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SST VARIABILITY AND EXTERNAL FORCING OF RECENT CLIMATE CHANGES IN SOUTHERN AFRICA

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INTRODUCTION

This study focuses on internal and external forcing factors for climate change in southern Africa. The former are discussed in terms of SST variability, the latter in terms of changing solar activity and volcanic influences.

2. DATA

The monthly Global Sea-Ice and Sea-Surface Temperature (GISST2.3b) data (1° x 1°, 1871-1998) and the Kaplan SST anomalies (5° x 5°, 1871-1991) are used in this study, as well as the solar irradiance reconstruction by Lean (1998) to determine solar influences on climate. Further sun-related factors as the number of sunspots, the solar diameter and the solar cycle length are additionally used. Volcanic influences on southern African climate are analysed by using the volcanic heat rate anomalies, developed by Denhard et al. (1997) on the basis of the Volcanic Explosivity Index (VEI).

3. METHODS AND RESULTS

3.1 SST VARIABILITY

The SST data have been subjected to principal component analyses (PCA) in order to identify main centres of SST variability. The dominant SST pattern refers to El Niño (see the first t-mode principal component in Fig. 1) with the well known time coefficients increasing since the mid-1970s).

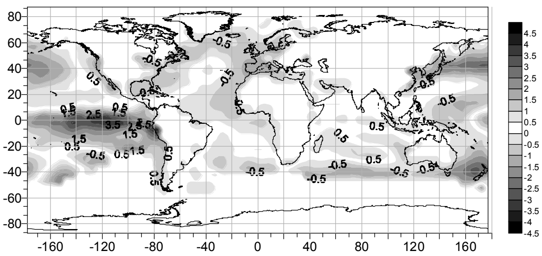

Fig. 1: First principal component for January SST. The explained variance is 14,5% of the total variance.

Other features, such as dipole patterns in the Atlantic and Indian Oceans, are rather secondary implying patterns of more regional than global influence.

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Nevertheless, CCA patterns for October show the strong coupling of the Indian Ocean tropical dipole with heavy precipitation in eastern Africa. The time coefficients of Saji et al. (1999) could well be reproduced by this analysis.

Additional CCAs were applied opposite to the common use of different climate elements (e.g. precipitation and SST) in order to investigate the coupling of tropical SSTs between the Atlantic, Indian and Pacific Oceans. For this purpose, the three oceans are assumed to have distinctly separate characteristics.

The correlation between the Atlantic and Indian Oceans is stronger than with the Pacific Ocean. The positive correlation between equatorial

Atlantic SSTs and the western Indian Ocean shows a marked trend mode. The canonical scores of the pattern with cold SSTs in the Atlantic and cold SSTs in the western Indian Ocean are decreasing since the mid-1930s whereas the positive coupling is increasing. These results are consistent for all months.

The correlations of Pacific SSTs to Atlantic and Indian Oceans SSTs are weaker. The strongest couplings are between the El Niño region in the eastern Pacific and the Indian Ocean except for the equatorial region. This region is coupled out of phase with both Atlantic and Pacific Ocean SSTs.

In most cases the highest correlations are found in the tropical Atlantic and western Pacific Oceans.

3.2 SOLAR INFLUENCES

Solar variability is a controversial factor of climate change across all time scales (Benestad, 2002; Rind, 2002). This study tries to establish statistical associations between various solar parameters and southern African climate. Reconstructed solar irradiance data, the number of sunspots, the solar diameter and the solar cycle length are therefore used, in order to identify possible links in the sun-climate relationship. Significant correlations were found between solar irradiance and surface air temperature with highest values in the region of Angola and the central interior of southern Africa. This region reveals the strongest increasing temperature trend in the 20th century. Correlations with precipitation and SLP show very unequal patterns, whereas correlations with SSTs are significant in the high southern latitudes. But the uncertain data quality in this region does not allow any further conclusions.

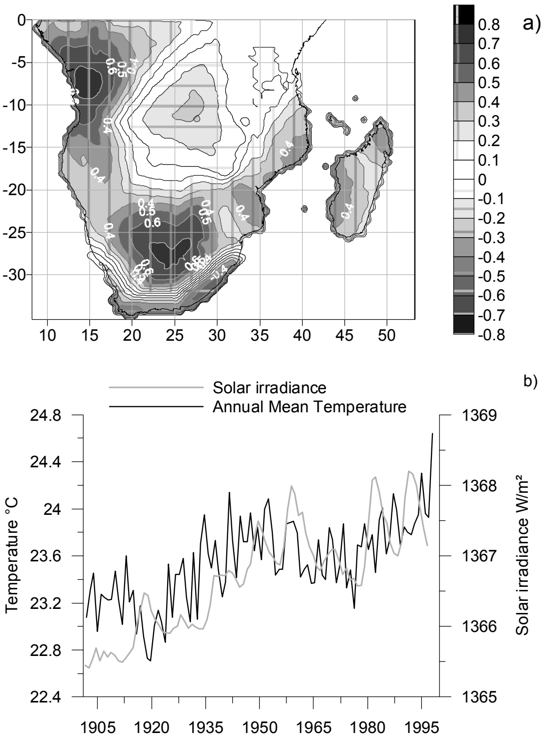

Fig. 2: Correlations of solar radiation and air temperature in southern Africa (a); time series of annual mean temperature for the region "Angola" and of the solar irradiation (b).

30-year running correlations show high values in the first half of the 20th century. Thus, increasing surface air temperatures may partly be due to increasing solar activity.

In the context of time series analyses, classical spectral analyses couldn't detect any conclusive result, thus wavelets will be used for more detailed analyses.

3.3 VOLCANIC INFLUENCES

Volcanoes are known for their impacts on weather and climate on time scales from days to several years. Exceeding beyond these short-term volcanic signals in surface temperature, investigations are focussed on possible cumulative effects on climate on decadal time scales.

For this purpose 30-year running means of the heat rate anomalies are correlated with air temperatures. Correlations show highly negative values in regions which have been shown to reveal the strongest warming trend within the last 100 years. Cumulative effects of volcanoes on climate are, comparable to sun-climate relationships, difficult to be physically proved, so that further efforts will be done to identify strong statistical connections.

4. DISCUSSION

External forcings on regional climate on decadal to secular time scales are difficult to proof. Statistical relationships are not able to establish physical explanations. But they are important to find possible links, which could further be investigated with different data and time series analyses.

5. ACKNOWLEDGMENTS

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