DOES CLIMATE CHANGE CONTROL LAND DEGRADATION IN THE SAHEL?

R. Fensholt[1], K. Rasmussen[1] and C. Mbow[2]

[1]Department of Geography and Geology, University of Copenhagen, 1350 Copenhagen, Denmark (rf@geo.ku.dk)

[2]Laboratoire d'Enseignement et de Recherche en Géomatique, Ecole Supérieure Polytechnique, Université Cheikh Anta Diop de Dakar, BP 25275 Dakar-Fann, Senegal

Abstract

Since the 1930's it has been discussed whether climate change /variability or human (mis-) management have been the main cause of the land degradation (and/or the reverse) in the semi-arid Sahel zone. This discussion has intensified since the great drought in the 1970's and 80's. The understanding of the causal mechanisms of change in Net Primary Productivity (NPP) of the vegetation cover, and in particular the relative weight of bio-physical and human factors, is critical in relation to developing adaptation strategies in relation to future climate change. The objective of this study is to contribute to resolving this question. Satellite data have opened up opportunities for continuous monitoring of NPP, which may be considered the most central indicator of land degradation. Data from the AVHRR (Advanced Very High Resolution Radiometer) sensor onboard the NOAA-series of satellites allow analysis of the development, since 1982, of 'vegetation greenness', which may serve as a proxy for NPP.

Based on time series trend analysis of the AVHRR GIMMS (Global Inventory Modelling and Mapping Studies) 8 km resolution NDVI (Normalized Difference vegetation Index) it is shown that, contrary to much of the standard rhetoric, a significant 'greening' of the Sahel has taken place since the start of the monitoring in 1982. This may be considered a partly recovery after the reduction in NPP associated with the drought period. In addition, newer sources of satellite images, such as data from the MODIS sensor onboard the Terra/Aqua satellites; provide better calibrated time-series with a higher spatial resolution (250 meter spatial resolution), yet only for the period 2000 to date. Time series trend analysis of the finer spatial resolution MODIS data allows analysis of a more precise relationship between human activities, such as changes in land use, and trends in NPP.

Using MODIS and AVHRR data as input for NPP estimates we will attempt to resolve the question of causality in two ways: Firstly, we will estimate trends in the 'rain use efficiency' (RUE), defined as the ratio of NPP to annual rainfall, suggested as an indicator of the non-rainfall controlled variations in NPP. Different continental scale rainfall products are used for the RUE calculation including the 0.1 degree spatial resolution rainfall estimates (RFE), produced by NOAA/CPC (Climate Prediction Center) from 1996 to present and rainfall data from the Global Precipitation Climatology Project (GPCP), 2.5-degree global grid from 1979 to the present. Assuming that NPP is proportional to annual rainfall in a semi-arid area such as the Sahel, any change of RUE in a semi-arid area should be attributable other factors, among which the human factors may play a significant role. The results of the 'time domain' part of the analysis, based on the NOAA AVHRR GIMMS data set, show that while vegetation greenness, and thus presumably NPP, has increased substantially over the period 1982 to date, changes in RUE are less consistent and generally negative. However, different rainfall data sets give significantly different results, and no firm conclusions may be drawn. Secondly, the spatial patterns of NPP trends may be expected to reflect spatial patterns of the driving forces behind the trends. Since human and climatic factors have widely different spatial statistics, this may be used as a means of identifying the most likely causal relations. With respect to the analysis in the combined temporal-spatial domain, using MODIS 250 meter resolution data from 2000 to date, it is shown that in the northern part of the Sahel most of the change observed seems to be climate related, while in the southern part NPP change is to some extent land use related. This is quantified by performing semi-variogram analysis of the trend maps produced from linear least square regression trend analysis.