**Impacts of Large-scale Reforestation Programmes on Regional Climate Change: A Regional Climate Modelling Study on the Loess Plateau, China**

*Lang Wang*

July 2015

Department of Environmental Sciences, Macquarie University

**Abstract**

Reforestation has been considered as a strategy for alleviating diverse environmental degradation problems and mitigating anthropogenic global warming in recent years. The ‘Grain for Green Project’ in China is one of the key reforestation programmes that have been implemented in recent years. The primary goal of the project is to mitigate soil erosion problems across the Loess Plateau region through converting erodible crop lands into forests. The large changes from agricultural land to forest can modify important biophysical characteristics of the land surface, potentially resulting in climate change at a variety of spatial scales.

The Loess Plateau, located in the northern part of China, is considered one of the world’s most sensitive areas to global climate change. The plateau is located in the semi-arid transition zone and is characterized by complex topography. The extensive reforestation in the plateau would lead to further complex conditions in the local climate. The local climate is critical for the rain-fed agriculture and natural vegetation primarily through affecting the water availability in this semi-arid area. However, relatively few studies explicitly documented the potential climatic effects of reforestation over the Loess Plateau.

The primary aim of this research was to understand the local climate features and predict the potential impacts of the reforestation programme on the climate over the Loess Plateau. The Regional Climate Model version 4.3 (RegCM4.3) was applied based on its generally good performance. The model was firstly validated over the Loess Plateau region. The simulation overall represented the major climate features well, including surface temperature, precipitation and regional circulation features at the near-surface level over the Loess Plateau. However the model was found with pronounced cold biases during winter. Analyses indicated that biases were generally caused by the combined effects of deficiencies in interior dynamical processes of the model and were exaggerated by uncertainties among the observational datasets.

Secondly, the major sensitivities of RegCM4.3 in simulating the regional climate over the Loess Plateau were examined. A series of simulations using different configurations were applied to investigate the model sensitivity to several critical model parameterizations. Results showed that the model simulation was significantly sensitive to the convective scheme and the land surface model (LSM). In general, the Grell convection scheme with Fritsch-Chappell closure combined with the LSM of Biosphere Atmosphere Transfer Scheme (BATS) and the Emanuel convective scheme combined with the LSM of Community Land Model (CLM) generated the most accurate simulation among all the configurations. Meanwhile, using higher horizontal resolution of 20-km could also effectively improve the spatial representation of the surface variables compared with the 50-km resolution.

Finally, the two best configurations selected from the sensitivity study in simulating the regional climate were applied to predict the climate responses to reforestation over the Loess Plateau. The conversion from agricultural land to forest led to pronounced changes in the local climate according to the BATS simulations, but only moderate changes in the CLM experiments. When the BATS was used, the surface temperature increased and precipitation decreased significantly during both summer and winter seasons. These patterns were particularly evident over the southeast of the plateau. In contrast, in the CLM simulations reforestation generally produced a warmer winter, as well as a cooler and more humid summer. The opposite climate responses to the same land change scenario were primarily caused by the different representation of the irrigated crop in the two LSMs. Furthermore, changes in surface albedo, evapotranspiration, and roughness length from agricultural land to forest also played important roles in the climate responses to reforestation.

Beyond the main aim, this study improved on past studies by providing regional model simulation guidance regarding the performance in such climate transitional zones with very complex topography. This study has also revealed the model’s strengths and weaknesses, and identified the key mechanisms that drove the simulated biases, which could help to explore future modelling efforts to produce more accurate climate information. The opposite climate responses to reforestation between two LSMs highlight the need for better descriptions of land surface characteristics in climate models in order to enable the reliable prediction of climate responses to land surface change. This study is a part of the efforts in improving our understanding of the local climate over the Loess Plateau, which could provide important references for future reforestation strategies and help reducing economic and ecological losses.