



Comparison of Climate Change Effects on Pome And Stone Fruit Phenology Between Balkan Countries and Bonn/Germany

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Abstract

The objective of the joint project between the two universities of Bonn and Sarajevo was to study the effects of climate change associated with warmer winter and spring temperatures on fruit tree phenology. Changes in flowering date of apple and cherry were correlated with local weather data obtained concomitantly on-site at four locations in the Balkan countries Slovenia, Serbia, B & H and at Bonn, Germany.

Phenological data of flower opening (F1; BBCH 61) of apple cv. ‘Golden Delicious’ originated from 55 years at Cacak (44°N, Serbia) and at Klein-Altendorf, University of Bonn (50°N), cv. ‘Bobovec’ from the University of Ljubljana (46°N, Slovenia) and cherry cv. ‘Burlat’ (35 years at Klein-Altendorf, 50°N) and 20–30 years at Tuzla (44°N, B & H) and Mostar (43°N, Bosnia & Herzegovina; B & H).

The annual precipitation showed a negligible change in the last 55 years of $\pm 5\%$ in the Balkan countries (e.g. Cacak, 699 mm), but only $\pm 1.8\%$ at Klein-Altendorf (605 mm) with a slight shift to more winter rainfall.

Regression analysis showed an increase in mean temperature of 1.7 °C (annual) and 1.45 °C for the vegetation period at Klein-Altendorf (last 55 years), Germany. In the evaluated Balkan stations, the greatest increase in annual air temperature between two climate phases (until 1987 versus from 1988 until now) was at Ljubljana (1.4 °C) and Cacak (1.2 °C) in contrast to the least increase (0.3 °C) at Tuzla (annual average 10 °C) and an intermediate value (0.9 °C) in the warmer Mostar (annual average 14.5 °C).

This recent temperature increase *advanced flower opening by 10–14 days for apple such as cv. ‘Golden Delicious’ at Cacak and 7–10 days (last 55 years) at Bonn and 4–5 days (last 35 years) for the early cherry cv. ‘Burlat’ at Klein-Altendorf/Bonn;* at Mostar and Tuzla, the effect of climate change was greater with the early cherry cv. ‘Burlat’ (26 days) compared with the difference of the late cherry cultivar (16 days). Before recent climate change (1973–1987), *cherry flower was advanced by 10 days in the warmer med climate at Mostar but delayed by 16 days in the cooler Tuzla.* The results, i.e. the flower advancement in the Continental climate but flower delay in the med climate, are discussed with respect to the risk of late frost and countermeasures to combat climate change effects.

Keywords Apple (*Malus domestica* L.) · Balkan states · Burlat · Cherry (*Prunus avium* L.) · Climate change · Flowering · Frost · Global warming · Phenology

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Vergleich der Klimawandelwirkungen in den Balkanstaaten und in Klein-Altendorf/Bonn auf die Phänologie von Apfel und Kirsche

Zusammenfassung

Ziel der vorliegenden Untersuchung im Rahmen der Zusammenarbeit zwischen den Universitäten Bonn und Sarajewo im Bereich Gartenbauwissenschaft war ein Vergleich der Klimawandelwirkungen (wärmere Winter) auf die Blühphänologie von Apfel und Kirsche an 5 ausgewählten Standorten auf dem Balkan in Slowenien, Serbien, Bosnien & Herzegovina (B & H) sowie in Klein-Altendorf.

Phänologische Aufzeichnungen des Blühbeginns (F1, BBCH 61) der Apfelsorte ‘Golden Delicious’ über 55 Jahre stammten aus Cacak (44°N, Serbien) und Klein-Altendorf (50°N) und der Apfelsorte ‘Bobovec’ aus Ljubljana (46°N, Slowenien) sowie der frühen Kirschsorte ‘Burlat’ über 35 Jahre aus Klein-Altendorf und 20–30 Jahre aus Tuzla (44°N, B & H) und Mostar (43°N, B & H).

Die jährliche Regenmenge veränderte sich über die letzten 55 Jahre kaum, ca. $\pm 5\%$ in den Obstbaugebieten der Balkanstaaten (z. B., Cacak 699 mm) und $\pm 1,8\%$ in Klein-Altendorf (605 mm).

Die Auswertung der Wetterdaten der letzten 55 Jahre in Klein-Altendorf zeigte zwei Phasen, eine vor dem Klimawandel bis ca. 1987 und eine ab 1988 mit Klimawandel mit einem Anstieg der Jahresdurchschnittstemperatur von 1,7°C bzw. 1,45°C in der Vegetationsperiode im Vergleich zu den Balkanstaaten mit einem Anstieg der Jahresdurchschnittstemperatur von 1,4°C in Ljubljana, 1,2°C in Cacak, 0,9°C im Mittelmeerklima von Mostar und 0,3°C in Tuzla.

Dieser Temperaturanstieg verfrühte die Apfelblüte von ‘Golden Delicious’ in den letzten 55 Jahren um 10–14 Tage in Cacak (Serbien) und um 7–10 Tage in Bonn sowie die Kirschblüte der frühen Sorte ‘Burlat’ um 4–5 Tage (letzte 35 Jahre) in Bonn, wohingegen ältere Aufzeichnungen (1973–1987) eine Blühverfrüfung der frühen Sorte um 10 Tage im Mittelmeerklima von Mostar aber Blühverzögerung um 16 Tage im kühleren Tuzla zeigten und die frühe Kirschsorte stärker vom Klimawandel betroffen war als späte Kirschsorten. Die Ergebnisse, d. h. Blühverfrüfung in kontinentalem, aber Blühverzögerung in Mittelmeerklima, werden im Hinblick auf die Spätfrostgefahr in der jeweiligen Anbauregion und möglichen Gegenmaßnahmen diskutiert.

Schlüsselwörter Apfel (*Malus domestica* L.) · Balkanstaaten · Blühzeitpunkt · Burlat · Erderwärmung · Klimawandel · Kirsche (*Prunus avium* L.) · Phänologie

Introduction

Perennial fruit crops are an ideal candidate to study the effects of climate change due to their longevity (Kunz and Blanke 2011). Prerequisites for these studies include weather and phenology data of the same cultivar at the same site for many years and the same phenology scale (Bergamaschi et al. 2008; Legave et al. 2013).

The former Yugoslavia was a major fruit growing region with long-standing stone fruit breeding in Cacak and pome fruit growing and stone fruit export e. g. of plums to Germany, CSSR and Russia. Today, in their new states, there is concern about the effect of climate change on agriculture and in particular, perennial horticultural fruit crops (Blanke and Kunz 2011) and first models were developed on the effect of climate change in agriculture (Kurtović et al. 2012; Knezević 2013).

Climate change effects are often examined specifically at one site with a long history of continuous data such as Bonn to study the local effects (Kunz and Blanke 2016; Kaufmann and Blanke 2017). Hence, the objective of the joint project between the two universities of Bonn and Sarajevo was to study the effect of climate change associated with

warmer spring temperatures on pome/stone fruit phenology, using apple as pome and cherry as stone fruit representative/model fruit and relate the findings to the inherent climate and risk of a late frost. Therefore, five sites with temperate climate were chosen with i) a mild maritime influence and predominantly Atlantic Westerly winds buffered by the river Rhine (Bonn-Meckenheim) versus ii) a temperate continental climate (Ljubljana—Slovenia), iii) a Continental climate (Tuzla—Bosnia and Herzegovina) and iv) a Sub-Mediterranean climate (Mostar—B & H) and v) temperate Continental climate at Cacak (Serbia).

Material and Methods

Fruit Crop Phenology

Phenological data of flower opening (F1—Baggiolini 1952; BBCH 61—Meier 1994) were obtained from fully grown bearing apple trees as described before (Blanke and Kunz 2009). For apple cv. ‘Golden Delicious’, 55 years of data originated from 1958 until present from Klein-Altendorf

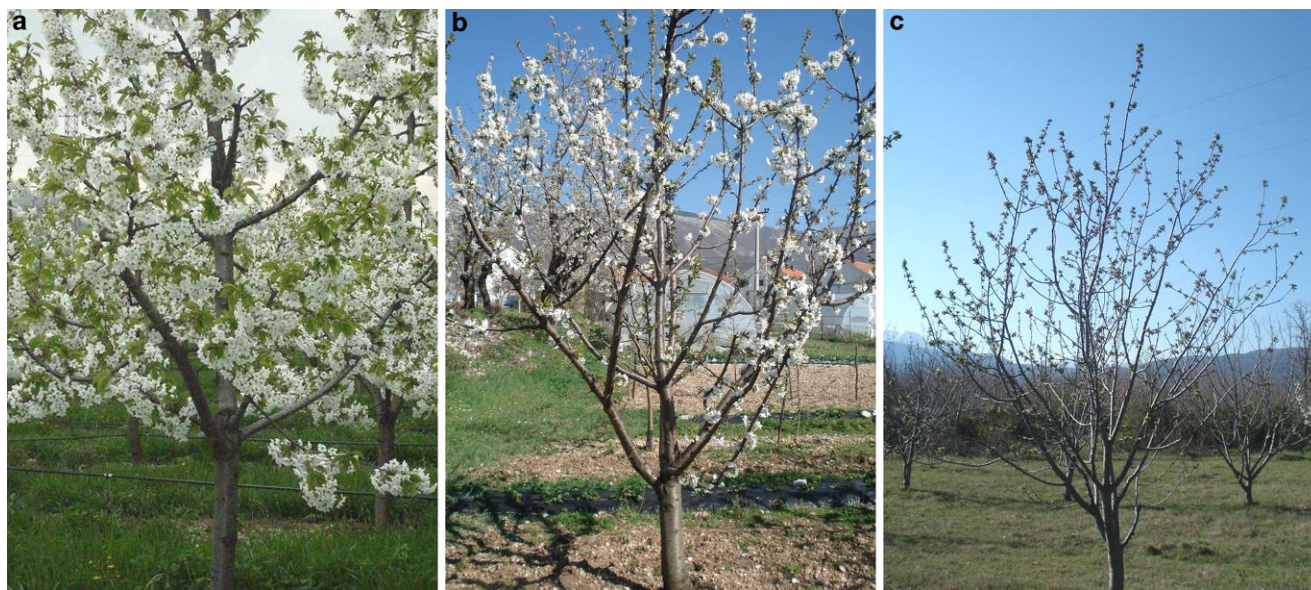


Fig. 1 Blossom of a cherry tree on Gisela 5 near Sarajewo (a), blossom of cv. ‘Burlat’ near Mostar (b) and cv. ‘Hrušt’ near Mostar (c)

(50.5 °N) and from 1962 in Cacak/Serbia (44 °N) and for apple cv. ‘Bobovec’ 1952–1999 from Ljubljana (Slovenia).

For cherry cv. ‘Burlat’, phenological data of flower opening (F1) from 1972 came from Klein-Altendorf (50.5 °N) and from 1967–2007 in Mostar (43 °N) (Fig. 1), and late cherry cv. ‘Hrušt’ from 1973–2006 in Tuzla (Table 1). Phenological records and weather data were correlated using linear curve fitting.

Locations and Their Microclimate

The concomitant weather records at Klein-Altendorf, Tuzla, Cacak and Mostar (Fig. 2; Table 1) included minimum, maximum and average air temperature in 2 m height according to international weather standards and precipitation over

the same 55 year period, measured in 1 m height in a rain gauge after Professor Hellmann.

Results

Climate Change Effects on Local Weather Pattern

Five sites were chosen with a temperate climate with a mild maritime influence and predominantly Atlantic Westerly winds buffered by the river Rhine (Bonn-Meckenheim) versus a temperate continental climate (Ljubljana, Slovenia), or Continental climate (Tuzla—Bosnia and Herzegovina, B & H), temperate Continental climate in Cacak (Serbia) and med climate in Mostar (B & H).

Table 1 Locations for the climate change comparison

Climate	Continental				Med
Station	Klein-Altendorf	Tuzla	Cacak	Ljubljana	Mostar
Climate					
Latitude	50.5 °N	44 °N	44 °N	46 °N	43.3 °N
Ann.Temp.	9.5 °C	10.7 °C	11.4 °C	11.1 °C	15.4 °C
Altitude	180 m	305 m	294 m	298 m	48 m
Climate	Temperate Continental with westerly Atlantic winds, Rhine river	Continental	Temperate Continental	Temperate Continental	Sub-Mediterranean
Phenology					
Apple and cherry data	Apple ‘Golden Delicious’ since 1958 Cherry ‘Burlat’ since 1978	Cherry ‘Burlat’ 1973–1984 ‘Hrust’ 1971–1979	Apple ‘Golden Delicious’ since 1962	Apple ‘Bobovec’ 1952–1999	Cherry ‘Burlat’ 1973–2007 ‘Hrust’ 1972–2007

Fig. 2 Location of the four selected sites in former Yugoslavia, Ljubljana in Slovenia, Cacak in Serbia and Mostar and Tuzla in B & H and Bonn/Germany

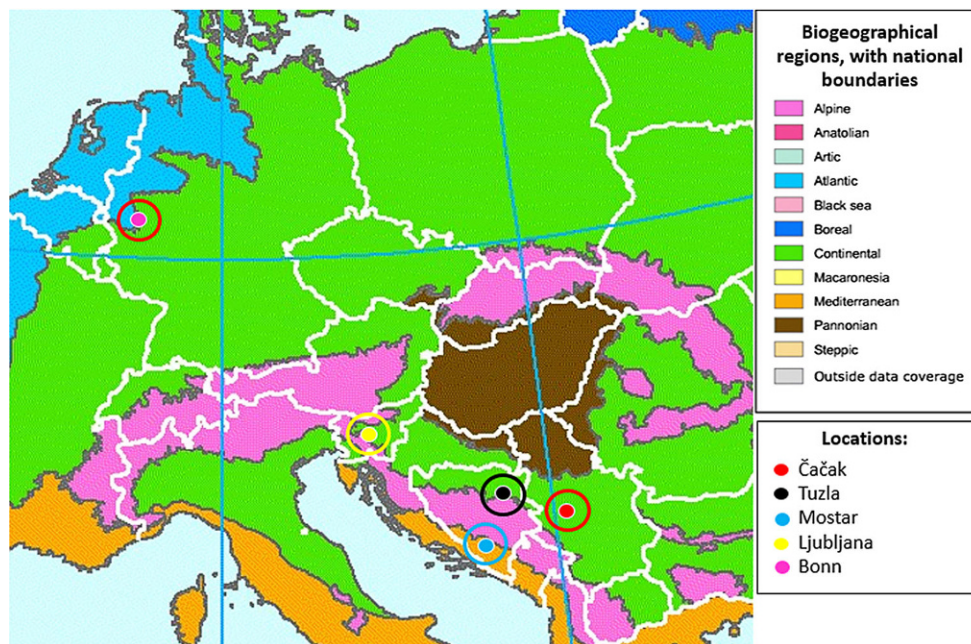
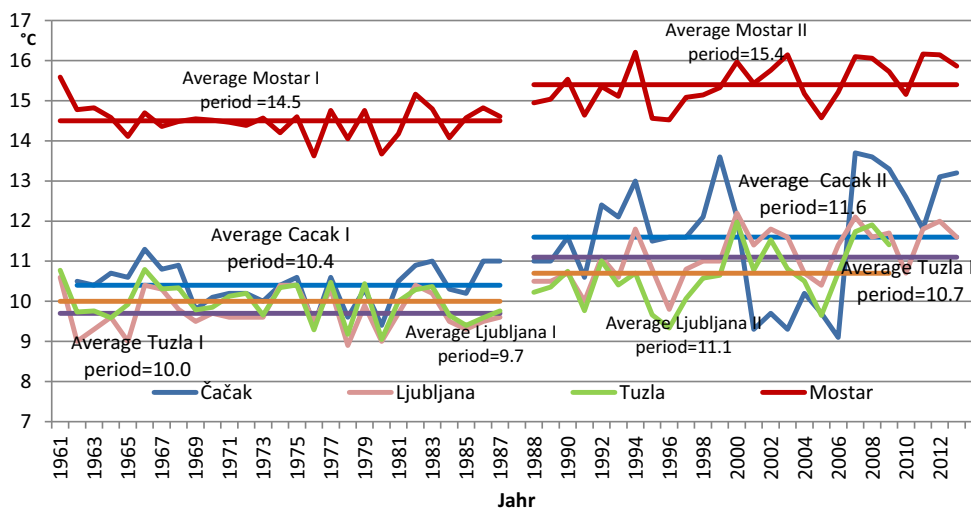


Fig. 3 The air temperature differences at 2m height in phase I (1961–1987) and in phase II (1988–2012) at Tuzla, Mostar, Cacak and Ljubljana



The climate of Bosnia and Herzegovina is strongly influenced by its geographical location (44°N) or local terrain topography; the Dinara Mountains have the most significant influence as well as the Adriatic Sea (Kurtović et al. 2012). In Bosnia and Herzegovina, the climate varies from temperate Continental climate in the Northern part along the Sava River, across the Alpine climate in the mountainous regions to the Mediterranean climate in the coastal areas of Herzegovina in the South and southeast of the country.

Temperature Rise in Tuzla and Klein-Altendorf—Differentiation of two Distinct Climate Phases

In the last 100 years (1911–2011), the average air temperature throughout all climate regions of Bosnia and Herzegovina has increased by 0.8°C in accordance with global trends, with a tendency of acceleration in the last decade 2000–2011, which was the warmest decade in the last 120 years (Hodzic et al. 2013). The quantity of precipitation depending on the specific area of Bosnia and Herzegovina shows minimal changes in the previous 100 years of maximum ±5%. But in the central mountain band, there is a trend of precipitation increase, while in South West area of Bosnia and Herzegovina there is a decrease (Hodzic et al.

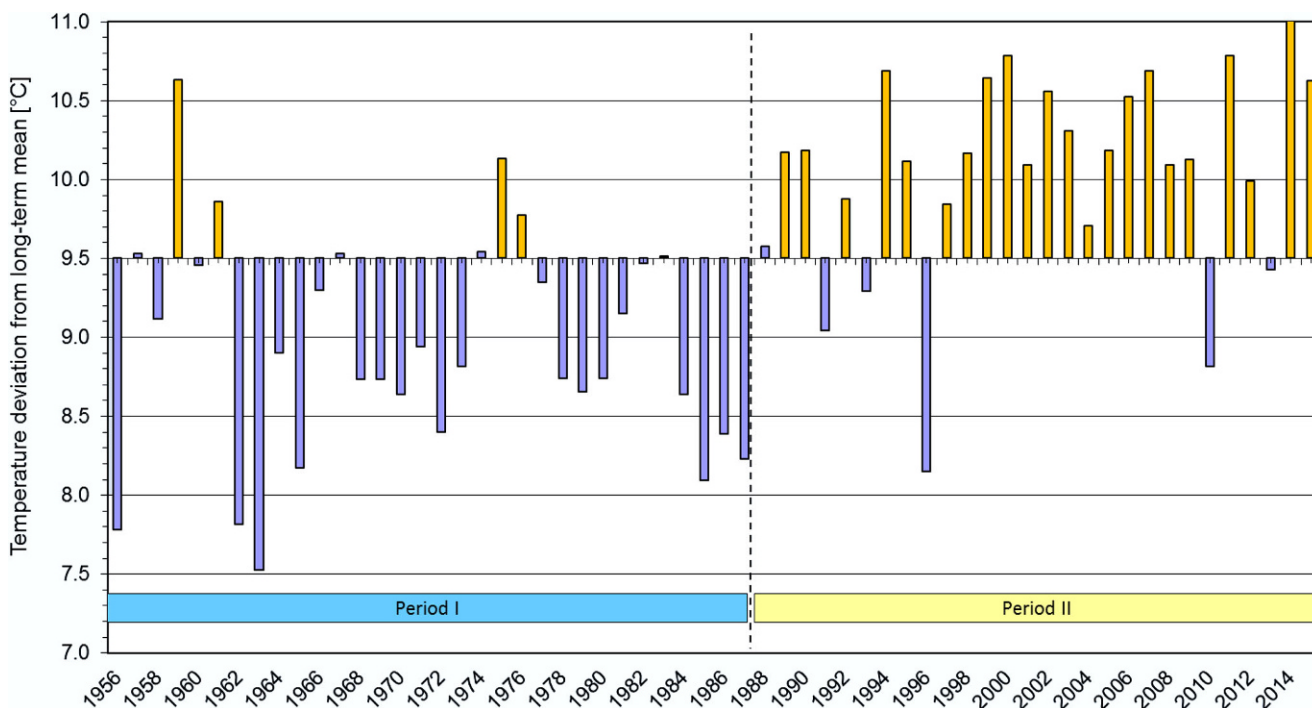
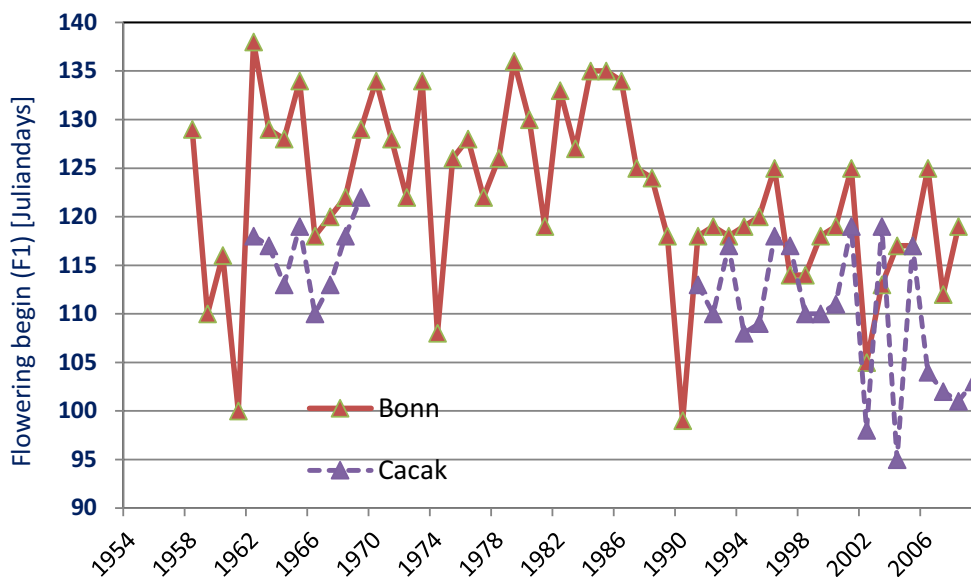


Fig. 4 Temperature differences in phase I (1956–1987) and in phase II (1988–2015) relative to the long-term, 60-year average temperature of 9.5 °C at Klein-Altendorf (2 m height). The vertical dotted line shows the deflection point or year before and after climate change

Fig. 5 Flowering (F1, BBCH 61) of apple cv. ‘Golden Delicious’ in Klein-Altendorf/ Bonn (50.5°N, Germany) and Cacak (44°N, Serbia) between 1958 and 2009

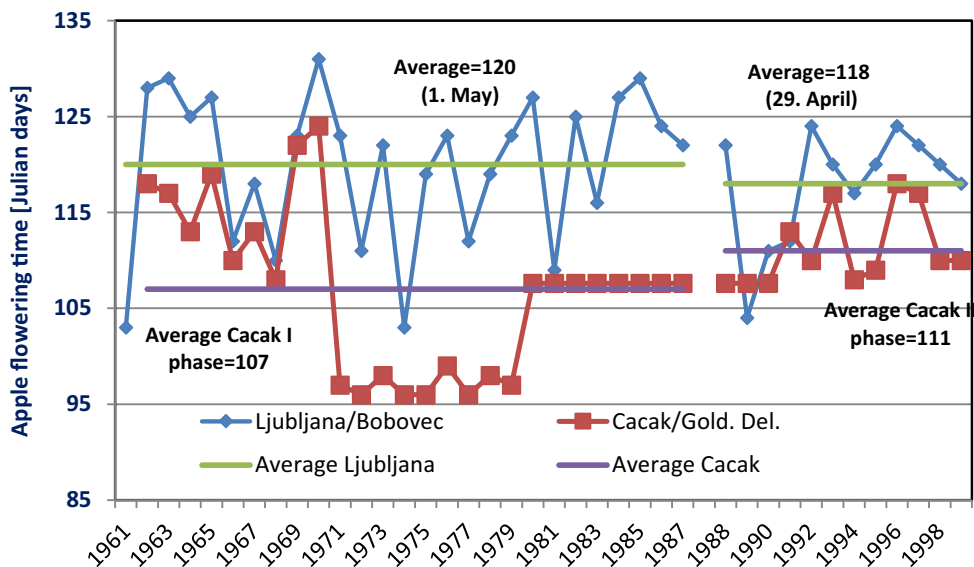


2013). Overall, variability in the weather pattern increased in all seasons including rapid changes of short periods (five to ten days) of extreme hot and cold weather conditions, drought and extremely high levels of precipitation (Custovic et al. 2013).

Fig. 3 shows the air temperature differences at 2 m height between phase I (1961–1987) and phase II (1988–2012) at Tuzla, Mostar, Cacak and Ljubljana. Over the last 52 years, the annual average of the air temperature at Tuzla, increased

from 10 °C in phase I to 10.7 °C in phase II. The annual average air temperature in phase II compared with phase I at Mostar increased from 14.5 to 15.4 °C. In Ljubljana the annual average air temperature increased from 9.7 °C in phase I to 11.1 °C in phase II. This increase at Cacak was from 10.4 °C in the first phase to 11.6 °C in the second phase. The greatest increase in air temperature was registered at Ljubljana (1.4 °C) and Cacak (1.2 °C), whereas Tuzla experienced the least increase in air temperature (0.3 °C)

Fig. 6 Flowering (F1, BBCH 61) of apple cv. ‘Bobovec’ in Ljubljana (46°N) and apple cv. ‘Golden Delicious’ in Cacak (44°N) between 1961 and 1999



with an intermediate value (0.9°C) for the warm med climate at Mostar.

Over the last 60 years, the annual average of the air temperature measured in 2 m height at Klein-Altendorf, increased from 8.6°C in 1956 to 10.3°C in 2015, using endpoints from linear curve fitting (Fig. 4). This is equivalent to an increase in air temperature of 1.7°C over the last 60 years observations and yearly averages. In the vegetation period (1 April–31 October), the average yearly temperature increased similarly from 13.7°C in 1956 to 15.2°C in 2015 over the last 60 years at Klein-Altendorf, i.e. by 1.45°C. Our calculated 1.7 and 1.45°C temperature rise for the last 60 years (1956–2015) for the annual and vegetation period, respectively in Klein-Altendorf resembles that of 1.40°C for the whole of Germany from 1955–2000 (Chmielewski et al. 2007, 2011).

Data analysis and correlation over the last 55 years showed two distinct climate phases in Klein-Altendorf, an earlier 32 year period (1958–1987) with a temperature of –0.5°C below the long-term, 55-year average of 9.5°C, followed by a ca. 28 year period of a +0.6°C temperature rise (1988 to 2015) (Fig. 4).

A comparison between phase I (1956–1987) with phase II (1988–2015) showed the largest monthly temperature increase in January, February and August with nearly +1.6°C each, followed by March, April, May and July with 1.3–1.4°C; smaller temperature rises were observed in the autumn and winter months from September–December (result not shown). The warmer winter and spring months January–April at Klein-Altendorf are responsible for the earlier bloom, which in turn explains the earlier fruit harvest.

Climate Change Effects on Pome Fruit Phenology

The flower advancement of up to 10 days for apple cv. ‘Golden Delicious’ observed at Bonn is similar or slightly less than the 10–14 days in Cacak, where an early warm period with early flowering dates in 1971–1979 was followed by a gap of records before date records resumed (Fig. 5).

Apple cv. ‘Bobovec’ from Ljubljana in phase I (Fig. 6) flowered 5 days earlier than ‘Golden Delicious’ apple from Bonn (Table 2). Comparison of the phenology data of cv. ‘Bobovec’ in phase I of Ljubljana with phenology data of cv. ‘Golden Delicious’ from Cacak in the same years showed a great difference of 13 days, which is considerably

Table 2 Advancement of the apple cv. ‘Golden Delicious’ flowering over 50 years at Klein-Altendorf (Blanke and Kunz 2011), calculated by comparing the flow-ering dates in the 20 years 1988–2007 versus the previous 30 years (1958–1987)

Period	F1 Apple flowering as calendar dates	F1 Apple flowering in Julian days
1958–1987	6 May	125 (Julian days)
1988–2007	27 April	116 (Julian days)
Days earlier flowering	10 days	10 days

Table 3 Advancement in cv. ‘Burlat’ cherry flowering over the last 35 years at Klein-Altendorf, expressed as a comparison of the period 1978–1995 versus the period 2002–2015

Period	F1 Cherry flowering expressed as calendar date	F1 Cherry flowering, expressed as Julian days
1978–1995	19 April	109.0 (Julian days)
2002–2015	14 April	104.5
Days earlier flowering	5 days	4–5 days

greater than the difference observed between Ljubljana and Bonn.

In the phase II, the difference in flowering between cv. ‘Bobovec’ from Ljubljana (Fig. 6) and cv. ‘Golden Delicious’ from Bonn (Table 2) was two days. A comparison of the phenology data of cv. ‘Bobovec’ in phase II with phenology data of cv. ‘Golden Delicious’ from Cacak in the same years showed a difference of 7 days (Fig. 6). Overall, these results indicate that in the second period decreased differences between observed apple cultivars related to the flowering stage F1.

Climate Change Effects on Stone Fruit Phenology and Cherry Flowering

Fig. 7 shows a comparison of cherry cv. ‘Burlat’ flowering at two locations in Bosnia & Herzegovina, starting with the earlier flowering in the sub-Mediterranean climate of Mostar, followed by later flowering in the continental cli-

mate of Tuzla. In these two locations, flowers of cv. ‘Burlat’ opened on average after 104 Julian days; a 10 days earlier flowering was observed in recent years at Mostar. This flowering difference of 26 days between these stations with contrasting climate is consistent with the differences in air temperature between these two stations from 1961 to 1987 (average air temperature in Tuzla was 10 °C, but 14.5 °C in Mostar).

Fig. 8 shows a comparison of a late flowering cherry cv. at two locations in Bosnia & Herzegovina, starting with an earlier flowering in the med climate of Mostar, followed by later flowering in the continental climate of Tuzla. In these two locations, average flowering of the late cherry cultivar was 100 Julian days. Up to 1988, the flowering at the warmer Mostar was 10 days earlier, whereas it was 6 days later at the cooler Tuzla (Fig. 8), resulting in 16 days difference between the two sites, which is consistent with the temperatures at these two stations from 1961 to 1987 (Fig. 3).

Fig. 7 F1 stage (flower opening) of early flowering cherry (‘Burlat’) at two locations in B & H with contrasting microclimate

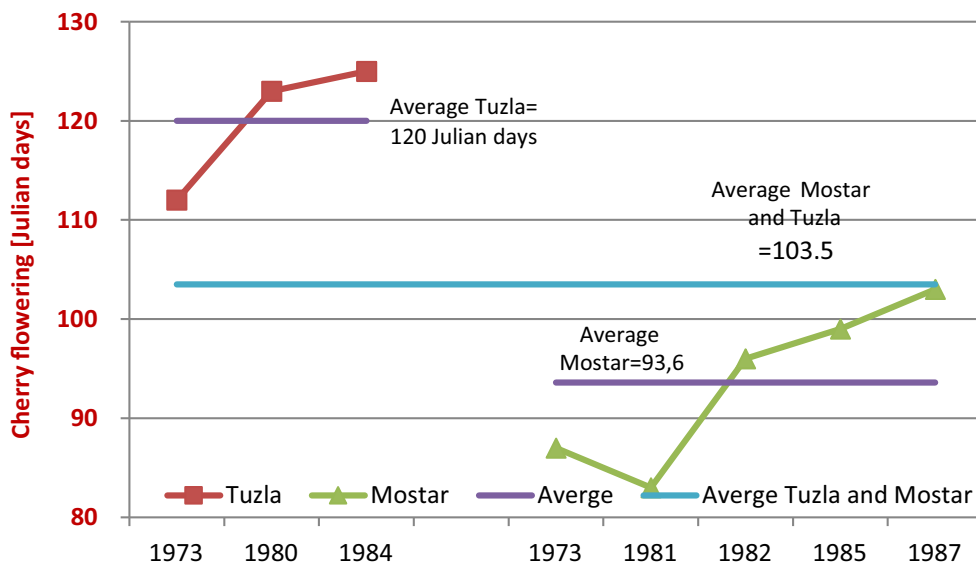
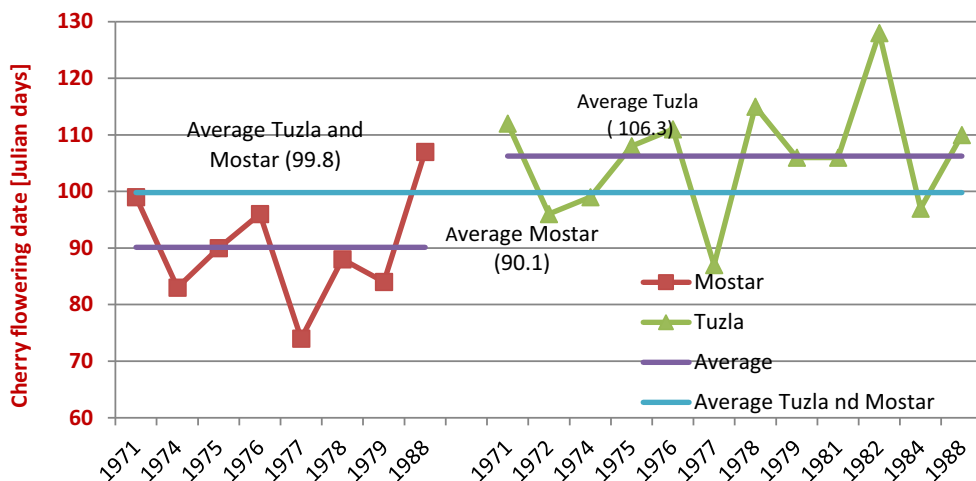


Fig. 8 F1 stage of late flowering cherry cultivars at two locations of B & H with contrasting climate



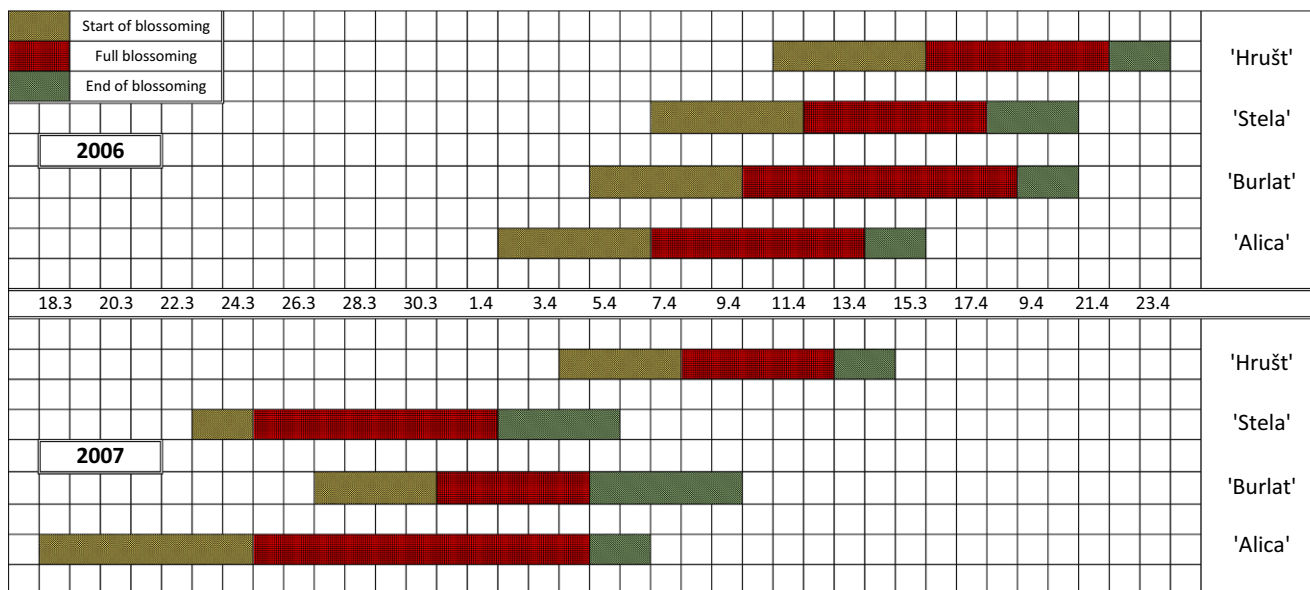
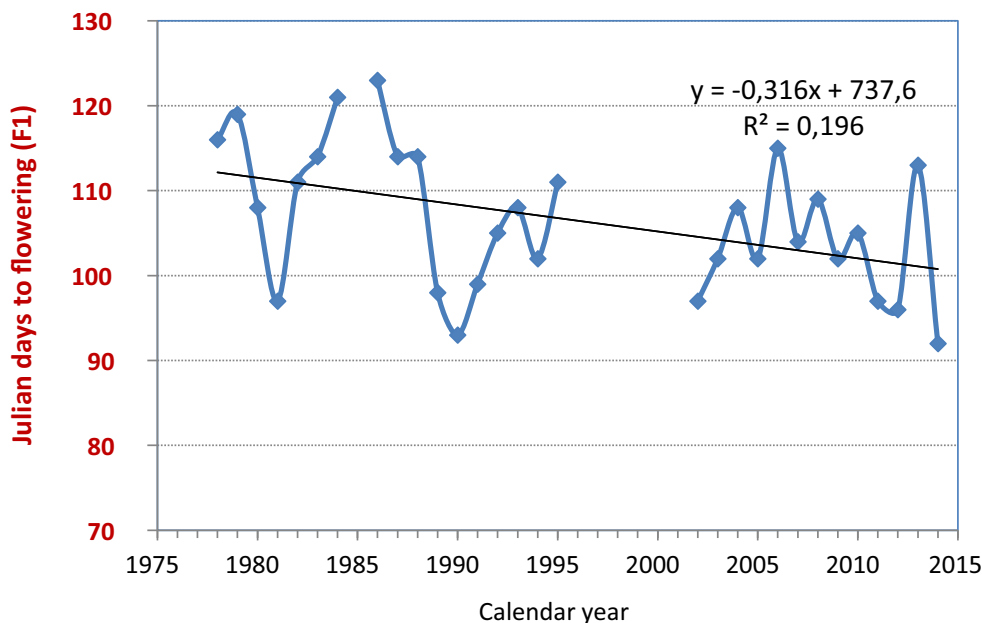


Fig. 9 Phenogram of cherry flowering in Mostar. (Adapted from Aliman and Drkenda 2009)

Fig. 10 Flowering date (F1) of cherry cv. 'Burlat' at Klein-Altendorf (50°N) since 1978 with linear curve fitting with a six-year-gap when records are missing



Regarding the data presented in Figs. 7 and 8, it could be concluded that the flowering difference between these two stations with contrasting climate or effect of climate change was greater with the early cherry cv. 'Burlat' (26 days) compared with the difference of the late cherry cultivar (16 days); these differences relate to the overall average flowering dates at Mostar and Tuzla.

Fig. 9 shows the phenology data of four cherry cultivars for Mostar. The autochthonous cherry cv. 'Alica' flowered first in both years (2006 and 2007) and cv. 'Hrušt' last. A comparison between the two years showed that the date of flowering started earlier in 2007 than in year 2006 in all four cherry cultivars. While the greatest difference in

flowering of 16 days between two years was in cv. 'Alica', the smallest difference of 6 days was obtained for cv. 'Hrušt' suggesting differences in temperature. Aliman and Drkenda (2009) reported that the year 2007 was 1.3°C warmer compared to the long-term average and 2006 was 0.4°C warmer. The greatest difference of average monthly temperature in 2006 compared with the long-term average appeared in April, which was 1.9°C colder, while in 2007, April was 4°C warmer (Aliman and Drkenda 2009).

Flowering dates of cv. 'Burlat' in the earlier years (1978–1995) was compared to the later years (2002–2015) at Klein-Altendorf (Fig. 10). An earlier flowering of 4–5 days in recent years was observed despite a short

Table 4 Critical frost temperatures of cherry

Critical temperature (°C)	Phenology stage	BBCH stage
-3.5	Flower bud swelling	52
-2.5	Bud burst	53
-2.0	Flowering	65
-1.5	End of flowering	69

6 year intermediate data gap between 1996–2001 at the beginning of climate change (Table 3). This flower advancement is less than the 10 days observed at the same site in apple cv. ‘Golden Delicious’ and others, when comparing the last 20 years with the previous 30 years (Table 2).

Risk of Frost Remains

The early flowering stages from pink bud (BBCH 57, stage E1, 620DD) to the balloon stage (BBCH 59, stage E2, 720DD) are less frost-sensitive in apple (Westwood 1999) and similarly in cherry (Table 4). In the last 20 years, the flowering stage affected by spring frost shifted towards flower opening in apple due to climate change, because these later flowering stages from flower opening (BBCH 61–67, stage 9, 760DD) are more frost-sensitive than the earlier stages (Westwood 1999) despite a remaining incidence of frost damage in the last 20 years (phase II) in Klein-Altendorf. Minimum temperatures in March and May over the last 20 years increased, but with a slight decrease in April. Hence, the risk of frost damage in April in the Meckenheim fruit growing area coincides with the flowering date now and remains, as shown on 19–20 April 2017.

Conclusions

A comparison of 60 years of weather records (and 30 years of cherry) phenology data at Klein-Altendorf and those in Tuzla (B & H) and Cacak (Serbia) showed:

1. the climate had changed in 1987/88 in Klein-Altendorf with two distinct climate phases, i. e. no change in phase I (1956–1987), but the temperature rise starting in 1988 (phase II)
2. the temperature rise in Klein-Altendorf of 1.7 and 1.45 °C in the vegetation period over 60 years is greater than in many other parts of Europe such as Sarajevo with 0.8 °C (120 years)
3. Both locations, Klein-Altendorf/Bonn and B & H showed a negligible change in annual precipitation over the last

60 years with $\pm 5\%$ in the Balkan states (Cacak—699 mm; Sarajevo—943 mm) and only $\pm 1.8\%$ at Bonn (605 mm).

4. the more severe rise in winter and spring (January to May) temperatures leads to earlier flowering, which coincides with the time of spring frost resulting in a remaining risk of frost damage to cherry flowers
5. an earlier flowering in ‘Golden Delicious’ by up to 10 days (last 55 years) in Bonn and 10–14 days at Cacak compared with 4–5 days in cv. ‘Burlat’ (last 35 years) at Bonn, but a flowering delay in the med climate of Mostar.
6. Cacak experienced an early regional climate change in 1971–1979 commensurate to the present climate change

The comparison between Bonn, Tuzla and Cacak showed the range of 4–14 days flower advancement (or delay in Mostar) throughout Europe and the relevance for future apple and cherry flower phenology monitoring.

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Conflict of interest P. Drkenda, O. Musić, S. Marić, D. Jevremović, S. Radičević, M. Hudina, S. Hodžić, A. Kunz and M.M. Blanke declare that they have no competing interests.

References

- Aliman J, Drkenda P (2009) Dynamic of blossoming of autochthonous and introduced cherry genotypes. Proceedings of 44th Croatian & 4th International Symposium on Agriculture, Opatija, pp 822–826
- Baggiolini M (1952) Stade reperes du pecher. *Revue Romande d’Agriculture. Vitic Arboricult* 4:29
- Bergamaschi M, Giovannini D, Liverani A, Sirri S (2008) Influence of climate on flowering phenology of pome and stone fruit in the Emilia Romagna, Italy. *European Hort. Congress She, Wien, 02.2008*, pp 111–112
- Blanke MM, Kunz A (2009) Misconceptions about the effects of climate change on horticulture. Proc. Benelux Horticultural Society Annual Meeting, Gembloux, 03.4.2009 (<http://www.beneluxshs.eu/index.html>)
- Blanke MM, Kunz A (2011) Einfluss des rezenten Klimawandel auf den Obstbau in Westeuropa. Climate change symposium, Bihac. Goethe-Institut, Bihac
- Chmielewski F et al (2007) Klio-Klimawandel und Obstbau in Deutschland. http://www.accc.gv.at/pdf/Klimawandel_und_Obstbau_.pdf. Accessed 4 April 2017
- Chmielewski F-M, Blümel K, Henniges Y, Blanke M, Weber RWS, Zoth M (2011) Phenological models for the beginning of apple blossom in Germany. *Meteorol Z* 20(5):486–496
- Custovic H, Tais M, Hodzic S, Ljusa M (2013) Assessment of the climate change impact on agriculture in Bosnia and Herzegovina, vulnerability and adaptation measures. Proceedings of 24th International Scientific-Expert Conference of Agriculture and Food Industry, Sarajevo, pp 12–16
- Hodzic S, Majstorovic Z, Bijedic A (2013) Global climate changes in the territory of Bosnia and Herzegovina and their impact on agriculture. Proceedings of 24th International Scientific-Expert Conference of Agriculture and Food Industry, Sarajevo, pp 27–32

- Kaufmann H, Blanke MM (2017) Performance of three numeric models to assess chilling—a case study with cherry for Germany. *Reg Environ Change* 17:1–9
- Knezević A (2013) Strategy of adaptation to climate change and low-emission development for Bosnia and Herzegovina. www.ba.undp.org/content/dam/.../CC%20LAT%20publish%20on%20WEB.pdf. Accessed 15 March 2017
- Kunz A, Blanke MM (2011) Effects of global climate change on apple cv. ‘Golden Delicious’ phenology—based on 50 years of meteorological and phenological data in Klein-Altendorf. *Acta Hort* 903:1121–1126 (Proc. 9th Intl. Congress on ‘Environmental Physiology and Orchard Systems’, Geneva, New York, USA, August 2008, 2 volumes, Robinson, T.C. and A.N. Lakso (eds))
- Kunz A, Blanke MM (2016) Effects of climate change on fruit tree physiology—based on 55 years of meteorological and phenological records at Klein-Altendorf. *Acta Hort* 1130:49–54. <https://doi.org/10.17660/ActaHortic.2016.1130.7> (Proc. Int. Hort Congress IHC Brisbane, Aug. 2014, Queensland, Australia (eds. S. Tustin et al.))
- Kurtović M et al. (2012) Fruit regionalization in the Federation of Bosnia and Herzegovina. http://fmpvs.gov.ba/upload_files/1440616881-361_1201_1813_b.pdf. Accessed 3 March 2017
- Legave J-M, Blanke MM, Christique D, Giovannini D, Matthieu V, Oger R (2013) A comprehensive overview of the spatial and temporal variability of apple bud dormancy release and blooming phenology in Western Europe. *Int J Biometeorol* 57:317–331
- Meier U (1994) Phänologische Entwicklungsstadien des Kernobstes (*Malus domestica* Borkh. und *Pyrus communis* L.), des Steinobstes (*Prunus*-Arten), der Johannisbeere (*Ribes*-Arten) und der Erdbeere (*Fragaria x ananassa* Duch.). *Nachrichtenblatt des Deutschen Pflanzenschutzdienstes*, 46, pp 141–153
- Westwood NM (1999) *Temperate zone pomology*, 3rd edn. Timber Press, Portland
- Kurtović M et al (2012) Fruit regionalization in the Federation of Bosnia and Herzegovina. http://fmpvs.gov.ba/upload_files/1440616881-361_1201_1813_b.pdf



Pakeza Drkenda After the Yugoslav wars Ms. Pakeza Drkenda spent her Sabbatical leave at the ACS Agroscope Wädenswil in Switzerland where she was promoted to work on Thinning and Fruit Quality in Plums. Within the scope of her duties Ms. Pakeza Drkenda worked on improving fruit quality of plums, wax bloom and quality and maturity criteria of plums. Today, Prof. Drkenda is Vice Dean for Research at the University of Sarajevo and she manages the Fruit Tree Research in Bosnia and Herzegovina. Her main research areas include, inter alia, new cultivation systems for raspberries, health-promoting ingredients of fruits and vegetables and Cornelian Cherry about which she writes an article which was received and published in *Erwerbs-Obstbau* in the 2014. In the summer of 2014, Prof. Drkenda, with the support of the DAAD, spent a short sabbatical leave at the University of Bonn, where she creates the first Draft of this article.