Sea level bias correction of the UK operational storm surge forecast

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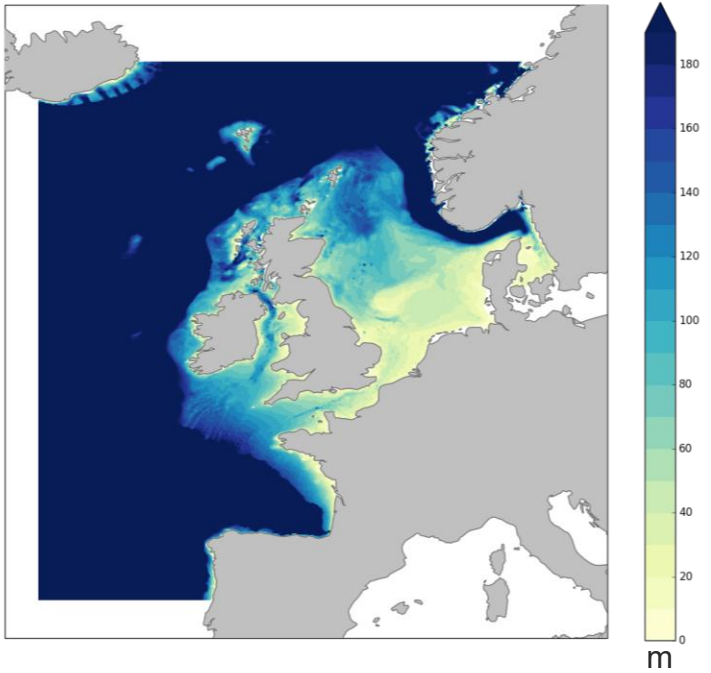
Introduction

UK operational surge forecasting

- NEMO modified for 2D
- ~7km resolution
- Inputs:
  - Tides at open boundaries as harmonic constituents
  - 10m wind and surface air pressure from Met Office global NWP models
- Spatially varying bottom friction



UK operational surge forecasting

- 4x daily
- Deterministic + ensemble

- Run full model and tide-only model → difference = model surge residual
- Model surge combined with harmonic tide prediction to provide forecast of total still water level

Goals of bias correction project

- Address systematic biases using new 40+ year surge hindcast (operational model, ERA5 forcing)
- Reduce need for manual intervention by forecasters
- Include whole grid, not just locations with tide gauge data
- Implemented operationally in August 2024

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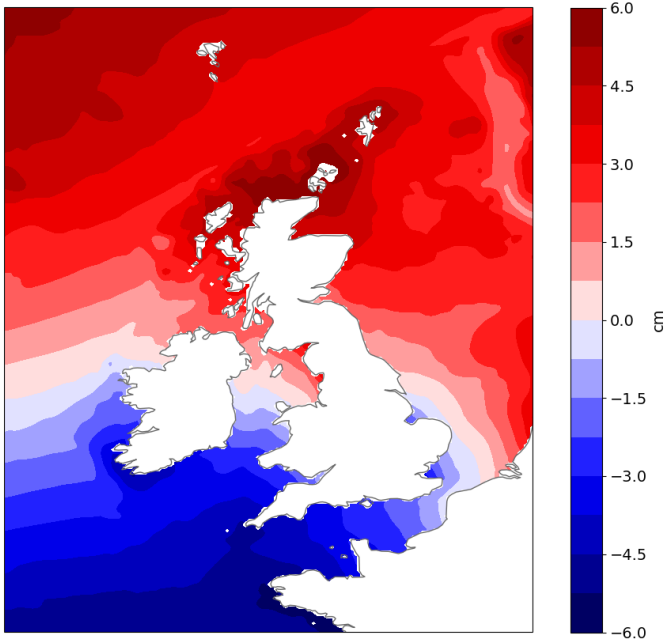
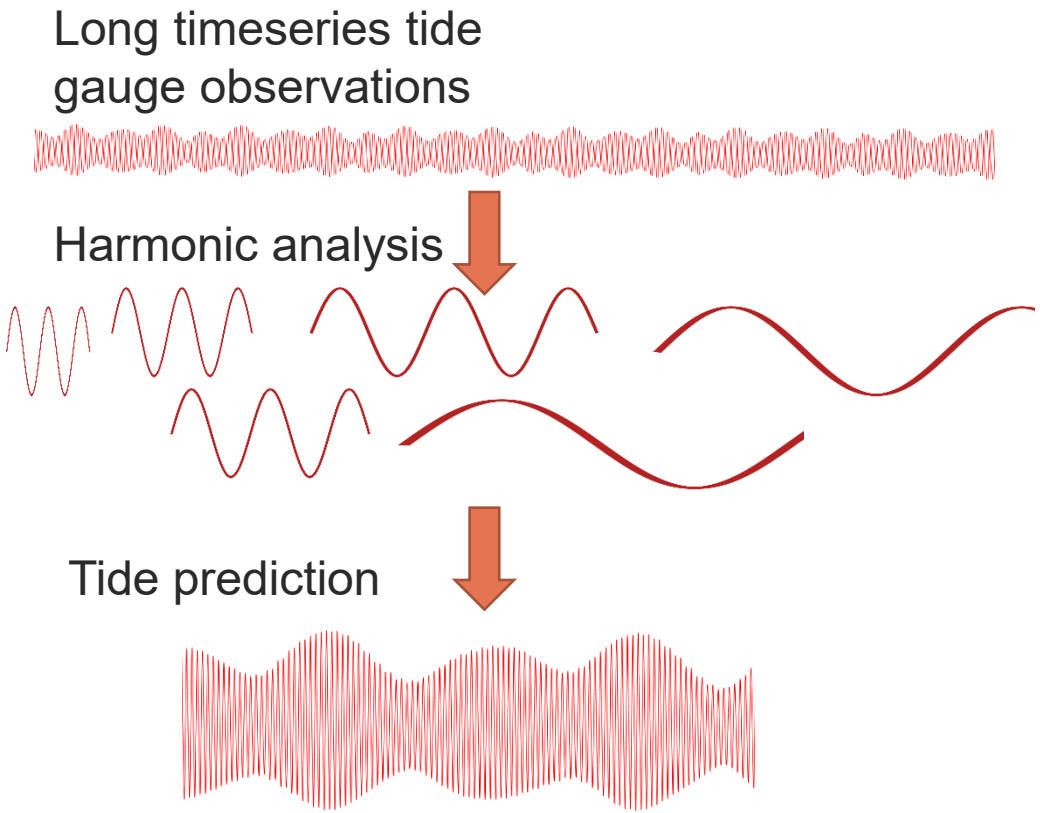
Bias corrections

1. Model mean sea level

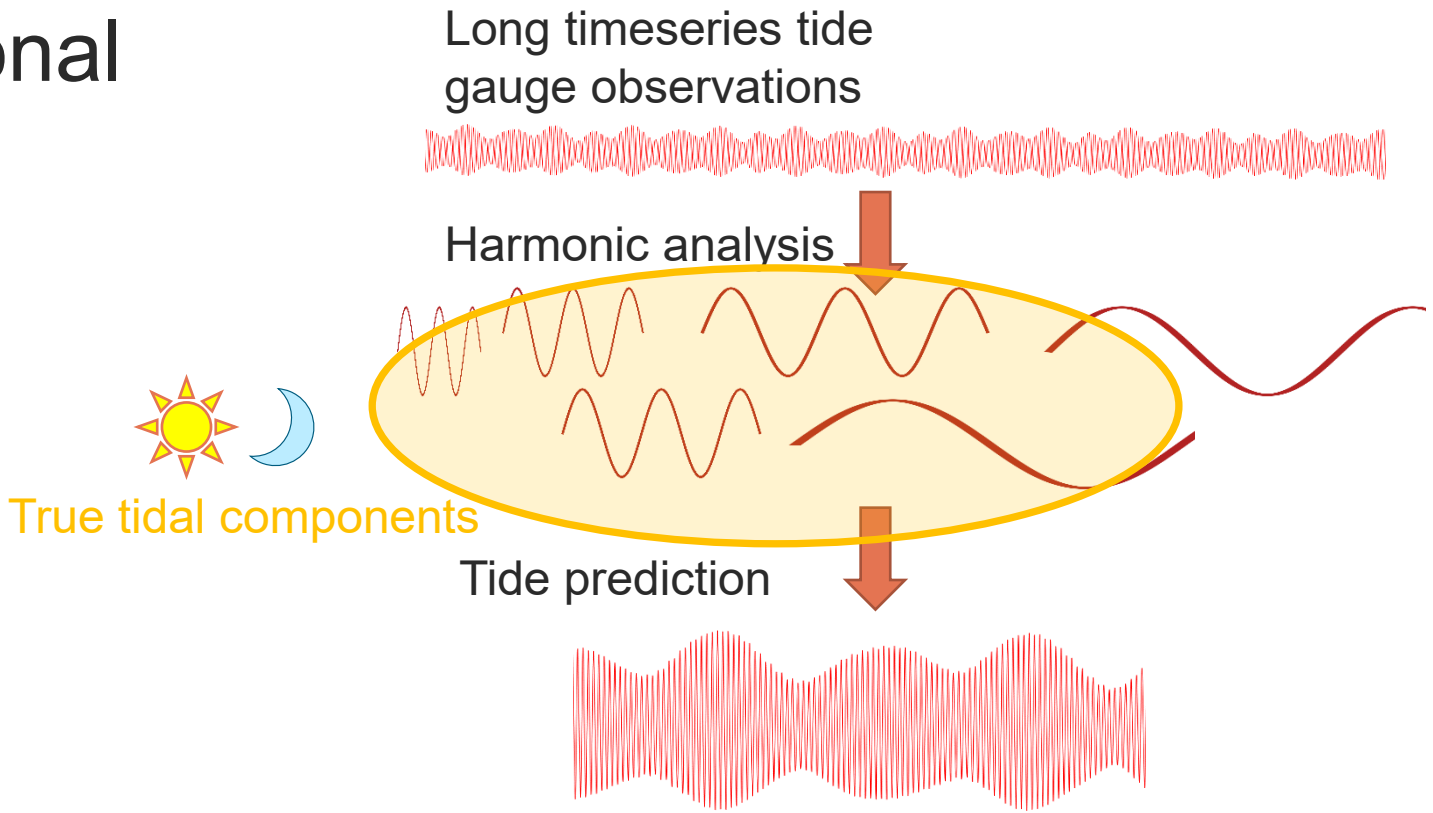
- NEMO water level is not referenced to any external datum
- NEMO MSL is different between the tide-only and forced run
- Mean calculated using 40 year hindcast



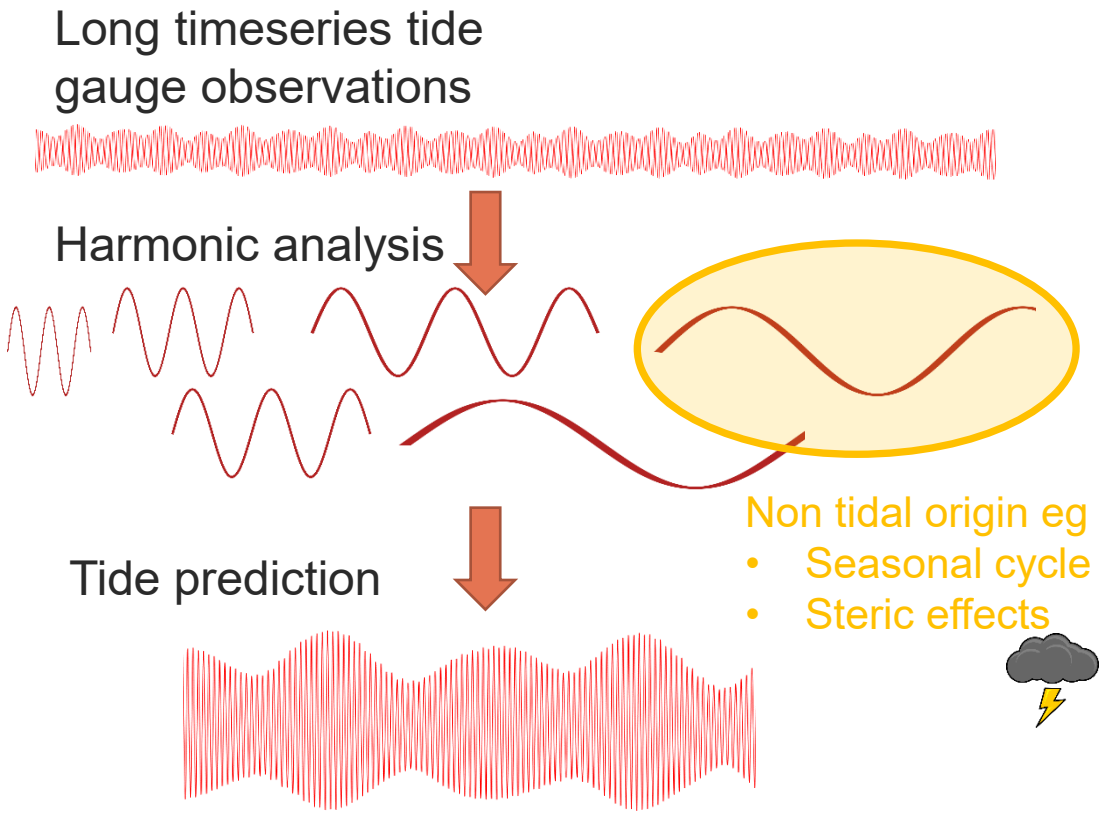
2. Seasonal


Long timeseries tide gauge observations
Harmonic analysis
Tide prediction

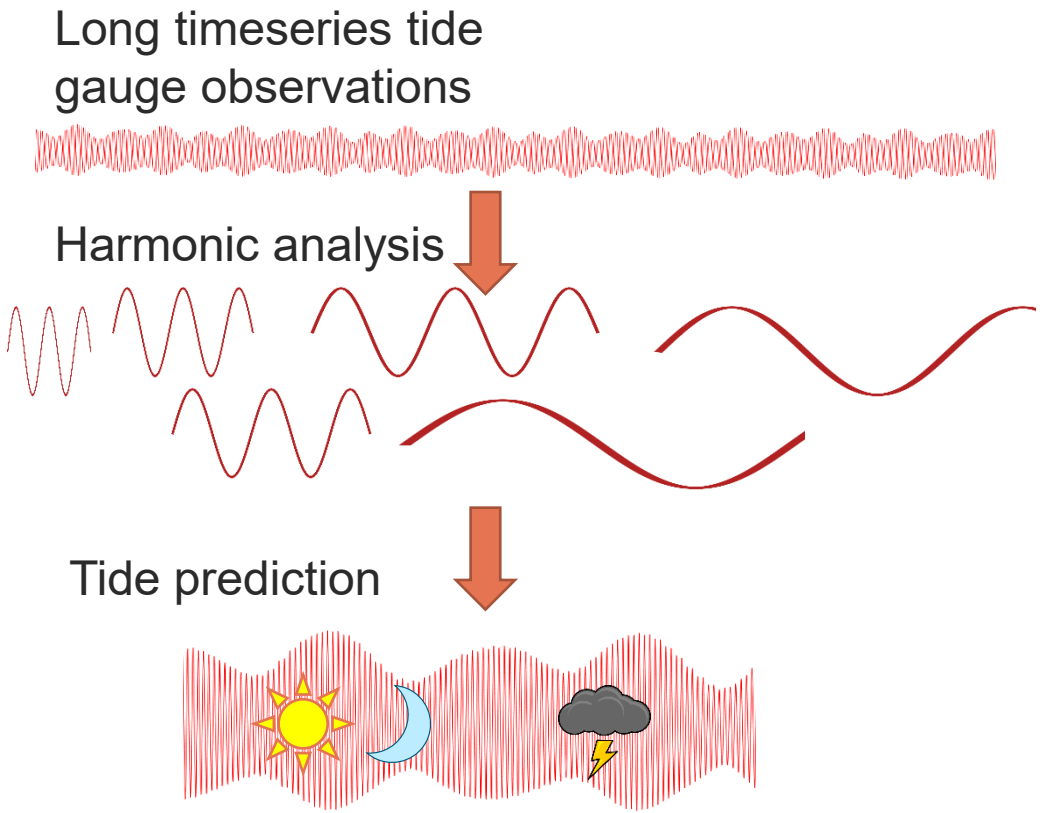
2. Seasonal


Long timeseries tide gauge observations
Harmonic analysis
True tidal components
Tide prediction

2. Seasonal


Long timeseries tide gauge observations
Harmonic analysis
Tide prediction
Non tidal origin eg
• Seasonal cycle
• Steric effects

2. Seasonal


Long timeseries tide gauge observations
Harmonic analysis
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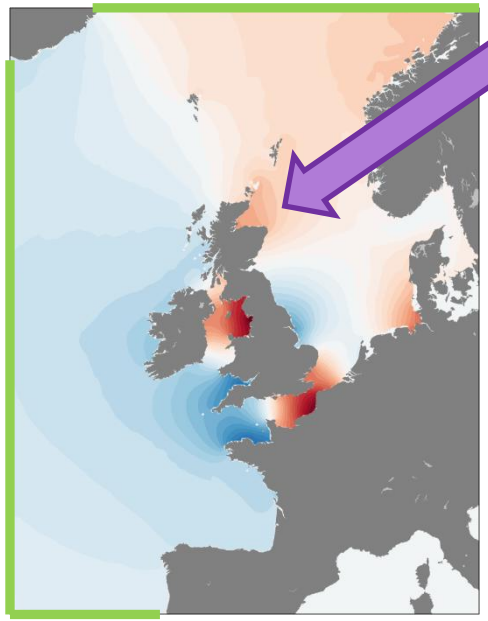
Surge model

NWP forcing

- Seasonal storminess included in model via NWP
- Steric effects not currently included

Tide bdys
Period < ~1 day



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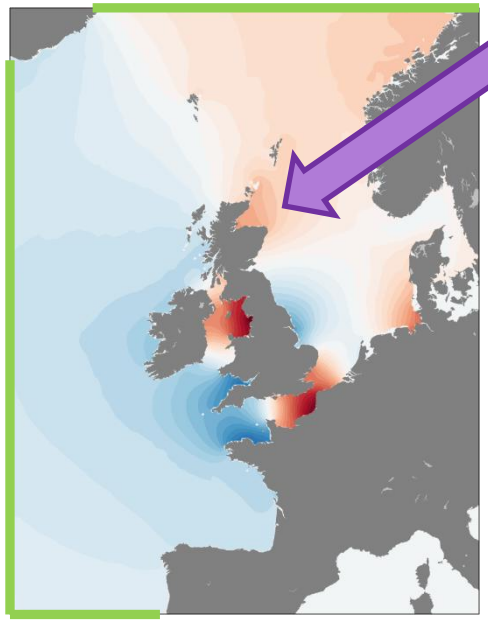

Observed water level = Tide gauge observation

Forecast total water = Model surge + predicted tide

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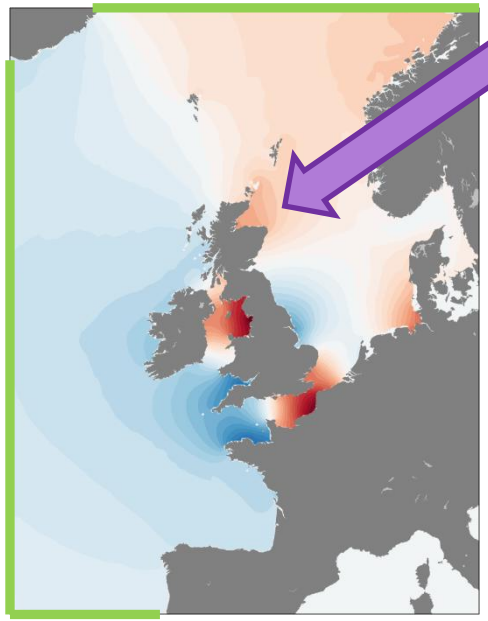
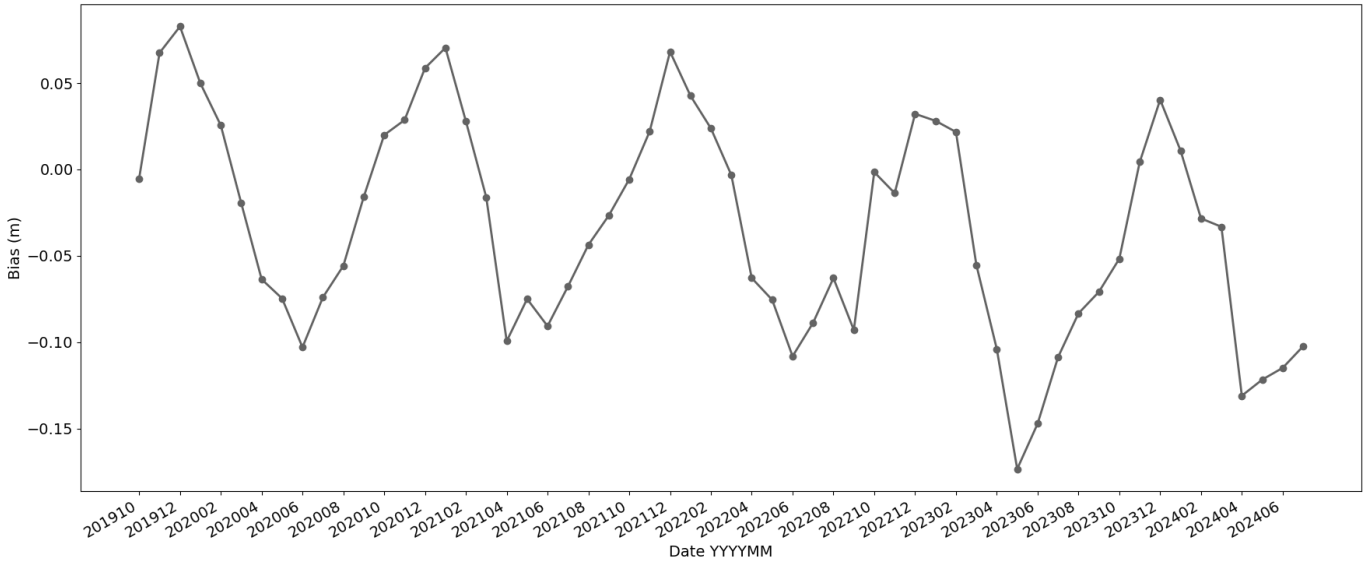


Observed surge = Obs total – harmonic tide

Model surge = Model total – model tide

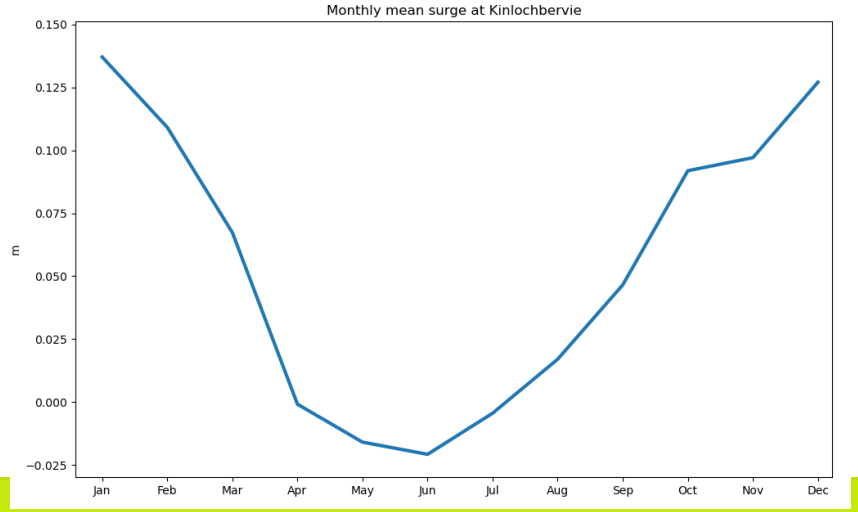
2. Seasonal

Model – observed surge bias at Kinlochbervie



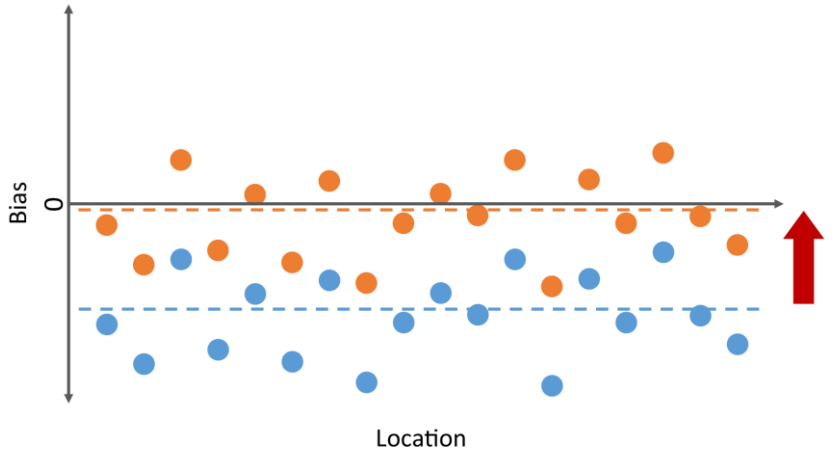
2. Seasonal

- Monthly means calculated from surge hindcast
- Smooths out seasonal changes in bias – more predictable



3. Grid-wide constant correction

- Apply corrections 1 & 2
- Compare model against last year of observations and calculate remaining bias
- Averaged across tide gauge locations and final value applied to the whole grid
- 10cm when implemented, reduced to 8cm last month after annual review



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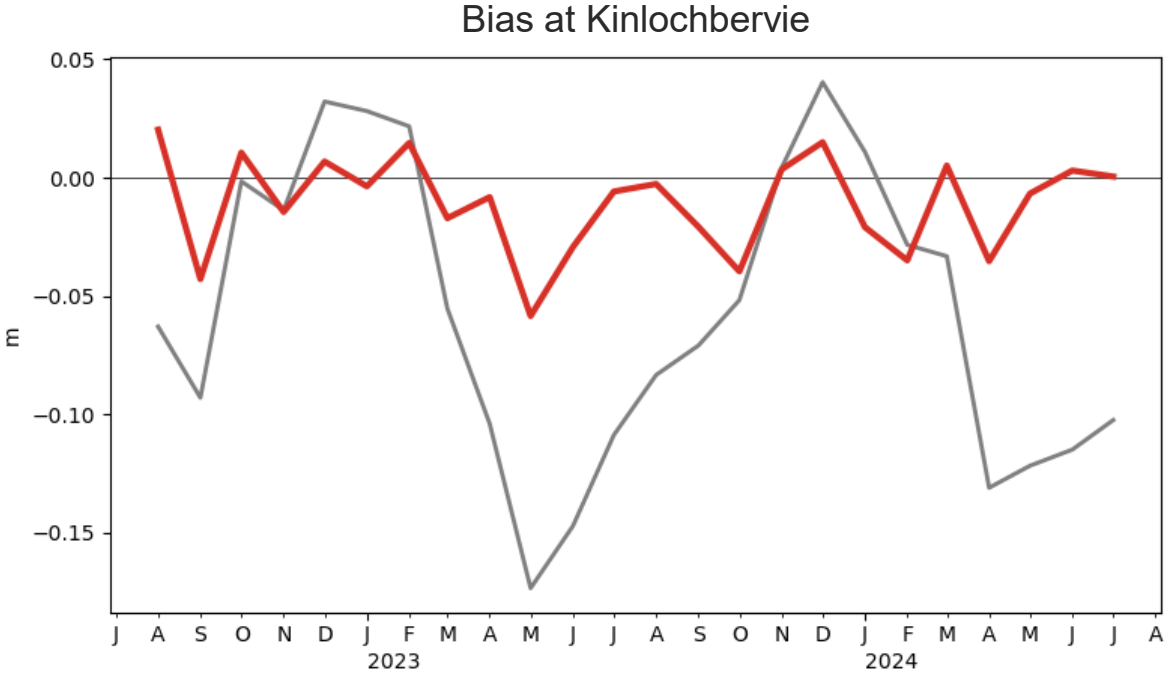
Results

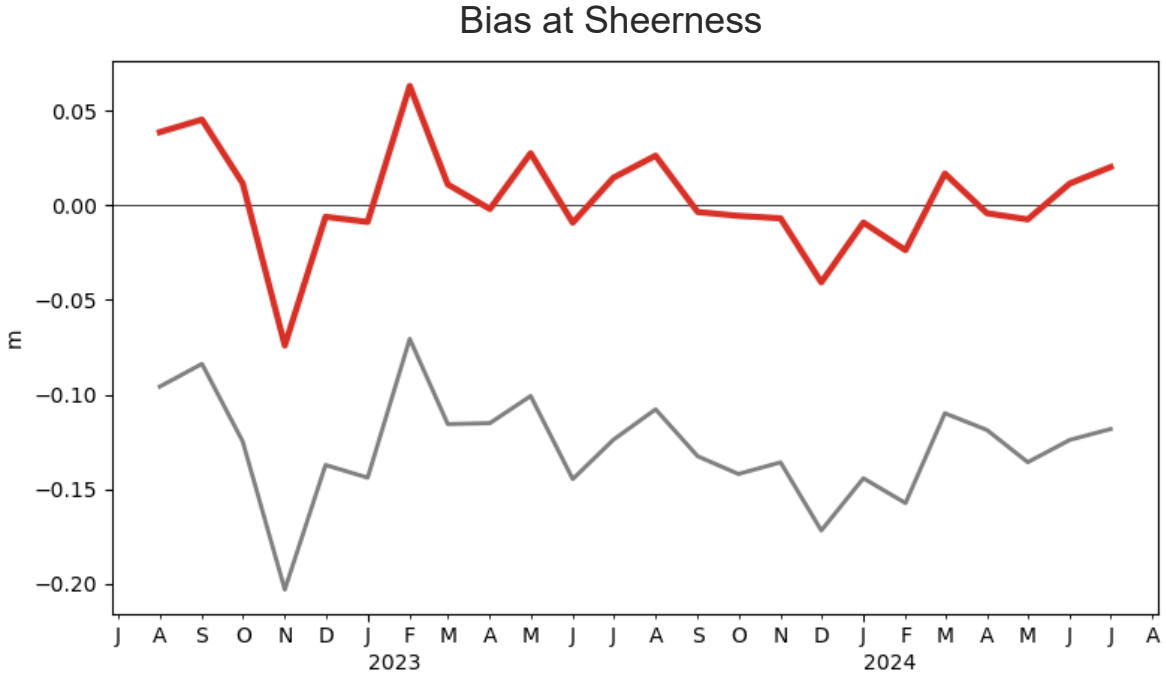
Results



With bias corrections

Original

Results



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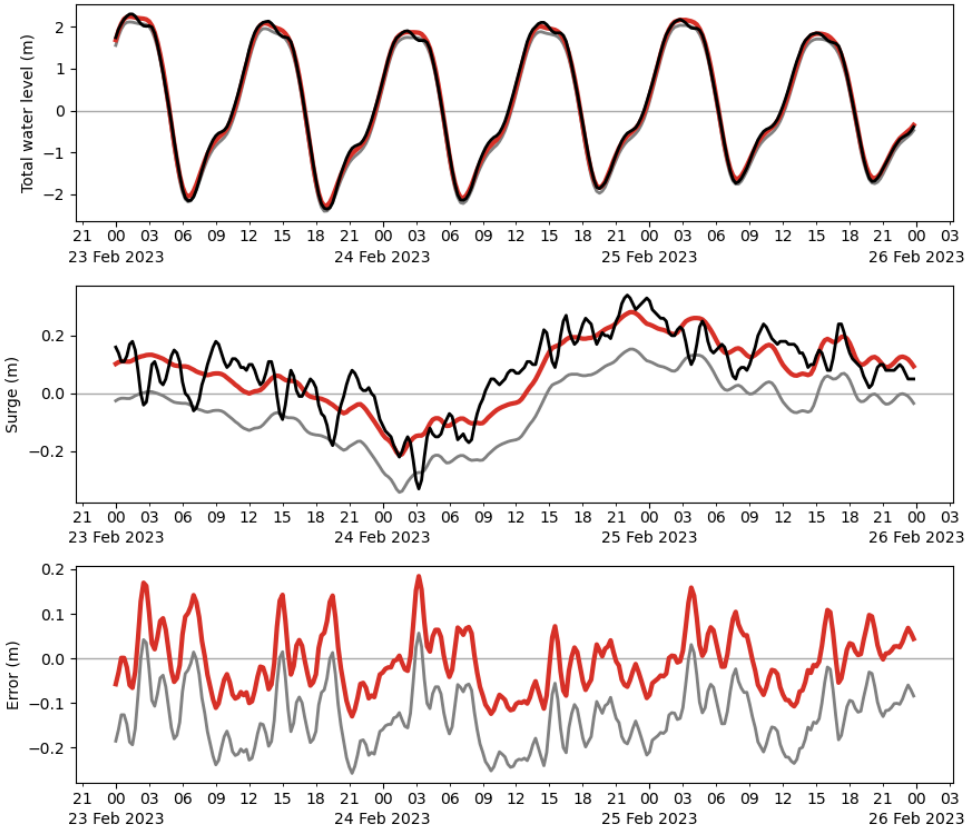
Portsmouth



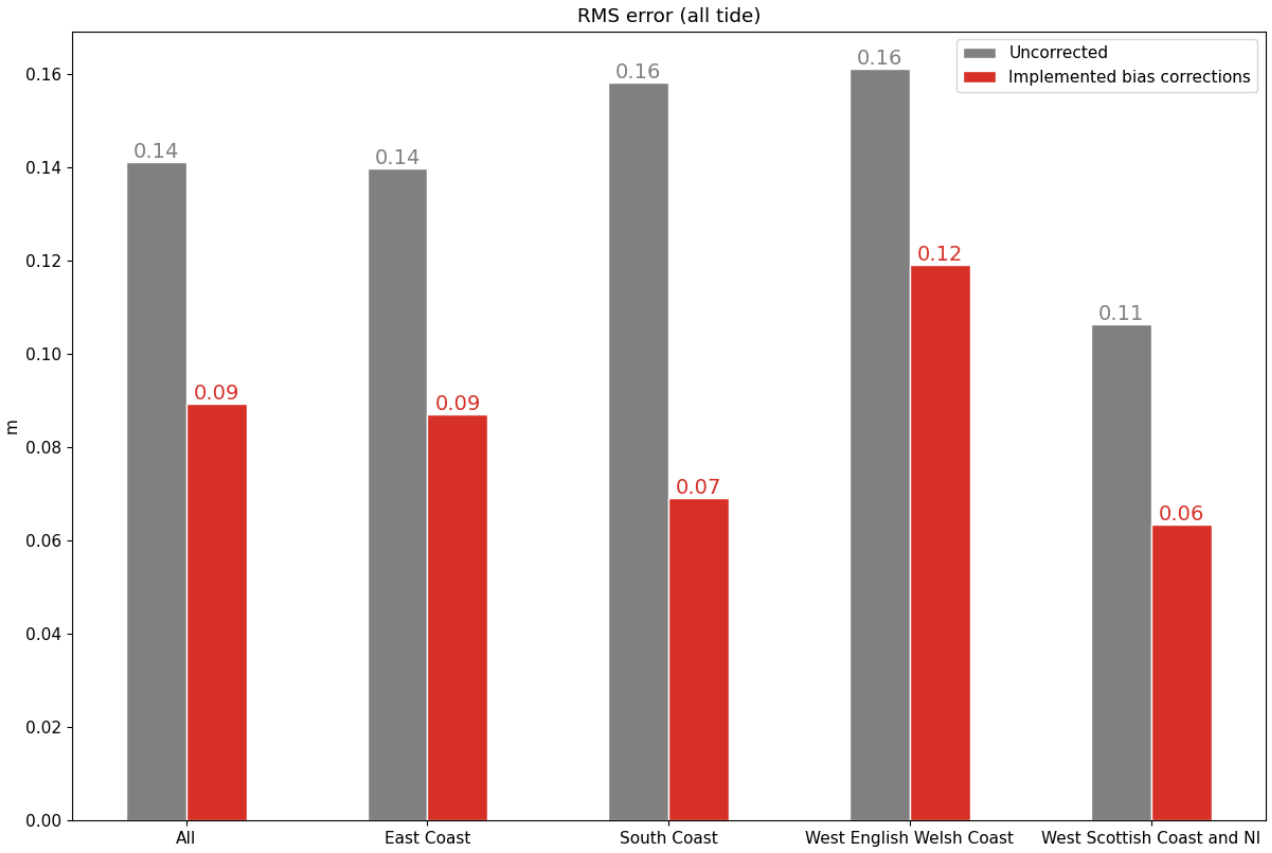
Observed

Original

With bias corrections

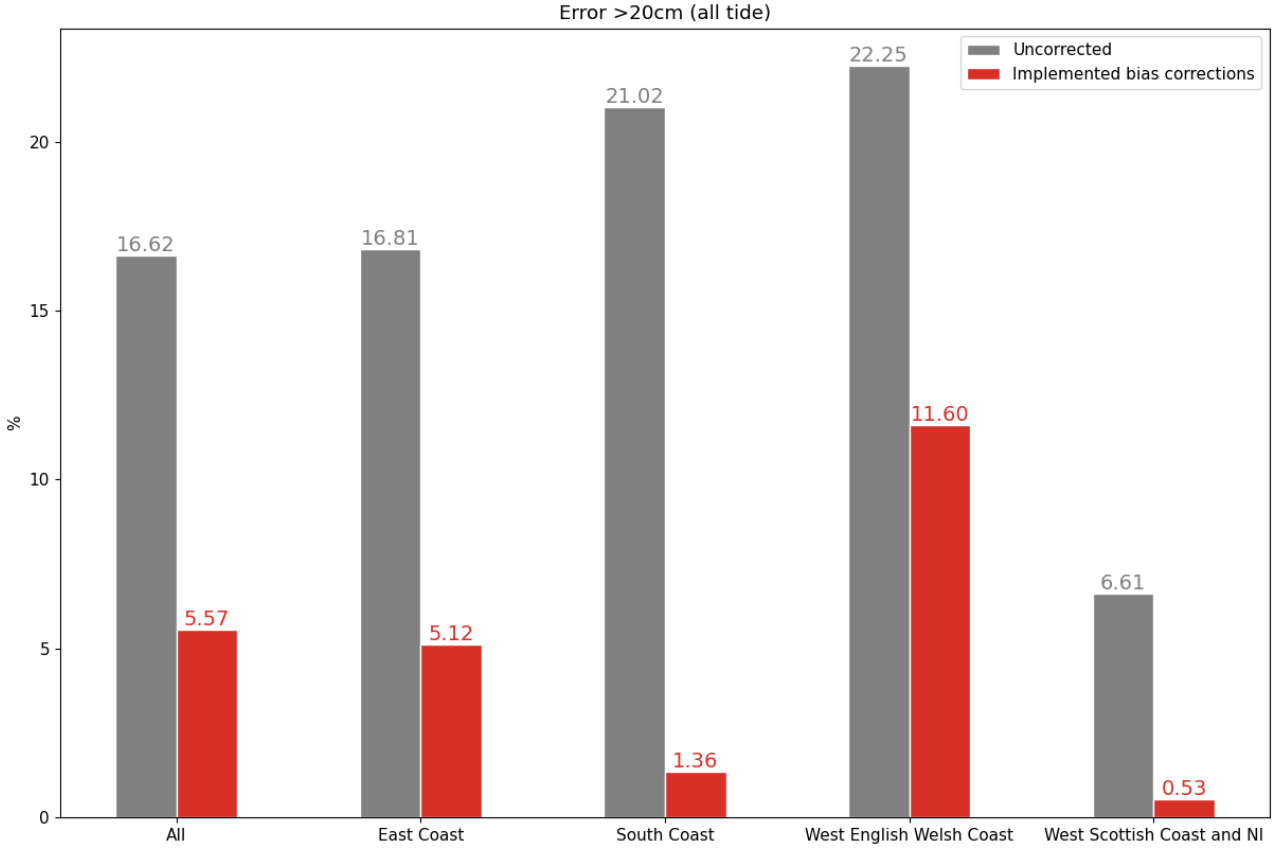
Results

Surge residual RMS error



Results

% forecasts outside 20cm target



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  - Impact on forecast is clear and predictable to users
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- Significantly improved statistics – better baseline
- Simple ☒
  - “One size fits all” 3rd correction
- Simple ☑
  - Impact on forecast is clear and predictable to users
  - Can be applied to whole 2D grid – consistent products
- Engagement with end users is crucial

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Future

- Long term - forecast water level directly from model
- Harmonic analysis on model hindcast
- Machine learning post-processing – Rtide
  - Will need to work with the users

Questions?

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