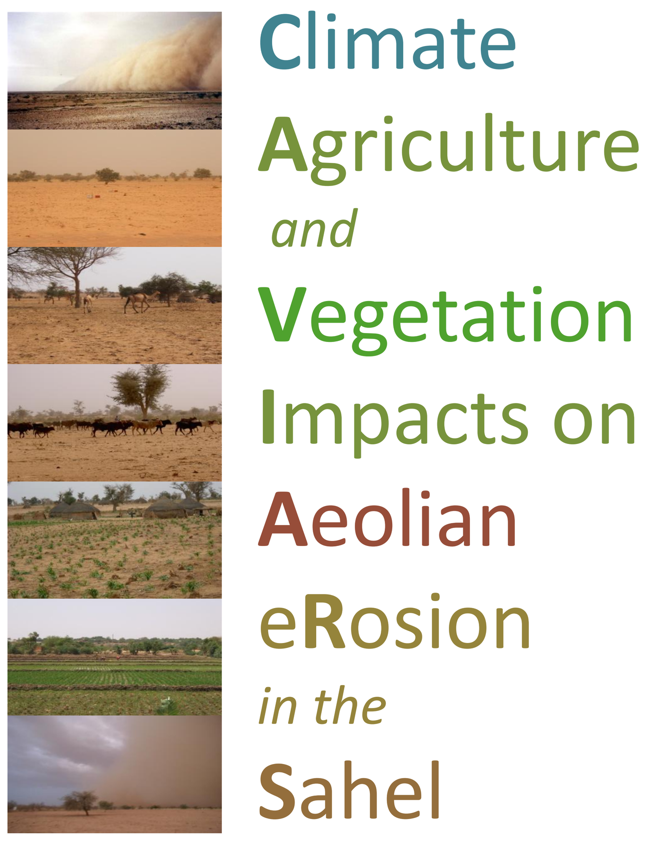


IMPACT OF CLIMATE, VEGETATION AND AGRICULTURE IN THE SAHEL IN THE RECENT PAST: THE CAVIARS PROJECT

Marticorena B.[1], Abdourhamane Touré A.[6], Baron C.[4], Bergametti G.[1], Bouet C.[1,2], Bouniol D.[5], Campos A.[1], Couvreux F.[5], Dardel C.[3], Guichard F.[5], Grippa M.[3], Hiernaux P.[3], Kergoat L.[3], Largeron Y.[5], Lebel T.[7], Mougin E.[3], Pennanech C.[1], Pierre C.[3], Quantin G.[7], Rajot J.L.[1,2], Siour G.[1], Tidjani A.D.[6], Valentin C.[2], Vischel T.[7]

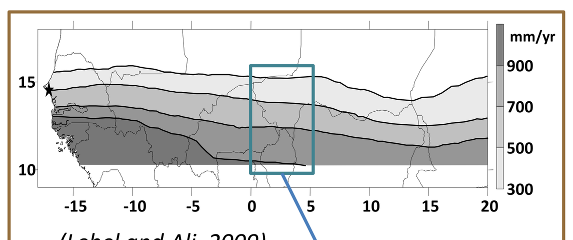
[1] LISA, UMR CNRS 7583, UPEC, UPD, IPSL, Créteil, France; [2] iEES-Paris, UMR IRD 242, Bondy, France; [3] GET, UMR CNRS 5563, Toulouse, France; [4] CIRAD, Montpellier, France; [5]CNRM-GAME, UMR CNRS 3589, Météo-France, Toulouse, France; [6]JEAI ADE, Université Abdou Moumouni, Niamey, Niger ; [7]LTHE, UMR CNRS 5564, Grenoble, France.

CAVIARS *is funded by the Agence Nationale de la Recherche* ANR *(ANR-12-SENV-0007-01)*

1. RATIONALE

Sahel

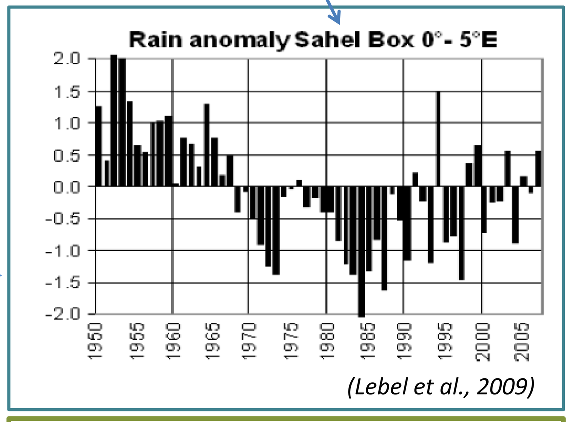
The Sahel is defined as the region located south of the Sahara desert between the isohyets 100 and 600 mm/yr, i.e. at the transition between arid and semi-arid climates.



(Lebel and Ali, 2009)

Climate

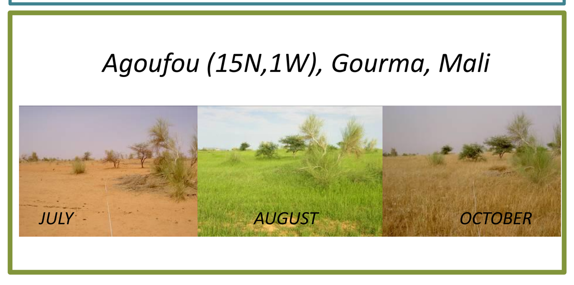
Precipitations in this region exhibit a strong variability with favorable conditions from 1950 to 1960 and severe droughts from 1970 to 1985.



(Lebel et al., 2009)

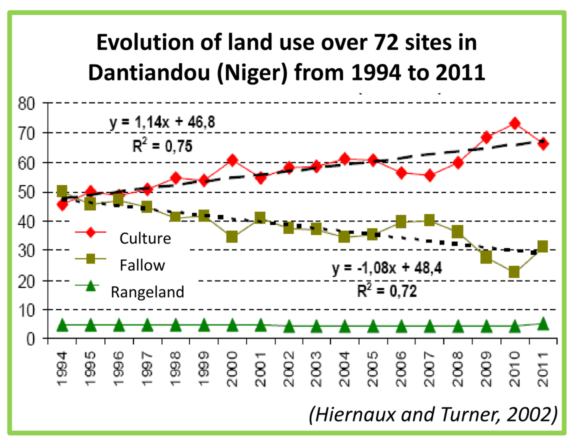
Vegetation

Vegetation is mainly herbaceous with a few bushes and trees. Vegetation cover is low with a strong seasonal dynamics induced by the monsonal precipitation regime.



Agriculture

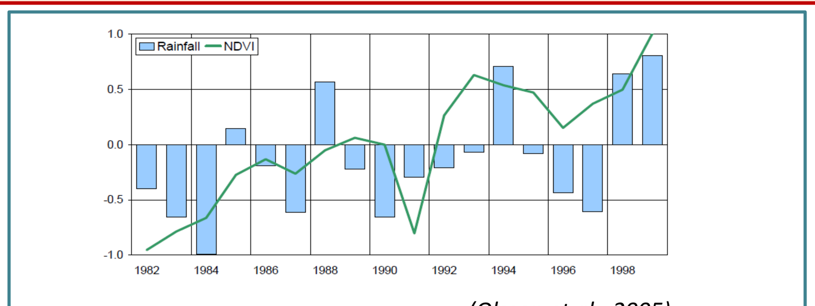
In response to the increase of population, an increasing fraction of natural and pastured lands are turned to cultivated fields.



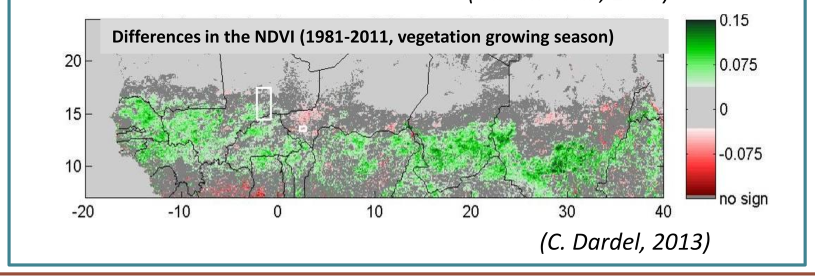
(Hiernaux and Turner, 2002)

Vegetation *and* Climate

The variability of precipitations induces a decrease in vegetation cover during the drought periods and a « re-greening » observed today by satellite and confirmed by field measurements.



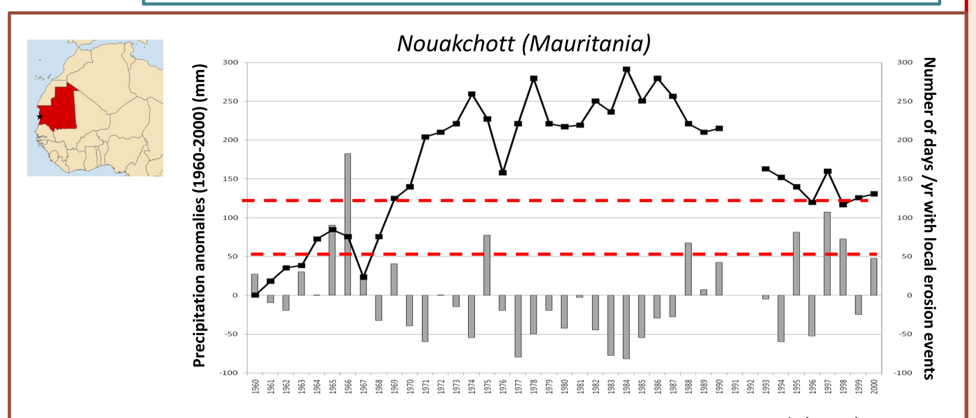
(Olsson et al., 2005)



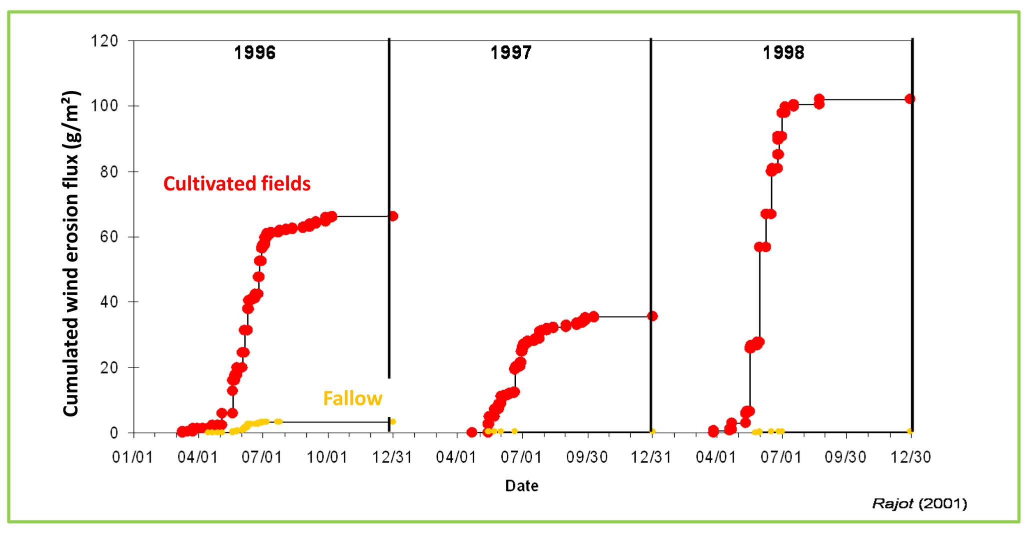
(C. Dardel, 2013)

Climate *and* Aeolian eRosion

Strong increases in aeolian activity have been recorded in phase with the precipitations variability and in particular during the drought periods. The recent aeolian activity remains higher than before the drought periods.



From Dumay et al. (2002)



Rajot (2001)

Agriculture *and* Aeolian eRosion

Today, wind erosion(at ~14N) is recorded almost only on cultivated fields, that are left bare before the rainy season, and is mainly due to the strong wind speeds associated to mesoscale convective events.

2. Objective and Strategy

The objective is to describe the evolution of aeolian erosion in the Sahel as a function of climate and land use changes during the recent past (~ last 50 yrs).

Strategy :

(1) Development of an integrated modeling tool quantifying the impact of the different elements (land use; aridity; wind regime …) responsible for the variations of the intensity of aeolian erosion in the region, based on state-of-the-art models of wind erosion and vegetation (Dust Production Model; STEP Sahelian vegetation model; SARRA-H crop model).

(2) Application to the present period where large amounts of data on climate, vegetation and erosion are available over West Africa for its validation.

(3) Evaluation of the capability of this modeling approach to reproduce changes in erosion activity recorded for contrasted climatic and different land use conditions.

Bottlenecks:

(1) Improving the parameterization of the wind erosion threshold and fluxes over cultivated Sahelian fields and rangelands.

(2) Including the representation of dry vegetation (litter and straws) in the vegetation and crop models.

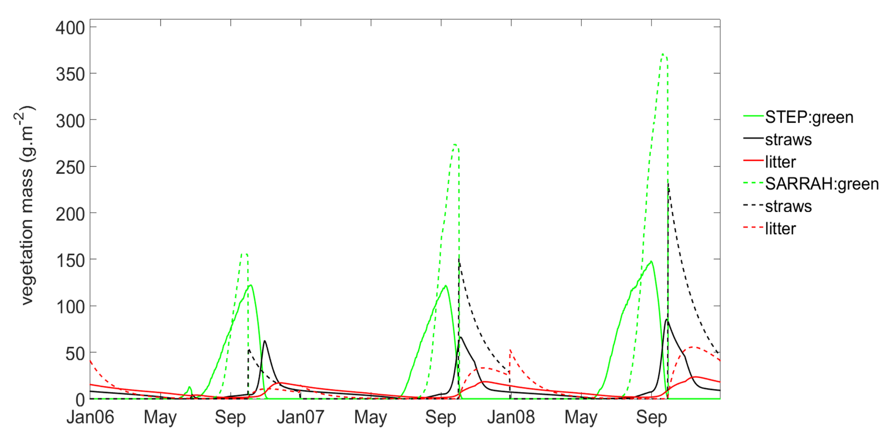
(3) Representing the strong surface wind speeds associated with convection in the wet season that are responsible for most of the present wind erosion.

(4) Representing realistic evolution of land-use and agricultural practices

3. Simulations at the local scale

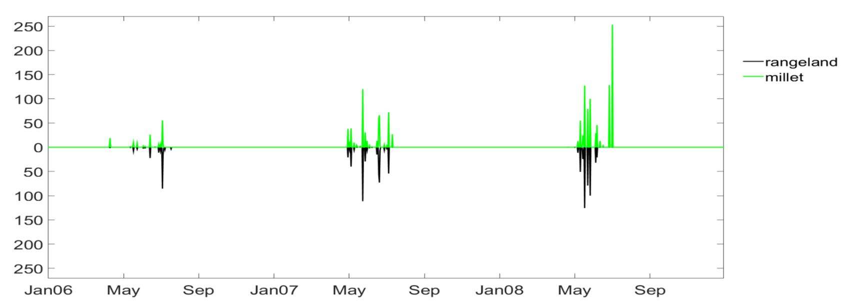
Modeling vegetation dynamics

The dynamics of the natural vegetation and of a cultivated millet field was simulated with the STEP and SARRA-H models, modified to simulate both the green and dry vegetation (straws and litter), over a 3 years period for two sites in Mali and Niger where meteorological forcing parameters (Precipitations,T°,etc ..) were measured.



Simulation of the erosion fluxes

The simulated vegetation cover and height are used to estimate the erosion threshold (Pierre et al., *2014a, 2014b*) and the erosion fluxes as a function of the measured wind speed (Pierre et al., *submitted*).



	2006	2007	2008
Précipitations (mm.yr^{-1})	376	287	227
Erosion flux (kg.m^{-2}. yr^{-1})			
Millet field	413	308	1152
Natural vegetation	89	229	985
Ratio cultivated/natural	4,64	1,34	1,17

The simulated erosion fluxes are in agreement with the ones measured in Niger. They are always higher on the cultivated field than on natural vegetation, but the difference depends on precipitations (Pierre et al., *submitted*).

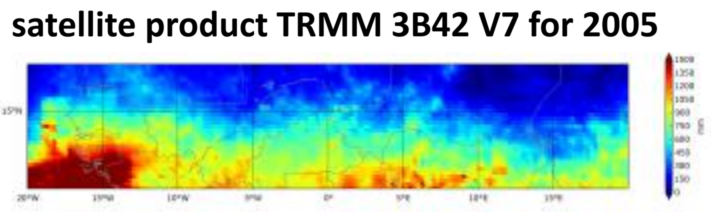
4. Regional simulations

A key issue is to collect and/or produce high quality data to be used as input of the models

Precipitations fields

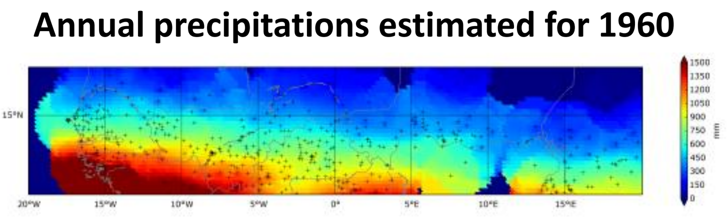
For the recent period, satellite products evaluated over the Sahelian region have been used to force the vegetation simulations.

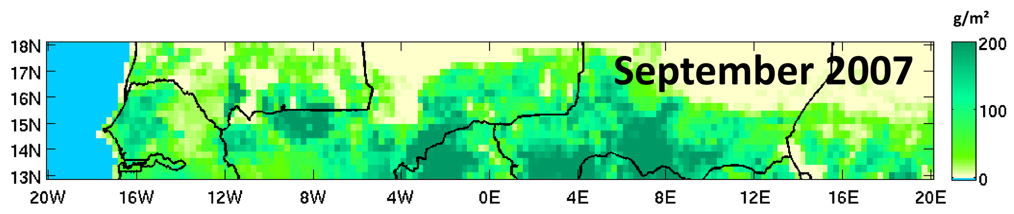
Annual precipitations estimated from the satellite product TRMM 3B42 V7 for 2005

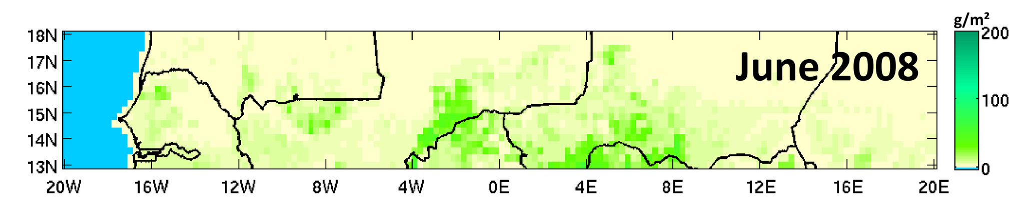


For the past periods, precipitations fields have been produced by a statistical approach based on measurements from local rain gauge network.

Annual precipitations estimated for 1960





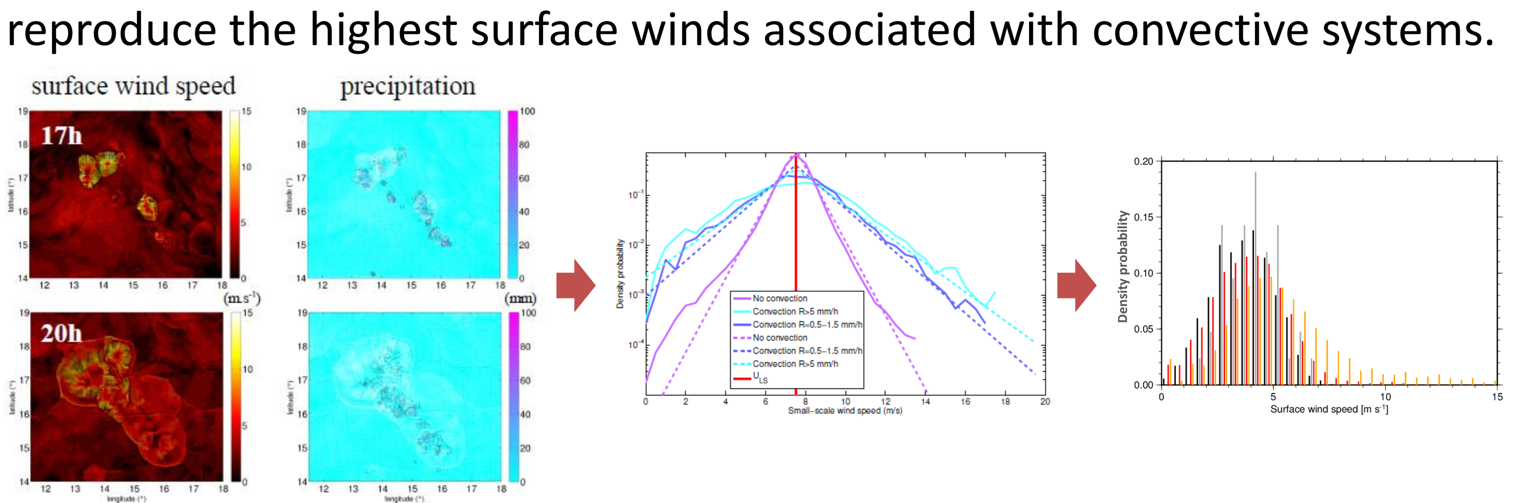


Natural vegetation simulations

The STEP model forced with the satellite precipitations products have been used to simulate natural vegetation over the Sahel. At the maximum of vegetation, most of the region is protected against wind erosion for the present day precipitation conditions. Before the following wet season (June), dry vegetation resulting from the degradation of the green vegetation from the previous year is a key factor for inhibiting aeolian erosion due to convective activity.

Surface wind speed

Surface wind fields provided by global meteorological models suffer from significant bias in the Sahel when compared to local observations at the seasonal and daily scales (Largeron et al., *GRL*, 2015). They don't reproduce the highest surface winds associated with convective systems.



A parameterization have been developed to describe the distribution of the surface wind speeds in high resolution simulations (CASCADE; 12 to 4 km; coll. Univ. Leeds, UK) for both non-convective and convective situations as a function of mean wind speed and precipitations rates.

ON GOING: the next step is to combine natural vegetation and cultivated fields and to simulate wind erosion fluxes