Geophysical Research Abstracts,
Vol. 10, EGU2008-A-02766, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-02766
EGU General Assembly 2008

Small scale patchiness of phototactic micro-organisms in turbulent flows

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We present a study of swimming micro-organisms advected by a model turbulent flow and attracted towards a localised light source (phototaxis). It is shown that motile particles aggregate on a dynamical attractor with fractal measure whose dimension depends on the strength of the phototaxis. Using an effective diffusion approximation for the flow we derive an analytic expression for the phototactic gain (increase in light exposure over the aggregate) and by extension an accurate prediction for the fractal dimension based on the properties of the advection dynamics and the statistics of the illumination field. This leads us to conclude the fractal characteristics of the aggregate are determined by the non-dimensional ratio of the kinetic energy of swimming and of the turbulent flow.