

Nuovi scenari di inondazione per l'Atlante delle coste italiane

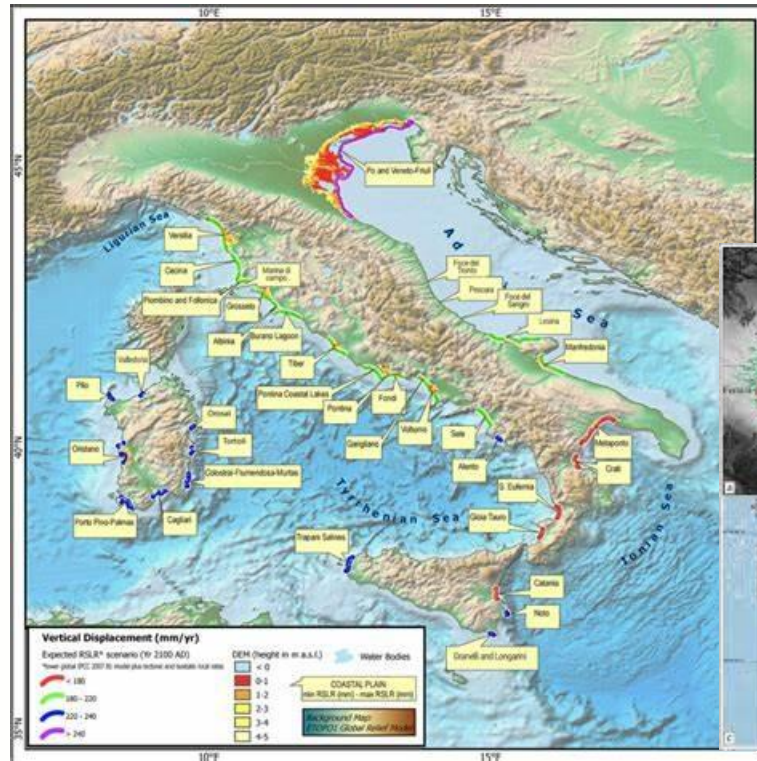
Sergio Cappucci - ENEA

VISIONI DAL CIELO

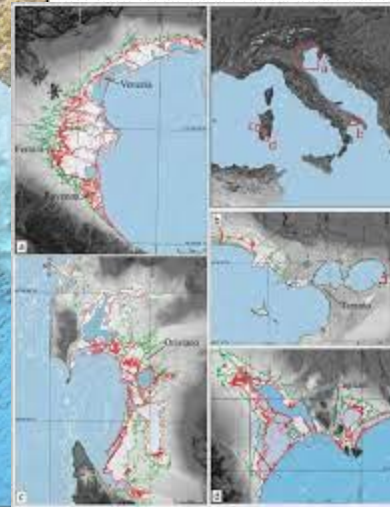
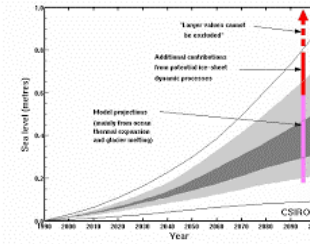
Crescere e imparare con CLMS

Introduction (1)

Bathtub



Attenuation



Storm surge



In the Mediterranean sea about 75% of the local population lives in coastal areas

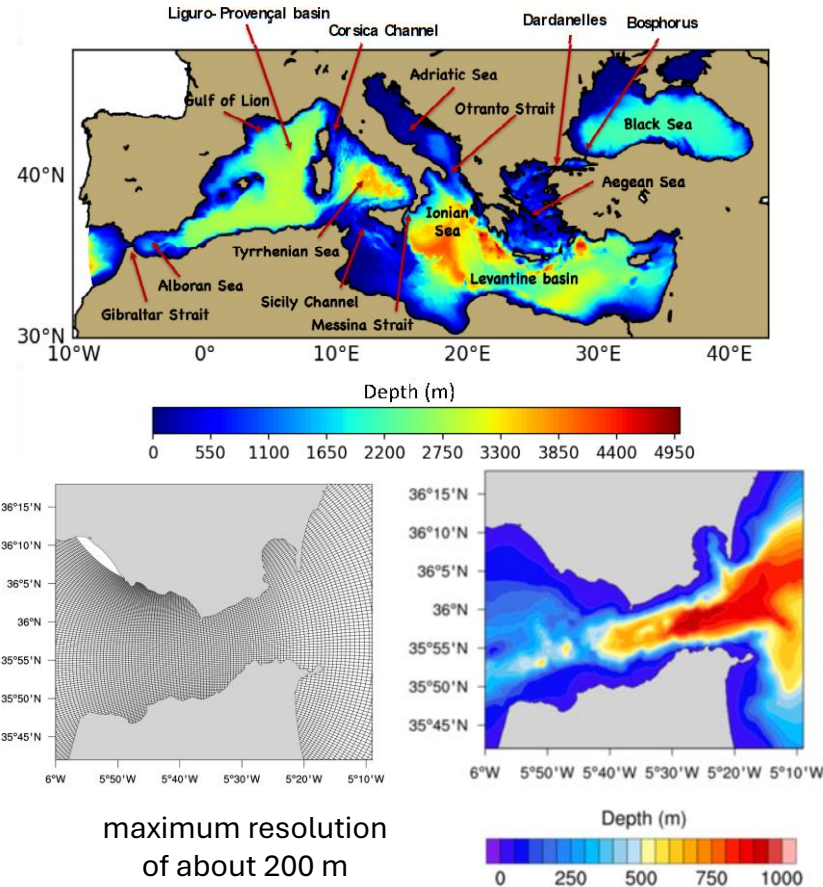
ENEA has been studying the impact of RSLR for many years.

Italy has almost 7900 Km of coastlines. More than 30 coastal areas are at risk of flooding by 2100 (left) and about 50% of contaminated sites (Industrial areas) are located in the same coastal areas (right).

Introduction (2) - MED16 model by ENEA

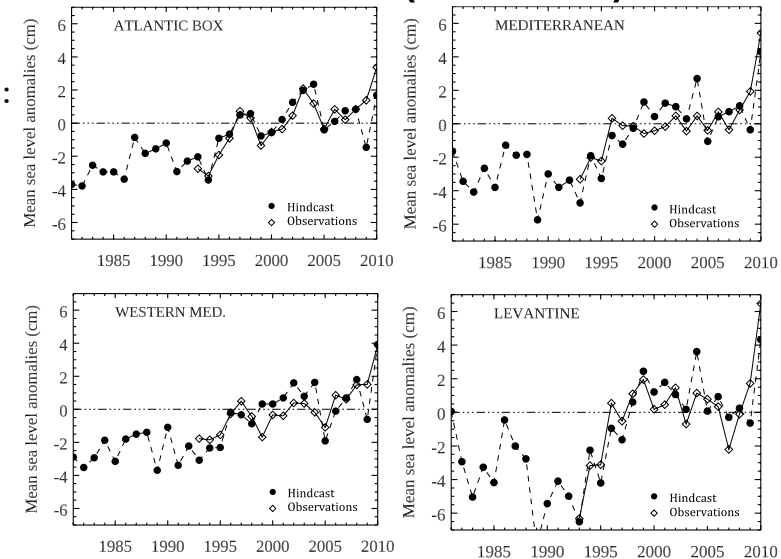
Sannino et al., 2022, Climate Dynamics <https://doi.org/10.1007/s00382-021-06132-w>.

A high-resolution implementation of the MITgcm ocean global circulation model (MIT), suitable for long-time climatic integrations. Navier–Stokes equations under the Boussinesq approximation -- MITgcm kernel (MIT) -- Horizontal resolution 1/16° (7 km), with grid refinement at the Gibraltar and Turkish Straits -- Includes the effects of the main tidal components

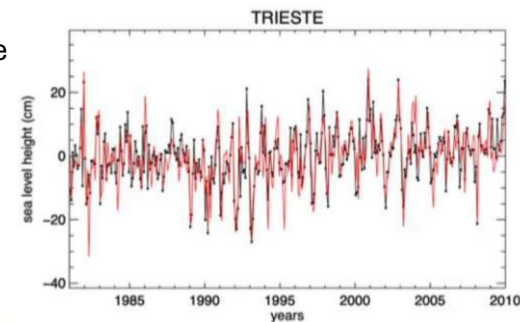


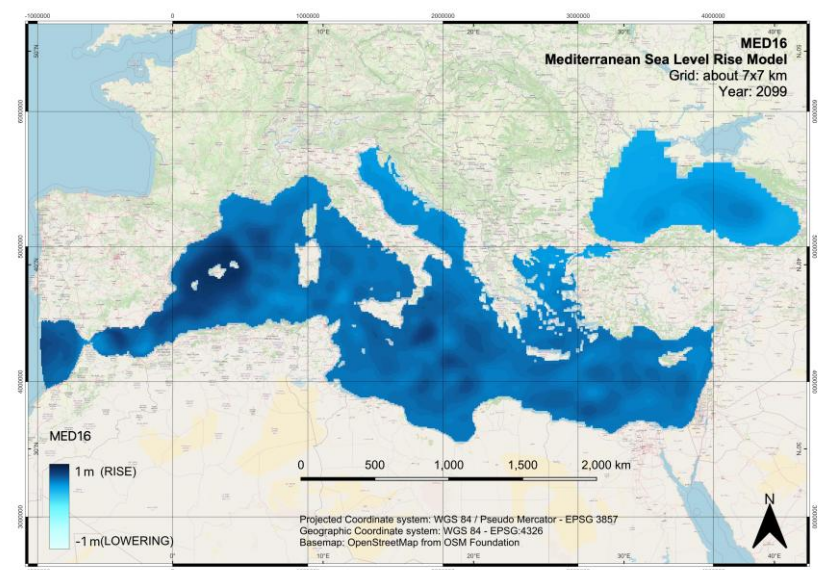
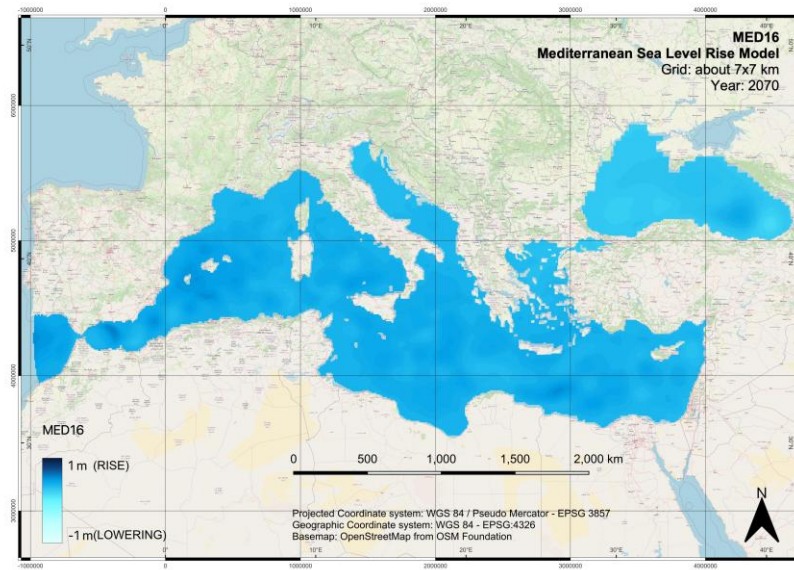
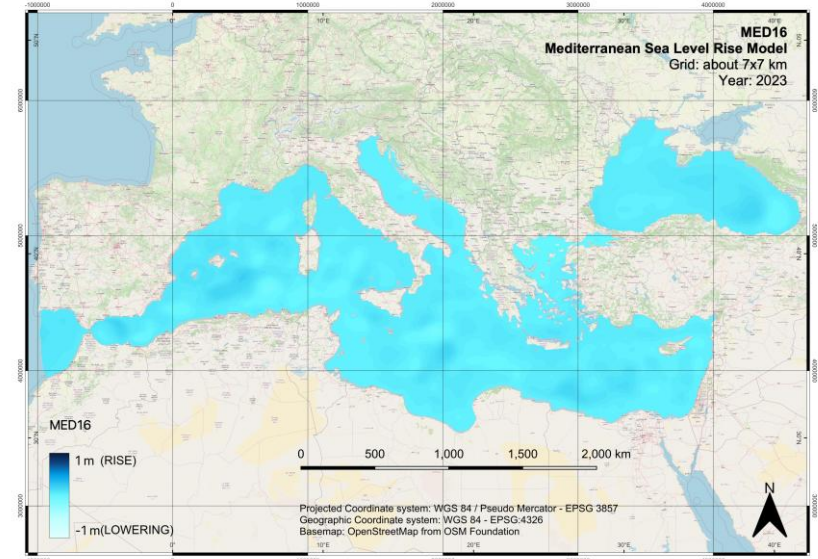
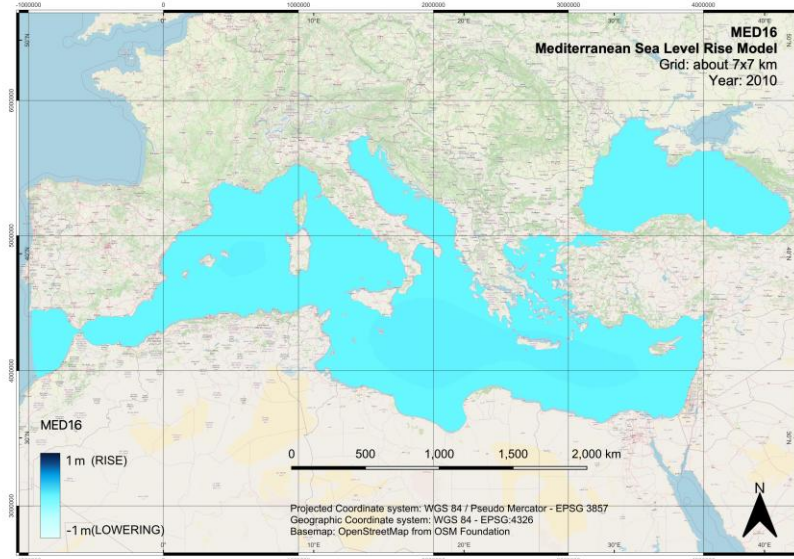
Validation:
satellite
altimeter

Hindcast (1980-2010)



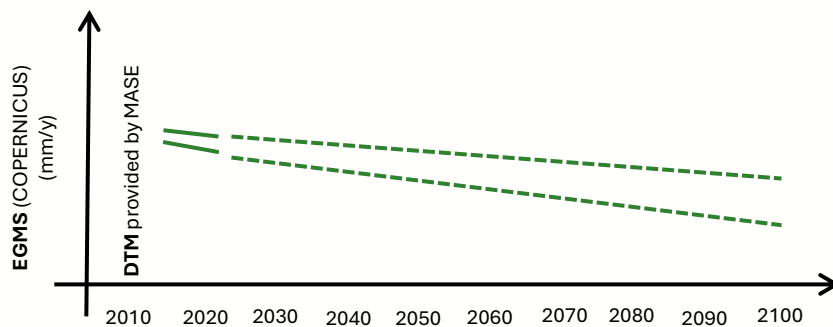
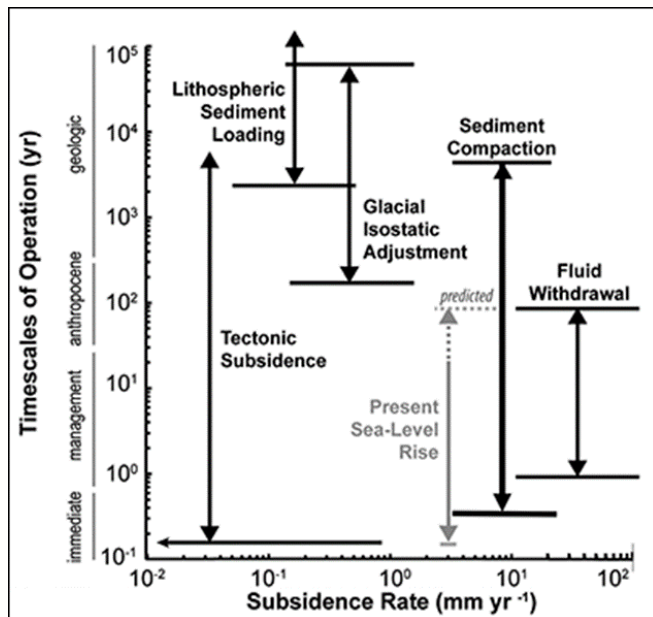
Validation: tide
gauge data



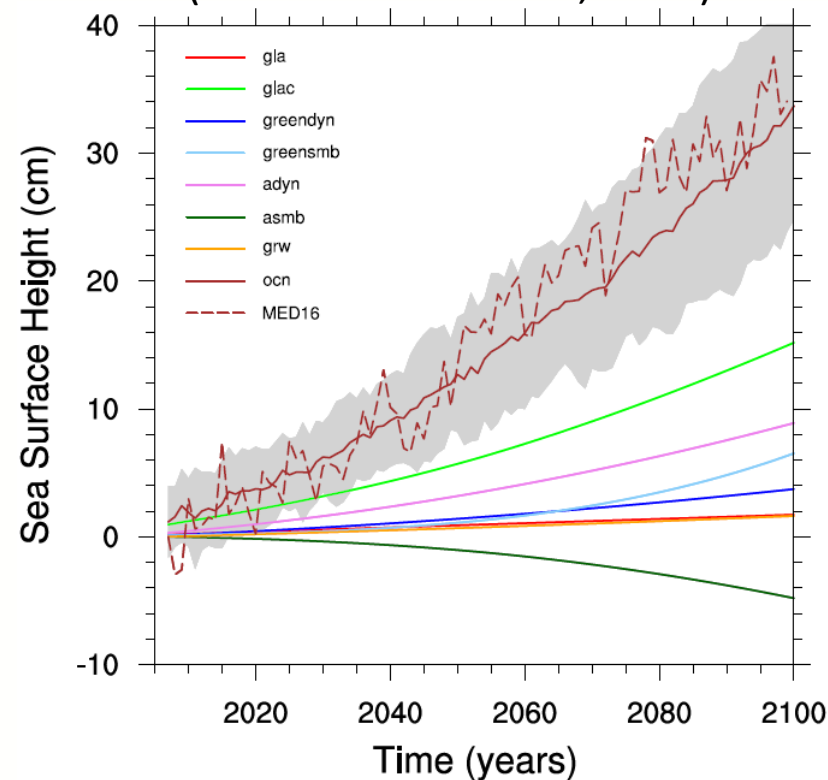


Introduction (3)

(From Allison et al., 2016)



(From Sannino et al., 2022)



EGMS* provides an integrated estimate of all geological contributions to ground motion without discriminating the effect of the single components. European product validated by Copernicus is a great step forward.

Calibration of preliminary results will include in situ measurement and geological dataset of different ground motion components

<https://land.copernicus.eu/pan-european/european-ground-motion-service>

Study areas (Italy)

Tuscany Region:

Marina di Campo (Elba) &
Piombino Follonica

Sardinia Region:

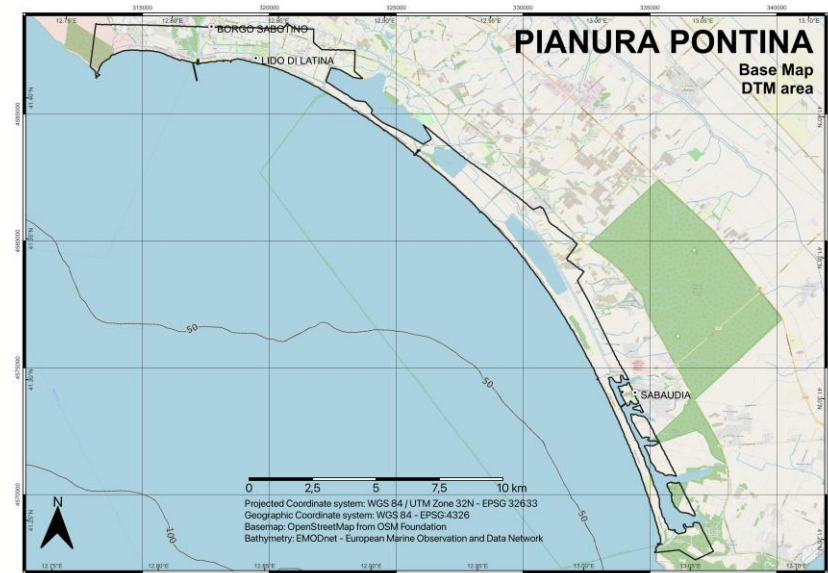
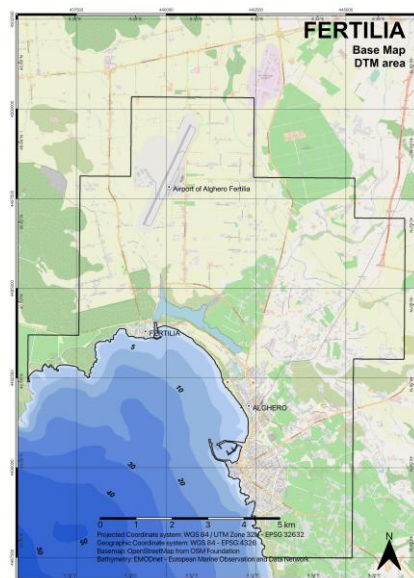
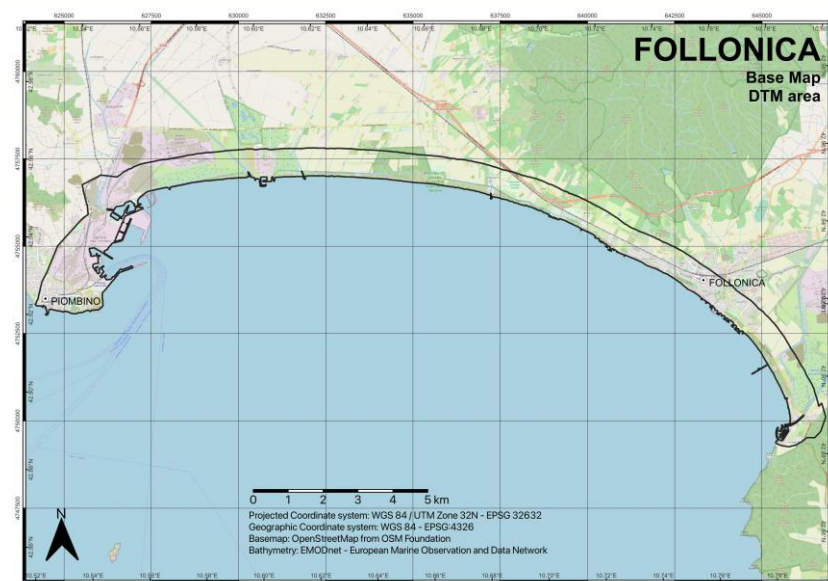
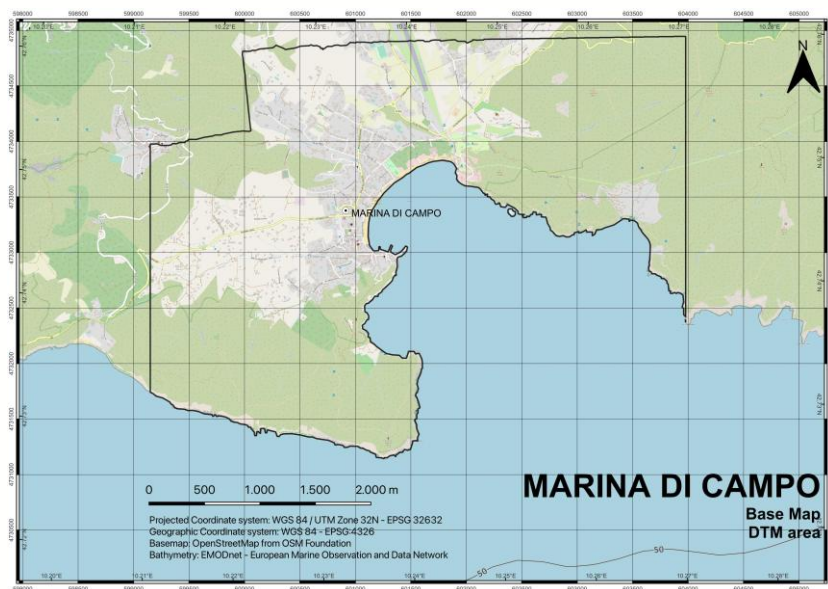
Fertilia- Alghero

Latium Region:

Latina-Sabaudia & Rome

*Cagliari, La Spezia, Taranto,
Brindisi, Napoli*

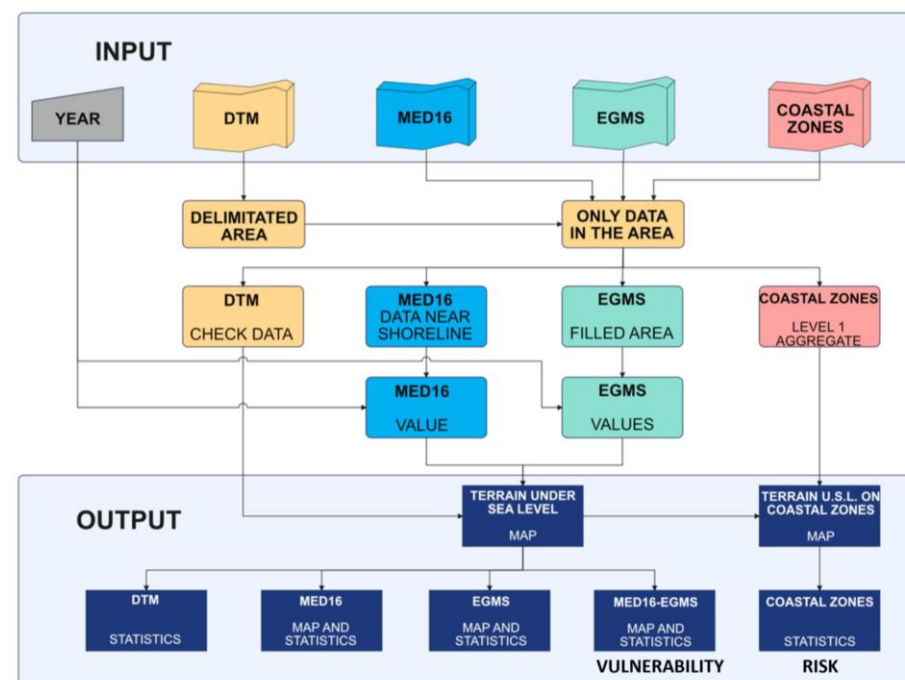




Methodology - Workflow

Timeline
2010-2099

INPUT	DATA PROCESSING	OUTPUT	AIM
LIDAR, Charts and Topo-bathimetric data	DSM/DTM	First Level Inundation Maps	VULNERABILITY
SLR MED16	Sea Level Variation		
Copernicus	Ground Motion		
CORINE	Land Cover	Second Level Exposed Assets	RISK

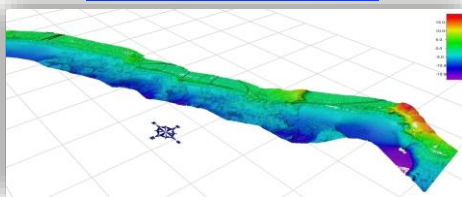
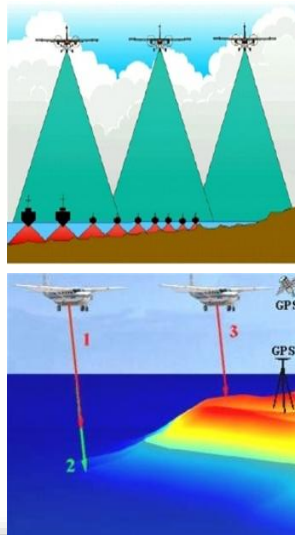


Methodology – Input Data (scheme)

DTM: TOPOGRAPHY

Resolution 2 x 2 m

2008-2012



GROUND MOTION

Resolution 100 x 100 m

2016-2020



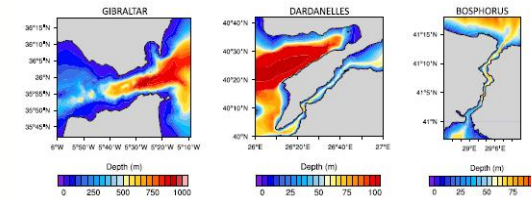
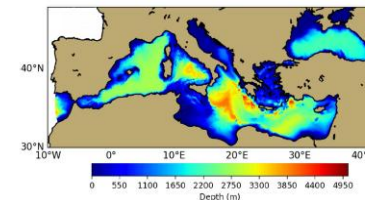
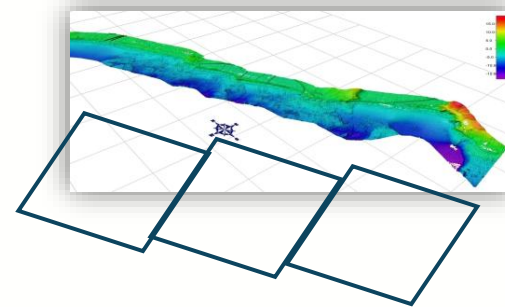
European Ground Motion Service



SEA LEVEL RISE

Resolution 7 x 7 km

2010-2100



LAND COVER/USE

Resolution 100 x 100 m

2018

Level 1 (of 5 levels)

URBAN

CROPLAND

WOODLAND and FOREST

GRASSLAND

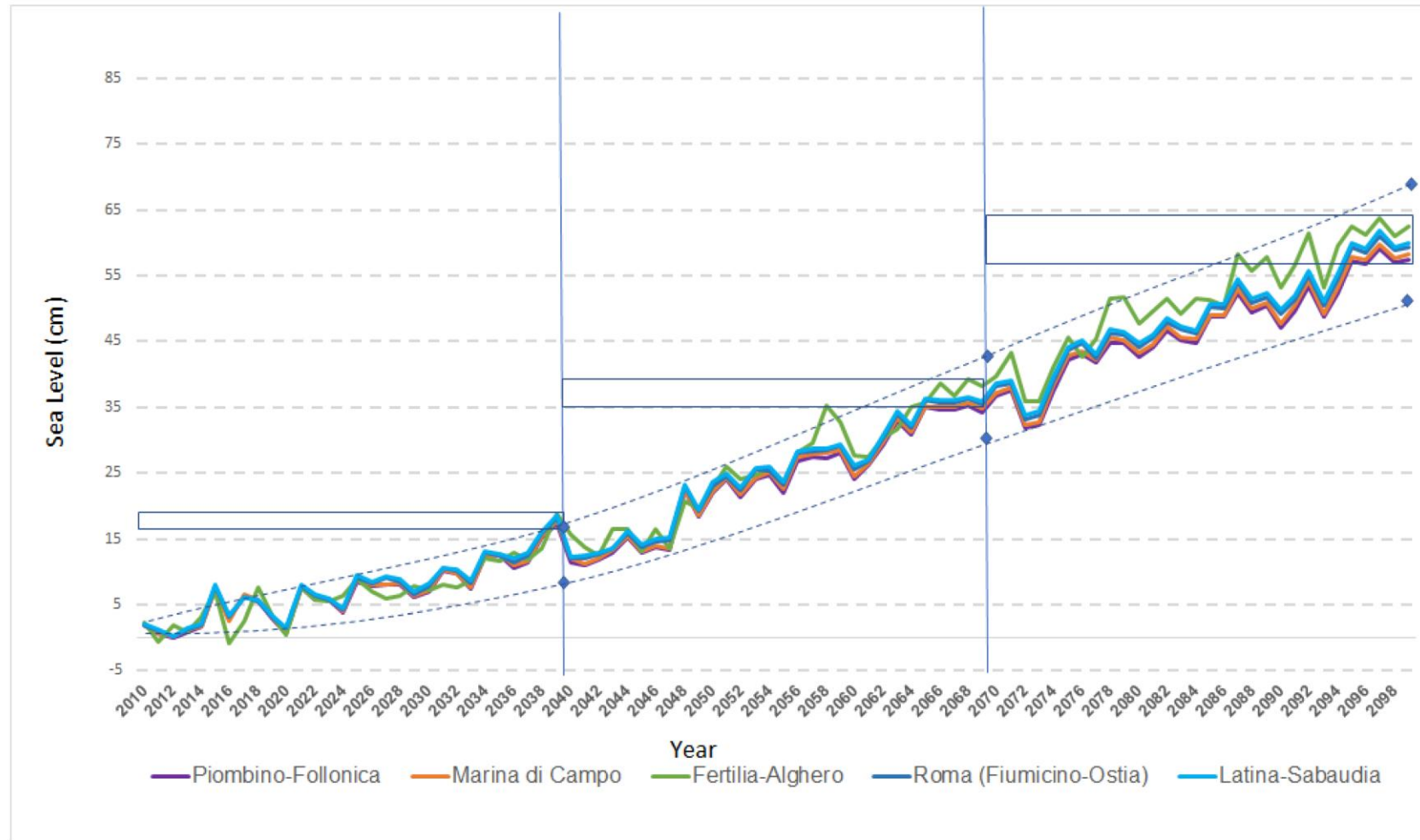
HEATLAND and SCRUBS

OPEN SPACES with LITTLE or NO VEGETATION

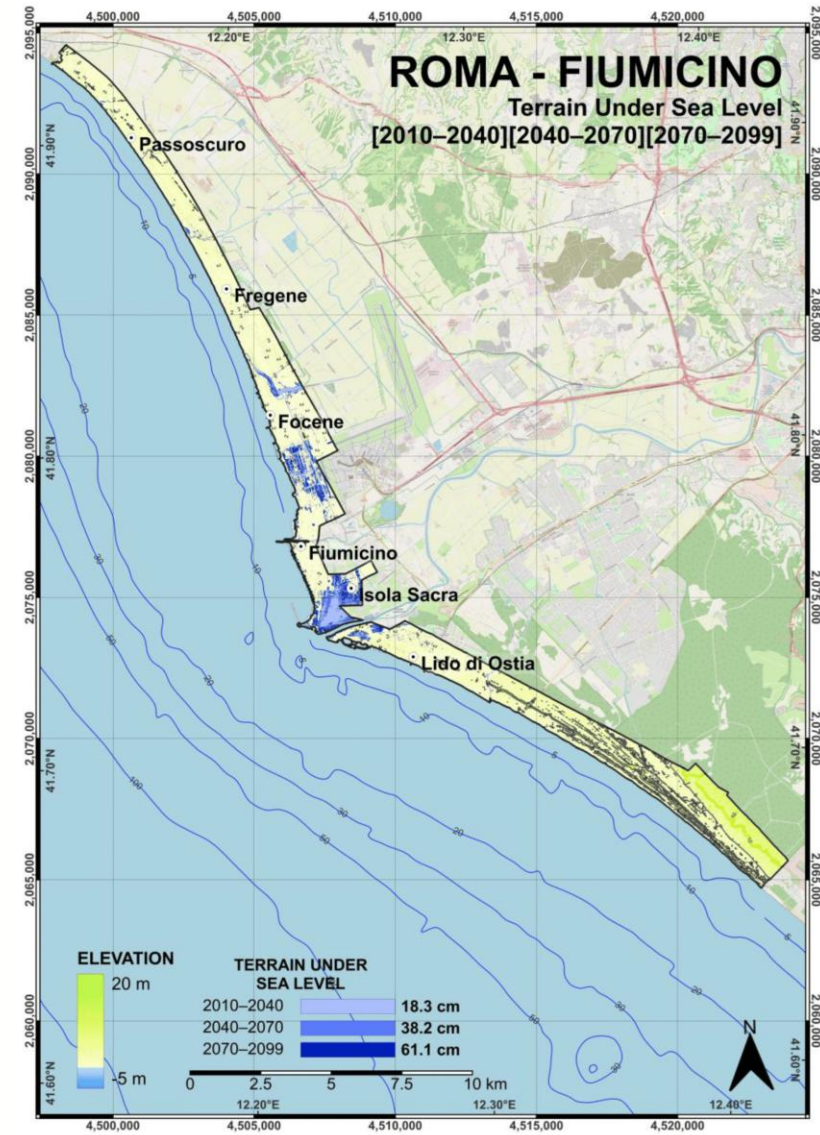
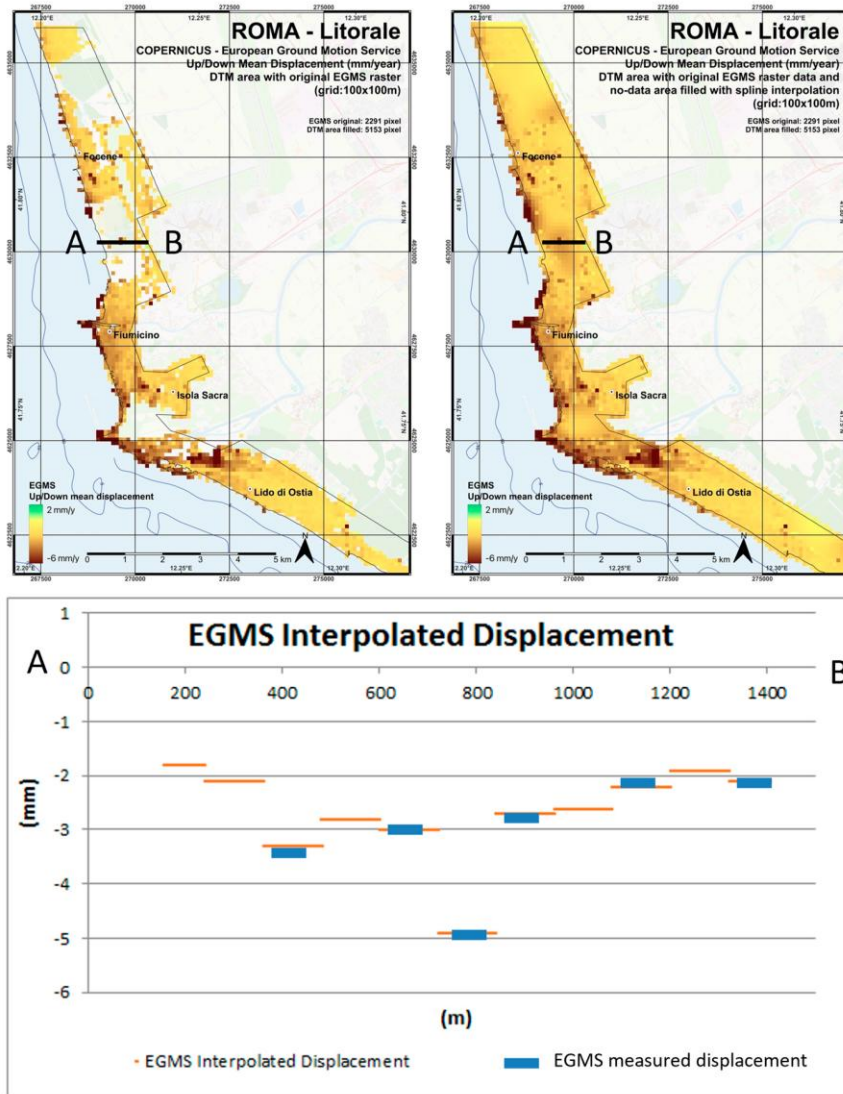
WETLAND

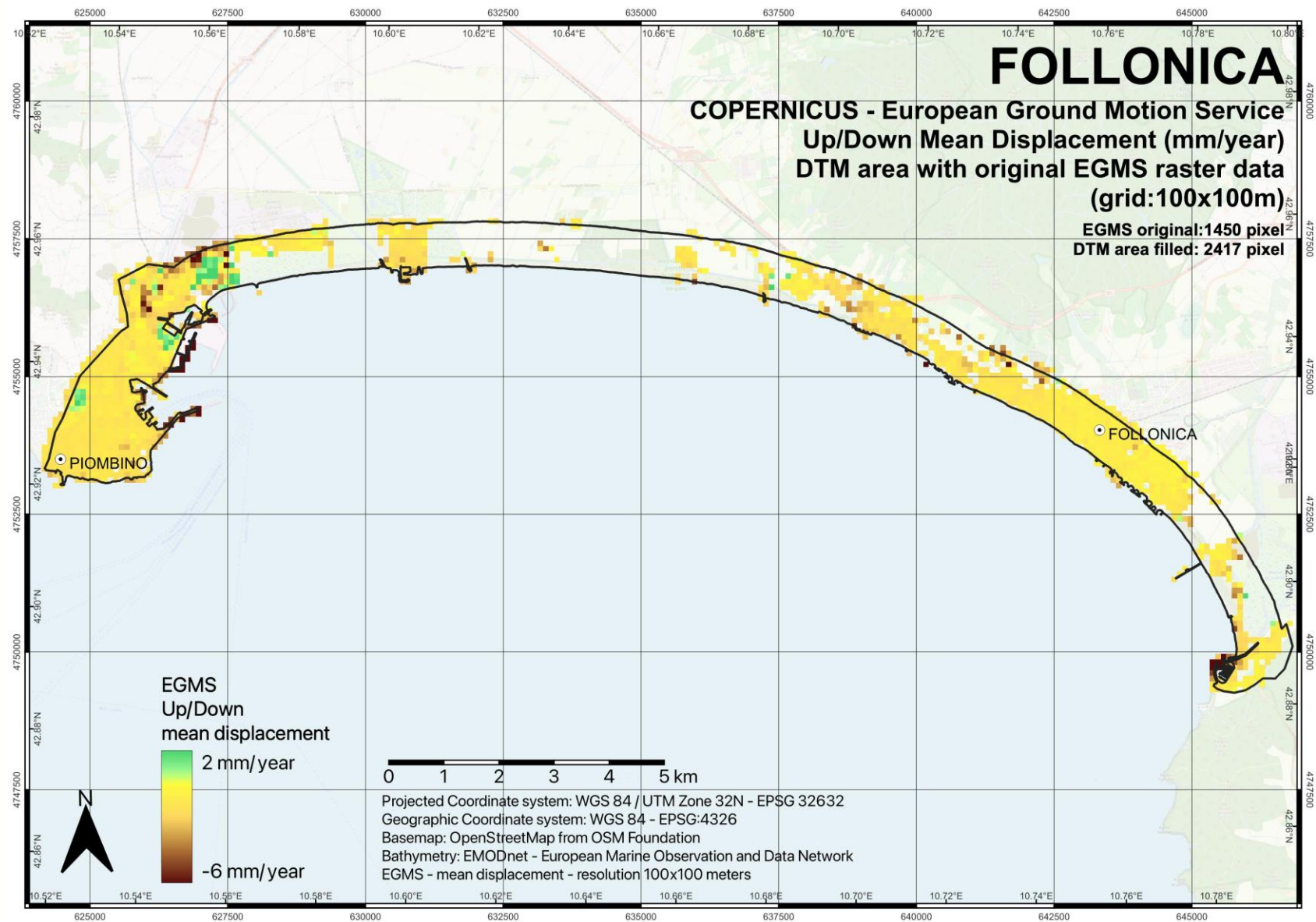
WATER

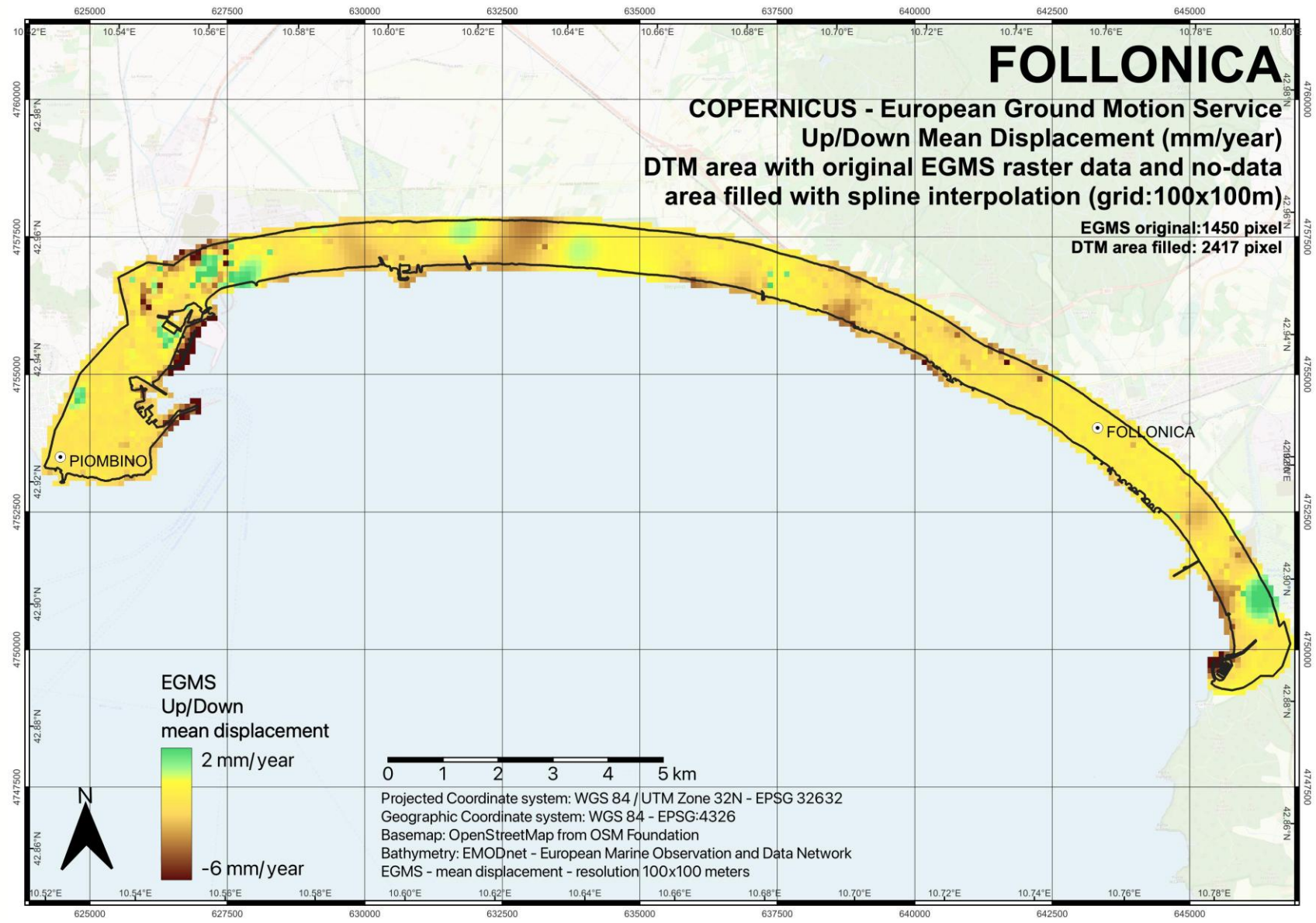
Methodology – Innovation 1



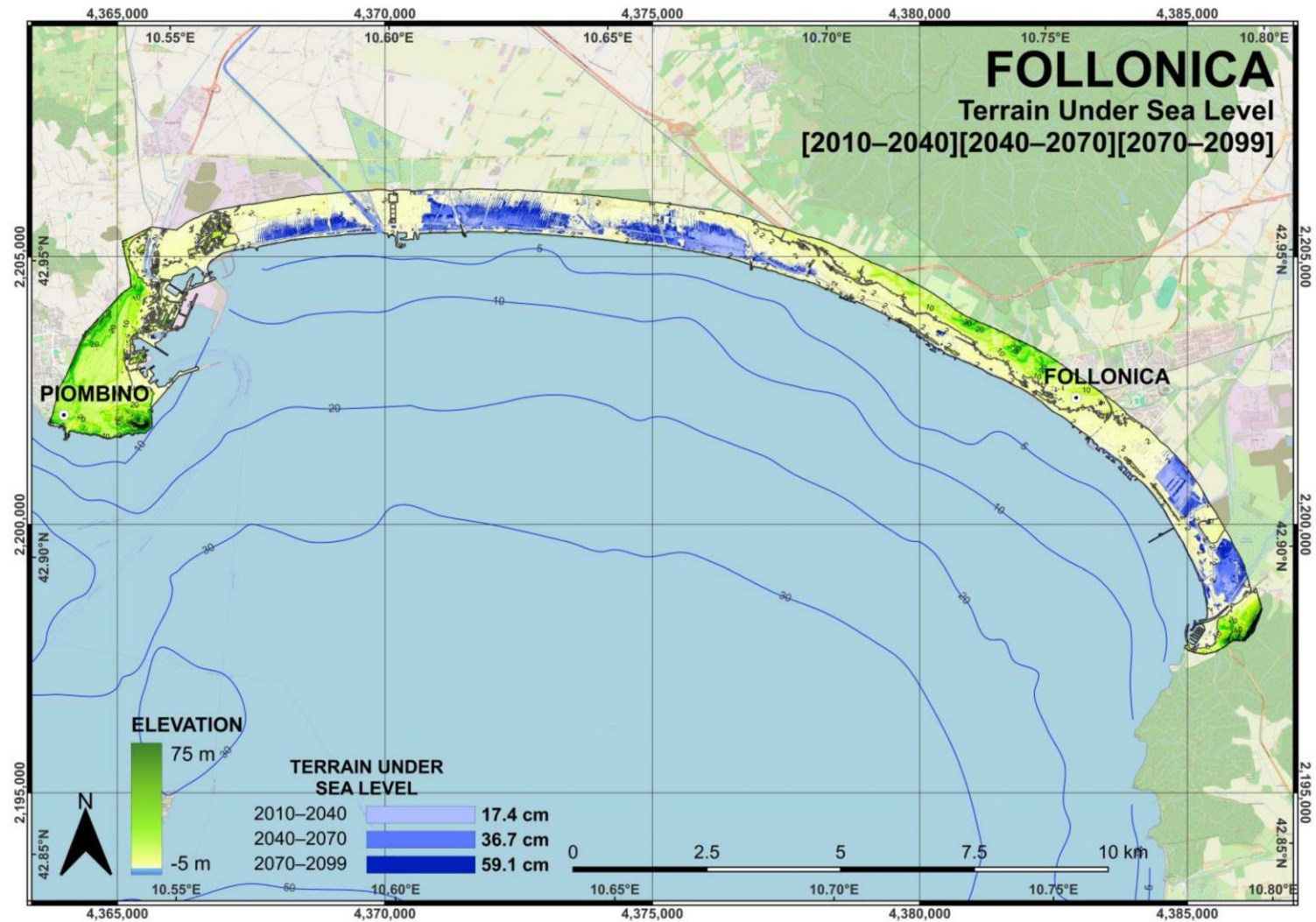
ROME – Innovation 2





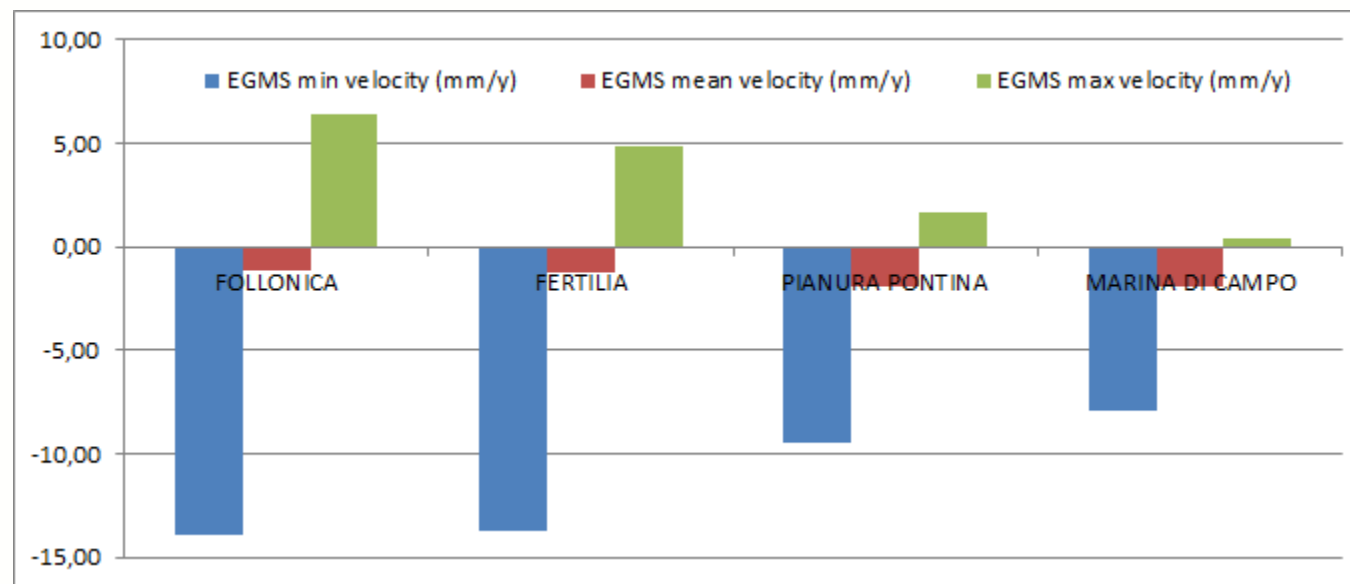


Methodology – Input Data: DTM



Results - inundation data

Location	PONTINA PLAIN			FOLLONICA			MARINA DI CAMPO			FERTILIA		
Year	2040	2070	2099	2040	2070	2099	2040	2070	2099	2040	2070	2099
SLR (cm) from MED16 (one mean value)	18,48	38,49	61,78	17,37	36,71	59,13	17,71	37,17	59,70	18,75	39,65	63,64
GM (cm) from EGMS (mean value of the whole area)	-6,77	-13,54	-20,07	-3,49	-6,98	-9,79	-5,96	-11,93	-17,69	-3,60	-7,20	-10,68
relative sea level rise (cm) (mean value of the whole area)	25,05	51,62	81,26	21,44	44,86	71,22	23,49	48,73	76,84	22,39	46,91	74,42
Surface under sea level (km ²) referred to baseline DTM	9,4324	12,0447	14,8421	1,3616	2,7215	4,5707	0,0372	0,0610	0,0918	0,9910	1,1349	1,4402



Results – Ground motion

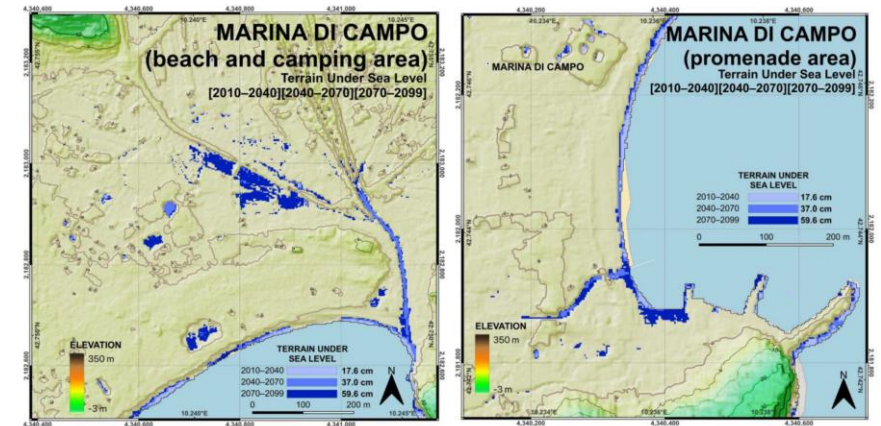
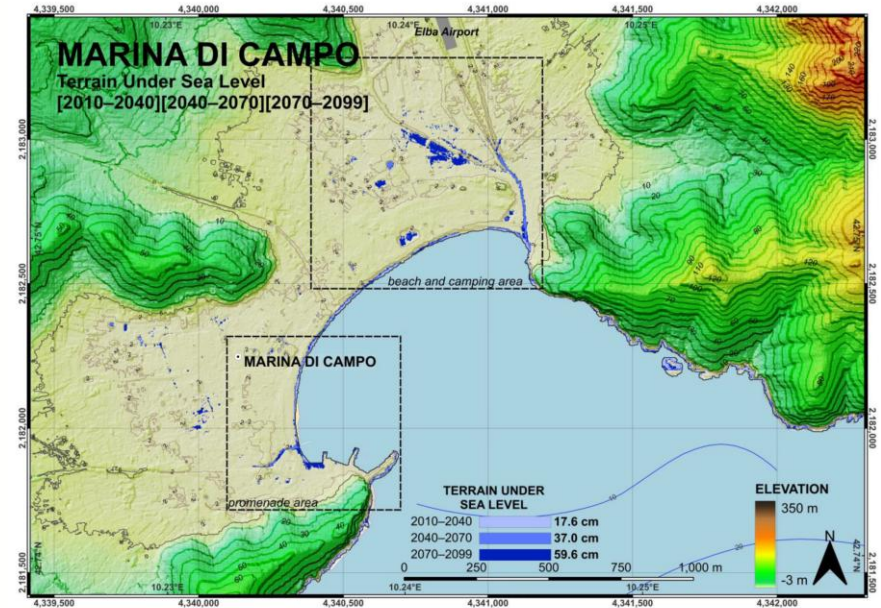
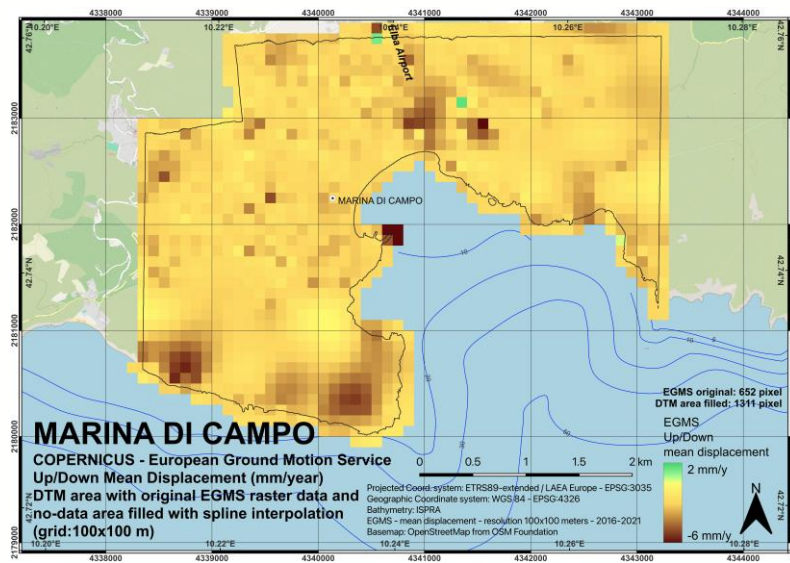
Ground Motion values from EGMS Copernicus service. Values represent minimum, mean and maximum variations measured in the time interval 2016-2021 within each of the five study areas of Piombino-Follonica, Marina di Campo, Fertilia-Alghero, Fiumicino-Ostia and Latina-Sabaudia.



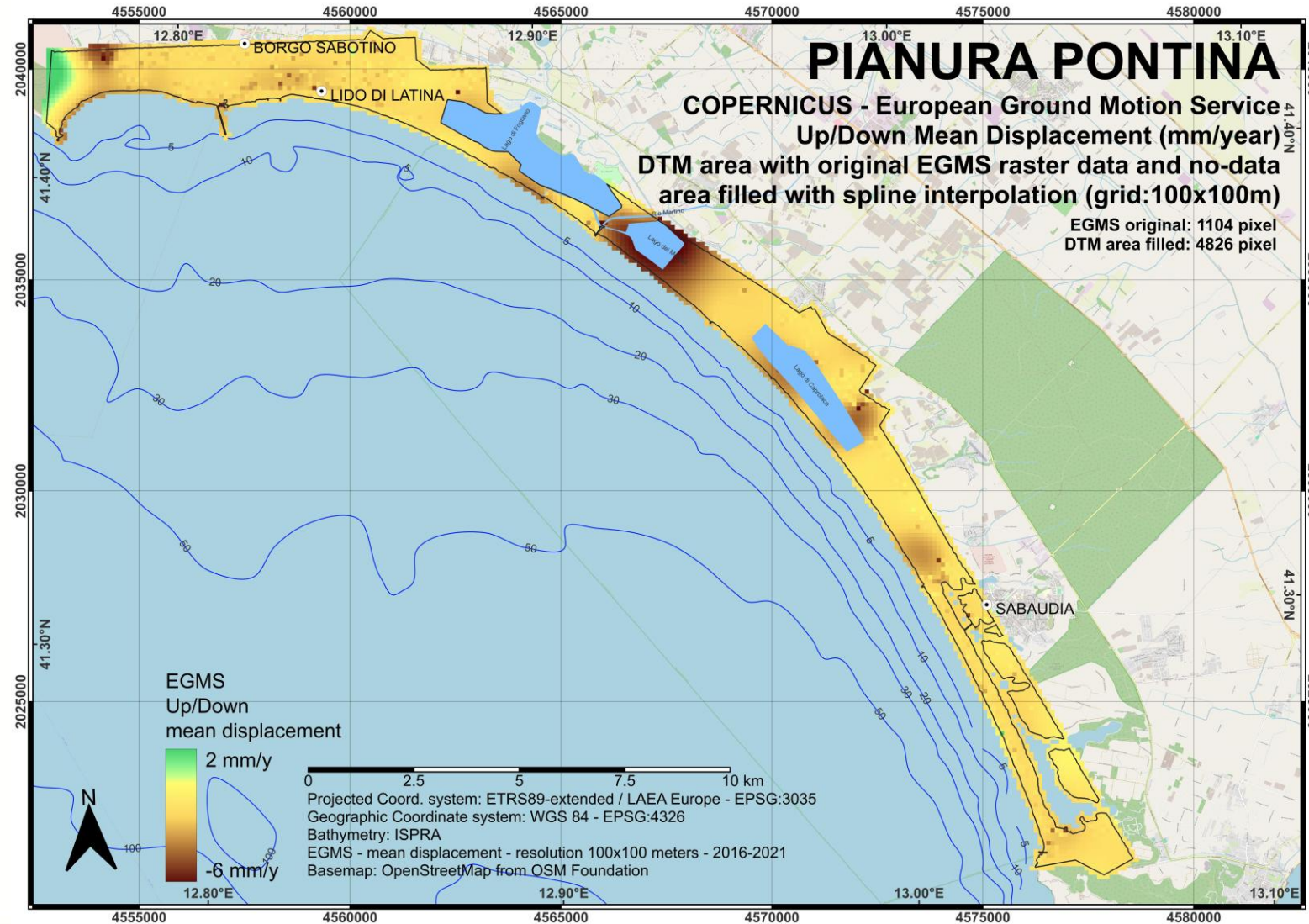
Results – inundation maps: Marina di Campo (Tuscany)

	Marina di Campo		Fertilia	
	SLR (cm)	SUSL (km ²)	SLR (cm)	SUSL (km ²)
Rahmstorf 2007*	143.2	0.39	145.2	2.29
IPCC 2013*	102.2	0.14	102.2	1.89
MED16 2022**	58.3	0.09	62.6	1.44

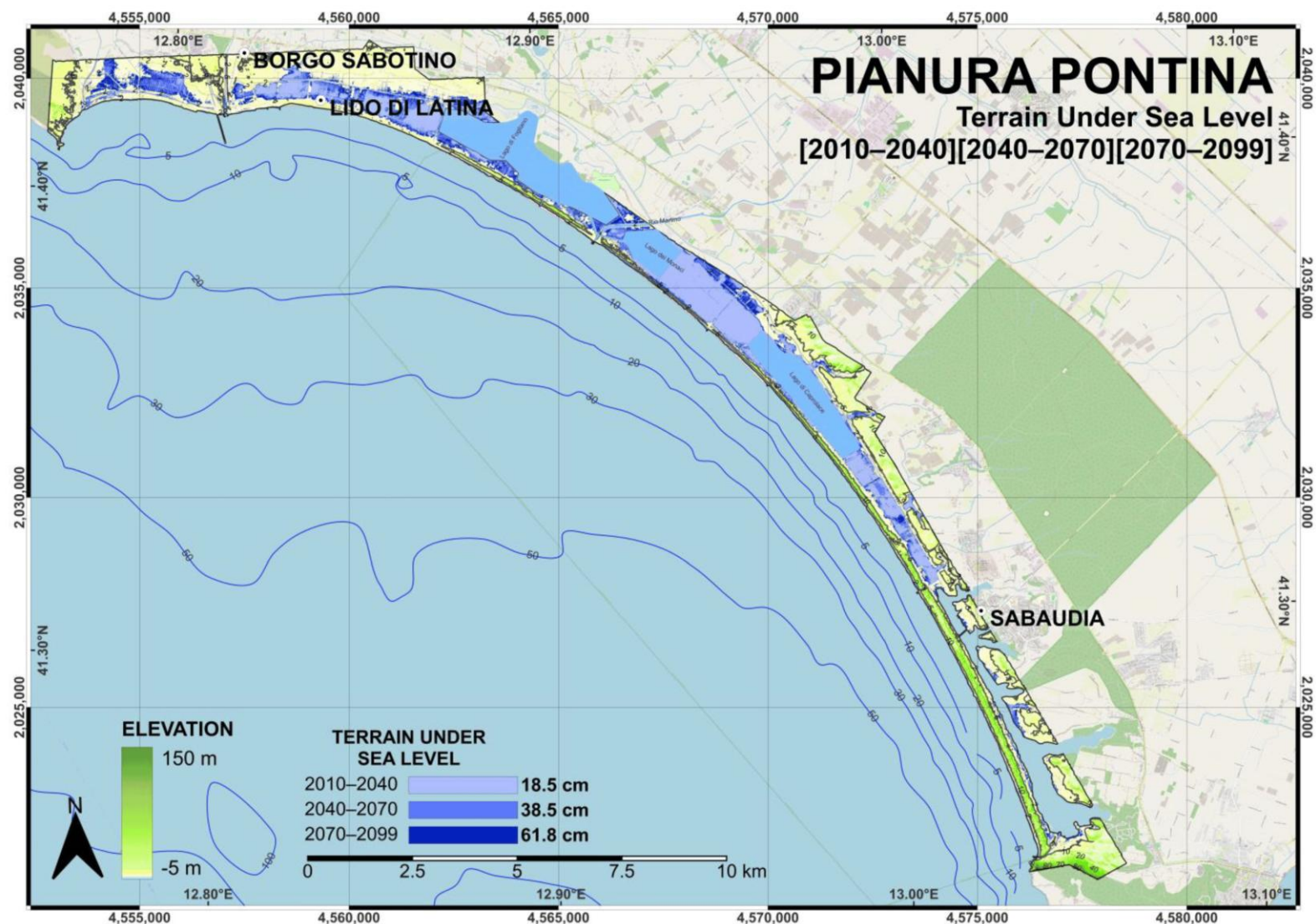
Comparison of terrain under sea level (km²) in 2100 predicted by using previous scenarios (Rahamstorf, 2007 and IPCC, 2013; Antonioli et al., 2020) and Med 16 Model of Sannino et al. (2022; Cappucci et al 2024).



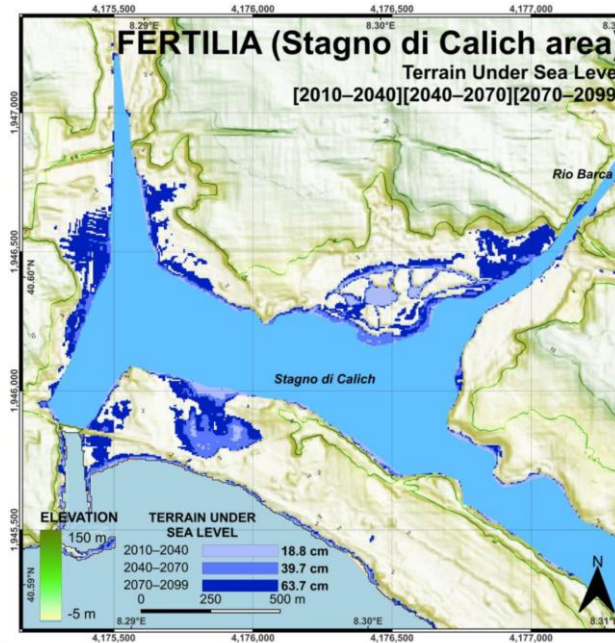
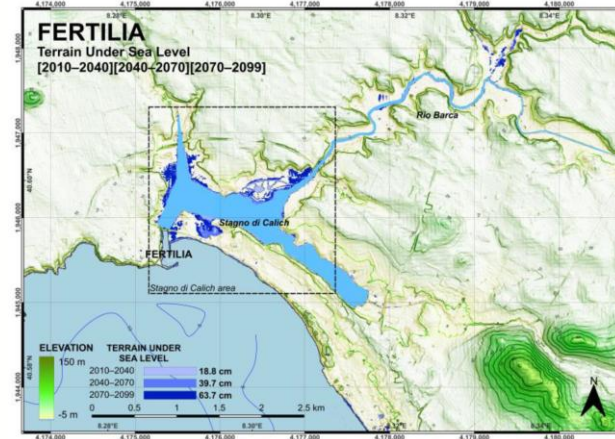
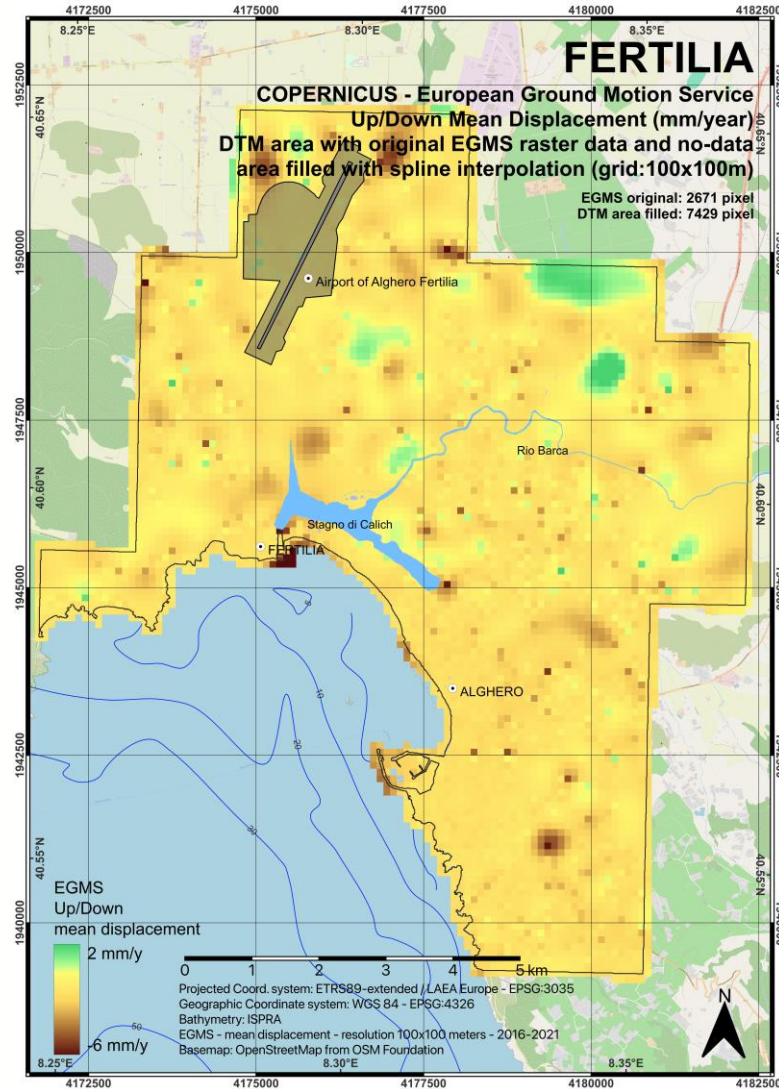
Subsidence within PNC



Results – inundation maps: Pontina plain (Latium)



Results – inundation maps: Fertilia (Sardinia)



Methodology – Input Data

CORINE Coastal Zones Land Cover/Land Use product

It provides a LC/LU dataset (pixel 100X100m) for areas along the marine coastline of the EEA39 countries. A 10 km inland buffer zone and the Corine Land Cover buffer zone seawards along the coastline define the Aol of the CZ mapping. The 2018 year product is here used (<https://land.copernicus.eu/local/coastal-zones>)

Level 1 (of 5 levels)
URBAN
CROPLAND
WOODLAND and FOREST
GRASSLAND
HEATLAND and SCRUBS
OPEN SPACES with LITTLE or NO VEGETATION
WETLAND
WATER



Copernicus Local Land Monitoring Services – EEA/DIS/R0/18/008
Production of Very High Resolution Land Cover/Land Use dataset
for Coastal Zones of the reference years 2012 and 2018

Service Contract No EEA/DIS/R0/18/008

Copernicus Land Monitoring Service – Local Component:
[Coastal Zones Monitoring](#)
Nomenclature Guideline
Date: 15/02/2021
Issue: 1.2

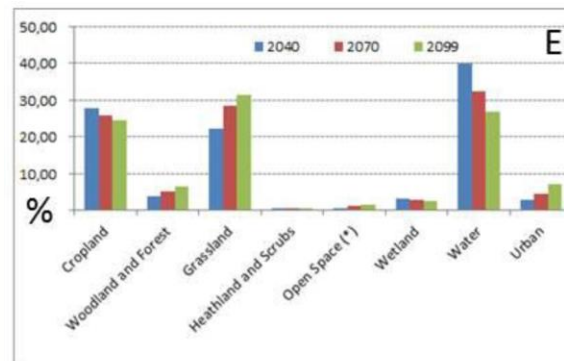
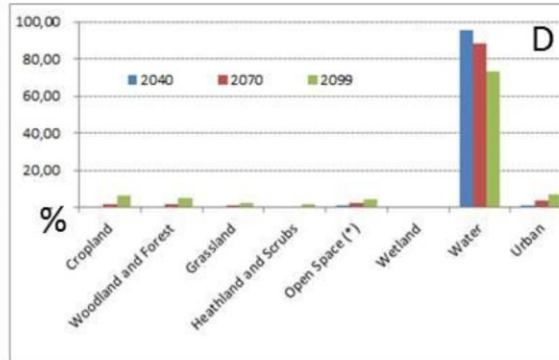
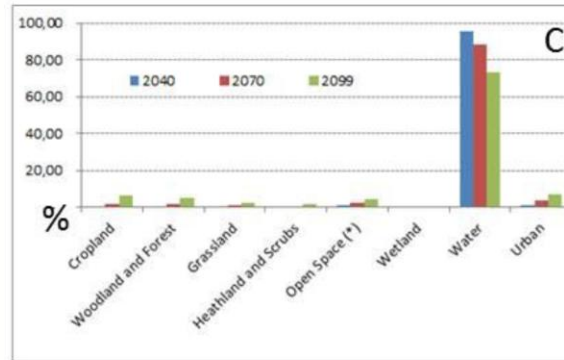
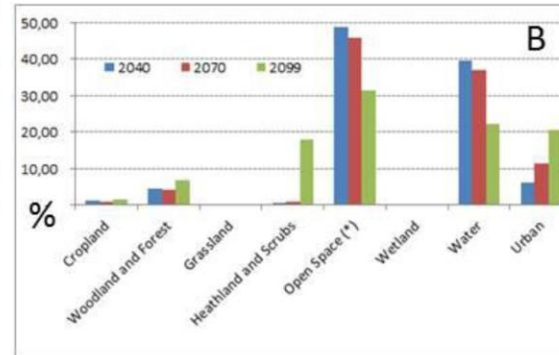
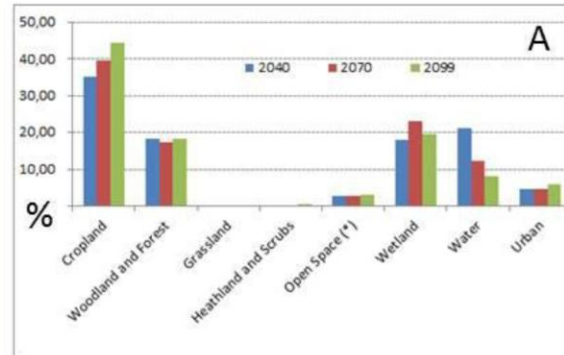
prepared by:


In cooperation with


CZ Nomenclature Guideline, Issue: 1.2 Date: 15/02/2021 Page 1

1111	continuous urban fabric (IMD>=80%)
1112	dense urban fabric (IMD>=30-80%)
1113	low density fabric (IMD<30)
1121	industrial, commercial, public and military units (other)
121	road networks and associated land
122	rail networks and associated land
1231	cargo port
1235	marinas
1236	local multi-functional harbours
1311	mineral extraction sites
132	land without current use
14	green urban, sports and leisure facilities
232	complex cultivation pattern
211	arable irrigated and non irrigated land
222	olive groves
311	natural & semi-natural broadleaved forest
321	natural & semi-natural coniferous forest
331	natural & semi-natural mixed forest
34	transitional woodland and scrub
35	lines of trees and scrubs
421	semi-natural grassland
53	sclerophyllous scrubs
6211	sandy beach
6312	coastal cliffs
711	inland marshes
721	salt marshes
812	highly modified water courses and canals

DISCUSSION



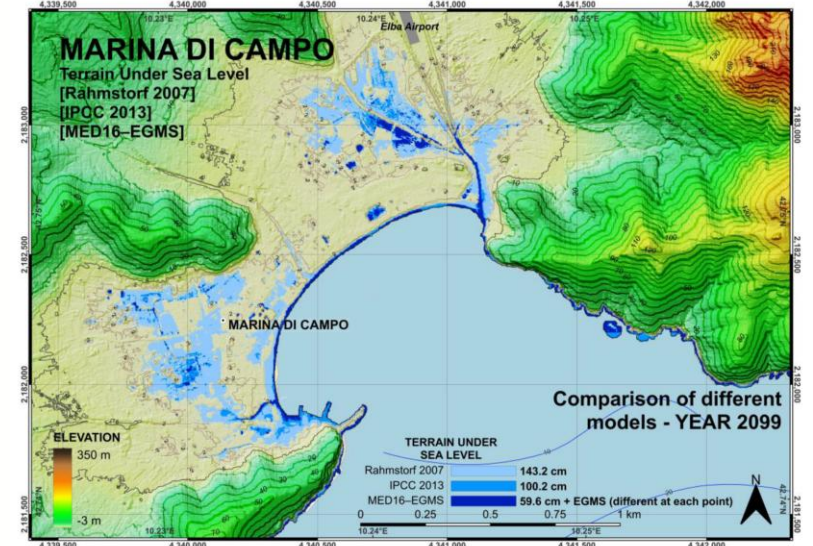
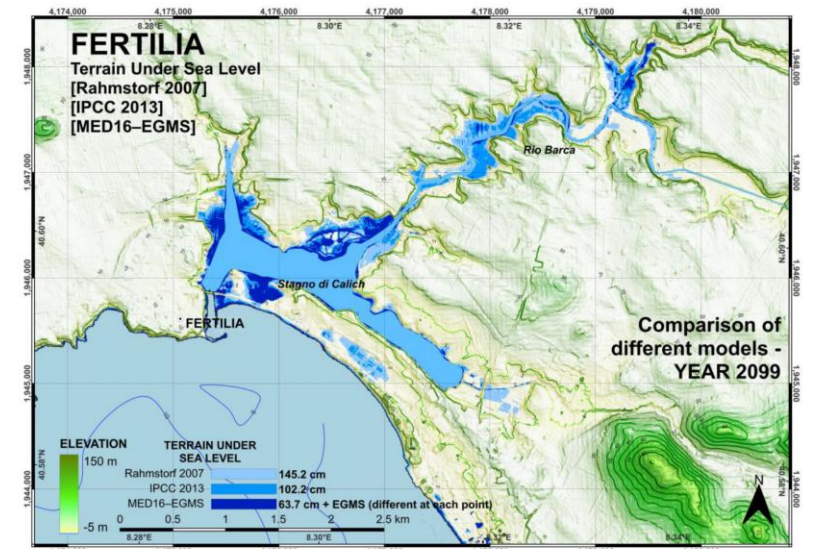
A: Piombino-Follonica

B: Marina di Campo

C: Alghero-Fertilia

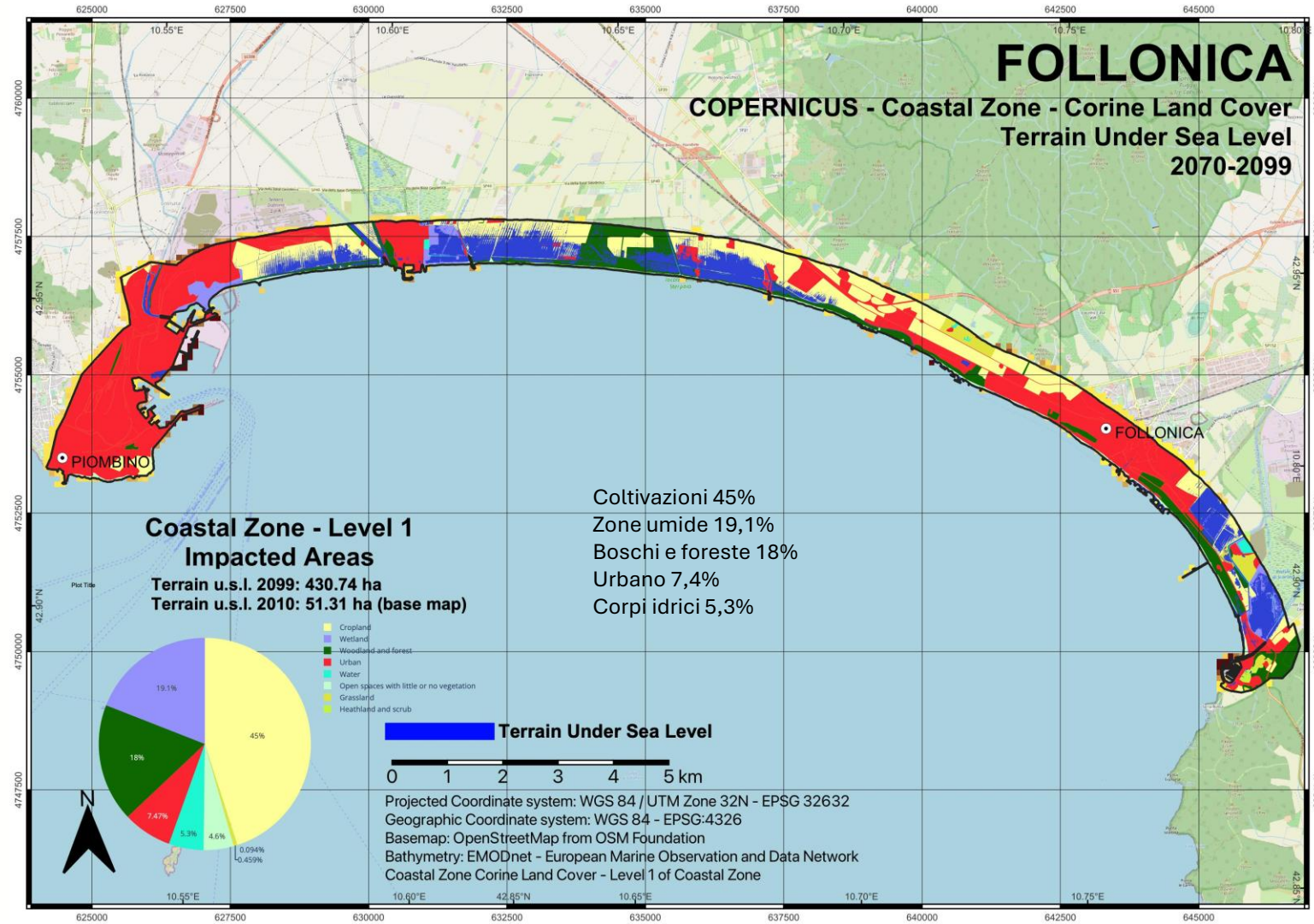
D: Rome (Fiumicino-Ostia)

E: Latina-Sabaudia



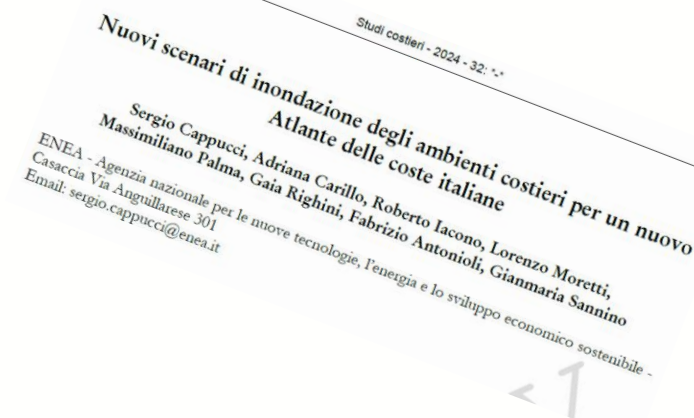
Results – inundation scenario: Follonica (Tuscany)

CZ level 1



CONCLUDING REMARKS

- The main assets exposed to the risk of flooding are:
 - (a) wetlands;
 - (b) backshore areas and
 - (c) maritime infrastructures.
- For wetlands and backshore areas, the risk of flooding is due to the low elevation of these areas with respect to the present mean sea level.
- Both the SLR and the ground motion components used in this study have limitations.
 - For the SLR, it should be noted that it is not possible to estimate the uncertainty of the projection using a single scenario simulation.
 - The main limitation concerning the ground motion component is associated with the short duration of the present EGMS dataset. This will be alleviated in the future since the dataset will be regularly updated on yearly bases.
- Future work should focus on the calibration of results based on in situ multi-source dataset and better evaluation of LU/LC.



GRAZIE

Cappucci, S.; Carillo, A.; Iacono, R.; Moretti, L.; Palma, M.; Righini, G.; Antonioli, F.; Sannino, G. *Evolution of Coastal Environments under Inundation Scenarios Using an Oceanographic Model and Remote Sensing Data*. Remote Sens. **2024**, 16, 2599. <https://doi.org/10.3390/rs16142599>

Cappucci, S.; Carillo, A.; Iacono, R.; Moretti, L.; Palma, M.; Righini, G.; Antonioli, F.; Sannino, G. *Nuovi scenari di inondazione degli ambienti costieri per un nuovo Atlante delle coste Italiane*. Studi Costieri, **2025**, 1, in press

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Crescere e imparare con CLMS



PROGRAMME OF THE
EUROPEAN UNION

