"**CCSEWAVS**: Estimating the effects of **C**limate **C**hange on **SE**a level and **WA**ve climate of the Greek seas, coastal **V**ulnerability and **S**afety of coastal and marine structures"

1. Objectives
2. Work Packages-Deliverables
3. Research Teams
4. Meetings-Workshops
5. Other Studies and Projects

1. OBJECTIVES

1) To estimate the future climate over the Aegean Sea.

Three different Regional Climate Models (RCMs), KNMI-RACMO2, MPI-M-REMO and RegCM are used, forced by the A1B SRES emission scenario, for the time period until the end of the 21st century.

The simulated air temperature, wind, precipitation and sea level pressure, resulting from the three models for the time span 1961-1990, are first compared and evaluated with observations.

New data archives for air temperature, wind, atmospheric pressure are developed for a period up to 2100.

Special attention is given to the development of a new data archive for the wind (speed and direction) with a spatial analysis of 10x10km for the Aegean Sea (1961-2100) based on the downscaling of the original model RegCM.

1. OBJECTIVES

2) To assess climate change effects on the marine climate of the Aegean Sea.

Estimation of mean sea level rise, as well as changes in waves and storm surges up to 2100.

Sea level change is assessed from the state-of-the-art results of all available climate IPCC models, which provide information on the steric and dynamic effects, and mass changes due to ice melting based on published information.

Waves are computed by means of the SWAN wave model for the time period 1961-2100. The model is calibrated with available in situ measurements and satellite data.

A two-dimensional model of hydrodynamic ocean circulation is used to simulate storm surges for the time period 1961-2100.

Both models use input data from the three RCMs.

1. OBJECTIVES

3) To quantify climate change effects on the severity and frequency of extreme meteorological and marine events.

Extreme temperature and winds and characteristics of deep depressions over the Aegean Sea are analysed, utilizing both parametric and non-parametric techniques.

Extreme waves and storm surges in the Aegean are then processed using extreme value methods for both time periods 1961-2000 and 2000-2100, including estimation of trends, fitting of appropriate distributions, estimating return levels associated with selected return periods and quantifying prediction uncertainty.

1. OBJECTIVES

4) To estimate Vulnerability Indexes, caused by the extreme marine climate in Greek coastal areas prone to flooding and erosion.

Flood and Erosion Vulnerability Indexes (FVI and EVI) are calculated respectively, by means of the quantified flood and erosion potentials of the study sites.

Flood potential is estimated through the maximum water level associated to each storm including meteorological effects (storm surge) and wave induced run-up.

Erosion potential of the storms is assessed through the magnitude of the induced profile changes, combining a beach profile evolution model with beach profile predictors.

1. OBJECTIVES

5) To analyze possible climate change effects on the design and functioning of marine and coastal structures in Greek coastal regions.

Methodologies and good practices to evaluate the response of structures to wave climate change and mean sea level variability. Within this framework, the vulnerability of such structures is also assessed and adaptation measures of such structures to future climate conditions are proposed.

WP1: Climatic predictions with Regional Climate Models for the Greek seas

Research Teams: GEO_AUTh, MARINE_AEGEAN

Work Tasks: 7

Duration: 01/01/2012-30/09/2013 (21 months)

Person Months: 56.5

Deliverables: 5

Three of the most updated Regional Climate Models (RCMs) will be analysed and future climate changes in eastern Mediterranean and particularly in the Aegean Sea will be assessed.

WP1: Climatic predictions with Regional Climate Models for the Greek seas

WT1.1 - GEO_AUTh:
Simulated data for wind, pressure and air temperature (from ENSEMBLES (2004-2009) data archive) will initially be compared and evaluated with observations for the time period 1961-1990. The simulated data will be derived from three Regional Climate Models KNMI-RACMO2, MPI-M-REMO and RegCM, for which future projections are available until the end of the 21st century.
Future projections are forced by the A1B SRES scenario (Jacob et al. 2007).

WT1.2 - GEO_AUTh:
A data archive of several meteorological parameters (air temperature, wind, precipitation), as well as atmospheric circulation parameters (sea level pressure) will be developed for the three above mentioned RCMs for the Aegean Sea and the eastern Mediterranean region for the control run period (1961-1990). The aforementioned models will be validated for the first time for their ability in the development of future projections for the specific domain of study.

WP1: Climatic predictions with Regional Climate Models for the Greek seas

WT1.3 - GEO_AUTh:
A data archive for temperature, wind and atmospheric pressure of the models future projections forced by the A1B SRES emission scenario will be developed for the time period until the end of the 21st century.

WT1.4 - GEO_AUTh:
A new data archive for the wind (speed and direction) with a spatial analysis of 10x10km for the Aegean Sea (1961-2100) based on the downscaling of the original model RegCM (its primary analysis is 25x25km), will be created.

WP1: Climatic predictions with Regional Climate Models for the Greek seas

WT1.5 - GEO_AUTh:

Future changes of the mean climate conditions and extreme events until the end of the 21st century will be examined and analysed. The relationship of the atmospheric circulation (using an up-to-date automatic classification scheme) with the examined climatological parameters will be analyzed as well as the stability of this relationship until the end of the 21st century under different climate conditions due to the anthropogenic emissions.

WT1.6 - MARINE_AEGEAN:

Determination of the variability of mean sea level height in the Greek Seas during the reference period (1961-2000), as well as the assessment of projected mean sea level rise in the Greek coastal areas from updated climate model results following the IPCC emission scenarios.

WP1-DELIVERABLES

1.1. Technical Report - GEO_AUTh **DUE DATE:30/06/2012**

Assessment of the capabilities of the Regional Climate Models for the simulation of the general atmospheric circulation, as well as the simulation of local meteorological parameters. (*WT 1.1*)

1.2. New data archive - **GEO_AUTh** **DUE DATE: 30/06/2013**

Several meteorological parameters (precipitation, temperature, wind) and atmospheric circulation parameters (sea level pressure) from the three models, at a spatial scale of 25x25km for the eastern Mediterranean region covering the time period from 1961 until 2100. (*WTs 1.2 and 1.3*).

1.3. New data archive - **GEO_AUTh** **DUE DATE: 30/06/2013**

Wind (speed and direction) with a spatial analysis of 10x10km for the Aegean Sea (1961-2100) based on the downscaling of the original model RegCM. (*WT 1.4*).

1.4. Technical Report. - **GEO_AUTh** **DUE DATE: 30/09/2013**

Estimations of the future changes of the mean and extreme values of the selected meteorological parameters until the end of the 21st century. (*WT 1.5*)

1.5. Technical Report - MARINE_AEGEAN **DUE DATE: 30/06/2013**

Model estimates of mean sea level for the period 1961-2100 and comparison with satellite altimetry data. (*WT 1.6*).

WP2- Simulation of wave height, storm surge and sea level accounting for climate change.

Research Teams: NAVAL_NTUA, HYDRO_AUTh, GEO_AUTh

Work Tasks: 4

Duration: 01/01/2012-30/06/14 (30 months)

Person Months: 76.5

Deliverables: 3

The effects of climate change on waves, storm surges and mean sea level will be studied.

The SWAN wave model and a two-dimensional model of hydrodynamic ocean circulation will be adapted, calibrated and applied, using input data from RCMs of WP1.
The relationships between the circulation types and the storm surges over the Aegean Sea will also be examined.

WP2- Simulation of wave height, storm surge and sea level accounting for climate change

WT 2.1 - NAVAL_NTUA:

The wave prediction system for the Greek Seas will be based on the SWAN wave model (Ris et al. 1999, Booij et al. 1999) and will utilise the wind field data (wind velocity and direction at 10m over the sea level), available through the data base provided by the three aforementioned climatic models. Climatic simulations and predictions will be produced for the periods 1961-2000 and 2000-2100.

WT 2.2 - HYDRO_AUTh:

A high resolution storm surge model (Vries et al. 1995) will be formulated for the Greek seas at large. The model validation and calibration will be performed using historic Sea Level Height data from several insitu stations, located along the Greek coasts (hindcast simulations). Moreover, the validated model will perform different forecast scenarios covering a period of 100 years.

WP2- Simulation of wave height, storm surge and sea level accounting for climate change.

WT 2.3 -HYDRO_AUTh, GEO_AUTh:

The impact of the meteorological data obtained by the three climatic models to the calculation of waves, storm surges and sea level will be investigated. Correlation analysis of the meteo-results from RCMs with time series of in situ measurements and of computation results will also be conducted (storm track analysis). Storm surge events in the Greek seas and their correlation to meteorological parameters (wind velocity and direction and intensity of the low barometric pressure field) and to types of atmospheric circulation will be examined. The occurrence of high sea level elevation with respect to the duration of the related events and the geographical configuration of the Greek coastal areas will also be studied.

WT 2.4 - GEO_AUTh:

This WT aims at analyzing the relationship between the circulation types and the storm surges over the Aegean Sea and examining if this relationship will remain the same until the end of the 21st century under future climate changes.

WP2-DELIVERABLES

2.1. Database – NAVAL_NTUA, HYDRO_AUTh **DUE DATE:31/12/2013**

Wave heights mean wave periods, mean wave directions, storm surges and sea levels for the time period 1961 - 2100. (*WTs 2.1 and 2.2*)

2.2. Technical Report –HYDRO_AUTH, GEO_AUTh **DUE DATE: 30/06/2014**

Estimation of the correlation of the studied meteorological parameters with waves, storm surges and sea level. (*WT 2.3*)

2.3. Technical Report- GEO_AUTh **DUE DATE: 30/06/2014**

Analysis of the relationships and links between the atmospheric circulation and the storm surges under the future climate conditions, due to the enhanced greenhouse effect. (*WT 2.4*)

WP3: Estimation of meteorological and marine extremes accounting for climate change.

Research Teams: HYDRO_AUTh, GEO_AUTh
Work Tasks: 3
Duration: 01/01/2013- 30/06/2015
Person Months: 36
Deliverables: 3

Analyses of extreme values of meteorological and marine variables in selected regions of the Greek seas (Thracian Sea, Eastern Aegean, Western Aegean, Northern Crete).
Meteorological extremes will be processed using parametric and non-parametric techniques.
Marine extremes will be studied utilizing extreme value techniques, under stationary and non-stationary conditions, considering uncertainty in return level estimates.
Extremes of the combined system of storm surges and their initiating mechanisms (atmospheric pressure, wind velocity) will also be studied.

WP3: Estimation of meteorological and marine extremes accounting for climate change.

WT 3.1 - GEO_AUTh

Initially, extreme meteorological parameters will be analysed. The analysis of the extreme temperature and wind values will be achieved by utilizing both parametric and non-parametric techniques and the characteristics of the deep depressions (intense cyclonic conditions) over the Aegean Sea will be analysed.

WT 3.2 - HYDRO_AUTh

Waves and storm surges will be considered and their extreme values will be selected and processed. Univariate extreme value techniques, such as the Poisson point process (Coles & Casson 1999) will be used to simulate wave height and storm surge extreme values for the time periods 1961-2000 and 2000-2100, in the abovementioned selected regions of the Greek Seas.

To incorporate the long-term trends in the wave height and storm surge extreme data, the parameters of the extreme value models considered will be simulated as parametric functions of time.

WP3: Estimation of meteorological and marine extremes accounting for climate change.

The effect of climate change on estimating wave height and storm surge prediction uncertainty will also be taken into account. More specifically, the epistemic uncertainties (epistemic uncertainty comprises of the model and the statistical uncertainty, which in turn is subdivided in parameter uncertainty and distribution type uncertainty) in return level estimates will be calculated for both stationary and non-stationary marine variables (waves and storm surges).
Statistical uncertainty will be quantified in the present research by means of the 95% confidence intervals of the return level estimates for both stationary and non-stationary marine variables.

WT 3.3 - HYDRO_AUTh

The processing of extreme meteorological (air temperature, wind speed and deep cyclonic conditions) and marine (wave height and storm surge) variables will be complemented with analyzing the combined system of the atmosphere and the sea. The dependence in the extreme values of the process of storm surges on their initiating mechanisms (wind speed and atmospheric pressure), based on the circulation types which were studied in WP2 (WT 2.4), will be investigated.

WP3-DELIVERABLES

3.1. Technical Report- GEO_AUTh. **DUE DATE: 31/12/2013**

Estimation and analysis of the extreme winds, temperature and deep cyclonic conditions (deep depressions) for present and future time periods. (*WT 3.1*)

3.2. Technical Report-HYDRO_AUTh. **DUE DATE: 30/06/2014**

Estimation of extreme wave height and storm surge events, considering the effects of climate change. (*WT 3.2*)

3.3. Technical Report-HYDRO_AUTh. **DUE DATE: 30/06/2015**

Joint probability analysis of extreme storm surges and their atmospheric initiating mechanisms. (*WT 3.3*)

WP4: Estimation of climate change effects on coastal vulnerability to flooding and erosion.

Research Teams: HYDRO_AUTh, MARINE_AEGEAN
Work Tasks: 3
Duration: 01/07/2013 – 30/09/2015 (27 months)
Person Months: 48.5
Deliverables: 2

Estimation of climate change effects on coastal vulnerability to flooding and erosion.

Storms will be classified and flood and erosion potential will be assessed.

Vulnerability Indicators (Flood Vulnerability Index (FVI) and Erosion Vulnerability Index (EVI)) will be calculated.

The coastal areas of Lesbos, Eastern Macedonia-Thrace and Crete are the regions for the applications of the proposed methodology, which are known to be vulnerable to flooding and erosion

WP4: Estimation of climate change effects on coastal vulnerability to flooding and erosion.

WT 4.1 - HYDRO_AUTh

Storms, based on similar characteristics of wave height, wave period and total sea level, will be classified for calculating the potential of the study sites to flooding and erosion. To maintain an analogy with existing extreme events classifications, a five-class scale will be adopted, ranging from weak to extreme marine events. Storms will be classified using the wave energy content of storms as a key variable and applying cluster analysis to recorded storms in each one of the studied areas, which are defined as events with significant wave height exceeding a defined threshold (Méndoza & Jiménez 2008). To analyze the magnitude of the storm impact, the two main induced processes, flooding and erosion, will be considered separately.

WT 4.2 - HYDRO_AUTh, MARINE_AEGEAN

After storm classification the flood potential of each storm class will be calculated. The flood potential is defined as the maximum elevation of the mean water level associated with each storm class, being calculated as the sum of the contributions of the wave run-up and the storm surge.

WP4: Estimation of climate change effects on coastal vulnerability to flooding and erosion.

WT 4.3 - HYDRO_AUTH, MARINE_AEGEAN:

The erosion potential can be described as the potential beach erosion induced by the impact of a storm when no constraints exist. It can be characterized by two bulk parameters: the value of maximum beach recession of a given control line in the beach and the maximum eroded volume inside the coastal area.

Beach erosion in selected locations of the coast will be evaluated utilizing the numerical morphodynamical model SBEACH (Larson & Kraus 1989, Wise et al. 1996), as well as advanced numerical models of nonlinear wave propagation, sediment transport and beach morphology evolution caused by wave action and sea level rise (Karambas & Koutitas 2002, Karambas 2002b). Erosion will be estimated for all storm events belonging to each storm class. These eroded volumes will then be parameterized using a profile change parameter J_A (Jiménez et al. 1993) and this parameter will be utilized to calculate erosion potential caused by storm events in each class.

Flood and erosion potentials will then be used to estimate the respective Vulnerability Indicators (Méndoza & Jiménez 2008), the Flood Vulnerability Index, (FVI) and the Erosion Vulnerability Index (EVI).

WP4-DELIVERABLES

4.1. Technical Report - HYDRO_AUTh, MARINE_AEGEAN **DUE DATE: 31/12/2014**

Storm classification and estimation of FVIs in the study sites. (*WTs 4.1 and 4.2*)

4.2. Technical Report HYDRO_AUTh, MARINE_AEGEAN **DUE DATE: 30/09/2015**

Estimation of erosion potential and EVIs in the study sites. (*WT 4.3*)

WP5: Estimation of the climate change effects on coastal and marine structures.

Research Teams: HYDRO_AUTh, MARINE_AEGEAN
Work Tasks: 3
Duration: 01/07/2014 – 30/09/2015 (15 months)
Person Months: 35.5
Deliverables: 3

Assessment of the probable influence of climate change on the design, functionality and safety of coastal and marine structures of the Greek coastal regions (WP4).

The vulnerability of such structures to the future climate and adaptations measures to reduce adverse effects will be considered.

WP5: Estimation of the climate change effects on coastal and marine structures.

WT 5.1. - HYDRO_AUTh:

The functionality and stability of selected coastal structures will be determined using a perturbation method, a useful technique to identify the first order changes in a given function, which is applied to different semi-empirical formulas describing such features. Changes in functional and safety parameters (overtopping discharge, weight of rubble-mound) will be computed indicating likely climate change effects.

Long-term trends in mean values of significant wave height will firstly be assessed using a LogNormal distribution function with time-varying parameters. These trends, as well as mean sea level variability, will be combined with the perturbated semi-empirical formulas used for overtopping, to quantify climate change impacts on structural functionality.

Long-term trends of mean sea level and extreme marine events (wave heights and storm surges) for the time period 2000-2100, estimated within WPs 1 and 3, respectively, will also be used in conjunction with perturbated semi-empirical formulas for structural stability to estimate climate change effects on the safety of coastal structures.

WP5: Estimation of the climate change effects on coastal and marine structures.

WT 5.2. - HYDRO_AUTh

The response of coastal structures used for wave protection will be investigated under the influence of climate change.

Upgrading of such structures will be investigated for meeting future conditions due to climate change like: (a) crest elevation increase and/or slope decrease (b) reduction of the incident wave height by constructing “front line” structures usually in the form of berm and low crested structures, resulting to partial scattering of the waves, or in the form of an overflow basin.

WT 5.3. - MARINE_AEGEAN

The response of coastal structures used for the coastal protection from the erosive action of waves in a changing climate will be investigated. The influence of sea level rise and the wave height on the effectiveness of coastal structures against erosion will be studied.

Measures for upgrading such structures will be investigated as: increase of coastal structure crest elevation and/or length, combination with additional beach nourishment, construction of additional innovative structures (such as artificial reefs and vegetation) in front of the existing structures to reduce incident wave height.

WP5-DELIVERABLES

5.1. Technical Report- HYDRO_AUTh. **DUE DATE: 31/12/2014**

Assessment of climate change effects on functionality and stability of coastal structures. (*WT 5.1*)

5.2. Technical Report-HYDRO_AUTh. **DUE DATE: 30/09/2015**

Performance and upgrading of coastal structures against flooding, accounting for climate change. (*WT 5.2*)

5.3. Technical Report-MARINE_AEGEAN. **DUE DATE: 30/09/2015**

Development of methodologies and "good practices" for the design and upgrading of coastal structures against erosion. Computational tools for the study of the coastal structures response to the forcing of the waves and the sea level rise. (*WT 5.3*)

WP6: : Dissemination of results.

Research Teams: HYDRO_AUTh, GEO_AUTh, MARINE_AEGEAN, NAVAL_NTUA

Work Tasks: 4

Duration:

Person Months:

Deliverables: 3

Results of the project will be disseminated.

WP6: : Dissemination of results.

WT 6.1 - HYDRO_AUTh

A leaflet and a web-site will be created. The leaflet will be disseminated to all interested organizations, policy makers and professionals.

A web-site will also be created, containing the objectives, the progress reports, as well as the project results.

WT 6.2 - HYDRO_AUTh

Two meetings will be organized, one in the middle and one at the end of the project, intending to inform the interested organizations, as well as the stakeholders on the results of the project.

WT 6.3 – HYDRO_AUTh, GEO_AUTh, MARINE_AEGEAN, NAVAL_NTUA

All Research Teams will publish their results obtained within the project in scientific journals, international and national conferences

WP6-DELIVERABLES

6.1. A leaflet and a web-site (*WT 6.1*) **- HYDRO_AUTh** **DUE DATE: 30/06/2012**

6.2. Minutes of the two meetings (*WT 6.2*) **– HYDRO_AUTh**

DUE DATE:

6.3. Publications in journals and conferences (national and international) (*WT 6.3*)

DUE DATE:

WP7- Project Evaluation

Research Teams: HYDRO_AUTh, GEO_AUTh, MARINE_AEGEAN, NAVAL_NTUA

Work Tasks: 1

Duration:

Person Months:

Deliverables: 1

WP7- DELIVERABLES

7.1. Technical Report-**ALL TEAMS** **DUE DATE: 30/09/2015**

Project Evaluation

3. Research Teams

Ερευνητική Ομάδα 1 : HYDRO_AUTh
Τομέας Υδραυλικής και Τεχνικής Περιβάλλοντος, Τμήμα Πολιτικών Μηχανικών Α.Π.Θ

Παναγιώτης Πρίνος (Καθηγητής Α.Π.Θ)
Γιάννης Ν. Κρεστενίτης (Καθηγητής Α.Π.Θ)
Χριστόφορος Κουτίτας (Καθηγητής Α.Π.Θ)
José Jiménez (Καθηγητής Universitat Politècnica de Catalunya)

Παναγιώτα Γαλιατσάτου (Μεταδιδάκτορας)
Αχιλλέας Σαμαράς (Μεταδιδάκτορας)
Αικατερίνη Κομπιάδου (Μεταδιδάκτορας)
Ιωάννης Ανδρουλιδάκης (Μεταδιδάκτορας)

Υποψήφιος Διδάκτορας
Υποψήφιος Διδάκτορας

3. Research Teams

Ερευνητική Ομάδα 2 : GEO_AUTh

Τομέας Μετεωρολογίας και Κλιματολογίας, Γεωλογικό Τμήμα Α.Π.Θ.

Κωνσταντία Τολίκα (Λέκτορας Α.Π.Θ)
Χριστίνα Αναγνωστοπούλου (Επ. Καθηγήτρια Α.Π.Θ)

Ιωάννης Τεγούλιας (Μεταδιδάκτορας)

Ευτυχία Ρούση (Υποψήφιος Διδάκτορας)
Γεώργιος Ζίττης (Υποψήφιος Διδάκτορας)

3. Research Teams

Ερευνητική Ομάδα 3 : MARINE_AEGEAN

Τμήμα Επιστημών της Θάλασσας, Πανεπιστήμιο Αιγαίου

Ελένη-Ανθή Τράγου (Επ. Καθηγήτρια Παν. Αιγαίου)
Θεοφάνης Καραμπάς (Αν. Καθηγητής Α.Π.Θ)

Ιωάννης Μαμούτος (Υποψήφιος Διδάκτορας)
Υποψήφιος Διδάκτορας

3. Research Teams

Ερευνητική Ομάδα 4 : NAVAL_NTUA

Τομέας Ναυτικής και Θαλάσσιας Υδροδυναμικής, Σχολή Ναυπηγών Μηχανολόγων Μηχανικών, Ε.Μ.Π

Γεράσιμος Αθανασούλης (Καθηγητής Ε.Μ.Π)
Κωσταντίνος Μπελιμπασάκης (Αν. Καθηγητής Ε.Μ.Π)
Θεόδωρος Γεροστάθης (Επ. Καθηγητής ΤΕΙ Αθηνών)
Eugen Rusu (Καθηγητής Dunarea de Jos Galati)

Παναγιώτης Γαβριλιάδης (Μεταδιδάκτορας)
Ιωάννης Γεωργίου (Υποψήφιος Διδάκτορας)

Ηβη-Σεβαστή Τσαντίλη (Υποψήφιος Διδάκτορας)

4. Meetings-Workshops

1. **Kick-off Meeting – April 2012- Host: HYDRO_AUTh**

2. **1st Annual Meeting – December 2012- Host: MARINE_AEGEAN**

3. **2nd Annual Meeting-December 2013- Host: NAVAL_NTUA**
   1st Workshop- December 2013- Host: NAVAL_NTUA

4. **3rd Annual Meeting- December 2014- Host: GEO_AUTh**

5. **Final Meeting- September 2015- Host: HYDRO_AUTh**
   2nd Workshop- September 2015- Host: HYDRO_NTUA

5. Other Studies and Projects

- **Τράπεζα της Ελλάδος- Ιούνιος 2011**

Οι περιβαλλοντικές , Οικονομικές και Κοινωνικές Επιπτώσεις της Κλιματικής Αλλαγής στην Ελλάδα

- **BALTEX Assessment of Climate Change for the Baltic Sea Basin- The BACC Project- May 2006**

- **THESEUS- FP7 Project- www.theseusproject.eu**

Innovative technologies for safer European coasts in a changing climate

5. Other Studies and Projects

- **MICORE-FP7 Project- www.micore.eu**

Morphological Impacts and COastal Risks induced by Extreme storm events

The MICORE project will provide the knowledge necessary to assess the present day risks and to study the economic and social impact of future severe storm events. The project will also develop operational predictive tools in support of emergency response to storm events. Together, these elements will have an important strategic impact on the safety of the people living in coastal areas. The project will also investigate with stakeholders and end-users the possibilities of producing EU-wide guidelines for a viable and reliable risk mitigation strategy.

5. Other Studies and Projects

- **VuCoMa- Spanish Project- J. Jimenez- UPC – 2009-2011**

- **Vulnerabilidad Costera a Múltiples Agentes Aplicación al Litoral Catalán**