LabEx OSUG@2020

Observatoire des Sciences de l'Univers de Grenoble

Ce projet est soutenu par le Laboratoire d'Excellence OSUG@2020 (ANR10 LABX56) financé par le programme d'Investissements d'Avenir lancé par l'Etat et mis en oeuvre par l'ANR.

Titre du projet : Gravity currents over complex terrain

Volet : Recherche

Porteur du projet :Maria Eletta Negretti

Laboratoires impliqués :LEGI, LTHE

Bilan final du projet

Bilan d'activité final

Gravity currents are key processes that control ocean, atmospheric and coastal circulation. They contribute to the shaping of the continental surface by avalanches and landslides. The correct parametrization of subgrid turbulent processes related to gravity flows at abrupt topography changes are a problem of growing concern since predictions are often unreliable when the overflows themselves and mixing processes are not correctly included in atmospheric, coastal and oceanic circulation models.

While previous research on gravity currents have focused on dense currents descending a flat or uniform sloping smooth bottom, this project focuses on deriving new entrainment laws, on quantifing the variation of the global gravity flow properties and on extending existent theory including more complex terrain conditions as the slope curvature, roughness and a mobile (erodible) bottom. It explores the conditions of existence of Görtler instabilities in stratified flows important for bottom entrainment/de-entrainment and for the turbulent fluxes at the sheared interface.

The project enabled to perform experiments on gravity currents on changing slopes giving interesting insights on the development of such flows with this conditions. I developed a new experimental design to study stationary gravity flows over curved slopes. The study was initially motivated by the findings of C. Brun, who observed the formation of Görtler instabilities in his numerical simulations (MesoNH) of catabatic flows over a convex slope simulating a particular slope in the Grenoble mountain area. I first dedicated much of the time trying to reproduce Brun's numerical results over a concave slope and then on a hyperbolic tangent shaped slope. However, until present no Görtler instabilities could be reproduced experimentally. For this a new experimental design is needed.

Further, I performed a set of experiments using the PIV technique to characterize the gravity current on concave slopes to be compared to straight slopes and hyperbolic tangent shaped slope to be compared to the numerical and field data of C. Brun. Laminar and turbulent conditions have been both investigated separately. The results relative to the sudden slope changes along with the development of the existing theory, now valid for any varying angle is included within a journal article for JFM under revision. The results relative to the comparison of the experimental data of gravity currents over tanh-shaped slopes and the numerical simulations and field data of the C. Brun are included in a second article in preparation for the Journal of Dynamics of Oceans and Atmospheres. DNS simulations in close collaboration with G Balarac have been performed reproducing the same conditions as in the experiments. The numerical results compare well with the experimental results. Further simulations over convex slopes have also been performed. A further journal article is planned including the numerical results for the Görtler instabilities.

Illustrations - avec légende et crédit *(à envoyer également séparément)*

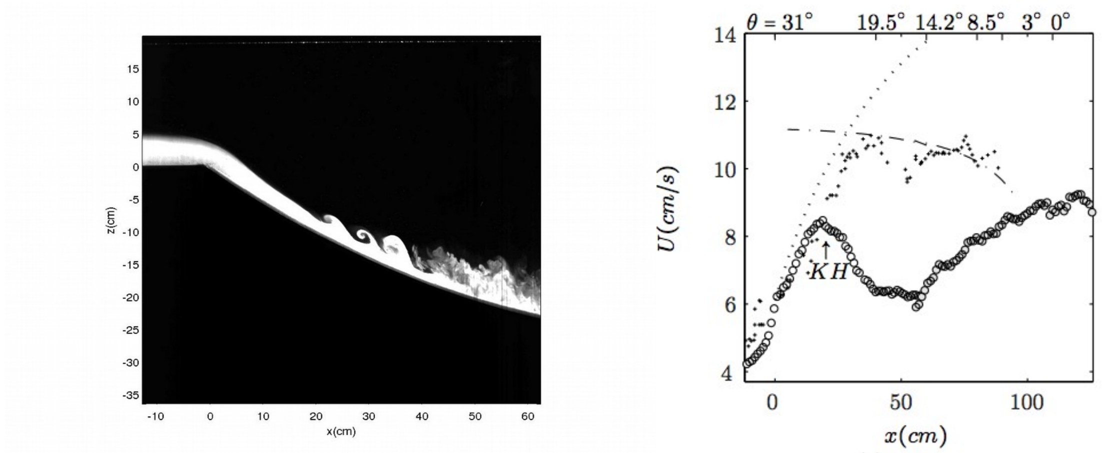

Figure 1 : (left) Dye visualization of the gravity current along a concave slope from the laboratory experiments. The physical dimensions are of 70x50 cm approximately. (right) Comparison between experimental(symbols) and theoretical(dotted/dashed lines) depth averaged density current speed versus the longitudinal direction ;

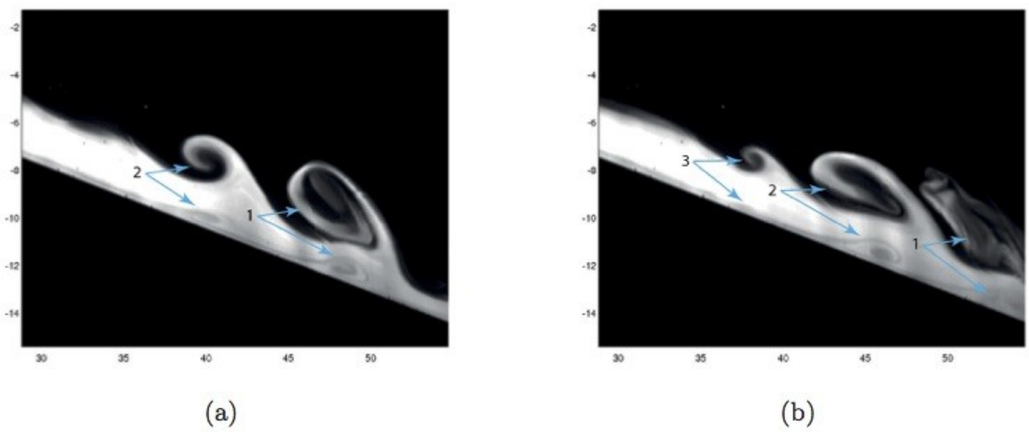

FIGURE 8. Series of zoomed views of the current at onset of KH instability, dye visualizations of experiment L1 with a time interval of 0.5s, showing the development of large bottom billows coupled with the development of the overlying KH billows. The approximate length scale of these boundary billows is 1cm.

Production scientifique *(articles scientifiques, actes de congrès…)*

- Brun, C. "Large-Eddy Simulation of katabatic jet along a convexly curved slope. Part 2: Evidence of Görtler vortices." *J. of Geophysical Research (**accepted**) 2017.*
- Negretti ME, Flor JB and Hopfinger EJ *Gravity currents on rapidly changing slopes under revision* for JFM.

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- Negretti ME and Brun C *Modeling turbulent fluxes and entrainment in a gravity flow : experiments versus numerical simulations,* in preparation for Dyn of Ocean and Atm.

Bilan financier succinct

In the first funding request **30k€** were requested for acquiring equipment for the laboratory and field experiments. These were in particular a CCD camera for 10k€ (with high pass filter and objective 2k€) to be added to an existent acquisition system acquired in a previous project funded by Pôle SMINGUE of UJF in order to have a complete acquisition system to be available for these experiments. Further equipment of roughly 8k€ was requested for the instrumentation related to field measurements (anemometers, temperature sensors and acquisition station, etc). The accorded fundings were finally roughly 50 % of the originally demanded, i.e. **16,2k€**. Thus, we decided to perform some improvements to the existent experimental facility instead of acquiring a low quality CCD camera which would need to be replaced in a close future. I could work using a CCD camera (which unfortunately needed to be repared during the experiments) made available for 6 months by the instrumentation service of LEGI. For the equipment of the field measurements, the contribution to the 1/2 Sonic 3D Anemometer Campbell CSAT3 as originally requested has been omitted.

A detail of the expenses is given below :

Reparation of CCD camera of instrumentation service LEGI	570€
Fiber Optic Cable for Laser line generation	1230€
Toolbox Matlab licence	200€
Pump and pump control for the outlet	1450€
Flow rate meter	406€
Other expenses (channel variations, salt etc)	500€
PC DELL for experimental data analysis for MII student	951€
MII Stage (Verbruggen S)	1308€
Scientific Books	278€
Sonic anemometer Vaisala 2D WMT700 for field measurements	1740€
Notebook replacement	1500€
MII stage February-June 2015 Cédric Lachaud	1500€
Other expenses (channel variations, slopes, automatic electric valves)	2500€
Other equipment for the field measurements as originally requested (temperature baloon and velocity anemometers, battery and acquisition station)	2000€
Total expenses	**16133€**

Since I was absent for maternity from December 2013 to August 2014, and then from July 2015 until november 2016 the project has been reported until now.