OECD/NEA/NSC/WPNCS-EGUACSA Phase V, July 2018

Validation using SCALE 6.2.3/TSURFER and traditional methods

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Clustered comments - 1

- Phase V has a major purpose by being "a blind test" – Valid point
- Lack of high similarity & quality benchmarks, reliable covariances
- IEU-MET-FAST-007 in Phase I had one perfect benchmark – Enough!
- TSUNAMI-3D was used to generate sensitivity files
- TSURFER determined C_k values for 15 applications vs. 33 benchmarks
- TSURFER determined biases and bias-corrected k_{eff} and σ values
- SCALE 6.2.3+ENDF/B-VII.1 CE, MCNP6.1+ENDF/B-VII.1 and -VIII.0
- 1 SCALE 6.2.3 result deviates from SCALE 6.2.1 & MCNP6.1 results

Clustered comments - 2

- Benchmarks selection limited to a few Pu, MIX, LEU and IEU cases
- Limited by low similarities, large uncertainties, extensive correlations
- Low positive biases for all 15 applications determined – Not evident
- k_{eff} from 0.998 to 0.992 for MCM-1-10 reduced biases 50-100 pcm
- Nuclear data uncertainties were reduced from 500 pcm to 300 pcm
- ORNL presented very different results at ANS Annual Meeting 2018
- TSURFER is easy to use and GLLSM powerful and flexible
- Results from TSURFER vary: Benchmark quality?, Covariances?
- A solid validation method should accept one perfect benchmark

Phase I – IEU-MET-FAST-007 as Application

- **IEU-MET-FAST-007 (IMF-007 or Big Ten) is accurate benchmark**
- **IMF-007 was believed to have no similar benchmarks**
- **IEU-MET-FAST-010 (ZPPR) was designed to reproduce IMF-7: C_k>0.99**

Year	Benchmarks (ICSBEP Id)	$k_{calc,prior}$	$\sigma_{cov,prior}$	$k_{bm,prior}$	$\sigma_{bm,prior}$
2008	IEU-MET-FAST-007 (Big Ten)	1.0204	-	1.0045	-
2008	IEU-MET-FAST-010	1.0144	-	0.9954	0.0024
2018	IEU-MET-FAST-007 (Big Ten)	1.0051	0.0299	1.0049	0.0008
2018	IEU-MET-FAST-010	0.9970	0.0297	0.9954	0.0024

MIX Benchmarks - SCALE and MCNP

BM	Benchmarks (ICSBEP Id)	$k_{calc,prior}$ S6.2.3/S6.2.1 ENDF/B-VII.1	$\sigma_{cov,prior}$	$k_{bm,prior}$	$\sigma_{bm,prior}$	MCNP6.1	
						ENDF/B 7.1	ENDF/B 8.0
19	MIX-COMP-MIXED-001-010	0.9919/0.9982	0.0043	0.9988	0.0045	0.9979	1.0012
20	MIX-COMP-THERM-001-001	1.0012	0.0062	1.0000	0.0025	1.0018	1.0046
21	MIX-MISC-MIXED-001-004	1.0024	0.0063	1.0011	0.0027	1.0024	1.0065
22	MIX-MISC-THERM-001-008	1.0041	0.0065	1.0000	0.0032	1.0038	1.0041
23	MIX-MISC-THERM -004-001	0.9945	0.0072	1.0000	0.0030	0.9944	0.9926
24	MIX-SOL-THERM-001-005	0.9989	0.0068	1.0000	0.0016	0.9981	0.9952
25	MIX-SOL-THERM-002-058	1.0023	0.0086	1.0000	0.0024	1.0017	0.9956
26	MIX-SOL-THERM-004-007	0.9952	0.0074	1.0000	0.0026	0.9960	0.9946

Pu Benchmarks - SCALE and MCNP

BM	Benchmarks (ICSBEP Id)	$k_{calc,prior}$ S6.2.3/7.1	$\sigma_{cov,prior}$	$k_{bm,prior}$	$\sigma_{bm,prior}$	MCNP6.1	
						E7.1	E8.0
27	PU-MET-FAST-030-001	1.0028	0.0048	1.0000	0.0021	1.0029	1.0018
28	PU-MET-FAST-036-001	1.0067	0.0058	1.0000	0.0031	1.0063	1.0060
29	PU-MET-FAST-037-008	1.0016	0.0040	1.0000	0.0033		
30	PU-SOL-THERM-007-001	1.0098	0.0079	1.0000	0.0047	1.0090	1.0069
31	PU-SOL-THERM-015-010	1.0054	0.0083	0.9971	0.0047	1.0033	0.9985
32	PU-SOL-THERM-022-013	0.9981	0.0070	1.0000	0.0016	0.9966	0.9946
33	PU-SOL-THERM-032-001	0.9960	0.0079	1.0000	0.0020	0.9957	0.9916

Ck values ICSBEP Id. Number Application Case	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LEU-COMP-THERM -002-001	0.18	0.03	0.10	0.19	0.02	-0.03	0.18	0.03	0.26	0.20	0.07	-0.02	0.17	0.01	0.14
LEU-COMP-THERM-008-009	0.07	-0.05	0.32	0.08	-0.05	0.28	0.08	-0.05	0.34	0.08	-0.08	0.26	0.07	-0.04	0.32
LEU-COMP-THERM-011-010	0.12	0.08	0.28	0.13	0.07	0.19	0.12	0.10	0.37	0.14	0.09	0.18	0.11	0.06	0.30
LEU-COMP-THERM-015-158	0.15	0.18	0.16	0.16	0.17	-0.01	0.15	0.20	0.35	0.16	0.18	-0.03	0.14	0.16	0.22
LEU-COMP-THERM-040-005	0.17	-0.04	0.13	0.17	-0.04	0.00	0.17	-0.06	0.27	0.18	-0.02	0.01	0.16	-0.05	0.17
LEU-COMP-THERM-042-004	0.11	-0.04	0.23	0.11	-0.04	0.12	0.11	-0.06	0.35	0.12	-0.05	0.09	0.10	-0.03	0.27
LEU-COMP-THERM-047-001	0.12	-0.03	0.23	0.12	-0.03	0.15	0.12	-0.01	0.31	0.13	-0.01	0.15	0.11	-0.03	0.25
LEU-COMP-THERM-051-010	0.12	0.06	0.28	0.13	0.05	0.19	0.12	0.07	0.37	0.13	0.08	0.18	0.11	0.04	0.30
LEU-COMP-THERM-061-001	0.16	0.19	0.15	0.17	0.18	-0.01	0.16	0.21	0.34	0.17	0.20	-0.02	0.15	0.16	0.21
LEU-COMP-THERM-077-003	0.12	-0.04	0.11	0.13	-0.03	-0.01	0.12	-0.05	0.24	0.13	-0.04	-0.01	0.11	-0.03	0.15
KRITZ-1_1-226 (IRPhE draft)	0.09	0.03	0.36	0.09	0.03	0.31	0.09	0.02	0.41	0.10	0.02	0.28	0.08	0.04	0.37
IEU-MET-FAST-021-001	0.01	0.11	0.31	0.01	0.09	0.48	0.01	0.13	0.08	0.01	0.11	0.56	0.01	0.09	0.18
IEU-MET-FAST-007-001	0.01	-0.09	0.31	0.01	-0.08	0.51	0.01	-0.12	0.05	0.01	-0.07	0.59	0.01	-0.10	0.16
IEU-MET-FAST -010-001	0.01	0.03	0.31	0.01	0.03	0.50	0.01	0.03	0.04	0.01	0.01	0.59	0.01	0.03	0.16
IEU-MET-FAST-002-001	0.01	0.21	0.32	0.01	0.19	0.48	0.01	0.25	0.09	0.01	0.21	0.56	0.01	0.18	0.18
IEU-MET-FAST-012-001	0.01	0.04	0.30	0.01	0.03	0.46	0.01	0.06	0.07	0.01	-0.03	0.54	0.01	0.07	0.17
IEU-MET-FAST-013-001	0.01	0.02	0.31	0.01	0.01	0.47	0.01	0.03	0.08	0.01	0.01	0.55	0.01	0.02	0.18
IEU-MET-FAST-016-001	0.01	-0.03	0.31	0.01	-0.02	0.50	0.01	-0.03	0.05	0.01	-0.03	0.58	0.01	-0.02	0.17
MIX-COMP-MIXED-001-010	0.49	0.43	0.52	0.50	0.45	0.34	0.52	0.41	0.76	0.47	0.29	0.26	0.51	0.50	0.64
MIX-COMP-THERM-001-001	0.54	0.52	0.30	0.53	0.51	0.12	0.60	0.56	0.56	0.55	0.48	0.12	0.53	0.51	0.41
MIX-MISC-MIXED-001-004	0.20	0.30	0.66	0.21	0.32	0.80	0.20	0.32	0.49	0.19	0.29	0.86	0.20	0.29	0.53
MIX-MISC-THERM-001-008	0.38	-0.01	0.33	0.38	0.00	0.22	0.44	-0.02	0.53	0.38	-0.03	0.19	0.37	0.01	0.43
MIX-MISC-THERM-004-001	0.51	0.12	0.26	0.50	0.11	0.14	0.60	0.23	0.46	0.52	0.15	0.17	0.50	0.07	0.33
MIX-SOL-THERM-001-005	0.47	-0.12	0.30	0.47	-0.09	0.19	0.56	-0.08	0.49	0.48	-0.08	0.21	0.46	-0.12	0.38
MIX-SOL-THERM-002-058	0.37	-0.01	0.29	0.37	0.01	0.22	0.44	0.02	0.44	0.40	0.04	0.26	0.35	-0.03	0.33
MIX-SOL-THERM-004-007	0.51	0.05	0.25	0.50	0.05	0.14	0.61	0.15	0.43	0.52	0.04	0.16	0.51	0.05	0.33
PU-MET-FAST-030-001	0.41	0.06	0.18	0.41	0.07	0.16	0.46	0.06	0.21	0.44	0.12	0.20	0.37	0.04	0.15
PU-MET-FAST-036-001	0.50	0.04	0.15	0.48	0.02	0.13	0.58	0.15	0.21	0.52	0.03	0.17	0.47	0.05	0.14
PU-MET-FAST-037-008	0.64	0.27	0.32	0.63	0.25	0.25	0.70	0.36	0.43	0.67	0.36	0.34	0.60	0.20	0.30
PU-SOL-THERM-007-001	0.53	0.00	0.23	0.52	0.00	0.13	0.63	0.00	0.39	0.54	0.00	0.18	0.53	0.00	0.28
PU-SOL-THERM-015-010	0.52	0.04	0.21	0.50	0.02	0.12	0.62	0.17	0.36	0.52	0.06	0.16	0.51	0.01	0.27
PU-SOL-THERM-022-013	0.54	0.04	0.23	0.53	0.00	0.13	0.55	-0.07	0.41	0.54	-0.02	0.17	0.54	0.09	0.30
PU-SOL-THERM-032-001	0.50	-0.02	0.23	0.49	-0.04	0.14	0.58	0.08	0.40	0.51	0.01	0.19	0.49	-0.06	0.29

App	Description	$k_{app,prior}$	$k_{app,post}$	EALF (keV)	$\sigma_{cov,prior}$	MCNP	
						E7.1	E8.0
1	PuO_2(100), H_2O(3), RG(C)	1.00594	1.00535	1.945	0.00523	1.00524	1.00489
2	MO_2(30), H_2O(3), RG(C)	1.00412	1.00302	0.530	0.00493	1.00157	1.00254
3	MO_2(12.5), H_2O(3), RG(C)	1.00387	1.00356	0.237	0.00463	1.00376	1.00163
4	UO_2(100), H_2O(3), RG(R)	1.00368	1.00311	2.110	0.00497	1.00256	1.00239
5	MO_2(30), H_2O(3), RG(R)	1.00520	1.00413	0.611	0.00455	1.00337	1.00340
6	MO_2(12.5), H_2O(3), RG(R)	1.00415	1.00401	0.311	0.00529	1.00460	1.00224
7	PuO_2(100), H_2O(3), WG	0.95454	0.95353	1.447	0.00572	0.95604	0.95433
8	MO_2(30), H_2O(3), WG	0.93548	0.93405	0.334	0.00552	0.93663	0.93553
9	MO_2(12.5), H_2O(3), WG	0.98831	0.98744	0.154	0.00435	0.99079	0.98805
10	PuO_2(100), H_2O(1), RG(C)	0.96071	0.96014	2.765	0.00494	0.96105	0.96015
11	MO_2(30), H_2O(1), RG(C)	0.92538	0.92412	0.915	0.00450	0.92386	0.92446
12	MO_2(12.5), H_2O(1), RG(C)	0.93083	0.93036	0.546	0.00552	0.92986	0.92925
13	PuO_2(100), H_2O(5), RG(C)	1.05471	1.05423	1.398	0.00540	1.05273	1.05260
14	MO_2(30), H_2O(5), RG(C)	1.05922	1.05833	0.310	0.00485	1.05809	1.05692
15	MO_2(12.5), H_2O(5), RG(C)	1.04265	1.04248	0.106	0.00437	1.04484	1.04062

Conclusions

- One very reliable and similar benchmark with low uncertainty is the best validation?
- Traditional validation works well if:
  - One (very low uncertainty) or more (larger uncertainties) reliable benchmarks are available
  - Some of the benchmarks are very similar to application
  - Benchmark correlations are accounted for adequately
- TSURFER method, providing best-estimate results, is promising
- The WPNCS should encourage further Phases using GLLSM
- Use GLLSM to evaluate new ICSBEP & IRPhE benchmark experiments
- Encourage improvement of cross-section covariances
- Use GLLSM to identify “weak” ICSBEP & IRPhE benchmarks
- Calculation method includes: Codes, nuclear data, equipment, installation, user