IRIS field report:

Airborne EM measurements of Baltic ice thickness in February 2003: The campaign

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IRIS — **Ice Ridging Information for Decision Making in Shipping Operations**

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CONTENTS

Abstract

This field report summarises flights and measurements carried out during the first IRIS airborne EM campaign in the Baltic between February 17 and 23, 2003. It also presents general ice conditions encountered during the flights and corresponding ice charts. Data analysis results will be presented in additional, later reports.

1. Introduction

The main objective of the IRIS project is the quantitative derivation of the amount of ridges from satellite imagery and their prediction by means of numerical models. The information is needed to further improve ice information for shipping, as. e.g. provided by national ice services.
In the Baltic the estimates of the amount of ridged ice are so far based on surface observations or surface profiles. However, the uncertainty in these estimates is large and thus no reliable statistics on the equivalent thickness of ridged ice volume yet exists. The proper parameterisation of models that seek to determine the ridged ice volume and ridge keel statistics from sail statistics requires joint profiles of the ice surface and ice draft. Such profiles can be obtained with ice thickness sensors based on electromagnetic (EM) induction.
From the surface profile obtained from the laser measurement the usual ridge parameters like ridge density and ridge height, together with their associated distribution can be determined. The joint thickness and surface profile data allows then the linking of the usual ridge parameters to the volume of ridged ice and to the keel parameters. The EM measurement gives also the level ice thickness between the ridges, and if the measured ridge field is recently created, the relationship of ridge ice block thickness (parent ice thickness) to the ridge statistics can be studied. This relationship is important for the parameterisation of ridging resolving dynamic ice models and for the estimation of ridging from SAR images.
Accordingly, there is a large work package (WP 2: Baltic field studies) for the acquisition of in-situ ice thickness and surface roughness data which can be used for the development of remote sensing algorithms and model parameterisations. The main goals are to collect sufficient amounts of unbiased data and to determine ridge height and ice thickness distributions along extended, representative profiles. To achieve these goals, an operational, helicopterborne EM ice thickness sensor designed for surveying Arctic ice tickness has to be calibrated for Baltic brackish water conditions.
This report summarises the measurements performed in February 2003 and presents the plan for further data analysis.

2. Sensors and measurements

2.1 EM bird

Electromagnetic (EM) induction sounding can generally be used to determine the distance to the interface of two layers with different electrical conductivities. The sea ice application is based on the fact the sea water is a conductive medium while sea ice is non-conductive. Thus the distance from the sensor to the ice/water interface, which is coincident with the ice underside, can be determined. The distance between the

sensor and the ice surface is measured by a laser distance meter. From the difference of both distances ice thickness is obtained.
Alfred Wegener Institutes (AWI) thickness sensor is a towed bird (EM bird) suspended with a 20 m long below a helicopter (Fig. 1). It uses two operating frequencies of 3.6 and 112 kHz. The length of the bird is 3.4 m and weight 120 kg. The bird is flown at an altitude of 10 to 20 m above the ice surface. The laser altimeter readings are directly displayed to the pilot for real-time altitude control of the bird. The bird requires a power supply of 28 VDC and 16 A (450 W) to be delivered from the helicopter. The power supply and the load hook are the only interfaces with the helicopter, so that the bird is quite platform independent. Data are radio-transmitted to a small notebook operated on the knees of one passenger in the helicopter. Data acquisition is performed at a sampling rate of 10 Hz, corresponding to a point spacing of 3 to 4 m with flight speeds of 60 to 80 knots.

Figure 1: EM bird in operation.

2.2 Laser altimeter

The Riegl LD90-3100HS laser distance meter inside the EM bird is not only used as a supplementary instrument for the computation of ice thickness, but also as a stand-alone laser profiler for measurements of ridge sail distributions and surface roughness. Its measurements enable to relate ridge profiles to overall thickness profiles.
The infrared laser operates at a wavelength of 905 nm with a ray divergence of 2 mrad. It has a range of up to 150 m with an accuracy of 0.002 m. To obtain a higher spatial sampling than with the thickness measurements, the laser is operated at a sampling rate of 100 Hz, corresponding to a point spacing 0f 0.3 to 0.4 m.

2.3 GPS

A standard GPS is included in the EM bird for recording the flight track with high accuracy. This enables later comparison of the data with data from other sources, e.g. satellite imagery.

2.4 Video camera

A downward looking digital video camera inside a metal housing was mounted directly to the helicopter (Fig. 2). The video was used to enable detailed investigations of the behaviour of the EM signal over different ice types and to judge the spatial resolution of the EM measurements. It was also used to document overall ice conditions with high flying altitudes.

Figure 2: Downward looking video camera.

2.5 Aerial photography

With conventional analogue and digital cameras still photographs were taken to document overall ice conditions and whenever there were peculiar ice features or situations. All photographs were documented with a GPS position to be able to specify their exact location when questions regarding interpretation of thickness data or satellite images should occur. The locations of all photographs taken are indicated as circles on the maps for every days flight track in Section 3.2.

3. The campaign

3.1. General

The 2003 helicopter ice thickness profiling campaign took between February 17 and 23. Flight tracks are shown in Figure 3 and are summarised in Table 1. In total, 12 flights with a total length of 1267 km have been performed. They lasted between 0.8 and 1.5 hours, corresponding to profile lengths of 73 to 141 km. As both the Gulf of Finland and the Gulf of Bothnia were well covered with ice (Fig. 4), we decided to survey both regions. Therefore, we moved from Helsinki northwards up to Raahe, and obtained an almost continuous coverage of the Finnish coast (Fig. 3). While two cross sections between Finland and Estonia could be achieved on February 23, helicopter range proved not to be sufficient to profile complete sections between the Finnish and Swedish coast.

The large number of flights was only possible due to favourable weather conditions. However, this also meant that there were no strong storms in the meantime. Therefore, there was probably not much change of the ice thickness distribution in the Gulf of Finland over the one-week period. To show such a change was the original idea behind the repeat flights from Helsinki on February 17 and 23. Section 3.2 and the Appendix describes in detail every days flights and the main ice conditions observed.

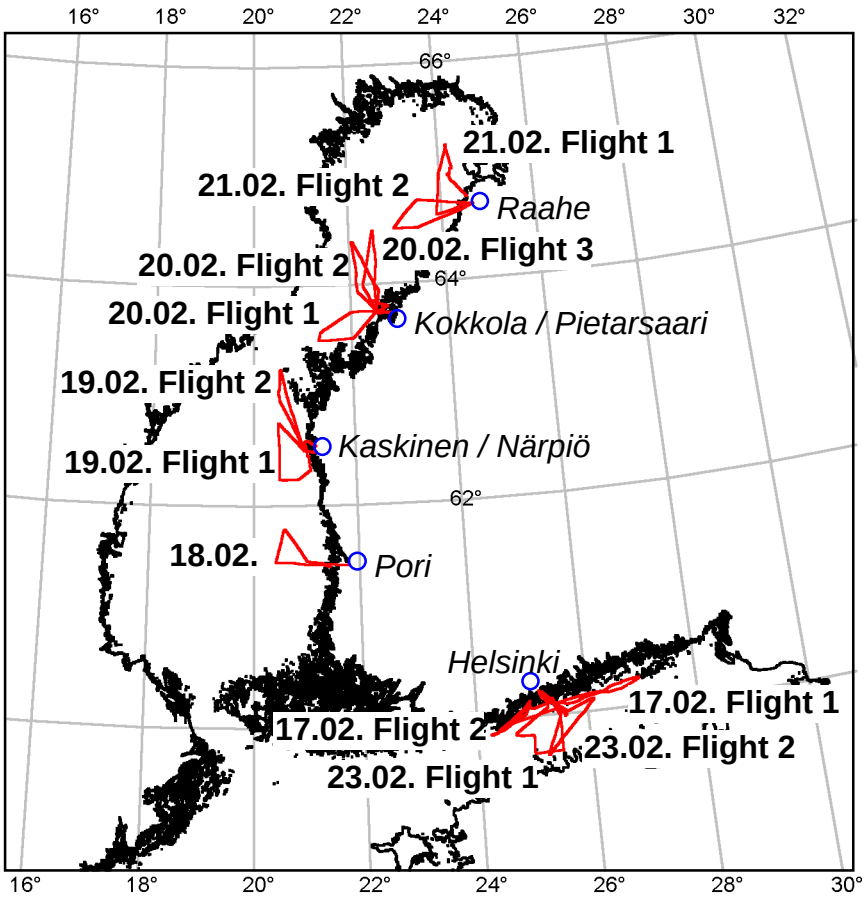


Figure 3: Map of all EM bird flight tracks during the 2003 ice thickness campaign between Febraury 17 and 23.

Table 1: Summary of all flights showing total flight duration and length of thickness profile obtained (flying altitude lower than 25 m).

Date	Base	Flight No.	Duration, h	Profile length, km
17.2.2003	Helsinki	1	1.5	140
		2	1.3	135
18.2.2003	Pori	1	0.8	81
19.2.2003	Närpiö	1	1.2	95
		2	1.3	141
20.2.2003	Kokkola	1	1.2	73
		2	1.2	100
		3	1.3	116
21.2.2003	Raahe	1	1.3	83
		2	1.4	95
23.2.2003	Helsinki	1	1.2	77
		2	1.3	131
Total			15.0	1267

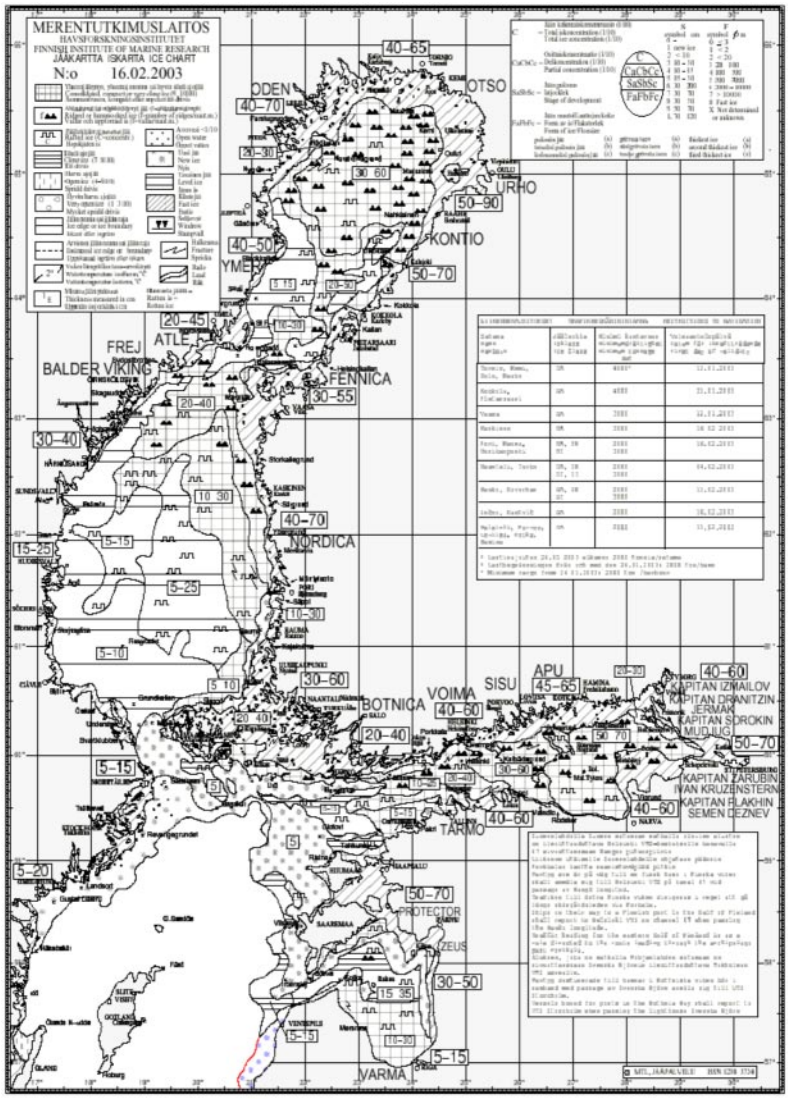


Figure 4: Ice situation on February 16, i.e. one day before the first flight. Map courtesy of FIMR.

3.1.1 Flying procedure

The flight tracks were designed in order to represent the prevailing ice conditions, and to perpendicularly cross boundaries of eventually different ice regimes. Plans were made every morning based on recent ice charts which had been ordered by fax from the Finnish Ice Service at FIMR (e.g. Fig. 4).

Between the airfields and the sea flying altitudes between 100 and 200 m have been chosen. The bird was already switched on to allow for warm-up of the analogue electronic components. For thickness sounding, the bird had to be flown at altitudes between 12 and 15 m above the ice surface. Operation speed was 80 knots. However, because the EM signal is subject to electronic drift, the bird was lifted to altitudes greater than 60 m every 10 to 15 minutes to monitor the EM signal without any presence of electrical conductors like the sea (Fig. 5). During the high altitude sections, signal nulling and internal calibration was performed to compensate and correct for the drift. This procedure resulted in interruptions of the thickness profiles for 3 to 5 minutes. In most cases, the video camera was switched on only during ascents to and descents from the high altitude sections.

During the flights, geo-referenced event markers were edited into the files to demarcate special features and to document general ice conditions along the flight tracks. The locations of event markers are indicated as crosses on the maps for every days flight track in Section 3.2 and the Appendix. Notes on every event are only available as hand-written paper copy.

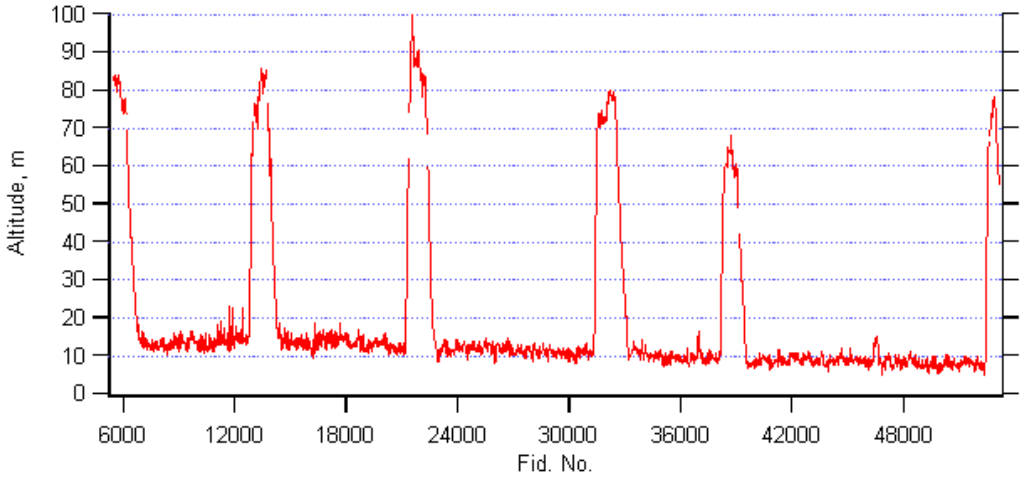


Figure 5: Typical GPS altitude pattern of 192 km long EM flight with actual thickness profiling performed during low altitude sections. Example from second flight on February 23. Fiducial numbers are in 0.1 s, i.e. 6000 Fids correspond to 10 minutes flying time.

3.1.2 Logistics

The flight plan required to operate from different airfields along the Finnish coast. Currently, the bird cannot be landed without ground-assistance. Therefore, it was not possible to fly it from one base to the next, but it had always to be returned to the starting point. Therefore, all equipment had to be transported from one base to the next every evening after the flights. For transport of the scientific equipment a van with a 4 m long loading platform was rented, which was just big enough to host all required equipment (Fig. 6). The science team consisted of three people (M. Lensu, W. Dierking, C. Haas).

For all flights, a MD-500 helicopter was chartered from Helitour Oy, Helsinki. Operation of the flights required a pilot and a technician. The technician was responsible on the ground for take-off and landing of the bird, which was directly landed into a specially built trolley. He also had to drive the refueling truck which was required on some bases (Fig. 6). Between bases, science and helicopter teams operated independently and met just in the morning at the respective airfield.

Figure 6: Photograph of the ground logistics, consisting of (from left to right): EM bird on trolley, MD-500 helicopter, refueling truck, and scientist equipment van.

3.2 Daily flight maps and ice conditions

In the appendix all daily flight tracks and ice conditions observed are presented. Two maps are shown for every flight. The first map shows the flight track superimposed on the daily ice chart provided by FIMR. The second map includes information on the flight altitude (colour coded) and on the locations of event markers (crosses) and photographs (circles). Ice thickness measurements are only available for altitudes between 10 and 20 m (see Sect. 3.1.1).
The information is completed by two photographs representing general ice conditions, as well as a table summarising ice conditions at all locations where photographs have been taken.

4. Data analysis plan

During in-flight data acquisition only the laser heights and relative secondary EM field strengths (in ppm) are displayed in the operators notebook and recorded (Fig. 7). This allows to judge the data quality and noise content in real time already during the flight. Generally, there was a clear signal from ridges and level ice during all flights, even at the low water salinities in the Bay of Bothnia. Unfortunately, due to strong winds on the flights from Raahe there was much noise in the data, which might allow accurate thickness retrieval only after low-pass filtering, thus removing some of the lateral resolution.

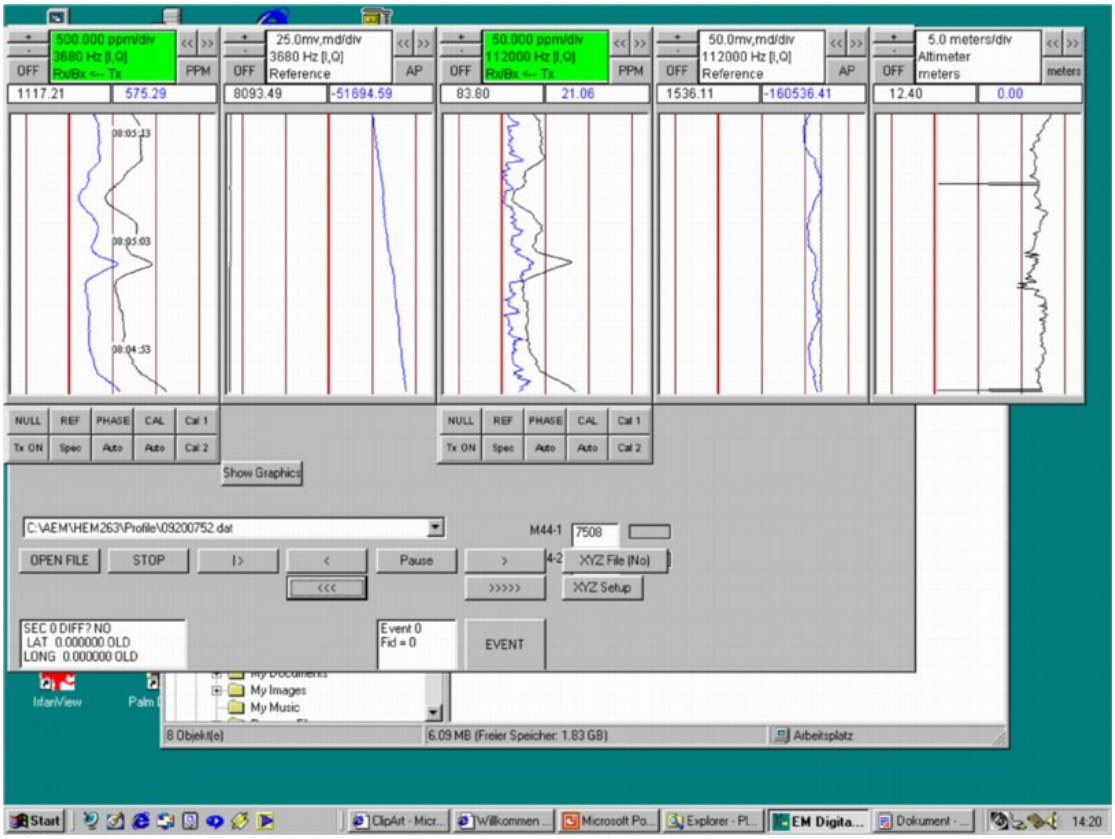


Figure 7: Screen shot of data acquisition software display, allowing real time control of all transmit and receive channels of EM field strengths and laser distances for quality control. The example shows a profile across a pressure ridge.

However, thickness retrieval from the EM field data is involved. Thickness profiles will only be available in late fall 2003. On the one hand, we have to develop geophysical inversion procedures which involve imagery and real components of the EM field at both frequencies. This work is under development. On the other hand, thicknesses have to be retrieved manually from each channel using interactive software. Much of this work is still under development and has to be optimised before routine procedures can be used. The main steps involved are presented below for a flight over the Gulf of Finland on February 23.

4.1 Drift compensation

As mentioned above, EM signals are subject to temporal drift due to electronic drift of the analogue electronic components, mainly heating of the coils. The drift can be monitored during high altitude sections, when there should be no signal in the absence of any conductor around the system. The deviation from null between two ascents is the drift, which has to be linearly interpolated and removed from all other samples in between. The procedure is illustrated in Figure 8. Here, drift amounted to 30 ppm which is relatively low because the profile has been obtained after 0.5 hours of operation, when all electronic components had almost achieved their equilibrium temperature.

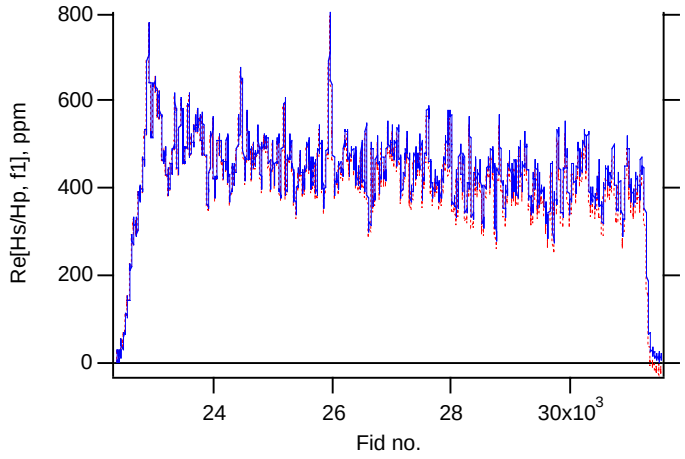


Figure 8: Typical profile of inphase component of f_1 (3.6 kHz) showing original (red, stippled) and drift-corrected trace (blue, solid). February 23, 2nd flight, file 200302231204*.

4.2 Calibration

An essential issue in EM sounding is calibration to be able to convert the measured voltages into EM field strength. Normally, absolute calibration is required to invert underground conductivities from the EM signals. This will also be necessary for the development of our geophysical inversion procedures.

However, the case of sea ice thickness measurements is comparatively simple, as normally the data contain some open water sections even in winter. As ice thickness is well known to be zero over open water, these sections provide some independent means for calibrating the data. Because the helicopters altitude is quite variable during a flight, open water sections are crossed at different heights and provide thus information on the relation between EM signal and bird distance to the water surface. This is illustrated in Figure 9. Open water sections are characterised by a maximum EM signal strength for a given bird height and are therefore easily identifiable. Some open water points can then be picked from a scatter plot of EM signal versus laser height, and can be used as sampling points for an exponential fit. The fit provides a transformation equation to convert the EM signal into a distance to the water surface.

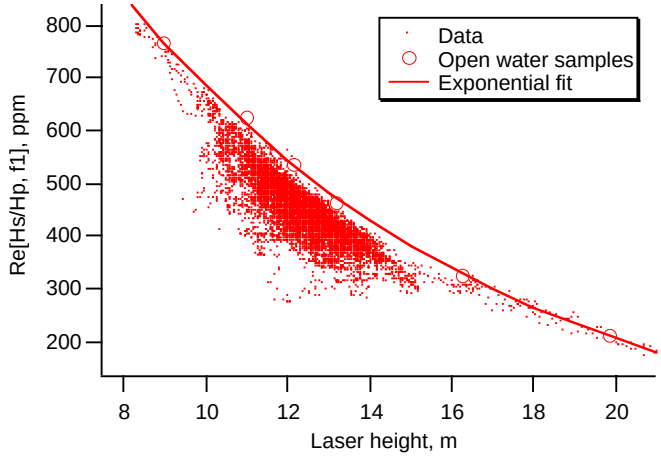


Figure 9: F_1 Inphase signal versus system height above the ice surface for the example from Figure 8. The exponential fit is performed only for open water samplong points.

4.3 Thickness computation

Figure 10a presents profiles of electromagnetically derived bird distance to the water surface computed as explained in 4.2, and the coincident laser height above the ice

surface. For better clarity, only a short section of the profile in Figure 8 is shown. Ice thickness is the difference between both curves (Fig. 10b). Figure 11 shows the corresponding thickness distribution. Mean ice thickness along the profile was 1.36 m with a typical thickness of 1.1 m.

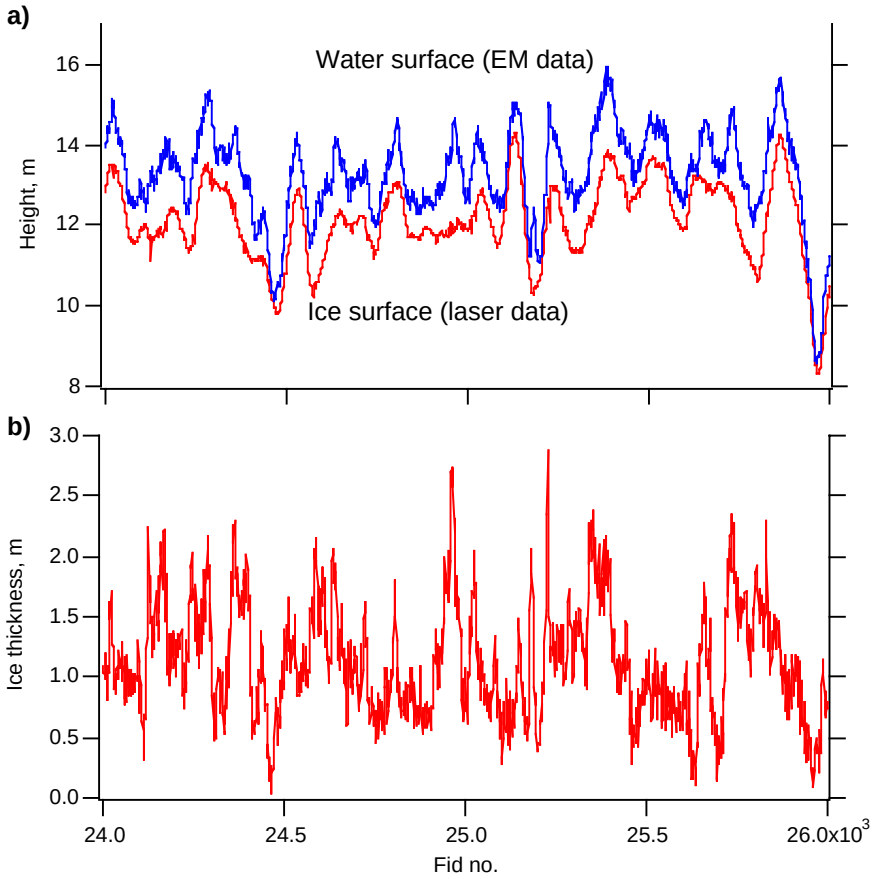


Figure 10: Profiles of bird height above the water (blue) and ice (red) surface **(a)** and ice thickness **(b)** derived by subtracting both curves in a). Section from the profile shown in Figure 8.

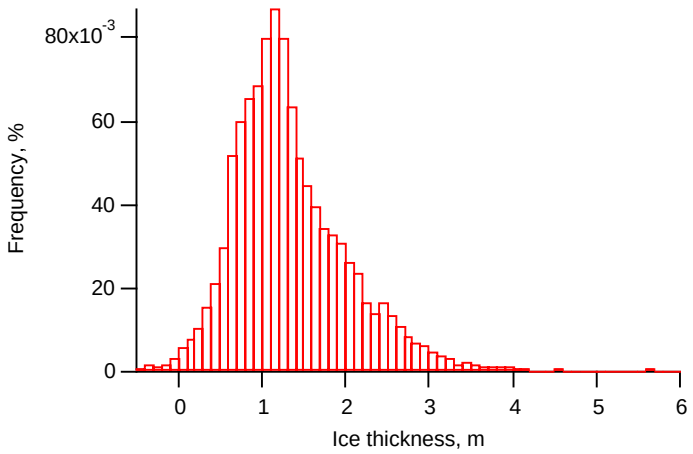


Figure 11: Thickness distribution of the profile shown in Figures 8 and 10.

4.3 Retrieval of ridge distributions

Ridge sail and keel distributions will be retrieved from both the laser data alone and the ice thickness profiles. With the laser profiles, helicopter motion inherent in the data will first be removed following standard procedures (high pass filtering, picking of minimum sampling points, and reconstruction, low pass filtering, and subtraction of helicopter motion). Both the location of ridge sails and keels along the profiles as well as the derived height, spacing, and cluster distributions will be delivered for subsequent parameterisation in models and for comparison with remote sensing (SAR) data.

5. Experiences and conclusions

Although we could not achieve as much work as originally planned (see IRIS Report No. 1: Field experiment plan: Airborne EM measurements of Baltic ice thickness in February 2003; Part of Deliverable No. 1), the 2003 airborne campaign has to be considered as extraordinarily successful. This was due to favourable weather conditions, professional helicopter service, and good performance of the EM bird over low salinity Baltic Sea ice. Although the latter will become clear only after complete data analysis, sufficient data quality could be judged already during the flights from low noise (4 ppm) and clear ice signals at the edges of ice floes and over ridges. Anyway, we could improve the signal-to-noise ratio by just flying lower (between 10 and 15 m) which did not pose a problem for the helicopter pilot.

Nevertheless, survey flights and transfer shipping of the equipment consumed quite some time, so that no extra flights could be performed for calibration purposes or other ice work. This has to be taken into account for future campaigns.

Around Pori, all EM measurements were seriously disturbed by radio transmissions from Pori radio station. There was extremely strong noise both on the transmitter as well as on the receiver side, which was even saturated.

Our flights provided a great opportunity to validate qualitatively the official FIMR ice charts. The charts proofed to be very accurate and represented all ice regimes very well. However, the representation of ridges was very poor, emphasising the importance of the campaign in putting forward the goals of the IRIS project.

Data processing and analysis has commenced and will be completed in late fall 2003.

6. Acknowledgements

The success of the campaign was only possible through the professionalism and enthusiasm of Helitour Oy, in particular by Pentti Törrönen and pilots and bird catcher Rene Koivisto and Ermo Löytömäki.

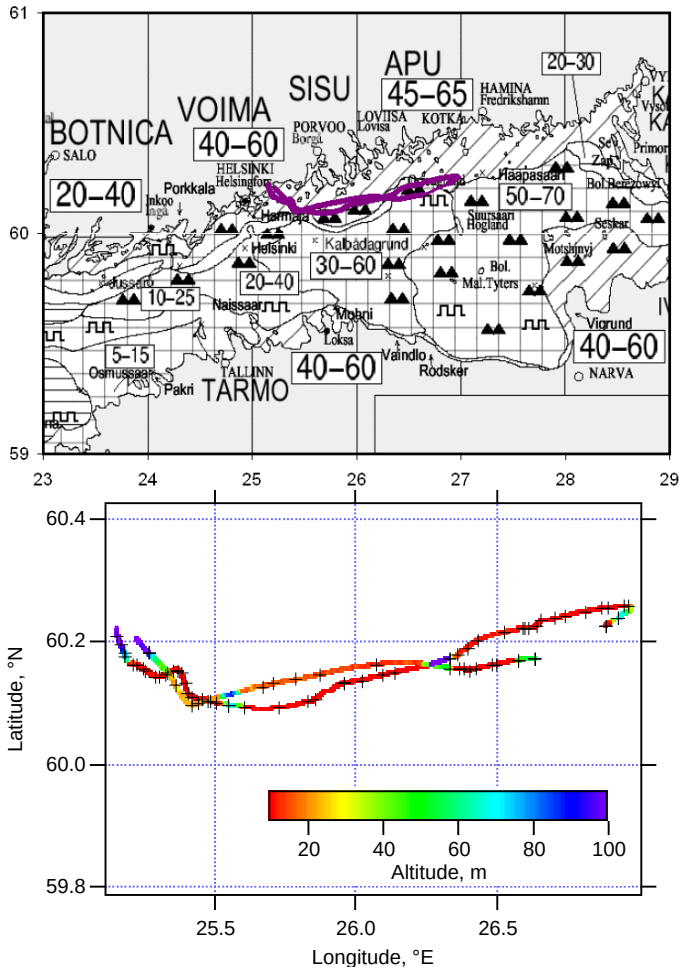
APPENDIX I

Daily flight maps and ice conditions

All daily flight tracks and ice conditions observed are presented. Two maps are shown for every flight. The first map shows the flight track superimposed on the daily ice chart provided by FIMR. The second map includes information on the flight altitude (colour coded) and on the locations of event markers (crosses) and photographs (circles). Ice thickness measurements are only available for altitudes between 10 and 20 m (see Sect. 3.1.1).
The tables list every days photographs and prevailing ice types and conditions.

February 17, Flight 1

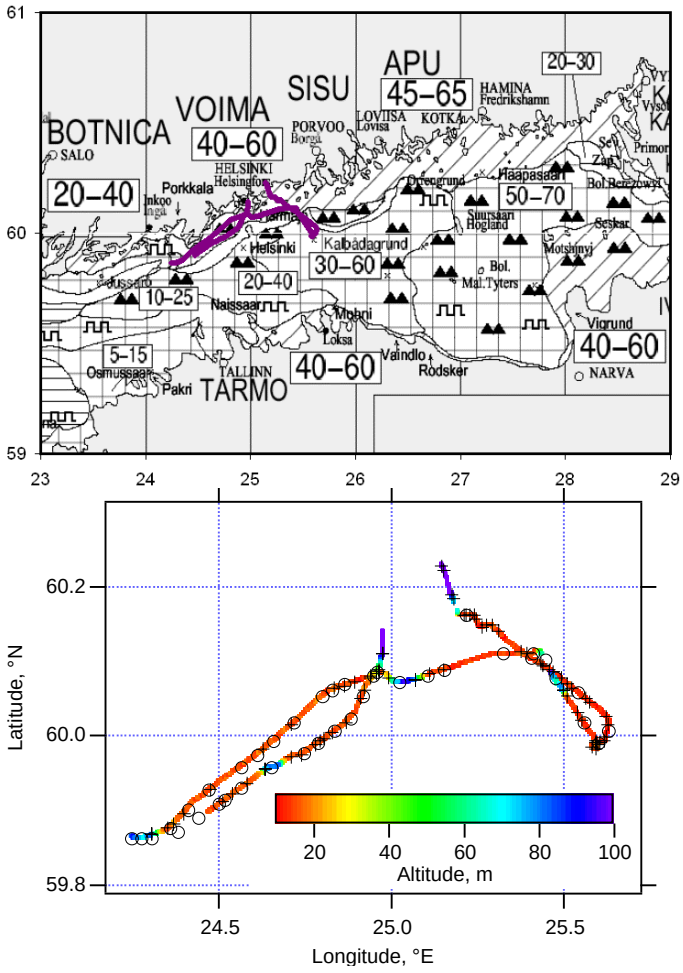
Flight from Helsinki along the fast ice/ drift ice boundary towards East.



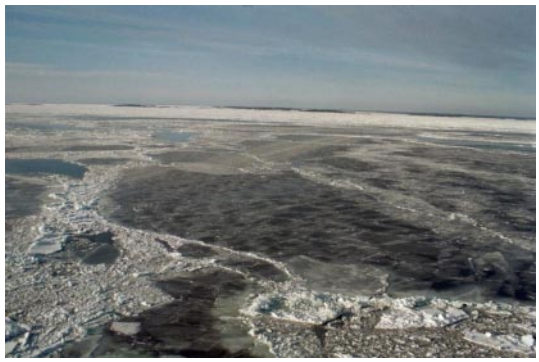
View from fast ice towards open water/drift ice in the North.

February 17, Flight 2

Flight from Helsinki towards West, and to an extended polynja in the Southeast.



Compact drift ice at the fast ice / drift ice boundary

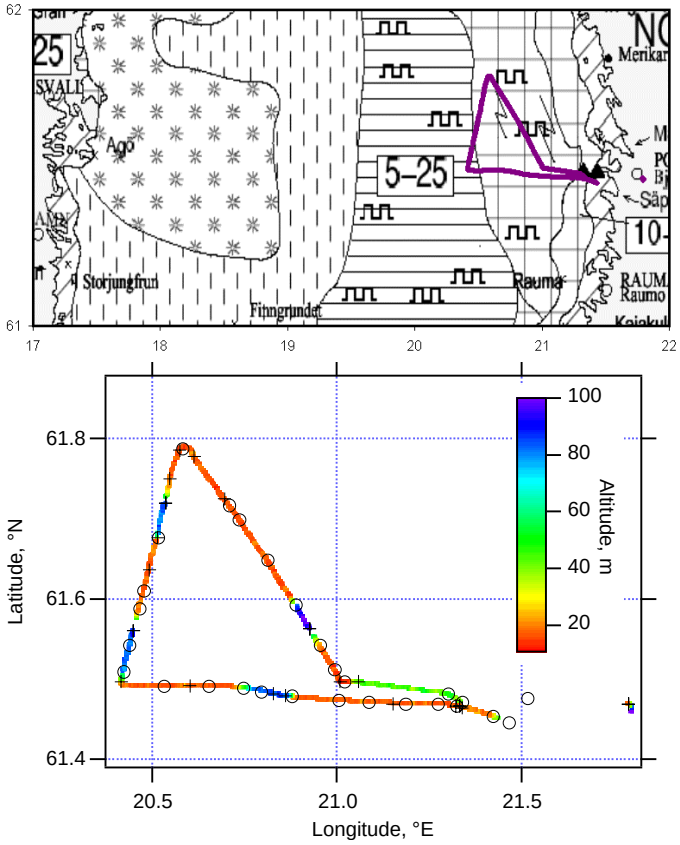


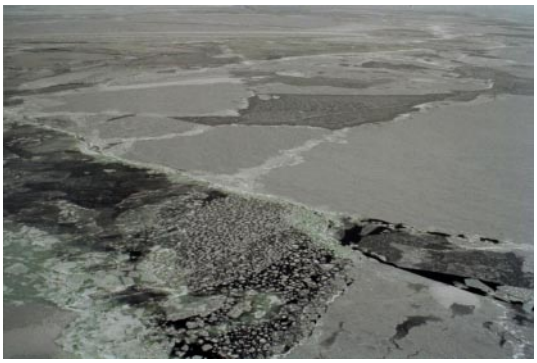
Dark nilas on polynja adjacent to fast ice in backgrond

FLIGHT 2, 14:45-15:15 local; Film 2, photos 12-13: pilot Rene Koivisto + Mikko Lensu; 14-37: Gulf of Finland (technician: Ermo Löytömäki)				
#	Position N	Position E	Altitude [m]	Remark
001	60°05.155	24°57.635	103	photo 14
002	60°03.083	24°54.940	43	photo 15, fragmented fast ice
003	60°01.394	24°52.952	39	photo 16
004	60°00.328	24°50.161	43	no photo, open water to the left, heading 280°
005	59°59.404	24°47.324	43	photo 17
006	59°58.658	24°44.937	76	photo 18
007	59°57.404	24°39.077	76	photo 19, open water to the left, heading 280°
008	59°55.787	24°33.924	41	no photo, thin ice
009	59°54.817	24°31.062	40	photo 20
010	59°54.467	24°30.128	40	photo 21
011	59°53.360	24°26.453	44	photo 22, to the left in 2 km distance open water
012	59°52.285	24°22.775	45	this way point shortly after flying along ice edge
013	59°51.715	24°18.409	44	photo 23
014	59°51.731	24°14.893	44	photo 24
015	59°51.778	24°16.520	90	new heading 50°, open water to the right
016	59°52.628	24°21.597	38	photo 25
017	59°54.098	24°24.563	35	photo 26
018	59°55.591	24°28.347	32	photo 27
019	59°57.460	24°33.776	33	no photo, small and large ice fragments
020	59°58.131	24°35692	34	no photo, smooth level
021	59°58.510	24°36.724	34	photo 28
022	59°59.504	24°39.363	37	larger patches of smooth ice, weak ridging, no sun
023	60°01.087	24°43.177	30	smooth thin ice, open water to the right in 2-3 km
024	60°03.156	24°48.005	36	large pieces of broken grey ice, snow covered
025	60°03.697	24°49.721	37	smooth ice
026	60°04.067	24°51.923	35	smooth dark grey ice
027	60°04.799	24°56.983	62	photo 29: open water with ice floe belt
028	60°04.283	25°01.396	109	photo 30: ice edge
029	60°04.833	25°06.464	73	photo 31-34 fragmented ice
030	60°05.301	25°09.219	44	photo 35
031	60°06.608	25°19.460	34	fragmented ice with ridges, ice edge in 2-3km dist.
032	60°06.662	25°24.735	33	photos 36-37
033	60°06.102	25°26.787	130	thin rafted ice, first signs of ridging
034	60°04.627	25°28.471	105	open water
035	60°01.020	25°33.604	39	open water, then lots of broken ice fragments
036	59°59.344	25°35.938	41	digital camera: ridged ice
037	60°00.361	25°37.663	34	open water with pieces of broken ice (digital photo)
038	60°03.544	25°32.409	33	thin ice with rafting and ridging, ice fragments: Film 3, photos 00, 0, 1-2
039	60°06.271	25°24.194	32	light house again, see photo 37, film 2
040	60°09.683	25°13.107	36	Photo 3: shiptrack
Photos 4-5: approaching the coast Disassembling, packing until ca 17:30 local; driving to Pori, arrival ca. 22:00				

February 18, Flight 1

Flight from Pori into Sea of Bothnia covered by dark and light nilas. Bad noise induced by Pori radio station.





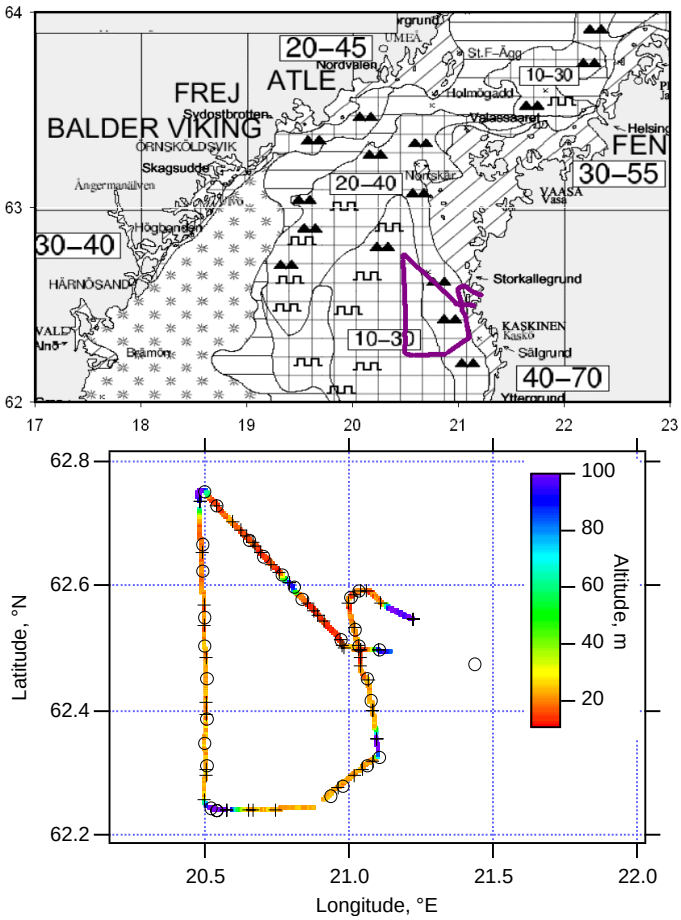
Mixed rafted dark and light nilas

Broken grey ice pieces embedded in nilas

18/02/03; film 3, photos 6-8 Pori airfield flight 3 from Pori, 11:00-11:25 local, photo 9: fast ice, return to base, bird: interference with local transmitter (radio antenna)				
Flight 4, 13:15-14:45, film 3, photo 10: flying towards coast				
#	Position N	Position E	Altitude [m]	Remark
041	61°28.561	21°30.971	129	photo 9
042	61°26.758	21°27.792	107	photo 11
043	61°27.212	21°25.138	50	photo 12
044	61°27.949	21°19.297	28	photo 13: transition fast ice -> pack ice
045	61°28.103	21°16.366	27	photo 14
046	61°28.139	21°11.204	30	photos 15-18
047	61°28.241	21°05.036	28	no photo, same situation, later broken ice fragments: photo 19
048	61°28.400	21°00.344	28	photo 20, later photos 21-23
049	61°28.642	20°52.721	61	photos 24-26
050	61°29.083	20°47.773	102	no photo, same situation
051	61°29.305	20°44.872	75	same situation, later dollar pancakes: photo 27
052	61°29.503	20°39.269	31	photo 28: dollar pancakes in waves
053	61°29.421	20°31.960	30	photo 29: nilas + grey ice; later photo 30: nilas with rafting, frost flowers ? snow drift ?
054	61°30.546	20°25.425	39	photo 31
055	61°32.508	20°26.443	80	no photo, same situation
056	61°35.232	20°27.892	41	photo 32: pancakes frozen together
057	61°36.582	20°28.658	42	photo 33
058	61°40.553	20°30.918	31	photo 34
059	61°47.302	20°34.972	25	photo 35: broken pancake cover in dark, rafted nilas; photo 36; changing film, photos 00+0
060	61°43.011	20°42.418	31	photos 1+2, film 4
061	61°41.918	20°44.117	31	pancake field, perhaps with ice slick between cakes
062	61°38.932	20°48.623	33	photos 3+4
063	61°35.523	20°53.378	89	photo 5
064	61°32.520	20°57.115	56	same situation: ridging and rafting
065	61°30.647	20°59.692	37	Larger pieces of ice frozen together
066	61°29.798	21°01.207	33	photos 6-9
067	61°28.804	21°18.178	61	rafting + ridging, transition to fast ice
068	61°28.229	21°20.366	67	fast ice
Photos 10+11 Pori airfield, fueling. Departure 16:00, arrival Kaskinen (Kaskö) 18:00				

February 19, Flight 1

Flight from Närpiö towards West, from deformed white ice into rafted nilas.



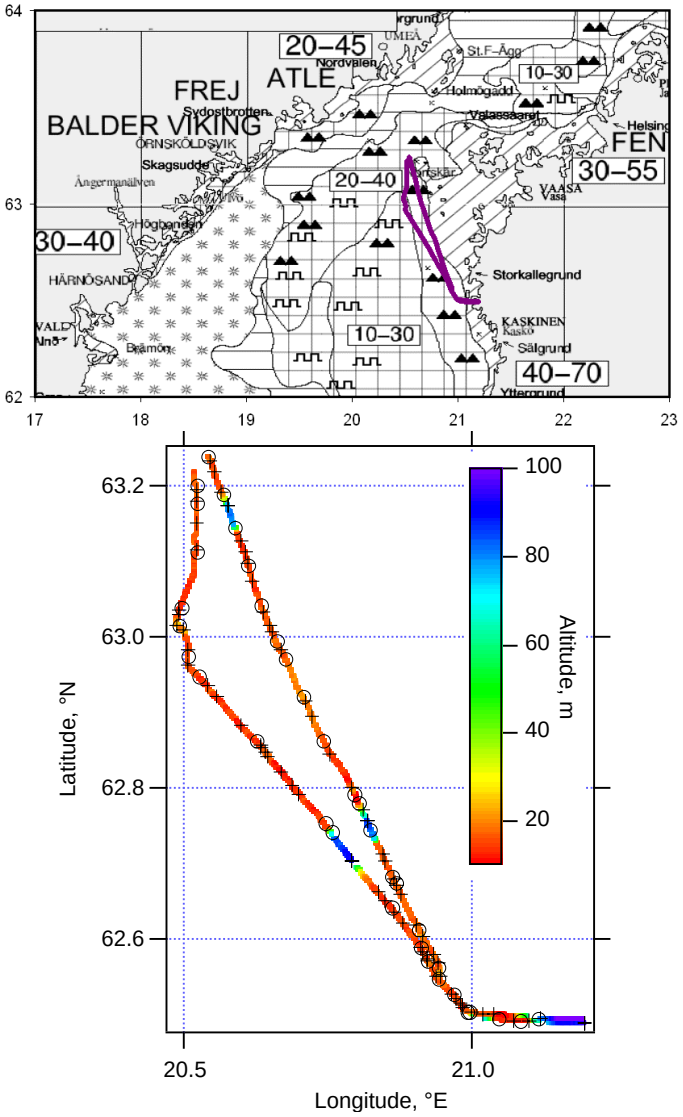
Deformed grey/white ice adjacent to fast ice in the background

Large stretches of rafted light nilas

19/02/03, departure Kaskinen 8:45. Parking lot of a filling station is used as airfield (film 4, photo 12)				
Flight 5, start 10:30, end 12:00. Photos 13+14 flying towards coast				
#	Position N	Position E	Altitude [m]	Remark
069	62°28.378	21°26.014	12	position filling station
070	62°29.715	21°06.230	103	photo 15: transition fast ice -> pack ice; later photos 16+17: broken, snow covered thin ice
071	62°30.732	20°58.132	53	between WP 70 + 72: photos 18-30
072	62°34.750	20°50.266	37	nilas, open water
073	62°35.786	20°48.232	93	photos 31+32
074	62°36.992	20°45.976	64	photo 33
075	62°38.845	20°42.280	32	photos 34,35: “milky” ice
076	62°40.371	20°39.235	26	no photo; 30-40% open water or dark nilas,
077	62°43.722	20°32.338	30	film # 5: photos 0+1
078	62°45.130	20°29.684	102	photos 2-5
079	62°39.989	20°29.202	44	photos 6+7
080	62°37.452	20°29.350	45	photo 8
081	62°33.032	20°29.779	49	photos 9-16
082	62°30.198	20°29.947	47	about 10% narrow open leads (no photo)
083	62°27.146	20°30.028	40	photos 16-23
084	62°23.145	20°30.046	46	photo 24
085	62°20.802	20°29.984	35	photos 25-27
086	62°18.716	20°30.074	43	ice concentration to left side > 90% (no photo)
087	62°14.492	20°31.090	99	photos 28-30
088	62°14.421	20°32.426	130	photo 31
089	62°14.421	20°32.426	130	photos 32-37
090	62°15.767	20°56.010	130	no photo, more snow (1-2cm), many ridges, fragmented ice, dark nilas + open water
091	62°16.719	20°58.431	130	a few ridges getting higher (no photo)
092	62°18.733	21°03.818	42	larger fragmented ice fields (50% of total area)
093	62°19.495	21°06.102	80	large smooth ice patch, flying ca 45° relative to the fast ice edge
094	62°25.005	21°04.613	45	parallel transition fast ice -> pack ice, but still over pack ice
095	62°26.973	21°03.697	41	thin ice + open water (large lead: ca 1000m long, 150-200m wide)
096	62°30.160	21°02.054	33	zone of heavy ridging
097	62°31.673	21°01.256	35	2 large thin ice floes, many smaller floes
098	62°34.843	21°00.313	51	3 digital photos
099	62°35.410	21°02.100	45	entering into fast ice

February 19, Flight 2

Flight from Närpiö across deformed white ice parallel to fast ice edge.

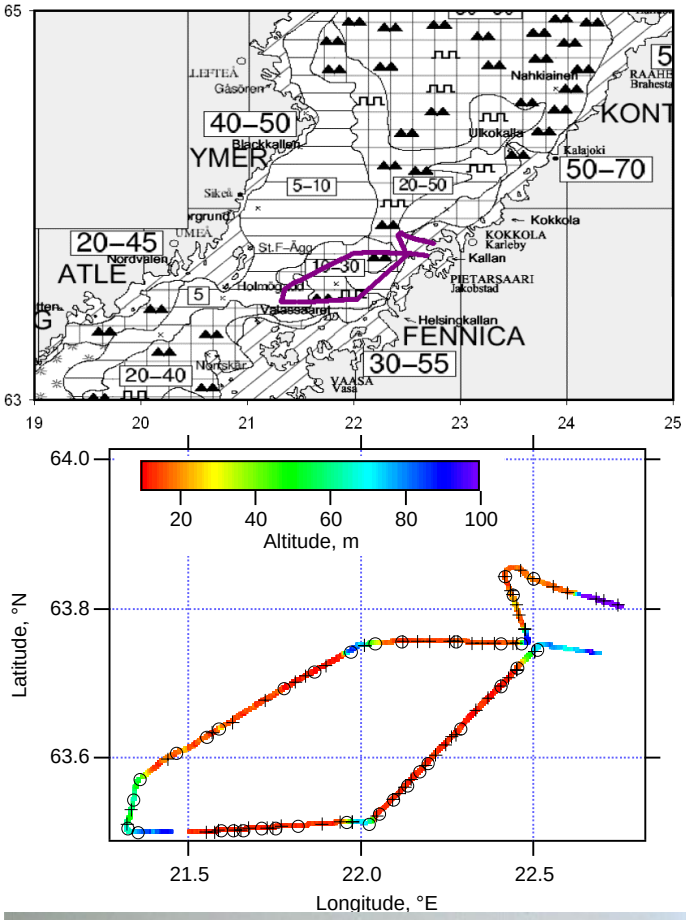


Broken, heavily deformed white ice floes adjacent to fast ice

19/02, flight 6 13:00-14:45 local, and film 6. Photos 1+2: helicopter shadow; photos 3+4: Finnish landscape				
#	Position N	Position E	Altitude [m]	Remark
100	62°29.686	21°06.959	100	transition fast ice / pack ice, photos 5-8 (ice deformations close to fast ice edge)
101	62°30.112	20°59.908	42	photo 9
102	62°33.751	20°56.716	29	photo 10, a little later ridged ice, then patches of “milky” ice, photo 11
103	62°36.752	20°54.565	34	fragmented ice with rims (such as seen on flight 5)
104	62°40.391	20°52.148	36	photo 12
105	62°40.994	20°51.739	36	photo 13 (there are also open water patches in the area)
106	62°44.722	20°49.482	102	photos 14+15
107	62°46.698	20°48.327	46	photos 16+17
108	62°47.533	20°47.870	34	photo 18, then ridged + fragmented ice again; photos 19+20
109	62°51.792	20°44.614	69	photo 21
110	62°55.201	20°42.463	71	photos 22+23
111	62°58.309	20°40.620	39	photo 24
112	62°59.677	20°39.588	37	photo 25
113	63°02.557	20°38.088	39	ridged and broken ice
114	63°05.697	20°36.749	35	film 7, photos 0-2
115	63°08.700	20°35.399	51	photo 3
116	63°11.283	20°34.106	32	photos 4+5
117	63°14.296	20°32.581	34	photo 6-9
118	63°12.145	20°31.227	35	old ship track ?
119	63°10.650	20°31.314	38	photo 10
120	63°06.777	20°31.247	24	photo 11
121	63°02.386	20°29.663	34	area of open water, start
122	63°00.841	20°29.483	48	area of open water, end
123	62°58.433	20°30.452	32	photos 12-13
124	62°56.827	20°31.538	33	still same situation
125	62°51.649	20°37.556	31	photo 14
126	62°45.113	20°44.696	30	photos 15+16
127	62°44.385	20°45.390	62	photos 17+18
128	62°38.459	20°51.664	31	same situation
129	62°35.228	20°54.800	38	large lead (open water + dark nilas) to the right
130	62°34.131	20°55.564	42	crossing lead
131	62°32.738	20°56.610	36	along lead edge
132	62°31.480	20°58.168	33	lead to the left, otherwise rough thin ice
133	62°30.195	20°59.735	34	photo19
134	62°29.563	21°02.772	43	over rough ice, lead behind
135	62°29.400	21°05.310	30	fast ice edge
photo 20: Mikko in front seat of the helicopter, photos 21+22: filling station “air field”; departure 15:30, arrival Kokkola 17:30 local				

February 20, Flight 1

Flight from Kokkola/Pietarsaari into Quarken, from deformed white ice into dark nilas.

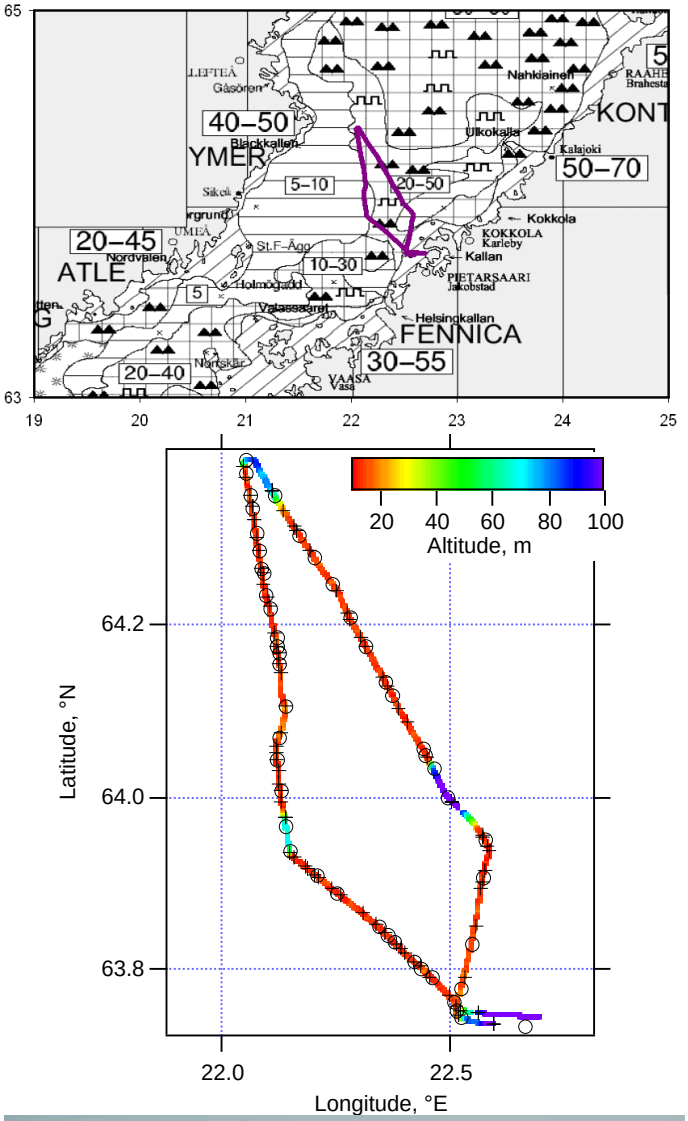


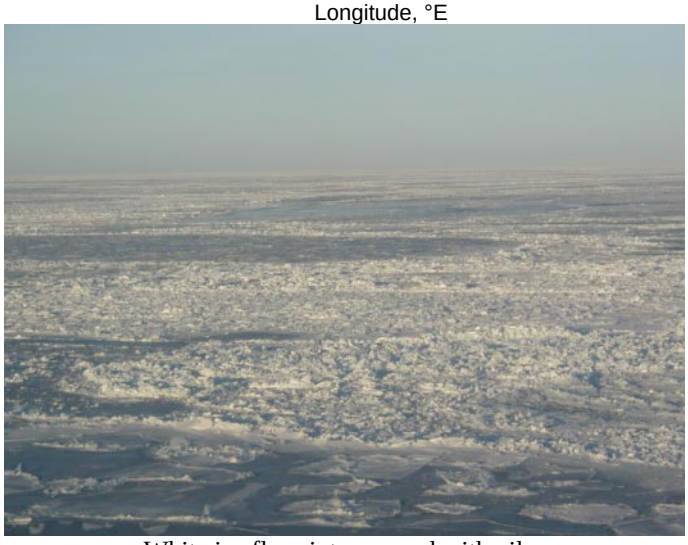
Rafted/deformed light nilas/grey ice in the Quarken

20/02/03 airfield south of Kokkola (photos 23+24 on film 7, photos 0-11 on film # 8). Position63°43.342N 23°07.922E; Flight 7 start 9:45, end 11:30; photos 12-16 on the way to the coast; photo 17: fast ice				
#	Position N	Position E	Altitude [m]	Remark
136	63°44.713	22°30.584	92	film # 8, photos 18+19, transition fast ice / pack ice
137	63°43.160	22°27.296	34	photo 20
138	63°41.714	22°24.465	19	photos 21-27
139	63°38.334	22°17.365	27	still same situation
140	63°35.564	22°11.701	30	film # 9, photos 00, 0, 1
141	63°34.846	22°10.198	31	photo 2
142	63°33.764	22°08.073	27	photo 3
143	63°32.575	22°05.569	29	nilas with rafting and ridging
144	63°31.427	22°03.057	29	patches of pancake covers
145	63°30.730	22°01.506	97	photos 4-6
146	63°30.774	21°57.680	55	pancake fields (ridged, broken), 20% nilas + grey level
147	63°30.547	21°49.152	27	level ice floes increasing in size, 20-30% areal coverage; dark nilas 20-30%, rest is pancakes
148	63°30.398	21°45.009	28	photos 7-10
149	63°30.333	21°42.690	27	rougher ice again, pancakes hardly recognizable
150	63°30.219	21°39.469	28	photo 11
151	63°30.158	21°37.844	29	heavy ridging
152	63°30.097	21°35.512	29	new nilas area, photos 12-27
153	63°29.983	21°28.521	95	same situation
154	63°30.037	21°21.233	96	same situation
155	63°30.250	21°19.331	84	same situation
156	63°32.642	21°20.623	47	same situation
157	63°34.250	21°21.697	54	same situation
158	63°36.333	21°27.994	23	same situation
159	63°37.583	21°33.058	33	first pancake fields again
160	63°38.246	21°35.370	42	about 50-50% nilas and pancake ice
161	63°41.522	21°46.758	44	nilas, pancakes, and smooth grey level ice, film # 10, photos 00-7, photo # 8 Mikko
162	63°42.905	21°52.039	32	photos 9+10
163	63°44.536	21°58.276	73	photos 11+12
164	63°45.131	22°02.448	81	same situation
165	63°45.309	22°07.084	44	photos 13-15
166	63°45.277	22°16.705	33	photos 16+17
167	63°45.182	22°24.325	27	photo 18
168	63°45.137	22°27.910	36	photo 19: fast ice
169	63°49.088	22°26.350	34	photos 20-23
170	63°50.464	22°25.144	32	broken ice, with smoother patches imbedded
171	63°50.332	22°30.062	37	fast ice, photo 24
film # 10: approaching the air field (photo 25). The “bird” (photos 26+27)				

February 20, Flight 2

Flight from Kokkola/Pietarsaari along boundary between rafted nilas and deformed white ice.



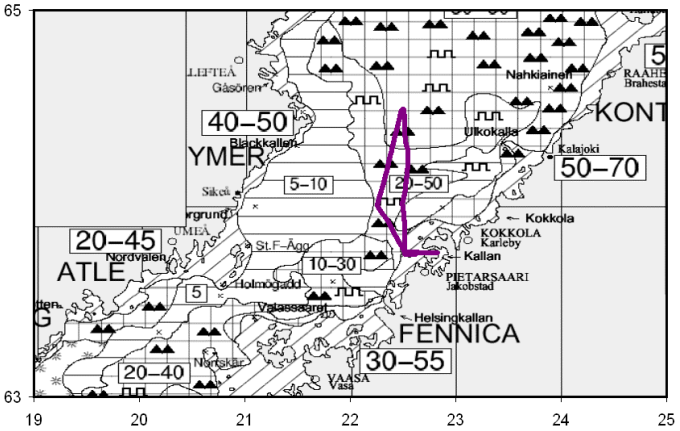


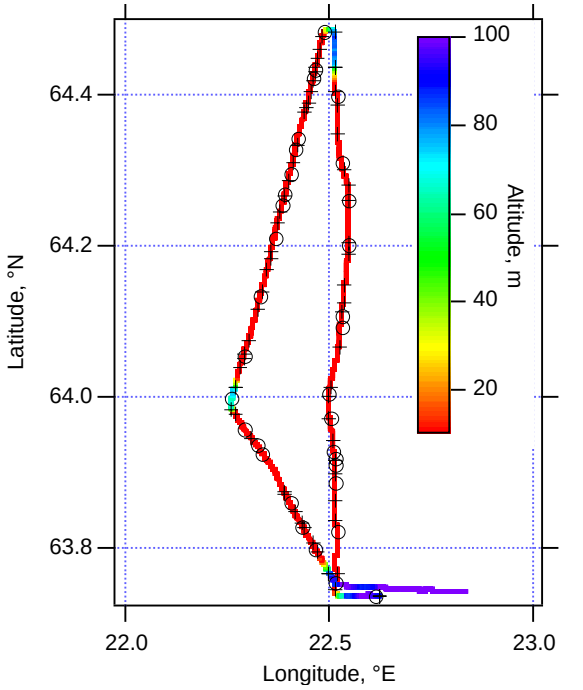
White ice floes interspersed with nilas

Flight # 8; Film 11, photos 1-3 on the way				
#	Position N	Position E	Altitude [m]	Remark
172	63°45.699	22°30.709	89	photos 4+5, transition fast / pack ice
173	63°47.367	22°27.740	58	nilas and grey ice, with ridging
174	63°47.990	22°26.349	58	smooth nilas area, > 100 m across
175	63°48.453	22°25.423	58	floes with rims, brash ice, smooth grey ice floes
176	63°49.808	22°22.823	55	crossing a ship track
177	63°50.285	22°21.940	55	crossing dark nilas
178	63°50.906	22°20.702	55	photos 6-9
179	63°53.349	22°15.036	57	photos 10,11
180	63°54.529	22°12.368	53	photo 12
181	63°56.255	22°08.903	56	photo 13
182	63°57.903	22°08.493	62	photos 14+15
183	64°00.445	22°07.663	33	photos 16-20
184	64°02.521	22°07.306	32	nilas with small fragments of thicker ice
185	64°04.092	22°07.516	33	very smooth dark nilas
186	64°06.264	22°08.303	37	photos 21+22
187	64°09.275	22°07.585	27	start flooded grey ice
188	64°10.000	22°07.364	29	end flooded grey ice
189	64°10.453	22°07.241	31	dark nilas
190	64°11.046	22°07.123	38	small pancakes; later photo 23
191	64°13.082	22°06.311	34	floes with raised rims, smooth broken ice floes (flooded)
192	64°14.022	22°05.846	30	larger patches of smooth grey ice between dark nilas, thicker grey or grey white floes, flooded
193	64°15.570	22°05.355	30	pancake field
194	64°15.965	22°05.233	30	pancakes + flooded floes in varying fractions
195	64°17.093	22°04.813	31	over smooth dark nilas, narrow open water lead
196	64°18.448	22°04.437	34	flooded grey ice, partly broken
197	64°20.112	22°03.980	32	dark, smooth nilas
198	64°21.089	22°03.677	38	ice fragments, mixed with open water and pancake patches: photo 23
199	64°22.631	22°03.078	31	open water, larger ice fragments, then smooth grey ice: photos 24,25
200	64°23.445	22°03.220	94	photo 26
201	64°21.047	22°06.859	90	nilas with broken, wet grey (grey-white ?) ice
202	64°18.220	22°10.234	36	broken ice with small fragments between floes, also pancakes
203	64°16.685	22°12.159	34	pancake field to the right
204	64°14.869	22°14.610	33	bands of pancakes with varying roughness, then broken floes with fragments between them
205	64°12.559	22°16.832	34	floes with ridging (convergent) or fragments between them (divergent)
206	64°10.532	22°18.964	38	very inhomogeneous: nilas, grey ice floes, fragments
207	64°07.969	22°21.646	36	larger grey ice floes with ice fragments between them
208	64°07.123	22°22.541	35	grey-white ice with ridges
209	64°03.307	22°26.572	31	photo 27
210	64°02.968	22°26.929	31	same situation
211	64°01.923	22°27.990	93	photo 28
212	63°59.99	22°29.833	123	ship track
213	63°57.013	22°34.753	31	film # 12, photo 00, later crossing a ship track
214	63°54.346	22°34.454	32	ridged level (fast ?) ice, photos 0
215	63°49.791	22°33.101	32	photo 1+2
216	63°46.595	22°31.641	32	over narrow strip (100 m) of rubble fast ice
217	63°45.158	22°31.050	30	end of strip
218	63°44.566	22°31.559	34	ship track in fast ice, photos 3-6
219	63°43.996	22°40.183	107	crossing coast line

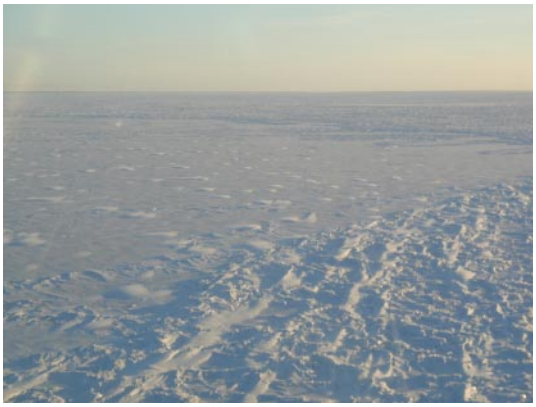
February 20, Flight 3

Flight from Kokkola/Pietarsaari into thicker and older ice in the North.





White ice fragments baked into nilas at the westernmost point of the profile

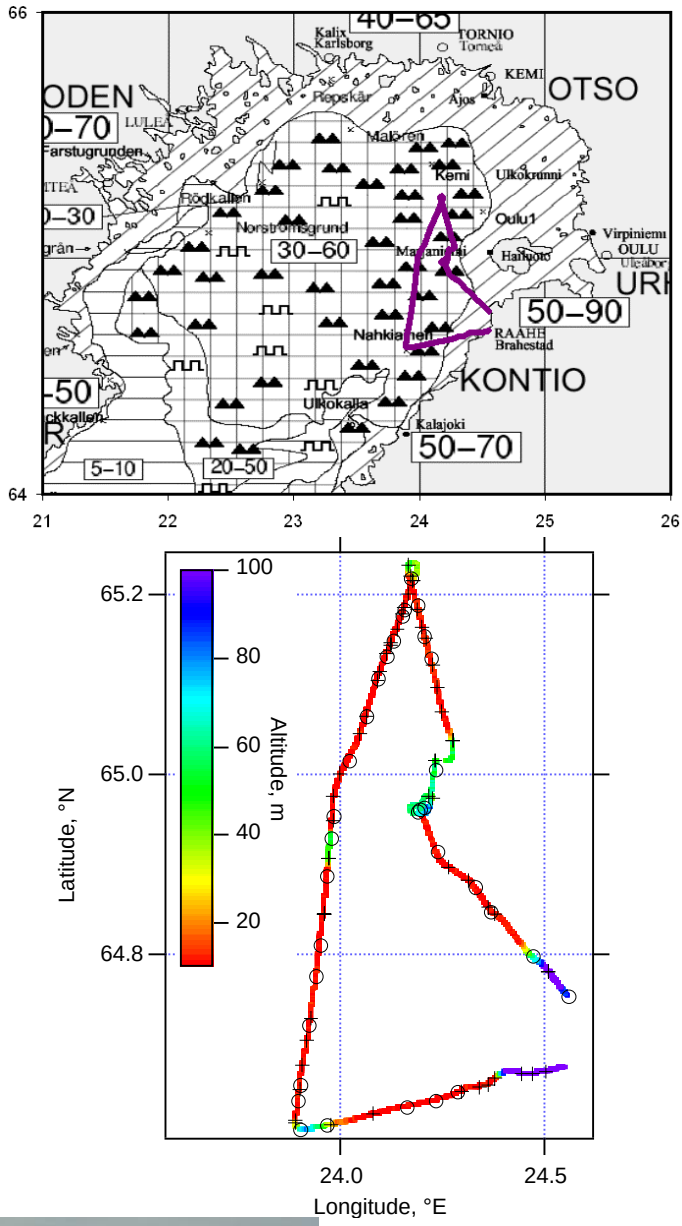


Heavily deformed white ice with snow drifts

Flight # 9, 20/02/03 15:15-16:55 local				
#	Position N	Position E	Altitude [m]	Remark
220	63°45.135	22°30.979	113	fast ice: snow dunes (photos 7-9 on film # 12), overview photos 10+11
221	63°47.764	22°28.117	27	photo 12
222	63°49.635	22°26.210	25	floes with raised rims, ridged grey ice
223	63°51.460	22°24.334	23	broken grey ice, more rafting, less ridging
224	63°55.500	22°20.231	18	photo 13
225	63°56.110	22°19.454	18	same situation
226	63°57.403	22°17.633	17	same situation
227	63°59.807	22°15.800	87	photos 14-16, dark nilas at the horizon to the left
228	64°03.209	22°17.559	28	same situation
229	64°08.011	22°19.944	32	before setting WP crossing ship racks
230	64.12°676	22°22.046	32	photo 17
231	64°15.195	22°23.220	2	photos 18+19
232	64°16.120	22°23.636	11	photos 20+21
233	64°17.691	22°24.312	17	crossing ship tracks
234	64°19.694	22°24.989	0	ridged grey ice, broken floes
235	64°20.584	22°25.369	0	photo 22, “rough islands”
236	64°25.227	22°27.626	6	ship track crossing
237	64°25.975	22°28.000	8	ship track crossing, ridged ice, no “rough islands”
238	64°29.009	22°29.506	0	photos 23+24
239	64°23.953	22°31.142	35	ridged grey + grey-white ice, 10% nilas
240	64°18.577	22°31.891	20	same situation, wind induced roughness: photo 25
241	64°15.484	22°32.829	19	floes with rough surface, ship tracks
242	64°12.097	22°32.966	21	same situation, many wind induced undulations
243	64°06.299	22°31.881	39	ship track + narrow lead
244	64°05.478	22°31.823	13	consolidated pancake cover, later slightly ridged grey ice
245	64°00.113	22°29.950	35	same situation
246	63°58.292	22°30.179	37	larger grey ice floes with rafting and a few small ridges
247	63°55.687	22°30.814	29	broken grey ice
248	63°55.106	22°30.854	28	rafted grey ice, ship racks
249	63°54.475	22°30.926	29	ridging
250	63°53.205	22°30.972	32	ship track, then fast ice with “dunes”, photos 26-28
251	63°49.259	22°31.176	33	same
252	63°44.203	22°36.685	117	same
Departure from airfield 17:15, arrival in Raahe 19:15				

February 21, Flight 1

Flight from Raahe into thick deformed, snow covered white ice; Some searching for earlier FMHI surface profiles close to Hailuoto.



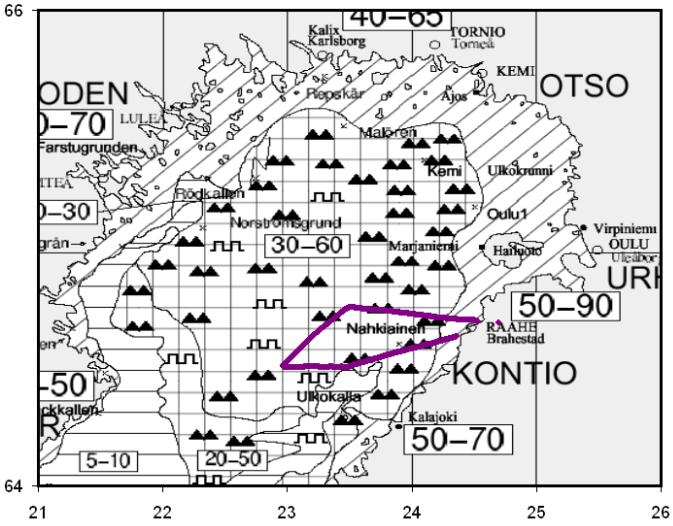
Thick, deformed snow covered ice

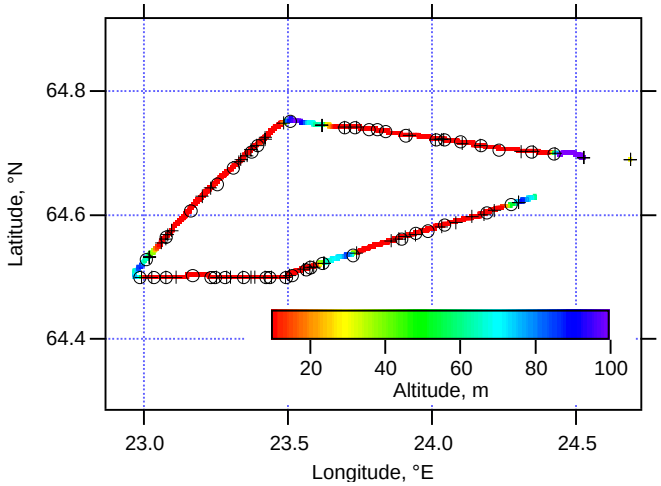
Ship channel at approaches to Raahe

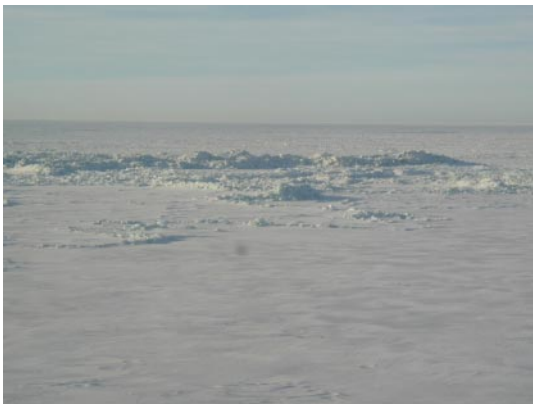
21/02/03, airfield north of Raahe arrival 9:20; position 64°41.256N 24°41.659E, Flight 10, 10:30-12:15 local; film # 13, photos 0-4 on the airfield				
#	Position N	Position E	Altitude [m]	Remark
253	64°45.226	24°33.721	107	fast ice
254	64°47.920	24°28.425	87	photos 5+6
255	64°50.923	24°22.432	31	photos 7+8, transition fast – pack ice
256	64°52.480	24°19.950	26	photos 9-12 taken between WP 255 and 257
257	64°54.823	24°14.363	23	photo 13, wind-induced roughness
258	64°57.744	24°11.913	51	photos 14-17
259	64°57.862	24°12.588	30	searching for “validation profile”
260	64°57.460	24°11.406	36	photos 20+21: “rough islands”
261	65°00.348	24°14.131	37	photos 22+23
262	65°07.676	24°13.459	33	photo 24, narrow lead, nilas, grey-white ice under snow
263	65°09.224	24°12.622	21	photos 25+26, ship tracks
264	65°11.323	24°11.523	17	photo 27, ship tracks
265	65°13.109	24°10.471	14	photo 28, large smooth floes 50-100m with ridges between wind-induced roughness
266	65°10.994	24°09.568	49	more ridged ice, starting film # 14
267	65°10.525	24°09.191	33	large smooth floes (scale 1 km), photos 0+1
268	65°08.945	24°07.811	26	photo 2 to the right: belt of grey ice with heavy ridging
269	65°07.897	24°06.949	23	photo 3: ship track
270	65°06.396	24°05.666	23	photos 4-12
271	65°03.915	24°03.929	23	photos 13-15
272	65°00.963	24°01.346	24	photos 16+17
273	64°57.286	23°59.077	25	photos 18-20
274	64°55.787	23°58.851	75	photos 21-23, ridges with flooding; photo 24
275	64°53.219	23°58.254	36	photo 25
276	64°48.617	23.57.168	34	photo 26
277	64°46.599	23°56.614	23	entering a very rough zone; photo 27: ridge flooding
278	64°43.339	23°55.654	22	film # 15, starting with Mikko’s hat
279	64°39.332	23°54.177	27	photos 1+2
280	64°38.312	23°53.986	29	photo 3
281	64°36.418	23°54.223	64	photos 4+5
282	64°36.611	23°58.135	32	photos 6+7
283	64°37.898	24°09.917	23	photos 8+9 (transition to fast ice)
284	64°38.318	24°14.074	26	reaching the fast ice
285	64°38.842	24°17.558	23	crossing ship track to harbour
286	64°39.794	24°23.086	22	harbour area, photos 10+11

February 21, Flight 2

Flight from Raahe towards west, into more broke ice fields with refrozen leads in between.







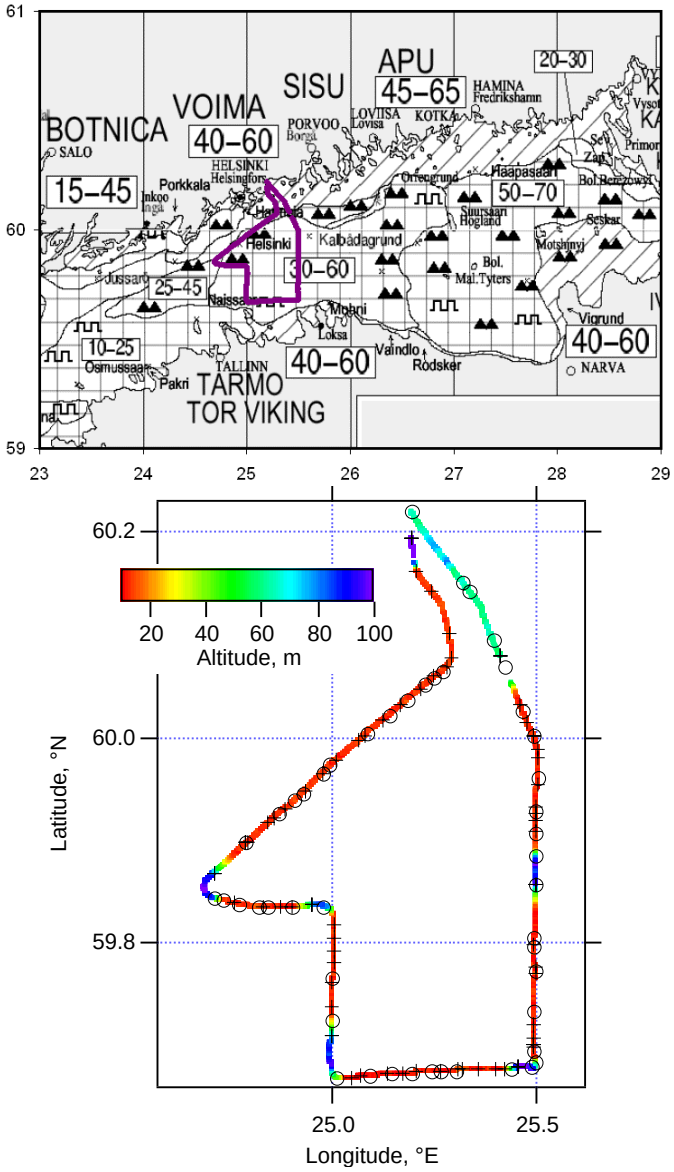
Grounded ridges at fast ice / drift ice boundary

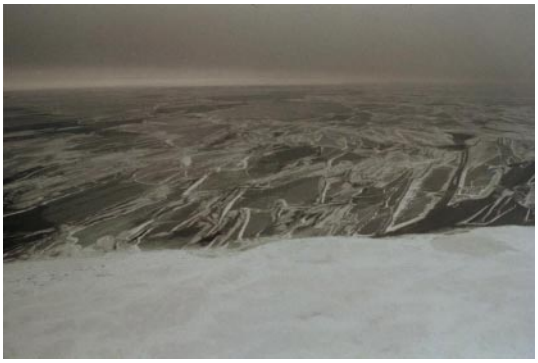
Old floes interrupted by refrozen leads

Photos 12-14, break; Flight 11: 13:55-15:45, still film # 15				
#	Position N	Position E	Altitude [m]	Remark
287	64°38.278	24°26.467	105	photo 15
288	64°36.912	24°16.635	68	first single ridges on fast ice
289	64°36.107	24°11.486	24	photo 16: huge ridge; after this level ice with a rougher surface, ridged, snow covered, single spots of grey ice
290	64°34.953	24°02.729	23	ridged ice
291	64°34.505	23°59.182	25	smooth level with wind-induced roughness
292	64°34.177	23°56.830	26	smooth grey ice with rough “islands”, later ridged ice
293	64°33.703	23°53.527	25	photo 17
294	64°32.125	23°43.356	87	photos 18+19 (high altitude), photo 20: wind features
295	64°31.249	23°37.245	73	distinct ridge
296	64°30.885	23°34.821	28	next distinct ridge belt
297	64°30.745	23°33.851	26	next distinct ridge belt, then grey ice: photo 21
298	64°30.211	23°30.883	28	ridged grey ice
299	64°29.958	23°29.747	31	same
300	64°30.024	23°26.246	33	photos 22+23
301	64°29.995	23°25.198	31	enter snow covered zone, very mixed surface types (smooth, rough, ridged), spots of bare grey ice; photo 24: ridge with flooding
302	64°30.006	23°20.500	31	smooth level with wind-induced roughness, 1 ship track, cracks in the ice
303	64°29.995	23°16.997	32	ridge belt
304	64°30.003	23°14.905	33	ridged grey ice with snow patches
305	64°30.031	23°13.754	36	bare and snow covered grey ice 50/50 areal coverage
306	64°30.060	23°10.122	36	photo 25
307	64°29.919	23°04.630	30	ship track
308	64°29.953	23°01.848	30	grey (“milky”) ice, partly snow covered, with cracks, closing ship tracks, very low ridge density
309	64°29.939	22°59.205	51	photo 26
310	64°31.610	23°00.562	85	photo 27
311	64°33.882	23°04.753	32	for a short while flying almost parallel to a ship track
312	64°36.464	23°09.848	30	ridge density higher than before; photo 28
313	64°38.989	23°15.084	27	ridge density low again
314	64°40.530	23°18.695	27	closing ship track
315	64°42.145	23°22.390	29	ship track
316	64°42.639	23°23.589	26	entering a rougher zone with more roughness islands and larger, broader ridges. But there are still larger smooth floes.
317	64°45.088	23°30.566	112	same situation; ice fragments between ice floes, ice is cracked, most parts are snow covered
318	64°44.398	23°41.716	31	same situation
319	64°44.356	23°44.145	30	high ridge density
320	64°44.225	23°46.942	46	ridges and rubble ice
321	64°44.134	23°48.521	41	start of a smooth ice floe
322	64°44.004	23°50.415	38	end of the smooth floe, later: ship track
323	64°43.694	23°54.687	14	centre of very rough area
324	64°43.259	24°00.852	27	entering a ridged area
325	64°43.172	24°02.448	32	leaving the ridged area
326	64°43.032	24°05.909	0	crossing narrow grey ice lead (smooth surface)
327	64°42.651	24°10.094	32	crossing smooth grey ice, then rough snow covered ice again
328	64°42.357	24°14.240	31	smooth fast ice
329	64°42.053	24°20.660	31	crossing first islands at the coast
330	64°41.837	24°25.394	36	crossing coastline

February 23, Flight 1

Western flight from Helsinki to Estonia, over white ice floes with refrozen leads and open water in between.





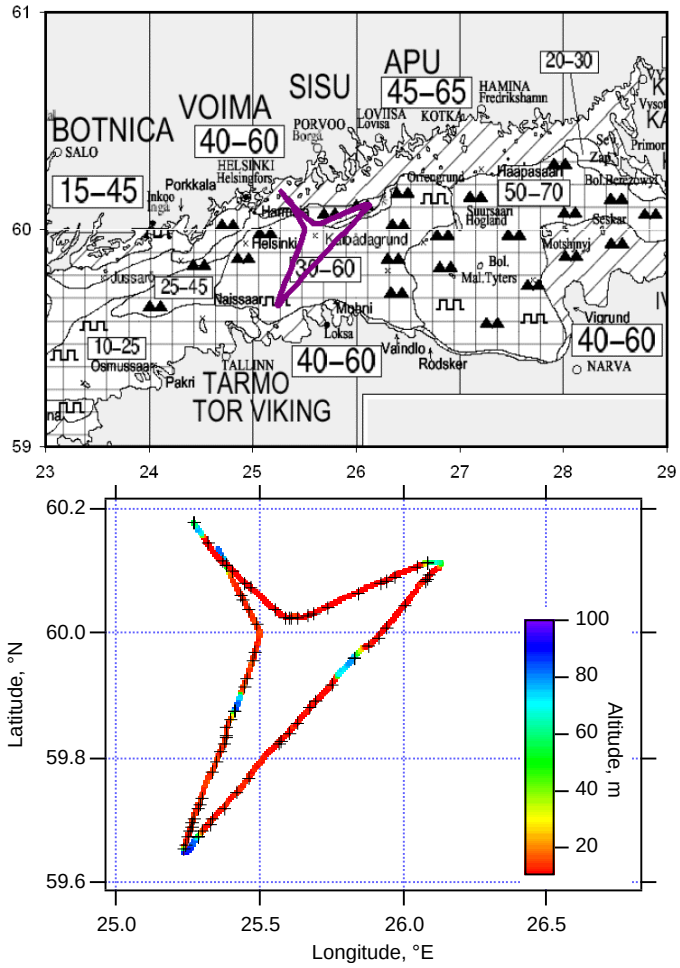
Nilas covered coastal polynja off Helsinki

Broken white ice floes

23/02 leaving hotel 9:00, Flight 13 10:15-12:00, still film #16; photos 18, 19: Malmi Airfield (60°14.923N, 25°02.983E); photos 20+21: Helsinki from the air				
#	Position N	Position E	Alt. [m]	Remark
339	60°13.212	25°11.733	82	over fast ice
340	60°09.045	25°19.412	86	still fast ice, last coastal islands, ship track on the left
341	60°08.588	25°20.282	85	ship track
342	60°05.660	25°23.904	79	photos 22+23: over rafted nilas
343	60°04.072	25°25.620	80	photos 24+25
344	60°01.533	25°28.227	6	photos 26-28
345	60°00.120	25°29.668	20	ship tracks
346	59°57.540	25°30.314	25	same situation as WP 344, new film # 17, photos 0-2
347	59°55.639	25°30.120	32	same situation
348	59°54.305	25°30.204	31	photo 3
349	59°53.013	25°30.283	82	again ship tracks
350	59°51.311	25°30.217	112	photos 4-11
351	59°48.203	25°29.955	40	smoother, snow covered area
352	59°47.761	25°29.954	38	rougher again (broken floes, a few ridges)
353	59°46.242	25°30.022	31	crossing narrow open water lead (10 m wide, 100 m long)
354	59°43.972	25°29.897	32	photo 12
355	59°41.570	25°29.953	32	between WP 354 and 355: photos 13-17
356	59°41.000	25°29.986	46	ridged ice
357	59°40.628	25°29.324	115	photos 18, 19, 20
358	59°40.600	25°26.427	124	photos 21-24
359	59°40.481	25°18.442	33	photo 25
360	59°40.476	25°15.964	28	large dark nilas lead again
361	59°40.433	25°14.711	26	film # 18, photo 0
362	59°40.340	25°11.955	24	photos 1+2
363	59°40.279	25°08.840	24	photos 3+4
364	59°40.155	25°05.725	22	mixed ice types
365	59°40.039	25°00.871	34	light+dark nilas, open water leads
366	59°43.364	24°59.979	44	photos 5-15, taken between WP 364+366
367	59°45.838	25°00.287	30	photo 16-18
368	59°50.090	24°58.888	76	photo 19
369	59°50.098	24°54.309	94	broken smooth ice, ship tracks
370	59°50.089	24°50.696	45	photo 20
371	59°50.089	24°49.270	38	ridged level ice
372	59°50.241	24°46.464	37	lead covered with light nilas
373	59°50.415	24°44.253	36	nilas between broken grey-white ice
374	59°50.552	24°42.769	48	photos 21-22
375	59°53.761	24°47.560	37	over open water (20x50m) adjacent another open water patch
376	59°55.563	24°52.393	31	broken smooth ice with a few ridges
377	59°56.264	24°54.684	32	photo 23 (ship)
378	59°56.741	24°55.899	31	broken, fragmented ice with lots of ship tracks
379	59°57.888	24°58.846	32	same situation
380	59°58.350	24°59.905	31	larger floes, 10s of metres, with ridges
381	60°00.228	25°05.326	30	photo 24
382	60°01.299	25°08.533	28	same situation
383	60°02.164	25°11.086	35	larger floes, 10s of metres, with ridges
384	60°03.111	25°13.972	34	photo 25
385	60°03.481	25°15.124	33	close to narrow open water lead
386	60°03.882	25°16.358	34	a larger area with dark nilas with “islands“ of thicker, snow covered ice
387	60°04.386	25°17.523	34	crossing coastal lead, start
388	60°05.777	25°17.480	35	coastal lead end
389	60°07.098	25°16.726	32	smoother fast ice
390	60°07.917	25°16.013	35	passing first coastal islands
391	60°09.622	25°12.719	35	crossing ship track
392	60°12.795	25°11.356	125	entering coastal area

February 23, Flight 2

Eastern flight from Helsinki to Estonia, over white ice floes with refrozen leads and open water in between.



Man-made leads in the central Gulf of Finland

Recently formed ridges close to Finnish fast ice edge

APPENDIX II

File inventory

This appendix summarises all files acquired with the EM bird and laser. The tables show columns with:

1. File name
2. File size
3. Date of acquisition
4. Time of acquisition
5. Comments on file contents

Feburary 17

Second flight from Helsinki, towards West

02171308.dat	526.59	17.02.2003	13:09	1 null
02171309.dat	4.173.486	17.02.2003	13:19	2 profile
02171333.dat	8.239.896	17.02.2003	13:52	3 null + cal
02171319.dat	501.744	17.02.2003	13:20	4 profile, unintentionally interrupted
02171320.dat	4.892.452	17.02.2003	13:31	5 null, cal; out of cal?
02171331.dat	559.540	17.02.2003	13:33	6 profile
02171352.dat	494.736	17.02.2003	13:53	7 null, cal, null
02171354.dat	3.421.466	17.02.2003	14:02	8 profile
02171403.dat	545.182	17.02.2003	14:04	9 null, cal
02171404.dat	8.416.065	17.02.2003	14:24	10 profile & channel
02171424.dat	1.234.042	17.02.2003	14:27	11 null, radio

Feburary 18

Too much noise around Pori!

02181139.dat	6.679.446	18.02.2003	11:55	1 approach & profile
02181155.dat	3.851.641	18.02.2003	12:04	2 new trial with profile
02181205.dat	1.190.649	18.02.2003	12:07	3 null + cal check
02181208.dat	2.345.139	18.02.2003	12:14	4 profile, better noise
02181214.dat	754.690	18.02.2003	12:16	5 some nulling + call'ing
02181216.dat	4.919.098	18.02.2003	12:29	6 profile, reasonable
02181229.dat	509.337	18.02.2003	12:30	7 null
02181231.dat	2.869.454	18.02.2003	12:40	8 increased altitude (40 m)just for laser
02181249.dat	912.941	18.02.2003	12:51	9 repeated landing after system re-start

Feburary 19

First flight out of Kaskinen

02190835.dat	442.174	19.02.2003	8:36	1 Null, cal
02190836.dat	3.539.780	19.02.2003	8:45	2 profile
02190845.dat	527.148	19.02.2003	8:46	3 Null, cal
02190846.dat	4.280.893	19.02.2003	8:56	4 profile
02190856.dat	566.578	19.02.2003	8:58	5 Null, cal
02190858.dat	8.010.486	19.02.2003	9:17	6 profile
02190917.dat	540.491	19.02.2003	9:18	7 Null, cal
02190919.dat	2.557.848	19.02.2003	9:25	8 profile
02190925.dat	2.400.113	19.02.2003	9:31	9 profile after turn
02190931.dat	613.303	19.02.2003	9:33	10 Null, cal
02190933.dat	6.190.516	19.02.2003	9:47	11 profile
02190947.dat	654.783	19.02.2003	9:49	12 Null, cal
02190949.dat	48.705	19.02.2003	9:49	13 ???

Second flight out of Kaskinen

02191115.dat	631.639	19.02.2003	11:17	1 Null, cal check, cal
02191117.dat	5.932.251	19.02.2003	11:31	2 profile
02191131.dat	514.35	19.02.2003	11:32	3 Null, cal
02191133.dat	7.780.381	19.02.2003	11:51	4 profile
02191151.dat	616.193	19.02.2003	11:52	5 Null, cal
02191152.dat	1.304.645	19.02.2003	11:55	6 profile & turning
02191156.dat	8.932.751	19.02.2003	12:17	7 profile cont'd to south
02191218.dat	586.234	19.02.2003	12:19	8 Null, cal
02191219.dat	3.735.816	19.02.2003	12:28	9 profile
02191228.dat	859.148	19.02.2003	12:30	10 profile
02191231.dat	551.034	19.02.2003	12:32	11 Null, cal check

Feburary 20

First flight out of Kokkola; synchronous with ENVISAT

02200805.dat	1.799.786	20.02.2003	8:09	1 Null, cal check, null
02200810.dat	609.530	20.02.2003	8:11	2 profile, unintentionally stopped
02200811.dat	5.458.104	20.02.2003	8:24	3 profile, cont'd
02200824.dat	431.096	20.02.2003	8:25	4 Null, cal check
02200825.dat	4.490.075	20.02.2003	8:36	5 profile
02200836.dat	2.741.398	20.02.2003	8:43	6 Null, cal check, null, cal check
02200843.dat	5.748.821	20.02.2003	8:56	7 profile
02200857.dat	480.386	20.02.2003	8:58	8 Null, cal
02200858.dat	3.820.199	20.02.2003	9:07	9 profile
02200907.dat	571.463	20.02.2003	9:08	10 Null, cal check, null
02200908.dat	3.597.404	20.02.2003	9:17	11 profile, ENVISAT
02200917.dat	975.172	20.02.2003	9:19	12 Null, cal check

Second flight from Kokkola; shortly after ENVISAT

02201024.dat	1.202.673	20.02.2003	10:27	1 Null, cal
02201027.dat	5.427.490	20.02.2003	10:40	2 profile
02201040.dat	833.882	20.02.2003	10:42	3 Null, cal
02201042.dat	9.036.888	20.02.2003	11:03	4 profile
02201103.dat	804.942	20.02.2003	11:05	5 Null, cal
02201105.dat	6.704.532	20.02.2003	11:21	6 profile
02201121.dat	780.494	20.02.2003	11:23	7 Null, cal
02201123.dat	4.725.729	20.02.2003	11:34	8 profile
02201134.dat	501.472	20.02.2003	11:35	9 Null, cal

Third flight from Kokkola; few hours after ENVISAT

02201322.dat	3.037.831	20.02.2003	13:30	1 Noise analysis, null, cal check
02201330.dat	4.909.807	20.02.2003	13:41	2 profile
02201341.dat	542.657	20.02.2003	13:42	3 Null, cal
02201342.dat	9.822.358	20.02.2003	14:06	4 profile
02201406.dat	779.698	20.02.2003	14:07	5 Null, cal
02201407.dat	12.717.359	20.02.2003	14:37	6 profile
02201438.dat	785.535	20.02.2003	14:39	7 Null, cal check

Feburary 21

First flight from Raahe; strong wind, therefore serious oscillations in f2 due to bird pitch; partially compensated by flying at 40 ft

02210842.dat	650.347	21.02.2003	8:44	1	Null, cal
02210844.dat	4.198.651	21.02.2003	8:54	2	profile
02210854.dat	1.112.980	21.02.2003	8:56	3	Null, cal, turning to look for FIMR profiles
02210901.dat	1.308.231	21.02.2003	9:04	4	Looking for flags, Null, cal
02210907.dat	556.175	21.02.2003	9:08	5	Looking for second line, Null, cal
02210909.dat	3.703.572	21.02.2003	9:17	6	profile to Kemi
02210917.dat	577.142	21.02.2003	9:19	7	Null, cal
02210919.dat	6.727.097	21.02.2003	9:35	8	profile
02210935.dat	633.606	21.02.2003	9:36	9	Nul, cal
02210936.dat	1.426.695	21.02.2003	9:39	10	flying at 40 ft to increase signal
02210939.dat	5.302.504	21.02.2003	9:52	11	cont'd after unintentional break
02210952.dat	4.043.891	21.02.2003	10:02	12	cont'd after turn
02211002.dat	1.122.368	21.02.2003	10:04	13	Null, cal

Second flight from Raahe; string wind, extreme bird pitch and oscillations in f2; played with flight speed and altitude

02211156.dat	97.950	21.02.2003	11:57	1	short noise test on ground
02211210.dat	775.048	21.02.2003	12:12	2	Null, cal
02211212.dat	5.709.485	21.02.2003	12:25	3	profile
02211225.dat	1.092.096	21.02.2003	12:28	4	Null, cal, reduce speed to 50 kn
02211228.dat	8.304.634	21.02.2003	12:47	5	profile
02211248.dat	866.856	21.02.2003	12:50	6	Null, cal check
02211250.dat	6.581.457	21.02.2003	13:05	7	profile, 60 knts
02211305.dat	1.005.119	21.02.2003	13:08	8	Null, cal
02211308.dat	7.658.734	21.02.2003	13:26	9	profile
02211326.dat	791.625	21.02.2003	13:27	10	Null, cal

Feburary 23

First flight from Helsinki to Estonia, more towards west

02230945.dat	397.065	23.02.2003	9:46	1	Null, cal check
02230926.dat	7.886.990	23.02.2003	9:44	2	Profile, cont'd
02230924.dat	829.783	23.02.2003	9:26	3	Profile, interrupted accidentially
02230922.dat	725.528	23.02.2003	9:24	4	Null, cal
02230916.dat	2.636.702	23.02.2003	9:22	5	Profile
02230915.dat	544.107	23.02.2003	9:16	6	Null, cal
02230909.dat	2.426.075	23.02.2003	9:14	7	Profile
02230907.dat	791.271	23.02.2003	9:09	8	Null, cal
02230855.dat	4.864.513	23.02.2003	9:07	9	Profile
02230854.dat	630.399	23.02.2003	8:55	10	Null, cal
02230845.dat	3.747.787	23.02.2003	8:54	11	Profile
02230844.dat	521.333	23.02.2003	8:45	12	Null, cal
02230835.dat	3.612.512	23.02.2003	8:44	13	Profile
xxx				14	Nulling not recorded; system restart & FID reset
02230826.dat	3.083.344	23.02.2003	8:35	15	Approach to profile

Second flight from Helsinki to Estonia, more to the East

02231254.dat	442.086	23.02.2003	12:55	1	Null, cal
02231232.dat	9.545.081	23.02.2003	12:54	2	Profile, costal polynja first
02231231.dat	507.261	23.02.2003	12:32	3	Null, cal check
02231221.dat	4.222.293	23.02.2003	12:30	4	Profile
02231219.dat	624.703	23.02.2003	12:21	5	Null, cal
02231204.dat	6.551.176	23.02.2003	12:19	6	Profile
02231202.dat	698.434	23.02.2003	12:04	7	Null, cal
02231149.dat	5.425.783	23.02.2003	12:02	8	Profile
02231148.dat	515.071	23.02.2003	11:49	9	Null, cal
02231137.dat	4.852.020	23.02.2003	11:48	10	Profile, costal polynja first
02231136.dat	522.498	23.02.2003	11:37	11	Null, cal