南方科技大学 **前沿与交叉科学研究院**

**风险分析预测与管控研究院（Risks-X）博士后招聘启事**

南方科技大学前沿与交叉科学研究院（以下简称南科大交叉研究院）致力于促进前沿科学的探索研究与学科发展的交叉融合。通过组织不同学科和专业背景的科研人员开展协同合作研究，创新体制机制，聚焦重大科研方向，跨越学科边界，实现学科间的思维碰撞与技术共享，积极地促进南方科技大学的前沿科学发展、学科交叉融合和先进技术创新。

风险分析预测与管控研究院（Risks-X）作为南科大交叉研究院七大X研究院之一，是由南方科技大学与瑞士苏黎世联邦理工学院（ETH Zurich）于2019年共同成立的联合研究院，是苏黎世联邦理工学院（2020QS世界大学排名第6）与中国大陆高校合作的唯一一个校级研究项目。研究院由瑞士工程院院士、苏黎世联邦理工大学企业风险系系主任Didier Sornette教授和中科院院士、南科大地球与空间系系主任陈晓非教授联合领导，致力于搭建一个革命性的动态风险管理平台，以交叉学科和数据驱动的方法为基础，发展应对不同自然和社会系统中极端风险的实时动态监控、模拟仿真、趋势分析和预警预测工具。研究院主要方向包括金融与经济系统风险、自然灾害、能源安全、公共健康、重大基础设施、社会动态与稳定、区块链与信息基础设施等七个高度跨学科交叉的方向。研究院目前已建立起包含3名院士在内的交叉学科研究团队30余人。

此次2020-2021年度计划开放5名博士后研究员招聘名额。拟聘用的博士后研究员须为具有优良道德品质、良好合作精神、扎实理论基础、较强科研能力的优秀博士毕业生，须有意愿以两年甚至于更长的时间致力于交叉科学的项目研究。

**1、招聘方向**

* 本次招聘的重点方向为：量化金融、社会经济数据挖掘、天使投资风险评估计、自然灾害风险建模、统计地震、基于多源数据的地震灾害预警；
* 本次招聘相关的研究项目见附件；
* 我们同时欢迎任何与Risks-X研究院相关方向的优秀候选人投递简历。

**2、博士后导师**

我们将根据申请人的意愿及方向进行导师匹配。包括2位院士在内的Risks-X研究院的所有教授均积极参与到与博士后的研究合作中。

**Didier Sornette院士，讲席教授**

瑞士工程院院士，世界著名经济学家、物理学家、地球物理学家，南方科技大学风险分析预测与管理研究院联席院长，瑞士苏黎世联邦理工学院（ETH Zurich）经济管理与技术学院、地球科学学院、物理学院三院联席讲席教授；ETH风险中心联合创始人，全球金融危机监测站主任；瑞士金融研究所（Swiss Finance Institute）金融学教授，美国促进科学会会士（AAAS Fellow）、世界创新基金会会士（WIF Fellow）。Sornette教授在复杂系统与极端风险管理领域是世界级的专家，运用严谨的数据驱动的数理统计分析方法，对复杂系统不稳定性和各类极端风险进行识别、控制和预测，将成果成功应用到了金融风险、地震预测、核能安全、网络信息安全、社会网络、医学等一系列复杂系统中。他提出了“龙王”理论（极端事件理论），并建立了全球金融危机实时监测站，对世界各国两万多种不同的金融资产进行实时监控，曾成功预测包括2007、2009和2015年三次中国股市泡沫破裂、2008年原油泡沫、2011年欧洲瑞朗脱钩等多次市场巨变。Sornette教授已在国际期刊发表800余篇论文，出版了9本专著，谷歌学术引用次数超过43000次，H-index引用指数达到101。他还曾在多家世界知名航空航天企业、银行、基金和再保险公司担任过专家顾问等角色，包括美国银行首席风险顾问，美国洛斯阿拉莫斯国家实验室专家顾问，法国再保险SCOR科学基金会董事会成员等。

**陈晓非院士，讲席教授**

中国科学院院士，著名地球物理学家，南方科技大学讲席教授、风险分析预测与管理研究院联席院长、地球与空间科学系系主任。2000年获聘为教育部“长江学者”特聘教授。2015年1月，当选国际大地测量与地球物理学联合会（IUGG）首批会士并获银质奖章（Silver Medal）。2015年12月，当选中国科学院院士。2017年担任中国地球物理学会理事长至今。2017年11月，参与研究的“非线性地震模拟”项目获得国际高性能计算应用领域最高奖“戈登·贝尔奖”。陈晓非院士长期从事地球物理学的教学与科研工作，发表论文150余篇，已培养60余名博士和硕士，曾主持国家自然科学基金会杰青项目、优秀创新群体项目、重点项目、国际（地区）合作项目、重大项目课题以及科技部973项目课题等科研项目20余项。主要研究方向为理论与计算地球物理学、地球动力学及其在防震减灾和资源勘探领域的应用。陈晓非院士1982年毕业于中国科学技术大学地球和空间科学系地球物理学专业，获学士学位；1985年在中国地震局地球物理研究所获硕士学位；1991年在美国南加州大学地球科学系获理学博士学位。1996年回国工作，曾先后任教于北京大学和中国科学技术大学, 2016年9月加盟南方科技大学。

**Arnaud Mignan副教授**

南方科技大学地球与空间科学系、风险分析预测与管控研究院副教授，博士生导师。研究方向为极端地震风险、地震物理和统计、累积风险和地球与能源风险治理等。Arnaud Mignan在苏黎世联邦理工学院地球科学系担任了10年的高级研究员和项目带头人，并曾在全球领先的灾难风险建模公司RMS（Risk Management Solutions）作为高级灾难风险研究员工作了4年。自2006年以来，Mignan教授在国际顶级期刊上发表了60篇论文，包括最近在《自然（Nature）》杂志上一篇关于在地震模式识别中使用和滥用人工智能的文章。他的Google学术引用量为1500， H指数为23。他的主要研究项目包括基于风险的自主决策和算法治理，用于地震预报的机器学习以及动态风险管理策略等。

**韩鹏助理教授**

南方科技大学地球与空间科学系、风险分析预测与管控研究院助理教授，博士生导师，兼任日本统计数理研究所及千叶大学外来研究员（guest researcher）。2006年毕业于北京大学地球物理学专业，获学士学位；2009年获中国地震局地球物理研究所硕士学位； 2013年3月获日本千叶大学博士学位（理学）。2013年4月至2017年7月先后在千叶大学和统计数理研究所任职博士后， 2017年8月加入南方科技大学。长期从事地球电磁学，统计地震学，地震预测及风险评估方面的研究。先后荣获日本电气学会“优秀论文奖（金赏）”，中国地球物理学会“傅承义青年科技奖”等奖励。迄今为止，在Surveys in Geophysics、Journal of Geophysical Research、Geophysical Journal International等学术期刊发表论文20余篇、引用400余次。

**陈克杰助理教授**

南方科技大学地球与空间科学系、风险分析预测与管控研究院助理教授，博士生导师。研究领域为空间大地测量学、自然灾害（如海啸、地震）预警等。2010年6月毕业于长安大学测绘工程专业，2012年6月年毕业于武汉大学大地测量学与测量工程专业，2016年5月毕业于德国地学研究中心/波茨坦大学地球物理专业。2016年5月年至2018年5月在美国宇航局喷气动力实验室从事博士后研究，2018年5月至2019年9月在加州理工学院地震实验室做研究科学家。2019年9月加入南方科技大学。陈克杰教授已在Nature Communications，Geophysical Research Letters等地学领域国际权威学术期刊发表论文20余篇，也是Nature Communications等二十余个杂志的审稿人。2020年入选中国科协青年人才托举工程。

**Sandro Lero助理教授**

南方科技大学商学院、风险分析预测与管控研究院助理教授，博士生导师。研究方向为社会经济系统数据挖掘、金融物理、复杂系统等。Sandro Lera于2018年取得苏黎世联邦理工大学经济管理技术与工程系的博士学位。毕业后曾在美国麻省理工学院媒体实验室（MIT Media Lab）师从著名数据科学家Alex Pentland任博士后，曾主持参加瑞士国家科学基金，新加坡国家研究基金等项目。在信息科学领域，尤其是，Sandro Lera在管理科学与复杂系统方面发表了一系列高水平的研究成果，包括在Phys Rev E，J. Int. Money Finance等国际权威学术期刊发表第一作者论文10篇，其中部分科研工作被多个杂志媒体报道。此外，Sandro Lera具有算法交易的行业背景，并为多家公司国际知名制定量化交易策略。

**3、招收条件**

1. 优秀博士毕业生或优秀应届博士生，有海外经历者优先；
2. 统计、物理、量化金融、数学、计算机、地球物理等理工科背景的优先；
3. 具备极强的抗压能力，并对于加入一个极具活力、不断学习与突破自我的国际化团队有强烈愿望和热情；
4. 以第一作者身份在专业领域顶级期刊发表过论文；
5. 年龄35周岁以下，具有良好的科学素养、事业心、责任感和团队协作精神；
6. 具有优异的英文阅读、写作和口头交流能力（研究院工作语言为英文）。

**4、拟聘人员薪资福利待遇**

1. 博士后聘用期为两年，年薪33万元起，含广东省生活补助15万元（税前）及深圳市生活补助6万元（税后），并按深圳市有关规定参加社会保险及住房公积金。博士后福利费参照学校员额内教职工标准发放。
2. 特别优秀候选人可以申请校长卓越博士后，年薪可达41万元。（含广东省及深圳市补助）。
3. Risks-X研究院院长将直接参与指导博士后的科研工作。
4. 在站期间，可依托学校申请深圳市公租房，未依托学校使用深圳市公租房的博士后，可享受两年税前2800元/月的住房补贴。
5. 拥有优良的工作环境和境内外合作交流机会，博士后在站期间享受两年共计2.5万学术交流经费资助。优秀候选人将有机会到苏黎世联邦理工大学进行3个月至1年的学术访问。
6. 交叉研究院和课题组提供充足的科研支持，协助博士后本人作为负责人申请中国博士后科学基金、国家自然科学基金及广东省、深圳市各级科研项目。
7. 课题组协助符合条件的博士后申请“广东省海外青年博士后引进项目”。即在世界排名前200名的高校（不含境内，排名以上一年度泰晤士、USNEWS、QS和上海交通大学的世界大学排行榜为准）获得博士学位，在广东省博士后设站单位从事博士后研究，并承诺在站2年以上的博士后，申请成功后省财政给予每名进站博士后资助60万元生活补贴（与广东省每年15万生活补助不同时享受，与深圳市每年6万元生活补助同时享受情况下以深圳市规定为准）；对获得本项目资助，出站后与广东省用人单位签订工作协议或劳动合同，并承诺连续在粤工作3年以上的博士后，省财政给予每人40万元住房补贴。
8. 博士后出站选择留深从事科研工作，且与本市企事业单位签订3年以上劳动（聘用）合同的，可以申请深圳市博士后留深来深科研资助。深圳市政府给予每人每年10万元科研资助，共资助3年。
9. 对于符合最新《深圳市新引进人才租房和生活补贴》相关政策要求的博士后，落户深圳后，可协助申请深圳市一次性租房和生活补贴3万元（免税，自主网上申请）。
10. 依据自身符合的条件情况，在站或出站留深博士后可申请 "深圳市孔雀计划C类人才"或者"深圳市后备级人才"，享受5年160万的奖励津贴（免税）（以深圳市最新相关人才申报要求为准）。
11. 博士后出站时根据考核，成绩突出者可优先考虑聘为交叉研究院研究序列教授。
12. 子女入学等后勤保障，按学校对博士后的规定统一办理。

**5、应聘材料（请以英文资料为主）：**

1. 详细个人简历，含学习、工作和科研经历，主要科研成果介绍。请提供中英文简历各一份；
2. 提供身份证、毕业证及学位证（或所在院校相关主管部门盖章的博士学位答辩决议）扫描件或复印件；
3. 提供2-3封推荐信及推荐人的姓名以及有效联系方式（需提供博士导师的联系方式）；
4. 其它可以证明工作能力的材料，如论文、专利等。

申请截止日期：2020年5月31日。

申请联系人：

吴柯（学术专业方向）：[wuk@sustech.edu.cn](mailto:wuk@sustech.edu.cn)

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南方科技大学 前沿与交叉科学研究院Risks-X

2020年4月

附部分研究项目介绍：

1. **The Chinese financial crisis observatory**

In 2008, in reaction to the widely spread belief that the great crisis was “bad luck” and could not have been predicted, at the chair of Entrepreneurial Risks of Prof. D. Sornette at ETH Zurich, we launched the Financial Crisis Observatory (FCO)[[1]](#footnote-1) with the goal of testing two nested hypotheses: (H1) financial bubbles can be diagnosed in advance before their bursts confirm their existence; (H2) given that a bubble is diagnosed in real time, its end can be probabilistically forecasted with skills significantly better than chance. These two hypotheses are built on a theory of financial bubbles that emphasizes the general mechanism of positive feedbacks, which leads in particular to specific signatures in the form of log-periodic power law singular (LPPLS) price behaviors. Since then, our group has published a large number of ex-ante real-time forecasts, with a quite remarkable track record. This suggests the possibility to develop operational early warning signals and actions that could mitigate bubbles and crashes.

We are now building a Chinese version of the financial crisis observatory to cover the major assets in China based on our existing systems and methodologies. The goal of this project is to develop a full picture of the financial bubble states in different Chinese assets, with input information from both structured data (price, fundamental data, etc.) and unstructured data (social networks and financial news). The Chinese FCO will also publish monthly reports in Chinese with in-depth analysis of Chinese and Global markets, based on more detailed data analysis, market news and macro policies. Currently we also have the following sub-projects under this framework:

* + Chinese stock market manipulation analysis and detection
  + Chinese equity analyst research reports analysis and evaluation
  + Bubble and crashes analysis and prediction based on Log Periodic Power Law Singularity (LPPLS)
  + Develop a convivial web-interface presenting graphical information on the bubble signals, with interactive feedbacks

1. **Market impact and performance of arbitrageurs of financial bubbles in an agent-based model**

Building on the previous project on the diagnostic and prediction of financial bubbles, what can be the market impacts of such predictions? Could there be severe unintended consequences deriving from a general use of such diagnostic methods? The present project has precisely to aim to address these outstanding questions of the market impact of potential superior knowledge on the development of bubbles.

The starting point is a versatile agent-based model (or computational economic model) with two or more assets, populated with different types of investors, fundamentalist and chartists. Fundamentalists form expectations on the return and risk of the risky assets and maximize their expected utility with constant relative risk aversion with respect to their allocation on the risky asset versus the risk-free asset. Chartists are subjected to social imitation and follow momentum trading. Allowing for random time-varying herding propensity, the model has been able to reproduce several well-known stylized facts of financial markets such as a fat-tail distribution of returns and volatility clustering. Moreover, transient faster-than-exponential bubble growth with approximate log-periodic behavior are observed and can be rationalized theoretically. The model accounts well for the behavior of traders and for the price dynamics that developed during the dotcom bubble in 1995–2000. Momentum strategies are shown to be transiently profitable, supporting these strategies as enhancing herding behavior.

The goal of this project is extend considerably the agent-based model to study the bubble dynamics, market impact and long-term growth of a financial market when either profit-seeking investors (“dragon-riders”), or a stability-oriented policy makers (“dragon-slayer”), or economic growth-focused authorities (“dragon-groomers”) or a mixture of them, employ the LPPLS methodology (and other bubble detection methods) for diagnosing bubbles in real time. Agent-based simulations will extend the existing model of super-exponential financial bubbles with two assets (risky and risk-free), in which fundamentalist and chartist traders (noise traders) co-exist.

One goal is to explore extensively the set of possible strategies of the dragon-riders, dragon-slayers and dragon-groomers, building on our expertise on agent-based models and our strong contact with the hedge-fund industry in particular, in order to develop realistic synthetic markets. We propose to endogenise the dynamics of the coupling strength between noise-traders by including feedback loops, in which the imitative mood of agents evolves as a function of the market dynamics and the interpretation of the agents on its generating mechanisms. We will also use machine learning and genetic algorithms to let evolve sophisticated specifications of LPPLS traders’ strategies. The goal of this part of the research is to quantify the stabilizing versus destabilizing impact of dragon-riders, exploring this question in the large universe of strategies while taking into account economic constraints that govern the evolution of the ecology of investors. We propose to build a large number of summary statistics of the resulting market dynamics to provide a full quantification of the different regimes.

Considering the dragon-slayers (supposed to embody a policy maker aiming at stabilizing financial markets), we want to explore what are the best strategies in the sense of their short-term goal of suppressing or minimizing bubbles and crashes as well as long-term consequences in terms of the market performance. Our ABM set-up can incorporate the feedbacks of policy decisions on monetary policy via the interest rates, as an example. From a different perspective, policy makers may want to project a positive investment environment to encourage the rebound of an anemic economy. The model will need to be extended to allow for credit creation, so that investors can borrow and leverage. We will incorporate a channel to feedback on the performance of the fundamental value reflecting the expected impact on innovation and real economic growth, which would be the target of the policy makers.

The agent-based model is also well adapted to explore the existence of trade-off between economic growth versus financial stability objectives. In this way, we want to provide an original approach to inform decision makers about the pros and cons of their large-scale interventions. Both dragon-riders and dragon-slayers (or dragon-groomers) coexist in reality and we aim at vigorously investigate the behaviors resulting from putting all these players together in our artificial world. In particular, we want to study economic performance, financial stability and the evolution of the ecology of investors that emerge from the selection process of the market dynamics. As the dynamics is inherently nonlinear with complex feedback loops, one should be prepared for unexpected behaviors.

We also need to investigate the interplay between the heterogeneity of time scales of different types of investors with the co-existence of many different strategy variants. One goal is to provide a robust answer to the question of the impact of an ecology of LPPLS traders and more generally of arbitrageurs of financial bubbles and market exuberance, in the presence of competing value investors and noise traders in stock markets exhibiting recurrent bubbles and crashes. Moreover, we want to study the dependence of the long-term macroeconomic growth rate on bubbles, by creating a feedback channel between financial markets and technological progress, in which above-average technological progress increases the dividend growth rate of the risky asset in the long run. This, in turn, will cause the stock’s value as seen by fundamentalists to rise, implying a higher stock price. We want to study the policy implications of regulating bubbles and crashes, which may involve a tradeoff between short-term stability and long-term growth.

1. **Angel Investment Fund of Fund Risk Assessment and Decision Analysis (in collaboration with Shenzhen Angel Fund of Fund)**

The PE & VC investment industry is prosperous in Shenzhen, with about 300 leading companies having gone public in Shenzhen in the past 30 years. To build Shenzhen as a Global venture capital center, and to support innovation and start-ups from an early stage, Shenzhen Government decided to setup an angel stage FoF – Shenzhen Angel FoF – in 2018, with an initial AUM of 5 billion Yuan. In order to better promote the venture capital market in Shenzhen, to better understand the dynamics and risks in this angel investment, we are teaming up with Shenzhen Angel FoF to initiate this project with the following objectives:

1. Risk assessment model and decision making model for angel stage investment and risk management.
2. On the basis of the existing government performance evaluation standards for angel FoF, study the performance evaluation and risk control models of the sub-funds,
3. Study the effectiveness of government guidance funds, risk management mechanisms and evaluation methods,
4. Develop Shenzhen Angel Investment Risk Index, Angel Fund Risk Management Professional Ability Ranking, and so on. through the Angel Investor Alliance established by Shenzhen Angel FoF.
5. **Earthquake Cascading Effects quantified by the Earthquake Hazard Adjacency Matrix using Graph Theory & Machine Learning for improved Societal Resilience**

As humans increase their impact on the planet, the risk associated with natural hazards can be amplified by emerging chains-of-events. This is especially true for large to great earthquakes, which are particularly prone to trigger other natural events, critical infrastructure failures, and further socio-economic disruption, with domino effects potentially leading to social unrest, economic slowdown, but even outbreaks and financial crises. Consequences of those super-catastrophes are usually unexpected. Cascading effects have so far been analyzed on a case-to-case basis or at a generic, semi-quantitative level, and never at a systematic, global level. Available data is uneven and scattered, often limited to secondary consequences or to specific critical infrastructures. The complex nature of interacting and interconnected relationships between different events thus needs to be integrated into a holistic framework. In this project, for the first time, we will take the ambitious approach of exploring the space of possible interactions, based on a systematic survey of all the available empirical evidence. We will develop a comprehensive, global database of past earthquake interdependencies based on an adjacency matrix (the Earthquake Hazard Adjacency Matrix or EQ-HAM) and analyze the main drivers of earthquake cascading disasters. We will first use data mining to extract all available information and encode it in the EQ-HAM. We will then investigate the statistical trends of earthquake risk amplification by using Graph Theory and Machine Learning, by defining indices that reflect the severity and depth of interconnections as a function of various environmental and macroeconomic parameters. Finally, we will provide decision-makers with a predictive tool for direct applications of the EQ-HAM in China. The aim of the proposed project is to help better understand, assess, and predict earthquake cascading effects from the local to the global scale and answer questions, such as: Above which magnitude does an earthquake trigger catastrophic cascading effects? How is earthquake risk amplification evolving over time? What are the spatial variations around the world and in China? What are the key drivers to earthquake cascading effects? The plan is consistent with the Sendai Framework for Disaster Risk Reduction 2015-2030 towards improved societal resilience. This project will indeed allow better mitigating earthquake risk amplification by focusing efforts on the critical event characteristics and environmental conditions which will be demonstrated to promote those catastrophic chains-of-events.

1. **Global Earthquake Forecast System for China**

The project consists in the extension and application to China of a Global Earthquake Forecast System started at ETH Zurich a few years ago under the direction of Prof. D Sornette, based on the wide range of data provided by different sensors on satellites and on the ground. In addition to a variety of international sources, the project aims at developing strong collaborations with various groups in China and in particular with the CEA and its Institute of Earthquake Forecasting. In a nutshell, the logic of the Earthquake Forecast System is based on

(i) the multi-phenomena nature of earthquake precursors,

(ii) a unifying theory in terms of stress activation of mobile electric charges,

(iii) multi-observations, multi-dimensional continuous monitoring,

(iv) multi-criteria multi-dimensional analyses and synthesis of precursors into a decision function providing earthquake alarms and likelihoods of target events,

(v) a decision making process towards operational activation and use by authorities, industry and citizens.

Forecasting earthquakes implies that there are time-varying processes, which depend on the changing conditions deep in the Earth’s crust prior to major seismic activity. These processes may be linearly or non-linearly correlated. In seismology, the research has traditionally been centered on mechanical variables, including precursory ground deformation (revealing the build-up of stress deep below) and on prior seismic events (past earthquakes may be related to or even trigger future earthquakes). Since the results have been less than convincing, there is a general consensus in the geoscience community that earthquake forecasting on time scales comparable to meteorological forecasts are still quite far in the future, if ever attainable.

The Global Earthquake Forecast System is based on innumerable reports of other types of precursory phenomena ranging from emission of electromagnetic waves from ultralow frequency (ULF) to visible (VIS) and near-infrared (NIR) light, electric field and magnetic field anomalies of various kinds (see below), all the way to unusual animal behavior, which has been reported again and again. Space and ground anomalies preceding and/or contemporaneous to earthquakes include:

|  |  |
| --- | --- |
| Satellite Component   1. Thermal Infrared (TIR) anomalies 2. Total Electron Content (TEC) anomalies 3. Ionospheric tomography 4. Ionospheric electric field turbulences 5. Atmospheric Gravity Waves (AGW) 6. CO release from the ground 7. Ozone formation at ground level 8. VLF detection of air ionization 9. Mesospheric lightning 10. Lineaments in the VIS-NIR | Ground Station Component   1. Magnetic field variations 2. ULF emission from within the Earth crust 3. Tree potentials and ground potentials 4. Soil conductivity changes 5. Groundwater chemistry changes 6. Trace gas release from the ground 7. Radon emanation from the ground 8. Air ionization at the ground surface 9. Sub-ionospheric VLF/ELF propagation 10. Nightglow |

These precursory signals are intermittent and seem not to occur systematically before every major earthquake. Researchers have not been able to explain and exploit them satisfactorily, but never together. Likewise, reports on pre-earthquake signals in the above list are not widely accepted by the geoscience community at large because no one could explain their origins. In addition the diversity of the signals makes them look disparate and unrelated, hampering any progress. Based on decades of research investment, there is now a unifying theory for a solid-state mechanism that is capable of providing explanations for the multitude of reported pre-earthquake phenomena. Analyzing satellite and ground station data, recorded before past large earthquakes, has provided clear evidence that precursory signals tend to become measurable days, sometimes weeks before the disasters. Since we have a serious scientific hypothesis of how these signals are generated, we now have a strong rational for a concerted initiative to continually monitor the Earth’s surface, both from satellites and from ground stations, with the goal of covering all relevant possible diagnostics. The appearance of different telltale signs will be consolidated in data centers, where data processing, analyses and synthesis will be carried out.

A crucial novelty is to use the multi-phenomena, multi-dimensional and multi-scale inputs to obtain robust decision outputs of earthquake alarms and the likelihood functions of target earthquakes, using rigorous statistical and machine learning techniques designed to tackle sparse intermittent multi-dimensional data. A strong emphasis on continuous statistical testing of the relevance and confidence of the precursors will be developed to assess and continue to improve the performance of the forecasts.

The Global Earthquake Forecast System is a revolutionary initiative, which is envisioned to transform the field of earthquake science by building a coherent edifice of signals for reliable earthquake forecasts. It will also be a cornerstone for the development of time-dependent preparatory measures of sensitive infrastructures and for the population, potentially saving billions of dollars and thousands of lives each year worldwide.

**6. Leveraging Space Geodetic Data to enhance seismic hazard forecasting, warning and rapid response**

Seismic hazards (e.g., damaging earthquakes, tsunamis) are extreme manifestations of the ongoing processes that shape and govern our dynamic Earth. Space geodetic data (GNSS: Global Navigation Satellite System, InSAR: Interferometric Synthetic Aperture Radar) can provide unique information for characterizing and monitoring inter-seismic strain accumulation, transient aseismic deformation, and evolving earthquake rupture, in turn supporting improved seismic hazard forecasting, warning and rapid response. Risks-X has long leveraged geodetic data for a range of influential studies (e.g., Prof. Kejie Chen’s real-time GNSS based tsunami early warning system at Jet Propulsion Laboratory), and we continue to develop innovative observation and analysis methods that push the boundaries of the field of geodesy as applied to seismic hazards research. Given the ongoing, rapid improvement in availability, variety, and precision of geodetic measurements, we are considering ways to fully utilize this observational resource for seismic hazard reduction is timely and essential. The project will focus on but not limited to:

1. Earthquake Rupture Forecasting based on long-term geodetic observations

Earthquake rupture forecast is the principal input for probabilistic seismic hazard assessment, which characterize possible earthquake sources in terms of their magnitudes, recurrence rates, and location of the causative fault ruptures. Traditionally the dates and fault displacements of past earthquakes, determined from geologic data, have provided the fault slip rate information for earthquake rupture forecasts. The geodetic data time-series reflects contemporary deformation rates, provide slip rate information on additional faults that lack geologic rate estimates, help quantify broadly distributed strain, and, in the future, may allow time-dependent forecasts to account for variation in slip rates throughout the earthquake cycle. In addition, geodetic data are unique in their sensitivity to creep rates and spatially variable fault interface coupling, including the down-dip limit of subduction zone locking, which are important factors in forecasting the potential size of future earthquakes and resulting ground motions, tsunami runups.

2. Earthquake/Tsunami Early Warning based on real-time GNSS observations

Earthquake/tsunami early warning involves predicting shaking intensity (or tsunami inundation) at user locations, which depends upon accurate, real-time determination of earthquake source characteristics including location, magnitude, fault orientation, moment release, and slip distribution. Real-time GNSS instruments directly measure co-seismic displacement and, unlike seismic data, can provide magnitude estimates that do not saturate for very large earthquakes. For earthquakes with magnitudes exceeding ~M7.5, finite fault modeling algorithms that use GNSS data might improve upon alerts by allowing more detailed characterization of the distance between the earthquake rupture and user locations which, along with the estimated magnitude, influences the accuracy of predicted shaking intensity and tsunami inundation.

3. Aftershock Prediction Based on Continuous GNSS Aseismic Deformation Observation

Forecasting aftershocks immediately after the main shock helps decision-makers evaluate risks and take appropriate actions to mitigate the effects of possible cascading seismic activity. Traditionally, operational aftershock forecasts are based on a statistical evaluation of the seismicity rate in an ongoing aftershock sequence without considering information regarding the long-term probability of earthquakes. During aftershock sequences, geodetic data record aseismic deformation with moment release that typically exceeds the cumulative seismic moment. In addition, spontaneous and triggered transient fault slip has been inferred using geodetic data in a variety of settings. While it is not yet known whether periods of transient aseismic deformation consistently correlate with changes in earthquake likelihood, the spatially dense, broad geographic coverage of continuous GNSS networks and the high sensitivity of borehole strainmeters yield data that could be systematically monitored for anomalous behavior, which could illuminate the relation between transient deformation and seismicity and potentially improve aftershock forecasting tools.

To achieve the goal of using geodetic observations for seismic hazard forecasting, warning and response, we need to overcome substantial technological challenges in data collection and handling. Data need to be freely and rapidly available in formats accessible for users from different fields and with various levels of experience. In particular we require:

1. Low latency tools and methods for delivering data from large, spatially distributed sensor networks;

2. Low latency tools and methods for automatic identification, discrimination, and verification of critical signals that indicate either increased risk or event occurrence;

3. Sensor placement in remote but critical regions, including the seafloor and parts of the cryosphere;

4. Full integration of data streams from many different kinds of sensors, including ground-based GNSS, seismometers, accelerators and space based InSAR, gravity, and optical imagery.

**7. Earthquake Hazard and Risk Assessment Based on Seismicity Analysis and Strong Ground Motion Prediction**

Keywords: Seismicity; Active fault; Probabilistic seismic hazard analysis (PSHA); Strong ground motion prediction; Earthquake hazard map

Earthquakes can cause landslides, tsunami, and bring about one fifth of the annual losses due to natural disasters, with an average death toll of over 25,000 people per year. To mitigate earthquake losses, it is necessary to evaluate the earthquake hazards and risks, as they could help decision makers in developing risk reduction measures that can include emergency response plans, the enforcement of building design codes, and development of insurance pools. The current project address this need by integrating the understanding of earthquake sources, active faulting, and ground shaking. This information is translated into a form that can be used to reduce the risk from earthquakes and to improve public safety. The project will focus on but not limited to:

(a) Seismic source characterization (Faults and Seismicity)

Source characterization describes the rate at which earthquakes of a given magnitude, and dimensions (length and width) occur at a given location. For each seismic source, the source characterization develops a suite of credible and relevant earthquake scenarios (magnitude, dimension, and location) and computes the rate at which each earthquake scenario occurs. The process involves: (1) geometrical models for active faults; (2) uncertainties in earthquake size, location and time of occurrence. The first step in the source characterization is to develop a model of the geometry of the sources, using the information from earthquake catalogues (historical and instrumental), active geological faults, geodetic estimates of crustal deformation, seismotectonic features and paleoseismicity. The second step includes models that describe the distribution of earthquake magnitudes, the distribution of rupture dimensions for each earthquake magnitude, the distribution of locations of the earthquakes for each rupture dimension, and the “Maximum Magnitude” for a given fault.

Related research fields: Paleoseismology; Active fault; Seismicity

(b) Strong Ground Motion Prediction (Empirical and Theoretical Modeling)

Strong ground motion is the strong earthquake shaking that occurs close to a causative fault. Predicting strong ground motion from future earthquakes is among the most important research topics in earthquake engineering and hazard assessment. The surface strong motion can be affected by the source effects related to the rupture process and the release of energy, the path effects related to the propagation of energy inside Earth, the influence of the shallow layers geotechnical characteristics: the so-called site-effects. The site effects are considered in risk mitigation through the evaluation of the seismic soil response. The process in this part involves: (1) empirical/numerical modeling of ground motion using virtual earthquake; (2) estimating the non-linear site response.

Related research fields: Seismic rupture process; Seismic modeling; Site effect

Requirements: The whole project aims to develop new methodologies and techniques for earthquake hazard and risk assessment and obtain high resolution PSHA at several topical urban agglomerations, such as Guangdong-Hong Kong-Macao Greater Bay Area. Applicant should be familiar with one or more research topics mentioned above.

1. <https://er.ethz.ch/financial-crisis-observatory.html> [↑](#footnote-ref-1)