SAFE(R): A Matlab/Octave Toolbox (and R Package) for Global Sensitivity Analysis

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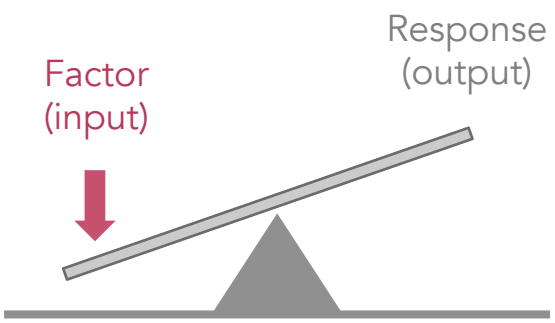
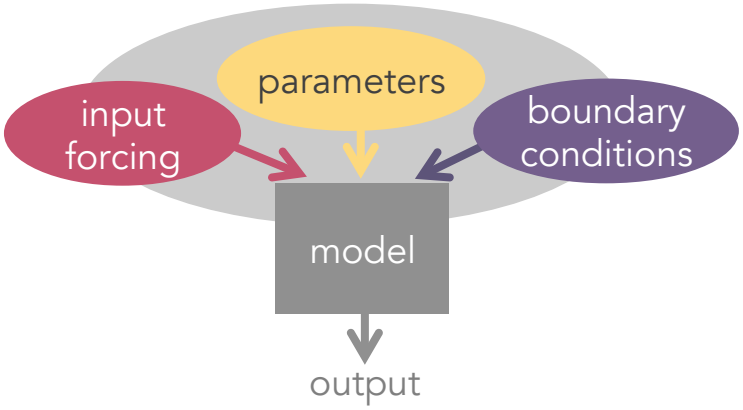
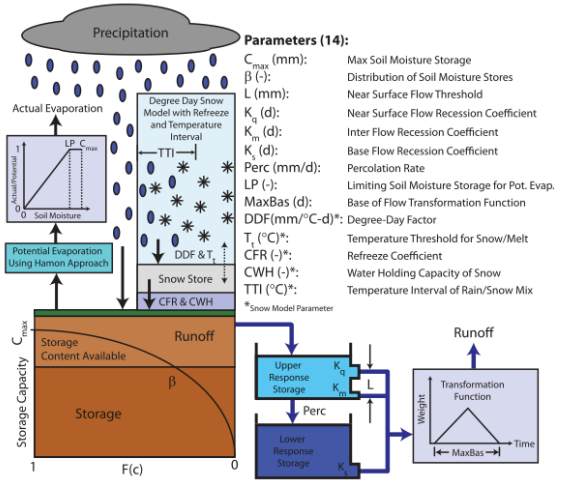
Global Sensitivity Analysis is a set of statistical techniques to investigate how variations in the output of a model can be attributed to variations in the model inputs

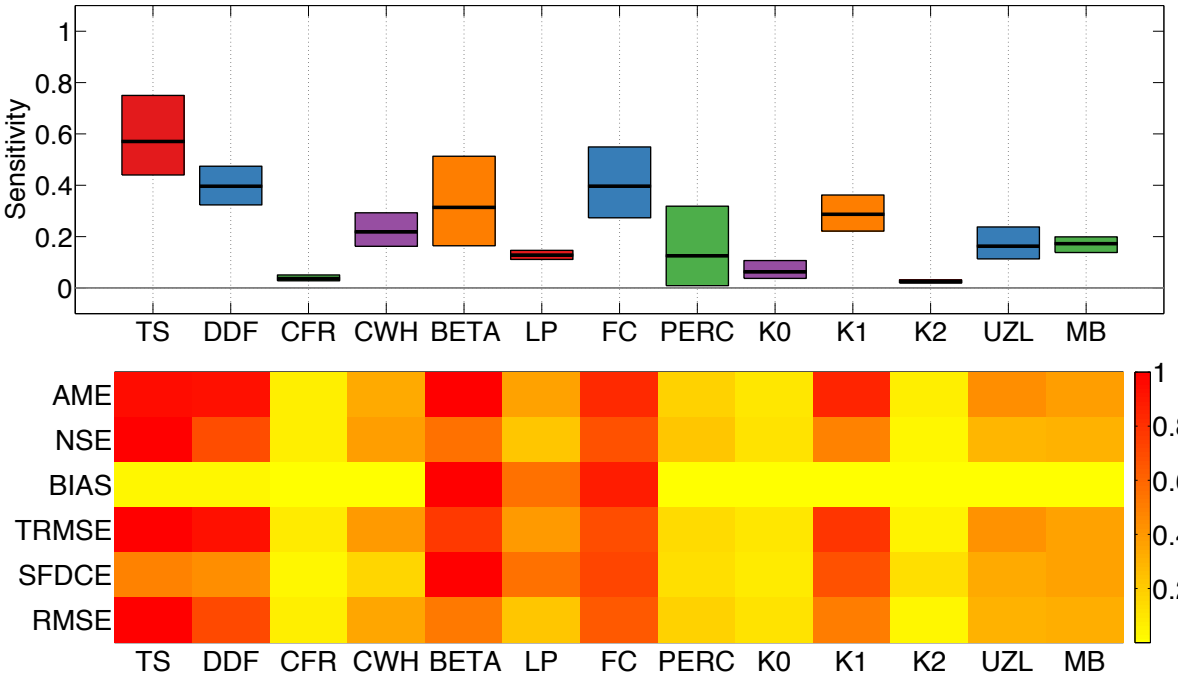


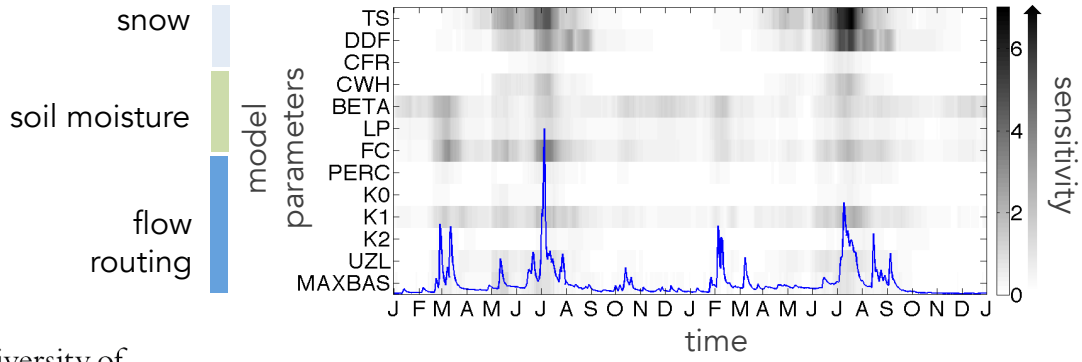


GSA provides a formal, structured approach to:
> support model calibration and verification
> investigate propagation of uncertainty through the model
> identify dominant controls of the model (system)

SAFE (Sensitivity Analysis For Everybody) is a matlab/octave/R toolbox that implements several GSA methods and tools







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bristol.ac.uk/cabot/resources/safe-toolbox/

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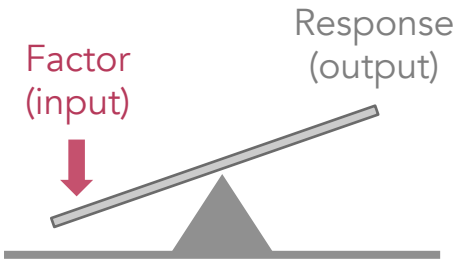
You should come to SAFE PICO presentation if

You want to learn more about SA and how it could be useful in your work



You already do or plan to do SA and you might be interested in using SAFE

You are interested in code development for academic use and want to discuss about
soft. architecture,
documentation,
obsolescence,
release strategy,
…

Features of SAFE toolbox

> Developed at University of Bristol within the NERC-funded CREDIBLE Project on Uncertainty and Risk in Natural Hazard assessment [NE/J017450/1]
credible.bris.ac.uk/about-us/

> Freely available for academic, non-commercial purpose since December, 2014

> Works under Matlab, Octave and R on Windows, Linux and Mac OS X

> Currently implemented methods:

- EET (Morris method)
- Variance-Based (Sobol' method)
- FAST
- Regional Sensitivity Analysis
- PAWN
- DYNIA

Paper in press:
Pianosi et al., A Matlab Toolbox for Global Sensitivity Analysis, *Env. Mod. & Soft.*

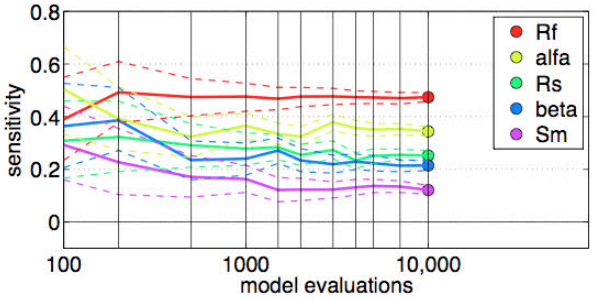
Architecture & Philosophy

modular structure
→ *facilitates multi-method approach*

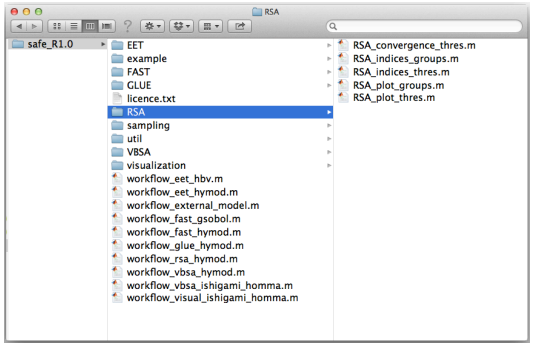
```
%% Step 3 (sample inputs space)
SampStrategy = 'lhs' ; % Latin Hypercube
N = 3000 ; % Number of samples
M = length(DistrPar) ; % Number of inputs
X = AAT_sampling(SampStrategy,M,DistrFun,DistrPar,N);

%% Step 4 (run the model)
Y = model_evaluation(myfun,X,rain,evap,flow) ;

%% Step 5a (Regional Sensitivity Analysis with threshold)

% Visualize input/output samples (this may help finding a reasonable value
% for the output threshold):
scatter_plots(X,Y(:,1),[],'rmse',x_labels) ;
scatter_plots(X,Y(:,2),[],'bias',x_labels) ;

% Set output threshold:
rmse_thres = 3   ; %  threshold for the first obj. fun.
bias_thres = 0.5 ; % behavioural threshold for the second obj. fun.

% RSA (find behavioural parameterizations):
threshold = [ rmse_thres bias_thres ] ;
[mvd,idxb] = RSA_indices_thres(X,Y,threshold) ;
```

more comments than commands

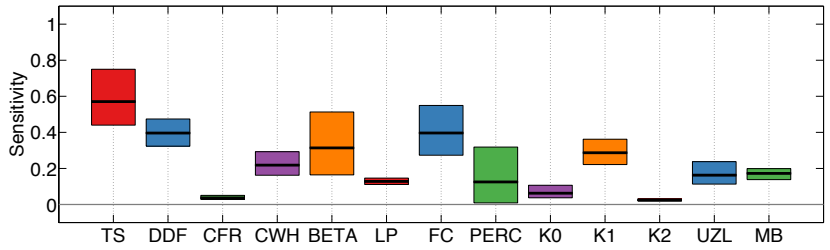
functions to assess robustness and convergence



minimum dependency on Matlab version, etc.
→ *reduce obsolescence*



tutorial scripts (workflows) to get started
→ *learn by doing*



many visualization functions

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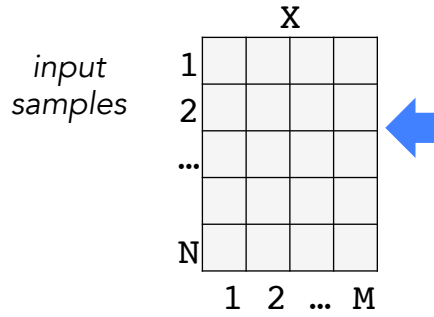
GSA steps	folders in SAFE Toolbox

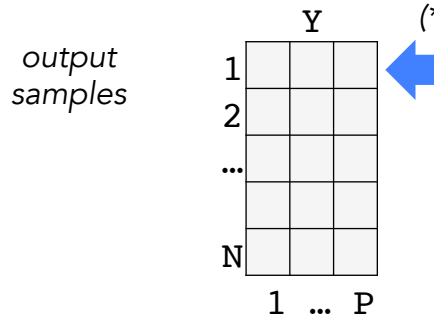


SAMPLING INPUT SPACE

sampling
functions for generic sampling strategies (e.g. Latin Hypercube) and ad hoc sampling (e.g. One-At-the-Time)

MODEL EVALUATION

(*)

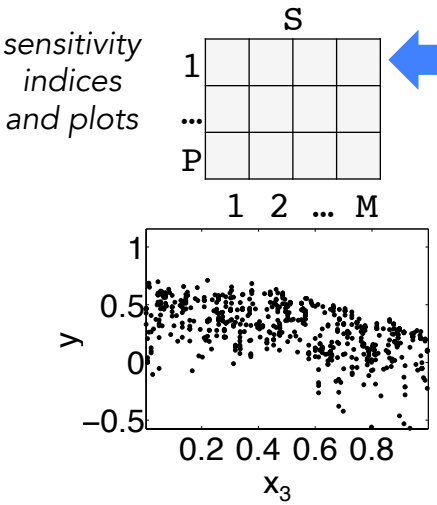


POST PROCESSING

methods

- Elementary Effects Test → **EET**
- Regional Sensitivity Analysis → **RSA**
- Variance-Based Sensitivity Analysis → **VBSA**
- … → *other methods to be plugged in …*

functions to compute and plot indices and analyze their convergence within a specific GSA method, e.g.
`EET_indices.m`
`EET_convergence.m`
`EET_plot.m`



visualization *generic plotting functions that can be used on their own or within different GSA methods*

util *shared utility functions*

example *functions implementing numerical models used in the workflow examples*

Upcoming EGU presentations where SAFE is used

Wed, 15 – 11:45 - Session NH1.6 - Room G6 - EGU2015-13145
The application of Global Sensitivity Analysis to quantify the dominant input factors for hydraulic model simulations by James Savage et al.

Wed, 15 – Session NP1.3/HS2.3.16 - Blue Posters - EGU2015-2218
Global Sensitivity Analysis of Environmental Models: Convergence, Robustness and Validation by Fanny Sarrazin et al.

Wed, 15 Apr – 16:45 – Session NP1.3/HS2.3.16 - Room B3 - EGU2015-997
Global sensitivity analysis of a SWAT model: comparison of the variance-based and moment-independent approaches by Farkhondeh Khorashadi Zadeh et al.

Thu, 16 Apr – Session HS2.3.12 - Red Posters - EGU2015-7547
Catchment Prediction In Changing Environments (CAPICHE): A collaborative experiment in an open water science laboratory by C. Hutton et al.

Fri, 17 – Session NH3.11 – Blue Posters - EGU2015-6555
Robustness for slope stability modelling under deep uncertainty
by Susana Almeida et al.