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First Data Document

Action B.3 – Summary report of albedo data

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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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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 surface albedo data sets gathered in the region around the surroundings of the Arctic Research Centre of FMI at Sodankylä in 2006 - 2010.

The ground based results are listed in tables of the Appendix. Every albedo 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 albedo values in this report. Therefore a table and a set of figures are presented to give the basic characteristics of the airborne albedo data sets.

1 Introduction

The albedo data sets reported in this document were measured in Sodankylä region during the NorSEN (Nordkalotten Satellite Evaluation co-operation Network) campaign in 2006 and during the SNORTEX (Snow Reflectance Transition Experiment) campaign in 2008-2010 (Manninen and Roujean, 2014). During the NorSEN campaign the ground based albedo values were measured in summer conditions. Airborne measurements were carried out in winter/spring conditions during the SNORTEX campaign 2008 – 2010. Use of the ground based albedo measurement data of the Appendix is freely available on the condition that reference is made to the following publications:

> Terhikki Manninen and Aku Riihelä, "ENVISAT/ASAR VV/HH backscattering and the radiation characteristics of Subarctic boreal forest", Proc. of PolInSAR 2009, 26-30 January 2009, Frascati, Italy, Special publication of ESA SP-668, 8 p.
>
> T. Manninen and A. Riihelä, 2008, "Subarctic boreal forest albedo estimation using ENVISAT ASAR for BRDF determination", Proc. of IGARSS'08, July 6 11, 2008, CD, 4p.

Use of the data described in this document is free on the condition that reference is made to the following publications:

> Manninen, T.; Korhonen, L.; Riihela, A.; Lahtinen, P.; Stenberg, P.; Roujean, J.; Hautecoeur, O., "Boreal forest albedo and LAI in SNORTEX 2008–2010," Geoscience and Remote Sensing Symposium (IGARSS), 2012 IEEE International , vol., no., pp.3335,3338, 22-27 July 2012 doi: 10.1109/IGARSS.2012.6350589
>
> Manninen, T., and J.-L. Roujean (Eds.) (2014), SNORTEX field campaigns 2008–2010, Finnish Meteorological Institute Reports 2014(7), 68 p.
>
> Manninen, T. et al., "Relationship of albedo and LAI in boreal forest in winter", in preparation.

2 Description of albedo measurements

2.1 Ground based measurements

During the NorSEN field campaign in August 3-5, 2006 albedo measurements were carried out using a portable Kipp & Zonen CM-14 albedometer, consisting of two back-to-back CM-11 pyranometers attached to a tripod. The wavelength range of the instruments is 0.31 μm … 2.8 μm and the expected instrumental accuracy ±2%. In summer in a forest the legs of the tripod do not cause marked error to the measured albedo value, because in any case there are tree trunks and field layer vegetation affecting the illumination conditions of a measurement point. In winter the tripod legs are estimated to block 6.6% and 9% of reflected radiation depending on snow anisotropy and solar direction (azimuth) relative to tripod (Riihelä et al., 2011).

During the NorSEN field campaign the albedo values were measured in a regular grid, for which also the leaf area index (LAI) values were measured using the LAI-2000 instrument. Photos were also taken about each point to characterize the canopy at the point surroundings and the ground vegetation at the point. The albedo values of the NorSEN campaign are listed in Appendix. They and the global and reflected radiation values are also in the excel-file Albedo_20060803_20060805. Existing photos of the measurements points and related documentation are in the zip file Photos_200608.

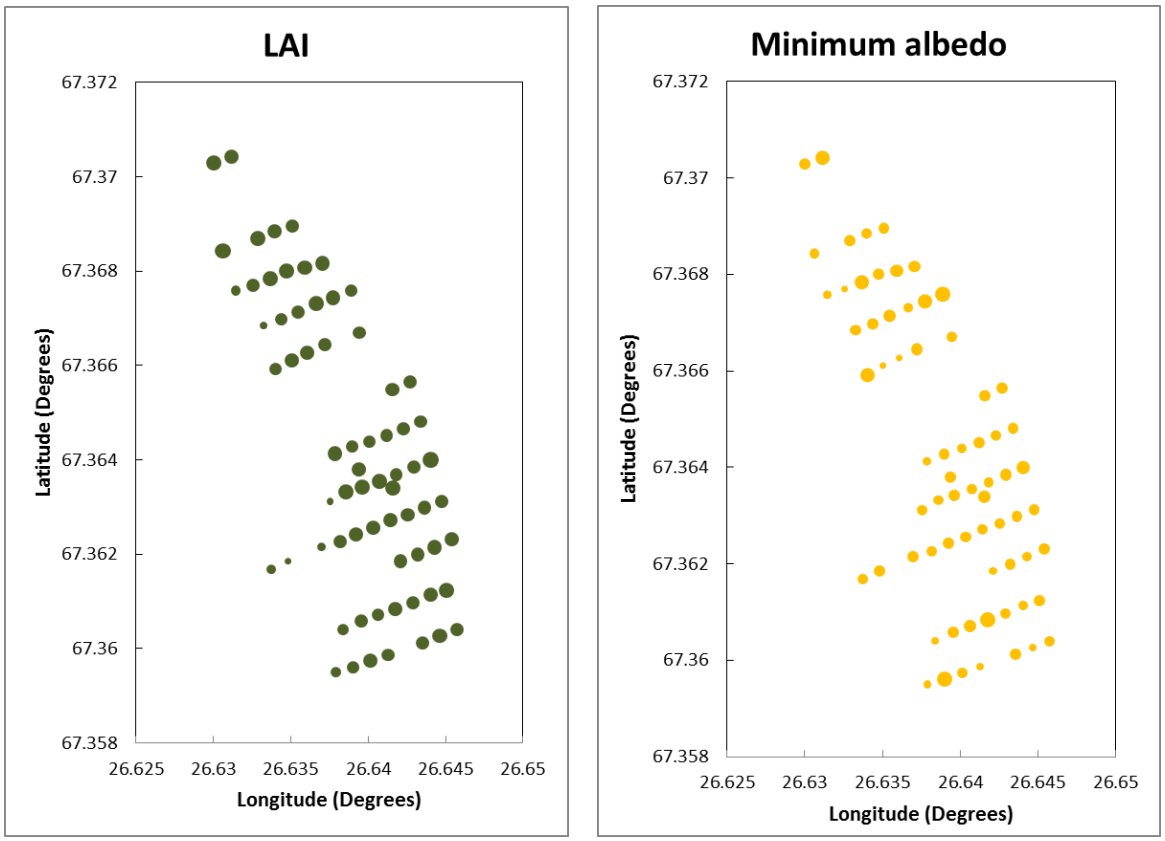

Figure 1. Location of the measured canopy LAI values (left) and corresponding forest floor surface albedo values (right) measured during the NorSEN campaign in 2006.

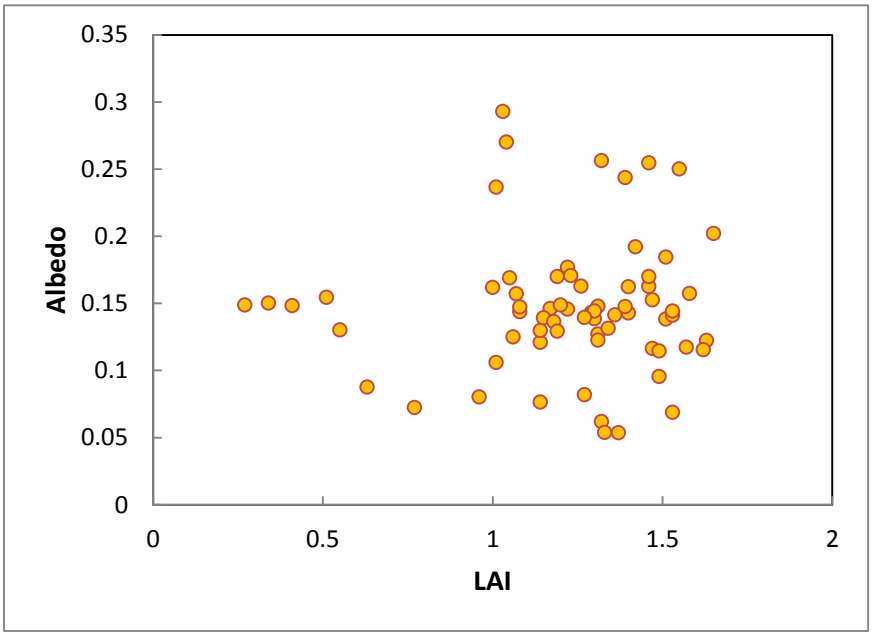

Figure 2. The measured surface albedo value of the forest floor vs. the canopy LAI value of the point. The albedo value is the minimum of four individual 1 minute integrated measurements.

Figure 3. Examples of albedo measurement points at LAI points 79 (top left), 31 (top middle) , 32 (top right), 215 (bottom left) and 216 (bottom right). The effect of shadows at the forest floor is obvious in the topmost images.

Figure 4. Examples of albedo measurement point ground vegetation: crowberry at LAI point 107, cowberry at LAI point 131, bilberry at LAI point 83, lichen at LAI point 189, marsh tea and bog bilberry at LAI point 83.

2.2 Airborne measurements

Two Kipp & Zonen pyranometers on either side of the helicopter were used for the global radiation measurements and another two for reflected radiation measurements (Manninen et al., 2012; Manninen and Roujean, 2014). The global and reflected radiation values were recorded at a 10 second interval. The calibration of the data consisted of instrument calibration, configuration calibration and altitude calibration (Manninen et al., 2012). GPS coordinates (latitude, longitude and height from sea level) and time was registered for each radiation measurement. In 2009 and 2010 there was an additional pressure gauge for altitude registration, as the vertical coordinate of GPS is not so accurate. The main facts concerning the airborne albedo data are listed in Table 1. The number of individual albedo 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 albedo variation its value is plotted for each flight as a continuous curve (Figure 5, Figure 7, Figure 9). In addition, the spatial albedo variation is demonstrated by plotting the albedo values as points in the co-ordinates so, that the size of the point is related to the albedo value (Figure 6, Figure 8, Figure 10).

When the helicopter turned or was deliberately flown in an inclined position (because of needs of other instruments), the pyranometers were not measuring radiation of the upper or lower hemisphere. This caused high peaks in the albedo values. Inclined measurements can easily be removed from the data by requiring the correlation of the left and right reflected radiation value to be high enough.

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

File name	Date	Latitude range	Longitude range	Altitude range (m)	Number of points
SNORTEX_albedo_20080402	April 2, 2008	67.27 – 67.39	26.61 – 26.72	170 - 460	430
SNORTEX_albedo_20080403	April 3, 2008	67.39 – 67.93	26.58 – 27.03	170 - 270	700
SNORTEX_albedo_20080407	April 7, 2008	67.36 – 67.81	26.61 – 27.11	180 – 1000	440
SNORTEX_albedo_20080410	April 10, 2008	67.36 – 67.40	26.57 – 26.79	180 - 400	450
SNORTEX_albedo_20090313	March 13, 2009	67.26 – 67.86	26.23 – 27.28	180 - 510	7062
SNORTEX_albedo_20090317	March 17, 2009	67.33 – 67.46	26.61 – 26.94	180 - 540	4272
SNORTEX_albedo_20090318	March 18, 2009	67.35 – 67.43	26.58 – 26.83	180 - 700	3024
SNORTEX_albedo_20090422	April 22, 2009	67.34 – 67.46	26.61 – 26.88	171 - 1110	8943
SNORTEX_albedo_20090424	April 24, 2009	67.35 – 67.45	26.61 – 26.87	180 - 1090	885 + 2629
SNORTEX_albedo_20090504	May 4, 2009	67.33 – 67.47	26.17 – 26.83	190 - 520	382
SNORTEX_albedo_20090505	May 5, 2009	67.30 – 67.89	26.25 – 27.39	180 - 500	5624
SNORTEX_albedo_20100318	March 18, 2010	67.27 – 67.45	26.17 – 26.83	180 - 820	1414
SNORTEX_albedo_20100319	March 19, 2010	67.35 – 67.44	26.61 – 26.79	180 - 810	4732

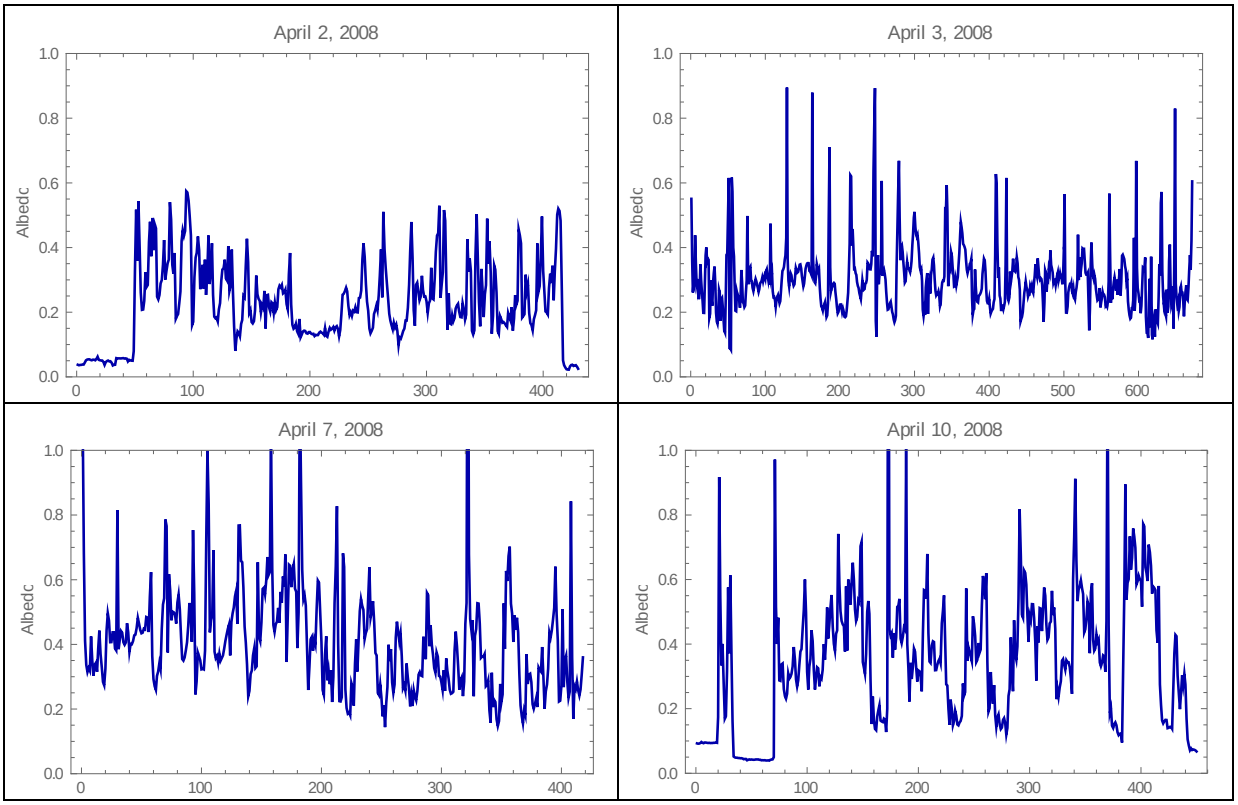

Figure 5. Albedo value variation in various flights during the SNORTEX campaign in 2008. The horizontal axes are not to scale.

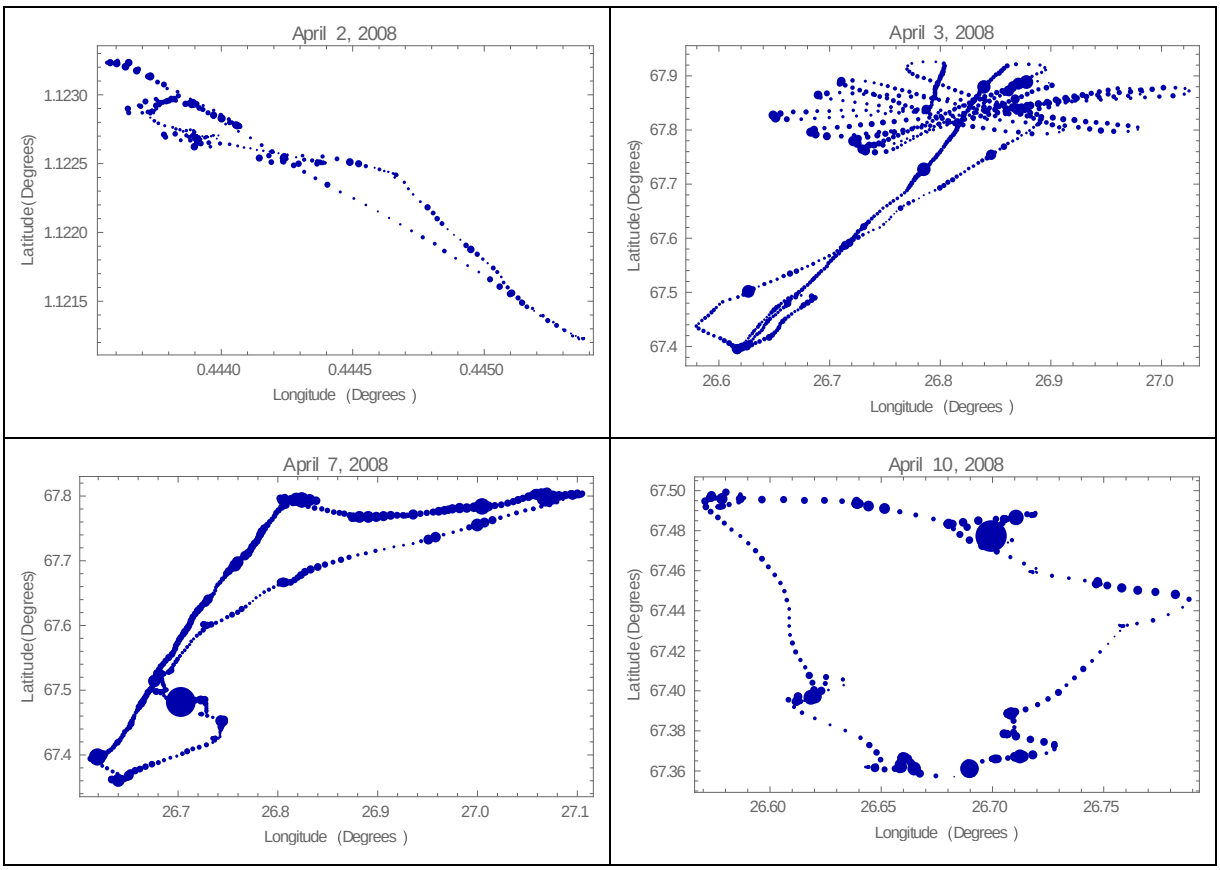

Figure 6. Albedo value variation along the flight routes during the SNORTEX campaign in 2008. The diameters of the points are related to the albedo values.

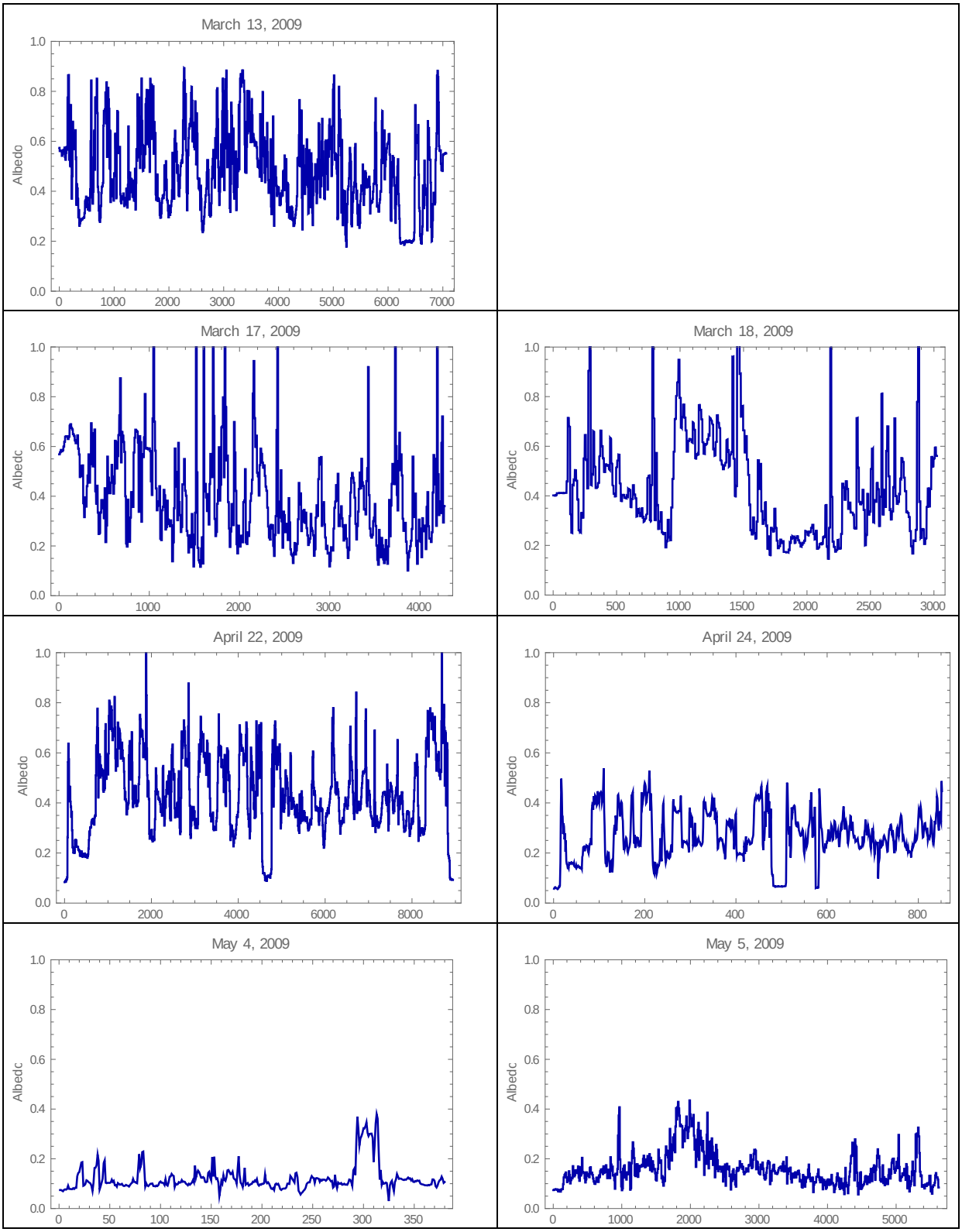

Figure 7. Albedo value variation in various flights during the SNORTEX campaign in 2009. The horizontal axes are not to scale.

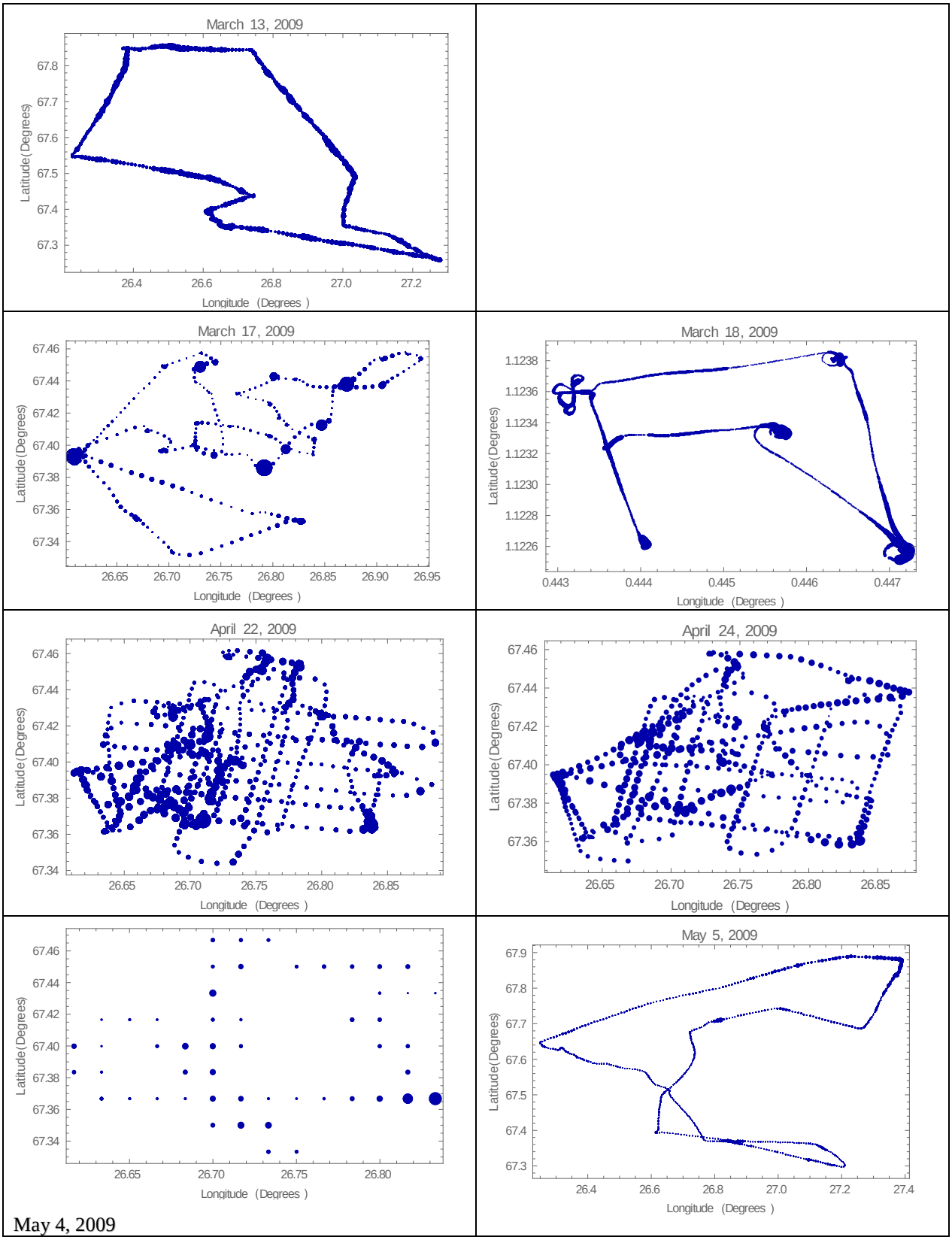

Figure 8. Albedo value variation along the flight routes during the SNORTEX campaign in 2009. The diameters of the points are related to the albedo values, but the scale varies from image to image.

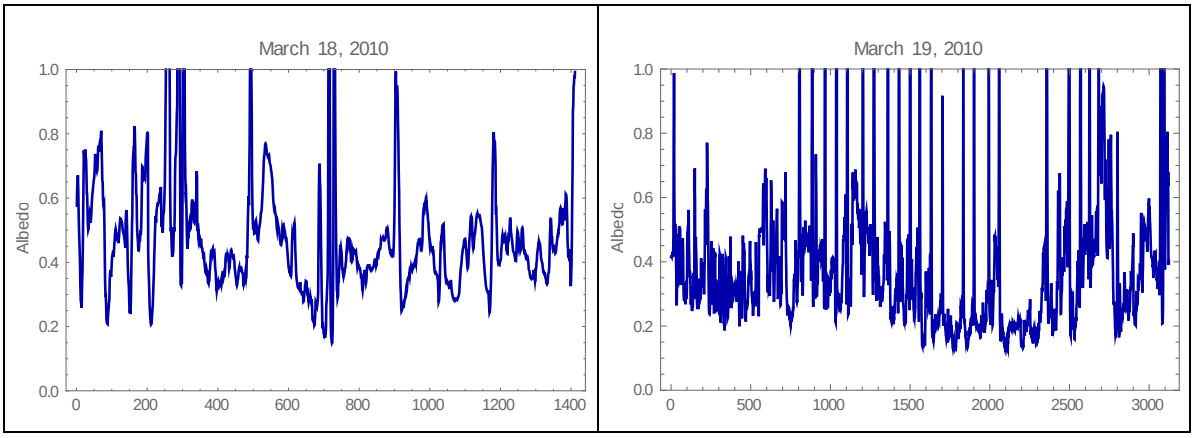

Figure 9. Albedo value variation in various flights during the SNORTEX campaign in 2010. The horizontal axes are not to scale.

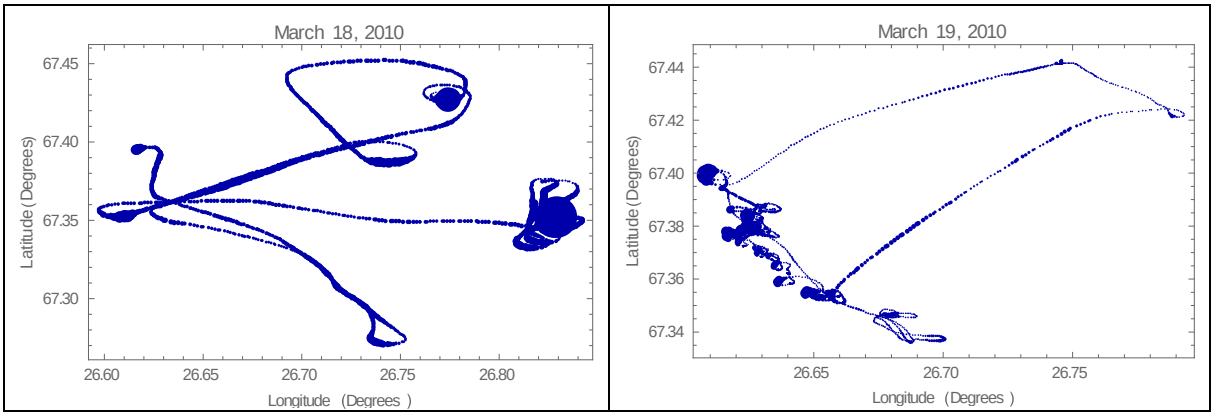

Figure 10. Albedo value variation along the flight routes during the SNORTEX campaign in 2010. The diameters of the points are related to the albedo values.

3 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.

Riihelä et al. 2011, "The RAdiation, Snow Characteristics and Albedo at Summit (RASCALS) expedition report", Finnish Meteorological Institute Reports 2011:8, 41p.

Appendix: Ground based surface albedo measurements in Sodankylä region

August 3 – 5, 2006. Average and minimum albedo values of 4 individual 1 minute integrated measurements of the forest floor.

Date	Time	LAI point	Longitude	Latitude	LAI	Average albedo	Minimum albedo	Comments
3/8/2006	10:09:02	304	26.63790454	67.3594973	0.77	0.087	0.072	Edge of 1st line
3/8/2006	10:19:32	305	26.63900376	67.35960501	1.03	0.347	0.293	
3/8/2006	10:30:02	306	26.6401527	67.35974068	1.31	0.188	0.127	
3/8/2006	10:43:32	307	26.64128153	67.35986278	1.14	0.077	0.076	
3/8/2006	11:01:02	309	26.64353545	67.36012576	1.17	0.148	0.146	
3/8/2006	11:08:32	310	26.64462939	67.36026938	1.53	0.091	0.069	
3/8/2006	11:17:02	311	26.64573426	67.36039394	1.15	0.170	0.139	Edge of 1st line
3/8/2006	11:36:02	285	26.64288959	67.3609655	1.14	0.131	0.121	Middle point of 3rd line
3/8/2006	11:45:32	286	26.64403546	67.36113934	1.47	0.122	0.116	more cloudy
3/8/2006	12:04:02	287	26.64508346	67.36123451	1.51	0.180	0.138	sun behind the clouds, half cloudy
3/8/2006	12:25:02	284	26.64176641	67.36083477	1.32	0.276	0.256	first sunny, then cloud in front of the sun
3/8/2006	13:03:32	283	26.64062971	67.36071087	1	0.206	0.162	sunny and cloudy, shadows
3/8/2006	13:18:02	282	26.63954915	67.36058258	1.22	0.148	0.146	sunny
3/8/2006	13:26:32	281	26.63838327	67.36040418	0.96	0.082	0.080	sunny
4/8/2006	06:14:32	261	26.64210022	67.36185246	1.27	0.089	0.082	full cloud cover
4/8/2006	06:26:02	262	26.64320102	67.3619907	1.34	0.136	0.131	full cloud cover
4/8/2006	06:39:32	263	26.64429282	67.36214684	1.49	0.120	0.114	full cloud cover
4/8/2006	06:54:02	264	26.64539838	67.3623082	1.4	0.164	0.162	full cloud cover, sun bright behind the clouds every now and then
4/8/2006	07:13:02	240	26.64475451	67.36311633	1.2	0.152	0.149	cloudy, sun bright every now and then
4/8/2006	07:28:32	239	26.6436336	67.3629865	1.31	0.150	0.148	8/8
4/8/2006	07:36:32	238	26.64254208	67.36282996	1.29	0.145	0.143	8/8
4/8/2006	07:45:02	237	26.64143547	67.36271259	1.36	0.146	0.141	8/8
4/8/2006	07:55:02	236	26.64033938	67.36256156	1.3	0.146	0.139	8/8
4/8/2006	08:03:02	235	26.63923052	67.36242416	1.4	0.149	0.143	8/8
4/8/2006	08:12:32	234	26.63817396	67.36226067	1.18	0.141	0.136	8/8
4/8/2006	08:24:02	233	26.63696539	67.36215402	0.51	0.155	0.155	
4/8/2006	08:37:02	231	26.63480995	67.36184495	0.27	0.150	0.149	8/8, relatively open, masts near
4/8/2006	08:46:32	230	26.633727	67.36168151	0.55	0.131	0.130	8/8
4/8/2006	09:02:32	210	26.63754801	67.36311359	0.34	0.152	0.150	8/8, open
4/8/2006	09:14:32	211	26.63857512	67.36332336	1.63	0.125	0.122	8/8, large number of thin trunks
4/8/2006	09:23:02	212	26.63962344	67.36342123	1.47	0.154	0.153	8/8, large number of thin trunks
4/8/2006	09:34:02	200	26.63937456	67.3637901	1.39	0.151	0.147	8/8, 1st LAI-point of the portable mast
4/8/2006	09:44:32	213	26.64074279	67.36355044	1.53	0.143	0.141	7/8
4/8/2006	09:51:02	214	26.64182648	67.36368344	1.06	0.139	0.125	7/8
4/8/2006	09:58:02	215	26.64295027	67.363845	1.26	0.164	0.163	7/8
4/8/2006	10:16:02	216	26.6440533	67.36399703	1.65	0.204	0.202	8/8
4/8/2006	10:33:02	192	26.64339507	67.36481343	1.08	0.163	0.144	7/8
4/8/2006	10:45:02	168	26.64267941	67.36564285	1.19	0.195	0.170	7/8
4/8/2006	10:54:32	167	26.64157561	67.36548554	1.3	0.153	0.144	7/8
4/8/2006	11:07:32	191	26.6422874	67.36466679	1.19	0.160	0.129	6/8
4/8/2006	11:18:02	190	26.6411965	67.3645161	1.07	0.161	0.157	6/8
4/8/2006	11:31:02	189	26.64010119	67.36438989	1.01	0.106	0.106	5/8
4/8/2006	11:42:02	188	26.63896955	67.36427744	1.08	0.192	0.147	5/8
4/8/2006	11:56:32	187	26.63785342	67.36412654	1.49	0.107	0.095	4/8
4/8/2006	12:54:32	5	26.63002509	67.37028733	1.46	0.208	0.163	4/8
4/8/2006	13:02:02	6	26.63116128	67.37042539	1.39	0.260	0.244	4/8
4/8/2006	13:58:32	52	26.63061164	67.36843013	1.57	0.171	0.117	3/8
4/8/2006	14:12:02	54	26.63289382	67.36869331	1.58	0.190	0.157	3/8
4/8/2006	14:20:32	55	26.63396587	67.36884525	1.31	0.138	0.123	3/8
4/8/2006	14:31:02	56	26.63508995	67.36895942	1.27	0.155	0.139	2/8
5/8/2006	06:21:02	76	26.63146111	67.36758755	0.63	0.094	0.088	3/8, cloudy
5/8/2006	06:27:32	77	26.63256071	67.36769794	1.32	0.110	0.062	3/8, cloudy
5/8/2006	06:34:02	78	26.63368869	67.36783201	1.55	0.338	0.250	3/8, sunny, large number of thin trunks
5/8/2006	06:43:02	79	26.63474428	67.3680057	1.53	0.150	0.144	
5/8/2006	06:50:02	80	26.63590379	67.36807151	1.42	0.308	0.192	
5/8/2006	06:57:02	81	26.63704347	67.36816731	1.46	0.189	0.170	
5/8/2006	07:33:02	108	26.64157294	67.36339591	1.51	0.223	0.185	
5/8/2006	07:52:32	106	26.63888385	67.36758176	1.04	0.299	0.270	
5/8/2006	08:04:32	105	26.63773771	67.3674351	1.46	0.277	0.255	
5/8/2006	08:13:02	104	26.63663904	67.36731324	1.62	0.148	0.115	
5/8/2006	08:23:32	103	26.6354669	67.36713418	1.22	0.186	0.177	
5/8/2006	08:33:32	102	26.63436745	67.36697134	1.05	0.190	0.169	
5/8/2006	08:42:02	101	26.63326328	67.36684295	0.41	0.151	0.148	
5/8/2006	08:56:32	125	26.63401975	67.36591807	1.01	0.251	0.237	
5/8/2006	09:05:32	126	26.63505009	67.36610803	1.37	0.058	0.053	
5/8/2006	09:14:02	127	26.6360693	67.36627518	1.33	0.073	0.054	
5/8/2006	09:25:02	128	26.63721343	67.36644529	1.23	0.199	0.171	
5/8/2006	10:19:33	130	26.63944322	67.36669682	1.14	0.168	0.130	
5/8/2006	13:46:32	A1				0.230	0.096	close to LAI point 200