UNIVERSITY OF BAYREUTH

Department of Micrometeorology

Complex TERRain and ECOlogical Heterogeneity (TERRECO)
WP 1-02: Spatial assessment of atmosphere-ecosystem exchanges via micrometeorological measurements, footprint modeling and mesoscale simulations

Documentation of the Observation Period May 12th to Nov. 8th, 2010, Haean, South Korea

Peng Zhao
Johannes Lüers
Johannes Olesch
Thomas Foken

With Contributions from:

Bora Lee, Steve Lindner, Bumsuk Seo, Miloslav Belorid and John Tenhunen

Arbeitsergebnisse
Nr. 45
Bayreuth, March, 2011

Arbeitsergebnisse, Universität Bayreuth, Abt. Mikrometeorologie, Print, ISSN 1614-8916
Arbeitsergebnisse, Universität Bayreuth, Abt. Mikrometeorologie, Internet, ISSN 1614-8926
Work Report University of Bayreuth, Dept. of Micrometeorology
http://www.bayceer.uni-bayreuth.de/mm/

Eigenverlag: Universität Bayreuth, Abt. Mikrometeorologie
Vervielfältigung: Druckerei der Universität Bayreuth
Herausgeber: Prof. Dr. Thomas Foken

Universität Bayreuth, Abteilung Mikrometeorologie
D-95440 Bayreuth

Contents

Index of Figures

Index of Tables

1. Introduction

The field campaign was carried out in the framework of TERRECO (Complex TERRain and ECOlogical Heterogeneity) project Work Package 1-02. The aim is to investigate the energy and matter exchange above subtropical farmlands (both flooded and unflooded fields) during the whole growing period including monsoon seasons in a complex, heterogeneous mountainous terrain.

The measurement was conducted from May 12th to November 8th, 2010, at Haean-myun Catchment, Yanggu-gun, Kangwon-do, South Korea (대한민국 강원도 양구군 해안면, 大韓民國江原道楊口郡亥安面), which is located close to the border between South Korea and North Korea (Figure 1-1). We chose a typical rice field and a typical potato field, which are two major types of farmlands in Haean. An eddy covariance measurement complex (USA-1, LI-7500) was installed to collect the fluctuation of the 3D wind vector, water vapor and carbon dioxide concentration at a sampling frequency of 20 Hz continuously. It was moved between the two fields so as to obtain data from both wet and dry surfaces. Biomass of the crops was sampled manually about every two weeks. Weather information includes data acquired by 14 automatic weather stations, weather charts downloaded from website of Korea Meteorological Administration, and manually observation.

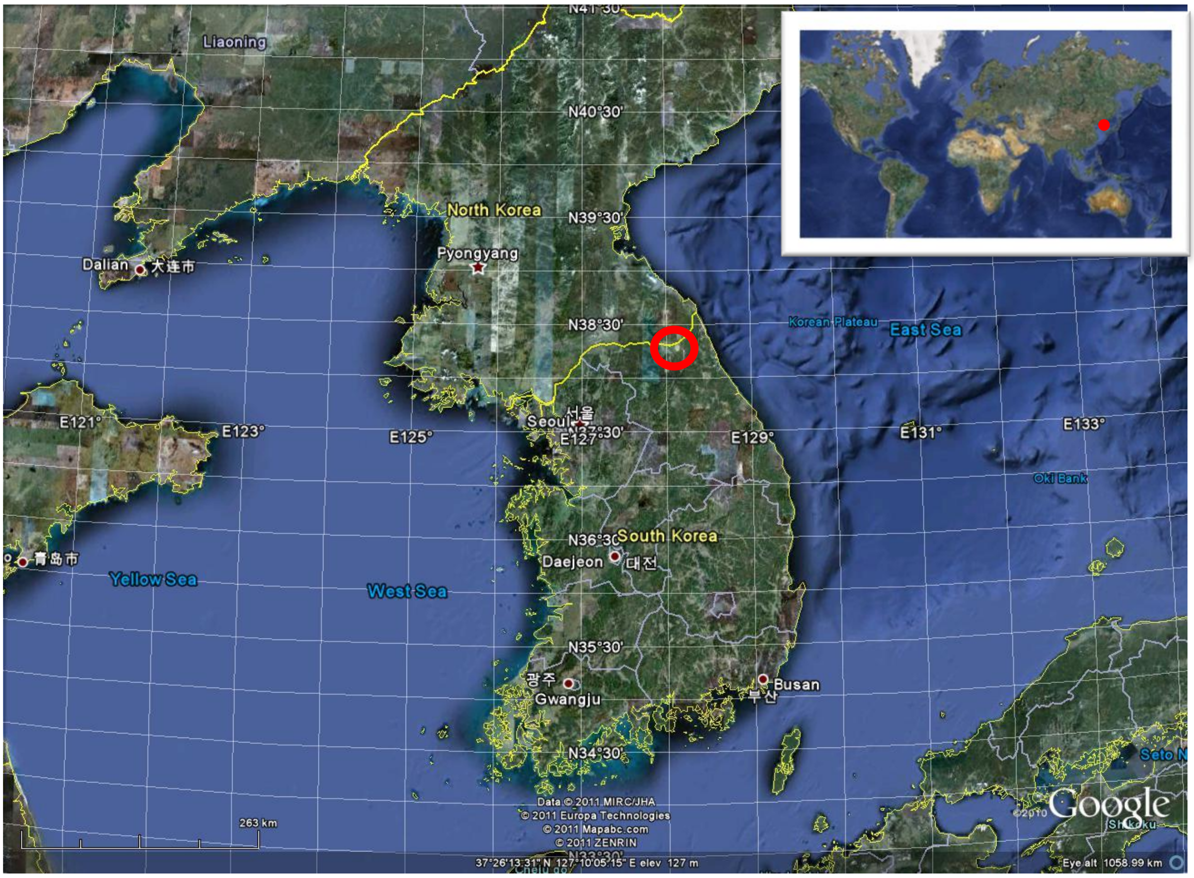

Figure 1-1: Location of Haean Catchment, close to the border between South Korea and North Korea

2. General Information

Haean basin is an intensively used landscape within the Soyang Lake watershed including Soyang Lake Reservoir, and a sub-catchment of the Han River system which drains 26% of the land surface of South Korea. The magnetic declination is calculated on the website of NOAA and the result shows that the geographical north is 8.25° east of magnetic north. The geographical north and Korean Stand Time (KST, in yyyy-mm-dd or mm-dd format) are used through the whole measurement.

Figure 2-1 shows locations of the rice field and the potato field. General information is listed in Table 2-1.

There were 4 measurement periods for each site, covering almost the whole growing seasons (Figure 2-2). Biomass was sampled 7 times for each site. See Table 2-2 for more information about the events during the campaign.

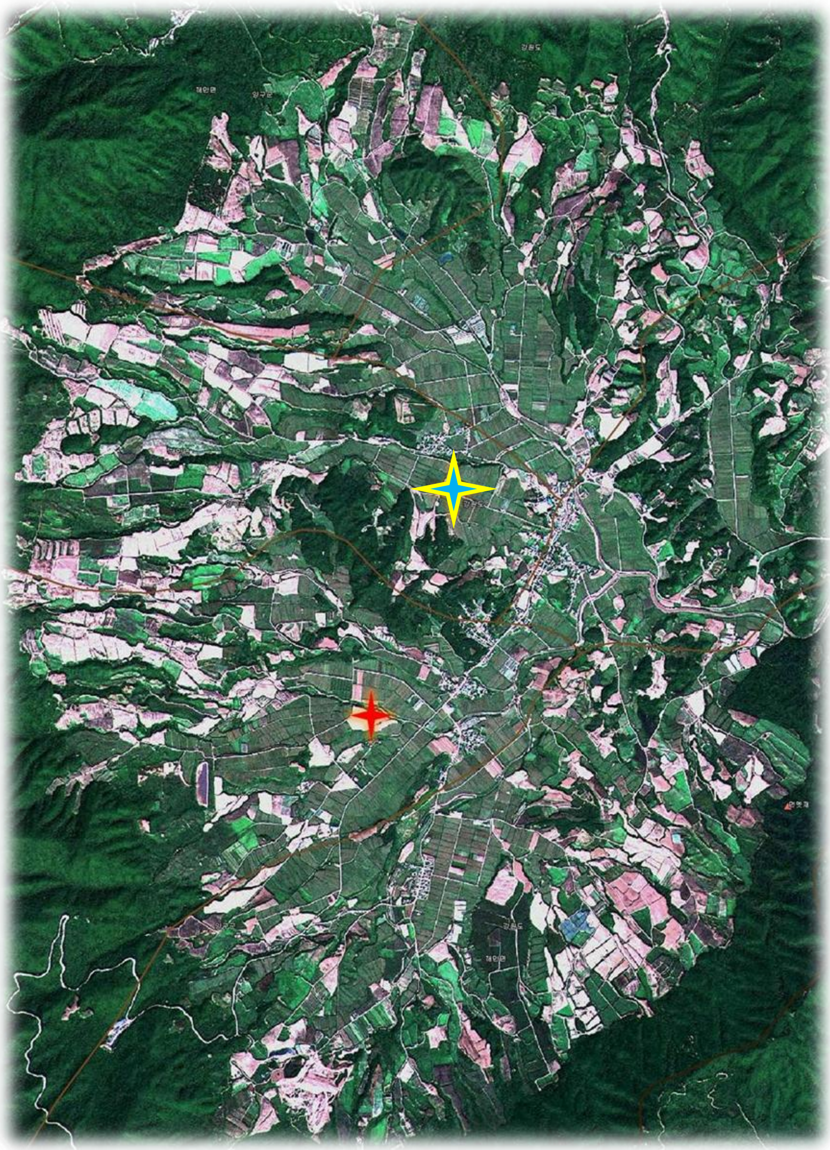

Figure 2-1: Locations of the measurement sites during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (red star: a potato field; blue star: a rice field; contributed by Bumsuk Seo, modified)

Table 2-1: Information about the field sites during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

Crop		Potato	Rice
Latitude		38°16’37.8” N	38°17’27.6” N
Longitude		128°07’28.5” E	128°07’52.0” E
Altitude		455 m ASL	457 m ASL
Planting time		2010-04-26	2010-05-24
Harvest time		2010-09-30	2010-10-17
Density		4.58 plants m^{-2}	20 plants m^{-2}
Plant height		2010-05-31: 0.13 m	/
		2010-06-20: 0.60 m	2010-06-28: 0.29 m
		2010-06-22: 0.57 m	2010-07-05: 0.36 m
		2010-07-07: 0.63 m	2010-07-27: 0.65 m
		2010-07-22: 0.33 m	2010-08-07: 0.79 m
		2010-08-13: 0.37 m	2010-08-31: 0.88 m
		2010-08-27: 0.09 m	2010-09-30: 0.88 m
		2010-11-03: bare soil	2010-10-30: bare soil
Measuring periods	1	2010-06-01 09:32 to 2010-06-24 10:41	2010-06-26 16:37 to 2010-07-05 10:07
	2	2010-07-06 11:21 to 2010-07-22 10:34	2010-07-22 14:41 to 2010-08-11 12:13
	3	2010-08-13 11:29 to 2010-08-28 10:41	2010-08-30 13:00 to 2010-10-01 09:41
	4	2010-11-02 16:56 to 2010-11-06 10:39	2010-10-28 16:56 to 2010-11-02 10:44

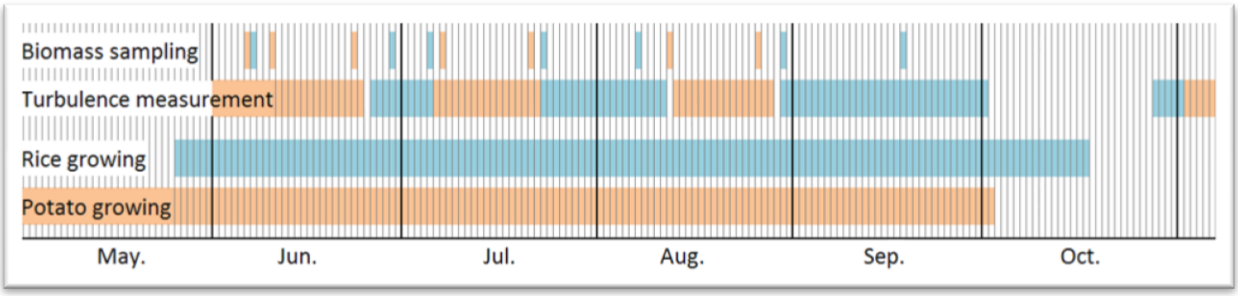

Figure 2-2: Calendar of TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (blue: rice field; brown: potato filed)

Table 2-2: General events during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (blue: rice field; brown: potato filed)

Date	Events
2010-04-26	Potatoes were planted
2010-05-11	Arrival at Haean
2010-05-14	A weather station (No. 12) started running at the rice field
2010-05-16	A weather station (No. 13) started running at the potato field
2010-05-24	Farmers transplanted rice plants
2010-06-01	Turbulence measurement started at the potato field (P1)
2010-06-06	Size measurement: 138 potato plants
2010-06-07	Biomass sampling: 5 potato plants (Kang's)
2010-06-07	Biomass sampling: 5 rice plants

Date	Events
2010-06-10	Biomass sampling: 5 potato plants (Kang's)
2010-06-22	Size measurement: 100 potato plants
2010-06-23	Biomass sampling: 8 potato plants (Kang's) with sizes
2010-06-24	Turbulence measurement ended at the potato field (P1)
2010-06-26	Turbulence measurement started at the rice field (R1)
2010-06-28	Inclinometer started new working mode
2010-06-29	Biomass sampling: 8 rice plants
2010-07-05	Biomass sampling: 8 rice plants
2010-07-05	Turbulence measurement ended at the rice field (R1)
2010-07-06	Turbulence measurement started at the potato field (P2)
2010-07-07	Biomass sampling: 8 potato plants
2010-07-07	Size measurement: 100 potato plants and 30 plants at Kang's
2010-07-21	Biomass sampling: 5 potato plants
2010-07-22	Turbulence measurement ended at the potato field (P2)
2010-07-22	Turbulence measurement started at the rice field (R2)
2010-07-23	Biomass sampling: 5 rice plants
2010-07-23	Li-7500 configuration was changed at 15:46
2010-08-11	Turbulence measurement ended at the rice field (R2)
2010-08-12	Biomass sampling: 5 potato plants
2010-08-13	Turbulence measurement started at the potato field (P3)
2010-08-26	Biomass sampling: 5 potato plants
2010-08-28	Turbulence measurement ended at the potato field (P3)
2010-08-30	Turbulence measurement started at the rice field (R3)
2010-08-30	Biomass sampling: 5 rice plants
2010-09-18	Biomass sampling: 5 rice plants
2010-09-30	Harvest at the potato field
2010-10-01	Turbulence measurement ended at the rice field (R3)
2010-10-17	Harvest at the rice field
2010-10-28	Turbulence measurement started at the rice field (R4)
2010-11-02	Turbulence measurement ended at the rice field (R4)
2010-11-02	Turbulence measurement started at the potato field (P4)
2010-11-06	Turbulence measurement ended at the potato field (P4)
2010-11-08	Departure

3. Instrumentation

3.1. Overview

The measured parameters and measuring devices are listed with installation details in Table 3-1. For more details of the installation, see Figure 3-1. The connection between the devices and cables were shown in Figure 3-2 and Figure 3-3. Photographs of all the devices are listed in Figure 3-4.

Following chapters describe the detailed information about the devices except the weather stations which are reported in Chapter 5.

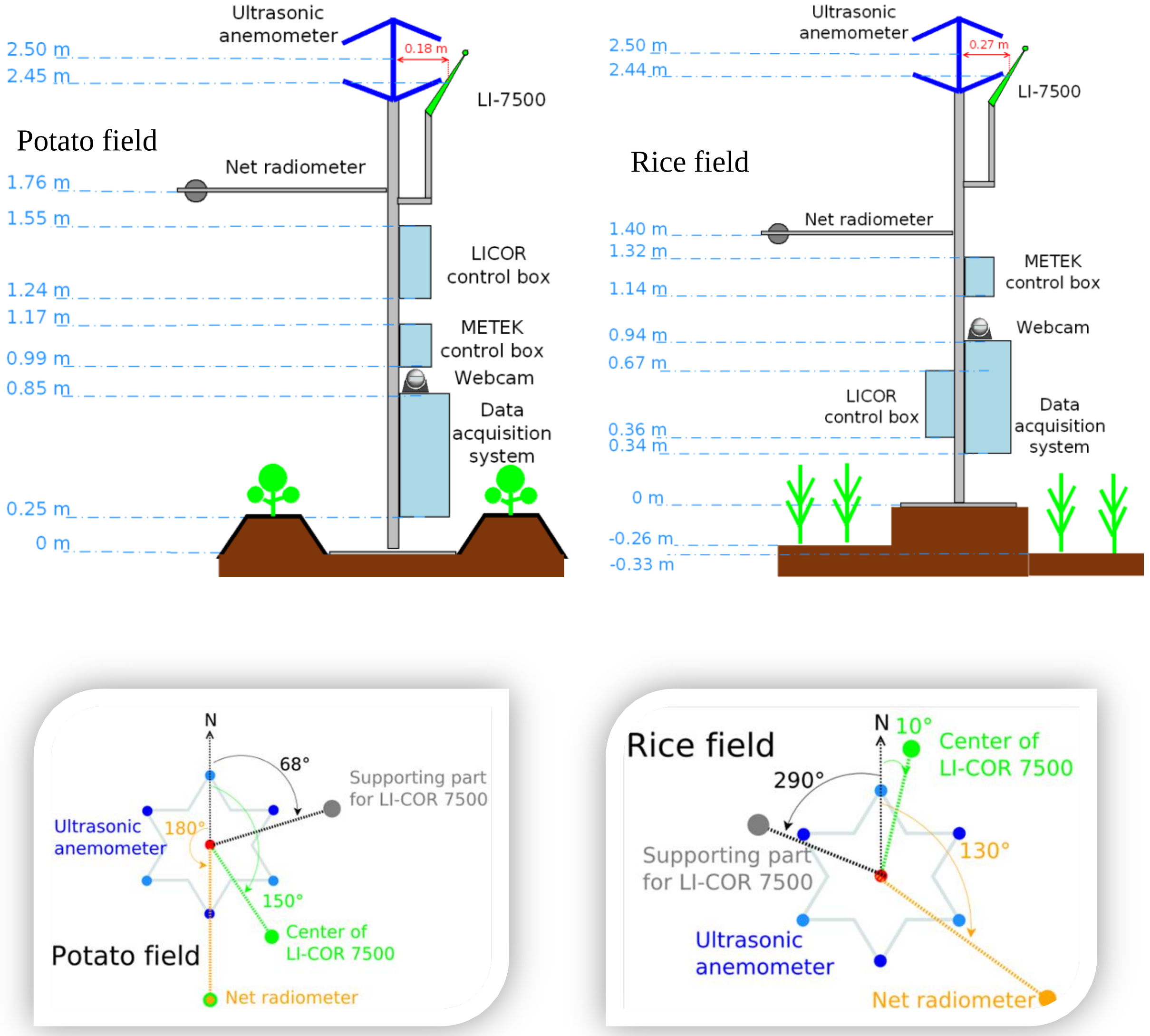

Figure 3-1: Installation and orientation of the masts during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

Table 3-1: List of devices during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

Parameter	Instrument	Serial number.	Uni. Inventory	Calibr. factor	Output	Height[m]	Vertical /Horizontal displacement[m]	Orientation
Wind vector	USA-1 „Scientific“	010202 1865	78787	/	[m s^{-1}]	2.50 [a] 2.80 [b]	/	0
Sonic temperature					[℃]			
H_2O concentration	LI-7500	75B-1632 (Control Box) 75H-1632 (Head)	78674	0 V–0 mmol m^{-3}, 5 V–1500[d], 2000[e] mmol m^{-3}	[V]	2.45[a] 2.74[b]	0.05/0.18[a]	150 [a] 10 [b]
CO_2 concentration				0 V–10[d], 5[e] mmol m^{-3}, 5 V–30 mmol m^{-3}			0.06/0.27[b]	
Pressure				/	[kPa]	approx.1.4 [a] approx.0.5 [b]	/	/
Net radiation	NR-LITE	980165	/	15.2 μV W^{-1} m^2	[V]	1.76[a] 1.70[b]	/	180 [a] 130 [b]
	Amplifier (Ina 118)	/	/	/	[V]	/	/	/
Inclination	AccuStar II/DAS 20	/	/	/	[V]	1.65[a] 1.94[b]	/	248 [a] 110 [b]
Wind speed	WS-GP1[c]	H10423[a] H7286 [b]	/	/	[m s^{-1}]	approx.2.5	/	−8[c]
Wind direction					[°]			
Temperature					[℃]	approx.2		
R. humidity					[%]			
Solar radiation					[W m^{-2}]			
Precipitation					[mm]			

[a] At the potato field.
[b] At the rice field.
[c] See Chapter 4.6 for details.
[d] Period from the beginning to 2010-07-23 15:46.
[e] Period from 2010-07-23 15:46 to the end.

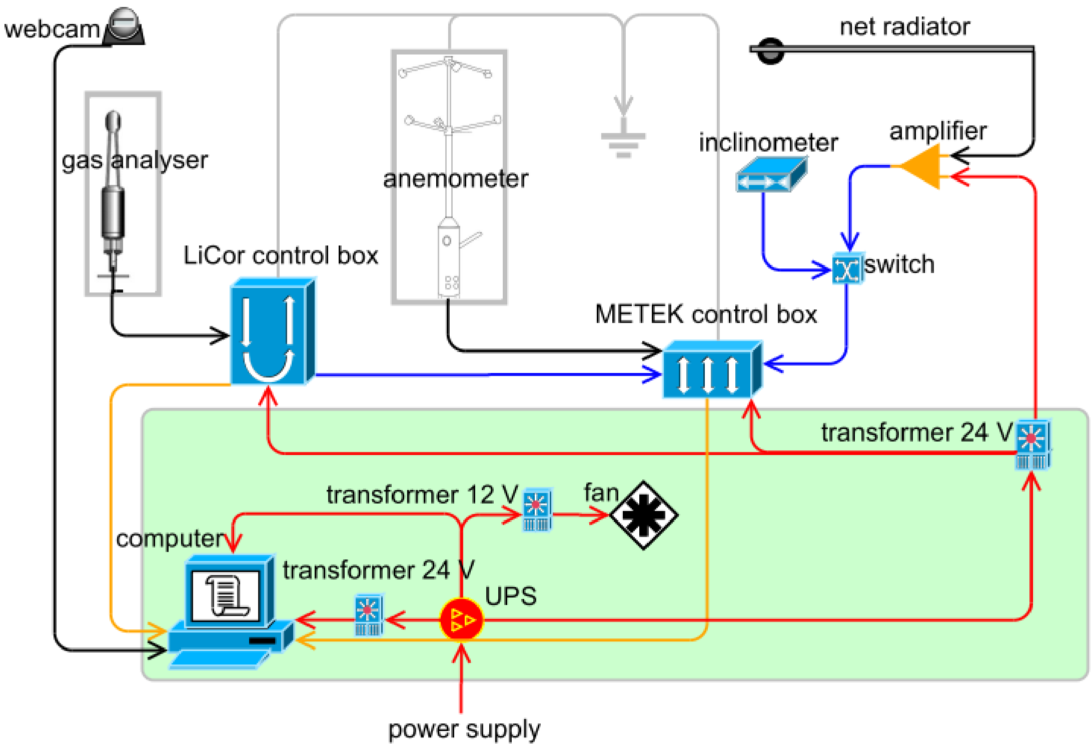

Figure 3-2: Schematic diagram of device connection during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (red lines: power cables; black lines: original signal cables from the sensors; blue lines: analogue signal cables; orange lines: RS-232 signal cables)

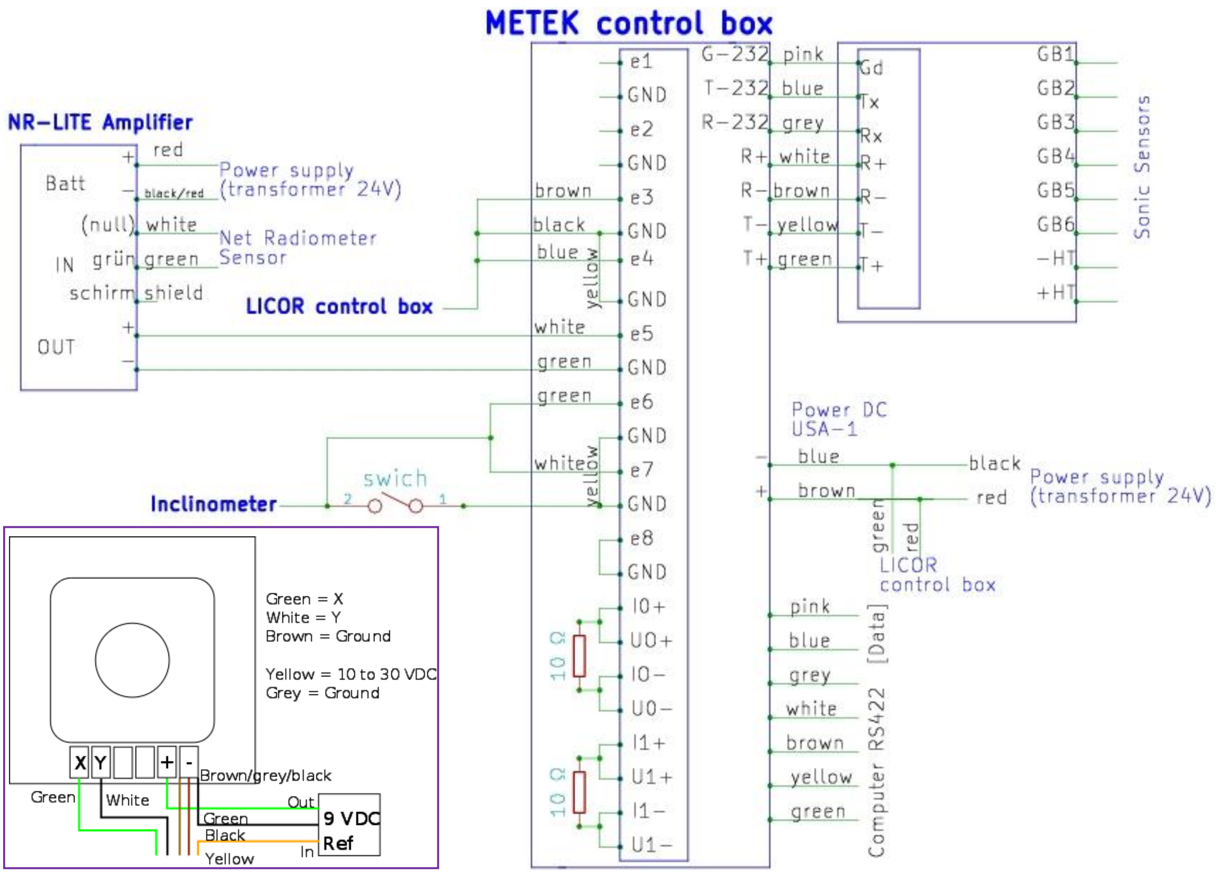

Figure 3-3: Connection in METEK control box during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (contributed by Miloslav Belorid, modified. Bottom left: Schematic diagram of the inclinometer AccuStar II/DAS 20)

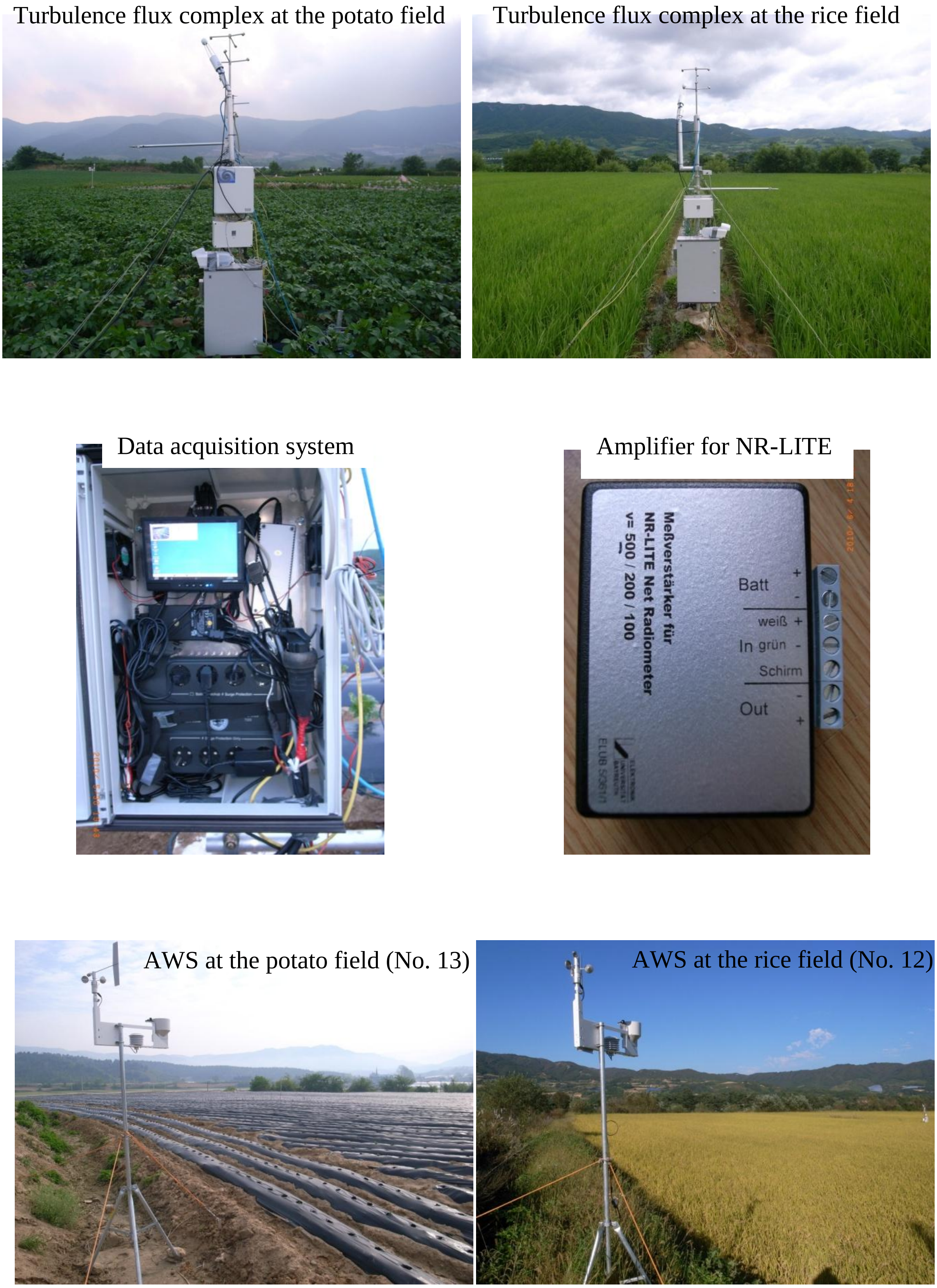

Figure 3-4: Photographs of the devices during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (photographs by Peng Zhao)

3.2. USA-1

Table 3-2: Specifications of USA-1 (Standard, Separated Version, Meteorologische Messtechnik GmbH., modified)

Measuring range and resolution	Wind Velocity	0 to 50 m/s ±0.01 m/s
	Wind Components	－50 to ＋50 m/s ±0.01 m/s
	Wind Direction	0 to 359 °±1 °
	Temperature	－30 to ＋50 ℃ ±0.01 K
	Analog Inputs	－10 to ＋10 V
Time Resolution	Sampling Rate	0.004 to 50 Hz
	Averaging Interval	1 to 65535 samples
Analog Data Output, 12 Bit Resolution, 0 to 20 mA, 500 Ω max. or 0 to 10 V	Wind Velocity	0 to 60 m/s (max. range)
	Wind Components	－60 to ＋60 m/s (max. range)
	Wind Direction	0 to 359 °
	Temperature	－30 to ＋50 ℃ (max. range)
Sensor Orientation	Azimuth	0 to 359 °(adjustable)
Power Consumption	Sensor Electronic	approx. 2.5 W
	Low Power Mode (no heating, SF < 1000)	approx. 1.5 W
	Sensor Heating (Option)	approx. 50.0 W
Dimensions	Sound Paths	175 mm
	Measuring Head (φ ×Height)	320 ×240 mm
	Sensor Height	660 mm
	Separated Electronic Box (L ×W ×H)	280 ×180 ×330 mm
	Mounting Clamp (inner φ ×Length)	40 ×100 mm
Weights	Separated Sensor Head	1.8 kg
	Separated Electronic Box	3.8 kg

3.3. LI-7500

Table 3-3: Specifications of LI-7500 (LI-COR, Inc., modified)

Type	Absolute, open-path, non-dispersive infrared gas analyzer
Detector	Thermo-electrically cooled lead selenide
Bandwidth	5, 10, or 20 Hz, software selectable
Path Length	12.5 cm
Operating Temperature	－25 to ＋50 ℃
User Interface	Windows® based software supports all setup, configuration and calibration functions through RS-232 serial port
Outputs	RS-232 (20 Hz Maximum); SDM (user selectable to 50Hz); 2 user scalable 16 bit DACs updated at 300 Hz
Auxiliary Inputs	2 channels for temperature and pressure sensors (during calibration); Auxiliary Input with pressure sensor: 0 to 4.096V (±5V common mode rejection)
Power Requirements	10.5 to 30 V DC. 24 V in our campaign
Power Consumption	30 W during warm-up, 10 W in steady state
Dimensions	Head: Dia. 6.5 cm, Length 30 cm Control Box: 35 cm ×30 cm ×15 cm (external dimensions) IRGA cable: 3 m (between sensor head and electronics control box) Power, Serial, DAC, Auxiliary Input and SDM cables: 4 m
Weight	Head 0.75 kg, Control Box and Cables 4.8 kg

Table 3-4: Specifications of LI-7500 calibration (LI-COR, Inc.) during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

CO_2		mol mol^{-1}	mmol m$^{-3\dagger}$	mg m$^{-3\dagger}$
Calibration range		0 to 3000	0 to 117	0 to 5148
RMS noise at ambient (370 ppm)	Bandwidth:			
PSD* = 35 ppb/Hz$^{0.5}$ typical	5 Hz	0.08	0.0031	0.13
70 ppb/Hz$^{0.5}$ max.	10 Hz	0.11	0.0043	0.19
	20 Hz	0.16	0.0061	0.27
Zero drift with temperature (per ℃)	Maximum	±0.3	±0.012	±0.5
	Typical	±0.1	±0.004	±0.2
Gain drift with temperature at 370 ppm	Maximum	±0.1%		
(% of reading per ℃)	Typical	±0.02%		
Direct sensitivity to H_2O (mol CO_2/mol H_2O)	Maximum	±4.00E−05		
	Typical	±2.00E−05		

H_2O		mmol mol^{-1}	mmol m$^{-3\dagger}$	g m$^{-3\dagger}$
Calibration range		0 to 60	0 to 2340	0 to 42
RMS noise at moist air (10 mmol mol^{-1})	Bandwidth:			
PSD* = 1.5 ppm/Hz$^{0.5}$ typical	5 Hz	0.0034	0.13	0.0024
2.5 ppm/Hz$^{0.5}$ max.	10 Hz	0.0047	0.18	0.0033
	20 Hz	0.0067	0.26	0.0047
Zero drift with temperature (per ℃)	Maximum	±0.05	±2	±0.04
	Typical	±0.03	±1	±0.02
Gain drift with temperature at 20 mmol mol^{-1}	Maximum	±0.3%		
(% of reading per ℃)	Typical	±0.15%		
Direct sensitivity to CO_2/ (mol H_2O /mol CO_2)	Maximum	±0.05		
	Typical	±0.02		

† At 25 ℃, 98 kPa

*Power Spectral Density

3.4. NR-LITE

Table 3-5: Specifications of NR-LITE (Campbell Scientific, Inc.)

Spectral	Spectral range	0.2 to 100 μm
	Detector type	Thermopile
	Detector protection	Teflon coating
	Detector profile	Conical
Directional	Directional error	(0 to 60 ° at 1000 W m^{-2}) <30 W m^{-2}
	Sensor asymmetry	±5% typical, ±10% worst case
Mechanical	Housing material	Anodized aluminum
	Cable material	Polyurethane
	Weight	200 g
	Cable length	2 m (can be extended up to 100 m)
	Physical dimensions	Sensor 8.0 cm diameter Support Arm 1.6 cm diameter × 80 cm L
	Weight	635 g
Environmental	Working temperature	−30 to +70 ℃
	Temperature dependence	0.12%/ ℃

3.5. Amplifier for NR-LITE

Table 3-6: Specifications of amplifier (Ina 118) for NR-LITE

Type	Ina 118
Error	< 1%
Linear range	Input < 25 mV and output < 2.5 V
Voltage supply	10 to 30 VDC
Amplifier factor	98.85, 201.8 or 501

3.6. Inclinometer

Table 3-7: Specifications of inclinometer (Measurement Specialties, Inc.)

Performance	Range	±20°
	Threshold / resolution	0.01
	Linearity	
	Null to 10°	±0.2°
	10°to 12°	±2.5% of reading
	12°to 15°	±3.0% of reading
	15°to 20°	Monotonic
	Null repeatability	±0.1
	Frequency response (-3db)	0.25 Hz (nominal)
	Weight	91 g with case, 31 g without case
Electrical	Voltage supply (nominal)	9 VDC
	Voltage supply range	Regulated 5.0 to 15.0 VDC
	Current	10 mA
	Analog output scale factor	100 mV/degree ±10%
	Pulse width output	
	Null	50% (duty cycle)
	Scale factor	0.7% / degree (nominal)
	Duty cycle	$t_2 / (t_1 + t_2)$ t_1 and t_2 varies from 0.2 to 0.7 msec
	Frequency	100 Hz nominal
Environmental	Temperature range	
	Operating	−20°to +65℃
	Storage	−55°to +65℃
	Temperature coefficient of Null	0.01°/℃
	Temperature coefficient of scale factor	0.10%/℃

3.7. Biomass Analysis

Each time 5 to 10 whole plants were sampled manually for biomass analysis. Each plant was immediately separated into leaves (green), dead parts (brown), stems, roots, etc.(Figure 3-5), and then weighed on a scale to obtain the fresh weights. Leaf areas were measured on a leaf area meter. All the separated samples were dried at 75 or 80℃ for at least 1 week in an oven, then weighed again to obtain the dry weights. Dried samples were shipped to the Univ. of Bayreuth for potential analysis.

Figure 3-5: Biomass sampling and separation of potato plants during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (photographs by Peng Zhao)

4. Data Acquisition

4.1. Dataflow

All the raw data were stored in the database in DVD archives.

Raw data from METEK control box include ultrasonic data, gas analyzer data, net radiation data, and inclinometer data, which were downloaded by tcopy.exe. The command line is:

tcopy.exe /b 38400 /lh /t COM2

Raw data from LiCor control box RS-232 output include gas analyzer data, air pressure, inside temperature, diagnosis information, which were downloaded by tcopy.exe. The command line is:

tcopy.exe /b 38400 /lh /t COM1

Raw data from weather stations were downloaded manually with the software Deltalink (Delta-T Devices Ltd.).

The turbulent fluxes are calculated and corrected using TK2 program (Mauder and Foken, 2004) with quality control. The results are used for further analysis.

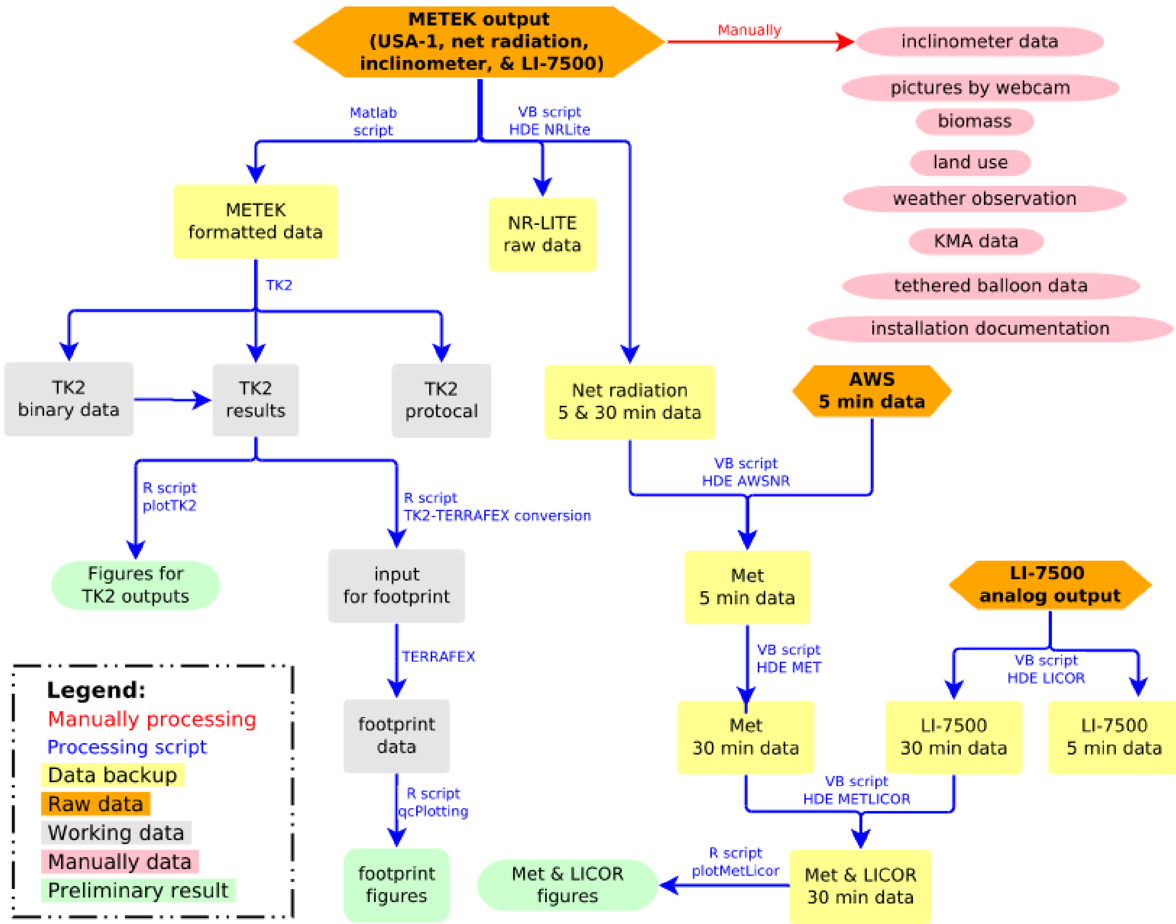

Figure 4-1: Dataflow during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

4.2. LI-7500 Calibration Values and Settings

LI-7500 CO_2/H_2O Analyzer Calibration values (20 Nov., 2008):

Table 4-1: Basic calibration of LI-7500 during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

	CO_2	H_2O
A	152.7640	5435.080
B	6243.750	4408670
C	4.806400e＋07	－3.101910e＋08
D	－1.583770e＋10	/
E	2.147180e＋12	/
XS	0.001300000	－0.001400000
Z	－0.001900000	0.01580000

Table 4-2: Zero / span calibration of LI-7500 during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

	CO_2 (at 600 ppm)	H_2O (at 12 C)
Zero	0.9082303	0.8764094
Span	0.9987253	0.9897679

Detailed setup parameters from the beginning to 2010-07-23 15:46:

(Ack(Received FALSE)(Val 0.000000))(Calibrate(SpanCO2(Date "20 11 2008 02:40")(Target 600.2000)(Tdensity 23.90000)(Val 0.9987253))(SpanH2O(Date "20 11 2008 03:25")(Target 11.91000)(Tdensity 455.6560)(Val 0.9897679))(ZeroCO2(Date "20 11 2008 02:37")(Val 0.9082303))(ZeroH2O(Date "20 11 2008 03:04")(Val 0.8764094)))(Coef(Current(Band(A 1.150000))(CO2(A 152.7640)(B 6243.750)(C 4.806400e+07)(D -1.583770e+10)(E 2.147180e+12)(XS 0.001300000)(Z -0.001900000))(H2O(A 5435.080)(B 4408670.)(C -3.101910e+08)(XS -0.001400000)(Z 0.01580000))(Pressure(A0 10.13000)(A1 26.03600))(SerialNo "75H-1632")))(Data(Aux 0.000000)(CO2D 14.59785)(CO2Raw 0.08016396)(Cooler 1.593000)(DiagVal 248)(H2OD 1055.532)(H2ORaw 0.1067097)(Ndx 20368)(Pres 96.12691)(Temp 25.39368))(Diagnostics(Chopper TRUE)(DetOK TRUE)(PLL TRUE)(Path 52.00000)(SYNC TRUE))(EmbeddedSW(Model "LI-7500 CO2/H2O Analyzer Application")(Version 3.0.1))(Error(Received FALSE))(Inputs(Aux(A 1.000000)(B 0.000000))(Pressure(Source Measured)(UserVal 98.00000))(Temperature(Source Measured)(UserVal 25.00000)))(Outputs(BW 10)(Dac1(Full 30.00000)(Source CO2MMOL)(Zero 10.00000))(Dac2(Full 1500.000)(Source H2OMMOL)(Zero 0.000000))(Delay 2)(RS232(Aux TRUE)(Baud 38400)(CO2D TRUE)(CO2Raw TRUE)(Cooler TRUE)(DiagRec TRUE)(DiagVal TRUE)(EOL 0A)(Freq 20.00000)(H2OD TRUE)(H2ORaw TRUE)(Labels FALSE)(Ndx TRUE)(Pres TRUE)(Temp TRUE))(SDM(Address 7)))-(Chart(LV None)(Lmax 100.0000)(Lmin 0.000000)(RV None)(Rmax 100.0000)(Rmin 0.000000)(Scroll(Coarse FALSE)(Smooth TRUE))(Units(Mins FALSE)(Secs TRUE))(Xmax 20))(Connect(Baud 38400)(Freq 20.00000)(Port 1))(Log(CI TRUE)(Del(Space FALSE)(Tab TRUE))(LogVals(CV TRUE)(Cabs TRUE)(Cden TRUE)(CdenMg TRUE)(Cmf TRUE)(Dew TRUE)(Habs TRUE)(Hden TRUE)(HdenMg TRUE)(Hmf TRUE)(PortB TRUE)(Pres TRUE)(RelTime TRUE)(Temp TRUE))(Name "D:\Program Files\LI7500v3_0_2\LogFile.txt")(Rem FALSE)(TS TRUE))

Detailed setup parameters from 2010-07-23 15:46 to the end:

(Ack(Received FALSE)(Val 0.000000))(Calibrate(SpanCO2(Date "20 11 2008 02:40")(Target 600.2000)(Tdensity 23.90000)(Val 0.9987253))(SpanH2O(Date "20 11 2008 03:25")(Target 11.91000)(Tdensity 455.6560)(Val 0.9897679))(ZeroCO2(Date "20 11 2008 02:37")(Val 0.9082303))(ZeroH2O(Date "20 11 2008 03:04")(Val 0.8764094)))(Coef(Current(Band(A 1.150000))(CO2(A 152.7640)(B 6243.750)(C 4.806400e+07)(D -1.583770e+10)(E 2.147180e+12)(XS 0.001300000)(Z -0.001900000))(H2O(A 5435.080)(B 4408670.)(C -3.101910e+08)(XS -0.001400000)(Z 0.01580000))(Pressure(A0 10.13000)(A1 26.03600))(SerialNo "75H-1632")))(Data(Aux 0.000000)(CO2D 14.66722)(CO2Raw 0.08008862)(Cooler

1.590364)(DiagVal 248)(H2OD 1059.809)(H2ORaw 0.1078892)(Ndx 4118)(Pres 96.08419)(Temp 25.40787))(Diagnostics(Chopper TRUE)(DetOK TRUE)(PLL TRUE)(Path 52.00000)(SYNC TRUE))(EmbeddedSW(Model "LI-7500 CO2/H2O Analyzer Application")(Version 3.0.1))(Error(Received FALSE))(Inputs(Aux(A 1.000000)(B 0.000000))(Pressure(Source Measured)(UserVal 98.00000))(Temperature(Source Measured)(UserVal 25.00000)))(Outputs(BW 10)(Dac1(Full 30.00000)(Source CO2MMOL)(Zero 5.000000))(Dac2(Full 2000.000)(Source H2OMMOL)(Zero 0.000000))(Delay 2)(RS232(Aux TRUE)(Baud 38400)(CO2D TRUE)(CO2Raw TRUE)(Cooler TRUE)(DiagRec TRUE)(DiagVal TRUE)(EOL 0A)(Freq 20.00000)(H2OD TRUE)(H2ORaw TRUE)(Labels TRUE)(Ndx TRUE)(Pres TRUE)(Temp TRUE))(SDM(Address 7)))|(Chart(LV None)(Lmax 100.0000)(Lmin 0.000000)(RV None)(Rmax 100.0000)(Rmin 0.000000)(Scroll(Coarse FALSE)(Smooth TRUE))(Units(Mins FALSE)(Secs TRUE))(Xmax 20))(Connect(Baud 9600)(Freq 1.000000)(Port 1))(Log(CI TRUE)(Del(Space FALSE)(Tab TRUE))(LogVals(CV TRUE)(Cabs TRUE)(Cden TRUE)(CdenMg TRUE)(Cmf TRUE)(Dew TRUE)(Habs TRUE)(Hden TRUE)(HdenMg TRUE)(Hmf TRUE)(PortB TRUE)(Pres TRUE)(RelTime TRUE)(Temp TRUE))(Name "D:\Program Files\LI7500v3_0_2\LogFile.txt")(Rem FALSE)(TS TRUE))

4.3. USA-1 Settings

AD=0	AE=0	AO=0	AT=0
AV=1	AZ=0	BM=0	BR=38400
D1=0	D2=0	D3=0	D4=0
D5=0	D6=0	D7=0	D8=0
FR=0	HC=1	HT=1	LC=23.03.09 10:43:22
LD=0	M1=	M2=	M3=
MD=20	N0=	N1=urcall	N2=urcall
N3=urcall	NO=31	O1=2564	O2=2547
O3=2455	O4=2454	O5=2386	O6=2392
OA=0	OD=141	P1=1746	P2=1753
P3=1754	PR=3	SA=0	SF=2000
SO=0	SY=0	TC=2205	TI=15.01.11 01:25:35
TR=4000	TV=0	VR=6000	ZR=100
version 4.42 serial no. 0102021865	vbatt = 3471	free 15359 used 0 unread 0	

4.4. Amplifier Setting

The amplifier for NR-LITE was set with a factor as 501, i.e. the output signal is 501 times as large as the original signal from NR-LITE.

4.5. Raw Data Format

A record from METEK control box is blow:

101106000000 Korea Standard Time H:05.11.10 23:58:10 x =   164 y =   30 z =   -1 t =   929 e1= -145 e2= 68 e3= 21072 e4= 14703 e5= -2728 e6=-31509 e7=-31546 e8=   -3

The format of this record is shown in Table 4-3.

Table 4-3: Format of METEK output during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

record*	explanation
101106000000 Korea Standard Time	Time stamp given by the data acquisition computer, YYMMDDhhmmss
H:05.11.10 23:58:10	Time stamp given by METEK control box, H:DD.MM.YY hh:mm:ss
x = 164 y = 30 z = -1	wind velocity x, y, z equal to 1.64 m s^{-1}, 0.30 m s^{-1}, −0.01 m s^{-1}, respectively
t = 929	sonic temperature is 9.29 ℃

record*	explanation
e1= -145 e2= 68	PT100 temperture (not installed)
e3= 21072	Analogue output of H2O measurement is 2107.2 mV
e4= 14703	Analogue output of CO2 measurement is 1470.3 mV
e5= -2728	Analogue output of net radiator is －272.8 mV
e6=-31509 e7=-31546	Analogue output of inclinometer is －3150.9 mV and －3154.6 mV
e8= -3	Analogue output for potential use (vacant)

* e3 to e8 are displayed from －9999.9 mV up to ＋9999.9 mV.

A record with labels from LI-7500 RS-232 output is blow:

100530220000 Korea Standard Time (Data (Ndx 1416182)(DiagVal 248)(CO2Raw 8.6644287e-2)(CO2D 1.6177368e1)(H2ORaw 5.8520436e-2)(H2OD 4.6218466e2)(Temp 1.1468566e1)(Pres 9.6240272e1)(Aux 0)(Cooler 1.3489209))

The format of this record is shown in Table 4-4.

Table 4-4: Format of LI-7500 serial output with labels during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

record	Explanation
100530220000 Korea Standard Time	Time stamp given by the data acquisition computer, YYMMDDhhmmss
Ndx 1416182	The index value is 1416182, which is incremented approximately every 6.5 milliseconds (e.g. 152 Hz) and ranges from approximately －2.0E8 to ＋2.0E8
DiagVal 248	Diagnostic value is 248
CO2Raw 8.6644287e-2	Absorptance of CO_2 measurement is 8.6644287e－2
CO2D 1.6177368e1	CO_2 concentration is 1.6177368e1 mmol m^{-3}
H2ORaw 5.8520436e-2	Absorptance of H_2O measurement is 5.8520436e－2
H2OD 4.6218466e2	H_2O concentration is 4.6218466e2 mmol m^{-3}
Temp 1.1468566e1	Temperature inside the control box is 1.1468566e1 ℃
Pres 9.6240272e1	Air pressure inside the control box is 9.6240272e1 kPa
Aux 0	Auxiliary input is 0 (not installed)
Cooler 1.3489209	Detector cooler voltage is 1.3489209 V

A record without labels from LI-7500 RS-232 output is blow:

101103150000 Korea Standard Time 12140425 248 0.08235 15.1412 0.04090 291.945 14.64 96.9 -0.00099 1.3499

The format of this record is shown in Table 4-5.

Table 4-5: Format of LI-7500 serial output without labels during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

Record	Explanation
101103150000 Korea Standard Time	Time stamp given by the data acquisition computer, YYMMDDhhmmss
12140425	The index value, which is incremented approximately every 6.5 milliseconds (e.g. 152 Hz) and ranges from approximately －2.0E8 to ＋2.0E8.
248	Diagnostic value
0.08235	Absorptance of CO_2 measurement
15.1412	CO_2 concentration in mmol m^{-3}
0.04090	Absorptance of H_2O measurement
291.945	H_2O concentration in mmol m^{-3}
14.64	Temperature inside the control box in ℃
96.9	Air pressure inside the control box in kPa
-0.00099	Auxiliary input (not installed)
1.3499	Detector cooler voltage in V

4.6. DVD Archive

The raw data and related information are archived in 3 DVDs (No. 515 - 517) in Dep. of Micrometeorology, Univ. of Bayreuth. Blow is the structure and brief explanation for each folder.

- 0_AWS (DVD 515)
  Including Automatic Weather Station data, detailed documentation for all the 14 AWS, and the programs running during different periods
- 1_METEK_potato (DVD 516)
  Including the high frequency output data from METEK control box at the potato field, i.e. the 3D wind vector, H_2O and CO_2 concentration, net radiation, inclination
- 2_METEK_rice (DVD 516)
  Including the high frequency output data from METEK control box at the rice field, i.e. the 3D wind vector, H_2O and CO_2 concentration, net radiation, and inclination
- 3_LICOR_potato (DVD 517)
  Including the high frequency output data from LICOR control box at the potato field, i.e. the H_2O and CO_2 concentration, air pressure, inside temperature, and diagnosis information
- 4_LICOR_rice (DVD 517)
  Including the high frequency output data from LICOR control box at the rice field, i.e. the H_2O and CO_2 concentration, air pressure, inside temperature, diagnosis information
- 5_LICOR_config (DVD 515)

LICOR configure files.

- 6_Webcam_potato (DVD 516)

  The pictures taken by the webcam at the potato field
- 7_Webcam_rice (DVD 515)

  The pictures taken by the webcam at the rice field
- 8_Diary (DVD 515)

  Including the plant size and biomass data, the documentation of eddy covariance complex installation
- 9_TetheredBalloon (DVD 515)

  Tethered balloon data from Kangwon National Univ.
- a_Landuse (DVD 515)

  Land use information
- b_KMA (DVD 515, 517)

  Including AWS data, the chart of Radar, satellite and weather analysis downloaded from the website of Korea Meteorology Administration
- c_LiYuelin20100731 (DVD 515)

  Related data contributed by Dr. Yuelin Li from Chinese Academy of Sciences
- y_WeatherObs (DVD 515)

  Manually observation of weather
- z_Inclinometer (DVD 515)

5. Automatic Weather Station (AWS) Network

5.1. Overview

A network composed by 14 AWS (numbered from 1 to 15 except No.5 which did not work) was running during the campaign (Table 5-1).

Figure 5-1: Locations of 14 AWS during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (contributed by Bumsuk Seo, modified)

Table 5-1: Locations and test dates of AWS during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

Location	S.N.	Latitude	Longitude	Altitude	Test Date*
01-Observatory	H7281	38.32788	128.12535	1050	2008-07-16
02-Military_Temple	H4308	38.24565	128.09990	977	2008-04-18
03-Sap1site	J2483	38.31554	128.14068	662	2009-02-06
04-TERRECOHouse	J2481	38.30558	128.12234	483	Not available
06-Han's	H10421	38.26758	128.12330	477	2008-10-21
07-Ok's_Field	J9834	38.27046	128.15450	561	2007-12-21
08-Glass_area	J2484	38.29907	128.10440	614	2009-02-06
09-Fruit_area	J3109	38.28497	128.11610	513	2009-02-23
10-Western_Forest	J3113	38.27555	128.10190	633	2009-02-23
11-Kang's_Rice	J3105	38.30430	128.13810	473	2009-02-23
12-Eddy_Rice	H7286	38.29092	128.13058	457	2008-07-16
13-Eddy_Potato	H10423	38.27703	128.12433	455	2008-12-21
14-Experimental_Field	H10419	38.29843	128.14280	451	2008-12-21
15-Mid_Forest	J3112	38.28820	128.13080	476	2009-02-23

* Tested by the manufacturer.

5.2. Specifications

Table 5-2: Specifications of AWS (Delta-T Devices Ltd.)

	Specification	Range/Notes
Logger GP1		
Accuracy analog	±(0.3 mV ＋ 0.01% reading)	typical at 20 ℃
	±(1.63 mV ＋ 0.05% reading)	max over －20 ℃ to ＋60 ℃
Temperature accuracy	± 0.07 ℃ typical at 20 ℃	for 10 K thermistor (at －20 to ＋60 ℃)
	±0.13 ℃ max. (－20 to ＋60 ℃)	
Readings	> 600,000	
Logging frequency	1 s to 24 hr	
Data collection	To PC or Pocket PC	
Logging status	Flashing LED	
Environmental	－20 ℃ to ＋60 ℃, IP67	
Wind speed		
Accuracy	±0.1 m s^{-1}	up to 10 m s^{-1} (22.7 mph)
	±1.1 % of reading	over 10 m s^{-1} (22.7 mph)
Range	0 to 75 m s^{-1} (0 to 167 mph)	
Starting threshold	0.4 m s^{-1} (0.9 mph)	
Wind direction		
Accuracy	±4°	
Range	0 to 356°	electrical
	0 to 360°	mechanical
Starting threshold	0.4 m s^{-1}(0.9 mph)	
Damping ratio	0.25	
Resolution	< 0.5°	
Temperature		
Accuracy at 25℃	±0.2℃	sensor and logger
	IP65	
Radiation Shield error	0.5 ℃	at 3 m s^{-1}
	1.0 ℃	at 2 m s^{-1}
	2.0 ℃	at 1 m s^{-1}
Relative Humidity (RH)		
Accuracy at 25℃	±2% RH	5 to 95% RH
	±2.5% RH	< 5% and > 95% RH
Envronmental	－20 to 80℃, 0 to 100% RH	IP65
Response time	< 10 s	90% of scale for a step change from 11% to 75% RH
Rainfall		
Sensitivity	0.2 mm per tip	up to 360 mm hr^{-1}
Solar Radiation		
Absolute accuracy	±5%	
Uniformity	±3%	
Repeatability	±1%	
Cosine response	±1%	45°zenith angle
	±4%	75°zenith angle
Environmental	－40 to 55℃, 0 to 100% RH	can be immersed

5.3. Events

Table 5-3: Events on AWS during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

Date	Sites	S.N.	Events
2010-05-14	12-Eddy_Rice	H10423	Installed. Program 2**
2010-05-16	13-Eddy_Potato	H10419	Installed. Program 2. Starting at 14:40.
2010-05-16	12-Eddy_Rice	H10423	Adjust the installation from 15:10 to 16:30.
2010-05-17	14-Experimental_Field	J3112	Installed. Program 2.
2010-06-09	02-Military_Temple	H4308	Program 1* ended and Program 3*** started.
2010-06-09	04-TERRECOHouse	J2481	Program 1 ended. Program 3 started.
2010-06-09	06-Han's	H10421	Program 1 ended. Program 3 started.
2010-06-09	08-Glass_area	J2484	Program 1 ended. Program 3 started.
2010-06-09	10-Western_Forest	J3113	Program 1 ended. Program 3 started.
2010-06-09	11-Kang's_Rice	J3105	Program 1 ended. Program 3 started.
2010-06-09	12-Eddy_Rice	H7286	Program 2 ended. Program 3 started.
2010-06-09	13-Eddy_Potato	H10423	Program 2 ended. Program 3 started.
2010-06-09	14-Experimental_Field	H10419	Program 2 ended. Program 3 started.
2010-06-19	15-Mid_Forest	H7284	Installed. Program 3
2010-06-21	07-Ok's_Field	J9834	Program 1 ended. Program 3 started.
2010-06-21	09-Fruit_area	J3109	Program 1 ended. Program 3 started.
2010-06-21	03-Sap1site	J2483	Laying on ground from 13:50 when farmers working. Program 1 ended and Program 3 started at 14:00.
2010-06-22	03-Sap1site	J2483	Moved back. Finished at 14:20. Orientation is 6 °.
2010-06-25	01-Observatory	H7281	Program 1* ended and Program 3*** started.
2010-11-01	03-Sap1site	J2483	Battery problem
2010-11-03	06-Han's	H10421	Battery problem
2010-11-03	08-Glass_area	J2484	Battery problem
2010-11-03	09-Fruit_area	J3109	Shadowed by a tree in the afternoon
2010-11-05	13-Eddy_Potato	H10423	Wind tail found on the ground. Reinstalled.
2010-11	All sites	All	Program 3 ended. Program 1 started.

* Program 1: 30 min average, 1 min sampling time, 12 wind rose
** Program 2: 5 min average, 1 s sampling time, 12 wind rose
*** Program 3: 5 min average, 20 s sampling time, 16 wind rose

5.4. Status Check

The status of batteries, levels, orientations (Table 5-4), and clocks (Table 5-5) were checked. Batteries were replaces with new ones if they were lower than approximately 6 V. Levels were readjusted if necessary. Clocks were recorded before synchronized. Orientations were recorded but not corrected.

5.5. Recommendations for Data Users

It is recommended to consider the possible errors and reject the wrong data before gap filling.

- Missing data. Battery voltage gets low when a battery failure happens or the battery runs out, which causes missing data. Here is a list:
    - 03-sap1site, 2010-10-01 to 11-02
    - 12-Eddy_Rice, 2010-05-27 to 06-01
    - 13-Eddy_Potato, 2010- 05- 26 to 06-01

- 14-Experimental_Field, 2010-05-23 to 05-27

Table 5-4: Orientation check of AWS during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

Checked by	Peng Zhao		Bora Lee		Steve Lindner		Peng Zhao	
Location	MM-DD	Orie.*	MM-DD	Orie.	MM-DD	Orie.	MM-DD	Orie.
01-Observatory	06-25	56	08-12	64	09-10	66	11-05	70
02-Military_Temple	06-09	0	07-26	8	09-07	−17	10-29	8
03-Sap1site	06-21	−4	07-26	6	09-08	13	11-01	2
04-TERRECOHouse	06-09	10	07-16	6	09-06	15	10-30	12
06-Han's	06-09	20	07-16	16	09-07	−7	11-03	24
07-Ok's_Field	06-21	32	07-26	38	09-06	8	11-03	34
08-Glass_area	06-09	52	07-26	60	09-06	5	11-03	66
09-Fruit_area	06-21	2	07-27	10	09-07	11	11-03	4
10-Western_Forest	06-09	40	07-16	28	09-07	11	11-03	34
11-Kang's_Rice	06-09	20	07-16	16	09-06	13	10-30	20
12-Eddy_Rice	06-09	8	N.A.	N.A.	09-08	8	11-02	8
13-Eddy_Potato	06-09	8	N.A.	N.A.	09-08	8	11-06	32
14-Exper_Field	06-09	26	07-26	18	09-08	20	10-30	26
15-Mid_Forest	06-19	0	07-27	10	09-08	11	11-04	0

* The rule of the orientation check is shown in Figure 5-2

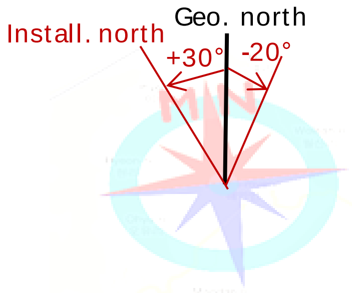

Figure 5-2: Rule of orientation check during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (recorded as positive if the installation north is west of geographic north, otherwise recorded as negative)

Table 5-5: Clock check of AWS during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

Checked by	Peng Zhao		Bora Lee		Steve Lindner		Peng Zhao	
Location	MM-DD	Clock	MM-DD	Clock	MM-DD	Clock	MM-DD	Clock
01-Observatory	06-25	−0:07	08-12	/	09-10	/	11-05	0:00
02-Military_Temple	06-09	0:13	07-26	0:06	09-07	0:10	10-29	0:04
03-Sap1site	06-21	0:40	07-26	0:10	09-08	0:12	11-01	0:13
04-TERRECOHouse	06-09	/	07-16	0:04	09-06	0:12	10-30	0:06
06-Han's	06-09	/	07-16	/	09-07	/	11-03	0:00
07-Ok's_Field	06-21	/	07-26	0:01	09-06	0:02	11-03	0:01
08-Glass_area	06-09	/	07-26	/	09-06	/	11-03	0:00
09-Fruit_area	06-21	/	07-27	−0:01	09-07	/	11-03	0:00
10-Western_Forest	06-09	/	07-16	/	09-07	0:02	11-03	0:01
11-Kang's_Rice	06-09	/	07-16	/	09-06	/	10-30	−0:02
12-Eddy_Rice	06-09	−11:07	N.A.	/	09-08	0:01	11-02	0:00
13-Eddy_Potato	06-09	/	N.A.	/	09-08	0:03	11-06	0:00
14-Exper_Field	06-09	/	07-26	/	09-08	/	10-30	−0:03
15-Mid_Forest	06-19	/	07-27	−0:01	09-08	0:01	11-04	0:00

** clock: positive when the logger clock goes ahead, and negative when behind. hh:mm

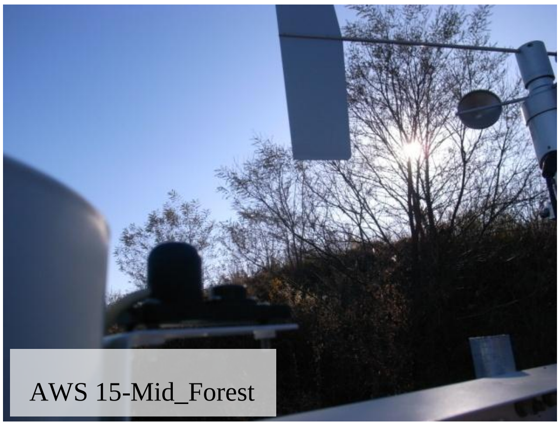

Figure 5-3: Photographs of AWS during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (photographs by Peng Zhao)

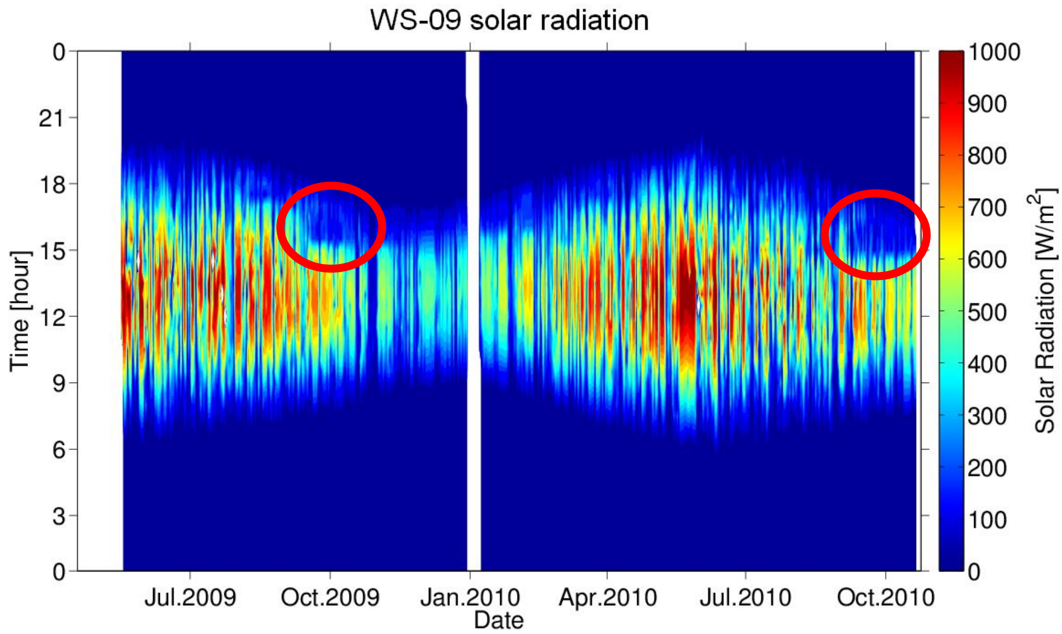

Figure 5-4: Solar radiation sensor possibly shadowed by the tree nearby (marked with red circles) during TERRECO campaign in 2009 and 2010 at Haean, South Korea.

- Surroundings. If the location where the weather station stands is not open or flat enough, then the representative area could be limited. Examples are AWS No. 03 and 15 (Figure 5-3), which were hidden in forests. Another example is the radiation sensor of weather station No. 09 (Figure 5-3) at the fruit area, which was shadowed by a tree nearby during winter time when the sun is low. This could cause a dropping down on the daily radiation plot (Figure 5-4).
- Clock. Most of the clocks in the weather stations were running synchronously, while some of them, such as No.02 at the military temple, No.03 at the sap site, and No.04 at the TERRECO house, were running faster (Table 5-5). The time stamps of them were right at the beginning after adjusting the clock, but went more and more ahead of other weather stations.
- Orientation. If the orientation of the weather station mast is wrong, then the station

does not know which direction is the south, so it gives wrong output for wind direction, sometimes even for solar radiation if the radiation sensor is shadowed by the wind sensor or rain gauge. The orientation check for each weather station is listed in Table 5-4, which could be used for wind direction correction and radiation check. An incorrect orientation could come from incorrect installation, magnetic declination, or a strong wind.

6. Weather Observation

The weather condition was observed manually. Additional weather data and charts can be found in the DVD Archive, No. 515 and 517 under 0_AWS and b_KMA.

Table 6-1: Weather observation during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

Date	Time of obs.	Weather	Cloud Type	Cloud Fraction
05-23	07:30	rainy, windy	Ns	8
06-04	15:32	shower starts	N.A.	N.A.
	15:52	shower ends	N.A.	N.A.
06-05	14:30	cloudy	Cu	1
	16:20	thundering	N.A.	N.A.
	16:50	shower starts	N.A.	N.A.
	21:30	clear,	N.A.	0
06-06	07:30	clear	N.A.	0
	14:30	cloudy, thundering	N.A.	N.A.
	21:30	clear	N.A.	0
06-07	07:30	clear	N.A.	0
	14:30	clear	N.A.	0
	21:30	clear	N.A.	0
06-08	07:30	sunny	N.A.	0
	14:30	sunny	N.A.	N.A.
	21:30	sunny	N.A.	N.A.
06-09	07:30	sunny	N.A.	N.A.
	14:30	sunny	N.A.	N.A.
	21:30	sunny	N.A.	N.A.
06-10	07:30	sunny	N.A.	N.A.
	14:30	sunny	N.A.	N.A.
	21:30	cloudy	N.A.	N.A.
06-11	07:30	cloudy	N.A.	N.A.
	14:30	cloudy	N.A.	N.A.
	21:30	cloudy	N.A.	N.A.
06-12	07:30	rainy	N.A.	N.A.
	14:30	rainy	N.A.	N.A.
	21:30	rainy	N.A.	N.A.
06-13	07:30	rainy	N.A.	N.A.
	11:30	sunny	N.A.	N.A.
	14:30	sunny	N.A.	N.A.
	21:30	clear	N.A.	N.A.
06-14	09:30	mist, overcast	Sc	8
	16:00	mist, overcast, rainy before lunch	Sc	8
06-15	19:30	rainy	Ns	8
06-16	07:30	mist, overcast	Ns	8
	14:30	cloudy	Sc	4
	19:00	cloudy	Cu,Cb	1
06-17	09:20	haze	St	8
	19:00	haze	St	8
06-18	08:00	haze	St	8
06-19	08:00	haze	Ns	8
06-20	08:00	haze	St,Cu	6
	14:30	haze	Cb	7
06-21	10:00	Mist	Cu	4
06-22	10:00	overcast	Cb	7
	15:20	cloudy	Ns	7
06-23	08:20	sunny	N.A.	2
	14:00	sunny	Ac	0
06-26	19:00	overcast	Ns	8
06-27	10:00	dizzy	Ns	8
06-28	08:00	overcast	Ns	8
	10:00	sun comes out	Ns,Cu	8
	14:00	cloudy	Cu,Ci	3
06-29	13:00	overcast, haze	St	8
	20:30	rain	N.A.	N.A.
06-30	07:00	overcast	Ns	8
07-01	07:00	overcast, foggy	St	8
	15:00	cloudy	Cu,Ci	2
07-02	07:00	overcast, foggy	Ns	8
	09:00	starting rain	Ns	8
07-03	07:30	rain	Ns	8
07-04	10:00	cloudy	CuAcCi	5
	15:00	overcast	Cu,St	8
	17:00	cloudy	Cu,Ci	5
07-05	08:00	cloudy after a storm	Cb,Ac	8
	19:00	cloudy	Cb	5
	20:00	thunderstorm	Cb	8
07-06	15:00	cloudy	Cu,Ci	6
	16:50	rainy	N.A.	N.A.
07-07	07:00	overcast	St	8
07-08	10:00	sunny	Cu,Ci	1
	15:00	overcast	Cu,Cb	8
	21:00	rain starts	N.A.	N.A.
07-09	09:00	overcast	St	8
	14:15	shower lasting 10 minutes	Ns,Cb	8
	16:30	shower	Ns	8
	18:30	shower	Ns	8
07-10	07:00	overcast	St	8
07-11	08:00	overcast, rainy	Ns	8
07-12	10:00	cloudy	Ac	5
	15:30	overcast	Ac	8
07-13	10:00	cloudy	Ac	5
	17:50	overcast	Ns	8
07-14	08:00	overcast	St	8
	15:00	cloudy	Cu	3
07-15	08:00	overcast	St	8
	16:00	cloudy, haze	Ac	6
07-16	09:00	cloudy, foggy	Ac,AS	6
	15:00	rain	Ns	8
07-17	08:00	rain	Ns	8
07-18	08:00	rain	Ns	8
07-19	08:00	overcast	Ns	8
	15:00	sun comes out	Ns	8
	18:00	cloudy	CuAcCi	5
07-20	08:00	cloudy	Sc	7
	15:00	cloudy	Cu	5
07-21	09:00	cloudy	Cu	7
	14:30	shower	Cb,Ns	8

Date	Time of obs.	Weather	Cloud Type	Cloud Fraction
	18:35	shower	Cu	7
07-22	10:00	overcast	Ns	8
	17:00	heavy rain	Ns	8
07-23	10:00	rainy	Ns	8
	15:00	overcast	Ns	8
07-24	10:00	overcast	St	7
07-25	09:00	overcast, foggy	St	8
	15:00	cloudy	St	5
07-26	08:00	cloudy, foggy	Ac	6
	12:40	light rain	Ns	8
07-27	09:00	overcast	Au	7
	15:00	cloudy	N.A.	N.A.
07-28	10:00	sunny	N.A.	N.A.
	15:00	cloudy	N.A.	N.A.
07-29	10:00	overcast	N.A.	N.A.
	15:00	overcast	N.A.	N.A.
07-30	10:00	rain	N.A.	N.A.
	15:00	overcast, foggy	N.A.	N.A.
07-31	10:00	overcast	N.A.	N.A.
	15:00	overcast	N.A.	N.A.
08-01	09:00	overcast	St	8
	14:00	overcast, sun comes out sometimes	St	8
08-02	08:00	heavy rain, windy	Ns	8
	10:00	overcast	St	8
08-03	08:00	overcast	St	8
	15:30	sunny	Ci,Ac	5
08-04	08:00	overcast	St	8
	16:00	cloudy	St	5
	23:00	shower	N.A.	N.A.
08-05	08:00	overcast	St	6
	14:00	overcast	Ac	7
	15:00	sun comes out	AcCi	7
	19:00	shower	Cb	8
	21:40	shower	N.A.	N.A.
08-06	08:00	overcast	Cb	8
	10:30	sun comes out for a while	Cb	8
08-07	08:00	rainy	Cb	8
08-08	08:00	sunny	Cu	1
	10:00	sunny	CuCiAc	3
	12:00	sunny	CuCi	4
	14:00	sunny	CuCi	5
	16:00	sunny	CuCi	6
	18:00	overcast	Cb	8
	18:27	rain starts	N.A.	N.A.
	20:00	rain starts	N.A.	N.A.
08-09	10:00	sunny	Cu	1
	13:00	sunny	Cu	5
	15:00	sunny	CiCu	6
	17:00	sunny	Cu	1
08-10	07:00	foggy	St	8
	09:00	sunny	CuCi	1
	11:00	rainy	Ns	8
08-11	08:00	overcast	St	8
08-13	08:00	rainy	Ns	8
	10:00	sun comes out	Cu	8
	12:00	overcast	Cu	8
	15:00	overcast	CuCi	8
08-14	09:00	overcast	St	8

Date	Time of obs.	Weather	Cloud Type	Cloud Fraction
	12:00	rainy	Ns	8
	13:30	overcast.sun comes out	St	8
	19:00	rainy	Ns	8
08-15	03:00	rainy heavily	N.A.	N.A.
	15:00	cloudy	CuCi	4
08-16	08:00	coudy	CiCc	6
	12:00	overcast	St	8
08-17	08:00	overcast	St	8
	10:00	sun comes out	Ci	1
	12:00	sunny	Cu	1
	14:00	sunny	Cu	1
08-18	08:00	rainy	Ns	8
	10:00	sunny	Ac	1
	12:00	cloudy	AcCu	6
08-19	08:00	overcast	St	8
	14:00	cloudy	Cu	6
08-20	08:00	sunny	Cu	1
	14:00	sunny	Cu	3
08-21	08:00	sunny	Ci	1
	14:00	sunny	CuCi	4
08-22	09:00	overcast	Cu	8
	12:00	cloudy,windy	Cu	5
	16:00	overcast	Cu	7
08-23	08:00	overcast, sometimes lightly rainy	Ac	8
08-24	08:00	overcast	St	8
08-25	08:00	rainy	Ns	8
08-26	08:00	overcast	Cu	8
08-27	08:00	overcast	St	8
	10:00	sun comes out	Cu	6
	16:00	cloudy	CuCi	5
08-28	08:00	overcast	St	8
	14:00	rainy	Ns	8
08-29	09:00	overcast	Ns	8
	10:30	rainy	Ns	8
	11:30	overcast	Ns	8
	14:00	rainy	Ns	8
08-30	14:00	cloudy. sun comes out from time to time	Cu	7
08-31	10:00	cloudy	CiAc	7
	12:00	rainy	St	8
	14:00	overcast	St	8
09-01	08:00	overcast	St	8
	15:00	rainy	Ac	8
09-02	08:00	rainy, typhoon No. 7	Ns	8
	14:00	typhoon is gone. light rain	Ns	8
09-03	09:00	overcast	AcCi	7
	11:00	cloudy	Ac	5
	12:00	overcast	Cu	8
	13:40	rainy	Cs	8
	16:00	sunny	Cu	8
	18:00	cloudy	Cu	7
09-04	08:00	sunny	Cu	7
	10:00	sunny	Cu	7
	12:00	sunny	Cu	6
	14:00	sunny	Cu	3
	16:00	sunny	Cu	4

Date	Time of obs.	Weather	Cloud Type	Cloud Fraction
	18:00	sunny	Cu	4
09-05	08:00	overcast	St	8
	10:00	overcast	St	8
	12:00	overcast	StCu	8
	14:00	overcast	StCu	8
	15:30	thunder	StCu	8
	16:16	rainy	Ns	8
09-06	08:00	rainy	Ns	8
	10:00	rainy	Ns	8
	12:00	rainy	Ns	8
	14:00	overcast	CuCi	7
	16:00	overcast	CuCi	6
09-07	08:00	sunny	Cu	2
	10:00	sunny	Cu	6
	12:00	sunny	Cu	6
	14:00	overcast	Cu	8
	16:00	overcast, light rain	Cu	8
09-08	08:00	cloudy	AcCi	6
	10:00	sunny	As	8
09-09	08:00	overcast, light rain	Ns	8
09-10	08:00	rainy	Ns	8
09-11	08:00	rainy	Ns	8
09-12	08:00	rainy	Ns	8
09-13	08:00	rainy	Ns	8
09-14	08:00	overcast	St	8
	10:00	overcast	St	8
	12:00	overcast	Cu	6
	14:00	overcast	Cu	5
	16:00	overcast	CuAc	5
	18:00	clear	Cu	0
09-15	08:00	clear	0	0
09-16	08:00	clear	0	0
09-17	08:00	overcast	St	8
	12:00	overcast, sun	St	7
	14:00	overcast, sun	St	7
09-18	08:00	overcast	St	8
	12:00	overcast	StCiCs	6
	14:00	cloudy	Ci	4
	16:00	clear	Ci	1
	18:00	clear	Ci	1
09-19	08:00	overcast	St	8
	10:00	overcast	St	8
	12:00	overcast	St	8
	14:00	rainy	Ns	8
	16:00	rainy	Ns	8
	18:00	rainy	Ns	8
09-20	08:00	rainy	Ns	8
09-21	08:00	rainy	Ns	8
09-22	08:00	overcast	St	8
09-23	08:00	overcast	St	8
	10:00	sunny	Cu	6
	12:00	sunny	Cu	5
	14:00	sunny	Cu	4
	16:00	sunny	Cu	3
	18:00	sunny	0	0
09-24	08:00	foggy	St	8
	10:00	sunny	Cu	0
	12:00	sunny	Cu	4
	14:00	sunny	Cu	7
	16:00	sunny	Cu	7
09-25	08:00	foggy	St	8
	10:00	sunny	Cu	3
	12:00	sunny	Cu	4
	14:00	sunny	Cu	6
	16:00	sunny	Cu	7
	18:00	sunny	CuCi	1
09-26	08:00	foggy	St	8
	10:00	sunny	CuCi	4
	12:00	sunny	Cu	6
	14:00	sunny	CuCi	5
	16:00	sunny	Cu	1
09-29	08:00	foggy	St	8
	10:00	foggy	St	8
	12:00	sunny	Ci	0
	14:00	sunny	Ci	1
	16:00	sunny	Ci	1
	18:00	sunny	Ci	0
10-29	08:00	sunny	Cu	0
10-30	08:00	sunny	Cu	0
	14:00	sunny	Cu	5
10-31	08:00	foggy	Cu	0
	10:00	foggy	Cu	0
	11:00	sunny	Cu	0
11-01	08:00	overcast	St	8
11-03	08:00	sunny	Cu	0
11-04	08:00	sunny	Cu	0
11-05	08:00	overcast	St	8

7. Surface Parameters

7.1. Meteorological Characteristics

The meteorological characteristics measured by the weather stations, including the air temperature, humidity, wind speed, wind direction, solar radiation, and precipitation, are shown in Figure 7-1 and Figure 7-2.

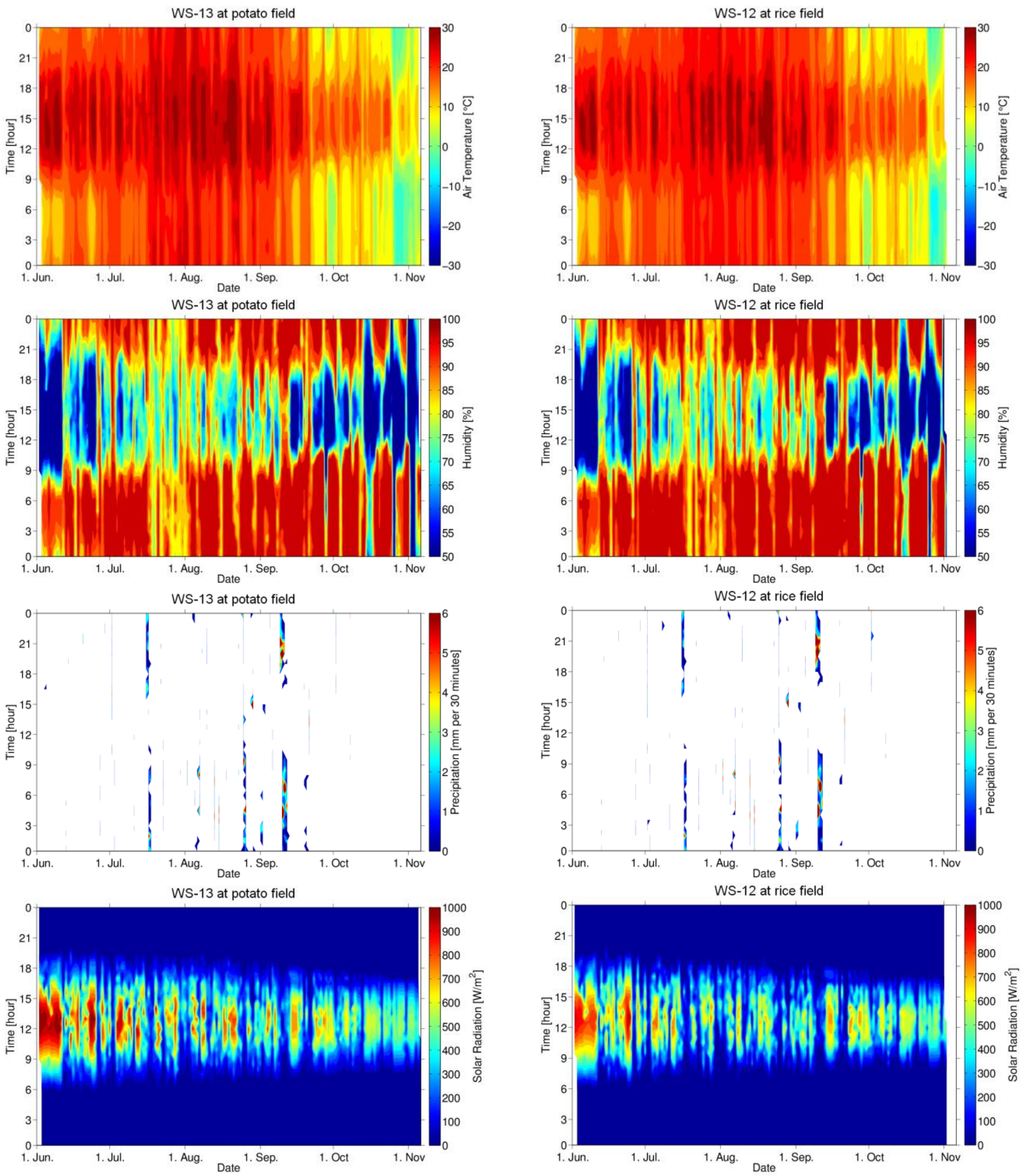

Figure 7-1: Air temperature, relative humidity, precipitation, and solar radiation during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (left: at the potato field; right: at the rice field)

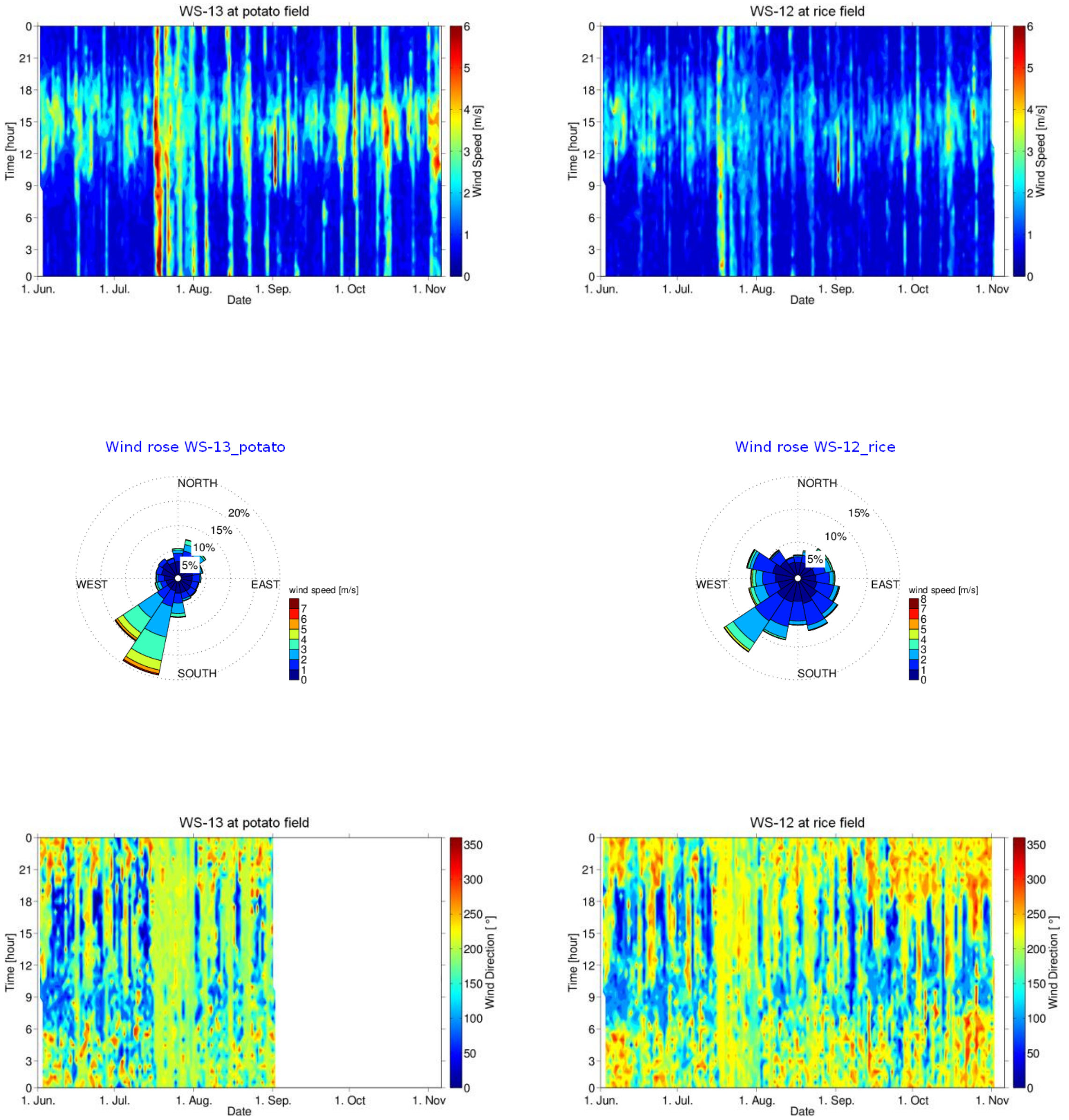

Figure 7-2: Wind speed and direction during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (left: at the potato field; right: at the rice field)

7.2. Land Use

Figure 7-3 shows that the potato field was close to a nearby bean field, and surrounded by some rice fields. Figure 7-4 shows that the rice field is surrounded by the same surface.

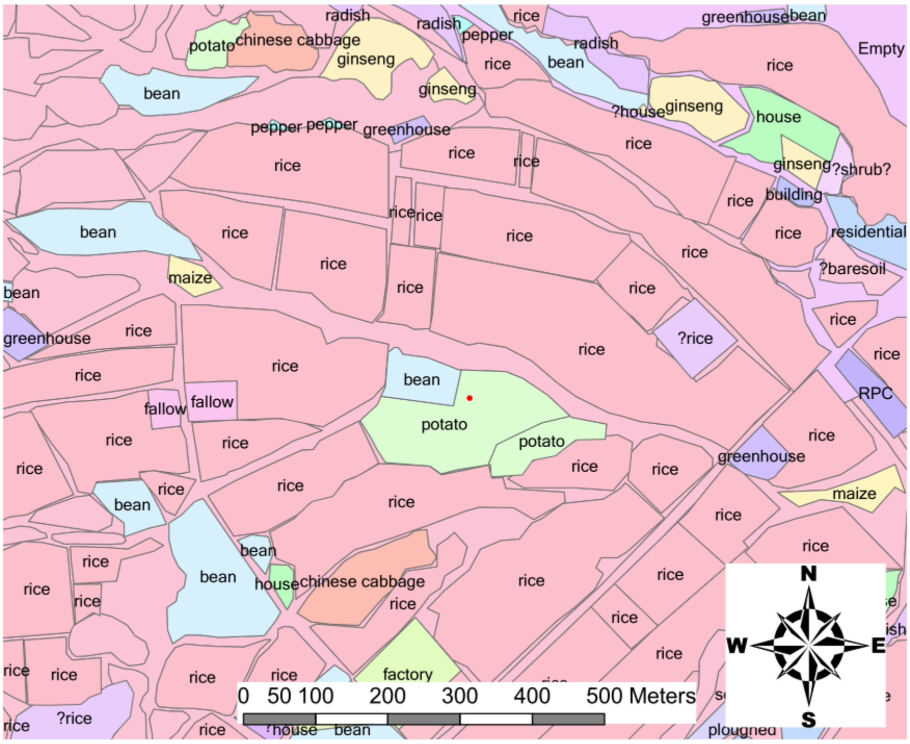

Figure 7-3: Land use surrounding the potato field during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (red dot: the turbulence mast; contributed by Bumsuk Seo; data from Korea government and field survey)

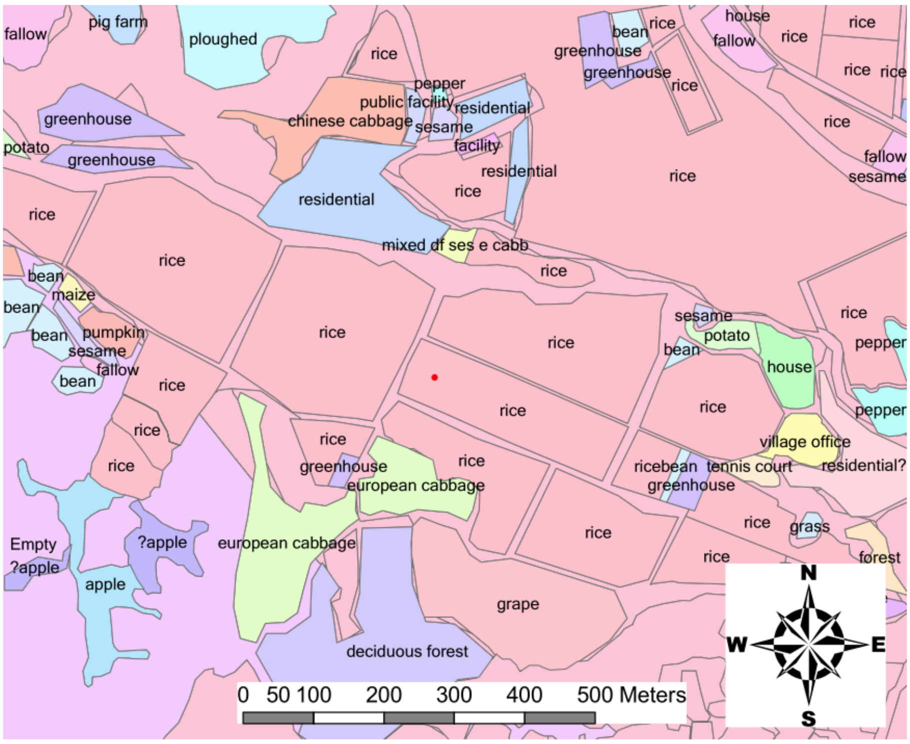

Figure 7-4: Land use surrounding the rice field during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (red dot: the turbulence mast; contributed by Bumsuk Seo; data from Korea government and field survey)

7.3. Topography

Figure 7-5 shows the topographical conditions at both sites. The potato field was flat with a small slope on the east side which was a bean field nearby. The rice field had a slight slope of 3 degree inclined towards the north and northeast.

Figure 7-6 and Figure 7-7 are the photographs taken at both sites.

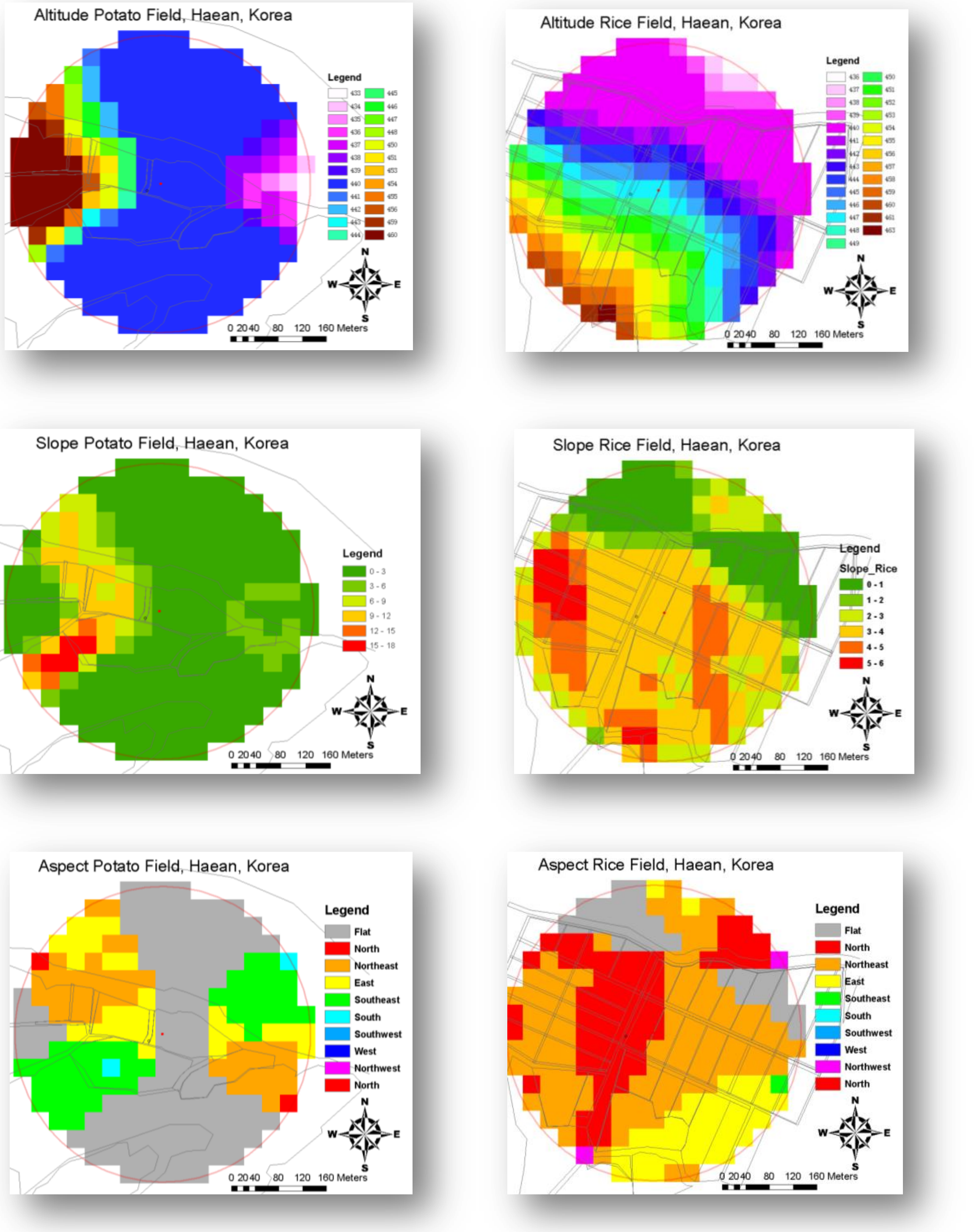

Figure 7-5: Topographical conditions of the field sites during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (red dot at the center: the turbulence mast; left: at the potato field; right: at the rice field; contributed by Bumsuk Seo, modified; data from Korea government and field survey)

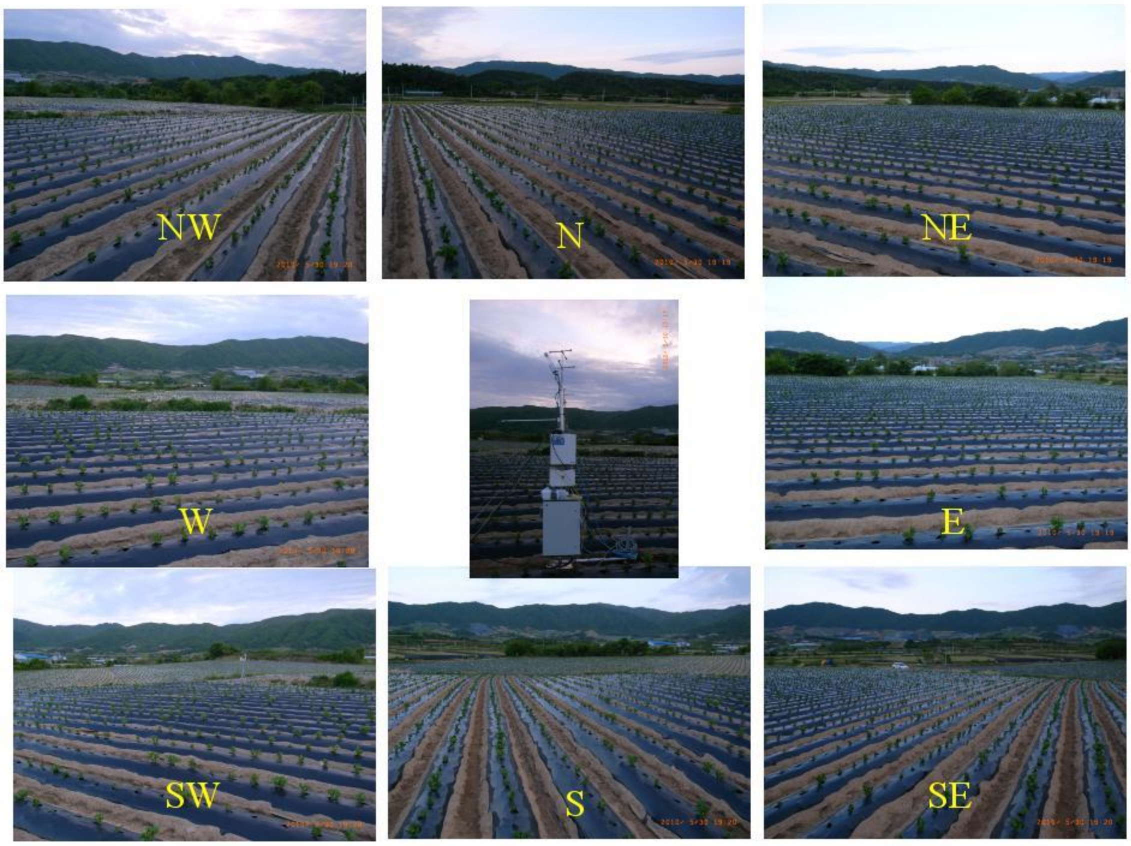

Figure 7-6: Photographs taken at the potato field at the beginning of TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (photographs by Peng Zhao)

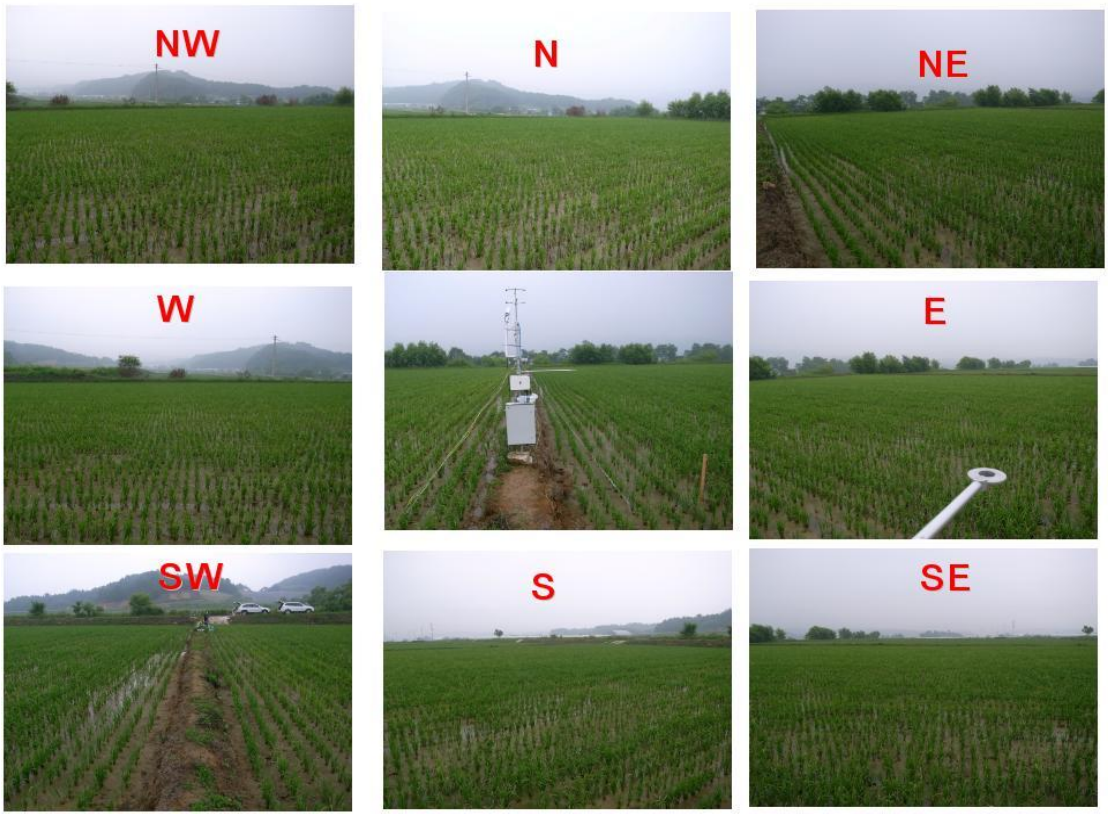

Figure 7-7: Photographs taken at the rice field at the beginning of TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (photographs by Peng Zhao)

7.4. Footprint

The height of an internal boundary layer δ is estimated by the relation with the fetch x (Raabe 1983). The areas which influenced the turbulence measurement are estimated by a footprint modeling package called TERRAFEX(Göckede et al. 2004; Göckede et al. 2006). The results are listed in Table 7-1 and Figure 7-8 to Figure 7-15.

Table 7-1: Fetch x, height of internal boundary layer δ and flux contribution from the target land use type during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

			30 °	60 °	90 °	120 °	150 °	180 °	210 °	240 °	270 °	300 °	330 °	360 °
Potato field		x in m	42	66	102	75	36	23	24	26	18	20	31	40
		δ in m	1.9	2.4	3.0	2.6	1.8	1.4	1.5	1.5	1.3	1.3	1.7	1.9
		Flux contribution form target land use type in %												
	P1	all	81	92	98	100	96	93	93	84	53	47	71	85
		unstable	98	100	100	100	99	99	/	95	86	87	90	100
		neutral	80	91	97	99	96	93	93	84	51	44	69	83
		stable	/	/	/	/	98	/	99	/	90	/	/	/
	P2	all	80	89	97	99	97	95	92	86	56	58	73	78
		unstable	/	100	100	100	100	98	98	94	89	88	97	98
		neutral	80	89	97	99	97	95	92	86	51	56	72	78
		stable	/	99	/	/	/	/	/	95	/	/	/	/
	P3	all	79	88	98	99	97	96	93	83	57	56	73	82
		unstable	/	/	100	100	100	99	98	93	83	86	92	/
		neutral	79	88	98	98	96	95	93	83	56	53	72	82
		stable	/	/	/	/	100	/	/	/	/	/	/	/
	P4	all	35	78	88	90	81	81	84	78	31	14	42	39
		unstable	/	/	/	/	/	/	/	/	/	/	/	/
		neutral	35	78	88	90	81	81	84	78	31	14	42	39
		stable	/	/	/	/	/	/	/	/	/	/	/	/
Rice field		x in m	48	60	41	38	47	43	39	48	40	37	44	52
		δ in m	2.1	2.3	1.9	1.9	2.1	2.0	1.9	2.1	1.9	1.8	2.0	2.2
		Flux contribution form target land use type in %												
	R1	all	71	88	91	88	83	72	77	89	92	89	92	88
		unstable	/	/	/	80	78	73	90	94	95	91	93	/
		neutral	71	88	91	89	84	72	76	89	91	89	92	88
		stable	/	/	/	77	/	73	/	/	/	/	/	/
	R2	all	68	86	87	89	84	70	74	85	90	90	91	88
		unstable	/	/	76	/	78	76	88	96	98	97	/	/
		neutral	68	86	88	89	84	70	74	84	90	90	91	88
		stable	/	/	/	/	/	/	/	/	/	/	/	/
	R3	all	68	83	84	83	82	71	75	89	91	90	94	88
		unstable	65	72	72	74	80	75	86	96	97	96	93	89
		neutral	68	83	85	85	83	71	75	89	90	90	94	88
		stable	/	/	/	/	/	/	/	95	96	/	/	/
	R4	all	74	92	93	92	89	71	79	78	82	82	85	91
		unstable	/	/	/	/	/	/	/	98	98	/	/	/
		neutral	74	92	93	92	89	71	79	78	81	82	85	91
		stable	/	/	/	/	/	/	/	/	/	/	/	/

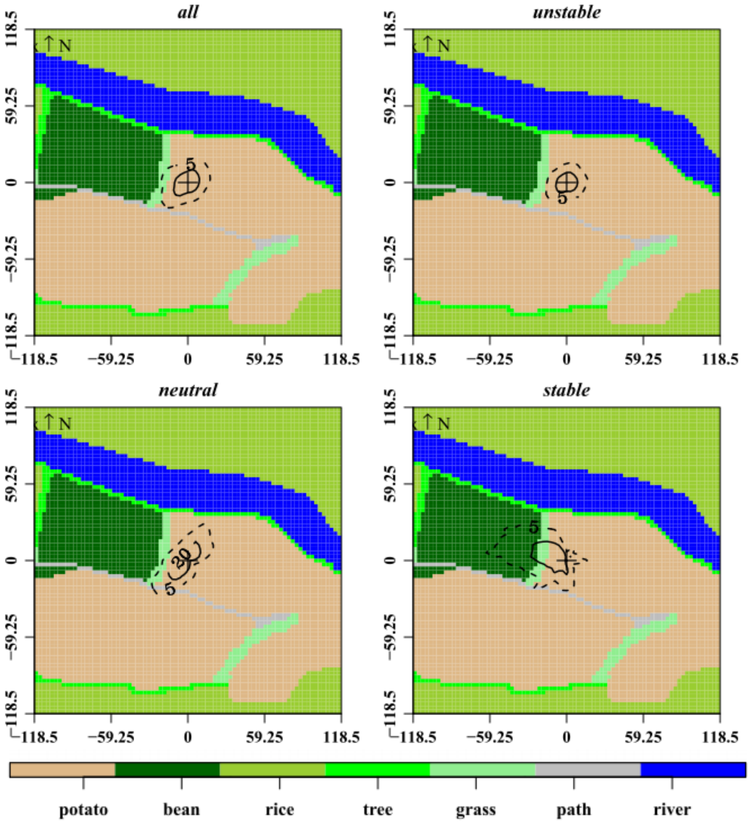

Figure 7-8: Footprint from 2010-06-01 to 2010-06-24 at the potato field during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

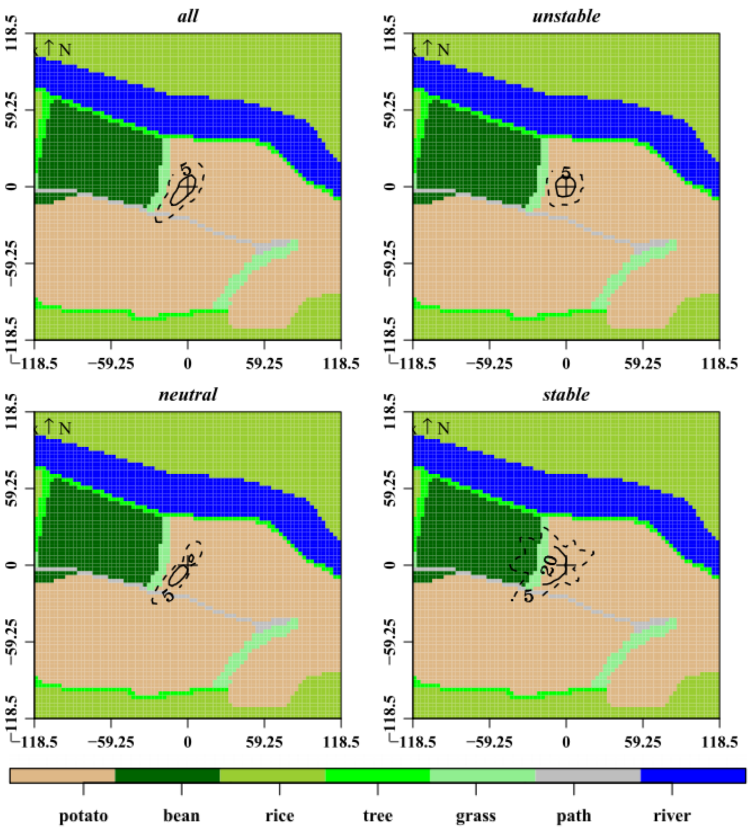

Figure 7-9: Footprint from 2010-07-06 to 2010-07-22 at the potato field during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

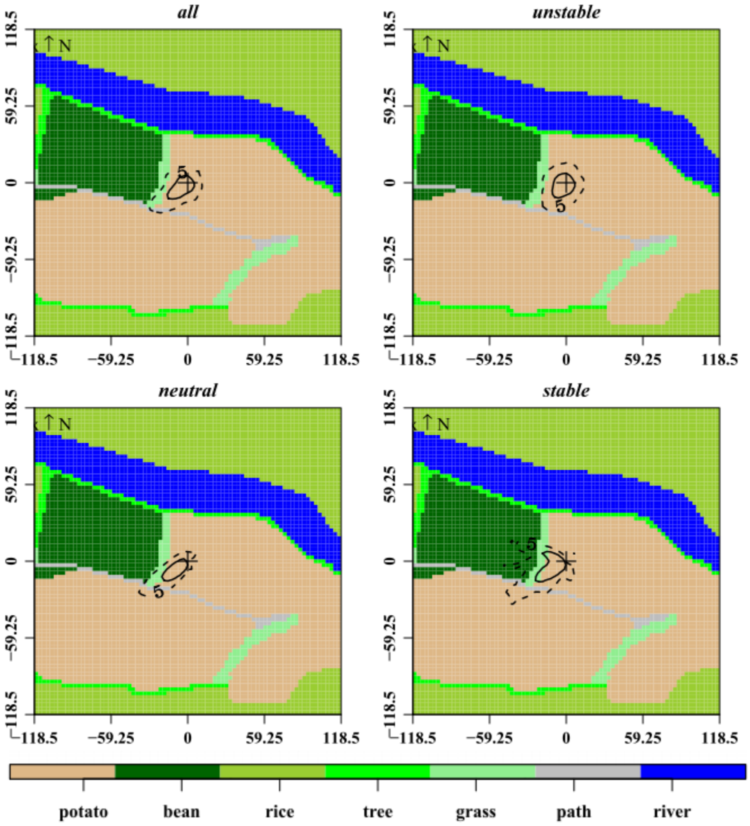

Figure 7-10: Footprint from 2010-08-13 to 2010-08-28 at the potato field during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

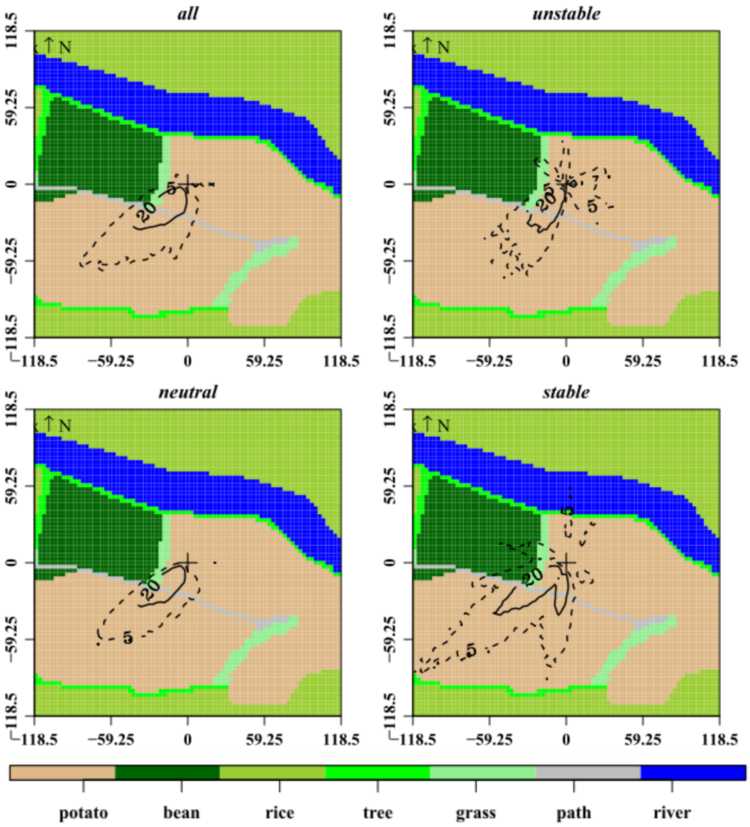

Figure 7-11: Footprint from 2010-11-02 to 2010-11-06 at the potato field during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

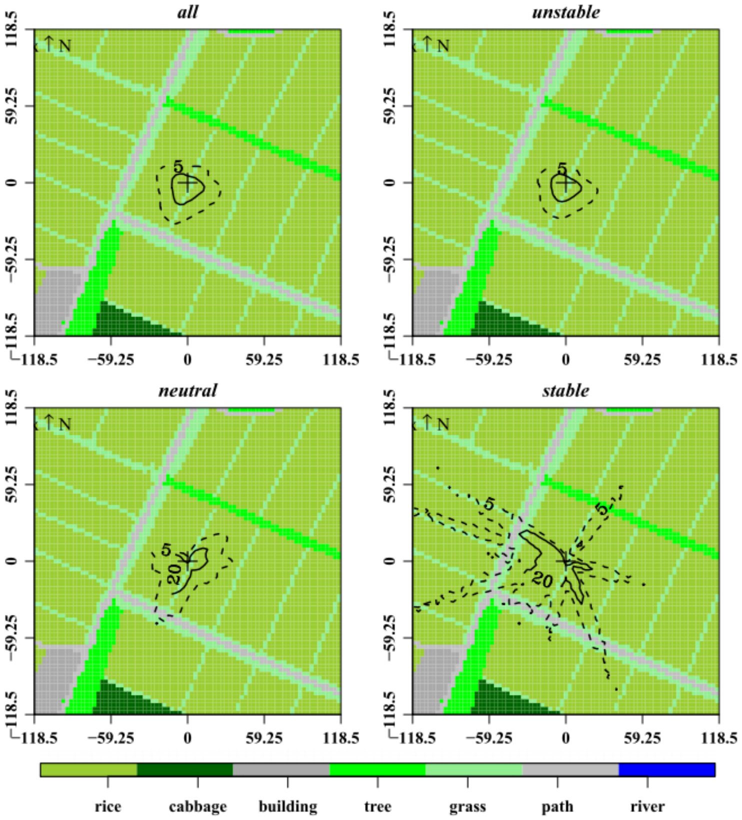

Figure 7-12: Footprint from 2010-06-26 to 2010-07-05 at the rice field during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

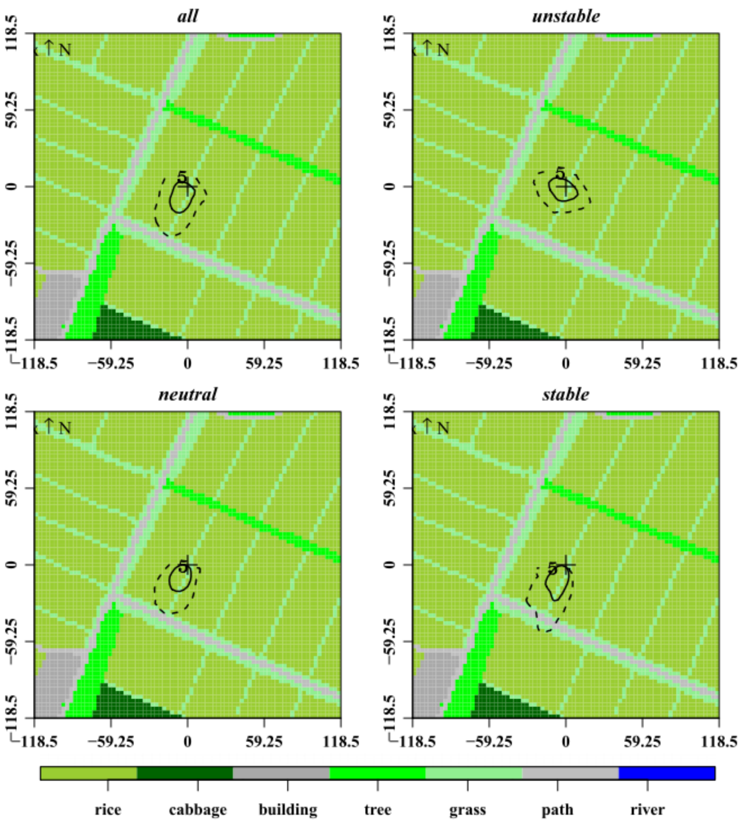

Figure 7-13: Footprint from 2010-07-22 to 2010-08-11 at the rice field during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

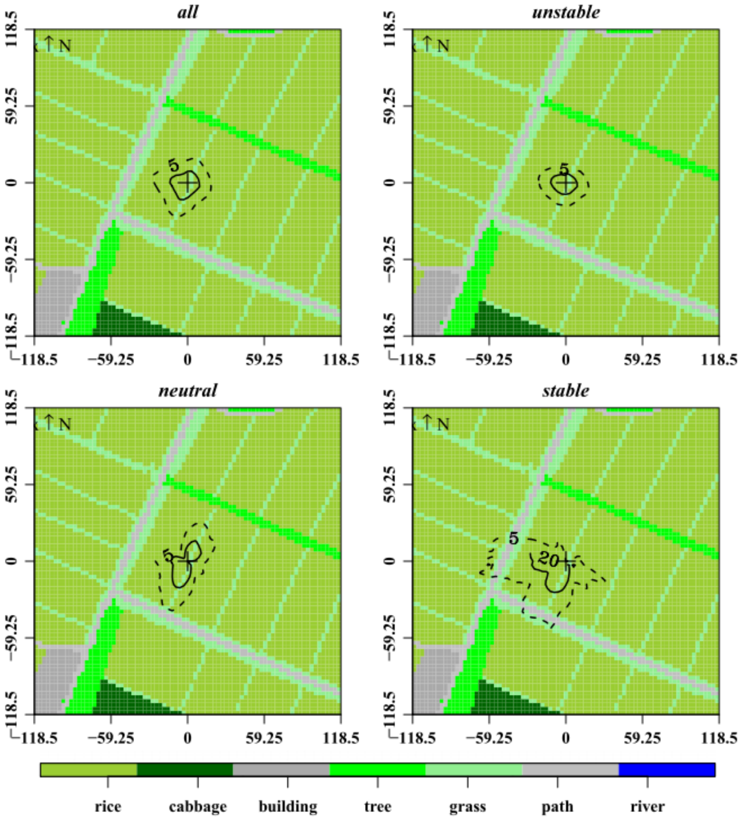

Figure 7-14: Footprint from 2010-08-30 to 2010-10-01 at the rice field during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea

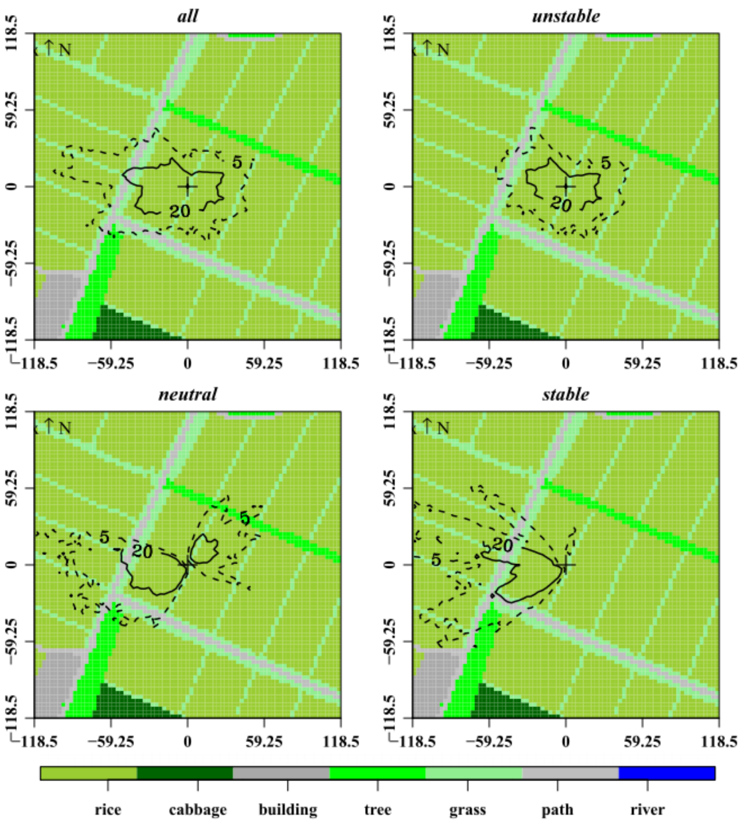

Figure 7-15: Footprint from 2010-10-28 to 2010-11-02 at the rice field during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea Biomass

7.5. Biomass

The biomass density and leaf area index are shown in Figure 7-16.

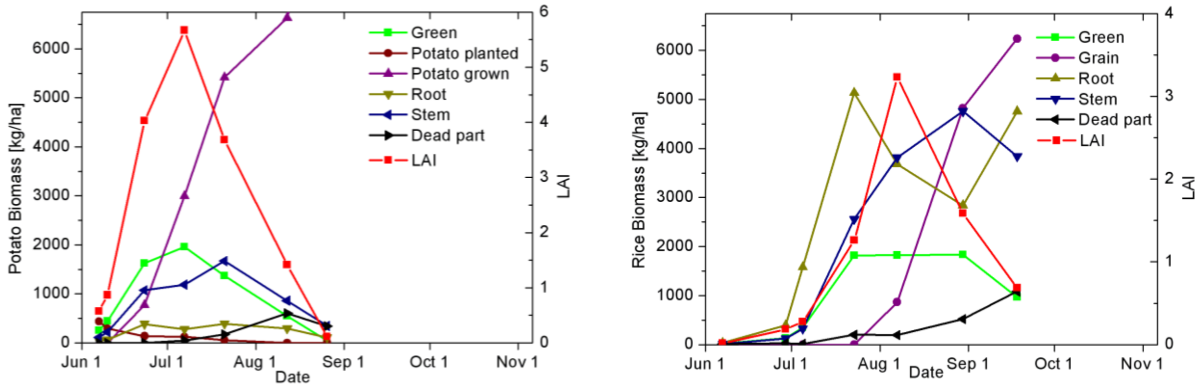

Figure 7-16: Biomass density and leaf area index during TERRECO-WP1-02 campaign in 2010 at Haean, South Korea (left: at the potato field; right: at the rice field)

8. Problems and Solutions

8.1. NR-LITE

Problem description

The analogue output of Net radiometer is obviously wrong at the beginning of the measurement in Korea. METEK receives about 20 mV from the amplifier. It does not change much even when the net radiation changes.

Connection when problem:

e5~~~~~amplifier output (＋)
GND~~~amplifier output (－)
e6~~~~~inclinometer(x) ~~~\
GND~~~inclinometer GND~~\
e7~~~~~inclinometer(y)~~~ ~inclinometer~~~power supply
GND~~~inclinometer GND~~/
e8~~~~~vacant
GND~~~vacant

Tests

#Test 1
e5~~~~~amplifier output (＋)
GND~~~amplifier output (－)
e6~~~~~vacant
GND~~~vacant
e7~~~~~vacant
GND~~~vacant
e8~~~~~vacant
GND~~~vacant

Result: The amplifier works well, alone.

#Test 2
e5~~~~~amplifier output (－)
GND~~~amplifier output (＋)
e6~~~~~inclinometer(x)~~~ ~\
GND~~~inclinometer GND~~~\
e7~~~~~inclinometer(y)~~~~~-inclinometer~~~power supply
GND~~~inclinometer GND~~~/
e8~~~~~vacant
GND~~~vacant

Result: If the connection of the amplifier ＋ and － is exchanged, METEK receives about 7.7 V from the amplifier. It does not change much even when the net radiation changes.

#Test 3
e5~~~~~inclinometer(x)~~~ ~\
GND~~~inclinometer GND~~~\
e6~~~~~inclinometer(y)~~~~-inclinometer~~~power supply
GND~~~inclinometer GND~~~/
e7~~~~~vacant
GND~~~vacant
e8~~~~~amplifier output (＋)
GND~~~amplifier output (－)

Result: The same problem happens.

#Test 4
e5~~~~~amplifier output (＋)
GND~~~amplifier output (－)
e6~~~~~inclinometer(x)~~~~\
GND~~~inclinometer GND~~~\
e7~~~~~inclinometer(y)~~~~-inclinometer~~~no power supply
GND~~~inclinometer GND~~~/
e8~~~~~vacant
GND~~~vacant

Result: The same problem happens. This time power supply for the inclinometer is cut off.

#Test 5
e5~~~~~amplifier output (＋)
GND~~~amplifier output (－)
e6~~~~~inclinometer(x)~~~~~\
GND~×~inclinometer GND~~~\
e7~~~~inclinometer(y)~~~~~~~-inclinometer~~~power supply
GND~×~inclinometer GND~~~/
e8~~~~~vacant
GND~~~vacant

Result: The amplifier works this time without the GND connection of the inclinometer.

#Test 6

Without the amplifier, the NR-LITE and inclinometer work well together. METEK control box works as a logger to receive NR-LITE signals. As the sensitivity of NR-LITE is 15 μV W^{-1} m^{2} and the resolution of METEK control box is 0.1 mV, it is not sensitive enough without the amplifier.

Results

The problem is due to the conflict between the GND cables of inclinometer and the amplifier.

Solution

e5~~~~~amplifier output (＋)
GND~~~amplifier output (－)
e6~~~~~inclinometer(x)~~~~~ ~~~~~~~\
GND~~~switch~~~inclinometer GND~~~\
e7~~~~~inclinometer(y)~~~~~~~~~~~~-inclinometer~~~power supply
GND~~~switch~~~inclinometer GND~~~/
e8~~~~~vacant
GND~~~vacant

During the campaign, a switch was connected between the inclinometer GND wire and METEK. It was normally switched off to output NR-LITE data, and switched on before reading inclinometer data. After reading, switch it off again. Inclinometer data must be read out manually.

After the campaign, a better solution was found. The inclinometer shared the power supply with the fan, and both the inclinometer and NR-LITE amplifier could work (Figure 8-1).

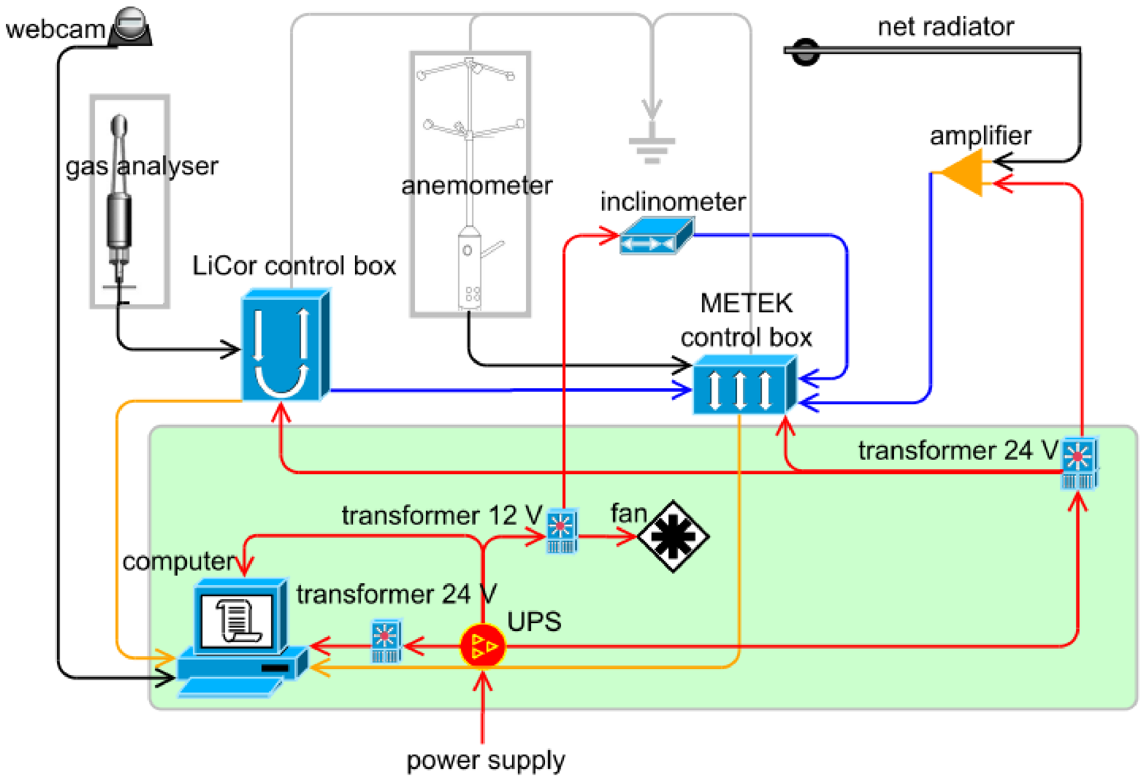

Figure 8-1: Schematic diagram of modified device connection (red lines: power cables; black lines: original signal cables from the sensors; blue lines: analogue signal cables; orange lines: RS-232 signal cables)

8.2. TK2

Problem description

A problem of TK2 was found when processing data. As TK2 does not support the format of the raw data (no such option in the parameter file), a Matlab script converts the raw data to a supported format. It worked well during the test without the inclinometer and NR-LITE. Then the Matlab script was modified for the format including inclinometer and NR-LITE data. The results look no problem, but TK2 does not work well until NR-LITE data column is deleted from the input files. It is strange because NR-LITE data is just like 20.3 W m^{-2} or something like that. Maybe it is a software bug.

Tests

#Test 1

At the beginning, the raw data was converted by the modified Matlab script, and in TK2 parameter file it is set what each column is. When TK2 was running, a command window with "reading ASCII data..." popped out and then disappeared immediately.

Result: wind data ＋ CO_2/H_2O data ＋ Radiation data ＋ inclinometer data (different column widths): Not working.

#Test 2

As it could be caused by the widths of some columns which were different from the required format, each column was converted to the same width. TK2 can read the data, but cannot find the time stamps. It reads all the input files one by one, and then it continues to search the next file for the given beginning time in the parameter file. All the input files are marked as invalid data with "Wrong number of fields".

Result: wind data + CO_2/H_2O data + Radiation data + inclinometer data (same column widths): Not working.

#Test 3

Then the Matlab script was modified again to convert the raw data to exactly the same as before, i.e. no inclinometer or net radiation data in the input files for TK2. This time TK2 worked well.

Result: wind data + CO_2/H_2O data (same column widths): Working.

#Test 4

In the end, based on Test 3, inclinometer data were added to the input files. TK2 works well, too.

Result: wind data + CO_2/H_2O data + inclinometer data (same column widths): Working.

Results

2 problems: TK2 cannot see the data format in Test 1, and cannot see the time stamp in Test 2.

Solution

Delete the NR-LITE data column and then TK2 works. Further study on TK2 is expected.

9. References

Göckede, M. et al., 2006. Update of a Footprint-Based Approach for the Characterisation of Complex Measurement Sites. *Boundary-Layer Meteorology*, 118, pp.635-655.

Göckede, M., Rebmann, C. & Foken, T., 2004. A combination of quality assessment tools for eddy covariance measurements with footprint modelling for the characterisation of complex sites. *Agricultural and Forest Meteorology*, 127(3-4), pp.175-188.

Mauder, M., Foken, T. 2004: Documentation an instructual manual of the Eddy Covariance Software Package, *Arbeitsergebnisse* 26. ISSN 1614-8916

Raabe, A., 1983. On the relation between the drag coefficient and fetch above the sea in the case of off-shore wind in the near-shore zone. *Zeitschrift für Meteorologie*, 33(6), pp.363-367.

Campbell Scientific, Inc.. NR-LITE Net Radiometer Instruction manual

Delta-T Devices Ltd.. WS-GP1 Weather Station Quick Start Guide (Version 1.0)

Measurement Specialties, Inc.. AccuStar ® II/DAS-20 Dual Axis Clinometer Description

Meteorologische Messtechnik GmbH . USA-1 User Manual, sc 03/2006 Version 4.xx/4.xxt.

LI-COR, Inc.. LI-7500 CO_2/H_2O Analyzer Instruction Manual

http://www.bayceer.uni-bayreuth.de/terreco/

http://www.bayceer.uni-bayreuth.de/mm/

http://web.kma.go.kr/eng/weather/images/satellite.jsp

http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp

Work report list

Volumes in the series ‚University of Bayreuth, Department of Micrometeorology

Nr	Author(s)	Title	Year
01	Foken	Der Bayreuther Turbulenzknecht	01/1999
02	Foken	Methode zur Bestimmung der trockenen Deposition von Bor	02/1999
03	Liu	Error analysis of the modified Bowen ratio method	02/1999
04	Foken et al.	Nachfrostgefährdung des ÖBG	03/1999
05	Hierteis	Dokumentation des Experimentes Dlouhá Louka	03/1999
06	Mangold	Dokumentation des Experimentes am Standort Weidenbrunnen, Juli/August 1998	07/1999
07	Heinz et al.	Strukturanalyse der atmosphärischen Turbulenz mittels Wavelet-Verfahren zur Bestimmung von Austauschprozessen über dem antarktischen Schelfeis	07/1999
08	Foken	Comparison of the sonic anemometer Young Model 81000 during VOITEX-99	10/1999
09	Foken et al.	Lufthygienisch-bioklimatische Kennzeichnung des oberen Egertales, Zwischenbericht 1999	11/1999
10	Sodemann	Stationsdatenbank zum BStMLU-Projekt Lufthygienisch-bioklimatische Kennzeichnung des oberen Egertales	03/2000
11	Neuner	Dokumentation zur Erstellung der meteorologischen Eingabedaten für das Modell BEKLIMA	10/2000
12	Foken et al.	Dokumentation des Experimentes VOITEX-99	10/2000
13	Bruckmeier et al.	Documentation of the experiment EBEX-2000, July 20 to August 24, 2000	01/2001
14	Foken et al.	Lufthygienisch-bioklimatische Kennzeichnung des oberen Egertales	02/2001
15	Göckede	Die Verwendung des Footprint-Modells nach Schmid (1997) zur stabilitätsabhängigen Bestimmung der Rauhigkeitslänge	03/2001
16	Neuner	Berechnung der Evaporation im ÖBG (Universität Bayreuth) mit dem SVAT-Modell BEKLIMA	05/2001
17	Sodemann	Dokumentation der Software zur Bearbeitung der FINTUREX-Daten	08/2002
18	Göckede et al.	Dokumentation des Experiments STINHO-1	08/2002
19	Göckede et al.	Dokumentation des Experiments STINHO-2	12/2002
20	Göckede et al	Characterisation of a complex measuring site for flux measurements	12/2002
21	Liebethal	Strahlungsmessgerätevergleich während des Experiments STINHO-1	01/2003
22	Mauder et al.	Dokumentation des Experiments EVA_GRIPS	03/2003
23	Mauder et al.	Dokumentation des Experimentes LITFASS-2003, Dokumentation des Experimentes GRASATEM-2003	12/2003
24	Thomas et al.	Documentation of the WALDATEM-2003 Experiment	05/2004
25	Göckede et al.	Qualitätsbegutachtung komplexer mikrometeorologischer Messstationen im Rahmen des VERTIKO-Projekts	11/2004
26	Mauder & Foken	Documentation and instruction manual of the eddy covariance software package TK2	12/2004
27	Herold et al.	The OP-2 open path infrared gas analyser for $CO_2$and H_2O	01/2005
28	Ruppert	ATEM software for atmospheric turbulent exchange measurements using eddy covariance and relaxed eddy accumulation systems and Bayreuth whole-air REA system setup	04/2005
29	Foken (Ed.)	Klimatologische und mikrometeorologische Forschungen im Rahmen des Bayreuther Institutes für Terrestrische Ökosystemforschung (BITÖK), 1989-2004	06/2005
30	Siebeke & Serafimovich	Ultraschallanemometer-Überprüfung im Windkanal der TU Dresden 2007	04/2007
31	Lüers & Bareiss	The Arctic Turbulence Experiment 2006 PART 1: Technical documentation of the ARCTEX 2006 campaign, May, 2nd to May, 20th 2006	07/2007
32	Lüers & Bareiss	The Arctic Turbulence Experiment 2006 PART 2: Visualization of near surface measurements during the ARCTEX 2006 campaign, May, 2nd to May, 20th 2006	07/2007
33	Bareiss & Lüers	The Arctic Turbulence Experiment 2006 PART 3: Aerological measurements during the ARCTEX 2006 campaign, May, 2nd to May, 20th 2006	07/2007

34	Metzger & Foken et al.	COPS experiment, Convective and orographically induced precipitation study, 01 June 2007 – 31 August 2007, Documentation	09/2007
35	Staudt & Foken	Documentation of reference data for the experimental areas of the Bayreuth Centre for Ecology and Environmental Research (BayCEER) at the Waldstein site	11/2007
36	Serafimovich et al.	ExchanGE processes in mountainous Regions (EGER) - Documentation of the Intensive Observation Period (IOP1), September, 6th to October, 7th 2007	01/2008
37	Serafimovich et al.	ExchanGE processes in mountainous Regions (EGER) - Documentation of the Intensive Observation Period (IOP2), June, 1st to July, 15th 2008	10/2008
38	Siebicke	Footprint synthesis for the FLUXNET site Waldstein/Weidenbrunnen (DE-Bay) during the EGER experiment.	12/2008
39	Lüers & Foken	Jahresbericht 2008 zum Förderprojekt 01879 - Untersuchung der Veränderung der Konzentration von Luftbeimengungen und Treibhausgasen im hohen Fichtelgebirge 2007 – 2013	01/2009
40	Lüers & Foken (Eds.)	Proceedings of the International Conference of "Atmospheric Transport and Chemistry in Forest Ecosystems" Castle of Thurnau, Germany, Oct 5 to Oct 8, 2009	10/2009
41	Biermann et al.	Mesoscale circulations and energy and gas exchange over the Tibetan Plateau – Documentation of the micrometeorological experiment, Nam Tso, Tibet , 25 June 2009 – 08 August 2009	12/2009
42	Foken & Falke	Documentation and Instruction Manual for the Krypton Hygrometer Calibration Instrument	01/2010
43	Lüers & Foken	Jahresbericht 2009 zum Förderprojekt 01879 - Untersuchung der Veränderung der Konzentration von Luftbeimengungen und Treibhausgasen im hohen Fichtelgebirge 2007 – 2013	07/2010
44	Biermann & Leipold (Ed.)	Tibet Plateau Atmosphere-Ecology-Glaciology Cluster Joint *Kobresia* Ecosystem Experiment: Documentation of the first Intensive Observation Period (IOP 1) summer 2010 in Kema, Tibet	01/2011
45	Zhao et al.	Complex TERRain and ECOlogical Heterogeneity (TERRECO) WP 1-02: Spatial assessment of atmosphere-ecosystem exchanges via micrometeorological measurements, footprint modeling and mesoscale simulations - Documentation of the Observation Period, May 12th to Nov. 8th, 2010, Haean, South Korea	03/2011