8 Summary and Discussion

The micro climate of a tropical montane rainforest was investigated on a location near the ECSF (Estación Científica San Francisco), province Zamora-Chinchipe, Ecuador. The automatically registering climate station was installed in the forest at 1950 m NN, measuring air temperature, humidity, PAR and wind speed at 4 m, 8 m and 13 m in the stand (no wind speed at 4 m). Furthermore all components plus total radiation and net radiation were taken at 20 m (i.e. 2 m above the canopy). The first part of this theses describes the micrometeorological situation in the forest in detail. In the second part the evapotranspiration of the forest stand is determined using the Penman-Monteith approach.

Microclimate

The climate conditions do not change much around the year as it is typical for a location in the inner tropics. The only exceptional month is November, with a short drier period.

The characteristic circulation of the area is a mountain and valley wind system. These thermal winds reach their highest speeds during the warmest periods. Thunderstorms as they are typical for lower tropical regions (Szarzynski 2000) with strong wind peaks were not observed. The highest wind speeds appeared in November during a period with warm winds from the mountains the whole day. A special feature of the region is the downflow of the cold air by night, which is normally strongest along the surfaces canopy and ground and lowest just below the canopy. This situation varies form the daylight situation when wind speed increases with increasing height.

Topography and clouds limit the radiation sum received on the plot to 3810 MJ/m^2 a year. 94% of the PAR were absorbed in the canopy layer, while the light intensity only lowers slowly from 13 m to the ground. At 4 m the measured radiation is 4,9% of the totally received PAR. This indicates a slightly higher radiation on ground level than Walter & Breckle (1991) measured in a montane rainforest in Venezuela (1-3% of original radiation level).

The thermal conditions vary very little around the year. Daily changes of temperature are greatest above the canopy but remain smaller further down in the stand. During the day a typical thermal inversion develops from the ground until above the canopy because of the heating from the top. As the cooling at night also happens on the top of the canopy a lapse situation at night was expected (Oke 1978 theoretically and Szarzynski 2000 by measurement in a lowland forest). In fact the inversion kept on the whole night. This can be explained by the slowly downflowing cold air masses from the mountains, which are heavier and therefore tend to flow along a surface. This model matches the increasing temperature and the decreasing wind speed in the stand during the night. Molion (1987) who found an inversion at night in the flat area of an amazonian rain forest explained the situation similarly. By radiation cooled air from the canopy should sink to the ground to form a sea of cold air just above the ground.

Precipitation and humidity situation in the region shows a sharp contrast between the relative dry November and the wet rest of the year. One precipitation event is normally quite short and weak but there are many all around the day. The specific humidity often shows two peaks - one in the late morning and one in the afternoon - as it was often described from other regions (MALBERG 1994). A more detailed investigation of the daily change in humidity of the different heights showed no decoupling of the lower region from the atmosphere as it was described for the lower rain forest (RIBEIRO et al. 1996, SZARZYNSKI 2000). However a stratification of the climate in the stand tends to develop. The lowest part shows a cooler and more humid situation, while the area between the lower vegetation and the canopy from 8 m up to 13 m show quite similar intermediate conditions. The canopy stratum shows the greatest changes around the day because of the canopy functioning as transformation site.

As pointed out above the region regularly experiences a drier period around November. In 2000 sixteen days without precipitation accompanied with dry warm winds from the mountains leaded to extreme conditions in the forest. On the last days of this period the humidity sank to values as low as 10% in the forest. The soil of the steep slopes was also very dry.

Evapotranspiration

In the second part of this theses the evapotranspiration of the forest stand was calculated using the Penman-Monteith-formula. As there exist no publications about the evapotranspiration of tropical mountain forests yet, results from studies in tropical lowland rainforests were taken for comparison.

Investigating the energy flux of one whole day the ground-stand-flux turned out to be especially important in the early morning and evening. But for a calculation of the total evapotranspiration of the stand over the year it is negligible because the morning and evening flux compensate each other.

The actual evapotranspiration turned out to be as low as 408 mm a year. Compared with an equivalent of net radiation of 718 mm the ratio is 0,58. SHUTTLEWORTH et al. (1984) and SZARZYNSKI (2000) measured similar ratios of 0,7 and 0,66 respectively in tropical lowland forests. As in SZARZYNSKI's (2000) study the ratio between actual and potential evapotranspiration was about two to three. This does not match with the results from LEOPOLDO et al. (1995) who found actual and potential evapotranspiration to be of the same amount by using the water balance method and not Penman-Monteith for calculating the actual evapotranspiration.

The measured amount of evapotranspirated water represents only 19,5% of the total precipitation over the study period. Compared with interception rates of 28% from precipitation measurements by WILCKE et al. (2001) in the same water catchment as the climate station, this value is comparably low. Possible errors for the water balance model exist in unmeasured ground water flow through the landslide material and in the great error possibility of the throughfall measurement. Both can lead to an overestimation of the interception. On the other hand the calculation with the Penman-Monteith-equation does not take in account any horizontal energy flux which can occur especially during the day. This possible energy flux to the stand could lead to an underestimation of the evapotranspiration of the forest. As a result the author proposes an evapotranspiration rate of about 25-35% of the precipitation combining both data sets and its possible failures.

Further investigations related with the water balance by the working group Wilcke, Zech (Univerität Bayreuth, Germany) and direct measurements of the transpiration (Motzer, in prep.) should lead to even more reliable results. In the end, all these investigations should help further research projects in other tropical mountain rain forests to profit from the experiences made in Ecuador.