

Development of a Non-ergodic GMPE for France

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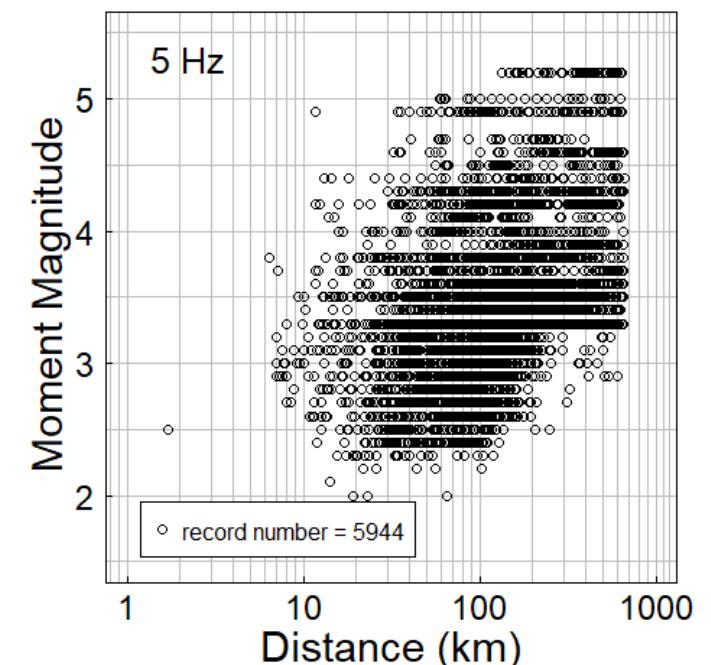
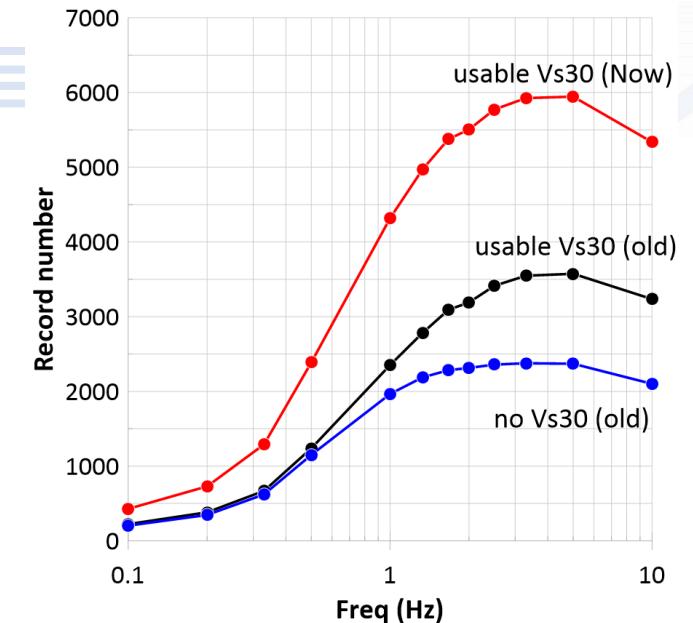
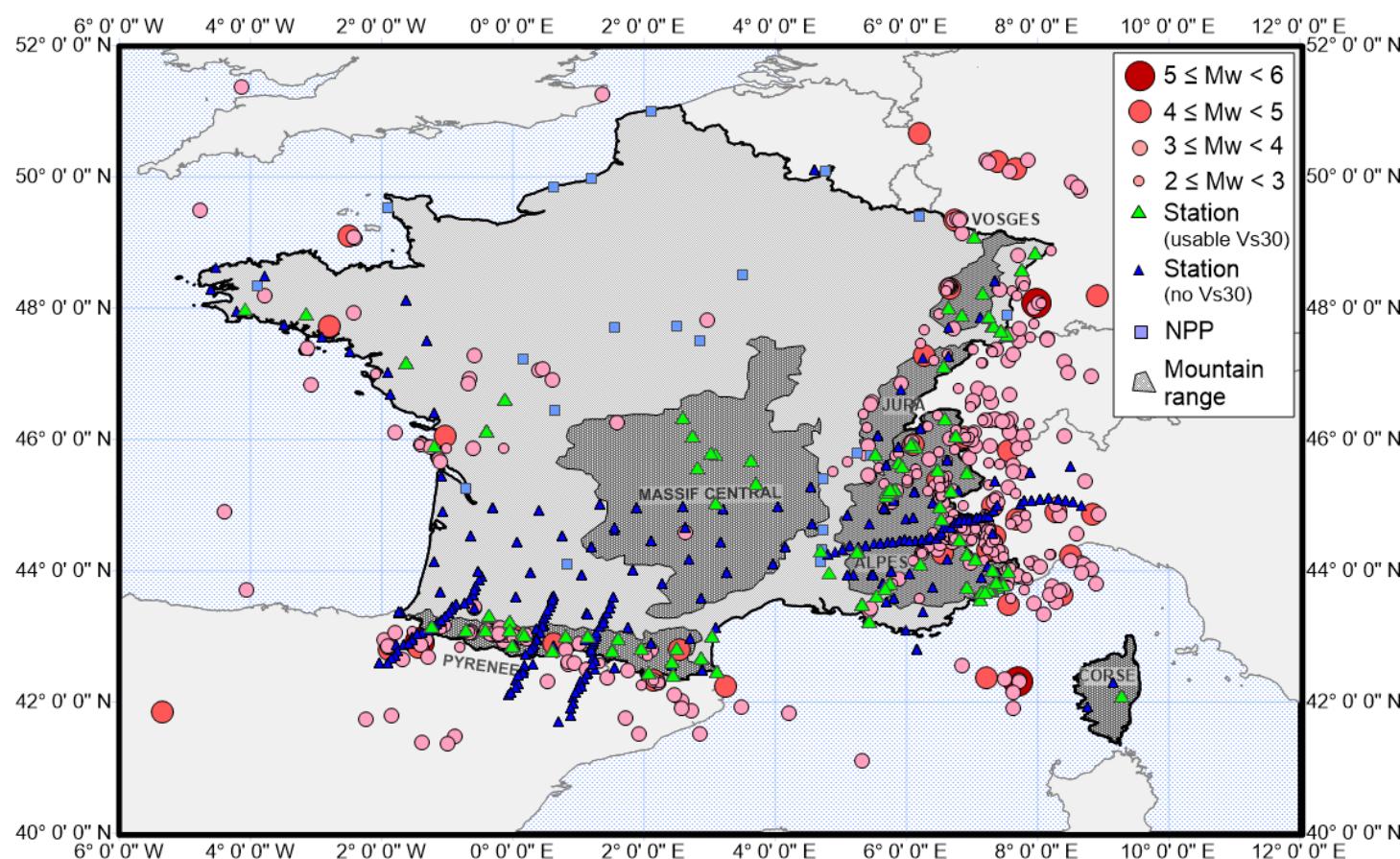
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we use an ergodic ground motion model (GMM) of California of Bayless and Abrahamson (2019) as a backbone and incorporate the varying-coefficient model (VCM) to develop a new French non-ergodic GMM based on the French RESIF data set (1996-2016):

- 463 earthquakes, 377 stations, 6044 records



Non-Ergodic GMPE

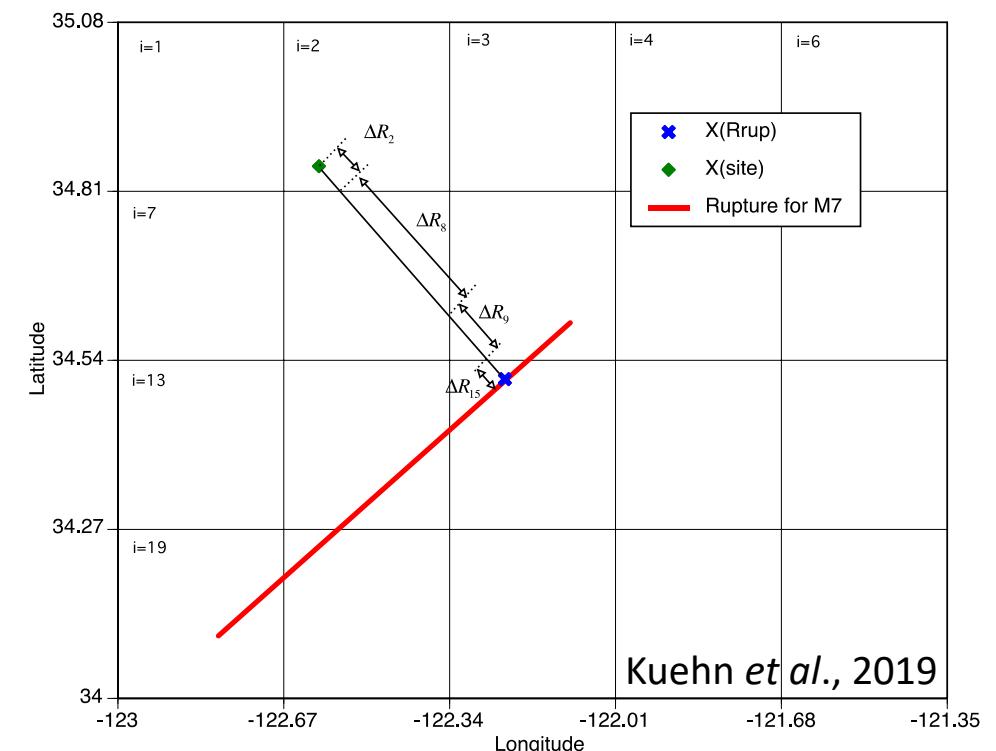
$$\ln(EAS) = GMPE_{base}(M, R_{rup}, Z_{tor}) + \beta_{-1}(\mathbf{t}_e) + \beta_0(\mathbf{t}_s) + \sum_{i=1}^{ncell} \beta_{3i} \cdot \Delta R_i(\vec{x}_{site}, \vec{x}_{Rrup}) + \beta_4(\mathbf{t}_s) \ln(\min(Vs30, 1000)/1000)$$

moment magnitude (M), closest distance to the rupture plane (R_{rup}), the time-averaged shear-wave velocity in the top 30 m of the soil column below the site ($Vs30$), Source effects are also modeled using the depth to the top of the rupture plane (Z_{tor}), $\hat{R} = \sqrt{R_{rup}^2 + h^2}$.
 \mathbf{t}_e is the event latitude and longitude. \mathbf{t}_s is the station latitude and longitude.

Step1: VCM (Varying-Coefficient Model) (Landwehr *et al.*, 2016)

- Regression estimates the variance structure of the coefficients (hyperparameters), not the coefficients themselves.
- Spatially correlated using separation distances between sites (VS30 scaling, $\beta_4(\mathbf{t}_s)$) and Site-specific term, $\beta_0(\mathbf{t}_s)$)
- Spatially correlated using separation distances between sources (Source term, $\beta_{-1}(\mathbf{t}_e)$)

Step2: Replace linear distance scaling with cells (Dawood and Rodriguez-Marek, 2013; Kuehn *et al.*, 2019)

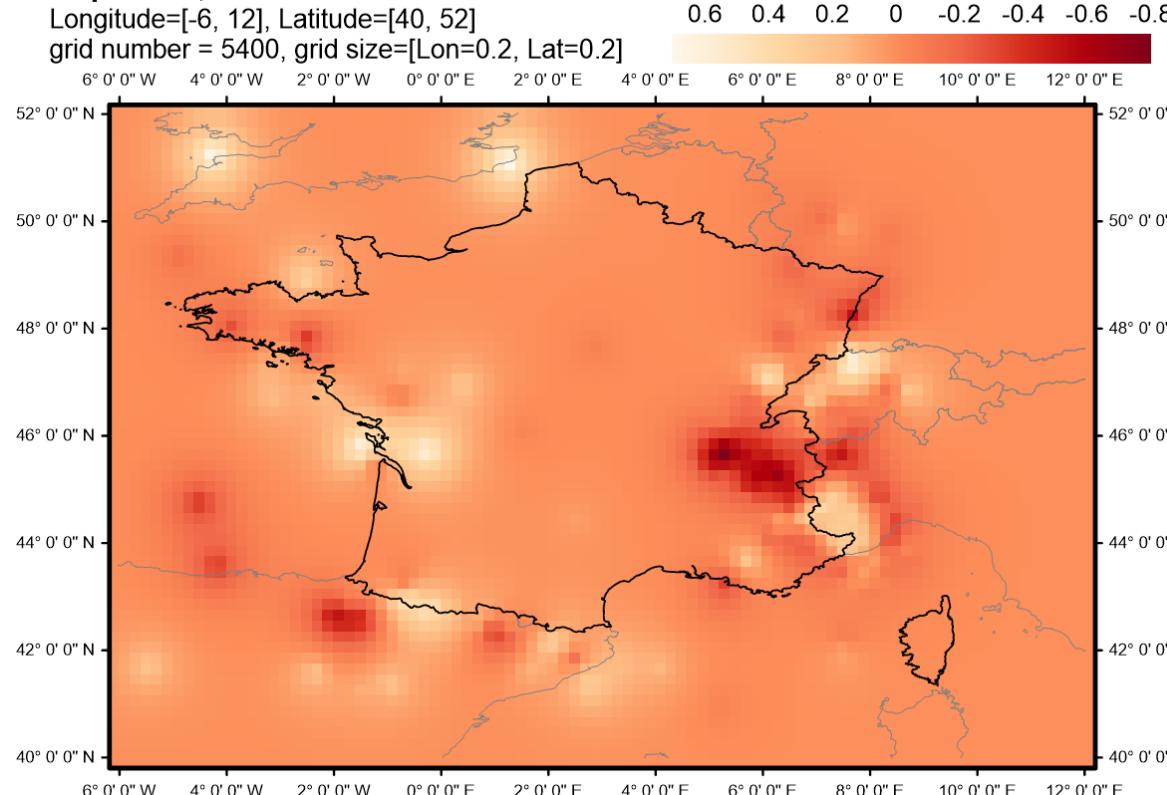


Non-Ergodic GMPE

$$\ln(EAS) = GMPE_{base}(M, R_{rup}, Z_{tor}) + \boxed{\beta_{-1}(\mathbf{t}_e) + \beta_0(\mathbf{t}_s)} + \sum_{i=1}^{n_{cell}} \beta_{3i} \cdot \Delta R_i(\bar{x}_{site}, \bar{x}_{Rrup}) + \beta_4(\mathbf{t}_s) \ln(\min(Vs30, 1000)/1000)$$

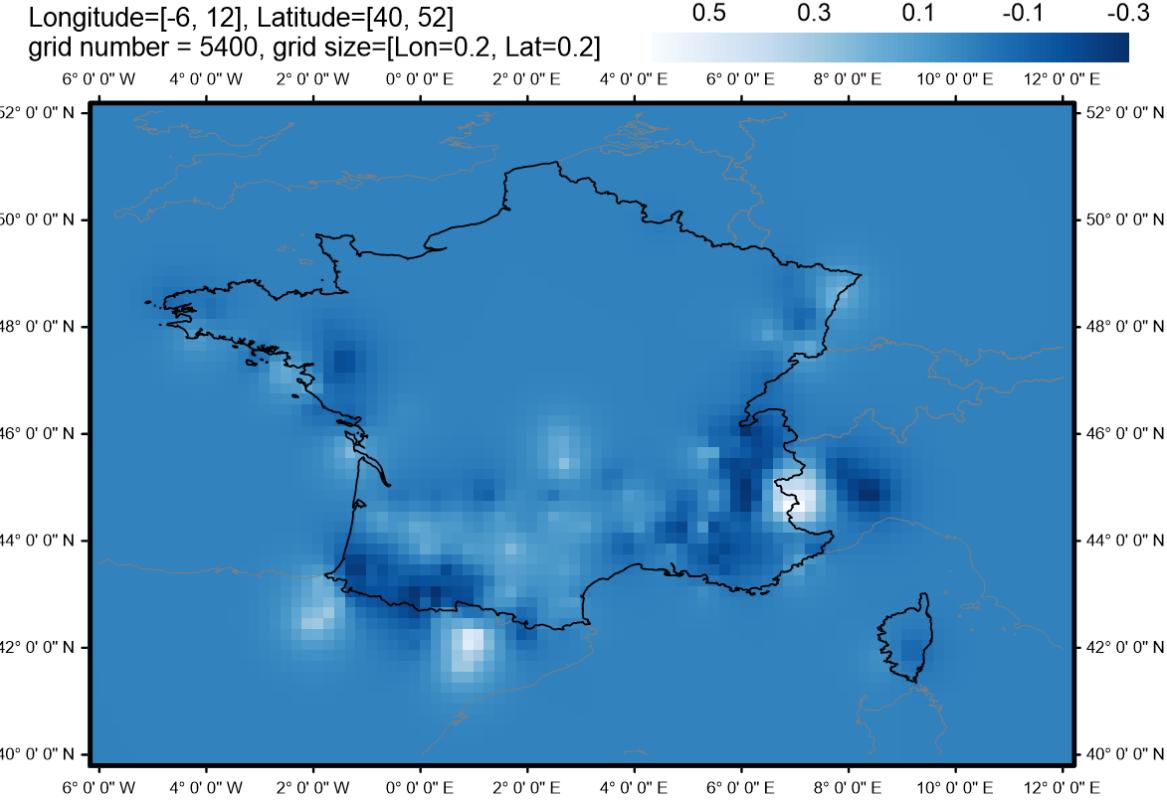
the source constant (adjustment term) per cell

Map of β_{-1} , 5Hz



the site constant (adjustment term) per cell

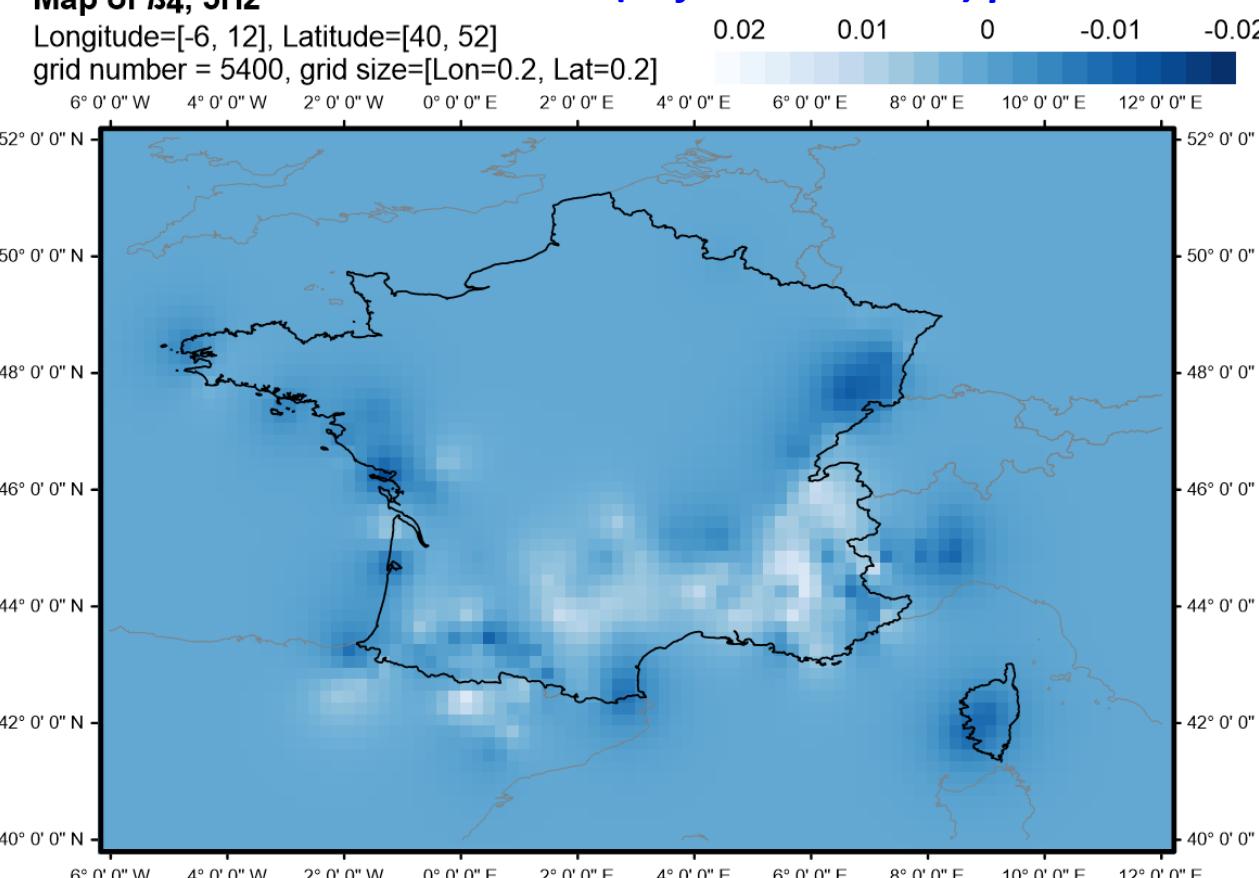
Map of β_0 , 5Hz



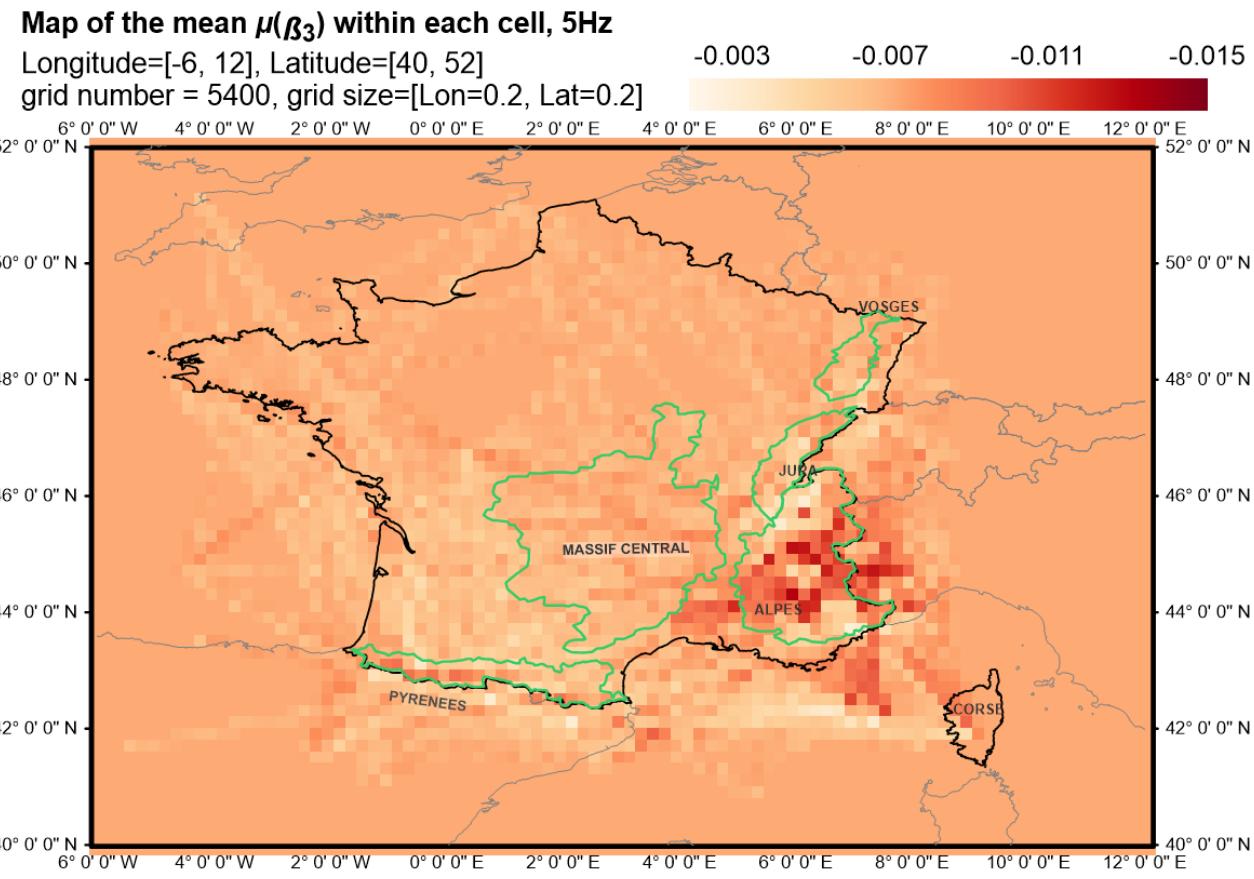
Non-Ergodic GMPE

$$\ln(EAS) = GMPE_{base}(M, R_{rup}, Z_{tor}) + \beta_{-1}(\mathbf{t}_e) + \beta_0(\mathbf{t}_s) + \sum_{i=1}^{ncell} \beta_{3i} \cdot \Delta R_i(\bar{x}_{site}, \bar{x}_{Rrup}) + \beta_4(\mathbf{t}_s) \ln(\min(Vs30, 1000)/1000)$$

Map of β_4 , 5Hz
the Vs30 term (adjustment term) per cell



the anelastic attenuation term per cell



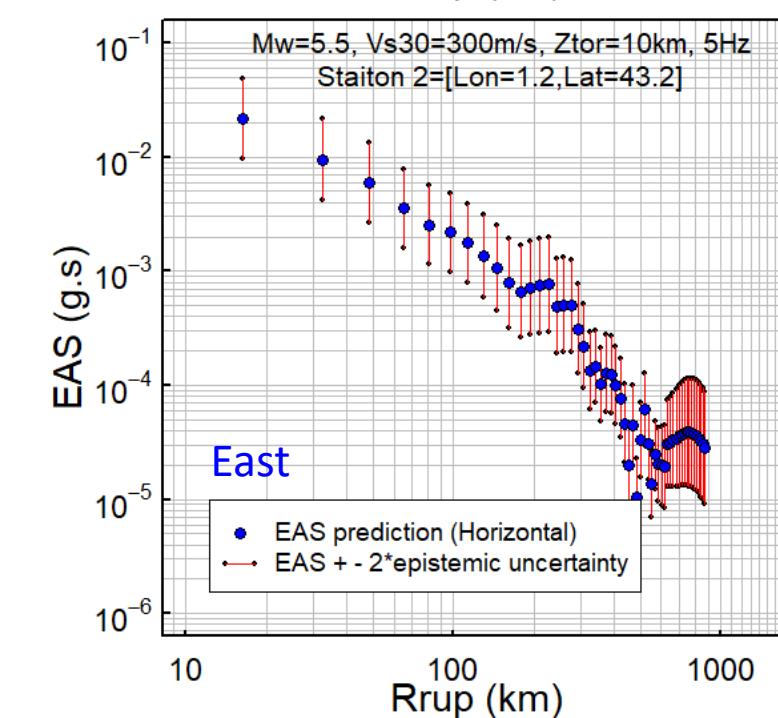
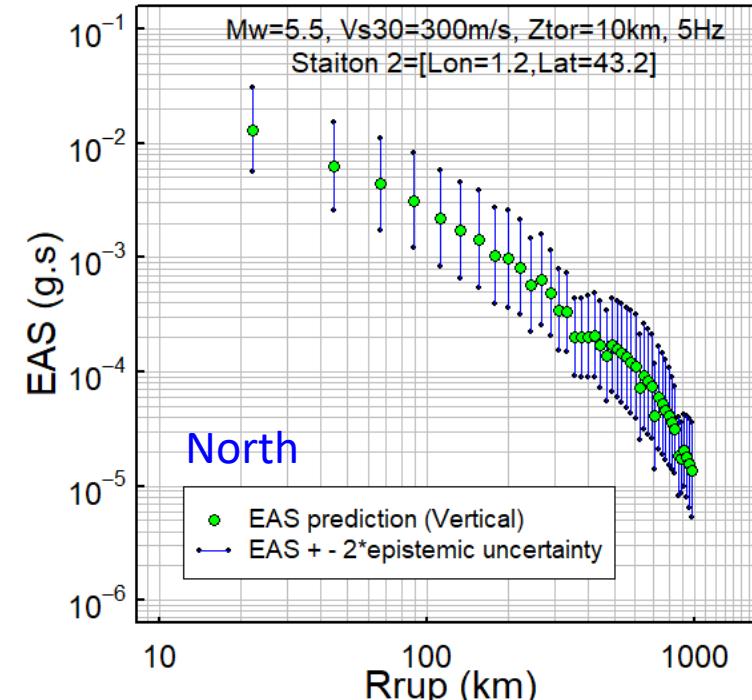
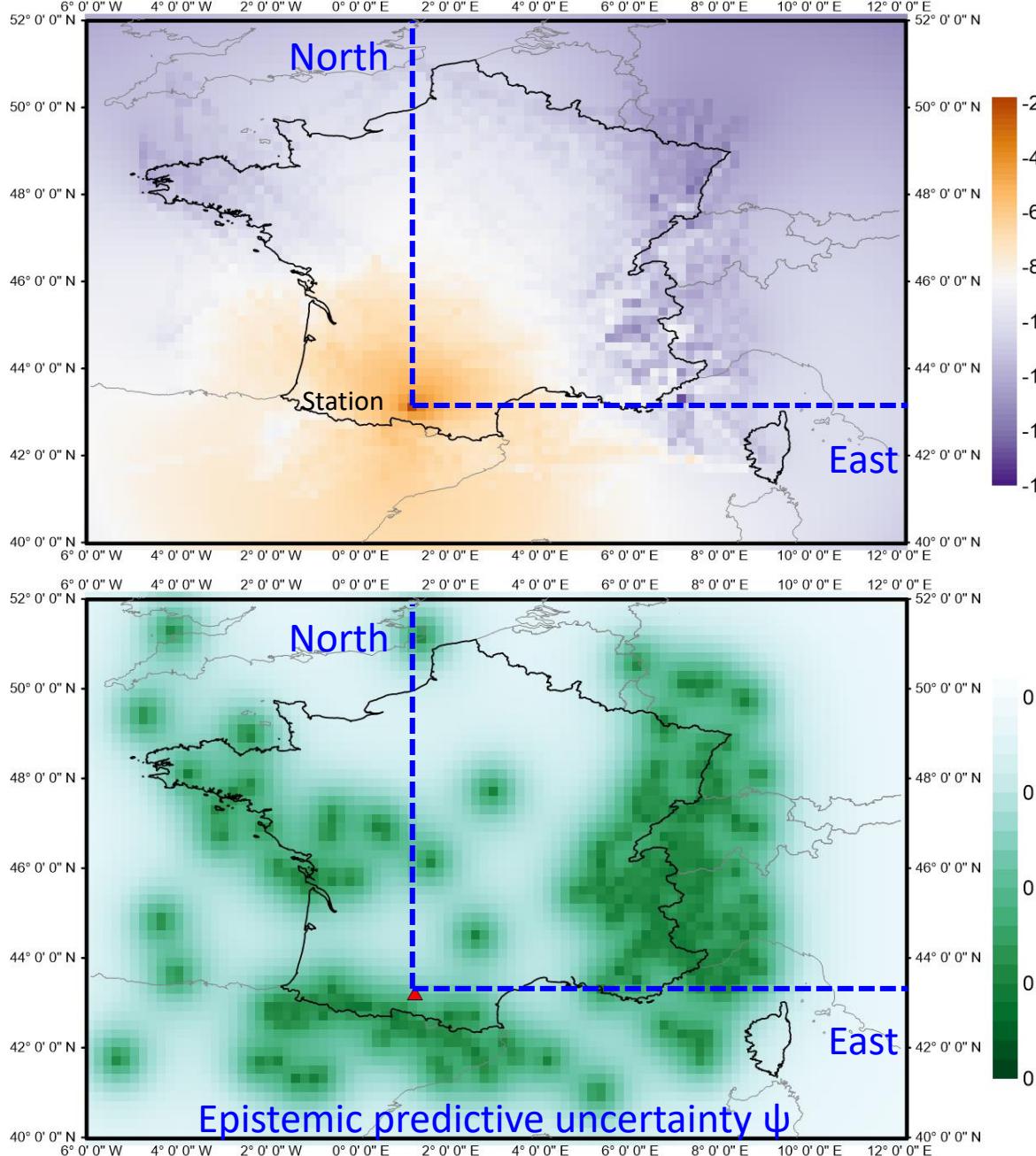
Map of In EAS predictions, 5Hz

Mw = 5.5, Vs30=300m/s, Ztor=10km

Longitude=[-6, 12], Latitude=[40, 52]

grid number = 5400, grid size=[Lon=0.2, Lat=0.2]

5 Hz



Residuals and Standard deviations

5 Hz

5Hz	σ_T	τ	φ_{S2S}	φ_{ss}
Ergodic	0.940	0.439	0.509	0.530
Non-Ergodic	0.721	0.238	0.375	0.467

φ_{ss} (Within-site residuals) per Rrup bin

