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7.6 Distribution in slowness space of regional array detections

One of the main features of advanced regional arrays is their ability to reliably determine the slowness vector of incoming signal energy. This is important for seismic phase identification, and can be used to characterize detected phases as teleseismic P or PKP, regional P, S, Lg or Rg (Mykkeltveit et al. 1990). As shown, e.g., by Kvaerna (1990), this ability can also be used to identify the origin of various seismic noise sources, many of which show very consistent azimuth, frequency and velocity characteristics.

This report summarizes statistics on the number of detections versus apparent slowness vector for the four regional arrays NORESS, ARCESS, GERESS and FINESA. In a series of 3-D plots, we display all of the detections reported by each individual array for the six-month period October 91 - March 92. We also show a figure with the slowness distribution for those detections that have been associated to an event in the IMS analysis.

Figs. 7.6.1 - 7.6.4 show number of detections versus slowness for each of the arrays. The slowness space corresponds to the same grid of 51 by 51 points used in the on-line broadband fk-analysis. The slownesses range from -0.4 to 0.4 s/km. This corresponds to apparent velocities ranging from 1.78 km/s to infinity.

The X-axis (left-right) corresponds to eastward direction. The Y-axis (front-back) correspond to northward direction. Each figure is separated into two parts. The upper part shows detections with estimated signal frequency below 6.0 Hz. The lower part shows detections with estimated signal frequency above 6.0 Hz.

Fig. 7.6.1 shows NORESS detections. There are dominant peaks in the center for high velocities and a ridge towards east-north for velocities around 3.0 km/s. The 3.0 km/s peaks have been documented as seismic Rayleigh waves from an industrial area and from the large river Glomma running north-south about 20 km east of NORESS (Kvaerna, 1990).

Fig. 7.6.2 shows ARCESS detections. Dominant peaks are found corresponding to P and S velocities from the Kola mines (azimuth 100-130 degrees). A large number of detections with direction from north and velocities around 6.0 km/sec have not been identified. The high frequency detections towards west may be noise from a main road passing the west side of the array.

Note that when the source is very close, or within the array, the slowness estimate may be wrong. See also section 7.9 for a report on correlation between number of detections and temperature fall (ice cracks) in the ARCESS array.

Fig. 7.6.3 shows FINESA detections. Dominant peaks are found corresponding to P, Lg and Rg velocities from the mines in Estonia. In addition, there is a large number of very low velocity detections from the north. The origin of these detections is unknown.

Fig. 7.6.4 shows GERESS detections. Here, the low frequency detections are concentrated to relatively high apparent velocities. The high frequency detections are spread well out in slowness space, but a typical ring of Pn velocities can be identified.

When evaluating the statistics given above, it must be taken into account that the f-k analysis can fail to give the correct estimate in some cases. From our experience, this can happen in particular if the signal frequency is high, or if the noise source is located within or very close to an array. Data spikes or segments of bad data quality may of course also produce erroneous results.

In sections 3.5 and 3.6 of this Semiannual report, we noted that the percentage of detections associated to events by either the Intelligent Monitoring System (IMS) or the Generalized Beamforming process (GBF) was in the range 11 to 20%. These low figures are obviously due to the fact that most of the detections have slowness estimates outside the range permitting the detections to be attributed to seismic phases such as Pn or Lg. A natural question is whether these phases actually belong to seismic events, and this may be answered by investigating the results of analyst review of the regional array bulletins.

Fig. 7.6.5 shows the number of detections versus slowness for phases automatically associated to events by IMS (upper part) and estimated slowness for phases accepted or associated by analyst (lower part). (Note that vertical scale is now 500 as opposed to 1000 for Figs. 7.6.1-7.6.4). These figures include detections for all of the four arrays. Detections should normally correspond to certain "seismic" slownesses, since the slowness parameter is used for event association rules. But in the lower figure, the analyst has all detections available regardless of slowness. A seismic phase may be associated and slowness overruled to include the arrival time as a defining parameter for the event solution.

We note from the lower figure that the number of very slow phases is about the same as in the upper figure. This indicates that the estimated slowness parameter is mostly consistent with the solution as accepted by the analyst.

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References

Kvaerna, T. (1990): Sources of short-term fluctuations in the seismic noise level at NORESS), *Phys. Earth Planet. Int.*, 63, 269-276,

Mykkeltveit, S., F. Ringdal, T. Kværna & R.W. Alewine (1990): Application of regional arrays in seismic verification, *Bull. Seism. Soc. Am.*, special issue, 80, 1777-1800.

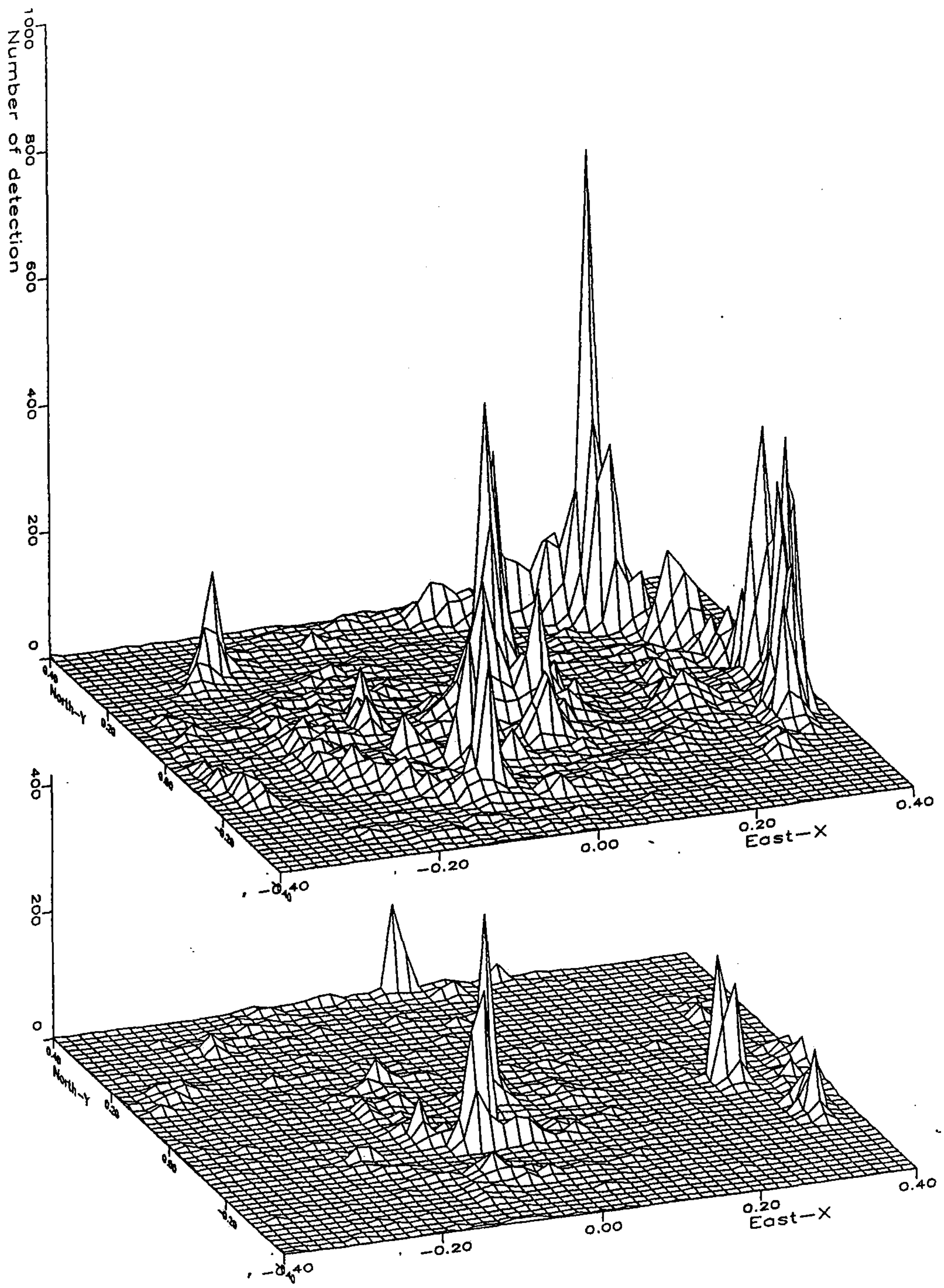

Fig. 7.6.1. Number of NORESS detections versus apparent slowness vector for the 6-month period October 1991 - March 1992. The X-axis (left-right) corresponds to eastward direction with 51 slowness points ranging from -0.4 to 0.4 sec/km. The Y-axis (front-back) correspond to northward direction with 51 slowness points ranging from -0.4 to 0.4 sec/km. The upper part shows detections with estimated signal frequency below 6.0 hz. The lower part shows detections with estimated signal frequency above 6.0 hz.

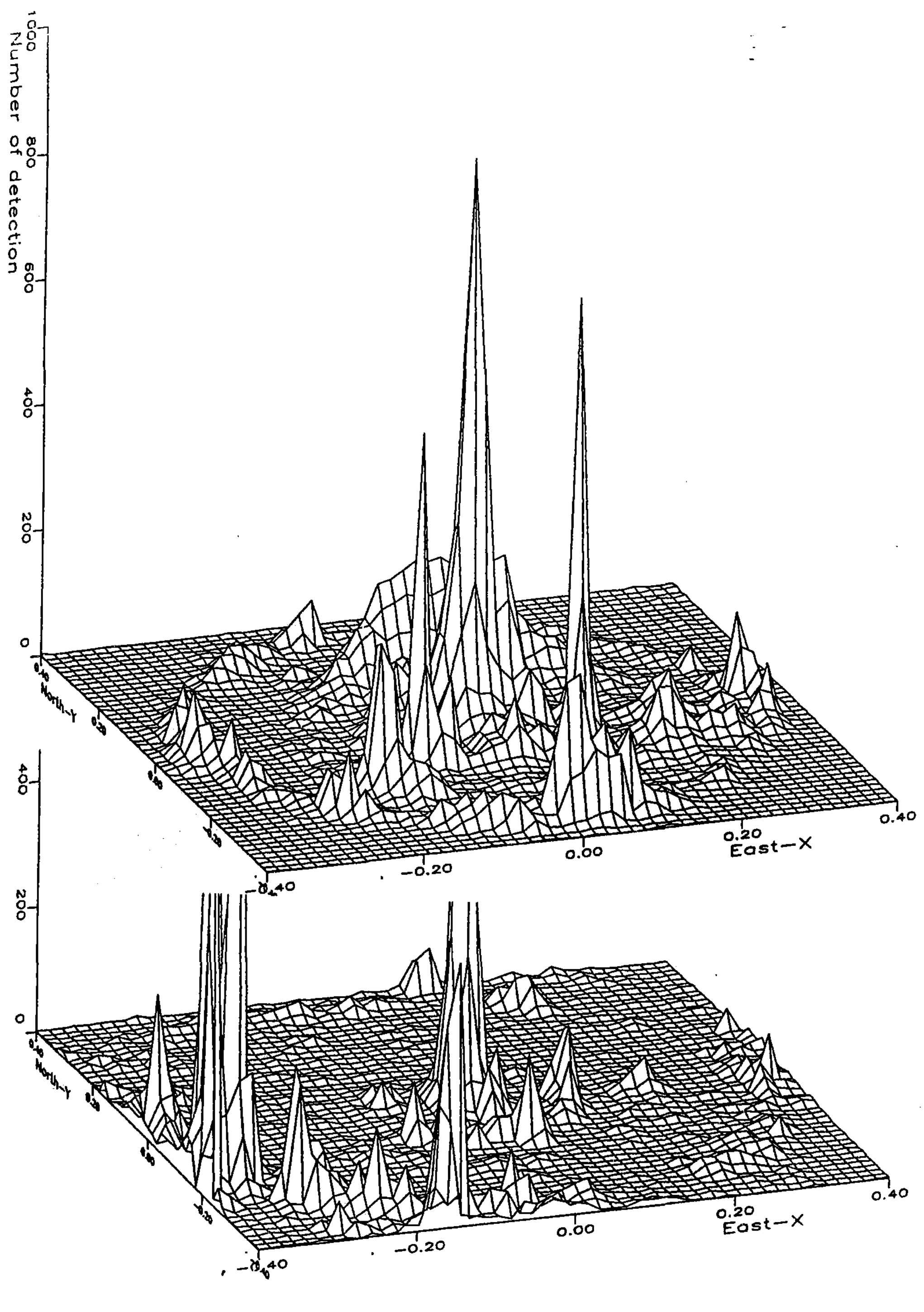

Fig. 7.6.2. Number of ARCESS detections versus apparent slowness vector for the 6-month period October 1991 - March 1992. The X-axis (left-right) corresponds to eastward direction with 51 slowness points ranging from -0.4 to 0.4 sec/km. The Y-axis (front-back) correspond to northward direction with 51 slowness points ranging from -0.4 to 0.4 sec/km. The upper part shows detections with estimated signal frequency below 6.0 hz. The lower part shows detections with estimated signal frequency above 6.0 hz. The lower figure has been clipped.

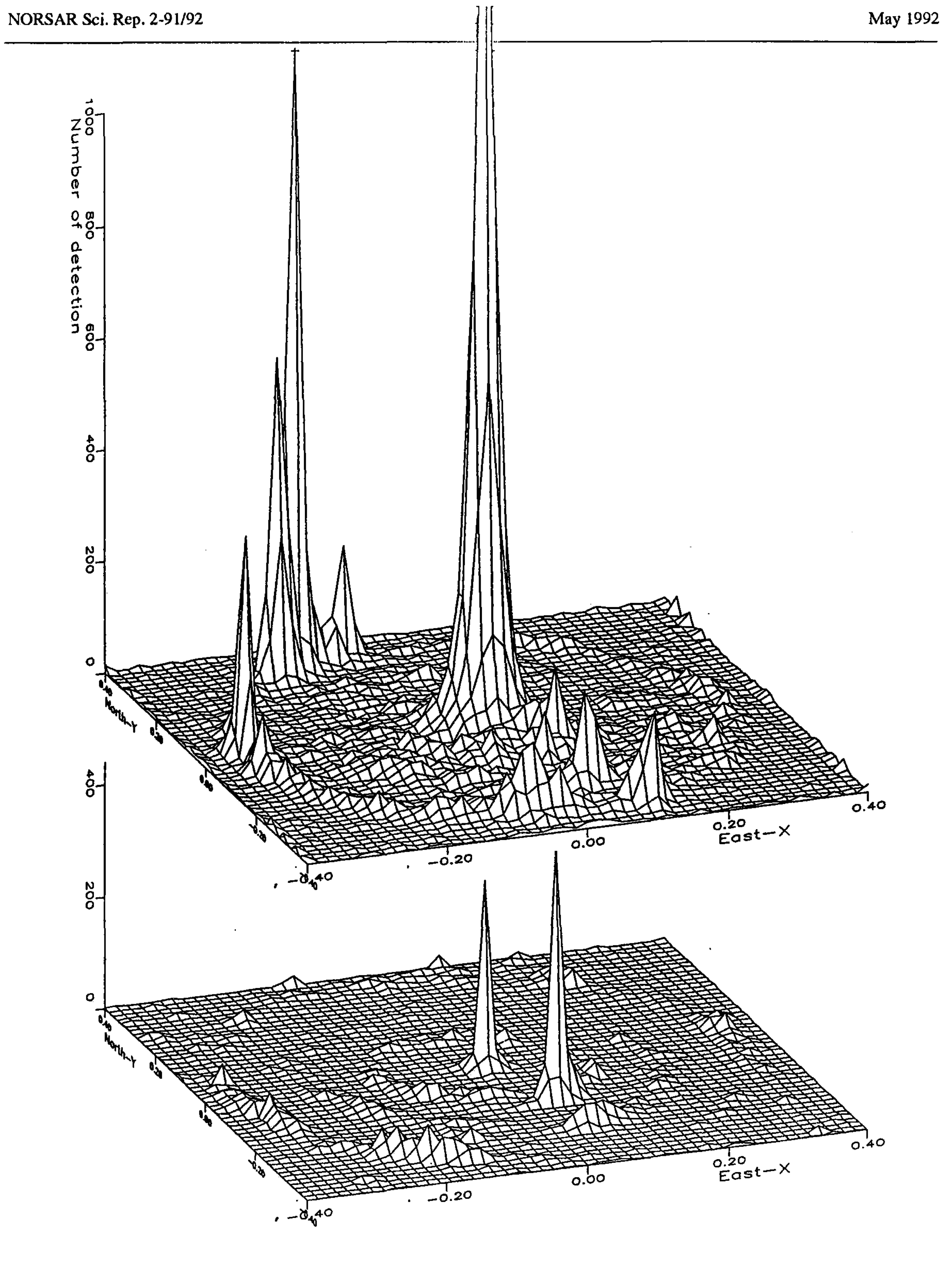

Fig. 7.6.3. Number of FINESA detections versus apparent slowness vector for the 6-month period October 1991 - March 1992. The X-axis (left-right) corresponds to eastward direction with 51 slowness points ranging from -0.4 to 0.4 sec/km. The Y-axis (front-back) correspond to northward direction with 51 slowness points ranging from -0.4 to 0.4 sec/km. The upper part shows detections with estimated signal frequency below 6.0 hz. The lower part shows detections with estimated signal frequency above 6.0 hz.

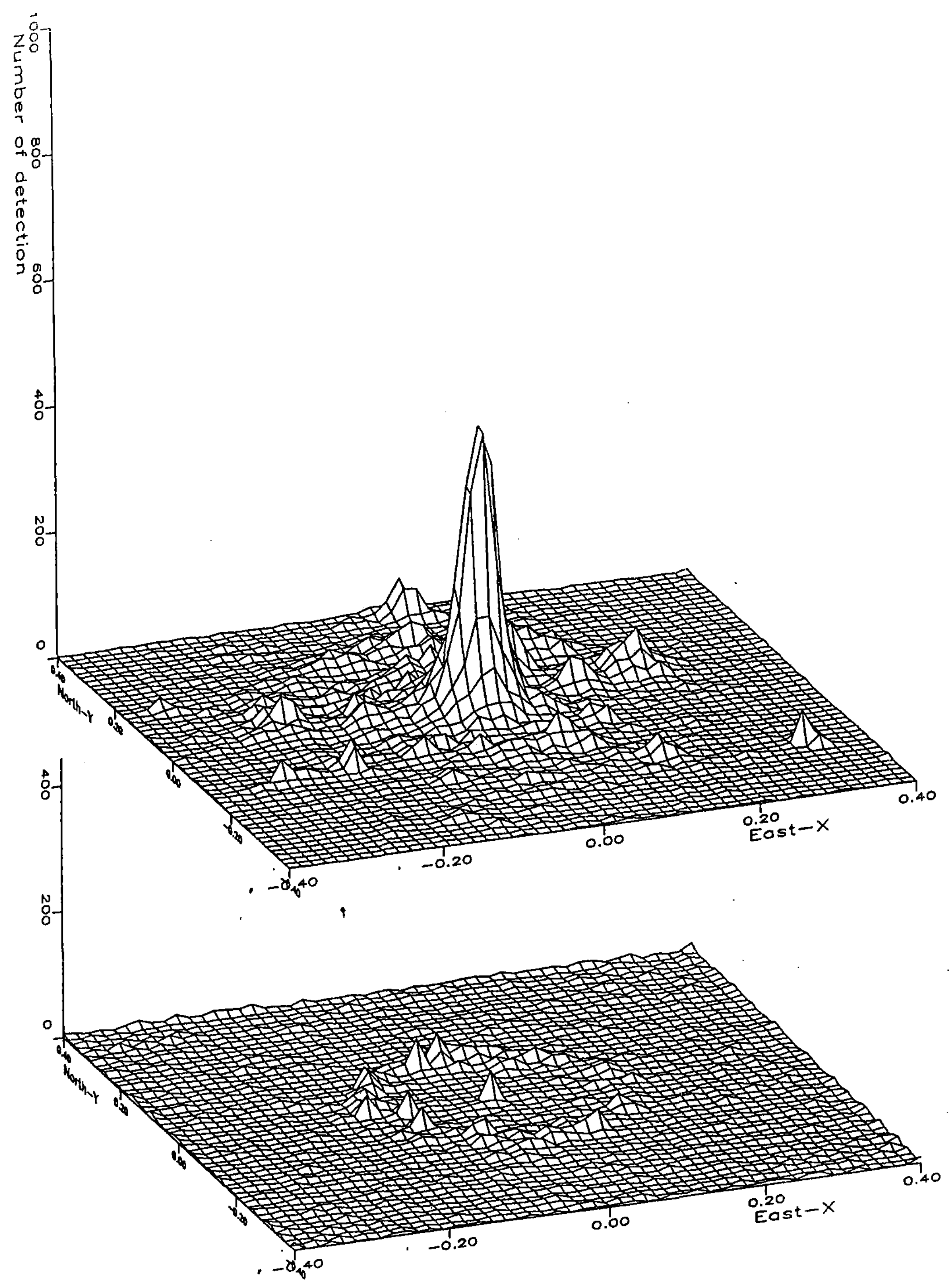

Fig. 7.6.4. Number of GERESS detections versus apparent slowness vector for the 6-month period October 1991 - March 1992. The X-axis (left-right) corresponds to eastward direction with 51 slowness points ranging from -0.4 to 0.4 sec/km. The Y-axis (front-back) correspond to northward direction with 51 slowness points ranging from -0.4 to 0.4 sec/km. The upper part shows detections with estimated signal frequency below 6.0 hz. The lower part shows detections with estimated signal frequency above 6.0 hz.

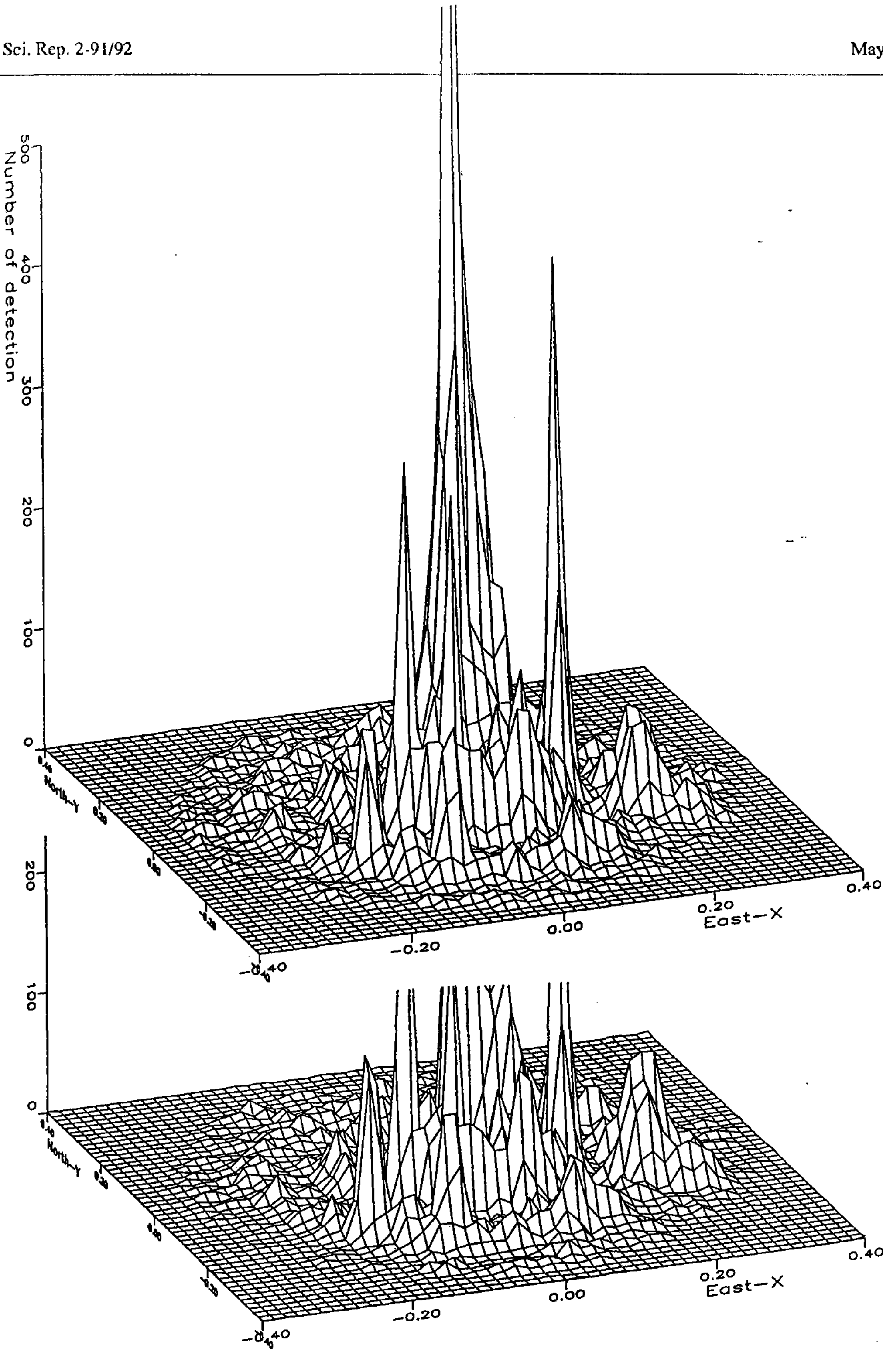

Fig. 7.6.5. The upper part shows number of detections versus apparent slowness vector for the 6-month period October 1991 - March 1992, for detections automatically associated to events by IMS. (All arrays). The X-axis (left-right) corresponds to eastward direction with 51 slowness points ranging from -0.4 to 0.4 sec/km. The Y-axis (front-back) correspond to northward direction with 51 slowness points ranging from -0.4 to 0.4 sec/km. The lower part shows number of detections associated to events that was accepted by analyst review.