PROPERTIES OF PERIODIC DYNAMICAL SYSTEMS MODELING: THE DIMETHYLSULFIDE(DMS)CYCLE

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Abstract

The variables of a model of dimethylsulfide (DMS) cycle and their interactions are analyzed in order to fit Mediterranan sea data. The outcome is a class of dynamical systems with periodic coefficients. A method to determine some mathematical properties conferred by these systems to the phase space is proposed to extract some information from the complexity of the solutions.

Keywords: Models, Geochemistry

Introduction

The dimethylsulfide (DMS) cycle of ecosystems may contribute to moderate anthropogenic forcing of climate. This field gives rise to a broad interest and to a large number of papers, but the magnitude of the DMS-climate feedback is difficult to appreciate.

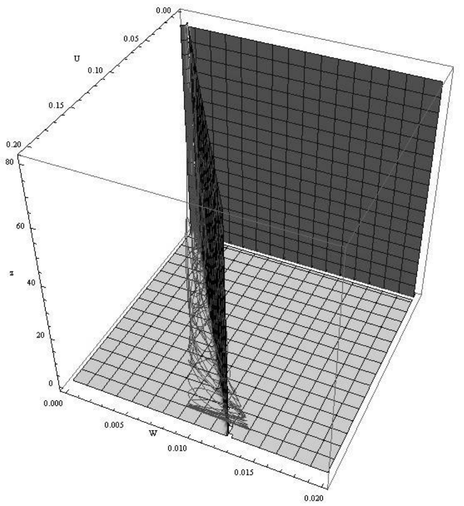

Fig. 1. Manifold (dark) and solutions trajectories in the three dimensional phase space DMS (U), DMSP (W), zooplankton (z)

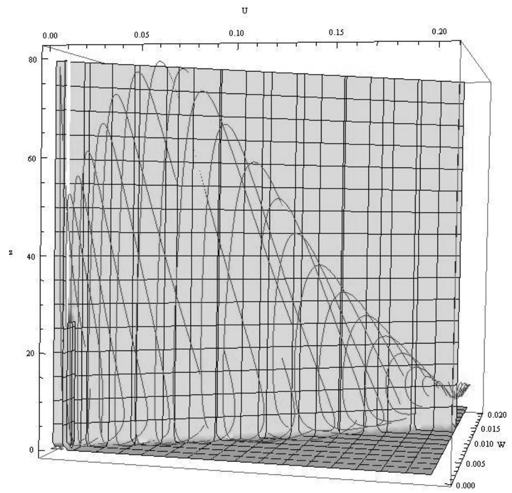

Fig. 2. Other perspective of the same phase space representation

Biologic study

The first part of this work is devoted to the construction of a model of the biogeochemical cycle of DMS based on works of A. J. Gabric & al.[1] and on experimental data from Mediterranean sea consisting in samplings of nutrients, phytoplankton, zooplankton and physical parameters such temperature, salinity and photometry [2]. The variables of an eight-dimensional mathematical model are concentration of phytoplankton, bacteria, zooflagellates, large protozoa, micro and mesozooplankton, dissolved inorganic nitrogen, dissolved dimethylsulfonio-propionate (DMSP) and dissolved DMS. The air-sea exchange of DMS depends in a complex way on the wind velocity and on the sea surface temperature (SST), which is a function of time. So, the original model is an eight-dimensional dynamical system with variable coefficients. At first, a numerical study allows to determine what variables have a significant influence in the DMS cycle, according the environment, in order to reduce the number of dimensions of the dynamical system. It is shown that, under some conditions, the three variables zooflagellates, large protozoa, micro and mesozooplankton, can be merged. Then, the nutrients can be introduced are an external input. So, the dimensions are reduced to five.

Mathematical study

Let us consider, for example, the dissolved DMS and DMSP concentrations. With some set of data, they autonomously oscillate with an irregular period of about one month. The high number of dimensions and this irregular oscillation contribute to the complexity of the solutions. The equation of an invariant manifold of an associated constant coefficient equivalent system (ACCES) is computed in a very simple way using differential geometry results [3]. This manifold plays an important role when the coefficients of the dynamical system depend on time [4]. When there is no wind, this manifold shows that the dissolved DMS and DMSP concentrations variations are almost synchronized. In the presence of wind, the manifold is periodically crossed by the solutions of the model as it is shown on the two figures, which are two perspectives of the projection of the same phase space on the (DMS, DMSP, zooplankton) tridimensional space. Then the DMS and DMSP respective influence is modulated by the sea surface temperature.

Conclusion

The respective influence of other set of variables could be studied by this method.

References

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