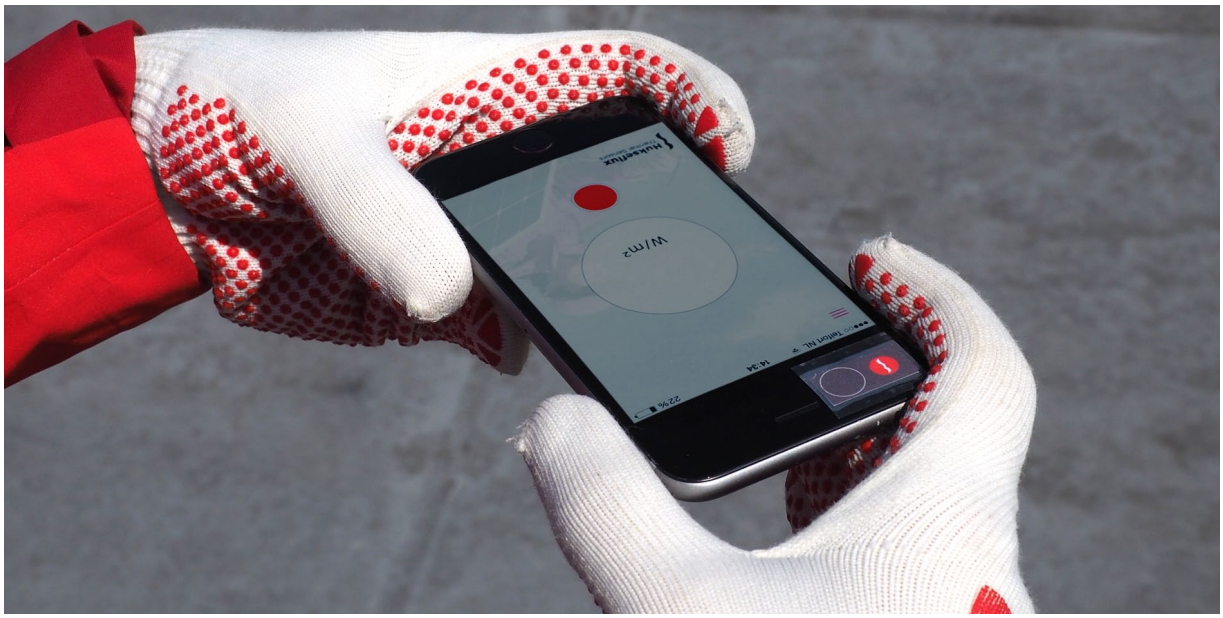
Hukseflux
Thermal Sensors

USER MANUAL

PYRANOMETER APP 2.0

Turn your iPhone into a pyranometer and measure solar radiation in Watt per square metre!



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Introduction

Name: Pyranometer App 2.0
Developer: Hukseflux Thermal Sensors / 9 to 5 development

Description: The Pyranometer App offers you measurement of solar radiation in Watt per square metre (W/m^2) on your iPhone. It is a gadget for fun and educational purposes only, provided free of charge by Hukseflux Thermal Sensors. Hukseflux is a market leader, both in technology and market share, of high-accuracy measurement instruments. With the introduction of this App in iTunes, Hukseflux became the inventor of the "camera+diffusor" measurement principle.
Hukseflux welcomes your feedback: e-mail us at app@hukseflux.com.

Figure 0.1 *Two iPhones measuring solar irradiance with the cameras aimed at the sun*

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1 User guide

1.1 The first App measuring solar radiation

Turn your iPhone into a 'pyranometer' with our Pyranometer App 2.0. It enables you to measure solar radiation in Watt per square metre (W/m^2) on your iPhone. The Pyranometer App is a gadget for fun and educational purposes only. It is not an accurate instrument. Professional measurement of solar radiation is done by highly accurate thermopile pyranometers. These instruments are used for measurements of weather, climate, solar energy production, agriculture and other related fields.

The Pyranometer App is provided free of charge by Hukseflux Thermal Sensors. Hukseflux is a market leader, both in technology and market share, of high-accuracy solar radiation measurement instruments. With the App, our clients, users and other interested people can give a glimpse to family and friends what concerns them in professional life. With the introduction of this App in iTunes, Hukseflux became the inventor of the iPhone "camera+diffusor" measurement principle.

How to proceed?

- download the App from your iTunes Store
- study the manual
- print the diffusor
- place the diffusor
- calibrate
- measure

Hukseflux welcomes your feedback: e-mail us at app@hukseflux.com.

1.2 Download the App

The Pyranometer App is available free of charge via your local iTunes Store:

https://itunes.apple.com/artist/hukseflux-thermal-sensors/id449857441

More information on the App can be found here:

http://www.hukseflux.com/product/pyranometer-app
https://prezi.com/atqbg1dvirgv/hukseflux-pyranometer-app-manual/

1.3 Print the diffusor

Since this App is measuring solar radiation, it needs to collect incoming light from all directions. Your phone camera has a limited view angle; to widen the field of view a 'diffusor' is placed on the lens. You need a diffusor so that the iPhone camera sees a 180-degree field of view (the complete sky). The camera without diffuser only has a field of

view of approximately 30 degrees. The diffusor also makes it possible to use the pyranometer App at lower light levels, such as indoors. You will need to 1) print and place a diffusor on the front-facing (selfie) camera lens and 2) perform an outdoor calibration. Both can be easily done via the App's setup menu.

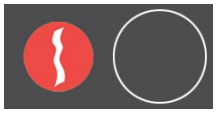

Figure 1.3.1 *diffusor, actual size*

The diffusor can be downloaded and transferred to your e-mail account, so you can print it with a standard printer.

To do so, open the App > Click on the 'hamburger' menu in the top left corner > Setup > Print & place diffusor > Print diffusor > Mail.

You may use Airprint via your iPhone as well, if you have a printer installed and suitable for Airprint. The page in the appendix of this manual can be printed directly too. Printing in colour is nice, but not necessary. Just make sure you use regular copier paper and do not scale the page too much.

1.4 Place the diffusor

Cut the diffusor with scissors and stick the diffusor to a piece of scotch or similar tape.

Go to Setup in the App menu > Print & place diffusor and place the diffusor in such a way on your iPhone that the white circle is surrounding the camera lens. The in-app view of your camera will help you to place the diffusor on the camera. Move tape with diffusor over the lens, lower the diffusor and cover the camera lens with the diffusor, as shown in figure 1.4.1 and 1.4.2. When you are satisfied, go to Setup > Calibration > Outdoor calibration.

Figure 1.4.1 *Stick diffusor on tape*

Figure 1.4.2 *Cover camera lens with diffusor*

1.5 Calibrate

Calibration can be skipped when taking a first look at this App, but if the calibration is not performed, the absolute values of irradiance will not be correct (way off!).

Go to Setup > Calibration > Outdoor calibration > Click the Start button

On a sunny day, look up a local weather station on the internet that measures solar radiation in Watt per square meter ($W/m^{2)}$. (usually an internet search of “weather station + location + W/m^2”, for instance “meteo station Amsterdam W/m^2” will do the job). Preferably wait for a sunny cloudless day around noon, between 11 and 14 hours.

Enter the current amount of solar radiation (in W/m^2) in your neighbourhood > Click Enter.

Next go outside and place your instrument in a horizontal position with the camera (with the diffusor in place) facing up. See Figure 1.5.1. Click ‘calibrate’.

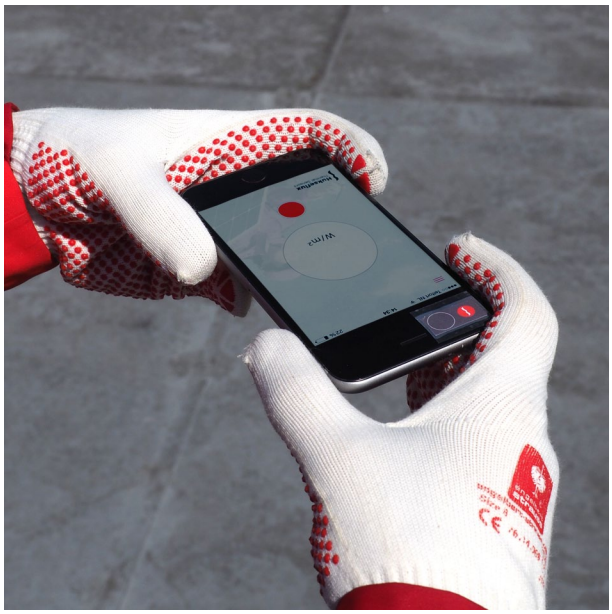

Figure 1.5.1 *The iPhone in horizontal position*

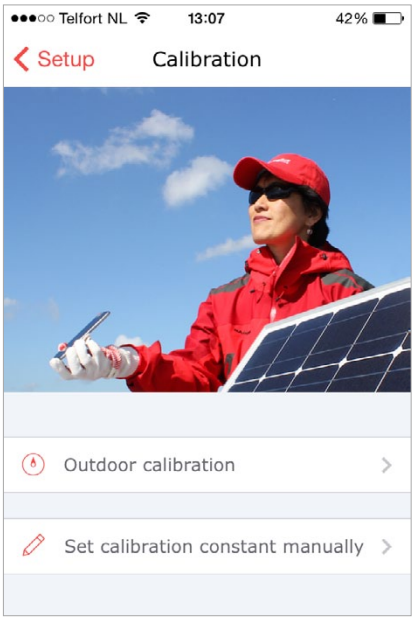

Figure 1.5.2 *Calibration menu*

After 5 seconds your iPhone has provided you with a calibration constant. Success! You are now ready to start measuring!

1.6 Measure

Click ‘Start measuring’ in the outdoor calibration menu or click on ‘measure’ via the ‘hamburger’ menu to start measuring.

Go outside when the sun is shining. Put the camera in horizontal position facing up (such as in Figure 1.5.1) and click the red button in your screen. It only takes 5 seconds to calculate all incoming data. Wait until the last beep. You can now read your measurement of solar radiation in W/m^2!

By clicking on ‘show details’ more information on your measurement is provided. All your measurements are stored in Data Review (Setup > Data review). You may delete measurements by choosing ‘Edit’.

You may perform a measurement with the camera pointed at the sun as well. The value pointed at the sun should be higher than that of the measurement in the horizontal position.

Figure 1.6.1 *Alternative measurement pointed at the sun*

1.7 Check measurement performance

Compare measurements in horizontal position to those of a local Weather station for different solar elevations (i.e. different times of the day). Deviations of ± 30 % can be expected.

Please note that you are also able to enter a calibration constant manually. Most modern versions of iPhones and iPods perform reasonable measurements when you enter ‘10’ as a constant. You may do so via Setup > Calibration > Set calibration constant manually.

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2 Specifications and interesting links

2.1 Specifications

Table 2.1.1 *Specifications of Pyranometer App 2.0*

PYRANOMETER APP 2.0 SPECIFICATIONS	
Measurand	hemispherical solar radiation
Purpose	fun, educational
Platform	iOS and iPhone
Cost	free of charge
Download	via iTunes Store
Supported iOS and iPhone versions	see iTunes Store
Calibration traceability	against local station
What to do?	download App
	study manual
	print diffusor
	install diffusor
	calibrate
	measure
Feedback?	e-mail to app@hukseflux.com

2.2 Interesting links

Scientific background: Wikipedia pyranometer
http://en.wikipedia.org/wiki/Pyranometer

Hukseflux Thermal Sensors pyranometers
http://www.hukseflux.com/product_group/pyranometer

9 to 5 development
http://www.9-to-5.nl

3 Educational (suggested experiments)

3.1 Horizontal solar radiation over a day

Perform a measurement in horizontal position. On a clear sunny day on an average altitude the measured value should peak at around noon (highest solar position) and be lower than that from sunrise to noon and noon to sunset. Maximum value is 1500 W/m^2. This means that at that moment a square metre of solar energy could power three bread toasters.

3.2 Indoor irradiance order of magnitude

Perform a measurement indoors under only artificial light. You will discover that you only need around 8 W/m^2 to be able to read a book!
Lessons learned: Indoor light levels are quite low, compared to outside! The human eye adjusts really well!

3.3 Horizontal versus tilted surface radiation level

Perform a measurement in horizontal position, then perform a measurement aimed at the sun (photo 3.3.1). With the camera aimed at the sun, the measurement value should be larger than that in the horizontal position. Solar energy installations are optimised to catch as much sun as possible, typically by aiming them south at an angle depending on the local latitude. (Horizontal at the equator, between 30 and 40 degrees in most of Europe, the USA, Japan, China).

Figure 3.3.1 *Alternative measurement measuring plane-of-array (tilted)*

3.4 Diffuse versus direct solar radiation

Perform a measurement in the horizontal position with the sun shining directly onto the diffuser. Repeat the same measurement; now shading the diffuser from direct solar radiation for example by casting a shadow on it using your hand, please keep at least 1 metre or 3 feet distance *(figure 3.4.1)*. Another option is to wait for a cloud to pass by! If the cloud isn't too big, it can block the direct radiation from the sun, leaving the indirect diffuse light only. When you subtract the diffuse radiation from the total radiation, you get the direct radiation. Lesson learned: direct solar radiation is dominant.

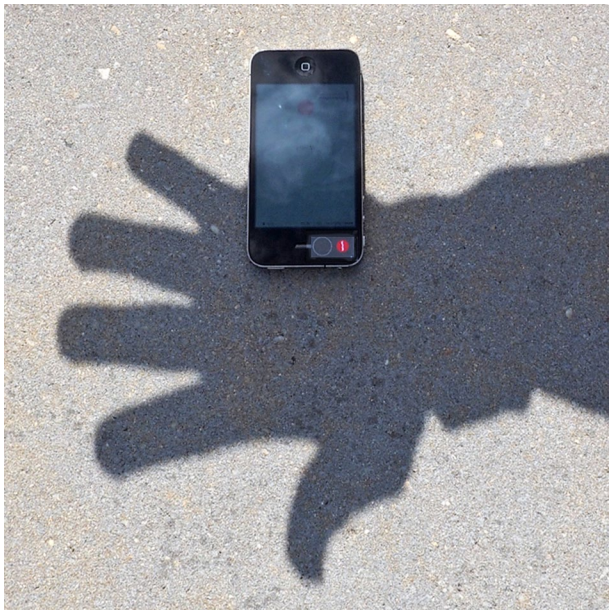


Figure 3.4.1 & 3.4.2 Alternative measurement of diffuse versus direct radiation

4 FAQ

- My local met station measures sunshine hours; can I use the data for calibration. Answer: No you cannot; the sunshine hour measurement does not represent radiation.

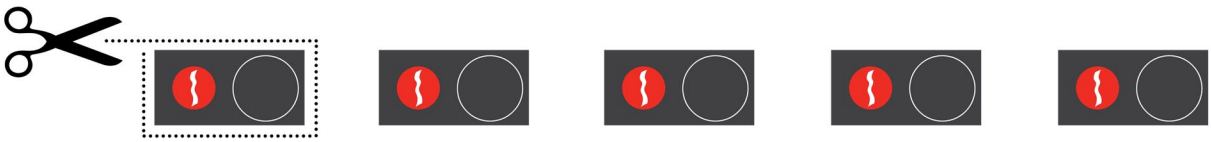
- My local measurement station measures Btu/square ft. Can I use the measurement data? Yes you can, but you should convert to W/m^2 (look for a site under “heat flux conversion”).

- I cannot find any actual solar radiation data in my neighbourhood, what can I do? Use the printed diffusor and set calibration constant manually to value ‘10’. Bear in mind that you increase your margin of error. The other possibility, is, wait for a perfect day and compare with a station further away. (200 kilometres is OK)

- I have no printer available in order to print a diffusor. As a diffusor you can use a tiny piece of general printing-paper, preferably double. Even when you calibrate, you will not reach the accuracy of the printable diffusor.

Appendix

Diffusor for Pyranometer App 2.0



Print the diffusor

The Pyranometer App 2.0 will only function properly with one of the diffusors above placed on the camera lens of your iPhone. Print this page; cut a diffusor with scissors, and stick the diffusor to a piece of Scotch or similar tape (Figure 0.1).

Place the diffusor

The diffusor should be placed in such a way that the diffusor area within the white circle covers the camera lens completely. In the Setup > Print & Place diffusor menu of the App, the camera-view of the App will help you position the diffusor. Placement is fine when the camera-view shows it is completely and evenly covered by the diffusor (Figure 0.2).

Ready? Start calibrating and measuring by going to Setup > Calibration > Outdoor calibration and click on “Start” (Figure 0.3).

Figure 0.1 *Cut diffusor and stick it on tape*

Figure 0.2 *Cover camera lens with diffusor*

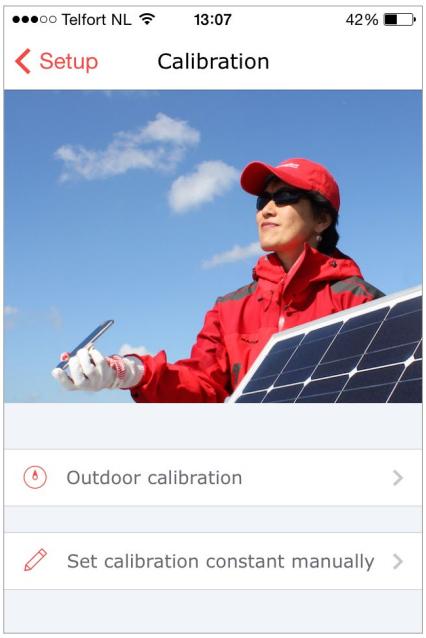


Figure 0.3 *Outdoor calibration*

Hukseflux Thermal Sensors B.V. is the inventor of the “camera + diffusor” measurement principle
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