Response #2 to RC1

Thank you for the insightful comments, which will very much help us to substantially improve the paper. Please find below our responses to the reviewers remarks. We will repeat these in italics and add our respective responses in normal letters.

This paper purportedly addresses Earth's outgoing scattered radiation in the spectral range from 200-1100 nm using many instruments on a single payload to measure spectral (at some unknown resolution) and broad-band outgoing and incoming radiation. Unfortunately, the paper appears to be written rather hurriedly, making it nearly impossible to understand the full concept. In places where some aspects of the concept can be interpreted, it appears to be flawed. In order for readers to fully comprehended their instrument design, the paper needs to be rewritten in a more orderly way, and many additional details must be provided. (A few examples are in the listed comments below.)

Response: Thank you for your comment. We will slightly modify the title of the paper:

"An instrument design to observe annual changes in Spectral Outgoing Radiation from 200-1100 nm"

The proposed instrument design is called Spectral Outgoing Radiation Auto-Calibrating Spectrometers SORACES and is intended for the long-term measurement of annual changes in spectral outgoing radiation SOR(λ,t) from 200-1100 nm. Two topics are targeted by remote sensing during a solar cycle period: the determination of annual changes in global vegetation cover in the spectral range 350 nm to 700 nm and spectral outgoing radiation SOR from 200 nm to 1100 nm. A global mapping of the vegetation area and the SOR as well as their annual changes should show the results.

(Note: In order to reinforce the topics of annual changes in vegetation cover and SOR, we have excluded the exploration of local changes in vegetation cover due to the complexity of the subtopic. This is achieved by using additional ASSI-type spectrometers instead of the photometers. It also improves redundancy and internal cross-calibration, which are important aspects of long-term observations.)

Based on the actual knowledge of the total solar irradiance TSI(t) from radiometers (Schmutz et al., 2013; Scafetta and Willson, 2014) and the spectral solar irradiance SSI(λ,t) from a Solar Auto-Calibrating XUV-IR Spectrometer instrument SOLACER (Schmidtke et al. 2019), SORACES applies the measurement method of the Solar Auto-Calibrating EUV Spectrometers SolACES (Schmidtke et al., 2014; Schaefer et al., 2017). Using 16 Airglow Solar Spectrometer Instruments ASSI (Schmidtke et al., 1985) with a total of 80 channels operating simultaneously, spectral outgoing radiation SOR(λ,t) of 200-1100 nm shall be observed with a higher spectral resolution of 350-700 nm. A schematic of the arrangement of the spectrometers is added at the end of this response.

To reduce the influence of drag on the accuracy of the data and the SOR dependence on local time, an orbital altitude of 800 km in a Sun-synchronous orbit is chosen. Lower orbits such as the ERBS orbit result in irregular solar activity-dependent altitude changes with decreasing target area of SOR data of 7 % (see manuscript Lines 233-240). The constant fields of view of all sub-instruments are 15 by 30 degrees. In this way, the annual signal averages of each detector provide SOR information on annual changes in the same target area.

Operational management, data handling and data evaluation are supported by artificial intelligence (AI) algorithms to be developed on ground and adapted to the measurement conditions during the mission. Pre-calibration in the laboratory and using the Sun enable the handling of the 80 detectors. The application of Lambert screen rules is used to provide the AI data pool from various green scenes such as grasslands or forests to be observed from rooftops, observation towers, drones and/or aircraft.

Another major weakness, in addition to missing fundamental information like spectral resolution, is the complete lack of measurement and mission requirements that are justified to meet science requirements. Stability is the lone variable requirement listed but the origin of that requirement is not given. Nothing is said about accuracy or precision, as if they are irrelevant.

Response: Thank you for this point. We will make this clearer to the reader in the revised version

Requirements - accuracy, precision/stability, spectral/spatial resolution:

Since neither annual changes in SOR data from 200-1100 nm nor in chlorophyll from 350-700 nm are known, we must use available instruments and data instead of formulating requirements. In this context we choice TSI(t) data as the main input with the given accuracy and the precision/stability of the radiometers. To determine the annual changes in SOR, the long-term stability of the measured values is the most important parameter, which is 5-7 mW m^{-2} yr^{-1} (Montillet et al., 2022). We call the long-term stability the annual average of precision. The accuracy of mW m-2 is not of interest in this context.

In order to repeatedly calibrate the ASSI spectrometers with high long-term stability to compensate for the degradation, we normalize

$$\int \mathrm{SSI}(\lambda, \mathrm{t}) d\lambda = TSI(t) \qquad (1).$$

In this way we should achieve stability of 0.1 Wm^{-2} over a period of a solar cycle or longer.

A radiometer for TSI(t) data and a SOLACER instrument for $\mathrm{SSI}(\lambda, \mathrm{t})$ data could be operated aboard the same or a different spacecraft.

Vegetation observation should be carried out by evaluating data in the spectral range from 350-700 nm due to absorption by chlorophyll and by scattering of green radiation. The chlorophyll absorption bands extend from 350 nm to 490 nm and from 620 nm to 690 nm. The green backscattering is active from 500 nm to 600 nm. In these regions, the spectral resolution changes from 5 nm to 40 nm depending on the SOR backscatter curvature.

To observe annual SOR changes from 200-1100 nm, the spectral resolution ranges from 20-50 nm outside of the range 350-700 nm.

The field of view is another parameter. Each sub-instrument is designed to monitor the same areas of 15 x 30 degrees.

Another issue that needs mentioning is that the measurement/instrument concept does not measure over the full shortwave spectrum nor does it measure Earth's emitted radiation. As such, it is inadequate to address the Earth's radiation imbalance. This is more of a minor comment – the authors mention energy imbalance only briefly – but considering the attention this topic is receiving in the peer-review literature, this should be recognized.

Response: Measuring of the Earth Energy Imbalance is not addressed in the manuscript. Instead, the need to include the amount of absorbed solar energy resulting in biomass should be considered in terms of a correction factor in Earth's energy imbalance (see manuscript Lines 2, 45/46 and 54/55). Since this aspect is not relevant to the SOR measurements, it will be deleted.

One final major point: it appears that a growing trend in the community is to submit measurement and mission concepts to the peer review literature before submitting those concepts to agencies that fund mission and instrument proposals. That is certainly fine, and in *fact, welcome and encouraged, but the instrument concepts published in the peer-reviewed literature require much more detail than what is provided here. The rather ambiguous diagrams in this paper provide no insights into how a single instrument actually works, let alone several tens of instruments the authors propose. The authors even call this a "proposal" in the title. A journal paper is distinct from a proposal. (On the other hand, this does not really look like a proposal either.) I repeat what I state at the top, I think this was a hurried submission. The authors are a quite capable group of scientists. I encourage them to do a complete rewrite of this paper.*

Response: Yes, the paper will be completely rewritten. It is not a proposal with predefined interfaces for a satellite payload. However, for the reader's better understanding, the method, geometric structure and each sub-instrument should be described. They are tested in space on rocket, satellite and ISS missions. SORACES could be realized on the basis of this broad experience.

Below is a only small, partial list of specific items that either need addressing or reveal fundamental flaws. Upon fully and better articulating the proposed concept, a more thorough list may be compiled.

Response: Thank you for this list. Below we will respond to the single items.

Line 8: "From the wide range of possibilities" Awkward start to abstract. Possibilities of what?

Response: This will be deleted.

Line 29: I don't understand the term in parentheses in "SOR (SOR_a)".

Response: SOR_a is the annual mean value of SOR(t). It will be reworded.

Line 32: "The proposed instrument is equipped with simultaneously measuring 12 spectrometers and 16 photometers." Perhaps: "The proposed instrument is equipped with 12 spectrometers and 16 photometers that make simultaneous measurements."

Response: This will be rephrased.The photometers are deleted.

Line 33: I have no idea what "20 radiation attenuators enable the adjustment of the Solar Spectral Irradiance SSI(t) to natural SOR values" means. (Edit: I think I understand after reading the entire paper that these are actually variable apertures. Those should not be called attenuators, a very misleading term.)

Response: This is explained in Section 4.2: The attenuators are thin metal plates with holes drilled by lasers. In this way, transmissions of 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} and 10^{-5} can be obtained. The attenuators ensure a stable radiation throughput. They attenuate or weaken the TSI to the optimum levels of the sub-instrumental data statistics. 32 attenuators can be placed in the attenuator wheel (see schematic view below) to compensate for different spectrometer efficiencies. They can also be placed in front of the detectors in the spectrometer. In this way, optimal count rates are achieved for each of the 80 detectors. This will be explained in detail.

Line 34: Have not identified the subscript in SOR_a

Response: This is explained in the comment on line 29.

Line 36: No analysis is provided to justify the adequacy the listed stability. This is, apparently a capability. What is required to meet the science goals?

Response: This is explained on pages 1 and 2 of this response: To meet the science goals, a stability of 0.1 Wm^{-2} over a period of a solar cycle is required.

Line 54: "Besides using a different measurement method". Different from what?

Response: This will be deleted.

Lines 79-87: This entire paragraph only superficially covers how the spectrometers will be calibrated using solar irradiance. The jump from TSI to SSI is insufficient to account for spectrally varying changes in either the instruments or the Sun.

Response: A reference to an earlier publication replaces this explanation.

*Line 85: "Normalizing TSI(t) to ΣSSI(t) adjusts the stability of both quantities so that in-space spectrometers and photometers can be calibrated with high stability to compensate for the instrument degradation." No, this is very misleading. This can only be applied uniformly across the spectrum but instrument degradation will have a wavelength dependance, as will solar variability and both of those are indistinguishable.*Response:

Respone: Using the SSI(t) data from a Solar Auto-Calibrating XUV-IR Spectrometer System SOLACER (Schmidtke et al., 2919), degradation with its dependence on wavelength is excluded by repeated calibration of the SORACER sub-instruments with the known spectral distribution SSI(t) in the range from 200-1100 nm. Then the individual photon effciency of each sub-instrument is known over time. In this way, the time and wavelength dependence are taken into account. 60 days per year is set to repeat the calibration. If there is significant degradation between two rounds of calibration, it can be corrected, since degradation is usually a time-dependent process following an e-function.

Lines 88-95: This paragraph is essentially incomprehensible. It appears to use a combination of solar irradiance models and a fixed TSI measurement, neither of which is accurate enough to account for solar variability required to meet the specified stability. I trust that the authors have something else in mind but I was unable to decipher that from what was written.

Response: See answer to Line 85 and Eq. 1.

Line 96: How does one account for the bandpass filter shapes and the fact that they will change over time?

Response: No bandpass filters are used in SORACER.

Line 113: Absorption by water vapor is curiously missing from this sentence.

Response: This will be added.

Page 5: Much of what is on this page reads as though it is from someone's notes rather than text for a peer-reviewed manuscript.

Response: This information was used to explain Table 1. It will be shortened.

Line 172: "The spectral resolution should be adjusted to the requirements of the spectral regions of the observables." What are those requirements and what drives them?

Response: See Page 2 below Eq. 1: Spectral resolution is adjusted to the curvature of the SOR. Significant changes in curvature occur in the spectral range of the chlorophyll absorption bands, which requires a spectral resolution of up to 5 nm, whereas a flat curvature requires a spectral resolution of up to 50 nm

Line 173-176: This works only if the sole source of instability is gaussian-distributed noise. There will be many other sources of instability.

Response: Annual TSI_a, SSI_a and SOR_a data are each a number. Multiple measurements over 300 days smooth out any sources of instability. It is a statistical method based on collecting data according to the same pattern year after year. The stability of the TSI_a data as a reference includes all sources of instability.

Line 188: "Changes in TSI(t) cause corresponding changes in SSI(t) and SOR(t)." But the spectral compositions of those changes is unknown. Seen comment on L. 79.

Response: Spectral composition changes in the SSI(λ,t) are known input from SOLACER.

Line 288: One of the co-authors (Jacobi) is listed in acknowledgements. It should be one or the other, not both.

Response: "C. Jacobi acknowledges support by Deutsche Forschungsgemeinschaft (DFG) through grant #JA836-48-1." – is required by the DFG.

References

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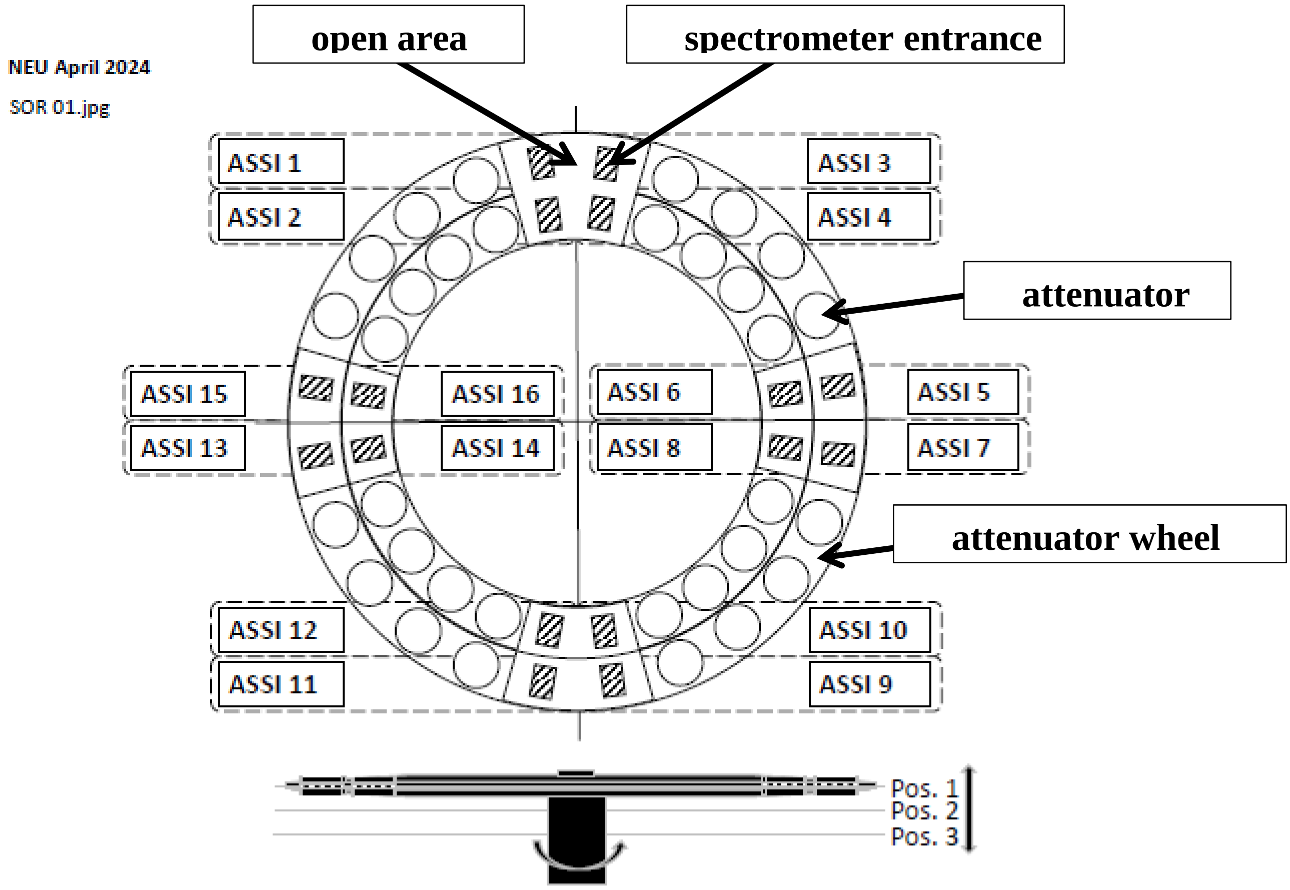

Schematic of the spectromters: the attenuator wheel