

# Zachary Espinosa

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## PUBLICATIONS & PROJECTS

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### **Machine Learning Gravity Wave Parameterization Generalizes to Capture the QBO and Response to Increased CO<sub>2</sub> | *Published* | [Geophysical Research Letters](#)**

- Espinosa, Zachary I., et al. "Machine Learning Gravity Wave Parameterization Generalizes to Capture the QBO and Response to Increased CO<sub>2</sub>." *Geophysical Research Letters* 49.8 (2022): 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 Quasi-Biennial 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 CO<sub>2</sub>, 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, and Justin Appleby
- 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

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Speaker   <b>AGU Fall Meeting</b>   Machine Learning Emulation of Parameterized Gravity Wave Momentum	Dec 2021
Speaker   <b>EGU General Assembly</b>   Machine Learning Emulation of Parameterized Gravity Wave Momentum	Apr 2021
Poster   <b>AGU Fall meeting</b>   A Data-Drive, Single column Gravity Wave Parameterization in an Idealized Model	Dec 2020
Speaker   <b>MSCAR</b>   A Data-Drive, Single column Gravity Wave Parameterization in an Idealized Model	Sep 2020
Speaker   <b>CalGFD</b>   A Data-Drive, Single column Gravity Wave Parameterization in an Idealized Model	Aug 2020
Poster   <b>APS March Meeting (Canceled)</b>   netQuil: A playground for quantum networking simulations	Mar 2020
Poster   <b>Stanford Deep Learning Poster Session</b>   Distracted Driver Detection	Jun 2018
Poster   <b>Stanford Artificial Intelligence Post Session</b>   Tracking Schistosomiasis with Computer Vision	Mar 2018