

Supporting Information for the article *Effects of climate change on pollen season features of herbaceous species in the Milan area, Northern Italy*

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ABSTRACT

Additional Results

We present the results of correlation tests for meteorological variables that show no strong evidence of correlation with pollen season parameters. Specifically, Table 1 reports the correlation test results between selected meteorological variables and SPInn, Table 2 with the pollen season peak day, and Table 3 with the pollen season peak value.

Table 1. Correlation test results between some meteorological features and SPIn. P-values < 0.05 are shown in bold.

Meteorological feature	Pollen taxon	$\hat{\rho}$	p-val (ρ)	$\hat{\rho}_S$	p-val (ρ_S)
temperature	<i>Ambrosia</i>	-0.030	0.878	0.027	0.893
	<i>Artemisia</i>	-0.168	0.392	-0.116	0.558
	Cannabaceae	0.142	0.472	0.060	0.760
	Chenopodiaceae/Amarantaceae	0.085	0.666	-0.001	0.999
	Poaceae	0.047	0.812	-0.151	0.443
	Urticaceae	-0.288	0.137	-0.317	0.101
wind speed	<i>Ambrosia</i>	0.469	0.012	0.496	0.008
	<i>Artemisia</i>	0.160	0.415	0.266	0.171
	Cannabaceae	0.263	0.176	0.279	0.150
	Chenopodiaceae/Amarantaceae	0.248	0.203	0.373	0.051
	Poaceae	0.094	0.633	-0.038	0.849
	Urticaceae	0.011	0.956	0.120	0.544
relative humidity	<i>Ambrosia</i>	-0.305	0.114	-0.303	0.117
	<i>Artemisia</i>	-0.133	0.501	-0.223	0.253
	Cannabaceae	-0.255	0.191	-0.276	0.154
	Chenopodiaceae/Amarantaceae	-0.326	0.090	-0.433	0.022
	Poaceae	-0.311	0.107	-0.166	0.397
	Urticaceae	-0.027	0.890	-0.225	0.250
precipitation	<i>Ambrosia</i>	-0.045	0.821	-0.130	0.509
	<i>Artemisia</i>	-0.052	0.793	-0.209	0.287
	Cannabaceae	-0.076	0.701	-0.208	0.287
	Chenopodiaceae/Amarantaceae	-0.096	0.628	-0.200	0.307
	Poaceae	-0.331	0.085	-0.172	0.379
	Urticaceae	0.176	0.371	0.073	0.714
solar radiation	<i>Ambrosia</i>	-0.037	0.853	-0.030	0.879
	<i>Artemisia</i>	-0.068	0.732	0.020	0.920
	Cannabaceae	0.279	0.151	0.226	0.247
	Chenopodiaceae/Amarantaceae	0.050	0.802	0.062	0.754
	Poaceae	0.320	0.097	0.227	0.245
	Urticaceae	-0.290	0.135	-0.158	0.423

Table 2. Correlation test results between some meteorological features and pollen season peak day.

Meteorological feature	Pollen taxon	$\hat{\rho}$	p-val (ρ)	$\hat{\rho}_S$	p-val (ρ_S)
temperature	<i>Ambrosia</i>	-0.026	0.895	-0.119	0.548
	<i>Artemisia</i>	0.129	0.514	0.181	0.358
	Cannabaceae	0.041	0.836	-0.041	0.834
	Chenopodiaceae/Amarantaceae	0.322	0.095	0.138	0.485
	Poaceae	-0.018	0.926	-0.172	0.383
	Urticaceae	-0.261	0.180	-0.200	0.309
wind speed	<i>Ambrosia</i>	0.082	0.678	0.046	0.815
	<i>Artemisia</i>	0.069	0.727	0.086	0.664
	Cannabaceae	0.019	0.922	-0.019	0.925
	Chenopodiaceae/Amarantaceae	-0.082	0.677	-0.235	0.229
	Poaceae	0.247	0.205	0.297	0.125
	Urticaceae	-0.094	0.634	-0.119	0.546
relative humidity	<i>Ambrosia</i>	0.095	0.630	0.285	0.141
	<i>Artemisia</i>	0.075	0.706	0.109	0.581
	Cannabaceae	0.028	0.886	0.042	0.832
	Chenopodiaceae/Amarantaceae	0.017	0.930	0.152	0.441
	Poaceae	-0.068	0.730	-0.076	0.700
	Urticaceae	0.207	0.290	0.340	0.077
precipitation	<i>Ambrosia</i>	-0.030	0.881	0.100	0.614
	<i>Artemisia</i>	-0.048	0.807	0.110	0.578
	Cannabaceae	-0.004	0.985	0.091	0.646
	Chenopodiaceae/Amarantaceae	-0.066	0.738	0.035	0.859
	Poaceae	-0.041	0.837	-0.006	0.975
	Urticaceae	0.238	0.224	0.342	0.075
solar radiation	<i>Ambrosia</i>	-0.195	0.320	-0.293	0.130
	<i>Artemisia</i>	0.162	0.410	0.117	0.554
	Cannabaceae	-0.182	0.355	-0.105	0.595
	Chenopodiaceae/Amarantaceae	0.246	0.207	0.031	0.877
	Poaceae	-0.337	0.080	-0.351	0.067
	Urticaceae	-0.136	0.491	-0.162	0.410

Table 3. Correlation test results between some meteorological features and pollen season peak value.

Meteorological feature	Pollen taxon	$\hat{\rho}$	p-val (ρ)	$\hat{\rho}_S$	p-val (ρ_S)
temperature	<i>Ambrosia</i>	-0.172	0.380	-0.181	0.356
	<i>Artemisia</i>	-0.221	0.259	-0.135	0.493
	Cannabaceae	0.265	0.172	0.284	0.143
	Chenopodiaceae/Amarantaceae	0.098	0.619	-0.099	0.617
	Poaceae	0.157	0.425	0.030	0.882
	Urticaceae	-0.323	0.094	-0.364	0.057
wind speed	<i>Ambrosia</i>	0.540	0.003	0.524	0.004
	<i>Artemisia</i>	0.273	0.159	0.329	0.087
	Cannabaceae	0.052	0.791	0.061	0.760
	Chenopodiaceae/Amarantaceae	0.271	0.163	0.333	0.083
	Poaceae	0.038	0.847	-0.056	0.777
	Urticaceae	-0.093	0.637	-0.064	0.746
relative humidity	<i>Ambrosia</i>	-0.122	0.535	-0.111	0.573
	<i>Artemisia</i>	-0.095	0.632	-0.127	0.518
	Cannabaceae	-0.101	0.607	-0.113	0.569
	Chenopodiaceae/Amarantaceae	-0.302	0.118	-0.292	0.132
	Poaceae	-0.311	0.108	-0.239	0.220
	Urticaceae	0.083	0.676	0.005	0.980
precipitation	<i>Ambrosia</i>	0.149	0.448	0.045	0.818
	<i>Artemisia</i>	0.013	0.947	-0.152	0.440
	Cannabaceae	0.061	0.758	0.017	0.931
	Chenopodiaceae/Amarantaceae	-0.064	0.746	-0.112	0.570
	Poaceae	-0.255	0.190	-0.169	0.389
	Urticaceae	0.294	0.128	0.249	0.201
solar radiation	<i>Ambrosia</i>	-0.169	0.391	-0.215	0.273
	<i>Artemisia</i>	-0.132	0.502	-0.049	0.803
	Cannabaceae	0.310	0.109	0.276	0.156
	Chenopodiaceae/Amarantaceae	0.050	0.801	-0.077	0.696
	Poaceae	0.334	0.082	0.304	0.115
	Urticaceae	-0.307	0.112	-0.210	0.284

Table 4. Annual pollen season descriptors for *Ambrosia* recorded from 1995 to 2022. Note: start-day and end-day define the pollen season dates; duration is the length of the season in days; peak-day is the date of the maximum concentration; peak-value is the maximum daily concentration (p/m^3); is the Seasonal Pollen Integral (p/m^3) calculated for the entire season; APIn is the Annual Pollen Integral (p/m^3) for the entire year; and ndays-over-1 is the number of days with concentrations above the threshold of 1 p/m^3 .

	year	start-day	end-day	duration	peak-day	peak-value	SPIn	APIn	ndays_over_1
1	1995	1995-08-16	1995-09-25	41	1995-09-04	225	2515	2627	41
2	1996	1996-08-11	1996-09-19	40	1996-08-24	250	3386	3541	40
3	1997	1997-08-15	1997-10-05	52	1997-08-28	387	5242	5516	52
4	1998	1998-08-11	1998-09-22	43	1998-08-28	369	4150	4338	43
5	1999	1999-08-11	1999-09-26	47	1999-09-02	359	4188	4389	47
6	2000	2000-08-09	2000-09-23	46	2000-08-27	447	6887	7194	46
7	2001	2001-08-06	2001-09-22	48	2001-08-30	461	4756	4988	48
8	2002	2002-08-10	2002-09-24	46	2002-09-03	310	3472	3648	44
9	2003	2003-08-09	2003-09-28	51	2003-08-30	292	4841	5075	51
10	2004	2004-08-14	2004-09-24	42	2004-08-31	337	6011	6325	41
11	2005	2005-08-13	2005-09-16	35	2005-09-02	433	4341	4513	35
12	2006	2006-08-18	2006-09-20	34	2006-09-06	737	5199	5455	34
13	2007	2007-08-13	2007-09-22	41	2007-08-31	288	4706	4940	41
14	2008	2008-08-09	2008-10-04	57	2008-08-30	255	3887	4074	57
15	2009	2009-08-08	2009-09-26	50	2009-09-01	308	6016	6323	49
16	2010	2010-08-17	2010-09-25	40	2010-08-27	296	3229	3376	40
17	2011	2011-08-09	2011-10-02	55	2011-08-28	253	3873	4067	53
18	2012	2012-08-13	2012-09-28	47	2012-09-07	194	2707	2841	47
19	2013	2013-08-12	2013-10-01	51	2013-09-03	48	638	668	47
20	2014	2014-08-09	2014-09-19	42	2014-09-04	75	756	790	38
21	2015	2015-08-13	2015-09-21	40	2015-09-02	48	477	499	34
22	2016	2016-08-15	2016-09-14	31	2016-08-29	61	789	814	31
23	2017	2017-08-04	2017-09-30	58	2017-08-31	17	243	254	45
24	2018	2018-08-09	2018-09-26	49	2018-09-05	34	570	591	39
25	2019	2019-08-14	2019-09-18	36	2019-09-03	278	1695	1759	33
26	2020	2020-08-06	2020-09-20	46	2020-08-19	81	752	787	42
27	2021	2021-07-31	2021-09-19	51	2021-09-02	112	1595	1677	44
28	2022	2022-08-11	2022-09-18	39	2022-08-29	108	938	982	36

Table 5. Annual pollen season descriptors for *Artemisia* recorded from 1995 to 2022.

	year	start-day	end-day	duration	peak-day	peak-value	SPIn	APIIn	ndays_over_1
1	1995	1995-08-09	1995-10-09	62	1995-08-20	60	602	629	40
2	1996	1996-08-01	1996-10-06	67	1996-08-19	71	609	637	44
3	1997	1997-08-07	1997-10-24	79	1997-08-15	73	786	825	56
4	1998	1998-08-08	1998-10-08	62	1998-08-18	46	390	408	33
5	1999	1999-07-23	1999-10-15	85	1999-08-19	59	602	632	55
6	2000	2000-08-01	2000-10-09	70	2000-08-16	56	725	762	57
7	2001	2001-08-04	2001-10-11	69	2001-08-15	43	510	531	38
8	2002	2002-08-06	2002-10-08	64	2002-08-13	39	536	561	43
9	2003	2003-08-02	2003-10-15	75	2003-08-17	21	229	238	40
10	2004	2004-08-10	2004-10-08	60	2004-09-14	45	351	368	43
11	2005	2005-08-08	2005-10-15	69	2005-08-20	31	211	220	26
12	2006	2006-08-11	2006-10-11	62	2006-08-23	35	339	353	43
13	2007	2007-08-02	2007-10-12	72	2007-09-21	36	267	281	36
14	2008	2008-08-01	2008-10-11	72	2008-08-15	22	276	289	47
15	2009	2009-08-05	2009-10-13	70	2009-08-18	26	307	321	42
16	2010	2010-08-10	2010-10-18	70	2010-09-25	25	236	248	38
17	2011	2011-08-05	2011-10-14	71	2011-10-01	20	349	364	41
18	2012	2012-08-09	2012-10-12	65	2012-09-27	43	278	289	39
19	2013	2013-08-13	2013-10-10	59	2013-09-23	18	136	140	30
20	2014	2014-08-08	2014-10-05	59	2014-09-19	10	113	117	25
21	2015	2015-08-14	2015-10-11	59	2015-09-22	14	110	113	17
22	2016	2016-08-12	2016-10-13	63	2016-08-21	18	182	188	32
23	2017	2017-08-14	2017-10-31	79	2017-09-29	34	147	153	17
24	2018	2018-08-08	2018-10-10	64	2018-09-26	22	208	215	32
25	2019	2019-08-10	2019-10-08	60	2019-08-19	11	121	125	25
26	2020	2020-08-11	2020-10-09	60	2020-09-22	21	166	174	28
27	2021	2021-08-09	2021-10-16	69	2021-09-23	20	198	208	37
28	2022	2022-08-16	2022-10-18	64	2022-09-24	32	292	305	35

Table 6. Annual pollen season descriptors for Cannabaceae recorded from 1995 to 2022.

	year	start-day	end-day	duration	peak-day	peak-value	SPIn	APIIn	ndays_over_1
1	1995	1995-08-01	1995-09-25	56	1995-08-21	41	394	414	39
2	1996	1996-07-01	1996-09-28	90	1996-08-19	68	669	703	53
3	1997	1997-07-29	1997-09-24	58	1997-08-20	48	771	809	52
4	1998	1998-07-16	1998-09-19	66	1998-08-18	56	833	875	48
5	1999	1999-08-09	1999-10-03	56	1999-09-09	41	530	554	48
6	2000	2000-07-12	2000-09-27	78	2000-08-13	88	1124	1181	62
7	2001	2001-07-08	2001-09-19	74	2001-08-23	55	820	860	45
8	2002	2002-08-06	2002-09-25	51	2002-08-19	43	602	631	44
9	2003	2003-08-05	2003-09-22	49	2003-08-15	88	958	1008	47
10	2004	2004-08-07	2004-09-19	44	2004-08-18	75	726	761	41
11	2005	2005-08-07	2005-09-10	35	2005-08-15	97	1102	1152	33
12	2006	2006-08-11	2006-09-14	35	2006-08-24	73	728	760	35
13	2007	2007-08-04	2007-09-17	45	2007-08-19	93	743	776	43
14	2008	2008-08-07	2008-09-14	39	2008-08-11	54	887	930	37
15	2009	2009-08-06	2009-09-11	37	2009-08-15	126	1304	1365	37
16	2010	2010-08-11	2010-09-18	39	2010-08-22	32	516	541	36
17	2011	2011-08-08	2011-09-12	36	2011-08-18	105	1222	1270	33
18	2012	2012-08-06	2012-09-18	44	2012-08-13	86	785	823	38
19	2013	2013-08-05	2013-09-10	37	2013-08-15	38	434	451	36
20	2014	2014-08-15	2014-09-18	35	2014-08-16	29	235	241	29
21	2015	2015-08-10	2015-09-18	40	2015-08-22	54	371	386	34
22	2016	2016-08-13	2016-09-11	30	2016-08-17	87	585	611	24
23	2017	2017-08-08	2017-09-28	52	2017-08-17	10	147	151	33
24	2018	2018-08-10	2018-09-14	36	2018-08-23	115	527	552	34
25	2019	2019-08-08	2019-09-18	42	2019-08-19	48	335	350	30
26	2020	2020-08-07	2020-09-15	40	2020-08-11	136	1347	1403	37
27	2021	2021-08-07	2021-09-15	40	2021-08-17	104	960	1001	40
28	2022	2022-07-08	2022-09-22	77	2022-08-28	35	584	609	49

Table 7. Annual pollen season descriptors for Chenopodiaceae/Amarantaceae recorded from 1995 to 2022.

	year	start-day	end-day	duration	peak-day	peak-value	SPIn	APIIn	ndays_over_1
1	1995	1995-06-22	1995-09-30	101	1995-09-10	26	265	277	57
2	1996	1996-05-23	1996-09-27	128	1996-07-12	13	329	345	81
3	1997	1997-06-13	1997-10-15	125	1997-09-06	20	337	352	57
4	1998	1998-06-25	1998-09-25	93	1998-09-01	12	194	201	41
5	1999	1999-07-04	1999-10-06	95	1999-09-03	19	279	293	51
6	2000	2000-06-02	2000-09-30	121	2000-09-09	38	766	799	114
7	2001	2001-05-28	2001-09-27	123	2001-06-26	13	613	644	111
8	2002	2002-05-22	2002-09-30	132	2002-06-24	23	622	652	108
9	2003	2003-06-29	2003-10-06	100	2003-09-08	19	386	405	56
10	2004	2004-06-30	2004-09-29	92	2004-09-10	22	260	272	34
11	2005	2005-06-21	2005-09-17	89	2005-09-06	23	308	322	47
12	2006	2006-06-21	2006-10-05	107	2006-09-06	31	381	398	47
13	2007	2007-06-25	2007-10-05	103	2007-09-15	19	365	383	53
14	2008	2008-07-06	2008-10-14	101	2008-09-07	16	232	244	43
15	2009	2009-06-17	2009-10-04	110	2009-09-09	17	293	307	50
16	2010	2010-06-11	2010-10-03	115	2010-08-30	20	183	188	37
17	2011	2011-07-28	2011-10-07	72	2011-09-17	9	149	155	34
18	2012	2012-06-20	2012-09-27	100	2012-09-19	12	173	181	40
19	2013	2013-07-12	2013-10-04	85	2013-09-09	5	87	90	25
20	2014	2014-06-23	2014-09-27	97	2014-09-12	12	108	112	20
21	2015	2015-06-17	2015-10-10	116	2015-09-18	7	103	107	18
22	2016	2016-07-03	2016-09-29	89	2016-09-09	5	74	76	18
23	2017	2017-06-13	2017-10-04	114	2017-08-31	6	90	92	21
24	2018	2018-07-02	2018-09-30	91	2018-09-24	11	159	167	36
25	2019	2019-06-08	2019-09-30	115	2019-09-05	10	141	146	30
26	2020	2020-05-28	2020-10-02	128	2020-08-29	11	186	194	40
27	2021	2021-06-03	2021-09-28	118	2021-09-14	17	329	345	62
28	2022	2022-06-11	2022-10-04	116	2022-09-07	36	677	711	68

Table 8. Annual pollen season descriptors for Poaceae recorded from 1995 to 2022.

	year	start-day	end-day	duration	peak-day	peak-value	SPIn	APIIn	ndays_over_1
1	1995	1995-04-21	1995-09-01	134	1995-05-08	103	2684	2820	118
2	1996	1996-04-18	1996-09-07	143	1996-05-06	253	3654	3819	134
3	1997	1997-04-01	1997-09-03	156	1997-05-02	168	2928	3079	153
4	1998	1998-04-21	1998-08-29	131	1998-05-11	102	2295	2411	119
5	1999	1999-04-26	1999-10-18	176	1999-05-02	105	1903	1997	143
6	2000	2000-04-20	2000-09-25	159	2000-05-02	110	2993	3139	154
7	2001	2001-04-15	2001-08-29	137	2001-05-07	318	5317	5577	137
8	2002	2002-04-05	2002-09-14	163	2002-05-08	215	4469	4694	154
9	2003	2003-04-19	2003-08-31	135	2003-05-07	352	6199	6523	134
10	2004	2004-04-20	2004-09-10	144	2004-05-18	204	4705	4939	142
11	2005	2005-04-17	2005-09-04	141	2005-05-10	303	4326	4543	137
12	2006	2006-04-20	2006-09-11	145	2006-05-06	300	5752	6026	142
13	2007	2007-04-04	2007-09-12	162	2007-04-26	317	6756	7091	158
14	2008	2008-04-08	2008-09-10	156	2008-05-28	126	3674	3855	150
15	2009	2009-04-23	2009-09-11	142	2009-05-04	106	3190	3346	139
16	2010	2010-04-17	2010-09-11	148	2010-05-17	133	3021	3171	138
17	2011	2011-04-12	2011-09-08	150	2011-04-21	167	3201	3356	141
18	2012	2012-04-13	2012-09-16	157	2012-05-26	95	2226	2336	140
19	2013	2013-04-25	2013-09-05	134	2013-05-03	207	3462	3629	125
20	2014	2014-04-11	2014-09-05	148	2014-04-28	185	3247	3388	136
21	2015	2015-04-12	2015-09-04	146	2015-04-26	151	2998	3142	130
22	2016	2016-03-29	2016-09-07	163	2016-04-29	113	2377	2492	144
23	2017	2017-04-08	2017-09-05	151	2017-04-25	186	2317	2434	124
24	2018	2018-04-20	2018-09-21	155	2018-04-28	183	2675	2798	144
25	2019	2019-04-20	2019-09-03	137	2019-06-06	198	2405	2527	118
26	2020	2020-04-08	2020-09-12	158	2020-05-04	218	4049	4247	148
27	2021	2021-04-17	2021-09-03	140	2021-05-09	229	5174	5442	138
28	2022	2022-04-16	2022-09-22	160	2022-05-19	256	3983	4166	155

Table 9. Annual pollen season descriptors for Urticaceae recorded from 1995 to 2022.

	year	start-day	end-day	duration	peak-day	peak-value	SPIn	APIn	ndays_over_1
1	1995	1995-05-09	1995-09-20	135	1995-08-20	138	3601	3772	126
2	1996	1996-05-09	1996-09-13	128	1996-08-26	312	5874	6159	125
3	1997	1997-05-04	1997-10-03	153	1997-09-02	285	8372	8789	152
4	1998	1998-04-27	1998-09-23	150	1998-07-05	108	5998	6276	143
5	1999	1999-05-03	1999-10-04	155	1999-08-26	348	7795	8158	153
6	2000	2000-04-27	2000-09-24	151	2000-08-17	463	10718	11043	146
7	2001	2001-05-03	2001-09-17	138	2001-08-23	413	10747	11291	136
8	2002	2002-04-24	2002-09-23	153	2002-09-17	376	13881	14424	151
9	2003	2003-04-29	2003-09-21	146	2003-08-27	132	4582	4802	146
10	2004	2004-05-02	2004-09-19	141	2004-08-20	167	6270	6589	140
11	2005	2005-05-02	2005-09-17	139	2005-09-02	391	7419	7731	136
12	2006	2006-05-02	2006-10-07	159	2006-08-24	356	7397	7738	157
13	2007	2007-04-16	2007-09-23	161	2007-09-02	206	6041	6344	155
14	2008	2008-04-29	2008-09-23	148	2008-06-28	598	9092	9466	145
15	2009	2009-04-27	2009-09-26	153	2009-08-14	254	7090	7427	149
16	2010	2010-04-30	2010-09-27	151	2010-08-27	223	4797	5046	144
17	2011	2011-04-16	2011-10-01	169	2011-08-20	141	4427	4631	165
18	2012	2012-04-26	2012-10-01	159	2012-06-25	73	2910	3054	154
19	2013	2013-05-02	2013-09-24	146	2013-05-02	214	3758	3918	142
20	2014	2014-04-13	2014-09-22	163	2014-08-30	394	5925	6138	151
21	2015	2015-04-23	2015-09-29	160	2015-08-29	70	2946	3057	155
22	2016	2016-04-23	2016-09-23	154	2016-08-24	247	4797	5032	142
23	2017	2017-04-09	2017-10-01	176	2017-04-13	276	2675	2762	170
24	2018	2018-04-29	2018-09-30	155	2018-09-09	167	4380	4591	154
25	2019	2019-04-22	2019-09-23	155	2019-09-17	171	3961	4146	138
26	2020	2020-04-19	2020-09-22	157	2020-08-29	188	5529	5755	154
27	2021	2021-04-25	2021-09-25	154	2021-04-26	198	6307	6582	152
28	2022	2022-04-21	2022-10-02	165	2022-04-29	262	5586	5834	159