Evaluation of the AK135 Velocity Model Performance in Earthquake Location in the Broader Area of Greece

M. Pirli[1] and N. Melis[2]

[1]Department of Geophysics-Geothermics, University of Athens, Greece pirli@geol.uoa.gr
[2]Geodynamics Institute, National Observatory of Athens, Greece nmelis@gein.noa.gr

ABSTRACT

The possibilities to improve International Seismological Centre (ISC) locations were investigated and discussed during the 2005 IASPEI General Assembly in Chile. It was then suggested that the Jeffreys-Bullen (JB) travel-time tables should be replaced by the AK135 tables, the latter providing more accurate solutions on a global scale. The comparison between the two models for the broader area of Greece is discussed here, using the corresponding bulletins produced by the ISC for the 10 month interval between January and October 2004. The two different solutions provided by the ISC are compared to those catalogued in local and/or regional bulletins and the resulting deviations between them are evaluated.

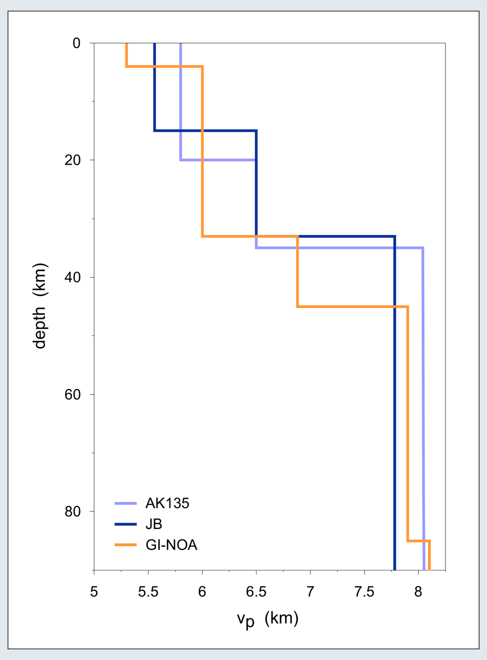

Figure 1. Crust and upper mantle representation according to the velocity models used in this study for P-type velocity.

INTRODUCTION

The most important recommendation derived from the first workshop on modernizing ISC location procedures held in Chile in 2005, was that ISC should adopt the spherical Earth model AK135 (Kennett et al., 1995) over the applied Jeffreys-Bullen model (Jeffreys and Bullen, 1940) for earthquake location procedures (Schweitzer and Storchak, 2006; Engdahl, 2006; Schweitzer, 2006).

In order to investigate for any systematic bias, on a regional scale, resulting from the application of the new velocity model, the ISC produced a 10 month dataset (January - October 2004) comprising of ~ 15,000 located events using both the Jeffreys-Bullen (JB) and the AK135 models. This contribution focuses on the area of Greece (34N-41N, 19E-29E) for which a subset of 270 seismic events was extracted from the corresponding ISC datasets.

Both ISC solutions were compared to the solutions of the National Seismographic Network (ATH) of the Geodynamics Institute of the National Observatory of Athens (GI-NOA) and to solutions calculated by the EMSC. In both cases (ATH and EMSC), hypocentre solutions are obtained applying the same regional velocity model developed at GI-NOA. The latter, as well as the two global models, for P velocities in the crust and upper mantle are depicted in Fig. 1.

Table 1

	AK135		JB	
	mean	median	mean	median
dto	0.67	0.53	0.70	0.52
RMS	1.215	1.221	1.211	1.210
Smaj	8.16	4.91	8.31	4.98
Smin	4.31	3.29	4.34	3.39
area	194.2	51.0	195.1	53.6
dz	6.1	4.7	6.1	4.9

Mean and median values for origin time error (dto - sec), RMS (sec), error ellipsoid major (Smaj - km), minor (Smin - km) semiaxis and area (km^2), and error in focal depth (dz - km), for the two solutions provided by the ISC (AK135 and JB)

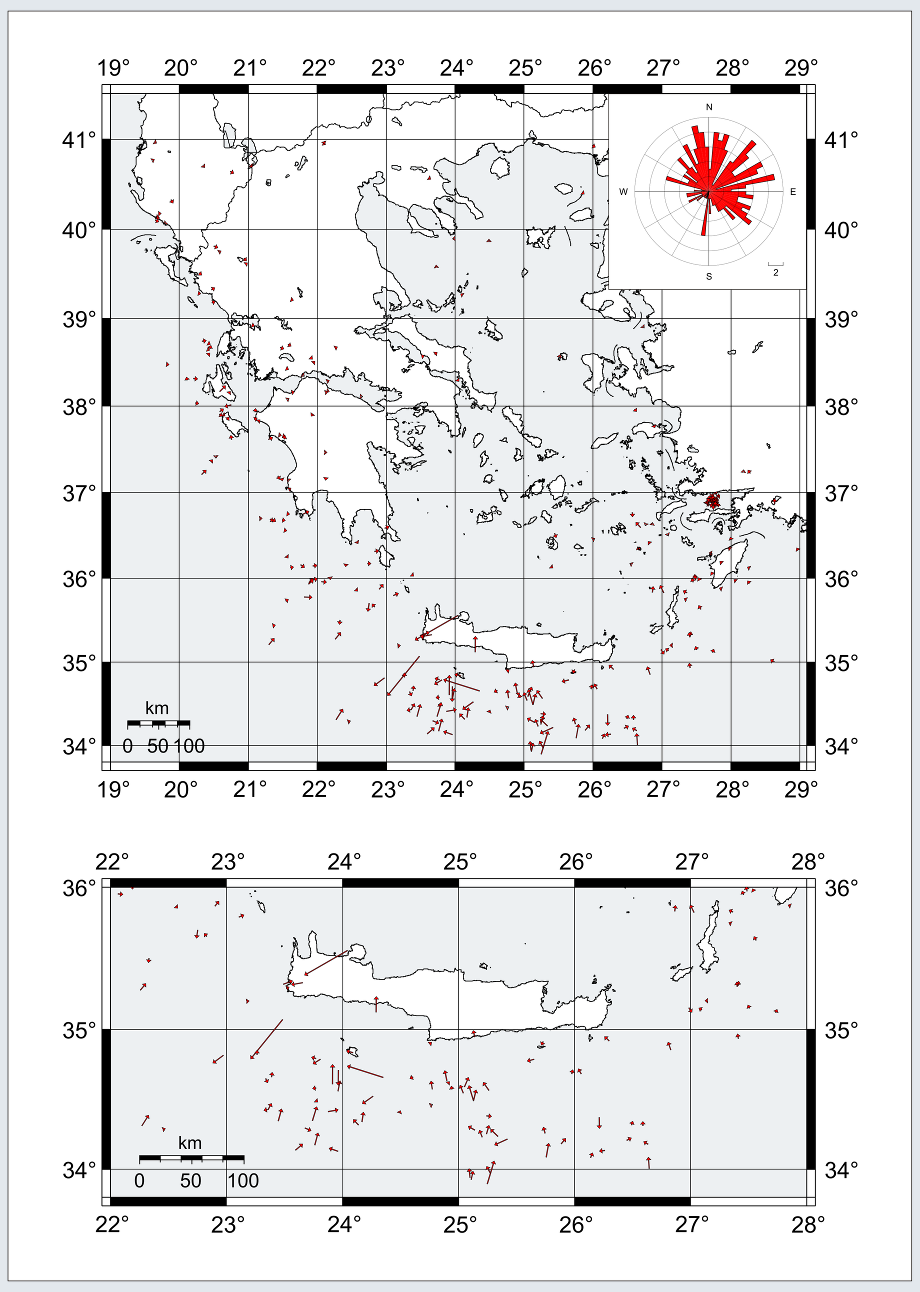

Figure 2. Epicentre dislocation vectors for the ISC - AK135 solutions (arrow head), in respect to corresponding ISC - JB solutions, for the 270 events used in this study. Rose-diagram of the distribution of vector azimuth (top). Same as above, for the broader area of Crete (bottom). Vectors are scaled to true dimensions.

COMPARISON BETWEEN THE TWO ISC SOLUTIONS

In general, only minor deviations are observed between the AK135 and JB solutions (Fig. 2 and 3). Larger discrepancies are observed only in the broader area of Crete (34N-35.5N and 23E-26E), where large azimuthal gap values affect hypocentre solutions. However, no systematic bias can be observed.

Regarding focal depth determination, the geographic distribution of available stations does not allow for sufficient resolution, depth being fixed in about 40% of the cases in the discussed dataset. Phase re-association applying model AK135 is expected to have a more significant contribution than the approach followed in the present research.

Resulting location errors (Table 1) indicate essentially same performance for both AK135 and JB in the area of Greece.

The effect of large azimuthal gap values, concentrated mostly in the broader area of Crete, can be observed on ncreasing deviation between corresponding locations (Fig. 4) and increasing error-ellipse dimensions (Fig. 5).

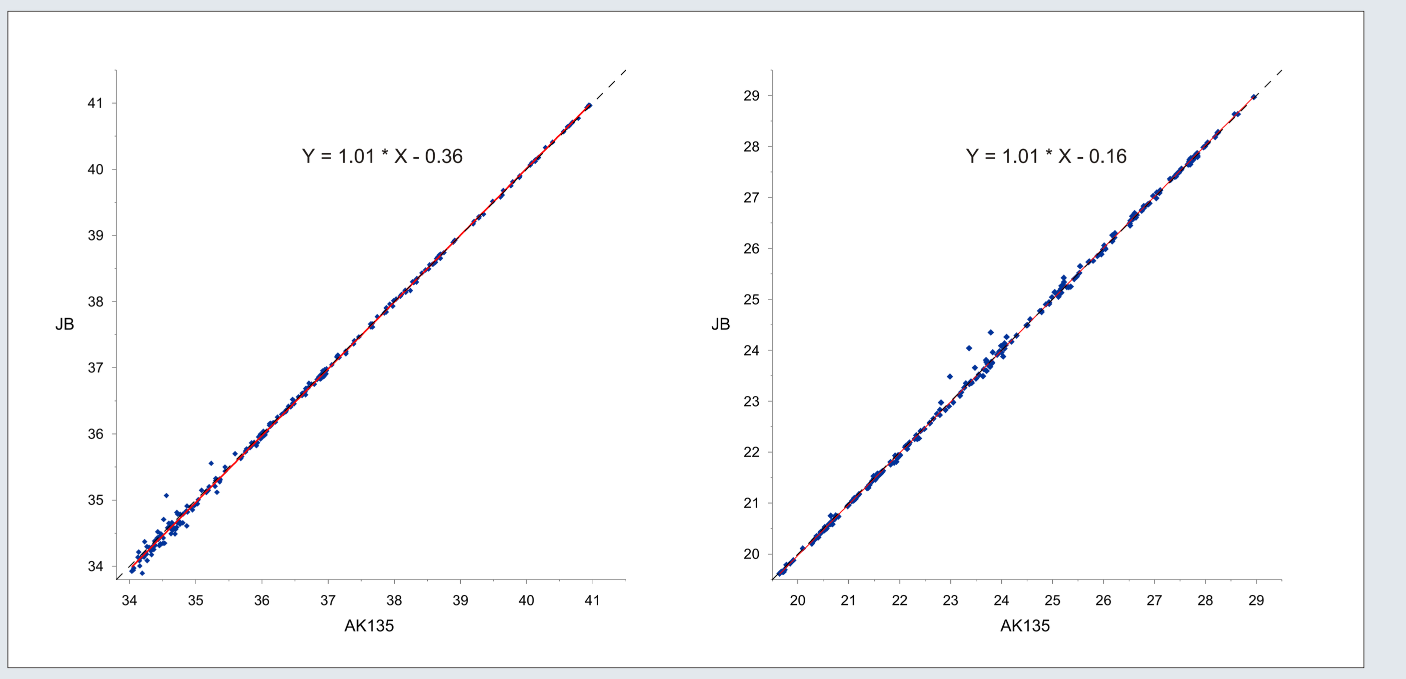

Figure 3. Scatter diagrams for latitude (left) and longitude (right) for the two solutions determined by ISC. The red line is the fit-curve corresponding to the displayed equations, while the black, dashed line denotes the Y = X function.

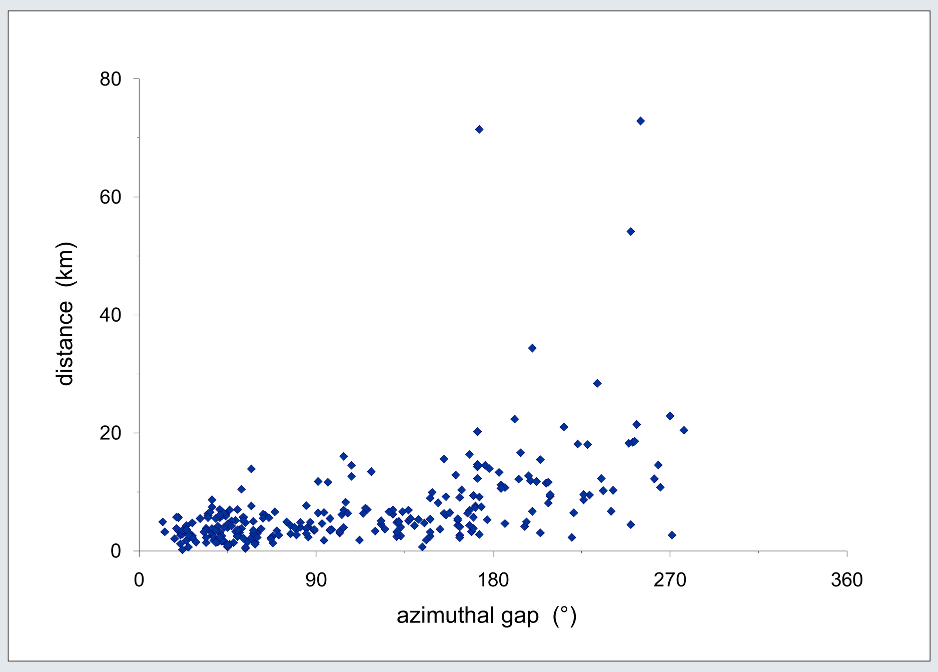

Figure 4. Distance between the ISC - JB and ISC - AK135 solutions against ISC azimuthal gap.

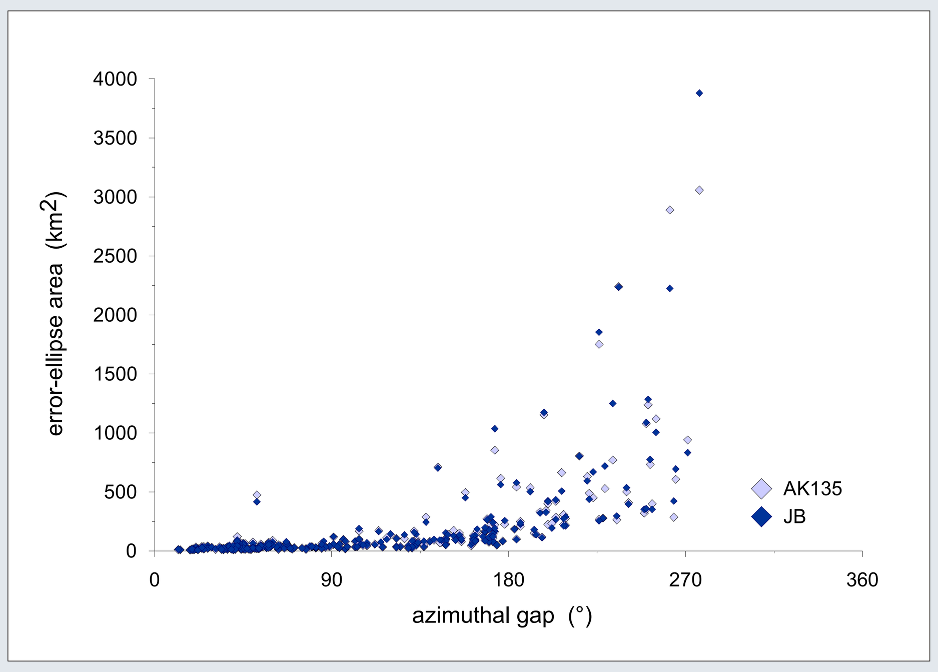

Figure 5. Error-ellipse area for the two solutions provided by ISC against azimuthal gap. Since no substantial deviation exist between the two versions, the gap values for AK135 solutions are used.

COMPARISON BETWEEN ISC AND ATH SOLUTIONS

For Greek mainland and Aegean Sea, only small deviations can be observed between the two different ISC solutions and the solutions of ATH (Fig. 6). Larger discrepancies are observed in the S-SE part of the Hellenic Arc, presumably due to large azimuthal gap.

A clear trend can be observed both for AK135 and JB solutions, regarding epicentre dislocation with respect to ATH solutions (Fig. 6 - inlay). This can be interpreted as the effect of the geographic distribution of ATH stations, tending to 'draw' epicentres closer to the network stations.

In general, AK135 solutions seem to be closer to ATH epicentres than corresponding JB solutions (Fig. 6 and 7). However, this deviation in distance is not large for most cases.

The effect of azimuthal gap on the deviation between both ISC and ATH solutions is obvious in Fig. 8.

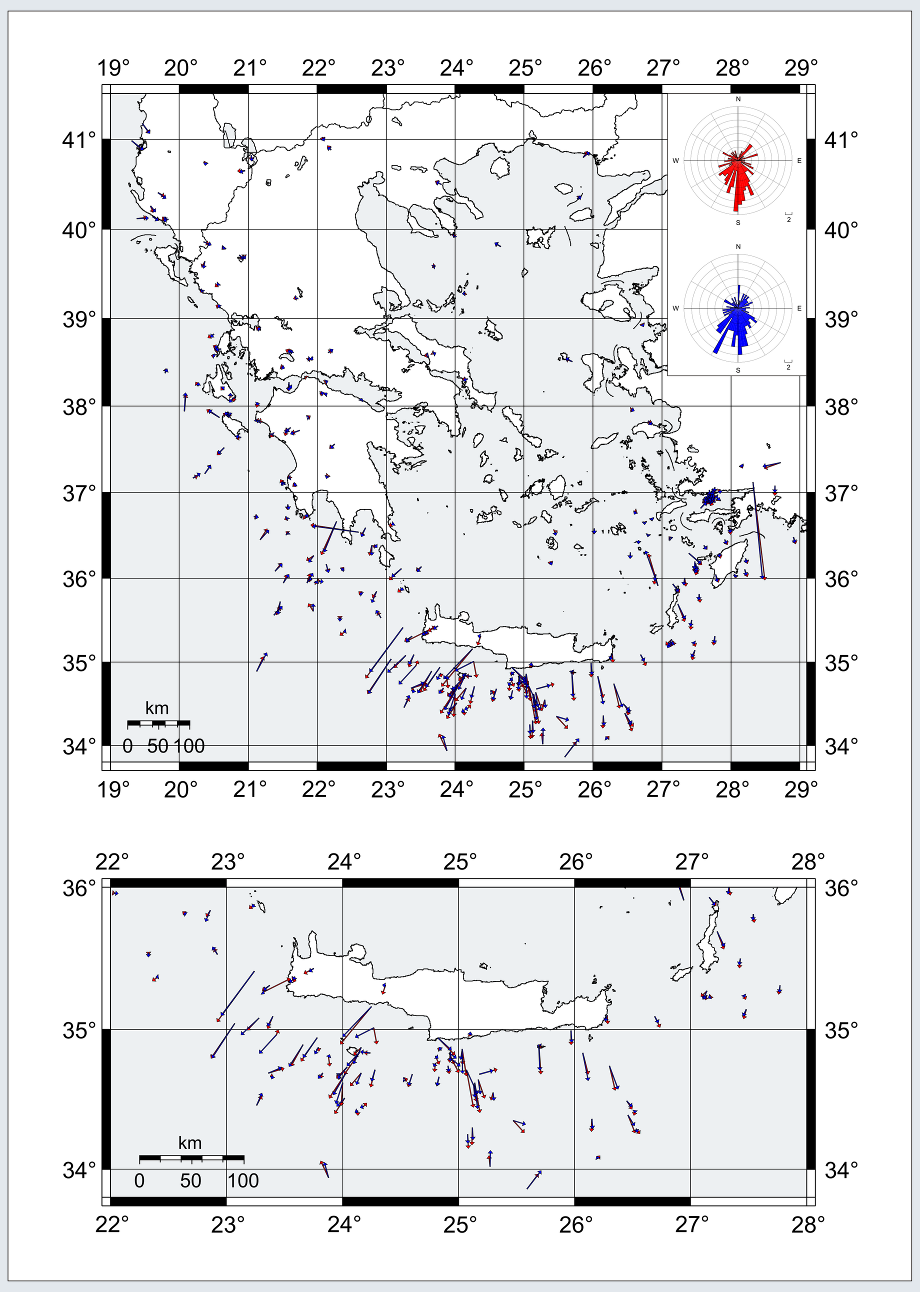

Figure 6. Epicentre dislocation vectors for the ISC - AK135 (blue) and the ISC - JB (red) solutions (arrow head), in respect to corresponding ATH solutions, for the 270 events used in this study. Rose-diagrams of the distribution of vector azimuth (top). Same as above, for the broader area of Crete (bottom).

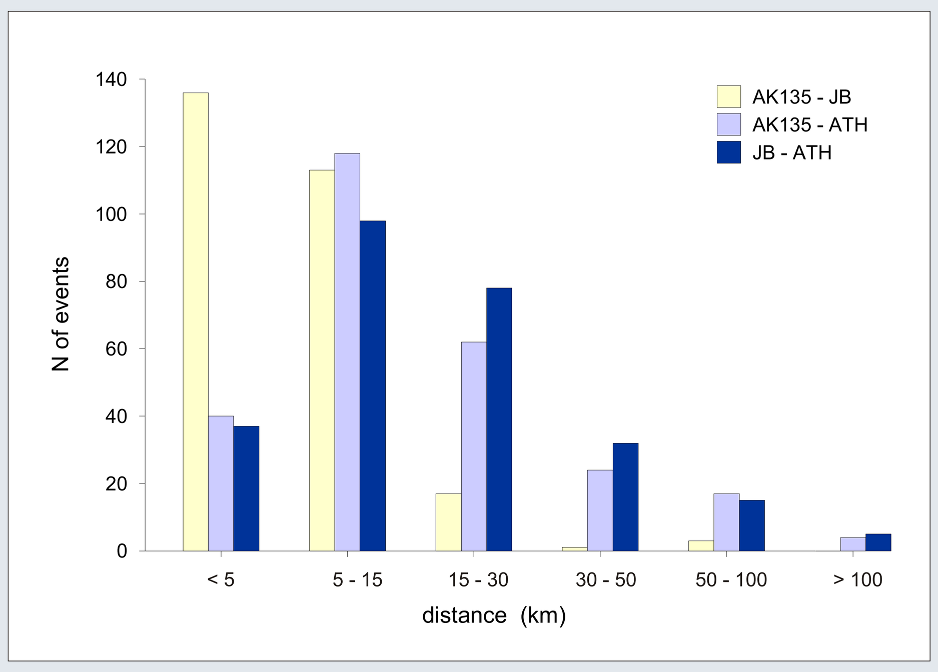

Figure 7. Distribution of the distance between the different epicentre solutions (see figure legend) discussed in this study.

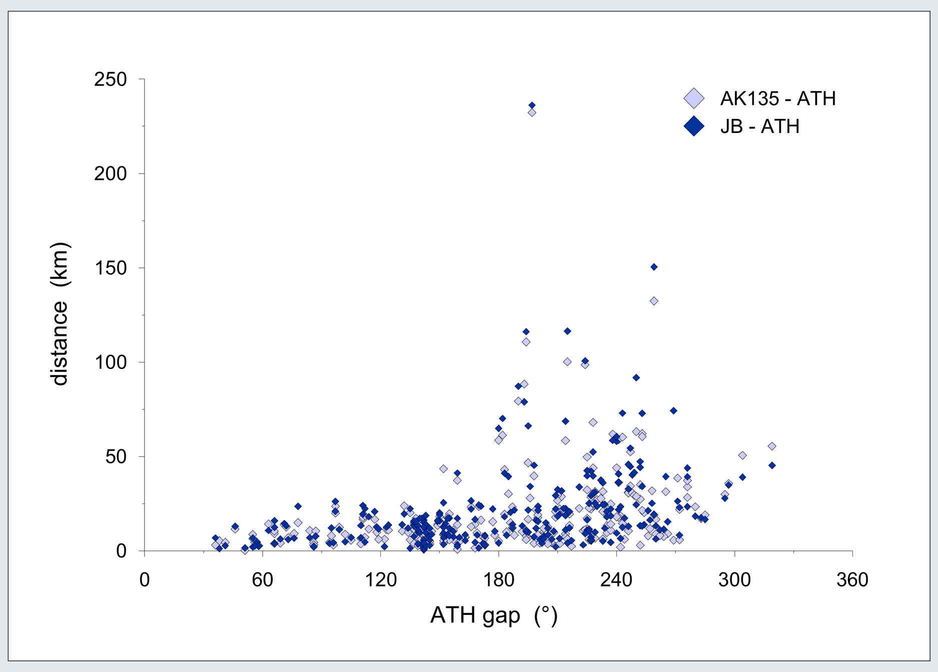

Figure 8. Distribution of epicentre distance between ISC and ATH solutions against ATH azimuthal gap.

COMPARISON BETWEEN ISC AND EMSC SOLUTIONS

Further comparison was made with the common (261) events in the Euro-Med Bulletin (Godey *et al.*, 2006), as EMSC solutions are expected to have smaller azimuthal gap values than ATH.

Similar conclusions to those of ATH are derived, as EMSC solutions do not deviate significantly from AK135 and JB ISC solutions, with few exceptions in the area of Crete and the eastern boundary of the Hellenic Arc (Fig. 9).

Available data did not provide any additional information.

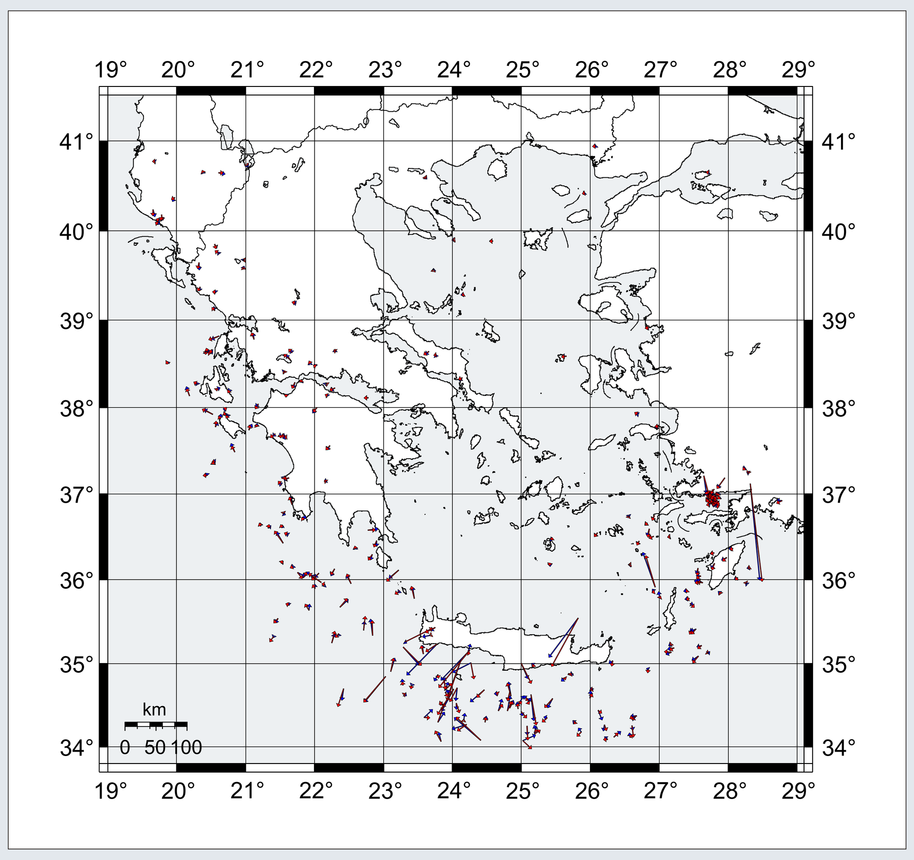

Figure 9. Epicentre dislocation vectors for the ISC - AK135 (blue) and the ISC - JB (red) solutions (arrow head), in respect to corresponding EMSC solutions, for the 259 common events between the two bulletins used in this study.

CONCLUSIONS

With respect to the dataset employed in the present study, no actual discrepancy is observed between the AK135 and the JB model for the area of Greece.

AK135 solutions are marginally closer to the National Seismographic Network of Greece solutions (ATH).

As expected, a strong dependence on azimuthal gap is observed for all the different solutions discussed here. Larger discrepancies are observed in cases of large azimuthal gap values (e.g. the broader area of Crete), independently of the velocity model.

Similar observations are derived from comparison of the two ISC solutions to corresponding EMSC locations: In the mean, AK135 solutions are closer to EMSC, discrepancy between solutions being larger in areas characterised by large azimuthal gap values.

Taking into consideration all above mentioned points, no systematic bias is expected for ISC locations in the area of Greece, with the introduction of the AK135 velocity model.

A relocation procedure that involves the re-association of recorded phases with the AK135 model is expected to provide better insight in the contribution of this model to location quality for the area of Greece.

REFERENCES

Engdahl, E.R. (2006). Application of an improved algorithm to high precision relocation of ISC test events. Phys. Earth Planet. Int., 158, 14-18.
Godey, S., R. Bossu, J. Guilbert, and G. Mazet-Roux (2006). The Euro-Mediterranean Bulletin: A comprehensive seismological bulletin at regional scale. Seismol. Res. Lett., 77(4), 460-474.
International Seismological Centre, 1964-2001. On-line Bulletin, International Seismological Centre, Thatcham, UK, http://www.isc.ac.uk/bulletin.
Jeffreys, H., and K.E. Bullen (1940). Seismological Tables. British Association for the Advancement of Science, London.
Kennett, B.L.N., E.R. Engdahl, and R. Buland (1995). Constraints on seismic velocities in the Earth from traveltimes. Geophys. J. Int., 122, 108-124.
Schweitzer, J. (2006). How can the ISC location procedures be improved? Phys. Earth Planet. Int., 158, 19-26.
Schweitzer, J., and D.A. Storchak (2006). Modernizing the ISC location procedures. Editorial, Phys. Earth Planet. Int., 158, 1-3.

ACKNOWLEDGMENTS

Stephanie Godey and Remy Bossu have kindly provided help with the Euro-Med Bulletin for the time interval addressed in this study and information on applied velocity models by the EMSC.