DIURNAL PRECIPITATION CYCLE OVER AUSTRIA AND ITS RELATIONSHIP WITH OROGRAPHICALLY INDUCED CIRCULATIONS

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Abstract: Diurnal precipitation patterns over Austria were analysed for different seasons. This study is based on data from the automatic station network. 132 stations were available for this analysis. It was observed that the diurnal precipitation over Austria exhibits systematic regional patterns and seasonal cycles reflecting the intensity and timings of the convective precipitation. The precipitation was found to be influenced by orographically-induced circulations.

Keywords: *convection*, *diurnal precipitation cycle, orographically-induced circulations, Austria*

1. INTRODUCTION

1.1 Motivation

A back trajectory clustering method was developed to identify synoptic patterns associated with heavy precipitation in Austria (Seibert et al., 2007). Extending this work from daily precipitation sums to accumulation intervals from 12 to 48 hours, we had to prepare the specific data required. The data base for this purpose are twice-daily precipitation observations at the climate stations of the Austrian Meteorological Service (ZAMG). They are performed at 7 and 19 CET (Central European Time) daily, giving two 12-hour intervals per day. However, before 1971 the evening observations was carried out at 21 CET. In order to estimate the 7-19 CET precipitation values from available 7-21 CET and 21-7 CET data, we studied the fraction of the 7-21 CET precipitation falling between 19 and 21 CET. This produced some interesting results encouraging us to further expand the study to the whole diurnal cycle of precipitation.

1.2 Aims

The aim of this paper is to analyse the diurnal variation of precipitation for different seasons in Austria and the effects of the regional topography on the diurnal cycle. The precipitation distribution over Austria depends on two major factors:

1. Synoptic scale weather systems (especially from the Adriatic Sea and the North Atlantic Ocean)
2. Complex topography and related thermal circulations (Whiteman, 2000)

Austria is mainly a mountainous country due to the presence of Alps as shown in Fig. 1. Different synoptic patterns affect the precipitation in Austria (Seibert et al., 2007). The precipitation in southern region of the Alps is mainly affected by the southerly flow bringing the humidity of the Mediterranean sea. The areas north and west of Alps receive precipitation mainly due to the northwesterly and westerly winds. The so-called Vb pattern taking up the humidity from the Adriatic sea on its way, causes much precipitation in large parts of Austria. Convective precipitation, which is relevant all over Austria, has a pronounced seasonal cycle.

2. DATA AND METHOD OF ANALYSIS

This study is based on data from the automatic station network built up in the last 20 years by the Austrian national meteorological service (ZAMG) and a few stations with longer records of hourly precipitation data. The minimum availability per station was set to five years. 132 stations were available for the analysis. The stations cover the whole territory of Austria and include some mountain stations as well.

Two types of measures were taken for the analysis:

1. The mean value of precipitation per hour was calculated for each season.
2. Relative values of precipitation per hour were calculated for each season, if the total daily precipitation exceeds the threshold of 1 mm. For this case the actual precipitation fraction was calculated as precipitation amount of one hour divided by that of the whole day (07-07 CET). It was then normalized by the hypothetical amount of precipitation falling in one hour for the case of a stationary precipitation falling

throughout the day. This means that the actual precipitation fraction was divided by (1/24) and then multiplied by 100 to give percent.

These calculations were done for mean of all the stations in Austria and also for some selected stations in different regions. As the stations chosen are not uniformly distributed across Austria, it is expected that the results may show a certain bias towards the regions having more stations.

3. RESULTS

3.1 Mean over Austria

The mean hourly precipitation exhibits characteristic seasonal variations. Figures 3a and 3b depict the average and normalized precipitation for each hour of the day for the average of all stations in Austria. As expected, the winter season is relatively dry and summer is associated with the highest precipitation. The diurnal amplitude of precipitation has its maximum in summer and almost vanishes in winter. Due to the influence of the sub-tropical high in summer, weak pressure gradients prevail and high amount of solar radiation are received making the summer season ideal for late afternoon convective showers and thunderstorms, hence the high summer amplitude. The amplitude is much less in spring due to the higher amounts of cloud cover. The autumn and spring amplitudes of the relative values lie close together (Fig 3b). A secondary maximum is observed in early morning in all seasons, most prominent in winter, for which we do not have an explanation yet.

In summer, the highest values of precipitation occurs between 16-19 CET corresponding to the normal diurnal cycle of convection. The precipitation maximum occurs later in spring (18-21 CET) than in autumn (17-19 CET) because of the longer duration of the day in spring.

3.2 Regional Characteristics

The station Litschau (Fig. 4) is located in northern Austria at 560 m asl in hilly terrain, far apart from the Alps. The amplitude and phase of the diurnal cycle of precipitation in this case thus reflect the diurnal cycle of convection not modified by thermal circulations as found in mountain areas. In summer the amplitude is largest and the maximum occurs around 19 CET. The amplitudes are similar in spring and autumn.

Warth (Fig. 5) is located in Vorarlberg near the Lech river at a height of 1475 m asl. The precipitation amplitudes (summer amplitude 0.7 mm/h) are higher in all seasons than the averaged precipitation over Austria (Fig. 3), due to the orographic effects (convergence of the thermal circulations over the mountains). The summer maximum occurs in the early evening (17-19 CET), whereas the spring (19-21 CET) and autumn (18-21 CET) maxima occur later. This could be attributed to the stronger intensity of the thermal circulation in these seasons.

St. Veit im Pongau (Fig. 6) is located in the Central Alps at a height of 750 m asl. This station behaves similar to Warth. Due to the thermal circulations, the precipitation amplitudes (summer amplitude 0.6 mm/h) for all seasons are higher than the amplitude of averaged precipitation over Austria. The summer maximum occurs in the early evening (18-20 CET), whereas the spring (18-20 CET) and autumn (19-21 CET) maxima occur later. The summer maximum is broader and later than at Warth. This may have to do with the location in the Central Alps and the longer reaction time of the wind system in the large Pongau-Pinzgau valley.

The station Eisenkappel (Fig. 7) is located in the Southern Alps at 623 m asl. The higher amplitudes of the precipitation can be attributed to the thermal circulations in the mountains. A shift in the phase to earlier hours, as compared to the other Alpine stations, in the evening appears in summer (16-17 CET) and spring (15-16 CET) for this site. This is due to its location in small detached mountain range (see Fig. 1) where the valley wind circulation reacts more quickly then in the larger Alpine valleys and thus shift the maximum to earlier times.

The very late occurrence of the precipitation maximum in autumn (20-23 CET) is striking. As it occurs mainly in autumn, it is obviously linked to southerly air flows advecting moist and unstable air masses from the Adriatic Sea. This pattern is responsible for heavy precipitation events in this region (Seibert et al., 2007). It seems that under such conditions the convective activity can extend long into the night.

4. CONCLUSIONS

The diurnal precipitation cycle averaged over Austria mainly reflects the diurnal convective cycle. The maximum amplitude lies in summer. The spring and autumn curves are similar, whereas in winter there is almost no diurnal precipitation cycle. The higher amplitude of precipitation at stations inside the Alps reflects the modifications of precipitation through convergence of thermal circulations.

The stations located within the Alps, e. g., St. Veit im Pongau and Warth, have higher amplitudes of the diurnal cycle of precipitation compared to the ones located away from the influence of Alps, e. g., Litschau. The maximum at the Alpine stations is broader and higher because of the influence of the thermal circulations. At Eisenkappel, we found indications of the faster reaction of the thermal wind system in a smaller mountain range. In autumn, convection continues late into the night probably due to the advection of moist and unstable Adriatic air masses in this location in the southern Alps.

The next step will be to identify regions with similar diurnal precipitation patterns, for which cluster analysis will be applied. Also the precipitation curves of the stations will have to be smoothed out, considering the different lengths of observation series.

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REFERENCES

Seibert, P., A. Frank, and H. Formayer (2007): Synoptic and regional patterns of heavy precipitation in Austria. *Theor. Appl. Climatol.*, **87** (1-4), 139-153, DOI 10.1007/s00704-006-0198-8.

Whiteman, D. C. (2000): Mountain meteorology. Oxford University Press.

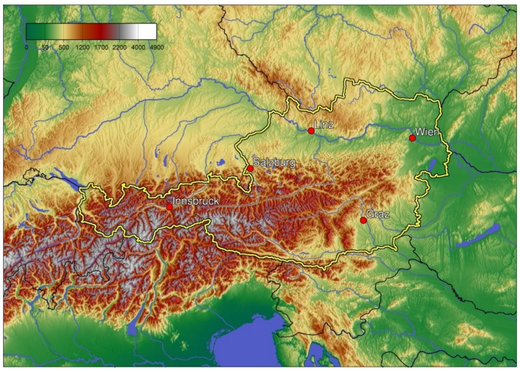

Figure 1: Topography of Austria

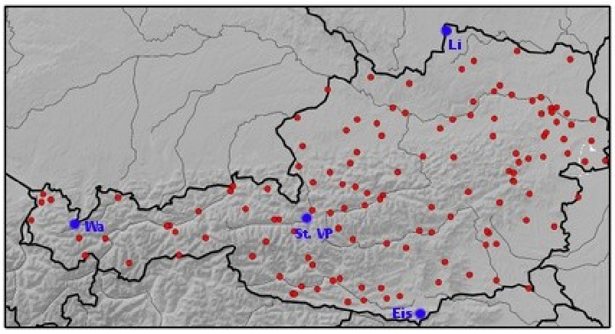

Figure 2: Weather stations used. The stations discussed in detail are highlighted in blue: Warth (Wa), St. Veit im Pongua (St. SP), Eisenkappel (Eis) and Litschau (Li)

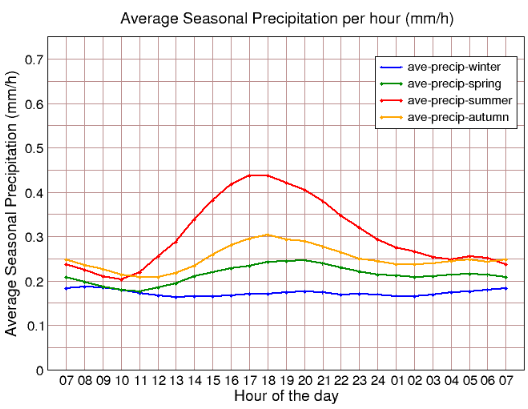

Figure 3a: Average precipitation per hour (mm/h) for different seasons.

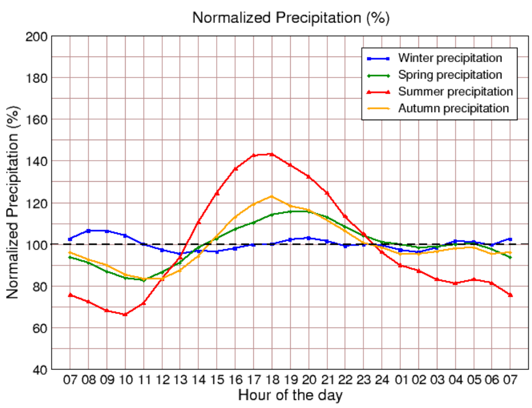

Figure 3b: Normalized precipitation per hour (%) for different seasons, as defined in the text (Section 2).

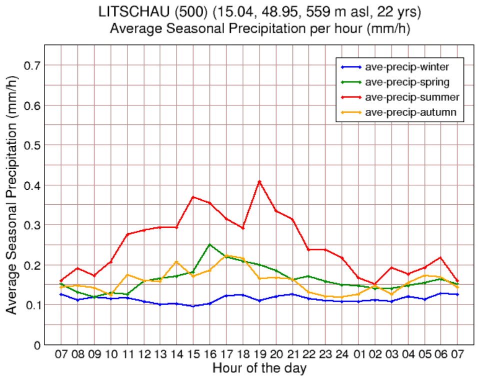

Figure 4a: Average precipitation per hour (mm/h) for different seasons for Litschau.

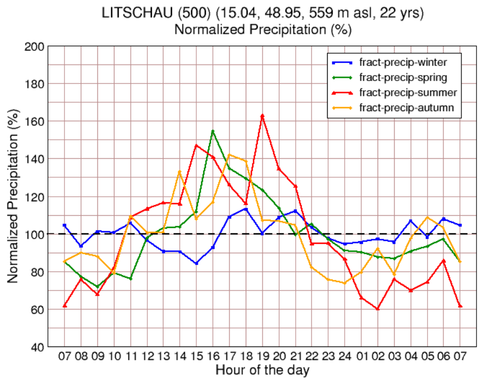

Figure 4b: Normalized precipitation per hour (%) for different seasons for Litschau.

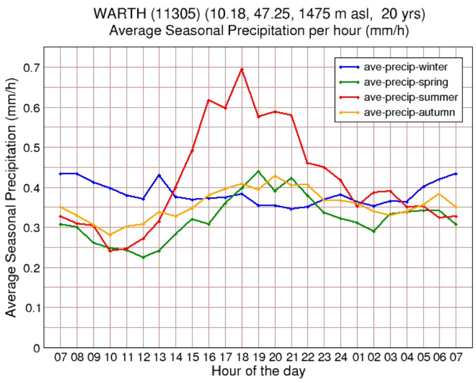

Figure 5a: Average precipitation per hour (mm/h) for different seasons for Warth.

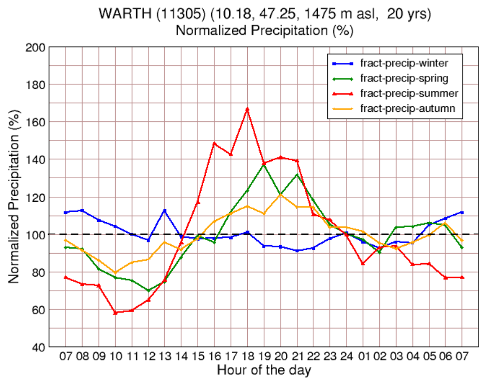

Figure 5b: Normalized precipitation per hour (%) for different seasons for Warth.

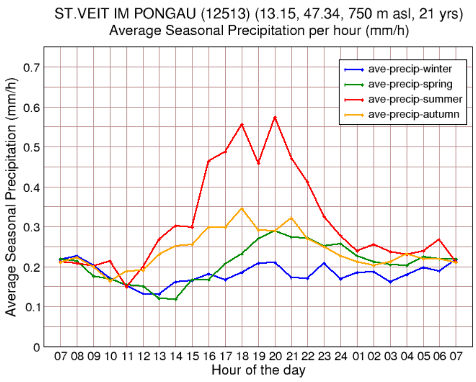

Figure 6a: Average precipitation per hour (mm/h) for different seasons for St. Veil im Pongau.

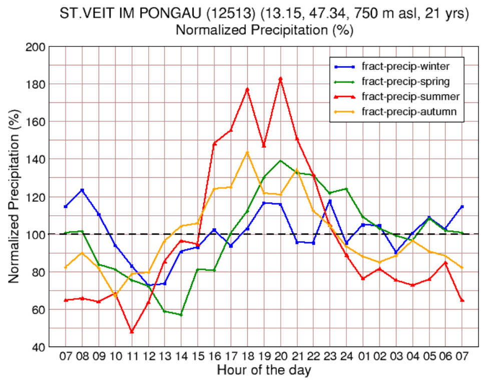

Figure 6b: Normalized precipitation per hour (%) for different seasons for St. Veil im Pongau.

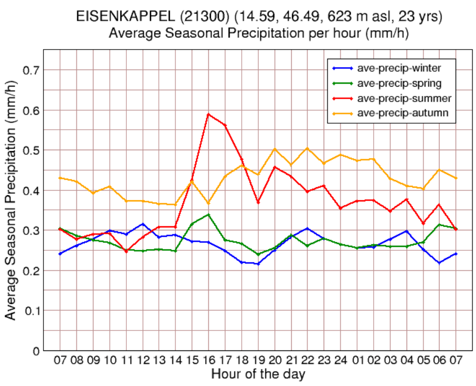

Figure 7a: Average precipitation per hour (mm/h) for different seasons for Eisenkappel.

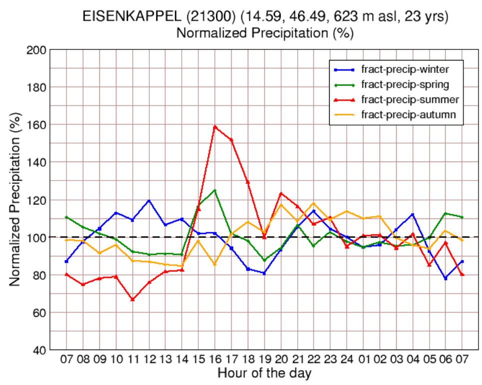

Figure 7b: Normalized precipitation per hour (%) for different seasons for Eisenkappel.