

# Wave and Turbulence Interaction and Measurement at Tidal Sites

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#### Contents

- What is the problem with measuring turbulence?
  - Why is it waves?
- Separating turbulence and waves:
  - Spectral filter wavelet synchrosqueezed transforms
  - Statistical filter empirical orthogonal function analysis
  - Combined filter
- Assessing filter performance





#### Turbulent kinetic energy k



- Wave action is clearly driving near-surface  $k_{ADCP}$
- We therefore observe that k<sub>ADCP</sub> measures both turbulence and waves

 $k_{\text{ADCP}} = k_{\text{t}} + k_{\text{w}}$ 

 We want a filter to separate these phenomena







#### Spectral filter











#### WTIMTS









WTIMTS

#### Spectral filter results





WTIMTS

Swansea University

Prifysgol Abertawe

## Statistical filter - EOFs



 Decompose space- & time-dependent variable (e.g., TKE) into separate time and space modes

$$\tilde{k}(\boldsymbol{x},t) = \sum_{i=1}^{N} \text{EOF}_{i}(\boldsymbol{x}) \times \text{EC}_{i}(t)$$

- Modes are ordered by magnitude of autocorrelation explained
- Waves are expected to have a common shape ( $\sinh^2(z)$ )
  - Therefore they could be picked out as a common mode
- If they are dominant, the "wave" mode should be the 1<sup>st</sup> mode
- Method modified to deal with mean bias







#### Statistical filter results







WTIMTS



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## **Combined filter**

- Spectral/WSST filter and statistical/EOF filter apply on either side of the variance method
- Therefore combining the methods is straightforward

#### **Combined filter**







log<sub>10</sub> TKE, J·kg<sup>-1</sup>



#### **Combined filter**

100

80



Relative error - effect of magnitude cap with filter depth 120%, depth 10% 100 Average relative error (%) EOF filter only Both filters 80 60 40 20 0 Cap 0.02 Uncapped Cap 0.01





Average relative error (%) 60 40 20

0 Width 5% Width 10% Width 15%

Relative error - effect of filter width with constant filter depth of 120%

EOF filter only

Both filters

Offshore Renewable

Energy

Superge

### Conclusions



- A combined spectral-statistical filter for ADCP measurements of TKE has been developed:
  - Simple structure
  - Minimal computational cost
  - Improved error vs. waves
- Open source code available at github.com/MTogn/WTIMTS
  - User manual also available



