Response to RC1

RC1: 'Comment on egusphere-2023-139', Anonymous Referee #1, 12 Apr 2023 reply

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.)

The manuscript is rewritten. It describes a single instrument Spectral Outgoing Radiation Auto-Calibrating Spectrometers SORACES with 12 compact spectrometers and 16 photometers as sub-components, completed by 20 radiation attenuators. Each spectrometer contains 5 photomultiplier tubes (PMT), which corresponds to 60 PMT detectors covering the complete spectral range from 200 nm to 1100 nm for observing Spectral Outgoing Radiation SOR(λ) with an expected stability (precision) of 0.1 W m^{-2} per year.

The instrument, with simultaneously operating spectrometers and photometers, enables the determination of the global green Earth coverage and its annual changes by measuring chlorophyll absorption from 350 nm to 490 nm and 620 nm to 690 nm and green backscatter from 500 nm to 600 nm to determine a Normalized Difference Vegetation Index (NDVI). The spectral resolution between 5 nm to 40 nm is adjusted to the changes in chlorophyll absorbance with wavelength.

SORACES is not a payload, but an instrument. Spectrometers and photometes are repeatedly recalibrated with high accuracy by spectral solar irradiance in space. With a estimated dimension of 500 x 500 x 500 mm^3 with a weight of 46 kg, it should become part of a small climate satellite.

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.

These points have been clarified.

Another issue that need 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.

The Earth Energy Imbalance (EEI) should be corrected for the amount of solar energy stored in biomass. No determination of EEI is addressed.

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.

Yes, this is not a proposal with predefined interfaces for a satellite payload. However, the method, the geometric layout and each sub-component are space-tested on rocket, satellite and ISS missions. It 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.

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

It was deleted.

Line 29: I don’t understand the term in parentheses in “SOR (SOR_a)”.

SOR_a is the annual mean value of SOR(t). It has been rephrased.

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.”

It has been rephrased.

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.)

It 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.

Line 34: Have not identified the subscript in SOR_a

It has been settled.

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?

That’s right: This is a capability. Stability data is not available for annual TOR data from 200 nm to 1100 nm.

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

It was 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.

This is explained in more detail (see Introduction).

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.

(see introduction): Degradation with its dependence on wavelength is ruled out by repeated calibration of the SOLACER spectrometers. After the calibration of the 8 planar grating spectrometers, the recorded SSI(t) is available as long as the instrument stability is guaranteed. 60 days per year is set to repeat calibration. If there is a significant degradation between two rounds of calibration, this can be corrected, since the 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.

(see introduction): SSI(t) should be derived from the XUV up to 3000 nm. Since TSI(t) also includes SSI(t) >3000 nm, this fraction of SSI(t) from a solar model must be added for each calibration to correctly normalize TSI(t) to ΣSSI(t).

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

The transmission of the bandpass filters in SolACES and SOLACER is repeatedly measured over time by placing them at the entrance of the spectrometers.

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

Thank you, it was 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.

This information serves to explain Table 1.

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?

The spectral resolution should be adjusted to the requirements of the spectral regions of the observables such as chlorophyll and green emission from plants.

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

TSI_a, SSI_a and SOR_a data are each a number. Multiple measurements over 300 days smooth out any sources of instability as long as there are no significant changes from one year to the next. It is a statistical method that needs to be realized and improved over time. Radiometers have taken more than 50 years to develop and are still being studied for further improvements.

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.

Changes in the SSI(t) are known and those in the SOR(t) are measured.

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

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