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Refinements to harmonic tidal predictions in estuaries and shallow water

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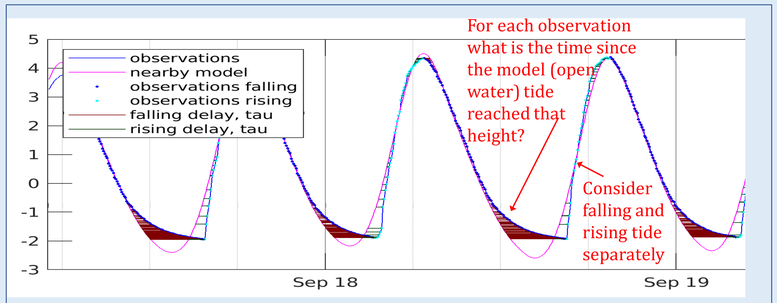
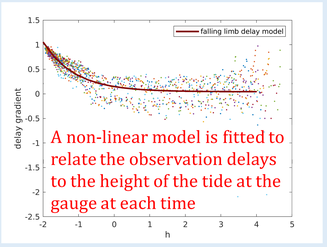
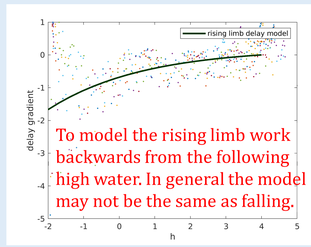
Problem: Standard methods of tide prediction give poor results up rivers and in shallow water, making it hard to validate surge modelling.
Suggestion: Can we instead model the local tide using height-dependent delay relative to a nearby point in deep water, where we know the tide from a model?
Progress? Looks promising! But predictions not yet tested.



Developing a delay model. The delay is locally dependent on the length and depth of the shallow channel between the gauge and open water, but the channel may not be straight. In general we don't know the distance or depth profile.
Assumption: we expect the delay to somehow relate to the heights measured at the gauge.
Delay is cumulative since high water. So we need to model the gradient of the total observed delay. How much more is the tide slowing each minute as the height falls?



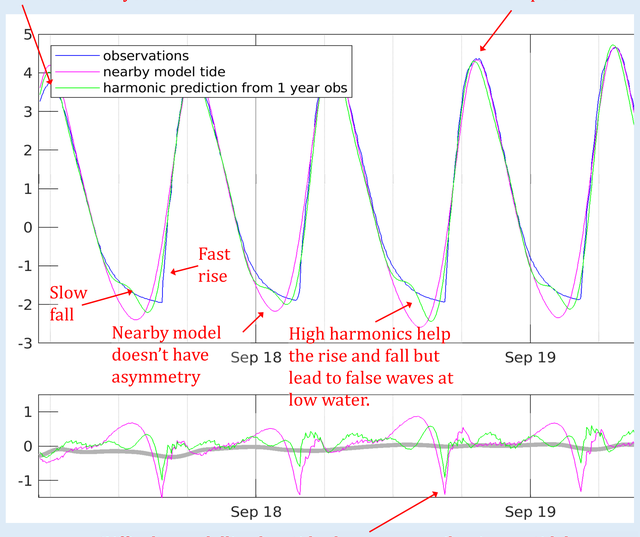


$$T(t) = Z_0 + \sum_N H_n f_n \cos\left[\sigma_n t - g_n + (V_n + u_n)\right]$$

Harmonic methods of tidal analysis fit a sum of symmetric waves to the local observations

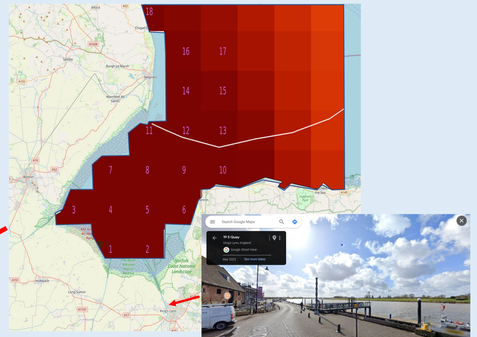
Very long data is needed to separate the higher harmonics, and this may not be available at every site. Here we use 1 year's observations.

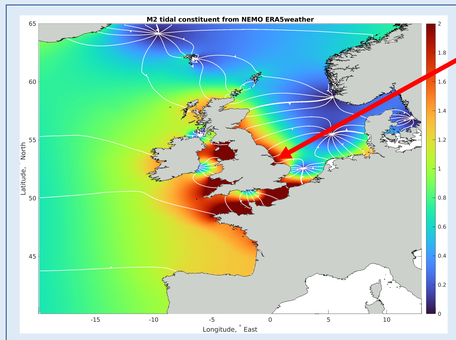
Aligned to mean HW for comparison



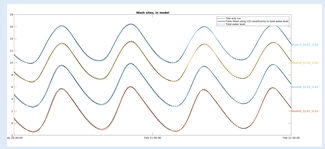
Difficulty modelling low tide shows up as spikes in non-tidal residuals and make validation of surge modelling difficult.

Operational modelling of storm surges and tides uses **a** NEMO Surge configuration on a 7km grid. It is a good model of tide and surge in open water. The nearest model point is about 10km from the gauge in the river at Kings Lynn.





A regional Tidal Atlas is available at NOC, with 115 constituents based on NEMO surge-and-tide model run at the Met Office, with 1980-2022 ERA5 forcing. See also poster X4.13, EGU24-10636

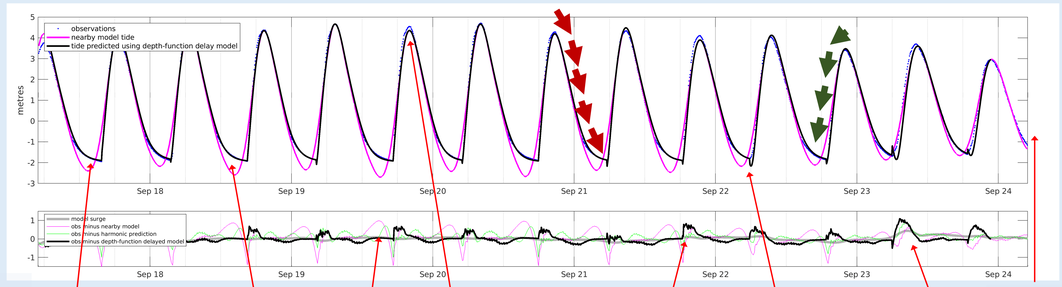


The model out at sea has some asymmetry but not as much as at the gauge.

Work In Progress! Results so far...

With parameters for the delay function $\frac{d\tau}{dt} = F(h)$ and nearby model, we timestep down the falling tide from each high water to construct the new prediction at the gauge.

Then we construct backwards from each model high water back down the rising tide.



Will it be possible to handle real double lows and highs?

We need to test: What if the river flow changes the minimum depth reached at low water?

Falling tide delay is modelled really well

Much lower residuals on falling tide than other methods

Tide up river has more diurnal inequality than open water tide, this method has no means to handle that.

Problems matching rising and falling limbs. Could smooth?

Rising tide is not so good as falling.

Small storm surge in model here. Need to test on more storm events

So far we've only tested within the training set! **Do predictions actually work?**

National Oceanography Centre

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