Value of weather and climate information for irrigated agriculture

Supervisors: Dr Timothy Foster (MACE), Prof David Schultz (SEES)

External supervisors and institution: Dr Anna Ghelli (European Centre for Medium Range Weather Forecasting – ECMWF, UK), Dr Taro Mieno (University of Nebraska-Lincoln, United States)

Primary Contact Name and Email: Dr Timothy Foster – timothy.foster@manchester.ac.uk

Introduction:

Weather and agriculture are intimately linked. In many parts of the world, rainfall is insufficient to satisfy crop water demands fully, and, as a result, farmers rely on supplemental irrigation to adapt to variable weather patterns and maximise crop yields. However, the availability of water for irrigation is increasingly under threat due to population growth and climate change, and, as such, there is an urgent need to identify cost-effective solutions to enhance agricultural water use productivity. Can you contribute to addressing this global societal challenge?

Typically, farmers' decisions about crop choice and irrigation management are based on past experience (e.g. previous year's weather) and/or highly simplified agro-climatic information (e.g. observations of current soil moisture). Recent research suggests that the provision of probabilistic weather forecast information can enable farmers to reduce irrigation water use and achieve higher profits than under conventional management practices (Hejazi et al., 2013; Mishra et al., 2013; Gunda et al., 2017). Yet, it remains unclear how the operational value derived from weather information is affected by the temporal scale (e.g. daily/weekly/seasonal) and skill (i.e. accuracy) of forecast products, along with farmers' behavioural responses to forecast uncertainty and production risks associated with inaccurate forecasts (Li et al., 2017).

Alongside forecast skill, the operational value of weather information for farmers also depends on their capacity to act on this new agro-climatic knowledge. Existing assessments of forecast value have commonly assumed that farmers have unlimited capacity to adjust irrigation and cropping decisions in response to weather forecast information. However, our recent research has shown that farmers often face significant physical and institutional constraints (e.g. low irrigation capacity, limited labour, energy supply interruptions) that restrict potential crop choices and irrigation scheduling decisions (Foster et al., 2014; Mieno et al., 2017). To what extent do these factors reduce the actual value that can be obtained by irrigated agriculture from weather forecasts? And how can forecasts products and weather information be adapted, and integrated with other datasets, to maximise yield and water productivity gains in the context of such constraints?

Project Summary:

The overall aim of the project is assess the operational value of weather and climate forecast information for optimizing use of limited water resources in irrigated agricultural systems. The project will have three core components, within which there will be significant scope for the successful candidate to tailor and adapt the research to their interests:

(1) Use of surveys and other primary data collection techniques to assess the structure and constraints underlying farmers' land and water use decision-making, and to what extent climate forecasts currently inform these choices. Data collection will focus on one or more specific case

studies, which will be selected collaboratively with the student and link with the supervisors' related ongoing research projects in Europe, North America, and/or South Asia.

(2) Development and calibration of crop growth (e.g. AquaCrop-OS – Foster et al., 2017) and farmer decision-making models to facilitate prediction of crop yields, irrigation water use, and farm profits as a function of weather and climate information provision.

(3) Numerical simulations using the developed models to quantify potential water savings and economic gains from alternative forecast products (e.g. ECMWF ensemble prediction system), and explore how value is affected by assumptions related to system constraints, farmers' risk attitudes, and availability of supplemental datasets (e.g. soil moisture monitoring).

The project would be well suited to a student with a quantitative background in a physical science or engineering discipline. Under the supervision of the expert project team, the student working on this cross-disciplinary project will gain a wide breath of training in meteorology, weather/climate services, agricultural production modelling, and natural resource economics. He/she will also benefit from unique opportunities to conduct research visits to world-leading partners in weather forecasting (ECMWF, UK) and agricultural water management (University of Nebraska-Lincoln, United States).

References

- Foster, T. et al. (2014). Modeling irrigation behavior in groundwater systems. *Water Resources Research* 50(8):6370-6389.
- Foster, T., et al. (2017). AquaCrop-OS: An open source version of FAO's crop water productivity model. *Agricultural Water Management* 181:18-22.
- Gunda, T., et al. (2017). Impact of seasonal forecast use on agricultural income in a system with varying crop costs and returns: an empirically-grounded simulation. *Environmental Research Letters* 12(3):034001.
- Hejazi, M.I., et al. (2013). Incorporating reanalysis-based short-term forecasts from a regional climate model in an irrigation scheduling optimization problem. *Journal of Water Resources Planning and Management* 140(5):699-713.
- Li, Y., et al. (2017). A coupled human-natural system to assess the operational value of weather and climate services for irrigated agriculture. *Hydrology and Earth System Sciences Discussions*, doi: 10.5194/hess-2017-304.
- Mieno, T., et al. (2017). Energy-water nexus in agriculture: The impact of energy supply interruption on groundwater use. *In preparation.*
- Mishra, A., et al. (2013). Short-term rainfall forecasts as a soft adaptation to climate change in irrigation