# Modelling temperature extremes in the Limpopo province: Bivariate time-varying threshold excess approach

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A common problem that arises in extreme value theory (EVT) when dealing with several variables (such as weather or meteorological) is to find an appropriate method to assess their joint or conditional multivariate extremal dependence behaviour. The method for choosing an appropriate threshold in peaks-over threshold (POT) approach is also another problem of endless debate. In this era of climate change and global warming, extreme temperatures accompanied by heat waves and cold waves pose serious economic and health challenges particularly in small economies or developing countries like South Africa. The present study attempts to address these problems, in particular, to deal and capture dependencies in extreme values of two variables, by applying bivariate conditional extremes modelling with a time-varying threshold to Limpopo province's monthly maximum temperature series. Limpopo and North West provinces are the two hottest provinces in South Africa characterised by heat waves and the present study is carried out in the Limpopo province at Mara, Messina, Polokwane and Thabazimbi meteorological stations for the period 1994-2009. With the aim to model extremal dependence of maximum temperature at these four meteorological stations, two modelling approaches are applied: bivariate conditional extremes model and time-varying threshold. The latter approach was used to capture the climate change effects in the data. The main contribution of this paper is in combining these two approaches in bivariate extremal dependence modelling of maximum temperature extremes in the Limpopo province of South Africa. The findings of the study revealed both significant positive and negative extremal dependence in some pairs of meteorological stations. Among the major findings were the significant strong positive extremal dependence of Thabazimbi on high temperature values at Mara and the strong negative extremal dependence of Polokwane on high temperature values at Messina. The findings of this study play an important role in revealing information useful to meteorologists, climatologists, agriculturalists, planners in the energy sector among others.