Supplement of Ocean Sci. Discuss., 12, 103–134, 2015
http://www.ocean-sci-discuss.net/12/103/2015/
doi:10.5194/osd-12-103-2015-supplement

Ocean Science
Discussions
Open Access

Supplement of

Atmosphere–ocean interactions in the Greenland Sea during solar cycles 23–24, 2002–2011

P. E. Binns

Correspondence to: P. E. Binns (pebinns@btinternet.com)

CONTENTS

Example of the Results of a 'Monthly' Cluster Analysis (here all Januarys from 2003 to 2011)

The first two columns in each month are the dates, the third is the sequence number, and the fourth and fifth are Euclidean Distance (day-to-day variability) and cluster number.

Euclidean Distance ↓ ↓ Cluster Number

JANUARYs ALL 2003-2011 O.I. DATA.

2003	1	1		6	2004	1	32		8	2005	1	63		20	2006	1	94		16	2007	1	125		15	2008	1	156		21	2009	1	187		16	2010	1	218		16	2011	1	249		2
2003	2	2	11	6	2004	2	33	24	22	2005	2	64	15	20	2006	2	95	16	16	2007	2	126	16	15	2008	2	157	16	21	2009	2	188	16	16	2010	2	219	21	23	2011	2	250	13	2
2003	3	3	12	6	2004	3	34	16	22	2005	3	65	17	20	2006	3	96	26	16	2007	3	127	25	15	2008	3	158	23	21	2009	3	189	14	16	2010	3	220	10	23	2011	3	251	10	2
2003	4	4	12	6	2004	4	35	12	22	2005	4	66	12	20	2006	4	97	28	21	2007	4	128	9	15	2008	4	159	14	21	2009	4	190	13	16	2010	4	221	16	23	2011	4	252	24	10
2003	5	5	15	6	2004	5	36	11	22	2005	5	67	14	20	2006	5	98	13	21	2007	5	129	15	15	2008	5	160	16	21	2009	5	191	13	16	2010	5	222	18	16	2011	5	253	16	10
2003	6	6	21	6	2004	6	37	14	22	2005	6	68	15	20	2006	6	99	19	21	2007	6	130	10	15	2008	6	161	10	21	2009	6	192	20	2	2010	6	223	8	16	2011	6	254	11	10
2003	7	7	12	6	2004	7	38	9	22	2005	7	69	8	20	2006	7	100	18	21	2007	7	131	11	15	2008	7	162	14	21	2009	7	193	26	12	2010	7	224	14	16	2011	7	255	13	10
2003	8	8	27	6	2004	8	39	19	22	2005	8	70	11	20	2006	8	101	16	21	2007	8	132	18	15	2008	8	163	9	21	2009	8	194	17	2	2010	8	225	14	16	2011	8	256	13	10
2003	9	9	15	6	2004	9	40	13	22	2005	9	71	11	20	2006	9	102	16	21	2007	9	133	13	15	2008	9	164	14	19	2009	9	195	12	2	2010	9	226	13	16	2011	9	257	22	14
2003	10	10	18	6	2004	10	41	20	3	2005	10	72	21	20	2006	10	103	18	21	2007	10	134	21	15	2008	10	165	9	19	2009	10	196	17	2	2010	10	227	20	16	2011	10	258	9	14
2003	11	11	12	6	2004	11	42	17	3	2005	11	73	16	20	2006	11	104	38	4	2007	11	135	15	15	2008	11	166	8	19	2009	11	197	13	2	2010	11	228	13	16	2011	11	259	8	14
2003	12	12	13	6	2004	12	43	16	3	2005	12	74	13	20	2006	12	105	19	4	2007	12	136	14	15	2008	12	167	19	19	2009	12	198	16	2	2010	12	229	14	2	2011	12	260	9	14
2003	13	13	12	6	2004	13	44	18	3	2005	13	75	9	20	2006	13	106	33	7	2007	13	137	14	15	2008	13	168	16	19	2009	13	199	13	2	2010	13	230	10	2	2011	13	261	12	14
2003	14	14	24	6	2004	14	45	8	3	2005	14	76	11	20	2006	14	107	25	21	2007	14	138	17	15	2008	14	169	21	19	2009	14	200	19	5	2010	14	231	7	2	2011	14	262	10	14
2003	15	15	17	17	2004	15	46	25	17	2005	15	77	19	20	2006	15	108	20	21	2007	15	139	9	15	2008	15	170	17	19	2009	15	201	11	5	2010	15	232	8	2	2011	15	263	14	14
2003	16	16	11	17	2004	16	47	14	17	2005	16	78	17	20	2006	16	109	17	21	2007	16	140	10	15	2008	16	171	12	19	2009	16	202	24	5	2010	16	233	10	2	2011	16	264	15	14
2003	17	17	13	17	2004	17	48	14	17	2005	17	79	18	20	2006	17	110	17	21	2007	17	141	11	15	2008	17	172	16	2	2009	17	203	32	12	2010	17	234	10	2	2011	17	265	15	14
2003	18	18	12	17	2004	18	49	25	17	2005	18	80	18	13	2006	18	111	12	21	2007	18	142	9	15	2008	18	173	18	2	2009	18	204	27	12	2010	18	235	7	2	2011	18	266	19	14
2003	19	19	15	17	2004	19	50	19	17	2005	19	81	20	13	2006	19	112	16	18	2007	19	143	13	15	2008	19	174	11	2	2009	19	205	8	12	2010	19	236	19	2	2011	19	267	13	14
2003	20	20	16	17	2004	20	51	14	17	2005	20	82	27	20	2006	20	113	14	18	2007	20	144	7	15	2008	20	175	11	2	2009	20	206	10	12	2010	20	237	11	2	2011	20	268	13	14
2003	21	21	10	17	2004	21	52	11	17	2005	21	83	18	20	2006	21	114	29	21	2007	21	145	18	15	2008	21	176	13	2	2009	21	207	8	12	2010	21	238	13	2	2011	21	269	16	14
2003	22	22	15	17	2004	22	53	20	17	2005	22	84	15	20	2006	22	115	13	21	2007	22	146	13	15	2008	22	177	9	2	2009	22	208	8	12	2010	22	239	7	2	2011	22	270	26	14
2003	23	23	18	17	2004	23	54	21	17	2005	23	85	14	20	2006	23	116	23	18	2007	23	147	18	15	2008	23	178	11	2	2009	23	209	12	12	2010	23	240	11	2	2011	23	271	16	14
2003	24	24	19	17	2004	24	55	29	17	2005	24	86	24	20	2006	24	117	20	18	2007	24	148	11	15	2008	24	179	17	2	2009	24	210	7	12	2010	24	241	11	2	2011	24	272	10	14
2003	25	25	14	17	2004	25	56	21	17	2005	25	87	31	9	2006	25	118	17	18	2007	25	149	15	15	2008	25	180	12	2	2009	25	211	8	12	2010	25	242	12	2	2011	25	273	11	14
2003	26	26	13	17	2004	26	57	26	17	2005	26	88	18	9	2006	26	119	12	18	2007	26	150	22	11	2008	26	181	17	2	2009	26	212	12	12	2010	26	243	14	2	2011	26	274	11	14
2003	27	27	6	17	2004	27	58	13	17	2005	27	89	16	9	2006	27	120	21	18	2007	27	151	22	11	2008	27	182	12	2	2009	27	213	15	12	2010	27	244	20	16	2011	27	275	12	14
2003	28	28	13	17	2004	28	59	12	17	2005	28	90	11	9	2006	28	121	22	18	2007	28	152	22	11	2008	28	183	13	23	2009	28	214	13	12	2010	28	245	12	16	2011	28	276	11	14
2003	29	29	17	17	2004	29	60	8	17	2005	29	91	21	9	2006	29	122	17	18	2007	29	153	24	15	2008	29	184	14	23	2009	29	215	8	12	2010	29	246	14	16	2011	29	277	15	14
2003	30	30	14	17	2004	30	61	13	17	2005	30	92	19	9	2006	30	123	31	21	2007	30	154	16	15	2008	30	185	19	23	2009	30	216	9	12	2010	30	247	16	2	2011	30	278	19	14
2003	31	31	23	17	2004	31	62	12	17	2005	31	93	14	9	2006	31	124	20	21	2007	31	155	22	1	2008	31	186	19	23	2009	31	217	19	12	2010	31	248	17	2	2011	31	279	15	14
Sum			451					496					493					605					458					430					442					389					419	
Avg.			15.0					16.5					16.4					20.2					15.3					14.3					14.7					13.0					14.0	
No. Clusters				2					4					3					5					3					4					4					3					3
No. Trans.				1					3					3					8					3					3					5					4					2

KEY TO COLUMNS

1	Year
2	Day date
3	Day sequence number
4	Dissimilarity (Hierarchical)
5	Average' cluster number

Example of the Results of an ‘Annual’ Cluster Analysis (here all June 2005 to May 2006)

Column format as above

JUNE 2005 TO MAY 2006 ALL O.I. DATA.

JUNE	1	1		14	JULY	1	31	11	18	AUG	1	62	19	24	SEPT	1	93	19	8
JUNE	2	2	8	14	JULY	2	32	11	18	AUG	2	63	11	24	SEPT	2	94	15	8
JUNE	3	3	10	14	JULY	3	33	13	18	AUG	3	64	14	24	SEPT	3	95	13	8
JUNE	4	4	13	14	JULY	4	34	12	18	AUG	4	65	11	24	SEPT	4	96	13	8
JUNE	5	5	13	14	JULY	5	35	15	20	AUG	5	66	11	24	SEPT	5	97	21	8
JUNE	6	6	10	14	JULY	6	36	20	20	AUG	6	67	15	24	SEPT	6	98	11	8
JUNE	7	7	15	27	JULY	7	37	14	20	AUG	7	68	9	24	SEPT	7	99	14	8
JUNE	8	8	11	27	JULY	8	38	14	20	AUG	8	69	12	24	SEPT	8	100	8	8
JUNE	9	9	16	27	JULY	9	39	20	2	AUG	9	70	13	24	SEPT	9	101	12	8
JUNE	10	10	11	27	JULY	10	40	14	2	AUG	10	71	10	24	SEPT	10	102	11	8
JUNE	11	11	10	27	JULY	11	41	17	2	AUG	11	72	13	24	SEPT	11	103	12	8
JUNE	12	12	20	27	JULY	12	42	16	2	AUG	12	73	12	24	SEPT	12	104	14	8
JUNE	13	13	18	12	JULY	13	43	14	2	AUG	13	74	17	24	SEPT	13	105	11	8
JUNE	14	14	16	12	JULY	14	44	17	2	AUG	14	75	16	24	SEPT	14	106	16	8
JUNE	15	15	14	12	JULY	15	45	15	2	AUG	15	76	13	24	SEPT	15	107	18	6
JUNE	16	16	13	12	JULY	16	46	11	2	AUG	16	77	15	24	SEPT	16	108	13	6
JUNE	17	17	11	26	JULY	17	47	12	10	AUG	17	78	13	24	SEPT	17	109	9	6
JUNE	18	18	11	26	JULY	18	48	11	10	AUG	18	79	19	24	SEPT	18	110	18	23
JUNE	19	19	12	26	JULY	19	49	17	10	AUG	19	80	11	24	SEPT	19	111	8	23
JUNE	20	20	16	26	JULY	20	50	13	10	AUG	20	81	11	24	SEPT	20	112	13	23
JUNE	21	21	16	26	JULY	21	51	18	10	AUG	21	82	24	8	SEPT	21	113	15	23
JUNE	22	22	18	26	JULY	22	52	11	10	AUG	22	83	16	8	SEPT	22	114	11	23
JUNE	23	23	18	26	JULY	23	53	14	10	AUG	23	84	12	8	SEPT	23	115	10	23
JUNE	24	24	11	26	JULY	24	54	10	10	AUG	24	85	11	8	SEPT	24	116	18	23
JUNE	25	25	13	26	JULY	25	55	17	10	AUG	25	86	11	8	SEPT	25	117	18	23
JUNE	26	26	12	26	JULY	26	56	16	10	AUG	26	87	15	8	SEPT	26	118	20	23
JUNE	27	27	11	26	JULY	27	57	17	10	AUG	27	88	18	8	SEPT	27	119	21	23
JUNE	28	28	16	18	JULY	28	58	11	10	AUG	28	89	16	8	SEPT	28	120	11	23
JUNE	29	29	15	18	JULY	29	59	21	24	AUG	29	90	20	8	SEPT	29	121	19	16
JUNE	30	30	15	18	JULY	30	60	16	24	AUG	30	91	9	8	SEPT	30	122	12	16
					JULY	31	61	15	24	AUG	31	92	15	8					
Sum			393					452					431					424	
Avg.			13.1					15.1					14.4					14.1	
No. Clusters																			
No. Trans.																			

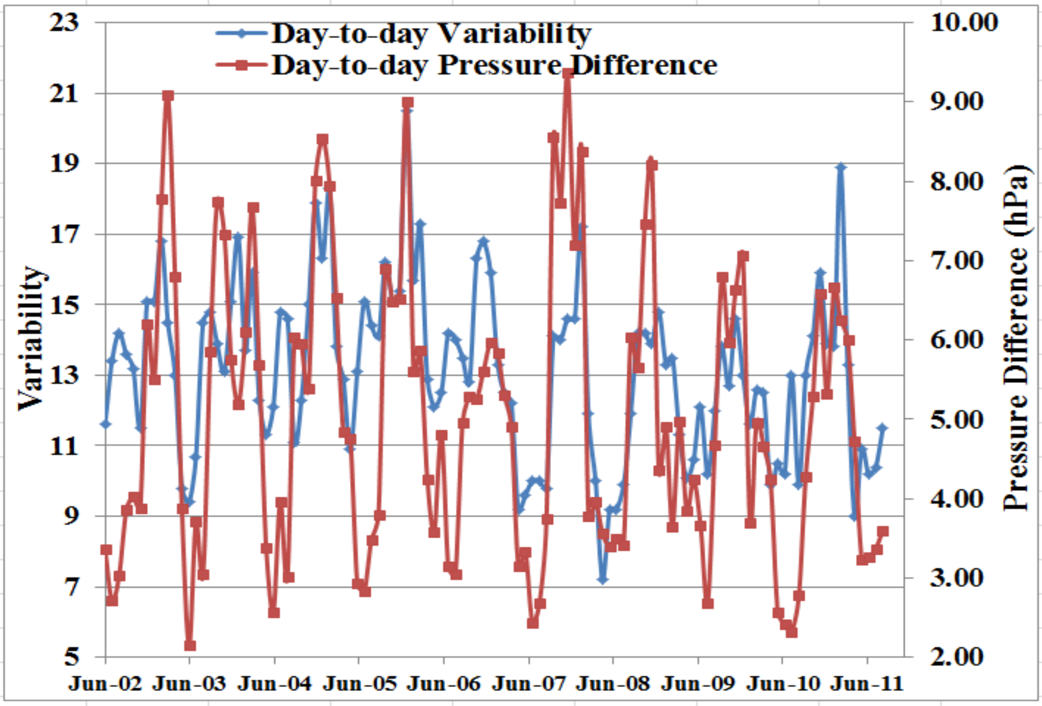
OCT	1	123	17	16	NOV	1	154	13	15	DEC	1	184	18	9	JAN	1	215	9	25
OCT	2	124	18	16	NOV	2	155	32	28	DEC	2	185	17	9	JAN	2	216	16	25
OCT	3	125	10	16	NOV	3	156	26	15	DEC	3	186	13	9	JAN	3	217	26	21
OCT	4	126	11	16	NOV	4	157	14	15	DEC	4	187	11	9	JAN	4	218	28	19
OCT	5	127	14	16	NOV	5	158	12	15	DEC	5	188	11	9	JAN	5	219	13	19
OCT	6	128	15	16	NOV	6	159	16	28	DEC	6	189	25	9	JAN	6	220	19	19
OCT	7	129	17	16	NOV	7	160	11	28	DEC	7	190	14	9	JAN	7	221	18	19
OCT	8	130	26	15	NOV	8	161	15	28	DEC	8	191	14	9	JAN	8	222	16	19
OCT	9	131	14	15	NOV	9	162	8	28	DEC	9	192	10	9	JAN	9	223	16	19
OCT	10	132	14	15	NOV	10	163	13	28	DEC	10	193	19	25	JAN	10	224	18	19
OCT	11	133	22	16	NOV	11	164	11	28	DEC	11	194	12	25	JAN	11	225	38	5
OCT	12	134	18	16	NOV	12	165	17	28	DEC	12	195	17	25	JAN	12	226	19	5
OCT	13	135	21	15	NOV	13	166	14	28	DEC	13	196	10	25	JAN	13	227	33	1
OCT	14	136	10	15	NOV	14	167	24	28	DEC	14	197	13	25	JAN	14	228	25	19
OCT	15	137	11	15	NOV	15	168	12	28	DEC	15	198	20	25	JAN	15	229	20	19
OCT	16	138	25	15	NOV	16	169	9	28	DEC	16	199	18	25	JAN	16	230	17	19
OCT	17	139	23	15	NOV	17	170	14	28	DEC	17	200	14	25	JAN	17	231	17	19
OCT	18	140	12	15	NOV	18	171	11	28	DEC	18	201	22	9	JAN	18	232	12	19
OCT	19	141	18	15	NOV	19	172	12	28	DEC	19	202	12	9	JAN	19	233	16	21
OCT	20	142	15	15	NOV	20	173	15	28	DEC	20	203	17	9	JAN	20	234	14	21
OCT	21	143	12	15	NOV	21	174	9	28	DEC	21	204	17	25	JAN	21	235	29	19
OCT	22	144	9	15	NOV	22	175	11	28	DEC	22	205	16	25	JAN	22	236	13	19
OCT	23	145	10	15	NOV	23	176	14	28	DEC	23	206	16	25	JAN	23	237	23	7
OCT	24	146	14	15	NOV	24	177	16	28	DEC	24	207	14	25	JAN	24	238	20	7
OCT	25	147	12	15	NOV	25	178	22	28	DEC	25	208	16	25	JAN	25	239	17	7
OCT	26	148	15	15	NOV	26	179	16	28	DEC	26	209	11	25	JAN	26	240	12	7
OCT	27	149	8	15	NOV	27	180	17	28	DEC	27	210	16	25	JAN	27	241	21	7
OCT	28	150	19	15	NOV	28	181	18	28	DEC	28	211	20	25	JAN	28	242	22	7
OCT	29	151	22	15	NOV	29	182	18	9	DEC	29	212	8	25	JAN	29	243	17	7
OCT	30	152	20	15	NOV	30	183	12	9	DEC	30	213	11	25	JAN	30	244	31	19
OCT	31	153	16	15						DEC	31	214	9	25	JAN	31	245	20	19
			486					453					461					614	
			16.2					15.1					15.4					20.5	

FEB	1	246	13	19	MAR	1	274	21	22	APR	1	305	8	4	MAY	1	335	12	21
FEB	2	247	22	11	MAR	2	275	14	22	APR	2	306	10	4	MAY	2	336	11	21
FEB	3	248	9	11	MAR	3	276	14	22	APR	3	307	13	4	MAY	3	337	9	21
FEB	4	249	21	11	MAR	4	277	21	22	APR	4	308	13	4	MAY	4	338	10	21
FEB	5	250	14	11	MAR	5	278	14	22	APR	5	309	13	4	MAY	5	339	14	21
FEB	6	251	26	11	MAR	6	279	13	22	APR	6	310	11	4	MAY	6	340	10	21
FEB	7	252	15	11	MAR	7	280	14	22	APR	7	311	8	4	MAY	7	341	21	25
FEB	8	253	13	11	MAR	8	281	14	22	APR	8	312	11	4	MAY	8	342	16	25
FEB	9	254	14	11	MAR	9	282	11	22	APR	9	313	11	4	MAY	9	343	13	25
FEB	10	255	17	11	MAR	10	283	10	22	APR	10	314	13	4	MAY	10	344	9	25
FEB	11	256	19	11	MAR	11	284	26	3	APR	11	315	18	4	MAY	11	345	9	25
FEB	12	257	17	11	MAR	12	285	25	22	APR	12	316	21	4	MAY	12	346	11	25
FEB	13	258	12	11	MAR	13	286	23	22	APR	13	317	19	21	MAY	13	347	8	25
FEB	14	259	20	11	MAR	14	287	25	22	APR	14	318	13	21	MAY	14	348	10	25
FEB	15	260	18	11	MAR	15	288	14	22	APR	15	319	10	21	MAY	15	349	13	25
FEB	16	261	18	11	MAR	16	289	24	22	APR	16	320	11	21	MAY	16	350	12	25
FEB	17	262	22	11	MAR	17	290	13	22	APR	17	321	11	21	MAY	17	351	10	25
FEB	18	263	21	11	MAR	18	291	24	22	APR	18	322	14	21	MAY	18	352	9	25
FEB	19	264	9	11	MAR	19	292	11	22	APR	19	323	15	21	MAY	19	353	9	25
FEB	20	265	15	11	MAR	20	293	19	22	APR	20	324	14	21	MAY	20	354	11	25
FEB	21	266	14	11	MAR	21	294	20	22	APR	21	325	10	21	MAY	21	355	7	25
FEB	22	267	20	22	MAR	22	295	14	22	APR	22	326	14	21	MAY	22	356	12	25
FEB	23	268	14	22	MAR	23	296	22	22	APR	23	327	19	21	MAY	23	357	16	25
FEB	24	269	19	22	MAR	24	297	15	22	APR	24	328	16	21	MAY	24	358	20	25
FEB	25	270	23	17	MAR	25	298	16	13	APR	25	329	14	21	MAY	25	359	17	25
FEB	26	271	18	17	MAR	26	299	17	13	APR	26	330	10	21	MAY	26	360	11	25
FEB	27	272	16	22	MAR	27	300	19	4	APR	27	331	9	21	MAY	27	361	15	28
FEB	28	273	11	22	MAR	28	301	15	4	APR	28	332	14	21	MAY	28	362	10	28
					MAR	29	302	11	4	APR	29	333	10	21	MAY	29	363	10	28
					MAR	30	303	11	4	APR	30	334	12	21	MAY	30	364	10	28
					MAR	31	304	10	4						MAY	31	365	10	28
			472					519					386					364	
			15.7					17.3					12.9					12.1	

KEY TO COLUMNS

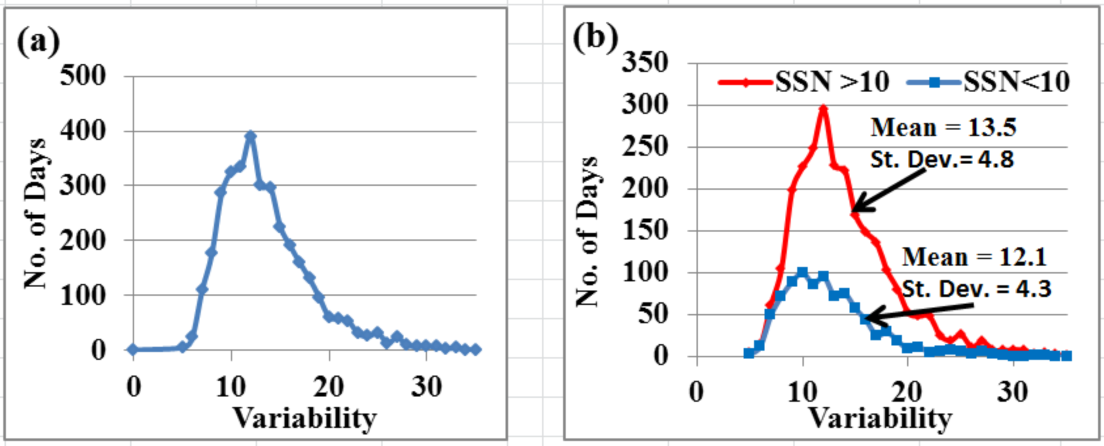
1	Year
2	Day date
3	Day sequence number
4	Dissimilarity (Hierarchical)
5	Average' cluster number

DAY-TO-DAY SST VARIABILITY AND SVALBARD LUFTHAVN SEA LEVEL PRESSURE VARIABILITY



Comparison of the day-to-day variability of the sea surface temperature field with the day-to-day variability of sea level pressure at the onshore meteorological station at Svalbard Lufthavn (eklima@met.no). Taking the seasons individually to avoid seasonal influence on correlation, the correlation coefficients are: MAM: 0.65; JJA: 0.07; SON: 0.49; DJF: 0.56. With the exception of the summer, the correlations are a further indication that day-to-day variability of the sea surface temperature field is real and due to the passage of weather systems.

TESTS OF STATISTICAL SIGNIFICANCE



Frequency distributions, day-to-day variability of the SST fields. The two populations comprise 2525 and 884 values. **(a)** All days. **(b)** Days separated into two groups, according to months with sunspot numbers below and above 10.

Two test methods have been applied, both using MATLAB's statistical toolbox:

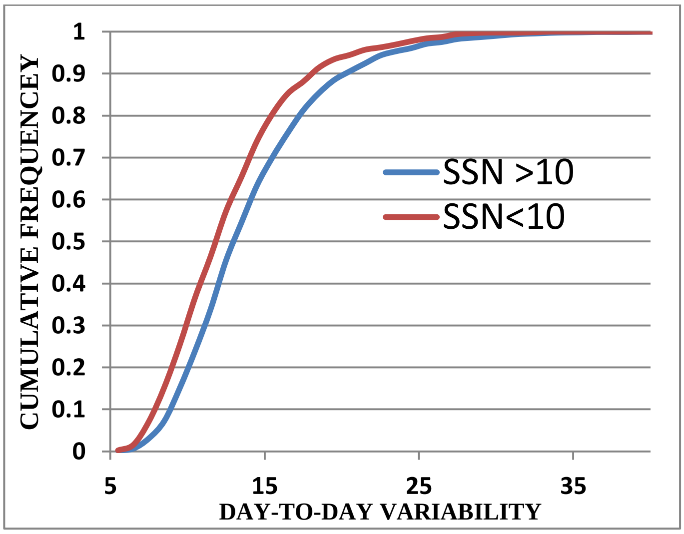
(a) t-test: (MATLAB ttest2, unequal means) "*Returns a test decision for the null hypothesis that the data in two vectors come from independent random samples from normal distributions with equal means and equal but unknown variance, using the two-sample t-test. The alternative hypothesis is that the data [in the two groups] come from populations with unequal means. The result h is 1 if the test rejects the null hypothesis at the 5% significance level*".

(b) Kolmogorov-Smirnov Test: (MATLAB kstest2) "*Returns a test decision for the null hypothesis that the data in two vectors [here groups 1 & 2] are from the same continuous distribution, using the two-sample Kolmogorov-Smirnov test. The alternative hypothesis is that the data [in the two groups] are from different continuous distributions. The result h is 1 if the test rejects the null hypothesis at the 5% significance level and 0 otherwise*".

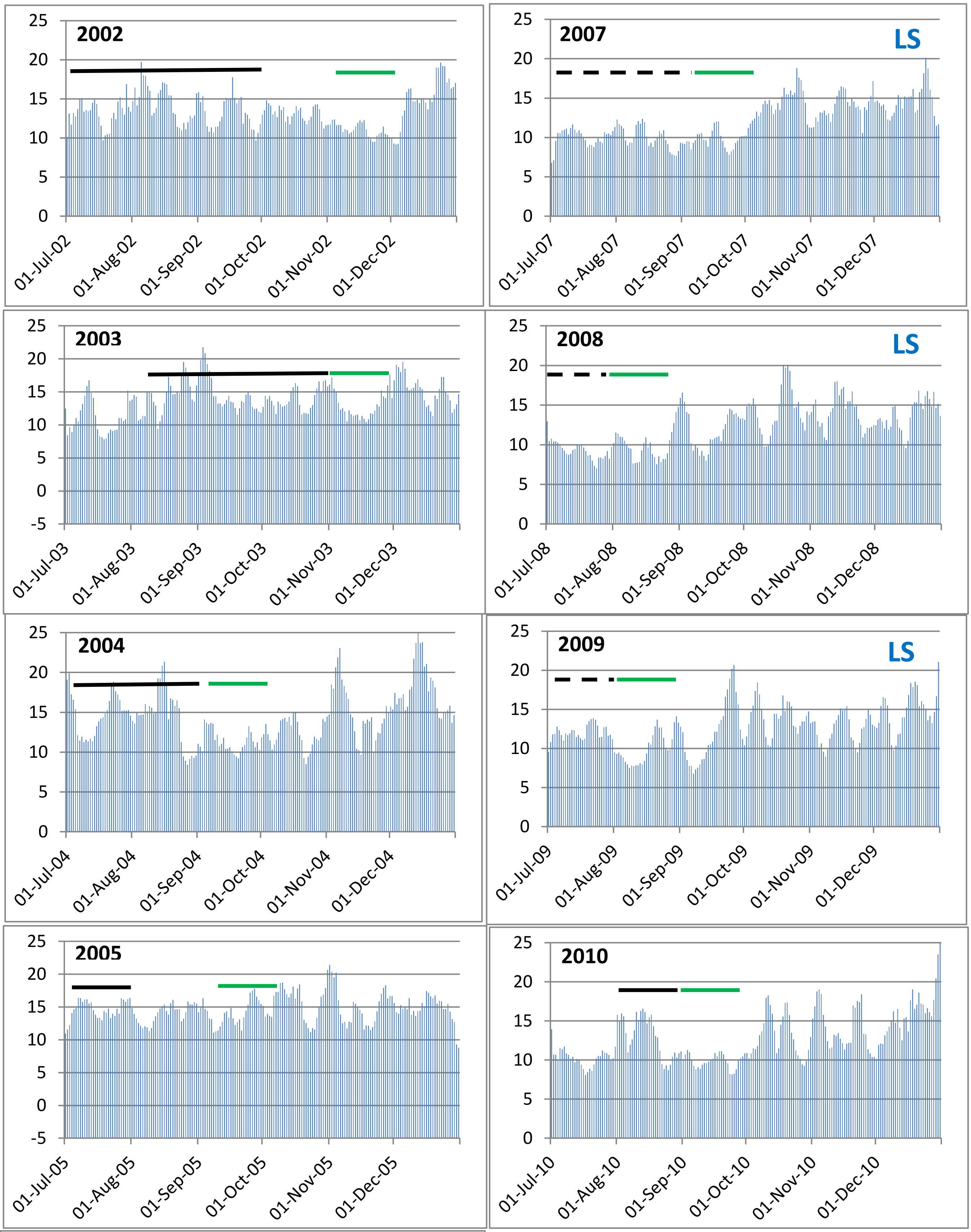
REFERENCE TESTS – Before testing for a difference between these two groups, a set of ten reference tests was made. In each of the ten tests (table below), two groups were randomly selected from the total population of day-to-day variabilities (Fig. SI-4a); a t-test and a non-parametric, Kolmogorov-Smirnov test were run. Of these ten tests, nine supported the null hypothesis that there was no significant difference between the two, randomly-selected groups. In contrast, when the standard t-test and the Kolmogorov-Smirnov tests were made on groups taken from periods with SSNs above and below 10 a statistically significant difference was established at the 5% level (Fig. SI-4b, Fig. SI-5). The same tests were also made to compare variability during the period with SSNs less than 20, and the remaining periods. Again the differecnes were statistically significant.

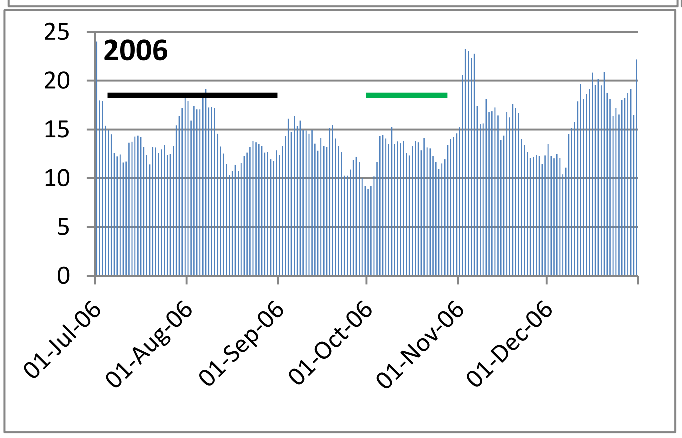
Two groups were selected at random from the total population of day-to-day variabilities

RUN	GROUP 1			GROUP 2			TTEST2		K-S TEST	
	No.	μ	σ	No.	μ	σ	h=	p=	h=	p=
1	1689	13.0	4.5	1716	13.2	4.9	0	0.92	0	0.60
2	1690	13.0	4.5	1738	13.2	4.5	0	0.90	0	0.69
3	1712	12.2	4.7	1694	13.0	4.7	0	0.12	0	0.67
4	1711	12.3	4.8	1695	12.9	4.6	1	0.0064	1	0.04
5	1693	13.1	4.8	1714	13.1	4.6	0	0.64	0	0.33
6	1728	13.1	4.9	1701	13.1	4.5	0	0.49	0	0.29
7	1681	13.2	4.9	1725	13.0	4.6	0	0.11	0	0.28
8	1689	13.2	4.7	1717	13.0	4.7	0	0.15	0	0.29
9	1661	13.1	4.6	1745	13.0	4.8	0	0.37	0	0.37
10	1742	12.9	4.6	1664	13.3	4.8	0	0.98	0	0.14



Kolmogorov-Smirnov Test. Result
K-S Statistic = 0.1357, h = 1 at the 95% level.





Months forming the pre-cursor (text Fig. 7). Dashe line indicated precursor faint or absent.

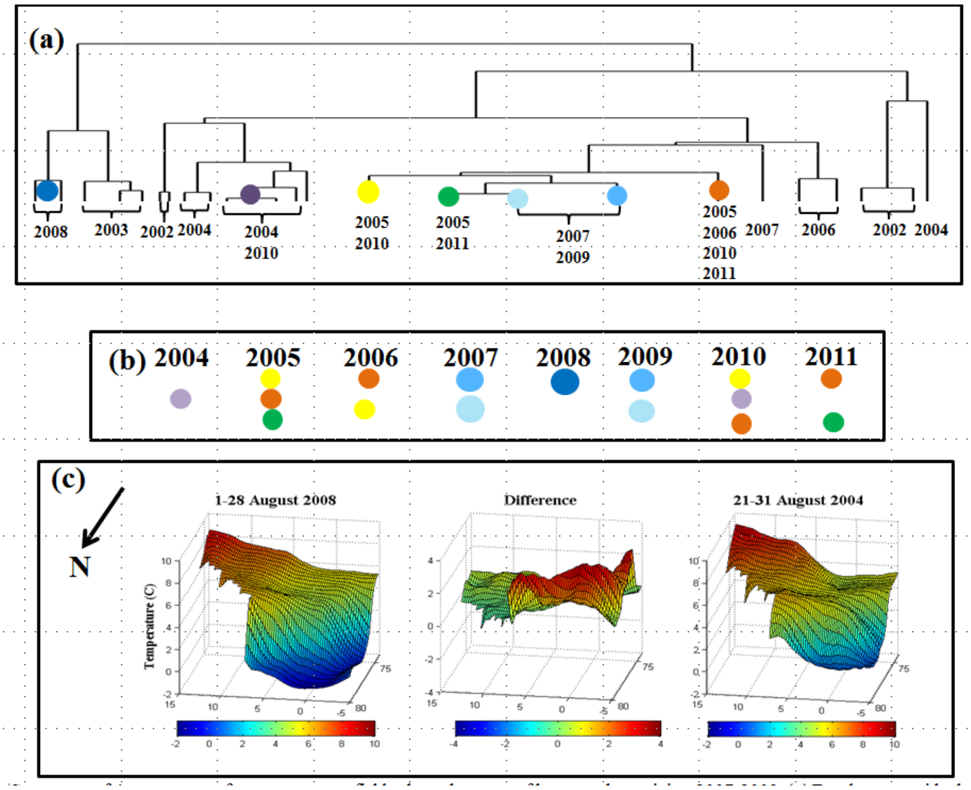
Months in which tracking starts (text Fig. 7).

LS Year with low solar activity.

Daily variability values during the transition from summer to winter (July-December). The pattern of a step-up in the level of variability in August-September is unique to the low solar years.

SYMMETRY OF AUGUST SST FIELDS ABOUT THE SOLAR LOW

Further explanation of Figure 8:



Symmetry of August sea surface temperature fields about the years of lowest solar activity, 2007-2009. (**a**) Dendrogram with clusters, which indicate symmetry in colour, together with the years in which they have been detected. (**b**) Symmetry about 2007-2009. Clusters represented in blue shades have only been detected in these years. The mauve, yellow, green and brown clusters have only been detected in the years before and after. (**c**) Comparison of an August 2008 sea surface temperature field (left) with an August 2004 field (right). The difference field (centre) indicates higher 2004 temperatures in the northwest. View from north. Horizontal axes are latitude and longitude.

The spreadsheet below shows the clusters into which all daily sea surface temperature fields in Augusts from 2002 to 2011 have been assigned (right hand column in each year). It is an alternative display to the dendrogram in Fig. 5 and the clusters have been colour coded as in Fig. 5. Augusts 2007, 2008 and 2009 (blues) are unique to these years, with the light blue clusters appearing either side of the 2008 clusters (dark blue). Other clusters appear only in the years before and after. For example, a single SST field was present thoughout the first 28 days of August 2008 (the deepest part of the solar low). This field was not detected in the August of any other year. Two similar SST fields were detected in both August 2007 and August 2009; again these were not detected in any other year. At the same time, other pairs of clusters were detected before and after 2007-2009. This pattern is consistent with the changes in the precursor described above.

AUGUSTs ALL 2002-2011 O.I. DATA.

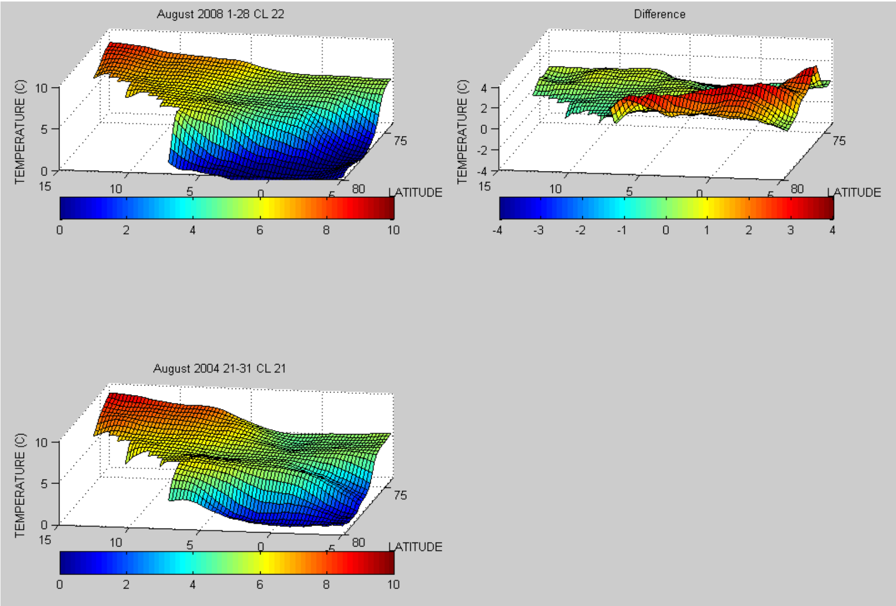
2002	1	1		18	2003	1	32		22	2004	1	63		2	2005	1	94		11	2006	1	125		23
2002	2	2	10	18	2003	2	33	12	22	2004	2	64	11	2	2005	2	95	11	11	2006	2	126	17	23
2002	3	3	19	18	2003	3	34	10	22	2004	3	65	15	2	2005	3	96	14	11	2006	3	127	16	23
2002	4	4	15	18	2003	4	35	11	8	2004	4	66	14	2	2005	4	97	11	11	2006	4	128	12	23
2002	5	5	18	3	2003	5	36	9	8	2004	5	67	19	2	2005	5	98	11	11	2006	5	129	25	10
2002	6	6	15	3	2003	6	37	11	8	2004	6	68	14	2	2005	6	99	15	11	2006	6	130	17	10
2002	7	7	32	20	2003	7	38	13	8	2004	7	69	11	2	2005	7	100	9	11	2006	7	131	17	10
2002	8	8	11	20	2003	8	39	13	8	2004	8	70	15	2	2005	8	101	12	11	2006	8	132	23	12
2002	9	9	14	20	2003	9	40	11	8	2004	9	71	21	17	2005	9	102	13	11	2006	9	133	15	12
2002	10	10	12	20	2003	10	41	28	8	2004	10	72	14	17	2005	10	103	10	11	2006	10	134	15	12
2002	11	11	11	20	2003	11	42	11	8	2004	11	73	18	17	2005	11	104	13	11	2006	11	135	17	23
2002	12	12	16	5	2003	12	43	11	8	2004	12	74	10	17	2005	12	105	12	11	2006	12	136	16	23
2002	13	13	12	5	2003	13	44	6	8	2004	13	75	11	17	2005	13	106	17	11	2006	13	137	10	23
2002	14	14	18	5	2003	14	45	8	8	2004	14	76	22	17	2005	14	107	16	11	2006	14	138	9	23
2002	15	15	21	5	2003	15	46	10	8	2004	15	77	36	15	2005	15	108	13	11	2006	15	139	12	23
2002	16	16	13	5	2003	16	47	17	19	2004	16	78	18	15	2005	16	109	15	11	2006	16	140	11	23
2002	17	17	21	20	2003	17	48	16	19	2004	17	79	18	15	2005	17	110	13	11	2006	17	141	11	23
2002	18	18	12	20	2003	18	49	15	19	2004	18	80	14	15	2005	18	111	19	11	2006	18	142	12	23
2002	19	19	17	20	2003	19	50	17	19	2004	19	81	8	15	2005	19	112	11	11	2006	19	143	12	23
2002	20	20	14	20	2003	20	51	22	19	2004	20	82	13	15	2005	20	113	11	11	2006	20	144	8	23
2002	21	21	13	20	2003	21	52	10	19	2004	21	83	31	21	2005	21	114	24	1	2006	21	145	15	23
2002	22	22	11	20	2003	22	53	10	19	2004	22	84	17	21	2005	22	115	16	1	2006	22	146	14	12
2002	23	23	11	20	2003	23	54	16	19	2004	23	85	10	21	2005	23	116	12	1	2006	23	147	13	12
2002	24	24	9	20	2003	24	55	18	19	2004	24	86	11	21	2005	24	117	11	1	2006	24	148	15	12
2002	25	25	13	20	2003	25	56	21	19	2004	25	87	9	21	2005	25	118	11	1	2006	25	149	11	12
2002	26	26	12	20	2003	26	57	25	4	2004	26	88	9	21	2005	26	119	15	1	2006	26	150	15	12
2002	27	27	15	20	2003	27	58	19	4	2004	27	89	8	21	2005	27	120	18	1	2006	27	151	13	12
2002	28	28	7	20	2003	28	59	11	4	2004	28	90	7	21	2005	28	121	16	1	2006	28	152	13	12
2002	29	29	13	20	2003	29	60	13	4	2004	29	91	8	21	2005	29	122	20	12	2006	29	153	11	12
2002	30	30	17	20	2003	30	61	12	4	2004	30	92	12	21	2005	30	123	9	12	2006	30	154	12	12
2002	31	31	10	20	2003	31	62	15	4	2004	31	93	11	21	2005	31	124	15	12	2006	31	155	11	12
Sum			432					419					436					412					415	
Avg.			14.4					14.0					14.5					13.7					13.8	

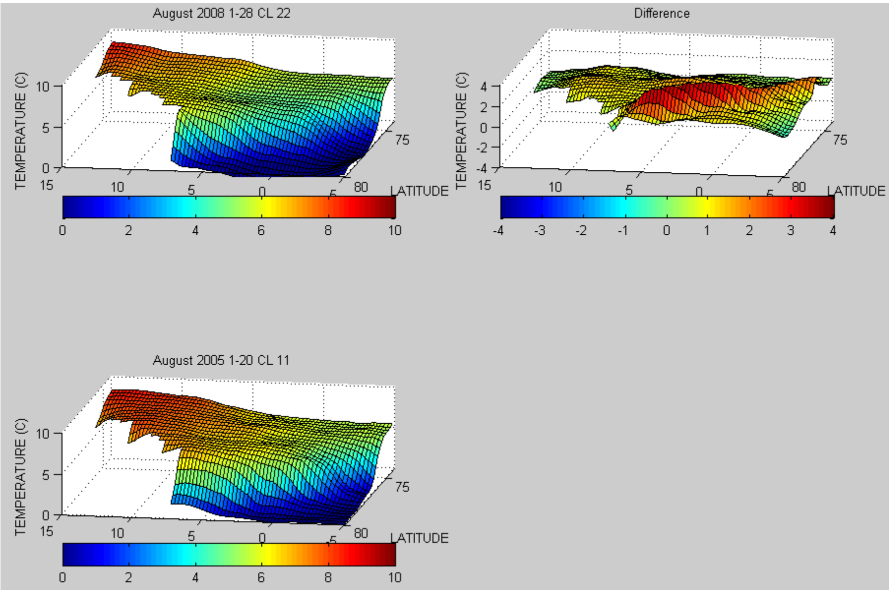
2007	1	156		7	2008	1	187		22	2009	1	218		7	2010	1	249		6	2011	1	280		1
2007	2	157	16	7	2008	2	188	15	22	2009	2	219	9	7	2010	2	250	18	6	2011	2	281	7	1
2007	3	158	15	7	2008	3	189	9	22	2009	3	220	9	7	2010	3	251	29	12	2011	3	282	10	1
2007	4	159	8	7	2008	4	190	15	22	2009	4	221	9	7	2010	4	252	6	12	2011	4	283	14	1
2007	5	160	7	7	2008	5	191	9	22	2009	5	222	11	16	2010	5	253	14	11	2011	5	284	9	1
2007	6	161	10	7	2008	6	192	7	22	2009	6	223	8	16	2010	6	254	11	11	2011	6	285	11	1
2007	7	162	9	7	2008	7	193	15	22	2009	7	224	8	16	2010	7	255	7	11	2011	7	286	9	1
2007	8	163	12	16	2008	8	194	7	22	2009	8	225	6	16	2010	8	256	17	11	2011	8	287	10	1
2007	9	164	9	16	2008	9	195	12	22	2009	9	226	7	16	2010	9	257	11	11	2011	9	288	10	1
2007	10	165	7	16	2008	10	196	7	22	2009	10	227	8	16	2010	10	258	17	11	2011	10	289	12	1
2007	11	166	13	16	2008	11	197	6	22	2009	11	228	9	16	2010	11	259	17	11	2011	11	290	12	1
2007	12	167	17	16	2008	12	198	6	22	2009	12	229	8	16	2010	12	260	19	11	2011	12	291	12	1
2007	13	168	14	16	2008	13	199	7	22	2009	13	230	7	16	2010	13	261	12	11	2011	13	292	8	1
2007	14	169	8	16	2008	14	200	13	22	2009	14	231	7	16	2010	14	262	17	13	2011	14	293	10	1
2007	15	170	10	16	2008	15	201	7	22	2009	15	232	10	16	2010	15	263	19	13	2011	15	294	11	12
2007	16	171	11	16	2008	16	202	14	22	2009	16	233	8	16	2010	16	264	15	13	2011	16	295	11	12
2007	17	172	7	16	2008	17	203	10	22	2009	17	234	10	16	2010	17	265	12	13	2011	17	296	10	12
2007	18	173	8	16	2008	18	204	11	22	2009	18	235	11	16	2010	18	266	16	13	2011	18	297	13	12
2007	19	174	10	16	2008	19	205	6	22	2009	19	236	14	16	2010	19	267	18	21	2011	19	298	10	12
2007	20	175	8	16	2008	20	206	10	22	2009	20	237	9	16	2010	20	268	11	21	2011	20	299	8	12
2007	21	176	15	14	2008	21	207	6	22	2009	21	238	15	7	2010	21	269	9	21	2011	21	300	12	12
2007	22	177	10	14	2008	22	208	8	22	2009	22	239	15	7	2010	22	270	10	21	2011	22	301	13	12
2007	23	178	12	14	2008	23	209	6	22	2009	23	240	16	16	2010	23	271	7	21	2011	23	302	12	12
2007	24	179	8	14	2008	24	210	12	22	2009	24	241	9	16	2010	24	272	10	21	2011	24	303	7	12
2007	25	180	10	14	2008	25	211	6	22	2009	25	242	9	16	2010	25	273	8	21	2011	25	304	8	12
2007	26	181	9	14	2008	26	212	8	22	2009	26	243	8	16	2010	26	274	11	21	2011	26	305	8	12
2007	27	182	7	14	2008	27	213	9	22	2009	27	244	9	16	2010	27	275	7	21	2011	27	306	8	12
2007	28	183	7	14	2008	28	214	10	22	2009	28	245	14	16	2010	28	276	11	21	2011	28	307	12	12
2007	29	184	7	14	2008	29	215	20	9	2009	29	246	10	16	2010	29	277	15	21	2011	29	308	10	12
2007	30	185	10	14	2008	30	216	12	9	2009	30	247	16	16	2010	30	278	11	21	2011	30	309	7	12
2007	31	186	8	14	2008	31	217	14	9	2009	31	248	19	7	2010	31	279	8	21	2011	31	310	9	12
			300					298					307					391					304	
			10.0					9.9					10.2					13.0					10.1	

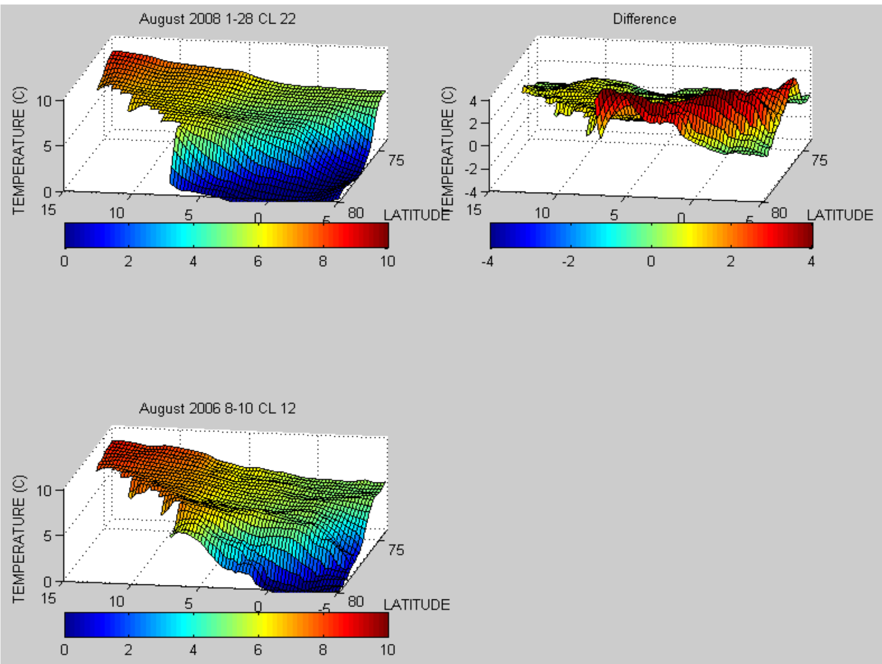
A similar comparison has been made for the September 2008 SST fields. The mean temperature of the 2008 field is the lowest of all, and both 2007 and 2008 fields again show the eddy terminations further to the southeast. As in August, comparison of mean SST fields between the same clusters before and after the central years shows little difference.

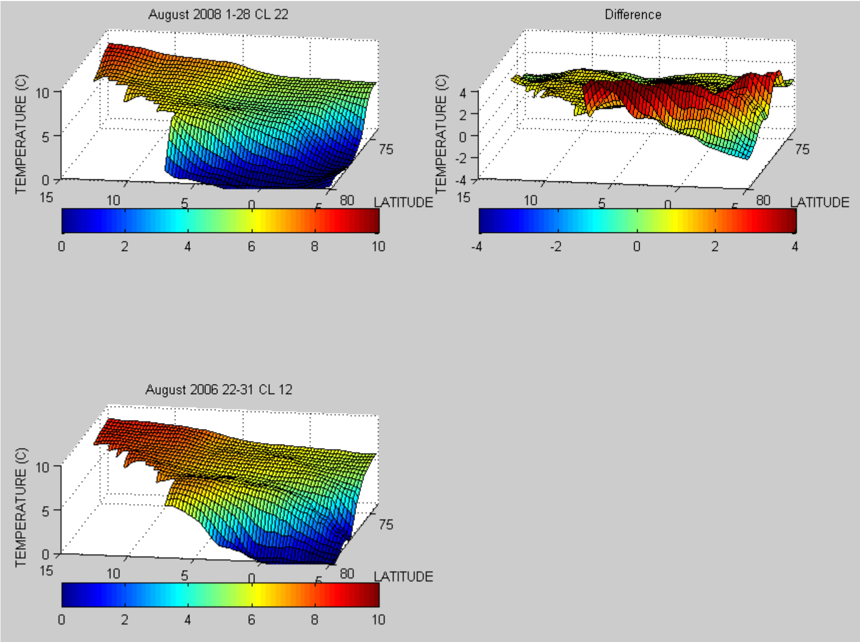
COMPARISON OF AUGUST SST FIELDS 2008 AND YEARS BEFORE AND AFTER – EXAMPLES OF DIFFERENCES IN THE MARGINAL ICE ZONE

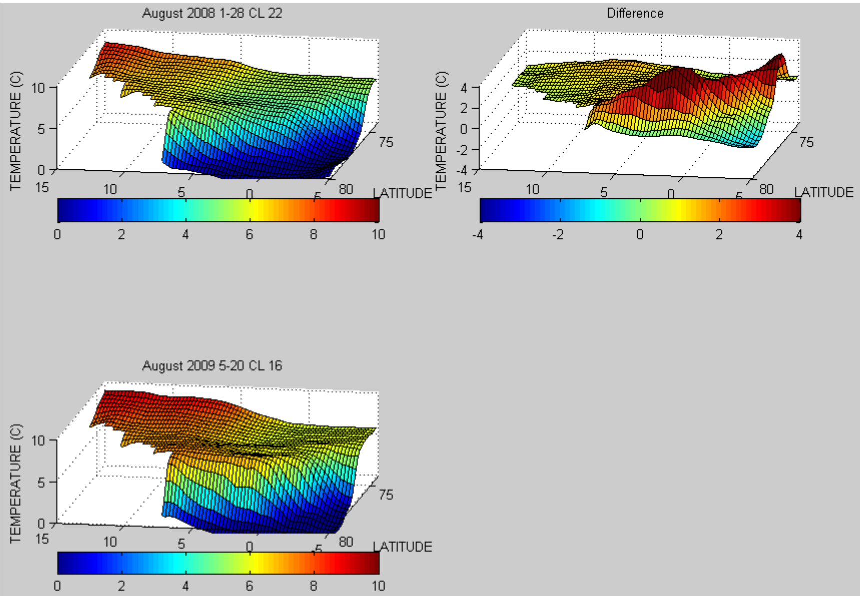
August 2008 (Cluster 22) compared with other years

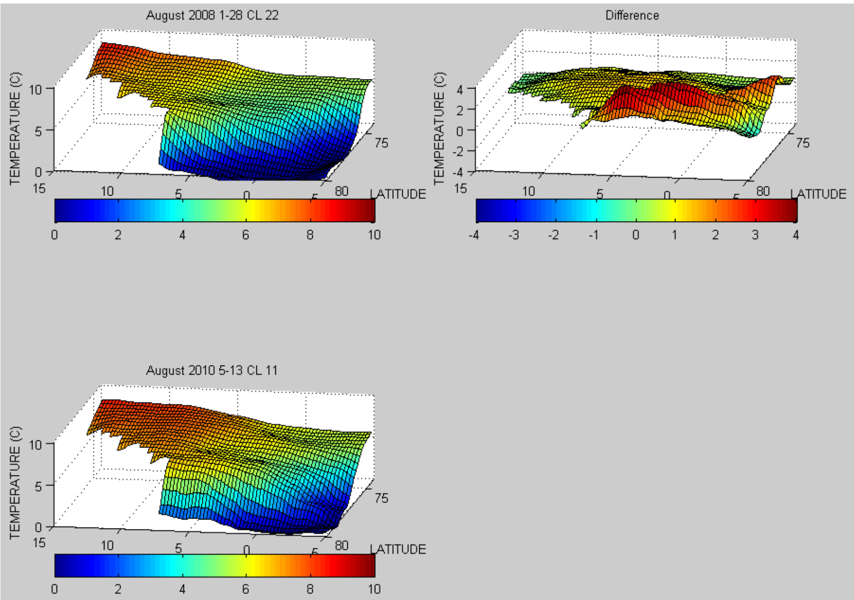




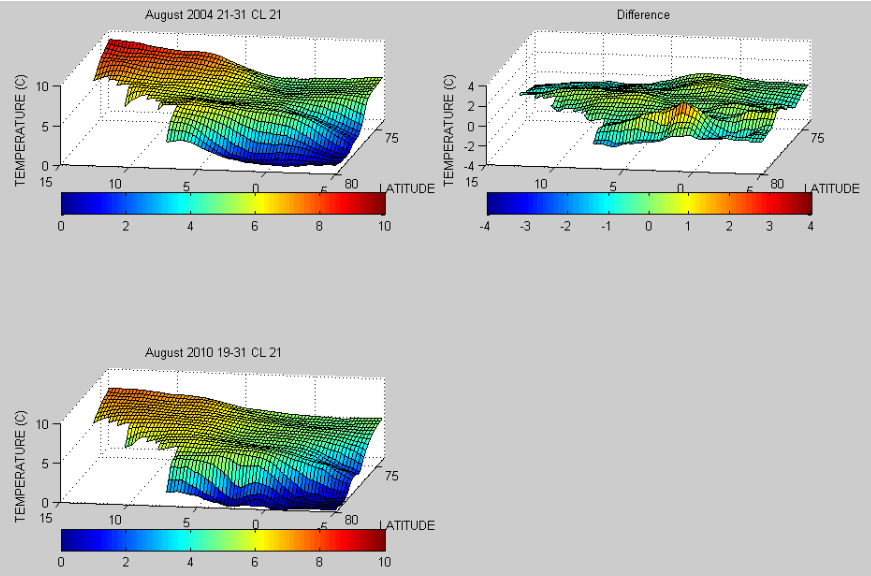


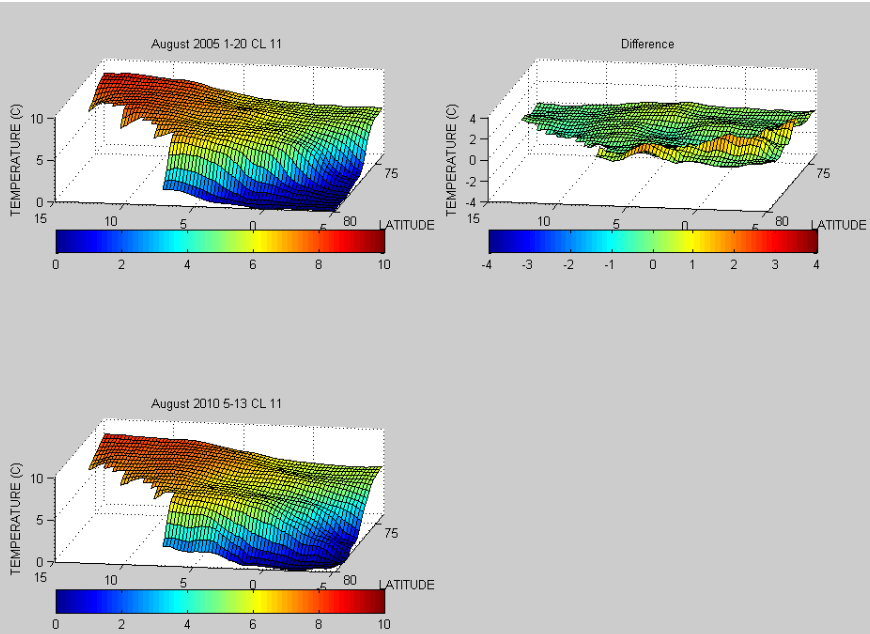

August 2008 1-28 CL 22
Difference
August 2006 22-31 CL 12
TEMPERATURE (C)
LATITUDE

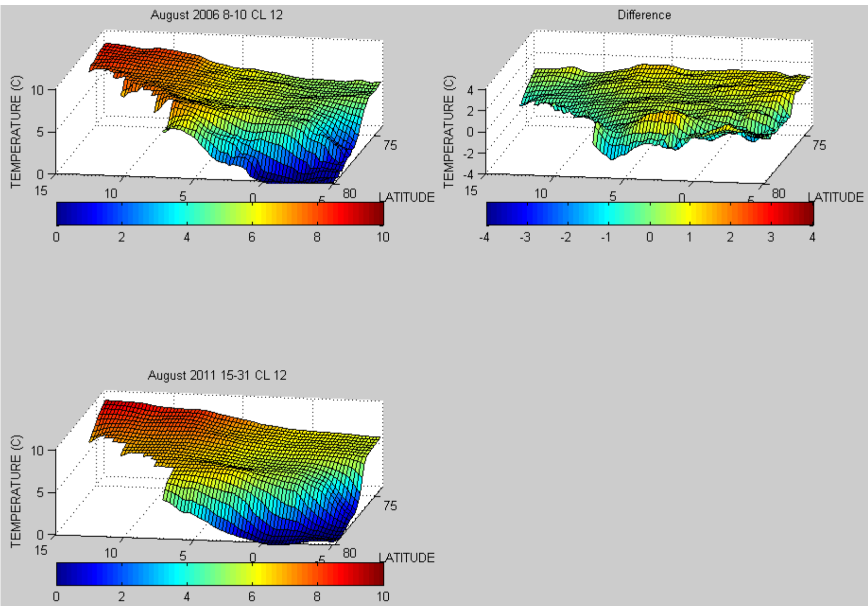

August 2008 1-28 CL 22
Difference
August 2009 5-20 CL 16
TEMPERATURE (C)
LATITUDE


August 2008 1-28 CL 22
Difference
August 2010 5-13 CL 11
TEMPERATURE (C)
LATITUDE

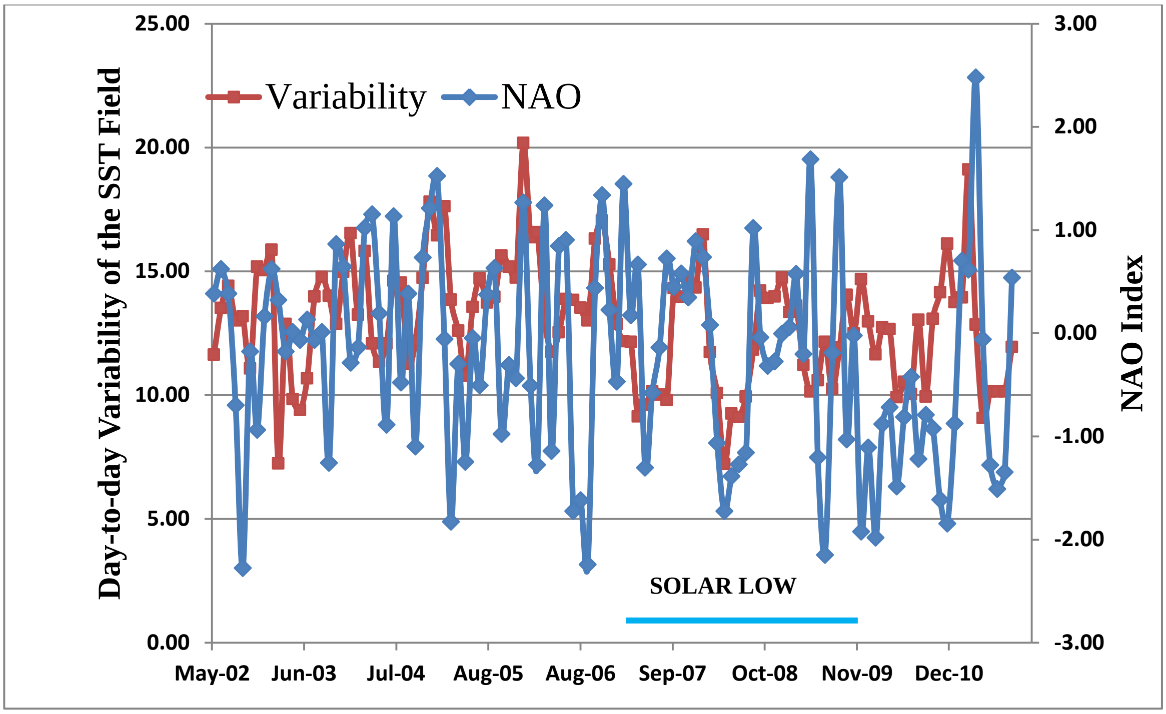
COMPARISON BETWEEN AUGUSTS BEFORE AND AFTER AUGUST 2008 – EXAMPLES OF SIMILARITY



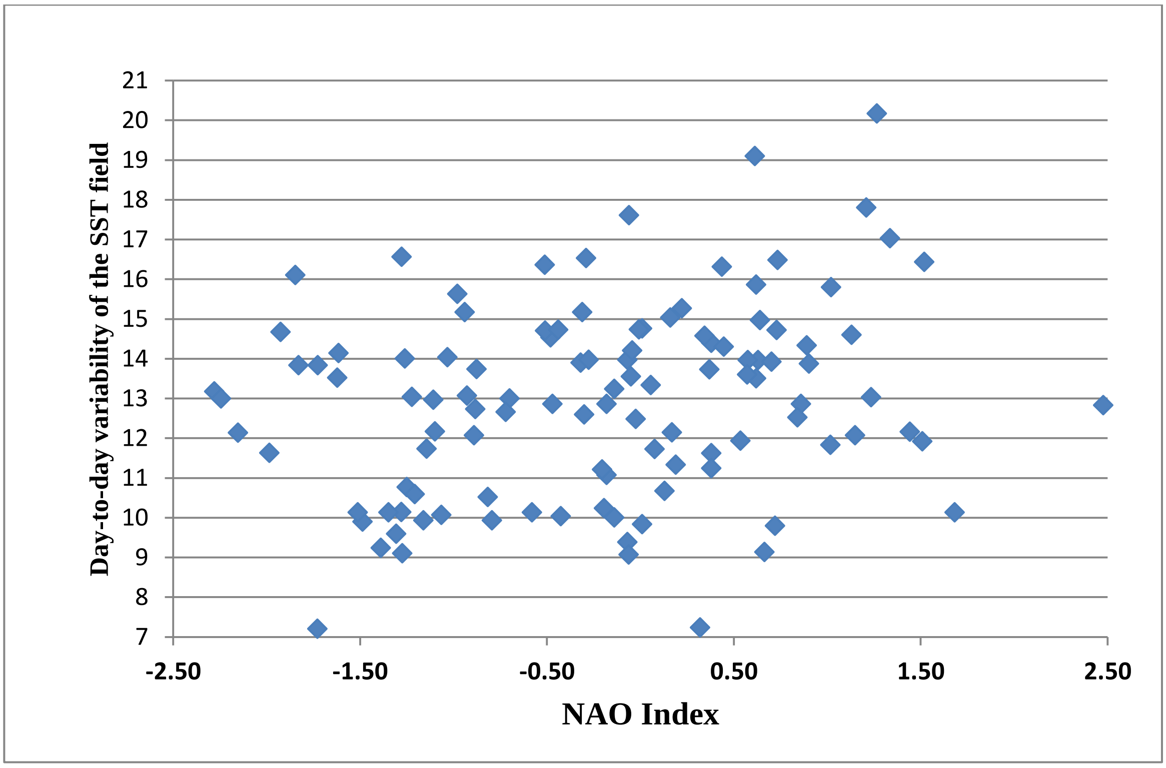




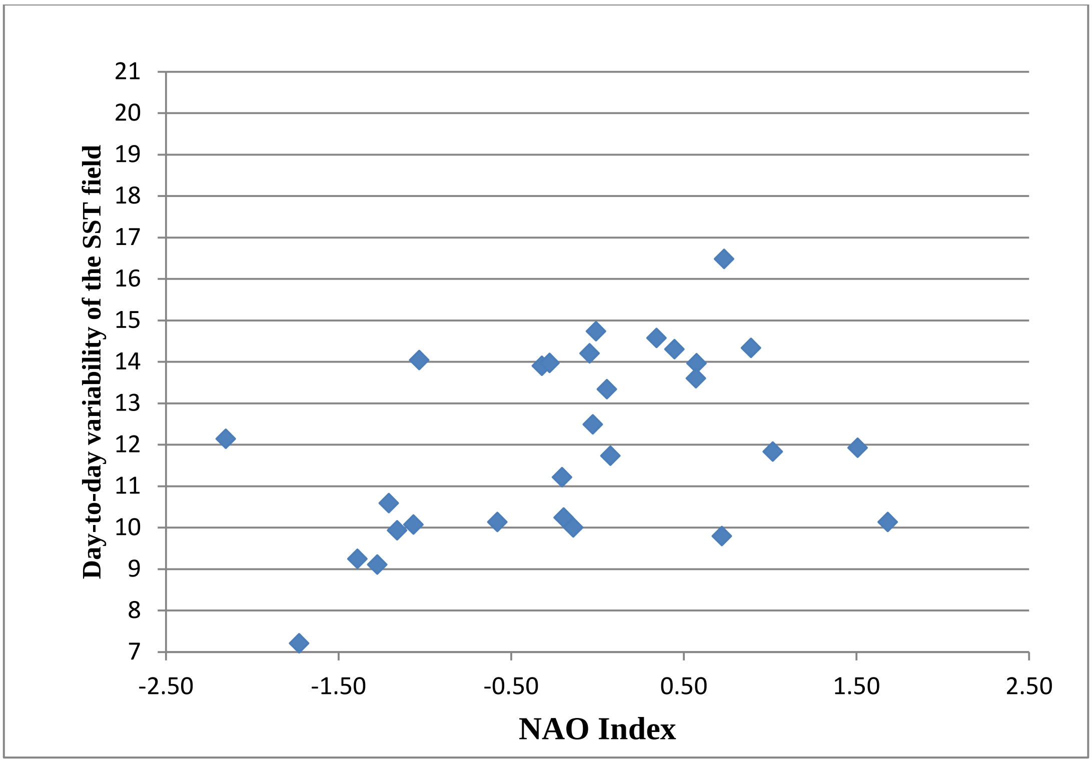
VARIABILITY AS A FUNCTION OF THE NAO



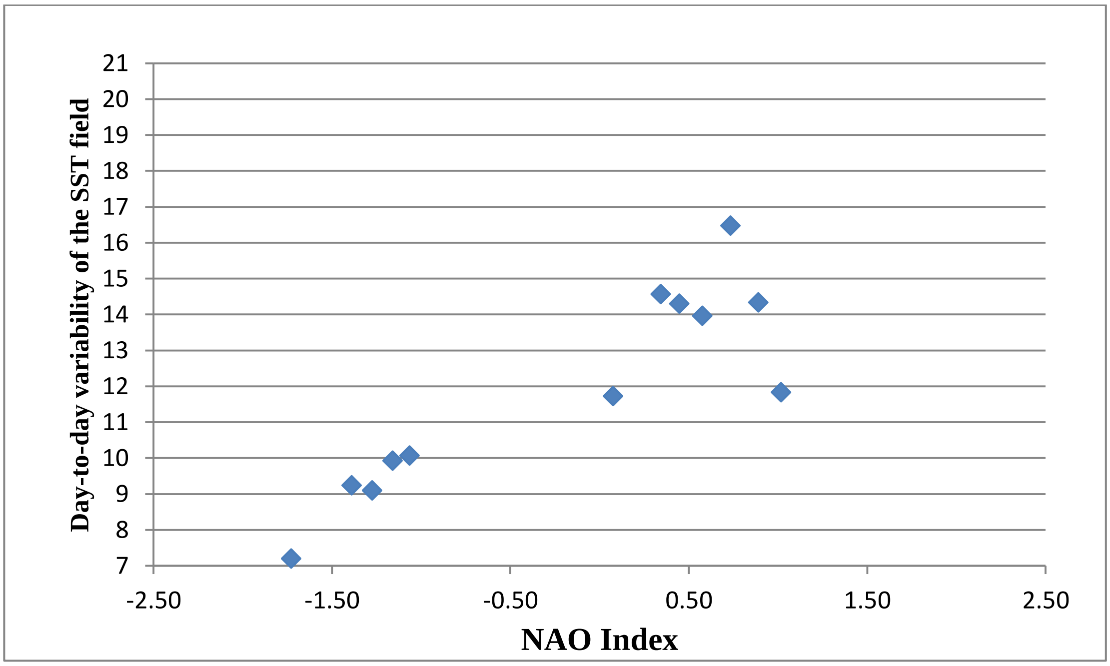
Day-to-day variability and the NAO.



Cross plot NAO and Day-to Day variability. Monthly means, all months.



Cross plot NAO and day-to day variability. Monthly means over the period of low solar activity, July 2007 – November 2009. R = 42%.



Cross plot NAO and Day-to Day variability. Monthly means, October 2007 – September 2008. R = 89%.

Key to Interpretation of AVHRR Infra-red Images

Each sheet records the observations of cloud morphology for the month, together with other data in this format:

YEAR	DATE	EUCLIDEAN DISTANCE BETWEEN DAYS (a measure of day-to-day variability)	CLUSTER NUMBER	SATELLITE OBSERVATIONS (AVHRR Channel 4)	METEOROLOGICAL DATA FROM ONSHORE SPITSBERGEN (NY-Ã…LESUND, 99910). Wind direction at 06.00, 12.00, 18.00, & Mean Velocity (m/s)				FEATURES ON DAILY TEMPERATURES DIFFERENCE PLOTS					PRESENCE OF WEATHER SYSTEM WITHIN AREA (with direction of origin)		
					DD06	DD12	DD18	FFM	REGIONAL HIGH	REGIONAL LOW	LOCAL HIGH	LOCAL LOW	ANOMALY IN MARGINAL ICE ZONE	SYSTEM & VARIABILITY HIGH	CLOUD STREETS	SYSTEM & VARIABILITY LOW

Description of observations of cloud morphology made from AVHRR data (www.sat.dundee.ac.uk). Brown text indicates a counted weather system; blue text indicates a feature, such a cloud streets indicating a northerly airflow.	
ABBREVIATIONS	
Spl	Spiral cloud
Com	Comma cloud
CM	Extensive cloud mass without structure
F	Featureless cloud
Anv	Anvil-shaped cloud
CS	Cloud streets
LOCATIONS	
Denoted by Lat & Long without degree sign	
ALTITUDE	
Indication of two cloud levels in red text	
SVALBARD = SPITSBERGEN	

NEXT

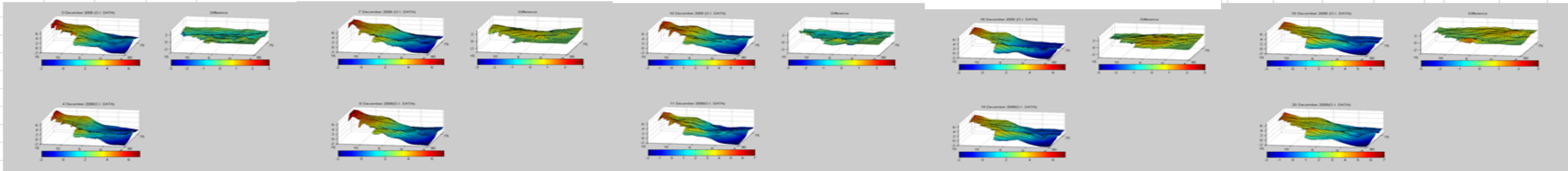
Example of Interpretation Sheet - AVHRR Infra-red Images

The results of examination of these images are recorded on sheets such as the one below. An Excel file is available, which contains one sheet per month for July 2004 to February 2005 and July 2008 to February 2009. The coloured plots at the base are in threes and represent two successive days and the difference field. The days selected are shaded in the dates column and represent days with significant cyclone activity.

DECEMBER 2008 | 99910 NY-Ã…LESUND Dec 20

YEAR	DATE	EUC. DIST.	CLUS. NO.	SATELLITE OBSERVATIONS (AVHRR Channel 4)	DD06	DD12	DD18	FFM	REG. HIGH	REG. LOW	LOC. HIGH	LOC. LOW	MIZ	SYST.	C.S	SYST. LOW VAR	
2008	1	13	15	04.34: F/Variable southeast of ice edge trend NE-SW; 118.53: F/Variable/Clr	283	280	152	3.4									
2008	2	15	15	02.43: Variable cloud; 04.23: Minor Anv in F 78N2W trend NW-SE; 09.10: Anv dispersed; 18.30: Variable cloud; 21.49: System(?) extending east from Greenland 78N	128	139	124	4.1						N			Same system
2008	3	11	15	02.33: CM (?Anv) covers area; 12.27: ?Spl 78N0; 21.25: Variable cloud trend NE-SW	124	157	234	5.2									
2008	4	18	15	04.03: CM Anv(?) 78N0, extends NW; 10.37: Variable cloud north of 78N, Clr to south	152	266	274	3.0						N			
2008	5	10	15	02.11: F west of 0, Clr/F to east; 08.48: Minor Spl 77N0; 12.06: F/Clr	124	251	149	2.2									
2008	6	10	15	02.01: F/Clr; 10.27: F/minor CS trend N-S; 11.56: Variable cloud; 18.37: Variable/Clr; ice edge 80N0 to 77N10W; 21.56: Maj system to 72N16W	153	293	104	2.9									
2008	7	11	15	03.31: F and Clr along ice edge; 10.00: Variable cloud	157	131	108	1.6									
2008	8	16	15	01.40: Variable cloud/Clr, maj. Spl 68N0 to 74N; 05.01 Spl 70N0 cloud to 75N; 09.40: Spl 70N1W cloud to 76N0; 19.30: Spl 70N2W cloud to 76N 10E	269	130	124	3.1						S			
2008	9	12	15	01.29: Spl dispersing; mottled cloud to ice edge; 10.57: CS between Svalbard and ice edge; 20.46: Maj. Anv from south over Greenland assoc. cloud to 0 ...	258	154	141	3.2						S			Same system
2008	10	12	15	01.18: ... assoc. cloud to 10E; 04.40: Anv moved east 80N5W covers area; 11.14: Anv moved east 78N 20E trend NE-SW; 20.23: mostly Clr	141	161	174	7.6						S			
2008	11	23	12	02.49: F/Clr; 09.25: Variable cloud to 75N; 11.04: System from south to 75N trend E-W, F further north; 12.44: System to 77N; 18.21: System from south to 77N (10W-10E); 21.40: System moved north to 80N...	183	257	292	5.8						S			
2008	12	11	12	04.19: ...System dispersing over Svalbard, Spl in Arctic; 09.47: Variable cloud, ?assoc. with Anv 75N trend E-W; 19.37: Cloud band (system?) NE-SW over area ...	136	230	120	2.0								?	
2008	13	8	12	02.28: ... moved north replaced by cloud stream Svalbard to south (Anv?), Clr over most of area; 10.43: Maj. Anv 80N40E extends to Svalbard; 12.23: Maj. Anv to 73N from south	130	104	102	2.4								S/P	
2008	14	6	12	02.18: Variable cloud to 75N/Clr/F to ice edge; 10.33: Anv 73N12W...; 12.12:...Anv to 75N/W of 1W, F over area at 76N, F/Clr to north; 22.10 System to west of 10W trend N-S ...	288	254	248	6.2									
2008	15	11	12	02.07: ... cloud assoc. with system now over area (Anv?)/Clr; 10.18: Variable cloud assoc. with system; 21.47: Variable cloud north of 76N, maj Anv 70N5E to 74N...	126	130	107	6.0								S/P	
2008	16	13	12	01.57: .., Maj. Anv moved north extends to N78N at 0 and south to Norway ..., also second Anv 79N20W extends east to Svalbard; 06.34: First Anv 76N10W extends southeast over most of area...; 11.51: ... First Anv rotated 76N0 tail to east ... 19.44: ...First Anv straddling 80N	122	94	103	11.0								S&W	South dominant
2008	17	10	12	01.46: Variable cloud/Clr, Spl 75N14W; 12.50: Anv 75N2E, Clr or F to north; 13.21: ...Anv/Spl to 78N ... 19.21: Spl assoc. with Anv 74N7W; 21.00: Spl cloud to 80N...	167	323	134	3.4								S	Same system
2008	18	13	12	01.35: ...cloud pattern remains; 09.51: Spl over Svalbard assoc. with Anv to east (from south), second system west from Svalbard trend E-W; 20.37: Unchanged...	124	287	115	4.8								S	Same system
2008	19	21	12	03.06: ...System north of 77N remains trend E-W, Clr to south; 09.41: Systems dispersing, new Anv 74N0 trend E-W; 13.00: Variable cloud over whole area; 18.35: F/CS from Svalbard to ice edge trend N-S...	123	271	112	5.3						N			
2008	20	18	15	02.55: ...F/CS, trend N-S; 06.38: minor Anv 78N5E; 11.41: Variable cloud; 21.31: Variable cloud, ?CS/Clr	110	123	132	8.2									
2008	21	15	15	02.45: CS trend N-S; 10.50: CS/Clr	135	133	142	3.8									
2008	22	10	15	02.34: Variable CS; 19.05: F/Clr trend NW-SE; 22.25: Maj. Anv with assoc. Spl over Iceland cloud to 73N20W...	154	267	161	1.2									
2008	23	20	15	05.44: Maj. Anv remains to west; 10.32: Maj. Anv in area, F/CS in northeast; 12.11: ...Anv/System moved northeast over area trend NW-SE; 18.42: Anv covers area...	125	119	132	2.6						S			
2008	24	13	15	02.13: ... Anv/system north of 80N 'tail' covers area; 10.28: New Anv from south 73N5W, cloud to 76N, Clr to northeast; 11.46: Anv cloud to 78N; 13.48: Anv covers over most of area; 21.38: Anv moved northeast to Svalbard ...	111	104	108	13.3								S	Same system
2008	25	14	15	02.03: Spl assoc. with Anv 76N1W, Clr/F to southeast; 05.23: Spl to 78N6E; 11.25: Variable cloud, F/Clr south of 79N	177	249	220	7.4								S	
2008	26	24	15	01.52: Variable cloud/F; 13.28: F; 19.12: F/CS trend NW-SE from ice edge...	285	314	310	9.9									
2008	27	13	15	01.41: ...CS; 12.18: System to 78N10W with assoc. cloud over area...	314	6	120	7.0									
2008	28	15	15	01.31: ... assoc cloud; 10.16: Band of cloud 72N-76N trend WSW-ENE, above F; 11.55: CS trend N-S under cloud band	247	311	327	6.5									
2008	29	8	15	01.20; CS under band of cloud; 11.16: Mottled cloud under dispersing band of cloud south of 76N	-999	-999	-999	6.0				NW					
2008	30	23	5	01.10: CS to ice edge trend N-S; 11.09: CS over whole area to ice edge trend N-S...	20	148	330	4.8									
2008	31	14	5	00.59: ...CS to ice edge trend N-S; 05.35: CS trend NW-SE	338	325	340	5.9									

Same system (18–19)



JULY 2004					
VARIABILITY	WEATHER SYSTEMS				
9/14	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	8	0	1	0	5
<=15	-1	-1	0	0	

AUGUST 2004					
VARIABILITY	WEATHER SYSTEMS				
9/10	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	7	0	1	3	1
<=15	-1	-1	-1	0	

SEPTEMBER 2004					
VARIABILITY	WEATHER SYSTEMS				
4/4	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	2	2	0	1	0
<=15	-1	0	0	0	

OCTOBER 2004					
VARIABILITY	WEATHER SYSTEMS				
4/5	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	4	1	0	0	1
<=15	-1	-3	0	0	

NOVEMBER 2004					
VARIABILITY	WEATHER SYSTEMS				
7/10	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	4	0	3	7	1
<=15	0	-1	-1	-13	

DECEMBER 2004					
VARIABILITY	WEATHER SYSTEMS				
19/20	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	4	2	4	8	1
<=15	-1	0	0	-1	

JANUARY 2005					
VARIABILITY	WEATHER SYSTEMS				
13/16	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	7	1	3	2	3
<=15	-1	0	0	-4	

FEBRUARY 2005					
VARIABILITY	WEATHER SYSTEMS				
9/17	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	3	1	3	6	8
<=15	-4	0	0	0	

JULY 2008					
VARIABILITY	WEATHER SYSTEMS				
0/0	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	0	0	0	0	0
<=15	-2	-1	0	0	

AUGUST 2008					
VARIABILITY	WEATHER SYSTEMS				
1/1	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	0	1	0	0	0
<=15	-1	-4	0	0	

SEPTEMBER 2008					
VARIABILITY	WEATHER SYSTEMS				
3/4	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	1	0	2	1	0
<=15	-1	-2	2	0	

OCTOBER 2008					
VARIABILITY	WEATHER SYSTEMS				
5/7	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	5	0	0	2	2
<=15	-1	0	0	0	

NOVEMBER 2008					
VARIABILITY	WEATHER SYSTEMS				
8/11	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	2	4	1	5	3
<=15	-1	0	-1	-6	

DECEMBER 2008					
VARIABILITY	WEATHER SYSTEMS				
5/8	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	4	2	0	5	3
<=15	-3	-1	-1	-6	

JANUARY 2009					
VARIABILITY	WEATHER SYSTEMS				
7/12	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	6	0	0	9	4
<=15	-2	-1	-3	-6	

FEBRUARY 2009					
VARIABILITY	WEATHER SYSTEMS				
3/5	System (South)	System (North)	System (Other)	Cloud Streets	No System
>15	0	2	1	3	2
<=15	-1	0	-1	-11	

TOTAL SYSTEMS = 79					
>15 = 61	S	39		CS	27
	N	7			
	?	15			
=<15 = 18	S	10		CS	18
	N	6			
	?	2			

TOTAL SYSTEMS = 62					
>15 = 31	S	18		CS	22
	N	9			
	?	4			
=<15 = 29	S	12		CS	29
	N	9			
	?	8			