Site effect determination and real-time ShakeMap implementation in Austria

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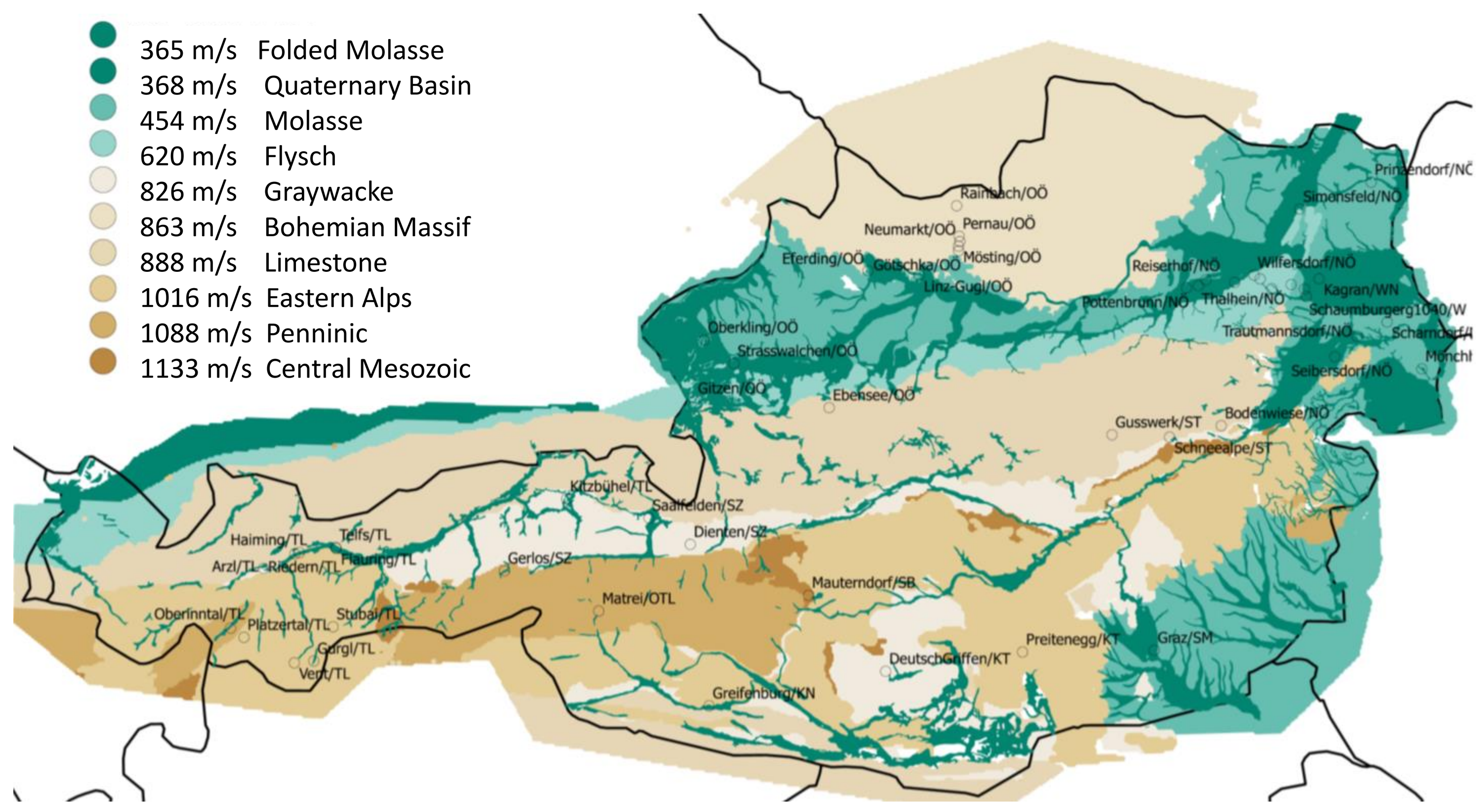
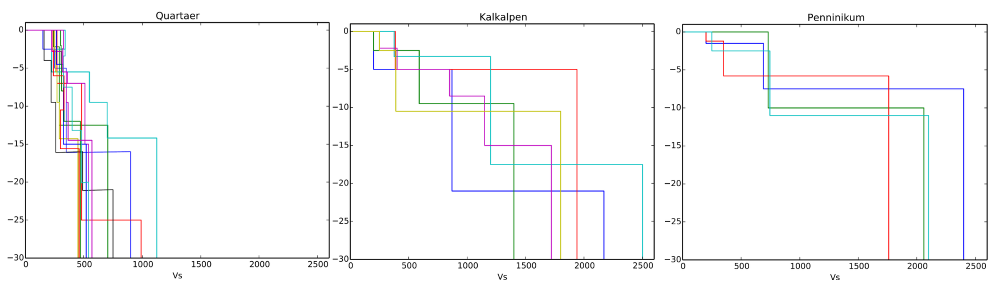
1. Abstract

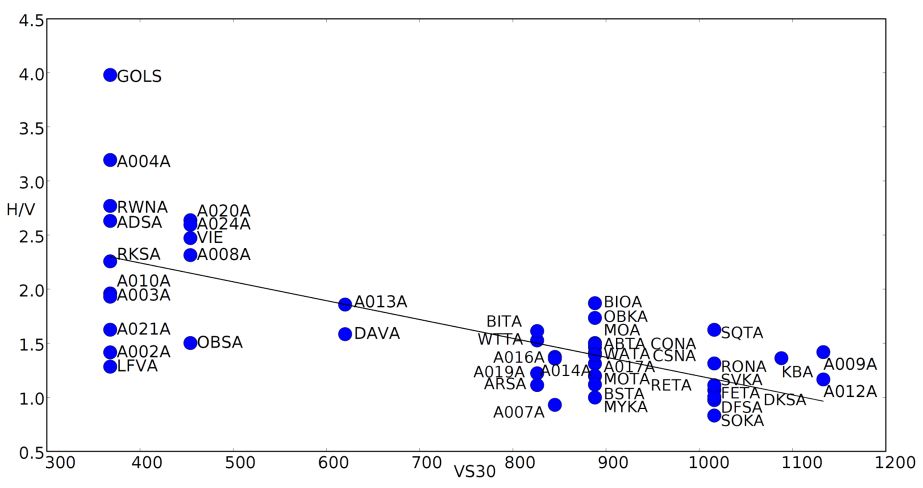
For seismic hazard assessments, a database with ground motion (GM) parameter was calculated and local adapted GMPEs were developed [1]. We are looking for site effect characterizations which can describe the entire area of Austria. After strong felt earthquakes, we want to generate ShakeMaps automatically with information of the expected and already reported effects [1]. New software packages and interactive presentations were tested and implemented in our BRTT-Antelope real-time system.

2. Geology - VS_{30} - Amplification



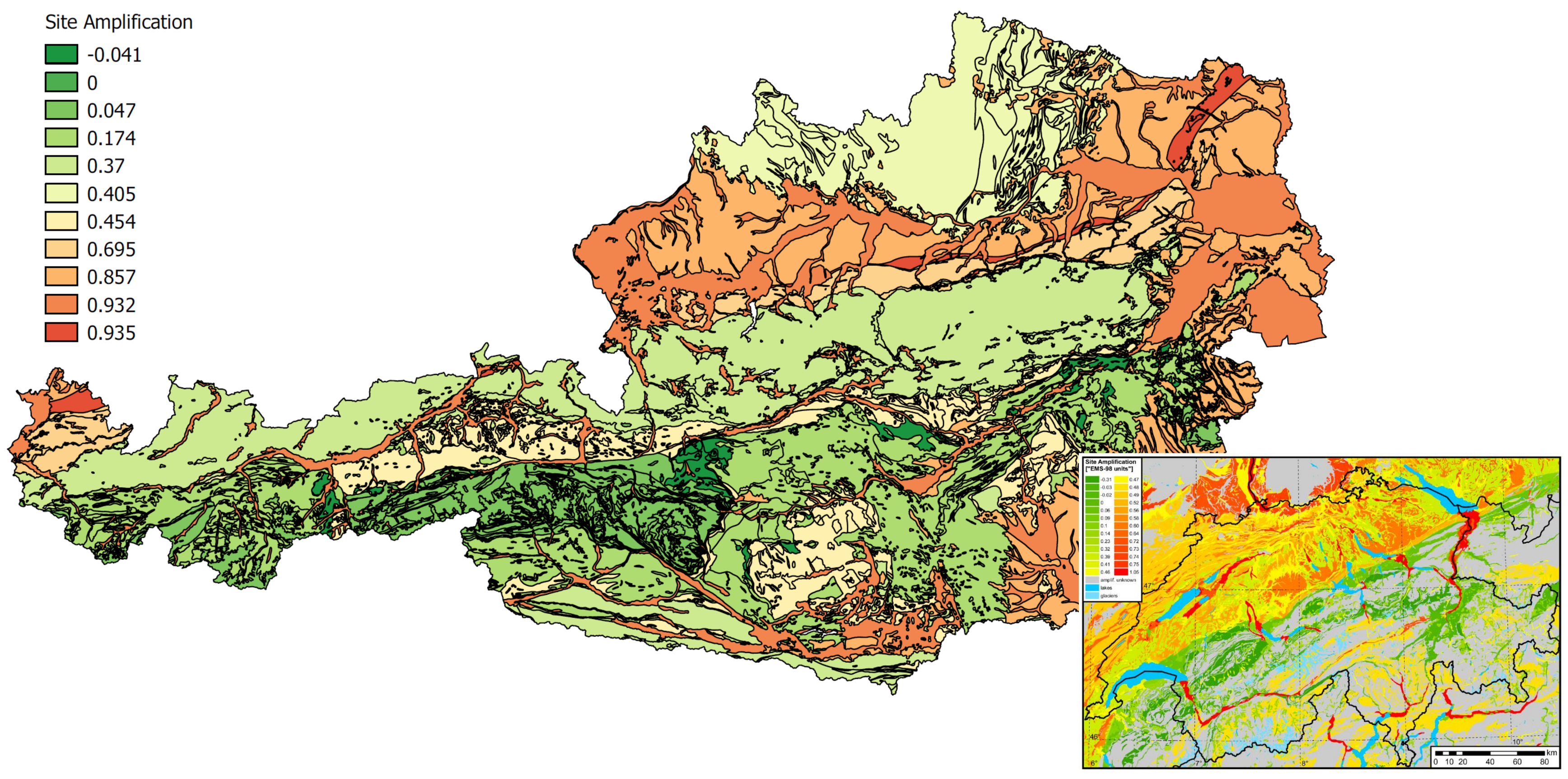


About 50 Vs_{30} profiles (Downhole measurements, MASW, Refraction Seismic) have been collected. They show a comparable seismic behavior per geological unit. As expected, the quarter sedimentary basin, molasse and flysch show significant lower Vs_{30} values than the alpine rock. The mean value of the measurements was assigned to the corresponding unit. All rocky areas belong to soil class A, units with sediments belong to soil class B (EUROCODE 8). The result was verified with a global Vs_{30} model from USGS [2] for active and stable tectonic regions.



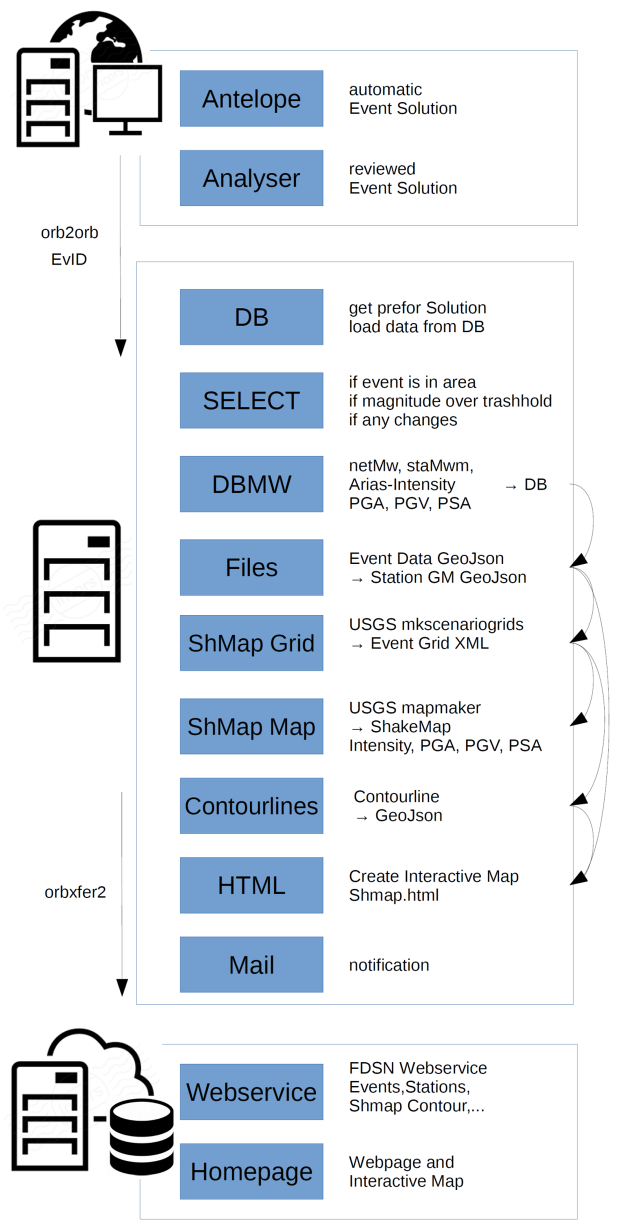
$$SPR_{max} = 2.94 - 1.74 \cdot 10^{-3} Vs_{30}$$
$$SPR_{max} \propto Amplification$$
$$I_{MSC} = 1.68 + 2.58 \cdot \log_{10}(PGA)$$
$$\Delta I_{EMS} = 2.58 \cdot \log_{10}(\Delta PGA)$$
$$\Delta I_{EMS} = 2.58 \cdot \log_{10}(2.9 - 1.7 \cdot 10^{-3} Vs_{30})$$

The H/V ratio is connected with the amplification [3]. The maximum value has been taken as amplification. The figure above shows the relation between H/V and the Vs_{30} of the station site. In basins and sediments, we have high H/V and huge variations. Hard rock areas show low H/V. The regression of the relation has been converted to the intensity range [4,5,6].



The seismic amplification map shows high amplification in basins and sediments, moderate amplification in the bohemian massive and negligible influence or a small decrease in the mountain areas. In comparison with the site amplification map for Switzerland, which was obtained from the analysis of macroseismic data, the results of two independent methods show similar behavior and comparable value range [7].

3. ShakeMap implementation in Austria

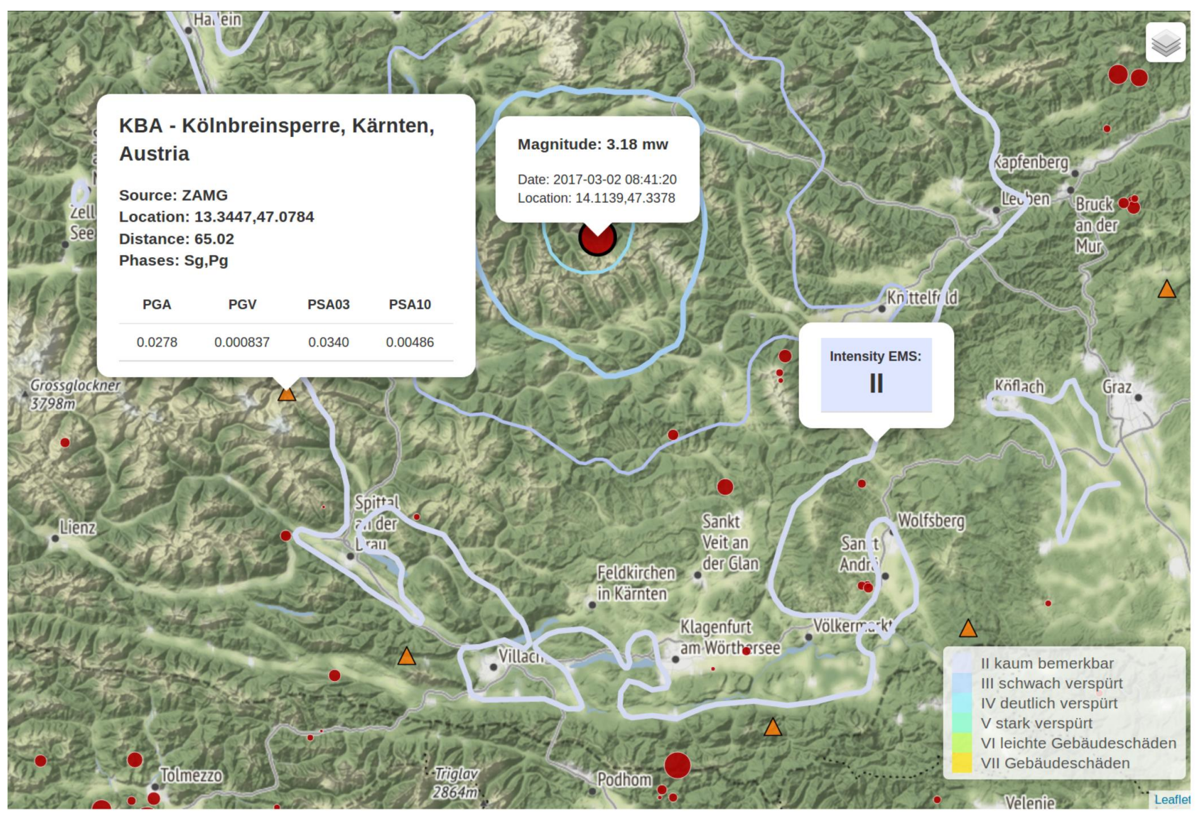


The calculation is implemented in our BRTT-Antelope real-time system. M_W will be calculated using DBMW developed by the University of Trieste [8]. All results are exported to GeoJson files for further calculations, presentations and webservices.

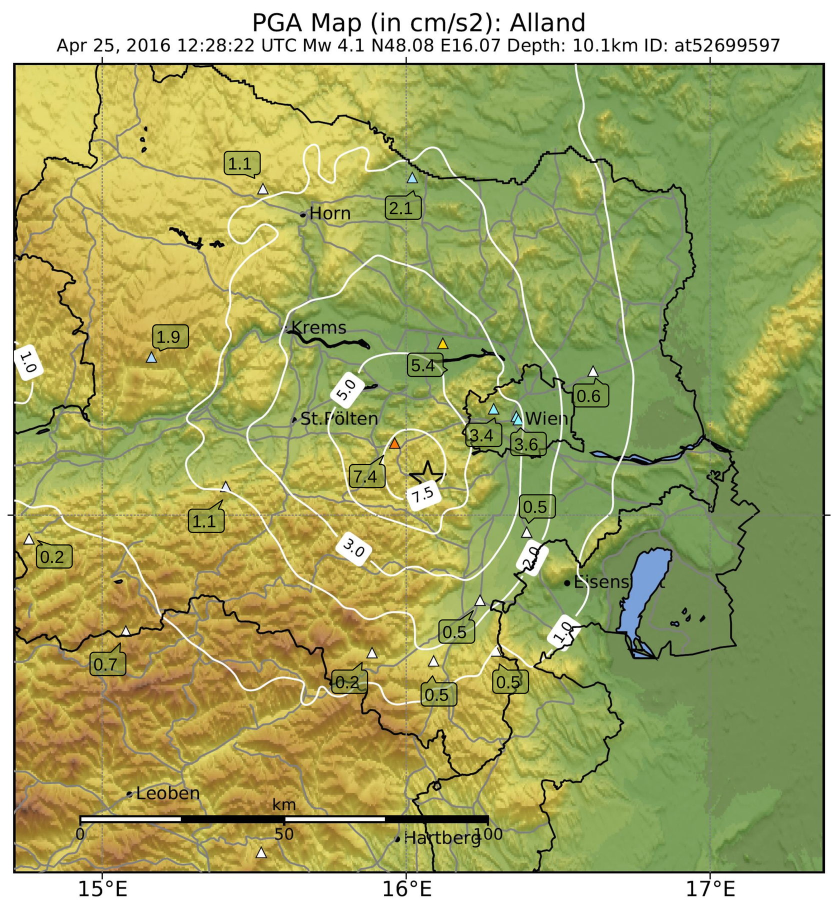
To calculate the ShakeMap we test the USGS ShakeMap V4.0 code [9] which is based on the OQ Hazard Library of GEM [10] and completely written and editable in Python. The code is currently in development. The oq-hazardlib provides a large selection of GMPEs, related hazard modules and complex source models.

The results are presented with classic ShakeMaps generated by USGS Mapmaker and interactive visualizations.

The output data can be provided by webservices in the FDSN query format [11].



The visualization is done with interactive maps based on open-source Leaflet features. The maps include event- and station-information, Ground Motion recordings, event history and ShakeMaps. Further maps include felt reports, arrival- and origin-information.



In the case of sufficient real-time GM-recordings, an event based GMPE inversion was tested. The advantage is the consideration of the event source effect and the regional path effects, which differ strongly according to the direction of radiation. The inversion of the recorded GM-data will be performed directly after the localization with the following GMPE-model.

$$\log_{10} GM = a_0 + a_1 M_w + a_3 \log_{10} D + a_4 D$$
$$a_5 rx_+ + a_6 rx_- + a_7 ry_+ + a_8 ry_- + SiteEffect$$

rx ... Strike-normal distance,
ry ... Strike-parallel distance [12]

Complex source models can be used, but in case of a real-time point source models, the coefficients correspond to the azimuth.

5. Conclusion

The greatest challenge of site effect characterization is to find parameter which are available for the entire area of Austria. Vs_{30} and H/V correlate similarly with geology. The site effects show expected trends wich were used for the ShakeMaps.

The new version of USGS Shakemap allows flexible development with well-equipped hazard libraries and will be hopefully finalized soon. In case of fast availability of sufficient measurement data, the results are definitely improved by using local, azimuth dependent and event base GMPEs, which are obtained in near-realtime [13].

Reference:

[1] Jia (EGU 2015), [2] Wald and Allen (2007), [3] Lermo et al. (1993), [4] Faenza and Michelini (2010), [5] Carlo Cauzzi et al. (2014), [6] Musson et al. (2009), [7] Kaestli and Faeh (2006), [8] Costa et al. (2006), [9] USGS Shakemap V4 on Github, [10] Global Earthquake Model (GEM), [11] FDSN Web Service Specification (2013), [12] Spudich et al. (2015), [13] Austrian Earthquake Catalogue (by ZAMG)

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