Geophysical Research Abstracts
Vol. 17, EGU2015-8903, 2015
EGU General Assembly 2015

Cooling biogeophysical effect of large-scale tropical deforestation in three Earth System models

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Vegetation cover in the tropics is limited by moisture availability. Since transpiration from forests is much greater than from grasslands, the sensitivity of precipitation in the Amazon to large-scale deforestation has long been seen as a critical parameter of climate-vegetation interactions. Most Amazon deforestation experiments to date have been performed with interactive land-atmosphere models but prescribed sea surface temperatures (SSTs). They reveal a strong reduction in evapotranspiration and precipitation, and an increase in global air surface temperature due to reduced latent heat flux. We performed large-scale tropical deforestation experiments with three Earth system models (ESMs) including interactive ocean models, which participated in the FP7 project EMBRACE. In response to tropical deforestation, all models simulate a significant reduction in tropical precipitation, similar to the experiments with prescribed SSTs. However, all three models suggest that the response of global temperature to the deforestation is a cooling or no change, differing from the result of a global warming in prescribed SSTs runs. Presumably, changes in the hydrological cycle and in the water vapor feedback due to deforestation operate in the direction of a global cooling. In addition, one of the models simulates a local cooling over the deforested tropical region. This is opposite to the local warming in the other models. This suggests that the balance between warming due to latent heat flux decrease and cooling due to albedo increase is rather subtle and model-dependent. Last but not least, we suggest using large-scale deforestation as a standard biogeophysical experiment for model intercomparison, for example, within the CMIP6 framework.