Climate modelling: a challenge for mathematicians

George R. Sell

Abstract

The key to building good climate models is to have a good understanding of the heat transfer phenomena in the oceans of the Earth. The physical forces driving the oceanic flows include the radiation from the Sun and the changes in the gravity due to the Earth, the Moon, the Sun and the other planets. The longtime dynamics of any climate model are located in the global attractor of the underlying oceanic model.

Since the time scales for many climate models run into the tens, or even hundreds, or thousands of years, it is natural to ask: what would happen to the longtime dynamics of a model if one were to ignore high frequency events, such as the daily rotation of the Earth or the Lunar phases? (One might use a partial time-averaging method to eliminate the physics of these events.) However, it must be noted, for example, that the daily heating and cooling of the Earth's surface due to the Sun's radiation is both a major physical force AND it differs widely from its mean value. In short, by adding the daily rotation of the Earth to some time-averaged model, one is introducing an apparent large perturbation into the model. "Large" perturbations can destroy many dynamical properties.

In this lecture we will describe the "essential" dynamics of a model. We will also show that there is a rigorous way of constructing a family of good climate models AND we will argue that there is a solid mathematical foundation for eliminating, or adding, the high frequency events while preserving the "essential" dynamics of these models. This theory has immediate applications in the area of the numerical simulation of climate modelling.