What are the odds? The probability of simultaneous "technical problems" at five radionuclide detection stations

Dr. F. Dalnoki-Veress
8/25/2019

Since the explosion at Nyonoska in northwestern Russia on August 8, a handful of radionuclide detection stations in Russia, all of them part of the International Monitoring System (IMS) of the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO), abruptly stopped feeding data to the CTBTO in Vienna. The Russians told the CTBTO that the stations stopping transmitting due to "communication and network issues." At last count, five of Russia's RN detection stations stopped relaying their data, with just two of them—both quite distant from Nyonoska—coming back online.

Could this be a random coincidence?

How likely it is that five detectors located thousands of km apart would fail at about the same time, assuming that they act independently? We can test the probability of random coincidence of two detectors not transmitting data at the same time and the probability that the downtime is as long as 10 days. To make a long story short: it is highly, highly, *highly* unlikely that this was just a random coincidence.

Think of it this way. Imagine that you and four other friends had not seen each other for an entire year and you both happened to call each other all exactly at the same time, jamming the phone lines. That is highly unlikely—unless you had scheduled a time to call each other.

I believe the detection stations were instructed to stop sending data. To show why, let's use the standard way that random coincidences are assessed. It is important to emphasize that the assumptions that we will make have nothing to do with the nature of the event in Nyonoska itself.

Introduction

Five detectors in Russia that very accurately detect radioactive particulates shut down on August 10 (Dubna and Kirov) or August 13 (Zalesovo, Peleduy, and Bilibino). These stations watch for nuclear testing across the entire planet. The IMS has successfully detected all six nuclear weapon tests by North Korea. Its detectors measure particulates (and for some detectors, also noble gases) that might come from an atmospheric nuclear explosion, traveling on the winds from thousands of kilometers away. However, they are also extremely sensitive to any kind of nuclear accidental release or incident. The particulate radionuclide counters were critical as an independent check on statements by Japanese authorities on radionuclide releases from the Fukushima Daiichi incident in Japan in 2011.

In this analysis we will put this claim to the test.

My assumptions

These are my assumptions in this calculation. I welcome critiques of these assumptions.

1) The five detectors operate independently and transmit data independently.
2) Data availability transmission (DAT) issues occur more or less randomly through the year. The duration of one DAT issue may stretch from one day to ten consecutive days (highly unlikely).

3) The sensors are collecting data 24/7 and have a data availability of 95%.[1] This means that the data availability transmission failure issues occur for < 5% or 18.25 days per year.
4) The detectors are not transmitting data for ten days straight, with all detectors going dark virtually at the same time (we will vary this time below).

Analysis

We can think of the detectors going dark for so long as a confluence of several unlikely coincidences and use standard probability theory to calculate the final probability that this could have occurred by chance (known as a chance coincidence). The argument is that if the probability we calculate is really low than it is likely that the sensors were deliberately prevented from transmitting data.

C1: Coincidence of data transmission (DAT) failure at the time of explosion

The C1 coincidence, is the coincidence that the data transmission (DAT) failures occurred at a time virtually coincident (within 4 days) of the Russian explosion on August 8th. Therefore, I will assume that the overlap time with the explosion was roughly d1=4 days so that we can divide a year into $m_1=365/d_1=91$ possible sensor overlap times. It is as if we have a die with 91 sides and all the sensors happen to choose the time to stop transmitting exactly on the 37th side corresponding to the August 8th 4-day period (see Figure 1 below).

Figure 1: Analogy with a 91-sided die. Each side of the die corresponds to one particular overlap time of the 5 sensors. August 8th corresponds to the 37th side. The Russian authorities want us to believe that throwing the die 5 times independently all fell on the 37th side. This is very unlikely, unless the die was altered.[2]

However, each sensor can have multiple times throughout the year that they can fail. Or in terms of dice, the sensor can have several tries at throwing the die to get the 37th side that corresponds to the time when the explosion happened. In fact, we know that the total time that data is not available is <5%=18.25 days or 4.5 tries at throwing the die to get the 37th side. The probability for all 5 to pick exactly the 37th slot is: $\mathrm{P(C1)} = \left(\frac{18.25/d_1}{365/d_1}\right)^5 = (18.25/365)^5$ = 3.1e-7, in other words, *highly unlikely* that the sensors went dark at the same time coincident with the time of the explosion due to a random coincidence.[3]

[1] Werzi, Robert. "The operational status of the IMS radionuclide particulate network." *Journal of radioanalytical and nuclear chemistry* 282, no. 3 (2009): 749. See Table 1.

[2] Image by Saharasav - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=35759126.

[3] Note that in terms of probabilities, the probability of throwing the die once and getting the 37th side is mutually exclusive from throwing another time. This means that the probabilities are additive for each of the times that the

C2: Coincidence that there were consecutive DAT failures all occurring within ten days

The second coincidence C2 is the fact that consecutive DAT failures all occurred for each station. To calculate this correctly, we need to make assumptions about the duration for a normal DAT failure. We don't know this except that we know the requirements for the station detectors is that they should have a data failure time of <5% = 18.25 days per year. Furthermore, we know that a requirement for the stations is that the annual down time should not be longer than 15 days, and should not have downtime longer than 7 consecutive days.

Recognizing that "downtime" is not the same as lack of transmission, we do know that the data is sent once per day so the smallest segmented time is of a one-day duration. The number of failures consistent with a 5% failure rate are m_2 = (18.25 days/d_2) where d_2 is the duration of one DAT event as we discussed above. The number of possible failures is s_2=(365/d_2) being the number of d_2 segments occurring in a year.

Therefore, the probability that one segment occurs in the second spot after the first one we already accounted for in C1, is one divided by the number of d_2 segments in a year: $\mathrm{P} = \frac{1}{365/\mathrm{d}_2} = \left(\frac{\mathrm{d}_2}{365}\right)$. So for a full 5% failure lasting 18.25 days we would have m_2, but the period of time the detectors are dark is more like 10 days (I am being generous). So m_2 overestimates the number of DATs. Instead we need to calculate it for a period of N=10 days in which case the number of consecutive segments for duration d_2 will be: n_2=N/d_2. We have already accounted for one d2 segment to line up all 5 detectors with the 4-day window coincident with the explosion so we now have to account for one (n_2-1) segments occurring consecutively afterwards. The final probability that (n_2-1) segments occur consecutively for one station is: $\mathrm{P} = \left(\frac{d_2}{365}\right)^{(\frac{\mathrm{N}}{\mathrm{d}_2}-1)}$. Now assuming that the same d_2 occurs for all 5 stations and a DAT total failure time of N=10 days we have the final probability for 5 stations to be: P(C2)= $\left(\frac{d_2}{365}\right)^{5\,(\frac{\mathrm{N}}{\mathrm{d}_2}-1)}$. The probability of the second coincidence occurring as a function of d_2 and for 5 stations varies not surprisingly wildly, all the way to 1% when the normal duration time is 10 days which we know it is not to 1 part in 10^{116} for the d_2 duration of one day. (Nope, not a typo: consider throwing a hundred-sided die from 1 to 50 consecutively so you get 1, then 2, then 3 all the way to 50. It's not hard to understand that this is very unlikely.)

This final probability that all of these events of consecutive DAT failures for all 5 detectors going dark in d1 days is the product of P(C1) and P(C2):

$$\mathrm{P}[\%] = \mathrm{P(C1)} * \mathrm{P(C2)} = 100\,\left(\frac{18.25}{365}\right)^5 \left(\frac{\mathrm{d}_2}{365}\right)^{5(\frac{\mathrm{N}}{\mathrm{d2}}-1)}.$$

die is cast and this number is 18.25 days/ d_1. However, the number of sides of the die is itself related to the coincidence time, which is why the C1 probability itself does not depend on the value of d_1.

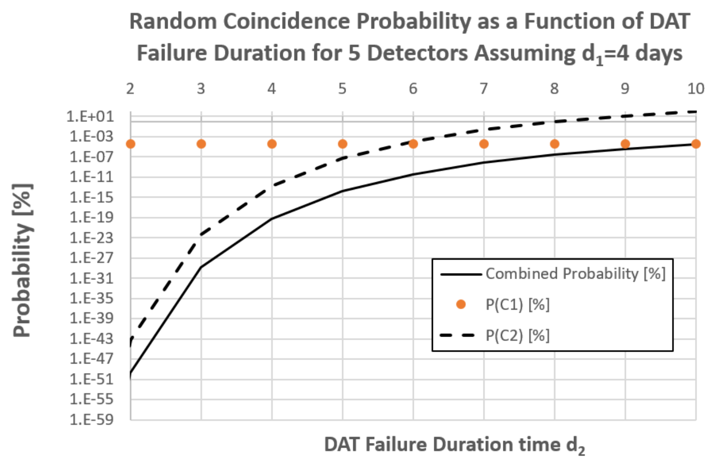

Figure 2: *Combined probability of C1 and C2 failures for all 5 stations. Notice that the random probability coincidence for C2 increases to 100%. This is because there is only one segment to place, and since we are looking for coincidences with consecutive segments the probability must be 1 because there are no more slots when d_2 = N. In addition, the C1 probability is constant because it does not depend on the DAT duration value d_2.*

Conclusions

I don't know how often DAT failures occur. Nor do I know the duration that a regular DAT blocks out data. However, I do know that the minimum standard failure rate is 5% of total data, and I suspect that now it is much better than that after more than a decade of experience. This fact as well as the fact that the 5 detectors went dark at about the same time allows us to put a bound on how likely this was to have been a random coincidence. If you assume that a station could not transmit data to IDC one day it is reasonable to assume that it would be fixed by the next data transfer on the next day. This means that if d_2=1 day, d1=4 days, and the probability of a random coincidence is astronomically low: one in 10^119.

OK, it takes longer to fix things then just one day, so let's assume that when there is a DAT error it stops transmission for d2=d1=4 days. Then the probability of a random coincidence is still worse: 1 in a billion times a billion.

Now I am sure there will be excuses/explanations. This analysis proceeds purely from a numerical point of view and makes no assumptions about the cause(s) of these events other than those stated above. The fact is, based on random probabilities, it is exceedingly unlikely for this to occur.

Questions that must be answered

Radionuclide stations operate by first sampling a large volume of air over a period of 24 hours onto a filter, then counting with highly sensitive High Purity Germanium counters. The final gamma spectrum is sent to the International Data Center in Vienna for further analysis. This final step is crucial but independent of the first two. Crucially, just because data is not being transmitted does not mean that the detectors are shut down. In fact, the delayed data should be transmitted as soon as the DAT event is resolved.

A reasonable question is why did the detectors stay dark so long? That is addressing the C2 probability. We can speculate that the event is still ongoing, releasing particulates. What explains DAT events occurring at virtually the same time? I have my own theories, but I think it is up to Russian officials to explain.