THE VARIABILITY OF HEAT WAVES AND DRY SPELLS IN THE FLAT AND MONTAINOUS REGIONS OF AUSTRIA

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Abstract. Based on quality checked time series of daily maximum temperature and 24h precipitation sums, heat waves at 12 stations up to an elevation of 800m and dry spells at 30 stations up to 3000m in Austria over the past 50 years were calculated and analysed. The analysis of the frequencies of heat waves and dry spells showed very differentiated results, because local environmental effects can partly compensate the given dependence on elevation. Since the 1950ies the number of hot days has increased. The largest increase (~25 days) occurred in regions of lower elevation, but an increase of 1 to 2 days can also be observed at elevations of about 700m above sea level. The variability of the number of dry spells is dependant on the location, on the duration of the period and on the season. Only the autumn season can be seen as consistent for the whole country concerning the decreases in the frequency of occurrence of dry spells lasting almost 10 to 30 days. As a result, the well known "*Altweibersommer*" is not to happen with the same reliability nowadays than in former times.

Keywords *– Austria; Heat Waves, Hot Days, Drought, Dry Periods, Dry Spells*

1. INTRODUCTION

In large parts of Central Europe, the year 2003 was characterized by extraordinary heat and an exceptional lack of precipitation (Schär et al., 2004). This was the motivation, to carry out the present study, discussing the variability of heat waves and dry spells in Austria starting in the mid 20th century.

2. DATA

The subset of suitable stations was selected from the quality and homogeneity checked dataset prepared in the frame of the StartClim1 project (Schöner et al., 2003). This dataset comprehends time series of daily maximum temperature and 24h precipitation sums of 71 stations in Austria for the years 1948 to 2003. The selection criteria contained the elevation above sea level, the start of the time series, homogeneity and the completeness of the time series. As a result, only 12 stations remained for the analysis of heat waves and concerning dry spells, 30 stations proved to be suitable for the analysis (see Fig. 1).

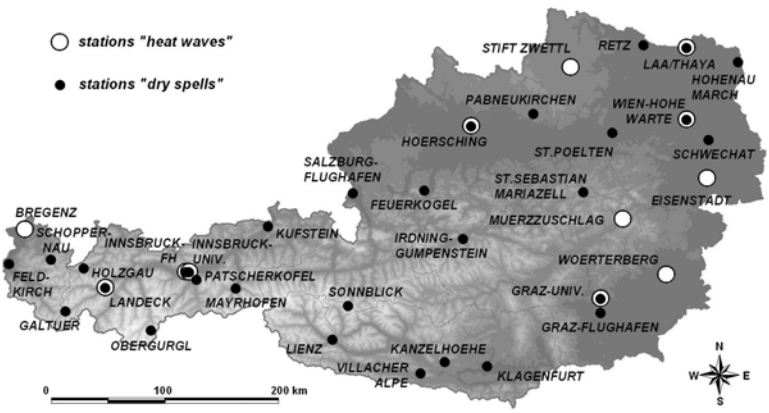

Figure 1: Spatial distribution of stations suitable for the analysis of heat waves and dry spells in Austria

3. METHODS AND RESULTS

3.1. Variability of Heat Waves

Heat waves in Austria were analysed by using the following, modified definition of Kyselý for the timeframe 1948 to 2003: *3 consecutive days must show a daily temperature maximum of at least 30°C, the maximum of each following day must not fall below 25°C and the mean temperature maximum during the whole period does not fall below 30°C.*

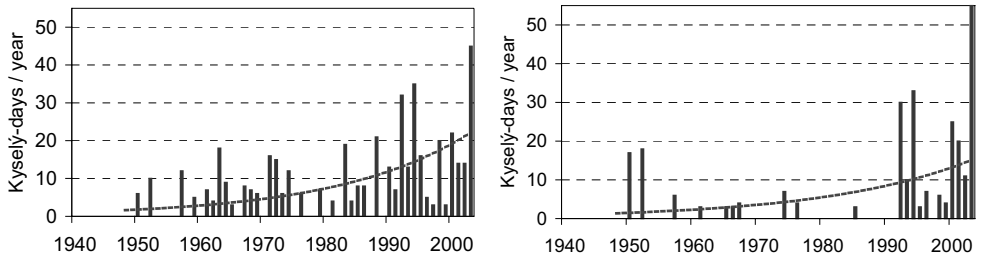

Figure 2. Time series of the annual number of Kyselý-days for the stations Wien-Hohe Warte (left) and Graz-University (right)

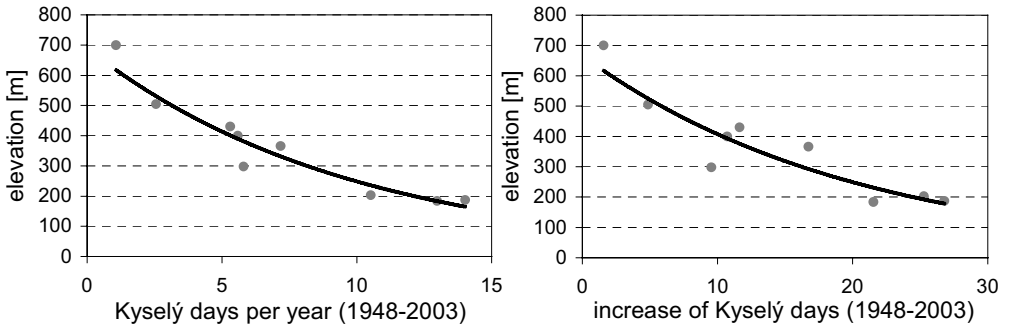

Figure 3. Dependence of hot days according to Kyselý on elevation during 1948 to 2003 (left) and their increase between 1948 and 2003 in dependence on elevation (right) in the North, East and South-East of Austria on the basis of daily temperature maxima

As can be seen in Figure 2, the yearly number of hot days under the terms of Kyselý has increased since the mid 20th century, while the largest increase occurred in the flat regions (~25 days at 200 m, ~6 at 500 m and 1 to 2 at 700 m asl, Fig. 3.). Regarding the whole data collective, the year 2003 is the year with the most days meeting the Kyselý criteria. Also with respect to the duration of heat waves, at the majority of stations the longest one was recorded 2003 (see Table 1).

Table 1. Maximum durations of heat waves 1948-2003.

		summer (year)			spring			autumn		
station	[m asl]	duration	from	to	duration	from	to	duration	from	to
Laa an der Thaya	187	32	08.07.95	08.08.95				7	04.09.73	10.09.73
Eisenstadt	184	29	02.08.03	30.08.03				8	03.09.73	10.09.73
Wien-Hohe Warte	203	29	02.08.03	30.08.03				6	04.09.73	09.09.73
Graz-Universität	366	28	02.08.03	29.08.03	4	06.05.03	09.05.03			
Wörterberg	400	28	02.08.03	29.08.03				3	06.09.73	08.09.73
Hörsching	298	27	03.08.03	29.08.03						
Innsbruck-Universität	578	20	23.07.94	11.08.94	5	05.05.03	09.05.03			
Stift Zwettl	505	18	25.07.94	11.08.94				3	05.09.73	07.09.73
Innsbruck-Flughafen	579	17	17.07.83	02.08.83	5	05.05.03	09.05.03	5	16.09.61	20.09.61
Landeck	798	17	17.07.83	02.08.83	4	17.05.53	20.05.53	9	16.09.61	24.09.61
Bregenz	424	11	04.08.03	14.08.03						
Mürzzuschlag	700	7	10.08.03	16.08.03						

3.2. Variability of Dry Spells

The definition of a dry spell used within this study is given by a *period of at least 10 consecutive days without precipitation to a threshold of 1 mm in 24 h*. Periods with an uninterrupted duration of such days were enumerated for 30 stations, classified in frequencies from 5 to 5 days and allocated to the single seasons. Periods, that matched two seasons, were allocated to the season with the majority of dry days.
Regarding the frequency of dry periods, it can be determined in general, that: about one third of the stations shows a rising trend (mainly situated in the East and Northeast), one third has a downside trend (mainly in the mountainous Western part), while the rest of the stations does not show any trend (see Fig. 4). In detail however, the single stations give a more complex view. The variability of the frequency of dry periods is highly dependent on local circumstances, on the duration of the period and on the season. Only the autumn season can be seen as consistent for the whole country.

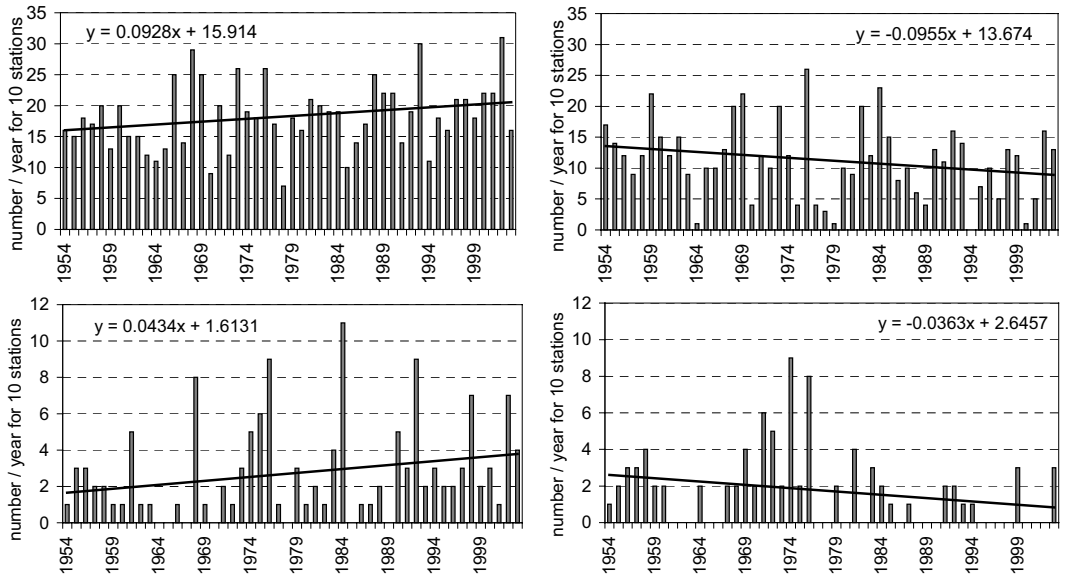

Figure 4. Time series of dry periods with durations of certain minimum thresholds (top: 10 days, bottom: 20 days) in Austria. left: sum of 10 stations with upward trend, right: sum of 10 stations with downside trend. Single values and linear trend 1954 to 2003 without taking into account the seasons.

Seasonal differentiation: Regarding *springtime*, there is no explicit change or trend to prove. Also, the spatial distribution of the stations does not show regional patterns of increase or decrease, there are solely remarkable accumulations of dry periods in single years. In the *summer* season, for two-third of all stations a tendency to an increase of dry periods with a duration of at least 10 days can be detected. Concerning dry periods with a longer duration of 20 days and more, the eastern part of Austria between Lienz and Hohenau an der March shows a slight increase of the frequency.

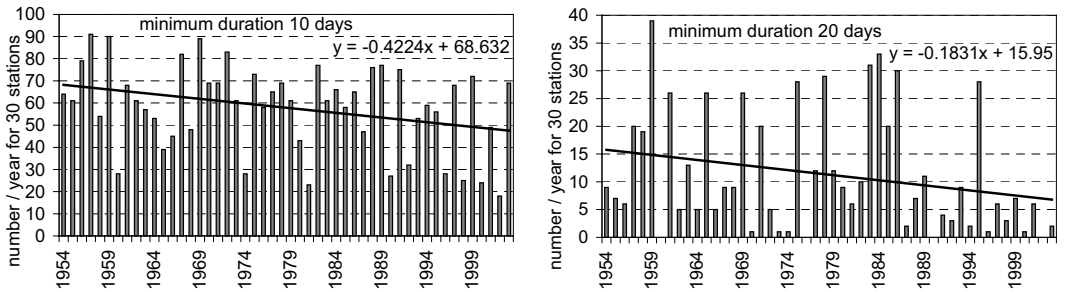

Figure 5. Time series of dry spells of certain minimum durations in Austria in autumn (sum of 30 stations). Single values and linear trend 1954 to 2003.

In contrast to the other seasons, dry periods in *autumn* show a nationwide decrease of durations with at least 10 and 20 days (see Fig. 5). Those typical periods of fine weather („*Altweibersommer*“) are not that numerous nowadays then they were during the 1950ies and 1980ies.The *winter* is the season for which dry spells are to be expected most frequently: one time per year and station with a duration of 10 to 14 days, every second year with a duration of 15 to 20 days. As special years with accumulations of dry events the years 2003 (52 events with at least ten days for the whole station sample) respectively 1983 (6 events with at least 20 days) were identified. Dry periods with a duration of at least 30 days occurred in the year 1959. The longest dry spells so far (more than 80 days in the South of Austria) occurred in winter. Particularly around the year 1990, an accumulation of dry winter days occurred. A positive trend for the durations of at least 10, 20 and 30 days can be determined for two-third of all stations, but without observable regional patterns. Due to the great year to year variability the trends are not statistically significant.

4. CONCLUSIONS

The frequency of *heat waves* is highly related to (and also limited by) the altitude, but also influenced by local effects. Since the mid 20th century the number of days with heat have increased remarkably in the low elevation regions of Austria and can be identified up to 800 m above sea level. Concerning the variability of *dry spells*, changes depend on the location, on the season, as well as on the lengths of the dry spells. For shorter periods (10 to 14 days); an increase in the flat eastern and north eastern regions is accompanied by a decrease in the mountainous parts of the western regions. The number of dry spells in autumn shows a pronounced, nationwide decrease since then, the former typical fine weather periods in autumn have become scarcer.

Besides the presented results, the investigation showed an urgent *need for further research* in respect to:

1 Development of methods for the homogenisation of daily data,
2 enlargement of the number of stations with daily temperature and precipitation data and
3 extension of the 50 years dataset to centennial ones.

To overcome a greater part of these deficiencies will be the Austrian contribution to the FORALPS project within the frame of INTERREG IIIB Alpine Space (Pj Nr. I/III/3.1/21) which has already started and will last until the end of 2007. http://www.unitn.it/foralps/index.htm

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