1. Additional information on the study regions

Major vegetation types of the study regions

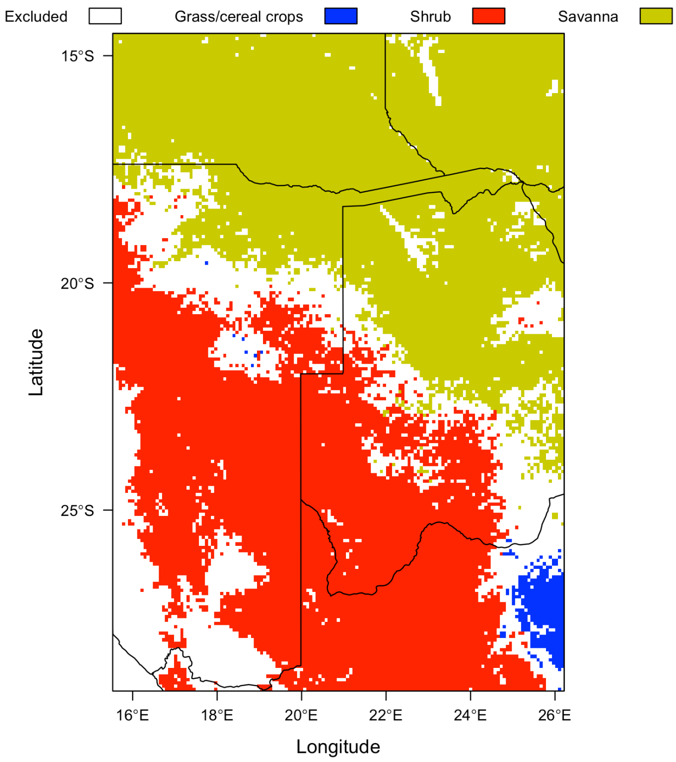

Figure S1: Overview map of vegetation types found in the South West African (SWA) study region derived from MODIS MCD12C Type 3 land cover data. White areas depict pixels excluded. Pixels have been nearest-neighbour-resampled to match the GIMMS spatial resolution.

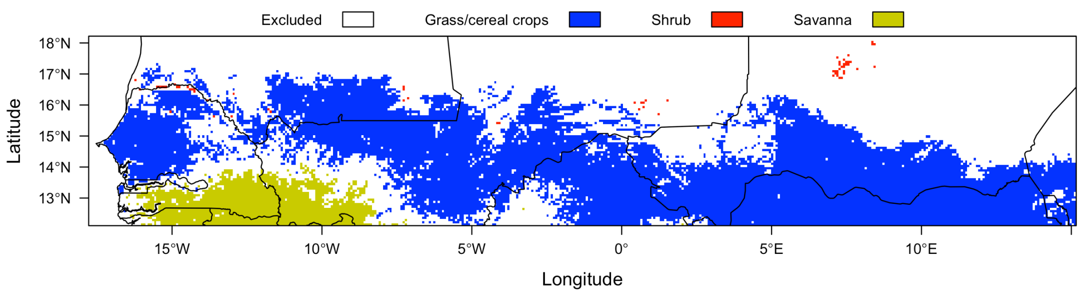

Figure S2: Overview map of vegetation types found in the West African (WA) study region derived from MODIS MCD12C Type 3 land cover data. White areas depict pixels excluded. Pixels have been nearest-neighbour-resampled to match the GIMMS spatial resolution.

Background of the SWA study region

The South West African (SWA) study region is characterised by southern hemisphere summer precipitation. The long-term mean rainy season in the region depending on the position lasts approximately from November to April with the southern parts experiencing significantly shorter seasons compared to the north (Whitford, 2002).

The study region in the southern quarter is part of the semi-desert landscape Nama-Karoo with annual low precipitation (< 150 mm MAP) (Whitford, 2002). Its vegetation consists mainly of perennial grasses which, however, have been widely replaced by poorly palatable annuals and dwarf shrubs (Ward and Ngairorue, 2000).

Virtually the entire east of the study area comprises parts of the western branches of the Kalahari semi-desert. Most of the Kalahari vegetation consists of a variety of tree-grass savanna landscapes with the dominating tree species being of the *Acacia* genus.

West of the Kalahari, former savanna landscapes have been widely replaced by shrubland with most of the shrub species being of the *Acacia* and *Dichrostachys* genus (Lohmann et al., 2012). The westernmost part of the study region comprises parts of the highly arid and only sparsely vegetated Namib desert. Vegetation in this region is mostly characterised of enduring grasses (Juergens et al., 2013).

Background of the the WA study region

The West African (WA) study region is characterised by northern hemisphere summer precipitation regime. The long-term mean duration of the rainy season is from approximately July to October (Anyamba et al., 2014).

The WA region recurringly is faced with periods of droughts and famines and is regularly identified as area being highly affected by land degradation (Verstraete, 1986). It has suffered severe droughts during the 1970s and 1980s following dramatically below long-term average precipitation (Nicholson, 2013). The consequence was a wide spread loss in available forage which triggered a decline of live stock populations of up to 40 % (Breman and de Wit, 1983) and severe famines (Dai, 2011). In the northern part the WA study region can be characterised as Saharan-Sahelian transition zone with the abundant plant community being dominated by perennial grasses (Anyamba et al., 2014). Further south, the Sahelian zone comprises a savanna type vegetation consisting of scattered trees of the *Acacia* genus and an annual grass understory (Hiernaux et al., 2009). The Sudano-Sahelian zone connects the Sahelian zone in the north with more humid regions in the south and in its natural occurrence comprises a savanna which is dominated by species of the *Combretacae* family in the tree layer and by annual grasses in the herbaceous story (Anyamba et al., 2014).

2. Background information on the methods used

Phenological parameterization model

The algorithm of the phenological model (Gangkofner et al., in press) used in this study is designed to handle vegetation index data in a bi-weekly temporal resolution.

In a first step, it ingests a set of 3 years of data with the year of interest being the centremost. This window is subsequently shifted along the temporal axis as soon as per time step all processing steps have been accomplished. Therefore, the following descriptions are generic and applicable to any given time window.

The first step then is to linearly interpolate negative outliers; considered a negative outlier is a value with a difference to the preceding and following value of 5 % of the value calculated as max – min of the respective two year period. . The start of the season (SOS) is found by means of an ancillary variable derived as moving sum of the differences between each value of the time series and its predecessor. The moving sum is built over each six consecutive differences, and can be understood as the average change over time during each 3-month window. In cases where no SOS can be found the average SOS of the other years is taken. SOS in in general refers to the start of the so called “vegetation year”. A vegetation year is defined as the time span of approximately 12 months containing commonly one (or two and more in regions with several rainy seasons) phenological cycle(s). It includes the cyclic part of the vegetation signal (cyclic fraction, CFR) and the dry (or cold) season and ends with the start of the subsequent vegetation year. To determine the onset and the end of the CFR of any given year, a baseline is derived, which constitutes the mean upper limit of the dry (or cold) season values between two vegetation peaks. Values above this baseline are part of the CFR. The baseline is calculated using the amplitude between the mean of the four lowest values ("low level mean") between two peaks and the average of these peaks. From the ratio of the amplitude and the low level mean a factor is calculated with an empirically derived regression equation that is multiplied with the low level mean. The multiplication result is considered the upper dry (cold) season limit. The factor increases with the ratio of the amplitude and the low level mean. The resulting upper dry season limit determines the maximum up to which the dry season values are finally used for determining the mean dry season level. The average of these values including the upper dry season limit is then multiplied with their standard deviation times 1.5, also an empirically derived value. The resulting base-values (one per dry or cold season) are interpolated leading to the aforementioned baseline. The CFR is consequently determined as sum of the distances of all time series values above the baseline to the latter. Thus the CFR constitutes the integral of the vegetation season values above the (local) "dry season greenness" level expressed by the baseline.

Shifting linear regression model (SLR)

The SLR is computed on a per-pixel basis. Thereby, the linear regression model is calculated over a given set of years denoted by the window, W, starting with the first set, and subsequently shifted along a temporal axis in one year steps until the end of the time series. Hence, for a given window size, n+1-W models are computed, where n denotes the number of years in the time series given annual values. For example, assuming a length of the time series of n = 29 and a window of W = 11, a set of 29+1-11 = 19 models is computed and linear slope coefficients is derived.

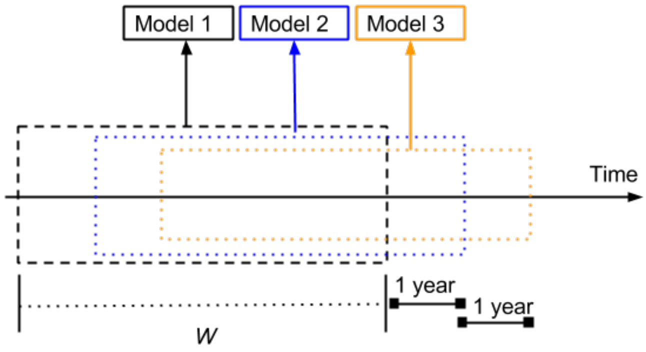

Figure S3: Schematic drawing of the SLR approach. W denotes the window length.

The principle of the SLR is depicted by Fig. S2 1. The first model in the time series thereby is Model 1 ingesting data from year 1 to year W, which is subsequently shifted by one year and becomes Model 2 etc.

Per model, the linear slope coefficient (β) is extracted. Slope coefficients are found relying on ordinary least squares (OLS) techniques.

The procedure is similar to moving correlation functions (Biondi and Waikul, 2004). However, the SLR derives quantitative slopes rather than correlation coefficients (r-values).

Supplementary analyses

Vegetation distribution

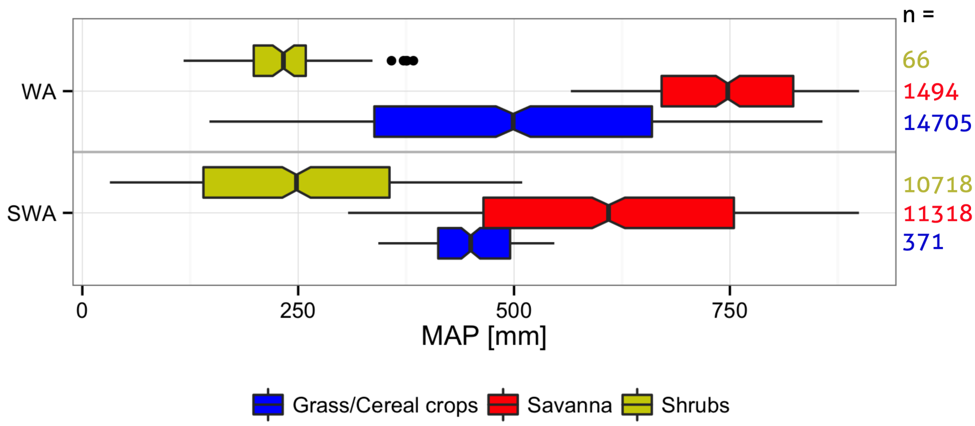

Figure S4: Distribution of the major land cover classes considered with respect to mean annual precipitation (MAP). Data have not been binned by mean annual precipitation. Distributions consequently comprise higher numbers (n) of data points.

Supplementary SLR analysis

To determine a potential effect of rainfall of previous years we conducted the entire analysis using the SLR framework but with two additional model setups. We extended the original model with rainfall of the concurrent year of the ANPP proxy with rainfall of the previous year resulting in a multiple linear regression. Morover we extended the latter model by incorporating an interaction term between rainfall of the concurrent year and rainfall of the previous year. To determine which model supersedes the other models over time and in space we computed time series of Akaike's Information Criteria (AIC) and determined for each SLR period the model with the lowest AIC. In a final step we created maps consisting of the mode of the model with the lowest AIC (Fig. S3 2 and Fig S3 3). As is apparent from both figures as well as from the relative contribution of the model mode to the total pixel count (Fig. S3 3) it is by far the model with only one variable (rainfall of concurrent year, termed “Single” in Fig. S3 1, S3 2 and S3 3) which supersedes both other models spatially and temporally.

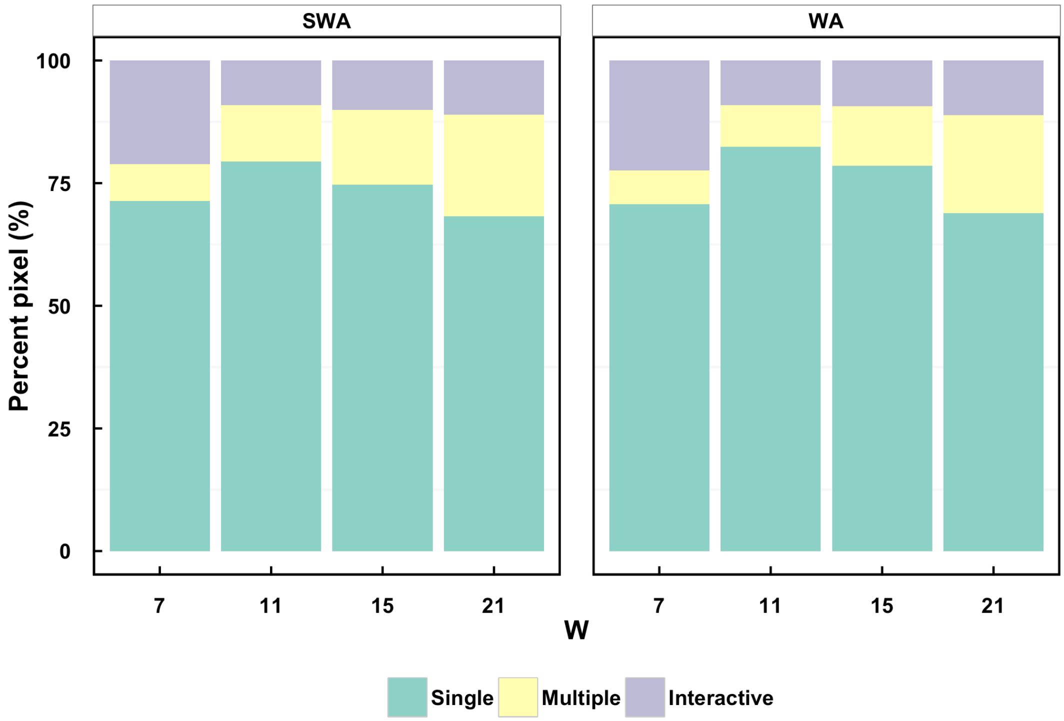

Figure S5: Percent pixel with the mode of the lowest Akaike’s Information Criterion (AIC) as a function of temporal shifting linear regression model (SLR) window length (W) and study region (South West Africa, SWA, and West Africa, WA). “Single” = model with only rainfall of concurrent year as explanatory variable, “Multiple” = model with rainfall of concurrent year and previous year as additive variables and “Interactive” = model with an added interaction term of the “Multiple” model.

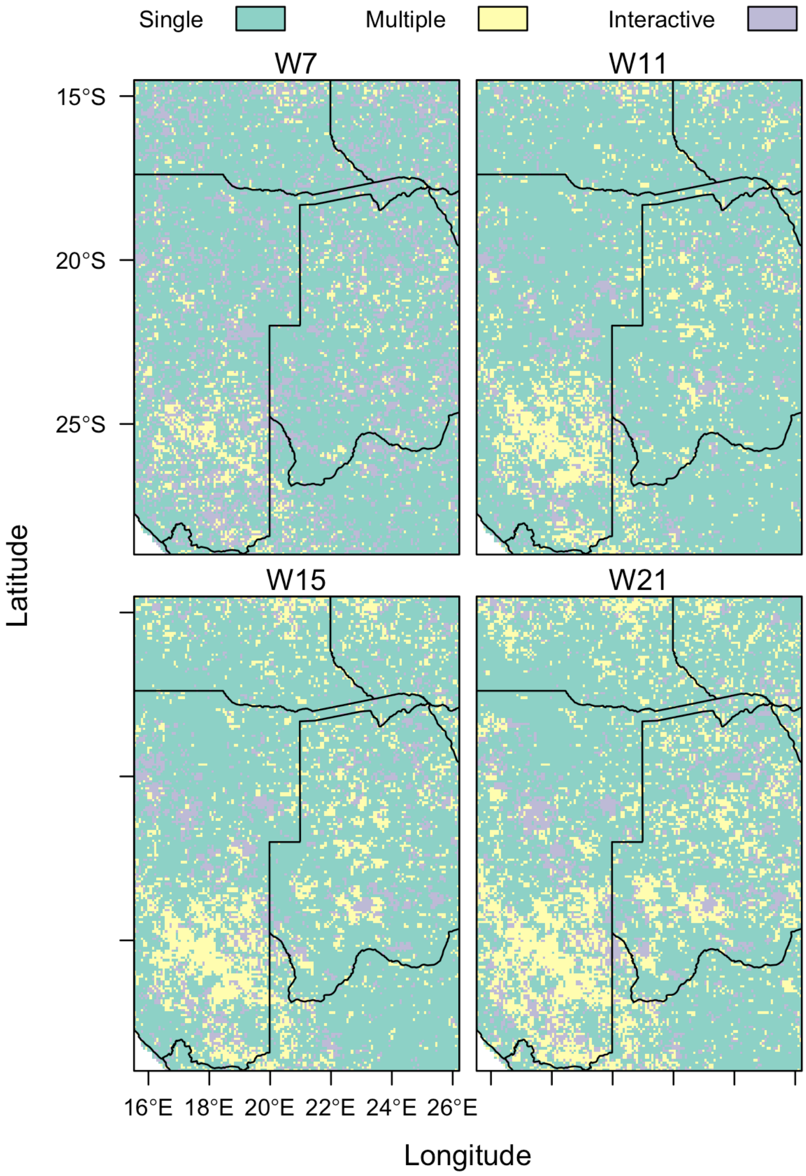

Figure S6: Maps of the South West African (SWA) study region of the mode of the shidting linear regression model (SLR) model with the lowest AIC. Map headings refer to SLR window length W. “Single” = model with only rainfall of concurrent year as explanatory variable, “Multiple” = model with rainfall of concurrent year and previous year as additive variables and “Interactive” = model with an added interaction term of the “Multiple” model.

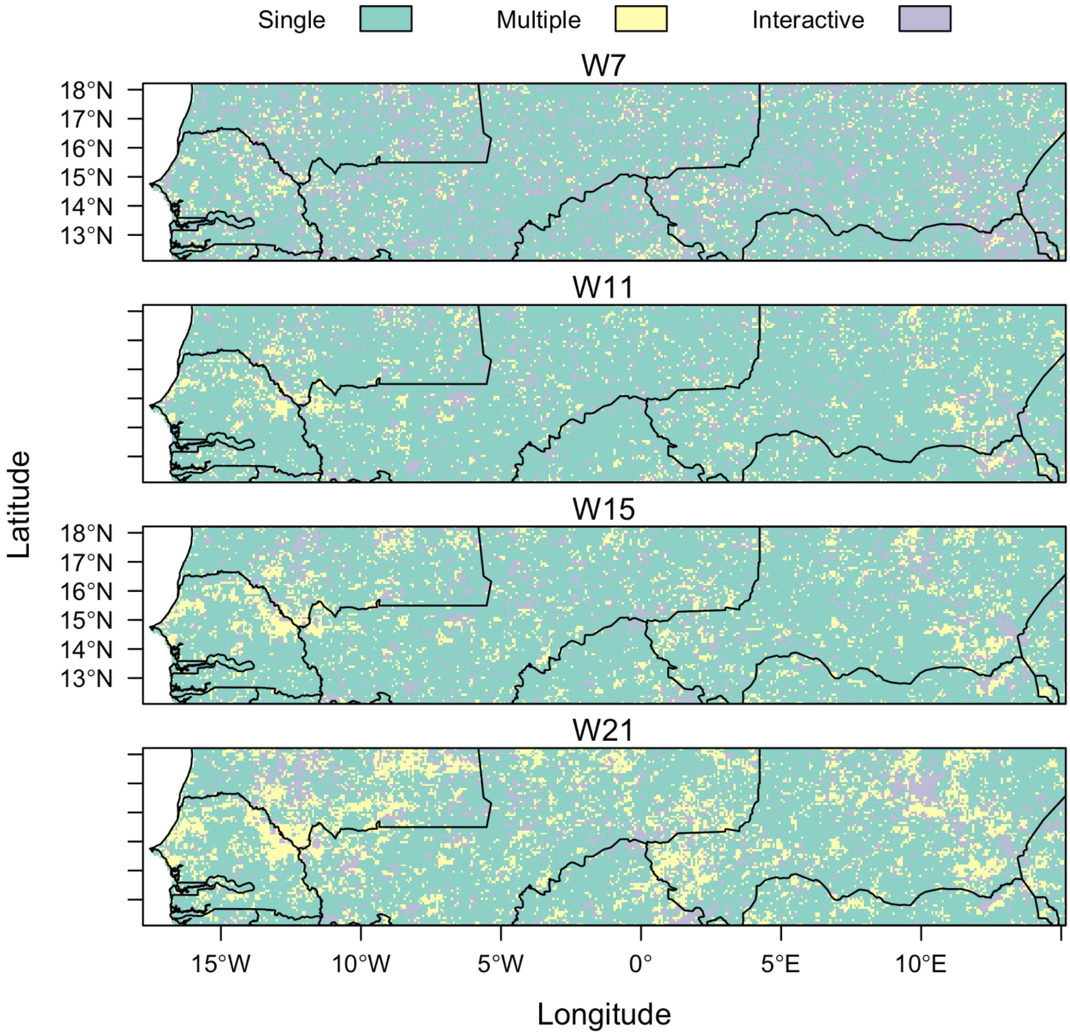

Figure S7: Maps of the West African (WA) study region of the mode of the shidting linear regression model (SLR) model with the lowest AIC. Map headings refer to SLR window length W. "Single" = model with only rainfall of concurrent year as explanatory variable, "Multiple" = model with rainfall of concurrent year and previous year as additive variables and "Interactive" = model with an added interaction term of the "Multiple" model.

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