LAS

Large Aperture Scintillometer

Instruction Manual

IMPORTANT USER INFORMATION

Reading this entire manual is essential for full understanding of the proper use and safe operation of this product

Should you have any comments on this manual we will be pleased to receive them at:

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Manual version: **0706**

Throughout the manual symbols are used to indicate to the user important information. The meaning of these symbols is as follows:

The exclamation mark within an equilateral triangle is intended to alert the user to the presence of important operating, maintenance and safety information

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LIST OF SYMBOLS

SYMBOLS

C_n^2	structure parameter of the refractive index of air [m$^{-2/3}$] ($C_n^2 = 10^{(U_{CN2}-12)}$)
C_T^2	structure parameter of temperature [K^2 m$^{-2/3}$]
C_Q^2	structure parameter of humidity [kg^2 m^{-6} m$^{-2/3}$]
d	zero-displacement height [m]
D	aperture diameter of receiver and transmitter unit [m]
f_T	universal stability function [-]
g	gravitational acceleration [~9.81 m s^{-2}]
G_s	soil heat flux [W m^{-2}]
G_1, HFP_1	soil heat flux plate 1 [W m^{-2}]
G_2, HFP_2	soil heat flux plate 2 [W m^{-2}]
H	sensible heat flux [W m^{-2}]
L	path length [m]
L_v	latent heat of vaporization [~2.45 × 10^6 J kg^{-1} @ 20 °C]
L_vE	latent heat flux (or evaporation ET) [W m^{-2}] [mm day^{-1}]
	(conversion [W m^{-2}] ↔ [mm day^{-1}]: 1 W m^{-2} = L_v/86400 ≅ 0.0353 mm day^{-1})
L_{MO}	Obukhov length [m]
Pot	potentiometer path length setting at ***Path length*** knob [-]
P	air pressure [Pa]
Press	air pressure [hPa]
	(conversion [Pa] ↔ [hPa]: 1 hPa = 100 Pa = 1 mbar)
PU_{CN2}	scaled C_n^2 [m$^{-2/3}$] ($C_n^2 = PU_{CN2} \cdot 10^{-15}$)
Q	absolute humidity [kg m^{-3}]
Q^*	net radiation [W m^{-2}]
R_d	specific gas constant for dry air [~287 J K^{-1} kg^{-1}]
RH	relative humidity [%]
R_n	net radiation [W m^{-2}]
R_v	specific gas constant for water vapour [~461.5 J K^{-1} kg^{-1}]
T	absolute air temperature [K]
$T+$	air temperature upper level [°C]
$T-$	air temperature lower level [°C][
	(conversion K [Kelvin] ↔ °C [Celsius]: × °C = × + 273.15 K)
T_*	temperature scale [K]
u	wind speed [m s^{-1}]
u_*	friction velocity [m s^{-1}]
U_{CN2}	**log** C_n^2 signal [V] ($C_n^2 = 10^{(U_{CN2}-12)}$) [-5 V to 0 V]
U_{DEMOD}	demodulated signal [V] ($U_{DEMOD} = I$) [-1 V to 0 V]
WD	wind direction [°]
z_{LAS}	(effective) height **LAS** or **XLAS** [m]
z_0	aerodynamic roughness length [m]
z_u	height wind speed measurements [m]

β	Bowen ratio [-] ($\beta = H/L_vE$)
λ	wavelength of EM radiation (880 nm) [m]
ρ	density of air [kg m^{-3}] [~1.2 kg m^{-3} (at sea level (1013 hPa)!)]
σ^2	variance
$\sigma^2_{\ln I}$	of natural logarithm of intensity fluctuations (ln(I)) [-]
$\sigma^2_{U_{DEMOD}} = \sigma^2_I$	of U_{DEMOD} or intensity I [V^2]
$\sigma^2_{U_{CN2}}$	of U_{CN2} [V^2]

ABBREVIATIONS

BET — Basic Evapo-Transpiration system

(X)LAS — (eXtra) Large Aperture Scintillometer

MOST — Monin-Obukhov Similarity Theory

A relationship describing the vertical behavior of non-dimensionalized mean flow and turbulence properties within the Surface Layer as a function of the Monin–Obukhov key parameters.

PBL — Planetary Boundary Layer

The PBL is the lowest region of the troposphere, which is directly affected by heating and cooling of the earth surface. In general the depth of the PBL varies between 100m to 2000m. The depth of the PBL increases during the day, when the surface is heated by the sun and decreases during the night due to radiative cooling.

RET — Radio Evapo-Transpiration system

RS — Roughness Sublayer

Lowest part of the SL, where the flow is influenced by individual roughness elements. Consequently, the SL can be divided into the Constant Flux Layer and the Roughness Sublayer. The height of the Roughness Sublayer strongly depends on the height (size and form) of the roughness elements, but also on the distribution. Usually, over tall vegetation 3 times the obstacle height is taken as the height of the Roughness Sublayer.

SL — Surface Layer

In general in the lowest 10% of the PBL the surface fluxes are constant with height, this part of the PBL is also known as the Constant Flux Layer or Surface Layer (SL). Therefore fluxes measured in the SL can be considered as being representative fluxes for the *heat and mass exchange processes between the atmosphere and the surface. In general the SL varies between 20m to 100m and like the PBL increases during the day and decreases again during the night.*

1. GENERAL INFORMATION

1.1 INTRODUCTION TO *LAS-BET* AND *LAS-RET* SYSTEMS

The **LAS-BET** and **LAS-RET** (ET stands for evapotranspiration) systems are scintillometer based surface flux monitoring systems, specially intended for earth energy balance and water management studies. Evapo-transpiration is an important term of the surface energy budget

$$Q^* = H + L_v E + G_s \quad [\text{W m}^{-2}], \tag{1}$$

where Q^* (or R_n) is the available energy known as the net radiation, H the sensible heat flux, L_vE 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 linked to the latent heat flux (L_vE) as follows

$$ET = \frac{L_v E}{L_v}, \tag{2}$$

where L_v is the latent heat of vaporisation (the energy required to evaporate 1 kg of water, $L_v \sim 2.45 \times 10^6$ J kg^{-1}). This means that ET can be expressed as an energy flux (L_vE in [W m^{-2}], mostly used in used in meteorology) or as a mass flux (ET in [mm day^{-1}], mostly used in hydrology). Approximately 1 W m^{-2} is equal to 0.0353 mm day^{-1}. The latent heat flux or ET is an important term of the soil water balance

$$\Delta S = \text{input} - \text{output}, \tag{3}$$

where ΔS is the change of storage of water in the soil, which is the result of the amount of input into the soil (e.g. due to rainfall or irrigation) minus the amount of loss of water (e.g. due to evapotranspiration, surface-runoff or drainage).

The **LAS-BET** and **LAS-RET** have been developed to provide area-representative surface fluxes of sensible heat (H) and latent heat (L_vE). Most unique feature of the both systems is the line of sight path-integrating capabilities of the (eXtra) Large Aperture Scintillometer (**LAS** / **XLAS**). This allows the user to measure area-averaged surface fluxes of sensible heat at scales of 0.2 to 8 km, over both homogenous and moderate heterogeneous areas. So far most traditional measurement techniques (e.g. Eddy-Covariance method, Flux-Profile method, Bowen-ratio method and Lysimeters) are actually point (*in-situ*) measurements and therefore less representative for large (natural and therefore heterogeneous) areas.

Basically, the **LAS-BET** and **LAS-RET** system consist of two parts, namely a scintillometer (**LAS** or a **XLAS**) and a weather station (developed by Theodor Friedrichs & Co). The structure parameter (C_n^2) measured by the **LAS** / **XLAS** and additional meteorological data (air temperature at 2 levels, wind speed and air pressure) collected by the weather station are used to determine the surface flux of sensible heat H. By adding a net radiometer and soil heat flux sensors, the latent heat flux can be derived, via

$$L_v E = Q^* - H - G_s, \tag{4}$$

i.e. L_vE is the residual term of the energy balance. Both the **LAS-BET** and the **LAS-RET** system provide L_vE according to the latter step.

Although the **LAS-BET** and **LAS-RET** provide the same output (H and L_vE) they differ in complexity and flexibility. The **LAS-BET** comprises a **LAS** (or a **XLAS**), a number of meteorological sensors (tower and arms are optional), a data logger and a software package. The data logger collects the output from all sensors including the **LAS** / **XLAS**. Signal cables limit the distance between the data logger and the sensors meaning that the **LAS** / **XLAS** receiver and the sensors must be roughly located at the same site as the data logger.

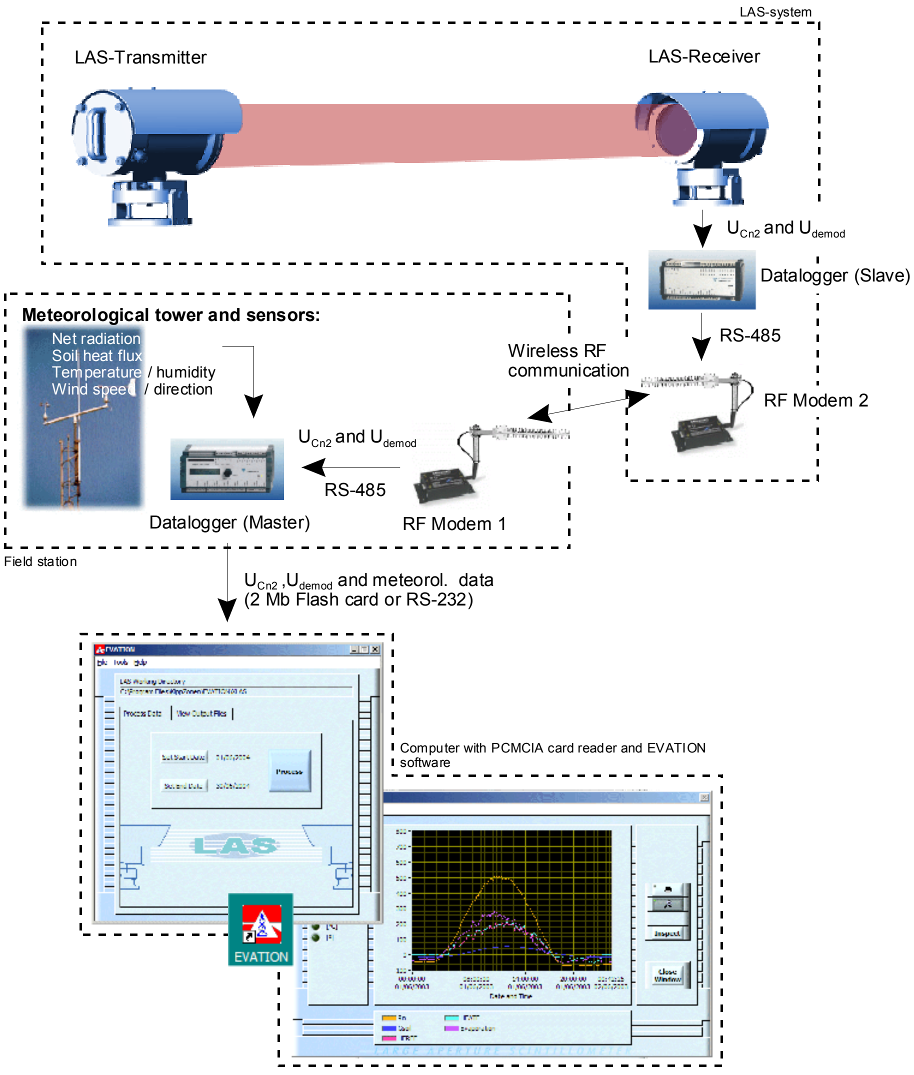

Figure 1: Schematic overview of the LAS-RET system. This system consists of a LAS / XLAS scintillometer, which is measured by a COMBILOG data logger (*SLAVE*). Using two RF radio modems the data from the LAS (U_{Cn2} and U_{demod}) is transmitted to the central COMBILOG data logger (*MASTER*) located at the weather station. Here all measured data is stored on a 2 Mb flash card. Once the data of the Flash card has been stored on a computer the EVATION software processes the data to fluxes of sensible heat and evaporation. The weather station comprises a 4 m tower and a number of sensors.

In order to improve the flexibility of installation, especially the site selection of the **LAS** / **XLAS** and the meteorological tower, the **LAS-RET** system is equipped with a 2.4 GHz RF link. The RF link transmits the signal output from the **LAS** / **XLAS** receiver to the main data logger of the meteorological station.

This station comprises sensors, a mast with cross arms and cable guys, a data logger and a power supply (battery and solar panel). In this way the user is able to place the meteorological station up to 5km away from the **LAS** / **XLAS** receiver, preferably near the centre of the path of the **LAS** / **XLAS** or at another representative spot. The RF telemetry link operates at 2.4 GHz, which is license free globally[1]. Extra advantage: all data including the signals of the **LAS** / **XLAS** are stored centrally at the meteorological tower on a 2Mb PCMCIA flash card.

The data processing of the **LAS-BET** and **LAS-RET** systems is done by a software program, called EVATION (stands for <u>eva</u>potranspira<u>tion</u>). This user-friendly program, developed by Kipp & Zonen, processes the data to (daily) fluxes of sensible and latent heat. In Figure 1 an overview is shown of the **LAS-RET** system. Figure 2 shows the **LAS-BET** system (without the RF telemetry link).

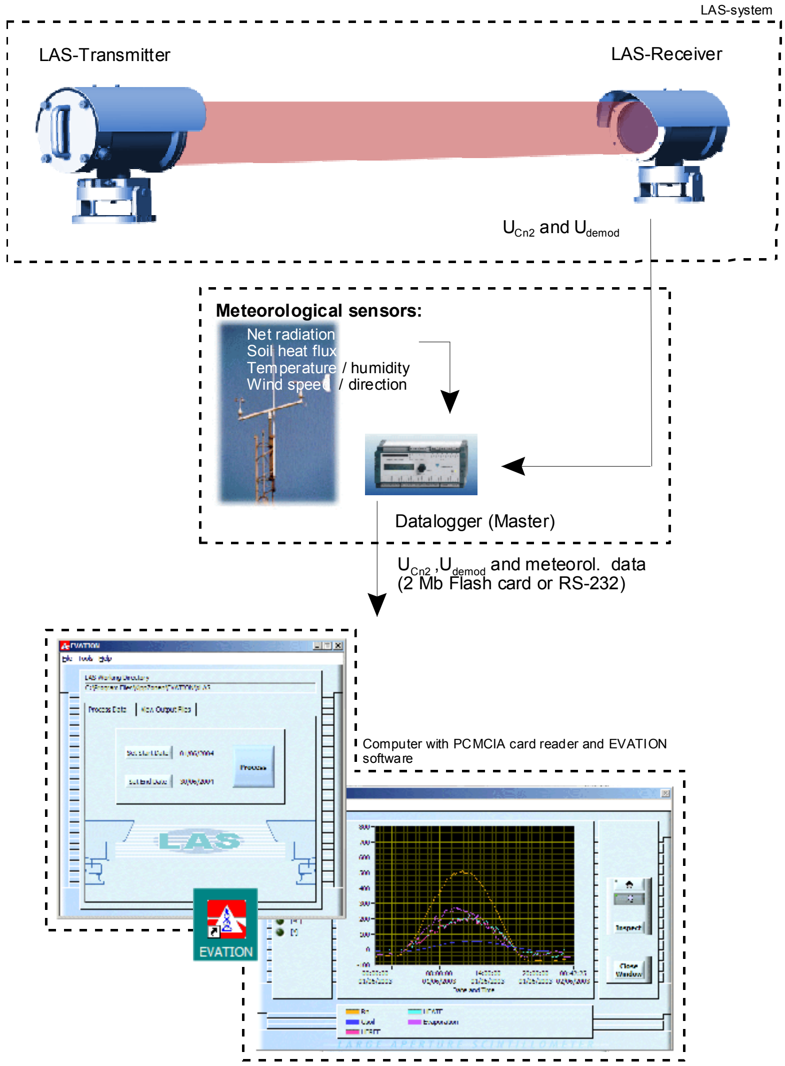

Figure 2: Schematic overview of the LAS-BET system. This system consists of a LAS / XLAS scintillometer and a number of meteorological sensors. All sensors (including the LAS) are measured by 1 COMBILOG data logger. The data is stored on a 2 Mb flash card. Once the data of the Flash card has been stored on a computer, the EVATION software processes the data to fluxes of sensible heat and evaporation.

[1] Optional license free bands are: 915 MHz (US & Canada) and 922 MHz (Australia & Israel)

Some **LAS-BET and LAS-RET** features are:

- Area-representative fluxes of sensible heat and (actual) evaporation (scale 0.2 km to 8 km [2])
- RF telemetry link between **LAS** / **XLAS** receiver and weather station[3]. Advantages of the RF link: the site selection of the weather station with respect to the **LAS** / **XLAS** is more flexible; ALL data is centrally stored at one location (PCMCIA flash fard).
- (Optional) Switching power supplies with universal AC input and backup batteries provide continuous operation in areas that have occasional net power drops.
- Solar battery powered weather station for flexible site selection[2].
- Easy downloading of data using 2 Mb PCMCIA flash cards.

Some features of EVATION:

- Runs on Windows 98/NT/2000/ME/XP platforms
- User-friendly but offers also special tools for experts
- Handles multiple **LAS-BET** and/or **LAS-RET** set-ups
- Uses research-grade processing algorithms
- Handles multiple processing algorithms[4]
- Built-in effective **LAS** / **XLAS** height calculator
- Data and flux averaging to daily means (e.g. ET in [mm day^{-1}])
- Configurable output allows analysis of wide range of meteorological quantities (i.e. turbulent surface fluxes, atmospheric stability, structure parameters)
- Automatic organizing of data files

1.2 MANUAL

This instruction manual is intended for customers who have purchased the **LAS-BET** or **LAS-RET** system. It includes all the main information necessary to properly install and operate the systems. More detailed information such as the operating specifications of a specific sensor/instrument can be found in the separate delivered manuals.

[2] Depending on atmospheric conditions

[3] Applies to LAS-RET system only

[4] Depending on LAS-BET / LAS-RET configuration

2. TECHNICAL DATA

2.1 LAS / XLAS

The operating specifications of the **LAS** / **XLAS** can be found in the **LAS** instruction manual.

2.2 WEATHER STATION AND SENSORS

Table 1: Operating specifications of sensors. For detailed information see manuals of supplied sensors. Note that the LAS-BET and LAS-RET system are not supplied with a relative humidity sensor. Instead a default value is used of 50%.

COMBILOG 1020 Data logger	
Operating temperature	-30 °C to +60 °C
Voltage and power	Nominal 12 VDC (~ 40 mA)
Analogue inputs	8 (16-bit)
Digital I/O	6
Interfaces	RS-232/RS-485
Data storage	- 256 kb internal RAM - PCMCIA Flash Memory Card (2Mb)
Temperature sensor	
Range	-40 °C to +60 °C
Output	PT100 (4-wire)
Calibration	Sensors are individually calibrated between -20°C to 50°C with an accuracy of 0.01°C @ 0°C
Wind speed sensor	
Operating temperature	-25 °C to +80 °C
Range	0 – 60 m s^{-1}
Voltage and power sensor Voltage and power heater	Nominal 12 VDC (~2 mA) Nominal 12 VDC (max 7 Watt)
Output	Digital: 0 – 600 Hz (corresp.; 0 – 60 m s^{-1})
Wind direction sensor	
Operating temperature	-25 °C to +80 °C
Range	0 – 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
Air pressure sensor	
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
Net radiation sensor (Kipp & Zonen NR-Lite)	
Operating temperature	-30 °C to +70 °C
Range	± 2500 W m^{-2}
Output	± 25 mV
Soil heat flux sensor	
Operating temperature	-30 °C to +70 °C
Range	± 2000 W m^{-2}
Output	± 20 mV

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

The **LAS-BET and LAS-RET** systems are not supplied with a relative humidity sensor. Instead a default value is used (50%). Note that the uncertainties in *RH* have little effect on the sensible heat flux and the evapotranspiration.

2.3 RF TELEMETRY LINK

Table 2: Operating specifications RF telemetry and antenna.

RF Modem	**2.4 GHz (X24-019PKI-R)**
Manufacturer	MaxStream (www.maxstream.net)
Operating temperature	-40 °C to +85 °C
Frequency	2.4000-2.4835 GHz (World wide license free)
Spread spectrum type	Frequency hopping, Wide band FM modulator
Interface	RS-232/RS-485/RS-422
Voltage	Nominal 12 VDC
Power	~200 mA (mode dependant)
Serial data throughout	19.2 kbps
RF baud rate	20 kbps
Transmit power output	50 mW (17 dBm)
Receiver sensitivity	-102 dBm
Antenna	
Operating temperature	-45 °C to +70 °C
Frequency	2.4000 – 2.4835 GHz
Type	Vagi (directional)
Gain	16 dBi
Impedance	50 Ohm
Range	~ 5 km

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3. INSTALLATION AND SET-UP

3.1 DELIVERY

In general the delivery of the **LAS-BET** and **LAS-RET** includes the following items[5]:

<u>Scintillometer part:</u>

<table>
<tr><th>LAS-BET</th><th>LAS-RET</th></tr>
<tr><td>
BET = Basic Evapo-Transpiration system

Flux station for measuring fluxes at field scale

LAS or XLAS scintillometer
• Telescopes
• 2× 5 m cable
• 2× sun / weather cover

Optional:
• 2× <u>Power Box</u> for transmitter and receiver, includes:
  ○ AC/DC converter
  ○ NET AC and power/signal cables
• 2× <u>Switching Power Box</u> for LAS transmitter and receiver, includes:
  ○ AC/DC converter with dual output
  ○ NET AC and power/signal cables
  ○ Battery (~85 Ah)
• Tripods
</td><td>
RET = Radio Evapo-Transpiration System

Flux station for measuring fluxes at kilometre scale

LAS or XLAS scintillometer:
• Telescopes
• 2× 5 m cable
• 2× sun / weather cover
• Stainless steel housing (protection class IP65) containing:
  ○ COMBILOG data logger
  ○ Overvoltage protection
  ○ 2.4 GHz RF modem, directional antenna, mounting kit and cable (~5 m)

Optional:
• 2× <u>Power Box</u> for transmitter and receiver, includes:
  ○ AC/DC converter
  ○ NET AC and power/signal cables
• 2× <u>Switching Power Box</u> for LAS transmitter and receiver, includes:
  ○ AC/DC converter with dual output
  ○ NET AC and power/signal cables
  ○ Battery (~85 Ah)
• Tripods
</td></tr>
</table>

[5] Depending on LAS-BET / LAS-RET configuration

Weather station and/or sensors[4]

LAS-BET	LAS-RET

BET = Basic Evapo-Transpiration system
 	
Flux station for measuring fluxes at field scale
 	
Meteorological **sensors**:
• Temperature sensor* (upper level)
• Temperature sensor* (lower level)
• Wind speed sensor
• Net radiation sensor (NR-Lite)
• Soil heat flux plates (2×)
• Stainless steel housing (Protection class IP65) containing:
  ○ COMBILOG data logger (plus 2 Mb PCMCIA Flash memory cards)
  ○ Overvoltage protection
  ○ Barotransmitter
 	
Optional:
• Aluminium mast (4 m) with cable guys, grounding and sensor arms (similar to LAS-RET)
	RET = Radio Evapo-Transpiration System
	
	Flux station for measuring fluxes at kilometre scale
	
	Meteorological **station**:
	• Aluminium mast (4 m, with steel guys, base plate and earth pins)
	• Lightning rod and grounding rod
	• U-shaped cross arm for:
	  ○ Wind direction sensor
	  ○ Wind speed sensor
	• Two-sided cross arm (upper level) for:
	  ○ Temperature sensor*
	  ○ Net radiation sensor
	• One-sided cross arm (lower level) for:
	  ○ Temperature sensor*
	• Soil heat flux plates (2×)
	• Stainless steel housing (protection class IP65) containing:
	  ○ COMBILOG data logger (plus 2 Mb PCMCIA Flash memory cards)
	  ○ Overvoltage protection
	  ○ Barotranmsmitter
	  ○ Solar controller
	  ○ Battery (~12V/85Ah)
	  ○ Solar panel (~100 Watt)
	  ○ 2.4 GHz RF modem, directional antenna, mounting kit and cable (~5 m)

*The air temperature sensors are individually calibrated (between –20°C to +50°C) and have an accuracy of 0.01°C @ 0°C in order to determine the stability of the atmosphere.
Kipp & Zonen reserves the right to make changes to the specifications without prior notice.

Additional components

- Data logger support software (supplied on 1 CD)
- PCMCIA flash card reader (built-in version, installation software/drivers, supplied on 2 CD's)
- Radio modem software xstreamCTU (plus additional parts: ½-wave dipole antenna, loopback adapter, null modem adapter (male-to-male), male & female RS-485/422 adapter, AC power adapter, 9 volt battery adapter)
- EVATION software (supplied on 1 CD)
- Additional algorithms for EVATION[6]
- Instruction manuals of supplied sensors and components
- 1 CD containing original COMBILOG programs with calibration coefficients, pdf file of LAS-system manual, xstreamCTU software)

[6] Depending on LAS-BET / LAS-RET configuration

3.2 STEP BY STEP INSTALLATION PROCEDURE

3.2.1 Site selection

For the installation of the **LAS**-system it is important that the following aspects are taken into account in order to have a reliable operational system:

The scintillometer (see also **LAS** instruction manual):

- **Orientation optical path: 1) it is advised to install the scintillometer such that the orientation of the path is north-south to prevent direct sunlight into the transmitter/receiver unit; 2) Install the LAS in a way that the path is (near) horizontal along the surface and that it is measuring within the constant flux layer and within the saturation free region; 3) The optical path must be free from obstacles, such as trees or high buildings.**
- Minimum height: depending on the surface conditions and the planned path length. First, the effective height of the scintillometer should be high enough to **avoid saturation of the signal**. For example high buildings, robust towers or surface topography can be used to mount the scintillometer (see e.g. Figure 3). Second, for reliable flux derivations the **LAS** / **XLAS** must measure within the so-called Constant Flux Layer of the Surface Layer (above the Roughness Sublayer), where MOST is applicable. For further instructions the reader is referred to section 3.3 of the **LAS** instruction manual!
- Availability of net AC power (in case no solar-battery power is used).

The weather station:

- A spot that is representative for the area of interest, away from forest edges or other rough surface elements.
- A spot, which is preferably near the centre of the path of the scintillometer (as the **LAS** / **XLAS** is most sensitive in the centre of its path).
- Availability of net AC power (in case no solar-battery power is used).
- In case a RF telemetry link is used (based on RF modems and antennas) the installation requirements of RF communication devices must be considered also. For detailed information the reader is referred to APPENDIX 3 – MOUNTING ANTENNAS.

The site selection of the **LAS** / **XLAS** and weather station involves an iterative procedure:

1. Select a proper site for the **LAS** / **XLAS** (Transmitter and Receiver), such that the observations of the instrument are representative for the area of interest, thereby taking into account the installation requirements of the **LAS** / **XLAS**.
2. Select a representative site for the weather station, also taking into account the installation requirements of the station (see above and section 3.2.4.1 Site selection).
3. Check the RF telemetry link (see APPENDIX 1 – TESTING RF TELEMETRY LINK)
    a. Communication established → continue with step 4
    b. Communication fails → go back to step 1 and/or 2
    c. If one uses no RF telemetry link → skip step 3 and continue with step 4
4. Check scintillometer path for saturation and MOST applicability (see section 3.3 of **LAS** instruction manual)
    a. No saturation and in compliance with MOST → continue with step 4
    b. Saturation is highly possible → go back to step 1
5. Install the weather station and the **LAS** / **XLAS** (and RF telemetry link)
    → go to next paragraph for further instructions

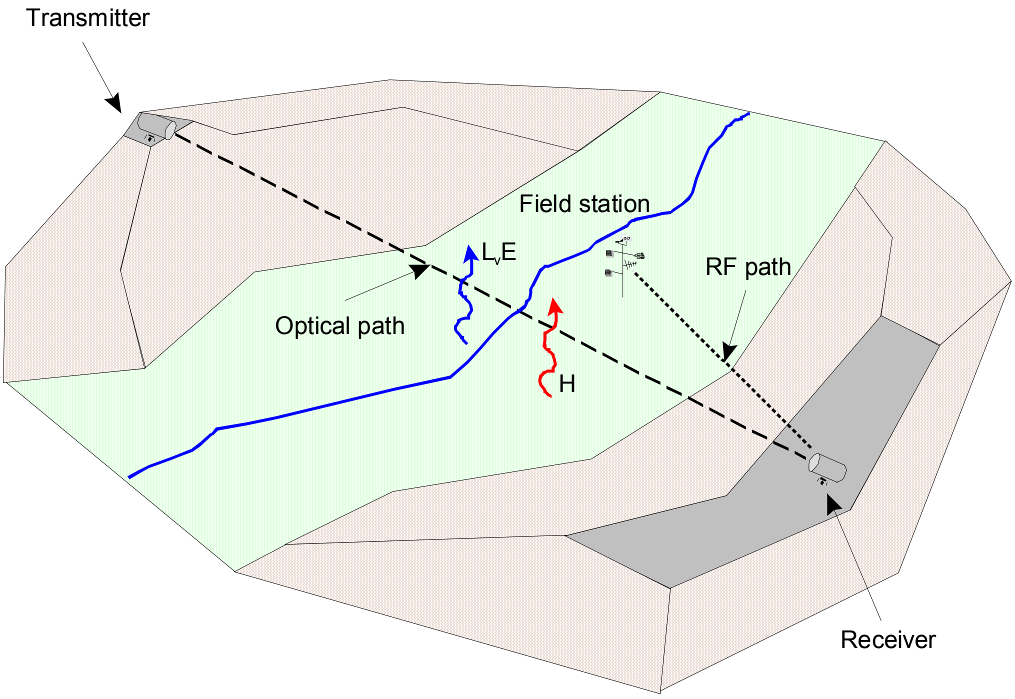


Figure 3: Schematic picture of a scintillometer installed over a valley. The weather station is located in the valley.

3.2.2 Installing LAS / XLAS

For reliable C_n^2 and flux (H and L_vE) measurements it is important to meet the installation requirements of the **LAS** / **XLAS**. These are:

- The LAS/XLAS must be placed on a robust and vibration free contruction.
- Avoid **saturation** of the signal by installing the **LAS** / **XLAS** at a minimum level (depends on surface conditions and path length).
- Be certain that the **LAS** / **XLAS** is measuring in the **Constant Flux Layer** for reliable flux derivations of the C_n^2 signal using MOST (depends on surface characteristics).

For detailed information the reader is referred to section 3.3.1, 3.3.2 and 3.4 of the **LAS** instruction manual.

3.2.3 Power supply LAS / XLAS

Depending on the customer’s request the power supply of the **LAS** / **XLAS** can be as follows:

1. (Optional) Power Box (12VDC/3.5A, manufactured by Kipp & Zonen).
2. (Optional) Switching Power Box (12VDC/10.5A & 12VDC/0.5A, with built-in backup battery (85Ah), manufactured by Kipp & Zonen,).
3. Alternative power supply (AC/DC converter, solar-battery power) with output specifications that meet the requirements of the **LAS** / **XLAS** and additional components.

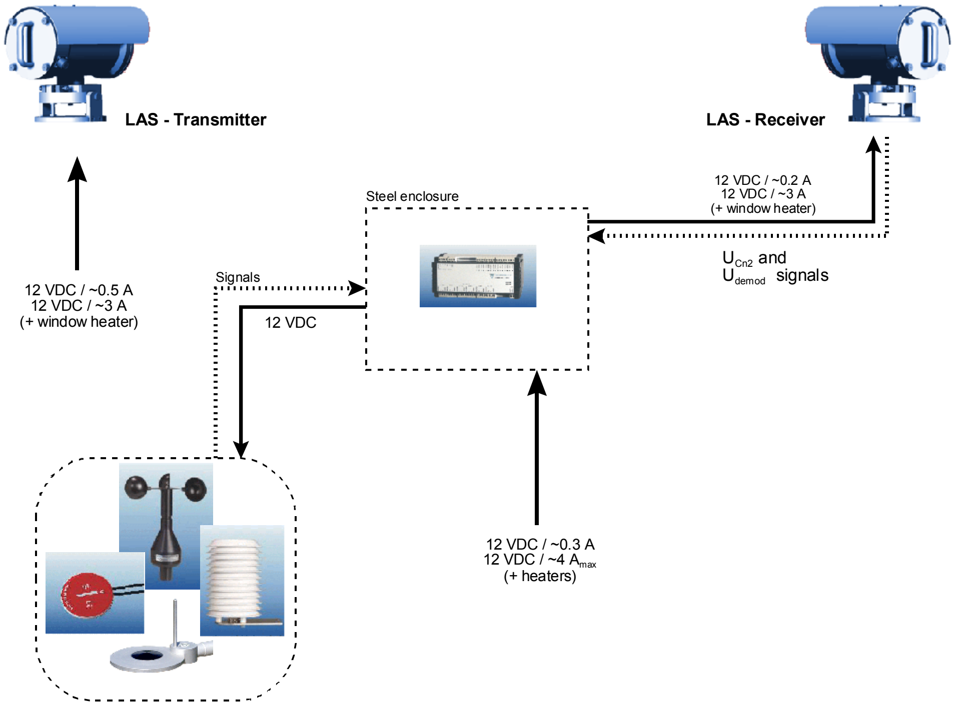


Figure 4: Required power supplies for LAS-BET system: 1 for the LAS-Transmitter and 1 for the LAS-Receiver + data logger and sensors.

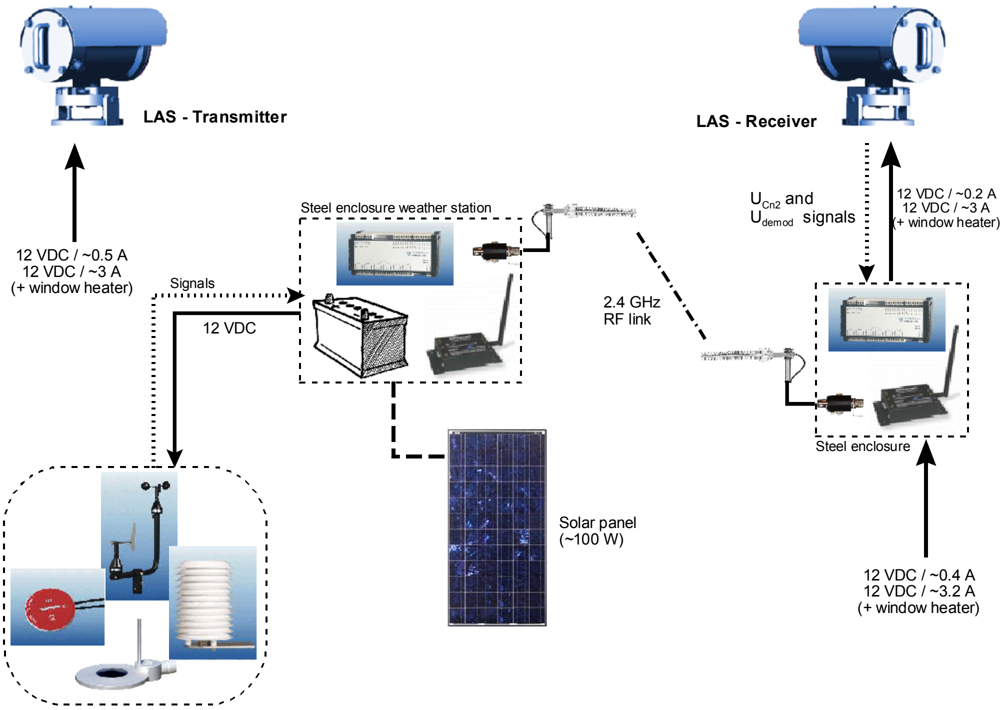


Figure 5: Required power supplies for LAS-RET system: 1 for the LAS-Transmitter and 1 for the LAS-Receiver + data logger and RF modem. The weather station operates on solar-battery power.

3.2.4 Installing weather station

3.2.4.1 Site selection

Selecting an appropriate site for the weather station is critical in order to obtain accurate data. In general the site should be representative for the area of interest and away from the influence of obstructions such as buildings, trees and other objects that might disturb the measurements (e.g. sprinklers). Use as rule of thumb:

$$\text{minimum distance} = 10h \qquad (5)$$

where *h* is height of the obstacle(s).

Checklist:
- Terrain must be free from obstacles that might influence the wind speed, temperature and radiation measurements.
- Terrain must be flat. As the anchoring of the mast is based on 3 provided earth nails the soil must be strong enough to keep the loads (also during rainy periods). If one expects that this is not the case replace the anchoring by a concrete foundation.
- A clear line-of-sight path between the antenna in the tower and the antenna at the **LAS**-receiver site in order to have a reliable RF telecommunication link.
- The site must NOT be located near commercial transmitters as their powerful signal can overwhelm the RF radio modem leading to communication problems.

It is strongly advised first to check whether the selected site meets all above-mentioned requirements before installing the weather station.

3.2.4.2 Installation of mast and mounting of sensors

The mast is pre-assembled, still horizontally on the ground in accordance with dimension sketch shown in Figure 11. Hereby care has to be taken that the admissible clamping zone is not exceeded (indicated by an upper and lower mark with red stripes in between for each section). The mast's nominal length is gained when clamping the sections at their lower marks. The base plate with its centre pin is screwed to the lowest section's bottom.

Figure 6: Clamping zone of mast sections are indicated by red stripes printed on the mast sections.

Sensor arms (a one-sided, a two-sided and an U-cross arm), sensors (temperature, relative humidity, net radiation, wind speed and wind direction), lightning rod, antenna are equally pre-assembled according to the individual system configuration (see Table 3 and Figure 7 to Figure 11). Connect the antenna cable to the antenna and use self-amalgamating tape to prevent water entering the connector. Use cable ties to fix all sensor cables to the mast/arms and lead them to the lower end of the mast, where at a later stage the steel enclosure will be mounted.

Figure 7: Mast, sensors, cables and guys are pre-assembled before the mast is erected.

Figure 8: Protect all antenna connectors from water using self-amalgamating tape.

The complete guys, consisting of 3 wires and 1 collar, incl. accessories, are supplied pre-assembled. The lower guy ends are 0.3 m longer than theoretically required in order to balance the mast on an uneven surface. Apart from that, a surface as plain and tight as possible should be selected for the weather station! Two guy ends have to be equipped with a plain thimble, while the third one gets an additional spanner, featuring a fine alignment after erection (see Figure 10).

After having defined the exact position of the mast, the mast is erected by two persons. While one person holds the mast in upright position the second person can determine the precise locations where the earth nails have to be driven into the soil (see Figure 9 and Figure 13). The nails should have an angle of about 20^o with respect to the vertical (Figure 11).

Figure 9: Determine the precise location of the nails using the guys.

The earth nail with additional spanner must be done as last. Before you determine the exact position of the last earth nail, first set the spanner to maximum range so you have enough room for adjusting the spanner for levelling the mast precisely (using a water balance). Finally, the base plate of the mast can be fixed using 4 small nails and the mast can be grounded via the grounding rod.

Figure 10: Fine adjustment of the spanner for levelling the mast.

Important: The wire tension has to be moderate and equal. By no means bending forces are allowed to be applied to the mast!

Important: It is very important to check the anchoring for correct and tight position, frequently. Especially after high wind speeds occurred. If the soil seems not to be tight enough to keep the loads, the anchoring has to be replaced by concrete foundations. If the load lengthens the wires, their length has to be readjusted. The wire condition has to be checked frequently. Damaged wires have to be replaced at once!

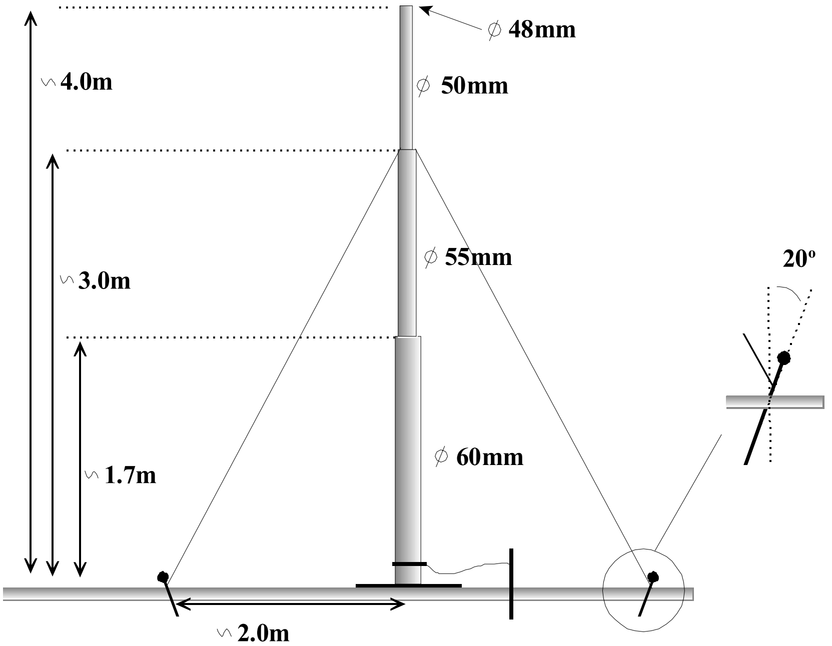


Figure 11: Dimension sketch of 4 m mast. The earth nails should have an angle of about 20° with the vertical.

KIPP & ZONEN
SINCE 1830

Important: The minimum distance between the upper and lower temperature sensor should be at least 1.7 m in order to measure a reliable temperature gradient, with the lower temperature at a height lower than 1m! When the sensors are positioned too close to each other (or both installed too high) no distinctive diurnal temperature gradient can be measured along the day. This will lead to misinterpretation of the atmospheric stability by the EVATION software.

Table 3: Typical sensor height and orientation of sensors in the 4 m mast.

	Sensor	Typical Height/depth	Arm	Orientation/Direction
1	Wind speed (*u*)	± 4.4 m	U-cross arm	-
2	Wind direction (WD)	± 4.2 m	U-cross arm	-
3	Antenna	± 3.5 m	-	To LAS-Receiver
4	Air Temperature (upper level) (T^+)	± 2.7 m	Two-sided cross arm	Opposite of radiation sensor
5	Net radiation (Q^* or R_n)	± 2.7 m	Two-sided cross arm	South on N. Hemisphere North on S. Hemisphere
6	Air Temperature (lower level) (T^-)	± 0.5 m	One-sided cross arm	Below upper temperature sensor (**lower temp. sensor must be lower than 0.8m! ; distance between upper and lower temp. sensor must be at least 1.7 m!**)
7	Soil heat flux plate 1 (G_1 or HFP_1)	0.003 – 0.03 m	-	At same side of mast as the net radiation sensor
8	Soil heat flux plate 2 (G_2 or HFP_2)	0.003 – 0.03 m	-	At same side of mast as the net radiation sensor
9	Air pressure (*P*)	-	Inside enclosure	-
9	Solar panel	At the base of the tower	Use extendable arms and small pins	South on N. Hemisphere North on S. Hemisphere
10	Enclosure for data logger and power supply	At the base of the tower	-	Opposite of solar panel

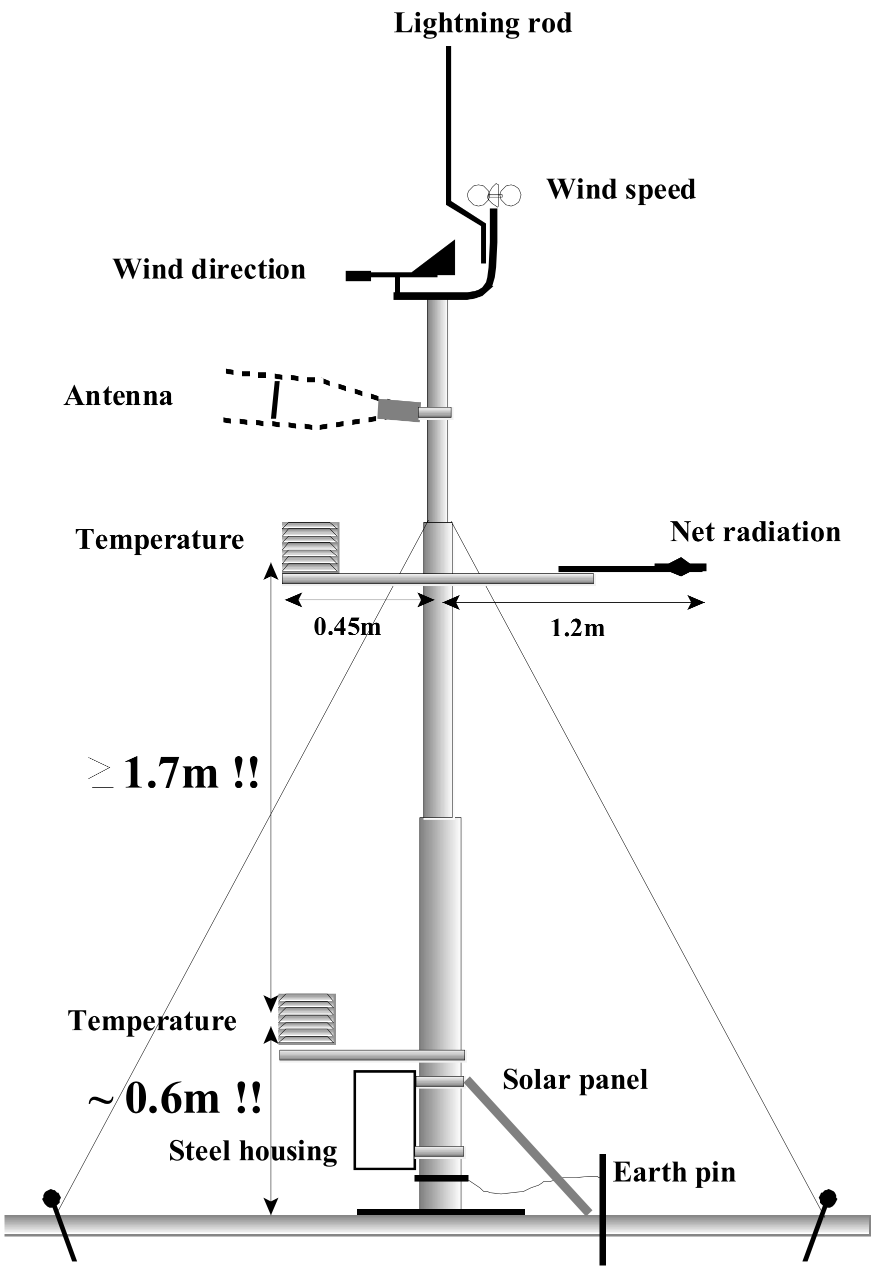


Figure 12: Overview of 4 m mast equipped with sensors, antenna, solar panel and steel enclosure for data logger, power supply (battery) and RF modem.

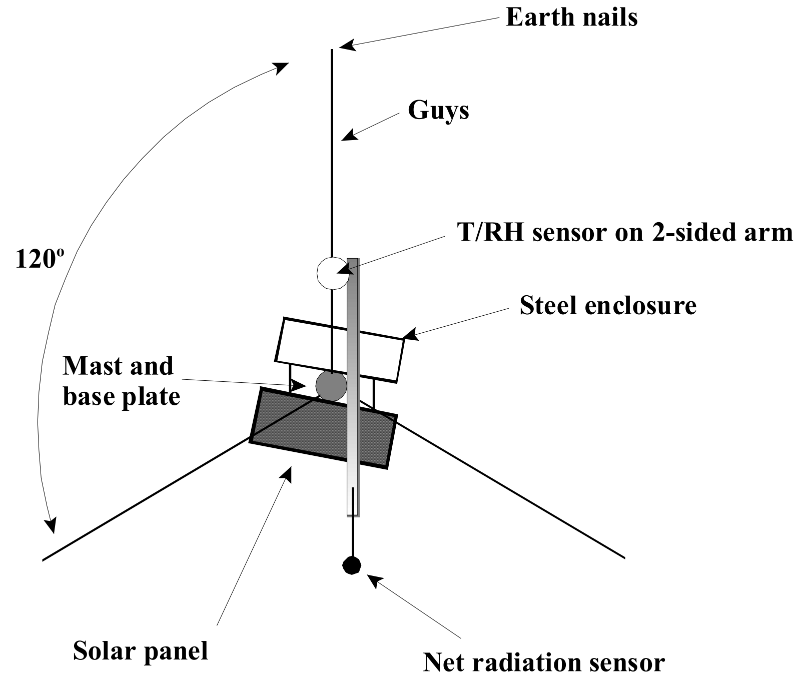


Figure 13: 4 m mast seen from above, showing the orientation of the sensors, enclosure, arms and guys.

The last sensors that have to be installed are the soil heat flux plates. Place them at the same side of the mast where the net radiation sensor is mounted, preferably at a spot that is not disturbed by footsteps. Remember that the measurements should be representative for a large area! Do not position the plates directly beneath the net radiation sensor, as they may disturb the net radiation measurements. Depending on the soil type and the presence of vegetation the plates are buried at a depth of about 0.03 m (bare soil conditions) or just beneath the surface at 0.003 m (fully covered soil). In the latter case the amount of 'missing' flux is as small as possible. Note that plates at depths of 10 cm can underestimate the soil heat flux by more than 50%! Prevent that the plates are measuring in air gaps or cracks (i.e. avoid air gaps between the soil and the plates)! When using more than 1 plate, burry them at the same depth. It is safest to install plates at depth's of > 3 cm from the side, to prevent disturbance of the covering soil layer!

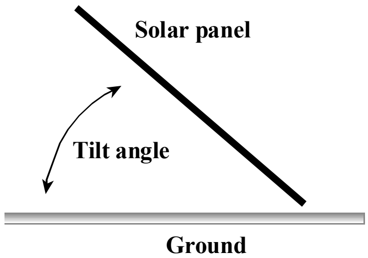
3.2.4.3 Mounting enclosure, solar panel and connecting wires

Once the mast (plus arms and sensors) is erected and levelled, the stainless steel enclosure plus the solar panel can be fixed on the mast. The solar panel should be facing south (on Northern hemisphere) or north (on Southern hemisphere) to have maximum insolation over the year. The solar panel is partly fixed on the mast and partly on the ground using 2 earth nails such that it is tilted to have maximum efficiency. Use the extendable legs of the solar panel to get the desired tilt angle. Once the tilt angle is set, use the 2 earth nails to fix the legs on the ground.

The enclosure is best mounted opposite of the solar panel. All cables (signal, antenna and power) enter the enclosure at the bottom through the cable ducts. Connect all sensor cables to the data logger (via the over voltage protection, see Figure 15) according to the connection plan (see APPENDIX 9 – CONNECTION PLAN) and the antenna cable to the RF modem via the adapter and lightning arrestor). Finally, the power cable of the solar panel can be connected to the solar controller. **Ensure correct polarity (brown is + and blue is -)!!!**

Figure 14: The steel enclosure is fixed to the mast opposite of the solar panel that is facing south (or north on southern hemisphere) and mounted as low as possible in order to leave enough flexibility for the lower temperature sensor. Finally, the wires are led into the enclosure via the cable ducts.

Site latitude [°]	Tilt angle [°]
0 – 10	10
11 – 20	Latitude + 5
21 – 45	Latitude + 10
46 – 65	Latitude + 15
> 65	80



⚠ **Important:** do not place the solar panel directly beneath the radiation sensor. Reflected solar radiation from the solar panel to the radiation sensor will significantly disturb the measurements.

Once the enclosure and the solar panel are properly fixed and all sensor cables are connected, the battery can be placed inside the enclosure. Connect the battery-power cables of the solar controller to the battery poles. **Ensure correct polarity (brown is + and blue is -)!!!** The data logger will automatically start measuring.

Once again, check that everything is properly fixed in the mast (i.e. the levelling of the net radiation sensor, the alignment/orientation of the antenna), preferably using a small portable ladder. Verify that the sensors and the RF link are working properly (see section 5. OPERATION and APPENDIX 6 – INSPECTION PROCEDURE) including the date and time setting of the COMBILOG data loggers. To change date and time go to APPENDIX 7 – SETTING DATE / TIME COMBILOG. In case you have multiple COMBILOG data loggers, check them all.

When the system is working properly roll up redundant signal, antenna and power cables and fix them to the mast (between the solar panel and the enclosure) using cable ties. Do not lay the cables on the ground as insects and small animals might damage the cables.

As final step we recommend to fill in the Installation Form of the **LAS**-system (see APPENDIX 5 – INSTALLATION FORM). This Installation Form will be used to configure the EVATION software (see Section 4.4 EVATION DATA PROCESSING SOFTWARE).

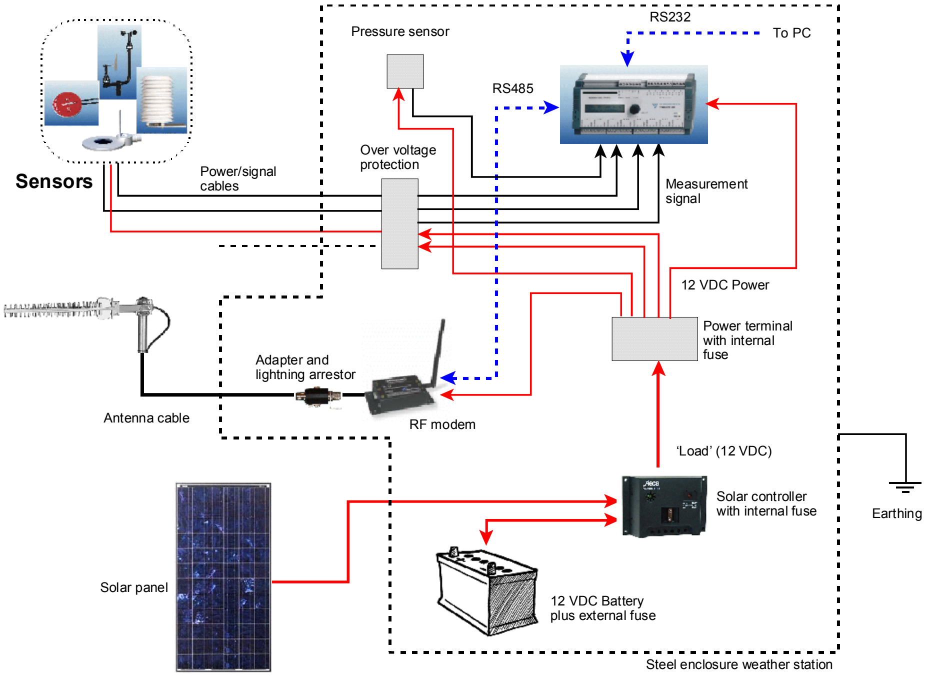


Figure 15: Overview of steel enclosure of weather station with RF-Telemetry link (LAS-RET system). The data from the LAS/XLAS is collected by the *MASTER* COMBILOG via the RF-telemetry link (i.e. via the RF modem and the RS-485 port of the COMBILOG).

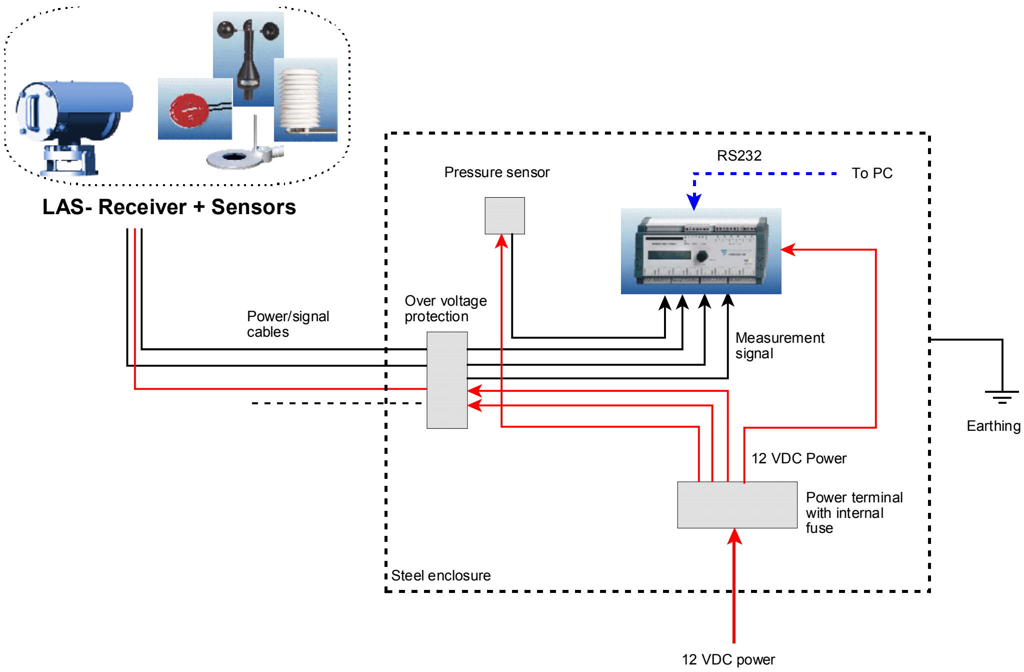


Figure 16: Overview of steel enclosure of LAS-BET system. The power source for the LAS-Receiver, data logger and sensors must be 12 VDC.

Figure 17: Operational weather station of LAS-RET system.

4. SOFTWARE

The software required for the **LAS-BET / LAS-RET** system consists of the following software programs:

1. COMBILOG support software
   To (re)configurate COMBILOG data loggers
2. PCI Swap-box Software [7]
   Drivers and manual for PCMCIA FLASH Memory **Card reader**
3. CardWare (PCCard Control)
   To read PCMCIA FLASH Memory Cards
4. EVATION data processing software
   To process data from the weather station (and **LAS** / **XLAS**) to surface fluxes
5. Modified algorithms for EVATION [8]

4.1 COMBILOG SUPPORT SOFTWARE

The COMBILOG support software enables the user to communicate with the COMBILOG data loggers, via the RS-232 interface. In this way the user can re-configure the data logger program, monitor measurements real time, change date and time, and download data from the internal memory (NOT from the PCMCIA Flash card!). Note that the COMBILOG data loggers are 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 selected drive (included in manual COMBILOG Data logger)
- In case the installation does not start automatically, invoke "*SETUP.exe*" on the COMBILOG CD-ROM
- Follow the instructions given by the installation program

After successful installation a new program group called COMBILOG V×.×× (Icon:) is created.

4.1.1 Setting communication parameters

Once the COMBILOG support software is started for the first time, the communication parameters have to be configured in order to communicate with the COMBILOG data loggers. Click on *Communication* and go to *Parameters*. A new window appears (see Figure 18). Set the communication parameters as follows:

Interface Kind : RS-232 RF-modem

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

[7] In case one uses a portable computer with built-in PCMCIA interface the SWAP-Box software is not required.

[8] Depending on configuration LAS-BET / LAS-RET system

Then click on OK. The software is now ready to communicate with the COMBILIOG data loggers.

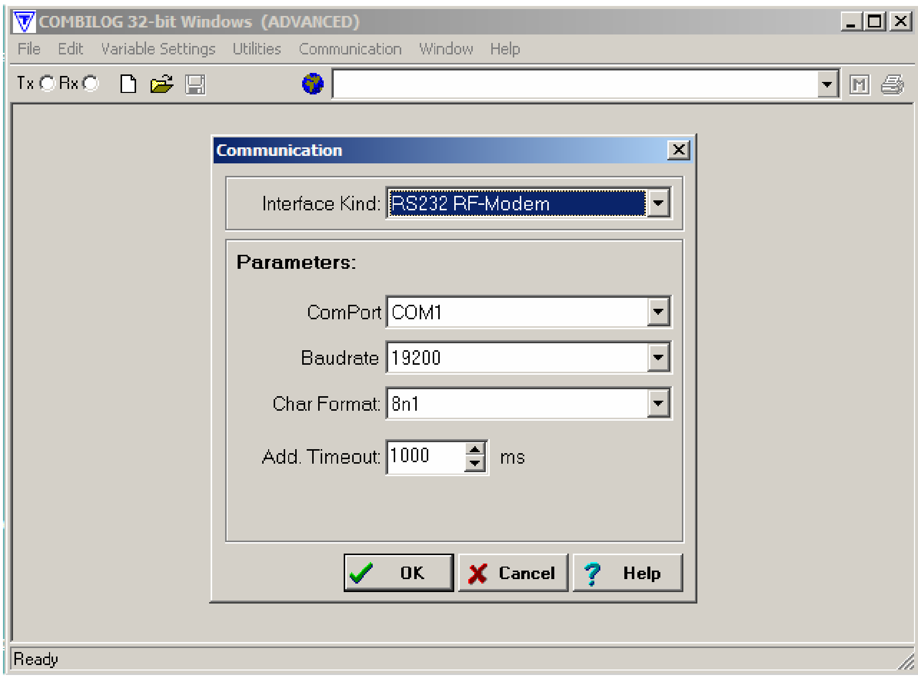


Figure 18: Setting of communication parameters in COMBILOG software.

How to communicate with COMBILOG data loggers?

- Start the COMBILOG support software.
- Connect the PC to the (*MASTER*) COMBILOG data logger (= "weather station") using the connected RS-232 interface cable.
- Click on *File* and go to *Scan Bus*. The software will automatically scan for connected COMBILOG data loggers.
- A list of found COMBILOG data loggers will appear on screen (see Figure 19). Depending on the configuration mode of the COMBILOG data logger, i.e. *MASTER* or *SLAVE*, one or more COMBILOG data loggers will appear on screen (typical names are "Weather Station" and/or "LAS"). If the PC is connected to the RS-232 of the *SLAVE*, the *MASTER* data logger will not be visible!
- The user can now select one of these data loggers to communicate with.

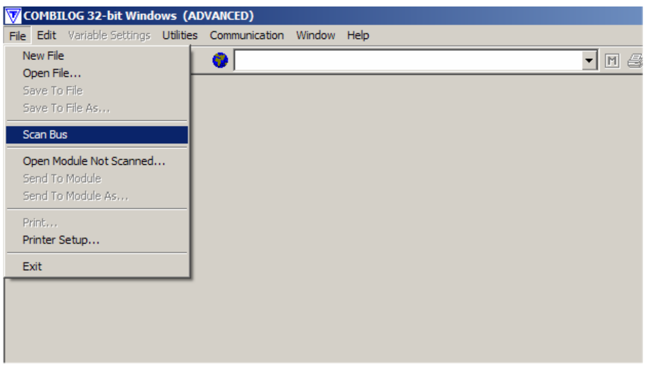


Figure 19: The COMBILOG software will scan the RS-232 interface for available COMBILOG data loggers.

4.1.2 Original COMBILOG module settings and programs

Depending on the **LAS-BET** / **LAS-RET** configuration either 1 or 2 (or more) COMBILOG data loggers are included in the system. The data logger(s) are pre-configured by Kipp & Zonen and will automatically start measuring once connected to a power supply. If necessary the user can re-configure the data loggers using the COMBILOG support software, e.g. when extra sensors are connected. For further instructions the user is referred to the COMBILOG instruction manual and COMBILOG support software. The original program(s) of each data logger can be found on the supplied CD.

In general the main configuration of the COMBILOG data loggers of the LAS-systems is as follows:

A. LAS-system with RF telemetry link (= **LAS-RET**, see Figure 1)

A.1 Original configuration COMBILOG 1 (Type 1020, *MASTER*) (see Figure 20):

Location:	Station-RET
Name:	Kipp
Filter freq.:	50Hz or 60Hz rejection
Auto off:	Disabled
LED:	Enabled
Address:	1
Protocol:	Profibus/ASCII
Baud rate:	19200
Char format:	8n1
Answer delay:	1 Char Timeout
Timeout:	1 s

A.2 Original configuration COMBILOG 2 (Type 1020, *SLAVE*) (see Figure 21):

Location:	LAS-RET
Name:	Kipp
Filter freq.:	50Hz or 60Hz rejection
Auto off:	Disabled
LED:	Enabled
Address:	2
Protocol:	Profibus/ASCII
Baud rate:	19200
Char format:	8n1
Answer delay:	1 Char Timeout
Timeout:	1 s

B. LAS system without RF telemetry link (= **LAS-BET**, see Figure 2)

B.1 Original configuration COMBILOG (Type 1020, *MASTER*) (see Figure 20):

Location:	LAS-BET
Name:	Kipp
Filter freq.:	50Hz or 60Hz rejection
Auto off:	Disabled
LED:	Enabled
Address:	1
Protocol:	Profibus/ASCII
Baud rate:	19200
Char format:	8n1
Answer delay:	1 Char Timeout
Timeout:	1 s

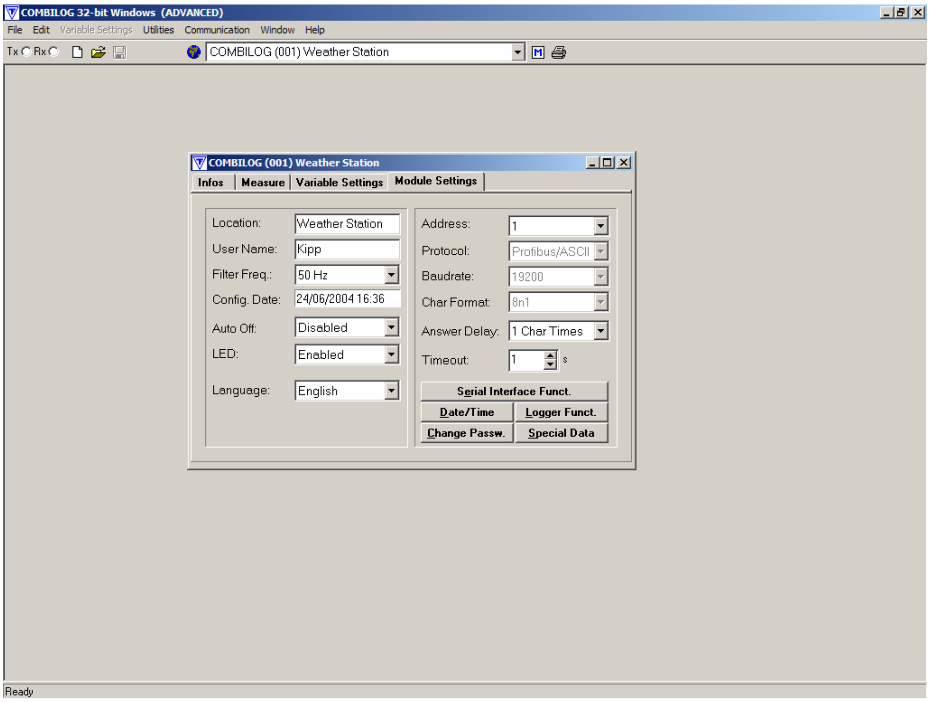


Figure 20: COMBILOG module settings 'Weather station'.

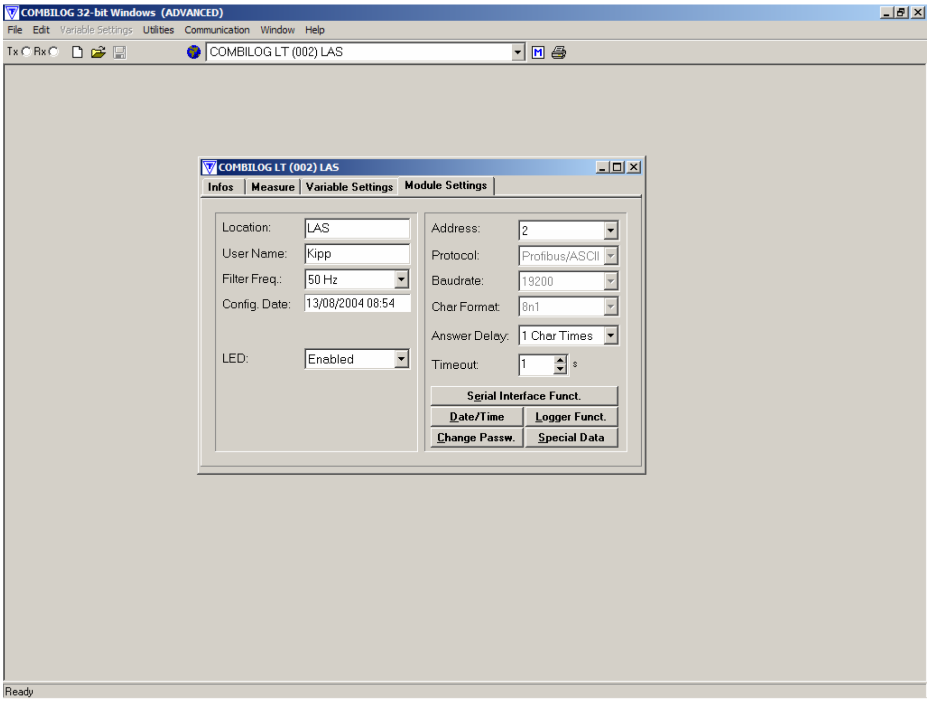


Figure 21: COMBILOG module settings 'LAS'.

4.2 PCI-SWAP-BOX SOFTWARE

The PCI-SwapBox software is part of the PCMCIA card reader package and is intended for desktop computers that are not equipped with a PCMCIA card reader. The installation involves two steps: the hardware installation of the reader in the desktop PC and the software installation of the drivers. For further instructions the reader is referred to the PCI SwapBox installation CD.

Figure 22: PCI-SwapBox card reader for desktop computers.

4.3 PCMCIA FLASH MEMORY CARD SOFTWARE (CardWare)

In order to read the PCMCIA flash memory cards using either a standard built-in PCMCIA card reader (applies to most portable computers) or the PCI SwapBox reader (see section 4.2, applies to most desktop computers), the user has to install the provided CardWare software. CardWare allows the user to ‘use’ the PCMCIA flash memory cards as if they were normal floppy or hard disk drives.

4.3.1 Installing CardWare software

In most cases, the following quick install procedure is all you need to know about CardWare. Once installed, CardWare automatically configures your system to recognize almost all PC Cards, with no intervention needed on your part. If you have special installation requirements, see Chapter "Installing CardWare" in the CardWare manual (see “*CardWare2000_XP.pdf*”) for a detailed description of the process. To install the CardWare software:

1. Remove all PC Cards from your system.
2. Run the “*CWMEM2K.exe*” installation program from the CD and follow the prompts through the first screens, clicking *Next* or *Finish* to move from screen to screen.
3. When the program ends, restart your system.
4. After entering the serial number you will get a fully functional version. The serial number is delivered separately in the file “*LICENCE.txt*” (available on the same CD).
5. The software is installed now. CardWare should load and automatically detect insertion and removal of PC Cards any time during system operation.

For details, see Chapter "Cardware Installation Options" in the manual (“*CardWare2000_XP.pdf*”).

Once the CardWare software is installed, the user can select during each booting sequence of the computer between two configuration profiles, namely the *original configuration* or the *CardWare configuration*. Select *CardWare configuration* when using the PCMCIA flash memory cards, otherwise select *original configuration* (to avoid conflicts with i.e. memory sticks or other memory cards).

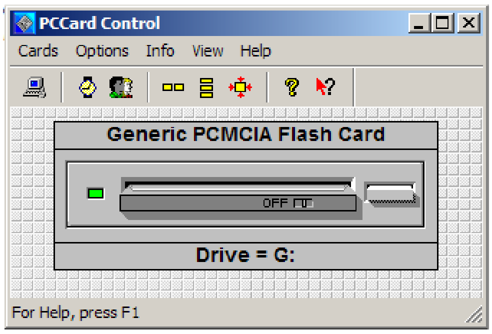


Figure 23: CardWare for Windows.

4.3.2 Reading PCMCIA Flash Memory Cards

To read PCMCIA cards proceed as follows:

- Start the computer and select from the boot option *CardWare configuration*. The computer is now able to understand the special format of the PCMCIA cards.

- Insert the PCMCIA card in the PCMCIA reader. The icon will appear in the task bar on your computer.
- Go to this new disk via “My Computer” or via “Microsoft Explorer”. On this disk the file COMBILOG.log can be found.
- Copy this file to the input subdirectory of your working directory in EVATION (see 4.4.3 Getting started) and rename the copied file (e.g. YYMMDD_STATION.log). Do NOT move, delete or rename the COMBILOG.log file from the PCMCIA flash card!
- In order to avoid crashing of Windows, eject the PCMCIA flash card using the eject/unplug hardware button in the task bar of your computer ( ). An alternative option is to use PCCard control software (see Figure 45 or Figure 46).
- In case the COMBILOG.log file is accidentally deleted or removed. Go to APPENDIX 8 – FORMAT PCMCIA FLASH MEMORY CARDS for further instructions.

Important: The function Eject Card should be used before removing the card from the device!

Important: PCMCIA flash memory cards cannot be read without the CardWare software!

Important: Never move, delete or rename the COMBILOG.log file from the PCMCIA flash memory card!

4.4 EVATION DATA PROCESSING SOFTWARE

4.4.1 Installing EVATION

Once the data from the PCMCIA flash cards are stored on the hard disk of the PC, the provided EVATION software can process the collected data to fluxes of sensible heat and evaporation. The EVATION software can organise and process data for multiple **LAS-BET** / **LAS-RET** stations (using selectable working directories, which in turn consist of in/output and configuration directories).

Insert the EVATION CD-ROM in your PC to start the installation of EVATION. In case the installation does not start automatically, invoke “SETUP.EXE” on the EVATION CD-ROM. All installed files reside in the selected EVATION program directory. After successful installation a new program group called EVATION is created. Start this program by clicking on the EVATION icon ( ).

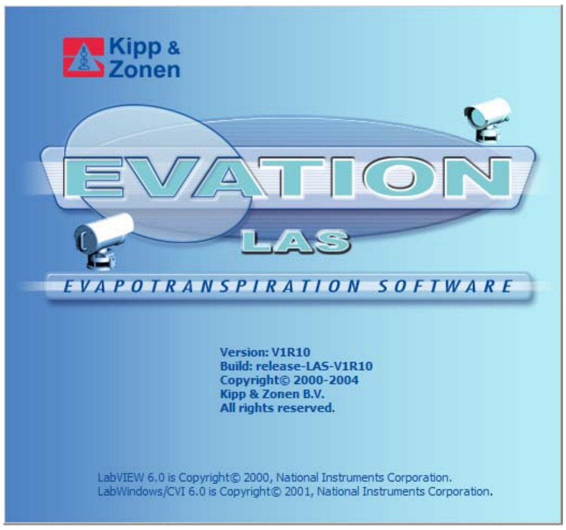


Figure 24: EVATION – LAS EVApoTranspiratION software.

4.4.2 Installing Modified Algorithms

Depending on the configuration of the **LAS-**system, the user may have to install an additional modified algorithm, which is required for the data processing to fluxes. EVATION is equipped with a default algorithm, specially designed for the **LAS-BET** / **LAS-RET** systems. Depending on the requested **LAS**-system and the supplied sensors this algorithm has been modified based on a compromise of calculating reliable fluxes and user friendliness. Note that the output of the EVATION software (i.e. calculation of the sensible heat flux *H* and/or latent heat flux L_vE) is depending on the **LAS**-system configuration.

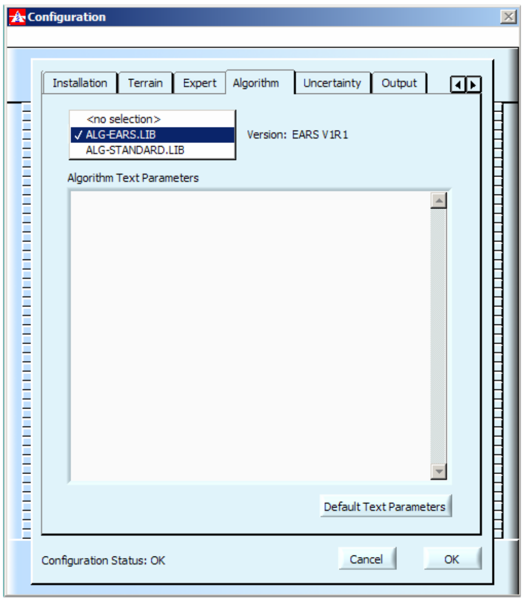


Figure 25: Depending on the LAS-ET (RF) configuration the standard or modified algorithm is selected.

The installation of additional modified algorithms is done separately and is done only after successful installation of the EVATION software. Modified algorithms can be found on separately delivered CD and are installed simply by clicking on ‘SETUP.EXE” and following the installation procedure. After successful installation the user can select between the different algorithms in the *configuration* menu of the EVATION software (see Figure 25).

Important: The use of an incorrect algorithm can lead to processing errors! Therefore carefully check if the selected algorithm applies to your **LAS-BET** / **LAS-RET** system!

Depending on the delivered **LAS**-system a modified algorithm (on a separate CD) is included.

4.4.3 Getting started

EVATION is a user-friendly software program that allows the user to process **LAS** measurements to surface fluxes of sensible heat and evaporation. Before the data of a **LAS**-system can be processed to fluxes, first some configurations have to be set in EVATION. The configuration involves a number of small steps (see Figure 26). First, a working directory (consists of an input subdirectory, an output subdirectory and a configuration subdirectory) has to be selected or configured. In case one uses more than 1 **LAS**-system, separate working directories have to be selected for each system. Once a working directory is selected EVATION will create subdirectories labelled “input”, “output”, “config” and “auxiliary”. Next the configuration of the **LAS**-system has to be entered in the EVATION software. This is done via the *configuration* window. Here, various parameters have to be set, such as **LAS**-type, sensor height (or depth), scintillometer path length, terrain characteristics (e.g. surface roughness), required algorithm (see section 4.4.2 Installing Modified Algorithms and Figure 25), and configuration of the output ‘flux’ files. To get familiar with EVATION we recommend first studying the help file before continuing with EVATION. The help file can be viewed by clicking on *help*, and following *contents*.

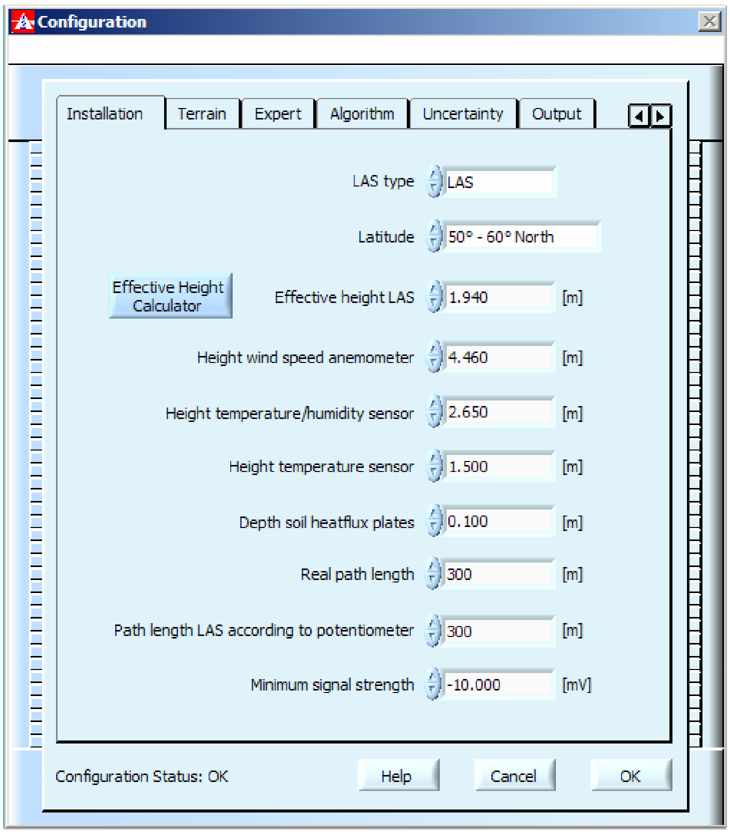


Figure 26: EVATION configuration menu.

5. OPERATION

Once the **LAS** / **XLAS** and the weather station are installed and connected to a power source, the data logger of the **LAS-BET** / **LAS-RET** system will automatically start measuring. All COMBILOG data loggers are pre-configured by Kipp & Zonen start automatically when connected to a power source. The actual measurements can be monitored using the display on the COMBILOG data logger or via the COMBILOG support software on a computer that is connected to the COMBILOG's RS-232 interface.

5.1 REAL-TIME MONITORING OF MEASUREMENTS

5.1.1 Via COMBILOG support software

Once a PC is connected to the COMBILOG data logger of the **weather station** ALL measurements can be monitored real-time. After selecting either the "weather station" or "**LAS**" labelled data logger (see 4.1.1 Setting communication parameters), the actual measurements can be viewed via the *Measure* window (see Figure 27 and Figure 28). In Table 4 the range and units of all measurement signals are given.

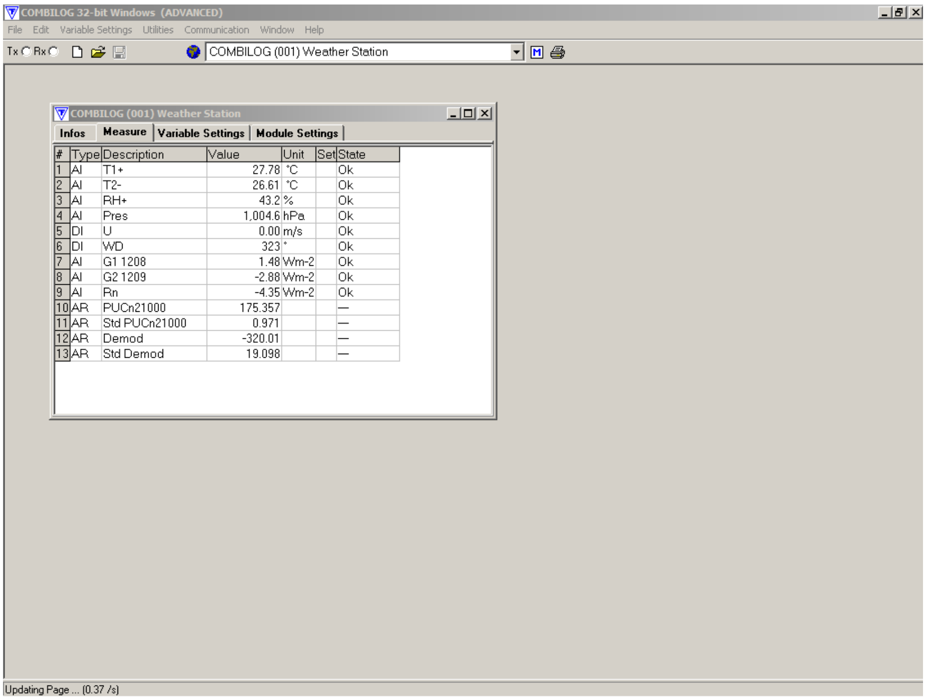


Figure 27: Real time monitoring of measurements of "weather station" (*MASTER*) data logger via the COMBILOG support software.

Note that for the **LAS-RET** system the COMBILOG data logger at the weather station is the *MASTER* data logger and the COMBILOG data logger at the LAS-receiver is the *SLAVE* data logger. This means that a PC, which is connected to the *MASTER* (= "weather station") data logger, can monitor the measurements of both the *MASTER* as well as the *SLAVE* (= "LAS") data logger. The *MASTER* is "transparent". When the PC is connected to the *SLAVE* data logger, the *MASTER* cannot be monitored! The "transparent" mode of the *MASTER* allows reprogramming (and downloading of data) of the *SLAVE* data logger via the RS-232 of the *MASTER*.

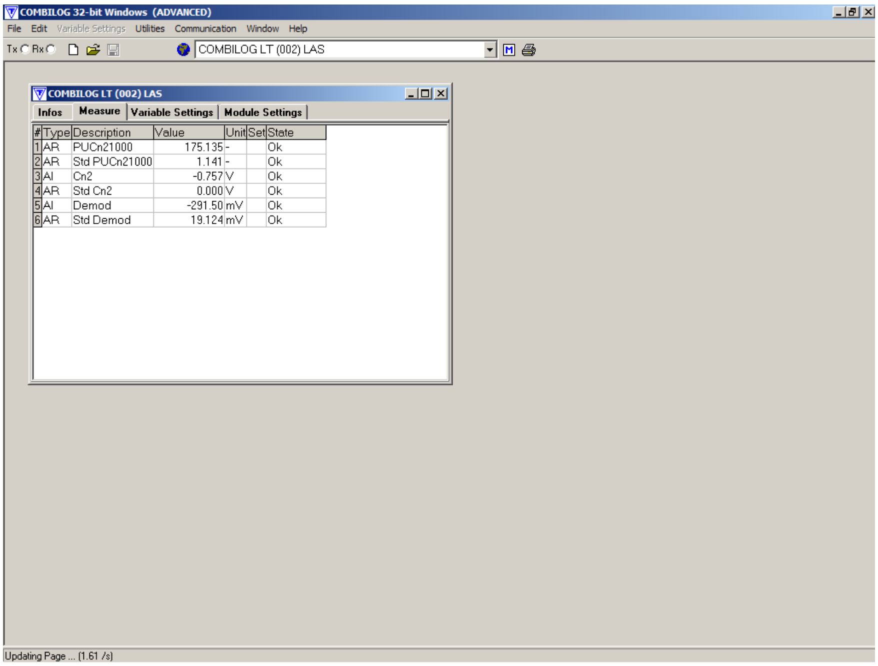


Figure 28: Real time monitoring of LAS/XLAS measurements of "LAS" (*SLAVE*) data logger via the COMBILOG support software (applies to LAS-RET system!).

Table 4: Symbol, measurement range and units of (optional) sensors of LAS-systems.

	Sensors	**Symbol**	**Unit**	**Range**
1	Air temperature upper level (Derived from upper PT100)	T+	°C	-20 to +50 °C
2	Air temperature lower level (Derived from lower PT100)	T-	°C	-20 to +50 °C
3	Relative humidity	DRH	%	Default @ 50 % [9]
4	Air pressure	Pres	hPa	600 to 1050 hPa
5	Wind speed	U	m s^{-1}	0 to 60 m s^{-1}
6	Wind direction	WD or DWD	°	0 to 360 °
7	Soil heat flux plate 1	G_1 or HFP_1-sn×××	W m^{-2}	-200 to +200 W m^{-2}
8	Soil heat flux plate 2	G_2 or HFP_2-sn×××	W m^{-2}	-200 to +200 W m^{-2}
9	Net radiation	Rn-sn×××	W m^{-2}	-250 to +1500 W m^{-2}
10	Resistance upper PT100	PT100-sn×××	Ω	80 to 120 Ω
11	Resistance lower PT100	PT100-sn×××	Ω	80 to 120 Ω
	LAS/XLAS signals	**Symbol**	**Unit**	**Range**
1	Scaled C_n^2 (= PUCn21000) (C_n^2 = PUCn21000 * 1.10^{-15})	PUCn21000	m$^{-2/3}$	0.01 to 1000 m$^{-2/3}$
2	Standard deviation of PUCn21000	Std PUCn21000	m$^{-2/3}$	
3	U_{CN2} (expressed as a voltage) $C_n^2 = 10^{(U_{CN2}-12)}$	Cn2	V	-5 to 0 V
4	Standard deviation of U_{CN2} (expressed as a voltage)	Std Cn2	V	
5	Signal strength (U_{Demod})	Demod	mV	-1000 to 0 mV
6	Standard deviation of signal strength (U_{Demod})	Std Demod	mV	

[9] The LAS-BET and RET system are not supplied with a humidity sensor. Instead a default value of 50% is used (the default value can be easily altered).

5.1.2 Via display of COMBILOG

The output of each channel can also be monitored on the display of the COMBILOG using the "SELECT" press/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 (see Figure 29).

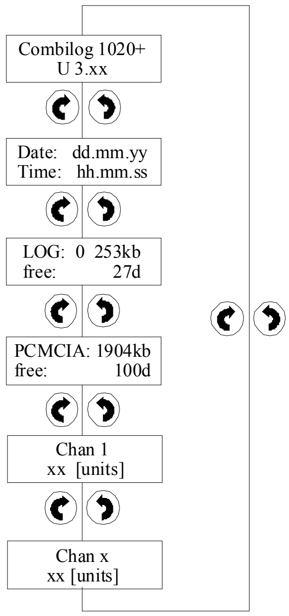


Figure 29: Main menu of COMBILOG to monitor the actual measurement output of each sensors (see Chan. 1 to Chan. X). Description symbols:

↻	….	Turn knob clockwise
↺	….	Turn knob counter clockwise

5.2 CALIBRATION COEFFICIENTS

Some of the sensors of the **LAS-BET** / **LAS-RET** system are supplied with calibration certificates, e.g. the radiation sensors, the soil heat flux plates and PT100 temperature sensors. The calibration constants can be found in either the separate instruction manuals or in the original COMBILOG data logger programs, which is programmed into the COMBILOG's internal memory. The original COMBILOG programs plus applied calibration constants are available on the supplied CD (see also 4.1.2 Original COMBILOG module settings and programs).

5.3 DATA FILES

The data files of the COMBILOG data logger (via PCMCIA Flash Cards) are formatted as follows (columns, separated by tabs):

1. Date
2. Time (= **Begin-Time of interval !!!**)
3. Air temperature upper sensor [T+, ^{o}C]
4. Air temperature lower sensor [T-, ^{o}C]
5. Relative humidity [*DRH*, default @ 50%]
6. Air pressure [P, hPa]
7. Wind speed [u, m s^{-1}]
8. Wind direction [*WD* or *DWD*, ^{o}]
9. Soil heat flux (plate 1) [G_1 or HFP_1, W m^{-2}]
10. Soil heat flux (plate 2) [G_2 or HFP_2, W m^{-2}]
11. Net radiation [Q^* or R_n, W m^{-2}]
12. Scaled C_n^2 [PU_{CN2}, $m^{-2/3}$]
13. Standard deviation of scaled C_n^2 [$m^{-2/3}$]
14. Demod (= signal strength) [U_{DEMOD}, mV]
15. Standard deviation of Demod [mV]

The number of columns (in this case 15) is constant and independent of the sensor configuration of the **LAS**-system. In case fewer sensors are used dummy values are placed (**-9999**) in the ‘empty’ columns of the specific missing sensor. **Note that the columns may not be interchanged!** A more detailed description of the data files and format can be found in the help file of the EVATION software.

6. MAINTENANCE

To be certain that the quality of the measurements is of high standard, care must be taken with the maintenance of the weather station. A visual inspection routine of the weather station, at regular intervals (~2 weeks) is therefore highly recommended (for more information go to APPENDIX 6 – INSPECTION PROCEDURE).

7. TROUBLE SHOOTING

The guidelines given in APPENDIX 6 – INSPECTION PROCEDURE help you to maintain the **LAS-BET** / **LAS-RET** system and if necessary to isolate "hardware" related problems such as:

- Power source problems of the weather station (e.g. short circuits, blown fuses, loose cables, battery status, etc)
- Sensor problems of the weather station, such as the net radiation, soil heat flux, air pressure, air temperature, wind speed and direction sensors (e.g. loose or damaged cables, dirt, leveling, sensor failure etc).
- **LAS** / **LAS** related problems (e.g. power failure transmitter/receiver units, blown fuses, misalignment, poor visibility, etc)
- RF telemetry problems between receiver and weather station (e.g. power failure, misalignment antennas, cable/connector damages, RF modem failure, etc)

If necessary, consult the separate manual of a specific sensor 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 still no satisfactory answer/solution is found after reviewing this manual, the separate instruction manuals and/or help files, please contact your supplier or Kipp & Zonen.

APPENDIX 1 – TESTING RF TELEMETRY LINK

Requirements:

- 1 × (portable) computer (Windows 95/98/2000, NT or XP) with an available RS-232 serial port.
- 2 × XStream-PKG-R RF Modems configured in RS-232 mode (see APPENDIX 2 – DIP SWITCH SETTINGS RF MODEM).
- 1 × standard 1:1 RS-232 cable with one 9-pin Sub-D male and one 9-pin Sub-D female connector.
- 1 × serial loop-back adapter
- 2 × 9V battery clip and 9V battery (or 2 × power adapters).
- 2 × Yagi/Vagi antennas and antenna kits (cables, adapters and surge protection)
- XCTU configuration software

Installing the XCTU software:

- Double-click the "setup-XCTU.exe" file located in the "Software" folder of the included CD.
- Follow the prompts of the installation screens.

Hardware set-up:

1. Connect one RF modem (Radio1) to the PC serial port using the RS-232 cable.
2. Attach the serial loop-back adapter to the DB-9 serial connector of the second RF modem (Radio2). The serial loop-back adapter configures Radio2 to function as a repeater by looping serial data back into the radio for retransmission.
3. Check that both RF modems operate in RS-232 mode (see APPENDIX 2 – DIP SWITCH SETTINGS RF MODEM).
4. Attach the directional Yagi/Vagi antennas (plus cables, adapters and lightning arrestors) to Radio1 and Radio2. For mounting instructions of the antennas the reader is referred to APPENDIX 3 – MOUNTING ANTENNAS.
5. Power Radio1 and Radio2 using the supplied power adapters or 9V battery clips.

Figure 30: Hardware set-up for RF communication test between Radio1 (located at weather station site) and Radio2 (located at LAS-Receiver site).

Procedure for testing RF communication link between the selected sites of the weather station and the LAS-Receiver:

1. Start the XCTU software program.
2. Select the PC Serial com port from the dropdown list that will be used to connect to Radio1 (see tab "Setup"). Generally COM1 is used. COM set-up should be as follows: Baud 19200; Flow control: NONE; Data Bits: 8; Parity: NONE; Stop Bits: 1 (see Figure 31).

3. Go to "Com Test" tab.
4. Check the box in the "RSSI" section to enable its display (Figure 32).
5. Choose the "Loop Back" option in the "Com Direction" section (Figure 32).
6. Click the "Start" button to begin the range test (Figure 32).
7. Monitor the signal strength indicator quality of sent/received data. If necessary move antennas (re-align, height, position) for better signal strength.

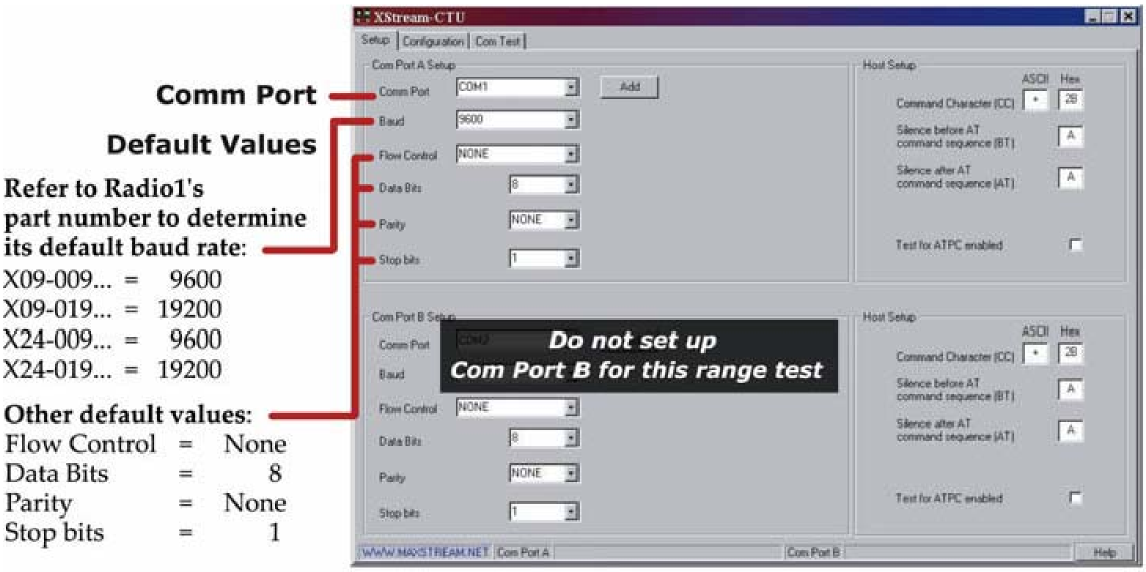


Figure 31: Configuration COM port of PC.

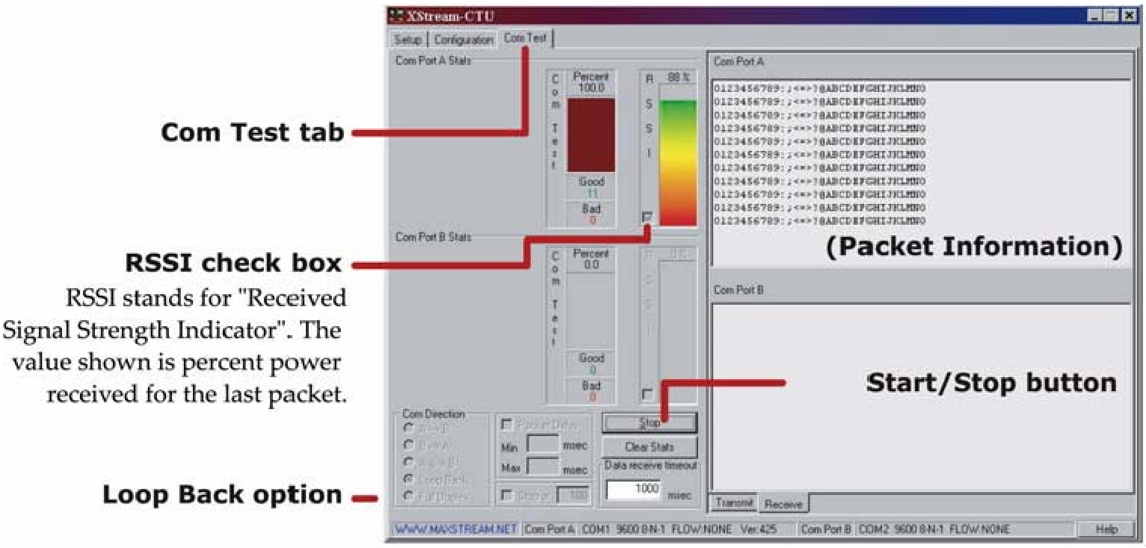


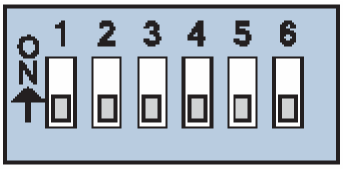
Figure 32: Communication test of RF telemetry link.

Important: This radio equipment is approved only for mobile and base station transmitting devices, separation distances of (i) 20 centimeters or more for antennas with gains < 6 dBi or (ii) 2 meters or more for antennas with gains ≥ 6 dBi should be maintained between the antenna of this device and nearby persons during operation. To ensure compliance, operation at distances closer than this is not recommended.

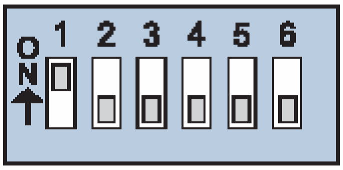
APPENDIX 2 – DIP SWITCH SETTINGS RF MODEM

1. DIP Switches RF Modem

RS-485 operation (for communication with COMBILOG data loggers using RS-485 interface cable):
(2-Wire half duplex)



RS-232 operation (for communication with PC using RS-232 interface cable):



2. Advanced RF Modem configuration

While XStream-PKG-R RF modems operate out-of-box without configuration, you can use the supplied Xstream-CTU configuration software to change the parameter settings of the RF modems (default settings RF modem, see Figure 33) such as:

- Changing Interface baud rates
- Advanced addressing capabilities, such as DT and HP (see below)
- etc

In case two or more **LAS-RET** stations are operational within several kilometres and the user(s) experience communication problems, the following settings can be modified:

- Module Address (DT): Used to set the Module Address of the module. Only modules with the same Module Address can communicate.

- Network Number (HP): Adjusting the network number allows the module to hop on a different hopping sequence. This allows independent networks of modules to operate in the same vicinity.

⚠ **Important:** Be sure that data loggers that have to communicate with each other have the same Module Address (DT) and same Network number (HP)!

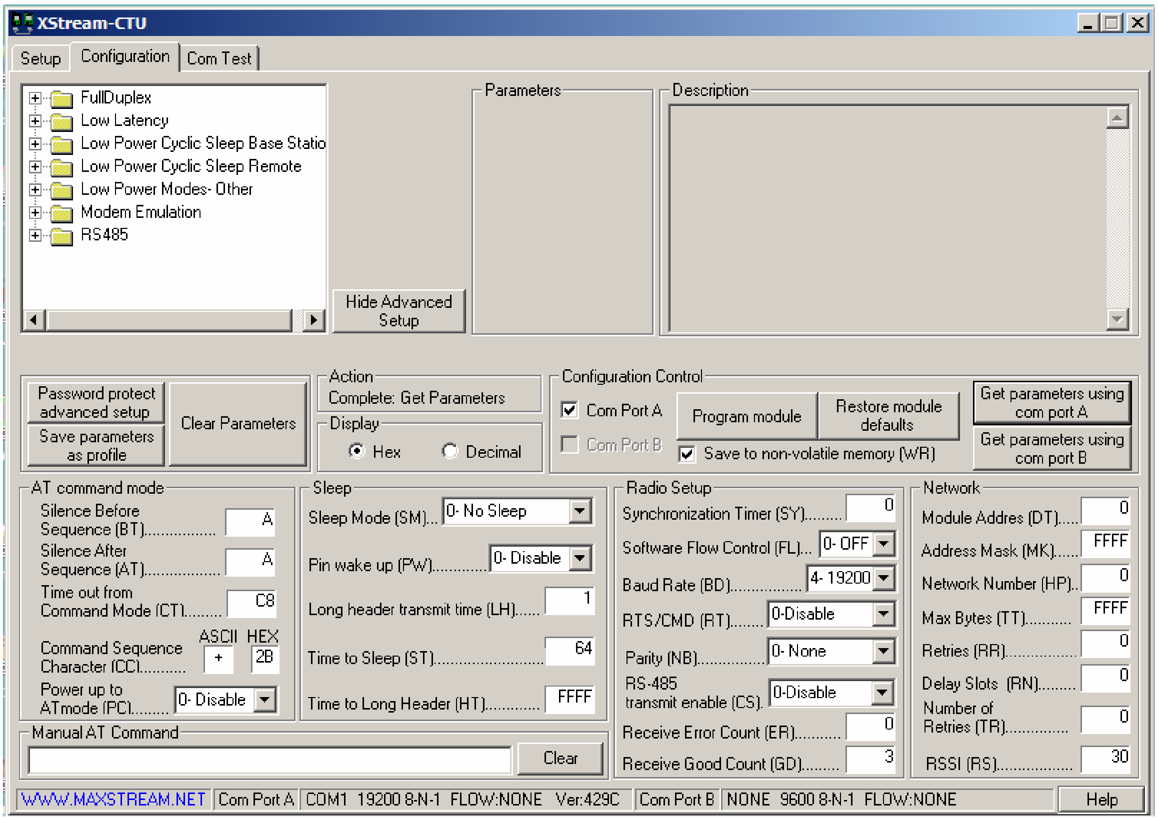


Figure 33: Configuration screen and default settings of supplied RF modems.

APPENDIX 3 – MOUNTING ANTENNAS

Warning: Do not install antennas near power lines. Serious electrocution hazard exists. You can be killed!

The supplied antenna for the radio modem at the **LAS** receiver side is a 16 dBi Vagi-type (2.4 GHz system) directional antenna, specifically designed to transmit in one particular direction allowing long range applications. The antennas can be mounted horizontally (horizontal polarization) or vertically (vertical polarization) (see Figure 34). To have radio communication both antennas must have the same polarization (in general vertically)!

Figure 34: Vagi in horizontal polarization (left) and in vertical polarization (right).

The antennas come with a standard N-female connector and can be connected to one end of the supplied 5 m antenna cable (N-male at both sides). The other end has to be connected to the gas discharge surge protector (N-female to N-female). The surge protector is an integral part of the antenna installation to protect the radio modem from surges caused by lightning. The surge protector has the ability to withstand multiple lightning strikes. Finally, using the N-male to RSPMA-male adapter the RF modem can be connected. Note that due to power loss the antenna cable cannot be extended to any desired length (use special coaxial 50 Ohm antenna cable with excellent electrical and mechanical properties).

To mount the antenna at the **LAS** receiver side a universal antenna mounting system is supplied. This mounting system allows the user a large variety of installation options for many different sites.

Important: During assembly and mounting avoid impact to antenna elements. Element breakage could occur!

In order to have a reliable RF communication link it is highly recommended to consider the following issues:

- The line-of-sight RF communication path must be clear of obstructions. For example buildings and trees will decrease the communication range. If the antenna's are mounted too close to the ground too much of the Freznel zone will be obstructed by the earth (see Figure 35 and Table 5). To avoid this problem the antennas should be mounted high enough of the ground. As the RF link is longer (> 1km) these aforementioned issues become more important. We recommend to use a LAS – weather station set-up according to Figure 3, where the LAS is installed at a higher level than the weather station, creating an ideal RF communication link with low interference of ground on the Freznel zone.
- The supplied antennas are 16 dBi directional antennas specially designed for long-range applications. Directional antennas in line-of-sight set-ups must be precisely aimed (aligned) and properly fixed to avoid communication problems during strong winds and the presence of birds.

- It is NOT recommend placing the antennas near commercial transmitters as their powerful signal can overwhelm the signal to communication problems! Low power emitters and receivers may not be a problem.
- Do not mount the antennas near large metal objects. When metallic objects are to close to the antenna it has the potential to interfere with the way the antenna radiates and may cause undesirable results.
- The **LAS-RET** is supplied with 2 high performance antenna cables of 5 m each. Do not extend the cables as they reduce the performance of the RF link (instead extend the RS-485 cables).
- Avoid rain inside the antenna connectors. Use self-amalgamating tape to waterproof all connectors.

It is highly recommended to first test the RF link before installing the **LAS** / **XLAS** and weather station!

Important: This radio equipment is approved only for mobile and base station transmitting devices, separation distances of ([1]) 20 centimeters or more for antennas with gains < 6 dBi or ([2]) 2 meters or more for antennas with gains ≥ 6 dBi should be maintained between the antenna of this device and nearby persons during operation. To ensure compliance, operation at distances closer than this is not recommended.

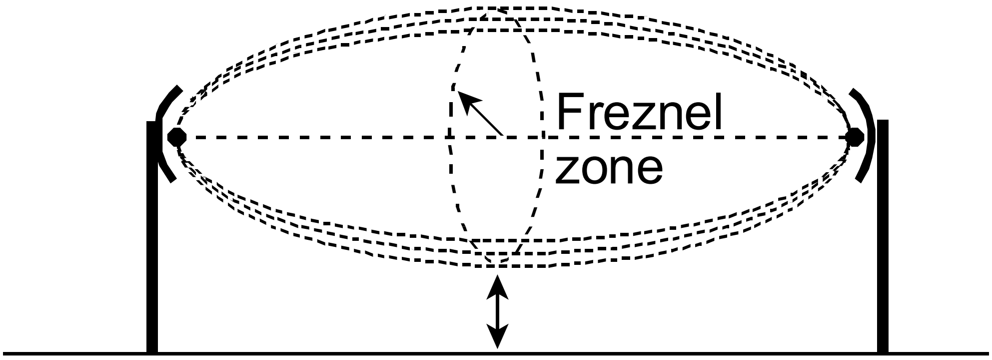


Figure 35: Shape of the Freznel zone between the antennas of the RF modems. The size of the Freznel zone is determined by the path length and the frequency of the RF modems. The interference of the ground with the central diameter of the Freznel zone must be small!

Table 5: Freznel zone diameters ($F = \sqrt{\lambda L}$, where F = Freznel zone, *L* = path length [m] and λ = wavelength [m], $\lambda = \frac{c}{f}$, where *c* = speed of sound [3×10^8 m s^{-1}], *f* = frequency [Hz])

Distance	Diameter Freznel zone (2.4 GHz RF modems)
300 m	5.4 m
1.6 km	8.4 m
8 km	15.2 m

APPENDIX 4 – SERIAL PORT CONNECTIONS

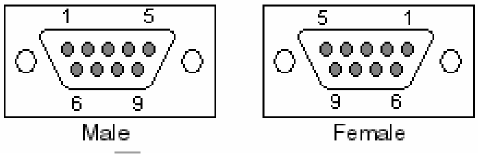


Figure 36: Standard RS-232 (DB-9) DCE connector and pin numbering.

1. **Computer ↔ COMBILOG**

Computer (DB-9 Female)	COMBILOG
Pin 3	RX (RS-232 Receive)
Pin 2	TX (RS-232 Transmit)
Pin 5	Com (RS-232 Common)

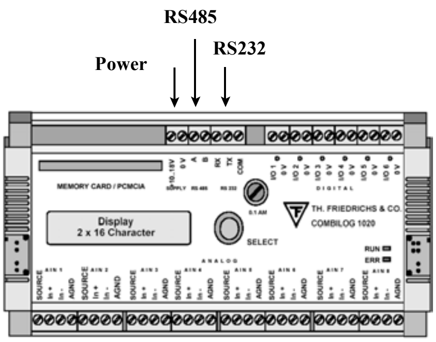
2. **Computer ↔ RF Modem** (modem in RS-232 configuration)

Computer (DB-9 Female)	RF Modem (DB-9 Male)
Pin 1	Pin 1
Pin 2	Pin 2
Pin 3	Pin 3
Pin 4	Pin 4
Pin 5	Pin 5
Pin 6	Pin 6
Pin 7	Pin 7
Pin 8	Pin 8
Pin 9	Pin 9

Use the included standard RS-232 cable that comes with the RF Modems.

3. **RF Modem** (modem in RS-485 2-wire half duplex configuration) ↔ **COMBILOG**

RF Modem (DB-9 Male)	COMBILOG
Pin 2	A (RS-485)
Pin 8	B (RS-485)



APPENDIX 5 – INSTALLATION FORM

Important: It is highly recommend to fill this form immediately after the installation of the **LAS-**system, as most of these parameters are required for the EVATION data processing software!

Date: …………………… [Year/Month/Day]

Installed by: ……………………

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

1. Weather station/sensors

Sensor	S/N	COMBILOG Channel [no]	Height/ depth [m]	Orientation [°]

GPS coordinates weather station: ……………………………….. [Latitude, °]
……………………………….. [Longitude, °]
……………………………….. [Elevation, m]

Height antenna in mast: ……………………………….. [m]

Mean vegetation height around weather station: ……………………………….. [m]

2. LAS/XLAS

Serial number LAS/XLAS:	……………………
GPS coordinates LAS-Transmitter:	…………………… [Latitude, °] …………………… [Longitude, °] …………………… [Height, m] ([10]) …………………… [Elevation, m] ([11])
"Current adjust" knob Transmitter:	…………………… [-]
Mean vegetation height at LAS-Transmitter site:	…………………… [m]
GPS coordinates LAS-Receiver:	…………………… [Latitude, °] …………………… [Longitude, °] …………………… [Height, m] ([8]) …………………… [Elevation, m] ([9])
Average signal strength Receiver (acc. to analogue meter): Short range/Long range knob set to: Mean signal strength at Receiver (U_{DEMOD}):	…………………… [-] short / long …………………… [mV]
"Path length" Potentiometer setting Receiver ($Pot_{LAS/XLAS}$): This corresponds to a distance of: (See LAS Instruction Manual section 3.8 for conversion units to meters)	…………………… [-] …………………… [m]
Exact path length (according to a GPS or map):	…………………… [m]
Distance LAS-Receiver to Weather station: = Path length RF Telemetry link (according to a GPS or map)	…………………… [m]
Height antenna at LAS-Receiver site:	…………………… [m]
Mean vegetation height at LAS-Receiver site:	…………………… [m]

[10] Height of LAS above the ground

[11] Height of the area above sea level (this information can be obtained from maps)

3. Effective height LAS / XLAS

The accuracy of the fluxes of sensible heat and evaporation depends strongly on the mean height of the **LAS** 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 very complex (such as shown in Figure 37) it becomes more difficult to determine the ***effective*** height of the **LAS** / **XLAS**. The EVATION software has a special tool that helps the user to determine the effective height ("*Effective height calculator*"). The "effective height calculator" needs the following input data: transmitter installation height, receiver installation height, the elevation of the transmitter and receiver site, and the elevation plus position of a number of points along the optical path of the **LAS** (i.e. EVATION needs a cross section of the **LAS** setup over the area). By entering this information in the "Effective height calculator" the software gives you the effective height of the **LAS**, which finally will be used in the actual data processing to fluxes. An example is shown in Table 6 and Figure 37. You can use the table below for collecting a number of points to determine the effective height of your **LAS** setup.

	Distance to reference [m]	Elevation [m]
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		

Table 6: Example of the cross section of a LAS set-up. These data points are used in EVATION to determine the effective height of the LAS (see Figure 37).

	Elevation in respect to reference[1] [m]	Distance from reference [m]	Height of LAS in respect to surface [m]
Transmitter site (here taken as reference) = **TX**	0	0	50[2]
Int. point 1	0	500	
Int. point 2	3	750	
Int. point 3	7.5	1000	
Int. point 4	7.5	2300	
Int. point 5	20	3000	
Int. point 6	20	3500	
Int. point 7	18	3700	
Int. point 8	18	4000	
Int. point 9	25	4500	
Receiver site = **RX**	36	4700[3]	30[4]

[1] Can be negative values with respect to the reference point
[2] Installation height transmitter unit
[3] Path length **LAS** / **XLAS**
[4] Installation height receiver unit

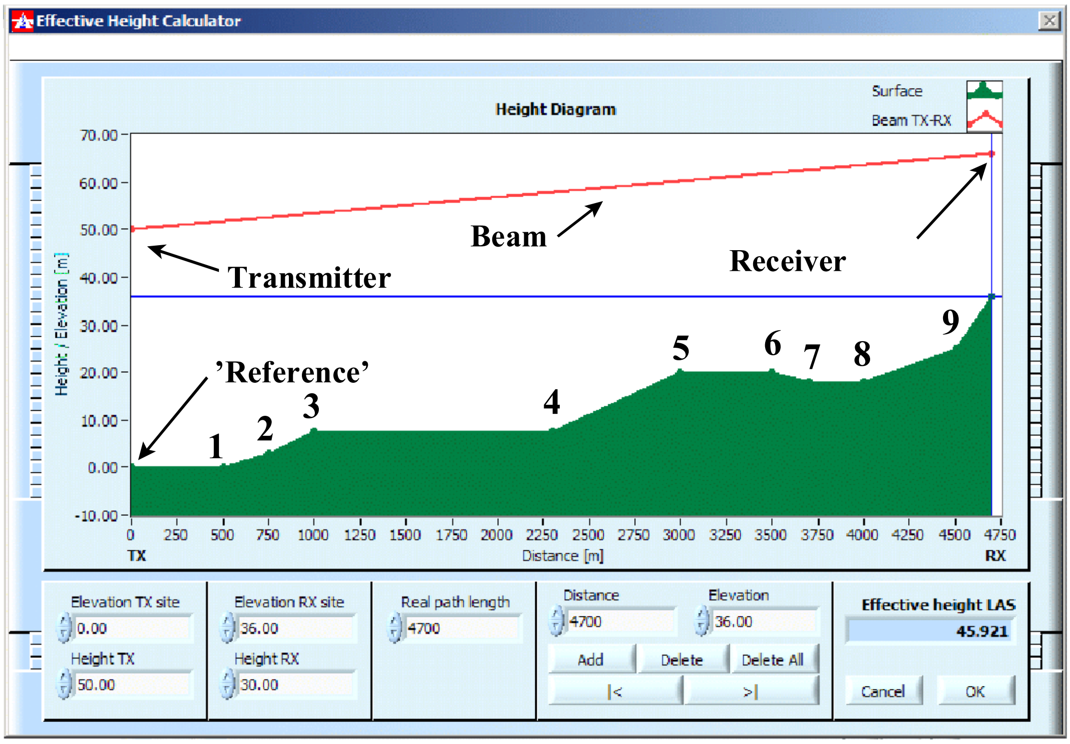


Figure 37: Determination of effective LAS height based the LAS set-up and cross section of the area.

APPENDIX 6 – INSPECTION PROCEDURE

Every time one visits the weather station and the **LAS** (preferably at a 2 week interval) it is recommended to follow the inspection procedure given here:

1. Check the power supply of the weather station (Solar panel and battery)

   Check if the green LED labelled "RUN" of 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.

   In case the COMBILOG is NOT responding check the power supply. First, check the LED information of the solar controller (see error messages (left LED 1, Table 7) and state of charge battery (right LED 2, Table 8)).

Table 7: Status and color left LED 1 of Solar Controller (error messages).

LED 1	Status	Load	Action
Green flashing	All OK	-	No reset
Red-green flashing	Load current is too high	Disconnected	Switch of or disconnected users, remove error, reconnect users
Red-yellow flashing	Module current is too high	Disconnected	Automatically, when over current does no longer exist
Constant red	Controller is over heated (> 85°C)	Disconnected	Automatically, when temperature has decreased
Yellow flashing	Battery voltage is too high (> 15 VDC)	Disconnected	Automatically, when voltage has fallen
Red flashing	Battery voltage is too low (< 10.5 VDC)	Disconnected	Automatically, when voltage is increased again

Table 8: Status and color of right LED 2 of Solar Controller (SOC).

LED 2	Level	State Of Charge battery (SOC)	Comments
Green	1	100 % (battery full)	-
	2	90 %	-
	3	80%	-
	4	70 %	-
	5	60 %	-
Yellow	6	50 %	-
	7	40 %	Pre-Warning: load is about to be disconnected (LED 2 is fast flashing)
	8	30 %	Load is disconnected (SOC < 30 %) Load will be connected again when SOC = 50%)
	9	20%	-
Red	10	0% (battery empty)	-

In case the solar controller is operational, the battery is in good condition (SOC > 50 %) and the load is connected, but the data logger and sensors are not functioning check the fuse located at the overvoltage protection unit (see Figure 38, location 1).

When the solar controller is not operational (all LED's are switched off) check the fuses located in front of the solar controller and the fuse located at the plus pole of the battery (see Figure 38, location 2 and 3).

Check the wiring both inside and outside the enclosure when fuses are broken. Finally, replace the fuses by new ones.

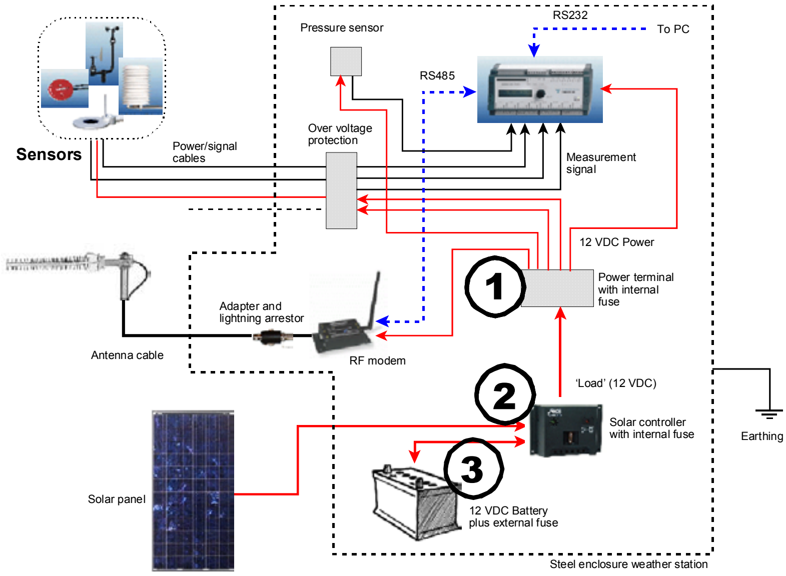


Figure 38: Location of fuses in enclosure of LAS-RET (1: Power terminal; 2: Solar controler; 3: Battery).

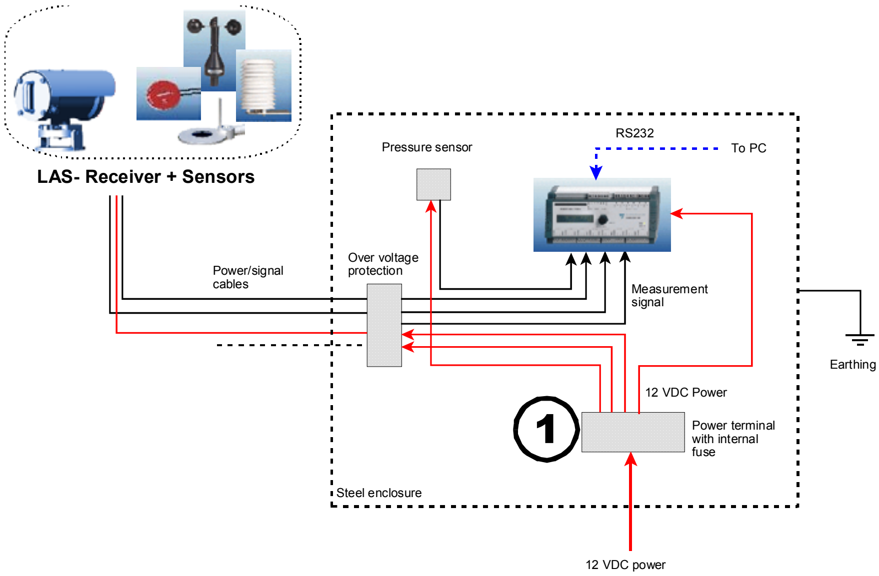


Figure 39: Location of fuses in enclosure of LAS-BET (1: Power terminal).

2. Check data logger date and time

   To change data/time see APPENDIX 7 – SETTING DATE / TIME COMBILOG for instructions or the COMBILOG instruction manual.

3. Check sensor output

   When all sensors of the weather station are operational the red LED “ERR” of the COMBILOG is switched OFF. In case one of sensors of the weather station is malfunctioning the red LED is ON. The output of each channel can be visualized on the display of the COMBILOG using the "SELECT" press/rotary knob on the data logger. **Table 4 shows a typical range for each sensor of the LAS-system.** Check if the output of the sensor lies within the given range.

If one of the station's sensors is defect or malfunctioning the value **–9999** is shown on the display. This applies for every sensor except for the wind speed sensor. In case this sensor is malfunctioning 0 m s^{-1} is displayed. Since 0 m s^{-1} can occur the LED "ERR" will not respond. Therefore, check the wind speed on the display and verify this by looking at the rotations of the sensor itself. If one of the **LAS** channels shows **–9999** check the **LAS** (see step 8). If the **LAS** channels show '***no answer***' check the RF telemetry link (see step 4).

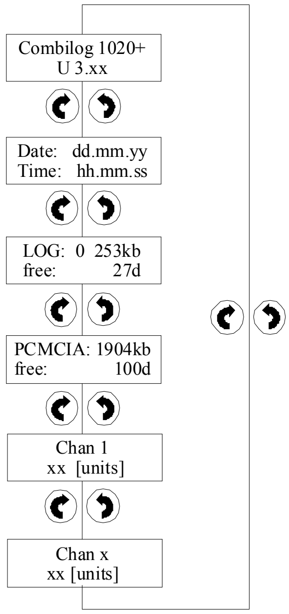


Figure 40: Main menu of COMBILOG, includes the actual sensor output of all sensors (see Chan. 1 to Chan. ×). Description symbols:

↻ .... Turn knob clockwise

↺ .... Turn knob counter clockwise

Note: For **LAS-RET** customers who are using the RF telemetry link: the LED "ERR" does not apply to the **LAS** / **XLAS**! Always check the **LAS** / **XLAS** signals manually by inspecting the demod and C_n^2 values on the display (or on site).

4. Check the RF telemetry link and RF modems

Check if the RF modem is operational by looking at the LED indicators at the front side of the modem (Table 9).

Table 9: Status and LED indicators RF modem.

LED's	Good radio communication	Failing radio communication	RF modem off
Yellow (serial data out)	Flashing	Off	Off
Green (serial data in)	Flashing	Off	Off
Red (power/TX indicator)	On/Flashing	On	Off

The RF telemetry link can also be verified by looking at the **LAS** / **XLAS** channels on the display of the COMBILOG. If the **LAS** channels say ‘***no answer***’ the RF link is not working. If this is case check:

- The connectors and antenna cables (also at **LAS** receiver site). Verify that all connectors have no water leakages (if necessary use ‘self-amalgamating’ tape to make the connectors waterproof) and check the condition of the antenna cables (damages).
- Check the condition and orientation of the antennas. **Note that the antennas are directional antennas, which means that a slight miss-alignment of the antenna can lead to communication failure!**
- Intensive rainfall, fog or high objects (trees, in particularly when the leaves are wet), commercial communication towers can also disturb the communication link.
- Check the power source of the RF-modem. No power means no RF-communication. In necessary replace broken fuses (and solve short-circuit problems) (see Figure 38).

5. Clean sensors, check signal/power cables and connectors

   Check the physical condition of all sensors to prevent malfunctioning (radiation sensor, wind direction, wind speed, air temperature, relative humidity). If necessary, clean sensors and remove any dirt (e.g. dust, spider webs and droppings). Check the condition of all cables and wires (also inside the stainless steel housing), including the various connections (over voltage protection and data logger. Finally check the leveling of the radiation sensor and the mast (see next step).

6. Check the condition of the tower, guys, spanner and anchoring

Important: The wire tension has to be moderate and equal. By no means bending forces are allowed to be applied to the mast!

Important: It is very important to check the anchoring for correct and tight position, frequently. Especially after high wind speeds occurred. If the soil seems not to be tight enough to keep the loads, the anchoring has to be replaced by concrete foundations. If the load lengthens the wires, their length has to be readjusted. The wire condition has to be checked frequently. Damaged wires have to be replaced at once!

7. Download the data from the COMBILOG: a) replace the PCMCIA Flash Card b) connect a computer to the RS-232 interface of the COMBILOG.

   a) For replacing the PCMCIA Flash Card proceed as follows:

   - Remove the ‘full’ PCMCIA card from the COMBILOG
   - Insert the new PCMCIA card in the COMBILOG

   When the display shows: “***FLASH card not empty***”
   - Rotate the press/rotary knob on the data logger, “***FLASH card: Append data?***” or “***FLASH card: Delete Card?***” will appear. Select “***FLASH Card: Delete card?***” and press the knob briefly to confirm, the FLASH card will be deleted and new data (plus header) will be stored in the empty FLASH card (this will take about 16 seconds).

   When nothing happens:
   - First, enable the press/rotary knob of the data logger.

For safety reasons the press/rotary knob of the data logger is disabled (automatically done by the COMBILOG data logger), meaning that part of the configuration menu cannot be accessed. In order to enable this knob, go to "**COMBILOG 1020+**" of the main menu by rotating the press/rotary knob. Press the knob briefly. The configuration menu will be accessed. Rotate the knob until "**Input disabled**" appears on the display. Again press the knob briefly. Rotate the knob again until "**Input < enable >**" appears and press the knob briefly. The knob is now enabled to modify all settings of the data logger manually. Go back to the main menu, by pressing the knob for about 1 second, you will return to the main menu ("**COMBILOG 1020+**" appears). Note that the knob will be disabled again after 30 seconds if no operations are performed on the knob.

- Second, delete the FLASH card.

  Go to "**PCMCIA: ……. kb; free: ……. d**" of the main menu by rotating the press/rotary knob. Press the knob briefly. On the display appears "Flash Card delete?". Press the knob briefly to confirm. The FLASH card will be deleted and new data (plus header) will be stored in the empty FLASH card (this will take about 16 seconds).

- To read the 'full' PCMCIA Flash using a computer. Go to 4.3.2 Reading PCMCIA Flash Memory Cards.

b) Downloading data via RS-232 interface:

When using PCMCIA Flash Cards this option CANNOT be used!

- Connect the PC to the RS-232 interface of the COMBILOG.
- Start the COMBILOG support software.
- Scan for available COMBILOG data loggers.
- Click on *Utilities* → *Read Logger* and follow instructions.

8. Check the **LAS** / **XLAS**

First check the output of the **LAS** signals (i.e. C_n^2 signal (= Cn2 or PUCn21000) and signal strength (= Demod or U_{DEMOD}) on the display of the COMBILOG (see step 3) at the weather station.

a) The display shows '***no answer***':

This message indicates that either the power supply of the RF modem is broken down or the problem lies in the RF communication link. Check the following:

- The connectors and antenna cables (at both sites). Verify that all connectors have no water leakages (if necessary use 'self-amalgamating' tape to make the connectors waterproof) and the status of the cables.
- Check the condition, direction and orientation of the antennas. **Note that the antennas are directional antennas, which means that a slight miss-alignment of the antenna leads to RF communication failure!**
- Intensive rainfall, fog or high objects (trees, in particularly when the leaves are wet), commercial communication towers can also disturb the communication link. Verify whether the RF links is operational during clear sky conditions.
- Check the power source of the RF-modem. No power means no RF-communication. In necessary replace broken fuses (and solve short-circuit problems) (see Figure 38).

b) The display shows **–9999**:

This means that the power supply of the RF modem is working fine. The problem is likely related to power source or signal strength problems of the **LAS** / **XLAS**. Proceed as follows:

- Check the power source of the transmitter, the status of the transmitter unit (see “power” LED) and the current through the LED (via current adjust knob and BNC socket). For further information see the **LAS** instruction manual.
- Check the power source of the receiver and the status of the receiver unit (see “power” LED). Perform a calibration check of the electronics. For further information see the **LAS** instruction manual.
- Check the windows of both the transmitter and receiver unit. Dust, water droplets and icing on the windows lead to signal attenuation. Regularly clean the windows and if necessary turn the window heater on.
- Check the transmitter and receiver units for water leakage and internal condensation on the lenses and windows, as this can also lead to signal attenuation (and even corrosions of the electronics!). Although the housing of the both the transmitter and receiver unit are sealed with O-rings (plus silicagel packages and RH-indicator), improper closure of the back panel and a loose cable plug can lead to water leakage and as a result to internal condensation problems. If necessary replace the silicagel packages by new ones (see RH-indicator on rear window). See **LAS** manual for further information.
- The alignment of the **LAS** (for further instructions see section 3.7 of the **LAS** / **XLAS** instruction manual). An unstable mounting construction for the **LAS** can regularly lead to a misalignment of the **LAS**.

c) The display shows **realistic values**:

This indicates that the **LAS** is working fine. Check if the signal strength (= Demod or U_{demod}) is stable and similar to the value when the LAS was installed and optically aligned. In theory the signal strength should be stable. Except during conditions of rain, fog, or low visibility the signal can drop to zero. In case the visibility conditions are good but the signal strength has dropped significantly, check the following:

- Check the windows of both the transmitter and receiver unit. Dust, water droplets and icing on the windows lead to signal attenuation. Regularly clean the windows and if necessary switch the window heater on.
- Check the transmitter and receiver units for water leakage and internal condensation on the lenses and windows, as this can also lead to signal attenuation (and even corrosions of the electronics). Although the housing of the both the transmitter and receiver unit are sealed with O-rings (plus silicagel packages and RH-indicator), improper closure of the back panel and a loose cable plug can lead to water leakage and as a result to internal condensation. If necessary replace the silicagel packages by new ones (see RH-indicator on rear window). See **LAS** manual for further information.
- The alignment of the LAS (for further instructions see section 3.7 of the **LAS** / **XLAS** instruction manual). An unstable mounting construction for the **LAS** can regularly lead to a misalignment of the **LAS**.

APPENDIX 7 – SETTING DATE / TIME COMBILOG

There are two ways to change the date/time of the COMBILOG data logger. First, by using the COMBLOG support software. Second, manually using the press/rotary knob on the COMBILOG data logger.

1. Automatically using the COMBILOG support software

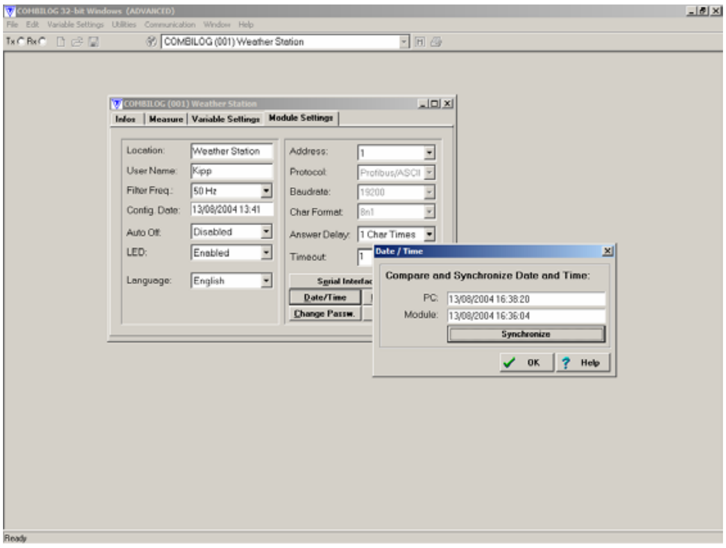


Figure 41: Synchronize date/time of the COMBILOG data logger using the PC date/time.

First check the PC date and time before synchronizing the data logger data and time.

2. Manually using press/rotary knob

The press/rotary knob on the data logger allows the user to modify the settings of the data logger manually. By turning/pressing the knob the several menu items can be selected in order to modify the COMBILOG settings, such data/time, scan interval etc.

The following symbols are used for the operations:

↻	….	Turn knob clockwise
↺	….	Turn knob counter clockwise
✓	….	Press knob briefly (confirmation)
×	….	Press knob for approximately 1-second minimum (abortion)

The instructions below plus details are also found in the COMBILOG instruction manual.

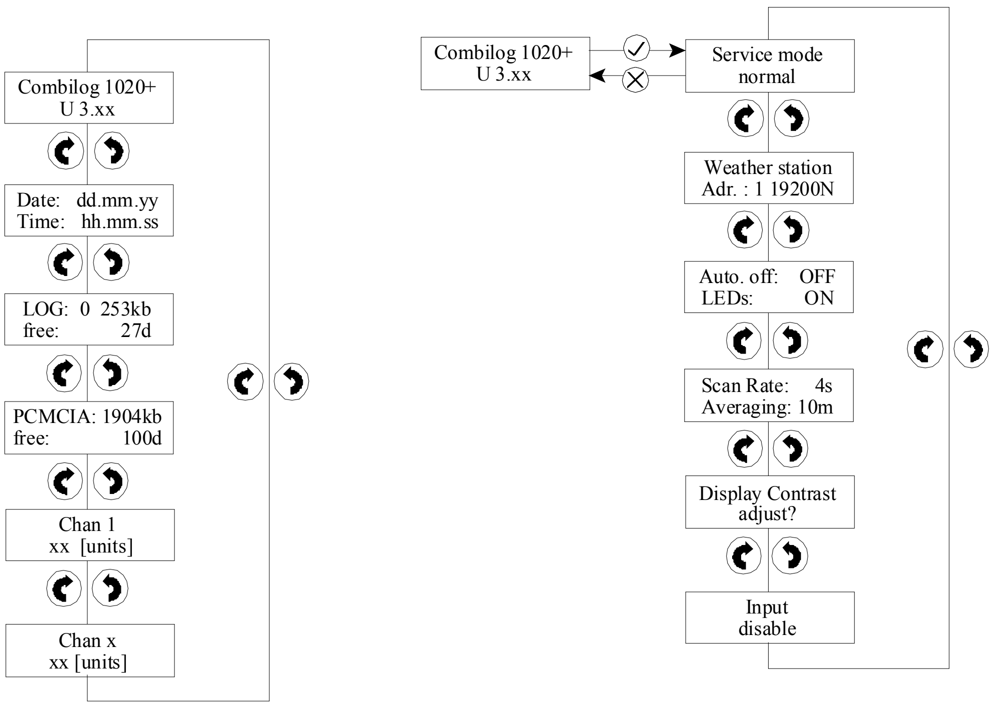


Figure 42: Main menu (left) and Configuration menu (right) of COMBILOG data logger.

Step 1: Enable the press/rotary knob of the data logger

For safety reasons the press/rotary knob of the dat alogger is disabled (automatically done by the COMBILOG data logger), meaning that part of the configuration menu cannot be accessed. In order to enable this knob, go to "***COMBILOG 1020+***" of the main menu by rotating the press/rotary knob. Press the knob briefly. The configuration menu will be accessed. Rotate the knob until "***Input disabled***" appears on the display (see Figure 42). Again press the knob briefly. Rotate the knob again until "***Input < enable >***" appears and press the knob briefly. The knob is now enabled to modify all settings of the data logger manually. Go back to the main menu, by pressing the knob for about 1 second, you will return to the main menu ("***COMBILOG 1020+***" appears).

Note that the knob will be disabled again after 30 seconds if no operations are performed on the knob.

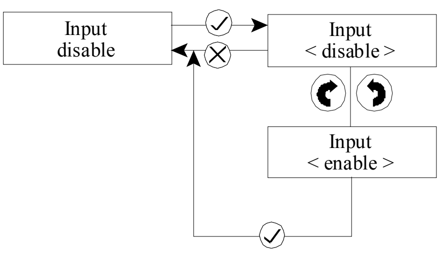


Figure 43: Lock/Unlock of the press/rotary knob of the COMBILOG data logger.

Step 2: Setting of date / time

Go to "***Date: YY.MM.DD / Time: HH.MM.SS***" in the main menu and press the knob briefly. Select between "***Set Date***" and "***Set Time***" (rotate knob). By pressing the knob briefly the date/time can be changed. Once the date/time is correct, press the knob briefly to confirm.

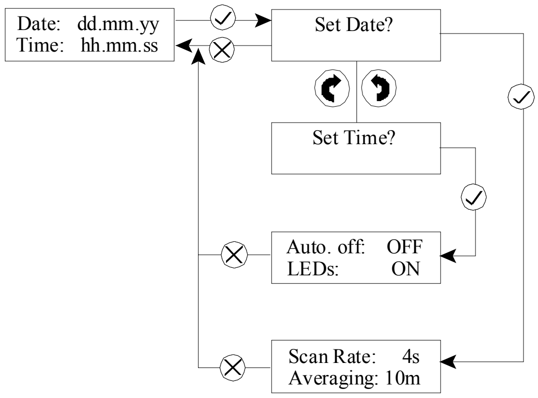


Figure 44: Setting of date and time of COMBILOG data logger.

APPENDIX 8 – FORMAT PCMCIA FLASH MEMORY CARDS

To format a Flash Memory Card for COMBILOG data loggers follow the following steps:

1. Insert the PCMCIA flash memory card into your card reader.
2. Start CardWare software (PCCard Control).
3. Go to taskbar *Cards* and click on *Open MCView* Main Window.

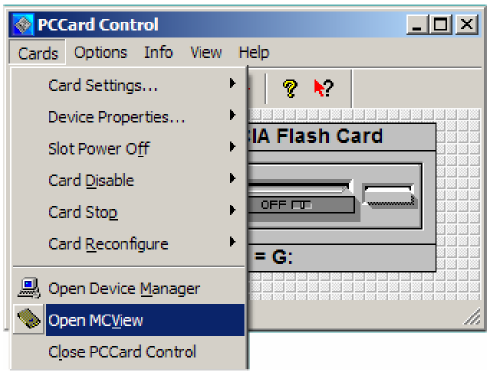


Figure 45: The memory Cards Viewer MCView is a control utility that enables special memory card operations to format Flash Memory Cards for usage in the COMBILOG.

4. Select *Erase Card* from the *Raw Access* menu.
5. After the card has been erased, write the predefined image data to the card using the Write Raw Data function (Go to *Raw Access* menu and select *Write Raw Data*…). The image files are available on the installation CD (sub directory *image files*) and are named accordingly to the size of the card (i.e. select the 2 Mb).
6. After writing the image, the file "*00000001.FIL*" is available on the file list. This file should be renamed to "*COMBILOG.LOG*", before the card is used with the COMBILOG data logger. (Click the right mouse button to the file name and choose *Rename*).

⚠ **Important:** The function *Card Stop* (see Figure 45) or *Eject Card* (via Open MCView, see Figure 46) should be used to eject/unplug the card before removing the card from the device/computer!

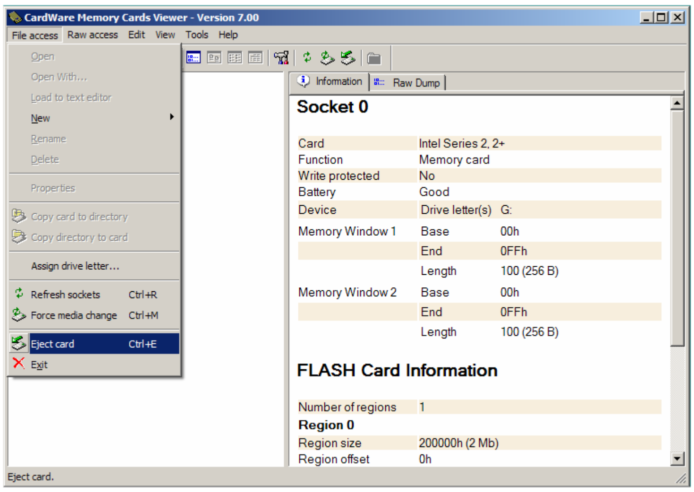


Figure 46: Eject/unplug the PCMCIA flash card from your computer via MCView window.

APPENDIX 9 – CONNECTION PLAN LAS-BET & LAS-RET

Overvoltage protection				COMBILOG Datalogger			
Sensor	Color wire	Channel number		Channel number	Channel	Power Terminal	
1 Wind speed (4035.0000X)	Yellow	1	→	Digital (Freq.)	I/O1		
	Green	2	→	Digital (Sig. Ground)	0V		
	Grey	3	→			+12VDC, ~0.6 A	Power for heater wind speed sensor
	White	4	→			+12VDC, ~2 mA	Power for wind speed sensor
	Pink	5	→			Ground	Power for heater of wind speed sensor
	Brown	6	→			Ground	Power for wind speed sensor
2 Kipp&Zonen NRLite	White	7	→	AIN2	In+		
	Green	8	→	AIN2	In-		
	Transparent	9	→	AIN2	AGND		
3 Kipp&Zonen LAS or XLAS	Brown	10	→	AIN3	In+		
	Green	11	→	AIN3	In-	1	
	Orange	12	→	ANI4	In+		
	x			ANI4	In-	1	
	Violet	13	→			+12VDC, ~0.2 A	Power for sensor
	Blue	14	→			Ground	Power for sensor
	White	15	→			+12VDC, ~3 A	Power for window Heater
	Grey	16	→			Ground	Power for window Heater
4 Temperature (2030.0000X)	White	17	→	AIN5	Source		
	Brown	18	→	AIN5	In+		
	Green	19	→	AIN5	In-		
Upper sensor	Yellow	20	→	AIN5	AGND		
5 Temperature (2030.0000X)	White	21	→	AIN6	Source		
	Brown	22	→	AIN6	In+		
	Green	23	→	AIN6	In-		
Lower sensor	Yellow	24	→	AIN6	AGND		
6 Heat Flux Plate 1 (2016.0000)	White	25	→	AIN7	In+		
	Green	26	→	AIN7	In-		
7 Heat Flux Plate 2 (2016.0000)	White	27	→	AIN8	In+		
	Green	28	→	AIN8	In-		
8 Air pressure (5004.0000X)	Yellow		→	AIN1	In+		
	Green		→	AIN1	AGND		
	Red		→			+12VDC, ~10 mA	Power for sensor
	Blue		→			Ground	Power for sensor

Total power requirements (12 VDC/~4 W), (12 VDC/~50 W heated)

[1] Must be connected (use common signal ground)

Figure 47: Connection plan LAS-BET system.

	Overvoltage protection			COMBILOG Datalogger			
	Sensor	Color wire	Channel number	Channel number	Channel	Power Terminal	
1	Wind speed	Yellow	1	Digital (Freq.)	I/O1		
	(4035.0000X)	Green	2	Digital (Sig. Ground)	0V		
		Grey	3			+12VDC, ~0.6 A	Power for heater wind speed sensor
		White	4			+12VDC, ~2 mA	Power for wind speed sensor
		Pink	5			Ground	Power for heater of wind speed sensor
		Brown	6			Ground	Power for wind speed sensor
2	Wind direction	Yellow	7	Digital (Freq.)	I/O2		
	(4123.0000X)	Green	8	Digital (Sig. Ground)	0V		
		Grey	9			+12VDC, ~0.6 A	Power for heater wind direction sensor
		White	10			+12VDC, ~2 mA	Power for wind direction sensor
		Pink	11			Ground	Power for heater of wind direction sensor
		Brown	12			Ground	Power for wind direction sensor
3	Temperature	White	13	AIN1	Source		
	(2030.0000X)	Brown	14	AIN1	In+		
		Green	15	AIN1	In-		
	Upper sensor	Yellow	16	AIN1	AGND		
4	Temperature	White	17	AIN2	Source		
	(2030.0000X)	Brown	18	AIN2	In+		
		Green	19	AIN2	In-		
	Lower sensor	Yellow	20	AIN2	AGND		
5	Heat Flux Plate 1	White	21	AIN4	In+		
	(2016.0000)	Green	22	AIN4	In-		
		Shield	23	AIN4	AGND		
6	Heat Flux Plate 2	White	24	AIN5	In+		
	(2016.0000)	Green	25	AIN5	In-		
		Shield	26	AIN5	AGND		
7	Kipp&Zonen NRLite	White	27	AIN6	In+		
		Green	28	AIN6	In-		
		Transparent	29	AIN6	AGND		
	Spare		30				
	Spare		31				
	Spare		32				
	Spare		33				
	Spare		34				
	Spare		35				
	Spare		36				
8	Air pressure	Yellow		AIN3	In+		
	(5004.0000X)	Green		AIN3	AGND		
		Red				+12VDC, ~10 mA	Power for sensor
		Blue				Ground	Power for sensor
Power requirements		Sensors + Datalogger + Modem: 12 VDC/~6 W, 12 VDC/~20 W (heated)					

Figure 48: Connection plan weather station LAS-RET system.

	Overvoltage protection				COMBILOG Datalogger			
	Sensor	Color wire	Channel number		Channel number	Channel	Power Terminal	
1	Kipp&Zonen LAS	Brown	1		AIN1	In+		
	or XLAS	Green	2		AIN1	In-	1	
		Orange	3		AIN2	In+		
		x			AIN2	In-	1	
		Violet	4				+12VDC, 0.2 A	Power for sensor
		Blue	5				Ground	Power for sensor
		White	6				+12VDC, ~3 A	Power for window Heater
		Grey	7				Ground	Power for window Heater
		spare	8					
Power requirements		LAS + Datalogger + Modem: 12 VDC/~6W, 12 VDC/~40 W (heated)						

[1] Must be connected (use common signal ground)

Figure 49: Connection plan scintillometer LAS-RET system.

Our customer support remains at your disposal for any maintenance or repair, calibration, supplies and spares.

Für Servicearbeiten und Kalibrierung, Verbrauchsmaterial und Ersatzteile steht Ihnen unsere Customer Support Abteilung zur Verfügung.

Notre service 'Support Clientèle' reste à votre entière disposition pour tout problème de maintenance, réparation ou d'étalonnage ainsi que pour les accessoires et pièces de rechange.

Nuestro apoyo del cliente se queda a su disposición para cualquier mantenimiento o la reparación, la calibración, los suministros y reserva.

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