

Editorial Note

Starting with the year 2006, we have been gradually limiting the publication of raw experimental data from the observatories of the Institute of Geophysics. The data will be available on the Institute's webpage.

Along this line, the present issue, with subtitle *Monographic Volume*, is published in place of the former yearbooks entitled: *Atmospheric Ozone, Solar Radiation, Belsk* and *Results of Atmospheric Electricity and Meteorological Observations, S. Kalinowski Geophysical Observatory at Świder*.

We also include reports on other topics dealt with at the Department of Atmospheric Physics, namely the lightning research. The next issues will contain papers with current information about the new developments in measurements, instrumental problems, and data processing relating to the observatories.

Total Amount of Atmospheric Ozone with the Dobson Spectrophotometer No. 84 at Belsk, Poland, 2006-2007

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Ozone observations have been made by means of Dobson spectrophotometer No. 84 in the Geophysical Observatory at Belsk since March 1963. This publication presents all total ozone values over Belsk in 2006 and 2007. Monthly means based on the daily values of total ozone were obtained according to the recommendations of the WMO. According to the International Ozone Commission of IAMAP and WMO recommendation, new ozone absorption coefficients (Bass-Paur scale) have been used in processing Dobson spectrophotometer total ozone data beginning on 1 January 1992. In June 2005 the instrument No. 84 from Belsk took part in the WMO Inter-comparison of Dobson Ozone Spectrophotometer in Hohenpeissenberg, Germany; first set of correction to N-values resulting from the comparison and the wedges recalibration have been applied since 1 July 2005. In Table 1, Table 2, Fig. 1 and Fig. 3 we present monthly means of total ozone [D] and the departures from long-term monthly means (in percent). In Fig. 2 and Fig. 4 we present daily means of total ozone [D] and the departures from long-term daily means.

Table 1

Monthly means of total ozone [D] and the departures (in percent) from long-term monthly means in 2006: 1 – long-term monthly means, 2 – monthly means, 3 – departures

2006	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	340	372	381	386	368	355	339	320	300	287	288	312
2	304	386	386	385	363	336	317	325	270	264	280	260
3	-10.6	3.7	1.3	-0.2	-1.3	-5.3	-9.3	1.2	-10.0	-8.0	-2.8	-16.7

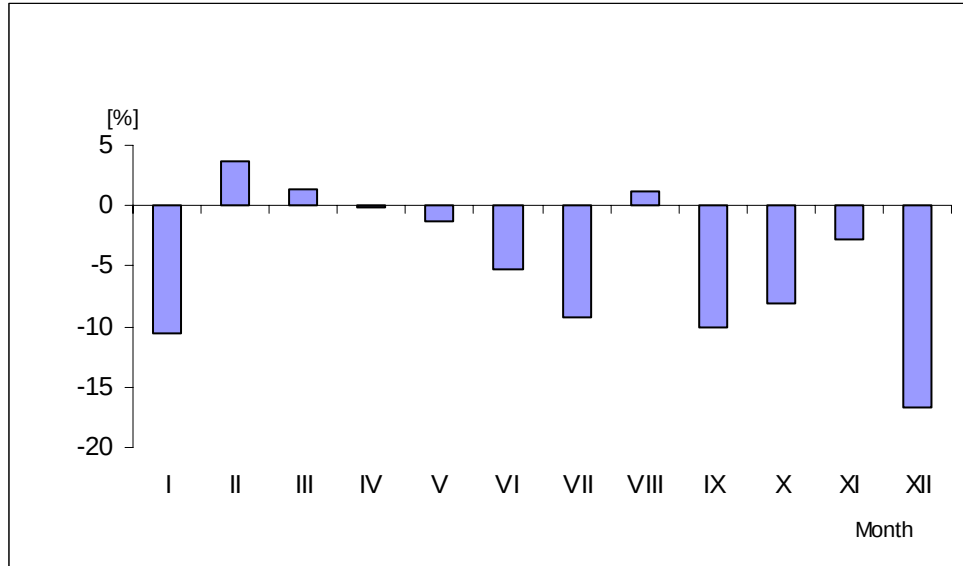


Fig. 1. Monthly means departures (in percent) from 43-year averages of total ozone measurements at Belsk in 2006.

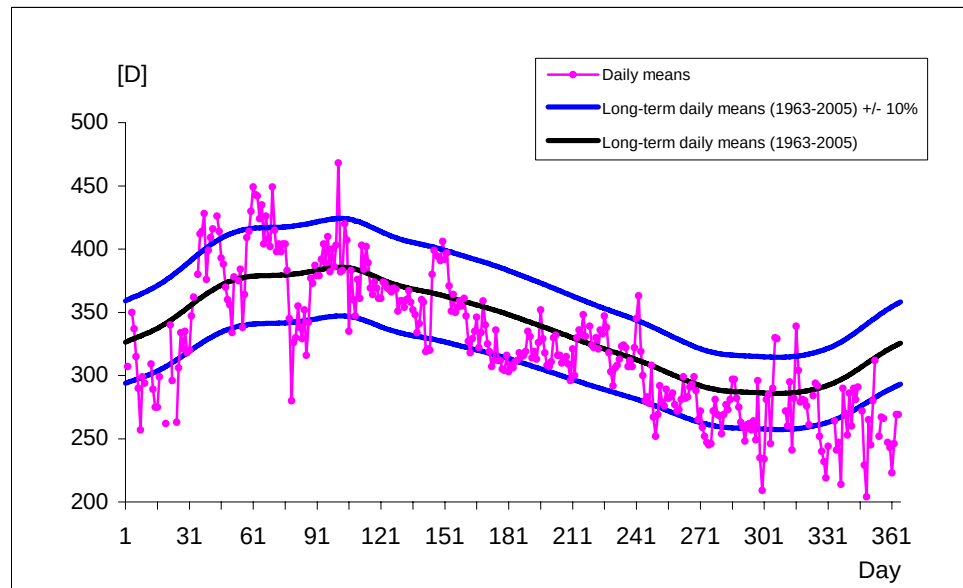


Fig. 2. Time series of the total ozone measurements at Belsk in 2006.

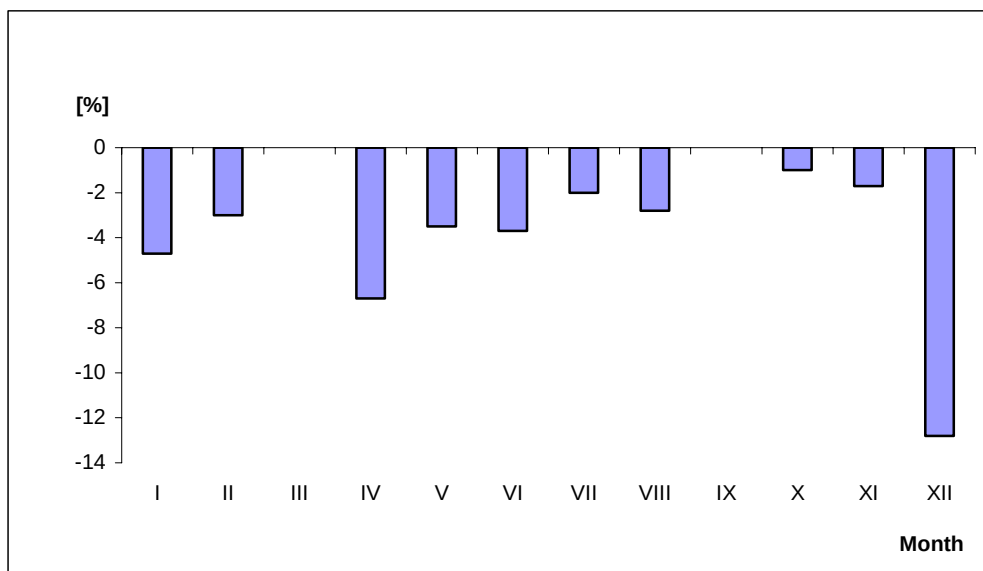


Fig. 3. Monthly means departures (in percent) from 44-year averages of total ozone measurements at Belsk in 2007.

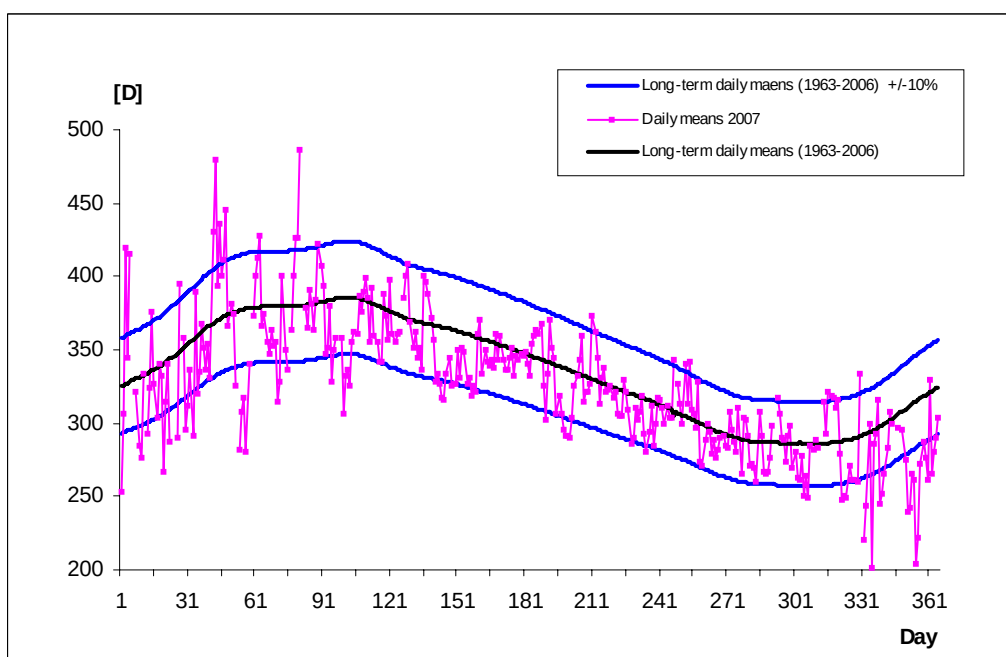


Fig. 4. Time series of the total ozone measurements at Belsk in 2007.

Table 2

Monthly means of total ozone [D] and the departures (in percent) from long-term monthly means in 2007: 1 – long-term monthly means, 2 – monthly means, 3 – departures

2007	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	340	372	381	386	368	355	339	320	300	287	288	312
2	324	361	381	360	356	342	332	311	301	284	283	272
3	-4.7	-3.0	0.0	-6.7	-3.5	-3.7	-2.0	-2.8	0.0	-1.0	-1.7	-12.8

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TOTAL AMOUNT OF OZONE

Observations are entered in the column in accordance with the codes explained below:

YY – Greenwich day of the month on which the observation is made.

GG – Time of observation to the nearest hour, Greenwich Mean Time.

μμμ – The relative path-length of sunlight through the ozone layer.

λ – Wavelengths used, reported according to the following code:

0 – wavelengths AD, ordinary setting,

2 – wavelengths CD, ordinary setting,

4 – wavelengths AD, focussed image,

6 – wavelengths CD, focussed image,

9 – wavelengths CD, focussed image with NiSO₄ filter.

S – Kind of observation, on sun or sky, reported according to the following code:

0 – on direct sun,

2 – on blue zenith sky – ZB,

3 – on zenith cloud – ZC (uniform stratified of small opacity),

4 – ZC (uniform or moderately variable layer of medium opacity),

5 – ZC (uniform or moderately variable layer of large opacity),

6 – ZC (highly variable opacity, with or without precipitation),

7 – ZC (fog).

ΩΩΩ – Total amount ozone in D (1 dobson = 1 milli atm-centimeter).

YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ
JANUARY 2006	14 11334 26287	27 12307 20335	09 9328 26393
	12346 26291	28 11286 20317	9305 26407
	12356 26289	11285 20319	9293 25387
	15 11330 26277	11288 20326	10270 25390
02 10388 26310	11339 26271	29 11286 26334	10253 06409
10371 26305	12351 26274	12295 26331	11247 06409
10366 26304	12359 26278	12300 26340	12272 26409
11364 26310	16 10346 22277	30 10301 26317	13285 26401
04 11360 26350	10337 22274	10289 26317	10 9293 26403
05 10381 26341	10331 20271	10283 26314	9277 26402
11367 26338	11328 20274	11279 26313	10263 06414
11358 26334	11326 20279	11278 26317	10254 06411
11357 26335	11329 22278	12288 26325	10248 06410
11364 26332	11334 20275	12296 26321	11244 06415
11372 26333	17 11331 26300	31 10293 26322	12262 06426
06 10376 26321	12337 26297	10282 26323	12274 26412
10364 26313	12344 26300	11276 26323	13290 26408
11355 26311	20 10328 25259	11275 26322	13310 26413
11356 26315	10319 25258	12288 26317	13335 26421
11366 26312	11313 25260	12294 26312	11 11240 02424
12378 26316	11313 25260	FEBRUARY 2006	11241 02422
07 11353 20284	11321 25267		11241 02421
11356 20286	12327 25267		13 10237 06436
11360 22286	12335 25264		11235 06433
11364 20290	12343 25264	01 10285 26348	11234 06431
12376 20294	22 12345 24338	10277 26340	11235 06431
08 11356 20258	12354 24341	11273 26338	14 9281 26417
11359 22357	23 10315 20297	11272 26342	9266 26409
12365 20255	10306 20294	12292 26362	10253 06422
12370 22258	11304 22297	12301 26358	11239 06423
12378 20259	11303 20300	02 11269 26361	15 10243 06408
09 10375 20298	11302 20294	11268 26366	10236 06405
10358 20299	25 10311 24261	11269 26362	10231 06402
10354 22298	10306 25258	04 11262 26391	11229 06398
11348 20301	11297 25262	13336 25371	12239 06390
11347 20301	11296 25260	05 11259 22414	12243 06393
11351 20299	12312 25271	11259 22403	12252 06397
12361 20299	12323 25264	11263 22409	13270 06405
12370 20299	26 10311 22310	12272 22406	16 11227 06397
10 10362 20299	10305 22305	12284 22416	11226 06393
10356 22296	10298 22304	13302 22415	11228 06394
10350 20295	11292 22310	13328 22424	12241 06392
11345 20300	12310 22303	13346 22413	13259 06397
11345 20298	27 10304 22329	06 10262 25418	17 9291 26369
11349 20298	10300 20324	11257 02418	9262 06382
11352 22289	10296 22322	11255 02421	10227 06378
11357 20287	10292 20327	13299 22417	11224 06379
12375 20282	11290 22328	07 12277 26425	11223 06375
13 11336 26310	11289 22333	12289 26431	12235 06375
11336 26305	11289 20338	08 11249 06386	12246 05369
11343 26309	11290 20339	11250 26368	13261 04368
12357 26311	12297 20339	12286 26384	13281 25372
14 11333 26288		13295 26374	

YY	GG	μμ	λ	ΩΩΩ	YY	GG	μμ	λ	ΩΩΩ	YY	GG	μμ	λ	ΩΩΩ	YY	GG	μμ	λ	ΩΩΩ
18	11	221	02	365	28	92	18	02	420	06	12	192	00	439	11	14	254	02	447
	11	221	02	366		92	13	02	420		12	197	02	444	12	82	20	00	420
	11	223	02	362		10	198	02	423		12	199	00	442		92	06	00	420
	12	233	02	362		11	197	00	419		12	204	02	442		91	90	00	425
	13	268	22	364		12	208	00	422		13	214	02	441		10	181	00	423
	13	275	20	358		12	217	00	421		13	228	02	441		10	176	00	425
	13	284	22	365		13	225	00	420	07	82	92	00	410		11	174	00	421
	13	293	20	361		13	236	00	422		82	47	00	412	13	82	59	02	418
19	13	289	25	358							92	24	00	415		92	01	00	406
20	92	58	02	341							92	01	00	409		91	91	00	404
	92	34	02	341							10	187	00	406		11	172	03	409
	10	225	02	339	01	11	195	02	434		11	183	00	413		13	209	05	402
	10	220	02	337		11	196	02	435		11	183	00	416	14	13	190	05	399
	10	217	02	337		11	198	02	433		12	187	00	415		13	209	05	408
	11	216	02	340		12	204	00	435		12	194	00	413		14	228	06	414
	11	216	02	339		12	210	02	433		12	199	00	411		14	241	06	419
	12	235	05	338		12	218	00	434		13	206	00	411	15	82	59	04	408
	13	257	06	344		13	228	02	434		13	226	02	411		91	89	04	410
21	10	219	06	371		13	230	00	439		13	231	00	404		10	170	00	407
	10	215	06	375	02	92	27	06	455	08	82	89	00	425		11	169	00	404
	11	213	06	376		11	193	02	451		82	56	00	425		11	169	00	406
	12	223	06	382		11	192	00	457		82	30	00	414		12	180	00	407
	13	241	06	389		11	192	00	458		92	09	00	431		12	183	02	411
	13	253	06	392		11	194	00	458		10	184	00	433		13	193	02	415
	13	265	26	387		12	196	00	459		11	181	00	434	16	11	168	06	424
	13	281	26	389		13	238	00	455		11	181	00	437		11	170	06	423
23	92	48	06	376		13	242	00	455		12	193	00	446		12	173	06	416
	92	36	06	374		13	249	00	453		12	200	00	444		12	181	06	407
	11	208	06	369		13	260	00	454		13	213	00	437		13	189	06	402
	13	271	22	379	03	82	65	00	444		13	237	00	435		13	194	06	400
	13	285	22	371		92	38	00	445		14	258	00	432		13	201	06	402
24	92	23	02	386		10	202	00	449	09	82	59	02	427	17	13	220	06	409
	10	219	02	387		10	192	00	453		10	186	00	431		14	251	06	411
	10	212	02	389		11	191	00	457		10	183	00	429		14	258	06	412
	10	208	02	392		12	200	00	451		11	179	00	398		14	274	06	408
	11	208	02	395		12	202	02	452		12	197	02	393	18	11	165	06	379
25	11	203	00	343		12	211	00	451		13	202	00	383		11	167	06	378
	11	205	00	344		14	353	20	371		13	220	02	387		12	174	06	380
	12	209	00	348		13	220	00	450	10	82	28	06	400		13	189	06	388
	12	218	00	348		13	236	00	452		92	09	06	404		13	202	06	395
	13	235	00	342		13	254	00	449		91	92	06	408		14	223	06	401
	13	256	00	341	04	12	200	02	455		10	185	06	414		14	260	06	407
27	82	83	20	418		13	212	02	450		11	177	06	403	19	11	163	06	364
	92	50	00	413		13	238	00	451		11	187	06	400		11	164	06	362
	92	24	00	414		14	262	00	447		13	201	06	415		13	203	04	345
	10	212	00	416	05	11	188	05	431		13	211	06	414		13	214	04	344
	10	204	00	421		12	191	04	431		14	260	06	422		14	241	04	348
	11	200	00	419		12	199	06	433	11	11	176	06	450		14	258	05	342
	12	204	00	415		13	228	06	428		12	193	04	456	20	91	73	06	289
	12	219	00	412		14	261	06	429		13	208	02	458		11	162	02	292
	13	238	00	407	06	11	184	06	451		13	226	02	462		11	161	02	291
28	82	62	22	423		12	188	02	450		14	241	02	455		14	259	02	293

YY	GG	μμ	λΣΩΩΩ	YY	GG	μμ	λΣΩΩΩ	YY	GG	μμ	λΣΩΩΩ	YY	GG	μμ	λΣΩΩΩ	
21	7251	06345		28	8188	00349		05	7213	06401		10	14217	06435		
	8236	06345			9171	02346			7202	06415			11	6260	06484	
	9187	06346			10156	02347			9152	05395				7195	06468	
	10161	63651			10152	00349			10147	05388				9142	06474	
	13198	06335			13187	05364			10144	05392				10142	06478	
	14223	04334			14232	05364			11143	06385				13173	06482	
22	14240	02331		29	7267	05374			11443	06379			14191	06481		
	7260	05326			7148	05385			12149	05383				14212	06471	
	8235	04324			8203	05386			14192	06392				15245	06469	
	8201	05323			8187	05385			14197	06393				15261	06472	
	9187	06330			9170	05386			14202	06393			12	6268	05383	
	10160	06337			30	7237	05378			14207	06396					6261
11159	06346		8189	05380			14211	06400			6252	05380				
14241	06351		9166	06382			15259	06398			7205	06380				
14266	06354		13174	02377			06	7203	00412			8183		06377		
7234	02367		13182	02381				8195	00412			9150		06381		
23	8199	02367		14204		02380			9164	02416			9142	06385		
	10159	00363		14244	00383			9162	00427			11137	05391			
	10158	00363		31	7233	06384			13177	05410			11137	05393		
	11157	00362			8210	06404			15252	05417			13153	05391		
	12171	00362			8186	06399		07	6264	00387			13175	05395		
	13180	00364			9169	06386			7221	00390			14186	04398		
13196	00369						7202		00390			14198	04400			
14207	00364		APRIL 2006				8184		00390			14208	05398			
14235	00355					9157	00391				15235	04406				
24	7307	00346		01	10149	06386				10141	02386		13	7234	05388	
	7258	00349			11147	02387		13176	04390			8157		02386		
	7242	00354			11147	00388		14188	04391			9151		00391		
	8206	00354			11147	00387		08	12148	00417				9149	00391	
	8190	00351			11148	02386			12154	00412				10140	00393	
	9166	00343			02	12153	05381			14199	00402				11136	05391
10159	00346		13171	02380			14212		00402			13158	05394			
11156	00339		13188	00382			15255		00404			14192	06392			
11158	00342		14196	00387			09		11141	06398		14	9147	06343		
12169	00340		14207	00389				12142	06403				11135	00431		
13177	00337		15253	02381				12152	06395				12144	00431		
14260	02346		03	7225	05396			13161	06395				12147	00430		
25	11157	05330			8171	05400			14204	06389				12148	00435	
	12162	05331			12152	00401			15231	06383				14194	00426	
	12169	05331			12154	00399		15268	06390			14208	00421			
	13183	05335			04	8177	05392		10	8186	06389			14212	00423	
	13194	05342				8170	06391			8175	06392			15259	00417	
	14204	05343		9164		06394		8166		06406			15264	00422		
26	12160	07364		10145		06408		10142		06406		15	6271	06399		
	12165	07352		11144		06412		10139		06402				6247	06429	
	13177	07362		11144		06407		10138		06404				7211	06411	
	27	11152	06320		11145	06407		11138	06405				7204	06421		
		11153	06321		14193	04258		12146	06403				7197	06424		
		11155	02324		14218	06426		14192	06420				10134	06409		
13191		06332		15242	06429		14195	06417			10134	06409				
28		7232	00351		15263	06426		14202	06426			11134	06413			
		8202	02348		05	7238	06419		14210	06435		16	10135	06342		

YY	GG	μμ	λΣΩΩΩ	YY	GG	μμ	λΣΩΩΩ	YY	GG	μμ	λΣΩΩΩ	YY	GG	μμ	λΣΩΩΩ	
16	10	134	05344	23	62	56	02393	30	62	60	06367	05	71	76	00379	
		11134	05342			7183	02395			6209	06363			9134	00379	
		11134	05349			7161	02395			6203	06367			9129	00380	
17	11	133	05386			9133	00393			7197	06363			10124	00378	
		11134	02393			10129	00393			10125	06373			11123	03377	
		11135	02394			11129	00397			10125	06373	0		12128	02376	
18	81	68	06372			11130	02398			11125	06376			12133	00376	
		8160	06372	24	71	92	05409							15204	05371	
		9149	05372			7182	02420							15219	06377	
		9141	06371			8153	05407					07		11124	06375	
		10132	02369			11128	06404	01	62	16	02363			12125	00379	
		11132	02372			13148	02400			6206	02367			12132	00377	
		11133	02368			14172	05406			7195	02368			13149	00377	
		13159	06366			25	6244	00385			7189	02367			14184	00379
		14178	06373				7198	02384			10126	04365	08		6194	00374
		15216	06371				8145	00398			11126	05366			7170	00375
19	62	34	02351				9138	00404			12127	05368			8148	00378
		7224	00358				11129	00402	02	62	23	05373			8142	00380
		7196	00355				12131	00402			7169	05373			9129	00382
		7177	00356				14196	04398			8160	05377			10125	00377
		9146	00355			26	9139	00387			11126	05385			10123	00374
		9140	00355				9134	00388			14157	05376			11122	00382
		9138	00356				10130	00389			14171	05378			16261	06375
		10132	00354				10128	00380			15192	05383	09		5261	20357
		14206	05352				10127	00381			15206	05384			6241	00357
		15212	05352				10127	00382			15222	05391			6224	00360
		15262	05351				13153	00375	03	13	142	02382			6214	00358
20	13	163	02379				14162	00373			13149	02381			6202	00361
		14179	02380				14188	00371			14169	02384			7170	00360
		14191	02382				15201	00370			14184	02387			8152	00360
		14198	02384				15222	00368			15198	02377			8143	00364
		15239	02387				15238	00370			15218	02379			9128	00358
21	62	54	00364	27	62	41	00373				15239	02376			9125	00363
		7206	00364				8151	00361			15258	02375			10123	00367
		7195	00365				8146	00372	04	62	48	00369			10121	00353
		8171	00368				9135	00375			6221	00372			11122	00354
		8160	00366				10128	00378			7192	00371			13145	00359
		8148	00365				11127	00371			7171	00375			13150	00360
		9136	00370				13149	00369			8147	00376			14164	00363
		10132	00370				15201	00371			9136	00378			15185	00359
		12137	00371				15209	00378			9128	00379			15212	00359
		13157	00371				15247	00372			10123	00380			15241	00359
		14173	00372	28	62	29	02387				11124	00378			16257	00360
		14192	00373				7204	02386			13147	00380	10		7154	02372
		14204	00369				8147	04383			14164	00379			8151	00370
		15226	00371				11126	00383			14176	00381			9134	00366
		15261	00367				13158	02387			15191	00379			9130	00367
22	11	131	04408				14182	00384			15204	00378			9125	00362
		12134	04409				15197	02386			15237	00375			10122	00365
		12137	05409			29	14177	06378			16260	00375			11121	02369
		14174	02411				14183	06378	05	62	60	02381			14168	00374
		14189	02408				15211	06369			6214	00373			14173	00373

YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ
11 6229 00368	16 6245 00355	24 11117 05324	31 10117 06402
6208 00369	6205 06356	11117 05326	10116 06401
6192 00366	8140 00363	13147 05333	14146 02401
7161 00364	10122 05355	14151 05327	15202 00399
8146 00367	17 8137 06364	14159 05337	16244 00400
8140 00370	9125 05353	15195 05330	
9126 00358	10119 06354	15210 05325	JUNE 2006
9124 00365	11118 05356	16231 05335	
10121 00368	15181 04364	16269 05340	01 7172 06407
11120 02371	18 7164 06359	25 8144 00392	8141 05411
13148 00371	8136 06351	8140 00395	9143 05412
14180 06365	9128 05350	8133 00394	10116 00410
15200 06368	12222 00346	9126 00390	10115 00407
12 6238 05360	15200 06339	9121 00387	11116 02410
8137 02360	15227 06341	11117 00384	15197 05405
9129 00360	19 9128 05346	15184 06389	15205 00406
10120 02360	10119 00340	26 5259 06402	16258 00400
10120 00367	11118 00353	8131 06409	02 6217 00378
11120 00368	11118 00366	8130 06405	6195 00373
13134 00364	16237 02366	9127 06406	8141 00379
15214 00363	16253 02360	9120 06417	9126 00384
15237 00361	20 5262 04361	10119 06413	03 5233 05354
16250 00360	6225 04364	10117 06409	6180 05357
16261 00358	6206 04366	27 12125 05404	7158 02359
13 5264 00368	7158 05363	13130 05396	9120 06360
6226 00369	9129 04376	13138 06394	10118 06356
6203 00369	10120 03374	14143 06411	04 11117 05376
7158 00370	21 16238 02363	14162 06408	14143 06372
8149 00367	22 5238 00327	15181 06405	14155 05374
8142 00365	6214 00331	28 5234 06405	14158 02372
8134 00367	6187 00332	6203 06401	05 5263 06361
9127 00368	8143 00328	7154 06403	5241 06355
9124 00369	8137 00325	8143 06399	10115 06358
10122 02362	9128 00323	9123 06401	11115 06357
14 5263 06383	9124 00328	29 7154 06393	14148 05357
6208 05375	10118 00328	7149 06405	14163 06362
6201 06374	11117 00331	14148 05392	06 5271 00361
9129 05370	15174 03326	14155 04396	5262 00358
9127 05372	23 5259 00321	14158 02403	5247 00361
9124 05371	5240 00321	14162 00393	6204 00363
9123 05366	6193 00324	15201 02402	6201 00361
10121 05375	7148 00333	16228 02396	6197 00363
10120 05383	11117 00340	16258 02393	10115 00359
15 5263 00370	11118 00333	30 5235 06417	10115 00366
6393 00378	14148 00332	6200 06416	11115 00361
7173 00375	14171 00335	11115 03417	11115 00360
8141 00366	15189 02332	11115 04413	13134 00366
9132 00363	24 5260 05320	11116 05409	15192 00364
9123 00364	6210 05323	13139 05416	15208 00363
10121 02361	9125 05327	14145 05418	07 5262 00360
10119 00363	10120 05322	31 5236 06404	7159 03359
11119 00363	10117 05327	6189 06398	9122 05361

YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ
07 10115 06363	13 11114 00338	19 8130 00351	25 5249 00317
11115 03646	12116 00341	8127 00355	6223 00317
15184 00367	13127 00345	10115 00353	6201 00317
15193 00367	14150 00343	10114 00352	6299 00317
15205 00366	14162 00342	13131 00351	6296 00317
16228 00366	15182 00343	15175 00341	6185 00317
16250 00363	16219 00339	16217 00347	7163 00322
08 6298 03358	16248 00337	16231 02346	8132 00325
7160 03357	16260 00335	20 5306 00330	8130 00324
11114 03355	14 5261 00335	5250 00332	9118 00328
14144 02364	6220 00336	6196 00332	10116 00329
14150 02325	6201 00334	6181 00332	10115 00326
14161 02347	6181 00336	8139 00335	10114 00330
16242 05363	7147 00341	8129 00332	26 5235 03323
16261 06362	8127 00345	9119 00331	8143 00322
09 5236 00366	9121 00347	10115 00330	8132 00324
6212 00366	9118 00348	11114 00340	9126 00326
6184 02361	11114 00346	11114 00341	9120 00324
8135 00372	12121 00351	13130 00339	10117 00325
9118 02365	14146 00351	14142 00337	10114 00325
11114 04364	15182 00354	14154 00339	10115 00326
13127 06365	15203 00356	15171 00335	14139 00322
16254 05335	15 12116 00351	15201 00330	14144 00320
10 12120 05354	12116 00354	16226 00330	14150 00320
12122 00357	12122 00356	16259 00327	15203 00321
14162 02353	13123 00357	21 8140 00330	16227 00318
15175 00355	13131 00357	8133 00330	16268 00315
16221 00353	13133 00355	8128 00331	27 9121 00312
11 12120 00336	14154 00360	9123 00328	10117 00310
13127 00336	14157 00361	9119 00329	10115 00309
14141 00335	16 7160 00328	10115 00328	11114 00310
15172 00336	8141 00330	10114 00333	15178 02319
15200 00334	8133 00330	11114 00335	16218 00320
16221 00335	8126 00332	12116 00334	16240 00318
12 5260 00322	9122 00333	15200 02335	16266 00318
6195 00326	10116 00330	22 6193 02317	28 5263 00307
7162 00326	11114 00327	6173 00317	6215 00310
7148 00327	12116 00330	8132 02317	6180 00306
9125 00329	12117 00333	8128 00317	7168 00308
9121 00330	13131 00338	10114 06316	8129 00317
10115 00330	14140 00338	12118 04318	10114 00324
13124 06328	15175 00332	16210 05320	12119 05322
14140 06329	15201 00334	23 6194 06327	15198 02318
13 5262 00334	16225 00333	7144 05322	16255 02309
6211 00339	16261 00330	11114 02323	29 7146 00329
6201 00337	17 13124 06343	12122 04323	9120 05325
7150 00334	13136 02343	15195 05325	10115 06327
8141 00334	14160 06341	24 12121 02348	11114 00329
9124 00335	18 5226 05376	12122 00349	15180 00324
9120 00337	8130 05370	15172 00346	15202 00320
9117 00335	10115 02371	15198 00342	16260 00318
10114 00337	19 7151 00350	25 5261 00315	30 5266 00308

YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ
30 6191 03307	04 15180 00328	09 15178 00344	15 8130 00360
8138 03309	15200 00326	15192 00342	10119 00365
11114 05315	16217 00326	16220 00340	10117 00362
16223 05309	16246 00325	16261 00339	10116 00364
JULY 2006	05 5264 02325	10 5265 00329	11116 00365
	6231 02323	6194 00335	16 12121 00345
	6206 02324	8143 00343	13127 00339
01 12116 04317	6185 02323	8129 00345	13132 00337
12119 04319	8141 02325	9123 00348	16237 03329
13128 05314	8134 02327	10116 00342	17 5260 00326
14149 05311	9120 02332	10115 00341	6228 00330
15168 05317	10116 02330	12117 00346	6203 00329
15199 04317	10115 02330	13138 00341	7168 00332
16230 03319	12120 06324	15167 00340	8141 00327
16263 03317	13127 06327	11 8144 03326	9130 00324
02 6224 00313	15199 05321	9126 00327	9126 00325
6181 00314	06 5260 00319	9120 00327	10116 00328
7163 00313	6225 00321	10116 00327	11116 00329
7150 00315	7155 00325	11115 00328	13125 00330
8137 00318	8141 00321	14163 00323	13132 00331
8128 00317	8130 00325	15183 00320	14143 00333
9123 00317	9124 00323	16210 02326	15167 00329
9119 00319	9120 00324	16240 00320	15184 00328
10115 00321	10117 00325	12 5259 00322	15212 00326
03 6182 00314	10116 00323	6229 00327	18 5258 00315
7163 00313	11114 00330	6194 00325	6228 00316
8136 00316	11114 00329	7168 00327	6202 00316
8130 00316	12116 00330	8146 00330	7181 00318
9123 00319	12122 00332	8133 00330	7150 00317
9118 00319	13125 00331	9127 00332	8140 00317
10115 00320	14145 00328	10118 00329	9130 00316
11114 00330	07 5265 00320	14151 00330	9126 00316
11114 00331	6195 00320	15177 02328	11116 04318
12117 00325	8137 00325	16252 02328	19 7153 00314
13126 00329	8128 00320	13 5250 00321	9129 00315
14141 00327	9124 00323	6210 00322	9126 00316
15169 00324	9120 00325	6205 00322	10119 00320
15194 00323	10118 00323	6200 00321	10119 00319
16261 00320	10115 00325	6196 00322	11117 00318
04 5263 00312	10117 00332	9126 04321	11117 00321
5249 00313	13134 00335	11115 00323	11117 00320
6227 00312	13136 00334	11115 00321	15188 02317
6206 00319	14153 00331	15201 04324	15202 00311
6194 00314	08 5264 00321	14 14148 06336	16224 00314
8140 00315	6211 02324	15193 06332	16258 00312
9123 00319	7150 00329	16234 02330	20 5253 00312
10115 00317	8131 00334	16249 02331	6219 00315
10115 00318	11117 00331	16262 02333	6201 00316
11114 00323	10115 02329	15 6211 06365	7180 00316
12121 00332	09 13131 02350	7157 00364	8146 00317
14140 00329	14141 00343	7155 00363	8133 00324
15165 00330	14161 00344	8131 00360	9128 00326

YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ
20 10118 00325	27 5268 00320	AUGUST 2006	09 16244 02326
11117 00324	5265 00319		16275 02329
13127 00333	6247 00320		10 6235 05338
15205 04328	6217 00323		8148 02339
21 6220 02337	6206 00323	01 10123 06339	8141 05344
6199 02340	6203 00324	11120 06343	15193 06341
9121 02340	7186 00325	11120 06338	15202 06342
11117 02336	8145 00324	11121 06328	16258 06342
13131 04338	9127 00323	14156 06332	11 6249 06323
14157 04341	9126 00324	15199 06336	6218 06322
22 12121 06348	10122 00328	15205 06333	7206 05321
12124 02348	10119 00325	15211 06332	7194 05321
14141 02349	11119 00324	02 8133 06333	7178 05324
14165 02347	11119 00327	13135 00348	7166 05323
14167 00335	12124 00327	14147 00347	8145 05325
16234 02334	13130 00326	15206 02345	9138 05326
16261 02333	13141 00325	16239 00338	9130 06327
23 12120 03325	14151 00324	03 6251 00338	10125 06337
12122 03324	14160 00325	7291 00341	11124 06333
14148 03328	15186 00321	7173 00341	13149 06335
14165 02328	15199 00320	8149 00340	14166 06334
24 5260 00327	15222 00320	8132 00340	14179 06339
6221 00328	16244 00321	8131 02337	12 8161 05344
6200 00330	16263 00319	11121 04330	8158 00344
7170 00327	28 6258 00313	14168 02336	9130 00349
8138 00326	6209 00314	15223 06332	10129 00347
9129 00322	7190 00317	16250 06344	10126 00350
9123 00320	8145 00319	04 7165 06351	11125 00350
10119 00327	8137 00325	13132 06353	13 6258 05335
12125 00322	9129 00316	13142 06362	6221 05336
13130 00321	10122 00319	14175 06359	7191 05330
14164 02327	11119 03319	15204 06343	8152 06345
15184 02326	11119 00321	16274 06362	8145 06346
25 6252 00311	15175 05317	05 12126 05345	10127 06350
6221 00315	29 6255 02301	13141 02342	14 6244 06358
7165 00317	6231 02299	14156 02337	7167 06361
9132 00318	6199 02302	15198 05329	9133 06360
9126 00322	7179 02306	07 8154 05347	11126 06363
10118 00326	9131 05305	8152 00349	13141 06361
11118 00328	10120 04316	10125 02352	14185 05348
14150 04325	30 14164 05323	10123 00346	15146 04354
15187 04329	15178 02327	12125 00351	16273 02352
26 5272 00316	15205 00323	14175 05343	15 7206 05343
6249 00317	16251 00319	08 7167 06337	7191 00344
6210 00317	31 6266 00302	9133 06340	7172 00344
6204 00316	7169 00310	11123 02340	9139 00350
7161 00320	8156 00311	11123 00336	10130 00350
9123 05318	9135 00311	14151 06334	10127 00350
11118 00329	9130 00315	16246 05327	11126 02350
13130 02331	10123 00308	09 10126 06328	11126 00348
14155 00332	10121 00314	11123 06343	16 8154 02330
15186 06326	14165 04309	13138 05328	8149 00326
		15220 04330	

YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ
16 9139 00327	23 7204 05337	31 11137 05330	08 8196 05272
10131 00328	9245 05332	13158 00331	10144 06279
10128 00327	10132 00332	14204 00327	11147 00280
11127 00328	11131 00332	14207 00327	12148 00278
12135 00326	12144 02337	14224 00327	14192 06288
13139 02329	15207 00337		15256 05288
14166 00329	24 7198 02321	SEPTEMBER 2006	09 12151 01305
15214 00328	11132 05328		12161 02305
15232 02325	11134 00336	01 6255 00305	13168 00301
17 6248 04317	14167 05329	7230 00305	13183 00300
7174 05317	14185 06331	7206 00307	14206 00300
9134 00318	15231 02327	10142 06306	15254 00296
11127 00316	15243 00325	10138 06308	10 7267 00286
11128 00311	25 6299 00312	14207 06306	7259 00285
12139 00314	6255 00314	02 11141 02289	7202 00285
13147 00317	6237 00312	12144 00283	8197 00286
13158 00312	7207 00317	13163 00288	8171 00287
14173 00308	8152 02316	14183 00288	11146 05290
14189 00311	9146 02316	14207 00289	11 7253 00282
15248 00307	11133 00321	15233 00289	7212 00284
15267 00304	11134 00317	03 6256 05289	8188 00279
18 6558 03300	13161 02320	7248 05288	8172 00281
7217 00299	14170 02319	7212 05290	9164 00282
8153 02299	15247 06317	7207 05289	9153 00282
8147 02298	26 12138 04320	8166 05290	10149 02281
9145 00302	12141 02323	04 7196 02288	11147 00285
11128 04302	13150 02320	7193 02288	13192 00290
19 6241 06316	13157 02321	9154 02292	14211 00288
8147 06309	14175 02319	11140 02285	14250 02284
9144 02315	14176 00320	11141 02285	15266 00286
10129 06310	15239 04324	13172 06282	12 7260 00292
20 14171 05306	15179 00349	05 7253 02313	11149 02299
14183 05310	27 7230 00309	7199 06312	12166 00297
15207 00315	7199 02313	9148 06316	13195 00299
15236 06307	8173 02318	11141 06320	14200 00297
21 2514 00320	8158 00318	15259 06313	14225 00296
7218 00318	9148 00319	06 7199 05278	14258 00295
7192 00318	28 8164 06322	11142 00278	15265 00294
8173 00320	13153 05333	12151 04271	13 7225 00282
8151 00323	13164 05325	13167 02275	8202 00283
9140 00323	14214 00328	13174 00276	8182 00289
10134 00325	15228 02324	14195 02270	9170 00288
10130 00327	15234 00328	07 6260 06262	9158 00291
11130 00326	29 6279 06351	8183 00262	10151 00291
13158 00326	6265 06351	8172 00262	11149 00290
14171 02326	30 6264 06374	9161 00261	12159 00294
22 7202 02320	6245 06365	9158 00258	13185 00294
8170 05322	31 7234 05326	11143 02263	14201 00293
11131 05338	8175 02324	11144 00262	14266 00291
11132 00333	9147 02330	12148 00262	14 7225 00287
13159 02341	10140 00325	13176 04263	8189 00287
15213 02342	10139 00327	14222 02264	8176 00288

YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ
14 9166 00289	20 10160 06308	26 8204 00286	02 8209 05247
10155 00290	10157 02309	9186 00292	9197 05245
10150 00292	13210 06306	9173 00296	9186 06255
11150 00290	21 7233 00288	10169 00298	12198 06258
12155 00293	8220 02285	11166 00305	12200 06261
12161 00294	8187 02295	13203 00297	14268 06252
13180 00293	9174 02293	14239 00297	03 7257 06249
13195 00294	9168 02293	14278 00299	8238 06252
14205 00292	10164 02291	27 6338 00270	8208 06250
14226 00293	10159 00292	7264 00269	9200 06256
14264 00292	11159 02286	8230 00270	9198 06232
15 7279 00290	13194 02287	8196 00272	9196 06236
7264 00290	13206 02286	9175 00273	12204 06262
7210 00290	14257 02289	10171 00272	13210 06258
8201 00292	22 7254 00285	10168 00275	13246 06259
9169 00290	8215 00286	12179 00273	14264 06269
10154 00293	8197 00291	13207 00272	04 9190 06275
10151 00293	9181 00294	13228 00272	9199 06278
11151 00294	9170 00292	14255 00272	10179 06280
12169 00298	10162 00294	28 8229 06279	10179 06283
13177 00295	12174 00290	8211 02279	10179 06287
13203 00295	13196 00288	8203 02279	10178 06284
14239 00296	13205 00289	10169 04276	12204 06278
14266 00292	14237 00288	29 7274 00265	13217 06275
16 8202 02292	14259 00289	7265 00266	14290 06270
8183 00284	23 10161 02293	8214 00266	05 8255 06284
9174 00286	11163 00297	8209 00265	8230 06285
9158 00285	11166 00296	10171 06260	9205 06294
10153 00287	12176 00299	12186 04263	10180 06293
11152 02286	13220 00299	13212 02271	11181 06289
17 12162 03278	14248 00300	14252 02270	12208 06277
12165 02285	14266 00298	14270 02268	13242 06285
13210 03277	24 7259 00297	30 11177 02258	13256 06289
14234 03277	8209 00299	11177 00260	06 8248 02280
14265 04276	8192 00300	12184 00260	8242 00278
18 8207 04282	9177 00302	12195 00260	9207 00277
8194 00278	10168 00301	13214 00260	9200 00277
9177 00281	10164 00301	13234 00257	10186 00277
9162 00283	11163 00299	14255 00256	11182 00275
10156 00282	25 7262 00304		11186 00277
13177 00284	8227 00305		12193 00275
14248 02282	8209 00304		12209 00274
14259 02283	9186 00304		13226 00274
14262 02282	9177 00305		13262 00273
19 7241 02288	10168 00309		07 11187 03270
8209 02287	10165 00309		11289 02275
10158 02288	11165 00309		12197 04272
11156 02290	13222 00304		12207 04276
11157 02290	14259 00303		13220 05282
14234 05293	14266 00303		08 12210 02260
20 8218 02303	26 7253 00287	02 7262 05245	12217 02259
8206 05302	8232 00286	8225 05248	13246 02261

YY	GG	μμ	λ	ΩΩΩ	YY	GG	μμ	λ	ΩΩΩ	YY	GG	μμ	λ	ΩΩΩ	YY	GG	μμ	λ	ΩΩΩ
08	13	264	05	259	14	11	201	06	305	20	11	218	00	276	30	10	239	00	291
09	82	63	06	276		11	204	06	302		11	219	02	274		11	239	00	291
	82	21	06	275		12	213	06	302	21	11	218	02	267		11	244	00	290
	92	10	06	275		12	232	06	301		11	228	02	267		12	258	00	290
	92	01	06	276		13	245	06	302		12	243	02	268		13	347	00	282
	10	193	06	273		13	265	06	303		13	266	02	267	31	92	55	02	252
	10	189	06	272	15	82	67	06	300	22	82	55	00	260		10	249	02	250
	11	188	06	273		82	64	06	298		92	27	00	262		10	244	04	245
	11	191	06	274		92	15	06	284		10	221	00	263		11	242	05	241
	12	205	06	275		92	13	06	284		10	218	00	265		11	244	05	243
	13	257	06	282		92	11	06	285		11	217	02	260		11	246	05	243
	13	261	06	280		92	08	06	279	23	92	54	05	264		12	266	06	245
10	82	58	00	278		10	200	06	289		92	50	05	262		NOVEMBER 2006			
	82	36	00	280		10	200	06	282		92	36	05	263					
	92	14	00	282	16	82	85	22	276		10	219	05	264					
	92	02	00	283		82	50	05	274		11	226	06	275	01	12	291	20	294
	10	194	00	285		92	12	06	277		12	234	06	277		12	299	20	290
	10	191	00	284		11	203	06	276		12	247	06	278		12	311	20	288
	11	190	00	287		13	249	06	285		12	262	06	274	02	92	62	06	331
	12	208	00	285	17	82	51	06	270	24	82	64	06	258		10	256	06	330
	12	225	00	286		92	33	06	272		10	228	02	256	03	11	251	05	334
	13	252	00	284		10	211	06	274		10	222	05	257		12	280	02	327
	13	266	00	282		10	205	06	265		11	231	06	261		12	293	02	332
11	82	71	05	281		12	224	06	268	25	12	250	05	293		12	313	22	327
	92	06	00	282		12	237	00	270		12	253	02	289	07	92	03	06	278
	92	04	00	281		12	240	02	265		12	259	02	287		93	02	26	265
	10	196	00	281		13	267	06	271		12	263	06	295		92	84	26	267
	10	192	00	279	18	82	72	00	263	26	92	48	02	244		11	263	26	274
	10	192	00	280		82	63	00	263		10	227	02	241		10	263	06	281
	11	195	00	279		92	32	00	263		11	228	02	239		11	266	26	270
	11	200	00	278		92	19	00	266		11	231	02	241		11	282	06	285
	13	234	00	277		92	14	00	267		12	263	04	239		12	294	26	269
12	82	71	06	279		10	208	00	266	27	82	80	05	218		12	305	26	268
	82	65	06	282		10	207	00	265		92	70	05	214		12	329	26	267
	92	08	05	277		11	213	00	265		92	67	05	213	08	93	06	24	269
	92	07	05	276		12	226	00	264		92	62	05	212		92	93	24	259
	10	194	05	281		12	238	00	264		92	57	05	213		92	87	24	256
	10	194	05	281		12	251	00	264		92	51	05	211		92	81	24	259
	10	194	05	282		13	367	00	263		10	233	05	212		12	292	26	262
	12	205	03	291	19	82	64	02	248		10	233	05	213		12	340	26	255
	12	219	03	297		82	48	02	250		11	234	04	221	09	93	15	26	295
	13	256	03	303		92	27	02	253		11	243	04	219		92	97	26	295
	13	267	03	306		10	215	02	252		12	253	04	222		11	284	22	295
13	10	197	02	299		10	214	00	259	28	92	70	02	238		11	287	22	295
	11	198	02	300		10	212	02	256		92	51	02	238	10	10	281	22	330
	11	200	02	300		10	210	02	255		10	237	02	241		10	275	22	334
	11	203	02	301		11	211	02	257		10	233	02	244		11	279	22	345
	12	210	02	301		11	213	02	259		10	233	00	246		11	284	20	343
	12	224	02	302	20	82	62	02	264	29	10	241	06	288		12	296	22	344
	13	247	02	310		82	51	02	262		10	240	06	283		12	326	20	352
	13	264	00	301		10	219	02	259		10	237	06	288	11	11	284	26	283
	13	270	02	309		11	215	02	266	30	10	243	00	289		11	294	26	281

YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ
11 12305 26278	18 12339 22260	30 11340 26262	11 11378 25281
12323 26284	12363 22261	11356 26264	13 10378 26267
12352 26285	20 9331 25271	12368 26269	10371 26266
12 9324 26335	10320 26272	12418 26270	11369 25270
9310 26331	10309 26282		11374 26275
10290 26340	10307 26277	DECEMBER 2006	11381 26285
10279 22339	11312 26282		14 10379 26230
13 10284 26309	12334 26297	01 9378 22251	11372 26226
10283 26311	12355 26291	10360 22244	11380 26231
10283 26319	21 9326 26294	10343 22242	15 10384 23206
11295 26293	12337 26291	11343 22241	10379 23204
12305 26298	12384 22291	11368 22240	10374 23206
12326 26305	12398 22298	12380 22236	10372 24204
12357 26292	22 9353 26289	12389 22235	11373 23204
14 9338 26283	11318 22291	02 11348 22244	11378 23204
9312 26281	11320 20299	10356 20249	11384 23201
9299 26273	11331 22293	11362 22244	11391 23204
10290 26279	12345 20292	11369 20252	16 11375 20265
11291 26277	12352 22290	12377 22247	11383 20266
12310 26269	12365 22290	03 11349 25219	11394 20265
12336 25275	12384 22287	11352 25214	17 10387 26253
12364 26287	23 9347 26254	11358 25215	10381 26241
15 10295 26280	11317 22252	11367 25212	10376 26243
10292 26281	12385 26255	12375 25208	11374 26241
10290 26277	12411 26252	04 12377 20288	11375 26239
11290 26281	24 9385 26232	12382 20295	18 10382 23289
12324 26285	9362 26229	12392 20291	11374 26276
12341 26282	9341 26233	12397 22287	11375 26277
12370 26283	10335 25234	05 9383 25271	11380 26278
16 9344 20277	11320 26242	10375 25269	19 10383 26318
9324 20282	11322 26244	06 10366 20252	10376 26314
10305 20284	12353 26250	11356 20256	11377 26310
10295 20279	12383 26253	11374 20253	11381 26309
11294 20281	25 11326 22239	12384 20250	11386 26311
12328 20277	11329 22235	07 10380 26287	21 10384 26250
12345 20278	11339 22230	10372 26285	10377 25253
12379 20279	11348 22224	08 10384 23259	11375 25253
17 9360 20266	26 9396 26216	11379 25260	11377 25252
9325 20272	9388 26213	13518 22260	11381 25252
10307 20272	9344 26220	09 10387 22289	11387 25250
10296 20277	10334 26222	10382 20288	22 10376 26268
11305 20277	10327 26221	10376 20290	11375 26265
12313 20282	11328 23223	10371 22291	23 10384 26269
12335 20279	27 9371 20238	10363 22290	10381 26266
12349 20280	10347 20240	10362 20290	10378 26266
12380 20277	10333 20245	11364 22294	10376 26265
18 10312 22265	11330 20246	10 10372 26281	11375 26264
10305 22265	10336 20245	11 10375 26306	25 10376 26254
10300 22262	12357 20248	10368 25288	11374 25246
11301 22259	12405 22244	10366 25302	11375 22247
11304 22257	30 10358 26265	11368 26291	11379 22246
12322 22259	10344 25255	11374 26293	26 10384 25250

YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ
26 10377 25247	28 10379 26245	29 10378 26265	30 10372 22268
10374 25235	10374 26248	10371 26267	11369 22266
11374 25240	11372 26249	11371 26273	11371 20270
27 11376 26226	11374 26247	11381 26275	11376 20270
11380 26224	11383 26243	30 10379 22273	11383 22261
11389 26218	29 10392 26267	10377 20279	

YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ
JANUARY 2007	13 11336 25309	22 10309 26347	01 12281 26325
	11340 26295	11307 26345	12295 26325
	12358 25288	12318 26337	13320 26334
01 11367 26249	12371 26275	12327 25330	13364 26323
11378 26257	14 12348 22330	12334 22338	02 9356 26286
02 10376 26316	12351 20324	12340 22341	10271 26297
10366 26299	12360 20323	23 10321 26305	11270 26295
11364 26314	15 10338 26387	10309 26286	11270 26285
11365 26306	10336 22378	10306 26280	12277 26288
11379 26304	10332 22379	11303 26287	12289 26287
03 10374 26421	11330 22371	11311 26290	13315 26292
10367 26417	11331 22377	12323 25284	13353 26291
11363 26419	11336 22375	12334 25279	03 9335 26395
11362 26418	12356 24364	26 10311 20286	9300 26387
04 11360 26353	16 10347 20325	10309 22286	10280 26385
11360 26349	10343 22323	10300 20280	11266 26386
11368 26342	10334 20325	10297 22283	11266 26390
12378 26340	10332 22329	11293 20294	04 9345 20324
12384 26341	11327 20332	11293 22298	9332 20316
05 11359 26426	11327 22325	12304 20299	9299 22314
11358 26418	11328 20327	12309 22298	11264 05310
11361 26416	11331 22325	12320 20289	05 9348 25312
12387 26399	11332 20328	27 10295 26403	9336 25315
08 10378 22327	11336 20323	11291 26396	9319 25316
10364 20325	12343 20328	11292 26387	9306 22324
10361 22324	12347 22325	29 10293 25375	9302 22324
10353 22322	12354 20330	10286 25348	11260 05339
11351 22320	17 10342 24310	11284 22362	11261 02348
11351 22318	10331 22315	11283 22362	13316 22337
11355 22315	10327 24300	11283 20357	13341 22341
11361 22315	11324 24298	11284 22356	13358 25342
09 10382 22293	11324 25300	12288 20357	06 9340 26366
10365 20294	12340 26303	12291 22356	9316 26366
10354 22280	12350 26300	12295 20358	9268 26372
12374 20271	18 11321 26340	12303 22350	9288 26358
12390 20273	19 11321 26333	12307 20359	11256 26377
10 10372 26276	11323 26332	30 11279 26290	13306 25366
10354 26274	20 10319 26270	11281 26289	07 11253 05374
10349 26273	10316 26268	12287 26303	12369 05366
11346 26275	11313 26242	12295 26300	12287 24350
11346 26276	11315 26267	31 11276 26317	13300 22354
12369 26280	11322 26261	11276 26300	13316 22353
12384 26277	12334 26263	11277 26308	13334 22351
11 10364 26346	21 9369 22310	FEBRUARY 2007	13352 22348
10354 26330	9377 22304		08 13304 26345
10346 26330	9345 22304	01 9351 26352	13316 25336
10342 26321	10340 22305	9320 26343	13336 26328
10344 26333	10321 20313	10301 26344	09 9326 26334
11352 26326	10318 20315	10291 26351	9321 26336
12363 26322	10313 20313	11273 26330	10265 26344
12385 26323	22 10318 26348	11274 26334	10261 06361
13 11337 26300	10312 26345		10258 06361

YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ
09 11249 06358	16 13282 26396	24 11206 05311	05 11187 03359
11251 06359	17 9281 00444	11209 05313	12195 04360
12264 06364	9261 00445	12211 05314	12204 04362
12272 06363	9259 02444	12223 05320	13247 05370
13287 26354	10241 00447	13247 05322	14259 05368
13315 26351	10236 02440	13267 25289	06 8261 04379
13346 26360	10233 02438	25 11205 05320	8239 05380
10 11244 05337	10227 00443	11207 05318	9211 06384
11244 05331	11224 02437	12210 05319	9204 06384
11247 05340	18 11221 02368	13243 05320	10187 02374
12261 05339	11221 02369	13263 05311	11185 02373
13296 25321	12333 02366	13270 05312	12203 06368
13315 25322	12241 02367	26 8295 26288	13215 06366
13342 25324	13264 02371	8282 26273	13244 06366
11 9312 26432	13269 22361	27 10208 06340	07 8279 00350
9298 25393	13274 22368		8256 02346
9281 26410	13278 22363	MARCH 2007	8240 00351
10264 25426	19 11219 06385		8232 02347
10258 05446	13269 26389	01 9247 05384	9222 02347
10244 05448	13294 26372	9237 06395	10194 02352
11241 05443	20 9271 26380	9226 04381	10187 02354
11241 05443	9250 06380	9214 05379	10184 03353
12 9290 25478	10233 06375	10198 02374	11183 02359
10248 05494	10225 06377	11196 04369	11184 02358
10241 05499	10221 06376	11195 06377	12204 00358
11239 05489	10218 06374	13220 06379	13207 02351
12256 05470	11216 06375	13230 06375	13219 00356
12265 05479	12226 06373	02 8269 00396	13246 00360
13303 25468	12237 06372	8262 04393	14262 02356
13331 25460	13255 06374	9234 02394	14270 00356
13 12240 07395	13280 26360	9230 00405	08 9208 03357
12257 07403	21 8288 25312	9215 02400	9205 05362
13283 26384	9267 22324	10205 02400	12185 06347
14 9297 25427	9260 02329	11193 06419	12195 05341
9276 26418	10223 02323	13245 06408	12197 03338
10239 06432	10219 02323	03 8259 06418	13203 03336
10235 06435	10216 04317	10203 06413	13239 05346
11232 06431	11214 05315	10196 06410	14261 05347
11232 06432	12220 05319	10192 06408	09 8264 06360
12245 06448	12239 05320	11191 06416	8245 06357
12250 06449	23 8284 00278	11191 06412	9219 06352
13301 26438	8275 00278	04 8261 06439	9203 06352
15 10238 06403	9257 02281	8244 06434	10180 06359
10235 06398	10224 00280	10200 06429	11179 06355
11229 06403	10220 02286	10199 06428	12186 06365
12244 06407	10214 00284	11189 06420	12189 06368
12252 06407	11209 00284	11189 06419	12197 06370
13267 26393	11209 00285	05 9225 02364	13235 06381
13282 26396	12215 00285	9217 02366	14255 06387
13299 26404	12217 02291	9209 00373	10 11178 02352
16 13259 26408	12225 02291	10191 03361	11178 02350
13262 06428	13236 02292	11187 03363	11179 00353

YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ	YY GGμμ λΣΩΩΩ
10 11180 00354	14 8258 02363	22 8201 06478	28 8193 00360
12193 05355	9185 04368	9189 05481	9178 02360
12198 06360	10179 02375	9176 05485	9174 00361
13202 06361	10175 00378	11159 05485	9164 00363
13216 06353	10173 02390	11159 02488	10155 00366
14242 06368	10171 00395	13201 06493	12165 00369
11 8250 05357	11171 02395	14212 06488	13194 00365
8234 03355	11171 00402	24 11158 02382	14200 00367
8226 02359	12178 00406	12160 00394	29 7260 00371
9214 02359	12184 00407	12162 02384	7231 00371
9206 02355	13196 00407	12168 02380	8195 00375
9197 00353	13220 00403	13189 00387	8178 00378
9195 02349	14241 00399	13199 02377	8162 00376
10186 04345	14262 00393	14215 02374	10154 00382
10177 06355	15 8260 05356	14258 02371	11150 00386
11176 06354	8229 06355	25 12160 02355	13176 00396
12 8259 02319	8212 05351	12162 00362	13189 00398
8246 02316	9201 02353	12168 02360	14239 00392
8218 00312	9181 02347	12169 00361	15260 00391
9208 02311	10170 06348	14206 00368	30 7252 00406
9196 00314	11169 06348	14212 02364	7222 00407
9193 02308	13193 06349	14237 00369	8200 00409
10179 00313	13203 06347	14259 00367	9174 00418
11174 00317	14232 06357	26 7257 00387	9160 00426
12179 02312	14264 06357	7230 00389	10154 00435
12180 00315	16 7262 02331	8200 00395	11150 00445
13199 02311	8255 00334	9169 00393	11186 00433
13202 00316	9203 02331	9162 00393	14204 00431
13213 02313	9197 00335	10156 00393	15260 00423
13223 00315	9188 02335	11155 00394	31 7260 00393
14234 00310	9183 00338	13187 02388	8203 00403
14282 00314	10169 06344	13195 00390	9162 00413
14319 00313	11168 06336	13197 02388	9156 00411
13 8253 02319	18 10172 06360	14221 00390	10150 00413
8247 00322	10166 06368	14241 02386	10148 00419
8228 00323	19 7261 06411	15266 00388	
9201 00324	8239 06405	27 7249 00377	APRIL 2007
9190 02321	9196 06395	8204 00379	
9186 00325	9189 06396	8189 00382	01 11147 02391
10182 00326	11163 06398	9166 00385	11147 02390
10174 00325	11163 06404	10160 02378	12153 02396
10173 02322	13190 06396	11153 00382	12154 02396
11172 00329	13194 06400	11153 00382	02 7263 04349
12179 00330	13203 06397	12157 00392	7229 04347
12187 00331	20 10162 07420	13174 00378	8206 05343
13198 02340	11162 07419	13183 00379	8184 05346
13206 00337	12165 07429	14203 00380	9156 03350
14230 02328	12170 07436	14222 00380	10149 05346
14238 00334	13207 07433	28 7243 00357	11146 03347
14258 00334	21 7261 07422	7230 02356	13175 04342
14293 00332	8238 07430	8211 00358	14200 04352
15338 00330	22 8218 06487	8202 02357	15249 04348

YY	GG	μμ	λ	ΩΩΩΩ	YY	GG	μμ	λ	ΩΩΩΩ	YY	GG	μμ	λ	ΩΩΩΩ	YY	GG	μμ	λ	ΩΩΩΩ
02	15	260	04	346	11	13	172	05	307	16	81	64	02	367	22	62	50	02	387
03	72	61	03	351		14	181	06	308		81	56	02	365		62	26	00	382
	72	40	03	352		14	201	05	310		91	42	02	365		72	03	00	384
	81	99	03	354		14	216	06	306		11	134	02	360		81	50	00	389
	81	92	04	353		15	244	06	311		13	161	02	361		81	48	00	386
	91	65	04	347		15	281	06	313		13	169	02	363		91	35	00	385
	10	149	04	346	12	62	47	00	326		14	177	02	362		10	130	00	384
	10	145	04	343		72	27	00	328		14	195	00	363		11	130	00	384
	13	186	06	359		71	93	00	329		15	222	02	359	23	62	23	05	350
	15	268	06	365		81	75	00	332		15	232	02	360		71	88	05	349
04	81	89	05	392		81	65	00	330		15	264	02	358		11	129	06	341
	91	56	02	394		91	51	00	329	17	62	60	00	354		12	134	02	355
	91	51	00	394		91	44	00	328		62	47	00	353		13	157	02	356
	10	147	02	390		10	140	00	327		81	72	00	358		14	172	02	356
	10	146	00	392		10	137	00	333		81	58	00	361		15	240	02	353
	10	144	02	384		12	145	00	337		91	51	00	364	24	71	69	06	373
	13	160	00	384		13	151	00	338		91	45	00	360		91	40	06	372
	14	203	00	372		13	164	00	338		10	135	00	366		11	128	06	393
	14	222	00	369		14	197	00	337		10	133	00	365		11	129	06	396
	15	259	00	368		15	224	00	334		11	133	02	361		14	183	06	392
05	72	07	03	330		15	264	00	332		13	152	00	363		15	204	06	396
	81	91	05	326		15	302	00	332		14	188	00	362		15	237	06	400
	10	145	03	323	13	62	51	00	337		14	204	00	364		15	269	06	408
	14	188	02	324		72	22	00	332		15	251	00	359	25	62	27	00	363
	14	192	02	323		72	05	00	334	18	62	42	00	371		72	04	00	364
	14	195	02	323		81	68	00	333		11	132	05	383		71	87	00	362
	14	200	02	324		81	58	00	335		13	161	00	400		81	47	00	353
	15	259	02	328		91	50	00	339		15	215	00	391		91	39	00	352
06	72	57	06	340		10	140	00	341	19	62	58	00	381		91	36	00	355
	72	32	06	345		10	138	00	335		71	87	00	382		11	128	00	358
	72	07	06	352		11	136	00	333		81	71	00	381		11	128	00	358
	81	68	06	346		13	174	00	340		10	136	00	371		12	141	00	359
	91	59	05	348		14	185	00	339		10	132	00	373		14	198	04	357
	91	51	06	346		14	209	00	337		10	132	00	371	26	62	48	00	356
	10	146	06	349		15	225	00	336	20	62	63	02	389		71	92	00	351
	10	143	06	351		15	261	00	338		62	32	02	380		78	78	00	351
	10	142	06	368		15	297	00	337		72	04	00	392		81	50	00	364
	14	201	06	365	14	63	02	00	322		71	98	02	387		81	45	00	360
07	10	141	04	361		62	60	00	322		71	84	02	386		10	130	00	355
	11	141	06	356		72	14	00	323		91	44	02	395		12	130	02	359
09	81	74	06	362		81	55	00	325		92	39	00	402		14	176	04	357
	81	64	06	364		91	46	00	327		91	36	02	397		15	202	06	356
	91	55	06	360		91	42	00	325		10	134	00	395		15	237	04	363
	91	48	06	347		10	138	00	328		10	133	02	388	27	62	53	02	344
	10	140	06	356	15	11	137	02	352		14	208	00	384		62	15	02	343
11	72	31	05	310		13	153	02	355		15	235	02	384		81	62	02	339
	72	06	05	310		14	179	00	356	21	11	133	00	389		81	55	00	341
	81	63	04	303		14	196	00	356		13	158	00	403		81	52	00	341
	91	56	05	302		15	226	00	355		13	162	00	403		91	34	00	341
	10	140	04	300		15	253	00	356		14	190	00	401		11	127	00	339
	10	138	05	302	16	62	63	03	365		15	234	00	400		12	133	00	343
	11	138	05	301		72	00	03	367		15	268	00	399		14	169	00	343

YY	GG	μμ	λΣΩΩΩΩ	YY	GG	μμ	λΣΩΩΩΩ	YY	GG	μμ	λΣΩΩΩΩ	YY	GG	μμ	λΣΩΩΩΩ
27	15	203	04341	04	71	64	00358	09	14	178	00407	16	16	191	04389
		15253	00341			8151	00357			15201	00405			16258	02391
28	12	134	02338			8139	00360	10	62	49	02369	17	62	41	02392
		13140	02341			9135	00361			7185	03369			6186	02397
		14181	05341			9129	00363			7170	03368			10120	00398
		15231	04344			10125	00367			7158	03364			11119	06397
		15253	02348			10123	00366			15237	06371			12124	00396
29	12	133	02388			12130	00363			16257	06379	18	52	60	00381
		12134	00392			12133	00364	11	62	54	02343			6206	00385
		12135	00390			12139	00368			8146	06345			7178	00384
		14176	02387			13148	00363			10122	02353			7157	00384
		14190	00389			15196	00363			10121	02359			9128	00385
		15212	00389			15214	00360			15204	06369			10118	05396
		15235	00386			15243	00364	12	52	55	02365			14147	05397
		15251	00384			16263	00366			6213	04368			15206	00402
30	62	20	00365			16305	00364			7155	05350			15213	02393
		7195	00366	05	12	127	04359			8148	05359			16260	02397
		8145	00374			12130	04358			8138	05365	19	11	119	00374
		9137	00371			13135	04359			8134	05353			11119	00373
		15226	00378			13144	04360			10123	06367			12126	00379
		15256	00379			13154	04359			10121	06367			14151	00372
		16299	00378			14168	04362			10120	06366			15192	00368
						14181	02369	13	11	121	00349			15201	02361
						15198	04366			13139	00345			16239	00366
						15221	04366			13147	00343			16259	02358
01	11	127	06391			16258	04367			14165	00342	20	11	118	00356
		14164	00417	07	62	54	06385			15197	00341			11119	00358
		14166	00418			6225	06382			15231	02339			12124	00357
		15196	00385			8144	06382	14	62	49	02351			13138	05343
		15200	00386			9130	00386			6206	02352			14160	06345
		15260	00386			9128	00385			9131	00351			15196	06345
02	62	43	00357			9127	00385			9125	00351			16259	06361
		6212	00362			11122	02378			11119	00350	21	52	58	02330
		6202	00361			14160	06385			14149	02354			6231	02330
		7163	00365			15207	06380			14156	00352			6222	02330
		8154	00360			16260	06383			16254	04347			6197	02327
		9133	00360	08	62	60	06389	15	52	55	02333			8140	02330
		11124	00363			6236	06388			6210	02333			8133	02330
		13148	02353			6197	06385			6201	02332			9126	02326
		14192	02363			8144	06401			8143	02336			9122	02327
		15247	02358			11122	02409			9124	05338			10118	02326
03	11	125	00357			11122	02406			9123	00347			11117	02329
		12129	00360			13150	04410			11119	04333			13133	04328
		14157	00354			14155	04402			14153	06342			14163	05328
		14176	00355			15192	04406			15202	06350			15208	05330
		15201	00352			15205	04404			15235	06352	22	52	65	04333
		15227	00354			16260	05393			16257	06357			6202	04331
		15259	00354	09	62	37	06400	16	11	119	06406			9129	04324
		16303	00352			9134	06401			11120	06407			10117	00332
04	62	47	00348			10121	00405			13146	06411			10117	00332
		6215	00350			12127	00412			14151	06404			11118	00328
		7190	00350			12128	00411			15197	06398			13135	00337

YY GGμμ λΣΩΩΩ			YY GGμμ λΣΩΩΩ			YY GGμμ λΣΩΩΩ			YY GGμμ λΣΩΩΩ																										
22	14170	00340	26	10117	02331	01	6185	06332	07	15206	00324																								
	15208	02334		27	12119		04335			7164	06323	08	5261	02318																					
	16228	02333					13131			04350			7157	06317		5249	00317																		
	16253	02333								14158			00344			9127	06319		6207	00316															
	5243	04325											14164			00343			10116	05320		6177	00321												
	6204	04326														15174			00344			10115	05321		7160	00318									
	6183	02326																	15179			02340			13138	06341		8141	00310						
	7150	02321																	28			6227			00319			16238	06349		8128	00315			
	8142	02319																							6195			02319			16260	06348		10116	00321
	10118	00328																										8132			02323	02		6180	06351
10118	00326		9123			00325			03																			11116			06332				13132
11117	00327			9120		00328						12118																06341							15177
13142	00328				10119	02324						12121			06335																				15203
14152	02327					10118	02324							14147	06350																				16216
14163	00325						10117			00324					14158		06353																		16229
14170	02326									16218			02341				15174			06356															16249
15184	02327									29			5269			00326				15203			06353												16262
16244	02328															6208			00326				16227			06356				09					11114
16264	02328																		6191			00323				16255			06360						11115
24	5246																		00312						7159	00322			04			7167			06333
	6199	02312																	9128						02324							11115		06327	
	7170	00311						10119											02324												15195	06327			
	7157	00313						11117			00332																	15203			06326	10			
	7148	00316						12118			00330							16231										05325							
	8136	00316						14149			00331							16261			05327														
	9128	00311						14158			02325				05			5303			00331														
	10119	00318								15191	00323							5255			00335														
	10117	00313									15209		02325							6216	00338														
	12121	00316											16230			02327					6198		04332										11		
13135	00319	30											5261			06327						7162	06340												
14169	00321												5233			06329							10116			06325									
15195	00324												6207			06332									13139	06327									
16229	00322												7162			05326									15205	00326									
16257	00323											7151	05320												16228	05328									
16312	00322											9127	06325												16245	00326									
25	6213						00311						9120		06329										16263	00324									
	7154						00314	31					9122		06351		06								5300	00314									
	8145						00314						10116		06346										5251	00315									
	8133						00314						11115		06346										6176	00314									
	9127	00311											13138		06352										7158	00315									
	10118	00317											14145		06349										8130	00315									12
	10116	00321											14152		06344										9121	00319									
	14158	00324											15187		06346										10114	00324									
	15208	00319											15210		06349										11115	02324									
	26	5254				00332								16232	06355											14162		04320							
6203		00332										16260		06358										15171		00326									
6192		02332																						15187		02333									
7176		00338																						16216		02332									
7148		00337																						11115		02326							07		
8138		00336					01					5259		06332										11115		00330									
9127		00337										5236		06339										12122		02327									
10118		00329										6222		06340										15197		00324									

YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ
12 15194 00353	18 10115 05341	23 10115 00346	29 11114 00351
16220 00349	11114 06344	10115 02348	10115 00353
16232 02350	15163 06348	10114 00348	14158 02355
16263 00350	19 5234 00345	24 5257 02359	15176 02353
13 5248 00338	6203 00347	5235 00352	15203 00357
6210 00342	6192 02344	8143 06351	16223 00356
6182 00344	7159 05349	10117 05349	16265 02354
7145 00342	10115 00364	11116 00351	30 5263 05352
8132 02340	11114 00364	10114 00350	6202 05347
9124 00340	13131 00368	25 6226 02335	7172 03353
9119 00341	13132 00369	6206 02332	7156 02355
11114 02346	15185 00365	6202 00330	7150 00352
11114 00345	15199 00364	6193 00329	8141 00346
14 5266 02337	15203 02359	7146 00335	9125 02344
5254 00336	15220 00360	8141 00334	10116 03342
6205 00335	16265 02356	9119 00336	10114 04343
6184 00336	20 5265 00347	10116 00339	
8135 00339	6222 00350	14147 02328	JULY 2007
8134 02337	6197 00350	15169 00327	
9123 00339	7170 00355	15189 00326	01 5231 00337
9120 00340	7162 02348	16232 02325	6199 02338
11114 00352	9122 00340	16266 00323	6186 00342
14157 04353	9118 00334	26 5268 04327	8142 00341
15185 04353	10116 02337	6205 05331	8137 02336
15203 04353	11114 00337	6191 05324	8129 02338
15 5253 02336	11114 00340	11114 06338	9120 02341
5247 00334	15165 02337	11115 06335	10115 05336
6204 00337	15201 00341	14156 02369	11114 05337
6177 00338	16242 00337	15191 02365	02 5240 00330
8142 00346	16264 00337	16216 02363	6200 02328
9125 00344	21 5262 02323	16265 02359	6181 00331
9124 00348	6199 02321	27 7155 00345	7169 02329
10114 00353	8129 04327	8139 00346	8140 02332
16232 06347	9124 04330	9118 02353	8135 00336
16248 06352	9121 02333	11114 00339	8129 02331
16 12121 06348	10114 00336	14157 06342	9121 02330
13123 06327	13132 00338	15201 06338	10116 02331
13127 05332	14137 00337	16255 06353	10114 02329
13137 05338	15187 04325	28 5261 05348	11114 02330
14142 06321	16259 06321	6222 05352	15195 04333
15191 06347	22 10117 06347	6203 06349	16213 04327
16212 06346	10114 06335	7145 03356	16259 05327
16239 06346	11114 06337	8133 03356	03 5262 06358
17 12120 00361	11114 06330	10114 05360	6226 06360
13123 00361	15170 06334	14146 02341	9118 06346
14154 00366	15178 06338	15168 04344	11114 00354
14158 00366	15188 06330	15180 02348	12117 04347
15202 00360	16222 06335	16230 02348	16208 05350
16239 00354	16256 06340	16242 02351	16261 05350
16246 00358	23 6197 02331	29 8141 04343	04 5264 05353
18 6192 05342	7157 00338	8127 00331	6204 06354
8131 00345	7150 05348	9126 00330	

YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ
04 13135 06364	12 7175 00355	16 15200 02300	20 14142 00294
14140 06368	7167 02352	16218 00286	15187 00294
05 5268 05368	7163 00352	16224 02299	15193 02293
6202 06364	8131 00347	16245 02302	15206 00295
8136 06370	10115 06357	16262 02299	16228 00294
14148 05355	11115 06354	17 5275 00292	21 10120 06307
15164 06358	15195 06360	6199 02291	10117 06306
06 16252 06362	16211 06359	6193 00295	11117 06302
16265 06360	16239 06360	7155 02292	11117 06300
07 11115 06349	16263 04357	8145 00288	11118 06300
14141 06364	13 5262 06355	8138 00293	22 11118 02313
14142 06356	6218 04344	9129 00290	15203 02331
15189 06376	6205 05350	10119 00290	16251 02332
15197 06372	7166 04346	11116 00289	16261 02329
15200 06373	9128 06342	12119 00291	23 6223 00324
16254 06365	9123 04331	15169 00300	7171 02321
16261 06370	10118 06336	15186 00300	8145 04321
08 11116 05325	10116 05334	15197 02300	10121 04324
12119 05328	11115 05346	15203 00302	11118 05323
13124 04330	15184 06345	16246 00299	12122 00336
14156 06321	15194 06346	18 5259 02289	13133 00337
15168 00331	16211 06355	5254 00290	14145 00331
15170 02327	14 5258 05309	6200 00291	15183 04320
16207 00326	6205 04314	6193 02293	15205 04320
09 5263 00298	7161 04311	8147 02295	16267 04320
6226 00298	8146 06303	14150 06294	24 7156 05329
6205 00297	8136 04302	15168 06297	9129 05328
8246 00302	9127 04297	15177 06300	11118 06334
9124 00303	10119 04297	16236 06288	14144 06343
11115 00305	10117 06315	19 5269 05290	15171 04346
11115 00309	11116 05319	6220 05295	15176 02346
14156 06308	15 12118 00319	6185 02288	15201 00345
10 5250 06327	14164 00318	7152 00292	15213 02340
6221 07332	15201 00319	8140 00291	16259 00342
6298 06333	16231 02318	8133 00287	25 6241 06334
14161 06340	16237 00318	9121 02286	8140 06363
15182 06339	16256 00315	10119 02286	15212 06362
16221 06344	16264 02318	10118 00289	15219 06368
16235 05328	16 5270 00309	11116 02291	16237 06370
16260 05321	6228 00317	12123 04290	16262 06367
11 6207 06371	6205 00314	14166 00299	26 6227 02317
7171 06369	7181 00317	15205 02293	6213 00318
9121 06357	7162 00306	16228 02296	7173 00320
10116 06372	8140 00306	16255 00294	8136 02321
10115 06363	8132 00302	16259 02292	11118 00315
11115 06361	9122 00298	20 6247 00283	11119 02315
15164 06361	10118 00304	6211 00285	14166 02311
15197 02372	10116 00303	8146 04284	15180 00308
16211 02373	14145 00306	8137 02289	15184 02310
16237 00371	14148 02303	8135 00287	15214 02308
16260 02369	14151 00299	10118 00289	16225 00307
12 5264 02350	14160 00308	11117 00292	16232 02313

YY	GG	μμ	λ	ΩΩΩ	YY	GG	μμ	λ	ΩΩΩ	YY	GG	μμ	λ	ΩΩΩ	YY	GG	μμ	λ	ΩΩΩ
26	16	269	02	313	02	91	35	00	312	07	15	221	00	329	14	15	233	02	318
27	62	03	02	317		91	31	00	310	08	62	39	03	313		16	278	02	319
	71	89	02	318		10	124	00	315		71	70	04	317	15	11	126	02	307
	81	54	05	315		11	121	00	317		91	36	02	314		13	146	06	304
	91	27	05	326		13	146	00	323		10	123	04	317		14	171	02	312
	11	19	05	329		14	157	00	323		11	123	00	317		15	205	06	306
	13	136	00	334		15	192	02	317		14	161	05	319		15	257	06	305
	15	222	06	341		15	204	02	317		15	203	06	319	16	62	35	00	285
28	12	121	05	315	03	52	58	06	328		15	227	05	314		72	01	00	286
	12	127	05	317		62	33	06	325		16	261	06	320		71	86	02	282
	14	162	06	324		62	14	06	323	09	62	26	06	324		81	68	00	287
	15	175	06	329		71	91	06	322		62	09	06	319	17	16	334	26	290
29	11	120	02	325		71	80	06	319		81	49	06	330	18	12	135	02	313
	12	124	02	329		10	123	06	339		11	123	06	337		13	143	00	313
	15	195	02	330		10	121	06	338		14	176	04	319		13	152	02	315
	15	200	02	327		14	150	06	337		15	200	05	319		14	167	02	317
	16	270	06	328		14	152	06	338		15	242	02	322		14	176	02	310
30	81	53	06	374		15	204	06	338		16	269	02	323		15	213	00	308
	11	120	06	364		16	269	06	338	10	15	189	02	313		15	227	02	309
	13	142	06	378	04	62	65	05	344		15	207	05	307		16	277	02	310
	14	154	02	379		71	97	05	342		16	258	02	304	19	12	132	04	307
	14	164	02	376		81	54	04	342		16	264	02	305		14	169	05	309
	15	183	02	377		81	40	05	332	11	91	41	06	307		14	195	02	304
	15	221	02	365		10	124	05	331		91	31	06	306		15	200	00	299
	16	263	02	366		10	122	06	335		10	128	06	306		15	218	02	302
31	62	20	06	365		10	121	06	337		10	125	06	305		15	269	02	305
	71	72	06	362	05	11	123	06	314		10	125	06	305		16	276	00	302
	91	33	06	355		12	126	06	317		11	124	05	298	20	72	19	06	315
	12	126	00	362		12	130	06	322	12	62	37	04	301		72	05	06	319
	12	127	02	359		13	139	06	320		72	08	04	308		12	134	05	301
	15	197	06	356		14	162	06	318		71	88	04	307		13	156	04	309
						15	184	06	320		81	65	05	309		14	171	04	306
						15	225	06	325		81	44	05	301		15	201	04	305
						16	269	06	331		91	33	04	309		15	232	06	303
01	62	01	02	348	06	62	64	05	317		10	126	05	303		15	264	05	308
	71	89	02	349		62	07	02	325		11	125	06	306	21	91	46	02	314
	71	60	00	344		71	91	02	324	13	91	32	06	328		11	130	06	317
	81	40	05	344		81	47	06	314		10	128	06	331		13	152	02	312
	91	32	06	344		91	38	05	313		10	126	06	326		14	174	04	316
	10	124	00	349		10	122	06	311		11	125	06	320		15	205	00	324
	10	120	00	348		11	122	05	310		15	200	06	332		15	215	02	318
	11	120	02	344		15	202	05	315		15	206	06	332		15	228	00	323
	11	120	00	339		15	232	02	319		15	235	06	337	22	62	55	00	293
	11	121	00	341		16	275	04	316		16	256	06	330		71	87	00	290
	14	163	02	337	07	62	61	02	313	14	71	70	04	316		91	45	00	294
	15	200	02	332		62	22	00	315		10	126	04	316		91	39	00	291
	16	241	02	332		71	92	00	321		11	126	00	323		11	130	00	295
	16	282	02	334		81	45	00	322		11	126	02	318	23	62	53	00	283
02	62	27	00	306		91	34	00	325		11	126	00	317		72	02	00	282
	71	82	00	307		11	122	00	329		13	143	00	320		81	51	00	280
	81	57	00	309		11	123	02	330		13	144	02	324		91	45	00	280
	81	44	00	312		14	161	00	331		13	149	00	328		10	131	04	277

YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ
23 14189 05282	30 7211 00320	06 10142 05319	14 9160 00296
15245 00282	8177 00312	10142 05322	9156 00294
15264 00281	8174 00311	13177 06325	10152 00293
24 8162 06283	8166 00310	14191 06327	11150 00293
9140 06287	11136 00305	07 7232 06319	14205 04293
11132 02288	11138 00306	9161 06307	14213 00301
11132 00287	15224 04311	9152 05306	14235 00302
11132 00286	15255 02313	10146 05311	14242 00290
13162 00305	31 6260 06306	10144 05314	14257 02298
14188 00302	10138 06291	11143 06311	15 11154 06326
14203 00299	11137 06293	11143 06314	12156 00334
15245 00302	11137 06297	14226 06317	12159 00326
25 6263 02314	13163 06296	15259 06319	14228 00325
6238 00303	14177 06314	08 12148 02298	14248 00328
7202 00306		13162 02299	14261 00327
8174 00313	SEPTEMBER 2007	13181 02302	16 7260 06280
9149 00311		14235 05305	7217 06271
10134 00319	01 12142 02313	15300 02309	8208 06274
11132 00320	12144 00313	09 8182 06342	9171 06296
26 6248 06277	14200 04315	8177 06349	10156 06272
7212 02284	14203 00311	9161 06347	11154 06275
7204 02285	14224 06314	9155 06332	17 7250 00270
8159 02284	15236 06319	10147 06335	8207 00269
10136 06275	02 6265 06302	10 8194 06319	8177 00270
11133 02282	7240 06302	9157 06309	9159 00264
27 6261 03298	7206 06301	10151 06306	10155 00263
7208 04298	9157 06298	11146 06315	10154 02266
8174 04300	10139 02303	11147 06312	11155 00276
10136 02304	03 6265 04304	14211 05316	12166 00272
11134 06306	6255 00303	11 11147 06340	13191 00274
13158 02302	7210 02304	11148 06335	14216 00277
14172 00300	7200 02303	14224 02342	14241 00276
15276 02292	8166 02304	14245 02342	18 8211 02289
28 6264 05320	9156 02308	15264 02342	8199 00291
8180 04316	11139 06308	12 11148 06307	8187 00289
9142 02319	13178 06314	13179 02314	9169 00289
10137 02318	14186 06328	13187 02311	11159 02287
10137 00315	15234 06326	14210 02308	11155 02285
10135 00314	15265 06324	14236 02302	12176 00284
10134 00320	04 6269 06343	14255 02308	13187 02284
12140 00315	9148 06333	13 7206 05306	19 8211 02297
12143 00321	11140 05352	8201 02306	8194 02301
13161 00317	11141 06349	8198 00306	10161 05300
14203 00316	12146 05335	9169 00309	11156 00300
15228 00316	13179 06339	11149 05307	13196 05301
15282 02311	14204 06346	11151 05307	14216 05302
29 7203 02318	14230 06341	13171 00307	20 7277 00296
8181 02316	15264 06347	14256 02305	7249 00291
8165 02314	06 6270 06336	15267 02306	8191 00291
12149 05315	6258 06334	14 7253 00295	9172 00294
14196 05315	8182 05325	8206 00306	11157 00294
14203 05313	8174 05325	9164 02294	12172 00298

YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ	YY GGμμμ λΣΩΩΩ
20 13193 00294	26 13200 06292	03 11177 00306	13 8255 02293
14230 04283	13212 06297	13231 02304	9212 06294
21 7304 00279	27 8232 06287	04 7275 02265	9210 06296
7229 00280	8203 06283	7258 00266	9207 06293
8193 00280	9180 05286	8213 06268	10195 06296
9171 00278	10172 04284	10178 05269	14 8262 00266
10159 02278	11167 02283	12196 06272	9225 00267
11159 02278	12177 02283	13222 06277	9213 00267
12177 02281	13204 02287	05 8247 05293	10203 02263
13202 04280	13213 02286	9208 05293	15 8251 02266
14226 03284	28 8199 06286	10181 04300	9226 02269
14250 02289	9174 06282	10180 00303	10205 02274
22 7248 02288	10170 06281	12209 06310	11200 02268
8197 02289	10168 06282	06 8249 06306	11201 00263
9178 00287	11169 06281	8214 06306	11202 00268
9176 02282	12195 05282	9201 06303	12211 00266
11160 02285	13204 05284	9190 06299	12222 00264
11162 00291	29 11170 06303	10183 02302	12243 00264
11164 00288	11176 00306	07 11188 05287	13256 00266
23 7258 02275	11183 00311	12196 06292	16 8268 02261
9180 02279	13200 00309	13222 02954	9212 00258
9176 02277	13220 00307	08 8262 07264	11203 02259
24 7247 00280	13241 02301	10185 06273	11204 00263
8207 00277	30 7159 06291	11187 06265	11209 00274
8189 00280	7244 06295	12207 05267	12218 00273
9174 00276	8209 06292	12218 02271	12236 00269
10165 00277	9182 05297	13235 05270	17 8246 02274
10162 00284	10171 05298	13268 06276	9221 00276
11163 02281		09 8253 02265	9218 02275
12174 00287	OCTOBER 2007	9210 02265	10211 00273
12182 00282		10192 02270	10206 00276
13199 00282	01 7266 00283	10188 00273	11206 02279
13219 00285	8231 02278	11188 00274	12240 00281
14235 00285	8210 00288	12199 00274	13261 00276
14297 00282	9184 00287	12209 00273	18 10207 06301
25 7237 00292	11173 02287	13234 06276	11217 06298
8210 00288	11174 00288	10 8235 00271	13269 02297
9188 00292	12180 00289	9216 00269	16283 00299
9175 00293	13221 03280	9205 00269	20 8262 06322
11164 02291	02 7260 06284	10193 00269	9242 06321
11164 00292	8239 06279	12208 02266	9221 05313
11660 00292	8205 06278	12222 02268	10213 05317
13197 00292	9200 06275	13232 02271	10211 04315
13220 00288	11175 06283	13238 00266	21 11214 00310
14254 00287	11177 06280	11 11193 02263	11216 00308
26 7241 06288	03 7254 02310	12202 00262	11223 00306
8215 06288	8228 05312	12219 02260	13273 00305
8198 06288	9203 05308	13240 02258	22 8264 06291
9185 06290	9182 02315	13260 02258	9248 06280
9177 06288	10181 02314	12 8256 06307	9224 06286
11166 06294	10176 02313	8241 06309	10218 06290
11169 06294	11177 02311	13 8261 02290	10216 06293

YY GGμμμ λΣΩΩΩΩ			YY GGμμμ λΣΩΩΩΩ			YY GGμμμ λΣΩΩΩΩ			YY GGμμμ λΣΩΩΩΩ			
22	11218	06292	30	10244	06263	14	11303	26313	22	12351	20267	
	11225	06291		11248	06265		12309	26305		12363	22265	
	12230	06289		12264	06264		12318	26312		12370	20270	
	13291	06294		31	10242		02276	12330		26318	12398	22260
	8260	06286			10241		00278	12345		26319	23	9382
23	9244	06291	10241	00278	15	12362	26320	9362	22257			
	11220	06282	11245	00278		10296	26320	9333	22257			
	11223	06288	NOVEMBER 2007			11290	22312	10324	22256			
	12250	06283				11294	22314	10319	20260			
	12261	02928				11302	20311	10316	22258			
24	9260	02271	01	10244	06254	11308	22309	11317	22263			
	9240	02271		10244	06254	12312	20310	11340	22263			
	9232	04270	02	10249	02263	12338	20307	12355	22269			
	10223	02274		10247	02265	12343	22310	12368	22266			
	10221	02270	11247	02264	12357	22307	12384	22259				
25	11222	02274	11248	00260	16	12366	20308	25	11324	26264		
	11227	00275	11261	00265		9356	20311		11334	26255		
	9256	06284	12281	00267		9341	20312		12361	26252		
	9242	06288	03	11251		05254	9325		20320	12416	26270	
	10225	06288		11253		05250	10301		20322	26	12431	26336
26	10224	06293	12269	26253	17	11302	22318	13465	26333			
	11228	06291	04	9284		26286	12338	26317	28	9401	20233	
	11234	06296		10261		06284	10296	26283	9369	20225		
	12243	06300	10255	06297		11297	26279	9358	20222			
	12259	06294	05	9303		26289	11299	26277	11333	20222		
9262	06296	11264		06289	11303	26276	11349	22219				
27	9247	06293	12316	26279	18	9350	26246	12359	22219			
	9236	02298	06	10259		06307	10310	26251	29	10344	20230	
	10129	06298		11266		06305	10299	26247		10336	20243	
	11235	06300	12281	26292		19	9350	26250	11336	22246		
	9263	05270	07	11264			06300	9324	26246	12366	20249	
28	9248	05274	10	9295	26317	10310	26255	12387	20249			
	10237	05274		10276	26313	10303	26250	12413	20246			
	10252	05269	10272	26313	11304	26253	30	12433	26302			
	10230	05268	11	9311	26283	12327		26254	13460	26297		
	10229	05268		9294	25292	12357	26250	DECEMBER 2007				
29	11235	05283	10276	26298	20	12387	26252	01	11342	26209		
	11240	05282	11277	25298		11313	25259		11350	26204		
	11247	05278	12	9321		26327	11317		25242	11361	24201	
	12251	05280		9305		26309	12357		26247	12371	25198	
	12256	05280	10290	26315		21	11317		25272	9370	25279	
12259	05279	10280	26324	11333	22272		10356	22284				
30	9259	05262	12279	26324	22	12346	22275	02	10344	22288		
	9247	05261	12310	26331		12358	22270		10368	26324		
	10241	02263	12357	26319		12401	22267		10361	26317		
	10239	02263	13	9319		26324	9350		20262	11353	26313	
	10236	06263		9295		26328	9333		22260	10357	26250	
30	10235	06266	10289	26318	22	10322	22261	05	10352	26242		
	12253	06268	11283	26313		10315	22261		11353	26238		
	9253	06260	14	9335		26331	10313		20258	11362	26248	
	10240	06261		9299		25341	11314		22259			
	10238	06260	10296	25337		12339	22262					

YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ	YY GGμμμ λSΩΩΩ
05 11373 26246	13 11369 20298	21 10378 26203	27 10377 22326
12282 26248	11374 22295	11376 26308	11373 22334
06 10355 25252	11378 20304	11379 26205	28 10383 26264
11355 25252	15 10389 26301	22 11377 22231	10373 25263
07 10379 26267	10377 26294	11388 22223	11373 25266
10366 26262	11372 26300	11395 22216	11377 25265
10359 26261	11373 26301	12402 22219	11383 25258
11357 26261	16 10378 26276	23 10384 22276	29 10378 22275
11374 26266	10375 26275	10380 22270	11371 22277
12289 26284	10374 26275	10377 22271	11371 20278
08 10360 25279	11372 26274	11375 22271	11376 22278
11361 25284	17 10381 26242	24 10382 26289	11381 20285
11368 25283	10375 26238	10377 26285	30 10385 26281
11378 25284	11373 26237	11376 26288	10377 26283
09 11363 26314	11384 26237	25 10376 26282	10371 26293
11365 26308	18 10383 26245	11375 26272	11371 26295
11375 26301	10374 26243	11375 26276	11384 26297
11384 26308	11384 26241	11377 26275	31 10397 26303
10 10380 26302	19 11379 26268	26 10379 26263	10376 25296
10374 26295	11383 26263	10374 25263	11368 26299
13 10385 20290	20 10377 26260	11374 25256	11371 26303
10372 20293	11375 26262	11376 25264	11378 26312
10370 20300	11388 26263	27 10381 22328	

**Total Ozone, Sulfur Dioxide
and UV-B Radiation Measurements
with the Brewer Spectrophotometer No. 64 at Belsk, Poland
2006-2007**

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The Brewer spectrophotometer No. 64 has been installed in the Geophysical Observatory of the Polish Academy of Sciences at Belsk in February 1991.

The Brewer spectrophotometer is an optical instrument which measures atmospheric ozone and sulfur dioxide by examining intensities of the attenuated incident solar ultraviolet radiation at five specific wavelengths. The automatic, computer-controlled operation of the instrument allows different types of measurements and calibrations to be made according to an adjustable schedule. The instrument is capable of taking direct sun, zenith sky, UV-B and Umkehr measurements in unattended operation for several days.

Contrary to the total ozone measurements taken with the Dobson instrument, in the case of Brewer spectrophotometer the effect of interfering absorption by SO₂ is accounted for. The daily means of ozone and SO₂ are computed only from observations with standard deviation less than 2.5 D.

Small negative SO₂ amounts may occur in the data. These values reflect the SO₂ measurement uncertainty to which the main contributions are from small errors in the ozone coefficients and wavelength settings. The SO₂ amounts from observations with slant paths greater than three are unreliable.

The Brewer instrument No. 64 contains also the UV-B monitor which enables it to measure spectral irradiance in the region between 290 and 325 nm by monitoring the photon count rate at wavelengths every 0.5 nm. The irradiance at each wavelength is integrated to produce a damaging ultraviolet radiation value (DU) using Diffey

erythmal weighting curve instead of the ACGIH-NIOSH erythmal weighting curve used before.

In May 2006 the instrument was calibrated at Lindenberg, Germany, against the transfer standard instrument (Brewer No. 17) by Mr Ken Lamb from International Ozone Services Inc., Canada.

In May 2007 the instrument was calibrated in Hradec Kralowe, Czech Republic, against the transfer standard instrument (Brewer No. 17) by Mr Ken Lamb from International Ozone Services Inc., Canada.

Accepted December 22, 2008

Observations are entered in the column in accordance with the codes explained below:

- Day – number of day of the month,
- Ozone – total amount of ozone in D (Dobson Units) (zs means zenith sky, ds means direct sun observations),
- Dev – standard deviation of ozone measurements,
- μ – harmonic mean of the relative slant paths at 22 km for each of the observations used to compute the daily value,
- N – number of direct sun or zenith sky observations,
- SO₂ – total amount of SO₂ (in milli-atmo-centimeters),
- Dev – standard deviation of SO₂ measurements,
- UV – daily integral of UV radiation (in J/m²),
- NN – number of damaging UV measurements.

BREWER OBSERVATIONS JANUARY 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	321.0	ZS	0.9	3.75	2	–	77	9
2	312.4	ZS	1.8	3.66	2	–	85	11
3	363.8	ZS	5.8	3.87	3	–	68	10
4	–	–	–	–	–	–	50	11
5	344.9	ZS	1.6	3.63	4	–	84	10
6	316.2	ZS	5.0	3.73	5	–	79	10
7	308.1	DS	2.7	3.69	15	–0.5	208	10
8	271.3	DS	0.9	3.69	16	0.1	238	10
9	308.4	DS	1.0	3.64	32	–0.5	219	22
10	300.0	DS	0.5	3.77	4	–1.0	77	3
11	279.7	ZS	2.6	3.60	4	–	167	10
12	286.6	ZS	2.6	3.45	3	–	86	11
13	310.1	ZS	1.4	3.73	2	–	86	11
14	292.9	ZS	2.1	3.55	4	–	121	11
15	273.0	ZS	1.7	3.43	5	–	167	11
16	284.5	DS	1.3	3.38	28	0.5	232	23
17	296.6	ZS	5.5	3.35	4	–	126	11
18	–	–	–	–	–	–	101	11
19	341.3	ZS	12.5	3.34	8	–	192	11
20	276.0	DS	8.0	3.37	3	–0.1	262	11
21	–		–	–	–	–	68	11
22	325.7	DS	2.9	3.66	2	–0.6	264	11
23	310.2	DS	4.9	3.32	49	0.4	288	15
24	300.1	DS	1.7	3.20	38	0.1	321	13
25	287.6	DS	1.7	3.13	16	1.1	289	12
26	320.6	DS	2.1	3.20	24	1.6	267	12
27	346.2	DS	1.2	3.17	51	1.3	273	15
28	330.5	DS	4.2	3.11	16	0.1	270	13
29	369.8	ZS	6.9	3.11	14	–	175	14
30	328.9	ZS	4.5	2.95	13	–	206	13
31	336.4	ZS	1.9	3.05	13	–	155	13
	312.2		3.2	3.45	14	0.2	171	12

BREWER OBSERVATIONS FEBRUARY 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	363.9	ZS	4.6	2.94	16	–	158	13
2	370.1	ZS	1.7	2.77	10	–	120	9
3	364.6	ZS	6.2	2.98	7	–	159	13
4	377.8	DS	1.3	3.64	3	–3.3	208	13
5	399.4	DS	4.0	2.91	24	–0.8	331	13
6	421.9	DS	0.8	2.90	6	–1.4	304	14
7	425.1	ZS	4.1	2.66	10	–	154	14
8	387.7	ZS	2.1	2.61	9	–	161	14
9	412.4	ZS	2.4	2.64	17	–	280	13
10	416.0	ZS	6.2	2.76	16	–	234	14
11	420.6	DS	2.0	2.47	7	1.2	336	14
12	455.7	ZS	2.1	2.58	9	–	201	14
13	430.0	ZS	3.8	2.49	11	–	–	
14	425.3	ZS	4.7	2.54	21	–	287	14
15	391.7	DS	0	2.30	1	0.2	317	15
16	388.7	ZS	4.0	2.48	14	–	164	15
17	366.3	DS	0	2.72	1	0.3	290	15
18	370.5	DS	1.6	2.51	27	0.3	535	15
19	371.5	DS	0	2.73	1	1.5	307	15
20	339.1	DS	4.1	2.44	20	1.5	563	15
21	380.6	ZS	10.1	2.34	17	–	236	15
22	406.9	ZS	1.2	2.39	9	–	160	16
23	363.9	DS	1.3	2.79	13	0.2	579	16
24	414.9	DS	4.1	2.16	19	0.3	597	16
25	350.9	DS	3.0	2.43	57	0.2	805	19
26	376.2	ZS	7.5	2.32	28	–	485	16
27	422.6	DS	6.3	2.28	56	–0.4	714	17
28	422.6	DS	4.8	2.40	49	0.3	651	16
	394.2		3.4	2.61	17	0.0	346	15

BREWER OBSERVATIONS MARCH 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	438.6	DS	5.5	2.26	34	0.3	642	16
2	464.1	DS	3.5	2.29	23	-1.3	600	16
3	458.0	DS	2.6	2.25	79	-0.1	683	23
4	460.1	DS	3.1	2.52	11	-1.2	476	17
5	432.5	DS	2.8	2.10	23	0.8	682	17
6	448.7	DS	2.5	2.27	7	-2.5	572	17
7	419.5	DS	6.3	2.15	78	1.1	833	21
8	443.4	DS	6.5	2.23	69	-0.4	803	21
9	413.5	DS	22.3	2.13	49	0.3	853	18
10	414.0	ZS	6.2	2.13	35	-	570	17
11	455.1	DS	2.4	2.09	12	0.5	598	17
12	429.8	DS	2.7	2.11	40	-0.3	955	17
13	410.8	DS	3.7	2.13	47	0.7	944	17
14	399.2	DS	1.1	1.96	3	1.5	660	18
15	413.4	DS	1.5	1.77	33	1.0	977	19
16	410.1	ZS	1.9	2.20	14	-	372	17
17	401.7	ZS	2.1	1.92	31	-	534	17
18	391.1	ZS	8.1	1.94	26	-	519	17
19	346.9	DS	4.1	2.17	5	0.8	869	17
20	280.3	DS	2.2	2.28	18	0.4	1640	18
21	328.2	DS	5.6	2.07	3	0.5	1026	20
22	317.6	DS	4.2	1.87	2	1.8	1003	20
23	366.3	DS	5.3	1.88	61	0.8	1525	25
24	345.1	DS	6.8	1.86	92	0.8	1694	21
25	329.0	DS	5.2	1.87	38	1.3	1408	21
26	353.7	ZS	4.8	1.74	20	-	512	21
27	325.4	DS	0.9	1.60	7	0	1310	21
28	352.4	DS	4.0	1.80	48	0.4	1213	24
29	395.4	ZS	3.2	1.76	28	-	573	22
30	382.4	DS	5.9	2.24	17	-0.1	1029	23
31	387.0	DS	0	2.54	1	-0.6	650	23
	394.0		4.4	2.07	31	0.3	862	19

BREWER OBSERVATIONS APRIL 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	389.0	DS	2.8	1.52	5	1.7	792	22
2	388.1	DS	7.4	1.94	13	0	1197	22
3	399.9	DS	8.3	2.12	16	-0.5	1105	23
4	414.9	ZS	8.6	1.63	23	-	755	22
5	395.8	DS	14.4	1.67	19	-0.2	1006	23
6	414.9	DS	10.5	2.11	17	-0.1	1183	22
7	391.9	DS	2.0	1.81	63	0.3	1483	21
8	414.9	DS	8.8	1.80	52	0.7	1391	23
9	391.2	DS	1.7	1.65	27	1.2	1128	23
10	401.9	ZS	11.6	1.55	9	-	358	22
11	480.8	ZS	6.1	1.55	17	-	581	23
12	397.9	DS	6.6	1.65	12	1.1	1333	22
13	389.5	DS	3.0	1.57	12	1.7	1121	23
14	428.5	DS	3.8	1.93	9	0.5	1070	24
15	398.5	DS	9.4	2.53	7	-0.6	1028	25
16	349.9	DS	2.4	1.60	10	1.3	1157	24
17	402.5	DS	5.0	1.54	7	0.9	1211	24
18	368.4	DS	3.6	1.45	11	0.9	1370	25
19	357.1	DS	2.3	1.71	48	0.6	1930	24
20	371.1	DS	8.0	1.73	28	1.0	1812	25
21	371.2	DS	3.6	1.69	65	0.2	2182	23
22	396.4	DS	8.0	1.61	32	1.3	1491	24
23	402.0	DS	2.6	1.68	48	1.3	1754	24
24	403.9	DS	5.0	1.49	16	1.0	1355	24
25	402.1	DS	7.0	1.53	50	0.8	1896	23
26	379.0	DS	2.6	1.59	76	0.5	2219	27
27	374.0	DS	1.7	1.62	95	0.6	2454	27
28	380.9	DS	3.1	1.64	52	1.6	1830	23
29	376.4	ZS	6.4	1.60	24	-	758	25
30	354.8	DS	2.4	1.52	3	1.6	1030	25
	392.9		5.6	1.70	29	0.7	1333	24

BREWER OBSERVATIONS MAY 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	385.9	DS	5	1.73	39	0.9	—	—
2	388.4	DS	10.2	1.73	43	0.6	1587	24
3	375.7	DS	3.5	1.59	95	1.0	2191	25
4	379.3	DS	2.8	1.42	55	1.7	2326	29
5	377.3	DS	..6.3	1.45	31	1.9	1538	25
6	376.3	DS	..3.0	1.47	31	1.8	1672	25
7	—	—	—	—	—	—	1766	25
8	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—
16	—	—	—	—	—	—	—	—
17	365.8	DS	5.4	1.50	7	0.8	452	10
18	339.0	DS	6.8	1.30	13	1.0	2425	27
19	347.6	DS	11.5	1.41	18	0.5	2497	26
20	368.1	DS	7.0	1.85	28	0.4	2461	25
21	399.4	DS	12.5	2.24	14	−1.2	1487	27
22	327.1	DS	3.4	1.56	76	0.6	3728	29
23	330.5	DS	7.3	1.74	30	0.7	2537	26
24	327.9	DS	5.2	1.40	31	1.3	2376	26
25	383.6	DS	6.9	1.52	20	1.1	2138	25
26	409.3	DS	8.5	1.63	10	0.3	1909	27
27	396.2	DS	4.6	1.71	30	0.2	2205	27
28	415.7	DS	8.0	1.86	17	−0.2	1686	27
29	390.5	DS	2.9	2.03	9	−0.1	1765	27
30	407.1	ZS	45	1.37	31	—	1916	25
31	395.8	DS	4.2	1.74	13	0.4	1817	28
	375.5		8.1	1.63	31	0.7	2023	25

BREWER OBSERVATIONS JUNE 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	408.5	DS	2.3	1.74	19	-0.1	2047	27
2	377.9	DS	7.4	1.80	43	0.1	2337	25
3	362.7	DS	1.8	1.67	11	0.5	1943	26
4	387.5	ZS	13.2	1.38	29	—	1399	26
5	353.4	DS	2.7	1.89	11	-0.1	1656	27
6	362.7	DS	1.7	1.60	25	0.2	2852	24
7	364.9	DS	3.4	1.89	28	0.2	2700	25
8	356.4	DS	3.0	1.67	36	0.4	3254	22
9	367.5	DS	2.8	1.70	20	0	2514	27
10	360.6	DS	5.7	1.81	36	0.1	3313	27
11	333.8	DS	2.4	1.63	52	0.2	3854	27
12	329.3	DS	3.5	1.79	41	0.3	3617	25
13	335.2	DS	2.5	1.51	84	0.5	4038	31
14	341.4	DS	5.6	1.65	54	0.4	3449	26
15	344.9	DS	5.7	1.50	47	0.8	3181	23
16	329.0	DS	2.5	1.51	68	0.4	3740	31
17	336.2	DS	2.3	1.85	21	1.2	1767	27
18	365.3	DS	10.8	1.59	9	0.5	2439	27
19	351.5	DS	7.0	1.69	42	0.1	3170	25
20	331.2	DS	2.6	1.46	97	0.8	4092	29
21	330.5	DS	4.8	1.43	84	0.8	3666	29
22	315.6	DS	1.8	1.50	25	0.5	3067	27
23	324.4	DS	2.4	1.46	23	0.3	3128	27
24	330.9	DS	8.2	1.69	53	0	3877	27
25	321.0	DS	2.5	1.55	85	0.7	4030	31
26	320.0	DS	2.0	1.48	91	0.5	3824	32
27	312.7	DS	3.2	1.55	61	0.4	4025	28
28	311.8	DS	3.4	1.73	55	0.3	3631	29
29	325.5	DS	11.6	2.20	9	0.5	3056	26
30	315.3	DS	4.9	1.78	46	-0.1	3294	27
	343.6		4.5	1.66	44	0.4	3099	27

BREWER OBSERVATIONS JULY 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	320.9	DS	2.0	1.60	63	-0.2	3754	27
2	319.5	DS	1.7	1.52	84	0.2	4311	29
3	319.1	DS	2.3	1.54	104	1.4	4249	26
4	318.4	DS	5.5	1.56	74	0.7	4117	29
5	325.0	DS	2.8	1.58	63	0.3	3852	24
6	324.8	DS	1.6	1.47	96	0.5	3909	30
7	324.5	DS	3.0	1.54	81	0.5	3750	28
8	326.7	DS	2.1	1.67	66	0.4	3737	27
9	338.0	DS	1.8	1.68	54	0.5	3027	26
10	337.3	DS	3.6	1.47	87	0.4	3379	31
11	321.5	DS	2.0	1.47	62	0.6	3237	30
12	325.3	DS	2.0	1.51	70	0.5	3379	27
13	319.1	DS	2.1	1.67	38	0.7	3213	27
14	315.9	DS	5.9	2.77	6	-0.4	1198	27
15	368.3	DS	7.1	1.71	28	-0.2	2770	26
16	335.8	DS	4.1	1.58	41	0.1	3701	27
17	326.2	DS	1.9	1.49	99	0.1	3932	29
18	315.1	DS	2.0	1.73	70	0.4	3501	32
19	312.6	DS	3.1	1.66	48	0.2	3731	27
20	322.4	DS	5.4	1.48	101	0.1	3815	29
21	331.6	DS	3.7	1.50	36	1.0	2901	27
22	329.0	DS	2.1	1.71	44	0.4	3097	26
23	324.5	DS	3.4	1.57	57	0	3288	26
24	323.7	DS	2.5	1.44	82	0.3	3471	30
25	321.1	DS	2.8	1.71	65	0.1	3506	31
26	325.7	DS	5.2	1.73	43	0	3158	26
27	322.5	DS	2.0	1.61	55	0.2	3591	27
28	313.5	DS	1.4	1.57	79	0.3	3657	26
29	312.4	DS	5.1	1.71	44	0.5	2996	26
30	323.8	DS	4.0	1.86	19	0.4	2669	26
31	309.8	DS	2.8	1.50	62	0.4	3241	20
	324.3		3.1	1.63	62	0.3	3424	27

BREWER OBSERVATIONS AUGUST 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	330.0	ZS	4.5	1.55	23	–	1329	26
2	334.9	DS	10.1	2.23	11	–0.1	1909	26
3	337.1	DS	2.4	1.59	47	0.5	2859	26
4	340.3	ZS	5.2	1.67	10	–	676	25
5	334.8	DS	2.1	1.76	13	0.3	2107	24
6	341.1	ZS	7.8	1.37	25	–	1240	24
7	342.6	DS	2.4	1.59	24	0.1	2349	24
8	330.6	DS	1.9	1.60	19	0.2	2162	25
9	329.3	DS	2.0	1.88	12	0	1629	25
10	330.4	DS	1.2	1.69	3	0.2	1560	25
11	326.3	DS	0.9	1.56	15	0.7	1715	25
12	343.5	DS	1.5	1.58	28	0.5	2446	25
13	338.6	DS	10.1	2.03	5	0.8	1299	25
14	345.4	DS	1.9	2.05	13	1.1	967	24
15	348.5	DS	1.1	1.57	17	0.5	2168	25
16	326.2	DS	1.7	1.67	41	0.3	2726	23
17	313.2	DS	1.8	1.62	45	0.5	2791	24
18	297.3	DS	1.2	1.69	17	0.6	1573	25
19	301.9	DS	1.1	2.14	15	–0.1	2222	25
20	302.2	DS	3.1	2.16	15	1.1	1525	24
21	321.0	DS	2.6	1.65	46	0.5	2358	24
22	330.9	DS	4.8	2.10	21	0.1	2000	25
23	332.4	DS	3.8	2.06	13	0.1	1669	25
24	323.2	DS	3.7	2.39	11	0.5	1667	25
25	316.6	DS	1.6	1.79	33	0.7	2217	25
26	318.8	DS	3.6	1.84	14	0.8	1832	25
27	318.3	DS	4.8	1.98	30	0.4	2199	24
28	323.4	DS	8.0	2.14	15	0.3	1588	23
29	341.5	ZS	5.3	1.61	26	–	779	23
30	363.1	ZS	5.3	1.64	15	–	542	23
31	327.7	DS	4.4	1.89	5	0.9	1745	23
	329.4		3.6	1.81	20	0.4	1802	25

BREWER OBSERVATIONS SEPTEMBER 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	305.8	DS	1.9	2.26	14	0.3	1185	21
2	285.9	DS	4.0	1.87	22	0.3	2066	23
3	290.0	DS	5.9	2.03	12	1.3	1258	23
4	280.3	DS	1.0	2.79	2	0.4	2249	21
5	307.0	DS	7.6	1.84	2	0.3	1083	23
6	276.1	DS	1.5	1.90	22	0.8	2086	23
7	262.0	DS	3.2	1.79	44	0.3	2149	23
8	280.8	DS	10.3	1.85	9	1.2	1691	23
9	304.2	DS	6.0	2.07	35	0.4	1854	23
10	286.0	DS	1.5	2.00	26	0.7	1755	23
11	285.5	DS	3.1	2.01	59	0.8	1992	25
12	296.4	DS	1.1	1.91	45	1.2	1846	22
13	290.6	DS	2.8	1.88	85	0.5	1859	24
14	292.8	DS	2.3	1.91	87	0.4	1797	23
15	295.4	DS	2.4	1.91	69	1.0	1742	22
16	285.6	DS	1.4	1.82	42	0.9	1720	21
17	286.0	DS	1.3	1.90	42	0.3	1723	20
18	282.0	DS	1.6	1.81	48	0.7	1639	22
19	286.3	DS	3.4	1.75	23	1.1	1288	21
20	300.0	DS	2.3	2.03	11	0.5	1177	21
21	291.0	DS	1.4	2.25	32	0.1	1655	25
22	290.5	DS	1.9	2.01	55	1.0	1564	19
23	297.1	DS	3.5	2.06	69	0.8	1491	22
24	301.6	DS	1.0	2.08	75	0.5	1338	22
25	306.5	DS	1.5	1.95	77	0.8	1303	21
26	293.7	DS	2.6	2.00	76	0.9	1324	22
27	275.9	DS	1.4	1.99	69	0.8	1341	20
28	269.3	DS	4.2	2.07	15	1.7	773	17
29	270.0	DS	2.9	2.42	28	0.7	1250	17
30	261.6	DS	1.5	2.17	63	0.4	1423	19
	287.9		2.9	2.01	42	0.7	1587	22

BREWER OBSERVATIONS OCTOBER 2006								
Day	Ozone		dev	μ	N	SO ₂	UVB	NN
1	263.7	DS	2.2	2.00	18	2.1	991	17
2	260.3	DS	1.1	2.26	8	1.3	779	17
3	245.5	ZS	7.2	2.17	27	–	775	17
4	262.7	ZS	1.5	2.14	24	–	415	17
5	285.9	ZS	4.4	2.01	23	–	665	17
6	277.7	DS	1.8	2.15	37	0.9	1101	17
7	275.1	DS	6.3	2.38	18	0.4	939	16
8	268.7	DS	3.3	2.07	13	0.6	1042	17
9	275.9	DS	0	2.55	1	0.6	664	16
10	287.5	DS	2.0	2.27	77	0.6	981	21
11	281.0	DS	3.6	2.29	36	0.2	971	16
12	291.0	DS	6.0	2.25	34	1.2	789	16
13	301.9	DS	1.8	2.29	33	1.6	711	15
14	294.1	ZS	3.1	2.26	7	–	175	15
15	277.1	ZS	2.0	2.21	22	–	413	15
16	277.6	DS	0.8	3.03	8	0.2	582	16
17	270.0	DS	0.7	2.66	11	0.5	595	15
18	268.0	DS	1.2	2.40	65	0.8	830	19
19	263.5	DS	7.0	2.53	38	0.9	781	15
20	275.9	DS	2.6	2.46	34	0.7	667	16
21	273.1	DS	4.2	2.46	33	0.9	672	15
22	267.6	DS	5.0	2.49	33	0.3	697	15
23	273.3	DS	1.3	2.25	7	0.3	431	15
24	259.5	DS	1.1	2.48	11	0.3	407	15
25	295.5	DS	0.9	2.81	3	0.5	267	15
26	250.9	DS	2.7	2.64	34	0.7	665	15
27	235.0	DS	2.2	2.72	28	0.5	352	6
28	245.2	DS	3.3	2.93	18	0.2	624	14
29	257.4	ZS	9.0	2.75	7	–	144	13
30	293.7	DS	2.7	2.77	67	0.2	527	20
31	256.7	DS	5.3	2.75	21	1.0	448	14
	271.3		3.1	2.43	26	0.7	648	16

BREWER OBSERVATIONS NOVEMBER 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	296.4	DS	1.9	3.06	8	0	292	13
2	325.2	ZS	1.7	2.64	10	—	194	14
3	345.3	DS	1.5	2.88	18	−0.1	312	13
4	327.3	ZS	0	3.19	1	—	119	14
5	294.3	ZS	4.4	2.71	4	—	114	13
6	293.5	ZS	1.4	2.74	6	—	114	13
7	274.2	ZS	2.4	2.79	12	—	230	14
8	277.8	DS	1.7	2.97	15	0.4	314	13
9	302.0	DS	0.3	2.84	2	0.2	194	13
10	—	—	—	—	—	—	261	14
11	302.2	ZS	3.6	2.97	9	—	180	13
12	347.1	DS	3.9	3.53	4	−1.6	188	13
13	331.3	DS	0	2.88	1	0.5	212	12
14	294.6	ZS	1.2	3.10	9	—	187	12
15	281.7	ZS	3.3	3.10	6	—	115	11
16	284.2	DS	1.5	3.23	49	0.2	284	16
17	283.8	DS	1.1	3.18	43	0.7	274	15
18	275.0	DS	0.7	3.11	11	0.6	246	11
19	292.6	ZS	1.8	3.23	5	—	107	11
20	296.3	DS	3.1	3.33	3	−0.1	170	11
21	293.4	ZS	5.5	3.43	6	—	131	11
22	305.7	DS	2.5	3.33	10	0.1	170	11
23	271.3	DS	0.8	3.17	4	2.0	164	11
24	235.9	ZS	4.1	3.27	4	—	133	11
25	250.9	DS	2.6	3.47	20	0.1	253	11
26	246.3	DS	1.0	3.48	20	0.5	227	11
27	250.9	DS	1.5	3.46	36	0.7	218	13
28	271.8	ZS	3.6	3.48	3	—	137	11
29	253.6	ZS	3.2	3.50	5	—	113	11
30	271.6	ZS	0.9	3.42	2	—	115	11
	288.8		2.1	3.15	11	0.3	192	12

BREWER OBSERVATIONS DECEMBER 2006								
Day	Ozone		dev	μ	N	SO2	UVB	NN
..1	260.0	DS	2.7	3.59	16	1.6	208	10
..2	258.5	DS	2.2	3.64	17	0.6	197	10
..3	248.9	DS	2.5	3.64	13	0.2	188	11
..4	299.2	DS	2.7	3.78	4	-0.6	133	10
..5	277.5	ZS	1.1	3.57	3	-	108	10
..6	256.6	DS	1.4	3.69	30	0.1	195	14
..7	290.0	ZS	0	3.63	1	-	90	9
..8	280.8	DS	0	3.93	1	-0.4	141	10
..9	296.0	DS	1.2	3.73	12	-0.4	154	10
10	-	-	-	-	-	-	333	10
11	316.5	ZS	0	3.66	1	-	111	9
12	-	-	-	-	-	-	41	9
13	267.9	ZS	4.5	3.71	3	-	60	10
14	213.9	ZS	0.9	3.78	2	-	104	9
15	234.8	DS	0.6	3.82	12	0.3	190	9
16	274.0	DS	3.2	3.83	11	-0.1	158	9
17	239.7	ZS	3.2	3.87	3	-	112	10
18	289.7	ZS	3.5	3.82	3	-	78	9
19	323.9	ZS	0	3.88	1	-	67	9
20	-	-	-	-	-	-	31	9
21	241.2	ZS	8.7	3.87	4	-	111	9
22	-	-	-	-	-	-	33	9
23	-	-	-	-	-	-	62	10
24	-	-	-	-	-	-	42	10
25	264.9	DS	0.7	3.86	5	-0.3	157	9
26	-	-	-	-	-	-	149	10
27	-	-	-	-	-	-	47	9
28	248.8	ZS	0	3.72	1	-	69	10
29	264.9	ZS	5.7	3.79	3	-	84	9
30	287.8	DS	4.4	3.80	12	-0.1	151	9
31	276.2	DS	3.4	3.75	6	-0.3	140	9
	272.7		2.4	3.69	8	0.1	111	10

BREWER OBSERVATIONS JANUARY 2007								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	277.3	ZS	4.3	3.70	4	–	67	9
2	323.4	DS	0	3.66	1	–0.5	79	10
3	–	–	–	–	–	–	48	9
4	372.3	ZS	2.5	3.68	3	–	64	10
5	412.6	ZS	0	3.65	1	–	45	7
6	340.4	ZS	0.8	3.63	2	–	45	10
7	355.9	ZS	0	3.79	1	–	31	10
8	336.1	DS	5.4	3.61	11	–0.5	141	10
9	290.8	DS	5.7	3.58	11	0.4	156	10
10	301	ZS	2.4	3.59	10	–	81	10
11	347.7	DS	0	3.42	1	–0.8	104	11
12	–	–	–	–	–	–	46	11
13	293	DS	2.7	3.56	3	–0.2	147	11
14	327.9	DS	1.2	3.65	2	–0.9	75	11
15	391.2	DS	1.5	3.41	10	–2.5	129	11
16	332.9	DS	1.9	3.42	30	–0.2	157	13
17	318.3	DS	3.4	3.31	5	0.1	140	11
18	364.1	ZS	3.6	3.41	2	–	75	11
19	355.7	ZS	1.1	3.29	5	–	81	12
20	287.3	DS	0.7	3.34	2	0.6	139	12
21	323.2	DS	3.3	3.28	14	–	206	11
22	353.2	DS	0.8	3.37	3	–0.7	154	11
23	319.5	ZS	3.2	3.28	13	–	165	11
24	322.7	ZS	3	3.16	11	–	102	11
25	359.3	ZS	2.5	3.11	6	–	164	11
26	313.5	DS	2.4	3.11	38	0.7	335	13
27	420.5	DS	3	3.27	7	–3.0	191	11
28	370.7	ZS	1.9	3.07	15	–	182	13
29	396.9	DS	2.1	3.10	14	–1.0	255	12
30	320.9	ZS	6.2	3.03	17	–	186	12
31	321.1	ZS	4	2.95	12	–	113	13
	339.6		2.4	3.39	9	–0.6	126	11

BREWER OBSERVATIONS FEBRUARY 2007								
Day	Ozone		dev	μ	N	SO ₂	UVB	NN
1	359.3	ZS	8.7	2.93	15	–	168	13
2	310.4	ZS	1.4	2.92	21	–	268	13
3	413.9	ZS	2.2	2.77	12	–	143	13
4	329.3	DS	4.6	2.86	22	0.4	312	14
5	341.8	DS	4.2	2.91	5	0.1	253	13
6	393.2	ZS	1.8	2.68	12	–	117	13
7	373.3	DS	3	2.95	8	0.5	225	14
8	–	–	–	–	–	–	108	14
9	361.8	ZS	2.6	2.71	21	–	228	13
10	330.9	DS	2.4	2.63	3	1.9	344	14
11	441.7	DS	6.5	2.51	11	0.6	324	13
12	486.6	ZS	6.7	2.63	15	–	215	14
13	391.8	ZS	10.4	2.58	15	–	199	14
14	430.7	ZS	7.3	2.47	9	–	167	13
15	404	ZS	5.5	2.53	19	–	200	14
16	436.9	ZS	12.4	2.41	19	–	225	14
17	441.9	DS	4	2.61	34	–1.2	390	15
18	375.5	DS	5.2	2.59	34	0.5	460	15
19	381.2	ZS	8.8	2.38	16	–	113	15
20	377.8	ZS	3.9	2.43	26	–	239	15
21	329.9	DS	2.1	2.42	22	0.7	545	16
22	361.5	ZS	5.6	2.48	9	–	142	15
23	294.1	DS	6.8	2.96	6	1.8	916	18
24	312.5	DS	1.1	2.36	3	2.5	616	15
25	325.4	ZS	2.4	2.42	37	–	476	15
26	321.9	ZS	11.7	2.61	15	–	276	16
27	331.6	DS	0	2.13	1	1.1	367	16
28	338.7	ZS	9.6	2.25	21	–	233	15
	370.3		5.2	2.60	16	0.8	295	14

BREWER OBSERVATIONS MARCH 2007								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	382.4	DS	5.1	2.05	3	1.1	471	16
2	410.0	DS	5.2	2.39	13	0.3	450	15
3	415.2	DS	2.6	2.51	4	0.2	296	16
4	417.2	ZS	1.5	2.15	5	–	127	16
5	374.7	DS	2.3	2.20	31	0.6	687	16
6	378.0	DS	3.4	2.15	17	0.6	616	16
7	357.6	DS	3.0	2.26	41	1.0	778	17
8	347.9	DS	5.3	2.08	6	1.7	485	17
9	362.9	DS	0	1.85	1	0.7	457	17
10	357.2	DS	2.1	1.94	23	1.3	738	17
11	359.2	DS	2.2	2.06	12	1.1	671	17
12	317.8	DS	1.8	2.09	82	0.7	1157	22
13	332.4	DS	4.3	2.09	83	0.6	1126	22
14	393.8	DS	22.8	2.07	60	0.7	856	21
15	350.0	DS	2.4	2.03	6	0.9	730	17
16	338.4	DS	2.1	2.20	31	1.4	821	18
17	422.5	DS	3.3	2.84	2	–2.0	248	17
18	379.5	ZS	3.9	1.82	30	–	451	17
19	395.3	DS	1.8	1.79	5	1.2	565	17
20	410.4	ZS	8.5	1.77	13	–	209	17
21	428.7	ZS	8.1	2.10	9	–	163	18
22	487.0	DS	3.6	1.95	7	–0.5	582	20
23	426.4	ZS	5.2	1.98	9	–	179	21
24	386.3	DS	3.4	1.94	47	0.8	1080	20
25	364.7	DS	4.9	1.94	62	0.9	1162	22
26	394.4	DS	2.1	1.93	90	0.4	1167	24
27	382.8	DS	2.2	1.85	83	0.7	1283	23
28	363.8	DS	4.1	1.81	57	1.6	1133	20
29	384.1	DS	9.6	1.87	96	1.0	1265	28
30	431.2	DS	11.1	1.78	86	1.1	1062	24
31	412.2	DS	3.3	1.82	56	0.9	1192	20
	385.9		4.6	2.04	35	0.7	716	19

BREWER OBSERVATIONS APRIL 2007								
Day	Ozone		dev	μ	N	SO ₂	UVB	NN
1	385.7	DS	5.4	1.66	29	1.5	943	22
2	352.8	DS	4.9	1.86	46	0.7	1436	23
3	351.5	DS	5.9	1.76	32	1.8	1262	23
4	383.9	DS	13.3	1.86	27	0.7	1381	23
5	327.3	DS	5.6	1.93	39	0.9	1704	22
6	356.8	ZS	8.0	1.68	38	—	1004	23
7	369.5	ZS	5.5	1.62	33	—	678	22
8	361.6	DS	3.3	1.59	6	1.4	1103	23
9	348.2	ZS	4.2	1.66	25	—	595	24
10	399.7	DS	0	1.95	1	1.5	605	23
11	304.5	DS	2.5	1.60	13	1.1	1896	23
12	334.5	DS	3.8	1.74	96	0.6	2265	26
13	339.9	DS	1.8	1.71	97	0.6	2247	29
14	331.4	DS	3.3	1.73	64	0.5	2347	21
15	355.7	DS	3.3	1.74	75	0.5	2228	26
16	362.6	DS	2.1	1.71	68	0.7	2167	25
17	364.5	DS	3.4	1.65	90	1.0	2158	25
18	378.9	DS	10.2	1.90	19	0.6	1373	25
19	375.8	DS	9.1	1.91	26	0.9	1697	24
20	396.3	DS	4.0	1.75	43	1.0	1805	27
21	397.1	DS	2.7	1.64	38	0.9	2099	24
22	382.0	DS	5.0	1.60	98	0.8	2374	26
23	354.0	DS	3.2	1.67	52	0.7	2191	25
24	372.7	DS	8.7	1.58	3	1.8	1224	25
25	365.3	DS	1.9	1.59	97	0.7	2409	26
26	354.9	DS	1.8	1.65	71	0.7	2381	26
27	341.0	DS	1.1	1.63	63	1.0	2481	27
28	336.8	DS	1.5	1.65	37	1.2	2353	25
29	375.6	DS	15.6	1.73	49	0.9	2305	25
30	374.1	DS	3.6	1.73	55	0.8	2215	31
	361.2		4.8	2.04	35	0.7	1764	25

BREWER OBSERVATIONS MAY 2007								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	383.8	DS	8.1	1.92	28	1	1565	24
2	355.6	DS	4.8	1.67	56	1.1	2747	24
3	349.3	DS	6.0	1.71	51	0.6	2968	22
4	359.3	DS	3.1	1.56	107	0.4	2900	29
5	362.3	DS	1.6	1.61	49	0.4	2726	25
6	341.5	DS	0	3.33	1	1.1	710	25
7	370.2	DS	6.1	1.27	12	1.3	2065	25
8	393.8	DS	3.4	1.69	7	1.3	1737	25
9	392.7	DS	2.8	1.45	16	1.2	1642	26
10	—		—	—	—	—	—	—
11	—		—	—	—	—	—	—
12	—		—	—	—	—	—	—
13	—		—	—	—	—	—	—
14	—		—	—	—	—	—	—
15	—		—	—	—	—	—	—
16	—		—	—	—	—	—	—
17	—		—	—	—	—	—	—
18	—		—	—	—	—	—	—
19	—		—	—	—	—	—	—
20	—		—	—	—	—	—	—
21	—		—	—	—	—	—	—
22	330.5	DS	4.5	1.47	42	−0.1	1408	15
23	324.3	DS	4.2	1.58	88	0.3	—	—
24	314.4	DS	3.8	1.51	106	0.4	3696	29
25	313.2	DS	4.3	1.40	85	0.6	3462	31
26	328.0	DS	2.0	1.59	34	1.2	2200	23
27	333.5	DS	2.6	1.63	40	0.7	2925	26
28	320.1	DS	3.6	1.48	81	0.6	3431	33
29	322.6	DS	2.9	1.55	84	0.7	3509	31
30	320.0	DS	3.4	1.72	5	1.2	1581	27
31	347.1	ZS	4.6	1.22	27	—	1047	27
	345.4		3.8	1.5	48	0.8	2351	26

BREWER OBSERVATIONS JUNE 2007								
Day	Ozone		dev	μ	N	SO ₂	UVB	NN
1	324.4	DS	2.1	1.24	10	-0,3	2304	26
2	348.1	ZS	10.6	1.49	24	—	866	26
3	344.4	ZS	5.9	1.50	30	—	1392	27
4	315.0	DS	0.7	2.62	7	0.9	1319	27
5	324.8	DS	4.9	2.25	20	1.0	2116	24
6	314.7	DS	3.3	1.68	38	1.5	3289	27
7	319.1	DS	1.4	1.64	54	1.0	3913	27
8	318.2	DS	5.1	1.57	71	0.5	3781	26
9	347.8	DS	5.9	1.50	34	0.6	2594	27
10	368.8	DS	7.8	1.23	16	0.5	2296	26
11	329.5	DS	5.4	1.48	93	0.3	3886	34
12	347.1	DS	2.0	1.57	124	0	3700	35
13	337.5	DS	1.8	1.58	63	1.4	2582	32
14	338.8	DS	4.7	1.54	56	0.6	3320	30
15	345.3	DS	4.9	1.43	60	0.5	3154	30
16	341.4	DS	3.8	1.69	28	0.4	2645	27
17	350.5	DS	8.0	1.61	58	0.4	3472	26
18	335.6	DS	4.6	1.45	20	1.0	1959	27
19	348.8	DS	6.4	1.92	40	0.4	2626	28
20	340.3	DS	7.0	1.61	64	0.7	1976	26
21	323.5	DS	2.7	1.49	55	0.6	3712	23
22	331.2	ZS	6.7	1.43	39	—	1123	27
23	338.6	DS	8.2	1.57	25	0.7	2718	27
24	341.6	DS	6.3	1.66	43	0.4	3525	32
25	325.8	DS	5.0	1.71	50	0.5	3334	27
26	341.4	DS	20.4	1.81	23	0.9	1748	27
27	336.4	DS	5.5	1.68	29	0.7	3044	27
28	345.6	DS	4.0	1.71	25	0.7	2956	26
29	350.0	DS	1.9	1.57	27	0.5	2727	27
30	341.5	DS	3.5	1.40	18	1.8	2728	27
	337.2		5.4	1.62	41	0.7	2694	28

BREWER OBSERVATIONS JULY 2007								
Day	Ozone		dev	μ	N	SO ₂	UVB	NN
1	335.8	DS	4.4	1.67	25	0.4	3105	27
2	327.8	DS	2.3	1.52	40	0.9	3338	26
3	342.0	DS	3.9	1.48	16	0.2	2400	27
4	333.4	DS	0	2.65	1	1.1	931	27
5	354.1	DS	3.9	1.75	3	0.6	1415	27
6	358.2	ZS	16.6	1.44	12	—	529	26
7	363.2	ZS	5.1	1.44	27	—	1450	26
8	318.5	DS	1.9	1.85	8	0.4	2634	27
9	296.8	DS	2.4	1.66	54	0.7	3618	29
10	332.1	ZS	6.5	1.49	8	—	883	19
11	358.9	DS	3.2	1.85	27	0.9	1867	25
12	354.1	DS	0.4	1.53	2	1.0	1465	18
13	330.3	DS	1.5	1.67	3	1.2	1879	22
14	303.1	DS	2.9	1.71	15	0.7	2874	22
15	313.1	DS	1.2	1.79	24	0.8	—	—
16	295.5	DS	3.7	1.39	69	1.0	3967	29
17	290.6	DS	2.5	1.67	106	1.1	4083	40
18	286.8	DS	1.4	1.80	15	1.3	1274	23
19	286.1	DS	2.6	1.62	39	0.6	3562	27
20	284.5	DS	4.2	1.52	39	0.8	3679	22
21	299.0	DS	1.0	1.75	13	−0.2	3427	21
22	—	—	—	—	—	—	3508	23
23	326.4	DS	5.6	1.64	46	1.0	3354	23
24	330.8	DS	14	1.80	16	0.8	2106	22
25	368.4	ZS	9.3	1.18	22	—	784	21
26	307.1	DS	2.5	1.70	36	0.7	3308	23
27	320.2	DS	6.6	1.58	32	1.3	2393	26
28	313.7	DS	2.3	1.49	20	0.8	2644	26
29	317.4	DS	2.6	1.46	11	0.5	2859	26
30	365.4	DS	7.5	1.91	12	0.4	1077	26
31	347.1	DS	2.6	2.11	3	−0.1	1608	23
	322.5		7.5	1.68	25	0.8	2401	25

BREWER OBSERVATIONS AUGUST 2007								
Day	Ozone		dev	μ	N	SO ₂	UVB	NN
1	335.3	DS	7.5	1.46	27	0.8	2799	26
2	312.2	DS	2.8	1.58	68	1.1	3236	25
3	315.7	DS	7.5	1.37	2	1.1	1416	24
4	334.4	DS	1.3	1.57	18	0.6	1937	24
5	323.4	ZS	3.1	1.53	51	—	1831	24
6	306.9	DS	5.1	1.91	16	0.6	2167	24
7	320.0	DS	3.6	1.71	47	1.3	2895	24
8	311.6	DS	2.0	1.57	28	1.2	2563	24
9	312.2	DS	2.9	2.11	10	0.5	1042	24
10	300.7	DS	2.0	2.14	11	1.0	2322	48
11	303.9	DS	3.9	1.71	12	0.4	1742	24
12	297.6	DS	1.8	1.62	20	0.6	3602	48
13	316.1	DS	2.4	1.51	2	1.4	1179	24
14	312.8	DS	2.2	1.54	45	1.0	1155	11
15	303.7	DS	3.6	1.72	48	0.9	2587	25
16	278.6	DS	2.4	1.68	47	0.8	—	—
17	287.5	DS	5.9	1.48	16	0.5	2545	24
18	305.0	DS	2.6	1.77	38	0.9	—	—
19	300.2	DS	1.8	1.78	39	1.2	2478	24
20	300.9	DS	1.5	1.93	14	1.1	1828	24
21	307.9	DS	8.6	1.84	31	0.7	2084	24
22	286.1	DS	2.6	1.62	44	0.6	2209	25
23	275.6	DS	2.1	1.75	39	0.9	2420	24
24	288.1	DS	9.0	1.84	33	0.7	2400	24
25	307.7	DS	7.2	1.85	36	1.2	2270	24
26	269.4	DS	2.8	1.74	11	1.1	2312	25
27	293.0	DS	2.8	1.95	24	0.8	1913	24
28	312.5	DS	3.3	1.89	29	1.0	2221	23
29	310.7	DS	1.7	1.98	34	0.8	1995	22
30	313.4	DS	6.1	1.92	20	1.2	2079	23
31	302.2	ZS	4.5	1.78	16	—	1208	22
	304.7		3.8	1.74	28	0.9	2153	25

BREWER OBSERVATIONS SEPTEMBER 2007								
Day	Ozone		dev	μ	N	SO ₂	UVB	NN
1	313.0	DS	1.2	1.56	5	1.2	1301	22
2	293.7	DS	2.3	1.50	4	0.6	1663	23
3	303.0	DS	3.5	2.00	19	0.8	1518	22
4	333.6	DS	2.7	1.49	7	0.9	1041	22
5	351.5	ZS	8.7	1.84	15	–	307	22
6	317.6	DS	3.7	1.49	3	1.7	912	22
7	311.3	DS	1.5	2.14	2	1.0	756	22
8	304.6	DS	1.8	1.81	37	0.7	1910	22
9	330.8	DS	0.6	2.36	2	0.3	889	22
10	315.1	DS	2.4	1.51	4	1.1	1025	22
11	336.5	DS	1.3	2.43	5	0.1	1081	22
12	309.9	DS	2.1	2.08	6	0.5	1374	22
13	304.2	DS	1.6	2.13	11	0.6	1495	22
14	294.7	DS	1.8	1.90	31	1.0	1776	21
15	316.6	DS	6.7	2.08	15	0.7	1294	21
16	272.6	DS	1.7	2.05	15	0.7	1331	20
17	268.0	DS	1.8	1.94	42	1.5	1844	20
18	287.1	DS	1.7	1.83	37	0.9	1488	20
19	299.6	DS	2.6	1.93	14	1.2	1336	20
20	294.8	DS	4.0	1.95	31	1.2	1344	20
21	284.4	DS	1.3	2.00	49	1.5	1573	19
22	288.5	DS	3.6	1.99	47	1.4	1515	17
23	281.2	DS	3.4	2.02	49	1.0	1343	17
24	281.1	DS	1.0	2.04	48	1.1	1423	17
25	286.7	DS	0.7	2.31	16	0.9	754	11
26	291.2	ZS	2.1	2.00	27	–	380	17
27	280.9	DS	1.3	1.97	25	2.2	1096	17
28	283.9	DS	1.4	1.78	17	1.1	805	17
29	312.5	DS	4.1	2.14	41	0.8	1131	17
30	306.0	DS	8.7	2.14	34	0.9	969	17
	301.8		2.7	1.95	22	1.0	1222	20

BREWER OBSERVATIONS OCTOBER 2007								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	283.6	DS	2.2	2.23	20	1.1	1153	17
2	275.8	DS	1.6	1.80	2	2.0	608	15
3	309.8	DS	5.2	2.26	9	0.7	692	17
4	270.7	DS	0.6	2.62	8	1.3	762	17
5	296.1	DS	1.4	1.94	7	2.1	677	17
6	284.0	DS	0.8	2.36	7	0.7	615	16
7	294.0	DS	4.5	2.49	12	1.0	766	17
8	266.3	DS	0.2	2.14	2	1.2	554	16
9	270.6	DS	1.5	2.33	20	0.8	868	16
10	268.7	DS	1.6	2.32	35	1.4	915	16
11	260.3	DS	2.0	2.28	19	1.5	731	15
12	309.6	ZS	2.4	2.21	27	–	208	15
13	302.9	DS	3.6	2.85	8	0.5	581	15
14	267.4	DS	1.6	2.48	23	0.7	842	15
15	267.5	DS	1.2	2.40	40	1.6	835	15
16	268.0	DS	2.9	2.45	34	0.9	779	15
17	278.6	DS	2.1	2.43	36	1.3	706	15
18	301.9	DS	2.4	2.84	4	0.5	353	14
19	339.7	ZS	1.7	2.39	24	–	241	15
20	323.3	DS	3.3	2.56	10	0.8	456	15
21	310.6	DS	3.7	2.50	36	0.8	613	15
22	282.3	DS	2.6	2.66	3	1.1	345	15
23	288.5	ZS	2.5	2.50	24	–	157	15
24	272.3	DS	2.2	2.58	20	1.5	500	15
25	296.5	ZS	3.4	2.58	27	–	208	14
26	292.1	DS	0	3.22	1	–0.4	274	14
27	282.0	DS	1.7	2.36	10	1.3	432	14
28	287.7	ZS	2.9	2.64	27	–	199	14
29	274.0	ZS	1.3	3.31	4	–	407	14
30	266.5	ZS	3.2	2.68	27	–	252	14
31	278.5	DS	3.2	2.47	7	1.1	364	13
	286.1		2.2	2.48	17	1.1	551	15

BREWER OBSERVATIONS NOVEMBER 2007								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	244.2	ZS	5.0	2.72	21	–	274	13
2	269.6	DS	1.2	2.93	7	0.1	374	13
3	265.4	DS	2.6	3.28	10	–0.1	315	13
4	296.4	DS	1.9	3.05	5	–0.1	251	13
5	293.5	ZS	3.3	2.79	15	–	226	13
6	301.9	DS	0	2.98	1	0.8	201	13
7	303.6	ZS	2.5	3.03	10	–	186	13
8	282.5	ZS	7.2	2.91	4	–	117	13
9	256.5	ZS	0	2.84	1	–	70	13
10	334.8	DS	3.2	3.76	3	–2.4	183	13
11	314.1	DS	2.1	3.38	3	–1.6	215	13
12	340.0	ZS	2.7	3.00	8	–	113	12
13	344.0	ZS	2.4	3.01	8	–	105	12
14	335.9	ZS	1.2	2.99	12	–	146	12
15	321.5	DS	0.9	3.29	9	–0.1	174	12
16	333.5	DS	3.5	3.31	16	–1	219	12
17	297.8	ZS	4.2	3.07	11	–	158	11
18	263.4	ZS	1.5	3.03	4	–	147	11
19	261.7	ZS	3.8	3.25	8	–	123	11
20	255.4	ZS	7.6	3.32	8	–	175	11
21	286.6	DS	1.7	3.67	7	–0.5	181	11
22	275.8	DS	1.7	3.51	25	0.4	216	11
23	273.6	DS	3.7	3.40	26	2.0	209	11
24	247.0	ZS	3.2	3.38	4	–	71	11
25	271.3	ZS	8.5	3.46	2	–	80	11
26	344.4	ZS	0	3.52	1	–	55	11
27	362.5	ZS	1.0	3.58	2	–	65	11
28	235.9	DS	2.1	3.62	12	0.1	230	11
29	264.1	DS	1.1	3.59	16	0.7	199	11
30	301.5	ZS	5.2	3.41	3	–	55	11
	292.6		2.8	3.24	9	–0.1	171	12

BREWER OBSERVATIONS DECEMBER 2007								
Day	Ozone		dev	μ	N	SO2	UVB	NN
1	201.6	ZS	1.9	3.47	3	–	156	10
2	310.8	DS	1.3	3.54	6	–0.4	114	10
3	–	–	–	–	–	–	57	10
4	–	–	–	–	–	–	40	10
5	–	–	–	–	–	–	79	10
6	252.8	ZS	12.5	3.75	4	–	79	11
7	290.1	ZS	0	3.57	1	–	66	10
8	314.1	DS	2.1	3.82	5	–2.9	116	10
9	333.4	DS	0	4.05	1	–4	72	10
10	–	–	–	–	–	–	39	10
11	–	–	–	–	–	–	27	9
12	–	–	–	–	–	–	24	9
13	317.4	DS	1.6	3.90	27	–1.8	120	13
14	–	–	–	–	–	–	46	9
15	–	–	–	–	–	–	55	9
16	295.8	DS	0.2	4.10	3	–1.7	73	9
17	–	–	–	–	–	–	73	9
18	227.1	ZS	0	3.89	1	–	36	9
19	–	–	–	–	–	–	39	9
20	257.5	ZS	0	3.91	1	–	29	9
21	189.4	ZS	1.6	3.77	2	–	47	9
22	246.5	DS	0.7	3.93	8	–0.2	132	9
23	294.2	DS	3	3.91	14	–0.8	116	9
24	–	–	–	–	–	–	23	9
25	–	–	–	–	–	–	33	9
26	298.8	DS	1.0	4.02	6	–1.2	98	9
27	353.2	DS	4.4	4.04	5	–4.4	74	9
28	298.0	DS	1.5	3.75	3	–1.0	110	9
29	303.9	DS	2.2	3.94	18	–1.2	125	9
30	300.7	ZS	3.7	3.72	2	–	62	9
31	322.6	ZS	0	3.86	1	–	70	9
	284.6		2.0	3.84	6	–1.8	72	10

Variability of Aerosols Forcing on the Surface UV Radiation: Analysis of Data Taken at Belsk, Poland, in Spring 2007

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Abstract

Potential impact of the atmospheric aerosol on surface UV radiation is presented. Sun-photometer data collected at Belsk in the period March 27 – April 19, 2007, as well as satellite data, were used to estimate the UV irradiance response to the aerosols optical depth (AOD) changes during smoke/dust event and advection of the clear Atlantic air mass. The mean attenuation of the erythemally weighted surface UV irradiance due to smoke was ~3% in the case of sun-photometer data and ~7% in the case of satellite data, whereas ~10% increase relative to the overall mean UV level was estimated during the clear Atlantic air episode.

It seems that the satellite observations can provide accurate estimate of the aerosol optical depths for “clear” air masses and when the AOD exhibits small intraday variations. It was also found that extrapolation of satellite data to UV range leads to an overestimation of AODs.

1. Introduction

Aerosols are being recognized as a major factor determining climate. In recent years, increased interest has been noted on studies of the aerosol properties in the ultraviolet (UV) range when it was established that the aerosols could significantly affect the intensity of UV radiation at the ground-level and play a more important role in attenuating UV irradiances than has been recognized previously. The observed ozone depletion at high and mid-latitudes triggered attention to the related increase of the UV

radiation at the Earth's surface. Many other factors, such as cloud cover and aerosol load of the atmosphere may also influence the UV radiation interfering with the ozone related changes (Bais *et al.* 2006). These factors sometimes could act synergistically rather than independently, posing challenging task related to description of expected range of the UV response to changes in one UV forcing factor.

Influence of atmospheric aerosol on solar UV radiation was recognized by Liu *et al.* (1991). Attenuation of the UV radiation depends on aerosol optical properties which are determined by aerosol microphysical structure and concentration. Temporary changes of the aerosol optical properties depend on the source of aerosol origin and transformation processes during the advection of aerosols. The variability of aerosols is rather wide and the life-time in the atmosphere is rather small comparing to other UV radiative forcing agents like ozone. For example, aerosol optical depth (AOD) can change more than two or three times in a few days. In some cases, changes of surface UV radiation induced by aerosol are comparable to that induced by ozone (Zerefos 1997, Krzyścin and Puchalski 1998). Jarosławski and Krzyścin (2005) reported that AOD at 320 nm in Belsk, Poland, has a decreasing tendency since the early 1990s, inducing an increase in surface UV irradiance of about 4%, that is comparable with the total ozone forcing on UV radiation in that period. Modeling of aerosol influence on surface UV radiation is rather difficult in global scale. Many studies revealed the strong influence of variations in the aerosol properties on long- and short-term variations in surface UV radiation (Chubarova *et al.* 2002, Arola *et al.* 2003, Kambezidis *et al.* 2005, Meloni *et al.* 2005).

Precise modeling of attenuation of UV radiation by aerosols is rather difficult and requires wavelength dependent aerosol radiative properties like AOD and total content of other forcing agents being input to radiative transfer models. On the basis of statistical analyses of UV data collected at Belsk (52°N, 21°E), Poland, Krzyścin (2004) introduced Radiation Amplification Factor (RAF) due to aerosol to describe aerosol impact on UV radiation. Modeling of aerosol radiative forcing by means of RAF requires information about aerosol optical depth at a certain UV wavelength. The measurements of aerosol optical thickness in the UV range (around 320 nm) are relatively rare and short (Cheymol and de Backer 2003, Groebner 2004, Jarosławski *et al.* 2003). This is caused by the difficulties connected with the measurement itself, relatively low signal level, necessity of knowledge of total ozone content at the time and place of measurement, large variability of signal intensity within the range of UV wavelengths. Only the world-wide sun-photometric network, AERosol Observing NETwork (AERONET), performs regular measurements of aerosol properties including AOD at 340 nm since the late 1990s (Holben *et al.* 1998).

Analyses of past, present, and future variations of the aerosols properties in the UV become one of the important pending problems. It becomes evident that more specific knowledge of aerosol characteristics in the UV range and their effects on the ground-level UV radiation lead to improved accuracy in the UV climatology modeling, proper scaling of the measured UV spectra, and reliable UV Index forecasting.

2. Observatory and Instrumentation

The Central Geophysical Observatory of the Institute of Geophysics, Polish Academy of Sciences, at Belsk is located in a rural site about 50 km SSW of Warsaw. It is surrounded by orchards and larch forest. A nearby village is located about 2 km from the observatory and a distance to nearby small town Grójec is about 10 km. Thus, Belsk observatory could be qualified as a background station weakly affected by large local pollutions. Measurements of atmospheric aerosol by means of sun-photometers and lidar as well as in-situ techniques are performed at Belsk. Various standard meteorological observations are also carried out, complementarily to aerosol measurements. In this work we examine sun-photometer data obtained by CIMEL instrument at the Belsk observatory and satellite data from MODIS instrument on Aqua and Terra satellite platform.

Belsk's CIMEL CE-318 sun-photometer, instrument #318, is part of AERONET network. The photometer contains two collimators and detectors mounted on sun tracker and an electronic module containing control unit and real time acquisition system. Collected data are transmitted via satellite to AERONET centre. The instrument uses two detection systems for registration of sun and sky radiances. A UV enhanced silicon detector is used for sun radiance measurements at 340, 380, 440, 500, 670, 870, 938 and 1020 nm. The other silicon detector is used for sky radiance registration. The sky radiance measurements are taken at 440, 670, 870 and 1020 nm by means of almucantar and principal plane scans. Direct sun measurements are used to determine aerosol optical depths at selected wavelengths, Angström exponent, and columnar water vapour concentration. Dubovik's numerical procedure (Dubovik and King 2000) is applied to the almucantar scans providing microphysical and radiative properties of the aerosol: aerosol particle size distribution, refractive index, single scattering albedo, and asymmetry factor.

Moderate Resolution Imaging Spectroradiometer (MODIS) is a main instrument onboard Earth Observing System (EOS) Terra and Aqua satellites. Both are polar-orbiting satellites; they repeat orbit every 16 days. MODIS instrument performs measurements of solar and earth thermal radiation from about 0.41 to 14 μm (Salomonson 1989). Seven channels from 0.47 to 2.1 μm are used in the atmospheric retrievals. MODIS uses predefined aerosol microphysical properties and look-up tables to estimate aerosol radiative properties over land and ocean, respectively. In this work (next subsection) we convert AODs by MODIS originally measured at 470 and 660 nm to AOD in the UV range.

2.1 Retrieval of AOD in UV range

Estimation of aerosol optical thickness in the UV is typically taken by the extrapolation of optical thicknesses from the visible range of wavelengths by the so-called Angström coefficient (Angström 1929). However, this extrapolation can lead to over-

estimation of AOD in the UV range. The reason is a dependence of Angström coefficient on wavelength. It decreases towards the shorter wavelengths (Jarosławski *et al.* 2003) and could be even negative for very short UV-B wavelengths. Another way to estimate AOD in UV range is to calculate aerosol optical properties using measured aerosol microphysical properties and Mie light scattering theory. This method provides good agreement with direct sun measurements (Pietruczuk and Jarosławski 2007). In this work we examine aerosol optical properties in the UV range that are directly measured by CIMEL sun-photometer at Belsk and inferred from the satellite observations at visible wavelengths.

Figure 1 shows a scatter plot of AOD at 340 nm measured by CIMEL sun-photometer versus that extrapolated from CIMEL AODs in the visible range using Angström exponent calculated between 440 and 870 nm wavelengths. A sample of about 70 simultaneous CIMEL AOD measurements taken in 2006 was examined. High correlation between measured and extrapolated data is found but the extrapolated AODs are in the mean ~13% larger than those from the direct CIMEL observations in UV. Figure 1 illustrates that the extrapolation method induces substantial overestimation. Figure 2 shows scatter plot of AOD at 340 nm measured directly by CIMEL versus that extrapolated from AODs measured by MODIS at 440 and 870 nm. Lower correlation coefficient is found between direct measurements and UV extrapolated satellite data. Extrapolated satellite data are about 37% larger than those from CIMEL measurements at 340 nm.

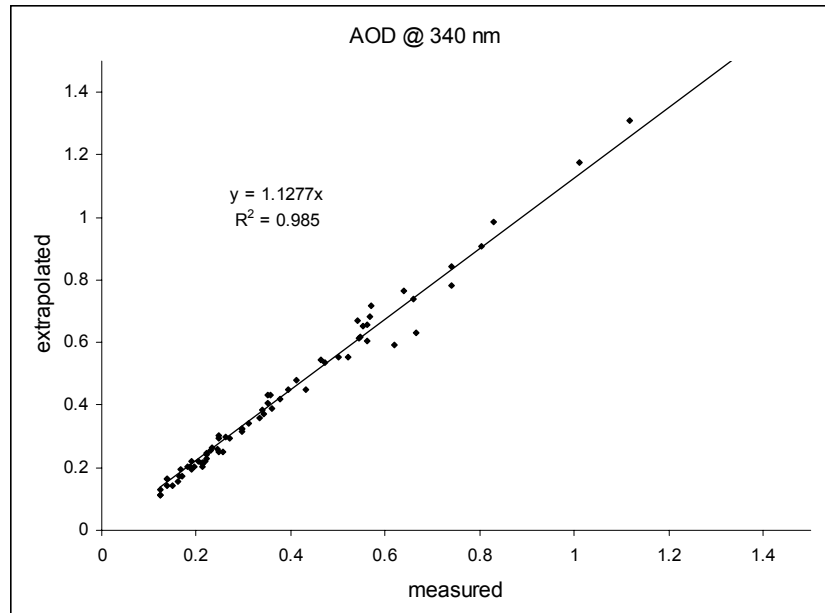


Fig. 1. Correlation between AOD at 340 nm directly measured by CIMEL sun-photometer and extrapolated from CIMEL measurements in visible range.

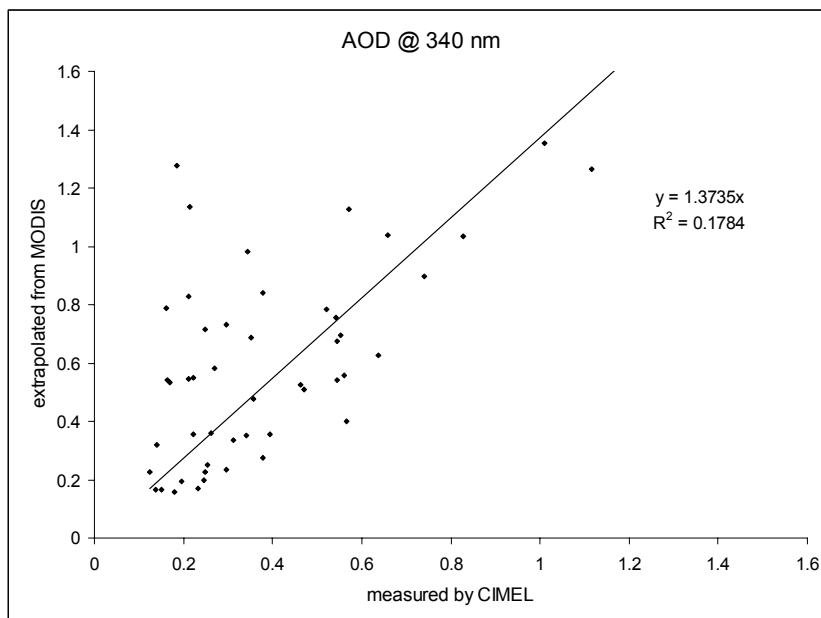


Fig. 2. Correlation between AOD at 340 nm directly measured by CIMEL and AOD extrapolated from MODIS measurements.

3. Synoptic Situation

In this work we analyze optical properties of aerosol measured during dust/smoke events and “clear air mass” event. Moreover, variability of aerosol forcing on surface UV during these events is discussed. Aerosol type and its origin site were determined by the backward trajectories analysis and aerosol diagnostic models. In back trajectory analysis we used HYSPLIT model (Draxler 1998). HYSPLIT is freely available at NOAA Air Resources Laboratory web pages, <http://www.arl.noaa.gov/>. The DREAM dust transport model (Nickovic 2001) and NAAPS (Navy Aerosol Analysis and Prediction System) prediction system were used to distinguish aerosol type and its loading. Results of DREAM dust model, like dust load and dust optical depths, are available on-line at Barcelona Supercomputing Center web pages, <http://www.bsc.es/projects/earthscience/DREAM/>. NAAPS results are available on-line at Naval Research Laboratory/Monterey Aerosol Page, <http://www.nrlmry.navy.mil/aerosol/>. NAAPS provides maps of surface concentration and optical depths of dust, smoke and sulfate aerosol.

Seasonal forest, grass and peat-bog fires are a main source of smoke aerosol in Eastern Europe. Such fires took place mainly in the Eastern Ukraine, Western Russia and Belarus. This spring (end of March 2007), large numbers of fires took place at the border between the Ukraine and Russia. Figure 3 shows fire activity in Eastern Eu-

rope at the end of March 2007 detected by MODIS instrument at Aqua and Terra satellite platform. MODIS fire products (Justice *et al.* 2002) are distributed by the University of Maryland, Fire Information for Resource Management System (FIRMS), are available on-line, <http://maps.geog.umd.edu>.

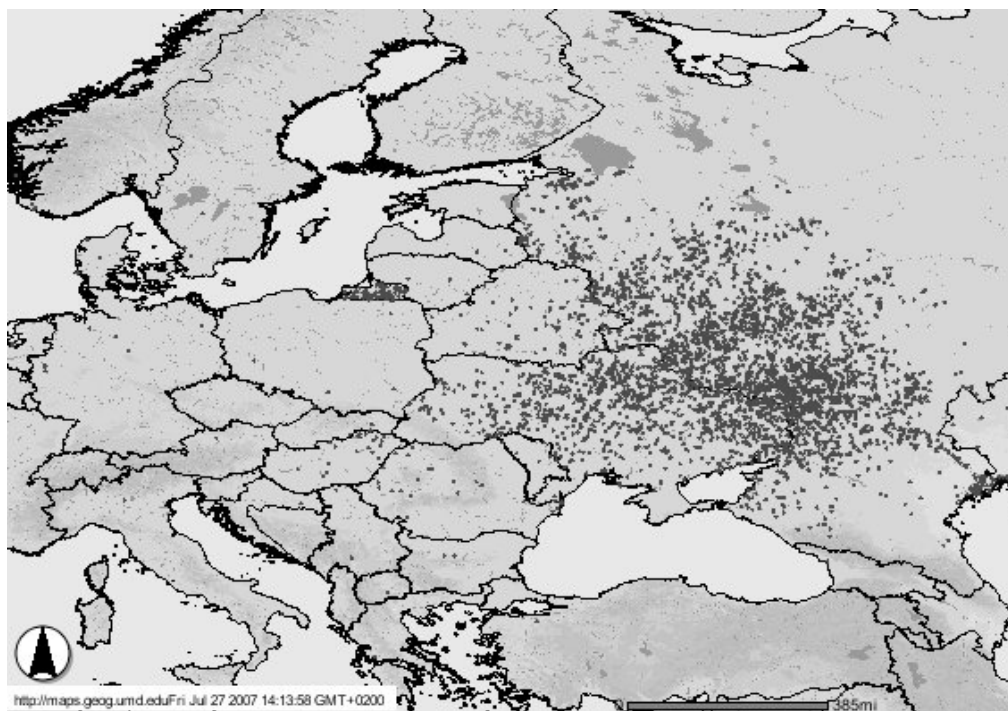


Fig. 3. Fires (dark dots) between 20 and 25 March 2007, provided by FIRMS system.

Biomass burning products were redistributed over Europe by the large-scale atmospheric circulation. Smoke plume was detected by lidar and sun-photometric stations in Minsk, Belarus and Belsk, Poland (Pietruczuk and Chaikovsky 2007). The smoke was transported mainly in the boundary layer but it was also injected into the free troposphere. The smoke layer was detected up to 3 km height. Smoke aerosol is dominated by fine particles which correspond to large values of Angström exponent. The presence of smoke over central Poland was predicted by NAAPS system for the whole period between 24 March and 04 April. Figure 4 shows a sample of vertical distribution of fine and coarse aerosol mode concentration measured 30 March. It is clearly seen that fine mode aerosol dominates the layer up to 2 km which is over a typical height of the boundary layer. This profile was derived from simultaneous lidar and sun-photometric measurements in Belsk.

Dust transported from Sahara to Europe is mainly observed in the Mediterranean region (Balis *et al.* 2006, Lyamani *et al.* 2005, Mona *et al.* 2006) but it affects Eastern

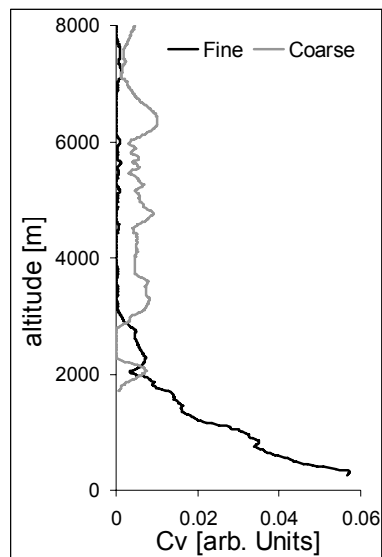


Fig. 4. Vertical profile of fine and coarse mode concentration derived from lidar measurements taken in Belsk, Poland, on 30 March 2007.

and Central Europe several times per year. Such events were detected and studied by lidar networks covering the whole continent (Ansmann *et al.* 2003) and by a single lidar station as well (Kardas *et al.* 2006). Almost the whole Europe was affected by large dust event at the end of March 2007. Transport of dust from Northern Africa over the Middle East towards Eastern Europe is clearly seen from DREAM model output (Fig. 5). The dust plume was followed by the smoke event (Fig. 6). Dust episodes were identified by the models on 23, 26/27 and 30/31 March 2007. Models' estimates are in good agreement with lidar measurements performed at Belsk (Pietruczuk and Chaikovsky 2007). The back trajectory analysis shows that during dust events the air masses present at high altitudes were advected from Northern Africa but at lower altitudes the air masses have their origin in the Eastern Ukraine, a source region of smoke (see Fig. 7a). In those cases the dust layer was lying over the smoke layer. During dust episodes aerosol was dominated by coarse particles, which corresponds to low values of Angström exponent.

At the beginning of April 2007, when fire activity was decreasing, the air circulation changed and the clear air mass from Atlantic Ocean appeared over Poland. These air masses were not affected by industrial areas, which is confirmed by the back trajectory analysis (Fig. 7b). During "clear air mass" event, extremely low values of AOD and extremely high values of meteorological visibility were registered at Belsk. These conditions lasted up to 12 April 2007. Later there was a small dust event but low values of AOD were still registered. Unfortunately, at the beginning of that event the sky was partially covered by clouds and sun-photometric observations up to 13 April were not performed.

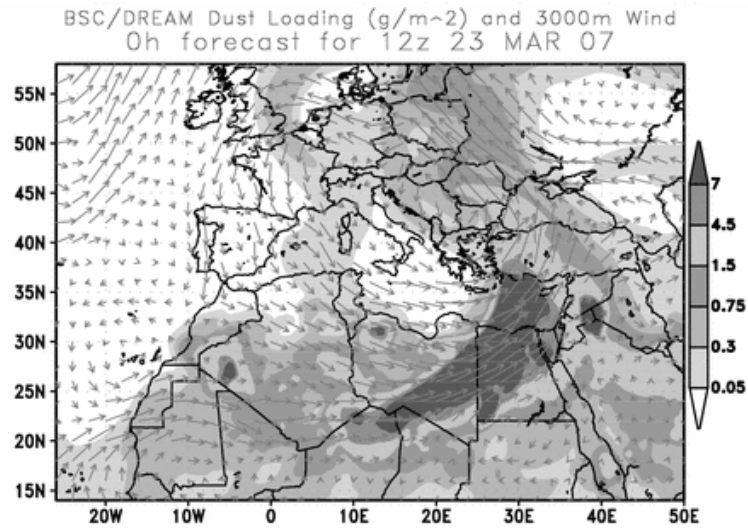


Fig. 5. Dust load over whole Europe on 23 March 2007, provided by DREAM model.

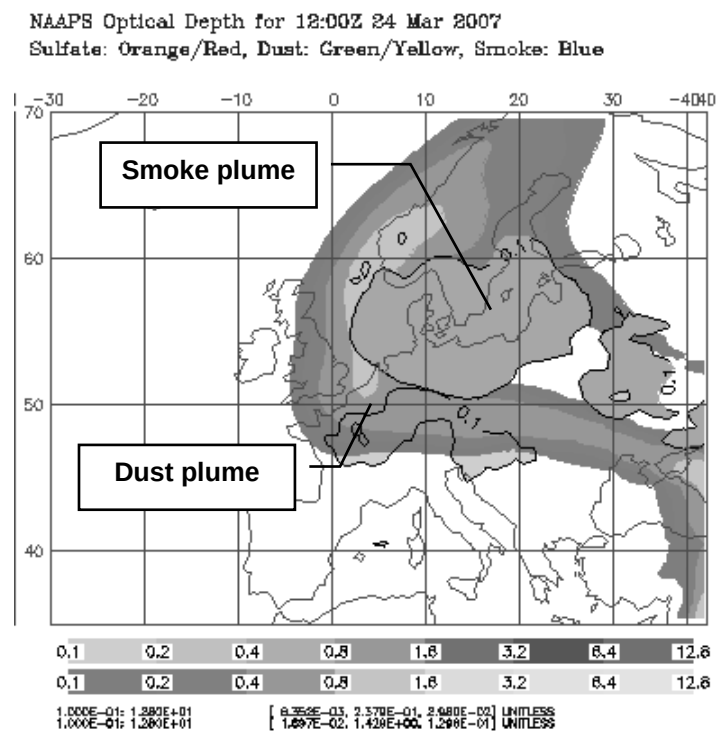


Fig. 6. Dust plume followed by smoke on 24 March 2007, provided by NAAPS system.

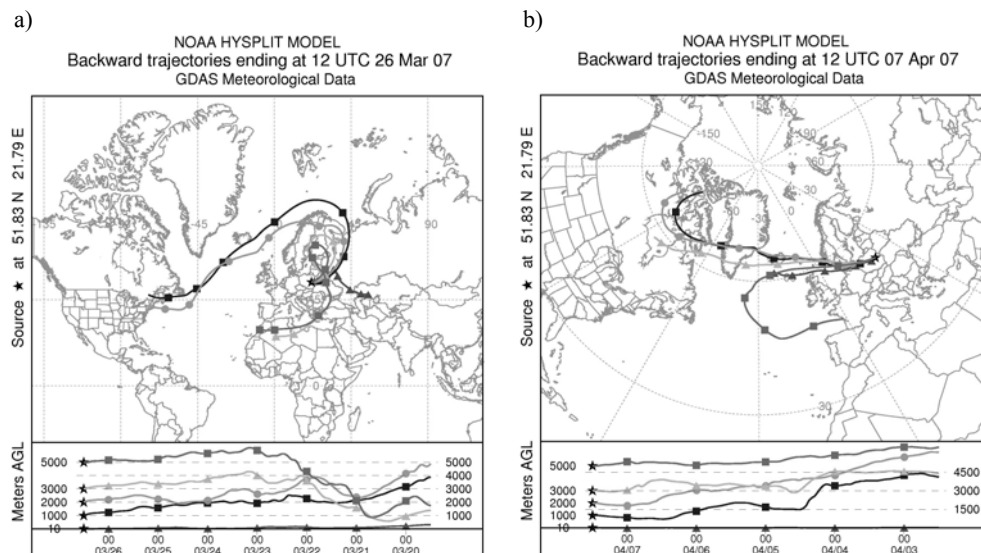


Fig. 7. HYSPLIT back trajectory analysis: (a) dust episode, 26 March 2007, (b) “clear air mass” episode, 07 April 2007.

4. Results and Discussion

Aerosol optical depths at 340 nm derived from direct CIMEL measurements and extrapolated from MODIS retrievals are shown in Fig. 8. It is shown that AOD exceeds the mean value (dashed line) during aerosol load events. The mean value is exceeded about twice on 28 March and up to four times during the 01/02 April event. Episode of the clear Atlantic air mass, from 4 to 12 April, was characterized by the AOD values about twice smaller than the overall mean value. Large variability of AOD in different timescale is also shown in Fig. 8. Long-term variability is probably due to advection of different types of aerosol with different particle concentrations. Diurnal variability of the aerosol properties seems to be strongly affected by conversion processes of aerosol. It should be mentioned that the diurnal variability of aerosol, clearly seen in CIMEL AOD time series, is not available from MODIS data because the satellite overpasses happen at most twice a day whereas CIMEL measures continuously throughout the whole day if weather conditions permit.

Large variability of aerosol properties is also seen at time series of Angström exponent (Fig. 9). Values of the parameter vary from about 0.6 during dust events up to 1.9 during smoke events. During “clear air mass” episode, the Angström exponent measured by CIMEL varies around its long-term mean value but pertaining values taken from MODIS retrievals are much higher and comparable to that measured during the smoke event. This difference could influence estimation of AOD in UV range taken from the MODIS extrapolation from AODs in visible range.

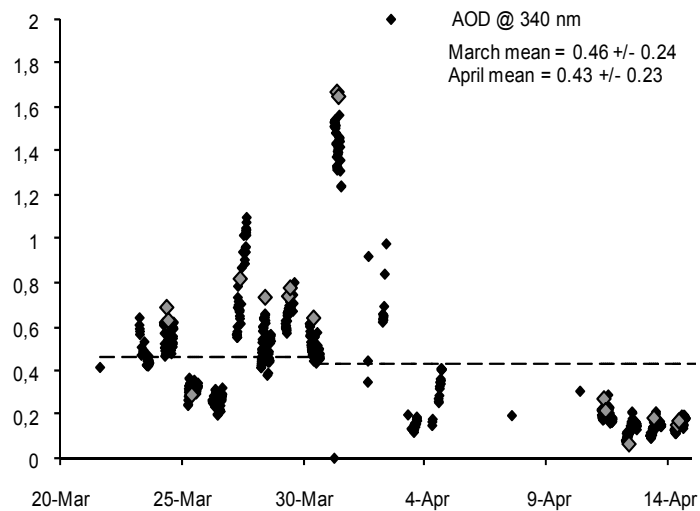


Fig. 8. Aerosol optical depth at 340 nm measured by CIMEL sun-photometer at Belsk (black diamonds) and extrapolated from MODIS retrievals (gray diamonds).

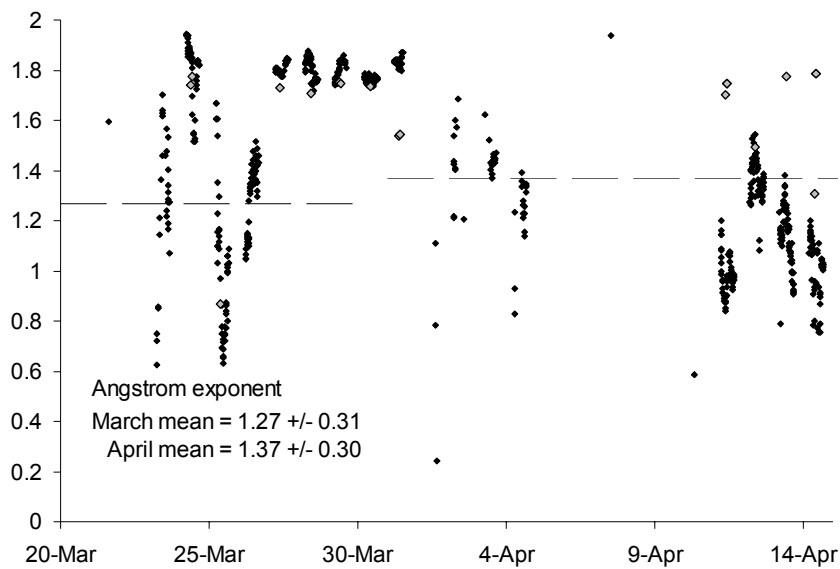


Fig. 9. Angstrom exponent taken from CIMEL measurements at Belsk, 440-870 nm (black diamonds) and MODIS retrievals, 470-670 nm (gray diamonds).

The value of Angström exponent is determined by the aerosol microphysical structure. The aerosol microphysical structure is determined by source of origin and conversion processes during advection and in situ processes (e.g., humidification).

Large values of the parameter are typical for aerosol dominated by fine mode fraction, like smoke, and small values are specific for the aerosol dominated by coarse fraction, like dust.

The back trajectory analysis shows that during days when the Angström exponent was extremely low, 23 and 26 March as well as after 14 April, the air mass at altitudes of about 3000 to 5000 m was advected from Saharan region; see for example Fig. 7a. During episodes when the Angström exponent was extremely high, air mass was advected only from regions of biomass burning. A dust layer over the smoke layer was detected on 30 and 31 March but the dust AOD was much smaller than the smoke AOD see the aerosol concentration profile in Fig. 4. During those days, the columnar properties of the aerosol were typical for the smoke aerosol being dominated by fine mode fraction of the aerosol size distribution. Mean values of aerosol optical properties characteristic for each type of episode are listed in Table 1. Period from 24 March to 4 April was qualified as a smoke event except of 26 March, which was described as a dust event. The period from 5 to 13 April was qualified as a “clear air mass” event.

Table 1

Mean values of aerosol optical properties by aerosol class directly measured by CIMEL and MODIS sun-photometer (AOD at 340 nm) and extrapolated from CIMEL and MODIS visible measurements (Angström exp.) in the period March/April 2007

Aerosol Class	AOD at 340 nm		Angström exp.	
	CIMEL	MODIS	CIMEL	MODIS
Smoke	0.68±0.01	1.00±0.10	1.75±0.01	1.68±0.05
Dust	0.30±0.01	0.28	1.12±0.03	0.87
“clear” air mass	0.16±0.01	0.18±0.06	1.13±0.03	1.67±0.06

We applied the aerosol RAF concept (Krzyścin 2004) to determine the variability of relative clear-sky UV irradiance for cases with different aerosol types. The aerosol RAF follows the power law formula used by Booth (1994) to describe total ozone effects on surface UV radiation. The aerosol RAF is defined by the following formula:

$$\frac{UV}{UV^*} = \left(\frac{\tau^*}{\tau} \right)^{RAF}, \quad (1)$$

where UV denotes the surface erythemally weighted UV irradiance under clear-sky conditions, τ is the actual AOD in UV range, τ^* denotes the overall mean AOD, UV^* represents the clear-sky erythemally weighted UV irradiance calculated from a radiative transfer model with actual total ozone and AOD = τ^* . The aerosol RAF is rather independent of solar zenith angle and equal to about 0.1 for AOD at 320 nm (Krzyścin 2004).

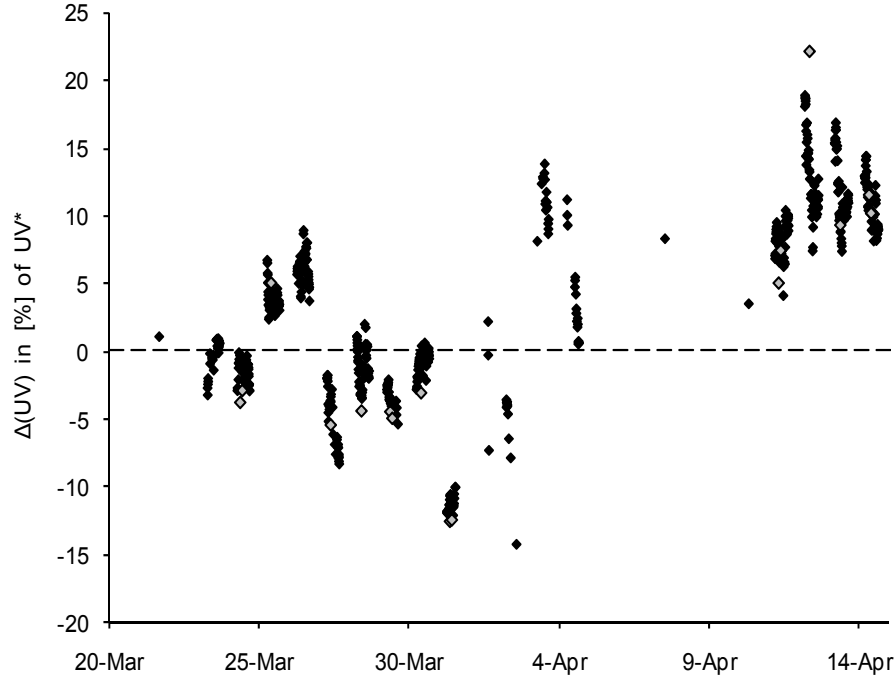


Fig. 10. UV response of changes in aerosol optical depth derived from CIMEL observations at Belsk (black diamonds) and the site MODIS overpasses (gray diamonds) in the period March/April 2007.

Figure 10 shows series of model (1) calculated surface UV level relative to the hypothetical UV^* for clear-sky conditions at Belsk with actual total ozone and overall mean aerosol properties. Our previous studies show that mean values of AOD registered in Belsk at 320 and 340 nm are comparable (Pietruczuk and Jarosławski 2007). Thus, the aerosol RAF constants calculated at 320 nm and 340 nm are equivalent. Drawing Fig. 10 we used formula (1) with $RAF = 0.1$ and the AOD series at 340 nm shown in Fig. 8. It is seen that the AOD variability induces large variations of the surface UV irradiance. In the case of MODIS retrievals, the variability is from -12.7% up to 22.1% and in case of CIMEL data from -14.2% up to 18.8% . Erythemally weighted surface UV irradiances during the smoke episodes were a few percents smaller than the overall mean. The value is around -3% in the case of CIMEL data and around -7% in the case of MODIS data. Dust episodes yield an increase of $\sim 4\%$ in cases of both instruments. Advection of clear Atlantic air masses enhances erythemally weighted UV irradiances of $\sim 10\%$ relative to the overall mean for both instruments. Mean values of aerosol influence on surface UV radiation are summarized in Table 2.

Table 2

Mean values of the UV response of changes in aerosol optical depth derived from CIMEL observations at Belsk and the site MODIS overpasses in the period March/April 2007

Aerosol Class	$\Delta(\text{UV})$ in [%] of UV*	
	CIMEL	MODIS
Smoke	-3.1 ± 1.7	-6.9 ± 1.8
Dust	4.5 ± 1.1	4.9
“clear” air mass	11.0 ± 1.4	10.4 ± 3.7

Figure 10 and Table 2 show that the mean aerosols effects on erythemally weighted surface UV irradiation by the CIMEL are smaller than that by the MODIS retrieval during smoke event and comparable during “clear air mass” and smoke episode. This is due to various spectrophotometers used, different methodologies for estimation of AOD in UV range, and specific time schedule for measurements. MODIS measures at most twice a day whereas CIMEL measures all day if clear Sun is present. Thus, MODIS provides temporary values of AOD around noon, which could be extreme or no representative for the whole day. CIMEL is able to monitor diurnal changes of AOD. Disagreement in case of large AODs (smoke event) is also possible as a result of extrapolation to AOD at 340 nm based on MODIS Angström coefficient derived from AOD at visible wavelengths. Such an algorithm leads to an overestimation of AOD as it was previously discussed in Section 2.

5. Conclusions

During dust/smoke events, large variations of AOD due to long- and short-term changes in aerosols inflow or transformation of aerosol size spectrum were registered by the CIMEL instrument. Variability of aerosol properties induces large variability of erythemally weighted surface UV irradiation. The extreme values of potential influence of changes of AODs on erythemally weighted UV surface radiation at Belsk were -15% during smoke and $+20\%$ during clean air mass event. Mean values are from around -7% up to 11% , respectively.

It seems that the satellite observations can provide accurate estimate of the aerosol optical depths for “clear” air masses and when the AOD exhibits small intraday variations. In case of large variations of aerosol optical properties and large values of AOD, extrapolation of MODIS data to UV range overestimates AODs. Moreover, the MODIS observations are not able to provide diurnal variability of AOD, thus the mean AOD may be not representative for the whole day. However, in first approximation, AODs from MODIS follow the pattern of daily changes of AOD directly measured by CIMEL sun-photometer. Thus, it seems that the MODIS retrieval of aerosol data provides valuable input data for diagnostic model dealing with long-term changes in surface UV.

During dust/smoke events, large variations of AOD due to long- and short-term changes in aerosols inflow or transformation of aerosol size spectrum were registered by CIMEL instrument. Variability of aerosol properties induces large variability of aerosol forcing on surface UV radiation

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Ultraviolet Radiation Measurements at Belsk Geophysical Observatory in 2006 and 2007

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Measurements of erythemally weighted solar radiation in UV-B range, as well as sunshine duration, were continued in the years 2006 and 2007. The results of measurements were used to calculate diurnal doses of UV-B radiation and UV index which indicates maximum power of UV-B radiation registered during each day. Measurements of solar radiation in UV range have been performed in Belsk Geophysical Observatory by means of Robertson-Berger (R-B) instrument since 1976 to 1994, and then continued by means of UV-biometers manufactured by Solar Light Co., Philadelphia, USA, since 1993. One year of simultaneous measurements of solar radiation by means of Robertson-Berger (R-B) and Solar Light (SL) instrument was necessary to provide continuous and homogeneous record of UV-B radiation. Usage of two UV-biometers (Solar Light 501A model) at Belsk allows to secure continuity of data series when instruments are calibrated and serviced.

Measurements performed in 2006 and 2007 are summarized in Tables 1 and 2. Diurnal doses are expressed in MEDs. One MED (minimal erythermal dose) is equal to 209.88 J/m^2 of erythemally weighted solar radiation. The tables also contain values of UV index, which is a daily maximum value UV flux (in watts per square meter) multiplied by 40. Its values range from 0 to 16.

Tables 3 and 4 present mean and extreme values for each month in 2006 and 2007. Columns from 2 to 4 contain mean, maximum and minimum values of UV radiation daily doses. Column 5 presents the mean values of UV index, column 6 the sunshine duration, column 7 the ozone content, and column 8 the mean value of UV radiation between 1976 and 2006. Column 9 presents the difference between UV radiation in 2007 and the long-term mean.

Data for the year 2007 were analyzed in greater detail.

Figure 1 shows monthly means of diurnal doses of UV-B radiation with standard deviation referred to long-term mean and extreme values for each month. Figure 2 shows differences between long-term mean and the UV-B radiation, ozone content and sunshine duration recorded in 2007.

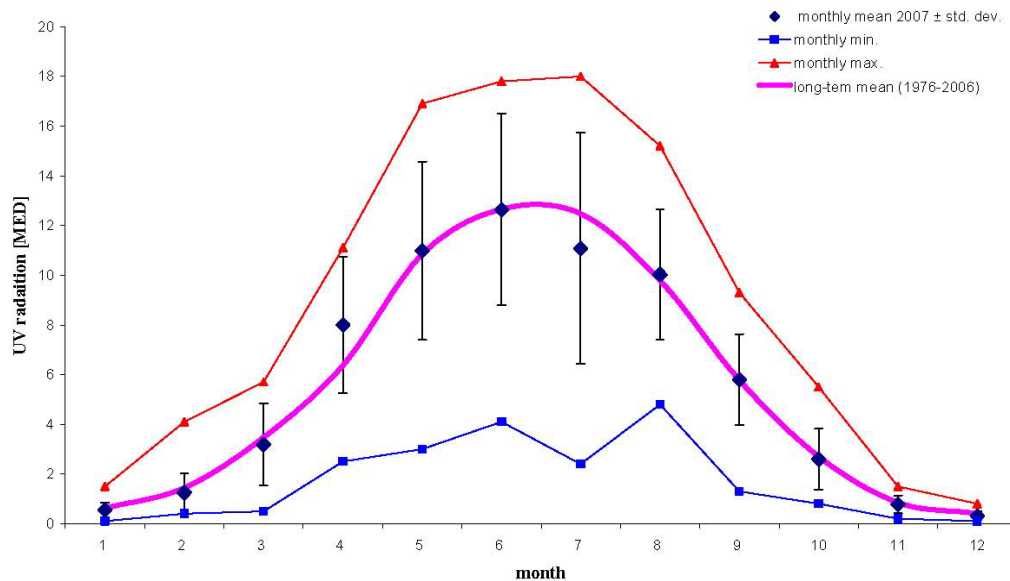


Fig. 1. Monthly means of UV radiation and extreme values in 2007.

The lack of UV-B radiation was registered during winter, early autumn and early spring. Maximum deviation from the long-term mean is 24% in December. In July, UV radiation was 11% lower than the long-term mean. The UV radiation larger than long term mean values by 26% was registered in April. It is clearly seen in Fig. 2 that the lack of UV radiation correlates with the lack of sunshine duration. It is caused by increased cloud cover reducing the solar radiation that reaches the Earth's surface. The lack of solar radiation and the sunshine duration greater than the mean value was observed during March 2007. Such a situation was caused by long-range transport of biomass burning products from western Ukraine and eastern Russia (Pietruczuk and Chaikovsky 2008). Smoke aerosol from fires in this region was transported over Central and East Europe reducing solar radiation. This kind of aerosol effectively scatters UV radiation because of its microphysical structure in which the fine mode is dominant.

Mean UV indexes for each month of 2007 and standard deviation as well as extreme values are shown in Fig. 3. The largest values of UV index were registered during summer season, which are obviously connected with small solar zenith angles. However, large UV indexes were measured in May 2007. The largest value (7.2) was registered on 9 July 2007.

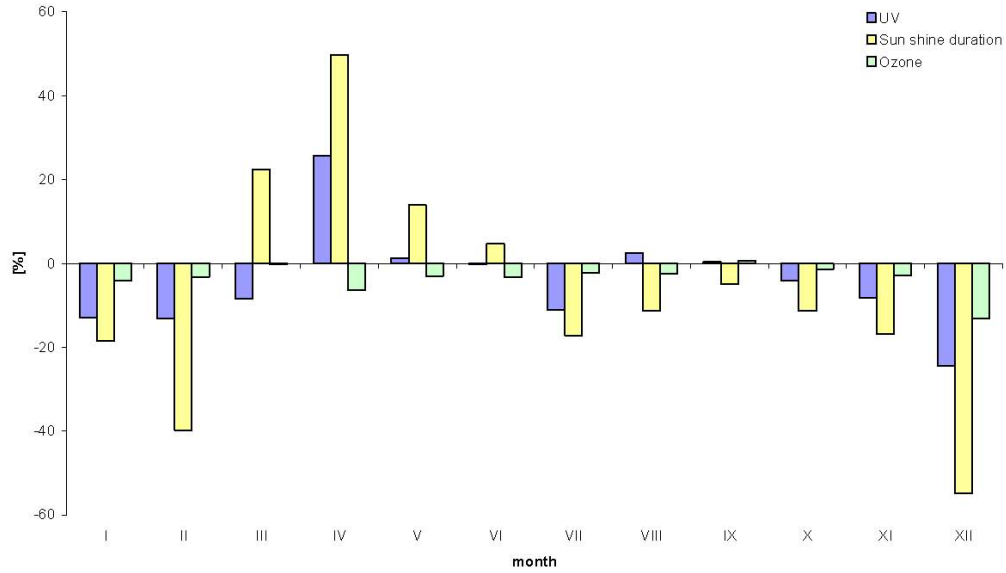


Fig. 2. Differences between long-term mean and monthly means of the UV radiation, sunshine duration and ozone concentration in 2007.

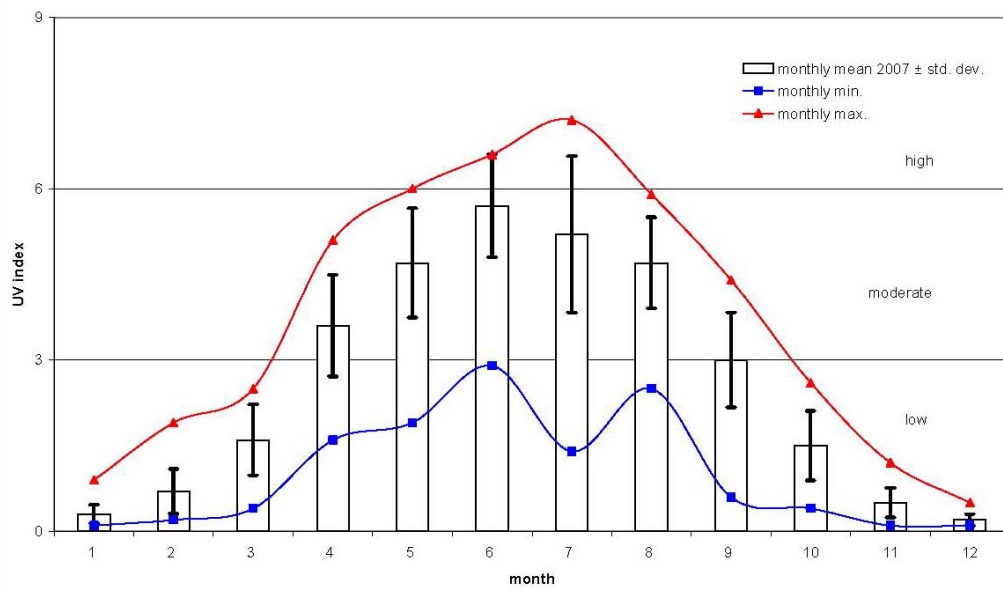


Fig. 3. Monthly mean of UV index and extreme values in 2007.

Figure 4 shows the number of days with UV index larger than 6.5, which is equivalent to 2.8 MED per hour. The number of days with high UV index, larger than

6.5, in June 2007 is smaller than in previous years although in July it is comparable with other years.

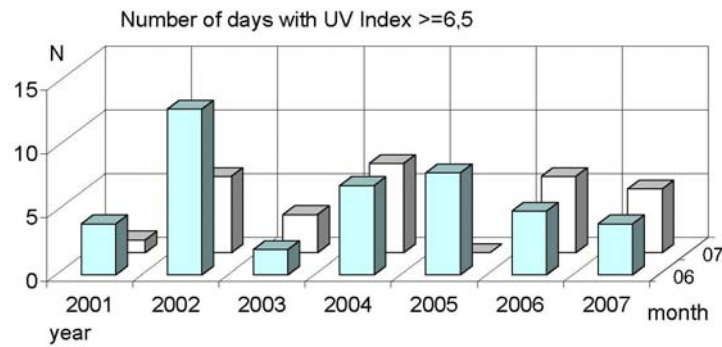


Fig. 4. Number of days with UV index larger than 6.5.

The Belsk ultraviolet radiation data for the years 2006 and 2007 are the last data printed in the year-book form. Data for next years will be available through the Internet at <http://www.igf.edu.pl/>.

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Table 1
Daily doses of UV-B and UV index, Belsk 2006

Month	I		II		III	
Day	UV-B [MED]	Index UV	UV-B [MED]	Index UV	UV-B [MED]	Index UV
1	0.3	0.2	0.6	0.4	2.7	1.3
2	0.3	0.2	0.5	0.3	2.6	1.3
3	0.3	0.2	0.6	0.6	2.9	1.4
4	0.2	0.2	0.9	0.6	2.2	1.2
5	0.3	0.2	1.4	0.8	3.0	1.5
6	0.3	0.2	1.2	0.6	2.7	1.5
7	1.0	0.5	0.6	0.4	3.6	1.6
8	1.1	0.6	0.6	0.4	3.4	1.6
9	1.0	0.5	1.1	0.6	3.8	1.7
10	1.0	0.5	1.0	0.5	2.5	1.2
11	0.8	0.4	1.4	0.9	2.6	1.5
12	0.4	0.3	0.8	0.4	4.2	1.9
13	0.4	0.2	0.9	0.5	4.1	1.9
14	0.5	0.3	1.3	0.8	2.8	1.5
15	0.8	0.4	1.3	1.0	4.3	2.2
16	1.1	0.6	0.8	0.6	1.6	0.8
17	0.5	0.3	1.3	0.8	2.3	1.2
18	0.4	0.3	2.4	1.2	2.3	1.2
19	0.9	0.5	1.4	0.9	3.9	2.5
20	1.2	0.6	2.5	1.5	7.4	4.2
21	0.3	0.1	1.1	0.9	4.8	2.8
22	1.2	0.6	0.6	0.3	4.5	2.2
23	1.3	0.6	2.5	1.2	7.0	3.1
24	1.4	0.8	2.6	1.4	7.9	3.3
25	1.3	0.8	3.6	1.7	6.5	3.0
26	1.2	0.6	2.0	1.3	2.3	1.3
27	1.3	0.6	3.1	1.4	5.9	3.7
28	1.2	0.8	2.8	1.3	5.8	3.1
29	0.8	0.4			2.5	1.4
30	0.9	0.5			4.6	3.0
31	0.6	0.3			2.8	1.5
Mean	0.78	0.4	1.46	0.8	3.85	2.0
Dev	26%		1%		11%	

Month	IV		V		VI	
Day	UV-B [MED]	Index UV	UV-B [MED]	Index UV	UV-B [MED]	Index UV
1	3.9	2.9	9.1	4.2	10.2	5.2
2	5.3	3.2	7.1	2.6	11.7	5.4
3	5.0	3.0	10.2	4.4	9.5	4.2
4	3.2	2.0	10.8	4.0	7.2	5.0
5	4.6	2.5	6.9	2.5	8.5	5.3
6	5.2	2.8	7.2	3.1	14.2	6.3
7	6.9	2.9	7.9	3.2	12.7	5.9
8	6.3	2.6	9.1	3.9	15.2	5.8
9	5.3	2.7	13.6	5.1	12.1	5.6
10	1.5	0.8	11.5	5.1	14.5	6.5
11	2.4	1.2	11.4	5.0	17.8	6.7
12	5.9	3.1	11.9	4.8	16.1	6.7
13	5.2	2.6	12.4	4.7	18.5	6.3
14	5.1	3.7	8.6	5.2	15.0	6.5
15	4.5	2.0	14.0	5.4	14.7	5.9
16	5.2	3.8	8.0	4.6	16.8	5.8
17	5.5	3.6	8.8	4.7	8.0	3.7
18	6.5	3.9	11.2	5.8	11.1	5.7
19	9.1	4.0	11.7	5.6	14.6	6.0
20	8.3	3.7	11.5	5.6	18.2	6.1
21	10.1	4.0	6.5	3.7	16.3	5.8
22	6.8	3.0	17.3	6.5	12.8	6.1
23	8.0	3.2	12.3	6.0	14.3	6.7
24	6.8	3.3	10.9	5.1	16.8	6.1
25	8.6	3.4	10.4	5.3	18.1	6.1
26	10.0	3.9	8.3	5.0	16.9	6.0
27	11.3	4.3	9.9	5.1	17.7	6.3
28	8.3	3.3	6.6	4.6	15.8	6.1
29	3.7	2.3	8.0	5.3	14.9	6.2
30	4.6	2.7	8.8	5.1	14.2	5.4
31			8.6	3.7		
Mean	6.10	3.0	10.02	4.7	14.15	5.8
Dev	-4%		-8%		12%	

Month	VII		VIII		IX	
Day	UV-B [MED]	Index UV	UV-B [MED]	Index UV	UV-B [MED]	Index UV
1	16.5	6.8	5.6	3.2	5.7	3.2
2	19.5	6.7	8.3	4.2	9.1	4.3
3	19.4	6.6	12.5	5.3	5.4	2.7
4	18.8	6.7	3.1	1.3	7.9	5.0
5	17.2	5.9	9.7	5.6	5.2	3.9
6	17.4	6.1	5.4	3.1	9.8	4.8
7	16.6	5.8	11.2	5.5	9.8	4.4
8	16.1	5.7	9.8	5.3	6.9	4.4
9	13.0	5.3	7.3	5.9	8.4	4.0
10	15.0	5.4	6.5	4.2	8.5	4.1
11	14.0	5.4	7.5	3.1	8.8	3.9
12	15.3	5.9	11.1	5.0	8.3	3.6
13	13.7	6.1	5.6	4.6	8.4	3.6
14	5.0	2.6	4.2	2.0	8.2	3.4
15	13.6	5.8	10.0	5.0	7.9	3.3
16	17.0	6.3	12.3	5.1	7.9	3.4
17	17.9	6.1	12.5	5.1	7.9	3.3
18	15.9	6.5	7.0	4.7	7.4	3.2
19	16.7	6.5	9.5	5.3	5.8	3.0
20	17.1	6.1	6.7	3.1	4.8	2.9
21	12.8	5.0	10.8	5.2	7.5	3.4
22	13.5	5.5	9.1	5.1	7.0	3.2
23	14.6	5.7	7.6	4.8	6.8	2.9
24	15.4	5.7	8.1	4.0	6.0	2.7
25	15.3	5.8	9.8	4.2	5.9	2.6
26	14.1	5.7	8.3	4.0	6.0	2.6
27	16.1	5.8	9.4	4.4	6.0	2.7
28	16.7	5.9	6.7	4.3	3.3	2.3
29	13.3	5.7	3.6	1.8	5.5	2.6
30	11.7	5.3	2.2	1.2	6.5	2.9
31	14.9	5.6	7.2	4.3		
Mean	15.29	5.8	8.02	4.2	7.09	3.4
Dev	24%		-19%		24%	

Month	X		XI		XII	
Day	UV-B [MED]	Index UV	UV-B [MED]	Index UV	UV-B [MED]	Index UV
1	4.4	2.7	1.3	1.1	0.9	0.5
2	3.6	1.5	0.8	0.5	0.9	0.5
3	3.2	1.7	1.3	0.8	0.9	0.4
4	2.0	1.3	0.5	0.4	0.5	0.3
5	2.8	1.9	0.5	0.3	0.4	0.3
6	5.1	2.5	0.5	0.3	0.9	0.5
7	4.2	2.3	1.0	0.5	0.3	0.2
8	4.5	2.5	1.4	0.9	0.6	0.3
9	2.9	1.4	0.8	0.8	0.6	0.4
10	4.4	2.0	1.1	0.6	0.1	0.1
11	4.3	2.2	0.8	0.5	0.4	0.3
12	3.4	1.7	0.8	0.6	0.2	0.1
13	3.0	1.5	0.8	0.5	0.2	0.2
14	0.8	0.4	0.8	0.5	0.4	0.3
15	2.0	1.5	0.4	0.3	0.9	0.5
16	2.6	1.5	1.3	0.6	0.8	0.4
17	2.7	1.5	1.2	0.6	0.4	0.3
18	3.8	1.8	1.1	0.6	0.3	0.3
19	3.6	1.7	0.4	0.3	0.3	0.1
20	3.1	1.5	0.8	0.5	0.1	0.1
21	3.0	1.5	0.5	0.3	0.5	0.3
22	3.1	1.6	0.8	0.4	0.1	0.1
23	1.9	1.1	0.6	0.6	0.2	0.2
24	1.8	1.5	0.6	0.4	0.2	0.1
25	1.2	1.0	1.1	0.6	0.6	0.4
26	3.0	1.5	1.0	0.5	0.6	0.3
27	2.7	1.4	1.0	0.5	0.2	0.2
28	2.7	1.5	0.5	0.3	0.3	0.2
29	0.6	0.5	0.5	0.3	0.3	0.2
30	2.4	1.2	0.4	0.4	0.6	0.4
31	2.0	1.2			0.5	0.4
Mean	2.93	1.6	0.82	0.5	0.46	0.3
Dev	9%		-4%		12%	

Table 2
Daily doses of UV-B and UV index, Belsk 2007

Month	I		II		III	
Day	UV-B [MED]	UV Index	UV-B [MED]	UV Index	UV-B [MED]	UV Index
1	0.3	0.3	0.6	0.5	1.8	1.5
2	0.4	0.3	1.2	0.6	1.9	1.2
3	0.2	0.1	0.6	0.5	1.3	1.1
4	0.2	0.2	1.4	0.8	0.5	0.5
5	0.2	0.2	1.1	0.6	3.0	1.5
6	0.2	0.1	0.5	0.4	2.7	1.5
7	0.1	0.1	1.0	0.5	3.4	1.6
8	0.6	0.3	0.4	0.3	2.2	1.3
9	0.6	0.4	1.0	0.6	1.9	1.6
10	0.3	0.2	1.4	0.9	3.3	1.7
11	0.4	0.3	1.3	0.6	2.8	2.0
12	0.2	0.2	0.9	0.4	5.3	2.4
13	0.6	0.4	0.8	0.5	5.1	2.3
14	0.4	0.4	0.6	0.4	3.8	1.7
15	0.5	0.3	0.9	0.5	3.4	1.9
16	0.6	0.4	1.0	0.5	3.9	2.3
17	0.6	0.4	1.6	0.9	1.1	0.6
18	0.3	0.2	1.9	1.0	1.9	1.5
19	0.4	0.3	0.4	0.3	2.5	1.4
20	0.6	0.4	1.0	0.4	0.9	0.6
21	0.9	0.5	2.5	1.3	0.8	0.6
22	0.6	0.4	0.5	0.2	2.5	1.8
23	0.8	0.5	4.1	1.9	0.8	0.4
24	0.4	0.2	2.7	1.3	4.8	2.0
25	0.8	0.4	2.0	1.1	5.2	2.3
26	1.5	0.9	1.2	0.8	5.3	2.3
27	0.8	0.5	1.5	1.5	5.7	2.5
28	0.8	0.4	1.0	0.6	5.1	2.3
29	1.1	0.6			5.7	2.5
30	0.8	0.5			4.7	1.9
31	0.4	0.3			5.3	2.2
Mean	0.54	0.3	1.25	0.7	3.18	1.6
Dev	-13%		-13%		-8%	

Month	IV		V		VI	
Day	UV-B [MED]	UV Index	UV-B [MED]	UV Index	UV-B [MED]	UV Index
1	4.2	1.8	8.1	3.8	10.4	5.0
2	6.1	2.8	12.5	4.6	4.1	2.9
3	5.5	2.6	13.7	5.0	5.7	5.6
4	6.6	3.2	13.2	4.8	5.7	3.8
5	7.7	3.8	12.3	4.8	10.7	6.6
6	4.6	3.3	3.0	1.9	15.4	6.0
7	3.0	1.9	9.6	4.4	17.5	6.2
8	5.2	3.7	7.1	4.6	16.9	6.1
9	2.5	1.6	8.1	5.0	11.4	5.5
10	2.7	1.7	6.2	3.2	10.3	5.8
11	8.8	3.9	9.5	5.0	17.8	6.2
12	10.3	4.1	9.6	5.0	17.0	5.8
13	10.2	4.0	13.6	5.6	11.8	5.3
14	10.7	4.2	13.3	5.0	14.9	5.4
15	10.1	4.0	11.3	5.3	13.9	5.6
16	9.8	3.9	4.0	2.7	12.3	5.7
17	9.7	3.8	8.9	4.7	16.7	6.2
18	6.0	4.0	10.7	5.0	9.3	5.6
19	8.4	4.3	14.0	4.8	12.2	5.8
20	8.6	3.7	14.0	5.2	16.6	6.2
21	9.7	3.9	12.3	4.4	17.0	6.2
22	10.8	4.1	12.1	4.7	5.1	3.1
23	9.6	4.1	13.9	5.1	12.2	6.5
24	5.4	2.6	16.9	6.0	16.3	6.5
25	11.0	4.2	15.9	5.8	15.9	6.3
26	10.8	4.2	10.2	5.3	9.0	5.9
27	11.1	4.3	12.7	5.2	14.2	6.6
28	10.2	4.2	15.5	5.8	13.2	5.9
29	10.9	4.5	16.1	5.9	13.3	6.3
30	9.9	5.1	7.4	3.1	12.5	6.1
31			4.7	3.1		
Mean	8.00	3.6	10.98	4.7	12.64	5.7
Dev	26%		1%		0%	

Month	VII		VIII		IX	
Day	UV-B [MED]	UV Index	UV-B [MED]	UV Index	UV-B [MED]	UV Index
1	14.3	6.2	13.5	5.6	6.2	4.0
2	15.2	5.9	15.2	5.6	7.7	4.4
3	10.4	6.5	5.6	3.6	7.1	3.4
4	4.0	2.4	9.1	4.1	4.8	2.2
5	7.0	3.8	8.3	3.9	1.3	0.6
6	2.4	1.4	9.4	4.7	4.1	2.4
7	5.9	4.7	13.6	5.3	3.4	2.5
8	12.6	6.5	11.4	5.5	9.3	4.1
9	16.5	7.2	4.8	2.5	4.2	4.1
10	3.9	2.6	6.0	4.3	5.1	3.2
11	8.4	3.9	8.3	5.4	4.6	3.3
12	9.1	3.8	8.9	4.7	5.8	3.7
13	8.9	5.3	5.8	3.2	7.0	3.7
14	12.4	6.0	12.4	5.5	8.3	3.8
15	16.6	5.8	12.5	5.3	5.8	3.1
16	18.0	6.5	14.7	5.9	6.3	2.9
17	18.0	6.3	11.6	5.1	8.8	3.8
18	5.9	3.4	11.8	5.1	6.9	3.1
19	17.2	6.7	11.5	4.6	6.0	3.4
20	17.7	6.3	8.2	4.5	6.9	3.3
21	11.3	5.9	9.7	5.2	7.3	3.2
22	11.6	5.8	10.4	5.4	7.2	3.1
23	15.5	5.7	11.3	5.2	6.3	2.9
24	10.0	5.4	11.1	5.3	6.8	3.0
25	5.0	4.7	10.4	4.5	6.3	2.7
26	16.1	6.3	11.0	5.2	1.7	0.9
27	11.2	5.7	10.1	4.8	5.1	2.6
28	12.8	5.4	10.4	4.6	3.9	2.6
29	13.3	5.9	9.3	4.3	5.4	2.5
30	5.7	4.4	9.0	4.6	4.4	2.4
31	6.7	5.0	5.5	3.0		
Mean	11.08	5.2	10.03	4.7	5.80	3.0
Dev	-11%		2%		0%	

Month	X		XI		XII	
Day	UV-B [MED]	UV Index	UV-B [MED]	UV Index	UV-B [MED]	UV Index
1	5.5	2.6	1.3	0.9	0.8	0.5
2	2.8	1.8	1.5	1.2	0.5	0.4
3	3.3	2.3	1.5	1.2	0.2	0.2
4	3.6	1.8	1.2	0.9	0.2	0.2
5	3.1	2.3	1.0	0.5	0.3	0.2
6	2.9	2.4	1.0	0.5	0.3	0.3
7	3.6	2.2	0.8	0.8	0.3	0.2
8	2.7	1.6	0.5	0.3	0.5	0.3
9	4.4	2.4	0.3	0.3	0.3	0.2
10	4.4	2.2	0.8	0.5	0.2	0.1
11	3.6	2.0	1.0	0.5	0.1	0.1
12	1.0	0.9	0.5	0.3	0.1	0.1
13	2.6	1.7	0.4	0.5	0.5	0.3
14	3.9	2.0	0.6	0.4	0.2	0.2
15	4.1	1.9	0.8	0.5	0.2	0.2
16	3.7	1.8	1.0	0.5	0.3	0.3
17	3.3	1.6	0.8	0.4	0.3	0.2
18	1.6	1.4	0.6	0.5	0.2	0.1
19	1.1	0.8	0.5	0.3	0.2	0.2
20	2.0	1.4	0.8	0.4	0.1	0.1
21	2.9	1.4	0.9	0.5	0.2	0.1
22	1.5	1.1	1.0	0.5	0.6	0.4
23	0.8	0.4	1.0	0.5	0.5	0.3
24	2.4	1.3	0.3	0.2	0.1	0.1
25	1.0	0.5	0.3	0.3	0.1	0.1
26	1.3	0.9	0.3	0.1	0.4	0.3
27	1.9	1.2	0.3	0.2	0.3	0.2
28	0.9	0.5	1.1	0.6	0.5	0.3
29	1.8	1.2	1.0	0.5	0.6	0.3
30	1.1	0.8	0.2	0.2	0.3	0.2
31	1.6	1.2			0.3	0.3
Mean	2.59	1.5	0.78	0.5	0.31	0.2
Dev	-4%		-8%		-24%	

Table 3

Mean daily values for each month in 2006

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	UV-B	UV-B	UV-B	Index	G	G/Go	US	OZON	UV-B/G	UV-B	d [%]
2006:	[MED]	[MED]	[MED]	UV	[MJ/m ²]		[HOUR]	[D]		76-05	
M	mean	min.	max.	mean	mean	mean	mean	mean	mean	mean	
1	0.78	0.2	1.4	0.4	3.18	0.38	1.7	305	0.25	0.62	26
2	1.46	0.5	3.6	0.8	5.29	0.38	1.7	386	0.28	1.44	1
3	3.85	1.6	7.9	2.0	10.43	0.49	3.2	386	0.37	3.46	11
4	6.10	1.5	11.3	3.0	14.49	0.47	5.1	389	0.42	6.38	-4
5	10.02	6.5	17.3	4.7	19.63	0.52	6.9	363	0.51	10.87	-8
6	14.15	7.2	18.5	5.8	23.48	0.57	9.0	336	0.60	12.61	12
7	15.29	5.0	19.5	5.8	25.65	0.64	11.9	317	0.60	12.38	24
8	8.02	2.2	12.5	4.2	13.57	0.40	4.5	325	0.59	9.85	-19
9	7.09	3.3	9.8	3.4	14.14	0.56	6.9	281	0.50	5.73	24
10	2.93	0.6	5.1	1.6	7.04	0.43	3.5	264	0.42	2.69	9
11	0.82	0.4	1.4	0.5	2.87	0.30	1.4	282	0.29	0.85	-4
12	0.46	0.1	0.9	0.3	2.04	0.30	1.3	260	0.23	0.41	12

Table 4

Mean daily values for each month in 2007

	UV-B	UV-B	UV-B	UV	SSD	OZONE	UV-B	Diff. [%]
				Index			1976-06	
2007:	[MED]	[MED]	[MED]		[HOUR]	[D]	[MED]	
M	mean	min.	max.	mean	mean	mean	mean	
1	0.54	0.1	1.5	0.3	1.2	324	0.62	-13
2	1.25	0.4	4.1	0.7	1.3	361	1.44	-13
3	3.18	0.5	5.7	1.6	4.3	381	3.47	-8
4	8.00	2.5	11.1	3.6	7.8	360	6.37	26
5	10.98	3.0	16.9	4.7	8.2	356	10.84	1
6	12.64	4.1	17.8	5.7	8.1	342	12.66	0
7	11.08	2.4	18.0	5.2	6.4	332	12.47	-11
8	10.03	4.8	15.2	4.7	6.4	311	9.79	2
9	5.80	1.3	9.3	3.0	4.6	301	5.78	0
10	2.59	0.8	5.5	1.5	3.0	284	2.70	-4
11	0.78	0.2	1.5	0.5	1.2	283	0.85	-8
12	0.31	0.1	0.8	0.2	0.4	272	0.41	-24

Global Solar Radiation and Direct Aerosol Forcing at Belsk, Poland

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Abstract

A comparison of global solar radiation fluxes at the bottom of the atmosphere and Direct Aerosol Radiative Forcing (DARF) values determined by two different methods is presented. Analysis of data covers the period from 2002 to 2005. Global solar radiation fluxes and DARF obtained at the Geophysical Observatory at Belsk by means of CM11 pyranometer are compared with fluxes and DARF calculated for Belsk AERONET station by radiation transfer model. Aerosol microphysical properties retrieved from almucantar measurements taken by Cimel CE318A Sun-sky scanning radiometer are used in the radiation transfer model. The analysis of fluxes of global solar radiation at the bottom of the atmosphere indicates that the average difference between data taken by the two methods is about 2%. Besides, 95% of cases are within 10% interval of differences, and 84% of cases are within 5%. In the case of DARF, the agreement of results taken by the two methods is much worse. The average percentage difference between DARF values calculated on the basis of measurements taken by the two methods is about 20%. Besides, only 20% of cases are within 10% interval of differences and 29% of cases are within 20%. In both cases, values obtained from pyranometric measurements are lower than the values from radiometric measurements.

1. Introduction

Aerosol particles have been recognized recently as one of the more important factors forming climate of the Earth. They modify the radiation balance of the Earth-atmosphere system directly, reflecting and absorbing solar radiation (Charlson *et al.* 1987, Ackerman 2000) as well as the Earth thermal (infrared) radiation (Vogelmann

et al. 2003). Aerosols affect climate also acting as condensation nuclei in the process of clouds formation (Twomey 1959) which have a large influence on planetary albedo. Influence of aerosols on the Earth's climate is commonly described by Aerosol Radiative Forcing parameter which is a difference between fluxes of solar radiation with and without the presence of aerosol in a column of the atmosphere.

The goal of this study was to make a comparison of solar radiation at the ground and Direct Aerosol Radiative Forcing (DARF) measured directly by pyranometer and calculated from radiative transfer model and aerosol microphysical parameters. Measurements were performed in the Geophysical Observatory at Belsk, Poland.

2. Site Description and Instrumentation

Geophysical Observatory at Belsk (51°50'N, 20°47'E) is located in central Poland about 50 km south of Warsaw, the nearest big city. The distance to the nearest industrial region (Silesia) exceeds 200 km (south-west direction). Therefore, the observatory may be considered as a background station.

The downward global radiant flux, in the spectral range from 300 to 2800 nm, was measured by the Kipp and Zonen pyranometer CM11. The data averaged over 5-minute time intervals were used in this study. Aerosol microphysical and optical properties were evaluated from measurements made by collocated CIMEL Sun-sky radiometer, which is part of AERONET network (Holben *et al.* 1998). We used level 2.0 of version 2 inversion products (Version 2 Inversion Products Description, <http://aeronet.gsfc.nasa.gov/>). Version 2 of AERONET inversion product contains aerosol microphysical properties and radiative fluxes at the top and bottom of the atmosphere, as well as direct aerosol radiative forcing values. Those solar radiation fluxes were calculated on the basis of aerosol microphysical properties derived from the direct and diffuse radiation measured by CIMEL radiometer and radiative transfer model (Dubovik and King 2000).

The direct Aerosol Radiative Forcing (according to AERONET) is defined by:

$$\Delta F = F_{A\downarrow}^p - F_{0\downarrow}^r \quad (1)$$

where ΔF is the DARF [W/m^2], $F_{A\downarrow}^p$ is the value of downwelling solar flux [W/m^2] in case of aerosol presence, and $F_{0\downarrow}^r$ is the value of downwelling solar flux [W/m^2] for the aerosol-free case. The solar flux for aerosol-free case was taken from AERONET inversions. Flux in the case of aerosol presence was directly measured by pyranometer or taken from AERONET inversions.

3. Results and Discussion

3.1 Downwelling flux

A comparison of solar flux at the bottom of the atmosphere measured by means of a pyranometer and that computed from CIMEL measurements is shown in Fig. 1. The presented data set contains 792 pairs of measurements collected from 01 May 2002 to 28 January 2006. The number of data pairs is limited by the number of CIMEL almucantar scans.

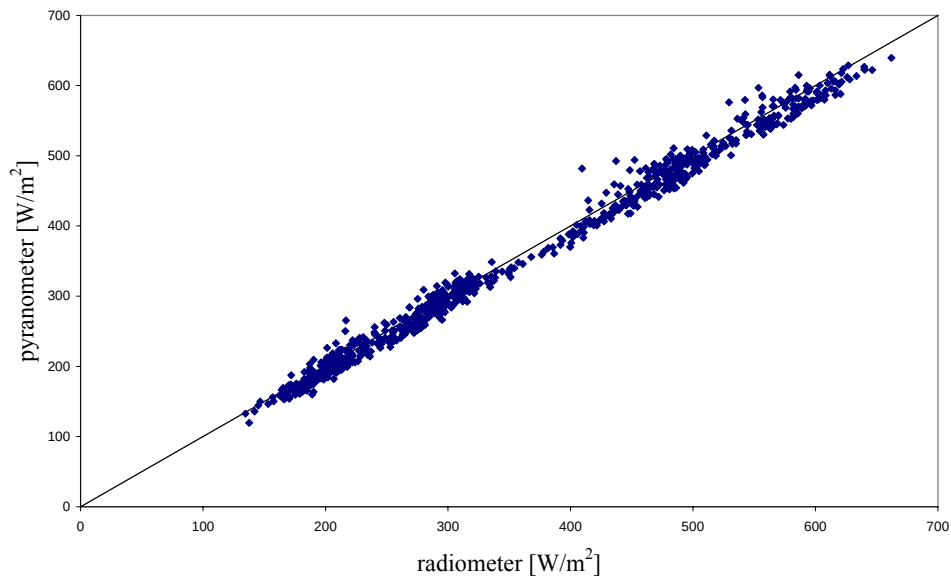


Fig. 1. Scatter plot of solar fluxes at the bottom of the atmosphere measured by pyranometer and derived from CIMEL almucantar inversions.

Table 1 presents squares of correlation coefficients and slopes of regression lines for the whole set of data and for the data taken at successive years. The presented values of slopes indicate that the values of downwelling solar fluxes measured by pyranometer are mostly less than those calculated from almucantar retrievals and provided by AERONET team. The largest differences are observed in 2002.

Table 1

Slopes and correlation coefficients

Year	2002-2005	2002	2003	2004	2005
Slope	0.9864	0.9620	0.9990	0.9915	0.9923
Square of correlation coefficient	0.9918	0.9958	0.9705	0.9926	0.9916

Table 2 presents values of average percentage differences between analyzed total solar fluxes and their standard deviations for the successive years of the analyzed period. The difference within the whole analyzed period is 2% with 4% standard deviation.

Table 2
Differences between the analyzed total solar fluxes

Year	2002	2003	2004	2005
Average percentage difference	2.9%	4.7%	0.9%	2.0%
Standard deviation of differences	3.5%	4.4%	4.0%	4.1%

3.2 Direct aerosol radiative forcing

Comparison of direct aerosol radiative forcing at the bottom of the atmosphere taken from measurements and calculations based on almucantar retrievals for the whole period is shown in Fig. 2. Regression line fitted to the pairs of points in this figure has a slope of -0.90 and a square of correlation coefficient is 0.63 . So, the DARF values measured by means of pyranometric method are smaller on the average than those retrieved from almucantar scans.

The average value of DARF for Belsk obtained by means of pyranometric method is -37.3 W/m^2 , while that calculated from AERONET retrievals is 30.5 W/m^2 . The difference in absolute values of these averages expressed in percentage is about 20%. The square of correlation coefficient value of 0.63 indicates correlation between the two parameters but it is much weaker than in the case of solar fluxes.

Figure 3 presents differences in DARF values obtained by means of the two methods as a function of DARF taken by means of radiometric method. The largest differences occur for the smallest values of DARF where errors of solar fluxes measurements are largest.

4. Summary

In the case of solar radiant flux, the agreement of results obtained by pyranometer and radiometer is quite good. The average difference of 2% which reveals during the data analysis lies within the range of errors connected only with the pyranometer used for measurements. The accuracy of data calculated from radiometric measurements is difficult to estimate. In particular, relatively high errors may occur in situations of low aerosol optical depths, high solar zenith angles or a decrease of angular coverage of scattering in the sky radiance (Dubovik *et al.* 2000).

In the case of DARF, the discrepancy of results obtained by the two methods is much higher. The agreement is better for the values of DARF larger than 60 W/m^2 .

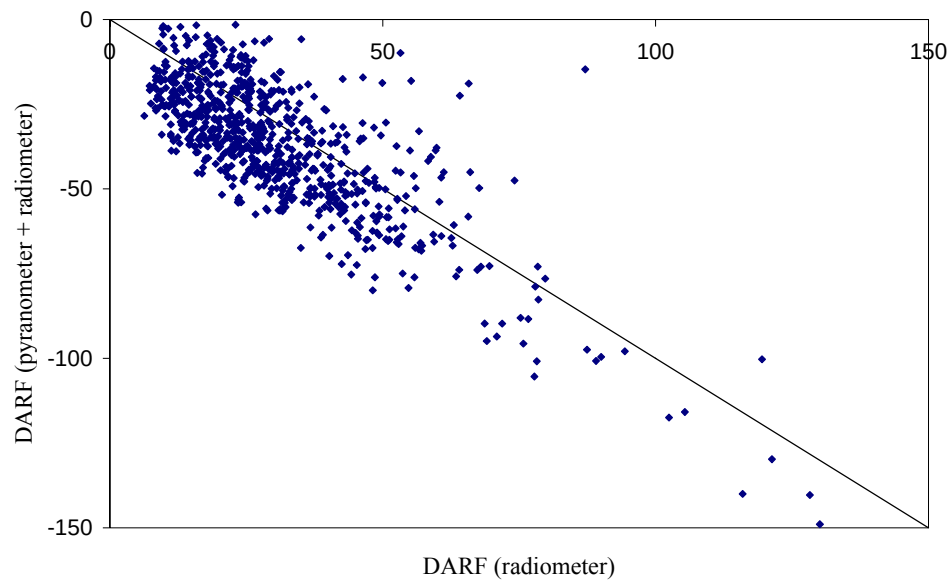


Fig. 2. Comparison of DARF values at the bottom of the atmosphere derived from almucantar retrievals and pyranometric measurements.

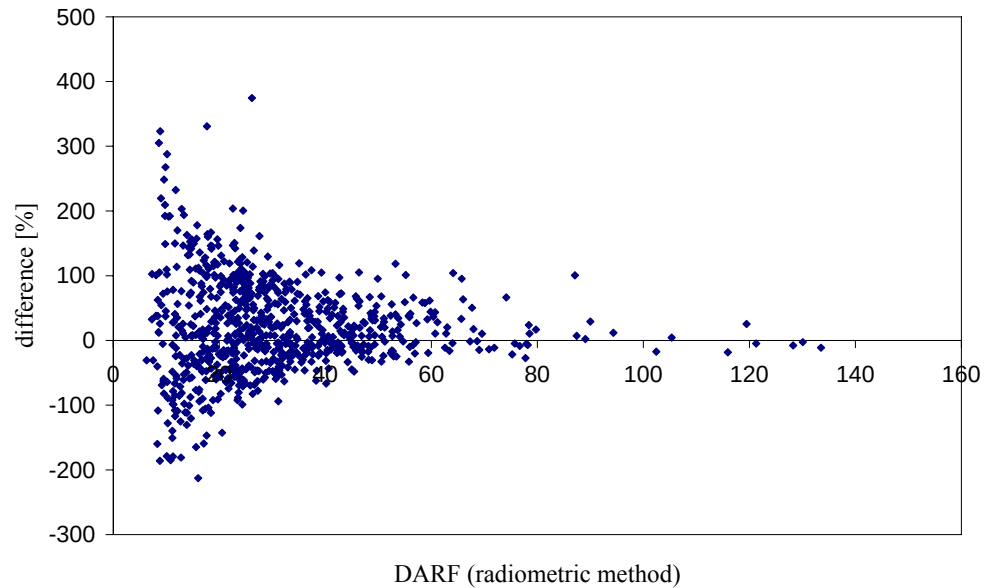


Fig. 3. Differences of DARF values obtained by the two methods as a function of DARF obtained by radiometric method.

5. Acknowledgment

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Lidar Observations of Stratospheric Aerosol over Belsk Geophysical Observatory in 1996-2006

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Abstract

Results of over 10 years of lidar measurements of stratospheric aerosol at 532 nm wavelength have been analysed. Averaged stratospheric aerosol optical depths and selected profiles of scattering ratio versus altitude are presented. Their analysis in relation to historical results of several authors in the sixties, seventies and eighties of the last century is made. It has been found that in the years 1996-2006 the stratosphere underwent a cleaning process, manifesting itself by decreasing aerosol optical depth, down to a level of about 0.002, that is, to the aerosol background level typical of the period before the Pinatubo eruption in 1991.

1. Introduction

The presence of aerosol in the stratosphere was postulated for the first time in 1927 by Gruner and Kleinert (1927). This postulate was confirmed experimentally by Junge (1961), Fiocco and Grams (1964), Grams and Fiocco (1967) as well as Castelman *et al.* (1973). The aerosol layer discovered at that time in the stratosphere, at an altitude of about 20 km, was named “Junge layer”. The main sources supplying aerosol to the stratosphere are the most powerful volcanic eruptions, which deliver volcanic ash, sulfur dioxide and water vapour to the altitudes above tropopause. Such powerful eruptions occur once per several years, and each time the aerosol level in the stratosphere rapidly increases after such an eruption, and then, after some alterations and falling out – reduces to a certain background level that remains stable until a next eruption. Lidar sampling makes it possible, under some assumptions, to determine

vertical profiles of aerosol scattering coefficients as well as aerosol optical depths of the stratosphere. On this basis it is possible, under some limitations, to estimate sizes of aerosol particles and their concentration.

2. Basic Formulas

A convenient form of presenting results of lidar sampling of the stratosphere is the use of a parameter called scattering ratio (SCR), which is a measure of the ratio of total to molecular scattering at fixed wavelength λ (Russel *et al.* 1976),

$$SCR(z) = \frac{\beta_2(z) + \beta_1(z)}{\beta_2(z)} = 1 + \frac{\beta_1(z)}{\beta_2(z)}$$

where $\beta_1(\lambda, z)$ [$\text{m}^{-1}\text{sr}^{-1}$] is the backscattering coefficient of aerosol, $\beta_2(\lambda, z)$ [$\text{m}^{-1}\text{sr}^{-1}$] is the backscattering coefficient of air molecules, z is the distance from a lidar.

The profile of backscattering coefficient in the stratosphere at a fixed wavelength can be determined from lidar signal profile $U(z)$ on the basis of the following formula (Puchalski 1999):

$$\beta_1(z) = \frac{U(z)\exp[A(z)]}{\frac{U(z_0)}{\beta_1(z_0) + \beta_2(z_0)} + 2S_1 \int_{z_0}^z U(r)\exp[A(r)]dr} - \beta_2(z)$$

where:

$$A(z) = 2(S_1 - S_2) \int_{z_0}^z \beta_2(r)dr$$

S_1 and S_2 are aerosol and air molecules lidar ratios, respectively, and z_0 is the distance to the upper boundary of the sampling layer. The profile of $\beta_2(\lambda, z)$ coefficient depends on the air density and can be determined from a model of the atmosphere, or a Raman lidar sampling. In this study, $\beta_2(\lambda, z)$ was determined from the standard model of the atmosphere (Bielenkii *et al.* 1987).

3. Optical Properties of Atmospheric Aerosol

Figure 1 shows a plot of maximum values of $\beta_1(z)/\beta_2(z) = SCR(z) - 1$ in the stratosphere at $\lambda_1 = 694.3$ nm as a function of time interval between Mt. Agung 1963 and Mt. Fuego 1974 volcano eruptions. The graph has been plotted on the basis of results of measurements collected from the literature (Russel *et al.* 1976).

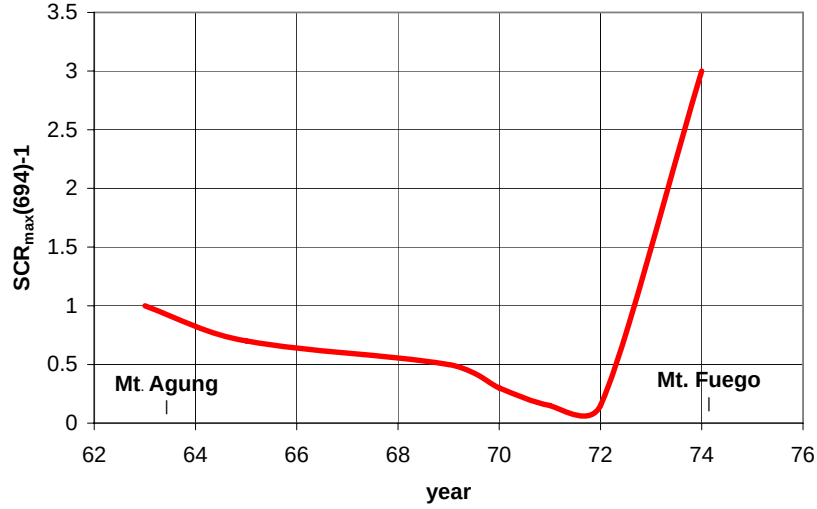


Fig. 1. A plot of $[\beta_1(z)/\beta_2(z)]_{\max} = \text{SCR}_{\max} - 1$ for the stratosphere at $\lambda_1 = 694.3$ nm between Mt. Agung and Mt. Fuego eruptions.

Figure 2 presents relations between scattering ratio $\text{SCR}(532)$ at $\lambda_2 = 532$ nm and atmospheric extinction, expressed by volume scattering coefficient $\alpha_1(532)$, for different altitudes H in the atmosphere. As can be seen, considerable differences of extinction coefficients may occur at different altitudes despite of the same value of SCR. So, the presentation of results of lidar sampling in the form of $\text{SCR}(H)$ reveals and exposes fine changes in aerosol extinction in the upper layers of the atmosphere and therefore is very suitable for investigation of the stratosphere.

Figure 3 presents plots of ratios of scattering ratios QSCR for the three most often used lidar wavelengths: $\lambda_1 = 694.3$ nm, $\lambda_2 = 532$ nm and $\lambda_3 = 1064$ nm as a function of $\text{SCR}(\lambda_2 = 532 \text{ nm})$, and for the three models of atmospheric aerosol (expressed by three values $(-1, 0, +1)$ of exponent m in Angstrom formula). These plots enable to estimate the dependence of SCR on wavelength, and then to link the results of sampling performed nowadays at 532 and 1064 nm with historical results performed mainly at 694.3 nm. As the stratospheric aerosol has features close to the specific aerosol (Table 1) (Valero *et al.* 1992), the differences between $\text{SCR}(\lambda_2 = 532 \text{ nm})$ and $\text{SCR}(\lambda_1 = 694.3 \text{ nm})$, as can be seen from Fig. 3, are not large and linking the results of sampling performed nowadays, mainly at λ_2 , with historical results performed at λ_1 is possible.

Identifying optical objects detected by lidar in the atmosphere, as shown by experience, is not a simple question (Puchalski 2006). Procedure of screening clouds and layers that are not aerosol requires detailed knowledge of physical and morphological properties of different optically active objects present in the atmosphere. In Table 1 characteristic values of optical objects investigated by lidar, set up on the

basis of results of investigations accessible in the literature and the authors' investigations (Puchalski 2006), are collected. This enables preliminary identification of these objects.

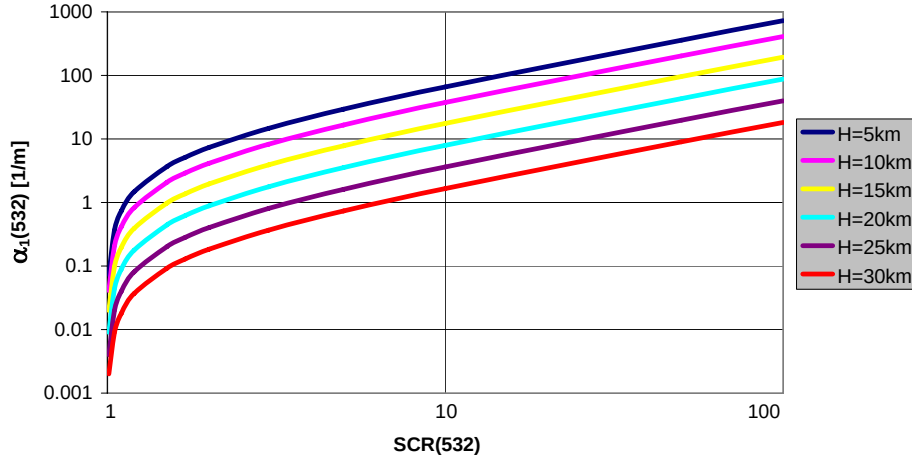


Fig. 2. Relation between atmospheric extinction, expressed by volume scattering coefficient of aerosol $\alpha_1(\lambda_2 = 532 \text{ nm})$, and $\text{SCR}(\lambda_2)$ for various altitudes H in the atmosphere.

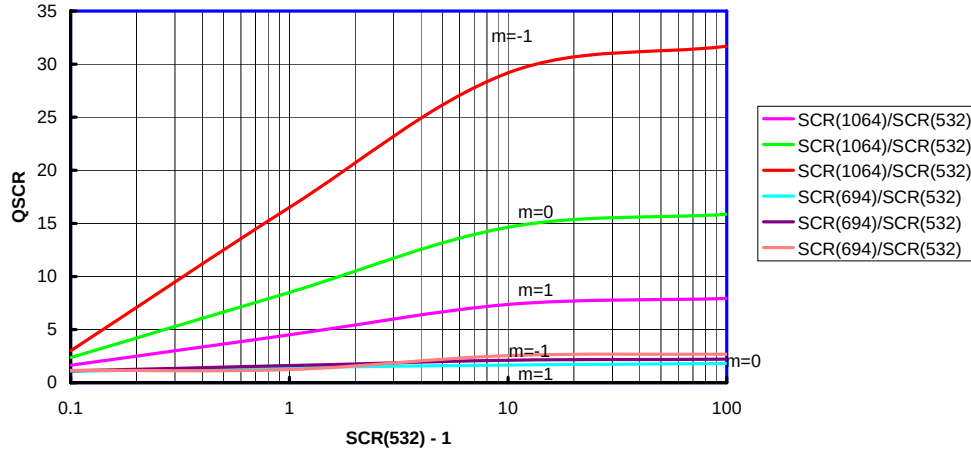


Fig. 3. Plots of dependences of scattering ratios QSCR on $\text{SCR}(\lambda_2 = 532 \text{ nm})$, for wavelengths most often used in lidar investigations of the stratosphere, and for three models of atmospheric aerosol expressed by exponents m in the Angstrom formula.

4. Lidar Observations at Belsk

Since 1996, lidar samplings of the stratosphere have been made at Belsk Geophysical Observatory with scheduled frequency of one sampling a month on the average. Prac-

Table 1

Typical features of optical objects in the atmosphere detected by lidar
at $\lambda_2 = 532$ nm (green channel) and $\lambda_3 = 1064$ nm (red channel)

Optical object	a	$m_{2,3}$	$\alpha_1(\lambda_2)$	$\tau(\lambda_2)$
1. Molecular background	< 1 nm	4.0	$< 10 \text{ m}^{-1}$	< 0.08
2. Aerosol background	0.5-5.0 μm	0	$< 50 \text{ m}^{-1}$	< 0.05
3. Continental aerosol	0.05-10 μm	1.3 ± 0.6	$0.05\text{-}0.5 \text{ km}^{-1}$	0.05-0.8
4. Marine aerosol	0.1-20 μm	0.5-1.0	$0.08\text{-}0.8 \text{ km}^{-1}$	0.05-0.7
5. Specific aerosol	0.7-1.5 μm	$-1.5\text{-}0.5$	$0.01\text{-}0.04 \text{ km}^{-1}$	0.01-0.04
6. Unformed clouds	0.5-5 μm	0.2-0.7	$0.2\text{-}0.8 \text{ km}^{-1}$	≤ 1
7. Formed clouds	5-40 μm	0	$5\text{-}100 \text{ km}^{-1}$	> 1

a = radius of aerosol particle, $m_{2,3}$ = Angstrom exponent, α_1 = aerosol extinction coefficient, τ = optical depth of the object.

tically, the frequency of measurements depends on weather conditions and technical abilities of lidar, which is a prototype device, currently subject to continuous improvement and development. For example, in 2004 there were no samplings of the stratosphere at all because of the instrument's reconstruction.

This study is based on results of lidar samplings of the stratosphere carried out in 1996-2007 at Belsk Geophysical Observatory by the Long Range Lidar (Puchalski 2003). 279 lidar profiles have been analyzed, and, after screening procedure (elimination of results which did not meet the required conditions as to the altitude range or signal quality), 140 profiles have been selected. These profiles were subject to further processing: conversion, integration and matching, which resulted in getting 80 profiles of SCR(H) for maximum attainable altitude range. At the same time, optical depths of 10 to 30 km altitude range layers were determined for each of these 80 profiles. Values of SCR(H) were calculated for a sample of 400 m depth and were obtained by averaging in the range of altitude $H = \pm 200$ m.

Figure 4 presents annually averaged aerosol optical depths of the stratosphere for the successive years of the analysed period.

The values in the years 2005-2006 ($\text{AOD} > 0.010$) can be considered as large, taking into account the lack of giant volcano eruptions since 1991 ("post Pinatubo" period), and, on the other hand, the values obtained in 2001, 2002 and 2003 confirm that the stratosphere after the Pinatubo eruption had already come to the state of aerosol background level with optical depth of about 0.002-0.003. This may be a real effect, but also a result of a little number of lidar samplings made last years. It should be assumed that aerosol in the stratosphere is not distributed uniformly. There are thin aerosol clouds present in the aerosol background, which, while moving in the stratosphere, can be observed as an increased level of aerosol while present in the field of view of lidar. This may result in increased value of averaged optical depths of the stratosphere if the number of samplings is too little.

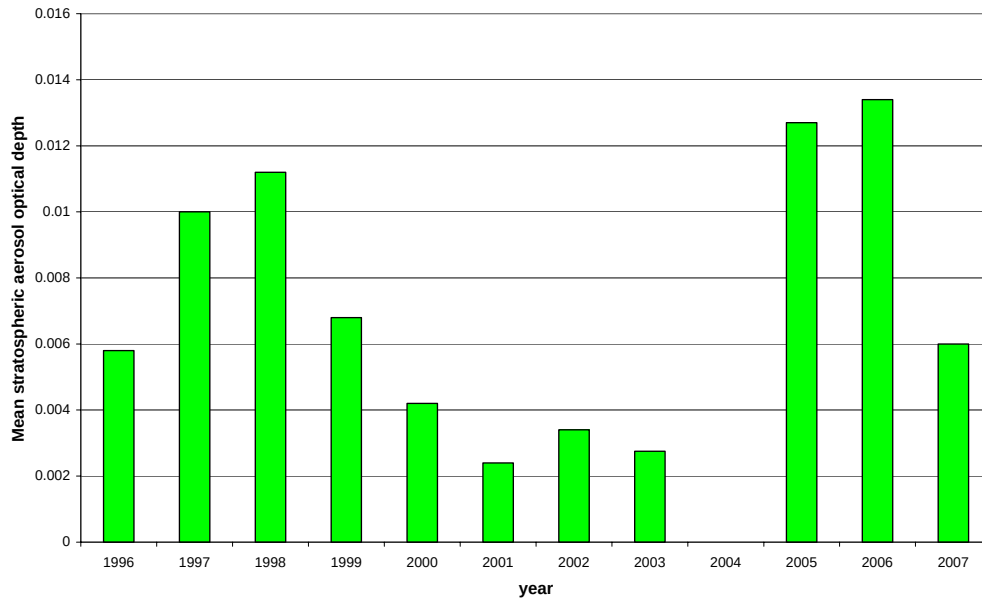


Fig. 4. Annually averaged optical depths of the stratosphere determined from lidar samplings carried out at Belsk in 1996-2007 at 532 nm wavelength.

During the last several years, the maximum optical depth of the stratosphere was observed in 1992, about a year after the Pinatubo eruption on the Philippines (Ans-mann 1994). That time, the optical depth of the stratosphere at 532 nm reached 0.120 over Europe (Jager *et al.* 1994), and 0.060 over Japan (Shibata *et al.* 1994), while over Hawaii it was 0.200 (Barnes *et al.* 1994). An analysis of historical data indicates that the level of aerosol background in the stratosphere for periods preceding big volcano eruptions, expressed in optical depth, was of the order of 0.002-0.003. Before the El Chichon eruption (1982) it got a value of 0.0024, while before the Pinatubo eruption (1991) it was 0.003 (Barnes *et al.* 1994). Historical data obtained for the undisturbed stratosphere in the sixties and seventies of the preceding century indicate that, on the average, the aerosol level at altitudes of 30-35 km is very low ($SCR < 1.05$), then increases with lowering the altitude to about 20 km ($SCR = 1.15-1.5$), and decreases towards the tropopause ($SCR = 1.1-1.3$) (Russell *et al.* 1976).

Analysis of 80 vertical profiles of $SCR(H)$ for the stratosphere leads to the conclusion that data obtained for Belsk are in agreement with historical data. Values of $SCR(20 \text{ km})$ obtained for all typical profiles are within the range from 1.05 to 1.50, the aerosol background for the stratosphere expressed in SCR values is of the order of 1.05-1.15, while expressed in optical depth is of the order of 0.002-0.003.

Figure 5 shows typical profiles of $SCR(H)$ for the stratosphere undisturbed and loaded with a great amount of aerosol. Profiles dated 18.01.2001, 13.05.2001 and

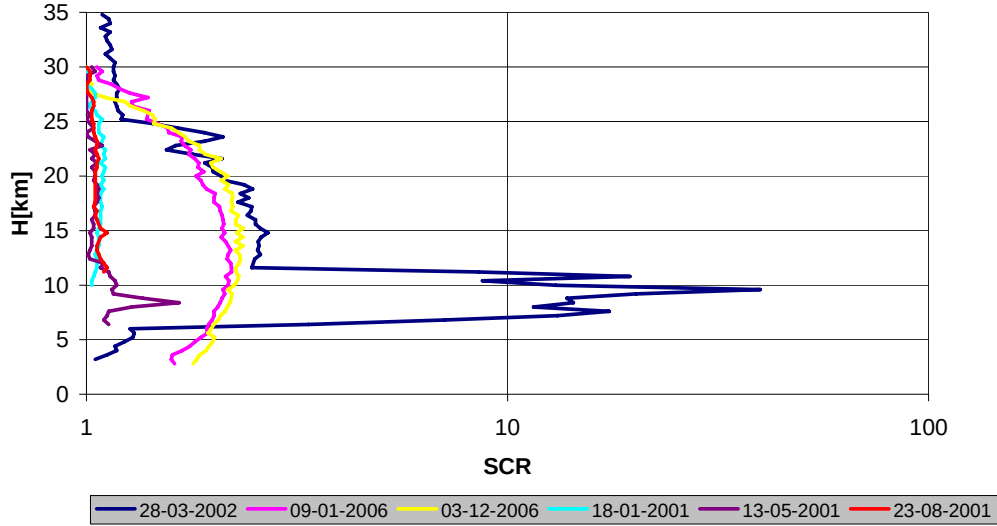


Fig. 5. Examples of SCR(H) profiles for undisturbed, clear stratosphere (18.01.2001, 13.05.2001, 23.08.2001) and for the stratosphere with heavy aerosol load (28.03.2002, 09.01.2006, 03.12.2006).

03.12.2001 are, both from the point of view of morphology and value of SCR(20 km) (lower than 1.15), typical of undisturbed stratosphere with aerosol of the background level.

Three interesting cases of untypical aerosol extinction profiles in the atmosphere have occurred. The first, obtained from sampling made on 28.03.2002, reveals the presence of a large cloud ($SCR \approx 20$) in the upper troposphere, at the altitude from 5 to 12 km, joined with an optically active layer ($SCR \approx 2.5$) at the altitude from 12 to 25 km. Analysis of parameters of the cloud on the basis of Fig. 2 and Table 1 leads to the conclusion that it is an aerosol cloud, located partly in the upper troposphere which penetrated through the tropopause and increased the level of aerosol background in the stratosphere up to about 25 km. The rest of the three interesting cases are samplings made on 09.03.2006 and 03.12.2006. Very untypical aerosol extinction profiles were obtained from them, exhibiting a lack of influence of the tropopause layer, with values of $SCR_{max} \approx 2.3$ within the 10 to 15 km range of altitude, considerably exceeding the level of aerosol background.

A positive valuation of lidar signal quality as well as the method of numerical analysis and assumptions that were made, is corroborated by SCR(H) profiles of aerosol background of undisturbed atmosphere, for which, within the range of altitude from 10 to 30 km, stable levels of aerosol background expressed by $SCR(H) \approx 1.05$ were obtained.

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Atmospheric Electricity Research at the Institute of Geophysics in the Years 2006-2007

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Through the years 2006-2007, the atmospheric electricity observations in the range of fair weather electricity on the background of the supplementary recordings were continued.

At the Geophysical Observatory at Świder (52.07°N, 21.16°E) the measurements included: atmospheric electric field, electrical conductivity of both polarities, vertical current density, aerosol concentration, radioactive and chemical pollution, as well as meteorological observations of temperature, humidity, precipitation, wind, and cloudiness. The yearbook for the year 2005 was the last printed edition of the results of atmospheric electricity measurements at Świder. We decided to make our data available only through the internet, and limit the printed version to short reports on the recent developments.

At the Arctic Station Hornsund (72°N, 15.5°E), the measurements included: atmospheric electric field, meteorological data from automatic station Vaisalla, and ground-based geomagnetic and ionospheric recordings.

Sensors, their installation, the recording instruments and methods used at Świder have been described in detail by Kubicki (2006).

The electric field strength was measured by radioactive collector with a heated insulator. The collector is connected to electrometer with a very high input resistance of 10^{14} Ohm. The electric conductivity of the air is measured by a standard Gardien condenser. The mobility of condenser is $2.6 \text{ cm}^2/\text{Vs}$.

The design of the electric field meter used at Hornsund was updated and new improvements were described by Berlinski *et al.* (2007), published in the Proceedings of the 13-th ICAE Conference, Beijing 2007.

The new version of rotating dipole field mill was constructed with special DC motor and radio transmission measurement signal used for monitoring electric field in the range from DC to 1 Hz and the intensity up to 10 kV/m. The meter consists of two main parts: the sensor head with transmitter and the receiver. Hourly mean values of electric field E_z , electric conductivity λ , and aerosol concentration Z are prepared for internet exchange.

Figure 1 shows the long-term variations of E_z , λ and Z at Świder from 1958 to 2007. The yearly mean values for the last two years are, respectively, 241 V/m, $21 \times 10^{-16} \text{ Ohm}^{-1}\text{m}^{-1}$, and 16500 cm^{-3} for 2006; and 216 V/m, $27 \times 10^{-16} \text{ Ohm}^{-1}\text{m}^{-1}$, and 12400 cm^{-3} for 2007.

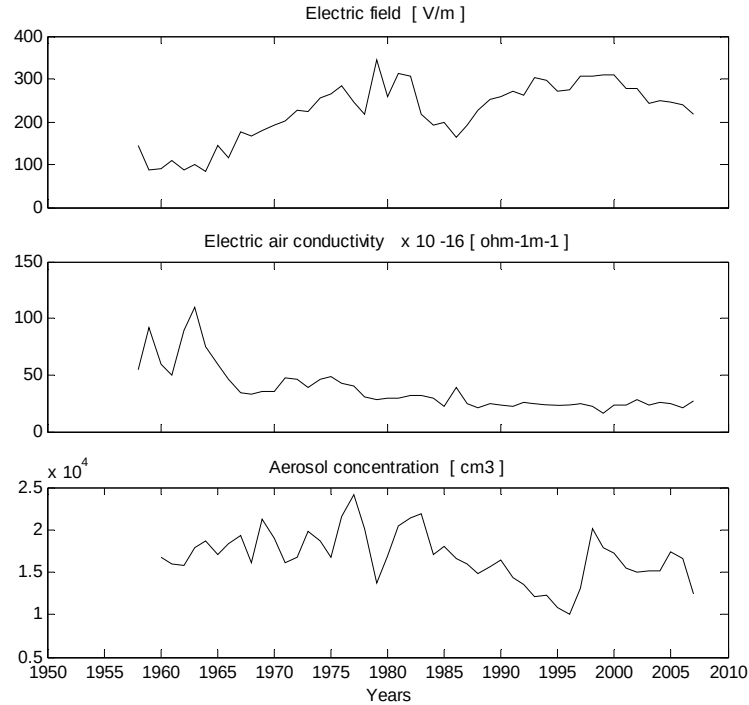


Fig. 1. Long-term variations of the electric field, electric conductivity of air and aerosol concentration at Świder Observatory.

The measurement results are used in studies of the atmospheric electricity response to local, regional and global environment changes of natural and artificial, i.e., man-made origin. In the years 2006 and 2007, our study was directed toward observation of some global electric current circuit changes that were associated with the supplementary lightning activity data, and on the search for and examination of the distinct response of the electric parameters in the lower atmosphere to the solar wind-magnetosphere-ionosphere changes, as observed at Hornsund and Świder.

Large deflections of E_z and J_z have been recorded at fair weather conditions at Hornsund during magnetic substorms and magnetic storms. The amplitude and sign of these departures were much larger than the average values for the corresponding day period observed at quiet magnetic state. They appear to depend on development stage of the storm and on site situation against the ionosphere potential patterns aligned to the position of the Sun. A new oscillatory feature of the E_z response to the substorm main phase was recorded. The E_z response to magnetic storm, never reported before in the middle latitudes, was observed in a number of cases at Świder (Fig. 2), most often during the main phase of magnetic storms. It is characteristic that

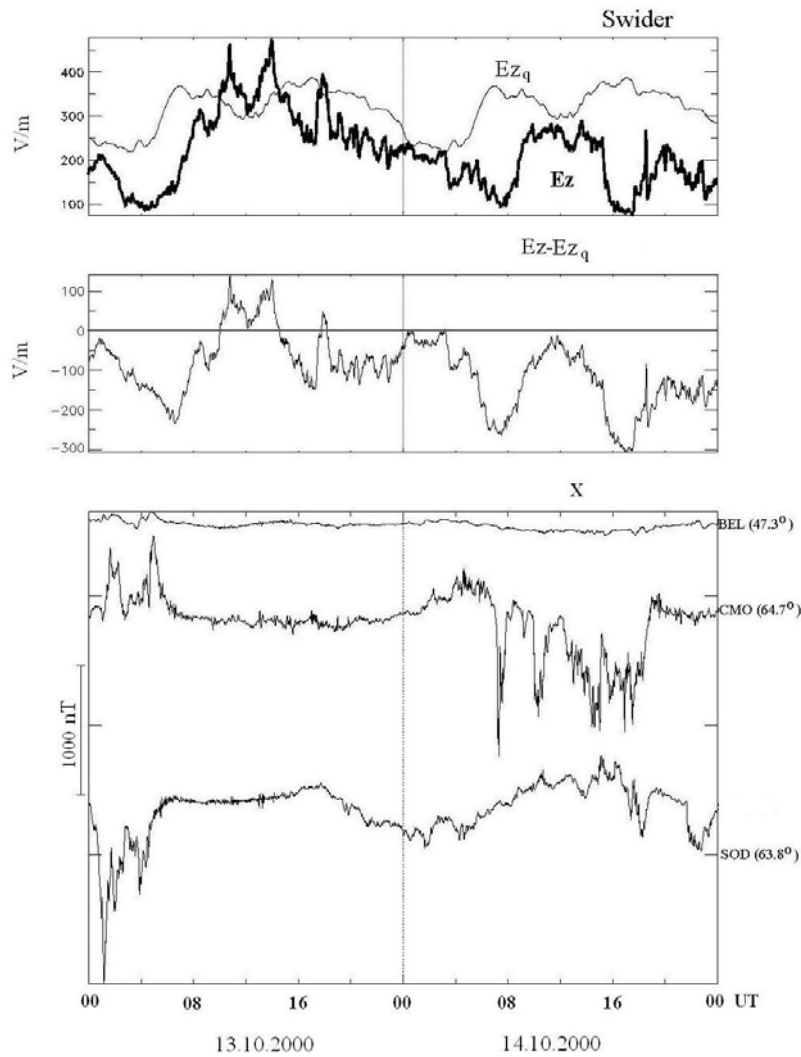


Fig. 2. The E_z variations at Świder during strong magnetic storm, 13-14 October 2000.

the E_z response effects appear then during the day, when no magnetic activity is noticed in a broad range in low and middle latitudes, while on the other hemisphere, at night, large substorms often occur in Alaska. The large amplitudes of the observed E_z responses, sustaining for a long time, are striking.

These findings are bringing new interesting information which seems to be very important in studies of the lower atmosphere couplings with solar wind changes. The results obtained in collaboration with the Earth's Institute of the Russian Academy of Sciences and the Uppsala University were presented on 13-th International Atmospheric Electricity Conference ICAE in Beijing and published in Proceedings of this Conference in 2007.

The seasonal and daily variations in E_z , λ , and Z were examined in detail on the basis of meteorological data. Some characteristic features of the behavior of these parameters were discussed in respect to local and global effects. The variations of the values recorded in 2006 and 2007 appear to have the shape similar to those for previous long term mean changes. Their analysis was published by Kubicki *et al.* (2007). The data on mean changes of these parameters in 2006 and 2007, including the mean yearly values for previous long term changes are available at www.igf.edu.pl

In January 2007 the new VLF (300 Hz – 50 kHz) recording system was installed and put in operation at Świder as an element of international AWESOME (Atmospheric Weather Electromagnetic System for Observation Modeling and Education)

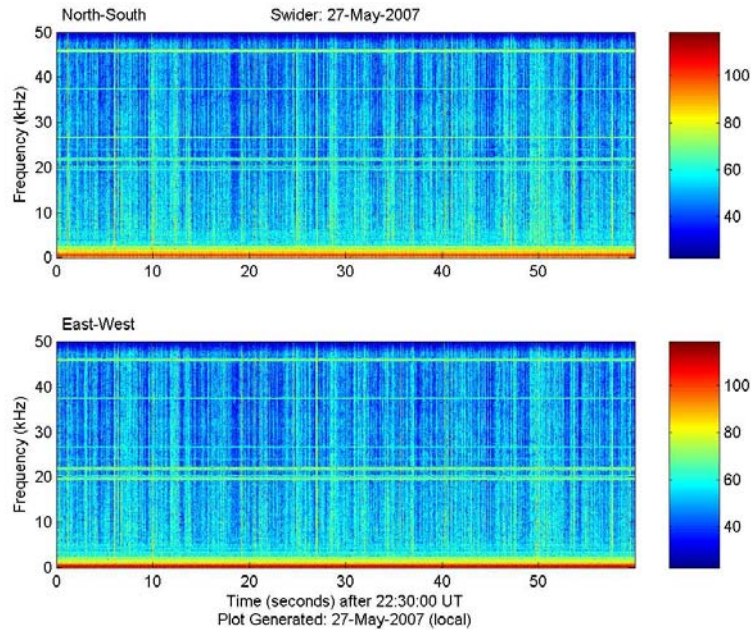


Fig. 3. VLF data spectrogram.

net of Stanford University (USA). The AWESOME system consists of VLF/ELF antenna, preamplifier box, and a line receiver. The data obtained at Świder have been used in studies of Earth's lightning discharge activity, local ionospheric disturbances and magnetospheric activity. An example of VLF spectrogram is shown in Fig. 3. The detailed information on AWESOME net is accessible at www.star-stanford.edu.

Relationships between the daily changes of global lightning discharge activity and the corresponding E_z variations recorded at Świder were investigated in 2007 on the basis of the Schumann resonance recordings made at Chylaty station of the Jagiellonian University in Kraków. The new method of decomposition of resonance signals was applied. The method is based on the spectral analysis of magnetic components B_x and B_y of Schumann resonance field observed within the 40-60 Hz frequency range. The analysis of the obtained results was published by Nieckarz (2007).

The case of a deep anomaly of E_z at Świder related to the strong Carpathian earthquake was reconsidered on the background of the updated new cases reported in world literature. The E_z anomaly was observed from 04:00 to 16:00 UT of 30.08.1986 before this earthquake (origin time 21:28 UT). The discussion in collaboration with the Institute of the Earth's Physics in Moscow was published by Nikiforova *et al.* (2007).

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Lightning Research Activities in the Institute of Geophysics, Polish Academy of Sciences, in the Years 2006-2007

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Warsaw atmospheric electricity group continues its many-year activity in the field of thunderstorm electricity observations and lightning research (Piotr Baranski: baranski@igf.edu.pl). Our measuring site with electric field sensors of different type, i.e., low frequency (LF) antennas and Maxwell current flat antennae, used for recent lightning recordings, is located on the roof of the building the Institute in Warsaw ($\lambda = 20.94^\circ\text{E}$, $\varphi = 52.245^\circ\text{N}$). The view on the installation of these sensors is in Figs. 1 and 2.

The main objectives of our electric field change measurements (ΔE) carried out during lightning cloud-to-ground (CG) or intracloud (IC) discharge events are:

- obtaining—in the form of digital files—return stroke (RS) waveform signatures with high time resolution (25 MHz sampling of ΔE records),
- determining the main time parameters, i.e., the rise time (t_r) and the decay time (t_d) of all collected RS waveform signatures,
- denoting characteristic signal features that occurred during the rising and decaying phases of particular RS waveforms, i.e., the “ γ -peaks”, slow and fast front for the rise stage and secondary or subsidiary peaks for the decay stage,
- comparing the obtained time characteristics of particular RS waveforms with the ones delivered by the SAFIR/PERUN lightning detection network system in Poland as CG lightning flash detection data.

Some results of examination of ΔE signatures of the first and subsequent return strokes recorded during different types of CG flashes which occurred in the monitored area 100×100 km around Warsaw in the summer 2005 thunderstorms were presented



Fig. 1. The measuring site used for lightning event observations in Warsaw. [a] – the flat-plate antenna with frequency band $20 \text{ Hz} \div 1.3 \text{ MHz}$ and based on charge amplifier AD 711 having feedback time constant $\tau = 5 \text{ ms}$; [b] – the Maxwell current flat antennae delivering the pulse of electric field change in the time domain, i.e. $(\partial E/\partial t)$, for the displacement current component of lightning flash events to be detected in the range of about 50 km from our measuring point and recorded by our data acquisition system. This system consists of 2-channel A/D PC 12-bit card having on its board a 64 MB memory buffer in each channel and triggered by the amplitude level of $(\partial E/\partial t)$ signal, and the GPS time module unit giving the same time stamping 0.1 ms as the one used by the SAFIR/PERUN lightning detection network in Poland.

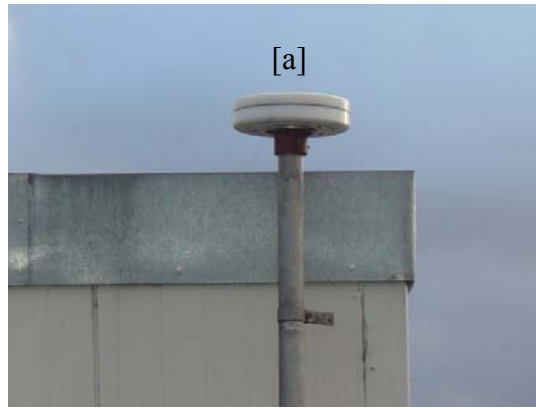


Fig. 2. The same as in Fig. 1, but with second LF antenna labeled [a] which is the PAD 04 unit with charge amplifier AD 825 (the same as that used by the SAFIR/PERUN system for CG flash discrimination) and having frequency band from 300 Hz to 3 MHz, and feedback time constant $\tau = 6.7 \text{ ms}$.

at the First COST P18 Symposium which was held on 2-3 April 2006 in Vienna (Barański and Loboda 2006). Details of this presentation are still available on www site (<http://www.costp18-lightning.org/>). On the other hand, during thunderstorm season in 2006 we collected additionally several cases of CG flash events with their electric field signatures containing the continuing current (CC) component. These observations have been examined to obtain the short-time Fourier transform (STFT) spectra of special spikes, the so-called M-components, appearing sometimes during CC stages of CG flashes. Our results were presented during the 13-th ICAE in Beijing, China (Barański *et al.* 2007) and one example of them is shown in Fig. 3.

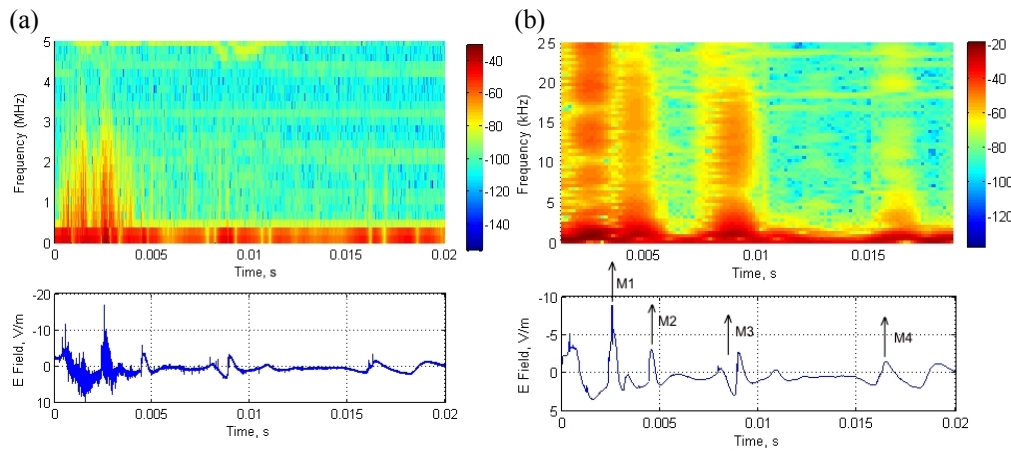


Fig. 3. Spectrograms and waveforms of electric field changes associated with the CC stage for (a) a wide frequency band which enables discrimination of the very fast spikes superimposed on the slow electric field change, and (b) a narrow frequency band which enables a better discrimination of their M-components. The colour scale of spectrograms amplitude is in dB units.

Although the CC changes are not as frequent components of CG flashes as for example the RS ones, the possible application of their dynamic spectra properties for CC detection and location by network lightning systems could be a considerable progress in lightning protection against their powerful and harmful effects on our ground objects or forests. We think that further extension and more detailed examination of dynamic spectra of the CC electric field changes and other important components of CG or IC lightning discharges would be useful in a search for some new detection algorithm procedures to be applied in computer processing.

The previous valuable recordings of the rarely occurring bipolar flashes during summer thunderstorms near Warsaw were reported and published in Barański (2006).

In 2007 we started our special research project entitled “Multiple cloud-to-ground lightning flashes – their development, parameters, hazard for people and risk of damages” in the frame of the COST P18 program in cooperation with Warsaw University of Technology, Institute of Meteorology and Water Management and Space

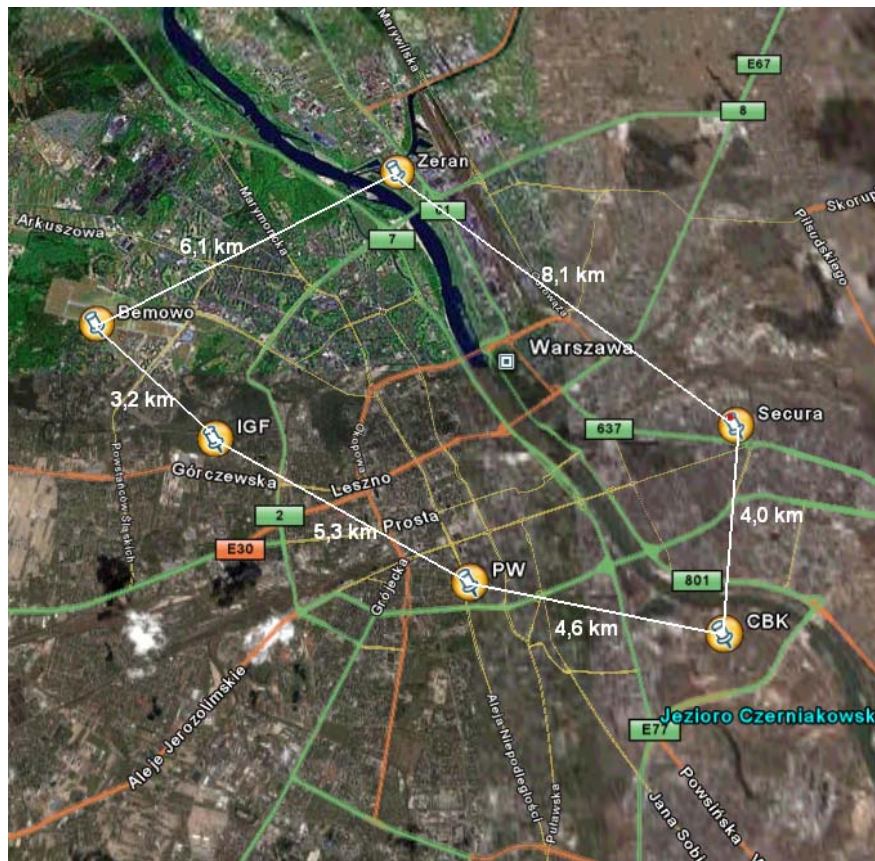


Fig. 4. Space configuration of the LLDS network in Warsaw with six measuring stations denoted by Zeran, Secura, CBK, PW, IGF and Bemowo.

Research Centre of the Polish Academy of Sciences. The preliminary task of that project is the design, construction and operation of the complementary local lightning detection system (LLDS) in the region of Warsaw as an additional source for validation and extension of data on multiple CG lightning flashes detected by the SAFIR/PERUN lightning detection system and eventually by the CELDN or the LINET data recorded from the Warsaw region. The LLDS network will consist of six stations installed in Warsaw area (see Fig. 4) and equipped with: electric field changes receiving antenna of frequency band up to 100 kHz, GPS time synchronization clock, pre-triggered A/D converter, and individual memory storage bank. The central analyzer with personal computer will be used for post processing of stored data from all simultaneously working antennas. The fast speed movie digital cameras (PHANTOM VRI-MIRO 4) will be applied for records of lightning development images in selected

regions of horizon containing tall structures. The main field measurement campaign is planned to be done in the spring and summer of 2009. We intend to extend the range of the collected data on relations between CG discharges (including multiple strokes) and the SAFIR/PERUN lightning detections, and meteorological radar observations, with different PPI and VCUT scans of those parts of the thundercloud precipitation shafts which may be involved in lightning flash initiation, aiming to get better knowledge on multiple discharge origin and its time and space development. Comparative examinations of the LLDS and the SAFIR/PERUN (and the CELDN/LINET) data are expected to verify the quality of lightning data available now over Warsaw from different location systems as well to enrich multiple lightning flash studies in the region of Warsaw.

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