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A European coastal storm impact database of resources: the ECFAS effort

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Abstract

This article introduces a novel database (DB) containing resources of information on extreme coastal storms that generated major damage and flooding along European coastal zones over the period 2010-2020. The methodology implemented for the construction of the database and its current contents are presented here. In the database, the storm events are linked to sites where impact was observed, making them test-cases for further activities of the EU H2020 ECFAS Project. This definition allows discriminating the collected information from different storms hitting the same area. The database is distributed as an Excel Workbook and constitutes a comprehensive and user-friendly inventory of different types of resources that report impact, flood characteristics, hydrodynamics and weather information related both to the pre-selected extreme events and to the test-cases. Polygons are also additionally provided in a GeoJSON format defining the sites. A total of 11 coastal events, 28 sites, 26 test-cases, and 207 resources are recorded in the database. New events, sites, test-cases and resources can constantly be incorporated, making it a “living tool”.

Keywords: Storm Database; Coastal storms; Flood damage; Flood impact; Europe

1. INTRODUCTION

Coastal flood events can cause a large variety of damages and economic losses along European coastlines, such as example the Xynthia storm in France in 2010 (Muller et al., 2017; Naulin et al., 2016) or the St’Agatha event in Italy in 2015 (Duo et al., 2018). It was estimated that coastal flooding can generate losses of €1.4 billion and affect hundreds of thousands of people every year (Vousdoukas et al., 2020). The yearly economic losses due to natural hazards have been increasing since the early 20th century (Svetlana et al., 2015), despite the increasing cooperation between countries in managing flood risk (Hall et al., 2015), the existence of specific policies at European level (e.g., the Flood Directive 2007/60/EC) and great scientific effort (Di Baldassarre et al., 2018).

The extent of low-lying coastal areas subjected to flood risk will increase due to relative sea-level rise and potential increase in storm frequency, as a result of climate change. Additionally, the rising socio-economic pressure on coastal areas will increase the exposure component of risk (van Dongeren et al., 2018). Therefore the study, monitoring and forecasting of coastal flood hazards and impacts is a key strategy for risk managers to tackle current and future challenges for coastal communities.

Databases collecting qualitative and quantitative information on both physical and socio-economic aspects of coastal storm impacts represent important tools for coastal management. Currently, most of the available databases collect general flood information, generally not specific to the coast, at the national level: as examples we can mention the Base des Donnèes sur les Inondations (Lang et al., 2016), the Sistema Informativo sulle Catastrofi Idrogeologiche (Guzzetti and Tonelli, 2004), the Catálogo Nacional de Inundaciones Históricas[a], and the Swiss flood and landslide damage database (Hilker et al., 2009). Due to language and cultural barriers, the collection of reliable information becomes a difficult task, expecially when the scale of the analysis is supra-national. The lack of a common methodological framework for the preparation of the datasets leads to a lack of homogeneity in terms of "extent" and "completeness" (Paprotny et al., 2018b).

[a] http://www.proteccioncivil.es/catalogo/naturales/cnih/cnih2014/Presentacion.html

At the European level different efforts have been made to build reliable coastal flooding impact databases. The most recent ones are those produced in the framework of the RISC-KIT (Ciavola et al., 2018) and HANZE (Paprotny et al., 2018a) projects. Despite the great effort in creating these databases, their content has not been regularly updated. Another aspect of interest for the current paper is that existing databases report pre-elaborated information that might generate biases for the user if proper guidelines on the data interpretation are not provided.

There is a need to provide a comprehensive database of information about coastal storm impacts. Such a tool should be freely accessible, user-friendly, and flexible, so that the gathered information could be used to address several scientific purposes (e.g., flood model validation, shoreline displacement studies, impact evaluation, etc.). For the sake of this work, a "resource" is defined as any type of source of information (digital or paper based) which provides details, descriptions, images or any material related to extreme coastal storms. These resources represent possible material to be analysed by users to retrieve quantitative or qualitative data, depending on the purpose of the assessment. The novel database should benefit from the information included in the pre-existing ones, providing - along with synthetic information on the storm and affected sites - all the available sources of information. These, in particular, should be properly categorised according to the type of resource (e.g., scientific reports, news, media, etc.) and addressed topic (e.g., weather, hydrodynamics, impacts, etc.). In this way, the user can select the resources of interest depending on the needs, and the processing and interpretation of the information is delegated to the final user. This should limit biases generated by the interpretation of non-quantitative and/or biased information, as the ones reported by blogs or media.

The ECFAS Database of Resources presented in this paper has been developed in the framework of the H2020 European ECFAS Project (A proof-of-concept for the implementation of a European Copernicus Coastal Awareness System), and it is publicly available at the project's web page [b]. The project aims to develop a Proof-of-Concept to enhance the Copernicus Emergency Management System, (CEMS [c]) through the implementation of a European Coastal Flood Awareness System, generating also coastal products to be added to CEMS Risk and Recovery products.

2. THE ECFAS DATABASE

The ECFAS Database of Resources collects information on coastal events affecting locations around European coasts. In this section the database (DB) structure, its contents, and the methodology followed for its generation are presented.

2.1 Database structure

The DB is composed by three main items:

i. The guidelines document meant to provide basic information on the structure and contents of the database, including the instructions on how to use the Excel Workbook file and retrieve the necessary information for further analysis.
ii. The GeoJSON files of the polygons delimiting the sites contained in the database.
iii. The WorkBook file which is structured in spreadsheets by dividing extreme events, sites, test-cases and available resources information. They are organized with linked fields to ensure cross-referencing for straightforward reading and compilation.

2.2 Resources collection and classification

The resources, material including information directly or indirectly related to the identified coastal events and affected sites, were collected after a thorough desk-top research that included the identification of relevant coastal events in the period 2010-2020, and the locations that experienced flood and erosion impacts. The resources were analysed to be categorized following the classification proposed in Table 1. To note that blogs and news have been included as a source as they have been proved to be generous providers of information to locate damages and consequences of coastal storms in general. Notably, these have been used as resources in different studies related to natural disasters (e.g. Santos et al., 2014; Tschoegl et al., 2006). However, it is necessary to consider that some type of resources could provide highly biased information, misrepresenting certain impacts. As an example, newspapers and media generally focus on urbanised coasts, emphasizing the impacts on people and assets, while impacts on natural beaches are generally overlooked (Sancho-García et al., 2021).

[b] https://www.ecfas.eu
[c] https://emergency.copernicus.eu

The identified references are collected in the resources spreadsheet and cross-linked to the event(s) and/or site(s) information included in the respective spreadsheets

Table 1. Types of the resources

RESOURCE	DESCRIPTION
Institutional Websites	Information provided by recognised organisations
Blog	Information gathered by people after the events
Scientific articles	Information derived from peer reviewed articles
Databases	Information contained in national and EU DB
News	Information provided by newspapers
Technical Reports	Non-peer reviewed technical documents containing quantitative analysis
Others	Information provided by other types of resources that do not correspond with any of the above categories

Additional information regarding the topics (Table 2) was included for each reference as a second classification method. Thus, the resources can be filtered by event, site, type of resource or topics. To facilitate the reference selection, the hyperlinks and complete URLs are also provided.

Table 2 Topics of the resources

TOPIC	DESCRIPTION
Weather	Information about precipitations, wind and temperature
Synoptic situation	Information related to the storm evolution in time and space
Hydrodynamics	Information regarding wave parameters, sea-level and flooding
Impacts	Information regarding the impacts and consequences caused by storms
Management/Actions	Information about the interventions after the storm

Consequently, each resource will have different tags, the one which indicates the type of resource and those describing the addressed topics.

2.3 Spatial coverage, sites and test-cases

Different criteria were considered for the selection and definition of the events and sites to be included in the database in order to represent the heterogeneity of coastal events on European coastlines. The sites were selected considering that different marine regional domains will be represented. At this stage, an Area of Interest (AoI) was defined following these criteria:

i. Where an activation of the Rapid Mapping Service was available in CEMS, the same Area(s) of Interest available in the Service was used.
ii. The extension of the polygon in areas where the activation was not available was defined using publicly available information related to the reported impacts and flooding extent.
iii. Where the events affected a very large area, the zone where the highest number of impacts occurred was selected.

The selected areas had to be affected by considerable flooding and impacts by specific meteo-marine events. In addition, different types of beaches (e.g., pocket, open, urban and natural), exposed to different tidal regimes (micro, meso and macrotidal) and different wave conditions (from low to high energy) were also considered. The total number of sites currently collected in the database is 26. The location and number of sites per country are shown in Figure 2. Information related to the sites is provided in the sites spreadsheet of the database, indicating the country and marine regional domain as well as the location of the sites. The information is cross-referenced to the spatial polygon defining the AoI of each site.

A test-case is defined as the combination of an extreme meteo-marine event and an affected site, and it is therefore characterized by both a spatial location, and a moment in time when the event occurred. Its definition derives from the fact that some sites experienced flooding due to different events, and some events impacted more than one site across different countries. The database currently collects 11 events and 28 test-cases. The “Extreme Events” spreadsheet in the Excel Workbook collects information regarding the period covered by the event on the reference area. In case the event is part of a cluster of storms, the official name of the storm, the maximum wave height and total water level registered during the storm and the main caused impacts follow the classification used by the RISC-KIT database.

In the test-cases spreadsheet the events and sites are indicated, as well as the information regarding their presence in CEMS, in the HANZE or in the RISC-KIT database. In the case that an activation of CEMS exists for a particular test-case, the hyperlink to its delineation map is also provided (Figure 1).

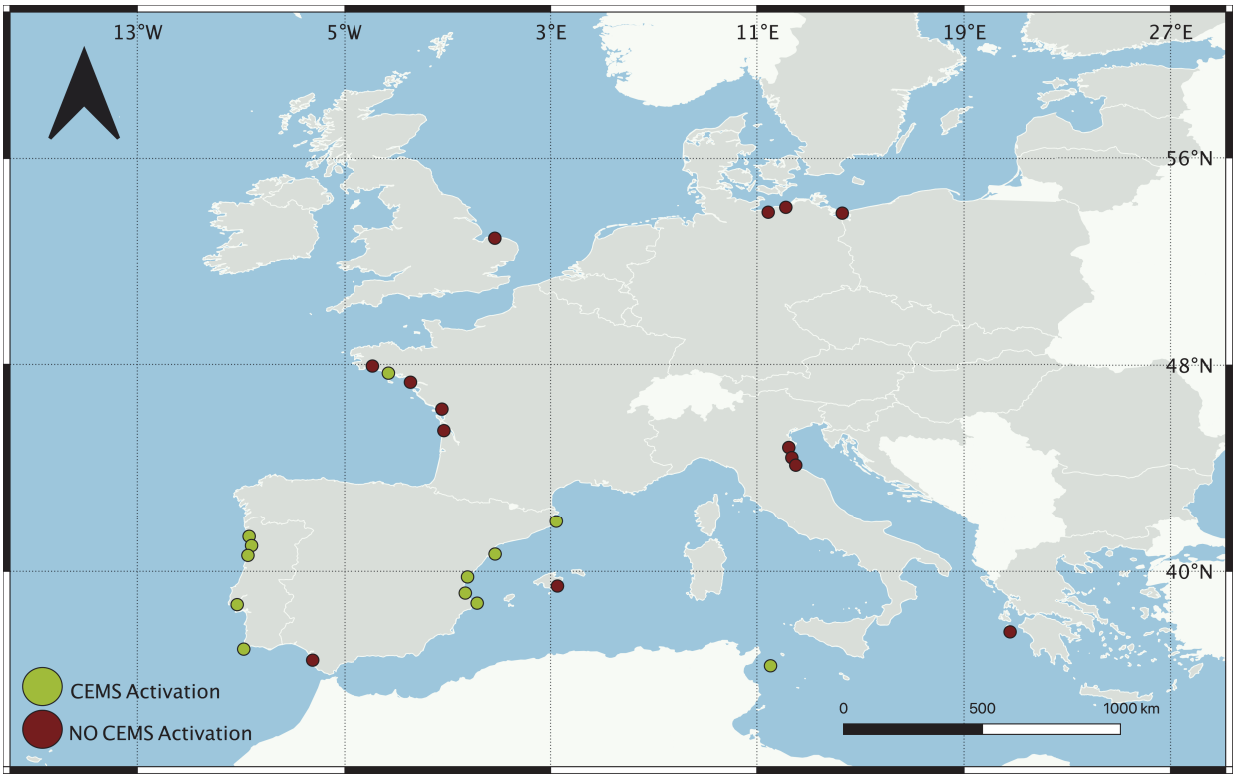

Figure 1. Test-cases currently included in the database. The circles indicate the sites' locations and the colours the existence (green) or not (red) of a Copernicus Emergency Management System activation for a specific event (test-case)

3. ECFAS DATABASE CONTENTS AND STATISTICS

The resources collected in the database have been classified by type and topic linking each one to the reference event and site (if the resource refers to areas located within the selected sites). The number (occurrences) of sites, number of events, number of test-cases and resources collected per country are shown in Table 3. In this table the resources that include information for more than one site and the ones giving information related to a storm not associated to a specific site, have not been considered.

Table 3. Statistics on spatial and temporal coverage

COUNTRY	NR. OF SITES	NR. OF EVENTS	NR. OF TEST-CASES	OCCURRENCES
France	6	3	6	29
Germany	2	1	2	5
Greece	1	1	1	3
Italy	3	3	5	14
Poland	1	1	1	0
Portugal	5	1	5	7
Spain	7	2	7	28
UK	1	1	1	10

The highest numbers of resources were retrieved for France and Spain due to the large number of cases in these countries. For the Poland test-case, which was affected by the same storm that hit the German sites, no information was obtained. This could be a language-related barrier or the absence of extreme event impact monitoring programs. Even if the former reason is the most likely, resources for the German sites were found either.

The occurrence per type of resource reporting to coastal storm events and their related damages and flooding is also not homogeneous (Table 4). The most frequent type of resource, accounting for 39,1% of the

total number of resources is the news, followed by scientific articles (18.8%) and institutional websites (15.5%).

Table 4. Number of occurrences per type of resources

TYPES OF RESOURCES	OCCURRENCES	PERCENTAGE
News	81	39.1
Scientific Article	39	18.8
Institutional Website	32	15.4
Videos	20	9.6
Technical Report	17	8.2
Database	11	5.3
Blog	4	1.9
Other	3	1.4

The distribution of the types of resources per country (Figure 2) shows that in Southern European countries (Portugal, Spain, Italy and Greece) there are more news and videos referring to information related to the 7 events considered. Scientific, technical or institutional information was expected because the considered storms are exceptional events such as the storm Gloria in Spain (2020) or the Vaia storm in Italy (2018). On the other hand, in Northern European countries there is a higher number of scientific articles, technical reports and institutional websites supplying information. This could indicate a higher awareness about these events or that the events selected in these countries had an even greater impact compared to the other European regions.

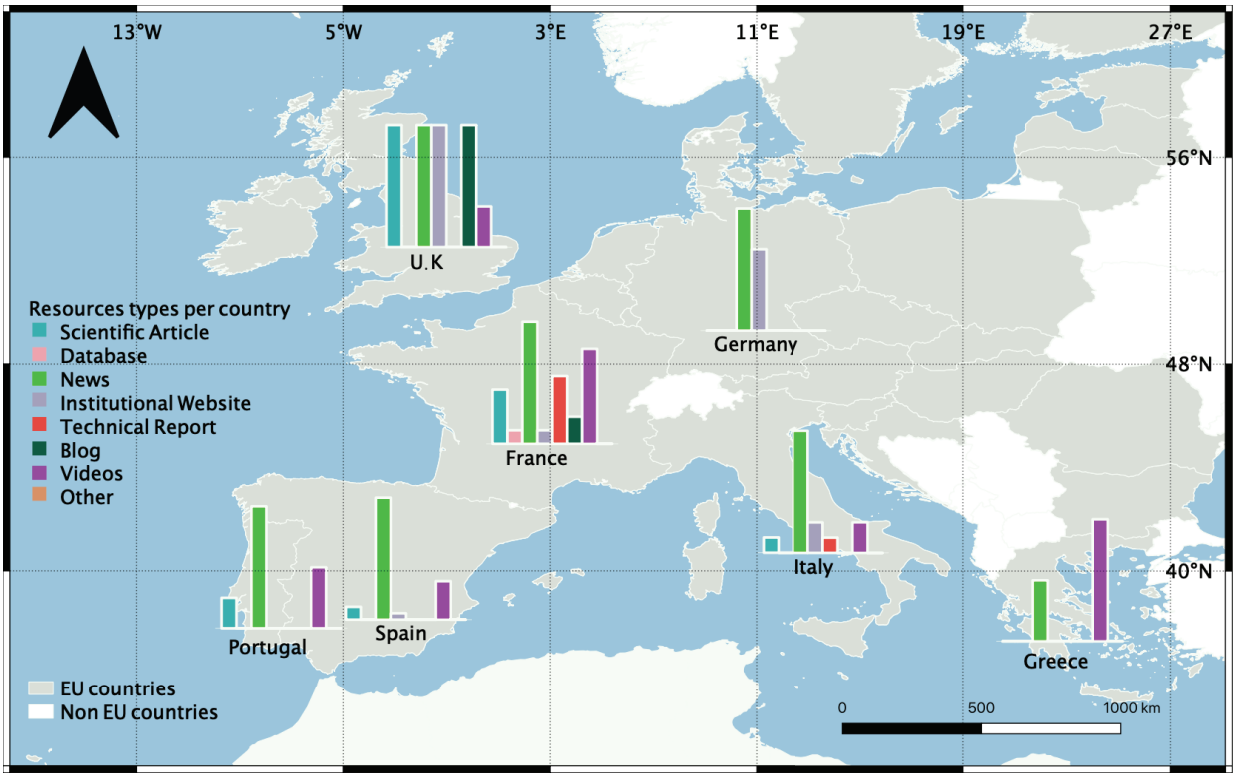

Figure 2. Distribution of the resource types per European country contained in the ECFAS database.

The representation of the different topics in the DB is presented on Table 5. The percentages were calculated using the total number of occurrences (n = 421), which is not equal to the number of resources as one resource can give information related to more than one topic.

The most frequent topic is impact (74.9%) and flooding (53.1%), as the news covering these events usually focus on the damages generated by the storms. The less addressed topic is often the weather (8.7%).

Table 5. Topics covered by the retrieved resources of information

TYPES OF RESOURCES	OCCURRENCES	PERCENTAGE

Hydrodynamics	56	27.1
Impacts	155	74.9
Flooding	110	53.1
Management/Actions	35	16.9
Synoptic	37	17.9
Weather	18	8.7

4. CONCLUSIVE REMARKS

The DB presented in this paper provides a comprehensive list of resources related to the events and test-cases identified in the framework of ECFAS H2020 Project. It is an intuitive and user-friendly tool where the synoptic, meteorological and hydrodynamic events characteristics and related flood and impact information are easily identified by using tags and filters. In addition, it can be easily updated as the different Workbook spreadsheets are linked between them to facilitate the incorporation of new events, sites, test-cases and/or resources. The information is stored here as resources, without any type of analysis or interpretation which could bias later studies.

The descriptive statistical analysis of the types of the resources suggests that there is a different level of awareness about coastal storms among the countries represented in the DB.

This finding highlights the need of a uniform and standardised program to monitor and report the impacts of extreme coastal events at pan-European level. Such program would be responsible for fostering reliable and easy-to-analyse information, which is particularly relevant for climate change adaptation policies for the coastal zone.

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