

CPEC306/310

Closed-Path Eddy-Covariance Systems



Guarantee

This equipment is guaranteed against defects in materials and workmanship. We will repair or replace products which prove to be defective during the guarantee period as detailed on your invoice, provided they are returned to us prepaid. The guarantee will not apply to:

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- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

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About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. primarily for the North American market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area: 1 in² (square inch) = 645 mm²

Length: 1 in. (inch) = 25.4 mm
1 ft (foot) = 304.8 mm
1 yard = 0.914 m
1 mile = 1.609 km

Mass: 1 oz. (ounce) = 28.35 g
1 lb (pound weight) = 0.454 kg

Pressure: 1 psi (lb/in²) = 68.95 mb

Volume: 1 UK pint = 568.3 ml
1 UK gallon = 4.546 litres
1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a “#” symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information



At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.



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Safety

DANGER — MANY HAZARDS ARE ASSOCIATED WITH INSTALLING, USING, MAINTAINING, AND WORKING ON OR AROUND **TRIPODS, TOWERS, AND ANY ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.** FAILURE TO PROPERLY AND COMPLETELY ASSEMBLE, INSTALL, OPERATE, USE, AND MAINTAIN TRIPODS, TOWERS, AND ATTACHMENTS, AND FAILURE TO HEED WARNINGS, INCREASES THE RISK OF DEATH, ACCIDENT, SERIOUS INJURY, PROPERTY DAMAGE, AND PRODUCT FAILURE. TAKE ALL REASONABLE PRECAUTIONS TO AVOID THESE HAZARDS. CHECK WITH YOUR ORGANIZATION'S SAFETY COORDINATOR (OR POLICY) FOR PROCEDURES AND REQUIRED PROTECTIVE EQUIPMENT PRIOR TO PERFORMING ANY WORK.

Use tripods, towers, and attachments to tripods and towers only for purposes for which they are designed. Do not exceed design limits. Be familiar and comply with all instructions provided in product manuals. Manuals are available at www.campbellsci.eu or by telephoning +44(0) 1509 828 888 (UK). You are responsible for conformance with governing codes and regulations, including safety regulations, and the integrity and location of structures or land to which towers, tripods, and any attachments are attached. Installation sites should be evaluated and approved by a qualified engineer. If questions or concerns arise regarding installation, use, or maintenance of tripods, towers, attachments, or electrical connections, consult with a licensed and qualified engineer or electrician.

General

- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations, such as those of the FAA in the USA.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, or 20 feet, or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.

Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

WHILE EVERY ATTEMPT IS MADE TO EMBODY THE HIGHEST DEGREE OF SAFETY IN ALL CAMPBELL SCIENTIFIC PRODUCTS, THE CUSTOMER ASSUMES ALL RISK FROM ANY INJURY RESULTING FROM IMPROPER INSTALLATION, USE, OR MAINTENANCE OF TRIPODS, TOWERS, OR ATTACHMENTS TO TRIPODS AND TOWERS SUCH AS SENSORS, CROSSARMS, ENCLOSURES, ANTENNAS, ETC.

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1. Introduction

The CPEC306 and CPEC310 (denoted as CPEC series from this point forward) are closed-path eddy-covariance (CPEC) flux systems used for long-term monitoring of atmosphere–biosphere exchanges of carbon dioxide, water vapour, heat, and momentum. The series replaces the Campbell Scientific CPEC200, which was a complete turnkey system that included a closed-path gas analyzer (EC155), sonic anemometer head (CSAT3A), data logger (CR6), sample pump, and optional valve module for automated zero and span.

The CPEC series provides users with three options that cater to various eddy-covariance applications. All CPEC systems use a CR6 data logger and the closed-path version of the data logger program *EasyFlux® DL* for automated post-processing flux calculations. All CPEC-series systems also include the latest improvements for compact packaging and mounting, as well as advancements in long-term automated operation. All CPEC-series systems now come with the current vortex intake technology on the EC155 gas analyzer.

The CPEC series is available as two systems:


- CPEC306 – a mid-level, expandable system with pump module
- CPEC310 – an expandable system with pump module and 3-valve zero-and-span module

NOTE:

This manual discusses two separate instrument packages, the CPEC306 and CPEC310, which are each suited to better address a wide variety of user needs. Throughout the manual, when the section being discussed applies to both systems, the systems will be referred to as the CPEC series. Where the manual discusses specifics that are unique to one of the systems, they will be specifically identified as a CPEC306 or CPEC310.

Before using any of the CPEC-series instrument configurations, please study:

- [Precautions](#) (p. 2)
- [Initial inspection](#) (p. 2)
- [Installation](#) (p. 23)

Operational instructions critical to the preservation of the system are found throughout this manual. Before using a CPEC series, please study the entire manual. Further information pertaining to the CPEC series can be found in the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual, available at www.campbellsci.eu 

Other publications that may be helpful include:

- *CR6 Measurement and Control Data Logger* manual
- *CSAT3B Three-Dimensional Sonic Anemometer* manual
- *LoggerNet Data Logger Support Software* manual
- *ENC 10/12, 12/14, 14/16, 16/18 Enclosures* manual
- *CM106B Tripod* manual
- *Tripod Installation Models CM110, CM115, CM120* manual

2. Precautions

General warnings

- Do not connect or disconnect the EC155 gas analyzer head or the CSAT3A sonic anemometer head from the EC100 electronics while the EC100 is powered. Doing so can result in unpredictable performance of the system or damage to the instrument head.
- Ground electrical components in the measurement system—this is critical. Proper earth (chassis) grounding will ensure maximum electrostatic discharge (ESD) protection and higher measurement accuracy.
- Use care when connecting and disconnecting tube fittings to avoid introducing dust or other contaminants.
- Do not overtighten the tube fittings. Consult [Using Swagelok fittings](#) (p. 153) for information on proper connection.
- Design the power source for a CPEC-series system thoughtfully to ensure uninterrupted power. Contact Campbell Scientific for assistance, if needed.
- Retain all spare caps and plugs, as these are required when shipping or storing any CPEC-series system.

3. Initial inspection

Upon receipt of the CPEC-series, inspect the packaging and contents for damage. File any damage claims with the shipping company. Contact Campbell Scientific to facilitate repair or replacement.

Immediately check package contents against shipping documentation. Thoroughly check all packaging material for product that may be trapped inside. Contact Campbell Scientific about any discrepancies. Model numbers are found on each product. On cables, the model number is often found at the connection end of the cable. Check that correct lengths of cables are received.

4. Overview

The CPEC306 and CPEC310 are closely related closed-path eddy-covariance systems, used for long-term monitoring of atmosphere–biosphere exchanges of carbon dioxide, water vapour, heat, and momentum.

Both the CPEC306 and CPEC310 have options for a VOLT 116 that allows for additional sensors for energy balance and meteorological measurements. The CPEC310 is equipped with a 3-valve module to allow automatic zero and span.

The systems come as complete, standalone systems consisting of a Campbell Scientific EC100 electronics module, closed-path gas analyzer (EC155), sonic anemometer (CSAT3A), and sample pump. Systems come wired for a CR6 data logger that can be purchased with the system, or they can be wired by users who already have a CR6 data logger. [CPEC306/310 system components](#) (p. 3) describes the basic components of both systems. [CPEC306](#) (p. 6) and [CPEC310](#) (p. 8) describe the specifics of each system in greater detail.

4.1 CPEC306/310 system components

The following sections describe the components that come standard with any of the CPEC-series systems.

4.1.1 EC100 electronics

The EC100 electronics module ([Figure 4-1](#) [p. 4]) controls the EC155 and CSAT3A. As a standalone enclosure, the EC100 must be mounted within 3.0 m (10.0 ft) of the EC155 and CSAT3A.



Figure 4-1. EC100 electronics module

4.1.2 EC155 gas analyzer


The EC155 is a closed-path infrared CO₂/H₂O gas analyzer. It shares integrated electronics (EC100 electronics) with the CSAT3A sonic anemometer head in CPEC systems. The EC155 includes a patented^{1/} vortex intake, which reduces intake maintenance and has an absolute pressure sensor in the sample cell for more accurate measurements and improved sample cell corrosion protection. The EC155 with vortex intake, shown in Figure 4-2 (p. 4), is included as part of both CPEC-series systems. For detailed information and specifications, see the EC155 CO₂/H₂O Closed-Path Gas Analyzer manual at www.campbellsci.eu 



Figure 4-2. EC155 CO₂/H₂O closed-path gas analyzer

^{1/}U.S. Pat. No. 9,217,692

4.1.3 CSAT3A sonic anemometer head

The CSAT3A, shown in [Figure 4-3](#) (p. 5), is the Campbell Scientific 3D sonic anemometer sensor head. It shares integrated electronics (EC100 electronics) with the EC155 gas analyzer. The CSAT3A and EC155 are mounted on the same platform to reduce separation between the instruments. For more details on the CSAT3AH operation, see the *CSAT3BH Three-Dimensional Heated Sonic Anemometer* manual.

NOTE:

The Campbell Scientific standalone sonic anemometer, CSAT3B, has its own electronics, whereas the CSAT3A shares the EC100 electronics with the EC155 gas analyzer to ensure optimal synchronization between the two sensors. The measurement specifications for the CSAT3A and CSAT3B are the same.

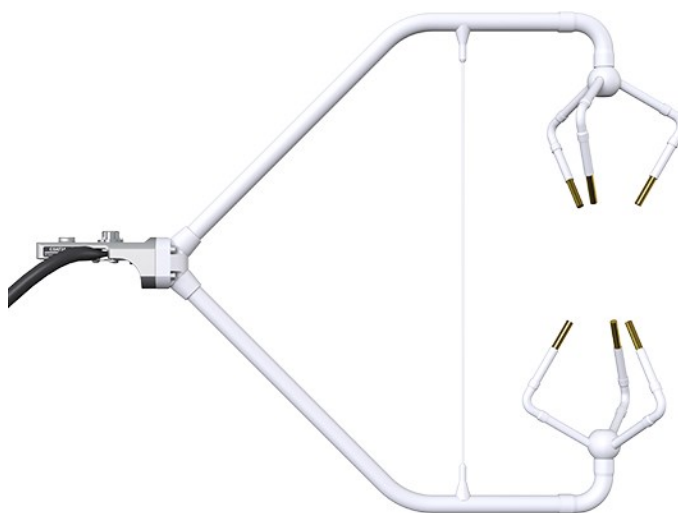


Figure 4-3. CSAT3A sonic anemometer

4.1.4 Pump module

The CPEC-series systems use a small, low-power diaphragm pump to draw air through the EC155 sample cell. The pumping speed is automatically controlled to maintain the volumetric flow at the set point (3 to 9 LPM). The pump module is temperature controlled to keep the pump in its operating temperature range of 0 to 55 °C. The pump module includes a large-capacity filter to protect the pump from contamination and dampen pressure fluctuations in the sample cell caused by the pump.

[CPEC306](#) (p. 6) and [CPEC310](#) (p. 8) describe each system in greater detail.

4.2 CPEC306

Figure 4-4 (p. 6) shows a typical configuration of a CPEC306 system, which is a mid-level expandable system.

The two enclosures of the CPEC306 system are the EC100 electronics enclosure and data logger and pump module enclosure. The EC100 electronics are housed separately from the data logger (Figure 4-1 [p. 4]). The CR6 data logger is positioned within the CPEC306 enclosure (Figure 4-5 [p. 7] and Figure 4-6 [p. 7]). The CPEC306 enclosure also includes the pump module and has capacity for an optional VOLT 116 module (see VOLT 116 [p. 11]) for energy balance and meteorological measurements.



Figure 4-4. CPEC306 system

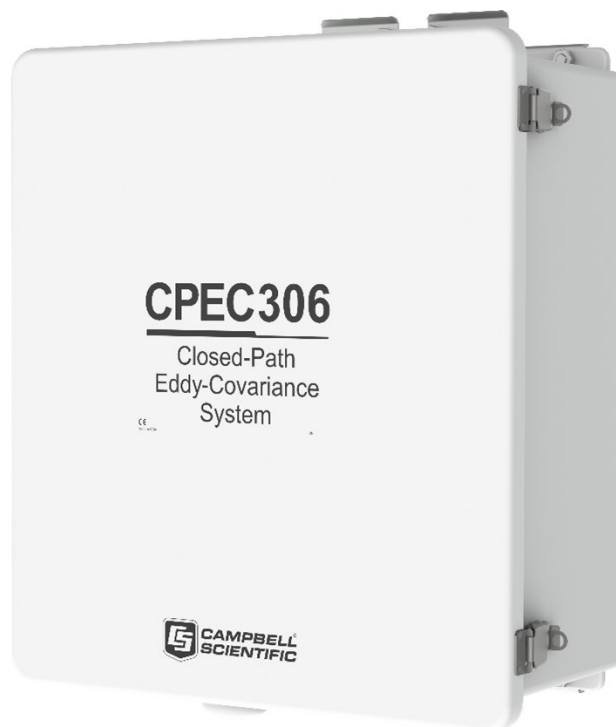


Figure 4-5. CPEC306 system enclosure

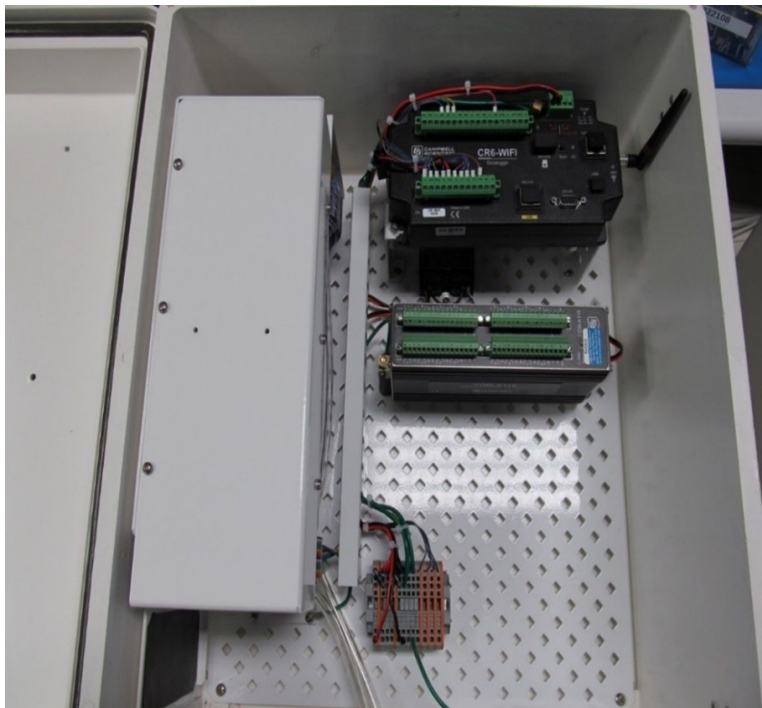


Figure 4-6. Interior of CPEC306 system enclosure

4.3 CPEC310

The CPEC310 includes the same features and components as the CPEC306, such as the capacity for a VOLT 116 (see [Figure 4-8](#) [p. 9] and [Figure 4-9](#) [p. 9]). Included with the CPEC310, however, is a 3-valve module that allows automatic zero and span. The CPEC310 can also be equipped with an optional scrub module providing a source of zero air for performing the zero-and-span procedures. A CPEC310 requires a CO₂ reference tank (as shown in [Figure 4-7](#) [p. 8]) and either a scrub module or a zero air reference tank to execute the automatic zero and span. (Campbell Scientific does not sell these reference tanks.)

[Figure 4-7](#) (p. 8) shows a typical CPEC310 system, including a scrub module.



Figure 4-7. Fully configured CPEC310 system

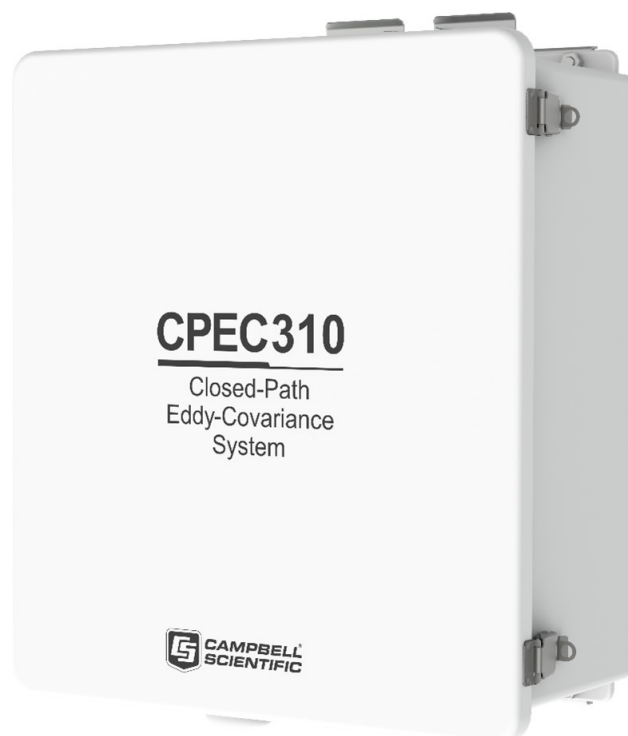


Figure 4-8. CPEC310 system enclosure

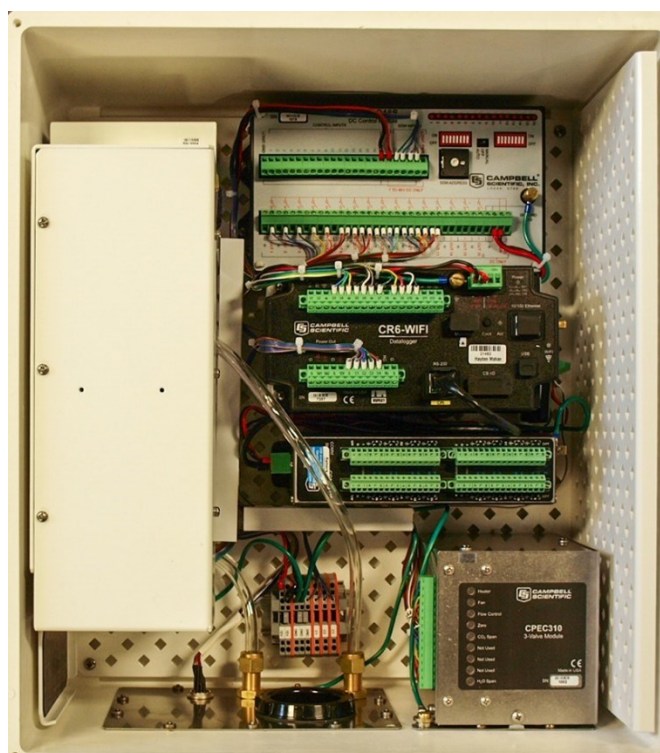


Figure 4-9. Interior of CPEC310 system enclosure

The CPEC310 3-valve module (Figure 4-10 [p. 10]) is housed in the CPEC310 enclosure and is used to automate zero and CO₂ span checks and automatically perform a field zero and field CO₂ span on a user-defined interval. Field H₂O span requires a dew point generator and cannot be automated because the dew point generator is a laboratory instrument and not designed for the long-term field deployment necessary for the automated zero-and-span operation. Therefore, H₂O spans must be performed under manual control.



Figure 4-10. CPEC310 valve module

4.4 Other components

The following section describes the CR6 data logger that is required for any of the CPEC-series systems. As many users already own the CR6 data logger, CPEC-series systems do not include the CR6 data logger in a standard system.

4.4.1 CR6 data logger

The CR6 and *EasyFlux DL* are the core of the CPEC-series systems. They store raw data, process that data, store fluxes, allow for remote communications to the station, and provide diagnostic information about the system. Additionally, the CR6 (Figure 4-11 [p. 11]) is used for system control of the pump and valves.

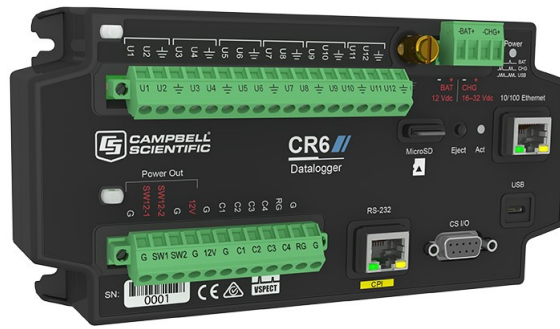


Figure 4-11. CR6 measurement and control data logger

4.5 Optional components

The following section describes optional components that are available to expand the capabilities of the CPEC-series systems. Specific configurations will depend on specific site conditions, data requirements, and research goals.

4.5.1 VOLT 116

The VOLT 116 (the VOLT 116 replaced the CDM-A116; see [Figure 4-12](#) [p. 11]) is a 24-bit analogue input module that can increase the capacity of analogue channels in a data logger system. The VOLT 116 has 16 additional channels available. The CPEC306 and CPEC310 enclosures both allow for the addition of a VOLT 116 module, making it possible to add energy balance and meteorological sensors. For more information on adding these sensors, see [Configure the EasyFlux® DL program](#) (p. 33) and [Wiring the CR6 and optional energy balance sensors](#) (p. 137).

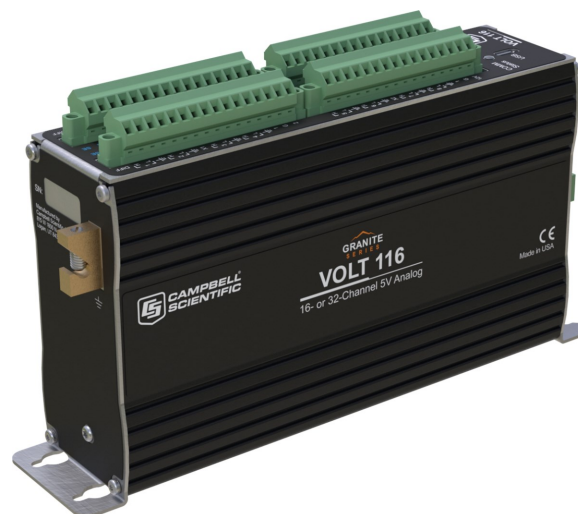


Figure 4-12. VOLT 116

4.5.2 CPEC310 scrub module

The CPEC310 scrub module provides a source of zero air used for zeroing the EC155. It consists of a pump and a three-stage molecular sieve and connects to the CPEC310 system enclosure. The scrub module (shown in [Figure 4-13](#) [p. 12] and [Figure 4-14](#) [p. 12]) eliminates the need for a cylinder of zero air. A cylinder of known CO₂ is still required. By reducing the need for one of the two cylinders traditionally required for zero/span, the module is useful in locations where transporting and replacing cylinders is inconvenient. Additional information regarding installation and maintenance of the CPEC310 scrub module is found in [CPEC310 scrub module installation, operation, and maintenance](#) (p. 158).



Figure 4-13. CPEC310 scrub module enclosure



Figure 4-14. Interior of CPEC310 scrub module


4.5.3 Carrying cases

The EC155 and the CSAT3A may be ordered with optional carrying cases. If the carrying cases are not ordered, the sensors are shipped in cardboard boxes.

4.5.4 Enclosure mounting options

The enclosures for any of the CPEC-series systems can be configured with one of several mounting options. The CPEC306 or CPEC310 system enclosure is similar to the Campbell Scientific ENC16/18 enclosure. The same mounting options are available:

- Triangular tower (UT10, UT20, or UT30)
- Tripod mast 3.8 to 4.8 cm (1.5 to 1.9 in) diameter
- Tripod leg (CM106B or CM106BK tripod only)
- Large pole 10.2 to 25.4 cm (4.0 to 10.0 in) diameter
- No mounting bracket

Consult the *ENC 10/12, 12/14, 14/16, 16/18 Enclosures* manual, available at www.campbellsci.eu  for details on mounting bracket options.

4.6 Common accessories

Several items may be required to complete the installation but are not included in a standard CPEC-series system. Some of the more common accessories are:

System power cable

Two power cables are required for a CPEC-series system: one for the main CPEC system and one for the EC100 electronics. The preferred power cable, CABLEPCBL-L, consists of a twisted red/black pair of 16-gauge (AWG) wires within a rugged Santoprene jacket. It is cut to the specified length, and the end is finished for easy installation.

NOTE:

The “-L” designation after certain parts designates a cable or tube length in feet. The length is specified by the user at the time of order.

SDM cable

An SDM communication cable is required to connect the EC100 to the CPEC-series system enclosure. The preferred SDM cable is CABLE4CBL-L. This cable consists of four conductors with a shield and drain wire and a rugged Santoprene jacket. It is cut to the specified length, and the end is finished for easy installation.

Pump tube

A tube must be used to connect the EC155 to the pump module. If the EC155 is within 50 ft of the CPEC series pump module, 3/8-in OD tubing is recommended. For longer distances (up to 500 ft), a larger 1/2-in OD tube is recommended to minimize pressure drop in the tube. Pre-swaged pump tube assemblies, 3/8-in OD or 1/2-in OD, are available for this purpose.

NOTE:

The fittings on the EC155 and the pump module are sized for 3/8-in OD tubing. A reducer is required at each end for the larger tubing size. These reducers are supplied as part of the pre-swaged tube assembly.

Zero/span tubes

Tubes must be used to connect the EC155 and the zero and CO₂ span cylinders to the valve module of the CPEC310. Bulk tubing with an aluminium core (to minimize diffusion through the tubing wall) and a UV-resistant, black, high-density polyethylene jacket can be cut to length and installed on site. The tubing should be 1/4-in OD to fit the Swagelok fittings on the EC155 and the valve module.

Minimize the length of these tubes to reduce the amount of equilibration time required after the zero or CO₂ span cylinder is selected. One long tube is required to connect the valve module to the EC155, and two short tubes are required to connect the zero and CO₂ span cylinders to the valve module. Pre-swaged tube assemblies are available for this purpose and are cut to a user-specified length.

USB memory card reader/writer

The USB memory card reader/writer is shown in [Figure 4-15](#) (p. 14). It is a single-slot, high-speed reader/writer that allows a computer to read a memory card. When used with Campbell Scientific equipment, the memory card reader/writer typically reads data stored on microSD cards, but it can read many different types of memory cards.




Figure 4-15. USB memory card reader/writer

4.7 Support software

Several software products are available for interfacing a computer to the CR6 data logger.

EasyFlux DL

EasyFlux DL CR6CP for closed-path eddy-covariance systems is a CRBasic program that comes pre-installed into the CR6 that was purchased with this system. If a user has a system that was not ordered with a CR6 or has an older CPEC system, the *EasyFlux DL* program can be downloaded here: www.campbellsci.eu/easyflux-dl.  *EasyFlux DL CR6CP* enables a CR6 data logger to collect fully corrected fluxes of CO₂, latent heat (H₂O), sensible heat, ground surface heat flux (optional), and momentum from a Campbell Scientific closed-path eddy-covariance system with optional energy balance sensors. The program processes the eddy-covariance data using commonly applied corrections in scientific literature. A more detailed description of this program and how to properly configure it for your application can be found in [Configure the EasyFlux® DL program](#) (p. 33).

PC400

PC400 is a free entry-level data logger support software that supports a variety of telecommunication options, manual data collection, and data display. *PC400* includes an easy-to-use program generator (*Short Cut*), as well as full-featured program editors (*CRBasic Editor*, *Edlog*).

LoggerNet

LoggerNet is a full-featured software package that supports programming, communication, and data collection and display. *LoggerNet* consists of a server application and several client applications integrated into a single product. This package is recommended for applications that require telecommunications support and/or scheduled data retrieval, or for large data logger networks.

4.8 Replacement parts

Vortex filter

For EC155 analyzers with a vortex intake, the bypass line from the vortex has a filter that will become clogged over time (typically many months) and requires replacement. The filter consists of a 25 µm particulate filter with 1/4-in Swagelok nuts on either side, as shown in [Figure 4-16](#) (p. 16). Replace the filter when the signal strength has dropped to 0.8 or less.



Figure 4-16. Vortex filter for EC155 intake

Sonic wicks

The spare sonic wicks kit is used to replace the wicks on the CSAT3A. The kit includes three top wicks, three bottom wicks, an installation tool, and adhesive (see [Figure 4-17](#) [p. 16]).



Figure 4-17. Spare sonic wick kit

Silica desiccant bags

Silica desiccant bags ([Figure 4-18](#) [p. 16]) are used to desiccate the CPEC-series system enclosure and should be periodically replaced. These can be purchased in packs of 1, 4, or 20.



Figure 4-18. Single desiccant pack

Humidity indicator card

The replacement humidity indicator card (Figure 4-19 [p. 17]) provides a visual reference of humidity level inside the enclosure.



Figure 4-19. Humidity indicator card

EC155 replacement molecular sieve

The EC155 has two small bottles filled with molecular sieve to remove CO₂ and water vapour from inside the sensor head. Two bottles are included when purchasing the replacement.



Figure 4-20. EC155 replacement molecular sieve

Diaphragm pump

The pump module for any of the CPEC-series systems includes a small double-head diaphragm pump with a brushless DC motor (Figure 4-21 [p. 18]). The pump includes a speed-control input and a tachometer to measure actual pumping speed. It is mounted in an insulated, temperature-controlled box inside the CPEC-series system enclosure.

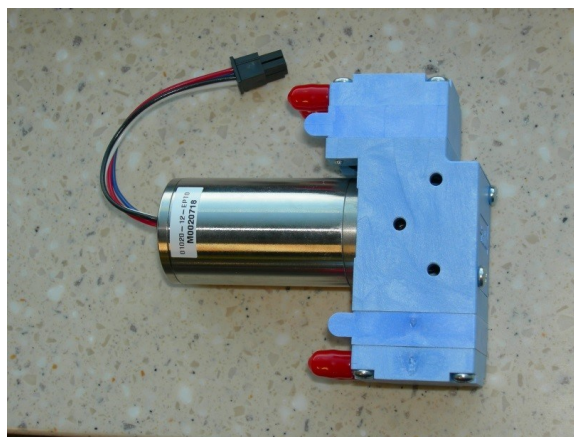


Figure 4-21. Diaphragm pump used in CPEC-series systems

4.9 Theory of operation

Any of the CPEC-series systems can be used for long-term monitoring of atmosphere–biosphere exchanges of CO_2 , water vapour, heat, and momentum. These systems all include a closed-path gas analyzer (EC155), a sonic anemometer head (CSAT3A), and a sample pump, and they are designed to work only with a CR6 data logger. The CR6 can be purchased with either system, or, if a CR6 has previously been purchased, the CPEC-series system can be pre-wired for installation. The CPEC306 and CPEC310 allow for increased sensor capacity with a VOLT 116 module to accommodate additional sensor measurements. The CPEC310 comes equipped with a 3-valve module for automated zero and CO_2 span of the EC155.

4.9.1 EC155 gas analyzer


The EC155 (Figure 4-22 [p. 18]) is a closed-path, mid-infrared absorption gas analyzer that measures molar mixing ratios of CO_2 and water vapour. More information about the operation of the EC155 can be found in the *EC155 $\text{CO}_2/\text{H}_2\text{O}$ Closed-Path Gas Analyzer* manual at www.campbellsci.eu 




Figure 4-22. EC155 gas analyzer

4.9.2 CSAT3A sonic anemometer head

The CSAT3A, as shown in [Figure 4-23](#) (p. 19), is an ultrasonic anemometer sensor head for measuring wind speed in three dimensions. It shares integrated EC100 electronics with the EC155 gas analyzer. It is similar to the sensor head for the CSAT3B sonic anemometer, with the primary difference being that the CSAT3B can be used as a standalone anemometer because it includes independent electronics.

The CSAT3A uses three nonorthogonal pairs of transducers to sense the wind velocity vector. Each pair of transducers transmits and receives ultrasonic pulses to determine the time of flight, which is directly related to the speed of sound and the wind speed along the line between the pair of transducers. The CSAT3A transforms the results into orthogonal wind components u_x , u_y , and u_z referenced to the anemometer head.

The CSAT3A also determines the speed of sound for each transducer pair. These measurements are averaged and converted to sonic virtual temperature (T_s) based on the relationship between speed of sound and air temperature. For more detailed information and specifications, see the *CSAT3B Three-Dimensional Sonic Anemometer* manual, available at www.campbellsci.eu 

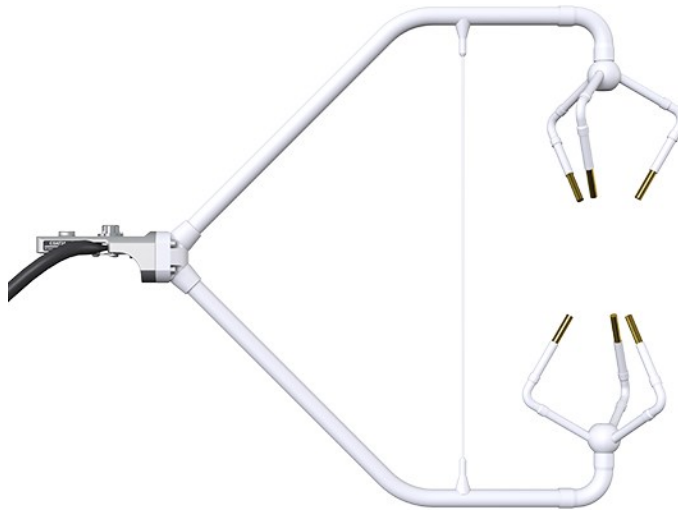


Figure 4-23. CSAT3A sonic anemometer head

4.9.3 CPEC310 valve module

The 3-valve module, shown in [Figure 4-10](#) (p. 10), is housed in the CPEC310 enclosure and is used to perform manual and automated zero and CO₂ span checks and manually and automatically perform a zero and CO₂ span on a user-defined interval. As described in [CPEC310](#) (p. 8), an H₂O span requires a dew point generator and cannot be automated.

NOTE:

In this section and later in the manual, the names or labels on ports are denoted by the usage of bold font. Variable names in the data logger program and Public table are denoted by a different font that also appears bold.

The CPEC310 zero and CO₂ span inlets are not bypass equipped, meaning that they flow only when selected. This allows the zero and CO₂ span tanks to be continuously connected for automatic, unattended operation.

The **H₂O Span** input is bypassed (vented to the atmosphere through the **H₂O Span Bypass** outlet) when it is not selected to permit continuous flow. This allows a dew point generator to be connected directly to the **H₂O Span** inlet. The internal pump of the dew point generator can push air into the valve module even when the **H₂O Span** valve is not selected, minimizing errors caused by pressurization inside the dew point generator. When the **H₂O Span** valve is selected, the dew point generator pushes moist air through the valve module to the EC155.

The CPEC310 pushes the zero/span flow backward through the EC155 sample cell and exhausts it through the intake tube to the atmosphere. Flow through the intake tube causes the sample-cell pressure to rise slightly above ambient pressure. The CPEC310 infers the flow rate from this pressure rise.

The EC155 has a pressure sensor in the sample cell to measure this pressure rise directly, but its accuracy is affected by a small offset drift. The accuracy of this pressure measurement can be improved by stopping all flow through the EC155, allowing the pressure in the sample cell to equilibrate with ambient pressure, and measuring the offset between sample cell and ambient pressures. This offset is then subtracted from subsequent measurements used to control the flow.

Because the pressure sensor offset can change over time, this offset is measured at the beginning of every zero/span cycle. This step requires at least 10 seconds to complete — 5 seconds for the pressure to equilibrate and 5 seconds to average and store the pressure offset measurement.

The CPEC310 valve module has a proportional control valve to actively control the flow of zero-and-span gas to the EC155. The *Easyflux DL* program for the CPEC310 adjusts public variable **valve_ctrl_press** as needed for the measured flow **valve_flow** to reach the desired flow, as indicated by **valve_flow_set_pt**.

The default value for **valve_flow_set_pt** is 1.0 LPM. This flow is adequate for lower measurement heights and allows for a shorter tube between the valve module and the EC155, but the setting of a higher flow rate may be required with long zero/span delivery tubes used on tall towers. The proportional valve is opened fully during an H₂O span operation to prevent pressurizing the dew point generator.

NOTE:

Even with higher flow rates, the time required to flush and equilibrate the delivery tubes on an extremely tall tower may make the automatic zero/span impractical. In this case, a manual zero/span as described in the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual should be performed.

The CPEC310 valve module includes a heater and a fan to keep the valves within their operating range of 2 to 50 °C. The valve heater turns on at 2 °C and will stay on until the valve temperature warms to 4 °C. The valve fan turns on at 50 °C and stays on until the valve temperature drops to 48 °C. To conserve power, temperature control is active just prior to and during the time when valves are in use. If the valves cannot be maintained within the temperature range, the valves are disabled. The valve module temperature control can be manually activated so that manual zero/span can be performed by the station operator on site or remotely. If starting from the minimum ambient temperature (–30 °C), the valves may take as much as 15 minutes to warm up to the operating range of 2 to 50 °C.

4.9.4 CPEC series pump module

The pump module for the CPEC-series systems pulls air through the system and exhausts it through the **Exhaust** fitting on the bottom of the enclosure. It uses a small double-head diaphragm pump with a brushless DC motor. This pump includes a speed control input and a tachometer to measure the actual pumping speed. It is mounted in an insulated, temperature-controlled box located inside the weathertight fiberglass enclosure. The pump module includes a large filter cartridge to dampen the pressure fluctuations from the pump and to protect the pump from particulates or debris.

The following sections describe operating parameters of the pump.

Pump speed

The pump tachometer is measured, converted to volumetric flow rate, and reported in public variable **pump_flow_raw**. A CPEC-series system will set the value of public variable **pump_flow_duty_cycle** to a value between 0 (off) and 1 (full speed) to adjust the pump speed as needed to match **pump_flow_raw** to the set point flow **pump_flow_set_pt**, which is a system configuration variable.

Pump inlet pressure

The measured inlet pressure of the pump is reported in public variable **pump_press**. This pressure will normally be slightly lower (~1 kPa) than the EC155 sample cell pressure due to the pressure drop in the pump tube.

Pump temperature

The temperature of the pump module is reported in public variable **pump_tmpr**. The operating range of the pump is 0 to 55 °C. If the pump temperature is outside this range, the CPEC-series system will disable the pump. The pump module has a heater (drawing 8 W while operational) that turns on if the pump temperature falls below 2 °C. If the CPEC-series system is started at a cold temperature, it may take up to 50 minutes to warm the pump module (from –30 to 0 °C). When it reaches 2 °C, the heater will cycle on/off as needed to maintain this temperature.

The pump module has a fan (drawing 0.7 W while operational) that turns on if the pump temperature rises above 45 °C. The fan will stay on until the pump temperature falls below 40 °C.

The outlet of the pump connects the **Exhaust** fitting on the bottom of the pump module enclosure. This fitting has a screen to prevent insects or debris from entering when the pump is off.

5. Specifications

System

Operating temperature:	–30 to 50 °C
Input voltage:	10.5 to 16.0 VDC
Power:	12 W (typical), 35 W (max; at cold startup)

System enclosure dimensions

CPEC306 or 310:	54.0 x 44.5 x 29.7 cm (21.3 x 17.5 x 11.7 in)
-----------------	---

Designed ingress protection rating of EC100:

IP65^{1/}

Weight basic system

CPEC306:	13.7 kg (30.3 lb)
CPEC310:	15.4 kg (33.9 lb)
VOLT 116 module:	0.9 kg (1.95 lb)

Pump module

Cable length:	3.0 m (10.0 ft)
Inlet connection:	3/8-in Swagelok

^{1/}Not intended for marine environments

Pressure sensor range:	15 to 115 kPa
Pumping speed:	3 to 9 LPM (automatically controlled at the set point, typically 7 LPM)

CPEC310 3-valve module


Inlets:	Zero, CO ₂ span, and H ₂ O span
Outlets:	Analyzer and H ₂ O bypass
Connections:	1/4-in Swagelok
Flow rate:	0.5 to 5 LPM (automatically controlled at user-entered set point)
Dimensions:	14.0 x 12.7 x 14.0 cm (5.5 x 5.0 x 5.5 in)
Weight:	1.5 kg (3.3 lb)

CPEC310 scrub module

Volume:	480.0 cm ³ (29.29 in ³) for each molecular sieve cylinder
Power:	2 W (typical)
Dimensions:	39.4 x 34.3 x 20.3 cm (15.5 x 13.5 x 8.0 in)
Weight:	9.6 kg (21.1 lb)

EC155 and CSAT3A specifications

See the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual and *CSAT3B Three-Dimensional Sonic Anemometer* manual.

View compliance documentation at www.campbellsci.eu/cpec300 

6. Installation

The following tools are required to install a CPEC-series system in the field. Additional tools may be required for a user-supplied tripod or tower.

- 9/16-in open-end wrench
- 1/2-in open-end wrench
- 11/16-in open-end wrench
- Adjustable wrench

- Small, flat-tip screwdriver (included with EC100 and CPEC-series system)
- Large, flat-tip screwdriver
- Sledgehammer (to drive grounding rod into the ground)
- 3/16-in hex-key wrench (included with CM250 levelling mount)

6.1 Mounting

6.1.1 Support structure

A CPEC-series system has three major components that must be mounted to a user-provided support structure.

Eddy-covariance sensors (EC155 and CSAT3A)

Mounted on a horizontal round pipe of 3.33 cm (1.31 in) outer diameter, such as a CM20X crossarm as in [Figure 6-1](#) (p. 26).

EC100 electronics (denoted as “closed-path eddy-covariance system” for the CPEC)

Mounted within 3.0 m (10.0 ft) of the eddy-covariance sensors. The EC100 mounting bracket will accommodate a pipe at any orientation, with outer diameter from 2.5 to 4.8 cm (1.0 to 1.9 in).

CPEC306 or CPEC310 enclosure

Mounted where it can be accessed easily to retrieve data from the microSD cards in the data logger. The CPEC306 or CPEC310 enclosure is similar to the ENC16/18, with the same mounting options (such as tower, tripod, leg, or pole).

The following sections describe a typical application using a CM210 tripod and CM202 crossarm. The CM210 tripod and leg mounting options are ideal for a low eddy-covariance measurement height to minimize wind disturbance.

6.1.2 Mount enclosures

Mount the EC100 electronics within 3.0 m (10.0 ft) of the eddy-covariance sensors (this measurement corresponds to the length of the cables on the EC155 and the CSAT3A).

For the EC100 and the system enclosure, open the sealed bag containing the desiccant packs and humidity card. Place two of the desiccant packs and the humidity indicator card in the mesh pocket in the enclosure door. Reseal the remaining two desiccant packs in the bag for later use.

NOTE:

The EC100 should be mounted vertically to prevent the ingress of water from precipitation.

The mounting bracket will accommodate a horizontal, vertical, or angled pipe from 2.5 to 4.8 cm (1.0 to 1.9 in) in diameter. See the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual for details on configuring the EC100 mounting bracket.

CPEC306

The CPEC306 enclosure and the EC100 electronics are mounted as shown in [Figure 4-4](#) (p. 6), with the two enclosures mounted on the legs of a tripod. They can also be mounted on a triangular tower or large-diameter pole, depending on the site requirements and the mounting options ordered.

CPEC310

The CPEC310 enclosure and the EC100 electronics are mounted as shown in [Figure 4-7](#) (p. 8), with the two enclosures mounted on the legs of a tripod. They can also be mounted on a triangular tower or large-diameter pole, depending on the site requirements and the mounting options ordered. If a scrub module for zeroing the system has been included with the system, then that can be mounted on the leg of the tripod or near the CPEC310 enclosure. Cylinders of CO₂ and zero air (needed in the absence of a scrub module) should be situated close to the base of the tower and secured with harnesses and additional poles to prevent the cylinders from falling over and damaging the system or injuring personnel.

6.1.3 Install eddy-covariance sensors

Install a horizontal mounting crossarm at the height desired for the eddy-covariance measurement. This crossarm must be within $\pm 15^\circ$ of horizontal to level the sonic anemometer. Point the crossarm into the predominant wind direction (for example, if the primary wind blows from the south, point the sensor to be facing south) to minimize wind disturbance caused by wind flowing past the mounting structure and eddy-covariance sensors. The outer diameter of the crossarm should be 3.3 cm (1.3 in). The CM202 crossarm is shown in [Figure 6-1](#) (p. 26).

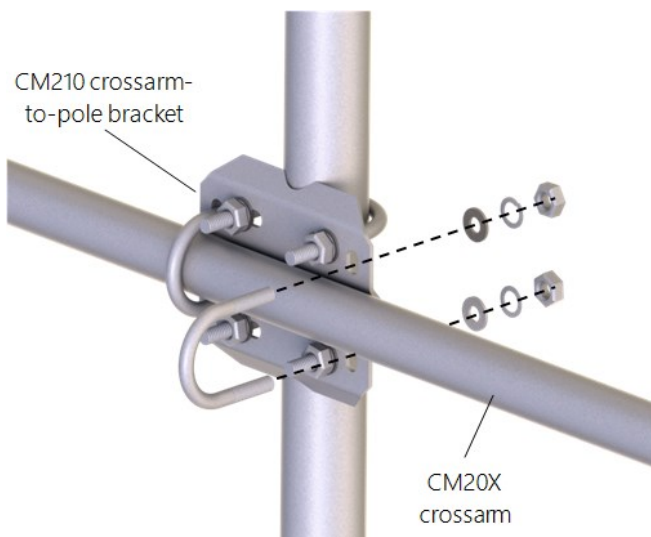


Figure 6-1. CM210 mounting bracket on a tripod mast

The EC155 gas analyzer and CSAT3A sonic anemometer head are mounted on the end of the crossarm using the CM250 levelling mount and the CPEC series mounting platform. [Figure 6-2](#) (p. 26) shows mounting for the EC155 with vortex intake. Adjust the tilt of the mounting platform to level the CSAT3A. For more details, see instructions in the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual.

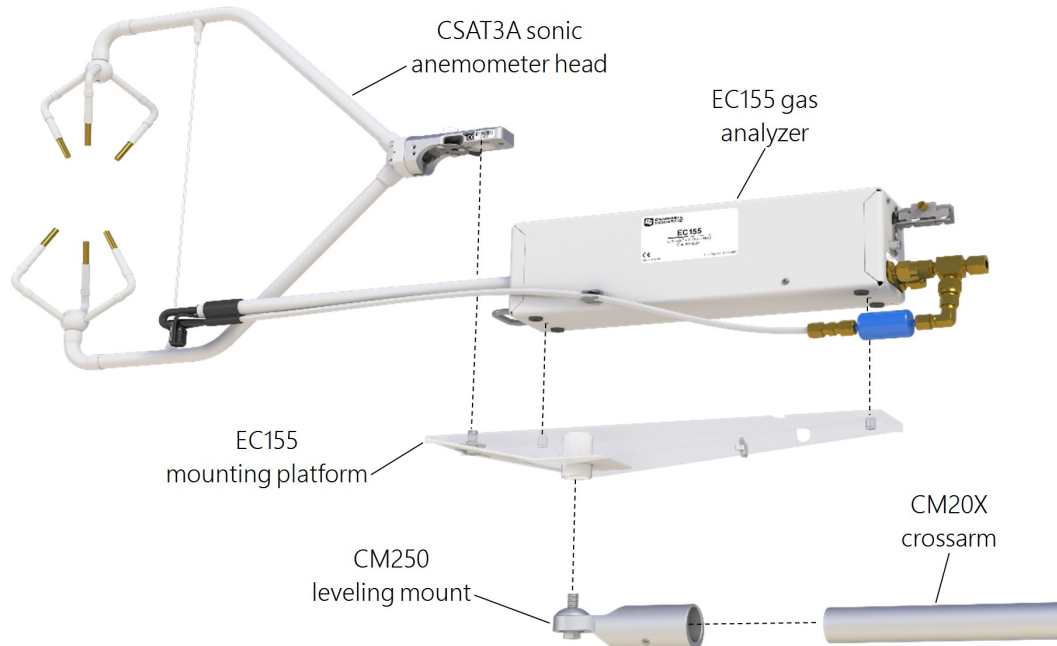


Figure 6-2. Mounting of EC155 and CSAT3A

6.2 Plumbing

Figure 6-3 (p. 27) depicts the plumbing required for the CPEC306, which includes the connection of the EC155 to the **Inlet** connector of the pump on the bottom of the CPEC306 enclosure.

Figure 6-4 (p. 28) depicts the plumbing for the CPEC310. The EC155 connects to the **Inlet** connector of the pump on the bottom of the CPEC310. To zero and span the EC155, 1/4-in OD tubing that has been swaged on both ends is used to connect the EC155 to the valve module. A CO₂ cylinder and either a zero gas (ultra-pure nitrogen) cylinder or scrub module is connected to the valve module for zero and spanning. More information on zero-and-span procedures can be found in [Zero and span](#) (p. 108).

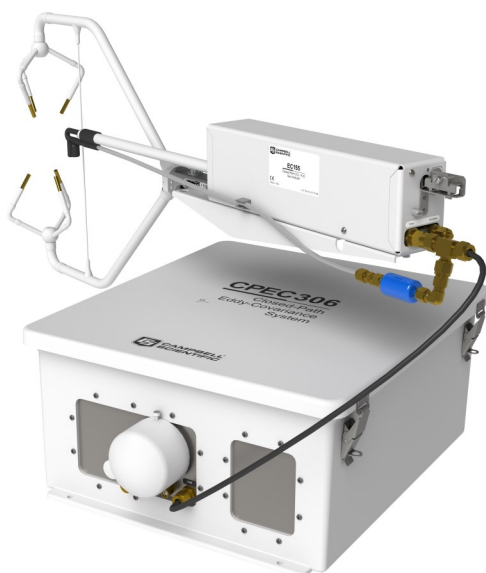


Figure 6-3. Plumbing connections for CPEC306

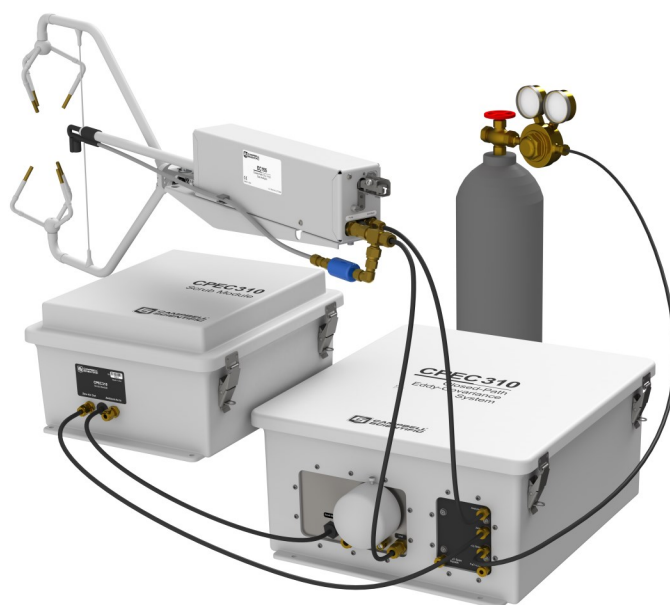


Figure 6-4. Plumbing for CPEC310 with optional scrub module

6.2.1 Zero/span with CPEC310

The CPEC310 can perform automated zero (CO_2 and H_2O) and CO_2 span of the EC155. The user must supply cylinders of zero air and CO_2 span gas with appropriate regulators. If the user has chosen the optional CPEC310 scrub module, then no cylinder of zero air is required.

The rest of this section assumes the use of cylinders of compressed gas; see [CPEC310 scrub module installation, operation, and maintenance](#) (p. 158) for details on the scrub module.

Install cylinders in close proximity to the CPEC310 system enclosure. Each cylinder must have a pressure regulator to control the outlet pressure at 10 psig and must have a 1/4-in Swagelok fitting on the outlet. Connect regulators to the valve module inlets using 1/4-in OD tubing or pre-swaged tube assemblies. Minimize the length of these tubes to reduce the equilibration time after the zero or CO_2 span cylinder is selected. Refer to [Using Swagelok fittings](#) (p. 153) for information on installing and replacing Swagelok fittings.

NOTE:

Flow meters and needle valves are not needed because the CPEC310 valve module has a proportional-control valve to actively control the flow of zero-and-span gas to the EC155.

NOTE:

Make sure no leaks exist in the regulators or the connections to the valve module. For automatic operation, the tank shutoff valves are left continuously open. A plumbing leak could cause the contents of the tank to be lost.

NOTE:

When inlets are not in use, replace the Swagelok plugs to keep the system clean.

Connect the valve module **Analyzer** outlet to the **Zero/Span** fitting on the back of the EC155 analyzer. Similar tubing or pre-swaged tube assembly is recommended for this connection. The length of this tube should also be minimized to reduce equilibration time.

Open the shutoff valves on the cylinders and set the pressure regulators for 10 ± 5 psig delivery pressure.

NOTE:

If the pressure is adjusted too high, slightly loosen the tube fitting to bleed off the excess pressure. Retighten the fitting when the proper setting is reached.

The **H2O Span** inlet is bypass equipped, allowing continuous flow. This inlet can be connected directly to the output of a dew point generator. The bypass on this inlet will avoid pressurizing the dew point generator.

NOTE:

Some systems, such as the AP200 CO₂/H₂O Atmospheric Profile System, require a tee in the connection from the dew point generator to bleed off excess flow and avoid pressurizing the dew point generator. Do not use a tee to connect a dew point generator to the CPEC310.

6.3 Wiring

6.3.1 Ground connections

Any CPEC-series system enclosure and the EC100 electronics must be earth grounded as illustrated in [Figure 6-5](#) (p. 30). Ground the tripod and enclosures by attaching heavy gauge grounding wire (12 AWG minimum) to the grounding lug found on the bottom of each enclosure. The other end of the wire should be connected to earth ground through a grounding rod. For more details on grounding, see the grounding section of the *CR6 Measurement and Control Data Logger* manual.



Figure 6-5. Enclosure and tripod grounded to a copper-clad grounding rod

6.3.2 Eddy-covariance sensor cables

Ensure the EC100 is not powered. Connect the EC155 gas analyzer head, EC155 sample cell, and CSAT3A sonic anemometer head to the EC100 electronics (Figure 6-6 [p. 30]).

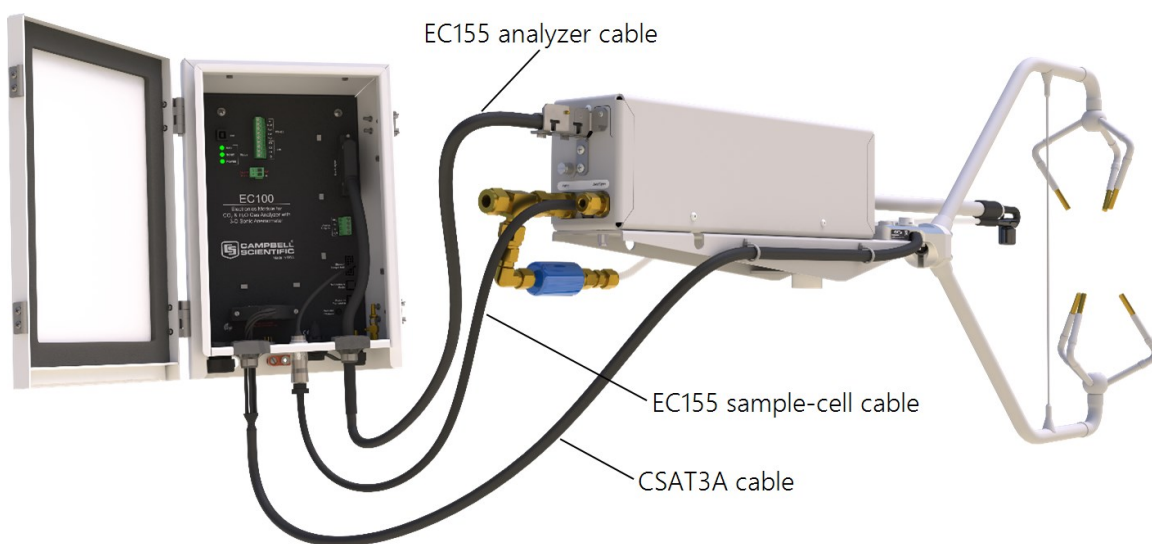


Figure 6-6. EC155 and CSAT3A electrical connections; mounting hardware and tubing not shown

NOTE:

CPEC-series instruments that are ordered with a CR6 are pre-wired with the appropriate EC100 wiring. Users who need to wire the system themselves should follow the next sections to wire the connection between the EC100 and the CPEC-series enclosure.

Wire the SDM communications cable (CABLE4CBL-L) between the EC100 and the CPEC-series enclosure as shown in [Figure 6-7](#) (p. 32) and [Figure 6-8](#) (p. 32). [Table 6-1](#) (p. 31) shows the colour scheme of the SDM wires.

Table 6-1: SDM wiring			
Description	Wire colour	EC100 terminal	DIN rail block
SDM data	Green	SDM-C1	SDM-C1
SDM clock	White	SDM-C2	SDM-C2
SDM enable	Red/brown	SDM-C3	SDM-C3
Signal ground	Black	Ground	Ground
Shield	Clear	Ground	Ground

NOTE:

To bring cables into the enclosure, remove the cap from the cable feedthrough by loosening the thumbscrew and pulling the cap off.

NOTE:

The CPEC-system wires connect to a DIN rail located inside the main enclosure. This DIN rail then connects to the CR6 data logger. To connect a wire to the DIN rail terminal blocks of the CPEC-system enclosure, insert a small screwdriver into the square hole to open the spring-loaded contacts. Insert the wire into the corresponding round hole and then remove the screwdriver. Gently tug the wire to confirm it is secure.

Ensure the CPEC-system enclosure is not powered, and wire the power cable (CABLEPCBL-L) from the EC100 electronics to the enclosure as shown in [Figure 6-7](#) (p. 32) and [Figure 6-8](#) (p. 32).

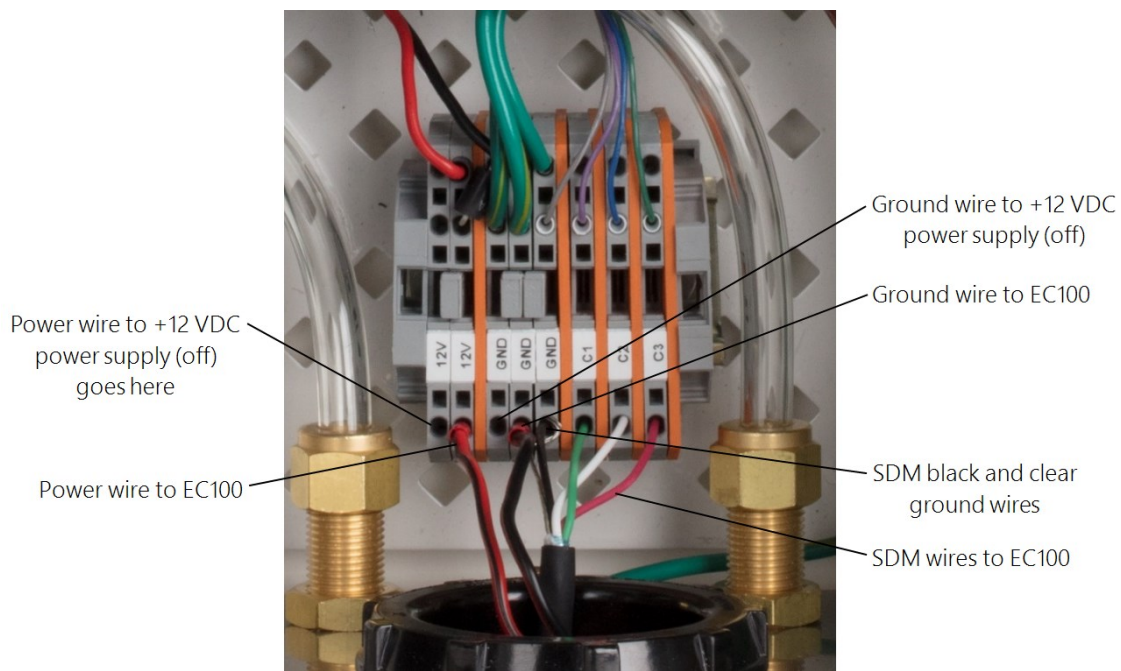


Figure 6-7. Wiring the EC100 to a CPEC enclosure

Secure the SDM and power cables in the EC100 with a cable tie.

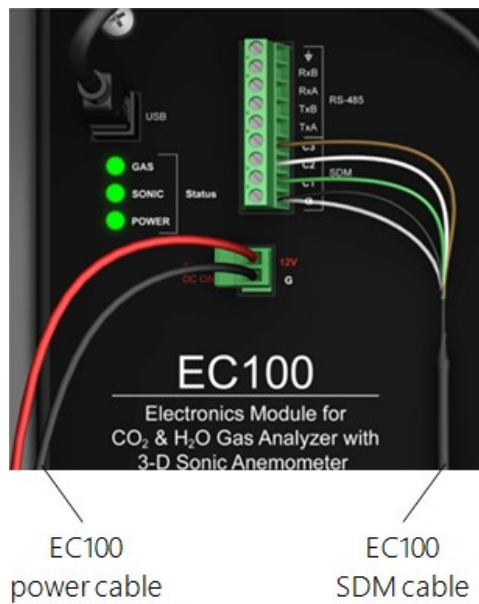


Figure 6-8. Wiring to EC100 electronics

6.3.3 Apply power

All CPEC-series systems require a 10.5 to 16.0 VDC power source. Its average power consumption is 12 W typically but will be slightly higher at cold temperatures, especially at startup in cold weather. In typical remote applications the power will be supplied from a user-provided 12 VDC battery system charged with solar panels.

NOTE:

Before applying power, verify all tubes and cables have been connected according to the instructions above.

CAUTION:

To reduce the risk of shorting the power supply, especially when using batteries, connect the power cable to the CPEC-series system first, then connect to the power source. Carefully design any DC power source to ensure uninterrupted power. If needed, contact Campbell Scientific for assistance.

Connect a power cable (CABLEPCBL-L) from the CPEC power terminals, as shown in [Figure 6-8](#) (p. 32), to a user-supplied 12 VDC power supply.

Replace the cap on the CPEC enclosure feedthrough. Gently bend the cables back as you slide the cap on and rotate the cap to minimize the space around the cables. Tighten the thumbscrew to further relieve strain on the cable. This will also minimize air infiltration and extend the life of the enclosure desiccant packs.

NOTE:

In very humid conditions or locations with insects and small rodents, it may be helpful to seal the cable feedthrough with plumber's putty.

7. Configure the *EasyFlux*® DL program

NOTE:

This version of the manual applies to *EasyFlux DL CR6CP* version 1.04.

EasyFlux® DL CR6CP is a CRBasic program that enables a CR6 data logger to collect fully corrected fluxes of CO₂, latent heat (H₂O), sensible heat, ground surface heat flux (optional), and

momentum from any CPEC-series system with optional GPS and energy balance sensors. The program processes eddy-covariance data using commonly used corrections in scientific literature. Because the number of analogue channels on the CR6 is limited, the program also supports the addition of a VOLT 116 analogue input module, which allows expansion to include a full suite of energy balance sensors, thus enabling the program to calculate the ground surface heat flux and energy closure. Specifically, the program supports data collection and processing from the following sensors:

CPEC306

- EC155 CO₂/H₂O gas analyzer with EC100 electronics
- CAST3A sonic anemometer
- Optional VOLT 116 analogue channel expansion module
- CR6 data logger
- System enclosure (houses CR6, pump module, VOLT 116 module)

CPEC310

- EC155 CO₂/H₂O gas analyzer with EC100 electronics
- CAST3A sonic anemometer
- Optional VOLT 116 analogue channel expansion module
- CR6 data logger
- System enclosure (houses CR6, pump module, VOLT 116 module)
- Valve module for automated zero and span of the gas analyzer
- SDM-CD16S solid-state DC controller
- Optional scrub module for providing zero gas (for example, gas without CO₂ or H₂O for zeroing the analyzer)

GPS receiver (optional, qty 0 to 1)

- GPS16X-HVS

Fine-wire thermocouple (optional, qty 0 to 1)

- FW05
- FW1
- FW3

Biometeorology (biomet) and energy balance sensors (optional)

- Air temperature/relative humidity (RH) probe (qty 0 to 1)
 - HMP155A
 - EE181
 - HygroVUE™10
- Radiation measurement instrument
 - Option 1
 - CS301 or CS320 pyranometer (qty 0 to 1)
 - CS310 quantum sensor (qty 0 to 1)
 - SI-111 infrared radiometer (qty 0 to 1)
 - Option 2
 - SN500SS or NR01 or CNR4 4-component net radiometers (qty 0 to 1; if using CNR4, a CNF4 ventilation and heater unit is also supported)
 - CS310 quantum sensor (qty 0 to 1)
- TE525MM rain gauge (qty 0 to 1)
- TCAV averaging soil thermocouple probe (qty 0 to 3)
- Soil water content reflectometer (qty 0 to 3)
 - CS650
 - CS655
- Soil heat flux plate
 - Option 1: HFP01 soil heat flux plate (qty 0 to 3)
 - Option 2: HFP01SC self-calibrating soil heat flux plate (qty 0 to 3)

NOTE:

It may be possible to customize the program for other sensors or quantities in configurations not described here. Contact Campbell Scientific for more information.

If the CPEC-series system is ordered with the CR6 factory-installed, the system is shipped with the **EasyFlux DL CR6CP** program installed. For users who will install a previously purchased CR6 into a CPEC-series system or for wiring of the optional sensors mentioned above, refer to [Wiring the CR6 and optional energy balance sensors](#) (p. 137).

7.1 Operation

Operating the *EasyFlux DL CR6CP* requires the user to enter or edit certain constants and input variables unique to the program or site. Constants are typically edited only once when first initializing the program. Site-specific variables are edited upon initial deployment and periodically as site conditions change (for example, canopy height is a variable that may need to be adjusted throughout a growing season). Refer to [Set constants](#) (p. 36) and [Edit input variables](#) (p. 45) for details.

Typical operation also includes periodic zeroing and spanning of the EC155 gas analyzer. [Zero and span](#) (p. 108) provides more details on this, either manually with the CPEC306 or automatically with the CPEC310.

7.2 Set constants

7.2.1 Categories of constants

To begin program operation, the values for constants should be set or verified. [Table 7-1](#) (p. 39) lists all constants with descriptions; [Table 7-2](#) (p. 41) lists all constants with descriptions that are applicable only to CPEC-series systems using a VOLT 116. Generally, the constants fall into five categories:

1. **System configuration constants**

These constants indicate the model of the system, which measurement peripherals are being used (such as VOLT 116 or scrub module), and settings related to the system configuration (such as EC100 bandwidth or EC155 sample cell type).

2. **Program function constants**

These constants determine the timing of code execution, frequency of writing to output tables, memory allocation, and data transfer options, for example. In most cases, the default constants for these values can be maintained.

3. **Sensor selection constants**

All sensor selection constants begin with the prefix *SENSOR*. The value is set to **TRUE** in the constant table if the system includes the sensor. For example, if a system has a fine-wire thermocouple, the constant **SENSOR_FW** should be set to **TRUE**. When set to **TRUE**, the wiring in [Table C-3](#) (p. 139) will apply to the sensor, and the data from that sensor will be included in the data output tables.

If a sensor is not used, ensure the constant is set to **FALSE**.

4. Sensor quantity constants

The value for these constants indicates the number of each type of sensor in the system. For example, if three soil heat flux plates are being used, the constant **NMBR_HFP** would be set to 3.

5. Sensor calibration constants

Some sensors have unique parameters for their measurement working equations (for example, multipliers and/or offsets for linear working equations) that are used to convert raw measurements of voltage into the values applicable in analysis. Typically, these parameter values are found on the calibration sheet from the original manufacturer of the sensor. For example, if a CS301 pyranometer is being used, a unique multiplier is set in the following line of code: **Constant PYRAN_MULT = 5**. The comments in the code explain that the value entered is the sensor multiplier provided in the CS301 calibration sheet.

NOTE:

Constants relating to a particular sensor have been grouped together with the sensor selection constant at the beginning, such that if the sensor selection constant is set to **FALSE**, then the other constants for that sensor may be ignored. For example, all constants dealing with the temp/RH probe are grouped together with the **SENSOR_TMPR_RH** constant at the top. If a temp/RH probe is not being used, **SENSOR_TMPR_RH** should be set to **FALSE**, thereby conditionally excluding the next four constants dealing with multipliers and offsets in the program.

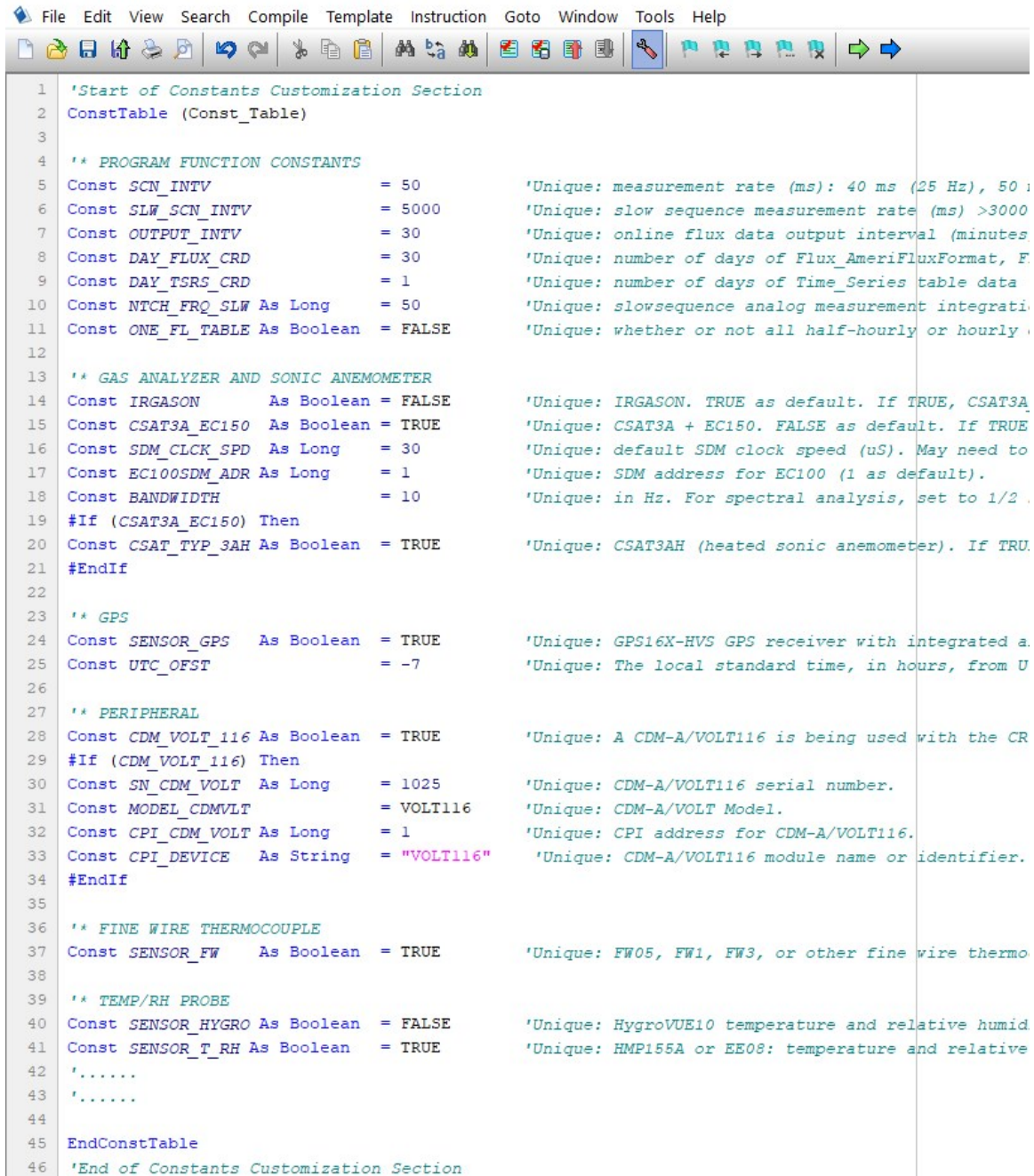
7.2.2 Accessing the constants

The constants may be accessed for editing by opening the program code in *CRBasic Editor*. Find the constants near the top of the program code, just after the introductory comments in a section titled *USER-DEFINED CONFIGURATION CONSTANTS*, subsection *Start of Constants Customization Section* (see [Figure 7-1](#) [p. 38]). A user may also search for the word “unique” to find lines of code with user-editable constants.

Once changes are completed, the program must be recompiled and saved. Save the program under a new or modified file name to keep track of different program versions. Finally, send the program to the CR6 using *LoggerNet* or *PC400* user-interface software. After sending the program, its site-specific variables are ready to be reviewed and edited; see [Edit input variables](#) (p. 45).

NOTE:

After constants are edited in *CRBasic Editor* and the program is loaded and running on the data logger, constants may still be viewed by accessing the **Const_Table** using the CR1000KD keypad or through the *LoggerNet Connect Screen*.



```
1 'Start of Constants Customization Section
2 ConstTable (Const_Table)
3
4 ** PROGRAM FUNCTION CONSTANTS
5 Const SCN_INTV          = 50          'Unique: measurement rate (ms): 40 ms (25 Hz), 50
6 Const SLW_SCN_INTV      = 5000        'Unique: slow sequence measurement rate (ms) >3000
7 Const OUTPUT_INTV       = 30          'Unique: online flux data output interval (minutes
8 Const DAY_FLUX_CRD      = 30          'Unique: number of days of Flux_AmeriFluxFormat, F
9 Const DAY_TSRS_CRD      = 1           'Unique: number of days of Time_Series table data
10 Const NTCH_FRQ_SLW As Long = 50       'Unique: slowsequence analog measurement integrati
11 Const ONE_FL_TABLE As Boolean = FALSE  'Unique: whether or not all half-hourly or hourly
12
13 ** GAS ANALYZER AND SONIC ANEMOMETER
14 Const IRGASON As Boolean = FALSE      'Unique: IRGASON. TRUE as default. If TRUE, CSAT3A
15 Const CSAT3A_EC150 As Boolean = TRUE   'Unique: CSAT3A + EC150. FALSE as default. If TRUE
16 Const SDM_CLK_SPD As Long = 30        'Unique: default SDM clock speed (uS). May need to
17 Const EC100SDM_ADR As Long = 1        'Unique: SDM address for EC100 (1 as default).
18 Const BANDWIDTH        = 10          'Unique: in Hz. For spectral analysis, set to 1/2
19 #If (CSAT3A_EC150) Then
20 Const CSAT_TYP_3AH As Boolean = TRUE   'Unique: CSAT3AH (heated sonic anemometer). If TRU
21 #EndIf
22
23 ** GPS
24 Const SENSOR_GPS As Boolean = TRUE     'Unique: GPS16X-HVS GPS receiver with integrated a
25 Const UTC_OFST        = -7           'Unique: The local standard time, in hours, from U
26
27 ** PERIPHERAL
28 Const CDM_VOLT_116 As Boolean = TRUE   'Unique: A CDM-A/VOLT116 is being used with the CR
29 #If (CDM_VOLT_116) Then
30 Const SN_CDM_VOLT As Long = 1025      'Unique: CDM-A/VOLT116 serial number.
31 Const MODEL_CDMVLT = VOLT116         'Unique: CDM-A/VOLT Model.
32 Const CPI_CDM_VOLT As Long = 1        'Unique: CPI address for CDM-A/VOLT116.
33 Const CPI_DEVICE As String = "VOLT116" 'Unique: CDM-A/VOLT116 module name or identifier.
34 #EndIf
35
36 ** FINE WIRE THERMOCOUPLE
37 Const SENSOR_FW As Boolean = TRUE      'Unique: FW05, FW1, FW3, or other fine wire thermo
38
39 ** TEMP/RH PROBE
40 Const SENSOR_HYGRO As Boolean = FALSE  'Unique: HygroVUE10 temperature and relative humid
41 Const SENSOR_T_RH As Boolean = TRUE    'Unique: HMP155A or EE08: temperature and relative
42 '.....
43 '.....
44
45 EndConstTable
46 'End of Constants Customization Section
```

Figure 7-1. Example screen from *CRBasic Editor* showing user-defined configuration constants

Table 7-1: Program constants

Indented constant names are only applicable if the prior non-indented constant is true/applicable.

Constant name	Default value	Description
SCN_INTV	100	Measurement rate in milliseconds. Valid options: 50 (20 Hz) and 100 (10 Hz).
SLW_SCN_INTV	6000	Slow sequence measurement rate in milliseconds.
OUTPUT_INTV	30	Interval in minutes over which to compute statistics and fluxes.
DAY_FLUX_CRD	30	Number of days of data to write to each flux data output file stored on the card before beginning a new file.
DAY_TSRS_CRD	2	Number of days of data to write to each time series output file stored on the card before beginning a new file.
NTCH_FRQ_SLW	60	Analogue integration parameter for measurements in the slow sequence. Options: 60 (filters 60 Hz noise) or 50 (filters 50 Hz noise). Choose the option that matches the AC power Hz at site.
ONE_FL_TABLE	FALSE	Set to TRUE to combine the Flux_CSFormat and ancillary Flux_Notes tables into one full or large table. Set to FALSE to keep the two tables separate.
CSAT_TYP_3AH	FALSE	Set to TRUE for heated CSAT3A option; set to FALSE for standard CSAT3A option.
SDM_CLK_SPD	30	SDM clock bit period in microseconds (μ s). If long cables are used that result in skipped scans, this value should be increased. In most cases, the default is adequate.
EC100SDM_ADR	1	SDM address of the EC100.
BANDWIDTH	500/SCN_INTV	Bandwidth for measurements from the EC100. For spectral analysis and general use, set to half the sampling frequency (same as 500/SCN_INTV). If spectra are not considered, may be set to 20 Hz for any sample rate. Options: 5, 10, 12.5, or 20 Hz.
CEL_PRSS_TYP	1	Set to 1 to indicate an absolute pressure sensor in the sample cell.

Table 7-1: Program constants

Indented constant names are only applicable if the prior non-indented constant is true/applicable.

Constant name	Default value	Description
CPEC306	FALSE	Set to TRUE for CPEC306, else set to FALSE .
CPEC310	TRUE	Set to TRUE for CPEC310, else set to FALSE .
CPEC310SCRUB	FALSE	Set to TRUE if the system has a scrub module, else set to FALSE .
ZRO_SPN_INTV	1	Number of days between each automatic zero and span.
ZRO_SPN_OFST	32	Number of minutes to offset the automatic zero/span. For example, if ZRO_SPN_INTV is 1, and ZRO_SPN_OFST is 32, then the auto zero/span will occur at 12:32AM each day.
TIME_ZRO_SPN	80	Number of seconds on sites or steps in the automatic zero and span (see Table 8-2 [p. 116]). Allow enough time for equilibration. For tall tower applications that have a large distance between CPEC310 system enclosure and the EC155 gas analyzer, this may need to be increased.
CHECK_ZERO	TRUE	Set to TRUE to measure and record the gas readings while zero gas is flowing but before the analyzer is zeroed. Set to FALSE to not measure and record.
SET_ZERO	FALSE	Set to TRUE to set the analyzer readings to zero while zero gas is flowing. Set to FALSE to not set the readings to zero.
CHECK_CO2SPN	TRUE	Set to TRUE to measure and record the gas readings while CO ₂ span gas is flowing but before setting the span. Set to FALSE to not measure and record.
SET_CO2SPN	FALSE	Set to TRUE to set the analyzer CO ₂ readings to the span gas concentration while CO ₂ span gas is flowing. Set to FALSE to not set the readings to the CO ₂ span concentration.
SENSOR_GPS	FALSE	Set to TRUE if using a GPS16X sensor, else set to FALSE .
UTC_OFST	-7	Difference between local time and UTC/GMT time in hours.

Table 7-2: Program constants for CPEC-series systems in which a VOLT 116 is used

*Constants in this table are only applicable and set to **TRUE** for CPEC306 and CPEC310 systems with a VOLT 116. Indented constant names are only applicable if the prior non-indented constant is true/applicable.*

Constant name	Default value	Description
CDM_VOLT	FALSE	Set to TRUE for CPEC306 or CPEC310 if they include an optional VOLT 116 device.
SN_CDM_VOLT	0000	Serial number of VOLT 116.
Model_CDMVLT	VOLT116	Model of VOLT 116.
CPI_CDM_VOLT	1	CPI address of VOLT 116.
CPI_DEVICE	"VOLT116"	A custom name the user can give the VOLT 116. It must be in quotation marks.
SENSOR_FW	FALSE	Set to TRUE if using a fine wire thermocouple, else set to FALSE .
SENSOR_T_RH	FALSE	Set to TRUE if using a temp/RH probe, else set to FALSE .
TMPR_MULT	0.14	Multiplier for the raw temperature reading. Set to 0.14 for HMP155A or 0.1 for EE181.
TMPR_OFST	-80.0	Offset for the temperature reading. Set to -80 for HMP155A or -40 for EE181.
RH_MULT	0.1	Multiplier for raw RH reading. Set to 0.1 for HMP155A or EE181.
RH_OFST	0.0	Offset for RH reading. Set to 0 for HMP155A or EE181.
SENSOR_HYGRO	FALSE	Set to TRUE if using a HygroVUE™10 sensor, else set to FALSE .
HYGRO_SDIADR	1	HygroVUE™10 SDI address.
SENSOR_CS301	FALSE	Set to TRUE if using a CS301 pyranometer, else set to FALSE . If TRUE , the following constants must be set to FALSE : SENSOR_CS320, SENSOR_NR01, SENSOR_CNR4, and SENSOR_SN500.

Table 7-2: Program constants for CPEC-series systems in which a VOLT 116 is used

*Constants in this table are only applicable and set to **TRUE** for CPEC306 and CPEC310 systems with a VOLT 116. Indented constant names are only applicable if the prior non-indented constant is true/applicable.*

Constant name	Default value	Description
PYRAN_MULT	5	Multiplier for the pyranometer reading. Set to 5 for CS301. Units: $W \cdot m^{-2} \cdot mV^{-1}$
SENSOR_CS320	FALSE	Set to TRUE if using a CS320 pyranometer, else set to FALSE . If TRUE , the following constants must be set to FALSE : SENSOR_CS301, SENSOR_NR01, SENSOR_CNR4, and SENSOR_SN500.
CS320SDI_ADR	2	SDI address of the CS320.
SENSOR_CS310	FALSE	Set to TRUE if using a CS310, else set to FALSE . If TRUE , SENSOR_NR01, SENSOR_CNR4, and SENSOR_SN500 must be set to FALSE .
QUNTM_MULT	100	Units: $\mu mol \cdot m^{-2} \cdot s^{-1} \cdot mV^{-1}$
SENSOR_SI111	FALSE	Set to TRUE if using an SI-111, else set to FALSE . If TRUE , SENSOR_NR01, SENSOR_CNR4, and SENSOR_SN500 must be set to FALSE .
m0_SI111	1.41970e ⁹	Enter the unique calibration parameter called m0 found on the sensor calibration sheet.
m1_SI111	7.84100e ⁶	Unique sensor calibration parameter.
m2_SI111	82213	Unique sensor calibration parameter.
b0_SI111	-1.72150e ⁷	Unique sensor calibration parameter.
b1_SI111	1.85020e ⁵	Unique sensor calibration parameter.
b2_SI111	13114	Unique sensor calibration parameter.
SENSOR_NR01	FALSE	Set to TRUE if using an NR01, else set to FALSE . If TRUE , the following constants must be set to FALSE : SENSOR_CNR4, SENSOR_SN500, SENSOR_CS301, SENSOR_CS320, SENSOR_CS310, and SENSOR_SI111.

Table 7-2: Program constants for CPEC-series systems in which a VOLT 116 is used

*Constants in this table are only applicable and set to **TRUE** for CPEC306 and CPEC310 systems with a VOLT 116. Indented constant names are only applicable if the prior non-indented constant is true/applicable.*

Constant name	Default value	Description
SENSOR_CNR4	FALSE	Set to TRUE if using a CNR4, else set to FALSE . If TRUE , the following sensors must be set to FALSE : SENSOR_NR01, SENSOR_SN500, SENSOR_CS301, SENSOR_CS320, SENSOR_CS310, and SENSOR_SI111.
SENSOR_CNF4	FALSE	Set to TRUE if using a CNF4 heating and ventilation unit. If set to TRUE , SENSOR_CNR4 must also be TRUE .
SW_IN_SNSTVT	15.0	If using an NR01 or CNR4, enter the unique sensitivity of the upward facing pyranometer as reported on the sensor calibration sheet. Units: $\mu\text{V}\cdot\text{m}^2\cdot\text{W}^{-1}$
SWOUT_SNSTVT	15.0	Unique sensitivity of the downward facing pyranometer. Units: $\mu\text{V}\cdot\text{m}^2\cdot\text{W}^{-1}$
LW_IN_SNSTVT	8.0	Unique sensitivity of the upward facing pyrgeometer. Units: $\mu\text{V}\cdot\text{m}^2\cdot\text{W}^{-1}$
LWOUT_SNSTVT	8.0	Unique sensitivity of the downward facing pyrgeometer. Units: $\mu\text{V}\cdot\text{m}^2\cdot\text{W}^{-1}$
SENSOR_SN500	FALSE	Set to TRUE if using an SN500SS, else set to FALSE . If TRUE , the following constants must be set to FALSE : SENSOR_NR01, SENSOR_CNR4, SENSOR_CS301, SENSOR_CS320, SENSOR_CS310, and SENSOR_SI111.
SN500SDI_ADR	3	SDI address of the SN500SS.
SENSOR_TE525	FALSE	Set to TRUE if using a TE525-series rain gauge, else set to FALSE .
TE525_MULT	0.1	If using a TE525-series rain gauge, enter the multiplier. Units: mm per tip. Multiplier for TE525MM = 0.1 mm/tip as default, TE525 = 0.254 mm/tip, TE525WS = 0.254 mm/tip, TE525WS w/ 8-in funnel = 0.1459 mm/tip.
SENSOR_TCAV	FALSE	Set to TRUE if using a TCAV, else set to FALSE .

Table 7-2: Program constants for CPEC-series systems in which a VOLT 116 is used

*Constants in this table are only applicable and set to **TRUE** for CPEC306 and CPEC310 systems with a VOLT 116. Indented constant names are only applicable if the prior non-indented constant is true/applicable.*

Constant name	Default value	Description
NMBR_TCAV	3	Number of TCAV probes used. Max: 3
SENSOR_CS65X	FALSE	Set to TRUE if a CS650 or CS655 is used, else set to FALSE .
NMBR_CS65X	3	Number of CS650 or CS655 probes used. Max: 3
CSSDI12_ADR1	4	SDI12 address of the first CS65X probe.
CSSDI12_ADR2	5	SDI12 address of the second CS65X probe.
CSSDI12_ADR3	6	SDI12 address of the third CS65X probe.
SENSOR_HFP01	FALSE	Set to TRUE if using an HFP01, else set to FALSE . If TRUE , SENSOR_HFPSC must be set to FALSE .
NMBR_HFP	3	Number of HFP01 or HFP01SC sensors used. Max: 3
HFP_SNSTVT_1	62.0	If using heat flux plates, enter the unique sensitivity of the first plate as reported on the sensor calibration sheet. Units: $\mu\text{V}\cdot\text{m}^2\cdot\text{W}^{-1}$
HFP_SNSTVT_2	62.0	Unique sensitivity of the second heat flux plate. Units: $\mu\text{V}\cdot\text{m}^2\cdot\text{W}^{-1}$
HFP_SNSTVT_3	62.0	Unique sensitivity of the third heat flux plate. Units: $\mu\text{V}\cdot\text{m}^2\cdot\text{W}^{-1}$
SENSOR_HFPSC	FALSE	Set to TRUE (–1) if using an HFP01SC, else set to FALSE (0). If TRUE , SENSOR_HFP01 must be set to FALSE .
HFP_OHM_1	95.0	Unique heater resistance in ohms of first HFP01SC as found in its calibration sheet. If HFP01 (non-self-calibrating) heat flux plates are being used, this constant is ignored.

Table 7-2: Program constants for CPEC-series systems in which a VOLT 116 is used

*Constants in this table are only applicable and set to **TRUE** for CPEC306 and CPEC310 systems with a VOLT 116. Indented constant names are only applicable if the prior non-indented constant is true/applicable.*

Constant name	Default value	Description
HFP_OHM_2	95.0	Unique heater resistance in ohms of second HFP01SC as found in its calibration sheet. If HFP01 (non-self-calibrating) heat flux plates are being used, this constant is ignored.
HFP_OHM_3	95.0	Unique heater resistance in ohms of third HFP01SC as found in its calibration sheet. If HFP01 (non-self-calibrating) heat flux plates are being used, this constant is ignored.
CAL_INTV	1440	If using an HFP01SC, this is the time interval in minutes between auto calibrations.

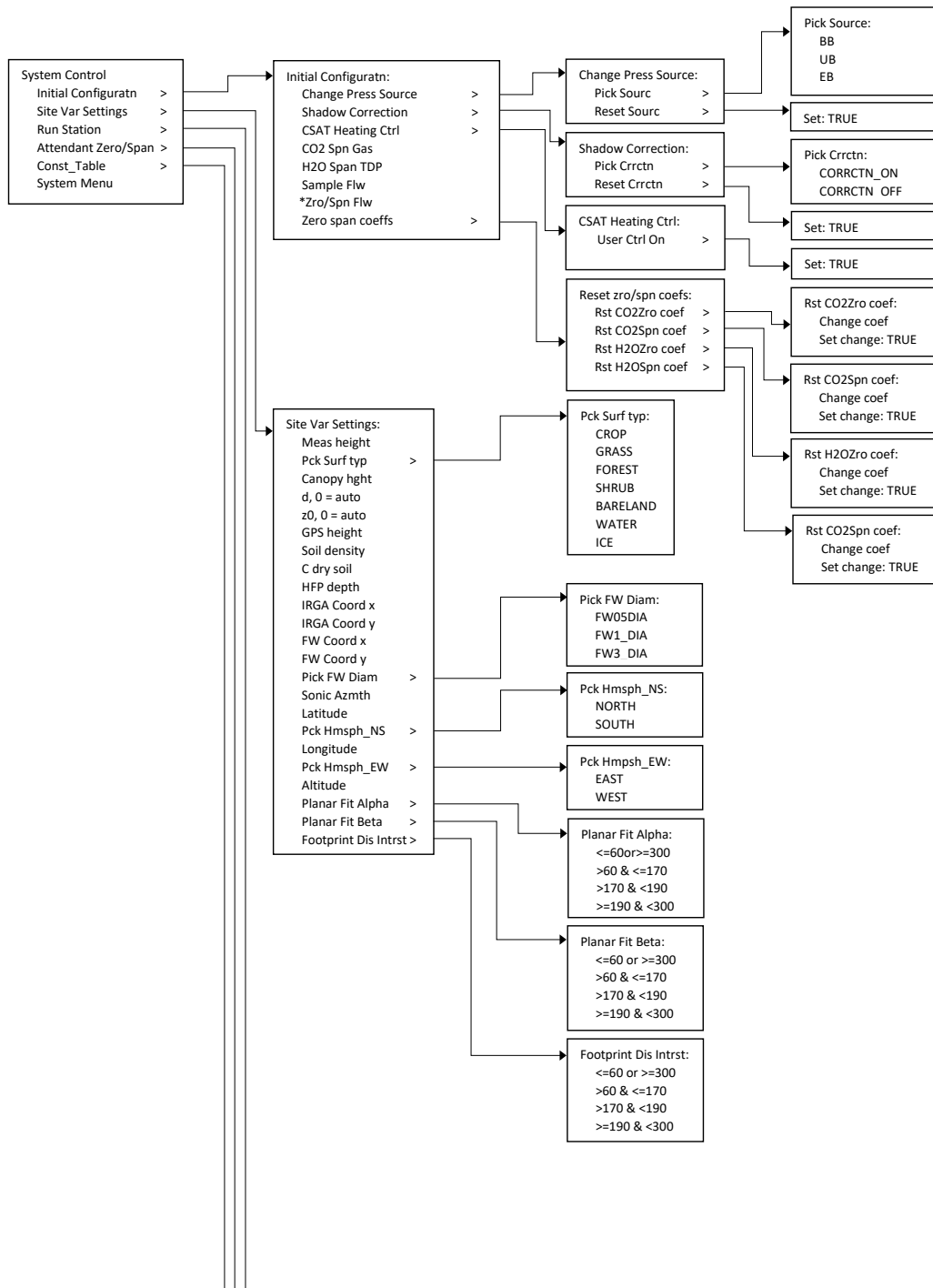
7.3 Edit input variables

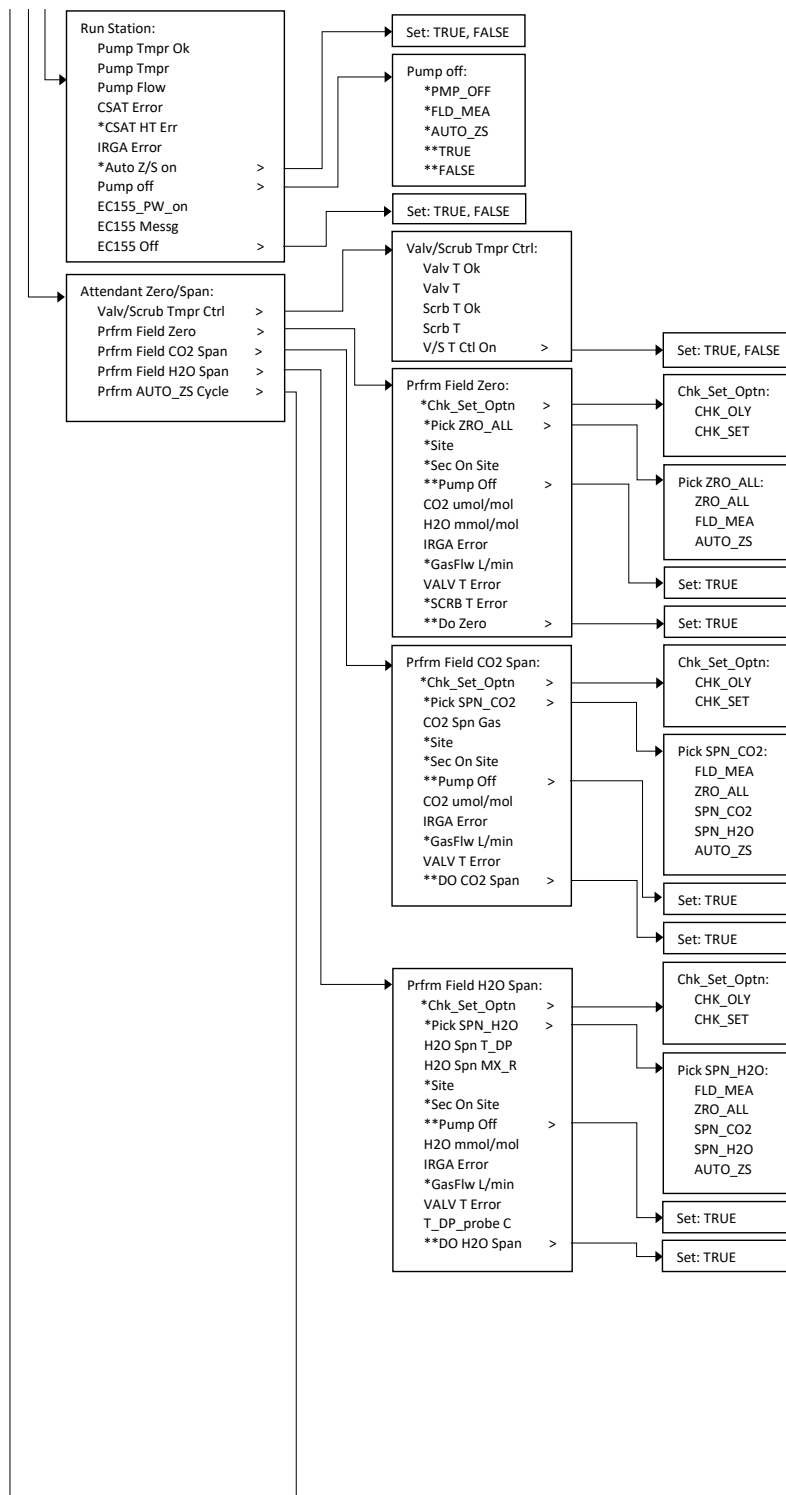
Before data and fluxes are processed correctly, the user must review and edit variables. This is done most conveniently with a CR1000KD keypad. After the CR1000KD is connected to the **CS I/O** port of the CR6 data logger and the program is loaded and running, press **Enter** twice to access the main menu. [Figure 7-2](#) (p. 49) shows an organizational schematic for all the keypad menus. Under the main menu, use the keypad down arrow to scroll down to each of the submenus. To select a submenu, highlight the desired submenu and press **Enter**. To return to a previous menu, press **Esc**. The three submenus titled **Initial Configuratr**n, **Site Var Settings**, and **Run Station** contain the variables that must be reviewed. A description of the variables in each of these submenus is found in [Table 7-3](#) (p. 50), [Table 7-4](#) (p. 54), and [Table 7-5](#) (p. 60), respectively.

If a CR1000KD is not available, an alternative option is to review and edit variables using **LoggerNet**. Under **Table Monitor** in the **Connect Screen**, select **Public Table** and then scroll to the appropriate variables. The last columns in [Table 7-3](#) (p. 50), [Table 7-4](#) (p. 54), [Table 7-5](#) (p. 60) show the corresponding variable name in the **Public Table**. To change a value of a variable in the **Table Monitor**, click on the cell to the right of the variable name, type the new value, and press **Enter**. The values of user-input variables are stored in memory such that if the station loses power, the values will be retained.

NOTE:

[Figure 7-2](#) (p. 49) is a schematic of the entire menu structure. When beginning operation of a system, the user must review and set variables in the following menus: **Initial Configuratr**n, **Site Var Settings**, and **Run Station**. The other menus shown in the schematic relate to doing a zero and span of the gas analyzer. More details on zeroing and spanning are found in [Zero and span](#) (p. 108).





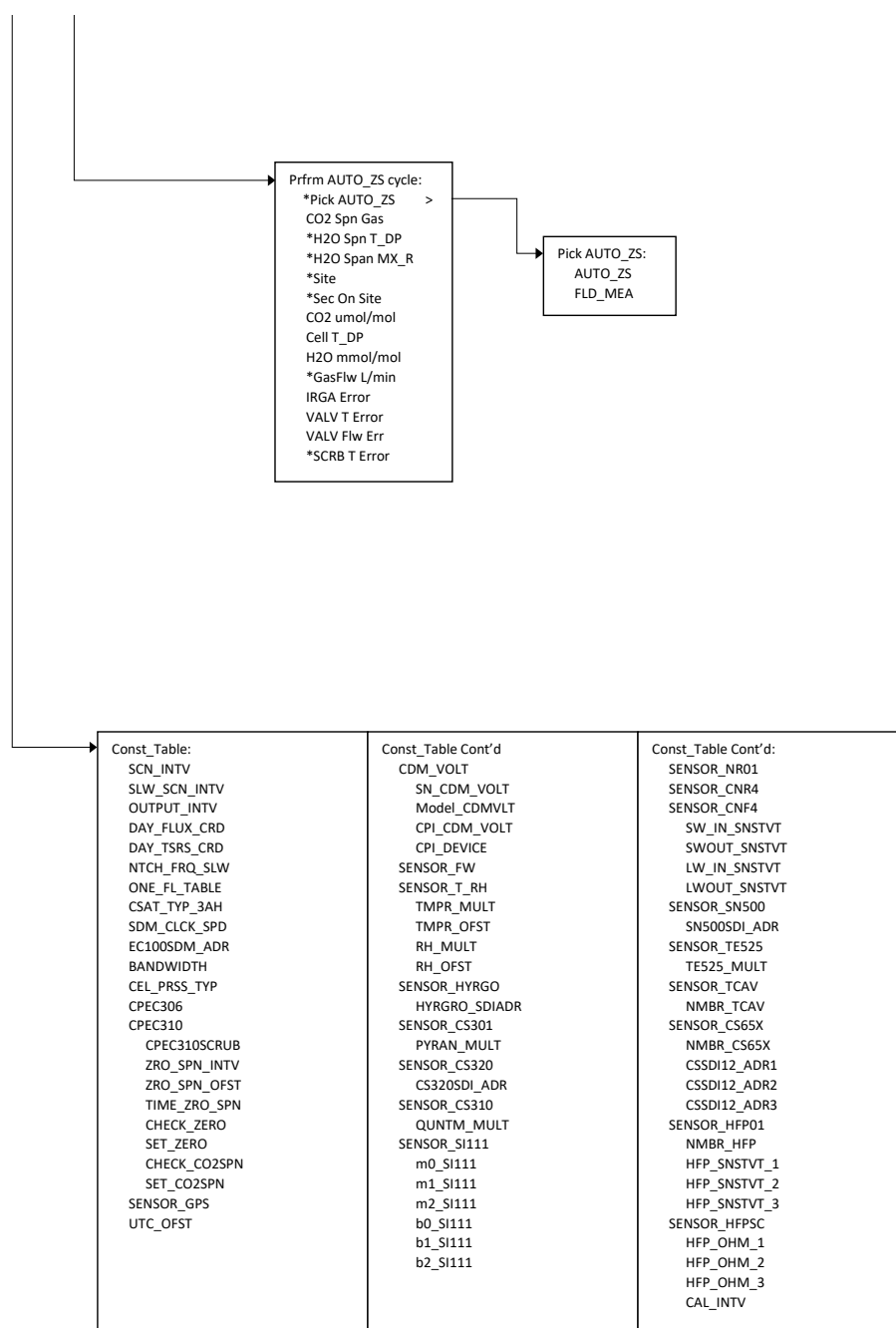


Figure 7-2. Custom keypad menu; arrows indicate submenus (the single asterisk [*] marks variables that are only displayed if the system is a CPEC310, and the double asterisk [**] marks variables that are only displayed if the system is a CPEC306)

Table 7-3: Variables from Initial Configuratrtn menu

Station variable		Default	Description	Name of variable in Public table (if no CR1000KD is available)
Change Press Source	Pick Sourc	EB	Used to select the barometer to use for measurements of ambient pressure. BB — EC100 on-board basic barometer UB — User-supplied barometer EB — EC100 enhanced barometer	press_source 0 = BB 1 = UB 2 = EB
	Reset Sourc	FALSE	If the variable Pick Sourc has been changed, this variable must be set to TRUE to enable the change. The program will return Reset Sourc to FALSE once the change has been applied.	set_press_source_flg -1 = True 0 = False
	Pick Crrctn	CORRCTN_OFF	Used to enable the Kaimal sonic transducer wind shadowing correction as described in the <i>CSAT3B</i> manual. CORRCTN_ON enables the correction, while CORRCTN_OFF disables it.	shadow_corr -1 = CORRCTN_ON 0 = CORRCTN_OFF

Table 7-3: Variables from Initial Configuratr menu

Station variable		Default	Description	Name of variable in Public table (if no CR1000KD is available)
Shadow Correction	Reset Crrctn	FALSE	If the variable Pick Crrctn has been changed, this variable must be set to TRUE to enable the change. Program will return Reset Crrctn to FALSE once change has been applied.	set_shadow_corr_flg -1 = True 0 = False
CSAT Heating Ctrl (only if heated sonic is used)	User Ctrl On	FALSE	Set variable to TRUE for CSAT3AH heating controls.	CSAT3H_ctrl_on -1 = True 0 = False
CO2 Spn Gas		400 ppm	Dry molar mixing ratio concentration of the CO ₂ span gas. A concentration close to ambient is recommended.	CO2_span_gas
H2O Span TDP		10 °C	Dew point temperature of the H ₂ O span gas (for example, the dew point temperature setting of the dew point generator).	Td_span_gas

Table 7-3: Variables from Initial Configuratrn menu

Station variable			Default	Description	Name of variable in Public table (if no CR1000KD is available)
Sample Flw			8 L·min ⁻¹	Set point for total flow into the gas analyzer. Note: If the vortex intake is installed, a portion of this flow will be diverted to the vortex bypass. See the <i>EC155 CO₂/H₂O Closed-Path Gas Analyzer</i> manual for more details.	pump_flow_set_pt
Zro/Spn Flw			1 L·min ⁻¹	Set point for flow of zero or span gas through the gas analyzer. Note: Only applicable to a CPEC310 with valve module.	valve_flow_set_pt
	Rst CO2Zro coef	Change coef	FALSE	Used to restore gas analyzer coefficients to 1 or a previously user-recorded value. Enter desired value in Change coef and then set Set change variable to TRUE in order to apply.	CO2_zero_coef
		Set change	FALSE	Program will return Set change to FALSE once change has been applied.	rst_CO2_zro_coef_flg

Table 7-3: Variables from Initial Configuratr menu

Station variable			Default	Description	Name of variable in Public table (if no CR1000KD is available)
Zero span coeffs: Reset zro/spn coeffs	Rst CO2Spn coef	Change coef	FALSE	Used to restore gas analyzer coefficients to 1 or a previously user-recorded value. Enter desired value in Change coef and then set Set change variable to TRUE in order to apply. Program will return Set change to FALSE once change has been applied.	CO2_span_coef
		Set change	FALSE		rst_CO2_spn_coef_flg
	Rst H2OZro coef	Change coef	FALSE	Used to restore gas analyzer coefficients to 1 or a previously user-recorded value. Enter desired value in Change coef and then set Set change variable to TRUE in order to apply. Program will return Set change to FALSE once change has been applied.	H2O_zero_coef
		Set change	FALSE		rst_H2O_zro_coef_flg
	Rst H2OSpn Coef	Change coef	FALSE	Used to restore gas analyzer coefficients to 1 or a previously user-recorded value. Enter desired value in Change coef and then set Set change variable to TRUE in order to apply. Program will return Set change to FALSE once change has been applied.	H2O_span_coef
		Set change	FALSE		rst_H2O_spn_coef_flg

Table 7-4: Variables and settings in Site Var Settings menu				
Station variable	Units	Default	Description	Name of variable in Public table (if no CR1000KD is available)
Meas height	m	2	Height of the centre of eddy-covariance sensor measurement volumes above ground.	height_measurement
Pck Surf typ	–	GRASS	Type of surface at measurement site; used to estimate displacement height.	surface_type 1 = CROP 2 = GRASS 3 = FOREST 4 = SHRUB 5 = BARELAND 6 = WATER 7 = ICE
Canopy hght	m	0.5	Average height of the canopy.	height_canopy
d	m	0 (Auto)	Displacement height; set to 0 for program to auto-calculate.	displacement_user
z_0	m	0 (Auto)	Roughness length; set to 0 for program to auto-calculate.	roughness_user
GPS height	m	1	Height of the GPS reciever above ground surface; variable is omitted if GPS is not used.	height_GPS16X
Soil density	$\text{kg}\cdot\text{m}^{-3}$	1300	Average density of soil; variable is omitted if energy balance sensors are not used.	soil_bulk_density
C dry soil	$\text{J}\cdot\text{kg}^{-1}\cdot\text{K}^{-1}$	870	Specific heat of dry mineral soil; variable is omitted if energy balance sensors are not used.	cds
HFP depth	m	0.08	Depth of soil heat flux plates; variable is omitted if energy balance sensors are not used.	thick_abv_HFP

Table 7-4: Variables and settings in Site Var Settings menu

Station variable	Units	Default	Description	Name of variable in Public table (if no CR1000KD is available)
IRGA Coord x	m	0.15020	Distance along sonic x-axis between sonic sampling volume and EC155 gas analyzer intake.	separation_x_IRGA
IRGA Coord y	m	-0.03218	Distance along sonic y-axis between sonic sampling volume and EC155 gas analyzer intake.	separation_y_IRGA
FW Coord x	m	0.02627	Distance along sonic x-axis between sonic sampling volume and fine-wire thermocouple; variable is omitted if no fine-wire thermocouple is used.	separation_x_FW
FW Coord y	m	-0.02306	Distance along sonic y-axis between sonic sampling volume and fine-wire thermocouple; variable is omitted if no fine-wire thermocouple is used.	separation_y_FW
Pick FW Diam	m	FW05_DIA	Diameter of fine-wire thermocouple. User enters a numerical value or selects which fine-wire thermocouple is being used to load appropriate diameter: 1.27×10^{-5} m for FW05_DIA, 2.54×10^{-5} m for FW1_DIA, and 7.62×10^{-5} m for FW3_DIA; variable is omitted if no fine-wire thermocouple is used.	FW_diameter Predefined constants: FW05_DIA FW1_DIA FW3_DIA
Sonic Azmth	decimal degrees	0	Compass direction in which the sonic negative x-axis points (for example, compass direction in which sonic head is pointing).	sonic_azimuth

Table 7-4: Variables and settings in Site Var Settings menu

Station variable		Units	Default	Description	Name of variable in Public table (if no CR1000KD is available)
Latitude		decimal degrees	41.766	Site latitude in degrees north or south.	Latitude
Pck Hmsph_NS		–	NORTH	Site latitudinal hemisphere; options are NORTH or SOUTH , relative to the equator.	hemisphere_NS 1 = North –1 = South
Longitude		decimal degrees	111.855	Site longitude in degrees east or west.	Longitude
Pck Hmsph_EW		–	WEST	Site longitudinal hemisphere; options are EAST or WEST , relative to the prime meridian.	hemisphere_EW 1 = East –1 = West
Altitude		m	1356	Site altitude, or elevation above sea level.	altitude
	<=60 or >=300	decimal degrees	0	Planar-fit alpha angle used to rotate wind when the mean horizontal wind is blowing from the sector of 0 to 60° and 300 to 360° in the sonic coordinate system (that is, wind blowing into sonic head). ^{1/}	alpha_PF_60_300
	>60 & <=170	decimal degrees	0	Planar-fit alpha angle used to rotate wind when the mean horizontal wind is blowing from the sector of 60 to 170° in the sonic coordinate system (that is, wind blowing from sector left and behind sonic head). ^{1/}	alpha_PF_60_170

Table 7-4: Variables and settings in Site Var Settings menu

Station variable		Units	Default	Description	Name of variable in Public table (if no CR1000KD is available)
Planar Fit Alpha	>170 & <190	decimal degrees	0	Planar-fit alpha angle used to rotate wind when the mean horizontal wind is blowing from the sector of 170 to 190° in the sonic coordinate system (that is, wind blowing from behind sonic head). ^{1/}	alpha_PF_170_190
	>=190 & <300	decimal degrees	0	Planar-fit alpha angle used to rotate wind when the mean horizontal wind is blowing from the sector of 190 to 300° in the sonic coordinate system (that is, wind blowing from sector right and behind sonic head). ^{1/}	alpha_PF_190_300
	<=60 or >=300	decimal degrees	0	Planar-fit beta angle used to rotate wind when the mean horizontal wind is blowing from the sector of 0 to 60° and 300 to 360° in the sonic coordinate system (that is, wind blowing into sonic head). ^{1/}	beta_PF_60_300
	>60 & <=170	decimal degrees	0	Planar-fit beta angle used to rotate wind when the mean horizontal wind is blowing from the sector of 60 to 170° in the sonic coordinate system (that is, wind blowing from left and behind sonic head). ^{1/}	beta_PF_60_170

Table 7-4: Variables and settings in Site Var Settings menu

Station variable		Units	Default	Description	Name of variable in Public table (if no CR1000KD is available)
Planar Fit Beta	>170 & <190	decimal degrees	0	Planar-fit beta angle used to rotate wind when the mean horizontal wind is blowing from the sector of 170 to 190° in the sonic coordinate system (that is, wind blowing from behind sonic head). ^{1/}	beta_PF_170_190
	>=190 & <300	decimal degrees	0	Planar-fit beta angle used to rotate wind when the mean horizontal wind is blowing from the sector of 190 to 300° in the sonic coordinate system (that is, wind blowing from right and behind sonic head). ^{1/}	beta_PF_190_300
	<=60 or >=300	m	100z	Upwind distance of interest from station when the mean horizontal wind is blowing from the sector of 0 to 60° and 300 to 360° in the sonic coordinate system (that is, wind blowing into sonic head). Note: Program will report the percentage of cumulative footprint from within this distance. The default value is 100× the aerodynamic height (z); z is the difference between measurement height and displacement height.	dist_intrst_60_300

Table 7-4: Variables and settings in Site Var Settings menu

Station variable		Units	Default	Description	Name of variable in Public table (if no CR1000KD is available)
Footprint Dis Intrst	>60 & ≤170	m	100z	Upwind distance of interest from station when the mean horizontal wind is blowing from the sector of 60 to 170° in the sonic coordinate system (that is, wind blowing from left and behind sonic head).	dist_intrst_60_170
	>170 & <190	m	100z	Upwind distance of interest from station when the mean horizontal wind is blowing from the sector of 170 to 190° in the sonic coordinate system (that is, wind blowing from behind sonic head).	dist_instrst_170_190
	≥190 & <300	m	100z	Upwind distance of interest from station when the mean horizontal wind is blowing from the sector of 190 to 300° in the sonic coordinate system (that is, wind blowing from right and behind sonic head).	dist_intrst_190_300
¹ Leave all planar fit alpha and beta angles set to 0 to use Tanner and Thurtell (1969) method of double coordinate rotations, and have the rotation angles auto-calculated each averaging interval.					

Table 7-5: Variables from the Run Station menu			
Variable name	Default	Description	Name of variable in Public table (if no CR1000KD is available)
Pump Tmpr Ok	–	A display (read-only) variable indicating whether pump temperature is within its operating range.	pump_tmpr_ok
Pump Tmpr	–	A display (read-only) variable showing temperature of the pump in °C.	pump_tmpr
Pump Flow	8.0 L·min ⁻¹	A display (read-only) variable showing volumetric air flow to the pump; if using vortex intake, this includes flow through both sample cell and vortex bypass.	pump_flow
CSAT Error	–	System diagnostic word; if set to 0, no error conditions are detected. (For more details, see System diagnostic word [p. 150].)	sonc_er
CSAT HT Err	–	System diagnostic word; if set to 0, no error conditions are detected. (For more details, see System diagnostic word [p. 150].)	sonc_htng_er
IRGA Error	–	System diagnostic word; if set to 0, no error conditions are detected. (For more details, see System diagnostic word [p. 150].)	irga_er

Table 7-5: Variables from the Run Station menu

Variable name	Default	Description	Name of variable in Public table (if no CR1000KD is available)
Auto Z/S on	FALSE	Set to TRUE to initiate an automatic zero and CO ₂ span of gas analyzer; system will return Auto Z/S on to FALSE once the zero/span is initiated and will return to eddy-covariance field measurements upon completion of the zero/span. Variable is omitted if the system is a CPEC306 (that is, no valve module).	prfm_auto_zero_span_flg
Pump off	FALSE	For CPEC306 systems, select TRUE to disable the pump and FALSE to enable the pump. For CPEC310 systems, select PMP_OFF to disable the pump, FLD_MEA to re-enable pump and resume normal eddy-covariance measurements, or AUTO_ZS to initiate an automatic zero/span cycle.	pump_off_flg
EC155_PW_on	–	A display (read-only) variable indicating whether the EC155 is powered on.	EC155_actual_pwr_on
EC155 Messg	–	A display (read-only) string describing current status of the EC155.	message
EC155 Off	FALSE	Set to TRUE to power down the EC155 and FALSE to power on the EC155.	ec155_pwr_off_flg

7.4 Data retrieval

The program stores a very limited amount of data to the internal CPU of the data logger, so a microSD flash card should be used with the CR6. [Table 7-6](#) (p. 62) shows the number of days of data a 2 GB, 8 GB, and 16 GB card will typically hold before the memory is full and data starts to be overwritten. For a real-time estimate of number of days remaining on the card, refer to the public variable `card_storage_available_days`.

In cases where real-time remote monitoring is desired, various telemetry options (such as cellular or radio) are available to transmit the processed flux data. Certain conditions may also allow remote transmittal of time series data. Contact Campbell Scientific for more details.

Table 7-6: microSD flash card fill times

microSD flash card size	Fill time with gas analyzer and sonic only	Fill time with gas analyzer, sonic, FW, and biomet/energy balance sensors ^{1/}
2 GB	~29 days	~23 days
8 GB	~121 days	~92 days
16 GB	~242 days	~184 days

^{1/}Biomet and energy balance sensors used for this fill time estimate include the following: HMP155A, CS301, CS310, SI-111, TE525MM, TCAV (qty 3), CS655 (qty 3), and HFP01 (qty 3).

NOTE:

The microSD flash cards from various manufacturers may have slightly different memory sizes on their 2 GB, 8 GB, and 16 GB cards, respectively. Also, as a card ages, some of its sectors may become unusable, decreasing the available memory. Fill time estimates given in [Table 7-6](#) (p. 62) are approximations for new cards.

CAUTION:


Campbell Scientific recommends and supports only the use of microSD cards obtained from Campbell Scientific. These cards are industrial grade and have passed Campbell Scientific hardware quality testing. Use of consumer grade cards substantially increases the risk of data loss.

7.5 Output tables

Besides the `Const_Table` (see [Set constants](#) [p. 36]) and the standard `Public`, `Status`, `CPI Status`, and `DataTableInfo` tables that the data logger reports, the program has eight output tables. [Table 7-7](#) (p. 63) gives the names of these output tables, along with a short description, the

frequency at which a record is written to the table, and the amount of memory allocated from the CPU and microSD card for each table.

NOTE:

Variable naming conventions used by AmeriFlux and other flux networks have been adopted. Additionally, an EasyFlux output table called **Flux_AmeriFluxFormat** reports the data variables in the order and format prescribed by AmeriFlux (see <http://ameriflux.lbl.gov/data/aboutdata/data-variables/> )

The **Flux_CSFormat** and **Flux_Notes** tables may have some of the same outputs as they did in prior versions of closed-path flux system programs, although variable names have been updated to conform to AmeriFlux convention. If the user would prefer to have the data fields contained in the **Flux_Notes** table appended to the end of the **Flux_CSFormat** table, rather than being placed in a separate output table, then the user should change the constant **ONE_FULL_TABLE** from **FALSE** to **TRUE**. See [Set constants](#) (p. 36).

Table 7-7: Data output tables				
Table name	Description	Recording interval	Memory on CR6 CPU	Memory on microSD card
Time_Series	Time series data, aligned to account for electronic delays	SCAN_INTERVAL (default 100 ms)	Auto-Allocate (typically less than 1 hour)	Time_Series is broken up into files of size DAY_TSRS_CRD (default is 1-day files); see Table 7-6 (p. 62) for estimates of total days
Diagnostic	Most recent diagnostic flags from gas analyzer and sonic anemometer	SCAN_INTERVAL (default 100 ms)	1 record (most recent scan)	0 records
EC100_Config_Notes	Settings for the gas analyzer and sonic anemometer	When settings are changed or system is power cycled	128 records	10*DAY_FLUX_CRD record (default 300 records)

Table 7-7: Data output tables

Table name	Description	Recording interval	Memory on CR6 CPU	Memory on microSD card
Flux_AmeriFluxFormat	Processed flux and statistical data following AmeriFlux reporting conventions and order	OUTPUT_INTERVAL (default 30 min)	NMBR_DAY_CPU (default 7 days)	Broken up into multi-day files, where the number of days on each file is defined by DAY_FLUXCRD (default 30 days); see Table 7-6 (p. 62) to calculate number of files
Flux_CSFormat	Processed flux and statistical data	OUTPUT_INTERVAL (default 30 min)	NMBR_DAY_CPU (default 7 days)	Broken up into multi-day files, where the number of days on each file is defined by DAY_FLUXCRD (default 30 days); see Table 7-6 (p. 62) to calculate number of files
Flux_Notes	Intermediate variables, station constants, and correction variables used to generate flux results	OUTPUT_INTERVAL (default 30 min)	NMBR_DAY_CPU (default 7 days)	Broken up into multi-day files, where the number of days on each file is defined by DAY_FLUXCRD (default 30 days); see Table 7-6 (p. 62) to calculate number of files

Table 7-7: Data output tables				
Table name	Description	Recording interval	Memory on CR6 CPU	Memory on microSD card
ZeroSpan_Check_Notes	Summary of field calibration data at the time of a zero or span check	When a zero or span check is performed	NUMBR_RCRDS_CHK_NOTES_CPU (default 30 records or approximately 1 month)	NUMBR_RCRDS_CHK_NOTES_CRD (default 1,398 records or approximately 1 year)
System_Operatn_Notes	Records any change in system status	When there is a change in system status	NMBR_RCRDS_OPRTN_NOTES_CPU (default 24 records)	NMBR_RCRDS_OPRTN_NOTES_CRD (default 1,198 records)

Table 7-8 (p. 65) through Table 7-15 (p. 107) give a description of all data fields found in each data output table and when each data field is included in the table.

NOTE:

Prior to coordinate rotations, the orthogonal wind components from the sonic anemometer are denoted as U_x , U_y , and U_z . Following coordinate rotations, the common denotation of u , v , and w is used, respectively.

NOTE:

Variables with _R denote that the value was computed after coordinate rotations were done. Variables with _F denote that the value was calculated after frequency corrections were applied. Similarly, _SND and _WPL refer to variables that have had the SND correction or the WPL correction applied, respectively.

Table 7-8: Data fields in the Time_Series output table			
Data field name	Units	Description	Data field included
Ux	$\text{m}\cdot\text{s}^{-1}$	Wind speed along sonic x-axis	Always
Uy	$\text{m}\cdot\text{s}^{-1}$	Wind speed along sonic y-axis	Always

Table 7-8: Data fields in the Time_Series output table			
Data field name	Units	Description	Data field included
Uz	$\text{m}\cdot\text{s}^{-1}$	Wind speed along sonic z-axis	Always
T_SONIC	deg C	Sonic temperature	Always
diag_sonic	–	Raw sonic diagnostic value (0 indicates no diagnostic flags set)	Always
CO2	$\mu\text{mol}\cdot\text{mol}^{-1}$	CO ₂ dry molar mixing ratio	Always
H2O	$\text{mmol}\cdot\text{mol}^{-1}$	H ₂ O dry molar mixing ratio	Always
diag_irga	–	Raw gas analyzer diagnostic value (0 indicates no diagnostic flags set)	Always
TA_1_1_1	deg C	Air temperature calculated from sonic temperature and humidity	Always
T_cell	deg C	Sample cell temperature	Always
PA_cell	kPa	Air pressure inside sample cell	Always
CO2_sig_strgth	–	CO ₂ signal strength	Always
H2O_sig_strgth	–	H ₂ O signal strength	Always
PA_diff	kPa	Differential pressure (difference between sample cell pressure and ambient pressure)	Always
PA	kPa	Ambient pressure	Always
pump_flow	$\text{L}\cdot\text{min}^{-1}$	Volumetric air flow to pump; if using vortex intake, this includes sample flow and vortex bypass flow	Always

Table 7-8: Data fields in the Time_Series output table			
Data field name	Units	Description	Data field included
sampling_regime	Binary number	For CPEC310, this identifies the current sampling regime (bits 0 through 3 correspond to the current sampling site, and bit 4 is the omit flag); for computing fluxes, filter all values $\neq 1$ (1 corresponds to site 1, which is sampling ambient air with no omit flag set; see Sampling site, regime, and mode [p. 134] for more information on sampling sites and regimes)	If system is a CPEC310
FW	deg C	Air temperature measured by fine-wire thermocouple	If FW05, FW1, or FW3 is used

Table 7-9: Data fields in the Diagnostic output table		
Data field name	Description	Data field included
sonc_er	Sonic error flag (TRUE or -1 if any sonic diagnostic flag detected)	Always
irga_er	EC155 error flag (TRUE or -1 if any irga diagnostic flag detected)	Always
pump_tmpr_error	Pump temperature error flag	Always
pump_flw_error	Pump flow error flag	Always
valve_T_error	Valve temperature error flag	If CPEC310 with valve module is used
valve_flw_error	Valve flow error flag	If CPEC310 with valve module is used
scrub_T_error	Scrub temperature error flag	If scrub module is used
diag_sonic	CSAT3A diagnostic word; if 0 , no error flags set (see <i>EC155 CO₂/H₂O Closed-Path Gas Analyzer</i> manual for more details)	Always

Table 7-9: Data fields in the Diagnostic output table		
Data field name	Description	Data field included
sonic_amp_l_f	Amplitude low diagnostic flag	Always
sonic_amp_h_f	Amplitude high diagnostic flag	Always
sonic_sig_lck_f	Signal lock diagnostic flag	Always
sonic_del_T_f_f	Delta temperature diagnostic flag	Always
sonic_aq_sig_f	Acquiring signal diagnostic flag	Always
sonic_cal_err_f	Calibration error diagnostic flag	Always
CSAT3H_user_ctrl_flg	CSAT3AH heating control start	If CSAT3AH is used
CSAT3H_ctrl_on	Control status of CR300 in controller (TRUE if on; FALSE if off)	If CSAT3AH is used
T_trnsd_uppr	Average temperature of upper transducer	If CSAT3AH is used
T_trnsd_lwr	Average temperature of lower transducer	If CSAT3AH is used
pwr_trnsds	Power heating transducers	If CSAT3AH is used
trnsd_heater_on	If TRUE , transducer heater is on; FALSE if off	If CSAT3AH is used
trnsd_heater_fail	If TRUE , transducer heater failure detected	If CSAT3AH is used
T_arm_uppr	Average temperature of upper arm	If CSAT3AH is used
T_arm_lwr	Average temperature of lower arm	If CSAT3AH is used
pwr_arms	Power heating arms	If CSAT3AH is used
arm_heater_on	If TRUE , arm heater is on; FALSE if off	If CSAT3AH is used
arm_heater_fail	If TRUE , arm heater failure detected	If CSAT3AH is used
pwr_trnsds_arms	Heater power	If CSAT3AH is used
diag_sonic_slwintv	Aggregated diagnosis code within a slow scan interval	If CSAT3AH is used
trnsd_ice_wet_lck	Number of seconds in the interval that transducers were locked due to ice and wet	If CSAT3AH is used
heating_inaplcbl_f	Flag to indicate sonic heating would be inapplicable to improve the measurements	If CSAT3AH is used

Table 7-9: Data fields in the Diagnostic output table		
Data field name	Description	Data field included
com_rslt_get	Failure times in communication of data logger getting data from CR300	If CSAT3AH is used
com_rslt_snt	Failure times in communication of data logger sending data to CR300	If CSAT3AH is used
T_amb_ctrl	Average ambient air temperature of controller	If CSAT3AH is used
RH_amb_ctrl	Average ambient relative humidity of controller	If CSAT3AH is used
T_DP_amb_ctrl	Average ambient dew point temperature of controller	If CSAT3AH is used
diag_irga	EC155 diagnostic word; if 0 , no error flags set (see <i>EC155 CO₂/H₂O Closed-Path Gas Analyzer</i> manual for more details)	Always
irga_bad_data_f	Any gas analyzer diagnostic flag is set	Always
irga_gen_fault_f	General system fault diagnostic flag	Always
irga_startup_f	Startup diagnostic flag	Always
irga_motor_spd_f	Motor speed diagnostic flag	Always
irga_tec_tmpr_f	Thermoelectric cooler (TEC) temperature diagnostic flag	Always
irga_src_pwr_f	Source power diagnostic flag	Always
irga_src_tmpr_f	Source temperature diagnostic flag	Always
irga_src_curr_f	Source current diagnostic flag	Always
irga_off_f	Gas head power down diagnostic flag	Always
irga_sync_f	Synchronization diagnostic flag	Always
irga_cell_tmpr_f	Cell temperature probe diagnostic flag	Always
irga_cell_press_f	Cell pressure diagnostic flag	Always
irga_CO2_I_f	CO ₂ I signal diagnostic flag	Always
irga_CO2_lo_f	CO ₂ I/O signal diagnostic flag	Always
irga_H2O_I_f	H ₂ O I signal diagnostic flag	Always

Table 7-9: Data fields in the Diagnostic output table		
Data field name	Description	Data field included
irga_H2O_lo_f	H ₂ O I/O signal diagnostic flag	Always
irga_CO2_lo_var_f	CO ₂ I/O variation diagnostic flag	Always
irga_H2O_lo_var_f	H ₂ I/O variation diagnostic flag	Always
irga_CO2_sig_strgth_f	CO ₂ signal strength diagnostic flag	Always
irga_H2O_sig_strgth_f	H ₂ O signal strength diagnostic flag	Always
irga_cal_err_f	Calibration file read error flag	Always
irga_htr_ctrl_off_f	Heater control off diagnostic flag	Always
irga_diff_press_f	Differential pressure out of bounds flag	Always
CO2_sig_strgth	CO ₂ signal strength (service sample cell when <80%; see <i>EC155 CO₂/H₂O Closed-Path Gas Analyzer</i> manual)	Always
H2O_sig_strgth	H ₂ O signal strength (service sample cell when <80%; see <i>EC155 CO₂/H₂O Closed-Path Gas Analyzer</i> manual)	Always

Table 7-10: Data fields in the EC100_Config_Notes output table			
Data field name	Units	Description	Data field included
config_type	String	String indicating why the EC100 was reconfigured	Always
mode	String	String indicating sampling mode; see Sampling site, regime, and mode (p. 134)	If system is a CPEC310
site	String	String indicating sampling site; see Sampling site, regime, and mode (p. 134) for more details	If system is a CPEC310
bandwidth_freq	Hz	EC100 bandwidth (5, 10, 12.5, or 20 for 5 Hz, 10 Hz, 12.5 Hz, or 20 Hz, respectively)	Always

Table 7-10: Data fields in the EC100_Config_Notes output table			
Data field name	Units	Description	Data field included
press_source	–	Sensor used by EC100 for ambient pressure (0 for EC100 basic barometer, 1 for user/custom barometer, 2 for EC100 enhanced barometer)	Always
diff_press_select	–	Parameter indicating whether to report ambient pressure (open-path system) or differential pressure (closed-path system); should be set to 2 , which will auto-select	Always
sample_cell_press_type	–	Parameter indicating whether the sample cell pressure sensor is differential or absolute; set to 0 for EC155 gas head serial numbers <2000 and 1 for serial numbers ≥2000	Always
tmpr_source	–	Sensor used by EC100 for ambient temperature; set to 0 for EC100 temperature probe, no other values valid	Always
CO2_zero_coeff	–	CO ₂ zero coefficient set from last CO ₂ zero	Always
CO2_span_coeff	–	CO ₂ span coefficient set from last CO ₂ span	Always
CO2_span_mixra	μmol·mol ⁻¹	CO ₂ mixing ratio of span gas	Always
H2O_zero_coeff	–	H ₂ O zero coefficient set from last H ₂ O zero	Always
H2O_span_coeff	–	H ₂ O span coefficient set from last H ₂ O span	Always
H2O_span_T_DP	deg C	Dew point temperature of span gas	Always

Table 7-10: Data fields in the EC100_Config_Notes output table			
Data field name	Units	Description	Data field included
EC155_pwr_off	–	Parameter indicating whether EC155 gas head is in sleep or power-down mode; set to 0 for power on and 1 for power off	Always
CR6_Volts	V	Battery voltage as measured at CR6 battery input terminal	Always
Heater_volts	V	Voltage applied for EC155 heater	Always
Shadow_corr	–	Application of transducer shadowing correction; set to 0 for off and 1 for on	Always

Table 7-11: Data fields in the Flux_AmeriFluxFormat output table			
Data field name	Units	Description	Data field included
TIMESTAMP_START	YYYYMMDDHHMM	Start time of the averaging period	Always
TIMESTAMP_END	YYYYMMDDHHMM	End time of the averaging period	Always
CO2	$\mu\text{mol}\cdot\text{mol}^{-1}$	CO ₂ flux after corrections	Always
CO2_SIGMA	$\mu\text{mol}\cdot\text{mol}^{-1}$	Standard deviation of CO ₂	Always
H2O	$\text{mmol}\cdot\text{mol}^{-1}$	Average H ₂ O molar mixing ratio (dry basis)	Always
H2O_SIGMA	$\text{mmol}\cdot\text{mol}^{-1}$	Standard deviation of H ₂ O	Always
FC	$\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	CO ₂ flux after corrections	Always
FC_SSITC_TEST	–	Result of steady state and integral turbulence characteristics for FC according to Foken et al. (2004)	Always

Table 7-11: Data fields in the Flux_AmeriFluxFormat output table			
Data field name	Units	Description	Data field included
LE	$\text{W}\cdot\text{m}^{-2}$	Latent heat flux after corrections	Always
LE_SSITC_TEST	–	Result of steady state and integral turbulence characteristics for LE according to Foken et al. (2004)	Always
ET	$\text{mm}\cdot\text{hour}^{-1}$	Evapotranspiration	Always
ET_SSITC_TEST	–	Result of steady state and integral turbulence characteristics for ET according to Foken et al. (2004)	Always
H	$\text{W}\cdot\text{m}^{-2}$	Sensible heat flux after corrections	Always
H_SSITC_TEST	–	Result of steady state and integral turbulence characteristics for H according to Foken et al. (2004)	Always
G	$\text{W}\cdot\text{m}^{-2}$	Calculated heat flux at the ground surface	If energy balance sensors are used
SG	$\text{W}\cdot\text{m}^{-2}$	Change in heat storage in the soil above soil heat flux plates during averaging interval	If energy balance sensors are used
FETCH_MAX	m	Distance upwind where the maximum contribution to footprint is found	Always

Table 7-11: Data fields in the Flux_AmeriFluxFormat output table

Data field name	Units	Description	Data field included
FETCH_90	m	Upwind distance that contains 90% of cumulative footprint; if NAN is returned, integration of the model never reached 90% within the allowable distance of integration	Always
FETCH_55	m	Upwind distance that contains 55% of footprint	Always
FETCH_40	m	Upwind distance that contains 40% of footprint	Always
WD	decimal degrees	Average wind direction	Always
WS	$\text{m}\cdot\text{s}^{-1}$	Average wind speed	Always
WS_MAX	$\text{m}\cdot\text{s}^{-1}$	Maximum wind speed	Always
USTAR	$\text{m}\cdot\text{s}^{-1}$	Friction velocity	Always
ZL	–	Stability	Always
TAU	$\text{kg}\cdot\text{m}^{-1}\cdot\text{s}^{-2}$	Momentum flux	Always
TAU_SSITC_TEST	–	Result of steady state and integral turbulence characteristics for TAU according to Foken et al. (2004)	Always
MO_LENGTH	m	Monin-Obukhov length	Always
U	$\text{m}\cdot\text{s}^{-1}$	Average streamwise wind	Always
U_SIGMA	$\text{m}\cdot\text{s}^{-1}$	Standard deviation of streamwise wind	Always
V	$\text{m}\cdot\text{s}^{-1}$	Average crosswind	Always

Table 7-11: Data fields in the Flux_AmeriFluxFormat output table			
Data field name	Units	Description	Data field included
V_SIGMA	m·s ⁻¹	Standard deviation of crosswind	Always
W	m·s ⁻¹	Average vertical wind	Always
W_SIGMA	m·s ⁻¹	Standard deviation of vertical wind	Always
PA	kPa	Average atmospheric pressure	Always
PA_SIGMA	kPa	Standard deviation of atmospheric pressure	Always
TA_1_1_1	deg C	Average air temperature calculated from sonic temperature and H ₂ O mixing ratio	Always
TA_SIGMA_1_1_1	deg C	Standard deviation of air temperature calculated from sonic temperature and H ₂ O mixing ratio	Always
RH_1_1_1	%	Average relative humidity calculated from TA_1_1_1, H ₂ O mixing ratio, and pressure	Always
T_DP_1_1_1	deg C	Average dew point temperature calculated from H ₂ O mixing ratio and pressure	Always
TA_2_1_1	deg C	Average air temperature measured by temp/RH probe	If temp/RH probe is used
RH_2_1_1	%	Average relative humidity measured by temp/RH probe	If temp/RH probe is used

Table 7-11: Data fields in the Flux_AmeriFluxFormat output table			
Data field name	Units	Description	Data field included
T_DP_2_1_1	deg C	Average dew point temperature calculated from temp/RH probe measurements	If temp/RH probe is used
VPD	hPa	Vapour pressure deficit	If temp/RH probe is used
T_SONIC	deg C	Average sonic temperature	Always
T_SONIC_SIGMA	deg C	Standard deviation of sonic temperature	Always
PBLH	m	Estimated planetary boundary layer height	Always
SWC_x_1_1	%	Average volumetric soil water content; x is an index for the number of sensors	If CS650 or CS655 is used
TS_x_1_1	deg C	Average soil temperature; x is an index for the number of soil temperature measurements made	If TCAV or CS65X is used
ALB	–	Albedo	If SN500SS, NR01, or CNR4 is used
NETRAD	$W \cdot m^{-2}$	Net radiation	If SN500SS, NR01, or CNR4 is used
PPFD_IN	$\mu mol \cdot m^{-2} \cdot s^{-1}$	Photosynthetic photon density	If CS310 is used
SW_IN	$W \cdot m^{-2}$	Incoming short-wave radiation	If SN500SS, NR01, CNR4, CS301, or CS320 is used

Table 7-11: Data fields in the Flux_AmeriFluxFormat output table			
Data field name	Units	Description	Data field included
SW_OUT	$\text{W}\cdot\text{m}^{-2}$	Outgoing short-wave radiation	If SN500SS, NR01, or CNR4 is used
LW_IN	$\text{W}\cdot\text{m}^{-2}$	Incoming long-wave radiation	If SN500SS, NR01, or CNR4 is used
LW_OUT	$\text{W}\cdot\text{m}^{-2}$	Outgoing long-wave radiation	If SN500SS, NR01, or CNR4 is used
P	mm	Precipitation in output interval	If TE525 is used
T_CANOPY	deg C	Canopy temperature	If SI-111 is used

Table 7-12: Data fields in the Flux_CSFormat output table			
Data field name	Units	Description	Data field included
FC	$\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Final corrected CO_2 flux	Always
FC_mass	$\text{mg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Final corrected CO_2 flux	Always
FC_QC	grade	Overall quality grade for Fc_molar and Fc_mass following Foken et al. (2012); see Quality grading (p. 151) for quality grade definitions	Always
FC_samples	count	Total number of time series samples used in calculation of Fc	Always
LE	$\text{W}\cdot\text{m}^{-2}$	Final corrected latent heat flux	Always
LE_QC	grade	Overall quality grade for LE following Foken et al. (2012); see Quality grading (p. 151) for quality grade definitions	Always
LE_samples	count	Total number of time series samples used in calculation of LE	Always

Table 7-12: Data fields in the Flux_CSFormat output table			
Data field name	Units	Description	Data field included
H	$\text{W}\cdot\text{m}^{-2}$	Final corrected sensible heat flux derived from sonic sensible heat flux	Always
H_QC	grade	Overall quality grade for H following Foken et al. (2012); see Quality grading (p. 151) for quality grade definitions	Always
H_samples	count	Total number of time series samples used in calculation of H	Always
H_FW	$\text{W}\cdot\text{m}^{-2}$	Final corrected sensible heat flux derived from fine-wire thermocouple measurements	If FW05, FW1, or FW3 is used
H_FW_samples	count	Total number of time series samples used in calculation of H_FW	If FW05, FW1, or FW3 is used
NETRAD	$\text{W}\cdot\text{m}^{-2}$	Average net radiation (corrected for wind)	If SN500SS, NR01, or CNR4 is used
G	$\text{W}\cdot\text{m}^{-2}$	Heat flux at ground surface	If energy balance sensors are used
SG	$\text{W}\cdot\text{m}^{-2}$	Change in heat storage in the soil above the soil heat flux plates during the averaging interval	If energy balance sensors are used
energy_closure	fraction	Ratio of sensible and latent heat fluxes over surface heat flux plus net radiation	If energy balance sensors are used
poor_engr_clsur	–	If TRUE (non-0) , energy closure is poor despite reasonably good micrometeorological conditions with no precipitation; alerts user to examine instruments	If energy balance sensors and rain gauge are used
Bowen_ratio	fraction	Ratio of final sensible heat flux over final latent heat flux	Always
TAU	$\text{kg}\cdot\text{m}^{-1}\cdot\text{s}^{-2}$	Final corrected momentum flux	Always

Table 7-12: Data fields in the Flux_CSFormat output table

Data field name	Units	Description	Data field included
TAU_QC	grade	Overall quality grade for TAU following Foken et al. (2012); see Quality grading (p. 151) for quality grade definitions	Always
USTAR	m·s ⁻¹	Friction velocity after coordinate rotations and frequency corrections	Always
TSTAR	deg C	Scaling temperature after coordinate rotations, frequency corrections, and SND correction	Always
TKE	m ² ·s ⁻²	Specific turbulence kinetic energy after coordinate rotations	Always
TA_1_1_1	deg C	Average ambient temperature calculated from sonic temperature and H ₂ O mixing ratio	Always
TA_SIGMA_1_1_1	deg C	Standard deviation of ambient temperature calculated from sonic temperature and H ₂ O mixing ratio	Always
RH_1_1_1	deg C	Relative humidity calculated from TA_1_1_1, H ₂ O mixing ratio, and pressure	Always
T_DP_1_1_1	deg C	Average dew point temperature calculated using H ₂ O mixing ratio and ambient pressure	Always
e	kPa	Average water vapour pressure calculated using H ₂ O mixing ratio and ambient pressure	Always
e_sat	kPa	Average saturated water vapour pressure calculated using TA_1_1_1 and ambient pressure	Always
TA_2_1_1	deg C	Average ambient temperature measured by temp/RH probe	If temp/RH probe is used

Table 7-12: Data fields in the Flux_CSFormat output table			
Data field name	Units	Description	Data field included
RH_2_1_1	%	Average relative humidity measured by temp/RH probe	If temp/RH probe is used
T_DP_2_1_1	deg C	Average dew point temperature calculated using temp/RH probe measurements	If temp/RH probe is used
e_probe	kPa	Average water vapour pressure derived from temp/RH probe measurements	If temp/RH probe is used
e_sat_probe	kPa	Average saturated water vapour pressure derived from temp/RH probe measurements	If temp/RH probe is used
H2O_probe	$\text{g}\cdot\text{m}^{-3}$	Average water vapour density derived from temp/RH probe measurements	If temp/RH probe is used
PA	kPa	Average ambient air pressure	Always
PA_SIGMA	kPa	Standard deviation of ambient air pressure	Always
VPD	kPa	Average vapour pressure deficit	Always
U	$\text{m}\cdot\text{s}^{-1}$	Mean streamwise wind speed after coordinate rotations	Always
U_SIGMA	$\text{m}\cdot\text{s}^{-1}$	Standard deviation of streamwise wind after coordinate rotations	Always
V	$\text{m}\cdot\text{s}^{-1}$	Average crosswind speed after coordinate rotations	Always
V_SIGMA	$\text{m}\cdot\text{s}^{-1}$	Standard deviation of crosswind after coordinate rotations	Always
W	$\text{m}\cdot\text{s}^{-1}$	Average vertical wind speed after coordinate rotations	Always
W_SIGMA	$\text{m}\cdot\text{s}^{-1}$	Standard deviation of vertical wind after coordinate rotations	Always

Table 7-12: Data fields in the Flux_CSFormat output table

Data field name	Units	Description	Data field included
T_SONIC	deg C	Average sonic temperature	Always
T_SONIC_SIGMA	deg C	Standard deviation of sonic temperature	Always
sonic_azimuth	decimal degrees	Compass direction in which the sonic negative x-axis points	Always
WS	m·s ⁻¹	Average wind speed	Always
WS_RSLT	m·s ⁻¹	Average horizontal wind speed	Always
WD_SONIC	decimal degrees	Average wind direction in the sonic coordinate system	Always
WD_SIGMA	decimal degrees	Standard deviation of wind direction in the sonic coordinate system	Always
WD	decimal degrees	Average compass wind direction	Always
WS_MAX	m·s ⁻¹	Maximum wind speed	Always
CO2	μmol·mol ⁻¹	Average CO ₂ dry molar mixing ratio	Always
CO2_SIGMA	μmol·mol ⁻¹	Standard deviation of CO ₂ dry molar mixing ratio	Always
CO2_density	mg·m ⁻³	Average CO ₂ mass density	Always
CO2_density_SIGMA	mg·m ⁻³	Standard deviation of CO ₂ mass density	Always
H2O	mmol·mol ⁻¹	Average H ₂ O dry molar mixing ratio	Always
H2O_SIGMA	mmol·mol ⁻¹	Standard deviation of H ₂ O dry molar mixing ratio	Always
H2O_density	mmol·mol ⁻¹	Water vapour mass density	Always
H2O_density_SIGMA	mmol·mol ⁻¹	Standard deviation of water vapour mass density	Always
CO2_sig_strgth_Min	–	Minimum CO ₂ signal strength	Always

Table 7-12: Data fields in the Flux_CSFormat output table			
Data field name	Units	Description	Data field included
H2O_sig_strgth_Min	–	Minimum H ₂ O signal strength	Always
FW	deg C	Average fine-wire thermocouple temperature	If FW05, FW1, or FW3 is used
FW_SIGMA	deg C	Standard deviation of fine-wire thermocouple temperature	If FW05, FW1, or FW3 is used
P	mm	Total precipitation	If TE525MM is used
NETRAD	W·m ⁻²	Average net radiation (raw, not corrected for wind)	If net radiometer is used
ALB	–	Average albedo	If SN500SS, CNR4, or NR01 is used
SW_IN	W·m ⁻²	Average incoming short-wave radiation	If SN500SS, CNR4, CS301, CS320, or NR01 is used
SW_OUT	W·m ⁻²	Average outgoing short-wave radiation	If SN500SS, CNR4, or NR01 is used
LW_IN	W·m ⁻²	Average incoming long-wave radiation	If SN500SS, CNR4, or NR01 is used
LW_OUT	W·m ⁻²	Average outgoing long-wave radiation	If SN500SS, CNR4, or NR01 is used
T_nr	K	Average sensor body temperature	If CNR4 or NR01 is used
T_nr_in	K	Average sensor body temperature for pyrgeometer measuring LW_IN	If SN500SS is used
T_nr_out	K	Average sensor body temperature for pyrgeometer measuring LW_OUT	If SN500SS is used
R_LW_in_meas	W·m ⁻²	Average raw incoming long-wave radiation	If CNR4 or NR01 is used
R_LW_out_meas	W·m ⁻²	Average raw outgoing long-wave radiation	If CNR4 or NR01 is used

Table 7-12: Data fields in the Flux_CSFormat output table

Data field name	Units	Description	Data field included
PPFD_IN	$\mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$	Average density of photosynthetic active radiation	If CS310 is used
sun_azimuth	decimal degrees	Solar azimuth	Always
sun_elevation	decimal degrees	Solar elevation	Always
hour_angle	decimal degrees	Solar hour angle	Always
sun_declination	decimal degrees	Solar declination	Always
air_mass_coeff	–	Air mass coefficient; ratio of the path length between the current solar position to solar noon	Always
daytime	fraction	Day time in fraction of an output interval	Always
T_CANOPY	deg C	Average temperature of targeted object	If SI-111 is used
T_SI111_body	deg C	Average temperature of sensor body	If SI-111 is used
TS_x_1_1	deg C	Average soil temperature for each soil temperature sensor; x is an index for the number of sensors	If TCAV or CS650 or CS655 is used
SWC_x_1_1	$\text{m}^3\cdot\text{m}^{-3}$	Average volumetric soil water content for each CS650 or CS655; x is an index for the number of each sensor model above	If CS650 or CS655 is used
CS65x_ec_x_1_1	$\text{dS}\cdot\text{m}^{-1}$	Average electrical conductivity for each CS650 or CS655 sensor; x is an index for the number of sensors	If CS650 or CS655 is used

Table 7-12: Data fields in the Flux_CSFormat output table			
Data field name	Units	Description	Data field included
G_PLATE_x_1_1	$W \cdot m^{-2}$	Average heat flux through plate; x is an index for the number of HFP01 or HFP01SC	If HFP01 or HFP01SC is used
G_x_1_1	$W \cdot m^{-2}$	Soil heat flux at ground surface; x is an index for the number of soil sensor sets	If HFP01 or HFP01SC and CS65X are used
SG_x_1_1	$W \cdot m^{-2}$	Change in soil heat storage; x is an index for the number of soil sensor sets	If HFP01 or HFP01SC and CS65X are used
FETCH_MAX	m	Distance upwind where the maximum contribution to footprint is found	Always
FETCH_90	m	Upwind distance that contains 90% of cumulative footprint; if NAN is returned, integration of the model never reached 90% within the allowable distance of integration	Always
FETCH_55	m	Upwind distance that contains 55% of footprint	Always
FETCH_40	m	Upwind distance that contains 40% of footprint	Always
UPWND_DIST_INTRST	m	Upwind distance of interest for the average wind direction	Always
FTPRT_DIST_INTRST	%	Percentage of footprint from within the upwind range of interest	Always
FTPRT_EQUATION	text	Returns either Kljun or KormannMeixner; the model of Kljun et al. (2004) is used for applicable atmospheric conditions, else the model of Kormann & Meixner (2001) is used	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
Ux	$\text{m}\cdot\text{s}^{-1}$	Average U_x	Always
Ux_SIGMA	$\text{m}\cdot\text{s}^{-1}$	Standard deviation of U_x	Always
Uy	$\text{m}\cdot\text{s}^{-1}$	Average U_y	Always
Uy_SIGMA	$\text{m}\cdot\text{s}^{-1}$	Standard deviation of U_y	Always
Uz	$\text{m}\cdot\text{s}^{-1}$	Average U_z	Always
Uz_SIGMA	$\text{m}\cdot\text{s}^{-1}$	Standard deviation of U_z	Always
UxUy_cov	$\text{m}^2\cdot\text{s}^{-2}$	Covariance of U_x and U_y	Always
UxUz_cov	$\text{m}^2\cdot\text{s}^{-2}$	Covariance of U_x and U_z	Always
UyUz_cov	$\text{m}^2\cdot\text{s}^{-2}$	Covariance of U_y and U_z	Always
TsUx_cov	$\text{deg C}\cdot\text{m}\cdot\text{s}^{-1}$	Covariance of T_s and U_x	Always
TsUy_cov	$\text{deg C}\cdot\text{m}\cdot\text{s}^{-1}$	Covariance of T_s and U_y	Always
TsUz_cov	$\text{deg C}\cdot\text{m}\cdot\text{s}^{-1}$	Covariance of T_s and U_z	Always
USTAR_R	$\text{m}\cdot\text{s}^{-1}$	Friction velocity after coordinate rotations	Always
UV_cov	$\text{m}\cdot\text{s}^{-1}$	Covariance of streamwise wind and crosswind after coordinate rotations	Always
UW_cov	$\text{m}\cdot\text{s}^{-1}$	Covariance of streamwise wind and vertical wind after coordinate rotations	Always
VW_cov	$\text{m}\cdot\text{s}^{-1}$	Covariance of crosswind and vertical wind after coordinate rotations	Always
UT_SONIC_Cov	$\text{m}\cdot\text{deg C}\cdot\text{s}^{-1}$	Covariance of streamwise wind and sonic temperature after coordinate rotations	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
VT_SONIC_Cov	$\text{m}\cdot\text{deg C}\cdot\text{s}^{-1}$	Covariance of crosswind and sonic temperature after coordinate rotations	Always
WT_SONIC_Cov	$\text{m}\cdot\text{deg C}\cdot\text{s}^{-1}$	Covariance of vertical wind and sonic temperature after coordinate rotations	Always
UW_Cov_fc	$\text{m}^2\cdot\text{s}^{-2}$	Covariance of streamwise wind and vertical wind after coordinate rotations and frequency corrections	Always
VW_Cov_fc	$\text{m}^2\cdot\text{s}^{-2}$	Covariance of crosswind and vertical wind after coordinate rotations and frequency corrections	Always
WT_SONIC_Cov_fc	$\text{m}\cdot\text{deg C}\cdot\text{s}^{-1}$	Covariance of vertical wind and sonic temperature after coordinate rotations and frequency corrections	Always
WT_SONIC_Covfc_SND	$\text{m}\cdot\text{deg C}\cdot\text{s}^{-1}$	Covariance of vertical wind and sonic temperature after coordinate rotations, frequency corrections, and SND correction	Always
sonic_samples	count	Number of raw sonic samples in averaging period without diagnostic flags	Always
no_sonic_head_Tot	count	Number of sonic samples where no sonic head was detected	Always
no_new_sonic_data_Tot	count	Number of scans where no sonic data was received	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
sonic_amp_l_f_Tot	count	Number of sonic samples with amplitude low diagnostic flag	Always
sonic_amp_h_f_Tot	count	Number of sonic samples with amplitude high diagnostic flag	Always
sonic_sig_lck_f_Tot	count	Number of sonic samples with signal lock diagnostic flag	Always
sonic_del_T_f_Tot	count	Number of sonic samples with delta temperature diagnostic flag	Always
sonic_aq_sig_f_Tot	count	Number of sonic samples with acquiring signal diagnostic flag	Always
sonic_cal_err_f_Tot	count	Number of sonic samples with calibration error diagnostic flag	Always
CSAT3H_user_ctrl_on_Tot	count	Number of times CSAT3H_user_ctrl_on from data logger to heater controller	If CSAT3AH is used
CSAT3H_ctrl_on_Tot	count	Number of times CSAT3H_ctrl_on in the heater controller itself	If CSAT3AH is used
T_trnsd_uppr	deg C	Average temperature of top transducer	If CSAT3AH is used
T_trnsd_uppr_Min	deg C	Minimum temperature of top transducer	If CSAT3AH is used
T_trnsd_lwr	deg C	Average temperature of lower transducer	If CSAT3AH is used

Table 7-13: Data fields in the Flux_Notes output table			
Data field name	Units	Description	Data field included
T_trnsd_lwr_Min	deg C	Minimum temperature of lower transducer	If CSAT3AH is used
pwr_trnsd_Max	W	Power used by heating transducers	If CSAT3AH is used
trnsd_heater_secs	s	Number of seconds in the interval that transducer was heating	If CSAT3AH is used
trnsd_heater_fail_Tot	count	Number of transducer heater failures	If CSAT3AH is used
T_arm_uppr	deg C	Average temperature of upper arm	If CSAT3AH is used
T_arm_uppr_Min	deg C	Minimum temperature of upper arm	If CSAT3AH is used
T_arm_lwr	deg C	Average temperature of lower arm	If CSAT3AH is used
T_arm_lwr_Min	deg C	Minimum temperature of lower arm	If CSAT3AH is used
pwr_arms_Max	W	Power used by heating arms	If CSAT3AH is used
arm_heater_secs	s	Number of seconds in the interval that arms were heating	If CSAT3AH is used
arm_heater_fail_Tot	count	Number of arm heater failures	If CSAT3AH is used
pwr_hr_trnsds_arms	W	Hourly power used by arms and transducers	If CSAT3AH is used
trnsd_ice_wet_lck	s	Number of seconds in the interval that sonic transducer was locked due to ice and wet	If CSAT3AH is used

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
heating_inaplcbl_f_Tot	count	Number of flags indicating sonic heating would be inapplicable to improve measurements	If CSAT3AH is used
T_amb_ctrl	deg C	Average ambient air temperature of controller	If CSAT3AH is used
T_amb_ctrl_Min	deg C	Minimum ambient air temperature of controller	If CSAT3AH is used
RH_amb_ctrl_Max	%	Maximum ambient relative humidity of controller	If CSAT3AH is used
T_DP_amb_ctrl_Max	deg C	Average ambient dew point temperature of controller	If CSAT3AH is used
com_rslt_get_Tot	count	Number of successes in getting data from CR300	If CSAT3AH is used
com_rslt_snt_Tot	count	Number of successes in sending data to CR300	If CSAT3AH is used
UxCO2_Cov	$\text{mg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of U_x and CO_2 density	Always
UyCO2_Cov	$\text{mg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of U_y and CO_2 density	Always
UzCO2_Cov	$\text{mg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of U_z and CO_2 density	Always
UxH2O_Cov	$\text{g}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of U_x and water vapour density	Always
UyH2O_Cov	$\text{g}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of U_y and water vapour density	Always
UzH2O_Cov	$\text{g}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of U_z and water vapour density	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
UCO2_Cov	$\text{mg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of streamwise wind and CO ₂ density after coordinate rotations	Always
VCO2_Cov	$\text{mg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of crosswind and CO ₂ density after coordinate rotations	Always
WCO2_Cov	$\text{mg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of vertical wind and CO ₂ density after coordinate rotations	Always
UH2O_Cov	$\text{g}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of streamwise wind and H ₂ O density after coordinate rotations	Always
VH2O_Cov	$\text{g}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of crosswind and H ₂ O density after coordinate rotations	Always
WH2O_Cov	$\text{g}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of vertical wind and H ₂ O density after coordinate rotations	Always
WCO2_Cov_fc	$\text{mg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of vertical wind and CO ₂ density after coordinate rotations and frequency corrections	Always
WH2O_Cov_fc	$\text{g}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$	Covariance of vertical wind and H ₂ O density after coordinate rotations and frequency corrections	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
CO2_samples	count	Number of CO ₂ samples without diagnostic flags, within threshold for CO ₂ signal strength (set in code to default of 0.7), and within factory calibrated CO ₂ measurement range (0 to 1000 $\mu\text{mol}\cdot\text{mol}^{-1}$)	Always
H2O_samples	count	Number of H ₂ O samples without diagnostic flags, within threshold for H ₂ O signal strength (set in code to default of 0.7), and within factory calibrated H ₂ O measurement range (0 to 72 $\text{mmol}\cdot\text{mol}^{-1}$)	Always
no_irga_head_Tot	count	Number of samples where no gas analyzer head was detected	Always
no_new_irga_data_Tot	count	Number of scans where no gas analyzer data was received	Always
irga_bad_data_f_Tot	count	Number of IRGA samples with any IRGA diagnostic flag set high	Always
irga_gen_fault_f_Tot	count	Number of gas analyzer samples with general system fault diagnostic flag	Always
irga_startup_f_Tot	count	Number of gas analyzer samples with startup diagnostic flag	Always

Table 7-13: Data fields in the Flux_Notes output table			
Data field name	Units	Description	Data field included
irga_motor_spd_f_Tot	count	Number of gas analyzer samples with motor speed diagnostic flag	Always
irga_tec_tmpr_f_Tot	count	Number of gas analyzer samples with TEC temperature diagnostic flag	Always
irga_src_pwr_f_Tot	count	Number of gas analyzer samples with source power diagnostic flag	Always
irga_src_tmpr_f_Tot	count	Number of gas analyzer samples with source temperature diagnostic flag	Always
irga_src_curr_f_Tot	count	Number of gas analyzer samples with source current diagnostic flag	Always
irga_off_f_Tot	count	Number of gas analyzer samples with gas head power down diagnostic flag	Always
irga_sync_f_Tot	count	Number of gas analyzer samples with synchronization diagnostic flag	Always
irga_amb_tmpr_f_Tot	count	Number of gas analyzer samples with ambient temperature probe diagnostic flag	Always
irga_amb_press_f_Tot	count	Number of gas analyzer samples with ambient pressure diagnostic flag	Always
irga_CO2_I_f_Tot	count	Number of gas analyzer samples with CO ₂ I signal diagnostic flag	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
irga_CO2_lo_f_Tot	count	Number of gas analyzer samples with CO ₂ I/O signal diagnostic flag	Always
irga_H2O_I_f_Tot	count	Number of gas analyzer samples with H ₂ O I signal diagnostic flag	Always
irga_H2O_lo_f_Tot	count	Number of gas analyzer samples with H ₂ O I/O signal diagnostic flag	Always
irga_CO2_lo_var_f_Tot	count	Number of gas analyzer samples with CO ₂ I/O variation diagnostic flag	Always
irga_H2O_lo_var_f_Tot	count	Number of gas analyzer samples with H ₂ O I/O variation diagnostic flag	Always
irga_CO2_sig_strgth_f_Tot	count	Number of gas analyzer samples with CO ₂ signal strength diagnostic flag	Always
irga_H2O_sig_strgth_f_Tot	count	Number of gas analyzer samples with H ₂ O signal strength diagnostic flag	Always
irga_cal_err_f_Tot	count	Number of gas analyzer samples with calibration file read error flag	Always
irga_htr_ctrl_off_f_Tot	count	Number of gas analyzer samples with heater control off diagnostic flag	Always
irga_diff_press_f_Tot	count	Number of gas analyzer samples with differential pressure out of range diagnostic flag	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
UxFW_cov	deg C·m·s ⁻¹	Covariance of U_x and fine-wire thermocouple temperature	If FW05, FW1, or FW3 is used
UyFW_cov	deg C·m·s ⁻¹	Covariance of U_y and fine-wire thermocouple temperature	If FW05, FW1, or FW3 is used
UzFW_cov	deg C·m·s ⁻¹	Covariance of U_z and fine-wire thermocouple temperature	If FW05, FW1, or FW3 is used
UFW_cov	deg C·m·s ⁻¹	Covariance of streamwise wind and fine-wire thermocouple temperature after coordinate rotations	If FW05, FW1, or FW3 is used
VFW_cov	deg C·m·s ⁻¹	Covariance of crosswind and fine-wire thermocouple temperature after coordinate rotations	If FW05, FW1, or FW3 is used
WFW_cov	deg C·m·s ⁻¹	Covariance of vertical wind and fine-wire thermocouple temperature after coordinate rotations	If FW05, FW1, or FW3 is used
WFW_cov_fc	deg C·m·s ⁻¹	Covariance of vertical wind and fine-wire thermocouple temperature after coordinate rotations and frequency corrections	If FW05, FW1, or FW3 is used
FW_samples	count	Number of valid fine-wire thermocouple measurements in the averaging period from which covariances may be calculated	If FW05, FW1, or FW3 is used

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
pump_tmpr	deg C	Average pump temperature	Always
pump_press	kPa	Average pump pressure	Always, but data is excluded during CO ₂ or H ₂ O span
pump_flow_duty_cycle	Adimensional	Average pump duty cycle (0 is off and 1 is full power)	Always, but data is excluded during CO ₂ or H ₂ O span
pump_flow_set_pt	kPa	Pressure set point of sample cell	Always
pump_heater_secs	s	Number of seconds in the interval that pump heater was on	Always
pump_fan_secs	s	Number of seconds in the interval that pump fan was on	Always
valve_tmpr	deg C	Average temperature of valve module	If CPEC310 with valve module is used
valve_heater_secs	s	Number of seconds in the interval that valve module heater was on	If CPEC310 with valve module is used
valve_fan_secs	s	Number of seconds in the interval valve module fan was on	If CPEC310 with valve module is used
scrub_tmpr	deg C	Average temperature of scrub module	If scrub module is used
scrub_press	kPa	Average pressure of scrub module	If scrub module is used
scrub_heater_secs	s	Number of seconds in the interval that scrub module heater was on	If scrub module is used

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
scrub_fan_secs	s	Number of seconds in the interval that scrub module fan was on	If scrub module is used
cell_tmpr	deg C	Average temperature of sample cell	Always
cell_tmpr_SIGMA	deg C	Standard deviation of sample cell temperature	Always
cell_press	kPa	Average pressure inside sample cell	Always
cell_press_SIGMA	kPa	Standard deviation of sample cell pressure	Always
diff_press	kPa	Differential pressure (the difference in pressure between sample cell and ambient)	Always
pump_flow	L·min ⁻¹	Average volumetric flow to pump (sum of sample flow and vortex bypass flow)	Always
pump_flow_SIGMA	L·min ⁻¹	Standard deviation of pump flow	Always
cell_e	kPa	Average vapour pressure in sample cell	Always
cell_T_DP	deg C	Average dew point temperature inside sample cell	Always
cell_e_sat	kPa	Average saturation vapour pressure inside sample cell	Always
cell_RH	%	Average relative humidity inside sample cell	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
alpha	decimal degrees	Alpha angle used for coordinate rotations (regardless of planar fit or double rotation method, the angle convention of Wilczak, Oncley, and Stage [2001] is used)	Always
beta	decimal degrees	Beta angle used for coordinate rotations (regardless of planar fit or double rotation method, the angle convention of Wilczak, Oncley, and Stage [2001] is used)	Always
gamma	decimal degrees	Gamma angle used for coordinate rotations (regardless of planar fit or double rotation method, the angle convention of Wilczak, Oncley, and Stage [2001] is used)	Always
height_measurement	m	User-entered measurement height of eddy-covariance sensors	Always
height_canopy	m	User-entered canopy height	Always
surface_type_text	text	User-entered surface type	Always
displacement_user	m	User-entered displacement height; 0 for auto calculation	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
d	m	Displacement height used in calculations (this will be equal to displacement_user if user entered a non-0 value; if displacement_user is 0 , program will auto calculate)	Always
roughness_user	m	User-entered roughness length; 0 for calculation	Always
z0	m	Roughness length used in calculations (this will be equal to roughness_user if user entered a non-0 value; if roughness_user is 0 , program will auto calculate)	Always
z	m	Aerodynamic height	Always
MO_LENGTH	m	Monin-Obukhov length	Always
ZL	m·m ⁻¹	Atmospheric surface layer stability	Always
iteration_FreqFactor	count	Number of iterations for recalculating Monin-Obukhov length and frequency factors	Always
latitude	decimal degrees	Latitude; positive for northern hemisphere, negative for southern hemisphere	Always
longitude	decimal degrees	Longitude; positive for eastern hemisphere, negative for western hemisphere	Always

Table 7-13: Data fields in the Flux_Notes output table			
Data field name	Units	Description	Data field included
altitude	m	Number of meters above sea level at the site	Always
UTC_offset	hr	Time offset in hours between the site local standard time and UTC/GMT	Always
separation_x_irga	m	Separation between sonic anemometer and gas analyzer with respect to sonic x-axis	Always
separation_y_irga	m	Separation between sonic anemometer and gas analyzer with respect to sonic y-axis	Always
separation_lat_dist_irga	m	Separation distance between sonic anemometer and gas analyzer along the axis perpendicular to oncoming wind	Always
separation_lag_dist_irga	m	Separation distance between sonic anemometer and gas analyzer along the axis parallel to oncoming wind	Always
separation_lag_scan_irga	scans	Number of scans to lag gas analyzer data relative to sonic anemometer data to account for separation along the axis of oncoming wind and wind velocity	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
separation_x_FW	m	Separation between sonic anemometer and fine-wire thermocouple with respect to sonic x-axis	If FW05, FW1, or FW3 is used
separation_y_FW	m	Separation between sonic anemometer and fine-wire thermocouple with respect to sonic anemometer y-axis	If FW05, FW1, or FW3 is used
FW_diameter	m	Effective diameter of fine-wire thermocouple junction	If FW05, FW1, or FW3 is used
separation_lat_dist_FW	m	Separation distance between sonic anemometer and fine-wire thermocouple along axis perpendicular to oncoming wind	If FW05, FW1, or FW3 is used
separation_lag_dist_FW	m	Separation distance between sonic anemometer and fine-wire thermocouple along axis parallel to oncoming wind	If FW05, FW1, or FW3 is used
separation_lag_scan_FW	scans	Number of scans to lag fine-wire thermocouple data relative to sonic anemometer data to account for separation along axis of oncoming wind and wind velocity	If FW05, FW1, or FW3 is used
time_const_FW	m	Calculated time constant of fine-wire thermocouple	If FW05, FW1, or FW3 is used

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
MAX_LAG	scans	Maximum number of scans to lag gas analyzer or fine-wire thermocouple data with respect to sonic anemometer data when doing cross correlation for covariance maximization (for example, if MAX_LAG = 2, the program will consider lags of -2, -1, 0, +1, and +2)	Always
lag_CO2	scans	Lag applied to CO ₂ data with respect to sonic anemometer data that maximizes covariance	Always
lag_H2O	scans	Lag applied to H ₂ O data with respect to sonic anemometer data that maximizes covariance	Always
lag_FW	scans	Lag applied to fine-wire thermocouple data with respect to sonic anemometer data that maximizes covariance	Always
FreqFactor_UW_VW	number	Frequency correction factor applied to momentum fluxes	Always
FreqFactor_WT_SONIC	number	Frequency correction factor applied to wTs covariance	Always
FreqFactor_WCO2	number	Frequency correction factor applied to wCO ₂ covariance	Always
FreqFactor_WH2O	number	Frequency correction factor applied to wH ₂ O covariance	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
FreqFactor_WFW	number	Frequency correction factor applied to fine-wire thermocouple derived wFW covariance	Always
rho_d	$\text{g}\cdot\text{m}^{-3}$	Average density of dry air calculated from eddy-covariance sensors	Always
rho_a	$\text{kg}\cdot\text{m}^{-3}$	Average density of ambient moist air calculated from eddy-covariance sensors	Always
rho_d_probe	$\text{g}\cdot\text{m}^{-3}$	Average density of dry air calculated from temp/RH probe measurements	If temp/RH probe is used
rho_a_probe	$\text{kg}\cdot\text{m}^{-3}$	Average density of ambient moist air calculated from temp/RH probe measurements	If temp/RH probe is used
Cp	$\text{J}\cdot\text{kg}^{-1}\cdot\text{K}^{-1}$	Specific heat of ambient moist air at constant pressure	Always
Lv	$\text{J}\cdot\text{g}^{-1}$	Latent heat of vaporization	Always
T_panel	deg C	Average temperature of data logger wiring panel	Always
T_panel_CDM_VOLT_x	deg C	Average panel temperature of VOLT 116, where x at the end of the name is an index from 1 to 4, representing each of the thermistors under the terminal strips of the VOLT 116	If VOLT 116 is used

Table 7-13: Data fields in the Flux_Notes output table			
Data field name	Units	Description	Data field included
nr01_heater_secs	s	Number of seconds in the averaging interval that NR01 heater was enabled	If NR01 is used
cnr4_fan_secs	s	Number of seconds in the averaging interval that CNR4 fan was enabled	If CNF4 with CNR4 is used
cnr4_heater_1_secs	s	Number of seconds in the averaging interval that CNR4 heater #1 was enabled	If CNF4 with CNR4 is used
cnr4_heater_2_secs	s	Number of seconds in the averaging interval that CNR4 heater #2 was enabled	If CNF4 with CNR4 is used
sn500_heater_secs	s	Number of seconds in the averaging interval that SN500SS heater was enabled	If SN500SS is used
V_CS320	mV	Output voltage from CS320	If CS320 is used
T_CS320	deg C	Body temperature of CS320	If CS320 is used
x_incline	decimal degrees	Pyranometer incline relative to its x-axis	If CS320 is used
y_incline	decimal degrees	Pyranometer incline relative to its y-axis	If CS320 is used
z_incline	decimal degrees	Pyranometer incline relative to its z-axis	If CS320 is used

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
shfp_cal_x_1_1	$\text{W}\cdot\text{m}^{-2}\cdot\text{mV}^{-1}$	Calibrated multiplier for heat flux plate (if HFP01 is used, this value is 1,000 divided by the sensitivity as reported in the calibration sheet; if HFP01SC is used, this is determined from self-calibration), where x is an index for the number of sensors	If HFP01 or HFP01SC is used
shfp_cal_fail_x_1_1	text	Reads TRUE if any readings from HFP01SC were not valid (NAN) or if calibrated sensitivity was <80% or >105% of the nominal sensitivity reported on the sensor calibration sheet (x is an index for the number of sensors)	If HFP01SC is used
batt_volt	volt	Average battery voltage supplying power to data logger	Always
slowsequence_Tot	count	Number of slow sequences during averaging interval (for example, the number of times biomet and energy balance sensors were measured)	Always
process_time	ms	Average processing time for each scan	Always
process_time_SIGMA	ms	Standard deviation of scan time	Always

Table 7-13: Data fields in the Flux_Notes output table

Data field name	Units	Description	Data field included
process_time_Max	ms	Maximum processing time for a scan	Always
process_time_Min	ms	Minimum processing time for a scan	Always
buff_depth	number	Average number of records stored in buffer	Always
buff_depth_Max	number	Maximum number of records stored in buffer	Always

Table 7-14: Data fields in the ZeroSpan_Check_Notes data output table

Data field name	Units	Description	Data field included
check	adimensional	String indicating to which type of zero or span the record corresponds (possible types: zero, CO2Span, H2OSpan)	Always
drifted_f	Boolean	Reads TRUE if the zero or span measurement drifted beyond a 95% probability of its being within a normal distribution of the expected value	Always
CO2_reference	$\mu\text{mol}\cdot\text{mol}^{-1}$	CO ₂ mixing ratio of reference gas during zero or span check	Always
CO2	$\mu\text{mol}\cdot\text{mol}^{-1}$	Measured CO ₂ mixing ratio during zero or span check	Always
H2O_reference	$\text{mmol}\cdot\text{mol}^{-1}$	H ₂ O mixing ratio of reference gas during zero or span check	Always
H2O	$\text{mmol}\cdot\text{mol}^{-1}$	Measured H ₂ O mixing ratio during zero or span check	Always
cell_tmp	deg C	Sample cell temperature during zero or span check	Always

Table 7-14: Data fields in the ZeroSpan_Check_Notes data output table

Data field name	Units	Description	Data field included
cell_press	kPa	Sample cell pressure during zero or span check	Always
diff_press	kPa	Differential pressure between ambient and sample cell during zero or span check	Always
valv_press_offset	kPa	Offset in differential pressure measured while pump is off	Always
Td_reference	deg C	Dew point temperature of reference gas during zero or span check	Always
Cell_T_DP	deg C	Dew point temperature inside sample cell during zero or span check	Always
valve_flow	L·min ⁻¹	Mean flow during zero or span check	Always
valve_flow_set	L·min ⁻¹	Set point for flow during zero or span check	Always
scrub_press	kPa	Scrub module gauge pressure during zero	If scrub module is used
CO2_sig_strgth_zero	adimensional	CO ₂ signal strength during zero	Always
H2O_sig_strgth_zero	adimensional	H ₂ O signal strength during zero	Always
valve_tmpr_ok	Boolean	Reads TRUE if valve module temperature is within operating range	If CPEC310 is used
scrub_tmpr_ok	Boolean	Reads TRUE if scrub module temperature is within operating range	If CPEC310 and scrub module are used

Table 7-15: Data fields in the System_Operatn_Notes data output table			
Data field name	Units	Description	Data field included
Message	Text string	Message describing a change of system status	Always
Current value	Text string	Additional information corresponding to Message	Always
Previous value	Text String	Additional information corresponding to Message	Always

7.6 Program sequence of measurement and corrections

The main correction procedures and algorithms implemented into the program are included in the following numbered list. For more information on the sequence of measurements and corrections, refer to [EasyFlux DL CR6CP process flow](#) (p. 125).

1. Despike and filter raw time series data using sonic anemometer and gas analyzer diagnostic codes and signal strength and measurement output range thresholds.
2. Coordinate rotations with an option to use the double rotation method (Tanner and Thurtell 1969) or planar fit method (Wilczak, Oncley, and Stage 2001).
3. Lag CO₂ and H₂O measurements relative to sonic wind measurements for maximization of CO₂ and H₂O covariances (Horst and Lenschow 2009; Foken et al. 2012), with additional constraints to ensure lags are physically possible.
4. Frequency corrections using commonly used cospectra (Moore 1986; van Dijk 2002a; Moncrieff et al. 1997) and transfer functions of block averaging (Kaimal, Clifford, and Lataitis 1989), line/volume averaging (Moore 1986; Moncrieff et al. 1997; Foken et al. 2012; van Dijk 2002a), time constants (Montgomery 1947; Shapland et al. 2014; Geankoplis 1993), sensor separation (Horst and Lenschow 2009; Foken et al. 2012), and tube attenuation (Ibrom et al. 2007; Burgon et al. 2015).
5. A modified SND correction (Schotanus, Nieuwstadt, and de Bruin 1983) to derive sensible heat flux from sonic sensible heat flux following the implementation as outlined in van Dijk (2002b). Additionally, fully corrected real sensible heat flux computed from fine-wire thermometry to be provided.

6. Data quality qualifications based on steady state conditions, surface-layer turbulence characteristics, and wind directions following Foken et al. (2012) for the Flux_CSFormat output table or Foken et al. (2004) for the Flux_AmeriFluxFormat output table.
7. If energy balance sensors are used, calculation of energy closure based on energy balance measurements and corrected sensible and latent heat fluxes.
8. Footprint characteristics are computed using Kljun et al. (2004) and Kormann and Meixner (2001).

NOTE:

The appendices in the *EasyFlux DL CR6OP or CR1KXOP* manual describe the implementation of the major corrections in *EasyFlux DL CR6CP*, with the exception of frequency correction for tube attenuation, which is described in Ibrom et al. (2007), Burgon et al. (2015), and the code itself. It should also be noted that the appendix on WPL density corrections for open-path is not applicable here, since the closed-path analyzer gas concentrations are output as dry molar mixing ratios.

8. Zero and span

Since a CPEC310 system includes a valve module, it may be configured to self-initiate an automatic zero and span of the EC155 gas analyzer. The timing, whether the system will simply check the drift or actually set new zero/span coefficients, and whether the automatic zero/span will include an H₂O span, are all determined by user-entered constants relating to a CPEC310 (see constants that are indented under the constant “CPEC310” in [Table 7-1](#) [p. 39]). An automatic zero-and-span cycle on a CPEC310 may be manually initiated at any time; instructions to do so are found in [User-initiated zero/span for CPEC310](#) (p. 115).

For CPEC310 systems that are not set up with a continuously available source of H₂O span gas, which is typically the case, H₂O spans must be manually set up and initiated by the user. More details are found in [CPEC310 manual H2O span](#) (p. 118).

CPEC306 systems require the user to manually set up and initiate the zero, CO₂ span, and/or H₂O span, since these systems do not include a valve module. More details are found under [User-initiated manual zero/span for CPEC306](#) (p. 119).

Regardless of system type, performing a user-initiated zero or span is most easily done using the CR1000KD keypad. This requires connecting a CR1000KD to the **CS I/O** port of the CR6 data logger and initiating the process while the program is running. Press **Enter** twice to access the main menu, then use the keypad down arrow to scroll to the submenu **Attendant Zero/Span**.

Highlight and press **Enter**. This menu accesses all menus and variables needed for doing a zero and span as explained in the following sections.

NOTE:

If a tall tower installation requires the CR6 to be far away from the EC155 gas analyzer, making it inconvenient to access the CR1000KD, it may be more practical to use a laptop running *ECMon* software to set the zero and spans, as explained in the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual.

For reference, [Figure 7-2](#) (p. 49) shows an organizational schematic for all the keypad menus. To return to a previous menu at any time, press **Esc**.

NOTE:

[Table 8-1](#) (p. 110) lists the variables found within the **Attendant Zero/Span** menu and its submenus. The table also shows the equivalent variable names in the data logger public table. If a CR1000KD is not available, performing a zero/span may alternatively be done from *LoggerNet* software by using the **Connect Screen** to create a numeric display that includes all the variables in [Table 8-1](#) (p. 110). Follow the instructions in the sections above, substituting public table variable names (last column in [Table 8-1](#) [p. 110]) for the variable names in the menus (first column in [Table 8-1](#) [p. 110]).

NOTE:

Aliases have been used for public variables found in the zero and span menus in order to make the meanings of the variable more readily understood or to shorten the length of the variable names so they fit on the keypad display screen.

Table 8-1: Variables found in menus for zero and span

Variable name		Default	Description	Name of variable in Public table (if no CR1000KD is available)
Valv Tmpr Ctrl or Valv/Scrub Tmpr Ctrl	Valv T Ok	–	A TRUE/FALSE read-only variable. It must read TRUE to perform an auto zero/span; if FALSE , the valve module temperature is not within its operating range, and Val T Ctl On should be set to TRUE to bring the temperature within range. (Omitted if the system is a CPEC306.)	valve_tmpr_ok
	Valv T	–	A read-only variable showing the temperature in °C of the valve module. (Omitted if the system is a CPEC306.)	valve_tmpr
	Scrb T Ok	–	A TRUE/FALSE read-only variable. It must read TRUE to perform an auto zero using scrub module as the zero gas source; if FALSE , scrub module temperature is not within its operating range, and V/S T Ctl On should be set to TRUE to bring the temperature within range. (Omitted if system lacks a scrub module.)	scrub_tmpr_ok
	Scrb T	–	A read-only variable showing the temperature in °C of scrub module. (Omitted if the system lacks a scrub module.)	scrub_tmpr

Table 8-1: Variables found in menus for zero and span

Variable name		Default	Description	Name of variable in Public table (if no CR1000KD is available)
	Val T Ctl On (or V/S T Ctl On if scrub module is included)	FALSE	Set to TRUE to enable temperature control (heaters and fans) of valve module (and scrub module, if applicable). Following an auto zero/span, this variable may be set back to FALSE to conserve power.	valve_tmpr_ctrl_flg
Prfrm Field Zero, Prfrm Field CO2 Span, or Prfrm Field H2O Span	Chk_Set_Optn (only if CPEC310 is used)	–	Set to CHK_OLY to perform a field zero check without changing zero coefficients; set to CHK_SET to perform a field zero check and set new zero coefficients.	atndnt_chck_set_option
	Pick ZRO_ALL Pick SPN_CO2 Pick SPN_H2O Pick AUTO_ZS (only if CPEC310 is used)	FLD_MEA	Indicates current sampling mode. Depending on which keypad menu is viewed, variable will be named to indicate which value to choose. For example, under the Prfrm AUTO_ZS cycle menu, the value of Pick AUTO_ZS should be changed from field measurements mode (FLD_MEA) to AUTO_ZS to initiate auto zero/span cycle.	mode Options: 1 = FLD_MEA 3 = ZRO_ALL 4 = SPN_CO2 5 = SPN_H2O 7 = AUTO_ZS

Table 8-1: Variables found in menus for zero and span

Variable name		Default	Description	Name of variable in Public table (if no CR1000KD is available)
Prfrm Field Zero, Prfrm Field CO2 Span, Prfrm Field H2O Span, or Prfrm AUTO_ZS cycle	Site (only if CPEC310 is used)	–	A read-only variable showing current sampling site. Monitor this variable to see progress of zero/span. (See Sampling site, regime, and mode [p. 134] for more details on sampling sites.)	site_ Options: 1 = fld smp 2 = offst P 3 = chk CO2 4 = chk zro 5 = set zro 6 = set CO2 7 = chk H2O 8 = set H2O 9 = equilib 10 = irg_off
	Sec On Site (only if CPEC310 is used)	–	A read-only variable showing number of seconds the system has been on current site.	Sec_on_site
	IRGA Error	–	A read-only variable showing the IRGA diagnostic word; a non-0 result indicates an error condition is detected. (For an interpretation of the IRGA diagnostic word, see Table D-1 [p. 150] in System diagnostic word [p. 150].)	irga_er
	GasFlw L/min (only if CPEC310 is used)	–	A read-only variable showing the current flow in L·min ⁻¹ through the sample cell.	Valve_flow
	VALV T Error	FALSE	A read-only variable showing a valve temperature outside of range; if TRUE , valve is <2 or >50 °C.	valv_tmpr_er

Table 8-1: Variables found in menus for zero and span

Variable name		Default	Description	Name of variable in Public table (if no CR1000KD is available)
Prfrm Field Zero, Prfrm Field CO2 Span, or Prfrm Field H2O Span	Pump Off (only if CPEC306 is used)	FALSE	A variable used to disable pump; pump should be disabled before conducting a manual zero or span.	Pump_off_flg
Prfrm Field Zero, Prfrm Field CO2 Span, or Prfrm AUTO_ZS cycle	CO2 $\mu\text{mol/mol}$	–	A read-only variable showing the current measurement of CO ₂ inside the sample cell in $\mu\text{mol}\cdot\text{mol}^{-1}$.	Sonic_irga_raw (6)
Prfrm Field Zero, Prfrm Field H2O Span, or Prfrm AUTO_ZS cycle	H2O mmol/mol	–	A read-only variable showing current measurement of H ₂ O dry molar mixing ratio inside the sample cell in $\text{mmol}\cdot\text{mol}^{-1}$.	Sonic_irga_raw (7)
Prfrm Field Zero or Prfrm AUTO_ZS cycle	SCRB T Error (only if CPEC310 is used)	FALSE	A read-only variable showing a scrub module temperature outside of range; if TRUE , scrub module is <5 or >50 °C.	scrub_tmpr_er
Prfrm Field CO2 Span or Prfrm AUTO_ZS cycle	CO2 Spn Gas	400	Dry molar mixing ratio of CO ₂ span gas in $\mu\text{mol}\cdot\text{mol}^{-1}$.	CO2_span_gas

Table 8-1: Variables found in menus for zero and span

Variable name		Default	Description	Name of variable in Public table (if no CR1000KD is available)
Prfrm Field H2O Span or Prfrm AUTO_ZS cycle	H2O Spn T_DP (only if CPEC310 is used)	10	Dew point temperature setting on the H ₂ O span gas source in °C.	Td_span_gas
	H2O Spn MX_R (only if CPEC310 is used)	–	A read-only variable showing the calculated dry molar mixing ratio of the H ₂ O span gas in mmol·mol ⁻¹ . The air pressure difference between ambient and dew point generator is taken into account when calculating.	H2O_span_gas
Prfrm Field Zero	Do Zero (only if CPEC306 is used)	FALSE	Set to TRUE to manually zero the analyzer. (Zero gas should be flowing and Pump Off set to TRUE .)	do_zero_flg
Prfrm Field CO2 Span	Do CO2 Span (only if CPEC306 is used)	FALSE	Set to TRUE to manually do a CO ₂ span of the analyzer. (CO ₂ span gas should be flowing and Pump Off set to TRUE .)	Do_CO2_span_flg
Prfrm Field H2O Span	Do H2O Span (only if CPEC306 is used)	FALSE	Set to TRUE to manually do an H ₂ O span of the analyzer. (H ₂ O span gas should be flowing and Pump Off set to TRUE .)	Do_H2O_span_flg
	T_DP_probe C	–	Dew point temperature from temp/RH probe. (Omitted if system lacks temp/RH probe.)	T_DP_probe

Table 8-1: Variables found in menus for zero and span				
Variable name		Default	Description	Name of variable in Public table (if no CR1000KD is available)
Prfrm AUTO_ZS cycle	Cell T_DP	–	A read-only variable showing current measurement of dew point temperature inside the sample cell in °C.	cell_T_DP
	VALV Flw Err	FALSE	A read-only variable showing a valve flow error outside of the valve flow set point (default of 1.0 L·min ⁻¹).	valv_flow_er

8.1 User-initiated zero/span for CPEC310

Before beginning a user-initiated zero/span, the temperature of the valve module (and scrub module, if applicable) must be within operating range. Select the submenu **Valv Tmpr Ctrl** (or **Valv/Scrub Tmpr Ctrl** if using a scrub module), found under the **Attendant Zero/Span** menu, by highlighting it and pressing **Enter**. The display will show some read-only values of the module temperature and whether it is within safe operating range. If the temperature is out of range, scroll down to **Val T Ctl On** (or **V/S T Ctl On** if using a scrub module), press **Enter**, highlight **TRUE**, and press **Enter**. This will enable the module temperature control. Continue to monitor the module temperature readings shown in this menu until they are within operating range.

NOTE:

Upon completion of a zero/span in a CPEC310 system, navigate again to **Val T Ctl On** (or **V/S T Ctl On** if using scrub module) and set its value back to **FALSE** to save power.

8.1.1 CPEC310 auto zero/span

To initiate the auto zero/span cycle or sequence, return to the **Attendant Zero/Span** menu and select the menu **Prfrm AUTO_ZS cycle**. Once in the menu, verify that the value for **CO2 Span Gas** matches the molar mixing ratio in ppm of the CO₂ span gas. If it needs to be edited, highlight the variable, press **Enter**, type in the correct value, and press **Enter** again to save.

Next, highlight **Pick AUTO_ZS**, press **Enter**, make sure **AUTO_ZS** is highlighted, and press **Enter**. This initiates the automatic zero/span cycle; [Table 8-2](#) (p. 116) shows the sequence and timing

through the automatic zero-and-span cycle. The progress of the cycle may be monitored on the CR1000KD screen by watching **Site** and **Sec On Site**. Real-time values of CO₂, H₂O, gas flow, and system diagnostic are also provided in the menu. Upon completion, the value for variable **Pick AUTO_ZS** will return to **FLD_MEA**, indicating that the system measurement mode has returned to normal eddy-covariance field sampling, and **Site** will return to **fld smp**, indicating all zero/span valves are closed and ambient air is being pulled into the sample cell.

NOTE:

For more information on sampling modes, regimes, and sites, refer to [Sampling site, regime, and mode](#) (p. 134).

Timing on most sites is determined by the user-set constant **TIME_ZRO_SPN**. Some sites may also be skipped, depending on CPEC310-related constants set by the user; see [Table 7-1](#) (p. 39).

Step in auto zero/span cycle	Description	Site name	Timing (sec)	Omit status (sec of measurements that are omitted from statistics or stored data)
1	Transition from eddy-covariance field measurements to the zero/span sequence	fld smp	1	1
2	Pump is turned off and system measures the offset between sample cell pressure sensor and ambient pressure sensor.	offst P	15	10 (the first 10 sec are omitted so the system may equilibrate; the last 5 sec of measurements are used and stored)
3	CO ₂ span gas flows from its tank to the sample cell. Pump is off. System measures CO ₂ but does not set CO ₂ readings to the CO ₂ span gas concentration.	chk CO2	TIME_ZRO_SPN Default: 60	TIME_ZRO_SPN – 5 Default: 55

Table 8-2: Site sequence and timing in the auto zero-and-span cycle

Step in auto zero/span cycle	Description	Site name	Timing (sec)	Omit status (sec of measurements that are omitted from statistics or stored data)
4	Zero gas flows from the scrub module or a tank to the sample cell. Pump is off. System measures CO ₂ and H ₂ O but does not set them to zero.	chk zro	TIME_ZRO_SPN + 20 Default: 80	TIME_ZRO_SPN – 5 Default: 75
5	Zero gas flows from the scrub module or a tank to the sample cell. Pump is off. Analyzer CO ₂ and H ₂ O measurements are zeroed.	set zro	10	10
6	CO ₂ span gas flows from tank to sample cell. Pump is off. CO ₂ span is set during the last 10 seconds.	set CO2	TIME_ZRO_SPN + 30 Default: 90	TIME_ZRO_SPN + 30 Default: 90
7 ^{1/}	H ₂ O span gas flows from its source to sample cell. Pump is off. H ₂ O span is not set, just measured.	chk H2O	3*TIME_ZRO_SPN Default: 180	3*TIME_ZRO_SPN – 5 Default: 175

Table 8-2: Site sequence and timing in the auto zero-and-span cycle				
Step in auto zero/span cycle	Description	Site name	Timing (sec)	Omit status (sec of measurements that are omitted from statistics or stored data)
8 ^{1/}	H ₂ O span is set on the analyzer.	set H2O	10	10
9	System prepares to resume operation in normal eddy covariance field measurement mode. All valves to zero and span gases are closed. Pump is on, and ambient air is pulled through sample cell.	equilib	30	30
^{1/} Because it is difficult to have an autonomous field H ₂ O span gas source, these steps in the auto zero/span sequence are skipped.				

8.1.2 CPEC310 manual H₂O span

Since the CPEC310 automatic zero/span cycle does not include an H₂O span, a manual H₂O span may be set up and initiated as follows.

The user must first connect tubing from an H₂O span gas source (such as a dew point generator) to the **H2O Span** port on the CPEC310 system enclosure. Turn on the dew point generator and allow H₂O span gas to flow. Even though the valve module is not yet allowing H₂O span gas to flow to the analyzer, back pressure is not an issue, as the CPEC310 system enclosure is designed to vent excess H₂O span gas flow.

Next, navigate to the **Prfrm Field H2O Span** menu found under the **Attendant Zero/Span** menu. Within this menu, verify that the value of **H2O Spn T_DP** matches the dew point setting on the H₂O span gas source/generator. If this value needs to be edited, highlight it, press **Enter**, type in the new value, and press **Enter** again to save. Next, highlight **Pick SPN_H2O**, press **Enter**, select **SPN_H2O**, and press **Enter**. This will initiate an automatic sequence that is a subset of the auto zero/span cycle shown in Table 8-2 (p. 116); specifically, it will progress only through steps 1, 6, 7, and 8 of the steps shown in Table 8-2 (p. 116). Progress of the H₂O span may be monitored by viewing the variables **Site** and **Sec on Site**. While **Site** reads **chk H2O**, monitor the real-time

readings of H₂O in the sample cell and ensure they have reached equilibrium (as in, they are not changing) before **Site** switches to **set H2O**. If equilibrium was not reached, the constant TIME_ZRO_SPN needs to be increased (see [Set constants](#) [p. 36]).

Upon completion of the H₂O span, the value of **Pick SPN_H2O** will return to **FLD_MEA**, indicating that the system measurement mode has returned to normal eddy-covariance field sampling, and **Site** will return to **fld smp**, indicating that all zero/span valves are closed, and ambient air is being pulled into the sample cell. [Table 8-2](#) (p. 116) includes descriptions of variables in the the menus related to zero and span.

NOTE:

If the CPEC310 system enclosure is a long distance from the EC155 gas analyzer (for example, a tall tower installation), it may be necessary to increase the value of the constant TIME_ZRO_SPN (see [Set constants](#) [p. 36]) to allow for more equilibration time, especially for H₂O. If the tubing is so long that it becomes impractical to wait for equilibration, the dew point generator may be taken up the tower and connected via a short length of tubing to the **Zero/Span** port on the back of the EC155. If this type of manual setup for doing an H₂O span is used, it may be easier to take a laptop PC up the tower and use **ECMon** software to do the H₂O span. See the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual for details on doing a span using **ECMon**.

8.2 User-initiated manual zero/span for CPEC306

The CPEC306 does not contain a valve module; therefore, this system requires the user to manually connect and flow a zero or span gas through the gas analyzer. The tubing carrying the zero or span gas should be connected to the port labeled **Zero/Span** on the back of the EC155 gas analyzer head, and the zero or span gas flow should be set using a flow regulator as described in the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual. Once plumbing connections are prepared, the following sections may serve as a guide to set the zero, CO₂ span, or H₂O span.

NOTE:

When doing manual zero and/or spans, track the drift of the analyzer. This requires the user to first check the CO₂ and/or H₂O readings against their span gas concentrations and against the zero gas before setting either the zero or span. Refer to the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual for more information on tracking the analyzer gain and offset.

NOTE:

If errors in setting up and performing a zero or span lead to nonsensical measurements or a despondent state of the analyzer, the analyzer CO₂ and H₂O coefficients may be restored to previous values by navigating to **Zero span coeffs** under the **Initial Configuratr**n menu. Once in this menu, highlight **Reset zro/spn coeffs** and press **Enter**. To change a coefficient, highlight the corresponding **Rst coef**, press **Enter**, type the desired value, and change **Set change** to **TRUE** to save the value. If the previous coefficient value is unknown, enter 1.00, which will restore it to its factory settings. The analyzer is now reset, and a proper zero/span may be attempted again.

8.2.1 CPEC306 manual zero

If zeroing the analyzer, use the CR1000KD keypad to navigate to the **Attendant Zero/Span** menu and then to the **Prfrm Field Zero** menu. Scroll down and highlight **Pump Off**, press **Enter**, highlight **TRUE**, and press **Enter** again. The pump is now turned off. Make sure the zero gas tubing is connected to the **Zero/Span** port on the back of the EC155 gas analyzer head and allow zero gas to flow. If needed, use higher flows ($>1 \text{ L} \cdot \text{min}^{-1}$) initially to flush out the sample cell, and then return to a low flow ($<0.5 \text{ L} \cdot \text{min}^{-1}$) when preparing to check and/or set the zero.

As zero gas is flowing, watch the CO₂ and H₂O readings until they indicate that the zero gas has flushed the sample cell and equilibrium has been reached. Then highlight **Do Zero** found at the bottom of the menu, press **Enter**, highlight **TRUE**, and press **Enter** again. The zero will take a few seconds to set, during which time the gas analyzer measurements may not be updated. Upon completion of setting the zero, the value of **Do Zero** will return to **FALSE**. Throughout the process of performing the zero, real-time measurements of CO₂, H₂O, and system diagnostic are displayed in the **Prfrm Field Zero** menu for convenience. If no additional zeros or spans are to be performed, **Pump Off** should be set back to **FALSE** to resume operation of the pump and resume normal eddy-covariance field measurements.

8.2.2 CPEC306 manual CO₂ span

If performing a CO₂ span of the analyzer, use the CR1000KD keypad to navigate to the **Attendant Zero/Span** menu and then to the **Prfrm Field CO2 Span** menu. Scroll down and highlight **Pump Off**, press **Enter**, highlight **TRUE**, and press **Enter** again. The pump is now turned off. Make sure the CO₂ span gas tubing is connected to the **Zero/Span** port on the back of the EC155 gas analyzer head and allow CO₂ span gas to start flowing. If needed, use higher flows ($>1 \text{ L} \cdot \text{min}^{-1}$) initially to flush out the sample cell, and then return to a low flow ($<0.5 \text{ L} \cdot \text{min}^{-1}$) before checking and/or setting the CO₂ span. Within the **Prfrm Field CO2 Span** menu, verify that the variable **CO2 Spn Gas** matches the concentration reported on the tank of the CO₂ span gas. If this value needs editing, highlight it, press **Enter**, type in the new value, and press **Enter** again to save the value.

The **Prfrm Field CO₂ Span** menu also includes readings of CO₂ molar mixing ratio. Watch the readings until they indicate that the span gas has flushed out the sample cell and equilibrium has been reached.

Once equilibrium is attained, highlight **Do CO₂ Span** found at the bottom of the menu, press **Enter**, highlight **TRUE**, and press **Enter** again. Setting the CO₂ span will take a few seconds, during which time measurements from the gas analyzer may not be updated. Upon completion of the CO₂ span, the value of **Do CO₂ Span** will return to **FALSE**. Throughout the CO₂ span, real-time measurements of CO₂ and system diagnostic are included in the **Prfrm Field CO₂ Span** menu for convenience. If no additional zeros or spans are to be performed, **Pump Off** should be set back to **FALSE** to resume operation of the pump and resume normal eddy-covariance field measurements.

8.2.3 CPEC306 manual H₂O span

If performing an H₂O span of the analyzer, use the CR1000KD keypad to navigate to the **Attendant Zero/Span** menu and then to the **Prfrm Field H₂O Span** menu. Scroll down and highlight **Pump Off**, press **Enter**, highlight **TRUE**, and press **Enter** again. The pump is now turned off. Make sure the H₂O span gas tubing is connected to the **Zero/Span** port on the back of the EC155 gas analyzer head and allow H₂O span gas to start flowing. If needed, use higher flows (>1 L·min⁻¹) initially to flush out the sample cell, and then return to a low flow (<0.4 L·min⁻¹) before checking or setting the H₂O span. Within the **Prfrm Field H₂O Span** menu, verify that the variable **H₂O Spn T_DP** is set to the dew point temperature setting on the dew point generator or other H₂O span gas source. If this value needs editing, highlight it, press **Enter**, type in the new value, and press **Enter** again to save.

The **Prfrm Field H₂O Span** menu includes readings of H₂O molar mixing ratio in the sample cell. Watch the readings until they indicate that the span gas has flushed out the sample cell and equilibrium has been reached. Once equilibrium is attained, highlight **Do H₂O Span** found at the bottom of the menu, press **Enter**, highlight **TRUE**, and press **Enter** again. Setting the H₂O span will take a few seconds, during which time the gas analyzer measurements may not be updated. Upon completion of the H₂O span, **Do H₂O Span** will return to **FALSE**. Throughout the H₂O span, real-time measurements of H₂O and system diagnostic are included in the **Prfrm Field H₂O Span** menu for convenience. If the system includes a temp/RH probe, the ambient dew point temperature is also reported for reference. If no additional zeros or spans are to be performed, **Pump Off** should be set back to **FALSE** to resume operation of the pump and resume normal eddy-covariance field measurements.

9. Maintenance and troubleshooting

Most of the basic diagnostic and troubleshooting issues for the CPEC-series systems are indicated in the **Diagnostic** data output table ([Table 7-9](#) [p. 67]). This section provides additional detail on some issues that may arise with hardware components.

9.1 Enclosure desiccant

Check the humidity indicator card in the mesh pocket in the CPEC-series system enclosure door and the EC100 enclosure door. The humidity indicator card has three coloured circles that indicate the percentage of humidity (see [Figure 4-19](#) [p. 17]). Desiccant packets inside the enclosure should be replaced with fresh packets when the upper dot on the indicator begins to turn pink. The indicator card does not need to be replaced unless the coloured circles overrun. Both the desiccant packs and humidity cards can be purchased as replacements. See [Replacement parts](#) (p. 15) for more detail.

CAUTION:

Campbell Scientific strongly suggests replacing desiccant instead of reactivating old desiccant. Improper reactivation can cause the desiccant packets to explode.

If the desiccant packs in a CPEC-series system enclosure require frequent replacement, check that the feedthrough cap is properly installed. In very humid conditions, it may be helpful to seal the cable feedthrough with plumber's putty as described in [Apply power](#) (p. 33).

9.2 EC155 windows

The EC155 gas analyzer reports a signal strength for both CO₂ and H₂O that decreases as the optics become contaminated. The factory calibration procedure allows some tolerance to window contamination. In general, the tolerance is higher for contaminants that are uniformly distributed on the windows and have flat spectral characteristics than for contaminants, such as water droplets, that can greatly disperse or refract the optical beam. The signal strength should be monitored as part of any quality assurance/quality check of incoming data. If the signal strength has dropped, CO₂ and H₂O values should be checked for validity, and windows should be cleaned during the next site visit. Clean the windows as instructed in the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual before the CO₂ and H₂O signals reach 0.80.

NOTE:

In an EC155 that has vortex intake, a decrease in signal strength likely means that the vortex filter is plugged and should be replaced.

9.3 EC155 molecular sieve bottles

If zero-and-span readings have drifted excessively, the molecular sieve bottles within the EC155 analyzer head should be replaced as detailed in the *EC155 CO₂/H₂O Closed-Path Gas Analyzer* manual.

9.4 Pump module filter

In very humid conditions, water may condense and collect inside the housing of the filter in the pump module enclosure. This is normal and will have no effect on the measurements. In most cases, the water will evaporate as ambient conditions change.

9.5 Testing wind offset


Usually, the CSAT3A sonic anemometer calibration remains valid unless a transducer fails or damage to the instrument leads to a change in geometry. The sonic anemometer requires calibration under two conditions:

- Developing a wind offset greater than the specification
- Setting diagnostic flags under dry conditions with little to no wind and with no obstruction in the ultrasonic paths

The wind offset is tested by creating a zero-wind environment. This is best done in a laboratory setting with HVAC vents closed or covered to reduce air currents, and by encircling the mounted sensor with a large plastic bag (for example, an unused trash bag). Caution should be used to not block the sonic paths. Once the CSAT3A is connected to an EC100 and powered on, wind offsets may be viewed by connecting the EC100 to a PC and using **ECMon** to graph u_x , u_y , and u_z wind components. In this zero-wind environment, u_x and u_y should be less than $\pm 8 \text{ cm}\cdot\text{s}^{-1}$ ($\pm 0.08 \text{ m}\cdot\text{s}^{-1}$), and u_z should be less than $\pm 4 \text{ cm}\cdot\text{s}^{-1}$ ($\pm 0.04 \text{ m}\cdot\text{s}^{-1}$). If recalibration is deemed necessary, contact Campbell Scientific.

10. Repair

All CPEC-series systems are designed to give years of trouble-free service with reasonable care. However, if factory repair is needed, contact Campbell Scientific to obtain an RMA number. An RMA number and product safety documents are required prior to the acceptance of any repair shipments at Campbell Scientific. See details in the [About this manual](#) section at the start of this document.

Contact Campbell Scientific to determine which parts or assemblies should be sent for repair. See www.campbellsci.eu/cpec300  for the appropriate contact. If the system enclosure is to be returned, plug the inlets and cap the ends of all tubes to keep debris out. Swagelok caps and plugs have been provided for this purpose.

Appendix A. *EasyFlux DL CR6CP* process flow

A.1 Sequence of program functions

A.1.1 Every SCAN_INTERVAL (default 100 ms)

Collect raw data from GPS sensor, battery voltage, CDM panel temp, FW, and rain gauge.



Store FW measurements in a table to be used later to align with sonic data.



Check for conditions that require EC100 reconfiguration.



Store sonic and gas data from the previous scan in temporary tables that will be used in later steps to align measurements and calculate covariances.



If the time for zero/span is approaching, turn on valve module heater (and scrub module heater, if applicable).



Calculate mean variables (for example, call site_block_mean table).



Check to see if the mode of operation has changed. If yes, perform functions associated with that mode (such as zero and span); when finished, return to eddy-covariance field measurements.



Record the prior scan time series data into final storage.



Parse out sonic diagnostic data, and filter bad sonic data from being included in statistical data.



Send sonic data to covariance tables to be included for 5 min and averaging interval covariances.



Parse out gas diagnostic data, and filter bad gas data from being included in statistical data.



Calculate climate and gas variables (for example, e , ρ_d , ρ_a , T_d , CO_2 _mixratio, H_2O _mixratio, RH).



Store gas data into multiple datasets or temporary tables that each have a different lag relative to sonic data (to be used later in cross correlation; lags from $-MAX_LAG$ to $+MAX_LAG$ are used; MAX_LAG default is 2); for each dataset with a particular lag, recalculate cell and ambient climate variables.



If using FW, store raw data in multiple datasets, each dataset with a different lag applied to FW data relative to sonic data (to be used later in cross correlation; lags from $-MAX_LAG$ to $+MAX_LAG$ are used; MAX_LAG default is 2).



Control pump speed to achieve pressure set point.



Measure rain gauge.

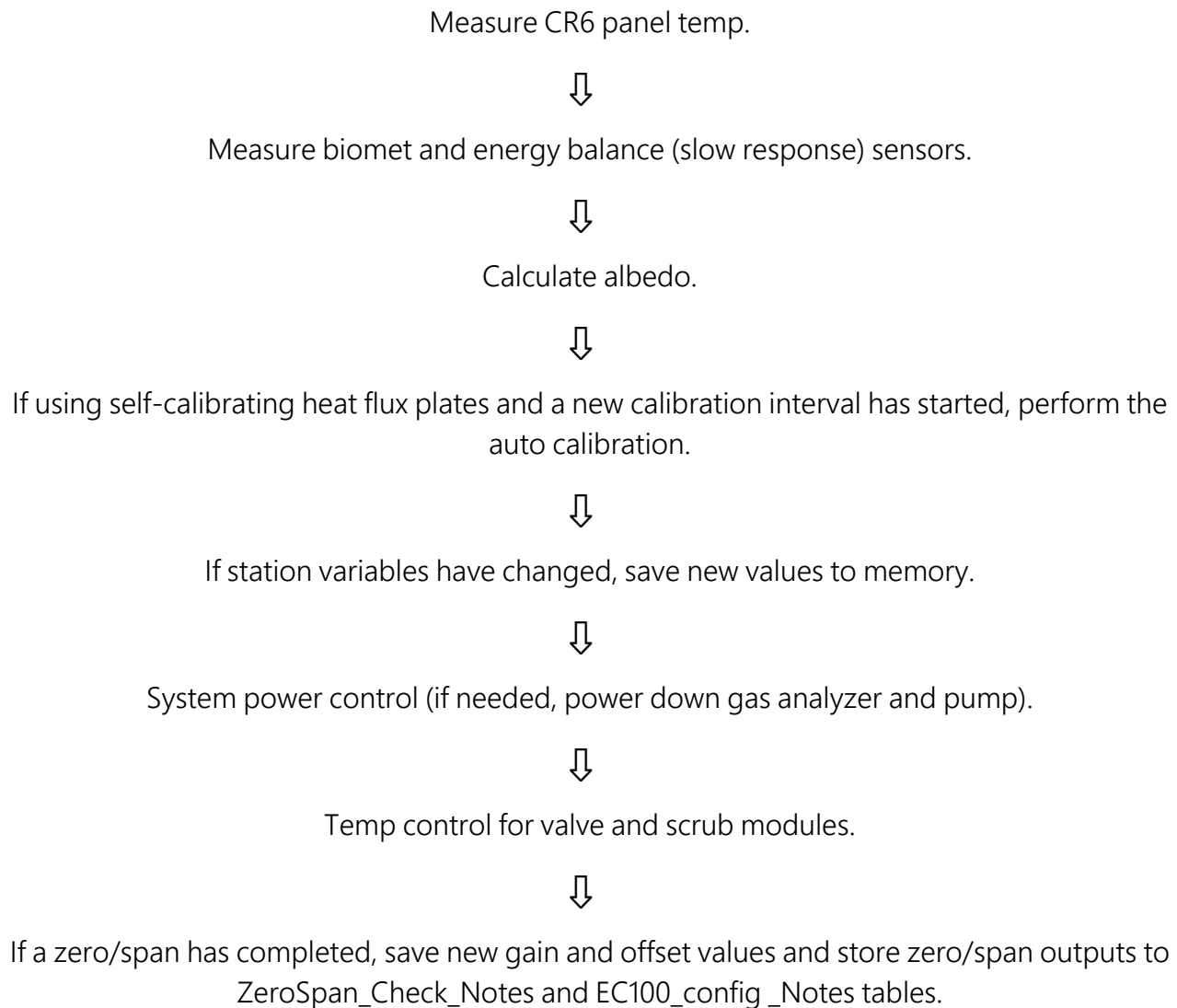


Record time series measurement diagnostics in the Diagnostic output table.



Ingest new raw sonic and gas measurements from the EC100.

A.1.2 Every SLOWSEQUENCE_SCAN_INTERVAL (default 5 sec)



A.1.3 Every 5 min

Do coordinate rotations and find the 5-minute covariances for u with w , v with w , T_s with w , CO_2 with w , and H_2O with w (used later for steady state test for quality grading; see *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix F, Data quality grading for more details).

A.1.4 Every AVERAGING_INTERVAL (default 30 min)

Filter out data with diagnostic flags or signal strengths or measurements outside of acceptable ranges.



Do coordinate rotations (use double coordinate rotation method unless planar fit angles have been entered by user) to find rotated orthogonal wind components, u , v , and w . Calculate sonic-related covariances (such as wTs , wu , vw). (See *EasyFlux DL CR6OP or CR1KXOP* manual: Appendix B, Coordinate rotations: Double rotation method and Appendix C, Coordinate rotations: Planar fit method.)



Use rotated wind components to find turbulent kinetic energy, friction velocity, and preliminary values of Monin-Obukhov length and stability.



Calculate frequency correction factors for wTs , wu , and vw to account for block averaging and line averaging. If conditions are stable, iteratively calculate Monin-Obukhov length, cospectral equations, and correction factors until factors change by <0.0001 or until 10 iterations have completed. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix D, Frequency corrections.)



Calculate value for steady state test using the 30-minute momentum covariances and the 5-minute momentum covariances. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix F, Data quality grading.)



Calculate the overall quality grade for momentum flux. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix F, Data quality grading.)



Calculate and use a new roughness length if: (1) the user did not enter a fixed value, (2) there is neutral stability, and (3) wind speed is >3 m/s and momentum flux quality grading is adequate ($\tau_{QC} \leq 6.0$). (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix G, Footprint.)



Calculate footprint characteristics using the Kljun et al. (2004) model if conditions are appropriate, otherwise use the Kormann and Meixner (2001) model. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix G, Footprint.)



Calculate the covariance of CO₂ and wind components for each lagged dataset and do coordinate rotation on covariances.



Find the effective lateral separation distance between gas analyzer and sonic (to use in frequency correction) and the effective separation scan lag (used to constrain which lagged datasets are physically possible). (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix D, Frequency corrections.)



Find the dataset with the physically possible lag that maximizes the covariance of CO₂ and vertical wind. Use this dataset for the Flux_AmeriFluxFormat and Flux_CSFormat output tables. If any results are invalid, continue with lag of zero. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix D, Frequency corrections.)



Calculate cospectra functions and the frequency correction factor for CO₂-related covariances, taking into account attenuation from block averaging, line averaging, spatial separation, and tube attenuation. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix D, Frequency corrections; Ibrom et al. 2007; Burgon et al. 2015; program code.)



Calculate covariances of H_2O and wind components for each lagged dataset and do coordinate rotation on covariances.



Find the dataset with the physically possible lag that maximizes the covariance of H_2O and vertical wind. Use this dataset for the Flux_AmeriFluxFormat and Flux_CSFormat output tables. If any results are invalid, continue with lag of zero. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix D, Frequency corrections.)



Calculate the frequency correction factor for covariances of H_2O and rotated wind components, taking into account attenuation from block averaging, line averaging, spatial separation, and tube attenuation. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix D, Frequency corrections; Ibrom et al. 2007; Burgon et al. 2015; program code.)



Calculate final momentum flux from rotated and frequency corrected covariances of u with w and v with w .



Apply SND correction to the rotated and frequency corrected covariance of w and T_s .



Calculate specific heat of ambient (moist) air and calculate final sensible heat flux.



Calculate scaling temperature (used for data quality grading). (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix F, Data quality grading.)



Calculate Bowen Ratio.



Calculate the overall quality grades for fluxes of sensible heat, latent heat, and CO₂. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix F, Data quality grading.)



Calculate soil surface energy flux for the averaging interval. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix H, Surface energy flux.)

Get calculated measurements of H , LE , and R_{net} for the averaging interval.



Calculate energy closure.



If energy
balance
sensors are
used



If FW05,
FW1, or
FW3 is
used

Calculate the covariance of FW temperature and wind components for each lagged dataset, then perform coordinate rotations on covariances.



Find the effective lateral separation distance between FW and sonic (to use in frequency correction) and the effective separation scan lag (used to constrain which lagged datasets are physically possible). (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix D, Frequency corrections.)



Find the dataset with the lag that maximizes the covariance of FW temperature and vertical wind. Use this dataset for the Flux_AmeriFluxFormat and Flux_CSFormat output tables. If any results are invalid, continue with lag of zero.



Calculate the time constant for the FW (to be used in frequency corrections). (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix D, Frequency corrections.)



Calculate frequency correction factors for covariances of FW temperature and rotated wind components, taking into account attenuation from block averaging, line averaging, spatial separation, and the FW time constant. (See *EasyFlux DL CR6OP or CR1KXOP* manual, Appendix D, Frequency Corrections.)



Calculate final fine-wire sensible heat flux.



Write records to the Flux_AmeriFluxFormat, Flux_CSFormat, and Flux_Notes output tables.



Calculate the number of days remaining on the data storage card of the data logger.

Appendix B. Sampling site, regime, and mode

Sampling sites, regimes, and modes are applicable to CPEC310 and help distinguish certain states of the system. A sampling site refers to a particular valve selection or air sampling source. [Table B-1](#) (p. 135) provides a list of the defined sampling sites.

A sampling regime consists of a site designation, a state of the pump (on or off), and an omit status, which is whether or not the current measurements are being included in calculations and statistics. For example, the steps in the auto zero/span sequence in [Table 8-2](#) (p. 116) each describe a sampling regime. The sampling regime at a given moment is described by the variable **sampling_regime**, which is included in the **Time_Series** output table, where bits 0 through 3 correspond to the site number, and bit 4 is set when measurements are being omitted from calculations. For example, if the system has just finished an auto zero-and-span cycle and has returned to normal eddy-covariance measurements (site 1), it will omit measurements from the covariance and other calculations for 25 seconds in order for the sample cell to be thoroughly flushed and the pressure equilibrated; during this 25-second time period, **sampling_regime** will have a value of 17, where bit 4 is set high (decimal value of 16) to indicate omitted measurements, and bit 0 is set to 1 (decimal value of 1), corresponding to site 1. After the 25-second period has passed, **sampling_regime** will show a value of 1, indicating the measurements are no longer omitted and the current site is site 1.

A sampling mode, or simply mode, is a timed or controlled sequence of one or more sampling regimes. [Table B-2](#) (p. 135) lists the various modes. For example, in the case of **AUTO_ZS** mode, a sequence of several sampling regimes is completed to perform a zero and span of the gas analyzer.

Table B-1: Site numbers, text descriptors, and descriptions		
Site number	Text descriptor of site (used on CR1000KD display)	Description
1	fld smp	Normal field sampling; pump is on and pulling ambient air into the sample cell
2	offst P	Pump is off; this setting is used to measure the offset between the sample cell pressure sensor and the EC100 barometer
3	chk CO ₂	Check CO ₂ span
4	chk zro	Check zero
5	set zro	Set zero
6	set CO ₂	Set CO ₂ span
7	chk H ₂ O	Check H ₂ O span
8	set H ₂ O	Set H ₂ O span
9	equilib	Idle or equilibration with ambient mode; pump is off
10	irg_off	Sleep or power-saver mode; EC155 and pump turned off, while CSAT3A remains on

Table B-2: Mode names and descriptions	
Mode name	Description
FLD_MEA	Eddy-covariance field measurement mode. Pump is on, and ambient air is sampled (site 1). Measurements from the first 25 sec after switching to this mode are omitted from calculations.
PUMP_OFF	Pump off mode. Pump is turned off, sample cell pressure equilibrates to ambient pressure, and a measurement of the pressure offset is made.
ZRO_ALL	User-initiated automatic zero all mode (applicable to CPEC310 systems). After a zero gas source is connected to the CPEC310 system enclosure and gas is flowing, this mode may be selected so the system will go through a sequence of sampling regimes that will zero the gas analyzer.

Table B-2: Mode names and descriptions	
Mode name	Description
SPN_CO2	User-initiated automatic CO ₂ span mode (applicable to CPEC310 systems). If a CO ₂ span gas source is connected to the CPEC310 system enclosure and gas is flowing, this mode may be selected so the system will go through a sequence of sampling regimes that will span the CO ₂ of the gas analyzer.
SPN_H2O	User-initiated automatic H ₂ O span mode (applicable to CPEC310 systems). After an H ₂ O span gas source is connected to the CPEC310 system enclosure and gas is flowing, this mode may be selected so the system will go through a sequence of sampling regimes that will span the H ₂ O of the gas analyzer.
IRG_SLP	IRGA sleep mode. Powers down the gas analyzer and pump and leaves the CSAT3A powered on and making measurements.
AUTO_ZS	Automatic zero and span mode. Will automatically check and/or set the zero and CO ₂ span of the gas analyzer. Whether or not the zero and span are set depends on the values to which the user set the zero/span constants. See Set constants (p. 36).

Appendix C. Wiring the CR6 and optional energy balance sensors

C.1 Overview

The user should install sensors and system components according to the respective product manuals. For standard program usability, when wiring the sensors to the data logger or to a VOLT 116, the user should follow the default wiring schemes, along with the type and quantity of instruments supported by *EasyFlux DL CR6CP*. [Table C-1](#) (p. 138) through [Table C-13](#) (p. 149) present the wiring schemes.

The minimum required equipment to operate *EasyFlux DL CR6CP* is one of the CPEC-series systems with its core components, as described in the introduction. The additional sensors described in Sections [C.1.3](#) through [C.1.12](#) are optional. The VOLT 116 is required for some optional sensors, since the CR6 itself does not contain enough channels for a full energy balance sensor suite; the VOLT 116 effectively increases the CR6 analogue channels. If one or more of the optional sensors is not used, the data logger or VOLT 116 module terminals assigned to the wires of that sensor should be left unwired.

NOTE:

If the standard data logger program is modified, the wiring presented in [Table C-1](#) (p. 138) may no longer apply. In these cases, refer directly to the program code to determine proper wiring, or contact Campbell Scientific for assistance.

C.1.1 IRGA and sonic anemometer

A closed-path EC155 gas analyzer and CSAT3A sonic anemometer must be connected to the EC100 electronics, and the EC100 must be wired to a CR6 data logger via a wiring terminal for *EasyFlux DL CR6CP* to be functional. [Table C-1](#) (p. 138) shows the default wiring for these sensors.

Table C-1: Default wiring for EC155 and CSAT3A(H) sonic anemometer				
Sensor	Quantity	Wire description	Wire colour	CPEC system enclosure wiring terminal
EC155 and CSAT3A (from EC100)	1	SDM data	Green	C1
		SDM clock	White	C2
		SDM enable	Red/brown	C3
		Signal ground	Black	G
		Shield	Clear	G

C.1.2 VOLT 116 module

Due to the limitations on channel count of the CR6, a VOLT 116 module is required when using a fine-wire thermocouple, a temp/RH probe, radiation sensors, soil temperature probes, and/or soil heat flux plates. A CPEC-series system already has a VOLT 116 installed, connected to the CR6, and configured, but it can be reconfigured if needed, as follows:

1. Connect the module to a 10-32 VDC power source.
2. Launch the Campbell Scientific *Device Configuration Utility* software (v2.12 or newer) and select **VOLT 100 Series** among the list of **GRANITE** devices. If this is the first time connecting, follow the instructions on the main screen to download the USB driver to the computer.
3. Select the appropriate COM port and click **Connect**.
4. Once connected, a list of settings is shown. Navigate to the bottom setting, **CPI Address**. Change this value to **1**. Click **Apply** and exit the software.
5. Use a CAT5e or CAT6 Ethernet cable (included with the VOLT 116) to connect the **CPI** port on the module to the CR6 or CR1000X **CPI** port.

C.1.3 GPS receiver

A GPS receiver such as the GPS16X-HVS is optional but will keep the data logger clock synchronized to GPS time. If the CR6 clock differs by one millisecond or more, *EasyFlux DL CR6CP* will resynchronize the data logger clock to match the GPS. The GPS receiver also calculates solar position. [Table C-2](#) (p. 139) shows the default wiring for the GPS16X-HVS.

Table C-2: Default wiring for GPS receiver				
Sensor	Quantity	Wire description	Wire colour	CR6 terminal
GPS16X-HVS	0 or 1	PPS	Grey	U1
		TXD	White	U2
		Shield	Clear	AG \perp
		12V	Red	12V
		Power ground	Black	G
		Power switch	Yellow	G
		Rx data	Blue	G

C.1.4 Fine-wire thermocouple

Several models of fine-wire thermocouple sensors are available that can be integrated with the IRGA and sonic anemometer for direct measurements of sensible heat flux. *EasyFlux DL CR6CP* can support from zero to one fine-wire thermocouple with the IRGA and sonic anemometer.

[Table C-3](#) (p. 139) shows the available types of and default wiring for adding a fine-wire thermocouple.

Table C-3: Default wiring for fine-wire thermocouple				
Sensor	Quantity	Wire description	Wire colour	CPEC-series system terminal
FW05, FW1, or FW3	0 or 1	Signal	Purple	CDM Diff 6H
		Signal reference	Red	CDM Diff 6L
		Shield	Clear	CDM AG \perp

C.1.5 Temperature and relative humidity probe

EasyFlux DL CR6CP can support from zero to one temperature and relative humidity probe. The default wiring for the HMP155A, EE181, and HygroVUE™10 is shown in [Table C-4](#) (p. 140).

NOTE:

[Table C-4](#) (p. 140) shows wiring for the HMP155A, EE181, and HygroVUE™10 temperature and humidity probes. Alternatively, an older model probe such as the HMP45C or HC2S3 may be used, but wiring for these models is not shown here. Instead, their wiring may be found in the


respective product manuals found at www.campbellsci.eu.  In any case, the user should carefully note the colours of the wires and jumper wire configuration of the probe being used. Table C-4 (p. 140) shows wire colours for HMP155A in regular text; colours for EE181 are noted by italic text.

Table C-4: Default wiring for temperature and relative humidity probe

Probe	Quantity	Wire description	Wire colour	VOLT 116 terminal
HMP155A/ <i>EE181</i>	0 or 1 (cannot be used with HygroVUE™10)	Temp signal	Yellow/ <i>yellow</i>	Diff 16H
		Temp signal reference	White/ <i>black</i>	AG \perp
		RH signal	Blue/ <i>blue</i>	Diff 16L
		RH signal reference	White/ <i>black</i>	AG \perp
		Shield	Clear/ <i>clear</i>	AG \perp
		Power	Red/ <i>red</i>	+12 V
		Power ground	Black/ <i>black</i>	G
HygroVUE™10	0 or 1 (cannot be used with HMP155A or EE181)	Temp/RH signals	White	U11
		Temp/RH reference	Clear	AG \perp
		Power	Brown	12 V
		Power ground	Black	G

C.1.6 Radiation measurements, Option 1

Two options are available for making radiation measurements with *EasyFlux DL CR6CP*. The program can support any combination of the four sensors described in Table C-5 (p. 141). Alternatively, it can support one of the three types of 4-component radiometers described in Table C-6 (p. 142). Table C-5 (p. 141) gives the default wiring for Option 1. Table C-6 (p. 142) shows the details of the default wiring for Option 2.

Table C-5: Default wiring for radiation measurements, Option 1				
Sensor	Quantity	Wire description	Wire colour	VOLT 116 terminal (unless otherwise indicated)
CS301 pyranometer	0 or 1	Signal	White	Diff 2H
		Signal reference	Black	Diff 2L
		Shield	Clear	AG \perp
CS320 digital thermopile pyranometer	0 or 1	SDI-12 signal	White	CR6 U11
		Signal reference	Blue	CR6 AG \perp
		Shield	Clear	CR6 AG \perp
		Power	Red	CR6 12V
		Power ground	Black	CR6 G
CS310 quantum sensor	0 or 1	Signal	White	Diff 3H
		Signal reference	Black	Diff 3L
		Shield	Clear	AG \perp
SI-111 infrared radiometer	0 or 1	Target temp signal	Red	Diff 4H
		Target temp reference	Black	Diff 4L
		Shield	Clear	AG \perp
		Sensor temp signal	Green	Diff 5H
		Sensor temp reference	Blue	AG \perp
		Voltage excitation	White	X1

C.1.7 Radiation measurements, Option 2

Three models of 4-component net radiometers are compatible with the *EasyFlux DL CR6CP* program: SN500SS, NR01, and CNR4. However, due to limitations in channel numbers and computation procedures, only one model can be used at a time. The default wiring for each of the 4-component net radiometers is shown in [Table C-6](#) (p. 142). [Table C-9](#) (p. 146) and [Table C-10](#) (p. 146) give information on adding an optional CNF4 ventilation and heater unit to the CNR4 4-component net radiometer.

A CNF4 ventilation and heater unit may be used with the CNR4 4-component net radiometer for more accurate radiation measurements. The CNF4 requires a solid-state relay to control the ventilator and heater. An A21REL-12 4-channel relay driver must be ordered (sold separately) and

installed in the system enclosure just below the VOLT 116 module. [Table C-7](#) (p. 144) lists the wiring connections needed to power and control the A21REL-12. [Table C-8](#) (p. 145) lists the wiring for the CNF4.

A CABLE3CBL-1 or similar 3-conductor 22 AWG cable is recommended for connections from the A21REL-12 to the VOLT 116, and a CABLEPCBL-1 or similar 2-conductor 16 AWG power cable is recommended for power connections from the A21REL-12 to the DIN rail terminal block.

For the CPEC310, no additional relay driver is required, since the system already includes an SDM-CD16S; however, some wiring from the valve module must be modified to accommodate the CNF4 (see [Table C-6](#) [p. 142], which lists the wiring for the CNF4 for either the CPEC306 or the CPEC310).

Table C-6: Default wiring for radiation measurements, Option 2				
Sensor	Quantity	Wire description	Wire colour	VOLT 116 terminal (unless otherwise indicated)
SN500SS 4-component net radiometer	0 or 1	SDI-12 signal	White	CR6 U11
		Shield	Clear	CR6 AG \perp
		Power	Red	CR6 12V
		Power ground	Black	CR6 G

Table C-6: Default wiring for radiation measurements, Option 2

Sensor	Quantity	Wire description	Wire colour	VOLT 116 terminal (unless otherwise indicated)
NR01 4-component net radiometer	0 or 1	Pyranometer up signal	Red (cbl 1)	Diff 1H
		Pyranometer up reference	Blue (cbl 1)	Diff 1L
		Pyranometer down signal	White (cbl 1)	Diff 2H
		Pyranometer down reference	Green (cbl 1)	Diff 2L
		Pyrgeometer up signal	Brown/grey or orange (cbl 1)	Diff 3H
		Pyrgeometer up reference	Yellow (cbl 1)	Diff 3L
		Pyrgeometer down signal	Purple or pink/brown (cbl 1)	Diff 4H
		Pyrgeometer down reference	Grey/green (cbl 1)	Diff 4L
		PT100 signal	White/yellow (cbl 2)	Diff 5H
		PT100 reference	Green (cbl 2)	Diff 5L
		Current excite	Red (cbl 2)	X2
		Current return	Blue (cbl 2)	AG \perp
		Shields	Clear	AG \perp
		Heater power	Brown	CDM SW12 ^{1/}
		Heater ground	Yellow	G
		Ground	Purple/pink	G
		Shield	Grey	AG \perp

Table C-6: Default wiring for radiation measurements, Option 2

Sensor	Quantity	Wire description	Wire colour	VOLT 116 terminal (unless otherwise indicated)
CNR4 4-component net radiometer	0 or 1	Pyranometer up signal	Red	Diff 1H
		Pyranometer up reference	Blue	Diff 1L
		Pyranometer down signal	White	Diff 2H
		Pyranometer down reference	Black	Diff 2L
		Pyrgeometer up signal	Grey	Diff 3H
		Pyrgeometer up reference	Yellow	Diff 3L
		Pyrgeometer down signal	Brown	Diff 4H
		Pyrgeometer down reference	Green	Diff 4L
		Thermistor signal	White	Diff 5H
		Thermistor V excite	Red	X2
		Thermistor reference	Black	AG \perp
		Shields	Clear	AG \perp

¹Use CR6 SW12-1 and G if self-calibrated soil heat flux plate is used.

Table C-7: A21REL-12 wiring (used with CNF4 in a CPEC306 system)

A21REL-12 terminal	Connecting terminal	Cable	Cable colour
+12V	CPEC306 enclosure DIN rail terminal block: 12V	CABLEPCBL-1	Red
Ground	CPEC306 enclosure DIN rail terminal block: GND	CABLEPCBL-1	Black
CTRL 1	VOLT 116 SW5V #1	CABLE3CBL-1	Red

Table C-7: A21REL-12 wiring (used with CNF4 in a CPEC306 system)			
A21REL-12 terminal	Connecting terminal	Cable	Cable colour
CTRL 2	VOLT 116 SW5V #2	CABLE3CBL-1	Black
CTRL 3	VOLT 116 SW5V #3	CABLE3CBL-1	White

Table C-8: Default wiring for CNF4					
Sensor	Quantity	Wire description	Wire colour	Wiring	Wiring
CNF4	0 or 1 (only if CNR4 is used)	Tachometer output	Green	CR6 U7	CR6 U7 ^{1/}
		Tachometer reference	Grey	CR6 AG $\frac{1}{2}$	CR6 AG $\frac{1}{2}$ ^{1/}
		Ventilator power	Yellow	A21REL-12 REL 1 NO	SDM-CD16S OUT 14
		Ventilator ground	Brown	A21REL-12 REL G	SDM-CD16S OUT G
		Heater #1 power	White	A21REL-12 REL 2 NO	SDM-CD16S OUT 15
		Heater #1 ground	Red	A21REL-12 REL G	SDM-CD16S OUT G
		Heater #2 power	Black	A21REL-12 REL 3 NO	SDM-CD16S OUT 16
		Heater #2 ground	Blue	A21REL-12 REL G	SDM-CD16S OUT G
^{1/} In a CPEC310, wiring the CNF4 requires moving the valve module thermistor signal wire (green) from CR6 U7 to VOLT 116 Diff 5L and the valve module thermistor reference (yellow) from CR6 AG to VOLT 116 AG.					

C.1.8 Precipitation gauge

EasyFlux DL CR6CP can support a single tipping rain gauge such as the TE525MM, or a precipitation gauge can be omitted. The default wiring for a precipitation gauge is shown in [Table C-9](#) (p. 146).

Table C-9: Default wiring for precipitation gauge				
Sensor	Quantity	Wire description	Wire colour	CR6 terminal
TE525MM tipping-bucket rain gauge	0 or 1	Pulse output	Black	U10
		Signal ground	White	AG \perp
		Shield	Clear	AG \perp

C.1.9 Soil temperature

The TCAV is an averaging soil thermocouple probe used for measuring soil temperature.

EasyFlux DL CR6CP can support up to three TCAV probes. The order of wiring, however, is important. If only one TCAV probe is used, it must be wired as described for TCAV #1 in [Table C-10](#) (p. 146).

CAUTION:

If only one TCAV is being used and it is wired to terminals **8H/8L** or **15H/15L** (leaving terminals **7H** and **7L** empty), the data logger will not record any TCAV measurements.

Table C-10: Default wiring for soil thermocouple				
Sensor	Quantity	Wire description	Wire colour	VOLT 116 terminal
TCAV #1	0 to 3	Signal	Purple	Diff 7H
		Signal reference	Red	Diff 7L
		Shield	Clear	AG \perp
TCAV #2		Signal	Purple	Diff 8H
		Signal reference	Red	Diff 8L
		Shield	Clear	AG \perp
TCAV #3		Signal	Purple	Diff 15H
		Signal reference	Red	Diff 15L
		Shield	Clear	AG \perp

NOTE:

The CS650 or CS655 sensors also measure soil temperature. If the CS650 or CS655 sensors are used but no TCAV probes are used, **EasyFlux DL CR6CP** will use soil temperature from the CS650 or CS655 to compute ground-surface heat flux. If available, soil temperature data from

the TCAV probe is preferred because it provides a better spatial average. See wiring details for these sensors in [Table C-11](#) (p. 147).

C.1.10 Soil water content reflectometers

EasyFlux DL CR6CP supports zero or one of two models of soil water content reflectometers: CS650 or CS655, and up to three of the one selected model are supported. The default wiring for each is shown in [Table C-11](#) (p. 147).

CAUTION:

If only one soil water content reflectometer is being used, the user should wire it according to the first sensor as described in [Table C-11](#) (p. 147). If only one sensor is being used but is wired according to the second or third sensor, *EasyFlux DL CR6CP* will record no soil water content measurements.

Table C-11: Default wiring for soil water content reflectometers

Sensor	Quantity	Wire description	Wire colour	CR6 terminal
CS650/ CS655 #1	0 to 3	SDI-12 data	Green	U11
		SDI-12 power	Red	+12 V
		SDI-12 reference	Black	G
		Shield	Clear	G
		Not used	Orange	AG \perp
CS650/ CS655 #2		SDI-12 data	Green	U11
		SDI-12 power	Red	+12 V
		SDI-12 reference	Black	G
		Shield	Clear	AG \perp
		Not used	Orange	G
CS650/ CS655 #3		SDI-12 data	Green	U11
		SDI-12 power	Red	+12 V
		SDI-12 reference	Black	G
		Shield	Clear	AG \perp
		Not used	Orange	G

C.1.11 Soil heat flux plates

EasyFlux DL CR6CP can support from zero to three soil heat flux plates. They can be the HFP01 plates (non-self-calibrating) or the HFP01SC (self-calibrating) plates. The default wiring for the HFP01 standard (non-self-calibrating) soil heat flux plates is shown in [Table C-12](#) (p. 148).

Table C-12: Default wiring for non-self-calibrating soil heat flux plates				
Sensor	Quantity	Wire description	Wire colour	VOLT 116 terminal
HFP01 #1	0 to 3	Signal	White	Diff 9H
		Signal reference	Green	Diff 9L
		Shield	Clear	AG \perp
HFP01 #2		Signal	White	Diff 10H
		Signal reference	Green	Diff 10L
		Shield	Clear	AG \perp
HFP01 #3		Signal	White	Diff 11H
		Signal reference	Green	Diff 11L
		Shield	Clear	AG \perp

C.1.12 Self-calibrating soil heat flux plates

If using HFP01SC self-calibrating soil heat flux plates, *EasyFlux DL CR6CP* can support from zero to three of them. The default wiring for the self-calibrating soil heat flux plates is shown in [Table C-13](#) (p. 149).

Table C-13: Default wiring for self-calibrating soil heat flux plates

Sensor	Quantity	Wire description	Wire colour	VOLT 116 terminal
HFP01SC #1	0 to 3	Signal	White	Diff 9H
		Signal reference	Green	Diff 9L
		Shield	Clear	AG \perp
		Heater signal	Yellow	Diff 12H
		Heater reference	Purple	Diff 12L
		Shield	Clear	AG \perp
		Heater power	Red	SW12-1 ^{1/}
		Power reference	Black	G
HFP01SC #2		Signal	White	Diff 10H
		Signal reference	Green	Diff 10L
		Shield	Clear	AG \perp
		Heater signal	Yellow	Diff 13H
		Heater reference	Purple	Diff 13L
		Shield	Clear	AG \perp
		Heater power	Red	SW12-1 ^{1/}
		Power reference	Black	G
HFP01SC #3		Signal	White	Diff 11H
		Signal reference	Green	Diff 11L
		Shield	Clear	AG \perp
		Heater signal	Yellow	Diff 14H
		Heater reference	Purple	Diff 14L
		Shield	Clear	AG \perp
		Heater power	Red	SW12-2 ^{1/}
		Power reference	Black	G

^{1/}The **SW12** terminals on the VOLT 116 are limited to 200 mA output, so no more than two HFP01SC sensors may be connected to each terminal. The user should connect heater power wires from HFP01SC #1 and #2 to **SW12-1** and connect heater wires from HFP01SC #3 to **SW12-2**.

Appendix D. System diagnostic word

Possible system flags are listed in [Table D-1](#) (p. 150).

Table D-1: Description of bits for system diagnostic			
Bit	Decimal	Name	Function
0	1	sonc_er	Sonic error. If any error condition or diagnostic flag is set on the sonic anemometer, this bit is set.
1	2	irga_er	IRGA error. If any error condition or diagnostic flag is set on the gas analyzer, this bit is set.
2	4	pump_tmpr_er	Pump temperature error. If pump temperature is $<0\text{ }^{\circ}\text{C}$ or $>55\text{ }^{\circ}\text{C}$, this bit is set.
3	8	pump_flow_er	Pump flow error. If pump flow is more than $\pm 0.5\text{ L}\cdot\text{min}^{-1}$ from the pump flow set point (default set point is $8\text{ L}\cdot\text{min}^{-1}$), this bit is set.
4	16	valv_tmpr_er	Valve temperature error. If valve module temperature is $<2\text{ }^{\circ}\text{C}$ or $>50\text{ }^{\circ}\text{C}$, this bit is set.
5	32	valv_flow_er	Valve flow error. If zero or span gas flow through the valve module is more than $\pm 0.5\text{ L}\cdot\text{min}^{-1}$ from the valve flow set point (default set point is $1\text{ L}\cdot\text{min}^{-1}$), this bit is set.
6	64	scrb_tmpr_er	Scrub temperature error. If scrub temperature is $<5\text{ }^{\circ}\text{C}$ or $>50\text{ }^{\circ}\text{C}$, this bit is set.

Appendix E. Quality grading

Table E-1 (p. 151) and Table E-2 (p. 152) show the quality grade definitions. Refer to Foken et al. (2012) for more details. See *EasyFlux DL CR6OP or CR1KXOP*, Appendix F, for more details on the implementation in the data logger program.


Table E-1: Grades of relative non-stationarity, relative integral turbulence characteristics, and wind direction in the sonic instrument coordinate system					
RN_{cov}		ITC_{sw} and ITC_{tau}		wnd_dir_sonic	
Relative non-stationarity (Foken et al. 2012, Model 2.3)		Relative integral turbulence characteristics (Foken et al. 2012, Model 2.5)		Wind direction	
Grade	Range (%)	Grade	Range (%)	Grade	Range (°)
1 (highest)	[0 , 15)	1 (highest)	[0 , 15)	1 (highest)	[0 , 150) and [210 , 360]
2	[15 , 30)	2	[15 , 30)	2	[150 , 170) and [190 , 210)
3	[30 , 50)	3	[30 , 50)	3 (lowest)	[170 , 190)
4	[50 , 75)	4	[50 , 75)		
5	[75 , 100)	5	[75 , 100)		
6	[100 , 250)	6	[100 , 250)		
7	[250 , 500)	7	[250 , 500)		
8	[500 , 1,000)	8	[500 , 1,000)		
9 (lowest)	$\geq 1,000$	9 (lowest)	$\geq 1,000$		

Table E-2: Overall grades for each flux variable by the grades of relative non-stationary, relative integral turbulence characteristics, and wind direction in the sonic instrument coordinate system^{1/}

Overall quality grade	RN_{cov}	ITC_{sw}	wnd_dir_sonic
	Relative non-stationarity	Relative integral turbulence characteristic	Wind direction
1 (best)	1	1 – 2	1
2	2	1 – 2	1
3	1 – 2	3 – 4	1
4	3 – 4	1 – 2	1
5	1 – 4	3 – 5	1
6	5	5	2
7	6	6	2
8	7 – 8	7 – 8	2
9 (worst)	9	9	3

^{1/}Simplified Table 4.5 in Foken et al. (2012).

Appendix F. Using Swagelok fittings

This appendix gives a few tips on using Swagelok tube fittings. For more information, consult your local Swagelok dealer or visit their website at www.swagelok.com .

General notes

- Do not use fitting components from other manufacturers — they are not interchangeable with Swagelok fittings.
- Do not attempt to use metric fittings. For example, 6 mm is very close to 1/4 in, but they are not interchangeable. Metric fittings can be identified by the stepped shoulder on the nut and on the body hex.
- Make sure that the tubing rests firmly on the shoulder of the fitting body before tightening the nut.
- Never turn the fitting body. Instead, hold the fitting body and turn the nut.
- Keep tubing and fittings clean. Always use caps and plugs to keep dirt and debris out.
- Do not overtighten fittings, as doing so will damage the threads.

If a nut cannot be easily tightened by hand, this indicates the threads have been damaged. Replace any damaged nuts and fittings.

F.1 Assembly

The first time a Swagelok fitting is assembled, the ferrules become permanently swaged onto the tube. Assembly instructions vary depending on plastic or metal tubing. The assembly instructions are also slightly different for an initial installation than for subsequent reassembly.

First-time assembly, plastic tubing

1. Cut the tubing to length.
2. Make sure the cut is square and free of burrs.
3. Some types of plastic tubing have an aluminium layer. Take care to not flatten the tube as you cut it.

4. Push an insert into the end of the tubing.
5. Do not remove the nuts and ferrules from the fitting. Simply insert the tube into the assembled fitting until it bottoms out.
6. Rotate the nut finger-tight.
7. While holding the fitting body steady, tighten the nut one and one-quarter turns. (For 1/16-in or 1/8-in fittings, tighten the nut three-quarters of a turn.)

First-time assembly, metal tubing

Extra care is needed to avoid overtightening brass fittings when used with metal tubing. The following steps apply to reducers and port connectors as well as metal tubing.

NOTE:

No insert is required with metal tubing.

1. Do not remove the nuts and ferrules from the fitting. Simply insert the tube into the assembled fitting until it bottoms out.
2. Rotate the nut finger-tight.
3. While holding the fitting body steady, tighten the nut until it feels tight. This will normally be less than one full turn. Tightening a full one and one-quarter turns will damage the threads on the fitting and nut.

Reassembly, plastic or metal tubing

You may disassemble and reassemble Swagelok tube fittings many times, but the assembly process is slightly different than the first assembly.

1. Insert the tube with pre-swaged ferrules into the fitting until the front ferrule seats against the fitting body.
2. Rotate the nut finger-tight.
3. While holding the fitting body steady, tighten the nut slightly with a wrench.

F.2 Common replacement parts

Tubing

Campbell Scientific can provide several types and sizes of plastic tubing as shown in [Table F-1](#) (p. 155). A tubing cutter can be used to cut these tubes.

Table F-1: Available plastic tubing sizes, construction, and usage guidelines					
Tubing type	OD (in)	ID (in)	Length (ft)	Construction	Notes
Synflex 1300	1/4	0.17	500	Black HDPE jacket, overlapped aluminium tape, ethylene copolymer liner	Aluminium layer limits diffusion; best for sample tubes
	3/8	1/4	250		
	1/2	3/8	250		
LLDPE	3/8	1/4	500	Black linear low-density polyethylene	More flexible than HDPE
	1/2	3/8	500		
HDPE	5/8	1/2	100	Black high-density polyethylene	Required for larger diameter

Tubing inserts

Inserts are recommended for use in plastic tubing. These inserts become permanently attached to the tubing at the first assembly, so spare inserts may be needed for replacing the ends of tubing.



Figure F-1. Swagelok insert

Table F-2: Dimensions and part numbers for Swagelok inserts		
Tubing OD (in)	Tubing ID (in)	Swagelok part number
1/4	1/8	B-405-2
1/4	0.17	B-405-170
1/4	3/16	B-405-3
3/8	1/4	B-605-4
1/2	3/8	B-815-6
5/8	1/2	B-1015-8

Ferrules

Each Swagelok fitting comes assembled with the front and back ferrules included. These ferrules are permanently swaged onto the tubing at the first assembly, so spare ferrules may be needed for replacing the ends of tubing.



Back ferrule Front ferrule

Figure F-2. Front and back Swagelok ferrules

Table F-3: Dimensions and part numbers for Swagelok ferrules	
Tubing OD (in)	Swagelok part number (front/back)
1/8	B-203-1/B-204-1
1/4	B-403-1/B-404-1
3/8	B-603-1/B-604-1
1/2	B-813-1/B-814-1
5/8	B-1013-1/B-1014-1

Plugs

Swagelok plugs are used to plug a fitting when its tube is disconnected. It is strongly recommended to plug all fittings to keep them clean. Spare plugs may be needed if they become lost or damaged.



Figure F-3. Swagelok plug

Table F-4: Dimensions and part numbers for Swagelok plugs	
Tubing OD (in)	Swagelok part number
1/8	B-200-P
1/4	B-400-P
3/8	B-600-P
1/2	B-810-P
5/8	B-1010-P

Caps

Swagelok caps are used to cap the end of tubes when they are disconnected from the fitting. It is strongly recommended to cap all disconnected tubes to keep them clean. Spare caps may be needed if they become lost or damaged.



Figure F-4. Swagelok cap

Table F-5: Dimensions and part numbers for Swagelok caps	
Tubing OD (in)	Swagelok part number
1/8	B-200-C
1/4	B-400-C
3/8	B-600-C
1/2	B-810-C
5/8	B-1010-C

Appendix G. CPEC310 scrub module installation, operation, and maintenance

The CPEC310 scrub module provides a stream of air that has been scrubbed of CO₂ and H₂O and is used for zeroing the EC155. The module is housed in a fibreglass enclosure that can generally be mounted to the same structure as the CPEC310 system enclosure. The enclosure is shown in [Figure G-1](#) (p. 158), and the specifications can be found in [Scrub module specifications](#) (p. 159).



Figure G-1. CPEC310 scrub module

G.1 Theory of operation

The CPEC310 scrub module provides an air stream with CO₂ and H₂O removed to zero the EC155. It includes a small diaphragm pump to push the zero air to the analyzer and three bottles containing a molecular sieve to remove CO₂ and water vapour from ambient air. The pump provides approximately 1.5 LPM flow. It has a heater and fan to keep it within its operating range (5 to 50 °C) over ambient temperatures down to –30 °C. The CPEC310 scrub module is intended to replace the cylinder of compressed zero air.

The CPEC310 scrub module pump pulls ambient air through three bottles of molecular sieve and pushes it to the valve module. The ambient air inlet and zero air outlet fittings are on the bottom of the enclosure. It uses a small diaphragm pump that is mounted in an insulated, temperature-controlled box inside the weather-tight fibreglass enclosure.

The following are descriptions of the operating parameters of the scrub pump.

Pump control

The pump is turned on automatically when the **Zero Air** valve is selected. The pump has a maximum flow rate of approximately 2.0 LPM and a maximum pressure rise of approximately 90 kPa.

Scrub pump outlet pressure

The measured outlet pressure of the pump is reported in public variable **scrub_press**. This pressure will normally be 1 to 23 kPa when it is running.

Scrub pump temperature

The temperature of the scrub pump is reported in public variable **scrub_tmpr**. The operating range of the pump is 5 to 50 °C. If the scrub temperature is within the operating range, the public variable **scrub_tmpr_ok** will be set to **True**. If the scrub pump temperature is outside this range, the CPEC310 will disable the pump, and the public variable **scrub_tmpr_ok** will be set to **False**. The scrub pump module has a heater (drawing 8W while operating) that turns on if the pump temperature falls below 7 °C. If the CPEC310 is started at cold temperature, it may take up to 20 minutes to warm the scrub pump module (from –30 to 5 °C). When it reaches 7 °C the heater will cycle on/off as needed to maintain this temperature.

The scrub pump module has a fan (drawing 0.7 W while operating) that turns on if the pump temperature rises above 45 °C. The fan will stay on until the scrub pump temperature falls below 40 °C.

G.2 Scrub module specifications

Operating temperature: –30 to 50 °C

Power consumption^{1/}

Quiescent:	0 W
With pump on:	2 W
With heater on:	8 W
With fan on:	0.7 W

^{1/}The typical average power consumption is generally negligible in a CPEC310 system because it is used for a short time each day.

G.3 Installation

Numerous mounting options for the scrub module exist, including tripod (mast or leg), tower, or pole. Enclosure mounts are specified when ordering the CPEC310 scrub module, and mounting the module is accomplished in the same way as mounting other CPEC310 enclosures as described in [Mounting](#) (p. 24).

Connect the scrub module cable to the CPEC310 system enclosure receptacle marked **Scrub Module**. Remove the Swagelok plugs from the inlet and outlet and store them in the mesh pocket in the door. Install the Swagelok nut with screen on the **Ambient Air** inlet. Connect a 1/4-in OD tube from scrub module to valve module on the **Zero** inlet. Remove the desiccant pack from its plastic bag and place the pack in the mesh pocket.

Edit the CPEC310 CRBasic program to set constant **CPEC310SCRUB = True** and recompile.

The CPEC310 program will add the appropriate variables. It will control the temperature of the scrub module whenever it controls the temperature of the valve module. It will turn on the scrub module pump whenever the **Zero Air** valve is selected. The scrub module will push a flow of ambient air that has been scrubbed of CO₂ and water through the valve module to the EC155.

G.4 Maintenance

Once per year, refill the first bottle with fresh molecular sieve (molecular sieve 13X, 1.6 to 2.5 mm beads) according to the following steps:

1. Power down the CPEC310 or unplug the scrub module cable from the CPEC310. This will ensure the scrub module pump does not turn on while you replace the molecular sieve.

2. Open the door of the scrub module enclosure to expose the bottles containing the molecular sieve as shown in [Figure G-2](#) (p. 161).



Figure G-2. CPEC310 scrub module interior

3. Disconnect the fully exposed black tube (S-shaped and tied to the centre of the cover as shown in [Figure G-2](#) [p. 161]) at both ends. This tube remains captive to the cover plate.

NOTE:

Disconnecting this tube ensures the bottles are not pressurized when the cover is removed. The scrub module has been designed to require this tube to be disconnected before removing the cover as a safety precaution.

4. Loosen the four thumbscrews (shown in [Figure G-2](#) [p. 161]) and remove the cover plate to gain access to the bottles ([Figure G-3](#) [p. 162]). Note that the thumb screws are captive; they remain attached to the cover plate.



Figure G-3. Interior of CPEC310 scrub module with tubing and cover removed

5. Disconnect the remaining tubes from the bottles at the Swagelok fittings.

NOTE:

Caps are spring loaded!

6. Remove the centre bottle from the scrub module and set it aside.
7. Remove the left bottle and place it in the centre position.
8. Remove the right bottle and place it in the left position.

9. Refill the bottle that was removed by twisting while pulling to remove the top cap. The caps are held in place by friction only and the spring inside the bottle may eject the cap.

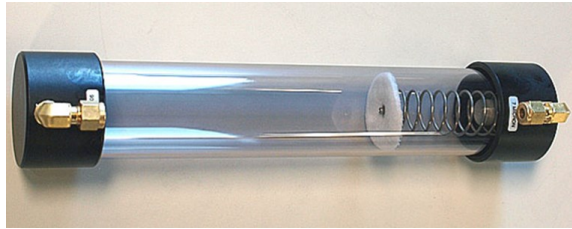


Figure G-4. Empty bottle showing the top (on the right with spring) and bottom (left) caps

10. Remove and discard of the spent molecular sieve in accordance with local ordinances and the manufacturer Safety Data Sheet.
11. Refill the bottle with new molecular sieve and replace the top cap (the cap with the spring).
12. Replace the freshly filled bottle in the open position on the right side of the enclosure.
13. Reconnect the tubes to the bottles.
14. Replace the cover plate and retighten the thumb screws.
15. Reconnect the black tube in its original location over the cover plate.
16. Close the scrub module enclosure.
17. Reconnect the scrub module cable as in [Installation](#) (p. 160) and restart the CPEC310.

Appendix H. References

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