**Emulating RRTMG with Deep Neural Networks for the Energy Exascale Earth System Model**

Anikesh Pal, Matthew R Norman

Oak Ridge National Laboratory

[pala@ornl.gov](mailto:sedovaaa@ornl.gov)

**Abstract**

The RRTMG radiation scheme in the Energy Exascale Earth System Model (E3SM), is a bottleneck and consumes approximately $50\%$ of the computational time. To simulate a case using RRTMG radiation scheme in ACME-MMF with high throughput and high resolution will therefore require a speed-up of this calculation while retaining physical fidelity. In this study, RRTMG radiation is emulated with Deep Neural Networks (DNNs).

The first step towards this goal is to run a case with ACME-MMF and generate input data sets for the DNNs. A principal component analysis of these input data sets is carried out. Artificial data sets are created using the previous data sets to cover a wider space. These artificial data sets are used in a standalone RRTMG radiation scheme to generate outputs in a cost-effective manner. These input-output pairs are used to train multiple architectures DNNs (1). Another DNN (2) is trained using the inputs to predict the error. A reverse emulation is trained to map the output to input. An error-controlled code is developed with the two DNNs (1 and 2) and will determine when/if the original parameterization needs to be used.