# Sahel drought and global climate change

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***Résumé française : Sécheresse au Sahel et changement climatique global***
*Cette note vise à clarifier le rôle du climat dans le changement environnemental, notamment la désertification, en reprenant les conclusions des études récentes. Celles-ci établissent la responsabilité des changements globaux des températures de surface de l'eau dans la sécheresse, longtemps attribuée au contraire à l'impact de l'action humaine sur l'environnement et notamment la réduction de la couverture végétale. Les modèles explicatifs alternatifs n'ont émergé que récemment, avec des simulations capables de reproduire les variations climatiques. Ils démontrent le lien entre la sécheresse au Sahel et le réchauffement des océans tropicaux. Mais ils posent également de nouvelles questions : la sécheresse était-elle due à des émissions de gaz à effet de serre et risque-t-elle de persister dans le futur ? Sur ce dernier point, les avis restent partagés, car on observe d'une part un relèvement pluviométrique mais d'autre part un risque lié à l'actuel réchauffement océanique global.*

The persistence of drought in the Sahel in the 1970s and 1980s was caused by variations in global sea surface temperature, not by regional environmental mismanagement. To what extent these oceanic variations are related to anthropogenic emissions of greenhouse gases and aerosols is the focus of current climate research. The mechanisms of change, recent past and future alike, are still debated, hence the uncertainty in regional climate change projections.

The objective of this note is to clarify the contribution of climate as a driver of environmental change - specifically desertification - in the Sahel. It summarizes conclusions from a recent series of studies which identified the cause of persistent drought in global-scale changes at the oceans' surface.

The issue of desertification has its origin in the Sahel drought of the 1970s and 1980s. Until recently, the accepted explanation for the persistence of drought in this region involved human impact on the environment. It was hypothesized that the change in land surface properties caused by mismanagement of natural resources, especially the reduction in vegetation cover, had sparked an irreversible change in the regional climate system. Land denudation translated into an increase in the albedo, or reflectivity of the Earth's surface, to which the atmosphere responded with subsidence, or downward motion of air parcels, to close the atmospheric energy budget. Since

downward motion of air parcels counteracts the upward motion that produces rainfall, this response results in a reinforcing *biogeophysical feedback'* (Charney 1975) - a human-induced reduction in vegetation cover leads to reduced rainfall, which further reduces vegetation naturally -leading to drought persistence.

Observational and modeling studies that supported an alternative explanation - that the cause of drought lay in global-scale changes in the patterns of sea surface temperatures (SST), e.g. Folland et al (1986) - failed to gather the same recognition, possibly because modeling results could not always be reproduced. However, in recent years, many studies with state-of-the-art climate models (Giannini et al 2003; Bader and Latif 2003; Lu and Delworth 2005; Tippett 2006) have consistently shown that these models are capable of reproducing the shift to persistent drought. Simulations with atmosphere-only models driven solely by the history of 20th century SST reproduce the recent drying of the Sahel. Simulations with coupled ocean-atmosphere models driven by the history of 20th century climate forcings, both anthropogenic and natural - i.e. emissions of greenhouse gases and aerosols on one hand, solar variability and volcanic eruptions on the other - also reproduce a late-20th century drying of the Sahel (Biasutti and Giannini 2006; Held et al 2005).

Drought in the Sahel, in observations and in simulations, is related to a generalized pattern of warming of the global tropical oceans, especially prominent in the Indian Ocean (Giannini et al. 2003; Bader and Latif 2003; Lu and Delworth 2005), combined with enhanced warming of the southern compared to the northern oceans (Hoerling et al 2006; Folland et al. 1986; Rotstayn and Lohmann 2002). This state of affairs naturally begs the questions:

- *Was the recent persistent drought in the Sahel anthropogenic?*

where *anthropogenic* here refers not to regional mismanagement of natural resources, but to global emissions of greenhouse gases and aerosols, mainly from industrialization.

- *Is drought likely to persist in the future?*

These questions are the focus of current research. There are sensible reasons to argue either way, given the uncertainty in regional climate change projections (Christensen et al 2007). Because it is well known that the Sahel is a region subject to large climatic fluctuations on decadal to centennial time scales, and because the rains have recovered since the mid-1980s (Nicholson 2005), it can be argued that the shift to dry conditions the 1970s and 1980s is within the bounds of natural variability, and that the future is in the recent upward trend. However, the association between warming of the global tropical oceans and drying of the Sahel should not be discounted, as continued warming is projected by climate change scenarios - advocating the necessity to refine our dynamical explanations to support projections of climate change for tropical regions.

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