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Activity Report 2011

Project-Team TOSCA

TO Simulate and CAlibrate stochastic models

RESEARCH CENTERS
Sophia Antipolis - Méditerranée
Nancy - Grand Est

THEME
Stochastic Methods and Models

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Project-Team TOSCA

Keywords: Financial Mathematics, Monte Carlo Methods, Population Dynamics, Stochastic Methods, Stochastic Modeling

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2. Overall Objectives

2.1. Overall Objectives

The Inria Research team TOSCA is located both at Inria Sophia-Antipolis – Méditerranée and Inria Nancy – Grand Est. The team develops and analyzes stochastic models and probabilistic numerical methods. The present fields of applications are in finance, fluid mechanics, molecular dynamics, chemical kinetics, neuroscience and population dynamics.

The problems where stochastic models arise are numerous, and the critical reasons for which stochastic models are used make analysis and simulations difficult.

The TOSCA team thus aims to develop calibration and simulation methods for stochastic models in cases where **singularities** in the coefficients or **boundary conditions** make them hard to discretize and estimate. For this, we are willing to tackle theoretical and numerical questions which are motivated by real applications.

We are interested in developing **stochastic numerical methods** and **transverse methodologies** that cover several fields of applications, instead of having chosen a particular field of application (e.g., Biology, or Fluid Mechanics, or Chemistry). We justify this way to proceed as follows:

- For a couple of years now, we have attacked singular problems to answer questions coming from economists, meteorologists, biologists and engineers with whom we collaborate within industrial contracts or research programs such as ACI, ANR, GDR. To solve their problems which are so complex that stochastic processes are involved in the modelling, these colleagues need to combine expertise and knowledge in many fields: deterministic computing, computer science, vision, algorithm analysis, etc. We are incompetent in these fields, and therefore we could not pretend to fully treat any of these problems. A contrario, we are requested to bring our expertise in stochastic modelling and simulation to extremely various domains of applications.
- In spite of this diversity, whatever the application is, one has to simulate stochastic processes as solutions to equations of the type

$$\left\{\begin{array}{rl} X_t(\omega) & = X_0(\omega) + \left(\displaystyle\int_0^t \int_{\mathbb{R}^d} b(X_s, y)\mu_s(dy)ds\right)(\omega) \\ & \quad + \left(\displaystyle\int_0^t \int_{\mathbb{R}^d} \sigma(X_s, y)\mu_s(dy)dZ_s\right)(\omega), \\ \mu_s & = \text{Law of } X_s \text{ for all } s \geq 0, \end{array}\right. \tag{1}$$

  in order to compute statistics of the laws of functionals of these solutions. In addition, several fields often produce very similar "pathologies" of the model (1) or of the statistics to compute: for example, Pope's Lagrangian stochastic particles in Fluid Mechanics and models in Molecular Dynamics produce the same degeneracy in (1), namely, one has to substitute 'conditional law of components of X_s given the other ones' for 'law of X_s'; as well, when studying chartist strategies in Finance and stochastic resonance in the electrical working of neurons, we encounter close questions on the density functions of the random passage times of processes (X_t) at given thresholds.
- Theory and numerical experiments show that each 'pathology' of the model (1) requires specific analysis and numerical methods. However, they require common abstract tools (Malliavin calculus, propagation of chaos theory, nonlinear PDE analysis, etc.) and common numerical methodologies (stochastic particle systems, Monte Carlo simulations, time discretization of stochastic differential equations, etc.). Thus each application takes benefit from the modelling and numerical knowledge developed for all the others.

The TOSCA team is currently studying models in relation with Geophysics, Neuroscience, Fluid Mechanics, Chemical Kinetics, Meteorology, Molecular Dynamics, Population Dynamics, Evolutionary Dynamics and Finance. We also construct and study stochastic particle systems for Fluid Mechanics, coagulation–fragmentation, stationary nonlinear PDEs, variance reduction techniques for Monte-Carlo computations and numerical methods combining deterministic and stochastic steps to solve nonlinear PDEs in Finance.

3. Scientific Foundations

3.1. Scientific Foundations

Most often physicists, economists, biologists, engineers need a stochastic model because they cannot describe the physical, economical, biological, etc., experiment under consideration with deterministic systems, either because of its complexity and/or its dimension or because precise measurements are impossible. Then they abandon trying to get the exact description of the state of the system at future times given its initial conditions, and try instead to get a statistical description of the evolution of the system. For example, they desire to compute occurrence probabilities for critical events such as the overstepping of a given thresholds by financial losses or neuronal electrical potentials, or to compute the mean value of the time of occurrence of interesting events such as the fragmentation to a very small size of a large proportion of a given population of particles. By nature such problems lead to complex modelling issues: one has to choose appropriate stochastic models, which require a thorough knowledge of their qualitative properties, and then one has to calibrate them, which requires specific statistical methods to face the lack of data or the inaccuracy of these data. In addition, having chosen a family of models and computed the desired statistics, one has to evaluate the sensitivity of the results to the unavoidable model specifications. The TOSCA team, in collaboration with specialists of the relevant fields, develops theoretical studies of stochastic models, calibration procedures, and sensitivity analysis methods.

In view of the complexity of the experiments, and thus of the stochastic models, one cannot expect to use closed form solutions of simple equations in order to compute the desired statistics. Often one even has no other representation than the probabilistic definition (e.g., this is the case when one is interested in the quantiles of the probability law of the possible losses of financial portfolios). Consequently the practitioners need Monte Carlo methods combined with simulations of stochastic models. As the models cannot be simulated exactly, they also need approximation methods which can be efficiently used on computers. The TOSCA team develops mathematical studies and numerical experiments in order to determine the global accuracy and the global efficiency of such algorithms.

The simulation of stochastic processes is not motivated by stochastic models only. The stochastic differential calculus allows one to represent solutions of certain deterministic partial differential equations in terms of probability distributions of functionals of appropriate stochastic processes. For example, elliptic and parabolic linear equations are related to classical stochastic differential equations, whereas nonlinear equations such as the Burgers and the Navier–Stokes equations are related to McKean stochastic differential equations describing the asymptotic behavior of stochastic particle systems. In view of such probabilistic representations one can get numerical approximations by using discretization methods of the stochastic differential systems under consideration. These methods may be more efficient than deterministic methods when the space dimension of the PDE is large or when the viscosity is small. The TOSCA team develops new probabilistic representations in order to propose probabilistic numerical methods for equations such as conservation law equations, kinetic equations, and nonlinear Fokker–Planck equations.

4. Application Domains

4.1. Application Domains

TOSCA is interested in developing stochastic models and probabilistic numerical methods. Our present motivations come from Finance, Neuroscience and Biology, Fluid Mechanics and Meteorology, Chemical Kinetics, Diffusions in random media, Transverse problems, Software and Numerical experiments.

Finance For a long time now TOSCA has collaborated with researchers and practitioners in various financial institutions and insurance companies. We are particularly interested in calibration problems, risk analysis (especially model risk analysis), optimal portfolio management, Monte Carlo methods for option pricing and risk analysis, asset and liabilities management. We also work on the partial differential equations related to financial issues, for example the stochastic control Hamilton–Jacobi–Bellman equations. We study existence, uniqueness, qualitative properties and appropriate deterministic or probabilistic numerical methods. At the moment we pay special attention to the financial consequences induced by modelling errors and calibration errors on hedging strategies and portfolio management strategies.

Neuroscience and Biology The interest of TOSCA in biology is developing in three main directions: neuroscience, molecular dynamics and population dynamics. In neuroscience, stochastic methods are developed to analyze stochastic resonance effects and to solve inverse problems. For example, we are studying probabilistic interpretations and Monte Carlo methods for divergence form second-order differential operators with discontinuous coefficients, motivated by the 3D MEG inverse problem. Our research in molecular dynamics focuses on the development of Monte Carlo methods for the Poisson-Boltzmann equation which also involves a divergence form operator, and of original algorithms to construct improved simulation techniques for protein folding or interaction. Finally, our interest in population dynamics comes from ecology, evolution and genetics. For example, we are studying the emergence of diversity through the phenomenon of evolutionary branching in adaptive dynamics. Some collaborations in biostatistics on cancer problems are also being initiated.

Fluid Mechanics and Meteorology In Fluid Mechanics we develop probabilistic methods to solve vanishing vorticity problems and to study the behavior of complex flows at the boundary, and their interaction with the boundary. We elaborate and analyze stochastic particle algorithms. Our studies concern the convergence analysis of these methods on theoretical test cases and the design of original schemes for applicative cases. A first example concerns the micro-macro model of polymeric fluids (the FENE model). A second example concerns Pope's Lagrangian modelling of turbulent flows, motivated by the problem of modelling and computing characteristic properties of the local wind activity in areas where windmills are built. Our goal is to estimate local energy resources which are subject to meteorological randomness by combining large scale wind models and small scale Monte Carlo techniques, and to simulate management strategies of wind resources.

Chemical Kinetics The TOSCA team is studying coagulation and fragmentation models, that have numerous areas of applications (polymerization, aerosols, cement industry, copper industry, population dynamics...). Our current motivation comes from the industrial copper crushers in Chile. We aim to model and calibrate the process of fragmentation of brass particles of copper in industrial crushers, in order to improve their efficiency at a low cost.

Diffusions in random media A *random medium* is a material with a lot of heterogeneity which can be described only statistically. Typical examples are fissured porous media within rocks of different types, turbulent fluids or unknown or deficient materials in which polymers evolve or waves propagate. For the last few years, the TOSCA team has been collaborating with the Geophysics community on problems related to underground diffusions, especially those which concern waste transport or oil extraction. We are extending our previous results on the simulation of diffusion processes generated by divergence form operators with discontinuous coefficients. Such an operator appears for example in the Darcy law for the behavior of a fluid in a porous media. We are also developing another class of Monte Carlo methods to simulate diffusion phenomena in discontinuous media.

Transverse problems Several of the topics of interest of TOSCA do not only concern a single area of application. This is the case in particular for long time simulation methds of nonlinear McKean-Vlasov PDEs, the problem of simulation of multivalued models, variance reduction techniques or stochastic partial differential equations. For example, multivalued processes have applications in random mechanics or neuroscience, and variance reduction techniques have applications in any situation where Monte Carlo methods are applicable.

Software, numerical experiments TOSCA is interested in designing algorithms of resolution of specific equations in accordance with the needs of practitioners. We benefit from our strong experience of the programming of probabilistic algorithms of various architectures including intensive computation architectures. In particular, our activity will concern the development of grid computing techniques to solve large dimensional problems in Finance. We are also interested in intensively comparing various Monte Carlo methods for PDEs and in the development of open source libraries for our numerical methods in Fluid Mechanics, Meteorology, MEG or Chemical Kinetics.

5. Software

5.1. CarbonQuant

Participants: Mireille Bossy [correspondant], Jacques Morice, El Hadj Aly Dia.

CarbonQuant is a simulator project of CO2 allowances prices on a EU-ETS type market, by an indifference price approach.

It aims to demonstrate the high potentiality of stochastic control solvers, to quantify sensibilities of a carbon market with respect to its design.

Starting in September 2011, CarbonQuant is an ADT [1] Inria.

See also the web page http://carbonvalue.gforge.inria.fr.

- Version: 0.1

6. New Results

6.1. Probabilistic numerical methods, stochastic modelling and applications

Participants: Mireille Bossy, Nicolas Champagnat, Julia Charrier, Julien Claisse, Madalina Deaconu, Samuel Herrmann, James Inglis, Pierre-Emmanuel Jabin, Antoine Lejay, Sylvain Maire, Sebastian Niklitschek Soto, Nicolas Perrin, Denis Talay, Etienne Tanré, Laurent Violeau.

6.1.1. Published works and preprints

- M. Bossy in collaboration with J.-F. Jabir (Univ. Chile) proved the well posedness of the confined Lagrangian models, in association with no-permeability boundary conditions.

  When the confining domain is a hyperplane, they proved the strong existence of the trace of the density of particles following the kinetic stochastic equation of a simplified McKean Vlasov Lagrangian model in [12], http://hal.inria.fr/inria-00515481/en.

  When the confining domain $\mathcal{D}$ is bounded with smooth boundary, they constructed a confined primitive of Brownian motion in $\mathcal{D}$ and characterized the solution to the corresponding martingale problem by showing that the time marginal density is the unique solution to a mild equation with specular condition. This key step allowed them to finish the construction in the non linear case, using previous work on Vlasov-Fokker-Plank PDE with specular boundary condition. Two papers are being written.

- In collaboration with J.-F. Jabir and J. Fontbona (CMM and Universidad de Chile, Santiago de Chile), M. Bossy and P.-E. Jabin have studied the link between the Lagrangian version of divergence free constraint (and the uniform density constraint), with an additional potential term, in the Lagrangian equation, having some similarity with the role of the Eulerian pressure term. They obtained the local existence of analytical solutions for an incompressible Lagrangian stochastic model in periodic domain. An article is currently being writen.

- N. Champagnat worked with A. Lambert (Univ. Paris 6) on splitting trees with Poissonian mutations. Assuming that each mutation is neutral and gives a new type in the population, they obtained in [15] explicit expressions for the expected number of types carried by a fixed number of individuals living in the population at time t. In [31], they also obtained large time convergence results on the sizes of the largest families and the ages of the oldest families in the population. http://hal.inria.fr/inria-00515481/en, http://hal.inria.fr/inria-00616765/en.

[1] Technology Development Action

- N. Champagnat and P.-E. Jabin studied the limit of some population dynamics models under the assumption that the time scale for mutations is much larger than the time scale for reproduction. They are able to provide the first full characterization of the corresponding limit equation [14], http://hal.inria.fr/inria-00488979/en.
- M. Deaconu and S. Herrmann developed a new method for the simulation of the hitting time of nonlinear boundaries for Bessel processes. This method is based on a walk on moving spheres algorithm and can be applied for the hitting time of a given level for the Cox-Ingersoll-Ross process [32], http://hal.inria.fr/hal-00636056/en. This work is part of the ANR MANDy project.
- S. Herrmann and E. Tanré worked on a scheme to construct an efficient algorithm to similate the first hitting time of curves by a one dimensional Brownian motion. They apply the result to estimate the spiking time of leaky integrate fire models in neurosciences. This work is part of the ANR MANDy project.
- P.-E. Jabin and F. Ben Belgacem (Univ. of Monastir, Tunisia) have studied a new class of models which have seen considerable development in applications for biosciences (flocking, chemotaxis, pedestrian flows...). These models include some non linear corrections to classical linear continuity equations. In [30], they introduce new, critical regularity estimates to obtain well posedness. http://www2.cscamm.umd.edu/~jabin/transportlcs2.pdf.
- P.-E. Jabin and M. Hauray (Aix-Marseille Université) have studied the mean field limit for systems of many interacting particles. It is the only result able to deal with singular forces and physically realistic initial configurations [33], http://hal.inria.fr/hal-00609453/en.
- P.-E. Jabin and A. Nouri (Aix-Marseille Université) studied a highly singular kinetic equation in dimension 1. This equation is obtained as a quasi-neutral limit in plasma physics. In [18], they were able to prove well posedness in short time of analytic solutions. http://dx.doi.org/10.1016/j.crma.2011.03.024.
- P.-E. Jabin and G. Raoul (Cambridge University) prove the convergence to a unique stable equilibrium for a wide class of competitive models in population dynamics [19], http://dx.doi.org/10.1007/s00285-010-0370-8.
- P.-E. Jabin and J. Calvo (Universidad de Granada) investigate the long time asymptotics of a new class of models for interacting particles inspired from various phenomena in the biosciences. In this model, when two particles collide they may coalesce and then completely stop moving [13], http://hal.inria.fr/hal-00601969/en.
- In collaboration with G. Pichot (INRIA Rennes Bretagne Atlantique), A. Lejay has developed a new Monte Carlo methods for discontinuous media that relies on the simulation of the Skew Brownian motion [22], [35], http://hal.inria.fr/hal-00642194/en, http://hal.inria.fr/hal-00649170/en.
- A. Lejay developped a new method for the simulation of a stochastic process in a layered media using the properties of the Brownian path [20], http://hal.inria.fr/inria-00583127/en.
- S. Maire and C. Prissette (Univ. du Sud – Toulon – Var) have developed in [21] a stochastic algorithm to solve Sudoku puzzles using estimation of distribution coupled with restart techniques. http://hal.inria.fr/inria-00591852_v1/
- S. Maire and E. Tanré have generalised the spectral methods for elliptic PDEs developed in [39], [40] to the case of pure Neumann boundary conditions. Some additional difficulties occur because the stochastic representation of the solutions is defined only up to an additive constant and as a limit involving local time approximations [38]. By taking into account these additional properties, they still obtained a spectral matrix having a condition number converging to one.
- D. Talay and E. Tanré, in collaboration with F. Delarue and S. Rubenthaler (Univ. Nice – Sophia Antipolis), have given a precise approximation of the interspike intervals for the LIF model, describing the activity of a single neuron. This work is part of the ANR MANDy project (see Section 7.1.1).

- D. Talay, in collaboration with M. Martinez (Univ. Paris-Est), achieved to develop their stochastic approach for one-dimensional transmission parabolic problems. Owing to their stochastic representation of the solutions, they obtained accurate pointwise estimates for the derivatives of these solutions, from which they got accurate convergence rate estimates in the weak sense for a numerically effective discretization scheme of stochastic differential equations with weighted local times which are related to elliptic partial differential operators under divergence form with a discontinuous coefficient [36], http://hal.inria.fr/inria-00607967/en.

6.1.2. Other works in progress

- N. Champagnat studies in collaboration with S. Méléard (Ecole Polytechnique, Palaiseau) adaptive dynamics and evolutionary branching in individual-based models of populations competing for resources, similar to those involved in chemostat systems of ODEs.
- N. Champagnat studies in collaboration with A. Lambert the process of the time to the most recent common ancestor in a family of subcritical branching processes whose genealogy is given by splitting trees.
- J. Charrier joined the team in September as a post-doctoral researcher and began working with M. Bossy and D. Talay on the long time behaviour of stochastic particules systems in McKean-Vlasov interaction.
- J. Claisse continued his PhD. under the supervision of N. Champagnat and D. Talay on stochastic control of population dynamics. He completed a finite-horizon and an infinite-horizon optimal control problem on a birth-death process. He is currently working on a birth-death process whose parameters depend on a controlled ordinary differential equation. In addition, he is working on applications of branching processes in biology and optimal control theory, and more specifically in cancer therapy.
- M. Deaconu and S. Herrmann continue the study of the hitting time for Bessel processes in the situation of noninteger dimensions.
- J. Inglis joined the team in October 2011 as a post-doctoral researcher (ANR MANDy), and began working with E. Tanré, D. Talay, F. Delarue (University of Nice) and S. Rubenthaler (University of Nice) on problems related to the rigorous justification of mean field models used in neuroscience.
- J. Inglis, E. Tanré and M. Tejo (PUC, Chile) started a collaboration on the numerical simulation of spiking times of neurons described by some new stochastic models related to the Hodgkin-Huxley equation. This work is a part of Anestoch associated team.
- A. Lejay and S. Maire study some new Monte Carlo methods for multi-dimensional discontinuous media.
- In collaboration with J.-R. Li (INRIA Rocquencourt & Neurospin), A. Lejay studies some probabilistic representation for interface condition arising in diffusion Magnetic Resonance Imaging.
- In collaboration with G. Pichot and J. Erhel (INRIA Rennes Bretagne Atlantique), A. Lejay studies Monte Carlo methods for discontinuous media as well as benchmarks and test on existing methods.
- With L. Coutin (Univ. Toulouse), A. Lejay studies some perturbation results for solutions of Rough Differential Equations.
- S. Maire develops with C. de Luigi (Univ. du Sud – Toulon – Var) and Jerôme Lelong (IMAG, Grenoble) resolution algorithms for the price of various european options in high dimension by coupling an adaptive deterministic integration algorithm and Principal Component Analysis tools.
- S. Niklitschek continued his PhD. under the supervision of D. Talay on discretized stochastic differential equations related to one-dimensional partial differential equations of parabolic type involving a discontinuous drift coefficient. He obtained accurate pointwise estimates for the derivatives of these solutions, from which he gets convergence rate estimates in the weak sense of the stochastic discretization scheme. Now he is working on the extension of these results to the multi-dimensional setup.

- N. Perrin continued his PhD. on stochastic methods in molecular dynamics under the supervision of M. Bossy, N. Champagnat and D. Talay. He is studying a method due to P. Malliavin (French Academy of Science) based on the Fourier analysis of covariance matrices with delay in order to identify the fast and slow components of a molecular dynamics and to construct simplified projected dynamics. He also studied probabilistic interpretation of the nonlinear Poisson-Boltzmann equation in Molecular Dynamics with BSDEs [37], http://hal.inria.fr/hal-00648180/en.
- L. Violeau continued his PhD. on *Stochastic Lagrangian Models and Applications to Downscaling in Fluid Dynamics* under the supervision of M. Bossy and A. Rousseau (MERE team, INRIA Sophia Antipolis – Méditerranée, Montpellier). He studied the convergence in law of a sequence of penalized processes to the so called reflected langevin process in a convex domain. He is currently working on the rate of convergence of the particle approximation of conditional McKean stochastic models.
- P-E. Jabin and D. Talay continue to develop their innovating approach, which combines stochastic analysis and PDE analysis, for the time varying Hamilton-Jacobi-Bellman-McKean-Vlasov equations of the Lasry and Lions mean-field stochastic control theory.

6.2. Financial Mathematics

Participants: Mireille Bossy, Paul Charton, El Hadj Aly Dia, Dalia Ibrahim, Denis Talay, Etienne Tanré.

6.2.1. Published works and preprints

- In collaboration with N. Maïzi (CMA – Mines Paristech) and O. Pourtallier (COPRIN team, INRIA Sophia Antipolis – Méditerranée), M. Bossy, and E.H.A. Dia studied the indifference pricing for carbon emission allowances, as a short term model value of carbon (see Section 7.1.2). The indifference pricing methodology describes the way an industrial agent on the emission allowances market chooses his production strategy. An utility function represents the preferences of the producer and its risk aversion. The outputs of its production have stochastic prices on the market, so that the optimal production strategy arises as the solution of a stochastic control problem.

  We extended the model hypotheses under which we get the well-posedness of the stochastic control problem and the associated HJB equation. We exhibited a simple case (marginal costs constant in time) where we proved the regularity of the value function via the explicit solution of the stochastic control problem [24], http://hal.inria.fr/hal-00645033/en. This particular case now can serve as a benchmark for the numerical solver currently developed in the framework of the ADEME Convention. It will also serve as a demonstrator case, with the objective of a public diffusion of the simulator CarbonQuant.
- M. Cissé (ENSAE-Sénégal), P. Patie (Univ. libre de Bruxelles) and E. Tanré have solved explicitly the optimal stopping problem with random discounting and an additive functional as cost of observations for a regular linear diffusion [17], http://hal.inria.fr/inria-00458901/en/.

6.2.2. Other works in progress

- P. Charton continued his PhD. under the supervision of M. Deaconu and A. Lejay. He studied some hedging strategies for day ahead markets of wind energy.
- **Mathematical modelling for technical analysis techniques** Since November 2009, D. Ibrahim has been working on her PhD. thesis on Mathematical modeling of technical analysis in finance, under supervision of D. Talay and E. Tanré. The aim of her work is to study the performances of a technical analysis tool designed to detect changes in the volatility term: the Bollinger Bands. First, she studied the performances of this indicator in a modified Black-Scholes model such that the rate of volatility changes at an unknown random time τ, independent of the Brownian motion governing the prices. She is interested to study whether this indicator can detect the changes in the volatility. So, she aims to study the tail probability of this indicator by using Karamata's Tauberian Theorem for Laplace-Stieltjes transforms.

Secondly, she exhibited a mathematical optimal strategy by modifying usual techniques in both the dual and the classical PDE approaches in stochastic control theory, in order to circumvent the discontinuity of the filtration generated by the price process.

This work is part of the contract with FINRISK (see Section 8.3).

- P. Protter (Columbia University) and D. Talay started to develop a new bubble time evolution model.

7. Contracts and Grants with Industry

7.1. Contracts with Industry

7.1.1. ANR projects

- N. Champagnat is member of the ANR MANEGE (Modèles Aléatoires eN Écologie, Génétique et Évolution, started in 2009 under the direction of S. Méléard, Ecole Polytechnique) whose aim is to provide methodological and conceptual advances in the study of stochastic processes modeling ecology, population genetics and evolution of life. This work is sustained by regular exchanges with biologists from several teams in France. In addition, the three working groups that operate in each of the three poles of the MANEGE project (Paris, Palaiseau, Marseille) gather all local probabilistic interests in the issues of this project. http://www.cmap.polytechnique.fr/~anr-manege/index_en.html
- N. Champagnat is member of the ANR MODECOL (Using mathematical MODeling to improve ECOLogical services of prairial ecosystems, started in 2009 under the direction of C. Mony, Univ. Rennes 1), whose goal is to develop computational ecological modeling of terrestrial plants communities via the simulation of a prairie in relation with environmental data. This project focuses on developing an original tool-box that takes advantage of complementary mathematical disciplines (partial differential equations, individual-based stochastic modelling...) to assess ecological problems. Simulations will be extensively processed using distributed computing and webcomputing. Our target application concerns the setup of herbal strips around intensive cereal fields for purificating water from extra nitrate and pesticides, imposed by the European Common Agricultural Policy. http://ecobio.univ-rennes1.fr/modecol/gb/description.php
- S. Herrmann, D. Talay and E. Tanré are member of the ANR MANDy (Mathematical Analysis of Neuronal Dynamics, started in 2009 under the direction of M. Thieullen, Univ. Paris 6). This project, which gathers mathematicians and neuroscientists, aims at developing mathematically rigorous approaches to neuroscience considering single neurons as well as interconnected neuronal populations. Our target is to conduct the mathematical analysis of existing models where there is still much work to be done and to enrich the modelling by proposing new models. See http://www.proba.jussieu.fr/pageperso/thieullen/MANDy/accueil.html for a more complete description of this project.
- P.-E. Jabin is member of the ANR MONUMENTALG (MOdélisation mathématique et simulations NUMériques pour la dégradation biologique des MONUMENTs et pour la prolifération des ALGues) on the dispersion of toxic algae, starting in 2010 (direrected by M. Ribot, Univ. Nice – Sophia Antipolis). http://math.unice.fr/~ribot/anr.html
- A. Lejay is member of the ANR ECRU (Exploration des Chemins RUgueux, 2009–2011), whose aim is is to explore new directions in the field of rough paths (directed by M. Gubinelli, Univ. Paris Dauphine). http://www.ceremade.dauphine.fr/~mgubi/ecru/index.html
- A. Lejay is member of the ANR SIMUDMRI (Simulation du signal d'IRM diffusion dans tissus biologiques) which started in November 2010 (directed by Jing-Rebecca Li, INRIA Rocquencourt).

7.1.2. Contracts with ADEME

Participants: Mireille Bossy, El Hadj Aly Dia, Jacques Morice, Laurent Violeau.

Local modeling for the wind velocity Since 2005, M. Bossy was member of a collaboration with the Laboratoire de Météorologie Dynamique (Université Paris 6, École Polytechnique, École Normale Supérieure), funded by the French Environment and Energy Management Agency (ADEME), concerning the modeling and the simulation of local wind energy resources. We collaborate with P. Drobinski. This year was the last year of the second phase of this collaboration started in October 2007, with two other partners: A. Rousseau (MOISE team, INRIA Grenoble – Rhône-Alpes) and F. Bernardin (CETE Clermont-Ferrand).

We investigated a new numerical simulation method for the downscaling in CFD, with a strong orientation in applications to meteorology, particularly for the simulation of wind at small scales. The local model that we propose consists in modeling the fundamental equations of fluid motion by a stochastic Lagrangian model describing the behaviour of a fluid particle.

Because of the both Lagrangian and stochastic nature of our model, it is discretized thanks to an interacting particle system, combining a time Euler scheme for stochastic differential equations and a Monte–Carlo approximation method

This model called *SDM* (Stochastic Downscaling Method) is adapted from previous works introduced by S.B. Pope [41] (see http://sdm.gforge.inria.fr/Accueil/index.en.php).

This year, we worked on the comparison of the SDM model (endowed with a physical geostrophic forcing and a wall log law) with simulations obtained with a LES method (Méso-NH code) for the atmospheric boundary layer (from 0 to 750 meters in the vertical direction), in the neutral case.

This work allowed to deeply understand the contribution of each elements of the Lagrangian model in terms of the turbulence production and dissipation, we analysed the returns of various closure parametrisation approaches, including viscosity turbulent approach. We also investigated anisotropic effect, with the introduction of a GLM model in SDM (see [41]), in particular the isotropic relaxation case. We gave our conclusions as a part of the final report for ADEME [28], http://hal.inria.fr/hal-00646422/en. A paper is in preparation.

Carbon value and carbon tax in the context of renewable energies deployment Since January 2009, M. Bossy was member of a collaboration funded by the French Environment and Energy Management Agency (ADEME), involving the Center for Applied Mathematics (CMA) at Mines ParisTech, and COPRIN and TOSCA teams at INRIA Sophia Antipolis. It focuses on a short term carbon value derived from the so-called financial *carbon market*, the European Union Emission Trading Scheme (EU ETS), which is a framework for GHG emissions reduction in European industry.

The objective of this project is to study the compatibility and complementarity of a carbon tax and a target for renewable energy deployment. As a first step, we are developing a method for assessing the EU ETS value. We consider the constraints related to emission allowances distributed through national plans of allocation (NAP) and the mechanisms of taxes that are taking place. The work will focus on electricity producers, key players in the market in its first phase (NAP-I, 2005-2007). The impact of the *Renewable Energies* park of the electricity producers on their own carbon value will be particularly studied.

We have selected the financial concept of indifference price as a relevant methodology to assess the European Union Emission Trading Scheme (EU ETS) value. In this setting, modelling strategies of production and emission of market quotas rely on stochastic optimal control problems and associated Hamilton-Jacobi-Bellman equations.

This year, we worked on the calibration (with EPEX Spot data) of the selected panel of electricity spot price models, as input of the indifference price solver. We also added the reduction cases (studied in our collaboration with CMA-MinesParisTech mentioned above) into the solver and we started to implement the 3D case solver, required for some electricity spot price models. We used the current version of CarbonQuant to compare a tax situation with the allowances market situation.

We also continued the study of a game theoretic approach based on the Nash equilibrium concept for the coupled electricity and carbon markets (see the 2011 Activity Report of the COPRIN team).

7.1.3. Industrial contracts

- TOSCA Nancy starts a working group with the SME Alphability on risk measures and rare events in finance.
- The contract between TOSCA and GDF-Suez on the hedging of power plants ended in January.
- In collaboration with V. Reutenauer (CA-CIB) D. Talay and E. Tanré worked on the contract with CA-CIB (ex-CALYON), which concerned
  - the study of the liquidity risk in the interest rate options market;
  - the minimization of the hedging error in interest rates Gaussian models by means of strategies designed in an effective way by using stochastic optimization algorithms.

  This contract ended this year.

8. Partnerships and Cooperations

8.1. National Initiatives

- N. Champagnat is a member of the ANR MANEGE and MODECOL (see Section 7.1.1).
- S. Herrmann, D. Talay and E. Tanré are members of the ANR MANDy (see Section 7.1.1).
- P.-E. Jabin is member of the ANR MONUMENTALG (see Section 7.1.1).
- A. Lejay is a member of the ANR ECRU and SIMUDMRI (see Section 7.1.1).
- D. Talay is the Vice-President of the Fondation d'Entreprise Natixis which aims to contribute to develop research in quantitative finance.
  He also serves as a member of the Scientific Committee of the Foundation, jointly with M. Crouhy (Président, Natixis), N. El Karoui (École Polytechnique), R. Gibson (Université de Genève), P.-L. Lions (Collège de France), J.-P. Laurent (Université Claude Bernard, Lyon).
- D. Talay is a member of the Scientific Committee of the AMIES Agency aimed to promote interactions between Mathematics and Industry.

8.2. European Initiatives

8.2.1. Collaborations in FP7 Programs

- A. Lejay participates to the *Multifractionality* (action Marie Curie *International Research Staff Exchange Scheme* FP7-PEOPLE-IRSES-2008) with Nancy, Kiev, Israël and Cardiff (2009–2011).

8.3. International Initiatives

8.3.1. INRIA Associate Teams

8.3.1.1. ANESTOC

Title: Stochastic modelling of renewable energies

INRIA principal investigator: Denis Talay

International Partner:

Institution: Pontificia Universidad Catolica de Chile (Chile)

Laboratory: ANESTOC

Duration: 2011 - 2013

See also: http://www.anestoc.cl/es/?page_id=1112

This associate team complements a CIRIC research program in Chile. We refer to the TOSCA-ANESTOC project on stochastic modelling of renewable energies, especially wind farms, and oceanic resources. Our associate team (”Équipe associée Inria”) will conduct its joint research at two different levels. Firstly, the mathematical work on its own which we have called the ”Mathematical Kernel” (MK) , motivated by a number of fundamental problems raised by the specific applications in which we are interested. The second level of research concerns two main axes of Applications: (A1) Applications to Engineering (Renewable energies) and (A2) Applications to Neuroscience. The Mathematical Kernel includes a number of fields in the domains of Stochastic Analysis, Statistics and Numerical Analysis. In particular, it is worth mentioning the following: 1. Probabilistic resolution of Boussinesq non-linear partial differential equations; 2. Stochastic approach to Pope's equations on wind dynamics; 3. Open system dynamics as a bridge between Molecular Dynamics and Stochastic Differential Equations; 4. Inference on Stochastic Processes; 5. Algorithms and simulation. The Applications include the stochastic modelling of renewable energy through ocean resources and wind farms (CIRIC-subproject). This subject will be developed with engineers of the Catholic University of Chile. In addition, applications to ion-channel dynamics through cell membranes will be considered jointly with biophysicists of the CINV (Neuroscience Centre of Valparaiso).

8.3.2. INRIA International Partners

- TOSCA participates to the NCCR FINRISK (Financial Risk) forum launched by the Swiss National Science Foundation and managed by the University of Zürich.

8.3.3. Visits of International Scientists

8.3.3.1. Visits of Professors and Researchers

- P. Carmona (Princeton University) has been visiting the team for three days in March.
- M. Cissé (ENSAE, St. Louis, Sénégal) has been visiting the team six weeks in September and October.
- J. Fontbona (Univ. de Chile) has been visiting the team twice three days in May and June.
- J.-F. Jabir (Univ. Toulouse) has been visiting the team three months between April and July, and one week in October.
- L. Lindholm (KTH Royal Institute of Technology, Sweden) has been visiting the team three weeks in August and September.
- A. Rousseau (MERE team, INRIA Sophia – Antipolis, Montpellier) has been visiting the team for two days in January.
- The TOSCA *seminar* organized by N. Champagnat and J. Charrier in Sophia Antipolis has received the following speakers: Viet Chi Tran (Université des Sciences et Technologies Lille 1), Martin Riedler (Heriot-Watt University Edimbourg, UK), Arturo Kohatsu-Higa (Osaka University, Japan), Dan Crisan (Imperial College, UK), Laurent Miclo (Université Paul Sabatier Toulouse), Sylvain Maire (Université du Sud Toulon – Var), Thomas Önskog (Umea University, Sweden), Denis Villemonais (Ecole Polytechnique, Palaiseau), Gérard Ben Arous (Courant Institute, New York University), Joaquin Fontbona (Universidad de Chile), Jun Yu (Ecole Polytechnique, Palaiseau), Julia Charrier (INRIA Sophia Antipolis – Méditerranée).

8.3.3.2. Internships

Omar Abbes

Subject: Stochastic approaches for wave modelling

Institution: Ecole Polytechnique de Tunisie (Tunisia)

Amine Chourou

Subject: Stochastic volatility models - new numerical methods

Institution: Ecole Polytechnique de Tunisie (Tunisia)

Jun Xu

Subject: Bank networks systemic risk propagation models

Institution: Ecole Polytechnique

Mauricio Tejo

Subject: Mean Field behaviour of ionnic channel in neuroscience

Institution: Pontifical Universitad Catolica (Chile)

8.3.4. Participation In International Programs

- P.-E. Jabin is member of the KiNet network, NSF Focus Research Group grant on kinetic description of multi-scale phenomena (as co P.I., main P.I.: E. Tadmor)
- D. Talay is the international coordinator of the MathAmsud program 08MATH05 - Stochastic Analysis and Mathematical Physics Research Network which started in 2009, and also involves M. Bossy, A. Lejay and E. Tanré.

9. Dissemination

9.1. Animation of the scientific community

- M. Bossy is a member of the Scientific Committee of the *École Doctorale "Sciences Fondamentales et Appliquées"* of the Université de Nice – Sophia Antipolis.
- M. Bossy is a member of the *Collectif Andromede* of the PACA Region council.
- M. Bossy is an elected member of the INRIA Evaluation Board, a member of the *Suivi Doctoral* Committee of INRIA Sophia Antipolis –Méditerranée, a member of the *NICE Committee* of INRIA Sophia Antipolis –Méditerranée.
- M. Bossy was a member of the hiring committee for Junior Researchers (Maîtres de Conférence) in the Centre de Mathématiques Appliquées at Mines ParisTech, Sophia Antipolis.
- N. Champagnat was an elected member of the *Comité de Centre* of INRIA Sophia Antipolis – Méditerranée until July.
- N. Champagnat was the coordinator of the Spring School *Modèles Aléatoires en écologie, génétique et évolution* of the ANR MANEGE in June in Agay http://www.cmap.polytechnique.fr/~anr-manege/StRaphael2011.html.
- N. Champagnat was a member of two hiring committees for Junior Researchers (Maîtres de Conférence) in Univ. de Nice – Sophia Antipolis and Univ. Lyon 1.
- N. Champagnat was a member of the PhD. committee of M. Salamat (Aix-Marseille Université, supervisor: E. Pardoux) in March and of M. Richard (Univ. Paris 6, supervisor: A. Lambert) in December.
- M. Deaconu is a member of the *COST-GTAI (Groupe de Travail Actions Incitatives)* of INRIA, of *Comité des Projets* and *Commission des Développements Technologiques* at INRIA Nancy, Grand-Est.
- M. Deaconu is a member of the *Conseil de Laboratoire* at Elie Cartan Institute in Nancy.

- S. Herrmann was a member of the *Conseil Scientifique* of the INPL University (Institut National Polytechnique de Lorraine).
- P.-E. Jabin organized the Summer School *Modèles Mathématiques de la dynamique des populations* in Ecole Polytechnique of Tunis, Tunisia.
- P.-E. Jabin gave a Master course in Ecole Polytechnique of Tunis about Bio-Mathematics.
- P.-E. Jabin was coordinator in Nice of the Erasmus Mundus Master Mathmods.
- A. Lejay has coordinated the organizing committee of the *Journées de Probabilités 2011* in Nancy in June 2011 and was also a member of the scientific committee of this conference.
- A. Lejay is one of the three co-editors of the *Séminaire de Probabilités* published yearly in the Lecture Note in Mathematics series by Springer-Verlag [26], http://hal.inria.fr/inria-00541922/en.
- A. Lejay is General Secretary of the *Société des Mathématiques Appliquées et Industrielles* (SMAI).
- A. Lejay is a member of the COMIPERS of INRIA Nancy Grand-Est, since 2011.
- D. Talay served as the Scientific Deputy of INRIA Sophia Antipolis — Méditerrannée.
- D. Talay served as an Associate Editor of: *Stochastic Processes and their Applications*, *ESAIM Probability and Statistics*, *Stochastics and Dynamics*, *SIAM Journal on Numerical Analysis*, *SIAM Journal in Financial Mathematics*, *Journal of Scientific Computing*, *Monte Carlo Methods and Applications*, *Oxford IMA Journal of Numerical Analysis*, *Communications in Applied Mathematics and Computational Science*, *Stochastic Environmental Research and Risk Assessment*, *Éditions de l'École Polytechnique*. He also served as the Co-editor in chief of *MathematicS in Action*.
- D. Talay is serving as a member of the Advisory Board of the Centro de Mathematica da Universidade do Porto (Portugal).
- D. Talay served as a member of the Scientific Committee of the 11th Colloque Franco–Roumain.
- D. Talay reported on Émmanuelle Clément's 'Habilitation à Diriger des Recherches' (Paris–Est University) and on several Ph.D. theses: Julia Charrier (University of Rennes I), Laurent Mertz (Paris 6 University), Xiaolu Tan (École Polytechnique), Denis Villemonais (École Polytechnique). He participated to other Ph.D. committees: Paul Gassiat (Paris 7 University), Julie Troyen (Paris–Est University).
- D. Talay participated to a junior position recruitment committee at Paris Dauphine University.

9.2. Teaching

Master: *Continuous Probabilistic Models with Applications in Finance*, 30h, M2 IMAFA (*Informatique et Mathématiques Appliquées à la Finance et à l'Assurance*), Ecole Polytechnique Universitaire, Univ. Nice – Sophia Antipolis, France (Mireille Bossy).

Master: *Risk management on energetic financial markets*, 9h, Master *Ingénierie et Gestion de l'Energie*, École des Mines de Paris) at Sophia-Antipolis, France (Mireille Bossy).

Master: *Stochastic Particle Methods*, 12h, M2 *Probabilités et Modèles Aléatoires* at Université Paris 6, France (Mireille Bossy).

Master: *Introduction to Quantitative Finance*, 9h, M1, Ecole des Mines de Nancy, France (Nicolas Champagnat).

Master: *Introduction to Quantitative Finance*, 18h, M1, ICN Business School Nancy-Metz, France (Nicolas Champagnat).

Master: *Introduction to Quantitative Finance*, 9h, M2, Ecole des Mines de Nancy, France (Nicolas Champagnat).

Master: *Population Genetics and Random Genealogies*, 30h, M2, Univ. Henri Poincaré, France (Nicolas Champagnat).

Licence: *Evaluation des méthodes d'analyse appliquées aux sciences de la vie et de la santé*, 27h, L1, Univ. Henri Poincaré, France (Paul Charton)

Licence: *Outils théoriques : probabilités statistiques*, 37h, L3, Univ. Henri Poincaré, France (Paul Charton)

Licence: Colles de mathématiques , 24h, L1, Univ. Henri Poincaré, France (Paul Charton)

Master: *Stochastic modeling*, 30h, M2, Université Henri Poincaré, France (Madalina Deaconu).

Master: *Probabilistic methods in simulation*, 30h, M1, Ecole des Mines de Nancy, France (Madalina Deaconu).

Licence: *Statistiques pour la Psychologie*, 50h, L2, Université de Bourgogne (Samuel Herrmann).

Licence: *Analyse*, 25h, L2, Université de Bourgogne (Samuel Herrmann).

Master: *Probabilités pour les mathématiques financières*, 45h, M1, Ecole des Mines de Nancy (Samuel Herrmann).

Master: *Modélisation et prévision*, 30h, M1, Ecole des Mines de Nancy (Samuel Herrmann).

Master: *Numerical methods*, 15h, M2, Université Henri Poincaré, France (Antoine Lejay).

Licence: *Probabilités et Statistiques*, 36 h, L2 MASS, Université de Nice – Sophia Antipolis, France (Nicolas Perrin).

Licence: *Probabilités*, 30 h, L2 BIM, Université de Nice – SophiaAntipolis, France (Nicolas Perrin).

Master: *Stochastic Numerical Methods*, École Polytechnique (up to August, Denis Talay had a part time position of Professor in this elite institution).

Master: *Stochastic Flows*, 12h, M2 *Probabilités et Applications* and M2 *Probabilités et Finance* at Université Paris 6, France (Denis Talay).

Master: *Advanced numerics for Computational Finance*, 40 h, M2, UNSA (Mathmodes Erasmus Mundus), France (Etienne Tanré).

Master: *Numerical Probability in Finance*, 20 h, M2, Ecole PolytechNice (IMAFA), France (Etienne Tanré).

Master: *Numerical Methods in Finance*, two sessions with 18 h, M2, ULB (University Certificates in Financial and Insurance Risk Modelling And Quantitative Methods in Finance), Belgium (Etienne Tanré).

Master: *Continuous Probabilistic Models with Applications in Finance* (exercice classes), 20h, M2 IMAFA (*Informatique et Mathématiques Appliquées à la Finance et à l'Assurance*), Ecole Polytechnique Universitaire, Univ. Nice, France (Laurent Violeau).

PhD in progress: Paul Charton, *Hedging strategies for wind energy prices*, September 2010, Madalina Deaconu and Antoine Lejay.

PhD in progress: Julien Claisse, *Stochastic control of population dynamics*, September 2010, N. Champagnat, D. Talay.

PhD in progress: Dalia Ibrahim, *Mathematical modelling for technical analysis techniques*, November 2009, D. Talay and E. Tanré.

PhD in progress : Geoffrey Nichil, *Provisionnement en assurance non-vie et optimisation du calcul du SCR*, 2011, S. Herrmann and P. Vallois.

PhD in progress: Sebastian Niklitschek-Soto, *Discretized stochastic differential equations related to one-dimensional partial differential equations of parabolic type involving a discontinuous drift coefficient*, September 2010, D. Talay.

PhD in progress: Nicolas Perrin, *Stochastic methods in molecular dynamics*, October 2009, M. Bossy, N. Champagnat, D. Talay.

PhD in progress: Laurent Violeau, *Stochastic Lagrangian Models and Applications to Downscaling in Fluid Dynamics*, October 2010, M. Bossy and A. Rousseau.

9.3. Participation to congresses, conferences, invitations...

- M. Bossy gave talks at the *Séminaire du CMA*, in January at École des Mines de Paris, an invited session talk at ICIAM, Vancouver in July, an invited lecture at the *Forum des jeunes mathematiciens*, at IMT Toulouse.
- N. Champagnat gave a 4h lecture on *Modèles stochastiques individu-centrés en dynamique adaptative et étude du branchement évolutif* at the Summer School and Workshop *Modèles mathématiques de la dynamique des populations* in April at the Ecole Polytechnique of Tunis, Tunisia.
- N. Champagnat gave talks at the *Bio-Mathematics seminar* at Univ. Bordeaux 2 in January, at the *visiting committee of AERES for INRIA Sophia Antipolis – Méditerranée* in February, at the *ANR MANEGE Workshop* at Univ. Paris 6 in February, at the *Seminar of Probability* at Univ. Henri Poincaré in September, and at the *Bio-statistics Seminar* at Univ. Henri Poincaré in November.
- J. Charrier gave seminar talks in Warwick and Poitiers in November.
- J. Claisse gave a talk at the *ANR MANEGE Spring School* in Agay, France in June.
- M. Deaconu was invited to give a talk in the *International Conference on Stochastic Analysis and Applications*, Hammamet, October 10 -15, 2011, Tunisia. M. Deaconu also gave a talk in *The Seventh Congress of Romanian Mathematicians*, June 29 - July 5, 2011, Braşov, Romania, and several talks at the *Institute of Mathematics of the Romanian Academy* in december 2011.
- S. Herrmann gave several seminar talks in Dijon, Lyon (ISFA and Institut Camille Jordan), Nancy and gave talks in the *IMPACT-Workshop in honour of Peter Imkeller's 60th birthday* in Berlin, and in the *5th International conference of stochastic analysis and its application* (Bonn, Germany).
- S. Herrmann and E. Tanré participate to the *Workshop on Mean-field methods and multiscale analysis of neuronal populations* at CIRM (Marseille) in October 2011.
- S. Herrmann and E. Tanré gave a 12 hours talk/course during the *Semester on Theoretical, Mathematical and Computational Neuroscience* http://www-sop.inria.fr/manifestations/SemesterCirm/ on *Stochastic models and simulations in neuroscience*.
- D. Ibrahim gave talks at the *Fourth European Summer School in Financial Mathematics* in Zürich, in septembre 2011.
- P.-E. Jabin gave talks at the *SIAM Conference on Analysis of Partial Differential Equations (PD11)*, San Diego, USA, at the *Vlasov Models in Kinetic Theory* Semester Workshop, Brown University, USA, at the Conference on *Continuum and kinetic methods in the theory of shocks, fronts, dislocations and interfaces*, in honor of C. Dafermos, Crete, at the Workshop *Perspectives in Mathematics and Life Sciences* as a part of the school BIOMAT 2011, Granada, Spain, at the *Summer School M3D*, Porquerolles, France, at the *2011 Annual Kinetic FRG Meeting*, Madison, Wisconsin, USA, and at the Conference on *Applied Mathematics from Waves to Fluids*, in honor C. Bardos, Nice.
- N. Perrin gave a talk at the *Mini-symposium on Méthodes numériques en simulation moléculare of the SMAI Congress 2011* in Guidel, France in May.
- D. Talay gave a series of Minerva Foundation Lectures at Columbia University and a seminar at the Courant Institute in September. He also gave an invited lecture at the 6th International Symposium on Backward Stochastic Differential Equations at USC, Los Angeles, in June.
- E. Tanré gave talks at the *Probability Seminar* of Univ. of Nice – Sophia Antipolis in September, and at the *Groupe de travail en mathématiques et neurosciences* at Institut Henri Poincaré, Paris, in January.

9.3.1. Invitations

- M. Deaconu was invited one week by Lucian Beznea at the *Institute of Mathematics of the Romanian Academy* in december 2011.
- S. Herrmann was invited one week in Bielefeld university, Germany.
- P.-E. Jabin spent 3 weeks at the University of Crete, Greece.
- D. Talay spent two weeks at Columbia University.

10. Bibliography

Major publications by the team in recent years

[1] C. BLANCHET-SCALLIET, A. DIOP, R. GIBSON, D. TALAY, E. TANRÉ. *Technical analysis compared to mathematical models based methods under parameters mis-specification*, in "Journal of Banking and Finance", 2007, vol. 31, n^{o} 5, p. 1351–1373.

[2] M. BOSSY, E. GOBET, D. TALAY. *A symmetrized Euler scheme for an efficient approximation of reflected diffusions*, in "J. Appl. Probab.", 2004, vol. 41, n^{o} 3, p. 877–889.

[3] M. BOSSY, B. JOURDAIN. *Rate of convergence of a particle method for the solution of a 1D viscous scalar conservation law in a bounded interval*, in "Ann. Probab.", 2002, vol. 30, n^{o} 4, p. 1797–1832.

[4] N. CHAMPAGNAT. *A microscopic interpretation for adaptive dynamics trait substitution sequence models*, in "Stochastic Process. Appl.", 2006, vol. 116, n^{o} 8, p. 1127–1160.

[5] M. DEACONU, N. FOURNIER, E. TANRÉ. *A pure jump Markov process associated with Smoluchowski's coagulation equation*, in "Ann. Probab.", 2002, vol. 30, n^{o} 4, p. 1763–1796.

[6] S. HERRMANN, P. IMKELLER, D. PEITHMANN. *Transition times and stochastic resonance for multidimensional diffusions with time periodic drift: a large deviations approach*, in "Ann. Appl. Probab.", 2006, vol. 16, n^{o} 4, p. 1851–1892.

[7] A. LEJAY. *An introduction to rough paths*, in "Séminaire de Probabilités XXXVII", Berlin, Lecture Notes in Math., Springer, Berlin, 2003, vol. 1832, p. 1–59.

[8] A. LEJAY, M. MARTINEZ. *A scheme for simulating one-dimensional diffusion processes with discontinuous coefficients*, in "Ann. Appl. Probab.", 2006, vol. 16, n^{o} 1, p. 107–139.

[9] B. ROYNETTE, P. VALLOIS, M. YOR. *Pénalisations et quelques extensions du théorème de Pitman, relatives au mouvement Brownien et à son maximum unilatère*, in "In memoriam Paul-André Meyer: Séminaire de Probabilités XXXIX", Berlin, Lecture Notes in Math., Springer, Berlin, 2006, vol. 1874, p. 305–336.

[10] D. TALAY, Z. ZHENG. *Approximation of quantiles of components of diffusion processes*, in "Stochastic Process. Appl.", 2004, vol. 109, n^{o} 1, p. 23–46.

Publications of the year

Articles in International Peer-Reviewed Journal

[11] M. BOSSY, M. CISSÉ, D. TALAY. *Stochastic representations of derivatives of solutions of one-dimensional parabolic variational inequalities with Neumann boundary conditions*, in "Annales de l'Institut Henri Poincaré - Probabilités et Statistiques", April 2011, vol. 47, n° 2, p. 395-424 [*DOI :* 10.1214/10-AIHP357], http://hal.inria.fr/inria-00579341/en.

[12] M. BOSSY, J.-F. JABIR. *On confined McKean Langevin processes satisfying the mean no-permeability boundary condition*, in "Stochastic Processes and their Applications", 2011 [*DOI :* 10.1016/J.SPA.2011.07.006], http://hal.inria.fr/inria-00559072/en.

[13] J. CALVO, P.-E. JABIN. *Large time asymptotics for a modified coagulation model*, in "Journal of Differential Equations", 2011, vol. 250, n° 6, p. 2807-2837 [*DOI :* 10.1016/J.JDE.2011.01.021], http://hal.inria.fr/hal-00601969/en.

[14] N. CHAMPAGNAT, P.-E. JABIN. *The evolutionary limit for models of populations interacting competitively via several resources*, in "Journal of Differential Equations", July 2011, vol. 251, n° 1, p. 179-195 [*DOI :* 10.1016/J.JDE.2011.03.007], http://hal.inria.fr/inria-00488979/en.

[15] N. CHAMPAGNAT, A. LAMBERT. *Splitting trees with neutral Poissonian mutations I: Small families*, in "Stochastic Processes and their Applications", 2011 [*DOI :* 10.1016/J.SPA.2011.11.002], http://hal.inria.fr/inria-00515481/en.

[16] N. CHAMPAGNAT, S. MÉLÉARD. *Polymorphic evolution sequence and evolutionary branching*, in "Probability Theory and Related Fields", 2011, vol. 151, n° 1-2, p. 45-94 [*DOI :* 10.1007/S00440-010-0292-9], http://hal.inria.fr/inria-00345399/en.

[17] M. CISSÉ, P. PATIE, E. TANRÉ. *Optimal stopping problems for some Markov processes*, in "Annals of Applied Probability", 2011, http://hal.inria.fr/inria-00458901/en.

[18] P.-E. JABIN, A. NOURI. *Analytic solutions to a strongly nonlinear Vlasov equation*, in "Comptes Rendus de l'Académie des Sciences – Series I – Mathematics", 2011, vol. 349, n° 9–10, p. 541–546, http://dx.doi.org/10.1016/j.crma.2011.03.024.

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[20] A. LEJAY. *Simulation of a stochastic process in a discontinuous layered media*, in "Electronic Communications in Probability", November 2011, vol. 16, p. 764-774, http://hal.inria.fr/inria-00583127/en.

[21] S. MAIRE, C. PRISSETTE. *A restarted estimation of distribution algorithm for solving Sudoku puzzles*, in "Statistics and Computing", 2012, http://hal.inria.fr/inria-00591852/en.

International Conferences with Proceedings

[22] J. ERHEL, A. LEJAY, G. PICHOT. *Comparison of some lagrangian schemes for the simulation of diffusion in discontinuous media*, in "MAMERN11: 4th International Conference on Approximation Methods and

Numerical Modelling in Environment and Natural Resources", B. AMAZIANE, D. BARRERA, H. MRAOUI, M. RODRIGUEZ, D. SBIBIH (editors), May 2011, p. 319-322, http://hal.inria.fr/hal-00642194/en.

Conferences without Proceedings

[23] M. BOSSY, R. CARMONA, N. MAÏZI, O. POURTALLIER. *Carbon Allowances and Electricity Prices: a Game-theory Approach*, in "7th International Congress on Industrial and Applied Mathematics - ICIAM 2011", Vancouver, Canada, 2011, http://hal.inria.fr/hal-00645038/en.

[24] M. BOSSY, D. EL HADJ ALI, N. MAÏZI, O. POURTALLIER. *Indifference prices for carbon emission allowances. The European carbon market context*, in "7th International Congress on Industrial and Applied Mathematics - ICIAM 2011", Vancouver, Canada, 2011, http://hal.inria.fr/hal-00645033/en.

Scientific Books (or Scientific Book chapters)

[25] C. GRAHAM, D. TALAY. *Simulation stochastique et méthodes de Monte-Carlo*, Les Éditions de l'École Polytechnique, 2011, ISBN : 978-2-7302-1582-4, http://hal.inria.fr/hal-00602795/en.

Books or Proceedings Editing

[26] C. DONATI-MARTIN, A. LEJAY, A. ROUAULT (editors). *Séminaire de Probabilités XLIII*, Lecture Notes in Mathematics, Springer-Verlag, 2011, vol. 2006 [*DOI :* 10.1007/978-3-642-15217-7], http://hal.inria.fr/inria-00541922/en.

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