

The influence of the hot and dry summer 2003 on the pollen season in Switzerland

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Abstract

A record-breaking heat wave affected the European continent in summer 2003. In Switzerland, the temperature in June, July and August exceeded the 1961–1990 mean by about 5 °C. These extreme temperatures had significant effects on the pollen production and on the airborne pollen loads. Especially affected was the grass pollen season, which started 1–2 weeks earlier than in the mean. During May and the first part of June the grass pollen production and dispersion was favoured by the warm and dry weather and many days with high pollen concentrations were registered. First water deficiencies occurred in June so that the grasses ceased to grow. The grass pollen season ended 7–33 days earlier than normal. For many of our stations of the Swiss pollen network this had never occurred as early as in 2003. The other herbaceous plants were not affected as much as the grasses. We measured very high *Chenopodium* and *Plantago* pollen concentrations, about normal concentrations of *Urtica* and *Rumex* and slightly lower *Artemisia* pollen concentrations than normal. The summer 2003 was exceptional and its reoccurrence is at the moment statistically extremely unlikely. But models of climatologists show that in the future, climate variations will increase and that in the period 2071–2100 about every second summer could be as warm or warmer and as dry or dryer than 2003.

1. Introduction

In Switzerland the year 2003 was 1.6–2 °C warmer than the mean of the climate period 1961–1990. In the region of the Lake of Geneva, in Valais and in Southern Ticino it was the warmest year since the beginning of climate measurements in 1864. In other parts of Switzerland the year 2003 belongs to the four warmest years ever measured together with 1994, 2000 and 2002. A record breaking heat wave affected the European continent in summer 2003. In a large area of Europe, mean summer (June, July and August) temperatures exceeded the 1961–1990 mean of about 3 °C (Schär et al., 2004). In Switzerland, which

was located close to the centre of this anomaly the mean temperature of June, July and August was 4.0–5.5 °C higher than normal (Figure 1, Bader, 2004). This summer temperature exceeded the mean by more than 5 standard deviations. The summer 2003 was exceptional and is based on the actual data series an extremely unlikely event with a very high return period (Schär et al., 2004). In 2003 already March and April temperatures were higher than normal and the beginning of May showed summer-like temperatures. The proper heat wave started in June and lasted until the end of August. It was just interrupted by a too warm but not extreme July (Figure 1). June and August 2003 showed the highest ever measured

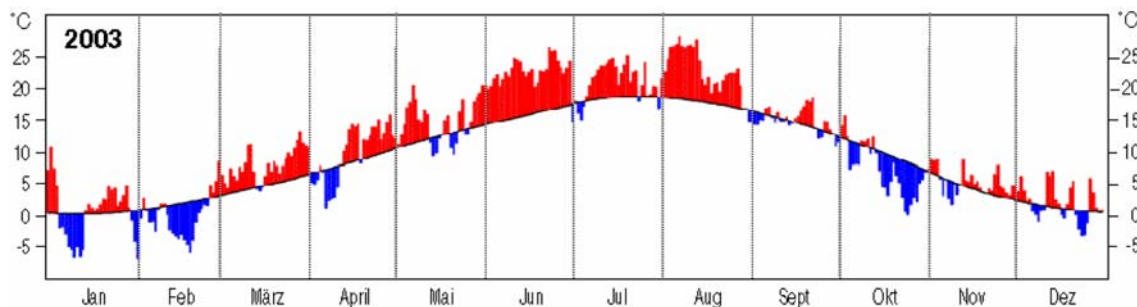


Figure 1. Daily mean temperature of Neuchâtel 2003 compared with the mean temperature of the climate period 1961–1990 (from Bader, 2004).

monthly mean temperatures in Switzerland. Additionally to the high temperatures, during the summer half year (April to September) precipitations reached only about 60–70% of the normal values in northern Switzerland and only about 50–60% in Southern Switzerland (Bader, 2004). This was not the driest summer ever measured since 1864 in Switzerland, but in addition with the extreme temperatures the drought was severe, so that big loss in agriculture occurred (Bader, 2004). The problem of drought was intensified, because precipitation was below normal since February.

In Europe the drought and the heat wave had enormous social, economic and environmental adverse effects. Such as the deaths of thousands of vulnerable elderly people, the destruction of large areas of forests by fire especially in southern Europe, substantial losses in agriculture and influence on rivers and water reserves. In Switzerland the loss in agriculture due to the drought was estimated to be 350 Million Francs (Swiss federal office for agricultur, 2003). In the forests the autumn colouring of the trees started already in mid August (Zingg and Brang, 2003) instead of the normal date in October (Defila, 2002).

The goal of this study was, to analyse the influence of these extreme weather conditions on the pollen concentrations.

2. Materials and methods

The pollen data originates from the 14 stations of the Swiss pollen network. They cover different vegetation and climate zones in Switzerland. The daily mean pollen concentrations were measured with Hirst-type Burkard pollen traps which are

located between 12 and 33 m above ground. The data was analysed using standard methods (Mandrioli et al., 1998). The weather data originate from the nearby automated stations of the MeteoSwiss national weather network. Table 1 shows the pollen stations of the Swiss pollen network with the respective date of the beginning of the data series which were included in this study.

The pollen data of the year 2003 is compared with the 10–21 years of pollen data series by using box plots. In the graphs the box plots show percentiles of 5%, 25%, 50%, 75% and 95% of the whole pollen data series. Outliers are marked with a cross. The value of 2003 is plotted with a diamond.

3. Results

The pollen season 2003 started already in the last days of December 2002. On 27 of December the first pollen grains of *Corylus* were measured in Geneva and on the 30 in Zurich. This is exceptional for Switzerland, because normally *Corylus* starts flowering in January or February. The beginning of the *Corylus* flowering depends mainly on December temperatures (Frei, 1995) and this extraordinarily early flowering is explained by the mild December temperatures which were 2–4 °C higher than normal (MeteoSwiss, 2002). The early flowering of *Corylus* is just an additional remarkable characteristic of the extreme year 2003 with its unusual weather pattern. A similar observation was made in the Swiss phenological network, where the bud burst of Horse Chestnut (*Aesculus hippocastanum*) is observed in Geneva since 1808. The date for the bud burst of

Table 1. The pollen measuring stations of the Swiss pollen network

Station	Altitude (m)	Abbreviation used for box plots	Begin of the data series
Basel	273	BS	1981
Bern	560	BE	1993
Buchs	445	BU	1985
La Chaux de Fonds	1040	CF	1993
Davos	1600	DS	1983
Genève	380	GE	1989
Lausanne	570	LS	1997
Locarno	366	LO	1989
Lugano	273	LU	1991
Luzern	460	LZ	1993
Münsterlingen	410	MU	1993
Neuchâtel	490	NE	1982
Visp	650	VI	1993
Zurich	556	ZH	1982

the vegetation season 2003 was reported on 28 December 2002. This is the earliest bud burst ever reported since the beginning of the observations (Defila, 2004a).

Since the heat wave started in May, the grass and herbal pollen were the most influenced and therefore the main importance of this research should be put on them. In 2003 the grass pollen season started very early (Figure 2). The beginning of the grass pollens season was defined as the first of four consecutive days with grass pollen and one of these daily grass pollen counts should be ≥ 10 pollen. For three stations it is the

earliest start ever measured. For the rest of the stations north of the Alps the start of the grass pollen season is in the first quartile, which means in the first 25% of the ever measured start dates. The start dates north of the Alps (only stations on the Swiss Plateau) ranged from 21 April to the 2 May, while the median start dates range from 29 April to the 12 May which means the 2003 start dates were about 10 days earlier than in the mean.

A similar picture as the start dates showed the beginning of high pollen values, which means daily grass pollen concentrations of ≥ 50 pollen.

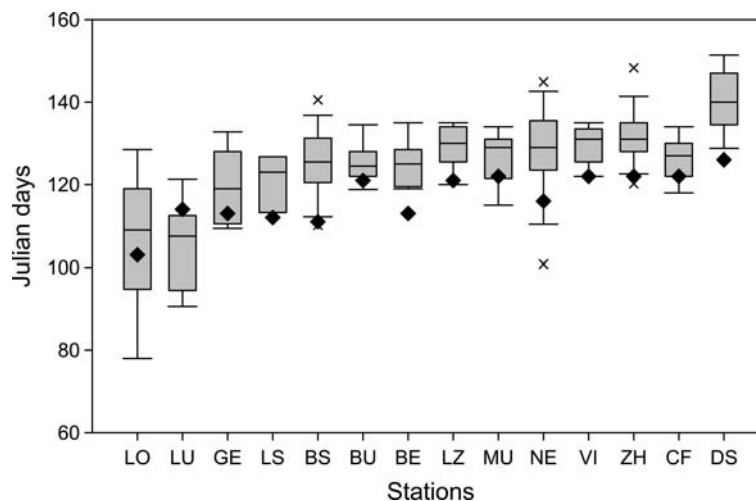


Figure 2. Start date of the grass pollen season 2003. The year 2003 (diamonds) is compared with the whole pollen data set at the stations of the Swiss pollen network. Box plots show the 5%, 25%, 50%, 75% and 95% percentiles of the whole pollen data set. For LS, BE, DS it is the earliest start ever measured.

Five stations showed the earliest ever measured start of this values (Figure 3). During May and June there was a long sequence of days with high grass pollen loads, while in normal years, the grass pollen season is interrupted frequently by rainfall. In the year 2003 the warm temperatures and the dry weather favoured the grass flowering and the release of grass pollen (Figures 4 and 5). Due to the favourable conditions for pollen release and transport, 10 of our stations showed higher SPI than normal, for two stations a maxi-

mal SPI could be measured. It is interesting to see, that the stations in the mountains (La Chaux-de-Fonds, Davos) showed higher seasonal pollen index (SPI) and number of days with high pollen loads too. In the Alps there was no severe moisture deficit, so the grass flowering profited from the sunny weather.

Exceptional was the end date of high pollen concentrations which occurred much earlier than normal at the end of June. Over all the end of high pollen concentrations occurred 7–33 days earlier

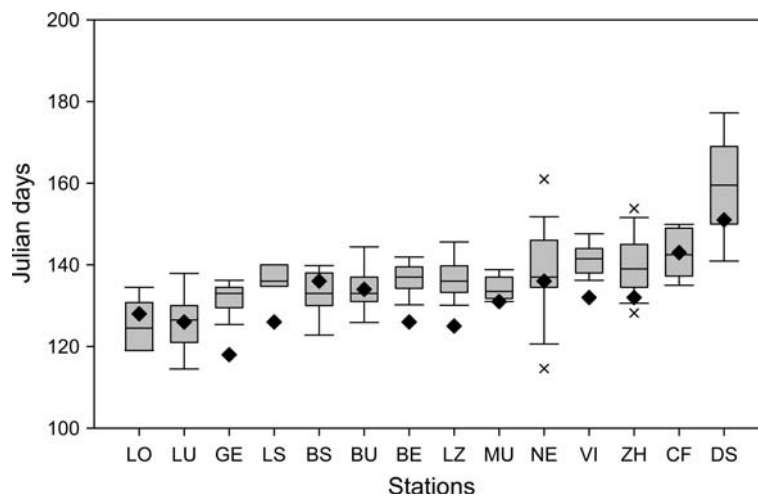


Figure 3. Start date of high grass pollen concentrations (daily pollen counts ≥ 50 pollen) 2003. The year 2003 (diamonds) is compared with the whole pollen data set at the stations of the Swiss pollen network. Box plots show the 5%, 25%, 50%, 75% and 95% percentiles of the whole pollen data set. For GE, LS, BE, LZ and VI it is the earliest start ever measured.

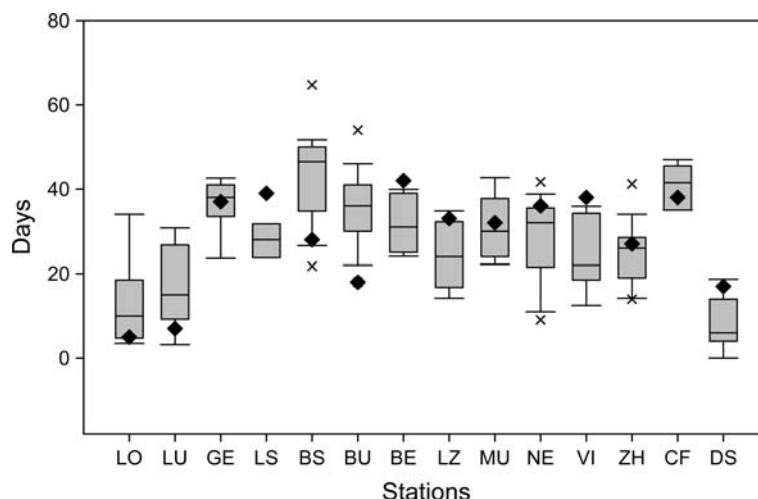


Figure 4. Number of days with high grass pollen concentrations (≥ 50 pollen) 2003. The year 2003 (diamonds) is compared with the whole pollen data set at the stations of the Swiss pollen network. Box plots show the 5%, 25%, 50%, 75% and 95% percentiles of the whole pollen data set.

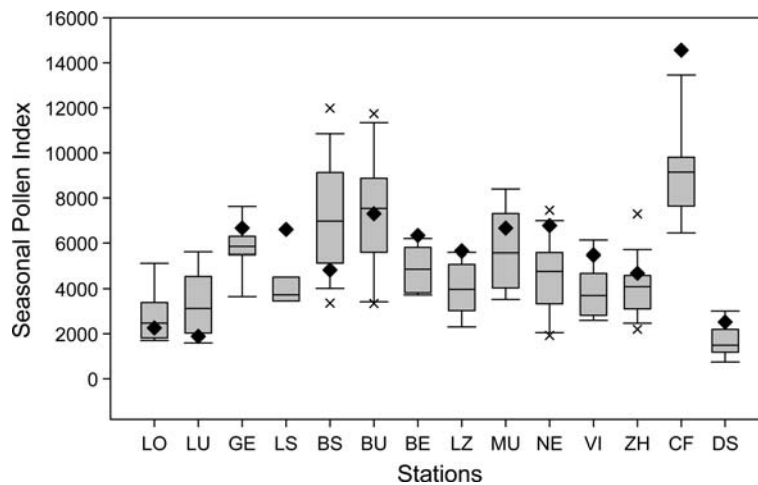


Figure 5. Seasonal pollen index of the grass pollen 2003. The year 2003 (diamonds) is compared with the whole pollen data set at the stations of the Swiss pollen network. Box plots show the 5%, 25%, 50%, 75% and 95% percentiles of the whole pollen data set.

than in the mean. For six stations it is the earliest end ever measured (Figure 6). Analysis of the soil moisture content shows that the first drought problems occurred around the 20 June. Calculations of the soil water content were made for Zurich (Figure 7). For this calculation, the main root layer for grass was assumed to be 60 cm. In a loamy soil the maximum water content, that means the field capacity, of 60 cm of soil is 210 mm (Eimern van, 1971). The first 40 mm of water is easy to use by the plants. If the water

content falls below 30% of the usable water capacity, than the first plants begin to wilt, but this process is reversible. The permanent wilting point is reached with 90 mm water content. The soil water content was calculated as the difference between precipitation and the evapotranspiration according to Primault (1981). The evapotranspiration values are calculated routinely by MeteoSwiss.

The herbaceous species *Plantago*, *Rumex* and *Urtica* are flowering from the end of April to September, Chenopodiaceae from June to September

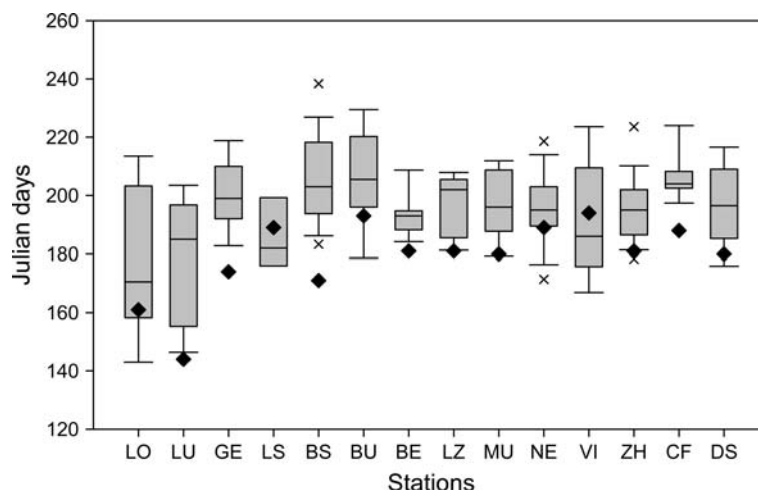


Figure 6. Termination date of the high grass pollen loads (last date with daily pollen counts ≥ 50 pollen) 2003. The year 2003 (diamonds) is compared with the whole pollen data set at the stations of the Swiss pollen network. Box plots show the 5%, 25%, 50%, 75% and 95% percentiles of the whole pollen data set. LU, GE, BS, BE, LZ, CF show the earliest end ever measured.

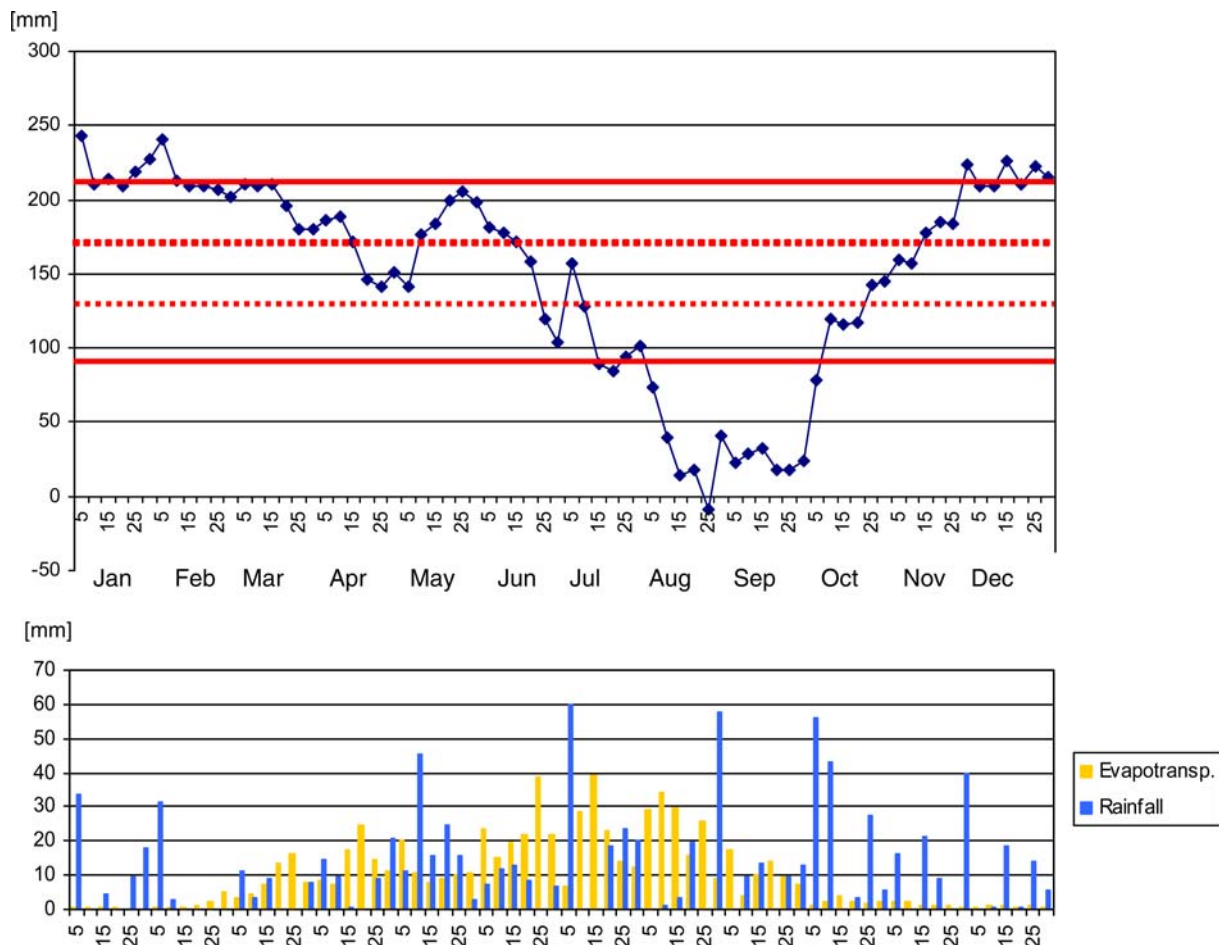


Figure 7. Soil moisture content, rainfall and evapotranspiration in Zurich 2003 calculated for sums of 5 days. Upper graph: soil moisture content (—◆—). The lines show the field capacity (210 mm), the lower limit of easy to use water (162 mm), 30% of the usable water content (126 mm) and the permanent wilting point (90 mm).

and *Artemisia* from July to September and were therefore affected by the heat wave too. In normal years their seasonal pollen index is rather low and they play a minor role for allergies in Switzerland. In 2003 the SPI of some of these species were much higher than normal, especially of *Plantago* and *Chenopodiaceae* (Table 2). According to their ecological habitats, *Plantago* and *Chenopodiaceae* are more tolerant to drought than the other species. During summer 2003 it was observed in agriculture fields, that several weed species developed better than normal and it is expected that weeds may become more competitive in a warmer climate (J. Fuhrer, Swiss Federal Research Station for Agroecology and Agriculture, pers. communication). Only in Southern Switzerland (Lugano, Locarno), where the period with negative water

balance started already in February, extremely low pollen concentrations of *Rumex*, *Urtica* and *Artemisia* were measured.

4. Discussion

The grasses were the most influenced by the heat wave of 2003. The start dates of the grass pollen season were on an average 10 days earlier than normal. For three stations it was the earliest start ever measured. The start of the grass pollen season depends on the temperatures of March and April. For the prediction of the grass pollen season a growing degree day model is used in Switzerland, which cumulates the daily mean temperatures from 1 March (Clot, 1998). March 2003

Table 2. Seasonal pollen index of herbaceous species in 2003 compared with the whole pollen data set in Switzerland and classified according to the percentiles 10%, 25%, 75% and 90% of the whole pollen data set

	Rumex	Plantago	Chenopod.	Urtica	Artemisia
Basel	–	=	=	--	--
Bern	=	+ +	+ +	+	=
Buchs	=	=	+ +	+	=
Geneva	+	+ +	+ +	–	=
La Chaux-d-F.	+ +	+ +	+ +	+	=
Lausanne	+ +	+ +	+ +	+	+ +
Locarno	--	=	+	--	--
Lugano	--	=	=	--	--
Luzern	=	+ +	+ +	=	–
Münsterlingen	=	+ +	+ +	=	=
Neuchâtel	=	+ +	+ +	=	=
Visp	=	+ +	=	=	=
Zurich	–	=	+ +	=	–

Percentiles: + +, >90%; +, 76–90%; =, 26–75%; –, 10–25%; --, <10%.

was clearly too mild with 2.5–3.5 °C higher temperatures than normal. Also April was warmer than normal with 1.5–2 °C above the mean (MeteoSwiss, 2003a, b). Similar results were obtained in the Swiss phenological network. In early summer and during summer all phenological observations showed early to very early occurrences (Defila, 2004b). The flowering of the Oxeye daisy (*Leucanthemum vulgare*) can be correlated well with the start of the grass pollen season. It was flowering with an advance of 10 days (Defila, 2004b). In southern Switzerland normal start dates of the grass pollen season were measured.

The duration of the grass pollen season was shorter than normal due to the drought. At the end of June the grass decreased its growth and also its pollen production. In 11 of the stations of our pollen network the high values of grass pollen immission ended before the end of June or at the beginning of July. This can be correlated very well with the beginning of the drought analysed for Zurich (Figure 7). As soon as the soil water content falls below the limit of 30% of the usable water content, the first plants begin to wilt. The same drought problems occurred in agriculture where the fodder production for life stock became problematic during this summer.

As a consequence, for allergic people the grass pollen season was very severe in May and June with long periods of days with high pollen loads. At the end of June the grass pollen season had terminated much earlier than normal, so that

the hay fever symptoms ceased. We observed over all a shift of the grass pollen season towards the end of April and a shorter but more severe period in May and June. The same shift could be shown for the mountains. Additionally, also in the Alps the pollen season was more severe than normal. Today in the Alps above about 1500 m, the pollen concentrations are remarkably lower than on the Swiss Plateau, so allergic people can take advantage of these regions for being less exposed to pollen (Gehrig and Peeters, 2000). In a warmer climate, the alpine regions can lose this benefit at least partly since, as the year 2003 shows, with warmer temperatures longer and stronger grass pollen seasons may occur.

The summer 2003 is still exceptional, but scenarios of future climate change show that summer will be warmer and drier than today. Schär et al. (2004) state that towards the end of the 21st century every second summer could be as warm or dry as the summer 2003. Also Beniston (2004) and Beniston and Diaz (2004) show that summers will become progressively as hot as the 2003 event, such that, in the latter part of the 21st century, it is likely to become the norm. The modelling of future precipitation patterns is still more difficult than for temperature. For the Alpine region of Europe the models predict an increase of precipitations in winter and there exist indications that summer precipitation will decrease and longer dry phases will become more frequent in the 21st century (Gyalistras et al., 1998; Occc, 2002).

5. Conclusion

The heat wave of the summer 2003 affected the pollen production and the airborne pollen loads remarkably. The grass pollen season occurred about 10 days earlier than normal and was very severe during May and June. Due to the extreme temperatures and the drought, the grass pollen season ended much earlier than normal. For the allergy situation this means a shorter, but more intense stress which is also valuable for the Alps. It is not sure, if the year 2003 gives us indications of a possible pollen situation in the latter part of the 21st century. But the physical processes that characterized the 2003 heat wave, such as soil moisture depletion and the positive feedback on summer temperatures, and the lack of convective rainfall in many parts of the continent are projected to occur with greater frequency in the future (Beniston, 2004). With climate change, precipitation may become an important factor for changes in pollen impact also in central Europe. It should be considered when modelling changes of the allergy situation. A further issue which has to be considered is a change in the composition of the vegetation. New species will become more competent in a changing climate and may influence the allergy situation. It will be our future challenge to model pollen occurrence and pollen loads with changing climate conditions.

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