STATISTICAL MODELING OF HYDROMETEOROLOGICAL EVENTS IN POORLY GAUGED COASTAL AREAS

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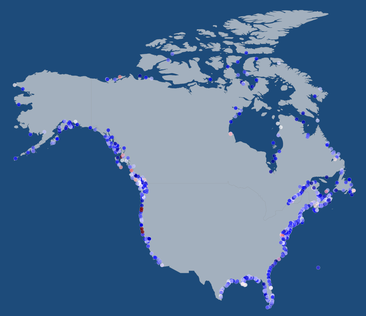
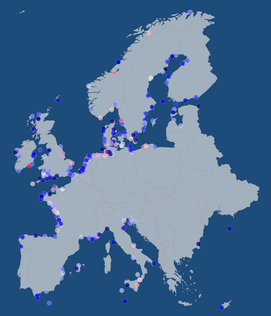
GESLA version 3 high-frequency tide gauge stations dataset | **≥ 1h** resolution ∩ **≥ 20y** record | **1245** sites

North America | Europe | Japan



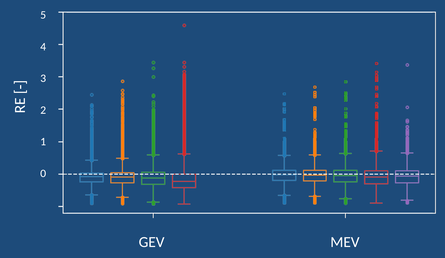


RAREST OBSERVED STORM SURGES

−400 −300 −200 −100 0 +100 +200 +300 +400

$RMSE_{MEV} - RMSE_{GEV}$ %

- MEV distribution **outperforms traditional methods** in rare storm surges estimation
- MEV regional approach **reduces estimation uncertainties** in data-scarce or ungauged sites

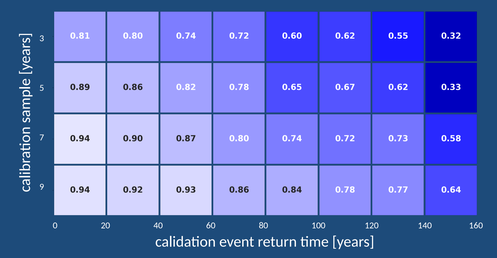


CALIBRATION YEARS PER SITE

9 | 7 | 5 | 3 | 1

all | 8 | 7 | 6 | 5

CALIBRATION SITES PER REGION

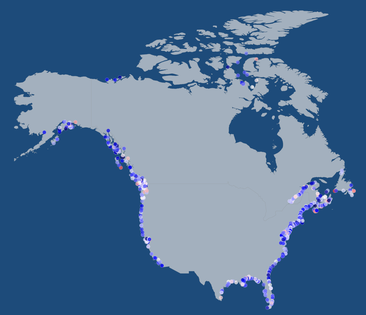


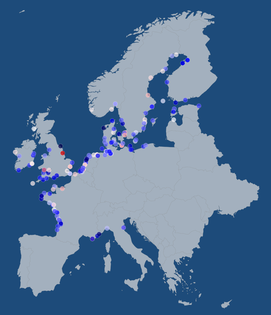
ALL OBSERVED STORM SURGES

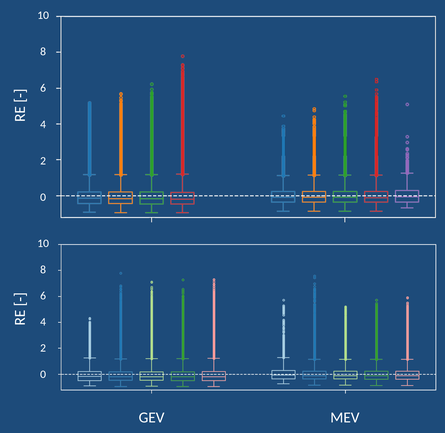
0.00 0.25 0.50 0.75 1.00 1.25

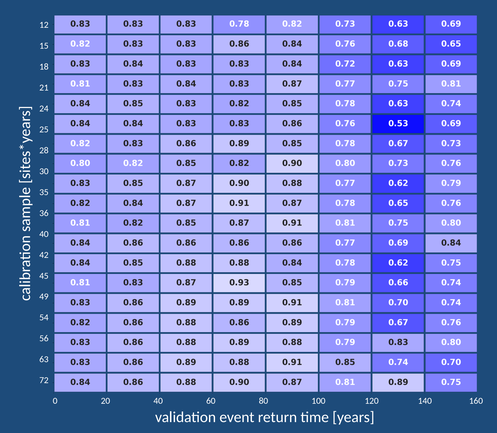
$RMSE_{MEV} / RMSE_{GEV}$

AT-SITE ESTIMATION





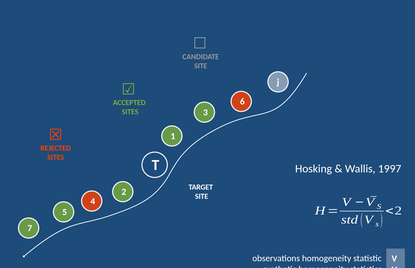




UNGAUGED ESTIMATION

Regionalization approach

- **Neighboring** tide gauge stations selection
- Simple **heterogeneity statistics** criteria



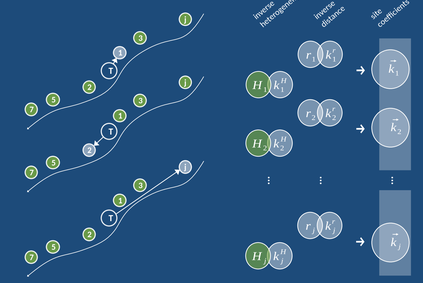
Hosking & Wallis, 1997

$$H = \frac{V - \bar{V}_s}{std(V_s)} < 2$$

observations homogeneity statistic V
synthetic homogeneity statistics V_s

Spatiotemporal coefficients

- Introducing **spatial interpolation** weights
- **"Leave-one-out"** heterogeneity influence



Metastatistical Extreme Value (MEV) distribution

- Annual maxima arise from independent **"ordinary events"**
- Accounting for **inter-annual** and **inter-site** variability of the parent distribution

Devò et al., 2025

$$\zeta(x;\vec{\theta};\vec{n}) = \sum_{i=1,j=1}^{N_Y,N_S} \vec{k}_{i,j} F(x;\vec{\theta}_{i,j})^{n_{i,j}}$$

k_{ij} spatiotemporal cofficients
N_Y total number of years
N_S total number of sites
F ordinary events distribution
Θ_{ij} per-block distribution parameters
n_{ij} per-block number of events

Cross-Validation (CV) technique

- Temporal sampling
  [9,7,5,3] and [1] years
- Spatial sampling
  [all] and [8,7,6,5] sites