MIJ-15 LAI series

LAI Explanation

How to use MIJ-15 LAI series

Environmental Measurment Japan, CO., LTD.
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LAI (Leaf Area Index) Explanations

1. Introduction

Leaf Area Index (LAI) is defined as the total projected area of leaves per unit surface area (e.g. 1m2) of a vegetative community. It is therefore an index with a dimensionless unit of m2/m2. It is widely used as an important indicator of vegetation's radiation absorption, photosynthesis/transpiration rate, and carbon absorption capacity.

As a conventional method, there is a cutting method that cuts all the leaves existing in the target plot and calculates the total area. While this method is a reliable index, it is also a labor-intensive and destructive method, and destruction is often a problem.

Non-destructive methods include optical methods and canopy using Li-Cor LI-2000, Delta-T Sunscan, SunfleckCeptometer, or fisheye lenses and cameras derived from measurements of radiation transmitted through the canopy to the ground. An all-sky photograph of the lower layer is included. Although these are optical, they measure the ratio of light and dark in monochrome, so they are actually plant area index (PAI; ratio of projected area of leaves, dead leaves, branches, and trunks per unit surface area) is measured and cannot be said to be LAI. In addition, there remains the problem that automatic continuous measurement is difficult.

2. Coverage measurement method using visible/near-infrared chlorophyll response

Most plant leaves carry out photosynthesis by absorbing visible radiation (PAR) with wavelengths of 400-700 nm. On the other hand, near-infrared radiation (NIR) of 700-1000nm is not used, and most of it is transmitted and reflected. Figure 1. Using these living leaves, or the unique spectral characteristics of chlorophyll, we can obtain vegetation coverage.

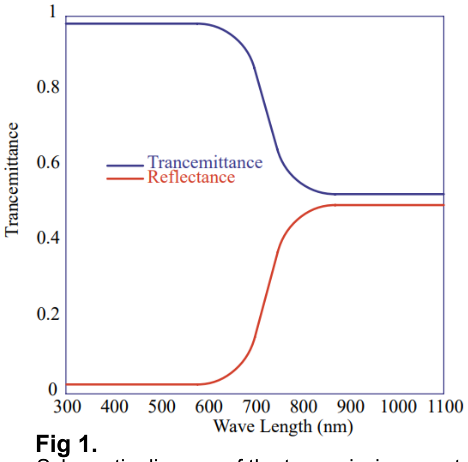

Fig 1.
Schematic diagram of the transmission spectrum of a leaf
Trancemittance
Refrectance

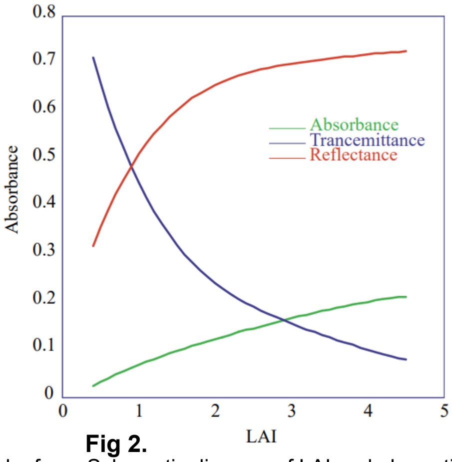

Fig 2.
Schematic diagram of LAI and absorption, transmission, and reflection spectra
Abrorbance

There is a Normalized Difference Vegetation Index (NDVI) that uses the reflected radiation from canopy. This technique is good for measuring plant coverage, but as leaves overlap the reflectance from the canopy surface saturates and becomes less variable. Figure 2. In addition, the reflection from the soil, which is the background of vegetation, has a large effect, and NDVI varies greatly depending on the ratio of bare soil in the target area, soil properties and moisture conditions, and the presence or absence of understory vegetation such as bamboo grass. It will end up. In other words, planar coverage can be obtained, but cubic LAI cannot be obtained.

3. Spectroscopic LAI measurement method

In the case of NDVI above, reflectance was used, but the method using leaf transmission is MIJ-15LAI TypeII/K2 or MIJ-15LAI/P. It has two advantages compared to reflection.

1. It is difficult to saturate with an increase in LAI.

2. When looking up at the vegetation from below, the background is not the soil or understory vegetation but the sky, and the ratio of NIR/PAR is kept extremely constant regardless of the season or weather conditions.

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LAI (Leaf Area Index) Bonus Information

4. Measurement method and its classification

LAI measurement methods are divided into direct and indirect methods.

Direct method

・Harvesting method (reaping method)

When a plurality of vegetation forms a group, all the leaves are harvested for one vegetation in the group, and the total area is calculated. Of course, we also measure the area of the ground where the cut leaves are and use the formula defined in 10 above to find the LAI. Also known as the model tree method.

・Non-Harvesting Methods: Techniques for Trapping Leaflitter

Although there is currently no definition for the structure of the trap, we prepared a box with an open top surface and a specified open surface area, and calculated the total area of fallen leaves accumulated in the box to obtain the LAI. increase. An uncertainty comes into play where wind affects the rate of leaf capture.

Indirect and contact method

・Point frame method

Using a long needle that penetrates two parallel plates with many holes on a square of a few centimeters, thread the needle through all the holes. A method of estimating LAI from the ratio of the number of times the tip hits a leaf and the number of holes in all, although a needle is pierced vertically from the top of the plant. A method used for relatively short plants.

Indirect and non-contact method

Each of the above methods is very labor intensive and often impractical, and the method that has been tried and tested over the last 20 years is an indirect and non-destructive method.

・Gap fraction distribution

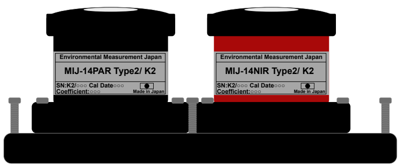
The principle is that if we can detect the total area of sunshine (gap) filtering through foliage and the total area shaded by leaves, it will be correlated with LAI. Specifically, we measure the ratio of the amount of light outside the tree trunk to the amount of light inside the trunk, or take monochrome images with an all-sky camera equipped with a fisheye lens and measure the ratio. LAI-2200, an all-sky camera, is a typical example of this equipment. Branches and trunks are also detected as leaves, so it is important to correct them using the measured values when the leaves have completely fallen in winter. Therefore, it is not suitable for measuring plants that do not lose their leaves.

・Gap size distribution

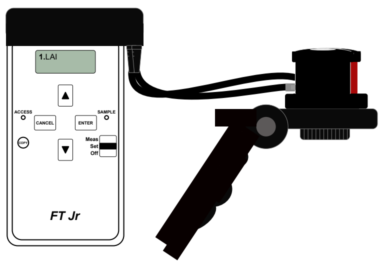
The principle is that the size of the gap will be correlated with the LAI. A typical example is a device called TRAC (Tracing Radiation and Architecture of Canopies). Since it is a method that scans the area to be measured, it is necessary to run around terribly, which is a physically demanding method.
See Fig 6 next page

・Spectroscopic method

This is an LAI measurement method that utilizes the property that the relationship between reflection and transmission of leaves varies greatly depending on the wavelength. (Details are given in the first half of this catalog.) The only representative equipment is the **MIJ-15LAI series**.



MIJ-15LAI/K2



MIJ-15LAI/P

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5. History and definition of LAI

It was first defined by Watson in 1947. After that, several definitions of LAI existed depending on the method or the convenience of researchers, but Watson's definition is the most widely known. Many definitions have been classified by Jonckheere et al. (2004), but the definition of leaf area per unit area of ground is the most commonly used. LAI=totalone-sidedarea of photosynthetic tissue/unitground surface area The area of the leaf here does not consider the area of both sides of the leaf, but only the area of one side. The illustration below shows this. Importantly, the definition of LAI is a value indexed by leaf overlap.

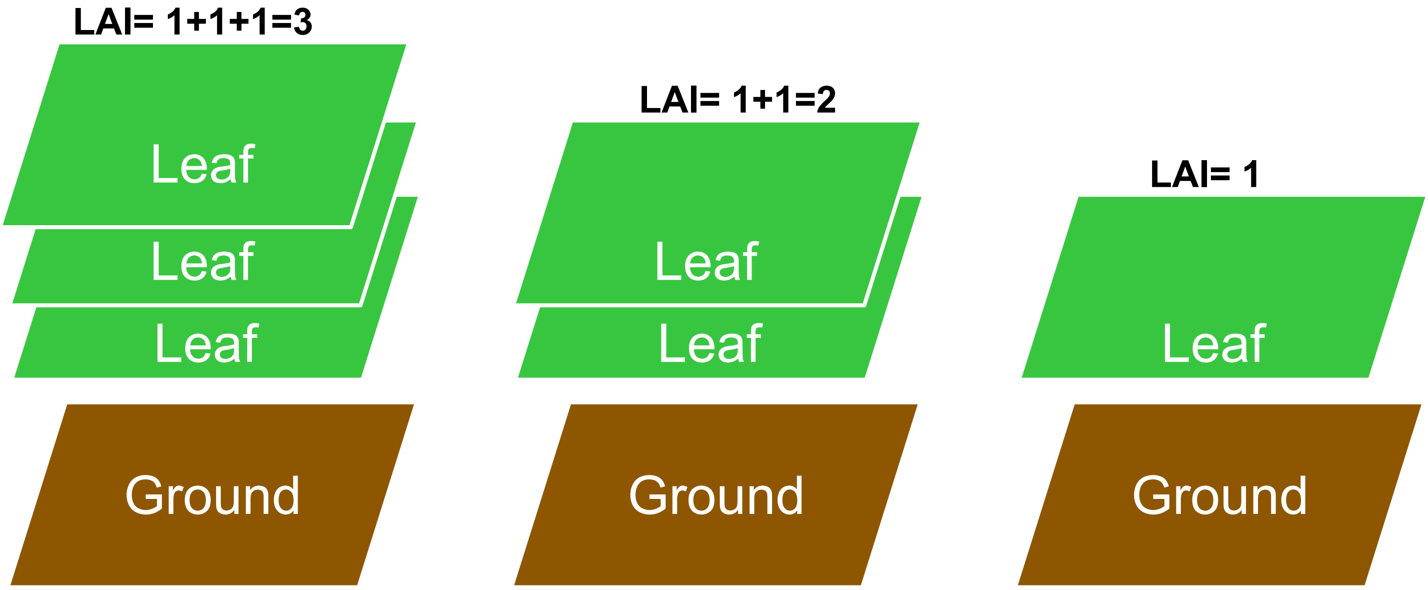

Fig 5. Schematic diagram of the LAI definition. Assuming there is one huge leaf in one layer

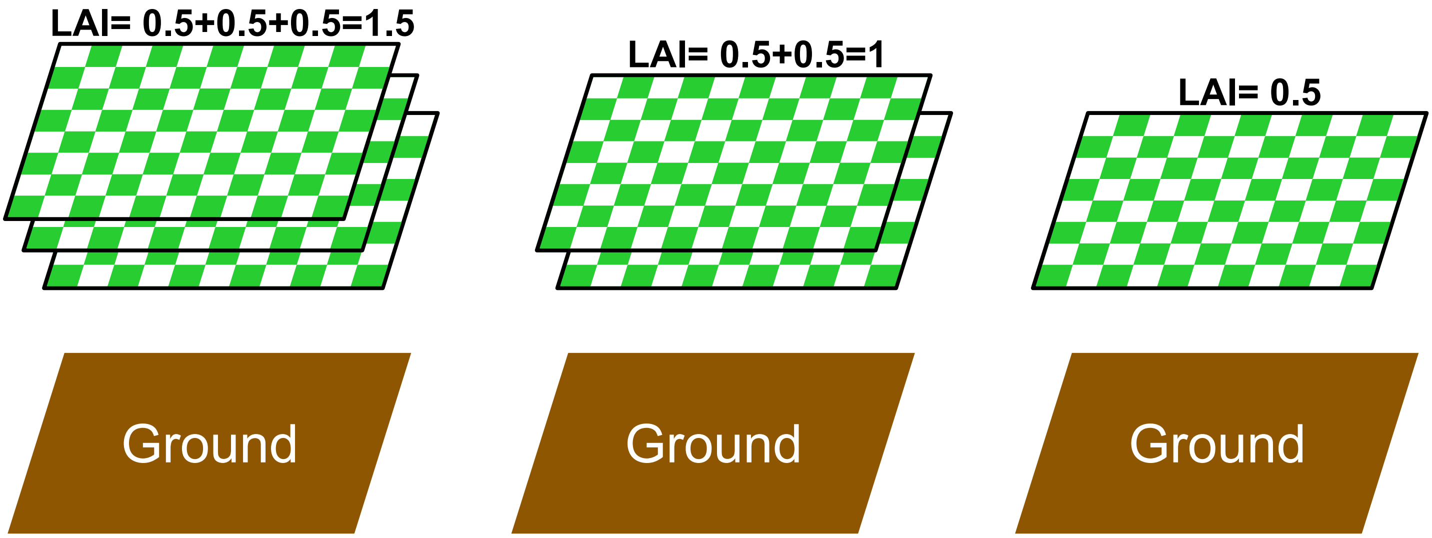

Fig 6. Assuming that one layer has leaves equivalent to LAI = 0.5

The big difference between Figures 5 and 6 is whether or not there is sunlight filtering through the ground. As you know, sunlight filtering through foliage certainly exists in real forests and vegetation, and the distribution is not divided into layers as shown in the figure, and the distribution of leaves is quite complicated. I think you can recognize it just by looking at it.

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How to use MIJ-15 LAI Series

6. LAI measurement by MIJ-15 LAI Type/K2, MIJ-15LAI/P and its precautions

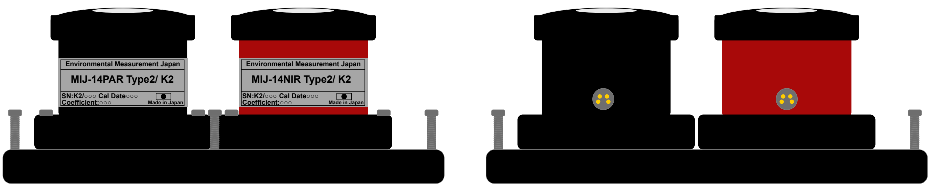
MIJ-15LAI TypeII/K2 is suitable for fixed point observation by connecting a data logger.

The following formula is used to convert /K2 and /P to LAI (the conversion formula is already entered in the logger before shipment). However, since this formula is a conversion formula for deciduous broad-leaved trees, applying this formula as it is to conifers and low-growing plants may lead to measurement errors. In order to measure accurately, we have no choice but to recreate the conversion formula or wait for the release of the formula for each tree species that has been confirmed in subsequent research presentations. For that reason, let's keep the measured values of PAR and IR without throwing them away. Even if the formula changes, it is possible to convert to LAI at a later date as long as the raw sensor data is stored.

Conversion formula LAI=2.80In(NIR/PAR)+0.69 In : natural logarithm
NIR : Near infrared (range of 700 to 1000 nm)

This formula derives from the fact that LAI can be calculated by measuring the two types of light that reach the forest canopy as a result of reflection and absorption of sunlight by chlorophyll in the tree trunk. Also, in order to reduce the effects of sun flecks and sun altitude (sun angle), we assume that the sensor will be installed stationary, continuous measurements will be taken, and the daily average value will be effective. Even if the sensor doesn't move, the sun moves, giving a similar effect to line transect measurements. In other words, MIJ-15LAITypeII/K2 is the only sensor that can measure LAI that can be used in this way, and it is a measurement method that stands out for its superiority. Although the vegetation structure of the canopy is generally complicated, it is possible to obtain the representative value of the LAI.

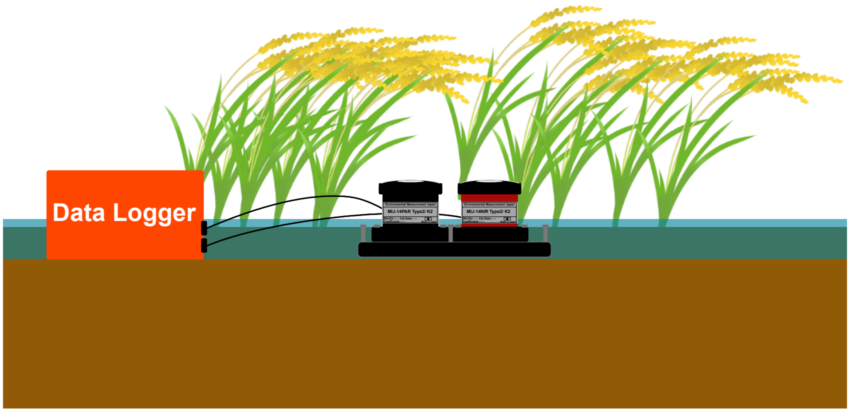
MIJ-15LAI TypeII/K2



Front Back

Fixed point observation image with MIJ-15LAI TypeII/K2

As shown in the illustration, simply combining it with a data logger enables unmanned continuous automatic observation of changes in LAI over time. (A data logger must be prepared separately.)



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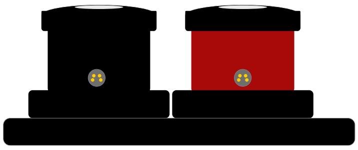
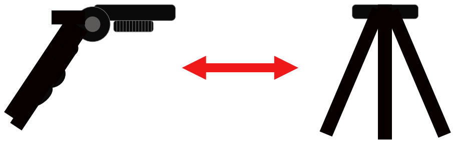
MIJ-15LAI TypeII/P

Front

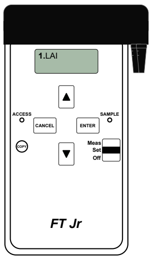


Back

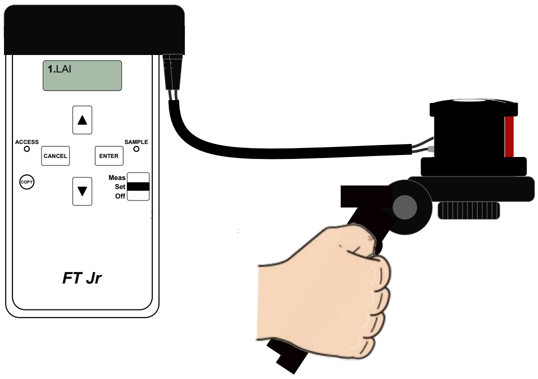


Gun Grip

Mini Tripod

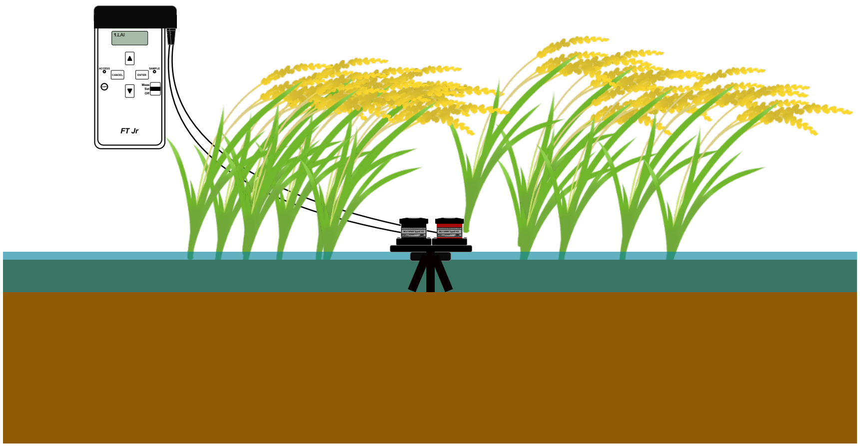


2ch Data Logger
（Non-waterproof）



Measurement image with MIJ-15LAI TypeII/P

As shown in the illustration, measurements can be taken while carrying the LAI/P and data logger. Gan Grip can also be used as a simple tripod, so it is possible to measure with the LAI/P placed on the ground in a field.



Creation of LAI conversion formulas suitable for target plants

Formula 6 (LAI = 2.80ln(NIR/PAR) + 0.69) is sufficient for deciduous broad-leaved trees, but it is better to create a new conversion formula to measure other vegetation correctly. connect. The most reliable method is to measure MIJ-15 while performing the pruning method, create a plot, and obtain a regression curve. The other method is to attach the leaves directly to the diffusion plate of the sensor and obtain plots when increasing the number of leaves by 1, 2, and 3. In this case, when the weather is fine, you can point the sensor fixed to the tripod toward the sunlight and measure it with leaves on it.

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How to use MIJ-15 LAI Series

Precautions when using MIJ-15LAI/P

When carrying out measurements, the sensor moves and the sun moves, so we have to be careful.

First of all, sun flecks refer to sun spots within a plant community. It is an image of sunlight filtering through foliage. When SunFleck happens to be directly illuminated on the sensor, it can no longer be said to be a representative light environment measurement value of the place. Next is the altitude of the sun, which varies both daily and annually. Plant communities are often dense and sparse, and differences in the sun's altitude lead to different paths of sunlight through the canopy. The rest is terrain. In extreme terms, the paths of sunlight on the north and south slopes are completely different at the same time.

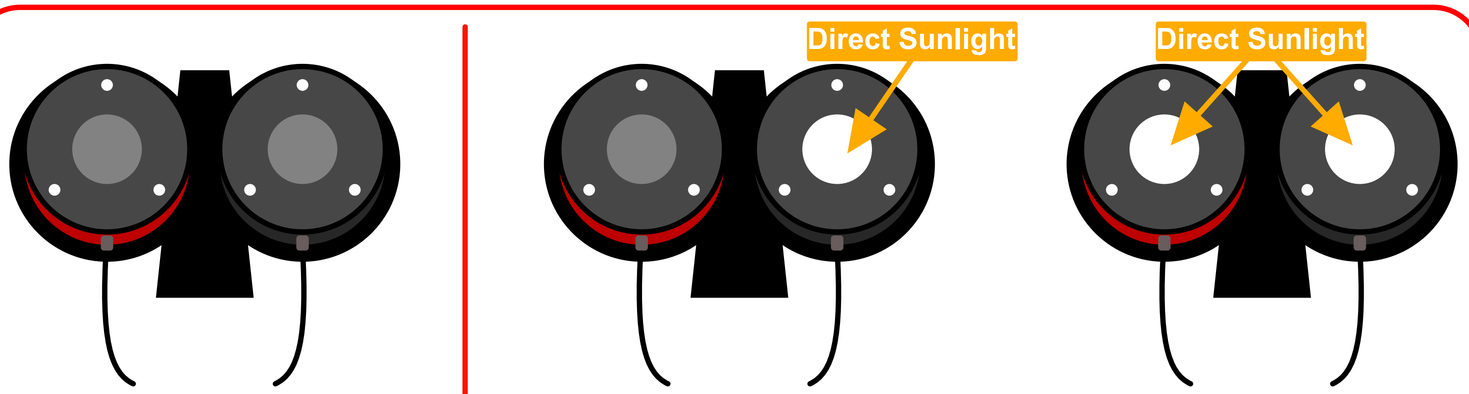
Regardless of any of the above, it is certain that the MIJ-15LAI/P is measuring the correct LAI at that moment and at that location. However, reproducibility depends on the positional relationship between the sun, the forest canopy, and the sensor because it is a portable measurement, resulting in low reproducibility as a whole.

Reproducibility can be improved by observing the following items as much as possible. This is an explanation assuming that multiple locations (however, the same location each time) are measured many times throughout the year on different days to measure a wide range of LAI.

- **a.** If possible, measure from 10:00 am to 3:00 pm.
- **b.** In order to improve the reproducibility of the location, consideration should be given to the same place and the same time as much as possible. Check your location with GPS if possible.
- **c.** Change the position of the sensor slightly at one place and measure several times, and finally take the average value as the effective value.
- **d.** When measuring near a large object other than a leaf that blocks solar radiation, position the operator on the side of the object and the sensor on the opposite side.
- **e.** If possible, you don't have to worry about a., c., and d if you measure in cloudy weather.

a. increases the reproducibility of the solar altitude and satisfies the time zone in which humans are more likely to act. **b.** is a consideration to improve positional reproducibility.**c.** is a consideration to reduce the influence of Sunfleck. Normally, you don't have to think much about **d.**, but it is a consideration when measuring near a huge wall, for example. **e.** means that when the weather is cloudy, the sunlight itself is already diffused, so the effect of **a.c.d** is naturally reduced.

There is also an advantage that it is easy to check how light hits the sensor because it is a portable measurement. In particular, it is the influence of Sunflec that hinders the reproducibility of measurements. A specific example of this is sunfleck, or direct sunlight on one or both sides of a NIR or PAR sensor. In other words, it can be said that part of the sunlight that passes through the gaps between the leaves is being irradiated onto the sensor. In this state, the light reaching the sensor is irrelevant to the leaves, and the LAI measurement does not work well. Measure in a position where both are not exposed to direct sunlight. In addition, this situation does not occur in cloudy weather, it is a caution only in fine weather. The diagrams below show correct and incorrect measurements.



NIR and PAR sensors are not exposed to direct sunlight ○

Direct sunlight on one side of the NIR or PAR sensor ✕

Both the NIR and PAR sensors are in direct sunlight ✕

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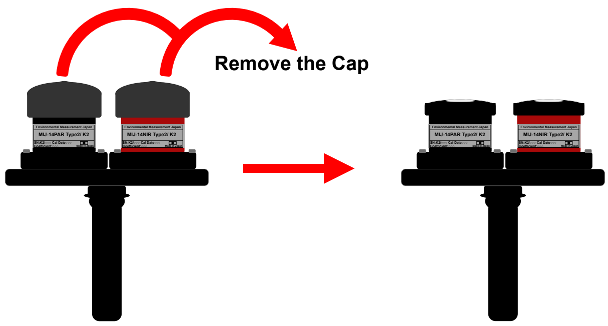
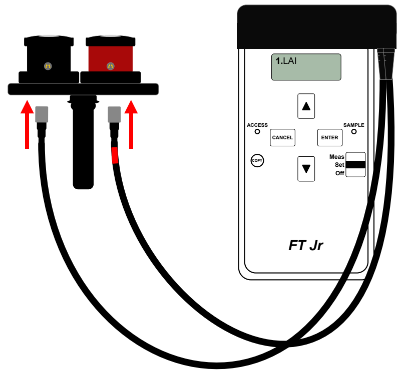
How to use FTjr 2ch Data logger with MIJ-15 LAI/P

7. MIJ-15LAI/P Manual

Setting

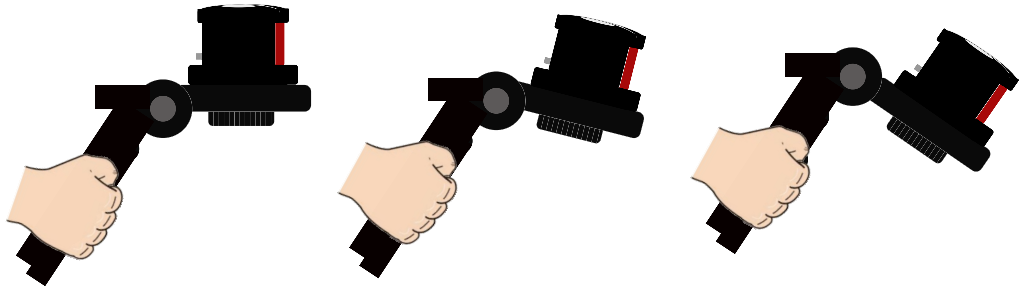
1. Remove the sensor and logger from the box and connect the cable to the sensor. Connect the **red** marked cable to NIR and the other to PAR. Remove the sensor cap.





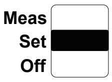
Red marked cable goes to NIR(Red body Sensor)

2. The grip can be adjusted to any angle, so fix it at an angle that is easy to use.

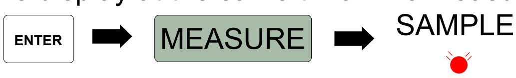


Start Measurement

1. Set the logger slide switch to SET. The display will automatically disappear after 60 seconds of inactivity, but pressing any button will restart it.



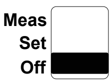
2. For measurement, press and hold the ENTER button (1 to 2 seconds), and when the logger accepts the operation, the SAMPLE LED lights up and MEASURE appears on the display at the same time. The measurement is now complete and the data is saved.

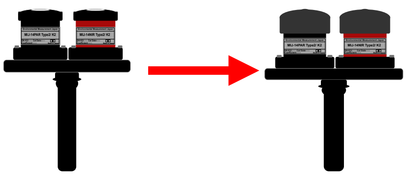


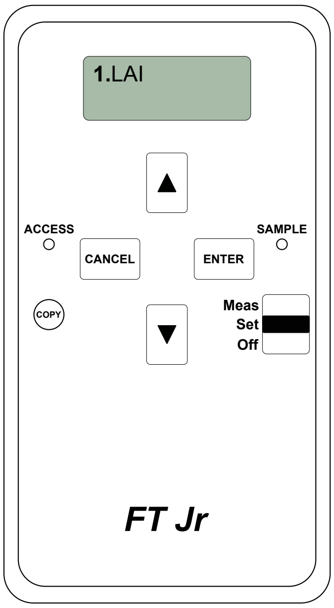
3. To see the LAI, NIR, and PAR values, press the ENTER button momentarily instead of holding it down.
1. LAI value, 2. NIR value, 3. PAR value, P. indicates the voltage of the built-in battery.

1.LAI | 2.NIR | 3.PAR | P. Battery

4. Set the slide switch to OFF when you finish the measurement. Remove the cable, put the cap on and store it.







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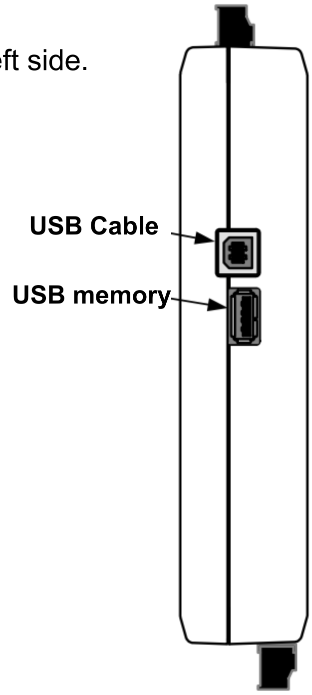
How to use FTjr 2ch Data logger with MIJ-15 LAI/P

Data Collecting: 2ways (USB memory or Cable)



USB memory:

1. Set the slide switch to the SET or MEAS position and insert your USB memory into the left side.

Meas / Set / Off **OR** Meas / Set / Off

2.Please press the COPY button(COPY). Data can be collected to a USB memory.

*At this time, if there are many files in the USB memory, the logger may judge that it has timed out, so please keep the number of files as small as possible.

USB cable:

1. Download LoggerSoft for FT Series from www.mcs-fs.com and install it on your PC.

2. Connect to your PC using the included USB cable. Launch the software.

3. Complete with connection menu → data collection.

Data Deletion

Basically, the data is deleted after the data is collected, but the data can be recorded up to 125,000 times of measurement without deleting it, so please decide arbitrarily.

1. Slide the slide switch to SET and press ENTER

Meas / Set / Off ➡ ENTER

2. Repeatedly pressing either the up or down arrow key will bring up Data Clr, press ENTER.

▲ **OR** ▼ Data Clr ➡ ENTER

3. Erase with a ▲button. Press the ▼ button to cancel deletion.

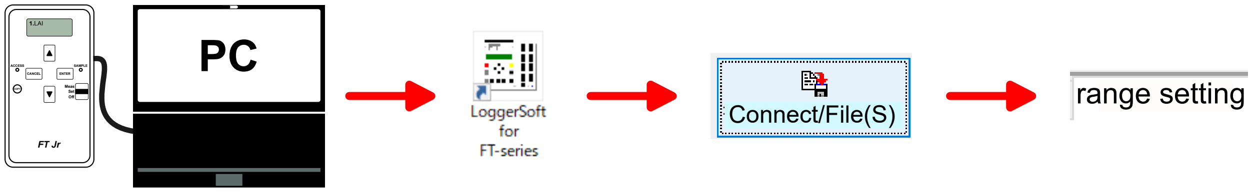
Other advanced settings > For details on the logger, refer to the attached "FtJr User's Manual".
For details on "LoggerSoft for FT Series", please download and refer to "LoggerSoft for FT Series Operation Manual".

Troubleshoot

1. The values of LAI, PAR and NIR are wrong?

Do the setting file and your PAR and NIR values match?

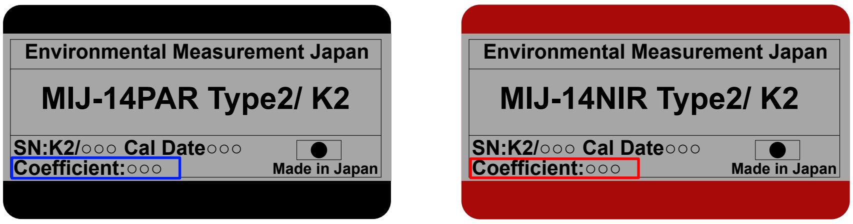
Connect FTjr to PC → Open LoggerSoft for FT Series → Select connection/file operation → Select range setting



After selecting the range setting, check if the value of the calculation formula and the coefficient written on the sensor body label match. If they do not match, be sure to enter the correct value and save.

NIR#001
PAR#002

Calculation formulas
#01*218.047
#02*190.161



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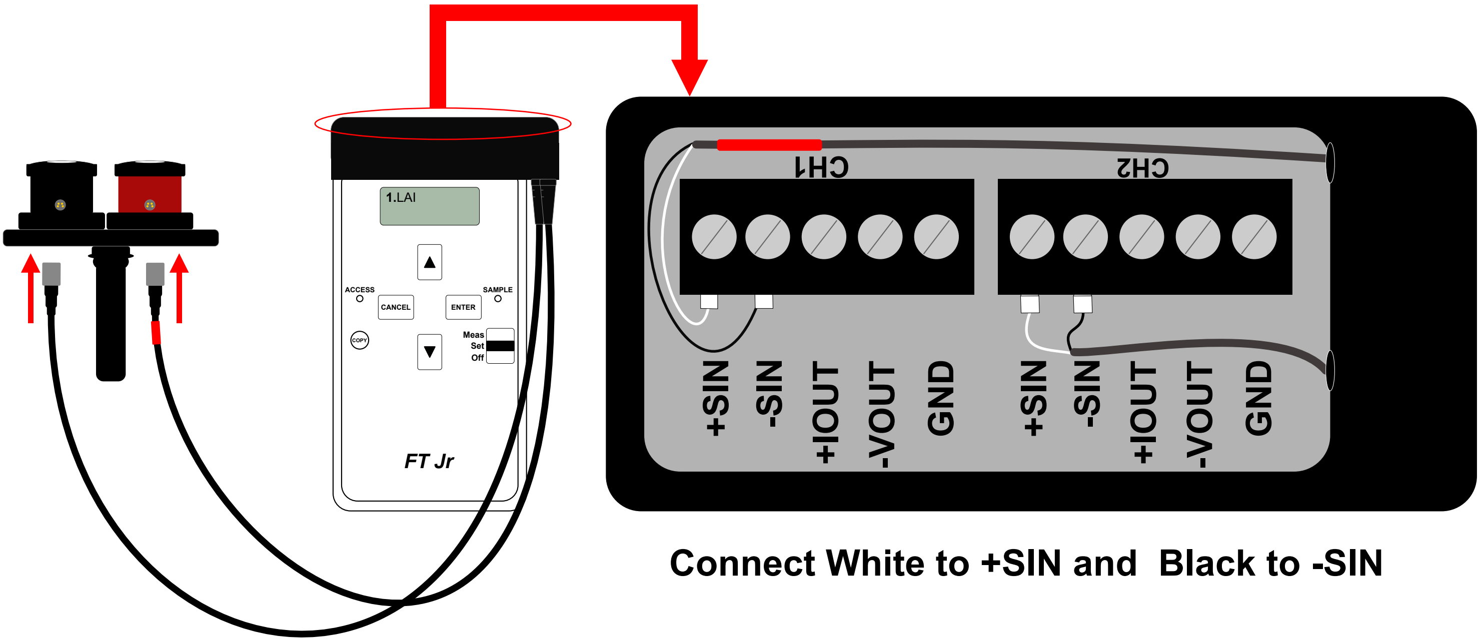
How to use FTjr 2ch Data logger with MIJ-15 LAI/P

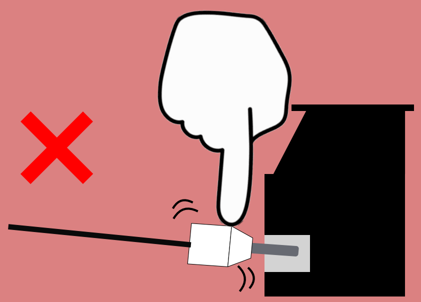
Does the arithmetic expression match the following?
If they do not match, enter them again as shown below and save.

Calculation formulas
2.8*E(#01/#02)+0.69
#01
#02

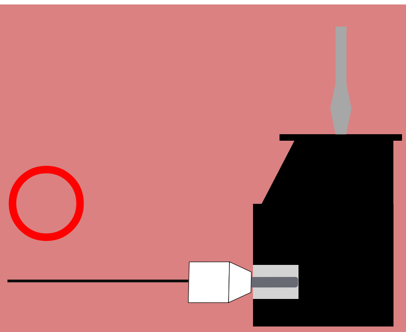
Are the wires connected to the terminal block (white and black wires) firmly connected?



Connect White to +SIN and Black to -SIN



The bar terminal wobbles when pressed with a finger.



Turn the flathead screwdriver to firmly fix the bar terminal to the terminal block so that it does not wobble.

If the problem persists even after checking all of the above, please contact us.

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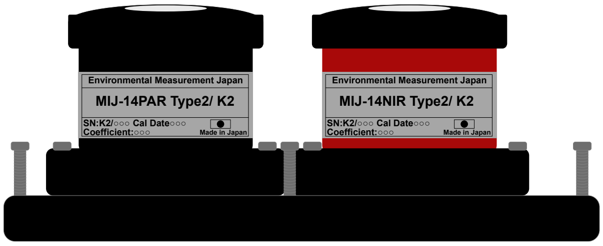
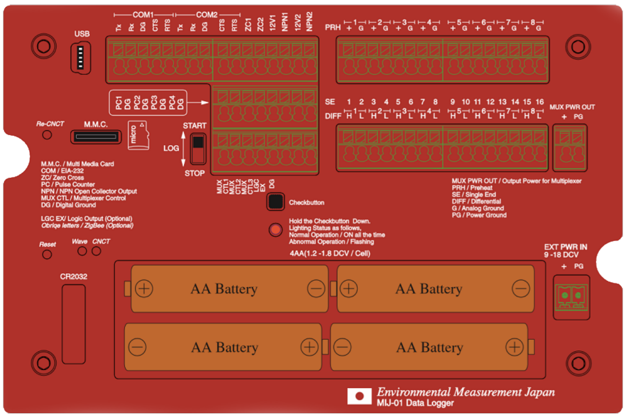
8. MIJ-15LAI/K2 with MIJ-01 Manual



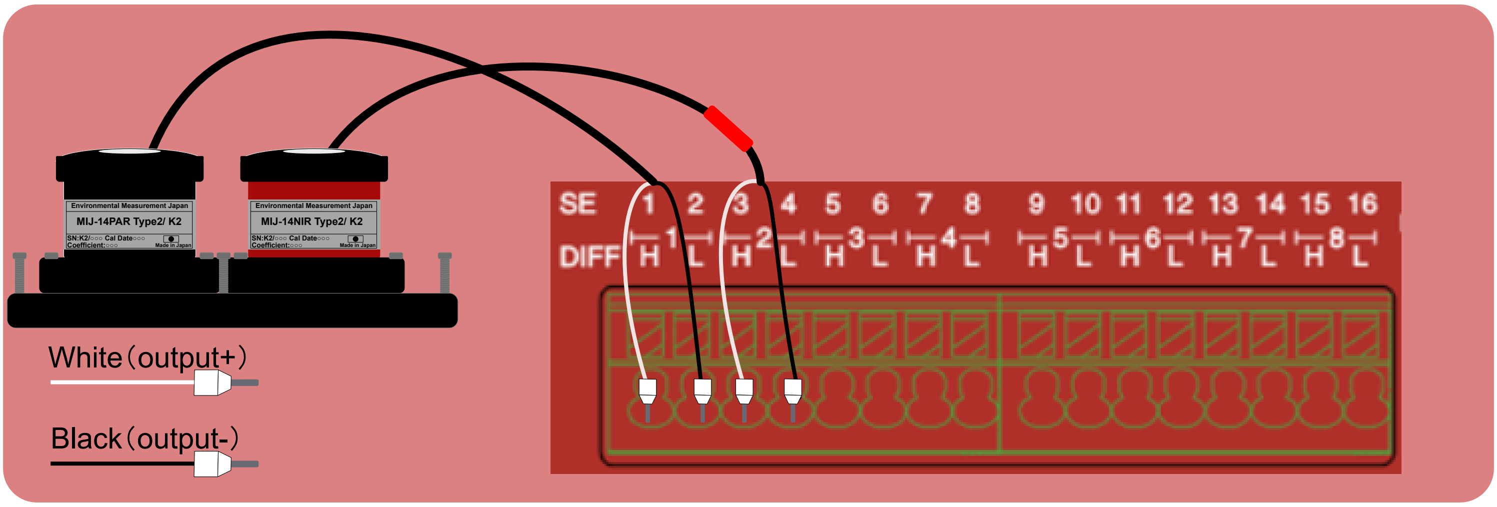
MIJ-15 LAI/K2



MIJ-01 Data Logger

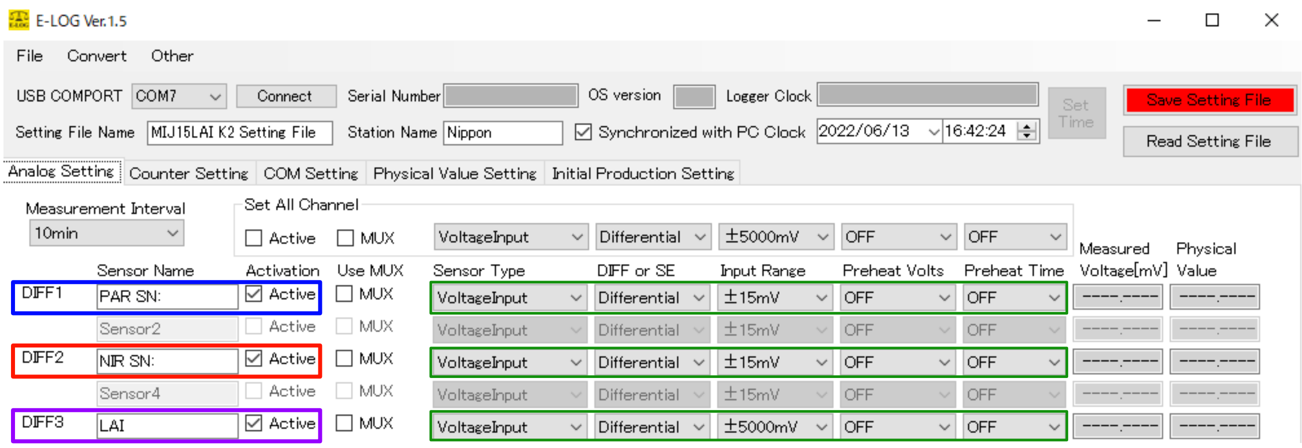
Wiring

Connect the sensor to the logger (MIJ-01). The connection method at this time is to connect with Differential.



Setting

When you purchase MIJ-15 LAI/K2 and MIJ-01, we will send you the MIJ-01 configuration file as an email attachment. Launch the E-LOG software, select Read Setting File, and select the setting file that was sent to you. The following settings will be displayed. (The photo below shows the case where PAR is connected to DIFF1 and NIR is connected to DIFF2.)



* LAI is input to DIFF3, but since data is not actually taken from the sensor here, there is no problem even if the input range is different from PAR and NIR.

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How to use MIJ-01 Data logger with MIJ-15 LAI/K2

The coefficient of each sensor is entered in the Physical Value Setting tab. At the same time, we have also entered an arithmetic expression so that the LAI value is also saved.

Save Setting File | Read Setting File

Analog Setting | Counter Setting | COM Setting | **Physical Value Setting** | Initial Production Setting

☑ Active Physical Value Calculation

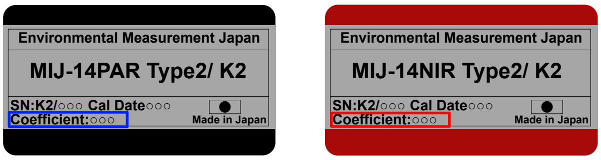
Variable	Activated Ch	Sensor Name	Enter Any Value(to Check Eq.)
X001	DIFF1	PAR SN:	1
X003	DIFF2	NIR SN:	3
X005	DIFF3	LAI	5

Equation Hint

You can use functions as shown below.
+,-,*,/,(,),ABS(X),EXP(X),INT(X),SIN(X),COS(X),TAN(X),PI

Some functions should to be input as shown right side below,
LN(X) → LOG(X)
LOG10(X) → LOG(X)/LOG(10)
LOG(X,A) → LOG(X)/LOG(A)
SQRT(X) → SQR(X)
POWER(X,Y)→ X^Y
RADIAN(X) → X*PI/180
DEGREE(X) → X*180/PI

Sensor Name	Equation		Result
PAR SN:	184.591*X001	Check	
NIR SN:	192.593*X003	Check	
LAI	2.8*LOG(192.593*X003/184.591*X001)+0.69	Check	

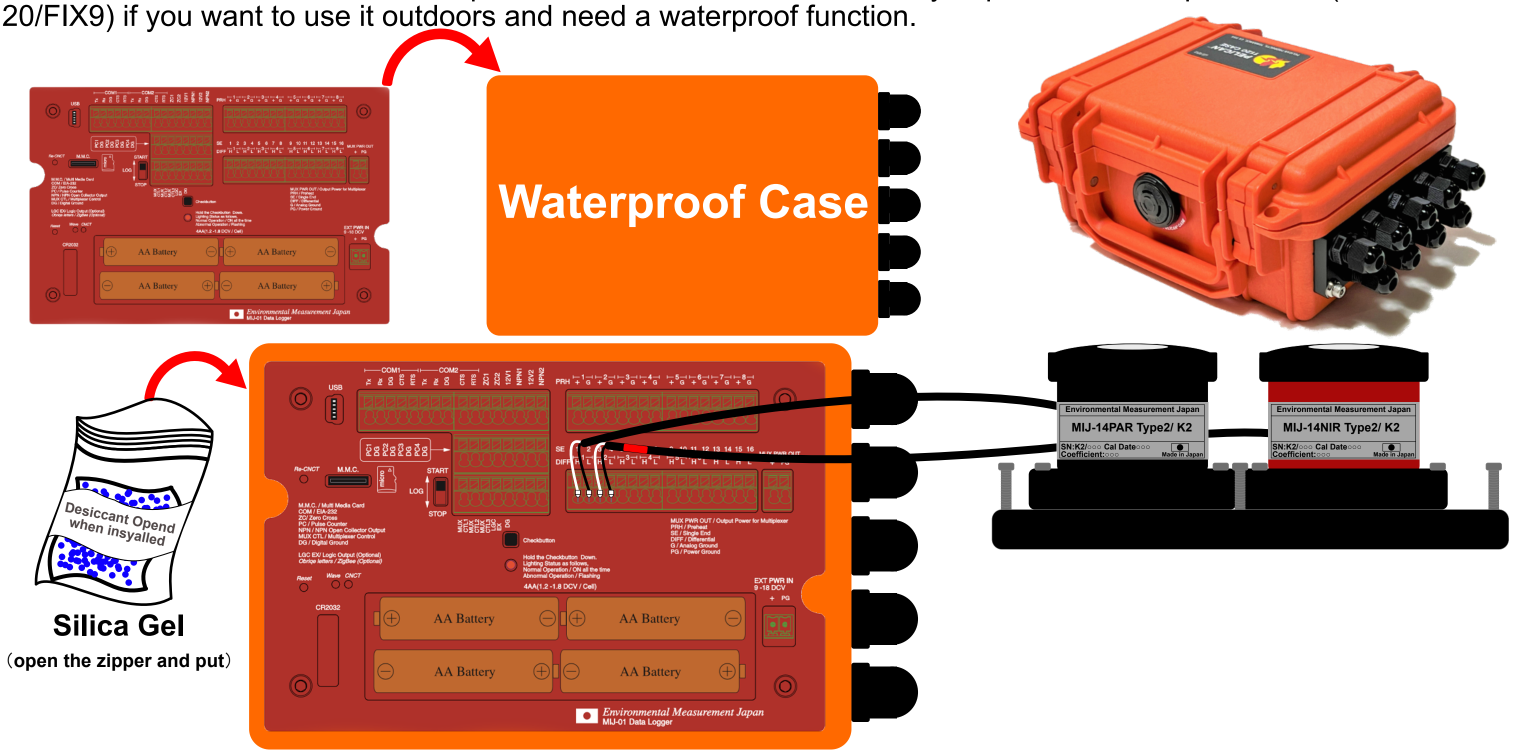


How to save settings: Select Save Setting File → BOTH (or To PC, To Logger) in the upper right.
If you select BOTH or To PC, the setting file will be saved on your PC.

Setting file image

MIJ-01 + Waterproof Case

Since MIJ-01 does not have a waterproof function, we recommend that you put it in a waterproof case (MIJ01/BOX1120/FIX9) if you want to use it outdoors and need a waterproof function.



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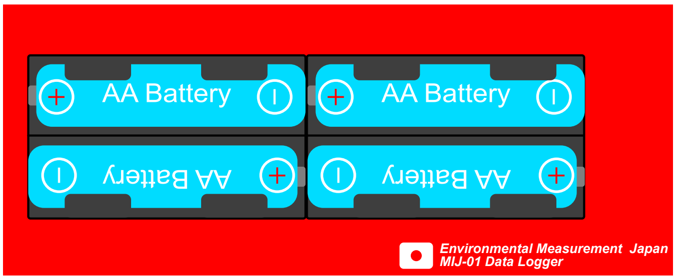
How to use MIJ-01 Data logger with MIJ-15 LAI/K2

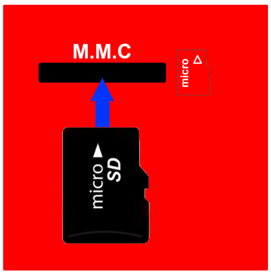
Quick Start Manual for MIJ-01 with MIJ-15 LAI/K2

The explanation assumes that the connection between the sensor and the logger and the saving of the configuration file to the logger have been completed.

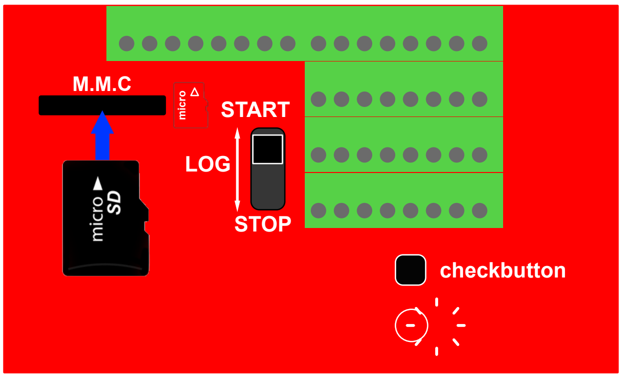
1.
Make sure the battery terminals are oriented correctly.



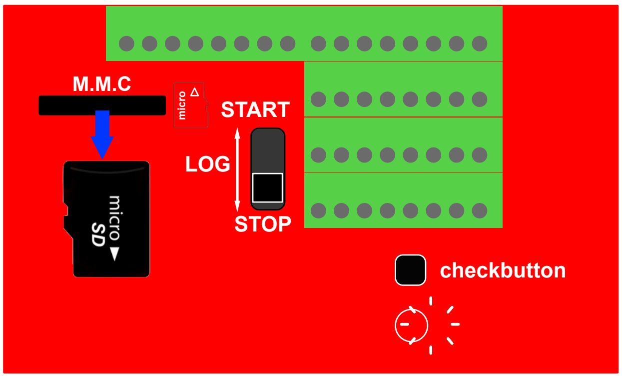
2.
insert micro sd card。



3.
Slide the LOG switch toward START. This operation will start the measurement.



4.
Slide the LOG switch toward STOP. At this time, the LED blinks, so please remove the SD card after blinking.



For more detail about MIJ-01: https://environment.co.jp/wp/wp-content/uploads/2021/01/MIJ-01-English-Manual.pdf

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