Reservoir computing for spatial reconstruction of Rayleigh–Bénard convection

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Turbulent thermal convection drives a variety of natural flows. This includes, but is not limited to, currents in the oceans, convection in the Earth's mantle, and atmospheric flows. The development of models for this flow will allow us to better understand and predict the environment at a macroscopic level. While turbulent flow modeling is difficult due to the complex underlying physical equations, the application of Machine Learning (ML) might be beneficial. A well-known standard model of thermal convection is Rayleigh–Bénard Convection (RBC). In this regard, long-term stereoscopic PIV experiments have recently been conducted for RBC in a cuboid cell of an aspect ratio of 10 for Rayleigh number of $Ra = 5.5 \times 10^6$ in the SCALEX facility at TU Ilmenau [1]. This study aims to apply ML, in particular reservoir computing, to the experimental data to model turbulent thermal convection. Several studies have recently shown the potential of reservoir computing in turbulent flow modeling [2] [3] [4]. The goal of the current study is to provide the reservoir with some of the flow properties and reconstruct the remaining properties of the flow. This will reveal to which extent the dynamics of the flow is distributed within the respective variables. Although this is a spatial reconstruction of the flow, it will open the way for modeling the flow with respect to time.

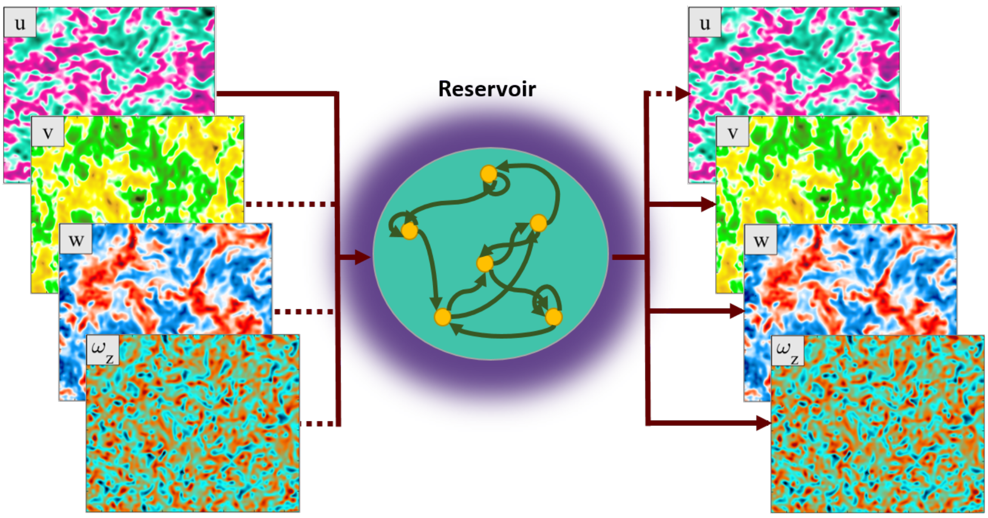

Figure 1: A schematic sketch of the study.

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[1] Sharifi Ghazijahani et al., *tm-Technisches Messen*, (2023).

[2] Sharifi Ghazijahani et al., *Measurement Science and Technology* **34**, 014002 (2022).

[3] Heyder and Schumacher, *Phys. Rev. E* **103**, 053107 (2021).

[4] Valori et al., *Phys. Rev. Research* **4**, 023180 (2022).