14-16 November 2023 – Latresne (33)

XIIIth STICS users seminar

BOOK OF ABSTRACTS

Modelling albedo and the energy budget using the STICS soil-crop model – Application to two Sub-Saharan sites

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Keywords: Biophysical effect, Energy partionning, Albedo, land management, conservation agriculture, modelling, STICS, energy budget

Introduction

Climate impacts of agricultural management practices such as mulching and no-tillage are usually evaluated with regard to soil organic carbon stock changes or greenhouse emissions. However, albedo effects of these practices that have been found to be of similar importance for climate change mitigation are usually ignored in this kind of assessment. This is even true for agricultural systems in Africa, which are less studied than temperate systems. In this study, we aim to assess the effect of land management on albedo dynamics and Radiative Forcing (i.e. climatic impact) in two long-term experiments established in Zimbabwe in 2013 with contrasting soil types. The Radiative Forcing (RF), is a metric used to quantify the change in Earth energy budget (radiation absorbed and emitted by the Earth) relative to an assumed default state (Betts 2000; Forster et al. 2007). The albedo of a cropland depends on soil properties, surface rugosity, soil moisture and coverage by plant litter, but also on plant density, phenology, architecture and spectral properties. Note that the latter may change for instance with phenology. The RFs resulting from land management changes are determined by their effects on the surface albedo dynamics but also by the solar radiation and atmospheric transmittance dynamics. Using a soil-crop model such as STICS coupled with a spatialization method that allows to represent changes in vegetation and soil properties is a promising solution to upscale RF related to albedo effects associated to land management changes at regional to global scales.

1. Modelling albedo using STICS

Surface albedo is the fraction of solar radiation reflected by Earth surface back to the space. Currently, STICS estimates surface albedo as a function of soil and vegetation albedo (Brisson et al., 2008). Soil albedo is a function of soil colour and moisture and also depends on the presence of mulch at the surface. Current formalism considers total leaf area index (LAI) , i.e. green and yellow parts taken together while field measurements suggest that albedo decreases with senescence leaves (Diop 2023). In this study, yellow LAI is introduced into the vegetation albedo equation in order to simulate the decrease during senescence.

2. Assessment of the energy budget components using STICS

Net radiation (RN) is simulated by STICS considering surface albedo and longwave radiations. Latent heat fluxes (LE) are estimated through the simulation of evapotranspiration but the current formalism of STICS to simulate soil evaporation is not relevant for sub-Saharan Africa. Therefore, this study will also try to improve the soil evaporation module based on field measurements in order to improve the estimates of albedo (that varies with soil superficial humidity) and the other components of the energy budget (i.e. ground heat flux sensible heat flux).

References

Betts, Richard A. 2000. « Offset of the Potential Carbon Sink from Boreal Forestation by Decreases in Surface Albedo ». *Nature* 408 (6809): 187-90. https://doi.org/10.1038/35041545.

Brisson, Nadine, Marie Launay, Bruno Mary, et Nicolas Beaudoin. 2008. « Conceptual Basis, Formalisations and Parameterization of the STICS Crop Model », 301.

Diop, Souleymane. 2023. « Four-Component Net Radiometers to Quantify Albedo and Heat Fluxes in Conservation Agriculture ». *Nature Reviews Earth & Environment*, avril. https://doi.org/10.1038/s43017-023-00432-x.

Forster, Piers, Venkatachalam Ramaswamy, Paulo Artaxo, Terje Berntsen, Richard Betts, David W Fahey, James Haywood, et al. 2007. « Changes in Atmospheric Constituents and in Radiative Forcing », 106.