

Parallel Computing and Model Evaluation for Environmental Systems:

An Overview of the SuperMUSE and FRAMES Software Technologies

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ISCMEM Workshop on Environmental Modeling

Rockville, Md

October 14, 2000

Model Evaluation Science (UA/SA/PE) Research Program

Research Questions:

How can model evaluation science and integrated modeling technologies be extended, packaged, and delivered to directly support EPA's needs related to exposure & risk assessments for problems of national significance?

- Dealing with the Big problems == Big systems, Big spaces, and Big time horizons
- Everyone who models faces similar operational problems, even if <big⁴

Why is this research important?

- Helps EPA form the needed technical basis to:
 - Identify needs for improved science and data;
 - More accurately assess uncertainties of science and data.

Need to facilitate improved models and regulatory programs through better characterization of UA/SA/PE and higher levels of quality assurance.

Approach:

- Provide methods/tools for simplifying the computational burdens of QA.
- Develop methods/tools for uncertainty analysis and parameter estimation; methods/tools for screening, local, and global-based sensitivity analyses.
- Demonstrate model evaluation abilities through various applications.

When Big or Not so Big is Your Problem.....

Discussion Points on Parallel Computing

Quantitative Aspects of UA/SA/PE:

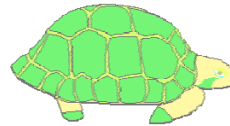
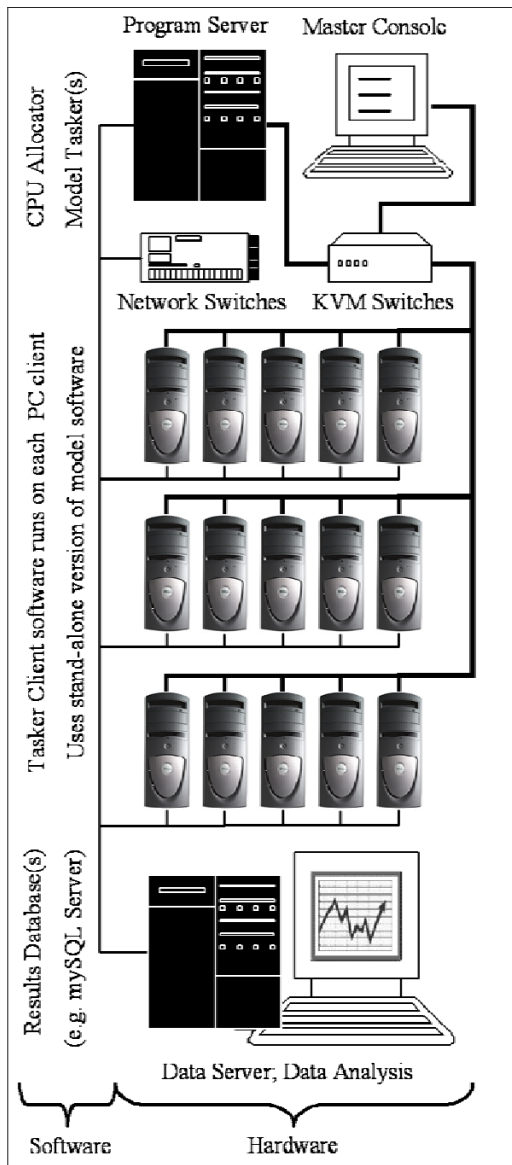
- Many techniques and methods available, improving constantly.
- Current knowledge and execution capabilities usually limited to a select few, out of reach from most model developers and model users.
- An “**embarrassingly parallel**” computational problem; solutions involve running a model over and over with slightly different inputs.
- Many EPA models written for Windows, but most supercomputing solutions today require “mainframes” or Linux-based PC clusters.

Parallel Computing and You

The UA/SA/PE Runtime Problem

- As model complexity, time & space grid density, or types of uncertainty and sensitivity analyzed increases, computational burden (runtime) typically **increases geometrically**.
- UA/SA/PE techniques not widely applied to EPA models due to **lack of Windows based computer processing capacity**.
- General trend → PC-based model developers increase model complexity over time, **offsetting concurrent gains in CPU speed**.
- Depending on the EPA model/application, **need 100's to 10's of millions of simulations**.

SuperMUSE: Hardware & Software



Speed of 1 PC



Speed of many

....tools to parallelize stand-alone PC-based models

Clustering to Increase Computational Capacity

Model Tasker

Model Dependent – Create an MT for each modeling system
Parallelizes a stand-alone PC-Model's System User Interface

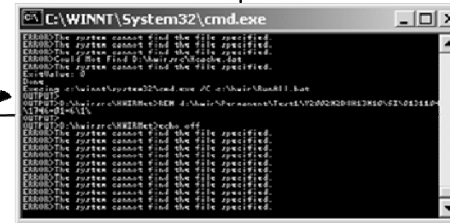
SUITasker
Registered with: 0101

Machine	Command	Assigned	Completed	Time(s)	Error
0416	ParSUITestY...	Wed Feb 20 ...	Incomplete	0	No
0212	ParSUITestY...	Wed Feb 20 ...	Incomplete	0	No
0608	ParSUITestY...	Wed Feb 20 ...	Incomplete	0	No
0111	ParSUITestY...	Wed Feb 20 ...	Incomplete	0	No
0302	ParSUITestY...	Wed Feb 20 ...	Incomplete	0	No
Unassign...	ParSUITestY...	Unassigned	Incomplete	0	No
Unassign...	ParSUITestY...	Unassigned	Incomplete	0	No
Unassign...	ParSUITestY...	Unassigned	Incomplete	0	No
Unassign...	ParSUITestY...	Unassigned	Incomplete	0	No
# Complete	19.0	# Errors	0		
Average Time	134.21052631571	Queued Runs	201		

4. Do job X = a single task line in any MT (e.g., single model run)

5. Send job X warnings, errors, and results to Data Server's project file area identified by MT.

3. TC_i requests job from MT_i
6. TC_i says done with job X.



Tasker Client (TC_k; k = 1...n_c)

Model independent.

Executes DOS commands in batch files delivered by MT.

CPU Allocator

Model Independent

Oversees Multiple Active Model Taskers

CPU Allocator
Machine Name: 0101

Machine	Description	Percentage
0101	ParSUITest	100.0

Restart Clients Turn Off Clients

At launch, MT's register with the CPU Allocator.

1. TaskerClient TC_i announces availability, one of many client PCs.

2. If no active MT, idles. This TC_i call was assigned to MT₁.

OO-JAVA design app.

3MRA 1.x SUITasker, CPU Allocator, and TaskerClient shown

EPA's SuperMUSE Cluster, Athens GA



Example SuperMUSE Tool: UpdateClient

Managing files and PC settings across your cluster via OS

Editing C:\ERD_IAM\SuperMUSE\RunApps\Server\UpdateClient\PushSuperMUSE_Update.bat

File Help

Execute Create command.csv Invert Selection

C:\Windows\system32\cmd.exe /c rem Now processing %n
C:\Windows\system32\cmd.exe /c xcopy /y /q /s E:\ERD_IAM_InstallZone\

WinXP_280

0102D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0103D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0104D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0105D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0106D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0107D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0108D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0109D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0110D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0111D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0112D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0113D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0114D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0115D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0116D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0201D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0202D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0203D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0204D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0205D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0206D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0207D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0208D, [WinXP_520], WinXP, Optiplex GX520, (c,\3mra), 1 Disks, 1 CPUs
0209D, [WinXP_270], WinXP, Optiplex GX270, (c,\3mra), 1 Disks, 1 CPUs
0210D, [WinXP_270], WinXP, Optiplex GX270, (c,\3mra), 1 Disks, 1 CPUs
0211D, [WinXP_270], WinXP, Optiplex GX270, (c,\3mra), 1 Disks, 1 CPUs
0212D, [WinXP_270], WinXP, Optiplex GX270, (c,\3mra), 1 Disks, 1 CPUs
0213D, [WinXP_270], WinXP, Optiplex GX270, (c,\3mra), 1 Disks, 1 CPUs
0214D, [WinXP_270], WinXP, Optiplex GX270, (c,\3mra), 1 Disks, 1 CPUs

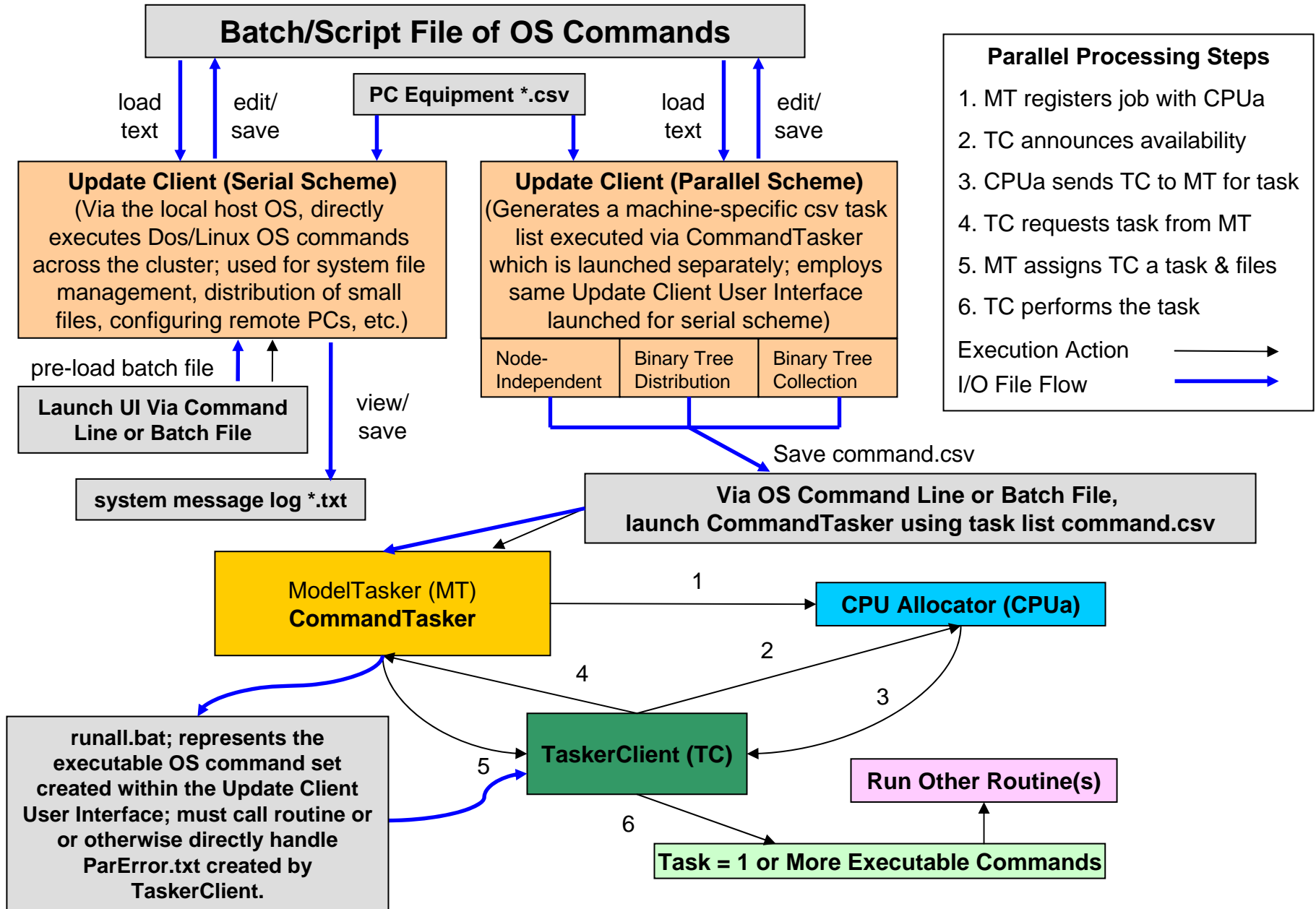
Works with Linux (i.e., scripts) and Windows (i.e., batch files) to run OS commands

Can run serially → via CPU of server hosting this app

or

In parallel → via instance of CommandTasker tool == a “generic” system-level ModelTasker

SuperMUSE 1.0 UpdateClient Tool Detail



SuperMUSE CPU Allocator, TaskerClient, & ClientMonitor Tools

The image displays three overlapping windows from the SuperMUSE suite:

- CPU Allocator:** Shows the machine name 'L2626UJBABENDR3'. It has two tabs: 'Jobs in system' and 'Machines Reset/Off wo Response'. Below the tabs is a table with columns 'Machine', 'Description', and 'Percentage'. At the bottom are buttons for 'Kill TaskerClients', 'Restart Clients', 'Shutdown Clients', and 'Normalize % Loads', along with a 'Pressed at' field.
- ClientMonitor:** Displays 'Client Status' with a table showing one client 'localhost' with status 'Success' at '2009-10-12 20:43:21'. Below the table are radio buttons for 'Show Successful', 'Show Problems', and 'Show All' (selected). It also shows 'Successful Clients: 1', 'Problem Clients: 0', and 'All Clients: 1'. There are 'Reset' and 'Close' buttons, and a checkbox for 'Enable Server Logging'. A status bar at the bottom reads 'Received: status_update,localhost,Success from 127.0.0.1'.
- TaskerClient:** A terminal window showing the output of the TaskerClient. It starts with '##### Running TaskerClient #####' followed by environment variables: 'JAVA_HOME= C:\Program Files\Java\jre1.6.0_07', 'ERD_IAM_PATH= C:\ERD_IAM', 'FRAMES_PATH= C:\ERD_IAM\FRAMESv2', 'FRAMES_CLIENT_PATH= C:\ERD_IAM\FRAMESv2', 'ERD_IAM_FTPServerShare= C:\ERD_IAM\FTPServerShare', 'SUPERMUSE_PATH= C:\ERD_IAM\SuperMUSE', and 'SUPERMUSE_CLIENT_PATH= C:\ERD_IAM\Client'. It then shows five lines of 'Told to idle by allocator: localhost'.

SuperMUSE ClientMonitor, CPU Allocator, and TaskerClient shown

Example Model Tasker → F2 FUITasker

The image displays two software interfaces. The top window, titled 'CPU Allocator', shows machine allocation details for 'L2626UJBABENDR3' with a 'study_test' description at 100.0% load. It includes buttons for 'Kill TaskerClients', 'Restart Clients', 'Shutdown Clients', and 'Normalize % Loads'. The bottom window, 'FUI Tasker Queue Manager', shows a list of tasks assigned to 'L2626UJBABENDR3', all marked as 'Incomplete'. A 'TaskerClient' window is overlaid on the right, showing a log of output commands and file paths. At the bottom, summary statistics show 0.0 completion, NaN average time, 0 errors, and 10 queued runs.

CPU Allocator

Machine Name: L2626UJBABENDR3

Jobs in system | Machines Reset/Off wo Response

Machine	Description	Percentage
L2626UJBABENDR3	study_test	100.0

Kill TaskerClients | Restart Clients | Shutdown Clients | Normalize % Loads | Pressed at

FUI Tasker Queue Manager

Registered with: localhost

Tasks | Failed Tasks | Failed Machines

Machine	Command	Assigned	Completed	Time(s)	Error	Fail Machine?
L2626UJBABENDR3	case Index_1_1	Mon Oct 12 21:39:11...	Incomplete	0	No	No
Unassigned	case Index_1_2	Unassigned	Incomplete			
Unassigned	case Index_1_3	Unassigned	Incomplete			
Unassigned	case Index_1_4	Unassigned	Incomplete			
Unassigned	case Index_1_5	Unassigned	Incomplete			
Unassigned	case Index_1_6	Unassigned	Incomplete			
Unassigned	case Index_1_7	Unassigned	Incomplete			
Unassigned	case Index_1_8	Unassigned	Incomplete			
Unassigned	case Index_1_9	Unassigned	Incomplete			
Unassigned	case Index_1_10	Unassigned	Incomplete			

Unassign | Fail Task Manually

# Complete	0.0	# Errors	0
Average Time	NaN	Queued Runs	10

TaskerClient

```
OUTPUT>MEERTData\APES\SampleHucs6yr\N200908
1\TxtInOut\urban.dat
OUTPUT>MEERTData\APES\SampleHucs6yr\N200908
1\TxtInOut\wnd.wnd
OUTPUT>After CopyFiles
OUTPUT>Mod1.UdpUI
OUTPUT>Mod2.SWATBasins-hsn
OUTPUT>After SetSwatUIDatasetHandle
OUTPUT>After SetSwatObject
OUTPUT>After WriteSwatUIDataset
```

CPU Allocator, TaskerClient shown with FRAMESv2 FUITasker Interface Example

Discussion Points on Model Evaluation

For a given class of problems (e.g., spatially explicit exposure/risk modeling) captured by a modeling system, decision support boils down to ...

- **An ability to manage the modeling system input vector at two distinct levels: Decision and Non-decision Subspaces**
- **An ability to allow users to explore system I/O relations:**
 - **Decision input space of a given problem statement (e.g., scenarios)**
 - Setting permutations of decision variable values to “run”.
 - **Non-decision input space of a given problem statement (i.e., data)**
 - Managing the uncontrolled inputs to be set by nature or others
 - Dealing with variability and epistemic uncertainty in these inputs
 - **Via science (i.e., models) used to translate an input vector (comprised of decision and non-decision subvectors) to an output vector.**
 - Providing context for accuracy and precision of “outcomes” by scenario.
 - Providing an ability to compare 2 or more scenarios.

Discussion Points on the Processes of Modeling and Decision-Making

Decision-Making Under Uncertainty Is “All About” Information and Integration

- **In the end....it is “all about” data and dimensionality reduction -- best decision.**

Modeling Under Uncertainty Is “All About” Indexing Data and Integration

- **In the endit is also “all about” data and dimensionality reduction, with a known (reproducible) level of quality -- best answer.**

Indexing is the engine room of science-based data reduction and decisions.....

Example Population-Based Risk Profiles

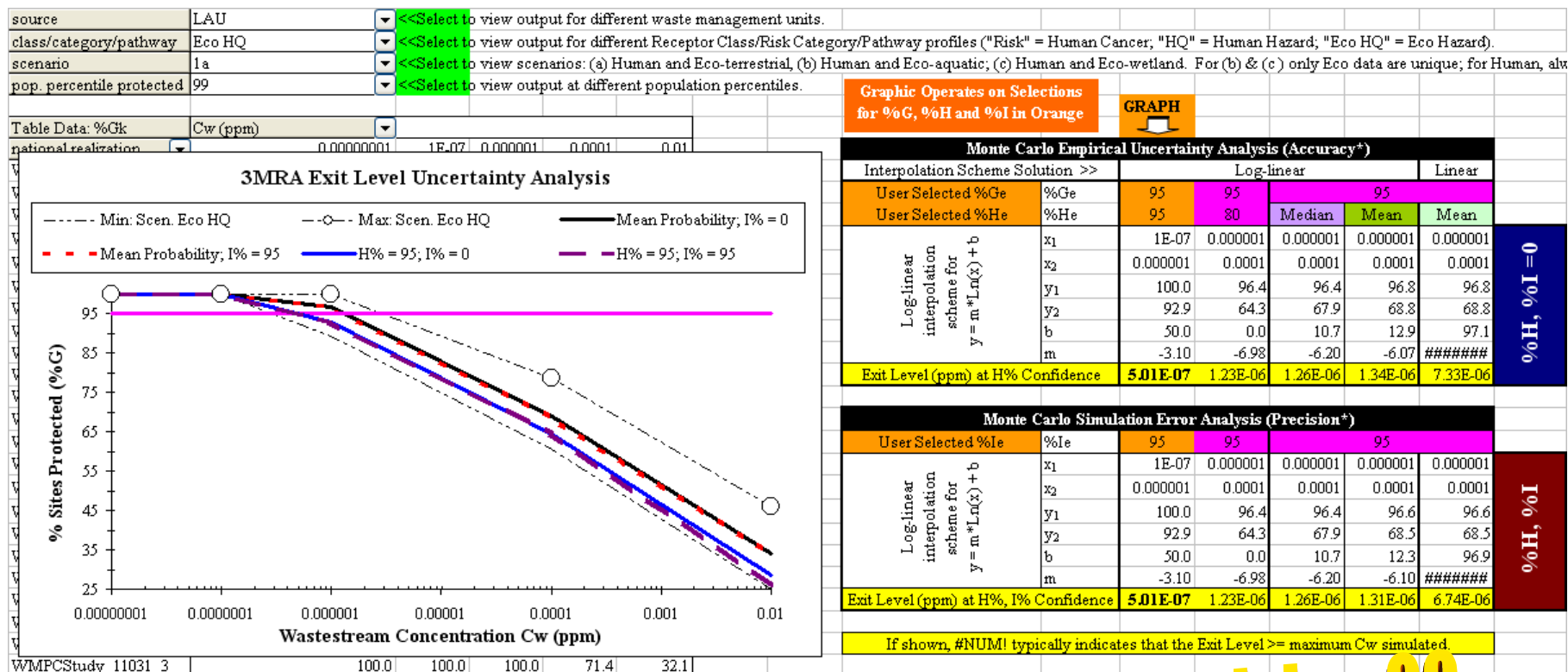
Possible in 3MRA 1.0/1.x/2.0

Human Roll-ups		Ecological Roll-ups
Distances (3)	Ring Distances (3)	Ring and Habitat Group (9)
Pathways (13)	Roll-up Options (6)	Ring and Habitat Type (36)
Receptor Type (5)	Habitat Group (3)	Ring and Receptor Group (27)
Cancer Risk Bins (7)	Receptor Group (9)	Habitat and Rec. Groups (27)
Hazard Risk Bins (4)	Trophic Level (5)	Hab. Grp. and Trop. Lev. (15)
Subtotal (21,840)		Subtotal (645)

Are you tracking 100s to 100s of millions of things??

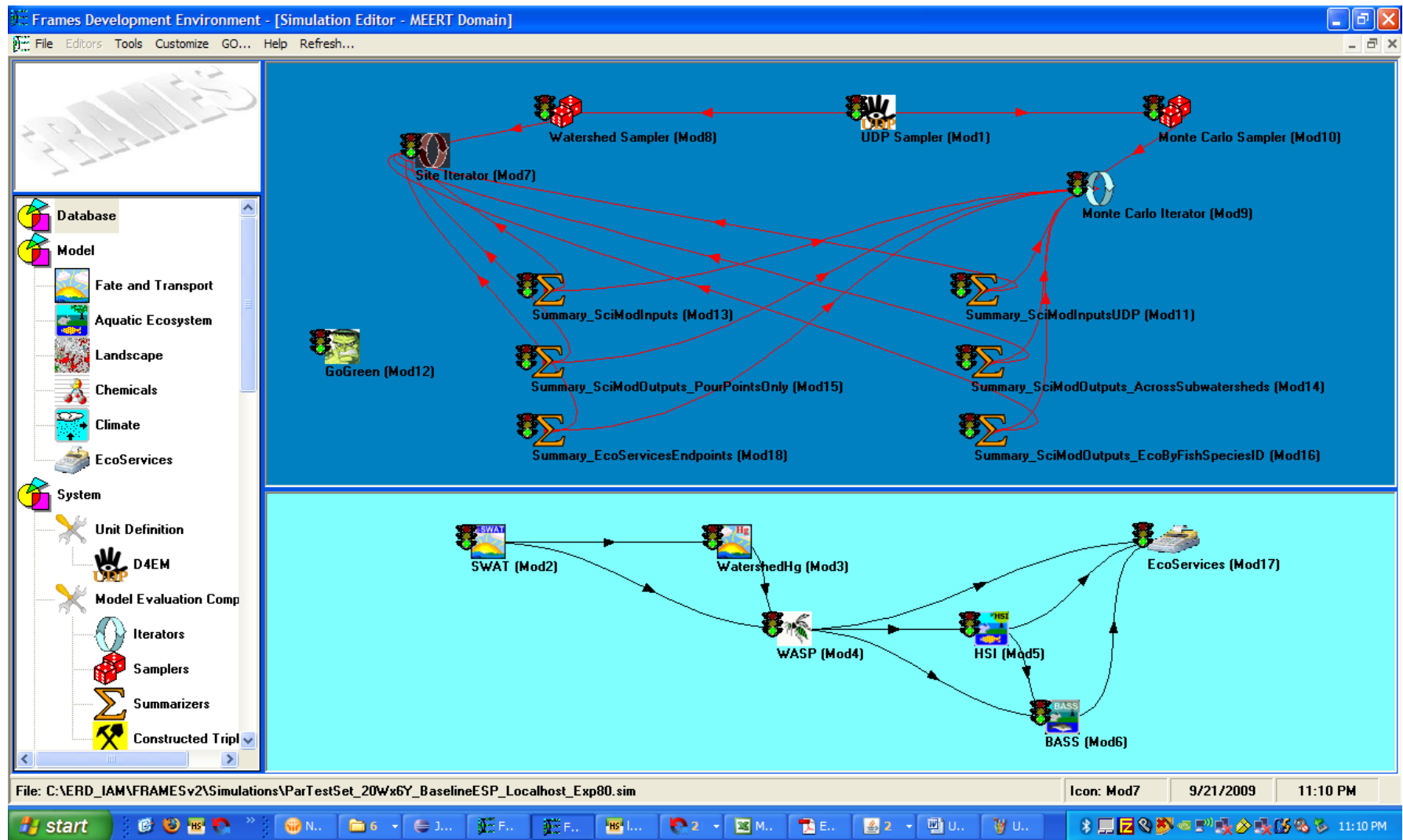
Total (22,485)	X	Population % (10)	X	Chemical (43 ⁺)	~ 10 ⁸⁺ permutations
		Risk Measures (2 ⁺)		Source Type (5)	

Example FRAMES-3MRA Uncertainty Analysis

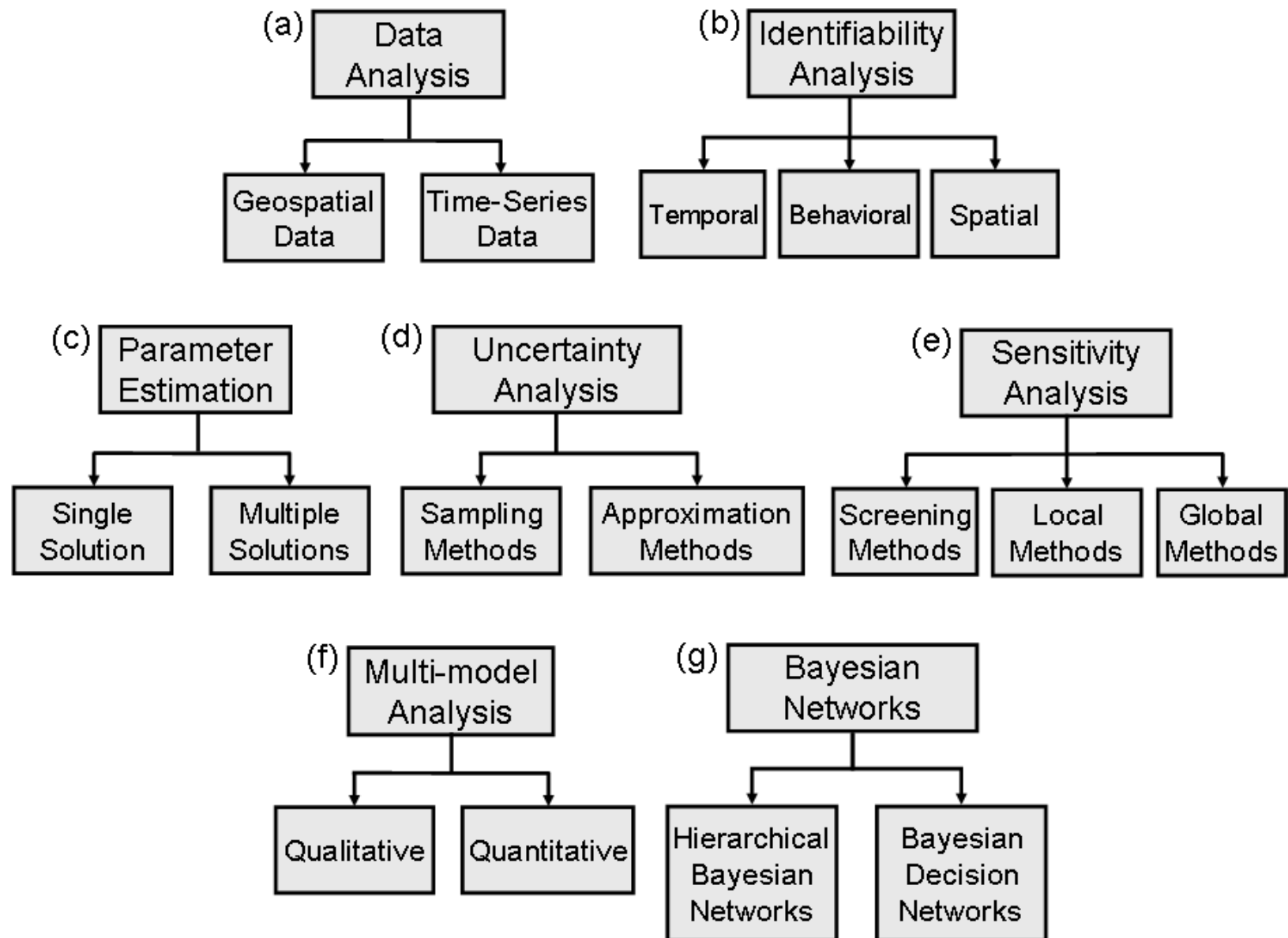


Do you need to do it with accuracy & precision??

FRAMESv2-MEERT App. Simulation Design with Cyclic System-level Model Evaluation Components



Model Evaluation Framework Implementation Plan



Recent and Ongoing Objectives

Develop FRAMESv2 capabilities for:

- Parallel-PC computations (100%),
- Multi-threading jobs on single PC to leverage multiple CPU cores (95%),
- Generic multi-"unit" assessment capability within base F2 API architecture (100%)
- Wide range of tools and pre/post-processing utilities for conducting UA/SA/PE, and data analysis/mining. (90%)

20+ iterators, samplers, summarizers, viewers, processors, tools - operational for the most part, undergoing beta testing

Systems Tools Development & Organization

The image displays two screenshots of a software application titled "Module Editor".

The left screenshot shows a list of modules with expandable/collapsible icons (+/-) to their left. The modules are:

- Data Reporter
- F2Iterator
- F2PEST
- F2PIterator
- F2RMCUI
- F2Sampler
- F2UST
- F2UVT
- GoGreen
- Iterator
- ModulePackager
- ModuleUnpackager
- MonteCarloAnalysis
- ObjectiveFunctionalizer
- RunExperiment
- Sampler
- SeriesViewer
- SimpleSummarizer
- SimulationFilter

The right screenshot shows the same application with a different set of modules and a "Viewer Properties" panel on the right.

The modules listed in the right screenshot are:

- SiteAnalysis
- Summarizer
- SystemPackager
- SystemUnpackager
- UDP
- UniformRandomSampler
- UnitsPackager
- Database
- Model
- Viewer
 - CDF
 - GenericViewer
 - Hist
 - NighthawkViewer
 - OutputViewer
 - PartialR
 - SamplerViewer
 - Stochlter Viewer
 - TripletViewer

The "Viewer Properties" panel on the right contains a "List of Modules" section with the following items:

- CDF (highlighted)
- GenericViewer
- Hist
- NighthawkViewer
- OutputViewer
- PartialR
- SamplerViewer
- Stochlter Viewer
- TripletViewer

FRAMESv2 Parallel Processing Elements

F2 Parallel Iterator

File

Total number of iterations
100000

☒ Serial ☐ Parallel

Tasker Name or IP Address

Firing Sequence (auto = let FRAMES auto-detect)
Mod1, Mod13, Mod2, Mod3, Mod4, Mod5, Mod6, Mod14

Index Sequence (none = no outer loops, or in serial mode)
Mod11

OK

FUI Tasker Queue Manager

Registered with: localhost

Tasks		Failed Tasks		Failed Machines	
Machine	Comma...	Assigned	Comple...	Time(s)	Error
L2626U...	case In...	Wed Oc...	Incompl...	0	No
Unassi...	case In...	Unassi...	Incompl...	0	No
Unassi...	case In...	Unassi...	Incompl...	0	No
Unassi...	case In...	Unassi...	Incompl...	0	No
Unassi...	case In...	Unassi...	Incompl...	0	No
Unassi...	case In...	Unassi...	Incompl...	0	No

Reset		Remove	
# Complete	0.0	# Errors	1
Average Time	NaN	Queued Runs	6

Example Summarizer Desktop F2 Summarizer

FRAMESv2 Simple Summarizer Configuration Utility

Alias	Variable	Summary Operation	Type	Units	Indices	Data Set
AvgSYLD	SedimentYield	Average	FLOAT	kg/day	1-* 1-*	Mod2.SWATAPESOutput
AvgHSI	HSI	Average	FLOAT	none	1-* 1-*	Mod5.HSIOutput
AvgHgFish	SpeciesChemConcMeHg	Average	FLOAT	mg/kg	1-* 1-*	Mod6.BASS_Output
MaxCBODU	CBODU	Maximum	FLOAT	mg/L	1-* 1-*	Mod2.SWATAPESOutput
AvgCBODU	CBODU	Average	FLOAT	mg/L	12_1-*	Mod2.SWATAPESOutput
MaxDailyPrecip	DailyPrecip	Maximum	FLOAT	mm	1-* 1-*	Mod2.SWATAPESOutput
HgIISurfSoilConc [1_1]	HgIISurfSoilConc	None	FLOAT	ug/kg	1-* 1-*	Mod3.WatershedHgOutput
CBODU [1_1]	CBODU	None	FLOAT	mg/L	1_1	Mod2.SWATAPESOutput

Add Variable Edit Variable Remove Variable

Current Iteration

Save Quit

Unit Summary Tool User Interface

Unit Summary Tool

File

Unit Summary Managed Index Variables Control

Search criteria: logical AND between columns, OR between rows

file	var	des	unit	dim	idx1	idx2	idx3	idx4	idx5	inputType	DicType

Select Variables

file	var	des	unit	dim	idx1	idx2	idx3	idx4	idx5	inputType	DicType
Mod2.SWATStan...	GIS	GIS code reprint...		1	SUB					INTEGER	grf
Mod2.SWATBasi...	SPCON	Linear paramete...		0						FLOAT	ssf
Mod17.ESP_Out...	ESP_Fish_Indic...	Indicator fish me...	fish/ha	1	UdpOutSimData...					FLOAT	grf
Mod1.UdpUI...	SWAT2005Data...	Location of SWA...		0						STRING	ssf
Mod1.UdpOutLa...	PercentNatural	Percent of landu...		0						FLOAT	grf
Mod6.BASS_Out...	TotalDensity	Total fish popula...	fish/ha	1	UdpOutSimData...					FLOAT	grf

Add to List Clear Search Table

Search criteria: logical AND between columns, OR between rows

alias	file	var	des	unit	dim	idx1	idx2	idx3	idx4	idx5	type	cmd	dist	pers	crits	IndexType	IOState

Design Key: **At** ForEach (e.g. slices of pools) **Analyze** AcrossAll (pools of things)

Summarized variables

alias	file	var	des	unit	dim	idx1	idx2	idx3	idx4	idx5	type	cmd	dist	pers	crits	IndexT	IOState
UnitID	Mod1.Udp...	CurrentUnit	Current A...		0						STRING	value				Unit	Input
MCIteration	Mod9.Itera...	Curriter	Current ile...		0						INTEG...	value				Uncert...	Input
FishSpeci...	Mod5.HSI...	FishSpeci...	Fish's sci...		1	ForEach(1 - Count(FishSpecie...					STRING	value				NotInd...	Output
HSI	Mod5.HSI...	HSI	Habitat Su...		2	ForEach(1 - Count(FishSpecie...	AcrossAll(1 - Count(Report...				FLOAT	perce...		1,5,25...		NotInd...	Output
SpeciesBi...	Mod6.BAS...	SpeciesBi...	Species t...	kg/ha	2	ForEach(1 - Count(FishSpecie...	AcrossAll(1 - Count(Report...				FLOAT	perce...		50,95		NotInd...	Output
SpeciesBi...	Mod6.BAS...	SpeciesBi...	Species t...	kg/ha	2	ForEach(1 - Count(FishSpecie...	AcrossAll(1 - Count(Report...				FLOAT	perce...		50,95		NotInd...	Output

Remove from output Shift variable up Shift variable down Clear Search Table ☐ Hide Index Columns

Ok

Choosing how and what model system I/O data you want indexed & summarized...

Unit Sample Processor Tool User Interface

EPA - Unit Sample Processor (USP) - UnitSummaryTestJB_Exp85Stop

Connect Disconnect Save Analysis Load Analysis Resync_IterIndex

Drop UnitIndex Synchronize Data Analyze Data

Sync UnitIndex Synchronize Tables Evaluate Unsynchronized Tables Evaluate Synchronized Tables

Number of Records in 'UnitIndex' Table: 6325
Number of Records in 'Sync_UnitIndex' Table: 6325

Available Tables

*_results Tables	# of Records	Table-Type	Index?	Sync?
APES_SciModInputsUDP	6325	UST	Yes	Yes
APES_SciModInputs	6325	UST	Yes	Yes
APES_SciModOutputs_AcrossSubwatersheds	6324	UST	Yes	Yes
APES_SciModOutputs_EcoByFishSpeciesID	6324	UST	Yes	Yes
EcoServicesEndpoints	6324	UST	Yes	Yes

Un-Index Selected Tables Index Selected Tables Sync Selected Tables Un-Sync Selected Tables Cancel Query

Consumes UST Tool Output (mysql format option)...allows multiple tables, etc

USP Tool: Setting-up Data Analysis

EPA - Unit Sample Processor (USP) - UnitSummaryTestJB_Exp85Stop

Connect Disconnect Save Analysis Load Analysis Resync_IterIndex

Number of Records in 'UnitIterIndex' Table: 6325
Number of Records in 'Sync_UnitIterIndex' Table: 6325

Drop UnitIterIndex Synchronize Data Analyze Data

Data Analysis Regression Analysis Distribution Analysis Percent Analysis Across Index Analysis Rollup Analysis

Add Scenario Scenario/Result Stats by Scenario Graph by Scenario CDF of Scenario Mean Stats X-Scenario Graph X-Scenario

Scenario Table

ScenarioID	Analyze?	Scenario	Alias	# of Results	UnitID	MCIteration
12	<input type="checkbox"/>	Scenario12		499	030101020501	Taken Across All
13	<input type="checkbox"/>	Scenario13		445	030101011401	Taken Across All
14	<input type="checkbox"/>	Scenario14		499	030101010803	Taken Across All
15	<input type="checkbox"/>	Scenario15		491	030101010502	Taken Across All
16	<input type="checkbox"/>	Scenario16		420	030101010101	Taken Across All
17	<input checked="" type="checkbox"/>			6325	Taken Across All	Taken Across All

Check or Uncheck Selected
Uncheck All
Remove Selected Scenario

Summarized Table Variables Available for Analysis

VarID	TableName	Var	User Alias	critVal	Summary	SummaryVar	Description
1	APES_SciModInputsUDP	Var2	Air_BC_Hg0		Variable	Value	Air concentration of elem...
2	APES_SciModInputsUDP	Var3	Air_BC_HgII		Variable	Value	Air concentration of divale...
3	APES_SciModInputsUDP	Var4	Air_BC_MeHg		Variable	Value	Air concentration of methy...
4	APES_SciModInputsUDP	Var5	BenthicAlgaeBottomFract...		Variable	Value	Fraction of sediment area...
5	APES_SciModInputsUDP	Var6	GroundTemperature		Variable	Value	Average temperature und...
6	APES_SciModInputsUDP	Var7	Groundwater_BC_Hg0		Variable	Value	Groundwater concentrati...
7	APES_SciModInputsUDP	Var8	Groundwater_BC_HgII		Variable	Value	Groundwater concentrati...
8	APES_SciModInputsUDP	Var9	Groundwater_BC_MeHg		Variable	Value	Groundwater concentrati...
9	APES_SciModInputsUDP	Var10	Groundwater_BC_NH4		Variable	Value	Ammonia concentration i...
10	APES_SciModInputsUDP	Var11	Sediment_FluxAmmonia		Variable	Value	Flux of ammonia-N from ...
11	APES_SciModInputsUDP	Var12	Sediment_FluxOxygenDe...		Variable	Value	Flux of oxygen from water ...
12	APES_SciModInputsUDP	Var13	Sediment_FluxPhosphate		Variable	Value	Flux of phosphate-P from ...
13	APES_SciModInputsUDP	Var14	Sediment_IC_CBOD1		Variable	Value	Initial sediment CBOD1 c...
14	APES_SciModInputsUDP	Var15	Sediment_IC_CBOD2		Variable	Value	Initial sediment CBOD2 c...
15	APES_SciModInputsUDP	Var16	Sediment_IC_CBOD3		Variable	Value	Initial sediment CBOD3 c...

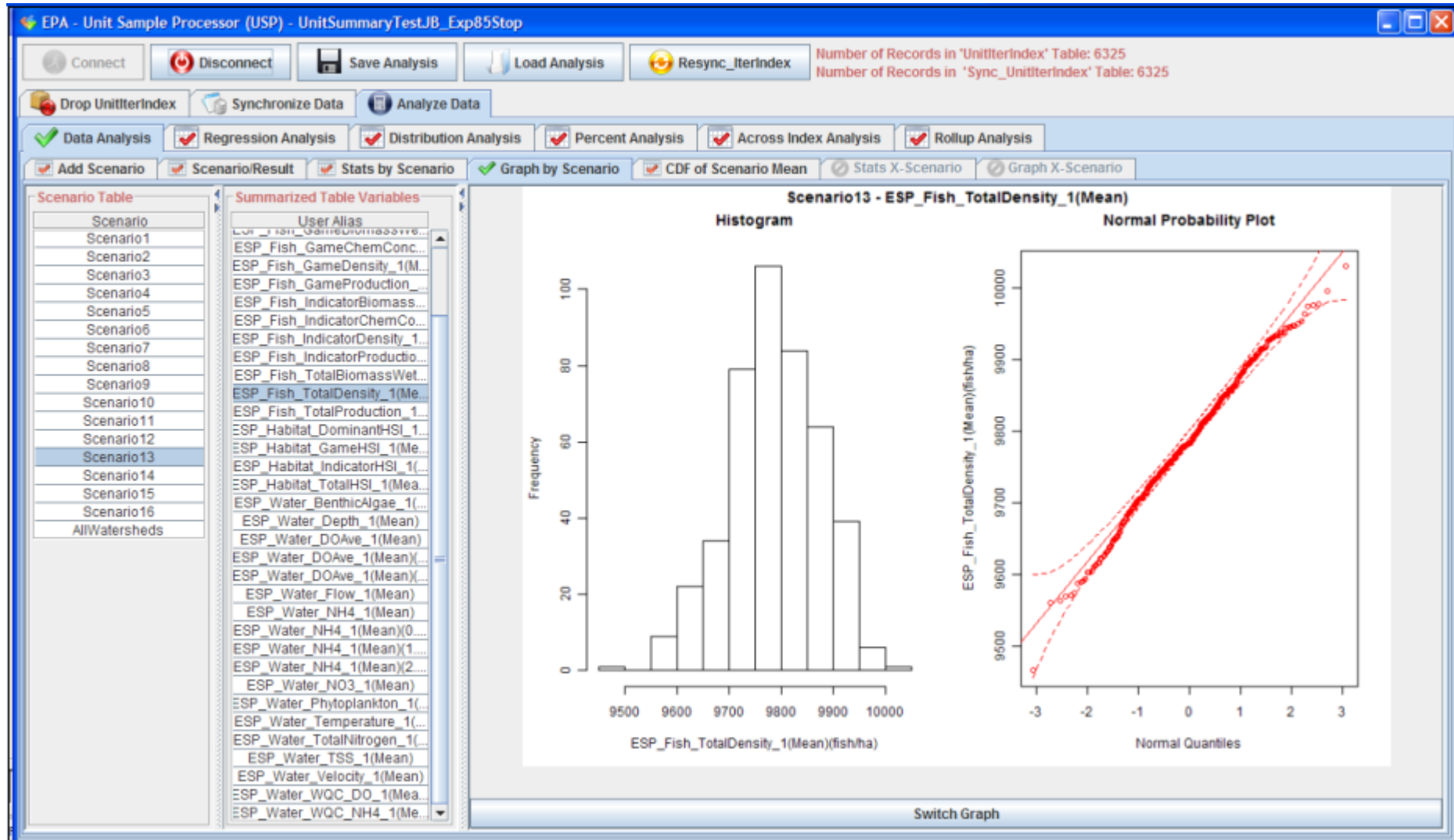
Show: ☒ Value ☐ Percentiles ☐ Normal Distribution ☐ Min ☐ Max ☒ Mean ☐ n - population ☐ Standard Deviation

☐ Log Normal Distribution ☐ Min ☐ Max ☒ Mean ☐ n - population ☐ Standard Deviation

Analyze by Scenario Across Scenario Remove Scenario Hide Conditions

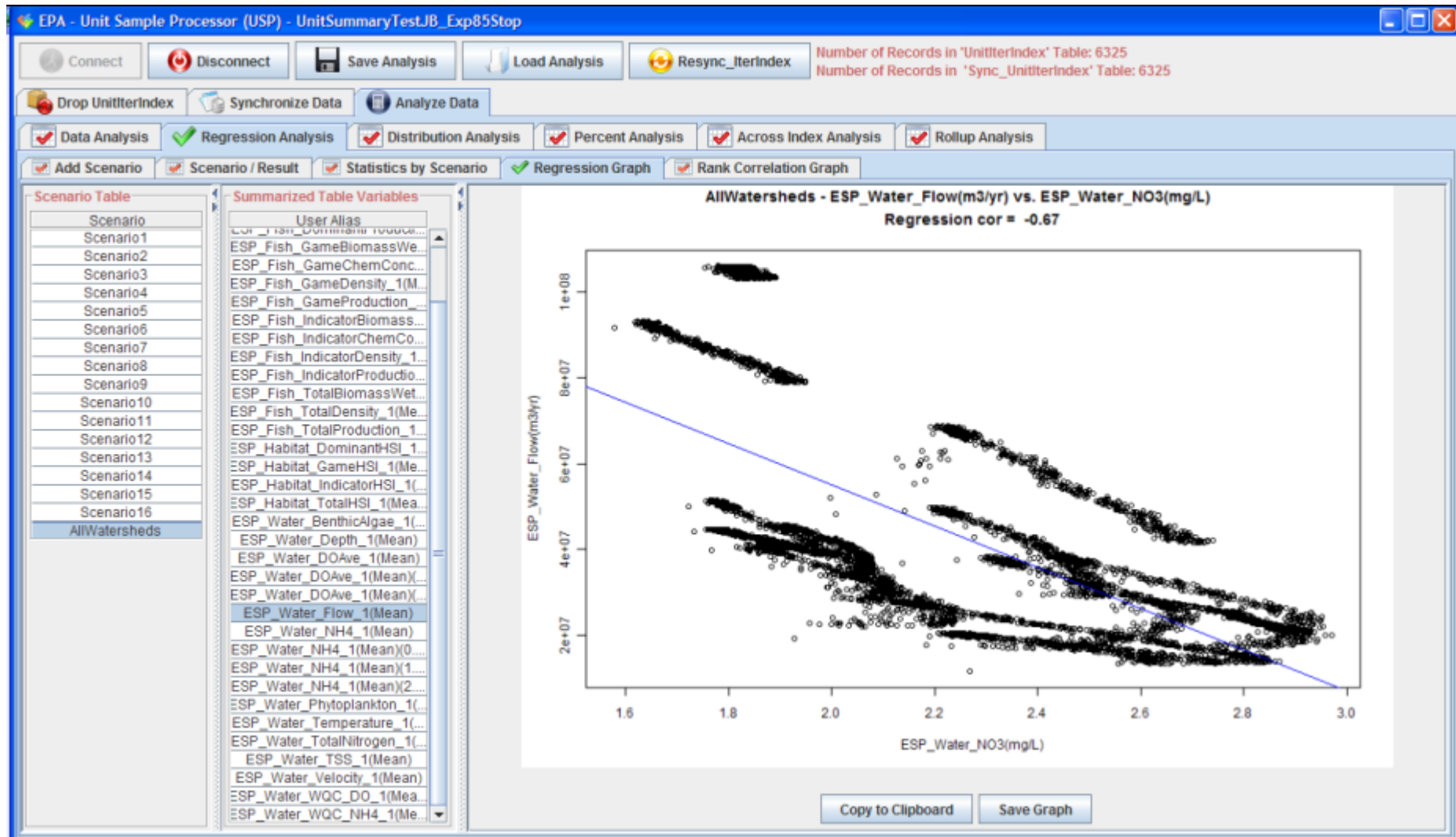
Example of choosing scenarios previously added, and variables of interest in analysis

USP Tool: Another Data Analysis Example



Example of graphical output in data analysis section.....

USP Tool: Regression Example



Example of graphical output in regression analysis section.....

USP Tool: Setting-up Rollup Analysis

EPA - Unit Sample Processor (USP) - UnitSummaryTestJB_Exp85Stop

Connect Disconnect Save Analysis Load Analysis Resync_Index

Number of Records in 'UnitIndex' Table: 6325
Number of Records in 'Sync_UnitIndex' Table: 6325

Drop UnitIndex Synchronize Data Analyze Data

Data Analysis Regression Analysis Distribution Analysis Percent Analysis Across Index Analysis Rollup Analysis

Add Scenario Scenario / Result Condition Filtering Data by Scenario U/A Table U/A Graph

Sync UnitIndex

UnitID

UnitID (Unit)	CheckBox
0301010101	<input checked="" type="checkbox"/>
030101010502	<input checked="" type="checkbox"/>
030101010803	<input checked="" type="checkbox"/>
030101011401	<input checked="" type="checkbox"/>
030101020501	<input checked="" type="checkbox"/>
030101020505	<input checked="" type="checkbox"/>
030101030406	<input checked="" type="checkbox"/>
030101030601	<input checked="" type="checkbox"/>
030101040101	<input checked="" type="checkbox"/>
030101050104	<input checked="" type="checkbox"/>
030101070701	<input checked="" type="checkbox"/>
030102010202	<input checked="" type="checkbox"/>
030102030502	<input checked="" type="checkbox"/>
030102050301	<input checked="" type="checkbox"/>
030102050806	<input checked="" type="checkbox"/>
030201030601	<input checked="" type="checkbox"/>

Check All Uncheck All

MCIteration

MCIteration (Uncertainty)	CheckBox
1	<input checked="" type="checkbox"/>
2	<input checked="" type="checkbox"/>
3	<input checked="" type="checkbox"/>
4	<input checked="" type="checkbox"/>
5	<input checked="" type="checkbox"/>
6	<input checked="" type="checkbox"/>
7	<input checked="" type="checkbox"/>
8	<input checked="" type="checkbox"/>
9	<input checked="" type="checkbox"/>
10	<input checked="" type="checkbox"/>
11	<input checked="" type="checkbox"/>
12	<input checked="" type="checkbox"/>
13	<input checked="" type="checkbox"/>
14	<input checked="" type="checkbox"/>
15	<input checked="" type="checkbox"/>
16	<input checked="" type="checkbox"/>
17	<input checked="" type="checkbox"/>
18	<input checked="" type="checkbox"/>
19	<input checked="" type="checkbox"/>

Check All Uncheck All

Help

1. Checked Values: For each index with selections, defines the set of values used in subsequent calculations. Actions upon sets of values selected depends on IndexType.
2. Unchecked Values: For each scenario defined by checked values, indicates pooling across the remaining unchecked indices during calculations (i.e. 'Across All').
3. To be pooled, all values must be unchecked for a given dimension. For indices with checked values, unchecked values are ignored.
4. A single scenario will only be added per 'Add Scenario' click.
5. The variable designated for IndexType = Unit represents the Rollup dimension for this analysis.

Select All Unselect All Add Scenario Help

Choosing from “U/V”, “Unit”, and “ExtDecVars” (latter not shown) available in the data structure which was generated by the UST tool...

USP Tool: Setting-up Rollup Analysis

EPA - Unit Sample Processor (USP) - UnitSummaryTestJB_Exp855Stop

Connect Disconnect Save Analysis Load Analysis Resync_IterIndex

Number of Records in 'UnitIndex' Table: 6325
Number of Records in 'Sync_UnitIndex' Table: 6325

Drop UnitIndex Synchronize Data Analyze Data

Data Analysis Regression Analysis Distribution Analysis Percent Analysis Across Index Analysis Rollup Analysis

Add Scenario Scenario / Result Condition Filtering Data by Scenario U/A Table U/A Graph

Scenario Table

ScenarioID	Analyze?	Alias	# of Results	UnitID	MCIteration
1	<input checked="" type="checkbox"/>	APES Regional Analysis	6325	0301010101, 030101010502, 0301010108...	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 1...

Summarized Table Variables Available for Analysis

VarID	TableName	DepVar 3	IndepVar	Variability 1	Roll Up Var 2	Alias	User Alias	critVal	Summary
3972		<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Var1	MCIteration		Variable
3971		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	Var0	UnitID		Variable
2927	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_1	ESP_Fish_DominantChemConcMeHg(1)		Variable
2936	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_10	ESP_Fish_DominantChemConcMeHg(10)		Variable
2937	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_11	ESP_Fish_DominantChemConcMeHg(11)		Variable
2938	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_12	ESP_Fish_DominantChemConcMeHg(12)		Variable
2939	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_13	ESP_Fish_DominantChemConcMeHg(13)		Variable
2940	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_14	ESP_Fish_DominantChemConcMeHg(14)		Variable
2941	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_15	ESP_Fish_DominantChemConcMeHg(15)		Variable
2942	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_16	ESP_Fish_DominantChemConcMeHg(16)		Variable
2943	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_17	ESP_Fish_DominantChemConcMeHg(17)		Variable
2944	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_18	ESP_Fish_DominantChemConcMeHg(18)		Variable
2945	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_19	ESP_Fish_DominantChemConcMeHg(19)		Variable
2928	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_2	ESP_Fish_DominantChemConcMeHg(2)		Variable
2946	EcoServicesEndpoints	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Var3_20	ESP_Fish_DominantChemConcMeHg(20)		Variable

Show: ☒ Value ☐ Percentiles ☐ Normal Distribution ☐ Min ☐ Max ☒ Mean ☐ n - population ☐ Standard Deviation

☐ Log Normal Distribution ☐ Min ☐ Max ☒ Mean ☐ n - population ☐ Standard Deviation

Analyze by Scenario Across Scenario Remove Scenario Hide Conditions

Choosing dependent and independent variables (e.g., ExtDecVars) for the rollup....

USP Tool: Setting-up Rollup Analysis

EPA - Unit Sample Processor (USP) - UnitSummaryTestJB_Exp85Stop

Connect Disconnect Save Analysis Load Analysis Resync_IterIndex

Number of Records in 'UnitIndex' Table: 6325
Number of Records in 'Sync_UnitIndex' Table: 6325

Drop UnitIndex Synchronize Data Analyze Data

Data Analysis Regression Analysis Distribution Analysis Percent Analysis Across Index Analysis **Rollup Analysis**

Add Scenario Scenario / Result **Condition Filtering** Data by Scenario U/A Table U/A Graph

Scenario Table

Scenario
APES Regional Analysis

Summarized Table Variables

User Alias
ESP_Fish_DominantChemConc
ESP_Fish_GameChemConcMeHg
ESP_Habitat_TotalHSI
ESP_Water_Temperature
ESP_Water_TotalNitrogen
ESP_Water_TSS
ESP_Water_Velocity
ESP_Water_WQC_NH4

ESP_Habitat_TotalHSI

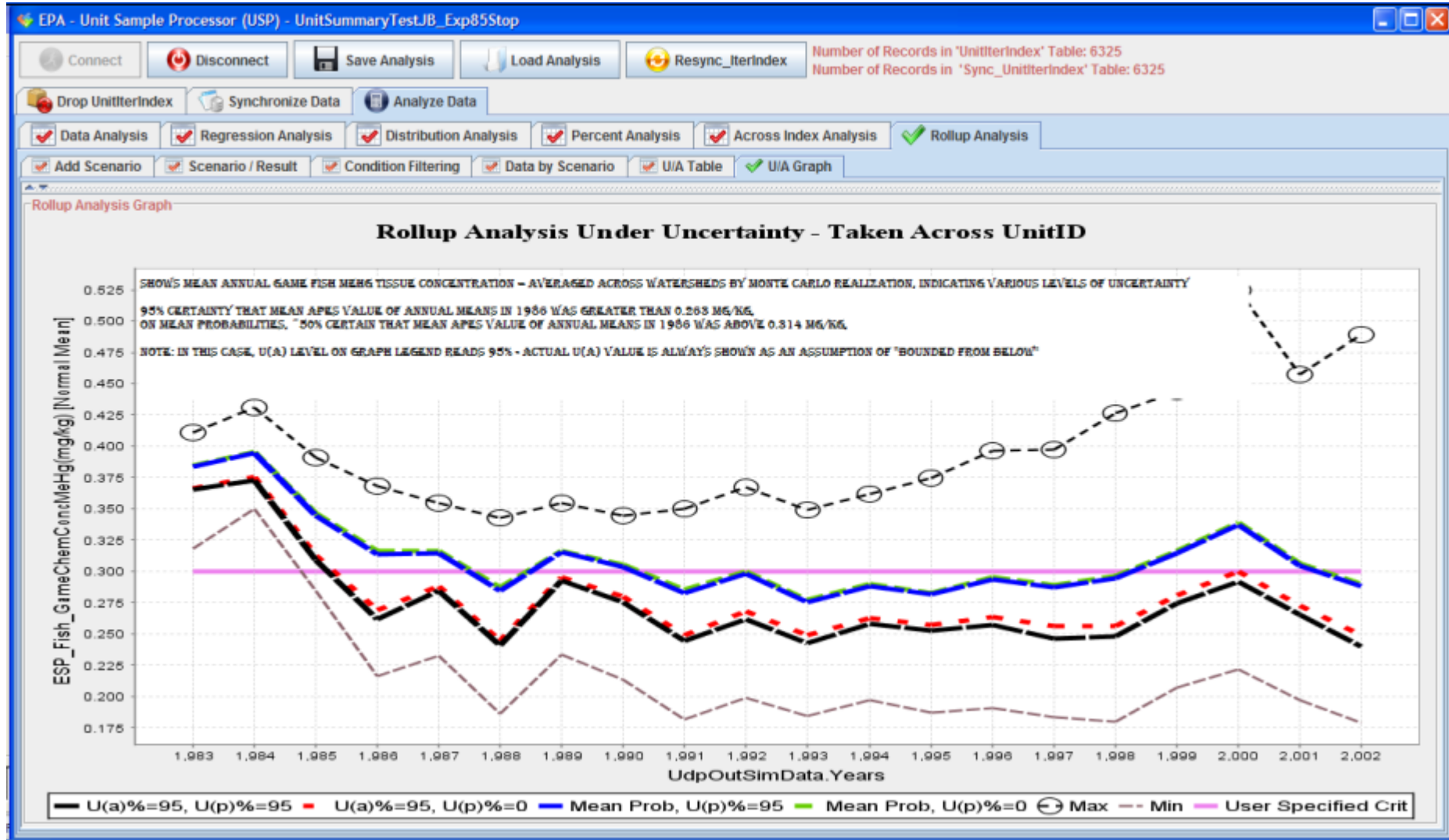
ESP_Habitat_TotalHSI(1)	ESP_Habitat_TotalHSI(10)	ESP_Habitat_TotalHSI(11)	ESP_Habitat_TotalHSI(12)	ESP_Habitat_To
0.174395007438877	0.171460220884902	0.182429913776356	0.182031225626106	0.17634854955347
0.174358845163113	0.171502547355986	0.182458876691308	0.18198243878017	0.17652477405031
0.176825868092702	0.172215247354499	0.185049231543527	0.184313448365585	0.17743475507715
0.174189530131313	0.171361061120702	0.181995380316599	0.181755544424679	0.17628040620304
0.178825940271167	0.172452130531523	0.186898794995439	0.185086904563767	0.17790070399396
0.177637555328984	0.172206935088147	0.185712038559759	0.184310676339894	0.17744969405647
0.175504318060517	0.172099946691031	0.183831329155342	0.183102525064835	0.17679032993924
0.174286792962786	0.171412404265141	0.181944241461835	0.181684611827536	0.17654460631889
0.176520415575402	0.172064431107855	0.184713169371384	0.183807050075771	0.17742507598843
0.17687749225171	0.172147330786559	0.184927489501625	0.184190612534313	0.17729372540938
0.178279594307909	0.172448028986255	0.186288844043848	0.184987371917566	0.17795685441568
0.176625351310713	0.172060415312071	0.184768100130392	0.183790357918212	0.17728286320069
0.174433480426308	0.171379064797426	0.182478490407826	0.181737825814861	0.17645672713985
0.174183398245944	0.171287862510281	0.181907362223504	0.181458677646831	0.17620645893459
0.176712059384103	0.171880624550665	0.184922725064141	0.184011894045495	0.17748886790729
0.175631118361342	0.171582204990776	0.183894321335331	0.183250400876996	0.17696997448749
0.174312649675286	0.171563351245946	0.182073169259304	0.181786253501706	0.1763866027336
0.17881864216216	0.17250269453042	0.186613208996052	0.185310718636356	0.17781647571287
0.179529896322168	0.172810589826081	0.187543179357442	0.185107035102946	0.17812958717330
0.174192063849505	0.171186771236712	0.182259888320607	0.181835512732602	0.17618786602071
0.176106901317901	0.171840245569705	0.184355488751996	0.183698172667947	0.17705342119261
0.174292405342134	0.171474736918006	0.18222828811433	0.18210147760909	0.17637925777497
0.179064568761432	0.17242379666548	0.186933978576794	0.185417963743408	0.17783704530671
0.179832446265004	0.172812369517599	0.187615207292803	0.185366627368171	0.17803985116810
0.174336516527694	0.171375719725176	0.182404993772705	0.182186587014555	0.17652957503420
0.174388052775329	0.171489040607322	0.181994793775833	0.182165216187213	0.17677772038196
0.179542699468311	0.172810064686223	0.187416527538737	0.185582489257152	0.17801423079308
0.174719831608119	0.171556532100896	0.182755290458085	0.1821033433896	0.17670333596998

Parametric Non-Parametric Binomial

Parametric Normal Mean Analyze Selected Condition ☒ Use Index as IndepVar?

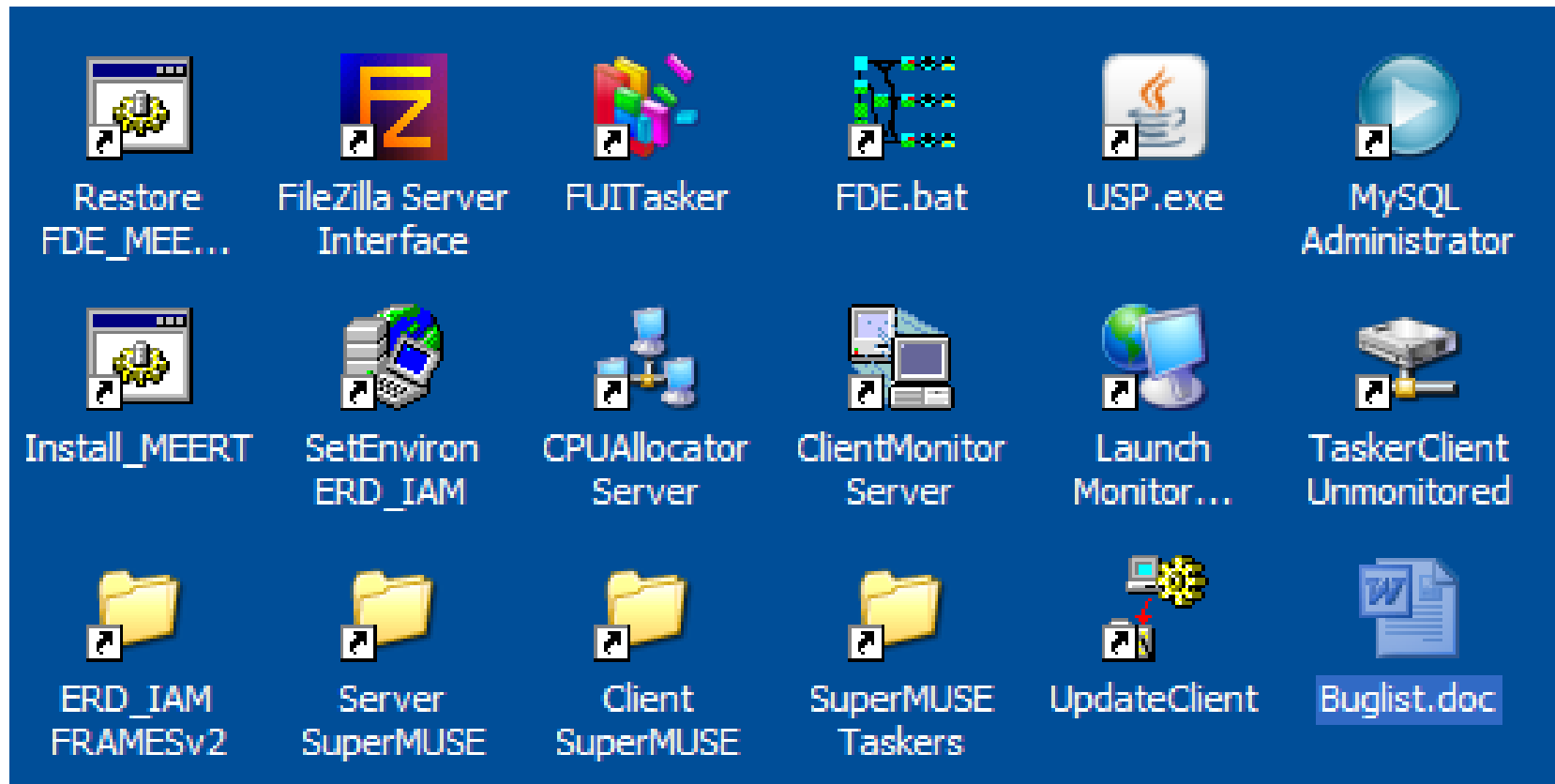
Choosing how you want the “unit” rollup dimension summarized.....i.e. pick a statistic

USP Tool: Rollup Analysis Example



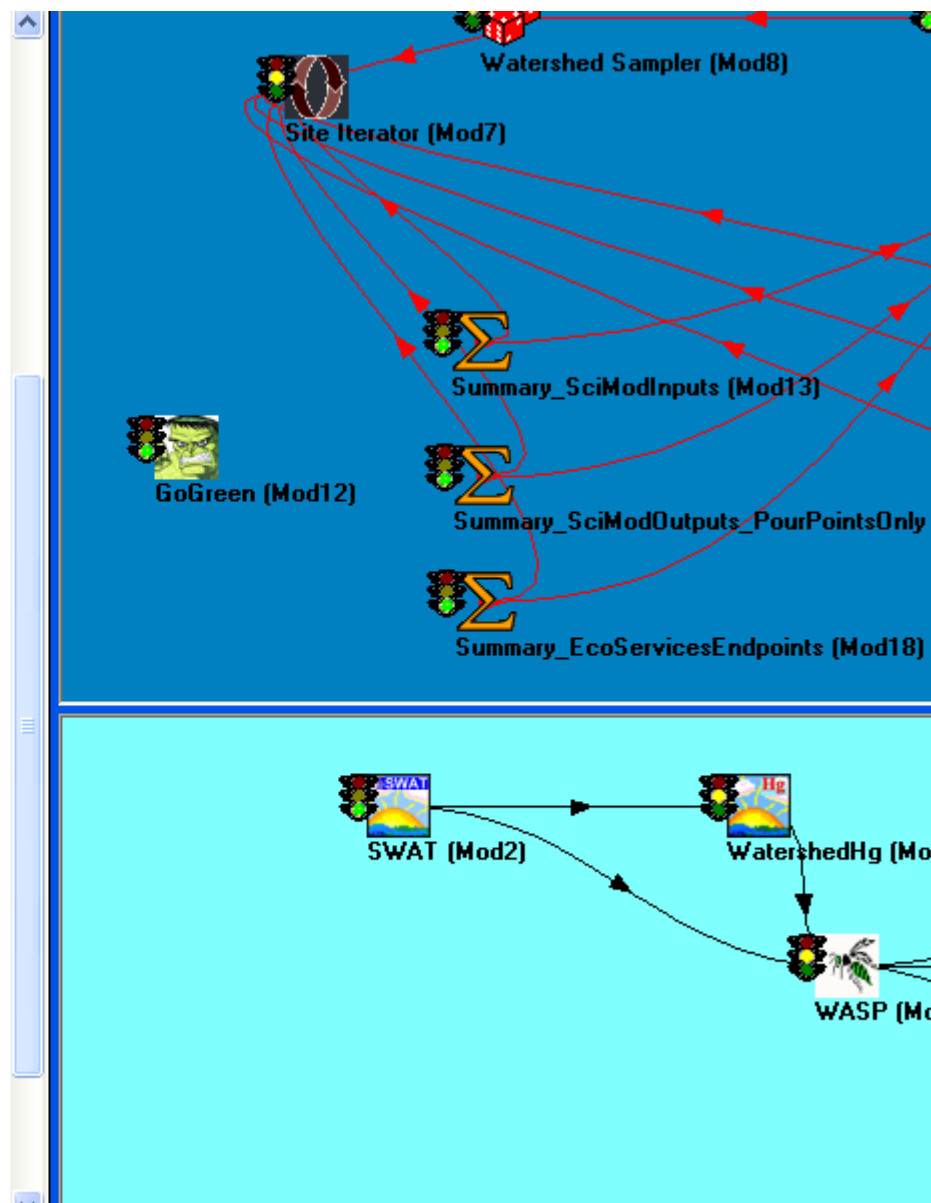
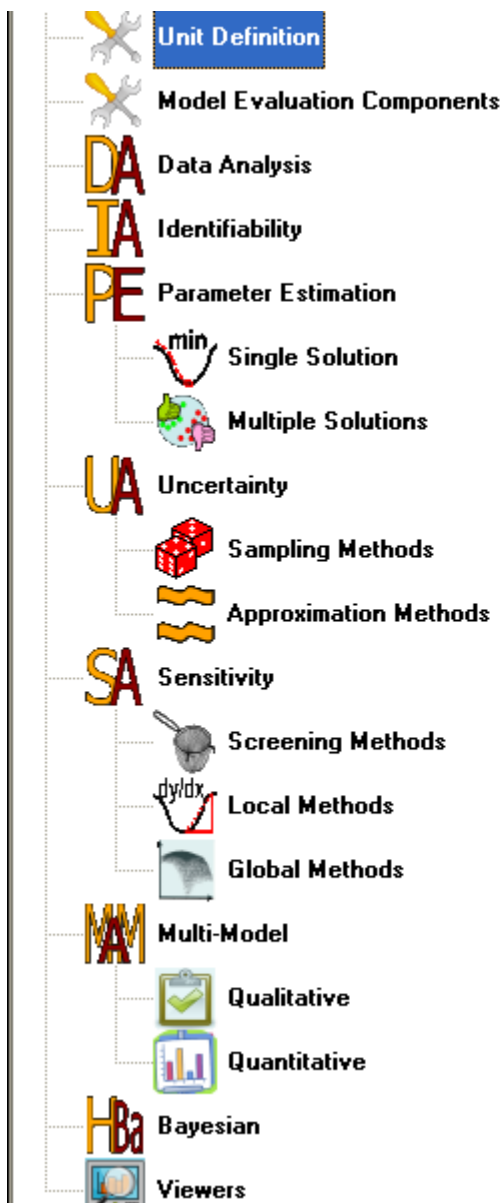
Example Rollup Analysis graphical output showing "population" analysis of units w/ UA

Simple Desktop Palette For Organizing & Launching F2 Stand-Alone PC, and Related SuperMUSE Ops

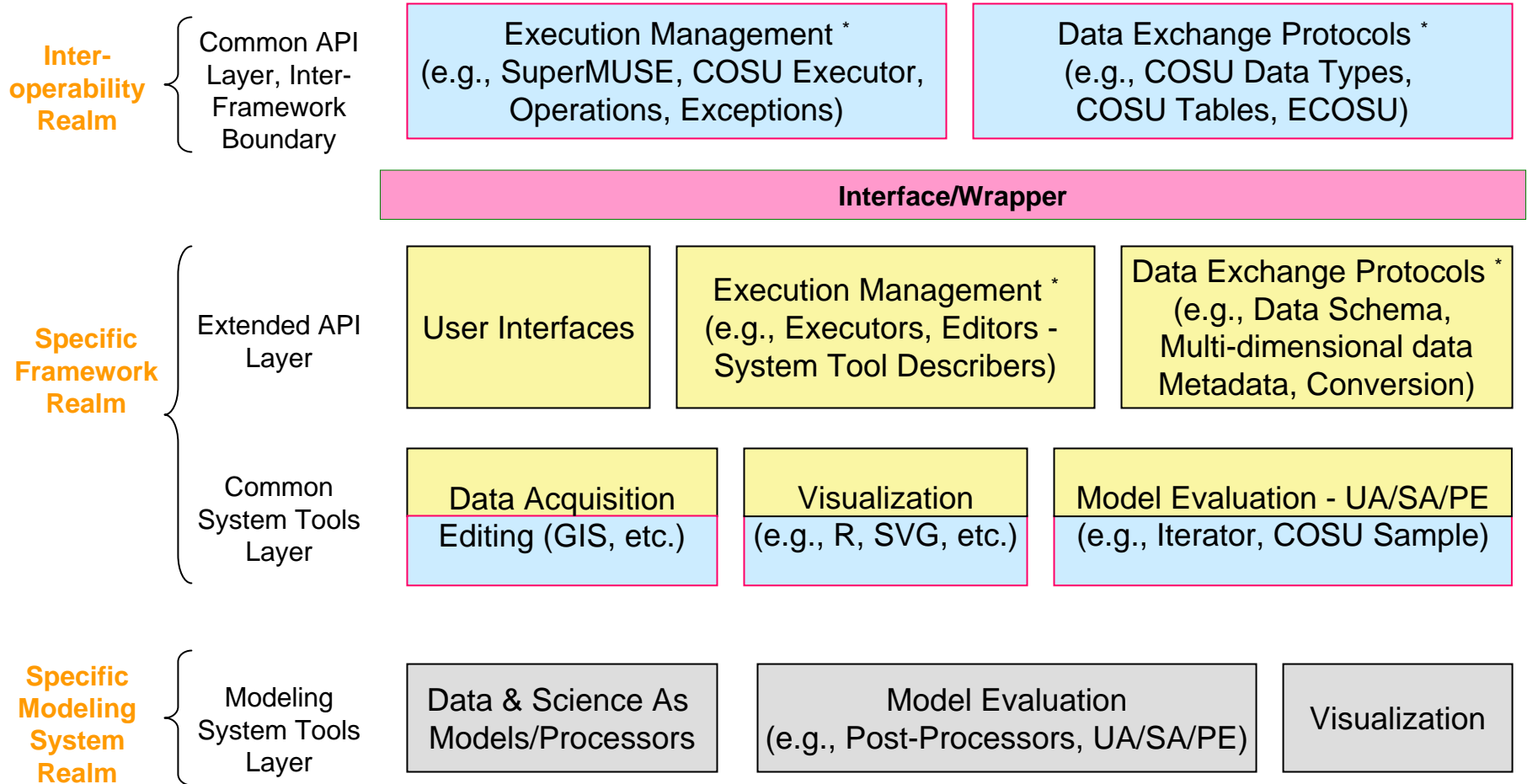


SuperMUSE 1.0 Software Status: beta form undergoing documentation & testing.... supporting multiple modeling systems, including now F2

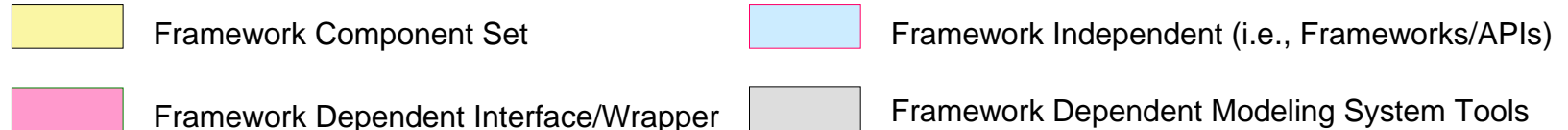
FRAMESv2 Envisioned Model Evaluation Palette

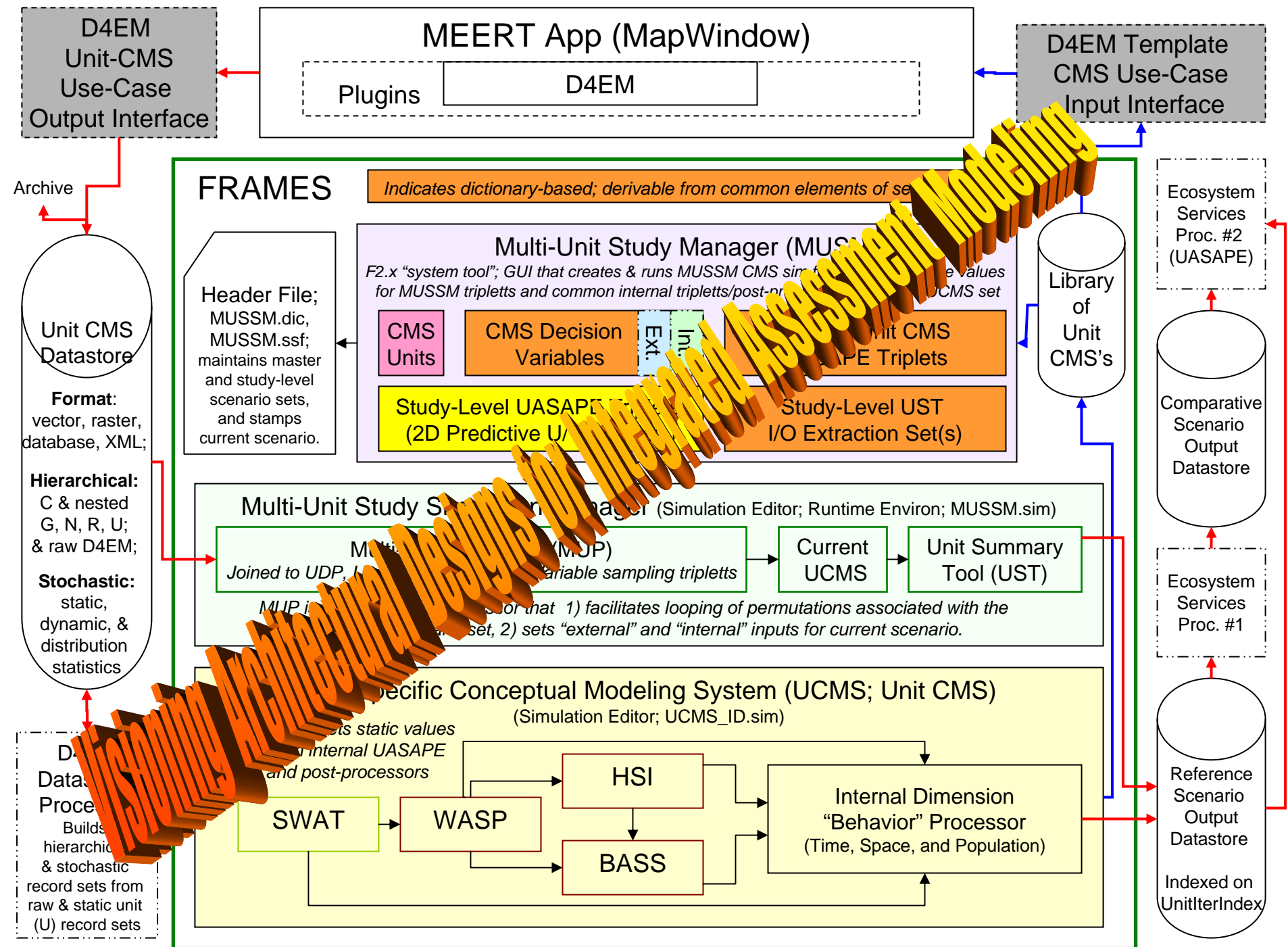


Generalized **Inter-Framework** Architecture Detail



* Includes Exception/Error Handling





Related Websites and Papers

<http://www.epa.gov/ceampubl/mmedia/3mra/index.htm>

- **CEAM Model Download Example: 3MRA Modeling System Files**
 - Source Code
 - Documentation
 - Installation procedures
 - Example Uncertainty Analysis of Seven Chemicals

<http://www.epa.gov/athens/research/modeling/supermuse/supermuse.html>

- **SuperMUSE**: Supercomputer for Model Uncertainty and Sensitivity Evaluation
 - Babendreier, J.E., Castleton, K.J.. (2005). Investigating Uncertainty and Sensitivity in Integrated Multimedia Environmental Models: Tools for FRAMES-3MRA. Journal of Environmental Modelling and Software, 20(8) pp: 1043-1055.

<http://www.epa.gov/athens/research/modeling/modelevaluation/>

- **EPA/ORD/NERL/ERD Model Evaluation Tools Website**
 - Matott, L. S., J. E. Babendreier, and S. T. Purucker (2009). Evaluating uncertainty in integrated environmental models: A review of concepts and tools, Water Resour. Res., 45, W06421, doi:10.1029/2008WR007301.

Disclaimer: Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

SuperMUSE Technical Support

Beta SuperMUSE Version 1.0

- Currently available in the F2 development community
 - Beta is beta, so users should use appropriate caution in disseminating results
 - Generally works pretty well, but specific network restrictions can apply
 - Software can be made available upon request
 - Can be used in desktop and cluster mode (e.g., 1 to 1000+ PCs)
- Documentation currently limited but in production, available 2010
 - Installation procedures with some discussion can be provided for now as feasible
 - Technical support and on-site installation help can be made available in a limited number of cases, as time, resources, and priorities allow
- Use and feedback by EPA is encouraged
 - Contact Justin Babendreier, EPA/ORD/NERL/ERD/RSB

Beta FRAMES Version 2

- Currently also available in the F2 development community
- Contact Gerry Laniak or Kurt Wolfe, EPA/ORD/NERL/ERD/RSB

SuperMUSE facilitates model evaluation functionality for both single desktop and cluster operations....multi-threaded F2 desktop ops soon - needs enhanced F2-API.