

NEWSLETTER

BREAKING: CCRS Featured in AGU Documentary Showcasing Global Climate Innovation

The American Geophysical Union (AGU) recently released its new documentary spotlighting CCRS’s scientific mission and global contributions to climate resilience. The film, now officially launched at the AGU Fall Meeting—one of the world’s largest gatherings of Earth and space scientists—showcases CCRS’s interdisciplinary strengths in Seamless Climate Prediction, finance, data science, and renewable-energy innovation.



Advancing Seamless Climate Prediction

The documentary opens with **CCRS Director Prof. LU Mengqian**, who summarized the purpose of the Center as advancing interdisciplinary research to deliver “actionable solutions that strengthen society’s capacity to tackle the challenges of climate change.” She highlighted the development of Hong Kong’s first fully coupled global climate model, designed to bridge the critical subseasonal-to-seasonal (S2S) forecasting gap. Prof. LU emphasized that seamless prediction supports industries ranging from renewable



Prof. LU Mengqian

-energy trading to water-resource management and logistics, noting that CCRS has been recognized by UNESCO as one of the world’s leading programs for climate and sustainable development.

AI, Data and High-Performance Computing



Prof. GUO Yike



Prof. ZHOU Xiaofang

The documentary also highlights CCRS’s strong expertise in data science and computational modeling. **Prof. GUO Yike** introduced HKUST’s cutting-edge AI supercomputing facilities—among the most advanced in Asian universities—which strengthen CCRS’s modeling and analysis capabilities through cross-center collaboration. He explained how integrating multi-source data with numerical models enables more powerful mid-range and long-range predictions. **Prof. ZHOU Xiaofang** emphasized the importance of high-quality environmental data and the challenges of managing massive datasets essential for climate research, reflecting the Center’s interdisciplinary strength in climate informatics.

Finance as the Bridge from Science to Impact

From the climate-finance perspective, **Prof. LOU Dong** described finance as the essential mechanism to scale scientific impact, remarking that “without finance, great ideas stay on paper— with finance, they become solar rooftops, wind farms, smart grids, and resilient coastal cities.” He outlined how CCRS translates physical and transition risks into financial metrics that can inform instruments such as green bonds and sustainability-linked loans.



Prof. LOU Dong

Innovation in Clean Energy Technologies



Prof. ZHOU Yuanyuan

On the clean-energy front, **Prof. ZHOU Yuanyuan** presented her team’s work on next-generation perovskite solar cells aimed at reducing the carbon footprint of electricity generation, stressing the importance of renewable-energy innovation amid rising global demand.

By bringing CCRS’s scientists to an international audience, the AGU documentary amplifies the Center’s leadership in advancing climate-prediction science, resilient finance, and green-technology innovation—reinforcing our commitment to shaping a sustainable, climate-ready future.

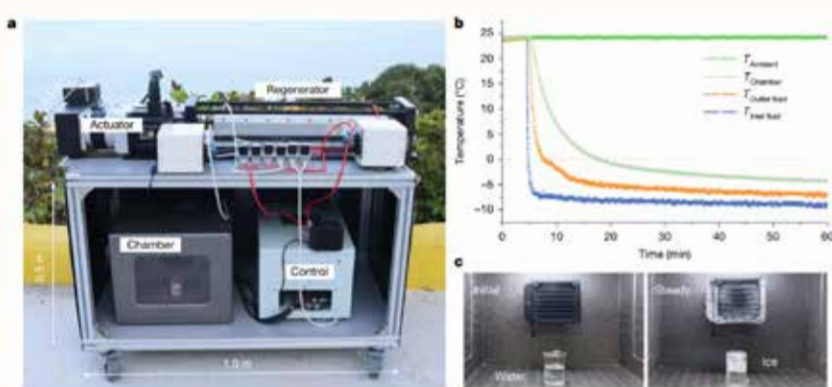
HKUST Engineering Develops World's First Sub-Zero Celsius Elastocaloric Green Freezer, Reshaping Freezing Industry with its Zero Emissions

HKUST engineers have developed the world's first Sub-Zero Celsius elastocaloric freezing device, achieving a minimum cold-source temperature of -12°C . This milestone overcomes the long-standing limitation of elastocaloric cooling to near-room-temperature applications and marks the entry of solid-state, zero-emission cooling technology into the global freezing industry. The breakthrough, published in *Nature*, was led by **Prof. SUN Qingping**, Chair Professor of Mechanical and Aerospace Engineering, with **Dr. ZHOU Guoan**—Research Assistant Professor and first author—**both affiliated with CCRS**.

The advance was enabled by innovations in materials, working fluid and system structure. The team designed a low-transition-temperature NiTi alloy that retains excellent superelasticity and substantial latent heat at sub-zero conditions; employed a freezing-resistant calcium-chloride solution with strong wettability to enhance heat transfer; and developed a cascaded tubular regenerator consisting of eight thin-walled NiTi-tube units capable of bearing high compressive stress. Operating at 1Hz, the desktop-scale prototype achieved a 36°C temperature lift, cooling from a 24°C heat sink to -12°C —the first sub-zero Celsius performance ever reported for elastocaloric cooling. Outdoor demonstrations further showed the system cooling an insulated chamber to -4°C and freezing water into ice, confirming real-world feasibility.



From left to right: Prof. LU Mengqian (Director of CCRS), Prof. SUN Qingping (CCRS member), Mr. Wayne TAN (Head, Bio-Medical & Healthcare, Office of Knowledge Transfer), Dr. ZHOU Guoan (CCRS member; first author), and Prof. QI Jin (CCRS member), at the 50th International Exhibition of Inventions Geneva.



The world's first Sub-Zero Celsius elastocaloric freezing device achieved a cold-source temperature of -12°C from a room-temperature heat sink (24°C), establishing a temperature lift of 36°C .

The work has major implications for global climate goals. Sub-zero freezing applications account for about 27% of projected HFC emissions—roughly 330 million tons of CO_2 equivalent annually. A zero-emission elastocaloric alternative therefore offers a powerful route to reducing greenhouse-gas emissions.

Prof. SUN emphasized the technology's strong potential for large-scale deployment and ongoing industrial collaboration, highlighting future efforts to improve system efficiency, power density and cost-effectiveness. Dr. ZHOU noted that this achievement represents a flagship outcome of the Center's deep-decarbonization agenda and advances Hong Kong's leadership in green cold-chain innovation.

HKUST Researchers Develop Pressure-Free Gel Polymer Electrolyte for Ah-Scale Silicon-Based Pouch Cells

Silicon is a promising anode material for next-generation lithium-ion batteries due to its high specific capacity, but severe volume expansion during cycling leads to electrode fracture, interfacial instability, and rapid capacity decay, often requiring external stack pressure. In this work, **LIU Fangzheng** and co-workers from **CCRS member Prof. SHAO Minhua's** team report a gel polymer electrolyte (GPE) with multiple hydrogen-bonding interactions that enables pressure-free operation of Ah-scale silicon-based pouch cells. The GPE is prepared via in situ copolymerization, forming a crosslinked polymer network with strong self-healing capability. This structure effectively confines the volume expansion of SiO_x particles and maintains robust interfacial contact between the electrode and electrolyte. As a result, silicon-based cells achieve 90.2% capacity retention after 400 cycles at 0.3C , and deliver 1000 stable cycles at 0.5C without external stack pressure. Notably, Ah-scale silicon-based pouch cells exhibit cycling stability comparable to liquid-electrolyte counterparts that require applied pressure. In addition to mechanical stabilization, the self-healing polymer suppresses electrode swelling, minimizes the formation of "dead silicon," and reduces gas generation, particularly at elevated temperatures, leading to improved safety. Owing to its compatibility with in situ polymerization techniques and existing battery manufacturing processes, this pressure-free quasi-solid electrolyte provides a practical and scalable strategy for commercializing high-energy-density silicon-based batteries.



Prof. SHAO Minhua | Dr. LIU Fangzheng

HKUST Researchers Propose ATMOSSCI-BENCH for Rigorous Evaluation of LLM Reasoning in Atmospheric Science

LLMs are emerging as potential “AI scientists,” capable of supporting or even autonomously conducting scientific workflows, yet reliable use in atmospheric science requires rigorous, domain-specific evaluation. In this work, **Director of CCRS, Prof. LU Mengqian’s** team together with **CCRS faculty Prof. YUAN Binhang’s** Relaxed System Lab, proposes ATMOSSCI-BENCH, with **LI Chenyue** from Prof. YUAN’s group leading the benchmark development and study. ATMOSSCI-BENCH systematically assesses LLM problem-solving across five core atmospheric-science categories—hydrology, atmospheric dynamics, atmospheric physics, geophysics, and physical oceanography—where solutions require multi-source knowledge integration and physics-grounded reasoning. The benchmark adopts a dual-format design: multiple-choice questions (MCQs) enable scalable automated evaluation, while open-ended questions (OEs) probe open-ended reasoning and deeper conceptual understanding. Using a template-based MCQ generation framework to create graduate-level problems with symbolic perturbations, the team evaluates representative LLMs across four groups—instruction-tuned, advanced reasoning, math-augmented, and domain-specific climate models—and finds that reasoning models consistently outperform other groups, while also revealing that even advanced models remain sensitive to symbolic perturbations, with minor changes in variable values or structure notably affecting accuracy, underscoring opportunities to improve reasoning robustness. By offering a standard and rigorous framework—with open-source implementation—ATMOSSCI-BENCH aims to accelerate trustworthy LLM development and deployment for climate services and atmospheric science research.



Prof. YUAN Binhang Dr. LI Chenyue

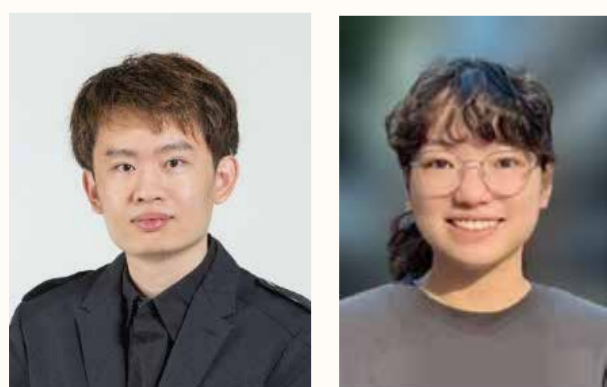
HKUST Researchers Develop Efficient Infrastructure Evaluation Framework for Sustainable Water Planning

Efficient water allocation systems and the improvement of water-related infrastructure are critical for socioeconomic development and environmental sustainability. To evaluate existing systems and identify promising infrastructure improvements, the research team led by **CCRS member Prof. QI Jin** has made significant progress in developing an aggregated rain-flow allocation model over a relevant time horizon to balance water supply and demand. The model is cost-agnostic, focusing on assessing the potential value of reservoir expansion and canal connection projects. Infrastructure projects are evaluated by quantifying the benefit throughout the improvement spectrum using the marginal value index and the ϵ -approximate allowable range, which are derived through linear optimization. This approach identifies the most promising projects based on their ability to improve supply-demand matching, allowing decision-makers to prioritize impactful projects while avoiding the significant effort required for cost-based analyses of all projects in advance. The framework is further extended to incorporate stochastic scenarios, capturing uncertainties in future water supply due to climate variability. A case study in the Greater Bay Area demonstrates the applicability of the model. For reservoir expansion projects, improving the reservoirs in Guangzhou is the most effective option to reduce shortages compared to other cities. Moreover, their findings validate the effectiveness of the recently implemented Pearl River Delta Water Resources Allocation Project. It also highlights that further canal expansions within this project could comprehensively resolve regional water imbalances and shortages, surpassing the benefits of any reservoir expansion project.



Prof. QI Jin Ms. HE Yihua

HKUST Researchers Develop Interpretable Stochastic Framework for Improved Tropical Cyclone Simulation and Uncertainty Quantification



Prof. ZHANG Jize ZHONG Xi

Accurate tropical cyclone (TC) simulation is critical for assessing wind hazards and protecting coastal communities. However, existing environment-dependent TC models often suffer from biases due to oversimplified physics, while their deterministic nature prohibits proper quantification of epistemic uncertainties. In this work, **ZHONG Xi** from the group of **CCRS member Prof. ZHANG Jize** developed a generalizable stochastic discrepancy discovery framework that treats existing TC models as prior knowledge and learns interpretable stochastic governing equations for their modeling discrepancies against historical observations. Leveraging symbolic regression and stochastic processes, the framework simultaneously achieves bias correction and uncertainty quantification with remarkable parameter efficiency, using only 26 parameters for the entire Western North Pacific basin. Validation demonstrates significantly improved track and intensity simulations, with hindcast results closely matching historical TC evolution. Applied to typhoon wind hazard assessment along China’s coastline, the estimated wind speeds agree well with design code recommendations, while the derived confidence intervals successfully capture results from alternative models. This work provides a principled approach to enhance environment-dependent TC models, paving the way for more informed TC risk assessment under changing climates.

From Plate to Planet: Exploring children's knowledge of food and environmental behavior

Just as a vibrant forest relies on a hidden mycorrhizal network to share nutrients and information, human society depends on an invisible web of understanding to sustain our planet. Yet, in an era of processed convenience, are our children losing their "roots"?

Our latest study examines the intertwined relationship between Chinese children's understanding of food origins and their emerging environmental awareness. Preliminary results found that while children are natural learners, the modern food system has introduced a

notable silence in the "orchestra" of their knowledge. Many young participants struggled to identify the biological origins of animal-based foods, particularly non-meat products like eggs and milk, as well as highly processed items.

Currently, **CCRS member Prof. CHENG Chen** and her team are examining how children's pro-environmental knowledge such as recycling and resource conservation develops with age, and how this emerging eco-consciousness relates to their understanding of food on their plates. To cultivate true stewards of the earth, it is essential to nurture in children an awareness that every meal is a gift from nature. By helping children envision the profound journey from soil to spoon, we can transform them from passive consumers into empathetic partners of the natural world, viewing the ecosystem not merely as a resource, but as kin.



Prof. CHENG Chen

HKUST Successfully Hosts the Second "Class at Sea"



Prof. QIAN Peiyuan (3rd left) attended the second "Class at Sea"

On January 7, the Hong Kong University of Science and Technology (HKUST), in collaboration with the Southern Marine Science and Engineering Guangdong Laboratory (Guangzhou) (GML), the First Institute of Oceanography of the Ministry of Natural Resources, and the **Otto Poon Center for Climate Resilience and Sustainability**, successfully held the second event of the "Class at Sea" Marine Science for Global Citizens—Exploring the Colourful Indian Ocean. Scientists and pilots aboard the research vessel Shen Hai Yi Hao connected with approximately 350 teachers and students in Hong Kong and Qingdao via live streaming, unveiling the mysteries of the Indian Ocean.

The event focused on the extraordinary ecosystems and diversity of deep-sea life found in typical deep-sea habitats of the Indian Ocean, offering participants a rare glimpse into the lesser-known depths of the ocean. The class featured marine science education, interactive Q&A sessions, an ocean knowledge quiz, and an exhibition of deep-sea samples. Through engaging and interactive activities, the event combined education with enjoyment, sparking strong interest among students in marine science.

The "Class at Sea" series forms an important component of the United Nations Ocean Decade-endorsed programmes CliMetS and Digital DEPTH, and the United Nations Science Decade-endorsed programme MOCSI. It aims to promote public marine science education among younger generations and the wider community, while building an influential brand in ocean literacy.

Dr. Shin Cheul KIM, Associate Vice-President for Research and Development (Knowledge Transfer) at HKUST, highlighted in his opening remarks that "public marine education plays a vital role in inspiring young minds to pursue careers in marine science and carrying the baton forward".

Prof. Pei-Yuan QIAN, Chair Professor of the Department of Ocean Science at HKUST, Deputy Director of GML, Programme Leaders of CliMetS and MOCSI, and **CCRS member**, emphasized that "deep-sea research is a key focus of China's future scientific development. "Class at Sea" brings the latest discoveries from deep-sea expeditions to the wider public, enhances overall ocean literacy in society, enhances public awareness of ocean conservation, and lays a solid foundation for nurturing future marine science talent".