

Ocean & Sea Ice SAF

Validation of ice products
January 2002 - September 2004

Version 1.0

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Keld Q. Hansen, Morten Lind, Søren Andersen

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1 Introduction

Validation takes a prominent position in the definition of the Ocean & Sea Ice SAF products. For the sea ice products, quality assurance involves the comparison of the automatic SAF sea ice analyses to navigational ice analyses as well as weekly overview ice charts issued by the ice centres in Denmark and Norway (DMI and DNMI).

For the background and the technical specifications of these products, please see the sea ice product manual available at

<http://saf.dnmi.no/docs/index.shtml>

This report describes the quality of the O&SI SAF sea ice products covering the period 1. January 2002 – 12. September 2004 (32 months).

2 Products Validation methods

For most advantageous utilisation of operational Ice Centre products and experience it was decided to validate the O&SI products west of 0° E/W in two separate ways:

1) Daily O&SI products compared visually / subjectively with the operationally prepared navigation ice charts or other relevant information using 3 categories, defined like:

ICE CONCENTRATION:

Good: SAF product average deviation better than 10%.

Acceptable: Average deviation 10-30%.

Bad: Average deviation more than 30% or major error

ICE EDGE:

Good: SAF product average deviation better than 10 km

Acceptable: Average deviation 10-50 km

Bad: Average deviation more than 50 km or major error

ICE TYPE:

Good: Determines the correct ice type in "most" ice areas

Acceptable: Correct ice type in about 35-65% of ice covered areas

Bad: Correct ice type in less than 35% of ice covered areas or major error

An example of a scheme used through the operational validation period are shown in Appendix A.

2) Once a week the O&SI products compared statistically to the weekly DMI ice analysis for the entire Greenland area. The weekly ice analysis compile all available satellite data, including Radarsat SAR and NOAA-AVHRR for a weekly reference date at 12 UTC (± 24 hours). No additional ice products are believed to have a better accuracy compared with coverage. The Greenland weekly ice analysis for operational use is available at

<http://www.dmi.dk/vejr/ice/iskort/index.html>

All ice analyses (older than 2-3 months) used for validation are available in the DMI archives. The resolution of the data grid extracted from the weekly analysis and the O&SI SAF products is 10 km. There were a few events of data errors and technical problems causing minor data delivery break downs, however these events did not disturb the overall results of the validation.

3 Ice conditions through the validation period

During the 32 months validation of the areas west of 0° E/W the sea ice conditions may generally be described as less ice than normal. Especially in late summer 2002 the East Greenland sea ice retreated to a record low minimum (79°N). The Baffin Bay / Davis Strait ice seasons were characterised by freeze up 2-3 weeks later than normal and break up 2-4 weeks earlier than normal.

4 Validation statistics

4.1 Daily validation of the SAF products

The following three figures summarise the result of the daily validation for the O&SI SAF ice concentration, ice edge and ice type products for the period of January 2002 - September 2004.

Ice concentration

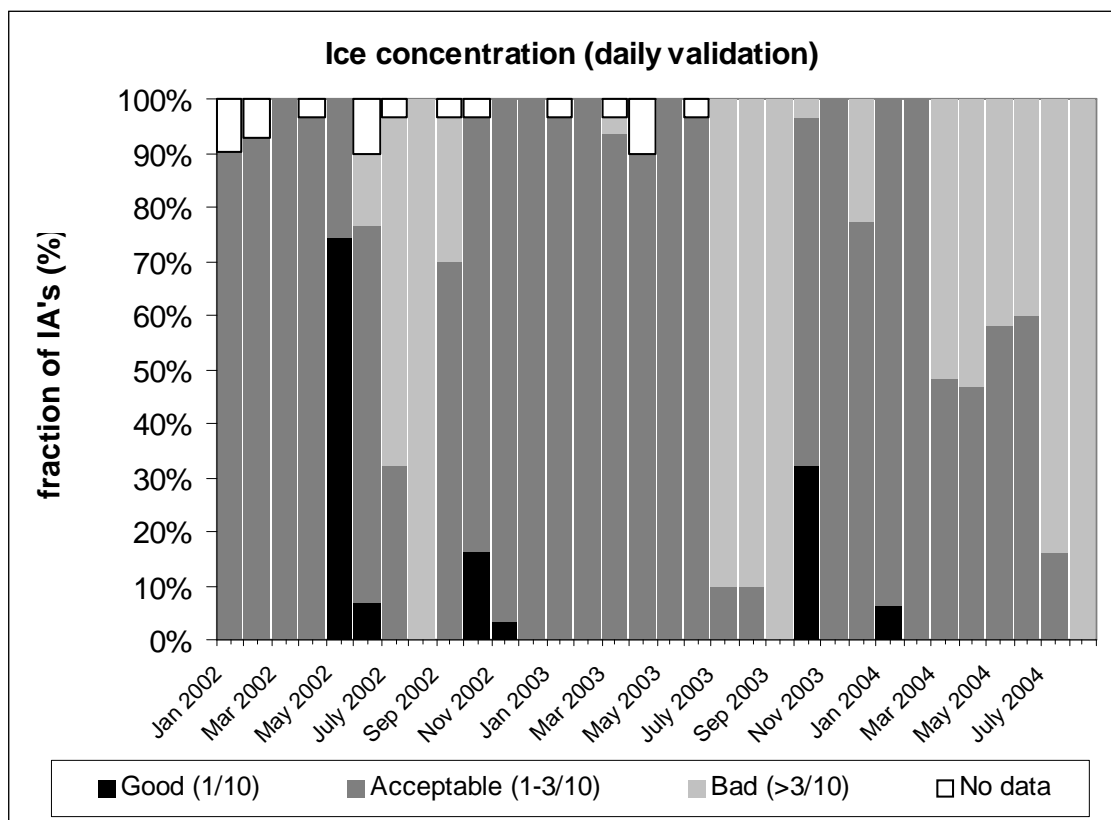


Figure Feil! Ukjent bryterargument.: Bar graph showing the daily validation of the SAF ice concentration product.

Ice edge

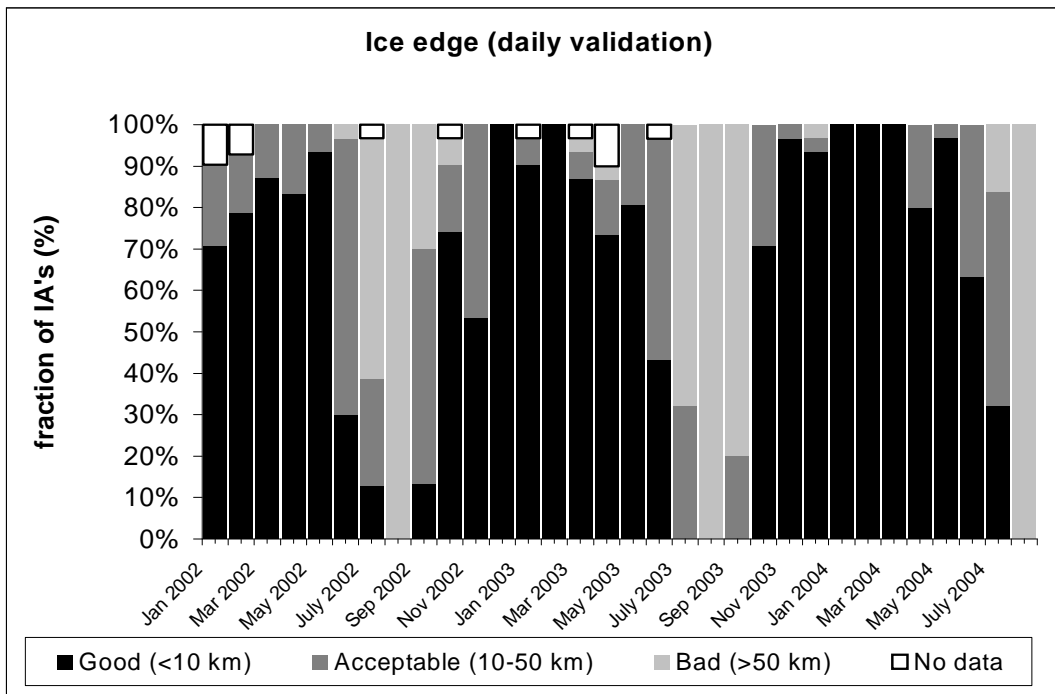


Figure Feil! Ukjent bryterargument.: Bar graph showing the daily validation of the SAF ice edge product.

Ice type

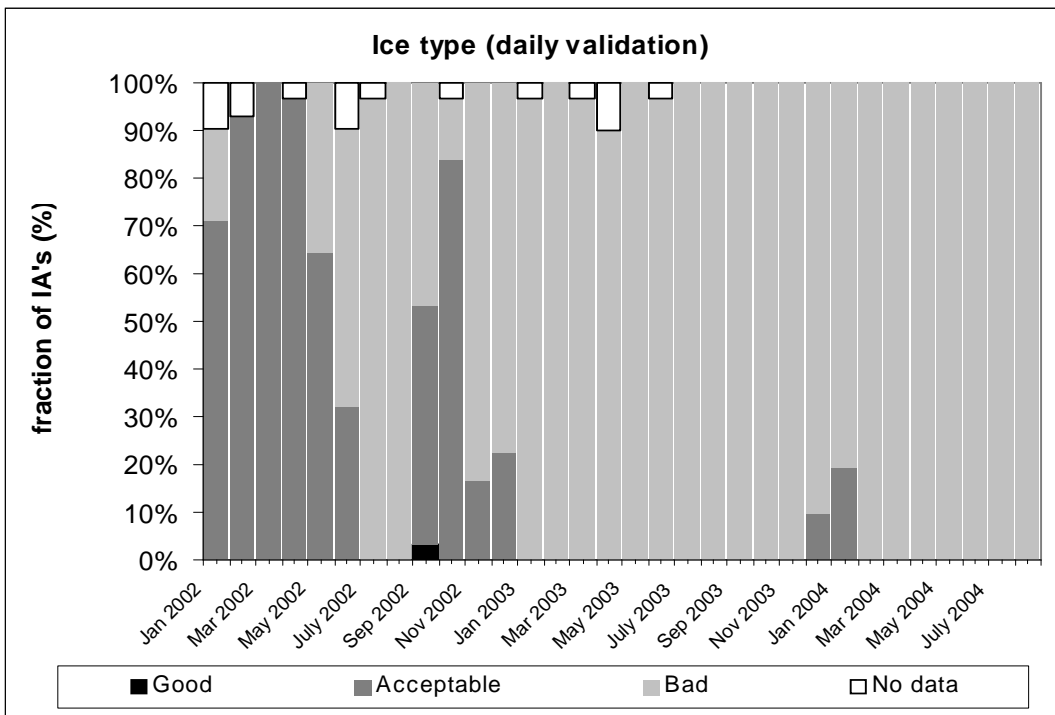


Figure Feil! Ukjent bryterargument.: Bar graph showing the daily validation of the SAF ice type product.

4.2 Weekly comparison of SAF product with the DMI ice analyses

The following two figures show the results of the weekly comparison between the SAF ice concentration/edge products and the weekly DMI ice analyses. The statistics that founds the basis for the following two figures can be found in appendix B.

Ice concentration

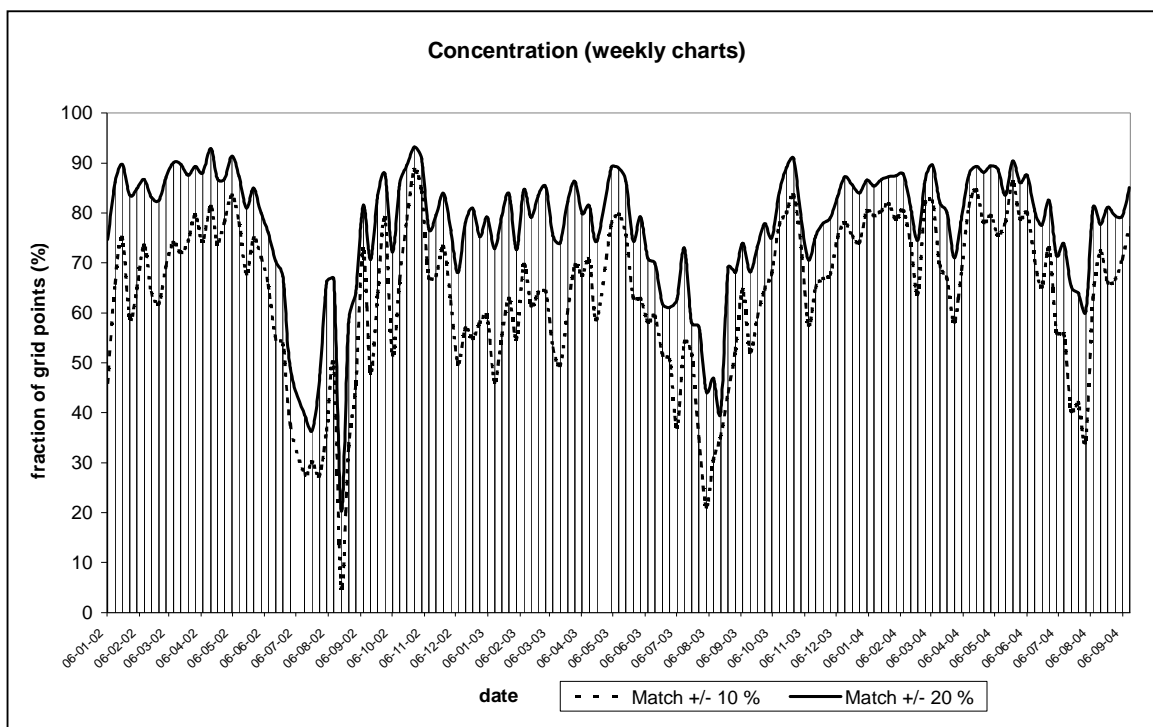


Figure Feil! Ukjent bryterargument.: Comparison between ice concentrations from the weekly DMI ice analysis and the SAF concentration product. 'Match +/- 10 %' corresponds to those gridpoints where concentration deviates within the range of +/-10%. Each vertical line indicates one comparison. The two situations where vertical lines are missing indicates two missing DMI ice analyses.

Ice edge

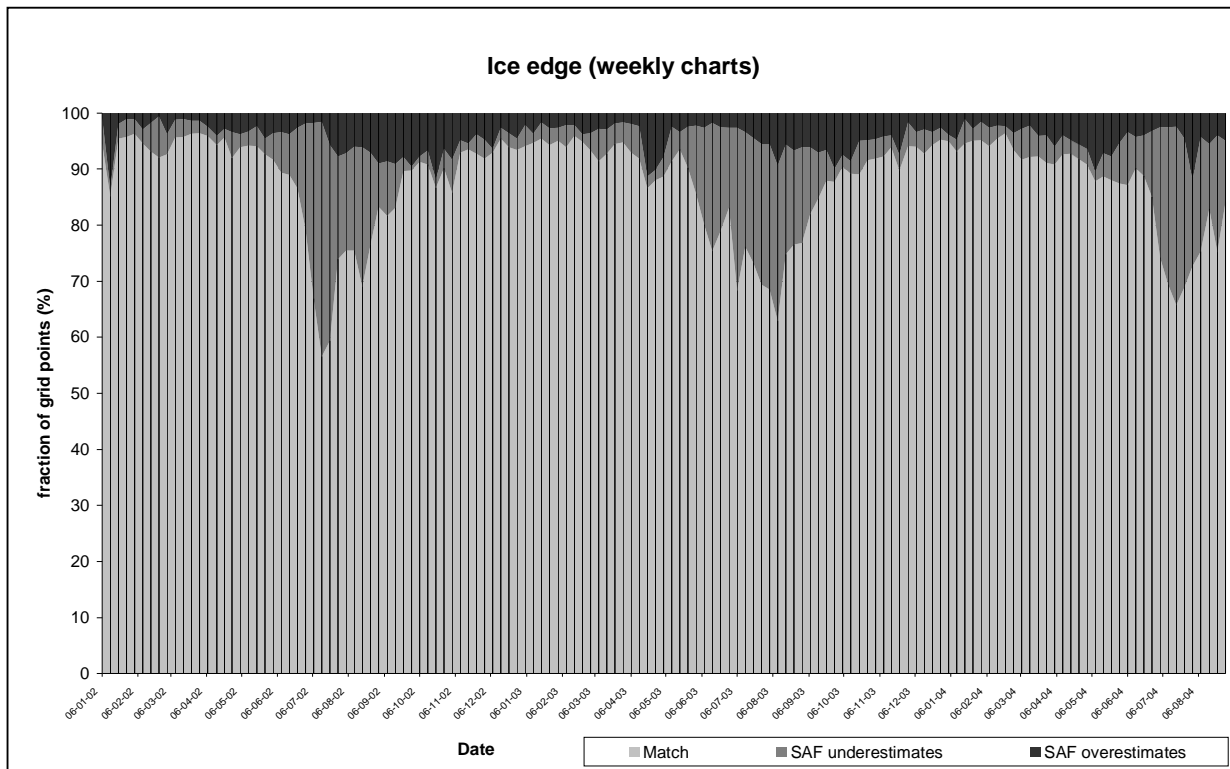


Figure Feil! Ukjent bryterargument.: Area graph showing the comparison between the weekly DMI ice analysis and the SAF edge product. 'SAF underestimates' means grid points where the SAF product indicated water and the DMI ice analysis indicated ice and vice versa for 'SAF overestimates'. Each vertical line indicates one weekly comparison.

5 Comments to validation stats

Each of the three parameters, ice type, ice concentration and ice edge were validated individually but the ice type parameter is hard to evaluate due to lack of direct measurements of the sea ice thickness.

Sea ice concentration

On a weekly basis the O&SI SAF grid was compared with the related weekly ice analysis grid and the quantitative ice concentration match (number of grid points) $\pm 10\%$ and $\pm 20\%$ was determined (see Appendix C for an example of the weekly statistics). Outside the melt season the match $\pm 10\%$ is generally 60-80% and for $\pm 20\%$ it is 80-90%, see **Feil! Ukjent bryterargument..** In melt season, Mid-June to Early September the match decreases dramatically.

Average Match, Summary	$\pm 10\%$	$\pm 20\%$
Concentration, Oct-May	68%	83%
Concentration, June-Sept	48%	63%

Table Feil! Ukjent bryterargument.: The average no. of grid points that match within +/- 10% and +/- 20% on a seasonal basis.

Predominately the SAF product underestimates the sea ice concentration Through the operational validation it was found that the concentration of Baffin Bay / Davis Strait sea ice is estimated better than for sea ice at the Greenland East coast.

Sea ice edge

Through the entire period the ice edge product proved high quality and stability, see **Feil! Ukjent bryterargument.** and **Feil! Ukjent bryterargument..** The match between the weekly ice analysis grid and SAF product grid is calculated as a fraction

$$\frac{\text{Number of matching grid points (ice-ice)}}{\text{matching grid points (ice-ice) + grid points(ice-water) + grid points(water-ice)}}$$

The summary of the weekly statistics is shown in the table below

Average Match, Summary	IA Ice ↔ SAF
Ice edge, Oct-May	92%
Ice edge, June-Sept	77%

Table Feil! Ukjent bryterargument.: No. of grid points that matches ice in both the SAF edge product and the DMI ice analysis.

Sea ice type

The SAF product is generally able to classify the sea ice type (first year ice) correctly in Baffin Bay / Davis Strait but it underestimates the amount of multi-year ice in the East Greenland Current. However, the general sense of this product is that it does not give operational information on top of basic sea ice climatic knowledge.

Appendix

APPENDIX A

DMI SAF Ice edge validation Month

Date	Good	Acc	Bad	Comments	Report to SAF manager
1					
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APPENDIX B

Ice edge IA SAF

Concentration

dato	Ice_ice	Ice-water	water ice	water water	Match %	Match ice	>=20	exact10	exact20	<=20	Match 10%	Match 20%
06-01 2002	16698	782	168	30126	98,0	94,6	8859	7580	12286	18	46,1	74,7
13-01 2002	14484	254	2285	29406	94,5	85,1	4618	9089	11878	82	65,9	86,1
20-01 2002	19208	529	392	29163	98,1	95,4	4403	13851	16588	230	74,9	89,7
27-01 2002	19978	650	233	28392	98,2	95,8	7690	11246	15939	133	59,0	83,6
03-02 2002	19388	527	215	28394	98,5	96,3	6277	12009	15707	231	64,9	84,8
10-02 2002	19371	516	601	28801	97,7	94,5	4398	13580	16015	494	73,5	86,7
17-02 2002	19864	1099	377	27915	97,0	93,1	6736	12486	16216	281	64,0	83,1
24-02 2002	20211	1602	134	27332	96,5	92,1	7377	12567	16769	374	61,9	82,5
03-03 2002	20473	798	828	27116	96,7	92,6	5932	13737	17239	117	69,4	87,1
10-03 2002	21463	696	276	26772	98,0	95,7	5003	15302	18617	364	74,0	90,1
17-03 2002	21707	713	243	26537	98,1	95,8	5509	14971	18663	310	72,0	89,8
24-03 2002	21911	529	308	26623	98,3	96,3	5005	15517	18274	361	74,3	87,5
31-03 2002	20446	469	300	28009	98,4	96,4	3345	15442	17323	619	79,6	89,3
07-04 2002	19972	341	515	28456	98,3	95,9	4413	13968	16538	404	74,4	88,0
15-04 2002	19633	340	840	28487	97,6	94,3	2834	15045	17202	646	81,2	92,9
21-04 2002	19472	308	575	29082	98,2	95,7	4343	13492	15873	435	73,8	86,9
28-04 2002	18816	948	687	28820	96,7	92,0	3390	14334	15900	594	78,3	86,8
05-05 2002	18427	452	748	29747	97,6	93,9	2117	14568	15932	753	83,5	91,4
12-05 2002	19089	499	670	29577	97,7	94,2	3235	14273	15985	794	78,0	87,3
19-05 2002	18887	704	481	29754	97,6	94,1	5425	12478	14879	472	67,9	81,0
26-05 2002	17262	529	845	31183	97,2	92,6	3593	12307	13964	533	74,9	85,0
02-06 2002	16750	863	663	31497	96,9	91,7	4278	11644	13095	457	71,1	80,0
09-06 2002	15935	1295	605	31615	96,2	89,3	5216	10449	12141	291	65,5	76,1
16-06 2002	15268	1247	649	32612	96,2	89,0	6813	8459	10827	130	54,9	70,3
23-06 2002	14479	1812	447	32956	95,5	86,5	6738	8001	10008	128	53,8	67,3
30-06 2002	12844	3064	306	33499	93,2	79,2	9070	5555	7223	130	37,6	49,0
07-07 2002	#/T	#/T	#/T	#/T	#/T	#/T	#/T	#/T	#/T	#/T	#/T	#/T
14-07 2002	9261	4354	239	34974	90,6	66,8	9087	3488	4976	0	27,7	39,6

21-07 2002	8258	6108	227	35178	87,3	56,6	9291	4007	4852	0	30,1	36,5
28-07 2002	6561	3857	637	40394	91,3	59,3	6991	2668	4514	53	27,5	46,5
04-08 2002	6450	1602	672	40971	95,4	73,9	4750	2754	4995	34	36,5	66,3
11-08 2002	6250	1437	595	41879	95,9	75,5	3571	3539	4802	82	49,2	66,8
18-08 2002	5713	1402	453	42649	96,3	75,5	6287	325	1348	10	4,9	20,4
25-08 2002	5649	2035	500	43245	95,1	69,0	4829	2344	4167	0	32,7	58,1
01-09 2002	5615	1212	520	44099	96,6	76,4	3472	2968	4154	51	45,7	64,0
08-09 2002	5856	546	630	44420	97,7	83,3	1624	4429	4960	34	72,8	81,5
15-09 2002	5868	705	616	44304	97,4	81,6	3207	3040	4463	66	48,2	70,7
22-09 2002	6269	597	684	43928	97,5	83,0	2328	4183	5470	40	63,9	83,5
29-09 2002	6745	192	587	43245	98,5	89,6	1344	5276	5873	70	78,9	87,8
06-10 2002	5834	44	623	43115	98,7	89,7	2646	2910	4063	73	51,7	72,2
13-10 2002	6210	66	525	42897	98,8	91,3	1946	4019	5168	59	66,7	85,8
20-10 2002	7429	205	547	42149	98,5	90,8	1497	5764	6551	59	78,7	89,5
27-10 2002	7916	134	1090	41231	97,6	86,6	815	6826	7179	65	88,6	93,2
03-11 2002	8953	340	638	39710	98,0	90,2	1286	7404	7962	80	84,4	90,8
10-11 2002	8831	609	851	39353	97,1	85,8	2874	5956	6831	68	66,9	76,8
17-11 2002	10571	259	547	38095	98,4	92,9	3063	6894	8131	268	67,4	79,5
24-11 2002	11996	142	692	36582	98,3	93,5	3041	8381	9609	27	73,2	83,9
01-12 2002	12586	471	511	35966	98,0	92,8	4618	7694	9443	22	62,4	76,6
08-12 2002	13238	481	689	35112	97,6	91,9	6443	6429	8767	14	49,9	68,0
15-12 2002	14459	110	995	33972	97,8	92,9	5823	7738	10642	52	56,8	78,2
22-12 2002	15449	309	432	32876	98,5	95,4	6629	8069	11909	13	54,8	80,9
29-12 2002	15127	408	582	33135	98,0	93,9	6043	8370	10847	0	58,1	75,3
05-01 2003	16477	358	794	31640	97,7	93,5	6327	9263	12350	12	59,4	79,2
12-01 2003	16678	672	378	31385	97,9	94,1	8425	7317	11533	75	46,3	72,9
19-01 2003	17946	313	697	30225	97,9	94,7	7592	9483	13586	21	55,5	79,5
26-01 2003	18040	554	306	29957	98,2	95,4	6415	10975	14628	64	62,9	83,8
02-02 2003	18022	586	516	29670	97,7	94,2	7745	9509	12572	54	54,9	72,6
09-02 2003	17782	442	490	30067	98,1	95,0	5076	11694	14210	25	69,6	84,6
16-02 2003	18140	762	411	29911	97,6	93,9	6709	10760	13848	24	61,5	79,2
23-02 2003	18859	371	428	29581	98,4	95,9	6417	11390	14873	0	64,0	83,5
02-03 2003	16588	238	655	29228	98,1	94,9	5438	10191	13506	219	64,3	85,2

09-03 2003	16893	558	655	29414	97,4	93,3	7632	8646	12325	62	52,9	75,4
16-03 2003	17444	1090	541	28467	96,6	91,4	8760	8607	12858	0	49,6	74,0
23-03 2003	17827	818	573	28248	97,1	92,8	7017	10532	14439	9	60,0	82,2
30-03 2003	22872	888	449	27931	97,4	94,5	6224	15276	18967	484	69,5	86,3
06-04 2003	22273	825	400	28644	97,7	94,8	6682	14375	17015	236	67,5	79,9
13-04 2003	21894	1210	464	28590	96,8	92,9	5803	15102	17440	519	70,5	81,4
20-04 2003	21587	1367	549	28628	96,3	91,8	8386	12446	15767	368	58,7	74,4
27-04 2003	#/T	#/T	#/T	#/T	#/T	#/T	#/T	#/T	#/T	#/T	#/T	#/T
04-05 2003	19355	479	2542	29754	94,2	86,5	3598	14434	16523	513	77,8	89,1
11-05 2003	19707	415	2276	29762	94,8	88,0	3013	14823	16545	756	79,7	89,0
18-05 2003	19985	785	1766	29562	95,1	88,7	3713	14573	16646	991	75,6	86,4
25-05 2003	20542	1380	554	29664	96,3	91,4	7310	12879	15207	244	63,0	74,4
01-06 2003	17215	583	616	31031	97,6	93,5	5940	10380	13080	191	62,9	79,2
08-06 2003	18024	1475	484	32163	96,2	90,2	7352	10534	12850	229	58,1	70,9
15-06 2003	16879	2407	434	32411	94,6	85,6	7174	10642	12529	118	59,3	69,9
22-06 2003	13458	2908	438	33743	93,4	80,1	7080	7672	9178	93	51,7	61,8
29-06 2003	12242	3724	279	34734	92,1	75,4	7158	7601	9166	254	50,6	61,1
06-07 2003	11954	2828	378	35597	93,7	78,9	8429	5055	8545	135	37,1	62,7
13-07 2003	10095	1733	324	37524	95,9	83,1	4938	5839	7875	14	54,1	73,0
20-07 2003	9476	4032	371	38151	91,5	68,3	6013	6442	7225	5	51,7	58,0
27-07 2003	8421	2272	370	39281	94,8	76,1	6656	3560	5854	2	34,8	57,3
03-08 2003	7969	2430	487	40833	94,4	73,2	7810	2110	4410	47	21,2	44,2
10-08 2003	7002	2535	556	41852	94,0	69,4	6366	2789	4293	0	30,5	46,9
17-08 2003	6258	2363	508	42060	94,4	68,6	5307	2904	3303	13	35,3	40,2
24-08 2003	6002	2643	898	42504	93,2	62,9	4669	3706	5798	14	44,2	69,1
31-08 2003	6803	1781	514	43033	95,6	74,8	3905	4350	5641	26	52,5	68,1
07-09 2003	6438	1419	559	43559	96,2	76,5	2688	4917	5623	3	64,6	73,9
14-09 2003	6576	1467	522	43528	96,2	76,8	3695	4054	5297	17	52,2	68,2
21-09 2003	7298	1063	548	43166	96,9	81,9	3278	4756	5885	8	59,1	73,2
28-09 2003	7979	773	668	42670	97,2	84,7	2964	5442	6546	2	64,7	77,9
05-10 2003	8436	524	634	42451	97,8	87,9	2754	5869	6482	16	67,9	75,0
12-10 2003	8474	218	968	42267	97,7	87,7	1866	6461	7005	0	77,6	84,1
19-10 2003	9581	228	785	41502	98,1	90,4	1847	7456	8306	19	80,0	89,1

26-10 2003	10069	259	969	40814	97,6	89,1	1582	8125	8846	29	83,5	90,9
02-11 2003	11329	754	636	39346	97,3	89,1	3030	8388	9034	21	73,3	79,0
09-11 2003	12521	486	666	38409	97,8	91,6	5112	6984	8564	34	57,6	70,6
16-11 2003	13499	507	686	37121	97,7	91,9	4558	8542	9897	27	65,1	75,4
23-11 2003	14408	562	652	36495	97,7	91,9	4539	9342	10893	101	66,8	77,9
30-11 2003	15196	335	645	35938	98,1	93,7	4637	9807	11437	39	67,7	79,0
07-12 2003	4732	148	393	3816	94,0	88,9	968	3035	3370	40	75,1	83,4
14-12 2003	18463	822	331	32520	97,8	94,0	3601	13823	15451	295	78,0	87,2
21-12 2003	17697	482	644	32269	97,8	93,8	4110	12667	14386	35	75,3	85,6
28-12 2003	19495	901	620	31091	97,1	92,5	4704	14115	15977	203	74,2	84,0
04-01 2004	19020	461	689	30878	97,7	94,1	3348	14469	15589	193	80,3	86,6
11-01 2004	19622	434	539	30966	98,1	95,1	3670	14644	15750	120	79,4	85,4
18-01 2004	19660	232	807	31415	98,0	94,8	3129	14689	15827	440	80,5	86,7
25-01 2004	19791	445	1012	30879	97,2	92,8	3109	15159	16176	265	81,8	87,3
01-02 2004	20556	947	227	30382	97,7	94,5	3880	15585	17315	340	78,7	87,4
08-02 2004	21283	477	643	29539	97,8	94,9	3698	16059	17506	191	80,5	87,8
15-02 2004	21395	722	356	28371	97,9	95,1	5142	14983	16486	189	73,8	81,2
22-02 2004	21798	753	613	28019	97,3	93,9	7306	13190	15392	135	63,9	74,6
29-02 2004	21232	519	494	28240	98,0	95,3	3301	16320	17250	288	82,0	86,6
07-03 2004	22968	295	565	28300	98,4	96,3	3558	17762	19311	237	82,4	89,6
14-03 2004	22151	720	850	28302	97,0	93,1	6193	14526	17164	192	69,5	82,1
21-03 2004	22520	1347	687	27244	96,1	91,5	7253	14933	17907	175	66,8	80,1
28-03 2004	22093	1325	547	27970	96,4	92,0	9031	12647	15440	59	58,2	71,0
04-04 2004	21120	842	941	28693	96,5	91,9	6315	13950	16105	56	68,7	79,3
11-04 2004	20349	1087	900	29733	96,2	90,7	3483	15992	17246	192	81,3	87,7
18-04 2004	19560	682	1301	30576	96,2	90,2	2288	15710	16581	561	84,6	89,3
25-04 2004	19490	698	845	31077	97,0	92,4	2967	14360	16188	1035	78,2	88,2
02-05 2004	19402	507	1003	31204	97,1	92,4	2433	14422	16237	1293	79,5	89,5
09-05 2004	18391	528	1125	32091	96,8	91,3	2228	13083	15353	2002	75,6	88,7
16-05 2004	18117	557	1271	32186	96,5	90,2	2056	13323	14232	1651	78,2	83,6
23-05 2004	16994	340	2014	32752	95,5	86,4	1849	13594	14265	338	86,1	90,4
30-05 2004	17224	811	1385	32686	95,8	87,8	3178	13019	14215	319	78,8	86,1
06-06 2004	16895	822	1484	32937	95,6	87,0	3058	12932	14118	156	80,1	87,4

13-06 2004	16285	1335	998	33021	95,5	86,8	4628	11416	13020	153	70,5	80,4
20-06 2004	15834	1721	614	33471	95,5	86,7	5470	10459	12448	114	65,2	77,6
27-06 2004	14904	931	706	35122	96,8	89,7	3699	10598	11990	245	72,9	82,5
04-07 2004	13543	1113	600	35536	96,6	88,3	5666	7413	9463	151	56,0	71,5
11-07 2004	13030	1815	485	36310	95,5	84,5	5939	7524	9988	70	55,6	73,8
18-07 2004	10920	3423	365	36930	92,7	73,6	7702	5278	8531	95	40,4	65,2
25-07 2004	9469	3839	342	38001	91,9	68,6	6858	5024	7656	85	42,0	64,0
01-08 2004	7919	3825	298	39596	92,0	64,9	6980	3729	6499	69	34,6	60,3
08-08 2004	6867	2647	450	41685	94,0	67,4	3255	5624	7239	56	62,9	81,0
15-08 2004	5116	1080	844	42145	96,1	68,9	1615	4202	4519	0	72,2	77,7
22-08 2004	5923	1607	334	43776	96,2	74,2	2402	4704	5774	14	66,1	81,1
29-08 2004	5726	801	381	44747	97,7	81,9	2031	4057	4837	0	66,6	79,5
05-09 2004	5373	1491	282	44293	96,6	74,2	1891	4602	5164	15	70,7	79,4
12-09 2004	5640	733	332	44539	97,9	83,3	1381	4685	5163	0	77,2	85,1

APPENDIX C

Example of the weekly statistics from the comparison of the SAF ice edge and ice concentration product with the DMI ice analysis.

Reading IA

Ice concentration comparison

Importing SAF CT field

Performing analysis

IA	NP	Error from IA range				exact	<+10%	<+20%	>+20%
		<-20%	>-20%	>-10%					
0 - 0	36423	1	0	0	96	2	1	1	
0 - 10	43	47	0	0	0	0	35	19	
10 - 30	3	33	0	0	0	0	0	67	
30 - 50	96	3	1	23	55	16	2	0	
50 - 70	569	89	11	1	0	0	0	0	
70 - 90	1337	14	5	9	58	15	0	0	
90 - 90	4651	43	20	23	0	13	0	0	
90 - 100	6183	5	4	15	72	4	0	0	
100 - 100	272	71	11	9	8	1	0	0	
Total:	49577	7	3	4	81	4	1	0	

Ice edge comparison

Importing SAF CT field

Performing analysis

Ice edge stats		
IA\SAF	Ice	Water
Ice	13499	507
Water	686	37121