Recent Changes in Storminess in the NW Coast of Scotland

Vincent Kümmerer[1], Óscar Ferreira[1], Carlos Loureiro[2]

[1] Centro de Investigação Marinha e Ambiental, Universidade do Algarve, Portugal
Correspondence: vkuemmerer@ualg.pt
[2] Biological and Environmental Sciences, University of Stirling, United Kingdom

ENCONTRO COM A CIÊNCIA E TECNOLOGIA EM PORTUGAL
28 a 30 JUNHO 2021
#ciencia2021PT
2021PORTUGAL.EU

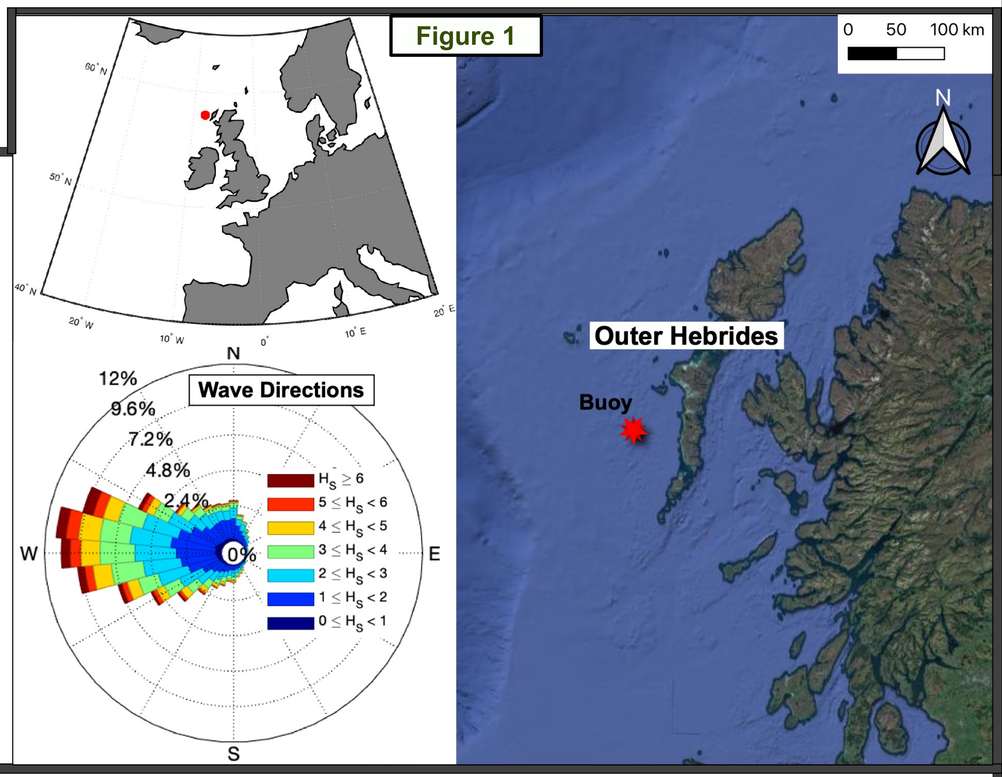
INTRODUCTION

Coastal **storms** correspond to periods of **high-energy wave events**, combined with increased water levels and strong currents. The coastal zone is able to buffer some of the most intense events, yet, coastal storms still cause **large economical** disruptions and significant **human losses**. Therefore, it is crucial to **investigate recent changes in storminess** to **understand future** scenarios for coastal zones.

The **Outer Hebrides** (Fig. 1), located along the North Atlantic storm track, are exposed to **frequent and intense storms** that reach the coast every year with waves as high as 12 m (Fig. 2). Although waves are measured with buoys, **numerical models** can be used to extend observational wave records backwards in time (hindcasting or reanalysis). The high energy events within long-term wave timeseries can be filtered out, allowing to investigate wave storm events and climatology.

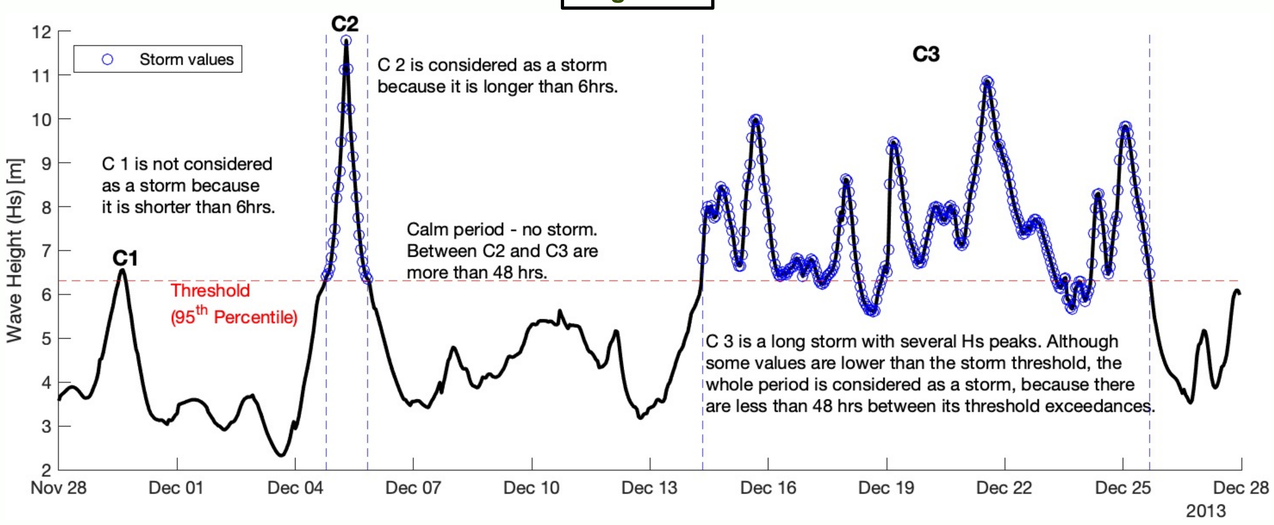
In this study we investigate the **variability** and **trends** in **wave storminess** in the last 70 years (1950-2020) for the Outer Hebrides, using two of the most recent and advanced wave re-analysis products.

Figure 1



METHODOLOGY

Figure 2



The data for this study were obtained from the CEFAS Outer Hebdrides wave buoy, ERA5 re-anylsis model of the **European Centre for Medium-Range Weather Forecasts** [1] and the Atlantic-European North West Shelf Wave Physics reanalyis of the **Copernicus Marine Service** [2], hereafter ERA5 and CMEMS, respectively. While ERA5 covers the last 70 years with hourly data, CMEMS is restricted to the last 40 years, with data every 3 hours.

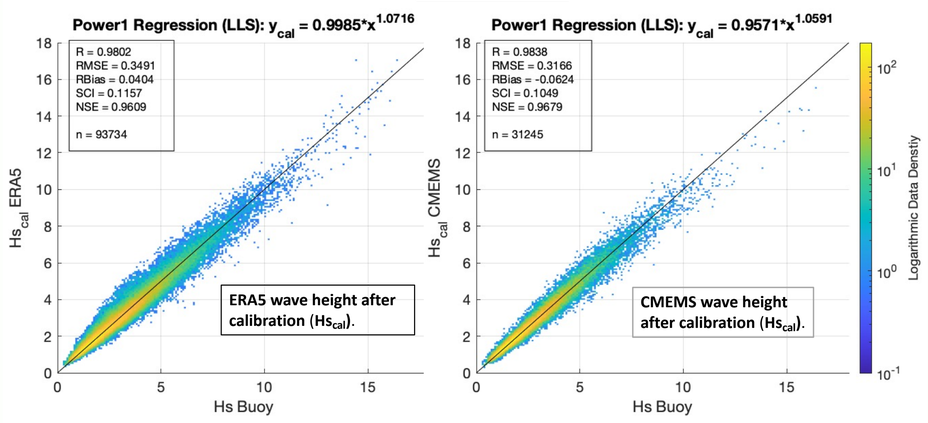
Modelled Waves were compared to buoy measurements for **validation and calibration**, following which the time series was **filtered** using a **Peaks Over Threshold** approach to extract **storm events** (see Fig. 2 for the used critera).

Several storm variables were calculated and evaluated for **long-term trends** using the Mann-Kendall significance test and Sen's slope estimation. **Correlations** of storm variables with climatic indices, such as the **North Atlantic Oscillation** (NAO) were also investigated.

RESULTS

There is a **strong positive correlations** between **model** and **buoy data.** For the calibrated wave height (Hs), the correlation coefficient (R) is higher than 0.98 and the root-mean square error (RMSE) is less than 0.35 m.The **calibration reduces model underestimation** by **7.8%** for ERA5 and **2.7%** for CMEMS (Fig. 3).

Figure 3



The **storm power**, a variable that incorporates the storm wave height and peak period, shows variability and periodicity with winters that have total storm powers up to $4x10^8$ Wh/m.

In the past 70 years there is a **significant increasing trend** in storm power. However, looking at the last 40 years there is no significant trend observed (Fig. 5).

Storminess, a function of storm wave height and storm counts, is characterized by a **significant increasing trend** when considering the **last 70 years** but a **decreasing trend** if only **the last 40 years** are analysed. CMEMS and ERA5 show similar storminess values along the years (Fig. 6).

A **strong correlation** exists between the wave **storminess** and the **NAO**. During positive NAO phases (strong subtropical high-pressure and deep low-pressure over Iceland), storminess increases at the Outer Hebrides, decreasing when the NAO is in a negative phase (Fig. 6).

From 1980 to 2019, a total of 519 and 518 storms were extracted from the ERA5 and CMEMS datasets, respectively. This value increases to **880 storms when considering the last 70 years**

85% of all the total storms occur during the winter season from **October until March** (Fig. 4), with 60% concentrated in the months between December and March.

Figure 4

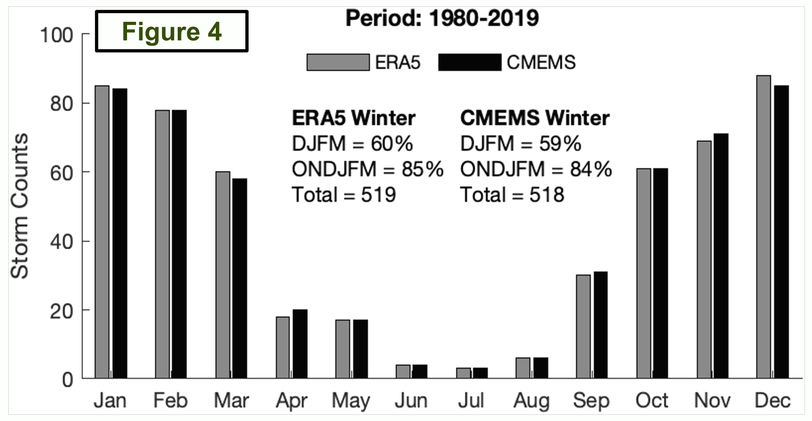


Figure 5

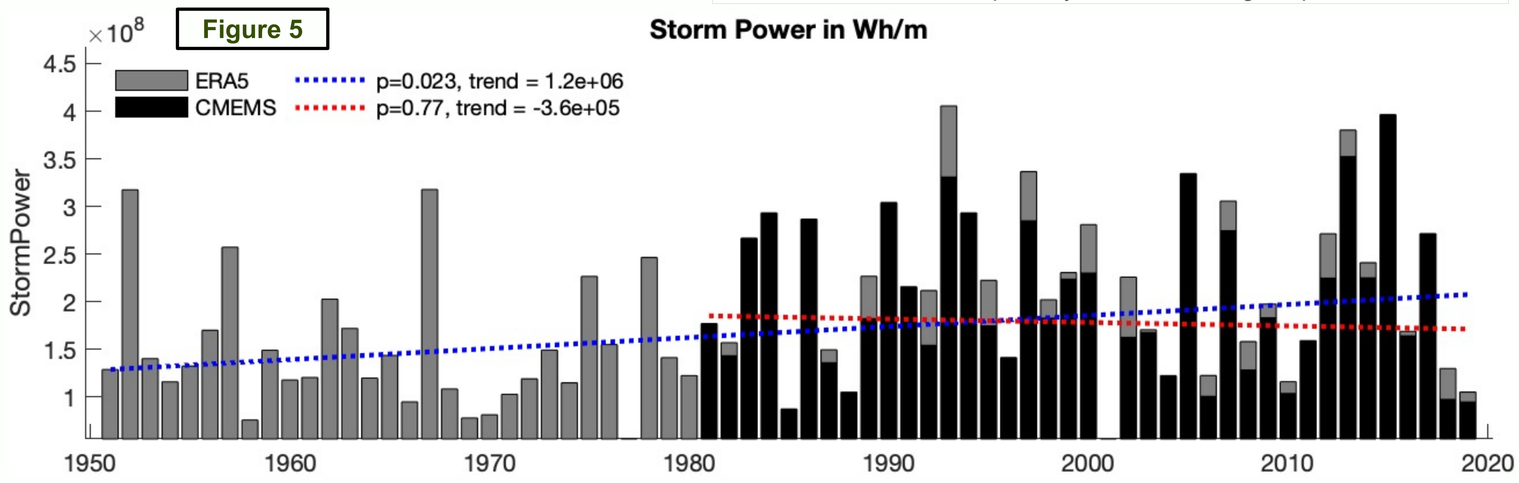
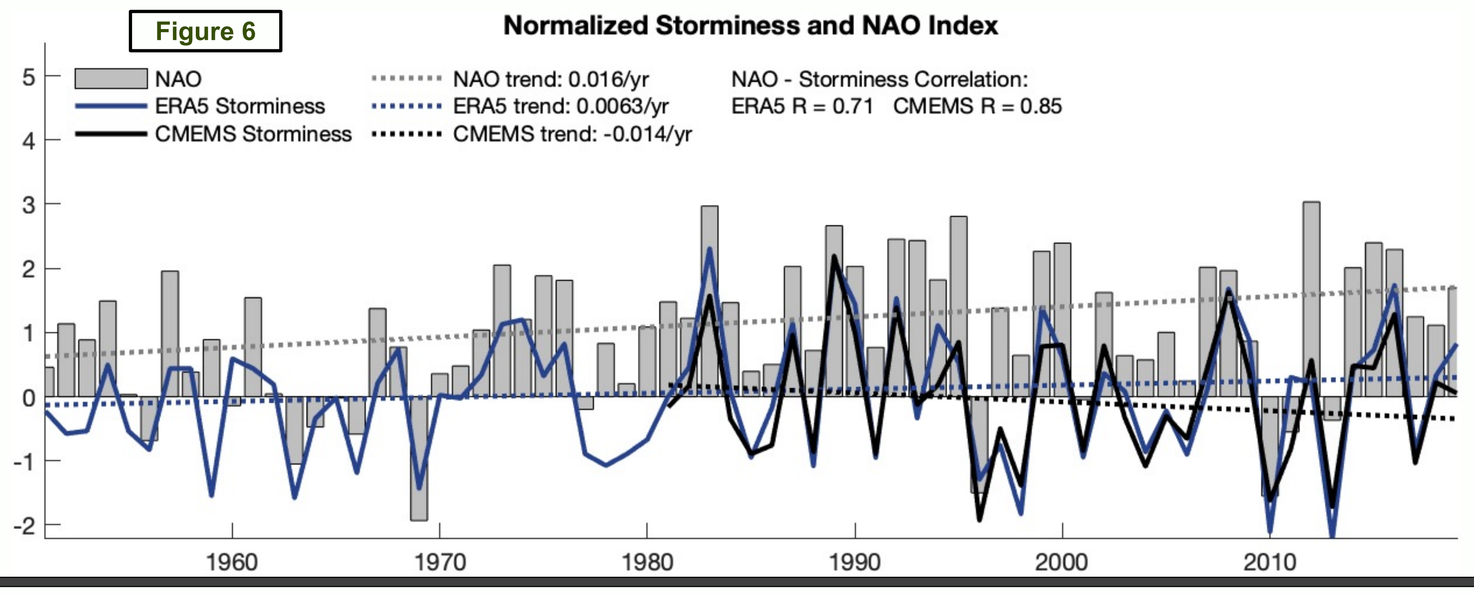


Figure 6



CONCLUSION

- ✓ ERA5 and CMEMS reanalysis perform well compared to buoy observations and are suitable to investigate wave climate variability in the study area, especially when calibrated.
- ✓ While trends depend strongly on the time frame of analysis, longer-term data (70 years) indicate increasing storminess and storm power, however with a decreasing trend for the last 40 years.
- ✓ The strong correlation between the NAO index and the storminess demonstrates a clear climatological control in interannual variability and periodicity of storms in the NW coast of Scotland.

REFERENCES

[1] Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A., Muñoz-Sabater, J., ... & Thépaut, J. N. (2020). The ERA5 global reanalysis. Q J R Meteorol Soc, 146(730), 1999-2049.
[2] Global Monitoring and Forecasting Center (2018) ATLANTIC- EUROPEAN NORTH WEST SHELF- WAVE PHYSICS REANALYSIS, *E.U. Copernicus Marine Service Information* [Data set]. Available at: https://resources.marine.copernicus.eu/?option=com_csw&view=details&product_id=NWSHELF_REANALYSIS_WAV_004_015

ACKNOWLEDGMENT

Vincent Kümmerer is receiving funding through FCT grant 2020.07497.BD.

FCT Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR
UAlg CIMA
UNIVERSIDADE DO ALGARVE
CENTRO DE INVESTIGAÇÃO MARINHA E AMBIENTAL
UNIVERSITY of STIRLING