Manuscript reference: CQG-109234
"The Virgo O3 run and the impact of the environment"

AUTHOR RESPONSE

In addition to the responses below, we would like to note that we have updated reference [19] as the corresponding article has been posted to arXiv in the meantime.

> REVIEWER REPORT(S):
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> Referee: 1
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> COMMENTS TO THE AUTHOR(S)
> Let me first congratulate the authors to a very detailed and instructive
> paper. It was a joy to read.

We would like to thank Referee 1 for their report and kind words.

> I have a few minor comments, mostly concerning the figures.
>
> Fig 3: The legend obscures part of the spectrum. It looks as if it can
> be made significantly
> smaller. Also, the grey percentiles are very hard to see.

The figure has been modified according to your suggestions.

> Fig 6: I assume it is folded over with a weekly period starting at
> Monday. If not, it would be
> helpful to explain how the O3 run fits into one week.

The "Holiday Season" and "Covid-19 Lockdown" periods cover each an integer number of weeks starting on a Monday morning at midnight. This is not the case for the "O3 Run" period whose exact UTC time boundaries have been used. But, in all cases, data computed around a given date generically labelled as " 20YY/MM/DD, HH:MM" accumulate in the weekly bin ", HH:MM". So some O3 bins may have 1 or 2 more entries than others, but this is negligible as O3 lasted 11 months in total.

> Seismon warnings (p21) - can you give an indication of the typical
> reaction times for Seismon and
> how often it was "quick enough" to engage EQ mode?

During O3, the Seismon overall latency was 15-20 minutes for significant earthquakes, a range mostly independent from the earthquake epicenter distance. It is too large for earthquakes occurring in the Mediterranean area or in the Atlantic ocean, but good enough

for Asia-Pacific earthquakes and West-coast US earthquakes (whose latency seems a bit smaller, probably because the USGS network is monitoring the USA best).
During O3, the EQ mode was engaged manually by the operator on-duty when he/she was seeing the suspensions starting to shake: that added “human latency” to the system and in some cases that reaction was probably too late. We’ll try to have this mitigation action automated during O4 to fully benefit from the earthquake early warnings. The robustness and the reliability of the updated framework for O4 will be tested in the coming months when the Virgo detector is operated in a near data-taking mode.

> Fig 19: The caption could do with some de-acronymization.

Fig. 19 has been moved after the corresponding text in which the various acronyms are defined. That should help the readers to understand the caption more easily.

> I'm not 100% sure that appendix A needs to be in this paper. Is there
> actually a need to have it here?

The study of the control losses during O3 is an important input to Section 4 -- Earthquakes -- as it was needed to find which control losses were due to earthquakes to trigger further analysis. Moreover, its results show that a large fraction of the control losses during O3 were due to hardware issues, not to "vulnerabilities" of the apparatus to external disturbances. Therefore, we have included it in the present article, but as an appendix as it is not among the main topics discussed. Internally, we had considered the possibility to make it a separate article, but we finally concluded that keeping it as an appendix here would be the best/simplest solution.

> Referee: 2
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> COMMENTS TO THE AUTHOR(S)
> This article is relevant to the environmental effects to Virgo in O3.
> The data and figures shown in the article are very reasonable and
> intelligible. It is impressive that the sensitivity (BNS range)
> fluctuation due to the seismic noise and wind is small. This fact
> allowed Virgo to attach importance to the data quality more than keeping
> the operation.

We would like to thank Referee 2 for their report.

> Two things confused; "the detector is quite robust against wind" on the
> BNS range (Page 35, Line 14) and "the Virgo detector appears robust
> against microseism but more sensitive to wind" on the duty cycle (Page
> 36, Line 50).

The first statement reflects the fact that the BNS range is not much affected by strong winds. The second one refers to a different analysis, which tries to decouple the effect of wind and microseism as bad weather usually mixes the two. And that analysis shows that the Virgo detector is more impacted by high microseism when the wind is very high – see Figure 23.

> Three different arrival times that stem from different assumed
> velocities are indicated in Figure 15. The line for 3.5km/s is
> consistent with the time that the correction was saturated. I understood
> that it is reasonable to employ 3.5km/s as the speed of Rayleigh wave.
> Is it correct? The authors should add some considerations.

As (very briefly) discussed in pages 19-20, the speed of the Rayleigh waves is not well known. That's why Seismon is providing by default the arrival times for three different speeds: 2, 3.5 and 5 km/s. And we have not really used that information during O3 (it is displayed on Figure 15 for reference) as the operator on duty was waiting to see the suspensions shaking to move manually to EQ control mode. Moreover, we have not studied in detail if and how we can disentangle the different seismic waves in our data. On the bottom plot of Figure 15 we see two successive "bumps" in the measured seismic noise that could correspond to the arrival of the P/S and Rayleigh waves. If this is true, the first Rayleigh waves would have arrived with a speed larger than 3.5 km/h while stronger waves would have arrived later. The fact that the saturation correction times match the expected arrival time for a 3.5 km/h speed seems just a coincidence.
We will try to extend that analysis during O4, by improving the accuracy of the prediction and by analyzing more in depth our data.

> There are some points to be corrected.
>
> Page 9, Line 17: "Kamioka" is the name of area. The name of mountain is
> "Ikenoue mountain".

Sorry for the confusion. The modified text now reads "(...) (located in Kamioka, Japan, under the Ikenoue mountain) (...)"

> Page 10, Line 10: What is "electroducts"? They may be ducts for electric
> cables.

We apologize for the unclear wording. We have replaced "electroducts" by "high-voltage power lines (electricity pylons and overhead line segments)".

> Page 29, Line 39: "top-left" --> "top-right"

Fixed.

> Page 41, Line 39: "A few seconds later" --> "A few tens seconds later"

The text was changed according to your suggestion.