Analysis of storm surge risks in a context of climate change in the North Adriatic coastal area – Preliminary results from the CLIMDAT project.

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Abstract

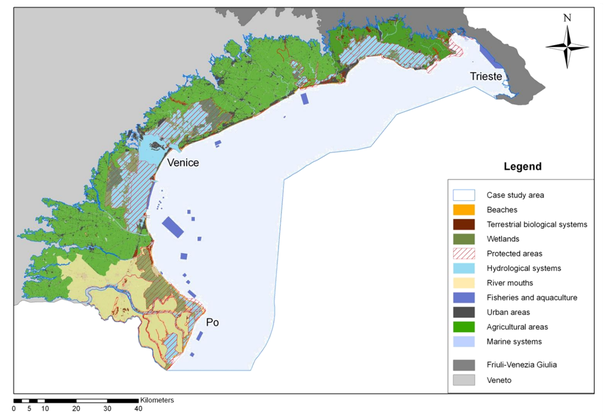
Coastal areas represent an irreplaceable and fragile ecological, economic and social resource. Being the result of a dynamic, unpredictable and interdependent set of subsystems, they are under increasing pressure leading to coastal resources depletion, conflicts between use, and natural ecosystems degradation. Recent reports of the Intergovernmental Panel on Climate Changes (IPCC) show that global warming is likely to have strong impacts on coastal communities and ecosystems. In particular, accelerated sea level rise and increased storminess are relevant consequences of global warming and are going to pose increasing threats to population, infrastructure, beaches, wetlands and ecosystems located in the exposed areas.
The main aim of this work is to improve the understanding of the risks related to extreme storm surge events in the coastal area of the North Adriatic Sea, considering potential climate change scenarios. The study is based on the use of current and historical data (i.e. meteo and mareographic time series coming from 28 tide gauge stations located in the Venice Lagoon, in the Marano and Grado Lagoon and the in the North Adriatic from the year 1989). Available data were validated and organised within a specific geodatabase, and were used as input for statistical models applied in the North Adriatic area in order to evaluate the intensity and the frequency of extreme storm surge events. All data will be used to construct climate change hazard scenarios and to apply a Regional Risk Assessment (RRA) methodology to the case study area in order to evaluate risks related to sea level rise and storm surge floodings.

Phase 1 – Analysis of tide gauge stations data

Phase 2 – Application of the Joint Probability Method

Phase 3 – Application of the Regional Risk Assessment methodology and the DSS DESYCO

The main aim of the CLIMDAT project is the analysis of the impacts of storm surge extreme events in the coastal areas of the North Adriatic Sea based on the analysis of historical time series.



The North Adriatic Sea (Italy) case study.

Phase 1 – Analysis of tide gauge stations data

Data collection

Within the first step of the project, available data coming from tide gauge stations have been collected, validated and organized within a geodatabase. More specifically historical series coming from 28 tide gauge stations located in the Venice Lagoon, in the Marano and Grado Lagoon and the in the North Adriatic (including Ancona, Ravenna and Trieste) from the year 1989 have been analyzed. The amount of data made available for this project amount roughly to 700 years, with an average of 25 years for each station.

Quality checks

To ensure high quality information, raw data have been submitted to a series of quality checks, both using numerical filters within the same time series and comparing data collected in nearby stations. Doubtful data or low quality series have been dismissed. Moreover, harmonic constants have been calculated from checked data to obtain the astronomical tide (Figure 1), useful for extra quality checks (time check). When a series pass all validation steps is released.

Moreover, the analysis of harmonic constants series allows to monitor changes in the water levels related to the interaction Earth-Sun-Moon. Significant changes in the harmonic constants series can be related to changes in hydraulic assets of an area (Figure 2).

Among the 28 station for which new time series has been prepared, 14 representative stations (10 within the Lagoon of Venice and 4 in the Adriatic sea) have been selected in order to apply the Joint Probability Method (Phase 2).

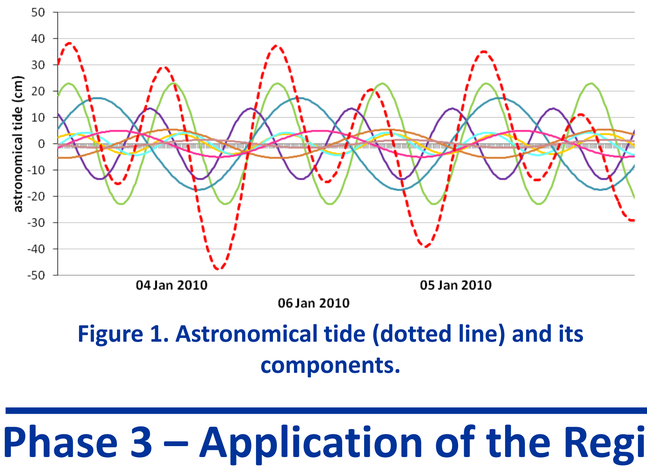


Figure 1. Astronomical tide (dotted line) and its components.

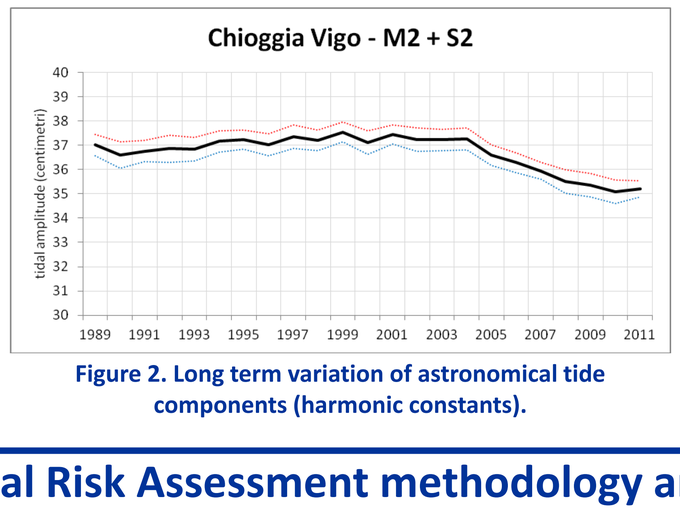


Figure 2. Long term variation of astronomical tide components (harmonic constants).

Phase 2 – Application of the Joint Probability Method

The Joint Probability Method (JPM, by Pugh-Vassie, 1979) is aimed at forecasting the return period and estimating the frequency of extreme events. It is a method where the separate action of tide and surges is considered. Astronomical tides and surges will be tabulated to produce normalized frequency distributions in bands with a tabulating interval of 5 cm and the frequency distributions of the observations will be assumed to be representative of the probability of future events. Briefly, the probability for the sea level to reach the value M is the joint probability (hence, a product) for the surge to be M and the tide to be zero, plus the probability for the surge to be M-1 and the tide to be unitary. Obviously, also surge being M+1 and tide being -1 will be considered, and so on.

The calculations will be based on the hourly measurements. This choice is important because the focus of the present study is the North Adriatic Sea, where the separation of different surges is made almost impossible by seiches (Tomasin-Pirazzoli, 1999), the free oscillations of the basin after a storm, very persistent due to the shape of the local morphology.

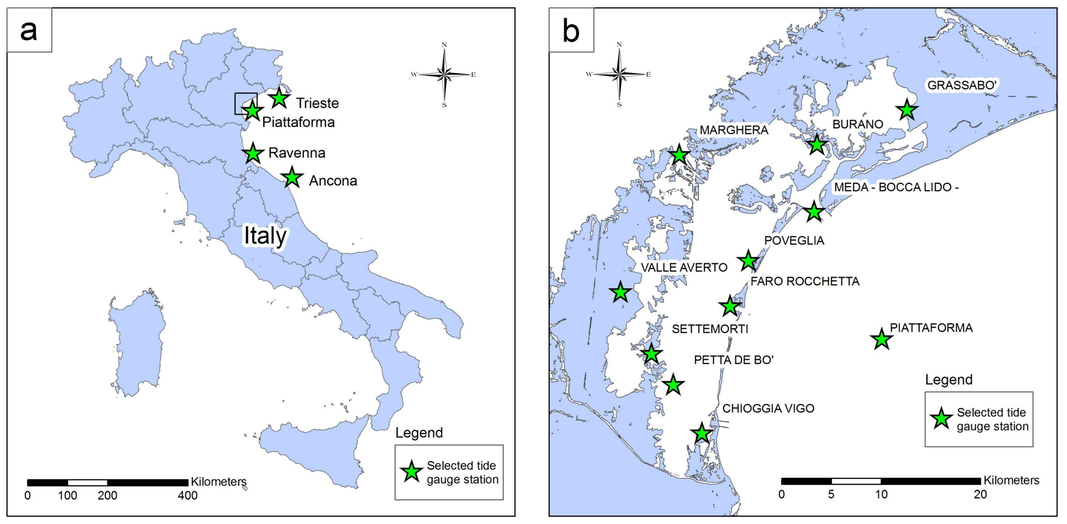
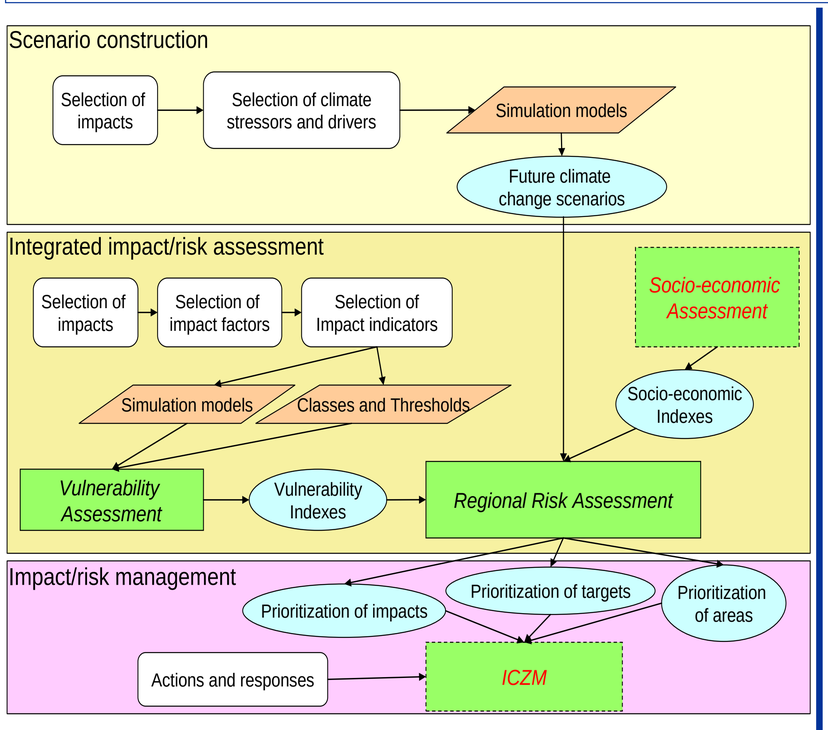


Figure 3. The 14 stations selected for the application of the JPM .

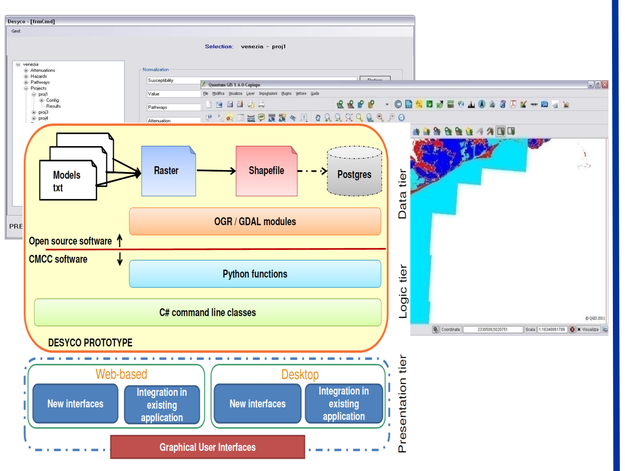
Phase 3 – Application of the Regional Risk Assessment methodology and the DSS DESYCO

DESYCO (DEcision support SYstem for COastal climate change impact assessment) is a GIS-based tool for the assessment and management of climate change impacts in coastal areas and related environments at the regional scale. It adopts an ecosystem approach and implements a Regional Risk Assessment (RRA) methodology, based on Multi-Criteria Decision Analysis (MCDA), in order to identify and prioritize areas and targets at risk in the considered region. The RRA methodology integrates climate change hazards analysis, based on the elaboration of output from climate, hydrodynamic, hydrological, hydrogeological and biogeochemical models, with vulnerability analysis of environmental and socio-economic features of the territory. DESYCO and the RRA result in exposure maps, representing the exposure to climatic changes against which a system operates, and vulnerability maps, representing the spatial distribution of environmental and socio-economic vulnerability factors. These outputs allow the prioritization of intervention options through the visualization of impacted areas and vulnerable receptors.



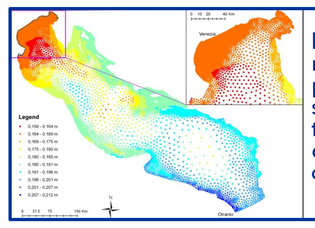
RRA conceptual framework for the analysis of climate change impacts on coastal zone at the regional scale.

DESYCO is a software that implements the RRA methodology in order to identify, prioritize and visualize areas and targets at risk from climate change impacts on coastal areas at the regional scale.

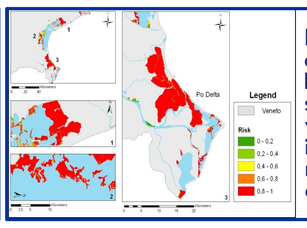


DESYCO is a useful tool to bridge the gap between climate information and stakeholder needs providing tailored climate services in the field of climate impact, vulnerability and adaptation assessment for a wild range of stakeholders.

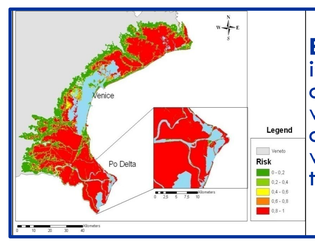
RRA output



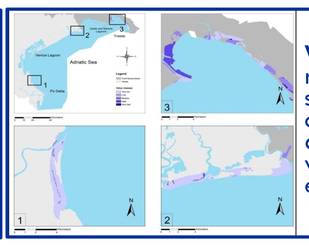
Hazard map: represents potentially significant hazards that could determine climate change impacts.



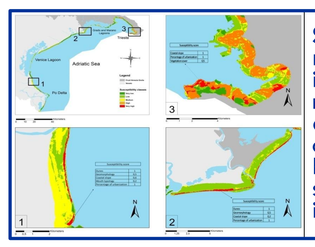
Risk maps: combination of hazard and susceptibility maps which enable the identification and ranking of areas and targets at risk.



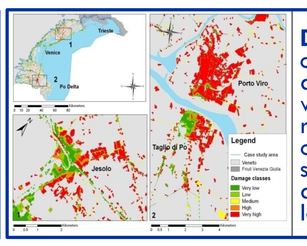
Exposure map: identifies and classifies the areas where the hazard can be in contact with the. potential targets.



Value map: represent the spatial distribution of environmental and socio-economic value associated to each receptor.



Susceptibility map: identify areas more susceptible to different climate change impacts based on site-specific information.



Damage map: combination of risk and value maps which provide a relative estimation of the potential social, economic and environmental losses.

Conclusion

- The methodology is flexible and can be applied at different spatial scales (i.e. from the local to the national and supra-national scales) and for the analysis of multiple climate change impacts on several natural and human receptors (ecosystem perspective).
- The provided classifications are not absolute predictions about the impacts of climate change. They are relative indices which provide information about the areas/targets within a region likely to be affected more severely than others.
- The RRA maps and the related indicators can be considered as a first-pass assessment for the spatial identification of areas and targets at higher risk at the regional (i.e. sub-national) scale and for the prioritization of management options.

References

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