

Ocean Sci. Discuss., referee comment RC1  
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## Comment on os-2021-103

Anonymous Referee #1

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Referee comment on "Ocean bubbles under high wind conditions – Part 1: Bubble distribution and development" by Helen Czerski et al., Ocean Sci. Discuss.,  
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The manuscript reports on comprehensive observations of bubbles in the upper 4m of the ocean during high wind conditions, with a focus on void fractions at 2m and 4m depth. Bubbles play a crucial part in air-sea gas exchange and are relevant to the transmission of optical and acoustic signals. The observations are consistent with a nearly permanent bubble layer in the top 1-2m and occasional deeper bubble plumes associated with Langmuir convergence zones. The conclusions drawn from this unique data set are solid but are asking for further in-depth analysis. The authors rightly point out that the bubble presence is not the most relevant parameter for air-sea gas exchange parameterizations, but bubble flux. The additional information on size distribution could help in addressing the related issue of bubble plume age. There is a companion paper which might just do this. The manuscript is well written and the topic is suitable for publication in Ocean Science.

Scientific issues:

Lin 334, Figure 4: Splitting the data into 3 cases seems very arbitrary. Give more detail on how the data were assigned to a particular case. For example, why are the Case 2 data with 2m void fraction  $< 7 \times 10^{-7}$  not part of Case 3. If there is no objective way to stratify the data, then present them as one case and a fit through all data – or best to remove this figure.

Ln352: What is the area of the camera FOV? Please quantify "very few". How does the observed number of breaking waves compare to the breaking rate reported in the literature? (E.g. there are several studies that quantify the active breaking rate from breaking crest length distributions obtained from video imagery). If the observed breaking rate is much lower than expected, it might indicate that the freely drifting buoy somehow avoids breaking waves., similar to wave buoys often missing the peak of a steep crest, or by the buoy being located preferentially in the convergence region of Langmuir

circulations. If so, the bubble statistics would be biased.

Ln405: Can you exclude the possibility of measurement saturation at high void fractions? Turbulence models assume TKE injection in breaking waves to a depth comparable to the significant wave height. It is surprising that bubbles would not get injected to 2m depth when  $H_s$  is 3 to 5m. Does this imply that void fractions in breaking waves are  $<10^{-4}$ ? Or does it mean that the breaking layer is  $\ll H_s$ ?

Section 3.3.2: Your analysis shows that void fraction does only poorly stratify with wind history. In almost all cases the median void fraction for rising/falling winds is within 1 standard deviation of the opposite situation. Similarly, wave age does not affect void fraction. Both results are not surprising. Void fraction is ultimately determined by wave breaking, which in turn is not directly linked to wave age or wind history. But is well correlated with the saturation of the wave field (see work by M. Banner and colleagues).

Ln 517: Can the (relative) age of a bubble plume be determined from the bubble size distribution? If this is done in the companion paper it should be mentioned here. If not, the analysis should be included here.

Ln594-619: The explanation of higher void fractions during decreasing wind speeds being the result of higher gas saturation is plausible. Another explanation is similarly plausible: during falling wind speeds the wave field is not equilibrated, resulting in a higher breaking rate (bubble production) associated with wave saturation at a prior time.

Technical issues:

Ln 24: define  $R_{Hw}$

Ln 159: change to: "Studies by Salter et al (2014) and Slauenwhite & Johnson (1999) observed...."

Ln294: The standard deviation of the measurement depth is not dimensionless (add units to both instances).

Figure 3: Change y-axis label to "Void fraction" on panel b and c

Figure 7: Specify in caption "...split by wind speed (bottom row) and wind-wave Reynolds number (top row)."

Figure9, caption Ln123: "There were no bubble camera data..."