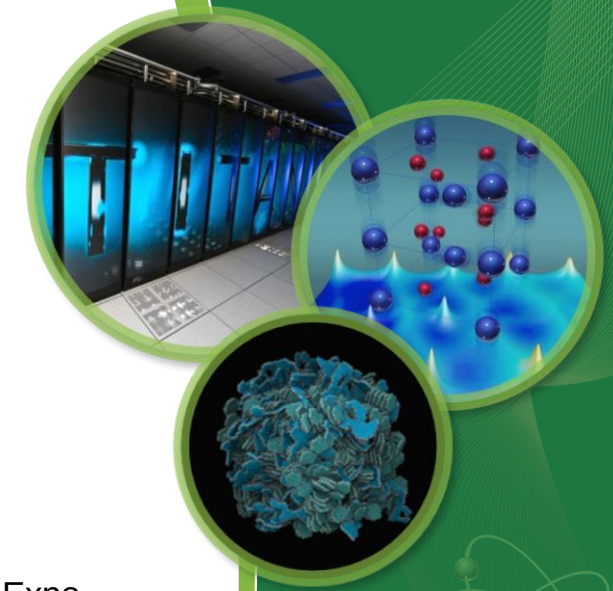
A Case Study in the Application of TSUNAMI-3D – Part 1, Multigroup



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Outline

1. Background and introduction
2. Direct perturbation (DP) calculations
3. Case study experiment description
4. Results
5. Conclusions

Background and introduction

- Use of sensitivity/uncertainty (S/U) methods has increased over the last decade
- Tools within both SCALE and MCNP can determine sensitivities and apply nuclear data uncertainties
- A case study in TSUNAMI use is presented here in multigroup (MG) and in a companion paper in continuous-energy (CE) to demonstrate proper use of tools
- Direct perturbations are especially important to generate reference results

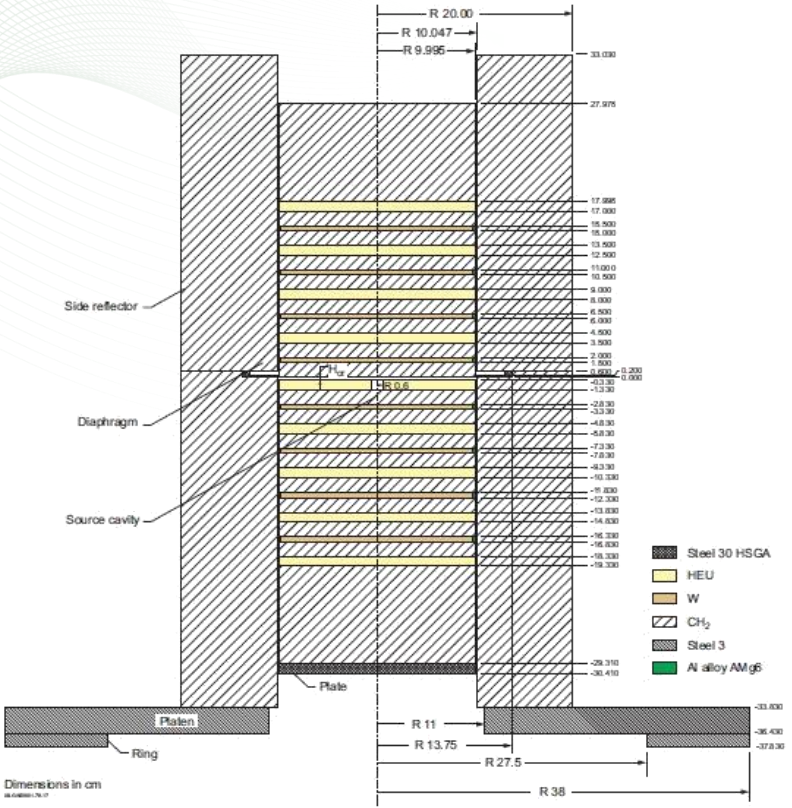
Direct perturbation calculations

- Sensitivity data file (SDF) is created using the TSUNAMI-3D sequence
- TSUNAMI sensitivity can be confirmed by using DP calculations
- DP sensitivity *is* the (reference) sensitivity
- Select important isotopes, elements, and/or materials of interest
  - Include at least the primary fission and moderator species
  - Also include materials/isotopes of interest (e.g., absorber/FP)

Direct perturbation calculations (cont.)

- Perturbation selected to cause ±0.5% Δ*k* change
  - Perturbation large enough to yield accurate results and small enough to generate a linear response
- Uncertainty-weighted linear least squares fit of k_{eff} points used to determine the DP sensitivity
  - Slope of the trend line is the sensitivity
- Desirable for the differences between TSUNAMI and DP sensitivities to be: 1) less than 5%, 2) less than 0.01 in absolute sensitivity, and 3) less than 2 standard deviations using the combined uncertainties

Case study experiment (HEU-MET-MIX-017)



- Model from the International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook
- 1 case/configuration
- Heterogeneous cylinder of alternating disks of HEU, polyethylene, and tungsten reflected by polyethylene
- Core is divided by a horizontal gap into 2 sections: a movable bottom part and a stationary top part
- Calculations used KENO V.a

Results

- Initial model generated with a single mixture in the model for each material
- Mesh size suggestions: 1) about one-tenth of size of fissile material or 2) On the order of the pitch for lattices or arrays
- Flux mesh ~0.5 cm radially by 7 cm axially
  - Difference between DP and TSUNAMI in ^{1}H sensitivity almost 60%
  - Model refinement(s) needed
- Mesh changed to 2 cm cubic mesh
  - Discrepancy in ^{1}H improved to 12%; more work needed

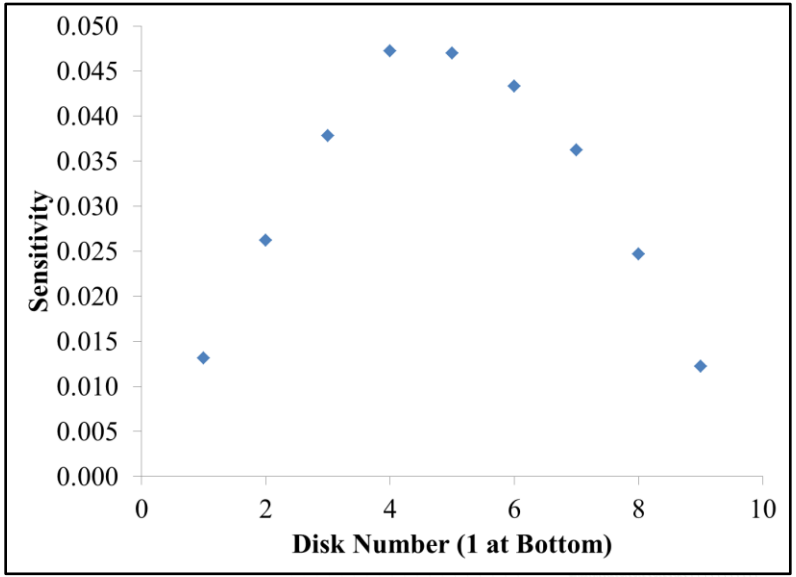
Results (continued)

- Separate mixtures in the model for each disk
  - Multiple identical copies of material descriptions
  - TSUNAMI calculates sensitivity by mixture, so this provides more detailed local results
  - Fluxes also collected by *region* – in some cases arbitrary subdivision can improve results (manual subdivision)
- 1D infinite slab cross section processing with all the mixture numbers specified
- Same 2 cm cubic mesh

Results (continued)

Isotope	ΔS (%)	ΔS (σ)	ΔS (abs)
C (refl)	2.33	2.16	0.0009
C (disks)	0.21	0.18	0.0001
H (disks)	9.07	3.57	0.0056
^{235}U (disk 1)	1.46	1.33	0.0002
^{235}U (disk 2)	4.27	3.94	0.0011
^{235}U (disk 3)	0.12	0.11	<0.0001
^{235}U (disk 4)	6.55	6.01	0.0029
^{235}U (disk 5)	4.40	4.15	0.0020
^{235}U (disk 6)	0.68	0.66	0.0003
^{235}U (disk 7)	2.11	1.96	0.0008
^{235}U (disk 8)	0.57	0.57	0.0001
^{235}U (disk 9)	2.59	2.45	0.0003

^{235}U sensitivity by disk



Conclusions

- Use of DP calculations provides confidence in calculated sensitivities
  - Essentially confirms settings yield correct results
- Case study for HMM-017 shows approach for challenging system
  - Results aren't always clean or unambiguously good
- Same case study presented in companion paper
  - CE attractive for systems with no 1D cell for XS processing

Acknowledgement

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