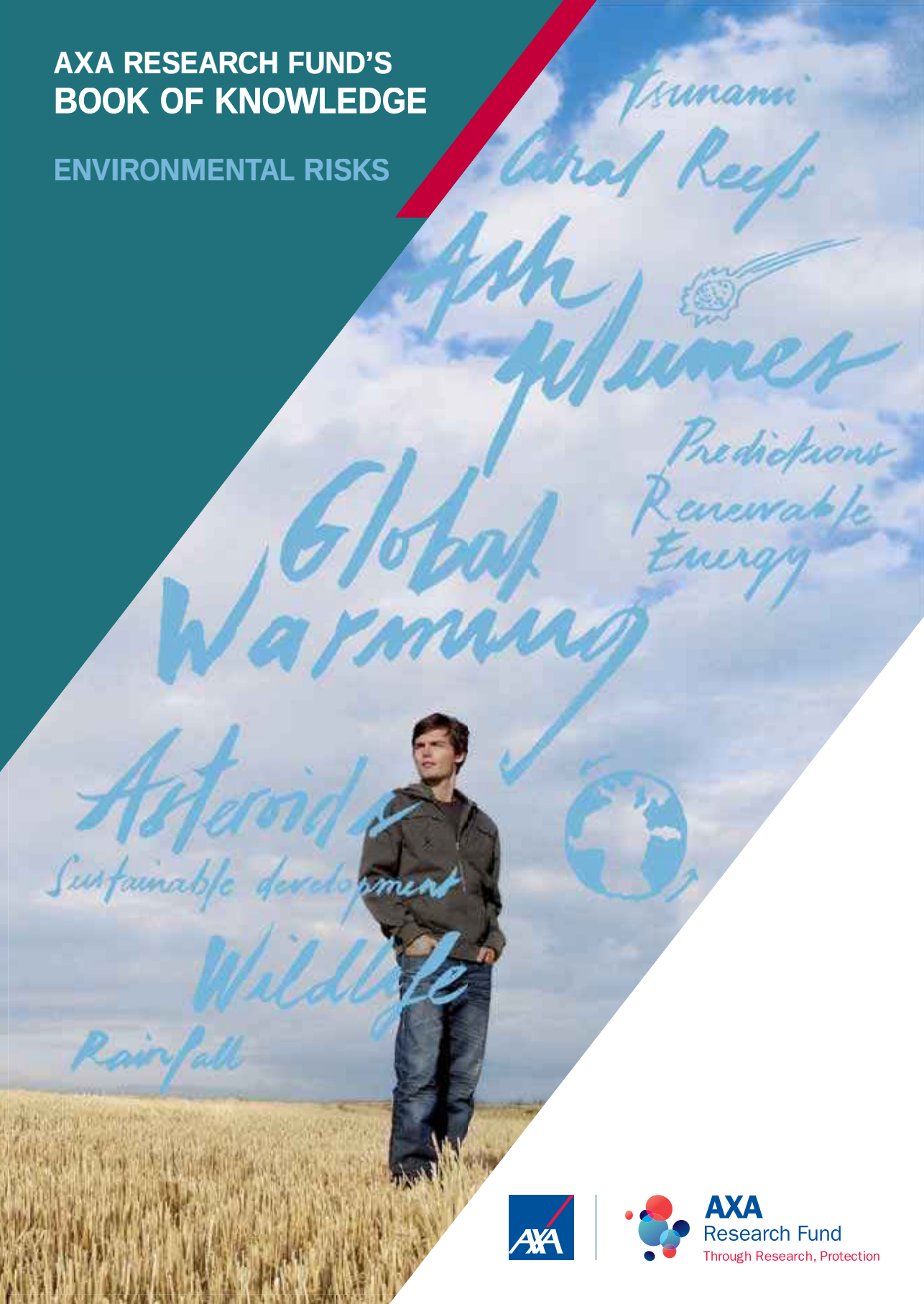
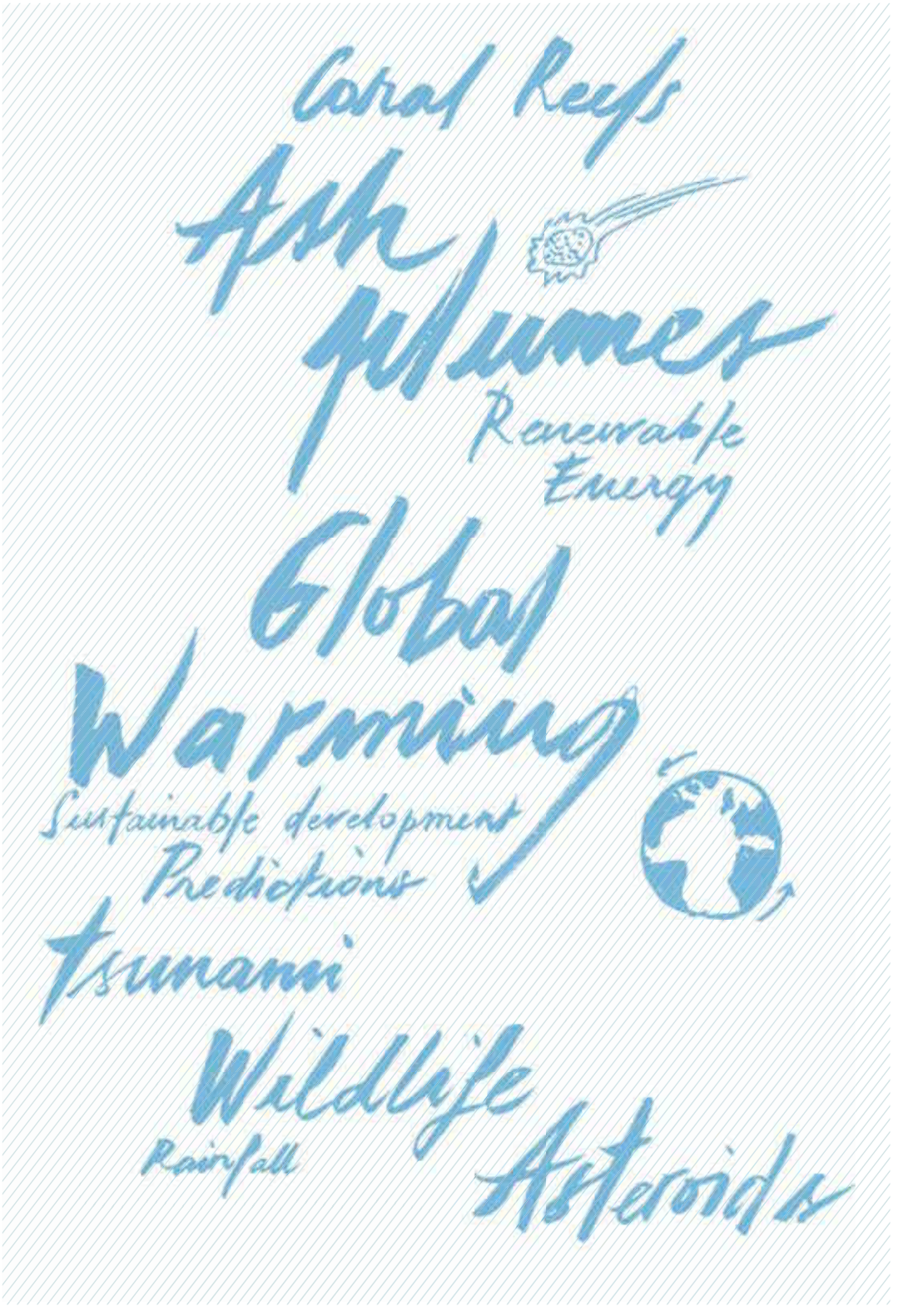
AXA RESEARCH FUND'S BOOK OF KNOWLEDGE

ENVIRONMENTAL RISKS



AXA Research Fund
Through Research, Protection


Coral Reefs
Ash
plumes
Renewable Energy
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Predictions
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Wildlife
Rainfall
Asteroids

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That the nature of the risks we face today has radically changed no longer needs to be demonstrated.
As a leading insurer, our key expertise lies in understanding and managing risk, our key responsibility in protecting people. This means that we have an essential and active role to play in making sure the ever-evolving risk landscape —the greatest risk coming from where it is least expected—is understood by society as a whole.

In 2008 we launched the AXA Research Fund, a philanthropic initiative which supports academic research on risk-related issues, with this in mind. Publicly sharing this research is one of the ways through which we hope to contribute to the engine of human progress.

Henri de Castries

FOREWORD BY JEAN-CHRISTOPHE MÉNIOUX

Chief Risk Officer, AXA Group Risk Management

How would you describe the AXA Group's involvement in protecting society from environmental risks?

Prevention is at the heart of insurance due to the role of insurance companies in society as people protectors, and because the best risk for the company is the risk our clients avoid. In this regard, environmental risks are no exception.
The past few years have been particularly active in terms of natural catastrophes, which have demonstrated the need for prevention. One striking example was 2011, with the succession of natural disasters, including the Tohoku tsunami in Japan, extreme tornadoes in the US and a series of earthquakes in New Zealand. The economic losses associated with natural disasters are following an increasing trend—they nearly tripled from the 1980s to the 2000s. The burden on insurers also is growing. Although this increase in losses is primarily due to a growth in economic exposure, we, as insurers, are more and more concerned about prevention in order to continue to play our role as people protectors vis-a-vis our clients.

Prevention goes hand in hand with knowledge. In my opinion, the role of a global insurer such as AXA, today, is no longer limited to paying for damage. Part of its core mission is to develop understanding and knowledge about risks and, through this enhanced expertise, to support our clients, people and industries in becoming better prepared for evolving potential threats.

Of course, an insurance company has to develop sophisticated models and tools in order to properly identify natural hazards, evaluate their frequency (i.e., the probability of their occurrence) and, ultimately, to estimate their severity in terms of damage costs. Insurance is a key area where the ability to identify and observe risks has developed: by relying on data of increasing volume and precision (e.g., geo-positioning of insurance risks, building characteristics, claims information, etc.), insurer portfolios contain invaluable information about losses and damages observed in the past as well as the vulnerability and exposure to present threats.

However, environmental risks are very complex in nature, and the evolution of such risks is extremely difficult to predict. This is especially true since new effects, such as global warming, are coming into play, which may have a material impact in the future.

"Constant progress and update of knowledge are essential to insurers' risk management and solvency in the long term."

The past may be less and less a reliable predictive indicator for the future, as new emerging risks are likely to step in. Thus, constant progress and update of knowledge are essential to insurers' risk management and solvency in the long term. This is where the AXA Research Fund comes into play. By supporting academic research, it contributes to a deeper understanding of environmental risks, aiming to better assess of all their dimensions.

As research in meteorology leads to a better understanding of the physical processes governing the earth system and progressively resolves uncertainties in climate projections, insurers can adapt and help prepare for the future. They can contribute to shedding light on new (or existing but evolving) risks that could threaten societies and economies in the next 20 to 50 years. Based on enhanced data, risk experts have the means to imagine reliable stress scenarios. More than that, they are well positioned to support industries in turning risks into opportunities—think of the development of green energies, for instance—by redesigning the protection they offer. To do so, coordinated research on emerging risks, both in the public and private fields, is needed. This is one of the objectives sought by AXA through its Research Fund, as research is paramount to help risk experts imagine better stress scenarios.

As Group Chief Risk Officer, how do you see interactions between AXA's Risk Management and the academic work performed by the Research Fund's Grantees?

As a member of the AXA Research Fund's Scientific Board, I have the opportunity and honor to read dozens of research projects each year and to keep track of them once selected. As far as climate research is concerned, a Groupe Risk Management team is dedicated to the assessment of climate risks and associated losses, and thus directly benefits from the outcomes of the research. Some meetings have been organized, producing interesting debates among experts. AXA is funding research on a philanthropic basis, so discussions with scientists are totally voluntary, open and free.

The topics supported by the AXA Research Fund are extremely relevant for today's insurance challenges and give interesting perspectives on likely risk evolutions. I can give a few examples for environmental risks:

- When you consider the losses generated by windstorms in Europe in recent years, you can certainly gain a better view of future forecasts thanks to excellent projects on weather hazards, such as the ones led by Prof. Stephenson, Prof. Gray and Prof. Knippertz.
- When you think about the air traffic disruption the world had to face in 2010, topics such as volcanic ash plume modeling, developed by Prof. Cashman and Prof. Dingwell, are most useful to understand the future socioeconomic risks linked to environmental events. Their funding is particularly timely.
- Another work that contributed to my reflection on challenges that affect our society is Prof. Kerry Sieh's research on natural hazards in Southeast Asia. This topic is particularly relevant as the rise of the sea level may have a severe impact in the future on property and casualty insurance.

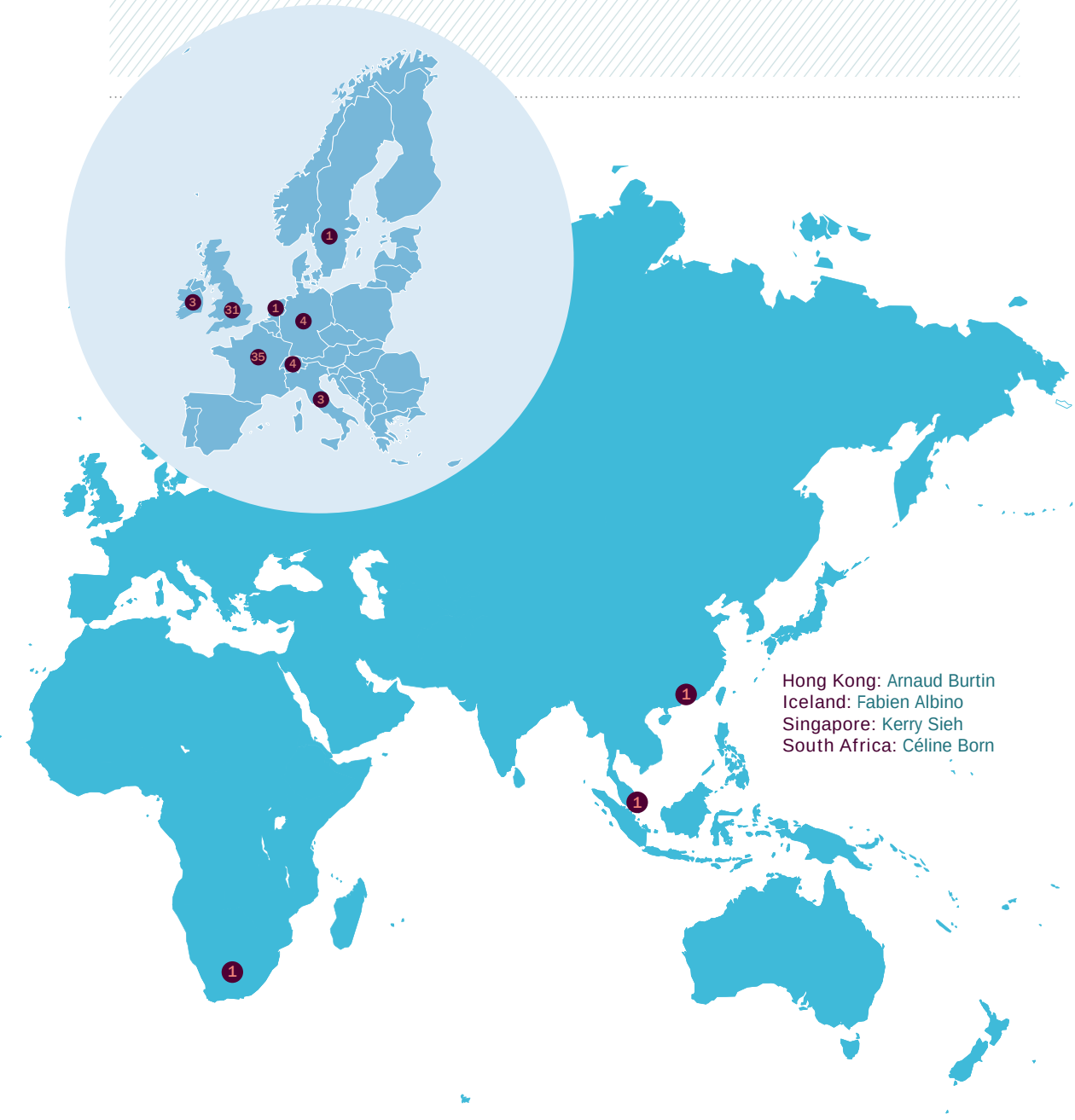
These are just a few examples that drew my attention and had a direct impact on the way my team and I deal with risk assessment. I am pretty sure there are many more to discover in the present installment of the AXA Research Fund's Book of Knowledge! I encourage every risk expert to use it as a starting point in her or his own inquiry about the risks she or he has to evaluate.

OUR RESEARCHERS AROUND THE WORLD

This map only includes Fellows working on Environmental Risks

Canada: Dominique Fasbender
Mexico: Loïc Barbara
USA: Claire Loiseau • David Polishook • Guy Ziv

Denmark: Ruth Fernández-García
France: Fanny Adloff • Swanni Tatiana Alvarado-Romero • Coline Arnaud • Pascaline Bourgain • Anaïs Boué • Delphine Cast • Élodie Chapuis • Élodie Charles • Camille Clerissi • Amandine Cozic-Houly • Esther Delbourg • Anne Duputié • Evelyn Freney • Simon Fresnay • Amaya Fuenzalida-Velasco • François Gemenne • Marie Genet • Katerina Goubanova • Abdou-Karim Gueye • Miho Janvier • Franck Lavigne • Zhun Mao • Lilian Marchand • Vanessa Mulot • Émilie Nolet • Laura Oberhaus • Gaëlle Ouzeau • Margot Pellegrino • Ramon Planet Latorre • Pascal Renard • Augusto Teixeira • Morgane Urli • Marion Vittecoq • Zuo Weiwei • Jianxia Zheng
Germany: Yubin Hu • Nina Keul • Marco Springmann • Uwe Ulbrich
Ireland: Patrick Bresnihan • Ted McCormack • Sophie Murray
Italy: Marco Brogioni • Iunio Iervolino • Giovanna Salomé
Switzerland: Michelle Bollschweiler • Simon Hug • Steven Weijs • Sébastien Wiederseiner
UK: Patricia Brekke • Katharin Cashman • Natasha Chamberlain • Alison Cook • Adam Cowlard • Donald Bruce Dingwell • Matteo Dossena • Sabrina Fossette • Suzanne Gray • Tehnuka Ilanko • Susanna Jenkins • Nancy Jones • Jessica Kandlbauer • Euripides Kantzas • Michael Kember • Peter Knippertz • Olivier Le Polain de Waroux • Valerie Livina • Christine Maggs • Steven Murray • Kelvin Peh • John Pennefather • Michael Sanderson • Atsuko Sato • Ayesha Siddiqi • David Stephenson • Petra Szilágyi • Natalia Vázquez-Riveiros • Rachel White • Rita Yu • Marcin Zielinski



Hong Kong: Arnaud Burtin
Iceland: Fabien Albino
Singapore: Kerry Sieh
South Africa: Céline Born

THE AXA RESEARCH FUND THROUGH RESEARCH, PROTECTION

The AXA Research Fund was created in 2008 on the basis that today's research will help better protect tomorrow. Its core mission is to promote first-class research worldwide in areas associated with environmental, life and societal risks.

It therefore provides researchers with the means, the time and the freedom to complete their work successfully, so that they feel encouraged to explore new avenues.

Since 2008, great flexibility has been offered by the diversity of funding schemes:

Permanent and rotating chairs: Through capital endowment, the Fund helps research institutions create permanent chairs to attract first-rate international scientists.

Calls for projects: The Fund initiates calls for projects, specific or open-ended themes, and thus finances teams of researchers for periods of up to five years.

Fellowships: The Fund provides support for talented young researchers from the outset of their careers, by awarding some sixty doctoral and postdoctoral grants each year.

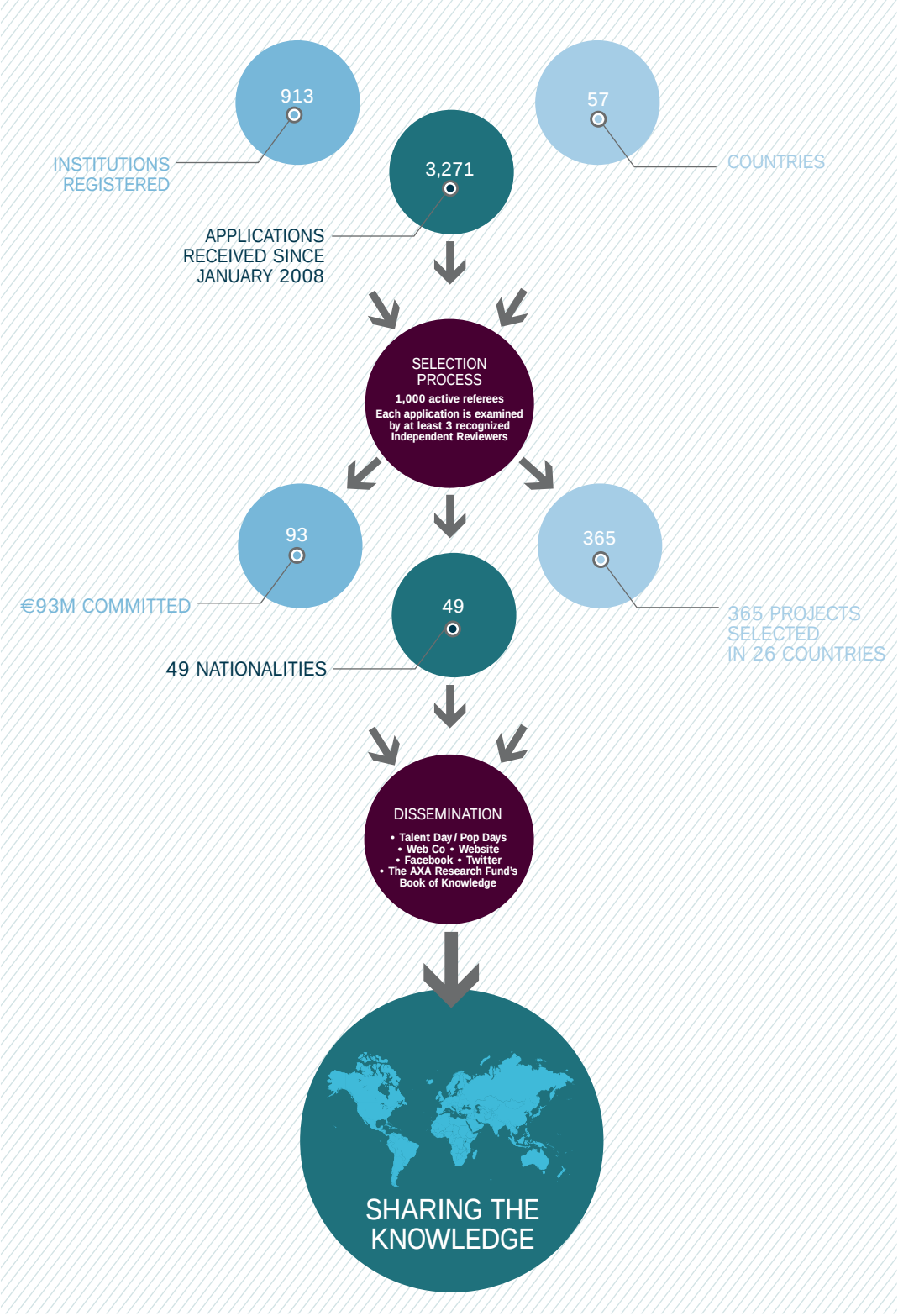
Support by the AXA Research Fund is not limited to funding. We also want our awarded scientists to have a say in the public debate, so that they can actively take part in building a social consensus on emerging risks threatening our societies. We thus provide them with tools enabling them to share their knowledge through:

Access to a dynamic research community composed of our grantees, some of our reviewers and AXA risk experts.

Regular workshops allowing them to:

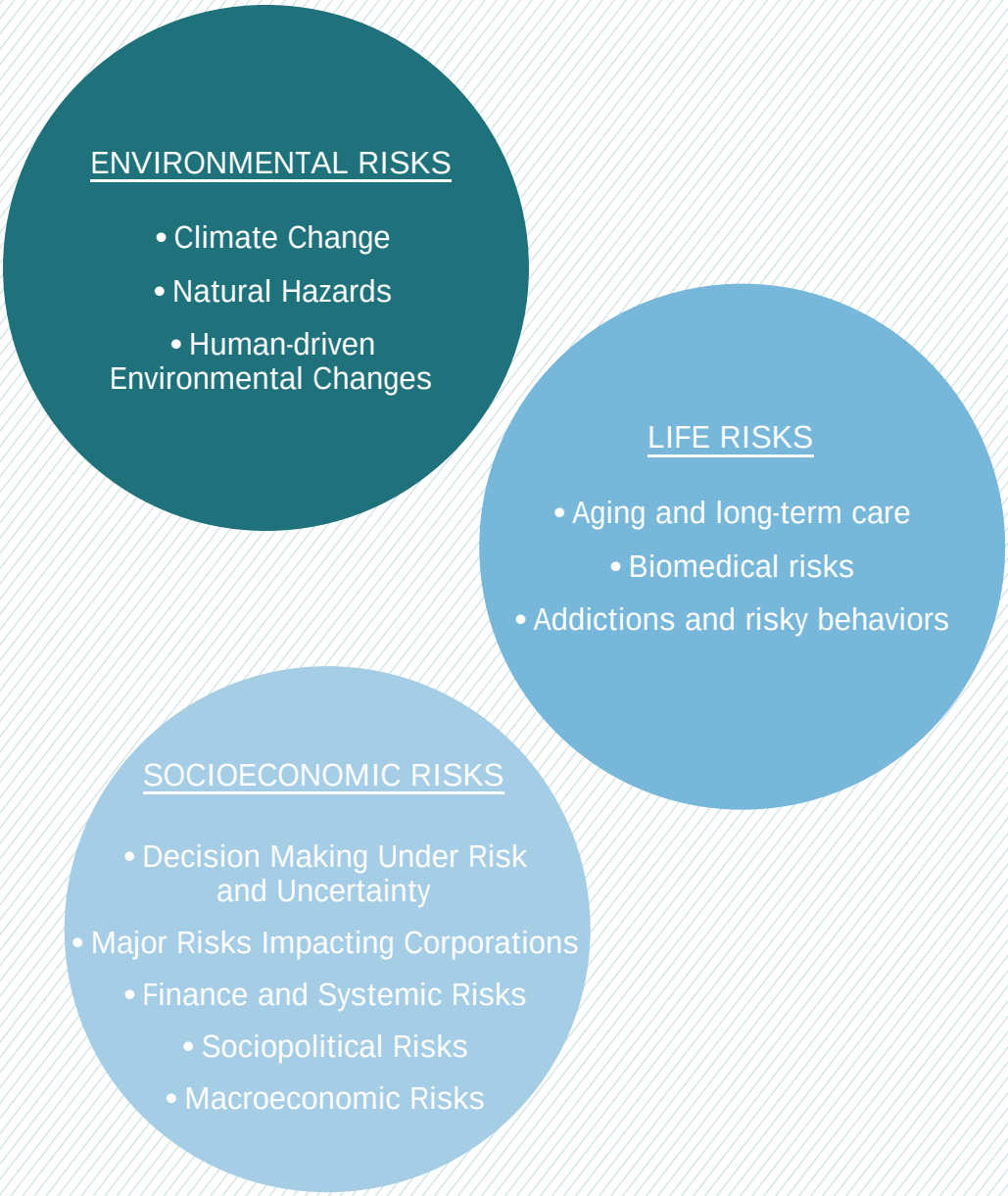
- learn from senior research master classes
- better popularize their research

Shared tools to spotlight their work and publications through printed and online media (The AXA Research Fund's Book of Knowledge, Facebook and Twitter), representing an appealing, popularized and thus concrete introduction to their work.


913
INSTITUTIONS REGISTERED
3,271
APPLICATIONS RECEIVED SINCE JANUARY 2008
57
COUNTRIES
SELECTION PROCESS
1,000 active referees
Each application is examined by at least 3 recognized Independent Reviewers
93
€93M COMMITTED
49
49 NATIONALITIES
365
365 PROJECTS SELECTED IN 26 COUNTRIES
DISSEMINATION
• Talent Day / Pop Days
• Web Co • Website
• Facebook • Twitter
• The AXA Research Fund's Book of Knowledge
SHARING THE KNOWLEDGE

ELIGIBLE RESEARCH FIELDS

Applications must be related to one of the subjects identified by the AXA Research Fund Board:



OUR SELECTION PROCESS

Our grants are awarded after a transparent and in-depth selection process: each application is examined by at least three recognized independent reviewers, who are able to give their opinion in complete freedom and anonymity, before being finally selected by the AXA Research Fund Scientific Board.

Criteria used to make the scientific and academic assessment of all applications are:

Academic excellence

The institution's reputation for academic excellence

Quality of its research: publication in scientific reviews, presence of internationally renowned researchers

Quality of the research environment and working conditions offered to researchers

Relationship to the international community: international impact of the research carried out

International reach/international scope of the host laboratory

Academic excellence of the project

Scientific originality and innovative nature of the project

The project's contribution to strengthening international networks

Robustness of the project

Consistency between the research project and the institution's long-term development policy
Operational strength and quality of the organization set up to support this project

Academic excellence of the Chair Holder, Principal Investigator, Doctoral or Postdoctoral candidate (publications, prizes and awards, participation in colloquia, etc.)

Additional criteria

For applications with equal levels of academic excellence, the following additional criteria may apply:

Diversity of topics:
Applications that focus on topics that have not been previously funded or have received less funding

Geographic diversity:
Applications that come from emerging new research centers with an ambitious long-term strategy, to help them emphasize their role in the international scientific arena

Mobility:
Applications that involve international mobility

SCIENTIFIC BOARD

CHAIRMAN

Professor Ezra Suleiman,
IBM Professor of International Studies and Professor of Politics at Princeton University (USA)
Member of the Board of Directors of AXA Equitable USA
Member of the Board of Directors of Suez Environnement

Since the inception of the AXA Research Fund, Prof. Suleiman, President of the Scientific Board, has played a key role in helping the Fund fulfil its goal of strengthening international networks and fostering cooperation between the academic and the corporate worlds. He helped establish the AXA Research Fund's operating and project selection process which ensure that the Fund respects the highest standards of excellence in all its activities.
Prof. Suleiman embodies the Fund's ambitions: an American citizen, he has taught and worked in many European Academic Institutions. He has forged strong connections with Europe, sharing the AXA Research Fund's vision of a worldwide and connected scientific community.
A graduate of Harvard and Columbia Universities, Professor of Political Science at Princeton University (IBM Chair), he has also established solid relationships with the corporate world through his presence on several Boards, both in the United States and Europe (AXA, SUEZ Environnement and AXA Equitable). He stands as an ambassador to the importance of dialogue between the academic and business worlds, dialogue that has resulted in greater support of research and spread of knowledge.

ACADEMIC MEMBERS

Professor José A. Scheinkman

Theodore A Wells '29 Professor of Economics, Princeton University (USA)

Prof. Scheinkman is an expert in Financial Mathematics. He has made advances in his field with his work on dynamic optimization theory, optimal growth theory, and nonlinear dynamics with its applications in economics and finance. He is an elected member of the National Academy of Sciences (USA), and a member of the Scientific Council of the Europlace Institute of Finance (France).

Professor Lawrence Lessig

Lawrence Lessig is the Roy L. Furman Professor of Law at Harvard Law School, and director of the Edmond J. Safra Center for Ethics at Harvard University

Prior to joining the Harvard faculty, Prof. Lessig was a professor at Stanford Law School and at the University of Chicago.
Prof. Lessig serves on the boards of Creative Commons, MAPLight, Brave New Film Foundation, Americans Elect, the AXA Research Fund and iCommons.org and on the Advisory Board of the Sunlight Foundation. He is a Member of the American Academy of Arts and Sciences, and the American Philosophical Association, and has received numerous awards, including the Free Software Foundation's Freedom Award and Fastcase 50 Award, and was named one of Scientific American's Top 50 Visionaries.
Prof. Lessig holds a BA in Economics and a BS in Management from the University of Pennsylvania,

The Scientific Board is composed of 13 respected individuals - researchers, international experts in their fields and AXA representatives. It is chaired by Prof. Suleiman

an MA in Philosophy from Cambridge, and a JD from Yale.

Professor Pascale Cossart

Head of the Bacteria-cell interactions Unit, Director of the Cell Biology and Infection Department, INSERM, Pasteur Institute (France)

Prof. Cossart is an expert in microbiology and chemistry, and is the foremost authority on Listeria monocytogenes, a deadly and common food-borne pathogen responsible for many diseases. Her work has led not only to a better understanding of this pathogen in particular, but also to a better understanding of bacterial infections in general. She is a member of the French Academy of Sciences and was formerly President of the Pasteur Institute's Scientific Board.

Professor James Vaupel

Founding Director of the Max Planck Institute for Demographic Research (Germany)

Director of the Center on the Demography of Aging, Duke University (USA)

Professor, Institute of Public Health, University of Southern Denmark

He recently won the European Lastis Price

Prof. Vaupel is an expert on aging research and demography, including biological and mathematical demography. In 1994, his finding that mortality is being postponed at older ages is a fundamental discovery about the biology of human aging. He is also known for his research on the heterogeneity of mortality risks, the deceleration of death rates at the highest ages, mortality forecasts and the policy implications of longer lives. He is a Member of the Max Planck Society, the German Academy of Sciences Leopoldina, the US National Academy of Sciences and the American Academy of Arts and Sciences.

Professor Daniel Laurent

Professor of Computer Science - Université Marne-La-Vallée

Scientific Counselor to the Chairman of the Board of Directors, AXA

Prof. Laurent is the former Vice-Chancellor of the Universities of Paris and the founder and first president of Marne-La-Vallée University. He is Member of the "University-Employment Commission", Co-Chairman of the "Professional Training Committee" set up by the French Minister of Education Valérie Pécresse and the Minister for Employment Xavier Darcos. He has contributed to many publications on education and research in France, especially for the Institut Montaigne.

Professor Brian Hoskins

Director of the Grantham Institute for Climate Change, Imperial College

Professor of Meteorology, Reading University (UK) Sir Brian Hoskins is a weather and climate scientist who is perhaps best known for his work on understanding fronts and cyclones and has produced research across many areas of meteorology including monsoons and teleconnections. He is currently a member of the UK Committee on Climate Change. He was knighted in 2007 for his services to the environment. He is a member of the scientific academies of the UK, USA and China, and has played significant roles in international weather and climate research and in the Nobel Prize winning international Climate Change Assessments.

AXA REPRESENTATIVES

Eric Chaney

Chief Economist, AXA Group, AXA Investment Managers SA

Anne-Juliette Hermant

Head of Global Learning and Development, AXA Group

Jean-Christophe Ménioux

Chief Risk Officer, AXA Group

George Stansfield

Head of Human Resources,

Member of Group Executive Committee

AXA Group General Counsel

Lucie Taleyson

Technical and Marketing Director, AXA Group Life Solutions

Véronique Weill

Chief Operating Officer of the AXA Group and Member of the Group Executive Committee. Supervision of Group Information Systems, Operational Excellence Divisions, Group Marketing and Distribution Divisions, Group Procurement and Central Administration (GIE AXA)


1.
Antarctic
CLIMATE CHANGE
Biosphere
Ocean
Seasons
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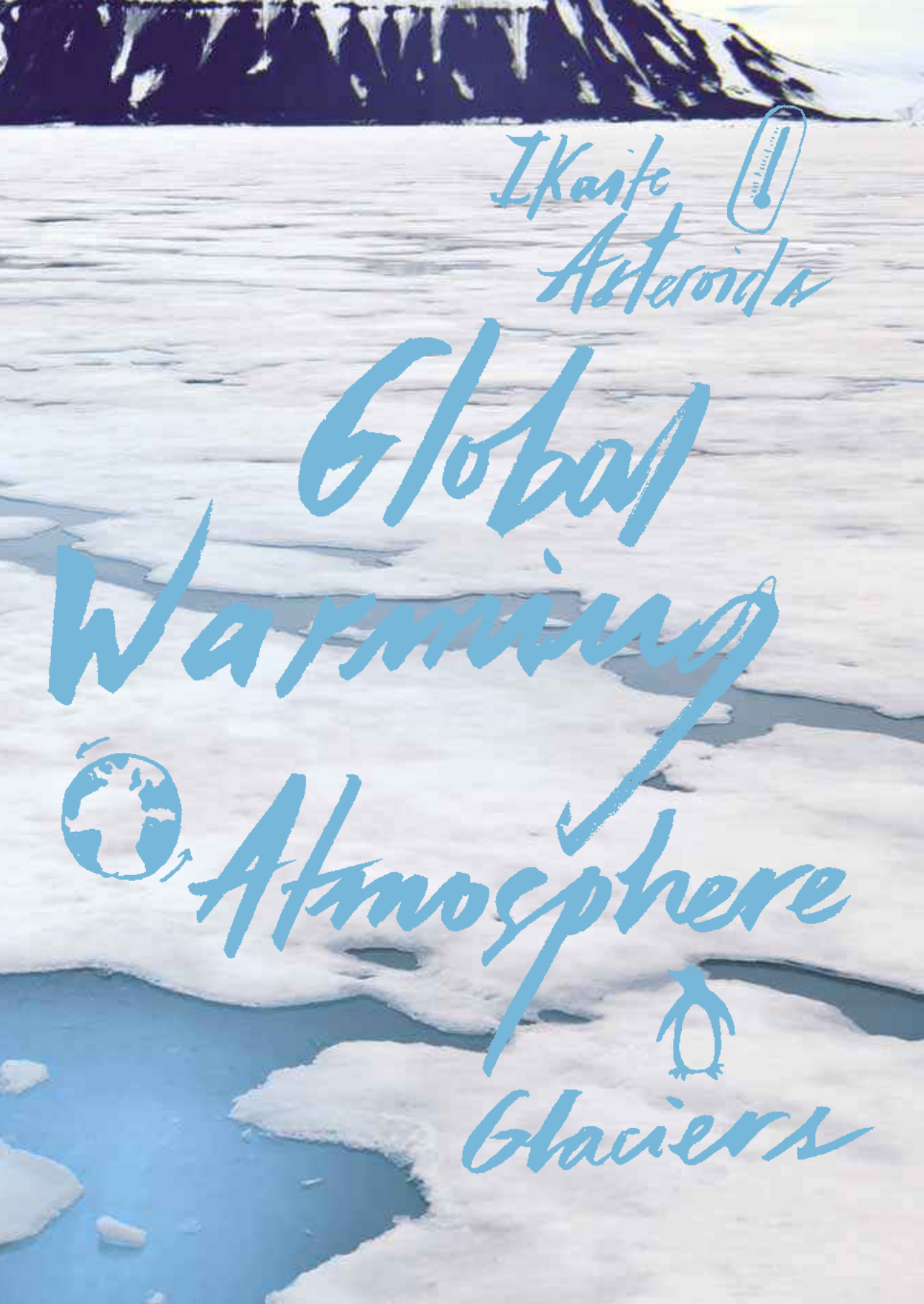
Ikaite
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Glaciers


Seasons
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Atmosphere
Biosphere
Asteroids
Antarctic

INTRODUCTION TO CLIMATE CHANGE

by Professor C. L. Johnny Chan

Professor Johnny C. L. Chan
School of Energy and Environment
City University of Hong Kong (Hong Kong)
Reviewer for the AXA Research Fund

Johnny L. C. Chan is currently Chair Professor of Atmospheric Science, Dean of the School of Energy and Environment and Director of the Guy Carpenter Asia-Pacific Climate Impact Centre at City University of Hong Kong. He is a Fellow of the American Meteorological Society and has published over 150 international journal articles.

It is beyond doubt that global temperature has been rising especially during the last 50 years. While part of this increase may be attributable to natural variability, the contribution from human activities through the emission of greenhouse gases,* notably carbon dioxide and methane, is unequivocal. Indeed, the current concentrations of these gases in the atmosphere are the highest in at least the last 400,000 years, if not longer.

Such a rise in global temperature has led to significant impacts in our earth system. Occurrences of extreme weather events such as heat waves, bitter cold winters, heavy precipitation and severe droughts have become more frequent. Glaciers and polar ice caps have been melting at a fast pace. Frequent occurrences of extremely low or high temperatures have contributed to more loss of lives and increases in diseases while heavy precipitation has caused more flooding in many places. Flooding in coastal areas is further exacerbated by the sea-level rise due to the melting of the polar ice caps. Severe droughts have brought about crop failures and starvation in many impoverished countries. In addition to the effects of humans, climate change has also affected the entire ecosystem, which includes the disappearance of many species of plants, insects and animals.

The effects of climate change on the entire earth system are therefore profound. While every effort is needed to mitigate the potential damages caused by climate change through energy conservation and efficiency, a switch to non-fossil fuels, carbon sequestration, etc., studies of the types of climate change that have already occurred and how society could adapt to the anticipated changes are equally important. The managers of the AXA Research Fund should thus be applauded for supporting young researchers to investigate problems related to climate change, from paleoclimatology to the prediction of future climate. The results from these investigations will provide solid foundations for further research for the benefit of our delicate earth system.

THE WHIMS OF A STAR

Doctor Miho Janvier

3D simulation of magnetic island dynamics during solar flare events

Doctor Miho Janvier
Postdoctoral Fellow
Observatoire de Paris (France)
€120K (2 years)

Does the prospect of the world coming to an end scare you? Rest assured, there are more pressing matters at hand, such as the whims of our old friend the Sun. Did you know that the sun is a changeable star, which follows an 11-year behavior cycle during which its intensity varies, thus changing the risks for the Earth?
The evolution of the sun's activity is directly linked to changes in its magnetic topology.* Regions of intense magnetic activity—aka sunspots*—appear as dark patches on the sun's surface, regularly releasing massive amounts of energy during so-called solar flares. Associated with these flares are violent bursts of plasma, otherwise known as coronal mass ejections which travel within solar winds until they reach the Earth. These induce geomagnetic storms with the power to disrupt entire electrical grids, satellites and commercial flights.

Yet, the start of a new solar cycle in 2008 marked the beginning of a three-year period of intense activity, which is of major interest to Dr. Janvier. Indeed, with heightened solar activity, the number of unpredictable magnetic disruptions is bound to increase, and this is where her work on 3D simulation steps in.
First, Dr. Janvier is investigating and performing 3D modeling of the dynamics involved in magnetic reconnection—the crucial point where magnetic field lines come so close to each other that they connect and release a massive burst of energy. This "reconnection" phenomenon is the focus of her work and, in the long run, the key to a better understanding of space physics as well as plasmas involved in the generation of nuclear fusion power. Secondly, this highly transient "reconnection" episode is believed to be one of the most efficient ways to convert stored-up magnetic energy into heating and thermal energy.

Considering that her achievements cover both fusion science and astrophysics, Dr. Janvier's work may not only lead to better predictions of space weather and a better understanding of nuclear fusion, but it also may result in better prevention of the consequences of geomagnetic storms on human lives and infrastructures.

SAVING ONE OF UNESCO'S WORLD HERITAGE SITES

Doctor Loïc Barbara

Studying the impact of climate change on the environment in the Gulf of California using sediment records and past environmental reconstructions

Doctor Loïc Barbara
Postdoctoral Fellow
Universidad Nacional Autónoma de México (México)
€120K (2 years)

If one of your dreams is to spend your holidays on the Gulf of California, you should plan your trip as soon as possible! Indeed, you may not be aware of it, but this beautiful region, listed as a World Heritage site by UNESCO, is extremely responsive to global warming* and is one of the most rapidly changing areas on Earth. The challenge of Dr. Loïc Barbara's postdoctoral research is to understand why this is so. This is a crucial question, as global warming* could change the extraordinary biodiversity* of the Gulf and threaten several fish species, which would in turn impact the fishing industry. The latter plays an important role in the Mexican economy and provides work to many people in the area.

For his study, Dr. Barbara will work on a reconstruction of environmental changes in the southern part of the Gulf of California over the last 6,000 years. The originality of his project stems from the comprehensive analyses of sediment* records that he will conduct. Dr. Barbara will apply robust dating techniques and will use diatoms,* which are microscopic algae fossilised in sediments. Each diatom species lives under specific conditions, e.g. at a given temperature, thus providing valuable information on the environmental conditions during its lifetime. Dr. Barbara will also carry out chemical analyses on sediment cores in order to study past rainfalls and river discharges in this region.

By investigating the past evolution of environmental conditions in the Gulf of California, Dr. Barbara hopes to unravel interactions between the ocean, the atmosphere and the biosphere* at different time scales. His work might bring a significant contribution to the scientific community working on the Gulf of California and particularly to scientists from the IPCC (Intergovernmental Panel on Climate Changes). His findings could also contribute to the Mexican National Agenda on Climate Change, a program created by the Mexican government and aimed at adapting the country to changing environmental conditions, by providing information for regional climate prediction models.

AN UNPREDICTABLE TEMPER

Anticipating the approach of critical thresholds in the earth's response to climate change

Doctor Valérie Livina
Postdoctoral Fellow
University of East Anglia (UK)
€60K (1 year)

Small changes in the climate may have serious consequences for our planet. Whether we can predict them or not is what Dr. Valerie Livina is studying. Due to human-induced global warming,* several components of the earth's system could cross critical thresholds and switch to different states. For instance, in the future, the Arctic sea ice could entirely melt during summer. The West African monsoon could be strongly disrupted, inducing severe droughts. Dr. Livina is developing novel statistical methods for the analysis of time series of data in order to identify potential indicators of the approach of critical thresholds. Dr. Livina's work might help anticipate, detect and forecast them, which is crucial for the development of sustainable strategies by policy makers. It could therefore have significant consequences for the future evolution of the climate on our planet.

SURVIVING IN AN ACIDIFYING OCEAN

Investigating how calcifying organisms such as plankton and corals will respond to ocean acidification

Nina Keul
PhD Fellow
Foundation Alfred Wegener Institute for Polar and Marine Research (Germany)
€120K (3 years)

Are you aware that the ocean is getting more acidic? No need to be concerned about swimming in the ocean. Yet this may have serious consequences for corals and plankton! And once again, our carbon emissions are responsible for this problem. Nina Keul investigated to what extent marine calcifying organisms may be affected by ocean acidification. The question is relevant because these tiny organisms play an important role in the marine ecosystem. Ocean acidification may thus indirectly have a major ecological and economic impact. For her study, Keul grew marine calcifiers in her laboratory and put them under increasing acidic conditions. She was surprised to observe that some species were more tolerant of acidic conditions than expected, depending on the way they calcify. Yet, this should not dissuade us from reducing our carbon emissions!

PAST INTERGLACIALS

Paleoceanographic constraints on climate sensitivity

Doctor Natalia Vazquez Riveiros
Postdoctoral Fellow
University of Cambridge (UK)
€60K (1 year)

What can we learn from the past? Foraminifera, small fossils preserved in marine sediments, register the characteristics of the water they lived in, such as temperature or sea level, providing records of climate variations in the past. Over the last 500,000 years, the earth's climate has witnessed strong glacial-interglacial changes. Some of the recent warm periods followed weak orbital changes, whereas others hardly responded to strong forcing. Dr. Natalia Vazquez Riveiros is trying to understand the reasons behind these differences. How does atmospheric CO_2 amplify these changes? What is the role of oceanic circulation on different climate states? Her study aims to understand the mechanisms that have been at work during past climate periods, to improve estimates of earth's climate sensitivity and assess the capacity of climate models to predict global warming.*

SIMULATING MEDITERRANEAN SEA-LEVEL RISE

Climate change scenario of Mediterranean Sea level: a multi-component regional climate modeling approach

Doctor Fanny Adloff
Postdoctoral Fellow
Météo-France / CNRM / GAME Laboratory (France)
€120K (2 years)

Major destination for international tourism, characterized by growing immigration, the coasts of the Mediterranean Basin are highly vulnerable to rising sea levels and therefore closely monitored. However, numerical climate simulations do not agree on future sea-level elevation. "They examine global geophysical effects but are unable to accurately describe the local processes that affect water masses—and therefore sea level," explained Dr. Adloff. To bridge this gap, she is participating in developing a new regional ocean model which incorporates all factors that contribute to the variations in Mediterranean Sea level, such as water exchange through the Strait of Gibraltar and atmospheric circulation. This type of model, combined with studies on coastal erosion in particular, will contribute to mapping areas at risk for the decades to come.

AEROSOL-CLOUD INTERACTIONS

Influence of anthropogenic emissions on particle-cloud interactions

Doctor Evelyn Freney
Postdoctoral Fellow
Université Blaise Pascal (France)
€60K (1 year)

Without them, there would be no clouds. Aerosols are essential for the formation of cumulus,* cirrus* and stratus clouds. They also affect the clouds' ability to reflect sunlight. "These particles play a major role in the climate system," stated Dr. Evelyn Freney. "However, the impact of anthropogenic emissions on global warming is still under debate." Through a combination of aerosol size and composition measurements, she strives to accurately describe the interactions between these particles and water droplets, which are the precursors of clouds. This data will then be incorporated into weather and climate models in order to improve their accuracy and contribute to developing new emission control protocols.

UNCERTAINTIES UNDER EXAMINATION

Predictability of high-impact weather events: sensitivity to upper-level atmospheric anomalies

Simon Fresnay
PhD Fellow
Université Paul Sabatier, Toulouse III (France)
€120K (3 years)

As powerful as they may be, numerical weather prediction models still contain uncertainties. In particular, their ability to represent multi-scale processes remains imperfect due to the nonlinear dynamics of the atmosphere. Rather than trying to combat these uncertainties, Simon Fresnay is examining them using simulations of upper-level atmospheric anomalies, which are precursors of storms and floods. "We need to better manage uncertainties in order to better manage emergencies and know when to activate warning systems." One promising way to reach this aim is to simultaneously use models with slight perturbations for the same forecast. The first results on flooding in southeastern France showed that the forecast was highly sensitive to small changes to upper-level atmospheric anomalies.

SPACE WEATHER FORECAST: SOLAR STORM WITH A CHANCE OF BLACKOUT

Fields and Flares: understanding the complex magnetic topologies of solar active regions

Sophie Murray
PhD Fellow
Trinity College Dublin (Ireland)
€120K (3 years)

Cell phones, Internet, TV, GPS, weather forecasting. These technologies are now fundamental pillars of our societies. Losing them, even for a few minutes, could literally paralyze our society and cost enormous amounts of money. And yet, since these technologies are relayed by our satellites, they are threatened by our Sun. Our star regularly sends toward us huge amounts of energetic particles during solar eruptions to which satellites are very sensitive. While we are not yet able to predict these eruptions, Sophie Murray is studying their cause: sunspots. These are small dark spots that appear on the surface of the Sun, which can create violent and sometimes huge ejections of matter. Murray's objective is to get closer to understanding them in order to be able to predict solar eruptions someday and thus prevent the risks of communication and electricity disruptions.

ARMAGEDDON: SCIENCE FICTION OR REALITY?

Investigating the nature of asteroids approaching the earth in order to better assess their disintegration processes and the potential risks for humanity

Doctor David Polishook
Postdoctoral Fellow
Massachusetts Institute of Technology (USA)
€120K (2 years)

You think that asteroid impacts on Earth are only seen in movies? This is not true! The risk is real, and that explains why Dr. David Polishook is working on the assessment of this threat coming from above. Recent observations have shown that asteroids approaching our planet are not made of one big rock but rather of a collection of small-sized rocks. This raises new questions about the potential consequences of asteroid impacts. To learn more about the shattered nature of asteroids, Dr. Polishook will carefully analyze a large number of observations from space and ground telescopes. His work should provide a fine description of the properties of potentially hazardous asteroids, which might help develop appropriate mitigation strategies. Dr. Polishook's work might also contribute to the definition of new targets for NASA's future missions.

IKAITE: THE NEW CELEBRITY OF THE CARBON CYCLE?

Studying how ikaite forms in sea ice in order to better understand its role in the carbon cycle

Yubin Hu
PhD Fellow
Foundation Alfred Wegener Institute for Polar and Marine Research (Germany)
€120K (3 years)

Never heard of ikaite?* Don't worry! That's probably because this rare mineral ($CaCO_3.6H_2O$) has only been recently discovered to appear in sea ice. Despite its tiny size (µm), the formation of ikaite could lead to CO_2 flux out of sea ice, while its dissolution could lead to the absorption of CO_2 from the atmosphere. Yubin Hu's current research investigates the role played by ikaite, which may contribute to an accurate understanding of its role in the carbon cycle*—a crucial issue for global warming prediction. Hu will explore the mysteries of ikaite formation based on laboratory experiments. He will use state-of-the-art scientific equipment to reproduce the conditions of polar sea ice. Hu's results may give a clue as to whether ikaite should be accounted for in climate models such as that of the Intergovernmental Panel on Climate Change (IPCC).*

AN ICE-BREAKING STUDY

Investigating the recent evolution of the upper Arctic Ocean in order to better understand the recent drastic sea ice melt

Pascaline Bourgain
PhD Fellow
Université Pierre et Marie Curie (France)
€120K (3 years)

You are certainly aware that polar bears are threatened by the Arctic sea-ice loss caused by global warming. This debated topic is being investigated by Pascaline Bourgain, who is studying the effects of warm water entering the Arctic Ocean.
One of the strengths of her study is that she analyzed huge amounts of data as well as obtained new measurements during an unforgettable three-month icebreaking expedition in the Arctic. At a global scale, sea-ice loss is a serious threat to ecosystems (disturbance of fauna and flora) and physical systems (e.g. ocean circulation). It affects the entire human population, particularly the Inuits, who are forced to adapt their way of life to changing sea-ice conditions.

KEEPING TABS ON ICE MELTING

Changes in glacier and ice shelf extents in a climate warming hot spot – the Antarctic Peninsula

Alison Cook
PhD Fellow
Swansea University (UK)
€120K (3 years)

The Antarctic Peninsula (AP) is both one of our planet's coldest locations and a major climate warming "hot spot," thought to be one of the largest contributors to the current rise in sea level. Alison Cook was not put off by the cold, however: she explored this remote and harsh area to gather data and survey glaciers over the course of three expeditions. The geometry and dynamics of glaciers have changed over the past century in this region. Cook is trying to identify the main drivers of glacial retreat, with particular attention to climatic conditions. Her innovative approach combines satellite imagery and aerial photographs to provide comprehensive coverage of the changes over a wide area. Her ultimate aim is to deliver a Geographic Information System (GIS) database of AP glaciers in order to identify patterns of change. She hopes to enable better predictions of glacier response to climate change over the next century in this sensitive region.

FROM GLOBAL SCENARIOS TO REGIONAL IMPACT

Regional impact of climate change on the atmospheric forcing over the Chile-Peru upwelling system

Doctor Katerina Goubanova
Postdoctoral Fellow
CNRS - Université Toulouse III - Paul Sabatier (France)
€90K (1.5 years)

Did you know that about 20% of the world's fish catch comes from a near-coastal region off Peru-Chile—an area accounting for only 1% of the ocean's surface? This wealth of fish resources is due to upwelling of cold, nutrient-rich waters induced by dominant southerly wind. Imagine how important it is to assess the impact of global warming on coastal upwelling! Yet, the coarse-resolution climate models used to obtain future climate projections do not allow it to be accurately represented. Dr. Goubanova seeks to fill this gap. Taking advantage of satellite data, she developed a statistical method for estimating regional upwelling-favorable wind from global climate scenarios. This approach will provide ocean modelers with realistic high-resolution atmospheric forcing and might be of use to regional risk assessors and fishery management.

SOMEWHERE OVER THE TROPOSPHERE

Stratospheric influence on monthly to seasonal climate predictability

Gaelle Ouzeau
PhD Fellow
CNRM-GAME (France)
€120K (3 years)

In 1999, three extreme storms hit Europe, taking more than 130 lives and causing about 130 billion euros in economic losses. Today, dynamical seasonal forecasting systems are mainly based on oceanic forcing, but they remain particularly poor in the northern extratropics, including over Europe, where the variability is only weakly influenced by oceanic conditions. To improve the forecasting from monthly to seasonal timescales, Gaelle Ouzeau is looking for additional sources of long-range climate predictability and studying the stratosphere,* the second major layer of Earth's atmosphere. She will develop and test a seasonal forecasting system using both oceanic and stratospheric* sources of climate memory, combined with dynamical and statistical tools. Her results may enable better prediction of extreme climate events, such as cold spells over Europe in the winter, which could be rougher in the coming decades.

LIFE IN PLASTIC IS FANTASTIC

New technologies to reduce CO_2 emissions: using CO_2 to make plastics

Doctor Michael Kember
Postdoctoral Fellow
Imperial College London (UK)
€60K (2 years)

There was a time when men wanted to turn lead into gold. Today, as the reduction of our CO_2 emissions is an absolute necessity, the supreme quest of alchemy could be turning CO_2 into plastics. And Dr. Michael Kember could be the 21st century alchemist. While societies strive to reduce their CO_2 emissions, new strategies are being developed to capture waste CO_2 instead of releasing it to the atmosphere. One strategy it is to store the CO_2 underground. However, this procedure is costly and long-term storage is risky. Working in sustainable chemistry, Dr. Kember suggests an alternative option: using waste CO_2 to make plastics, which are currently manufactured from fossil fuels. He has developed a new, robust class of catalysts* which could make the development of plastics from low pressure waste CO_2 streams a possibility: CO_2 would then turn from a polluting component to a raw material to manufacture part of the plastics our society needs.

WHAT PROCESSES DETERMINE THE WAVE CONDITIONS IN THE PRESENT AND FUTURE CLIMATE?

Doctor Elodie Charles

Climate change impact on wave climate in coastal area using dynamical downscaling: Application to the Aquitanian coast, France

Doctor Elodie Charles
PhD Fellow
BRGM (France)
€120K (3 years)

Coastal areas, which are characterized by a high density of population, transportation and activities, are particularly vulnerable to external marine influences. They can be subject, among others, to marine submersion or coastal erosion. The Aquitanian coast, as well as most coastal regions, is influenced by several hydrodynamic factors, such as sea level, waves, currents and storm surge. These factors can be affected by climate change. Dr. Elodie Charles investigated the impact of climate change and certain patterns of the atmospheric circulation on the wave conditions in the Bay of Biscay and along the Aquitanian coast.

Her first step was to produce a wave database of wave conditions (height, period and direction) in the Bay of Biscay for the present and future climate. Using dynamical downscaling, waves were modeled from the North Atlantic Ocean towards the Bay of Biscay at a 10-km spatial resolution exclusively from wind. Waves were simulated using the WAVEWATCH III wave model for the present climate (wind obtained from the ERA-40 reanalysis) and three future greenhouse gas emission scenarios (A2, A1B, B1) (wind obtained from the ARPEGE-Climat climate model).

This database enabled her to investigate the present climate interannual variability and to highlight a strong link between local wave conditions and certain preferential patterns of the atmospheric circulation above the North Atlantic Ocean. For instance, a larger gradient between the Iceland high and the Azores low, corresponding to a positive phase of the North Atlantic Oscillation, is strongly related to an increase in wave heights and periods in the Bay of Biscay. In terms of the future climate, wave condition changes between present climate (1961-2000) and future scenarios (2061-2100) were analyzed, showing a general decrease in wave heights in the Bay of Biscay as well as a clockwise shift of summer wave directions and winter swell directions.

This work provides a better understanding of the present and future wave climate in the Bay of Biscay and new material to investigate the potential impact of climate change on the morphodynamics of the Aquitanian coast.

KEEPING AN EYE ON THE EARTH'S LAST UNEXPLORED CONTINENT

Doctor Marco Brogioni

Study of the temperature evolution in Antarctica: a contribution to monitoring global warming

Doctor Marco Brogioni
Postdoctoral Fellow
CNR-IFAC (Italy)
€80K (1 year)

Antarctica is icy—probably icier than you think. It is so icy that it could elevate the global sea level by more than 60 meters if it melted entirely. It is also so cold and so wide that it affects the climate of the whole earth. It is thus hardly surprising that this huge continent deserves the attention of the scientific community. Regrettably, such environmental conditions make conventional exploration and monitoring—or even human life—almost impossible.

Thanks to optical satellite sensors currently monitoring Antarctica several times a day, scientists have been able to give a rough estimate of its surface temperature. Unfortunately, we do not know whether the temperature remains stable or not, even though this would make a big difference for the future of mankind.

One weakness of optical sensors is that they can become blind if weather conditions are not good and therefore, they are not always able to provide information on temperature. Moreover, they only have access to the snow surface of the ice.

To overcome these limits, Dr. Marco Brogioni has decided to use the microwave passive satellite sensors* to retrieve temperature information. His idea is to extend this approach, which is currently used in some parts of Antarctica, to the whole continent. This method has two main advantages: not only can electromagnetic waves* see through clouds, but they can also see the subsurface of ice. They can penetrate the snow surface up to one meter deep. The inner part of the ice is in fact more stable, as it is much less influenced by meteorological conditions, such as the intensity of the sun or the presence of clouds. This means that the data retrieved from the subsurface of the ice allows for more stable and accurate knowledge about the evolution of temperatures in this region.

According to Dr. Brogioni, it is possible to deduct the temperature of the ice from the intensity of the electromagnetic waves emitted by it. Working at the forefront of electromagnetic modeling for remote sensing, he has developed an innovative model to interpret electromagnetic-wave emissions, so as to calculate changes in the climate.

Understanding the trends of energy in Antarctica could thus help monitor the global warming process. Dr. Brogioni's findings will contribute to the IPCC's* future reports on climate change and be useful for future recommendations on global warming to policy makers.

NOTES


2.
WEATHER HAZARDS
Floods
Floods
Embankments
Predictions


Sting jets
Drought
Hurricane
Rainfall
Storm
Snow


Jet Stream
Drought
Hurricane
Rainfall
Storm
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Floods
Clouds
Embankments
Predictions

INTRODUCTION TO WEATHER HAZARDS

by Professor Kevin Hamilton

Professor Kevin Hamilton
International Pacific Research Center
School of Ocean and Earth Science and Technology
University of Hawaii
Reviewer for the AXA Research Fund

Kevin Hamilton is an expert on computer modeling of the atmospheric circulation. He was a pioneer in modeling the meteorology of the stratosphere. In recent years, he has focused on modeling feedback processes of the climate system in global warming.

Much of our technology and our infrastructure investments have been designed to minimize the impact of weather on our activities. However, even today in the most advanced countries, as much as one third of economic activity is significantly affected by the weather. Over recent decades, severe weather has caused more insured property loss than any other hazard.

Increased understanding of the dynamics of weather phenomena has produced improved modeling and forecast capability. The benefits to society of improving weather forecasts over the last several decades have included a steady reduction in loss of life due to severe weather events and the safe and efficient operation of an immense civil aviation system. While much has been accomplished in terms of forecasting, there are still obvious shortcomings in current approaches, and there remain some very practical benefits of research that will result in improvements in the accuracy and reliability of weather forecasts at a range of lead times.

Mitigation of weather hazards can be achieved through engineering to limit actual damage to facilities and through market—based financial instruments such as insurance and catastrophe bonds—to compensate those who suffer losses. As seen in this chapter, the AXA Research Fund is supporting young graduate students and postdoctoral researchers in an impressively wide portfolio of weather-related topics. These range from rather basic research to understand the atmospheric dynamics involved in individual or severe events to dynamical and statistical approaches to actual forecasting.

Public concerns about anthropogenic global warming has stimulated more research in modeling long-term trends in atmospheric behavior. Increasingly, our understanding of and modeling capability for atmospheric phenomena are being applied to climate forecasting on time scales from interannual to multi-centennial. With the forward-looking support of the AXA Research Fund some of the young researchers are engaged in innovative projects to evaluate the impact of global climate change on severe weather.

HOW WILL HAIL CHANGE IN THE FUTURE?

Doctor Michael Sanderson

Evolution of hail storms over Europe in a changing climate

Doctor Michael Sanderson
AXA Project
MET Office (UK)
€240K

A few years ago, in the town of Ottery St Mary in Devon, a localized but very intense hail storm left cars and buildings buried in up to nearly one meter of ice. Heavy rain accompanied this storm, which caused widespread flooding. Although it was a rare and unusual event, will such events become more severe and frequent in the future? There may be fewer storms, but they will likely be much more intense or, because the climate is warmer, hail reaching the ground may be smaller due to increased melting.

Dr. Michael Sanderson, senior climate researcher from the MET Office, will work in collaboration with the European Severe Storms Laboratory using a regional climate model in order to understand how the characteristics of hail storms may change over Europe between the present day and the 2050s. This regional climate model will be used with a well-established model of hail formation to understand how the frequency and severity of hail storms and the size of hail stones will evolve under a changing climate.

He has already assessed the hail model consisting of observed and simulated meteorological data from across the UK, which is an effective proxy for all of Europe. Dr. Michael Sanderson also measured this model's ability to reproduce individual hail storms and compared the number of hail storms and hail stone sizes. Overall, the distribution and seasonality of hail storms were reasonable; however, the frequency turned out too high. He is now working to improve this model to take into account the disagreement between observations and hail databases as well as to test it on a number of observed hail storms. Finally, to enhance the level of certainty in the projections of hail storms, the improved hail model will be used with three new regional climate model simulations for the period from 1990 to 2060 in order to evaluate how hail storms will evolve across Europe under a changing climate.

His study of the evolution of hail storms across Europe and the resulting modeling tools will help build a greater understanding of the future impact of these destructive weather events.

THE STING OF A STORM IS IN ITS TAIL

Doctor Suzanne Gray

Sting jet windstorms in current and future climates

Doctor Suzanne Gray
AXA Project
University of Reading (UK)
€340K

Remember the damaging winds of the infamous great October storm of 1987, which scoured the coasts of Europe, uprooting trees, damaging property and taking lives? It killed more than fifty people in France alone and left one million homes without power in western France. It was the first storm in which a sting jet was formally identified.

Strong winds commonly occur in the warm sector of cyclones. Some but not all cyclones have a second localized region of strong short-lived but damaging gusts. This region is located close to the tail of the characteristic hook of the cloud head as it wraps around the cyclone and is known as the "sting at the end of the tail" or "sting jet."

Dr. Suzanne Gray and Prof. Peter Clark, leading meteorologists established at University of Reading and University of Surrey respectively, have recently developed an innovative diagnostic for the detection of sting jet precursor conditions in low-resolution datasets. Despite large socioeconomic impacts, much remains to be known about sting jets: few sting jet storms have been analyzed, and the latest generation of high-resolution climate models is able to represent the larger-scale features of storms but not sting jets *per se*.

Dr. Gray and Prof. Clark intend to investigate whether the characteristics or even the existence of sting jets are sensitive to small changes in environmental conditions. They will determine the variability and predictability of sting jet storms using the Met Office weather forecast model and data from state-of-the-art climate simulations. Next, they will document their frequency and preferred tracks in the current climate and possible future climates. Finally, they will determine the likely distribution of sting jet strength in these climates.

Global warming may increase the havoc wreaked by intense windstorms and the sting jets within them and thus their societal costs. Enhanced knowledge of sting jet storms in current and future climates will serve a wide range of stakeholders from the building construction industry to those responsible for the management of forests.

TRACKING FUTURE WINDSTORMS IN EUROPE

Professor David Stephenson

Regional Assessment of Climate impact on European WINdstorms: track clustering and multi-peril dependency (RACEWIN Project)

Professor David Stephenson
AXA Project
University of Exeter (UK)
€275K

Large annual losses can arise from the collective risk associated with European windstorms. This is due to the clustering of successive storms and the dependency between storm-related wind speed and rainfall extremes. There is growing scientific evidence that natural variations in the large-scale flow induce dependency between successive storms and between wind and rainfall extremes. “For example, the severe storms that impacted France in December 1999 were due to the persistence of a strong upper-level jet stream. We know that this condition provides the energy needed for the explosive growth of damaging windstorms,” explained Prof. David Stephenson.

Prof. David Stephenson is leading a project aimed at quantifying future changes in the collective risk associated with European windstorms. More specifically, he is assessing the potential evolution of European windstorm events by focusing on large-scale changes in the North Atlantic storm track and their relationship to regional changes in landfall windstorms across Europe. He is also examining the relationship between extremes of precipitation, wind speed, wind damage and floods as well as the clustering of extreme events related to windstorms across Europe.

He is collaborating with the UK Met Office to statistically analyze these storm tracks from a set of state-of-the-art high-resolution regional climate model projections for the 21st century. This will allow him to better quantify trends and clustering in future European windstorms. He will then look at the dependency between successive storms as well as between extreme winds speeds and extreme precipitation. In addition, the project will set up a European windstorm research network to help bring together critical mass in this important area of climate science.

The global modeling results may lead to an analysis of the large-scale driving factors of European windstorms under a changing climate, while the European regional modeling runs will provide an understanding of the hazards produced by storms. These more dynamic predictions are highly relevant for the insurance industry, as they provide knowledge about the changing rates of hazards.

TRACKING BIASES IN CLIMATE PROJECTIONS OF SEVERE STORMS

Doctor Peter Knippertz

A seamless approach to assessing model uncertainties in climate projections of severe European windstorms

Doctor Peter Knippertz
AXA Project
University of Leeds (UK)
€450K

"Robust projections of the latitude and strength of the Atlantic stormtrack near the British Isles are not yet possible, as the differences between models are too large." This conclusion published in the 2009 UK Climate Projections was the starting point for Dr. Knippertz's project, which addresses the problem of climate model uncertainty. Indeed, despite the advances made in climate change research, the use of different approaches to measure storminess has made it very difficult to identify single causes of errors.

In his project, Dr. Knippertz thus intends to clearly separate and quantify different sources of uncertainties in future projections of potentially damaging storms over Europe and to better understand the mechanisms that lead to disagreement between different models. In order to do so, the research team is evaluating short-term predictions of intense storms at different lead times using a wide range of weather and climate models. The project aims to find possible biases in storm intensity and track and to understand to what degree these biases depend on the resolution of the model.

Despite the enormous risk to European societies and (re)insurance companies associated with extreme cyclones, such an approach has never been used before and will help to improve future generations of forecast models. In this respect, the project will make a strong contribution to the World Weather Research Program THORPEX (The Observing System Research and Predictability Experiment). Indeed, according to Dr. Knippertz, the project aims to "build a bridge between scientists in climate-change impact research, atmospheric modeling, climate research and dynamical meteorology for the sake of a much more robust prediction of future windstorm impact across Europe."

WHEN AIR AND SOIL MOISTURE FLIRT WITH THE RISK OF LARGE-SCALE FLOODS

Professor Uwe Ulbrich

Large-scale European flooding under climate change

Professor Uwe Ulbrich
AXA Project
Freie Universität Berlin (Germany)
€300K (3 years)

The devastating floods in 2002 brought damage to large parts of the Elbe catchment. While large floods are repeatedly affecting the central European river catchments, the extreme severity and problems in handling these events have brought them to the attention of the public. Concerns have been raised that climate change could lead to more and even stronger flooding events in the future.

Prof. Uwe Ulbrich, leading meteorologist at the Institut für Meteorologie of Freie Universität Berlin, is addressing the economic risks of flooding in large river basins under current climate conditions by uniquely combining meteorological and hydrological approaches. In collaboration with Prof. Bruno Merz, leading hydrologist from GeoForschungsZentrum Postdam, he is developing a methodology for the Elbe river basin, which takes into account the complete flood risk chain from the flood-triggering weather event, to runoff* generation in watersheds, to flood routing in rivers and finally to flood damage.

Their approach starts by identifying and classifying the hydrological and meteorological preconditions that lead to flood situations in the Elbe river basin. From a hydrological perspective, around 50% of flood situations are preceded by high soil-moisture content throughout the whole catchment. On the other hand, there are also floods that result from high soil moisture restricted to the highlands or the upstream part of the catchment.
For the weather conditions that lead to summer flooding, the main pattern preceding the events shows a cyclone over southern Europe, which transports moist air from the Mediterranean towards central Europe. This is typical of what is known as a “Vb situation.” During the winter, the patterns mostly show a strong zonal flow carrying moist air from the North East Atlantic.

This pattern analysis will also serve as the basis for estimating joint probabilities of the occurrence of hydro-meteorological pattern combinations that are flood prone and assessing damage associated with basin runoff, opening new opportunities for flood-risk management.

BLUE GOLD

Improving models of water availability

Rachel White
PhD Fellow
Imperial College London (UK)
€120K (3 years)

Water more valuable than oil? This may become true as water demand increases rapidly due to population growth. The urgent need to have accurate estimates of water availability was one of the motivations for Rachel White's PhD. She worked with a widely used regional climate model to simulate rainfall and runoff, which control water availability. She focused on the case of the Olifants Basin in South Africa, an area under severe water stress. White noticed strong discrepancies between the runoff calculated by the model and the runoff observed. By implementing a new method to describe water penetration into the soil and its evaporation, she obtained results much closer to her observations. White's work might now be used for studies of water availability around the world, which are essential for enabling nations and NGOs to design water management solutions.

AN UNFAILING WORK

Developing tools to assess the integrity of earth flood protection structures

Doctor Marcin Zielinski
Postdoctoral Fellow
University of Strathclyde (UK)
€80K (3 years)

If you are lucky enough to own a house by the riverside, you may still be worried about the solidity of flood-defense embankments. Ask Dr. Marcin Zielinski what he thinks about it! Dr. Zielinski developed novel methods allowing high-resolution imaging of fissure networks in earth embankments and dams. The stakes are high: for example, the 1959 Malpasset dam break caused 423 fatalities and devastated thousands of acres of agricultural land. For his study, Dr. Zielinski used a multidisciplinary approach including laboratory experiments, field work and technical developments of imaging methods. He focused on British embankments, but his results could be used anywhere. His work might help local authorities in charge of flood defences design more efficient maintenance strategies, which could significantly reduce the risk of embankment failure.

TREE STORIES

Using tree rings to study past occurrences of debris flows and to investigate how their frequency is influenced by climate change

Doctor Michelle Schneuwly-Bollschweiler
Postdoctoral Fellow
University of Fribourg (Switzerland)
€51K (1 year)

Would you believe that trees tell stories? At least to those who know how to read them. Dr. Michelle Schneuwly-Bollschweiler uses tree rings to study past occurrences of debris flows* and to investigate the impact of climate change on the frequency of such events. Dr. Schneuwly-Bollschweiler samples trees showing signs of injury from debris flows and counts the annual growth rings formed after the scars in order to date the debris-flow event. Using this method, she managed to obtain a picture of debris-flow occurrences in the Swiss Alps from 1600 to the present day! She linked her results to the occurrence of extreme rainfall* over the past few decades. Dr. Schneuwly-Bollschweiler's results may help predict the future frequency of debris flows. This may ultimately be useful to local authorities for safe land-use planning and the building of protection structures.

BETTER THAN A FROG: RAIN FORECASTING

Developing a statistical approach to forecast precipitation at a local scale

Doctor Dominique Fasbender
Postdoctoral Fellow
Institut national de la recherche scientifique (Canada)
€60K (1 year)

Should you take your umbrella with you today? Rain forecasting is not always accurate as you may have noticed... but researchers are working on it! During his postdoctoral research, Dr. Dominique Fasbender developed an innovative statistical approach aimed at predicting precipitation at a local scale. The challenge of rainfall prediction is that multiple parameters need to be accounted for, including atmospheric conditions but also topography. Dr. Fasbender's approach allows the integration of all these parameters. In the future, it could be useful at several levels. It might help improve early warning systems* in the case of extreme rainfall events. His work might also be used to study how climate change may increase the risk of local extreme events happening. It would then help provide recommendations to private and public authorities in charge of land-use planning.

GUINNESS? NO, WATER FROM TURLOUGHS!

Modeling water level fluctuations in turloughs and understanding their ecological impact

Ted McCormack
PhD Fellow
Trinity College Dublin (Ireland)
€120K (3 years)

You certainly know Guinness. But have you heard of turloughs? Probably not, yet this is another Irish speciality! Turloughs are seasonal lakes fed predominantly by groundwater that flood and empty over the course of the year. Why study them? Ted McCormack has two good reasons for this. First, they host a unique flora and fauna. McCormack is conducting field work to assess how concentrations of nutrients, which are essential for life, are influenced by water-level fluctuations in turloughs. The other motivation for McCormack's PhD is that turloughs may flood when intense rainfall increases groundwater levels. McCormack is developing a model aimed at simulating the risk of turlough flooding based on rainfall. His results might be useful for designing optimal land-use policies that are beneficial for both local farmers and biodiversity conservation.

DO YOU BELIEVE IN FLOODS?

An anthropological approach of flood management through three case studies in Fiji Islands (Melanesia)

Doctor Emilie Nolet
Postdoctoral Fellow
Université de Provence (France)
€60K (1 year)

Flooding is one of the most devastating natural hazards faced by certain populations. And yet, some people consider it a blessing. This is the case for certain communities in the Fiji islands, which are the focus of Emilie Nolet's research. For them, flooding is a natural part of a cycle which, among other benefits, brings fertile land and provides the opportunity to put conflicts aside and strengthen both social and family ties. Drawing from extensive fieldwork in the Fiji Islands, Nolet is examining traditional systems of preparedness, the socioeconomic impacts of floods and the social representations of risk. Nolet emphasizes how the perception and management of "catastrophic" events are, in fact, framed by a complex network of social dynamics and values. She thus shows the importance of the cultural aspect in the perception of risk and risk assessment.

GIANTS WITH FEET OF CLAY

Understanding internal erosion in embankment structures

John Pennefather
PhD Fellow
Imperial College London (UK)
€120K (3 years)

Embankment dams* save lives. Along with flood embankments,* these strong structures supply us with water, guard us from floods and contribute to power generation. On a global scale, 45,000 large dams were built to withstand all odds, yet what can be done when this power wanes? Research has shown that internal erosion—a process whereby soil particles are "washed out" under the action of water seepage forces—is eating away at the integrity of these superheroes. With the help of an industrial advisory panel, John Pennefather's mission as embankment protector is to simulate and model internal erosion at the scale of individual particles in order to study the formation of weak zones in dams or their foundation and assess the vulnerability of existing structures. Thanks to his work, dam engineering design may be improved to prevent collapses and better protect human lives and infrastructures against climate change.

GOING AGAINST THE FLOW

Marine submersion: new challenges, new legal practices

Vanessa Mulot
PhD Fellow
Université Paul Cézanne - Aix-Marseille Université, Faculté de droit (France)
€120K (3 years)

The prospect of increased marine flooding in the future should deter urban sprawl along French coasts. However, this is not yet the case. Six million residents and an equal number of tourists are crowded together on only 4% of France's territory, which increases human and economic vulnerability to flooding. Taking into consideration coastal erosion and further sea-level rise, Vanessa Mulot is addressing sensitive issues such as private ownership and public responsibility towards coastal risks from a legal perspective. Through prevention, protection and adjustment, she is working on new legal means to reduce socioeconomic vulnerability to marine submersion. New mechanisms could include local planning policies as well as innovative risk prevention plans. In addition to the role of national actors and local public managers, the involvement of local citizens and economic agents within the insurance sector will be decisive for the development of future strategies.

FISH-FRIENDLY DAMS

Investigating the effects of dam constructions on fish biodiversity

Doctor Guy Ziv
Postdoctoral Fellow
Princeton University (USA)
€60K (1 year)

No luck with fishing today? This may be due to a dam. Dr. Guy Ziv investigated how dams impact fish populations. Built for multiple purposes, including energy production, dams may have harmful socioeconomic effects in regions where fishing is a dominant industry: they prevent fish migration which may lead to the extinction of certain species. Dr. Ziv focused on a multiple dam plan in the Mekong Basin in Southeast Asia, where the fish feed millions of people. He showed that the plan would induce a decrease in the fish population equivalent to thousands of tons of food and concluded: “Some tributary dams can and should be avoided." The damage they would cause would be greater than the additional power produced. The assessment of the pros and cons of dams provided by Dr. Ziv's work may be a valuable tool to support the decisions of policy makers.

EUROPEAN DROUGHT UNDER CLIMATE CHANGE AND THE ASSOCIATED UNCERTAINTIES

Climate change and extreme weather events

Rita Yu
PhD Fellow
University of East Anglia (UK)
€120K (3 years)

In addition to floods, droughts are one of the most damaging natural hazards in human, environmental and economic terms. Climate change is creating demand from decision-makers and other stakeholders for a better understanding of the potential characteristics of future drought, in order to identify effective measures to reduce drought risks and the associated impacts. Our incomplete understanding of the behavior of the climate system has led to the development of various emission scenarios and climate models. Uncertainties also arise from the different types and definitions of drought. Rita Yu seeks to examine the effects of climate change on European drought and to illustrate the robustness of these projections by quantifying the effects of using different emission scenarios, GCMs and drought definitions, specifically meteorological and hydrological droughts.

GOOD INSURANCE TAKES A GOOD WEATHERMAN

Doctor Abdou Karim Gueye

Evaluation of decadal predictability of rainfall over sub-Saharan Africa

Doctor Abdou Karim Gueye
Postdoctoral Fellow
Institut de Recherche pour le Développement (France)
€60K (1 year)

Dr. Abdou Karim Gueye is the son of a farmer. As local drought was a major problem for his family in Senegal during his childhood, one day he decided that he would find a way to help them face this critical situation. Thanks to his strong motivation, he started a brilliant career as a researcher at the University of Dakar. Today, Dr. Gueye is conducting his research in France, where he focuses on precipitation in the Sahel, which has been identified by the United Nations as one of the world's nine "hot spots" of global environmental change. Based on rainfed crops, agriculture in the Sahel entirely depends on water resources, which are extremely scarce. The ability to forecast climatic fluctuations within days or months of the event is the first step to reducing poverty, since this can make a real difference for the strategies used by rural populations in Africa to adapt to climate change. Dr. Gueye is a specialist in processing environmental data using advanced statistical tools, especially climate and weather tools. His research may contribute to decision making by highlighting the most relevant meteorological variables so that they can be included in the operational systems of national weather services. These predictions could contribute to the development of "index insurance,*" a new type of policy created for people living in vulnerable regions, whose livelihoods are closely linked to their environment. Instead of taking into account losses suffered by the policy holder and caused by weather hazards, this type of policy is linked to the fluctuation of a weather variable. Insurance payouts are therefore based on the performance of a weather index, such as rainfall, regardless of the actual loss suffered by the farmer. However, if uncertainty about weather forecast is too high, premiums can become unaffordable. Dr. Gueye aims to reduce this uncertainty through a better understanding of climate change over the coming decades. By improving weather predictions, Dr. Gueye's research may contribute to mitigating climate risks in the sub-Saharan Africa region. It may also significantly improve the economic conditions of farmers by helping them access the insurance coverage and bank loans that are essential for their livelihood.

NOTES

3. Air travel

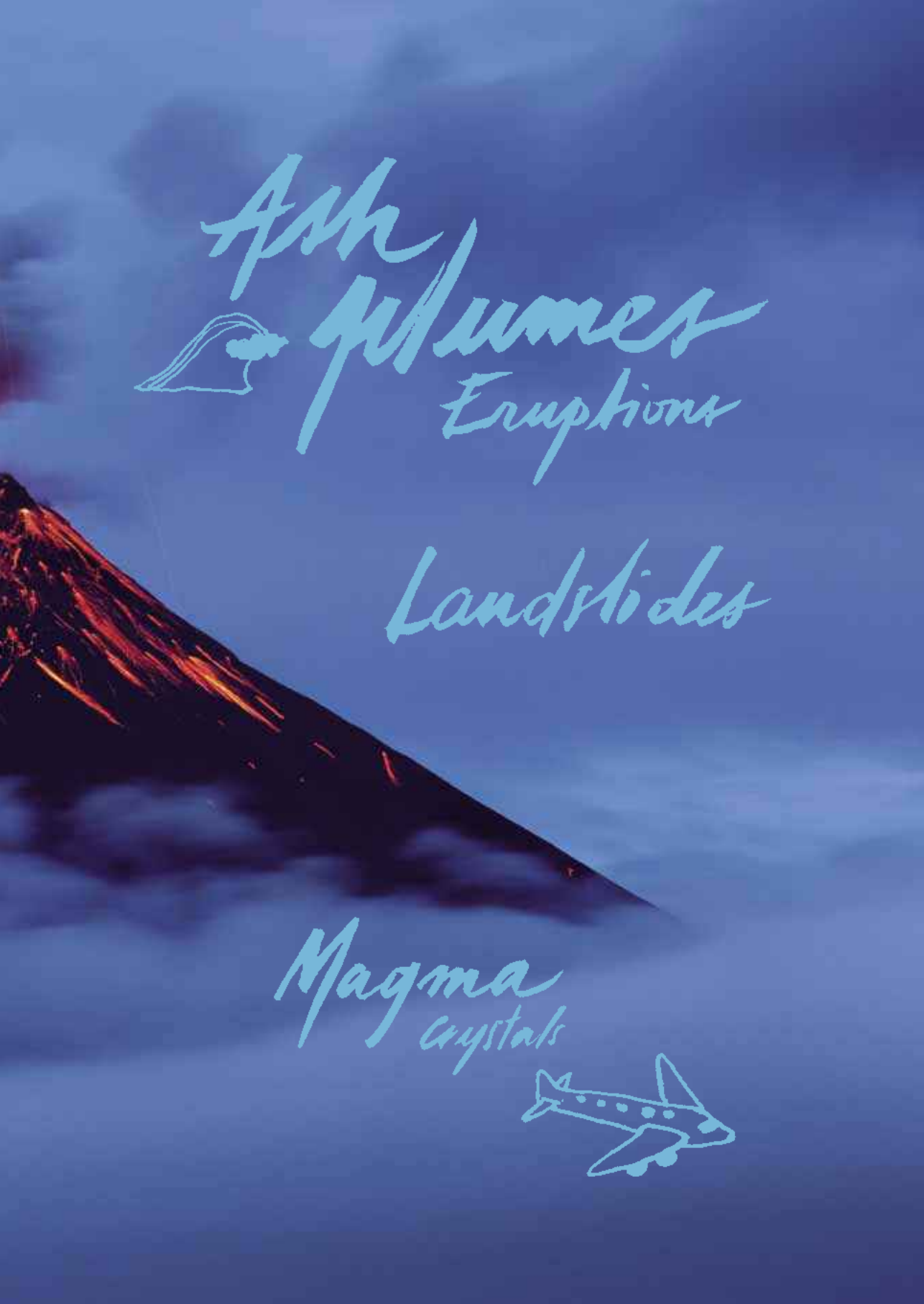
VOLCANIC & SEISMIC RISKS

tsunami

tectonic plates

Earthquakes

Epicenter


Ash
plumes
Eruptions
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Ash
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Earthquakes
Epicenter
Air
Travel
Tsunami
tectonic plates

INTRODUCTION TO VOLCANIC AND SEISMIC RISKS

by Professor Raul Madariaga

Professor Raul Madariaga
Ecole Normale Supérieure in Paris (France)
Reviewer for the AXA Research Fund

Raul Madariaga is professor of Geophysics at the Ecole Normale Supérieure in Paris. He is a seismologist interested in wave generation and propagation in the earth's interior. In recent years, his research has focused mainly on the study of mega earthquakes, such those that hit Chile in 2010 and Japan in 2011. He was awarded the Harry F. Reid Medal of the Seismological Society of America in 2004 and the Stephan Mueller Medal of the European Geophysical Society in 1999.

The earth has constant seismic and volcanic activity, which threatens human populations and their habitat and creates great technological risks. Recent mega earthquakes in Sumatra, Chile and Japan, as well as the very large emission of particles and gas by the Eyjafjallajökul volcano in Iceland or the Chaiten and Puyehue eruptions in Chile, have reminded us that these events remain largely unpredictable in spite of remarkable improvements in monitoring techniques. Not only are extreme events dangerous, but local earthquakes often have devastating effects, as recent events in Haiti, Italy and New Zealand have sorely reminded us. Much progress has been made, but the actual process by which an earthquake or volcanic explosion is triggered remains elusive, and possible precursors remain difficult to discern among the many signals emitted by earthquakes and volcanoes.

A complementary approach is prevention: protecting populations from disasters by appropriate planning, diminishing their exposure to risks and, especially, taking measures so that industrial sites can resist the effects of earthquakes and volcanoes. This is not a simple task as we have recently learned from the disastrous effects of tsunamis triggered by mega earthquakes or the perturbation of air transport caused by large volcanic clouds.

One of the most appropriate responses to seismic and volcanic risks is early warning: rapid identification of a catastrophic event in the initial moments as it begins to develop into a major event. Early warning has become possible thanks to rapid communication and improved monitoring techniques both from earth and space; it is not easy, but initial successes with Pacific tsunami warning, volcano monitoring and the rapid detection of seismic signals have opened new ways to protect populations against natural catastrophes.

The AXA Research Fund has supported research in many aspects of volcano and earthquake studies ranging from the study of past events to the detailed study of seismic and volcanic events as well as how to cope with the emergencies they produce.

FROM MAGMA AT DEPTH TO DIFFUSE ASH CLOUDS IN THE ATMOSPHERE

Professor Katharine Cashman

Professor Katharine Cashman
AXA Chair on Volcanology
University of Bristol (UK)
€617K (Temporary)

An estimated 10% of the world's population now lives on or near potentially active volcanoes, and increases in the global population continue to place more people in volcanically hazardous areas. Societies must be prepared to act upon scientific recommendations, and be bothered in advance about hazard mitigation, rather than take a chance on the event not happening again. However, convincing communities to prepare for the effects of natural disasters and volcanic eruptions in particular has proved challenging because of the nature of these events: they occur only infrequently, yet they may have far-reaching effects.

Prof. Katharine Cashman scrutinizes explosive volcanic eruption, created by the rapid movement of gas-saturated magma from the subsurface to the atmosphere. Ash is ejected into the troposphere,* creating ash plumes that travel with the prevailing weather systems. Currently, these ash plumes are tracked using a combination of satellite observations and volcanic ash transport and dispersion models. However, a recent review has identified severe deficiencies in both remote detection capabilities and the source parameters used as input to these models, which depend on empirical correlations of eruption parameters (plume height, mass eruption rate, fine ash content), such parameters varying substantially between eruptions.

In particular, we are unable to predict the origin, abundance and dispersal properties of ash that is fine enough to remain suspended for several days. This points to a fundamental gap in our understanding of how magma that contains dissolved volatiles deep below the Earth's surface is transformed into fine particles that can circle the globe. Prof. Katharine Cashman intends to bridge this gap by developing a continuum view of volcanic systems that links magma properties at depth to properties of diffuse ash clouds in the atmosphere.

Her research team will be conducting high pressure-temperature experiments using laboratory materials that behave in similar ways to magma. This will lead to an understanding of phenomena such as crystallization in the magma, providing detailed and practical insights into a process that happens under great temperature and pressure, beyond reach beneath the ground. Experiments at room temperature will also be performed to observe

"We wish to develop better scientific methods for predicting how volcanic plumes behave. This should benefit local communities who live near volcanoes, as well as airlines that need to know if it is going to be safe to fly".

processes that are not observable in the high pressure-temperature experiments. For example, the team will run experiments using golden syrup (a sugar syrup with a viscosity that is similar to magma) to study the movement of air (analogous to volcanic gases) through both viscous fluids and through suspensions of viscous fluids and particles (analogous to crystals). These experiments can identify conditions generating gas loss (and less explosive eruptions) or gas build-up (and more explosive eruptions).

The novel approach taken by Prof. Katharine Cashman and her team involves considering how the physical characteristics of a volcanic ash cloud depend on an evolving set of internal and extensive parameters, such as magma composition, temperature and pressure or magma ascent path, regional stress field, and ice-cap melting. The research is scheduled to run for three years, after which it is hoped that the team will have developed better scientific methods for predicting how volcanic plumes behave. This should benefit local communities who live near volcanoes as well as airlines that need to know if it is safe to fly.

Prof. Katharine Cashman is a volcanologist with a long interest in the connection between chemical processes that control the formation of bubbles and crystals in rising magma and the physical processes that control volcanic eruptions. At the same time, her early work as Public Information Scientist for the US Geological Survey during the 1980-1986 eruption of Mount St. Helens introduced her to both the challenges and importance of not only improving volcanic hazard assessment, but also developing effective channels of communication to public officials and communities. She has spent most of her career as a professor at the University of Oregon, USA. Her work has taken her to volcanoes around the world to study lava flows in Hawaii and Italy, cinder cone eruptions in Mexico and Oregon, explosive eruptions in Alaska and Ecuador, and eruptions under the ocean in the western Pacific.

The Chair is based in the School of Earth Sciences at the University of Bristol, one of the leading centers for research and teaching in the Earth Sciences, ranked in the top four UK departments of its kind since 2001. Research activity is organized into six groups covering a wide range of topics from climate and environmental change, to paleobiology and geochemistry. Volcanic hazards and risks are one of the School's leading interests and areas of expertise. The Chair is also part of the Cabot Institute at the University of Bristol, which brings together the University's fundamental and responsive research on risks and uncertainties in a changing environment across science, social science and engineering.

By creating the AXA Chair in Volcanology, the AXA Research Fund places the University of Bristol at the forefront of programs that integrate fundamental volcanological research with assessment and implementation of volcanic risk assessment and risk reduction strategies. It will also solidify the multidisciplinary research themes envisioned for the newly developed Bristol Environmental Risk Research Centre.

A BLACK SWAN NAMED TAMBORA

Jessica Kandlbauer

The environmental impact of an 1815 Tambora-style eruption in 2015

Jessica Kandlbauer
PhD Fellow
University of Bristol (UK)
€120K (3 years)

The year 1816 was known as "the year without summer." On April 5, 1815, the Tambora volcano located on the island of Sumbawa in Indonesia suddenly erupted with a resounding detonation that could be heard 1,400 km away. This already massive eruption was nothing compared to what came 5 days later in what would become the largest volcanic eruption in recorded history. Over 100 km^3 of pulverized rock was ejected into the atmosphere in an explosion 52,000 times more powerful than the Hiroshima bombing, killing at least 60,000 people.

As a result, not only did the mountain go from a height of 4,300 m to 2,850 m, but CO_2 was released into the atmosphere in such quantities that it impacted the climate on a global scale. In 1816, several regions of the world experienced a climatic shift, with a temperature drop of a few degrees Celsius, impacting agriculture to such an extent that it caused famine and disease in Europe.

What if such an eruption were to happen in our modern society? This is the question Jessica Kandlbauer is trying to answer through her PhD at the University of Bristol. In order to do so, Kandlbauer is conducting a four-phase research project. First, she investigated historical documents and contemporary literature in order to reconstruct the Tambora eruption. Then, she focused on the volcanology aspect, studying how particles are formed and spread in the air. This will allow Kandlbauer to assess the climate reaction in case a Tambora-style eruption were to happen today. However, she is going beyond the environmental aspect by also examining the socioeconomic aspect of such a disaster.

Do you remember the suspension of all air traffic across Europe due to the 2010 Eyjafjallajökull eruption? This time the situation would be even more problematic in terms of population evacuation, sanitary issues, migratory flows as well as the economic cost of the disaster. Thanks to her research, Kandlbauer aims to develop a model not only of what would happen, but also of what could be planned in order to limit both human casualties and the socioeconomic impact if the Black Swan were to erupt once again.

SURVIVING A VOLCANO

Modeling evacuation and land-use planning for volcanic emergencies

Doctor Susanna Jenkins
Postdoctoral Fellow
University of Bristol (UK)
€120K (2 years)

Volcanic crises can continue for years or even decades and have global socioeconomic implications that are not yet well understood. Dr. Susanna Jenkins decided to focus her research on this largely unappreciated risk. In addition to scientific information, Dr. Jenkins emphasizes the importance of physical, socioeconomic and political factors for timely and effective risk-reduction decisions, such as evacuation. Using an inclusive Bayesian* approach, she aims to integrate influential factors such as human behavior and vulnerability into a robust decision-support framework that is capable of assessing the risk for populations exposed to volcanic hazards and quantifying the consequences of potential risk-reduction decisions. The framework could have wider applications and become a valuable tool for supporting evacuation protocols and reducing risk to natural hazards.

AN OPEN-SOURCE CAMERA TO MAP VOLCANIC GAS

The dynamics of explosive volcanism

Doctor Euripides Kantzas
Postdoctoral Fellow
University of Sheffield (UK)
€60K (1 year)

Just like the pop of a Champagne bottle, the power that drives volcanic eruptions comes from gases contained in the magma. However, such gas measurements are inherently difficult to obtain and suffer from poor resolution. That's why Dr. Euripides Kantzas and his colleagues pioneered the use of a revolutionary ultraviolet digital camera to measure volcanic gas and, in particular, sulfur dioxide. He then spent months on the volcanic island of Stromboli, where he used his camera to capture a truly unprecedented gas-based record of explosive volcanism.* This data was then combined with simultaneously acquired geophysical information in order to model the observed explosive behavior in far more detail than previously possible. Dr. Kantzas also developed a freely downloadable software interface to monitor his camera, an enormous benefit for many developing countries where volcanic risks are high, yet monitoring budgets, low.

LISTENING TO THE ROLLING STONES

Monitoring landslides through recordings of the ground vibrations that they induce

Doctor Arnaud Burtin
Postdoctoral Fellow
University of Cambridge (UK)
€60K (2 years)

Do you like listening to the rolling stones? Dr. Arnaud Burtin loves it, but he does it literally! Burtin uses the sound generated by landslides propagating rock debris downstream to develop new monitoring methods. The catastrophic nature of landslides* prevents local measurements. An alternative method is to record ground vibrations yielded by landslides using distant seismometers. Dr. Burtin has started to assess the potential of this method. For this purpose, he conducted extensive field work in Taiwan and in the Alps, where landslides are frequent, and analyzed seismic records collected on his trips. Landslides constitute a major hazard and are expected to become more frequent in the future due to climate change and increased extreme rainfall. Dr. Burtin's work might become useful for local authorities for establishing efficient early warning systems.*

THE VOICE OF VOLCANOES

Using voice detection systems to seismic records of volcanic activity in order to improve eruption forecasting

Anaïs Boué
PhD
Université de Savoie (France)
€120K (3 years)

You have one explosive message on your voice mail! Is it from your boss? No, it's from a volcano. You may not know it, but volcanoes emit complex signals akin to human voices. Interpreting their messages will be the exciting challenge of Anais Boué. Her innovative idea is to adapt methods initially developed for voice recognition devices to decipher volcanic signals recorded by seismometers. Using these methods, she hopes to be able to distinguish signals of different source origins like magma ascent for instance, which would give precursory tools for the prediction of eruptions. Boué will work on developing software that could be delivered to volcanologic observatories. Improved predictions of eruptions might then allow more efficient evacuation strategies and help reduce the number of fatalities due to eruptions.

LAVA LAKES: A PARADISE... FOR VOLCANOLOGISTS

Studying the Erebus lava lake (Antarctica) to derive information on magma transport within the volcano and eruption styles

Tehnuka Ilanko
PhD Fellow
University of Cambridge (UK)
€120K (3 years)

Feel like swimming in a lake? Make sure it's not made of lava! Lava lakes are absolutely not a paradise for swimmers, but they are for volcanologists and in particular for Tehnuka Ilanko! They are rare, but they offer a unique window into the volcano plumbing system. Ilanko will work on unraveling all the secrets of the Erebus volcano lake in Antarctica. She will endure strenuous field conditions to collect data about the lake's properties. Back at the lab, Ilanko will develop a numerical model to complete her data. One of the goals of her PhD is to better understand the transition from quiescence to explosive activity, which is a key problem in volcanology. Her results on the Erebus might then be extended to volcanoes that are considered highly hazardous because of the proximity of large cities and help improve risk assessment for these cities.

SMALL BEADS FOR BIG STAKES

Investigating physical mechanisms underlying complex geophysical flows, based on laboratory experiments

Doctor Sébastien Wiederseiner
Postdoctoral Fellow
Ecole Polytechnique Fédérale de Lausanne (Switzerland)
€60K (1 year)

Predicting how mayonnaise will spread on an inclined surface is extremely difficult. This may not seem of serious concern to you, but it actually illustrates our imperfect knowledge of the physics of complex fluid flows, which also applies to debris flows, torrential floods and snow avalanches. To learn more about these processes, Dr. Sébastien Wiederseiner is carrying out laboratory experiments using mixtures of fluids and beads and analyzing them with advanced visualization methods. He is studying how heterogeneous mixtures behave—a matter of intense debate. The answer to this question is crucial for the development of predictive models, which are to date based on speculative theories. The aim of Dr. Wiederseiner is to develop more relevant models that may be used by local authorities in charge of land settlement in potentially hazardous areas.

DANGEROUS LIAISONS

Magma movements and associated stress changes at Eyjafjallajökull and Katla volcanoes, Iceland

Doctor Fabien Albino
Postdoctoral Fellow
Institute of Earth Sciences - University of Iceland
€60K (1 year)

You may have noticed that if someone close to you is experiencing a stressful period, it may influence your stress level. As this simple rule also applies to volcanoes, Dr. Fabien Albino has decided to focus his research on interactions that are triggered by stress changes in the crust due to magmatic activity between two neighboring subglacial Icelandic volcanoes, Katla and Eyjafjallajökull.
Can magmatic activity affect the stability of the nearby volcano's magma reservoir or even potentially trigger an eruption? Dr. Albino has chosen to examine the effect of 2010 Eyjafjallajökull eruption, which disrupted air traffic in Europe for several days, on the dangerous nearby volcano, Katla. The liaison between these two volcanos will be quantified and incorporated into a fully functional 3D numerical model. More generally, this tool could be used to identify, forecast and mitigate eruptions triggered by stress interactions for all neighboring volcanoes around the world.

FROM GRAIN AVALANCHES TO EARTHQUAKE PREDICTION

Improving our knowledge of earthquake occurrences through a laboratory study of grain avalanches with similar behavior

Doctor Ramon Planet Latorre
Postdoctoral Fellow
Université Claude Bernard Lyon 1 (France)
€120K (2 years)

Will earthquake prediction ever become possible? Researchers are working on it! Statistical laws describe the occurrence of earthquakes well. For instance, the biggest earthquakes are the least frequent. Could this statement serve as a starting point to predict large earthquakes? This is one of the questions that Dr. Ramon Planet Latorre will investigate during his postdoctoral research, based on laboratory experiments. On Earth, earthquakes occur due to friction between moving tectonic plates. To mimic this system at the laboratory scale, Dr. Planet Latorre will use a novel experimental setup, investigating the shearing of a thin layer of grains. Shearing induces avalanches of grains, which follow laws similar to those of earthquakes. Dr. Planet Latorre will study what influences the distribution of avalanche sizes and will try to detect precursors to large earthquakes.

VOLCANIC ASH: FROM ERUPTION TO FLIGHT CHAOS

Professor Donald Bruce Dingwell

Risk from volcanic ash in the earth system

Professor Donald Bruce Dingwell
AXA Project
Ludwig Maximilians University (Germany)
€557K (3 years)

Over 107,000 flights were cancelled during the 8-day travel ban, accounting for 48% of total air traffic and involving roughly 10 million passengers. The 2010 eruption of the Eyjafjallajökull volcano in Iceland was a succinct demonstration of the vulnerability of our society to the disastrous socio-economic impacts of volcanic activity.

During transport and upon deposition, ash creates a range of hazards over great distances from the volcano and on various timescales. Recent technological advances now permit the thorough study of ash and have for the first time given access to the main processes that take place during the life cycle of ash. Prof. Donald Dingwell intends to map out these processes in a strictly quantitative and physiochemical manner using a series of experiments performed under controlled laboratory conditions.

He will specifically track the mechanisms of ash generation in the volcano, determining the physical properties and the amount of fine material produced during eruptions. He will also study mechanisms of ash alteration and ash aggregation during transportation and deposition, which are mainly driven by the ash's original properties and interaction with volcanic gases. Finally, Prof. Donald Dingwell will analyze drivers of ash melting and sintering processes as well as the inflammatory potential of ash.

The fundamental stakeholder value of the research is the establishment of a new, robust, physio-chemical basis for risk associated with volcanic ash. It involves the science of volcanic ash itself as well as the vulnerability of aviation to volcanic ash events. Prof. Donald Dingwell will generate the basis for a reliable dialogue between scientists and societal stakeholders. If he's convincing, he may persuade us to act based on well-constrained prior knowledge.

LAHARS: CONNECTING PEOPLE

Professor Franck Lavigne

SEDIMER – Sediment-related disasters and hazards following the 2010 centennial eruption of Merapi Volcano, Java, Indonesia

Professor Franck Lavigne
AXA Project
Université Paris 1 – Sorbonne (France)
€519K (3 years)

We all know about the destructive power of volcanoes, yet did you know how much damage a simple word like Lahar can carry? Most widely used in Indonesia, it first described water-saturated mass flows of volcanic debris before being applied as a general term for rapidly flowing, high-concentration, poorly sorted sediment-laden mixtures of rock debris and water from a volcano.

Because they pose a constant threat to downstream villages and towns, lahars are one of the most destructive phenomena associated with composite volcanoes all around the world. What is more, despite their regular occurrence, the behavior and propagation of rain-triggered lahars are poorly understood, thus impeding any consistent assessment of their political and socioeconomic costs for local residents. Yet, that was before Prof. Lavigne set out to study one of the most active volcanoes in the world: Mt. Merapi in Indonesia.

Indeed, due to a devastating eruption in 2010, it is now crucial to determine what may happen in the next five years to the river valleys downstream from Mt. Merapi. Prof. Lavigne and his team are seizing this unique opportunity to compile a database on lahar occurrence thanks to a collaborative and multi-disciplinary study gathering experienced international experts and young scientists from seven countries including Indonesia. Their innovative methods rely on a combination of high-tech instrumentation and socioeconomic calculations to model and quantify the impact of lahars on local populations.

Thanks to this integrative approach, Prof. Lavigne seeks to obtain a comprehensive understanding of the occurrences and impacts of lahars with results which may immediately be used by policy makers for land use and emergency response planning. Eventually, his work might help reduce exposure and improve the resilience of local populations to threats from lahars.

CHILE: THE WORLD LEADER IN MEGA EARTHQUAKES

Amaya Fuenzalida-Velasco

Assessing seismic hazards in Northern Chile

Amaya Fuenzalida-Velasco
PhD Fellow
École Normale Supérieure de Paris (France)
€120K (3 years)

What is the biggest earthquake ever recorded? If you think it occurred in Japan or in Indonesia, you are wrong! It was actually a magnitude-9.5 earthquake that took place in Southern Chile in 1960 and left 2 million people homeless. Because Chile is located at the frontier between two converging tectonic plates, it is frequently struck by very big quakes. The goal of Amaya Fuenzalida is to better assess seismic hazards in her native country.

She focuses part of her study on Northern Chile, where the latest very large earthquake occurred in 1877 and induced one of the most destructive tsunami in history. Since 1877, energy has accumulated due to plate convergence.* The Tocopilla earthquake in 2007 released some of this energy, but according to seismologists, the worst is yet to come!

To assess present-day seismic risk in Northern Chile, Fuenzalida first needed to know all about the 2007 Tocopilla event... and luckily she had an unprecedented amount of high quality data available. Indeed, the Tocopilla earthquake was recorded by an extensive monitoring network, installed by French, German and Chilean institutions working in collaboration with each other. Fuenzalida also tries to evaluate the effects of a potential future event similar to that of 1877, including the risk for a tsunami that could spread across the Pacific.

In parallel, Fuenzalida works on the Maule earthquake, which occurred during her PhD, in 2010, in Southern Chile. She led field work to collect data about the aftershocks of this event and is currently analyzing them.

Large Chilean earthquakes can cause numerous fatalities and have a high economical cost. In 1985, an earthquake in Central Chile produced an economic negative impact of nearly 2% of the Gross National Product. Fuenzalida's study might be useful for the mitigation of seismic hazards by Chilean authorities, and contribute to reducing their harmful consequences.

IN SEARCH OF A PLACE TO STAY: FACING THE HOUSING CRISIS IN HAITI

Giovanna Salomé

Catastrophe, emergency and social mobilization: an ethnography of post-disaster Haiti

Giovanna Salomé
PhD Fellow
Università degli studi di Messina (Italy)
€120K (3 years)

On January 12, 2010 an earthquake of magnitude 7.0 on the Richter scale struck the Republic of Haiti. After the disaster, authorities and local residents were faced with a high number of casualties and missing persons as well as the destruction of a great number of houses and public buildings in the country. Within this context of prolonged emergency, the reconstruction process is slow to show progress. Earthquake and post-disaster emergency management have revealed some previous issues inscribed in the socio-political system of Haiti. This system has already been affected by previous natural disasters and is characterized by social and political instability and a pressing need for humanitarian assistance.

In particular, the daily interaction of these humanitarian actions with local reality and the context of emergency have produced a variety of experiences* which are connected, at various levels, to the housing crisis issue that Giovanna Salome aims to investigate.

Starting from this premise, Salomé decided to conduct an anthropological survey to explore the logic and practices that accompany the housing crisis caused by the earthquake in the urban context of Port-au-Prince. She aims to explore, in particular, how inhabitants have coped with the housing crisis and to examine the different social actors engaged in the reconstruction process.

As part of her research, Salomé is analyzing accounts given by beneficiaries of the humanitarian projects, relating to resettlement. Her analysis focuses on the needs, representations and spontaneous practices of the population.
Salomé will then reflect on the encounter between the assistance provided by international organizations and the informal reconstruction process followed by the population.

Her findings will contribute to our understanding of the mechanisms of social reactions to disasters and violent crisis. Identifying the factors that influence local social response to catastrophes may help define and design future aid programs. It could also be helpful for staging humanitarian operations based on the specific needs and behaviors of local populations.

NOTES

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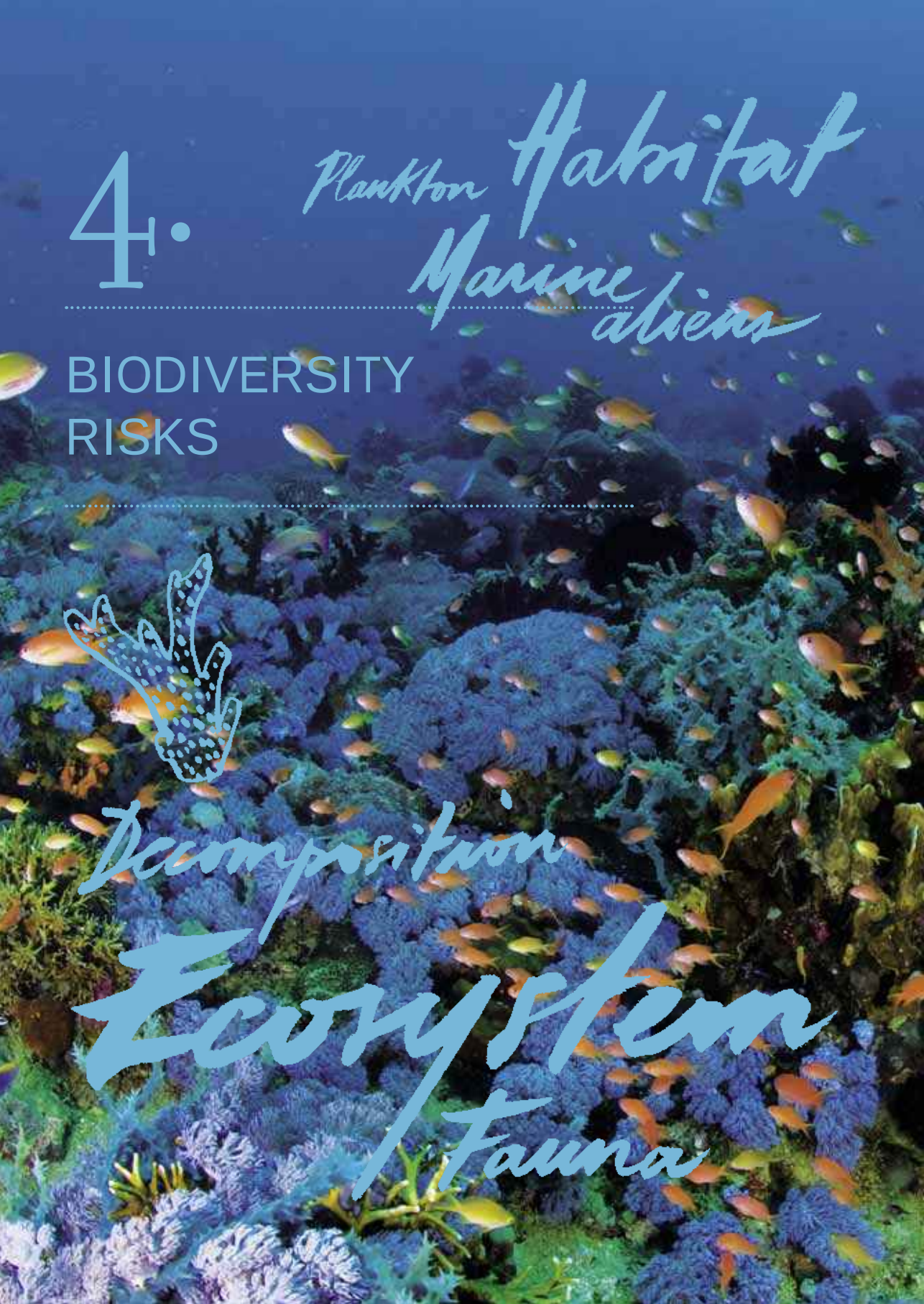
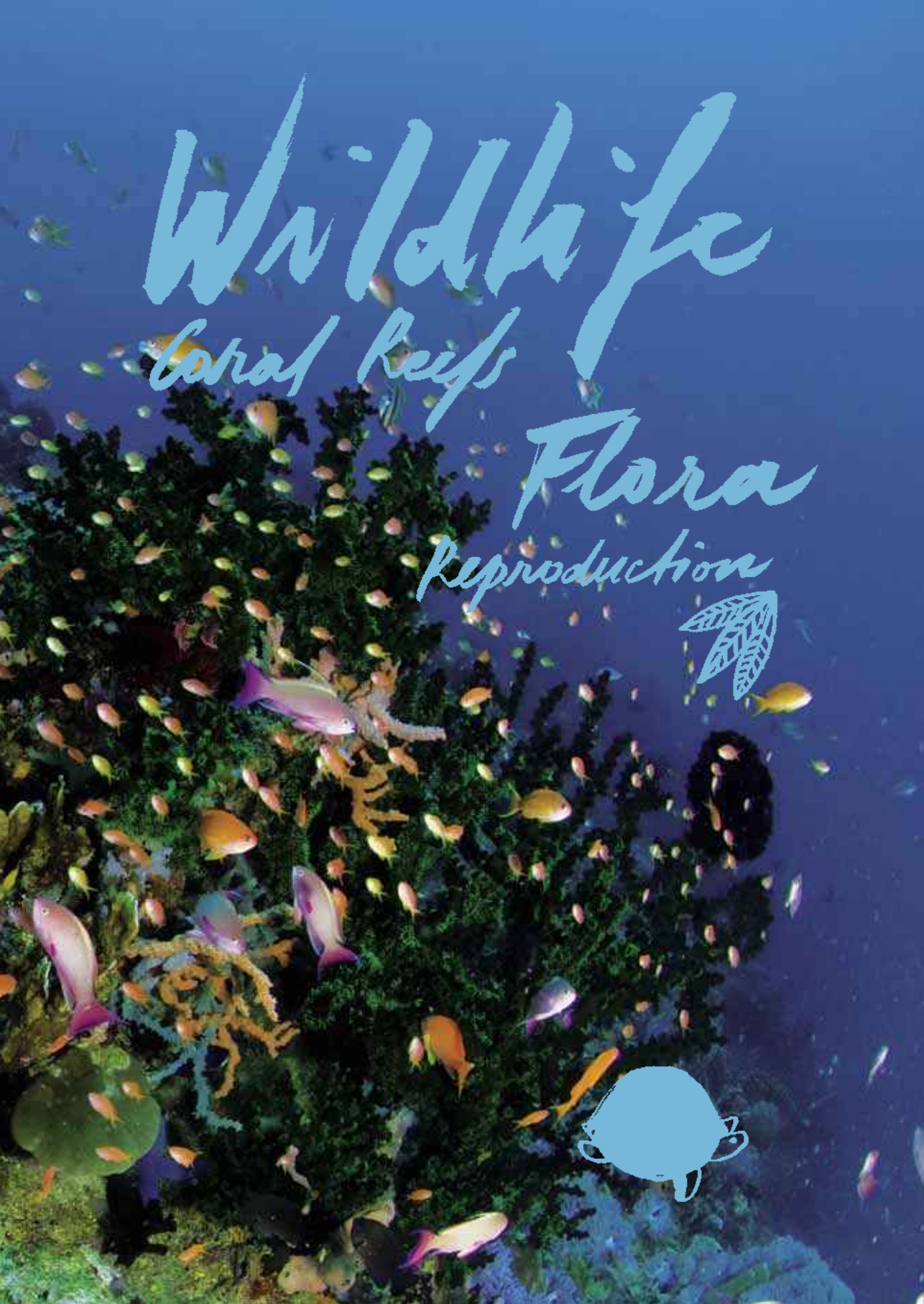
BIODIVERSITY RISKS




Wildlife
Coral Reefs
Flora
Reproduction


Wildlife
Coral Reefs
Plankton
Flora
Reproduction
Habitat
Marine aliens
Decomposition
Ecosystem
Fauna

INTRODUCTION TO BIODIVERSITY RISKS

by Professor Robert McCredie May

Professor Lord Robert May of Oxford OM, AC, FRS
Oxford University and Imperial College
(joint Professorships) Department of Zoology
Reviewer for the AXA Research Fund

Robert McCredie May, Lord May of Oxford, OM, AC, FRS has held appointments at Harvard and Sydney as a physicist and at Princeton and Oxford as an ecologist. He has been President of The Royal Society (2000-2005) and Chief Scientific Adviser to the UK Government and Head of the UK Office of Science and Technology (1995-2000).

We do not know exactly how many distinct species of plants and animals we share today's world with. We know even less about the diverse roles that particular species play in the structure and functioning of their ecosystems. However, we do know that over the past century, the extinction rates within better-known species suggest that we are on the breaking tip of a sixth wave of mass extinctions comparable with the Big Five in the fossil record, which extinguished the dinosaurs.

Such loss of biodiversity will have many effects on the services delivered to us by natural ecosystems. These services range from those classified as "supporting" (e.g., nutrient cycling, soil formation, pollination), "provisioning" (e.g., food, fresh water, wood and fiber), "regulating" (e.g., mitigating flooding, affecting climate, purifying water) and also "cultural" (e.g., aesthetic, educational, recreational). It is disturbing that, of the 24 headings under which these services are classified in the recent Millennium Ecosystem Assessment, 15 are assessed as being degraded, four as improving, and five as insufficiently known for any evaluation to be possible. Moreover, although these services are not included in current calculations of GDP, rough estimates of their value puts it comparable with, or greater than, the global GDP of conventional economics. Indeed, some economists argue that many such services are crucial for life as we know it, thus defying any GDP-like evaluation—making them literally priceless.

This chapter on Biodiversity Risks presents authoritative case studies of threats to specific species and ecological systems. These studies include both plants and animals, in both terrestrial and marine settings. The very wide range of geographical sites and kinds of ecosystems is particularly notable, reflecting the appropriately diverse backgrounds of the authors themselves. In short, the chapter gives us an excellent wide-angle view of the many and varied risks that confront us as a result of current and likely future losses of biological diversity.

READY TO FACE THE ENEMY

Professor Christine Maggs

Investigating the impact and dynamics of marine aliens in the context of climate change: reducing risk by developing evidence-based policies

Professor Christine Maggs
AXA Project
Queen's University Belfast (Northern Ireland)
€350K

Survival of the fittest! This is what evolutionary theory has taught us. Yet did you know that this could result in full-fledged wars in the marine world? The proliferation of invasive marine species to new geographical areas has become a widespread and expanding phenomenon which now endangers the capacity of native species to face genetic drifts.

In addition to this new weakness, the increase of water transport has contributed to the multiplication of pathways and points of entry for marine aliens and biological colonization. Serious economic damage has been an inevitable result, thus making Invasive Alien Species* (IAS) the second most important cause of global biodiversity loss.

Currently Head of the School of Biological Sciences at Queen's University Belfast, Professor Christine Maggs's project aims to provide extensive and valuable knowledge on the status of coastal marine invasions in Europe, with a view to identifying and monitoring the impact of climate change and human pressure on the dynamics of coastal marine ecosystems. In the face of alarming rates of IAS spread in recent years, Professor Maggs's initiative is an innovative response to biodiversity loss, as it brings together a consortium of multidisciplinary stakeholders, researchers and decision makers at the European level.

Indeed, Professor Maggs's strategy, which has been further strengthened by collaborations with Spanish, French and British research institutions, manages to combine top-down (ecological theory-based) and bottom-up (collation of novel and historical data sets of invasion) approaches in a dual model-fitting view. This method facilitates comparison between different invasive species and has potential applications for managing invasions and policy-making.

In addition to reducing the threat of marine biodiversity loss, Prof. Maggs's results could be crucial for the elaboration of management guidelines, in keeping with the European Strategy on IAS, to preserve biodiversity.

THE RESPONSE OF PLANKTON

Responses of diatom and doccolithophore growth, productivity and metabolism to pCO_2 and metal levels (Zn, Co, Cd) and setup of chemostats

Doctor Amandine Cozic-Houly
Postdoctoral Fellow
Institut Universitaire Européen de la Mer (France)
€60K (1 year)

Reproducing the impact of climate change on marine phytoplankton in a laboratory setting was the aim of Dr. Cozic-Houly's postdoctoral research. The change in atmospheric CO_2 concentration will alter phytoplankton productivity by affecting the bioavailability of trace metals and could, through feedback, result in major effects on the composition of the atmosphere. Dr. Cozic-Houly evaluated the effects of a change in the concentration of certain trace metals considered to be micronutrients in the physiology of microalgae. In order to do so, she developed bioreactors in order to cultivate, in a controlled setting, various species of phytoplankton. The ultimate aim of these experiments was to design new models capable of simulating the effects of ocean acidification on marine organisms.

WHAT A POND DOES FOR CLIMATE CHANGE

Investigating how the role of freshwater ecosystems in the global carbon cycle* may be altered by temperature changes

Matteo Dossena
PhD Fellow
Queen Mary, University of London (UK)
€120K (3 years)

Freshwater ecosystems play a key role in the global carbon cycle.* They process huge amounts of carbon and can either act as sinks, sequestering CO_2 and driving it to the sea, or sources, emitting CO_2 into the atmosphere. Matteo Dossena is investigating how global warming may affect these processes. He has demonstrated that the 4°C rise in global temperatures expected by 2100 will increase the rate of decomposition mediated by communities of aquatic organisms. For his PhD, Dossena will investigate how structural changes in the community affect the processing of carbon at the level of an ecosystem. If a rise in temperatures alters the sink/source capacity of freshwater ecosystems, more carbon could be released into the atmosphere, thereby increasing the current rate of global warming. His work may help understand links between temperature rises and carbon cycles, which will be crucial in predicting future changes in the climate.

AN EXCITING CRUISE ABOARD THE TARA SCHOONER

Investigating the interactions between phytoplankton and their viruses and how they could be modified by climate change

Camille Clerissi
PhD Fellow
Université Pierre et Marie Curie (France)
€120K (3 years)

Did you know that planktonic viruses* are the most numerous and most diversified biological entities on Earth? Camille Clerissi must have been busy working for Tara-Oceans, a 2.5-year marine and scientific expedition around the world that studies the effect of climate change on planktonic ecosystems. Clerissi focused on interactions between Mamiellophyceae, a widespread class of unicellular green algae, and their viruses using genetic molecular data. His work was interdisciplinary, combining the acquisition of new data aboard the Tara schooner* and the use of advanced methods of DNA sequencing. As phytoplankters are the foundation of the ocean food chain, Clerissi's work might contribute to assessing whether global warming could contribute to their decline, which would be harmful for fish and, indirectly, for regional economies based on the fishing industry.

HOT TOPIC

Assessing flammability parameters for forest fire fuels in order to set up an improved risk index

Doctor Adam Cowlard
Postdoctoral Fellow
University of Edinburgh (UK)
€60K

Do you feel like more and more forests go up in flames every year? You're right! This is yet another devastating consequence of global warming: hotter and dryer conditions increase the risk of forest fires. Dr. Adam Cowlard's postdoctoral research aims at anticipating the impact of fire outbreaks on forests and the environment in general. Using facilities at the University of Edinburgh, Dr. Adam will conduct laboratory experiments to study the flammability parameters of various fuels. He will focus on species that are representative of the forest floor where fires start and spread. Dr. Adam will also test construction materials to determine the impact of fire spread to urban areas. His results may lead to an improved definition of the traditional fire risk index used by fire fighters to minimize the devastation caused by wildland fires.

ADAPTATION OF ECOSYSTEMS

Evolutionary consequences of global warming on molluscan communities

Doctor Élodie Chapuis
Postdoctoral Fellow
CNRS-EDD (France)
€60K (1 year)

The impact of global warming goes far beyond melting ice. Entire ecosystems could potentially be altered, and the living things making up these environments will have no other choice but to adapt. The method implemented by Dr. Élodie Chapuis aims to assess these changes over the short term. "My work is based on community genetics, a new discipline that examines the evolutionary processes that occur among interacting populations," she explained. Applied to freshwater snails in Guadeloupe, her work will be used to develop new strategies for protecting natural habitats affected by drought and hurricanes in tropical areas through better management of the interaction between native and invasive species.

BAD TIMES FOR BIRDS AND SQUIRRELS

Studying the mechanisms underlying wildlife response to global warming

Coline Arnaud
PhD Fellow
CNRS (France)
€120K (3 years)

"The weather is out of control!" This popular saying describes the impact of climate change on wildlife well: global warming disrupts the timing of seasonal processes such as reproduction and migration. Coline Arnaud's work aims to improve understanding of this newly observed phenomenon by focusing on specific species of birds and squirrels. She is conducting a multidisciplinary study including field work as well as statistical and genetic analyses. One of Arnaud's aims is to find out whether changes in breeding and migration times involve genetic modifications or whether genotypes remain unchanged but are expressed differently due to different environmental conditions. Her results might contribute to obtaining a clearer picture of the mechanisms underlying wildlife response to climate change, which is essential for building efficient conservation programs.

ADAPTABILITY OF TREES

Evolution of tree distribution under global change: colonization dynamics of Holm oak populations at the northern edge of the distribution area

Morgane Urli
PhD Fellow
INRA (France)
€120K (3 years)

How will trees be able to cope with the current rapid rate of climate change? They have two solutions: migrating towards more favorable habitats or adapting to new environmental conditions often characterized by more severe droughts. "Scientists, managers and policy makers need to gain a better understanding of these processes in order to appropriately manage tomorrow's forests," stated Morgane Urli.
The originality of her project lies in the combined use of two complementary disciplines. Biogeography is based on field observations used to verify whether the direction and speed of migration of the species are consistent with predictive models, while the ecophysiological approach aims to better understand the mechanisms of drought resistance in trees.

BETTER THAN AN ORGANIC BEVERAGE!

Studying how roots stabilize slopes depending on soil moisture content

Doctor Marie Genet
Postdoctoral Fellow
Institut Scientifique de Recherche Agronomique (France)
€60K (1 year)

How can we use roots to save human lives? Certainly not by drinking them in weird organic mixtures! Roots save lives by increasing soil strength and preventing shallow landslides. During her postdoctoral research, Dr. Marie Genet investigated how root reinforcement properties were affected by soil humidity. This is a crucial question in the present context of climate change, which influences soil moisture content. Yet getting an answer is a challenge because of the difficulty of sampling root systems. Dr. Genet overcame this difficulty by collecting a large number of root samples on the field using advanced core techniques. She also conducted various in situ and laboratory measurements to assess soil strength and moisture content. Her results could help engineers design efficient and sustainable ecological protection against shallow landslides.

HOW TO SURVIVE: FIGHT AND/OR FLIGHT

Tree range evolution under climate change

Anne Duputié
Postdoctoral Fellow
CNRS (France)
€60K (1 year)

Species may respond to climate change via two non-exclusive strategies: they may track favorable climates and/or quickly change and adapt their phenotype* (such as drought resistance or timing of spring events). Using a model that infers the survival and reproductive output of temperate trees from climatic data, Dr. Anne Duputié could identify selective pressures that act on key traits of the trees' life cycle. For the first time, potential genetic changes and dispersal abilities were jointly taken into account to calculate a more accurate probability of the trees' persistence in changing environments. Parameterized for the pedunculate oak, this model can be extended to other species, providing information about the existing genetic variation for these traits. These results could contribute to creating future biodiversity scenarios.

DOLPHINS IN DANGER

Investigating the effects of climate change on marine species

Doctor Ruth Fernández-García
Postdoctoral Fellow
University of Copenhagen (Denmark)
€120K (2 years)

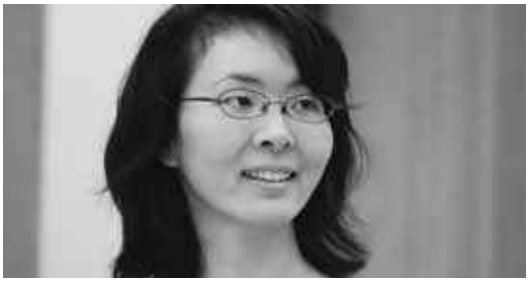
Climate change affects biodiversity. Species migrate to areas where the climate suits them, which may isolate groups of populations, reduce their genetic diversity and ultimately lead to their extinction. Negative effects on biodiversity could in turn have economic consequences. In marine zones, cetaceans, which control the distribution of many fish species, seem particularly at risk. To what extent will they be affected? During her postdoctoral research, Dr. Ruth Fernández-García will focus on the fate of two cold-water species of dolphins living in different environments. She will try to predict their future distribution by combining climate and habitat modeling and will investigate genetic variations caused by environmental change. Her research may then be extended to other species, including fish species of commercial importance.

WANT TO KNOW MORE ABOUT MARINE ECOSYSTEMS? FOLLOW THE TURTLES

Impact of climate change on marine biodiversity: the case of plankton-feeding species

Doctor Sabrina Fossette
Postdoctoral Fellow
Swansea University (UK)
€90K (18 months)

Marine ecosystems are facing extreme and rapid changes. In particular, there are concerns that jellyfish may be taking over the oceans due to overfishing. Jellyfish are very difficult to study; however, an original approach is to study their more accessible main predator, the leatherback turtle. Leatherbacks explore variable oceanic environments as they undertake long-distance migrations every 2-3 years from tropical nesting sites to temperate foraging grounds to feed on jellyfish. Their behavior is therefore deeply influenced when a shift in the abundance of jellyfish takes place. This species can therefore be considered a bio-indicator, since its migration habits may help us understand how natural and human-driven environmental changes affect marine ecosystems. Dr. Sabrina Fossette spent several months in French Guiana to equip turtles with satellite tags and follow them during their migration across the Atlantic Ocean in search of their gelatinous meal.



TRANSFORMATION UNDER STRESS: DARWIN VS. KAFKA

Environmental effect on animal development with a special focus on chordat neural patterning*

Doctor Atsuko Sato
Postdoctoral Fellow
University of Oxford (UK)
€60K (1 year)

In Kafka's book *The Metamorphosis* a man turns into a giant insect overnight. According to Dr. Atsuko Sato, this is not fiction: environmental changes can be drivers for the evolution of new forms and not only a major cause of species extinction. A genome can accommodate multiple evolution paths, and life can adapt itself to its surroundings. For example, snails can change the shape of their shells as a defense mechanism. Dr. Sato focused on ascidians* to investigate how temperature changes could alter morphology and gene expression pattern during development. Ascidians are settled marine invertebrates with a simple and small genome and the closest invertebrate relatives of vertebrates. They therefore provide an excellent model to study the impact of environmental stress on our genome. Dr. Sato's work is unique since there have been few studies on the effect of rising temperature on the development of marine organisms at genomic scale.

GREEN FIREMEN AT IBITY MOUNTAIN

Effects of global changes on the vegetation management plan of the Ibity protected area in Madagascar

Swanni T. Alvarado
PhD Fellow
Université d'Avignon (France)
€120K (3 years)

Madagascar is one of the largest reservoirs of biological diversity in the world. Yet in the last 50 years, its ecosystems have suffered from great pressures, leading to a profound modification of natural processes (e.g. fire regimes), contributing to environmental and, ultimately, to socio-economic and cultural impoverishment of the island and its inhabitants. As part of a prospective conservation project, Swanni T. Alvarado has joined forces with local institutions and communities in an effort to better manage and protect the vegetation of the Ibity Mountain from its greatest threat: fire. She is combining data on the effects of fire frequency on Ibity's biodiversity, climate and annual burned areas with ecological and socio-geographic analyses in order to propose an appropriate vegetation management plan. Besides its paramount importance for local actors, Alvarado's work may inform land-use management policies.

WIND AND DISPERSAL

How does climate change affect the dispersal ability of plant species? A case study of the fine-scale spatial genetic structure of Azorella selago on sub-Antarctic Marion Island

Doctor Céline Born
Postdoctoral Fellow
University of Stellenbosch (South Africa)
€60K (1 year)

How does climate change affect seed and pollen dispersal, an essential process for plant reproduction? To gain an in-depth understanding, Dr. Céline Born traveled to Marion Island in the sub-Antarctic Indian Ocean to study *Azorella selago*, a "keystone" plant species due to its critical importance to ecosystem function. Using the genotyped specimens found on the island, she is studying the impact of wind patterns on pollen dispersal of *Azorella*. "Our research will be used for the development of a conservation plan for the sub-Antarctic region, which is particularly affected by climate change," she explained.
This data will be used to predict colonization of the plant based on various global warming scenarios.

THE LAST STAND OF CORAL REEFS

Quantifying Risk to Tropical Reefs ('QUARTR')

Nancy Jones
PhD Fellow
University of Bristol (UK)
€120K (3 years)

Marine eden or underwater desert? As they fight for survival against rising temperature and acidifying oceans, the magnificent coral reefs of our oceans may not survive… Using a cutting-edge computer model of her making, Nancy Jones is trying to figure out if future generations will experience the pleasure of contemplating a coral reef, which has never been more uncertain. Throughout her PhD, Jones is looking at the way humans are directly and indirectly affecting reefs. Her aim is to ensure the conservation of coral reefs and to study the economic impact their disappearance might have. Tourism, biodiversity and fisheries are indeed deeply linked to coral reefs. Jones's research will help to identify the reefs that are most at risk of collapse as well as reef sites which could be key to management strategies in the future.

WHEN GENETICS LOOKS LIKE GARDENING

Evolution of the mechanisms of plant adaptation to climate change

Delphine Cast
PhD Fellow
Université de la Méditerranée (France)
€108K (3 years)

Every gardener knows that a plant needs the right light, temperature, water and fertilizer to grow properly. Biologists call these non-living factors abiotic* ones. Plants majorly adapt to abiotic stress caused by climate change, but the molecular mechanisms that perceive environmental changes and allow the plant to adapt accordingly are still largely unknown. Using a small moss, which is a new model plant for genetic analysis, Delphine Cast investigated the role played by a family of regulatory proteins in this adaptation. She has thus proved that these genes are crucial regulators of plant development in response to abiotic stress. As these proteins are found in all plants, these findings may ultimately lead to reducing the difficulties faced by farmers suffering from recent climate changes and will probably change the way you look at your tomatoes forever.

WHAT'S IN A NAME? WOULD A HIHI BY ANY OTHER GENES FLY JUST AS SWEET?

Doctor Patricia Brekke

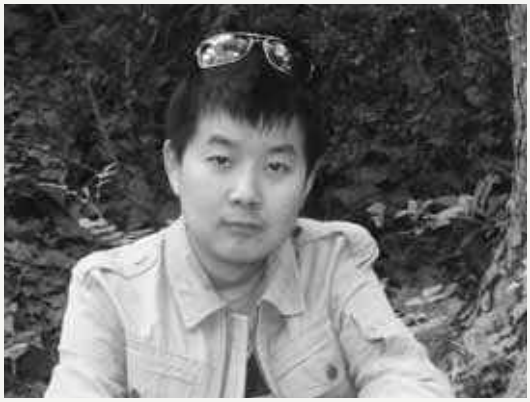
Micro-evolutionary response to climate change in wild populations

Doctor Patricia Brekke
Postdoctoral Fellow
Institute of Zoology, Zoological Society of London (UK)
€120K (2 years)

Survival of the fittest: the old saying is back on the agenda for the 22nd century as rapid climate changes produce a range of new selection pressures on wild populations. Indeed, as physical environments evolve, species must adapt to cope with these changes. Understanding their response will be of extreme importance to the maintenance of biodiversity and climate change mitigation. Yet, Dr. Brekke points out that most studies to date have been based on range shift* and phenotypic plasticity,* whereas the role of evolutionary adaptation (i.e. genetic change) remains elusive. Indeed, there is a limited understanding of the relative importance of evolutionary adaptation or how it interacts with phenotypically plastic responses. While some advocate plasticity as the most important mechanism to cope with climate change, others consider genetic adaptation to be key, as it is a requisite for coping with long-term environmental changes. Finally, understanding how wild species respond to climate change when range shift is nearly impossible (e.g. island or fragmented populations) is especially important, as a vast number of threatened species fall into this category. This lack of information hinders our ability to predict and manage the effects of climate change on biodiversity. Dr. Brekke's study will address this gap by using a novel approach of coupling climate change studies with reintroduction (translocation) biology, focusing on an endemic* New Zealand bird, the hihi. The hihi are endangered forest-dwelling birds, restricted to a single self-sustaining remnant island population. However, they have been subject to a number of reintroductions, which have been intensely monitored. In addition to this data, Dr. Brekke's pioneering work prompts her to combine experimental translocation and quantitative genetics using multiple life-history traits and climatic factors, with a view to understanding how two contrasting, but not mutually exclusive mechanisms (plastic and genetic) can explain evolutionary responses within populations of the hihi. Besides contributing to our understanding of adaptation to global climate change and informing conservation management and NGO policies, this study will also generate information that could be used in climate change forecasts to predict changes in biodiversity.

MODELING ROOT REINFORCEMENT

Zhun Mao



Temporal and spatial modeling of root reinforcement in natural mountains and protected forests

Zhun Mao
PhD Fellow
INRA (France)
€120K (3 years)

How can we best manage our forests in the face of the challenge of global warming? At a time when our planet is increasingly affected by landslides and erosion—consequences of extreme weather conditions—this question preoccupies many scientists. Among them, Zhun Mao specifically focuses on mountain areas. “These areas are home to many of the world’s forests and fertile land,” he explained. “Their role is therefore essential in order to feed the growing global population, which should reach 9 billion men and women by 2050.”

His investigations aim to better understand how to use plant roots, and mainly tree roots, in order to reinforce soil to protect against landslides. In order to do so, he is studying the development of the root systems of various species, including Norway Spruce, Silver Fir and European Beech, based on samples collected in Chamrousse, a small mountain village in Isère, France. The data will then be incorporated into various models of growth over time and space in order to identify areas at risk as well as areas where the land is reinforced by roots.

“The aim is then to determine the best possible combination of species capable of withstanding environmental pressures in the long term,” stated Zhun Mao. “This will mitigate soil degradation, which poses serious problems in Europe and around the world.”

Such a tool, developed for all types of forests, whether natural, semi-natural or planted, will be used by foresters to help make land-use planning decisions. The results will also be incorporated into an expert computer system, which will be freely accessible online, providing advice on managing areas vulnerable to landslides, erosion and storms.

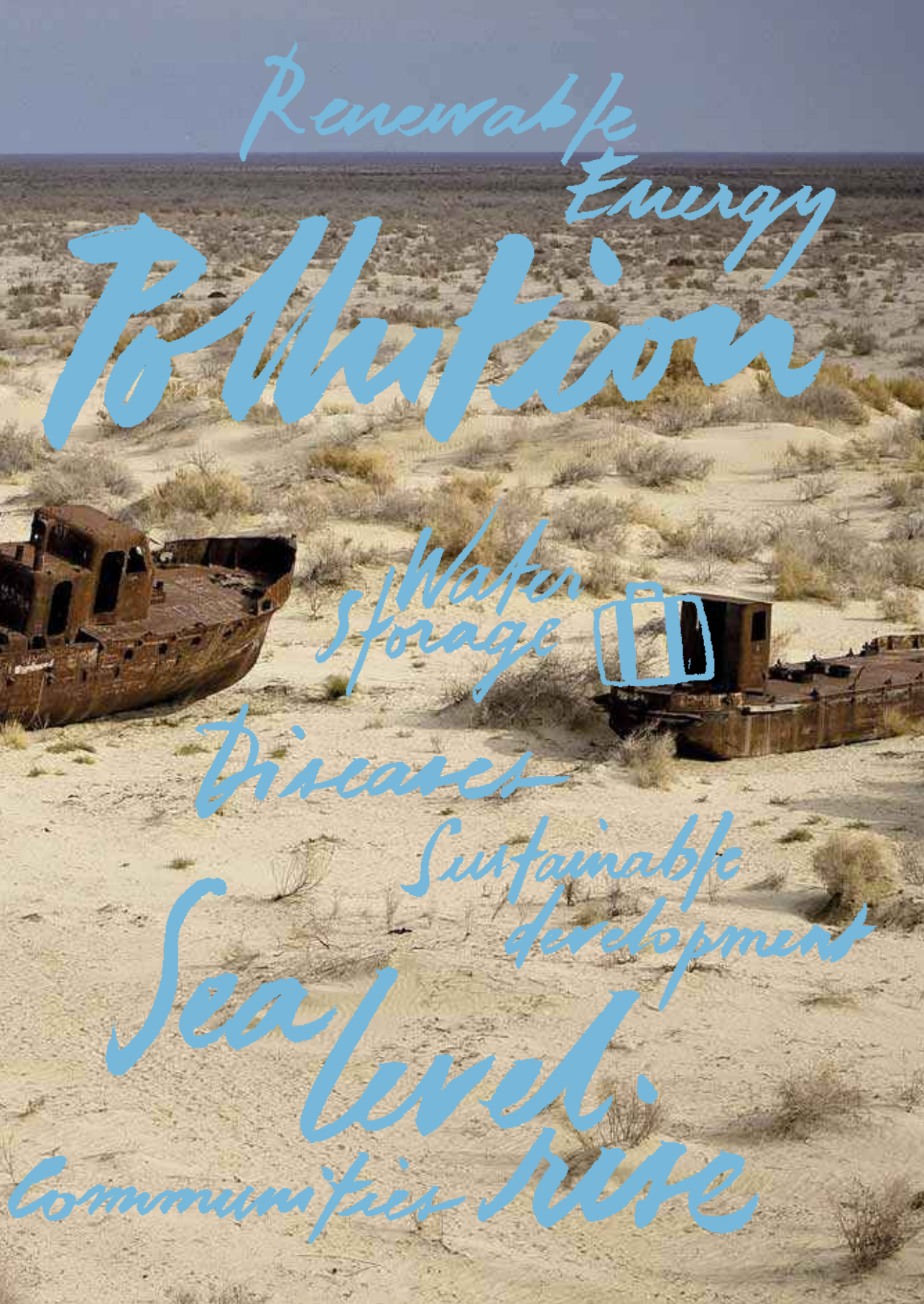
NOTES

5. SOCIOECONOMIC CONSEQUENCES OF ENVIRONMENTAL RISKS

Conflicts

Migration

Early warning systems


Renewable Energy
Pollution
Water storage
Diseases
Sustainable development
Sea level rise
communities


Communities
Pollution
Renewable Energy
Diseases
Sea level rise
Early Warning Systems
Sustainable development
Migration
Water storage
Conflicts

INTRODUCTION TO SOCIOECONOMIC CONSEQUENCES OF ENVIRONMENTAL RISKS

by Professor Wendy B. Jacobs

Professor Wendy B. Jacobs
Harvard Law School (United-States)
Reviewers for the AXA Research Fund

Wendy B. Jacobs is a Clinical Professor at Harvard Law School and Director of its Environmental Law and Policy Clinic. She has practiced environmental and administrative law since graduating from Harvard Law School in 1981. She began her career as an appellate attorney at the U.S. Department of Justice.

Environmental risks run the gamut from the local (contaminated water) to the global (climate change); from the immediate (chemical plant explosion) to the very long-term (sequestration of carbon dioxide); from the visible (strip mining) to the invisible (exposure to nano particles); from the tangible (soot) to the intangible (radiation). How we perceive and rank these risks depends upon our perspective as individuals, scientists, economists, governments and nations. How we allocate our finite resources to manage and mitigate risks depends on our risk analysis. Until recently, environmental risk was analyzed through the narrow lens of "environmental impact assessments," which focus on the direct—and usually local—impact of an activity on human health and the environment. Now, we have better tools for expanding the analysis to include a wide range of environmental and socio-economic impacts—lifecycle analyses. These examine not only the direct impacts of an activity but also the upstream impacts from the extraction and transport of raw materials and production of energy needed for the activity to proceed and the downstream impacts. The results better equip us to make informed decisions. So, for example, with the benefit of a careful lifecycle analysis, we can better assess the carbon imprint of a product or activity. We can assess its sustainability from multiple perspectives. We can make informed decisions about whether to invest in renewable energy or in the capture and sequestration of carbon dioxide emitted by fossil-fueled electric generation plants or in the fracturing of shale to extract natural gas for producing electricity. We can compare the activities' respective use of energy and consumption of natural resources as well as their emissions of pollutants. If our ultimate goal is to mitigate climate change, then we need to undertake lifecycle analyses to make informed decisions among these options and so many other decisions that in the aggregate contribute to climate change. Many of the studies funded by AXA develop data needed for lifecycle analyses.

TOWARDS A COMPREHENSIVE PANORAMA OF NATURAL HAZARDS IN SOUTHEAST ASIA

Professor Kerry Sieh

Professor Kerry Sieh
AXA Chair in Natural Hazards
Nanyang Technological University (Singapore)
€3M (Permanent)

It's as if Jakarta were standing on quicksand… Several places of the capital city of Indonesia are subsiding at rates of about 1-15 cm per year, and a few locations have subsidence rates of up to 28-30 cm per year. Such land subsidence* has been reported for many years and is stressful when one knows that today, the city has a total population of about 10 million people inhabiting an area of roughly 660 km^2. This phenomenon, which is being investigated by Prof. Abindin Hasannuddin (Bandung, Java), is strongly related to urban development activities in Jakarta and is driven by groundwater extraction, the load of construction, natural consolidation of alluvial soil as well as tectonic subsidence. Land subsidence obviously introduces environmental problems and affects the urban development plan and process.

The explosion of the human population in the past six decades has placed a very large, double-digit percentage of the planet's 7 billion humans at risk from natural hazards. The victims of the great 2004 tsunami are a notable case in point. Of the 350,000 inhabitants of Banda Aceh, the capital city of the northern Sumatran province of Aceh, about 90,000 perished. Had that natural event occurred just a century earlier, the loss of lives there would have numbered in the hundreds or low thousands, as the city's total population at the time was only a few thousand. Another important consideration of the problem of natural hazards is that very long periods of repose between a region's major earthquakes, tsunamis and volcanic eruptions lull potential victims and cultures into a false sense of security.

Prof. Sieh and his students discovered that the immediate predecessor to the 2004 tsunami happened more than five centuries earlier, so long ago that it had completely disappeared from Aceh's collective memory. Spans of time as great as this between cataclysmic events are common. Finally, and tragically, even scientists had not anticipated the 2004 event, because no one had researched the history of previous events from the historical or geological record, let alone publicized it among those who were at risk. Prof. Sieh acknowledges that scientific issues in Southeast Asia have not been extensively explored.

"I got involved in earth science related to geohazards because I felt a need to do something with my brain that actually helps sustain society and contributes to make the world a safer place."

Southeast Asian cities are expanding unwittingly on coastal plains that are prone to tsunamis, powerful storm surges and sea-level rise. Chains of active volcanoes that arc through Asia are slumbering menaces to the region and, in some cases, even to the world at large. Tambora's 1815 eruption, east of Bali, for example, was much greater than the infamous Krakatau eruption of 1883 and led to famine across North America and Europe. Even smaller eruptions can be regionally or globally significant, a case in point being the Icelandic eruptions of 2010.

Climate change and sea-level rise will also strongly affect Southeast Asia. Given its significant coastal populations and large river deltas, small increases in sea level pose significant risks to a broad range of countries. Changes in temperature, precipitation and ocean acidity threaten the region's agricultural, marine and timber-based industries, which constitute a large portion of the region's GDP.

Most of these hazards are at present inadequately understood scientifically. The Earth Observatory of Singapore (EOS), led by Prof. Sieh, strives to foster geophysics research in three main areas: improving the comprehension of earthquake-generating faults, better understanding the inner workings of active volcanoes, and understanding climate change, namely to forecast the nature of sea-level rise and to develop enhanced monitoring of climate variables.

Prof. Sieh has looked back hundreds to thousands of years into the past to understand earthquakes. His early work led to the discovery of how often the San Andreas Fault has generated earthquakes in Southern California. This research initiated the field of paleoseismology,* a geoscience sub-discipline that uses geological layers and landforms to understand the geological faults that produce significant earthquakes.

He found that the San Andreas earthquakes occurred irregularly (from fifty to three hundred years apart) but was unable to ascertain why this is so, because radiocarbon dating was too imprecise. Thus, he began working in Sumatra where he could use U-Th* to precisely date corals and measure deformation. His work along the Sunda megathrust,* a great undersea fault which extends under Sumatra, has revealed patterns of ancient rupture and current straining and has led to a significant success in forecasting several large earthquakes in Sumatra. This ongoing research also suggests that the megathrust* is poised to produce yet another giant earthquake in western Sumatra within the next 30 years.

Prof. Sieh is a member of the US National Academy of Sciences, one of the highest honors that can be accorded to a US scientist. He has also been elected as a Fellow of the two main American professional earth science organizations, the Geological Society of America and the American Geophysical Union.

With the endowment from AXA, Nanyang Technological University has established the AXA-Nanyang Chair in Natural Hazards at the EOS with Prof. Sieh as inaugural incumbent. These funds will enable one of Singapore's five Research Centers of Excellence to become an enduring pillar in earth science research and dissemination in the region, creating multidisciplinary research programs: creating cross-disciplinary connections to the risk assessment and management, policy, economic and educational domains of natural hazards and climate change as well as strengthening integrated research capabilities through joint appointments with other research entities at NTU.

CONFLICTUAL CLIMATE

Exploring the link between climate change and armed conflicts and how adaptation to climate change may contribute to peace building

Natasha Chamberlain,
PhD Fellow
University of Exeter (UK)
€120K

Will climate change lead to armed conflicts? Mass migration and competition over natural resources due to the impacts of climate change may lead to a rise in violent conflict in developing countries. Yet adaptation may play a key role in terms of building the resilience of communities to lessen the severity of future climate impacts, fostering cooperation between social groups and promoting peace and reconciliation. Natasha Chamberlain is investigating the relationship between climate change adaptation and human security. Through fieldwork conducted with pastoral societies in Ethiopia and Kenya, she will examine how communities adapt to climate change, to what extent they are successfully assisted by international aid organizations and whether adaptation strategies have had any impact on outbreaks of violent conflict.

MALARIA, TAKING FLIGHT!

Global climate change and the spread of malaria

Doctor Claire Loiseau
Postdoctoral Fellow
San Francisco State University (USA)
€60K (1 year)

Everyone enjoys a bit of summer heat, but no one as much as parasites and diseases! Unfortunately, global warming is opening new areas of the world, particularly in northern latitudes, to an ever-widening range of pathogens and hosts, such as migratory birds and mosquitoes, which are cold sensitive. Malaria is one of those dreadful candidates for international spread. Since it kills more than a million people every year, Dr. Loiseau and her team decided to address its spread and transmission in Alaska, where the effects of climate change are bound to be dramatic. To understand how climate change will impact the transmission of avian malaria parasites overtime, she will first monitor changes in malaria prevalence* and diversity through blood sampling and then investigate shifts in parasite patterns due to seasonal variance. In the future, she expects to develop predictive models to inform policy decisions relevant to the eradication of wildlife and human malaria.

CHEAP ALKANES, THE WAY TO SUSTAINABLE CHEMISTRY?

Sustainable chemistry from alkanes

Doctor Zuo Weiwei
Postdoctoral Fellow
CNRS (France)
€60K (1 year)

Plastics, synthetic fibers, pharmaceutical drugs: a few examples among a wealth of added-value products that are now born out of an alkane-based chemical synthesis. Indeed, alkanes or hydrocarbons, are the primary constituents of clean-burning fuels and natural gases, coveted by chemists. Yet, due to the generally unreactive nature of alkanes, chemical syntheses do not automatically yield the best possible results, with significant quantities of alkanes left unused. Besides ruining the latter's ecological virtues, this is an undeniable loss for the economy. Thus, to overcome the problems of such methods, Dr. Zuo Weiwei chose to make better use out of cheap alkanes that were not properly converted. He developed new dehydrogenation catalysts to form a new higher-added value chemical, the olefin. This process represents a particularly important step toward an optimal use of natural resources, thereby meeting society's need to find cheaper and cleaner sources of materials and energy.

GREEN CHEMISTRY

Sustainable biomass valorization based on iron-catalyzed reactions

Jianxia Zheng
PhD Fellow
Université de Rennes 1 (France)
€120K (3 years)

In an effort to design more eco-friendly products, Jianxia Zheng is using green chemistry, an approach that aims to limit or even eliminate the use of hazardous substances. To reach this aim, she is investigating biomass as a viable alternative to petroleum-based products, which are widely used today. "The challenge lies in identifying new chemical reactions that are robust, energy efficient and environmentally friendly," she explained. "We are therefore exploring new methods based on the use of iron as a catalyst in order to facilitate the conversion of biomass into products of interest." Today, her efforts are focused on the synthesis of alcohols intended for use in the pharmaceutical, agricultural and cosmetic industries.

"HYDROGEN PUMPS" RATHER THAN GAS PUMPS?

Designing methods for the storage of hydrogen in a solid state

Doctor Petra Szilágyi
Postdoctoral Fellow
University of Edinburgh (UK)
€120K (2 years)

Fed up with paying too much at the gas pump? Alternative forms of energy carriers are emerging, just be patient! One may be hydrogen: when hydrogen is combined with oxygen in a fuel cell, electricity is produced. Dr. Petra Szilágyi is working on potential solutions for the safe, reversible and economical storage of hydrogen. Indeed, this is a major issue to resolve before any extensive use of this new technology can be made. What makes the storage of hydrogen challenging is that, in its natural state, hydrogen is a gas. Dr. Szilágyi is conducting state-of-the-art high-pressure experiments to find solutions for solid-state storage. For on-board, automotive applications, her research could help hydrogen energy become a replacement for fossil fuels, which are limited and polluting. Ultimately, this could have a profound impact on the global economy, as we take one more step towards a new "hydrogen economy."*

LONG LIVE NATURE!... BUT WHAT NATURE?

Innovative responses to environmental threats: the role of "local" knowledge

Patrick Bresnihan
PhD Fellow
Trinity College Dublin (Ireland)
€120K (3 years)

It may seem obvious that the urgent ecological problems of our time, from climate change to resource depletion, require higher regulation of the natural world. But what if there were more than one Nature? After spending several months working on commercial fishing boats, Patrick Bresnihan realized that while fishermen are concerned about the problems of overfishing, they do not always identify with the idea of a natural world that is external, predictable or manageable. Through the concept of "commoning,"* Bresnihan shows how everyday interaction with an unpredictable environment produces many different perceived natures which are not understandable within one management model. This raises important questions for policy makers: how can everyday practices of "commoning" become part of new forms of ecological organization? How can we develop forms of management and organization that are sensitive and open to the many natures produced within specific ecological contexts?

CARBON TARIFFS: ANOTHER NAME FOR GREEN PROTECTIONISM?

Marco Springmann

Carbon tariffs: an instrument for tackling climate change?

Marco Springmann
PhD Fellow
DIW Berlin (Germany)
€120K (3 years)

Carbon tariffs are a tax on carbon-intensive imports, which recently triggered heated international debates. Certain industrialized countries have been advocating the adoption of carbon tariffs on products imported from developing countries, such as China. According to Marco Springmann, a physicist turned economist, the main reason is that certain rich nations have implemented binding targets to reduce greenhouse gas emissions, while poorer countries have so far resisted legal commitments. Additionally, because many of them simply do not set a price on carbon, they can produce cheaper carbon-intensive goods. Promoters of carbon tariffs thus think that taxing such goods at the border will make up for this difference in price and indirectly regulate the associated emissions.

However, almost a quarter of China's CO_2 emissions come from its exports. So China and other nations view carbon tariffs as trade sanctions and protectionism. They even threatened to start a "trade war" if such schemes were to be put into place. They stress the role that carbon emissions have played in the industrialization of advanced economies and demand increased financial aid in order to reduce their emissions.

To avoid this coming carbon war, Springmann proposes to recycle the tax revenues from carbon tariffs (claimed in the importing country) to the exporting country as investments in climate change mitigation and adaptation measures. This coupled scheme addresses the concerns about competitiveness and reducing emissions in one part of the world and economic progress in the other. Since it acknowledges the demand for imports as an emissions-causing factor, it may therefore represent a consensus solution within a global climate policy. According to Springmann, a preliminary assessment has indicated that the revenue from this scheme would range between $8 and $50 billion per year, depending on the price of carbon. In comparison, at the climate summit in Copenhagen in 2009, it was agreed to create a "Fast Start Fund" to support climate adaptation and clean technology in developing countries. The pledged contribution is $30 billion over the next three years. Carbon tariffs would add significant revenue streams to this effort.

FROM GREEN TO BLUE: CLEAN WATER THROUGH THE USE OF PLANTS

Phytoremediation in Constructed Wetlands (CWs) of water and sediments contaminated by trace elements

Lilian Marchand
PhD Fellow
INRA (France)
€120K (3 years)

Thanks to their curative value, plants are celebrated as mighty healers. But did you know about their cleansing power for water? Lilian Marchand's research is about to add to the great reputation of plants thanks to his investigation of phytoremediation,* i.e. the ability to clean up groundwater using plants and associated microbes. By pumping contaminated water into constructed wetlands with suitable vegetation, Marchand seeks to remove significant traces of soil pollutants with the help of roots and the microorganisms they host. To this end, he is conducting experiments on a large selection of plants to identify the best candidates for decontamination based on their functioning and physiological response. In the light of European legislation on the treatment of wastewater, this cost-effective and aesthetically pleasing method definitely sounds promising.

MAPPING GLOBAL WATER RESOURCES FOR THE 21ST CENTURY

Global water resources: the impacts of climate change and population dynamics

Steven Murray
PhD Fellow
University of Bristol (UK)
€120K (3 years)

Scarcity of freshwater resources—hydrological stress—not exactly the stuff dreams are made of. Yet, climate change and demographic evolutions will ultimately exert an ever-increasing pressure on water availability and demands. But what if we could anticipate and identify "hot spot" regions where water stress* is likely to become a major economic and/or political issue? This is precisely what Steven Murray sought to achieve via an innovative global hydrological model, which combines biological and physical processes with socio-economic dynamics to locate high-risk regions a hundred years from now. Strong emphasis is notably placed on how changes in vegetation distribution and structure will influence water cycles. Murray's results intend to help policy makers for future water management and thus improve the prospects of enhanced global water security.

HYDROPOWER: WHEN POLITICS CAN ACT AS A BUFFER AGAINST CLIMATIC RISK

An economic assessment of the role of climate change and transboundary cooperation in hydropower production in the Niger Basin

Esther Delbourg
PhD Fellow
Ecole Polytechnique (France)
€60K (18 months)

The risk of conflict over water in Africa depends on a multitude of human (economics, politics, culture and history) and natural factors (geography and climatic uncertainty). Esther Delbourg is studying a critical component in water negotiations: hydropower, an energy that requires high investment costs as well as a proper geographical setting and is highly dependent on climatic features. She has set out to assess the economic impact of climate change on hydropower production using the various relations between hydro-investment, past climatic data and climatic scenarios, cooperation and economic performance. By estimating the impact of hydropower variations on countries' GDP, her results should help better understand whether climate change will significantly impact future cooperation or conflict between African transboundary countries.

MANAGING LOSSES IN ECOSYSTEMS: A PRACTICAL TOOLKIT

Quantifying the risks caused by habitat loss: a practical toolkit for informed decision making

Doctor Kelvin Peh
Postdoctoral Fellow
University of Cambridge (UK)
€120K (2 years)

Intact ecosystems play vital roles for human well-being, not just by providing harvestable goods such as timber and fish, but also by delivering a suite of less tangible services, such as stabilizing local and global climate, regulating hydrological flows and absorbing storm energy. With looming threats of climate change and natural disasters, Dr. Peh stresses that the preservation of these ecosystem services* is critical to limiting the risks faced by local communities—particularly in poor rural contexts. Indeed, one suppressed element could topple the whole equilibrium of a given ecosystem. Yet, policy and decision makers are constantly confronted with such losses, with little to no information on preferred alternatives. To fill this gap, Dr. Peh used a multidisciplinary approach to develop a decision support toolkit to allow individuals with limited technical training to provide rapid assessments of the net social effects of land-use change at a local level.

THE SOCIAL QUEST FOR INDOOR COMFORT

Urban and architectural retrofit in a climate-changing scenario: the significance of users' behavior and comfort analysis to face overheating risks

Doctor Margot Pellegrino
Postdoctoral Fellow
Université Paris Ouest Nanterre La Défense (France)
€120K (2 years)

At least 35,000 people lost their lives in August 2003 due to the exceptional heat wave that hit Europe. To better understand the phenomenon of overheating in highly populated urban areas, Dr. Margot Pellegrino plans to study social responses to overheating by including them in an integrated model, together with technical and environmental characteristics of buildings. How do people feel when it is hot inside a building? What kind of action do they take to deal with overheating? Dr. Pellegrino will monitor actions, choices, decisions and comfort perceptions in the Ile de France region based on factors such as building typologies of individual adaptation mechanisms. She will provide guidelines on possible architectural as well as urban retrofitting* actions to help the people living in these buildings improve their indoor comfort.

MONITORING AEROSOLS

In-cloud multiphase chemistry: a new way to improve the evaluation of health and climate change risks due to atmospheric aerosols

Pascal Renard
PhD Fellow
Université de Provence (France)
€120K (3 years)

Predicting air quality also means monitoring aerosol formation in the atmosphere. "These gases can be harmful to human health and cause respiratory problems," stated Pascal Renard. "Some aerosols are even classified as carcinogenic." To learn more, he is studying the formation of secondary organic aerosols in the clouds. These are reaction products of isoprene, one of the major organic compounds emitted by plants. In order to better describe the physical and chemical processes involved, he is recreating the atmospheric conditions in which these processes take place in a laboratory setting. His initial results show that small polymers* are synthesized in photochemical reactions in the aqueous phase. This data is being incorporated into the climate prediction models being developed by the Intergovernmental Panel on Climate Change (IPCC).*

WHEN CLIMATE CHANGE SHAPES POLITICAL DISCOURSE

Political environment: the impact of climate change on politics in South Asia

Ayesha Siddiqi
PhD Fellow
King's College London (UK)
€120K (3 years)

Pakistan is a country going through numerous political challenges due to disasters and conflict. Yet things could get worse: what if militant Islamist groups were to win the country's next elections? Indeed, climate change is increasing the frequency of disasters, paralyzing the government and increasing support for radical ethnic and religious groups in post-disaster Pakistan. After two years working as a consultant specializing in the socio-economic consequences of climate change, Ayesha Siddiqi is now studying its impact on politics in South Asia. She is addressing three key questions, which are all but absent from academic literature: how climate-related disasters are impacting religious and ethnic politics in Pakistan; how ethno-national and religious politics are able to use the discourse on climate change to meet their own goals; and finally, how this affects the political stability of the region.

THE ART OF STREAMING UNCERTAINTIES

Optimal risk-based decisions by maximizing extraction of environmental information for streamflow forecasts

Doctor Steven Weijs
Postdoctoral Fellow
Ecole Polytechnique Fédérale de Lausanne (Switzerland)
€120K (2 years)

Water is fickle, water flows are unpredictable. Yet, we have never been in such dire need of accurate streamflow forecasts to manage water systems! Operating the latter means relying on a sequence of timely decisions to obtain optimal benefits and minimize risks and uncertainties. In the case of hydropower reservoirs for instance, the daily water releases should both maximize power production benefits and offer sufficient flood storage to guard against flood risks. To effectively combine real-time information and understanding of the physical processes involved in droughts and floods, Dr. Weijs chose to focus on the Val Ferret watershed in the Alps. By balancing information flows from intensive measurements and state-of the art models, Weijs's methods will be essential to move from a detailed physical understanding to probabilistic streamflow forecasts that can be produced cost-effectively and to inform decisions reducing flood and drought risks.

RANDOM INTERLACEMENTS
Corrosion and interlacement percolation

Doctor Augusto Teixeira
Postdoctoral Fellow
Fondation Sciences Mathématiques de Paris (France)
€60K (1 year)

Conversion of radioactive waste, spread of epidemics, computer network failure… Although very different, all of these events involve transition from one state to another, a process which is described today using percolation* theory. "When applied to materials science, the drawback of this theory is that it considers each element of the material under study independently. However, this does not reflect reality," explained Dr. Augusto Teixeira. He is participating in the development of an alternative model, known as random interlacement, which incorporates the notion of dependence between the different elements of a crystalline material. His aim is to pinpoint the differences and similarities between these two types of models. This should help scientists choose the most appropriate model based on their applications.

ZOONOSES*: BURNING ISSUE IN A WARMING WORLD
Climate change and emerging infectious diseases in the Mediterranean wetlands

Marion Vittecoq
PhD Fellow
Fondation Tour du Valat (France)
€120K (3 years)

Let us take a wild guess and assume you know nothing about zoonotic pathogens.* Chances are we would not be far from the truth, even though they are the source of most emerging diseases. As infectious agents that circulate in animals and can infect humans, their dynamics are highly complex. This fact is further enhanced by climate change, which creates opportunities for pathogens to encounter new hosts and thus migrate to new regions. Marion Vittecoq focused on the Mediterranean Basin, a key area for parasite spread, at the crossroads of several continents. She investigated the epidemiology of two important emerging zoonotic viruses, avian influenza and West Nile viruses, and correlated her findings with data on wildlife, domestic birds and humans, in the light of climate change. Now that host-pathogen interactions are increasingly altered by global climate change, her work may have a significant impact on virus surveillance strategies and public health.

REAL-TIME COST-EFFICIENT RISK REDUCTION FOR FACTORIES

Professor Iunio Iervolino

Professor Iunio Iervolino
AXA Project
Analisi e Monitoraggio del Rischio Ambientale (AMRA) / Università Federico II di Napoli (Italy)
ISLAR – Industrial Seismic Loss Assessment and Reduction
€92K (2 years)

March 2011: after the Tohoku earthquake, most assembly factories of the Japanese automobile sector, including Toyota, Honda and Nissan, were halted, and the operations were crippled for over two weeks. This historic standstill was due to several causes: obviously, the dramatic amplitude of the disaster but also the cascading losses due to supply chain interruption—especially in a just-in-time manufacturing system.

Prof. Iunio Iervolino's aim is to go beyond the usual effort to characterize risk in terms of direct economic losses. As a researcher at the highly ranked school of Engineering of the University of Naples Federico II, he is exploring the ripple effect of seismic disruption in the manufacturing industry throughout the economic supply chain. He is developing a framework to compute risk in industrial facilities by considering that the earthquake directly affects at least one of the locations of the supply chain. This holistic approach better accounts for financial damage. It could also help prevent risk by providing a risk-management tool that monitors risk and performs cost-benefit and "what-if" analyses.

However, Prof. Iervolino's ambition goes even further: he aims to assess the benefits of earthquake early warning in terms of loss avoidance. This is a critical idea in a context where, according to specialists, earthquake engineers are not fully prepared to take advantage of the capabilities of such automated security measures. Implementation on a test site should prove the efficiency of such warning systems before the ground motion hits the location—showing that action taken in a few tens of seconds may greatly limit the extent of non-structural and content loss (which is by far more significant than structural damage in industries).

Prof. Iervolino is well equipped to achieve his goals: he has teamed up with co-investigators with strong track records and works with partners in the prestigious German GeoForschungsZentrum, a world renowned center for hazard engineering with a broad range of international collaborations, including key links with Turkey and tsunami warning in the Indian Ocean. If the test site is successful, no doubt there will be followers!

INVESTIGATING THE LINK BETWEEN FORCED MIGRATION AND CONFLICT

Professor Simon Hug

Forced migration, environmental risks and conflict

Professor Simon Hug
AXA Project
University of Geneva (Switzerland)
€160K (2 years)

Refugees are rightly viewed as victims of persecution and war. However, recent research has suggested that they may also play an active role in conflict dynamics. Yet the mechanisms that link refugees and conflict remain poorly understood. Moreover, a number of policy makers and activists have warned lately that the flow of displaced persons may rise significantly over the next decades due to climate change. This could increase the risk of conflict as competition for ever-declining resources is heightened.

Despite the wide recognition of the importance of both location of refugee settlements and the environment in the relationship between forced migration and conflict diffusion, little has been undertaken to assess these claims. This very question is raised by Prof. Hug and his team. They emphasize that although much research has been carried out on conflict-induced migration and conflict diffusion, few studies have investigated the link between the two. In addition, the literature has been limited to national-level studies and has focused solely on conflict-induced migration. Their project consequently takes a disaggregated approach assessing not only the impact of the spatial location of refugees on the risk of conflict, but also analyzing whether environmentally-induced migration carries risks of conflict diffusion similar to those of conflict-induced migration.

Thus, with the help of global and European research networks and building on data from UNHCR and other actors, Prof. Hug and his team seek to fill the gap by developing spatial datasets on displaced persons relating to both conflict and environmentally-induced displacements in order to uncover possible links.

Thanks to this innovative research and its strong interdisciplinary aspect combining geography with political science and conflict with environmental risk research, Prof. Hug and his team strive to deliver an accurate assessment of the mechanisms by which forced migration may affect the propensity of violent conflict. This will contribute not only to risk identification, but also to risk prevention for international actors in decision-making and crisis-management.

WOULD A NATURAL HAZARD MAKE YOU PERMANENTLY LEAVE YOUR HOME?

Doctor François Gemenne

Climate change impacts and the global transformation of migration patterns: towards new normative frameworks

Doctor François Gemenne
Postdoctoral Fellow
IDDRI - Institut du développement durable et des relations internationales (France)
€120K (2 years)

Although people have always migrated for environmental reasons throughout history, climate change sheds new light on this phenomenon: not only because of its unprecedented scale, but also due to the debated anthropogenic dimension, which raises the question of environmental responsibility. However, whereas the scientific basis for climate change is now well established, less research has been conducted on the human impacts of climate change and, in particular, how it could affect migration patterns. In many cases, migration induced by climate change is perceived as a "failure to adapt" rather than a risk-reduction strategy for the affected populations.

While working with the Asian Development Bank and the Refugee Studies Centre at Oxford University, Dr. François Gemenne demonstrated that current environmental and migration policies were unable to adequately address migration flows induced by climate change, and thus to protect the migrating populations.

Dr. Gemenne first reviewed how migration patterns were affected after a disaster, but also in situations of slow-onset changes, such as desertification or sea-level rise. He has demonstrated the predominant role played by public policies and social vulnerabilities in migration behaviors, refuting a deterministic approach to environmental migration. On this basis, he has recommended that policies addressing environmental migration be framed in a development agenda rather than in a security or humanitarian agenda. Such policies include portability of social rights for migrants, better regional cooperation and increased attention given to those who stay behind, who are often the most vulnerable. With the right policies, migration can be an efficient adaptation strategy in situations of environmental stress.

Dr. Gemenne now plans to assess the political feasibility of developing such normative frameworks as well as to incorporate them into risk assessments and adaptation strategies. He has created the first-ever course on "Environment and Migration" at Sciences Po Paris and has written two books, which are used as references by many actors on the political and economic stage.

APPENDIX

GLOSSARY

CLIMATE CHANGE

Aka sunspots
Regions of intense magnetic activity which appear as dark patches on the sun's surface.
Source: Dr. Miho Janvier, cf. p. 18

Biosphere
Sum of all living organisms on Earth. The term biosphere is also used to designate the part of the Earth where life exists.

Catalysts
A substance, usually used in small amounts relative to the reactants, that modifies and increases the rate of a reaction without being consumed in the process.
Source: The free dictionary

Cirrus
A high-altitude cloud composed of feathery white patches or bands of ice crystals.
Source: The free dictionary

Carbon cycle
Set of exchanges of carbon between the atmosphere, hydrosphere (ocean, rivers, etc.), biosphere (living organisms) and lithosphere (rocks).

Cumulus
A bulbous or billowing white or dark grey cloud associated with rising air currents.
Source: The free dictionary

Diatoms
Any microscopic unicellular alga of the phylum *Bacillariophyta,* occurring in marine or fresh water singly or in colonies, each cell having a cell wall made of two halves and impregnated with a chemical compound named "silica".
Source: The free dictionary

Electromagnetic wave
A wave of energy having a frequency within the electromagnetic spectrum and propagated as a periodic disturbance of the electromagnetic field when an electric charge oscillates or accelerates.

Global warming
Increase of the average temperature of the atmosphere and ocean at the planetary scale, observed since the late 19th century and thought to result from emissions of greenhouse gases by human activities.

Greenhouse gas
A gas in an atmosphere that absorbs and emits radiation within the thermal infrared range.

Ikaite
Mineral name for the hexahydrate of calcium carbonate ($CaCO3 \cdot 6H2O$).

IPCC
Intergovernmental Panel on Climate Change (French: GIEC): international body created in 1988 and aimed at providing objective scientific information on climate change and its potential environmental and socio-economic impacts. IPCC is opened to all members of the United Nations and World Meteorological Organization, and currently gather195 countries.

Microwave passive satellite sensor
Sensor mounted on a satellite that measures the energy naturally emitted by the Earth in microwave frequencies.
Source: Marco Brogioni, cf. p. 28

Sediment
Grain of varying size, shape and origin involved in various geological processes, including erosion, transport (by water, wind and ice), and deposition.

Stratosphere
The second major layer of Earth's atmosphere.

Sunspots
Regions of intense magnetic activity which appear as dark pools on the Sun's surface, regularly releasing massive amounts of energy during so-called solar flares.

Topology
Detailed, precise description of a place or region.

WEATHER HAZARDS

Debris flows
Flows of water, rocks and debris propagating down a slope at high velocity. The difference with landslides is the amount of water, which is much larger in debris flows than in landslides.

Early warning system
Automated system aimed at informing populations of an incoming danger such as a tsunami, a volcanic eruption, a flood or a landslide.

Embankment
A mound of earth or stone built to hold back water or to support a roadway.
Source: the free dictionary

Embankment dam
A massive artificial water barrier, typically created by the emplacement and compaction of a complex semi-plastic mound of various compositions of soil, sand, clay and/or rock.

Extreme rainfall
Greater than average precipitation during one or several days, likely to induce flooding and landslides.

Index insurance
A type of policy whose payouts are based on the performance of a weather index, instead of the losses actually suffered by the policy holder.

Runoff
Flow of rain or snow-melt waters over the ground surface. Runoff occurs when water cannot penetrate the soil.

VOLCANIC AND SEISMIC RISKS

Landslides
Mass movement of soil and rocks down a slope, under the action of gravity. Landslides are mainly triggered by extreme rainfall events and to a lesser extent by earthquakes and volcanic eruptions, which modify the soil properties.

Plate convergence
Movement of two tectonic plates toward one another. It can lead either to a collision with mountain building or to a subduction with the sinking of one plate beneath the other.

Troposphere
The lowest portion of Earth's atmosphere.

Volcanism
The phenomenon connected with volcanoes and volcanic activity. It includes all phenomena resulting from and causing magma within the crust or mantle of a planet to rise through the crust and form volcanic rocks on the surface.

BIODIVERSITY RISKS

Abiotic factors
In ecology and biology, non-living chemical and physical factors in the environment, which affect ecosystems.

Ascidians
Settled marine invertebrates, having simple and small genome, the closest invertebrate relatives of vertebrates.
Source: Dr. Atsuko Sato, cf. p. 72

Biodiversity
The degree of variation of life forms within a given species, ecosystem, biome, or an entire planet. Biodiversity is a measure of the health of ecosystems.

Endemic
In ecology, native to or confined to a certain region.
Source: the free dictionary

Genetic analysis
Study of the genetic information carried by DNA molecules, which defines hereditary characteristics.

Genotype
Full set of genes of an individual.

Invasive Alien Species (IAS)
A species living outside its native distributional range, which has arrived there by human activity, either deliberate or accidental, whose establishment and spread modifies ecosystems, habitats, or species.

Phenotype
The observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences.
Source: the free dictionary

Phenotypic plasticity
The ability of an organism to change its phenotype in response to changes in the environment.

Planktonic virus
Type of virus specifically affecting plankton, and playing a key ecological role.

Range shift
When a plant or animal moves from the geographic region in which it normally lives or grows.
Source: the free dictionary

Schooner
Type of sailing boat characterized by a forward mast not taller than the rear one, and with a sail oriented along the line of the ship rather than perpendicular to it.

SOCIOECONOMIC CONSEQUENCES OF ENVIRONMENTAL RISKS

Commoning
A concept which pushes us to recognize and foster the many ways in which social and ecological realities are produced through non-instrumental, material exchanges between human and non-human agents. Rather than presuming that we exist as rational individuals acting in and on a 'dumb' natural world of discrete and finite resources, 'commoning' suggests that we are always part of unfolding relations between people, animals and things. This way of thinking about production questions the primacy of human agency, as well as forcing us to recognize the multiple agencies of the non-human.
Source: Patrick Bresnihan, cf. p. 86

Ecosystem services
Resources and processes supplied by natural ecosystems such as clean drinking water or decomposition of wastes. The United Nations Millennium Ecosystem Assessment (MEA) regrouped them into four categories: provisioning, regulating, supporting and cultural.
Source: Dr. Kelvin Peh, cf. p. 89

Hydrogen economy
Expression used to evoke a hypothetic future system where most energy would come from hydrogen rather than from fossil fuels.

Land subsidence
The motion of a surface (usually, the Earth's surface) as it shifts downward relative to a datum such as sea-level.

Megathrust
A sudden slip along a fault between a subducting and an overriding plate; results in a major earthquake.
Source: Wiktionary

Paleoseismology
A geoscience sub-discipline that uses geological layers and landforms to understand the geological faults that produce significant earthquakes.

Percolation
In physics, chemistry and materials science, percolation concerns the movement and filtering of fluids through porous materials.

Percolation theory
In mathematics, percolation theory describes the behavior of connected clusters in a random graph. The applications of percolation theory to materials science and other domains are discussed in the article percolation.

Phytoremediation
The ability to clean up ground waters using plants and associated microbes.
Source: Lilian Marchand, cf. p. 88

Polymers
Any of numerous natural and synthetic compounds of usually high molecular weight consisting of up to millions of repeated linked units, each a relatively light and simple molecule.
Source: the free dictionary

Urban retrofitting
Addition of new technology or features to older systems to improve existing buildings.

U-Th
Uranium-thorium dating, is a radiometric dating technique commonly used to determine the age of calcium carbonate materials such as speleothem or coral.

Water stress
Water stress occurs when the demand for water exceeds the amount available during a certain period or when poor quality restricts its use. This frequently occurs in areas with low rainfall and high population density or in areas where agricultural land or industrial activities are intense.
Source: United Nations Environment Programme

Zoonoses
Infectious agents circulating in animals which can infect humans.
Source: Marion Vittecoq, cf. p. 92

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AXA Research Fund
40 rue du Colisée
75008 Paris – France
www.axa.com