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Using observed hydro-climatic and land-use changes to explain the desiccation of Lake Urmia

Bahram Khazaei (1), Sina Khatami (2), Seyed Hamed Alemohammad (3), Changshan Wu (4), Kaveh Madani (5,6), Zahra Kalantari (7), Georgia Destouni (7), Amir Aghakouchak (8,9)

(1) Department of Civil and Environmental Engineering, University of Wisconsin-Milwaukee, United States (bkhazaei@uwm.edu), (2) Department of Infrastructure Engineering, University of Melbourne, Australia, (3) Radiant.Earth, USA, (4) Department of Geography, University of Wisconsin-Milwaukee, USA, (5) Yale University, USA, (6) Centre for Environmental Policy, Imperial College London, UK, (7) Department of Physical Geography, and Bolin Centre for Climate Research, Stockholm University, Sweden, (8) Department of Civil and Environmental Engineering, University of California, Irvine, USA, (9) Department of Earth System Science, University of California, Irvine, USA

Understanding the climatic and direct human drivers of abrupt drying of lakes in many parts of the world is a high research priority, particularly for water resources management and restoration. Lake Urmia, a shallow endemic lake in north-west Iran and one of the major saltwater bodies on earth, has undergone a dramatic decline in its water level (WL) in the past decades, resulting in about 80% of loss in the lake's water content. Different explanations have been discussed regarding the primary cause of this WL decline, including climate change, and regional human-driven land- and water-use changes. This paper reports a comprehensive study of the possible primary drivers of the lake's desiccation. Using classical exploratory statistical methods, the analysis accounts for the relationships between climate change (precipitation P, temperature T), land-surface and hydrological evolution (soil moisture SM, and WL), and vegetation cover (VC) change in the region. The latter includes human-driven changes of irrigation and expansion of agricultural lands. Observations over the period 1981-2015 indicate that the observed variability in P, T, and SM cannot explain the sharp decline in the lake WL since 2000. Instead, land-surface analysis shows VC was nearly doubled after 2000 in the Lake Urmia watershed, indicating that the WL decline is mainly associated with human-driven agricultural increase of VC. The expansion of agricultural activities in the watershed has led to increasing transpiration and hence, total evapotranspiration, decreasing the runoff during the increase in VC (inherently including irrigation, storage, and water diversion). Our results are consistent with similar cases around the world identifying human activities and interventions as the main driver of hydrologic changes, while climate change will likely increasingly contribute to such changes and their impacts in the future.