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Abstract

Regional centroid moment tensor solutions have been determined for seven moderate-sized earthquakes in eastern Canada during 2015. 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. In the past, focal mechanisms were most often determined by the polarity distribution of first motions. This method is tedious 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. The moment tensor inversion, which makes use of a longer portion of the waveform, is a more robust and more objective method to determine focal mechanisms. They 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 size. However, moment tensors use relatively long-period data and they, too, do not always result in good-quality solutions for smaller earthquakes. Having said that, there has been an increase in the percentage of magnitude 4+ earthquakes for which focal mechanisms could be determined since regional centroid moment tensor (RCMT) method was implemented in eastern Canada around 2005-2006. The impact is most notable in the north where it was difficult to obtain focal mechanism solutions 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 2014 nineteen solutions were obtained via the RCMT inversion method for twenty-two events evaluated in the same region (Bent, 2015a.b) and another five out of five for 2015 (this paper).

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 that 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 Bent (2015a,b) catalogued eastern solutions for 2011-2014. The current paper catalogs the RCMT solutions for eastern Canada in 2015. Solutions that met the minimum quality criteria were obtained for seven out of eight earthquakes evaluated. This report is the third 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. For all earthquakes summarized in this paper a 1.0/1.0/1.0 (sec) time function is assumed. Because it 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 pick accurately for small earthquakes and which require a larger number of good quality recordings for a unique solution to be determined.

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. 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* and hh*) stations are used in the inversion. Standard practice is to use only stations from which data are received in real time by the Geological Survey of Canada (GSC; CNWA, 2016). 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.

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- 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 southern model is shown in Table 1. For the northeast the thickness of layer 3 is decreased to 19 km. The lowermost layer is a mantle half-space.

Table 1
Velocity Model for Southeastern Canada

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	24	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. The 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 should be used with some caution even if the fit is reasonably good.

Regional Centroid Moment Tensor Solutions for Eastern Canada

Eight earthquakes were evaluated (Figure 1 and Tables 2 and 3). Solutions of quality C4 or better were obtained for all events in Table 2. The event in Table 3 is one for which the solution quality was not acceptable.

Table 2
Earthquakes Evaluated: Solutions Obtained

Date	Time (UT)	Lat (°N)	Lon (°W)	Mag (M_W)	Location/Region	Quality
2015-01-16	13:05:28	49.43	66.79	3.9	37 km N of Cap-Chat, QC	B3
2015-02-12	02:11:41	72.05	75.09	4.8	125 SE of Pond Inlet, NU	B4
2015-05-02	09:49:24	73.64	70.26	4.1	271 km NE of Pond Inlet, NU	B2
2015-06-03	10:01:08	62.85	60.06	4.2	306 km E of Resolution Island	B1
2015-07-01	18:32:53	44.09	66.25	3.8	30km N of Yarmouth, NS	B3
2015-08-18	11:01:34	71.98	75.20	3.9	124 km SE of Pond Inlet, NU	B4
2015-11-18	10:19:53	71.19	64.35	3.9	Baffin Bay	C4

Table 3
Event Evaluated: No Reliable Solution Obtained

Date	Time (UT)	Lat (°N)	Lon (°W)	Mag (M_L)	Location/Region	Quality
2015-02-18	23:58:59	50.94	50.97	4.1	Offshore Newfoundland	NA

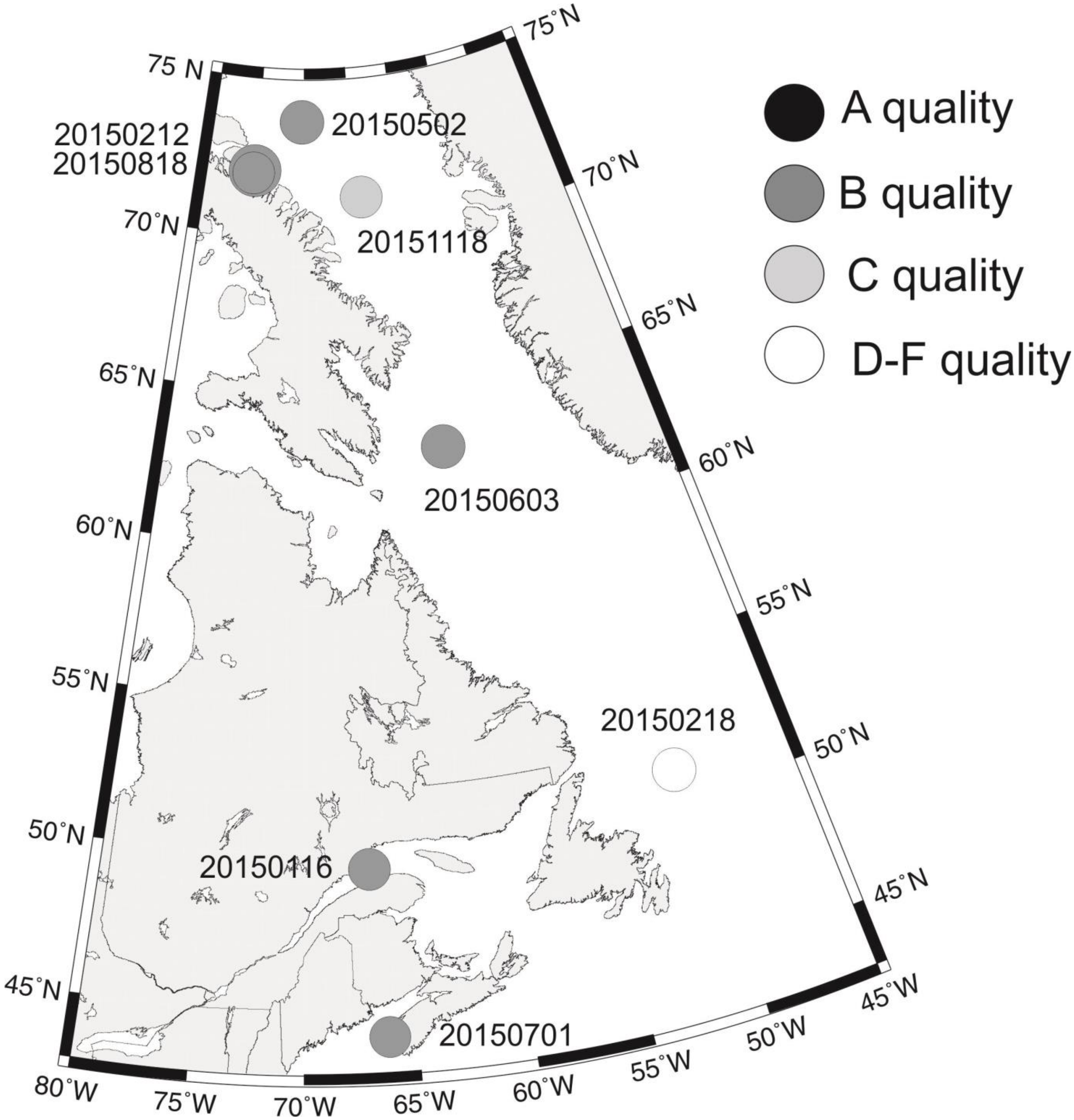

Figure 1: Locations and quality of solutions of all earthquakes evaluated in this study. Note that some points may plot on top of each other. Symbol size is scaled to M_W if a solution of A-C quality was obtained and to the magnitude type listed in Table 3 otherwise.

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, 2016). 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 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, 20151118, Figure 2g) whereas a sharp dip in the misfit function is an indication of a well-constrained depth (for example, 201603, Figure 2d). 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, 20150502, Figure 2c). If two significantly different mechanisms have similar misfits (for example, 20141003, Figure 2f in Bent, 2015b) anyone with a particular interest in that earthquake may need to consider both as viable options or apply additional techniques to the data to determine which solution is better.

Below that, 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). 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. Give 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.

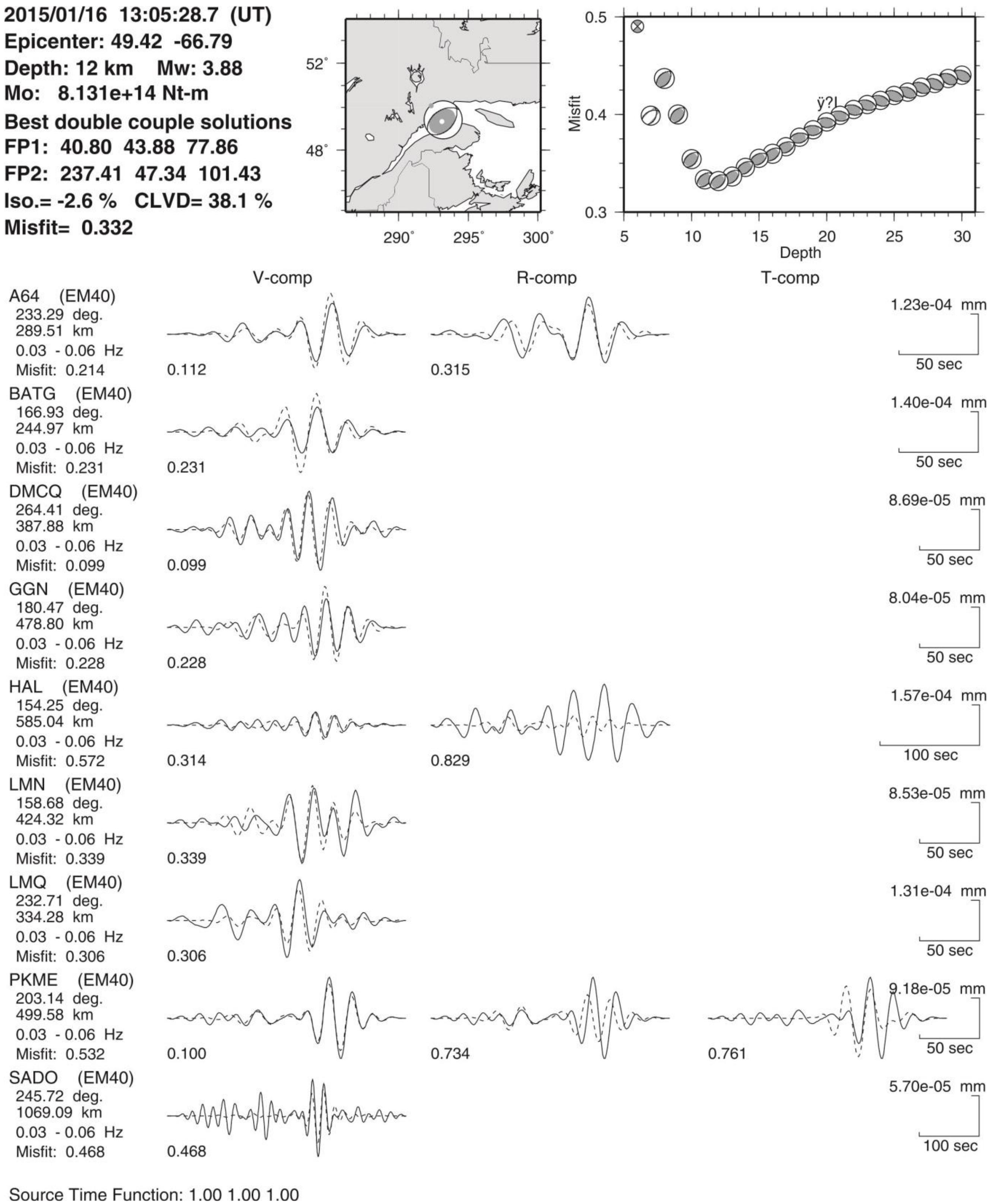
2015/01/16 13:05:28.7 (UT)
Epicenter: 49.42 -66.79
Depth: 12 km Mw: 3.88
Mo: 8.131e+14 Nt-m
Best double couple solutions
FP1: 40.80 43.88 77.86
FP2: 237.41 47.34 101.43
Iso.= -2.6 % CLVD= 38.1 %
Misfit= 0.332
52˚
48˚
290˚
295˚
300˚
0.5
0.4
0.3
Misfit
5
10
15
20
25
30
Depth
V-comp
R-comp
T-comp
A64 (EM40)
233.29 deg.
289.51 km
0.03 - 0.06 Hz
Misfit: 0.214
0.112
0.315
1.23e-04 mm
50 sec
BATG (EM40)
166.93 deg.
244.97 km
0.03 - 0.06 Hz
Misfit: 0.231
0.231
1.40e-04 mm
50 sec
DMCQ (EM40)
264.41 deg.
387.88 km
0.03 - 0.06 Hz
Misfit: 0.099
0.099
8.69e-05 mm
50 sec
GGN (EM40)
180.47 deg.
478.80 km
0.03 - 0.06 Hz
Misfit: 0.228
0.228
8.04e-05 mm
50 sec
HAL (EM40)
154.25 deg.
585.04 km
0.03 - 0.06 Hz
Misfit: 0.572
0.314
0.829
1.57e-04 mm
100 sec
LMN (EM40)
158.68 deg.
424.32 km
0.03 - 0.06 Hz
Misfit: 0.339
0.339
8.53e-05 mm
50 sec
LMQ (EM40)
232.71 deg.
334.28 km
0.03 - 0.06 Hz
Misfit: 0.306
0.306
1.31e-04 mm
50 sec
PKME (EM40)
203.14 deg.
499.58 km
0.03 - 0.06 Hz
Misfit: 0.532
0.100
0.734
0.761
9.18e-05 mm
50 sec
SADO (EM40)
245.72 deg.
1069.09 km
0.03 - 0.06 Hz
Misfit: 0.468
0.468
5.70e-05 mm
100 sec
Source Time Function: 1.00 1.00 1.00

Figure 2a

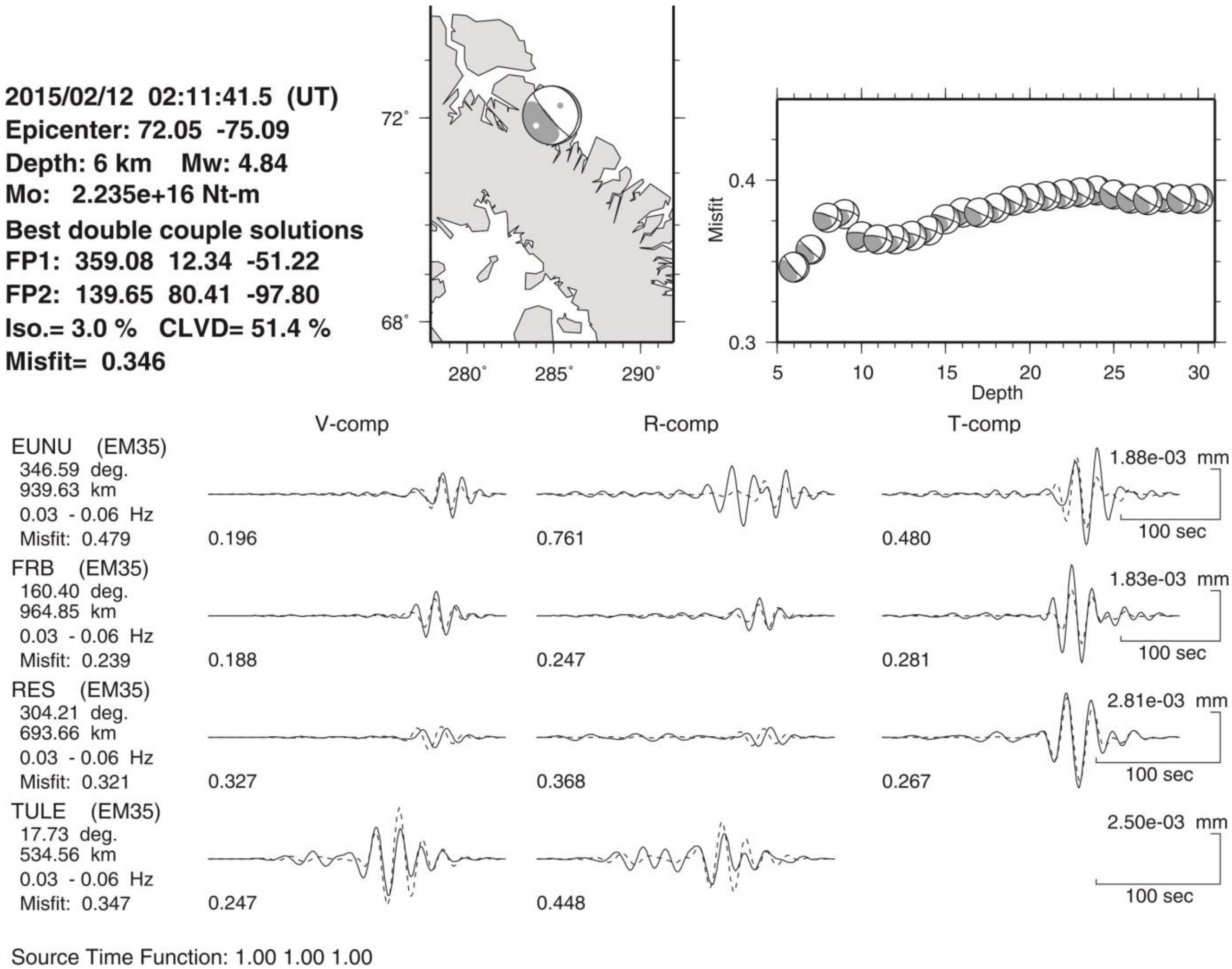
2015/02/12 02:11:41.5 (UT)
Epicenter: 72.05 -75.09
Depth: 6 km Mw: 4.84
Mo: 2.235e+16 Nt-m
Best double couple solutions
FP1: 359.08 12.34 -51.22
FP2: 139.65 80.41 -97.80
Iso.= 3.0 % CLVD= 51.4 %
Misfit= 0.346
72°
68°
280°
285°
290°
Misfit
0.4
0.3
5
10
15
20
25
30
Depth
V-comp
R-comp
T-comp
EUNU (EM35)
346.59 deg.
939.63 km
0.03 - 0.06 Hz
Misfit: 0.479
0.196
0.761
0.480
1.88e-03 mm
100 sec
FRB (EM35)
160.40 deg.
964.85 km
0.03 - 0.06 Hz
Misfit: 0.239
0.188
0.247
0.281
1.83e-03 mm
100 sec
RES (EM35)
304.21 deg.
693.66 km
0.03 - 0.06 Hz
Misfit: 0.321
0.327
0.368
0.267
2.81e-03 mm
100 sec
TULE (EM35)
17.73 deg.
534.56 km
0.03 - 0.06 Hz
Misfit: 0.347
0.247
0.448
2.50e-03 mm
100 sec
Source Time Function: 1.00 1.00 1.00

Figure 2b

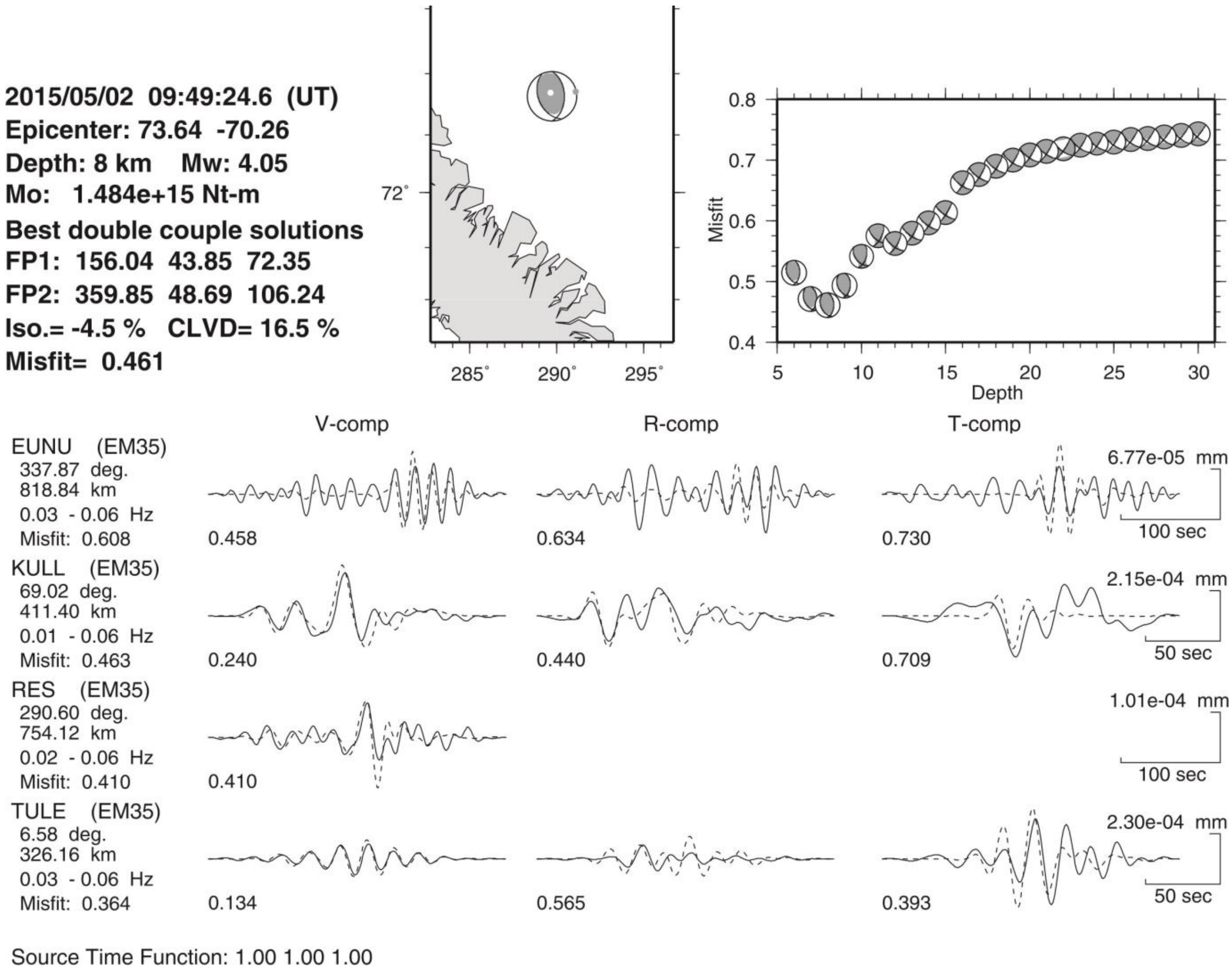
2015/05/02 09:49:24.6 (UT)
Epicenter: 73.64 -70.26
Depth: 8 km Mw: 4.05
Mo: 1.484e+15 Nt-m
Best double couple solutions
FP1: 156.04 43.85 72.35
FP2: 359.85 48.69 106.24
Iso.= -4.5 % CLVD= 16.5 %
Misfit= 0.461
72°
285°
290°
295°
Misfit
Depth
V-comp
R-comp
T-comp
EUNU (EM35)
337.87 deg.
818.84 km
0.03 - 0.06 Hz
Misfit: 0.608
0.458
0.634
0.730
6.77e-05 mm
100 sec
KULL (EM35)
69.02 deg.
411.40 km
0.01 - 0.06 Hz
Misfit: 0.463
0.240
0.440
0.709
2.15e-04 mm
50 sec
RES (EM35)
290.60 deg.
754.12 km
0.02 - 0.06 Hz
Misfit: 0.410
0.410
1.01e-04 mm
100 sec
TULE (EM35)
6.58 deg.
326.16 km
0.03 - 0.06 Hz
Misfit: 0.364
0.134
0.565
0.393
2.30e-04 mm
50 sec
Source Time Function: 1.00 1.00 1.00

Figure 2c

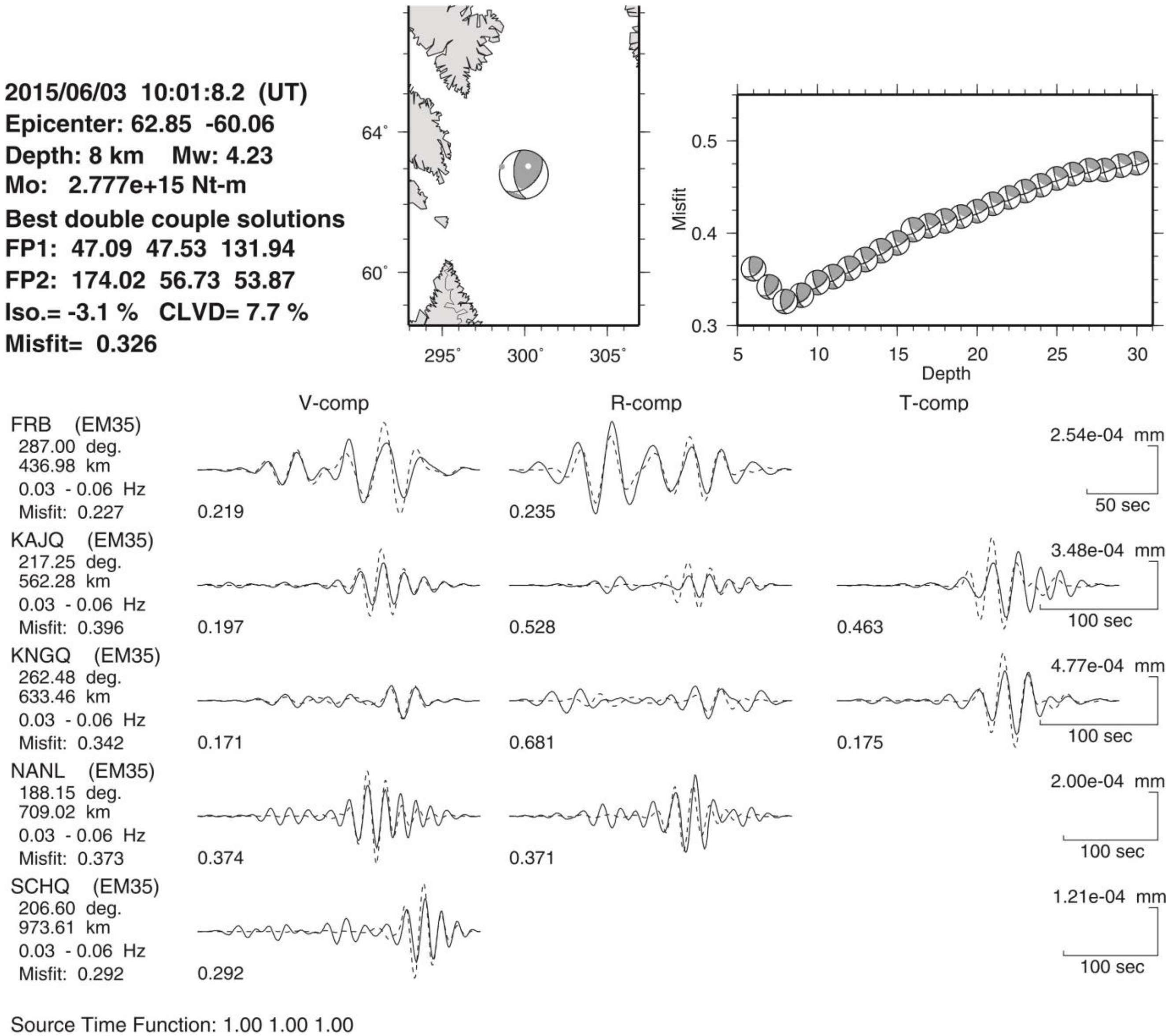
2015/06/03 10:01:8.2 (UT)
Epicenter: 62.85 -60.06
Depth: 8 km Mw: 4.23
Mo: 2.777e+15 Nt-m
Best double couple solutions
FP1: 47.09 47.53 131.94
FP2: 174.02 56.73 53.87
Iso.= -3.1 % CLVD= 7.7 %
Misfit= 0.326
64°
60°
295°
300°
305°
Misfit
0.5
0.4
0.3
5
10
15
20
25
30
Depth
V-comp
R-comp
T-comp
FRB (EM35)
287.00 deg.
436.98 km
0.03 - 0.06 Hz
Misfit: 0.227
0.219
0.235
2.54e-04 mm
50 sec
KAJQ (EM35)
217.25 deg.
562.28 km
0.03 - 0.06 Hz
Misfit: 0.396
0.197
0.528
0.463
3.48e-04 mm
100 sec
KNGQ (EM35)
262.48 deg.
633.46 km
0.03 - 0.06 Hz
Misfit: 0.342
0.171
0.681
0.175
4.77e-04 mm
100 sec
NANL (EM35)
188.15 deg.
709.02 km
0.03 - 0.06 Hz
Misfit: 0.373
0.374
0.371
2.00e-04 mm
100 sec
SCHQ (EM35)
206.60 deg.
973.61 km
0.03 - 0.06 Hz
Misfit: 0.292
0.292
1.21e-04 mm
100 sec
Source Time Function: 1.00 1.00 1.00

Figure 2d

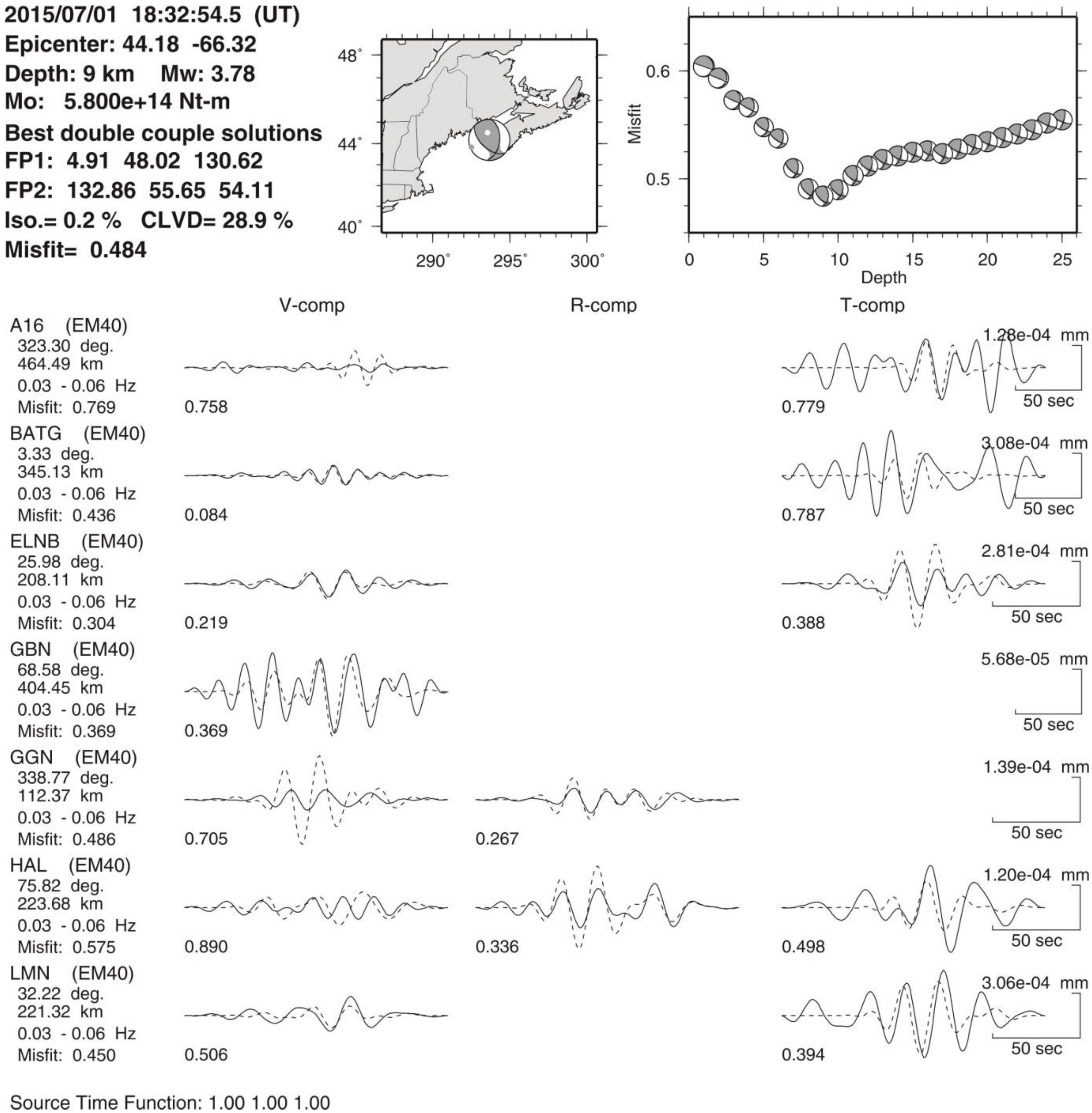
2015/07/01 18:32:54.5 (UT)
Epicenter: 44.18 -66.32
Depth: 9 km Mw: 3.78
Mo: 5.800e+14 Nt-m
Best double couple solutions
FP1: 4.91 48.02 130.62
FP2: 132.86 55.65 54.11
Iso.= 0.2 % CLVD= 28.9 %
Misfit= 0.484
48˚
44˚
40˚
290˚
295˚
300˚
Misfit
0.6
0.5
0
5
10
15
20
25
Depth
V-comp
R-comp
T-comp
A16 (EM40)
323.30 deg.
464.49 km
0.03 - 0.06 Hz
Misfit: 0.769
0.758
0.779
1.28e-04 mm
50 sec
BATG (EM40)
3.33 deg.
345.13 km
0.03 - 0.06 Hz
Misfit: 0.436
0.084
0.787
3.08e-04 mm
50 sec
ELNB (EM40)
25.98 deg.
208.11 km
0.03 - 0.06 Hz
Misfit: 0.304
0.219
0.388
2.81e-04 mm
50 sec
GBN (EM40)
68.58 deg.
404.45 km
0.03 - 0.06 Hz
Misfit: 0.369
0.369
5.68e-05 mm
50 sec
GGN (EM40)
338.77 deg.
112.37 km
0.03 - 0.06 Hz
Misfit: 0.486
0.705
0.267
1.39e-04 mm
50 sec
HAL (EM40)
75.82 deg.
223.68 km
0.03 - 0.06 Hz
Misfit: 0.575
0.890
0.336
0.498
1.20e-04 mm
50 sec
LMN (EM40)
32.22 deg.
221.32 km
0.03 - 0.06 Hz
Misfit: 0.450
0.506
0.394
3.06e-04 mm
50 sec
Source Time Function: 1.00 1.00 1.00

Figure 2e

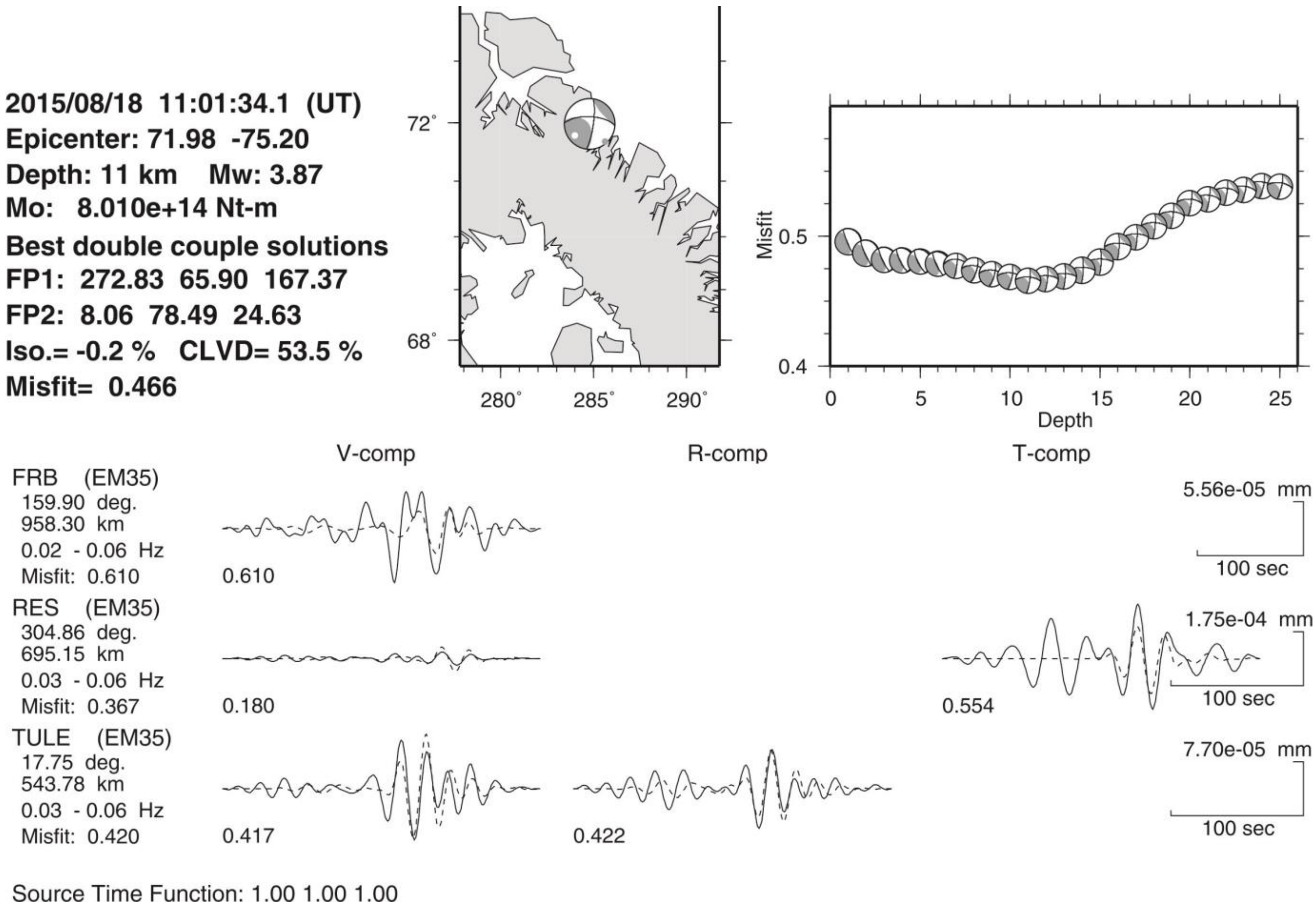
2015/08/18 11:01:34.1 (UT)
Epicenter: 71.98 -75.20
Depth: 11 km Mw: 3.87
Mo: 8.010e+14 Nt-m
Best double couple solutions
FP1: 272.83 65.90 167.37
FP2: 8.06 78.49 24.63
Iso.= -0.2 % CLVD= 53.5 %
Misfit= 0.466
72°
68°
280°
285°
290°
Misfit
0.5
0.4
0
5
10
15
20
25
Depth
V-comp
R-comp
T-comp
FRB (EM35)
159.90 deg.
958.30 km
0.02 - 0.06 Hz
Misfit: 0.610
0.610
5.56e-05 mm
100 sec
RES (EM35)
304.86 deg.
695.15 km
0.03 - 0.06 Hz
Misfit: 0.367
0.180
0.554
1.75e-04 mm
100 sec
TULE (EM35)
17.75 deg.
543.78 km
0.03 - 0.06 Hz
Misfit: 0.420
0.417
0.422
7.70e-05 mm
100 sec
Source Time Function: 1.00 1.00 1.00

Figure 2f

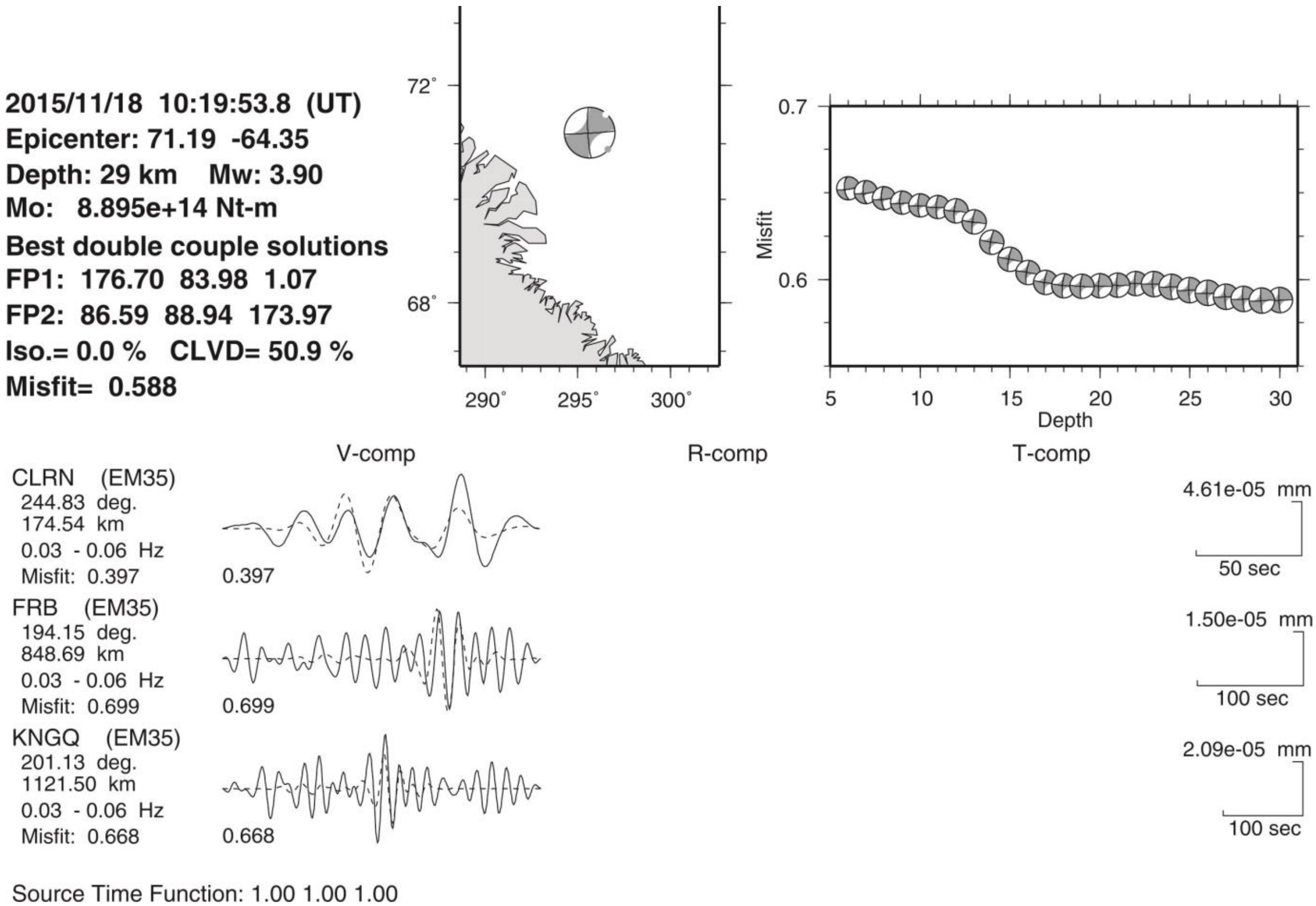

Figure 2g

Related Studies

The section below provides a brief summary of known studies or alternate solutions related to earthquakes catalogued in this paper. It also discusses one study that uses this catalog as part of its dataset.

The earthquake of 16 January 2015 occurred within the Lower St. Lawrence Seismic Zone. While it was not the subject of a detailed study, a regional moment tensor solution was also determined by Herrmann (2016), whose solution suggests a more north-south striking focal mechanism at a slightly greater depth (19 km) although his depth is not well–constrained.

Very few earthquakes occur onshore in Nova Scotia and thus the magnitude 3.8 earthquake and a smaller (M_N 2.2) aftershock that occurred on 1 July 2015 between Yarmouth and Digby provided a rare research opportunity. This earthquake has been studied in detail by Bent et al. (2016), who include the RCMT presented in the current study. A regional moment tensor solution was determined by Herrmann (2016). The focal mechanism of Herrmann (2016) is very similar to the one determined in this study although he obtains a slightly greater depth (12 km) and smaller M_W (3.5). The uncertainties in the two studies overlap and the difference is of little concern. The Bent et al. (2016) paper also included the results of the Regional Depth Phase Method, which gave an average depth of 10.5 km with results from individual stations ranging from 8.5 km to 12 km.

Magnitude recurrence rates are a primary data source for seismic hazard assessment in Canada and elsewhere. For hazard assessments to be uniform across the country it is essential that magnitudes be uniform in space and time. Moment magnitude is currently the preferred magnitude scale and a series of magnitude conversion relations have been developed for the various magnitude scales in common use across the country, in particular m_N in the east (Bent, 2011) and M_L in the west (Ristau et al., 2004, 2007). The Lg-based m_N scale cannot be used for offshore eastern events as Lg does not propagate in oceanic crust and the M_L scale is used instead. An M_L-M_W conversion relation could not be developed previously because of the scarcity of M_W values available for offshore earthquakes. However, with the implementation of the RCMT method in the east, the number of M_W's for this region has increased in recent years and it is now possible to establish a conversion relation. Using the results of this study, the two previous RCMT catalogs (Bent 2015a,b) and a handful of other offshore moment magnitudes, Bent (2016) was able to establish that for the eastern offshore region

$M_W = M_L – 0.21$.

Summary

Regional moment tensor solutions have been determined for seven moderate earthquakes occurring in eastern Canada during 2015. An eighth event was evaluated but a good quality solution was not obtained. These moment tensor solutions include focal mechanisms, depths and moment magnitudes which provide input into further studies regarding seismic hazard, regional seismotectonics or stress field to name a few. 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. A highlight of 2015 was obtained the first known focal mechanism solution for an earthquake occurring onshore in Nova Scotia. This paper is the third in what is intended to be a series of annual updates but other methods, such as an online database, for disseminating the solutions are being explored.

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Appendix
Complete Moment Tensor Solutions for Earthquakes in Table 1

For each event listed in Table 1 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.

2015-01-16

6	1.0000	1.0000	0.10000E+01	-0.10000E+01	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00	
7	0.6383	0.3988	-14.55354	-37.33959	105.98734	51.58540	-33.40866	-18.95355	
8	0.5895	0.4367	-50.58563	-83.81283	177.91947	61.31291	-27.15459	-16.92674	
9	0.4904	0.3997	-50.37606	-64.80808	128.56384	38.48860	-15.67374	-10.71592	
10	0.4348	0.3540	-54.90417	-58.99003	115.89596	34.67639	-14.88489	-9.85675	
11	0.4075	0.3335	-51.53506	-48.36773	96.01677	30.33400	-13.91085	-9.27203	
12	0.4063	0.3319	-49.08766	-41.40256	83.72205	28.15002	-13.52385	-8.37281	
13	0.4063	0.3366	-45.76126	-34.63634	72.43301	24.63219	-12.76856	-7.79880	
14	0.4148	0.3459	-43.65289	-28.63053	63.81720	20.57954	-11.98693	-6.59765	
15	0.4203	0.3549	-42.89937	-23.71064	57.83566	16.04286	-11.42153	-5.98854	
16	0.4293	0.3597	-44.57361	-30.76731	67.29354	18.52409	-12.81566	-5.66939	
17	0.4344	0.3668	-44.56448	-24.22722	60.90498	11.30639	-12.24749	-5.36323	
18	0.4442	0.3765	-44.59825	-18.45875	55.46468	4.90564	-11.49155	-4.49831	
19	0.4518	0.3842	-45.04793	-16.36241	53.75033	0.52477	-11.36356	-4.15790	
20	0.4622	0.3921	-44.09043	-14.03472	50.15677	-3.19851	-10.69047	-2.91683	
21	0.4675	0.3989	-42.59822	-13.55651	47.70741	-5.87896	-10.30454	-2.35484	
22	0.4748	0.4051	-39.85816	-12.24065	43.52717	-7.52408	-9.67043	-1.43744	
23	0.4799	0.4100	-38.54792	-12.22336	41.83038	-8.91826	-9.53671	-0.97044	
24	0.4846	0.4145	-37.34691	-12.35366	40.69834	-10.61087	-9.11329	-0.54072	
25	0.4927	0.4194	-36.91054	-11.32046	39.28597	-12.34162	-8.63249	-0.04720	
26	0.4974	0.4229	-37.34542	-11.88852	40.19195	-14.40595	-8.53190	0.44749	
27	0.5047	0.4277	-37.54827	-10.13509	39.20675	-16.60226	-7.97681	1.50065	
28	0.5084	0.4315	-37.78042	-8.88053	38.72646	-19.09637	-7.54820	2.10639	
29	0.5170	0.4368	-38.82877	-6.39808	38.03820	-21.69557	-7.16968	3.27507	
30	0.5194	0.4402	-39.33707	-5.30067	38.18216	-23.84622	-7.04869	4.00948	

a64	1	0.213541	0.111649	0.315434	0.986070
batg	-1	0.230942	0.230942	0.975102	0.965247
dmcq	0	0.098567	0.098567	0.995705	0.991545
ggn	0	0.228344	0.228344	0.889354	0.952783
hal	-1	0.571688	0.314153	0.829223	0.940659
lmn	-2	0.338555	0.338555	0.994235	0.988683
lmq	1	0.305749	0.305749	0.911415	0.996658
pkme	0	0.531903	0.100032	0.734332	0.761344
sado	-3	0.468104	0.468104	0.927126	0.778569

2015-02-12

6	0.4425	0.3465	-160.33099	719.06254	-324.41345	760.22048	-1249.69094	-1591.44765
7	0.4547	0.3570	-330.29906	518.89778	98.81938	749.68621	-1089.85566	-1342.45626
8	0.4561	0.3769	-627.48165	240.99490	649.50938	743.74051	-990.17859	-1171.89872
9	0.4359	0.3792	-817.86776	117.18850	843.34033	766.89200	-921.64253	-1059.91076
10	0.4087	0.3652	-1084.04562	241.34849	897.08125	1059.11416	-1155.52440	-1280.86847
11	0.4047	0.3634	-952.49364	361.44931	580.04517	1031.81697	-1058.94598	-1154.27768
12	0.4030	0.3636	-863.22167	465.29814	358.60136	1033.57468	-1017.66447	-1096.09388
13	0.4021	0.3658	-823.19289	560.84118	208.28650	1070.02077	-1021.83931	-1091.71426
14	0.4024	0.3690	-770.82733	617.15706	92.63974	1067.37124	-995.23251	-1055.53404
15	0.4061	0.3760	-708.58946	634.37341	6.47783	1049.91210	-974.52846	-1045.21849
16	0.4065	0.3801	-684.16228	680.17378	-59.33699	1074.78021	-1126.51629	-1189.88352
17	0.4066	0.3799	-663.53146	741.69337	-137.95932	1078.08333	-1105.55619	-1144.75539
18	0.4094	0.3829	-625.83300	763.95697	-195.58525	1063.12976	-1091.36732	-1122.94162
19	0.4145	0.3872	-630.36915	796.64441	-223.57035	1077.04801	-1113.91340	-1152.33184
20	0.4179	0.3888	-502.58835	674.19709	-217.60543	885.51290	-921.19863	-948.89941
21	0.4182	0.3902	-469.49576	675.27655	-250.13853	885.96564	-914.12378	-941.54840
22	0.4169	0.3913	-469.97014	706.57942	-281.02821	911.11708	-945.43712	-970.35464
23	0.4166	0.3924	-453.22143	709.06169	-298.64335	902.10563	-940.76083	-962.13334
24	0.4165	0.3936	-437.23477	709.39819	-313.34742	894.55465	-935.95009	-953.39786
25	0.4144	0.3910	-487.68902	806.66190	-361.07288	981.75411	-1002.47188	-1002.59804
26	0.4132	0.3886	-472.08109	806.79851	-375.02361	977.83893	-996.49961	-994.98363
27	0.4131	0.3877	-455.98652	804.43844	-387.00121	975.72717	-990.80006	-984.17504
28	0.4157	0.3892	-469.24526	821.73472	-392.07894	1004.84122	-1020.81257	-1017.69481
29	0.4153	0.3884	-432.72342	805.51190	-411.39033	1022.18570	-1014.35345	-1009.92117
30	0.4155	0.3886	-411.07339	797.21763	-422.25519	1027.48875	-1006.69113	-996.35327

eunu	3	0.479099	0.196224	0.760970	0.480103
frb	-1	0.238704	0.188142	0.247161	0.280808
res	1	0.320653	0.327189	0.367837	0.266933
tule	2	0.347453	0.247196	0.447709	0.908796

2015-05-02

6	0.5693	0.5142	-8.83893	-107.92059	122.64644	-23.53209	38.44490	-23.68848
7	0.5409	0.4714	-18.48111	-121.44272	136.30752	-23.95595	31.58187	-18.75652
8	0.5463	0.4612	-18.08112	-141.52418	139.53462	-27.97591	31.07964	-19.04642
9	0.5771	0.4933	1.25897	-124.46771	93.52390	-28.14246	27.75347	-15.90054
10	0.6166	0.5416	24.10837	-119.11164	60.34111	-31.96841	27.68183	-16.16883
11	0.6333	0.5756	41.24185	-109.71026	35.07338	-33.83391	26.44722	-15.28285
12	0.6117	0.5625	52.41985	-104.02119	20.60096	-35.13760	25.38340	-14.61892
13	0.6277	0.5794	59.36581	-100.50715	12.44678	-35.88439	24.46748	-14.14095
14	0.6389	0.5961	63.52792	-98.14672	7.74941	-36.15961	23.66891	-13.80305
15	0.6486	0.6136	65.81959	-96.37232	5.00032	-36.05239	22.95627	-13.61032
16	0.6973	0.6622	63.24151	-94.35682	8.49960	-34.70797	24.52536	-14.75505
17	0.7068	0.6756	65.69033	-94.19061	6.37642	-34.86211	24.70496	-14.89849
18	0.7222	0.6895	59.23045	-82.81906	4.31225	-30.54484	22.03288	-13.33011
19	0.7311	0.6998	58.14598	-80.03445	3.26842	-29.17743	21.68635	-13.18764
20	0.7407	0.7079	49.67990	-67.41755	2.03121	-24.43919	18.59140	-11.34735
21	0.7460	0.7138	50.19223	-67.70801	1.57447	-23.95063	19.09762	-11.73215
22	0.7518	0.7187	48.76822	-65.53476	1.15425	-22.46379	18.93077	-11.71514
23	0.7556	0.7240	48.40860	-63.11623	-0.41917	-20.66676	19.20504	-11.37304
24	0.7603	0.7270	47.55678	-60.71423	-1.54558	-18.33304	19.73894	-10.85049
25	0.7664	0.7295	57.05199	-71.30251	-3.22547	-19.50703	24.68024	-12.67847
26	0.7697	0.7336	52.65388	-64.85340	-3.77259	-15.65100	23.60655	-11.49207
27	0.7745	0.7354	51.92871	-63.16640	-4.29526	-13.12562	23.90338	-11.15617
28	0.7791	0.7378	51.40201	-62.04318	-4.69608	-10.77046	24.09619	-10.88657
29	0.7822	0.7401	52.14852	-62.22134	-5.08774	-9.42515	24.06699	-10.78084
30	0.7865	0.7427	54.58763	-64.20844	-5.25212	-8.02503	24.73626	-11.02117

eunu	3	0.607551	0.458448	0.633872	0.730335
kull	1	0.463388	0.240209	0.440457	0.709498
res	1	0.409852	0.409852	0.952289	0.994306
tule	-1	0.363848	0.133647	0.565151	0.392745

2015-06-03

6	0.3719	0.3616	28.45205	-153.53575	135.94867	83.04610	102.26745	82.71152
7	0.3556	0.3417	11.69584	-227.76793	215.06308	108.72854	116.09821	91.68316
8	0.3514	0.3259	11.47215	-235.71259	198.38157	109.21962	105.28070	81.24411
9	0.3662	0.3328	46.85952	-224.02434	132.47028	118.06560	103.49522	76.40772
10	0.3827	0.3468	86.66312	-198.73417	64.09470	124.41776	99.46315	69.60878
11	0.4032	0.3531	114.28909	-182.67773	24.16446	132.16846	97.01735	65.12278
12	0.4236	0.3617	127.53358	-168.97534	2.84839	135.19901	92.27496	60.74066
13	0.4458	0.3717	133.99453	-158.98730	-8.77985	137.18752	88.29971	57.35627
14	0.4689	0.3807	136.37241	-150.67048	-15.61451	138.30819	84.87476	54.68138
15	0.4919	0.3896	136.32941	-143.21093	-19.96414	138.80369	81.85309	52.52938
16	0.5157	0.4035	135.45959	-133.95128	-25.26973	139.77121	89.60202	57.81707
17	0.5381	0.4081	131.88251	-124.00002	-29.20054	138.75368	87.26084	55.08658
18	0.5536	0.4132	128.11151	-116.07288	-31.41384	136.45657	85.61521	52.38530
19	0.5677	0.4180	123.46110	-106.74744	-34.67395	134.93632	83.20628	51.06400
20	0.5817	0.4240	118.70818	-98.23315	-37.02191	135.76106	81.51101	50.43189
21	0.5971	0.4318	112.21588	-89.16054	-38.37993	134.19443	79.15734	48.95021
22	0.6095	0.4387	108.31362	-80.41070	-42.07685	132.71645	77.04600	47.56299
23	0.6209	0.4455	104.98450	-72.24921	-45.83620	131.45070	74.87934	46.27378
24	0.6303	0.4519	102.36222	-64.77562	-49.67678	130.45189	72.63619	45.06935
25	0.6355	0.4593	101.95746	-60.40401	-52.71490	128.21518	71.01213	43.68200
26	0.6403	0.4638	100.88326	-54.29759	-56.78244	127.79457	68.77275	42.53922
27	0.6438	0.4681	100.59061	-48.82563	-61.01050	127.78089	66.56701	41.37066
28	0.6459	0.4684	101.14733	-45.50267	-64.34684	132.63435	64.60031	42.07393
29	0.6500	0.4733	99.90107	-40.63219	-67.25924	134.03923	62.74356	40.78303
30	0.6500	0.4758	102.52690	-36.93690	-72.54140	135.88941	60.85437	39.36432

frb	-1	0.226892	0.219116	0.234668	0.538146
kajq	-1	0.396032	0.196974	0.528178	0.462943
kngq	-1	0.342379	0.170860	0.681280	0.174999
nanl	0	0.372608	0.374311	0.370905	1.000000
schq	0	0.291691	0.291691	0.924113	0.831723

2015-07-01

1	0.6691	0.6040	11.13422	-12.42304	1.84622	-10.88687	72.90223	24.76094
2	0.6510	0.5929	12.38352	-14.09193	3.00054	-11.75824	39.23248	14.53949
3	0.6227	0.5727	10.29529	-12.35781	3.84615	-10.12127	21.64135	7.36321
4	0.6056	0.5658	10.73194	-14.46709	6.62732	-11.00195	17.34583	4.83932
5	0.5825	0.5480	10.39630	-18.93092	12.82052	-12.79351	15.91105	3.61004
6	0.5681	0.5370	11.67491	-21.69294	14.39428	-14.69062	17.10488	3.12367
7	0.5403	0.5098	8.83949	-28.65699	24.58355	-16.83105	16.30154	1.68924
8	0.5230	0.4907	8.04533	-46.99517	42.95727	-25.27519	21.05633	0.84542
9	0.5083	0.4840	8.54085	-50.32372	42.20157	-27.63614	20.18717	-0.03142
10	0.5104	0.4900	12.08166	-50.44813	36.30181	-29.75924	19.43114	-0.54987
11	0.5198	0.5028	15.40307	-48.19079	29.70460	-30.55405	18.21097	-0.90275
12	0.5280	0.5119	17.91032	-46.49131	25.13884	-31.25395	17.22851	-1.46204
13	0.5338	0.5178	19.71775	-45.26267	22.07918	-31.96711	16.48212	-2.05609
14	0.5395	0.5212	20.83890	-44.40904	20.17167	-32.23352	15.68271	-2.77468
15	0.5461	0.5246	21.73276	-43.67012	18.58948	-32.85440	15.16844	-3.32632
16	0.5516	0.5257	21.70414	-44.34406	19.87504	-33.42886	16.77665	-4.25651
17	0.5443	0.5231	16.29729	-31.47023	13.25297	-24.69541	11.88935	-3.26402
18	0.5506	0.5274	16.81729	-30.56609	11.95721	-25.21069	11.74784	-3.19771
19	0.5581	0.5316	17.25834	-29.76431	10.85683	-25.56965	11.67931	-3.43084
20	0.5645	0.5343	17.56133	-29.06038	9.88767	-25.98450	11.66836	-3.72711
21	0.5715	0.5380	17.85704	-28.55842	9.09522	-26.28485	11.68974	-3.94880
22	0.5779	0.5416	18.04270	-28.01018	8.34826	-26.72429	11.69736	-4.18927
23	0.5839	0.5451	18.31490	-27.49384	7.58924	-27.24507	11.76442	-4.42877
24	0.5927	0.5514	17.61306	-25.64464	6.56951	-26.33145	11.19596	-4.39393
25	0.5992	0.5545	17.87393	-25.29999	6.00203	-26.88291	11.24634	-4.56044

a16	-1	0.768870	0.758392	0.961631	0.779348
batg	0	0.435891	0.084319	0.972519	0.787463
elnb	0	0.303621	0.218956	0.830158	0.388286
gbn	-2	0.369249	0.369249	0.972238	0.991236
ggn	0	0.485962	0.704754	0.267171	0.885142
hal	2	0.574616	0.889673	0.335820	0.498353
lmn	0	0.450138	0.506098	0.879825	0.394177

2015-08-18

1	0.5022	0.4956	-16.36064	40.70148	-23.73591	27.18529	-74.83132	-179.06340
2	0.4916	0.4869	-17.38996	44.72838	-25.45951	31.04997	-60.52065	-135.14248
3	0.4896	0.4819	-16.85837	44.15181	-24.67937	32.86535	-43.88262	-95.41878
4	0.4920	0.4814	-17.00186	42.57633	-22.00564	34.30741	-36.13201	-75.43045
5	0.4942	0.4805	-17.83780	39.31870	-16.42644	36.42976	-31.19431	-63.93040
6	0.4976	0.4788	-19.88413	34.20601	-10.51877	38.81985	-32.32017	-65.28487
7	0.4986	0.4771	-21.24211	26.84808	-2.04013	40.02401	-27.26134	-53.72648
8	0.4969	0.4738	-23.02297	21.95967	3.40087	44.10989	-25.19833	-48.07907
9	0.4948	0.4706	-21.78798	19.43064	3.11727	49.55807	-23.79832	-44.08686
10	0.4956	0.4687	-17.83152	18.96054	-1.48956	55.58018	-22.75457	-41.13510
11	0.4919	0.4657	-12.99801	16.48093	-4.09017	64.65845	-22.10945	-38.95028
12	0.4934	0.4670	-8.32269	14.67312	-7.16522	72.59604	-21.52792	-37.19933
13	0.4943	0.4688	-4.30006	11.93583	-8.50474	80.80882	-21.12918	-35.87446
14	0.5090	0.4736	-2.41688	14.95237	-13.92012	129.37449	-31.44784	-52.07800
15	0.5040	0.4801	-0.79035	14.19587	-14.97111	131.66899	-30.98719	-51.01716
16	0.5141	0.4919	-1.23639	16.67149	-17.05767	126.65054	-35.23692	-57.56458
17	0.5215	0.4990	-3.47624	16.29076	-14.05506	89.22315	-27.25759	-44.39681
18	0.5319	0.5075	-6.66579	20.99311	-15.62132	82.63203	-28.27587	-46.52822
19	0.5422	0.5157	-10.36606	25.45378	-16.39483	75.42060	-29.68881	-48.73742
20	0.5530	0.5252	-12.33111	28.06028	-17.00373	67.60584	-29.72822	-48.70683
21	0.5582	0.5281	-14.20467	31.16880	-18.25768	64.45819	-31.09150	-50.81669
22	0.5647	0.5334	-14.98693	32.40701	-18.67553	60.00461	-31.17677	-50.80836
23	0.5672	0.5353	-17.03936	35.37996	-19.53473	57.55529	-31.09109	-50.50589
24	0.5714	0.5386	-17.13616	35.82955	-19.85562	55.37012	-31.24828	-50.55923
25	0.5723	0.5379	-17.69604	37.48398	-20.96642	56.21525	-32.73051	-52.72170

frb 1 0.610131 0.610131 0.935852 0.835397
res -2 0.367103 0.180108 0.868228 0.554099
tule 0 0.419843 0.417368 0.422317 0.860810

2015-11-18

6	0.6624	0.6526	3.23476	-6.16487	2.92968	18.73150	9.63226	0.74676
7	0.6610	0.6502	2.51573	-6.64322	4.12204	21.92745	8.67817	0.39066
8	0.6590	0.6467	1.43127	-6.57736	5.14133	25.08976	8.10153	0.03918
9	0.6575	0.6442	-0.42365	-6.08728	6.50683	28.48461	7.73659	-0.28675
10	0.6553	0.6427	-3.09923	-4.61527	7.71118	30.42311	7.20164	-0.60087
11	0.6529	0.6417	-6.77741	-2.42213	9.19667	33.18607	7.11982	-0.96431
12	0.6524	0.6395	-16.32384	1.04471	15.27585	51.27789	10.35630	-1.97421
13	0.6438	0.6331	-21.84247	5.72862	16.11145	51.04824	10.07235	-2.40415
14	0.6340	0.6215	-18.55512	6.67556	11.87854	36.46070	7.15469	-1.96675
15	0.6274	0.6116	-19.77021	7.82141	11.94853	36.40136	7.11377	-2.10776
16	0.6243	0.6040	-20.77596	6.40274	14.37370	41.14867	8.37837	-2.58048
17	0.6236	0.5982	-19.83386	4.57508	15.26070	44.09569	8.56870	-2.61006
18	0.6242	0.5965	-17.24705	1.63171	15.61873	45.88584	8.39543	-2.49022
19	0.6258	0.5961	-15.31706	-1.53860	16.86064	50.33218	8.58769	-2.48149
20	0.6260	0.5963	-12.96794	-4.58606	17.56057	53.05000	8.45733	-2.38602
21	0.6259	0.5967	-10.98589	-7.36082	18.35470	56.04544	8.35308	-2.32578
22	0.6274	0.5977	-10.52370	-8.53814	19.07154	57.77396	8.13108	-2.21931
23	0.6304	0.5974	-9.18951	-11.46841	20.66912	62.91125	8.38406	-2.25976
24	0.6301	0.5958	-7.87764	-13.58050	21.47046	66.14585	8.33591	-2.27758
25	0.6291	0.5939	-6.70929	-15.56244	22.28490	69.63661	8.29546	-2.32573
26	0.6279	0.5921	-5.63038	-17.42583	23.06999	73.25246	8.26284	-2.40125
27	0.6261	0.5901	-4.60536	-19.25510	23.87464	77.29217	8.23656	-2.51743
28	0.6243	0.5887	-3.62645	-20.89466	24.53560	81.25025	8.21467	-2.65808
29	0.6224	0.5878	-2.68008	-22.34504	25.03943	85.26017	8.20096	-2.83681
30	0.6207	0.5880	-1.77913	-23.48965	25.28202	89.02881	8.19607	-3.04715

clrn	1	0.396604	0.396604	1.000000	0.977589
frb	0	0.699023	0.699023	0.962665	1.000000
kngq	2	0.667729	0.667729	0.968135	1.000000