Probabilistic Assessment of Exposure to Coastal Hazards at a Nuclear Power Station Development Site in the UK

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Abstract

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1. BACKGROUND

Nuclear power is a vital clean energy source. Many nuclear power plants are situated in coastal areas which expose them to external hazards such as coastal flooding and erosion. These hazards can arise from various processes (meteorological, oceanographic, etc.) that act on a wide range of spatial and temporal scales. Therefore, the assessment of coastal hazard potential is a complex problem that requires consideration of multiscale variabilities. Here, we apply a weather-typing downscaling method to probabilistically assess the exposure to coastal flooding and erosion at Hartlepool nuclear station, UK.

2. DATA & METHOD

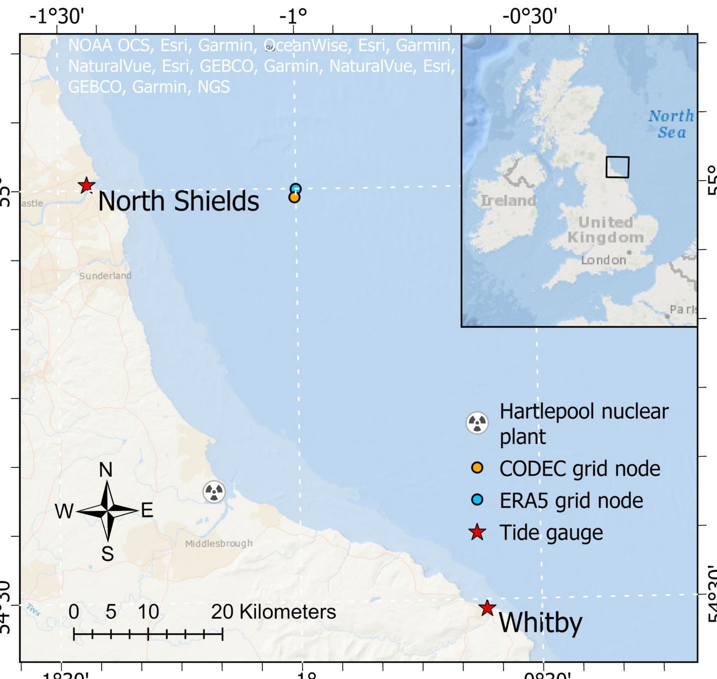

Fig. 1. Map of study location.

Table 1. Summary of datasets used.

	Variables	Source	Range
Predictors	Sea level pressure (SLP) and squared SLP gradient (SLPG)	ERA5	1979-2018 (40 years)
Predictands	Wave parameters	ERA5	
	Non-tidal residuals (storm surge)	CODEC	

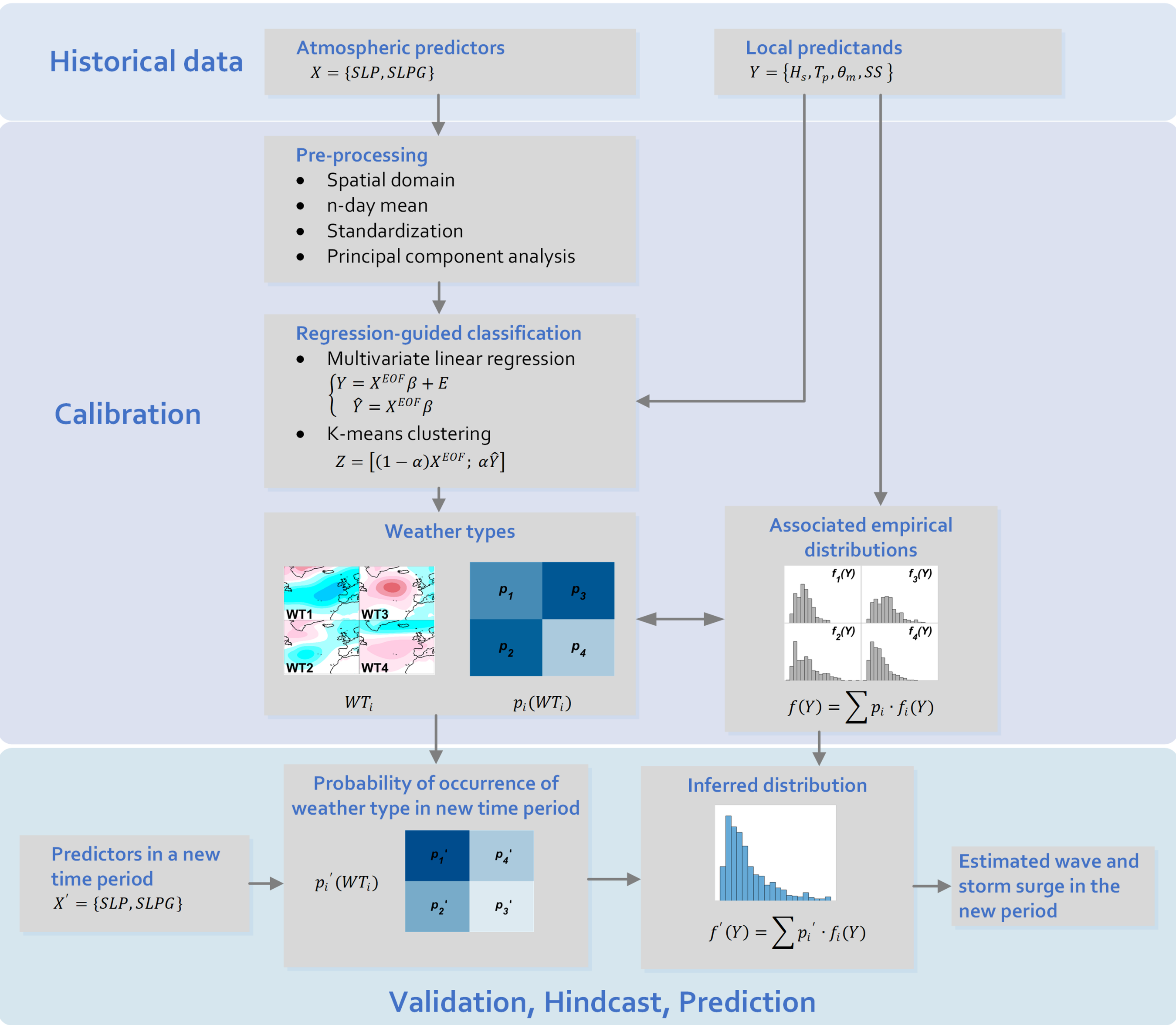

Fig. 2. Flowchart of the weather typing method (based on Camus et al., 2014, 2016).

3. RESULTS

3.1 Developed weather types and empirical distributions

We developed 36 weather types (WTs) as a representative set of synoptic situations over the UK and the surrounding Atlantic and European areas (Fig. 3). Each WT is associated with unique distributions of local wave climate and storm surge (SS) which serve as a connection between regional atmospheric conditions and local sea states at Hartlepool. WTs with intense pressure gradients (e.g., WT25 and 31) tend to produce waves with larger -than-average significant wave height (H_s), whereas WTs with low pressure gradients (e.g., WT 16 and 22) generate predominantly waves with low H_s (Fig. 4).

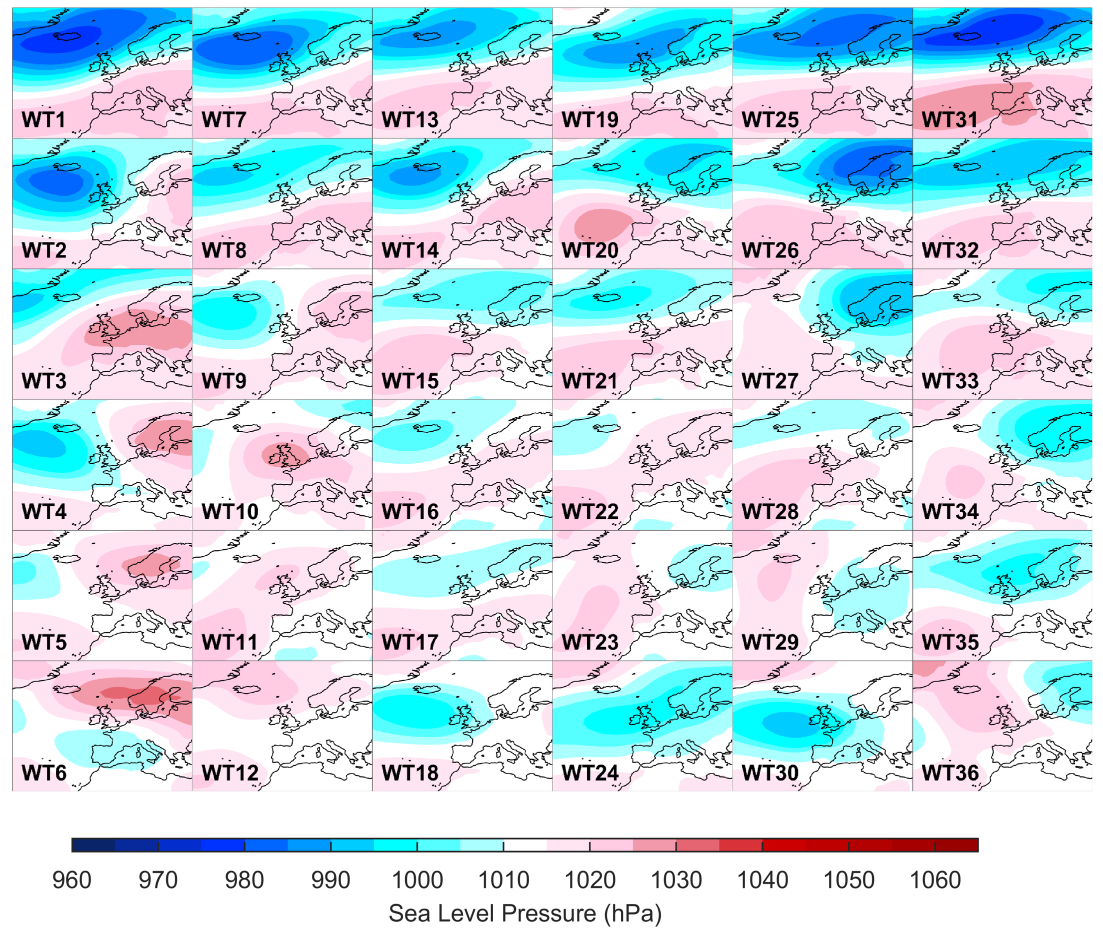

Fig. 3. Weather types developed for Hartlepool.

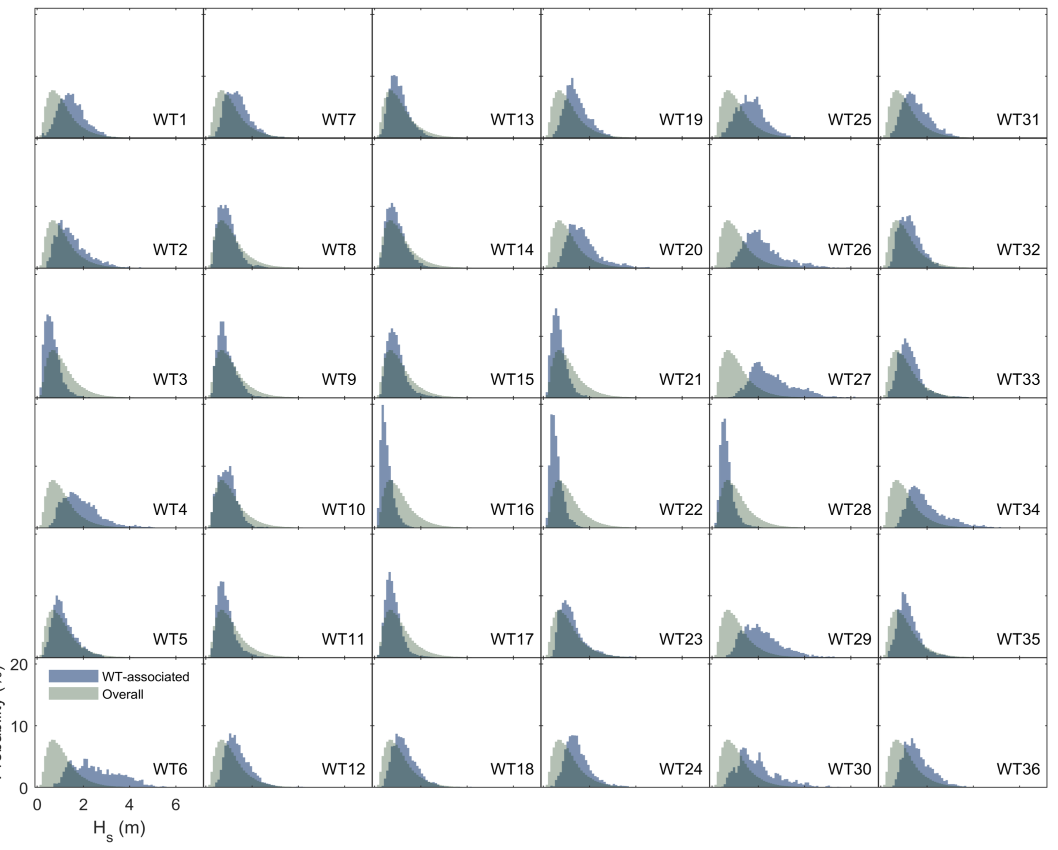

Fig. 4. H_s probability distributions associated with each weather type (blue) and the overall condition (green).

3.2 Identify coastal-risk weather types

The derived empirical distributions (e.g., Fig. 4) are very helpful in objectively identifying WTs with higher risk potential. Fig. 5 displays the median and spread of those distributions. In terms of waves, WT27 and 29 can potentially cause extreme events with a 10-year return period. This is useful in reducing the number of scenarios necessary for more detailed hazard modelling.

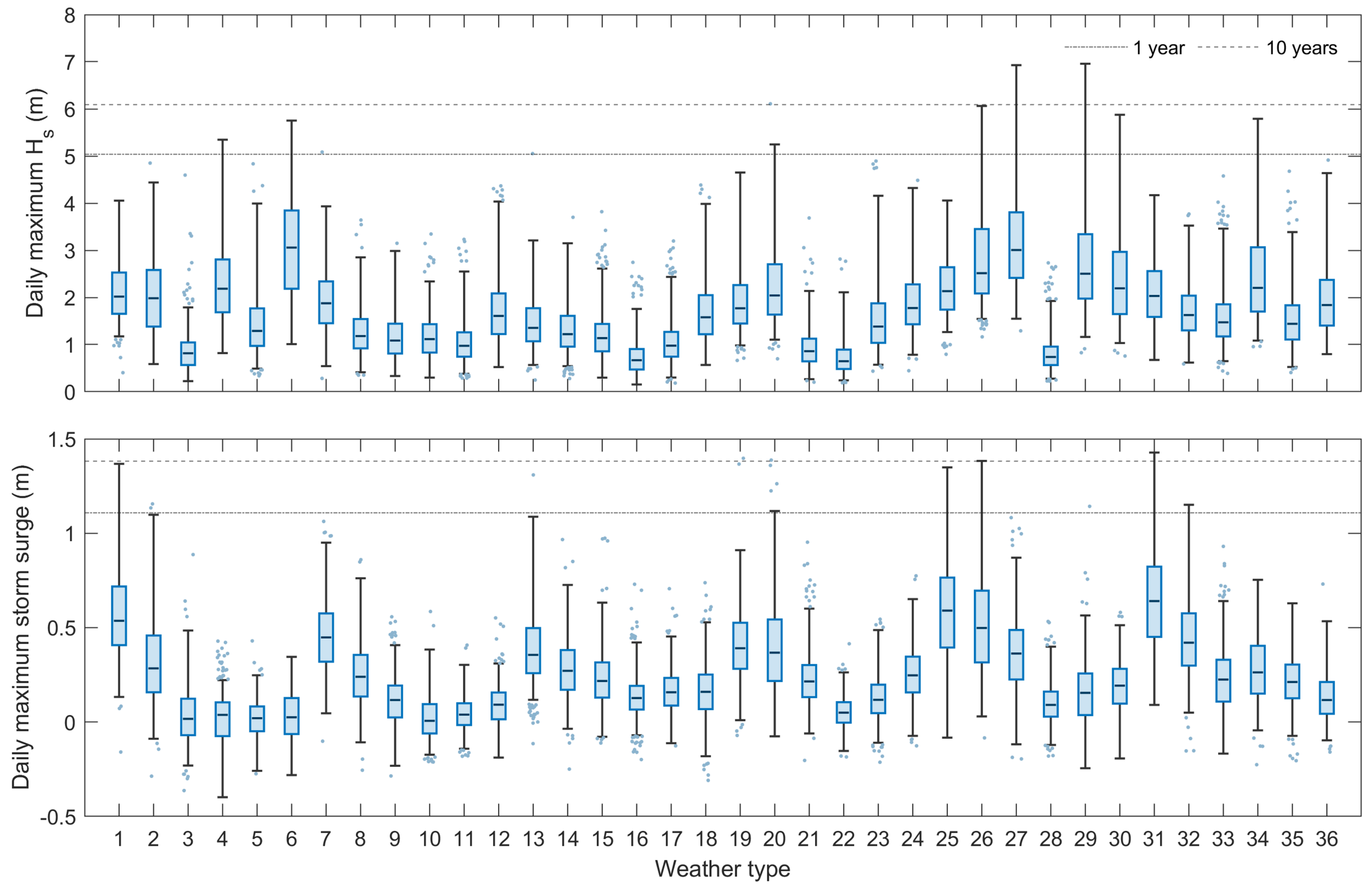

Fig. 5. Distributions of daily maximum H_s and SS for each WT.

3.3 Sensitivity analysis

- Using both SLP and SLPG as the predictor yields better performance compared to using either one individually (Fig. 6).
- H_s, θ_m and SS_{95} are not very sensitive to spatial domain (not shown) or temporal coverage (Fig. 7), but T_p gets more accurate on larger domain and longer coverage.

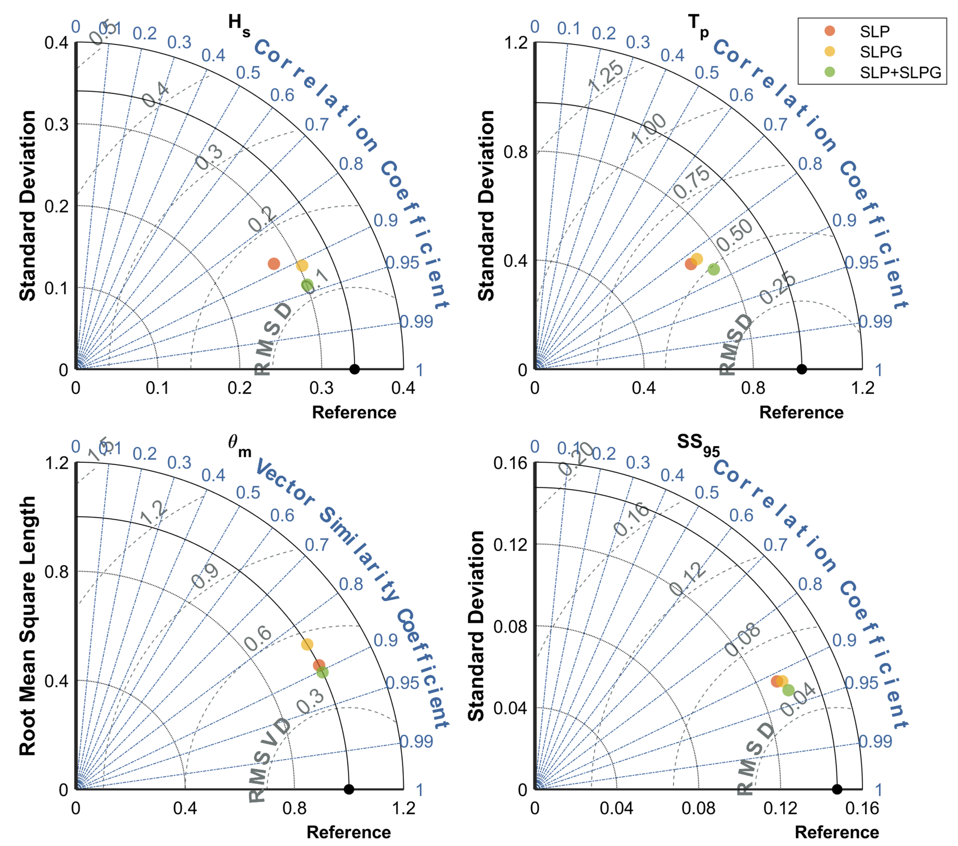

Fig. 6. Sensitivity analysis on predictor variable (T_p: peak wave period; θ_m: mean wave direction; SS_{95}: the 95th percentile of storm surge).

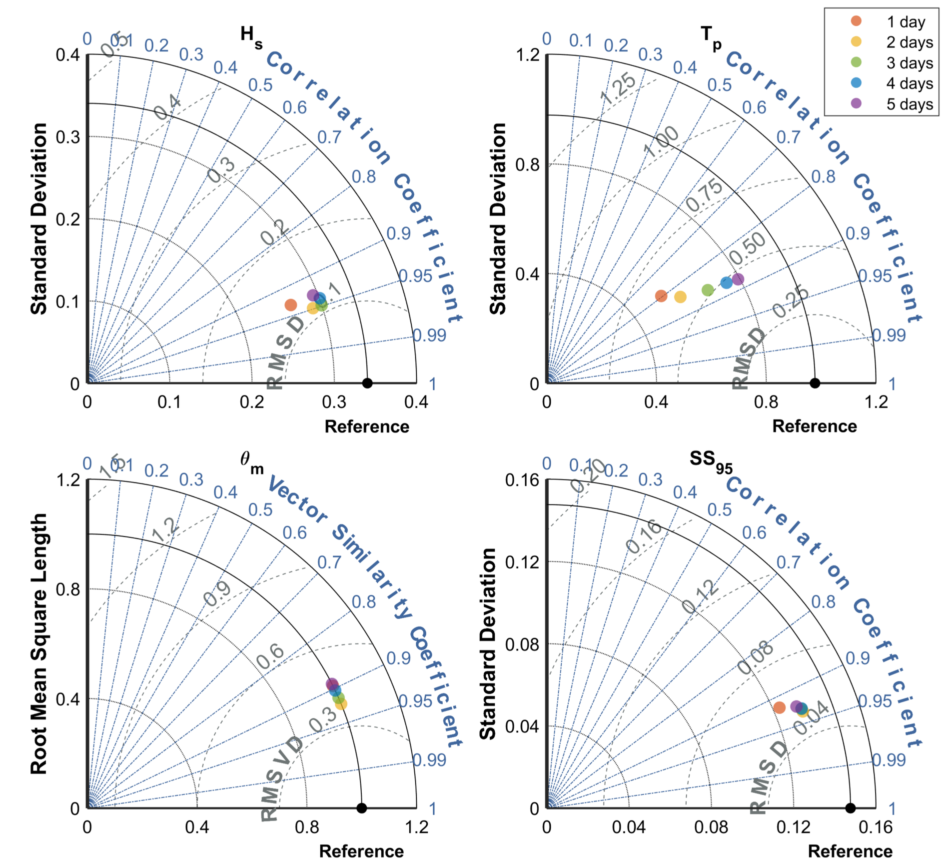

Fig. 7. Sensitivity analysis on temporal coverage (i.e., the number of days to be averaged, see Fig. 2).

4. CONCLUSIONS

- A set of 36 weather types were developed to downscale from regional atmospheric conditions to local wave climate and storm surge at Hartlepool.
- The empirical distributions associated with each weather type are helpful to understand the relationships between large-scale atmospheric patterns and local sea states, and identify coastal-risk weather types.
- A series of sensitivity analyses were conducted to test what factors are important in downscaling different local parameters .

REFERENCES

Camus, P., Menendez, M., Mendez, F. J., Izaguirre, C., Espejo, A., Canovas, V., ... & Medina, R. (2014). A weather-type statistical downscaling framework for ocean wave climate. Journal *of Geophysical Research: Oceans*, 119(11), 7389-7405.

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