Sobol Global Sensitivity Analysis to Determine Effective Rabies Control

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Introduction

- Sensitivity analysis (SA) investigates influence of model parameters on model outputs
- Sobol SA is a variance-based Global SA method that is often used in ecology, but so far rarely applied to epidemiological models[1,2]
- Sobol SA accounts for interactions between model parameters and non-linear relationships between model parameters and outputs, which commonly exist in complex simulation models

Field study on Elcho Island, Northern Australia

Objectives

- Application of Sobol SA to a agent-based, spatially explicit, dog rabies simulation model (developed for Northern Australia)[3-5]
- Investigation of the sensitivity of three model outcomes to model parameters and their interactions

→ Inform:
- scientists to refine models
- policy makers to plan efficient control strategies

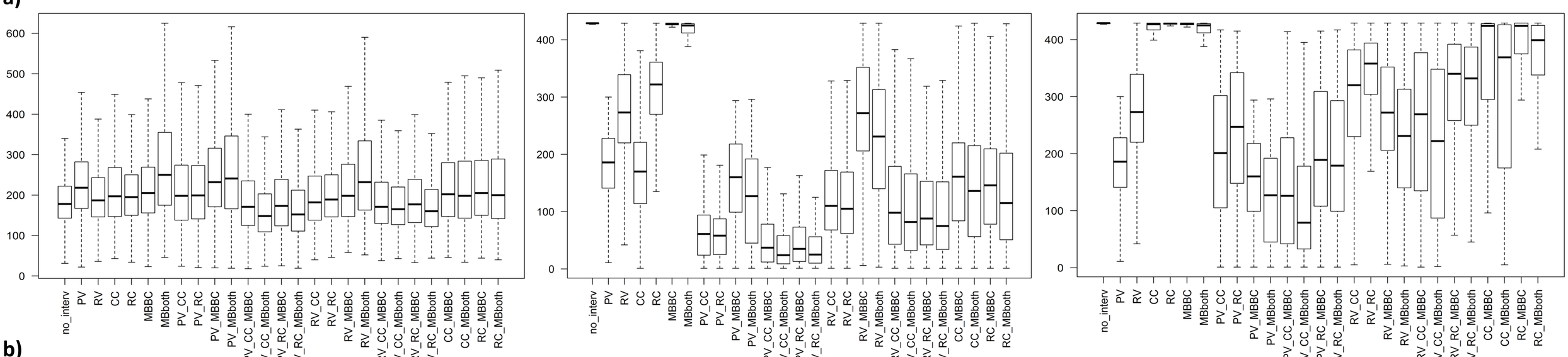
Methods

Investigation of 27 scenarios :
- 12000 – 34000 iterations simulated per scenario
- Using R package *sensitivity*, function *sobolmartinez*
- Parallel runs on high performance cluster computer (Ubelix)
- Calculation of first effect and total effect Sobol indices (the latter considers interactions between model parameters) of all parameters for 3 model outputs per scenario

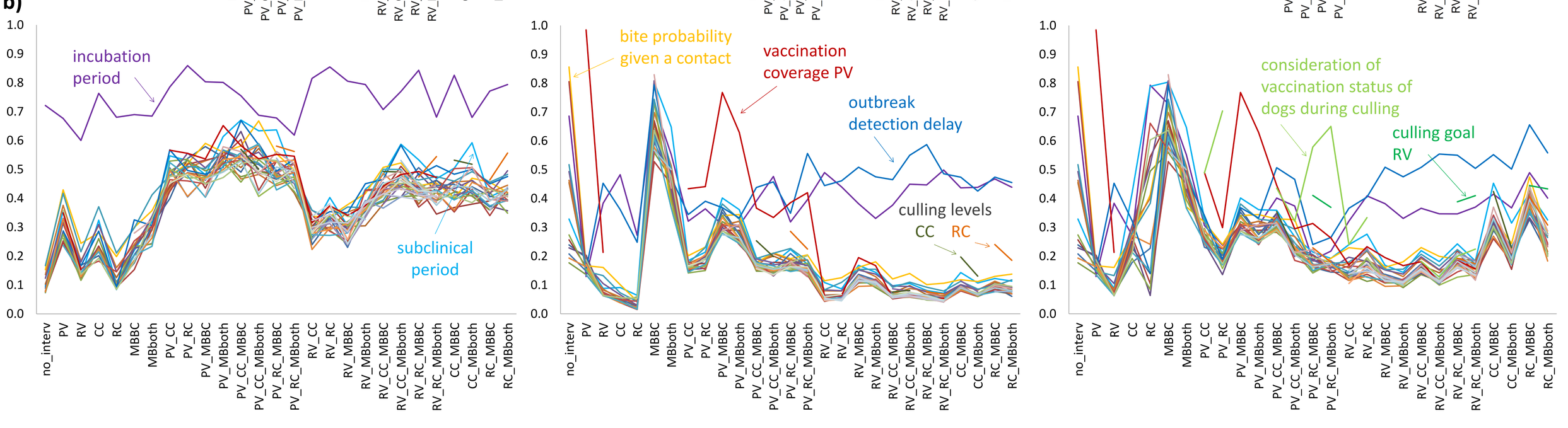
Scenarios (interventions simulated separately and in combinations):
- Non-intervention (**no_interv**)
- Preventive vaccination (**PV**, coverage 40-80%)
- reactive vaccination (**RV**, coverage 40-80%)
- targeted culling exposed dogs (**CC**, level 50-90%)
- random culling (**RC**, level 10-50%)
- restrictions of dog movements between (**MBBC,** compliance levels 70-95%) +/- within communities (compliance levels 50-95%) (**MBboth**)

Results

a)



b)



a) Effect of the 27 scenarios on rabies outbreaks
b) Total effect Sobol indices [0,1] represent the influence of the parameters on the model outputs (different colours represent individual model parameters)

Discussion and Conclusions

Sobol SA helped to identify the parameters to which model outputs are most sensitive, i.e. for which more information is needed to increase accuracy of predictions (reduce uncertainty), or increase impact of disease control (reduce variability). Based on our results, improving surveillance or increasing disease awareness – to reduce detection delay – are attractive investments. Additional information on the incubation period, bite probability given a contact and rate of permanent dog movement between communities might be obtained from a systematic literature review, outbreak reports, expert opinion or monitoring data collected in specific regions. Nevertheless, high total effect Sobol indices for most parameters in combined intervention strategies imply substantial interaction between parameters. Although challenges of the Sobol SA were encountered (e.g. computing time, limitations in performance), it is a powerful tool for both improving the design of the model and of the intervention strategies, thus contributing to better preparedness planning.

Acknowledgements
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References: 1. Sobol et al, 2001, Mathematics and Computers in Simulation; 2.Brookes et al, 2015, PLoSOne; 3. Dürr and Ward, 2014, Prev Vet Med; 4. Dürr and Ward, 2015, PLoSNTD; 5. Hudson et al, 2016, PLoSNTD