The climate challenge
UNDERSTANDING, FIGHTING AND ADAPTING

IMPACT
XXL tech to survey the distant universe

ADDED VALUE
Mercator Ocean: a flagship European company

PROFILE
Ange Nzihou: a catalyst for talent
KEY FIGURES FOR THE UNIVERSITÉ FÉDÉRALE TOULOUSE MIDI-PYRÉNÉES

STUDENTS
110,000 students
29.8% students; 47% male; 53% female

INTERNATIONAL STUDENTS
15,553 international students (representing 12.7% of enrolled students) of which 12.6% registered in exchange programmes

Fraction of students by grade level
- Bachelor degree: 37.7%
- Master degree: 27.7%
- Others: 16%
- PhD: 10.7%
- Engineering school programme: 7.9%

Country breakdown
- Africa: 38.1%
- Asia and the Middle East: 24.4%
- European Union: 21%
- America: 10.6%
- Europe non-EU: 5.8%
- Oceania: 0.2%

RESEARCH
149 research laboratories
15 doctoral schools covering the entire range of disciplines
807 PhD degrees awarded in 2013-2014
2,671 Researchers from Ministry of National Education, Higher Education and Research (representing 5,342 academics) – 2,013 in Public scientific and technological institutions (EPST) – 1,712 in Public industrial and commercial institutions (EPIC) – and 244 others

STAFF
9,311 staff dedicated to teaching and research
6,043 administrative and technical staff

Enrollments per academic year

www.univ-toulouse.fr
In Toulouse, science knows no country

BY MARIE-FRANCE BARTHET
Chancellor of the Université Fédérale Toulouse Midi-Pyrénées

When someone says “Toulouse” to you, you will most likely think of aeronautics. Yet, did you know that the “Pink City” of the south of France is a scientific and technical hub of high international standing? The Nobel Prize for economics awarded in 2014 to Jean Tirole, from the Toulouse School of Economics, is the most recent example of this. All the subject areas are represented within the Université Fédérale de Toulouse, from human and social sciences, archaeology, economics and law, all the way to astrophysics and bio and agrotechnology, including, of course, aeronautics and space.

This umbrella group, the result of the commitment of all its members, brings together 4 universities, 14 grandes écoles and 5 national scientific research-based bodies. All in all, this includes almost 10,000 researchers, 200 laboratories and 110,000 students. Furthermore, scientific research here is valued both on an economic and societal level thanks to our Technology Transfer Acceleration Company (SATT). It is also presented in a plain and easy-to-understand language via various bodies and scientific culture associations. These are all valuable assets that have led to Toulouse being chosen to host the Euroscience Open Forum (ESOF), making it the European capital of science in 2018.

Therefore, it is with this wealth of information and tradition that I invite you to discover, in the English edition of Exploreur, the magazine by the Université Fédérale de Toulouse, which will be published once a year and will include the best articles from our French edition. Through the news, in-depth features and profiles, you will discover scientific projects with a major impact, remarkable work, original personalities, and scientific culture initiatives, including most certainly our numerous international collaborations.

To successfully complete this awareness raising endeavour, our federal character is an asset. It gives us appeal and visibility and allows us to carry out multidisciplinary scientific projects. As a clear sign of recognition, in 2012 we obtained the IDEX (Excellence Initiative) certification from the French State, which has allowed us to set up and finance various research and education schemes.

In particular, every year in Toulouse, we open up chairs to foreign researchers. Internationally, we already have 3 branches in Brazil, China and Indonesia, as well as the Maison universitaire Franco-Mexicaine for the whole of France.

We hope that Exploreur will make you want to find out more and maybe even initiate such collaborations. Researchers and professors from Toulouse posted abroad or on a temporary placement are, undoubtedly, the best ambassadors for this magazine and our federal university. Why not subscribe for free to the English and French versions? More info on www.univ-toulouse.fr/Exploreur

I hope you enjoy reading our magazine.
There are only good reasons to do your PhD in Toulouse!

Toulouse, the best place to study in France

The École des doctorats of the Université Fédérale Toulouse Midi-Pyrénées is the federation of 15 doctoral schools, representing a total of 4,500 PhD students (40% international students), with 850 PhD awarded per year. It covers all scientific domains and it is located in the Midi-Pyrénées region. The École des doctorats offers language classes (French as foreign language, English...) and a wide range of non-disciplinary training programmes adapted to the PhD students’ needs. It has a unique dedicated PhD International Office, providing information, advice and support for PhD candidates. More information: phd-international@univ-toulouse.fr
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How were the first galaxies born, how did they grow and what about the mysterious black holes they harbour in their centres? How did these galaxies combine into gigantic clusters, therefore giving the Universe its structure? These two enigmas are at the heart of astrophysics research. To attempt to solve them, the design of the X-IFU (X-ray Integral Field Unit) instrument began in Toulouse. It will be the centrepiece of the Athena (Advanced Telescope for High-Energy Astrophysics) mission from the European Space Agency (ESA), which will take off in 2028. “X-IFU is extraordinary due to its size and complexity,” sums up Didier Barret, from the Astrophysics and Planetology Research Institute (IRAP) and the scientist responsible for the instrument. Associated with the Toulouse Space Centre of the French National Centre for Space Studies (CNES), the IRAP (now one of the main French astrophysics institutes, already with numerous missions to its credit), was designated leader of the international X-IFU consortium (see textbox).

The instrument is an optical spectrometer which will capture and analyse X-rays resulting from phenomena which give off high energy. This is the case, for example, when very dense gas, which is brought to millions of degrees, circulates between the galaxies. It is also the case for extreme phenomena: when a black hole “accretes” matter, in other words when matter is irresistibly attracted by the force of gravity and starts to spiral and heat up greatly, before disappearing into the black hole. Athena will not be the first X-ray observatory. Its predecessors, like XMM-Newton from the ESA, or Chandra from NASA, have already made observing these invisible phenomena from Earth possible. However, it is now a case of seeing a lot further into space and...
time. "With Athena, we will be able to go back to approximately one billion years after the Big Bang and therefore study the first black holes which formed in the Universe," Barret points out. It is about comparing the growth of the black holes to that of the galaxies which contain them, in order to understand their influence on one another. Athena will also indirectly see the first structures of dark matter, the invisible matter which represents more than 25% of the Universe, compared to the visible matter we are made of, which only accounts for 5%. Dark matter essentially traps the visible matter, which is therefore organised into filaments. Where these filaments intersect, the first clusters of galaxies were formed. X-IFU will allow these objects to be mapped and to understand their physics. Lastly, in our own galaxy, the Milky Way, other “extreme” objects like supernovae (stars which explode at the end of their life span) will be observed in a very detailed way. “Having these scientific goals requires a spectrometer 50 times more accurate than those of XMM and Chandra,” Barret explains. In addition, Athena will carry a second important instrument; a WFI (Wide Field Imager). This will provide X-ray images of the sky over a wide field of view. The result is that Athena and its instruments have colossal dimensions (see figures). Technological challenges of this size require engineers coordinated by the CNES, which will design the X-IFU. The first of these challenges involves cooling (see diagram). Essentially, to capture the X-rays while getting rid of the distorting effects, the X-IFU’s sensors need to be maintained at the temperature of the space vacuum: 0.05 kelvin, or very near to absolute zero (0 kelvin equivalent to ~273°C). The second challenge is the precise assembly of roughly 4,000 sensors and their read out electronics. “The Toulouse Space Centre has both strong technical experience in numerous areas, including cryogenics and sensors, and experience in project management of complex systems, including internationally. For example, we have created the Integral spectrometer, another space telescope of the ESA in the 1990s,” highlights Thierry Carlier, Athena project manager for the CNES. Therefore, for cryogenics, the option selected is that of a series of successive coolings which will be designed and tested by the CNES (see diagram). The detailed study of X-IFU will last until the end of 2018, before the actual manufacturing of the instrument, followed by countless tests. "For a researcher, it is a lifelong mission,” concludes Didier Barret. “X-IFU will take up the majority of my time until my retirement!”

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**WITH ATHENA, WE WILL BE ABLE TO GO BACK TO APPROXIMATELY ONE BILLION YEARS AFTER THE BIG BANG**

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**The Athena space observatory of the ESA will observe X-rays emitted by the “distant” Universe: black holes, supernovae and gas clouds at temperatures of millions of degrees.**

**The X-IFU instrument’s sensors will be cooled gradually until they reach 0.05K thanks to several walls nested like Russian dolls. Mechanical gas compressors designed to last at least five years will ensure this cooling.**

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**15m**  
Athena’s length

**6 tonnes**  
Its mass

**800kg**  
The mass of X-IFU

**4,000**  
The number of sensors
Alongside an international team, a Toulouse researcher shows that an Australopithecus fossil discovered in South Africa is older than the famous Lucy.

It is the most complete Australopithecus fossil ever discovered. Named “Little Foot”, it is casting doubt over the geographical origin of mankind. The geomorphologist Laurent Bruxelles, from the INRAP1, affiliated to the TRACES2 laboratory, has just proven that it is a lot older than the last dating led them to believe. At 3.7 million years old, it could be the direct ancestor of humankind... The work was published by Nature magazine.

Little Foot was discovered in South Africa, in 1997, in the Silberberg cave in Sterkfontein, by the South African paleoanthropologist Ron Clarke. His team have spent fifteen years extracting all the fossil from its rock matrix. Remarkably, in terms of archaeology, it is 95% complete. It is an Australopithecus, an extinct type of hominid which includes several species, including the famous 3.2-million-year old Lucy, discovered in 1974 in Ethiopia.

Yet the dating of Little Foot poses a problem. Due to its morphology, Ron Clarke dated it at 3.3 million years. With no accurate method to hand for dating the bones, the rock which encases it was examined. In 2002, a chemical analysis therefore re-dated Little Foot to 2.2 million years, which makes it the contemporary of Homo habilis. However, the cave’s geology is very complex and to get a certain date, you would need an exact record of the deposits of different sedimentary layers. Laurent Bruxelles was therefore called upon: “When I got on-site, I quickly understood that I would need years to rebuild the geological history of the cave. Little Foot was doubtless killed by falling to the bottom of this cave. Debris and stones fell at the same time, then they were covered by other layers coming from the chasm’s entrance.”

After a study lasting over eight years, substantiated by the chemical analysis of the rocks by Marc Caffee and Daryl Granger, from Purdue University (USA), a verdict was reached: Little Foot died 3.7 million years ago... So he could have been the ancestor of Homo habilis and therefore make South Africa a new possible cradle for mankind, alongside East Africa, where Lucy was discovered. AD

Laurent Bruxelles was the winner, in 2015, of the bronze medal from the French National Centre for Scientific Research (CNRS), which rewards the initial work of a researcher and marks him or her as a talented specialist in their field.

© Laurent Bruxelles – INRAP   — © Carole Bruxelles

**Proust throughout time**

Isabelle Serça, style specialist at the Heritage, Literature and History laboratory, is launching a cross-disciplinary research project on the notion of time which is based around the works of Marcel Proust.

**Exploreur (E): Why this “ProusTime: considering time with Marcel Proust” project?**

**Isabelle Serça (IS):** Everyone refers to time, but no one has been able to give it a precise definition. So I wanted to compare views on time in very different disciplines, starting from the ideas that I have taken from *À la recherche du temps perdu* like “anachronism” and “linearity” for example. This is why the ProusTime group brings together historians, linguists, psychologists, mathematicians, physicists, astrophysicists, specialists in neuroscience, economists and others.

**E: What can this research provide?**

**IS:** ProusTime will create a synergy between researchers who do not ordinarily meet. It will also highlight the precursory nature of literature, as Proust’s description of the working of memory shows and to which neuroscience expressions, like the “Proust phenomenon” and the “Proustian hypothesis”, refer, in order to talk about the phenomenon of reminiscence – that caused by the famous madeleine for example!

**E: What will be the fruit of this collective work?**

**IS:** We will work via seminars. In June, we already worked on two notions: interpolation and anachronism. The aim is to publish a sort of lexicon on time, the “entries” of which will be written by researchers from different disciplines. Interview by CP.

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**Mimausa**

**ALBI AT THE CUTTING EDGE OF MATERIALS**

The MIMAUSA research and innovation platform was inaugurated on 12th January 2015 in the Albi-InnoProd technopole. Although it sounds like a plant, in reality its name describes a technical platform over 600m² dedicated to “using materials for aeronautics and active monitoring”\(^1\). Running the platform there is the Clément Ader Institute (ICA\(^3\)), born in 2009 out of the merger of the regional laboratories working on mechanics of materials at the École des mines d’Albi-Carmaux, the Higher Institute of Aeronautics and Space (ISAE), the Toulouse National Institute of Applied Sciences (INSA) and the Université Toulouse III — Paul Sabatier. The financing, surpassing 4 million euros, was provided in equal parts by the French State, the Midi-Pyrénées regional council and the urban community of Albigeois. “With MIMAUSA, the partner companies and laboratories will be able to create new materials, develop industrial processes, carry out mechanical tests and study the behaviour and durability of their materials,” explains Thierry Cutard, industrial director of the ICA. They will find diverse industrial pilots there, but also a process and material resistance monitoring laboratory and fatigue testing machines. They will also benefit from the skills of some 200 teacher-researchers, engineers, technicians and doctoral students from the ICA. One of the first pilots hosted by the platform consists of moulding metal alloys heated by infrared lamps. A procedure which is of interest to many aeronautical companies from the region. AD

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\(^1\) Heritage, Literature and History (PLH) - Université Toulouse – Jean-Jaurès. • 2. In literature: the action of introducing into a text an element which was not in the original. In statistics: the action of determining, from a series of values that are too far apart, new intermediary values for which no measurement has been carried out. • 3. Clément Ader Institute (ICA) — École des mines d’Albi-Carmaux, CNRS, INSA Toulouse, ISAE, Université Toulouse III — Paul Sabatier.
In business, a sincere smile

IS WORTH ITS WEIGHT IN GOLD

In business, can you trust a smile? It seems the answer is yes according to an experiment carried out by Astrid Hopfensitz and Paul Seabright at the Experimental and Behavioural Economics Group from the Institute for Advanced Study in Toulouse (IAST). They gave some euros to 198 volunteers and suggested that they decide whether or not to send them to strangers after having viewed a video in which each of these same strangers introduced themselves. Those who received money were then given triple the amount, which they had the choice to keep or share equally with their donor. Sharing took place in over half of the cases, thanks to a key element: the smile displayed by the recipients in the introduction video. The more the donors found it to be sincere, the more they were disposed to send them money. It seems they were right to do so, as the more sincere their smile was, the more those receiving money tended to share their gift. AD

BIRDS’ FEATHERS AND SHARKS’ SKINS

Alessandro Bottaro has just packed his bags for the Fluid Mechanics Institute of Toulouse (IMFT), where he will spend twelve months over the next five years. For the Italian researcher from the university of Genoa, winner of one of the thirteen IDEX 2013 appeal chairs, Toulouse is a “global centre of excellence in fluid mechanics”. His aim? To understand why animal skins, even though they are rough and covered in fur, feathers or scales, offer a dynamic that is sometimes better than those of the smoothest aeroplane wings or boat hulls.

A counter-intuitive concept, which François Charru, IMFT director, believes a great deal in: “We are going to use Alessandro’s scientific qualities and communicative energy to develop this biomimetics theme in our laboratory.” Equipped with 601,000 euros, in addition to winner’s placements and research expenses, the chair finances four study grants. Two doctoral students started to work on this subject last February. A third will join the team in 2016, then a postdoctoral researcher in 2017. AD

In July 2018, Toulouse will host the EuroScience Open Forum (ESOF), the biggest interdisciplinary science forum in Europe. A chance to highlight the European dimension of Toulouse research. We interview Anne Cambon-Thomsen, scientific lead for the project.

Exploreur (E): On 1st December 2014, Toulouse was awarded the organisation of the ESOF in 2018. What convinced the jury? Anne Cambon-Thomsen (ACT): It was Toulouse’s European scientific and international side, with its numerous laboratories and research institutes in all the disciplines. It was also the appeal of our city and region, with major industrial sectors like aeronautics, space, agro and biotechnologies. A region which has remarkable scientific sites, like the Pic du Midi observatory in the Pyrenees and the Moulis Experimental Ecology Station (see p. 16). Lastly, thanks to the richness of our associative network, we have a lot of experience in organizing scientific events for varied audiences. Soon we will host them in an entirely new facility, the Quai des savoirs.

E: So you’re inviting European researchers to participate? ACT: Yes, and I encourage the laboratories to plan for this event in their budgets and in those of their European projects, considering the importance accorded to this event by the European Commission. In addition to the numerous thematic sessions in all the disciplines, discussions will be dedicated to the future of European scientific policy.
A stressed airline pilot, fixated on a sequence of actions to be undertaken, doesn’t hear an alarm which was, nevertheless, ringing out loudly… This is entirely possible, and the consequences can be dramatic. Since 2014, at the Higher Institute of Aeronautics and Space (ISAE), the “Human and Neuro-Ergonomics factors” team, led by Frédéric Dehais, have been specialising in studying phenomena which alter pilots’ perception and developing measures to counteract them. A scientific expertise distinguished by the AXA fund for research, which gave it a chair in 2014 with, on top of that, 1 million euros over twenty years. “Currently, we are using this provision to develop wearable cerebral activity monitoring devices for pilots based on infrared sensors,” explains Frédéric Dehais. The second conference on this theme took place at the ISAE on 2nd and 3rd April. With this aim in mind, the team will also have a new building and new analysis tools, in the context of the State-Region plan contract. JFH

INFO ON THE ESOF

Created in 2004, under the initiative of Euroscience, this major research and European innovation meeting will take place for the first time in France and will be hosted in Toulouse from 9th to 14th July 2018. It includes a very high-level multidisciplinary scientific forum, specific programmes dedicated to innovation strategies, scientific policy, careers, media and a general public exhibition part. With this forum, Toulouse will be labelled “European City of Science” in 2018. This operation, with an estimated budget of 5 million euros, has already received support from the French ministry of Research, is benefitting from a specific line in the H2020 with support of 1 million euros shown for 2017–18 and intends to obtain regional and national, private and public funding. In addition to the national and European solutions, this application is supported locally by the Midi-Pyrénées regional council, Toulouse Métropole and the Toulouse chamber of commerce and industry.

www.esof.eu

E: Can we suggest ideas for this event?
ACT: Of course, it is not limited to Toulouse researchers! Currently we are collecting ideas which we will soon use to launch calls for thematic sessions. Please do send them to us and register on our circulation list to get information. Call for ideas: http://www.univ-toulouse.fr/node/11310

Contact and registration on the circulation list at office@esof2018toulouse.eu

Pilot equipped with a brain-machine interface in near infrared to estimate his workload in real time.
The climate challenge

Understanding, fighting and adapting

BY JEAN-FRANÇOIS HAÏT

Keeping a global temperature rise to no more than two degrees higher than in the mid 19th century, by 2100, is an ambitious political goal, substantiated by scientific data.” This is how Serge Planton, climatologist at the National Centre for Meteorological Research1 in Toulouse and member of the GIEC2, summed up the challenge of COP21, the global conference on climate which will take place in Paris from 30th November to 11th December. To negotiate, understanding the phenomenon was a prerequisite. The Toulouse researchers have been working on this for a long time, in the Artic, where everything happens faster, and in Ariège, by studying animal and plant species. They have also been doing this thanks to climate models – the one produced in Toulouse is globally renowned – and to measurements via satellite, a real regional speciality. Yet how can they fight and achieve the goals of the Paris conference? Perhaps by implementing a CO2 emissions deal which would be genuinely motivating. Lastly, climatologists, geographers and architects are joining forces to adapt cities to heat waves and other extreme events.

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1. National Centre for Meteorological Research (CNRM) - CNRS, Météo-France.
2. Group of Intergovernmental Experts on Climate change.
The Arctic
A climate laboratory

To predict the consequences of climate change over the entire planet, researchers are studying them in high-latitude areas. It is there that they appear on a greater scale.

By Anne Debrouse

Over the last few years we have seen the Arctic change in a spectacular manner,” attests Elena Zakharova, researcher at the Geophysics and Spatial Oceanography Studies Laboratory (LEGOS1). “Over thirty years the surface of the ice flow has been halved.” The Arctic is heating up twice as quickly as the rest of the planet. The violence of the consequences of this global warming has been the subject of an exemplary study for all those who are interested in the consequences of climate change.

In 2008, the French ministry for Higher Education and Research invited French research to join forces around an “Arctic working group”. Armed with its expertise on climate questions and its privileged access to satellite observation, Toulouse research was restructured in order to respond to the calls for tender of this measure. Therefore, in 2015, the Midi-Pyrénées Observatory launched the cross-disciplinary scientific action “Arctic: variability, interactions and feedback”, directed by Elena Zakharova and Alexei Kouraev from LEGOS. Its aim: to unify the research projects over the next five years which combine different disciplines, from geochemistry to medicine, including anthropology and climatology2. In particular, the “InHERA” (man-environment interactions in the Arctic regions) project is financed in the context of the Cross-Disciplinary Excellence Initiative of the Université Fédérale Toulouse Midi-Pyrénées.

At the heart of this research are the observations from the Satellite Cryosphere team, which Étienne Berthier is a member of, at LEGOS: “We are using the images from the Spot and Pléiades satellites to assess the development of the continental ice, notably the ice sheet which covers Greenland, Spitsbergen, Alaska, the north of Canada and Siberia.” The comparison of topographical maps drawn up from images taken at intervals of a few years allows us to calculate the glaciers’ loss in mass. “Between 2003 and 2009, the Arctic therefore lost 177 billion tonnes of ice per year,” he highlights. The Arctic represents two thirds of the world’s glacier melt, which itself is responsible for a third of the increase in the average sea level. This fundamental data has been made available to the scientific community and has been used for the creation of the latest GIEC3 report.

Along with the melting of the continental glaciers there is permafrost, the ground that is frozen all year, but which is caused to melt as the surface heats up. The water coming from this melting drains various chemical elements (carbon,
heavy metals, etc.) into the ocean. Roman Teisserenc, professor at the Polytechnic National Institute – Toulouse National Higher Agricultural School (INP-ENSAT), from the Biogeochemical Interface Transfer team of the Functional Ecology and Environment Laboratory (EcoLab⁵), has been monitoring the flow of organic materials into the largest Arctic river, the Yenisei, since April 2014 in the context of the TOMCAR-Permafrost⁵ project: “Our initial observations revealed that the amounts of carbon exported into the ocean were a lot more significant than we had thought, particularly during the spring flood. Moreover, during this period, it is matter with little degradation, which therefore still has the potential to decompose and therefore produce CO₂, which could be added to that emitted by human activities and accentuate global warming.” Once integrated into the global carbon models, this new data will allow for a better understanding of the carbon cycle and its role in climate change.

Could the exacerbated effect of this in the Arctic also encourage the propagation of certain infectious diseases? That is one of the questions asked by Jean-François Magnaval, doctor-parasitologist and member of the AMIS laboratory (Molecular Anthropology and Image Synthesis ⁶). In 2012, along with Yakut colleagues, his team carried out an epidemiological survey of the inhabitants of the two villages of the region of Verkhoyansk, located beyond the polar circle and reputed to be the coldest in the world: “We were surprised to find, in the blood samples, antibodies which show that a notable proportion of the inhabitants were infected by zoonoses which we thought were restricted to warmer areas, like Lyme’s disease which is transmitted by ticks.” The increase in summer temperatures could even extend the area of this type of disease.

Mercurial fish

In the Arctic, global warming has had an unexpected effect: an increase in mercury pollution. Even though it is very far from industrial and mining areas, the fauna of the region is exhibiting the highest contamination rates on the planet from this element. Jeroen Sonke, at the Toulouse Geoscience Environment Laboratory⁷, has been studying this paradox thanks to financing from the European Research Council (ERC).

“The mercury is emitted in a gaseous form by industry. After approximately six months in the atmosphere, it is deposited in the oceans, where it is turned into methylmercury by bacteria, capable of contaminating the food chain,” highlights Jeroen Sonke. His samples in the Arctic ocean indicate that the methylmercury transformation takes place at 20 metres in the Arctic, although it is produced between 400 and 1,000 metres elsewhere. The reason? “Due to the stratification of the water from the temperature, the microbes which assimilate the mercury to turn it into methylmercury are confined to the upper layer of the Arctic water,” explains the researcher. At this depth, life is abundant and the methylmercury therefore builds up in the food chain. Such a mechanism could increase with the wide-scale melting of the glaciers, which will strengthen the stratification of the Arctic water.

7. Toulouse Environment Geoscience (GET) / OMP – Université Toulouse III – Paul Sabatier. CNES, CNRS, IRS.
The impact of global warming on species is confirmed

Researchers from the Moulis Experimental Ecology station (Ariège) have shown that in response to higher temperatures, the animal species studied are developing more quickly, yet their survival at adult age is reducing.

BY JEAN-FRANÇOIS HAÎT

Behind an ordinary industrial area at the entrance of Saint-Girons (Ariège, close to the Pyrénées), a globally unique scientific instrument is hiding: the Metatron. On a pasture, one part of which is a wetland, 48 cages have been placed, connected by corridors of approximately 20 metres in length. Viewed from the sky, it all looks like a giant electronic circuit. This is the flagship installation of the Moulis Experimental Ecology station, based 15 kilometres away in the village of the same name.

“In each cage, we can modify the temperature and the light thanks to a shading system, and even control the humidity via sprinkling,” explains Olivier Guillaume, research engineer responsible for infrastructure. The Moulis researchers have released lizards, toads, newts, butterflies and dragonflies there and are observing their movements, depending on the conditions that these animals face. In particular, they are studying the effects caused by humans: the fragmentation of natural habitats and climate change, which has become an important issue in Moulis.

“Now we are publishing the initial large-scale results since the Metatron has actually been operational, in 2012,” Jean Clobert, the director of the site, is pleased to say.

Julien Cote, researcher at the Evolution and Biological Diversity laboratory, and his doctoral student Elvire Bestion have reproduced the temperature conditions that we will encounter in fifty to sixty years’ time in the cages; two degrees higher than today. Some lizard populations have been subject to this. “We have observed that their growth is greater, their development quicker and their reproduction earlier. Yet survival at adult age dropped by 20% compared to those individuals who were not subject to a high temperature. The

Simulating

THE OCEANS AND THE RIVERS

To better study the impact of environmental changes on species, Moulis will benefit from additional means in the form of a 5.5 million euro provision in the context of the second State-Region Plan Contract. In the pipeline is the study of the aquatic ecosystems thanks to an “aquatic Metatron”, which will be made up of 95 communicative pools to reproduce the network of oceans, as well as a system simulating, over 100 meters, the course of a river. The “hydro-ecology” will also benefit from a new building, which will house three new teams representing up to 45 additional people.

1. Metatron: from “meta” = network (of populations and ecosystems) and “tron” = a generic suffix to describe an experimental system. • 2. Moulis Experimental Ecology Station (SEEM) – Affiliated to the CNRS from the outset, and a partner of Labex Tulip. Moulis will become a combined service and research body of the Université Toulouse III – Paul Sabatier from January 2016. The French National Museum of Natural History (MNHN) is also one of its supervisory bodies.

© Elvire Bestion

The 48 interconnected cages of the Metatron are able to subject the living species to temperature, light and humidity variations and to study their movements in response to these environmental changes.
warming therefore led to an acceleration in the pace of life. The consequence for the population studied is a possible extinction in ten to twenty years,” explains Julien Cote. A grim outlook indeed! Of course, the extinction of an animal population does not mean that of the species, whose distribution area may be very large. Yet the results obtained highlight the major risk of extinction on a regional scale. This is why the Moulis scientists are also carrying out observations on the ground. They have been monitoring a population of Cévennes lizards for twenty-six years.

“With these animals, we have observed, just like in the Metatron, a more significant size and a larger number of eggs. We do not yet have information concerning survival at adult age,” explains Jean Clobert. Climate change leads to other alterations. On the Moulis site, the researchers are breeding female viviparous lizards in cages. Going into the area, the heat and humidity prevail and the crickets, which serve as the lizards’ food, can be heard singing. “We have noticed colour variations in these animals. This is why we are studying the adaptation to climate change by measuring the degree of melanism 5: do the lizards get lighter to absorb less heat, or do they get darker in order to be more protected from ultraviolet rays? We do not yet have the answer,” emphasizes Julien Cote. Another observation is that of a “thermal preference”: when the females are experimentally subject to higher temperatures than normal, their offspring show a preference for lower temperatures. Global warming therefore has effects on descendants. Julien Cote is also interested in the microbiota of lizards, in other words the microbial flora of their digestive system. With Elvire Bestion, he has shown that with higher temperatures, the diversity of bacteria reduces by almost 20%. Whether it is in lizards or humans, microbiota play a fundamental role in digestion and therefore on individual health. Their reduction can therefore have consequences on the populations.

Yet studying species on an individual or population-wide scale is not enough. We must also understand the phenomena at the scale of the ecosystem. In Moulis, this is the aim of the Theory and Biodiversity Modelling Centre led by Michel Loreau. “We are developing mathematical models to predict the stability of ecosystems, notably when faced with climate change,” he explains. “These models show that the ecosystems rich in species come off better in the short term. The surviving species can balance out for a while. Yet this cannot last.” Work published by the team showed that climate change could, for example, cause a plant and its pollinating insect to become “out of sync”: both are active too early, but not at the same speed, with, in the long term, the possibility of the system’s extinction.

Now, Michel Loreau wants to go further and integrate human beings into the models, to study, over the long term, the stability of our current development method.

WE ARE DEVELOPING MATHEMATICAL MODELS TO PREDICT THE STABILITY OF ECOSYSTEMS

Michel Loreau has just obtained an advanced grant from the European Research Council (ERC). His project, “Bistases”, aims to better predict environmental changes and the stability of ecosystems and to integrate a social dimension into the ecosystem models.
Climate models
more and more precise and reliable

Models analyse climate change. Can we trust them? We get some answers with Olivier Thual, professor at the French National Polytechnic Institute – National Higher School of Electrical Engineering, Electronics, Computer Science, Hydraulics and Telecommunications (INP-ENSEEIHT) of the European Centre for Research and Advanced Education in Scientific Calculation (CERFACS). 1

E: What is a model?
OT: It is a set of mathematical equations which will be solved by a computer. The climate models simulate the development of all parts of a climate system: atmosphere, oceans, ice and continental surfaces. They integrate various parameters, like the topography of the Earth, physics equations from fluid mechanics, the energy provided by the Sun, but also greenhouse gases, the water cycle, etc. The development of greenhouse gases in the future is derived from probable economic growth scenarios that economists provide us with.

E: How much trust can we place in them?
OT: To evaluate the models, we undertake several kinds of exercises. We can provide them with recent data describing the fluctuations in solar radiation or greenhouse gases and see if they reproduce the current climate trends accurately. We can also test their ability to predict the appearance of climatic events like El Niño (a climate disturbance linked to changes in the ocean currents in the Pacific), or the development of climatic oscillations over decades. We can even simulate the cooling caused by volcanic eruptions, when they inject ash into the atmosphere. Twenty-five years ago the models were not capable of doing that. Now, we are confident in their capacity to anticipate climate development over the century to come, as they reproduce the physical processes observed now with a good performance.

E: How many models are used worldwide?
OT: There are numerous ones, but only 20 groups are working on models with simulations that are considered in the GIEC reports. Among them, two are French: the IPSL (Pierre-Simon Laplace Institute in Paris) and the one from the National Meteorological Research Centre (CNRM) in Toulouse. The CNRM-GAME 2 and the CERFACS are working on the sixth version of the Toulouse model (CNRM-CM6), which will be used from 2016 to feed into the next GIEC report.

E: What are the expected improvements?
OT: The performance of the models, in other words their ability to take into account climate change observed with a good temporal and spatial resolution, increases with computing power. Our role at the CERFACS consists of exploring the new capacities of machines to run models with more precise temporal and spatial resolutions to optimise the way they work. Running code over thousands of processors, managing the data exchanges between the various parts of the model (atmosphere, ocean, etc.), is not easy. The next model (CNRM-CM6) will simulate the atmosphere with resolutions ranging from 150 to 50 kilometres (compared with 200 currently). These resolutions allow us to take into account smaller-scale phenomena like tropical cyclones.

INTERVIEW BY
JEAN-FRANÇOIS HAÏT

Exploreur (E): Why measure the height of the oceans to study climate?
Benoit Meyssignac (BM): Because the level of the oceans is a very good indicator of climate change. The rise in temperatures has two effects: on the one hand it causes the ocean to expand and on the other it melts the continental glaciers and the ice caps, the water from which eventually goes back into the sea. The result is the level rises. Thanks to altimetry satellites, we now measure this rise to an accuracy of less than a centimetre. Topex-Poséidon in 1992, then Jason 1 and Jason 2 , all from a collaboration between the CNES and NASA, have been constantly providing standardised data for over twenty years, which is essential in climatology. We are eagerly awaiting the launch of Jason 3 initially planned for August, but which has been delayed following the failure of the Falcon 9 rocket.

E: What have you discovered at LEGOS?
BM: The significant result, coming from the work led by Anny Cazenave on the spatial altimetry database, is that the level of the oceans has risen by 3.3 millimetres per year on average over the last twenty years. Now we have models which can describe the expansion of the ocean. Moreover we know its variability, in other words all the natural phenomena which make the ocean change. From them, we deduce that the rising of the observed level can only be explained by the emission of greenhouse gases of human origin in the atmosphere. They upset the energy balance of the Earth, in other words the link between the amount of energy provided by solar radiation and the energy sent back into space by the Earth. It is the oceans which mainly absorb this imbalance by heating up.

E: Millions of people in the world are threatened by the rise in the sea levels. Can we prevent it?
BM: It all depends on the timescale being considered. Over ten years, the natural variability of the oceans dominates. This variability has a random and chaotic nature, therefore it is very difficult to predict where the water will rise. However, over twenty, thirty or a hundred years, we are seeing the effects of anthropic emissions more and more, which force changes in climate. Over hundred years, we can make projections: the sea level will be approximately 29 centimetres higher if we stabilise greenhouse gas emissions by 2030, but it will be 90 centimetres higher or more if we do not do anything, with a very significant impact on the coast!

E: What can be done to improve the predictions?
BM: It is about viewing these rising phenomena with greater precision and nearer to the coasts. This will be one of the roles of SWOT, the new CNES and NASA satellite which will be launched in 2020. It will also allow us, and this is new, to measure the variability of the continental water reserves, in other words the lakes and rivers and the impact that climate change could have on this.
Saving the climate, at what cost?

For the researchers from the Toulouse School of Economics, the reduction of CO2 emissions occurs through the creation of a global carbon market. Yet what price should we give to a tonne of CO2 and what cost is there for the consequences of climate change?

BY ANNE DEBROISE

In 1992, the signatory States of the Kyoto protocol committed to limiting their greenhouse gas emissions. Yet they have not kept their commitments. This is why, before the COP21 in Paris, we have been asking for the introduction of economic tools which could make the next agreements more effective,” highlights Christian Gollier, member of the GREMAQ, director of the Toulouse School of Economics (TSE) and a member of the GIEC. Specialised in decision making in uncertain contexts, Gollier attributes the current political standstill to the delay which exists between greenhouse gas emissions and their consequences. Yet certain economic mechanisms allow for the cost of climate change to be paid by the generations which are responsible for it, and not their descendants.

“There is, for example, the carbon taxes to be applied on consumer products. Yet they are not very well received by populations and therefore are unlikely to materialize… We can also cite the international carbon emission permit system,” explains Christian Gollier.

Such a system has been imposed on European companies emitting large quantities of greenhouse gas since 2005, like electricity producers and cement manufacturers. Each year they have a quota of emissions permits. If they use them up, they can buy more from more virtuous companies, who are therefore compensated for their efforts. However, the European market has lost all efficiency following...
the economic stagnation and the delocalization of certain activities outside of Europe, which have led to a drop in the cost of a tonne of CO2 (see the figures text). The solution proposed by Jean Tirole, Economics Nobel Prize winner in 2014, and Christian Gollier consists of encouraging the countries to sign up to a global market (under penalty of an imports surtax, supervised by the World Trade Organisation), by fixing a sufficiently high price, which would be sustained by a strict management of quotas put into circulation.

Once again, this price must correspond to the damage caused by the emissions, in accordance with the polluter pays principle. This is why, at TSE, 30 researchers are working on the economic value of the environmental components, which for some are directly affected by climate change. They therefore seek to define methods to assess the cost of the loss of biodiversity, desertification, deforestation, health effects from polluting the atmosphere, etc.

The question of the health impact is therefore at the heart of the work of Nicolas Treich, a researcher at the INRA and manager of the Environmental Economics group at TSE: “Climate change has, for example, effects on the death rate: heat waves kill, vector-borne diseases spread and there is a risk of malnutrition increasing. However, we must now reflect on the efforts that we are prepared to make to limit this future increase in the death rate.” His work shows that uncertainty hinders the efforts that States and citizens are prepared to agree to: the more the expected gain is uncertain, the less we are prepared to invest in the future. According to Christian Gollier, uncertainty is therefore the main cause of little commitments being taken by States during the previous Conferences of the Parties (COP). This is why this question was dealt with during the conference organised on 14th October 2015 in Paris by the TSE economists, in partnership with the “Climate” chair of the Université Paris-Dauphine.

WE HAVE BEEN STUDYING AN INTERNATIONAL CARBON EMISSION PERMIT SYSTEM

1 tonne of CO2 equals 8 tanks of petrol

€17
The price of a tonne of CO2 on the European market in 2001

€7
The price of a tonne of CO2 on the European market in 2015

€100
The price of a tonne of CO2 recommended by the GIEC for 2030

€40
The price of a tonne of CO2 recommended by Christian Gollier and Jean Tirole

Sharing water

“Climate change will lead to a greater variability in water resources, with longer periods of drought. There’s therefore a greater risk of conflicts,” predicts Stefan Ambec, member of the Natural Resources Economics Laboratory (LERNA) at TSE. From historic data on water resources, he has designed a water sharing treaty which could always be respected by the parties. His study was on the Syr-Darya River, used by Kyrgyzstan upstream to produce electricity for heating in winter and by Uzbekistan and Kazakhstan downstream for irrigation in summer. The best agreement consists of defining, month by month, the minimal flow that Kyrgyzstan must ensure and the compensations (coal, gas, petrol) that the countries downstream must provide them in times of shortages. This work could serve as a reference against the backdrop of the renegotiation of water sharing agreements in the region.

It is hotting up in the city!

Urban dwellers are the first to suffer summer heat-waves. The cause is a phenomenon called “urban heat islands”. How do we deal with them? Geographers, town planners and climatologists are working together in order to consider solutions to cool cities down.

BY CARINA LOUART

Cities are hotter than their surrounding countryside and not just by a few tenths of a degree… “The temperature gap between city centres and the surrounding rural areas in France can range from 2 to 10°C in summer depending on the characteristics of the city,” explains Julia Hidalgo, researcher in urban climatology at the LISST-CIEU 1. “The more artificial the area of the populated city is, the higher the city-country temperature differential is”. By way of an example it is 10°C in Paris and 7 to 8°C in Toulouse and Strasbourg. With global warming, the harmful effects of this phenomenon will only get worse.

Contrary to a widespread view, this phenomenon of urban heat islands (UHI) is not mainly due to pollution and human activities. Rather it is due to the mineralisation of our cities. The cause of this is the materials of the buildings, the concrete of the roads, which store solar energy and give it off at the end of the day, which limits the cooling of the air. “It is during the night that the temperature gap between the city and the country is most significant, when the body needs to recover, which exposes the most vulnerable people to risk of death,” highlights Valéry Masson, climatologist responsible for the Urban Climate Research team at the French National Centre of Meteorological Research 2 in Toulouse. During the 2003 heatwave, 15,000 additional deaths were recorded in France, including 5,000 in Île-de-France alone.

Faced with what has become a real public health challenge, multi-disciplinary research has been increasing. In Toulouse, the ANR Applied Modelling and Climate Town planning and Energy projects (MAPUCE3) led by Valéry Masson’s team and the Multidisciplinary Environmental Requalification of Neighbourhoods Assessment (EUREQUA4), coordinated by the LISST, brings together climatologists, geographers, sociologists, town planners and architects. The aim is to combine the skills of each of them in order to establish the best city adaptation strategy to be implemented by the planning stakeholders. In order to measure the additional degrees, Valéry Masson’s team has, since the start of the last decade, been developing an original digital urban climate model named TEB5. Launched in 2014, the MAPUCE project aims to introduce new parameters into this: the energy consumption of buildings and offices and the residents’ use of air-conditioning and heating. “At the end of the project, in 2018, we hope to offer a tool which decision makers can rely on to implement local energy saving and climate management policies,” specifies the climatologist. Still, the vulnerable areas must be identified. The 2003 episode shows that the death rate is linked

to a specific residential situation: accommodation located on the top floor, in badly insulated apartment blocks and situated in dense neighbourhoods, which have little vegetation and are therefore more exposed to UHIs. The EUREQUA study was specifically designed to obtain an objective (based on physical measures) and subjective (experienced by the residents) assessment of the living conditions of urban dwellers. Undertaken since 2012 in three cities (Toulouse, Paris and Marseille) on a neighbourhood-wide scale, it relies on a team combining geographers, sociologists, atmosphere physicists, acousticians and architects and is focused on three types of environmental criteria: the climatic comfort, noise and air quality.

The first lesson, coming from measuring temperatures and surveys with residents: “We have noticed the inequality of urban dwellers as regards climate risk,” highlights Sinda Haouès-Jouve, coordinator of the EUREQUA project. Indeed, the study undertaken on Bordelouge-Papus-Tabar neighbourhood in Toulouse revealed that from one street to another, the temperature could vary by 4°C. The study also yielded other surprising results: the exposure to noise and pollution is a significant obstacle to regulating climatic comfort with a view to adapting to an increase in temperature. “These disturbances are such a restriction that households are not ventilating their accommodation,” the geographer notes. Due to be completed in spring 2016, EUREQUA will propose environmental quality improvement actions taking into account both the scientific expertise and the expectations and suggestions of residents, as, in the fight against urban heat islands, the participatory dimension is crucial.

Aude Lemonsu, CNRS researcher at the GAME laboratory, is taking measurements of meteorological parameters (air temperature, wind, humidity) and air quality, on the Seysses road in Toulouse.

The freshness island

OF MONTAUDRAN

In 2019, buildings will shoot up from the ground in the heart of the new urban development zone of Montaudran-Aérospatiale in Toulouse, by the former asphalt runway of the French Airmail Service, a place of remembrance which has been preserved. Yet how do you reduce the furnace-like effect that it will produce in summer? This is the subject of a study called “IFU” (Urban Freshness Islands) carried out by a team of researchers at the request of the Environment and Energy Control Agency (ADEME), in partnership with Toulouse Métropole. It has advanced four scenarios. Green: doubling the number of trees compared to the initial project; blue: increasing the number of water surfaces in the neighbourhood; white: lightening the roofs and facades of the buildings and “prospect”: doubling the height of the buildings to ensure more shade. “The best scenario is the blue one, which cools the air by 2 to 6°C depending on the location, followed by the green one. The height of buildings has no effect and the lightening is counter-productive as it heats the air,” explains Luc Adolphe, professor of the Civil and Urban Engineering department of the INSA of Toulouse and coordinator of the study. This is why more fountains and misters are now planned in the project.

Jing Guo

**THESIS:** Serious games for e-health: application for training general practitioners

*Exploreur (E):* Tell us about the subject of your thesis...

**Jing Guo (JG):** It is about responding to doctors’ needs to develop communicational skills so that they have a centralised approach to patient concerns, ideas and fears. They must be able to discover what is “hidden” from them by patients, all the while being understandable themselves, so that the decision at the end of a consultation is shared and to establish a long-term relationship. My work at the Jean-François Champollion University Centre is on the development of a method to digitally model the consultation dialogues which will be played out. So I am formalizing a prototype, whilst the audiovisual laboratory of the Université Toulouse – Jean Jaurès is carrying out a filmed approach.

*E: Why work on communication training for doctors?*

**JG:** These skills are still too neglected in initial training and by practicing doctors. Many think that they are personal aptitudes. Yet studies show that they can be learnt. Developing a serious game on the basis of defined pedagogical content with doctors will help training them throughout their career, by sticking to the principle of player motivation like in a recreational game. It is the thesis subject which led me to apply to IRIT, one of the biggest computing laboratories in France.

*E: What are your professional plans?*

**JG:** I would like to work in computer engineering applied to health and preferably in France, a very advanced country in this sector and where the research environment is very pleasant.

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Marcel Oliver Becker

**THESIS:** Bets on sporting competitions: a reconcilable antagonism between sport integrity and economic profit? Different perspectives in German and French laws

*Exploreur (E):* Tell us about the subject of your thesis...

**Marc Oliver Becker (MOB):** Business puts a lot of pressure on sport. The royalties that operators pay to the State or organisers to have the right to offer bets on competitions can provide them with lots of money. The organizers can also be tempted to offer bets directly on their own competitions. This creates a serious risk to the integrity of the sport. Yet there is no point banning betting as people play a lot and the Internet allows for the bans to be circumvented. Is it possible to reconcile these two worlds, knowing that sport needs this money? My work shows that you must legislate, at a European level, as bets are understood in very different ways depending on the country. Yet this will not be any good if the sporting organizations do not establish internal rules and ensure that the money which comes in from sport business is put towards the sport.

*E: Why choose a thesis in France in collaboration with the university of Regensburg in Bavaria?*

**MOB:** I completed my studies in Germany before coming to do a specialised European law Masters at the Université Toulouse 1 Capitole. The Maurice Hauriou Institute has a very good reputation and it is specialised in economic action law. Thanks to this collaboration, I can compare French and German laws as there are several codes which apply. There are differences between decisions from the EU Court of Justice, the constitutional courts of France and Germany, the Lausanne Sport Arbitration Court, etc.

*E: What are your professional plans?*

**MOB:** I would like to be a European lawyer! But at the same time remain in the university sphere. I have already been giving talks since 2013 on international economic law at the School of International Business and Entrepreneurship near Stuttgart.
How do you process massive amounts of environmental data at a low cost? You use cloud computing!

The TORUS European project, undertaken by a Toulouse geographer, aims to show this in Vietnam and Thailand.

It is this gap that the TORUS project proposes to fill. First of all by training the professors from four establishments, two Vietnamese ones and two Thai ones. Two manuals will be published, which will serve as a reference for the professors and their students. TORUS will also finance the purchasing of servers and the training of technicians in charge of their maintenance.

Lastly, several research projects have already been selected: one will exploit satellite data to model erosion, another will process sets of big data to model atmospheric pollution, in Asia and more locally in Hanoi.

Bui Quang Hung, director of the Center of Multidisciplinary Integrated Technologies for Field Monitoring (FIMO) in the university of Hanoi and the kingpin of TORUS in Asia, is very pleased with the financing of the project: “TORUS will provide us with high-performing computing tools to monitor the environment. It is especially important in our regions to manage the risks of natural disasters against the backdrop of climate change.” What is more, the university of Hanoi will be implementing a “cloud computing and environmental data” Masters.
Collective intelligence

En route towards big data

An intensive computing platform, CALMIP, is available to all the Midi-Pyrénées laboratories, but also to innovative companies. From fluid mechanics to ecology, many are using its high-performing parallel computing and soon the big data processing abilities.

BY PASCAL NGUYEN

Only a few years ago, intensive computing was the prerogative of only a few scientific sectors like the physical chemistry of materials and fluid mechanics. Nowadays, everyone is using it!” enthuses Boris Dintrans, director of the Midi-Pyrénées Centre for Intensive Computing (CALMIP). After the inauguration in May of the new EOS supercomputer, the demand for computing time after just a month and a half reached 80% of the 100 million hours available yearly. With the planned arrival of big data, this demand certainly will not be decreasing...

The current rush at CALMIP (400 researchers from 30 labs!) is explained by the space taken up in research by scientific calculations. It allows you to carry out digital simulations and data processing which would take aeons under traditional experimentation or which simply would not be feasible. It is also explained by the fact that this pooled service offers a computing power that no laboratory could offer.

For example, fluid mechanics has, historically, been one of the sectors which has exploited scientific calculations for decades and has turned to CALMIP. “We have been using computing, in parallel with experimentation, practically since computing existed,” highlight Pascal Fede and Hervé Neau, from the Toulouse Fluid Mechanics Institute2. “Our institute now uses approximately 5 million computing hours per year.” One of their digital simulations on its own uses over 1.5 million hours.

Yet the shared platform has seen new laboratories arrive in sectors that are not that familiar to computing, like ecology. During the preparation of his thesis in 2009, Ivan Paz-Vinas was working on a fish population research project carried out jointly by the Moulis Experimental Ecology Station3 (see p.16) and the Evolution and Biological Diversity laboratory4: “To process our data, I had 6 or 7 computers in the lab. Yet each calculation took one to two weeks. However I had hundreds to do...” Then a colleague told me about CALMIP, which you can request computing hours from. “Not only did we do all our calculations a lot more quickly, but we were able to enlarge our

WHERE SCIENTISTS WERE WORKING ON 10 MOLECULES, NOW THEY NO LONGER HESITATE IN STUDYING 100!

Collective intelligence

research, like including all the demographic history of four fish species,” he highlights. The team got into computing. From 2,000 in 2010, the number of hours for this project reached a peak of 130,000 in 2013. The scientific sectors using CALMIP have multiplied. At the same time, their work has got more complex. Intensive calculation opens up the range of possibilities, as Boris Dintrans explains: “In chemistry, for example, where scientists were working on 10 molecules, now they no longer hesitate in studying 100!” This requires CALMIP to stay at the cutting edge of technology. EOS provides a power equivalent to that of 3,000 office computers put together. When it was installed, it was ranked 183rd in the top 500 most powerful machines in the world. To maintain this performance level, the supercomputer is replaced roughly every four years. EOS is therefore seven times more powerful than its predecessor, Hyperion. Boris Dintrans has already announced its replacement in 2017, which is a further seven times more powerful.

Staying at the top performance-wise allows CALMIP and therefore the Midi-Pyrénées region to stay very attractive, which should increase with the new project driven against the backdrop of the State-Region plan contract. Boris Dintrans is not only aiming for an increase in computing power but also in storage capacity: “We have entered the era of big data. We will need to process big data produced by equipment currently being developed in astronomy, genomic sequencing in biology and even human science sociological research.” CALMIP (Calculation in Midi-Pyrénées) could therefore become CADAMIP (Data Calculation in Midi-Pyrénées) in 2016 as an investment of over 2 million euros in a big data storage and processing unit has already been granted.

In October 2014 CALMIP moved into brand new premises in the heart of the Espace Clément-Ader, the first building of the future Montaudran-Aérospatiale campus devoted to research. A choice symbolic of the strategic place which scientific calculation now occupies. “It is cross-disciplinary and shared by the academic world but also by the world of business,” confirms Boris Dintrans, director of CALMIP. Having a geographically close platform is an asset and reassuring for future neighbouring structures: the Saint-Exupéry Technological Research Institute and the Maison de la Formation Jacqueline-Auriol – which will include students in mechanical, manufacturing and aeronautical engineering from the Université Fédérale Toulouse Midi-Pyrénées – as well as start-ups.

A strategic site

In October 2014 CALMIP moved into brand new premises in the heart of the Espace Clément-Ader, the first building of the future Montaudran-Aérospatiale campus devoted to research. A choice symbolic of the strategic place which scientific calculation now occupies. “It is cross-disciplinary and shared by the academic world but also by the world of business,” confirms Boris Dintrans, director of CALMIP. Having a geographically close platform is an asset and reassuring for future neighbouring structures: the Saint-Exupéry Technological Research Institute and the Maison de la Formation Jacqueline-Auriol – which will include students in mechanical, manufacturing and aeronautical engineering from the Université Fédérale Toulouse Midi-Pyrénées – as well as start-ups.

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3. Moulis Experimental Ecology Station (SEEM) – Attached since its beginning to the CNRS and a partner of the Labex Tulip. Moulis will become a combined service and research body of the Université Toulouse III – Paul Sabatier. The French National Museum of Natural History (MNHN) is also under its administrative supervision. 4. Evolution and Biological Diversity (EDB) - Université Toulouse III – Paul Sabatier, CNRS, ENFA. This laboratory is a member of the Labex Tulip.
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Andreas Munzel

Fake spotter

What are Internet users’ reviews worth on websites? How can fake reviews be detected? At the Management Research Centre, Andreas Munzel is busy helping companies and consumers make sense of the tangled web of online business.

**Exploreur (E):** Why have you decided to research “electronic word of mouth”?

**Andreas Munzel (AM):** I like to focus on subjects that concern everyone, casting marketing in a bit of a critical light, because unfortunately there are some bad habits out there. At the Management Research Centre (CRM), I analyse what motivates people to post reviews on websites – especially to do with tourism – and the effects that these reviews have on purchasing patterns. As well as the consequences – particularly of bad reviews – on company management.

**E:** What have you found out?

**AM:** One of my experiments sought to find out how a company can best manage the situation when Internet users describe a bad experience – to be able to come up with alternatives to bad habits. Indeed, companies are sometimes pushed by e-reputation agencies to inundate websites with fake glowing reviews. We therefore put together two samples of companies that posted public explanations, and we found that the best strategy involved recognising their responsibility, rather than apologizing but blaming someone else – a supplier for example.

**E:** By working for the benefit of consumers, do you consider yourself to be a committed researcher?

**AM:** I am trying to help consumers make sense of an environment bombarded by publicity messages – and marketers to reconsider some practices so that a responsible, useful and good-natured form of marketing might be achieved. Incidentally, “positive marketing” – an American movement kick-started by a research centre in New York very much strikes a chord with me. I am yet to find any colleagues in France who are working on the same subject!

In 2014, the Journal of Service Management gave Andreas Munzel the Robert Johnston Highly Commended Award for the article “Creators, multipliers and lurkers: who contributes and who benefits at online review sites”, in which he lists the different types of contributors to online reviews and analyses their underlying motives.
Mercator Ocean

A flagship European company

In 1995, the scientific and industrial conditions in Toulouse were just right for a new team specializing in operational oceanography to be set up and, twenty years later, Mercator Ocean has become the European leader in the sector.

BY PASCAL NGUYEN

Toulouse may be without sea or ocean, but Europe’s leading centre for ocean analysis and forecasting is situated in Ramonville, at the gateway of the “Pink City”. This service of general interest role was entrusted to Mercator Ocean by the European Union in 2014 and, in this way, the company scooped a seven-year contract for performing one of the six services of Copernicus, Europe’s ambitious Earth-monitoring programme. Mercator, which employs 60 people, now works alongside giants such as the European Space Agency (ESA), the European Centre for Medium-Range Weather Forecasts (ECMWF) and the European Environment Agency (EEA). “This is immense recognition!” says Pierre Bahurel excitedly, who heads up Mercator Ocean. “Oceanography is one of France’s great strengths at international level.” And his company is one of its spearheads. Mercator Ocean collects and analyses data concerning oceans worldwide, forecasts changes and makes this information available digitally to the widest possible audience. Free of charge. Such technical and scientific feats have been made possible thanks to the way the company came about. Mercator Ocean was founded back in 1995 by six public institutions, which opted to pool their efforts by setting up a single service provider, and are both shareholder and customer of Mercator Ocean, except the CNES which is still a major partner. “We are a non-profit company,” adds Bahurel. “We primarily handle public money and have a general interest role to play: making clear, coherent information available to the widest possible audience, particularly with a view to developing economic activities.”

The data provided by Mercator Ocean is above all for the attention of specialist suppliers for meeting the needs of skippers, sea rescue operations, the French Navy or oil pollution surveillance for example. Through observation (satellites, specific buoys, site-specific measures) and cutting edge digital modelling, Mercator Ocean can identify the temperature, salinity, acidity, thickness of sea ice or current for example, and their trends over time anywhere in the world. The company thus provides customised expert appraisals, or ready-to-use information for the purposes of boosting economic activity in operational oceanography, such as telling sailors what the fastest maritime routes are, providing offshore thermal energy developers with a history of the temperature differentials in deep water around tropical regions, or locating potentially worthwhile fishing zones.

Mercator Ocean was not set up in Toulouse by chance. “The concept of operational oceanography first came about in the Research Laboratory of Spatial Oceanography and Geophysics (LEGOS) with the first spatial altimetry missions, above all Topex-Poséidon (Franco-American), launched in 1992,” explains Yves Morel, head of LEGOS. Pierre Bahurel adds: “There was a convergence...

SKIPPERS, POLLUTION SURVEILLANCE OR FISHERMEN BENEFIT FROM MERCATOR’S FORECAST

The Mercator Ocean Service Desk taking calls from users all over the world.
of infrastructure and science behind the emergence of operational oceanography.” Describing the ocean in real time along with its changes involves several techniques: observations (spatial and maritime), digital models, powerful computing infrastructure, and specific research to validate and improve these systems. And all of this can be found in Toulouse. The connection with research – especially with LEGOS – has always been kept up. The company relies on the expertise of the laboratory for modelling and observing the ocean, and it makes direct use of some data produced by the laboratory. “Our work concerns major ocean regions and we have expert oceanographic knowledge on the whole of the tropical belt, the Antarctic Circumpolar Current, the Bay of Biscay and the Gulf of Lion,” explains Morel, LEGOS is thus working on improving mathematical models for incorporating observational data as well as those that can be used for regional forecasting together with Mercator Ocean. “LEGOS is also a skill pool: our company recently recruited one of their researchers to head up its scientific management,” adds Pierre Bahurel.

In seven years’ time, the Copernicus Marine Service delegation won last year will be up for grabs once again. “We are therefore going to have to continue firing on all cylinders if we want to keep this mandate – and even ensure the bottom line is that, when it comes to operational oceanography, France – and more specifically Toulouse – is where it is at,” warns Pierre Bahurel.

1995
Foundation of Mercator Ocean

2001
First forecast report on the North Atlantic

2005
Covers all of the world’s oceans

2010
Interconnects European data providers for the project MyOcean (60 partners)

2015
Operates Europe’s Copernicus Marine Service

OLIVIER BOUYSSOU,
Manager of App4Nav, publisher of the Weather4D app

How has Mercator Ocean helped you to develop your business?
I created the Weather4D app for smartphones five years ago. It started out as an app for amateur sailors and the fishing industry alike to get information about the weather. When I got wind that Mercator Ocean was making data about currents available free of charge through the Copernicus Marine Service, I wasted no time incorporating this data into my app to optimise maritime routing calculations.

Could this data not be accessed before? It was out there, but far too expensive. Mercator Ocean’s data is free and, what is more, of a very high quality. It is now available to my 45,000 subscribers – 80% of whom come from Europe.

How do you get hold of this data? The data is downloaded automatically. If there is a technical problem, I get in touch with the helpline. They get back to me promptly and the problem is generally resolved within the hours that follow.
Short bio

1966
Born in Dolisie (Republic of the Congo)

1994
PhD at the INP-ENSIACET

Since 1998
Professor at the École des mines d’Albi-Carmaux

2005
Set up the cycle of international conferences, WasteEng

2010
Founded the journal Waste and Biomass Valorization and won the Presidential Green Chemistry Academic Award

2015
Progress and Innovation in Research award - Chinese Academy of Sciences

2016
Organizing WasteEng 2016 in Albi in May
Ange Nzihou

A catalyst for talent

A world-renowned professor, founder of a cycle of international conferences and a scientific journal on biomass and waste recovery, Ange Nzihou – a recipient of one of America’s most prestigious awards – has also woven closer ties between the members of his scientific community.

BY CAMILLE PONS - PHOTOGRAPHY BY FRÉDÉRIC MALIGNE

His manner of speaking reflects the welcome he extends to the Exploreur team in his office at École des mines d’Albi-Carmaux (EMAC) – entirely without pretension, when this researcher is one of the few non-American recipients of the Presidential Green Chemistry Academic Award for all of his work. “My scientific life has been all about pragmatism,” Nzihou sums up modestly. “I asked myself when I first started out how my work might tackle industrial and societal challenges at the same time.”

There has been a fair amount of perseverance too, for this process engineering doctor (whose thesis looked at the crystallisation of compounds from petroleum products) finally found his calling in greener pastures as it were: biomass and waste recovery for generating energy and renewable materials – and he has gone on to forge an international reputation in this domain. Appointed director of the Rapsodee Research Centre in which he got his projects underway, Nzihou is now a visiting professor in no fewer than four universities, in China and the United States – most notably Princeton.

But for all that, Ange Nzihou, who was born in the Republic of the Congo, decided to stay in France – the country that welcomed him at the end of 1987 – and to spend his first few years in Toulouse where he earned his PhD at the INP-ENSIACET, before setting up in Albi. Nzihou jokes that this choice was made “when my African comrades who had come to welcome me told me that the other city I could settle in – Nancy – was cold!”

I ASKED MYSELF HOW MY WORK MIGHT TACKLE INDUSTRIAL AND SOCIETAL CHALLENGES AT THE SAME TIME
A STRING OF PROJECTS

With his PhD under his belt, Nzihou tells us that he would work in an SME for a year, before being unemployed for two years until he acquired French nationality. He does not dwell on this period in his life, however. It was a difficult time, during which he worked as a volunteer to keep his scientific career afloat – and which he turned to his advantage to build the project on which he would forge his reputation.

Two key dates mark his work: 2000, when he signed a sustainable contract with the international chemistry group Solvay and began working on combustion residue recovery with his long-term partner, Professor Patrick Sharrock, from IUT de Castres (Université Toulouse III – Paul Sabatier), and 2004, when he returned from his first trip to Princeton. This American university “brought the international stage within his reach”, and he came back with a mindset that spurred him to “take more initiatives” and which would form the springboard for a string of projects to come. There are ten on the go to date, involving teams across five countries (United States, China, India, Senegal and Colombia) and 38 researchers – including 8 doctoral students and 2 post-docs from all four corners of the globe.

INDUSTRIAL RESEARCH IN THE SERVICE OF KNOWLEDGE

Ange Nzihou could not have seen these through without nurturing a close relationship with industry. He has formed a dozen or so partnerships particularly with Solvay, but also with Terreal, which specialises in terracotta building materials, and with which he is working on the manufacture of innovative materials – primarily bricks and tiles – including agricultural residues and co-products. On phosphates he has teamed up with the OCP group in Morocco, a world leader, and the Belgian company Prayon. Four patents have already resulted from these projects, including two with Solvay. Such partnerships are also a means of funding basic research. One of the team’s flagship projects currently underway, together with Princeton University and industrial partners, is aimed at developing catalysts with controlled properties with a view to producing biofuels. Other end markets for these projects are: materials for the thermal storage of energy (the nature of which is still confidential), and low-cost filters for treating wastewater, particularly aimed at developing countries.

CREATING A CLOSER-KNIT COMMUNITY OF SPECIALISTS

Ange Nzihou could have been content with the acclaim his work has garnered, and left it at that. But he was also determined to bring his community closer together. So he launched a cycle of international conferences on waste – the WasteEng Conference Series. The first of these was held in Albi, and it will be returning there in 2016 for the sixth series. after travelling to Greece, China, Portugal and Brazil. Today, these conferences are attended by 400 to 500 researchers from all over the world. To cement ties between researchers even further, in 2010 Nzihou launched the sector’s first dedicated scientific journal, Waste and Biomass Valorization, and talked Springer – a prestigious publisher – into publishing it. He would be the managing editor from the outset – a more than worthy responsibility for, as summed up by Fritz Schmuhl, senior publishing editor focused on environmental economics at Springer: “Ange Nzihou combined a wealth of sound publications with the support of an impressive group of leading researchers from all over the world."

The journal was very quick off the mark to gain visibility, as it has already acquired its impact factor this year – “which is relatively quick for so young a journal,” remarks Schmuhl, and at a high level already. “A quite exceptional feat,” confirms Patrick Sharrock, “due both to his work and to the thought he has given to the key challenges in this area.” For his part, Nzihou sets great store by his multicultural team, without whom none of this work would have been possible. He also says his peers count a great deal for him and, when he is first starting out on a project, he never thinks twice about asking the opinion of his outstanding colleagues who lend an objective critical eye. Because I am naturally cautious,” explains Ange Nzihou. “Incidentally, I like the martial arts – especially karate where you do not attack until you are sure to hit your target!”

Last but not least, and this is not the least bit paradoxical as far as he is concerned, this ally of big industry also shouts from the rooftops his commitment to serving the public, by giving conferences and working on State or local authority projects in particular: “It seems only normal to me to give something back to this beautiful country, France, which has given me everything and where I have found where I fit in.”
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