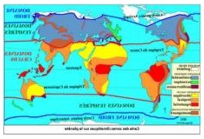
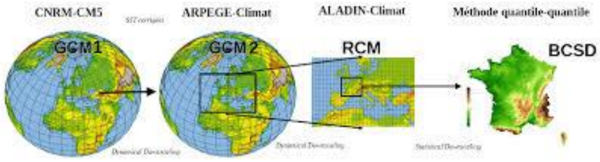
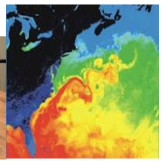
CEA Saclay –Service de Physique de l’Etat Condensé (SPEC) (page web)
Laboratoire *SPHYNX*

PROPOSITION DE STAGE/THESE 2022/2023

SOBER SIMULATIONS OF CLIMATE BIFURCATIONS

Greenhouse gases produced by human activity influence the Earth's climate, producing elevation of mean temperature, localized extreme events, and even bifurcations. Such bifurcations have been observed in laboratory experiments or simple models of climate. Reproducing them and studying them with classical simulation is both a challenge, and a problem in itself: indeed, the climate system is multi-component, and implies a pharaonic range of scales: for example, the simulation of the atmosphere (one of the components of the climate) requires in principle the consideration of all scales between that of hurricanes (100 km) and those at which energy is dissipated (0.1 mm), or a range of scales of 10^{11}. This range of scale is inaccessible to the largest computers currently in existence, which have neither enough memory nor enough CPU to handle such a large number of degrees of freedom.
On the other hand, even if it were possible, the corresponding simulation would be a energy sink: to simulate climate at a resolution 10km for 100 years takes 6 years of real time, and consumes as much electric energy as 50 french families during that time.

We are just facing a paradoxical situation where simulating the effects of climate change participates to climate change.

The solution to be able to perform sober simulations is to decimates degres of freedom, and simulate just those that are relevant to our purpose. How to achieve this is however a theoretical challenge, and no viable solution has been proposed so far.

In this project, we propose a new approach, which combines two new theoretical tools: the first one, called information geometry, is a new technique that allows to caracterize non-equilibrium transitions; the second one, called log-lattices, allows to perform sober numeical simulation by considering the whole range of scales, but by reducing the number of scales taken into account as we go down in size. The corresponding model is without adjustable parameters, and can be simulated on a laptop.

The main purpose of this project is then to study some simple bifurcations that can occur in the climate system, by applying it to a simplified representation of the atmosphere or the ocean. Most of the work will involve simulations in Python on a small computer.

The core of this project is numerical and statistical, but theoretical developments on turbulence theory via multi-fractal formalism and wavelet transforms can be carried out. This project will be supervised by B. Dubrulle (CNRS). The internship subject requires a solid background as a physicist, particularly in non-linear physics, as well as a strong taste for numerics. It may lead to a PhD on a related topic, in co-tutella with E-J. Kim (Coventry University).

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