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The impact of afforestation on projected climate in Australia during the 21st Century

J. Chu

School of Geography, Planning and Environmental Management, The University of Queensland, Brisbane, Australia (jiantingchu@gmail.com)

Forests play significant role in adjusting climate variability, sustaining hydrological balance, and in conserving biodiversity. Deforestation, with different spatial-temporal scales, has evident influence in mean climate, as well as extreme events. The potential of reforestation in mitigating global warming trend has also been in focus. In this paper, we design different scenarios in woody vegetation fraction in the CSIRO variable resolution Conformal-Cubic Atmospheric Model (CCAM) to investigate the climate responses under different Representative Concentration Pathways (RCPs) forcing scenarios.

The first step is to accurately represent key land surface characteristics in the climate model. We evaluated two datasets currently used in CCAM, i.e. vegetation cover and Leaf Area Index (LAI). The vegetation cover in CCAM is derived from the IGBP (International Geosphere-Biosphere Programme) dataset during 1990's, which does not capture recent modification, clearing, or regrowth of forest in eastern Australia. In order to addressing this problem, we firstly selected and normalized high-resolution land cover maps in Australia, resampled them according to IGBP rule, and then, aggregated them together to reflect the current forestation, cropping, urbanization condition, etc. The global LAI currently in CCAM is based on the MODIS Collection 4 product, and improved by the Boston University and CSIRO. This dataset has low accuracy for semi-arid regions, and does not capture the recent clearing of native vegetation. Therefore, we compared it with other two LAI sources. The one is used in the Community Land Model (CLM), the other is developed by Beijing Normal University (BNU). BNU dataset is derived from MODIS C5 production, captures LAI for the period 2000-2009, and we found this dataset performs better than the CCAM or CLM. So, we updated the global seasonal LAIs in CCAM with BNU dataset. The impact of these updated datasets in Australia is evaluated in the CCAM simulations for selected climate variables.

The second step is to design reasonable re-vegetation scenarios. For this step, we employ parallel sensitivity experiments with different incremental changes of vegetation fraction in CCAM model under CMIP5 Representative Concentration Pathways (RCPs) forcing datasets. The purpose of these experiments is to determine suitable criteria values in spatial-temporal extents of re-vegetation to produce statistically significant impacts on mean climate and extreme indices. This study can provide clue to reasonable forest ecosystem management behaviour under future climate projections in 21st Century.