site-specific feature
- ranking does not enable to maintain natural gradient and strongly expert based
- EI is area extent dependant comparison between different areas is senseless

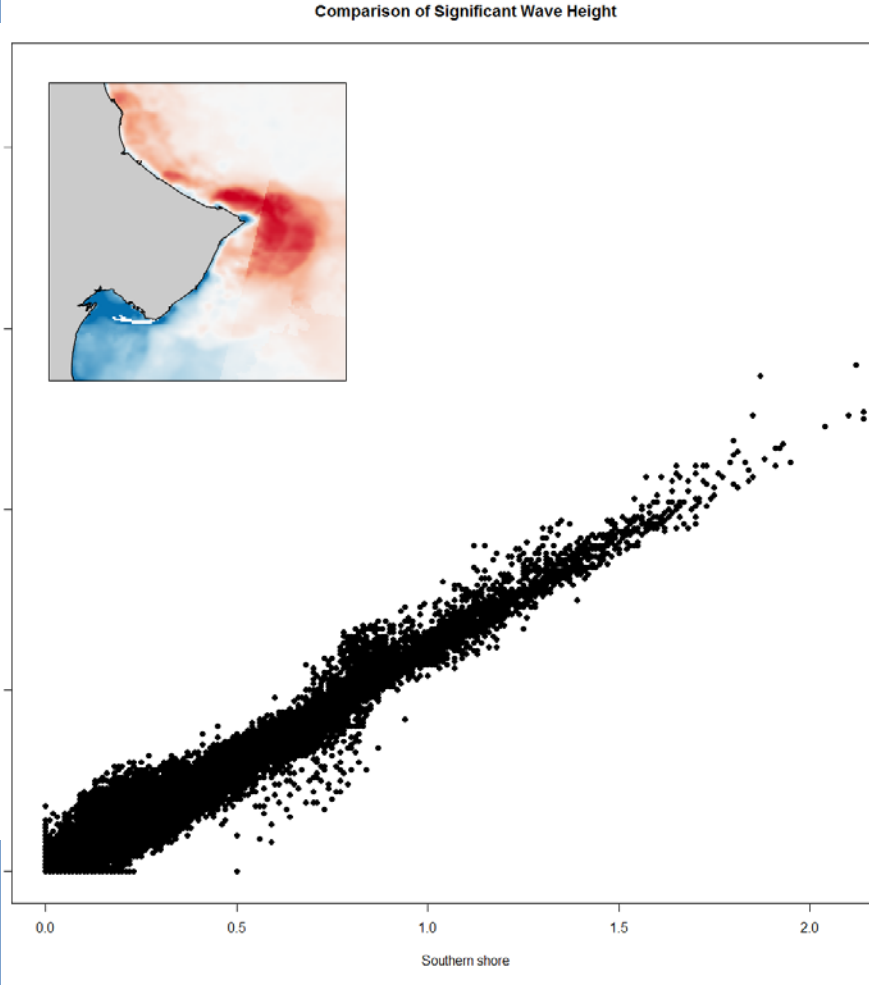
Fuzzy Approach

- allows the inclusion of multiple variables but they should be rasterizable and varying continuously in space (habitat generally don’t respond to this assumption)
- is a-priori site specific
- can merge different kinds of parameters (e.g., environmental and health, and quantitative and qualitative)
- strong reliance on subjective inputs
- can fail to capture the ranges of values in complex data sets and the correlations among the parameters

Coastal processing chains design and new products

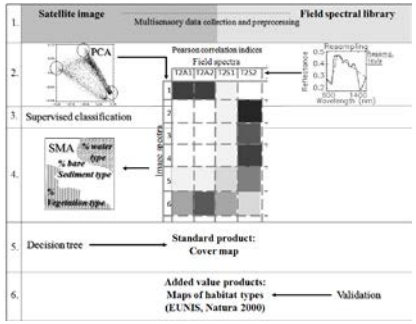
Coastal Subsidence

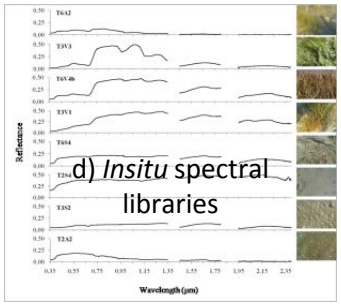




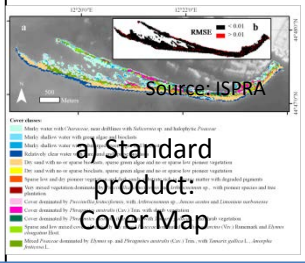
This initiative is implemented by the `GIO Lot2 User Uptake` project funded by the European Commission

Estuarine Habitat type mapping

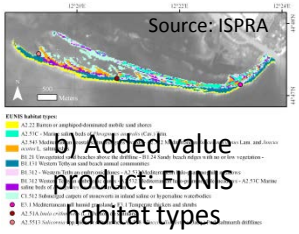




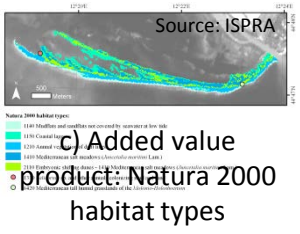
d) *Insitu* spectral libraries



a) Standard product: Cover Map

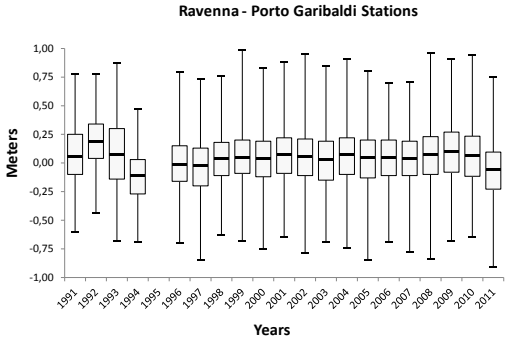


b) Added value product: EUNIS habitat types

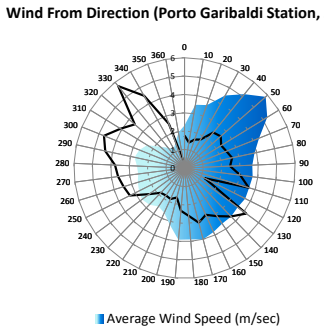


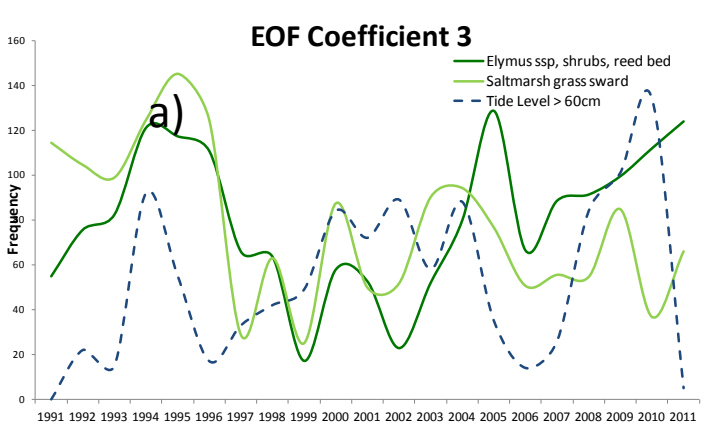
c) Added value product: Natura 2000 habitat types

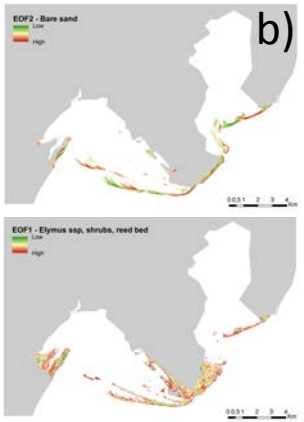
From 1998 increase in frequency of both high tide levels (> 60cm) and low tide levels (<60cm). winds are dominated from NW sector while a greater intensity of winds comes from ne sector. the temporal trend of high tide level frequency finds relationships with eof coefficient 3 for vegetation fraction maps.



Spatial - temporal biophysical integration



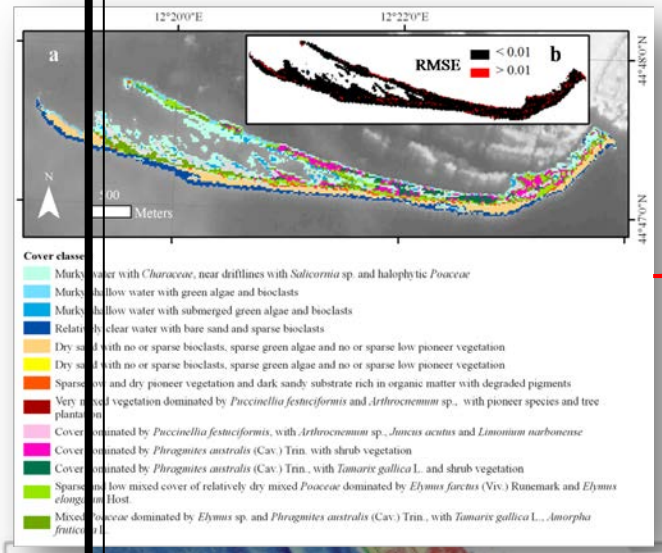




a) Temporal EOFs component of sediments and vegetations from SMA compared with insitu measurements of tide levels > 60 cm in the same temporal series; b) spatial components of sediments EOF 1 and EOF 2 (Source: ISPRA).

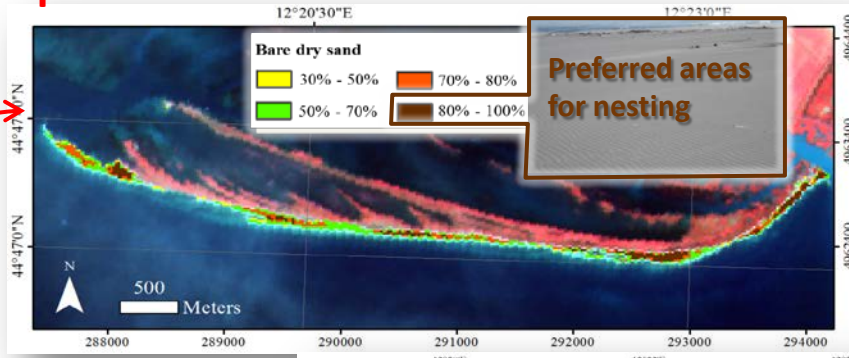
This initiative is implemented by the `GIO Lot2 User Uptake` project funded by the European Commission

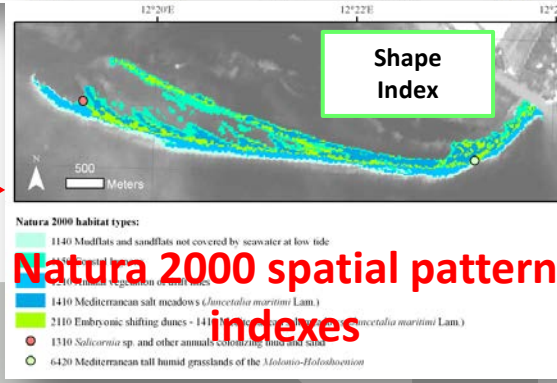
FROM a Detailed cover map of both aquatic and terrestrial environments



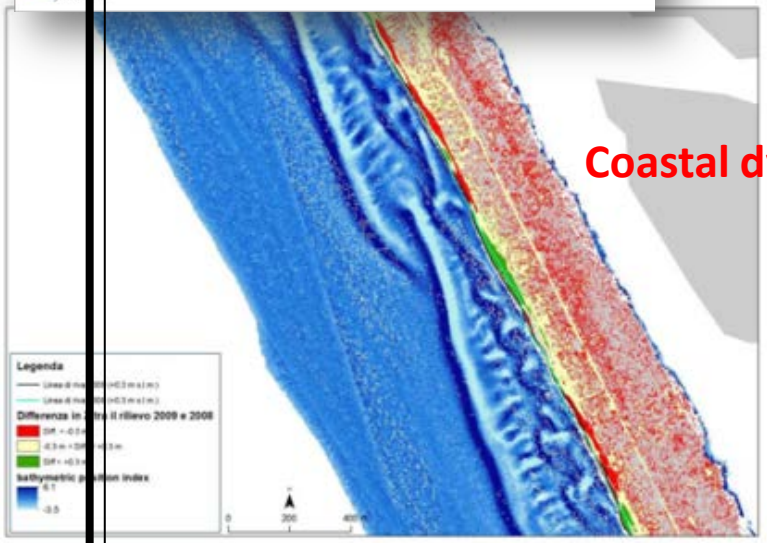
TO

Specific coastal sites

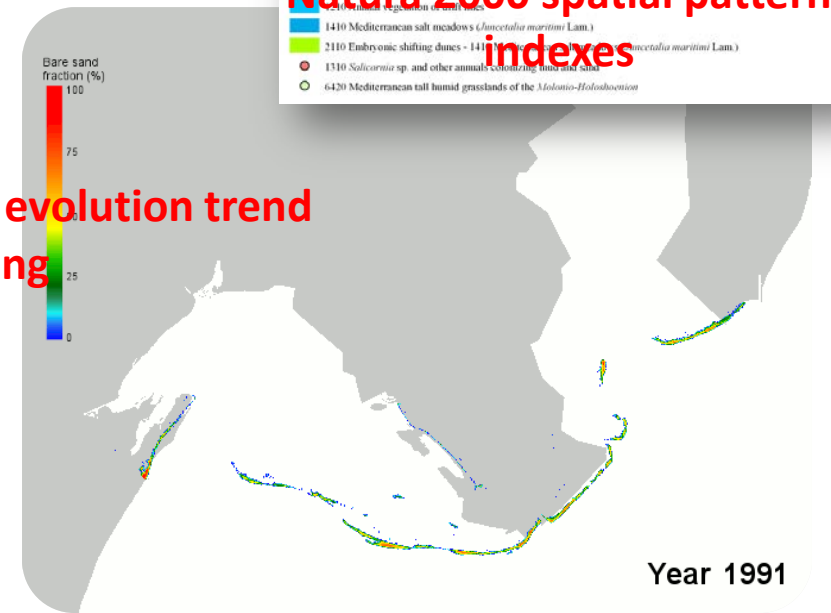




Natura 2000 spatial pattern indexes



Coastal dynamics and evolution trend monitoring



IMPLICATIONS

COPERNICUS CORE and DOWNSTREAMING SERVICES

A better understanding of potential climate change impacts (scenarios) at both regional and local levels,
the development of improved methods to quantify the uncertainty of climate change projections,
the construction of usable climate change indicators,
and an improvement of the interface between science and policy formulation in terms of assessment to formulate and inform better adaptive strategies

Copernicus Cores and Downstreaming services are an effective tool for generating time series of environmental indicators to support stakeholders and decision makers in the Maritime Spatial Planning.
Future challenges would be the development of scenarios by means of EO modeling assimilation and multisensory measurements integration.

AKNOWLEDGEMENTS

The support of the European Commission through the projects:

*"**Lot2- GMES**/Copernicus User Uptake" (DG ENTERPRISE) http://www.user-uptake-portal.org/*
*"**MERMAID** - Innovative Multi-purpose offshore platforms: planning, design and operation", Contract 288710, FP7-OCEAN.2011-1 (DG RESEARCH AND INNOVATION), www.mermaidproject.eu*
*"**ECOSTRESS** - Ecological COastal Strategies and Tools for Resilient European Societies (DG ECHO) http://www.ecostress.eu/*

is gratefully acknowledged.

Thanks to ESA - CAT-1 project n. 7963 for the provision of satellite data access

and to the just funded "**ECOPOTENTIAL**: IMPROVING FUTURE ECOSYSTEM BENEFITS THROUGH EARTH OBSERVATIONS" H2020 - SC5-16-2014 that will allow us to go further in our research developing the ***E-COPERNICUS*** downstreaming service.

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Zanuttigh, B., Angelelli, E., Bellotti, G., Romano, A., Krontira, Y., Troianos, D., Taramelli A, Filipponi F, … & Broszeit, S. (2015). Boosting Blue Growth in a Mild Sea: Analysis of the Synergies Produced by a Multi-Purpose Offshore Installation in the Northern Adriatic, Italy. Sustainability, 7(6), 6804-6853.

O. Q. Gutiérrez OQ, Filipponi F, Taramelli A, Valentini E, Camus P and Méndez FJ, (2015), On the feasibility of the use of wind SAR to downscale waves on shallow water, In press, Ocean Science

Taramelli, A.; Valentini, E.; Cornacchia, L., (2015), Remote Sensing Solutions to Monitor Biotic and Abiotic Dynamics in Coastal Ecosystems, Coastal Zones. http://dx.doi.org/10.1016/B978-0-12-802748-6.00009-7

Manzo C., Valentini E., Taramelli A, Filipponi F., Disperati L. (2015), Spectral characterization of coastal sediments using Field Spectral Libraries, Airborne Hyperspectral Images and Topographic LiDAR Data (FHyL), International Journal of Applied Earth Observation and Geoinformation 36, 54–68

Valentini, E.; Taramelli, A.; Filipponi, F.; Giulio, S.; (2015), An effective procedure for EUNIS and Natura 2000 habitat mapping in estuarine ecosystems integrating ecological knowledge and remote sensing analysis, Ocean and Coastal Management, 108: 52-64, http://dx.doi.org/10.1016/ j.ocecoaman.2014.07.015

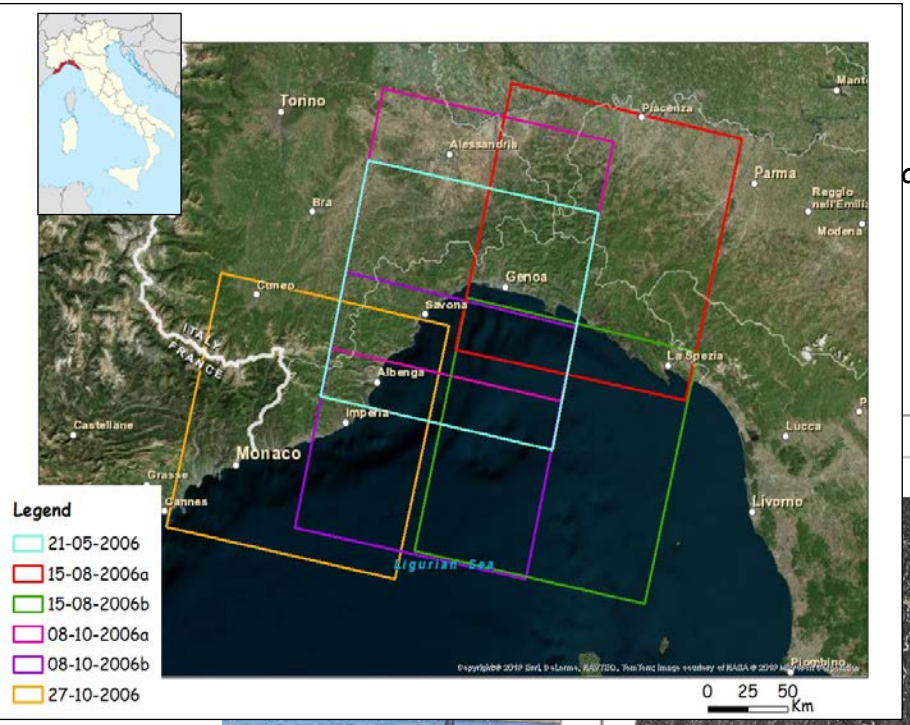
Taramelli, A.; DiMatteo, L.; Ciavola, P.; Guadagnano, F.; Tolomei, C. (2015), Temporal evolution of patterns and processes of the coastal area in Bevano Estuary (Northern Adriatic) - Italy. Ocean and Coastal Management, 108: 74-88, http://dx.doi.org/10.1016/j.ocecoaman.2014.06.021

Taramelli, A.; Valentini, E.; Sterlacchini, S.; (2015), A GIS-based approach for hurricane hazard and vulnerability assessment in the Cayman Islands. Ocean and Coastal Management, 108: 116-130, http://dx.doi.org/10.1016/j.ocecoaman.2014.07.021

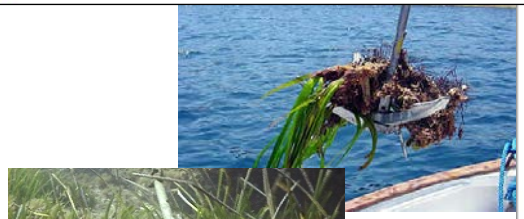
Pieralice, F., Proietti, R., La Valle, P., Giorgi, G., Mazzolena, M., Taramelli, A., & Nicoletti, L. (2014). An innovative methodological approach in the frame of Marine Strategy Framework Directive: A statistical model based on ship detection SAR data for monitoring programmes. Marine environmental research, 102, 18-35. DOI:10.1016/j.marenvres.2014.07.006

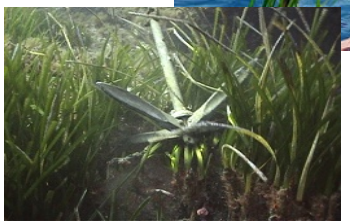
Taramelli, A.; Valentini, E.; Cornacchia, L.; Mandrone, S.; Monbaliu, J.; Thompson, R.; Hogart, S.; Zanuttigh, B. (2014), Modelling uncertainty in estuarine system by means of combined approach of optical and radar remote sensing, Coastal Engineering. 87: 77-96 10.1016/j.coastaleng.2013.11.001

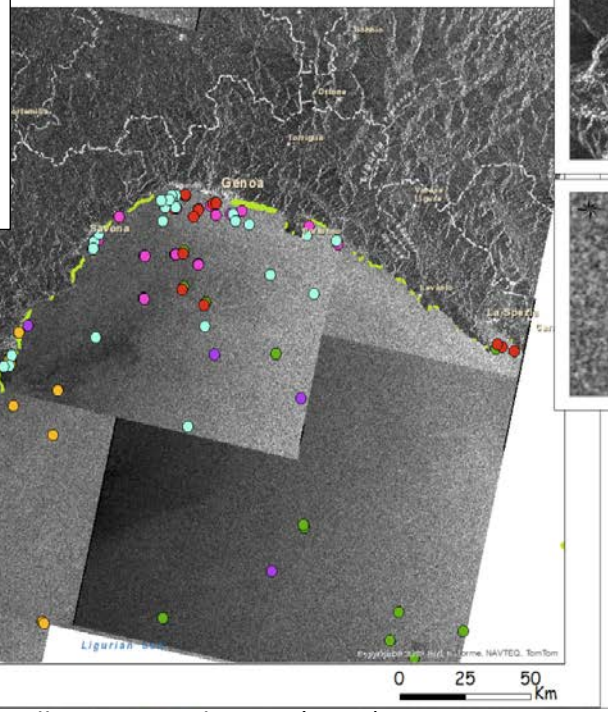
STUDY AREA: Liguria Region (Northern Tyrrhenian Sea, Italy)

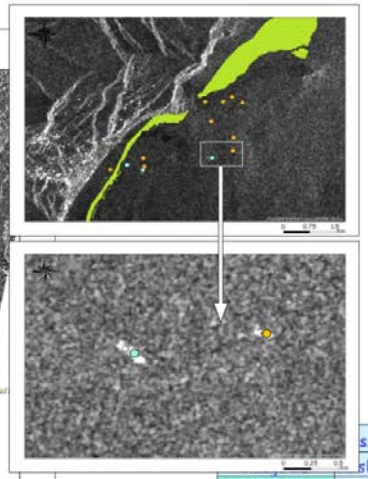


Nella Marine Strategy Framework Directive (MSFD) è richiesto di determinare la pressione abrasione sul fondo del mare. L'utilizzo delle immagini SAR da COPERNICUS Earth Observation per i monitoraggi ambientali offre diversi vantaggi, come la buona frequenza di rivisitazione, ovvero la possibilità di acquisire immagini della stessa area con brevi intervalli temporali, costi contenuti rispetto alle acquisizioni aeree, possibilità di indagare aree vaste, capacità di acquisizione dei dati in ogni condizione meteorologica.









ssed results

ships detected	
21-05-2006	27
15-08-2006a	13
15-08-2006b	14
08-10-2006a	17
08-10-2006b	13
27-10-2006	25

Ship Length Parameters [m]			
Length	min	max	mean
Major axis	32.0	470.8	143.1
Minor axis	16.8	130.4	70.3

Pieralice, F., Proietti, R., La Valle, P., Giorgi, G., Mazzolena, M., Taramelli, A., & Nicoletti, L. (2014). An innovative methodological approach in the frame of Marine Strategy Framework Directive: A statistical model based on ship detection SAR data for monitoring programmes. Marine environmental research, 102, 18-35. DOI:10.1016/j.marenvres.