



## Multi-method event attribution of 2015 OND drought in subtropical southern Africa

**Neven Fuckar**<sup>1</sup>, Friederike Otto<sup>1</sup>, Flavio Lehner<sup>2</sup>, Piotr Wolski<sup>3</sup>, Emma Howard<sup>4</sup>, and Sarah Sparrow<sup>5</sup>

<sup>1</sup>University of Oxford, Environmental Change Institute, Oxford, UK (neven.fuckar@ouce.ox.ac.uk)

<sup>2</sup>National Center for Atmospheric Research, Boulder, CO, USA

<sup>3</sup>University of Cape Town, Climate System Analysis Group, Cape Town, South Africa

<sup>4</sup>University of Reading, Department of Meteorology, Reading, UK

<sup>5</sup>Oxford e-Research Centre, Department of Engineering Science, University of Oxford, Oxford, UK

The subtropical (south of 15deg.S) southern Africa experienced one of the most severe droughts in the record - accompanied with an exceptional heat wave - during the austral spring (October through December - the first half of the main rainy season) of 2015. The observed surface hydro-meteorological conditions led to substantial socio-economic impacts in the region - with mostly semi-arid climate and high spatial-temporal variability - where drought is the principal type of widespread natural disaster. More specifically, very low precipitation - compounded with very high surface air temperature (SAT) - caused low runoff, water shortages and restrictions, reduced electricity generation, and considerable loss of crops and livestock prompting Botswana, Namibia, Lesotho, Malawi, Swaziland and Zimbabwe to declare national drought emergencies. Every extreme event is the result of a combination of external drivers, natural (solar forcing and volcanos), and anthropogenic (carbon dioxide emissions, land use, etc.), and internal variability. The risk-based or probabilistic event attribution assesses to what extent anthropogenic forcing modifies the probability and magnitude, and hence the risk of an extreme event or a class of events to occur (i.e. to identify "the sharp edge" of climate change). This study utilises multiple long-term observations (CRU TS 4.03, GPCC v2018, NOAA PREC/L, etc.), and AGCM and CGCM historical simulations (12 models in total spread across CMIP3, CMIP5 and CMIP6 generations) to estimate risk indicators such as probability (risk) ratio (RR) and intensity change for the OND 2015 drought with respect to the beginning of the 20<sup>th</sup> century or pre-industrial conditions. Our multi-method approach indicates significant influence of climate change in total OND precipitation, e.g. RR = 1.48 (with 95% CI: 1.20, 1.85), and precipitation-temperature (mean OND SAT) ratio fields over the subtropical southern Africa, but uncertainty of risk indicators can be substantial. The crucial elements of atmospheric circulation and teleconnections (such as Angola Low and ENSO influence) associated with this extreme event are analysed and elaborated using the latest NOAA-CIRES-DOE 20<sup>th</sup> Century Reanalysis version 3.