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Using 3D wave field modeling in analysis of historical macroseismic observations

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The Luroy earthquake of August 31, 1819 with MS around 6.0 is by many colleagues, rated as the largest in NW Europe in historical times (pre-1900) and even up to present. Local shaking manifestations were most spectacular with rock and mud avalanches. Also mast-high waves in nearby Rana fjord and even liquefaction were reported. Most surprisingly, at epicentral distances exceeding 100 km except for Stockholm 800 km away, very few macroseismic observations are available. Another peculiarity was the lack of any significant housing damage even in the Luroy parish itself. In a recent paper, we postulated that the earthquake was of moderate size, re-estimated at MS = 5.1, but of shallow depth between 5 - 10 km causing the intense local shaking. In this presentation we add a new dimension to the many Luroy earthquake studies namely simulating the seismic wave field response of Luroy itself and adjacent areas characterized by steep topographic relief. We use a 3D finite difference scheme and compute ground motions for a shear wave point source at a focal depth of 5 km. Water covered areas are replaced by crystalline crust due to the dearth of dense bathymetric data. Main results are that the topography of the Luroy, close to the mountain peak at 685 meter, cause wave field amplification by a factor of 20 and even stronger. Further away in the Rana fjord and surrounding areas, we also got strong amplification in particular where the relief is sharpest thus explaining triggering of avalanches in a quantitative manner. In other words, macroseismic observations would be biased upward due to the topographic focusing effects and unless properly corrected for also will increase the final earthquake magnitude estimate. We take these results to support our claim that the historic Luroy earthquake was of moderate size of MS = 5.1 and not at MS = 6.0

class as claimed in the past. We have also simulated likely shaking of our hometown Bergen for given earthquake scenarios. Again, macroseismic shaking reports appear upward biased due to topographic effects and thus quantitatively explain why no serious housing damages have ever been reported in Bergen nor any other cities in Norway
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