MODELING GLOBAL SURFACE DUST DEPOSITION USING PHYSICS-INFORMED NEURAL NETWORKS

CONSTANZA A. MOLINA CATRICHEO, FABRICE LAMBERT, JULIEN SALOMON, AND ELWIN VAN 'T WOUT

ABSTRACT. Physics-Informed Neural Networks (PINNs) follow an innovative approach to data analysis and physical modeling through machine learning, as they incorporate physical principles into the data-driven learning process. They can numerically solve partial differential equations while fitting the approximated function to a dataset. While these algorithms have attracted a lot of attention recently, their predictive skill on empirical data is still uncertain. Here, we develop PINNs to reconstruct global maps of atmospheric dust surface deposition fluxes from measurement data in paleoclimatic archives.

Paleoclimatic measurements serve to understand geophysical processes and evaluate climate model performances. However, their spatial coverage is generally sparse and unevenly distributed across the globe. Statistical interpolation methods are the prevalent techniques to grid such data, but these purely data-driven approaches sometimes produce results that are incoherent with our knowledge of the physical world.

In this study, we design an advection-diffusion equation to consider dominant wind directions at various latitudes, which prevents dust particles from flowing upwind. PINN calculations are performed on empirical data for the Holocene and Last Glacial Maximum periods. The results show that our PINN improves on standard kriging interpolation by allowing variable asymmetry around data points. The reconstructions display realistic dust plumes from continental sources towards ocean basins following prevailing winds.

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SCHOOL OF ENGINEERING, PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE, SANTIAGO, CHILE

GEOGRAPHY INSTITUTE, PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE, SANTIAGO, CHILE

INRIA PARIS, ANGE PROJECT-TEAM, PARIS, FRANCE AND CNRS, LABORATOIRE JACQUES-LOUIS LIONS, SORBONNE UNIVERSITÉ, PARIS, FRANCE

INSTITUTE FOR MATHEMATICAL AND COMPUTATIONAL ENGINEERING, PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE, SANTIAGO, CHILE
Email address: e.wout@uc.cl