

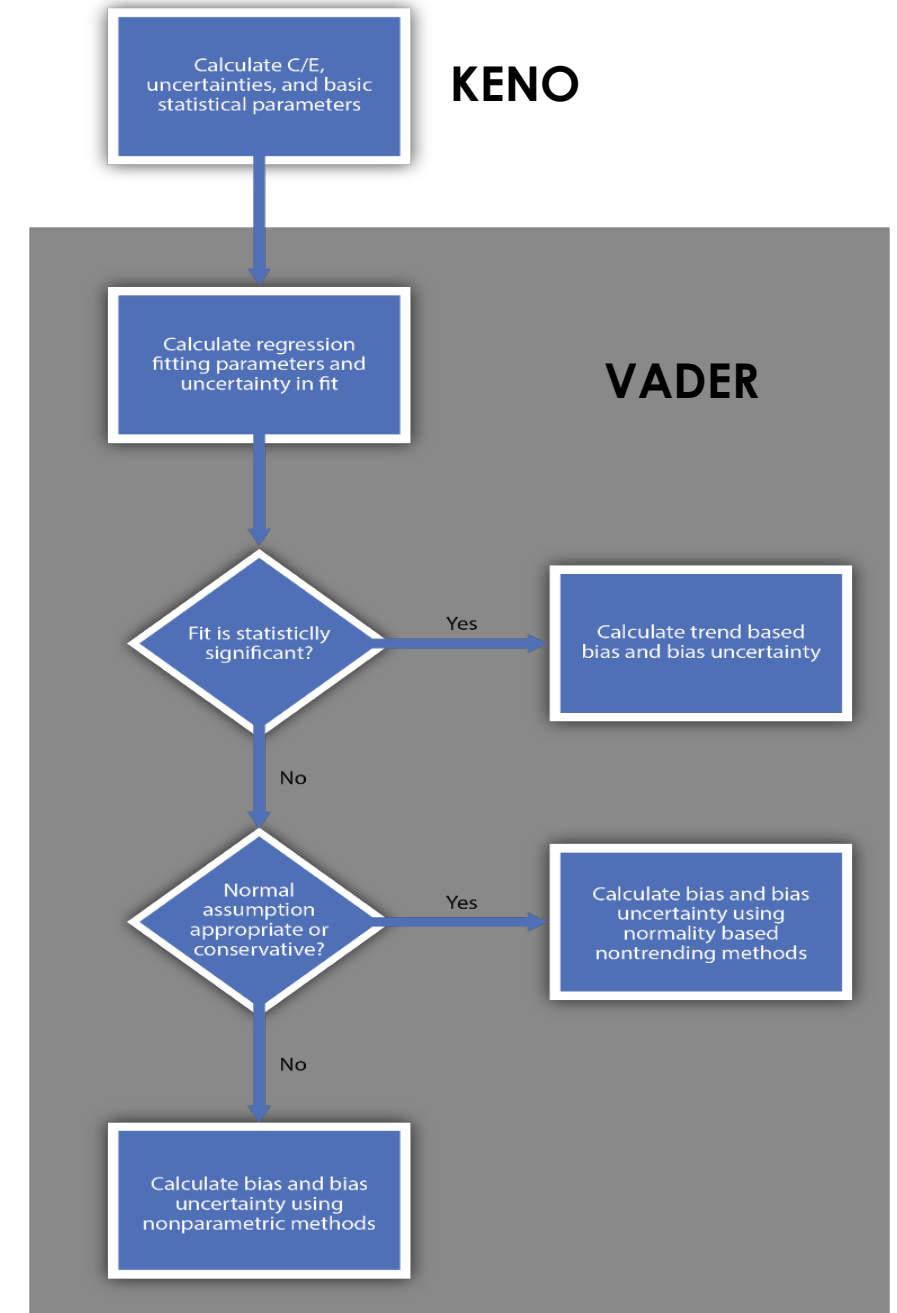
VADER in a Nutshell

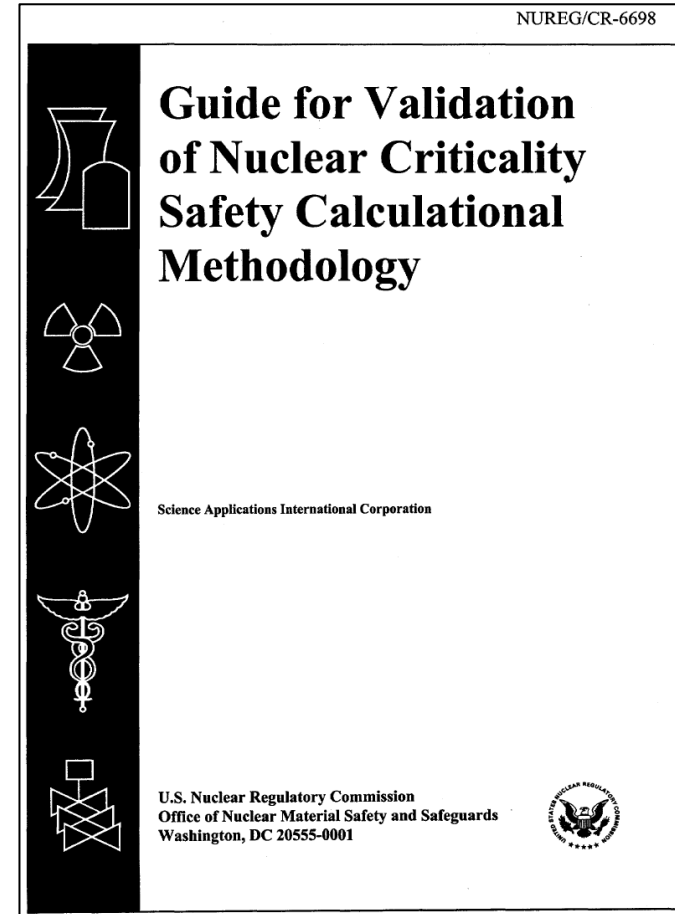
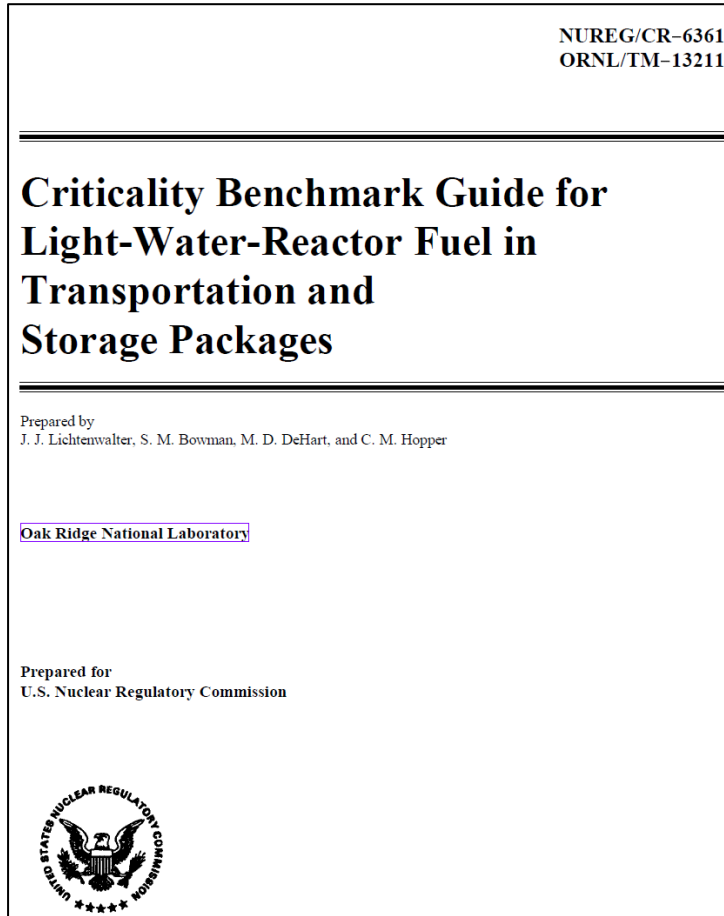
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Validation

- Given a set of benchmarks:
 - Select physically meaningful trending parameter(s)
 - Develop trend(s)
 - Test for statistical significance of trend(s)
 - **If significant, use bias and bias uncertainty with value from application**
 - If no trend, test for normality
 - **If normal, use parametric lower tolerance limit**
 - **Otherwise use nonparametric lower tolerance limit**





Validation and Data Analysis Resource: **VADER**

Development

- USLSTATS methods and code described in NUREG/CR-6361
- Validation methodology guidance provided in NUREG/CR-6698
- VADER:
 - Includes all methodologies from both reports
 - USL1, USL2, nontrending, trending, nonparametric
 - Includes both inverse variance weighted and unweighted nontrending and trending approaches
 - Becomes an official SCALE sequence
 - Incorporates directly within Fulcrum, eliminating java GUI and Javapeno
 - Has modular design to allow incorporation of new methods

VADER input

- Data
 - Data to be analyzed: (trending parameter value, C/E, $\sigma_{C/E}$)
- Title
 - Option title for calculation
- Parameters
 - Global parameters to use in analysis
- Trend_values
 - Any specific trend values at which the user desires the USL(s)

VADER input (2)

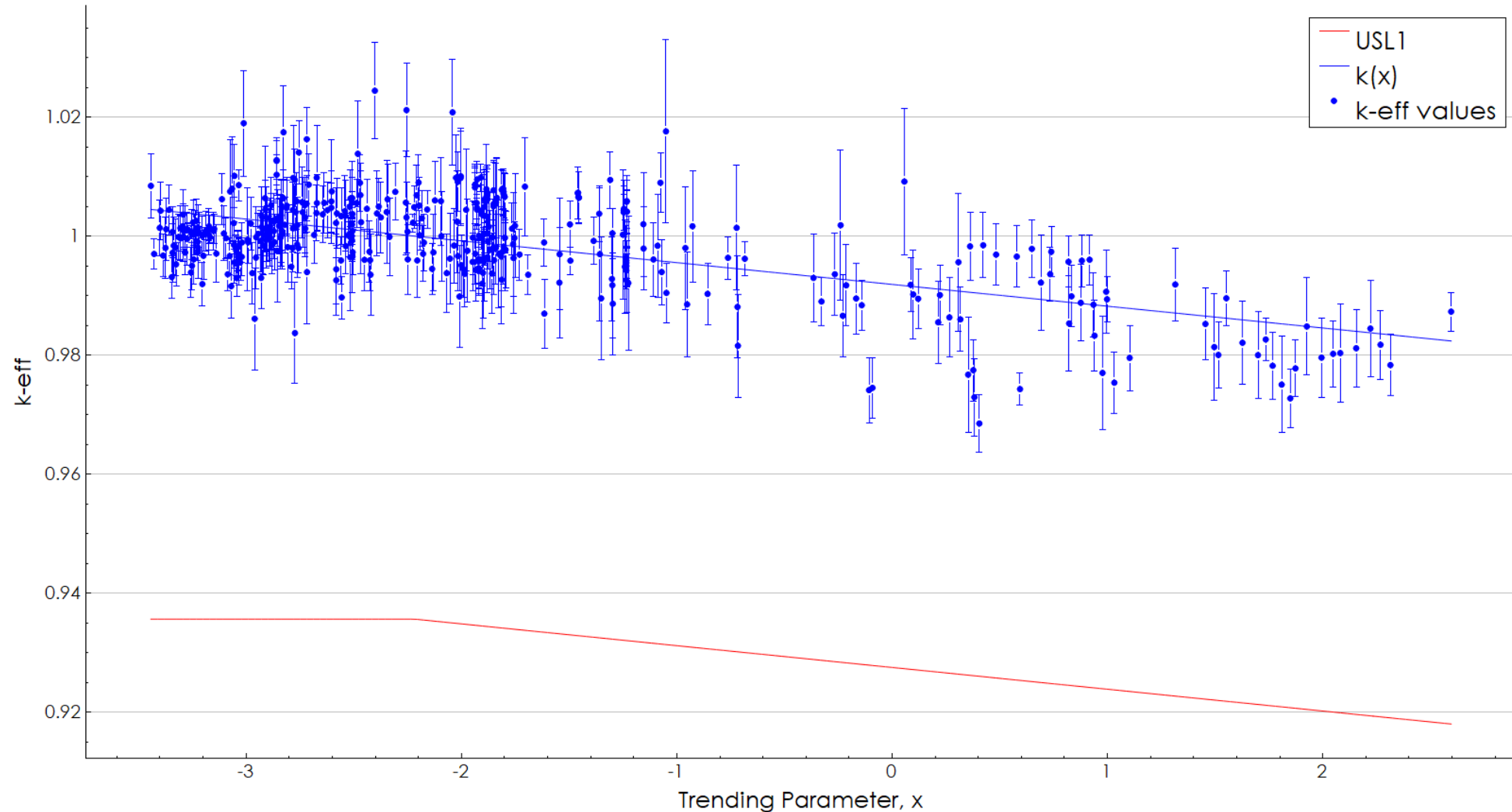
- Methods
 - Statistical analysis methods to be used
 - Parameters provided with a specific method override global parameter value
 - Multiple methods can be used in a single calculation
- Tests
 - Normality testing via χ^2 and/or Anderson-Darling
 - t-test of trend significance

Example input and output:

```
1 |vader
2 data=[
3 -2.506  0.99656 0.00598
4 -1.301  0.99280 0.00713
5 -2.525  1.00009 0.00350
6 -1.236  0.99648 0.00528
7 -3.138  0.99706 0.00489
...
435 -2.508  1.00195 0.00291
436 -2.912  1.00017 0.00290
437 -2.895  0.99967 0.00370
438 ]
439 %
440 trend_values=[1]
441 '
442 methods{
443 USL1{}
444 }
445 %
446 tests{
447 t-test {confidence=0.95}
448 }
449 end
```

```
956 =====
957 | Tests Output |
958 =====
959
960 Test (1 of 1): Trend Significance t-test
961 =====
962 Null Hypothesis: Data have a slope of zero (no trend).
963 Test: Null Hypothesis Rejected
964
965 -----
966 Test Results
967 -----
968 Test statistic:                                     1.9655
969 t_fit value (null hypothesis rejected if above test statistic): 16.003
...
1007 -----
1008 Trend Values
1009 -----
1010 Equation:
1011           0.927483 + (-0.003663)*X (X > -2.216751)
1012           0.935603                (X <= -2.216751)
1013
1014 Trend Value      k(x)      Adj. k(x)  Bias  Unc.(x)  Adm. Margin      USL
1015      -3.44200      1.00449      1.00000    0.01440  0.05000      0.93560
1016      -2.57943      1.00133      1.00000    0.01440  0.05000      0.93560
1017      -2.21675      1.00000      1.00000    0.01440  0.05000      0.93560
1018      -1.71686      0.99817      0.99817    0.01440  0.05000      0.93377
1019      -0.85429      0.99501      0.99501    0.01440  0.05000      0.93061
1020       0.00829      0.99185      0.99185    0.01440  0.05000      0.92745
1021       0.87086      0.98869      0.98869    0.01440  0.05000      0.92429
1022       1.00000      0.98822      0.98822    0.01440  0.05000      0.92382
1023       1.73343      0.98553      0.98553    0.01440  0.05000      0.92113
1024       2.59600      0.98237      0.98237    0.01440  0.05000      0.91797
```

VADER output plot in Fulcrum:



VADER future plans

- Near term
 - Add Shapiro-Wilks normality test
 - Extensive testing and bug fixes
 - Expanding and improving manual
 - Polishing input options and connections of tests and data sets
- Longer term
 - Add Whisper and/or other EVT validation methodologies
 - Other methodologies, especially treatment for correlated data
 - Expand use to other domains
 - Incorporate two-sided statistical approaches for some applications

Acknowledgment

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Questions?

