Determining Tidal Phase Differences from X-Band Radar Images of Wave Fields

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Talk Structure

MOTIVATIONS & BACKGROUND

Why accurate, high resolution bathymetry is so important

What has been done so far in this area

Where studies have been undertaken

METHOD AND RESULTS

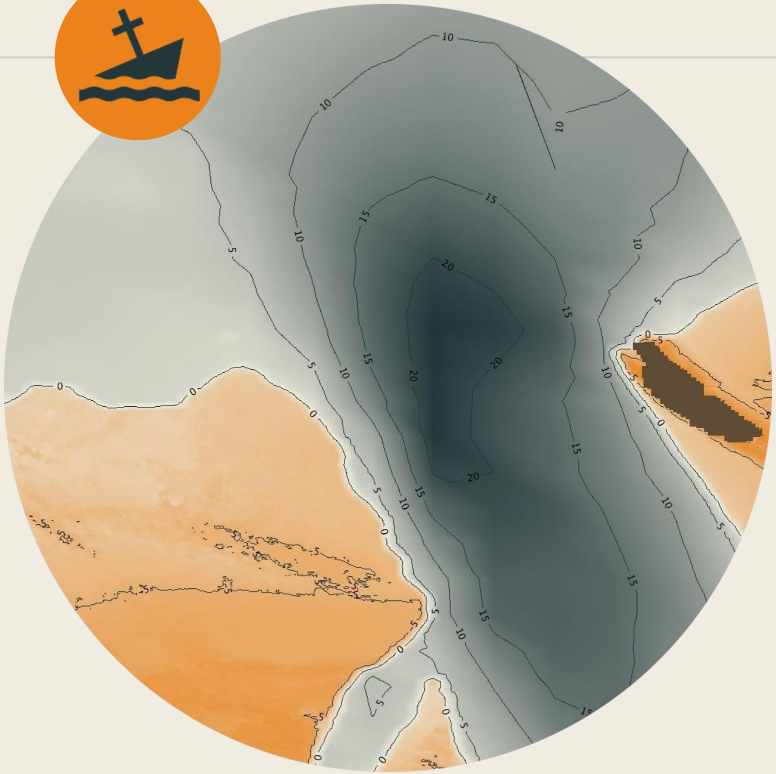
Overview of the **method**

Results so far

Early attempts at **validation**

The current state of affairs

What, where, how and why?



Accurate bathymetry is essential for many applications.

- Ocean Modelling
- Shipping
- Coastal Management
- Flood Defence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ELSEVIER

A temporal waterline approach to mapping intertidal areas using X-band marine radar

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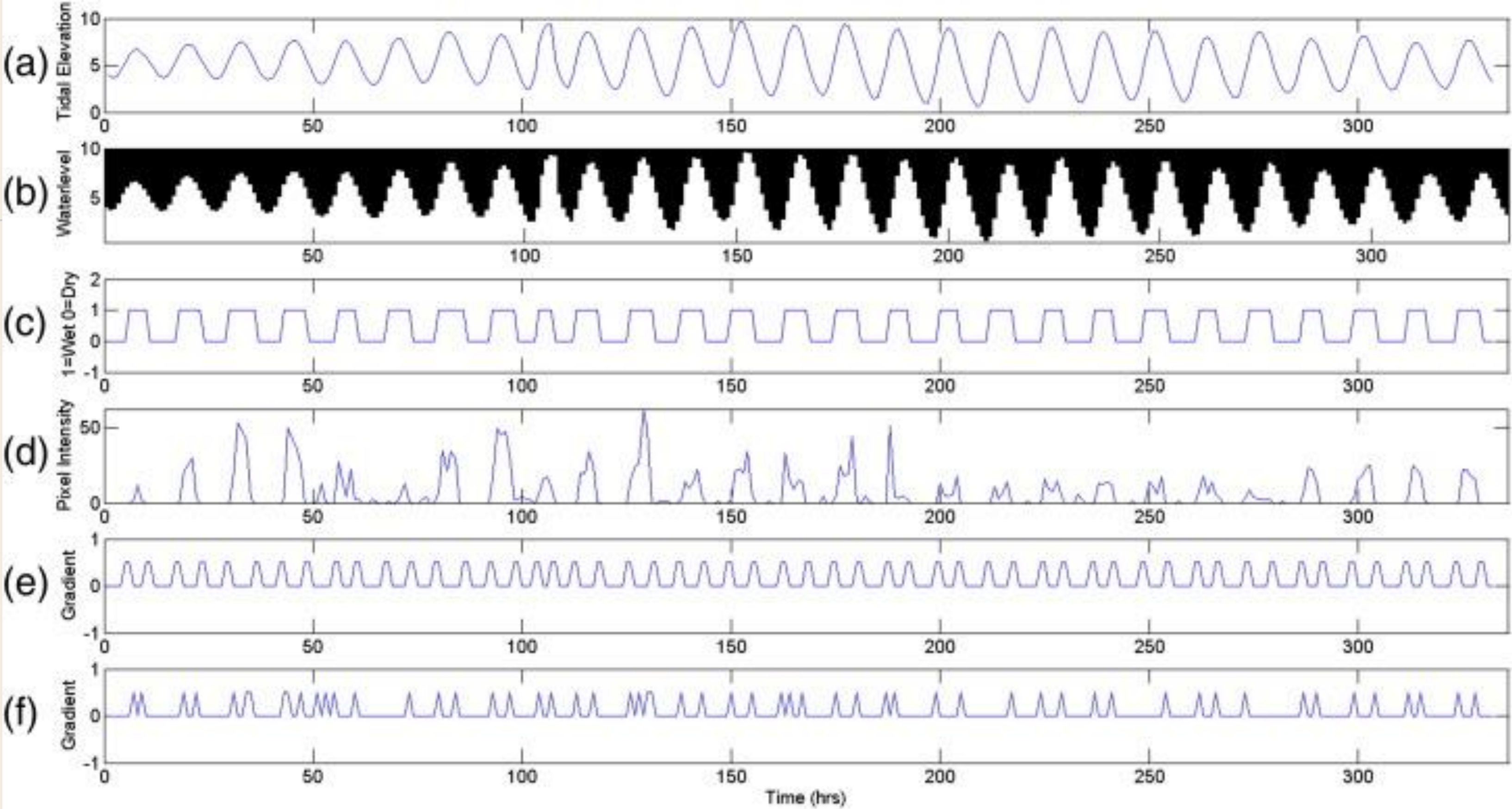
ABSTRACT

Mapping the morphology of intertidal areas is a logistically challenging, time consuming a
to their large expanse and difficulties associated with access. A technique is presented h
marine navigational radar operating at X-band frequency. The method uses a series of t
ages over the course of a two-week tidal cycle to identify the elevation of the wetting
each pixel in the radar images, thereby building up a morphological map of the target
poral Waterline" method is applied to a dataset acquired from Hilbre Island at the mo
spanning March 2006 to January 2007. The radar gathered data with a radial range
evation maps describe the intertidal regions of that area. The results are compared
veyed over the same area and within the radar survey time period. The re
agreement across large areas of beach and sandbanks, with concentrations o
that are shadowed from the radar or likely to suffer from pooling water. T
framework of the method and demonstrates its stability and accuracy. T
is aimed at providing a useful tool for the monitoring and operational

At a reg

A method was developed by Bell, Bird & Plater (2016) to use X-band radar to obtain intertidal bathymetry.

This method uses the strongly returned intensity signal from the waterline, compared with a tidal signal, to obtain a full intertidal survey every spring-neap cycle.



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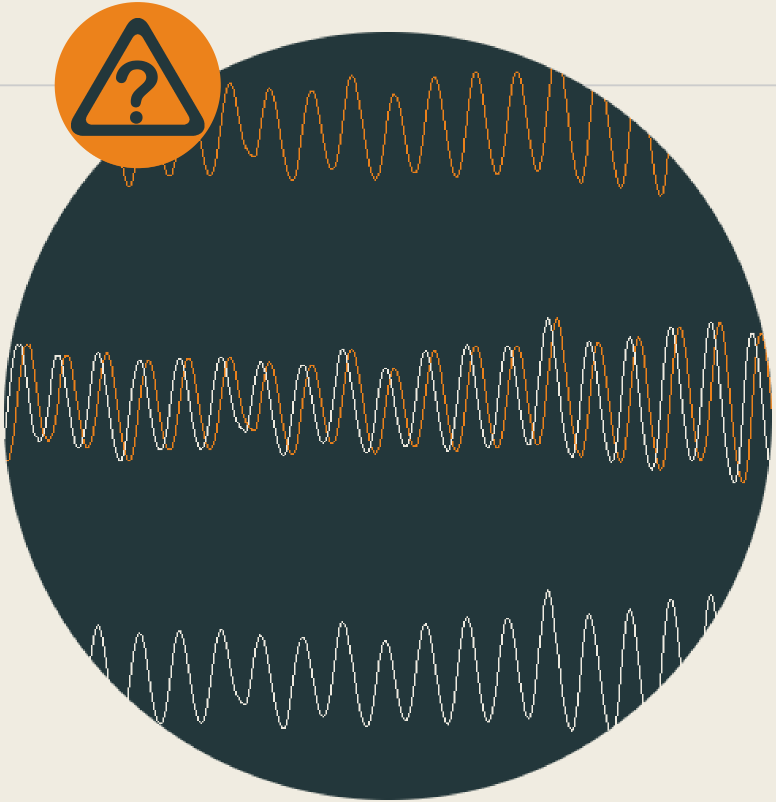
Where are we looking at?

Bell, Bird & Plater applied their method to the Dee Estuary, between the Wirral and North Wales.

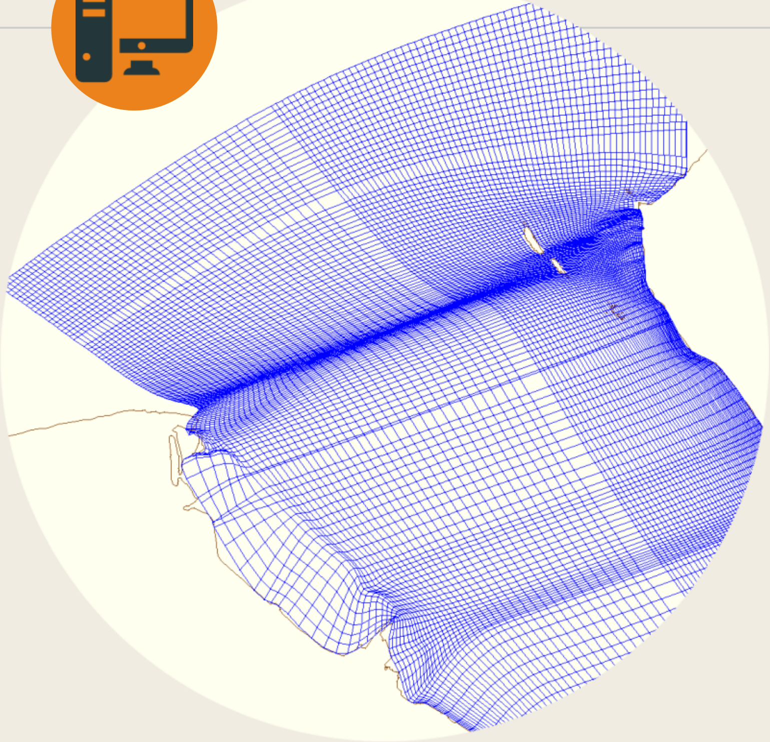
So where do I come in?

Well, there's room for improvement!



The current method applies a spatially uniform tidal signal over the entire domain.

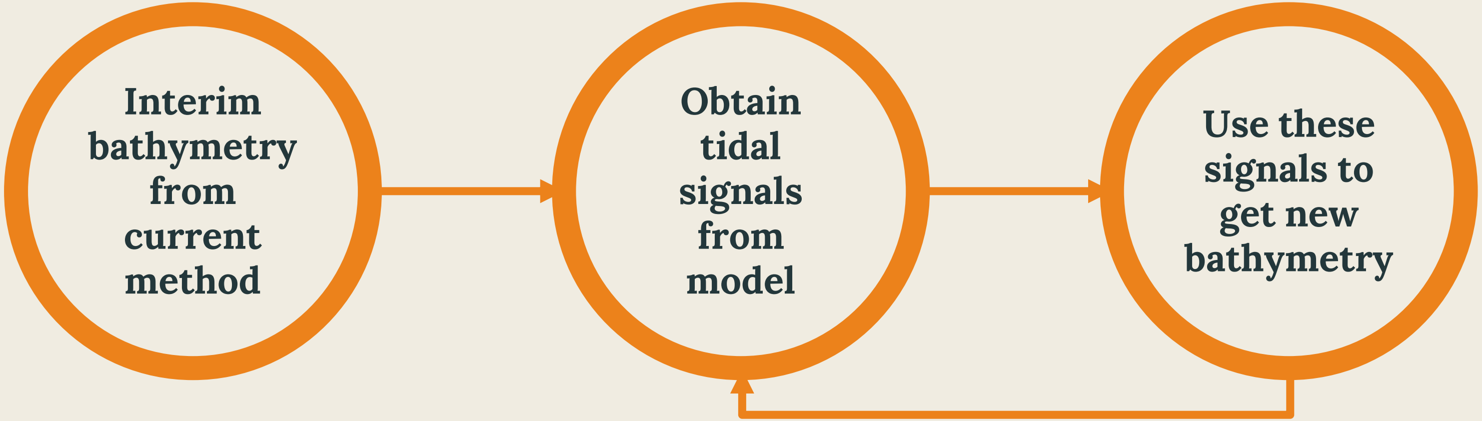
This means that differences in tidal phase and local variations in water level will affect the accuracy of the generated bathymetry.



One method to try and fix this is using models.

Using the DELFT3D-FLOW coastal model and the SWAN wave model, with bathymetry from the current method, I will aim to get a unique tidal signal for each 5m grid square.

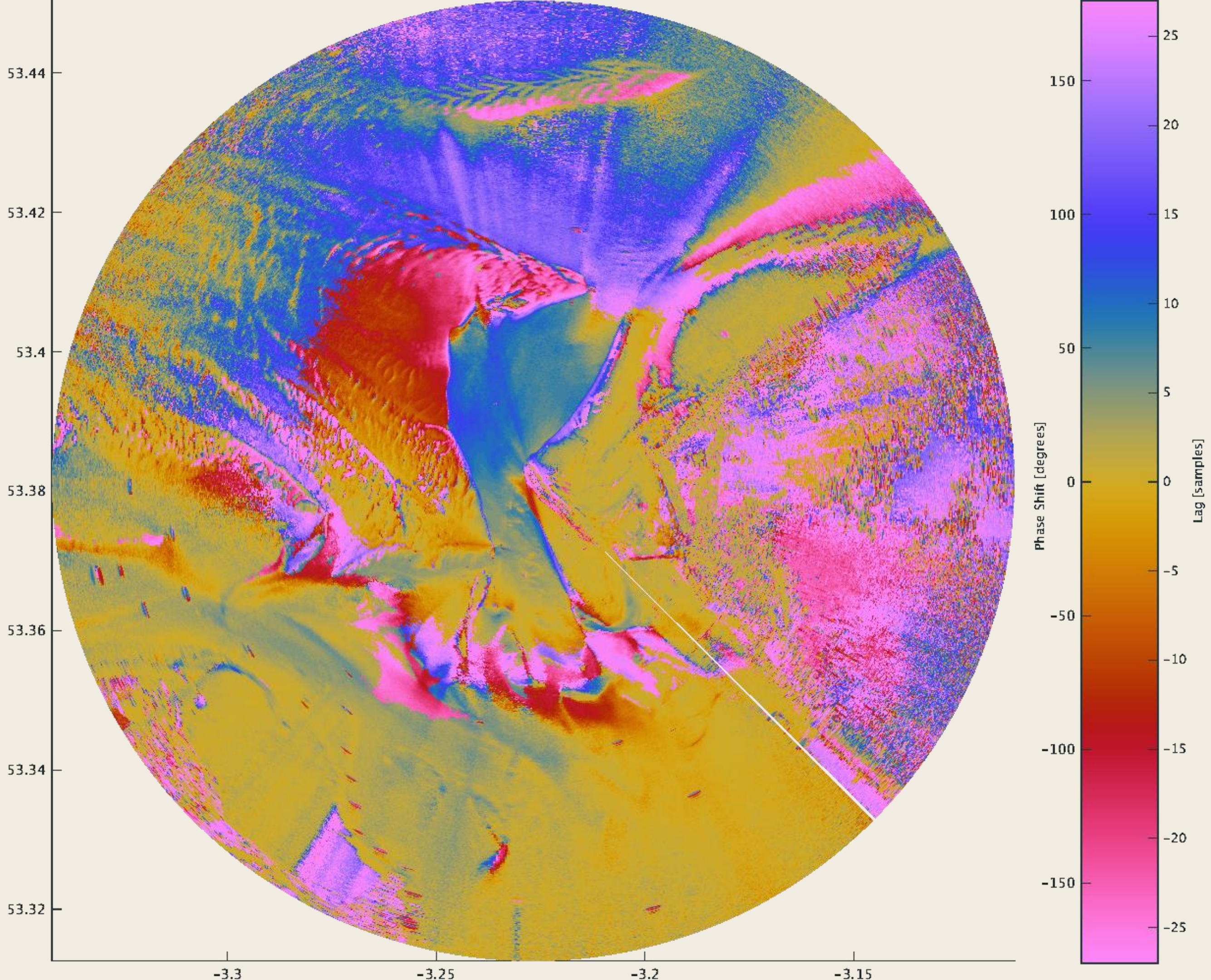
Then, iterate the methods.



Another method uses the radar signals directly.

Taking the cross correlation of the intensity signal of each pixel with the tidal signal, we can estimate the lag between the two signals. This gives local differences in tidal phase.

- Pixel time series $I_t^{r,\theta}$
- Tidal elevation η_t
- Cross-covariance at lag T:
  $\sigma_{\eta,I}(T) = \frac{1}{N-1}\sum_{t=1}^{N}(\eta_{t-T} - \mu_\eta)(I_t^{r,\theta} - \mu_I)$
- Cross correlation is then
  $$\chi_{\eta,I}(T) = \frac{\sigma_{\eta,I}(T)}{\sqrt{\sigma_{\eta,\eta}(0)\sigma_{I,I}(0)}}$$
- Then, find peaks in $\chi_{\eta,I}(T)$



53.44
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53.4
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53.36
53.34
53.32
-3.3
-3.25
-3.2
-3.15
Phase Shift [degrees]
150
100
50
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-50
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-150
Lag [samples]
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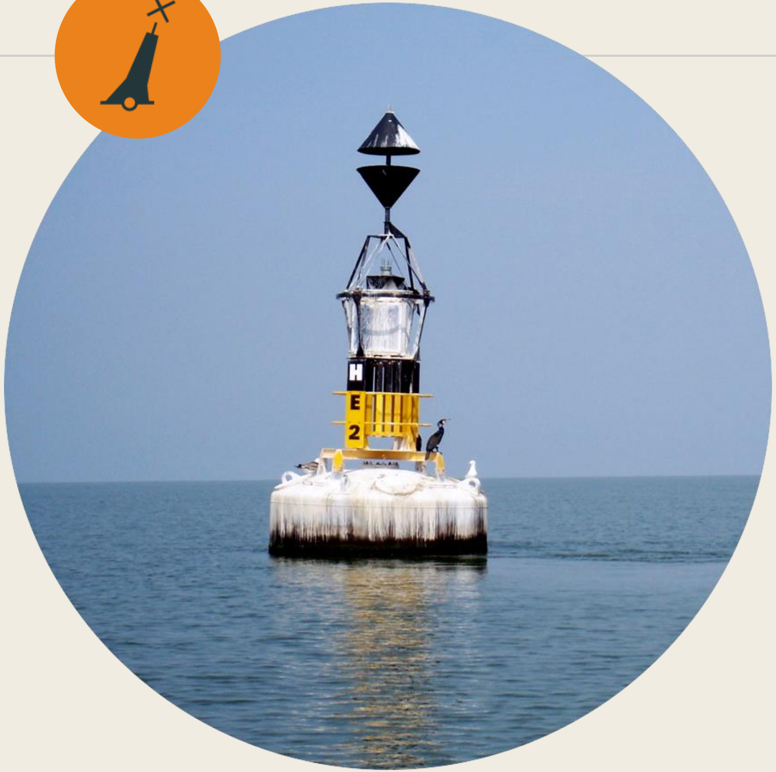
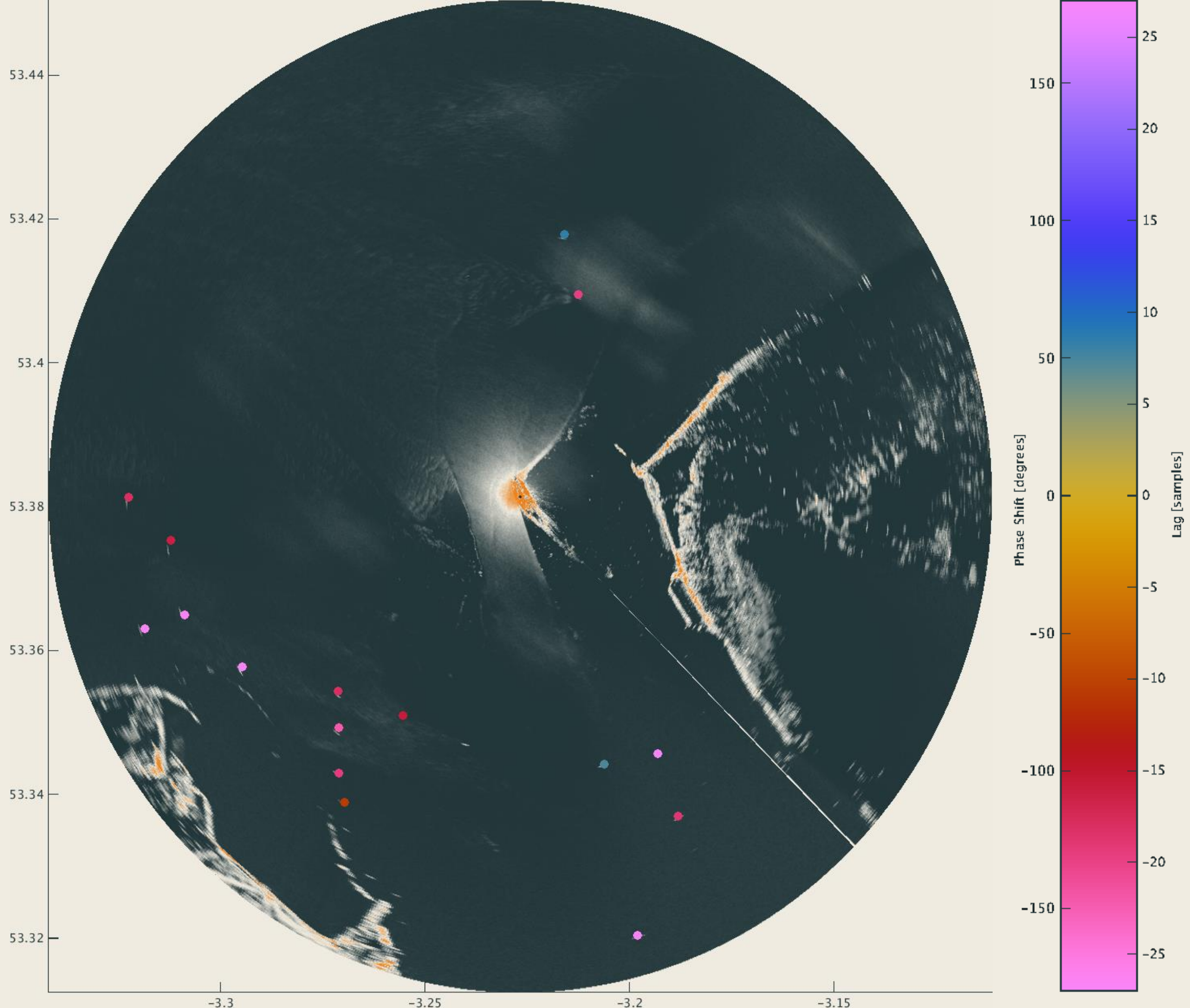


- Buoys show up as strong returns on the radar plot.
- We can then track the buoys moving on their moorings, to get a time series related to tidal currents.
- Then, apply the same correlation method as before.



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Is it any good?

Validation

Compare with ADCP or elevation data

Compare buoy and raw data methods

Compare phase with model results

Time series do not overlap

Apply method to areas with more data

Current: POLCOMS 180m Liverpool Bay

Future: DELFT3D-FLOW at ~5m resolution

Conclusions

- These methods could provide a way to determine local tidal phase differences.
- This would have a direct effect on the accuracy of the waterline method for bathymetry estimation.
- However, more validation is needed to determine the true accuracy of the method.

Thanks!

Any questions ?