Improving the Capabilities and Computational Efficiency of the RTE+RRTMGP Radiation Code

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Making good radiation better

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The past

RTE+RRTMGP is a new radiation code brought to you by me and AER (RRTMG)

RTE solves the radiative transfer equation; RRTMGP defines a problem for gases

RRTMGP is accurate because it's trained on current spectroscopic data, but algorithms are well-established*. The focus was computational, with inter-related goals of flexibility, efficiency, and hygiene

*Well-established but complete: including scattering of LW radiation, flexible coupling with surface properties, sophisticated examples of cloud optics…

See https://github.com/earth-system-radiation/rte-rrtmgp, https://doi.org/10.1029/2019MS001621

The present

Code is integrated into E3SM, default within ECP, just missed v2 water cycle campaign

WUR built a C++ front end (used as part of RCEMIP)

A collaboration with DOE started us on the road to an OpenACC GPU enabled version. This is now running at CSCS for very high-resolution QUIBICC simulations as part of an all-GPU version of ICON

Usability enhancements: Jacobian of longwave flux w.r.t surface temperature, more flexible specification of solar source (NRLSSI2, TSI)

Algorithmic enhancements: faster treatment of scattering of LW radiation by clouds; pre-processing for topography

Two ML replacements for gas optics lookup tables (but not ready for prime time)

Spinoffs: Clima/Julia, ECP/YAKL… at least we made it look easy

The future

More GPU: CUDA kernels, integrate OpenMP integration (Nichols Romero LANL)

More C++ (targeted SCREAM): front-end to synchronize development with Fortran reference

Less "cost": develop alternative data with varying spectral detail and sensitivity, targeted at applications

More physics: first-order effects of a spherical atmosphere, more consistent treatment of gas and cloud optics

Less shoe-horning: investigate alternative spectral structures for better coupling to vegetation, ocean