# THERMAL BIOCLIMATE CONDITIONS IN THE ALPINE REGIONS OF AUSTRIA

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**Abstract**: Data of 46 climate stations located from 1000 m to 3105 m a.s.l. were used to describe the thermal human bioclimate conditions in the alpine regions of Austria. Austria possesses a dense network of climate stations with daily measurements and observations of air temperature, relative humidity, wind velocity and mean cloud cover at 7, 14 and 19 LMT . To show the special climate conditions in alpine regions the behaviour of this parameters in relationship to the human energy balance is used to give a description of the effect of the thermal environment on humans. The importance of topography leading to inversions during the cold seasons and clothing resistance to modify the individual thermal bioclimate will be shown exemplarily.

***Keywords*** *–Bioclimate, Austria, Alps, Mean Radiation Temperature, Physiological Equivalent Temperature, clothing resistance, winter inversion, thermal comfort, tourism*

## 1. INTRODUCTION

Especially the higher alpine regions have an important relevance in the discussion of the thermal human Bioclimate conditions. Straight in these regions tourism is as well as in winter as in summer very distinctive. The meteorological parameters in these areas are strongly influenced by the topographical and orographical conditions and therefore lead also to very typical mean radiation temperatures and thermal indices like PET. The description of the thermal bioclimate gives the possibility to obtain better information about the special features of the alpine regions as suitable for recuperation or simple sport activities. The feasibility to alter one's individual thermal comfort is to wear different layers of clothes or clothes with special thermal qualities, which prevent the body to cool down. Mathematically in the modeling this can be taken into consideration by using different clothing factors ($I_{cl}$).

## 2. METHODS

This analysis has been made by using 46 stations of the Austrian climate station network all lying above 1000 m a.s.l. Nine of these has been selected to describe the climate conditions and the thermal comfort exemplarily. To describe the thermal comfort the full application of the energy balance equation of the human body was used. It gives detailed information on the effect of the thermal environment on humans (VDI, 1998). Common outputs of the equation are PMV (Predicted Mean Vote), PET (Physiological Equivalent Temperature) (VDI, 1998, Höppe, 1999, Matzarakis et al, 1999), SET* (Standard Effective Temperature) (Gagge et al., 1986) or Outdoor Standard Effective Temperature (Out_SET*) (Spangolo and de Dear, 2003) and Perceived Temperature (Tinz and Jendritzky, 2003). All this thermal indices are well documented and include important meteorological and thermo-physiological parameters. The advantage of these thermal indices is that they require the same meteorological input parameters: air temperature, air humidity, wind speed, short and long wave radiation fluxes. From the meteorological input data the radiant fluxes are most difficult to deal with, because representatively measured data are more often than available. Thus they must be parameterized (VDI, 1994 and 1998) and then be related to the special geometry of a human being by the mean radiant temperature.

There are some such state-of-the-art approaches available. In this case a certain temperature related to fixed standard conditions such as physiologically equivalent Temperature (PET) (Höppe, 1999), was used. The PET values are averages and can be calculated for each day and time of the year. The PET can be classified in thermal perception and grade of physiological stress.

The mean radiant temperature and PET have been calculated by the RayMan Model (Matzarakis et al., 2000), which can be applied in different thermal environments. The used thermal index (PET) can be classified according to the unit degree Celsius. The classification allows the quantification of the thermal environment in comfort stages or thermal stress levels. All the values of the periode 1996 - 2000 have been used for the interpretation. The vertical profile was calculated and using the feature of Rayman the clothing factor was varied too.

## 3. RESULTS

The annual course of the monthly means of air temperature shows for all nine stations in sea levels between 1000m and 3105m quite similar shapes with means -11°C to +2°C in the winter months and +4°C to +20°C in August.

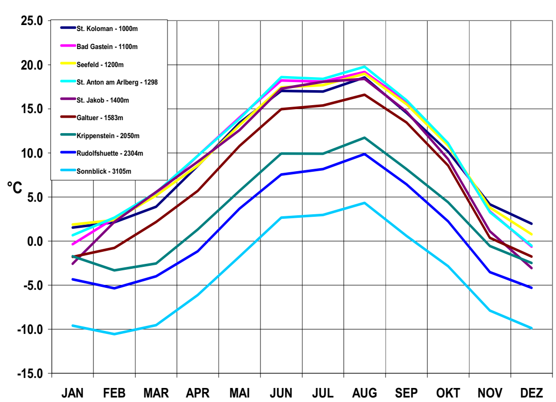


**Figure 1.** Monthly mean air-temperature at 14 LMT for stations at different sea levels

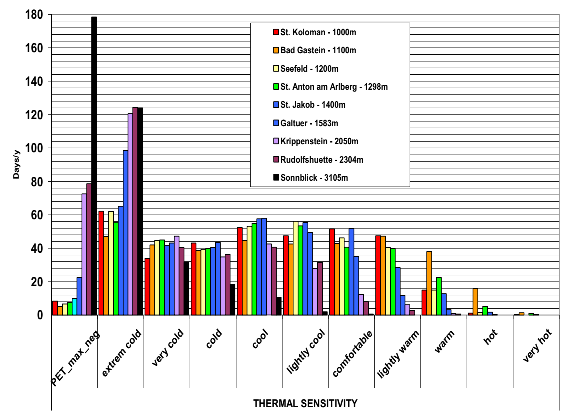


**Figure 2.** Days with PET for different comfort stages at 14 LMT

Figure 2 shows the PET – values (14 LMT) for different comfort stages. The computations were made for a standing male, 35 years old, 1,75 m tall and a weight of 75 kg. For stations lower than 1500 m a.s.l. the thermal comfort stages from comfortable to extremely cold are regularly distributed. Most of the days are lightly cool or comfortable. High alpine regions show maximum days with extreme cold or cold sensitivities and only few days with comfortable or warm grades of physiological stress.

Figure 3 shows the distribution of days with different comfort stages at Galtuer for 7, 14 and 19 LMT. In the morning and evening the grade of physiological stress is in all the days of the year lightly cool to extreme cold. one. Comfortable or warm days do not occur at all. And even at 14 LMT you find the maximum of days with extreme cold thermal sensitivity. But you always have to bear in mind that the person is wearing clothes with only 0,9 clo which is of course unrealistic.

The effect of a variable clothing factor can be seen in figure 4. The days with different thermal sensitivities for Sonnblick at 14 LMT have been calculated for a standing male, 35 years old, 1,75 m tall and a weight of 75 kg. Realistic clothing factors are lower than 3.5 clo and the graph should show the effect of bigger clothing insulation. But here it is shown that the RayMan model, which computes with an average activity turnover of 90W, calculates no days with comfortable sensitivity even with clothes with good insulation.

Figure 5 shows the distribution of PET – values in dependency of the sea level for all the calculated stations in January at 14 LST. Under 500 m PET shows an increasing linearly trend and over 500 m PET decreases with increasing height. Also with PET values you have a clear signal for the height of the inversion during the winter months.

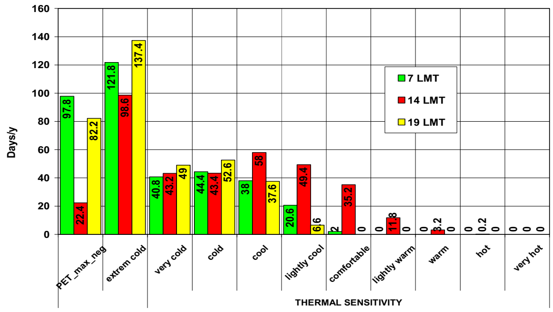


**Figure 3.** Total number of days with different comfort stages for Galtuer at 7, 14 an 19 LMT

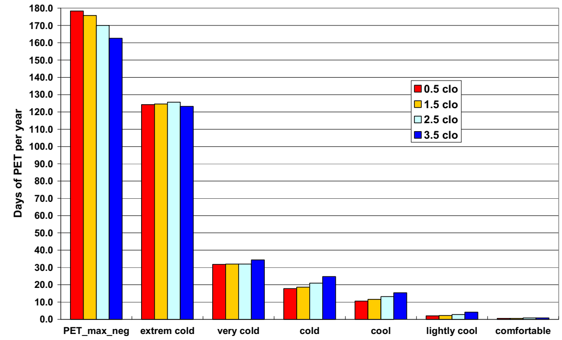


**Figure 4:** Days with different thermal sensitivities for different clothing factors on Sonnblick (3105m)

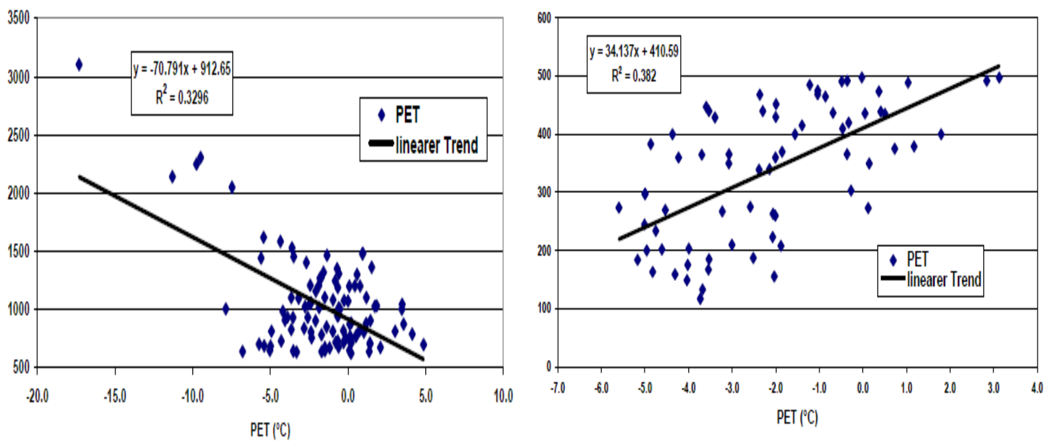


**Figure 5.** PET distribution with height over 500 m (left) and under 500 m (right) in January at 14 LMT

## 4. CONCLUSION

Calculating the grades of physiological stress with the RayMan Model (Matzarakis et al., 2000), gives a lot of advantages in obtaining better information about the special features of the alpine regions as suitable for recuperation or simple sport activities. Areas with extreme wind exposure do not show comfortable or warm conditions at all if you do not raise your personal activities. Even with thick clothes most of the year you will suffer of cold or even extreme cold sensations. In an alpine valley with a height over 1500 m like in Galtuer you will have to increase your stage of activity. Only during a few days of the year you will feel comfortable or only lightly cool without increasing your metabolism by some sport activities like e.g. hiking.

As air quality and climatic conditions are becoming more and more decisive reasons for planning and choosing holiday locations. The results of this study can give some important advices.

- Because of the winter inversion height of approximately 500 to 600 m a.s.l. air quality of regions above 600 m a.s.l. will be much better than below of it.
- From 600 to 1500 m a.s.l. climate conditions allow an adequate number of days with comfortable or only lightly cool or warm grades of physiological stress also for people who are simple looking for holidays in a healthy and comfortable climate without any special activities.

- Above 1500 m a.s.l. climate allows holidays with special sport activities like hiking, climbing, biking etc.

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