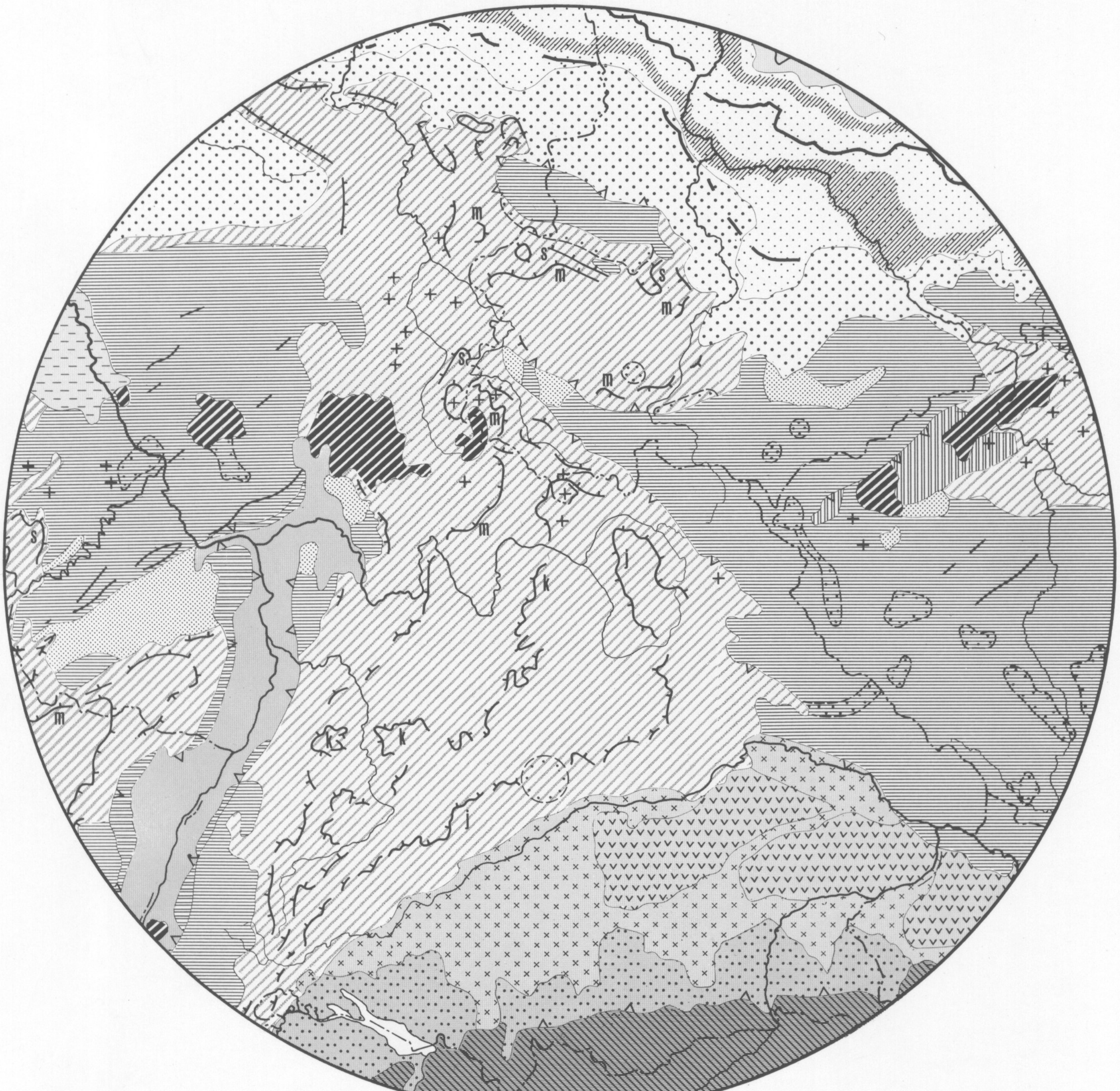
Physical Geography in the Federal Republic of Germany



Edited by
Hans-Jürgen Klink and Herbert Liedtke

Schöningh

Bochumer Geographische Arbeiten, Heft 44 / 1984

APPLIED CLIMATOLOGY IN THE FEDERAL REPUBLIC OF GERMANY SINCE 1970

Wilhelm KUTTLER, Bochum

For the concluding list of works from the field of applied climatology it has been taken into account that there has been a rapid boom of works with climatic-ecological problems together with the improvement of methods. Beside the limited area (FRG), the chosen works were limited with reference to topicality to the year 1970 as the starting point. Main aspects are the results of applied climatology from examinations in the sphere of agglomerations, regional and landscapeplanning as well as the potential utilization of regenerative forms of energy. Priority was given to works with an extensive bibliography (of secondary literature) while the given choice cannot be seen as an evaluation.

1. INTRODUCTION

The term 'climate' was defined by Alexander von HUMBOLDT (1845, vol. 1, p. 340) in an indeed oldfashioned and for actual conditions no longer sufficient, but partly also in an topical way, as ..."expression, (which) in general (defines) all changes in the atmosphere, which irritate the organs noticably ... and are important (not only) for the organic development of plants the ripening of fruits, but also for the feelings and psychic conditions of human beings". The numerous climate definitions of the times after HUMBOLDT in a geographical sense (see examples in HEYER (1981) and BLÜTHGEN & WEISCHET (1980)) set up new priorities as i.e. emphasis on climatic mean values for the characterization of areas by KÖPPEN (1931) and CONRAD (1936), mean value climatology) respectively the resolution of mean values initially demanded by KNOCH (1942) and realized by SCHNEIDER-CARIUS (1961) with strong regard to the distribution of measured values with a more or less regional references (BLÜTHGEN & WEISCHET 1980 borrowing from SEKIGUTI 1951). In contrast to the just quoted climate definition HUMBOLDT's was more general and extensive, the climatic influences on beings illustrate his reference to application, which is today related to the field of bio-climatology respectively bio-meteorology (BERG 1947, FAUST 1977, FLACH 1981, HENTSCHEL 1982).

Applied climatology is intended to comprise the whole sphere of man and economy only lead by the reference to application, independent from its position in different scenery, as are the basis for the classification of climatology (WEISCHET 1956, ERIKSEN 1975).

Applied climatology is indeed a functional research dealing in broad sense with the climatic effects on man and economy as well as with the intended anthropogene influences on the climate itself. The last - named influences, which can be found in several works by FLOHN (i.e. 1973) are not dealt with in this survey. This way of observation produces a close contact of applied climatology to the neighbouring sciences meteorology and geophysics. Beside this interlacing and dependence THORNTHWAITE's (1962) opinion is supported that it is especially the task of a physical and not only descriptive geography to work as an applied climatology, for only this basis can cover whole areals scientifically. A short and partly tabular presentation of applied climatology's fields of work can be found in BLÜTHGEN & WEISCHET (1980).

2. APPLIED-CLIMATOLOGICAL INVESTIGATIONS IN URBAN AGGLOMERATIONS

Applied-climatological investigations in urban and industrial agglomerations should consider the topics radiation and heat balance ('heat-island' effect), amounts of pollution and its deposition figures as well as the weather-dependent, small-spaced and spacious ventilation of urban structures with view to their relevance to planning. General aspects, especially the modified radiation and energy balances in urban areas, the atmospheric arrangement in air layers as well as the urban wind circulation, can be found in the work by STEIN (1979). In the discussion of the 'heat-island' effects several authors, i.e. GEHRKE et al. 1977 or WEISCHET 1979, have hinted at the fact that the expectation of a single-centric heat island in a given urban area must be replaced by a polycentric one which is determined by the structure of settlements, for it is more differentiated with respect to the effect on temperatur structures. There are already several works from different cities available making explanations about the statics and dynamics of urban 'heat islands'.
These are i.e. for Kiel (ERIKSEN 1964), Bonn (EMONDS 1972, KESSLER 1971), Munich (BAUMGARTNER et al. 1983, THIELE 1974), Stuttgart (HAMM 1969), Freiburg i. Breisgau (WEISCHET 1974, NÜBLER 1979, AHRENS 1983), Giessen (HERRMANN et al. 1973), Berlin (SCHULZE 1969, ZACHARIAS 1972), Cologne (KALB 1962), Hannover (WILMERS 1981), Regensburg (DITTMANN 1982), Duisburg (GEHRKE 1982), Mannheim-Ludwigshafen (SEITZ 1975), Nürnberg (GREUPNER et al. 1982) and for two towns in the southern Munsterland beyond sphere of influence of Rhenish-Westphalian industrial region, that are Recklinghausen (SCHREIBER 1984) and Lünen (KUTTLER 1984).

The range of application mainly refers to planning and thus requires definite values either gained during measuring tours or from permanently running networks. At times of certain, mostly autochthone, weather conditions measuring tours have to be preferred because of the lack of time and a closer estimation of these important dynamic process. Measuring tours, however, have the disadvantage of a primarily exemplary evaluation of the conditions of urban climate.
It's a lucky chance to rely on long-term values and really optimizes any analysis of urban climate.
Works relying on extensive values are climate monographs of 'representative cities in Germany' published by the 'Deutscher Wetterdienst' and gradually further developed. Investigations about Hamburg (CAPPEL & KALB 1976), Hannover (KALB & SCHMIDT 1977) and Munich (SCHÄFER 1982) are already available.
However, it is a disadvantage of these monographs that the evaluated data mostly derive from only one station, so that no comparison between the city and its surroundings is possible as is with the evaluation of several stations.

Despite many promising methodical approaches in different fields of applied urban climatology research the size and course of urban exchange and ventilation processes has not yet been explained into detail referring to decisive improvements of air quality during critical weather conditions. For these processes proceed at times with low winds, not only the horizontal qualification is difficult, but especially the vertical one. In this connection we attach importance to climatic-meliorating efficiency of i.e. urban greens (See i.e. works by EICK (1979), HORBERT & KIRCHGEORG (1982), MIESS & MIESS (1980), SUKOPP (1979), PRINZ (1973), WILMERS (1975), SPERBER (1974), BRAHE (1974), BERNATZKY (1982), GÖDDE (1982), SUKOPP & WERNER (1983), FINKE (1976), FEZER (1976), KUTTLER (1982); biblography about greens in cities in POLL & WELDER (1982).

The fact is considered as a problem and is not yet solved that it is extraordinarily important for the spheres of application to determine the size of greens which can change the meso-climate, its efficiency and most of all the extension of its influence increasing the quality of air and climate in the urban surroundings. Works about this topic are encouraged by different institutions,however it will be Verydifficult to come to general conclusions, for the numerous factors which have single or synergistical effects can be typical only for the examined city. Therefore examinations from one city cannot be applied to all others.

Model investigations and calculations, as were carried out (See i.e. BECKRÖGE 1980), illustrate the limitations of single statements. Measurements and calculations about the air dynamics of ground-layers and the parameters determining ground-layer exchange were carried out by WOLFSEHER & GERTIS (1978) and PLATE (1974).

Investigations about the special effects of small greens on their closer surroundings have been taken up here and there. Measurements i.e. about the climatic effect of roof greens not only show a reduction of surface temperatures, but also of the maximum outside temperatures. In the rooms the temperature decreased with closed windows by 1 to 2 K. Compared with a gravel roof the content of dust was reduced by 10 - 20 % at the lee-side end of the roof (HÖSCHELE & SCHMIDT 1974).

Although the creation of new urban greens is basically positive, it is uncertain whether roof greens and the caused lower air temperatures prevent a desired convection for the bio-climatic surroundings (BAUMGARTNER et al. 1983).
A further problem, which can frequently be observed during measuring tours, is missing consideration of measurements in backyards or free spaces between lines of houses because of practical or technical reasons. But just these areas show totally different values than usual street climates (NYC 1978).

In this connection I may hint at the fact that infra-red photography is to be seen as an important methodical aid for many years (HIRT & KELLERSMANN 1972, STOCK 1982, STOCK & PLÜCKER 1978, FEZER 1977, ROBEL et al. 1978, MAHLER & STOCK 1977, GOSSMANN et al. 1981). The results are utilized for decisions and advices for planning in urban and industrial areas. The application of this aid, however, is not always without problems, for the determined radiating temperatures can neither be related to the corresponding surface temperatures nor to the air temperatures above the measured object. To get these values it is necessary to carry out field measurements additionally. In relative comparisons excluding absolute values applied infra-red photography renders good services.

As a cause of manifold urban agglomeration process investigations about the climatic control of transmission and immission of gaseous and particle-sized pollutants have gained in significance in the last few years. These do not only consider maximum loads (WEISCHET 1973, KUTTLER 1979a, b, FETT 1982, AHRENS 1983) but also the bio-climatic effects of high and medium concentrations (NEUWIRTH 1976, KUTTLER 1979a). To this subject other investigations with similar topics appeared in the "Schriftenreihe der Landesanstalt für Immissionsschutz (LIS), North Rhine-Westphalia".

Models quantifying the spreading of pollutants from different points of view were shown at times (i.e.: FORTAK 1972, 1973; WILLNER 1977). Additionally, statistical classifications of the pollution in air-hygienically more or less polluted cities make secure comparisons possible, as the works by FRÄNZLE & KILLISCH 1979 show.

Cities mostly have influences to increasing precipitation

- by the increased concentration of air pollution
- by reinforced thermals caused by an increased absorption of radiation
- and by various aerodynamic changes produced by an increased roughness of the surface.

In general one can observe an increase of heavy rains and a higher number of thunderstorms (REIDAT 1971, SCHLAAK 1972, 1976 ;HAVLIK 1981, STAHLMANN 1976, LINDENBEIN & MALBERG 1973, ERIKSEN 1972) with values of, in some cases, up to 20 % above those of the unaffected surroundings.

Beside investigations about the change of precipitation quantities in urban areas special attention has been directed to the quality of precipitation in the last few years (See GEORGII & PANKRATH 1982, KUTTLER 1983a, b).
The concentrations of pollutants change with the intensities of rainfall (KINS 1982) and determine the degree of pollution of urban sewage together with the amount of rainwater running off (PECHER 1974).

It should be the first principle of applied works to make findings available for utilization. Several of the actual scientific findings, which have sometimes been gained with a high technical and financial expense, unfortunately often are not utilized sufficiently. It may be one reason that planners are not sufficiently trained in the interpretation and application of the results, and that the scientists do not interpret with a special reference to planning. Some approaches have fortunately been made (ERIKSEN 1971, MIES 1972, 1974; LORENZ 1973, BAUMÜLLER 1975, WEISCHET 1980, JURKSCH 1982, DEUTSCHER WETTERDIENST 1980, BARTELS et al. 1978,further examples can be found in FRANKE 1977). However - I may finally hint at the fact - a stronger consideration of the evaluation of urban climate has to be realized in any planning decision (ROTH 1979).
Numerous works of applied urban climatology are available in form of unpublished manuscripts at various weather-bureaus of the 'Deutscher Wetterdienst' in Germany. A list of summaries from a colloquy about problems of applied urban climatology can be found in FETT (1978).

3. APPLIED CLIMATOLOGY IN REGIONAL AND LANDSCAPE PLANNING

KLINK (1982, p. 93 following pages) rightly points out that after the completion of the climate atlas for the German Bundesländer by the 'Deutscher Wetterdienst' "the contribution of climatology to regional geography is mainly seen in the enlargement of a further development of the states climate research" - and at another passage in the same book he writes that landscape-ecology, of which applied climatology is an in-

tegrated part, "(must) be enlarged to a prognostic science".
For the fulfilment of these aims for the sphere of regional and landscape planning the gained values and maps from the observation net of the Deutscher Wetterdienst can only conditionally be utilized for regional planning for the used scales of the maps are too small. (A list of the maps published by the 'Deutscher Wetterdienst' with scales from 1 : 500,000 to 1 : 10 million can be found in KALB (1979)).

If planning with reference to the climate is according to HADER (1980, p. 42), considered as "any activity for the conservation of optimal climatic favours ... by well-considered interferences in given scenic conditions by a timely realization of a climate-related risk" , the fulfillment of the planners' wishes (i.e. for the supervisional planning of buildings respectively the mapping of local air-flow currents) depend on the investigation of values on a small-spaced scale in consideration of (seasonal) temporary parameters referring to the differing weather conditions (BAUMÜLLER 1975).
The size scale for applied climatological work in regional and landscape planning is determined by SCHIRMER (1981) on a distance of 100 m to 50 km. Statements about the landscape climate should - according to WILMERS (1979, p. 114) - be gained "without requiring a great deal of energy". Beside field estimates with the utilization of topographical and orographical conditions it is necessary to register precise values in a vast range of different climatic elements in their small-spaced and temporal distribution. At places where direct measuring methods cannot be made, he proposes that important climatic elements like air temperature and the effects of radiation should be evaluated indirectly for example by support of phenological methods. In this connection I may remark that phenology became more and more important in the last few years not only for applied climatology. FREITAG (1983) quotes four ranges of application which give way to the following conclusions by the determination of differing phase-beginning dates of plants (Phaseneintrittszeiten) without any detailed measurements:

- the preference of slope expositions by radiation
- the different heating of a large city
- disadvantages of certain valley locations by the downslope flow of cold air masses
- or yield differences caused by deviations in soil climate.

K.-F. SCHREIBER (1983a, b) reports about the "phenological development of vegetation as a biological indicator for natural and anthropogene heat conditions in cities and in the country". He could differentiate between seven relative heat stages (from rather cool to very mild) with the aid of phenological investigations in exemplary areas in the southern Munsterland and the Ruhr District and its surroundings. The mapping of these heat stages gives way to an immediate application of temperature conditions for regional and landscape planning.

Fundamental works about this very important and interesting field of applied climatology were carried out by SCHNELLE (for example 1981). WITTERSTEIN (1978) informs about "the importance and tasks of the Phenological Service".

The production and flow of cold air in a certain area is determined by the plant cover and nature of surface (concave, convex, plain) as well as its catchment area, altitude, slope and exposition.

The amount of 'albedo' (reflection) is influenced by the duration and intensity of radiation. The reflection of different surfaces gains in significance especially during weather conditions with high rates of radiation because of the induced circulation by the different heating of the surfaces. Therefore, a registration of the differing amounts of 'albedo' on the smallest possible space are to be seen as an important factor for the development of cold air flows in the ground layers of atmosphere.
MAYER (1980) has determined the amounts of albedo for small areas in the Upper Rhine Valley analysing topographic maps with regard to the surface structures. Thus, open spaces, and in most cases greens, play an important part in frame of regional "processes of air mass exchange. They can act as a climatic-ecological regeneration performance" if they are suitable in an optimal way for the climate of a certain site. This is the distinctive feature of open spaces covered with vegetation of reducing pollution transported in the atmosphere (WERNER 1979). However, it has to be emphasized that relevant regeneration performances of greens are closely bound to topographical regeneration performance at places where this is not the case (WERNER 1980).

Beside the area of cold air production in frame of regional exchange processes the flow to places with expected meliorating effects on the climate must be guaranteed. The mass flows for different catchment areas are illustrated in figure 1.

These mass flows are called according to their dimensions downslope winds or mountain breezes. A typical dimension of a downslope wind is i.e. a catchment area of cold air of some square kilometers, a wind speed of 2 meters per second as well as a vertical distance of about 50 m and a width of some hundred meters.

According to WERNER (1979) the smallest catchment area of a downslope wind is 3 square km and a mass flow of $10^4 m^3$ per second. Mountain winds are classified with the additional factor 10.
According to measurements and calculations by KING (1973) in a small valley in east-west direction with a length of 250 m a temperature reduction of 1.8 K and a 10 to 12 % share of energy from infrared radiation which is related to cold air production one has to expect a cold air production per unit area of 12 m^3 cold air per m^2 and hour.

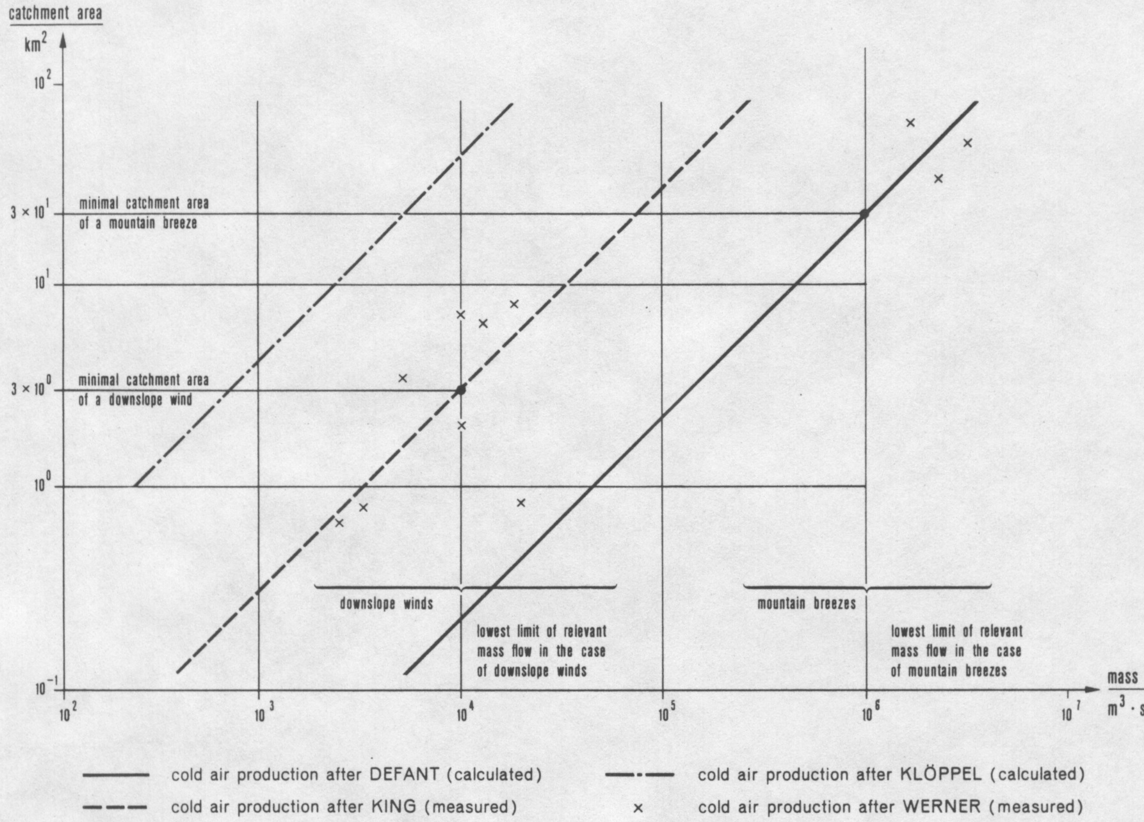
The well-known mountain wind called "Höllentäler" (HARLFINGER 1976) - having often been investigated and having bioclimatical as well as climatic-hygienic effect - which supplies the city of Freiburg i. Br. with cool, fresh air during autochthone weather conditions causes a reduction of gaseous and particle pollutants.

The quantities of cold air flows into valleys of the Palatinate Forest and in the Haard are given in the work by GEIGER (1983) as well as for an exemplary valley at the Moselle in the work by KLÖPPEL (1970). Local compensative air flows in the southern Upper-Rhine Plain (Staufen-Basin) were investigated by PARLOW (1983).

A mapping of the landscape climate considering several factors, as was done for the Palatine by LESER (1982) in a scale of 1 : 300,000, gives indications about cold air production and flow, radiation intensities, dangers of frost, distinct effects of urban climate, tendencies for hail and sultriness as well as about the occurence of foehn. Such synthetic maps about functional climate have already been made for small areas as was shown by VENT-SCHMIDT (1981) in the Pforzheim region.

Closely related to cold air production and flow

Fig. 1 The dependence of cold air production on the size of the regeneration area (after WERNER 1979, altered)



is the problem of fog occurence, especially in spring and fall. As soon as the dew-point of a certain air mass is reached, the hugeness of the cold air becomes visible by the formation of fog in the valley filled with cool air. Maps - showing the distribution of the average upper levels of these valley-fogs as well as the lower levels of high or cloud-fogs as well as the average number of foggy days per year, which has for example been carried out for the Deutscher Planungsatlas for North Rhine-Westphalia by SCHNIRMER (1976) - must be seen as important instruments for planning, especially for road building and the classification of recreation areas and because of the impacts of fog on human health.

Very differentiated investigations, as those done by SCHIRMER (1977) for Bad Kissingen, even determine the periods of foggy weather which is a very important information for road traffic (SCHNEIDER (1972). A precise knowledge about the spatial occurence of fog, however, can also be important for water economy.

SCHIRMER (1970) hints at the fact that the water balance of medium altitudes (450 - 500 m), where cloud-fog is a frequently observed phenomenon, is increased by 20 to 30 % if fog-preferring trees, like i.e. the Sitka spruce, are cultivated. Precise facts about the occurence and duration of foggy periods are often wanted in connection with the dying forests (Waldsterben). Analyses of the precipitation of rain and fog are carried out to determine the content of pollutants show clearly higher concentrations in the water from fog than in the rainwater. Vegetation in mountains with a higher frequency of fog (Peplopause) is affected to a higher degree by anthropogene depositions of pollutants than vegetation at locations where fog seldom occurs.

The planning of nature parks, healths-resorts and recreation areas closely depends on the determination of the local-climatic particularities (NEUWIRTH 1968). For this purpose BECKER (1972) illustrated the bio-climatic spheres (and their degrees) of polluted, preserving and stimulating climates for for the whole country in his well known map called "The Bioclimate in the Federal Republic of Germany". Various threshold values - which are determined by correlation of bioclimatic effects - make possible the mapping of the bioclimate as a sum of the effects affecting man.

Man-affecting climates, especially determined by sultriness are found in lowlands, troughs and basins up to altitudes of 250 m beyond sea or coastal climates.

BECKER's map, however, only contains average values which do not show the conditions of the different seasons, not those of single months. Supporting SCHIRMER (1982) it is desirable to create these maps on a monthly basis and make it available for medical meteorology and bioclimatology. New ways are shown in this respect by JENDRITZKY (in print) who created a monthly-based evaluation system for health resorts. In my opinion it is additionally necessary to consider the changes in clean air areas by pollution for any revised mapping. In this respect a seasonal distribution of the given conditions is of special advantage. Newly drafted maps informing about pollution with the most important pollutants (SO_2, O_3, NO_x) should take into consideration that the conditions of clean air areas have deteriorated since the increase of long-range transport of pollution some years ago. This is revealed by the latest investigations about the transport of ozone as well as for the years measured values of SO_2 concentrations in clean air areas (UMWELTBUNDESAMT 1982).

The contained information of bioclimatic maps should be increased by the fact, that the population can choose between clean air and recreation areas according to the given weather condition. This is especially the case for anticyclonal inversion conditions with different weather conditions in two marked air layers with a foggy and polluted cold air layer separated at a certain altitude by the above lying, relatively warm clean air. Detailed proposals of planning have already been made. Recreation areas for the population have been mapped exemplarily for times of extreme smog periods in a clean air area near to an industrial region (KUTTLER in print).

FAUST (1979) created two maps about the bioclimate in North Rhine-Westphalia, one of them illustrating the thermal efficiency, the other one the actinic efficiency. Even FAUST himself is sorry to say the air-hygienic conditions could not be considered properly in his maps for there is still a lack of data, which is absolutely necessary for an illustration of the 'aeorsol climate'. These maps are not only extraordinarily helpful for the planning of health resorts and recreation areas, but also for short-distance recreation and tourism.

A further field of work of applied climatology are investigations of wind and frost protection. Wind screens are built to cause a yield increase in agriculture and serve to

- an avoidance of late frostdamages to crops
- a decrease of evapotranspiration
- an increase of dew deposition, soil humidity and air temperature
- a prevention of mechanic winddamages and soil erosion as well as
- a protection against particle and gaseous pollutants (OLSCHOWY 1978).

An aimed wind protection can also have economic advantages in human settlements. Thus, measurements at very high hedges with a width of 1.2 m (Fagus sylvatica) in the Monschau Land (Eifel) showed that high windspeeds were reduced up to 50 %, the air temperatures in the lee of the hedges were - according to the weather conditions - some Kelvin higher than on the other side and the effects of heavy rains at the lee-side house-walls were reduced by up to 80 % (BECKMANN 1982).

Frost protection is of primary importance in fruit- and wine-growing (See work by AICHELE (1965) and WEGER (1955). Thus extensive linear and areal climatological measurements after the consolidation of vineyards in the Kaiserstuhl (Black Forest) showed that the transformation of small terraces into wide terraces ("plains at the slope") caused that on some of them the produced cold air cannot flow down. The reason is that the terraces with areas of about 5 ha are relatively large, so that a lot of cold air can be produced at a given time and cannot flow down because of the "hill-side gradient" of 2 to 4 %. ENDLICHER (1980), who carried out these very differentiated investigations with measuring vehicles, fixed stations and the evaluation of thermalphotographs, furthermore analysed a bibliographical list of no less than 320 different works.

Applied climatological investigations from the field "plant and climate" have been matter of research for several decades. These are meteorology and climatology for forestry and agriculture, but their results cannot be discussed in this survey. An extremely extensive survey about the works in this field can be found in the annually published "Agrarmeteorologische Bibliographie" of the 'Deutscher Wetterdienst' containing hundreds of works are listed and discussed to the topics: "atmospheric conditions and soil, plant, agriculture, plant diseases respectively pests and animals". Bibliographies are already available for the period 1950 to 1982 by different editors (JUNG 1983).

FRANKENBERG (1983) has previously carried out investigations in the field of climatology about the correlation between weather and its effects on agricultural yields in Germany. The exemplary calculations for the yield of winter wheat and sugarbeet were carried out on district level and show spatial differences in yield as they occurred after a dry summer (1976).

The problem of the determination of the water balance in Germany is dealt with in the works by KELLER (1978), as well as FRANKENBERG & LAUER (1981). D. SCHREIBER (1973) additionally examined the dependence of agricultural cultivation on the water supply and the photo-actinic conditions of the environment. As an utilization for stable-building in Germany's agriculture D. SCHREIBER (1982) developed a "Map of temperature zones for summer and winter" from a previously introduced map for the DIN-Norm 18910. A criterion of classification was the number of winterly ice-days which allow a spatially very differentiated presentation of winterstrength in Germany. With this map it is possible to get instructions for the heat insulation in building construction and guidance for the intensity of domestic heating.
In another work D. SCHREIBER developed a map of the "zones of winter-strength for coppice" for Germany and Europe (HEINZE & D. SCHREIBER, in print). This map is based on the evaluation of the mean annual minimum temperatures. Eleven different temperature zones are related to tree species which can cultivated differently refering to winter strength (important for expensive trees and grafted plants).

A rather new field of applied climatology was created in North Rhine-Westfalia where "pollenflight forecasts" were executed. These measurements are an extremely important instrument of prophylaxis for allergie people by informing them about the actual occurence of the most important kinds of pollen. A guidance from the pollen-calendar, on the other hand, only is a vague help because of its mean beginnings of blooming phases which can deviate from year to year by about 6 weeks because of the dependence on the weather conditions. The prognostical test for grass pollen showed in the average total the quite good value of 71 % (PULS 1983).

For the planning of location of new power plants applied climatological investigations are urgently necessary for the rating and limitation of waste heat. Two spacious investigations of that kind were carried out, one in the region High Rhine/Upper Rhine (CLIMOD project = climate modification, started in 1975; WINIGER 1982), another one in the Upper Rhine Region (BARTELS et al. 1982; SÜSSENGUTH et al. 1983). These projects included the measurements and calculations of the parameters necessary for the discussion of the problem, as there are the balance of ra-

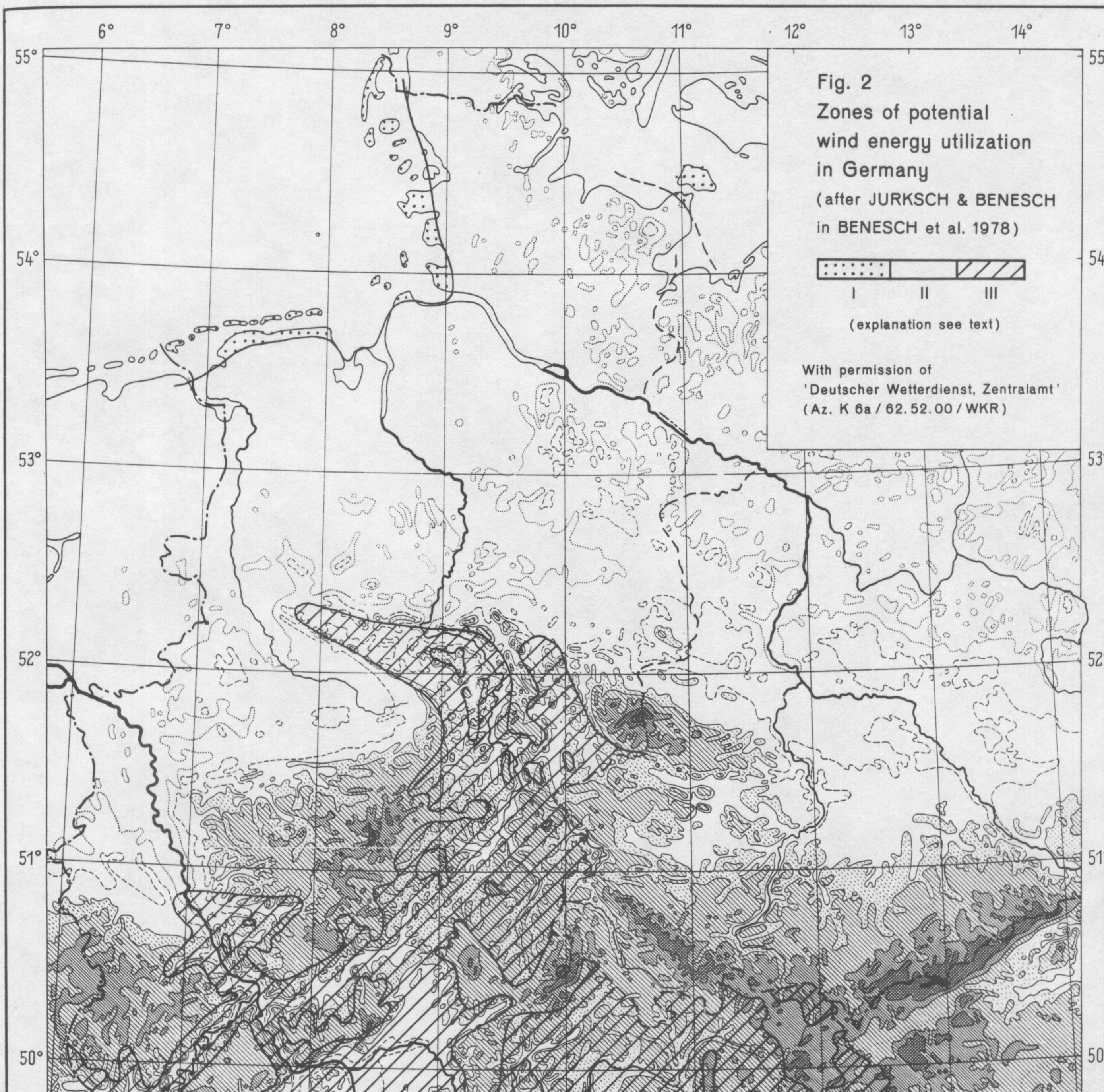


Fig. 2
Zones of potential wind energy utilization in Germany
(after JURKSCH & BENESCH in BENESCH et al. 1978)

diation and latent and sensitive heat flows with which areas could be limited sensitive to additional heat sources.

SCHMIDT (1980) deals in his work "The climatic aspects of the building of power plant" with general problems arousing of the building of power stations. These are the regional change of energy balance, ventilation conditions and a possible change of the regional climate (radiation balance and formation of convection-clouds). He prognosticated the climatic change with help of model calculations.

Investigations related to the utilization of "regenerative sources of energy" (i.e. wind and solar energy) are described by BENESCH et al. (1978) and JURKSCH (1980). These authors created 'applicability maps' with reference to the utilization of wind energy in Germany. One of them is shown in figure 2. Germany is subdivided into three zones according to the potential utilization of wind energy.

Zone I is mainly restricted to the coastal areas. There we have relatively high wind velocities, even the mean monthly and annual number of hours with wind velocities $v \geq 12 m/s$, a value which is high enough for an utilization of wind energy by bigger wind power stations.

Zone II on the whole covers the area of the North-German Lowland where lower threshold values of mean monthly and annual number of hours with wind velocities between $v = 5$ m/s and $v = 8$ m/s are reached. These areas allow a certain utilization of wind power.

Zone III represents the major part of Germany. An utilization of wind power by power stations is not recommendable because of the high number of lulls and the low number of hours per year with prevailing higher wind velocities.

That is the reason why the share of the utilization of wind energy among the total utilization of energy must be estimated as low even for the future. The prospects for the utilization of solar energy will not either be profitable at present (KLECKER 1979). At most places in Germany the sun only shines 1300 to 1800 hours per year (correspondingly 30 to 41 % of the possible sunshine duration). In addition to this the highest radiation intensity is in summer, the lowest in winter when most of the energy is used for heating. Thus, June is the month with the highest amount of radiation in Hamburg with a daily mean of global radiation of 5437 Wh/m^2, in December on the other hand, one 401 Wh/m^2 are measured, which is a ratio of 13 to 1 (GOLCHERT 1981). The energy economy proceeds on very optimistic assumptions (DELHI 1981) solar energy could cover the total energy demand in the future by a maximum of 20 % in middle Europe. An optimal utilization of wind power as well as solar energy substantially depends on improvements and further developments of technology.

The quoted examples from the wide-spread field of applied climatology in Germany illustrate the importance of this science for man and economy nowadays and in the future. Therefore an intensification of applied climatological works is imperatively desirable.

SUMMARY

It is the intention of this paper to give a survey about applied climatology in the Federal Republic of Germany. Applied climatology is understood as functional research dealing with the effects of climate on man and economy as well as with the intended and not intended anthropogene influences on the climate.

As the result of the abundance of works and the restricted space I have mainly considered works which appeared since 1970.
The different fields of applied climatology in the Federal Republic of Germany are described from the sphere of industrial and urban agglomerations, regional and landscape planning as well as the utilization of regenerative forms of energy with several examples.

LITERATURE

Used abbreviations

B.D.W. = Berichte des Deutschen Wetterdienstes

N. Arch. Nds. = Neues Archiv für Niedersachsen

AHRENS, D.: Klimagerechte Interpretation von Immissionsmessungen verschiedener Schadstoffe in Abhängigkeit von Naturraum und Siedlungsstruktur. In: Freiburger Geographische Hefte, 1983, H. 21

AICHELE, H.: Weinbau-Meteorologie. In: Weinberg und Keller 12, 1965, S. 1-14

BARTELS, H.; B. RUDOLF; H.J. SWANTES; V. VENT-Schmidt: Klima als Faktor der Regionalplanung. In: Lufthygienisch-meteorologische Modelluntersuchung in der Regio Untermain, 6. Arbeitsbericht und Abschlußbericht, Frankfurt/M. 1978

BARTELS, H.; H. FUCHS;, G. JURKSCH; J. MELCHIOR; G. SÜSSENGUTH: Klimatologische Beschreibung des Oberrheingebiets im Hinblick auf Abwärmeprobleme. Abwärmeprojekt Oberrheingebiet Teil I. In: B.D.W., Nr. 160, 1982

BAUMGARTNER, A.; H. MAYER; W. BRÜNDEL; E.-M. NOACK: Untersuchung des Einflusses von Bebauung und Bewuchs auf das Klima und die lufthygienischen Verhältnisse in bayerischen Großstädten. Forschungsvorhaben Nr. 8272-VI/46-7106 im Auftrag des Bayerischen Staatsministeriums für Landesentwicklung und Umweltfragen. Kurzmitteilungen Nr. 5 und 6, München 1983

BAUMÜLLER, J.: Ein Beitrag der Meteorologie zur Raumplanung. In: Baupraxis 1, 1975, S. 11-14

BECKER, F.: Die Bedeutung der Orographie in der medizinischen Klimatologie. In: Geogr. Taschenb., 1972, S. 342-356

BECKMANN, R.: Die Hausschutzhecken im Monschauer Land unter besonderer Berücksichtigung ihrer klimatischen Auswirkungen. Arb. z. Rhein. Landeskde., 1982, Nr. 49

BECKRÖGE, W.: Auswirkungen von Parkanlagen auf die städtische Wärmeinsel. Dipl.-Arb. am Institut für Meteorologie u. Klimatologie d. Univ. Hannover 1980

BENESCH, W.; G. DUENSING; G. JURKSCH; R. ZÖLLNER: Die Windverhältnisse in der Bundesrepublik Deutschland im Hinblick auf die Nutzung der Windkraft. In: B.D.W., Nr. 147, 1978

BERG, H.: Einführung in die Bioklimatologie. Bonn 1947

BERNATZKY, A.: The contribution of trees and green spaces to a town climate. In: BITAN, A., 1982, S. 301-310

BITAN, A. (ed.): The impact of climate on planning and building. Lausanne 1982

BLÜTHGEN, J. & W. WEISCHET: Allgemeine Klimageographie, 3. Aufl., Lehrbuch der allgemeinen Geophie, Berlin 1980

BRAHE, P.: Klimatische Auswirkungen von Gehölzen auf umbauten Stadtplätzen. In: Das Gartenamt 23, 1974, S. 61-70

CAPPEL, A. & M. KALB: Das Klima von Hamburg. Analyse für Zwecke der angewandten Klimatologie mit Datenkatalog. In: B.D.W., Nr. 141, 1976

CONRAD, V.: Die klimatologischen Elemente und ihre Abhängigkeit von terrestrischen Einflüssen. In: Handb. d. Klimatologie, Berlin, von W. KÖPPEN und R. GEIGER, 1936

DELHI, M.: Energie von der Sonne. Hrsg. v. d. Informationszentrale der Elektrizitätswirtschaft e.V., Bonn 1981

DEUTSCHER WETTERDIENST (Hrsg.): Klima und Planung. I. Meteorologische Fortbildung. In: promet H. 3 und H. 4, 1980

DITTMANN, Ch.: Regensburg - Stadtklima und Luftverunreinigung. In: Acta Albertina Ratis Bonensia Naturw. Vereins Bd. 41, 1982

EICK, K.: Ökologische Funktion von Grünflächen. In: Landestagung 1979, Feuchtgebiete und ihre ökologische "Bedeutung", LÖLF, NRW, 1979, S. 55-65

EMONDS, H.: Das Bonner Stadtklima. In: Arb. Rhein. Landeskde., 7, 1972

ENDLICHER, W.: Geländeklimatologische Untersuchungen im Weinbaugebiet des Kaiserstuhls. B.D.W., Nr. 150, 1980

ERIKSEN, W.: Beiträge zum Stadtklima von Kiel. Schriften Geogr. Inst. Univ. Kiel, Bd. 22, H. 1, 1964

ERIKSEN, W.: Die stadtklimatischen Konsequenzen städtebaulicher Entwicklung. In: Städtehygiene 11, 1971, S. 259-262

ERIKSEN, W.: Zur Niederschlagsmodifikation im Bereich von Großstädten. In: Städtehygiene 23, Nr. 7, 1972, S. 164-166

ERIKSEN, W.: Probleme der Stadt- und Geländeklimatologie, Darmstadt, 1975

FAUST, R.: Das Bioklima in Nordrhein-Westfalen. Verein z. Förd. d. Kurortklimadienstes und der Kurortklimaforschung i. Lande NRW, Bad Salzuflen, 1979

FAUST, V.: Biometeorologie. Der Einfluß von Wetter und Klima auf Gesunde und Kranke. Stuttgart 1977

FETT, W. (Hrsg.): Angewandte Stadtklimatologie. Stand der Fragen und Antworten bei Anwendung meteorologischer Erkenntnisse in der Stadt- und Grünflächenplanung. Deutsche Meteorologische Gesellschaft, AKUMET, Berlin 1978

FETT, W.: Meteorologische Studien zur Lufthygiene. In: Wabolu-Berichte 2, 1982

FEZER, F.: Wieweit verbessern Grünflächen das Siedlungsklima? In: Ruperta Carola 55, 1976, S. 77-79

FEZER, F.; R. SEITZ (Hrsg.): Klimatologische Untersuchungen im Rhein-Neckar-Raum. Studien für die Regional- und Siedlungsplanung. Heidelberger Geogr. Arb., H. 47, 1977

FINKE, L.: Zuordnung und Mischung von bebauten und begrünten Flächen. Schriftenr. "Städtebau. Forsch." des Bundesministers für Raumordnung, Bauwesen und Städtebau, 03.044., 1976

FLACH, E.: Human Bioclimatology. In: H.E. LANDSBERG: World Survey of Climatology. Vol. 3, Amsterdam 1981

FLOHN, H.: Geographische Aspekte der anthropogenen Klimamodifikation. In: Hamburger Geogr. Stud. 28, 1973, S. 13-30

FORTAK, H.: Anwendungsmöglichkeiten von mathematisch-meteorologischen Diffusionsmodellen zur Lösung von Fragen der Luftreinhaltung. Hrsg. v. Minister f. Arbeit, Gesundheit und Soziales des Landes NRW, Düsseldorf, 1972

FORTAK, H.: Anwendungsmöglichkeiten von immissionsklimatologischen Ausbreitungsmodellen. In: VDI-Berichte Nr. 200, 1973, S. 173-188

FRANKE, E. (Hrsg.):Stadtklima, Ergebnisse und Aspekte für die Stadtplanung. Stuttgart 1977

FRANKENBERG, P.: Der "trockene" Sommer des Jahres 1976 in seiner Auswirkung auf die Erträge an Winterweizen und Zuckerrüben in der Bundesrepublik Deutschland. In: Ztschrift f. Agrargeogr., H. 2, 1983, S. 144-162

FRANKENBERG, P. & W. LAUER: Wasser und Raum in der Bundesrepublik Deutschland. In: Erdkunde 35, 1981, S. 231-234

FRÄNZLE, O. & W.F. KILLISCH: Untersuchungen zur städtischen Belastungsstruktur der Bundesrepublik Deutschland mit Hilfe der Biplot-Technik und numerischer Klassifikationsverfahren. Ein Beitrag zur angewandten Statistik. Kieler Geogr. Schriften, Bd. 50, 1979, S. 211-245

FREITAG, E.: Phänologie - ein Arbeitsgebiet des Deutschen Wetterdienstes. In: Mitt. Dtsch. Meteorol. Gesell. 3/83, 1983, S. 3-22

GEHRKE, A.: Klimaanalyse Stadt Duisburg. Kommunalverband Ruhrgebiet, Essen, 1982

GEHRKE, A.; W. NÜBLER; W. WEISCHET: Oberflächen- und Lufttemperatur in Abhängigkeit von der Baukörperstruktur (Beispiel Freiburg i. Br.). In: Annal. Meteorol.(N.F.), Nr. 12, 1977, S. 193-196

GEIGER, M.: Geländeklima - Untersuchungen für die Landschaftsplanung an der Weinstraße. In: Mannheimer Geogr. Arb., Heft 14, 1983, S. 25-42

GEORGII, H.W. & J. PANKRATH (eds.): Deposition of atmospheric pollutants. Dordrecht, Holland 1982

GÖDDE, M.: Veränderung der ruderalen Flora des engeren Stadtgebietes von Münster im Zeitraum von 35 Jahren. In: Natur u. Heimat 42, 1982, S. 109-112

GOLCHERT, H.J.: Mittlere monatliche Globalstrahlungsverteilungen in der Bundesrepublik Deutschland. In: Meteorol. Rdsch. 34, 1981, S. 143-151

GOSSMANN, H.; M. LEHNER; P. STOCK: Wärmekarten des Ruhrgebietes. In: Geogr. Rdsch. 33, H. 12, 1981, S. 556-563

GREUPNER, P.; G. ZEUNER; U. HAMMEL: Die flächendeckende bioklimatische Belastungskartierung für die Stadt Nürnberg. Inst. f. Umweltschutz, Dortmund 1982

HADER, F.: Klimagerechtes Planen. In: Klima und Planung '79, Geogr. Inst. Bern, Nr. 6, 1980, S. 42-45

HAMM, J.M.: Untersuchungen zum Stadtklima von Stuttgart. In: Tübinger Geogr. Studien, H. 29, 1969

HARLFINGER, O.: Die bioklimatische Bedeutung des "Höllentälers" für Freiburg. In: Meteorol. Rdschau 29, 1976, S. 15-18

HEINZE, W. & D. SCHREIBER: Eine neue Kartierung der Winterhärtezonen für Gehölze in Europa. In: Mitteilungen der deutsch. Dendrologischen Gesellschaft, Bd. 74, im Druck

HENTSCHEL, G.: Das Bioklima des Menschen. Berlin 1982

HERRMANN, R. & B. MEISER: Untersuchungen über die zeitliche und räumliche Änderung des Temperaturfeldes im Stadtgebiet von Gießen. In: Die Erde 104, 1973, S. 226-246

HEYER, E.: Witterung und Klima. Leipzig 1981

HIRT, F.-H. & H. KELLERSMANN: Luftaufnahmen. Wärme-Infrarotmessungen als neue Informationsquelle für Planungszwecke. Siedlungsverband Ruhrkohlenbezirk, Essen 1972

HÖSCHELE, K. & H. SCHMIDT: Klimatische Wirkungen einer Dachbegrünung. In: Garten u. Landsch. 84, 1974, S. 334-337

HORBERT, M. & A. KIRCHGEORG: Climatic and air-hygienic aspects in the planning of inner-city open spaces: Berlin Großer Tiergarten. In: BITAN, A. (1982), S. 311-322

HUMBOLDT, A. von: Kosmos - Entwurf einer physischen Weltbeschreibung. Bd. 1, Stuttgart 1845

JUNG, E.: Agrarmeteorologische Bibliographie 1982. Offenbach/M. 1983

JURKSCH, G.: Regenerative Energiequellen. In: promet 4/80, 1980, S. 12-15

JURKSCH, G.: Problems of urban and regional planning described by meteorological investigations in the Upper Rhine Area. In: BITAN, A. (1982), S. 11-14

KALB, M.: Einige Beiträge zum Stadtklima von Köln. In: Meteorol. Rdsch., H. 4, 1962, S. 92-99

KALB, M.: Klimakarten des Deutschen Wetterdienstes für den Bereich der Bundesrepublik Deutschland. In: Natur u. Landschaft 54, Nr. 7/8, 1979, S. 250-252

KALB, M. & H. SCHMIDT: Das Klima ausgewählter Orte der Bundesrepublik Deutschland. Hannover. Statistische Auswertungen und Erläuterungen für Zwecke der angewandten Klimatologie. In: B.D.W., Nr. 143, 1977

KELLER, R.: Hydrologischer Atlas der Bundesrepublik Deutschland im Auftrag der Deutschen Forschungsgemeinschaft, hrsg. v. U. de Haar, 1978

KESSLER, A.: Über den Tagesgang von Oberflächentemperaturen in der Bonner Innenstadt an einem sommerlichen Strahlungstag. In: Erdkunde 15, 1971, S. 13-20

KING, E.: Untersuchungen über kleinräumige Änderungen des Kaltluftflusses und der Frostgefährdung durch Straßenverkehr. In: B.D.W., Nr. 130, 1973

KINS, L.: Temporal variation of chemical composition of rainwater during individual precipitation events. In: GEORGII, H.-W.; PANKRATH, J. (eds.): Deposition of Atmospheric Polluants, 1982, S. 87-96

KLECKER, P.M.: Sonnenscheindauer und Globalstrahlung in der Bundesrepublik Deutschland unter bes. Berücksichtigung des Einsatzes von Systemen zur Nutzung der Sonnenenergie. Dipl.-Arbeit, unveröffentlicht, Geogr. Inst. Ruhr-Univ. Bochum, 1979

KLINK, H.-J.: Physisch-geographische und geoökologische Landesforschung. - Stand und Weiterentwicklung als Aufgabe der Landeskunde - In: Ber. dt. Landeskde. Bd. 56, H. 1, 1982, S. 87-112

KLÖPPEL, P.: Versuch einer Berechnung der Kaltluftbewegung am Modell des Schadbachtals bei Graach/Mosel. In: Landschaft und Stadt 3, 1970, S. 122-132

KNOCH, K.: Weltklimatologie und Heimatklimakunde. In: Meteorol. Z. 59, 1942, S. 245-249

KÖPPEN, W.: Grundriss der Klimakunde. 2. Auflage, Berlin und Leipzig 1931

KUTTLER, W.: Einflußgrößen gesundheitsgefährdender Wetterlagen und deren bioklimatische Auswirkungen auf potentielle Erholungsgebiete - dargestellt am Beispiel des Ruhrgebietes und des Sauerlandes. In: Bochumer Geogr. Arb., H. 36, 1979a

KUTTLER, W.: London-Smog und Los-Angeles-Smog. In: Erdkunde, Bd. 33, 1979b, S. 236-240

KUTTLER, W.: The role of evergreen vegetation in industrial agglomeration areas. In: Energy and Buildings 5, 1982, S. 23-30

KUTTLER, W.: Trockene und nasse Schwefeldepositionen im Mittleren Ruhrgebiet. In: Verh. Ges. f. Ökol., Bd. X, 1983a, S. 457-472

KUTTLER, W.: Anthropogenes Schwefelproblem und saure Niederschläge. In: Wohnbauforschung in Österreich, H. 1/2, 1983b, S. 1-8

KUTTLER, W.: Stadtklimatologische Untersuchungen in Lünen. In: KUTTLER, W. & D. SCHREIBER: Stadt- und geländeklimatische Untersuchungen im südlichen Münsterland. In: Materialien zur Raumordnung aus d. Geogr. Inst. d. Ruhr-Univ. Bochum, 1984, S. 15-76

KUTTLER, W.: Peripheral clean areas near industrial regions during smog weather conditions - contribution to planning of industrial nearby clean air areas. Vortrag auf dem Symposium über "The impact of climate on planning and building", Tel Aviv, Israel, Nov. 1983 (im Druck)

LESER, H.: Gelände- und Stadtklima der Pfalz. In: Pfalzatlas, Textband, III, H. 33, 1982, S. 1298-1306

LINDENBEIN, B. & H. Malberg: Die Verteilung lokaler Regenfälle im Westberliner Stadtgebiet. In: Meteorol. Abhdl. 140, Nr. 2, 1973, III.

LORENZ, D.: Meteorologische Probleme bei der Stadtplanung. In: Baupraxis 9, 1973, S. 57-62

MAHLER, G. & P. STOCK: Oberflächentemperaturverhalten städtischer Flächen, ermittelt aus Infrarotaufnahmen. In: Stadtbauwelt, 55, 36, 1977, S. 212-215

MAYER, H.: Problematik bei der Kartierung der Oberflächenalbedo in einem mesoskaligen Gebiet. In: Ann. Meteorol. (N.F.), Nr. 16, 1980, S. 8-84

MIESS, M.: Klimaökologische Aspekte der Stadtentwicklung. In: Das Gartenamt 21, (3), 1972, S. 115-120

MIESS, M.: Planungsrelevante und kausalanalytische Aspekte der Stadtklimatologie. In: Landschaft und Stadt, 6, 1974, S. 9-17

MIESS, M. & B. MIESS: Klimaanalyse regionaler Grünzug D. Grenzbereich der Städte Bochum-Gelsenkirchen, Herne-Herten. Im Auftrag des Kommunalverbandes Ruhrgebiet, 1980

NEUWIRTH, R.: Medizin-Meteorologische Untersuchungen als Beitrag zur Planung von Naturparken. In: Natur und Landschaft 43, 1968, S. 292-294

NEUWIRTH, R.: Der Einfluß der Wetterlagen auf die Luftreinheit von Städten. In: Z. f. phys. Med. 4, 1976, S. 154-160

NÜBLER, W.: Konfiguration und Genese der Wärmeinsel der Stadt Freiburg. In: Freiburger Geogr. Hefte, H. 16, 1979

NYC, J.: Grundlagen und Aspekte des Mikroklimas von Wohnhöfen. In: Meteorol. Abhdl. N.F., Serie A, Bd. 3, H. 2, 1978

OLSCHOWY, G.: Landespflegerische Mittel zur Lenkung des örtlichen Klimas. In: OLSCHOWY, G. (Hrsg.): Natur- und Umweltschutz in der Bundesrepublik Deutschland, Hamburg und Berlin 1978, S. 234-245

PARLOW, E.: Geländeklimatische Untersuchungen im Bereich der Staufener Bucht unter besonderer Berücksichtigung lokaler Ausgleichsströmungen. In: Freiburger Geogr. Hefte, H. 20, 1983

PECHER, R.: Der jährliche Regenwasserabfluß von bebauten Gebieten und seine Verschmutzung. In: Abwasser 21, 1974, S. 113-120

PLATE, E.J.: Der Wind als Faktor der Bauwerks- und Städteplanung. In: Der Bauingenieur, 49, 1974, S. 457-466

POLL, R. & U. WELDER (Hrsg.): Grün im Stadtbereich. Ein Literaturkatalog zur Grünplanung und Freiraumplanung. Schriften d. Univ. Erlangen-Nürnberg Nr. 14, 1982

PRINZ, B.: Freizonen als Frischluftreservoire. In: Umwelt, 5, 1973, S. 62-65

PULS, K.E.: Pollenflugvorhersage in Nordrhein-Westfalen - Ein Feldversuch. In: Ann. Meteorol. (N.F.), Nr. 20, 1983, S. 141-142

REIDAT, R.: Über den Einfluß der Stadt auf die Niederschlagsverteilung bei starken Regenfällen in Hamburg. In: Wetter und Leben 23, 1971, S. 1-6

ROBEL, F.; U. HOFFMANN; A. RIECKERT: Daten und Aussagen zum Stadtklima von Stuttgart auf der Grundlage der Infrarot-Thermographie. Beitr. z. Stadtentwicklung, 15, 1978

ROTH, D.: Klimahygienische Aspekte des Stadtklimas. In: Landschaft und Stadt 11 (1), 1979, S. 13-17

SCHÄFER, P.J.: Das Klima ausgewählter Orte der Bundesrepublik Deutschland. München. In: B.D.W., Nr. 159, 1982

SCHIRMER, M.: Beitrag zur Methodik der Erfassung der regionalen Nebelstruktur. In: Aktuelle Probleme Geographischer Forschung, Abh. d. 1. Geogr. Inst. d. Freien Univ. Berlin, Bd. 13, 1970, S. 135-146

SCHIRMER, H.: Deutscher Planungsatlas. Klimadaten, Bd. I Nordrhein-Westfalen, Lieferung 7, Hannover 1976

SCHIRMER, H.: Die klimatologischen Wirkungsfaktoren und ihre Bedeutung für die Planung. In: Jahrbuch für Regionalwissenschaft, 1981, S. 140-148

SCHIRMER, H.: Bioklimatische Stufen für eine Raumbeurteilung zu Kur- und Erholungszwecken in Niedersachsen. In: N. Arch. Nds., 2, 1982, S. 188-194

SCHLAAK, P.: Mittlere und extreme Niederschlagsverhältnisse in Berlin. In: Beil. z. Berl. Wetterkarte 8/72, 13.01.1972

SCHLAAK, P.: Die Temperatur- und Niederschlagsverhältnisse im Gebiet von Berlin und ihre Auswirkungen auf die Vegetation. In: Berliner Naturschutzbl. 20, Nr. 59, 1976, S. 231-241

SCHMIDT, H.: Kraftwerke und andere Industrieanlagen. In: promet. 1980 4/80, S. 1-4

SCHNEIDER, M.: Kaltluftstau an Straßendämmen? - Nicht immer! In: Meteorol. Rdschau 25, 6, 1972, S. 187-188

SCHNEIDER-CARIUS, K.: Das Klima, seine Definition und Darstellung. In: Veröff. Geophys. Inst. Univ. Leipzig, 2. Ser., 17, 1961

SCHNELLE, F.: Beiträge zur Phänologie Europas IV. Lange phänologische Beobachtungsreihen in West-, Mittel- und Osteuropa. B.D.W., Nr. 158, 1981

SCHREIBER, D.: Entwurf einer Klimaeinteilung für landwirtschaftliche Belange. Bochumer Geogr. Arb., 1973, Sonderreihe Bd. 3

SCHREIBER, D.: A scientifically-founded measurement for winter cold load on structure parts and their mapping for the Federal Republic of Germany. In: BITAN, A., 1982, S. 205-213

SCHREIBER, D.: Stadtklimatologische Untersuchungen in Recklinghausen. In: KUTTLER, W. & D. SCHREIBER: Stadt- und geländeklimatische Untersuchungen im südlichen Münsterland. In: Materialien zur Raumordnung aus d. Geogr. Inst. d. Ruhr-Univ. Bochum, 1984, S. 77-102

SCHREIBER, K.-F.: Die thermischen Verhältnisse des Ruhrgebietes und angrenzender Räume - dargestellt mit Hilfe der Phänologischen Entwicklung der Pflanzendecke. In: WEBER, P. & K.-F. SCHREIBER (Hrsg.): Westfalen und angrenzende Regionen. Festschrift zum 44. Deutsch. Geographentag in Münster, Teil I, 1983a, S. 307-319

SCHREIBER, K.-F.: Die phänologische Entwicklung der Pflanzendecke als Bioindikator für natürliche und anthropogen bedingte Differenzierungen der Wärmeverhältnisse in Stadt und Land. In: Verh. Ges. Ökologie, Bd. XI, 1983b, S. 385-396

SCHULZE, P.: Die horizontale Temperaturverteilung in Großstädten, insbesondere die West-Berlins in winterlichen Strahlungsnächten. In: Meteorol. Abhdl., 1969, Bd. 91, H. 2

SEITZ, R.: Stadtklima Mannheim-Ludwigshafen. Diss., Heidelberg 1975

SEKIGUTI, T.: On the representation of climate. In: Geophys. Mag. 22, 1, Tokyo 1951, S. 29-33

SPERBER, H.: Mikroklimatisch-ökologische Untersuchungen an Grünanlagen in Bonn. Diss. Bonn 1974

STAHLMANN, V.: Starkregenhäufigkeit im Emscher- und Lippegebiet. In: Wasser und Boden, 1, 1976, S. 3

STEIN, N.: Zentrale Forschungsfelder einer ökologisch orientierten Stadtklimatologie: Strahlungs-, Energie- und Wärmehaushalt. In: Landschaft und Stadt, 11, (3), 1979, S. 99-110

STOCK, P.: Beispiele des Einsatzes von Thermaldaten im Ruhrgebiet. Beitr. Akad. Raumforsch. u. Landespl. 62, 1982, S. 49-67

STOCK, P. & K. PLÜCKER: Wärmeaufnahmen des Ruhrgebietes für die regionale und städtische Umweltplanung. Intern. Jahrbuch f. Kartographie Vol. XVIII, 1978

SÜSSENGUTH, G.; H. BARTELS; G. JURKSCH: Beitrag zur Klassifikation abwärmebezogener Wetterlagen mit Hilfe der thermischen Schichtung. Modellgebiet Oberrheingraben, Abwärmeprojekt Oberrheingebiet Teil II. B.D.W., Nr. 163, 1983

SUKOPP, H.: Ökologische Grundlagen für die Stadtplanung. In: Landschaft und Stadt 11, (4), 1979, S. 173-181

SUKOPP, H. & P. WERNER: Urban environments and vegetation. In: HOLZNER, W.; M.J.A. WERGER; I. IKUSIMA: Man's impact on vegetation. London 1983

THIELE, A.: Luftverunreinigung und Stadtklima im Großraum München. Bonner Geogr. Abh., H. 49, 1974

THORNTHWAITE, C.W.: The geographer's role in Climatology. In: LEIDLMAIR, A.: Hermann von Wissmann - Festschrift, Tübingen 1962, S. 81-88

UMWELTBUNDESAMT: Großräumige Luftverunreinigung in der Bundesrepublik Deutschland. Texte 33/82, Berlin 1982

VENT-SCHMIDT, V.: Eine synthetische Karte der lokalklimatischen Struktur im Großraum Pforzheim. In: Natur und Landschaft 56, Nr. 1, 1981, S. 8-11

WEGER, N.: Zur Methodik der Kleinklimakartierung im Weinbau. In: Mitt. Dt. Wetterd. Nr. 14, Bd. 2, 1955

WEISCHET, W.: Die räumliche Differenzierung klimatologischer Betrachtungsweisen. Ein Vorschlag zur Gliederung der Klimatologie und zu ihrer Nomenklatur. In: Erdkunde 10, 1956, S. 109-122

WEISCHET, W.: Notwendigkeit und Möglichkeit einer raum- und klimagerechten Fassung der "Technischen Anleitung zur Reinhaltung der Luft" (TA-Luft). In: Verh. Ges. Ökol. 1973, S. 329-249

WEISCHET, W.: Innerstädtische Klimadifferenzierung aufgrund von thermischen und hygienischen Meßwerten. Das thermische Verhalten der Oberflächen bei unterschiedlicher Baukörperstruktur mit A. GEHRKE. In: Untersuchung der stadtklimatischen und lufthygienischen Verhältnisse der Stadt Freiburg im Breisgau. Arbeitsbericht einer interdisziplinären Arbeitsgruppe. Hrsg. v. Stadtplanungsamt, 1974, Freiburg

WEISCHET, W.: Problematisches über die städtische Wärmeinsel und die Notwendigkeit einer Baukörperklimatologie. In: Siedlungsgeographische Studien, 1979

WEISCHET, W.: Stadtklimatologie und Stadtplanung. In: Klima und Planung '79. Tagung am Geogr. Inst. d. Univ. Bern 19./20. Sept. 1979, Nr. 6, Bern 1980, S. 73-95

WERNER, G.: Regionale Luftaustauschprozesse und ihre Bedeutung für die räumliche Planung. In: Landschaft und Stadt 11, (1), 1979, S. 17-25

WERNER, G.: Ein Modellansatz zur Bewertung der klimaökologischen Nutzungsverträglichkeit. In: Werkstattreihe, H. 6, INFU, Dortmund 1980

WILLNER, L.: Immissionsprognosen - Vergleich verschiedener Verfahren. In: Staub.- Reinh. Luft 7, 1977, S. 260-266

WILMERS, F.: Klimatologische Überlegungen zur Bebauung von Freiflächen in Stadtgebieten - besonders am Rande von Flußniederungen. In: N. Arch. Nds. 24, 1975, S. 259-277

WILMERS, F.: Grundfragen zu einer Kartierung des Landschaftsklimas. In: Verh. Ges. Ökol. Bd. VII, 1979, S. 113-119

WILMERS, F.: Temperaturmessungen in der City als Beitrag zum Bioklima von Hannover. In: Ges. f. Ökologie, Bd. IX, 1981, S. 343-347

WINIGER, M.: Klimatische Aspekte des Kernkraftwerkbaues (Studie CLIMOD). In: Geogr. Rdschau, 34, H. 5, 1982, S. 218-227

WITTERSTEIN, F.: Bedeutung und Aufgaben des phänologischen Dienstes. In: Mitt. Dt. Wetterd. Nr. 19, 1978

WOLFSEHER, U. & K. GERTIS: Bodennahe Aerodynamik. In: Gesundheits-Ingenieur H. 9. S. 259-274, H. 11, S. 321-332, 1978

ZACHARIAS, F.: Blühphaseneintritt an Straßenbäumen (insb. Tilia x enchlora KOCH) und Temperaturverteilung in Westberlin. Diss. Berlin 1972

ADDENDA

HAVLIK, D.: Großstädtische Wärmeinsel und Gewitterbildung - ein Beispiel anthropogener Klimamodifikation. In: Festschrift für Felix Monheim zum 65. Geburtstag. Geogr. Inst. RWTH Aachen, 1981, S. 91-109

JENDRITZKY, G.: Die Bewertung der thermischen Reizstärke in heilklimatischen Kurorten. In: Z. Phys. Med., in print