ECOLE DOCTORALE DES SCIENCES DE L'ENVIRONNEMENT D'ILE DE France N° 129

Proposition de sujet de thèse pour la rentrée 2018

Nom du Laboratoire d'accueil : LMD N° UMR : 8539

Nom du Directeur du laboratoire : P. Drobinski
Adresse complète du laboratoire : ENS, 24 rue Lhomond, Paris
Nom et adresse de l'Equipe d'accueil si différente: FST

Nom du Directeur de thèse : V. Zeitlin
Téléphone : 0144322220
Mail : zeitlin@lmd.ens.fr

Nom du co-encadrant éventuel :
Téléphone :
Mail :

• Titre de la thèse :

Quantifying the influence of humidity, condensation and vaporisation upon the large-scale dynamics of the tropical atmosphere

• Sujet proposé (2 pages maximum) :

a. State of the art

In spite of significant progress and massive efforts (a review of the literature would largely exceed the length limits of the proposal), evolution of water vapor, clouds and precipitations remain a weak point of weather forecasts, especially long-term ones, while predictions of climate models are notoriously divergent in this respect. Thermodynamics of the moist air including phase transitions is complicated, and water cycles in the atmosphere are usually represented with the help of simplified parameterizations. The essentially nonlinear, switch character of condensation and related latent heat release poses specific problems in modeling the effects of humidity. This intrinsic mathematical difficulty, together with the overall complexity of the general circulation models make difficult the quantification of the influence of the condensation and vaporisation processes upon the large-scale long-time dynamics and related circulation patterns and, as a consequence, a proper assessment of the impacts of climate change. A new class of simplified multi-layer moist-convective models **[1,2]** provides an optimal compromise between fidelity and simplicity of representation of the moist processes in large-scale atmospheric dynamics. These conceptual models represent a useful alternative/complement both to the meso-scale and general circulation models, and can be used both at synoptic scale on mid-latitude and equatorial tangent planes, and at planetary scale on the whole sphere. An efficient, mathematically consistent and easy implementable front-resolving numerical scheme was developed for these models, allowing, in addition, for consistent incorporation of topography. Its one- and two-layer versions were successfully tested, respectively, for reproduction of the life-cycles of the moist barotropic and baroclinic instabilities **[3,4]**, and for understanding the role of moisture in the development of instabilities of tropical cyclones **[5].** In these works the simplest version of the model was used, where only water vapor condensation and related latent heat release was taken into account, the liquid water, as well as vaporisation and related cooling being dropped out. These latter effects, as well as entrainment of water by convective updrafts, are included in the "improved" version of the model, rendering representation of moist convection more realistic **[6]**. At the same time, horizontal temperature gradients, lacking in standard shallow water model, can be included in the framework of so-called "thermal shallow water" model, giving a possibility to couple the atmospheric model with sea-surface temperature. Thus obtained moist-convective shallow water model will be applied in order to provide a rough, but robust, quantification of the effects of moisture upon dynamics in various moist-convective phenomena, including propagation and intensification of tropical cyclones,

dynamical mechanisms behind the Madden-Julian Oscillation, and self-organization of convection at large scales. The model will be also used to develop and test the data assimilation schemes in the presence of moist convection, which is a notoriously difficult problem, and is worth approacing within a simplified model.

b. Objectives

To quantify the influence of condensation and vaporisation upon dynamics of waves, jets and vortices in tropics, including interactions of tropical waves with topography, resonant interactions of tropical waves and tele-connections mid-latitudes – tropics, instabilities of jets and vortices, and formation of coherent structures, including self-organisation of convection. To develop prototype schemes of data assimilation with moist convection.

c. Methodology and possible choices

Depending on the orientation and desiratum of the candidate the subject of the proposal can be narrowed to a specific sub-class of dynamical phenomena, or to furter development of the model and numerical and data assimilation schemes, and the accent can be made on theoretical or numerical aspects, using the methods and numerical schemes developed and applied by the supervisor and collaborators (see e.g. **[5, 7]** for stability studies, and **[8 - 10]** for theoretical approaches).

1. F. Bouchut, J. Lambaerts, G. Lapeyre and **V. Zeitlin**, 2009, Fronts and nonlinear waves in a simplified model of the atmosphere with moisture and convection, Phys. Fluids, **21**, 116604.
2. J. Lambaerts, G. Lapeyre, **V. Zeitlin** and F. Bouchut, Simplified two-layer models of precipitating atmosphere and their properties, 2011, Phys. Fluids, **23**, 046603.
3. J. Lambaerts, G. Lapeyre and **V. Zeitlin**, 2011, Moist vs dry barotropic instability in a shallow water model of the atmosphere with moist convection, J. Atmos Sci., **68,** 1234**.**
4. J. Lambaerts, G. Lapeyre and **V. Zeitlin**, 2012, Moist vs dry baroclinic instability in a simplified two-layer atmospheric model with condensation and latent heat release, J. Atmos. Sci., **69**, 1405.
5. N. Lahaye and **V. Zeitlin**, 2016, Understanding instabilities of tropical cyclones and their evolution with moist-convective shallow water model, J. Atmos. Sci., **73**, 505
6. M. Rostami and **V. Zeitlin** , 2018, Improved moist-convective rotating shallow water model, with applications to dynamics of tropical cyclones, Q. J. Roy. Met. Soc – *under consideration*
7. B. Ribstein, **V. Zeitlin** and A.S. Tissier, 2014, Barotropic, baroclinic, and inertial instabilites of the easterly Gaussian jet on the equatorial beta-plane in rotating shallow water model, Phys Fluids, 26, 056605.
8. J. Le Sommer, G.M. Reznik and **V. Zeitlin**, 2004, Nonlinear geostrophic adjustment of long-wave disturbances in the shallow-water model on the equatorial beta-plane , J. Fluid Mech. 515, 135
9. S. Medvedev and **V. Zeitlin**, 2005, Weak turbulence of short equatorial waves, Phys. Letters A, 342, 217.
10. G.M. Reznik and **V. Zeitlin**, 2007, Resonant interactions of free Rossby waves with semi-transparen equatorial waveguide, Physica D, 226, 55.

• Type de Financements prévu autre que ED 129 (CNES, CEA, ADEME etc…) :

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• Encadrement :

. Liste des autres doctorants que vous encadrés au 1er janvier 2018

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