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Hellenic Foundation for Research & Innovation

Description of the funded research project

2nd Call for H.F.R.I. Research Projects to Support Post-Doctoral Researchers

Title of the research project: Methodological framework for the Assessment and monitoring of the erosion Risk of touristic Island beaches under Climate Change

Principal Investigator: Isavela Monioudi

Reader-friendly title: MARICC

Scientific Area: Environment & Energy

Institution and Country:

Host Institution: University of the Aegean

Collaborating Institution(s): GEOTHIRA M.A.E., Captain Fanourakis Foundation

Project webpage (if applicable):

Budget: 170813 €

Duration: 30 months

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Research Project Synopsis

The objectives of the proposed research project MARICC are to develop state-of-the-art approaches and frameworks for (a) the assessment of beach erosion at a regional (island) scale under Climate Variability & Change (CV&C); (b) the prioritization of the adaptation response for individual island beaches on the basis of procedures involving objective physical and socio-economic indicators and; (c) the long-term, high frequency monitoring of the beach response to coastal hydrodynamics. These will be tested in two Greek islands.

MARICC is structured in 5 work packages. The spatial characteristics (e.g. area, maximum width) and other attributes (e.g. the density of the backshore development) of the islands' beaches will be recorded from the available historical satellite imagery in a user friendly GIS data base. This information will be then used in conjunction with state–of-the-art probabilistic projections of extreme sea levels (ESLs) and the corresponding waves for different future dates and climatic scenarios which will force crossshore morphodynamic model ensembles to obtain assess beach erosion under future mean and extreme sea levels.

Long term, high frequency monitoring of beach morphology and hydrodynamics (nearshore sea levels and waves) will be undertaken in (two) vulnerable to erosion beaches, in order to (a) identify morphodynamic patterns and controls and validate the satellite imagery, and (b) provide the inputs/outputs for the training and testing of state-of-the-art neural models that will be employed to project beach evolution under the changing nearshore hydrodynamics. Such monitoring is prescribed by law according to the amended European Environmental impact Assessment Directive 2014/52/EU for all future coastal protection structures. Finally, a framework will be developed to grade the exposure/vulnerability of the beaches under CV&C, which will be tested in the two islands. Multi-criteria analysis will be employed which will utilize/test several criteria/indicators

Project originality

Extreme beach erosion and flooding are driven by the extreme waves and sea levels, i.e. the sum of the mean sea level (*MSL*), the astronomical tide (η_{tide}) and the episodic coastal water level rise (η_{CE}) due to storm surges and wave set ups. An innovation in the proposed study will be to use bivariate copula statistics to match the total water levels (and corresponding η_{CE}) with the most likely corresponding wave parameters (significant wave height (H_s), period (T) and wave direction); these waves will be then used to force the cross-shore morphodynamic models that will project beach erosion under the mean levels and ESLs in the 21st century.

In the MARICC Project, *state-of-the-art* integrated autonomous optical (video) monitoring systems (AOMSs) developed by team-members of the proposed project will be installed at the experimental beaches to provide long-term, high frequency and geo-referenced information on beach morphodynamics. AOMS image collection will be synchronised with *in situ* long-term meteorological and, particularly, wave time series from nearshore pressure/wave sensors. Image processing techniques will be tested to estimate nearshore wave directions at the wave sensor locations from the AOMS images. Moreover, the analysis of the unique datasets (in terms of sampling frequency and duration) will provide new insights in the forcing-response of beach morphodynamics, including in the case of the protected by breakwaters experimental sites.

Modeling of beach morphodynamics under changing hydrodynamic conditions presents significant challenges due to the inherent uncertainties in the forcing and the high non-linearities in the forcing -response functions. In the MARICC project *state-of-the-art* neural networks will be also used to model shoreline evolution on the basis of a few input parameters (e.g. the sea level and wave characteristics and the basal width/distance of the offshore structures).

Expected results & Research Project Impact

Expected scientific impacts are related to the proposed research tasks which will enhance our understanding of coastal processes. The development of a low-cost, autonomous optical monitoring system may results in a valuable tool for the short and medium-term monitoring of beach changes by coastal scientists/engineers and planners, both in Greece and abroad.

Moreover, MARICC project will: i) benefit the National Administration, local authorities and other stakeholders as well as the general public through the assessment of beach erosion risk under Climate Variability & Change at island scale, which will inform policies and responses and, thus, enhance the sustainable development prospects of island coastal communities; and ii) provide benefits in the field of academic education, including the urgently needed increases in the available human resources in coastal science and engineering.

Beaches constitute the primary island natural resource. Assessments of beach erosion like that proposed in MARICC will be increasingly required to provide appropriate coastal management solutions. This has been already recognised in international frameworks (e.g. the Paris Agreement, the Sendai Framework for Disaster Risk Reduction and the EU Climate Change Adaptation Strategy) and prescribed in legislation (e.g. the 2008 ICZM Protocol to the Barcelona Convention, the EU Floods Directive 2007/60/EC and the Directive 2014/52/EE). Assessments of and responses to the beach erosion risk will require a wider public accord as well as significant costs. In the Mediterranean region, for example, introduction of the urgently needed ‘set-back’ zones prescribed in the 2008 ICZM Protocol (Art. 8.2) will have significant economic and political ramifications for both island coastal communities and Contracting States, the resolution of which will require objective and science-based governance and management which should be based in approaches like those proposed by MARICC.

The importance of this funding

The proposed project will greatly benefit the career of the research team, as it will provide them with the opportunity to collaborate with experts of different scientific fields and develop further the skills needed to be competitive in the open market, by using state-of-the-art techniques for assessing coastal hydro-morphodynamic processes (deployment of oceanographic instrumentation and data analysis, image processing and software development, data mining, application of neural-networks). In addition, the team members will benefit from their active participation to the project's outputs (deliverables, scientific publications, participation in conferences and workshops).

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