A Spatially Transferable Drought Hazard and Drought Risk Modeling Approach Based on Remote Sensing Data

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Globe Drought

Introduction

As a result of climate change, an increased frequency of extreme weather events including droughts is predicted (IPCC 2013). Droughts adversely affect vegetation conditions and agricultural production and consequently the food security and livelihood situation of the often most vulnerable communities. In spite of recent advances in modeling drought risk and impact, coherent and explicit information on drought hazard, vulnerability and risk is still lacking over wider areas. The aim of this study was to develop a spatially transferable drought hazard, vulnerability and risk modelling framework reflecting regional conditions, that is based on remote sensing data and time series crop yields data from the Food and Agriculture Organization (FAO).

Methods

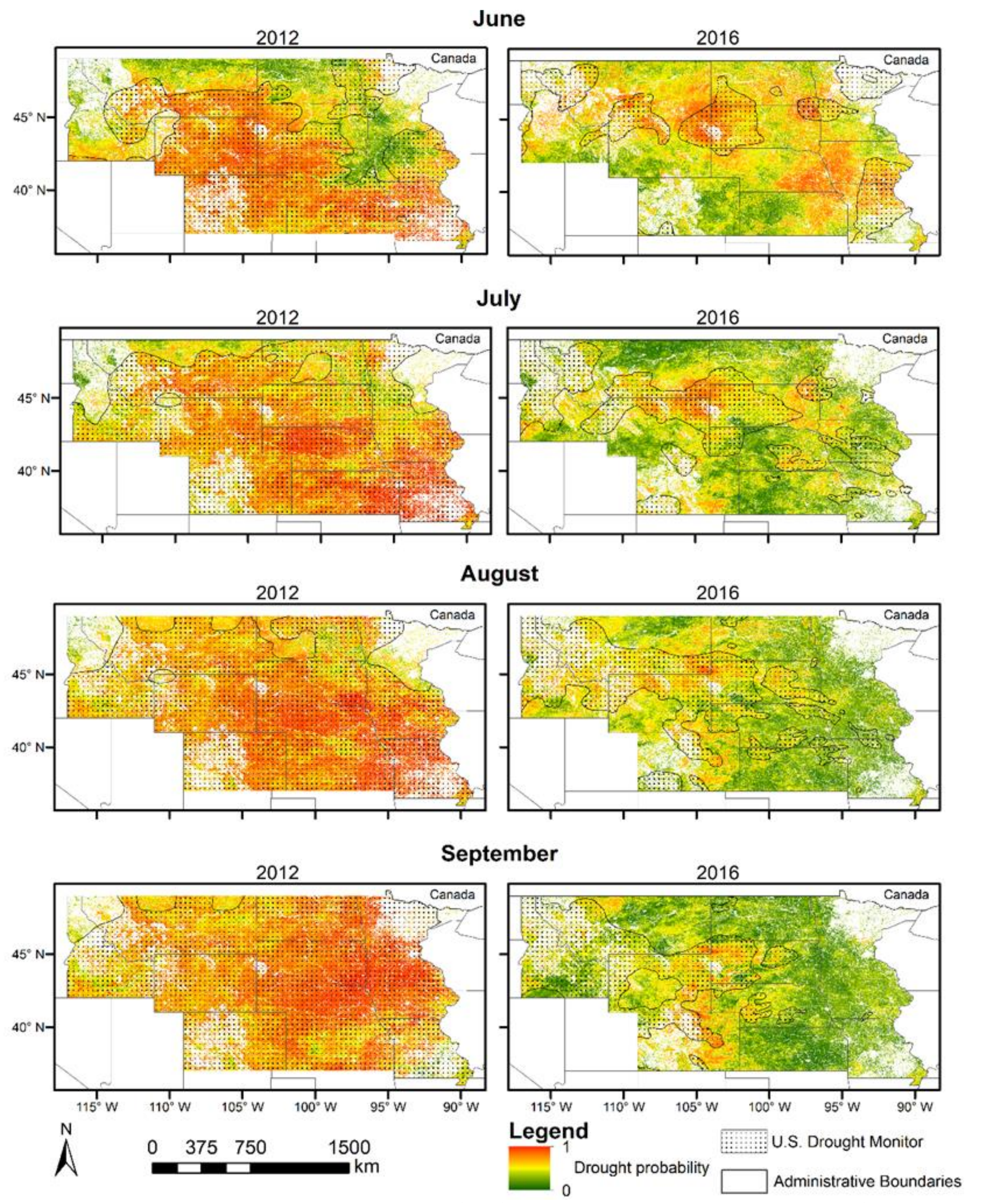
A logistic regression model was developed to predict drought hazard for rangelands and croplands in the USA. The cross-verified model was transferred and calibrated for South Africa and Zimbabwe, where the plausibility of the model was evaluated by using regional climate patterns, published drought reports and through visual comparison to a global drought risk model and food security classification data. The drought hazard model used time series crop yields data from the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) and biophysical predictors from satellite remote sensing (SPI, NDII, NDVI, LST, albedo).

Results and Discussion

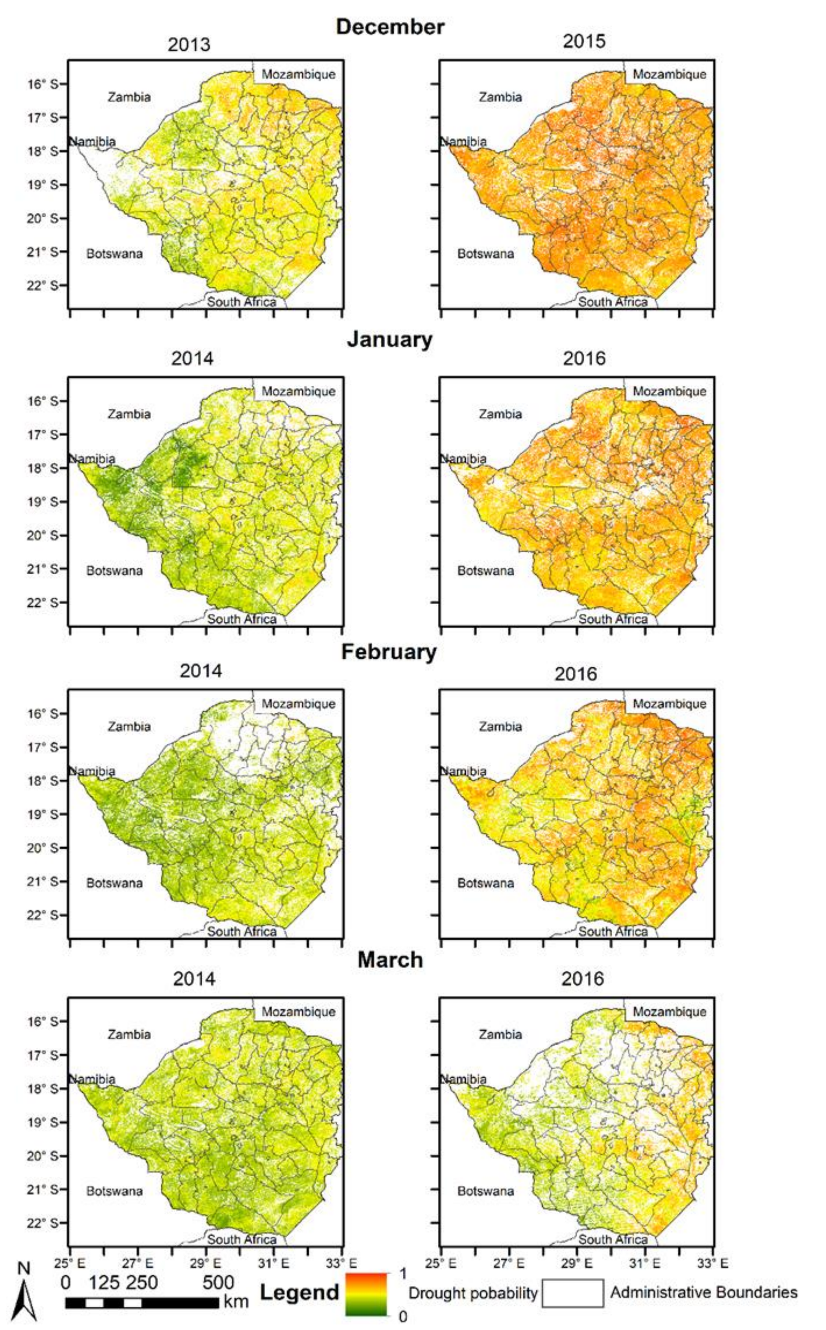
The model results in the USA showed a good spatiotemporal agreement within the cross-verification with the United States Drought Monitor (USDM), using visual interpretation, while the model in Southern Africa also performed well according to the evaluation of the results. Additionally, the McFadden's Pseudo R^2 value of 0.17 indicated a good model fit for South Africa. Drought risk and vulnerability were assessed for Southern Africa and could be mapped in a spatially explicit manner, showing, for example, lower drought risk and vulnerability over irrigated areas. This developed modeling framework can be applied globally, since it uses globally available datasets and therefore can be easily modified to account for country-specific conditions.

Conclusion

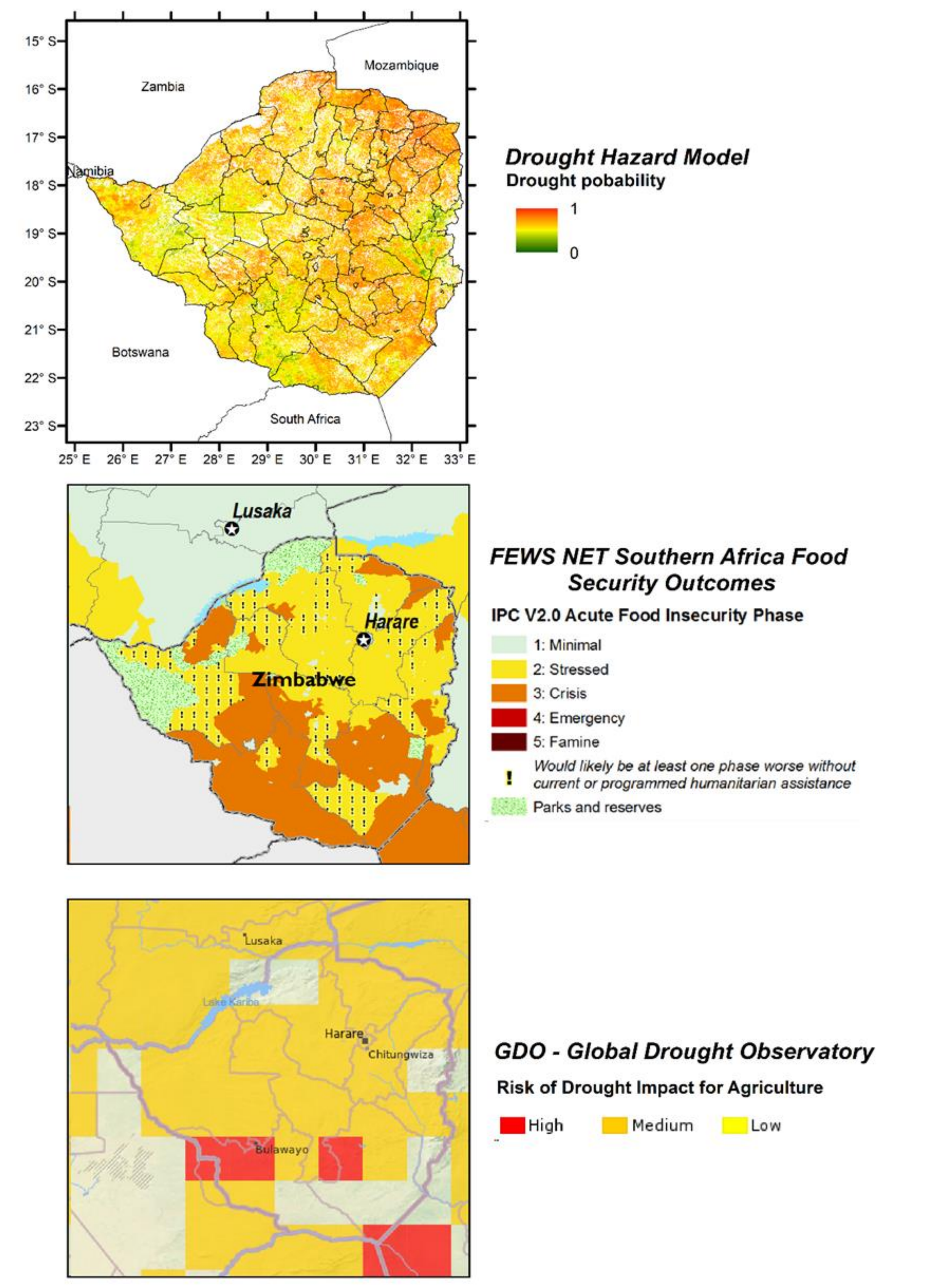
This study presented a satellite data-driven logistic regression model that can model drought hazard for agricultural areas, grass- and shrubland biomes while being spatially transferable. The model addressed the gap between global drought models, that cannot accurately capture regional droughts, and sub-regional models that may be spatially explicit but not spatially coherent. The approach of this study can potentially be used to identify risk and priority areas and possibly in an early warning capacity while enhancing existing drought monitoring routines, drought intervention strategies and the implementation of preparedness measures.



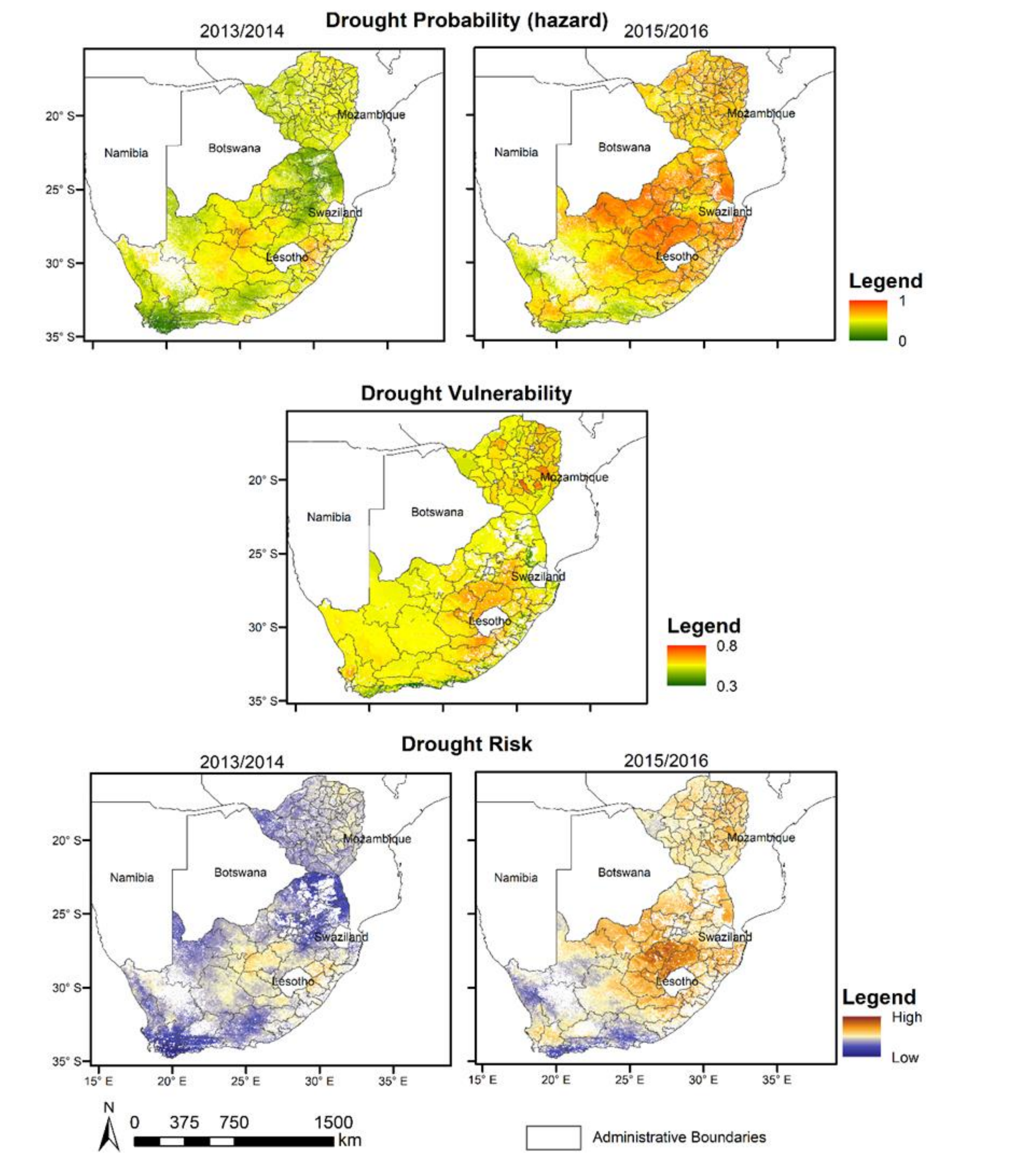
Modeled drought hazard in the Missouri Basin (USA) compared to the U.S. Drought Monitor (dotted polygons) for agricultural, grass- and shrubland in a drought (2012, left) and non-drought year (2016, right).



Modeled drought hazard in Zimbabwe for agricultural, grass- and shrubland in a non-drought year (2013/2014, left) and a drought year (2015/2016, right).



Comparison of the drought hazard model results (top) with food security classification data from FEWS NET (http://shapefiles.fews.net.s3.amazonaws.com/HFIC/SA/southern-africa201602_CS.png) (center) and the Global Drought Observatory (https://edo.jrc.ec.europa.eu/gdo/php/index.php ?id=2001) (bottom) for the month February in 2016.



Drought hazard, vulnerability and risk for South Africa and Zimbabwe for the growing seasons December to March 2013/14 and 2015/16. Drought hazard is only presented for crop-, grass- and shrubland, drought vulnerability excludes urban areas and drought risk is presented for crop-, grass- and shrubland additionally excluding urban areas.

Quellen: **Di Wu, Qu J. J., Hao X. (2015)**: Agricultural drought monitoring using MODIS-based drought indices over the USA Corn Belt. In: International Journal of Remote Sensing. 36(21), S. 5403–5425.; **IPCC (2013)**: Summary for Policymakers. In: IPCC (Hrsg.): Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge: Cambridge University Press.; **Owrangi M. A., Adamowski J., Rahnemaei M., Mohammadzadeh A., Sharifan R. A. (2011)**: Drought Monitoring Methodology Based on AVHRR Images and SPOT Vegetation Maps. In: Journal of Water Resource and Protection. 03(05), S. 325–334.

Daten: **Funk C., Peterson P., Landsfeld M., Pedreros D., Verdin J., Shukla S., Husak G., Rowland J., Harrison L., Hoell A., Michaelsen J. (2015)**: The climate hazards infrared precipitation with stations - a new environmental record for monitoring extremes. In: Scientific data. 2), S. 150066.; **Homer C., Dewitz J., Yang L., Jin S., Danielson P., Xian G., Coulston J., Herold N., Wickham J., Megown K. (2015)**: Completion of the 2011 National Land Cover Database for the Conterminous United States - Representing a Decade of Land Cover Change Information. In: Photogrammetric Engineering & Remote Sensing. 81(5), S. 345–354.; **The National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration (2018)**: U.S. Drought Monitor. Data. URL: http://droughtmonitor.unl.edu/Data.aspx.; **Vermote E. F., Roger J. C., Ray J. P. (2015)**: MODIS Surface Reflectance User's Guide - Collection 6. URL: http://modis-sr.ltdri.org/guide/MOD09_UserGuide_v1.4.pdf (20.04.2018).