Report from UK- China Critical Zone Observatory Meeting

9^{th} – 11^{th} June 2017

Huangguoshu Conference Hall,
Renaissance Hotel,
Guiyang, China

Hosted by:
National Natural Science Foundation of China
Natural Environment Research Council, UK

Organised by:
State Key Laboratory of Environmental Geochemistry, CAS, China

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1. Agenda

UK-China CZO Meeting
Guiyang, China
10th to 11th June 2017

Friday 9th June, Registration at Panjiang Hotel Lobby, whole day

Saturday 10th June, Huangguoshu Conference Hall of the Renaissance Hotel

8:30 – Opening and Welcome by Chinese NSFC and UK NERC
8:50 - UK-China CZO Program Summary by Dr Sarah Dennis (Programme Coordinator)
9:00 – SPECTRA: Soil Processes and Ecological Services in the Karst Critical Zone of SW China – Prof Tim Quine and Prof Dali Guo
9:50 – Coffee Break
10:10 –Red Soil CZ: From Natural to Anthropogenic Evolution of Red Soil and its Impact on Ecosystem Function in the Critical Zone– Prof Paul Hallett and Prof Ganlin Zhang
11:00 – The transmissive critical zone: understanding the karst hydrology-biogeochemical interface for sustainable management – Prof Susan Waldron and Prof Xi Chen
12:00 – Lunch, buffet at the BLD restaurant on the 2ed floor of the Renaissance Hotel
13:30 – Using Critical Zone Science to Enhance Soil Fertility and Improve Ecosystem Services for Peri-Urban agriculture in China – Prof Steven Banwart and Prof Yongguan Zhu
14:20 – Modelling and managing critical zone relationships between soil, water and ecosystem processes across the Loess Plateau
– Prof Lianhai Wu and Prof Ming'an Shao
15:10 – Coffee Break
15:40 – Program Integration session
15:45 - Overview of KE capability (Susan Waldron)
16:00 - Overview of cross-site measurements (Andy Binley and Tim Quine)
16:30 - Brainstorm – Panel of 10 PIs Chaired by Simon Kerley.
18:00 – Close for the day
(18:10 – PI's review the following day's breakout sessions topics)
19:30 – Dinner offered by SKLEG and IGCAS (a coupon with the details will be given at the registration desk)

Sunday 11th June, Huangguoshu Conference Hall of the Renaissance Hotel

8:30 – Review the brainstorm and introduce the breakout sessions (Sarah Dennis)
9:00 – Breakout sessions
- The number of groups will be determined by the number of areas to discuss suggested in the brainstorm
10:00 – Coffee Break
- Continuation of breakout sessions
11:00 – Regroup to summarise breakout session discussions and opportunities to ask any questions we didn't have time for the day before.

12:00 – Lunch, buffet at the BLD restaurant on the 2ed floor of the Renaissance Hotel

The following is 2 Parallel Sessions:

13:30 – PIs with NSFC/NERC and RCUK

- Agree actions and schedule for integration activities

13:30 – Early Career researchers meet to discuss any forum, regular skype seminar series they think would benefit them all.

- Feed back to Sarah Dennis who will assist with organisation of any suggestions and fed back to PI's.

16:00 – Close

2. Report on the 5 Project Summary presentations

a. SPECTRA: Soil Processes and Ecological Services in the Karst Critical Zone of SW China – Prof Tim Quine and Prof Dali Guo

- Intensive period of sample collection and analysis has been undertaken and progressing with sample sharing and the development of a database.
- Work Package 1-3 are building detailed understanding of the Karst CZO structure and mechanisms
    - Work Package 1
        - High resolution DEM creation and soil depth measurements with 100 measurements of soil depth at each of the 64 plots in the Chenqi watershed.
        - Plant lead stoichiometric variations have been investigated for 4 vegetation types, primary forest, secondary forest, shrub and grasslands.
        - Soil stoichiometric variation with geology have been investigated at 64 plots using soil pits and rock cores to 3m.
    - Work Package 2
        - Ongoing work to characterise relationships between primary minerals and weathering products, relationship to porosity developments, and order of reactions.
        - 2016 soil profiles include some ^{137}Cs, but no ^{210}Pb or ^{10}Be as yet.
        - Analysis of the relationships between ^{137}Cs and total C, SOC, soil stock is underway.
    - Work Package 3
        - Results show that sloping farmland has the lowest microbial abundance while abandoned farmland has the largest and most stable microbial community.
        - Secondary forest has a stable but stressed microbial population, with Actinobacteria taking the fungal niche.
- Work Package 4 has built understanding of controls on CZO function across a range of scales
- Next stages will be to develop new quantitative understanding of CZO processes and function in Work Package 1-3 and build into models developed within Work Package 4.
- Socio-economic, knowledge transfer and partnership aims remain a focus.

b. Red Soil CZ: From Natural to Anthropogenic Evolution of Red Soil and its Impact on Ecosystem Function in the Critical Zone– Prof Paul Hallett and Prof Ganlin Zhang

- Morphological, biogeochemical and biological indicators have characterized the structure of the Red Soil CZ.
- Land cover and management have a large influence on soil processes and evolution. Large proportion of rainfall driving nitrogen into groundwater then surface water (>500 mm/year)
- Rainfall recharges soil water frequently, but replaces the 0-100 cm “old water” completely within about 2-3 months in wet season.

- Soil erosion rate up to 3500 ton km^{-2} yr^{-1}. SOC stock and erosion interactions being modelled to determine sink vs. source.
- The CO2 assimilation coupled with Fe(II) oxidation was experimentally proved.
- Models allowing for ecosystem processes and hydrology to be predicted at plot scale, with extension to larger scales underway.
- What's next?
    - Integration of models and data;
    - Nitrogen transformation and translocation (e.g. acidification, movement to environment);
    - Fe-C interactions with aggregation;
    - Separate upland and paddy ecosystems for hydrological modelling;
    - Use modelling output to inform policy decisions.

c. The Transmissive Critical Zone: Understanding the Karst Hydrology-biogeochemical Interface for Sustainable Management – Prof Susan Waldron and Prof Xi Chen

- Over the last 1.5 years a Critical Zone Observatory at the Houzhai catchment has been developed.
- The Karst Critical Zone architecture is being refined with the additional added value collaboration with Lancaster University.
- Work Package 1 and Work Package 2 – Hydrological cycle of hillslope - water quantity and quality.
    - Hillslope flow contributes water to depression.
    - Ground water sensors show depression water composition.
    - Novel isotope tracing shows new and old water flow mixture.
    - ^{14}C is also an important tracer and there is very little ^{14}C data for China so this is a highly novel data set.
    - Monthly grab samples of N and P show [NO_3^- – N] are below WHO guidelines but is P now an emerging issue?
    - [NO_3^- – N] is responsive to hydrological conditions and land management at timescales monthly grab sampling would miss.
    - Moving on to event focused work to allow to disentangle sources and processes to inform integrated modelling.
- Work Package 3 - Karst desertification: how much water does vegetation need?
    - A 9 month transpiration time series has been determined using chambers and TDR.
    - The measured transpiration can be modelled.
    - A full eco-hydrological year of data collection to refine modelling will be completed in the next 6 months.
- Faecal indicator organisms are also part of water quality. Faecal pollution are affected by event flow.
- Work Package 4 upscaling now coming into consideration.
- Work Package 5 have been gathering information to inform science effectiveness: Knowledge Exchange.
    - Spoken to 15 county leaders, 8 town leaders and 24 village leaders along with 321 farmers in total (20 to 57 surveys carried out in each village).
    - Future work is to identify knowledge that can be shared with the stakeholders and have "advisory board" meeting (UK and China external delegates).

d. Using Critical Zone Science to Enhance Soil Fertility and Improve Ecosystem Services for Peri-Urban agriculture in China – Prof Steven Banwart and Prof Yongguan Zhu

- Work Package 1:
    - field mesocosm experiments have been set up to test the effects on wheat and vegetable production on 1) 100% chemical fertiliser, 2) 100% sewage sludge, 3) 100% pig manure, and 4) 50% chemical fertiliser and 50% pig manure.
    - The experiments are being monitored to assess the impact of these treatments on biogeochemical cycles, water flow and transport of agrichemicals to surface and groundwater, and to assess the occurrence and transport of antibiotic resistance genes (ARGs) in the organic fertilisers, soils, water and crops.
    - Carbon-14 labelled antibiotic compounds are currently being synthesised for use in fate and transport studies in the field mesocosm experiments.
- Work Package 2:
    - Manure-derived antibiotic compounds significantly reduced rates of microbial denitrification and anaerobic ammonia oxidation.
    - A meta-analysis of 141 studies worldwide showed that replace some or all of mineral fertilisers with organic fertilisers generally improved crop yields, reduced N- and C- greenhouse gas emissions and reduced soluble and particulate N loss in drainage waters.
- Work Package 3:
    - The biogeography of ARG occurrence within 4 sub-catchments of the Critical Zone Observatory demonstrated correlation of ARG numbers with land use including relation to agricultural land and sewage discharge areas and showed dynamic seasonal behaviour.
    - Laboratory studies of soil-plant-water interactions showed that application of manure significantly increased the occurrence of ARGs in soil and plant leaves.
- Work Package 4:
    - The land use history and change in land area of characteristic land uses has been re-constructed for the past 40 years.
    - The geospatial distribution of metals contamination in soil, the occurrence of antibiotics and of ARGs has been mapped across the site.
    - Process modelling of coupled C-N dynamics in the watershed, rainfall-run off-soil water dynamics in land uses is ongoing and a new modelling research fellow is appointed to quantify the mechanistic interactions of soil processes with the full Critical Zone, i.e. with the atmosphere, vegetation, soil, surface waters and aquifers.

e. Modelling and Managing Critical Zone Relationships between Soil, Water and Ecosystem Processes across the Loess Plateau– Prof Lianhai Wu and Prof Ming'an Shao

- Recent landscape changes in the Critical Zone of Loess Plateau region
    - Vegetation coverage 2000 – 2014 has been studied; it shows mainly moderate vegetation cover with increase from Northwest to Southeast.

    - Temporal trends in vegetation cover change – with the lengthening of the time period the vegetation cover improved consecutively. The significant vegetation restoration covered 52% of the Loess Plateau mainly distributed in Zones of FOR-GRASS and GRASS during 2000-2014 comparing to that of 2% at the initial stage (2000-2005).
    - Restoration caused significant changes and were reinforced through time
    - Socioeconomic activities had significant influence on ecological restoration effectiveness
        - Negative impact - Population and industrial developments; Population pressure revealed a stronger negative effect in this case. There has been a sharp increase in secondary and tertiary industry since 2007. Secondary industry was the major contributor for this negative effect.
        - Positive impact - The improvements of agricultural economy; Income improving wasn't the dominant factor.
        - Restoration effectiveness could be enhanced from promoting rural economy.
- The vertical profile of soil moisture content and nitrate has been measured in the Plateau Critical Zone.
- Variations of magnetic susceptibility are observed both in the vertical soil profile and across different sites. Precipitation affects soil magnetic property changes, especially for the shallow soils (<30 m)
- Model development in runoff, soil, C and N losses – revisiting the SCS-CN method.
- Changwu's long-term data has been used to validate SPACSYS. SPACSYS predicted well the yield for normal and wet years; dynamics were well captured, good agreement with the experiments and LAI peak well predicted.
    - N and C budgets using SPACSYS with Changwu's long-term data show denitrification and leached loss are small. SOC is decreasing suggesting winter wheat monoculture is not sustainable.

3. Report on the Project Integration Session

a. Summary of Cross Project Work

- Knowledge exchange

Steps completed so far to deliver the outputs include researching what type of KE exists in China; surveys and interviews to collect data about KE practice, type of learning and science-policy-practice interface. Scientists have been surveyed from all 5 projects. Currently ongoing interviews and surveys of leaders and farmers from Puding. Results show that farmers mainly learn farming methods from their families. Both Farmers and Leaders agree that more training is required to increase productivity though farmers would prefer this gain this new knowledge by visiting farmers whereas Leaders would prefer to pass knowledge on through training. Written instruction does not go down well. Demonstration field sites were strongly suggested.

- Portable Gamma Spectrometer

A north/south transect has been measured using the Portable Gamma Spectrometer at 14 spot sites in the Chenqi Catchment. Next step is to compare the transect results with the geophysical data which shows significant lateral variation in resistivity suggesting large variation in bedrock and very thin soil cover in places. An application is in at other CZO programme sites to coordinate with the geophysics work.

- Geophysical surveys in the China critical zone observatories

Geophysical surveys in the Chenqi catchment. Completed multiple 2D ERT and GPR on 6 small plots used by SPECTRA. 3 hillside ERT transects crossing SPECTRA plots. Many ERT transects in Chenqi valley near known sinkholes and other features. Loess Plateau geophysics - Plot scale experiments to examine unsaturated transport (linked to modelling) Small catchment studies to look at using geophysical data as proxy for hydraulic properties. Red Soil ERT - Currently hoping for field campaign in Sunjia first 2 weeks July.

b. Summary of the Panel discussion

Simon Kerley chaired a panel discussion of the project PIs. The PIs were asked to brain storm and suggest ideas and comment on ways we can integrate further across the programme.

Across Programme integration

	Nitrate	Animal manure/fertiliser	Bacteria/genes	Residence time	Remote sensing	Other?
SPECTRA	X	X	X			
HYDRA	X	X	X	X	X	
RED SOIL	X			X		
PERI-URBAN	X	X	X	X	X?	
LOESS	X			X	X	

It was highlighted that the Nitrogen appeared to be a science thread that went through the whole programme and every project. Suggested comparing the nitrogen transformation across all site.

Everyone was impressed by the knowledge exchange work done at the Karst site and felt other groups could learn from this.

Microbial role in stabilising carbon has been a recent question and this programme could cover this with the work they are already doing.
The work the USA CZO programme are doing across their sites was discussed– constraining discharge, deeper storage of Organic Carbon in the Critical Zone, what is the architecture of the Critical Zone, what forms it and how does it change?
The point about how close are we to answering the "simpler" questions was raised; e.g. how much nitrate is in the soil? Are farmers using fertilisers when it is not required? Can we test the soil to see if it is needed? How much nitrogen do the soil and crops actually need?
A stakeholder panel across all projects in about one years' time is a good idea and will bring the projects together.
Modelling collaboration was discussed, USA are doing this but are data poor/model rich. Also need models that can feed into simpler more communicable tools and output too.
Joint publications were discussed. Need to have science at the centre. Ideas were: resilience of the critical zone under stresses; nitrates across the different landscapes; about the need to move to natural fertilisers by 2020 (includes nitrogen loading and manure use).
The ODA objectives are very unique to the UK-China CZO programme. We should play on this and make it clear. Need to be able to demonstrate that Critical Zone Science is giving more intellectual outcomes that individual science – what is the added value?

From these discussions 6 working group topics were selected as most important and to be discussed further. These were Knowledge Exchange, Joint papers, Nitrogen, Architecture of the Critical Zone, Model collaborations, Microbiome.

4. Breakout working group summaries

a. Knowledge Exchange – Ying Zheng

- Research impacts were mentioned in most projects, mainly including impacts from research publications, workshop and students/post-doc exchange.
- There has been not much readily established KE pathway, apart from Karst CZO project.
- Key components in KE delivery in China includes:
  a) Access to multi-level government department (therefore it'll be helpful that each project can suggest someone for more direct communicate for such HR resource, if any KE collaboration between projects can happen);
  b) The utilization of social media, to strengthen the connection and interaction between our research and the public (to do so, WeChat is suggested in China whilst Twitter in the UK)
- Workshop/webinar/online video can be used to help facilitate the technique sharing among five projects.
- To improve the international impact of our CZO projects, we can have more communication with other similar projects, such as the red soil research in India, and CZO-US programmes.
- Producing joint paper(s) is also important for our CZO programme, as to increase KE within 5 projects as well as the public impacts.

b. Joint papers – Susan Waldron

Ideas for Joint papers:

- Anthropogenic influence on the critical zone? Reshaping of geomorphology over 3000 – 4000 years. Peri-urban is an extreme example but so are terraced farmlands. Loess is top down, Karst is bottom up, weathering process.
- Link with Nitrogen group on deep Nitrogen. BBSRC? NSFC.
- DEM and discussion of the value of the 5 CZO projects.
- Critical zone science and why do we need instrumentation.
- Young researcher paper – combination of a range of PhD student projects to CZO science.
- Revegetation being used to restore soil – possible modelling paper?
- Things that can be tackled now?
    - Conceptual - Geomorphology, urbanisation, historic landscapes, management, deep Earth, Residence time. E.g. what will Nitrate Vulnerable Zone, for example, look like in the future?
    - Data rich – Nitrogen, bacteria.
- Things that will need thought of in the Future
    - Data rich – Fe rich, Fe isotopes.
    - Engineering plant-soil interaction for sustainable CZ; a modelling paper.

c. Microbiome – Sarah Buckerfield

Several points of shared interest across CZO projects were identified, with potential for collaboration both between geochemical and microbial fields and across microbial methods.

- The soil rock interface: identification of 'hot spots' and 'hot moments' for microbial and geochemical activity, recognised as being closely coupled. Potential for combined sampling campaigns.
- Deeper profiling of geochemistry and the microbial community (currently most knowledge and research is focused on the near surface). Also potential for combined sampling campaigns.
- Quantifying and tracing faecal contamination of water resources: microbial source tracking (MST) methods are being used in the peri-urban project with development of new DNA microarrays (chips). These newly developed chips have been offered as a tool available to other projects and could add great value to results from culture based methods currently being used in the karst transmissive critical zone project.
- Impacts of increased CO2 levels on microbial activity: what can be expected under the effects of climate change?

d. Model comparison and integration – Joseph Oyesiku-Blakemore

Model comparison is difficult as the models selected work on different temporal and spatial scales and have different targets. The objective of the modelling work will necessitate the approach taken and, for comparison to be feasible, we must select models which produce similar outputs for similar scales (both temporal and spatial). For this to be possible we must have an understanding of one another's work.
To this end the working group came up with 5 main suggestions for collaboration between the projects.

- Produce a spreadsheet to be populated with information on the modelling work which is being conducted in each of the projects.
- Each project will produce a model framework for each site which highlights the key processes governing each critical zone. The framework could be populated with fundamental values e.g. the residence time of water or the carbon content of soil.
- Each site would be modelled using the same model(s) with the goal of providing increasing the scale of and providing interesting contrasts on simulations of whichever critical zone processes are to be modelled. It would require a model which can function on basic input data which will be available at all sites. It will also require sharing of data between projects.
- A paper will be written comparing the selection and use of different models for the different projects. It will discuss how these are governed by the importance of different drivers, stresses and services in each of the regions.
- Where similar scales of interest and objectives are present and where data availability allows comparisons should be made between the performances of different models. The variety of approaches being used means this may only be between two or three of the projects.

Additionally, where possible models will be made available for use for other projects and, where there is demand for it, training for using these models will be put on.

e. Nitrogen Story – Tim Daniell

The group recognised that each project had work that was relevant to the nitrogen cycle. Initially we drew up a table summarising the areas that each project covered. There was significant commonality in the approaches taken by each of the projects especially in the measurement of N pools. Unsurprisingly the peri-urban project, which focusses on the benefits and risks associated with changes in fertilisation, includes the most comprehensive assessment of N cycling including measurements of pools, fluxes and associated community dynamics.

It was felt that with shifting policy requirements restricting the growth of chemical fertiliser application in the future the area is likely to become more important as fertilisation patterns are likely to change relying on a greater proportion of nutrient input from recycled sources such as slurry or compost. The key points of the discussion are listed below:

1. It was felt that the CZO consortium is in a good position to provide key data and interpretation in this area especially as the consortium works in a wide range of soil types across China and elsewhere.
2. There is a clear desire for collaboration between groups in the consortium especially where there is complementary skills, it was however, recognised that further funding was required to drive such collaboration.
3. Discussion moved onto to possible funding routes for collaboration in the area. Key to these are probably current and future Newton related research grant calls in association with Chinese funders such as MOST. There is a relevant call currently open from NEWTON through InnovateUK, BBSRC and MOST which would be explored with a view for an application. It was recognised that there was very limited time to respond to this call but the preparation would be valuable to respond to other call which are likely in the future. Additionally, this area may provide a subject suitable for further rounds of CZO funding.

f. Architecture –

5. Minutes of the Early Career Discussions.

Report from Joseph Oyesiku-Blakemore.

The outcomes of the discussion were that we would have monthly meetings on the first Wednesday of each month at 9am UK time (4pm China time) (using skype if less than 25 participants or free bridge if more). We decided that we would look for volunteers to give short presentations in each of the meetings and these could for the basis for discussions. Hopefully participants will be able to share ideas, get help with problems and look for collaborations on papers.

We also got a list of the Early Career Researchers who were attending Guiyang meeting. We need to add to that list the other Early Career Researchers who are part of the programme.

Follow up questions by Sarah Dennis…on who is organising this? When will the first one start?

First meeting is to be held on the 5th July 2017 at 9am.