LONG-TERM PHENOLOGY AND VARIABILITY OF SOUTHERN AFRICAN VEGETATION.

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1. INTRODUCTION

Satellite-derived phenology allows monitoring of terrestrial vegetation on a global scale and provides an integrative view of the regional landscape-scale processes. Understanding these seasonal phenological patterns is essential to (i) the characterization and classification of vegetation, (ii) studying the impact of climate change [1], and influence of rainfall variability (iii) monitoring desertification [2] and (iv) detecting changes in land use/land cover.

This study analyzed vegetation phenology across Southern Africa in order to investigate which phenometrics (and their inter-annual variability) distinguish biomes based on functional patterns. A second objective was to quantify the inter-annual variability of phenometrics during a 16-year period (1985 to 2000). Lastly the differences in phenology between natural and altered land cover types (e.g. cultivation and plantations), were quantified.

2. METHODOLOGY

Long-term (1985-2000), 1km² AVHRR (10-day NDVI) data of Southern Africa [3] were analyzed using the TIMESAT program [4]. An adaptive Savitsky-Golay filter, using local polynomial fitting together with small moving windows in two fitting steps, proved to be the most appropriate in producing a smoothed curve while capturing rapid phenological changes. Remaining outliers were removed. A user defined threshold of 10% of the seasonal amplitude (as measured from the left minima of a seasonal curve) was set as the start of season position. Similarly the end of growing season was defined as date at which the right edge has declined to 10% as measured from the right minima. The standard phenometric outputs (Table 1) from TIMESAT were used to calculate long term means, standard deviation and coefficient of variation over 16 years. The National Land Cover 2000 data was used to distinguish between natural vegetation and altered surfaces pixels.

Table 1: List of phenometrics calculated by the TIMESAT software.

<table>
<thead>
<tr>
<th>Date related phenometric</th>
<th>NDVI related phenometric</th>
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</thead>
<tbody>
<tr>
<td>Start of growing season</td>
<td>Base level</td>
</tr>
<tr>
<td>End of growing season</td>
<td>Amplitude</td>
</tr>
<tr>
<td>Mid position of growth season</td>
<td>Maximum value</td>
</tr>
<tr>
<td>Length of growth season</td>
<td>Small Integral</td>
</tr>
<tr>
<td></td>
<td>Large Integral</td>
</tr>
</tbody>
</table>

3. RESULTS

3.1. Decision tree analyses of phenometrics per biome
Approximately 400 random points were generated per biome and pixel values for all phenometrics and were extracted at a total of 3400 points for decision tree analyses. The mean mid-season date and mean standard deviation of the large integral were the most important variables in distinguishing the biomes based on phenology. Similar results were obtained by using random forest regression trees, with approximately 75% of the inter-biome variation explained by mean and standard deviation of the phenometrics.
3.2. Inter-annual variability in phenology
The standard deviation or coefficient of variation was calculated for each of the phenometrics and evaluated per biome or ecoregion. Figure 1 indicates the mean start date of the growing season while Figure 2 illustrates the standard deviation in start date. In arid areas the start date and other date-related metrics varied by as much as 3 months.

3.3. Phenology of altered surfaces
Dryland agriculture in Western Cape was compared to natural fynbos and showed significant phenological differences as were cultivation in the grasslands of the Highveld. Cultivation in the Western Cape have a larger amplitude and less variability than natural vegetation such as fynbos. In contrast dryland agriculture in the grassland biome showed extensive inter-annual variation in start and end date of growing season.

4. CONCLUSIONS
This comprehensive analysis of a unique 16-year, 1km² AVHRR dataset provided novel insights into the phenology and inter-annual variability of Southern Africa’s vegetation. The high inter-annual variability in phenology of natural vegetation may make it difficult to detect the impact of climate change from trends in phenometrics. Human-induced land cover changes had very distinct impacts on phenology representing significant changes in the movement of energy and matter between the biosphere and atmosphere.

5. REFERENCES