Quick Look: Variance Reduction at Scale

Improving IMC variance reduction methods for thermal transport problems

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Background & Interests

Education, Work, and Research

- **Gonzaga Univ., Spokane WA**
  - Physics & Math-Computer Science
- **Consultant for GroGuru Inc.**
  - Established an async. RS-485 serial communication protocol variant for two indep. µCs via near field magnetic induction antennae
- **GSRP 2018 Summer Intern**
  - Designed a cosmic ray muon detector advancing upon the MIT Cosmic Watch project
  - Capable of particle energy approx. and air-shower coincidence detection
  - AJP publication in review
- **Electrical Impedance Tomography**
  - Cont. Fall 2019; Numerical Methods for PDE approx. for medical imaging technologies

My History and Interests

Background & Overview of Research

Variance Reduction for IMC

- IMC is stochastic – there is inherent uncertainty in the solution
- Variance reduction methods are implemented to improve simulation efficiency while producing equivalent unbiased results

Response Functions and Research Objective

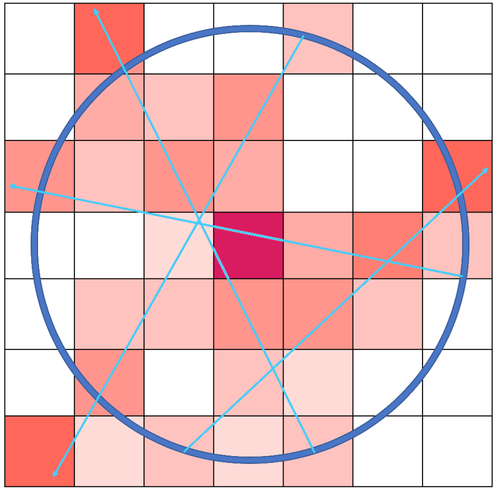
- A response function VRM is designed to reduce variance by increasing the number of particles that contribute to solution tallies
- Explore use in modeling astrophysical events such as multi-dimensional supernova transients

Method

1. Calculate the backwards approx. to get a response opacity for each cell
2. Run simulation using the response opacity to contribute to the tally:

$$Contribution = E_{particle} * e^{-\left(\sigma_r + \frac{1}{c\Delta t}\right) d_{tally}}$$

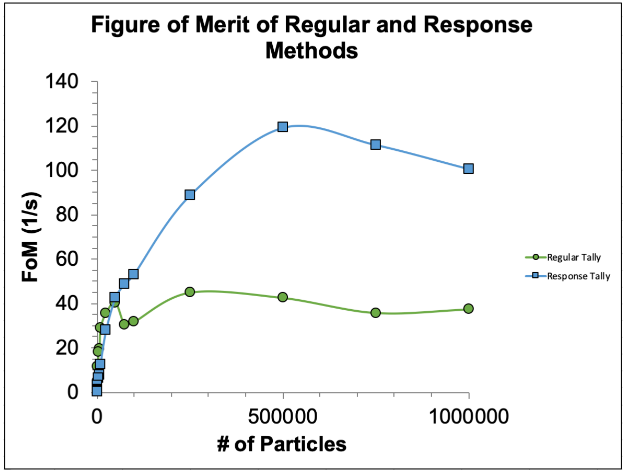
3. At birth and every scattering event, a contribution is added to tally

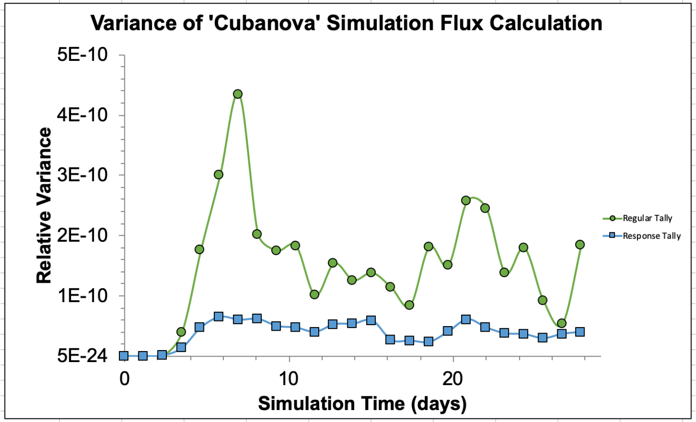


The Backwards Approx:

Particles are traced from the tally (blue) towards the source (purple). As they pass through the mesh, a ‘response value’ is calculated from a weighted average of all particles based on the distance they traveled and its weighted opacity from all cells it has passed through

Results & Conclusions





Left Top:

Figure of Merit of the response function against a standard method. This shows that >50k particles, our method has far lower variance.

Left Bottom:

Rel. variance vs time of a supernova simulation. This also demonstrates our method results in a smaller variance.

Right Top:

Side by side of the true opacity vs the response value/opacity.

Right Bottom:

The electron temperature of the supernova at the end of simulation. Overheated regions likely result from small corner cells.