United Kingdom – China International Workshop on Critical Zone Observatories

2nd-3rd November 2015

Chinese Academy of Science (CAS) Research Centre for Eco-Environmental Research (RCEES), Beijing, China

[1]Workshop Report

Version 1.0 15th May 2016

SUMMARY

Sixteen Chinese and British science leaders participated in this workshop which was jointly sponsored by specific institutes of the Chinese Academy of Sciences and the UK Natural Environment Research Council Centre for Ecology and Hydrology with support from the Newton Fund. The workshop aim is to build on the current NERC-NSFC Programme on Critical Zone Observatories and related NERC and NSFC research programmes and to develop further priorities for joint research in Critical Zone science that will deliver transformative science advances that address the challenges of delivering environmental sustainabilty with economic growth. Participants identified that the most important over-arching societal challenge in common was land-use transitions and the extreme economic pressure in UK and China to intensify land use. Three priority areas for future joint research were recommended for development into future joint China-UK research programmes as a strategic partnership.

1. Urban-rural transitions and the urban-rural interface
2. Ecosystem restoration
3. Sustainable intensification of agriculture

Mechanisms to build a UK-China joint research capability in these areas were identified as

1. Joint conferences, training courses, summer schools at Chinese field stations/CZOs,
2. New Phytologist symposium,
3. Academic exchange for early career and established scientists,
4. International network – moving from programmes to long-term strategic partnership,
5. PhD Research Networks,
6. Research project funding, and
7. 2nd Round Newton Fund and Global/Grand Challenges Research Funds.

[1] Contact: Steven A. Banwart, The University of Sheffield, s.a.banwart@sheffield.ac.uk

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Programme: Critical Zone Observatory Workshop

Venue Chinese Academy of Sciences Research Centre for Eco-Environmental Sciences (RCEES), Beijing, China

Participants

Liding Chen – China organiser, CAS RCEES
Steven Banwart – UK organiser, U. Sheffield
Bojie Fu, CAS RCEES
Yongguan Zhu, CAS Institute of Urban Environment
Ganlin Zhang, CAS Institute of Soil Sciences
Bridget Emmet, NERC Centre for Ecology and Hydrology (CEH)
Terry Parr, NERC CEH
Dali Lu, CAS Inst. of Geographic Sciences and Natural Resources Research
Xiaoyuan Yan, CAS Institute of Soil Sciences
Hongyan Guo, U. Nanjing
Michael Bowes, CEH
John Crawford, Rothamsted Research
Tim Daniell, James Hutton Institute
Siliang Li, CAS Institute of Geochemistry
Yihe Lu, CAS RCEES
Xianli Xu, CAS Institute of Subtropical Agriculture Ecology

Aim

The workshop aims to build on the current NERC-NSFC Programme on Critical Zone Observatories and related NERC and NSFC research programmes and develop further priorities for joint research in Critical Zone science that address functional biodiversity, soil and water resources and the integration of mass, energy, and gene fluxes and transformation rates for improved process understanding. The joint research will aim foremost to deliver high quality and transformative science advances, and will also address the international challenges of delivering environmental sustainability whilst promoting continued economic development. In doing so, future research will enable long-term collaboration and joint national strengths and international leadership in Critical Zone science that is focussed on soil and water resources and biodiversity and can integrate into the international network of Critical Zone and related environmental observatories.

Objectives

1. Bring together UK & China science leaders from CEH and CAS, along with UK and Chinese Critical Zone experts, to discuss the framework for a joint research programme for biodiversity, soil and water security centred upon Critical Zone science,
2. Present current advances in Critical Zone research and development and existing infrastructure in the UK and China, plus infrastructure and site requirements for such a longer-term collaborative research programme,
3. Identify key research questions, within the context of China's and the UK's environmental stresses, where science advances will transform knowledge to improve resilience of soils and water resources to human perturbation,
4. Propose the necessary capacity building for collaborative Critical Zone research and data management & application, as well as the capacity for integrating activities between the UK and China, for research design, field experimentation and mathematical modelling and
5. Define integration goals, methods for integration and a timetable for achieving such collaborative goals.

Workshop Schedule of Activities

2nd November 2015

9:00-9:10	Open Workshop and Welcome Participants	Bojie Fu
9:10-9:30	Workshop aims and expected outcomes	Steve Banwart

Current Research and Frontiers in Critical Zone Science

9:30-10:00	Soil and Land Resources	Ganlin Zhang
10:00-10:30	Water Resources	Michael Bowes
10:30-11:00	Urbanisation	Yonguan Zhu
11:00-11:20	Example CZO site	Xianli Xu
11:20-11:50	Chinese Academy of Sciences – CZO network concepts	Bojie Fu

11:50-12:30 Discussion: common research challenges and expected outcomes in 10 years

12:30-13:30 Lunch

Afternoon discussion sessions: key research questions and joint research priorities

13:30-13:15 Discussion group objectives and format Steve Banwart

13:15-16:00 Group discussion: key science questions and outcomes in 10 years

Discussion topic 1. Rural-Urban Transition

Discussion group 2. Ecosystem Restoration

Discussion group 3. Agriculture sustainable intensification

16:00-17:00 Reporting and agreeing joint research questions and priorities

17:00 END OF DAY 1

18:30 Evening dinner together

Workshop Schedule of Activities

3rd November 2015

Design concepts for Critical Zone Observatories (CZOs) and networks of research sites

9:00-9:30	NERC CEH – CZO network concepts	Bridget Emmett Steve Banwart

Critical Zone Observatories – China example sites and infrastructure

Critical Zone Observatories – China example sites and infrastructure

9:30-9:50	Site 1	Ganlin Zhang
9:50-10:10	Site 2	Xue Fa
10:10-10:30	Site 3	Yongguan Zhu
10:30-10:50	Site 4	Yihe Lu
10:50-11:10	Site 5	Siliang Li
11:10-11:40	Data Integration: UK AgriTech Innovation Centre for Big Data	John Crawford
11:50-12:20	UK Concepts for Integrated Environmental Observation	Terry Parr

12:20-13:00 Discussion: opportunities to link and share sites for CZ research

13:00-14:00 Lunch

Afternoon discussion sessions: steps to advance a joint UK-China CZO research programme

14:00-16:00 Structured Discussion

Discussion Topic 1. Key areas for collaboration on land use transition

Discussion topic 2. Next steps and funding mechanisms for UK-China collaboration

Reporter: Steve Banwart

16:00 END OF DAY 2

18:30 Dinner for colleagues remaining in Beijing

Outcomes from Day 1 Discussions on key science questions for the next 10 years

Meeting participants agreed priorities for long-term science advances and identified areas for immediate impacts on solutions and economic growth. Participants agreed that the over-arching societal challenge was land-use transitions and the extreme economic pressure in UK and China to intensify land use. Three topics were covered.

4. Urban-rural transitions and the urban-rural interface
5. Ecosystem restoration
6. Sustainable intensification of agriculture

Outputs from discussion for each topic included a list of science questions and expected resulting advances in knowledge over the coming 10 years, expected short-term impacts for economic improvements (2-3 years), and identification of commercial sectors for partnership.

Priority Area 1. Urban-rural transitions and the urban-rural interface

Discussion leaders: Yongguan Zhu and Michael Bowes

There are common challenges for London and Chinese urban areas (e.g. Beijing and Yangtze River delta). These include insufficient water availability from the catchment area, e.g. water transfers from other catchments are already in place for Beijing and being planned for London, potentially providing a range of environmental issues; increased flood risk from sealing; and increased risk of untreated sewage discharges during stormwater peaks.

Rural systems have largely closed nutrient cycling, with human and animal wastes being reapplied to land. Urbanisation has broken this cycle, and is now importing nutrients from the rural areas, but disposing of nutrient waste locally within the urban area. China and UK urbanisation has problems of common emerging contaminants and health and ecosystem risks, urban hydrology and hydrogeology.

A number of potential collaboration areas exist. These include high frequency chemical water monitoring will greatly increase the understanding of sources and fates of pollutants within these highly dynamic systems. Collaboration potential exists on high-throughput biological monitoring of genetic diversity and pathogenic/faecal organisms; soil microbiome, plant microbiome and air microbiome as a component of human health. Additional collaboration potential exists for renaturing cities – selecting the fraction and design of green space for multiple functions for social value; closing the topsoil loop – building soil function without soil import – building waste/rubble with organic waste to create soil function to support vegetation that delivers specific ecosystem functions (green space, ornamental, shading, ET for cooling, etc.); spongy cities – SUDS and carbon sequestration, for water quality management, flood risk reduction, and pollution attenuation.

Areas of common interest that are policy relevant for urban environment include upstream catchment environments of urban river corridors, and catchments and aquifer impact gradients across the rural-urban interface.

Science advances that can be achieved through collaboration over next 10 years includes: high-throughput, high-frequency physical, chemical and biological monitoring. Tackling these challenges simultaneously would transform the theoretical ecology basis for community-level response to environmental change (air pollution, nutrient loads, organic pollutants, emerging contaminants) in human-dominated environments (urban). Major knowledge advances could be achieved on the impact of highly channelled environmental flows on the biogeography and geospatial functioning of urban ecology, and the impact of extreme weathering and conditions on urban ecosystem response. A step change in systems analysis for rural-urban interfaces could be achieved by advancing a common theory and analysis framework for ecosystem metabolism that is general for combined natural and urban systems and includes the energy and thermal balance of cities.

- **Potential short-term impacts for economic improvement**
- Recover and recycle resources from urban waste stream;
- Improve the efficiency and safety of peri-urban food production system
- reduced urban flood risk and economic loss
- Minimise environmental impact (biodiversity, human health) of further rapid urbanisation

- **Commercial sectors for research and impact partnership**
- urban landscaping
- waste management
- peri-urban food production
- sightseeing agriculture
- Water Companies
- Leisure / tourism industry

Priority Area 2. Ecosystem restoration

Discussion leaders: Bridget Emmett and Liding Chen

Current UK challenges include improving ecosystem function and increased ecosystem resilience; improving the area of specific habitats (woodland, wetland), improving the condition of existing habitat, increasing the connectivity, increasing the hydrological functioning, increasing the overall diversity of organisms (e.g. vegetation, etc.). These 4 properties are hypothesised to form the basis for ecosystem resilience (area, condition, connectivity, diversity)

Discussions on China focussed on the regional scale. Priorities include understanding the balance between the vertical scale (e.g. water balance to support plant growth) and the spatial scale which includes balance in patterns of diversity in different locations in the region, and the balance between human needs and environmental capacity. There is a question of how many people can be served by area which involves the balance/trade-off between different environmental services within the area.

Research priorities include the need for mathematical models to quantify the trade-offs; linking biodiversity, ecosystem functions and ecosystem services; quantifying trade-offs and synergies for decision-making on resource allocation and management. There is a need to apply modelling approaches that link ecosystem functions, sustainable development and economic decisions. There is also a need to understand system dynamics and then identify process understanding gaps and design measurements and monitoring to advance this understanding.

There is a need to decouple economic growth and environmental degradation (under degraded ecosystems this can be achieved) and a need to identify areas where degradation limits economic growth and then analyse how to act in order to reverse degradation. This analysis is also needed to identify where avoided risk will enable significant future savings. A further research challenge is to develop and apply methods to identify where (not obviously degraded) ecosystem properties are potentially limiting economic growth – and to identify human choices to achieve different future conditions

The science advances over the next 10 years include: metrics for resilience, a theoretical framework and translation to mathematical models and development of measurements and parameter sets that together can quantify changes in resilience in response to changes in the 4 ecosystem properties (noted above).

Potential short-term impacts for economic improvement

- improved human daily life by increasing ecosystem services
- increased land-production stability
- improved food safety
- reduced economic loss due to natural hazards
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Commercial sectors for research and impact partnership

- eco-tourist planning
- water-saving and carbon trade
- land management consultation

Priority Area 3. Sustainable intensification of agriculture

Discussion leaders: John Crawford and Ganlin Zhang

The big challenge is maintaining and increasing productivity gains with less inputs. Advances could be made by renaturing agriculture as an integrated Critical Zone system rather than a linear superposition of parts (soil, monoculture, water, inputs). Challenges include determining how to increase productivity with increased resilience and greater efficiency (in resource use); how to move away from green revolution approaches which were about maximising yields by maximising inputs; how to balance productivity and sustainability; and how to focus on a natural environmental system rather than a production system.

Critical Zone science offers an integrated approach where all components of this system should be taken into account; with combined study of biophysical and management indicators and thresholds for a sustainably intensified system. A priority is to apply Critical Zone concept to develop these indicators and thresholds – not only for soil, but also groundwater and the entire agricultural ecosystem. A consensus view of participants is that plant nutrition is currently about feeding the plant, not feeding the soil and that current research prioritises breeding the plant to produce under optimal nutrient conditions, while advances are needed in breeding the plant to grow successfully in sub-optimal below-ground conditions. Critical Zone science has the potential for a better understanding of natural processes that underpin crop production and also crop protection.

Joint research that will have value globally is to focus on fragile ecosystem (marginal land, arid and mountainous region, geologically controlled areas – karst, granite, sloped land with rapid erosion and thin, vulnerable soils). Application of new knowledge should focus on the demand for multiple ecosystem services – carbon sequestration, biodiversity, water quality, and others, and on better risk management that does not rely on massive inputs (pesticides, fertiliser, water, etc.). Priority policy areas include Payment for Ecosystem Services (PES) and food and commodity prices interacting with farming decisions on extent and intensity of production.

Additional priorities include understanding the long-term nutrient dynamics and storage in the deeper Critical Zone and the long-term transition from mineral P to organic P in soil and saprolite. Additional areas of systems analysis include understanding the upstream constraints on production and what burden of inputs this requires, and the downstream consequences of intensive agriculture into aquifers and surface waters to the coast.

Separate discussions tackled marginal land conversion and the risk of irreversible change in marginal land transition; quantifying the boundary between marginal (for agriculture) and productive (sustainably) land; understanding the geological evolution of the Critical Zone that sets the constraints; the human dimension of capital utilised for agricultural production and the understanding what the changing demand for productive land means as an evolving definition of marginal and what land will be attempted for production.

- **Potential short-term impacts for economic improvement**
- Reduced agrochemical input and increased use efficiency thus higher immediate monetary benefit
- Minimized environmental impacts from agricultural system
- Reduced water extraction and use

- **Commercial sectors for research and impact partnership**
- Water irrigation
- Fertilizer production
- Field observation instrument

Outcomes from Day 2 Discussions: Focus topics for UK-China collaboration

The meeting participants agreed that following the Day 1 discussion, two general areas for collaboration would be taken forward for international collaboration. These are

- Ecosystems restoration and intensification of services including agriculture
- Urban-rural transition zones

General objectives for collaboration across both areas are:

1. To develop long-term research collaboration between the UK and China in order to draw on the combined expertise of the scientific community in order to establish joint strengths and international leadership in key area of Critical Zone science that will support economic growth and sustainable development.
2. Transform fundamental knowledge and process understanding of the biophysical thresholds of CZ change under pressures of land-use change, especially land-use intensification, and
3. Apply knowledge in order to achieve CZ resilience to human pressure and land-use change.

The following priorities were identified as specific topics for collaboration over the coming 2 years.

Map of current observations against CZO framework to identify gaps that can be filled by collaboration

Joint research on urban/peri-urban and mountain to coast catchments

- Urban water cycle and flood mitigation
- Water and environmental quality changes along the rural/urban gradient
- Environmental quality and biodiversity of urban water bodies
- Predicting impacts of rapid urbanization on chemical and biological status of water and soils
- (Peri-)Urban soils and ecosystem functions
- Flows and transformations of microbial genes
- Highly channeled environmental flows of mass and energy
- Green space and green infrastructure
- Circular economy and waste recycling
- Emerging contaminants

Ecosystem services modelling of loess plateau ecosystem restoration studies with a focus on trade-offs between services that occur between restoration management options

- How to improve landscape structure and ecosystem function
- Trade-offs between different human needs
- Metrics for ecosystem services and health across scales (plot, catchment, regional, etc)
- Upscaling methods
- What confers resilience and how to restore it
- Identify risks and target resources for action on land use change/management

Mobilisation of terrestrial carbon and associated mass and energy stocks and their transport from catchments and transformation during river transport

- Land use and management impacts on C dynamics
- Coupling between carbon input and other element dynamics
- Contribution of biodiversity to carbon storage
- Key biological processes and element budgets
- Element transport and transformations in aquifers and rivers
- C,N GHG emissions

Environmental capacity and impacts of agricultural intensification and urbanisation

- Biophysical indicators and thresholds for a sustainably managed system
- Environmental capacity for sustained, increased production
- Off/under-site unintended consequences – environmental quality, land use demand elsewhere, food safety
- Increased resource efficiency, recycling and waste reduction
- Time scales and capacities for accumulation and attenuation of soil contamination
- Water demand, irrigation impacts and related challenges of agricultural water use

Shared experimental methods between field research sites and other facilities for CZ research

- Highly instrumented in-situ mesocosm process studies for reactive transport and plant-soil-water interaction mechanisms
- Common process-oriented studies in UK and China
- Novel analytical and monitoring technologies and sensors
- Simultaneously going higher and deeper in CZ
- Expanding process understanding across physical, biological, chemical
- Implementing nested scales of observation – lab to region
- Data and modelling platforms and integration

Environmental Forecasting

- Methods for constructing scenarios of land use change
- Social and economic narratives of future change
- Interactions with climate change mitigation and adaptation
- Driving forces of land use change across scales (home to region)
- Impacts of land use change on the environment, ecosystems and processes
- Adaptive management
- Uncertainty and confidence intervals of forecasts
- Extending across time scales – hindcasting and forward long-term change

Next Steps and Mechanisms to Fund Collaboration

The workshop participants committed to working together and with their national colleagues in order to advance UK-China collaboration in Critical Zone science over the coming 2 years. The participants agreed to pursue the following and potential funding sources mechanisms for collaboration in the short-term and use these activities to create a long-term, strategic partnership in Critical Zone science between China and the UK.

Mechanisms of UK-China Critical Zone Science Collaboration and Funding Sources
Conferences, Training courses, summer schools in Chinese research stations/CZOs Diverse funding sources nationally and internationally
New Phytologist symposium – CZO conference following Tansley Review Support from New Phytologist symposium fund
Academic exchange for early-career and established scientists China Ministry of Science and Technology (MOST), Chinese Academies (CAS, CAAS), National Natural Sciences Foundation of China (NSFC), UK Science and Technology Facilities Council (STFC) Network + with China on sustainable agriculture, Royal Society Newton Fellows scheme
International Network – moving from programme to long-term strategic partnership UK Natural Environment Research Council (NERC) International Opportunities Fund (IOF), Chinese Academy of Sciences
PhD Research Networks China Scholarship Collaboration (CSC) funding, Research Councils UK (RCUK) Doctoral Training Partnerships (DTP) and Centres (DTC), European Commission Training Networks
Research Project Funding Collaborative proposal submissions to NERC, BBSRC and NSFC, MOST, European Commission Horizon 2020 calls
Mechanisms for Building Strategic Partnerships in Critical Zone Science • Next Generation Newton Funding / UK Global Challenges Fund – propose joint research from the above workshop topics • Preparation for 2nd international strategic programme – build UK-China community from current NERC-NSFC programmes in soil, water, biodiversity and Critical Zone Science and submit to future rounds of NERC Strategic Programmes calls • International CZO Forum with NSFC, NERC, NSF (USA), DFG (Germany), ANR and CNRS (France) – use collaboration arising from this workshop to support establishment of the Forum and an international programme of CZO research

Short-Term Actions to Advance Collaboration

The following immediate actions were agreed as first steps to take UK-China collaboration on Critical Zone science forward.

The workshop report will be circulated to participants in draft form by 6th November with comments and edits returned by 13th November and final version completed by 30th November 2015.

*Additional internal UK and China consultations will be used to agree specific next steps. These consultations will include the following.

- UK workshop invitees will consult within their organisation and more widely as needed to agree UK actions and report to workshop participants by 31st January 2016
- Workshop organizers to discuss with China science leaders and report agreed actions to workshop participants by 31st January 2015.

Workshop participants will discuss with funders to clarify the eligibility and timing of funding mechanisms for the collaboration activities outlined above.

Workshop organisers Banwart and Zhu will report the outcomes from this workshop to the international CZO programme workshop scheduled for 13th December 2015 in San Francisco.

The workshop organises will prepare and submit a meeting report (500 word limit) to EOS magazine.

Banwart will propose a NERC Planet Earth feature on Newton Fund activities on CZOs.

*The organisers will circulate by 31st January 2016 a schedule of any additional actions arising from the internal UK and China discussions, and potentially from the international CZO workshop in San Francisco.

*NOTE 15th May 2016

This document is proposed to continue as an informal, living document that can be posted online (proposed to be via NERC CEH, SSP and CZO programme web sites) with updates to content according to further input from UK and China science leaders to the report corresponding author Steve Banwart.

The agreed follow-up actions that have been completed include the following.

1. This report passed to CEH Directors and NERC Swindon Office to inform discussions on next round Newton Fund and to inform RCUK meetings with VP NSF China during his mission to UK 17-23 April 2016

2. This report is recommended to be tabled for information to the CEH Strategic Development Group and to NERC Soil Security Programme Advisory Board