ANALYSING DROUGHT RELATED STRESS IN A SEMI-ARID ENVIRONMENT USING MSG-SEVIRI TIME SERIES ANALYSIS

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ABSTRACT

Water scarcity limits vegetation growth over 40 per cent of Earth's vegetated surfaces and water is the single most important limiting factor for global vegetation growth. In the 1970s and 80s the semi-arid zone of Africa suffered from a severe prolonged drought and in first 5 years of the new millennium a second severe drought period has hit the East African part of the sahelian region. Also large parts of Europe were affected by a severe drought in the summer 2003, with widespread crop failure as a consequence. In perspective of global climate change climate variability is projected to increase and drought conditions to be more frequent and severe. Given the extreme relevance of limited water resources in both Europe and Africa, it is of outmost importance to develop capacities for improved drought monitoring. Earth Observation (EO) remains the only viable means for systematically monitoring the different aspects of vegetation water stress on a regional, continental or global scale and is thus a critical component of famine and drought early warning systems, such as the United Nations Food and Agricultural Organization Global Information and Early Warning System (FAO-GIEWS) or the United States Agency for International Development Famine Early Warning Systems (USAID-FEWSNET). However, the use of conventional polar orbiting environmental satellite-based (POES) information is limited owing to the low temporal sampling frequency of the EO systems together with persistent cloud cover especially during the critical crop growing season for instance in the semi-arid zone of Africa. In order to overcome this problem, a range of procedures have been employed to compile time series composite data that minimize cloud contamination or eliminate them depending on the composite period. Yet, given the persistent cloud cover problem, there is still need for spatially continuous cloud-free imagery with sufficient temporal resolution to study different aspects of vegetation dynamics over the entire global land surface area. With the launch of the geostationary Meteosat Second Generation (MSG) METEOSAT-8 satellite with its Spinning Enhanced Visible and Infrared Imager (SEVIRI), unprecedented data for scientific exploration of natural resources including vegetation drought stress are now available to Earth system scientists. SEVIRI measures every 15 minutes radiation in 12 spectral wavebands whereof three are specifically suited for vegetation studies: the red, the near-infrared (NIR) and shortwave-infrared (SWIR) bands centered at 635, 810 and 1640 nm, respectively. Numerous studies have shown that changes in water content in plant tissues have a large effect on the leaf and canopy reflectance in the SWIR (1300–2500 nm) spectral region whereas the NIR range (700–1300) is mainly affected by structural characteristics. Algorithms and indices based on these spectral regions are therefore very useful to monitor water stress in vegetation. For instance, the Shortwave Infrared Water Stress Index (SIWSI) based on MODIS data proved to be sensitive to variations in leaf water content and enabled an improved quality of primary production estimates in the African Sahel.

The aim of this study was to assess the potential improvement within the domain of temporal resolution using geostationary MSG-SEVIRI data for drought related vegetation stress monitoring. We calculated daily SIWSI from time series (2005–2008) of MSG-SEVIRI observations for the growing season of the Dahra study site located in the semi-arid northern part of Senegal (15.33°N, 15.48°W). We examined the robustness and performance of the SEVIRI-SIWSI by considering spectral configuration of the sensor, the atmosphere, illumination and viewing geometry. Daily measurements of energy fluxes (Q_e), rainfall and soil moisture conducted at the Dahra field site were used as a reference and indicator of water stress. Finally data compositing period lengths of SEVIRI data sets and their impact on SIWSI were examined.

With the very high temporal data sampling frequency and consequently an increased probability of producing cloud free data for a short time composite period, it is expected to substantially improve various applications of satellite based natural resource management with MSG-SEVIRI observations, including crop condition monitoring, vulnerability assessment and

food security monitoring in near real-time. In particular the initiation of events such as droughts can now be monitored and identified early enough to minimize their impacts on society.