Inter-comparison campaign of solar UVR instruments at Réunion Island (21.0°S, 55.5°E): findings and recommendations
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**INTER-COMPARISON CAMPAIGN OF SOLAR UVR INSTRUMENTS AT RÉUNION ISLAND (21.0°S, 55.5°E): FINDINGS AND RECOMMENDATIONS**


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**Introduction**

Réunion Island (21.0°S, 55.5°E) is a French and European territory situated in the Indian Ocean in the tropics where solar ultraviolet radiation (UVR) levels are high almost all year round. This is mainly due to intense solar radiation combined with weak stratospheric ozone columns. Yet, very few UVR and ozone measurements are available or operational in these regions, especially in the south-west Indian Ocean country. Since 2000, the Réunion University, a French and European university, started a research program based on ground-based solar UVR and ozone observations. Continuous UVR measurements require instrument monitoring and calibration processes in terms of wavelength and intensity on regular intervals and with regular comparison against a reference instrument. Several UV instruments comparison has already been done [1], but a comparison at high UV levels can highlight different instrument trends. In this framework of the NDACC (Network for the Detection of Atmospheric Composition Changes) and in collaboration with the LCA (Laboratoire d’Optique Atmosphérique, University of Lille, France) a Bentham DM300 spectrometer (BT) is operated at Réunion Island. We recently implemented an inter-comparison campaign between the Bentham spectrometer and four other UV instruments: a KeppleKoren UV-2, a Solar Light 501 (SL), a SitaLux UV-CDS (SG) and a Davis radiometer (DV), with the Bentham spectrometer as a reference. It should be pointed out that the KeppleKoren and Solar Light 501 radiometers were calibrated during the International UV Filter Radiometer Comparison in summer 2017 organised by PMOD/WRC at the WCC-UV in Davos [2]. In order to identify clear sky conditions, an all-sky camera recording cloud fraction (CF) has been operating at the observation site.

**Materials**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Type</th>
<th>Date range</th>
<th>Parameters</th>
<th>Uncertainty</th>
<th>Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>(B) Bentham DM300 Spectro-radiometer</td>
<td>10/17 to 06/18</td>
<td>5 min, 0.5 nm, 180-450 nm</td>
<td>±5%</td>
<td>Intensity, Absorption (every 3 months)</td>
<td></td>
</tr>
<tr>
<td>(K) KeppleKoren UV-2 Radiometer</td>
<td>10/17 to 06/18</td>
<td>5 min</td>
<td>±7%</td>
<td>Intensity, SZA, ozone (06/2017)</td>
<td></td>
</tr>
<tr>
<td>(S) Solar Light 501 Radiometer</td>
<td>03/18 to 06/18</td>
<td>1 min</td>
<td>±5%</td>
<td>Intensity, SZA, ozone (06/2017)</td>
<td></td>
</tr>
<tr>
<td>(G) SitaLux UV-CDS Radiometer</td>
<td>03/18 to 06/18</td>
<td>1 min</td>
<td>±5%</td>
<td>Intensity (12/2017)</td>
<td></td>
</tr>
<tr>
<td>(DV) Davis UV-sensor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Réunion1 all-sky camera Camera</td>
<td>10/17 to 06/18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Methods of comparison**

All data are interpolated on a 1 degree grid of solar zenith angle. The comparison is performed by calculating bias per SZA, MAPE, correlation and RMSE

$$\text{Bias} = \frac{\sum_{i=1}^{n} (B_i - T_i)}{n}$$

$$\text{MAPE} = \frac{\sum_{i=1}^{n} \left|\frac{B_i - T_i}{T_i}\right|}{n}$$

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} (B_i - T_i)^2}{n}}$$

$$\text{R} = 1 - \frac{\sum_{i=1}^{n} (B_i - T_i)^2}{\sum_{i=1}^{n} (B_i - \bar{B}_i)^2}$$

**Clear sky filtering**

For manually selected clear sky days, all the sky index values are between 2 and 10. Figure 1 shows an example of clear sky day at La Réunion on 11/04/2018 with a constant cloud fraction of 2%. Cloud fraction data from all the sky camera are in good agreement with other clear sky filtering methods [8].

**Conclusion**

The cloud condition doesn’t affect the bias between the instruments. The effect of the cloud cover on the UV is the same on all the co-localised instruments.

- **KZ**: Good coherence with BT. KZ measurements seem to be SZA-dependent but overall bias remain below 2%, as stated in the specification. Nevertheless, the reason of this SZA dependency have to be clarified.
- **SL**: There is no SZA dependency as the SL was calibrated in order to take into account effects of SZA and ozone absorption during Davos inter-comparison campaign [2]. However there is a constant positive bias of 30%. This shift can be corrected by using a lower calibration factor
- **SG**: Good agreement with the BT: low and constant bias
- **DV**: The UV is clearly functional of SZA. The bias is low, within 5% for low solar zenith angle

**Recommendations**

The SL501 shift can be corrected by using a new calibration factor according to the bias found, 0.69 W/m²/m³ instead of 0.866 W/m²/m³. A new calibration can also be performed to solve this issue.

**Reference**

