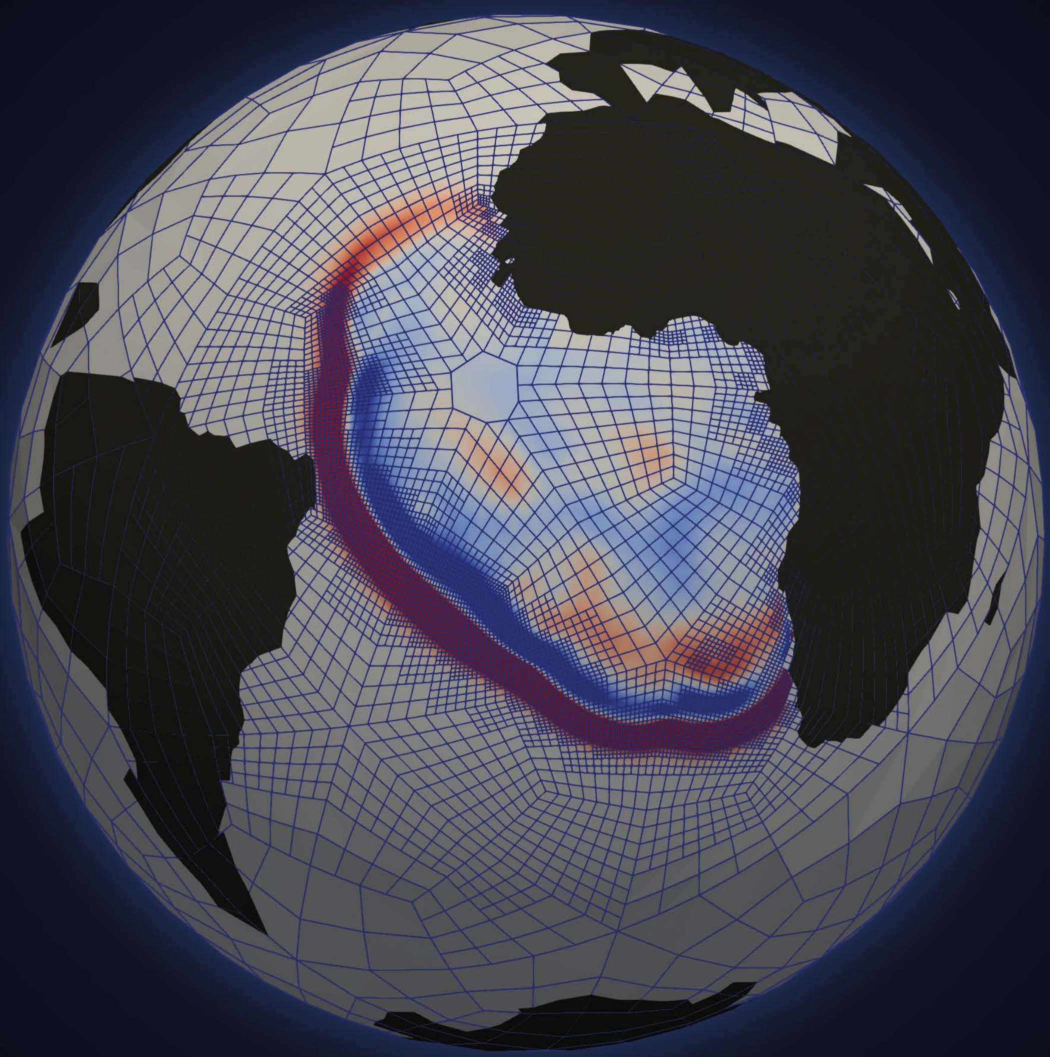
MASTER

APPLIED MATHEMATICS



EPFL

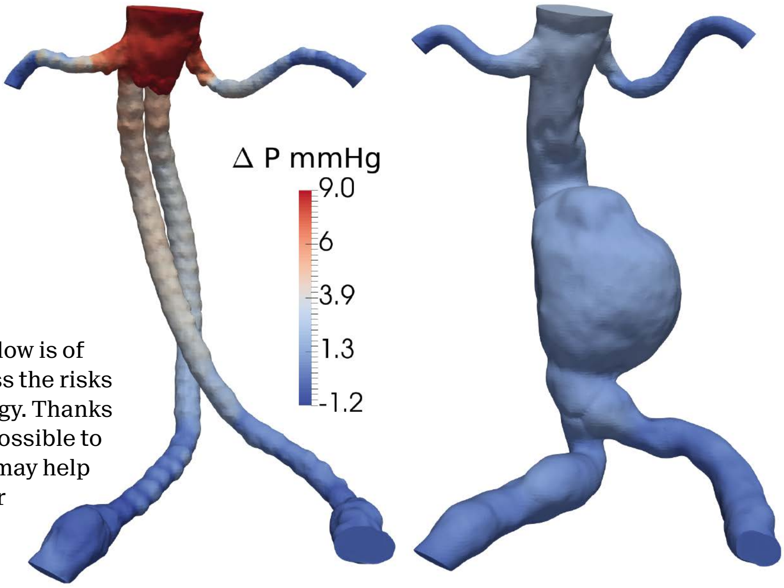
The language of science and the study of practical problems.

Mathematics is one of the oldest fields of human intellectual endeavor. As technology emerges, mathematicians are increasingly involved in practical problem solving.

When studying abstract concepts, applied and pure mathematics are strongly linked. Significant breakthroughs in physical and computational sciences, as well as the data revolution have given rise to a plethora of challenges in the field of applied mathematics. Its applications are varied: statistics for finance and environmental sciences; powerful data compression algorithms for communication systems; simulation of blood flow using numerical methods.

The master in Applied Mathematics provides students with all the advanced skills needed in various fields, such as Statistics, Probability or Scientific Computing.

Cardiovascular simulations



The images shows the drop in presence of an AAA and after surgical intervention with EndoVascular Aneurysm Sealing (EVAS) [Colciago, Deglise, Deparis, Dubuis 2019].

Prof. Deparis

A better understanding of vascular flow is of crucial importance to better assess the risks associated to a specific pathology. Thanks to numerical simulation it is possible to provide flow indices which may help in the decision making for surgery.

For example, in presence of an Abdominal Aortic Aneurism (AAA), the surgeon has to decide upon intervention. Access to patient specific numerical simulations allows to better evaluate the opportunity of an intervention.

From the modeling point of view, the blood flow is described by the Navier-Stokes equations and the arterial wall by specific non-linear elastic laws. The finite element method is a perfect tool to correctly approximate the vascular flows. Mathematics is important to ensure the coupling between fluid and structure, but also to control the accuracy of the simulation. Since the non-linear system involves a huge number of unknowns, it is also necessary to devise parallel algorithms for its resolution.

William Cappelletti: "I chose Mathematics as I felt it is part of many aspects of our life. I wanted to know more about it, as I think in this increasingly connected world, having a strong knowledge in Statistics and Algorithms can open many doors. That's why I am satisfied with my master, not to mention that it gives me the chance to study with amazing people in a stimulating environment."

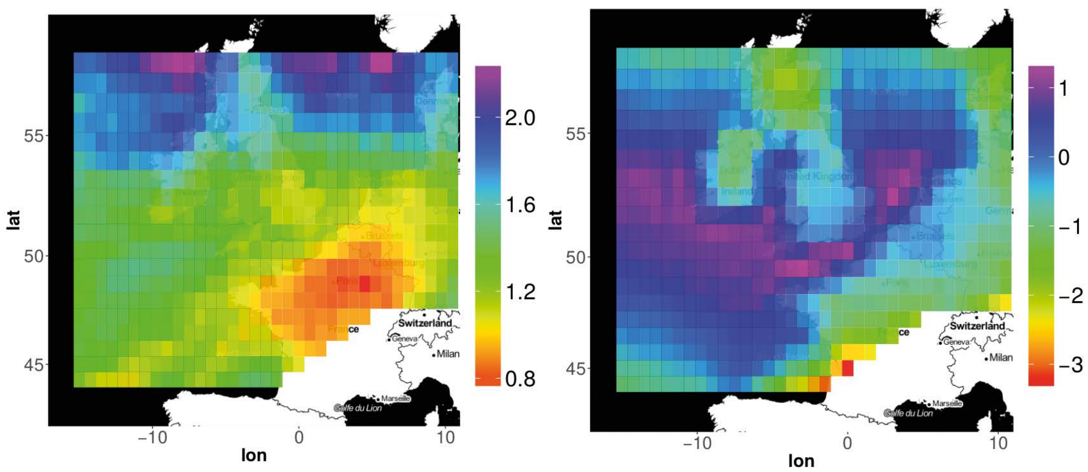
Extreme wind storms

Prof. Davison

Often the risk for human infrastructure or insurance portfolios due to extreme windstorms is based on catalogues of events that are used as `stress tests'. These catalogues usually consist of historical records or are artificially generated by climate models, and can have severe limitations when estimating the risk of events even more severe than those previously seen.

Stochastic weather generators are mathematical models that create random but realistic events which could be used to enlarge or even create catalogues. Extreme value theory describes the statistical behavior of extreme events and provides a mathematical framework to extrapolate above the intensity of historical records. These approaches have been used to develop a generator of extreme European wind storms that can simulate events of unprecedented severity, such as the one shown below. The new methods can be used to understand the impact of climate change on extreme events and thus help to assess the exposure of current infrastructure to climatological risk, as well as helping to plan for the future.

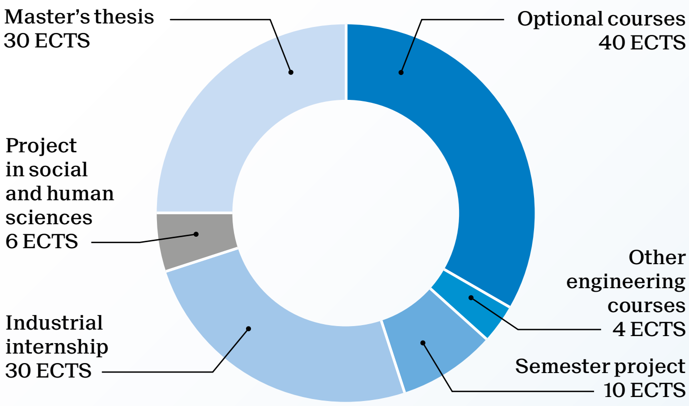
Anne-Sophie Van de Velde: "What I love in mathematics is the rigor found in reasoning. Studies in mathematics enable to develop a critical spirit and to visualize quickly what is superfluous in a proof. In my minor in informatics, I see real-life applications of theoretical concepts that are explained in my mathematical courses. That is fascinating!"



Master of Science in

APPLIED MATHEMATICS

2-year program - 120 ECTS



Students must choose at least 30 ECTS worth of courses labelled A.

Optional courses are classified in the following tracks:

- Algebra and geometry
- Algorithmic and discrete mathematics
- Analysis
- Numerical analysis
- Probability
- Statistics

On top of the Optional courses (40 ECTS) students must choose 4 ECTS in another engineering program, except if they opt for a 30 ECTS engineering minor.
Recommended courses:

- Biological modeling of neural networks
- Biomedical signal processing
- Signal processing for communications
- Statistical signal and data processing through applications
- Applied data analysis
- Algorithms
- Advanced algorithms
- Information theory and coding
- Investments
- Credit risk
- Fixed income analysis
- Quantitative risk management
- Principles of microeconomics
- Relativity and cosmology I
- Relativity and cosmology II

Students opting for a minor in engineering may shorten their industrial internship.

		Credits
Optional courses	A	40
Algebra and Geometry		
Algebraic K-theory		5
Complex manifolds		5
Homotopical algebra		5
Introduction à la géométrie riemannienne		5
Introduction to algebraic geometry		5
Lie groups		5
Linear algebraic groups		5
Modern algebraic geometry		5
Modular forms and applications		5
Number theory in cryptography	A	5
P-adic numbers and applications		5
Representation theory of semisimple Lie algebras		5
Riemann surfaces		5
Topics in algebraic geometry		5
Topics in number theory		5
Algorithmic and discrete mathematics		
Integer optimisation		5
Mathematical modeling of behavior		5
Optimisation on manifolds		5
Analysis		
Analyse fonctionnelle II	A	5
Analysis on groups		5
Calculus of variations		5
Differential geometry of framed curves	A	5
Dispersive PDEs		5
Distribution and interpolation spaces		5
Harmonic analysis		5
Inequalities and trace theory for Sobolev spaces		10
Mathematical modeling of DNA	A	5
Optimal transport		5
Numerical analysis		
Computational finance	A	5
Computational linear algebra	A	5
Low-rank approximation techniques	A	5
Numerical integration of stochastic differential equations		5
Numerical methods for conservation laws	A	5
Numerics for fluids, structures and electromagnetics	A	5
Stochastic simulation	A	5
Probability		
Combinatorial statistics	A	5
Gaussian processes	A	5
Lattice models	A	5
Martingales in financial mathematics	A	5
Probabilistic methods in combinatorics	A	5
Probability theory	A	5
Statistical mechanics and Gibbs measures	A	5
Stochastic simulation	A	5
Théorie du calcul stochastique	A	5
Statistics		
Applied biostatistics	A	5
Bayesian computation	A	5
Biostatistics	A	5
Modern regression methods	A	5
Multivariate statistics	A	5
Risk, rare events and extremes	A	5
Robust and non-parametric statistics	A	5
Spatial statistics	A	5
Statistical analysis of network data	A	5
Statistical genetics	A	5
Statistical machine learning	A	5
Statistical theory	A	5
Statistics for genomic data analysis	A	5
Other courses		
Gödel and recursivity		5
Set theory		5

School of Basic Sciences
go.epfl.ch/master-applied-mathematics
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