Machine Learning Parameterizations from the Surface to the Clouds

***David John Gagne**, Rich Loft, Andrew Gettelman, Jack Chen, Tyler McCandless, Branko Kosovic, Tom Brummet, Sue Ellen Haupt, Bai Yang**

*National Center for Atmospheric Research, *ERT, Inc., FDR/ARL/NOAA*

Motivation

We use machine learning to either emulate or improve on existing atmospheric parameterization.

1. Microphysics: Can we emulate a computationally-intense scheme within a more efficient scheme?
2. Surface Layer: Can we use many observations to train a ML model to improve on existing schemes?

Microphysics Methods

Problem: Use neural networks to emulate bin microphysics processes in bulk microphysics scheme

Data: Run CAM6 globally for two years globally with TAU bin and MG2 bulk microphysics

Inputs: QC, QR, NC, NR, density

Outputs: Cloud and Rain Water Tendencies

Models: Dense neural networks

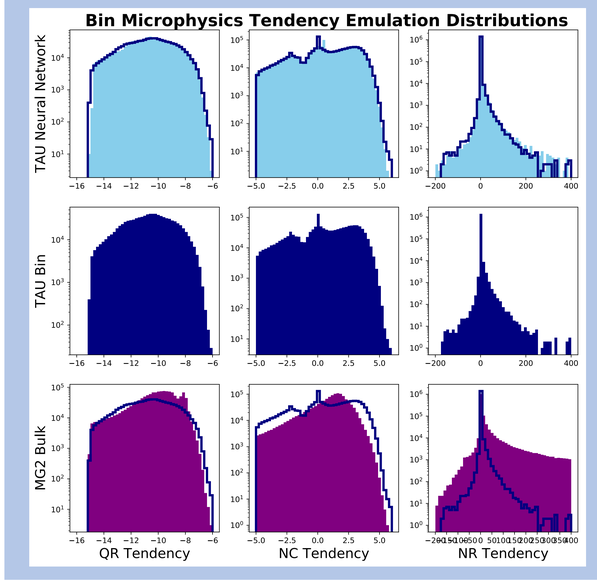
Surface Layer Methods

Problem: Predict surface momentum and heating fluxes from surface atmospheric profiles

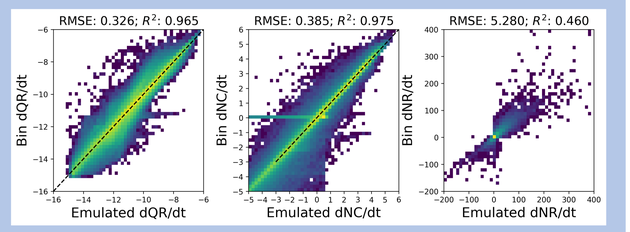
Data: Flux and tower observations from Cabauw, Netherlands, and Scoville, Idaho

Models: Random forests and neural networks for u*, θ*, and q*

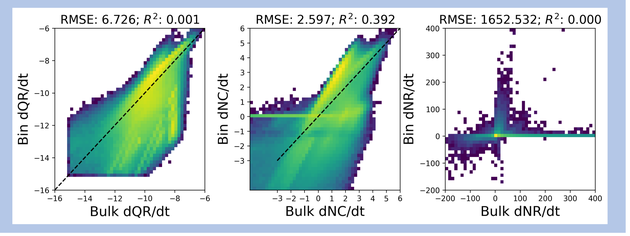
Neural networks can emulate the distributions and sensitivities of the cloud-to-rain conversion processes in a bin microphysics scheme.



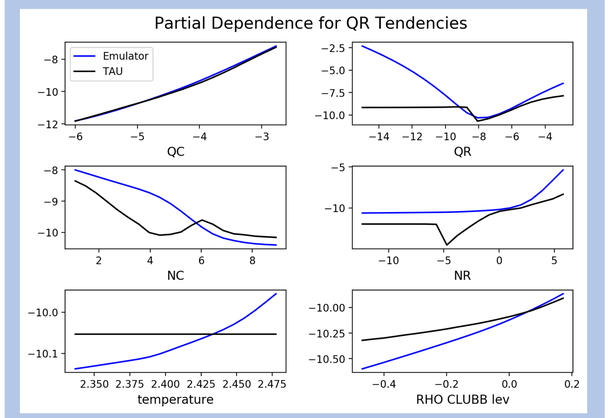
Neural Network vs. TAU Bin



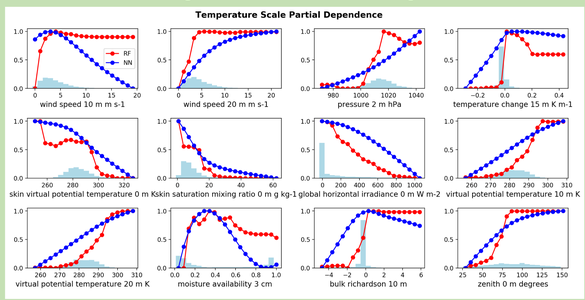
MG2 Bulk vs. TAU Bin



Microphysics Partial Dependence



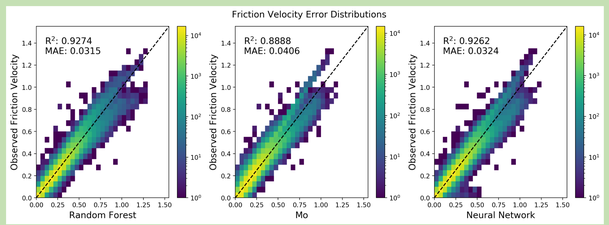
Surface Layer Partial Dependence



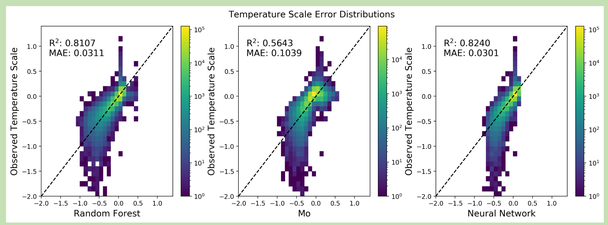
Partial dependence shows the sensitivity of mean prediction to changes in input values.

Machine learning of surface layer energy fluxes improves on Monin-Obukhov similarity theory.

Friction Velocity



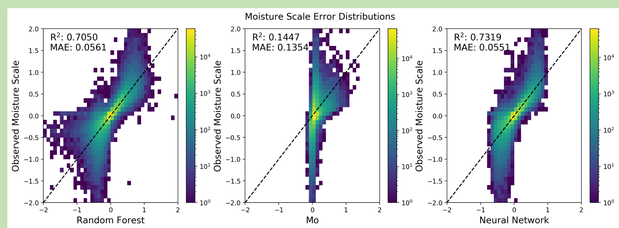
Temperature Scale



ML Cross-Testing R^2

Cabauw Data	U*	θ*	Q*
MO	0.90	0.44	0.14
RF from Cabauw	0.93	0.82	0.73
RF from Idaho	0.90	0.77	0.49

Moisture Scale



Next Steps

Fortran neural network and random forest parameterization modules have been developed. Now integrating Fortran ML parameterizations with WRF and CESM.

Please Contact Me

Email: dgagne@ucar.edu

Twitter: @DJGagneDos

Github: djgagne

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