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Centennial to millennial-scale variability of Holocene climate and environmental dynamics in the western Mediterranean (Lake Sidi Ali, Middle Atlas, Morocco)

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The Western Mediterranean region including the North African desert margin is considered one of the most sensitive areas to future climate changes. In order to refine long-term scenarios for hydrological and environmental responses to future climate changes in this region, it is important to improve our knowledge about past environmental responses to climatic variability at centennial to millennial timescales. During the last two decades, the recovery and compilation of Holocene records from the subtropical North Atlantic and the Mediterranean Sea have improved our knowledge about millennial-scale variability of the Western Mediterranean palaeoclimate. The variabilities appear to affect regional precipitation patterns and environmental systems in the Western Mediterranean, but the timescales, magnitudes and forcing mechanisms remain poorly known. To compare the changes in Holocene climate variability and geomorphological processes across temporal scales, we analysed a 19.63-m long sediment record from Lake Sidi Ali (33°03' N, 5°00' W, 2080 m a.s.l.) in the sub-humid Middle Atlas that spans the last 12,000 years (23 pollen-based radiocarbon dates accompanied with ^{210}Pb results). We use calibrated XRF core scanning records with an annual to sub-decadal resolution to disentangle the complex interplay between climate changes and environmental dynamics during the Holocene. Data exploration techniques and time series analysis (Redfit, Wavelet) revealed long-term changes in lake behaviour. Three

main proxy groups were identified (temperature proxies: 2ky, 1ky and 0.7ky cycles; sediment dynamic proxies: 3.5ky, 1.5ky cycles; hydrological proxies: 1.5ky, 1.2ky, 0.17ky cycles). For example, redox sensitive elements Fe and Mn show 1ky cycles and higher values in the Early Holocene and 1.5ky cycles and lower values in the Mid- to Late Holocene. All groups show specific periodicities throughout the Holocene, demonstrating their particular climatic and geomorphological dependencies. Furthermore, we discuss these periodicities relating to global and hemispheric drivers, such as the North Atlantic Oscillation (NAO), El-Niño Southern Oscillation (ENSO), Innertropical Convergence Zone variability (ITCZ) and North Atlantic cold relapses (Bond events).