VISUALISING SEASONALITY WITH SAILING SIMULATIONS:

THE CASE OF MONSOONAL EARLY MODERN PERIOD SOUTHEAST ASIA

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MONSOONS IN SOUTHEAST ASIA

The climate of Southeast Asia is largely governed by the Asian and Australian monsoons. These weather systems are millions of years old and define the wind and rainfall regimes of the region, which in turn have affected the lives, livelihoods, and movement of the people living there throughout history. The exact rain and wind patterns and their timings vary geographically across Southeast Asia, but generally, roughly half of the year is wet with prevailing winds from one direction, while the other half is dry with winds from the opposite direction. On the one hand, the winds are dependable and predictable, but on the other hand, they limit the directions in which one can sail. During the era of sailing ships, this made long-distance maritime movement highly seasonal (fig. 1).

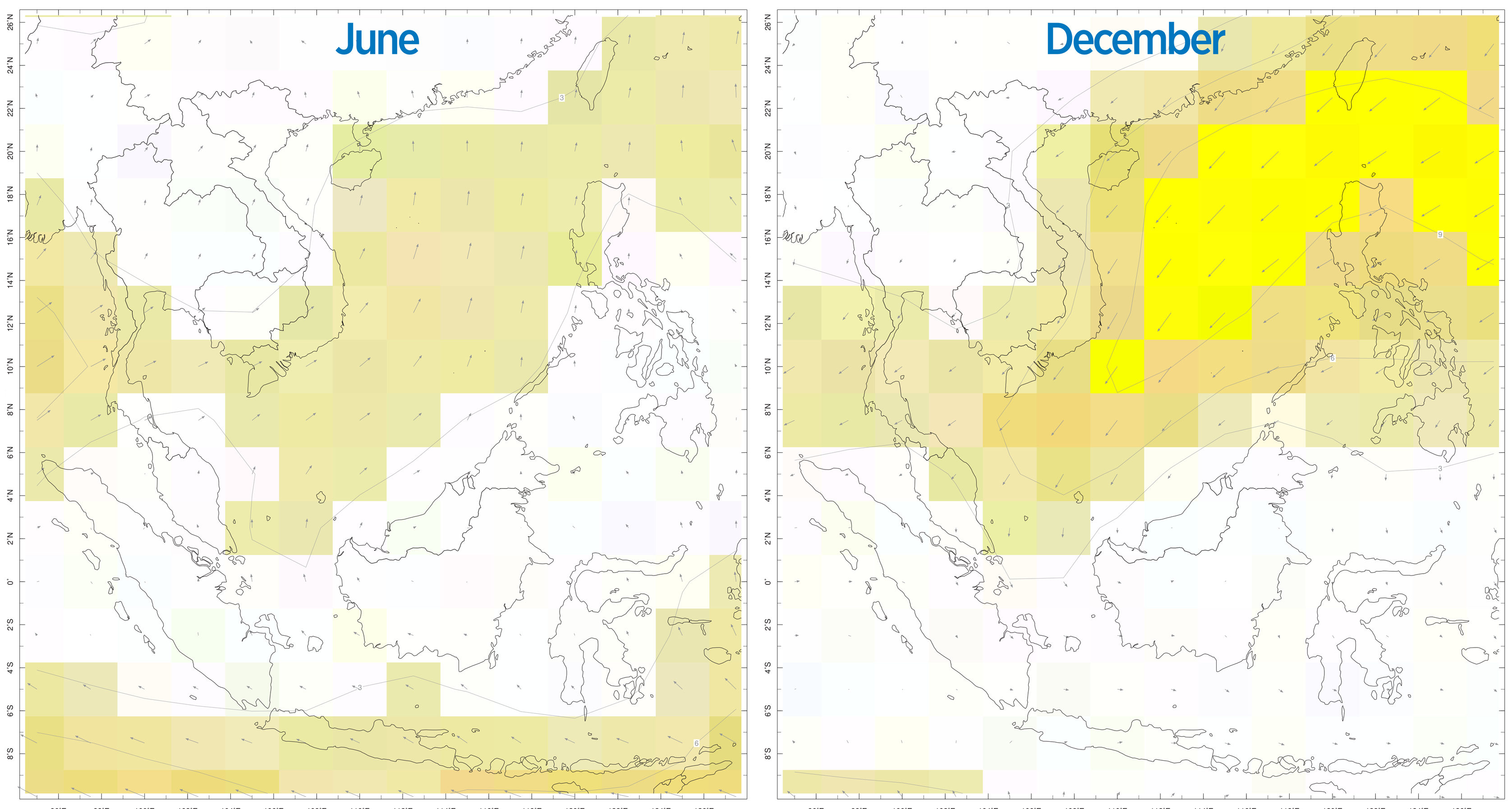

Fig. 1 Monthly average winds in June and December according to the 1991-2020 base period (NCEP/NCAR Reanalysis).

SAILING SIMULATIONS

One way to study this seasonality is sailing simulations. Typically, sailing models utilise information about the ship's sailing characteristics and environmental factors such as the wind, ocean currents and location of the shoreline in order to find an optimised route with the shortest sailing duration from point A to point B. Ships can be sent at the desired interval – for example, daily or weekly – to see how the optimal routes and durations change throughout the year. As detailed historical environmental datasets do not exist, modern data is usually used as a proxy.

WHAT DO YOU NEED TO MODEL SAILING?

- SAILING SIMULATION SOFTWARE
  - e.g. qtVlm, a free and ready out-of -the-box navigation and weather routing program
  - made for modern sailing applications but can be used to model historical sailing (Gal et al. 2021)
  - https://www.meltemus.com/
- ENVIRONMENTAL DATA
  - e.g. wind speed and direction from ERA5 – hourly data on single levels from 1940 to present
  - https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=form
  - download 10m u- and v-components of wind in .grib format
- POLAR CHART
  - a representation of the ship's sailing performance in different wind speeds and points of sail
  - can be measured for example from the sea trials of reconstructed historical ships
  - imported to qtVlm as a .csv file

POLAR FOR EARLY MODERN PERIOD SOUTHEAST ASIA SHIPS

The main local ship type used in long-distance trade throughout the Early Modern Period was the Chinese junk/Southeast Asian djong. However, I have been unable to find a polar chart derived from direct measurements for these types of ships and therefore opted to use performance values based on depictions of historical voyages with roughly similar ships (fig 2). Luckily, the Selden Map of China (Batchelor 2013), dating from c. 1619, contains information about sailing routes and their durations, and the results can be benchmarked against it. In our tests (Perttola 2022, Perttola & Kallio 2024; Perttola et al. n.d. a, n.d. b), the simulated sailing durations have matched with the Selden Map fairly well. The simulations can also be redone and refined if a better polar becomes available.

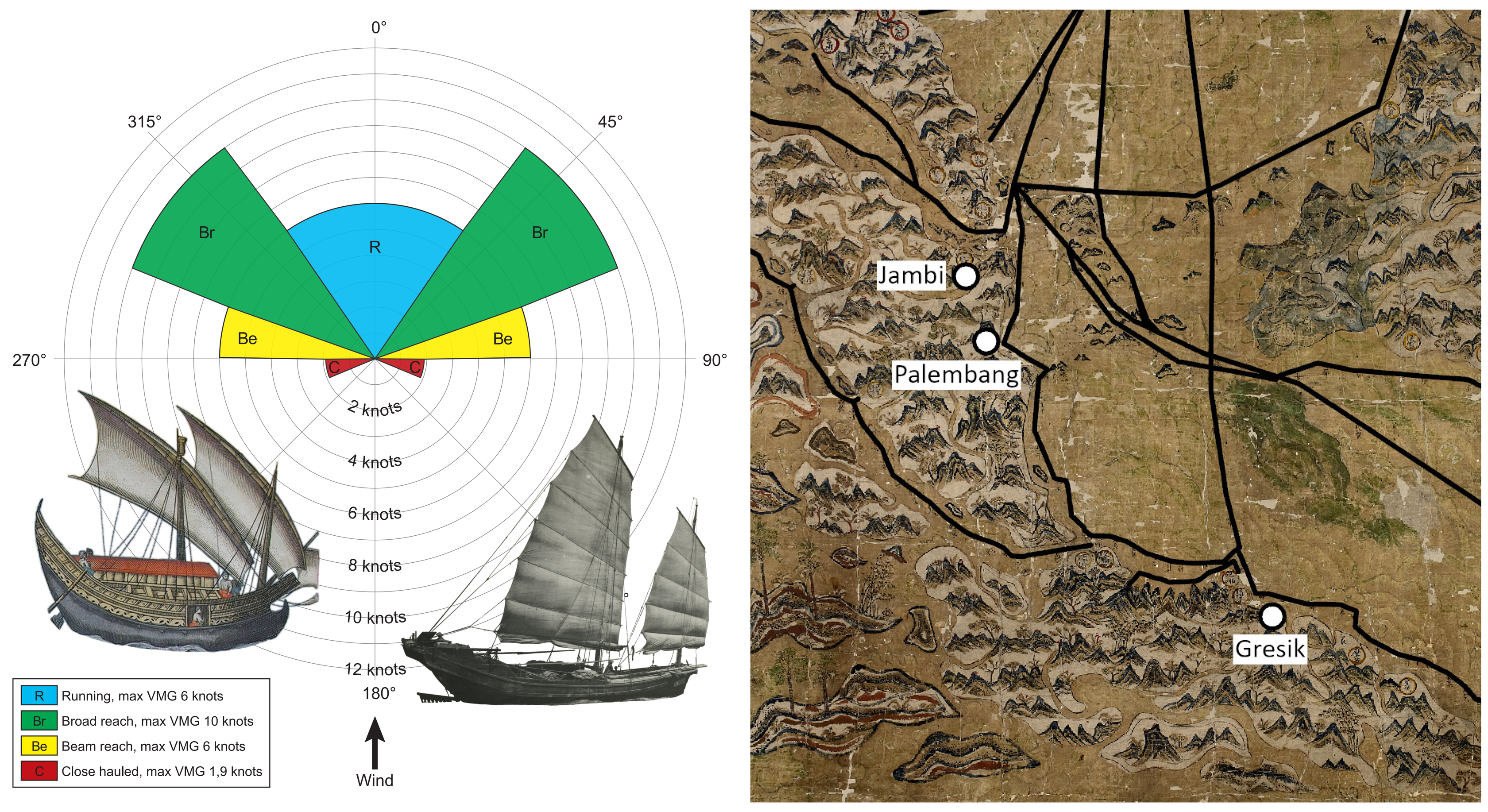

Fig. 2 *Left:* Polar chart of the effects of points of sail on the modelled ship's maximum velocity made good (VMG) (Perttola 2022, adapted from Whitewright, 2011: 14, fig. 5). Ships: Southeast Asian djong depicted by early European explorers (de Bry & de Bry 1599) & Chinese junk (photo: unknown, c. 1910, KITLV 104058, public domain). *Right:* A detail from the Selden Map of China showing the sailing routes (emboldened by the author) in the South China and Java Seas (photo: Bodleian Libraries, University of Oxford, MS. Selden Supra 105, Map recto, CC-BY-NC 4.0).

RESULTS

In this example, we simulated the sea portion of weekly voyages from Gresik, Java, to Palembang, Sumatra, using wind data from 1959–2020. The route is historically important because Jambi, in particular, became dependent on imported food due to cash-cropping black pepper in the early 17th century, while Java was a major producer and exporter of rice and salt. Our results (fig. 3) show that the simulated ship can make the c. 1000 km journey in May–September in an average of 6.8 days, and that the unrestricted routes cut through the open sea. However, the route instructions on the Selden map hug the coast and indicate a sailing duration of about 9.8 days. When forced to follow the coast, the simulated average duration increases to 11.8 days. Therefore, pure speed was not the only consideration when sailors chose their routes, and, for example, the ease of navigation when within the view range of landmarks was valued. Additionally, the start and end dates of the optimal sailing window can fluctuate by several weeks from year to year. This can be partly explained by the El Niño–Southern Oscillation (ENSO); for example, the year 2011 had a moderate La Niña event.

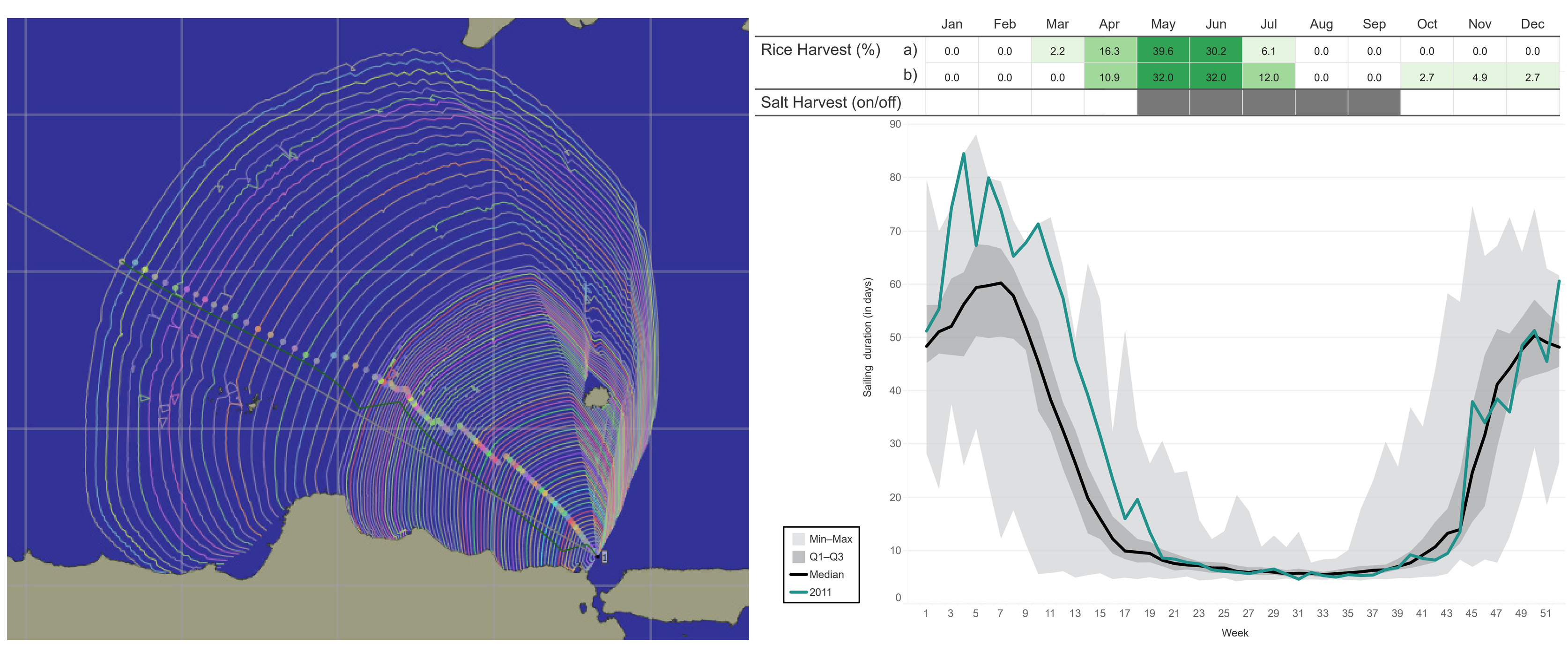

Fig. 3 *Left:* qtVlm simulation from Gresik to Palembang underway. qtVlm uses the isochronal method, where each isochrone line shows the furthest distance a ship could sail in a specific amount of time. *Right:* Five-number summary of the weekly sailing durations on the route Gresik–Palembang throughout 1959–2020 based on qtVlm simulations (Perttola et al. n.d. b) in comparison to the production schedules of rice and salt near Gresik.

CONCLUSION

Free out-of-the-box software such as qtVlm and high-resolution environmental datasets have made getting off the ground with sailing simulations more accessible than ever. The optimised routes they produce should not automatically be understood as the same as the actual routes used in the past, but rather as starting points for discussions on how maritime networks functioned. These networks do not function in a void; instead, they require interaction with the wider maritime cultural landscape. For example, by combining sailing simulations with production schedules on land, we can gain a better understanding of the timings within society. The methods are not limited to any geographical region or time period and can be used to simulate sailing on any sea or large lake. However, in areas where wind regimes are more erratic, a long-term analysis, as shown in fig. 3, becomes even more important to capture the variation.

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