

# Gas transfer by breaking waves

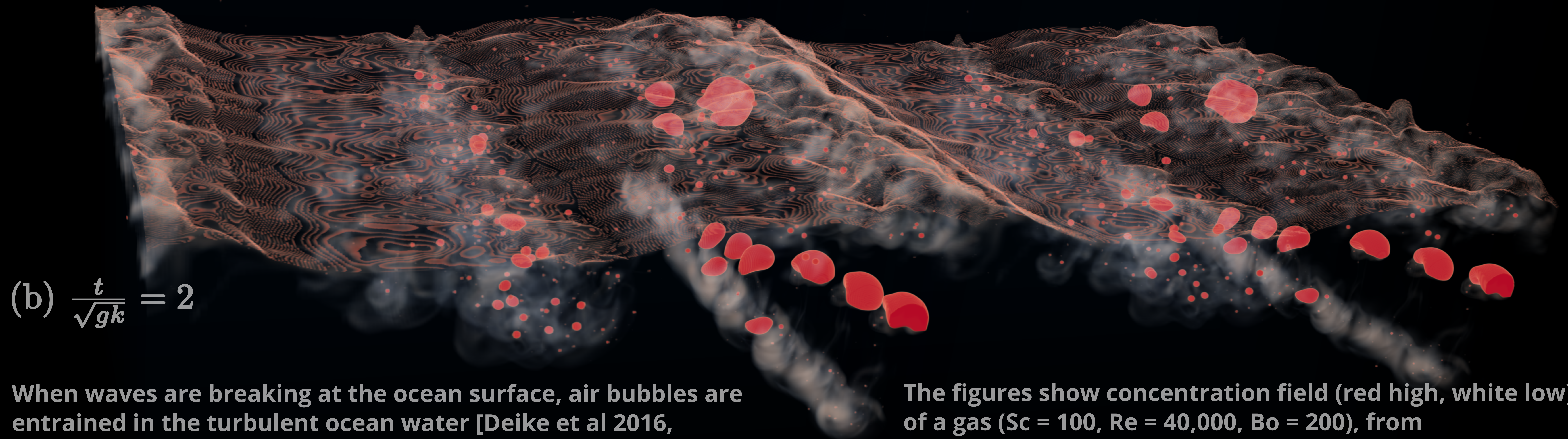
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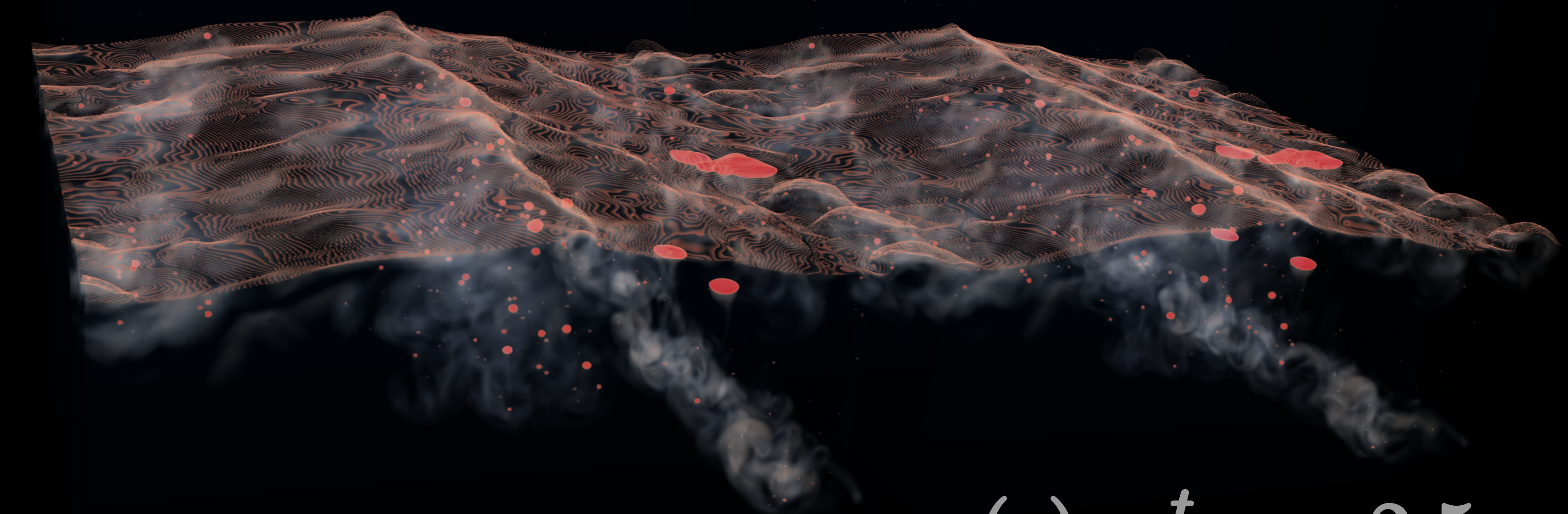
(a)  $\frac{t}{\sqrt{gk}} = 1$  Wind driven waves on the sea-air interface undergo breaking after reaching a critical amplitude.



(b)  $\frac{t}{\sqrt{gk}} = 2$

When waves are breaking at the ocean surface, air bubbles are entrained in the turbulent ocean water [Deike et al 2016, Deike & Melville, 2018] Gas exchange is enhanced by the presence of turbulent motion around the bubbles, with thin boundary layer following the vorticity structure of the flow, as visible on the figures [and Farsoiya et. al. 2021]. The total amount of gas exchange is controlled by the individual bubble transfer rate and the residence time (or rise velocity) of the bubbles in the water, both modulated by turbulence.

The figures show concentration field (red high, white low) of a gas ( $Sc = 100$ ,  $Re = 40,000$ ,  $Bo = 200$ ), from Direct numerical simulations of breaking wave using Basilisk PDE solver [Popinet and Collaborators, <http://basilisk.fr>, Farsoiya and Popinet and Deike, 2021]



(c)  $\frac{t}{\sqrt{gk}} = 2.5$