



Climate Basis Monitoring Program

Nuuk Basic, 2007-2008

Project no.: B53-05

Asiaq Report 2009-10

June 2009

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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.

The ClimateBasis monitoring program includes collection, quality control and communication of data, which describes the climate at the research station in Kobbefjord.

In 2007/2008 the ClimateBasis monitoring program includes two climatological measuring stations; climate station 1 (Asiaq no. 652) and climate station 2 (Asiaq no. 653), two hydrometric stations; hydrometric station 1 (Asiaq no. 650) and hydrometric station 2 (Asiaq no. 651) and three diver stations, diver station H3, H4 and H5 (Asiaq no. 654,655 and 65). For a description see The ClimateBasis Manual for Nuuk Basic (Iversen and Thorsøe, 2009). This report only contains information about Climate Station 1 and Climate Station 2.

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

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1 Measuring Program 2007-10-22 to 2008-12-31

An overview of the measuring program 22nd October 2007 to 31st December 2008:

Parameter	Sensor type	Sensor height (m.a.t.)	Measuring range	Sensitivity (resolution)	Accuracy	Data stored in the data logger ¹	
						Average/sum	Sample/maximum/min
Air temperature	Vaisala HMP 45D	2 m	-40 – +60 °C	0.1 °C	+/- 0.4 °C	[0;30] _{10 sec} ^{30 min} Average	[–] _{10 sec} ^{30 min} max/min
Relative Humidity	Vaisala HMP 45D	2 m	0.8 – 100 %RH	0.1 %	+/- 3 %	[0;30] _{10 sec} ^{30 min} Average	
Air pressure at station	Campbell Scientific PTB101 B	1.5 m	600 – 1060 hPa	0.1 hPa	+/- 4 hPa	[0;30] _{10 sec} ^{30 min} Average	
Wind speed	Met One 034B	10 m	0.4 – 49 m/s	0.1 m/s	+/- 0.12 m/s (>10.1 m/s 1.1%)	[0;10] _{10 sec} ^{10 min} Average	[–] _{10 sec} ^{30 min} max/min
Wind speed	Theodor Friedrichs & Co 4034.0000	2 m	0.5 – 60 m/s	0.1 m/s	+/- 0.3 m/s	[0;10] _{10 sec} ^{10 min} Average	[–] _{10 sec} ^{30 min} max/min
Wind direction	Met One 034B	10 m	0 – 360°	0.5°	+/- 4°	[0;10] _{10 sec} ^{10 min} Average	[–] _{10 sec} ^{30 min} at max wind
Short wave radiation, incoming and outgoing	CNR1	2 m	0 – 1000 W/m ²	0.6 – 2.7 W/m ²	+/- 10 % for daily sums	[0;5] _{10 sec} ^{5 min} Average	
Long wave radiation, incoming and outgoing	CNR1	2 m	+/-250 W/m ²	0.3 – 1.1 W/m ²	+/- 10 % for daily sums	[0;5] _{10 sec} ^{5 min} Average	
UV-B	Solar Light & Co 501A	2 m	0 – 583 mW/m ²	< 0.583 mW/m ²	+/- 5 % for daily total	[0;5] _{10 sec} ^{5 min} Average	
Net radiation	NR Lite	2 m	+/- 2000 W/m ²	0.7 W/m ²	+/- 10 %	[0;5] _{10 sec} ^{5 min} Average	
PAR	Kipp & Zonen PAR Lite	2 m	0 – 3700 μmol/(S*m ²)	1.2 – 1.8 μmol/(S*m ²)	+/- 10 %	[0;5] _{10 sec} ^{5 min} Average	
Relative vegetation index	Skye Inst. SKR110	2 m	<500 μmol/m ² /s	100 μmol/m ² /s	+/- 3 – 5 %	[0;5] _{10 sec} ^{5 min} Average	
Precipitation	Ott Pluvio	-	0 - 99.99 mm	0.05 mm/h		[0;60] _{10 sec} ^{60 min} sum	[–] _{10 sec} ^{x min} Sample
Snow depth	Campbell Scientific SR 50	-	0.5 – 10 m	0.1 mm	+/- 1 cm or 0.4 %		[0;179] _– ^{180 min} Sample

¹ Data stored in the data logger is given as $[a; b]_c^d$, where 'd' is the interval between outputs written to the data logger, 'c' is the interval between scans of the sensor, 'a' and 'b' are minutes into the interval between output. Average values are found by averaging data values measured with interval c between 'a' and 'b'. Sample values are measured 'a' minutes into the interval between output.

2 Inspections of the Stations during 2008

The Asiaq technicians visited the Nuuk Basic climate stations on two occasions in 2008. Additional visits to the stations were carried out by other Asiaq personnel. A summary of the work done on each station is given below.

2.1 Time Line and Summary of Events for Climate Station 1, st.652

2007-10-22	Start of quality check period
2008-06-18	Data collected, new program uploaded: Air pressure and all radiation parameters are now stored with 7 digits. Still radiation data are not saved.
2008-06-25	Data collected, new program uploaded: Radiation parameters are stored.
2008-08-01	Data collected
2008-09-04	Visual inspection of the measuring station revealed that the mounts on 2 m mast weren't entirely level. Consequently all radiation sensors placed on the mount were not level (CNR1, NR-lite and UVB). Apart from a few bent fans on the precipitation wind shield no other installations were visually damaged. The 2 m mast was adjusted to vertical. No other changes to station C1. Technicians focus on climate station 2.
2008-10-06	Technicians visit the station. The CNR1-sensor and UVB-sensor are not level. Following sensors were replaced: Snow Depth, RVI, PAR, Net Radiation (lite) and UVB-sensor. The wind sensor was moved from the 2 meter mast to the 10 m mast (still placed at 2 m.a.t). The RVI-sensor was moved to the 2 m mast. An additional mast was erected to carry the new snow depth sensor.
2008-10-17	Data collected.
2008-10-21	Data collected.
2008-12-31	End of the quality check period

2.2 Time Line and Summary of Events for Climate Station 2, st.653

2007-10-22	Start of quality check period
2008-06-18	Data collected, new program uploaded: Air pressure and all radiation parameters are now stored with 7 digits. Still radiation data are not saved.
2008-06-25	Data collected, new program uploaded: Radiation parameters are stored.
2008-08-01	Data collected.
2008-09-04	Technicians visit the station and adjust the 2 m mast to vertical. Following sensors were replaced: Snow Depth, RVI, PAR, Net Radiation (lite) and UVB-sensor. The wind sensor was moved from the 2 meter mast to the 10 m mast (still placed 2 m.a.t). The RVI-sensor was moved to the 2 m mast. An additional mast was erected to carry the new snow depth sensor.
2008-10-06	Technicians visit the station but focus on climate station 1. Visual inspection of the CNR1-instrument revealed a large fissure sensor that measures long wave incoming radiation.
2008-10-17	Data collected.
2008-10-21	Data collected. The compact flash card was reformatted. No data the card since 2008-10-06.
2008-12-31	End of the quality check period

2.3 The Results of the Reference Tests at Climate Station 1, st.652

Parameter	Unit	2008-09-04			2008-10-06		
		Logger	Reference	Time	Logger	Reference	Time
Wind speed 10 m	m/s	1.56	0.3	17:34	9.80	10.5	10:32
Wind direction 10 m	Degree	209	216	-	208.95	210	10:34
Relative Humidity 2 m	%	89.59	89.05	17:22	41.89	-	10:21
Wind speed 2 m	m/s	-	-	-	-	10.5	10:32
Air temperature 2 m	°C	6.59	7.32	17:21	-2.79	-	10:21
Precipitation	mm	126.4	(13cm)	17:25	320.61	(17 cm)	10:20
Air pressure	hPa	999.17	999.07	17:22	984.43	984.95	10:22
Logger temperature	°C	8.46	-	17:26	-1.35	-	10:24
Battery	V	12.56	12.88	17:45	12.63	-	10:24
CNR1 Short Wave in	W/m ²	58.8	-	17:45	57.88	58.79	10:45
CNR1 Short Wave out	W/m ²	-	-	-	6.38	-	10:45
CNR1 Long Wave in	W/m ²	344.69	-	17:45	102.81	-	10:45
CNR1 Long Wave out	W/m ²	359.85	-	17:45	1.03	-	10:45
PAR	μmol/m ² /s	327.87	-	17:26	315.84	-	10:45
UVB	W/m ²	7.12	-	17:45	8.67	-	10:45
RVI 660 nm	μmol/m ² /s	9.47	-	17:45	8.21	-	10:45
RVI 730 nm	μmol/m ² /s	7.56	-	17:45	5.68	-	10:45
Snow Depth	m	-	0	17:37	-	0	10:45
Distance to snow	m	-	2.35	17:37	-	-	-

Table 1 Arrival reference test September 4rd and October 10th at C1.

Parameter	Unit	2008-09-04			2008-10-06		
		Logger	Reference	Time	Logger	Reference	Time
Wind speed 10 m	m/s	-	-	-	2.83	2.90	14:31
Wind direction 10 m	Degree	-	-	-	210	212	14:42
Relative Humidity 2 m	%	-	-	-	34	34	14:45
Wind speed 2 m	m/s	-	-	-	0.28	1.20	14:40
Air temperature 2 m	°C	-	-	-	-2.09	-1.30	14:24
Precipitation	mm	-	-	-	-	(5 liter)	14:55
Air pressure	hPa	-	-	-	984.19	983.99	14:23
Logger temperature	°C	-	-	-	-0.61	-	14:27
Battery	V	-	-	-	12.42	12.20	14:29
CNR1 Short Wave in	W/m ²	-	-	-	74.39	76.43	14:51
CNR1 Short Wave out	W/m ²	-	-	-	9.69	-	14:51
CNR1 Long Wave in	W/m ²	-	-	-	98.88	-	14:51
CNR1 Long Wave out	W/m ²	-	-	-	1.03	-	14:51
PAR	μmol/m ² /s	-	-	-	214.32	-	14:51
UVB	W/m ²	-	-	-	16.00	-	14:51
RVI 660 nm	μmol/m ² /s	-	-	-	1.11	-	14:51
RVI 730 nm	μmol/m ² /s	-	-	-	1.28	-	14:51
Snow Depth	m	-	-	-	0.22	0.19	14:51
Distance to snow	m	-	-	-	1.61	1.62	14:49

Table 2 Departure reference test September 4rd and October 10th at C1.

2.4 The Results of the Reference Tests at Climate Station 2, st.653

Parameter	Unit	2008-09-04			2008-10-06		
		Logger	Reference	Time	Logger	Reference	Time
Wind speed 10 m	m/s	3.64	4	13:50	1.48	1	11:45
Wind direction 10 m	Degree	215.66	216	13:48	215.92	216	11:45
Relative Humidity 2 m	%	73.71	71.71	13:24	43.26	42.10	11:43
Wind speed 2 m	m/s	2.38	1.5	13:26	3.03	3.00	11:42
Air temperature 2 m	°C	8.6	9.34	13:24	-2.48	-1.81	11:43
Precipitation	mm	-	-	13:43	459.81	(11.7 cm)	-
Air pressure	hPa	1000.83	1000.99	13:21	-	-	-
Logger temperature	°C	-	-	13:27	-	-	-
Battery	V	12.75	12.65	13:28	-	-	-
CNR1 Short Wave in	W/m ²	-	-	-	90.59	62.17	-
CNR1 Short Wave out	W/m ²	-	-	-	-	-	-
CNR1 Long Wave in	W/m ²	-	-	-	-	-	-
CNR1 Long Wave out	W/m ²	-	-	-	-	-	-
PAR	μmol/m ² /s	-	-	-	-	-	-
UVB	W/m ²	-	-	-	-	-	-
RVI 660 nm	μmol/m ² /s	-	-	-	-	-	-
RVI 730 nm	μmol/m ² /s	-	-	-	-	-	-
Snow Depth	m	-	-	-	-	-	-
Distance to snow	m	-	-	-	-	-	-

Table 3 Arrival reference test September 4th and October 10th at C2.

Parameter	Unit	2008-09-05			2008-10-06		
		Logger	Reference	Time	Logger	Reference	Time
Wind speed 10 m	m/s	5.15	5.7	13:07	-	-	-
Wind direction 10 m	Degree	216.41	217	13:08	-	-	-
Relative Humidity 2 m	%	92,9	95,35	13:05	-	-	-
Wind speed 2 m	m/s	4.07	4.75	13:05	-	-	-
Air temperature 2 m	°C	6.49	7.35	13:04	-	-	-
Precipitation	mm	-	-	-	0	(7.7 cm)	13:13
Air pressure	hPa	986.66	986.60	13:04	-	-	-
Logger temperature	°C	-	-	-	-	-	-
Battery	V	12.6	12.2	13:12	-	-	-
CNR1 Short Wave in	W/m ²	-	-	-	-	-	-
CNR1 Short Wave out	W/m ²	-	-	-	-	-	-
CNR1 Long Wave in	W/m ²	-	-	-	-	-	-
CNR1 Long Wave out	W/m ²	-	-	-	-	-	-
PAR	μmol/m ² /s	-	-	-	-	-	-
UVB	mW/m ²	-	129.335	13:15	-	-	-
RVI 660 nm	μmol/m ² /s	-	-	-	-	-	-
RVI 730 nm	μmol/m ² /s	-	-	-	-	-	-
Snow Depth	m	-	-	-	0.20	0.19	-
Distance to snow	m	-	-	-	1.69	1.71	-

Table 4 Departure reference test September 4th and October 10th at C2.

3 Data Processing

The aim of the data processing is to establish one data series of high quality for each measured parameter.

The data processing includes the following steps:

1. Any necessary corrections of the data are performed.
2. Data exceeding the physical limits for the given parameter are removed.
3. Comparison of data from sensors measuring the same parameter (when available) and/or from sensors measuring related parameters is used to identify outlying data points. Also the reference tests are included in the data evaluation.
4. If possible the data series from each station are or corrected using regression, interpolation or arithmetic's. Gaps created due to editing are filled in step 5.
5. Data from each station are normally combined by averaging data from each station. In case of missing data correlated values are included in the average:

Data on both stations	Only data on St.652	Only data on St.653	No data
$\frac{1}{2}(\text{St.652}+\text{St.653})$	$\frac{1}{2}(\text{St.652}+ \text{St.653}=\alpha\text{St.652}+\beta)$	$\frac{1}{2}(\text{St.653}+ \text{St.652}=\alpha\text{St.653}+\beta)$	No data

List of correlations used in case of missing data on one of the stations:

	2008-01-01/2008-12-31		2008-01-01/2008-09-04		2008-09-04/2008-12-30	
	coefficient	offset	coefficient	offset	coefficient	offset
ATA	0.992303	0.066780				
ATM	0.993545	0.051066				
ATN	0.990464	0.074320				
RH	0.991661	-1.076930				
LRI			0.994622	4.414360	<i>0.994622</i>	<i>4.414360</i>
LRO			0.998559	2.005550	1.007940	-1.147620
SRI			1.022080	-1.210430	1.046320	-0.022550
SRO			0.917312	0.306744	0.971383	0.053318
UVB	<i>1.000000</i>	<i>0.000000</i>				
NR2	1.071690	1.242030				
PAR	1.018370	-0.019661				
QFE	0.996347	3.987530				
WS12	0.957585	0.066255				
WS16	0.983255	0.034983				
WSM12	0.944068	0.186645				
WSM16	0.989046	0.019931				

Table 5 Station 652=coefficient*(Station 653)+offset. The radiation masts were corrected 2008-09-04. Therefore two correlations are calculated for all radiation parameters. Otherwise data from 2008-01-01 to 2008-12-31 are included in the regression lines. The correlations marked with red a correlation could not be estimated due to missing data. In that case the previous correlation is used.

A short description of the data processing for each parameter is given below. The figures with regression lines display unedited data. The production time series are stored in the Greenland Ecosystem Monitoring Database.

The data processing is including data from the period October 22th 2007 to December 31st 2008.

3.1 Air Pressure

The air pressure is measured at station 652 and 653. The logged air pressure data values reflect the air pressure at the position of the sensor (no altitude correction).

On both stations the data resolution is 1 hPa until 2008-06-18. After 2008-06-18 it is 0.01 hPa

Station 652, air pressure

- 15 records are missing (0.02% of all data records in the period)
- None measurements lie outside the interval [900 hPa; 1100 hPa]
- 47 data points were deleted as they were too low

Station 653, air pressure

- 56 records are missing (0.09% of all data records in the period)
- None measurements lie outside the interval [900 hPa; 1100 hPa]
- 18 data points were deleted

KOB, air pressure

- 7 data points are missing

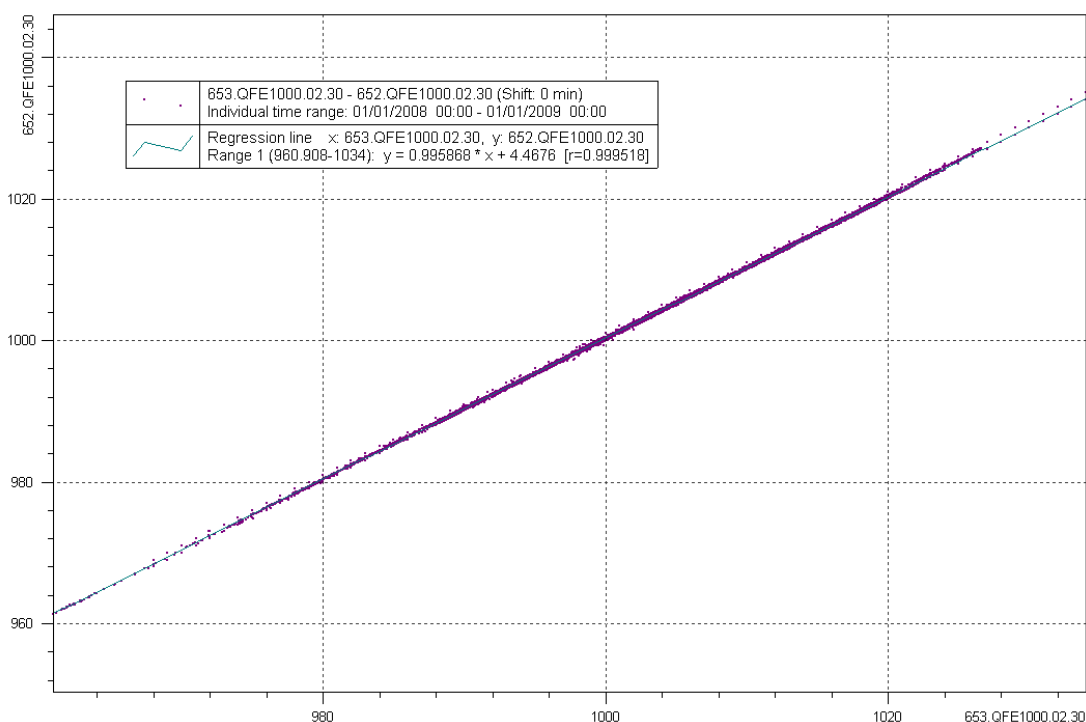


Figure 3.1 Air pressure measured at station 652, y, as a function of air pressure measured at station 653, x. The regression line may have changes due to editing, see Table 5.

3.2 Air Temperature

The air temperature is measured 2 meter above terrain at station 652 and station 653.

The air temperature is measured using temperature probes housed in radiation shields. The radiation shields are not artificially ventilated due to the limited power supply at the stations. Studies show that this may give too high temperature measurements in case of calm winds and clear sky, Andersson & Mattisson (1991), Arck & Scherer (2001). A correction of these data has not been performed.

The data processing is including data from the period October 22th 2007 to December 31st 2008.

Station 652, air temperature at 2 meters above terrain

- 15 records are missing (0.07% of all data records in the period)
- None of these measurements lie outside the interval [-40°C; 25°C]
- 1 data point was deleted
- 6 data points are suspect as they differ more than 1°C from station 653. 2008-01-10 03:00-04:30 and 2008-03-26 13:30.

Station 653, air temperature at 2 meters above terrain

- 57 records are missing (0.3% of all data records in the period)
- None of these measurements lie outside the interval [-40°C; 25°C]
- 6 data points are suspect as they differ more than 1°C from station 652. 2008-01-10 03:00-04:30 and 2008-03-26 13:30.

KOB, air temperature

- 7 data points are missing

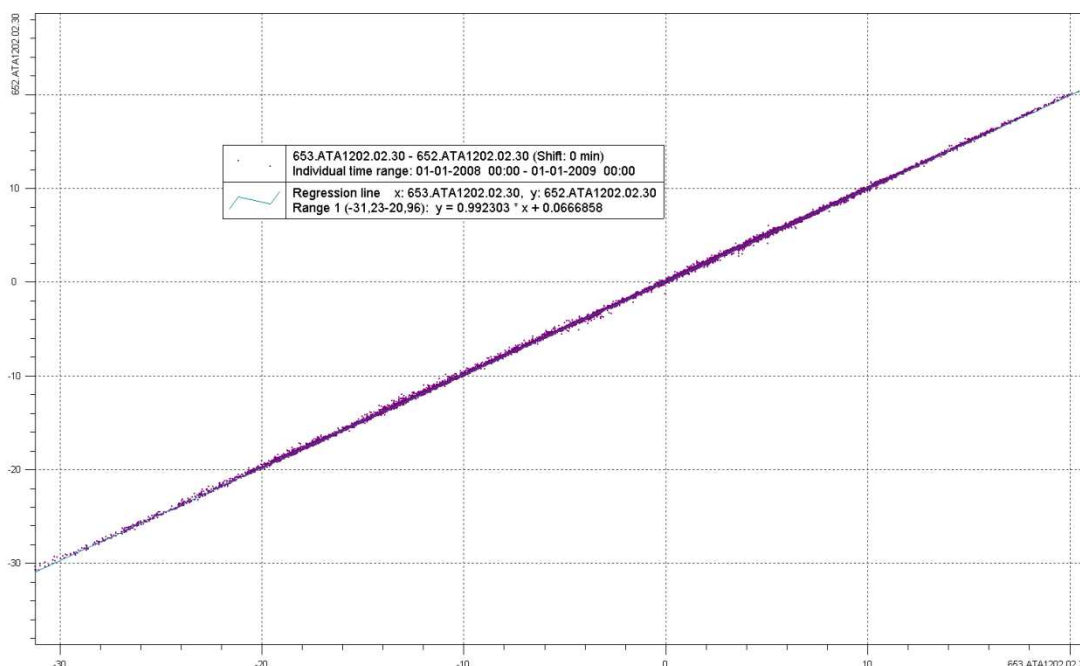


Figure 3.2 Average air temperature measured at station 652, y, as a function of air temperature measured at station 653, x. The regression line may have changes due to editing, see Table 5.

3.3 *Relative Humidity*

The relative humidity is measured by the same sensor units as the air temperature. The data processing is including data from the period October 22th 2007 to December 31st 2008.

Station 652, relative humidity measured 2 meters above terrain

- 15 records are missing (0.02% of all data records in the period)
- 21 records lie outside the range [20; 104] or differ more than ± 6 % from station 653
- 1 record was deleted
- On average station 652 measures 1.7 % lower relative humidity than station 653. This difference is lower during the
-

Station 653, relative humidity measured 2 meters above terrain

- 55 records are missing (0.3% of all data records in the period)
- 21 records lie outside the range [20; 104] or differ more than ± 6 % from station 653.
- 0 records were deleted
- On average station 653 measures 1.7 % higher relative humidity than station 652. This difference is lower during the summer

KOB, relative humidity

- 7 data points are missing

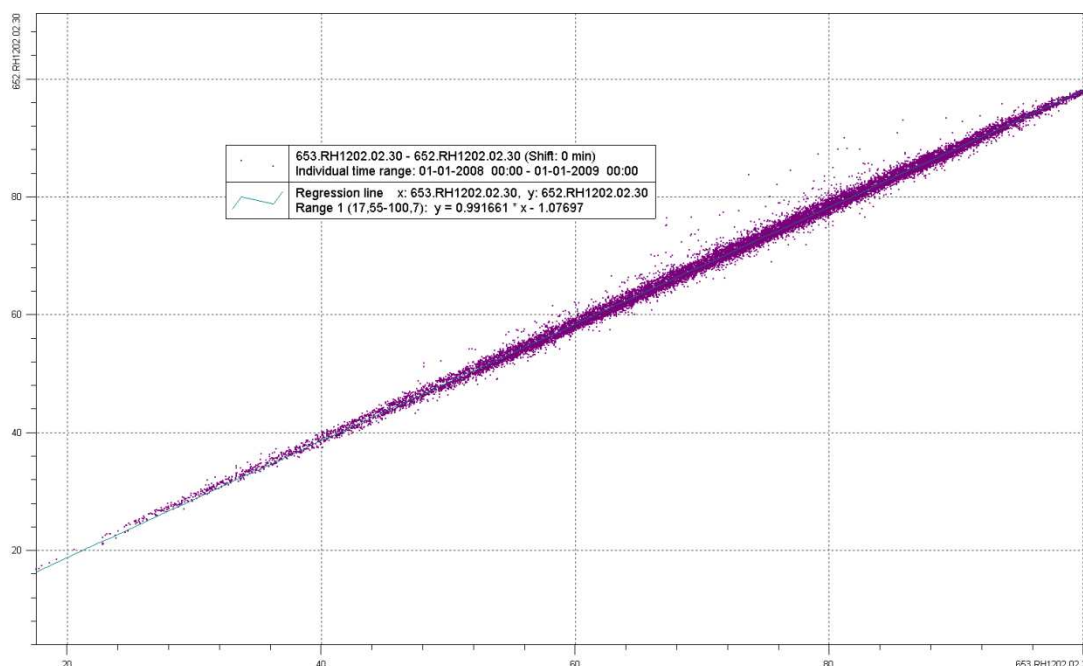


Figure 3.3 Average relative humidity measured at station 652, y, as a function of relative humidity measured at station 653, x. The regression line may have changes due to editing, see Table 5.

3.4 Wind Speed

The wind speed is measured 2 and 10 m above terrain at both station 652 and station 653.

For station 652 and station 653 data from 2 m above ground can only be processed after October 6th and September 5th respectively, as there are too many erroneous data before. This is due to high resistance in the cable from the sensor to the datalogger. On October 6th and September 5th the problem was solved. In the period October 27th 2007 to December 31st 2008 no major problems with wind speed 10 m above terrain are observed.

The wind speed measured 2 m above terrain on station 652 is generally lower than measured on station 653. This is especially evident on higher wind speeds, see Table 6.

Wind speed	Number of records	Average difference
>10 m/s	398	-0.58
5-10 m/s	3523	-0.27
<5 m/s	8521	-0.05
Total	12442	-0.13

Table 6 Differences in wind speed (WS652 – WS653).

Station 652, wind speed at 2 m

- No missing values in the period
- 609 values were deleted

Station 652, wind speed at 2 m

- 15 missing values in the period (0.5% of all data records in the period)
- 482 values were deleted

KOB, wind speed at 2 m

- 404 data points are missing

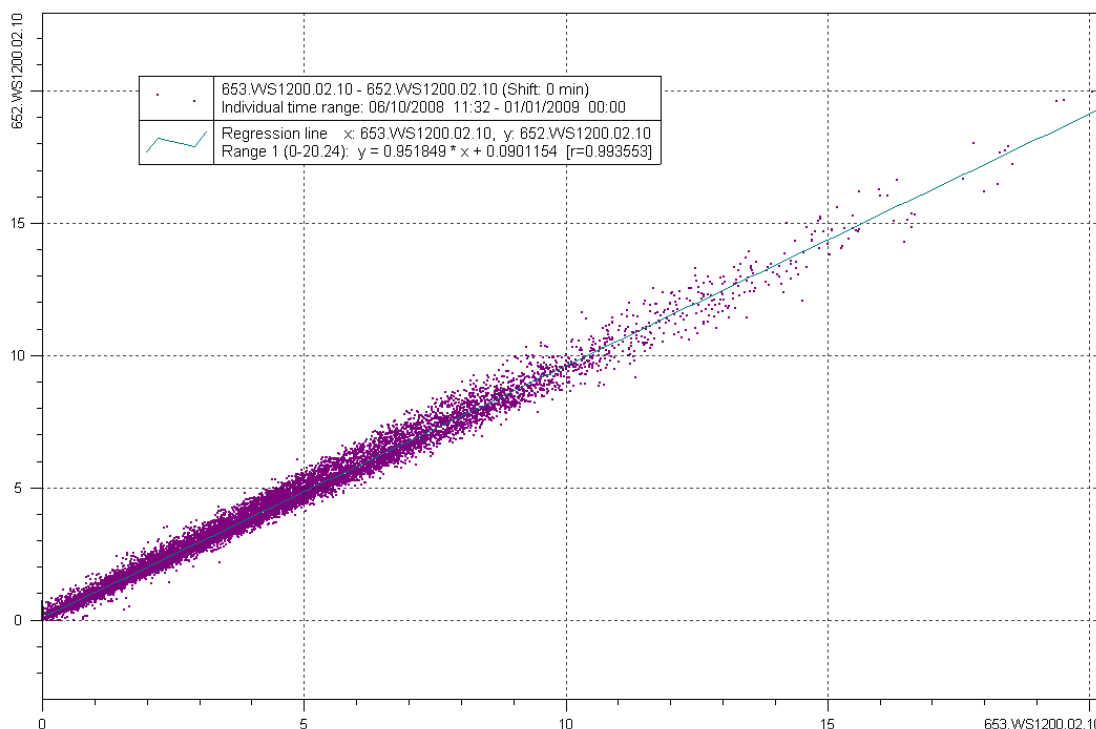


Figure 3.4 Wind speed measured 2 m above ground at Kobbefjord station 652, y, as a function of wind speed measured 2 m above ground level at Kobbefjord station 653, x. The regression line may have changes due to editing, see Table 5.

Station 652, wind speed at 10 m

- 45 records out of 62855 are missing due to maintenance of the station corresponding to 0.07% of the time series.
- 535 records are deleted due to erroneous records corresponding to 0.85% of the time series. Data are mainly deleted due to frozen sensor or an offset error.

Station 653, wind speed at 10 m

- 168 records out of 62849 are missing due to maintenance of the station corresponding to 0.27% of the time series.
- 190 records are deleted due to erroneous records corresponding to 0.30% of the time series. Data are mainly deleted due to frozen sensor or an offset error.

error.

KOB, wind speed at 10 m

- 134 data points are missing

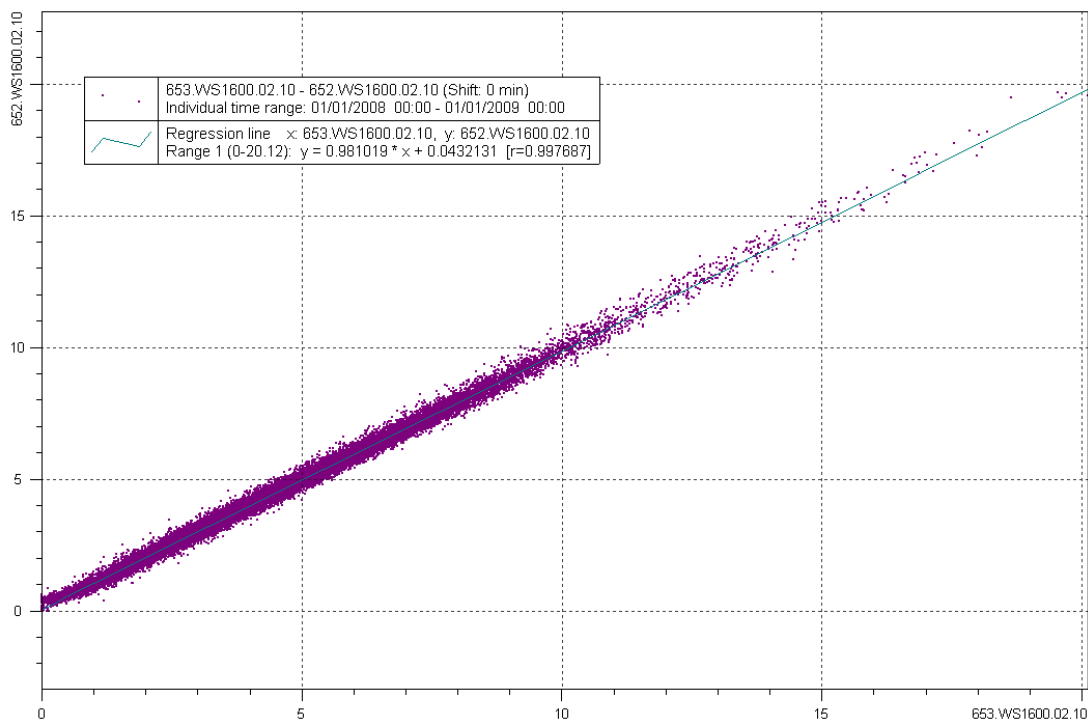


Figure 3.5 Wind speed measured 10 m above ground at Kobbefjord station 652, y, as a function of wind speed measured 10 m above ground level at Kobbefjord station 653, x. The regression line may have changes due to editing, see Table 5.

3.5 Wind Direction

Wind direction is measured 10 meters above terrain at station 652 and 653. The wind direction is relative to geographic north.

Data from the period October 22th 2007 to December 31st 2008 is included in the data processing.

Station 652, wind direction, 10 m above ground

- 45 data values are missing (0.07% of all data records in the period)
- 117 data values were deleted. Most of them due to maintenance of the station on 6-7 October 2008.

Station 653, wind direction, 10 m above ground

- 168 data values are missing (0.3% of all data records in the period)
- 151 data values were deleted (sensor was frozen)

3.6 Incoming Short Wave Radiation

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

Data from the period June 25th 2008 to December 31st 2008 are included in the data processing. The results of the data checks are summarized below. The main data source will be an average between the two stations.

Station 652, incoming short wave radiation

- 87 missing records (corresponding to 0.2% of the data). In these cases the data records were replaced with data from station 653 by using linear regression, Figure 3.6, if it was possible.
- 35.4% of the records showed negative incoming radiation and 15.4% of the records showed positive incoming radiation in cases where the sun was more than one degree below the horizon. These records were set to zero.
- 94 records (corresponding to 0.2% of the data) with values higher than the maximum theoretical direct incoming radiation (when this report refers to *the maximum direct incoming radiation* it is calculated according to Gray and Male (1981), with a transmissivity of the atmosphere of 1, i.e. no absorption or reflection of radiation through the atmosphere). The measurements were replaced in cases where the data records exceeds the theoretical value and the theoretical value is higher than 25W/m^2 (corresponding to the sun being more than one degree above the horizon). In these cases the data records were replaced with data from station 653 by using linear regression, see Figure 3.6, or with the theoretical value, if data from station 653 also exceeded the theoretical maximum.

Station 653, incoming short wave radiation

- 4061 missing records (corresponding to 7.5% of the data). In these cases the data records were replaced with data from station 652 by using linear regression, Figure 3.6, if it was possible.
- 33.5% of the records showed negative incoming radiation and 17.3% of the records showed positive incoming radiation in cases where the sun was more than one degree below the horizon. These records were set to zero.
- 1893 records (corresponding to 3.5% of the data) with values higher than the maximum theoretically possible direct incoming radiation. The measurements were replaced in cases where the data records exceeds the theoretical value and the theoretical value is higher than 25W/m^2 . In these cases the data records were replaced with data from station 652 by using linear regression, see Figure 3.6, or with the theoretical value, if data from station 652 also exceeded the theoretical maximum.

In September on days with clear sky one can see a sudden drop in the radiation in the period from approximately 12 to 13 caused by a shadow from a nearby mountain. The low hanging position of the sun in that month is the cause of the shadow, which also can be seen in the outgoing short wave radiation and the photosynthetic active radiation. This phenomenon can also be seen in the linear regression between the two stations, Figure 3.6, where the outlying points are caused by the shadow reaching the stations at a different time.

The sensor was not in level from June 25th 2008 to September 4th 2008 13:20. This causes a cigar formed correlation, Figure 3.6. A correlation covering the data from September 4th 2008 14:15 to December 31st 2008 will be used.

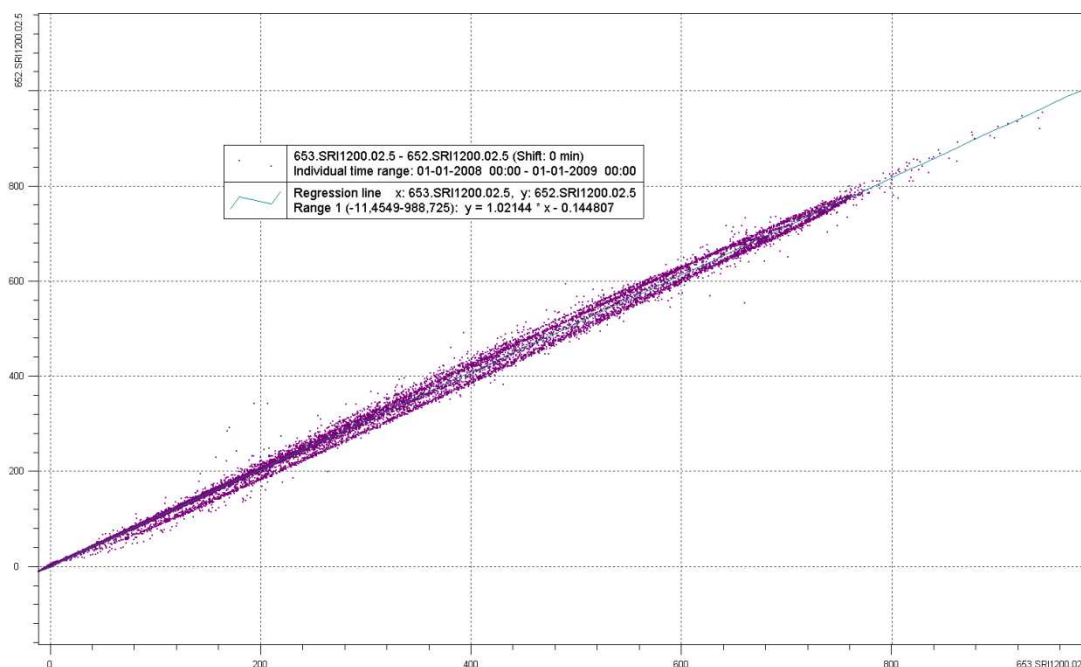


Figure 3.6 Incoming short wave radiation (W/m^2) measured at station 652, y, as a function of incoming short wave radiation measured at station 653, x. The regression line may have changes due to editing, see Table 5.

3.7 Outgoing Short Wave Radiation

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

Normally there will be a winter and a summer correlation for the outgoing short wave radiation, but since we do not have an entire year of data and the sensor was not in level from June 25th 2008 to September 4th 2008 13:20 there will be used an correlation covering the data from September 4th 2008 14:15 to December 31st 2008, Figure 3.8.

Data from the period June 25th 2008 to December 31st 2008 are included in the data processing. The results of the data check are summarized below. The main data source will be an average between the two stations.

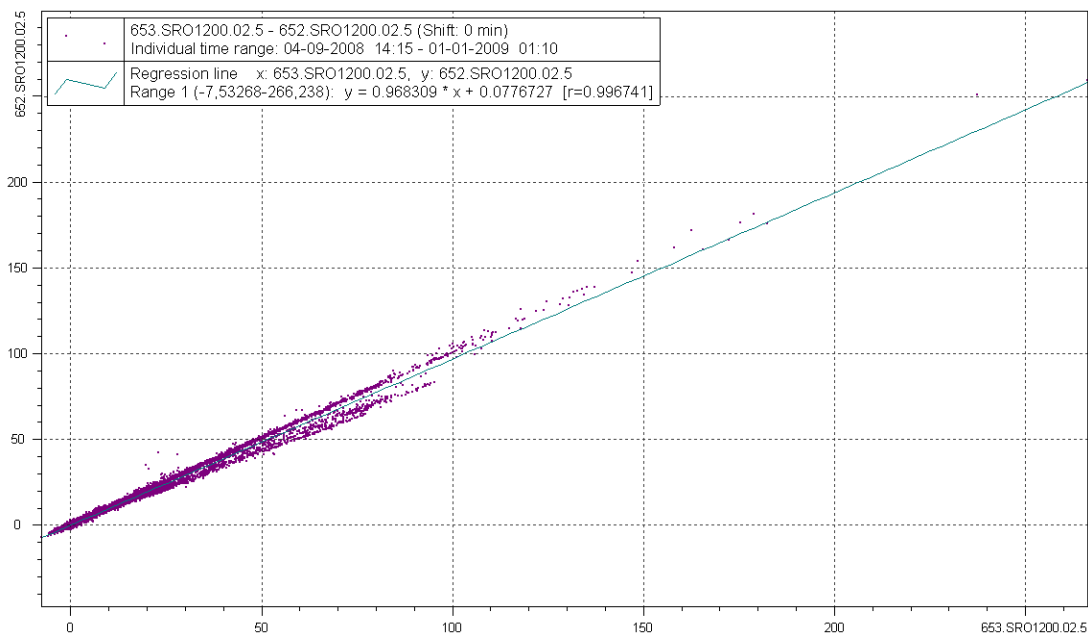


Figure 3.7 Outgoing short wave radiation measured at station 652, y, as a function of outgoing short wave radiation measured at station 653, x. The regression line may have changes due to editing, see Table 5.

Station 652, outgoing short wave radiation

- 87 missing records (corresponding to 0.2% of the data). In these cases the data records were replaced with data from station 653 by using linear regression, Figure 3.8, if it was possible.
- 8.1 % of the records showed negative outgoing radiation and 43.3 % of the records showed positive outgoing radiation in cases where the sun was more than one degree below the horizon. The magnitude of this error is not more than 13.2 W/m^2 and normally below 1.7 W/m^2 . These records were set to zero.
- 87 records where the measured value was larger than the maximum theoretical possible direct incoming radiation (mainly in the night) and 2046 records (corresponding to 3.8 % of the data) where the outgoing radiation was larger than the incoming radiation. Where the outgoing radiation exceeded the incoming radiation on both stations, the outgoing radiation was set equal to the incoming radiation (from the quality controlled time series, as described above).

Station 653, outgoing short wave radiation

- 4061 missing records (corresponding to 7.5% of the data set). In these cases

the data records were replaced with data from station 652 by using linear regression, Figure 3.8, if it was possible.

- 8.2% of the records showed negative outgoing radiation and 43.2% of the records showed positive outgoing radiation in cases where the sun was more than one degree below the horizon. The magnitude of this error is not more than 13.9 W/m^2 and normally below 1.5 W/m^2 . These records were set to zero.
- 1887 records (corresponding to 3.5 % of the data) where the measured value was larger than the maximum theoretical possible direct incoming radiation (mainly in the night) and 2421 records (corresponding to 4.4 % of the data) where the outgoing radiation was larger than the incoming radiation. Where the outgoing radiation exceeded the incoming radiation on both stations, the outgoing radiation was set equal to the incoming radiation (from the quality controlled time series, as described above).

In September on days with clear sky one can see a sudden drop in the radiation in the period from approximately 12 to 13 caused by a shadow from a near by mountain. The low hanging position of the sun in that month is the cause of the shadow, which also can be seen in the incoming short wave radiation and the photosynthetic active radiation. This phenomenon can also be seen in the linear regression between the two stations, figure 3.8, where the outlying points is caused by the shadow reaching the stations at a different time.

3.8 Incoming Long Wave Radiation

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 $42 \mu\text{m}$. The sensor has app. the same sensitivity (spectral response) to all wavelengths in the interval.

Data from the period June 25th 2008 to December 31st 2008 are included in the data processing. The results of the data check are summarized below.

Station 652, incoming long wave radiation

- 87 missing records (corresponding to 0.2% of the data set)
- 29535 records were temperature corrected using the temperature from the near by 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 25/6-08 18:45 to 6/10-08 07:55. The used temperature measurements from the UVB sensor correlate well with valid temperature measurements from the Kipp & Zonen sensor ($r=0.999597$).
- No data were deleted

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 (25/6-08 19:00 to 5/7-08 07:30 and 13/7 18:30 to 13/8-08 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 25/6-08 18:45 to 13/08-08 07:55. The used temperature measurements from the UVB sensor on station 652 correlate well with valid temperature measurements from the Kipp & Zonen sensor ($r=0.999409$).
- 39117 data point were deleted. A crack was formed in the sensor gradually decreasing the quality of measurements (no valid data later than 13th August).

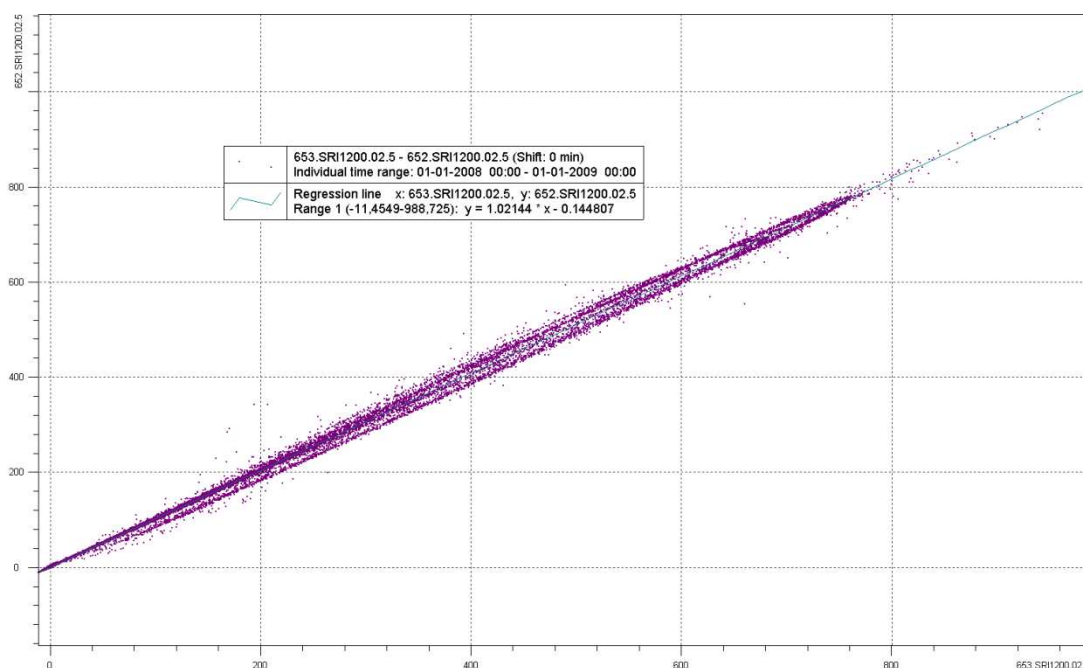


Figure 3.8 Incoming long wave radiation (W/m^2) measured at station 652, y, as a function of incoming short wave radiation measured at station 653, x. The regression line may have changes due to editing, see Table 5.

3.9 Outgoing Long Wave Radiation

The outgoing long wave radiation is measured 2 meters above terrain at both station 652 and station 653. The outgoing 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 the period June 25th 2008 to December 31st 2008 are included in the data processing. The results of the data checks are summarized below.

Station 652, outgoing long wave radiation

- 87 missing records (corresponding to 0.3% of the data set)
- 29535 records were temperature corrected using the temperature from the near by 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 25/6-08 18:45 to 6/10-08 07:55. The used temperature measurements from the UVB sensor correlate well with valid temperature measurements from the Kipp & Zonen sensor ($r=0.999597$).

- No data were deleted

Station 653, outgoing long wave radiation

- 4057 missing records (corresponding to 7.5% of the data set).
- 29535 records were temperature corrected using the temperature from the UVB-sensor on station 652. The raw measurement of long wave radiation must be compensated for the sensors own temperature. Sensor temperature measurements are invalid in the period 25/6-08 18:45 to 6/10-08 07:55. The used temperature measurements from the UVB sensor on station 652 correlate well with valid temperature measurements from the Kipp & Zonen sensor ($r=0.999409$).
- No data were deleted

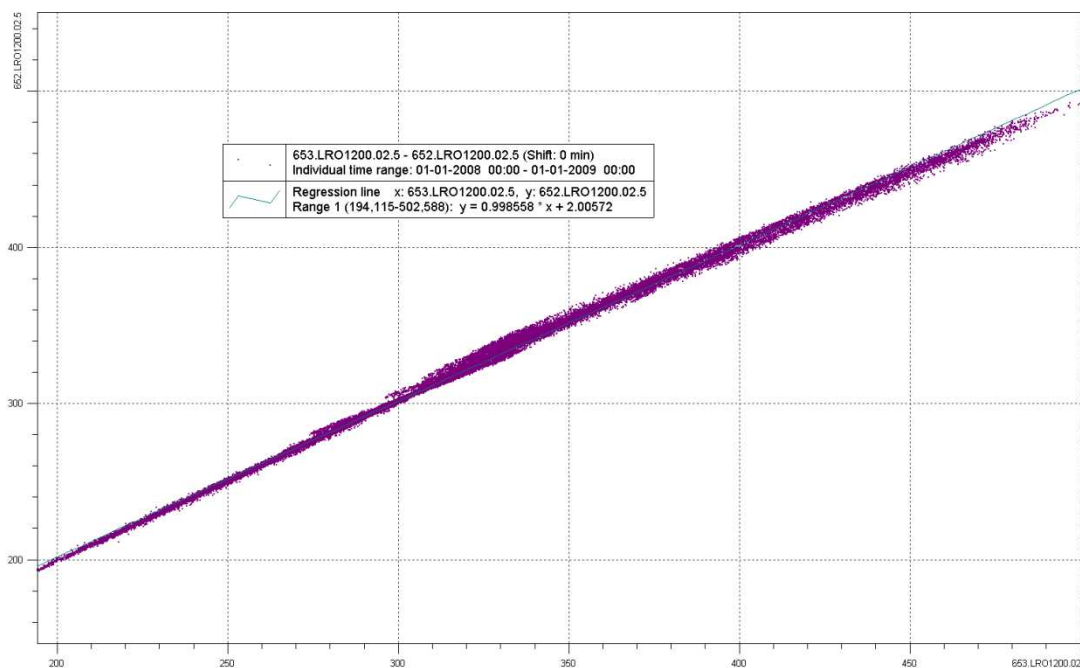


Figure 3.9 Outgoing long wave radiation (W/m^2) measured at station 652, y, as a function of Outgoing long wave radiation measured at station 653, x. The regression line may have changes due to editing, see Table 5.

3.10 Photosynthetic Active Radiation (PAR)

The photosynthetic active radiation (PAR) is measured 2 meters above terrain at station 652 and 653. The measurements were started summer 2008. PAR is measured with a Li-Cor quantum sensor, which measures the radiation with wavelengths between 400 and 700 nm. The sensor has app. the same sensitivity (spectral response) to all wavelengths in this interval.

Data from the period June 25th 2008 to December 31st 2008 are included in the data processing. The results of the data checks are summarized below.

Station 652, PAR

- 87 missing records (corresponding to 0.3% of the data). In these cases the data records were replaced with data from station 653 by using linear regression, Figure 3.611, if it was possible.
- 1.2% of the records showed negative PAR radiation and 49.1% of the records showed positive PAR radiation in cases where the sun was more than one degree below the horizon. These records were replaced by zero.

Station 653, PAR

- 4061 missing records (corresponding to 7.5% of the data). In these cases the data records were replaced with data from station 652 by using linear regression, Figure 3.611, if it was possible.
- 1.4% of the records showed negative PAR radiation and 12.2% of the records showed positive PAR radiation in cases where the sun was more than one degree below the horizon. These records were replaced by zero.

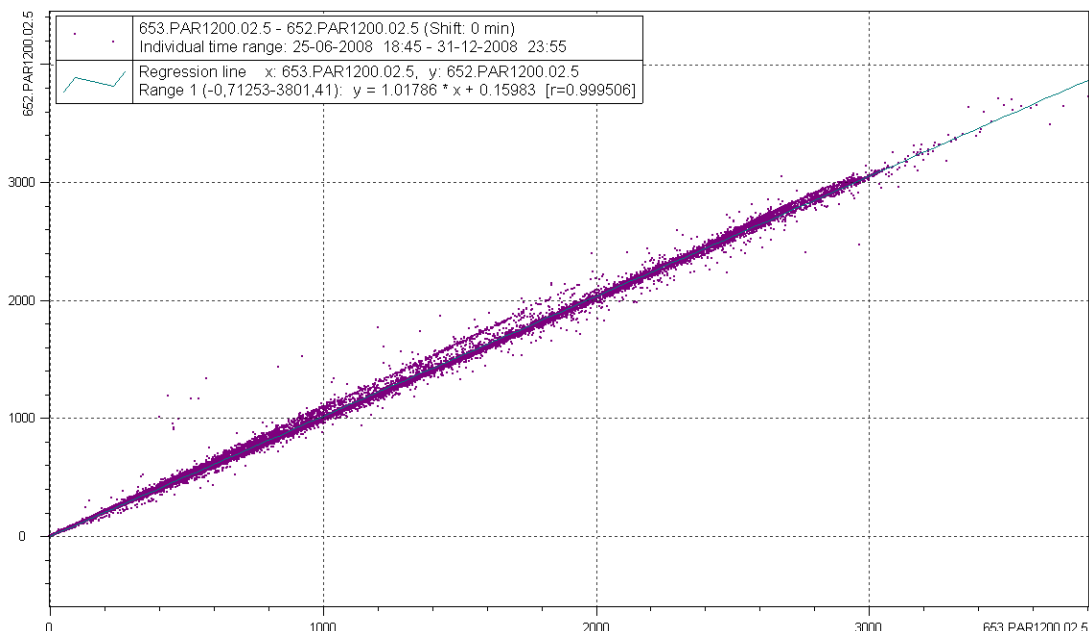


Figure 3.11 Photosynthetic active radiation ($\mu\text{mol}/(\text{s}\cdot\text{m}^2)$) measured at station 652, y, as a function of Photosynthetic active radiation measured at station 653, x. The regression line may have changes due to editing, see Table 5.

In September on days with clear sky one can see a sudden drop in the radiation in the period from approximately 12 to 13 caused by a shadow from a near by mountain. The low hanging position of the sun in that month is the cause of the shadow, which also can be seen in the incoming and outgoing short wave radiation. This phenomenon can also be seen in the linear regression between the two stations, figure 3.11, where the outlying points is caused by the shadow reaching the stations at a different time.

3.11 UVB

The ultraviolet radiation (UV-B) is measured 2 meter above terrain at st.652 and st.653. The UV-B has since June 2008 been measured with a Solar Light UV-Biometer.

The UV-B measurement depends on the temperature of the sensor. Due to the limited power supply at the station the sensors built-in thermostat have not been used. In the data processing the measurements are thus compensated for the deviation of the temperature of the sensor from 25 °C according to the formula given by the manufacturer, Solar Light Co Inc. (1991). This compensation is carried out by program routines in the data logger.

Data from the period June 25th 2008 to December 31st 2008 are included in the data processing. The results of the data checks are summarized below.

Station 652, UVB

- 87 records are missing, corresponding to 0.3 % of the period.

Station 653, UVB

- The data measured at the station is incorrect, probably due to a fault in the wiring of the sensor.

Since UVB is only measured at station 652 in the period, the resulting time series will only consist of data from st.652 and the 87 missing records could not be replaced.

3.12 Net Radiation

The net radiation is measured 2 meters above terrain at station 652 and 653. The net radiation is measured with Kipp & Zonen net radiometer, 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).

Data from the period June 25th 2008 to December 31st 2008 are included in the data processing. The results of the data check are summarized below.

Station 652, net radiation

- There were 6 records with net radiation less than -200 W/m^2 . All records were deleted as they were unrealistic in that data context.
- 87 records are missing, corresponding to 0.2 % of the period.
- There were no records with error values.
- 2 records were deleted due to an unrealistic value.

Station 653, net radiation

- There were 9 records with net radiation less than -200 W/m^2 . 6 of the records were deleted as they were unrealistic in that data context.
- 4059 records are missing, corresponding to 7.5 % of the period.
- There were 2 records with error values.
- 2 records were deleted due to an unrealistic value.

The used correlation, Figure 3.12, only covers data from September 4th 2008 14:15 to December 31st 2008 because the sensor was not in level from June 25th 2008 to September 4th 2008 13:20

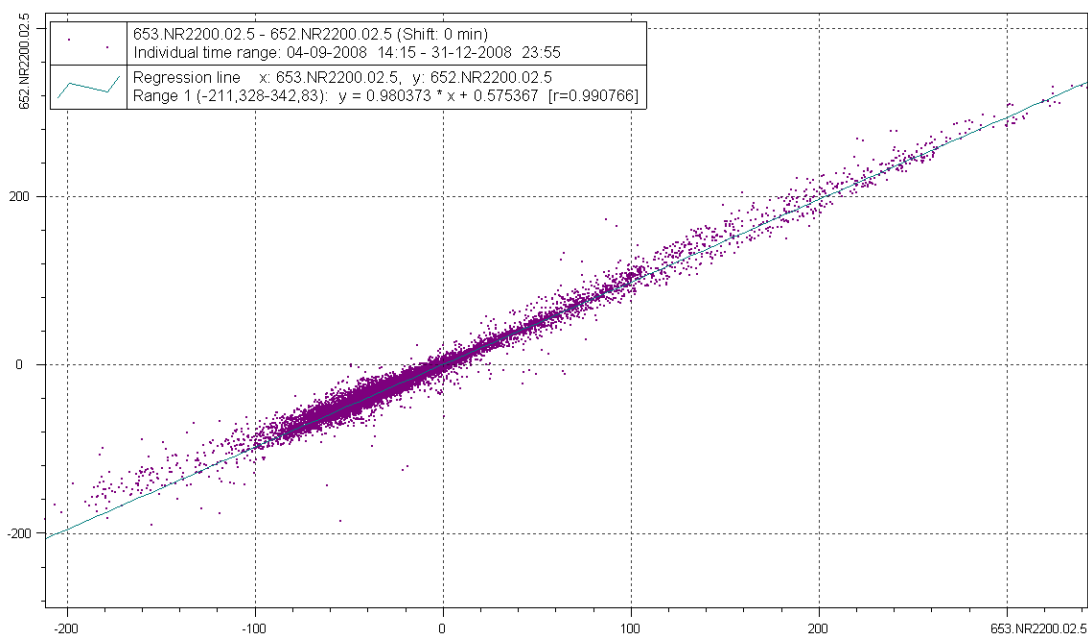


Figure 3.102 Net radiation data measured at station 652, y, as a function of net radiation data measured at station 653, x. Regression line and formula are shown.

3.1 Albedo

The albedo is calculated from the quality checked incoming and outgoing short wave radiation. There are data in the period June 25th 2008 to December 31st 2008. As the relative uncertainties increase with decreasing radiation input, the albedo is only calculated when both incoming and outgoing shortwave radiation are greater than 10 W/m². Two time series are produced: A) a 5 min time series and B) a time series that computes the albedo at solar noon as a proxy for day values, see Sicart, J. E. et al. 2001.

Station 652, albedo measurements (5 min)

- 54720 invalid or missing data points. Corresponding to 77 % of the time period.

Station 652, albedo measurements (day values)

- 44 invalid or missing data points. Corresponding to 23 % of the time period.

Station 653, albedo measurements (5 min)

- 39556 invalid or missing data points. Corresponding to 71 % of the time period.

Station 653, albedo measurements (day values)

- 58 invalid or missing data points. Corresponding to 31 % of the time period.

3.2 Relative Vegetation Index

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: $NDVI = (NIR - VIS) / (NIR + VIS)$.

Unfortunately both sensors have been registered with a too low resolution. This has resulted in 99% of the data being invalid. Therefore a NDVI-time series cannot be processed.

3.3 Precipitation

The precipitation is recorded with Ott Pluvio rain gauges. On both stations the quality of measurement varies over the season. Generally the rain gauges are well correlated in above freezing point conditions and less correlated in below freezing point conditions. Both gauges has a periodical tendency to produce false pulses especially in below freezing point conditions. These periods have been identified during the quality check. However during precipitation events it is very difficult to identify false pulses.

Station 652, precipitation

- Three longer periods with false pulses have been identified: 2008-12-30 to 2008-01-11, 2008-02-28 to 2008-03-30 and 2008-12-11 to 2008-12-25.
- In the period 2007-10-22 to 2008-12-31 a total of 1024.4 mm was deleted. This corresponds to 43 % of the recorded precipitation.

Station 653, precipitation

- Four longer periods with false pulses have been identified: 2007-12-25 to 2007-12-27, 2007-12-30 to 2008-01-11, 2008-02-24 to 2008-03-30 and 2008-12-11 to 2008-12-31.
- In the period 2007-10-22 to 2008-12-31 a total of 1008.9 mm was deleted. This corresponds to 47 % of the recorded precipitation.

3.4 Snow Depth

The automatic snow depth measurements were reestablished the 6th October 2008. Data from 6th October 2008 to 31st December 2008 is included in the quality check.

Snow depth on station 652:

- 50 data values (7% of the data set) were deleted
- No values were missing

Snow depth on station 653:

- 10 data values (1% of the data set) were deleted
- No values were missing

4 References

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