

Oceanographic connectivity: finding the climate change signal

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Key words:	Physical oceanography, connectivity, dispersal, climate change, model
Research theme(s):	• Oceanography, Climate and Palaeoenvironment
Eligible courses for this project:	• DPhil in Earth Sciences (3-4 years) • Interdisciplinary Life and Environmental Science Landscape Award (ILES�A) • Intelligent Earth (UKRI CDT)

Overview

Where do things drift in the ocean? This simple question is incredibly important for many applications, from marine ecology to tracking plastic pollution, yet we still lack a robust understanding of how drift through ocean currents may change in the future. While climate change is expected to significantly impact surface currents from an *Eulerian* perspective (Peng et al., 2022), it is unclear to what extent this transfers to *Lagrangian* metrics such as potential connectivity (the likelihood of something drifting from point A to B over a certain drift time).

There is enormous variation in connectivity at sub-climate timescales due to eddies, seasons, and other modes of ocean-climate variability (e.g. Vogt-Vincent et al., 2023, fig. 1). With large (and often stochastic) variability in connectivity being the baseline, identifying a climate change signal is not straightforward. The goal of this DPhil project is to rigorously identify the physical drivers of temporal variability in connectivity at different scales, and to determine to what extent long-term changes in connectivity can be attributed to climate change. If climate change and/or quasiperiodic modes of ocean-climate variability are significant drivers of connectivity in the ocean, it may be possible to forecast connectivity (and consequences for marine ecosystems, pollution, etc.) over long timescales.

Methodology

For this project, we will use the NW Pacific as a case study, using state-of-the-art high-resolution ocean simulations spanning the 21st century. Using these hydrodynamic data and Lagrangian particle tracking, you will run large-scale dispersal simulations under past and future oceanographic conditions. You will develop robust statistical tests to investigate how the spatial structure of connectivity changes through time, and whether these changes can be attributed to different physical mechanisms (e.g. climate change, ENSO, etc). You will also investigate how these results depend on spatial scale and drift time, for instance whether there is a stronger climate change signal for shorter drift times or more closely

connected populations. Depending on your interests, you may wish to investigate particular applications of interest, such as implications for ecological range shifts or pollution.

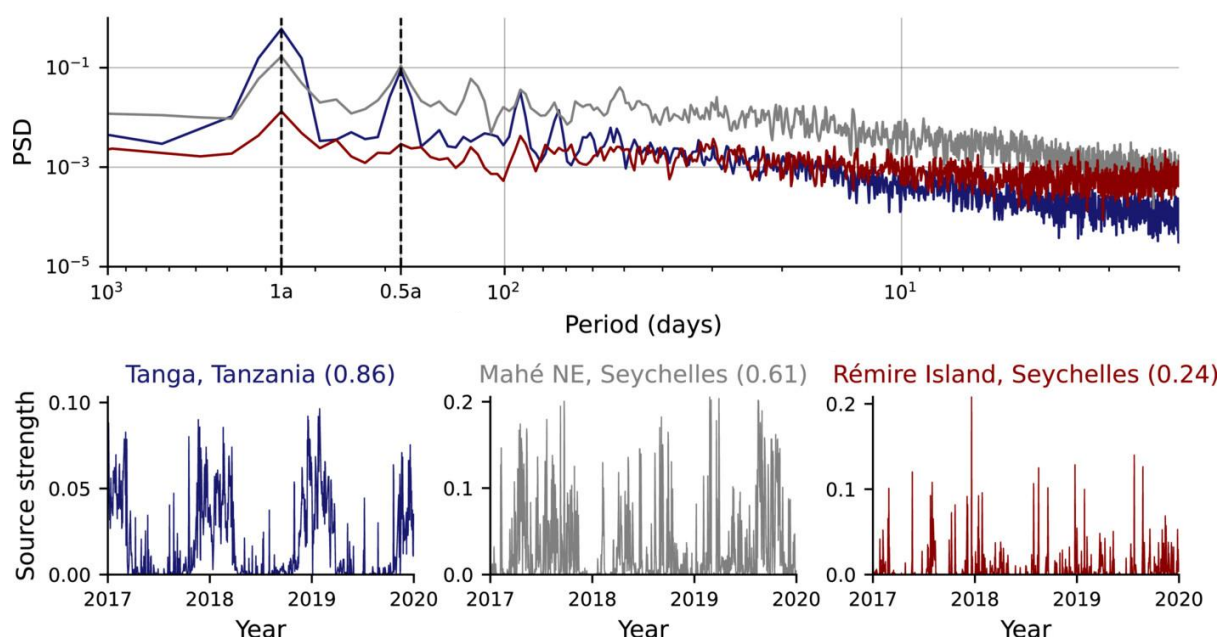


Figure 1: Frequency analysis of a connectivity metric between different sites, exhibiting strong seasonality (Tanga), weak seasonality (Mahé), and largely random variability (Rémire). Any climate change signal will need to be assessed relative to this background. Figure adapted from Vogt-Vincent et al., 2023.

Timeline

Year 1: Training and rotation projects (ILES/Intelligent Earth).

Years 2 and 3: Lagrangian simulations and analysis of climate-change simulations.

Year 4: Deep-dive into particular areas of interest and thesis write-up.

Training & Skills

The student will be provided training as required in physical oceanography and numerical modelling. Depending on student interests, further training and/or collaborators may be introduced into the project (e.g. in marine ecology). A strong quantitative background (ideally physical oceanography, physics, mathematics, engineering, or similar) is desirable for this project but specialist knowledge of oceanography is not essential.

References & Further Reading

Peng, Q., Xie, S.-P., Wang, D., Huang, R.X., Chen, G., Shu, Y., Shi, J.-R. and Liu, W. (2022). Surface warming–induced global acceleration of upper ocean currents. *Science Advances*, 8(16). doi:10.1126/sciadv.abj8394.

Vogt-Vincent, N.S., Mitarai, S. and Johnson, H.L. (2023). High-frequency variability dominates potential connectivity between remote coral reefs. *Limnology and Oceanography*, 68(12), pp.2733–2748. doi:10.1002/lno.12455.

Further Information

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