Addendum to GCOS-174 (File Version: 20230310)

During the 17th BSRN Scientific Review and Workshop (2022) it has been agreed to start submitting all new station-to-archive files by including the logical record LR4000 related to raw pyrgeometer signals (calibrated signals in W/m^2 and temperatures in °C). This documents defines the format of the logical record LR4000 (Section 1.1), and the metadata information referred to the pyrgeometer(s) that should be included in the commentary section, following a coding defined in Section 1.2. This information (k_i constants) is crucial to be able to recompute the longwave components from raw data, and to apply some consistency checks between LR4000 and LR0100 (or any LR storing final pyrgeometer derived quantities).

1.1. LR4000 format

This section defines the format of the LR4000 following the approach defined in GCOS-174 (König-Langlo et al., 2013) for any other Logical Record. Hence, the logical record identifier, should be prepended by a *U/*C in case it is Unchanged or Changed with respect to the previous monthly file.

Table A.1. BSRN station-to-archive file format update LR4000 – pyrgeometer temperatures

Logical record	Line no.	Description of field / format of line	Range of values	Missing code	Format of v./l.
4000	1	date [day]	1-31		I2
pyrgeo.	1	time [minute]	0-1439		I4
temp	1	dome temperature 1 downward long-wave instrument [°C]		-99.99	F6.2
	1	dome temperature 2 downward long-wave instrument [°C]		-99.99	F6.2
	1	dome temperature 3 downward long-wave instrument [°C]		-99.99	F6.2
	1	body temperature downward long-wave instrument [°C]		-99.99	F6.2
	1	thermopile output downward long-wave instrument [W/m²]		-999.9	F6.1
	1	dome temperature 1 upward long-wave instrument [°C]		-99.99	F6.2
	1	dome temperature 2 upward long-wave instrument [°C]		-99.99	F6.2
	1	dome temperature 3 upward long-wave instrument [°C]		-99.99	F6.2
	1	body temperature upward long-wave instrument [°C]		-99.99	F6.2
	1	thermopile output upward long-wave instrument [W/m²]		-999.9	F6.1
		(X,I2,X,I4,X,4(F6.2,X),F6.1,2X,4(F6.2,X),F6.1)			
4nnn pyrgeo. temp. at nnn meter		Pyrgeometer temperatures from instruments mounted on towers at a height of nnn meters are coded according to the definitions for pyrgeometers at a standard height (~2 m), see LR4000			

Note: the thermopile outputs are defined as U(output voltage of the thermopile)/C (sensitivity of the pyrgeometer)

1.2 The @LR4000CONST metadata information (within LR0003)

Any station-to-archive files containing a LR4000 (or LR4nnn) should also include in LR0003 (commentary section), one metadata line for each pyrgeometer whose raw data are recorded in LR4000 (or LR4nnn), i.e., at least two lines in case the raw data of two pyrgeometers are included in LR4000 (one measuring downward and the other upward LW irradiance).
Each line, starting with the meta-code **@LR4000CONST** (or @LR4nnnCONST), should contain the information about the pyrgeometer IDs (manufacturer and WMO), calibration certificate id (CertificateCodeID, see naming convention below), and correction parameters as defined by the following template :

@LR4000CONST, s/n (Manufacturer), s/n (WMO), CertificateCodeID[1], C, k0, k1, k2, k3, f

with *C*, *ki* and *f* referring to the general equation of the pyrgeometer (§9.2.3 McArthur, 2005; Philipona et al.

[1] Please send a copy of your calibration certificates to BSRN PM or WRMC director or upload them in your BSRN calibration folder.

1995), that appears as follows

$$L = k_0 + \frac{U_{emf}}{C}(1 + k_1\sigma T_B^3) + k_2\sigma T_B^4 - k_3\sigma(T_D^4 - T_B^4) - f\Delta T_{N-S}$$

where C is the thermopile responsivity (μV W^{-1} m^2), k_i are the instrument dependent calibration constants, T_B and T_D the body and dome temperatures in degrees K, U_{emf} the electrical output from thermopile and $f\Delta T_{S-N}$ a correction factor for infrared irradiance on unshaded domes.
Any non available terms should be set to "ND".

1.2.1 Number of metadata lines to include in LR0003

As mentioned above, at least one metadata line per type of LW measurement whose raw data are recorded in the LR4000 (or LR4nnn), i.e., at least two metadata lines if both the LW downward and upward fluxes are measured. However, there may be more if there are instrument changes, because all pyrgeometers used during the month should be described by one corresponding metadata line. Since the pyrgeometer ID (WMO/BSRN) is included in the metadata line, the information about the time of instrument change is given in LR0008, while LR0009 already indicates what parameter is measured by each pyrgeometer and thus which pyrgeometer replaced which other one.

1.2.2 Clarification on the CertificateCodeID definition:

The station scientist can define CertificateCodeId according to one of the following options:

1) the reference number of the official certificate used to fill the LR0008 record. The CertificateCodeId to be used is generally indicated as an alphanumerical code in the Calibration Certificate, as shown in Figure 1.

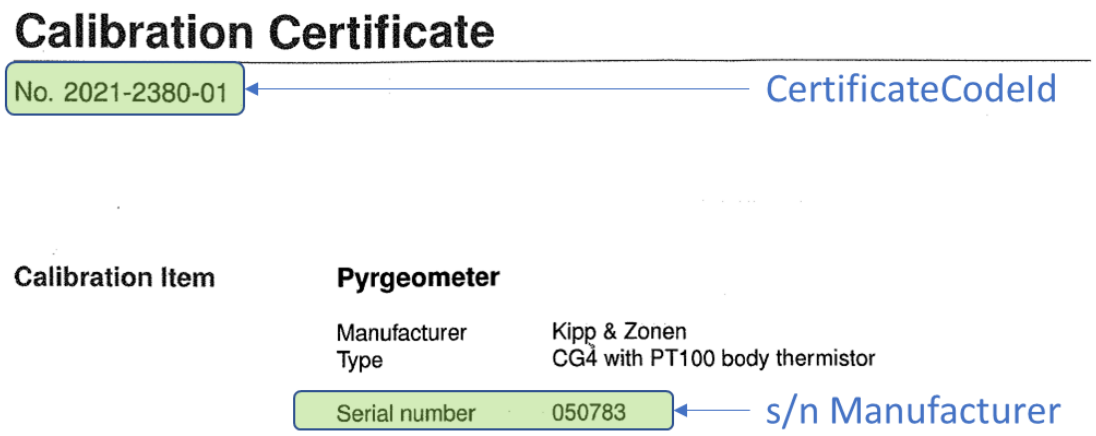

Figure 1: Extract of a certificate of calibration for the instrument CGR4 produced by Kipp and Zonen with serial number 050783 (Courtesy of IZA station scientist). The s/n of the manufacturer and the CertificateCodeId are highlighted.

2) In case the station already agreed to the BSRN initiative aimed to store centrally the calibration documents of all instruments adopted by the network, the station scientist should already have associated a name to the archived copy of his calibration document. In this case, the **CertificateCodeId** to be reported in @LR4000CONST metadata, can be also the name associated to the PDF (JPG) of the document sent to the BSRN calibration archive, without extension.

The calibration documents stored in the centralized archive should follow a naming convention defined as:

CAL_yyyymmdd_manufact_model_serialnum_WRMCnum_N{.pdf, jpg}

with:

- yyyymmdd: date of the calibration certificate issued

- manufact: KZ (Kipp and Zonen), EP (Eppley), HF (Hukseflux), EK (Eko), AP (Apogee), SL (Solar Light), PM (PMOD/WRC), …(capital 2-letter code)
- model: CH1,CH1P,CM11,CM21,CM21P,CM22,CM22P,CG4,CGR4,... (capital)
- serialnum: the serial number as it appears in the calibration certificate/instrument plate
- WRMCnum: the one used in your station-to-archive files (LR0008/0009) to identify the instrument with this serial number (e.g. for dom: "74xxx", with xxx=001,002,003,...)
- _N: for jpeg only, if the calibration certificate is made of several pages (_1,_2, ...)

Hence, for example, in case the station scientist already stored the document in Figure 1 to the archive, it should appears in the listing as CAL_20160426_EK_MS802F_F15509FR_61011.pdf. Note that, as the lines of LR0003 should fit a maximum length of 80 characters, the line should be splitted in two consecutive records in case it exceed 80 characters (use a **&** continuation character to indicate it, see following example).

The @LR4000CONST metadata line can be compiled, either as method (1)

@LR4000CONST, 050783, 61008, 2021-2380-01, 9.62, ND, 0.02, 0.9974, ND, ND

Or method (2)

@LR4000CONST, 050783, 61008, CAL_20211026_KZ_CGR4_050783_61008,&
9.62, ND, 0.02, 0.9974, ND, ND

BSRN advises to adopt Method (2) to any station scientist who internally calibrates their own instrument w.r.t. a reference instrument traceable to PMOD/WRC WISG. The station scientist is encouraged to issue a short calibration report to document the calibration procedure adopted and the results obtained (instrument identification, traceability chain, calibration period and method, C, ki's, …). The digital version of the report should be named as indicated here and submitted to the archive calibration storage (contact PM or Archive director for further details).

1.3 LR4nnn naming convention

LR4000 records the raw data of LW downward and upward flux measured at standard height (from LR0100 and LR0300, respectively). In case measurements are made at non-standard height above ground, typically on towers, the **final** data should be in LR3nnn, where *nnn* gives the height above ground in meters. Currently there are BSRN stations providing data measured at 10, 30 and 300m with LR3010, LR3030 and LR3300, respectively. The **raw** data should be recorded in LR4nnn with the same convention (i.e., LR4010, LR4030 and LR4300 in this case). Similarly, one metadata line per pyrgeometer used during the month should be included in LR0003 with meta-codes @LR4010CONST, @LR4030CONST and @LR4300CONST (in such case).

References

König-Langlo, G. , Sieger, R. , Schmithüsen, H. , Bücker, A. , Richter, F. and Dutton E.G. 2013: The Baseline Surface Radiation Network and its World Radiation Monitoring Centre at the Alfred Wegener Institute.

McArthur L.J.B. 2005: Baseline Surface Radiation Network (BSRN). Operations Manual. WMO/TD-No. 1274, WCRP/WMO.

Philipona, R. C. Fröhlich, Ch. Betz, 1995: Characterization of pyrgeometers and the accuracy of 25 atmospheric long-wave radiation instruments. *Applied Optics*, 34(9) 1598-1605.