FINAL REPORT PROGRAM LEFE

Program LEFE/MANU	**Project Title** **Relaxing "traditional" approximation in atmosphere-ocean modeling**	**Years 2016– 2017**

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Participating Laboratories:
LAMA, Scripps (US)

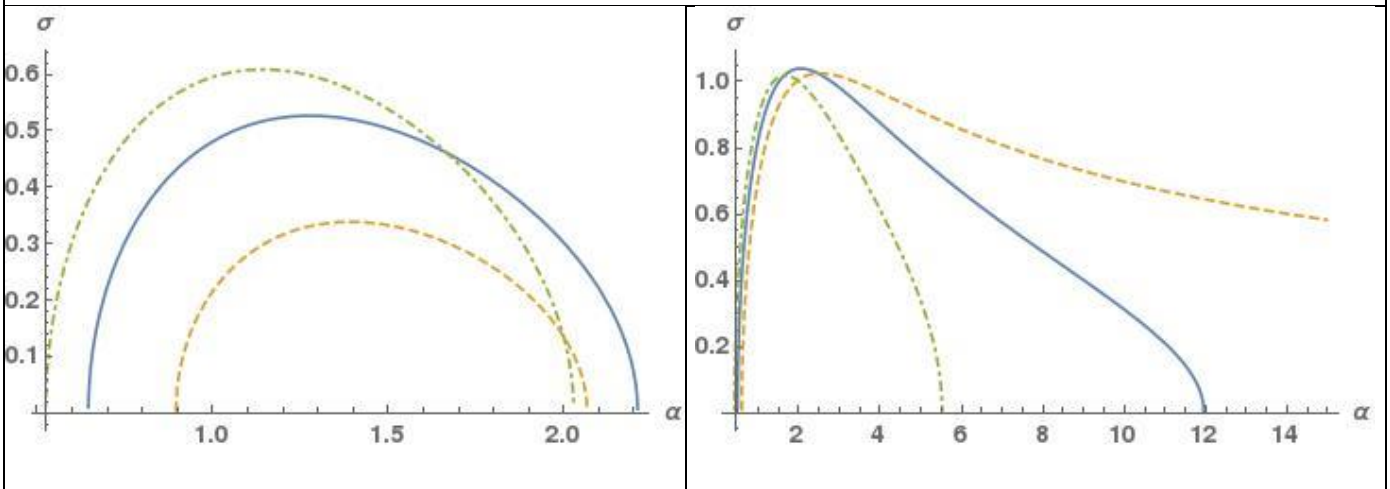
(No Contribution to specific international programs)

(No other funding sources)

Context: *Traditional atmosphere-ocean models neglect the "non-traditional' components of the Coriolis force.*

***Objectives / scientific questions*:**
Analysis of the influence of usually neglected "non-traditional" terms in the full Coriolis force upon hydrodynamic instabilities and propagation of inertia-gravity waves. Development of numerical codes including full Coriolis force

Main results:
It is shown that symmetric instability which is of particular importance in the mixed layer of the ocean, drastically changes upon inclusion of the full Coriolis force: the threshold, the parameter range, the growth rates, and the character of the instability all change, and dependence on the sign of the background shear appears. It was found that non-traditional effects are essentially different with and without hydrostatic approximation.
It is shown that in terms of energy radiated from the storm track, non-traditional effects are small for wind-driven near-inertial waves.
A numerical scheme is constructed for shallow-water equations on the sphere that solves the equations via a cell interface solver. It is consistent with the Rankine-Hugoniot conditions, is low diffusive on contact discontinuities, satisfies a discrete entropy inequality, which ensures its robustness, and is coordinate-system independent, which allows its use on any grid.



Left panel: Growth rates of symmetric instability as a function of the slope of the wave-vector of the unstable modes. Traditional (solid) vs full Coriolis force (non-traditional, NT) cases. Dashed – negative, dot-dashed – positive background shear. Order-one *difference in the growth rates*, and *asymmetry between positive and negative shears* in the non-traditional case are clearly seen.
Right panel: Comparison of non-dissipative growth rates with and without non-traditional contributions at the critical value of Richardson number, when the *range of unstable modes becomes infinite in NT* case with anticyclonic shear, and the instability becomes of *convective type*.

Future of the project:

Implementation of the shallow-water code with full Coriolis force in simplified models of the tropical atmosphere

Nombre de publications, de communications et de thèses

1. V. Zeitlin, 2016, Understanding inertial instability on the f-plane with complete Coriolis force, Proceedings of the VIII International Symposium on Stratified Flows, La Jolla, *https://escholarship.org/uc/item/3tn9s414, 8pp.*
2. Tort, M, Winters KB., 2018, Poleward propagation of near-inertial waves induced by fluctuating winds over a baroclinically unstable zonal jet, *J.Fluid Mech.*. **834**, p**.** 510-530.
3. V. Zeitlin, 2018, "Geophysical Fluid Dynamics. Understanding (almost) everything with Rotating Shallow Water Models", Ch. 16: Rotating shallow water models with full Coriolis force, Oxford University Press, 488pp.
4. V. Zeitlin, 2018, Symmetric instability drastically changes upon inclusion of the full Coriolis force, Phys. Fluids, **30**, 061701.