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History of droughts in the Middle East as documented by the Elbrus Mt. ice core

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Ice cores are one of the most valuable paleoachieves. Dust records from the ice cores can provide data not only about amount of dust particles in the atmosphere but also about dust sources and its changes in the past. A 182 meter ice core has been recovered at the Western Plateau of Mt. Elbrus (5115 m a.s.l.) in 2009. This record was extended with the shallow ice core drilling in 2013 and 2017. Ice samples were analysed for major ions, trace elements, concentrations of dust and black carbon, and particle size distributions. Ca2+ is a common dust tracer used for ice core records interpretation. Here we present analysis of the annual average Ca2+ concentrations recorded in Elbrus ice core over the period 1920-2017.

To characterize possible sources of aerosols three-dimensional 3-day backward trajectories arriving at Elbrus were calculated using the NOAA HYSPLIT-4 model for the 2007 to 2017. Cluster analysis was performed and a potential source contribution function values for the grid cells were calculated. The majority of the trajectories show a south-west origin and specifically the Middle East region. The next important aerosol source is the Western and Eastern Europe due to prevailing of the westerlies. Lowest share of summer trajectories is attributed to regions located to the north and east from Caucasus. In total during 2007-2017 the Middle East region was a dominant source of air masses arriving at Elbrus (30-40%).

The Elbrus Ca2+ record reveals a quasi decadal variability with a general increasing trend. The maximum annual concentrations were recorded in 1999 and 2000 annual layers. We compared ice core data to various parameters in the potential source regions for natural dust. Ice core dust record was compared to AOD measurements and satellite information (AERONET, Terra, Aqua, SeaWi). In addition, results of 10 CMIP5 models, as well as ERA-Interim reanalysis were used. It was revealed that in the last 15 years there is indeed a positive trend of aerosol optical thickness over the territory of the Middle East however CMIP5 models do not reproduce any dust concentration trends. Using multiple regression analysis we found a statistically significant spatial correlation of the Elbrus Ca2+ annual concentrations and precipitation and soil moisture content in Levant region (specifically Syria and Iraq). The Ca2+ record also correlates with SPEI index for the region of Fertile Crescent ($r=0.62$ $p<0.001$). Therefore we can conclude that Elbrus ice cores can be used to reconstruct the dust variations over the Middle East region and more specifically to reconstruct droughts variability in Fertile Crescent. There is a prominent increase in distant dust concentration in the ice core over the past 200 years which suggests that the recent droughts in Fertile Crescent 1998-2012 period were most severe for the past two centuries.

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