Modeling drift-induced maritime connectivity between Cyprus and its surrounding coastal areas during early the Holocene

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Introduction / Motivation

Maritime connectivity between Cyprus and other Eastern Mediterranean coastal regions on the mainland constitutes a critical factor towards understanding the origins of the early visitors to Cyprus during the onset of the Holocene (circa 12,000 years before present) in connection with the spread of the Neolithic in the region (Dawson, 2014).

Estimates of probable sea-routes in the region, as well as their duration, have been previously provided for the early Holocene (Bar-Yosef Mayer et al., 2015), capitalising on the interpretation of the archaeological record in the broader area, present-day wind data, as well as reconstructed paleo-coastlines based on global mean sea-level curve models.

We report here initial results on a physically-based simulation study regarding drift-induced seaborne movement (a proxy for potential maritime connectivity) using particle tracking from selected source locations in the same region (see Figure 1) and period under similar assumptions. We believe this is the first time such a study is undertaken in the context of island visitation and/or colonisation in the Eastern Mediterranean for the early Holocene, along the lines of similar studies being conducted elsewhere (Bird et al., 2018).

Materials and Methods

Under the assumption of no significant differences between prehistoric and present-day circulation patterns, we apply wind and current forcing to model ocean circulation dynamics over a 1 nautical mile spatial resolution grid covering the Eastern Mediterranean area. Notwithstanding the complexity of paleogeographic reconstruction (Benjamin et al., 2017), the bathymetry used in this work is based on EmodNet's and SRTM (2004) bathymetry, land topography, and a recent R/V Marion survey of the Eratosthenes sea mount. The present-day bathymetry model is then shifted (upwards) by ~60m m to account for the sea-level postulated for the early Holocene (Bar-Yosef Mayer et al., 2015), and is then integrated and sub-sampled at a 0.01 arc degrees grid(Figure 2), in accordance with Schattner et al. (2010).

The Regional Ocean Modeling System (ROMS, Shchepetkin and mcWilliams, 2005), forced by Copernicus Marine portal hydrological data, with wind forcing derived from a combination of global reanalysis data and regional-scale numerical weather predictions (ERA5 and E-WAVE products), are employed to provide the physical and atmospheric conditions.

Particle-tracking is carried out using the OpenDrift model (Dagestad et al., 2018) to simulate drift-induced movement. We select several coastal locations spread out along the Eastern Mediterranean shorelines and the island of Cyprus (Figure 1) as sources of particle release for a leeway type simulation (Allen and Plourde,1999), whereby the floating object corresponds to a surf board with a standing person. The simulations are run for one (1) year, starting every day at 06:00 UTC and producing hourly results for a duration of 120 hours (5 days).

Materials / Results

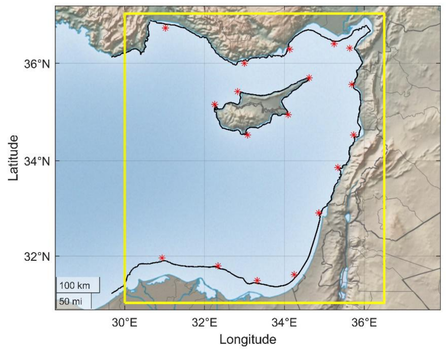

Figure 1. Study area (yellow-line box) with reconstructed paleo-coastline (black line), and particle release locations (red asterisks).

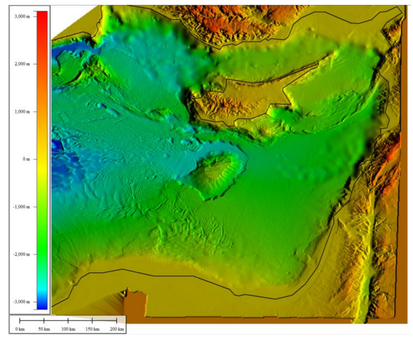

Figure 2. Reconstructed prehistoric bathymetry and coastline.

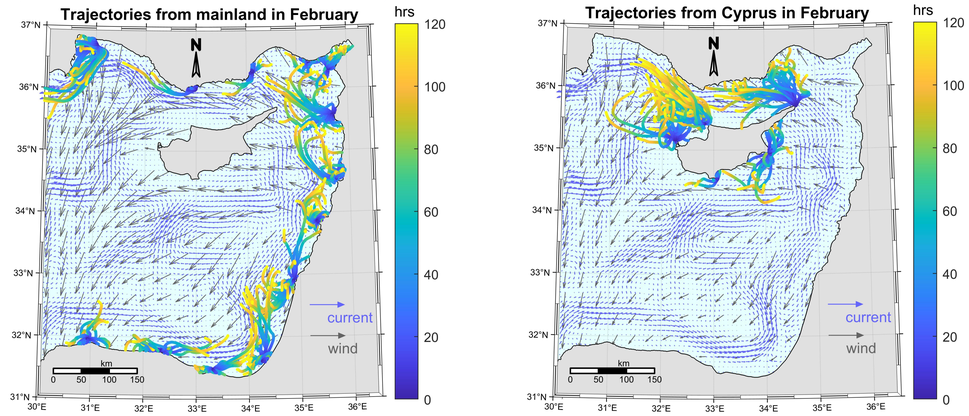

Figure 3. Drifting vessel routes during February. Each trajectory point is color-coded according to the time elapsed since the particle release from the source location. Blue-colored and grey-colored arrows represent current and wind vectors, respectively, for the departing time of middle day of the given month.

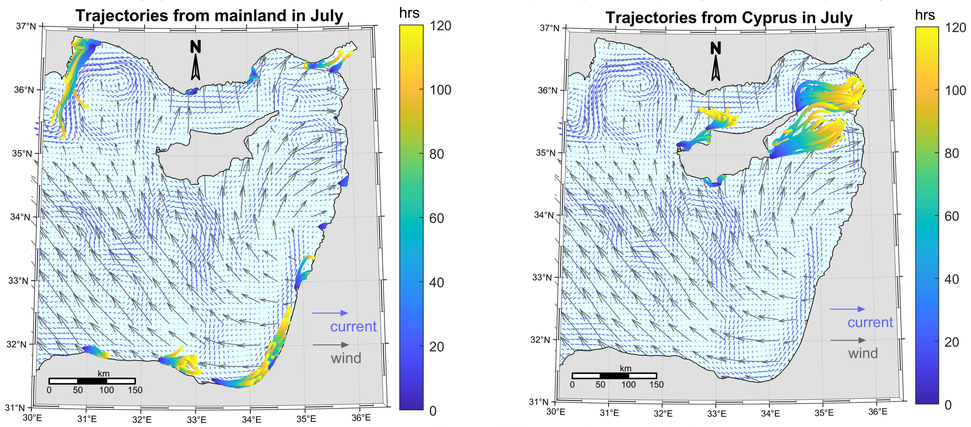

Figure 4. Drifting vessel routes during July.

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EmodNet bathymetry (https://www.emodnet.eu/bathymetry)
SRTM topography (2004 version; https://www2.jpl.nasa.gov/srtm/)

Discusion

The simulation results indicate two main periods, one in the winter and one in the summer, during which there is a significant likelihood for the ocean circulation in the region to aid postulated drifting vessels to arrive from the mainland to Cyprus, and an even higher likelihood to travel from Cyprus to the south coasts of Asia Minor.
During Winter time, with February as a representative month, the accelerated currents near the northern mainland coasts seem to push the drifting vessels over long distances (Figure 3, left), thus enabling drift-induced travel.
From the north side of Cyprus, the sea currents appear very favorable for the northbound trip to the southern coasts of Asia Minor (Figure 3, right), even without any human effort requirements.
The current formations during the Summer period, with July as a representative month, appear to develop barriers for the simple motion of a drifting vessel from the mainland to the open sea (Figure 4, left).
At the same period, the trip from Cyprus to the eastern coasts of the Levant (present-day Syria and Lebanon) appears favorable, as shown in Figure 4 (right).

Conclusions

This work represents initial, yet highly innovative, efforts towards modelling drift-induced sea-borne movement between Cyprus and its surrounding mainland areas under conditions approximating those postulated during the onset of the Holocene. As such, this work contributes significantly to the process of understanding the role of maritime connectivity within the context of the spread of Neolithic cultures in the Eastern Mediterranean.

Overall, the simulation results indicate that:

- there exist at least two periods, during winter for South to North routes, and during summer, for East to West routes, whereby the sea state is favorable to drifting vessels, especially for shorter distances.
- during almost all the time, departures from the southern side of mainland are blocked by currents flowing towards west.

Current work involves the extension of the simulation period, the augmentation of the number of particle release locations, as well as the investigation of the response of different postulated vessels.
Future work will be directed towards modelling voluntary sea-borne movement; that is, estimating the effort required for vessels to overcome current forces so as to maintain pre-selected routes.

Acknowledgements

This work was conducted as part of project SaRoCy, a two-year research project implemented under the "Excellence Hubs" Programme (contract number EXCELLENCE/0198/0143) of the RESTART 2016-2020 Programmes for Research, Technological Development and Innovation administered by the Research and Innovation Foundation of Cyprus. The project's website is https://sarocy.cut.ac.cy