ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΑΤΡΩΝ
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Triton

Development of management tools and directives for immediate protection of biodiversity in coastal areas affected by sea erosion and establishment of appropriate environmental control systems

Development of management Tools and diRectives for immediate protection of blodiversity in coasTal areas affected by sea erOsion and establishment of appropriate eNvironmental control systems/TRITON

Numerical model of coastal erosion processes in the pilot area of the Gulf of Patras

Athanassios Dimas, Professor

Georgios Leftheriotis, PhD

Outline

1. Introduction
2. Objectives
3. Methodology
   - Division into Subregions
   - Nearshore processes in the Gulf of Patras
4. Results
   - Nearshore processes in the Gulf of Patras
   - Coastal Erosion Vulnerability Assessment
5. Conclusions

Introduction

The study area

- The Gulf of Patras is characterized by its biodiversity and the increased urban and recreational development that is expanding along its shoreline.
- The dominant coastal erosion processes in the pilot area of the southern part of the Patras Gulf, were examined.
- The coastal zone of the area is mainly affected by wind-generated waves of northeastern, northwestern, western, and southwestern direction.

Objective - Method

- Assessment of coastal vulnerability in the pilot area of the Gulf of Patras.

- Coupled numerical simulations of wave propagation, wave-generated currents, sediment transport and bed morphodynamics (MIKE 21 by Danish Hydraulic Institute -DHI).

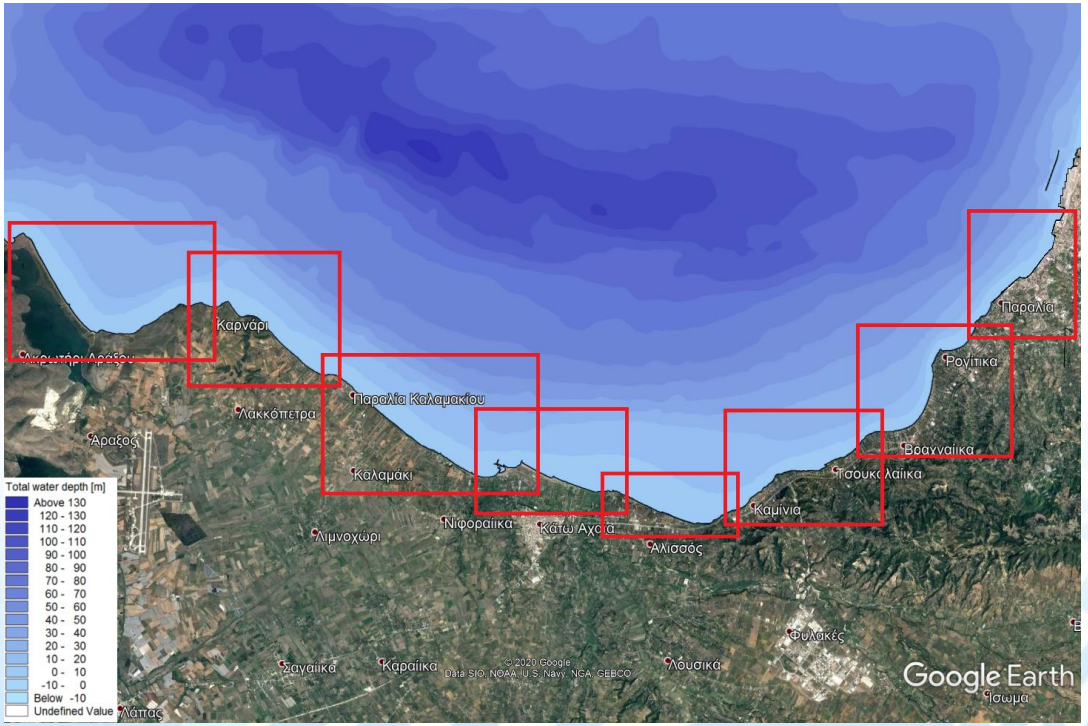
Methodology

Division into Subregions

For clarity and better understanding of the coastal processes, the pilot area was divided into 8 coastally independent subregions.

The 8 subregions of the pilot area of the Gulf of Patras from west to east, and the corresponding values of the mean sediment grain diameter, D_{50}, in the coastal zone of each subregion.

Number	Subregion	Mean Grain Diameter (mm)
1	Papas Lagoon – Karnari	0.173
2	Karnari – Ioniki Akti	0.393
3	Ioniki Akti – Alykes	0.292
4	Alykes – Gialos (Peiros estuary)	0.263
5	Gialos – Western Kaminia	0.102
6	Western Kaminia – Western Vrachneika	0.140
7	Western Vrachneika – Roitika	0.138
8	Roitika – Glafkos	0.150



Satellite image (Google Earth) of the pilot area of the Gulf of Patras showing the 8 coastal independent subregions.

Methodology

The numerical simulations include 4 stages:

1. Determination of wave generation and growth in the deep waters of the Gulf of Patras due to the dominant NE, E, SW, S and NW winds with 1 year return period in the area.
2. Numerical simulation of wave propagation and transformation in the coastal zone of the pilot region of the Gulf of Patras for the wind cases of Stage 1.
3. Numerical simulation of wave-generated currents in the coastal zone of the pilot region of the Gulf of Patras for the wind cases of Stage 1.
4. Numerical simulation of sediment transport and morphodynamics in the coastal zone of the pilot region of the Gulf of Patras for the wind cases of Stage 1.

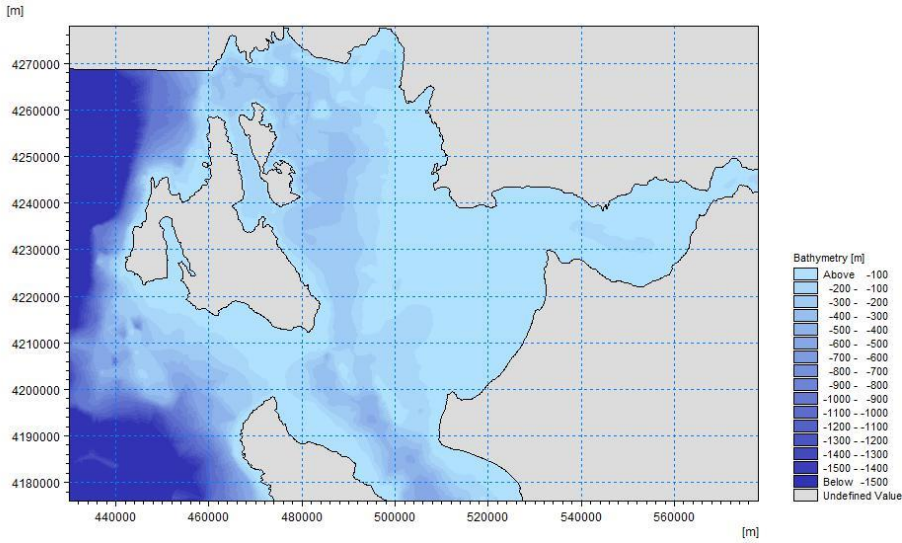
Methodology

Wave Development in the Gulf of Patras

- Wave characteristics in the deep waters were computed using wind data from the HNMS meteorological stations at Nafpaktos (1977-2011) and Araxos (1955-2011).
- The wind speed, U_{10}, of 1 year return period was calculated, per each wind direction.
- Numerical simulations of wind-induced wave generation, growth and propagation were performed in the Gulf of Patras and the Ionion Sea between the islands of Kefallonia and Zakynthos and the Gulf of Patras.

DHI MIKE 21 (2014) Spectral Waves (SW)

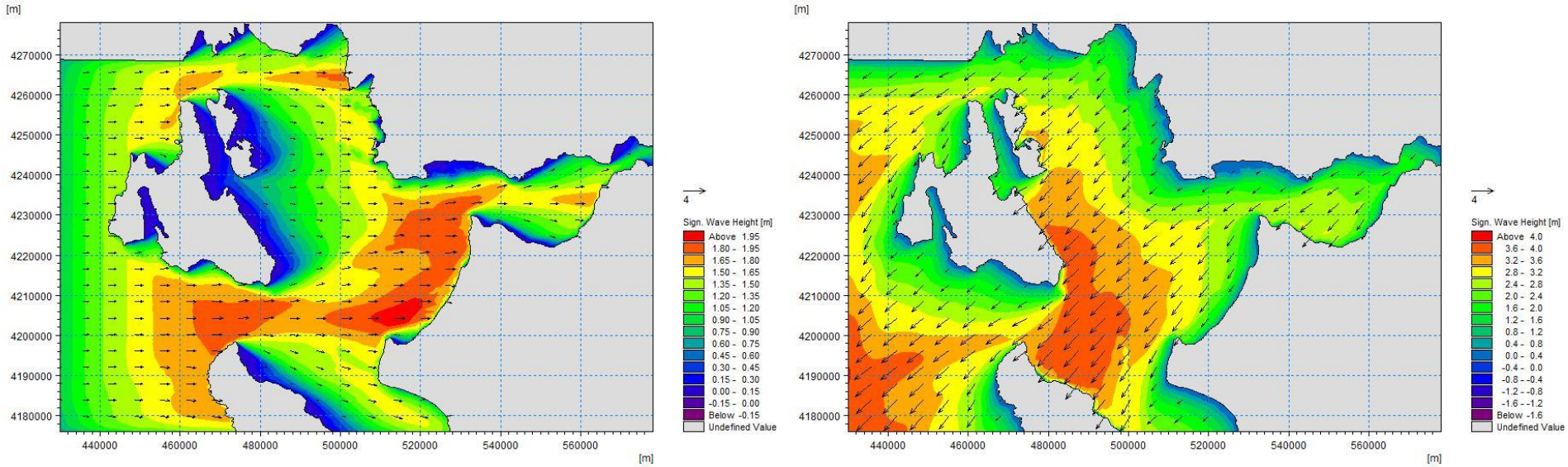
- Solves numerically the wave action equation.
- Bathymetry data from the digital database DHI C-MAP (2014), and bathymetric measurements performed in the framework of the TRITON research project.
- The computational field was discretized with 181,406 triangular cells in an unstructured computational mesh.
- The module SW was set to compute the steady state of the wave propagation.



The bathymetric computational mesh of the Ionian Sea west of the Gulf of Patras, used the numerical in simulations of wind-induced wave generation, growth and propagation.

Results

Wave Development in the Gulf of Patras



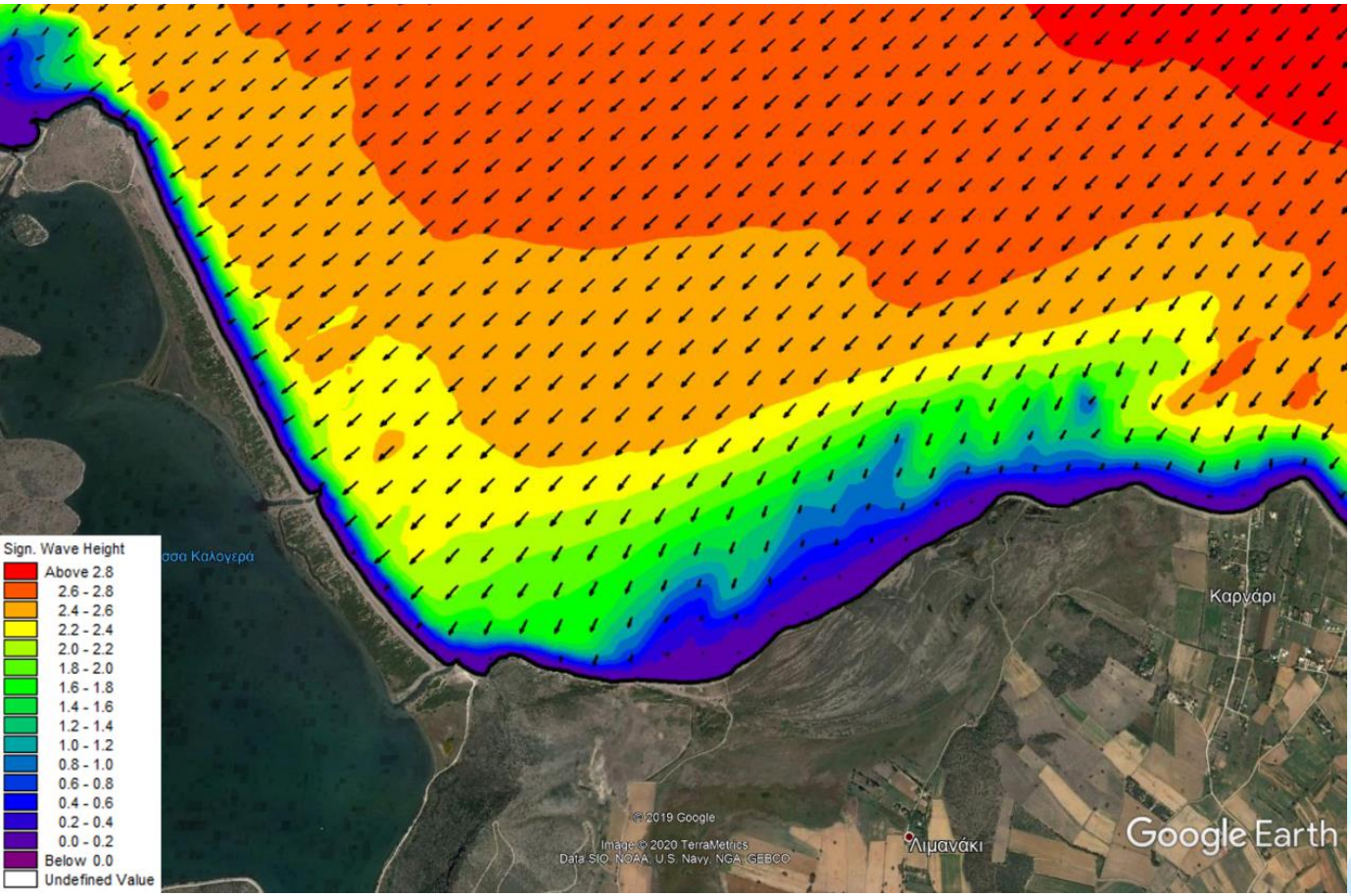
Wave height, celerity and mean direction distribution in the area of the Ionian Sea west of the Gulf of Patras due to the action of Western winds (left) and Northeastern winds (right).

HNMS Station		Nafpaktos		Araxos		
Wind Direction		NE	E	NW	W	SW
Wind Speed, U_{10}	m/s	18.9	10.3	9.3	13.0	11.6
Wind Intensity	Beaufort	8	5	5	6	6
Significant Wave Height, $H_{S\text{-}1yr}$	m	2.7	0.6	0.6	1.8	1.5
Wave Spectrum Peak Period, $T_{P\text{-}1yr}$	s	8	4.4	5	8	6.8
Wave Direction with respect to the North	°	45	60	315	270	235

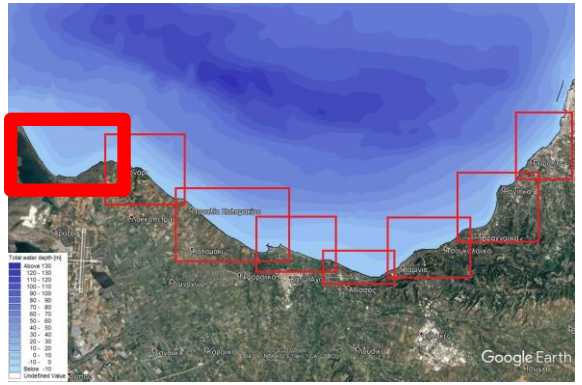
Wind and wave data with a return period of 1 year, per wind direction, in deep waters offshore of the coastal zone of the pilot area of the Gulf of Patras.

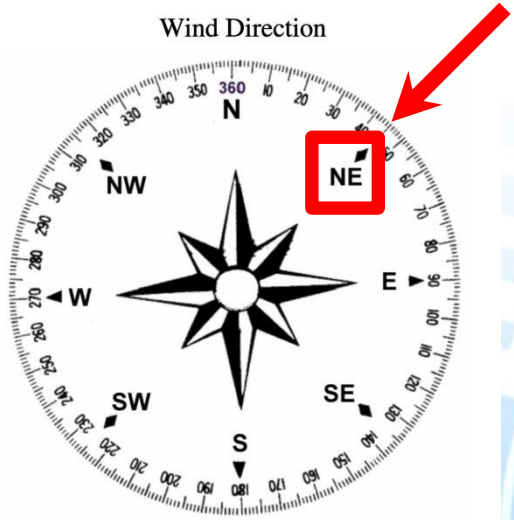
Results

Coastal Erosion Vulnerability Assessment



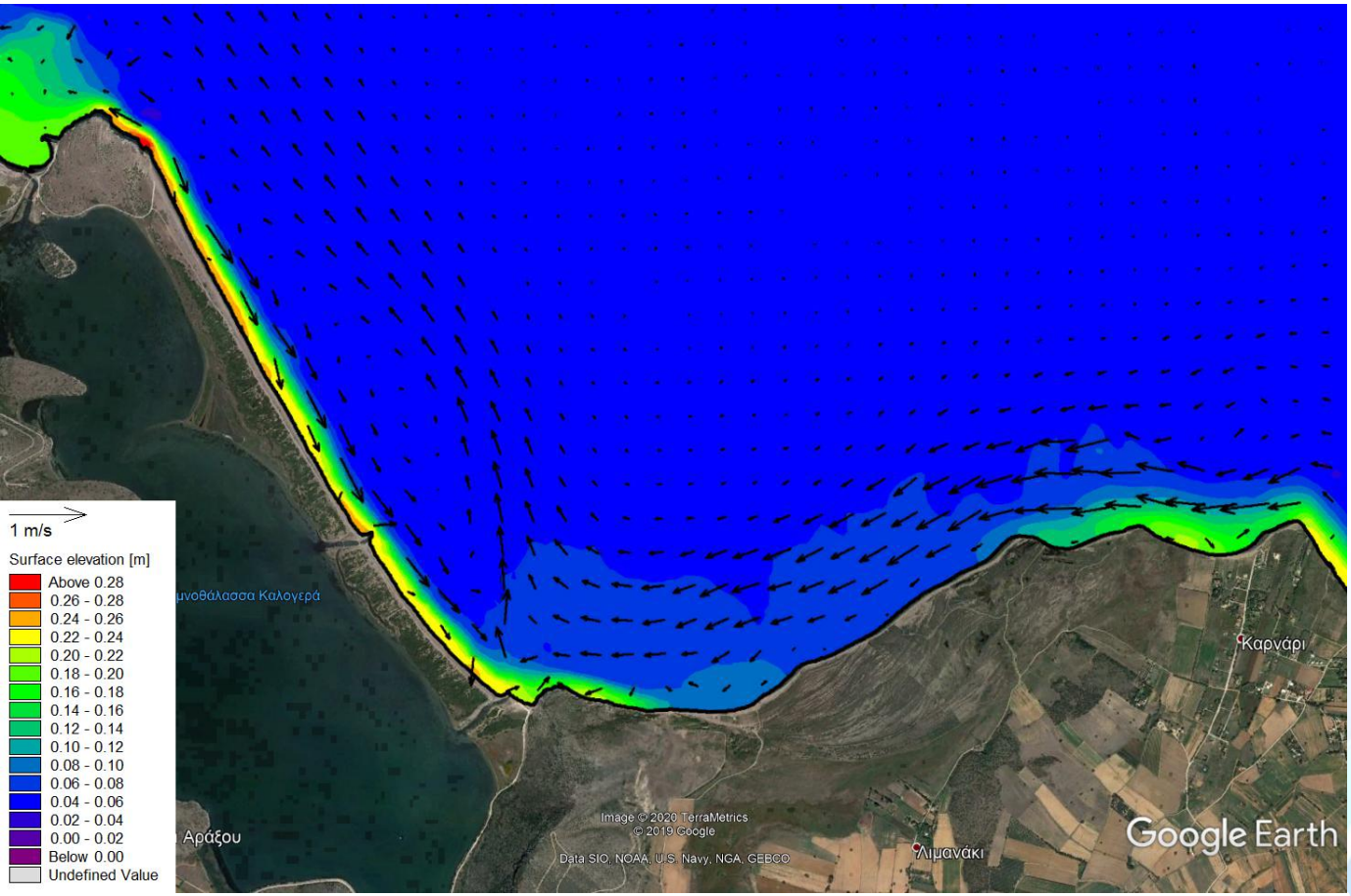
Significant wave height and celerity (vectors) distribution due to NE waves in the coastal zone of subregion 1.



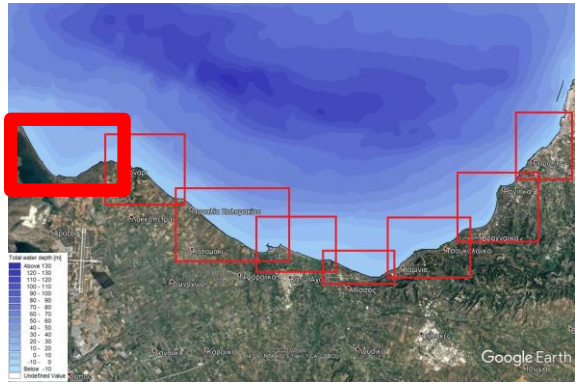


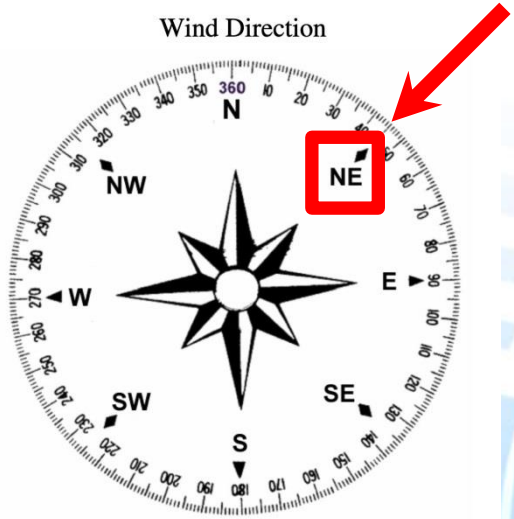
Results

Coastal Erosion Vulnerability Assessment



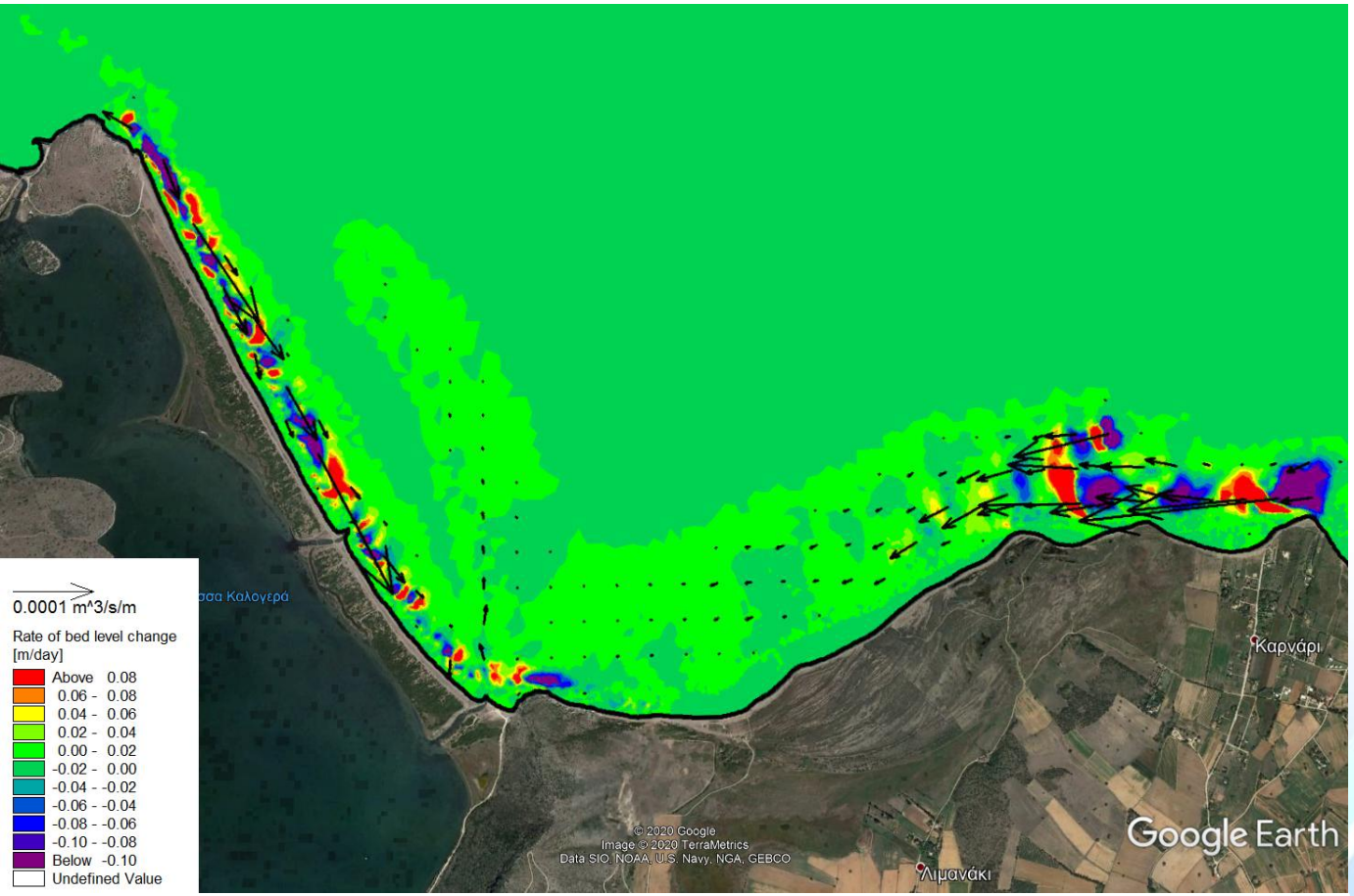
Wave-generated currents (vectors) and wave setup due to northeastern waves in the coastal zone of subregion 1.



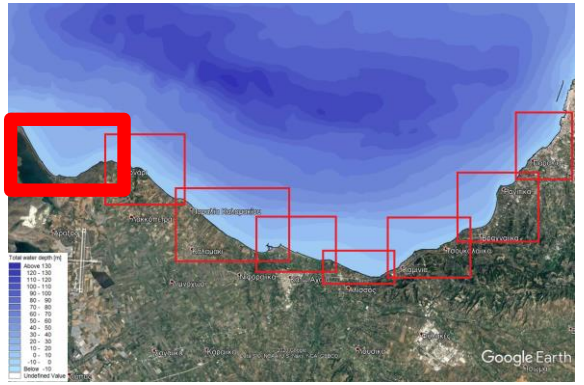


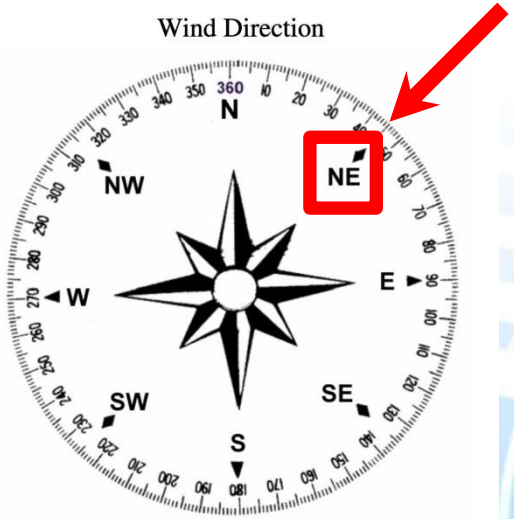
Results

Coastal Erosion Vulnerability Assessment

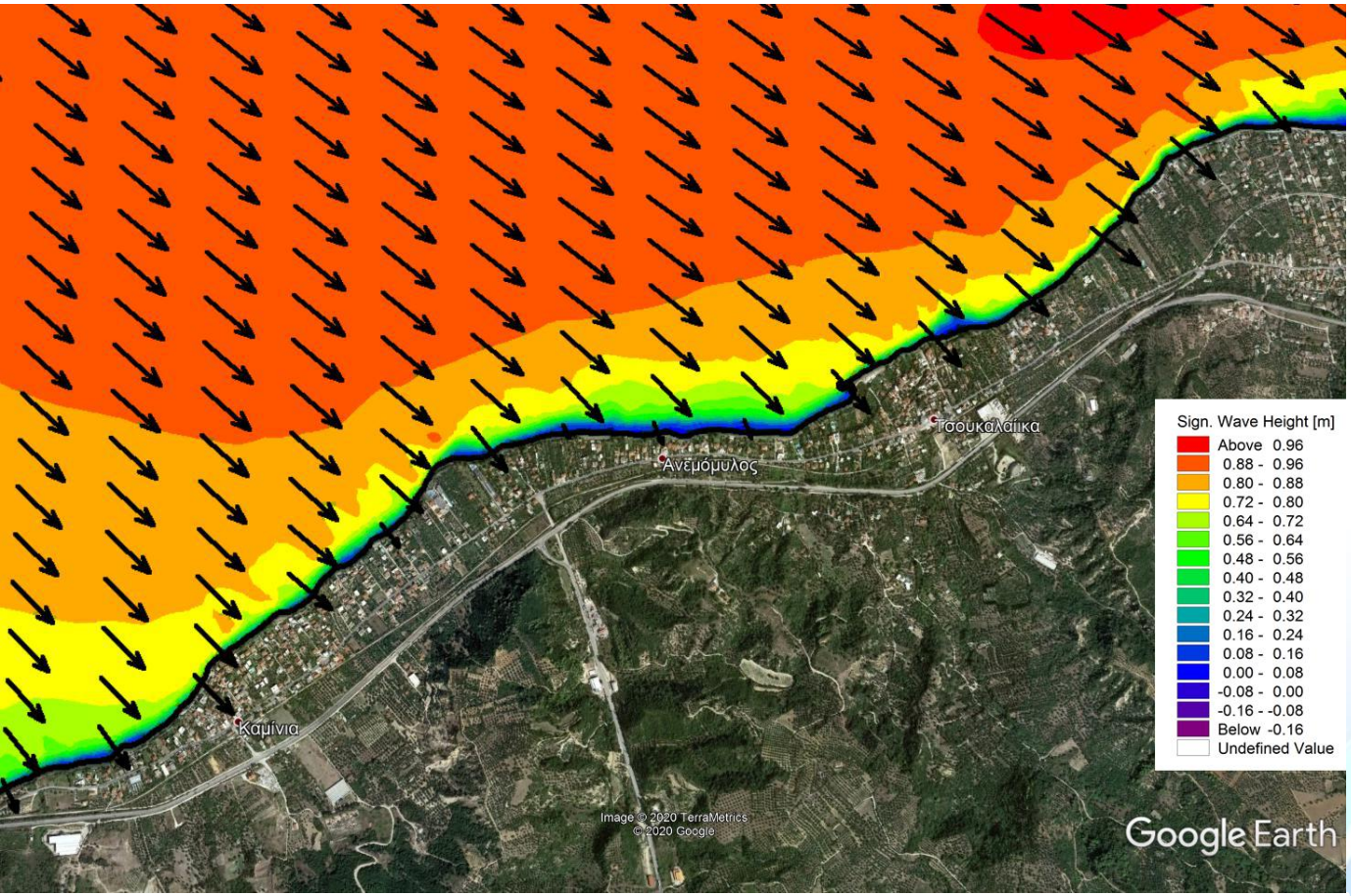


Bed level change due to northeastern waves in the coastal zone of subregion 1.

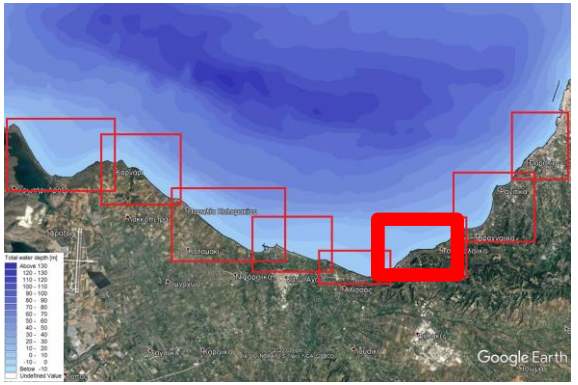


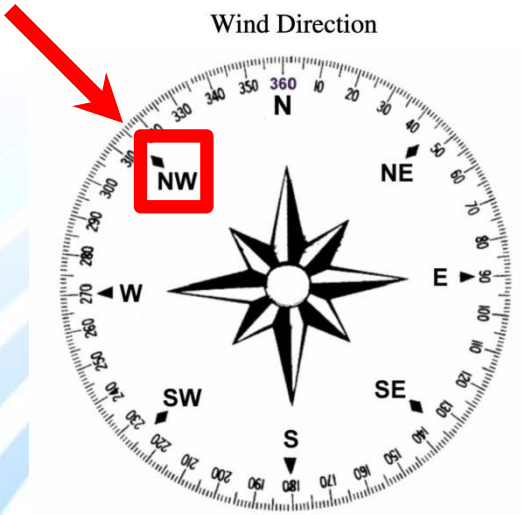


Coastal Erosion Vulnerability Assessment



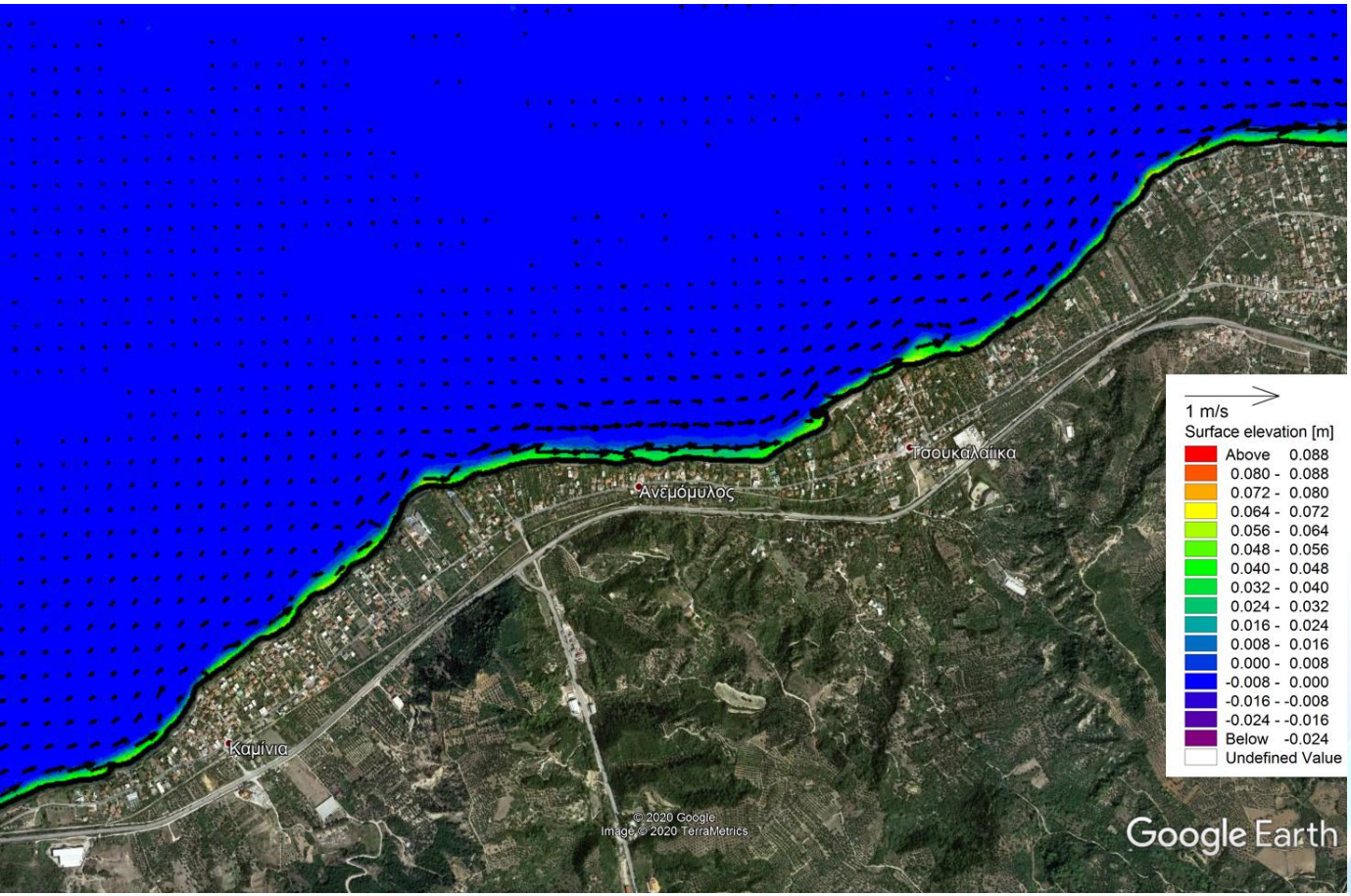
Significant wave height and celerity (vectors) distribution due to northwestern waves in the coastal zone of subregion 6.



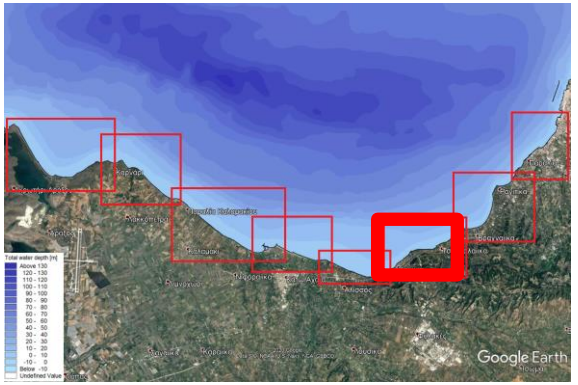


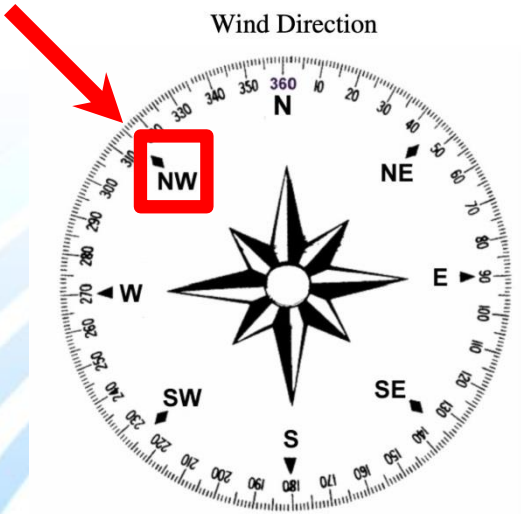
Results

Coastal Erosion Vulnerability Assessment



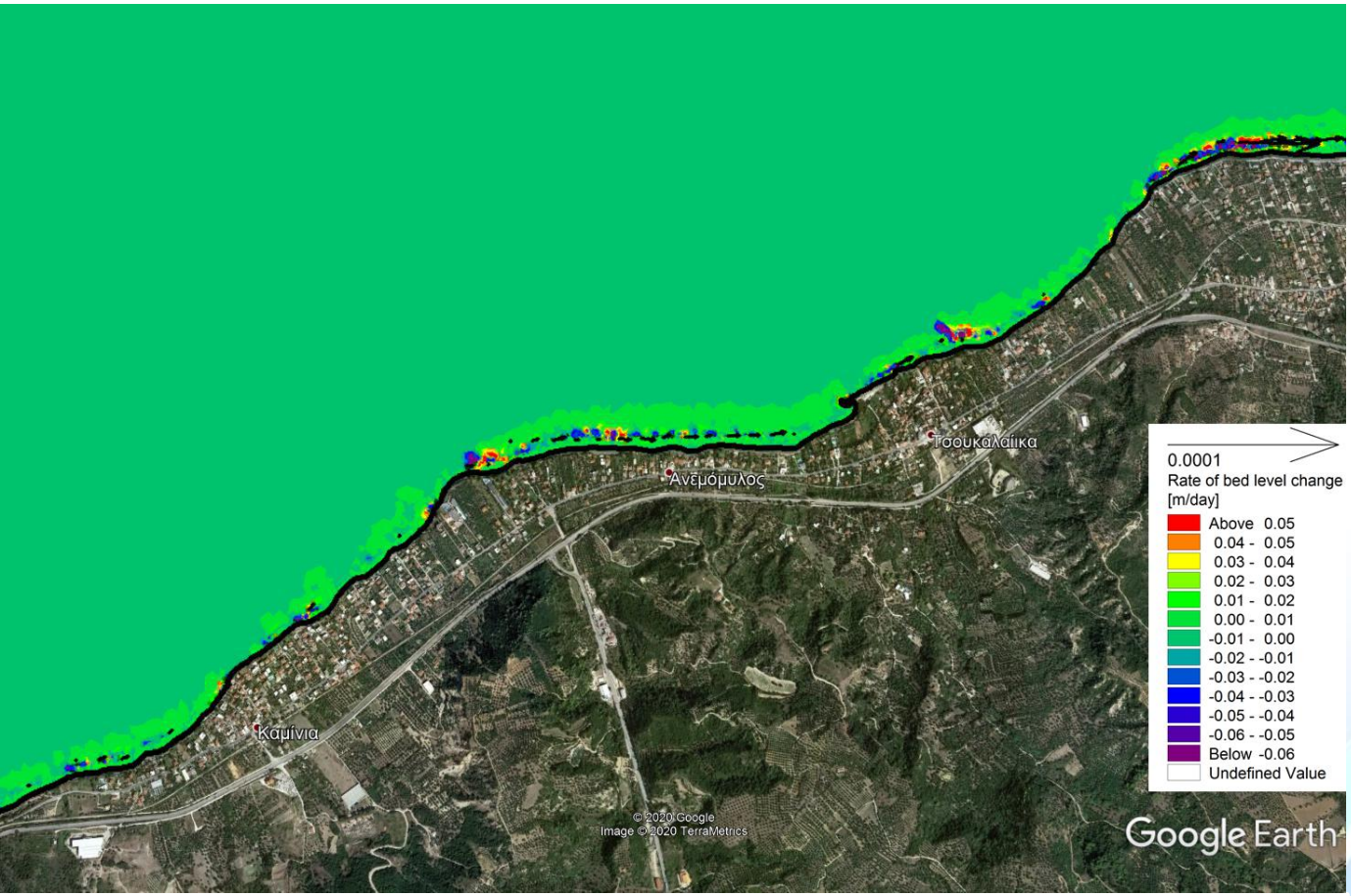
Wave-generated currents (vectors) and wave setup due to northwestern waves in the coastal zone of subregion 6.



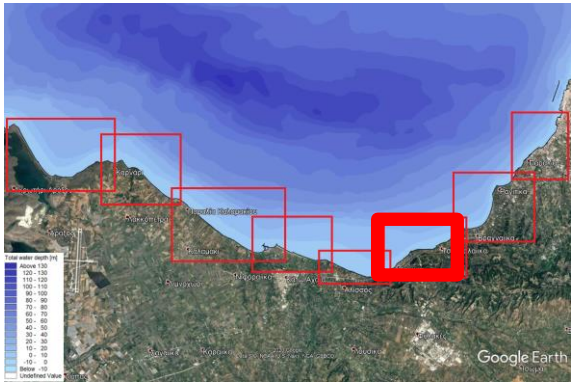


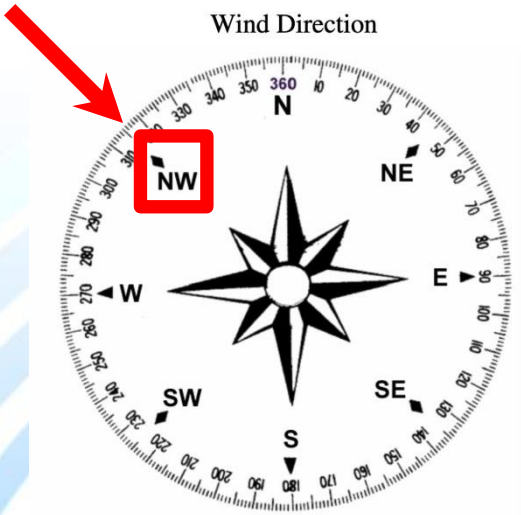
Results

Coastal Erosion Vulnerability Assessment



Bed level change due to northwestern waves in the coastal zone of subregion 6.





Conclusions

Wind-generated northeastern waves

- They have a strong impact on coastal erosion in the pilot area.
- Strong wave-generated currents are created as well as sediment transport along the coastline, which is generally directed from east to west, but locally it is reversed creating more intense erosion conditions.
- This impact applies to the entire coastal zone of the pilot area, except for the eastern part of the area, and specifically from Anemomylos to the Glafkos river estuary.

Wind-generated northwestern waves

- They have also a significant impact on coastal erosion of the pilot area.
- Quite interesting is the creation of cross-shore sediment transport conditions towards the deep waters through rip currents in the eastern part of the area, and specifically from Anemomylos to the Glafkos river estuary.

Wind-generated western and southwestern waves

- The effect of wind-generated western and southwestern waves is generally weak throughout the coastal zone of the pilot area.
- Erosion conditions occur only in the eastern part of the area, and specifically from Roitika to the Glafkos river estuary.

Conclusions

Characterization of the erosion intensity in the 8 subregions of the pilot area of the Gulf of Patras, for each wind direction, according to the numerical results of the present work.

#	Subregion	NE	NW	W	SW
1	Papas Lagoon – Karnari	High	Low	Zero	Zero
2	Karnari – Ioniki Akti	High	Low	Zero	Zero
3	Ioniki Akti – Alykes	Moderate	Low	Zero	Zero
4	Alykes – Gialos (Peiros estuary)	High	Low	Zero	Zero
5	Gialos – Western Kaminia	Moderate	Moderate	Low	Zero
6	Western Kaminia – Western Vrachneika	Moderate	High	Moderate	Zero
7	Western Vrachneika – Roitika	Low	High	High	Low
8	Roitika – Glafkos	Zero	High	High	Low