Using the ENVI-MET program to simulate the micro climate in new Town HASHTGERD

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ABSTRACT

ENVI-met is a computer program to simulate the microclimate in urban environment. It is a helpful program to simulate the urban climate in cities and can assist for environmental planning of new towns. One of the objective of climatological part of the project Young Cities 'Developing Energy-Efficient Urban Fabric in the Tehran-Karaj Region' is to simulate the micro climate (with 1m resolution) in 35ha area of new town Hashtgerd, which is located 65 km far from mega city Tehran.

Key words: ENVI-met, microclimate in new towns

1. INTRODUCTION

The Project aims are developing, implementing and evaluating building and planning schemes. The new technologies allows to plan and build sustainable, energy-efficient and climate sensible form mass housing settlements in arid and semi-arid regions ("energy-efficient fabric"). The idea of ENVI-met is to built up houses and to find out the changes of the environmental and climatology conditions in urban areas. ENVI-met give the solution how the urban environment could be designed to give the best possible microclimate conditions to the citizens, which is very important for human health. It is possible to find out the effects of wind gusts caused by jet effects at building corners. With the program ENVI-met, environmental planers and architects will have a good quality of urban areas and they can aware the urban microclimate.

Good climate conditions and good air quality are essential for the human wellbeing and determining factors for flora and fauna and also for agriculture systems. Fresh air production as well as air cleaning are important functions of an intact climate system, with regard to climate change. To determine and analyze relevant climate information, climate can be structured into a micro, meso and macro scale level. Micro climate can be assigned to small sized areas or structures up to few meters (like building complexes or trees) which is relevant for human health as well as for plants and animals.

Relevant meteorological indicators are temperature, wind direction and speed, evaporation, relative humidity and sunshine duration. For instance, sealed surfaces have negative effects on the local climate, they heat up strongly during the day and cooling slowly down during the night. Furthermore those areas have a very low capacity for filtering air pollutants and binding dust particles. Negative effects for the climate is mainly caused by emissions and also barriers for air exchange processes (e.g. building structures) or elimination of open/green spaces influence the microclimate.

These impacts may result in a local over warming which in turn may result in even more adverse effects on the local climate. For this reason, ENVI-met is an important program which gives all the information for urban climate in towns.

The Young Cities project is sponsored by the 'Federal Ministry of Education and Research, Germany by the funding program 'The Urban Transition, Research for Sustainable Development of the Megacities of Tomorrow'. Iran is located in an arid and semi-arid zone.

Its climate is characterized by great temperature extremes, varying between more than 50°C in summer and 20°C in winter.

The average rainfall in Iran is about 250 mm which is less than one third of the average worldwide rainfall. It is estimated that if the CO2 concentration doubles by the year 2100, the average temperature in Iran will increases by 1.5- 4.5°C which will cause significant changes in water resources, agriculture, land use and energy demand.

The pilot project (35 ha area, Hashtgerd) is intended for testing and demonstrate of methodological, technological or capacity development solutions developed on a central project area. Hashtgerd lies about 50 km west of Teheran. For the 35 ha area pilot project in 'Hashtgerd New Town' the part of the Institute of Meteorology is, to simulate the climatological situation with the program ENVI-met. The Eulerian model ENVI-met [2] is a micro-scale climate model. The program gives information about the vegetation and green area on the micro climate up to 1 m resolution. The input data are the height of the buildings and the structure of the city.

Due of no micro climate stations in the 35 ha area, the input data are up to now standard meteorological information from surrounding meteorological stations. The result by ENVI-met with different influences of the buildings and vegetation show how the micro climate change, which is relevant for human thermo-physiological effects of the atmospheric environment.

2. MICROSCALE MODEL DESCRIPTION

The three-dimensional microclimate model ENVI-met [1] see figure 1 is a three-dimensional model for simulating microscale climate in urban environment with a typical resolution of 0.5 to 10 m in space and 10 sec in time. ENVI-met is a prognostic model based on the fundamental laws of fluid dynamics and thermo- dynamics.

The output of ENVI-met is the flow around and between buildings. The program simulates exchange processes of heat and water vapour at the ground surface and at walls, turbulence, exchange at vegetation and vegetation parameters. ENVI-met analyze the effects of small scale changes in urban design (e.g. trees, backyard greening, new building constellations) on microclimate under different mesoscale conditions. For the 35 ha area of Hashtgerd ENVI-met has been run with information from topography, downscaled climate data with neuro-fuzzy method, building height and different vegetation variants (low and high number of trees).

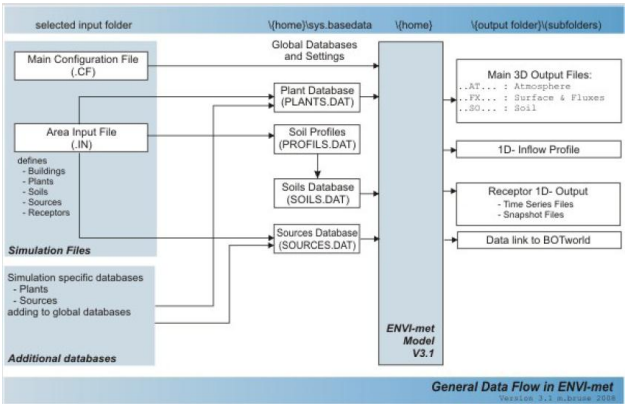

Figure 1. Data flow in ENVI-met.

2.1 INPUT PARAMETERS

The meteorological data (daily temperature, maximum and minimum temperature, precipitation, relative humidity and sunshine duration) were prepared from the Institute of Meteorology (Free University of Berlin) provided by the Iranian weather service IRIMO. From 3-hourly observations, hourly data were generated from 1985 to 2006. Afterwards averages were formed for each month. The average education occurs while the values were added and were divided by the number of the values. The synoptical data are based on standard measurements by the WMO (World Meteorological Organization).

The temperature is measured at a height of 2m, also the maximum and minimum temperature. The daily maximum temperature is measured at 15 UTC (Universal Time) and the minimum temperature at 03 UTC of the last 24 hours. Figure 2 shows the diurnal variation of maximum and minimum temperature as a mean value per hour for the year 2005 for Hashtgerd. The maximum temperature is reached at 12 UTC with 39.65°C and the minimum temperature at 3 UTC with -15.51°C. Building height and different vegetation variants (low and high number of trees) were given of the project partners of the Technical University of Berlin. Figure 3 shows the 35 ha area of Hashtgerd New Town. The white colour describe buildings and green colour is vegetation. Figure 4 display the difference of the vegetation density.

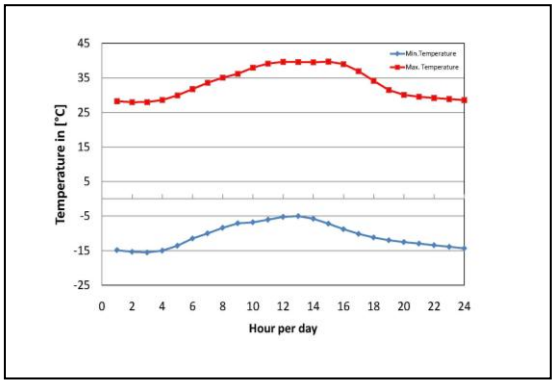

Figure 2. Diurnal variation of min. and max. temperature interpolated for Hasshtgerd for 2005

Figure 3: The 35 ha area of Hashtgerd, Iran

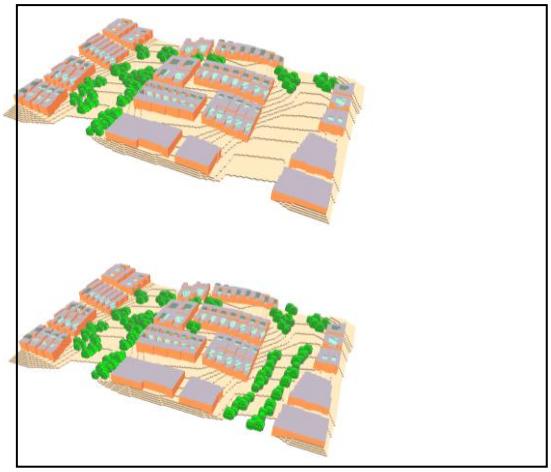

Figure 4: Sub-grid of the 35 ha area of Hashtgerd with the different vegetation density.

3. RESULTS

An important factor for building construction is wind speed. The design of the 35 ha area follows the idea to block the prevailing winds from west and northwest as well as the hot and dusty winds in summer time from the southeast. The quarter's low skyline follows the topography and therefore the buildings have a maximum of three floors (carpet style). This style of buildings allows free movement of air, which is of high importance for fresh air supply. The simulation results of the wind direction (figure 5) shows calm wind in inner courtyards in 2 m height in different colours, while the houses are black.. The wind speed between the houses on the right and left side behavior 2 m/s without trees, with trees the wind near the surface is reduced up to 0.7 m/s (Fig. 5 lower figure).

Figure 6 shows the temperature at 2m height, here the high number of trees leads to lower temperature by about 2 K and therefore for a better climate for human health. With trees, the climate shows a positive effect of the temperature, especial between the houses. The increase of inbuilt areas of the 35 ha area reduces the heat island effect through cooling caused by vegetation and increase of air humidity which caused by trees evaporation. Figure 7 shows the simulation of the relative humidity. Here the upper figure is a simulation with no trees and the lower with trees. The relative humidity increase with trees by about 10%.

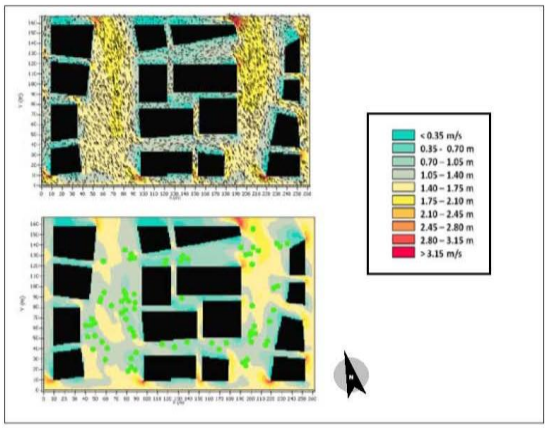

Figure 5: Wind speed simulations 15.7.2005, 12 UTC of the sub-grid for Hashtgerd.

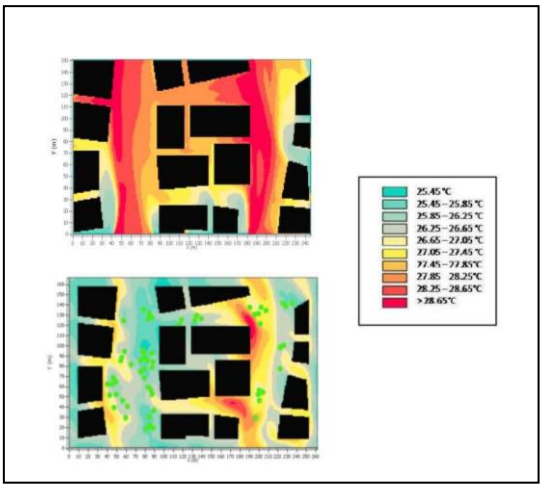

Figure 6. Temperature (2 m) simulations at 15.7.2005, 12 UTC of the sub-grid for Hashtgerd.

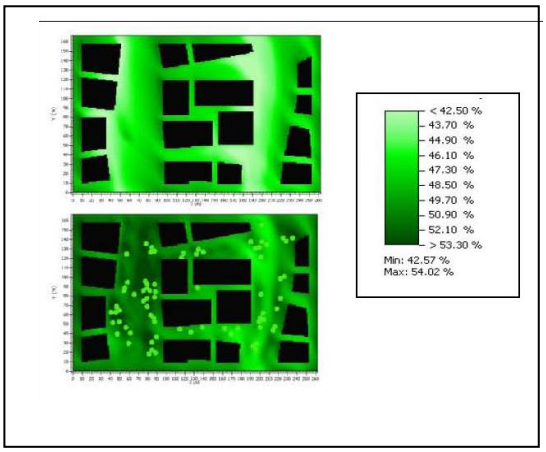

Figure 7: Rel. humidity simulations, 15.7.2005, 12 UTC of the sub-grid for Hashtgerd.

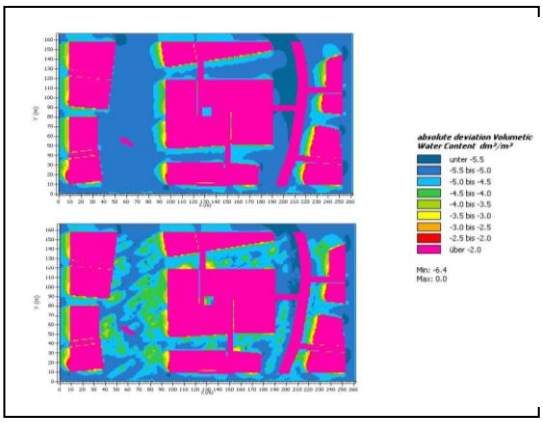

Figure 8: Volmetric water content as a difference between 14:00 and 6:00 UTC at 0.03-cm depth

With ENVI-met the ground water content was determined for the 15.07.2005 between 6:00 and 14:00 UTC. Figure 8 shows the ground water content for 0.03cm depth. Without vegetation (left picture) a consumption of 4.5 dm^3/m^3 is expelled. With vegetation on the right sides of figure 8 appears that rather by the shadow throw less water is used. The roots lie in a deeper layer and therefore no water is used.

4. CONCLUSIONS

The micro climate simulation with the program ENVI-met can be used to estimate the effect of changing climate conditions in cities. This study for Hashtgerd shows, that with trees, which are elements of urban planning the microclimate decreased by about 2 K and the wind velocity by about 0.7 m/s. Vegetation on the road sides leads to a surface temperature decrease of 9 K. Increase of planting distance caused turbulence near the surface and the close planting increased the Turbulent Kinetic Energy (TKE). The program ENVI-met also help to improve the human thermal comfort by reducing air temperature and reflected radiation. For microclimate simulation ENVI-met is the only program which is free for everybody and downloaded by the internet.

ACKNOWLEDGMENT

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