ABSTRACT:

In the winters 2005/06 and 2008/09 the snow height in Lower Austria was eminently high. In the last 10 years there were six winters with an eminently high snow cover, considering the one hundred year records. The analysis of the snow depth shows that the winter precipitation in the Alps of Lower Austria has increased by 10 % to 20 %. At the same time the summer precipitation has decreased by about the same amount. This means that we expect many winters with high snow depth in the next years or maybe centuries, despite the general rise of air temperature in Alpine regions. The increase of winter precipitation particularly affects the work of the emergency service. In the year 2006 the Avalanche Service Lower Austria was established.

In the last three years many avalanches on an unprecedented scale were registered. In the Lower Austrian Alps there were many situations in which gliding snow avalanches endangered streets. The consequence of these situations was that the avalanche commission and all members of the avalanche service were going through intensive education and avalanche trainings. This paper shows how the administration of Lower Austria professionally works against the impact of the climate change.

** Friedrich Salzer, Government of Lower Austria, Dep. for Hydrology and Geographic Information, A-3109 St. Pölten, Landhausplatz 1; Email: friedrich.salzer@noel.gv.at

* Arnold Studeregger, Institute for Meteorology and Geodynamics, Costumer Service Graz, Klusemannstraße 21, 8053 Graz, Austria; Email: a.studeregger@zmaq.ac.at

The Department for Hydrology and Geographic Information of the bureau of the government of Lower Austria operates a measuring net of currently about 260 precipitation measuring stations. About half of these stations also take measurements of air temperature and snow height.

The measurement series of the oldest stations date back to the year 1895. An evaluation of the long-term measurement series enables an interesting and valuable insight into the development and progression of single climate elements over a period of more than one hundred years, and therefore also allows a preview of the possible future.
1. AIR TEMPERATURE

In Lower Austria the air temperature measurement series recorded an increase of the air temperature in the past one hundred years. The annual average of air temperature has risen by 1.5° to 2.0° between 1985 and 2009. This trend has been very pronounced since the beginning of the 1980ies. Almost all annual average air temperatures have been above the long-term average from this point onwards.

This rise in temperature is not regularly distributed across the year, but is limited to the summer months. The average air temperatures of winter months show no significant changes over the same period (1995-2009) but have stayed almost the same. The very cold winters in the 1940ies during the 2nd World War are for example very noticeable (fig. 3).

2. PRECIPITATION

The annual precipitation totals have not significantly changed in the period of 1985-2009. However, there is a shift of precipitation from the summer to the winter half-year identifiable, especially in Alpine regions. In Alpine regions the summers have turned dryer while the winters are now with higher precipitation.

Figure 2: hydrometeorological monitoring network in Lower Austria

Figure 3: Air temperature annual average in Lower Austria (1895 – 2009)

Figure 4: Air temperature winter average (Dec.-Feb.) in Lower Austria (1895 – 2009), deviation from long-term average

Figure 5: Relative trend of winter precipitation (Difference 1900 – 2000 in percent)
In the Alpine region, high levels are common, like in Lackenhof, where the average winter air temperature is around -2°C to -3°C, this generally means an increase of the amount of snow.

Figure 6: Relative trend of winter precipitation (Difference 1900 – 2000 in percent)

Figure 7: Air temperature winter average (Dec.-Feb.) in Lackenhof (1895 – 2009)

Figure 8: Winter precipitation (Dec.-Feb.) at the measuring station Lackenhof

Figure 9: snow level in Lackenhof from 1895 – 2010 (summation of fresh snow)

Considering the past twelve winters (1998-2010) in Lackenhof, about half of them are among the snow richest winters since the beginning of records in 1895.

Figure 10: snow depth in Lackenhof from 1895 – 2010 (summation of fresh snow), arranged by size

Figure 11: Snow situation in Lackenhof in winter 2008/2009
The snow situation was particularly extreme in winter 2008/2009. At the weather station Lackenhof a total of 1038 cm of fresh snow was measured. Within only three weeks there was an amount of fresh snow of 500 cm registered. This has been the greatest ever measured figure. This increase of fresh snow has proved exceptional in the one hundred years of measurement series at Lackenhof.

4. CONCLUSIONS – CLIMATE CHANGE IN LOWER AUSTRIA

In the past decade there has been a particularly frequent occurrence of snow rich winters in the Alpine region of Lower Austria. This situation is expected to continue in the years and decades to come if we consider the general increase of precipitation in winter. However, it is reckoned there will also be a higher hydrological resp. meteorological variability.

This means that in future particularly cold and snow rich winters could be followed by extremely warm winters with little snow. The situation definitely constitutes a challenge for both winter tourism and the Avalanche Warning Service of Lower Austria alike.

Because summers in the Alpine region of Lower Austria are generally getting warmer and dryer, it could mean a new chance for summer tourism in the mountain area of the region.

5. AVALANCHE SITUATION IN LOWER AUSTRIA

The changes of winter precipitation affect the avalanche situation in Lower Austria. The government of Lower Austria reacted fast when it comes to the increase of winter precipitation and installed a new Avalanche Warning Service in the winter season 2006/2007. Consequently, the Avalanche Warning Service of Lower Austria was the youngest avalanche warning service in the Alps (vgl. Salzer F., Studeregger A., ISSW 2009, Davos).

In the winter season 2006/2007 the Avalanche Warning Service of Lower Austria was already face with a serious test. When implementing the avalanche warning service, the idea to publish information for people going on ski tours was already incorporated.

Because of the heavy snowfalls in the season 2006/2007, the operational avalanche warning service of ZAMG Graz (executive agency) soughted close collaboration with the Department for Civil Protection of the government of Lower Austria. The information flow between the individual departments was just as important to have the ability to make quick decisions. Therefore a close collaboration between the Hydrology Lower Austria, the Avalanche Warning Service Lower Austria and the Department for Civil Protection was established.

The Avalanche Warning Service provided the authorities concerned with advance information regarding the development of the snow and avalanche situation on February 21st, 2009. Because of the foresighted advance information all action force could be notified beforehand. As a result, preventive measures were instructed and major damage prevented.

Fig. 14 the action force digs snow from the roofs
Fig. 15 the Zwieberg avalanche reached the street.

Fig. 16 in the season 2008/2009 many streets were closed.

The Avalanche Warning Service is challenged to adapt to the new underlying conditions that are caused by the snow rich winters and the numerous avalanches (different crack zones and avalanche tracks). The Avalanche Warning Service Lower Austria is already paying off considering that in the past years the following tasks were realized:

- Intensified education of members of the avalanche commissions with reference to the snow rich winters
- Further improvements concerning the collaboration between departments with annual work meetings
- Advance information is automatically forwarded from the avalanche service
- Intensified involvement of local experts
- Inspection of crack zones in summer to better assess changes of the soil

Another aspect the Avalanche Warning Service has to increasingly deal with is the expected variability of winter precipitation. Therefore the scope of duties will also change. It is expected that the Avalanche Warning Service will have to deal with advance information of departments and the evaluation of avalanche danger concerning infrastructure.

Another important point will be the coordination of local experts on-site. Because of the experience of the past snow rich winters, the Avalanche Warning Service Lower Austria could establish practical Know-How and is additionally equipped with all necessary modern sources of information to be able to solve future problems they will be faced with.

References:

