Effects of vegetation dynamics on evapotranspiration and soil moisture in northwestern Mexico
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Summary
Most land surface models use a fixed seasonal vegetation cycle and are unable to fully capture the spatiotemporal changes in vegetation in northwestern Mexico, a region characterized by an abrupt increase in rainfall and ecosystem green-up during the North American monsoon (NAM). In this study, time-varying leaf area index (LAI) and a fixed seasonal LAI cycle, both inferred from the Moderate Resolution Imaging Spectroradiometer (MODIS), were compared as inputs to the Variable Infiltration Capacity (VIC) model over northwestern Mexico during 2001-2008. Model results for the two sets of simulations were compared with latent heat fluxes observed by two eddy covariance tower sites for three summer periods. The results show that both vegetation greening onset and dormancy dates vary substantially from year to year with a range of more than half a month. Using the fixed season LAI cycle, the model tends to under- (over-) estimate evapotranspiration (ET) and over- (under-) soil moisture (SM) when vegetation greening occurs earlier (later) than the mean greening onset date. The discrepancies in ET were large, especially during a period of approximately two week at the beginning of the monsoon. The effect of vegetation dynamics on ET estimates was about 10% in the Sierra Madre Occidental (SMO) and 30% in the continental interior east of the mountain range.

Study Area

Monsoon precipitation onset date, vegetation greening onset date, and vegetation dormancy date from 2001 to 2008 for the nine sub-domains, arranged from north (left) to south (right). The bars indicate the standard deviations of the dates. The greening onset date varies substantially from year to year, with a larger range of dates in the south (about one month) as compared to the north (about half a month). The range of the dormancy date is larger in the north (about one month) than in the south (about half a month).

Vegetation Greening

Rapid vegetation greening during NAM

Before vegetation green-up

After vegetation green-up

MODIS LAI variations

Vegetation greening results

Comparisons of simulated and observed ET and SM at the Rayon site during DOY 199-290 in 2004, 194-227 in 2006 and 192-240 in 2007 (upper three panels); and the Tesopaco site during DOY 192-275 in 2004, 151-274 in 2005 and 151-275 in 2006 (lower three panels). SM was normalized and scaled to [0, 1]. Shown are daily ET estimates (ET_D) and SM estimates (SM_D) using the time-varying LAI (LAI_D); and ET estimates (ET_F) and SM estimates (SM_F) using the fixed seasonal cycle of LAI (LAI_F).

Conclusions

The VIC model with a fixed seasonal cycle of LAI tends to under- (over-) estimate ET when the vegetation greening comes earlier (later) than the mean greening date. The VIC model with fixed seasonal cycle of LAI could induce about 10% bias in ET estimation at the western slopes of the SMO and about 30% bias in ET estimation in the interior continental regions east of the SMO.

References
Tang et al., Links between vegetation, evapotranspiration and soil moisture in northwestern Mexico during the North American monsoon, Journal of Climate (submitted).

Results

Comparisons of the 8-day ET estimates (ET_D) using the time-varying LAI (LAI_D) and ET estimates (ET_F) using the fixed seasonal cycle of LAI (LAI_F) from June to September of 2001-2008 for the sub-domains S0A and B0C.