NEW METHODS FOR QUANTIFYING CLIMATE VARIABILITY AROUND AFRICA OVER THE LAST 400 KA AND IMPLICATIONS FOR ANATOMICALLY MODERN HUMAN EVOLUTION AND DISPERSAL

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ABSTRACT
Numerous hypotheses have attempted to correlate key periods of human evolution and migration with climate and landscape changes. Many of these hypotheses operate within a unidirectional backdrop of decreasing tree cover and increasing aridity, trends evident in offshore dust flux, soil carbonate isotope and fossil faunal records. Often, like the variability selection hypothesis, focus on alternating climate extremes which would have required early humans to adapt to climate variability and a changing mosaic of habitat types. The more recent accumulated plasticity hypothesis states that species which experienced increased temporal variation within their environment is naturally selected to have more adaptive strategies while being less fit for any one particular type of environment. These adaptive strategies would equip a species for dispersal into new habitats.

Direct comparisons between climate variability and human evolution have been difficult due to the lack of well-dated, long-term, regionally specific climate records. Aside from generalized insolation variability, climate variability has not adequately been defined and quantified for proxy records in any testable manner. We use two different methods to quantify and define climate variability through 31 climate/environmental records developed using different techniques and timescales. The new methods allow direct comparisons between different records offering insight into complex, multi-regional climate dynamics of the last 400,000 years. Furthermore, the records span the African continent as well as the southern Levant and Southern Europe offering an unparalleled spatial understanding of how multiple regions relevant to the rise and expansion of Homo sapiens responded to global climatic events.

Our study shows that five separate climate regions experienced both periods of high and low climate variability, and that these periods are not synchronous across Africa and into Europe. Higher latitude regions are more sensitive to global climate forcing as is tropical Africa. East Africa has a dampened response to glacial/interglacial cycles except for the transition out of MIS 5 and into MIS 4, and 5, which is a period of high climate variability for the region. Furthermore, major human migrations occur after periods of increased climate variability in at least one of the regions, with the prolonged period of repeated migrations during MIS 5 occurring during a period of increased variability everywhere but East Africa. However, the migration of H. sapiens occurred after a period of extreme variability in East Africa.

RESULTS

The mean tracks the general trend of the environmental signal. For example, a higher dust flux mean indicates a trend towards drier conditions. In marine core ODP 721/722, off East Africa, the high mean at 155ka represents overall dry conditions for the period 155ka-160ka while the lower mean at 105ka represents wetter conditions for 100ka-110ka.

The standard deviation and summed weighted rate of change track fluctuations in the record, often with both calculations paralleling each other. In ODP 721/722, the higher summed weighted rate of change at 50ka, 105ka and 115ka, indicate that there are more changes in the dust flux off the coast of East Africa between 50ka-120ka. This accumulated change would indicate a period of high variability.

The mean summed rate of change is the average rate-of-change for all records for that region. The analysis shows that each region experienced periods of both high variability and low variability, and these periods are not always synchronous through all the regions.

DISCUSSION AND CONCLUSION
Climate variability in Southern Europe and Southwest Asia, North Africa and the Southern Levant, Tropical Africa and South Africa is influenced by global climate shifts such as glacial/interglacial transitions and the intensification of the equatorial temperature gradient in the Atlantic (Rohling et al., 2013).

East Africa is less influenced by global climate shifts with increases in variability occurring at the transitions into MIS 9 and into MIS 4 and 5. This may be due to a weakening of the Walker circulation during the last glacial maximum which would have allowed for more local convection and increased rainfall to occur (Dinizio et al., 2016).

Regional differences in variability indicate that local environmental feedbacks and thresholds may have been more important for early human than generalized insolation parameters. Critical parameters as an index of environmental variability do not capture the full range of environmental variability experienced by African hominins over the last 400ka.

Major human migrations over the last 400ka occur after periods of increased variability in at least one region studied. The prolonged period of repeated migrations between 120-90ka (MIS 5) occurred during a period of higher variability in Southern Europe and Southeast Asia, North Africa and the Southern Levant, Tropical Africa and South Africa.

The last two major out of Africa migrations of modern humans occurred after periods of increased variability in East Africa and North Africa and the Levant.

The recent discovery of MSA tools at Ongolongue Basin, Kenya dates to a period of high variability in the region (Dengo et al., 2018).

This new method offers an approach to linking climate variability as actually experienced by hominins to evolutionary and dispersal events in hominin history. More high-resolution records are needed to narrow down regional differences in climate variability.

REFERENCES

1. XRF: X-ray fluorescence is an unsplit count of relative abundance for an element in a sample. It is often displaced as a ratio of one element to another. X-ray fluorescence can be used to measure elements that have low detection limits.

2. Pollen: Pollen in marine cores is a composite of vegetation of the nearby continent. Contributions from trees, shrubs and grasses influence vegetation composition and abundance. See figure 1 for more about our pollen records.

3. TOC: TOC is the percentage of total organic carbon in a sample. It is an indicator of biogenous contribution to the sediment and higher values are interpreted as wetter conditions.

4. SIC: SIC is the ratio of total organic carbon in a sample. Higher values indicate higher SIC, vegetation (green) and may point to moister environments.

5. Bulk geochemical: Bulk geochemistry is a direct measurement of elements in a sample. Bulk geochemistry is a direct measurement of elements in a sample. Bulk geochemistry is a direct measurement of elements in a sample.


