Scientific aims of Climate Science for Service Partnership-China (CSSP-China)

The CSSP-China project aims to build a strong strategic partnership between UK and Chinese climate scientists through an accelerated and enhanced collaborative climate science programme.

The partnership will focus on research and innovation, establishing a firm foundation of cutting-edge science that can underpin the development of climate services to support climate-resilient economic development and social welfare. Hence the project is called the Climate Science for Service Partnership.

The science plan for the CSSP-China is built upon the existing collaborations over many years, and is consistent with the MOU signed between the Met Office and IAP in January 2013, Met Office and CMA in March 2014, and builds on the joint research program developed during the Dartington Hall workshop January 2013 and the Guangzhou Workshop February 2014.

The science plan for CSSP currently has five work packages agreed at the meeting in Beijing 9-11th June 2014.

WP 1. Monitoring, attribution and reanalysis

The observational record of East Asian climate needs to be developed to enable increased confidence in our understanding. Climate variability takes place over a range of timescales, including multi-decadal, so long data sets are needed. To understand extremes we need observational data at daily or sub-daily timescales and to capture regional processes we may need to increase the spatial resolution of gridded datasets. In all cases, the quantification of uncertainties in those observational data is essential.

The long-term goals of this work package are to:

- Improve the observational basis for understanding East Asian climate variability and change by including early years’ data through digitisation, and by developing techniques, software and tools to improve gridded datasets, including at higher temporal and spatial resolution and to assess their uncertainties. One focus could be on precipitation, to better enable the understanding of the East Asian Summer Monsoon and the wider hydrological cycle (see also WP3).

- Develop a collaborative programme on the attribution of climate-related extreme events and long term trends in the East Asian region, and their likely causes.

- A long-term goal of the CSSP-China could be to develop a regional reanalysis for East Asia.
WP 2. Global dynamics of climate variability and change

The climate science community recognises that understanding of global climate dynamics is needed to improve regional climate predictions. This science underpins our ability to make forecasts from months to decades ahead and to have confidence in future projections of regional climate change. Hence this underpinning science lies at the heart of many of the objectives of CSSP-China. Modes of variability such as ENSO and the Pacific Decadal Oscillation and changes in the East Asian Summer Monsoon are crucial for East Asian climate variability and change. Similarly, in the UK the North Atlantic Oscillation drives much of our climate variability and adds uncertainty to climate change projections. Yet the representation of these sources of variability, their interconnections and drivers, and their influences on regional climate remains uncertain in climate models. Therefore the CSSP-China will aim to evaluate our climate models and investigate the dynamical mechanisms and predictability of modes of variability and associated regional climate variability from months to decades ahead.

The long-term aspirations of this work package are to:

- Develop a vibrant and collaborative community of scientists in the MOHC and China with expertise in the climate dynamics of oceans and atmosphere.
- Use advanced dynamical analysis tools and diagnostics to evaluate and understand global modes of climate variability and their teleconnections to regional climate.
- Develop a comprehensive understanding of the mechanisms and predictability of regional climate variations on seasonal and longer timescales, and use this to critically examine performance of climate models and predictions.
- Increased confidence and a reduction of uncertainty in regional climate predictions for Europe and China through an increased understanding of the dynamical mechanisms.

WP 3. East Asian climate variability and extremes

The focus in WP 2 is on global aspects of modes of variability. WP 3 is focused on regional expression of these modes and their teleconnections and impacts on regional water cycle and climate extremes within the East Asian region. This will include the understanding of physical mechanisms and potential of predictability, evaluating and improving modelling capabilities and prediction skills; and the assessment of climate risks and development of early warning methods. This WP will build upon existing UK-China collaborations in seasonal forecasting, high resolution modelling and regional drought.

The long-term goals of this work package are to:

- Increase the understanding of East Asian climate variability and assessment of its predictability for improving climate prediction skills over East Asia on seasonal to decadal timescales.
• Increase the understanding of drivers of regional drought and flooding and developing the capability of early warning methodology.

• Develop convection permitting models for the East Asian region, to capture extreme climate events and their impacts such as heat waves, flash floods and the impact of large scale urbanisation and mega cities.

WP 4. Development of models and climate projection systems

The continuous development of climate prediction models underpins the modelling capability within a climate prediction programme. The aims are to develop UK-China collaborations to study methodologies for evaluating and improving the physical and dynamical processes in the numerical models of atmosphere, ocean, land, and sea-ice and to evaluate the coupling between these components in the climate system. The process based evaluation can involve (i) confronting models against new observations of physical processes (link to WP1) (ii) making use of the seamless approach to evaluate physical processes in the models across a range of timescales from weather to climate, (iii) developing novel diagnostic techniques (e.g. Nudging, initial tendencies) to highlight the source of model systematic errors/structural uncertainties at the process level with a focus on impacts on East Asian climate variability (iv) performing targeted sensitivity tests to changes in model formulation (e.g. parametrisation settings, vertical resolution) and study perturbed parameter ensemble optimal parameter settings, (v) evaluate physical processes in global prediction systems against higher resolution regional convective scale (~1km) simulations over East Asia.

Societies need predictions of 21st century climate on timescales ranging from a season to a century or more ahead. WP4 will focus on the 5-40 year time scale, for which projections are needed to inform a range of sectoral adaptation choices during a period in which uncertainties associated with natural variability and climate modelling are expected to exceed those arising from future emissions pathways. Addressing these uncertainties will be a specific focus of the work. In particular, a new perturbed parameter ensemble (PPE) of the HadGEM3 coupled ocean-atmosphere model will be explicitly designed to represent important process uncertainties identified by model parameterization experts. This work will exploit the latest developments and understanding built into the Met Office Unified Model, and will also inform future model development work by providing information on the drivers of systematic errors in the East Asian region. Following a rigorous development and evaluation phase, new simulations of historical and future climate will be run.

In parallel, uncertainty quantification methods based on existing PPE and multi-model ensemble (MME) techniques will be extended to assess the potential to obtain more robust estimates of plausible ranges of future variability and change over East Asia. This could potentially be achieved, for example, by combining results from both types of ensemble (rather than relying exclusively on CMIP5 results in isolation), both to sample plausible future outcomes in a more comprehensive fashion, and to discover new emergent observational constraints which can be shown to be robust to different choices of ensemble design. Ultimately, these two strands of work (new HadGEM3 PPE and ensemble combination
and constraint methods) will be pulled together in a collaborative assessment, to inform the potential to provide improved Climate Services out to the 2050s.

The long-term goals of this work package are to:

- Accelerate the development of climate models with a range of complexities to inform climate projections, through joint development of a methodology for process based evaluation of the models across a range of prediction timescales.

- Develop a methodology to define an ensemble of perturbed parameter variants of the HadGEM3 coupled ocean-atmosphere climate model, capable of providing a set of state-of-the-art realisations of climate variability and change for 5-40 years ahead for East Asia and other world regions.

- Develop methods to derive robust information on uncertainties in future climate variability and change in East Asia during the 21st century, consistent with current understanding of key earth system processes, model capabilities and observational constraints derived from multi-model and perturbed parameter climate projection ensembles, and suitable to inform decision-making and impacts analysis.

**WP 5. Climate services**

With these key elements of the underpinning science needed for service development in place, the CSSP will be in a strong position to develop climate services based on such building blocks. There is tremendous potential to develop such services as part of the China Framework for Climate Services response to the WMO Global Framework for Climate Services. The CSSP will develop pilot projects for particular sectors. It will also develop the translational science needed to produce usable knowledge and applications built on a solid scientific foundation.

The long-term goals of this work package are to:

- Develop translational science, a multi-disciplinary approach to bridge the gap between climate science and society to produce useable knowledge and applications.

- Identify user needs and develop climate services for particular sectors which could include the energy, water and agriculture sectors for example. The aim would be to develop case studies to demonstrate the value of climate science for services by translating climate information into beneficial decisions.
Ways of enabling collaborative working

There are a number of ways of working which will facilitate the CSSP partners to achieve these scientific aims and build a strong partnership between the UK and China. These could include:

- Continued Visiting Scientist exchange programmes between the MOHC, IAP and CMA;
- Exchange of data;
- Joint projects with project leads from the UK and China;
- Supercomputer usage in the UK and China;
- Workshops and joint meetings: for science leads, for climate services; including end users and partners (e.g. energy), and regular annual workshops to review work package progress;
- The formation of a Science Review Panel;
- Training programme for students, including summer schools, PhD Supervisors, workshops.