A novel Monte Carlo thermal radiative transport method: vectorizable variance reduction for the energy spectra

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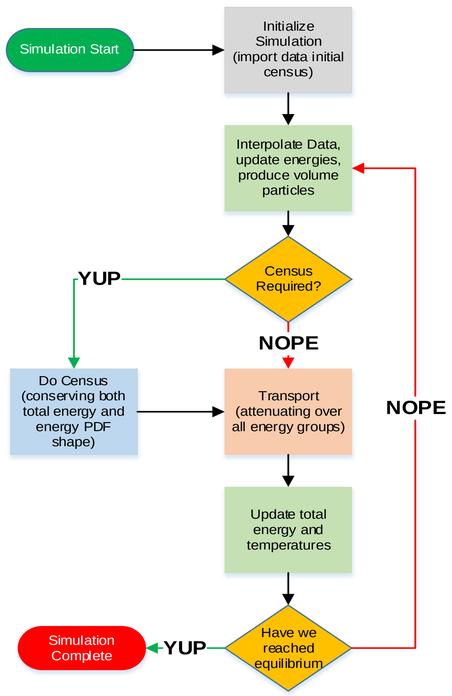
Objective

Produce a variance reduction method to resolve the energy space in MC TRT.

Method

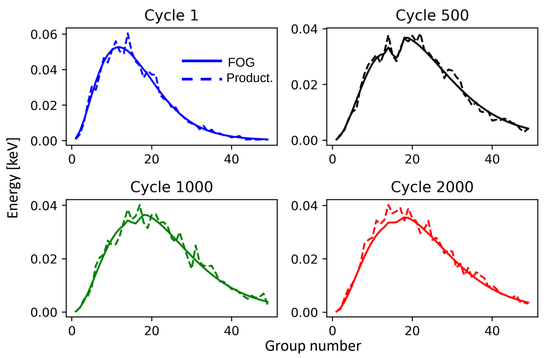
- A “flock of geese” (FOG) particle is sent through traditional transport carrying a vector of energy weights over all groups
- Presents multiple locations within transport that will be data parallel
- Does not require major alterations to fit into current production codes



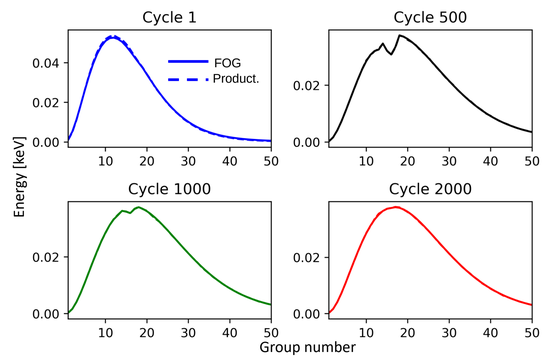
Confirmation of Method

Energy Spectra

The method can use an order of magnitude fewer particles to get the same resolution in energy space as production codes



FOG Particles: 10k, Production Particles: 10k



FOG Particles: 10k, Production Particles: 5mil

Temp v Time

The method matches temperature profiles through time of production codes

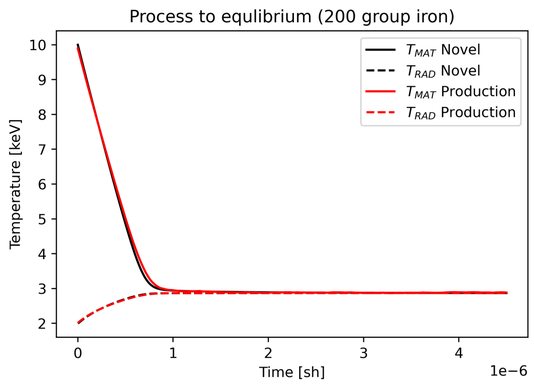


Table of Runtimes

We can mitigate the performance hinderance of the method via vectorization but still take a hit

#	Condition	Particle Count	time [s]
1	FOG vec off	10k	48.40
2	FOG vec on	10k	16.33
3	Production	10k	7.64
4	Production	2mil	2345

The order-of-magnitude decrease in particle count needed for our method to achieve similar variance outweighs the modest increase in runtime

Conclusions

The method provides good variance reduction at amenable runtimes, though further work is required

Future Work

- Take test bench from 0 to 1 spatial dimension
- Split thick and thin opacity groups to avoid forcing collisions
- Test on other architectures
- Test with a Marshak wave

References

Thompson, Kelly Glen, Mathew Allen Cleveland, Alex Roberts Long, Kendra Phyllis Long, Ryan Thomas Wollaeger, Benjamin Ransom Ryan, and Timothy M Kelley. *Jayenne Physics Manual, Revision 1.0 - An Implicit Monte Carlo Code for Thermal Radiative Transfer* (2021). Web.

Acknowledgements

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