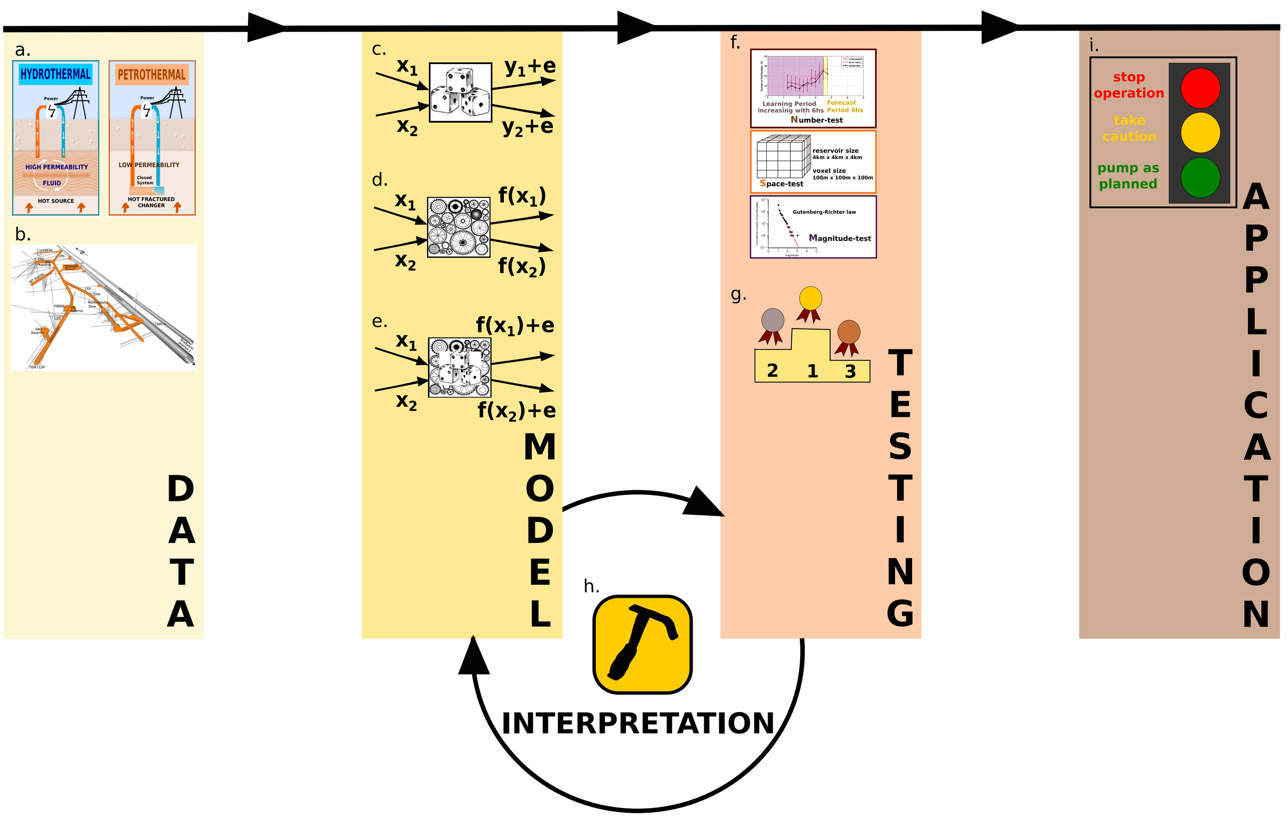
Developing a Test Bench for Induced Seismicity Modelling in Deep Geothermal Energy Projects

E. Király[1], J. Zechar[1], V. Gischig[2], D. Karvounis[1], J. Doetsch[2] and S. Wiemer[1]
(1) Swiss Seismological Service - ETH Zürich, Switzerland; (2) Swiss Competence Center for Energy Research (SCCER-SoE), ETH Zürich, Switzerland
email: eszter.kiraly@sed.ethz.ch

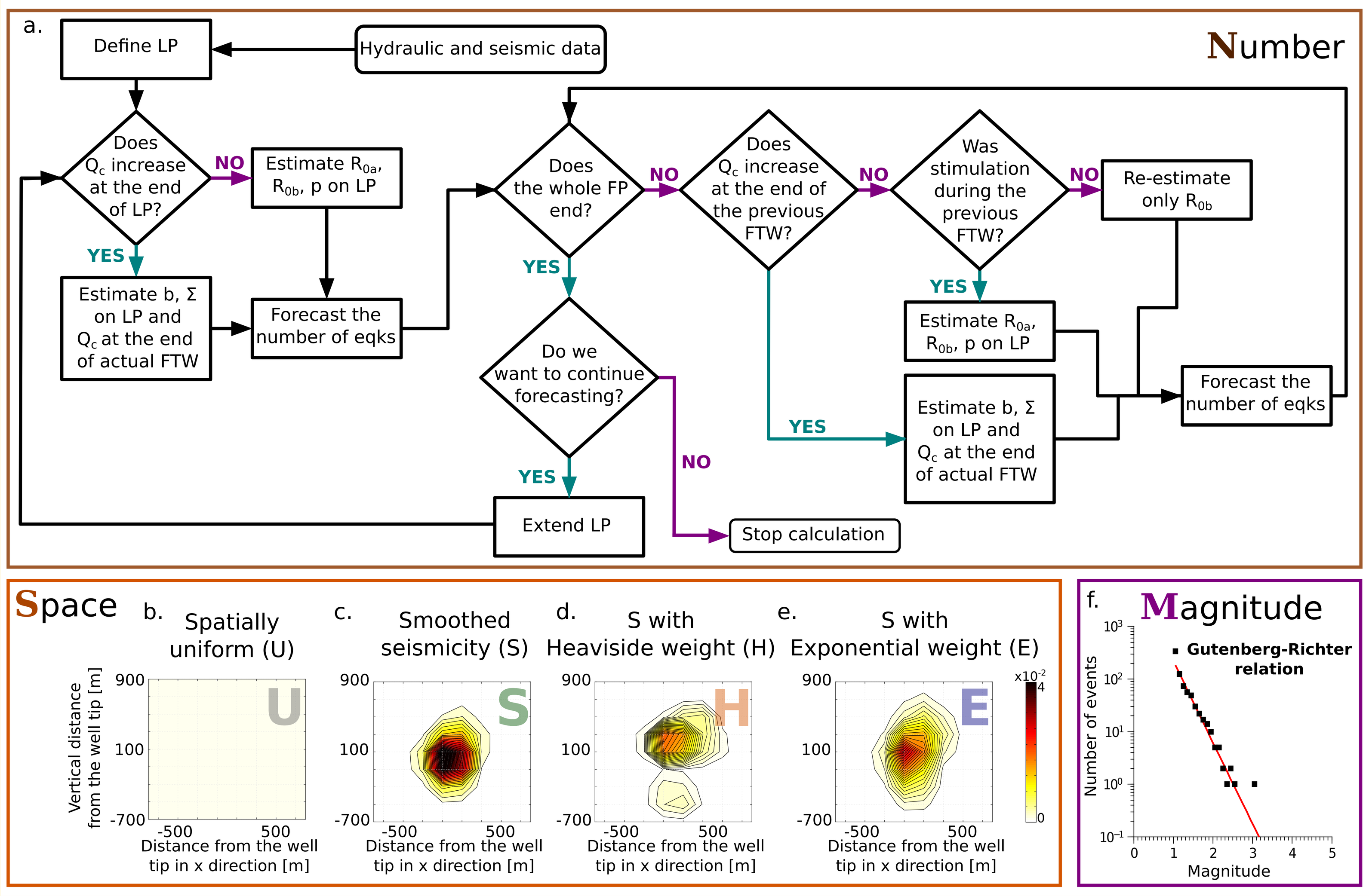
INTRODUCTION

INDUCED SEISMICITY MODELING TEST BENCH

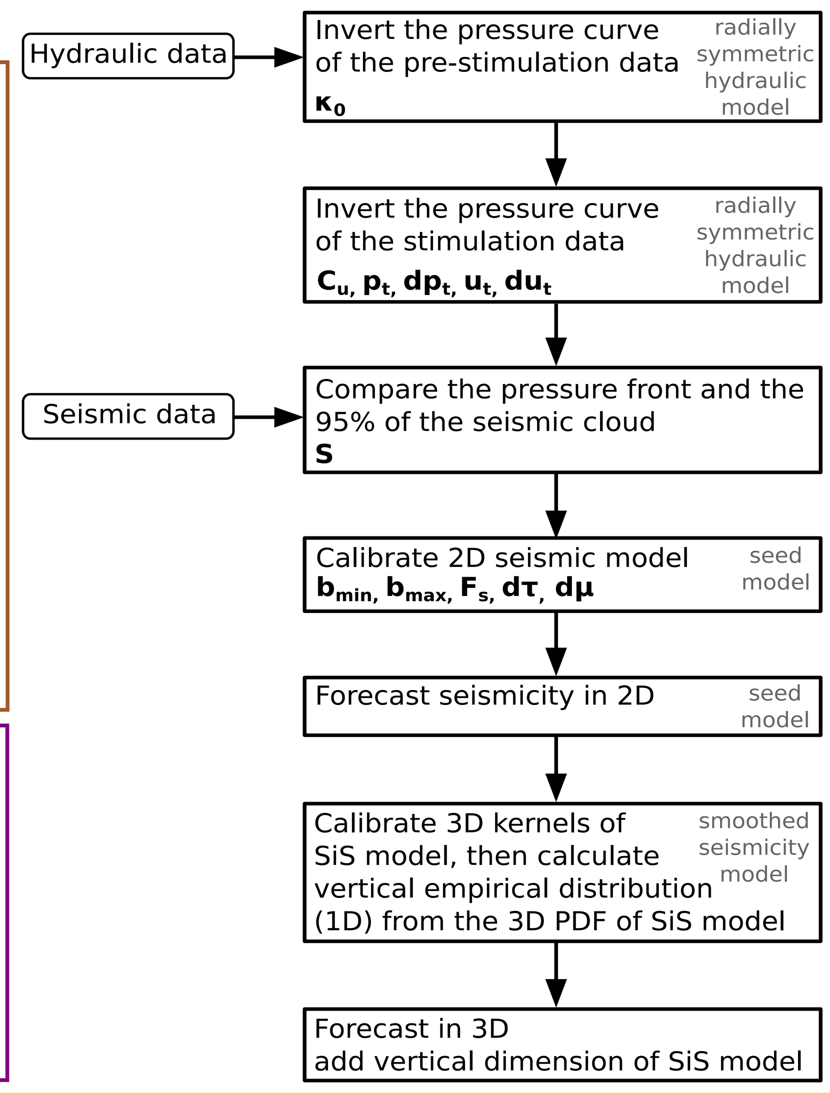


MODELS

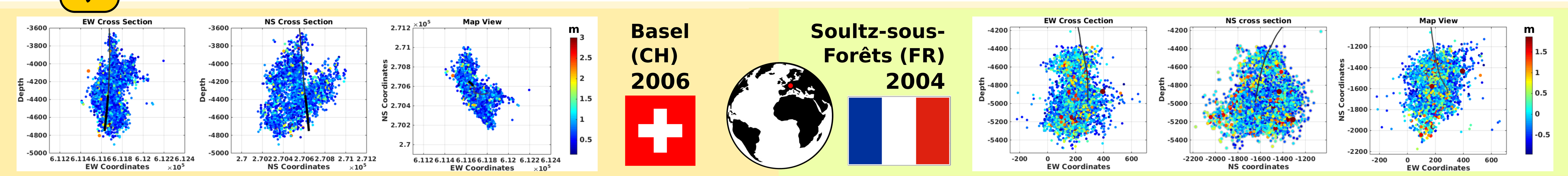
Shapiro in Space (SiS) model



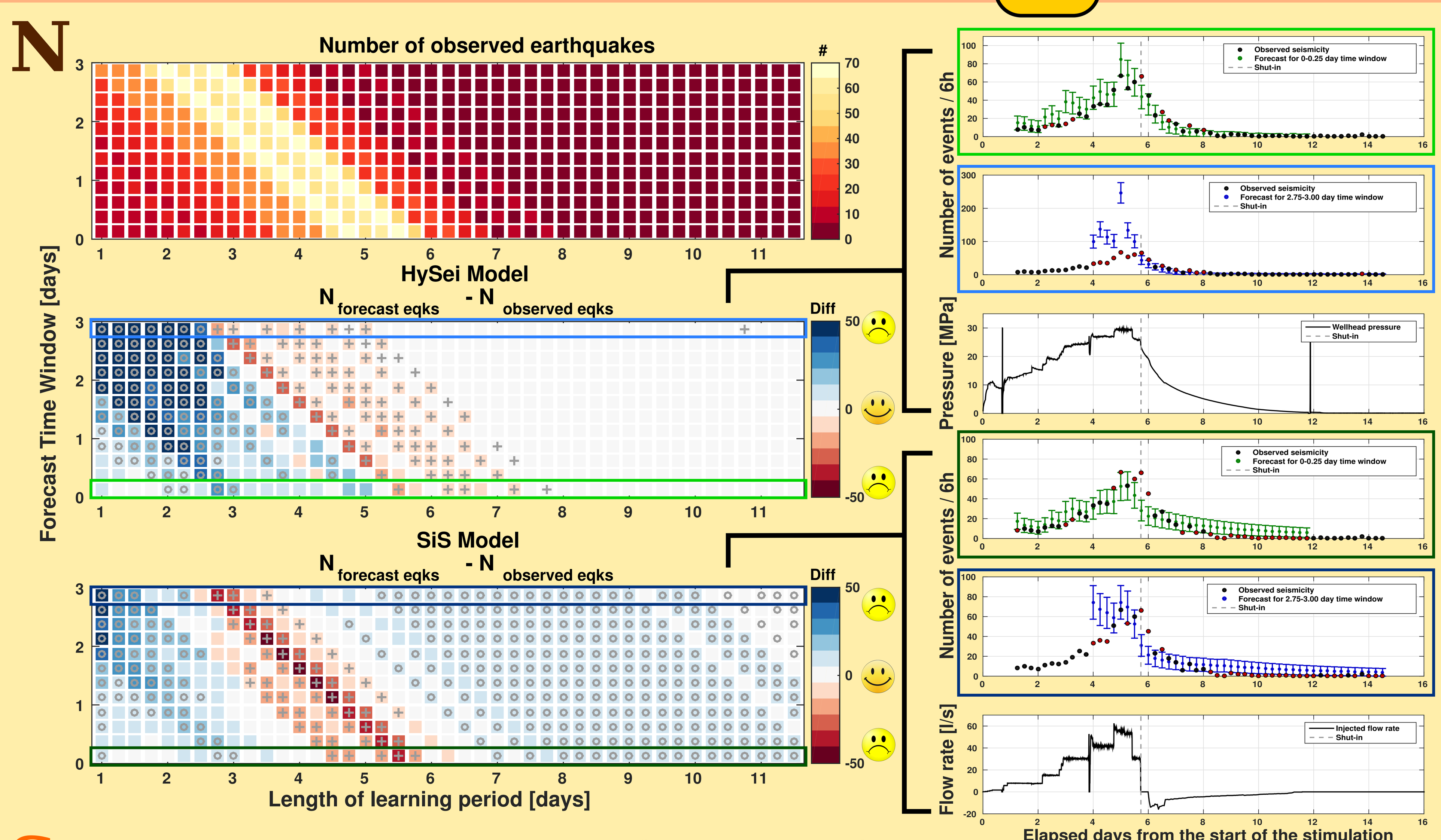
Hydraulics and Seismics (HySei) model

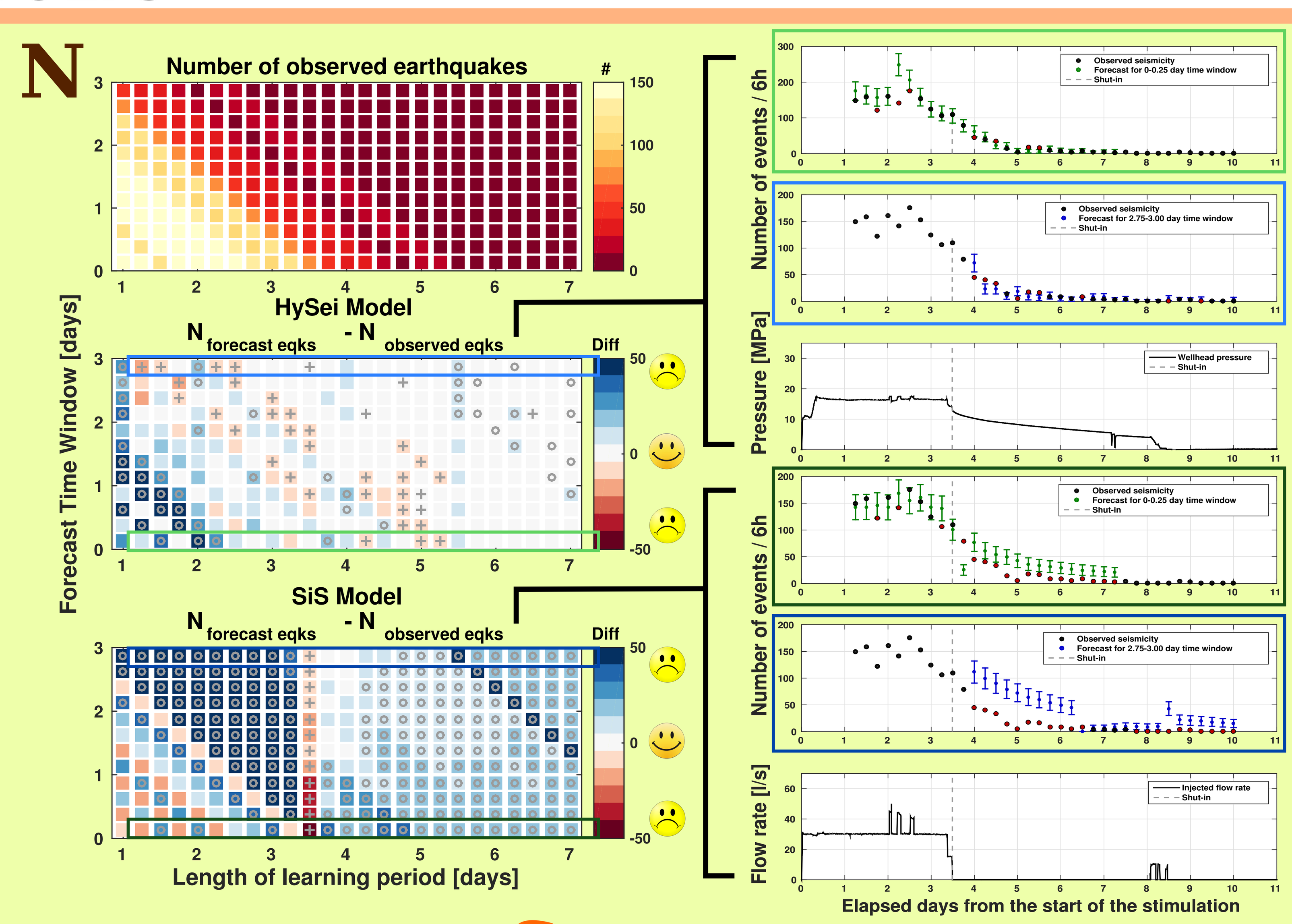


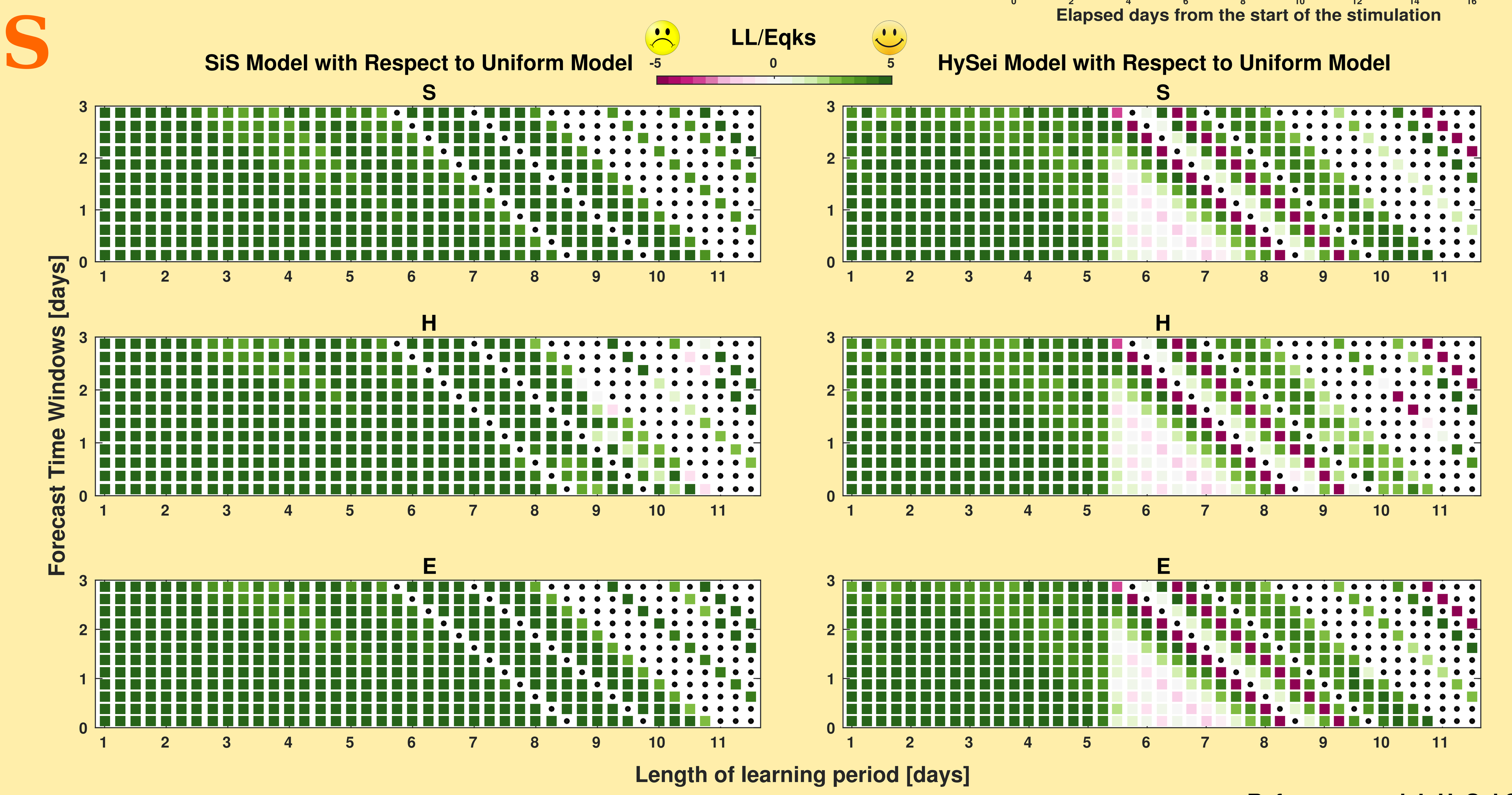
DATA



TESTING RESULTS







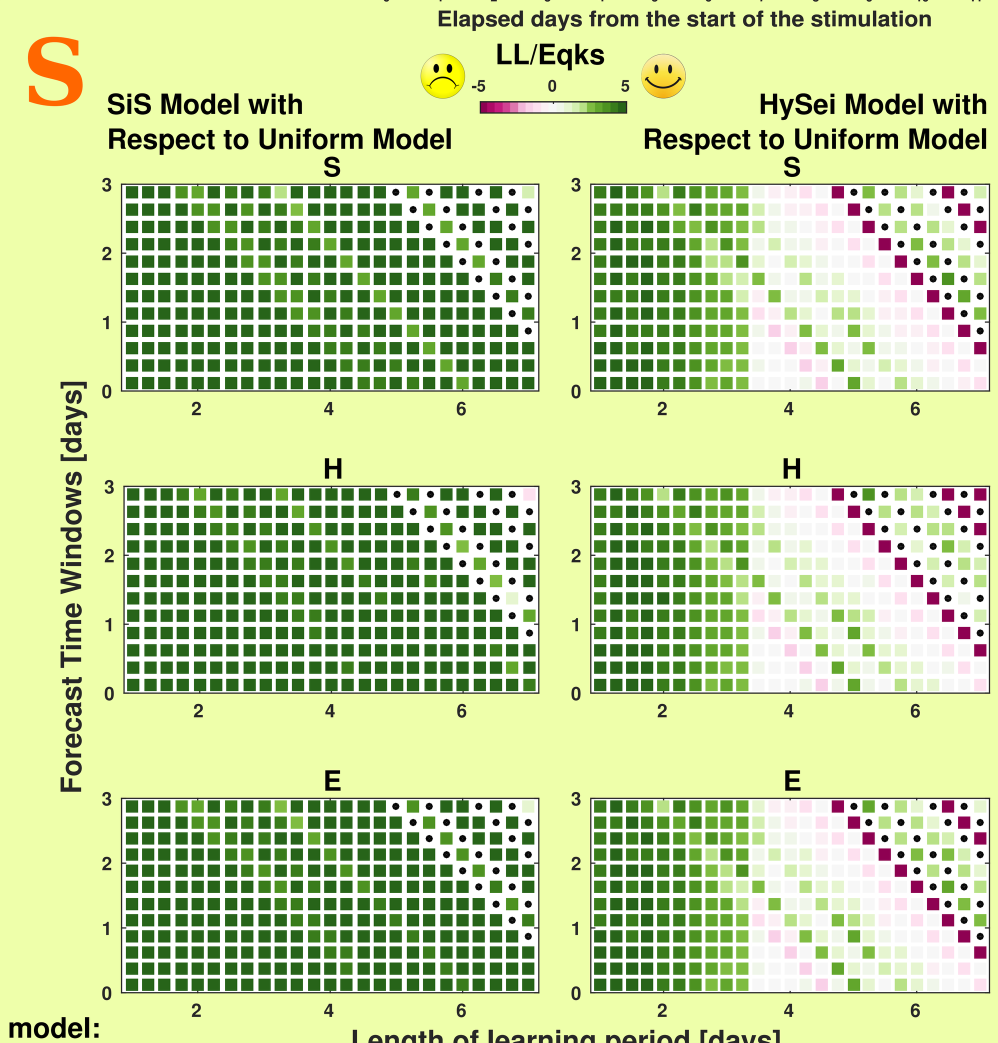
Joint log-likelihood

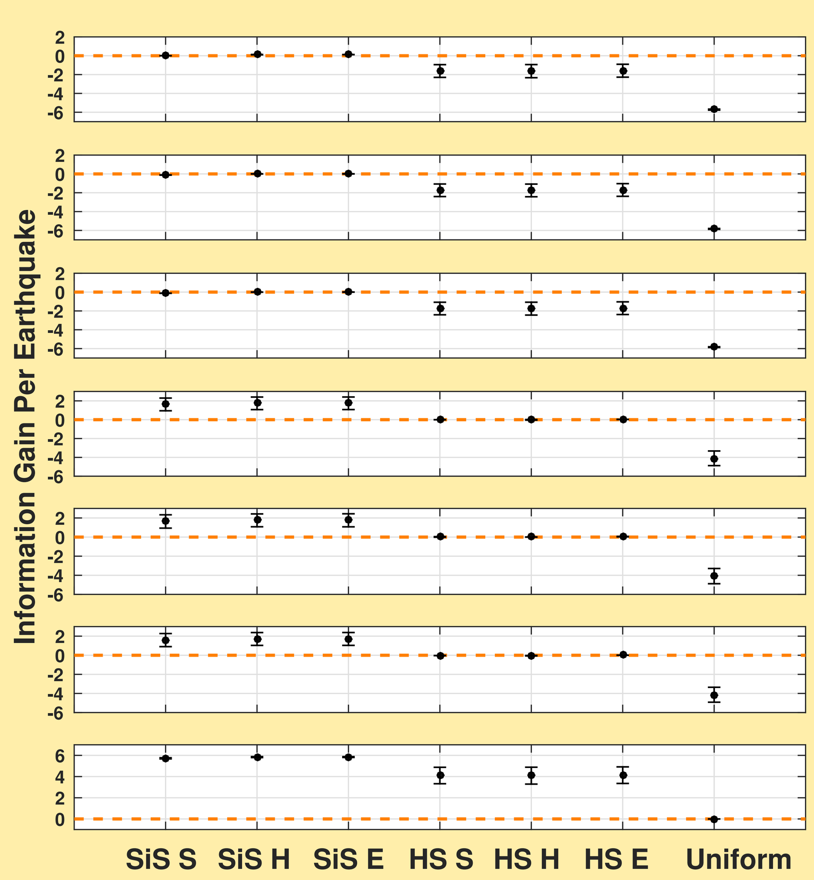
$$LL(A)=\sum_{i=1}^{N}(k_i \cdot \log(\lambda_{A_i}) - \lambda_{A_i} - \log(k_i!))$$

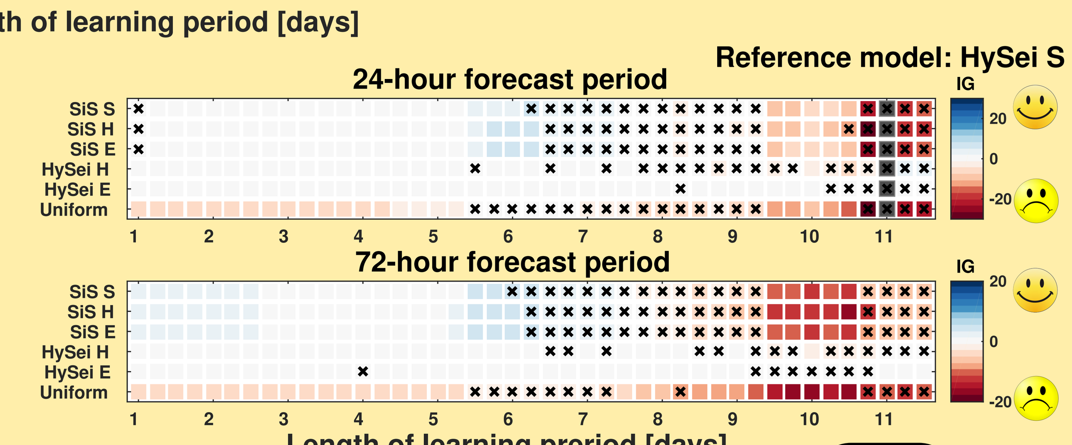
Information gain per earthquake

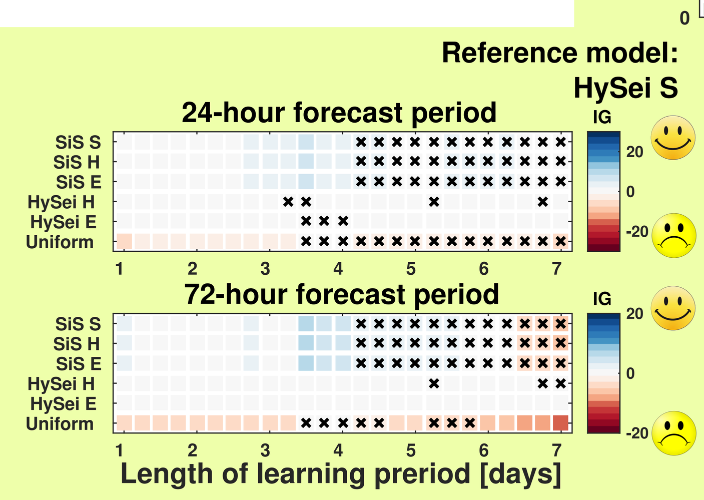
$$I_N(A,B)=\left(\frac{1}{N}\sum_{i=1}^{N}\ln\frac{\lambda_{A_i}}{\lambda_{B_i}}\right)-\frac{N_A-N_B}{N}$$

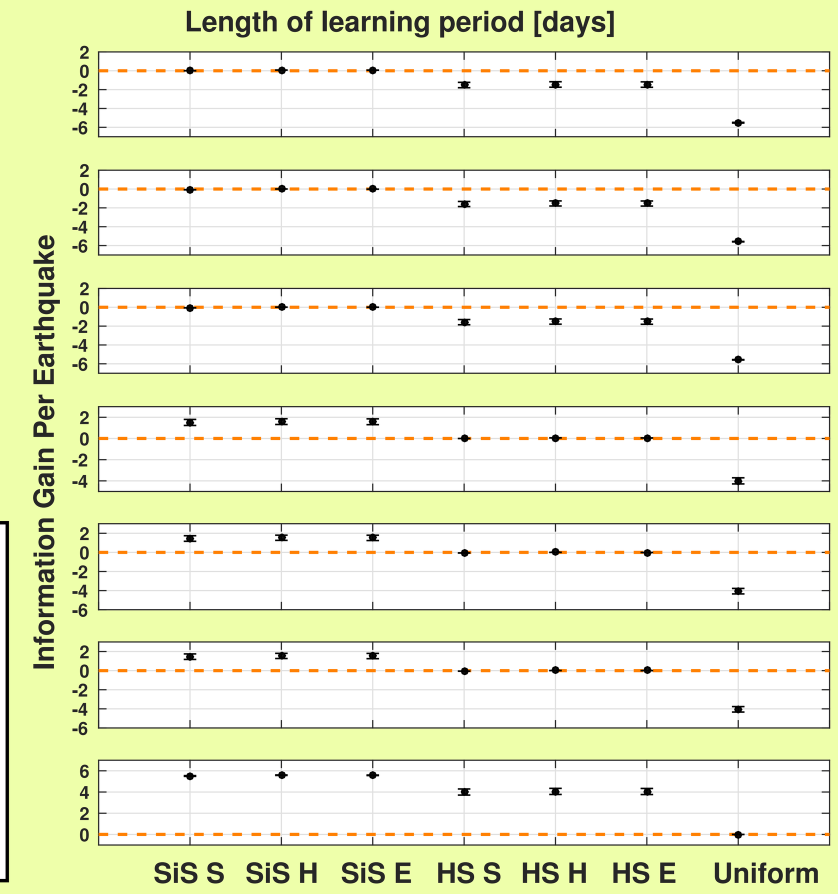
n: number of voxels
k_i: number of earthquakes observed in the i^{th} voxel
I_N: average information gain of a sample of population
N: total number of observed earthquakes
N_A: total number of earthqaukes in model A
N_B: total number of earthqaukes in model B
λ_{A_i}: forecast seismicity rate of











CONCLUSIONS

- All models performed generally better than the spatially uniform model.

- Smoothed seismicity based on the learning period is an efficient tool to forecast induced seismicity.

- Shut-in appeared to be a crucial moment for both models: they underestimated the number of observed events, in addition, the spatial performance of the HySei model decreased from the shut-in phase for the rest of the investigated period.