MENEX - THE MAN-ENVIRONMENT HEAT EXCHANGE MODEL AND ITS APPLICATIONS IN BIOCLIMATOLOGY

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INTRODUCTION

Evaluation of the thermal conditions is very important in bioclimatic research and many different indices were proposed in this purpose (Lee, 1980). The most complex method of heat load assessment is study of the human body heat balance. Existing models of the human heat budget are adopted for stationary or for unstationary conditions of heat exchange and may be used in limited fields of bioclimatology (Morgan & Baskett 1974).

This study presents a new man-environment heat exchange model (MENEX) which may be used in many branches of bioclimatological research.

METHOD

The general equation of heat exchange between man and his surrounding has the following form:

$$M + R + E + Res + C + L = S,$$

where: 'M' is heat gain from metabolism, 'R' absorbed solar radiation, 'E' evaporative heat loss, 'Res' respiratory heat loss, 'C' convective heat exchange, 'L' heat exchange by long-wave radiation, and 'S' net heat storage.

Quantities of particular heat fluxes are calculated using modified Budyko-Cicenko (1960) equations. The best results could be received when skin temperature and all meteorological parameters are measured simultaneously. The simplified procedures for the estimation of mean skin temperature as well as absorbed solar radiation could be also used.

The heat strain in man caused by environmental factors is defined by two values: the net heat storage (i.e. increase or decrease of body heat content) as well as absorbed solar radiation. The maximal time of exposure should be used as additional characteristic.

The MENEX model may be used for stationary and unstationary conditions of heat exchange. Its stationary option is useful with general evaluation of bioclimate. The unstationary option of MENEX model allows to assess heat strain in man in different weather and terrain conditions as well as with varied work load.

The model was tested during outdoor climato-physiological investigations performed in different climatic zones and weather situations as well as in different landscape types. Meteorological parameters and skin temperature at 10 standing, healthy subjects were measured simultaneously every hour from 6 a.m. to 8 p.m. of the local time. The subjects wore cotton sports wear with insulation 1 clo and albedo of 30%.

RESULTS

Weather conditions strongly influence heat load in man. During cool, cloudy and windy weather net heat storage varied from -20 to 40 W m^{-2} and absorbed solar radiation was about 20 W m^{-2}. The most intensive heat load was observed during sunny, calm, hot weather; absorbed solar radiation reached 40-50 W m^{-2} and net heat storage was 60-70 W m^{-2} in the midday hours (Blazejczyk 1991).

Comparison of different climatic zones shows that in the continental climate of central Asia a slightly higher absorbed solar radiation was observed, as an effect of high transparency of the atmosphere. In dry subtropical and tropical climatic zones evaporative heat losses were considerable higher than in the maritime climate of central Europe (Blazejczyk 1991).

Figure 1 shows an example of the study with spatial distribution of the human heat balance in the local scale. Types of heat load were distinguished on the base of detailed outdoor climatophysiological investigations. Mild thermal conditions were observed in the forests and slightly loaded - in the bottom of the valley as well as on the East/West slopes. Loaded conditions occur on the South slopes and on the top of a ridge, however strongly loaded situations -on small, closed gravel trains on the valley's bottom.

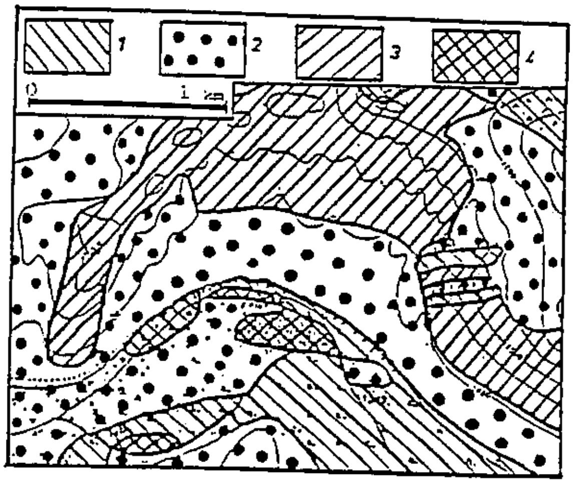

Fig. 1 Spatial differentiation of heat load in man within mountain valley (Khentey, central Mongolia):
1 - mild conditions,
2 - slightly loaded conditions,
3 - loaded conditions,
4 - strongly loaded conditions

CONCLUSION

The **MENEX** model allows for the estimation of heat exchange between man and his surroundings in stationary and unstationary conditions. It may be used with general bioclimatic evaluation of different regions or seasons as well as assessment of heat strain in different meteorological situations, landscape types and with varied work load.

REFERENCES

1. Lee, D.H.K. 1980. Seventy-five years of searching for a heat index. *Environm. Res., 22,* 331-356

2. Morgan, D.L., Baskett, R.L. 1974, Comfort of man in the city, An energy model of man-environment coupling. *Int. I. Biometeor.*, 18, 184-198

3. Budyko, M.I., Cocenko, G.V. 1960, Climatic factors of thermal sensations in man (in russian). *Izv.AN SSSR, s.Geogr.*, 3, 3-11

4. Blazejczyk, K. 1991, Heat balance of the human body in different weather conditions, *Grana,* 30, 277-280

5. Blazejczyk, K., Krawczyk, B. 1991, Influence of climatic conditions upon heat balance of the human body. *Int. I. Biometeor., 35,* 103-106.