MODELLING THE EFFECT OF FOOD WEB ON BIOGEOCHEMICAL PROCESSES

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Model structure. Modelling is still at the beginning. Its progress depends strongly on the state of description of the system, the dynamics of which is intended to simulate. The food chain concept is an important element of the biogeochemical models. Different trophic levels are usually considered. However, the knowledge of small organisms has progressed rapidly during the recent years. This part of the trophic web was ignored ten years ago mainly because neither the sampling and observations means were developped, nor the concepts elaborated. The food web structure has to be introduced in models.

The microbial food web which parallels the macrobial food web and allows the complete recycling of nutrients is necessary to explain most of the properties of regeneration of nutrients. Although model structure has to stay simple it should embed the major biological and chemical properties known from experimental studies. Interactions between biological, chemical and physical processes are important but the space and time where interaction develops is very often not at the scale selected for the design of the model.

At the other end of the food web the gelatinous organisms or large crustaceans are well described but their role is not well understood. These large organisms are scarse compared to bacteria so that their effect is not easily measured. They are important for the dynamics of many chemical elements either by their fecal pellet production or by their strong vertical migration. During some short period of time these large gelatinous organisms are relatively abundants (appendicularians, salps). The determinism of these blooms is not well understood but the strong effect of their feeding on particulate matter lay the task of developping the proper processes interactions on the modellers.

Different models have been developped to deal with food web which can be the base of simulations of segments of the geochemical cycle of some elements.

Processes to incorporate into models. A model should have a vertical dimension to accommodate the vertical passive transport by sinking or active transport by migration. Fronts which are the most productive in the Mediterranean sea are also the place where organic particulate matter is injected continuously in deep water. Hydrodynamic processes are forcing strongly biological processes in such areas. The second thing to improve in models is a set of biological functions which can represent the conditions of assimilation, storage, transfer of a chemical element in the food web. Factors regulating the ratio between the amout of a chemical element and biomass for different biological variables, as well as the function structure should be defined. Another important improvement will be in the speciation of chemical elements in the water and under the effect of the substances produced by living organisms.

The third important field of development is the scaling effect. In nature the small scale processes have an average effect on the mesoscale. Non-linearities are characteristics of biological processes and express couplings which underlay the processes effects.

Biomass of an element of the food web is usually considered as a single variable. It should have a more complex dynamics because cell cycle is important for unicellular organisms (it has been demonstrated for picoplankton) and cohort dynamic is basic for zooplankton. It is now clear that most of the food web structure and of the interactions have to be carefully reconsidered for each case study. The sub grid parametrization is an important step in the process of model design.

Scales, data acquisition. A model cannot be designed without any time and space domain which is characteristic of the phenomenon considered. Data are necessary to define this domain and also to calibrate and validate the model. Modelling is one of the method essential to understand a phenomenon. Observation and experimentation are two others. They have to interact and continuously exchange information and results.

Exernal forcings. The major problem in coupling physical processes with biological or chemical ones is that the scale of interaction is not well known at present. Vertical mixing, for instance, which can be of different types, keeps the biological system in a permanent initial state if it is strong enough and, in any condition, damps out nearly most of the dynamics of the biological system (limit cycle, multiple equilibrium points). However the effect of external variables, wind, calorific energy, river input, is usually assumed constant or slowly variable, although it is mostly short and intense.

It appears that, on one hand, the long term internal behaviour of a system is not well defined and on the other hand long term forcings are not very well evaluated, mainly because they are multidimensional.

In order to improve the biogeochemical models, it is necessary to continue on these lines and develop observations at sea and experimental work in parallel to models :

- on short term response because interactions are mostly at the small scale and we have the capacity to measure continuously or to experiment in mesocosms at these time scales;
- on long term behaviour because most of the interactions of climate and ecosystems are presumably developping also at this time scale.