Average Diurnal Temperature Devolution for Different Weather Situations - a Prognostic Aid for Regions with Complex Topography

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Introduction

The air temperature and the amount of clouds are the most important meteorological parameters determining the condition of a road. In most cases the amount of clouds can be well estimated by the regional weather forecast models. The temperature shows larger differences between different locations, because it is a product of several elements, for example the altitude. Temperature also varies between day and night considerably.
The diurnal devolution of temperature in mountainous regions is dependent from the location of the measuring station. Especially in the winter season, when the position of the sun is low, the exposition has a great influence to the temperature. On sunny days in the afternoon a south faced slope is about 3 or 4 degrees warmer then a north faced slope. The steepness of a valley is even more important. In narrow steep valleys the night is very less cold then a flat opened valley. Another important factor is the tendency to fog conditions. When a station is situated near a river or a lake, there are more days with fog than in other locations, especially with anticyclonic weather situations. Also, if the weather is determined by strong winds, temperature and other climatic elements would have large variations between different stations, because the mountains induce Foehn- and barrage effects.

The study region

The region of this study is the canton Lucerne in the centre of Switzerland. Its size is about 1400 qkm. The altitude of the stations differs between 400 and 800 m.a.s.l.. 3 different stations were choosen:

1. Wiggen
2. Rickenbach
3. Weggis

Wiggen has an altitude of 800 m. a. s. l. in a flat, open valley. During the night on clear sky conditions there is a strong inversion or in other words a regional lake of cold air. On the other hand, fog occures very rarely. Rickenbach is situated on 700 m. a. s. l. or 250 or 300 meters above the deepest locations of the canton Lucerne. The terrain of this station is rather sloped. Therefore, inversions are in the most cases inexistent. The altitude of the station Weggis is 450 m. a. s. l. The lake of Lucerne is situated only several 100 meters from this station. Due to the higher humidity in the air, fog is very common, but temperature inversions are weakened by the influence of the lake.

The climatic differences

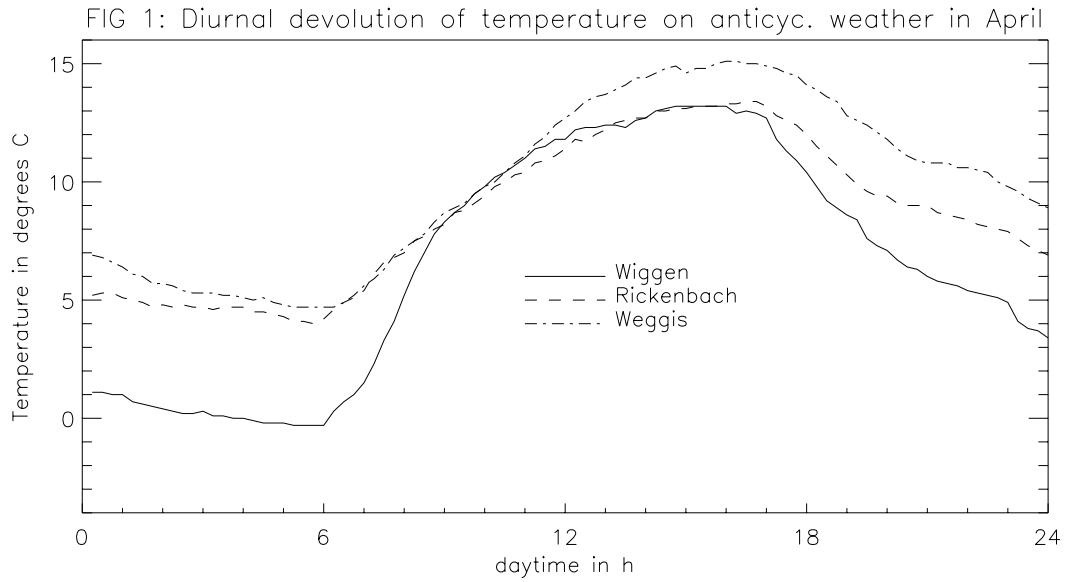
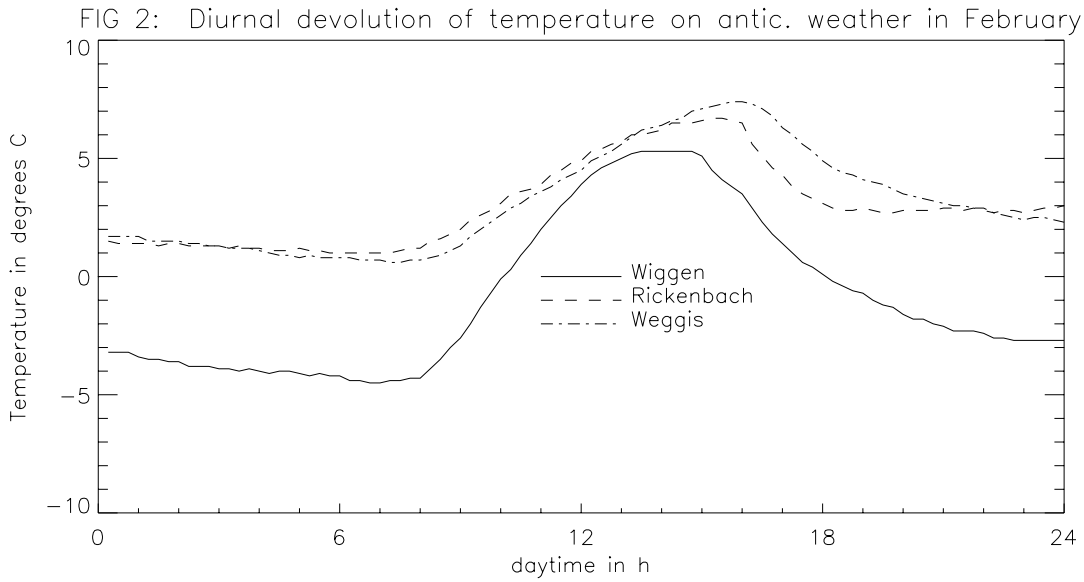


FIG 1 shows the temperature devolution on high pressure conditions in April. Due to the high positive net radiation during the day, the temperature arises strongly until the afternoon. The temperature amplitude decreases with altitude, because stations at higher altitudes are better ventilated. So Weggis shows the higher diurnal temperature variation than Rickenbach. Especially in the afternoon, when the atmosphere is well mixed, Rickenbach is cooler than Weggis. At night the difference is rather small, because at night the atmosphere is more stable due to the large outgoing long wave radiation of the earth surface. Wiggen shows at night different temperatures than Weggis or Rickenbach. In Wiggen the lake of cold air induces about 5 degrees deeper temperatures than Rickenbach, whereas during day, Weggis and Rickenbach have almost the same values.



On FIG 2, the diurnal devolution of temperature on high pressure conditions in February are plotted. Due to the deeper position of the sun the warming during the day is reduced compared to April and the amplitudes are 2 degrees smaller. The stable atmospheric condition during the night does not completely disappear until the afternoon. Hence, Weggis and Rickenbach have almost the same temperatures. Wiggen, on the other side, is 5 degrees colder during the nigh than the other two stations due to the lake of cold air.

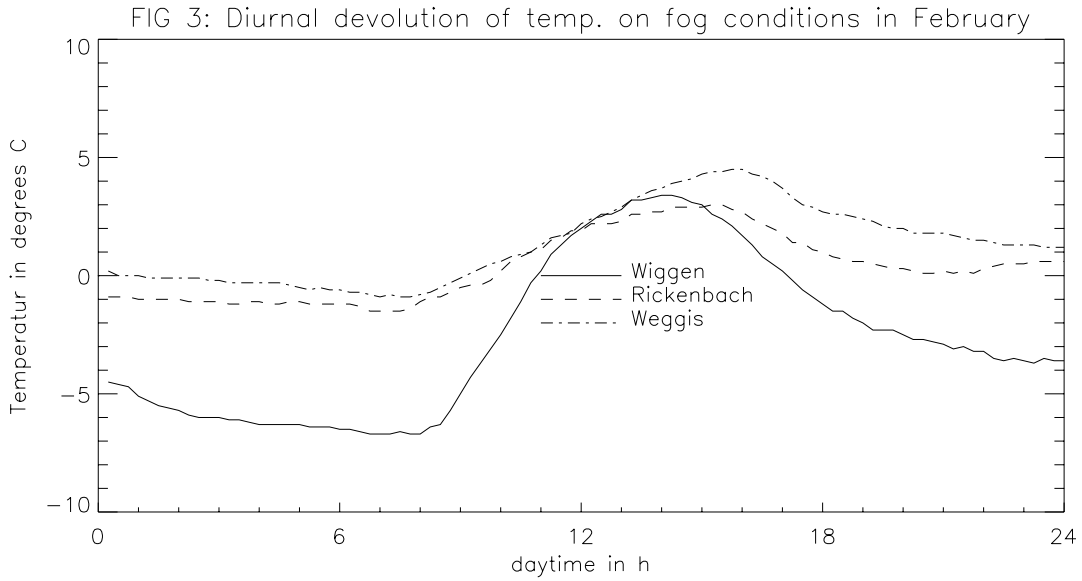
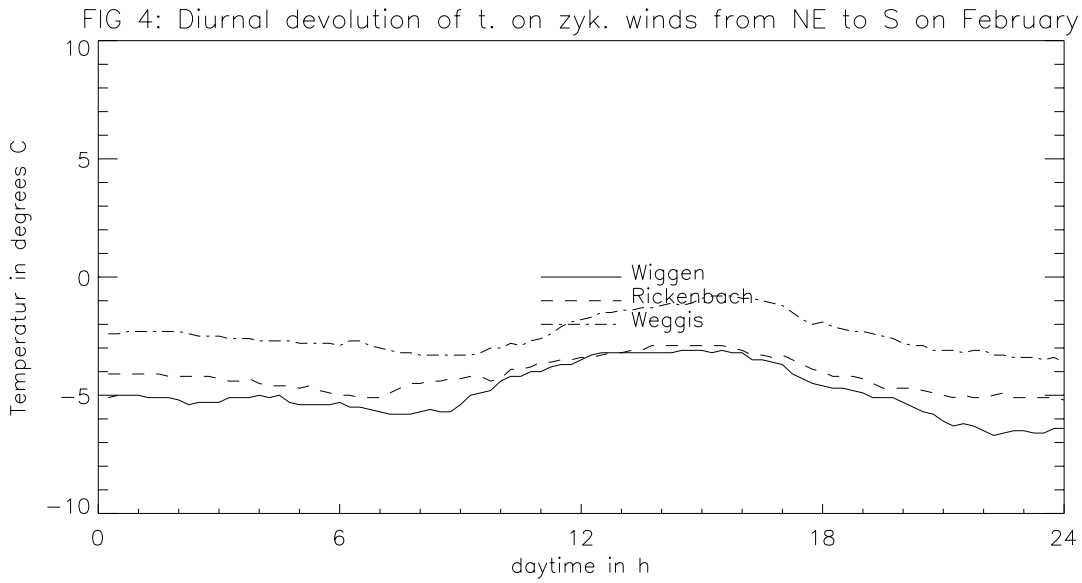


FIG 3: During high pressure weather fog occures in the deeper regions most of the time in winter. This fog has a top of 600 to 700 m. a. s. l. In that case the temperature amplitudes are a little bit smaller then at clear sky weather. But the difference is not very great, because the small fog layer cools down almost so strong like the earth surface on clear sky conditions. On the other hand, in many cases the fog resolves during the morning in February and the shortwave incoming radiation can heat up the air. Wiggen, which is situated on 800 m. a. s. l.,

has no fog in such weather conditions. Under this condition a lake of cold air that establishes during the night, too.



As Fig 4 shows, there are totally other temperature devolutions by cloudy and wet weather. If region has this weather type, cyclonal winds come from the sectors Northeast and South. Then, the amplitude of the temperature during the whole day is with 2 degrees only very small. In Wiggen, there is no lake of cold air, and the temperature in Wiggen and in Rickenbach are almost the same. Weggis has the same amplitude like the other two stations, but the temperature is 2 degrees higher. Therefore, the vertical temperature gradient is about 0.7 degrees of 100 m, which is normally the case for cloudy and wet weather conditions.

Conclusions

The advantage of climatology for different weather conditions consists of the knowledge of the diurnal temperature devolution due to the radiation type. They are always in the same ranges at specific weather types and months. Especially at cyclonal weather conditions the the advection of colder or warmer air masses has to be considered. But this changes of air masses can be estimated from the weather forecast models. If the time interval and the amount of advection are known, they can be added to the diurnal temperature devolution due to the radiation. In most cases, with this procedure a fairly good temperature forecast for the next 12 or 24 hours can be obtained.
If the weather conditions are known, the forecaster has not to worry about local climatological phenomena, because they are almost the same in a specific weather type.

The same procedure as the determination of the temperature can be made with the dewpoint. For other parameters, such as wind, at least a qualitative information could be obtained.

The implementation to an automatic forecasting procedure is planned at MeteoSwiss forecasting centre in Zürich.