Analysis of tidal currents in the North Sea from shipboard ADCP mesaurements

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Introduction:

- The North Sea is a well monitored marine area, however, extensive current measurement data sets are rare.
- The objective of this study is to determine the tidal currents for a large area of the North Sea, using a data sef of direct current measurements of considerable extent both spatially and temporally.
- Northern North Sea is an area of differing dynamical regimes, with tidal current amplitudes of a few cm/s reported in some regions and upward of 1 m/s elsewhere (Rodhe, 1987; Turrell et al., 1990).

Data & Method:

- ADCP-measurements from 1999-2002 and 2008-2016, obtained from two ships of opportunity that both traverse the North Sea on a regular basis. (See Figure 1 for cruise tracks, where current observations were made)
- Harmonic analysis is performed on least squares fits of current observations to a set of Gaussian basis functions defined in certain "knot points " (Method based on work by Wang Et al., 2004).
- Observations from moored current meters at a few locations are used to validate results.
- Output from regional barotropic tide model (Egbert et al., 2010) is compared with our results.

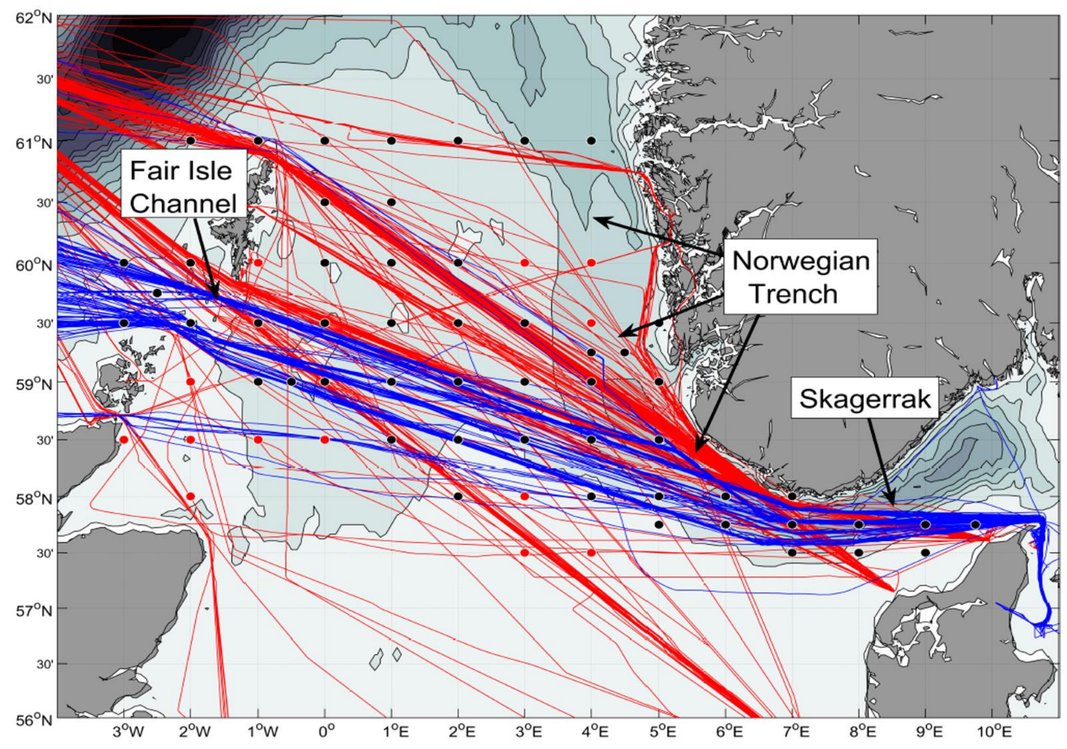

Figure 1: Distribution of ADCP cruise tracks in the North Sea, and knot point locations marked by black dots.

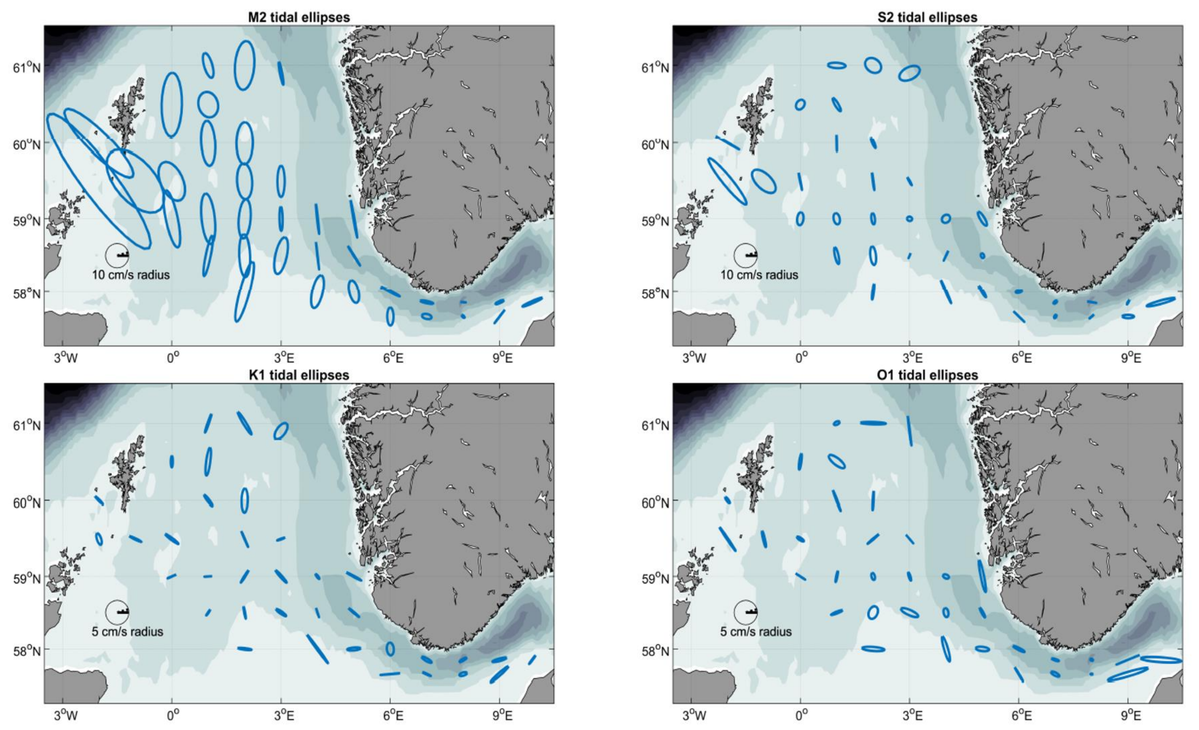

Figure 2: Current ellipses for the two most predominant semi-diurnal and diurnal tidal constituents from our harmonic analysis. Note that the black reference circle has a radius of 10 cm/s in top two panels and 5 cm/s in the lower panels.

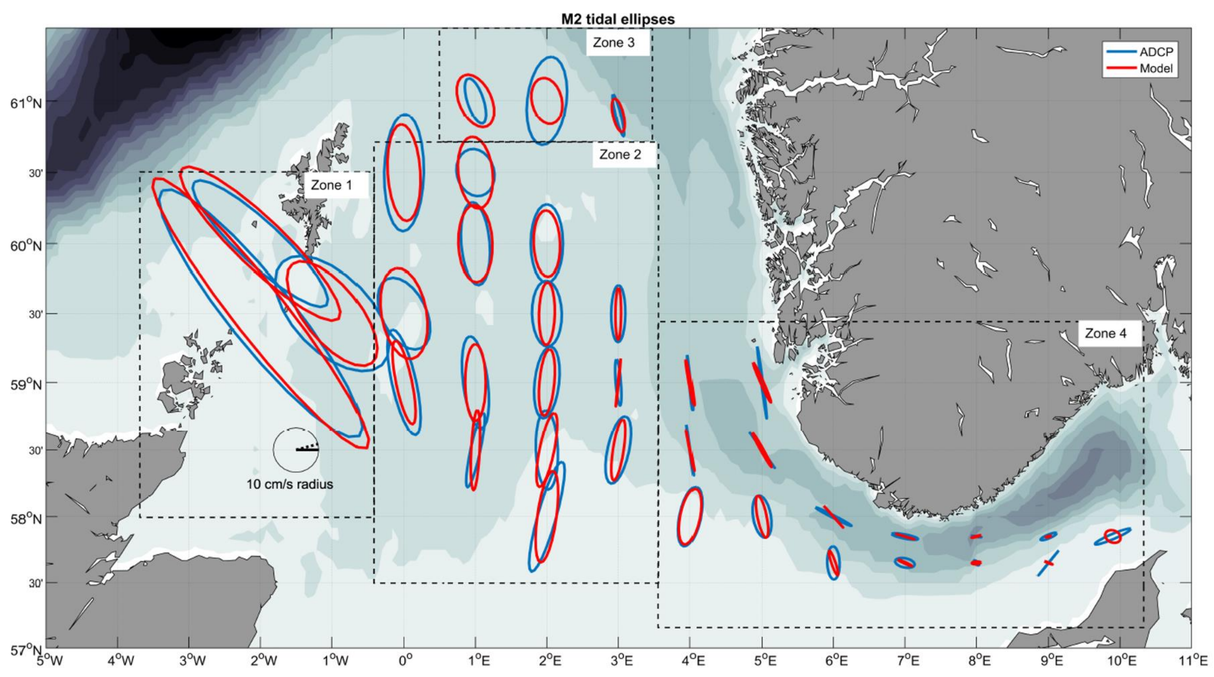

Figure 3: Comparison between M2 tidal current ellipses determined from ADCP data and from output from regional barotropic tide model.

Results:

- The principal lunar constituent, M2, is the dominating component of the tide by far in most of the study area (See Figure 2).
- The strongest tidal currents are found in the Fair Isle Channel where the ellipses are oriented along the channel.
- M2 ellipses on the plateau west of the Norwegian Trench are quite elongated with semi-major axes varying between 10 and 25 cm/s, which are mostly oriented more or less meridionally.
- Tidal currents in the Norwegian Trench and the Skagerrak are weaker, semi-major axes of the M2 are 8 cm/s on average and typically oriented along the trench.

- Comparison with M2 tidal current estimates from moored current meters shows good agreement with M2 currents estimated from the shipboard ADCP data in areas where ADCP data are abundant (See figure 4).

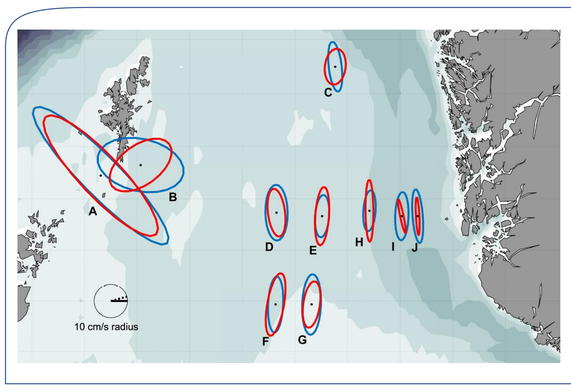

Figure 4: Comparison between M2 ellipses calculated from ADCP(red) and moored current meter data(blue).

- The second most prominent semi-diurnal constituent is S2, with currents of approximately one third the strength of M2.
- and the two most prominent diurnal components in our harmonic analysis, K1 and O1, are both approximately one sixth the strength of the M2 current.

- The regional barotropic tide model mirrors the results of our M2 tide very closely with the exception of a few areas , eg. Zone 3 in Figure 3 where ADCP coverage is relatively bad, and toward the coast of Denmark where the model underestimates the M2 current compared to our Harmonic Analysis.

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Rodhe, J. The large-scale circulation in the skagerrak; interpretation of someobservations. Tellus A, 39(3), 1987.

Turrell, W., Henderson, E., and Slesser, G. Residual transport within the fair isle current observed during the autumn circulation experiment (ace). Continental Shelf Research, 10(6), 1990.

Wang, Y.-H., Chiao, L.-Y., Lwiza, K. M. M., and Wang, D.-P. Analysis of flow at the gate of taiwan strait. Journal of Geophysical Research: Oceans, 109(C2), 2004.