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Center of Excellence for Exascale in Solid Earth

Source Parameter Sensitivity of Earthquake Simulations assisted by Machine Learning

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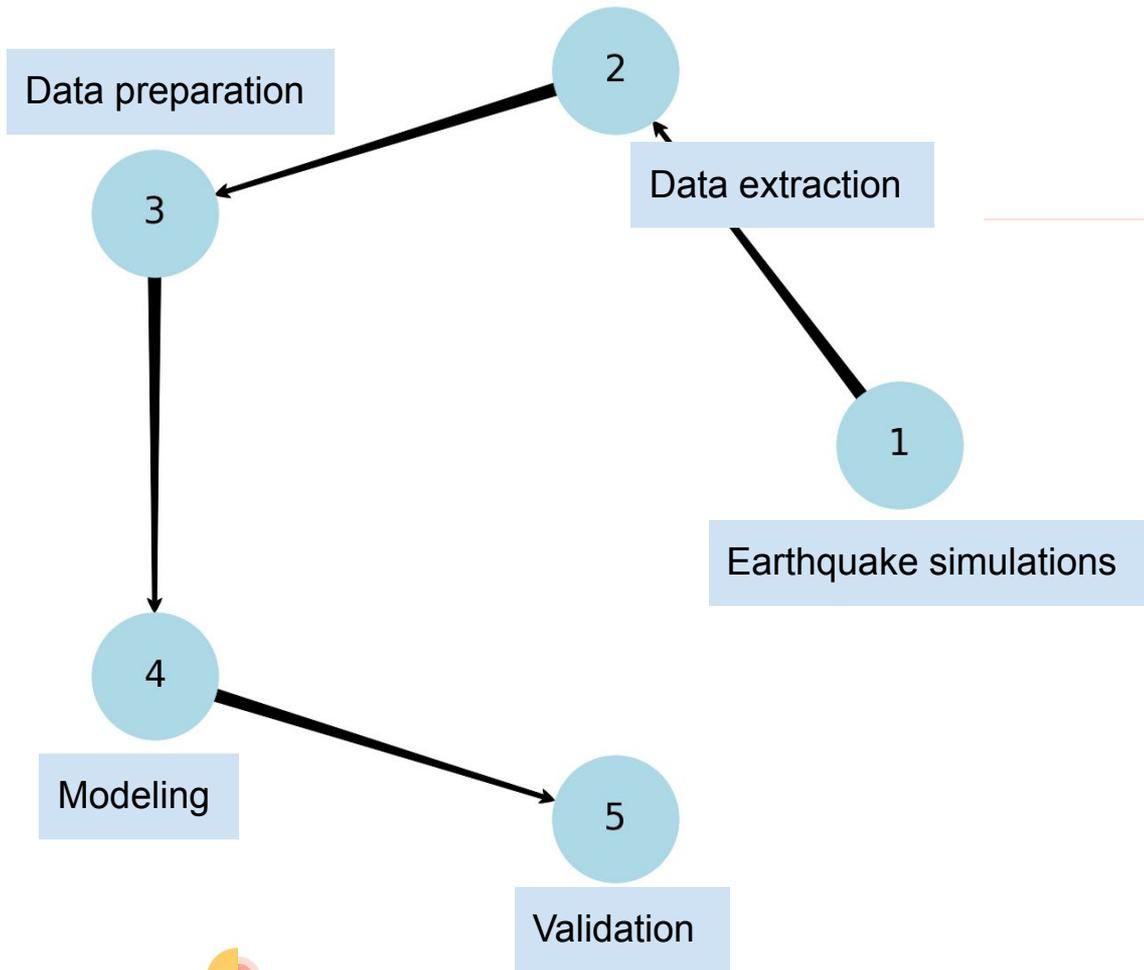
OBJECTIVE

Developing a **workflow prototype** based on analogous **ML models** to **fast-generate intensity maps** in a given region few seconds after an earthquake occurs.





WORKFLOW PROTOTYPE



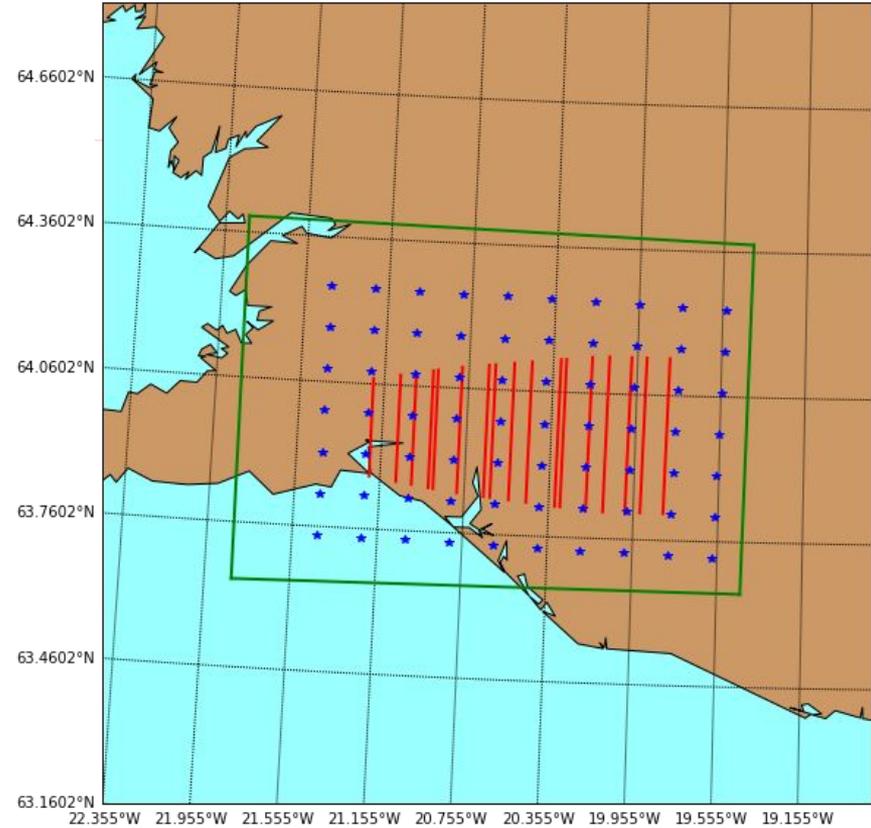
PRECOMPUTED EARTHQUAKE SIMULATIONS

- 15 faults of the South Iceland Seismic Zone (**SISZ**)
- 1D velocity model
- 144 synthetic stations

CyberShake⁽¹⁾ platform

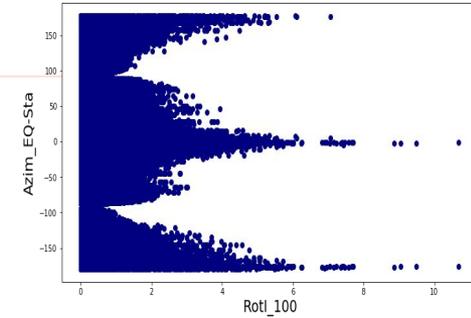
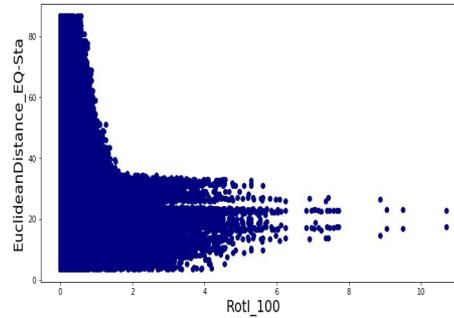
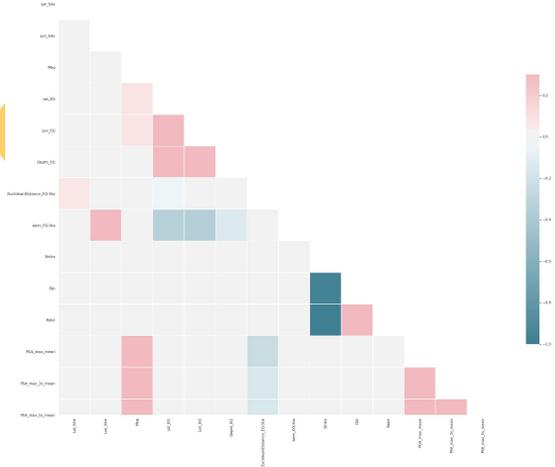


236180 synthetic EQ's



⁽¹⁾ We thank the Southern California Earthquake Center (SCEC) for providing advanced tools for earthquake modeling and seismic hazard analysis.

DATA EXTRACTION & PREPARATION

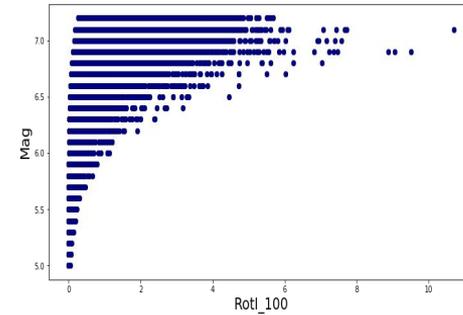


Target:

- Intensity Measures (RotI_100, PSA_3s, PSA_5s)

Features:

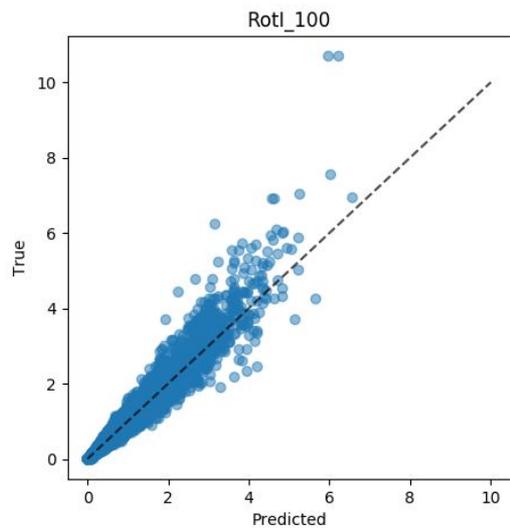
- Mw
- EQ location
- Station location
- Focal Mechanism



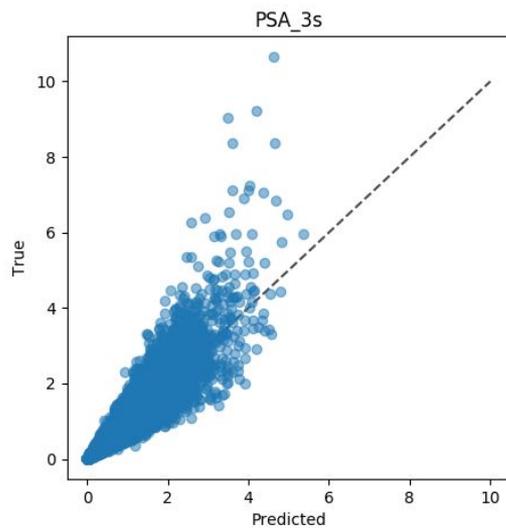


MODELING

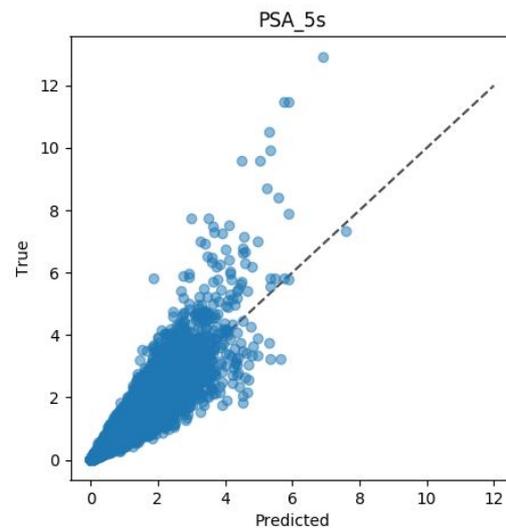
Random Forest regression



$r^2 = 0.96$
mse = 0.01



$r^2 = 0.91$
mse = 0.03

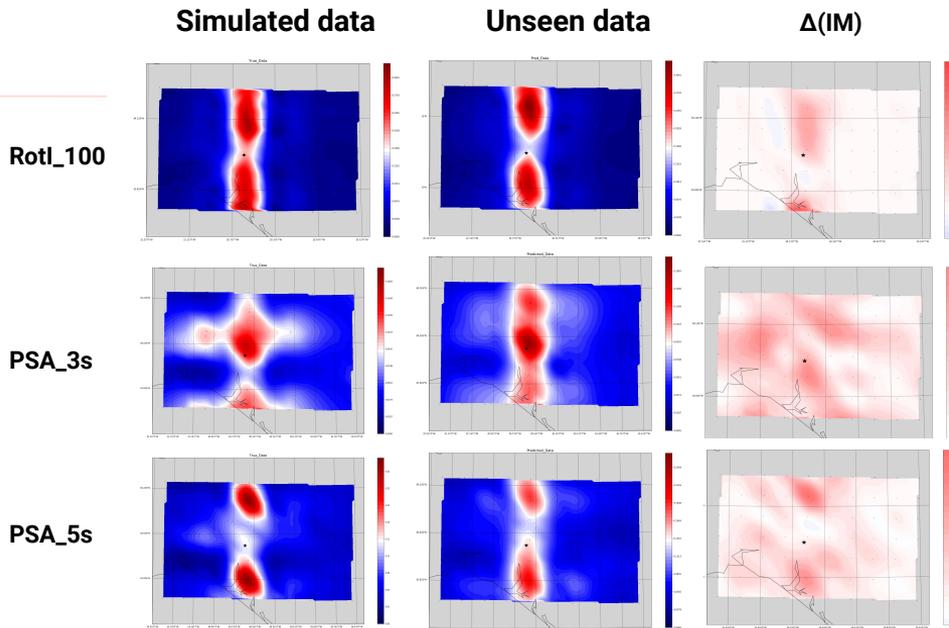


$r^2 = 0.90$
mse = 0.04

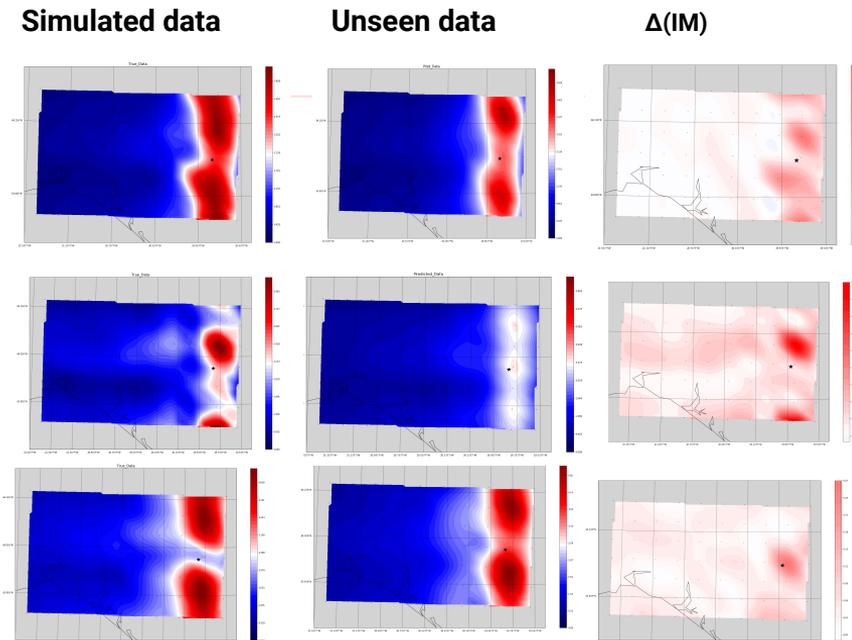


VALIDATION

$$\Delta(\text{IM}) = \text{abs}(\text{True_IM} - \text{Pred_IM}) / \text{max}(\text{True_IM})$$



Mw	Depth [km]	Lat (°)	Lon (°)	MF (stk, dip, rake)	$\Delta(\text{rot I}_{100})$	$\Delta(\text{PSA}_{3s_{100}})$	$\Delta(\text{PSA}_{5s_{100}})$
6.6	5.9	63.975	-20.322	(0,90,180)	36%	22%	28%



Mw	Depth [km]	Lat (°)	Lon (°)	MF (stk, dip, rake)	$\Delta(\text{Rot I}_{100})$	$\Delta(\text{PSA}_{3s_{100}})$	$\Delta(\text{PSA}_{5s_{100}})$
7.2	9.75	63.976	-19.807	(10,70,160)	24%	54%	27%

Maximum Difference $\Delta(IM)$

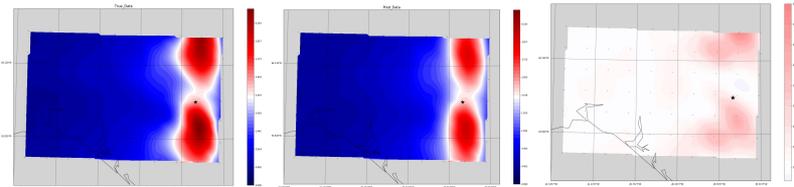
$$\Delta(IM) = \text{abs}(\text{True_IM} - \text{Pred_IM}) / \max(\text{True_IM})$$

Simulated data

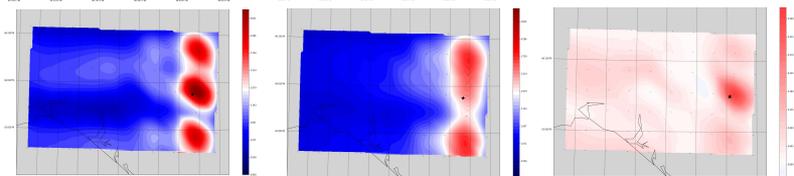
Unseen data

$\Delta(IM)$

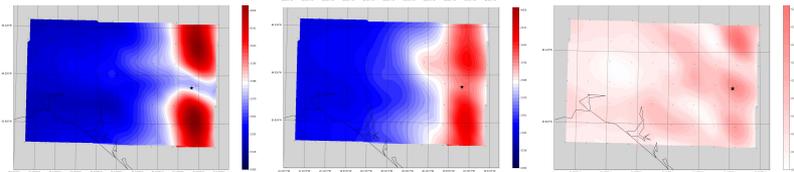
Rotl_100



PSA_3s



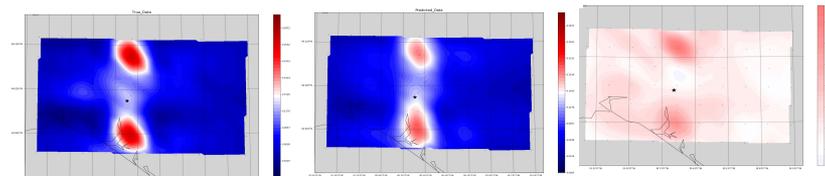
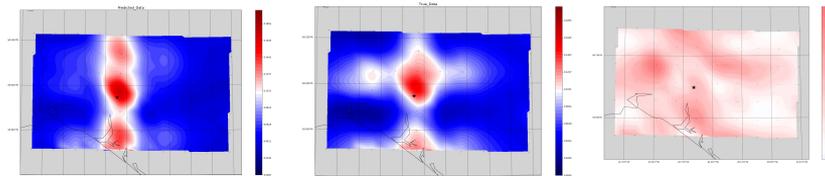
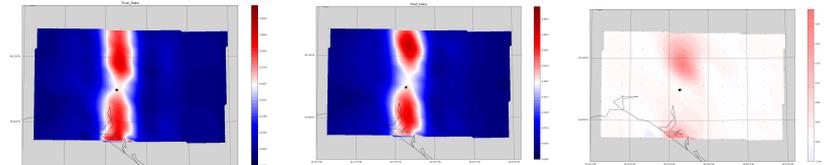
PSA_5s



Simulated data

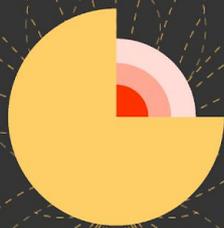
Unseen data

$\Delta(IM)$



Mw	Depth [km]	Lat (°)	Lon (°)	MF (stk, dip, rake)	$\Delta(\text{rot_l}_{100})$	$\Delta(\text{PSA3s}_{100})$	$\Delta(\text{PSA5s}_{100})$
7.2	9.75	63.976	-19.807	(0,90,180)	24%	36%	27%

Mw	Depth [km]	Lat (°)	Lon (°)	MF (stk, dip, rake)	$\Delta(\text{rot_l}_{100})$	$\Delta(\text{PSA3s}_{100})$	$\Delta(\text{PSA5s}_{100})$
6.0	5	63.976	-20.322	(5,75,170)	24%	27%	24%



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Thank you

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