Luminy: Laboratory Experiments on The Influence of Breaking Waves on Air-Sea Gas Transfer

by

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The air-sea transfer velocities of gases are only known approximately. Breaking waves are a major, but poorly understood, factor that enhances the air-sea exchange of poorly soluble gases by at least three mechanisms:

1) Transfer associated through turbulence generated by breaking waves.
2) Transfer, while gas is within bubbles in the ocean.
3) Transfer across the sea surface when the microlayer has been disrupted by bubbles bursting.

These mechanisms are investigated in experiments in the large air-sea interaction simulation tunnel of IRPHE-IOA (Marseille, France) using combinations of aeration devices, mechanical wave generation and wind. A number of gases with widely varying solubilities and molecular diffusion constants have been measured in order to investigate the functional dependence of the transfer velocity. A large number of physical parameters are measured including wind stress, wave characteristics, whitecap coverage and bubble fluxes. The experiments with aeration devices have demonstrated the remarkable efficiency of bubble-mediated transfer (particularly for the least soluble gases) and the ability of bubbles to force the supersaturation of dissolved gases. The experiments with wind and mechanical wave generation have demonstrated the sensitivity of wave breaking to "sea state" at a fixed wind speed. The experiment has elucidated the role of breeking waves in air-sea gas exchange. Once it is recognised that gas transfer velocities are sea state dependent, and this applies both to simulation facilities and the real world, it is necessary to seek practical parameters for predicting transfer in addition to the wind speed or stress. Thus, we must relate gas transfer coefficients to whitecap coverage, bubble statistics or energy disspation.

European Commission
Directorate-General
Science, Research and Development
Directorate for Environment

Marine science and technology programme (MAST)

Sea-Air Exchange: Processes and Modelling

Scientific report of the workshop on sea-air exchange:
Processes and modelling
Kjeller, NILU, 11 to 13 June 1997

Edited by:
Jozef M. Pacyna [1], Dag Broman [2] and Elisabeth Lipiatou [3]

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EUR 17660 EN