Jo – thanks for the useful comments. Some replies below. Phil

Hi Phil, Thank-you for writing this up and the talk you gave on it last year. I'm sure it'll get sent to review a bit further away, but in the meantime here's a few points I've picked up on.

Thanks again.

The distinction between M1 and M1' is quite hard to keep track of, especially as existing software conflates them, and M1' is the degree-2 constituent usually labelled M1. Is there a clearer notation you could adopt, eg d2-M1 for M1' and d3-M1 for your M1? It might also help to define this up front in case we end up looking at other degree-3 tides in the future. Also M1' is used in the abstract before definition.

I agree that the different historical notations are confusing – you have to read all the papers and decide what each person was actually meaning by the different names (see my Footnote 2). There was an international attempt to standardise the names of tidal lines by the IHO Tides Committee (IHO, 2006) but I am not sure if everyone follows that. I don't think in the present case that the situation would be improved by inventing yet another set of notations. In my case, I was attempting to build on the previous work of Doodson and Cartwright, and so I adopted the Doodson-type definition of M1´ as I explained in the footnote. I have edited the abstract to define M1´ as suggested.

Confusion with NO1 is also likely, especially for users of the Foreman-derived codes (including T_tide and U_tide). In these codes only NO1 is named in the standard constituent list, with the same frequency as line 7 from Table 1. (In contrast, only M1 is named in the NOCtide or TIRA list, with the same frequency as line 4). Could you clarify the difference?

All tidal analysis software comes with its own history, and in the NOC case that was very much influenced by Doodson, hence the definition of M1´ as a combination of four lines as I explained, which is then confusingly called M1 in the software. Now, by far the largest of those four in the tidal potential (Table 1) is line (7), so I can see why in a different software the authors might chose to fit to that alone, as you say happens in T_tide and U_tide, rather than the combination of the four. As you know, in any routine tidal analysis one has a limited number of constituents to fit to and what is included in that list depends on the local research experience. I think NOAA software also fits just to line 7 (see Bruce Parker's NOAA tidal analysis manual) and in fact that was what Cartwright (1975) did, in his case confusingly giving the name M1´ to line (7) alone – see my footnote 2.

As for 'NO1', beware again of the usage of the name. These other packages (and also IHO, 2006) could well give the name 'NO1' to the fitted harmonic with the frequency of line 7. The packages will of course determine the amplitude and phase of the tide with that frequency that results in the ocean directly from line 7 in the tidal potential, plus any interaction of N2 and O1. In the present paper, we (i.e. in the quotes from the work of Richard Ray) refer to 'NO1' as just the interaction part. I hope that is clear from the text.

Also, though P&W 2014 does have an explanation of the degree-2 & degree-3 polynomials, it's not easy to find unless you know what you are looking for. A brief explanation here would be useful.

I do not want to go more into text book mode in what is a research paper. The degree-3 components of the tide come from the 3rd degree Legendre polynomial part of the tidal potential, which are described adequately in outline at least in Agnew (2007), and more briefly in Pugh (1984) and Pugh and Woodworth (2014). There is a cartoon of the degree-3 component of the tidal potential in Cartwright (1975). It is otherwise necessary to get to grips with Cartwright and Tayler (1971).

The abstract could include an estimate of the maximum amplitude.

Done. Thanks.

Oh yes, and there's no scales on some of the amplitude maps (I was quite disappointed when I realised it was mm rather than cm!)

Yes, things are very small (several mm usually or about 1 cm around the North Sea). There were units given on all the figures in the paper, either on the figures themselves or in the captions. I have remade figures 5 and 7 to ensure the units are now on all the figures.

p7 line 21: Presumably large V could also arise from frequent tide-surge interaction, which may be a contributing factor in the North Sea?

An interesting suggestion. I daresay if the mis-match between the left and right-hand sides of Equation 2 produces large V due to the complexities of tidal interaction (like NO1), then tide-surge interaction might also play a part, although it is hard to see how off-hand. I guess there is a need for a modelling study.

Figure (5c) doesn't exist, should it be Supp. Fig. 3c?

Thanks. Fixed.

In Table 1, frequency is given as degrees/hour not cycles/hour.

Thanks. Fixed.

Are there other significant degree-3 tides that you know about, or is M1 a lot bigger than the rest? What led you to pick up on M1?

M3 can be locally important in some shelf areas (e.g. see Huthnance, Deep-Sea Res, 1980). Otherwise, see the tables in Cartwright and Tayler for the relative importance of each line – most of the other degree-3 terms are very small, although they can cause complications by overlapping with degree-2 lines with similar frequencies, and of course familiar constituents such as N2 and L2 have perigean variations which are degree-3. I was interested in M1 myself because it was unfinished business from Cartwright et al. (1988).