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# Comment on amt-2022-259

Stefan Wacker (Referee)

Referee comment on "A new airborne broadband radiometer system and an efficient method to correct dynamic thermal offsets" by André Ehrlich et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-259-RC1, 2022

General comments:

The manuscript presents the Broadband AirCrAft RaDiometer Instrumentation (BACARDI), which is designed for the observation of incoming and outgoing broadband shortwave and longwave radiative fluxes from the surface into the lower stratosphere using thermopile-based radiometers on board of the High Altitude and Long Range (HALO) research aircraft. The manuscript describes corrections for the temperature dependency of the sensor thermopile sensitivity, the sensor response time and the attitude of the aircraft. In addition, a new method is introduced to correct for thermal offsets. The correction uses the measured body temperature of the sensor to calculate the thermal offsets. The corrections were evaluated using measurements from the Elucidating the role of clouds-circulation coupling in climate (EUREC4A) field campaign. Vertical profiles of observed radiative fluxes up to 10 km altitude demonstrate that the proposed thermal correction reduces the thermal offset from original 10 and 20 $Wm^{-2}$ for pyrgeometers and pyranometers, respectively, to below 10 $Wm^{-2}$. In addition, comparisons with radiative transfer calculations for the shortwave wavelength range confirm that the corrections reduce the uncertainties substantially.

The radiation balance in the atmosphere plays a fundamental role in the climate system. However, in-situ observations for the validation of model outputs and satellite products are limited to a few profile and in-situ measurements taken from aircraft and balloons. In addition, these measurements suffer from higher uncertainties due to the challenging atmospheric environment with rapidly changing temperature conditions and the attitude of the platform which have a considerable impact on the accuracy of radiation measurements. The radiometer set-up and the correction methods presented in this manuscript will definitely contribute to a better accuracy and reliability of such in-situ profile observations.

The manuscript is very well structured and very clearly written. The methods are thoroughly described and the results reasonable. The literature has been selected and

cited carefully. Graphics and tables are clear and the captions self-explanatory. This work is a very interesting and a highly valuable contribution to the atmospheric science community and is in my opinion absolutely suited for publication in AMT. I recommend publishing with minor revisions and technical corrections.

Specific comments:

- Corrections methods and their evaluation are thoroughly described for the shortwave and longwave. In addition, a comparison of the observations with radiative transfer calculations for the downwelling and upwelling shortwave radiative fluxes for horizontal, circular flight patterns has been presented. Such a comparison would be also highly valuable for the (downwelling) longwave in order to estimate the reliability of the longwave observations and to study potential effects which may become relevant in the longwave on such flights. For instance, the fraction of the direct solar beam above the cut-on of a pyrgeometer, which is at about 4.5 µm for a CGR4. This unintentionally observed portion of the direct solar beam depends on the water vapor content (and thus altitude) and the solar zenith angle and hence may exceed 5 $Wm^{-2}$ significantly on such flights (e.g., Marty, 2000). In addition, the dependency of the pyrgeometer sensitivity on the water vapor content, which is estimated to be about 5 $Wm^{-2}$ in cloud-free conditions, may also be considered in such applications (e.g., Nyeki et al., 2017).
- Would it possible to calculate an uncertainty budget for the BACARDI package or at least to give a conclusive uncertainty estimate for the individual components of the observed radiative fluxes and the net radiation?
- It is indicated that the thermal offset correction coefficient β of the upper and lower pyrgeometer is more consistent compared to the upper and lower pyranometer due to the position of the pyrgeometers in front of the pyranometers with respect to the flight direction, which allows the pyrgeometers to be ventilated more effectively. Would it possible to place the pyranometer to the side of the pyrgeometers to further reduce thermal offsets or impedes the mounting system of BACARDI or limited space in the fuselage such a setup?

Minor comments and/or technical corrections:

- Line 32: may use "… by radiometers, … pyranometers … pyrgeometers"
- Line 55: may use "Actively stabilized pyranometers, …"
- Line 83: may use "The radiative energy budget of a broadband radiometer"
- Lines 129/140: In my opinion, the sensitivity is normally given in units of V $W^{-1}m^{2}$ (see line 189). Hence, the stated unit $Wm^{-2}$ $V^{-1}$ refers to the reciprocal of the sensitivity à

may use "…adjusted reciprocal of the pyrgeometer/pyranometer sensitivity…"

- Line 157: delete one "the"
- Line 313: "… depends…"
- Fig. 5: Is there an indication for the cause of the "outliers" in Fig. 5 (grey points)? Are these the same datapoints for the shortwave and longwave? May give a short statement in the text.
- Line 346/347: I would replace "… a few W $m^{-2}$" by "…to values below 10 W $m^{-2}$" (as in the abstract). For the downwelling shortwave flux, values are rather between 5 and 10 W $m^{-2}$ above 6 km but also partly near the surface. Only in the upwelling shortwave and in the downwelling shortwave up to 6 km values are a few W $m^{-2}$.
- Line 416: Delete either "the" or "a"
- Line 432: I do not understand the expression "… false detection of clouds above the aircraft…". May rephrase, e.g., "… caused by cloud contamination above the aircraft in the filtered dataset, …" or similar. Significant lower observed irradiances with respect to the calculated fluxes are either due to real clouds above the aircraft or a not properly corrected misalignment of the sensor.
- Line 433: "… conditions of high solar zenith angles, …"
- Lines 413-456: I got a bit confused here: Fig. 9a is presented and described in lines 413-423. Then Fig. 10a and 10b are described in lines 424-448. Finally, you go back again to Fig. 9b in lines 449-456. It might be easier for the reader, if the description of Fig. 9b (lines 449-456) was placed right after the description of Fig. 9a in line 423. However, you may have good reasons not to do it.

References:

Marty, Ch.: Surface radiation, cloud forcing and greenhouse effect in the Alps. PhD-Thesis, No. 13609, Swiss Federal Institute o Technology (ETH), Zurich, 2000.

Nyeki, S., Wacker, S., Gröbner, J., Finsterle, W., and Wild, M.: Revising shortwave and longwave radiation archives in view of possible revisions of the WSG and WISG reference scales: methods and implications, Atmos. Meas. Tech., 10, 3057–3071, 2017. https://doi.org/10.5194/amt-10-3057-2017.