Monitoring System for Assessment of Vegetation Sensitivity to El-Niño over Africa

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Abstract. The study investigated vulnerability of vegetation to El-Niño Southern Oscillation (ENSO) over Africa by correlating Normalized Difference Vegetation Index (NDVI) data from the Advanced Very High Resolution Radiometer (AVHRR) and two ENSO indices, namely Multivariate ENSO Index (MEI) and Southern Oscillation Index (SOI). The study developed a new monitoring approach (ENSO vulnerability assessment system) that examined and quantified associations between monthly maximum NDVI anomalies and month-to-month correlations with the ENSO indices over the vegetated land areas of Africa throughout the period from 1982 to 2006 at the pixel scale. This system was engaged for an assessment of the long-time vegetation sensitivity to ENSO warm events occurred during the study period. A map of vegetation vulnerability to ENSO was produced. Areas with various vulnerability degrees were measured within main vegetation cover classes. The results suggested that the vulnerability of vegetated tropical land surfaces to climate extremes like EL Nino depends considerably on vegetation type. In particular, it could be shown that equatorial forest areas are more reliable to drought stress than other wooded and non-wooded vegetation categories.

1 Introduction

Global climate anomalies linked to El Niño-Southern Oscillation (ENSO) leading to a redistribution of precipitation and temperature patterns on the Earth surface are one of the major topics of scientific investigation (IPCC, 2007; Chattopadhyay and Bhatla, 1993; Fuller and Murphy, 2006). It is a coupled atmospheric and oceanic mechanism responsible for changes in
the Walker circulation system that in turn affects the global atmospheric circulation and, therefore, the weather and climate in other parts of the world (Hoerling and Kumar, 1997; Fox, 2000). The recurrence of this phenomenon with a periodicity of 2 to 7 years has enormous social, economic and ecological impacts worldwide (Glantz, 1996). Africa belongs to the most affected areas. It is well known that the warm event of ENSO or El Niño causes unfavourable climate conditions in broad areas of Africa (Hoerling and Kumar, 2000). Therefore, understanding of the impact of ENSO warm events on ecosystems at all scales is an important component of Earth system science research.

Remote sensing research has also been directed toward the investigation of ENSO impacts in different geographical regions. The Normalized Difference Vegetation Index (NDVI) has been the most used satellite product for these investigations. NDVI has been shown to be correlated with a number of measures of the relative abundance of green biomass, including leaf area index, intercepted fraction of photosynthetically active radiation and density of chlorophyll in plants (Asrar et al., 1984; Sellers et al., 1997; Heinsch et al., 2006). These useful properties of the NDVI led to its adoption as an operational indicator for climate dynamics (Yang et al., 1998; Tateishi and Ebata, 2004; Li et al., 2002; Wang et al., 2003). Time series of satellite-derived NDVI data have been proofed to contain the ENSO signal in various regions and vegetation types (Gutman et al., 2000; Gurgel and Ferreira, 2003; Nagai et al., 2007; Prasad et al., 2007). Furthermore, negative anomalies of NDVI in Africa, indicative of drought, have been shown to be associated with ENSO warm events (Verdin et al., 1999; Anyamba and Estman, 1996; Anyamba et al., 2001).

The goal of this study is to investigate and quantify the vulnerability to ENSO warm events for the vegetated area of Africa throughout the period of 1982-2006. This study developed an effective assessment system for ENSO vulnerability by means of moving window correlation analysis (MWCA) between time series of NDVI and ENSO indices (MEI and SOI) at the pixel scale. Employing this assessment system to vegetated areas of Africa, spatial patterns of land surface response to El-Niño over the period 1982 – 2006 were mapped and discussed. The degree and extent of the vegetation sensitivity to ENSO warm events was also measured within each land cover type.