Stochastic relation between anomalous propagation in the line-of-sight VHF radio band and occurrences of earthquakes

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We would like to thank Dr. M. N. Dubrov for taking time for reading and evaluating our manuscript. We would like to answer to comments follows:

Comment 1: *In order to reduce the diurnal variation of a signal strength the authors divided a day into 72 time slots and performed a statistical analysis separately for each specific time slot, page 6833, line 24. Mean values (m) and standard deviations (σ) of observed data were separately calculated for each time slot through the observing period, page 6834, line 1. From these explanations, it is not quite clear how many mean values (m) and standard deviations (σ) will be obtained through the observing period completely. Reader can understand this only after thorough investigation the Figure 3, 5 and 6: there are only 72 mean values (m) and 72 standard deviations (σ) which are repeated every day for each temporal evolution on the Figures. This passage of the paper text needs for explanation that is more comprehensive.*

Authors' answer: We needed a new criterion for detecting anomaly in the line-of-sight propagation. Because the transmitting waves from line-of-sight region can be received normally. Then, we adopt the statistical criterion which is based the means (m) and standard deviations (σ), written in the paper from page 6833, line 17 to page 6834, line 10.

However, received signal strength even from the line-of-sight region has fluctuation. Normally received signal strength in the daytime is weaker than in the nighttime. Fluctuation range in the daytime is smaller than in the nighttime. If only one mean (m) and only one standard deviation (σ) are adopted as criterion throughout a day for detecting anomaly, decision of detecting anomaly is different between daytime and nighttime. Therefore, we divided a day into 72 time slots and calculated the mean (m) and standard deviation (σ) each time slot separately.

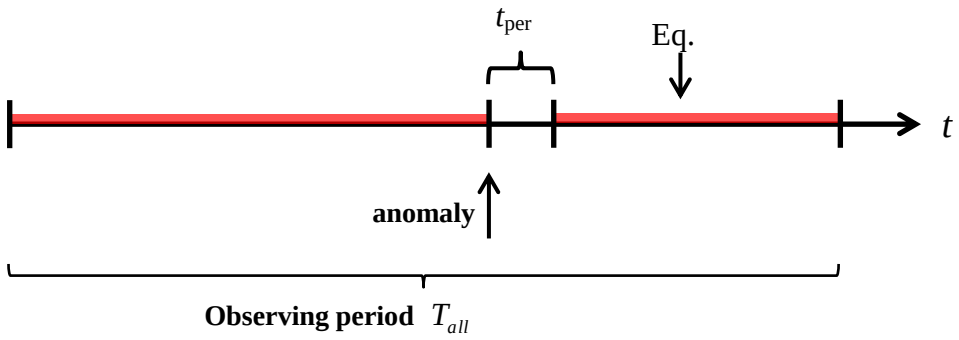
The other hand, Figure 3, 5 and 6 were drown by using smoother lines of means (m) and standard deviations (σ) which were used 5-minute time slots, a day divided into 288 time slots. Because 20-minutes time slots graph is choppy. Both statistical results, in 20-minute time slots and 5-minute time slots, are almost coincidence. One example is attached to end of this supplement as appendix, which is numerical list of the means (m) and plus minus three standard deviations ($m \pm 3\sigma$) in each time slots of Fig. 3 (b).

Comment 2: *The authors use the equation for unrelated probability $P_{unrel}(t_{per})$ estimation without any basis comments or references on its validity, page 6835, line 11. It is important because the using the other equations for statistic of two unrelated occurrences: anomalous propagations (1) and earthquakes (2) would bring to the probability P_{unrel} dependence not only on the defined length of time t_{per}, page 6835, line 16, but on the number of occurrences N_{anom} and number of earthquakes N_{eq} too. The results of calculations may differ from the obtained in the paper.*

Authors' answer: The equation of the probability P_{unrel}, page 6835, line 11, is original. However, it can be obtained by using basic probability theory, as follows.

Let's consider that only one anomaly and only one earthquake occurs under no relation during the entire observing period, T_{all}. When earthquake occurs within defined length of time period t_{per} after the anomaly, we consider that the earthquake is associated with anomaly.

At first, we derive a probability of NOT sequential occurrence of both in defined time period t_{per}, $\overline{P}_{unrel}\left(t_{per}\right)\Big|_{Neq=1}$. To simplify, time of occurrence of anomaly is fixed, a black up-pointing allow as below figure. The $\overline{P}_{unrel}\left(t_{per}\right)\Big|_{Neq=1}$ is the probability of occurrence of earthquake at complementary time period, indicated in red lines as following figure.



Therefore, the $\overline{P}_{unrel}\left(t_{per}\right)\Big|_{Neq=1}$ can be obtained as follows.

$$\overline{P}_{unrel}\left(t_{per}\right)\Big|_{Neq=1} = \frac{T_{all} - t_{per}}{T_{all}}$$

Next, let's consider two earthquakes occur out of defined time period, t_{per}. It's probability is equal to the square of $\overline{P}_{unrel}\left(t_{per}\right)\Big|_{Neq=1}$. Because it is the conditional probability that first earthquake occurs out of t_{per} and second earthquake occurs out of t_{per} too.

$$\overline{P}_{unrel}\left(t_{per}\right)\Big|_{Neq=2} = \left(\frac{T_{all}-t_{per}}{T_{all}}\right)^2$$

By the same token, when the number of earthquakes which occur out of t_{per} is N_{eq}, the probability can be obtained as next equation.

$$\overline{P}_{unrel}\left(t_{per}\right)\Big|_{Neq} = \left(\frac{T_{all}-t_{per}}{T_{all}}\right)^{Neq}$$

The event which the anomaly and earthquakes just happen to occur in a defined time period t_{per} is complementary event of $\overline{P}_{unrel}\left(t_{per}\right)\Big|_{Neq}$. Therefore, the unrelated probability $P_{unrel}\left(t_{per}\right)$ of the sequential occurrence of the anomaly and earthquakes can be obtained as follows.

$$P_{unrel}\left(t_{per}\right) = 1 - \overline{P}_{unrel}\left(t_{per}\right)\Big|_{Neq} = 1 - \left(\frac{T_{all}-t_{per}}{T_{all}}\right)^{N_{eq}}$$

Above explanation is in the case of one anomaly and N_{eq} times earthquakes. For each anomaly the probability $P_{unrel}\left(t_{per}\right)$ is same, therefore, the $P_{unrel}\left(t_{per}\right)$ is the probability that earthquakes just happen to occur after one anomaly sequentially in a defined time period t_{per} under no relation.

On the other hand, the probability $P_{obs}\left(t_{per}\right)$, page 6835, line 20, is the observational probability. It is obtained as the number of occurrences of anomalies associated with earthquakes divided by the number of all anomalies. It means the $P_{obs}\left(t_{per}\right)$ is occurrence probability of anomaly associated with earthquake for each anomaly. Both the $P_{unrel}\left(t_{per}\right)$ and the $P_{obs}\left(t_{per}\right)$ are the probability for each anomaly. Therefore, the number of occurrences of anomalies, N_{anom}, is not included in the equation of the probability P_{unrel}, page 6835, line 11.

Short description of the above explanation is added into the revised paper.

Comment 3: *The author should comment or show any data on the weather observation during occurrences of anomalous VHF radio wave propagation. Was there connection between the recorded anomalies and the atmospheric phenomena? It is necessary to give the exact number of earthquakes that happened before and after anomalous VHF propagation occurrences, ("before" is included to running paper title).*

Authors' answer: We had considered the relation between the anomalous VHF radio propagation and the atmospheric phenomena. Until now, we have no clear statistical results which indicate existence of the relation between both. However, we have noticed an empirical relation between anomalous VHF radio wave propagation and surface wind velocity near the propagation path. We investigated the weather data of Kumagaya local meteorological observatory, which located near the propagation path from Tokyo-tower to Kiryu monitoring point. It is located 64km from Tokyo-tower. When the wind velocity was 3 m/s or more at Kumagaya observatory, anomalous propagation was not monitored at all. Although an anomalous propagation happened to appear under no wind condition, it disappeared with increasing the wind velocity.

The number of earthquakes that happened after anomalous VHF propagation occurrences was four for t_{per} = 2 days, it corresponded to the number N_{obs} = 4 for $M \geq 4.5$ in Table 2, page 6841. The other hand, no earthquake happened before anomalous VHF propagation occurrences for same t_{per}.

Short descriptions about the relationship to surface wind velocity and the number of earthquakes that happened before and after anomalies are added into the revised paper.

Comment 4: *The authors have to explain or present more correct data imaging on the Figures (Fig. 3, 5 and 6): 72 mean values (m) and 72 standard deviations (σ) in every day yield 20 minutes digitization. Why more detail temporal evolutions are shown on the Figures.*

Authors' answer: Answer for comment 4 is same explanation for comment 1.

Comment 5: *The presented review on the electromagnetic phenomena associated with seismicity (1 Introduction) would be more valuable if earlier investigations in this field were mentioned, for example:* . . . . . .

Authors' answer: We understood your comment. We missed some earlier investigations, therefore, we add a reference as follows to the revised paper.

Gokhberg, M. B., Morgounov, V. A., Yoshino, T., and Tomizawa, I.: Experimental measurement of electromagnetic emissions possibly related to earthquakes in Japan, J. Geophys. Res., 87, B9, 7824-7828, 1982.

Comment 6: *The References (page 6839, line 4-21) require checking and correction in author's names and journal title.*

Authors' answer: Thank you for pointing out mistakes in References. We checked the references and corrected mistakes. Moreover, we changed the difficult-to-get references for readers to easily-obtainable other papers. Therefore, we modify the references as follows in the revised paper.

References

Fujiwara, H., Kamogara, M., Ikeda, M., Liu, J.Y., Sakata, H., Chen, Y. I., Ofuruton, H., Muramatsu, S., Chuo, Y. J., and Ohtsuki, Y. H.: Atmospheric anomalies observed during earthquake occurrences, Geophys. Res. Lett., 31, L17110, doi:10.1029/2004GL019865, 2004.

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Hayakawa, M., Kawate, R., Molchanov, O. A., and Yumoto, K.: Results of ultra-low-frequency magnetic field measurements during the Guam earthquake of 8 August 1993, Geophys. Res. Lett., 23, 3, 241-244, doi:10.1029/95GL02863, 1996.

Hayakawa, M., Kasahara, Y., Nakamura, T., Muto, F., Horie, T., Maekawa, S., Hobara, Y., Rozhnoi, A. A., Solovieva, M., and Molchanov, O. A.: A statistical study on the correlation between lower ionospheric perturbations as seen by subionospheric VLF/LF propagation and earthquakes, J. Geophys. Res., 115, A09305, doi:10.1029/2009JA015143, 2010.

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Smith, A. C. F., Bernardi, A., McGill, P. R., Ladd, M. E., Helliwell, R. A., and Villard Jr., O. G.: Low-frequency magnetic field measurements near the epicenter of the Ms 7.1 Loma Prieta earthquake, Geophys. Res. Lett., 17, 9, 1465-1468, doi:10.1029/GL017i009p01465, 1990.

Yasuda, Y., Ida, Y., Goto, T., and Hayakawa, M.: Interferometric direction finding of over-horizon VHF transmitter signals and natural VHF radio emissions possibly associated with earthquakes, Radio Sci., 44, RS2009, doi:10.1029/2008RS003884, 2009.

Yonaiguchi, N., Ida, Y. and Hayakawa, M.: On the statistical correlation of over-horizon VHF signals with meteorological radio ducting and seismicity, J. Atmos. Sol-terr. Phys., 69, 661-674, doi:10.1016/j.jastp.2007.01.007, 2007.

Comment 7: *Some English expressions are wrong or unclear: panel are, page 6834, line 4; period associated anomalous propagation with, page 6835, line 12; probability shows comparable*

to, page 6835, line 24, etc.

Authors' answer: Thank you pointing out some wrong expressions. We checked expressions and correct in the revised paper.

Appendix

List of local time, means (*m*), *m* plus 3 standard deviations (σ) and *m* minus 3σ of 5-minute time slots in Fig. 3(b)

(VHF TV broadcasting wave: TV Asahi, f=205.25MHz)

Time(LT)	m	$m+3\sigma$	$m-3\sigma$	(in dBm)
00:00	-74.065	-61.256	-86.874	
00:05	-73.964	-61.142	-86.786	
00:10	-74.049	-60.719	-87.378	
00:15	-74.028	-61.070	-86.985	
00:20	-73.959	-61.232	-86.686	
00:25	-73.994	-61.155	-86.834	
00:30	-73.962	-61.406	-86.517	
00:35	-73.862	-61.125	-86.599	
00:40	-73.833	-61.244	-86.422	
00:45	-73.795	-60.936	-86.654	
00:50	-73.855	-61.170	-86.540	
00:55	-73.788	-61.391	-86.184	
01:00	-73.891	-61.292	-86.489	
01:05	-73.718	-61.176	-86.259	
01:10	-73.467	-60.860	-86.074	
01:15	-73.490	-60.733	-86.247	
01:20	-73.701	-60.406	-86.996	
01:25	-73.718	-60.472	-86.964	
01:30	-73.722	-60.428	-87.015	
01:35	-73.641	-60.566	-86.717	
01:40	-73.680	-60.433	-86.926	
01:45	-73.604	-60.439	-86.769	
01:50	-73.583	-60.784	-86.383	
01:55	-73.535	-60.713	-86.358	
02:00	-73.863	-61.055	-86.672	
02:05	-73.856	-60.889	-86.823	
02:10	-73.865	-60.962	-86.768	
02:15	-73.755	-60.588	-86.922	
02:20	-73.896	-60.507	-87.285	
02:25	-73.666	-60.359	-86.973	
02:30	-73.512	-60.019	-87.005	
02:35	-73.478	-60.274	-86.681	
02:40	-73.527	-60.378	-86.676	
02:45	-73.493	-60.054	-86.931	
02:50	-73.535	-60.361	-86.710	
02:55	-73.543	-59.971	-87.116	
03:00	-73.323	-59.880	-86.766	
03:05	-73.375	-59.708	-87.042	
03:10	-73.256	-60.263	-86.249	
03:15	-73.424	-59.956	-86.893	
03:20	-73.377	-60.302	-86.453	
03:25	-73.200	-59.923	-86.476	
03:30	-73.274	-59.971	-86.577	
03:35	-73.192	-59.791	-86.594	

217	03:40	-73.248	-59.878	-86.617
218	03:45	-73.332	-59.906	-86.759
219	03:50	-73.250	-59.937	-86.564
220	03:55	-73.221	-59.234	-87.207
221	04:00	-73.539	-59.300	-87.778
222	04:05	-73.424	-59.894	-86.954
223	04:10	-73.491	-60.362	-86.620
224	04:15	-73.409	-60.234	-86.584
225	04:20	-73.218	-59.846	-86.589
226	04:25	-73.127	-59.603	-86.652
227	04:30	-73.396	-60.318	-86.474
228	04:35	-73.461	-60.406	-86.516
229	04:40	-73.351	-60.291	-86.410
230	04:45	-73.490	-60.279	-86.701
231	04:50	-73.480	-59.824	-87.137
232	04:55	-73.356	-60.060	-86.652
233	05:00	-73.431	-60.111	-86.752
234	05:05	-73.409	-60.513	-86.305
235	05:10	-73.215	-60.407	-86.023
236	05:15	-73.369	-60.272	-86.466
237	05:20	-73.443	-60.237	-86.649
238	05:25	-73.519	-60.552	-86.485
239	05:30	-73.452	-60.411	-86.493
240	05:35	-73.418	-60.663	-86.173
241	05:40	-73.400	-60.328	-86.472
242	05:45	-73.449	-60.423	-86.474
243	05:50	-73.141	-60.599	-85.683
244	05:55	-73.229	-60.352	-86.105
245	06:00	-73.320	-60.134	-86.505
246	06:05	-73.673	-60.634	-86.712
247	06:10	-73.772	-60.369	-87.174
248	06:15	-73.361	-60.674	-86.048
249	06:20	-73.204	-60.510	-85.898
250	06:25	-73.100	-60.436	-85.765
251	06:30	-73.290	-60.732	-85.847
252	06:35	-73.546	-60.684	-86.408
253	06:40	-73.581	-60.605	-86.557
254	06:45	-73.631	-60.878	-86.384
255	06:50	-73.622	-60.548	-86.696
256	06:55	-73.351	-60.606	-86.097
257	07:00	-73.509	-60.733	-86.285
258	07:05	-73.662	-60.818	-86.507
259	07:10	-73.765	-60.448	-87.081
260	07:15	-74.177	-60.662	-87.692
261	07:20	-74.037	-60.879	-87.194
262	07:25	-73.823	-60.644	-87.002
263	07:30	-73.792	-60.774	-86.810
264	07:35	-74.088	-60.598	-87.578
265	07:40	-74.104	-60.517	-87.692
266	07:45	-73.975	-60.522	-87.428
267	07:50	-74.168	-60.712	-87.624
268	07:55	-74.696	-60.866	-88.526
269	08:00	-74.058	-60.664	-87.452
270	08:05	-74.022	-60.508	-87.536
271	08:10	-74.356	-60.835	-87.878
272	08:15	-74.418	-60.551	-88.286
273	08:20	-74.514	-60.915	-88.112
274	08:25	-74.709	-61.216	-88.202
275	08:30	-74.635	-61.135	-88.135
276	08:35	-74.933	-61.411	-88.455
277	08:40	-75.308	-61.774	-88.842
278	08:45	-75.291	-62.075	-88.508
279	08:50	-75.575	-62.297	-88.853
280	08:55	-75.747	-62.207	-89.287
281	09:00	-75.611	-62.408	-88.814

282	09:05	-75.696	-62.725	-88.667
283	09:10	-75.800	-63.144	-88.457
284	09:15	-75.886	-63.025	-88.747
285	09:20	-76.068	-63.240	-88.896
286	09:25	-76.348	-63.729	-88.966
287	09:30	-76.547	-63.970	-89.124
288	09:35	-76.624	-64.403	-88.846
289	09:40	-76.687	-64.274	-89.099
290	09:45	-76.743	-64.597	-88.890
291	09:50	-76.847	-64.582	-89.111
292	09:55	-77.042	-65.041	-89.043
293	10:00	-76.825	-65.023	-88.628
294	10:05	-76.915	-65.331	-88.500
295	10:10	-77.105	-65.516	-88.695
296	10:15	-77.341	-65.795	-88.887
297	10:20	-77.438	-66.146	-88.730
298	10:25	-77.460	-66.024	-88.897
299	10:30	-77.297	-66.092	-88.502
300	10:35	-76.986	-66.038	-87.934
301	10:40	-76.938	-66.399	-87.478
302	10:45	-77.067	-66.357	-87.777
303	10:50	-77.064	-66.595	-87.533
304	10:55	-77.194	-66.825	-87.563
305	11:00	-77.072	-66.853	-87.291
306	11:05	-77.201	-66.798	-87.603
307	11:10	-77.328	-67.237	-87.418
308	11:15	-77.112	-66.905	-87.320
309	11:20	-77.329	-67.055	-87.603
310	11:25	-77.968	-67.644	-88.291
311	11:30	-78.243	-67.886	-88.599
312	11:35	-78.179	-67.753	-88.605
313	11:40	-78.188	-67.931	-88.444
314	11:45	-77.869	-67.949	-87.788
315	11:50	-77.823	-68.188	-87.458
316	11:55	-77.809	-67.773	-87.846
317	12:00	-77.784	-67.925	-87.643
318	12:05	-77.883	-68.250	-87.516
319	12:10	-77.946	-68.352	-87.541
320	12:15	-77.983	-68.349	-87.618
321	12:20	-77.920	-68.132	-87.708
322	12:25	-77.877	-68.076	-87.678
323	12:30	-77.953	-68.149	-87.757
324	12:35	-78.096	-68.265	-87.927
325	12:40	-78.299	-68.207	-88.391
326	12:45	-78.388	-68.209	-88.568
327	12:50	-78.217	-68.208	-88.226
328	12:55	-78.334	-68.296	-88.373
329	13:00	-78.048	-68.129	-87.966
330	13:05	-78.505	-68.062	-88.948
331	13:10	-78.307	-68.286	-88.328
332	13:15	-78.335	-68.437	-88.233
333	13:20	-78.262	-68.292	-88.233
334	13:25	-78.336	-68.599	-88.073
335	13:30	-78.296	-68.819	-87.772
336	13:35	-78.337	-68.245	-88.430
337	13:40	-78.332	-68.569	-88.096
338	13:45	-78.249	-68.637	-87.860
339	13:50	-78.234	-68.492	-87.977
340	13:55	-78.044	-68.442	-87.646
341	14:00	-77.507	-68.175	-86.839
342	14:05	-77.563	-68.375	-86.751
343	14:10	-77.509	-68.189	-86.828
344	14:15	-77.528	-68.199	-86.858
345	14:20	-77.613	-68.150	-87.075
346	14:25	-77.667	-68.256	-87.078

347	14:30	-77.607	-68.340	-86.874
348	14:35	-77.678	-68.384	-86.972
349	14:40	-77.566	-68.098	-87.034
350	14:45	-77.416	-68.012	-86.820
351	14:50	-77.679	-68.015	-87.342
352	14:55	-77.876	-68.157	-87.595
353	15:00	-77.841	-68.146	-87.537
354	15:05	-77.323	-68.130	-86.517
355	15:10	-77.279	-67.726	-86.833
356	15:15	-77.296	-67.924	-86.668
357	15:20	-77.248	-67.862	-86.634
358	15:25	-77.221	-67.843	-86.598
359	15:30	-77.359	-67.923	-86.796
360	15:35	-77.348	-67.833	-86.863
361	15:40	-77.199	-67.793	-86.605
362	15:45	-77.281	-67.593	-86.968
363	15:50	-77.210	-67.773	-86.647
364	15:55	-77.046	-67.731	-86.362
365	16:00	-77.010	-67.681	-86.338
366	16:05	-77.043	-67.640	-86.446
367	16:10	-77.106	-67.307	-86.904
368	16:15	-76.979	-67.233	-86.725
369	16:20	-77.020	-67.185	-86.856
370	16:25	-76.943	-66.990	-86.896
371	16:30	-76.853	-66.761	-86.945
372	16:35	-76.900	-67.008	-86.791
373	16:40	-76.719	-66.937	-86.501
374	16:45	-76.571	-66.805	-86.337
375	16:50	-76.930	-66.923	-86.938
376	16:55	-77.017	-67.076	-86.958
377	17:00	-77.035	-66.947	-87.122
378	17:05	-77.046	-67.094	-86.999
379	17:10	-76.891	-66.863	-86.918
380	17:15	-76.882	-66.611	-87.153
381	17:20	-76.743	-66.532	-86.954
382	17:25	-76.708	-66.405	-87.011
383	17:30	-76.650	-66.496	-86.804
384	17:35	-76.523	-66.501	-86.545
385	17:40	-76.380	-66.581	-86.179
386	17:45	-76.340	-66.082	-86.598
387	17:50	-76.245	-65.976	-86.514
388	17:55	-76.203	-66.106	-86.299
389	18:00	-76.290	-65.998	-86.582
390	18:05	-76.154	-65.631	-86.678
391	18:10	-76.108	-65.660	-86.556
392	18:15	-76.149	-65.446	-86.852
393	18:20	-75.984	-65.934	-86.035
394	18:25	-75.928	-65.767	-86.089
395	18:30	-75.920	-65.546	-86.295
396	18:35	-75.843	-65.532	-86.153
397	18:40	-75.832	-65.348	-86.315
398	18:45	-75.766	-65.364	-86.168
399	18:50	-75.694	-64.898	-86.490
400	18:55	-75.633	-64.743	-86.523
401	19:00	-75.757	-64.921	-86.593
402	19:05	-75.698	-64.757	-86.640
403	19:10	-75.630	-64.316	-86.943
404	19:15	-75.517	-64.280	-86.753
405	19:20	-75.357	-64.266	-86.449
406	19:25	-75.398	-64.116	-86.679
407	19:30	-75.464	-64.150	-86.777
408	19:35	-75.445	-63.906	-86.983
409	19:40	-75.370	-63.967	-86.773
410	19:45	-75.380	-63.578	-87.182
411	19:50	-75.332	-63.173	-87.491

412	19:55	-75.218	-63.362	-87.074
413	20:00	-75.266	-63.416	-87.116
414	20:05	-75.103	-63.290	-86.915
415	20:10	-75.133	-63.404	-86.863
416	20:15	-75.180	-63.334	-87.027
417	20:20	-75.122	-63.134	-87.109
418	20:25	-75.025	-62.967	-87.083
419	20:30	-74.977	-62.817	-87.138
420	20:35	-74.976	-62.813	-87.139
421	20:40	-74.996	-63.175	-86.817
422	20:45	-74.963	-62.566	-87.361
423	20:50	-74.903	-62.548	-87.259
424	20:55	-74.641	-62.580	-86.702
425	21:00	-74.446	-62.334	-86.558
426	21:05	-74.414	-62.164	-86.663
427	21:10	-74.311	-62.175	-86.447
428	21:15	-74.264	-61.951	-86.577
429	21:20	-74.221	-61.847	-86.595
430	21:25	-74.236	-61.556	-86.916
431	21:30	-74.243	-61.811	-86.674
432	21:35	-74.150	-61.801	-86.499
433	21:40	-74.102	-61.549	-86.656
434	21:45	-74.000	-61.641	-86.360
435	21:50	-73.993	-61.532	-86.454
436	21:55	-74.083	-61.748	-86.418
437	22:00	-73.997	-61.455	-86.540
438	22:05	-74.152	-61.701	-86.602
439	22:10	-74.087	-61.526	-86.648
440	22:15	-74.132	-61.905	-86.359
441	22:20	-74.055	-61.500	-86.610
442	22:25	-74.061	-61.549	-86.572
443	22:30	-74.221	-61.330	-87.111
444	22:35	-74.064	-61.370	-86.757
445	22:40	-74.028	-61.317	-86.739
446	22:45	-74.025	-61.473	-86.577
447	22:50	-74.053	-61.209	-86.897
448	22:55	-74.027	-61.246	-86.808
449	23:00	-74.164	-61.356	-86.971
450	23:05	-74.081	-61.198	-86.965
451	23:10	-73.827	-60.779	-86.876
452	23:15	-74.005	-60.858	-87.152
453	23:20	-74.114	-61.137	-87.090
454	23:25	-74.243	-61.491	-86.994
455	23:30	-74.211	-61.523	-86.899
456	23:35	-74.260	-61.234	-87.286
457	23:40	-74.208	-61.426	-86.990
458	23:45	-74.244	-61.527	-86.961
459	23:50	-74.200	-61.311	-87.089
460	23:55	-74.166	-61.385	-86.947
461				