Fiche sujet de stage

Titre du sujet de stage :

An energetic study of turbulence in tropical cyclones

Description du sujet (1 page maximum) :

The dramatic improvement in computational skills and performances of climate models has made possible to resolve scales associated with low probability, high impact weather phenomena, such as tropical cyclones. These abruptly energized processes profoundly influence the energetic state of the system, even globally and potentially on climatological timescales. Thus, understanding energy exchanges in their interior is a crucial task for the knowledge of the climate system internal variability and the prediction of its evolution. Furthermore, the energy that is "lost" at the discretization scales of the model severely constrains the energy consistence of long-term climate predictions. It is crucial for climate and weather models to appropriately represent such modes of variability. Modelling processes that occur at scales smaller than the resolution of the model usually requires "parameterizing the sub-grid scale processes", i..e describing processes that are not explicitly resolved in the model, relying on the resolved scales. Thus, the energetic consistency of commonly used sub-grid scale parametrizations is challenged by the introduction of higher-resolution models.

The student will adapt equations for the Available Potential Energy (APE) and Kinetic Energy (KE) in a Lorenz Energy Cycle (LEC) context, to study the energy transfer in high resolution simulations of tropical cyclones. In order to do so, he/she will benefit from a recently developed filtering technique, the Duchon-Robert technique [1]. This allows to determine whether at a specific filtering scale the energy is transferred upscale or downscale, thus being particularly suitable to investigate the loss of energy at the discretization scale of a model. The starting point will be a turbulent energy equation, as recently defined in [2] for a stratified axisymmetric rotating fluid with isotropic turbulence, and more recently in Faranda et al. 2018 [3] for a large-scale atmospheric dynamics context. This equation contains a third-order term, accounting for the KE inter-scale transfers, and another one for the horizontal flux of buoyancy variance, the share of the two terms sometimes being referred to as "efficiency", because it describes the APE-KE conversion. A system of two equations will be derived from that, separately accounting for KE and APE turbulent energy, in order to be consistent with the LEC framework. The APE and KE equations will then be used to diagnose the energetics in a set of idealized simulations tracking the life cycle of a tropical cyclone, e.g. using the non-hydrostatic SAM model [4] and DYNAMICO, a model developed at the home institution [5].

We expect that the student has a solid background in atmospheric dynamics and basis in the energetics of the climate system. In order to test the equations and run the model, knowledge of Python language is a significant advantage.

[1] Duchon & Robert Nonlinearity, 13(1), 249 (2000)

[2] Kuzzay D, Faranda D, and Dubrulle B. *Physics of Fluids* 27.7 (2015): 075105.

[3] Faranda et al. *Journal of the Atmospheric Sciences* 75.7 (2018): 2175-2186

[4] Khairoutdinov et al. 2003 *Journal of the Atmospheric Sciences*, *60*(4), 607-625.

[5] http://forge.ipsl.jussieu.fr/dynamico

Résumé en anglais (5 lignes) :

The goal of the internship is to adapt the equations for the Available Potential Energy and Kinetic Energy in a Lorenz Energy Cycle to study the energy transfer in high resolution simulations of tropical cyclones. The Available Potential Energy and Kinetic Energy equations will then be used to diagnose the energetics in a set of idealized simulations tracking the life cycle of a tropical cyclone, e.g. using the non-hydrostatic SAM model and in DYNAMICO, a model developed at the home institution.

Responsable du stage (Nom/prénom/statut) :

FARANDA, Davide (Chercheur CNRS)

Laboratoire concerné :

LSCE, LMD, SPEC

Equipe de recherche concernée (si pertinent) :

D Faranda(LSCE), S Fromang (LSCE), A Jezequel (LMD), B Dubrulle (SPEC). The student will also benefit from the tele-supervision of V Lembo (U Hamburg), expert in the energy cycles for atmospheric flows.

Niveau du stage (Licence, M1, M2, internship) :

M2

Licence ou Master(s) où sera proposé le sujet :

Masters associés à l'ED129 + Master Physique Systèmes Complexes (i-PCS) + Masters « climat » en France et à l'étranger

Thème scientifique de l'IPSL concerné :

Variabilité interne et forcée

Durée du stage :

5-6 mois

Période :

idéalement 03/02/2020 ▯ 02/08/2020

Est-il prévu une thèse dans le prolongement du stage ?

Non