



# Instruction Manual

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**LAS MkII ET System**

## IMPORTANT USER INFORMATION

Dear customer, thank you for purchasing a Kipp & Zonen instrument. It is essential that you read this manual completely for a full understanding of the proper and safe installation, use, maintenance and operation of your new LAS MkII ET System.

Please read this manual in conjunction with the instruction manual for the LAS MKII scintillometer.

We understand that no instruction manual is perfect, so should you have any comments regarding this manual we will be pleased to receive them at:

Kipp & Zonen B.V.  
Delftechpark 36, 2628 XH Delft, - or  
P.O. Box 507, 2600 AM Delft,  
The Netherlands

T: +31 (0) 15 2755 210  
F: +31 (0) 15 2620 351  
support@kippzonen.com  
www.kippzonen.com

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## 1 INTRODUCTION

Throughout this manual the following symbols are used to indicate to the user important information.



General warning about conditions, other than those caused by high voltage electricity, which may result in physical injury and/or damage to the equipment or cause the equipment to not operate correctly

**Note** Useful information for the user

### 1.1 Product overview

**Note** Please read this manual in conjunction with the instruction manual for the LAS MKII scintillometer.

The LAS MkII ET System (ET stands for evapo-transpiration) is designed for scintillometer-based surface flux measurements and is specially intended for Earth energy balance and water management studies. Evapo-transpiration is an important term of the surface energy budget:

$$Q^* = H + L_v E + G_s \quad [\text{W/m}^2]$$

where  $Q^*$  is the available energy, also known as the net radiation ( $Rn$ ),  $H$  the sensible heat flux,  $L_v E$  the latent heat flux and  $G_s$  the soil heat flux. In some cases extra storage and/or advective terms can be added to the surface energy balance. The evapo-transpiration ( $ET$ ), which stands for the evaporation ( $E$ ) from bare soil and the transpiration ( $T$ ) by vegetation, is related to the latent heat flux ( $L_v E$ ) as follows

$$ET = \frac{L_v E}{L_v}$$

where  $L_v$  is the latent heat of vaporisation (the energy required to evaporate 1 kg of water,  $L_v \sim 2.45 \times 10^6 \text{ J kg}^{-1}$ ).

This means that ET can be expressed as:

- an energy flux ( $L_v E$ ) in  $\text{W/m}^2$ , mostly used in used in meteorology, or
- as a mass flux (ET) in  $\text{mm/day}$ , mostly used in hydrology, where  $1 \text{ W/m}^2$  is equal to  $0.0353 \text{ mm}$  of water per day.

The latent heat flux ( $L_v E$ ), or ET, is an important term in the soil-water balance:

$$\Delta S = \text{input} - \text{output}$$

where  $\Delta S$  is the change of storage of water in the soil, which is the result of the amount of input into the soil (due to rainfall or irrigation) minus the amount of loss of water (due to evapo-transpiration, surface run-off and drainage).

The LAS MkII ET System has been developed to provide area-representative surface fluxes of sensible heat ( $H$ ) and latent heat ( $L_v E$ ). A unique feature is the line of sight path-integrating capability of the large aperture scintillometer. This allows the user to measure area-averaged surface fluxes of sensible heat at scales from 100 m to 4.5 km, over both homogenous and moderately heterogeneous areas.

Traditional measurement techniques (the eddy-covariance method, flux-profile method, Bowen ratio method and lysimeters) are point (in-situ) measurements and therefore are less representative of large areas, particularly the pixel area of satellite instruments.

## 1.2 Key parts of the LAS MkII ET system

The LAS MkII ET system consists of four parts; a LAS MKII scintillometer, an extended set of meteorological sensors with a mast, a data logger in a weatherproof enclosure, and data processing software to run on a Windows® compatible computer.

The structure parameter of the refractive index of air ( $C_n^2$ ) measured by the LAS MKII, air temperature, wind speed, and air pressure, are used to determine the surface flux of sensible heat ( $H$ ). By adding a second temperature sensor, net radiometer, and soil heat flux sensors, the latent heat flux ( $L_vE$ ) can be derived, via

$$L_vE = Q^* - H - G_s$$

$L_vE$  is the residual term of the energy balance.

The data processing of the LAS MkII ET system is done by the EVATION (evapotranspiration) software program. This user-friendly program, developed by Kipp & Zonen, processes the raw data to fluxes of sensible and latent heat.

LAS MkII transmitter



LAS MkII receiver



Datalogger



## 2 INSTALLATION

Please follow the instructions in this section carefully for the mechanical and electrical installation of the LAS MkII ET System.



Do not turn on power to the transmitter, receiver or data logger until instructed to do so.



Ensure that fixings and mountings are securely tightened when instructed to do so.

### 2.1 Included with the system

Check the contents of the shipment for completeness (see below) and note whether any damage has occurred during transport. If there is damage, a claim should be filed with the carrier immediately. In the case of damage and/or the contents are incomplete, contact your local Kipp & Zonen representative or e-mail the Kipp & Zonen customer and product support department at: [support@kipazonen.com](mailto:support@kipazonen.com)

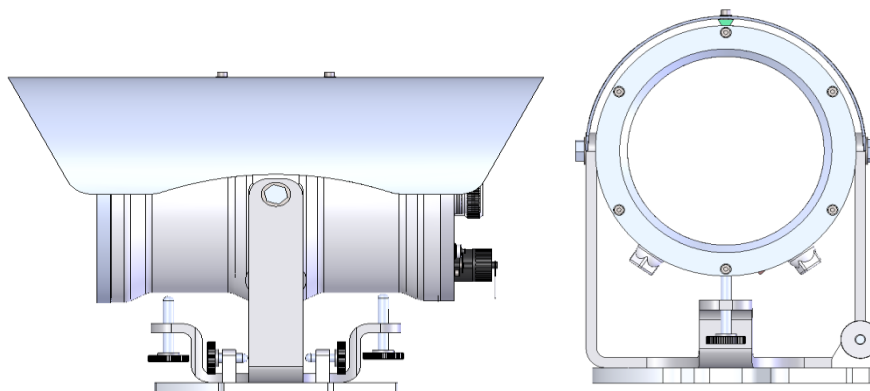
**Note** The LAS MkII is rugged, but it contains sensitive optical and electronic parts. Please keep the original transport case and packaging to safely transport the scintillometer to measurement sites or for other shipments.

#### 2.1.1 LAS MkII scintillometer

The following items are included with the LAS MkII scintillometer:

- LAS MkII transmitter with pan and tilt adjuster and baseplate
- LAS MkII receiver with pan and tilt adjuster and baseplate
- 2 × alignment telescope with detachable mounting, adjusted for each transmitter and receiver
- 2 × sun shield with two fixing screws
- 2 × 100 mm diameter aperture restrictor with fixing kit, for transmitter and receiver
- 1 × 10 m cable with 4-pin plug for transmitter signal output and receiver analogue connections
- 1 × 10 m cable with 8-pin plug and 9-pin D-connector for receiver digital communication connections
- 2 × 10 m cable with 4-pin connector for 12 VDC power input
- 2 × 3 mm hexagonal Allen keys, for fitting the sun shields
- 2 × 4 mm hexagonal Allen keys, for fitting the telescopes
- 1 × USB memory stick containing EVATION software and a pdf file of the LAS MkII instruction manual
- 8 × spare desiccant packs
- 1 × GPS antenna with 2 m cable and 8-pin plug, affixed on aluminium mounting arm
- 1 × aluminium transport case to hold above parts

For a full description of the LAS MKII scintillometer refer to its instruction manual.



### 2.1.2 Meteorological sensors and mast

The following items are included with the meteorological sensors and mast:

<b>Temperature sensor x 2, upper and lower</b>	
Range	-40 °C to +60 °C
Output	PT-100 (4-wire)
Calibration	0.03°C 1/10 DIN accuracy
<b>Wind speed sensor</b>	
Operating temperature	-25 °C to +80 °C
Range	0 to 60 m/s
Voltage and power sensor Voltage and power heater	Nominal 12 VDC (~2 mA) Nominal 12 VDC (max 7 Watt)
Output	Digital 0 to 600 Hz
<b>Wind direction sensor</b>	
Operating temperature	-25 °C to +80 °C
Range	0 to 360°
Voltage and power sensor Voltage and power heater	Nominal 12 VDC (~2 mA) Nominal 12 VDC (max 7 Watt)
Output	8-bit Gray Code
<b>Air pressure sensor (mounted inside data logger enclosure)</b>	
Operating temperature	-25 °C to +70 °C
Range	600 – 1050 hPa
Voltage and power	Nominal 12 VDC (~10 mA)
Output	0.3 – 4.9 VDC
<b>Soil heat flux sensor</b>	
Operating temperature	-30 °C to +70 °C
Range	± 2000 W/m <sup>2</sup>

Output	± 20 mV
<b>Mast, telescopic</b>	
Height	4 m maximum
Guy wires	3 stainless steel wires with securing pins
Baseplate	With socket for mast
Lightning protection	Mast top rod and earth spike
Mounting arms	U-shaped - wind speed and direction sensors 2-sided - upper temperature sensor and NR Lite2 1-sided - lower temperature sensor

### 2.1.3 NR Lite2 Net Radiometer

The mast includes a mounting arm for the Kipp & Zonen NR Lite2 net radiometer.

Net radiation sensor, NR-Lite2	
Operating temperature	-40 °C to +80 °C
Range	± 2000 W/m <sup>2</sup>
Output	~ ± 20 mV

### 2.1.4 COMBILOG Data Logger

The data logger is fitted in a stainless steel weather-proof enclosure with a clamp for the mast.

COMBILOG 1022 data logger Stainless steel enclosure, over-voltage input protection, mast mountings	
Operating temperature	-20 °C to +60 °C
Supply voltage	10 to 30 VDC
Analogue inputs	8 (16-bit)
Digital I/O	6
Interfaces	RS-232/RS-485/USB/Ethernet
Data storage	7 MB internal RAM, expandable by SD card
<i>Optional</i>	<i>AC to 12 VDC power supply and backup battery</i>
<i>Optional</i>	<i>GSM data modem</i>

### 2.1.5 Additional items

The data logger is fitted in a stainless steel weather-proof enclosure with a clamp for the mast.

- LAS MkII manual, EVATION software and manual (supplied on a USB memory stick with the LAS MkII scintillometer)
- Documentation for the meteorological sensors
- COMBILOG support software (supplied on CD-ROM) and manual
- NR Lite2 instruction sheet and calibration certificate (supplied with the NR Lite2)

**Note** Kipp & Zonen reserves the right to make changes to specifications without prior notice.

**Note** The ET system is not supplied with a relative humidity sensor. A default value (50%) is used in the EVATION software. Uncertainties in *RH* have only a small effect on the sensible heat flux and the evapo-transpiration.

## 2.2 Site selection procedure

This section provides information on selecting an appropriate installation site.

### 2.2.1 LAS MkII scintillometer

For the general installation and site requirements of the LAS MkII scintillometer please refer to its manual.

For reliable air ( $C_n^2$ ) and flux ( $H$  and  $LvE$ ) measurements it is important to meet the installation requirements of the scintillometer. These are:

- The LAS MkII transmitter and receiver must be placed on robust and vibration free supports.
- Avoid saturation of the signal by installing the LAS MKII at a suitable height (depending upon surface conditions and path length).
- Ensure that the LAS MKII is measuring in the Constant Flux Layer for reliable flux derivations of the  $C_n^2$  signal using MOST (depends on surface characteristics).



Pay attention to orientation, installation height and beam height requirements. For detailed information refer to the LAS MkII instruction manual.

### 2.2.2 The meteorological sensors and mast

The LAS MKII receiver is supplied with a 10m long cable for connecting the 0 V to 2.4 V and 0 V to 2 V analogue signal outputs to the data logger. Normally, the weather station is sited within 10 m of the receiver, but, if necessary, these can be extended to optimise the weather station location.

Selecting an appropriate site for the weather station is critical in order to obtain data that is representative of the LAS beam path. It must be sited away from the influence of obstructions such as buildings, trees and other objects which might disturb the measurements of wind speed, temperature and net radiation. As a rule of thumb, the minimum distance from an obstruction of height  $h$  is  $10h$ .

The ground around the mast should be flat. As the anchoring of the mast is based on 3 securing pins to hold the guy wires, the soil must be stable enough to hold the load in high winds or when the ground is wet. If in doubt, use a concrete foundation.

There must be a good, firm place to drive in the lightning rod earth spike.

## 2.3 Power supply

The LAS MKII transmitter requires 12 VDC nominal (9.6 – 15 VDC), 6 W maximum with heater off and 54 W maximum with heater on (typically 26 W).

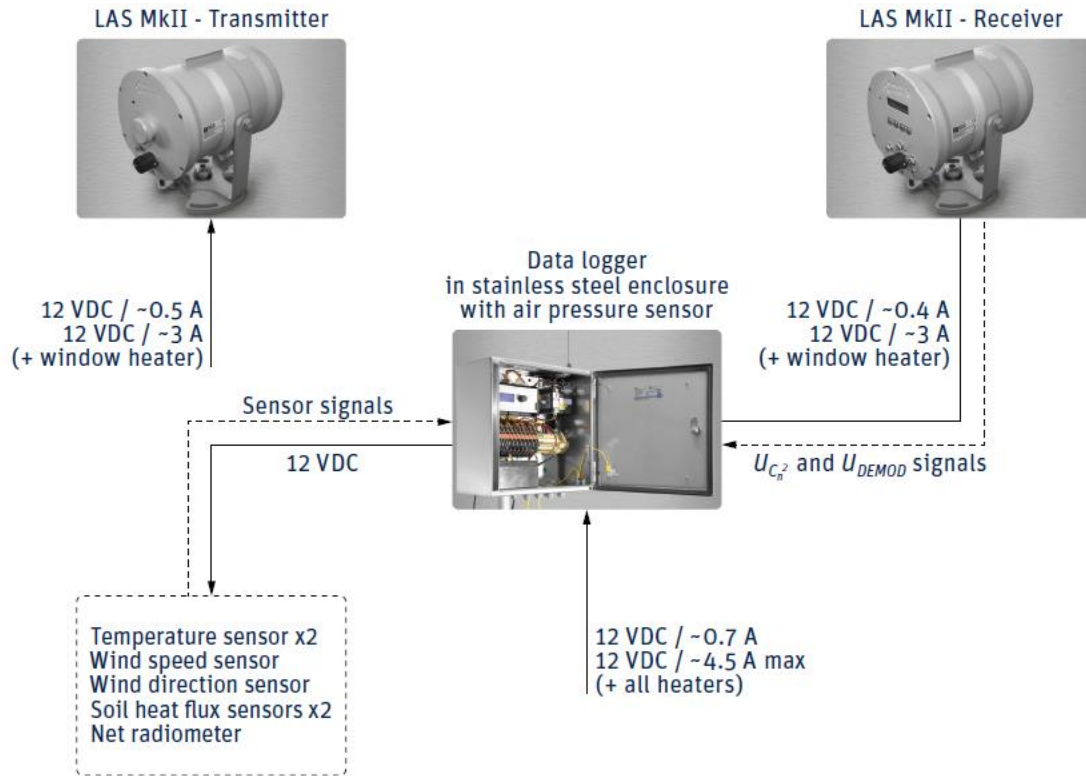
The LAS MKII receiver requires 12 VDC nominal (9.6 – 15 VDC), 5 W maximum with heater off and 51 W maximum with heater on (typically 23 W).

For more information, please read the LAS MkII scintillometer manual.

The meteorological sensors and data logger require 12 VDC nominal, 4 W maximum with heaters off and 18 W maximum with heaters on.

**Note** The data logger power requirement will be higher if an optional communication modem is fitted. Please refer to the data logger and/or modem manual.

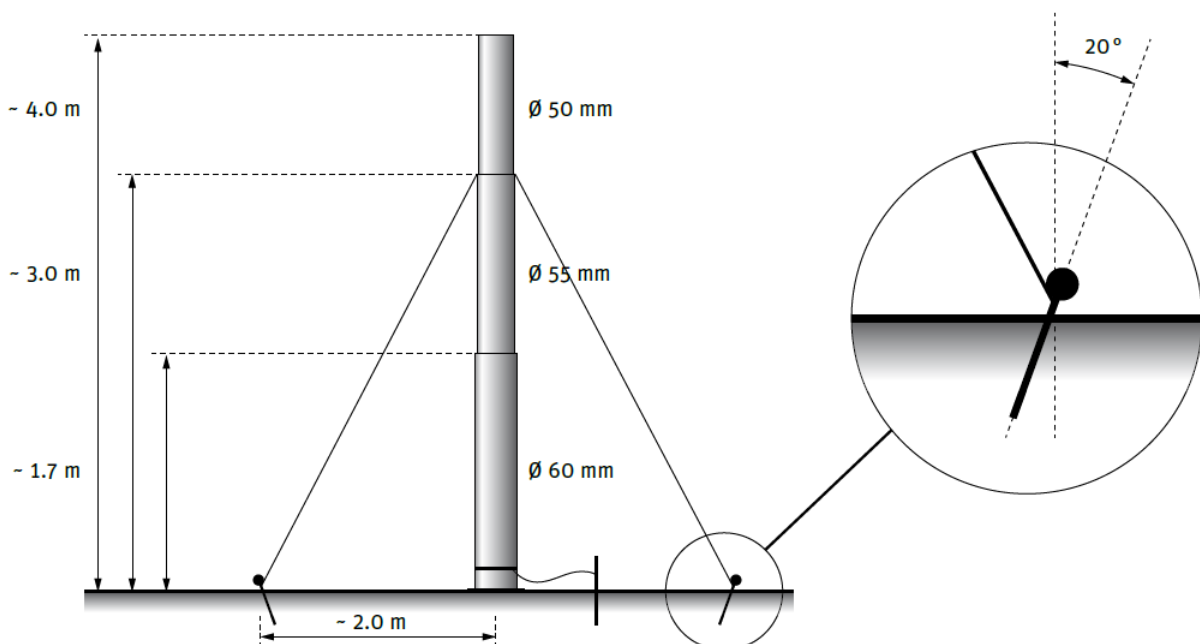
Mains AC power must be available for AC to 12 VDC convertors, if solar panel / battery power supplies are not used.



## 2.4 Assembling the meteorological mast and sensors

### 2.4.1 The mast

Assemble the mast horizontally on the ground in accordance with the dimensions shown below.





The safe clamping zone of each section is indicated by red stripes on each mast section, as shown below.



1. The nominal mast height of 4 m is achieved when clamping the sections at their lower marks.
2. The guy wires are supplied pre-assembled to triangular collar. This must be slid over the upper section of the mast, as shown above, before fitting any other items.
3. The base plate has a socket for the bottom of the lowest mast section.

#### 2.4.2 The mounting arms and sensors

Assemble the mounting arms and sensors to the mast as in the image below.



1. The U-shaped mounting arm is fitted to the top of the mast.  
The wind direction sensor (*WD*) is mounted on the lower (shorter) 'leg' of the arm.  
The wind speed sensor (*u*) and lightning rod are mounted on the upper (longer) 'leg'.
2. The 2-sided mounting arm is fitted to the middle section of the mast at about 2.7 m.  
The upper temperature sensor (*T+*) is mounted on the longer side of the arm.  
The NR Lite2 net radiometer (*Q\** or *R<sub>n</sub>*) is mounted on the shorter side of the arm.  
The bubble level and the anti-bird stick must be facing upwards.  
The net radiometer must be pointing towards the equator to avoid shadows from the mast.
3. The 1-sided mounting arm is fitted to the lower section of the mast at a height of about 0.5 m.  
The lower temperature sensor (*T-*) is mounted on the arm.  
The sensor must be oriented vertically below the upper temperature sensor.



When the temperature sensors are positioned too close to each other no reliable direction for the temperature gradient can be measured, particularly during the day. The minimum distance between the sensors is 1.7 m.



The lower temperature sensor should not be mounted more than 1m above the ground (or the effective surface height, such as the mean level of grass or a crop around the mast).

4. Use cable ties to fix the sensor cables to the mast and mounting arms and lead the cables to the lower end of the mast, where at a later stage the data logger enclosure will be mounted.

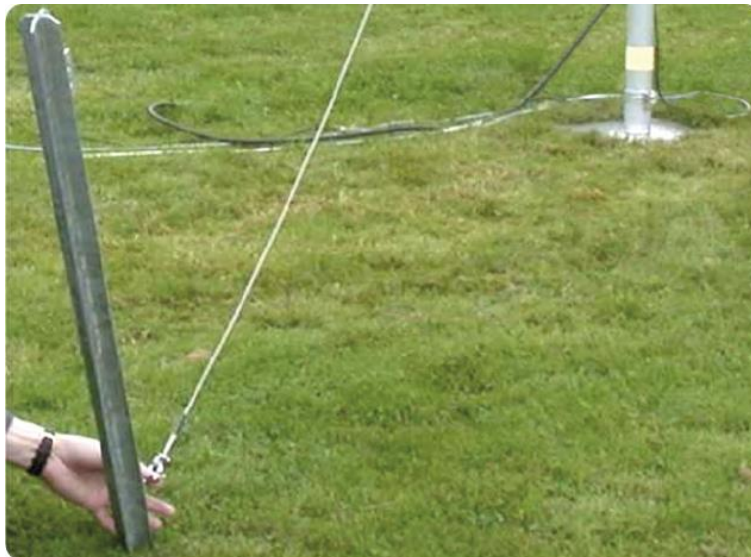
## 2.5 Installing the mast

Two persons are required to erect the mast. One person holds the mast in an upright position whilst the second person determines the positions where the guy wire securing pins will be driven into the ground.

1. The lower guy ends are 0.3 m longer than theoretically required in order to hold the mast vertical on an uneven surface. Two guy wire ends have a plain thimble, while the third has a turnbuckle (cable tensioning device) for adjustment after erection of the mast.



The 3 guy rope securing pins should be driven in at an angle about 20° outwards from vertical, as shown below and in 2.4.1.



2. The securing pin for the guy wire with the turnbuckle should be driven in last. First set the bottle screw to its maximum length. Locate the securing pin so that the mast leans slightly away from it. Use the bottle screw and a spirit level to make the mast vertical.



The 3 guy ropes should have moderate and equal tension, do not put a bending force on the mast.

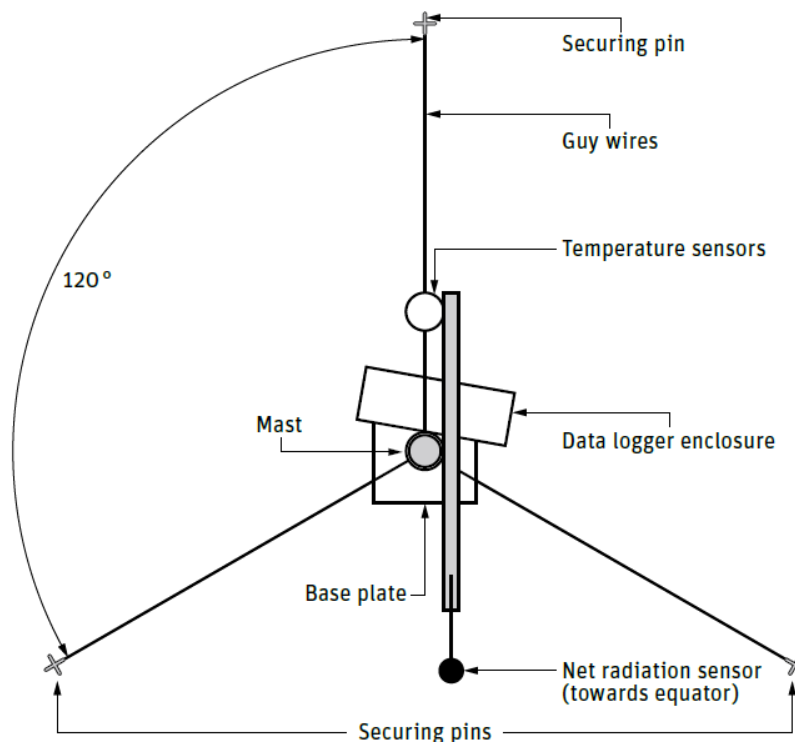
3. Fix down the base plate of the mast with 4 smaller securing pins.
4. Finally, drive in the lightning rod earth spike

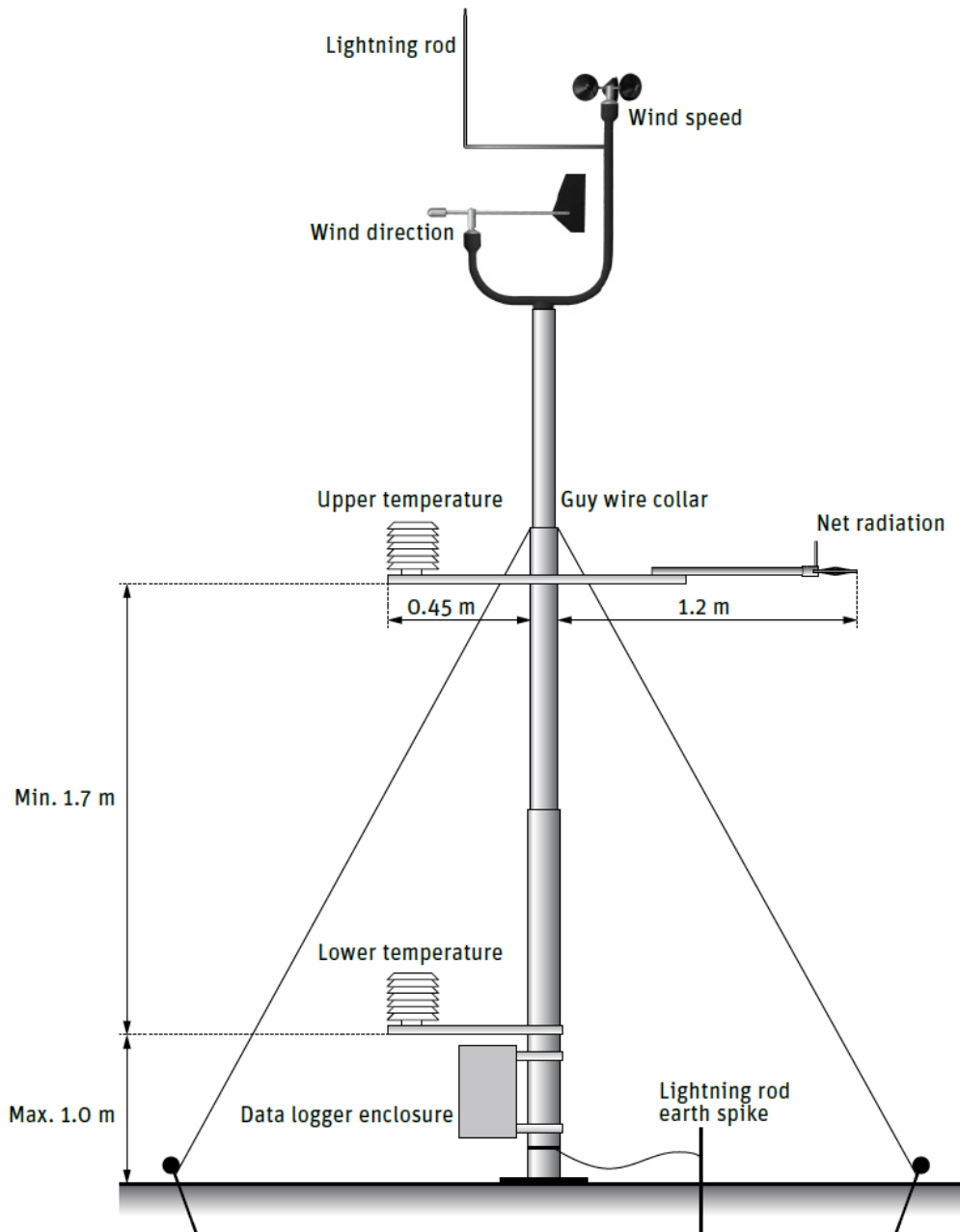


Check the guy wire tension and the mast alignment frequently. If the ground is not firm enough to keep the mast vertical in all weather conditions, use concrete for anchoring.

## 2.6 Mounting the data logger enclosure

Once the mast, with mounting arms and sensors, is erected and levelled the stainless steel data logger enclosure can be fixed to the lower section of the mast, as shown in the next two drawings. Use the two clamps already fitted to the back of the enclosure. Allow at least 0.1 m clearance below the enclosure for the cables to enter.





The installation should now be as in the drawings above.

**Note** Check that the net radiometer is horizontal using the bubble level on its upper surface.

## 2.7 The soil heat flux sensors

The last sensors to be installed are the soil heat flux plates. Place them on the same side of the mast as the net radiation sensor (towards the equator) and at a spot that is not disturbed by footsteps. The measurements should be representative of the general area covered.



Do not position the plates directly beneath the net radiation sensor, as they may disturb the measurements

Depending on the soil type and the presence of vegetation the plates should be buried at a depth of about 30 mm for bare soil conditions or just beneath the surface of fully covered soil (a few mm). In the latter case the amount of 'missing' flux is as small as possible. Both plates should be at the same depth and laterally separated by 30 - 100 mm.

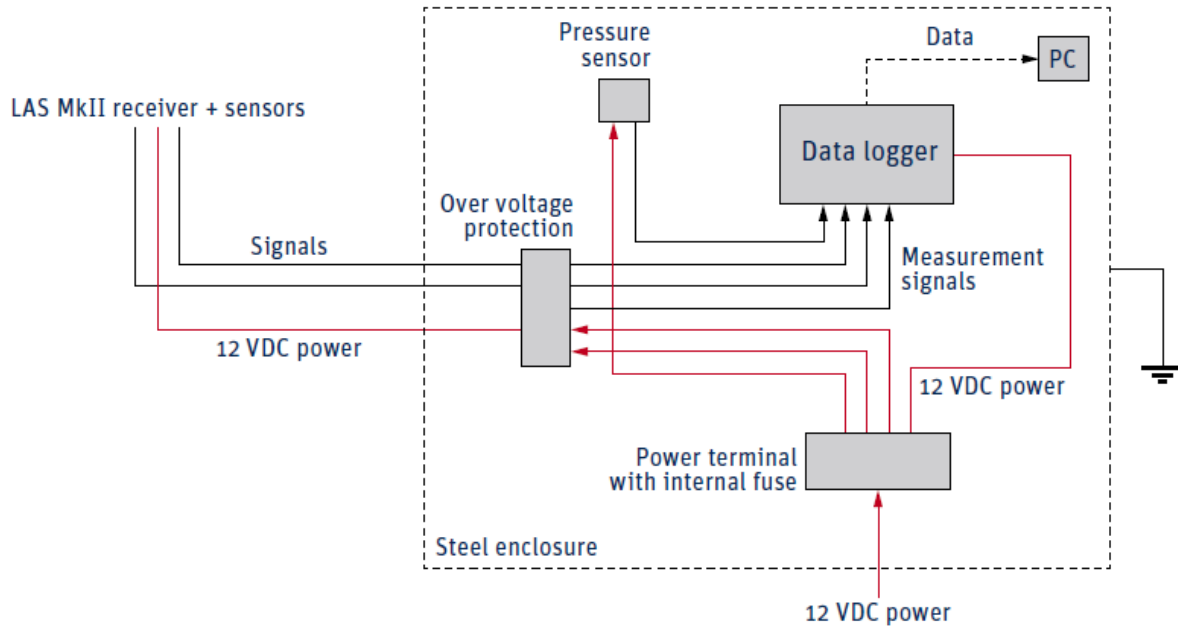
Do not bury the plates too deeply. At depths of 100 mm they can underestimate the soil heat flux by more than 50%. Ensure that the plates are not measuring in air gaps or cracks. They must be in full contact with the soil. When using more than 1 plate, bury them at the same depth.

## 2.8 Sensor overview

Sensor	Height/depth	Arm	Orientation/Direction
Wind speed ( $u$ )	4.4 m	U-shaped	Long 'leg'
Wind direction (WD)	4.2 m	U-shaped	Short 'leg'
Upper air temperature ( $T_1$ )	2.7 m	2-sided	Opposite to radiation sensor
Net radiation ( $Q^*$ or $R_n$ )	2.7 m	2-sided	Towards equator to avoid shadows
Lower air temperature ( $T_2$ )	0.5 - 1.0 m	1-sided	Directly below upper temperature sensor
Soil heat flux plate 1 ( $G_1$ or HFP <sub>1</sub> )	3 - 30 mm	In ground	Towards equator, not below net radiometer
Soil heat flux plate 2 ( $G_2$ or HFP <sub>2</sub> )	3 - 30 mm	In ground	As flux plate 1, separated by 30-100 mm
Air pressure ( $P$ )	-	In logger enclosure	Breathes through sintered vent in bottom of data logger enclosure
Data logger enclosure	At least 0.1 m	On mast	

## 2.9 Connecting the sensors

Note that the air pressure sensor (*P*) is pre-installed inside the data logger enclosure.



All cables (signal and power) enter the data logger enclosure at the bottom through weatherproof cable glands and connect to the over-voltage protection (OVP) module terminals as in the following table. The over-voltage protection blocks have spring-loaded terminals. 'Logger Terminal' refers to pre-wired screw terminals on plug-in connectors on the data logger.

(the following 4 tables are new and should replace the existing ones)

### Digital input /output channels

Instrument	Wire / Function	OVP	Logger Terminal	Input
Wind Speed	Yellow	1	I/O	D1
	Green	2	0V	
Wind Direction	Yellow	3	I/O	D2
	Green	4	0V	

### Analogue input channels

Instrument	Wire / Function	OVP	Logger Terminal	Input
Pressure sensor		19	SRC	AIN1
	Yellow	20	In+	
	Green	21	In-	
		22	AGND	
Net Radiation		23	SRC	AIN2
	Red (Thermopile +)	24	In+	
	Blue (Thermopile -)	25	In-	
		26	AGND	
UCn2 from LAS MkII		33	SRC	AIN3
	Red	34	In+	
	Yellow	35	In-	
		36	AGND	
UDemod from LAS MkII		37	SRC	AIN4
	Green	38	In+	
	Make link wire to pin 35	39	In-	
		40	AGND	
Upper Temperature (T1) Pt-100	White	47	SRC	AIN5
	Brown	48	In+	
	Green	49	In-	
	Yellow	50	AGND	
Lower Temperature (T2) Pt-100	White	51	SRC	AIN6
	Brown	52	In+	
	Green	53	In-	
	Yellow	54	AGND	
Heat Flux Plate, HFP1		57	SRC	AIN7
	White	58	In+	
	Green	59	In-	
		60	AGND	
Heat Flux Plate, HFP 2		61	SRC	AIN8
	White	62	In+	
	Green	63	In-	

	64	AGND
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### 12 VDC Power Output Terminals

Instrument	Wire / Function	Terminal	Power
Wind Speed	Pink / Brown	13	0 V
	Grey / White	14	+12 V
Wind Direction	Pink / Brown	15	0 V
	Grey / White	16	+12 V
Pressure sensor	Blue	17	0 V
In COMBILOG Enclosure	Red	18	+12 V

### 12 VDC Power Input

Customer Cable	Wire	Terminal	Input
DC power cable suitable for continuous outdoor use and compliant with national and site safety requirements (to be supplied locally).	Usually Yellow / Green	PE	PROTECTIVE EARTH
	Usually Red	56	12V Pos
	Usually Black	55	12V Neg
High current lightning and surge conductor	Heavy-duty copper cable or strip to ground spike	Stud in enclosure	EXTERNAL GROUND

\*PE' refers to a Protective Earth for AC mains electrical safety and grounding ESD/OVP charges.



Where the solar radiation equipment is mounted on a roof, the building power distribution 'Earth' at an AC power outlet socket is suitable for electrical safety as a Protective Earth. It is not sufficient for lightning and ESD discharge, which should have a separate conductor directly from lightning rods on the roof, down the outside of the building, to a ground spike.

Ensure that all AC and/or DC power to the COMBILOG is turned off when making connections. This may require removing a fuse, or connector, to the positive terminal if a battery is supplied.

Insert instrument and power cables through individual cable glands in the COMBILOG enclosure, but only tighten the gland nuts by hand until the cables are firmly gripped, tools may cause damage.

### 12 VDC Battery Connections (if supplied)

This sealed lead-acid back-up battery (7Ah capacity) must be installed after the COMBILOG enclosure is mounted. The battery sits in the bottom of the COMBILOG enclosure. Pre-wired cables with push-on spade terminals connect to the battery terminals, with red (positive) to battery + and the black (negative) to battery -. There is a load protection fuse installed in the red battery cable.

Check that everything is properly fixed to the mast and that the net radiation sensor is level.

Read the relevant sections of the COMBILOG data logger manual.

**Note** The COMBILOG data logger in the ET System is pre-configured by Kipp & Zonen and will automatically start measuring once connected to a power supply.

Switch on the power to the data logger enclosure and verify that all the sensors are working properly.

Adjust the date and time setting of the COMBILOG data logger if necessary.



At this stage do not turn on the power to the LAS MKII scintillometer.

When the system is working properly, roll up extra lengths of signal and power cables and fix them to the mast behind the data logger enclosure using cable ties.



Do not lay cables on the ground as insects and animals might damage them.

## 2.10 Installing the scintillometer

Install, configure and optically align the LAS MKII scintillometer using the display and menu keys, or the EVATION software, as described in the LAS MkII Manual.



When the scintillometer is working properly, switch off the power. Ensure that the power to the data logger enclosure is turned off.

Connect the receiver analogue outputs for Log  $UC_{r^2}$  and  $Udemod$  to the data logger OVP inputs, as in the previous table.

Switch on the power to the scintillometer transmitter and receiver and to the data logger enclosure and verify that the scintillometer signals are displayed and recorded correctly.

**Note** As the final step we recommend filling in the Installation Form for the System (see Appendix A). The information in this form will be used to configure the EVATION software.

## 3 ACCESSORIES

There are a number of accessories available for the LAS MKII scintillometer and these are described in the LAS manual.

## 4 SOFTWARE INSTALLATION AND CONFIGURATION

The software required for the LAS MKII ET system consists of the following programs:

EVATION software to process measured data into surface fluxes and to configure the LAS MkII scintillometer (as an alternative to using the receiver display and menu keys).  
COMBILOG support software to (re)configure the data logger. This is supplied with the logger manual.

### 4.1 EVATION software

The installation, configuration and operation of the EVATION software are described in the LAS MkII Manual.

### 4.2 LAS MKII configuration

Configuration of the LAS MKII receiver using the display and menu keys, or the EVATION software, is described in the LAS MkII Manual.

### 4.3 Effective height calculator

Use EVATION to calculate the effective height of the scintillometer path as described in the LAS MkII Manual.

### 4.4 COMBILOG support software

The COMBILOG support software enables the user to communicate with COMBILOG data loggers, via the RS-232, RS-485, Ethernet or USB interfaces. In this way the user can re-configure the data logger, monitor measurements in real-time, change the logger date and time, and download data from the internal memory.

The optional SD cards for memory expansion must be taken out and downloaded directly to a computer. Note that the COMBILOG data logger in the ET System is pre-configured by Kipp & Zonen and will automatically start measuring once connected to a power supply.

The installation of the COMBILOG support software is carried out as follows:

- Insert the installation CD into the computer drive
- In case the installation does not start automatically, click on 'SETUP.exe' on the COMBILOG CD-ROM
- Follow the on-screen instructions in the installation program

After successful installation a new program group called COMBILOG V<sub>x.xx</sub> (Icon: ) is created.

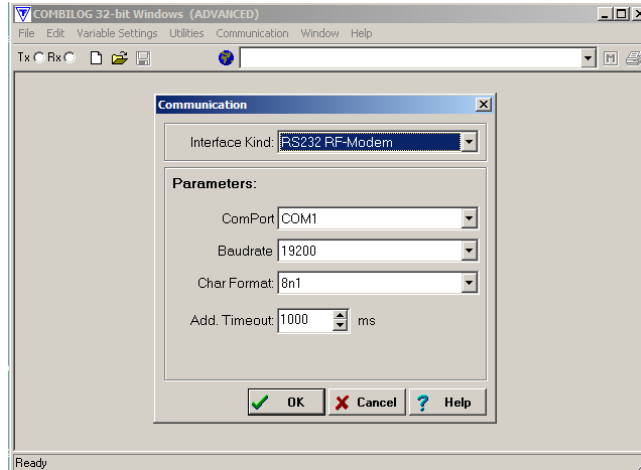
The COMBILOG 1022 data logger has 7MB of integrated memory. A small part is reserved for the logger configuration. The rest is available for measured and arithmetically calculated data. All the memory is non-volatile. Data measured at the sampling interval is held in RAM until stored at the logging interval.

The memory can be expanded by inserting a SD-Card into the front panel slot. Please note that the COMBILOG only supports 'standard speed' cards; SDHC, etc. will not work. The COMBILOG can only address 2 GB of external memory, if larger capacity cards are inserted they may be recognised but only 2 GB will be used.

#### 4.4.1 Setting communication parameters

When the COMBILOG support software is started for the first time, the communication parameters must

be configured in order to communicate with the data logger. Select 'Communication' and the following window appears.



Set the communication parameters to suit the computer, for example:

Interface Kind : RS-232

**Parameters:**

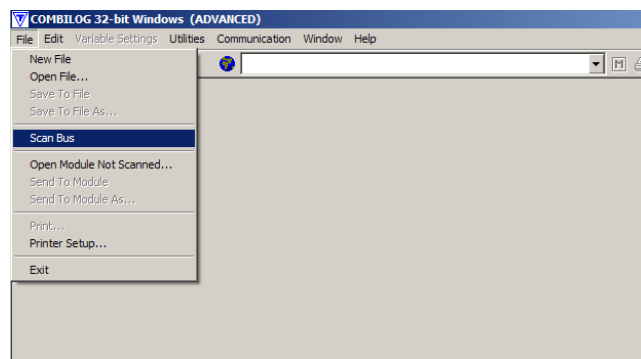
ComPort : COM1  
 Baudrate : 19200  
 Char Format : 8n1  
 Add Timeout : 1000 ms

Click on 'OK'.

The software is now ready to communicate with the COMBILOG data logger.

#### 4.4.2 Communicating with the COMBILOG

- Start the COMBILOG support software.
- Connect the PC to the COMBILOG data logger using the RS-232, RS-485, Ethernet or USB interfaces.
- Click on 'File' and select 'Scan Bus'. The software will automatically scan for connected COMBILOG data loggers.
- The user can now select the data logger to communicate with.



#### 4.4.3 Original COMBILOG module settings and programs

The data logger is pre-configured by Kipp & Zonen and will automatically start measuring when connected to a power supply. If necessary the user can re-configure the data logger using the COMBILOG support software, for example if extra sensors are connected.

For further instructions the user is referred to the COMBILOG instruction manual and the COMBILOG support software. The original configuration program for the data logger can be found on the supplied CD-ROM

## 5 OPERATION AND MEASUREMENT

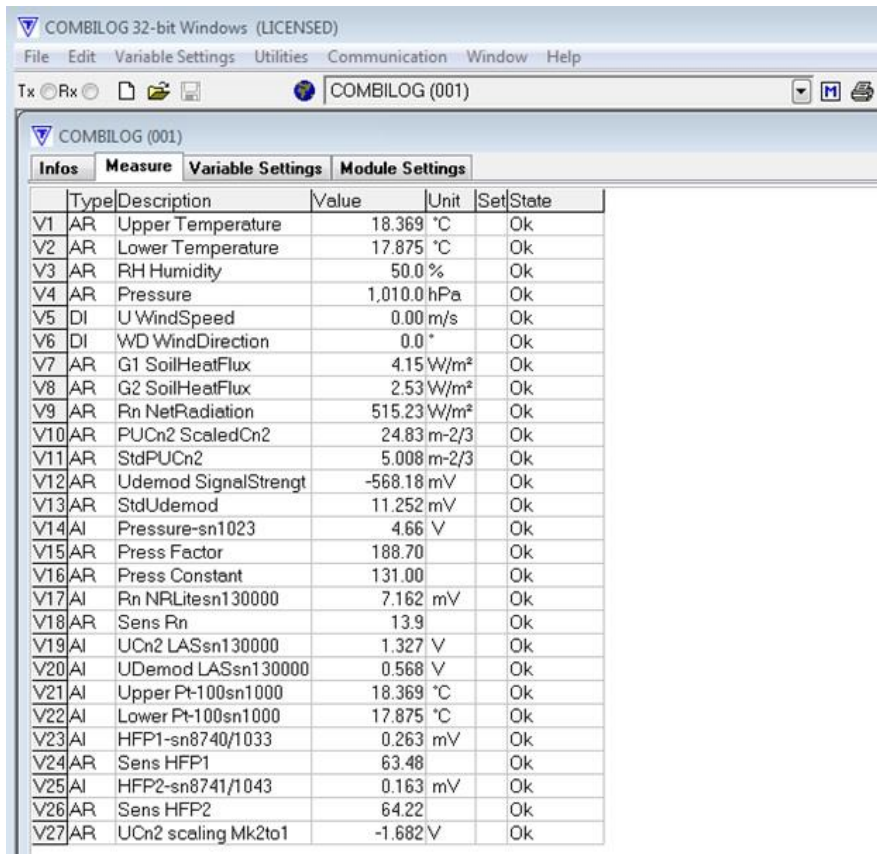
Once the LAS MKII scintillometer and the weather station have been installed and connected to a power source, the data logger of the LAS MKII ET System will automatically start recording.

### 5.1 REAL-TIME MONITORING OF MEASUREMENTS

The measurements can be monitored via the COMBILOG support software or by using the display on the data logger.

#### 5.1.1 Via COMBILOG support software

Once a PC is connected to the COMBILOG data logger the measurements can be monitored in real-time via the 'Measure' window (refer to the manual).



Infos	Measure	Variable Settings	Module Settings
Type	Description	Value	Unit Set/State
V1	AR	Upper Temperature	18.369 °C Ok
V2	AR	Lower Temperature	17.875 °C Ok
V3	AR	RH Humidity	50.0 % Ok
V4	AR	Pressure	1.010.0 hPa Ok
V5	DI	U WindSpeed	0.00 m/s Ok
V6	DI	WD WindDirection	0.0 ° Ok
V7	AR	G1 SoilHeatFlux	4.15 W/m² Ok
V8	AR	G2 SoilHeatFlux	2.53 W/m² Ok
V9	AR	Rn NetRadiation	515.23 W/m² Ok
V10	AR	PUCn2 ScaledCn2	24.83 m-2/3 Ok
V11	AR	StdPUCn2	5.008 m-2/3 Ok
V12	AR	Udemod SignalStrengt	-568.18 mV Ok
V13	AR	StdUdemod	11.252 mV Ok
V14	AI	Pressure-sn1023	4.66 V Ok
V15	AR	Press Factor	188.70 Ok
V16	AR	Press Constant	131.00 Ok
V17	AI	Rn NRLitesn130000	7.162 mV Ok
V18	AR	Sens Rn	13.9 Ok
V19	AI	UCn2 LASsn130000	1.327 V Ok
V20	AI	UDemod LASsn130000	0.568 V Ok
V21	AI	Upper Pt-100sn1000	18.369 °C Ok
V22	AI	Lower Pt-100sn1000	17.875 °C Ok
V23	AI	HFP1-sn8740/1033	0.263 mV Ok
V24	AR	Sens HFP1	63.48 Ok
V25	AI	HFP2-sn8741/1043	0.163 mV Ok
V26	AR	Sens HFP2	64.22 Ok
V27	AR	UCn2 scaling Mk2to1	-1.682 V Ok

The measurements that can be viewed in real-time are shown in the following table.

	Sensors	Symbol	Unit	Range
1	Air temperature upper (derived from 10)	T1	°C	-40 to +60
2	Air temperature lower (derived from 11)	T2	°C	-40 to +60
3	Relative humidity (no sensor connected)	RH	%	Default value 50
4	Air pressure	P	hPa	600 to 1050
5	Wind speed	U	M s <sup>-1</sup>	0 to 60
6	Wind direction	WD	°	0 to 360
7	Soil heat flux plate 1	G <sub>1</sub> or HFP <sub>1</sub> -snxxx	W m <sup>-2</sup>	-200 to +200
8	Soil heat flux plate 2	G <sub>2</sub> or HFP <sub>2</sub> -snxxx	W m <sup>-2</sup>	-200 to +200
9	Net radiation	Rn-snxxx	W m <sup>-2</sup>	-250 to +1500
	LAS signals	Symbol	Unit	Range
1	Scaled C <sub>n</sub> <sup>2</sup> (= PUCn21000)	PUCn21000	m <sup>-2/3</sup>	0.01 to 10000
2	Standard deviation of C <sub>n</sub> <sup>2</sup>	Std PUCn21000	m <sup>-2/3</sup>	
3	U <sub>CN2</sub>	UCN2	V	0 to 2.4
4	Standard deviation of U <sub>CN2</sub>	Std UCN2	V	
5	Signal strength U <sub>Demod</sub>	Demod	mV	-2000 to 0
6	Standard deviation of U <sub>Demod</sub>	Std Demod	mV	

### 5.1.2 Via the COMBILOG display

The output of each channel can also be monitored on the display of the COMBILOG using the rotary knob on the data logger. Simply by rotating the press/rotary the Main Menu can be scanned, which includes the actual measurements of each sensor plus the units.

## 5.2 Calibration coefficients

Some of the sensors of the LAS MKII ET system are supplied with calibration certificates, for example the net radiation sensor and the soil heat flux plates. The calibration coefficients can be found in either the sensor instruction manuals / certificates or in the original data logger program, which is stored in the COMBILOG's internal memory. The original program with the calibration coefficients is on the supplied CD-ROM.

### 5.3 Data files

The data files of the COMBILOG are formatted as follows (columns, separated by tabs):

1. Name / code (from Combilog)
2. Date Time (= End Time of measurement interval separated by space)
3. Air temperature upper sensor [ $T1$ , °C]
4. Air temperature lower sensor [ $T2$ , °C]
5. Relative humidity [ $RH$ , %], the default value is 50 %
6. Air pressure [ $P$ , hPa]
7. Wind speed [ $u$ ,  $\text{m s}^{-1}$ ]
8. Wind direction [ $WD$ , °]
9. Soil heat flux (plate 1) [ $G_1$  or  $HFP_1$ ,  $\text{W m}^{-2}$ ]
10. Soil heat flux (plate 2) [ $G_2$  or  $HFP_2$ ,  $\text{W m}^{-2}$ ]
11. Net radiation [ $Q^*$  or  $R_n$ ,  $\text{W m}^{-2}$ ]
12. Scaled  $C_n^2$  [ $PU_{CN2}$ ,  $\text{m}^{-2/3}$ ]
13. Standard deviation of scaled  $C_n^2$  [ $\text{m}^{-2/3}$ ]
14. Demodulated signal strength [ $U_{DEMOD}$ , mV, note negative sign]
15. Standard deviation of Demod [V]

The number of columns (in this case 15) is constant and independent of the sensor configuration of the LAS MkII ET System. If fewer sensors are used dummy values (-9999) are inserted in the 'empty' columns for the specific missing sensor.

**Note** The columns must not be reordered.










A more detailed description of the data files and format can be found in the LAS MkII manual, Appendix H.

## 5.4 Combilog 1022 configuration file for LAS MkII ET system

COMBILOG 32-bit Windows (LICENSED)

File Edit Variable Settings Utilities Communication Window Help

C:\PROGRAM FILES (X86)\THEODOR FRIEDRICH'S\COMBILOG VERSION 3.2\CONFIGURATION\LAS\_MKII\_ET\_SYSTEM\_UKZN\_VS2.PRO

Infos	Variable Settings	Module Settings							
Type	Variable Name	Sensor	Type of	Connection	Terminals	Format/Adjustment	Range/Error	Additional	DP Real Cfg.
V1	AR	Upper_Temperature				f.f.f.f [ °C]		V22	93h
V2	AR	Lower_Temperature				f.f.f.f [ °C]		V23	93h
V3	AR	RH_Humidity				f.f.f.f [%]		50	93h
V4	AR	Pressure				f.f.f.f [hPa]		V14*V15+V16	93h
V5	DI	U_WindSpeed	Frequency		I/O 1 0V	f.f.f [m/s]		TimeBase = 1 s	93h
V6	DI	WD_WindDirection	Gray Code		I/O 2 0V	f.f.f.f [°]			93h
V7	AR	G1_SoilHeatFlux				f.f.f.f [W/m²]		V24/(V25/1000)	93h
V8	AR	G2_SoilHeatFlux				f.f.f.f [W/m²]		V26/(V27/1000)	93h
V9	AR	Rn_NetRadiation				f.f.f.f [W/m²]		V17/(V18/1000)	93h
V10	AR	PUcn2_ScaledCn2				f.f.f.f [m-2/3]		power(10:V28)*1000	93h
V11	AR	StdPUcn2				f.f.f.f [m-2/3]		SDev(V10)	93h
V12	AR	Udemod_SignalStrengt				f.f.f.f [mV]		V21*1000	93h
V13	AR	StdUdemod				f.f.f.f [mV]		SDev(V12)	93h
V14	AI	Pressure-sn1023	Voltage Differential		②SOURCE AIn 1	f.f.f.f [V]	2.00 6.00	Arithm. Averaging	93h
V15	AR	Press_Factor				f.f.f.f		188.7	93h
V16	AR	Press_Constant				f.f.f.f		131	93h
V17	AI	Rn_NRLitesn130000	Voltage Differential		②SOURCE AIn 2	f.f.f.f [mV]	-50.000 50.000	Arithm. Averaging	93h
V18	AR	Sens_Rn				f.f.f.f		13.9	93h
V19	AI	UCn2_LASsn130000	Voltage Differential		②SOURCE AIn 3	f.f.f.f [V]	0.000 2.500	Arithm. Averaging	93h
V20									
V21	AI	Udemod_LASsn130000	Voltage Differential		②SOURCE AIn 4	f.f.f.f [V]	0.000 2.500	Arithm. Averaging	93h
V22	AI	Upper_Pt-100sn1000	Pt 100 4 Wire		②SOURCE AIn 5	f.f.f.f [ °C]	-40.000 80.000	Arithm. Averaging	93h
V23	AI	Lower_Pt-100sn1000	Pt 100 4 Wire		②SOURCE AIn 6	f.f.f.f [ °C]	-40.000 80.000	Arithm. Averaging	93h
V24	AI	HFP1-sn8740/1033	Voltage Differential		②SOURCE AIn 7	f.f.f.f [mV]	-25.000 25.000	Arithm. Averaging	93h
V25	AR	Sens_HFP1				f.f.f.f		63.48	93h
V26	AI	HFP2-sn8741/1043	Voltage Differential		②SOURCE AIn 8	f.f.f.f [mV]	-25.000 25.000	Arithm. Averaging	93h
V27	AR	Sens_HFP2				f.f.f.f		64.22	93h
V28	AR	UCn2_scaling_mk2to1				f.f.f.f [V]		V19*2.5-5	93h
V29									
V30									
V31									
V32									

Ready

## 6 MAINTENANCE AND RECALIBRATION

Every time one visits the site, preferably at 2 week intervals, it is recommended to follow the inspection procedure described.

### 6.1 Check the power is on

Check if the green LED labelled “RUN” on the COMBILOG data logger is activated. If so the display of the COMBILOG should show the actual date and time and the real time measurements of all sensors. There is a fuse within the 12 VDC power distribution terminal block in the data logger enclosure.

Press any menu key of the LAS MKII receiver to activate the display and check that it is measuring.

### 6.2 Check COMBILOG date and time

For instructions refer to the COMBILOG instruction manual.

### 6.3 Check sensor signals

When all the sensors of the weather station are operational the red LED ‘ERR’ of the COMBILOG is switched OFF. If one of the sensors is malfunctioning the red LED is ON. The output of each channel can be seen on the display of the COMBILOG using the ‘SELECT’ press/rotary knob on the data logger.

The table in section 5.1.1 shows the range for each sensor of the LAS-system. Check if the output of each sensor lies within the given range and is reasonable for the prevailing conditions.

If one of the sensors is defective or malfunctioning the value -9999 is shown on the COMBILOG display. This applies for every sensor except for the wind speed sensor. In case this sensor is malfunctioning  $0 \text{ m s}^{-1}$  is displayed. Since  $0 \text{ m s}^{-1}$  can actually occur the LED ‘ERR’ is inhibited. Therefore, check the wind speed on the display and verify this by looking at the rotation of the sensor itself.

If one of the two scintillometer channels shows -9999, check the display of the LAS MkII receiver to see the channel values and LAS status.

### 6.4 Check sensor condition

Check the physical condition of all the sensors (net radiation, wind direction, wind speed, air temperature x 2). If necessary, clean the sensors and remove any dirt (dust, sand, spider webs, insects, etc).

Check that the net radiation sensor is horizontal.

### 6.5 Check cables and connections

Check all cables and connections for damage, and ensure that all connections are tight, including those inside the data logger enclosure.

### 6.6 Check condition of the tower, guy wires and anchoring



Check that the mast is vertical. The 3 guy ropes should have moderate and equal tension, do not put a bending force on the mast.



Check the guy wire tension and the mast alignment frequently. If the ground is not firm enough to keep the mast vertical in all weather conditions, use concrete for anchoring.

## 6.7 Download the data from the COMBILOG:

It is recommended to download data from the COMBILOG every two weeks.

- Connect a computer to one of the COMBILOG communication ports.
- Start the COMBILOG support software.
- Scan for available data loggers.
- Click on 'Utilities' and then 'Read Logger' and follow the instructions.

Refer to the COMBILOG manual for more information.

## 6.8 Check the LAS MkII Scintillometer

Carry out the maintenance checks for the LAS MKII as described in the scintillometer manual.

Check the receiver signal outputs ( $C_n^2 = Cn2$  or  $PUCn2$ , and signal strength = Demod or  $U_{DEM0D}$ ) on the display of the COMBILOG at the weather station. The values should be similar to the readings on the LAS receiver display.

**Note** The readings may not be exactly the same due to differences in sampling time, averaging and logging interval configurations between the LAS receiver and the COMBILOG.

# 7 SPECIFICATIONS

The specifications of the LAS MKII scintillometer are given in the scintillometer manual.

The specifications of the COMBILOG data logger are given in the COMBILOG manual.

The specifications of the rest of the ET System are given in sections 2.1.2, 2.1.3 and the NR Lite2 Instruction sheet.

## 8 TROUBLE SHOOTING

The LAS MkII scintillometer and the ET System are designed for long periods of operation with little operator maintenance. However, if a problem occurs that cannot be corrected using the standard operating information supplied in the preceding sections of this manual, and in the scintillometer manual use the information below to identify and solve the problem.



There are no user-serviceable parts within the LAS Mk II and the transmitter or receiver must not be opened without the agreement and instruction of Kipp & Zonen.

In addition to the Trouble Shooting section the LAS MkII manual, most problems are likely to be related to power or signal connection issues.

- Power source problems at the weather station; short circuits, blown fuses, loose cables, etc.
- Sensor problems at the weather station; loose connections or damaged cables, dirt, levelling, sensor failure, etc.

If necessary, consult the separate manuals of the specific sensors and/or the COMBILOG manual for further information and instructions to solve problems.

For software related problems, isolate which software program appears to give problems and consult the available help files for further instructions.

If the problem persists contact [support@kippzonen.com](mailto:support@kippzonen.com)

## 9 CUSTOMER SUPPORT

If you require any support for your Kipp & Zonen product please contact your local representative in the first instance. The information can be found in the 'Contact' section of our website at <http://www.kippzonen.com/Contact>

Alternatively, you can contact us directly at **support@kippzonen.com**

Please include the following information:

- The ET system location
- The system Installation Form (see Appendix A)
- Instrument, sensor or data logger model with the problem
- Instrument, sensor or data logger serial number
- Details of the fault or problem
- Examples of data and log files
- Computer type and operating system
- Interfaces and power supplies used in the installation
- History of any previous repairs or modifications
- Pictures of the installation and site
- Overview of the local environment conditions

Kipp & Zonen guarantees that your information will not be shared with other organisations.

For details on the service options available please contact **support@kippzonen.com**

## APPENDIX A. SYSTEM INSTALLATION FORM

**Note** As the final step we recommend filling in an Installation Form for the System). This information in this form will be used to configure the EVATION software.

### General Information

Date: ..... [Year/Month/Day]

Installed by: .....

Station name: ..... (convenient to use in EVATION as the working directory)

### Weather station sensors / data logger channel

Sensor type	Sensor serial number	Logger input channel number	Height/depth [m]	Orientation [°]

Coordinates of weather station: ..... [Latitude, °]  
 ..... [Longitude, °]  
 ..... [Height, m] (above ground)  
 ..... [Elevation, m] (above sea level)

Mean vegetation height at station site: ..... [m]

## LAS MKII Scintillometer

### Scintillometer

Serial number : .....  
Exact path length (according to GPS or map): ..... [m]

### Transmitter

Coordinates of LAS MkII transmitter: ..... [Latitude, °]  
..... [Longitude, °]  
..... [Height, m] (above ground)  
..... [Elevation, m] (above sea level)  
Power adjustment setting: ..... [-]  
Mean vegetation height at transmitter site: ..... [m]

### Receiver

Coordinates LAS MkII receiver: ..... [Latitude, °]  
..... [Longitude, °]  
..... [Height, m] (above ground)  
..... [Elevation, m] (above sea level)  
Signal strength on receiver display( $U_{\text{DEMOD}}$ ): ..... [mV]  
Path length set at receiver ..... [m]  
Mean vegetation height at receiver site: ..... [m]

## Effective Height of LAS MKII Scintillometer

The accuracy of the fluxes of sensible heat and evapo-transpiration depends strongly upon the mean height of the LAS MkII optical beam above the surface. In case the area is completely flat the average beam height can be easily derived from the transmitter height and the receiver height.

In case the area is complex it becomes more difficult to determine the effective height of the beam. The EVATION software has a special tool that helps the user to determine the effective height; the effective height calculator.

The calculator needs the following input data:

- The elevation of the transmitter site
- The installation height of the transmitter above the ground
- The elevation of the receiver site
- The installation height of the receiver above the ground
- The elevation and position of a number of points along the beam (a cross-section over the optical path)

By entering this information into the effective height calculator the software provides the effective height of the LAS MkII beam, which will be used in the processing of data into fluxes.

Use a table, such as that below, to collect a number of cross-section points. In this case the 'Reference' point is ground level at the transmitter site.

Points in optical path cross-section	Elevation with respect to reference site ground [ $\pm$ m]	Horizontal distance from reference site [m]	Installation height of LAS MKII with respect to the site ground [m]
Transmitter site, Tx (Reference)	0	0	50
Intermediate point 1	0	500	
Intermediate point 2	3	750	
Intermediate point 3	7.5	1000	
Intermediate point 4	7.5	2300	
Intermediate point 5	20	3000	
Intermediate point 6	20	3500	
Intermediate point 7	18	3700	
Intermediate point 8	18	4000	
Intermediate point 9	25	4500	
Receiver site, RX	36	4700 Path Length	30

The effective height of the LAS beam can then be calculated as shown below.

