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**First Data Document**

**Action B.3 – Summary report of LAI data**

Reporting Date

**25/09/2014**

LIFE+ PROJECT NAME or Acronym

**Climate change indicators and vulnerability of boreal zone  
applying innovative observation and modelling techniques**

Data Project

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Data Beneficiary

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**List of abbreviations**

FMI-ARC	Arctic Research Station of Finnish Meteorological Institute in Sodankylä
LAI	Leaf Area Index
NorSEN	Nordkalotten Satellite Evaluation co-operation Network
SAF	Satellite Application Facility, project type of EUMETSAT
SNORTEX	Snow Reflectance Transition Experiment

## Summary

This report describes the leaf area index (LAI) data sets gathered in the region around the surroundings of the Arctic Research Centre of FMI at Sodankylä in 2007 - 2010.

The ground based results are listed in tables of the Appendix. Every LAI value is provided the latitude and longitude co-ordinates. The dates and UTC times of the measurements are given as well. Some of the measurements include information about the dominant species.

The airborne data constitutes a vast data set, so that it is not possible to include the individual LAI values in this report. Therefore a table and a set of figures are presented to give the basic characteristics of the airborne LAI data sets.

## Introduction

The leaf area index (LAI) data sets reported in this document were measured in Sodankylä region during the NorSEN (Nordkalotten Satellite Evaluation co-operation Network) campaign in 2007 and during the SNORTEX (Snow Reflectance Transition Experiment) campaign in 2008-2010 (Manninen and Roujean, 2014). During the SNORTEX campaign the ground based LAI values were measured both in summer and winter conditions, during the NorSEN campaign only in summer conditions. Airborne measurements were carried out in winter/spring conditions during the SNORTEX campaign 2008 – 2010. Use of the data described in this document is free on the condition that reference is made to the following publications:

Manninen, Terhikki, Lauri Korhonen, Pekka Voipio, Panu Lahtinen and Pauline Stenberg, 2009, "Leaf Area Index (LAI) Estimation of Boreal Forest Using Wide Optics Airborne Winter Photos", *Remote Sensing*, 2009, 1(4), 1380-1394.

Manninen, Terhikki, Lauri Korhonen, Pekka Voipio, Panu Lahtinen and Pauline Stenberg, 2011, "Airborne estimation of boreal forest LAI in winter conditions: A test using summer and winter ground truth", *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 50, No.1, pp-68-74, 10.1109/TGRS.2011.2173939.

Manninen, T., and J.-L. Roujean (Eds.) (2014), SNORTEX field campaigns 2008–2010, Finnish Meteorological Institute Reports 2014(7), in press.

## 1 Description of LAI measurements

### 1.1 Ground based measurements

During the NorSEN field campaign in July- September 2007 LAI measurements were carried out using LAI2000 instrument or hemispherical photos. The images were analysed in University of Eastern Finland by Lauri Korhonen. During the SNORTEX campaign LAI measurements were based solely on hemispherical photos. In 2008 a larger set of LAI data was gathered in August - September and in winter during the campaign 8 test sites matching airborne vertical profiling sites were measured. In 2009 hemispherical photos were taken in individual locations, mostly at the meteorological mast of FMI-ARC. In 2010 hemispherical photos were taken in 40 points and marked with black crosses, so that the airborne and ground based LAI measurements could be co-located with high accuracy. Results are described in Manninen et al. 2009 and Manninen et al. 2011.

### 1.2 Airborne measurements

A normal Canon pocket camera with wide optics was attached to the helicopter looking orthogonally downwards (Manninen et al., 2009; Manninen et al., 2011, Manninen and Roujean 2014). The images were taken every 3 seconds and the GPS coordinates (latitude, longitude and height from sea level) and time were registered for each image frame. In 2009 and 2010 there was an additional pressure gauge for altitude registration, as the vertical coordinate of GPS is not so accurate. The images were stored directly to a laptop used for operating the camera. The camera was on during most flights, but specific vertical LAI profiles were measured in March 13, 2009 and in March 19, 2010. The main facts concerning the airborne LAI data are listed in Table 1. The number of individual LAI values is so large, that it is not possible to list them in the Appendix like the ground based measurements. To

give and idea about the LAI variation its value is plotted for each flight as a continuous curve (Figure 1, Figure 3, Figure 5). In addition, the spatial LAI variation is demonstrated by plotting the LAI values as points in the co-ordinates so, that the size of the point is related to the LAI value (Figure 2, Figure 4, Figure 6).

Table 1. The airborne LAI data gathered is stored in the following files.

File name	Date	Latitude range	Longitude range	Altitude range (m)	Number of points
SNORTEX_20080330_20080402	March 30, 2008 April 2, 2008	67.27 – 67.93	24.91 – 26.72	160 - 400	43 + 203
SNORTEX_20080403_20080407	April 3, 2008 April 7, 2008	67.36 – 67.93	26.58 27.11	130 - 1200	5058 + 3088
SNORTEX_20090313	March 13, 2009	67.26 – 67.86	26.23 – 27.28	200 - 500	2471
SNORTEX_20090317	March 17, 2009	67.33 – 67.46	26.61 – 26.94	180 - 540	1222
SNORTEX_20090422	April 22, 2009	67.34 – 67.45	26.62 – 26.80	260 - 1100	1306
SNORTEX_20090424	April 24, 2009	67.35 – 67.44	26.61 – 26.72	190 - 1090	469
SNORTEX_10200318	March 18, 2010	67.33 – 67.43	26.60 – 26.86	280 - 820	884
SNORTEX_10200319	March 19, 2010	67.34 – 67.44	26.61 – 26.79	140 - 810	1084

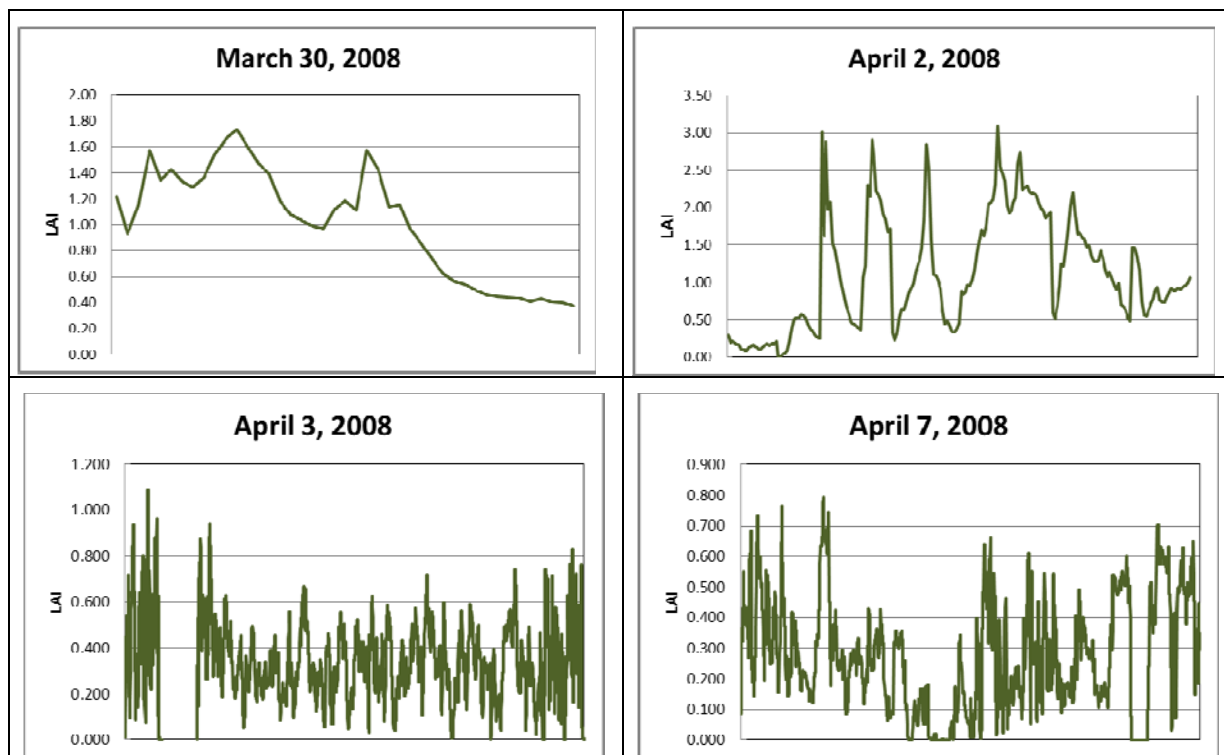


Figure 1. LAI value variation in various flights during the SNORTEX campaign in 2008. The horizontal axes are not to scale.

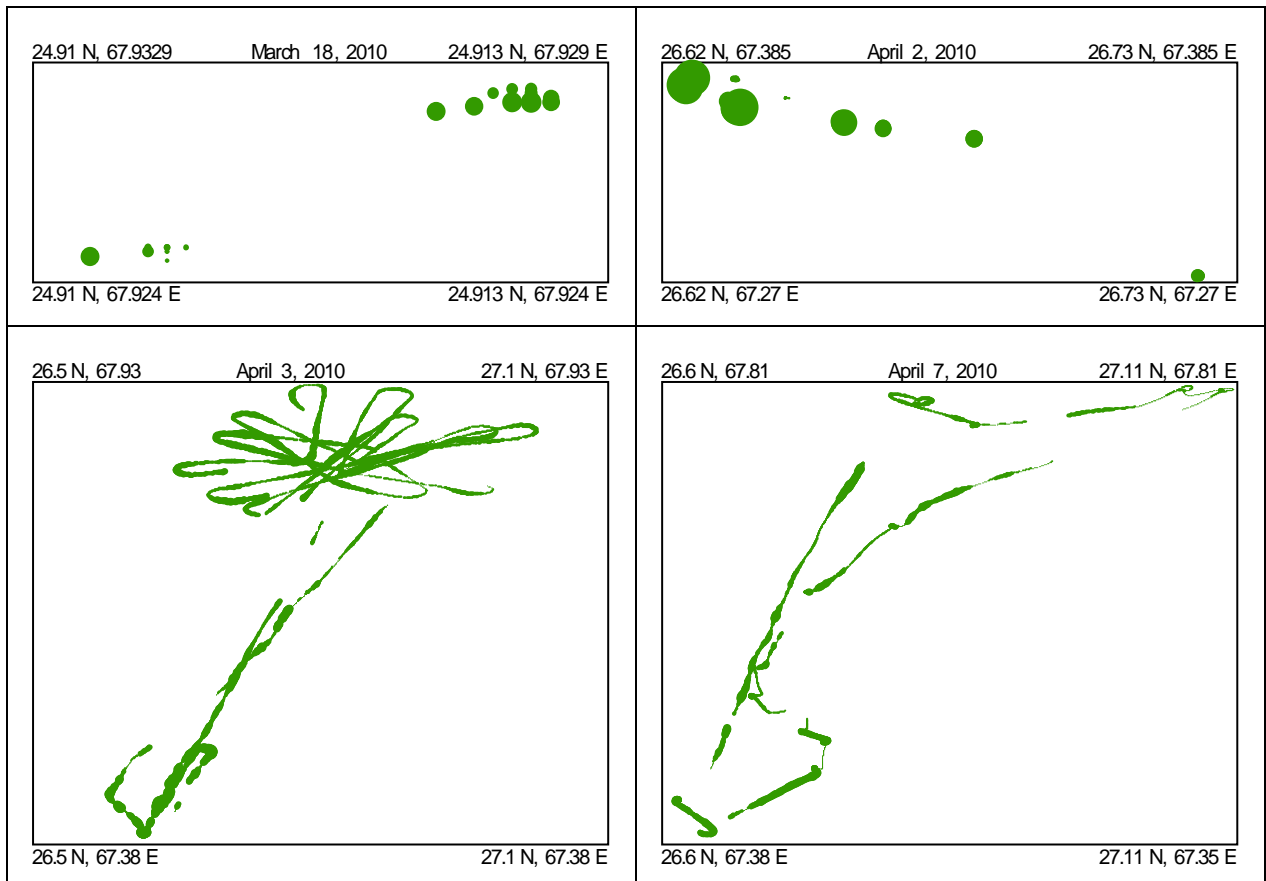


Figure 2. LAI value variation along the flight routes during the SNORTEX campaign in 2008. The coordinates of the corners are given. The diameters of the points are related to the LAI values, but the scale varies from image to image.

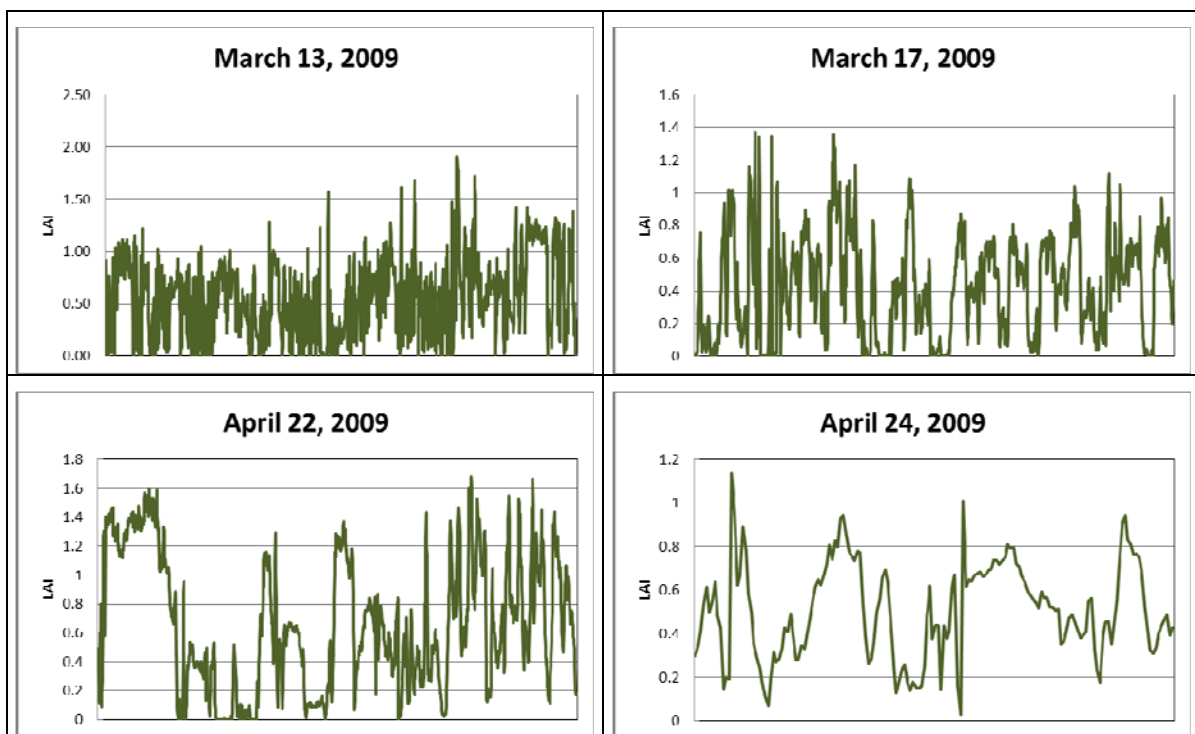


Figure 3. LAI value variation in various flights during the SNORTEX campaign in 2009. The horizontal axes are not to scale.

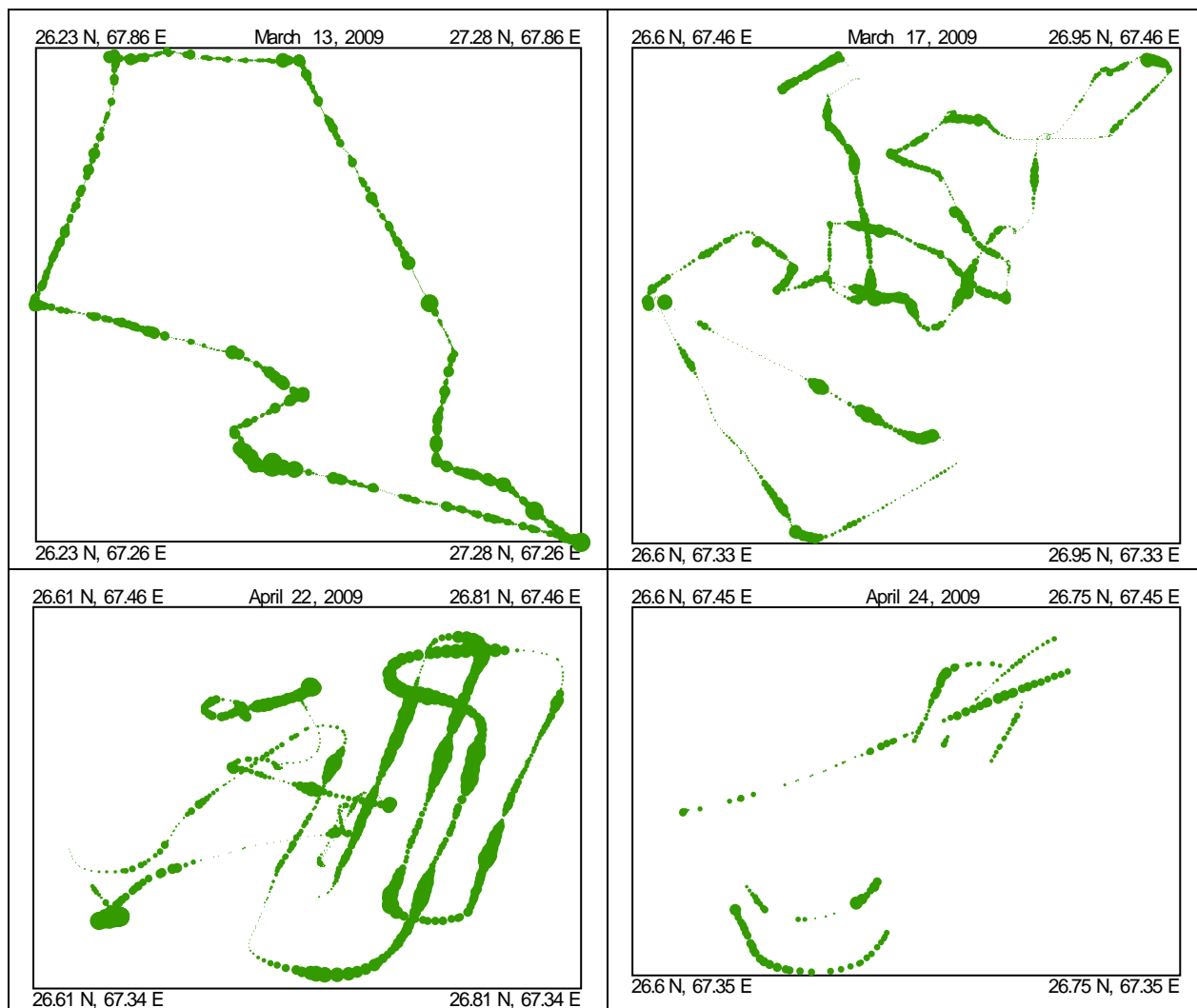


Figure 4. LAI value variation along the flight routes during the SNORTEX campaign in 2009. The coordinates of the corners are given. The diameters of the points are related to the LAI values, but the scale varies from image to image.

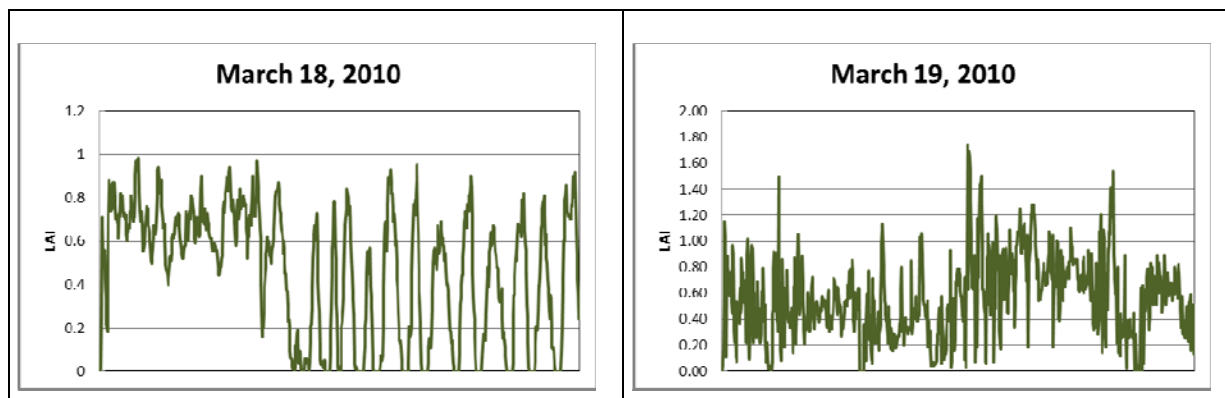


Figure 5. LAI value variation in various flights during the SNORTEX campaign in 2010. The horizontal axes are not to scale.

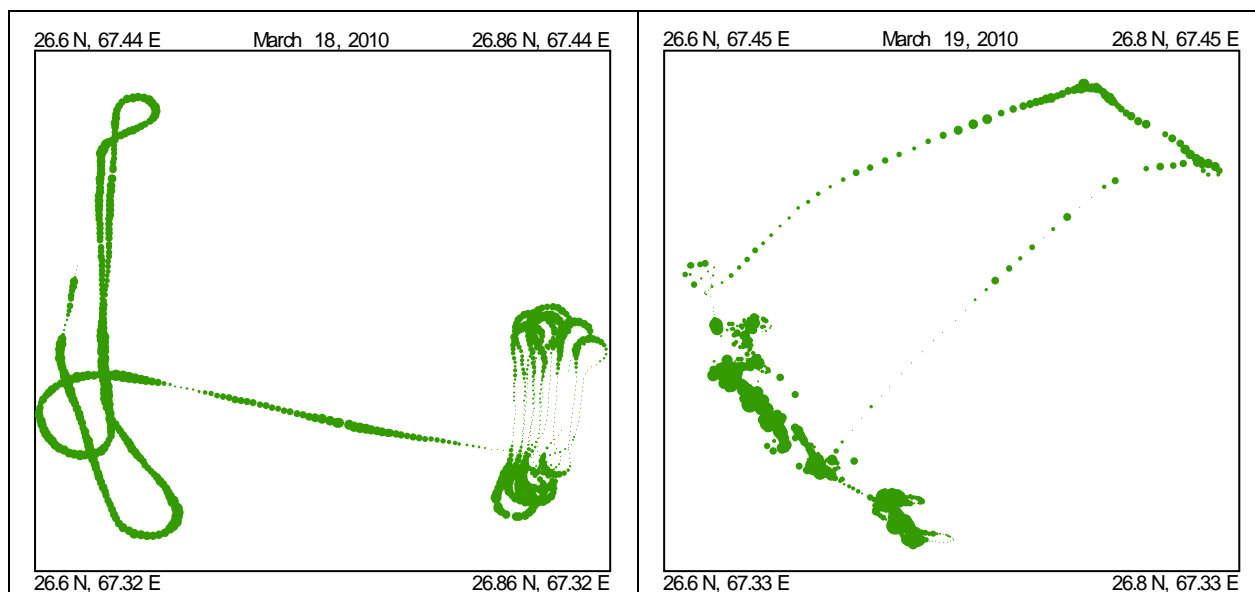


Figure 6. LAI value variation along the flight routes during the SNORTEX campaign in 2010. The coordinates of the corners are given. The diameters of the points are related to the LAI values.

## 2 References

Manninen, Terhikki, Lauri Korhonen, Pekka Voipio, Panu Lahtinen and Pauline Stenberg, 2009, "Leaf Area Index (LAI) Estimation of Boreal Forest Using Wide Optics Airborne Winter Photos", *Remote Sensing*, 2009, *1*(4), 1380-1394.

Manninen, Terhikki, Lauri Korhonen, Pekka Voipio, Panu Lahtinen and Pauline Stenberg, 2011, "Airborne estimation of boreal forest LAI in winter conditions: A test using summer and winter ground truth", *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 50, No.1, pp- 68-74, 10.1109/TGRS.2011.2173939.

Manninen, Terhikki, Lauri Korhonen, Aku Riihelä, Panu Lahtinen, Pauline Stenberg, Jean-Louis Roujean and Olivier Hautecoeur, 2012, Boreal forest albedo and LAI in SNORTEX 2008-2010, *Proc. of IGARSS'12*, 978-1-4673-1159-5/12, pp. 3335 – 3338.

Manninen, T., and J.-L. Roujean (Eds.) (2014), SNORTEX field campaigns 2008–2010, *Finnish Meteorological Institute Reports 2014*(7), in press.



**Appendix: Ground based LAI measurements in Sodankylä region**

July 23 – September 13, 2007

<b>Plot</b>	<b>Date</b>	<b>LAI_method</b>	<b>Dominant species</b>	<b>kkjN</b>	<b>kkjE</b>	<b>LAI</b>
153	23.7.	LAI-2000	Scots pine	7476079.459	3483992.1	0.21
154	23.7.	LAI-2000	Scots pine	7475876.253	3484225.8	1.13
155	23.7.	LAI-2000	Scots pine	7475788.451	3484254.3	1.78
156	23.7.	LAI-2000	Scots pine	7475623.511	3484269.9	1.62
157	23.7.	LAI-2000	Scots pine	7475466.596	3484385.6	0.95
158	23.7.	LAI-2000	Scots pine	7475508.0	3484441.9	1.49
159	23.7.	LAI-2000	Scots pine	7476207.496	3484028.7	1.26
160	31.7.	LAI-2000	Scots pine	7476675.588	3484397.6	1.08
161	31.7.	Hemi-images	Scots pine	7476685.851	3484463.2	0.00
162	23.7.	LAI-2000	Scots pine	7475632.0	3484039.1	1.13
163	31.7.	LAI-2000	Scots pine	7476813.0	3484356.2	1.24
164	31.7.	LAI-2000	Scots pine	7477135.737	3484266.2	1.00
165	31.7.	Hemi-images	Scots pine	7477209.459	3484165.2	0.05
166	31.7.	LAI-2000	Scots pine	7477710.86	3484397.0	0.37
167	31.7.	LAI-2000	Scots pine	7477719.637	3484324.6	1.31
168	31.7.	LAI-2000	Scots pine	7477225.059	3484276.2	0.30
169	23.7.	LAI-2000	Scots pine	7476254.32	3483915.8	1.13
170	31.7.	LAI-2000	Scots pine	7477886.215	3483419.8	0.35
171	23.7.	LAI-2000	Scots pine	7475002.693	3484588.3	1.43
172	23.7.	LAI-2000	Scots pine	7475064.921	3484544.7	0.37
173	9.9.	Hemi-images	Scots pine	7473810.794	3485406.4	0.74
174	9.9.	Hemi-images	Scots pine	7473958.423	3485537.4	0.32
175	9.9.	Hemi-images	Scots pine	7474491.716	3484740.5	1.12
176	4.8.	LAI-2000	Scots pine	7474845.0	3484443.6	0.78
177	4.8.	LAI-2000	Scots pine	7474873.9	3484463.6	1.43
178	6.9.	Hemi-images	Scots pine	7467720.941	3488732.0	1.63
179	6.9.	Hemi-images	Scots pine	7467394.787	3488720.1	1.91
180	6.9.	Hemi-images	Scots pine	7466340.286	3489167.7	0.00
181	6.8.	Hemi-images	Scots pine	7468157.355	3488082.7	0.79
182	3.9.	Hemi-images	Scots pine	7486493.119	3473350.7	0.37
183	3.9.	Hemi-images	Scots pine	7486878.231	3472335.3	0.91
184	3.9.	Hemi-images	Norway spruce	7487403.817	3463928.2	1.81
185	3.9.	Hemi-images	Scots pine	7487369.771	3463888.3	1.25
186	11.9.	Hemi-images	Scots pine	7465101.299	3488159.3	0.84
187	11.9.	Hemi-images	Norway spruce	7455434.911	3492000.3	0.94
188	11.9.	Hemi-images	Norway spruce	7456791.027	3489776.6	1.78
189	7.9.	Hemi-images	Scots pine	7474877.61	3484498.1	1.32
190	9.8.	Hemi-images	Deciduous	7475435.633	3484874.9	0.00
191	5.9.	Hemi-images	Scots pine	7476625.012	3484236.6	0.18

192	9.8.	Hemi-images	Scots pine	7476563.34	3484290.0	0.05
193	5.9.	Hemi-images	Norway spruce	7476499.152	3483897.4	2.53
194	5.9.	Hemi-images	Deciduous	7476640.8	3484130.8	0.84
195	5.9.	Hemi-images	Scots pine	7476576.3	3484113.5	1.82
196	5.9.	Hemi-images	Deciduous	7476385.115	3483863.8	2.47
197	3.9.	Hemi-images	Deciduous	7475242.06	3484894.4	1.99
198	5.9.	Hemi-images	Norway spruce	7476420.335	3484001.2	2.78
199	5.9.	Hemi-images	Scots pine	7476629.624	3484100.7	0.91
200	3.9.	Hemi-images	Norway spruce	7475980.765	3484689.9	1.90
201	3.9.	Hemi-images	Norway spruce	7474020.055	3485291.6	2.36
202	3.9.	Hemi-images	Scots pine	7474022.172	3485235.8	1.70
203	3.9.	Hemi-images	Norway spruce	7473065.21	3486374.0	1.82
204	3.9.	Hemi-images	Norway spruce	7473865.999	3486658.1	2.36
205	3.9.	Hemi-images	Norway spruce	7474303.323	3486640.1	2.43
206	3.9.	Hemi-images	Norway spruce	7474404.354	3486629.8	2.74
207	3.9.	Hemi-images	Norway spruce	7474628.365	3486595.2	2.23
208	3.9.	Hemi-images	Deciduous	7474698.001	3486633.3	1.39
209	4.9.	Hemi-images	Norway spruce	7463120.106	3491362.4	1.43
210	4.9.	Hemi-images	Norway spruce	7463278.767	3491426.4	1.42
211	3.9.	Hemi-images	Scots pine	7473146.657	3486260.4	1.85
212	6.9.	Hemi-images	Norway spruce	7461452.943	3500145.3	1.33
213	6.9.	Hemi-images	Norway spruce	7463239.488	3500031.6	0.46
214	9.9.	Hemi-images	Scots pine	7473644.944	3485648.3	0.67
215	10.9.	Hemi-images	Norway spruce	7463516.418	3501850.4	0.72
216	10.9.	Hemi-images	Norway spruce	7462096.994	3500380.6	0.65
217	11.9.	Hemi-images	Norway spruce	7449838.753	3498182.8	2.12
218	12.9.	Hemi-images	Scots pine	7474907.762	3484322.8	1.17
219	12.9.	Hemi-images	Scots pine	7476357.397	3483958.5	1.76
220	13.9.	Hemi-images	Norway spruce	7462556.085	3492631.4	2.41

August 26–September 5, 2008

LAI2000

Point	Place and description	Dominant species	Latitude	Longitude	LAI
AA01	Ruonivaaran tyvi	Scots pine	67.35353953	27.00292733	1.47
AA02	Rahkavaaran tyvi	Scots pine/Birch	67.328228	27.13242344	1.20
AA03	Tulkkila	Scots pine	67.2589861	27.2794767	2.11
AD01	Sattanen	Scots pine	67.49003005	26.60910345	1.25
AD03A	Peurapalontie	Scots pine	67.84530167	26.733335	0.70
AD03B	Peurapalontie	Scots pine	67.84505407	26.73482113	0.90
MA04	Kommattivaaran tyvi	Scots pine	67.4410036	26.74537525	0.96
MC03	Kiimalaen tyvi	Scots pine	67.54652319	26.22889713	0.89
MD08	Pahtavaarankuusikon laita	Norway spruce	67.85525218	26.48333476	1.10
MD09	Makkaratievat	Norway spruce	67.85197318	26.38458436	1.12
MD15	Kaita-aavankuusikko	Norway spruce	67.84992275	26.5351725	1.37
MD16	Tenniövaara	Scots pine	67.84642656	26.41205078	1.05
MF10	Sammakkoapa	Birch	67.48855671	27.03580314	0.08
P12	Tähtelä	Scots pine	67.37685768	26.62636468	1.72
P13A	Kursala	Norway spruce	67.34567413	26.67895688	1.37
P13B	Kursala	Scots pine	67.346189	26.67952008	0.82
P24	Tähtelä pikatie	Scots pine	67.37767417	26.63285367	1.02
P33	Tähtelä	Scots pine	67.35117429	26.66154229	0.70
P36	Tähtelä	Scots pine	67.37237117	26.62383239	0.40
P6A	Tähtelä	Norway spruce	67.35390008	26.653467	1.91
P6B	Tähtelä	Scots pine	67.35420767	26.65217533	1.87
P8	Tähtelä	Birch	67.3651414	26.6443878	1.95
UP1A	Kaikkonen	Scots pine	67.35386	26.684673	1.45
UP1B	Kaikkonen	Norway spruce	67.35313589	26.68580011	2.06

April 6 – 13, 2008

<b>Point</b>	<b>Place</b>	<b>Date</b>	<b>Time</b>	<b>Latitude</b>	<b>Longitude</b>	<b>LAI</b>
P12	Tähtelä pohjoinen, plot 195	6.4.2008		67:22.6176	26:37.563	0.88
P12	Tähtelä pohjoinen, plot 195	6.4.2008		67:22.6176	26:37.563	1.02
P24	Tähtelä pohjoinen, pikatie, plot 160	6.4.2008		67:22.6722	26:37.959	1.01
P8	Halssiaavan reuna, plot 197	6.4.2008		67:21.9024	26:38.6646	0.67
P8	Halssiaavan reuna, plot 197	6.4.2008		67:21.9024	26:38.6646	0.65
Plot176	NorSEN-masto	6.4.2008		67:21.6876	26:38.0382	0.54
P29	Käyräsjokisuuraa, plot 186	13.4.2008	11:34	67:16.456	26:43.287	0.48
P13	Kursala, plot 203	13.4.2008	12:51	67:20.736	26:40.747	0.74
P33	Halssinkankaannokka, plot 214	13.4.2008	13:41	67:21.046	26:39.729	0.17
P6	Halssikangas, plot 201	13.4.2008	14:27	67:21.246	26:39.229	0.93

March 19 – May 7, 2009

Place	Date	Time	Latitude	Longitude	LAI
Forest at the meteorological mast, left side	19.3.2009	n. 11	6721.71	2638.21	1.21
Clearing at the meteorological mast	19.3.2009	n. 11	6721.71	2638.21	0.41
Forest at the meteorological mast, left side	19.3.2009	10:19	6721.71	2638.21	1.05
Forest at the meteorological mast, left side	19.3.2009	10:42	6721.71	2638.21	1.15
Forest at the meteorological mast, left side	19.3.2009	11:05	6721.71	2638.21	1.19
Melalampi, road to the snowpit points	21.4.2009	11:28	6723.67	2643.851	0.43
Melalampi, road to the snowpit points	21.4.2009	11:28	6723.66	2643.85	0.83
Melalampi, road to the snowpit points	21.4.2009	11:28	6723.65	2643.84	1.04
Melalampi, road to the snowpit points	21.4.2009	11:28	6723.62	2643.82	0.69
Melalampi, road to the snowpit points	21.4.2009	11:28	6723.6	2643.82	0.81
Melalampi, clearing at spectrometer measurements	21.4.2009	11:32	6723.56	2643.66	0.02
Melalampi, clearing at spectrometer measurements	21.4.2009	11:32	6723.56	2643.66	0.02
Melalampi, clearing at spectrometer measurements	21.4.2009	11:33	6723.56	2643.66	0.04
Melalampi, clearing at spectrometer measurements	21.4.2009	11:33	6723.56	2643.66	0.07
Melalampi, clearing at spectrometer measurements	21.4.2009	11:34	6723.56	2643.66	0.05
Melalampi, spectrometer point 1.	21.4.2009	11:42	6721.72	2638.03	0.43
Melalampi, spectrometer point 2.	21.4.2009	11:44	6721.72	2638.03	1.06
Melalampi, spectrometer point 3.	21.4.2009	11:45	6721.72	2638.03	0.82
Melalampi, spectrometer point 4.	21.4.2009	11:46	6721.72	2638.03	0.96
Melalampi, spectrometer point 5.	21.4.2009	11:54	6721.72	2638.03	0.96
Melalampi, spectrometer point 6.	21.4.2009	11:56	6721.72	2638.03	0.49
Melalampi, spectrometer point 7.	21.4.2009	11:57	6721.72	2638.03	0.93
Melalampi, spectrometer point 8.	21.4.2009	12:00	6721.72	2638.03	0.92
Forest at the meteorological mast, left side	26.4.2009	12:34	6721.71	2638.21	0.90
Forest at the meteorological mast, left side	26.4.2009	12:36	6721.71	2638.21	0.74
Forest at the meteorological mast, left side	26.4.2009	12:44	6721.71	2638.21	0.88
Forest at the meteorological mast, right side	28.4.2009	12:45	6721.71	2638.21	1.11
Forest at the meteorological mast, right side	28.4.2009	12:46	6721.71	2638.21	1.12
Clearing at the meteorological mast	28.4.2009	12:56	6721.71	2638.21	0.33
Forest at the meteorological mast, right side	7.5.2009	15:32	6721.71	2638.21	1.17
Forest at the meteorological mast, right side	7.5.2009	15:33	6721.71	2638.21	1.13

March 16-19, 2010

Point	Place	Dominant species	Latitude	Longitude	LAI
P12M_195	Tähtelä forest	Scots pine	67.376993	26.626081	0.64
P6G_202	Halssinkankaannokka	Scots pine	67.354159	26.652697	1.08
P33O_214	Halssinkankaannokka	Scots pine	67.351206	26.661885	0.26
P13A_203	Kursala	Norway spruce	67.345595	26.679090	0.82
P13O_203	Kursala	Scots pine	67.346254	26.679292	0.50
UP1_H	Kaikkonen	Norway spruce	67.353188	26.686367	1.73
UP1_K	Kaikkonen	Scots pine	67.353841	26.685168	1.05
MA04_C	Punamultajänkä	Scots pine	67.441093	26.745143	0.60
AD01_G	Heikinpalo	Scots pine	67.490006	26.609191	0.87
153	Tähtelä forest	Scots pine	67.372503	26.623291	0.25
154	Tähtelä forest	Scots pine	67.370694	26.628759	0.98
155	Tähtelä forest	Scots pine	67.369908	26.629434	1.52
156	Tähtelä forest	Scots pine	67.368430	26.629821	1.51
158	Tähtelä forest	Scots pine	67.367404	26.633841	1.49
160	Kehtomaa	Scots pine	67.377870	26.632649	1.20
163	Kehtomaa	Scots pine	67.379100	26.631667	0.45
164	Kehtomaa	Scots pine	67.381989	26.629524	0.35
167	Kehtomaa	Scots pine	67.387227	26.630804	1.27
168	Kehtomaa	Scots pine	67.382790	26.629745	0.20
171	Halssikangas	Scots pine	67.362881	26.637318	0.35
172	Halssikangas	Scots pine	67.363436	26.636295	0.42
174	Halssinkankaannokka	Scots pine	67.353566	26.659538	0.77
175	Ollinlampi	Scots pine	67.358307	26.640927	0.11
178	Kurkiaapa	Scots pine	67.297778	26.734475	0.05
179	Ala-Aavanmaa	Scots pine	67.294853	26.734232	1.64
181	Yli-Aavanmaa	Scots pine	67.301665	26.719360	0.80
186	Käyräs jokisuuraa	Scots pine	67.274267	26.721457	1.86
187	Pyhä-Luosto	Norway spruce	67.187723	26.811198	0.25
188	Kiiskimännikkö	Norway spruce	67.199813	26.759702	0.98
191	Tähtelä forest	Scots pine	67.377408	26.628907	1.52
192	Tähtelä forest	Scots pine	67.376858	26.630158	1.51
193	Tähtelä shore	Norway spruce	67.376261	26.621026	1.49
196	Tähtelä shore	Deciduous	67.375237	26.620260	1.20
198	Tähtelä shore	Norway spruce	67.375560	26.623453	0.45
205	Kaikkonen	Norway spruce	67.356710	26.685149	0.96
206	Kaikkonen	Norway spruce	67.357616	26.684899	1.83