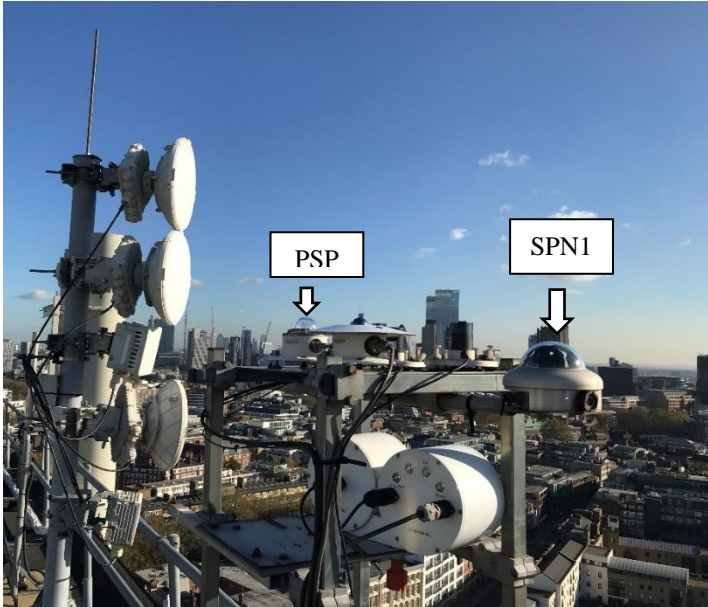
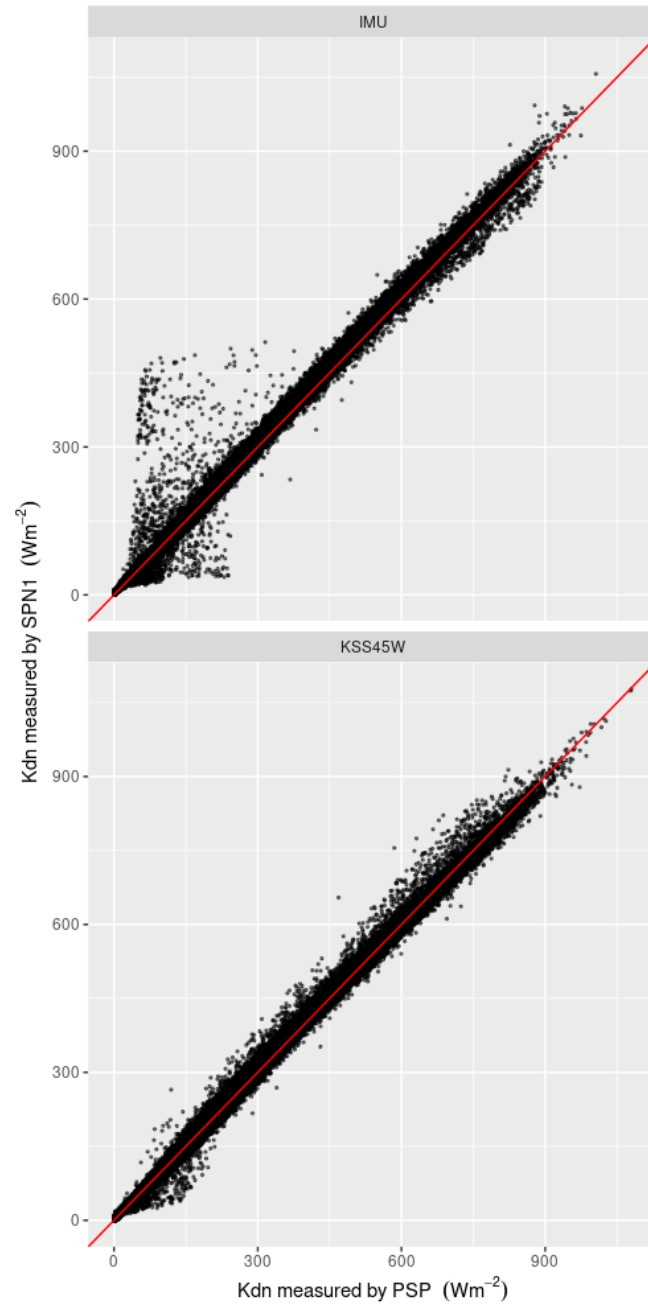


Author	Kit Benjamin (November 2020)										
Date	04/11/2020										
Summary	Suspected interference of incoming shortwave radiation measurements, taken by two sensors, when the sun is at certain angles, by nearby telecommunications equipment.										
Issue	Discrepancy between $K_{\downarrow}$ sensors (see background for details).										
Site	<a href="#">IMU</a> , Michael Cliffe House, Islington, London										
Instruments affected	Eppley <a href="#">PSP</a> and Delta-T <a href="#">SPN1</a> Pyranometers										
Siting	<p>Instruments were on the same stand, less than 0.40 m apart (Figure 1).</p>  <p>Figure 1: PSP and SPN1 set up at IMU. Photo looking South East, with building railing is oriented East-West. Taken 04/11/2020.</p>										
Period affected	2018-05-30 to 2020-11-04.										
Variables affected	<p><math>K_{dn}</math>, <math>K_{\downarrow}</math>, incoming shortwave radiation</p> <p>Units: <math>W\ m^{-2}</math></p>										
Implications	Data when the sun is at certain angles is inaccurate from at least one of the sensors.										
Recommendations	Take caution to check data taken when the sun was at these angles. Compare the measurements from the two instruments before using the data. Even if the two instruments agree note that it is possible that both are being affected and are therefore inaccurate. It's therefore recommended that data is not used when the sun is at these angles as it is possible the measurements are not accurate.										
Results	<p>Data when the sun angle is within the following angles is predicted to be affected by a telecommunications pole blocking or reflecting the sun:</p> <table border="1"> <thead> <tr> <th>Altitude max</th><th>Altitude min</th><th>Azimuth max</th><th>Azimuth min</th></tr> </thead> <tbody> <tr> <td>35°</td><td>10°</td><td>105°</td><td>70°</td></tr> </tbody> </table>			Altitude max	Altitude min	Azimuth max	Azimuth min	35°	10°	105°	70°
Altitude max	Altitude min	Azimuth max	Azimuth min								
35°	10°	105°	70°								
Background	<p>If both instruments are functioning properly, and without interference from other objects, then a close to 1:1 relation would be expected between the downward shortwave radiation (<math>K_{dn}</math> or <math>K_{\downarrow}</math>) measured by each instrument. The same instruments were previously set up in the same way at the Strand building, Kings College, London (<a href="#">KSS45W</a>). At this site <math>K_{dn}</math> values were clustered close to the 1:1 line (Figure 2). However, a significant number of values deviate from this at the IMU site, especially at low values (Figure 2).</p>										



*Figure 2: Kdn measurements by PSP and SPN1 instruments at sites IMU (top) from 2016-05-04 to 2020-11-04 and KSS45W (bottom) from 2012-02-27 to 2016-04-14.*

Attribution to discrepancy

To explain these differences in measurement values, a set of points where the two instruments significantly differ were manually chosen (labelled as ‘Significant difference’ in Figure 3). To see when these points occurred and whether they systematically occur at a certain time, the timing of the ‘Significant difference’ points after sunrise has been plotted (Figure 4). It is clear that the majority of the difference occurred between April and October 2020. There is an apparent cycle in this time frame. The ‘Significant difference’ points become more frequent and occur longer after sunrise from April until the summer solstice and then decrease from the solstice to October, at a similar rate. A similar, yet significantly weaker, pattern is also visible in 2019. This is indicative of systematic interference of the observations, dependent on time of year, starting in 2019/2020.

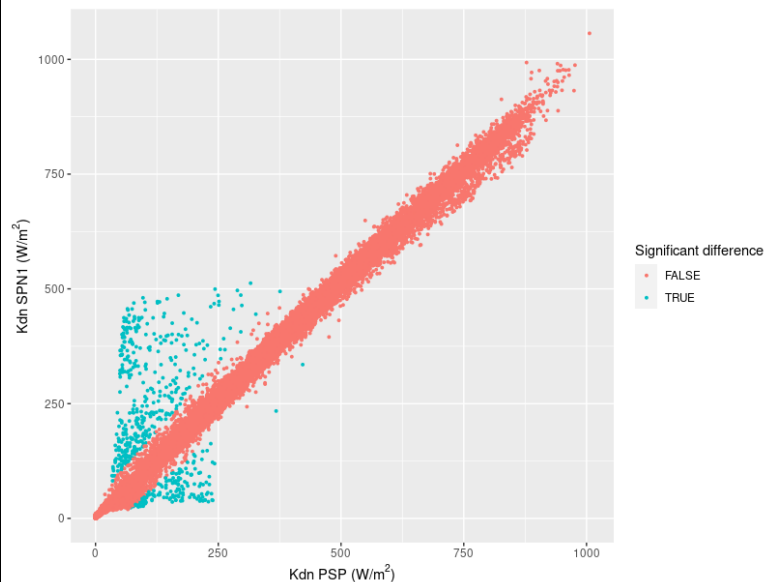


Figure 1: Kdn recorded by PSP and SPN1 with points where there is a “significant difference”, and hence used for further inspection, highlighted.

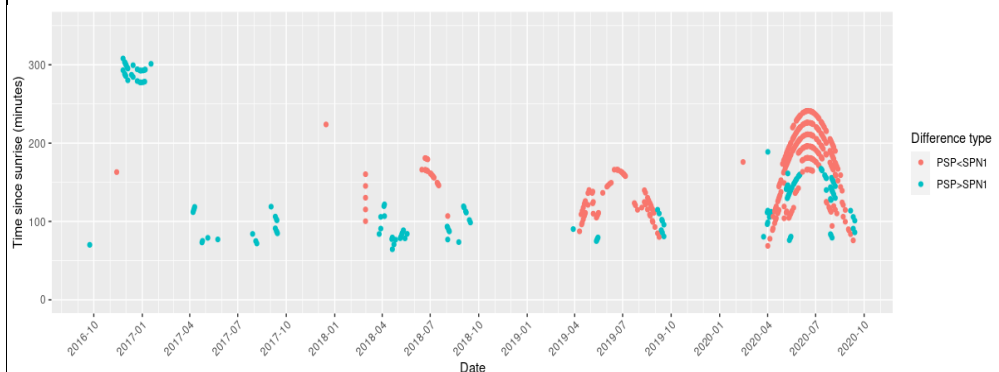


Figure x. 2: The minutes since sunrise of each point of “Significant difference” throughout the deployment time period

Each point in 2020 in which there was a significant difference between the instruments was placed into 1 x 1 degree bin of sun azimuth and zenith angle (Figure 5). It can be seen that at times when Kdn measured by the PSP is larger than that measured by SPN1, and times when Kdn measured by the PSP is less than that measured by SPN1, fall into exclusive sun angle bins. This is consistent with an object influencing (reflecting or blocking the sun) the readings since the direction of incoming radiation appears to have an impact on which instrument records a larger value.

A likely candidate for this interference is a pole, with communications equipment attached to it, that was set up in close proximity to the PSP and SPN1, approximately a metre to the East (e.g., see Figure 1). The direction of this communications pole, relative to the radiometers, is consistent with the fact that the points that are affected occur when the sun is to the East.

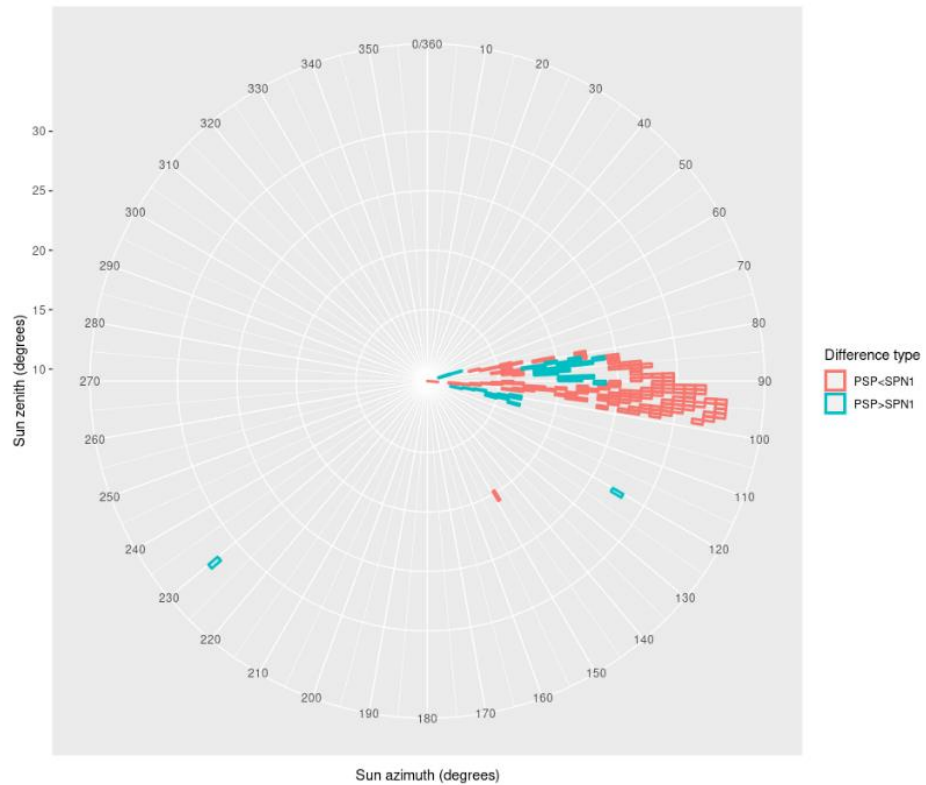


Figure 3: 1 degree by 1 degree 2D histogram of sun azimuth and zenith. The bins contain points where there is a 'significant difference' between PSP and SPN1 measured Kdn in 2020.

This pole was initially set up at some point between July 2017 and May 2018, based on photo records of the site, and has been incrementally developed and added to over time (Figure 6). Figure 6 shows the difference between the PSP and SPN1 Kdn measurements when the sun angle is within the bins shown in figure 5, over the whole deployment period. Photographs of the development of the pole in question is also shown. The pole has had more dishes added to it, with dishes being placed higher on the pole, over time. This increased development on the pole coincides with greater magnitude and frequency of disagreement between the instruments when solar radiation is incoming from the directions in figure 5. The disagreement between the two instruments being dependent on the angle of the sun, and the fact that the disagreement increased as the pole was developed on, thus making it more intrusive, strongly suggests that shadowing and/or reflection from equipment on this pole are the reason for this disagreement.

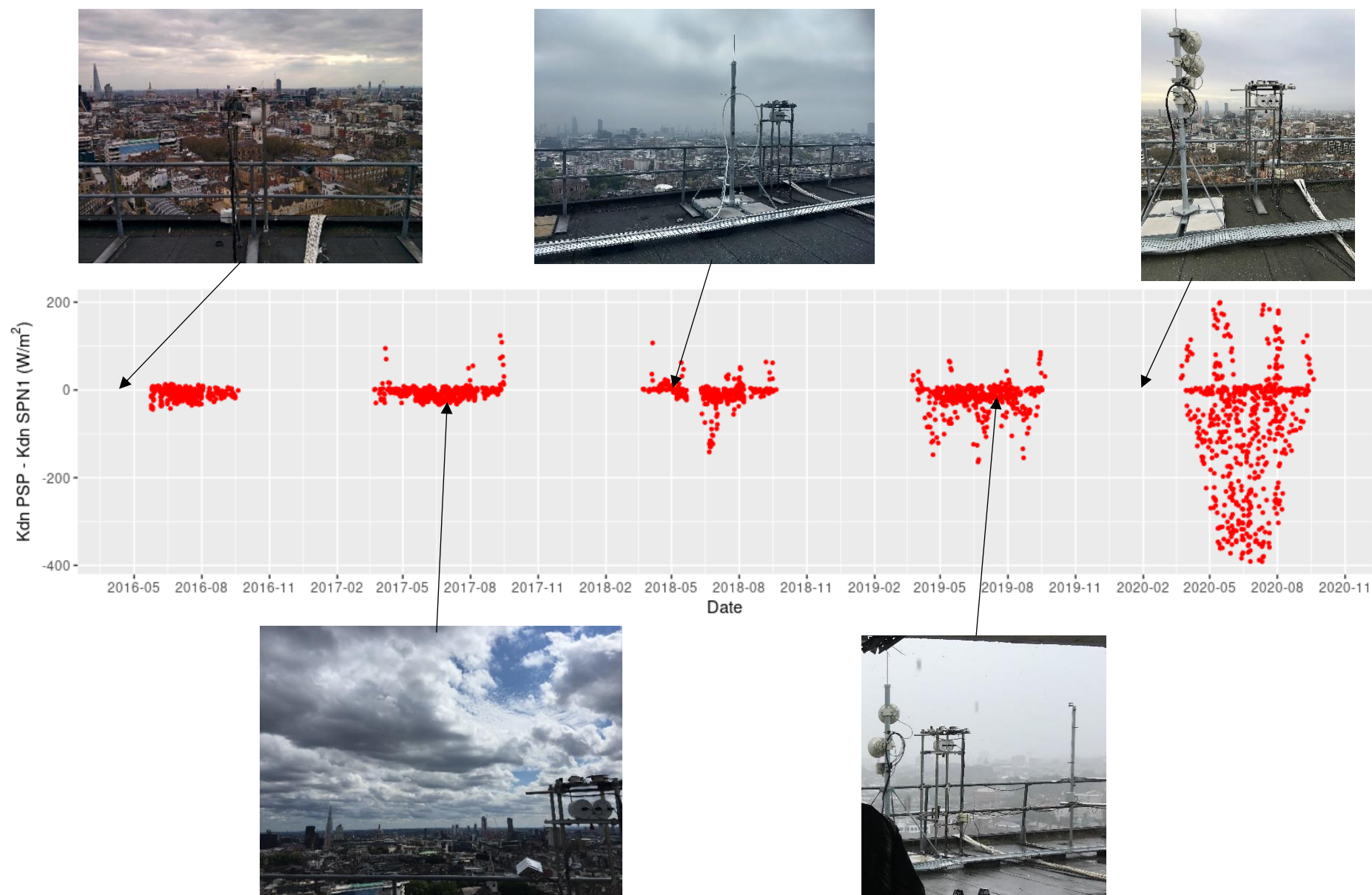


Figure 4: Difference in Kdn measured by PSP and SPN1 at IMU for every measurement during a time when the sun angle was within a sun angle bin containing a "Significant difference" measurement in 2020 (see figure 5). Also, the development of the communications pole in the vicinity of the sensors, matched to the date on the plot. Note the additional equipment added to the pole between July 2019 and February 2020.