

Norwegian National Seismic Network

Technical Report No. 30 B



STATION RELOCATION

by

Marte L. Strømme

Based on technical report no. 28:
Station Relocation Coordinates, by Maren Kjos Veim

Department of Earth Science, University of Bergen

Spring 2019

BACKGROUND

In 2015, Maren Kjos Veim made an updated list of all station coordinates. These differs up to several hundred meters from the actual station position, as they are based on map readings done many decades ago. For more information, see Technical Report No. 28 - *Revision of Station coordinates*, by Maren Kjos Veim.

Before applying the updated station coordinates on the database, an update (in a test directory) using the old station coordinates was applied on the entire NNSN database. This was necessary in order to check for any changes or errors introduced by changes in the locating routine. The editing and checking was done by Marte L. Strømme, with advice from Jens Havskov and Lars Ottemöller where needed. Revision/completing of the database update was done in April 2019, see Technical Report No. 29 - *Database Update* for more information.

All scripts and outputs used can be found here: `/home/seismo/WOR/maren`.

The NNSN database was updated (in the test directory `/maren`) using the corrected station coordinates STATIONR.HYP file, and comparing this with the old, original coordinates. These differs up to several hundred meters from the actual station position, and are based by map readings many decades ago. For more information, see Technical Report No. 28 - *Revision of Station coordinates*, by Maren Kjos Veim.

The events are segregated in local and distant events and for the following four time windows: 1980-1989, 1990-1999, 2000-2009, 2010-present.

Definition of event changes that required manual check:

Before 2000, local events:

Epicentral change more than 20km, depth more than 15km, RMS more than 0.3.

Before 2000, distant events:

Epicentral change more than 10km, depth more than 10km, RMS more than 0.2.

After 2000, local events:

Epicentral change more than 15km, depth more than 10km, RMS more than 0.3.

After 2000, distant events:

Epicentral change more than 10km, depth more than 10km, RMS more than 0.2.

STATION RELOCATION

A new STATIONR.HYP file was created with updated station coordinates. To be careful , it is stored in /marte directory and used as a symbolic link:

STATIONR.HYP -> /home/marte/relocate/STATIONR.HYP

In a test directory, the NNSN database was updated using the STATIONR.HYP file with the new, correct coordinates. The events are segregated in the following time windows, and for local and distant events: 1980-1989, 1990-1999, 2000-2009, 2010-present, using same parameters for flagging as in the above described database update.

See /home/seismo/WOR/maren/korrektekoordinater for complete lists of flagged changes.

GENERAL COMMENTS, BY DISTANCE AND DECADE

1980-89, local:

For this decade, 40 local events are flagged and only one of these is before 1985. The bulk of flags are due to minor changes in depth calculations, and depths are still within 0 km - 31 km range.

1980-89, distant:

183 flagged events, 8 of these has been changed (appendix, p. 6). USGS database is used for fixing solutions or depth where applicable.

1990 - 99, local:

73 flagged events. Minor changes, general improvement in RMS, some depth changes. No major changes or clear trends. Some events have corrected depth, some ends up >31km. These has been fixed before completing the update. A few (<5) events showed

big changes. Table 1 presents two examples showing improvement and problem in location, respectively.

<p>Example of improvement, confirmed explosion in Mongstad: Old: 1997 514 0959 16.7 LE 62.067 6.647 0.0F BER 3 2.5 1.1CBER New: 1997 514 0959 36.9 LE 60.820 5.114 0.0F BER 3 0.4 1.0CBER change epicentre,depth,rms: 160.6 0.0 -2.1</p> <p>Problem occur in solution, LP in Kiruna/Malmberget. Original solution fixed: 1999 5 3 2326 16.5 LP 67.881 20.258 0.0F BER 3 0.5 1.6LBER 1999 5 3 2326 19.3 LP 66.587 8.509 0.0F BER 3 1.7 1.9LBER change epicentre,depth,rms: 523.8 0.0 1.2</p>

Table 1: Examples local changes 1990-1999. Old solution above, new below.

1990-1999, distant events:

Same as for 1980 - 1989 when it comes to depth changes. Only very minor changes in locality or RMS. No events shows any changes in magnitude.

Two events gets increased RMS using stationR.hyp, see table 2.

<p>1994 130 2102 14.9 D -1.402-151.025 15.0 BER 3 2.0 1994 130 2102 15.7 D 0.474-166.883 15.0 BER 3 2.4 change epicentre,depth,rms: 999.0 0.0 0.4</p> <p>1998 1018 0831 47.0 D -7.106 155.581152.0F BER 5 0.5 5.4BPDE 1998 1018 0827 30.1 D -21.400 155.024152.0F BER 5 7.5 5.4BPDE change epicentre,depth,rms: 999.0 0.0 7.0</p>

Table 2: Increased RMS 1990-1999. Old solution above, new below.

2000-2009, local events:

99 flagged events. Mostly small/negligible changes, see appendix for full list of changes.

2000-2009, distant events:

136 events flagged, only 6 of these changes significantly, These has beed fixed to PDE location/depth where applicable. PDE solution is already in the s-files. For the remaining flagged events, the changes

are mainly depth estimates, which have a high uncertainty anyway, and/or minor changes in hypocentre (tens of km). These have not been edited.

2010 - 2019, local events:

Some events in Storfjorden and otherwise has depth changes (f.ex. from 15 to 31km, 15 to 0km). See appendix for list of edits

Many events from late 2018 and 2019 changes because GRANE, LEIR, VAGH stations is not listed in the STATIONR.HYP file, since it was made a few years ago. These flags has been ignored, as the more recent events will be checked anyway.

2010-2019, distant events:

95 flagged events (excluding the unfinished ones in april 2019), almost exclusively depth related changes. Only one event has more than very minor changes in location or RMS. This has been fixed to PDE, see appendix.

SUM UP

- There is not much difference when using correct station coordinates compared to the old ones. The amount of flagged events or nature of the changes can not be compared to the ones that occurred before database update, described in Technical Report No. 29 - DATABASE UPDATE.
- Most of local events are flagged due to depth changes.
- Changes in the coordinates for KBS, Jan Mayen and Western Norway (e.g. Ask, Hya) seems to have more impact than in other areas.

- Most of the changes are done by fixing depth to default 10km (oceanic crust) or 15 km (continental crust). These events are marked with comment line:

Calculated depth is uncertain, set to 10km before database update. MIs 2019 B3

- Depth was checked using select on all local events after station coordinates update. 136 events had depth more than 35km (mainly Jan Mayen events between 35 km and 40 km depth).
- Likewise, a RMS check should be done (for L and D events).

APPENDIX

DISTANT CORRECTIONS, 1980-1989:

1982 130 0231 10.9 D -30.439 -76.369 15.0 BER 4 2.2
1982 130 0228 21.4 D -50.794 -51.932700.0 BER 4 5.0
change epicentre,depth,rms: 999.0685.0 2.8

1983 412 1217 51.9 D 68.393 -21.587 15.0 BER 317.0
1983 412 1216 56.7 D 66.206 -34.384 15.0 BER 318.4 5.7sBER
change epicentre,depth,rms: 598.1 0.0 1.4

1984 830 1611 2.7 D -12.704 135.142 15.0 BER 4 4.5 5.5sBER
1984 830 1608 0.9 D -21.430 154.760700.0 BER 4 5.6
change epicentre,depth,rms: 999.0685.0 1.1

1984 913 1557 23.9 D 59.936 6.240 15.0 BER 399.9
1984 913 1557 28.6 D 60.276 5.265 15.0 BER 399.9
change epicentre,depth,rms: 65.9 0.0 0.0

1987 223 1549 25.5 D -22.364 147.971 15.0 BER 3 3.6
1987 223 1549 20.8 D -19.825 170.256 15.0 BER 3 0.6
change epicentre,depth,rms: 999.0 0.0 -3.0

1988 310 1023 40.3 D -29.061 169.961 15.0 BER 12 2.6
1988 310 1024 6.9 D -14.405 161.228 0.0 BER 12 2.8
change epicentre,depth,rms: 999.0 15.0 0.2

WHAT DIS

1988 12 4 1512 5.9 D 70.222 26.097600.7 BER 7 0.1
1988 12 4 1512 35.5 D 68.229 20.146568.9 BER 7 0.1
change epicentre,depth,rms: 322.0 31.8 0.0

1989 4 2 2057 27.1 D 19.306-154.746 15.0 BER 8 1.4
1989 4 2 2057 17.1 D 17.886 174.106 15.0 BER 8 2.1
change epicentre,depth,rms: 999.0 0.0 0.7

DISTANT CORRECTIONS, 1990-1999:

1993 6 4 0131 57.2 D 16.295 -25.323 15.0 BER 4 0.2
1993 6 4 0133 50.3 D 23.726 -24.361700.0 BER 4 0.0

1994 130 2102 14.9 D -1.402-151.025 15.0 BER 3 2.0
1994 130 2102 15.7 D 0.474-166.883 15.0 BER 3 2.4
change epicentre,depth,rms: 999.0 0.0 0.4

1995 727 0551 31.1 D -10.667 77.525 15.0 BER 4 0.3 5.9bBER
1995 727 0552 56.6 D -7.758 76.182700.0 BER 4 0.3 5.3bBER
change epicentre,depth,rms: 355.8685.0 0.0

1996 1112 1659 39.9 D -18.016 85.289 15.0 BER 9 5.4 6.8sBER 6.3bBER 6.5BPDE
1996 1112 1701 3.2 D -22.554 70.204700.0 BER 9 5.3 6.0bBER 6.5BPDE

1997 426 0543 46.8 D -6.328 157.902192.0F BER 3 0.3 5.2BPDE
1997 426 0539 28.0 D -21.186 156.775192.0F BER 3 7.1 5.2BPDE
change epicentre,depth,rms: 999.0 0.0 6.8

1998 4 1 1756 23.1 D 0.781 100.787 4.8 BER 11 6.5 6.6sBER 6.4bBER 6.2BPDE
1998 4 1 1756 24.1 D 0.855 100.910 13.4 BER 11 6.5 6.6sBER 6.4bBER 6.2BPDE
change epicentre,depth,rms: 16.0 8.6 0.0

1998 1018 0831 47.0 D -7.106 155.581152.0F BER 5 0.5 5.4BPDE
1998 1018 0827 30.1 D -21.400 155.024152.0F BER 5 7.5 5.4BPDE
change epicentre,depth,rms: 999.0 0.0 7.0

LOCAL CORRECTIONS, 2000-2009:

2000 4 8 1631 36.2 L 60.940 3.967 0.0 BER 5 0.7 0.2CBER
2000 4 8 1631 41.6 L 60.972 5.007 16.7 BER 5 1.7 0.2CBER
change epicentre,depth,rms: 56.2 16.7 1.0
Flagged not to be relocated before database update.

2002 5 6 2351 44.0 L 57.515 7.582 21.7 BER 2 0.3 1.9CBER
2002 5 6 2351 39.4 L 59.197 5.270292.1 BER 2 0.3 1.9CBER
change epicentre,depth,rms: 230.2270.4 0.0
Flagged not to be relocated before database update.

2003 3 4 0631 17.0 L 57.114 6.938 15.0 BER 3 1.0 1.6LBER 2.0CBER
2003 3 4 0631 17.0 L 57.541 6.006211.9 BER 3 0.2 1.7LBER 2.0CBER
change epicentre,depth,rms: 73.3196.9 -0.8
Calculated depth is uncertain, set to 15km before database update. mls 2019

2003 414 2152 18.4 L 78.554 7.192 0.0 BER 3 0.4 3.8NBER 2.2CBER 2.4LNAO
2003 414 2152 32.0 L 78.451 12.589 0.0 BER 3 0.9 2.4LBER 2.2CBER 2.4LNAO
change epicentre,depth,rms: 119.9 0.0 0.5
Flagged not to be relocated before database update.

2003 1116 1445 47.4 L 78.276 7.988 10.0F BER 5 0.8 4.8NBER 3.3CBER 3.1LNAO
2003 1116 1445 56.0 L 78.392 13.064 10.0F BER 5 0.9 3.4LBER 3.3CBER 3.1LNAO
change epicentre,depth,rms: 114.6 0.0 0.1
Flagged not to be relocated before database update.

2004 323 1407 3.5 L 59.185 7.429 10.7 BER 4 1.0 0.8LBER 1.5CBER
2004 323 1407 0.3 L 59.085 7.613 80.1 BER 4 0.3 1.0LBER 1.5CBER
change epicentre,depth,rms: 15.3 69.4 -0.7
Calculated depth is uncertain, set to 10km before database update. mls 2019

2005 415 1455 26.4 L 78.240 7.489 2.1 BER 3 0.4 2.3LNAO
2005 415 1455 39.1 L 78.261 12.408 0.0 BER 3 0.8 2.3LNAO
change epicentre,depth,rms: 111.1 2.1 0.4
Flagged not to be relocated before database update.

2005 7 7 1111 42.1 L 60.610 5.689 15.0 BER 4 0.8 1.2CBER
2005 7 7 1111 41.6 L 60.854 3.513 8.3 BER 4 0.3 1.2CBER
change epicentre,depth,rms: 121.2 6.7 -0.5

Not changed. No indications for LP, LQ, area. RMS improves with corrected station coordinates, four stations is used. Conclusion: New location might be better.

2005 10 3 1339 17.2 L 78.249 7.613 2.8 BER 3 0.4 2.0LNAO
2005 10 3 1339 28.4 L 78.304 12.429 0.0 BER 3 1.0 2.0LNAO

change epicentre,depth,rms: 108.7 2.8 0.6

Flagged not to be relocated before database update

2006 7 2 2323 22.6 L 58.548 1.819 0.1 BER 3 0.3 1.3LBER 1.9CBER

2006 7 2 2323 22.6 L 58.305 1.650 77.7 BER 3 0.1 1.4LBER 1.9CBER

change epicentre,depth,rms: 28.7 77.6 -0.2

Calculated depth is uncertain, set to 10km before database update. mls 2019

2008 329 1431 51.6 L BER 3 0.9CBER

2008 329 1431 51.5 L 58.361 7.600 0.0 BER 3 0.2 1.3LBER 0.9CBER

change epicentre,depth,rms: 999.0 0.0 999.2

2009 116 2312 38.1 L 77.086 19.259 80.0 BER 5 1.5 2.3LBER 2.4CBER 2.1LNAO

2009 116 2312 34.3 L 76.979 18.612 15.0 BER 5 0.5 2.3LBER 2.4CBER 2.1LNAO

change epicentre,depth,rms: 20.0 65.0 -1.0

DISTANT CORRECTIONS, 2000-2009:

2001 4 9 0900 41.4 D -35.588 -77.910 11.0F BER 6 8.2 6.3sBER 6.1BPDE
2001 4 9 0911 41.7 D 40.881 -47.753 11.0F BER 6 8.5 5.5sBER 5.5bBER 6.1BPDE
change epicentre,depth,rms: 999.0 0.0 0.3

2003 1113 0249 13.7 D -52.617 144.344 10.0F BER 4 0.3 5.5sBER 5.4BPDE
2003 1113 0254 35.8 D -23.468 121.372 10.0F BER 4 42.8 5.3sBER 5.4BPDE
change epicentre,depth,rms: 999.0 0.0 42.5

2003 1217 1627 20.1 D 22.585 121.754 15.0 BER 4 0.2 5.1sBER 5.2BPDE
2003 1217 1627 19.5 D 22.853 121.530 0.0 BER 4 0.2 5.1sBER 5.2BPDE
change epicentre,depth,rms: 37.7 15.0 0.0

2004 328 1456 3.7 D 45.146 24.730 61.7 BER 7 0.7 4.7bBER 4.5BPDE
2004 328 1455 14.5 D 39.933 23.695 37.7 BER 7 0.5 4.9bBER 4.5BPDE
change epicentre,depth,rms: 585.7 24.0 -0.2

2004 918 1919 51.9 D -36.243 179.065 14.5 BER 6 1.5 4.8BPDE
2004 918 1920 33.6 D -13.283 168.149 5.0 BER 6 1.5 4.8BPDE
change epicentre,depth,rms: 999.0 9.5 0.0

2007 416 1320 44.8 D -57.659 147.063 10.0F BER 2 0.9 6.3sBER 5.7BPDE
2007 416 1326 27.9 D -23.198 142.442 10.0F BER 2 251.6 6.1sBER 5.7BPDE
change epicentre,depth,rms: 999.0 0.0 50.7

LOCAL CORRECTIONS, 2010-2019:

2010 214 2154 44.2 L 77.170 18.629 15.0 BER 4 0.8 1.6CBER
2010 214 2154 45.0 L 77.151 18.574 31.0 BER 4 0.9 1.6CBER
change epicentre,depth,rms: 2.5 16.0 0.1
Several of these. Not corrected if depth is less than 33km.

2011 2 4 0442 58.9 L 67.499 34.500 26.3 BER 4 0.5 2.5CBER
2011 2 4 0442 58.7 L 67.870 34.180236.0 BER 4 0.1 2.5CBER
change epicentre,depth,rms: 43.3209.7 -0.4
Calculated depth is uncertain, set to 15km before database update. mls 2019 B3

2012 217 1800 54.4 L 75.126 9.817 15.0 BER 7 7.5 3.5LNAO
2012 217 1800 10.5 L 71.655 -1.534 15.0 BER 7 0.2 3.5LNAO
change epicentre,depth,rms: 525.6 0.0 -7.3

2016 214 1638 26.1 LE 67.034 12.511 0.0F BER 8 2.8 0.9LBER
2016 214 1638 24.7 LE 66.398 14.783 0.0F BER 8 0.4 0.9LBER
change epicentre,depth,rms: 122.1 0.0 -2.4
Rana Gruver.

2012 321 1830 46.3 L 72.030 0.429 44.0 BER 4 0.2 3.2LNAO
2012 321 1830 42.8 L 72.028 0.408 0.1 BER 4 0.2 3.2LNAO
Example of improved location.

2012 616 0327 4.5 L 79.653 4.367 15.0 BER 3 0.6 2.7NBER
2012 616 0327 4.5 L 79.754 4.111 38.0 BER 3 0.6 2.5NBER
change epicentre,depth,rms: 12.3 23.0 0.0
Calculated depth is uncertain, set to 10km before database update. mls 2019

2012 9 6 1513 35.0 L 79.606 4.028 15.0 BER 3 0.6 3.0NBER
2012 9 6 1513 34.9 L 79.702 3.714 37.9 BER 3 0.6 2.8NBER
change epicentre,depth,rms: 12.4 22.9 0.0
Calculated depth is uncertain, set to 10km before database update. mls 2019

2012 925 1812 55.1 L 79.423 4.809 15.0 BER 3 0.4 2.9NBER
2012 925 1812 55.0 L 79.488 4.427 35.7 BER 3 0.4 3.0NBER
change epicentre,depth,rms: 10.6 20.7 0.0
Calculated depth is uncertain, set to 10km before database update. mls 2019

2012 1120 2038 26.4 LP 66.120 14.881 0.0F BER 4 1.4 0.9LBER
2012 1120 2038 30.2 LP 66.361 14.686 0.0F BER 4 0.4 0.6LBER
change epicentre,depth,rms: 28.1 0.0 -1.0
Rana gruber LP, location improves with corrected station coordinates.

2013 212 0411 22.5 LQ 73.946 9.127 15.0 BER 3 0.3 3.5NBER

2013 212 0411 22.8 LQ 73.809 8.975 65.3 BER 3 0.2 3.6NBER
change epicentre,depth,rms: 15.9 50.3 -0.1
Calculated depth is uncertain, set to 10km before database update. mls 2019 B3

2014 726 0823 21.0 LQ 74.365 9.273 15.0 BER 4 0.5 3.6NBER
2014 726 0823 21.1 LQ 74.245 8.985 64.0 BER 4 0.4 3.6NBER
change epicentre,depth,rms: 15.9 49.0 -0.1
Calculated depth is uncertain, set to 10km before database update. mls 2019 B3

2015 2 7 2006 2.8 LQ 65.610 5.652 29.7 BER 27 0.6 2.1LBER
2015 2 7 2006 3.4 LQ 65.618 5.622 47.9 BER 27 0.6 2.1LBER
change epicentre,depth,rms: 1.6 18.2 0.0
Calculated depth is uncertain, set to 10km before database update. mls 2019 B3

2016 8 8 1346 58.0 LQ 73.618 8.551 15.0 BER 5 0.4
2016 8 8 1346 58.8 LQ 73.557 8.453 46.2 BER 5 0.4
change epicentre,depth,rms: 7.4 31.2 0.0
Calculated depth is uncertain, set to 10km before database update. mls 2019 B3

2017 1129 1608 0.3 LQ 79.707 3.545 28.3 BER 6 0.6 2.7NBER
2017 1129 1608 0.5 LQ 79.786 3.700 55.4 BER 6 0.7 2.7NBER
change epicentre,depth,rms: 9.3 27.1 0.1
Calculated depth is uncertain, set to 10km before database update. mls 2019 B3

2018 424 1938 51.3 LQ 80.810 -2.168 30.9 BER 6 0.5 2.2NBER 0.9LDNK
2018 424 1938 51.6 LQ 80.850 -2.116 51.2 BER 6 0.6 2.2NBER 0.9LDNK
change epicentre,depth,rms: 4.5 20.3 0.1
Calculated depth is uncertain, depth set to 10km B3

DISTANT CORRECTION, 2010-2019:

2011 312 0259 11.8 D 18.408-164.380 15.0 BER 2715.5 6.3bBER 5.8 PDE
2011 312 0257 58.2 D 1.835-174.374 15.0 BER 2715.6 6.5bBER 5.8 PDE
change epicentre,depth,rms: 999.0 0.0 0.1