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Characterisation of the expected weather conditions in the main European coastal traffic routes

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ABSTRACT

The maritime traffic in the European seas is analysed in order to characterize the different areas in terms of traffic density and average navigational distance from the coast, assessing the relative weight of each coastal area with respect to the total European seaborne trades. The main coastal routes are also detected by highlighting the tracks that present a higher density of geo-located ship reports. The state-of-the-art ERA-interim weather database is used to compute the weighted average characteristics of the sea-state conditions in those routes, providing a meaningful reference for the waves that ships are asked to face in the coastal areas, where the occurrence of accidents is higher and further effort is required to minimize the risk at sea.

1. Introduction

Maritime ports in the EU-28 handled 3.8 billion tonnes of seaborne goods in 2014 (Eurostat, 2016) and, due to economical and geographical reasons more than half of it is handled by four member states, namely the Netherlands, the UK, Italy and Spain. Moreover, some forced passages, especially the British Channel, the Strait of Gibraltar and the Canal of Suez, contribute to the creation of congested maritime highways around Europe. The seaborne traffic is composed by deep sea shipping and short sea shipping. The former represents the share of goods arriving from overseas carried by large ocean-going vessels; while the latter, accounting for 58% of the total maritime freights (Eurostat, 2015), includes both the pure intra-European trades and the feeder service to/from hub ports such as Rotterdam.

The study of the maritime trade system is usually focused on economical and logistical considerations (Fremont, 2007; Hu and Zhu, 2009; Kaluza et al., 2010). Port operations are analysed in order to retrieve information about the network system, rather than actually map the trajectories at sea. Nevertheless, a global traffic control vision (Corbet, 1992) can only be achieved through an increased awareness on the maritime traffic distribution all along the ship routes, rather than confined to port areas and canals, providing a reference in the development of regulatory frameworks to ensure the maritime safety and survey the oceanic traffic.

The sources available to detect and analyse the ship paths are typically databases of radar observations (Yao et al., 2010) and Automatic Identification System (AIS; Silveira et al., 2013) if a specific zone close to coastal areas where this data is easier to collect is considered. For a more comprehensive investigation ship reports deriving from the Voluntary Observing Ships' (VOS) program (Fletcher, 2008) can be used as shown in Vettor and Guedes Soares (2015). The VOS database provides a unique source of geo-referenced reports, which, besides giving a huge dataset of meteorological parameters, specify the exact position of each observing ship during its operations. A more extensive analysis of this type of wave data has been made by Vettor and Guedes Soares (2016d, 2016e) where comparisons with the ERA-interim reanalysis is made. Comparisons between this and other existing wave databases is made by Campos and Guedes Soares (2016a, 2016b).

2. Scope of the study

One of the primary objective of identifying the coastal maritime traffic and their characteristics is to provide a reference to studying and reducing accidents in those areas. Indeed, the risk of accident is generally higher near the coast than offshore, and three main reasons can be identified. First of all the possibility of grounding, typically due to human error (Graziano et al., 2016) and machinery failure (Wu et al., 2016), which consequences can be catastrophic in restricted waters. Secondly coastal areas often experience specific weather conditions, that is steeper waves due to shoaling, stronger currents and more variable wind (Guedes Soares et al., 2001). Finally the ship traffic intensifies, including, among the others, ocean-going vessels approaching the ports, cabotage ships, fishing boats and leisure activities (Silveira et al., 2013). It has been shown that accidents occurrence is higher in the congested coastal areas (Guedes Soares and

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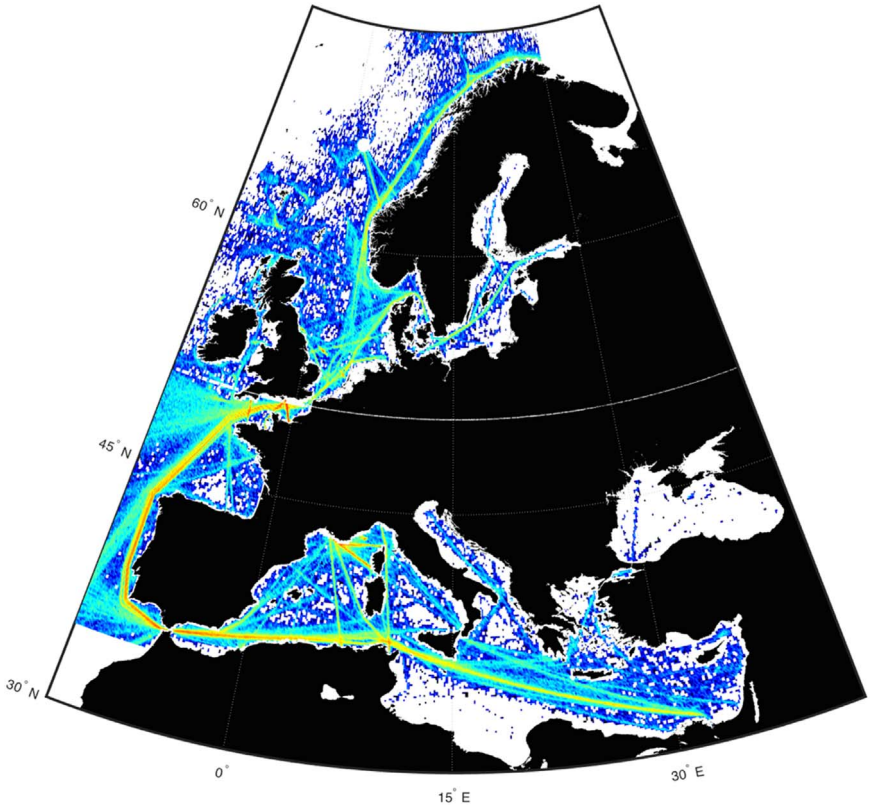

Fig. 1. Density map of VOS reports on the European waters. Colours indicates the number of reports per unit area normalised to the highest value.

Table 1
Characteristic of traffic in the European waters and its zones.

Zone/route	Sea area [km^2]	Mean distance [nmi]	Traffic rate [%]	Relative traffic density [%]
Europe	7,004,073	58	100.0	100
Atlantic coast	1,260,994	72	26.4	146
North Sea	550,635	51	10.8	137
British Channel	76,924	21	6.2	568
Baltic Sea	423,141	23	3.5	58
Norwegian Sea	880,402	87	15.6	124
Mediterranean	2,541,322	43	33.5	92
Black Sea	471,867	41	0.3	5

Teixeira, 2001; Pike et al., 2013).

When sailing near the coast, large ships must respect the Traffic Separation Schemes (TSS; IMO, 1972) introduced for safety reasons, which require to navigate through a relatively narrow passage depending on the direction and, sometime, the type of ship/cargo, aimed at minimising the risk of collision in critical areas. Thus the navigation along the coast is often conditioned by the TSSs which are in general within 50-60nmi distance from the shore, for instance near Norway or the Iberian Peninsula. TSS can be found even at greater distance where the traffic is particularly intense, and this is the case of the southern North Sea due to the presence of several busy ports.

The motivation for the present work has been the concerns about the safety of ship operations in coastal waters and approaches to ports, already expressed, for instance, in Teixeira and Guedes Soares (1998). With the implementation of the Energy Efficiency Design Index (EEDI), that assesses "impact to environment", in terms of CO_2 emissions, weighted by the "benefit to society", proportional to the deadweight and the ship speed, new ships are required to keep this index lower than a specific baseline (IMO, 2012). To fulfil this requirement, ships tend to have lower propulsion power installed and there are concerns that this may lead to a lack of manoeuvring capabilities in heavy weather (Papanikolaou et al., 2016). To deal with these situations, an effort has been made to characterise what could be the adverse conditions to be considered when specifying the manoeuvring standards for these ships (Bitner-Gregersen et al., 2016; Lucas et al., 2016) although there are opinions that this effect can only be taken into consideration indirectly through manoeuvring standards in calm water (Sutulo and Guedes Soares, 2016c).

The representative weather conditions in the main ship routes in the North Atlantic have been considered in Vettor and Guedes Soares, (2015, 2016d) and even a more generic weather avoidance effect has been modelled in Vettor and Guedes Soares (2016e). Bitner-Gregersen et al. (2016) considered the wave conditions in some coastal areas providing a good contribution to the understanding and quantification of their effects. Nevertheless, the analysis is based on a limited number of locations, while the present study addresses the all main coastal routes in Europe. In this work, by determining the rate of traffic in the coasts around Europe and along the most important European routes, the zones where the concentration of traffic is higher are identified. Then the mean and extreme weather conditions in these areas are studied to provide an important reference for updating the definition of adverse conditions in coastal areas.

3. Data used in the analysis

The peculiarity of the present work requires the use of several databases, providing detailed information about both the weather climate and the ship traffic.

A wave database contains climatological data in a spatial grid covering a specific area, which can be obtained from simulation models, measurements or observations. Modern phase averaging third generation wave models (Komen et al., 1994; WISE Group, 2007) predict the spatial and temporal evolution of the directional spectrum solving the spectral energy equation. For operational purpose and