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By
Jørgen Torstveit (ed.)

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VI.5 Upper mantle heterogeneities beneath Eastern Europe

Travel time residuals for east European seismograph stations (see Fig. VI.5.1) as reported to the ISC have been used in a study of upper mantle heterogeneities beneath eastern Europe. Standard 3-D inversion procedures were used in the data analysis and the results obtained are displayed in Fig. VI.5.2. In the next section these results will be discussed in some detail, and also a comparison will be made with similar results reported for central Europe (Hovland et al, 1981) and Greece and adjacent areas (Hovland and Husebye, 1981).

3-D inversion results for eastern Europe

The east European inversion results in terms of percentage seismic velocity anomalies are displayed Fig. VI.5.2. The standard earth reference model used was that of Dziewonski et al (1975) for continental regions. The estimated standard errors were of the order of 0.6 per cent except for poorly resolved peripheral nodes (resolution less than 0.5). For details see Table VI.5.1. In the following we will comment on the velocity anomaly patterns at the respective levels.

Level 1 (0-100 km). The anomaly pattern is dominated by velocity lows over the Pannonian Basin and western Turkey, both of which are characterized by high heat flows. Most of the peripheral nodes are poorly resolved but in this respect the velocity high near the northwest corner is exceptional. From its estimated resolution (0.7) and standard error (0.7 per cent) this node should be rated significant, but its estimated bias error (Thomson and Gubbins, 1982) is of the order of 3 per cent.

Level 2 (100-300 km). The areas of velocity lows are even more dominant at this level, and there is a certain overlap with level 1 results for the Pannonian Basin and the western Turkey/Aegean Sea. The velocity highs are found towards west and north. An axiom of modern plate tectonic hypothesis is a lithosphere/asthenosphere decoupling which in this particular case should imply rather pronounced anomaly pattern differences between the level 1 and 2 results. This clearly does not apply to areas of pronounced velocity lows like the Pannonian Basin and the Aegean Sea. However, both of these areas are hypothesized to be associated with upwelling asthenospheric material (for discussion here, see Hovland and Husebye, 1981) and thus a level 1/2 coupling is indeed expected for these two areas.

Level 3 (300-500 km). Relative to level 2 the anomaly pattern here changes rather abruptly with a pronounced velocity high now in the Aegean Sea, while areas of velocity lows are of rather modest extents.

Level 4 (500-600 km). The anomaly pattern of level 3 is essentially retained here with relatively pronounced anomalies in comparison to those observed for Fennoscandia for these two levels.

Discussion

The station distribution within the eastern European seismograph network (as defined in Fig. VI.5.1) is skew in the sense that most stations are found in the NW and SE quandrants. This in turn is reflected in relatively poorly resolved nodes in the NE and SW quadrants as demonstrated in Table VI.5.1. Notwithstanding this kind of problems, the stable tectonic units of the region under investigation, namely, the Ukranian Shield and the East European Platform, correspond to those areas which exhibit modest velocity anomalies at the four levels of Fig. VI.5.2.

The eastern European region as defined in Fig. VI.5.x overlaps partly with that of Central Europe (Hovland et al, 1981) and southeast Europe (Hovland and Husebye, 1981). Although different data sets are used, the anomaly patterns of the various studies correlate well in the overlapping areas (not unexpected).

An intriguing aspect of the results presented is the existence also in the asthenosphere of strong velocity anomalies. This feature is less pronounced for platform and shield areas, which exhibit relatively very good P-wave propagation regimes in terms of early phase arrivals with relatively strong high-frequency signal amplitudes. This and associated topics of 3-D seismic modelling of the lithosphere/asthenosphere will be the subject of future NORSAR research studies.

J. Hovland

E.S. Husebye

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Hovland, J., D. Gubbins & E.S. Husebye, 1981: Upper mantle heterogeneities beneath central Europe. Geophys. J.R. astr. Soc., 66, 261-284.

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RESOLUTION								STANDARD ERROR						
							LEVEL 1							
0.3	0.7	0.2	0.3	0.1	0.0	0.0		0.8	0.7	0.6	0.7	0.4	0.1	0.1
0.7	0.7	0.6	0.7	0.6	0.1	0.0		0.7	0.6	0.7	0.6	0.6	0.3	0.1
0.4	0.5	0.6	0.5	0.4	0.5	0.0		0.8	0.7	0.7	0.7	0.7	0.6	0.1
0.0	0.2	0.2	0.5	0.5	0.5	0.0		0.2	0.6	0.6	0.7	0.7	0.7	0.2
0.0	0.4	0.2	0.6	0.6	0.5	0.6		0.2	0.5	0.6	0.6	0.7	0.7	0.7
0.0	0.0	0.0	0.6	0.5	0.5	0.3		0.1	0.1	0.2	0.6	0.5	0.6	0.7
0.0	0.0	0.0	0.1	0.1	0.0	0.0		0.0	0.0	0.1	0.5	0.4	0.1	0.1
							LEVEL 2							
0.6	0.8	0.7	0.6	0.4	0.1	0.0		0.8	0.6	0.7	0.7	0.7	0.4	0.1
0.8	0.8	0.8	0.7	0.7	0.5	0.0		0.7	0.5	0.5	0.5	0.5	0.6	0.3
0.6	0.7	0.7	0.7	0.7	0.6	0.3		0.7	0.5	0.5	0.5	0.6	0.4	0.8
0.2	0.6	0.6	0.6	0.7	0.7	0.2		0.7	0.6	0.6	0.5	0.5	0.5	0.7
0.5	0.6	0.5	0.7	0.7	0.7	0.8		0.7	0.4	0.7	0.5	0.5	0.5	0.6
0.0	0.1	0.3	0.6	0.7	0.6	0.6		0.3	0.4	0.6	0.4	0.5	0.5	0.7
0.0	0.0	0.0	0.4	0.5	0.1	0.0		0.0	0.0	0.3	0.8	0.7	0.5	0.3
							LEVEL 3							
0.6	0.8	0.8	0.7	0.7	0.5	0.0		0.8	0.6	0.6	0.7	0.7	0.7	0.4
0.8	0.8	0.8	0.8	0.8	0.7	0.3		0.7	0.5	0.4	0.4	0.5	0.5	0.7
0.6	0.8	0.8	0.8	0.7	0.7	0.6		0.7	0.5	0.5	0.5	0.5	0.5	0.8
0.5	0.7	0.7	0.7	0.7	0.7	0.6		0.8	0.5	0.5	0.5	0.5	0.5	0.8
0.4	0.5	0.7	0.7	0.8	0.7	0.7		0.8	0.7	0.5	0.5	0.4	0.5	0.7
0.2	0.4	0.6	0.7	0.7	0.7	0.6		0.8	0.8	0.5	0.5	0.5	0.5	0.8
0.0	0.0	0.3	0.5	0.6	0.5	0.1		0.1	0.1	0.8	0.8	0.8	0.8	0.6
							LEVEL 4							
0.2	0.4	0.5	0.5	0.3	0.3	0.0		0.6	0.8	0.8	0.8	0.8	0.8	0.3
0.3	0.5	0.6	0.6	0.5	0.4	0.2		0.8	0.8	0.7	0.7	0.7	0.7	0.6
0.4	0.4	0.5	0.6	0.5	0.4	0.3		0.8	0.7	0.7	0.7	0.7	0.7	0.7
0.2	0.4	0.5	0.5	0.5	0.5	0.4		0.7	0.7	0.7	0.7	0.7	0.7	0.8
0.1	0.2	0.4	0.4	0.5	0.5	0.4		0.5	0.6	0.7	0.7	0.7	0.7	0.8
0.0	0.2	0.3	0.3	0.4	0.4	0.3		0.3	0.6	0.7	0.7	0.7	0.8	0.8
0.0	0.0	0.1	0.1	0.2	0.2	0.1		0.1	0.2	0.5	0.7	0.7	0.7	0.5

TABLE VI.5.1

Resolution and standard errors for the individual knot estimate of velocity perturbations shown in Fig. VI.5.2.

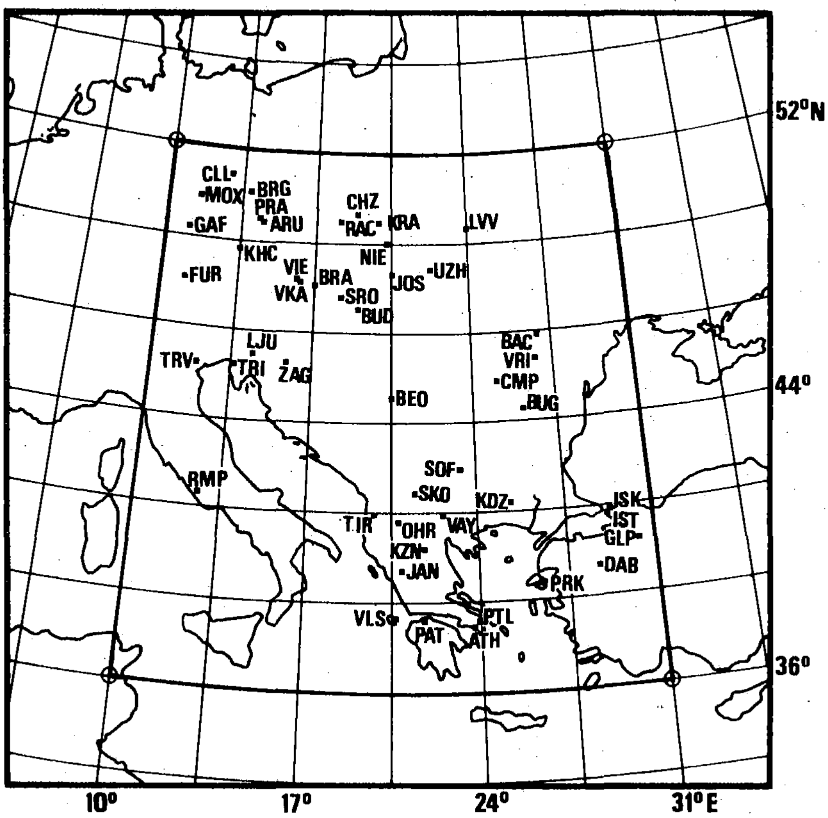

Fig. VI.5.1 The eastern Europe seismograph station network used in analysis. The intersections of the latitude/longitude grid system correspond to the knots in the time residual inversion results shown in Fig. VI.5.2.

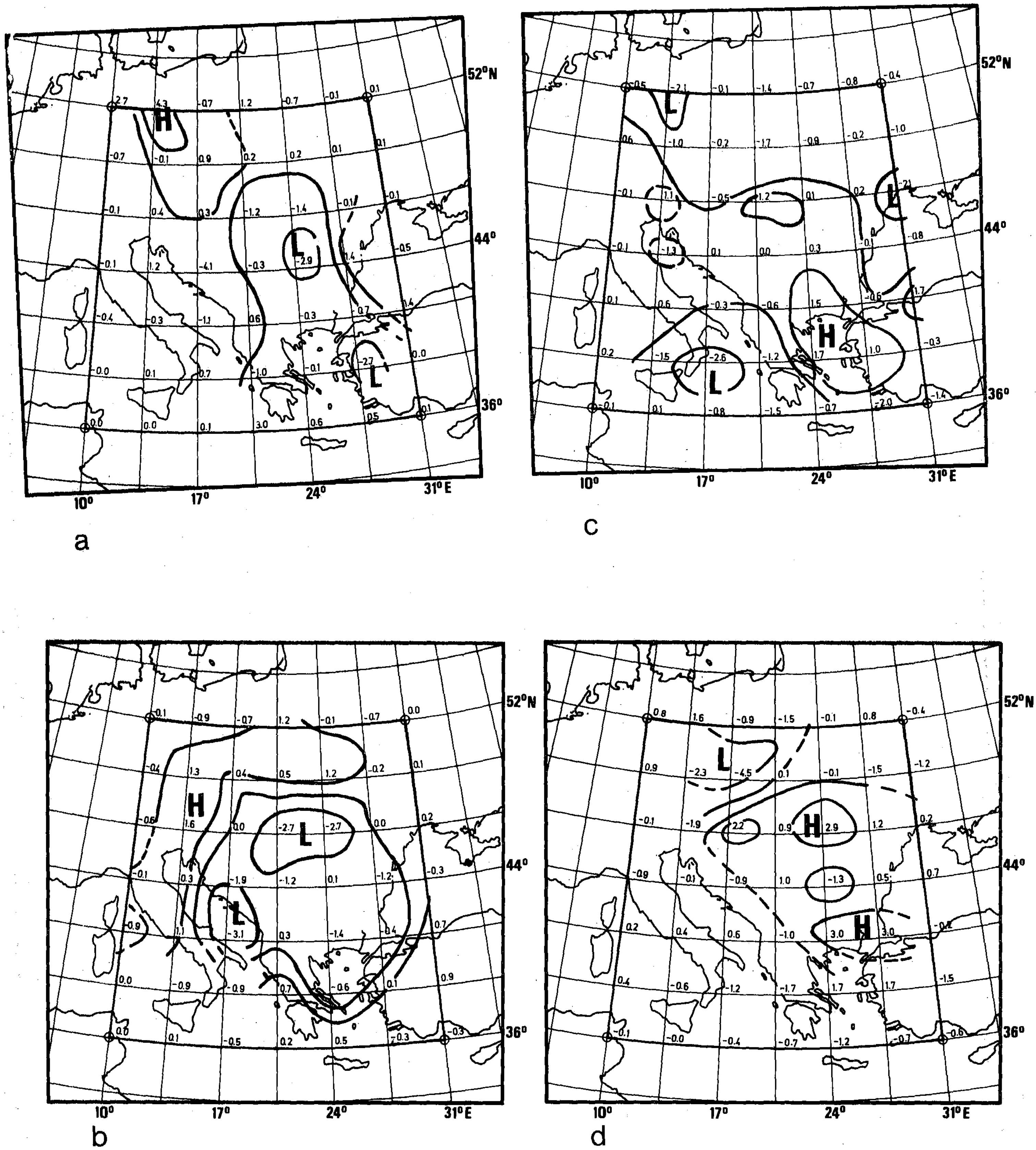

Fig. VI.5.2 (a) Velocity perturbations (in per cent) for Level 1. Areas of high and low velocities are indicated by capital letters H and L. Resolution and standard errors for all knots are listed in Table VI.5.1. (b) Velocity perturbations (in per cent) for Level 2. (c) Velocity perturbations (in per cent) for Level 3. (d) Velocity perturbations (in per cent) for Level 4.