Comparison of ISC seismic event locations with data of Polish mining industry

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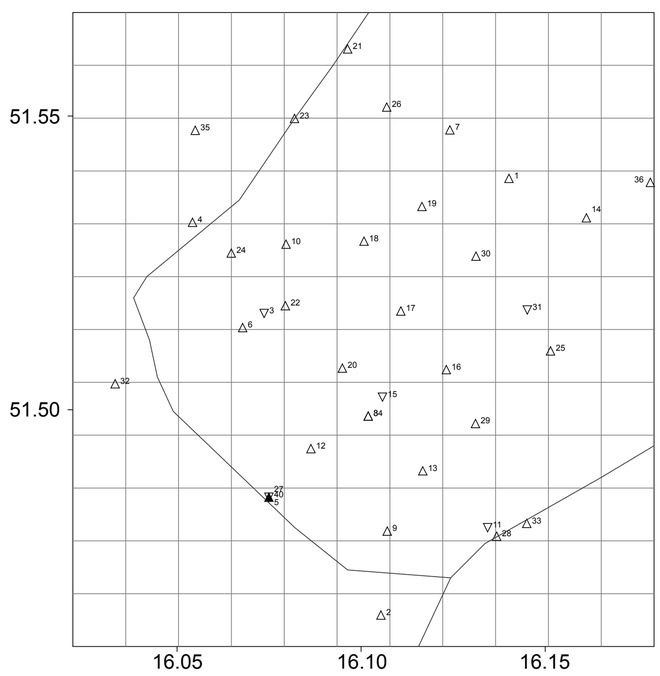
The International Seismological Centre (ISC) is using the Jeffreys-Bullen (JB) velocity model as standard. For the first 10 months of 2004 ISC also recomputed its locations using AK135 velocity model which is used frequently today. Unfortunately it was too short period to obtain enough data from Poland. The time window was extended over 2002 and 2003 in order to have sufficient amount of data. This paper presents a comparison of ISC JB and AK135 epicenter locations with high precision locations performed as part of operations by the mining industry in Poland.

Induced events are the main source of seismicity in Poland and are concentrated in two large mining areas: Upper Silesian Coal Basin and Lubin Copper Basin. Locations from the mining industry are based on seismic arrivals from 15 to 50 stations, that are installed on various excavation levels, ventilation shafts above or, in a few cases, in wells below the level where most events occur. Effectively 3-D station positioning, combined with local engineering knowledge, allows for very precise location. As a result, positions of the events are known with an accuracy of 300m. Origin times though cannot be determined since local seismic networks use internal timing that is not synchronized with UTC. The timing nevertheless is accurate enough to associate locations given by mines with the data from the closest station of Polish seismic network and therefore with corresponding events in the ISC bulletin.

Accurate local data offer a unique benchmark that can be used to verify that using the AK135 velocity model in ISC operations does not cause unexpected systematical biases in locations in Poland and vicinity.



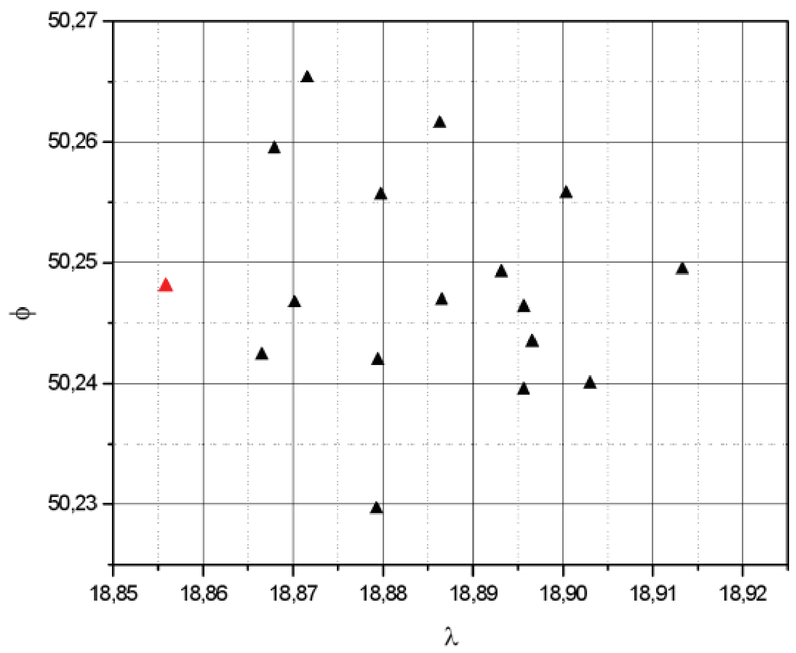
Distribution of seismic stations in Rudna Mine, Lubin Copper Basin

Monitoring seismicity in Upper Silesia Coal Basin is the duty of Central Institute of Mining (CIM) with 11 stations. Institute is using also data from 25 mines operating in this area, each having a seismic network of 8-24 sensors depending on the size of the mine. Exchange of data between mines is difficult because each mine keeps its own un synchronized time.

The figure on right shows distribution of stations located at Halemba Mine. Red triangle denote surface station of the CIM, black ones are underground station of the mine itself.

In Lubin Copper Basin operate three mines, each of them provides its own network of 20-35 underground stations.

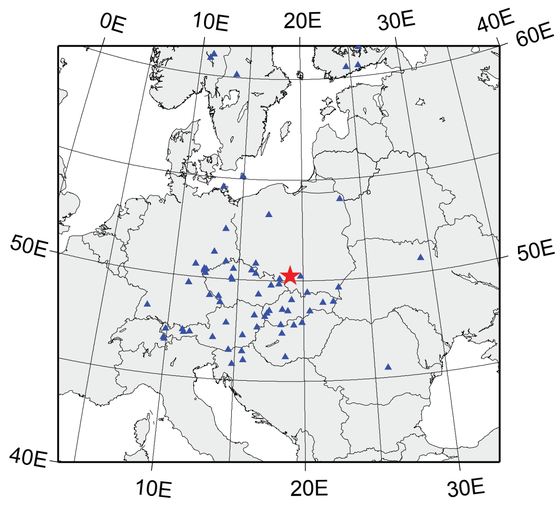
The figure on left shows distribution of stations located in Rudna Copper Mine. Reversed triangles denote stations placed in shafts above excavation area, black triangles denote stations placed in wells beneath excavation area. Since the start 2002 there have been 8 changes of individual station locations. Mines have synchronized time but only internally. Time may drift up to several seconds between the manual UTC synchronizations that are performed on monthly basis.



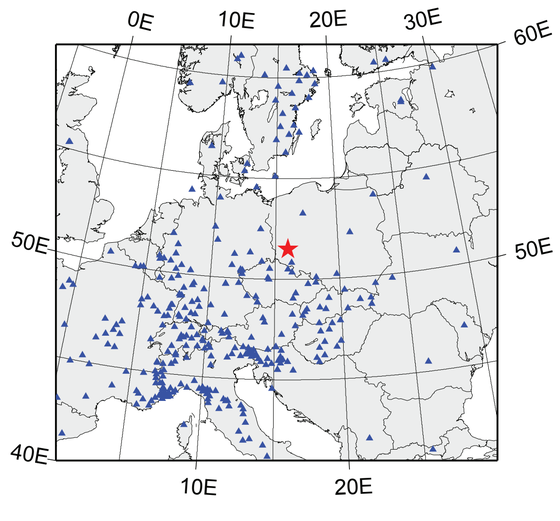
Distribution of seismic stations in Halemba Mine, Upper Silesia Coal Basin

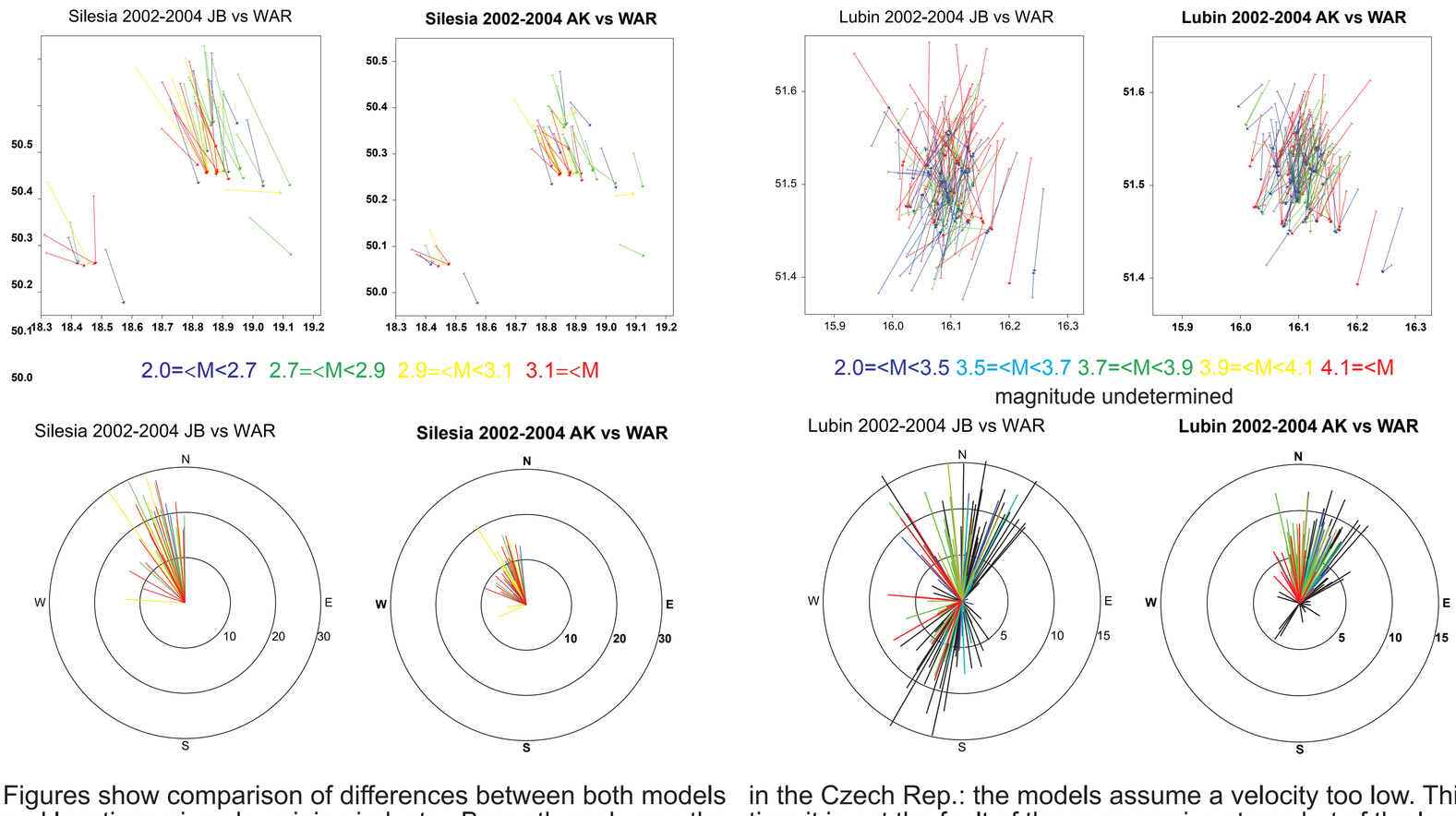
Mining induced events from Polish mining industry are recorded mainly by European seismic agencies. Events from Upper Silesian Coal Basin are generally smaller so they are registered by fewer stations than those from Lubin Copper Basin.
Figures show distribution of stations used by ISC to locate 47 events from Upper Silesia (top) and 180 from Lubin Region (bottom).

Distribution of seismic station recorded events from Upper Silesia 2002-2004



Distribution of seismic station recorded events from Lubin Coper Basin 2002-2004





Figures show comparison of differences between both models and locations given by mining industry. Beneath each map the diagram shows azimuthal distribution of differences.
In Upper Silesia reason for the offset seems to be anisotropy of the P wave velocity. Most stations are southwest and south of Upper Silesia. The offset is northwest. For the southwesterly stations the distance to the epicenter is about the same, no matter if a few km to the NW or to the SE. It does matter however for the southerly stations. If the true P wave velocity is higher than expected from the model, the epicenters will appear to the NW of their true locations. Waves travelling S and SE on their way encounter the Carpathian Orogen which formed incompressive regime along the N-S direction or - in particular -in the NNW-SSE direction along the Western part of the Carpathians. In view of present compressive stress the P waves travelling along the direction of the stress axis (i.e. NNW-SSE) travel at a speed a little higher than the one given by the model and this results in the offset of the location. This offset of about 9 km which corresponds to roughly 2 s early arrival; at the typical epicentral distances of the stations. This corresponds to something of the order of 0.1 km/sdifference in velocity.

In case of Lubin the situation is in a way similar although the cause of the offset is not anisotropy of the P wave velocity. Small Lubin events are offset to the NE by the SW-directioned stations in the Czech Rep.: the models assume a velocity too low. This time it is not the fault of the compressive stress but of the local structure at Lubin which has unusual 6.0 km/s velocity at distances from 5 to 75 km. In comparison with the 200-400 km distance to the Czech stations the higher velocity over the first 75 km distance matters and results in having the locations offset to the NE. The unusual high local P wave velocity over 75 km saves the wave about 2 seconds on travel time and therefore neglecting the unusual high P wave velocity the events appear about 10 km more distant than they really are. Larger events are however recorded by the numerous seismic stations in the Alpine region, which record seismic waves going through deeper layers of the crust where the local high velocity anomaly does not exist and the average models (AK or JB) apply. These Alpine stations stabilize the locations at correct distance in respect to these stations, therefore leaving freedom only in the N-S direction. The data from the near Czech stations cannot then cause the locations to drift NE but what they still can do is to cause some drift to the North - and this is exactly what they do.