**Highlights**

n-Alkyl leaf waxes obtained from ancient Atacama rodent middens can be used to infer past climate change

An elevational survey of leaf cuticular waxes in the Atacama Deserts shows that their composition varies at the ecosystem scale

n-Alkane composition and plant macrofossils from ancient middens show major vegetation responses to millennial-scale hydroclimate shifts over the last 17,000 years

Our reconstructed hydroclimate record tracks the Central Andean Pluvial Event (CAPE) and indicates that paleomiddens are a valuable source for leaf waxes