



Climate Basis Monitoring Program
Nuuk Basic, 2007-2008
Re-evaluation

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Foreword

The ClimateBasis monitoring program in Nuuk is part of the Nuuk Basic Research Project (NERO). The aim of NERO is to contribute to the monitoring of changes in the low arctic environment and to improve the understanding of the composition, function and dynamics of the ecosystem in the low arctic.

Asiaq, Greenland Survey, is responsible for the operation of ClimateBasis. The Danish Energy Agency finances the ClimateBasis monitoring program.

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1 Re-evaluation and New Parameters Measured 2008-06-25 to 2008-12-31

The recent quality check of climate data from station 652 and 653 has revealed new problems in some of the parameters that have already been released. Other parameters haven't previously been quality checked, but the data cover the last part of 2008. The quality check of these data is presented here.

The re-evaluation affects the correlations between equal parameters on the two stations because data has changed. Table 1 summarizes the affected parameters

	2008-01-01/2008-12-31		2008-01-01/2008-09-04		2008-09-04/2008-12-31	
	coefficient	offset	coefficient	offset	coefficient	offset
LRI					0.9946	4.4144
UVB					1	0
NR2					1.00196	0.834745
PAR					1.0184	-0.0197
RVI660¹⁾					0.9771	-0.0162
RVI730¹⁾					0.9652	-0.0529
SD²⁾					0.8604	-0.0124

Table 1 Station 652=coefficient*(Station 653)+offset. Empty cells in the table are unchanged correlations. The radiation masts were corrected 2008-09-04. Therefore two correlations are calculated for all radiation parameters. 1) Data from 2008-10-06 14:20 to 2008-12-31 23:55 are used to calculate the regression. 2) Data from 2008-10-06 to 2009-04-12 are used to calculate the regression.

1.1 Incoming Long Wave Radiation (re-evaluation)

The incoming long wave radiation is measured 2 meters above terrain at both station 652 and station 653. The incoming long wave radiation is measured with Kipp & Zonen net radiometers, which measures radiation with wavelength 4.5 to 42 μm . The sensor has app. the same sensitivity (spectral response) to all wavelengths in the interval.

Data from 2008-06-25 18:50 to 2008-12-13 23:55 are included in the re-evaluation. Re-evaluation is required because it is now possible to point out periods where the upper pyrgeometer were covered with snow. The re-evaluation does not influence the correlation between st. 652 and 653 as the re-evaluated data is in a period were only st. 652 recorded valid data. The results of the data check are summarized below.

Station 652, incoming long wave radiation

- 87 missing records (corresponding to 0.162% of the data set)
- 28616 records were temperature corrected using the temperature from the nearby UVB-sensor. The raw measurement of long wave radiation must be compensated for the sensors own temperature. Sensor temperature measurements are invalid in the period 2008-06-25 18:50 to 2008-10-06

07:55. The temperature measurements from the UVB-sensor correlate well with valid temperature measurements from the Kipp & Zonen sensor ($r=0.9996$).

- 1939 data points (corresponding to 3.56% of the data in the quality control period) were deleted as the sensor was covered with snow (the deleted values lie in a period where only station 652 measure valid data, therefore the correlation with station 653 remains unchanged).

Station 653, incoming long wave radiation

- 4057 missing records (corresponding to 7.5% of the data set)
- 11614 records were temperature corrected using the temperature from the UVB-sensor on station 652 (2008-06-25 19:00 to 2008-07-05 07:30 and 2008-07-13 18:30 to 2008-08-13 13:50). The raw measurement of long wave radiation must be compensated for the sensors own temperature. Sensor temperature measurements are invalid in the period 2008-06-25 18:45 to 2008-08-13 07:55. The temperature measurements from the UVB-sensor on station 652 correlate well with valid temperature measurements from the Kipp & Zonen sensor ($r=0.9994$).
- 39117 data points were deleted. A crack was formed in the sensor, gradually decreasing the quality of measurements (no valid data later than 13th August).

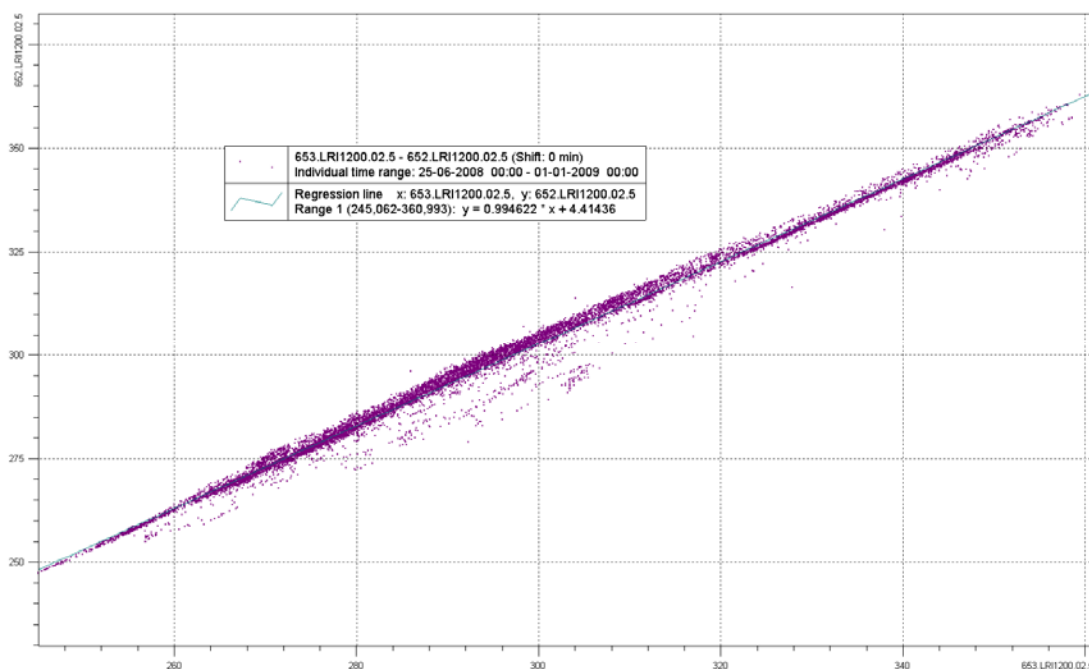


Figure 1 Incoming long wave radiation (W/m^2) measured at station 652, y, as a function of incoming short wave radiation measured at station 653, x. The regression line may have changes due to editing, see Table 1.

1.2 Photosynthetic Active Radiation (PAR) (re-evaluated)

Data from 2008-06-25 18:50 to 2008-12-13 23:55 are included in the re-evaluation.

All radiation levels have been adjusted by multiplying with 0.604. The quality check for the period 2008-01-01 to 2008-12-31 falsely applied a correction factor of 1/0.604. The correlation between the PAR measurements at station 652 and 653 remains unchanged.

1.3 UVB (re-evaluated)

Data from 2008-10-06 14:20 to 2008-12-13 23:55 are included in the re-evaluation.

Data until 2008-10-06 14:20 remains unchanged. Data after 2008-10-06 are corrected using a reference sensor, which was installed from 2009-08-01 to 2009-08-09. This test adjusts the UVB radiation level in W/m^2 by a factor 0.87. No correlation can be calculated between st. 652 and 653 as st. 653 doesn't measure valid data.

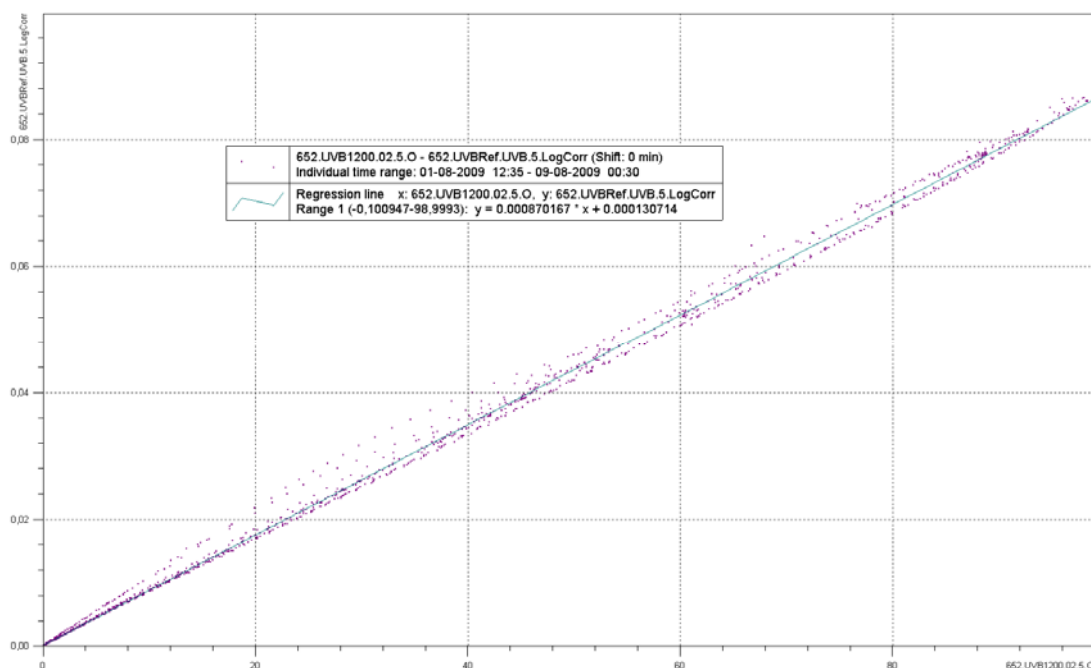


Figure 2 UVB radiation (W/m^2) measured with a reference sensor, y, as a function of UVB radiation (mW/m^2) measured at station 652, x. The regression line used to correct the measured UVB levels is $y=(0.8702+0.1307)*10^{-3}$.

1.4 Net Radiation (calculated from CNR1)

The net radiation is calculated from the four quality checked time series of short-, long-, in- and outgoing radiation. The CNR1 instrument (pyrradio-/pyrgeometer) measures the difference between incoming and outgoing radiation with wavelengths in two spectral ranges; 300 to 2800 nm and 5 to 50 μm , i.e. both short wave and long wave radiation. The sensor has app. the same sensitivity (spectral response) to all wavelengths in the interval.

Data from 2008-06-25 18:50 to 2008-12-13 23:55 are included in the re-evaluation.

KOB, net radiation 2 meters above terrain

- 2027 records are missing (3.7 % of the data in the period 2008-06-25 to 2008-12-31). 1963 records could not be calculated because the sensor likely was covered with snow.

1.5 Net Radiation (NR lite)(re-evaluation)

Data from 2008-06-25 18:50 to 2008-12-13 23:55 are included in the re-evaluation.

The net radiation is measured 2 meters above terrain at station 652 and 653. The net radiation is measured with Kipp & Zonen net radiometer (NR lite), which measures the difference between incoming and outgoing radiation with wavelength 300 to 3000 nm, i.e. both short wave and long wave radiation. The sensor has app. the same sensitivity (spectral response) to all wavelengths in the interval.

As the sensors measure the long wave radiation it is to some degree sensitive to the wind speed, due to convective cooling by the wind. The measurements are compensated for the effect of the wind in accordance with the formula given by the manufacturer, Campbell scientific (2002).

Net radiation records are prone to errors under certain conditions. Duchon and Brotzge (2000) describe different conditions that might compromise the quality of the records with the NR-lite, such as snow, rain, frost, dew, debris on the sensor etc. This quality check have evaluated whether or not the records are affected by rain or snow.

The results of the data check are summarized below.

Station 652, Net radiation at 2 meters above terrain

- 77 records are missing (0.14% of all data records in the quality check period)
- 11808 records were deleted (21.7% of all data records in the quality check period). 11704 records were deleted due to measurement problems associated with rain events. 104 records were deleted due to problems associated with snow or sleet covering the sensor.
- 1892 records (3.36% of all data records in the quality check period) were flagged as the sensor might have been covered with snow or sleet.

Station 653, Net radiation at 2 meters above terrain

- 3167 records are missing (5.81% of all data records in the quality check period)
- 11808 records were deleted (21.7% of all data records in the quality check period). 11704 records were deleted due to measurement problems associated with rain events. 104 records were deleted due to problems associated with snow or sleet covering the sensor.
- 1832 records (3.34% of all data records in the quality check period) were flagged as the sensor might have been covered with snow or sleet.

The used correlation only covers data from 2008-09-04 14:15 to 2008-12-31 23:55 because the sensor was not in level from 2008-06-25 to 2008-09-04.

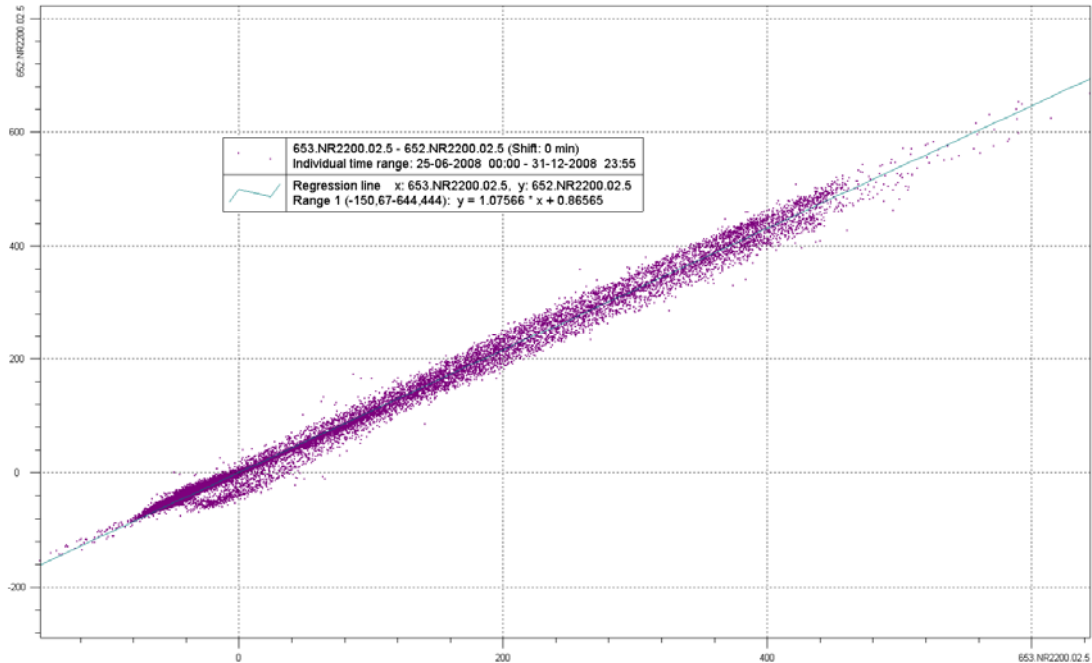


Figure 3 Net radiation measured at station 652, y, as a function of net radiation measured at station 653, x. Regression line and formula are shown.

1.6 Albedo (new parameter)

Data from 2008-06-25 18:50 to 2008-12-13 23:55 are included in the re-evaluation.

The albedo is calculated from the quality checked and combined time series of incoming and outgoing short wave radiation. Two time series are produced:

- A 5 minute time series that calculates the albedo when the sun height is higher than -1 degree and both the incoming and outgoing short wave radiation are positive.
- A 1440 minute time series that calculates the albedo at solar noon as a proxy for day values; see Sicart, J. E. et al. 2001. The reason for this is that the albedo varies with the incidence angle of the short wave radiation i.e. more short wave radiation is reflected at low sun heights. Also the relative uncertainties of radiation records increase with decreasing light intensity.

KOB, albedo 2 meter above terrain, calculated 5 minute values

- 28725 (52.7 % of all data records in the quality check period) are missing or not calculated
- 66 records could not be calculated because of missing data.
- 27461 records were not calculated because the sun was more than one degree below the horizon.

- 1198 times the albedo was not calculated because either the incoming or outgoing short wave radiation was zero.

KOB, albedo 2 meter above terrain, calculated day values

- 1 record could not be calculated because of missing data at solar noon (0.01% of data in the quality check period).

1.7 Relative Vegetation Index (new parameter)

At station 652 the PAR sensor was mounted 2008-10-06 14:25 i.e. the quality check period covers data from 2008-10-06 14:25 to 2008-12-31 23:55.

At station 653 the PAR sensor was mounted 2008-09-05 12:55 i.e. the quality check period covers data from 2008-09-05 12:55 to 2008-12-31 23:55

The RVI-sensor measures the reflection of near infra-red radiation (NIR, 730 nm) and visible radiation (VIS, 660 nm). This can be used to compute a relative vegetation index (NDVI) that covers a numeric span from -1 to 1. Very dense rain forest has a NDVI close to 1: $NDVI = (NIR - VIS) / (NIR + VIS)$.

All RVI-data in 2008 were collected with a very low resolution. This affects the accuracy of the calculated NDVI, especially when the emitted radiance is low. In this period the NDVI is therefore not calculated unless both NIR and VIS exceed a threshold of $6 \mu\text{mol s}^{-1} \text{m}^{-2}$.

The NDVI calculated at solar noon is used as a proxy for day values.

Station 652, RVI660nm, 2 meters above terrain

- No records are missing
- 600 records are negative (2.41% of all data records in the quality check period) and 52 records were positive when the sun was more than one degree below the horizon (0.21% of all data records in the quality check period). These values were set to zero.

Station 652, RVI730nm, 2 meters above terrain

- No records are missing
- 56 records are negative (0.23% of all data records in the quality check period) and 116 records were positive when the sun was more than one degree below the horizon (0.47% of all data records in the quality check period). These values were set to zero.

Station 653, RVI660nm, 2 meters above terrain

- 3756 records are missing (11.10% of all data records in the quality check period)
- 13112 records are negative (38.76% of all data records in the quality check period) and 2042 records were positive when the sun was more than one degree below the horizon (6.04% of all data records in the quality check period). These values were set to zero.

Station 653, RVI730nm, 2 meters above terrain

- 3756 records are missing (11.10% of all data records in the quality check

period)

- 10648 records are negative (31.48% of all data records in the quality check period) and 4092 records were positive when the sun was more than one degree below the horizon (12.10% of all data records in the quality check period). These values were set to zero.

KOB, NDVI, 2 m above terrain, calculated day values

- In the period 2008-09-05 to 2008-12-31 a day value for NDVI could only be calculated 10 times because of too low resolution in the source time series (RVI660nm and RVI730nm).

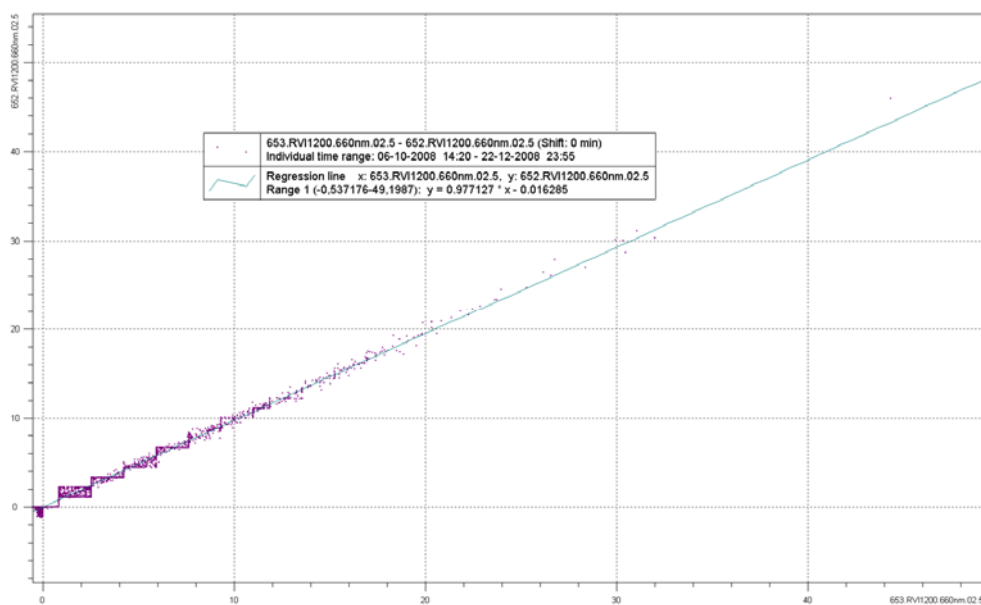


Figure 4 RVI660nm measured at station 652, y, as a function of the RVI660nm measured at station 653, x. The displayed regression line is valid.

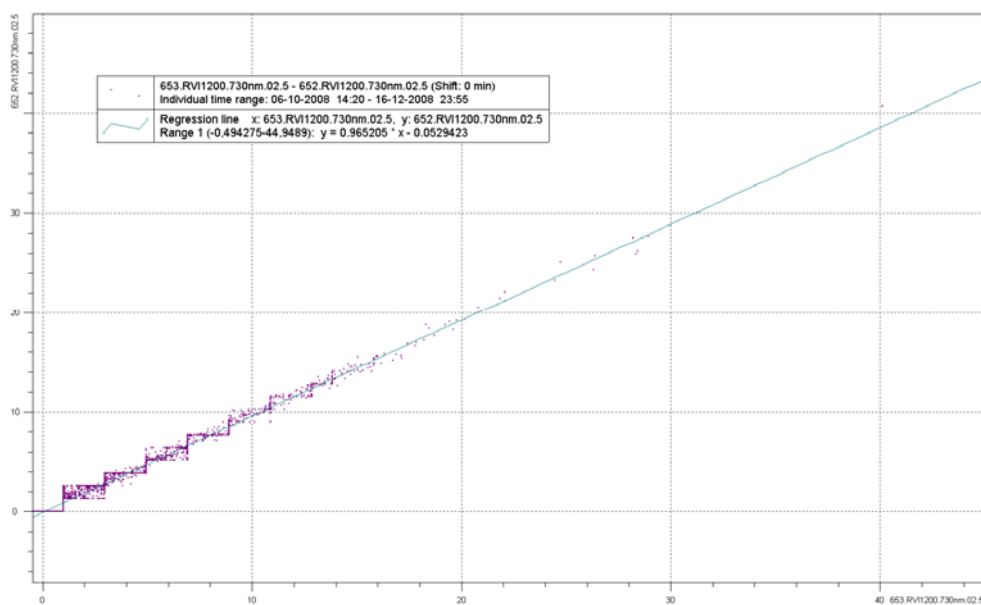


Figure 5 RVI730nm measured at station 652, y, as a function of the RVI730nm measured at station 653, x. The displayed regression line is valid.

1.8 Snow Depths (re-evaluation)

Data from 2008-10-06 12:00 to 2008-12-31 21:00 are included in the re-evaluation.

The re-evaluation includes an offset correction of 0.019 m at station 652 and 0.028 m at station 653 and in case of missing data on one of the stations a correlation is now used to fill in data from the other station.

Station 652, snow depth

- 3 records are missing (0.2% of all data records in the quality check period).
- 36 records lie outside the sensor height interval [0.000m; 1.835m].
- 50 records were deleted as they were error values.

Station 653, snow depth

- 0 records are missing.
- 30 records lie outside the sensor height interval [0.000m; 1.895m].
- 10 records were deleted as they were error values.

KOB, snow depth

- 5 records are missing (1% of all data records in the quality check period).

2 References

Campbell Scientific, Inc. 2002. *NR-Lite net radiometer instruction manual*.
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Duchon, C.E. and Brotzge, J.A., (2000). *A Field Comparison among a Domeless Net Radiometer, Two Four-Component Net Radiometers, and a Domed Net Radiometer*.
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Sicart, J. E., P. Ribsten, P. Wagnon, and D. Brunstein (2001), Clear-sky albedo records on a sloping glacier surface: A case study in the Bolivian Andes, *J. Geophys. Res.*, 106 (D23), 31,729–31,737.