Geophysical Research Abstracts
Vol. 13, EGU2011-11321, 2011
EGU General Assembly 2011
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What do moisture recycling estimates tell? Lessons from an extreme global land-cover change model experiment

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Moisture evaporated from the continents (recycled moisture) contributes up to 80% to total atmospheric moisture and, hence, precipitation in some regions. The recycled moisture fraction (RMF) is sometimes used to indicate a region's rainfall-dependence on upstream land-surface evaporation. Accordingly, the RMF is used to quantify the hydrological consequences of land-cover change. However, moisture is not a passive but an active tracer in the atmosphere. Hence, the value of the RMF as indicator for consequences of land-cover change is unclear.

To explore the predictive value of the RMF regarding land-cover change, we conduct two global experiments with an atmospheric general circulation model: (I) with present-day conditions and (II) with extreme land-cover change conditions, namely with totally suppressed continental evaporation. Using the simulated fields of moisture, wind, and evaporation from the present-day experiment, we compute continental RMFs with a vertically integrating tracing scheme. We then compare the computed RMF patterns with the hydrological changes that follow the suppression of continental evaporation.

While the RMF increases from continental upstream to downstream regions with respect to the prevailing winds, almost all continental regions experience severe (often total) precipitation loss, no matter if situated upstream or downstream. The strong warming of the continents due to the absence of latent cooling at the surface reaches far into the troposphere, particularly in the extratropics. This warming effectively suppresses precipitation.

Our results demonstrate that the predictive value of the RMF regarding the hydrological consequences of land-cover change is questionable because of the active role of moisture in the atmosphere. With some caution we expect that this finding can be transferred to more realistic land-cover change scenarios that are less extreme in the spatial extent and/or in the degree of evaporation reduction. Our results suggest that land-cover change affects on-site precipitation rather than downstream precipitation.