



IMPC THEME A7: Characterization and Communication of Uncertainty

Saman Razavi, September 15, 2017

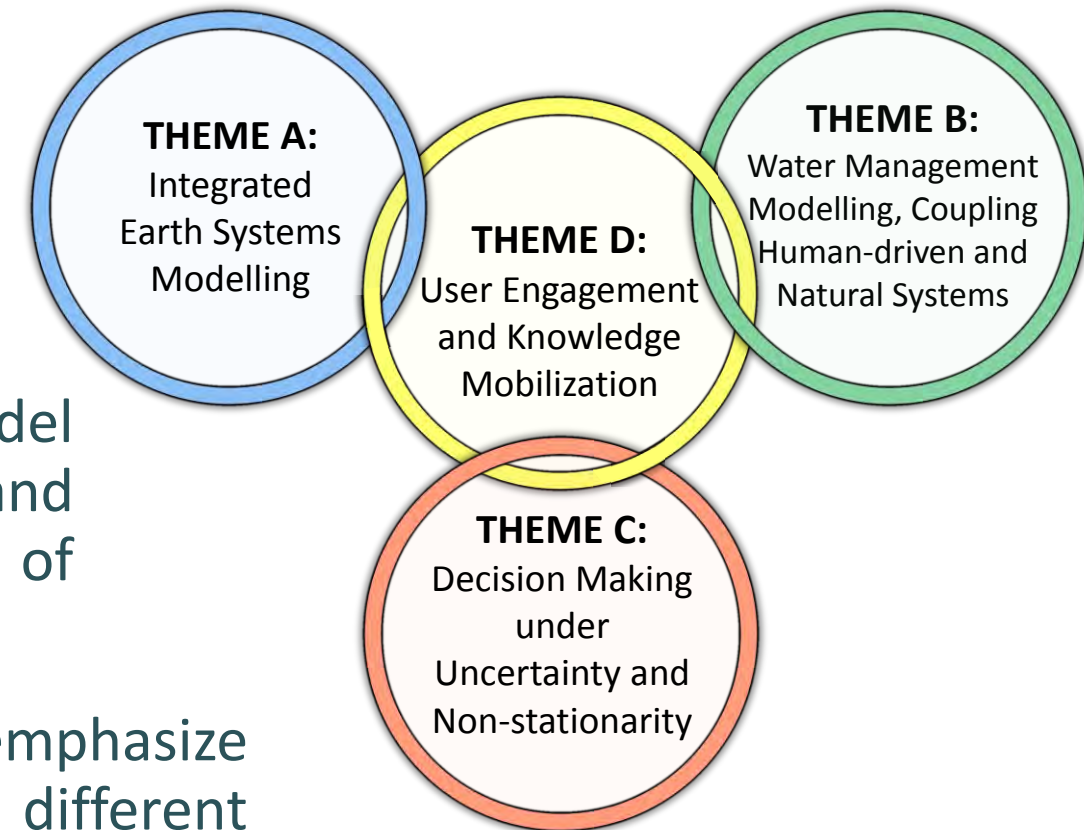


GLOBAL WATER FUTURES
INTEGRATED MODELLING
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Objective

The overarching goal is to characterize and communicate model uncertainties across all program themes:

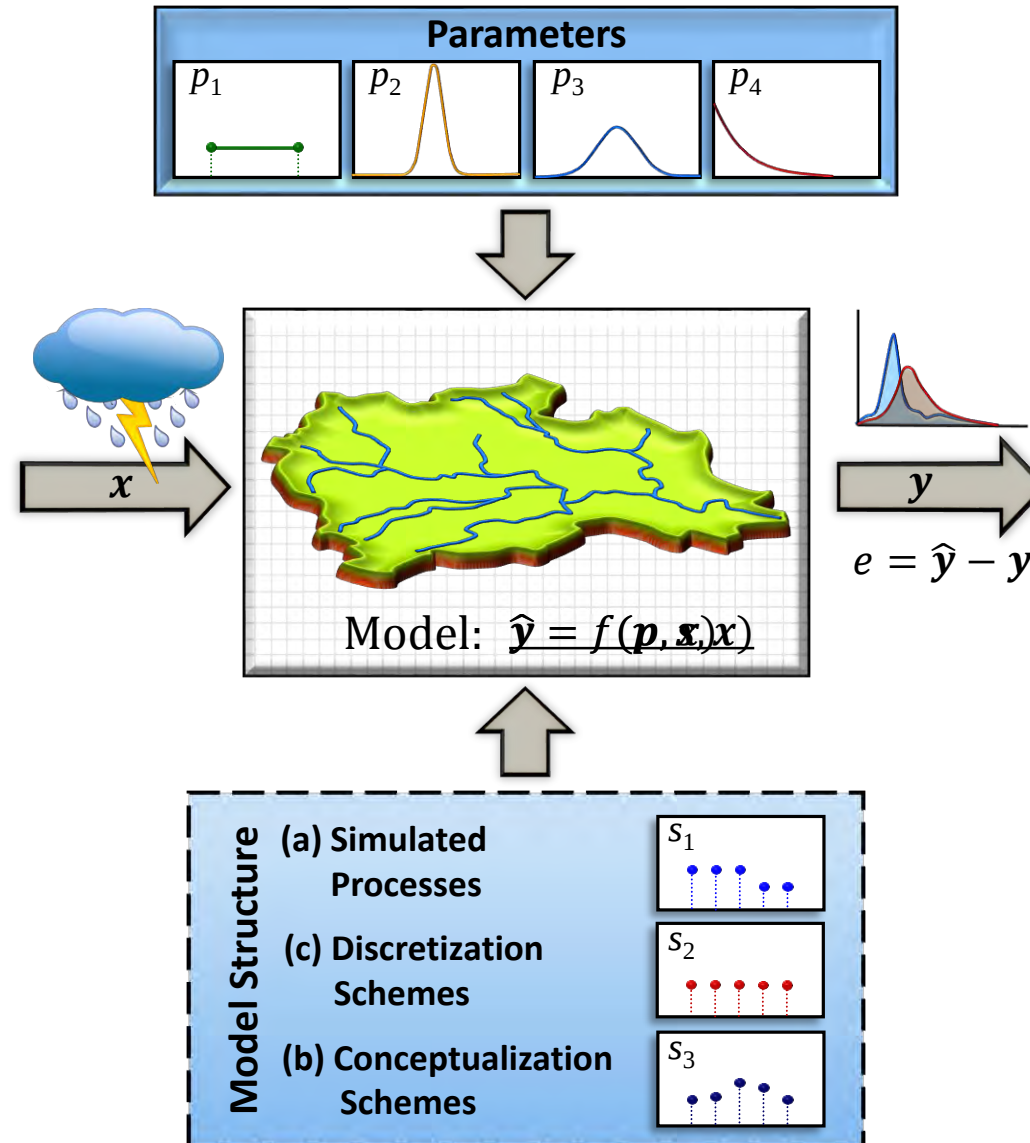
- For Themes A, this will support model development, including diagnostic testing and the identification of major sources of uncertainty.
- For Themes B, C and D, this will emphasize characterizing the predictive uncertainty in different variables of interest such as streamflows, water quality indices, and water resources system performance metrics, and apportioning that uncertainty to different contributing sources.
- A major focus will be on the communication of uncertainty within the Decision Making Under Uncertainty process (Themes C and D).



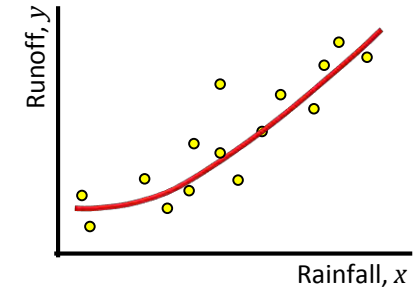
Uncertainty is intrinsic to all aspects and components of the current generation of Earth system models.



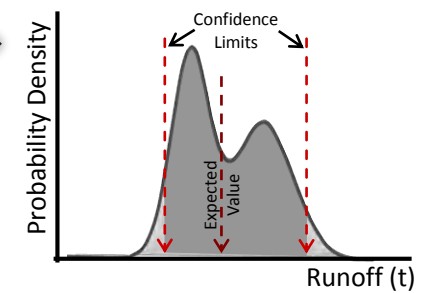
- Some sources of uncertainty in modelling can be 'adequately' characterized and incorporated into subsequent analyses, via probability theory.
- Adequate characterization of uncertainty and its representation in any decision problem formulation is essential.



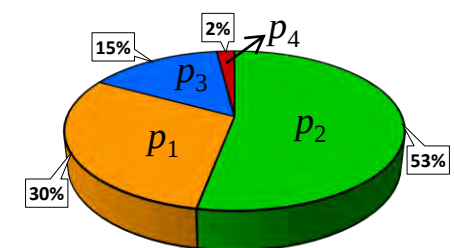
Optimization



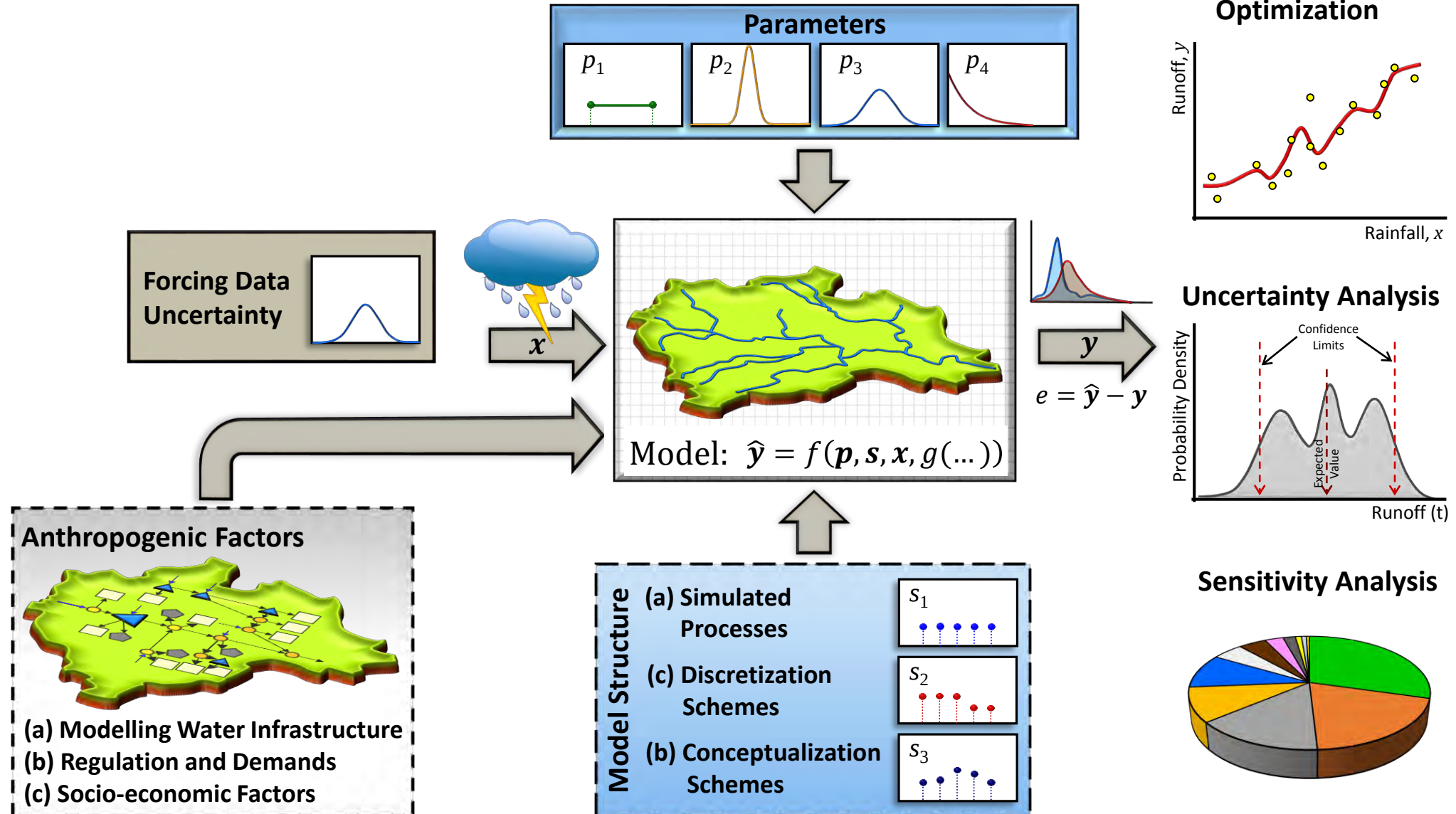
Uncertainty Analysis



Sensitivity Analysis



Some Factors are “Deeply Uncertain” and Probability Theory is of No/Limited Help

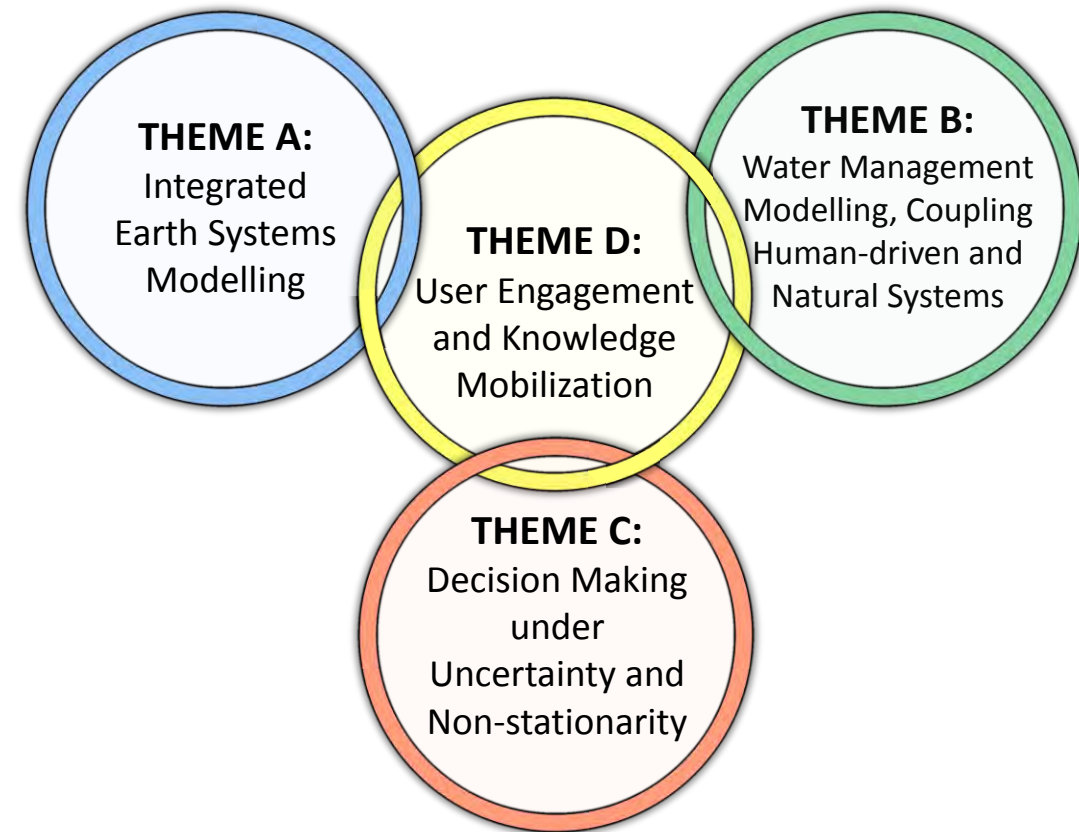


What To Do ...

As a team, we need to be consistent with the approaches used and how we communicate uncertainty with modelling results.

Characterizing predictive uncertainty is critically important for Decision Making Under Uncertainty.

Let's discuss and develop a common plan for characterization and communication of uncertainty.



VARS-TOOL:

A Toolbox for Sensitivity and Uncertainty Analysis



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Razavi's Watershed Systems Analysis and Modelling Lab

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Next Generation Sensitivity and Uncertainty Analysis

The Watershed Systems Analysis and Modelling Lab is home to the VARS sensitivity and uncertainty analysis framework. VARS is applicable to the full range of computer simulation models, including Earth and Environmental Systems Models (EESMs). VARS is under continuous development and new capabilities and features are forthcoming.

You can download a soft copy of the VARS-Tool manual from [VARS-Tool Manual](#).

To obtain a free copy of the VARS package for non-commercial purposes, please contact Dr. Saman Razavi at saman.razavi@usask.ca. For commercial purposes, please contact John Geikler at johng@tla.arizona.edu, and CC saman.razavi@usask.ca.



What is Global Sensitivity Analysis (GSA)?

Global sensitivity analysis is a systems theoretic approach to characterizing the overall (average) sensitivity of one or more model responses across the factor space, by attributing the variability of those responses to different controlling (but uncertain) factors (e.g., model parameters, forcings, and boundary and initial conditions).

AGU PUBLICATIONS

Water Resources Research

REVIEW ARTICLE

10.1002/2014WR016527

Key Points:
• No unique definition exists for "global sensitivity" across the problem space

What do we mean by comprehensive characterization of global sensitivity and environmental systems?

Saman Razavi¹ and Hoshin V. Gupta²

AGU PUBLICATIONS

Water Resources Research

RESEARCH ARTICLE

10.1002/2015WR017558

Companion to Razavi and Gupta [2016], doi:10.1002/2015WR017558.

A new framework for comprehensive global sensitivity analysis

Saman Razavi^{1,2} and Hoshin V. Gupta³

AGU PUBLICATIONS

Water Resources Research

RESEARCH ARTICLE

10.1002/2015WR017559

Companion to Razavi and Gupta [2016], doi:10.1002/2015WR017558.

Key Points:
• Star-sampling (STAR) enables VARS to fully characterize global sensitivity
• Case studies show VARS is highly efficient, even for high-dimensional problems
• STAR-VARS is more robust, stable, and efficient than either Sobol or Morris

A new framework for comprehensive global sensitivity analysis: 2.0

Saman Razavi^{1,2} and Hoshin V. Gupta³

¹Global Institute for Water Security & School of Environment, University of Saskatchewan, Canada, ²Department of Civil and Geological Engineering, University of Saskatchewan, Canada, ³Department of Hydrology and Environmental Engineering, University of Illinois at Urbana-Champaign, USA

Abstract Based on the theoretical framework of Response Surfaces" (VARS), developed in the companion paper (Razavi and Gupta, 2016), we present a "star-based" sampling strategy (called STAR-VARS), for the application of VARS to real-world problems. We also develop a bootstrap approach to provide confidence level estimates for the VARS sensitivity metrics and to evaluate the reliability of inferred factor rankings. The effectiveness, efficiency, and robustness of

VARS-Tool

A Comprehensive,
Efficient, and
Robust Toolbox for

Global Sensitivity Analysis

Version 1.0

USER'S MANUAL

Saman Razavi

February, 2016

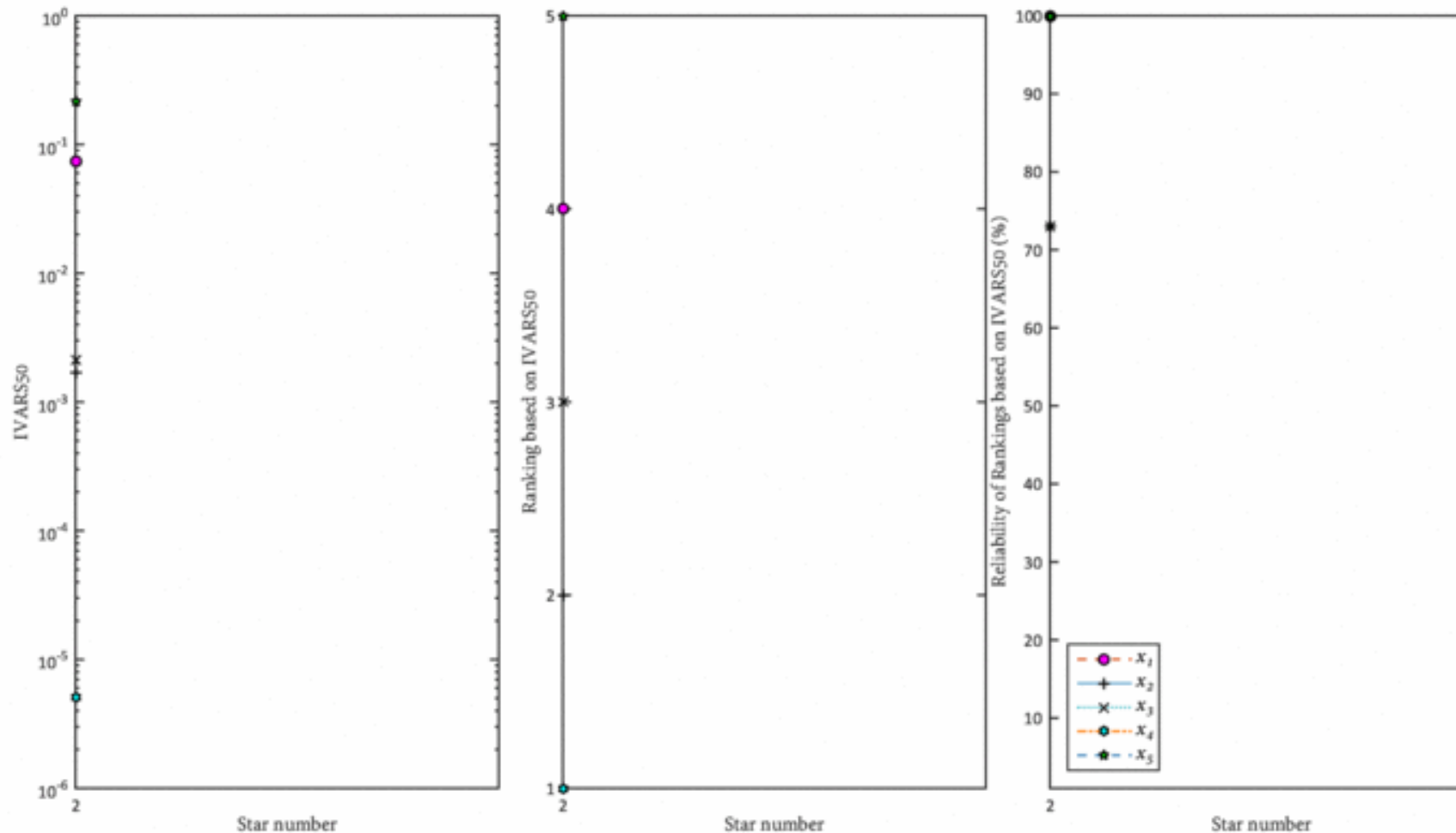


Features of VARS-TOOL

- Multiple Sampling Strategies (NEW)
- Multiple Sensitivity/Uncertainty Analysis Algorithms (NEW)
- Sensitivity Analysis of Dynamical Systems Models (NEW)
- Bootstrapping: Characterizing Confidence and Reliability
- Factor Grouping: Dealing with High-dimensional Problems (NEW)
- Reporting and Visualization: Monitoring Stability and Convergence (NEW)
- Model Emulation: Handling Model Crashes (NEW)
- Beyond MATLAB: Running in any Programming Languages & Operating Systems
- Test Functions (NEW)
- Example Case Studies (NEW)

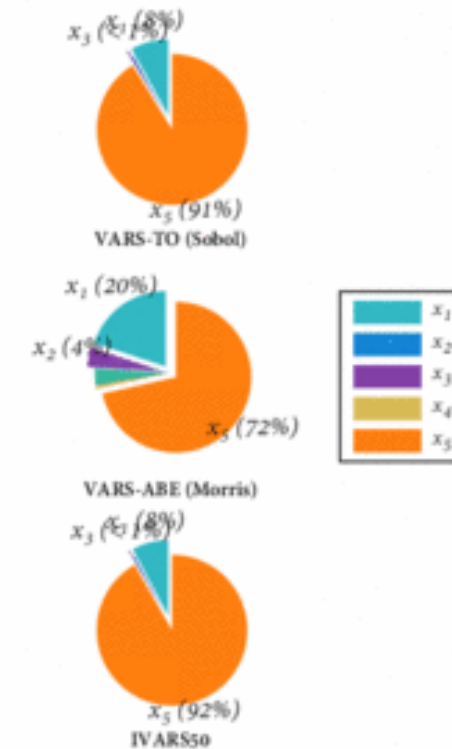
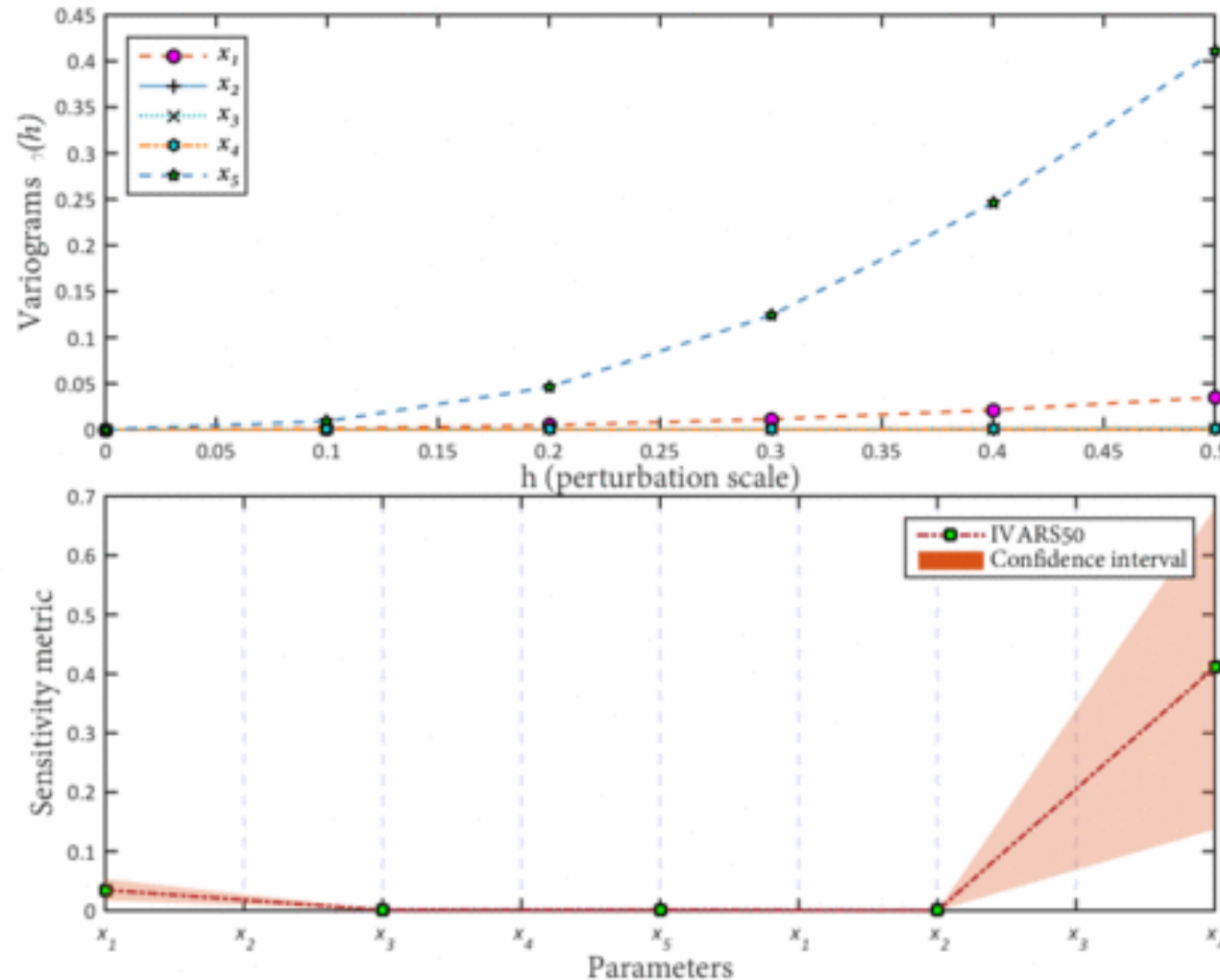
VARSTOOL: New Visualization Tools

To Monitor Convergence and Stability ...



VARS-TOOL: New Visualization Tools

To Monitor Convergence and Stability ...



Water
means
the **WORLD**
to Us...



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