Multitemporal Analysis of the Radiation Temperature of the Urban Surface Heat Island in the City of Basel

Gergely Rigo*, Eberhard Parlow

Institute of Meteorology, Climatology and Remote Sensing, University of Basel

*Gergely.Rigo@unibas.ch

UNI BASEL

Several satellite images from 1984 to 1999 of the Basel Region have been analysed for the distribution of the urban heat island. As first step after geocoding, the images were atmospheric corrected with the WINDOW model. First result showed, that there is a strong annual temperature variability as Fig. 1 shows. In both images the urban heat island and the industrial sites are clearly visible. The Black Forrest in the northeast and the Jura Mountains in the southwest can be easyily identified as the coldest spots on the image.

Fig. 2 shows the differences between all nine daytime overpasses and the two night passes for each landuse class. The used landuse classification which was created 1992 is shown in Fig. 3.

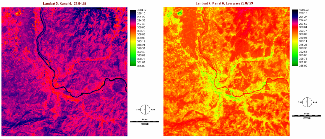

Fig. 1: Radiation temperatures from 21.04.85 and 25.07.99 overpasses as seasonal comparison

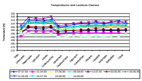

Fig. 2:Comparison of mean temperatures for all landuse classes and all overpasses

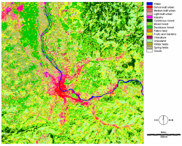

Fig. 3: Landuse classification

The temperature differences depend on the different longwave emissivities of different surface materiels. Coupled to the energy balance equation, this emissivity is therefore dependent of the NDVI and because of this, of the vegetation. The NDVI can be calculated from the channels 3 (Red) and 4 (Near IR) of the Landsat satellite and ranges between –1 and +1. Water, bare soil without vegetation and urban surfaces show negative values. As shown on the images below (Fig. 4) the NDVI is also dependent from the seasons.

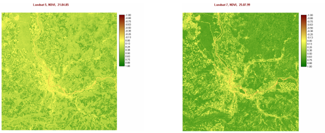

Fig. 4: Comparison of NDVI images from 21.04.85 and 25.07.99

The next step was, to find out approximately how big the influence of the vegetation on the radiation temperature was. To acquire this, regressions have been calculated between radiation temperatures and the NDVI images. The regression coefficients (R^2) ranged from 0.01 for a spring image from 25.04.84 and 0.36 for a summer image from 25.07.99. These two represent very good the different seasons, because for all the spring images the values were around 0.1 and for the summer images, the R^2 ranged between 0.3 and 0.4 .

This shows how great the influence of the vegetation is, depending of the season, on the radiation temperatures is in the city the surrounding areas. As a further step the land use classification was included in addition into the regression.

The values for R^2 could be clearly increased by the addition of the landuse classes and achieved values between 0.3 and 0.62 what clarifies the dependence of the radiation temperature of the land use and the vegetation coverage.

A residuum image shows (Fig. 5), where particularly the largest differences between the picture predicted with the regression (Fig. 6) and the original occur (Fig. 1 to the right). It can be clearly recognized that the extrema are smoothed in every scene. In the Black Forest, the greatest negative differences between original and predicted image can be detected, while on the other hand the settlements are slightly cooler on the regression image than on the original.

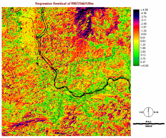

Fig. 5: Residuum image

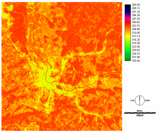

Fig. 6: Regression image

The calculated global linear regressions above show the global R^2 , but it doesn't show the spatial distribution of the regression. To show the spatial distribution of R^2, a locale linear regression can be calculated.

For this calculation a 7 x 7 pixel window is sliding across the image and calculates the R^2 for the covered area. As we can see on Fig. 7, the left, spring image shows a far worse correlation than the right, summer image. Especially the north and western part of the image. The city and inhabited areas show far better values as does the river Rhine. On the right image, the worst results are shown in the Black Forest area in the northeast.

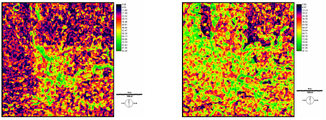

Fig. 7: Multiple locale linear regression from 21.04.85 (left) and 25.07.99 (right)