Finite-frequency phase shift

Improving the accuracy of time-domain surface-wave measurements: evaluation and correction of the finite-frequency phase shift

Yihe Xu[1,2] (yx362@cam.ac.uk), Sergei Lebedev[1,2], Thomas Meier[3]

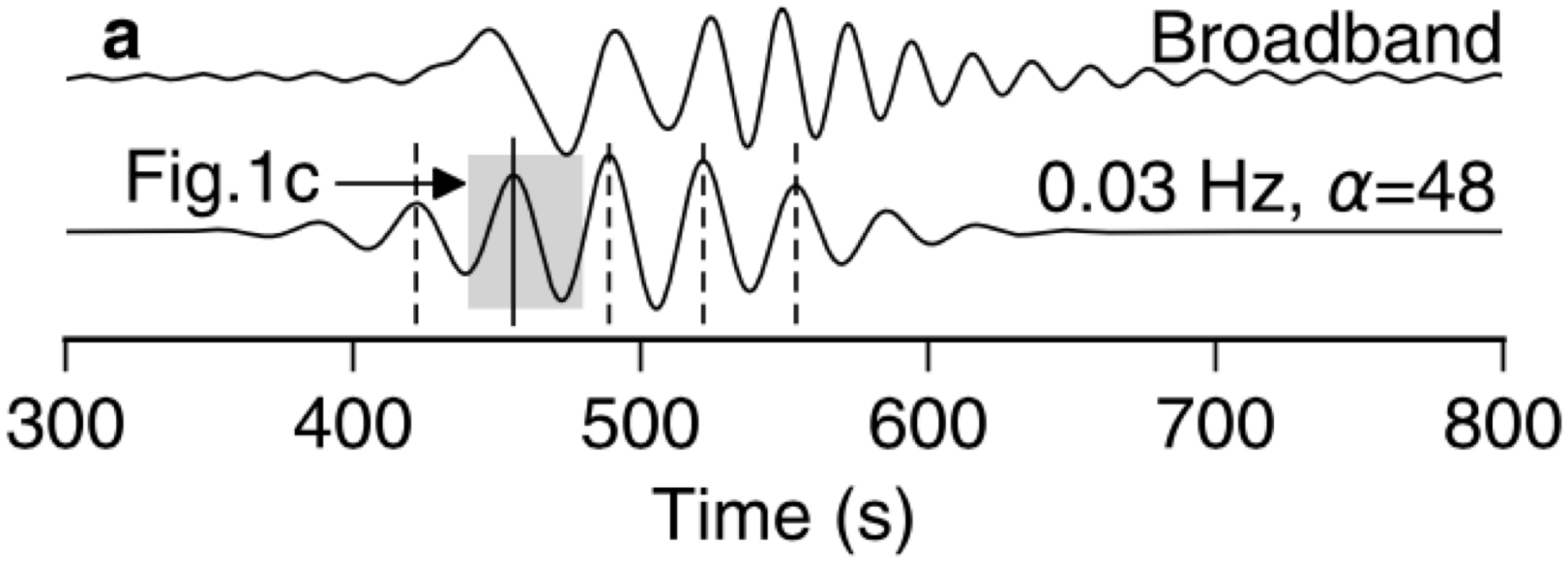
1 Department of Earth Sciences, Bullard Laboratories, University of Cambridge, Cambridge, UK
2 Geophysics Section, School of Cosmic Physics, Dublin Institute for Advanced Studies, Dublin, Ireland
3 Institute of Geophysics, Christian-Albrechts University Kiel, Kiel, Germany

25 May 2022, Vienna (Virtual)

EGU22-5753

Surface waves

- Surface waves travel along the Earth surface
- Surface waves are **dispersive**
- Reason: high-frequency surface waves are sensitive to shallower depth; low-frequency (or long-period) surface waves are sensitive to greater depth.

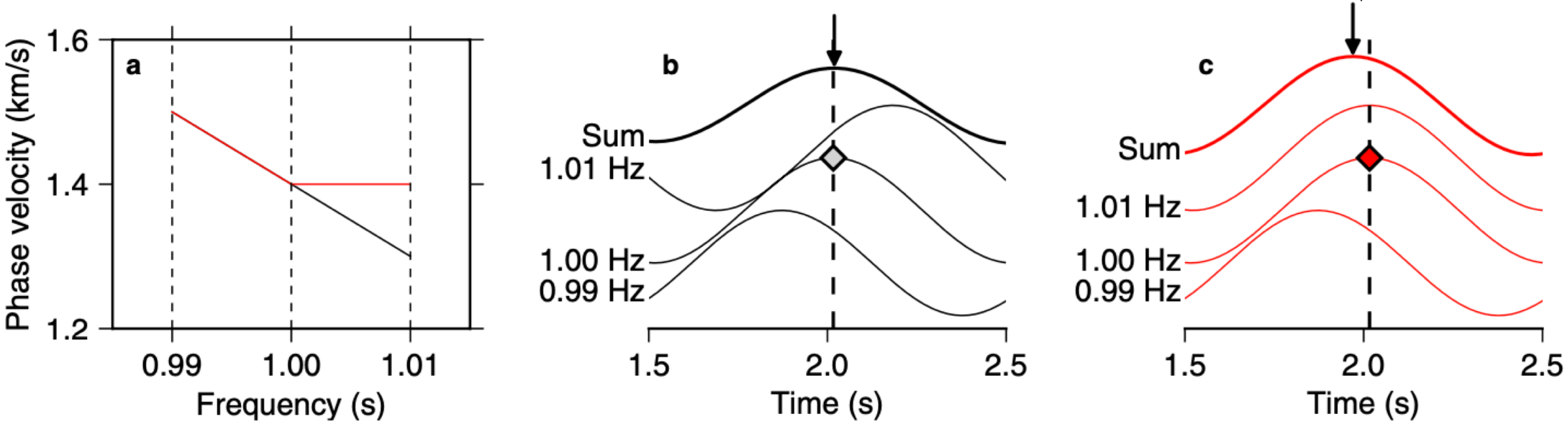


Xu et al., 2022

Finite-frequency phase shift

Assumption: narrow-band surface wave shares the same arrival time as the central frequency one.

Finite-frequency phase shift

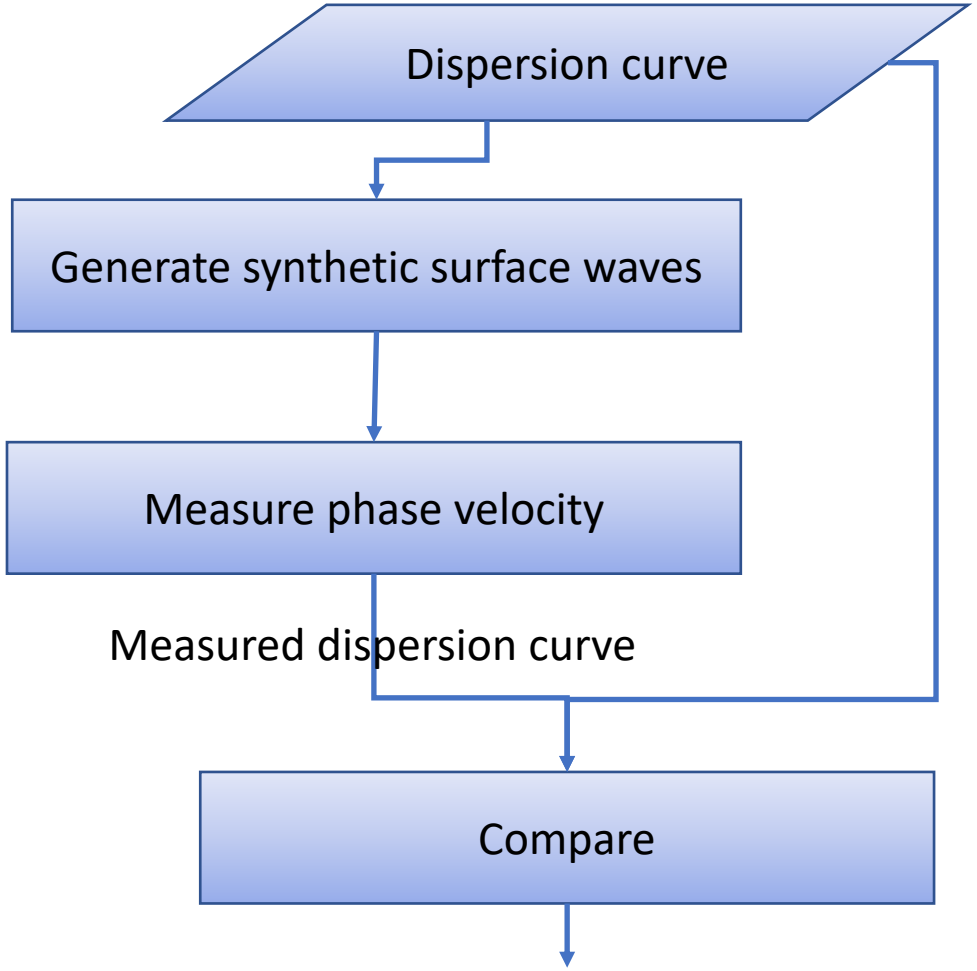


EGU22-5753

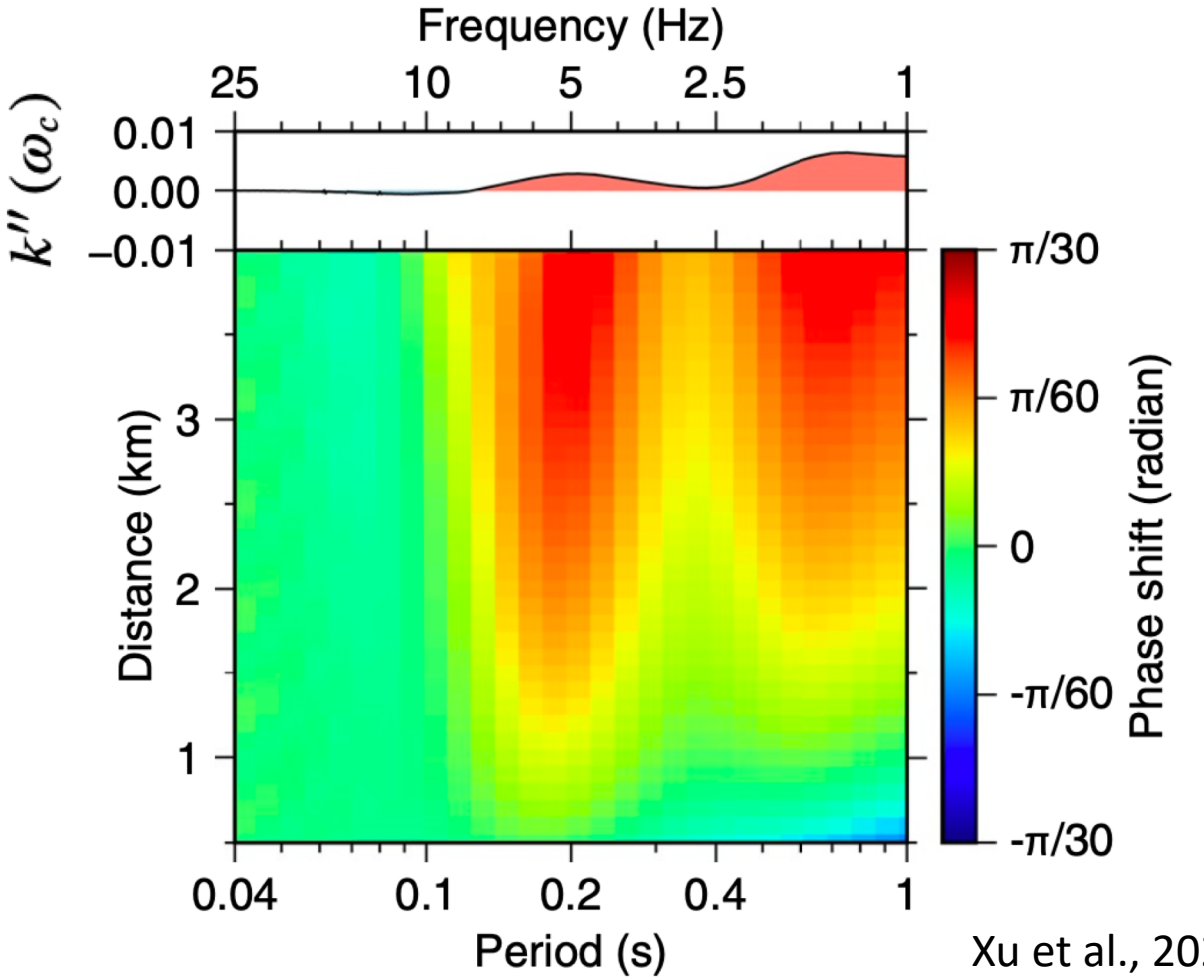
Early studies: Herrmann 1973; Wielandt and Schenk, 1983

Xu et al., 2022

Evaluation and removal of the error



Correction $\frac{1}{c} = \frac{1}{\tilde{c}} - \frac{\delta\phi}{\omega\Delta}$



EGU22-5753

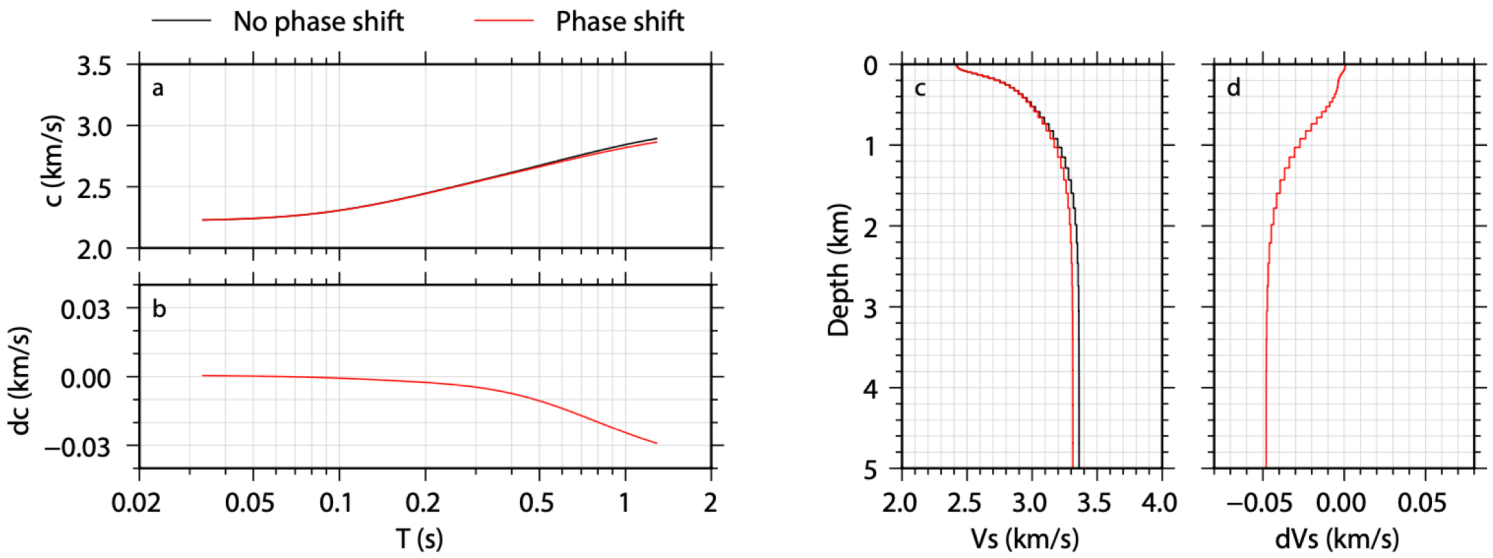
Xu et al., 2022

Is the phase shift relevant to my study?

Error ~ 1%

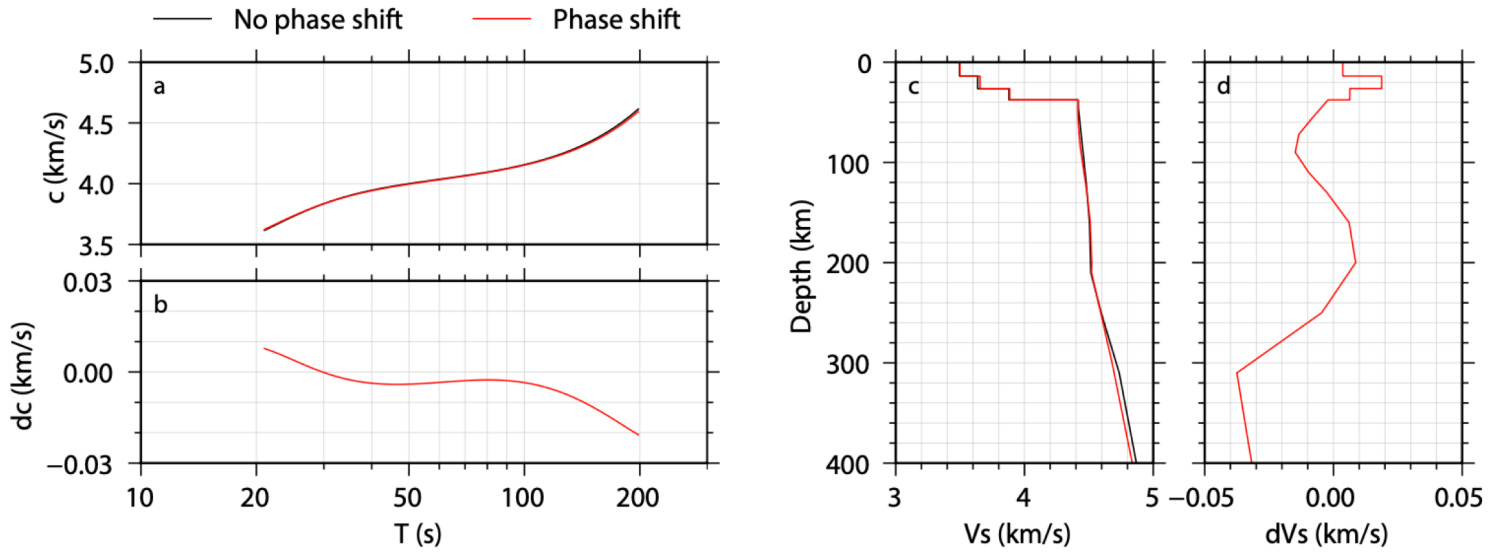
dVs ~ 50 m/s

- Bandwidth of the filter is not narrow enough
- large variations in phase velocity curves



Dublin basin

1-30 Hz



ak135

20-200 s

EGU22-5753

Xu et al., 2022

Conclusion

When your phase velocity measurements are **highly accurate (relative error < 1%)**, you should consider the correction of the finite-frequency phase shift (applies to time-domain methods).

Reference

Xu, Y., Lebedev, S., & Meier, T. (2022). Imaging the Earth using time-domain surface-wave measurements: Evaluation and correction of the finite-frequency phase shift. Journal of Geophysical Research: Solid Earth, 127, e2021JB023701. https://doi.org/10.1029/2021JB023701

Software and Data

Xu, Y. (2021). blazing216/finite-frequency-phase-shift: November 22, 2021 Release (Version 1.0.1) [Software]. Zenodo. https://doi.org/10.5281/ zenodo.5718901

Github

https://github.com/blazing216/finite-frequency-phase-shift/tree/v1.0.1

PHASE SHIFT

yx362@cam.ac.uk

EGU22-5753