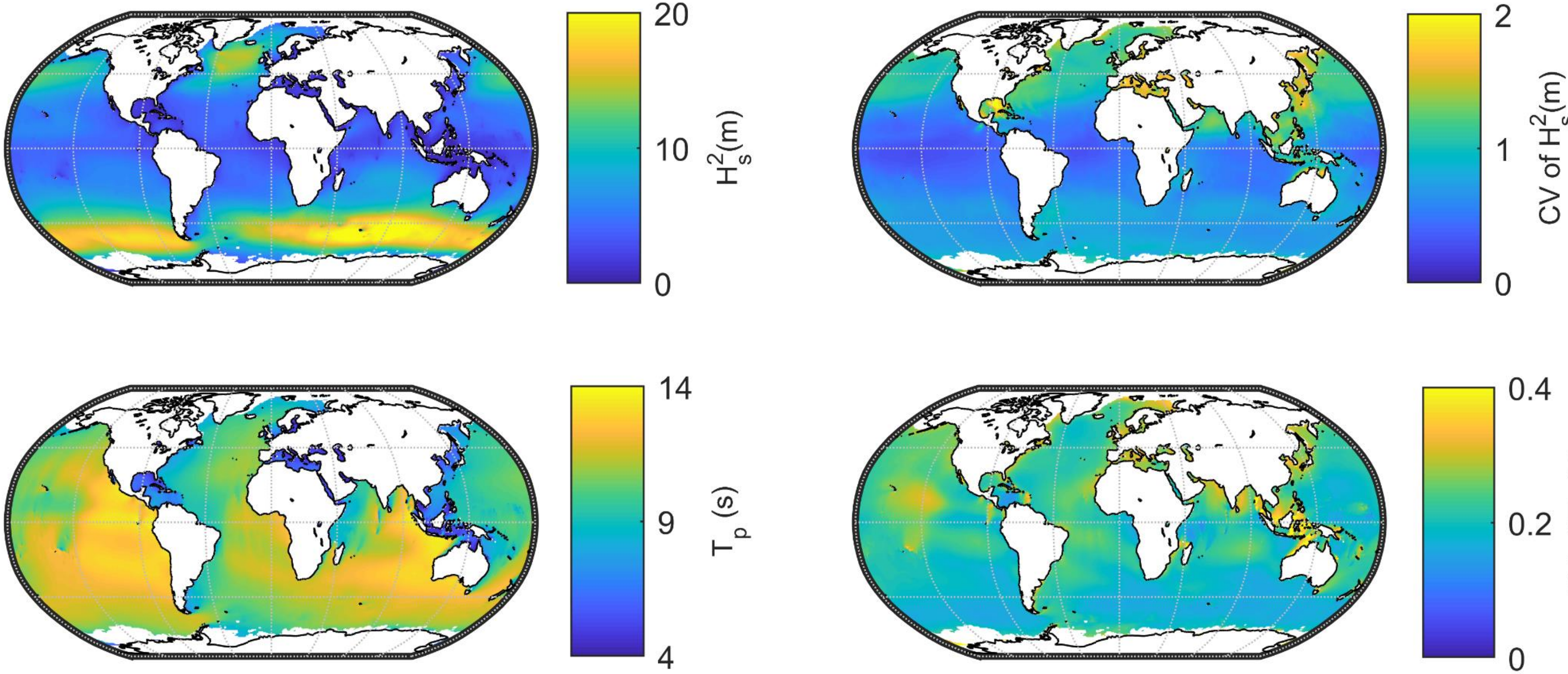
Classifying the global wave climate for the purposes of wave energy extraction

Iain Fairley*, Ian Masters, John Chapman and Dominic Reeve

*i.a.fairley@swansea.ac.uk, Energy and Environment Research Group, College of Engineering, Swansea University

Introduction



ECMWF ERA5 DATA from 2000 – 2011, 3hrly intervals

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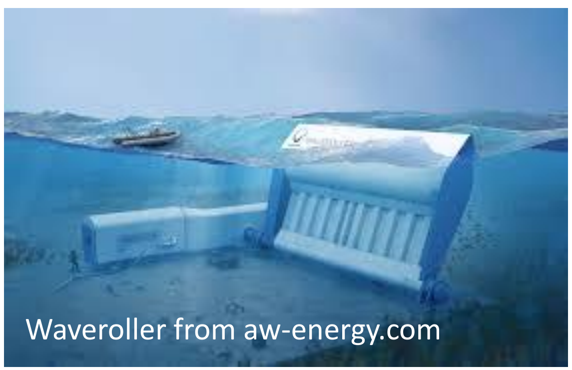
Introduction

- Huge range of wave energy converter designs
- Utilising both kinetic and potential energy
- Different deployment areas from shore attached to deep sea


Waveroller from aw-energy.com


WaveDragon from wavedragon.net

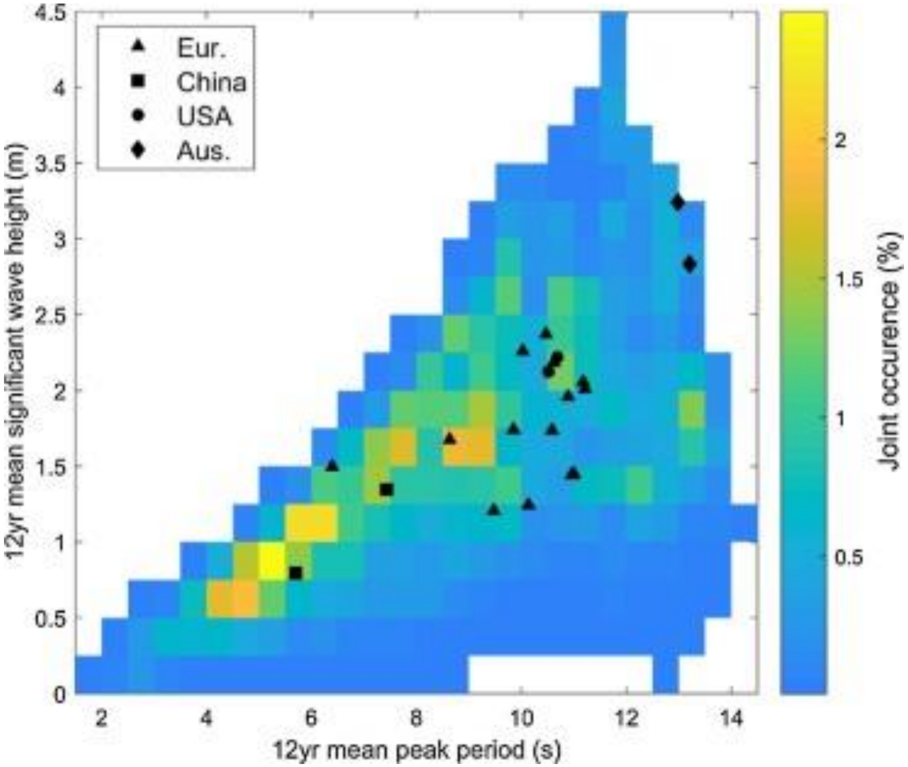

Pelamis from emec.org.uk


Marine Power Systems WaveSub

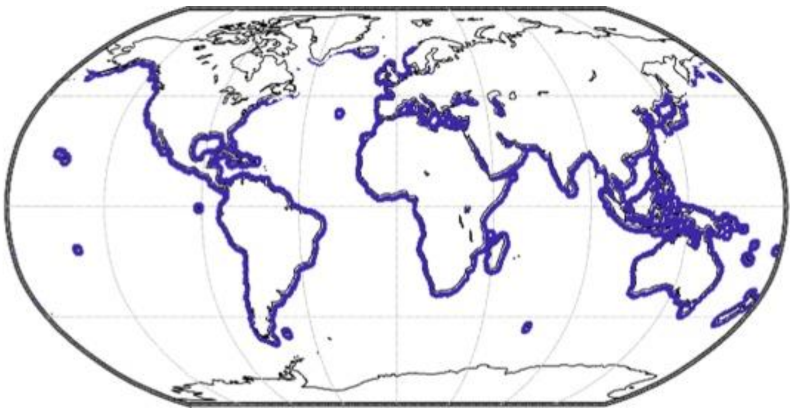

OPT PowerBuoy


Mutriku oscilating water column, from: https://www.renewable-technology.com/projects/mutriku-wave-energy-plant/

Introduction



Joint occurrence in global coastal space not time

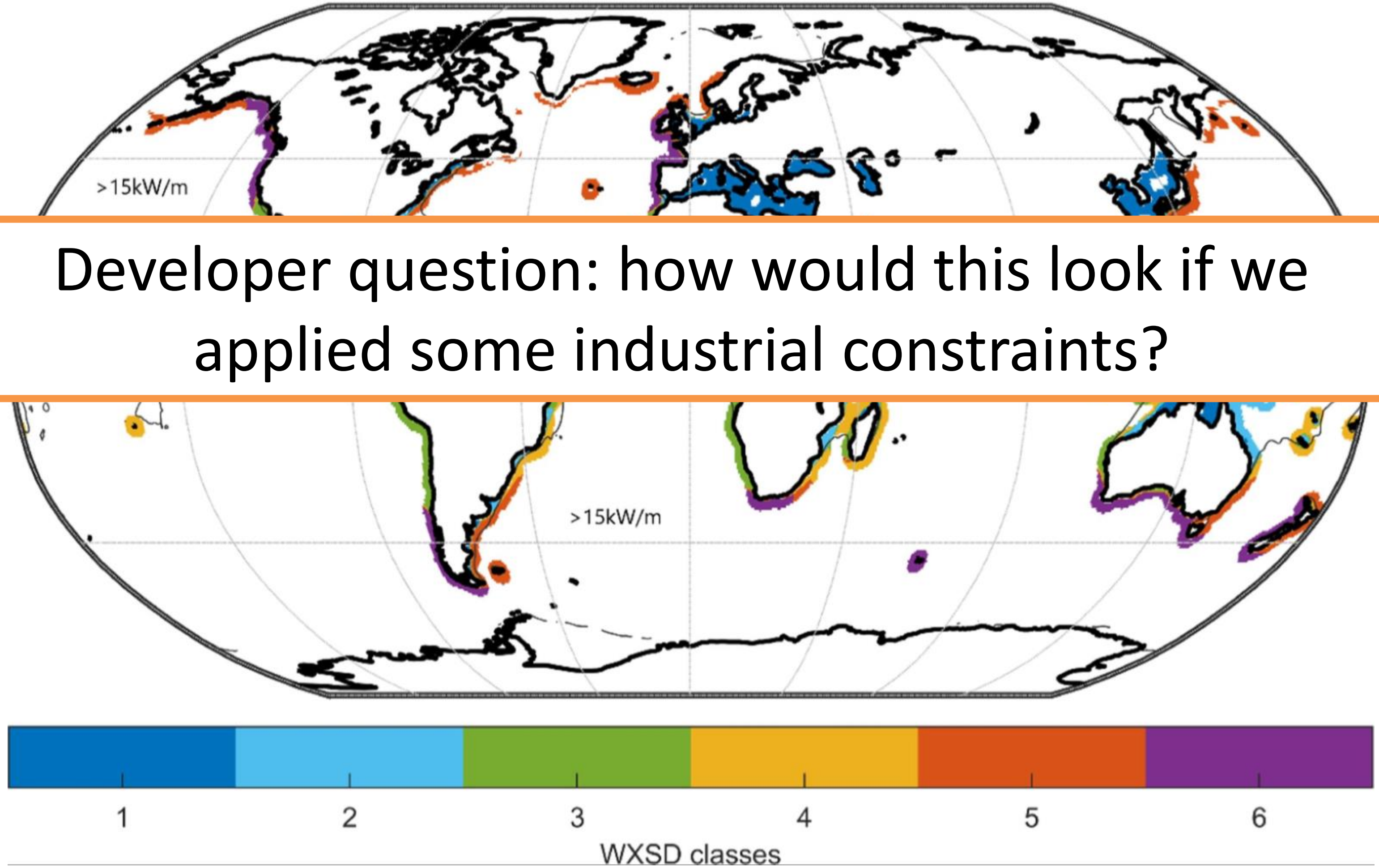


Can we define a global wave resource classification to:

- Identify areas of alternative resource characteristics
- Assist with global roll-out of existing devices

Fairley et al, 2020, A classification system for global wave energy resources based on multivariate clustering, Applied Energy. https://doi.org/10.1016/j.apenergy.2020.114515

Introduction

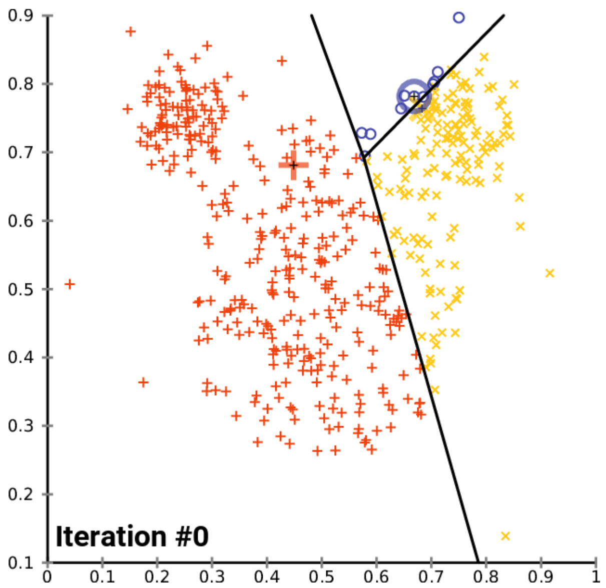


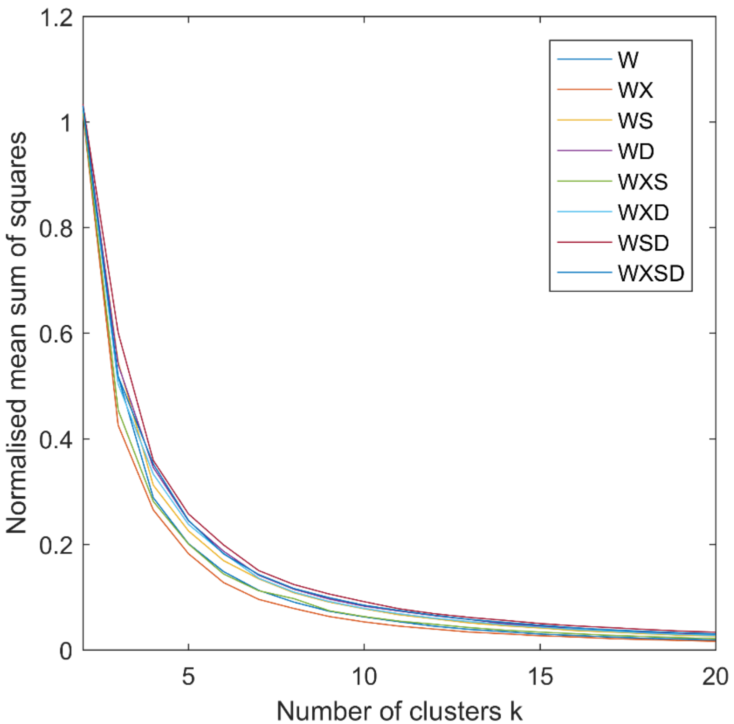
Developer question: how would this look if we applied some industrial constraints?

Fairley et al, 2020, A classification system for global wave energy resources based on multivariate clustering, Applied Energy. https://doi.org/10.1016/j.apenergy.2020.114515

Method

- K-means clustering to define classes
- Parameters normalised to provide equal weighting,
- Elbow / silhouette tests to determine no. of classes





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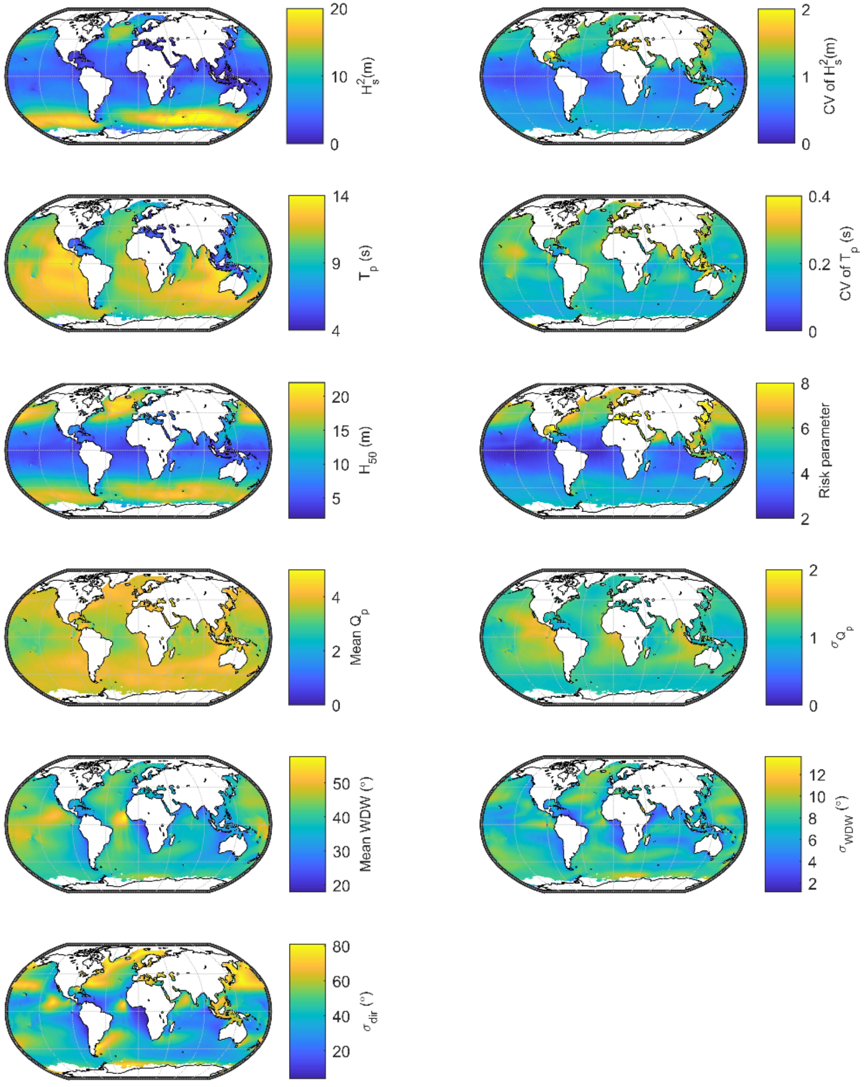
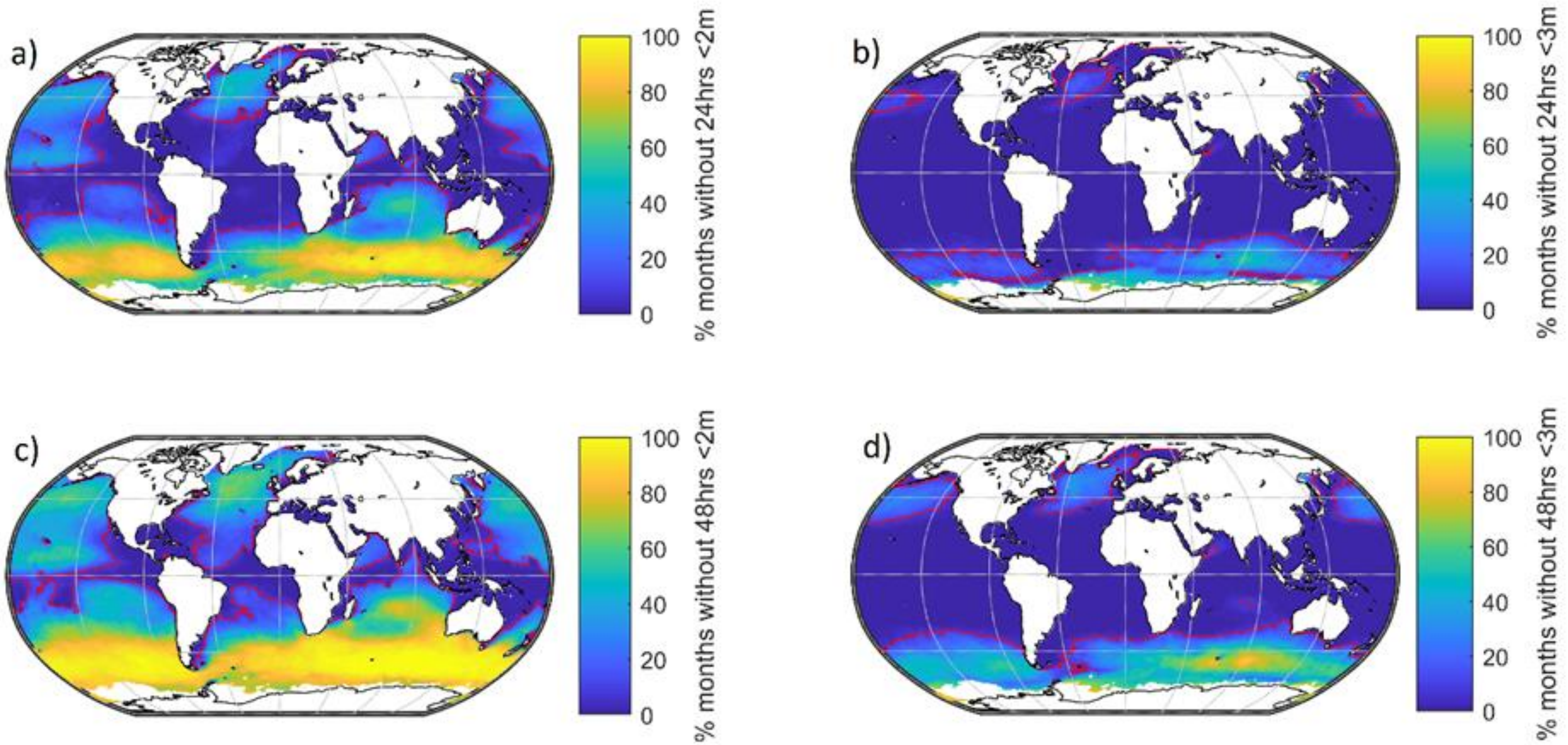
Method

- Data from ECMWF ERA5 between 2000-2011 at 3hrly intervals,
  - Mean and coefficient of variation of H_s^2
  - Mean and CoV of T_p
  - 50 year return period extreme wave height
  - Risk factor (H_{50} / mean(H_s))
  - Mean and standard deviation of Q_p
  - Mean and standard deviation of directional width
  - Standard deviation in direction

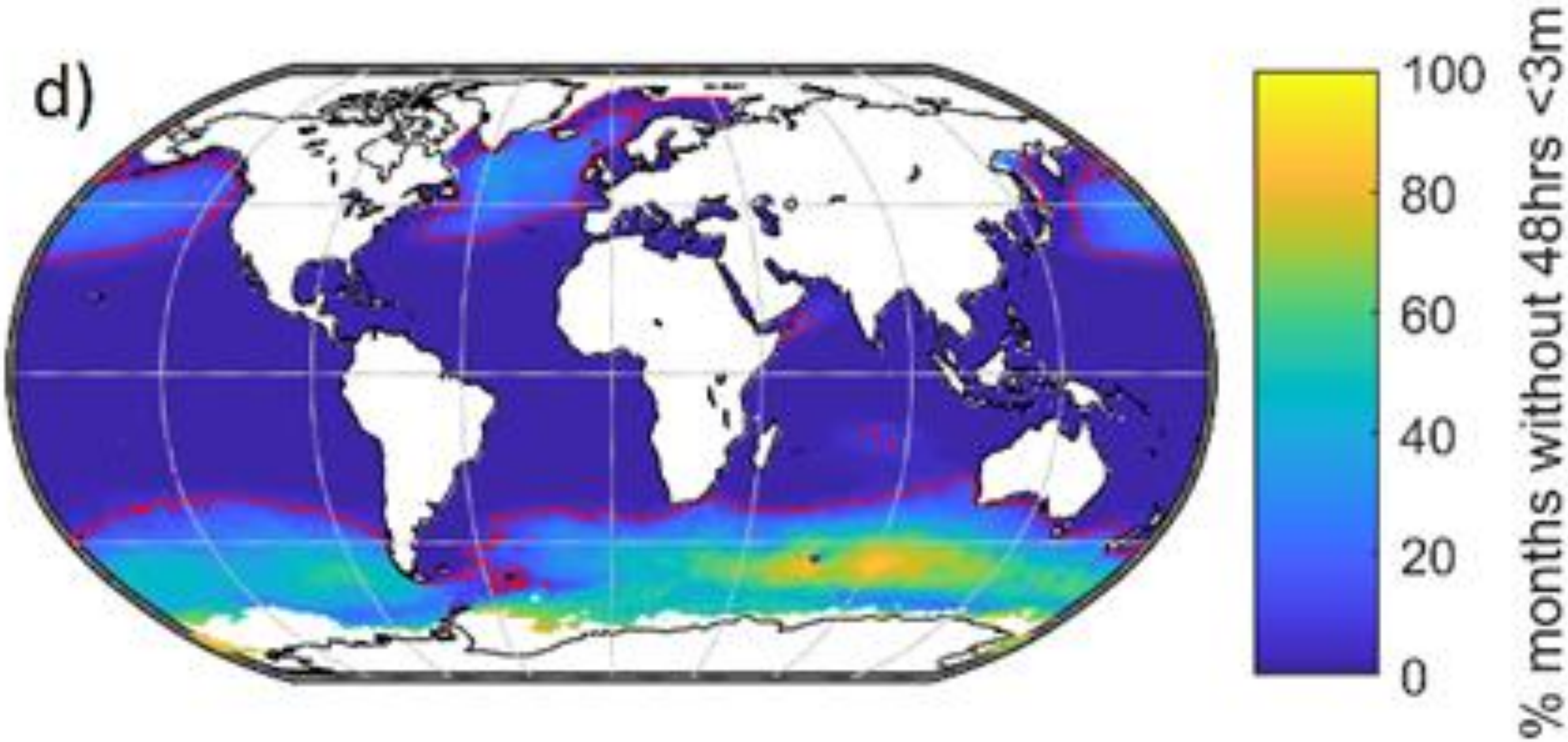


Weather windows



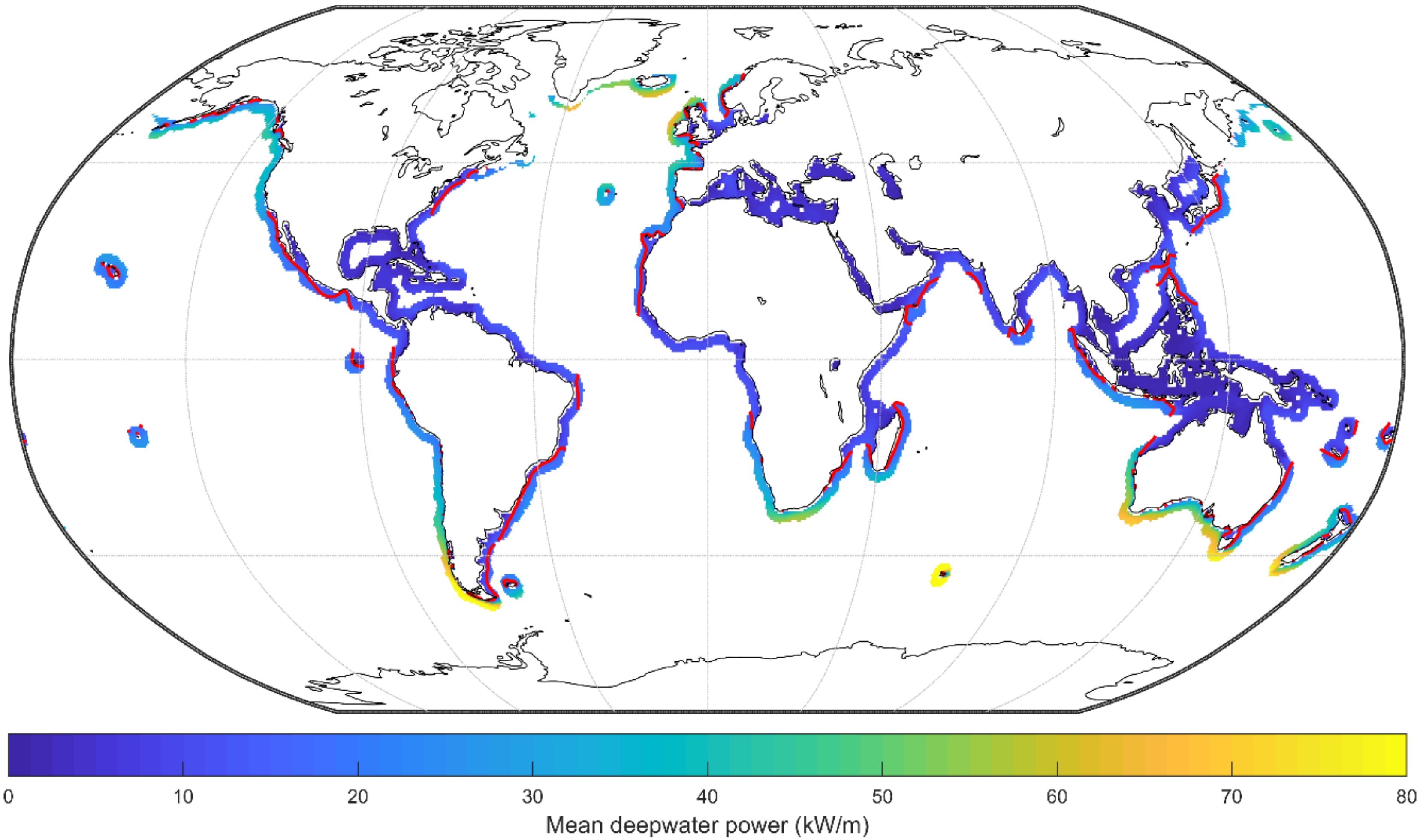
- Requirement to be able to access sites for 11 out of 12 months on average

Weather windows



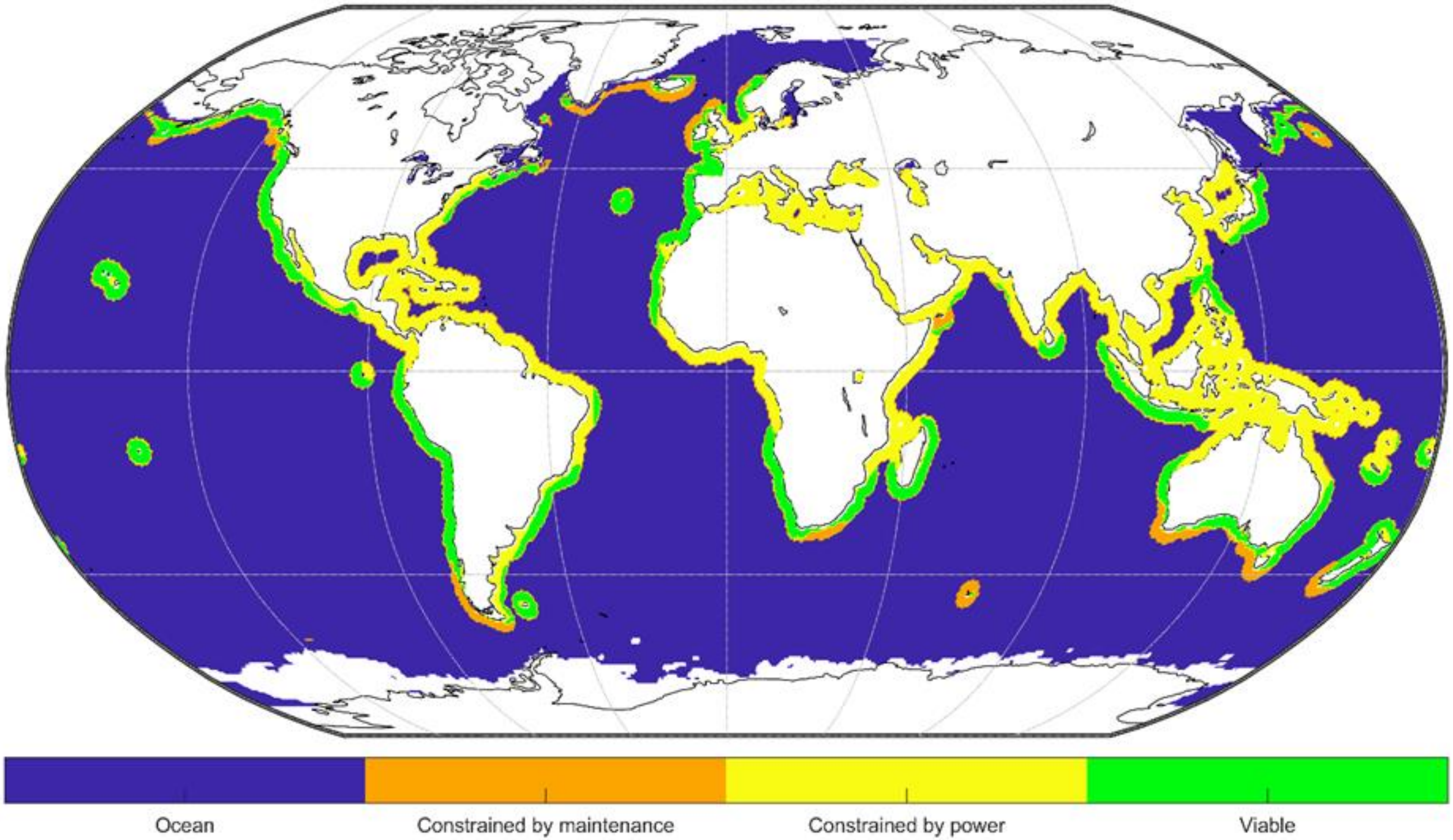
- Criteria 48 consecutive hours with H_s <3m

Power constraint



- Red line indicates 15 kw/m threshold

Constrained area



Reduction in area tested between coastal globe and constrained area

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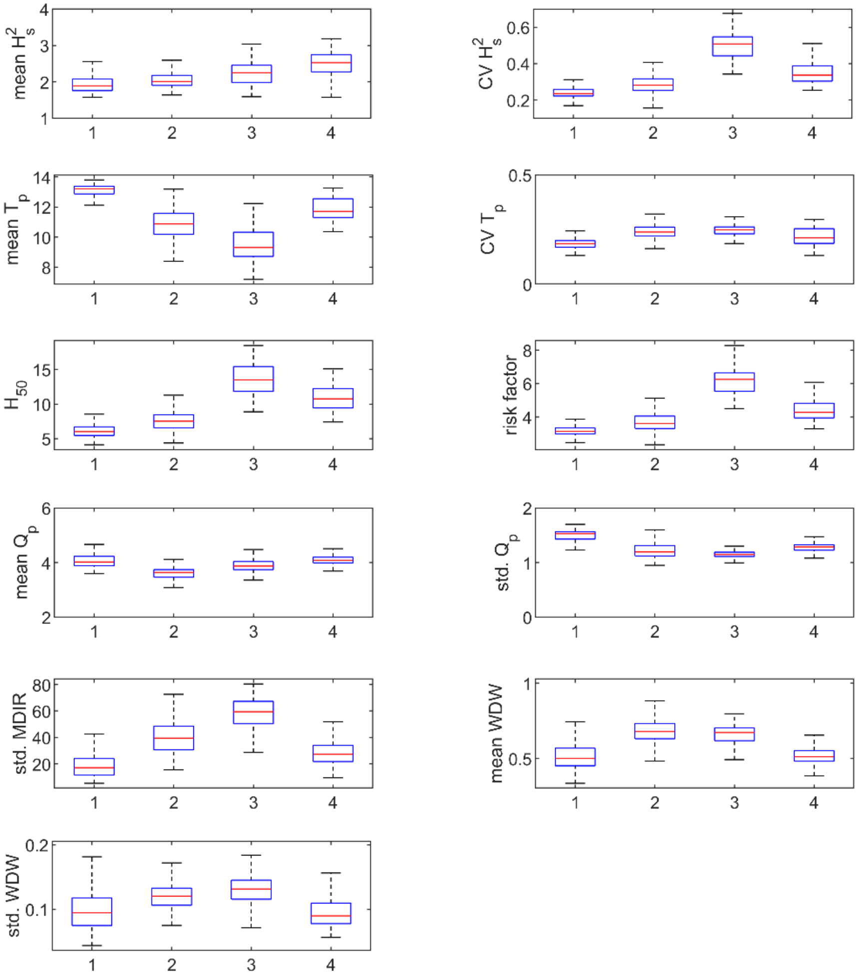
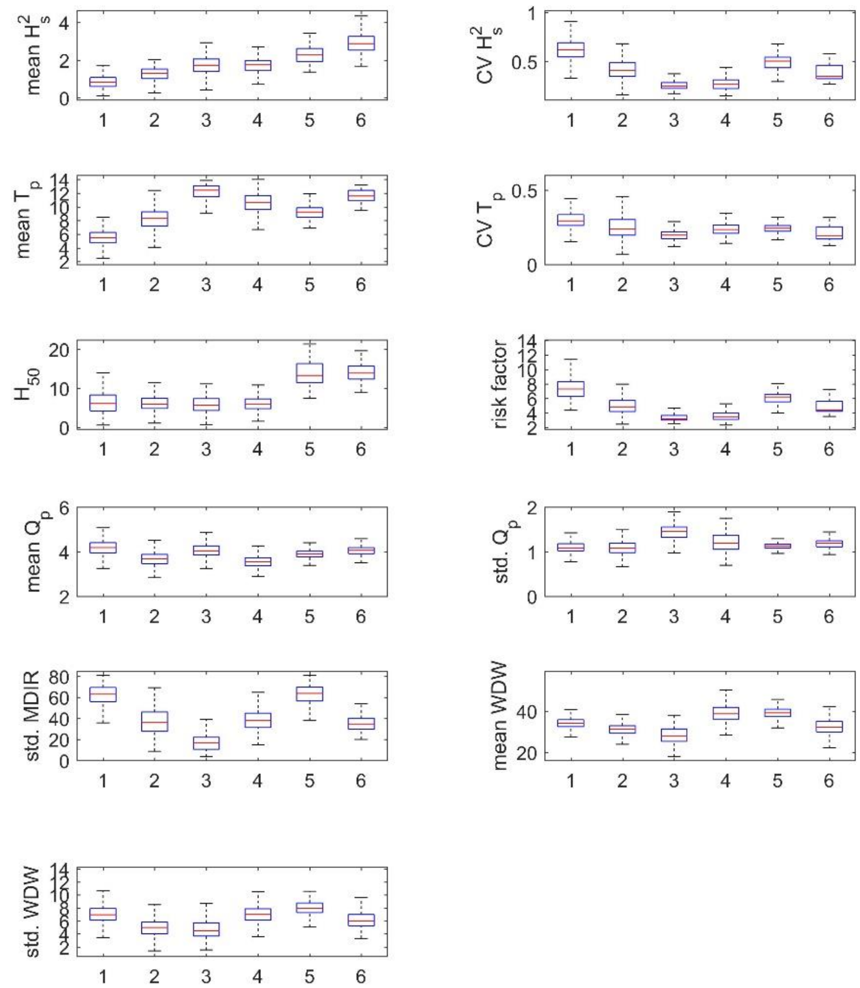
Comparison of parameters

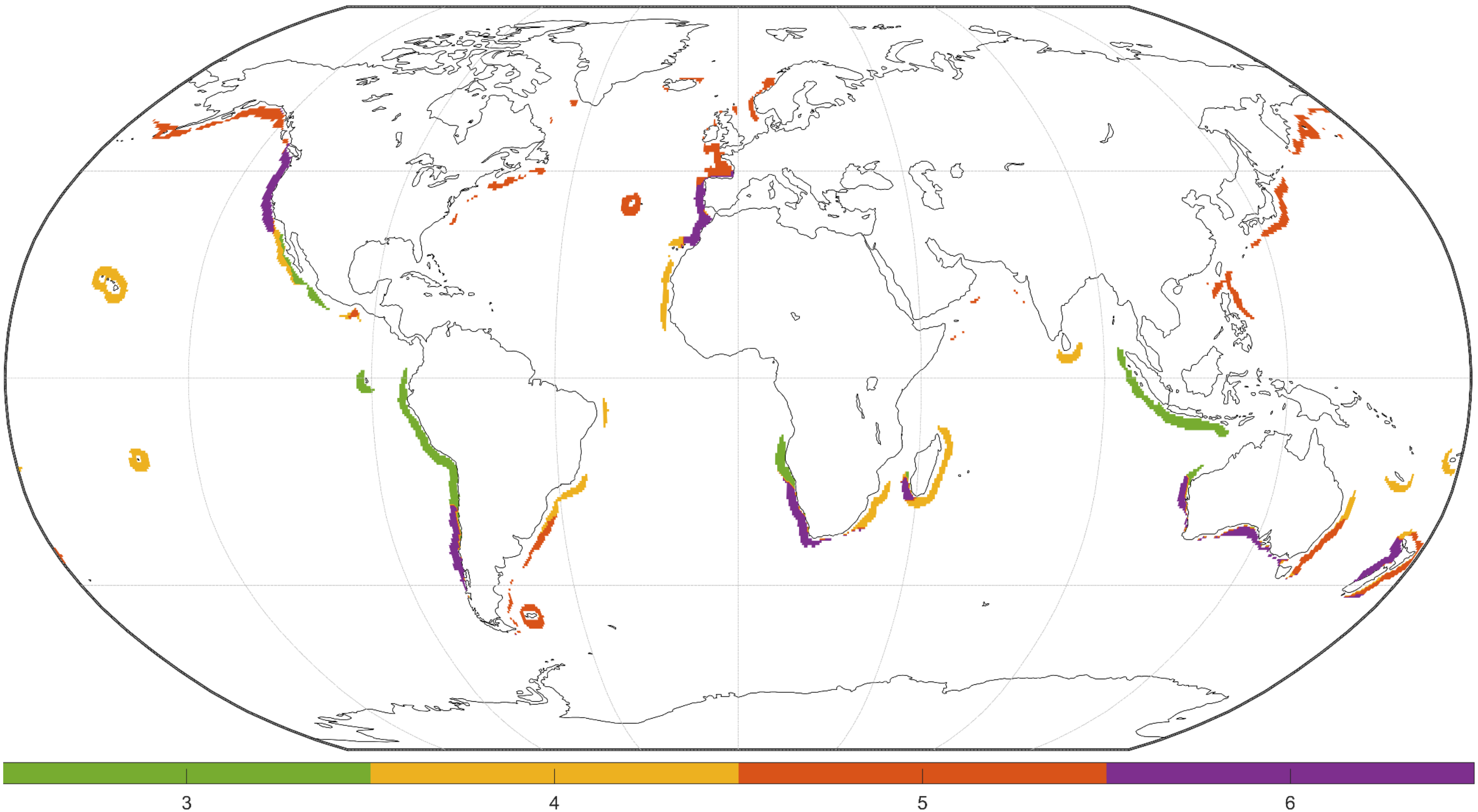
Constrained area



Coastal globe

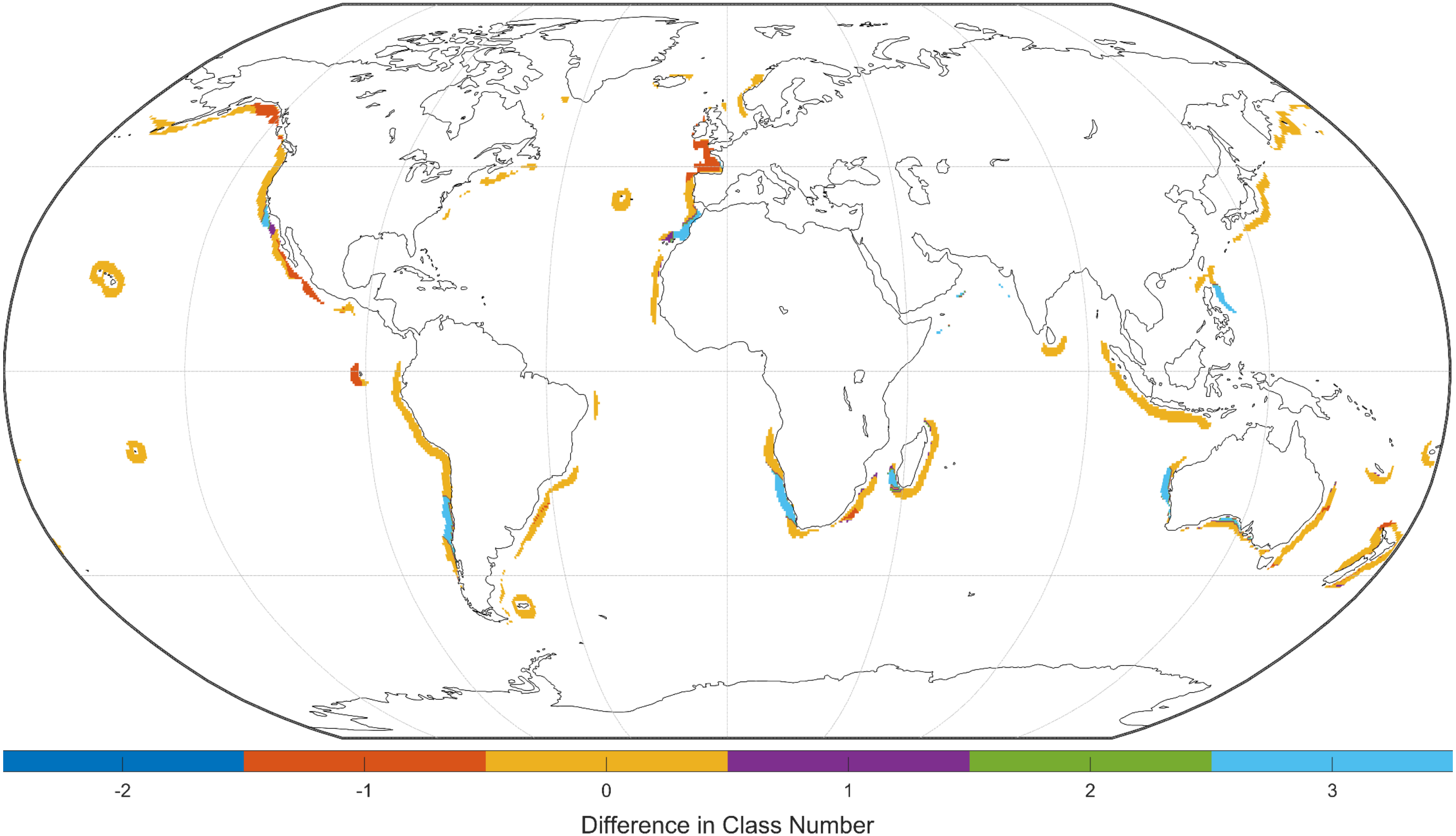


Geographical spread: Constrained area



Class number labelling changed from 1-4 to 3-6 to match global classification labelling

Geographic spread: Comparison



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Conclusions

- Reducing area reduces number of classes from 6 to 4.
- For constrained area, classes equivalent to classes 3-6 in coastal globe classification based on parameter space.
  - Lowest two classes dropped
- Geographical spread similar;
  - NW Europe drops to class five
  - Areas in Southern hemisphere go from class 3 to 6
- Both areas give classifications that intuitively match existing knowledge
- Limited benefit to adding constraints?
- Extension does demonstrate robustness of

  the classification methodology

Fairley et al, 2020, https://doi.org/10.1016/j.apenergy.2020.114515