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2025 *Activity Report*

RESEARCH CENTRE: **Inria Centre at Rennes University**

IN PARTNERSHIP WITH: **Université de Rennes**

Project-Team

SIMSMART

SIMulating Stochastic Models with pARTicles

In collaboration with Institut de recherche mathématique de Rennes (IRMAR)

Project-Team SIMSMART

Creation of the Project-Team: 2019 January 01

Each year, Inria research teams publish an Activity Report presenting their work and results over the reporting period. These reports follow a common structure, with some optional sections depending on the specific team. They typically begin by outlining the overall objectives and research programme, including the main research themes, goals, and methodological approaches. They also describe the application domains targeted by the team, highlighting the scientific or societal contexts in which their work is situated. The reports then present the highlights of the year, covering major scientific achievements, software developments, or teaching contributions. When relevant, they include sections on software, platforms, and open data, detailing the tools developed and how they are shared. A substantial part is dedicated to new results, where scientific contributions are described in detail, often with subsections specifying participants and associated keywords. Finally, the Activity Report addresses funding, contracts, partnerships, and collaborations at various levels, from industrial agreements to international cooperations. It also covers dissemination and teaching activities, such as participation in scientific events, outreach, and supervision. The document concludes with a presentation of scientific production, including major publications and those produced during the year.

Keywords

Computer sciences and digital sciences

A6. – Modeling, simulation and control

A6.1. – Methods in mathematical modeling

A6.1.1. – Continuous Modeling (PDE, ODE)

A6.1.2. – Stochastic Modeling

A6.1.4. – Multiscale modeling

A6.2. – Scientific computing, Numerical Analysis & Optimization

A6.2.1. – Numerical analysis of PDE and ODE

A6.2.2. – Numerical probability

A6.2.3. – Probabilistic methods

A6.2.4. – Statistical methods

A6.2.5. – Numerical Linear Algebra

A6.2.6. – Optimization

A6.3. – Computation-data interaction

A6.3.1. – Inverse problems

A6.3.2. – Data assimilation

A6.3.4. – Model reduction

A6.3.5. – Uncertainty Quantification

A6.5. – Mathematical modeling for physical sciences

A6.5.2. – Fluid mechanics

A6.5.3. – Transport

A6.5.5. – Chemistry

Other research topics and application domains

B1. – Life sciences

B2. – Digital health

B3. – Environment and planet

B3.2. – Climate and meteorology

B4. – Energy

B4.2. – Nuclear Energy Production

B4.2.1. – Fission

B5.3. – Nanotechnology

B5.5. – Materials

Contents

1 Team members, visitors, external collaborators

Research Scientists

- Mathias Rousset [Team leader, INRIA, Researcher, HDR]
- Frederic Cerou [INRIA, Researcher]
- Patrick Heas [INRIA, Researcher]
- Mouad Ramil [INRIA, Researcher]

Faculty Member

- Valérie Monbet [UNIV RENNES, Professor, HDR]

PhD Student

- Victor Bertret [CIFRE, PureControl]

Administrative Assistant

- Gunther Tessier [INRIA]

2 Overall objectives

As the constant surge of computational power is nurturing scientists into simulating the most detailed features of reality, from complex molecular systems to climate or weather forecast, the computer simulation of physical systems is becoming reliant on highly complex stochastic dynamical models and very abundant observational data. The complexity of such models and of the associated observational data stems from intrinsic physical features, which do include high dimensionality as well as intricate temporal and spatial multi-scales. It also results in much less control over simulation uncertainty.

Within this highly challenging context, SIMSMART positions itself as a mathematical and computational probability and statistics research team, dedicated to *Monte Carlo simulation* methods. Such methods include in particular particle Monte Carlo methods for rare event simulation, data assimilation and model reduction, with application to stochastic random dynamical physical models. The main objective of SIMSMART is to disrupt this now classical field by creating deeper mathematical frameworks adapted to the management of contemporary highly sophisticated physical models.

3 Research program

Introduction. Computer simulation of physical systems is becoming increasingly reliant on highly complex models, as the constant surge of computational power is nurturing scientists into simulating the most detailed features of reality – from complex molecular systems to climate/weather forecast.

Yet, when modeling physical reality, bottom-up approaches are stumbling over intrinsic difficulties. First, the timescale separation between the fastest simulated microscopic features, and the macroscopic effective slow behavior becomes huge, implying that the fully detailed and direct long time simulation of many interesting systems (*e.g.* large molecular systems) are out of reasonable computational reach. Second, the chaotic dynamical behaviors of the systems at stake, coupled with such multi-scale structures, exacerbate the intricate uncertainty of outcomes, which become highly dependent on intrinsic chaos, uncontrolled modeling, as well as numerical discretization. Finally, the massive increase of observational data addresses new challenges to classical data assimilation, such as dealing with high dimensional observations and/or extremely long time series of observations.

SIMSMART Identity. Within this highly challenging applicative context, SIMSMART positions itself as a computational probability and statistics research team, with a mathematical perspective. Our approach is based on the use of *stochastic modeling* of complex physical systems, and on the use of *Monte Carlo simulation* methods, with a strong emphasis on dynamical models. The two main numerical tasks of interest to SIMSMART are the following: (i) simulating with pseudo-random number generators - a.k.a. *sampling* - dynamical models of random physical systems, (ii) sampling such random physical dynamical models given some real observations - a.k.a. *Bayesian data assimilation*. SIMSMART aims at providing an appropriate mathematical level of abstraction and generalization to a wide variety of Monte Carlo simulation algorithms in order to propose non-superficial answers to both *methodological and mathematical* challenges. The issues to be resolved include computational complexity reduction, statistical variance reduction, and uncertainty quantification.

SIMSMART Objectives. The main objective of SIMSMART is to disrupt this now classical field of particle Monte Carlo simulation by creating deeper mathematical frameworks adapted to the challenging world of complex (*e.g.* high dimensional and/or multi-scale), and massively observed systems, as described in the beginning of this introduction.

To be more specific, we will classify SIMSMART objectives using the following four intertwined topics:

- Objective 1: Rare events and random simulation.
- Objective 2: High dimensional and advanced particle filtering.
- Objective 3: Non-parametric approaches.
- Objective 4: Model reduction and sparsity.

Rare events (Objective 1) are ubiquitous in random simulation, either to accelerate the occurrence of physically relevant random slow phenomenons, or to estimate the effect of uncertain variables. Objective 1 will be mainly concerned with particle methods where *splitting* is used to enforce the occurrence of rare events.

The problem of high dimensional observations, the main topic in Objective 2, is a known bottleneck in filtering, especially in non-linear particle filtering, where linear data assimilation methods remain the state-of-the-art approaches.

The increasing size of recorded observational data and the increasing complexity of models also suggest to devote more effort into non-parametric data assimilation methods, the main issue of Objective 3.

In some contexts, for instance when one wants to compare solutions of a complex (*e.g.* high dimensional) dynamical systems depending on uncertain parameters, the construction of relevant reduced-order models becomes a key topic. Model reduction aims at proposing efficient algorithmic procedures for the resolution (to some reasonable accuracy) of high-dimensional systems of parametric equations. This overall objective entails many different subtasks: 1) the identification of low-dimensional surrogates of the target "solution" manifold, 2) The devise of efficient methodologies of resolution exploiting low-dimensional surrogates, 3) The theoretical validation of the accuracy achievable by the proposed procedures. This is the content of Objective 4.

With respect to volume of research activity, Objective 1, Objective 4 and the sum (Objective 2+Objective 3) are comparable.

Some new challenges in the simulation and data assimilation of random physical dynamical systems have become prominent in the last decade. A first issue (i) consists in the intertwined problems of simulating on large, macroscopic random times, and simulating *rare events* (see Objective 1). The link between both aspects stems from the fact that many effective, large times dynamics can be approximated by sequences of rare events. A second, obvious, issue (ii) consists in managing *very abundant observational data* (see Objective 2 and 3). A third issue (iii) consists in quantifying *uncertainty/sensitivity/variance* of outcomes with respect to models or noise. A fourth issue (iv) consists in managing *high dimensionality*, either when dealing with complex prior physical models, or with very large data sets. The related increase of complexity also requires, as a fifth issue (v), the construction of *reduced models* to speed-up comparative simulations (see Objective 4). In a context of very abundant data, this may be replaced by a sixth issue (vi) where complexity constraints on modeling is replaced by the use of *non-parametric statistical inference* (see Objective 3).

Hindsight suggests that all the latter challenges are related. Indeed, the contemporary digital condition, made of a massive increase in computational power and in available data, is resulting in a demand for more complex and uncertain models, for more extreme regimes, and for using inductive approaches relying on abundant data. In particular, uncertainty quantification (item (iii)) and high dimensionality (item (iv)) are in fact present in all 4 Objectives considered in SimSmart.

4 Application domains

4.1 Domain 1 – Computational Physics

The development of large-scale computing facilities has enabled simulations of systems at the *atomistic scale* on a daily basis. The aim of these simulations is to bridge the time and space scales between the macroscopic properties of matter and the stochastic atomistic description. Typically, such simulations are based on the ordinary differential equations of classical mechanics supplemented with a random perturbation modeling temperature, or collisions between particles.

Let us give a few examples. In bio-chemistry, such simulations are key to predict the influence of a ligand on the behavior of a protein, with applications to drug design. The computer can thus be used as a *numerical microscope* in order to access data that would be very difficult and costly to obtain experimentally. In that case, a rare event (Objective 1) is given by a macroscopic system change such as a conformation change of the protein. In nuclear safety, such simulations are key to predict the transport of neutrons in nuclear plants, with application to assessing aging of concrete. In that case, a rare event is given by a high energy neutron impacting concrete containment structures.

A typical model used in molecular dynamics simulation of open systems at given temperature is a stochastic differential equation of Langevin type. The large time behavior of such systems is typically characterized by a hopping dynamics between 'metastable' configurations, usually defined by local minima of a potential energy. In order to bridge the time and space scales between the atomistic level and the macroscopic level, specific algorithms enforcing the realization of rare events have been developed. For instance, splitting particle methods (Objective 1) have become popular within the computational physics community only within the last few years, partially as a consequence of interactions between physicists and Inria mathematicians in ASPI (parent of SIMSMART) and MATHERIALS project-teams.

SIMSMART also focuses on various models described by partial differential equations (reaction-diffusion, conservation laws), with unknown parameters modeled by random variables.

4.2 Domain 2 – Meteorology

The traditional trend in data assimilation in geophysical sciences (climate, meteorology) is to use as prior information some very complex deterministic models formulated in terms of fluid dynamics and reflecting as much as possible the underlying physical phenomenon (see *e.g.*). Weather/climate forecasting can then be recast in terms of a Bayesian filtering problem (see Objective 2) using weather observations collected *in situ*.

The main issue is therefore to perform such Bayesian estimations with very expensive infinite dimensional prior models, and observations in large dimension. The use of some linear assumption in prior models (Kalman filtering) to filter non-linear hydrodynamical phenomena is the state-of-the-art approach, and a current field of research, but is plagued with intractable instabilities.

This context motivates two research trends: (i) the introduction of non-parametric, model-free prior dynamics constructed from a large amount of past, recorded real weather data; and (ii) the development of appropriate non-linear filtering approaches (Objective 2 and Objective 3).

SIMSMART will also test its new methods on multi-source data collected in North-Atlantic paying particular attention to coastal areas (*e.g.* within the inter-Labex SEACS).

4.3 Other Applicative Domains

SIMSMART also focuses on other applications including:

- Tracking and hidden Markov models.
- Robustness and certification in Machine Learning.

5 Social and environmental responsibility

5.1 Footprint of research activities

Members of SIMSMART have avoided air traveling, with the notable exception of rare international conferences with publications for PhD students (this year Theo Guyard) which are considered important for their academic future.

6 Latest software developments, platforms, open data

6.1 Latest software developments

6.1.1 Screening4L0Problem

Keywords: Global optimization, Sparsity

Functional Description: This software contains "Branch and bound" optimization routines exploiting "screening" acceleration rules for solving sparse representation problems involving the L0 pseudo-norm.

URL: https://gitlab.insa-rennes.fr/Theo.Guyard/bnb-screening

Publication: hal-03462171

Contact: Cedric Herzet

Participants: Clément Elvira, Theo Guyard, Cedric Herzet

6.1.2 Screen&Relax

Keywords: Optimization, Sparsity

Functional Description: This software provides optimization routines to efficiently solve the "ElasticNet" problem.

URL: https://gitlab.insa-rennes.fr/Theo.Guyard/screen-and-relax

Publication: hal-03462191

Contact: Cedric Herzet

Participants: Clément Elvira, Theo Guyard, Cedric Herzet

6.1.3 npSEM

Name: Stochastic expectation-maximization algorithm for non-parametric state-space models

Keyword: Statistic analysis

Functional Description: npSEM is the combination of a non-parametric estimate of the dynamic using local linear regression (LLR), a conditional particle smoother and a stochastic Expectation-Maximization (SEM) algorithm. Further details of its construction and implementation are introduced in the article An algorithm for non-parametric estimation in state-space models of authors "T.T.T. Chau, P. Ailliot, V. Monbet", https://doi.org/10.1016/j.csda.2020.107062.

URL: https://github.com/tchau218/npSEM

Contact: Thi Tuyet Trang Chau

Participants: Valérie Monbet, Thi Tuyet Trang Chau

6.1.4 NHMSAR

Name: Non-Homogeneous Markov Switching Autoregressive Models

Keyword: Statistical learning

Functional Description: Calibration, simulation, validation of (non-)homogeneous Markov switching autoregressive models with Gaussian or von Mises innovations. Penalization methods are implemented for Markov Switching Vector Autoregressive Models of order 1 only. Most functions of the package handle missing values.

URL: https://CRAN.R-project.org/package=NHMSAR

Contact: Valérie Monbet

Participant: Valérie Monbet

6.1.5 3D Winds Fields Profiles

Keyword: Motion estimation

Functional Description: The algorithm computes 3D Atmospheric Motion Vectors (AMVs) vertical profiles, using incomplete maps of humidity, temperature and ozone concentration observed in a range of isobaric levels. The code is implemented for operational use with the Infrared Atmospheric Sounding Interferometer (IASI) carried on the MetOp satellite.

URL: https://www.esa.int/Applications/Observing_the_Earth/Meteorological_missions/MetOp/About_IASI

Contact: Patrick Heas

Participant: Patrick Heas

6.1.6 Screening4SLOPE

Keyword: Optimization

Functional Description: This software provides optimization routines to solve the SLOPE problem by exploiting "safe screening" reduction techniques.

URL: https://gitlab-research.centralesupelec.fr/2020elvirac/slope-screening

Publication: hal-03400322

Contact: Cedric Herzet

Participants: Clément Elvira, Cedric Herzet

7 New results

7.1 Objective 1 – Monte Carlo simulation and Stochastic analysis

Monte-Carlo simulation

Participants: Frédéric Cérou, Patrick Héas, Mathias Rousset, Mouad Ramil.

In [2], we proposed a new rare event sampling methodology in a context where evaluations of the score function defining the rare event is amenable to reduced modeling with pointwise error bounds. The novelty is the use of an Importance Sampling cost criteria that automatically choose the level at which costly evaluation of the true model are performed.

In [3], we extend the previous methodology to target distributions that include Bayesian posteriors. Methodological improvements and application to uncertainty quantification are discussed.

In [6], Eyring-Kramers law for mean exit times of stochastic dynamics is extended to kinetic Langevin processes.

7.2 Objective 2 and 3 – Data assimilation and statistics

Participants: Patrick Héas, Valérie Monbet.

In [1] and in [5], we address the intricate challenge of reconciling environmental sustainability with economic viability within wastewater treatment plants (WWTPs). This study compares various modeling approaches to predict ammonium concentration in WWTPs, with a focus on integrating data assimilation techniques. It explores white-box, grey-box, and black-box models, evaluating their ability to capture the complex dynamics of WWTPs and manage uncertainties associated with limited data and sensor noise. The article highlights the importance of data assimilation for simultaneously calibrating model parameters, latent variables (such as unmeasured species concentrations), and quantifying prediction uncertainty. Simulation results demonstrate that the non-parametric black box model outperforms all other models in terms of predictive accuracy and uncertainty estimation.

7.3 Objective 4 – Model Reduction and Sparsity

Participants: Patrick Héas, Théo Guyard.

Reduced modeling of a computationally demanding dynamical system aims at approximating its trajectories, while optimizing the trade-off between accuracy and computational complexity. In [4], , we propose to achieve such an approximation by first embedding the trajectories in a reproducing kernel Hilbert space (RKHS), which has interesting approximation and calculation capabilities, and then solving the associated reduced model problem. More specifically, we propose a new efficient algorithm for data-driven reduced modeling of nonlinear dynamics based on linear approximations in a RKHS. This algorithm takes advantage of the closed-form solution of a low-rank constraint optimization problem while exploiting advantageously kernel-based computations. Reduced modeling with this algorithm reveals a gain in approximation accuracy, as shown by numerical simulations, and in complexity with respect to existing approaches.

8 Bilateral contracts and grants with industry

8.1 Bilateral contracts with industry

8.1.1 CIFRE grants

Participants: Valérie Monbet.

PhD project of Victor Bertret: *AI and stochastic control for automatic optimal driving of industrial systems* with company Purecontrol.

8.1.2 Meteorological Satellite Data Processing

Participants: Patrick Héas.

Industrial Partner: EUMETSAT of Darmstadt.

Partner Contact: `Regis.Borde@eumetsat.int`

The transferred technology concerns an algorithm for the operational and real-time production of vertically resolved 3D atmospheric motion vector fields (AMVs) from measurements of new hyperspectral instruments: the infrared radiosounders on the third generation Meteosat satellites (MTG), developed by the European Space Agency (ESA) and the Infrared Atmospheric Sounding Interferometer (IASI) on MetOp-A and MetOp-B developed by the French Space Agency (CNES).

9 Partnerships and cooperations

9.1 National initiatives

9.1.1 ANR

ANR SINEQ (2021-2025).

Participants: Mathias Rousset, Frédéric Cérou.

Simulating non-equilibrium stochastic dynamics. The goal of the SINEQ project is, within a mathematical perspective, to extend various variance reduction techniques used in the Monte Carlo computation of equilibrium properties of statistical physics models.

The partners involved in the project are: CERMICS (PI: G. Stoltz), CEREMADE and Inria Rennes.

ANR DySLos (2026-2030)

Participants: Mouad Ramil.

Dynamique en temps long de systèmes stochastiques. The goal of the project is to develop tools from PDEs and potential theory to study the exit times of stochastic dynamics from metastable states (Eyring-Kramers law).

9.1.2 PEPR

Projet "PaRticules En interaction dédiées aux DynamIques ChaoTiques : un besoin pour la simulation d'évènements climatiques extrêmes (PREDICT)".

Participants: Mathias Rousset, Frédéric Cérou, Patrick Héas.

The goal of the present project is to stimulate interactions between i) physicists (Francesco Ragone, Univ. Louvain and J. Wouters, Univ. Reading) who have led recent works on numerical simulations of climate rare events, and ii) mathematicians and scientific computing experts (Mathias Rousset, Patrick Héas and Fred Cérou, IRMAR and Inria Univ Rennes) who have developped methodologies and the mathematical analysis of similar rare event Monte Carlo algorithms. The project will be led by Mathias ROUSSET (IRMAR and Inria, Rennes) and Francesco Ragone (Louvain, Belgium).

Financement (7.5 kEuros) Institut des Mathématiques pour la planète Terre IMPT. PI: Mathias Rousset et Francesco Ragone.

10 Dissemination

10.1 Promoting scientific activities

10.1.1 Scientific events: organisation

Participants: Frédéric Cérou, Patrick Héas, Mathias Rousset.

Complete organization of the workshop "Evènements rares et réduction de modèles", Paris, 27 mars 2025 supported by the Groupement de Recherche Information Apprentissage Signal Image VIsion (GdR IASIS) and the Research network on Uncertainty Quantification (RT UQ).

Reviewer - reviewing activities

Participants: Frédéric Cérou, Patrick Héas, Mathias Rousset, Valérie Monbet.

Many journals in Probability, Statistics, Applied Mathematics ... (SIAMs, AAP, JCompPhys, StatComp, ...)

10.1.2 Invited talks

Non-exhaustive list :

Participants: Mathias Rousset.

- GdR IaSIS, RT UQ, Paris, march 2025.
- Séminaire de Probabilité, Toulouse, December 2025.

Participants: Mathias Rousset, Mouad Ramil.

- "SINEQ final conference", Gran Sasso Science Institute (L'Aquila), Italy, October 2025.
- Workshop "QSD and Related Fields", Ecole des Ponts (Marne-la-Vallée), France, May 2025.

Participants: Mouad Ramil.

- "New trends and applications around generalized Fokker-Planck operators", Bernoulli center (Lausanne), Switzerland, July 2025.
- 12ème Biennale de la SMAI, VTF Carcans (Bordeaux), France, June 2025.
- Conference "CY Days in Nonlinear Analysis", Maison internationale de la Recherche (Cergy), France, May 2025.

10.1.3 Leadership within the scientific community

Participants: Valérie Monbet.

- Directrice de l'Agence Lebesgue

10.1.4 Scientific expertise (Hiring Committees for permanent positions)

Participants: Valérie Monbet.

- Chaire de Professeur Junior, Ecobio, Univ Rennes

Participants: Mathias Rousset.

- CRCN and ISFP positions Inria Univ Rennes

10.1.5 Research administration

Participants: Valérie Monbet.

- Membre du bureau d'AMIES
- Membre du bureau de la commission recherche de l'Université de Rennes

10.2 Teaching - Supervision - Juries - Educational and pedagogical outreach

10.2.1 Teaching

Participants: Patrick Héas.

A course on "Statistique Mathématique", travaux dirigés, parcours mathématiques fondamentales, Master 1-ère année, université de Rennes (24 h équivalent TD).

Participants: Mathias Rousset.

- A Python course for probability and statistics in Master 1 cryptography, univ Rennes (8h eqTD) .
- A course on "Large Deviations Theory", Master 2 Maths, université de Rennes (32 h équivalent TD).
- Responsible of the preparation of "modélisation option proba stat, Agrégation" .
- Preparation of "modélisation option proba stat, Agrégation" (12h eqTD) .

10.2.2 Supervision (Master Level)

Participants: Mathias Rousset.

- Arthur Carette, ENS Lyon, "Limits of Mean-field particle models and Hewitt-Savage theorems".

10.2.3 Supervision (PhDs)

Participants: Valérie Monbet.

- V. Bertret, thèse CIFRE PureControl, Controle optimal stochastique pour les installations industrielles, en coencadrement avec R. Le Goff-Latimier, SATIE, ENS Rennes - soutenance le 18 dec 2025 .
- D. Martin, thèse IRMAR-DIGISPORT, Performances sportives et microbiote intestinal, coencadrement F. Derbre, M2S, Univ Rennes 2 - soutenance juin 2025 .

10.2.4 Supervision (Post-Docs)

Participants: Valérie Monbet.

- M'Hammed Oudrane, postdoc passerelle, AMIES, 10 mois. Recruté à TopSolid (poste à l'interface de la géométrie différentielle et de l'IA); un article soumis.

10.2.5 PhD Juries

- Shokoufa Zeinali, mid-PhD, Lund University, Sweden, opponent
- Emma Thuiliez, PhD, INSA Rouen, présidente

10.2.6 PhD reviewing

Participants: Valérie Monbet.

- Camille Cadiou ("Une approche statistique pour l'étude de l'intensité et de la dynamique des vagues de froid extrêmes en Europe"), PhD, Paris Saclay, rapportrice

Participants: Mathias Rousset.

- Jason Beh ("Échantillonnage préférentiel adaptatif en grande dimension pour l'estimation de probabilité d'évènements rares : analyse théorique et développements numériques"), PhD, Univ Toulouse, rapporteur

11 Scientific production

11.1 Publications of the year

International journals

[1] V. Bertret, R. L. G. Latimier and V. Monbet. ‘Data assimilation for prediction of ammonium in wastewater treatment plant: From physical to data driven models’. In: *Water Research* 282 (2025), p. 123673. DOI: 10.1016/j.watres.2025.123673. URL: https://hal.science/hal-05055967 (cit. on p. 10).

[2] F. Cérou, P. Héas and M. Rousset. ‘Adaptive Reduced Multilevel Splitting’. In: *Statistics and Computing* 36.1 (3rd Nov. 2025), p. 13. DOI: 10.1007/s11222-025-10724-5. URL: https://inria.hal.science/hal-04364553 (cit. on p. 10).

[3] F. Cérou, P. Héas and M. Rousset. ‘Adaptive reduced tempering for bayesian inverse problems and rare event simulation’. In: *SIAM/ASA Journal on Uncertainty Quantification* 13.4 (24th Dec. 2025), pp. 2022–2053. DOI: 10.1137/24M170510X. URL: https://inria.hal.science/hal-04764656 (cit. on p. 10).

[4] P. Héas, C. Herzet and B. Combès. ‘Nonlinear Reduced Modeling of Dynamical Systems Using Kernel Methods and Low-Rank Approximation’. In: *Journal of Nonlinear Science* 35.3 (8th Mar. 2025), p. 51. DOI: 10.1007/s00332-025-10149-4. URL: https://hal.science/hal-04354110 (cit. on p. 10).

Conferences without proceedings

[5] V. Bertret, R. Le Goff Latimier and V. Monbet. ‘Analysis of uncertainties in predictive control applied to wastewater treatment plants’. In: ROADEF 2025 - 26ème Congès Annuel de la Société Française de Recherche Opérationnelle et de l’Aide à la Décision. Paris, France, 2025, pp. 1–2. URL: https://hal.science/hal-04985652 (cit. on p. 10).

Reports & preprints

[6] S. Lee, M. Ramil and I. Seo. *Eyring-Kramers Law for the Underdamped Langevin Process*. 16th Mar. 2025. URL: https://hal.science/hal-04994921 (cit. on p. 10).