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Herds of methane chambers grazing bubbles

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Water to air methane emissions from freshwater reservoirs can be dominated by sediment bubbling (ebullitive) events. Previous work to quantify methane bubbling from a number of Australian sub-tropical reservoirs has shown that this can contribute as much as 95% of total emissions. These bubbling events are controlled by a variety of different factors including water depth, surface and internal waves, wind seiching, atmospheric pressure changes and water levels changes. Key to quantifying the magnitude of this emission pathway is estimating both the bubbling rate as well as the areal extent of bubbling. Both bubbling rate and areal extent are seldom constant and require persistent monitoring over extended time periods before true estimates can be generated. In this paper we present a novel system for persistent monitoring of both bubbling rate and areal extent using multiple robotic surface chambers and adaptive sampling (grazing) algorithms to automate the quantification process. Individual chambers are self-propelled and guided and communicate between each other without the need for supervised control. They can maintain station at a sampling site for a desired incubation period and continuously monitor, record and report fluxes during the incubation. To exploit the methane sensor detection capabilities, the chamber can be automatically lowered to decrease the head-space and increase concentration. The grazing algorithms assign a hierarchical order to chambers within a preselected zone. Chambers then converge on the individual recording the highest 15 minute bubbling rate. Individuals maintain a specified distance apart from each other during each sampling period before all individuals are then required to move to different locations based on a sampling algorithm (systematic or adaptive) exploiting prior measurements. This system has been field tested on a large-scale subtropical reservoir, Little Nerang Dam, and over monthly timescales. Using this technique, localised bubbling zones on the water storage were found to produce over 50,000 mg m-2 d-1 and the areal extent ranged from 1.8 to 7% of the total reservoir area. The drivers behind these changes as well as lessons learnt from the system implementation are presented. This system exploits relatively cheap materials, sensing and computing and can be applied to a wide variety of aquatic and terrestrial systems.