Royal Netherlands
Meteorological Institute
Ministry of Infrastructure
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Probability density function for Opende 22-02-2020 event

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Introduction

The Opende event on 22-02-2020:18:12:55.2 with a local magnitude of 1.42 was detected by the KNMI network (*KNMI*, 1993) and located near-real time with the Hypocenter method (*Lienert et al.*, 1986). This fast solution uses an average 1D model for the north of the Netherlands (*Kraaijpoel and Dost*, 2013). Here the epicenter is improved by using a best-fitting traveltime versus distance model based on a database of local P-wave traveltime picks. This data-driven model naturally incorporates actual underburden velocities and only well pickable phase arrivals. An error estimate is derived from the spread in picking times from the best-fitting model. This error incorporates both the local variations of the velocity field as well as picking errors. These errors are propagated further into an epicentral probability density function (PDF). This results into an updated epicenter and its 95% confidence region. For post-2014 events within the Groningen network, also an updated hypocenter solution is available (*Spetzler et al.*, 2018).

Method and Results

Fig. 1 shows the seismic sensors where manual P-wave picks are available for this event. A grid search is done for a region around the Hypocenter solution, as indicated by the red box in Fig. 1. In the first step, equal differential time (EDT, *Zhou*, 1994) residuals are computed. That is, for each grid point and for each station combination, the traveltime differences are forward modelled and tabulated. From these values, the observed traveltime differences are subtracted to obtain the EDT residuals. In the second step, the PDF (*Tarantola*, 2005) is derived from the EDT residuals, using a L1 norm. Fig. 2 shows the 95% confidence area of the resulting PDF[1]. The location with the maximum probability is assigned to be the new epicenter.

Probability density function

This section contains the main output of the analysis. The new epicenter is listed both in wgs84 and in the Dutch national triangulation system (RD). Also a gridded version of the 95% confidence contour of the PDF, and its major and minor axes, can be found.

Epicenter in wgs84 [deg]: 6.176, 53.138

Epicenter in RD [m]: 207820, 572610

PDF major axis [m]: 1047

PDF minor axis [m]: 817

Orientation of the PDF ellipse [deg]: 30.9

95% confidence contour RDx [m]: 207649, 207700, 207760, 207790, 207850, 207880, 207930, 207970, 208000, 208030, 208060, 208090, 208120, 208146, 208165, 208180, 208207, 208219, 208236, 208241, 208249, 208250, 208242, 208235, 208214, 208200, 208180, 208150, 208120,

[1]Note that a smaller PDF would be obtained if also S-wave time differences and P-S delay times were included. For this purpose, the S-wave velocity model needs to be calibrated. This is work in progress.

208088, 208030, 208000, 207940, 207880, 207820, 207760, 207730, 207687, 207640, 207610, 207580, 207550, 207520, 207490, 207464, 207446, 207430, 207405, 207395, 207379, 207370, 207367, 207367, 207370, 207380, 207400, 207412, 207430, 207460, 207490, 207520, 207558, 207610, 207649

95% confidence contour RDy [m]: 572100, 572094, 572099, 572104, 572121, 572134, 572160, 572185, 572207, 572233, 572262, 572295, 572333, 572370, 572400, 572430, 572490, 572520, 572580, 572610, 572670, 572730, 572790, 572820, 572880, 572910, 572941, 572978, 573007, 573030, 573060, 573071, 573083, 573085, 573078, 573062, 573051, 573030, 573002, 572981, 572957, 572928, 572896, 572858, 572820, 572790, 572757, 572700, 572670, 572610, 572550, 572520, 572460, 572430, 572370, 572310, 572280, 572250, 572208, 572177, 572152, 572130, 572108, 572100

The underlying waveform data used in the above analysis is publicly available and can be obtained through

a GUI: http://rdsa.knmi.nl/dataportal/

FDSN webservices: http://rdsa.knmi.nl/fdsnws/dataselect/1/

PGV values

The following table contains peak ground velocity (PGV) values as obtained at a few nearby accelerometers. The 'max rotated' PGV is listed, which is the maximum particle velocity in the horizontal plane. For computing the 'max rotated' PGV, a time window around the S-wave arrival is used and the maximum value of the resultant of both horizontal components is taken.

Station name	**Epicentral distance [km]**	**PGV [mm/s]**
GK040	15.65	0.047
N020	19.90	0.010
N010	19.96	0.012

References

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Zhou, H.-w. (1994), Rapid three-dimensional hypocentral determination using a master station method, *Journal of Geophysical Research: Solid Earth*, *99*(B8), 15,439–15,455.

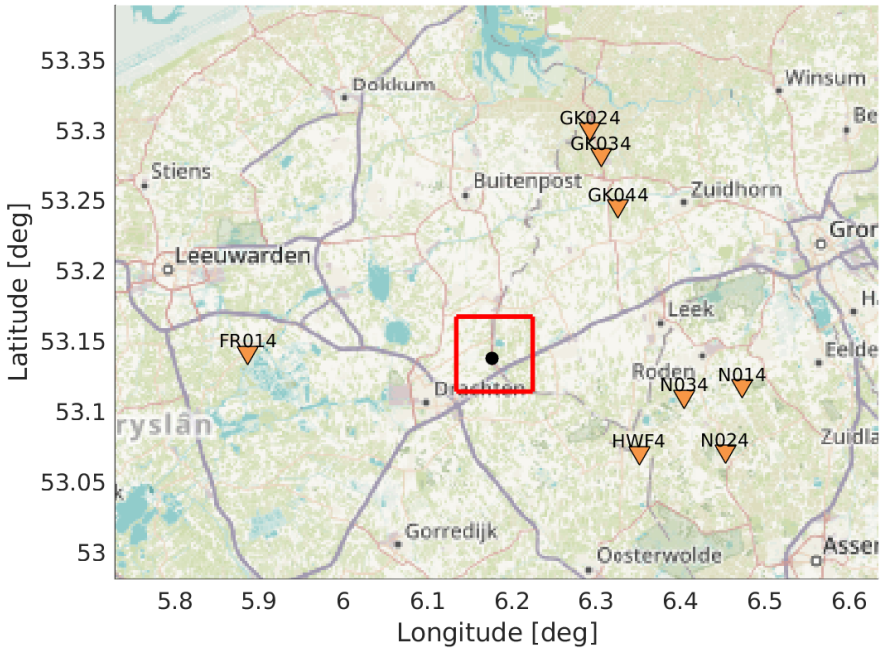

Figure 1: Overview map with locations of stations (yellow triangles) where P-wave onsets were picked, the fast Hypocenter solution (black dot) and the boundary line of the area in which a grid search is done (red box). Background map is from www.openstreetmap.org.

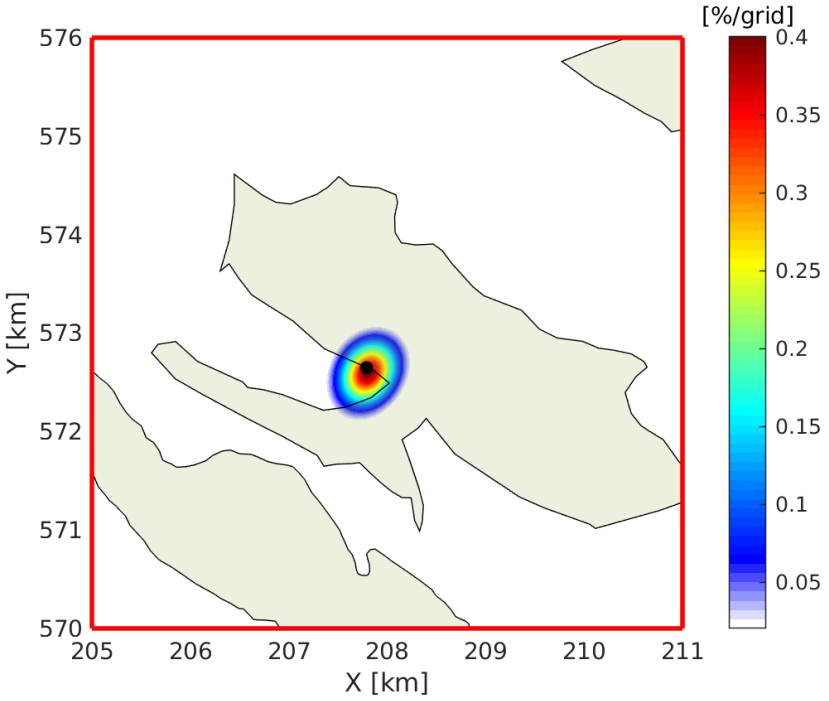

Figure 2: Map showing hydrocarbon fields (green-filled polygons), the fast Hypocenter solution (black dot) and the epicentral probability density function (PDF) using time-differences and an optimized model. The 95% confidence area of the PDF is shown, with probabilities expressed in percentage per grid point. The field polygons are from www.nlog.nl, using the March 2020 update.

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