# GLOBAL MODELLING OF COUPLED CHEMICAL-CLIMATIC CHANGES

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During the last decades, the environmental perturbations due to human activities have been growing to the point where they begin to alter the state of the global Earth system. The most significant indicators of these changes of the global system are the general growth of atmospheric carbon dioxide, methane and other trace gases, the observed increase of the mean global surface temperature during the last hundred years and the recent development of the ozone hole over Antarctica. The initial step of this programme is to develop a radiative-convective-climatic model including the main carbon reservoirs to investigate the natural and anthropogenic atmospheric and climatic perturbations. In particular, a two-dimensional model of the stratospheric and tropospheric chemistry including advective, turbulent and wave transport and coupling with surface processes will be developed. It will be used in combination with scenarios of anthropogenic gas release to investigate perturbations to the surface energy budget, the dynamics of the stratosphere and the thermal structure. Changes in the distribution of carbon in the atmosphere, biomass and the oceans in the past and the future will also be studied with a simplified GCM coupled with ocean box models.

We are currently developing a two-dimensional (latitude and altitude) model of the global atmosphere-ocean-biosphere system to investigate the effects of the future increase in atmospheric carbon dioxide and trace gases (methane, nitrous oxide, chlorofluorocarbon compounds) on the global climate and atmospheric chemistry. The emphasis will be put on the analysis of the connection between atmospheric chemistry and climate. As a result, our atmospheric chemical scheme will be as detailed as possible, including detailed modelling of the tropospheric and stratospheric chemistry. For instance, the model will consider the complex chemical processes associated with the formation of the ozone hole over Antarctica. The climatic part of the calculation will be developed to fully describe the complex interactions between atmospheric chemical, radiative, dynamical and climatic processes. It will also consider the influence of the ocean and the biosphere on climate. A detailed model of the carbon cycle will be included to explicitly calculate the increase of the atmospheric carbon dioxide concentration. This sub-model will also consider the role of the oceans and the biosphere.

Our objective is to develop a global numerical model of the Earth system which could simultaneously be used to analyze the implications for this system of the general increase of atmospheric greenhouse gases, as well as the photochemical, radiative and climatological impacts of the global ozone decrease associated with the release of chlorofluorocarbon compounds (CFCs) in our atmosphere. To this end, we plan to use a two-dimensional (2-D) model of the atmosphere as well as a chemical-dynamical three-dimensional model of the troposphere including distributed sources of natural and anthropogenic constituents (IMAGE model).

The interrelationship between climate change and the continental biosphere will be considered in details. In particular, the importance of the biomass as a carbon storage reservoir, its dependence on climate evolution as well as the internal redistribution of ecosystems under changing climatic conditions will be numerically simulated.

Funding has also been granted to the University of Liège group within the EEC EPOCH programme to participate in the European programme on Global Carbon Cycle and its Perturbations by Man and Climate. Our role will be to study with a detailed chemical ocean model the relationship which has been observed between the atmospheric $CO_2$ content and the global temperature during glacial-interglacial changes. A basin division of the ocean will be adopted to simulate the marine carbon cycle. We shall consider the dependence of the rate of photosynthesis on the available $CO_2$ amount, the concentration of nutrients, the temperature and the flux of solar radiation (of potential importance in the polar regions). The decay of organic matter in the water column will be considered by modelling the oceanic cycle of oxygen. The terrestrial carbon cycle will be modelled in each latitude zone. The rate of photosynthesis depends not only on the atmospheric $CO_2$ partial pressure, but also on the availability of nutrients and solar light, on the temperature and on the air relative humidity. Weathering of the continental areas will also be considered, since this process depends on temperature and $CO_2$ pressure. The consideration of weathering will be of particular importance to estimate the global budget of nutrients.

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