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PUBLICATIONS & PROJECTS

Machine Learning Gravity Wave Parameterization Generalizes to Capture the QBO and Response to Increased CO2 | *Published* | **Geophysical Research Letters**

- Espinosa, Z. I., Sheshadri, A., Cain, G. R., Gerber, E. P., & DallaSanta, K. J. (2022). Machine learning gravity wave parameterization generalizes to capture the QBO and response to increased CO2. *Geophysical Research Letters*, 49, e2022GL098174. https://doi.org/10.1029/2022GL098174
- We present single-column gravity wave parameterizations (GWPs) that use machine learning to emulate non-orographic gravity wave (GW) drag and demonstrate their ability to generalize out-of-sample. A set of artificial neural networks (ANNs) are trained to emulate the momentum forcing from a conventional GWP in an idealized climate model, given only one view of the annual cycle and one phase of the QuasiBiennial Oscillation (QBO). We investigate the sensitivity of offline and online performance to the choice of input variables and complexity of the ANN. When coupled with the model, moderately complex ANNs accurately generate full cycles of the QBO. When the model is forced with enhanced CO2, its climate response with the ANN matches that generated with the physics-based GWP. That ANNs can accurately emulate an existing scheme and generalize to new regimes given limited data suggests the potential for developing GWPs from observational estimates of GW momentum transport.

Drivers of the Seasonal Delay of Rainfall in the Amazon Rainforest

- Authors: Zachary I. Espinosa, Lai-yung Ruby Leung, Fengfei Song
- Tropical precipitation has a distinct annual cycle characterized by an amplitude, the range between wet and dry seasons, and phase, their onset timing. Previous studies have reported a seasonal delay in the onset of precipitation in observations over the northern tropical land driven by changes in greenhouse gases (GHG) and anthropogenic aerosols (AER). Here, we use multi-model output of historical and individual forcing simulations to show that the seasonal delay of precipitation in the Amazon rainforest cannot be fully explained by changes in GHG and AER. We examine the impact of land use and land cover change, and we perform an atmospheric energy budget analysis for the Amazon Basin.

NetQuil: A Quantum Playground for Distributed Quantum Computing Simulations | *Publicly Accessible* | **NetQuil**

- Contributors: Zachary I. Espinosa, Matthew Radzihovsky, Yewon Gim
- We built and published an open-source Python framework designed for simulating quantum networks and distributed quantum protocol. NetQuil is built on the quantum computing framework pyQuil, by Rigetti Computing, and is useful for extending current quantum computing experiments and testing ideas in quantum network topology and distributed quantum protocol.

Henry's Fork Foundation Water Quality Monitoring Site | *Publicly Accessible* | **HFF WQM**

- Contributors: Melissa Muradian, Zachary I. Espinosa, and Justin Appleby
- We built an automated data-collection network of sensors in the Henry's Fork Water Shed near Yellowstone National Park. We then built and published a water quality monitoring website that is updated in real-time and used by local scientists to study the health of the hydrological system. This project has also served as the cornerstone of HFF's scientific communication mission.

PRESENTATIONS & POSTER SESSIONS

Speaker | **AGU Fall Meeting** | Machine Learning Emulation of Parameterized Gravity Wave Momentum — Dec 2021

Speaker | **EGU General Assembly** | Machine Learning Emulation of Parameterized Gravity Wave Momentum — Apr 2021

Speaker | **AGU Fall meeting |** A Data-Driven, Single-Column Gravity Wave Parameterization in an Idealized Model — Dec 2020

Speaker | **MSCAR |** A Data-Driven, Single-Column Gravity Wave Parameterization in an Idealized Model — Sep 2020

Speaker | **CalGFD |** A Data-Driven, Single-Column Gravity Wave Parameterization in an Idealized Model — Aug 2020

Poster | **APS March Meeting (Canceled) | N**etQuil: A playground for quantum networking simulations — Mar 2020

Poster | **Stanford Deep Learning Poster Session |** Distracted Driver Detection — Jun 2018

• Used ensembled model of ResNet-18, DenseNet-121, and Inception-V3 to detect distracted drivers through dashboard camera.

Poster | **Stanford Artificial Intelligence Post Session |** Tracking Schistosomiasis with Computer Vision — Mar 2018