Vegetation Phenology and the Hydrological Cycle of Monsoons

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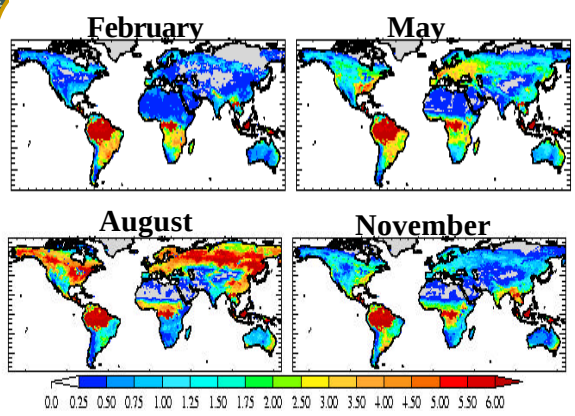


Fig. 1 Climatological seasonal cycle of Leaf Area Index (LAI) from 9-yr ISLSCP II dataset.

Introduction

It is well known that climate and weather affect the distribution and growth of vegetation. Conversely, vegetation can influence climate through exchanges of moisture, energy, and momentum between the land surface and the atmosphere.

In this study, we make use of satellite estimates of vegetation properties (leaf area index) to **prescribe a seasonal cycle of vegetation**. The sensitivity of the Met Office Unified Model to such a forcing is investigated, particularly with respect to impacts on the hydrological cycle of seasonally arid monsoon regions.

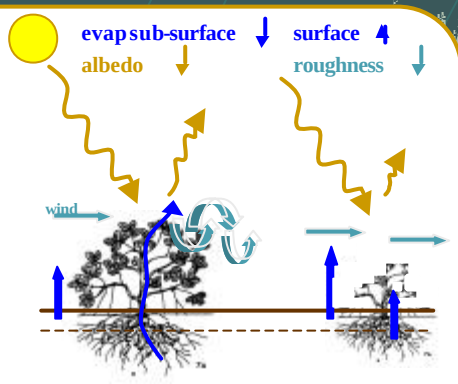
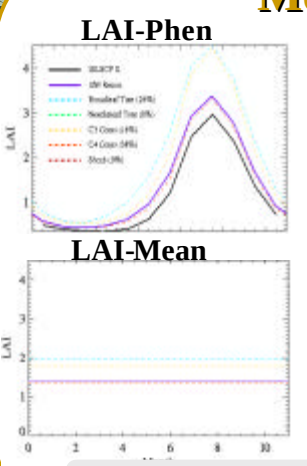


Fig. 2 Schematic of processes through which a vegetation seasonal cycle can influence climate.

Model Runs



- HADAM3 with MOSES 2 (Met Office Surface Exchange Scheme) and climatological SSTs
- LAI prescribed -
  - **LAI-Phen**: LAI varies across season
  - **LAI-Mean**: LAI set to annual mean value
- LAI controls **canopy height**, **surface roughness**, **surface albedo**, and **canopy water capacity** in model

Fig. 3 LAI for each plant functional type for LAI-Phen and LAI-Mean experiments..

Area of Sensitivity

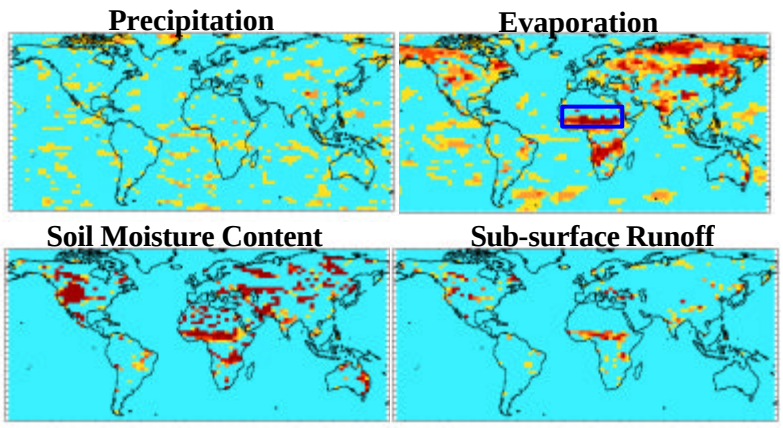


Fig. 4 Number of months per year when variable in LAI-Phen run is statistically different from LAI-Mean run. One month per year (yellow), three months (orange), five or more months (red).

Hydrological Cycle

Precip. **13 mm yr^{-1} (3%)**

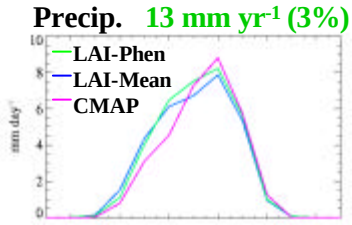
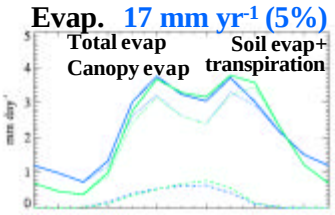
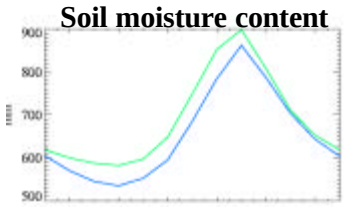


Fig. 5 Comparison of hydrological cycle in West African monsoon region for LAI-Phen and LAI-Mean experiments.

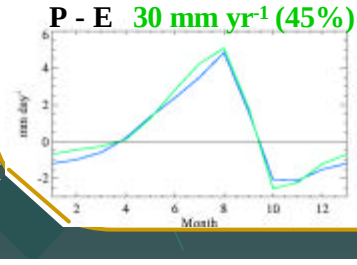
Evap. **17 mm yr^{-1} (5%)**



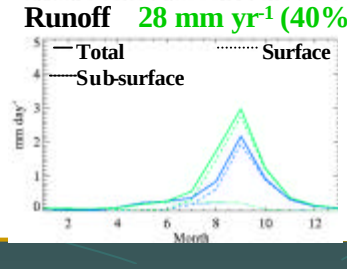
Soil moisture content



P - E **30 mm yr^{-1} (45%)**



Runoff **28 mm yr^{-1} (40%)**



Summary

- **Soil moisture content**, **evaporation**, and **sub-surface runoff** show strong sensitivity to incorporation of vegetation phenology, particularly in seasonally arid regions. The impact on precipitation is minimal.
- In the West African monsoon region, **reduced evaporation in spring**, when LAI is low and therefore **access to sub-surface moisture stores is restricted**, leads to an **increase in total soil moisture content**. The soil moisture increase is sustained until the end of the monsoon season, leading to enhanced sub-surface autumn runoff.

$P = E_s + E_v + E_c + R + dM/dt$ Surface water balance

P = Precipitation

E_s = Soil evaporation E_v = Transpiration E_c = Canopy evaporation

R = Runoff dM/dt = Change in soil moisture storage