

## ***Interactive comment on “Summer upwelling at the Boknis Eck time series station (1982 to 2012) – a combined glider and wind data analysis” by J. Karstensen et al.***

**J. Karstensen et al.**

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Please note the full response to all three reviewers comments in the attached supplementary material.

Reviewer 3 raised major issues - we hope that the reformulated MS improved in clarity and addresses all points raised by the reviewer.

Reviewer 3:

After reading the ms I have to confess that I am not able to identify the sense of the paper. The authors play with data, but they neither posed a scientific question nor any hypotheses. So the goal of the paper remains unclear. The fact that regional upwelling

C2036

occurs in the Baltic Sea is well known.

Authors Response:

In this manuscript the authors investigate the occurrence and frequency of wind driven summer upwelling at the Boknis Eck time series site (BE). BE is a ship based (monthly visits) time series in the western Baltic Sea (Belt Sea) and one of the longest time series of physical, biological and chemical parameters in the Baltic proper (see also [www.bokniseck.de](http://www.bokniseck.de) as well as other papers that belong to the BG Special Issue - Boknis Eck Time Series Station (SW Baltic Sea)). The authors utilize high-resolution hydrography and biogeochemical data from a glider survey at BE in combination with wind data from a nearby meteorological station to derive the specific wind forcing conditions that triggered two summer upwelling events observed in the glider data. The analysis confirms the general view that the wind intensity is a good indicator for upwelling intensity. Moreover, basic mechanisms for coastal upwelling in shallow waters such as the offshore/onshore flow and the heaving and relaxation of the density field depending on the strength of the wind forcing are identified from the glider data. By using the wind time series that goes back to 1982, a time series of wind impulse for the BE area is derived, which in turn is aligned with the monthly BE ship visits. In this way, all summer BE ship visits under the impact of wind driven upwelling are reconstructed. Finally, the BE time series of selected parameter-anomalies (mean seasonal cycle removed) and investigate in respect to upwelling forced anomalies. It can be shown that strong upwelling and large anomalies are well aligned. Moreover, the wind intensity and direction threshold derived in this study may enable future investigators at BE to identify whether a specific data set was under the impact of upwelling or not and which in turn may help interpreting the data. From a technological point of view it could be shown that autonomous gliders are a useful vehicle in recording the temporal evolution of parameter fields under the impact of short term upwelling events in very shallow coastal areas of the Baltic Sea.

Reviewer 3:

C2037

I also cannot identify any new aspect concerning the theory of upwelling. There is no progress in improved understanding of upwelling compared to the classical papers of Yoshida and Mao (1957, J Mar. Res. 16, 40-53) and Yoshida (1967, Jpn. J. Geophys. 4, 1-75).

Authors Response:

Please accept that this paper is a discussion of observational data and not a theoretical paper. As such its purpose is not primarily to advance the theory of upwelling but to identify theoretical aspects of upwelling in observational data. It is very likely that this comments is a result of (1) the lack of clear writing of the manuscript and (2) not citing the relevant theoretical papers. Both of these points have been addressed in the revised manuscript.

Reviewer 3:

It is also not clear why the authors combine high resolution data for very short periods with monthly mean monitoring data.

Authors Response:

As outlined above (response to first comment) we probably were not clear enough in our wording about "what" we do and "why". However, we are confident that the reformulated text does explain the connection in a clear and comprehensive way.

Reviewer 3:

The aspect of diapycnal mixing is rather confusing. On P 2767 L23-24 I read the statement "we were interested if diapycnal mixing was associated with upwelling" followed four lines later by the statement "we ignore any effect diapycnal mixing may have". And it ends with the statement "diapycnal mixing is assumed to be small. (P2772 L23-24).

Authors Response:

This section has been reformulated to explain in more detail our strategy.

Reviewer 3:

C2038

Furthermore I cannot understand how the authors conclude that Kelvin waves do not play a significant role?

Authors Response:

We have indeed not correctly explained our conclusion. For the single point observations with the glider we cannot exclude the role of a Kelvin wave in the upwelling during the survey week in July 2010. However, inspecting the satellite images the propagation of the upwelling along the coast cannot be identified. When identifying the wind driven upwelling in the BE time series we were able to align many surveys with anomalous parameter records, and what appeared as "data outliers" of the time series, to strong upwelling events. However, certain anomalous events could not be aligned with wind-induced upwelling and other processes such as upwelling initiated by Kelvin Waves may explain them. We now added a statement to the text. Revisiting the work by Gill Clarke (Deep Sea Res. 1974) confirmed our assumption that in the shallow waters and close to the coast we are operating here the local wind effect should be dominating.

Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/11/C2036/2014/bgd-11-C2036-2014-supplement.pdf>

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Interactive comment on Biogeosciences Discuss., 11, 2759, 2014.

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