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Acronyme/short title	**MathOcean**
Titre du projet *(en français)*	Analyse mathématique en océanographie et applications
Titre du projet/Proposal title *(en anglais)*	Mathematical analysis in oceanography and applications

Les pages seront numérotées et l'acronyme du projet devra figurer sur toutes les pages du document en pied de page.
Un sommaire du document est bienvenu

S'il s'agit d'un projet déposé dans le cadre d'un accord de coopération internationale*, préciser avec quelle agence étrangère :
☐ National Natural Science Foundation of China (NSFC)
☐ Japan Society for the Promotion of Science (JSPS)
☐ Japanese Science and Technology Agency (JST)
☐ National Science Council of Taiwan (NSC)

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1. Programme scientifique / Description du projet *Technical and scientific description of the proposal*

1.1 Problème posé/Rationale

This research project aims at a better understanding of a wide range of natural phenomena which are commonly observed in oceanography.

The complexity and variety of these phenomena, among which wave breaking, weak turbulence and optimization of coastal structures, require advances in often disconnected research areas, which range from physical modeling to abstract mathematical analysis, and include numerical simulations and environmental applications.

We will derive new physical models and develop efficient mathematical tools to describe these phenomena. These results will be validated in industrial situations and in situ experiments.

Our team has been brought together with the purpose of covering a large scientific spectrum and with the shared intention of working towards a better articulation, at a national and international level, of all the scientific efforts related to oceanography (through pluridisciplinary websites, workshops etc.). It gathers oceanographers (Bordeaux and Montpellier), mathematicians specialized in the analysis of equations of fluid mechanics (Bordeaux, Chambéry, Montpellier, and ENS Paris) and experts in the numerical simulations of oceanographic phenomena (Bordeaux, Chambéry and Montpellier).

We expect that the mathematical and numerical tools that will be developed in this project will have a scope that goes far beyond oceanography. In particular, central to our project will be the analysis of boundary value problems (and coupling) of complex systems of partial differential equations, and a

rigorous approach to weak turbulence. Numerical algorithms of a general interest, such as optimization algorithms, new well-balanced and residual based schemes, will be developed.

1.2 Contexte et enjeux du projet/*Background, objective, issues and hypothesis*

The term « oceanography » gathers many phenomena of very different kinds and occurring at very different time and spatial scales. These phenomena must be understood and very often coupled one to each other. The different points to which our project gives special attention reflect this diversity. We divided this project into four parts (Coastal flows, Energy dissipating processes, Rotating fluids, Complex fluids and environmental issues), which obviously interact; we believe that mutualizing the research efforts in all these areas will be highly beneficial.

A) Coastal flows

By « coastal flows » we refer to all the phenomena describing the evolution of the waves from the continental shelf to the shoreline. These phenomena include:

i) Wave shoaling as the water depth decreases
ii) Wave breaking
iii) Vorticity generation (e.g., rip-currents)
iv) Shoreline dynamics (e.g., run-up)

i) The shoaling process can be described very well by Boussinesq like models derived from the free surface Euler equations. Fully nonlinear Boussinesq models (generally called Green-Naghdi, or Serre equations) which do not require any « small amplitude/depth ratio » assumption have been obtained [W] and give a very good account of the shoaling process up to the breaking point. In [AL], a rigorous derivation of these models has been given and the challenge is now to couple them to other (deep water) models or to modify them in order to take into account the breaking of waves and subsequent phenomena.

ii) When the waves break, the flow becomes diphasic (bubbles), energy is dissipated and vorticity is created. There are at least two approaches to study this phenomenon at the « macroscopic » scale of the waves: the firsts one consists in adding an artificial dissipation to the models used to describe the shoaling phase (see the « roller » concept developed in [M], which is used in the software FUNWAVE) while the second one uses the natural dissipation of the shocks provided by the (hyperbolic) shallow-water equations; none of these two methods is satisfactory because the first one is far too sensitive to the artificial dissipation while the second one is based on the shallow water equations which do not give a correct account of the shoaling.

iii) Wave breaking induces large scale vertical vorticity (rip currents) when the energy dissipation rate is not uniform. This very important phenomenon still lacks a rigorous mathematical analysis and the numerical simulations (e.g., [N]) that address this problem still need to be seriously improved.

iv) The treatment of the shoreline and of the run-up is a very challenging mathematical and numerical issue. It is possible to handle mathematically the situation where the water depth vanishes with simple shallow water models [BD], but for more complex models including dispersive effects, the problem is completely open. Numerically, the code developed in [Mar] gives very good results for the computation of the run-up over complex topographies but should be improved to take into account dispersive effects and large-scale vertical vorticity.

[AL] B. Alvarez-Samaniego, D. Lannes, *Large time existence for 3D water-waves and asymptotics* , Invent. math. **171** (2008) 485–541
[BD] D. Bresch, B. Desjardins, *Existence of global weak solutions for a 2D viscous shallow water equations and convergence to the quasi-geostrophic model*, Comm. Math. Phys. **238** (2003) 211-223.
[M] P.A. Madsen et al., *Surf zone dynamics simulated by a Boussinesq type model. Part I. Model description and cross-shore motion of regular waves*, Coastal Engineering **32** (1997) 255-287
[Mar] F. Marche et al., *Evaluation of well-balanced bore-capturing schemes for 2d wetting and drying processes*, Int. J. Num. Meth. Fluids **53** (2007) 867–894.
[N] S. Noelle et al., *Well-balanced finite volume schemes of arbitrary order of accuracy for shallow water*

flows, J. Comp. Phys. **213** (2006) 474–499
[W] G. Wei et al, *A fully nonlinear Boussinesq model for surface waves. Part 1. Highly nonlinear unsteady waves*, J. Fluid Mech. **294** (1995) 71-92

B) Energy dissipating processes

The way energy dissipates in oceanographic phenomena is far from being understood and many explanations are controversial. We plan to work on the following aspects:

i) Energy dissipation in wave breaking
ii) Weak turbulence

i) We have seen that an estimate of the energy dissipated when waves break is of considerable importance for the description of coastal flows. There have been some attempts to compute the energy dissipated by the droplets due to capillarity [G], and bubbly fluids have also drawn some attention recently [GT,BDGG]. One should work more in that direction, compare these predictions with direct numerical computations in the spirit of [L], and possibly implement them into coastal flows models.

ii) The goal of weak turbulence is to understand the way small-scale phenomena can affect large scale dynamics [B]. This can be modeled through a power law for the energy spectrum (Kolmogorov spectrum, see for instance [DKZ] for an application to surface water waves) or by a viscous dissipation with eddy viscosity.

[B] G. Barenblatt, *Nonlinear Dynamics and Turbulence*, Pitman, 1983.
[BDGG] D. Bresch, B. Desjardins, J.-M. Ghidaglia, E. Grenier, *On global weak solutions to a generic two-fluid model*, submitted
[DKZ] A. I. Dyachenko, A. O. Korotkevich, V. E. Zakharov, *Weak turbulent Kolmogorov spectrum for surface gravity waves*, Phys. rev. lett. **92** (2004)
[GT] S.L. Gavrilyuk, V.M. Teshukov, *Generalized vorticity for bubbly liquid and dispersive shallow water equations*, Continuum Mech. Thermodyn. **13** (2001)
[G] Goodrige et al., *Breaking Faraday Waves : Critical Slowing of Droplet Ejection Rates*, Phys. Rev. E, **56** (1997)
[L] P. Lubin et al., C. R. Mecanique 331 (2003) 495–501

C) Rotating fluids

At a much larger scale than the coastal flows previously described, one must use a rotating fluid approach to describe the behavior of large-scale currents (e.g., the Gulf Stream); the main features of the analysis are the following:

i) Mathematical analysis of rotating fluids
ii) Dependence on the latitude
iii) Role of stratification and global structure of the oceanic circulation
iv) Influence of the wind and coupled ocean/atmosphere models

i) The classical rotating fluid problem [CDGG] consists in studying the asymptotic behavior of the Navier-Stokes-Coriolis equations with a singular penalization coming from the Coriolis force. The system is shown to exhibit a fast oscillatory behavior, with Kelvin and Poincaré waves, the persistence of which depends on the horizontal domain under consideration. A precise asymptotic analysis allows then to determine the envelope equations for these waves and the vertical boundary layers which are responsible of an important dissipation process, referred to as the Ekman succion [CDGG,DG,M].

ii) The Coriolis parameter depends actually on the latitude. For some simple 2D models (typically shallow water models), it is possible to take the latitude effects into account [GS1], which gives rise to an additional family of waves, called Rossby waves. Near the equator, we have further exhibited a wave-guide effect due to the vanishing of the penalization [GS2]. These studies should be refined by taking into account the vertical variation of the fields and possible horizontal boundary conditions.

iii) The vertical structure of the ocean circulation is also related to the variations of the density, the so-called stratification of the oceans. Theoretical works by physicists [P] have brought some understanding about the full density and velocity structure of the wind-driven circulation by going

beyond the quasi-geostrophic approximation to consider the important effect of the ventilation of the thermocline, which occurs as density surfaces rise to intersect the surface layer. Such qualitative theories need however to be validated by some rigorous asymptotic analysis.

iv) All these contributions consider the wind as a given source term, which is computed statistically from experimental data. A very challenging open problem consists in deriving coupled models for the atmosphere and the oceans, and to study their qualitative features.

[CDGG] J.-Y. Chemin, B. Desjardins, I. Gallagher, E. Grenier, *Basics of Mathematical Geophysics*, Oxford Lecture Series in Mathematics and its Applications **32**, Oxford University Press (2006).
[DG] B. Desjardins, E. Grenier, *On the Homogeneous Model of Wind-Driven Ocean Circulation*, SIAM J. on Appl. Math. **60** (1999), 43-60.
[GS1] I. Gallagher, L. Saint-Raymond, *Weak convergence results for inhomogeneous rotating fluid equations*, J. Anal. Math. **99** (2006), 1-34.
[GS2] I. Gallagher, L. Saint-Raymond, *Mathematical study of the betaplane model : equatorial waves and convergence results*, to appear in Mémoires SMF (2008).
[M] N. Masmoudi, *Ekman layers of rotating fluids: the case of general initial data*, Communications in Pure and Applied Mathematics **53** (2000), 432–483.
[P] J. Pedlosky, *Ocean circulation theory*, Springer, 1996.

D) Complex fluids and environmental issues

In this project, we plan to focus especially on the following points, whose description cannot be reduced to the sole study of the flow of a single fluid:

i) Shape optimization for passive defense structures against littoral erosion
ii) Sedimentation and transport of pollutants
iii) Flows over complex topographies
iv) Internal waves

i) The design of passive defense structures against littoral erosion had motivated the ANR project COPTER. Simulations, prototyping and in-situ testing permitted to verify the effectiveness of immerged structures [ABIM1,2]; these results have been evaluated on industrial configurations. However, two points need clear improvements: one should use an accurate time-dependant shallow water model (Boussinesq or Green-Naghdi) instead of the simple refraction/diffraction model used so far, and one should improve the optimization algorithm.

ii) The analysis of sediment/pollutant transport is important to predict and prevent natural disasters. Many models describing the bed evolution exist in the literature. For instance, sediment-transport routines have been added recently to the US based ocean circulation code ROMS, but future versions need to model cohesive sediments and mixed sediments.

iii) Complex topographies can considerably change the properties of the flow. For instance, rough bottoms induce changes in the propagation speed and diffusion effects on coastal flows [RP,CGNS] ; they can also induce nonlinearities in the usual linear Stommel and Munk boundary layers or memory effects on quasi-geostrophic models [BGV1, BGV2]. These phenomena are not fully understood yet. Similarly, the derivation of the shallow water equations from Navier-Stokes is very sensitive to the boundary conditions and finding nontrivial bottom laws (e.g., for granular media) is challenging in itself.

iv) The behavior of the interface between two fluids raises many interesting problems. Internal waves (at the interface of two fluids of different densities) are described by many nonlinear dispersive equations (such as Benjamin-Ono). Until very recently, the derivation of these models was formal ([CGK] and references therein); in [BLS] many models, some of them new, have been proved to be consistent with the original equations, and a rigorous justification of the Benjamain-Ono equation has been established [OI] in presence of surface tension. Many of the asymptotic models still need to be investigated and one must understand why the Kelvin-Helmhotz instabilities which arise in absence of surface tension are « harmless » in many physical situations.

[ABIM1] P. Azerad, F. Bouchette, D. Isebe, B.Mohammadi, *Shape optimization of geotextile tubes for sandy beach protection*, International Journal for Numerical Methods in Engineering (2008).

[ABIM2] P. Azerad, F. Bouchette, D. Isèbe, B. Mohammadi, *Optimal shape design of coastal structures minimizing short waves impact*, Coastal Engineering **55** (2008).
[BGV1] D. Bresch, D. Gérard-Varet, *About roughness effect on the quasigeostrophic equations model*, Comm. Math. Phys. **253** (2005) 179-200.
[BGV2] D. Bresch, D. Gérard-Varet, *Homogenization problems from shallow water theory*, Applied Math Letters **20** (2007) 505-510.
[BLS] J. Bona, D. Lannes, J.-C. Saut, *Asymptotic Models for Internal Waves*, to appear in J. Math. Pures Appl.
[CGK] W. Craig, P. Guyenne, H. Kalisch, *Hamiltonian Long-Wave Expansions for Free Surfaces and Interfaces*, Comm. on Pure and Applied Mathematics **58** (2005)1587–1641
[CGNS] W. Craig, P. Guyenne, D. P. Nicholls, C. Sulem, *Hamiltonian long-wave expansions for water waves over a rough bottom*, Proc. R. Soc. A **461** (2005) 839–873
[OI] K. Ohi and T. Iguchi, *A two-phase problem for capillary-gravity waves and the Benjamin-Ono equation*, to appear in Discrete Contin. Dyn. Syst.
[RP] R. Rosales, G. Papanicolaou, *Gravity waves in a channel with a rough bottom*, Stud. Appl. Math. **68**, (1983) 89–102.

1.3 Objectifs et caractère ambitieux/novateur du projet/*Specific aims, highlight of the originality and novelty of the project*

As explained above, our project deals with various aspects of oceanography. Our goal is to make significative advances in the four main research areas of the project (Coastal flows, Energy dissipating processes, Rotating fluids, Complex fluids and environmental issues) and to mutualize and coordinate our efforts to make our advances useful beyond the scope of their direct motivation. In particular, we plan to develop new tools for the analysis of boundary value (and coupling) problems for complex PDE systems and for the analysis of weak turbulence.

I- Specific goals in oceanography (specific aims)

We describe here some of the result we wish to obtain in the different research areas described in the previous section.

A) Coastal flows

We project strong advances in the understanding of coastal flows; in particular, at the theoretical/modeling level, we plan to:

- Understand how wave break through asymptotical models
- Analyze the creation of large scale vertical velocity (rip-currents)
- Analyze mathematically the coupling of a shallow-water model with a deep-water model
- Analyze the behavior of the models at the shoreline

For the numerical part, we will coordinate all our efforts in order to:

- Develop a numerical platform for the simulation of coastal flows

B) Energy dissipating processes

The rigorous analysis of energy dissipating processes is only at its early stage. Our contribution to this long-term research project should be:

- A rigorous analysis of wave turbulence including the derivation of the kinetic equations.
- Obtaining rigorous estimates on the energy dissipated by capillarity in wave breaking
- Implementing a two-fluid approach to wave breaking

C) Rotating fluids

We propose significative improvements of the models used to describe large-scale currents:

- Solve the open case of nonhomogeneous penalizations
- Take into account stratified fluids.
- Take into account nontrivial horizontal boundary conditions

- Derive and analyze coupled ocean-atmosphere models

D) Complex fluids and environmental issues

Our main goals concerning this part of the project are:

- Develop an accurate and industrially evaluated software for the design of coastal structures
- Model, analyze and implement numerically new sediment transport models
- Derive rigorously new models for complex topographies and non trivial bottom laws
- Analyze rigorously internal waves models and study the singularity formation

II- Development of new mathematical tools (specific aims)

Many of the scientific goals mentioned require a good understanding of the physical phenomena and new physical models should be written to understand some phenomena for which no satisfactory explanation exist, even at a formal level (wave breaking, turbulence, etc.). Moreover, the scientific program presented here requires the development of new mathematical tools whose interest goes far beyond the scope of oceanography:

- Coupling of nonlinear, dispersive systems of PDEs
- Mathematical tools for the treatment of weak turbulence

1.4 Description des travaux : programme scientifique/*For each specific aim: a proposed work plan should be described (including preliminary data, work packages and deliverables)*

I- SPECIFIC GOALS IN OCEANOGRAPHY (detailed work plan)

A- Coastal flows

- UNDERSTAND HOW WAVES BREAK THROUGH ASYMPTOTICAL MODELS. The derivation of asymptotical models from the free surface Euler equations is well understood from [AL,BL] but the prediction of these models stops to be valid when the slope of the waves becomes infinite (mathematical wave breaking). However, the wave does not experience any significant physical change at this point. We plan to derive asymptotic models for parameterized surfaces (rather than graphs) that will take into account the overturning of the waves. This would be very useful since we could then compute at reasonable numerical cost some wave profiles very close to the overlapping point; these results could then be used as initial data for the very heavy direct computations, such as [L] for instance.

[AL] B. Alvarez-Samaniego, D. Lannes, *Large time existence for 3D water-waves and asymptotics* , Invent. math. **171** (2008) 485–541
[BL] P. Bonneton, D. Lannes, *Derivation of asymptotic two-dimensional time-dependent equations for ocean wave propagation*, submitted.
[L] P. Lubin et al., C. R. Mecanique 331 (2003) 495–501

- ANALYZE THE CREATION OF LARGE SCALE VERTICAL VELOCITY (RIP-CURRENTS). In the physical paper [B], it has been discussed that, in 1DH, the dissipation of energy at the shocks for the nonlinear shallow water equations is somehow the physical one (if momentum is conserved during wave breaking). We plan to generalize this approach to the 2DH case and to give it a rigorous mathematical basis. It will then be possible to study whether, and how, nonuniform bathymetries can create rip currents. Finally, this analysis should be generalized to the more realistic (but nonhyperbolic) Green-Naghdi equations.

[B] P. Bonneton, *Modelling of periodic wave transformation in the inner surf zone*, Ocean Engineering **34** (2007) 1459-1471.

- ANALYZE MATHEMATICALLY THE COUPLING OF A SHALLOW-WATER MODEL WITH A DEEP-WATER MODEL. See below the section devoted to the development of new mathematical tools.

- ANALYZE THE BEHAVIOR OF THE MODELS AT THE SHORELINE. In [BM], vanishing depth has been taken into account for the lake equations. We will work on generalization of this result for coastal oceanography models. Taking advantage of recent papers recently written on lubrication models with vanishing depth, see for instance [GiOt], and using the recent formal shallow water derivation due to J.P. Vila and justified in [BN], we will focus on the contact angle problems for shallow water. We hope by this way to derive more physical boundary conditions than those used in [BM].

[BM] D. Bresch, G. Métivier, *Global existence and uniqueness for the lake equations with vanishing topography: elliptic estimates for degenerate equations*, Nonlinearity **19** (2006), 591-610.
[BN] D. Bresch, P. Noble, *Mathematical justification of a shallow-water model*, to appear in Methods, Analysis and Applications (2008).
[GO] L. Giacomelli, F. Otto, *Rigorous lubrication approximation*, Interfaces and free boundaries **5** (2003), 483-529.

- DEVELOP A NUMERICAL PLATFORM FOR THE SIMULATION OF COASTAL FLOWS. Various members of the team will coordinate their efforts towards this goal:
  - P. Bonneton and D. Lannes should supervise a transdisciplinary PHD thesis starting in 2008-09 (the grant for this thesis has just been asked at the BQR of University Bordeaux I as a transverse project) on the numerical coupling of a deep-water model to a shallow water model. The deep water should be fully dispersive (and solved with spectral methods in the spirit of [GN]) and to begin with, the shallow-water code should be SURF_WB developed by F. Marche.
  - F. Marche and collaborators will work on improvements of the SURF_WB code. A hybrid finite-volume and finite-difference schemes for weakly non-linear weakly dispersive Boussinesq like models is under investigation and uses a new splitting process: SURF_WB (or rather its recent improvement [BM]) is used for the conservative part of the equations, in the Godunov-type shock-capturing spirit while the dispersive terms are discretized with high order Finite-Difference schemes. This new model, which is obviously conservative, can provide a very high resolution for the solutions of a large range of 2D phenomena, including steep-front wave propagation, breaking waves interactions with complex topography, vertical vorticity dynamic and moving shoreline evolution. An extension to fully non-linear Green-Naghdi models is likely.
  - M. Ricchiuto will in the meantime investigate whether the so-called « residual approach » gives good results for shallow-water models including dispersive terms. In the residual approach, the unknowns are the values of the water height and of the discharge in the nodes of the mesh. Using these values, in each cell a polynomial is constructed, which is used as local approximation; the equation is thus satisfied only up to a residual. On unstructured meshes one can show [R] that the schemes preserve the accuracy of the spatial approximation and that the balance between flux terms and source terms is respected up to machine accuracy. This framework allows a natural extension toward higher accuracy, simply by changing the local polynomial basis, while this is more complex in the FV case. It is therefore worth investigating whether this technique gives good results for the third order dispersive terms (for diffusion terms, this has recently be done in [N]).

- Finally, we will numerically investigate the fully coupled interactions of surface waves with rip currents and the nearshore circulation generated by wave transformations on a double-bar system. Numerical results will be compared to a 5-days intensive field experiment, where a large array of instruments (1 S4, 1 AWAC, 2 ADCP, 4 ADV and 4 pressure sensors) was deployed.

[BM] C. Berthon, F. Marche, *A positive preserving vfroe scheme for shallow water equations: a class of relaxation scheme*, submitted.
[GN] P. Guyenne, D.P. Nicholls, *A high-order spectral method for nonlinear water waves over moving bottom topography*, SIAM J. Sci. Comput. **30** (2007) 81-101
[N] H. Nishikawa, J. Comput. Phys. **227** (2007)

B- Energy dissipating processes

- A RIGOROUS ANALYSIS OF WAVE TURBULENCE STARTING FROM THE KINETIC EQUATIONS. We plan to work in two directions:
  - Prove the convergence of the BBGKY hierarchy. The main steps are to find the relevant scaling, the good decoupling assumption, and to determine on which time scale the approximation is valid.
  - Study the stability of Kolmogorov's solution. One of the main points to understand is to determine which kind of stability is relevant: dynamic stability? Statistical stability?

- RIGOROUS ESTIMATES ON THE ENERGY DISSIPATED BY CAPILLARITY IN WAVE BREAKING: we plan to work on the modeling of energy dissipation by capillarity and of the formation of microstructure using a kinetic formulation (one variable being the size of the droplets).

- A TWO-FLUID APPROACH TO WAVE BREAKING. After wave breaking, the presence of small droplets makes a description of the interface too complicated and a two-fluid approach can prove useful, especially for the understanding of energy dissipation. Such an analysis has been recently performed in [BDGG] for specific stress tensor and pressure laws. We propose to extend such result to more general pressure laws and more general stress tensors forms. Mehmet Ersoy will do his PhD thesis on this thesis, with co-advisors C. Bourdarias and S. Gerbi.

[BDGG] D. Bresch, B. Desjardins, J.-M. Ghidaglia, E. Grenier, *On global weak solutions to a generic two-fluid model*, submitted

C- Rotating fluids

- SOLVE THE OPEN CASE OF NONHOMOGENEOUS PENALIZATIONS. We plan to consider a 3D domain (typically, a strip with bottom and surface boundary conditions) and penalize the Navier-Stokes equations with a nonhomogeneous Coriolis force. The first task will be to identify its eigenmodes. We will then proceed to write the boundary layer operator, whose coefficients will depend on the horizontal coordinates.

- TAKE INTO ACCOUNT STRATIFIED FLUIDS. A new density variable (depending essentially on the vertical variable) will be added to the model, as in [P]. We will then describe the waves and boundary layers associated to this model and determine the mean motion (Sverdrup relation).

- TAKE INTO ACCOUNT NONTRIVIAL HORIZONTAL BOUNDARY CONDITIONS. We will consider the case of bounded horizontal domains. Few mathematical results exist considering three-dimensional horizontal domains in the ill prepared case except [BDGV] where highly rotating fluids in a cylinder are considered looking at anisotropic rigid-lid Navier-Stokes equations with homogeneous Dirichlet boundary conditions. We propose to extend this

result to more general boundary conditions: mixed boundary conditions (Dirichlet-Navier, Dirichlet-Wentzell, Dirichlet-open boundary conditions), Islands or ridges boundary conditions.

- DERIVE AND ANALYSE COUPLED OCEAN/ATMOSPHERE MODELS. Instead of considering, say, the wind as a given external force acting on the ocean,we will study coupled models where the atmosphere and the ocean interact.

[BDG] D. Bresch, B. Desjardins, D. Gérard-Varet, *Rotating fluids in a cylinder*, DCDS-A **1** (2004) 47-82
[P] J. Pedlosky, *Ocean Circulation Theory*, Springer, 1996.

D- Complex fluids and environmental issues

- DEVELOP AN ACCURATE AND INDUSTRIALLY EVALUATED SOFTWARE FOR THE DESIGN OF COASTAL STRUCTURES. The optimization platform developed during the previous ANR project COPTER will be improved and tested as follows:
  - The physical model. The physical modeling used at this time in our optimization platform supposes that sand motion can be treated after a splitting of the water motion: wave energy and orbital velocity are evaluated using a refraction/diffraction model, then sand displacement is evaluated after current calculations (as a post processing step). One therefore assumes that erosion is reduced if the design decreases the overall orbital velocity. Our aim through this project is to account for some of the missing physics in the design and in particular in sensitivity evaluation. Indeed, even if the mentioned splitting hypothesis is correct, the final design might not be robust enough. The first step shall be to validate the current designs with a more complete physics (including current evaluation and shallow water modeling removing the mild slope hypothesis). This may be achieved using efficient and accurate 2DH time-dependant non-linear shallow water models, or even more complex models like Boussinesq or Green-Naghdi models, which can account for shoaling processes [Mar,WK]. One shall also evaluate the sensitivity of the functionals when upgrading the physics.
  - Multi-point and multi-criteria optimizations. Looking for design of coastal structures we observed that optimization can lead to non-intuitive shapes and set up locations. Also, the functionals involved are usually far from being convex and have several local minima. However, engineering design often deals with multiple and conflicting objective functions (fluid and structure based for instance). And, it is unlikely that the optimum of the different functionals coincide. Hence, one rather looks for trade-off between conflicting objectives. The traditional method for multi-objective optimization is the weighted sum method. It is reported that this approach often produces nonuniform distributions of points over the front and that it does not find Pareto optimal solutions in non-convex regions. Our aim is to extend what is already done for global optimization using solution of boundary value problem with free surface to the case of multi-criteria optimization for coastal structures [MP]. One aims to avoid the use of genetic algorithms usually seen as natural ways to generate Pareto fronts, but at a very high computational cost.
  - Following previous collaborations, these ingredients shall be evaluated on industrial configurations provided by BRL. Also, experiments and prototyping will be performed by Sogreah (Grenoble) and GeoScience laboratory (Montpellier).

[Mar] F. Marche et al., *Evaluation of well-balanced bore-capturing schemes for 2d wetting and drying processes*, Int. J. Num. Meth. Fluids **53** (2007) 867–894.
[MP] B. Mohammadi, O. Pironneau*, Applied Shape Optimization for Fluids*, Oxford University Press (2008)

[WK] G. Wei, J. T. Kirby, *A time-dependant numerical code for extended Boussinesq equations, Journal of Waterway*, Port, Coastal and Ocean Engineering, **120** (1995) 251-261.

- MODELING, ANALYSIS AND NUMERICAL IMPLEMENTATION OF NEW SEDIMENT TRANSPORT MODELS. Through an INRIA collaboration between the MOISE project (Grenoble) and CESR (UCLA), C. Lucas and D. Bresch will visit CESR during one month (November 2008) to begin to work on some modeling approaches with the aim of writing refined multiscale models (various time scales, various scales in space) for coastal areas. One of the goals is to take into account cohesive or mixed sediments.

- RIGOROUS DERIVATION OF NEW MODELS FOR COMPLEX TOPOGRAPHIES AND NON-TRIVIAL BOTTOM LAWS. At least two directions will be investigated:
  - In collaboration with W. Craig and C. Sulem, D. Lannes will work on the rigorous derivation of shallow-water models for rough bottoms, in many physical regimes (depending on the size of the roughness, its length scale, etc.).
  - Following recent works on submarine avalanches and tsunami initiation, D. Bresch and collaborators will try to take into account the particularities of granular media in nonlinear shallow water equations (elasto-plastic behavior). For numerical computations, it will be necessary to couple well-balanced finite volume schemes and adequate numerical methods for the non-Newtonian part (for instance Glowinski's Augmented Lagrangian or Bermudez-Moreno's methods).

- RIGOROUS ANALYSIS OF INTERNAL WAVES MODELS AND PRECISE STUDY OF THE SINGULARITY FORMATION. We will particularly focus on the following aspects:
  - Analysis of internal waves models. In [BLS], the consistency of many 2DH models with the internal waves equations has been proved. Many of these models are new or still require a mathematical analysis (e.g., well-posedness). Special focus will be given on the 2DH generalization of the shallow water equations for internal waves because they exhibit a quite unexpected nonlocal operator. Collaboration with J.-C. Saut and P. Guyenne (Univ. Delaware) is likely on this point.
  - Singularity formation for internal waves. The internal waves equations are known to be ill-posed in absence of surface tension. However, physical observations show that there are in practical no strong instabilities. Understanding better this point will be part of the PhD thesis of V. Duchene (co-advised by D. Lannes and T. Colin).

[BLS] J. Bona, D. Lannes, J.-C. Saut, Asymptotic Models for Internal Waves, to appear in J. Math. Pures Appl.

II- DEVELOPMENT OF NEW MATHEMATICAL TOOLS (detailed work plan)

- COUPLING OF NONLINEAR, DISPERSIVE SYSTEMS OF PDES. Before coupling different systems of PDEs, one has to understand well the mixed problem (initial and boundary conditions) for these systems. If some results exist for hyperbolic systems such as the nonlinear shallow water equations, very little is known when, say, dispersive terms are present. For some very specific Boussinesq systems, it is possible to carry on the analysis [BC] but the proof relies heavily on the particular structure of the systems under consideration. We plan during this project to make a general analysis of the mixed problem for nonlinear dispersive systems of equations. Such results would find a direct application in oceanography (coupling of a deep water to a shallow water model for instance), but also in many other areas of mathematical physics.

[BC] J. Bona, M. Chen, *A Boussinesq system for two-way propagation of nonlinear dispersive waves*, Physica D **116** (1998) 191-224

- MATHEMATICAL TOOLS FOR THE TREATMENT OF WEAK TURBULENCE. Our main objective is to develop some mathematical theory taking into account the nonlinear effects at the statistical level. More precisely, we would like to settle some new tool catching both the coherent structures that are expected to be governed by some geometric equation, and the background repartition of energy that is expected to be governed by some kinetic equation. The main points are therefore to introduce suitable variables so as to separate both types of behaviors, then to describe the coupling (of course, we will start this programme with the study of toy models).

1.5 Résultats escomptés et retombées attendues/Expected results and potential impact

The goals of this project have been stated in Section 1.3 and explained with some detail in Section 1.4 . Strong advances are expected in the four main research areas of the project (Coastal flows, Energy dissipating processes, Rotating fluids, Complex fluids and environmental issues).
Moreover, we hope to derive new mathematical tools of general interest, in particular for the analysis of boundary value problems in PDE and the understanding of weak turbulence.
A numerical platform for the simulation of coastal flows and an accurate software for the optimization of coastal structure will also be developed; it is our aim to make these codes key tools for the study of environmental issues in coastal areas.
The results will be published in international scientific journals and the numerical simulations will also be validated through in situ experiments and/or industrial configurations.
We will also work to develop pluridisciplinary structures such as workshops and congresses. A congress directly related to the ANR project will be held every year.
Moreover, the website MathOcean http://mathocean.math.cnrs.fr/ currently developed by various participants of this project will be used for a wide divulgation of our results in both communities (mathematicians and oceanographers).

1.6 Organisation du projet/*Project flow*

The implication of the different partners of the present research project is summarized in the table below.

Tasks	Bordeaux I	ENS Paris	Chambéry	Montpellier 2
Coastal flows				
Wave breaking	X			
Large scale vorticity	X			X
Coupling of models	X		X	X
Shoreline			X	X
Numerical platform	X		X	X
Energy dissipating processes				
Wave turbulence		X		
Wave breaking-capillarity		X		
Wave breaking-two fluids			X	
Rotating fluids				
Nonhomogeneous penalization		X		
Stratified fluids		X	X	
Horizontal boundary conditions		X	X	

Ocean-atmosphere coupling		X		X
Complex fluids, environment				
Coastal structure				X
Sediment transport			X	
Bottom laws	X		X	X
Internal waves	X		X	

1.7 Organisation du partenariat/*Consortium organisation*

1.7.1 Pertinence des partenaires/*Consortium relevance*

The different partners of the project have a solid expertise on modeling and mathematical analysis of oceanography related problems and the specific goals described in Section 1.3 are natural milestones of their research program:

- At the University of Bordeaux I, D. Lannes has been working on water-waves these last few years and justified the many asymptotical models used until wave breaking. He will therefore dedicate part of his efforts to the asymptotical description of some phenomena still misunderstood: wave breaking, internal waves, rough topographies… He also developed some abstract PDE tools which should qualify him for the analysis of mixed and coupling problems for systems of nonlinear dispersive PDEs; moreover, G. Métivier (currently chairman of the mathematics department) is one of the best international experts on nonlinear PDEs and his contribution one this point should be highly valuable.
  P. Bonneton leads the oceanography team METHYS in the geology department of the University of Bordeaux I and is specialized in coastal oceanography. He will therefore play a central role in all the modeling aspects as well as in the building of the numerical platform for which he will also furnish experimental data.
  Mario Ricchiuto is a numerical expert on high order discretization for conservation laws, residual based methods and shallow water equations. His implication in the development of an alternative approach to Marche's one for the treatment of nonlinear dispersive systems such as Green-Naghdi is therefore natural.
- At the ENS Paris, L. Saint-Raymond has been interested in many singular perturbation problems, both for kinetic and fluid models. In particular, she has developed weak compactness methods to study large-scale oceanic motions. Together with A.-L. Dalibard, she has recently studied the influence of the wind forcing on these motions, in particular when resonant effects destabilize the fluid. I. Gallagher has been working since her PhD on questions related to rotating fluids, namely in understanding the influence of the rotation of the Earth on the stability of the ocean. She is the co-author of a book presenting the mathematical methods allowing such an analysis, under simple geometrical assumptions on the domain. Together with L. Saint-Raymond she has studied more realistic assumptions on the rotation vector field, in particular in the vicinity of the equator. She directed the PhD of F. Charve, where the stratification of the fluid was also taken into account in the mathematical analysis of rotating fluids. An important research theme for this group, involving in particular L. Saint-Raymond, I. Gallagher and B. Texier, is the mathematical understanding of weak turbulence and of related dissipation processes, which is based on the derivation of kinetic equations for the distribution of energy among the oscillation modes.
- At the University of Chambéry, D. Bresch has been working on the mathematical analysis of oceanographic models these last years. He will dedicate part of his efforts to the asymptotic description of some phenomena: wave breaking, non-Newtonian aspects, vanishing depth, and sedimentation. C. Bourdarias, S. Gerbi and M. Gisclon have worked on numerical simulations around shallow water type equations. They have developed various kinetic and finite volume schemes. They will focus on bifluids and two-layers

models. C. Robert comes from the MOISE Inria project and got a research engineer position at LAMA in December 2007. She will play a central role for the development of the platform based on well-balanced finite volume schemes around shallow water and diphasic flows description.

- The group at the origin of ANR-Copter project and involved in the regional platform Gladys (www.gladys-littoral.org) gathers P. Azerad, F. Bouchette (from GeoSciences Montpellier and associate research partner at I3M Laboratory), F. Marche and B. Mohammadi. D. Isèbe wrote his PhD thesis (defense in 11/07) in that context. B. Alvarez-Samaniego has been spending 18 months as a postdoc working on morphodynamic models. A. Lambert is working as a postdoc on experimental validation of the Copter-prototypes in wave channels and tanks in collaboration with Legi/Sogreah/Grenoble. Our aim is to build an industrial simulation and design environment for littoral and offshore engineering projects integrating up-to-date research in Mathematics and related physics. Our interest goes to modeling, simulation, prototyping and when possible on site experiments through industrial partnerships.

NB : A description of the research structures of each partner is also given in the Annex.

1.7.2 Complémentarité et synergie des partenaires/*Added value of the consortium*

The four partners of this project have all been working on oceanography related topics recently and have shared their experiences on more than one occasion. All of them supported the creation of the pluridisciplinary website http://mathocean.math.cnrs.fr/ dedicated to oceanography and often participated to pluridisciplinary workshops such as MAMNO (organized in Bordeaux by oceanographers and mathematicians www.math.u-bordeaux.fr/~lannes/MAMNO/Mamno.htm). Moreover, the skills of the four partners complement one each other and will allow this project to have a wide spectrum:

- Bordeaux is specialized in PDE, modeling of coastal flows and residual methods for the numerical simulation of shallow water models;
- Paris is specialized in PDE with a special focus on kinetic and statistical methods and, for the applications, is concerned by oceanographic phenomena (large scale currents) of a larger scale than the coastal flows;
- Chambéry is specialized in the mathematical analysis of Navier-Stokes equations with a very strong focus on environmental applications (pollutants, sedimentation, submarine avalanches and tsunamis…);
- Montpellier has acquired a strong experience in the study of fluid/structure interaction in the context of oceanographic flows (previous ANR project COPTER) and F. Marche has developed the numerical code SURF_WB that should play an important role in our project of numerical platform of coastal flows. Also, having R. Carles at the institute brings us a local expertise on nonlinear dispersive PDEs useful for the analysis of the Green-Naghdi equations. We also take advantage of research on fluid/structure interaction by B. Koobus in the context of aeronautics. This connection links us to leading research teams at INRIA (Dr. Alain Dervieux) and Stanford University (Prof. Charbel Farhat). These connections are particularly useful to identify suitable coupling algorithms between fluid and structure models and also low complexity approaches to break the complexity issues for stiff simulations.

1.7.3 Qualification du coordinateur du projet et des partenaires/*Principal investigator and partners : résumé and CV*

QUALIFICATION OF THE PRINCIPAL INVESTIGATOR (PI) TO COORDINATE THE PROJECT

Various members of this project already directed an ANR or ACI project in the past few years, which where mostly dedicated to oceanography related topics: during 2004-2007, D. Lannes and D. Bresch where PI of the ACI Jeunes Chercheurs « Nonlinéarités et Dispersion » and « Analyse mathématique de paramétrisations en océanographie », and B. Mohammadi led the ANR project COPTER in the years 2005-08.
During the last two years, the PI has developed research structures and organized events in order to articulate better the research efforts from in situ measures to mathematical analysis. In 2006, the PI and P. Bonneton initiated a regular multidisciplinary workshop dedicated to both oceanographers and mathematicians: Modélisation, Analyse Mathématique et Numérique en Océanographie (MAMNO, www.math.u-bordeaux.fr/~lannes/MAMNO/Mamno.htm). In 2006, the PI organized a one week congress with F. Boyer (Marseille) at the CIRM called « New trends in fluid mechanics: modeling and analysis » opened to physicists and mathematicians (with theoretical and numerical aspects). Similarly, two mini-symposia dedicated to oceanography where organized in 2007 by the PI, D. Bresch and W. Craig at the SIAM PDE annual meeting, in Phoenix.
These multidisciplinary events allowed the PI to develop strong ties with the different partners, from which the idea of the present project emerged. Partner IV (University of Montpellier 2) participated to MAMNO on a regular basis and the mutual benefit of a stronger collaboration became clear to both sides. Moreover F. Marche, who developed the code SURF_WB during his PhD thesis at Bordeaux I (coadvised by the PI, P. Bonneton, and P. Fabrie), has been hired as Maître de Conférences in Montpellier in 2007 and should play a central role in the articulation between the project of a numerical platform on coastal flows (Bordeaux) and the platform on optimization of coastal structures COPTER (Montpellier).
A few month ago, and after various meetings, the PI and Partners II and III (ENS Paris and Univ. Chambéry) noticed that one needed a stronger coordination at the national level in oceanography. In particular, many oceanography related workshops exist in France (for instance, Partner II animates a workshop with climatologists and Partner III participates regularly to the workshops of the INRIA project MOISE in Grenoble) and it would be useful to create a federative structure. This is why we decided to create the website MathOcean http://mathocean.math.cnrs.fr/ (still under construction), opened to all the teams working on the subject. This website is likely to have a large international audience and would naturally serve as a platform for the divulgation of the results obtained by our team.

SHORT CV OF THE PI AND OTHER PARTICIPANTS
See Annex.

1.8 Accès aux grands instruments/Access to large facilities

Not relevant.

1.9 Stratégie de valorisation et de protection des résultats/*Data management, data sharing, intellectual property strategy, and exploitation of project results*

Not relevant.

Collez ici le tableau de récapitulatif des données financières de la fiche budgétaire.

Récapitulatif des données financières

	EQUIPEMENTS (€)	Personnels						Prestations de service externe (€)	Missions (€)	Autres dépenses (€)	Dépenses justifiées sur facturation interne (€)	Totaux (€)
		permanents		non permanents à financer par l'ANR		Autres non permanents						
		personne. mois	Coût (€)	*personne. mois*	Coût (€)	*personne. mois*	Coût (€)					
Partenaire1	-	52	255 252	-	-	54	118 962	-	31 000	33 100	-	438 314
Partenaire2	-	72	187 236	-	-	36	118 800	-	31 000	26 100	-	363 136
Partenaire3	5 000	81	323 544	-	-	25	55 516	-	31 000	31 100	-	446 159
Partenaire4	-	79	205 055	-	-	-	-	-	25 000	10 000	-	240 055
	5 000	**284,40**	**971 087**	**-**	**-**	**115,20**	**293 278**	**-**	**118 000**	**100 300**	**-**	**1 487 664**
											Frais de gestion / frais de structure demandés (€)-->	8 932
											Frais d'environnement (€)	1 011 491
											Coût complet (€)	**2 508 088**
											Coût éligible pour le calcul de l'aide : Assiette (€)	**232 232**
											Aide demandée (€)	***232 232***

2 Justification scientifique des moyens demandés/*Requested budget : detailed financial plan*

2.1 Partenaire 1 : Université Bordeaux I

2.1.1 Equipement/*Large equipment*

Aucun.

2.1.2 Personnel/Manpower : SOMME TOTALE = 374.213,70€

NOM (permanents)	Grade	Côut Mensuel	Implication	Personne.Mois	Coût
D. Lannes	CR1 CNRS	4837,00€	90%	32,4	156.718,80€
G. Métivier	PR0	4712,50€	25%	9	42.412,50€
P. Bonneton	DR2 CNRS	5907,00€	20%	7.2	42.530,40€
M. Ricchiuto	CR2 INRIA	3775,00€	10%	3.6	13.590,00€
			TOTAL	52,2	255.251,70€

NOM (non permanents)	Grade	Côut Mensuel	Implication	Personne.Mois	Coût
V. Duchene	Doctorant	2203€	50%	18	39.654,00€
S. Israwi	Doctorant	2203€	100%	36	79.308,00€
			TOTAL	54	118.962,00€

NB : S. Israwi bénéficie d'une allocation ministérielle pour sa thèse depuis septembre 2007
V. Duchene débutera sa thèse en septembre 2008 pour laquelle une Allocation Couplée a été demandée.

2.1.3 Prestation de service externe/*Services, outward facilities*

Aucune.

2.1.4 Missions/*Travels*

Frais de mission : 31.000€. Somme calculée sur une base approximative de 3500 euros par an et par personne à 100% pour financer les déplacements entre les divers sites d'implantation du projet, pour assister à des congrès nationaux ou internationaux, et pour visiter des laboratoires ou chercheurs en France et à l'étranger pour valorisation des travaux.

2.1.5 Dépenses justifiées sur une procédure de facturation interne/*Expenses for inward billing*

Aucune.

2.1.6 Autres dépenses de fonctionnement/*Other expenses*

Achats d'ordinateurs portables, de logiciels et de livres : 9.000 €. Somme calculée sur une base approximative de 3000 euros par personne à 100% sur la totalité du projet.

Invitations supérieures à une semaine de chercheurs étrangers de premier plan : 14.100€. Nous prévoyons d'inviter 2 chercheurs par an sur une durée moyenne de 15 jours. Nous comptons 1000€ pour l'avion et un perdiem de 90€ pour l'hôtel et la nourriture.
Une liste des invités potentiels est : J. Bona (UIC, USA), A. Constantin (Trinity College, Irlande), W. Craig (Hamilton, Canada), M. Hubbard (U. Leads, Angleterre), T. Iguchi (U. Keio, Japon), F. Linares (IMPA, Brésil), S. Schochet (Tel Aviv, Israel), C. Sulem (U. Toronto, Canada).

Organisation de congrès : 10.000€

- Congrès en l'honneur de G. Métivier : 7.000€. Un congrès international sera organisé à Bordeaux en 2010 en l'honneur de G. Métivier à l'occasion de ses 60 ans. Une partie des thématiques abordées recoupe celles de ce projet.
- Journées ANR MathOcean : 3.000€. Nous prévoyons d'organiser tous les ans un workshop rassemblant les membres du projet et des invités extérieurs. Chacun des partenaires sera impliqué dans l'organisation et l'aide demandée sur l'ensemble du projet est donc répartie entre les 4 partenaires.

2.2 Partenaire 2: ENS Paris

2.2.1 Equipement/*Large equipment*

Aucun.

2.2.2 Personnel/*Manpower* SOMME TOTALE = 306.036€

NOM (permanents)	Grade	Côut Mensuel	Implication	Personne.Mois	Coût
L. Saint-Raymond	PR1	3.673,50€	50%	18	66.123,00€
F. Charve	MC	1.887,50€	50%	18	33.975,00€
I. Gallagher	PR2	2.953,50€	50%	18	53.163,00€
B. Texier	MC	1.887,50€	50%	18	33.975,00€
			TOTAL	72	187.236,00€

NOM (non permanents)	Grade	Côut Mensuel	Implication	Personne.Mois	Coût
A.-L. Dalibard	Postdoc	3.300,00€	50%	18	59.400,00€
B. Haspot	Postdoc	3.300,00€	50%	18	59.400,00€
			TOTAL	36	118.800,00€

2.2.3 Prestation de service externe/*Services, outward facilities*

Aucune.

2.2.4 Missions/*Travels*

Frais de mission : 31.000€. Somme calculée sur une base approximative de 3500 euros par an et par personne à 100% pour financer les déplacements entre les divers sites d'implantation du projet, pour assister à

des congrès nationaux ou internationaux, et pour visiter des laboratoires ou chercheurs en France et à l'étranger pour valorisation des travaux.

2.2.5 Dépenses justifiées sur une procédure de facturation interne/*Expenses for inward billing*

Aucune

2.2.6 Autres dépenses de fonctionnement/*Other expenses*

Achats d'ordinateurs portables, de logiciels et de livres : 9.000 €. Somme calculée sur une base approximative de 3000 euros par personne à 100% sur la totalité du projet.

Invitations supérieures à une semaine de chercheurs étrangers de premier plan : 14.100€. Nous prévoyons d'inviter 2 chercheurs par an sur une durée moyenne de 15 jours. Nous comptons 1000€ pour l'avion et un perdiem de 90€ pour l'hôtel et la nourriture.
Une liste des invités potentiels est : W. Craig (McMaster, Canada), J. Rauch (AnnArbor, USA), V. Panferov (McMaster, Canada), M. Escobedo (Bilbao), J. Velasquez (Madrid, Espagne).

Organisation de congrès : 3.000€

- Journées ANR MathOcean : 3.000€. Nous prévoyons d'organiser tous les ans un workshop rassemblant les membres du projet et des invités extérieurs. Chacun des partenaires sera impliqué dans l'organisation et l'aide demandée sur l'ensemble du projet est donc répartie entre les 4 partenaires.

2.3 Partenaire 3 : Université de Chambéry

2.3.1 Equipement/*Large equipment*

Aucun.

2.3.2 Personnel/*Manpower :* SOMME TOTALE=379.059,30€

NOM (permanents)	Grade	Côut Mensuel	Implication	Personne.Mois	Coût
D. Bresch	DR2 CNRS	5.907€	70%	25,2	148.856,40€
C. Bourdarias	MCE	2.418,50€	35%	12,6	30.473,10€
S. Gerbi	MC1	2.418,50€	35%	12,6	30.473,10€
M. Gisclon	MC1	2.418,50€	35%	12.6	30.473,10€
C. Robert	IR2	4.626€	50%	18	83.268,00€
			TOTAL	81	323.543,70€

NOM (non permanents)	Grade	Côut Mensuel	Implication	Personne.Mois	Coût
M. Ersoy	Doctorant	2.203€	70%	25,2	55.515,60€
			TOTAL	25,2	55.515,60€

NB : Mehmet Ersoy bénéficie d'une allocation ministérielle pour sa thèse débutée en septembre 2007.

2.3.3 Prestation de service externe/*Services, outward facilities*

Aucune.

2.3.4 Missions/*Travels*

Frais de mission : 31.000€. Somme calculée sur une base approximative de 3500 euros par an et par personne à 100% pour financer les déplacements entre les divers sites d'implantation du projet, pour assister à des congrès nationaux ou internationaux, et pour visiter des laboratoires ou chercheurs en France et à l'étranger pour valorisation des travaux.

2.3.5 Dépenses justifiées sur une procédure de facturation interne/*Expenses for inward billing*

Ordinateur fixe pour calcul et graphisme : 5.000€. C. Robert a obtenu un poste d'Ingénieur de recherche au LAMA en décembre 2007. Elle aura besoin d'un très bon PC pour participer au développement de la plateforme numérique.

2.3.6 Autres dépenses de fonctionnement/*Other expenses*

Achats d'ordinateurs portables, de logiciels et de livres : 9.000 €. Somme calculée sur une base approximative de 3000 euros par personne à 100% sur la totalité du projet.

Invitations supérieures à une semaine de chercheurs étrangers de premier plan : 14.100€. Nous prévoyons d'inviter 2 chercheurs par an sur une durée moyenne de 15 jours. Nous comptons 1000€ pour l'avion et un perdiem de 90€ pour l'hôtel et la nourriture.
Une liste des invités potentiels est : P. Zhang, Z. Xin, H. Nussenzveig Lopes en ce qui concerne la partie théorique, E. Fernandez Nieto et R. Leveque pour la partie numétique, ainsi que les physiciens R. Klein, S. P. Pudasaini, P. Nielsen et J. Mc Williams.

Organisation de congrès : 8.000€

- Colloque franco-russe « Mathematical challenges for compressible flows »: 5.000€. Ce colloque, organisé à la mémoire d'Alexandre Kazhikov et prévu en 2009 sera en grande partie centré sur les thématiques du projet ; la participation estimée est d'une cinquantaine de personnes.
- Journées ANR MathOcean : 3.000€. Nous prévoyons d'organiser tous les ans un workshop rassemblant les membres du projet et des invités extérieurs. Chacun des partenaires sera impliqué dans l'organisation et l'aide demandée sur l'ensemble du projet est donc répartie entre les 4 partenaires

2.4 Partenaire 1 : Université de Montpellier 2

2.4.1 Equipement/*Large equipment*

Aucun.

2.4.2 Personnel/*Manpower :* SOMME TOTALE=204.055,20€

NOM (permanents)	Grade	Côut Mensuel	Implication	Personne.Mois	Coût
B. Mohammadi	PR1	3.673,50€	70%	25,2	92.572,20€
P. Azerad	MC1	2.418,50€	50%	18	43.533,00€
F. Bouchette	MC2	1.887,50€	30%	10.8	20.385,00€
F. Marche	MC2	1.887,50€	70%	25,2	47.565,00€
			TOTAL	79,2	204.055,20€

2.4.3 Prestation de service externe/*Services, outward facilities*

Aucune.

2.4.4 Missions/*Travels*

Frais de mission : 25.000€. Somme calculée sur une base approximative de 3500 euros par an et par personne à 100% pour financer les déplacements entre les divers sites d'implantation du projet, pour assister à des congrès nationaux ou internationaux, et pour visiter des laboratoires ou chercheurs en France et à l'étranger pour valorisation des travaux.

2.4.5 Dépenses justifiées sur une procédure de facturation interne/*Expenses for inward billing*

Aucune

2.4.6 Autres dépenses de fonctionnement/*Other expenses*

Achats d'ordinateurs portables, de logiciels et de livres : 7.000 €. Somme calculée sur une base approximative de 3000 euros par personne à 100% sur la totalité du projet.

Organisation de congrès : 3.000€

- Journées ANR MathOcean : 3.000€. Nous prévoyons d'organiser tous les ans un workshop rassemblant les membres du projet et des invités extérieurs. Chacun des partenaires sera impliqué dans l'organisation et l'aide demandée sur l'ensemble du projet est donc répartie entre les 4 partenaires.

Annexes

Description des partenaires/*Partners informations* (cf. § 1.7.1) *(1 page maximum par partenaire)*

Partenaire I : University of Bordeaux I

Two components of the Université Bordeaux I are implied in this project, the Institut de Mathématiques de Bordeaux and the laboratory of Environnements et Paléoenvironnements OCéaniques (EPOC, UMR CNRS 5805).

- Institut de Mathématiques de Bordeaux (IMB, UMR CNRS 5251). The IMB is structured around three teams (Analysis and geometry, Number theory and Applied Mathematics). The participants to this project belong to the Applied Mathematics team (MAB, directed by T. Colin). The IMB gathers 140 researchers and benefits from the technical support of 16 persons; 66 students are currently doing their PhD at the IMB. It participates already to 11 ANR projects.
- Environnements et Paléoenvironnements OCéaniques (EPOC, UMR CNRS 5805). The research areas of EPOC are mainly coastal oceanography, paleoclimates and environment at the ocean-continent interface. It is structured around 5 teams; P. Bonneton, who participates to this projects, leads the oceanography team METHYS. In EPOC, there are around 60 researchers, 50 PhD students and 50 technical staff.

Moreover, the research institute INRIA is also implied in this project through the participation of Mario Ricchiuto, member of the IMB and full time researcher at INRIA Bordeaux Sud-Ouest (ScAlApplix project). The exact composition of the component in Bordeaux is the following:

- D. Lannes (CR1 CNRS at the IMB), principal investigator. Implication in the project: 90%
- P. Bonneton (DR2 CNRS at EPOC). Implication in the project: 20%
- V. Duchene (PhD student at the IMB). Implication in the project: 50%
- S. Israwi (PhD student at the IMB). Implication in the project: 100%
- G. Métivier (PR0 at the IMB). Implication in the project: 25%
- M. Ricchiuto (CR INRIA, ScAlApplix project). Implication in the project: 10%

Partenaire II : ENS Paris

The component at ENS Paris gathers researchers from many Paris universities, namely from University Denis Diderot (Paris VII), University Paris Dauphine (Paris IX), University Paris XII-Val de Marne and from the Ecole Normale Supérieure, who have both interest and skills in the mathematical study of geophysical flows.
The Département de Mathématiques et Applications of the ENS is structured around 3 teams: Laure Saint-Raymond, who coordinates the project for Paris, leads the team « Partial Differential Equations », which is constituted of 5 permanent members, 5 part-time researchers or teachers-cum-researchers and 7 PhD or post-doctoral students. That team develops theoretical methods, numerical methods and modeling tools for PDEs and nonlinear analysis.

The grouping of the project at the Département de Mathématiques et Applications of the ENS has two specific goals: interdisciplinarity and formation of students. It should on the one hand favor collaborations with physicists from the Laboratoire de Physique Statistique and from the Laboratoire

de Météorologie Dynamique of the ENS. On the other hand, because of the national educational mission of the ENS, it should allow to recruit many top-level PhD students.

The exact composition of the component at ENS Paris is the following:

- L. Saint-Raymond (PR at the DMA), local coordinator. Implication in the project: 50%
- F. Charve (MC at Univ. Paris XII). Implication in the project: 50%
- A.-L. Dalibard (postdoc at Univ. Paris IX). Implication in the project: 50%
- I. Gallagher (PR at Univ. Paris VII). Implication in the project: 50%
- B. Haspot (postdoc at Univ. Paris XII). Implication in the project: 50%
- B. Texier (MC at Univ. Paris VII). Implication in the project: 50%

Partenaire III : University of Chambéry

The University of Chambéry is involved in the project through the Laboratoire de Mathématiques (LAMA, UMR CNRS 5127). The LAMA is structured around three teams (Geometry, Logics and PDEs). The participants to this project belong to the PDEs team (directed by D. Bresch). The LAMA gathers 27 researchers and benefits from the technical support of 1 person; 10 students are currently doing their PhD at the LAMA. It participates already to 2 ANR projects.

The exact composition of the component at the University of Chambéry is the following:

- D. Bresch (DR CNRS at the LAMA), local coordinator. Implication in the project: 70%
- C. Bourdarias (MC at the LAMA). Implication in the project: 35%
- M. Ersoy (PhD student at the LAMA). Implication in the project: 70%
- S. Gerbi (MC at the LAMA). Implication in the project: 35%
- M. Gisclon (MC at the LAMA). Implication in the project: 35%
- C. Robert (IR2 at the LAMA). Implication in the project: 50%

Partenaire IV: University of Montpellier 2

The Université of Montpellier II is present through the Institut de Mathématiques et de Modélisation de Montpellier (I3M, UMR CNRS 5149).

I3M is structured around three teams (Analyse, Calcul Scientifique Industriel et Optimisation de Montpellier (ACSIOM), Probabilité et Statistiques (EPS) and Géometrie-Topologie-Algèbre (GTA)). The participants to this project belong to the ACSIOM team gathering 25 researchers and benefits from the technical support of 2 persons; more than 15 students are currently doing their PhD in connection with ACSIOM members at Montpellier or in associate academic laboratories as well in industry. ACSIOM members are PI in 2 ANR projects (COPTER ending in 2008 and DECISIONPROX ending in 2008).

The exact composition of the component at the University of Montpellier is the following:

- B. Mohammadi (PR – UM2/I3M), local coordinator. Implication in the project: 70%
- P. Azerad (MC – UM2/I3M). Implication in the project: 50%
- F. Bouchette (MC UM2/Geosciences and Research associate at I3M). Implication in the project: 30%
- F. Marche (MC UM2/I3M). Implication in the project: 70%

Biographies/*Résumés and CV* (cf. § 1.7.3) *(1 page maximum par personne)*

Partenaire I : University of Bordeaux I

DAVID LANNES (RESPONSABLE PRINCIPAL)
34 ans, Chargé de recherches 1ère classe au CNRS à l'IMB depuis octobre 2000
HDR décembre 2004
www.math.u-bordeaux.fr/~lannes

- Responsabilités et tâches administratives.

- Membre de deux commissions de spécialistes (26 à Bordeaux et 25-26 à Nantes).
- Juin 2006- : Responsable local du GDR MOAD (Modélisation, Asymptotique, Dynamique nonlinéaire).
- 2004-2007: Responsable de l'ACI Jeunes Chercheurs « Dispersion et nonlinéarités ».
- 2006 : Membre d'un panel d'expertise pour la NSF (Washington) en analyse appliquée.
- 2005 : Expert de projet ANR.
- Encadrement de 4 thèses (dont une en cours et une débutant en septembre) et d'un postdoc sur la thématique.

- Animation et coordination scientifique en lien avec le projet

- 2008 : création (avec D. Bresch) d'un site web pluridisciplinaire consacré à l'océanographie (http://mathocean.math.cnrs.fr/)
- 2006-- : création du groupe de travail MAMNO consacré à l'océanographie et commun à l'IMB et au laboratoire d'océanographie EPOC
- 2007: Co-Organisation (avec W. Craig et D. Bresch) de deux mini-symposium au congrès PDE07 du SIAM, Arizona, USA.
- 2006: Co-organisation (avec F. Boyer) d'un congrès au CIRM, Nouveaux challenges en mécanique des fluides: modélisation et analyse.
- 2006: Co-organisation (avec J. Bona, M. Colin, T.Colin) d'une session à la 6th International Conference on Dynamical Systems and Differential Equations, à Poitiers, consacrée en grande partie à l'analyse d'EDP provenant liées à l'océanographie.
- 2006 : comité d'organisation du colloque « Water waves » en l'honneur de J. Bona.
- 2004 : Organisation à Bordeaux d'une journée multidisciplinaire avec des laboratoires de mécanique.
- 2003 : Comité d'organisation d'un workshop consacré à des modèles de type shallow water (Bordeaux).

- Production scientifique

- 18 articles dans des revues à comité de lecture, 1 chapitre de livre, 6 actes de conférence, 2 articles soumis.
- 16 conférences dans des congrès internationaux, 11 conférences dans des congrès nationaux, 10 séminaires à l'étranger, 23 séminaires en France.
- 6 cours de niveau recherche dont 3 à l'étranger.

- Collaborateurs internationaux : J. Bona, A. Constantin, W. Craig, F. Linares, C. Sulem.

- Liste des cinq publications les plus significatives

➢ B. Alvarez-Samaniego, D. Lannes, *Large time existence for 3D water-waves and asymptotics*, Invent. Math. **171** (2008) 485-541

➢ J. Bona,D. Lannes, J.-C. Saut, *Asymptotic models for internal waves*, to appear in J. Math. Pures et Appl.

- D. Lannes, *Sharp estimates for pseudo-differential operators with symbol of limited smoothness and commutators*, J. Funct. Anal. **232** (2006), 495-539
- D. Lannes, *Well-Posedness of the Water Waves Equations*, J. Am. Math. Soc. **18** (2005), 605-654
- J. Bona, T. Colin, D. Lannes, *Long Wave Approximations for Water-Waves*, Arch. Rat. Mech. Anal. **178** (2005), 373-410

PHILIPPE BONNETON

45 ans, Directeur de recherches CNRS 2ème classe à l'UMR EPOC, Université Bordeaux 1

- Carrière

- Ingénieur de la Météorologie (1987-1993)
- Doctorat en Mécanique des Fluides (1992)
- CR1 à l'IMFT, Toulouse (1993-1997)
- CR1 à l'UMR EPOC, Bordeaux (1997-2006)
- Habilitation à Diriger des Recherches (1999)
- DR2 à l'UMR EPOC, Bordeaux 1 (2006-2008)

- Reponsabilités et tâches adminitratives.

- Membre du Conseil de Direction du DGO-EPOC, 1998-2002.
- Coordinateur dans le PNEC-ART7 des recherches sur le littoral aquitain, 2002-2003.
- Responsable de l'Equipe METHYS (Modélisation Expérimentation en HYdrodynamique Sédimentaire) de l'UMR EPOC. 3 chercheurs CNRS (1 DR2, 1CR1 et 1CR2), 5 enseignant-chercheurs (1 Pr et 4 MC) et 12 thésards et post-doctorants.
- Membre du Conseil de Direction de l'UMR EPOC, 2005-2008.
- Membre du Comité Scientifique du PATOM puis de LEFE-IDAO, 2005-2008.
- Expert de projets ANR 2006-2007.

- Animation et coordination scientifique en lien avec le projet

- 2006 : participation à la création du groupe de travail MAMNO consacré à l'océanographie et commun à l'IMB et au laboratoire d'océanographie EPOC
- 2007: Coorganisateur de la session S19 "Ondes et écoulements à surface libre" du 18ème Congrès Français de Mécanique, Grenoble 2007.

- Production scientifique

- 40 publications dans des revues avec comité de lecture
- 50 publications dans des actes de congrès avec comité de lecture
- Cours dans les Ecoles d'Ingénieur ENM, ENSEEIHT, MATMECA et ENSTA

- Collaborateurs internationaux : R. Cienfuegos, A. Falques, D. Roelvink

- Liste des cinq publications les plus significatives

- Bonneton, P., Chomaz, J.M. and Hopfinger, E.J. 1993 Internal waves produced by the turbulent wake of a sphere moving horizontally in a stratified fluid. *J. Fluid Mech*., **254**, 23-40.
- Galmiche, M., Thual, O. and Bonneton, P. 2002. Direct numerical simulation of turbulence-mean field interactions in a stably-stratified fluid. *J. Fluid Mech*., **455**, 213-242.
- Castelle, B., Bonneton, P., Sénéchal, N., Dupuis, H., Butel, R. and Michel, D. 2006 Dynamics of wave-induced currents over a multi-barred beach on the Aquitanian coast. *Continental Shelf Res.,* **26**, 113-131.
- Bonneton, P. 2007 Modelling of periodic wave transformation in the inner surf zone. *Ocean Engineering*, **34**, 1459-1471.
- Marche, F., Bonneton, P., Fabrie, P. and Seguin, N. 2007 Evaluation of well-balanced bore-capturing schemes for 2D wetting and drying processes. *Int. J. Numer. Meth. Fluids*, **53** (5), 867-894.

VINCENT DUCHENE
25 ans
Agrégé de Mathématiques (2007)
Elève de l'Ecole Normale Supérieure de Lyon (début de scolarité septembre 2004)
Début de thèse en septembre 2008 sous la direction de D. Lannes et T. Colin, « Modélisation d'écoulements bifluides ; applications à la microfluidique et à l'océanographie ».

SAMER ISRAWI
25 ans
DEA de mathématiques de l'Université Libanaise (2006-07)
Début de thèse en septembre 2007 sous la direction de D. Lannes « Analyse mathématique de modèles océanographiques ».

GUY METIVIER
58 ans
Délégation à l'Institut Universitaire de France, membre senior, 1997-2002, renouvelée 2002-2007.
Visiting Professor Rutgers University, janvier-mai 1985.
Professeur Université Rennes I 10/1980- 09/2002, Université Bordeaux 1, 09/2002 –
Associate Professor Purdue University 1979-80
Attaché de recherche CNRS, affecté à Nice 10/1973 - 09/1980.

- Responsabilités et tâches administratives récentes :

- 2005- : Directeur de l'Institut de Mathématiques de Bordeaux
- 2004-05 : Président de la CS 26 de l'Université de Bordeaux
- 2004- : Membre du CS de l'Université de Bordeaux
- 1999-2000 : Président du groupe d'expert PEDR pour les mathématiques
- 1996-2000 : Membre du Comité de Programmation du Centre Emile Borel, IHP

- Production scientifique :

- Environ 130 articles et comptes rendus de conférences
- Nombreuses conférences plénières et cours dans des conférences internationales.

- Collaborateurs internationaux : J. Rauch, S. Schochet, M. Williams, K. Zumbrun, F. Colombini.

- Prix ou distinctions :

- Prix Lequeux de l'Académie des Sciences en 1993.
- Médaille de bronze du CNRS en 1980.

- Liste des cinq publications les plus significatives :

- D. Bresch, G. Métivier, *Global existence and uniqueness for the lake equations with vanishing topography*, Nonlinearity **19** (2006) 591-610
- O. Guès, G. Métivier, M. Williams, K. Zumbrun, *Navier-Stokes regularization of multidimensional Euler shocks*, Ann. Scient. Ec. Norm. Sup. **39** (2006) 75-175
- O. Guès, G. Métivier, M. Williams, K. Zumbrun, *Multidimensional viscous shocks I: degenerate symmetrizers and long time stability*, J. Amer. Math. Soc (2005)
- O. Guès, G. Métivier, M. Williams, K. Zumbrun , *Existence and Stability of Multidimensional Shock Fronts in the Vanishing Viscosity Limit*, Archive for Rational Mechanics and Analysis (2005)
- O. Guès, G. Métivier, M. Williams, K. Zumbrun , *Multidimensional viscous shocks II: The small viscosity limit*, Comm. Pure and Appl. Math. (2004)

MARIO RICCHIUTO
32 ans, CR INRIA depuis octobre 2005 (projet ScAlApplix)

- Production scientifique

- 5 articles parus dans des revues à comité de lecture, 2 soumis.
- Plusieurs conférences dans des congrès internationaux et nationaux

• Collaborateurs internationaux : Herman Deconicnk (von Karman Intsitute for Fluid dynamics) A. Bollermann (RWTH Aachen)

• Prix ou distinctions :
- Theodor von Karman prize. Granted by the von Karman Institute for excellence in study and research (2001).
- Best student paper award. ICCFD3 conference in Toronto (2004).

• Liste des cinq publications les plus significatives

- A. Csik , M. Ricchiuto and H. Deconinck, *A Conservative Formulation of the Multidimensional Upwind Residual Distribution Schemes for General Nonlinear Conservation Laws*, Journal of Computational Physics **179** (2002) pp. 286-312
- J. Dobes, M. Ricchiuto and H. Deconinck, *Implicit space-time residual distribution method for unsteady laminar viscous flow*, Computers and Fluids **34** (2005) pp. 593-619
- H. Steadtke, G. Franchello, B. Worth, U. Graf, P. Romsted, A. Kumbaro, L. Garcia-Cascales, H. Paillere, H. Deconinck, M. Ricchiuto, B. Smith, F. De Cachard, E.F. Toro, E. Romenski and S. Mimouni, *Advanced three-dimensional two-phase flow simulation tools for application to reactor safety (ASTAR)*, Nuclear Engineering and Design **235** (2005) pp. 379—400
- M. Ricchiuto, A. Csik and H. Deconinck, *Residual distribution for general time dependent conservation laws*, Journal of Computational Physics, **209** (2005) pp. 249—289
- M. Ricchiuto, R. Abgrall and H. Deconinck, *Application of conservative residual distribution schemes to the solution of the shallow water equations on unstructured meshes*, J. Comp. Phys. **222** (2007) pp. 287-331

Partenaire II : ENS Paris

LAURE SAINT-RAYMOND (COORDINATRICE LOCALE)
32 ans, Professeur à l'Université Pierre et Marie Curie (Paris VI) depuis septembre 2002
et à l'Ecole Normale Supérieure (Paris) depuis septembre 2007
HDR janvier 2002

• Responsabilités et tâches administratives.
- Direction des études de mathématiques à l'ENS
- Membre de deux commissions de spécialistes (ENS et Rouen)
- Membre du comité éditorial de « Kinetic and Related Models »

• Animation et coordination scientifique en lien avec le projet
- Coordination du groupe de travail « Mathématiques et océanographie » à l'ENS
- Organisation avec I. Gallagher d'un colloque « Turbulence faible » (mars 2008)

• Production scientifique
- 26 articles dans des revues à comité de lecture, 1 chapitre de livre, 1 livre soumis, 3 articles soumis, 3 articles de vulgarisation scientifique.

• Collaborateurs internationaux : D. Levermore, N. Masmoudi

• Prix ou distinctions :
- Prix Louis Armand, Académie des Sciences (2003).
- Lauréate de la fondation Claude-Antoine Peccot, Collège de France (2004).
- Médaille Pie XI, Académie des Sciences Pontificale (2004).

- Prix ``Analysis of Partial Differential Equations'' avec François Golse, Society for Industrial and Applied Mathematics (2006).
- Conférence invitée au Congrès Européen de Mathématiques (2008).

• Liste des cinq publications les plus significatives

- F. Golse, L. Saint-Raymond.*The Vlasov-Poisson system with strong magnetic field*, J. Math. Pures Appl. **78**, 791–817 (1999)
- L. Saint-Raymond. *Convergence of solutions to the Boltzmann equation in the incompressible Euler limit*, Arch. Ration. Mech. Anal. **166**, 47–80 (2003). .
- F. Golse, L. Saint-Raymond *The Navier-Stokes limit of the Boltzmann equation for bounded collision kernels.* Invent Math **155** (2004) 81--161.
- L. Saint-Raymond. *Some improvements of the relative entropy method*. accepté pour publication, Annales de l'IHP (2008).
- I. Gallagher et L. Saint-Raymond, *Mathematical study of the betaplane model: equatorial waves and convergence results*, accepté pour publication, Mémoires de la Société Mathématique de France (2008).

FRÉDÉRIC CHARVE

30 ans, Maître de conférences depuis septembre 2006,
http://perso-math.univ-mlv.fr/users/charve.frederic/index.html

• Responsabilités et tâches administratives.

- Co-responsable du Master 1e année « Mathématiques et applications » à l'Univ. Paris 12.

• Production scientifique

- 4 articles dans des revues à comité de lecture, un article en finition.
- 2 colloques à l'étranger, 1 séminaire à l'étranger, 1 colloque, 8 séminaires et 3 groupes de travail en France.

• Liste des cinq publications les plus significatives

- F. Charve, *Global well-posedness and asymptotics for a geophysical fluid system,* Communications in Partial Differential Equations, **29 (11 & 12)** (2004), 1919-1940.
- F. Charve, *Convergence of weak solutions for the primitive system of the quasigeostrophic equations*, Asymptotic Analysis, **42** (2005), 173-209.
- F. Charve, *Asymptotics and vortex patches for the quasigeostrophic approximation*, Journal de Mathématiques pures et appliquées, **85** (2006), 493-539.
- F. Charve, *Global well-posedness for the primitive equations with less regular initial data*, accepté aux Annales de la faculté de Toulouse en 2007.
- F. Charve, V.-S. Ngo, *Asymptotics for the primitive equations with small anosotropic viscosity*, en finition.

ANNE-LAURE DALIBARD

25 ans, ancienne élève de l'Ecole normale supérieure (Ulm, scolarité de 2001 à 2005)
Thèse sous la direction de Pierre-Louis Lions, « Homogénéisation de lois de conservation scalaires et d'équations de transport »; soutenue en octobre 2007.
Allocataire de recherche à l'Université Paris-Dauphine; post-doctorante au DMA (ENS Paris)

• Production scientifique

- 7 articles dans des revues internationales à comité de lecture
- 2 conférences dans des congrès internationaux, 1 conférence dans un congrès national, 10 séminaires en France.

• Liste des cinq publications les plus significatives

- A.L. Dalibard, *Initial layer for the homogenization of a quasilinear parabolic equation with vanishing viscosity,* Arch. Rat. Mech. Anal., **185** (2007) 515-543.

- A.L. Dalibard, *Homogenization of a linear transport equation in a stationary ergodic setting,* Comm. Partial Differential Equations, à paraître.
- A.L. Dalibard, *Kinetic formulation for a parabolic conservation law. Application to homogenization,*SIAM J. Math. Anal., **39** (2007) 891-915.
- A.L. Dalibard, *Homogenization of nonlinear scalar conservation laws,* Arch. Rat. Mech. Anal.*,* à paraître.
- A.L. Dalibard, L. Saint-Raymond, *Mathematical study of resonant wind-driven oceanic motion,*en préparation.

ISABELLE GALLAGHER

34 ans, Professeur à l'Université Paris Diderot (Paris VII) depuis septembre 2004
HDR mai 2002
http://www.math.jussieu.fr/~gallagher/

- Responsabilités et tâches administratives.

- Membre de deux commissions de spécialistes (Paris VII et Paris XIII)
- Membre de deux conseils d'UFR (Paris VI et Paris VII)
- Présidente de la Commission de Pédagogie de l'UFR de Maths de Paris VII
- Membre du Comité de rédaction de Panoramas et Synthèses

- Production scientifique

- 26 articles dans des revues à comité de lecture, 1 livre, 1 chapitre de livre, 11 actes de colloque, 2 articles soumis.

- Collaborateurs internationaux : H. Bahouri, S. Ibrahim, M. Majdoub

- Liste des cinq publications les plus significatives

- I. Gallagher, *Applications of Schochet's methods to parabolic equations*, Journal de Mathématiques Pures et Appliquées, **77** (1998), 989-1054.
- I. Gallagher, D. Iftimie et F. Planchon, *Asymptotics and stability for global solutions to the Navier--Stokes equations*, Annales de l'Institut Fourier, **53**, 5 (2003), 1387-1424.
- J.-Y. Chemin, B. Desjardins, I. Gallagher et E. Grenier*, Mathematical Geophysics: An introduction to rotating fluids and to the Navier-Stokes equations*, Oxford University Press, 2006.
- I. Gallagher et L. Saint-Raymond, *On the influence of the Earth's rotation on geophysical flows* Handbook of Mathematical Fluid Dynamics Vol IV, 2006.
- I. Gallagher et L. Saint-Raymond, *Mathematical study of the betaplane model: equatorial waves and convergence results*, accepté pour publication, Mémoires de la Société Mathématique de France.

BORIS HASPOT

28 ans, ATER à l'université Paris XII
Thèse soutenue en Novembre 2007 sous la direction de Raphael Danchin

- Liste des cinq publications les plus significatives

- B. Haspot, *Cauchy problem for Navier-Stokes system with a specific term of capillarity,* submitted.
- B. Haspot, *Existence of global weak solution for compressible fluid models with a capillary tensor for discontinuous interfaces*, submitted.
- B. Haspot, *Existence of solutions for compressible fluid models of Korteweg type*, submitted.
- B. Haspot, *Existence of weak solution for compressible fluid models of Korteweg type*, submitted.
- B. Haspot, *Local Theory in critical Spaces for compressible Navier-Stokes equation*, submitted.

BENJAMIN TEXIER

32 ans, maître de conférences à l'Université Paris Diderot (Paris 7) depuis Octobre 2005.

- Responsabilités et tâches administratives.

- Membre de la commission de spécialistes 25ème Section de Paris 7.

- Production scientifique

- 8 articles dans des revues internationales à comité de lecture, 1 article soumis.

- Collaborateurs internationaux : Kevin Zumbrun (Indiana University)

- Liste des cinq publications les plus significatives

- B. Texier, *The short wave limit for nonlinear, symmetric, hyperbolic systems,* Advances in Differential Equations, **9** (2004), 1-52.
- T. Colin, G. Ebrard, G. Gallice, B. Texier, *Justification of the Zakharov equations from Klein-Gordon-Waves systems,* Communications in Partial Differential Equations, **29** (2004), 1365-1401.
- B. Texier, K. Zumbrun, *Relative Poincaré-Hopf bifurcation and galloping instability of viscous shoc waves,* Methods ad Applications of Analysis, **12** (2005), 348-380.
- B. Texier, *Derivation of the Zakharov equations,* Archive for Rational Mechanics and Analysis, **184** (2007), 121-183
- B. Texier, K. Zumbrun, *Hopf bifurcation of viscous shock waves in gas dynamics and MHD,* Archive for Rational Mechanics and Analysis, to appear (2008).

Partenaire III: Université de Chambéry

DIDIER BRESCH (COORDINATEUR LOCAL)
39 ans, Directeur de Recherche CNRS section 01.
Chef d'équipe EDP et Directeur adjoint du LAMA (Chambéry).

- Responsabilités et tâches administratives.

- 2008 : création (avec D. Lannes) d'un site web pluridisciplinaire consacré à l'océanographie (http://mathocean.math.cnrs.fr/)
- Co-responsable du GdR MABEM (CNRS) avec E. Grenier.
- 2004-2007 : Porteur ACI jeunes chercheurs et jeunes chercheuses: « analyse mathématique de paramétrisations en océanographie. »
- Membre de 6 comités scientifiques de workshops et colloques et du GdR MOAD.
- Co-initiateur des journées EDP Rhône-Alpes : 2003--..
- Porteur du projet Rhône-Alpes : "Equations Saint-Venant visqueuses et problèmes d'environnement".
- Aout 05: Expert sur deux projets ANR.
- Membre du bureau structure fédérative RNVOR : Vulnérabilités des ouvrages aux risques (http://vor.inpg.fr/)

- Animation et coordination scientifique en lien avec le projet

- Décembre 2007 : co-organisation avec W. Craig et D. Lannes de deux mini-symposiums sur des thématiques liées à l'océanographie
- Juillet 2006 : Co-organisation avec P. Noble d'une session hydraulique dans le cadre du congrès international Hyp2006 sur l'ENS Lyon.
- Janvier 2006 : Co-organisation avec E. Dumas d'une session du GdR Chant au sein de l'Institut Fourier (Grenoble) sur fluides complexes et surface libres.
- Juillet 2004 : co- organisation avec J. Videman et J.M. Urbano de deux écoles d'été et un workshop internationaux au Portugal. Thématiques : "les sciences de l'atmosphère et dynamiques du climat" et "l'océanographie, les lacs et les rivières".
- Mars 2002 : co-organisation avec E. Blayo d'un colloque "les Mathématiques Appliquées et le Calcul Scientifique pour l'océanographie" à Grenoble.

- Production scientifique

- 48 articles internationaux à comité de lecture.

- Conférencier invité à 17 congrès internationaux et 38 séminaires en France, 19 à l'étranger.
- Plusieurs écoles d'été en tant qu'orateur dont : Ecole d'été GdR EAPQ, Roscoff 2004, cours sur« Mathématiques et océanographie ».

• Collaborateurs internationaux : E. Fernandez-Nieto, R. Klein, D. Le Roux, C.K. Lin, Z.P. Xin, P. Zhang.

• Prix ou distinctions :
- Morningside lecturer par l'académie des sciences de Chine 2007.
- Prix Maurice Audin 2007 parrainé par la SMAI et la SMF.
- Handbook invité par C. Dafermos et M. Pokorny, 2008.

• Liste des cinq publications les plus significatives

- D. Bresch, B. Desjardins, *On the existence of global weak solutions to the Navier-Stokes equations for compressible and heat conducting fluids*, J. Math. Pures et Appl, **87** (2007)
- D. Bresch, G. Métivier, *Global existence and uniqueness for the lake equations with vanishing topography : elliptic estimates for degenerate equation*, Nonlinearity, **19** (2006) 591- 610
- D. Bresch, D. Gérard-Varet, *About roughness induced effects on the quasi-geostrophic model*, Commun. Math. Phys, **253** (2005) 181-119
- D. Bresch, B. Desjardins, *Existence of global weak solutions for a 2D viscous shallow water equations and convergence to the quasi-geostrophic model*, Comm. Math. Phys. **238**, (2003)
- D. Bresch, P. Noble. *Mathematical justification of a shallow water model*, to appear in Math. Anal. Appl. (2008)

CHRISTIAN BOURDARIAS

51 ans, Maître de Conférences (classe exceptionnelle), HdR.
Professeur de Maths en lycée entre 1975—1993.
Agrégé de Mathématiques.

• Responsabilités et tâches administratives
- Responsable DESS.

• Animation et coordination scientifique en lien avec le projet
- Responsable du projet EMC2 environnement et montagne entre Chambéry et Corte.

• Production scientifique
- 10 articles dans des revues à comité de lecture.
- Contrats avec EDF Chambéry.
- Conférencier invité sur plusieurs congrès internationaux et séminaires.

• Liste des cinq publications les plus significatives

- C. Bourdarias, S. Gerbi, *A finite volume scheme for a model coupling unsteady flows in open channels and in pipelines*, A paraître dans J. Comp. Applied Math (2007).
- C. Bourdarias, S. Gerbi, J. Ohayon, *A three dimensional finite element method for biological active soft tissue. Formulation in cylinder polar coordinates*, M2AN **37** (2003) 725-739.
- C. Bourdarias, M. Gisclon, S. Junca, *Existence of weak entropy solutions for gas chromatography with one or two species and non vconvex isotherms*, A paraître dans Comm. Math. Sciences.
- C. Bourdarias, M. Gisclon, A. Omrane, *Transmission boundary conditions for a model-kinetic decomposition domain*, DCDS-B (2002) 69-94.
- C. Bourdarias, S. Gerbi., J. Ohayon, *Does the collagen netwok contributes to normal ventricula wall thickening ? A theoretical study in continuum mechanics,* (2003), FIMH03, Lyon.

STÉPHANE GERBI

43 ans, Maître de conférences (1ère classe), HdR.

• Responsabilités et tâches administratives

- Responsable du Master 1ère année Ingénierie Math 2002-2006

• Production scientifique

- 10 articles dans des revues à comité de lecture.
- Contrats avec EDF Chambéry.

• Liste des cinq publications les plus significatives

- C. Bourdarias, S. Gerbi, *A finite volume scheme for a model coupling unsteady flows in open channels and in pipelines*, A paraître dans J. Comp. Applied Math (2007).
- C. Bourdarias, S. Gerbi, J. Ohayon, *A three dimensional finite element method for biological active soft tissue. Formulation in cylinder polar coordinates*, M2AN **37** (2003) 725-739.
- R. Cautrès, T. Gallouet, S. Gerbi, R. Herbin, *A Neuman-Neuman method using a finite volume discretization*. In Domain decomposition methodes in Sciences and engineering. Papers of the 13th international conference on domain decomposition methods (2002), 207-214.
- C. Bourdarias, S. Gerbi, *An implicit finite volume scheme for unsteady flows in deformable pipelines*. In Finite volume for complex applications III, problems and perspectives (2002).
- *Transmission boundary conditions for a model-kinetic decomposition domain*, DCDS-B (C. Bourdarias, S. Gerbi., J. Ohayon, *Does the collagen netwok contributes to normal ventricula wall thickening ? A theoretical study in continuum mechanics,* (2003), FIMH03, Lyon.

MARGUERITE GISCLON

39 ans, Maitre de conférences depuis 1996
Titulaire de la prime d'encadrement doctoral.
Détachement CNRS en 2007.

• Responsabilités et tâches administratives

- Responsable du séminaire

• Production scientifique

- 10 articles dans des revues à comité de lecture.
- Conférencière invitée sur plusieurs congrès internationaux et séminaires

• Liste des cinq publications les plus significatives

- C. Bourdarias, M. Gisclon, S. Junca, *Existence of weak entropy solutions for gas chromatography with one or two species and non vconvex isotherms*. A paraître dans Comm. Math. Sciences, (2007).
- C. Bourdarias, M. Gisclon, A. Omrane, Transmission boundary conditions for a model-kinetic decomposition domain. DCDS-B, (2002), 69-94.
- B. Bidegary-Fesquet, F. Castella, E. Dumas, M. Gisclon. From Bloch model to the rate equations II : The case of almost degenerate energy levels, M3AS, vol. 14, no. 12, 1785-1817, (2004)
- D. Bresch, M. Gisclon, C.K. Lin. An example of low Mach (Froude) number effects for compressible flows with nonconstant density (height) limit, M2AN 39 (2005) 477-486
- C. Bourdarias, M. Gisclon, S. Junca, *Some mathematical results on a system of transport equations with an algebraic constraint describing fixed-bed adsorption of gases*, J. Math. Anal. And Appl., **313** (2006) 551-571

CÉLINE ROBERT

34 ans, Ingénieure de Recherche depuis 2007 au LAMA.
Post-doctorat de 2005 à 2007 : *Développement et implémentation de méthodes de frontières ouvertes pour des modèles de circulation océaniques.*

• Responsabilités et tâches administratives

- Responsable du réseau LAMA
- Correspondante LAMA pour la Grille Calcul MUST (LAPP-LAPTH-LAMA).
- Responsable développement calcul LAMA.

- Production scientifique

- 3 articles dans des revues à comité de lecture.
- Conférencière invitée sur plusieurs congrès internationaux et séminaires

- Liste des cinq publications les plus significatives

- C. Robert, E. Blayo, J. Verron, *Comparison of reduced order sequential, variational and hybrid data assimilation methods in the context of a tropical pacific ocean model*, Ocean Dynamics (2006).
- C. Robert, E. Blayo, J. Verron, *Reduced order 4D-Var : A preconditioner for the incremental 4D-Var data-assimilation method*, GRL **33** (2006).
- C. Robert, S. Durbiano, E. Blayo, J. Verron, J. Blum, F.-X. Le Dimet, *A reduced order strategy for 4D-Var data assimilation*, JMS (2005).

Partenaire IV : Université de Montpellier

BIJAN MOHAMMADI (COORDINATEUR LOCAL)
43 ans, Professeur à UM2 depuis 1997, CR1 Inria avant.
www.math.univ-montp2.fr/~mohamadi

- Responsabilités et tâches administratives.

- Responsable Equipe ACSIOM / I3M
- Directeur Adjoint I3M
- CNU 26

- Animation et coordination scientifique en lien avec le projet

- Responsable ANR COPTER (2005-2008)

- Production scientifique

Plusieurs articles dans des JACL autour de la mécanique des fluides numériques, l'adaptation de maillage, le calcul parallèle, la microfluidique, l'optimisation de formes et le couplage entre modèles.

- Collaborateurs internationaux :

Collaborations récentes : avec R. Arina de Polytechnico de Turin (Aeroacoustics), P. Moin et J. Santiago à Stanford (Turbulence et optimisation de formes pour les microfluides), J. Tuomela, Joensu Finlande (Involutivité et EDP sous contrainte).

- Prix ou distinctions :

- Prix Compagnie de Signaux en 98.
- Grand Prix Académie des sciences Aymé Poirson (2004).
- IUF 2000.

- Liste des cinq publications les plus significatives

- B. Mohammadi, O. Pironneau, *Applied shape optimization for fluids,* Oxford Univ. Press (2003 et second edition prévue 2008).
- B. Mohammadi, *Global optimization and Level set dynamics, J*CFD, 21-2 (2007).
- B. Mohammadi, J. Tuomela, *Simplifying numerical solution of constrained PDE systems through involutive completion,* M2AN **39** (2005).
- B. Mohammadi, O. Pironneau, *Shape optimization in fluid mechanics,* Annual Review of Fluid Mechanics, Vol. 36, (2004).
- B. Mohammadi, JH. Saiac, *Pratique de la simulation numérique,* Dunod (2003).

PASCAL AZERAD

46, MCF à l'UM2, HDR

- Responsabilités et tâches administratives.
- Responsable scientifique bibliothèque département mathématiques UM2

- Animation et coordination scientifique en lien avec le projet
- Co-responsable ANR-COPTER
- Co-encadrement thèse D. Isèbe sur l'érosion du littoral
- Encadrement de B. Alvarez-Samaniego pendant 18 mois comme postdoc COPTER

- Production scientifique
- 10 articles dans JACL.
- 5 actes de conférences.

- Collaborateurs internationaux : E. Baensch (Erlangen) Prof invité à Montpellier en 2008 pour les écoulements à surface libre.

- Prix ou distinctions :
- Fellow au Zentrum fur TechnoMathematik Breme.

- Liste des cinq publications les plus significatives

- P. Azerad, F. Bouchette, D. Isebe, B ; Mohammadi, *Shape optimization of geotextile tube*, IJNME DOI 10.1002.
- P. Azerad, F. Bouchette, D. Isebe, B ; Mohammadi, *Optimal shape design of coastal structures minimizing short waves impact,* Coastal Engineering, **55** (2008).
- P. Azerad, E. Baensch, *Asymptotic stability of the primary flow in a cone and plate viscometer,* J.Math.Fluid Mech. **6** (2004).
- P. Azerad, F. Guillen, *Mathematical justification of the hydrostatic approximation in geophysical fluid dynamics,* SIAM J. Math Anal. **33** (2001).
- P. Azerad, P. Perrochet, *Space-time integrated least-square : solving a pure advection equation with a pure diffusion operator,* J. Comput. Phys. **117** (1995).

FREDERIC BOUCHETTE

33 ans, MCF Geosciences Montpellier/UM2-UMR CNRS 5243.

- Responsabilités et tâches administratives.
- Responsable plate-forme GLADYS
- Responsable thématique dynamique littorale à Montpellier

- Animation et coordination scientifique en lien avec le projet

Animateur GLADYS (Plate-forme régionale supportée par la région LR) : hydrodynamique en zone littorale et pré-littorale. Interaction houle / sédiment et mesure en bassin.

- Production scientifique

3 articles JACL, 5 conférences

- Collaborateurs internationaux : Nombreuses collaborations européennes et américaines (Delaware) dans les domaines de l'expérimentation, modélisation et simulation appliquées à la dynamique du littorale.

- Liste des cinq publications les plus significatives

- P. Azerad, F. Bouchette, D. Isebe, B ; Mohammadi, *Optimal shape design of coastal structures minimizing short waves impact,* Coastal Engineering, **55** (2008).
- F. Bouchette, C. Denamiel, Y. Leredde, *Atténuation des houles de cyclones. Implications sur le concept de limite d'action des vagues*. 9ème Congrès des sédimentologues Français (2003).

- F. Bouchette, L. Briqueu, C. Lauer, P. Pezard, *Rôle des phénomènes catastrophiques (tempêtes et crues torrentielles) dans la formation d'un littoral sableux. Exemple de l'Holocène du Golfe d'Aigues Mortes (Gard, Hérault, France).* Cg ASF2003. (2003).
- D. Isèbe, F. Bouchette, B. Mohammadi ,P. Azerad, *A coupled water wave-induced hydrodynamics / shape optimizer model: towards an assisted design of coastal structures,* Proceedings of European Geosciences Union, Geophysical Research Abstracts, **7** (2005).
- D. Isèbe, F. Bouchette, B. Mohammadi ,P. Azerad, *Shape optimization of a sandy coast with the wave refraction-diffraction REFDIF model coupled to the BMO optimizer (Gulf of Aigues-Mortes, NW Mediterranean sea, France).* Proceedings of European Geosciences Union, Geophysical Research Abstracts, **7** (2005).

FABIEN MARCHE

29, Maitre de conférences depuis 2007

- Responsabilités et tâches administratives.

- Responsable du séminaire ACSIOM

- Production scientifique

- 4 articles dans des revues internationales à comité de lecture
- 3 conférences internationales et 2 nationales

- Collaborateurs internationaux : C.Parès, N.Pankratz

- Liste des cinq publications les plus significatives

- F.Marche, *Derivation of a new two-dimensional viscous shallow water model with varying topography, bottom friction and capillary effects*, *E*uropean Journal of Mechanic /B: Fluid **26** (2007) 49-63.
- F.Marche, P.Bonneton, P.Fabrie, N.Seguin, *Evaluation of well-balanced bore-capturing schemes for 2D wetting and drying processes*, Int. J. Num. Meth. Fluids **53** (2007) 867-894.
- F.Marche, P.Fabrie*, Another proof a stability for global weak solutions of 2D degenerated shallow water models, to appear in J.Math F.luid .Mech. (2008)*
- F.Marche, C.Berthon, *A positive preserving high order VFRoe scheme for shallow water equations : a class of relaxation scheme*. In revision for SIAM J. Sc. Comp.

Implication des personnes dans d'autres contrats/*Partner's involvement in other projects* (cf. § 1.7.3) *(un tableau par partenaire)*

Partenaire I : Université de Bordeaux

Partenaire Partner	Nom de la personne participant au projet Name of the person involved in the project	Personne. Mois Man.month	Intitulé de l'appel à projets Source de financement Montant attribué Name call for proposals Other fundings from different organisms Allocated budgets	Titre du projet Proposal title	Nom* du coordinateur Name Principal Inverstigator	Date début - Date fin Start- End of the project
N°1	P. Bonneton	3,6	ANR programme Vulnérabilité : milieux et climats 100k€ attribués à EPOC	VULSACO	Déborah Idier (BRGM, Orléans)	2007-2010
N°1	P. Bonneton	9	ANR programme Vulnérabilité : milieux et climats 105k€ attribués à EPOC	MISEEVA	Charlotte Vinchon (BRGM, Orléans)	2008-2011

Partenaire II : ENS Paris

Partenaire Partner	Nom de la personne participant au projet Name of the person involved in the project	Personne. Mois Man.month	Intitulé de l'appel à projets Source de financement Montant attribué Name call for proposals Other fundings from different organisms Allocated budgets	Titre du projet Proposal title	Nom* du coordinateur Name Principal Inverstigator	Date début - Date fin Start- End of the project
N°2	I. Gallagher	28,8	ANR Programme Blanc	SCASEN	Christophe Cheverry	01/01/06- 31/12/08
N°2	B. Texier	18	ANR Programme Blanc	SCASEN	Christophe Cheverry	01/01/06- 31/12/08

NB : I. Gallagher est investie à 80% dans l'ANR SCASEN et à 50% dans le présent projet. L'ANR SCASEN se terminant à la fin de l'année civile, il n'y aura pas (ou très peu) de chevauchement entre les deux projets et l'investissement total d'I. Gallagher ne dépassera donc pas 100%.

Partenaire III : Université de Chambéry

Pas de projet en cours.

Partenaire IV : Université de Montpellier

Partenaire Partner	Nom de la personne participant au projet Name of the person involved in the project	Personne. Mois Man.month	Intitulé de l'appel à projets Source de financement Montant attribué Name call for proposals Other fundings from different organisms Allocated budgets	Titre du projet Proposal title	Nom* du coordinateur Name Principal Inverstigator	Date début - Date fin Start- End of the project
N°4	B. Mohammadi	10.8	ANR Blanc	COPTER	B. Mohammadi	01/01/06- 31/12/08
N°4	P. Azerad	25.2	ANR Blanc	COPTER	B. Mohammadi	01/01/06- 31/12/08
N°4	F. Bouchette	12.6	ANR Blanc	COPTER	B. Mohammadi	01/01/06- 31/12/08
N°4	F. Marche	10	VMC	MISEEVA	C.Vinchon (BRGM)	01/01/08- 31/12/10

NB : P. Azerad est investi à 80% dans l'ANR COPTER et à 50% dans le présent projet. L'ANR COPTER se terminant à la fin de l'année civile, il n'y aura pas (ou très peu) de chevauchement entre les deux projets et l'investissement total de P. Azerad ne dépassera donc pas 100%.

Demandes de contrats en cours d'évaluation[1]/Other proposals under evaluation

Partenaire I : Université de Bordeaux

Pas de contrat en cours d'évaluation.

[1] *Mentionner ici les projets en cours d'évaluation soit au sein de programmes de l'ANR, soit auprès d'organismes, de fondations, à l'Union Européenne, etc. que ce soit comme coordinateur ou comme partenaire. Pour chacun, donner le nom de l'appel à projets, le titre du projet et le nom du coordinateur.*

Partenaire II : ENS Paris

Partenaire Partner	Nom de la personne participant au projet Name of the person involved in the project	Personne. Mois Man.month	Intitulé de l'appel à projets Source de financement Montant demandé Name call for proposals Other fundings from different organisms Expected grants	Titre du projet Proposal title	Nom* du coordinateur Name Principal Inverstigator
N°2	Anne-Laure Dalibard	18	ANR Jeune Chercheur	RUGO	David Gérard-Varet

Partenaire III : Université de Chambéry

Partenaire Partner	Nom de la personne participant au projet Name of the person involved in the project	Personne. Mois Man.month	Intitulé de l'appel à projets Source de financement Montant demandé Name call for proposals Other fundings from different organisms Expected grants	Titre du projet Proposal title	Nom* du coordinateur Name Principal Inverstigator
N°3	Didier Bresch	10.8	ANSYCOMM	Non connu à cette date	L. Bocquet
N°3	Céline Robert	10.8	ANSYCOMM	Non connu à cette date	L. Bocquet
N°3	Marguerite Gisclon	23.4	ANR Blanc	DYCO	D. Bucur
N°3	Céline Robert	7.2	ANR Blanc	DYCO	D. Bucur

Partenaire IV : Université de Montpellier

Pas de contrat en cours d'évaluation.