EGUsphere, author comment AC2
https://doi.org/10.5194/egusphere-2022-726-AC2, 2022

Reply on RC2

Bert G. Heusinkveld et al.

Author comment on "A new accurate low-cost instrument for fast synchronized spatial measurements of light spectra" by Bert G. Heusinkveld et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-726-AC2, 2022

-
  - **RC2**: 'Comment on egusphere-2022-726', Anonymous Referee #2, 11 Oct 2022 reply

Our replies to the reviewer are presented below in italic font

The manuscript describes the design and performance for a new solar radiation sensor ("FROST") with spectral and broadband/hemispheric sensitivity. While there are limitations to the sensor, it is very low-cost and also provides some technical advantages in response time that the design team exploits. I agree with the design team that FROST could be of wide interest for several applications. The manuscript is suitable for publication in AMT but requires revision largely to increase clarity and provide missing information. The text is straight-forward, but could use improvements in organization. As I read the manuscript, I made many comments and notes only to find the answer appear much later. For example, there are two separate sections describing the cosine response. Consolidation of like sections and discussion would help. Additionally, I would like to see more of the analysis defended with quantitative data: For example, what were the results of the cosine tests in Section 2.4? My specific comments are as follows:

Based upon the valuable feedback received from the two reviewers, we agree the manuscript organization can be improved. We think that by addressing comments related to confusing sentences, sections, or figure references, we can improve the overall structure and clarity of the manuscript. This includes elaboration on the Discussion section as suggested by Reviewer 1, and e.g. moving certain paragraphs to a different section as suggested by Reviewer 2 below.

Regarding the cosine response tests in Section 2.3, the article is organized such that Section 2 describes the instrument design and measurement method. Results can be found in Section 3 (see Section 3.3 and Fig. 12.

The manuscript requires copy editing: There numerous grammatical errors, unnecessary words, errant spaces, spurious pluralization, awkward wording, etc.

Agreed, we will proofread the manuscript by a native speaker

L59: I don't understand what you mean by "their vision".

It refers to Martinez et al. 2009 (the second "their version" will be removed).

L73: I know it's defined in the abstract, but you should also define GHI here.

Accepted

L93-100: Doesn't this paragraph belong in Section 2?

Good suggestion, we will work on this to further improve the manuscript organization.

Section 2: In Section 2 there are a lot of unanswered questions. For example, What serial protocol(s) the system uses for external communication? How data is archived; format, volume etc. What are the temperature limits on components/power? What is the transmittance of the diffuser? How long does the battery last? Many of these questions are answered later in Section 3. Either general reorganization to Sections 2 & 3 or some additional text in Section 2 describing where more details will be found later is needed.

These issues seem related to the organization of the manuscript so we will improve it. We explained the Serial protocol in L197-198.

Data archival was explained in Section 2.5

Diffuser transmittance was explained in Fig. 9.

The battery run time can be inferred from the information in L121-123. On battery power supply, it would last about 40 hours. This will be added to the text.

What are the temperature limits of components/power?

We did not test temperatures below 5°C, but we expect that low temperatures will impact the LiPo battery capacity.

Experimental results are presented in Section 3. We think it fits better in Section 3 than in Section 2. But we will add additional text in Section 2 that diffuser transmission data can be found in Section 3.

Section 2: Check the numbering of your subsections.

Yes, second 2.1 should be 2.2 and 2.2 should be 2.3

L179-186: What were the results of LED test? Can you provide a figure and analysis?

See Section 3 with results of experiments in Fig. 12.

Lines201-210: The commercial grade SDcard seems like a significant and critical vulnerability given these fast read/writes. Have you considered more robust (and more expensive) aMLC/SLC industrial versions that might be more reliable?

We did not consider other SD cards since we never encountered a missing line of data, not even during the 2.5 months of continuous measurements, see L429. We think this shows the reliability of the commercial grade SDcard. Note that we are dealing with very slow write times. We are writing less than 2 KB per second whereas our SDcard can handle up to 85 MB per second. The large capacity of 32 GB means that this card will not wear down fast. We think it is useful to add this information to the manuscript.

L214: This DOI is password-protected. I can’t get the Restricted Access for Review link to work. It’s unclear to me if this information is to be open access or not.

We explicitly added L215-219 to allow open access for anyone that reads the manuscript. After final acceptance, the reference in L213-214 will be open access (it is the same Zenodo record).

L235: The BSRN reference is Driemel et al.: https://essd.copernicus.org/articles/10/1491/2018/

Accepted, we will add this.

L242-243: Are these filters the ones that were first discussed at L169-177? I think a little more clarity is needed here.

We will clarify this in more detail. The filter in L169-177 is only used to test crosstalk since it blocks all light below 1000 nm.

L250-254: Can we see these results in a figure?

Yes, we will provide this.

Figure 5. What are the units? This is a fraction? Can you be explicit in the caption? Maybe this is defined later at L295 and that definition could be moved up to Figure 5? That said, I don't understand the definition. Further, because the radiance at the observed and interfering bands are different, I'm unclear how the fraction translates to a radiance bias.

Figure 5 shows a fraction [-], unitless. The bias is explained in L270-280. We will provide some additional text because we realize it can be confusing. At 410 nm the crosstalk is about 55%, it means that when the sensor is illuminated with the xenon light source 55% of the sensor signal is from the near infrared (>1000 nm) and not from the 410 nm waveband. We can add some text in the figure caption to explain this further.

We realize that the crosstalk definition is different for Figs. 6 and 8, since they show crosstalk for a flat spectrum, so will clarify this.

L273: Wouldn't cloudy conditions actually increase crosstalk because the incident IR increases at all wavelengths?

Clouds do increase thermal infrared but reduce the near infrared waveband that are responsible for the crosstalk (see L392 or Durand et al., 2021).

Figure 6. For clarity, please label the green, blue, red sensors on the figure since this is how you refer to them in the text

This is a very good suggestion!

Figure 8. I would like to know the performance cost incurred for including the KG filters. Two comments. First, please show the results for the KG1/red. This is particularly important because of the substantial transmission losses in the red band. Second, I'm also concerned that the results as depicted are deceptive. The responsivity is shown in normalized rather than in absolute units. Therefore, with the filter applied and the crosstalk removed, the in-band responsivities appear to increase, but they should decrease and I would like to know by how much.

The KG filters do reduce the in-band signal levels, as can be seen in the KG transmission curves in Fig. 7. Considering the red sensor with a KG-1 filter: 940 and 900 nm are reduced such that the crosstalk from shorter wavelengths become very dominant, see L336 and Fig. 6 lower right panel. The 560 nm and 585 nm wavebands lose about 5%, the 645 nm about 20% and the 705 nm about 40% signal but it greatly reduces crosstalk.

We will change Fig. 8 into the same formatting as Fig. 6 and add the red sensor including a KG-1 filter.

L318-319: Why does the diffuser add crosstalk? Is it because the more light is collected at large zenith angles where the infrared signal is larger? Is it then primarily a clear-sky problem?

No, see Fig. 9, the diffuser absorbs a lot more in the shorter wavelengths and therefore enhances the impact of infrared crosstalk (see also L322).

L325: Since you are comparing three versions, I feel like there should be three sets of symbols in Figure 10 comparing to the field spec, but I only see 2 (circles and pluses corresponding to versions 1 and 3).

Good point, we will change the circles in the lower panel (it is the third sensor version).

L327: I'm confused about the world "calculated". Figure 10 are all measurements, yes?

No, the FROST response is calculated from the measured spectrum multiplied by the normalized response curve and considering transmission of diffuser and KG filters. For example, the underestimation of the blue sensor without correction filter and with a thick PTFE diffuser (as in Fig. 8 left panel) would be more sensitive for the NIR for most of its channels and therefore it underestimates the solar radiation at the expected wavebands. Figure 19 clearly shows a real-world example of how much the waveband improvement is using the KG filters.

Figure 13, 14, 15: Can you be more explicit in the legend about which sensor is which?

Yes, this is clearly missing.

Sections 4 & 5: I think these can be just one section.

Agreed

Section 3. The stated purpose of the diffuser is to increase the sensitivity of the sensor from the nominal 41 deg FOV to the hemisphere but it seems it should also provide the advantage of collapsing the cosine response function to a constant, specifically its value at 45 deg, the effective diffuse angle (Vignola et al. p.158). Notably, this effective angle is still outside the FOV and the consequences of that are not obvious to me. Can you comment on this?

Vignola, Frank, Joseph Michalsky, and Thomas Stoffel. Solar and infrared radiation measurements. CRC press, 2019

We do not have access to the book you refer to. The diffuser increases the field of view to 180°; ideally the sensor should respond have a cosine response curve. For example. light at the 45° zenith angle should output 70.71% of the signal it would receive if the light source would be placed at the zenith angle).