Wind / Wave directional modelling: a compositional approach

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The problem

- One of the main parameters involved in wave impacts for coasts and harbours is the angle (α) between wave crests approaching to the coast and shoreline orientation
- Regarding coastal dynamics: potential sediment transport rate (Ql), as well as magnitude of the wave-induced longshore currents (vl) are function of the wave angle in breaking conditions
- Harbour breakwaters are designed to face the main wave crests direction, projecting the harbour entrance to prevent as much as possible the incoming wave energy into sheltered harbour areas and thus harbour agitation
- Changes in wave angle may have a significant potential impact in sediment transport rates and beach evolution and in harbour operability
- According to [2], a shift on the wave direction may induce a significant increase in harbour agitation in the nearby ports

Data

- Tortosa buoy: directional Datawell waverider with a sensor type heave-pitch-roll and accelerometers to record horizontal movements.
- Located in the NW mediterranean, 8km front the Ebre delta at 60m depth. Recording data from 1990 until 2012 as part of the old XIOM oceanographic network.

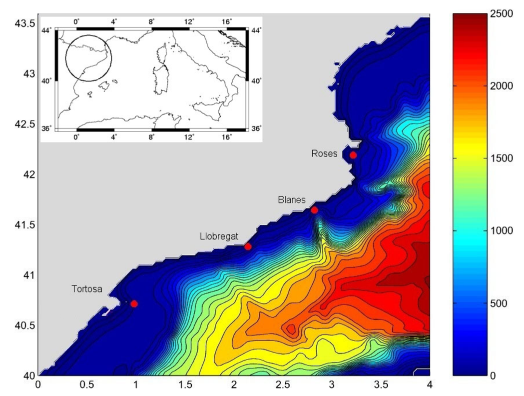

Figure 1: Bathymetric map of the Western Mediterranean with location of the Tortosa buoy.

- Four predominant wind directions present in North-Western Mediterranean: NE, E, SW and NW
- Maximum velocities recorded from Eastern winds in agreement with storm conditions associated with cyclonic activity over the NW Mediterranean [1]
- Ebre delta: particular region where NW winds funnelled through the Ebre river valley are the most typical. These offshore winds result in a fetch and duration limited wave climate where eastern waves have a maximum fetch below approximately 700 km.

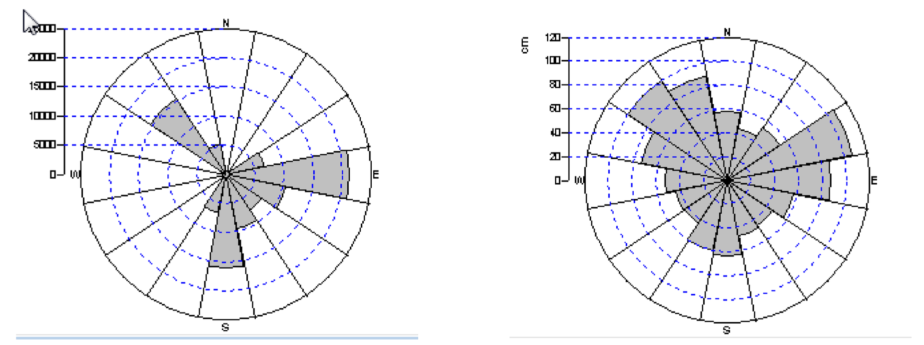

Figure 2: Number of wave observations by sector off the Ebre delta position (1990-2012) (left). Mean significant wave heights and directions off the Ebre delta position (1990-2012) (right).

Fig. 2 shows rose diagrams of waves off the Ebre delta. The largest number of observations occur from the East, South and East with the highest waves from the NEE and the lowest from the South. Therefore, the typical wave climate shows a predominance of NW and E conditions, with significant South storms.

Acknowledgements

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Model

- The frequencies of observation of wave directions can be considered as compositional [4]
- The relative scale of significant wave-height and period must be treated properly [3]
- The probability of observation of a certain direction is computed through a multinomial logistic model:

$$f(p_i) = g(\log(H_S) + \log(Tp))$$

Results

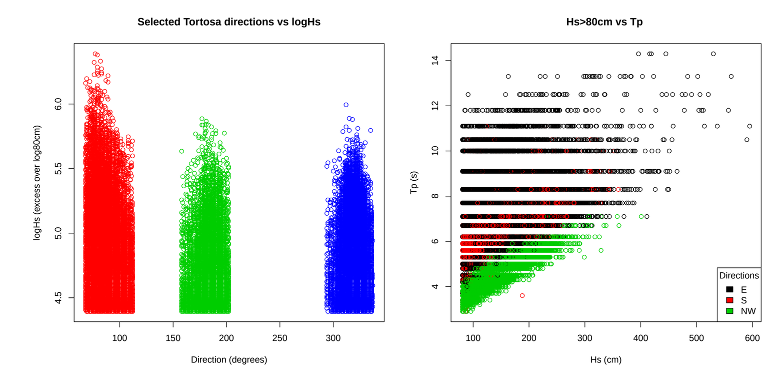

Figure 3: A subset of the original series, containing only E/S/NW has been selected (left fig.). NW sea states seem to have different Hs and Tp characteristics than E/S direction. Although E sea states show higher Hs and Tp values, there is some confusion with S states for lower values (right figure).

	Coefficients		
	(Intercept)	logHs	logTps
S	7.65	-0.61	-2.97
NW	-10.47	13.76	-34.87
	Wald		
	(Intercept)	logHs	logTps
S	31.65	-11.43	-37.68
NW	-20.16	60.00	-72.78

Table 1: Coefficients of the multinomial logit model (E as reference direction) (Upper table). Ward statistics (Lower table). All coefficients are significant.

Obs/pred	E	S	NW
E	14931	1010	801
S	6012	725	387
NW	166	110	15552

Table 2: Cross-classification table: Observed vs predicted direction (max. prob). NW is well predicted. Some confusion among E/S directions, according to the observed data (Fig.3).

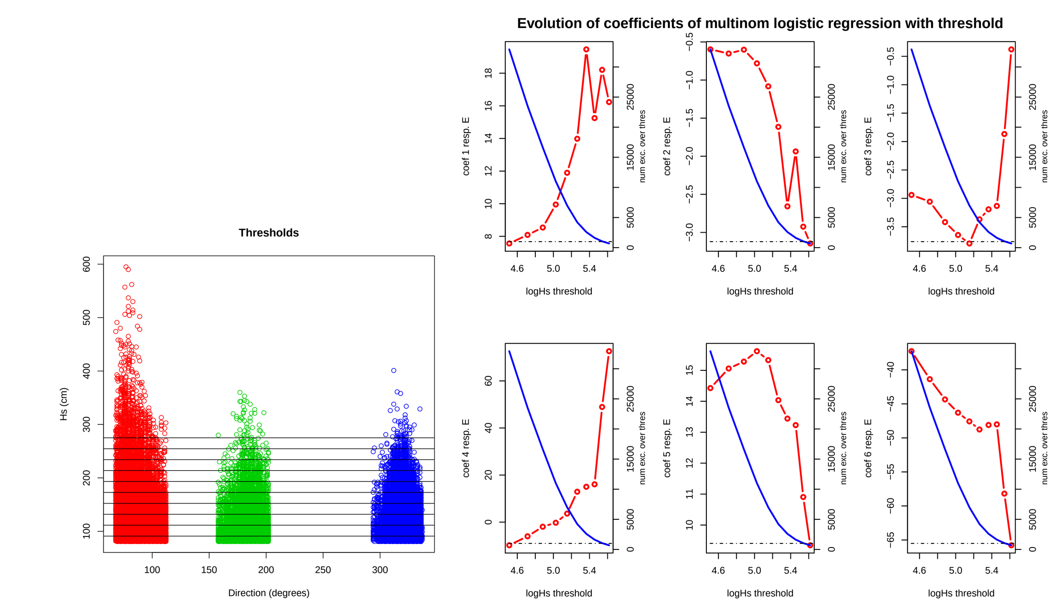

Figure 4: Selected thresholds for the assessment (left figure). Evolution of the coefficients of the model for excessess over selected threshold (right,red line). Number of excesses over selected threshold (right, blue line). The evolution of coefficient points to the differentiation of directions, according to the different characteristics in Hs and Tp in observed data (Fig. 3)

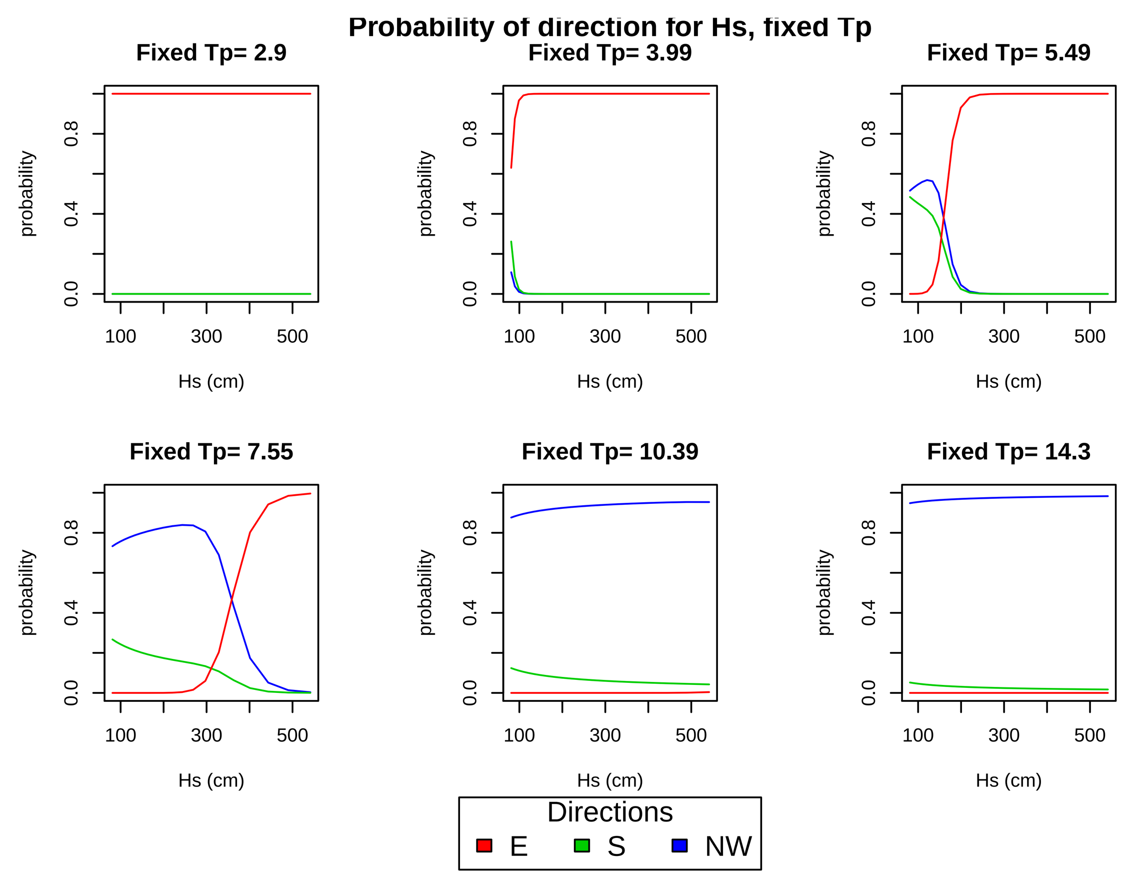

Figure 5: Predicted probability of direction for each significant wave-heigt (Hs), given the period (Ts).

Discussion

- The proposed logistic model is very simple, but performs well. The main characteristics of the waves in the area are captured and the obtained probabilities correspond to the deep knowledge of the specialists.
- Considering the appropiate scale of variables (compositional character, relative scale) adds extra quality to predictions.

References

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