

Influence of climate change on airborne pollen concentrations in Madrid, 1979–2018

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None.

Key Messages

We observed a 1.3°C increase in temperature in Madrid over 40 years.

This was associated with earlier onset of the pollen season and increase in atmospheric pollens.

Preliminary data suggest possible impacts on the rates of allergic sensitization to Cupressaceae, *Platanus* and *Quercus*.

To the Editor,

Several retrospective studies based on historical data have shown that a global warming of the atmosphere exists, with an estimated average increase in the temperature of the earth's surface of 1.1°C during the last century.¹

Climate change and human impact on vegetation may modify the timing and intensity of the pollen season. Severity of pollen-induced symptoms depends on the number of pollen grains and their allergenicity, variables related to pollution and local climate.² Therefore, climate change could potentially change pollen exposure, sensitization and symptoms.³⁻⁵

However, only sparse data exist regarding the direct correlation between climate changes, pollen seasons and allergic sensitization. Furthermore, due to geographic variability of climatic conditions, flora and climate change impact, long-term studies are needed in each geographic region. We evaluated the impact of climate change on ambient temperatures, pollen counts and sensitization to pollens in Madrid over a 40-year period.

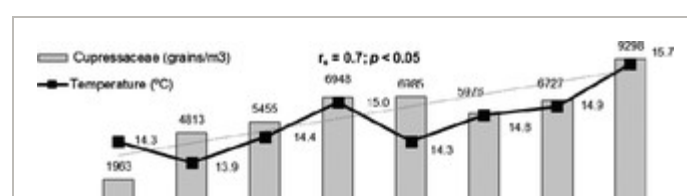
Pollen counts have been carried out in Madrid since 1978, where Poaceae are the most

allergenic pollens. Up to 88% of pollinosis patients are polysensitized, usually to *Poaceae*, *Olea europaea*, *Platanus acerifolia*, *Cupressus arizonica*, and in recent years, also to *Quercus ilex* which implies an increased duration of symptoms throughout the year.^{6,7} The aim of our study was to verify whether any increase in temperature has affected the aerobiological and clinical behaviour of the main allergenic pollens in Madrid, over 40 years.

Temperatures were recorded daily from the Barajas-Madrid Station of the National Meteorological Agency. Pollen counts were carried out between 1979 and 2018, using a Burkard 7-day recording volumetric spore trap, as described previously,⁷ following the European Aerobiology Society's Network Group recommendations. The trap was installed on the 20-metre-high roof of our centre, located in the east Madrid urban area (40° 26' 12" N 03° 40' 39" W), at 667 metres above sea level. Pollen identification was conducted by expert technicians and based on comparisons to reference slides and photographs, as described in the atlas of airborne pollen grains.

The first of three consecutive days with >10 grains/m³ of air was considered to be the start of the season, and the end, the last of three consecutive days with <10 grains/m³ of air. Likewise, we evaluated the percentage of positive responses to skin prick tests to common aeroallergens (Immunotek Laboratory) in three groups of patients who had attended our clinic spontaneously for pollinosis, in the years 1979 (*n* = 100), 1994 (*n* = 316) and 2019 (*n* = 100) consecutively. There was a total of 516 patients aged 4–77 years (average 27), all born and living in or around Madrid. Ninety-eight percent had rhino-conjunctivitis and 41% had asthma. These years were the only available data on local sensitizations. The pollen species utilized in skin prick testing were collected from herbaceous plants and trees in our surrounding area, as part of routine clinical practice, and prepared as extracts at 1:20 wt/vol, as previously described,⁷ with 10 mg/ml histamine chlorhydrate and 50% glycerol as controls. All skin tests were read after 15 min. A positive reaction was a wheal of ≥3 mm × 3 mm in the presence of appropriate control responses. A control group of 15, non-atopic subjects, was also tested with the extracts.

A 1.3°C increase in the 5-year mean temperature records over 40 years in Madrid was observed (*r*_s = 0.81, *p* = .014). Four of the five pollen types studied had their highest recorded count in the most recent 5-year period (2014–18). *Platanus* 5297 grains/m³ (30 Mar 2015), *Quercus* 1880 grains/m³ (13 May 2015), *Poaceae* 958 grains/m³ (5 Jun 2016), *Olea* 780 grains/m³ (9 May 2017) and *Cupressaceae* 3306 grains/m³ (21 Feb 1991). The 5-year mean total pollen concentrations of *Cupressaceae*, *Platanus*, *Quercus* and *Olea*, but not *Poaceae*, increased more dramatically, and were significantly correlated with the increase in temperature (Figure 1).



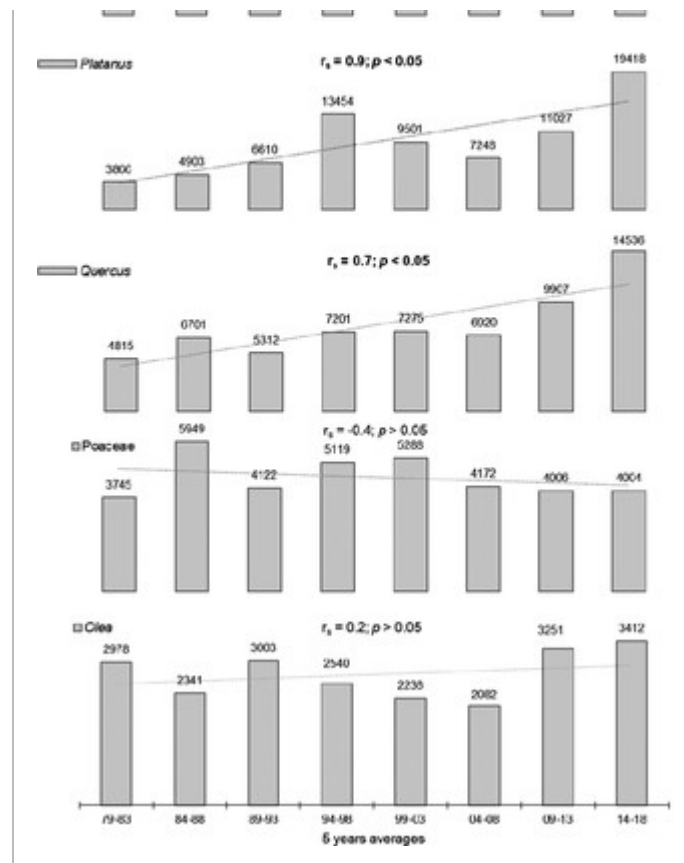


FIGURE 1

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Temperature (°C) and pollen counts expressed in grains/m³ of air, 5-year averages. Note the increase in temperature and *Cupressaceae*, *Platanus* and *Quercus* concentrations. Also note the close significant correlation between both variables

It could be argued that this increase in pollen counts may be due to the increase in new trees planted in Madrid, especially for *Cupressus* spp. and *Platanus*, ornamental trees planted within the city. However, the increase in *Quercus ilex* pollen counts cannot be explained this way, because this is a non-urban tree, whose numbers are unlikely to have increased. *Quercus* trees may have increased slightly due to decreased livestock pressure, the abandonment of farmland and the application of management plans for natural areas, but this is unlikely to be sufficient to explain the pollen increase. Moreover, other trends suggest that tree numbers are unlikely to explain changes in pollen counts.

Platanus pollen counts were lower in the 5-year period between 1999 and 2003, compared with the previous 5-year period (9,501 vs. 13,454 *Platanus* pollen grains/m³), and this is likely to be explained by a drop in temperature from 15 to 14.3°C between the two 5-year periods (Figure 1).

Additionally, the increased presence of *Cupressaceae* and *Platanus* trees cannot explain by itself the significant variations in the start and end of the pollen seasons across the years, which in turn, are associated with the temperature increase (Figure 1 and Table 1). The

temperature rise is not likely to be due to the growth of the city, since the meteorological data were recorded outside the city, near Barajas Airport, 9 km away from our pollen collector.

TABLE 1. Start, end and duration of the pollen seasons (5-Year averages)

5-year averages	T	Cupressaceae*			Platanus**			Quercus**			Poacea
		Days beginning		Days end	Days beginning		Days end	Days beginning		Days end	Days beginn
		-31		-18	-6		-2	-13		-6	-4
		Start	End	Duration	Start	End	Duration	Start	End	Duration	Start
79–83	14.3	120	207	87	87	119	32	115	177	62	13
84–88	13.9	94	179	84	88	121	33	110	171	61	10
89–93	14.4	103	172	69	81	120	39	110	174	64	8
94–98	15.0	69	190	121	73	110	37	89	162	73	8
99–03	14.3	90	170	81	75	111	35	96	163	65	8
04–08	14.8	74	197	123	80	117	38	102	174	71	6
09–13	14.9	92	220	128	84	115	31	98	171	78	6
14–18	15.7	71	180	109	84	117	33	99	176	77	8

Note

*Day of the year from 1st October the previous year; **Day of the year from 1st January; *** Day of the year from 1st May; **** Day of the year from 1st April; Start and End dates of the pollen seasons, comparing the average of each period, with the mean of all the periods. T = temperature in °C.

The lack of increase in Poaceae concentrations may be explained because we know that the pre-seasonal rainfall in Madrid and not the temperature, is mainly responsible for the total annual concentrations of grass pollen.⁷ The slight decrease in Poaceae counts during these 40 years could be related to the construction of new buildings that have progressively separated our collector from the fields, together with the earlier withering of the grass due to the temperature increases in June.

In our study, we observed an early onset of the start of the season which correlated significantly with the 5-year mean temperature: Cupressaceae −31 days, −31%), ($r_s = -0.76$, $p = .18$), *Olea* −7 days, −2.5%, ($r_s = -0.71$, $p = .047$) and Poaceae −4 days, −2.4%, ($r_s = -0.690$, $p = .058$). An early start was also seen regarding *Quercus* (−13 days, −8.9%) and *Platanus* (−6 days, −2.1%). Furthermore, an early end to the season was observed for Poaceae (−7 days, −4.3%) and *Olea* (−8 days, −2.8%) (Table 1). These data concur with previous research published in the US and Europe that emphasize the early onset of the season and the increase in pollen concentrations due to global warming.^{3, 8, 9} From a clinical point of view, attention is especially drawn to Cupressaceae, whose start of the season has shifted from late January to early December.

Rates of positive skin tests also increased for *Cupressus arizonica* (0%, 20%, 59%), *Platanus acerifolia* (2%, 52%, 56%), *Quercus ilex* (0%, 14%, 22%) and *Olea europaea* (50%, 61%, 71%), but not for Poaceae (*Trisetum* and/or *Dactylis*), (90%, 87%, 88%). Noteworthy is the fact that this finding only occurred with the types of pollen that had an increased presence in the atmosphere of Madrid, and sensitization rates were stable for Poaceae, whose concentrations did not increase (Figure 1). This suggests that the main factor responsible for this phenomenon has been the increase in pollens in the atmosphere due to increasingly warm winters, and hot and sunny springs, caused by the change in climate over the last 40 years.

One could perhaps argue that the difference observed in the prevalence of sensitization was due to variances in the quality of the extracts tested, rather than to a real change. However, the extracts were always obtained from the same places in Madrid and produced in exactly the same way.

The effect of rain, air humidity and pollution has not been studied here, and remains relevant for future studies.

The strength of our study resides in its duration (40 years), which has allowed us to objectively observe how the temperature fluctuations correlated with the large fluctuations in pollen concentrations, and the timing of tree pollen seasons. For example, during the period 1994–2003, temperatures fell, pollen concentrations also fell, and the season started later (Figure 1).

In summary, our study describes how the increase in temperatures over a 40-year period in Madrid was associated with early pollen season set for the majority of pollen types, increased pollen counts and increased rates of allergic sensitisation to Cupressaceae, *Platanus*, *Quercus* and *Olea* among patients in this city.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

AUTHOR CONTRIBUTIONS

SJ: The conception and design of the study. Acquisition of data, analysis and interpretation of data and critical revision for important intellectual content. **CM:** Analysis and interpretation of data. Drafting the article. Critical revision for important intellectual content and submission. **C-RJM:** Statistical analysis and interpretation of data. **NMJ and CJC:** Collection of samples. **All authors:** Final approval of the version to be submitted.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

IRB APPROVALS

Not applicable.

CONSORT STATEMENT CHECKLIST

Included in a submitted file.

Open Research



DATA AVAILABILITY STATEMENT

All data generated or analysed during this study are included in this published article.

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