37th SIL 2024
FOZ DO IGUAÇU | BRAZIL

Transport and mixing induced by internal seiche destabilization on sloping topography

Rafael de Carvalho Bueno, Tobias Bleninger, and Andreas Lorke

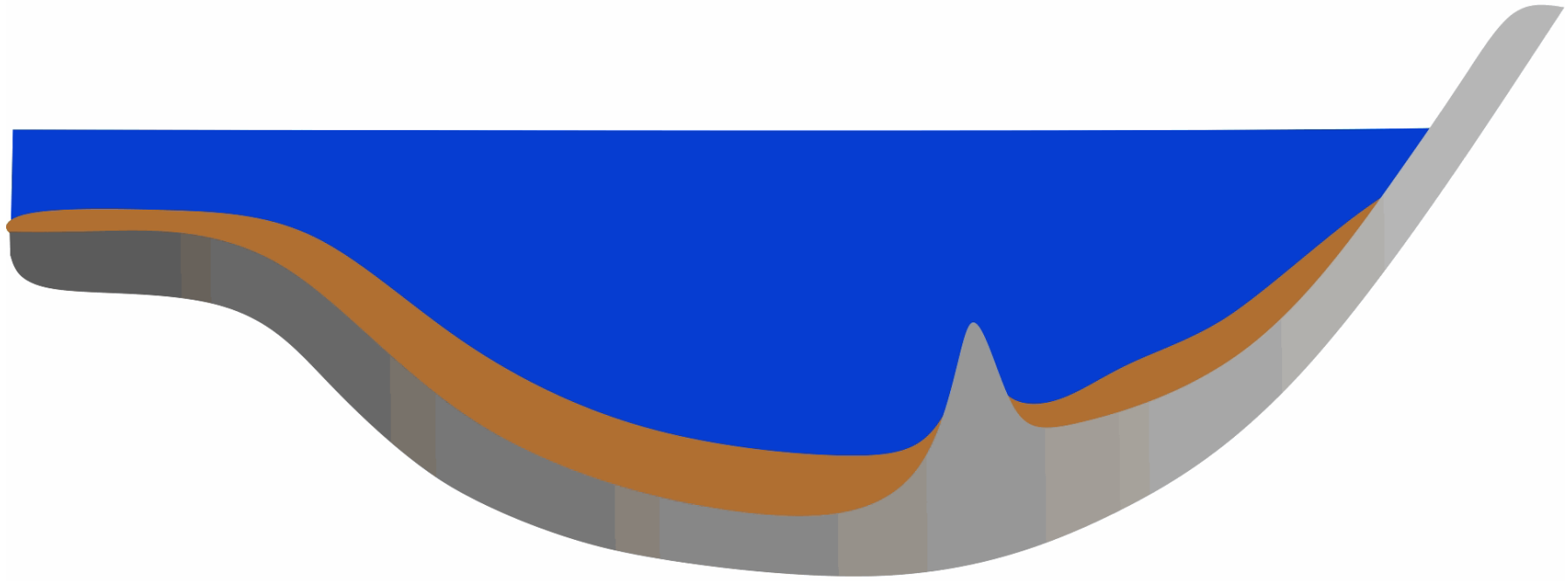




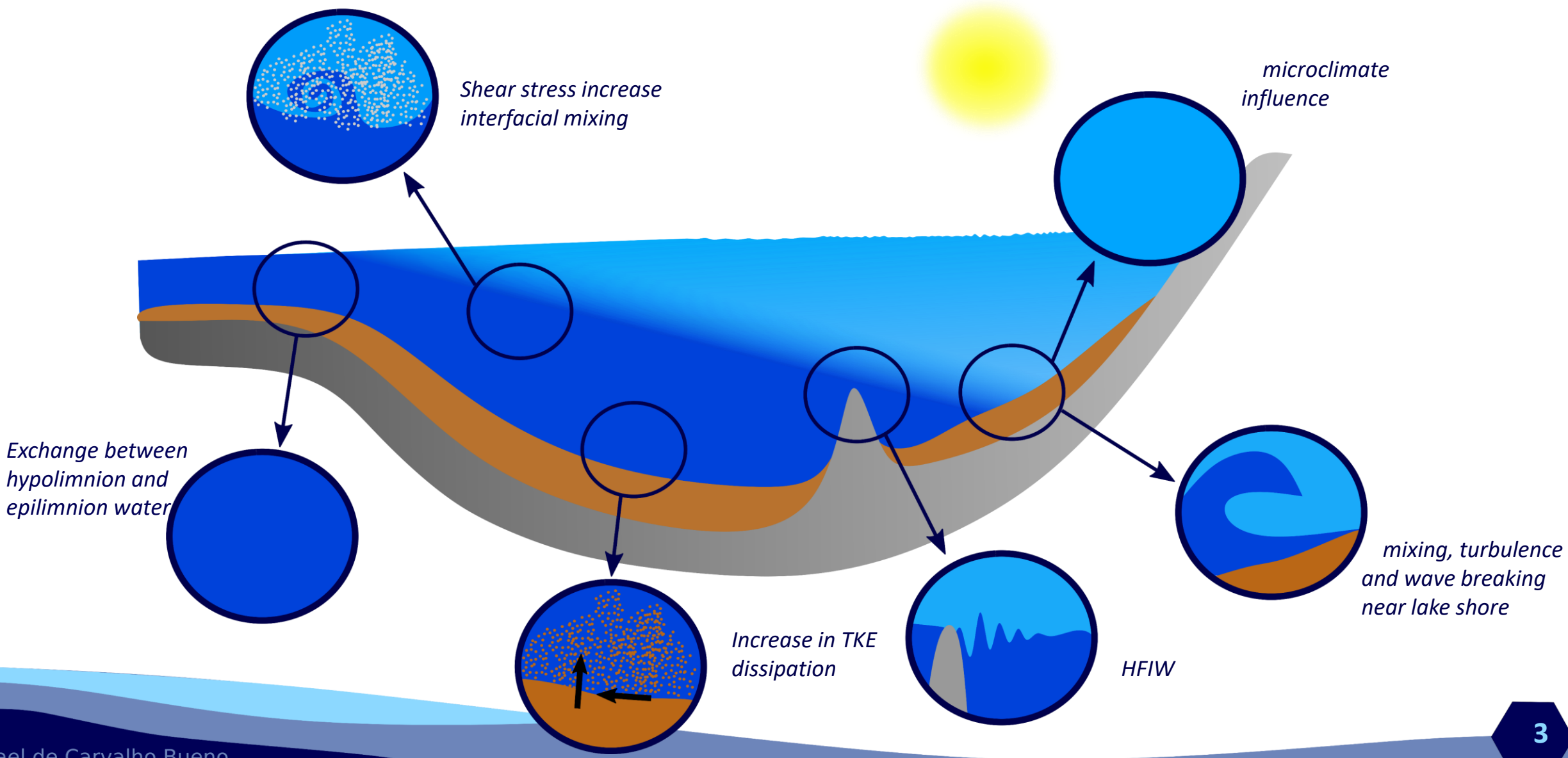




Internal waves in lakes and reservoirs



1. Introduction



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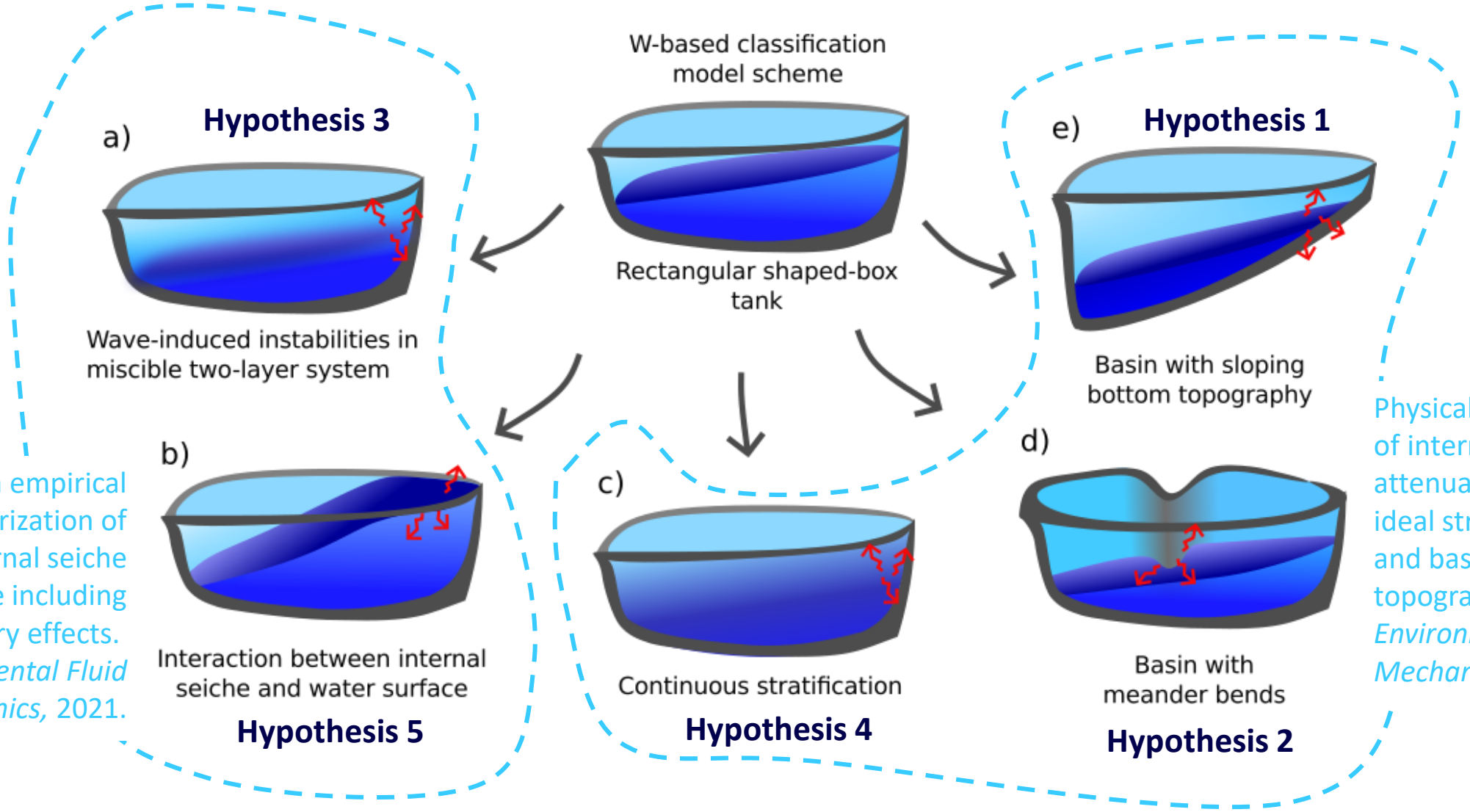
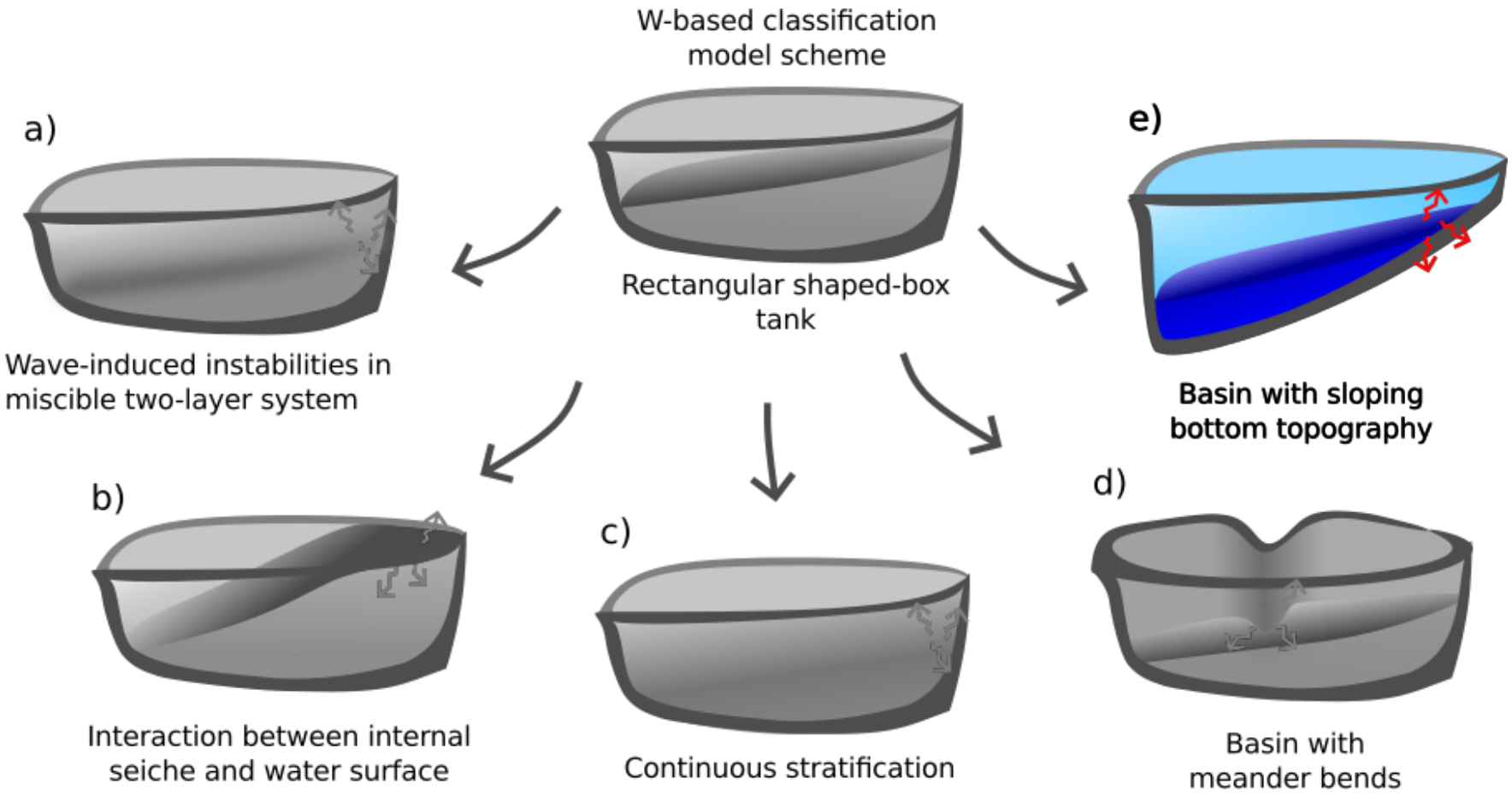


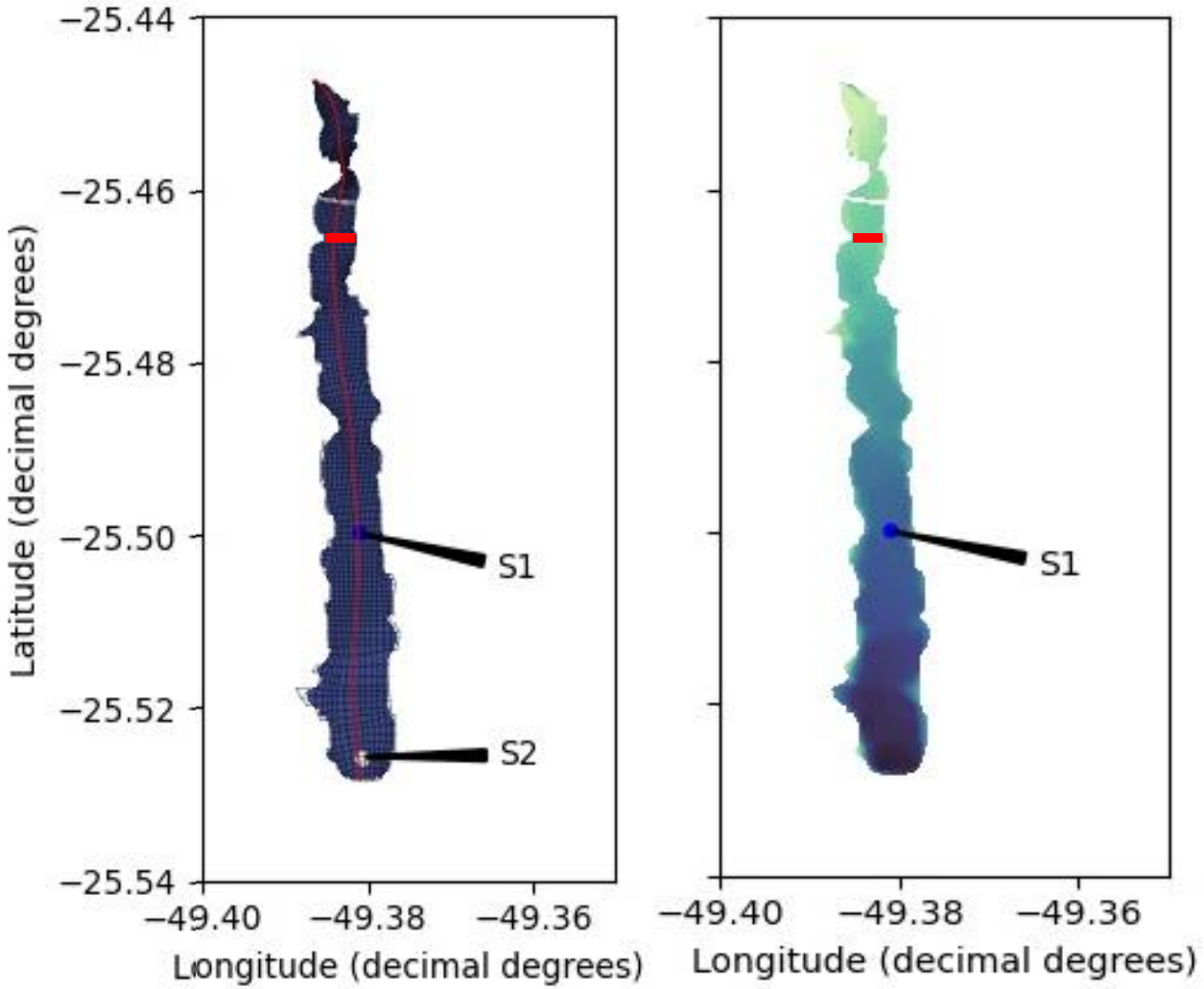
An empirical parametrization of internal seiche amplitude including secondary effects. *Environmental Fluid Mechanics,* 2021.

Physical mechanisms of internal seiche attenuation for non-ideal stratification and basin topography. *Environmental Fluid Mechanics, 2023*.

1. Introduction



2. Methods



Delft3D - Hydrostatic approximation

2 scenarios

1. *Rectangular shaped-box tank*
2. *Reservoir with sloping topography*

horizontal grid	*from 10 m to 100* m
vertical resolution	*75 cm (20 layers)*
temporal resolution	*1 minute*

2. Methods

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Internal wave analyzer for thermally stratified lakes

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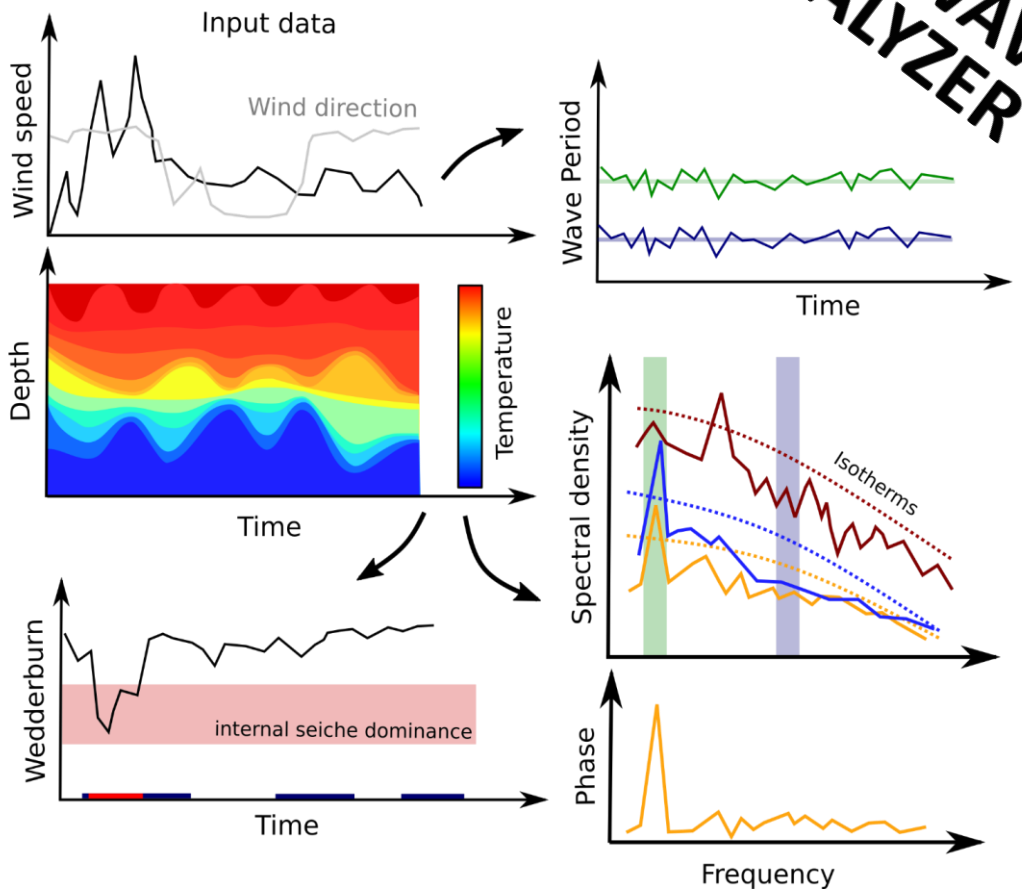
Internal wave spectrum
Spectral analysis
Isotherm fluctuation
Internal wave model
Lake mixing

ABSTRACT

Interwave Analyzer is an open source software that provides detailed characterization of the dynamics of internal waves in lakes and reservoirs. It is based on well-established theories and empirical knowledge on internal waves and lake mixing and facilitates a general physical classification of lakes and reservoirs. As input data, the program requires time series of water temperature from various depths and meteorological data, which can be obtained from measurements or numerical models. Interwave Analyzer performs an in-depth analysis of periodic motion by spectral analysis to identify predominant internal wave periods. To facilitate the identification of wave modes, the software is coupled with a multi-layer model. Interwave Analyzer is a powerful, easily accessible, and universal tool, which can be used for obtaining detailed understanding lake hydrodynamics not only in physical sciences, but also in the context of water quality, ecological interactions and biogeochemical fluxes in aquatic ecosystems.

de Carvalho Bueno, R., Bleninger, T., & Lorke, A. (2021). Internal wave analyzer for thermally stratified lakes. *Environmental Modelling & Software*, *136*, 104950.

INTERWAVE ANALYZER

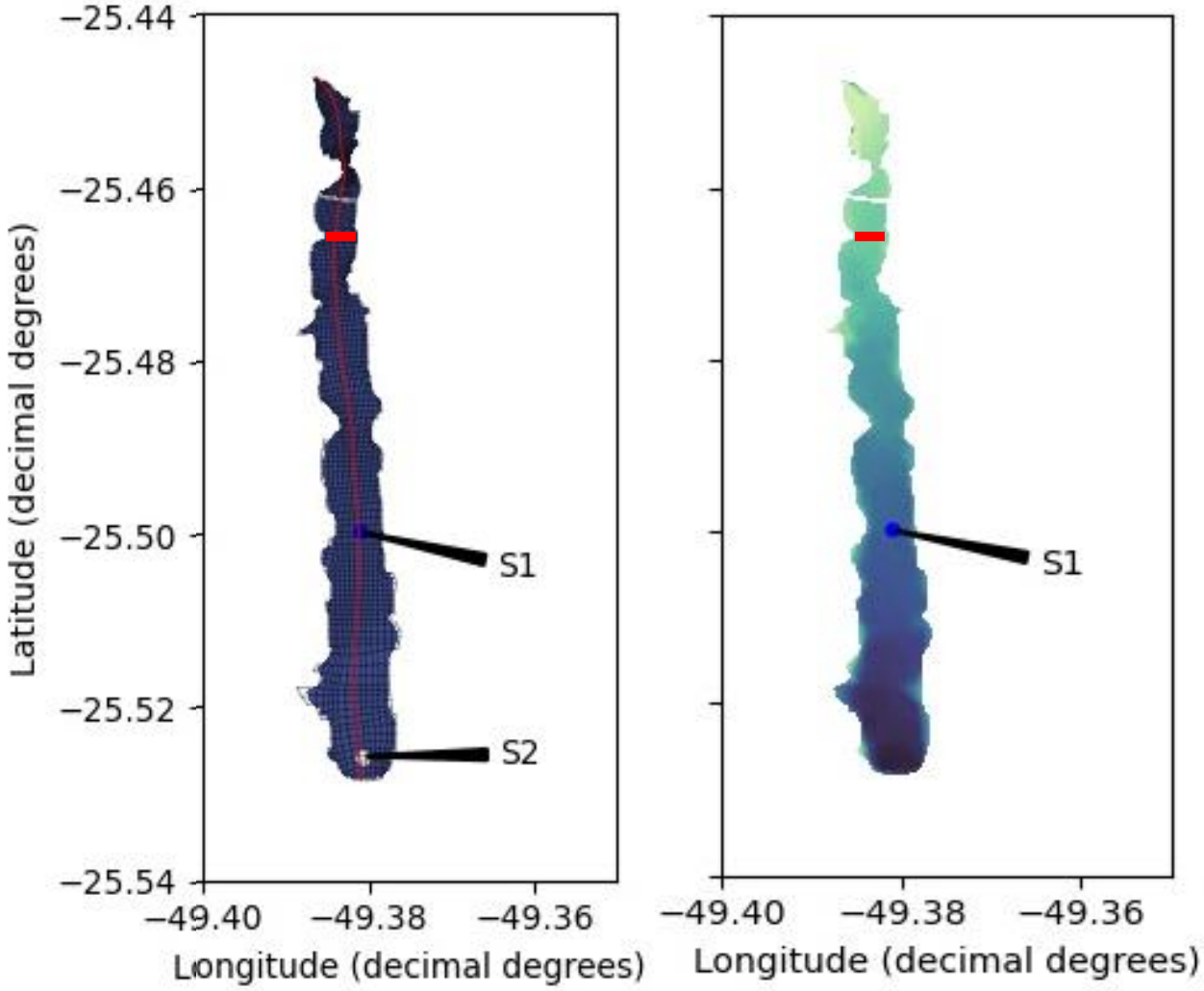


2. Methods

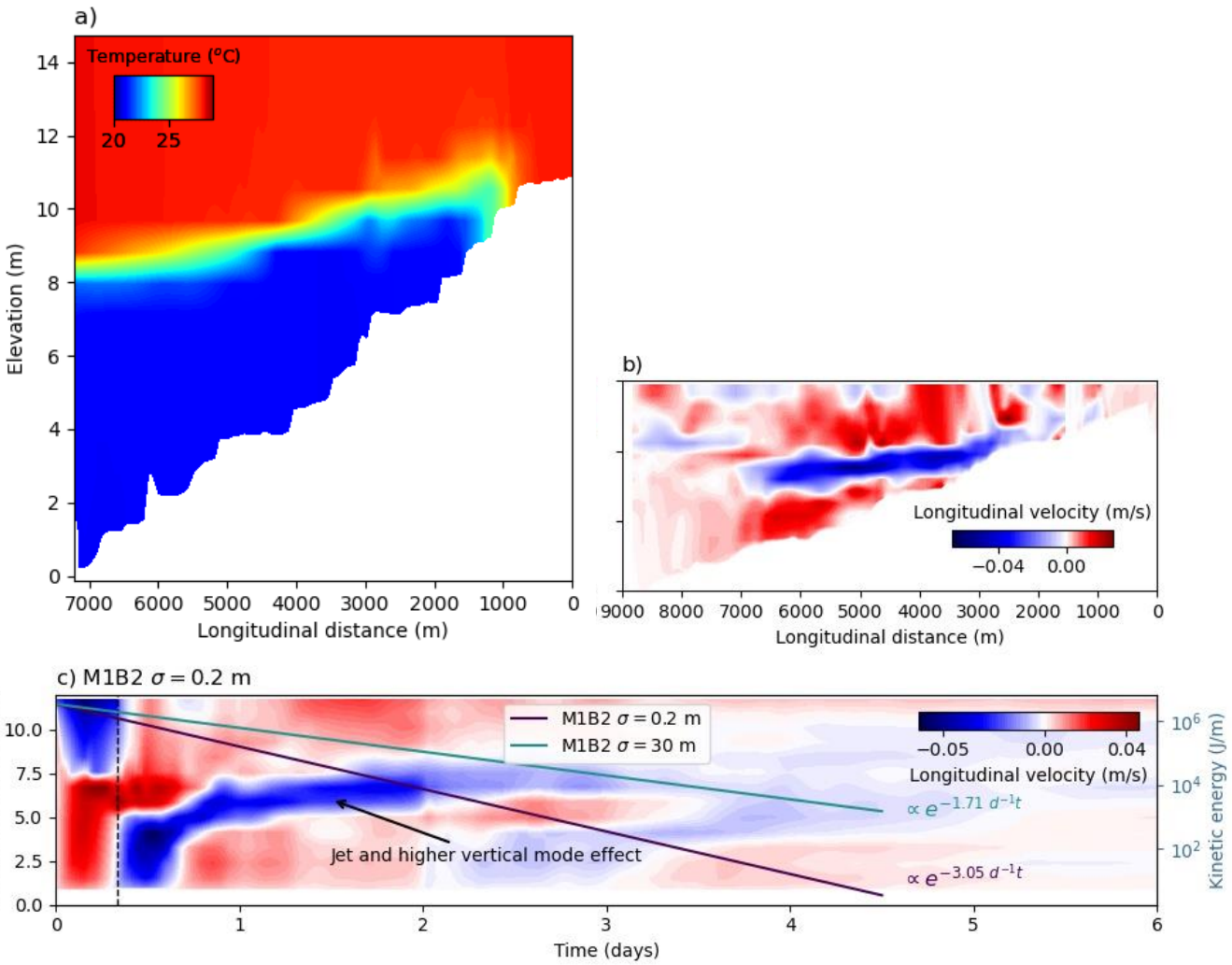
$$E(t) = \int_0^L \int_0^B \int_{z_o}^H \rho(x,y,z)\, u(x,y,z,t)^2 \mathrm{d}z\, \mathrm{d}y\, \mathrm{d}x$$

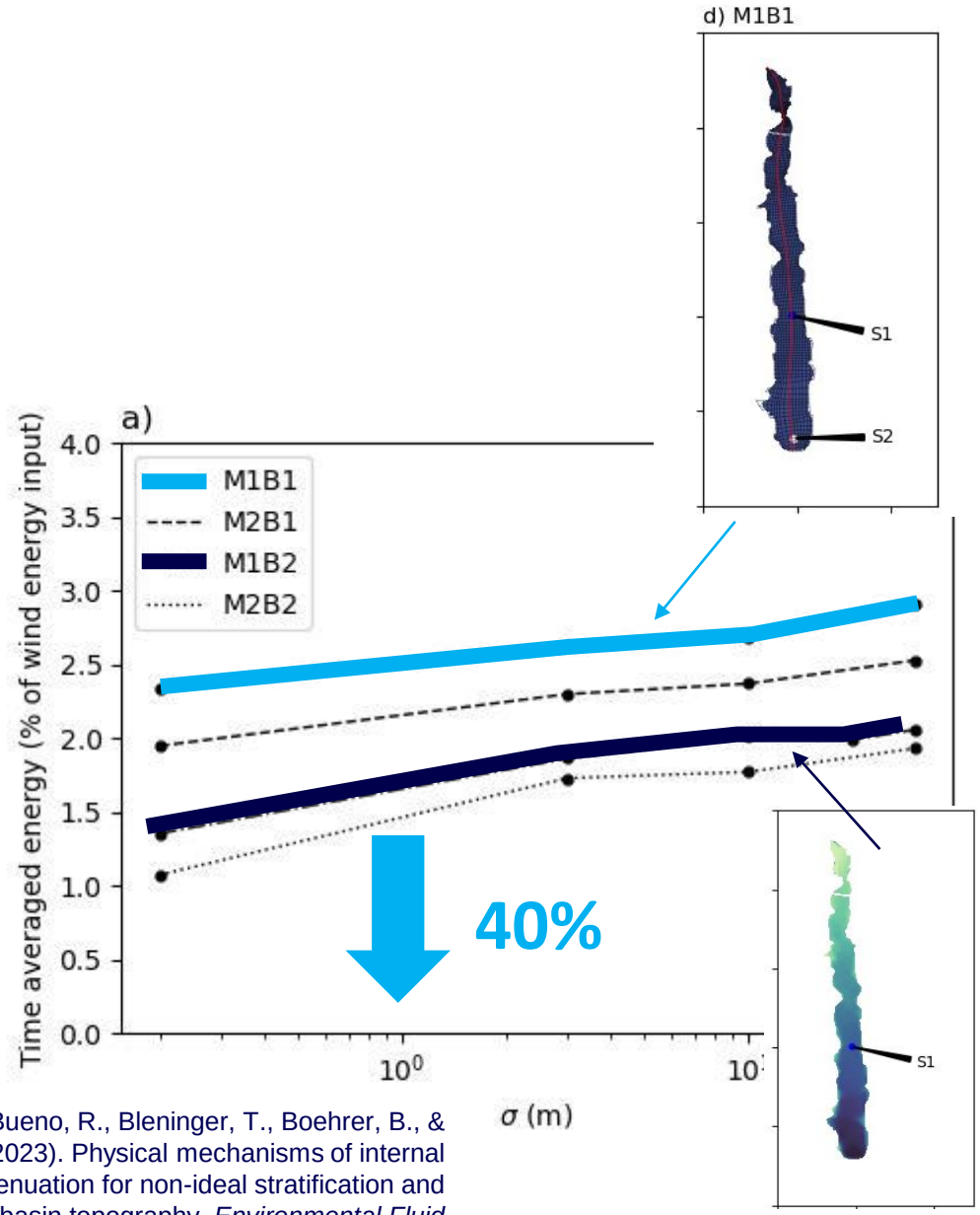
Wind energy transferred to water

$$E_{\text{wind}} = \tau \int_0^{T_{\text{wind}}} \int_0^L \int_0^B u_{z=0}(x,y,t)\, \mathrm{d}y\, \mathrm{d}x\, \mathrm{d}t,$$



3. Results





de Carvalho Bueno, R., Bleninger, T., Boehrer, B., & Lorke, A. (2023). Physical mechanisms of internal seiche attenuation for non-ideal stratification and basin topography. *Environmental Fluid Mechanics*, *23*(3), 689-710.

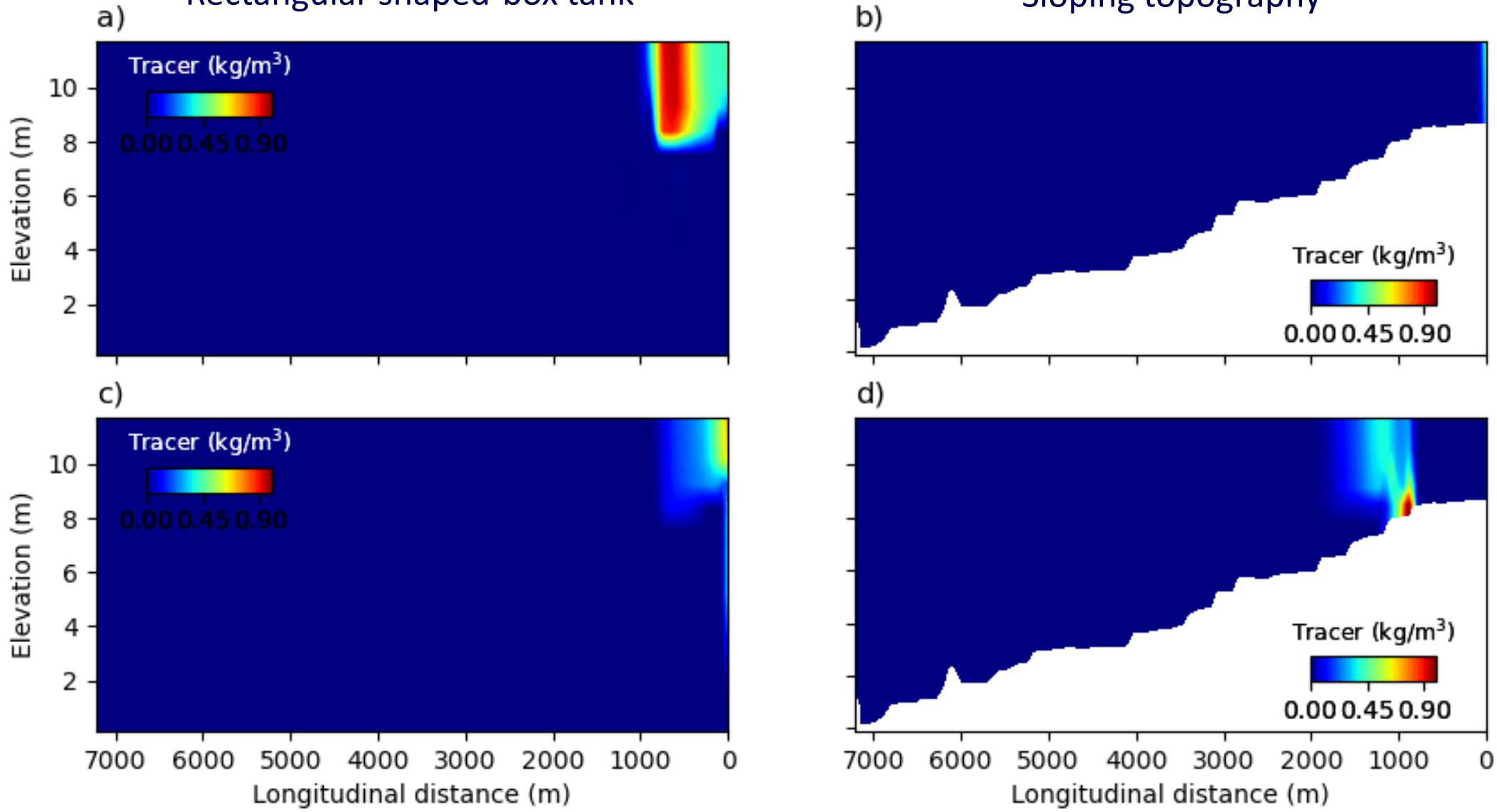
3. Results

Rectangular shaped-box tank

Sloping topography

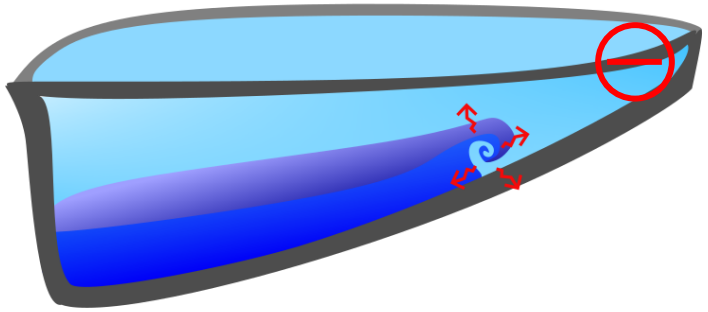
Surface tracer (kg/m³)

Middle depth - thermocline tracer (kg/m³)

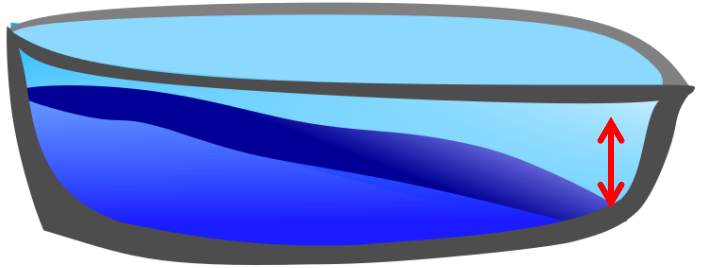


4. Conclusion

- Internal seiche destabilization on gently sloping beds may contribute to increased vertical mixing of substances and organisms near the thermocline region. In lakes with steep topography, substances tend to be transported more up and down due to the passage of internal waves.



- Gentle lake topography may attenuate transport and mixing at the surface boundary layer, whereas in steep topography, waves may increase mixing within the surface boundary layer due to continuous wave motion



Thank you for your attention !!

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