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Regional centroid moment tensor solutions for Eastern Canadian earthquakes: 2017

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Abstract

Regional centroid moment tensor solutions have been determined for seven moderate-sized earthquakes in eastern Canada during 2017. Two additional earthquakes were also evaluated but their solutions did not meet the minimum quality standards for acceptance. The moment tensor inversion method is used to determine the focal mechanism, depth and seismic moment of the earthquakes. These parameters, in turn, provide information about the seismotectonic environment in which the earthquakes occur and may help improve seismic hazard estimates. The purpose of this report is not to provide an in-depth analysis of any specific earthquake but to catalog the solutions and data used to obtain them to make them available for future research projects.

Introduction

Earthquake focal mechanisms provide information about the orientation and direction of motion on the fault that generated the earthquake. A suite of focal mechanisms from a particular region can be used to improve the understanding of the seismotectonic environment in which the earthquakes occur. Prior to the early 2000s, focal mechanisms for eastern Canada were most often determined by the polarity distribution of first motions. This method is time-consuming and requires a large number of clear readings from a wide variety of azimuths, which makes it difficult to obtain unique solutions for smaller earthquakes or those occurring in regions, such as the offshore, where the station density is low and azimuthal coverage poor. Moment tensor inversion, which makes use of a longer duration of the waveform, is a more robust and more objective method to determine focal mechanisms. Moment tensor solutions also provide the hypocentral depth, which has implications for seismic hazard as well as information about regional seismotectonics, and seismic moment (and moment magnitude), which is generally considered the best measure of earthquake magnitude. However, moment tensors use relatively long-period data and they, too, do not always result in good-quality solutions for smaller earthquakes, which do not always have a good signal to noise (S/N) ratio at the frequencies of interest, roughly 0.06-0.03 Hz. Having said that, since roughly 2005-2006 when the regional centroid moment tensor (RCMT) inversion method (Kao et al., 1998) was implemented in eastern Canada there has been an increase in the percentage of magnitude 4+ earthquakes for which focal mechanisms could be determined. The impact is most notable in the north and offshore regions where it was difficult to obtain focal mechanism solutions based on first motions for all but the few earthquakes large enough to be well-recorded at teleseismic distances. For example, Bent et al (2003) were able to obtain focal mechanisms for only four of fourteen events evaluated in the region extending from the Labrador Sea to northern Baffin Bay-Baffin Island during the period 1994-2000. From 2011 through 2016 twenty-seven solutions were obtained via the RCMT inversion method for thirty-six events evaluated in the same region (Bent, 2015a.b, 2017, 2018) and another six out of eight in the Arctic for 2017.

For seismological purposes eastern Canada is roughly defined as east of 100°W longitude. Some judgment calls in whether to treat earthquakes as western or eastern, however, are made in the case of the extreme north where lines of longitude are close together and where the M_N or Nuttli magnitude scale (Nuttli, 1973) used for eastern Canada may be used as the primary or database magnitude for earthquakes west of this line. As a general practice earthquakes falling within the territory of the United States or Greenland are not included although exceptions may be made in the case of any event close to the border that was widely felt in Canada. In some cases the closest seismograph station to the earthquake may be in the United States or Greenland even if the earthquake is in Canada. With respect to offshore earthquakes there are no strict criteria used to determine which earthquakes to study but most earthquakes occurring close enough to Canadian territory to have been recorded by a reasonable number of seismograph stations at distances between 150 and 1500 km will be evaluated.

RCMT solutions for all of Canada through the end of 2010 were summarized by Kao et al. (2012) and eastern solutions for 2011-2016 were catalogued Bent (2015a,b, 2017, 2018). In western Canada, RCMT solutions have been routinely determined since 2001 although there are solutions for some earthquakes dating back to 1995 (for example, Ristau, 2004). In eastern Canada, RCMT was adopted for routine use in approximately 2005 although there are solutions for some events that occurred in the earlier 2000s. The current paper catalogs the RCMT solutions for eastern Canada in 2017. Solutions that met the minimum quality criteria, discussed in the RCMT Inversion Method section, were obtained for seven out of nine earthquakes evaluated. This report is the fifth in a series of RCMT summaries for eastern Canada intended to be produced on an annual basis although other options for the dissemination of RCMT solutions, such as the creation of an online database are being explored. It should be noted that although this report focuses on eastern Canada, the RCMT method is also routinely applied to earthquakes in western Canada. (for example, Ristau, 2004; Ristau et al., 2007; Kao et al., 2012)

Regional Centroid Moment Tensor Inversion Method

Moment tensor inversion is one method by which earthquake focal mechanisms, or faulting parameters may be determined. It also provides additional source parameters including depth, seismic moment and source time function as well as a measure of any non-double couple component of the source. Note that source time function is generally not well resolved for small and moderate earthquakes because it is small relative to the frequencies modeled. For all earthquakes summarized in this paper a 1.0/1.0/1.0 (sec) time function is assumed. In the case of very large earthquakes, the default value may not be appropriate and a different value may be used. Because the RCMT method is based on fitting a relatively long portion of the recorded waveform and provides a quantitative measure of the fit, the RCMT is advantageous over other methods of focal mechanism determination, such as first motions which are based on a very small portion of the waveform, which can be difficult to accurately determine for small earthquakes or emergent arrivals or arrivals within the noise and which require a larger number of good quality recordings for a unique solution to be determined. In theory, an RCMT solution can be obtained from a single station. However, it is preferable to have more to ensure that the preferred solution is the one that provides the best fit for a range of azimuths and distances.

The RCMT method used to analyze Canadian earthquakes is that of Kao et al (1998). More details about the method may be found in that paper and an in-depth discussion of its implementation in Canada is covered by Kao et al (2012). Both papers also include references which provide supplementary background information on centroid moment tensors. The discussion below is focused on topics specifically related to eastern Canada.

In eastern Canada the RCMT inversion is run for all earthquakes of magnitude 4.0 or greater. Note that the Nuttli (M_N) magnitude is the most commonly used magnitude scale in eastern Canada but that M_L may be listed as the magnitude for offshore earthquakes for which the Lg wave is either not observed or is strongly attenuated. This minimum threshold is used only for identifying events large enough for the RCMT method to be a viable analysis tool. The selection is based on the value and not the magnitude type.

Moment magnitude, M_W, for eastern Canada is, on average, about 0.5 magnitude units smaller than M_N (Bent, 2011). Good quality solutions cannot always be obtained for the smallest earthquakes because the signal to noise ratio is generally poor at the long periods modeled. The default frequency range is 0.03-0.06 Hz but the inversion code will modify the range if there is sufficient long period energy in the data in other frequency bands, sufficient energy being roughly defined as a signal to noise ratio (S/N) of 2.0 or greater.

Data from three-component broadband (both bh* or 40 Hz and hh* or 100 Hz) stations are used in the inversion. Standard practice is to use only stations from which data are received in real time by Natural Resources Canada (CNWA, 2019). Data from additional stations may be added if an earthquake is of particular interest and if additional data are likely to improve the quality of the solution. For example, data from Greenland often help constrain the solutions for earthquakes occurring in Baffin Bay. Similarly, data from New England improve coverage for the southeastern offshore regions.

Two velocity models are used- one for southeastern Canada and one for the north. Essentially these are the same model, the only difference being the depth of the Moho discontinuity, which is at 40 km for the south and 35 km for the north. These are referred to as EM40 and EM35 models respectively. With the exception of the modified Moho depth the velocity model is that of Brune and Dorman (1963). The boundary between north and south is at approximately 60°N. If an earthquake occurs close to the boundary the inversion may be run with both models and the best solution selected. At some future point a suite of regional models may be implemented if there is evidence that this would improve the quality of the solutions. The current model is based on shield paths but it should be noted that even for those earthquakes that occur in the Appalachians most of the paths modeled are sufficiently long that there will be a strong shield component. This statement may not be true for all offshore events. The northern model is shown in Table 1. For the southeast, the thickness of layer 3 is increased to 24 km. The lowermost layer is a mantle half-space. It should be noted that the southern model was used for the suite of earthquakes that occurred in Barrow Strait as it was found to provide a better fit to the data at larger distances. The choice of model is discussed in further detail by Bent et al. (2018).

Table 1
Velocity Model for Northeastern Canada (EM35)

Layer	Thickness (km)	Vp (km/s)	Vs (km/s)	Density (g/cm^3)
1	6	5.64	3.47	2.70
2	10	6.15	3.64	2.80
3	19	6.60	3.85	2.85
4	-	8.10	4.72	3.30

Solutions are rated using the quality classification table in Kao et al. (2001). The classification consists of a character value from A through F based on the average misfit and a numerical value from 1 through 4 based on the compensated linear vector dipole (CLVD) component. Solutions must have a minimum quality of C4 to be accepted. Any user of these solutions should bear in mind that the quality classification is strictly based on the fit of the solutions to the data modeled and does not consider the number of components modeled. Solutions based on small numbers of modeled waveforms, roughly defined as three or fewer stations, should be used with some caution even if the fit is reasonably good.

Regional Centroid Moment Tensor Solutions for Eastern Canada

Nine earthquakes were evaluated (Figure 1 and Tables 2 and 3). Solutions of quality C4 or better were obtained for the seven events in Table 2. The two events in Table 3 are those for which the solution quality was not acceptable. While the details of why a solution is not acceptable may vary from event to event, it is most often because the average misfit was in the D-F range and did not show an appreciable improvement for any combination of stations tested even if the data set was reduced to only the few best stations. A misfit value is not included in Table 3 because it is not necessarily representative of the best possible solution but would merely indicate the quality of the best solution obtained prior to deciding that further work on the event would be unlikely to produce a solution that met the quality criteria. For reference, the boundary between C (acceptable) and D (not acceptable) is an average misfit of 0.7.

Table 2
Earthquakes Evaluated: Solutions Obtained

Date	Time (UT)	Lat (°N)	Lon (°W)	Mag (M_W)	Location/Region	Quality
2017-01-08	23:47:11	74.27	92.13	5.9	Barrow Strait, NU	B2
2017-01-09	17:55:35	74.37	92.15	5.0	Barrow Strait, NU	B4
2017-01-09	19:43:46	74.32	92.24	4.1	Barrow Strait, NU	C2
2017-01-20	01:26:15	78.18	106.60	4.7	97 km SE of Isachsen, NU	C2
2017-02-10	15:01:49	74.29	92.17	5.3	Barrow Strait, NU	B4
2017-05-22	01:35:52	75.00	72.75	4.0	Baffin Bay, NU	C1
2017-12-28	08:51:12	47.18	76.29	3.7	83 km NW of Ferme-Neuve, QC	C2

Table 3
Earthquakes Evaluated: No Acceptable Solution Obtained

Date	Time (UT)	Lat (°N)	Lon (°W)	Mag	Location/Region	Quality
2017-10-15	02:09:32	65.40	91.29	4.1 (M_L)	231 km NNW of Chesterfield Inlet, NU	NA
2017-11-26	11:42:11	60.80	58.01	4.1 (M_L)	376 km E of Resolution Island, NU	NA

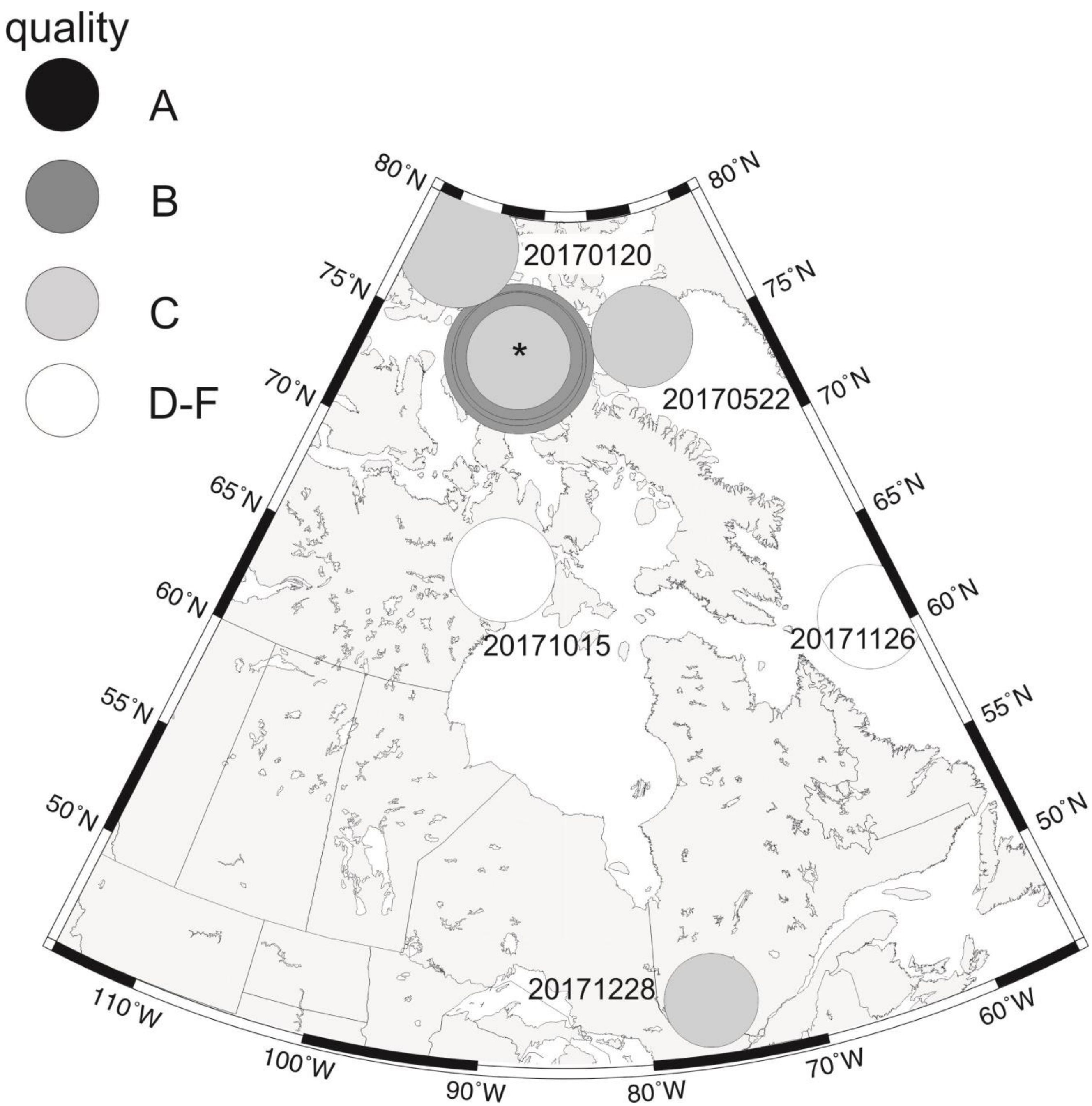


Figure 1: Locations and quality of solutions for all earthquakes evaluated in this study. Symbol size is scaled to M_W if a solution of A-C quality was obtained and to the magnitude type listed in Table 3 otherwise. Note that no A quality events were obtained for 2017. Also note that four earthquakes (the Barrow Strait sequence) plot at essentially the same point on this map; they have been plotted with the largest at the back of the layer and smallest in front. The events are labeled by date of occurrence. Four earthquakes plot almost at the same point. They are indicated by the "*". From outermost to innermost circle they are 20170108, 20170210, 20170109.1755 and 20170901.1943.

The solutions for the earthquakes listed in Table 2 are presented below (Figures 2a-2g) in chronological order without additional comments. Each solution is presented as a figure with the format discussed in the next few paragraphs. The solution is summarized in the upper left corner. The origin times and epicenters are taken from the Canadian National Earthquake Database (CNED, 2019). All other parameters are derived from the RCMT inversion. Only the best fitting double couple solution is summarized on the figure. The complete moment tensor solutions may be found in the Appendix. The Appendix also includes the moment tensor solutions for the range of depths modeled.

The map in each plot shows the best fitting focal mechanism (lower hemisphere projection) from the inversion. The solid lines show the best fitting double couple solution and the shaded and white regions show the full moment tensor solution with the shaded regions representing compressional regions and white dilations. The P- and T-axes are indicated by gray and white dots, respectively.

To the right of the map the average misfit is plotted as a function of depth. The best fitting focal mechanism for each depth is plotted and the size of the symbol is scaled to the moment magnitude for that particular solution. Lack of variation in symbol size, as is most often the case, indicates that the calculated seismic moment is not heavily dependent on depth. A flat misfit plot indicates that the depth is not well constrained (for example, 20170109 17:55, Figure 2b) whereas a sharp dip in the misfit function is an indication of a well-constrained depth (for example, 20170522, Figure 2f). In most cases the focal mechanism is relatively independent of depth but there are solutions for which this is not the case. If the best fitting mechanism has a significantly lower misfit than one indicating a different style and/or orientation of faulting it is likely correct (for example, 20171228, Figure 2g). If two significantly different mechanisms have similar misfits (for example, 20141003, Figure 2f in Bent, 2015) then both mechanisms need to be considered as viable options or additional techniques applied to the data to determine which solution is better.

In the bottom section, the waveforms are shown with the solid lines representing the data and the dashed lines the synthetic seismograms. For each station the waveforms from left to right are the vertical, radial and tangential components respectively. The misfit is indicated below the waveforms. The horizontal (time) and vertical (amplitude) scales are indicated to the right. The waveforms for each station are scaled to the largest amplitude at that station. Components not plotted were not used in the inversion. The most common reason for rejecting a component is a poor signal to noise ratio at the periods modeled. There could be other reasons, however, such as lack of data from one component. Note that the RCMT inversion program allows for more complicated weighting schemes but practice is to use either 1.0 (full weight) or 0.0 (not used). This provides a stable comparative base among RCMT catalog solutions over the years. There were other weighting schemes proposed in RCMT studies in other regions, such as given higher weighting for stations with good S/N or lower weight for a group of stations in the same area. Given the station distribution in eastern and northern Canada there have been no obvious benefits derived from using other weighting schemes. The text to the left of each set of waveforms provides information about the station. The first line is the station code and velocity model used. The second line indicates the azimuth of the station with respect to the epicenter. The third line gives the epicentral distance, the fourth the frequency range modeled and the fifth the average misfit for the station.

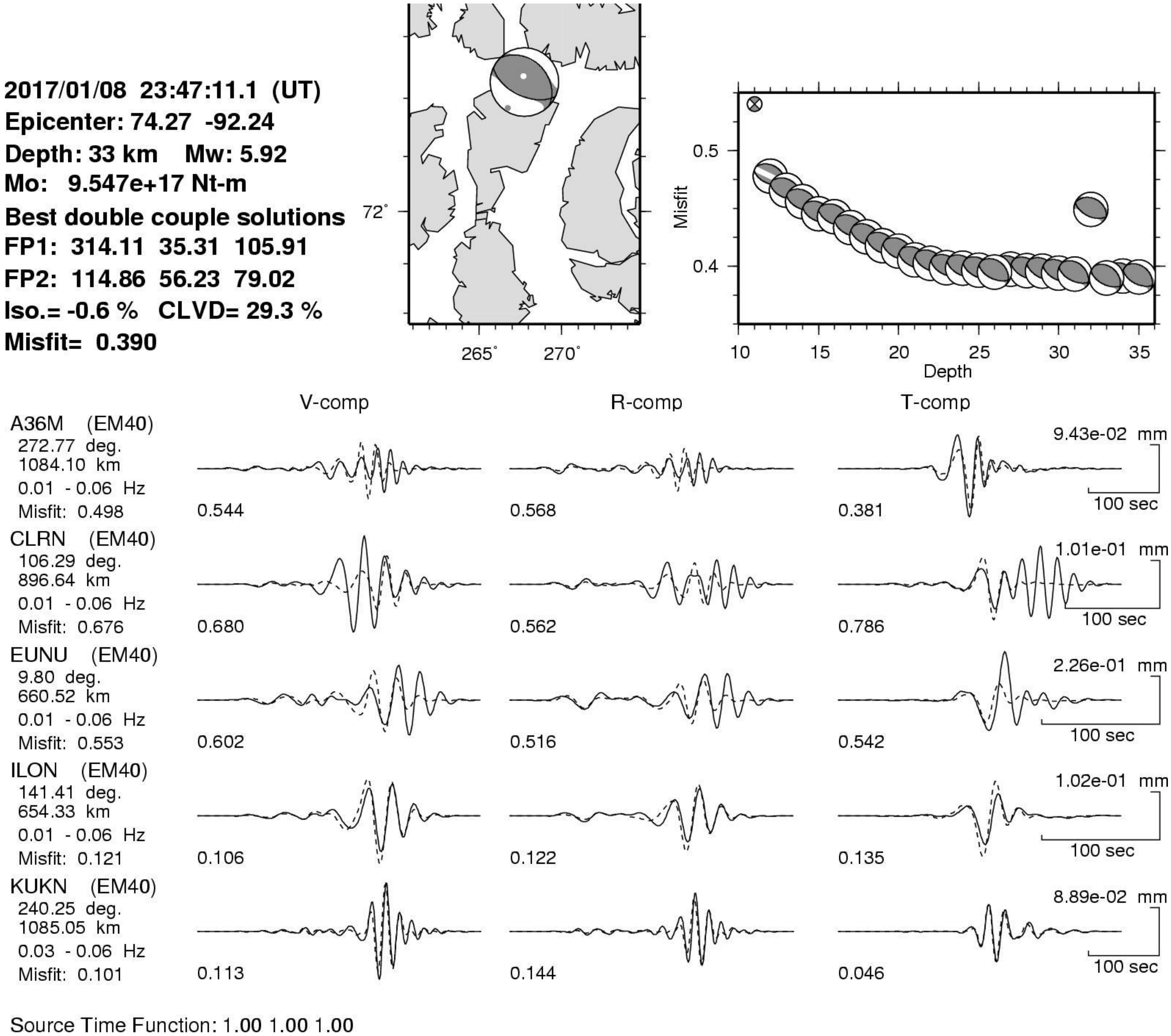


Figure 2a: RCMT solution for event 2017-01-08. See text for explanation of figure.

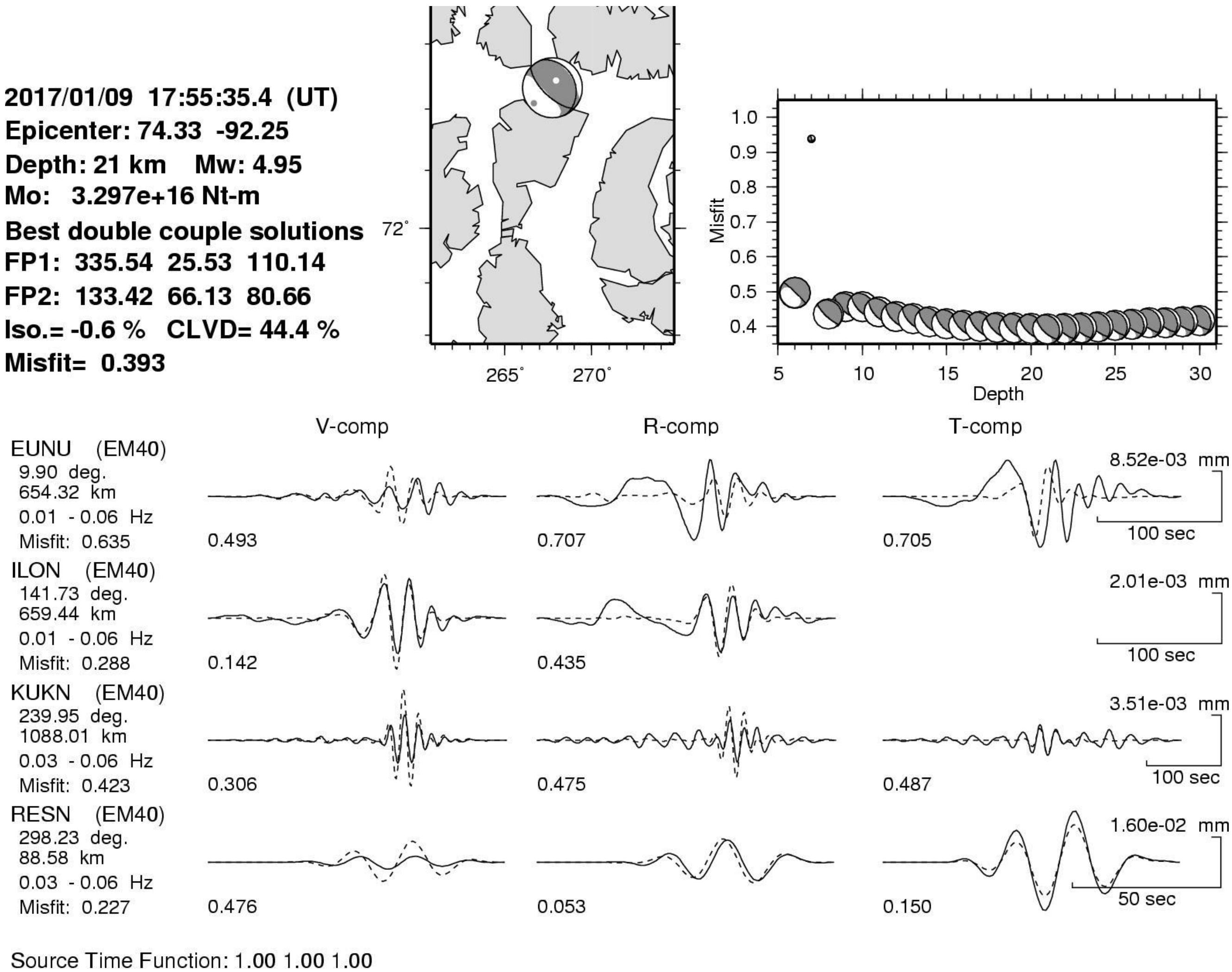


Figure 2b. RCMT solution for event 2017-01-09 at 17:55. See text for explanation of figure.

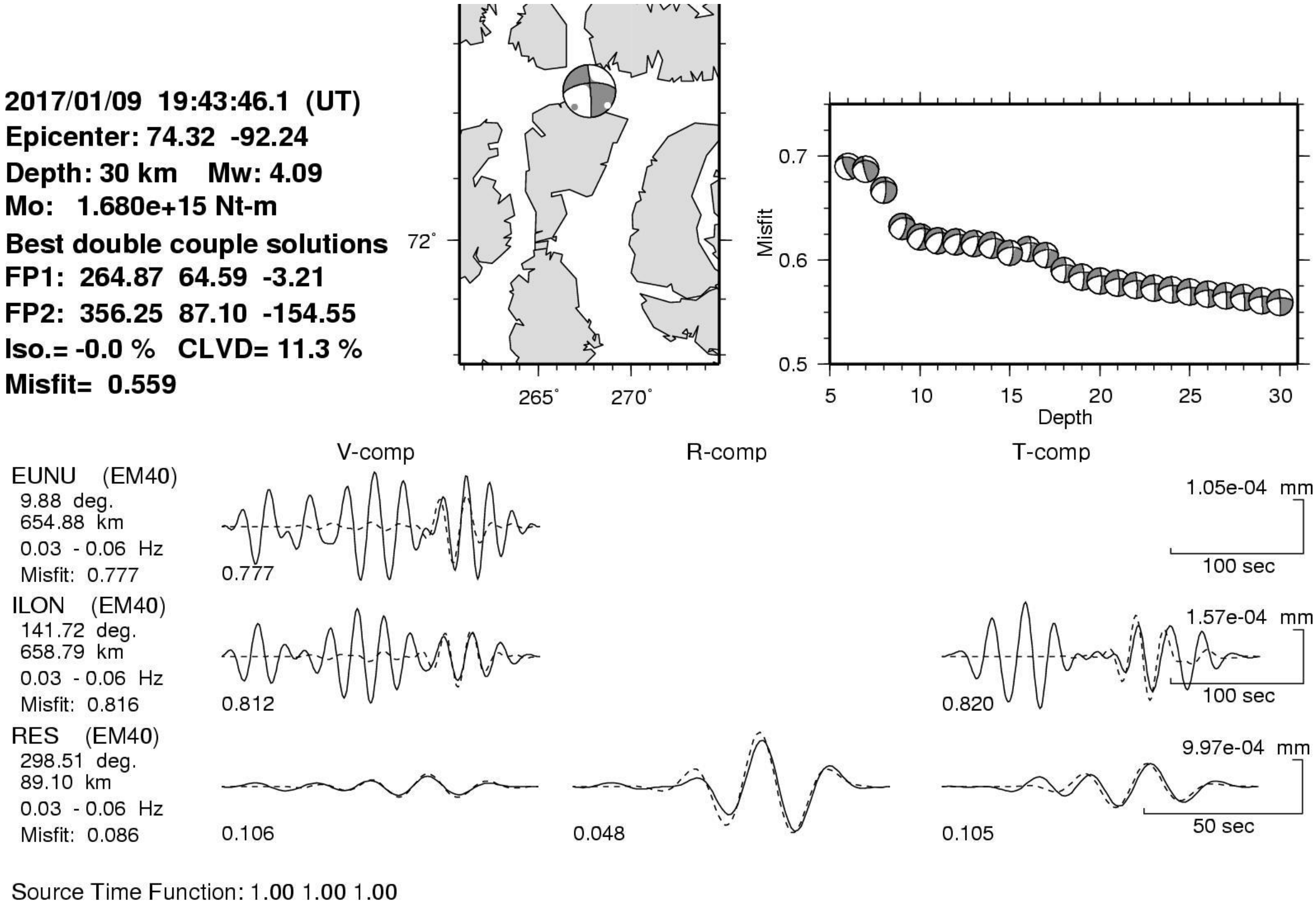


Figure 2c: RCMT solution for event 2017-01-09 at 19:43. See text for explanation of figure.

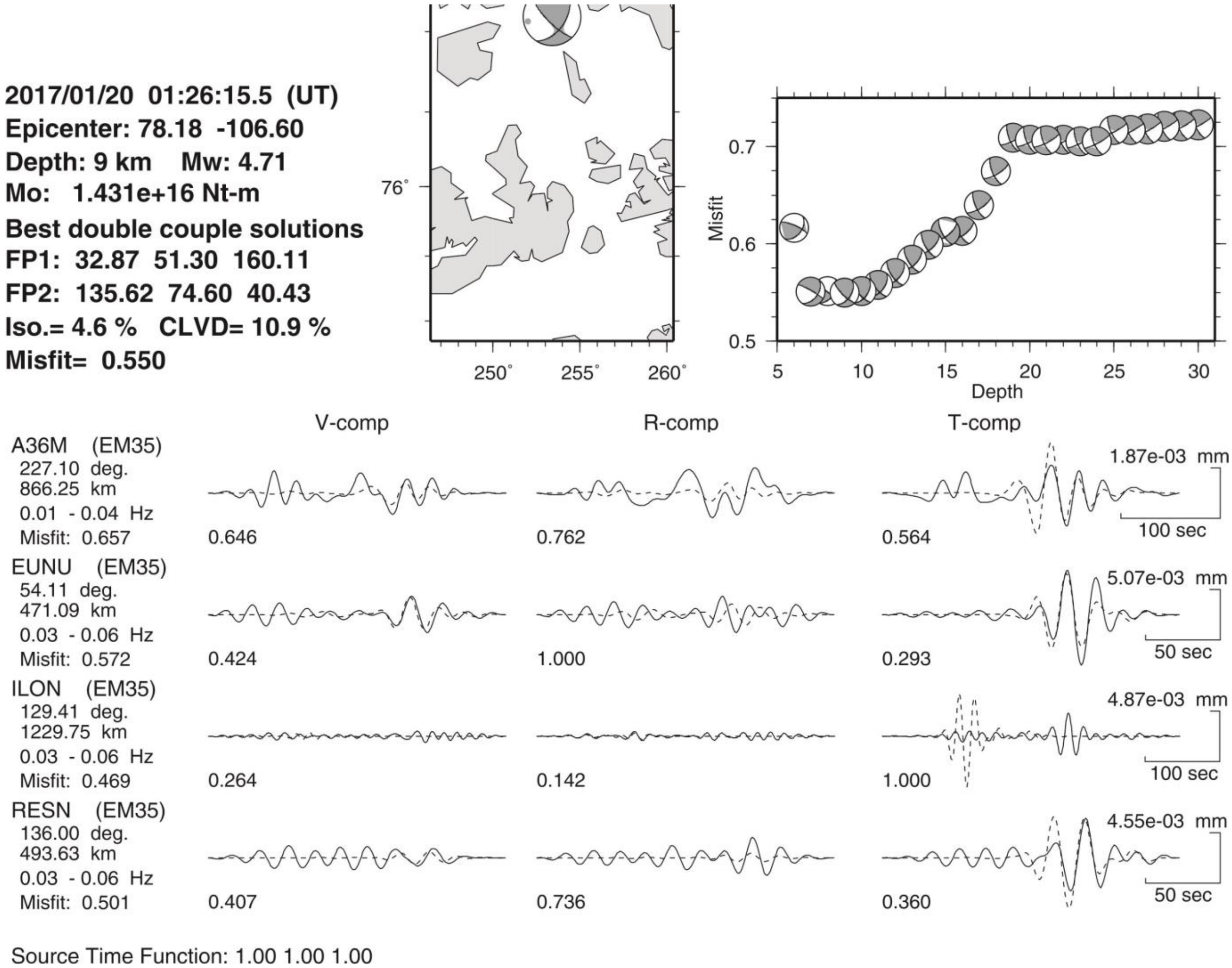


Figure 2d: RCMT solution for event 2017-01-20. See text for explanation of figure.

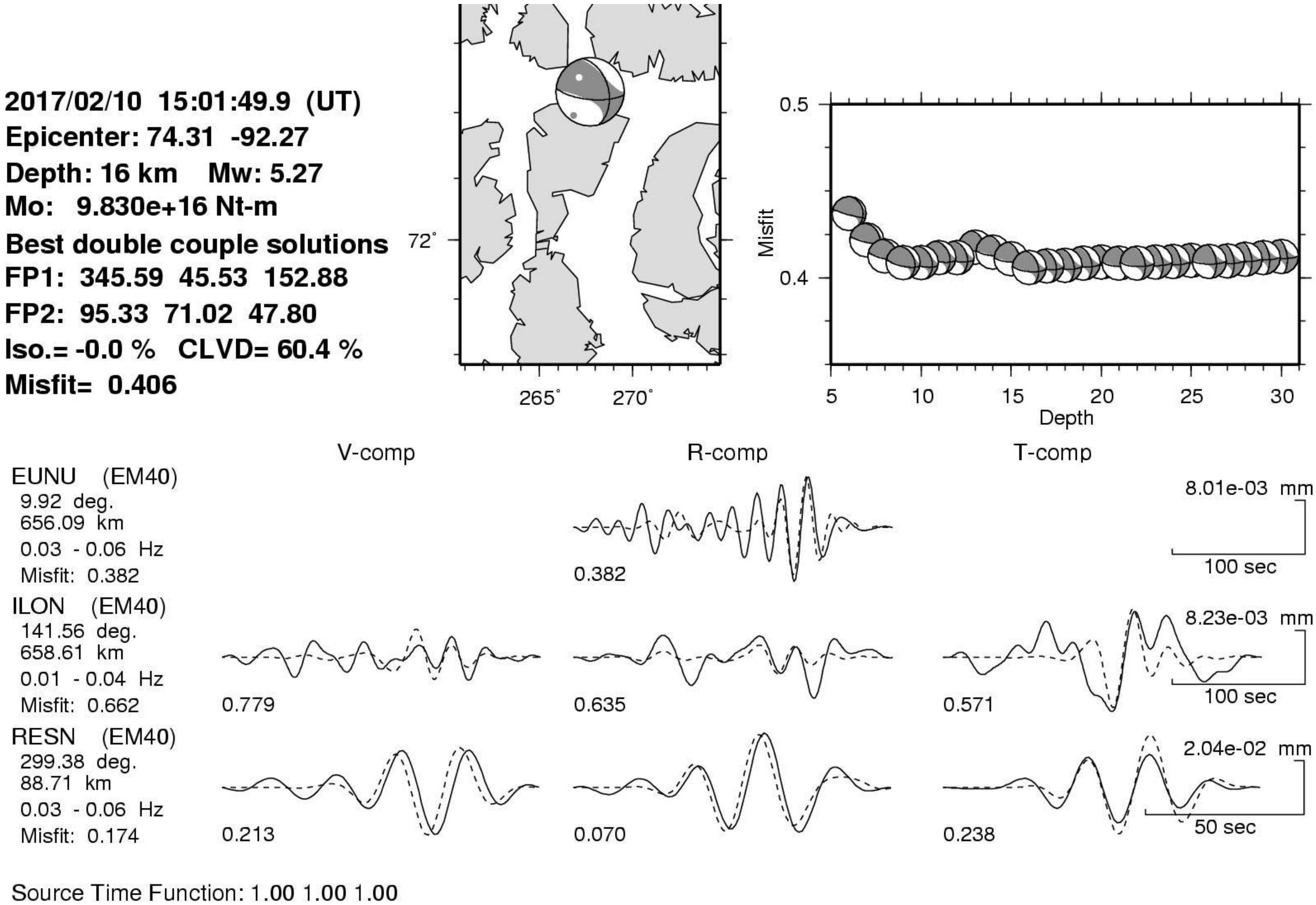


Figure 2e: RCMT solution for event 2017-02-10. See text for explanation of figure.

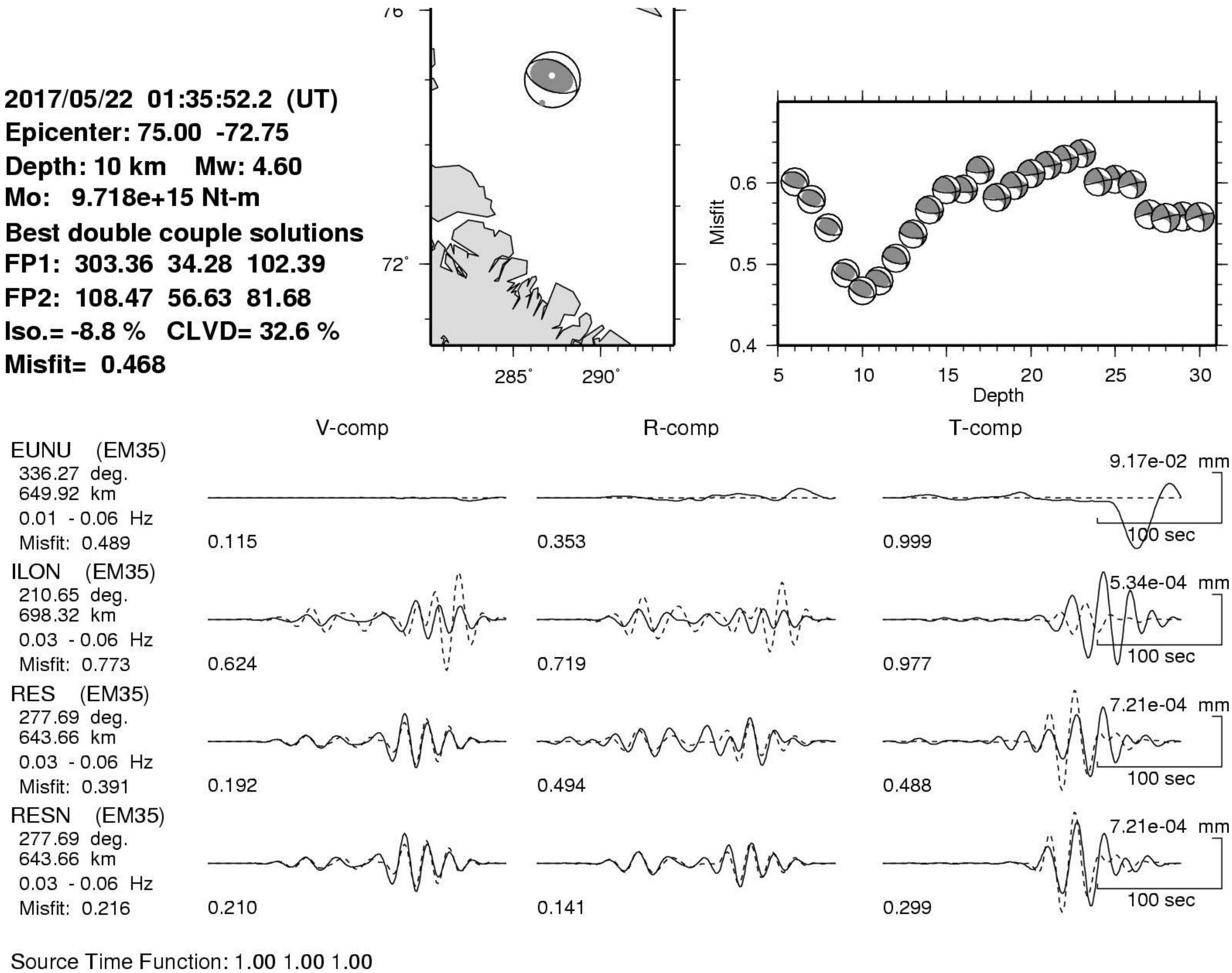
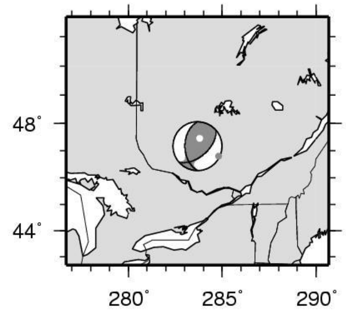
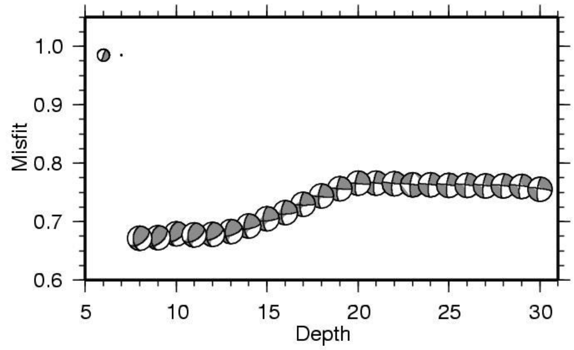
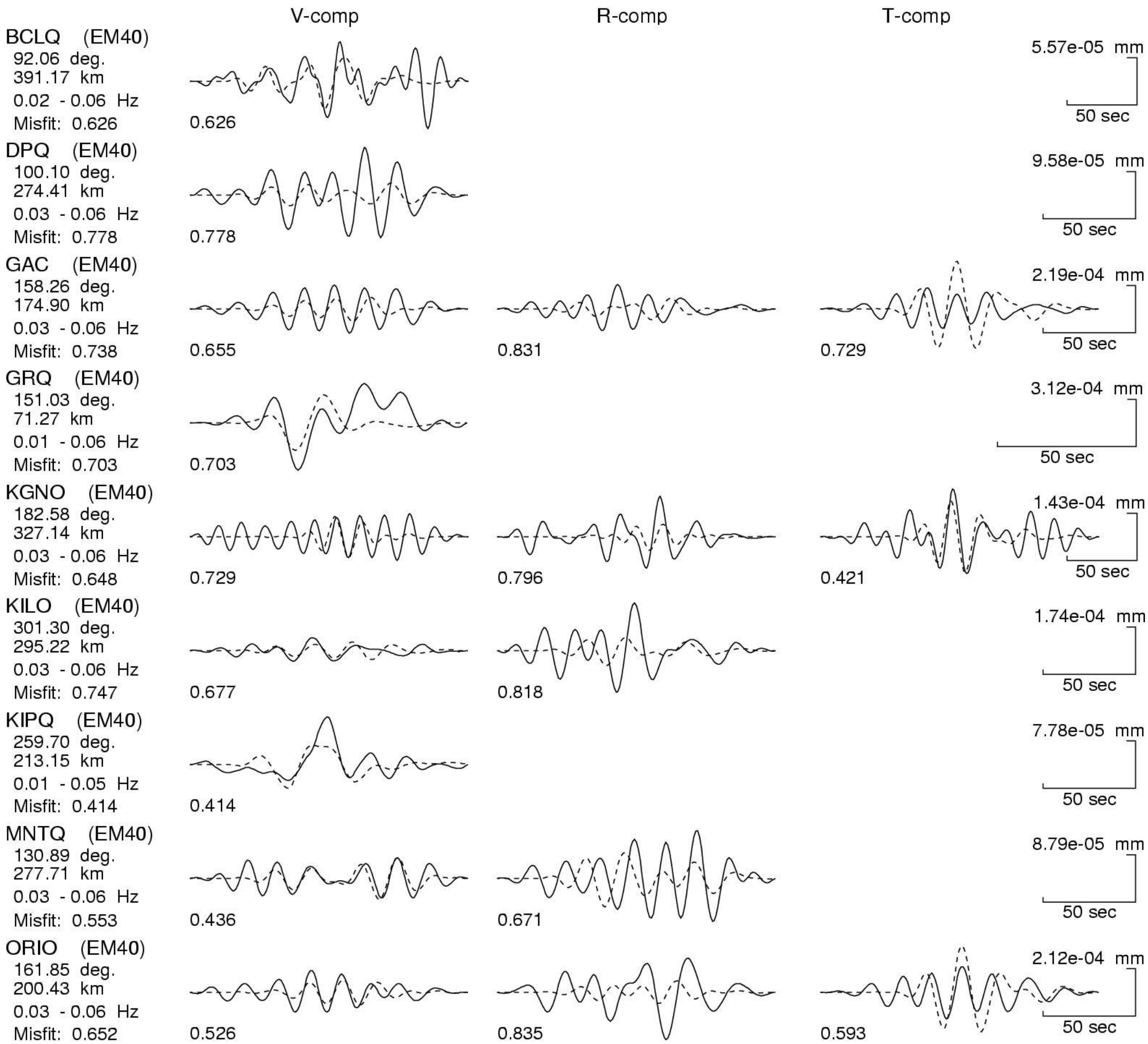


Figure 2f: RCMT solution for event 2017-05-22. See text for explanation of figure.

2017/12/28 08:51:12.4 (UT)
Epicenter: 47.17 -76.31
Depth: 8 km Mw: 3.71
Mo: 4.538e+14 Nt-m
Best double couple solutions
FP1: 179.34 46.64 50.99
FP2: 49.05 55.60 123.68
Iso.= 13.5 % CLVD= 15.0 %
Misfit= 0.672







Source Time Function: 1.00 1.00 1.00

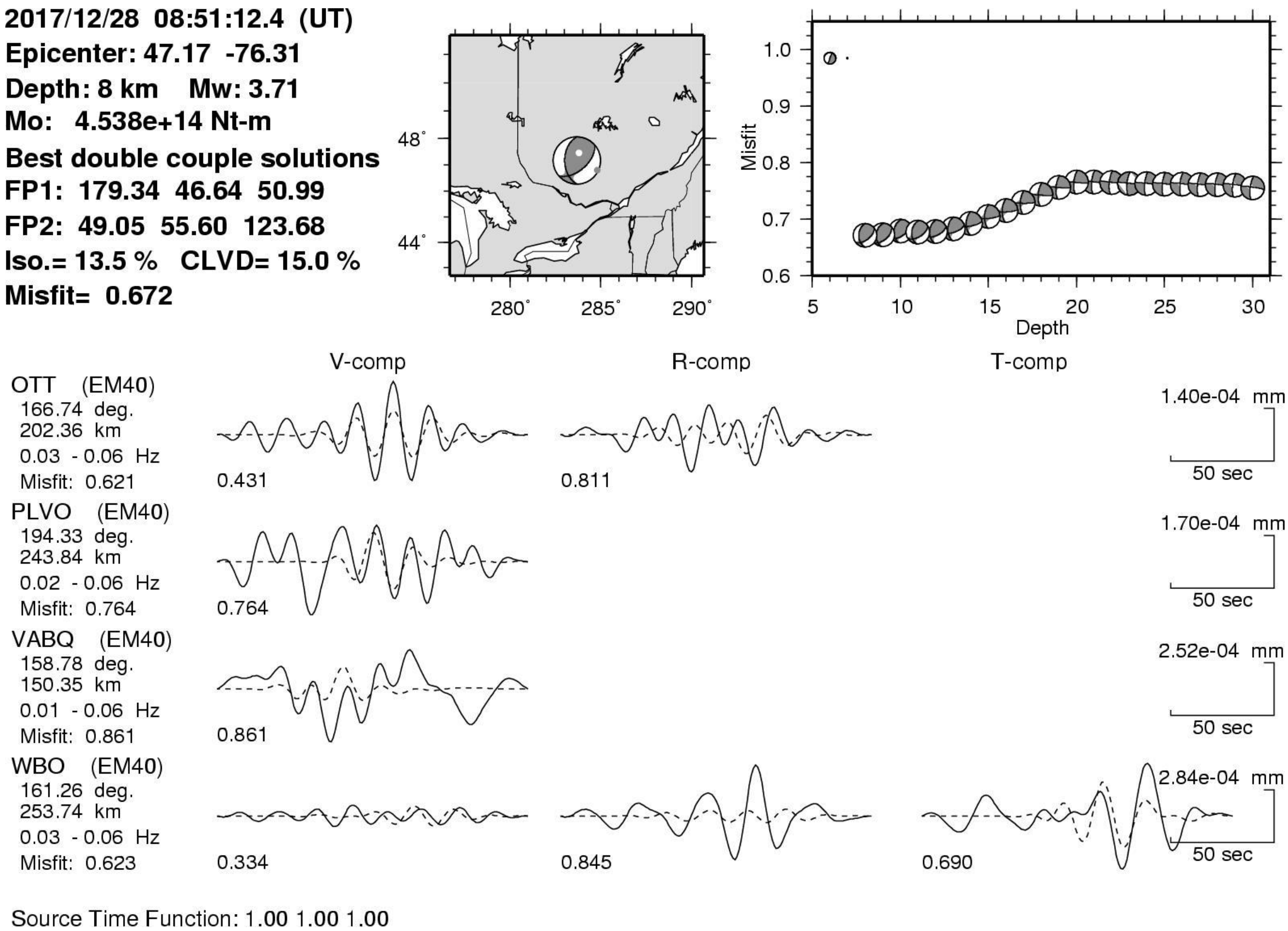


Figure 2g: RCMT solution for event 2017-12-28. See text for explanation of figure. Note that the solution for this event is plotted in two parts as the plotting package allows a maximum of nine stations per page.

Related Studies

The 8 January 2017 M_W 5.9 earthquake that occurred in Barrow Strait was one of the largest earthquakes to occur in eastern Canada during the past 50 years. It and its largest aftershocks as well as the 20 January 2017 earthquake southeast of Isachsen were studied by Bent et al (2018) in greater depth than presented in the current paper. In particular, analysis of teleseismic depth phases confirmed that the events were relatively deep, 33-35 km for the mainshock. Preliminary analysis of the spectra suggested that the mainshock was a high stress drop (~90 MPa) event although many of the aftershocks appear to have been lower stress drop events. Bent et al. (2018) noted that the occurrence of magnitude 5 and greater earthquakes in the north tends to coincide with periods of enhanced seismicity that is not attributable to the occurrence of aftershocks. More research is needed before it can be established whether the link is cause, effect or coincidence. A second paper on the Barrow Strait sequence by Motazedian and Ma (2018) obtained similar results in terms of focal mechanism and depth.

Summary

Regional moment tensor solutions have been determined for seven moderate earthquakes occurring in northeastern Canada during 2017. Two other events were evaluated but good quality solutions were not obtained. The moment tensor solutions include focal mechanisms, depths and moment magnitudes which provide input into further studies regarding seismic hazard, regional seismotectonics or stress field. These results are particularly valuable in regions, such as the north and offshore, where there have been considerable difficulties in obtaining these parameters through other methods. This paper is the fifth in what is intended to be a series of annual updates. In addition, other methods for disseminating the solutions are being explored, such as an online database.

Acknowledgments

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Appendix
Complete Moment Tensor Solution for Earthquakes in Table 2

For each event listed in Table 2 the full moment tensor from the RCMT inversion is given. The format is described below (written communication from Kao, 2005). The earthquakes are identified by date of occurrence. In the case of two events on the same day, the origin time (hh:mm) is added for clarification.

Line 1-25: depth, E_nosh, E_sh, Mxx, Myy, Mzz, Mxy, Mxz, Myz

(E_nosh: average misfit without any shift of synthetic seismograms)

(E_sh: average misfit with shift of synthetic seismograms)

< repeat for each depth >

Line 26: station(i), ishift(i), E(i), Ez(i), Er(i), Et(i)

(station: station name)

(ishift: number of shifted points,

original position + ishift = final position)

(E: average misfit for this station at the best-fitting depth)

(Ez: Z-comp misfit for this station at the best-fitting depth)

(Er: R-comp misfit for this station at the best-fitting depth)

(Et: T-comp misfit for this station at the best-fitting depth)

< repeat for each station >

Author's note: the misfit for each component is given for all stations used regardless of whether the component was used in the inversion; the average misfit, both for each station and overall, is calculated only from the components that were used.

2017-01-08

11	1.0000	1.0000	0.10000E+01	-0.10000E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
12	0.6471	0.4778	-47706.68442	-13047.75599	99305.92252	-30917.39414	26127.31165	-537.69639
13	0.6300	0.4656	-48387.17894	-15886.08658	93787.95568	-31063.85594	24394.27713	-739.97542
14	0.6142	0.4559	-47633.99231	-17005.81351	87715.16681	-30407.20867	24984.95905	681.88636
15	0.6019	0.4453	-45838.29811	-16997.78635	80970.04903	-30266.46855	25064.60074	1456.60144
16	0.5921	0.4429	-50388.56762	-20865.71807	88811.46395	-31167.73031	28194.72020	1855.10675
17	0.5823	0.4332	-49252.76225	-20365.94693	83459.90430	-31923.35558	29372.34991	2966.17038
18	0.5571	0.4254	-55786.27052	-23148.98122	91471.45597	-36664.80084	32908.44201	3885.05823
19	0.5442	0.4179	-55406.25138	-22747.63493	88186.93639	-37874.12142	32233.03208	3787.00557
20	0.5361	0.4132	-54369.42202	-21930.52734	85084.80640	-38923.98836	33348.60595	4862.49002
21	0.5229	0.4055	-54357.26861	-21520.08572	83597.04304	-39424.49051	33178.29522	5160.59402
22	0.5204	0.4025	-53643.89235	-20972.26138	81419.14590	-40465.70094	33899.91855	6414.44266
23	0.5090	0.3985	-54152.68360	-20778.15313	80657.82140	-41054.26061	33780.50953	6652.89214
24	0.5077	0.3981	-51869.52329	-19517.67752	75947.57868	-40535.23014	33425.73073	7130.95109
25	0.5001	0.3965	-52353.03287	-19300.47426	75261.39677	-40838.05999	33683.59188	7374.49350
26	0.4915	0.3949	-53333.45213	-19112.39810	75020.37816	-42445.45463	33289.39160	7017.58492
27	0.4874	0.3974	-53739.28688	-19009.82791	74515.24026	-42822.71371	34474.01228	8180.04363
28	0.4797	0.3962	-55036.67031	-18860.03594	74773.84352	-44628.43674	34045.91970	7771.90501
29	0.4786	0.3957	-55606.41668	-18610.15269	74481.14015	-46059.26595	34820.04544	8288.13398
30	0.4729	0.3941	-57097.86313	-18855.42554	75527.02112	-47077.95584	34244.73669	8747.39170
31	0.4728	0.3930	-57863.09116	-18630.36473	75693.69067	-48697.98344	34885.30008	9164.83470
32	0.5210	0.4490	-62968.18833	-348.48277	61292.33483	-37681.39081	27368.06066	13507.01405
33	0.4617	0.3899	-61507.59930	-18632.14729	78265.97873	-52066.63936	34594.26559	8829.55301
34	0.4622	0.3914	-62799.86745	-18753.98558	79246.26855	-52966.91796	35385.02881	9687.66450
35	0.4569	0.3905	-65366.10395	-18940.56878	81472.07230	-55869.79138	34810.34766	9151.90276

a36m	0	0.497510	0.543518	0.567681	0.381331
clrn	-2	0.676320	0.680378	0.562133	0.786451
eunu	2	0.553383	0.601797	0.516137	0.542215
ilon	2	0.121191	0.105902	0.122229	0.135442
kukn	-1	0.101142	0.112851	0.144248	0.046328

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6	0.5163	0.4962	1199.53329	801.74180	-652.08600	-719.16702	2743.73848	2647.70894
7	0.9388	0.9388	0.42702E-06	0.45920E-06	0.13896E-06	-0.12513E-05	0.11704E-05	0.16946E-05
8	0.4496	0.4354	26.19360	-821.50919	2581.69828	-1034.89005	2279.52541	2100.31964
9	0.4704	0.4572	-484.19290	-1125.75564	2614.53498	-819.72539	1421.22583	1260.45082
10	0.4625	0.4569	-603.06054	-1235.85294	2433.29292	-796.87945	1174.63695	1028.88372
11	0.4504	0.4417	-575.05741	-1238.55034	2164.53428	-814.68240	1069.78683	935.13276
12	0.4439	0.4292	-524.63349	-1173.79689	1901.71953	-822.91205	962.45388	839.33241
13	0.4406	0.4229	-748.13174	-1921.95882	2859.61122	-1459.94822	1595.94950	1403.73737
14	0.4347	0.4135	-682.65705	-1872.02461	2645.72333	-1529.45690	1538.62681	1351.55161
15	0.4316	0.4075	-499.94026	-1597.35909	2113.86565	-1401.64547	1350.99785	1194.48117
16	0.4352	0.4037	-654.39024	-1658.26686	2355.91278	-1466.67023	1545.02765	1376.02918
17	0.4337	0.4006	-553.12463	-1570.32297	2128.23459	-1473.44761	1516.06839	1362.62884
18	0.4338	0.3976	-560.77562	-1557.48891	2100.22324	-1564.64660	1535.29116	1386.29919
19	0.4351	0.3959	-557.46850	-1490.17954	2014.70722	-1606.40372	1505.97715	1363.59619
20	0.4379	0.3938	-511.47225	-1473.39786	1937.87943	-1678.23649	1544.17704	1399.82551
21	0.4399	0.3931	-549.71248	-1466.97260	1956.46818	-1789.83419	1568.26314	1436.66307
22	0.4440	0.3946	-537.74625	-1415.36337	1878.77762	-1827.44700	1637.90801	1489.72561
23	0.4482	0.3964	-545.89994	-1313.70590	1779.88953	-1836.45245	1569.59441	1428.33073
24	0.4543	0.3994	-529.91535	-1293.78179	1739.92329	-1932.50958	1614.48135	1470.64679
25	0.4600	0.4031	-569.85817	-1295.91852	1774.32750	-2087.70710	1654.26141	1506.83343
26	0.4665	0.4070	-519.62241	-1266.37188	1695.91630	-2142.49197	1647.17013	1493.93843
27	0.4713	0.4101	-533.21810	-1247.89596	1690.38202	-2255.86353	1637.23955	1483.24977
28	0.4769	0.4108	-549.45088	-1230.22863	1689.36466	-2377.44217	1626.03490	1471.59111
29	0.4854	0.4139	-528.38811	-1254.78885	1697.59325	-2524.47214	1659.16946	1506.03816
30	0.4880	0.4162	-567.14613	-1213.55564	1697.55959	-2614.08221	1678.06864	1510.43681

eunu	0	0.634876	0.493437	0.706528	0.704662
ilon	-1	0.288392	0.141509	0.435274	1.000000
kukn	-2	0.422684	0.306039	0.475292	0.486720
resn	0	0.226555	0.476382	0.052838	0.150444

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6	0.7274	0.6898	-56.61115	-39.00135	75.53304	-69.45091	28.24642	99.03706
7	0.7227	0.6871	-35.83885	-14.87458	21.35367	-75.86968	29.60411	102.52960
8	0.6954	0.6674	9.00035	29.51970	-71.41259	-78.74015	31.34830	112.43758
9	0.6704	0.6323	41.12349	59.19039	-127.98668	-83.03031	31.86095	114.74700
10	0.6588	0.6223	46.68073	63.05761	-128.45487	-83.32910	27.88777	100.47844
11	0.6510	0.6185	39.00782	55.47957	-107.17181	-84.16703	24.22579	86.90508
12	0.6472	0.6173	34.14502	53.19260	-97.30849	-95.05290	23.93112	84.59760
13	0.6408	0.6159	27.57253	47.65056	-82.81023	-97.60281	22.26593	75.84727
14	0.6350	0.6143	20.72190	41.99472	-68.54174	-98.77141	20.46313	68.85999
15	0.6197	0.6067	12.42343	29.54336	-45.46675	-76.54088	14.88070	48.16006
16	0.6137	0.6108	12.20554	32.26313	-46.85224	-83.80785	17.91882	54.77951
17	0.6035	0.6046	8.51045	31.02473	-41.33183	-92.16288	18.81320	56.39954
18	0.5960	0.5903	4.82186	28.51595	-34.59065	-95.28399	18.67824	55.19137
19	0.5884	0.5837	1.99893	31.93718	-34.99334	-118.73136	22.40627	65.98845
20	0.5840	0.5800	-0.90671	29.50607	-29.45181	-120.84869	21.92214	66.63856
21	0.5812	0.5776	-3.65507	27.99345	-25.01957	-123.70161	21.54781	65.44591
22	0.5788	0.5758	-6.23057	26.54961	-20.84774	-126.24959	21.30258	65.60496
23	0.5768	0.5731	-8.57830	25.31356	-17.12504	-128.76090	21.05175	65.96103
24	0.5757	0.5714	-10.84062	24.47161	-13.91635	-131.00602	20.71844	66.58551
25	0.5743	0.5695	-12.90180	23.66760	-10.97384	-133.58952	20.40350	67.15921
26	0.5723	0.5670	-14.33246	21.51503	-7.41237	-130.42085	19.02905	65.59705
27	0.5715	0.5654	-16.15685	21.11462	-5.14278	-133.18922	18.65652	66.10009
28	0.5716	0.5641	-17.87052	22.34692	-4.59161	-141.38376	19.27583	70.19112
29	0.5701	0.5609	-19.86345	22.00129	-2.30587	-145.67973	18.49473	70.34074
30	0.5698	0.5595	-21.90450	22.06737	-0.30472	-149.47199	18.05186	71.31872

eunu	2	0.776616	0.776616	0.944767	0.727039
ilon	0	0.815791	0.811539	0.984049	0.820043
res	0	0.086205	0.105535	0.048062	0.105016

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6	0.6937	0.6164	1418.46557	-729.56510	-524.73495	-541.48173	860.36449	691.02270
7	0.6237	0.5507	1220.66470	-849.96656	-159.72601	-410.38698	784.52784	560.13402
8	0.6229	0.5513	1052.49187	-1052.28346	230.56605	-335.80604	739.22949	464.08875
9	0.6215	0.5499	885.43348	-1251.38419	564.86996	-236.62079	708.77885	393.77921
10	0.6181	0.5514	807.46811	-1375.75031	708.73900	-113.77450	702.34350	341.79213
11	0.6209	0.5578	796.03600	-1421.92957	708.63170	-9.69714	684.70471	305.56575
12	0.6294	0.5697	821.31076	-1429.28329	645.59792	109.19187	671.90995	276.80158
13	0.6409	0.5835	860.29581	-1422.12075	566.45944	243.16226	663.48970	251.94830
14	0.6540	0.5990	903.68567	-1411.79690	488.97854	385.99978	658.04112	229.40646
15	0.6668	0.6124	920.06079	-1361.67605	406.79819	511.27064	635.01244	201.67981
16	0.6677	0.6133	997.75586	-1474.26083	442.34725	587.19206	754.54351	196.82506
17	0.6916	0.6399	1029.66721	-1434.32465	356.32450	787.57913	754.91480	183.48261
18	0.7146	0.6746	1080.57452	-1430.45808	294.72790	904.24815	764.74238	163.56944
19	0.7468	0.7088	1133.01092	-1433.60051	241.75405	993.26617	775.44661	144.83293
20	0.7439	0.7071	1185.08954	-1437.46128	190.55547	1045.88827	770.09652	132.44873
21	0.7396	0.7063	1239.60995	-1453.41020	151.87120	1093.33833	781.70801	115.51759
22	0.7367	0.7071	1289.97317	-1472.20865	123.18112	1130.84139	795.98000	96.39015
23	0.7337	0.7054	1345.64886	-1497.74056	94.57242	1152.23057	807.55015	79.86202
24	0.7314	0.7051	1401.87762	-1526.82675	69.33159	1167.46919	818.38008	63.27315
25	0.7286	0.7170	1452.13681	-1565.94801	59.97418	1196.58785	829.29574	62.31170
26	0.7271	0.7172	1510.34676	-1601.94327	40.00639	1206.87298	838.82453	44.93957
27	0.7261	0.7179	1569.67128	-1640.59231	21.69203	1217.86204	846.95363	27.24802
28	0.7258	0.7204	1632.14053	-1676.83700	-4.10377	1237.82600	837.93142	16.92489
29	0.7258	0.7211	1695.67068	-1724.30012	-18.68402	1252.94775	844.39095	-2.60285
30	0.7264	0.7225	1761.69455	-1773.46544	-32.24984	1272.39920	848.66155	-22.75240

a36m	4	0.657210	0.646020	0.761846	0.563764
eunu	3	0.572499	0.424305	1.000000	0.293191
ilon	-8	0.468587	0.263814	0.141946	1.000000
resn	1	0.501332	0.407273	0.736416	0.360307

2017-02-10

6	0.6474	0.4371	-1823.91778	514.34345	1404.86005	-4737.28643	9608.59233	3588.86167
7	0.6311	0.4216	-2600.61820	158.45186	2568.81159	-5433.57503	8328.02354	2847.56650
8	0.6111	0.4126	-3373.75691	-204.36952	3681.75336	-6040.27975	7538.17594	2356.12167
9	0.5881	0.4087	-4038.38728	-456.96505	4539.13331	-6562.12923	6901.75007	1932.24492
10	0.5649	0.4088	-4237.11329	-480.21357	4685.31067	-6681.61455	6186.42536	1609.64772
11	0.5473	0.4116	-4436.38408	-447.93067	4792.33369	-6962.06722	5821.27318	1414.36900
12	0.5357	0.4116	-4342.20150	-346.45043	4570.02620	-6923.05232	5207.05419	1158.79297
13	0.5203	0.4176	-4386.73652	-212.22068	4468.00496	-7153.26206	4994.42907	1027.71132
14	0.5056	0.4148	-4059.90829	-112.18988	4039.42711	-6751.67412	4421.06188	872.74195
15	0.4955	0.4110	-4088.13839	-31.63348	3992.53245	-6921.13702	4279.87180	806.99026
16	0.4815	0.4058	-4402.15069	-234.28284	4630.96645	-7289.40842	4742.94230	747.78765
17	0.4742	0.4069	-4422.61913	-235.18060	4658.28757	-7446.85309	4622.04791	680.88383
18	0.4615	0.4071	-4200.48126	-194.99556	4400.43489	-7254.78219	4422.60618	665.75426
19	0.4574	0.4083	-4184.35324	-196.29787	4390.77201	-7381.87459	4333.96630	633.03110
20	0.4581	0.4092	-4152.49880	-221.82795	4385.55817	-7512.73958	4249.88974	607.18906
21	0.4534	0.4085	-4172.29130	-216.27607	4409.36797	-7680.57795	4148.37845	544.71469
22	0.4502	0.4084	-4144.41829	-215.77649	4388.73387	-7833.47757	4091.71294	517.91040
23	0.4483	0.4089	-4112.25717	-220.00118	4366.27313	-8001.38278	4042.89291	508.84409
24	0.4472	0.4093	-4089.63383	-219.99885	4347.00588	-8163.72635	3996.66746	509.93436
25	0.4454	0.4101	-4067.69293	-216.44629	4325.72540	-8351.95791	3958.17392	501.98083
26	0.4430	0.4095	-3848.66678	-192.43639	4079.04180	-8150.73297	3835.64982	543.35982
27	0.4410	0.4096	-3846.17441	-175.76424	4062.02145	-8336.34370	3803.39751	534.98778
28	0.4408	0.4107	-3843.50291	-179.44719	4062.29890	-8551.41311	3774.63528	547.76416
29	0.4432	0.4116	-3889.86798	-186.53721	4112.17976	-8805.70127	3709.25643	542.98573
30	0.4434	0.4122	-3897.81970	-187.38105	4120.03693	-9062.07112	3679.46575	553.61635

eunu	-2	0.382269	1.000000	0.382269	1.000000
ilon	0	0.661639	0.778729	0.635062	0.571126
resn	1	0.173548	0.212565	0.069780	0.238297

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6	0.6553	0.6011	-522.83437	-285.10848	894.92041	-137.52053	388.23699	20.07120
7	0.6149	0.5794	-649.47660	-420.99442	1107.57635	-146.00178	335.32871	27.47516
8	0.5782	0.5447	-725.67867	-494.04508	1159.34707	-158.72506	311.58556	29.37462
9	0.5539	0.4891	-653.87791	-412.24436	917.44947	-169.66143	291.94454	22.53431
10	0.5549	0.4675	-749.62364	-368.20333	865.22086	-262.74571	389.88299	18.03619
11	0.5652	0.4795	-668.38450	-229.75641	621.55825	-304.67094	405.69577	17.06421
12	0.5847	0.5071	-621.53928	-122.98066	461.67589	-351.20077	424.37262	20.84988
13	0.6087	0.5374	-602.45515	-42.23118	361.30659	-401.39865	445.36901	27.78421
14	0.6336	0.5673	-566.18259	17.83008	282.18493	-428.56359	440.84742	36.58994
15	0.6532	0.5918	-564.22492	66.68815	237.11232	-471.06683	450.13548	45.52148
16	0.6552	0.5924	-553.68517	65.43746	269.27871	-470.27656	477.19189	59.15273
17	0.6732	0.6160	-522.24624	100.38868	221.81884	-480.74936	462.48818	62.84780
18	0.6266	0.5821	-589.78372	151.45311	221.75581	-577.10657	528.27557	77.37185
19	0.6396	0.5967	-591.24480	180.62512	203.80237	-607.93024	533.59321	86.56916
20	0.6536	0.6117	-575.20408	191.33211	182.80198	-626.02310	538.65338	102.91434
21	0.6604	0.6218	-586.69099	215.95502	177.15124	-658.94187	547.43760	114.18909
22	0.6644	0.6291	-602.69873	241.27404	174.85483	-693.97880	557.30627	126.28791
23	0.6681	0.6360	-584.02732	252.74598	162.19515	-687.42905	530.34861	124.13096
24	0.6264	0.6011	-647.26912	297.25628	176.25618	-771.79091	575.23764	144.70003
25	0.6260	0.6047	-676.49453	327.69130	181.15578	-814.86676	585.67052	157.29866
26	0.6256	0.5980	-709.95426	361.53501	187.17003	-861.44752	595.16331	169.29477
27	0.5856	0.5615	-749.63955	401.54555	193.08753	-912.17959	602.78480	178.74892
28	0.5875	0.5567	-766.19119	423.34781	189.55431	-952.45640	609.52638	195.38815
29	0.5887	0.5589	-818.19112	471.85267	196.74218	-1015.02546	615.83342	205.09098
30	0.5906	0.5580	-875.89234	531.18214	204.49761	-1085.42547	620.29271	213.54704

eunu	3	0.488991	0.115214	0.352981	0.998780
ilon	5	0.773396	0.624485	0.718687	0.977015
res	2	0.391237	0.191757	0.494245	0.487709
resn	2	0.216334	0.209555	0.140739	0.298706

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6	0.9850	0.9850	0.24720E-07	-0.18690E-07	-0.33766E-07	-0.24905E-07	0.54879E-07	-0.17436E-06
7	0.9850	0.9850	-0.14998E-03	-0.12181E-04	0.15885E-03	0.13632E-03	-0.90366E-04	0.34792E-05
8	0.7114	0.6716	8.57358	-29.17216	40.56765	21.70310	17.40817	0.74400
9	0.7159	0.6721	3.85724	-32.31705	42.02920	23.23255	16.36528	0.81237
10	0.7258	0.6788	0.67460	-30.68568	37.74272	25.64627	15.64604	0.83861
11	0.7355	0.6770	-1.55259	-27.33374	32.43206	27.91651	14.83940	0.95091
12	0.7438	0.6785	-3.27817	-22.80248	26.93422	30.20878	14.31914	0.93454
13	0.7515	0.6830	-4.98380	-17.87701	21.92625	32.49511	14.00924	0.83183
14	0.7607	0.6928	-6.42793	-13.41918	17.75081	34.71531	13.74280	0.79727
15	0.7681	0.7047	-7.85658	-9.18758	14.04893	36.97438	13.65318	0.71688
16	0.7744	0.7157	-9.92679	-5.83333	12.56580	38.91758	15.42432	0.86049
17	0.7826	0.7299	-11.09488	-1.84611	9.05028	41.38031	15.26868	0.71395
18	0.7919	0.7436	-12.02206	1.61645	6.07832	43.55589	15.24161	0.56328
19	0.8000	0.7565	-12.77071	4.69840	3.57806	45.63596	15.19462	0.37002
20	0.8052	0.7653	-12.90358	6.46040	1.49086	46.00377	14.73615	0.40139
21	0.8054	0.7660	-13.09887	8.09943	-0.64833	47.74998	14.47715	0.42287
22	0.8040	0.7650	-13.36307	9.49392	-2.29643	49.50748	14.30815	0.28354
23	0.8029	0.7632	-0.13382E+02	0.10422E+02	-0.36264E+01	0.51036E+02	0.14122E+02	-0.88177E-03
24	0.8022	0.7629	-13.54288	11.68252	-4.87046	52.55472	14.12143	-0.24981
25	0.8008	0.7621	-13.60254	12.77160	-6.02331	53.99265	14.16702	-0.43929
26	0.8004	0.7620	-13.66062	13.89255	-6.94986	55.42540	14.21834	-0.62509
27	0.8007	0.7609	-13.69299	15.05755	-7.85872	56.59836	14.33815	-0.89854
28	0.8007	0.7605	-13.66638	16.13945	-8.65313	57.09602	14.78589	-1.11051
29	0.8021	0.7600	-13.44885	17.10670	-9.38980	57.30447	15.33670	-1.07311
30	0.8028	0.7553	-13.39564	18.47744	-10.19967	57.81287	15.86095	-1.47465

bclq	2	0.626377	0.626377	0.972308	0.989335
dpq	-2	0.778199	0.778199	0.974338	0.966095
gac	0	0.738174	0.654935	0.830985	0.728603
grq	0	0.703492	0.703492	0.963199	0.884992
kgno	1	0.648400	0.728618	0.795828	0.420754
kilo	0	0.747368	0.677164	0.817572	0.850849
kipq	6	0.414118	0.414118	0.992082	0.932262
mntq	0	0.553180	0.435801	0.670559	1.000000
orio	0	0.651502	0.526465	0.835043	0.592999
ott	2	0.621416	0.431405	0.811426	1.000000
plvo	2	0.764311	0.764311	0.997279	0.994139
vabq	2	0.861425	0.861425	0.998220	0.996212
wbo	4	0.623003	0.334017	0.844651	0.690342