Geologische Abhandlungen von Hessen 2004, 114, 42-53 (Engl. translation 2010)

HEIDRUN JAGOUTZ*

The Effect of Wind

1. Introduction

The evaluation of the wind conditions in the wine locations of the Rheingau has been revised in this new edition of the Atlas of the Wine-Growing Regions of Hesse. The first edition included a map of zones of equal wind conditions (in relation to a main station). Over the years, this presentation has proven to be of little practical use since this does not take into account the effect of wind on vineyard climate. This map has not been re-printed for the new edition and has been replaced by an analysis of the wind statistics for the period between 1961 and 1990. This approach is based on the study by HORNEY (1975) "The Ecological Effect of Wind".

The effect of wind in the vineyard is important for winegrowers for many reasons. Continuous strong winds may damage the vines and impede growth. On the other hand, wind causes rain or dew to dry more quickly thus reducing the risk of fungal infection. However, wind also affects the thermal conditions of a vineyard. A large proportion of the solar radiation absorbed by the vineyard is converted to heat at the soil and at the leaf surfaces. Under calm conditions and direct sunlight, this can lead to a distinct vineyard climate. Air temperature and humidity may be higher under the canopy and between rows than outside the vineyard. Direct sun irradiation may cause leaf temperature to increase by up to 10 °C above the temperature of the surrounding air. However, this beneficial distinct climate of the alleys and leaves is destroyed by wind. The warmer and more humid air within the vineyard is mixed with cooler air or just blown away. The wind cools the leaves. The distinct climate within a vineyard is disrupted by wind speeds exceeding 1 m per second parallel to the rows and 2 m per second across the rows (VOGT & SCHRUFT 2000).

Since the distinct vineyard climate only evolves under sunny conditions, it is important to know the wind conditions on fine days. When shape and slope of the vineyard permit, it is advisable to plant the vines in rows transverse to the prevailing winds in fine weather conditions. In the Rheingau the prevailing direction is east or west, therefore rows should be planted in a North – South direction. Here this planting scheme has several advantages. Firstly, it ensures that each row protects the next from the wind. Secondly, a North-South orientation also means that both sides of the plant are equally exposed to the sun: the east side in the morning and the west side during the afternoon. Neither side is directly exposed to the hot midday sun, only a few outer leaves. The solar radiation strikes the ground between the rows, heating the soil. This heat is then emitted during the night.

Producing wine in areas near to the northern climatic boundary for wine growth is only possible in thermally favored locations. In these marginal areas high quality wine production will have little success on windward slopes exposed to the stronger prevailing winds. The cooling effect can be so large that the minimal temperatures for growth and maturation are not attained (HORNEY 1975).

* Dr. H. Jagoutz, National Meteorological Service (DWD), Agrometeorology, Kreuzweg 25, D-65366 Geisenheim.

2. General principles

Studies of vineyard climate have lead to a specific interest in the frequency of wind directions during sunny periods. German grapes grow along the northern margin of the wine growing regions in Europe. Under these conditions, the plants depend on the special climate within a closed plantation under bright sunshine to reach an optimum degree of maturity. A closed plantation is always warmer than the surroundings on sunny days. Even though temperature differences may not seem to be very significant, they have a profound effect during the vegetation period. The temperature difference between vineyard and surroundings is greatest on calm sunny days. The stronger the wind, the greater the equilibrating effect on the temperature difference, as warm air is removed from the vineyard. Thus, wind prevents the air in the vineyard from heating up and therefore has a negative effect on vine development (Horney 1972).

The optimum temperature for vines is the temperature when maximum assimilation occurs. The optimum leaf temperature according to Bosian (1964) is 25° C. This temperature is only rarely attained in spring or especially in autumn during the ripening period. A temperature increase in the vineyard is vitally important for the development of good quality grapes. However, wind prevents this temperature increase. Even on very hot summer days, when temperatures are far beyond optimum, the wind effect is not positive. The cooling effect of wind on the hot leaves is offset by an increased evaporation. However, this causes the vine to close the stomata to prevent excessive evaporation. Although this reduces evaporation, it also leads to a suppression of assimilation because the required carbon dioxide is taken up via the stomata. Thus, the effect of wind is negative even when air temperatures are so high that the removal of warm air from within the stand is not an issue (Schneider & Horney 1969).

3. Presentation of the results

A study of the effects of wind described above clearly shows that the negative outcome of removing warm air from the vineyard only occurs on sunny days. However, the positive drying effect after rain usually occurs under overcast conditions, if one discounts the drying of dew after clear nights.

The evaluation of wind conditions in wine growing regions plays an important role in site evaluations as well as for planning wind defence structures.

3.1. Statistical assessment of wind directions in Geisenheim

In an approach to evaluate the wind effects as described above, the frequency distribution of wind directions on clear days was assessed for Geisenheim between April and October. A clear day was defined as a day where the sun shines for at least 50 % of the maximum astronomical sunshine duration (in minutes). The distribution of clear and overcast days between April and October is presented in Table 1. These results show that 10 – 20 % more overcast than sunny days were recorded for the period between April and September. In October the proportion of overcast days increases to 74 % because of the persistent morning fog that often forms in the Rhine Valley. In an analysis of meteorological data recorded between 1961 and 1990, 60 % of the days during the vegetation period were classified as overcast and 40 % as clear days.

Tab. 1. Proportion of overcast and clear days during the vegetation period between 1961–1990

Month	Proportion overcast days [%]	Proportion clear days [%]
April	61	39
May	58	42
June	58	42
July	54	46
August	53	47
September	58	42
October	74	26

The difference of wind conditions between clear and overcast days were analyzed in the next step. This involved assessing midday wind conditions (between 1 and 2 pm) on clear as well as overcast days. The results for clear days are summarized in Fig. 1a, for overcast days in Fig. 1b. The results are presented in the form of compass roses depicting wind direction as well as the respective speed in four categories. The number in the centre of the rose represents the proportion of calm periods. The values at the end of the wind direction lines represent the proportion of winds from this particular direction as a fraction of all recorded events.

The analysis indicated that at noon 25 % of all winds recorded came from E or ENE (Fig. 1a) on clear days and from south westerly directions on mostly overcast days.

In preparation for the vineyard evaluation, frequency counts of wind directions on clear days were carried out for all synoptic stations within the wine growing region. These also showed that the predominant wind direction on clear days is E to NE. However, local wind directions are

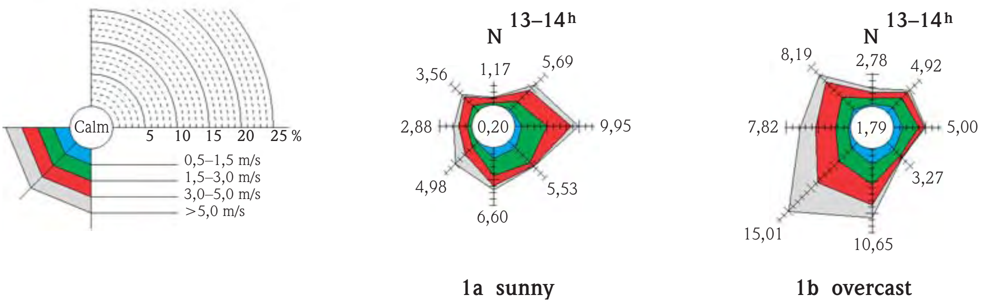

Fig. 1a, 1b. Distribution of wind directions and speeds on sunny and overcast days in Geisenheim.

strongly influenced by orography. The Rheingau is a special case in that the orography favors easterly winds. However, local orography may also completely obscure this easterly component in some locations.

The evaluation of wind directions

The hourly wind measurements from the period between 1961 and 1990 were used to evaluate the wind directions on clear days for every three hours. The night hours were also included since the wind direction on nights following clear days gives some indication of the movements of cold air in the Rheingau.

Besides including a category for calm weather, wind speed was differentiated into the following 4 speed categories:

0.5–1.5, 1.5–3, 3–5 and >5 m/s.

These categories were selected because wind speeds less than 2 m/s (measured 10 m above ground) have little effect in vineyards planted with conventional spacing of less than 2 m, even when blowing parallel to the rows. Because they are more economical to manage, the number of vineyards planted with rows spaced more than 2 m apart (wide spaced vineyards) will increase in future. Wider spacing also means that warm air within the stand is more easily removed, which will have a negative effect on the quality. The monthly results for the period between April and October are summarized in Figures 2 – 8 (s. S. 47–53).

An examination of the three-hourly frequencies of wind directions over a period of 30 years reveals three characteristic directions. The most frequent wind direction is from the SW, which is typical for this region. However, the results also show a maximum for E to ENE and another at NW to NNW, especially at night. Remarkably, the frequency of northerly winds is very low during the daytime hours.

3.1.1. Daylight time wind directions on clear days

Most morning winds (between 6 – 9 am) even on clear days blow from the SW. During the course of the morning (between 9 – 12 am) the maximum shifts towards S and E. The winds blow from the E during the afternoon in spring and summer. During this period the wind quite often reaches speeds >3 m/s. The data also reveals that in autumn (September and October) the afternoon winds blow from two main directions. One peak is found in the NE and a second in SW. Northern winds are very rare in this region.

3.1.2. Night time wind directions on clear days

The peak at NNW can only be explained in relation to the daily shift of wind directions. As mentioned previously, the prevalent daytime wind direction on clear days is E to ENE. At sunset (6 pm in the winter half-year, 9 pm in the summer half year) the wind direction jumps to NNW. As soon as solar radiation ceases, cooler air streams down from the mostly forested heights of the Rheingau Mountains towards the valley. As the clear night progresses the wind shifts again towards a W to SW direction at around 3 am. After sunrise, the direction changes again to E to ENE.

The movement of cold air is also affected by orography. Thus, the cold air usually streams down the valleys orientated towards the Rhine and fans out in the foothills. The prevalent direction of these katabatic (drainage) winds is NNW, perpendicular to the average direction of the slopes. In specific cases, especially where cold air production at the head of such a valley is more intense than in forests, such as over fields and fallow land, the fall wind can attain considerable speeds. In these situations, the wind may continue until dawn and the 3 am directional shift does not take place.

3.2. The distribution of wind in the course of a year

The examination of the individual wind diagrams provides an additional explanation for the observed characteristic frequency distribution. During the summer months (June, July and August) the wind frequently blows from a southerly direction between 9 am and 3 pm. This maximum is explained by local upslope winds, which develop during the morning on clear days. Because of the orography of the Rheingau, these winds blow from the south.

The observed wind conditions are most pronounced on clear autumn days (September and October). This is just the time when general temperatures are far below optimum and the warming of the stand by solar radiation is of utmost importance. Any removal of the warm vineyard air is especially disadvantageous. The implication for the Rheingau is that easterly winds are especially detrimental. Of course, this fundamental observation is more or less valid for any area where clear day winds tend to blow from the E. However, the Rheingau is especially affected by this phenomenon because the prevalent winds determined by the large-scale weather pattern amplify the situation.

4. Conclusions

In conclusion, it is important to repeat the following observation: a study of the frequencies of wind directions on clear days reveals a distribution that varies considerably from the general prevalence of wind directions. The warming of the vineyard by solar radiation is decisive for determining grape quality in this region. Since these winds may destroy a favorable vineyard climate (Richter 1965), knowledge of clear day wind distribution is an important element in vineyard ecological studies.

The prevalence of clear day winds from E to ENE documents the special conditions of the Rheingau where orography strongly modifies wind conditions. This has a particularly negative effect on east-exposed slopes and concurs with empirical observations that east-facing slopes are generally less favorable for growing wine than south or west facing slopes.

In clear nights, the daytime east winds of the Rheingau are superimposed by cool NNW katabatic winds from the heights of the Rheingau Mountains. During the second half of the night the wind direction usually rotates via E to SW and jumps back to E again at dawn. However, foggy conditions or low stratus clouds during the night are usually accompanied by a continuous E wind.

5. References

Bosian, G. (1964): Assimilations- und Transpirationsbestimmungen an Reben im Freiland mit klimatisierten Küvetten. – Weinwissenschaft, **19**: 265–271; Mainz.

Horney, G. (1972): Die klimatischen Grundlagen des Anbaues von Weinreben in Deutschland. – Weinberg u. Keller, **19**: 305–320; Frankfurt am Main.

Horney, G. (1975): Die ökologische Wirkung des Windes. – Berichte des Deutschen Wetterdienstes, **138**: 20 S.; Offenbach.

Richter, G. (1965): Bodenerosion. Schäden und gefährdete Gebiete in der Bundesrepublik. – Forsch. dt. Landeskde, **152**: 592 S.; Bonn.

Schneider, M. & Horney, G. (1969): Auswirkungen von Beregnung auf Boden- und Bestandsklima, sowie auf Blatttemperaturen im Weinbau. – Zeitschrift für Bewässerungswirtschaft, **2**: 162–199; Frankfurt am Main.

Vogt, E. & Schruft, G. (2000): Weinbau. – 456 S.; Stuttgart.

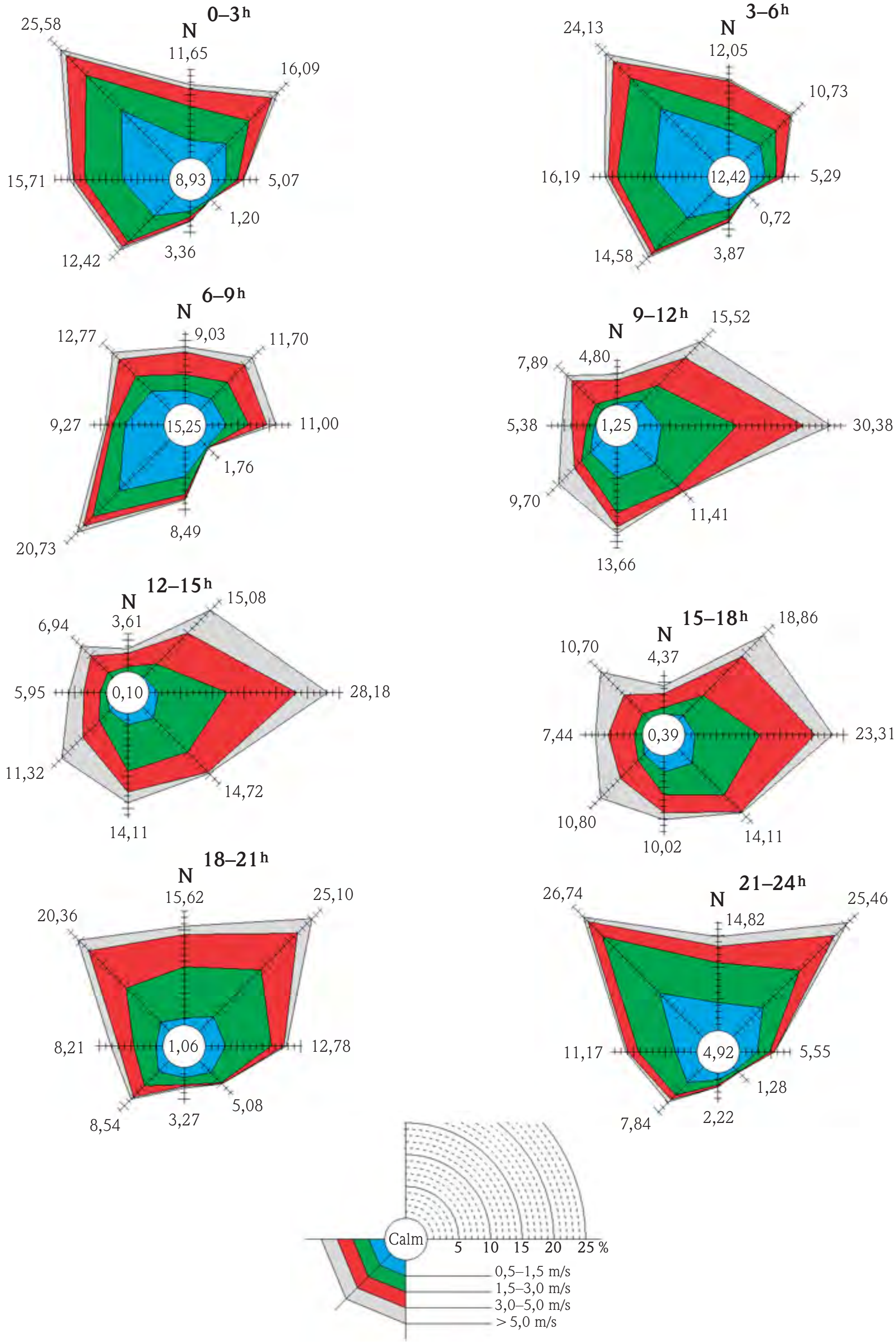

Fig. 2. Mean wind directions and speeds on clear days in Geisenheim 1961–1990, month April.

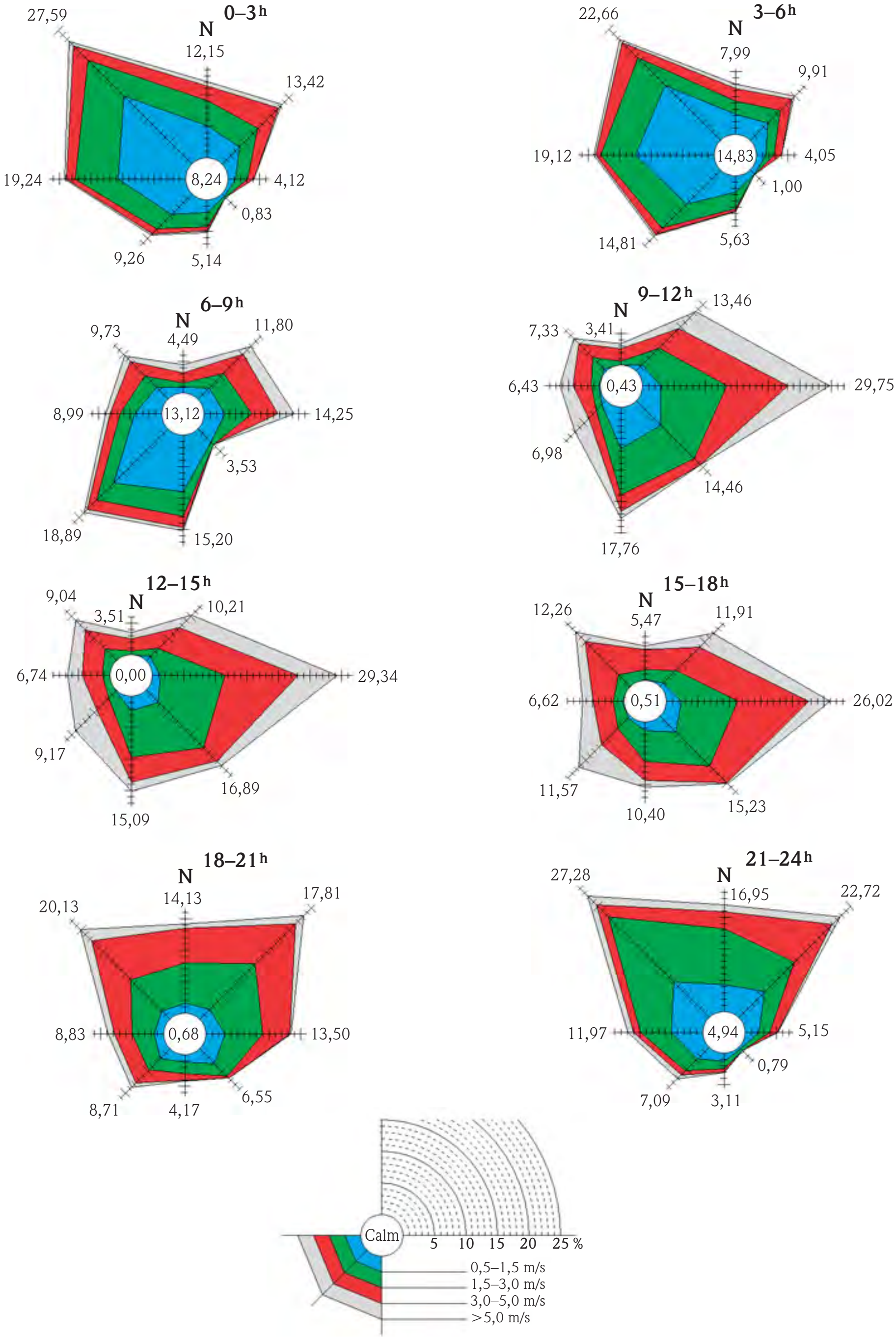

Fig. 3. Mean wind directions and speeds on clear days in Geisenheim 1961–1990, month May.

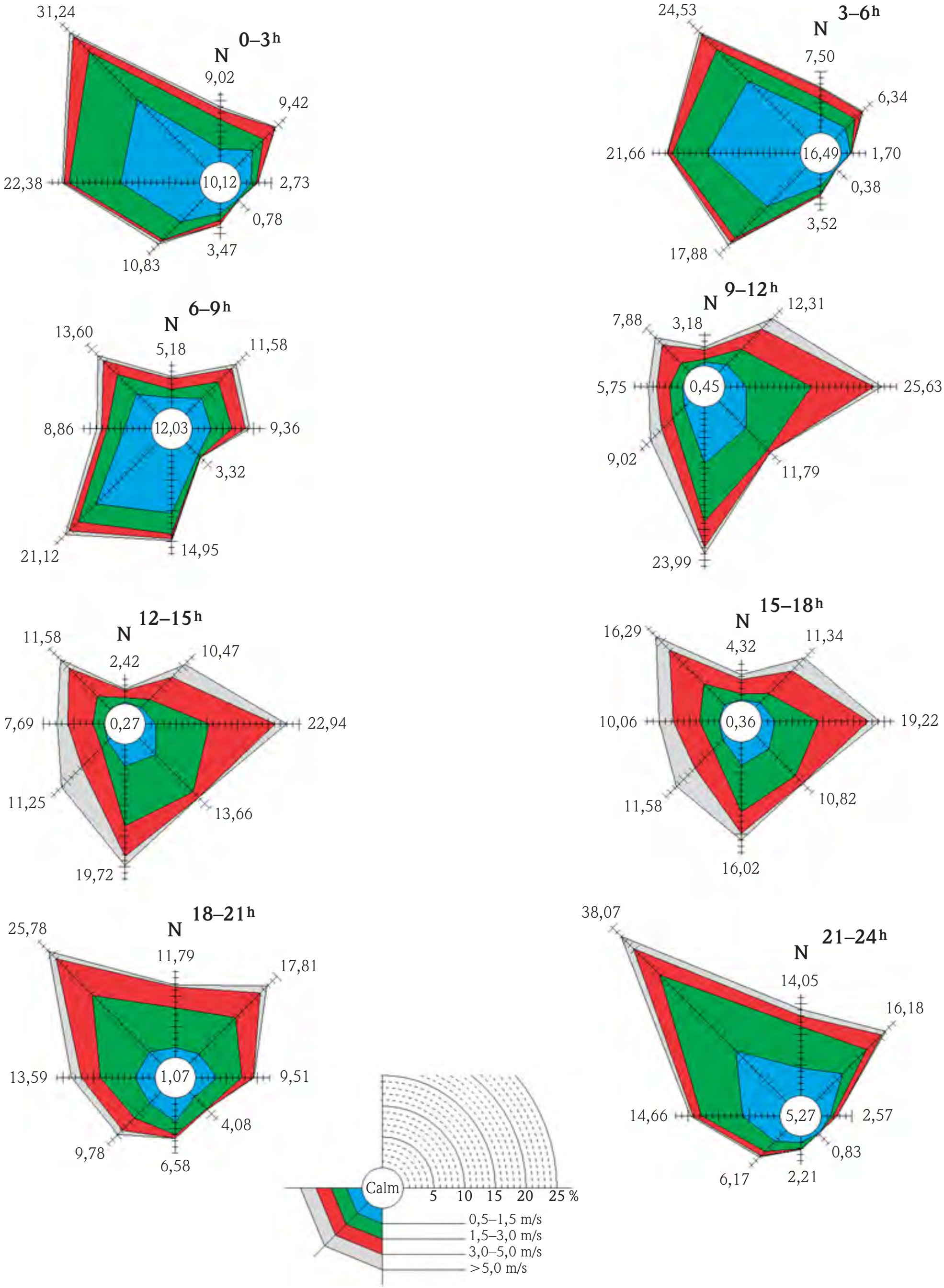

Fig. 4. Mean wind directions and speeds on clear days in Geisenheim 1961–1990, month June.

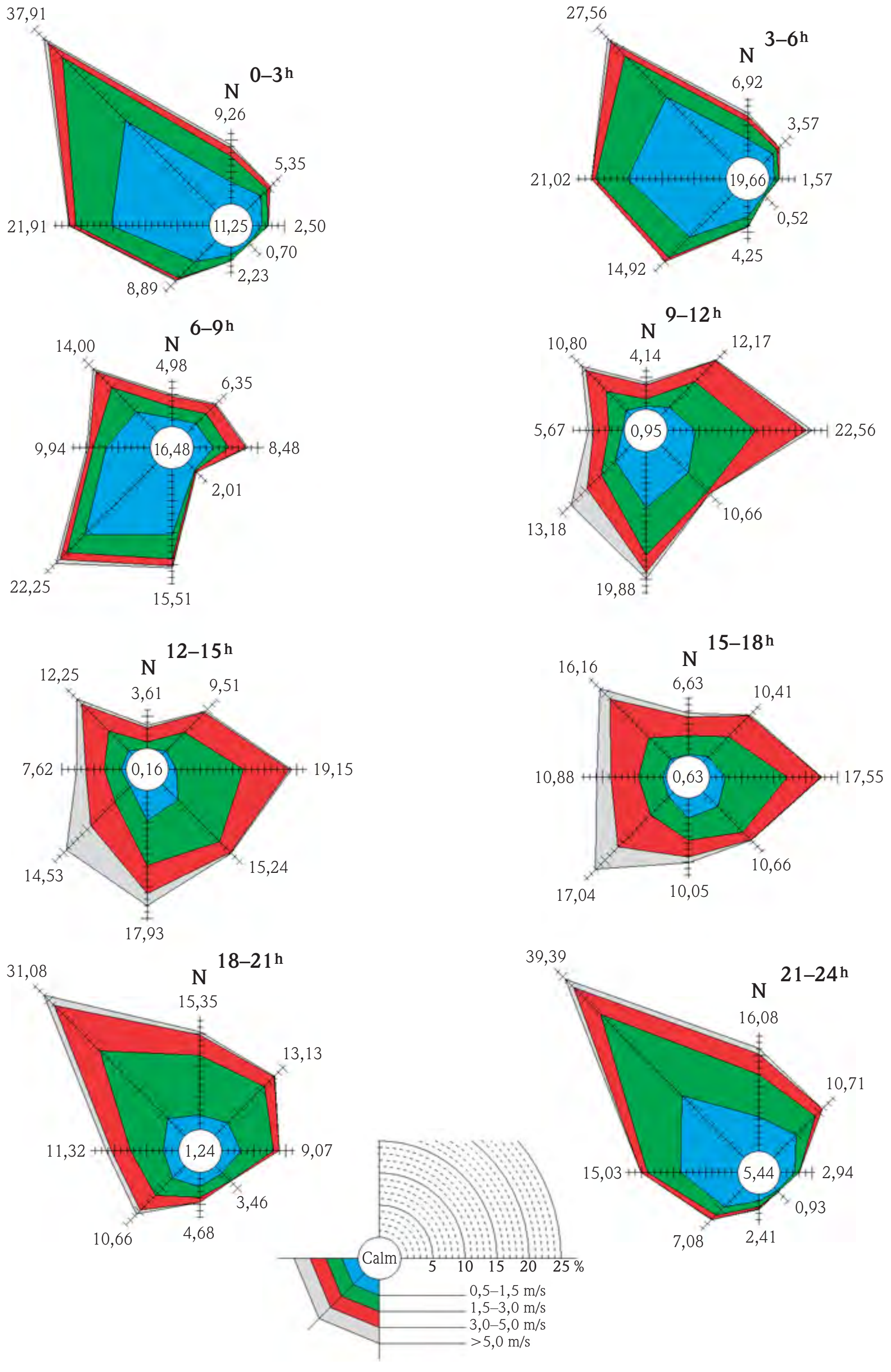

Fig. 5. Mean wind directions and speeds on clear days in Geisenheim 1961–1990, month July.

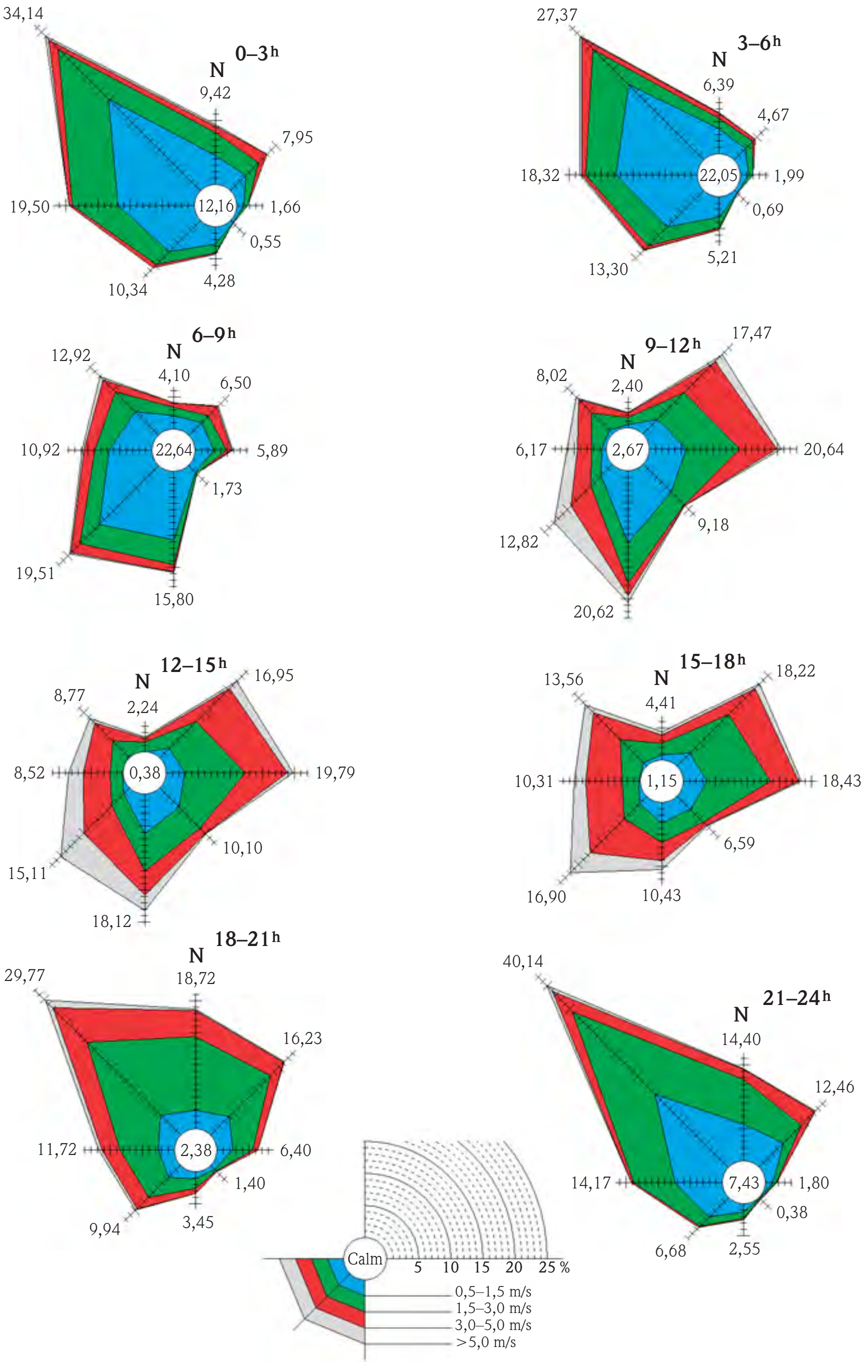

Fig. 6. Mean wind directions and speeds on clear days in Geisenheim 1961–1990, month August.

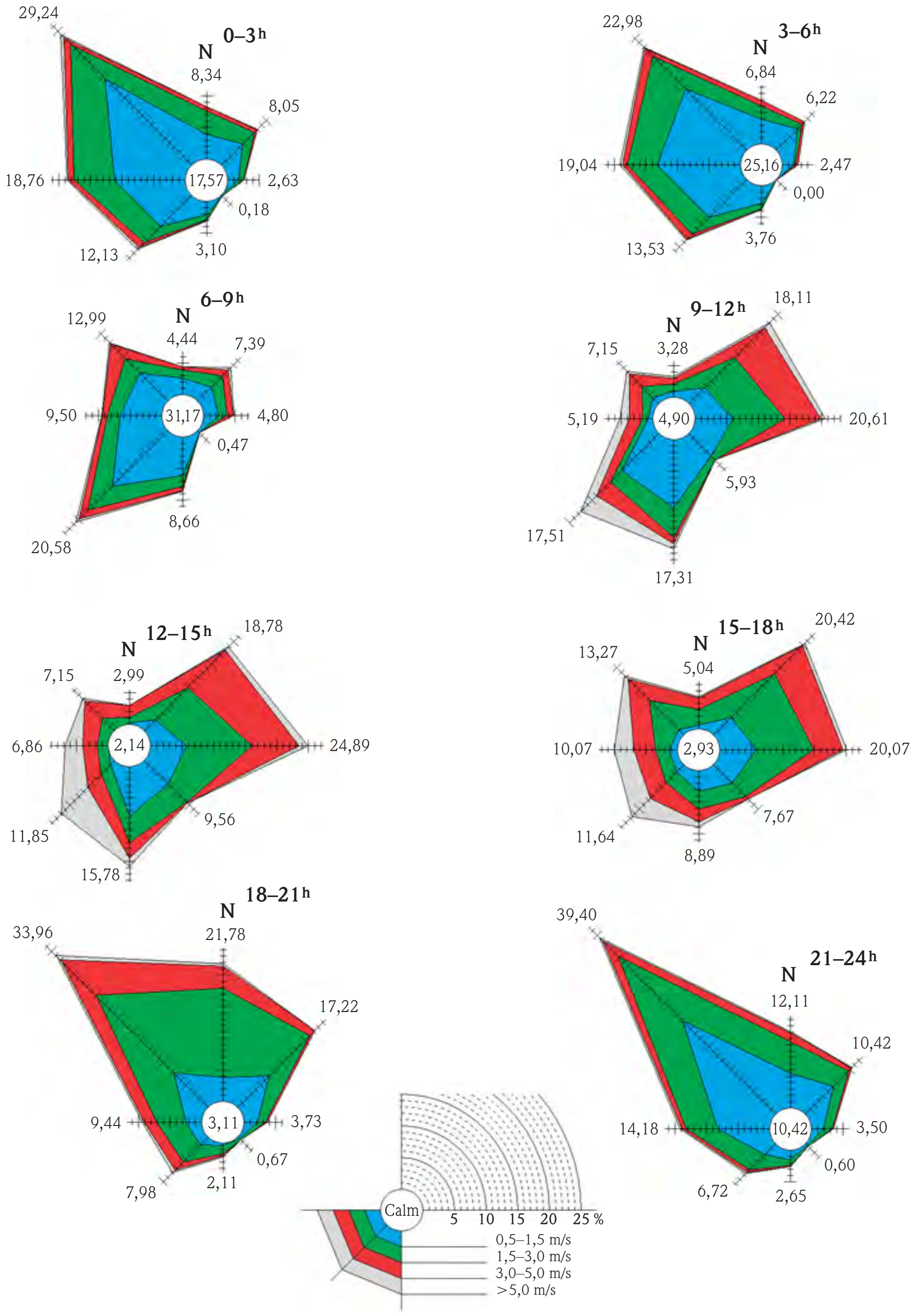

Fig. 7. Mean wind directions and speeds on clear days in Geisenheim 1961–1990, month September.

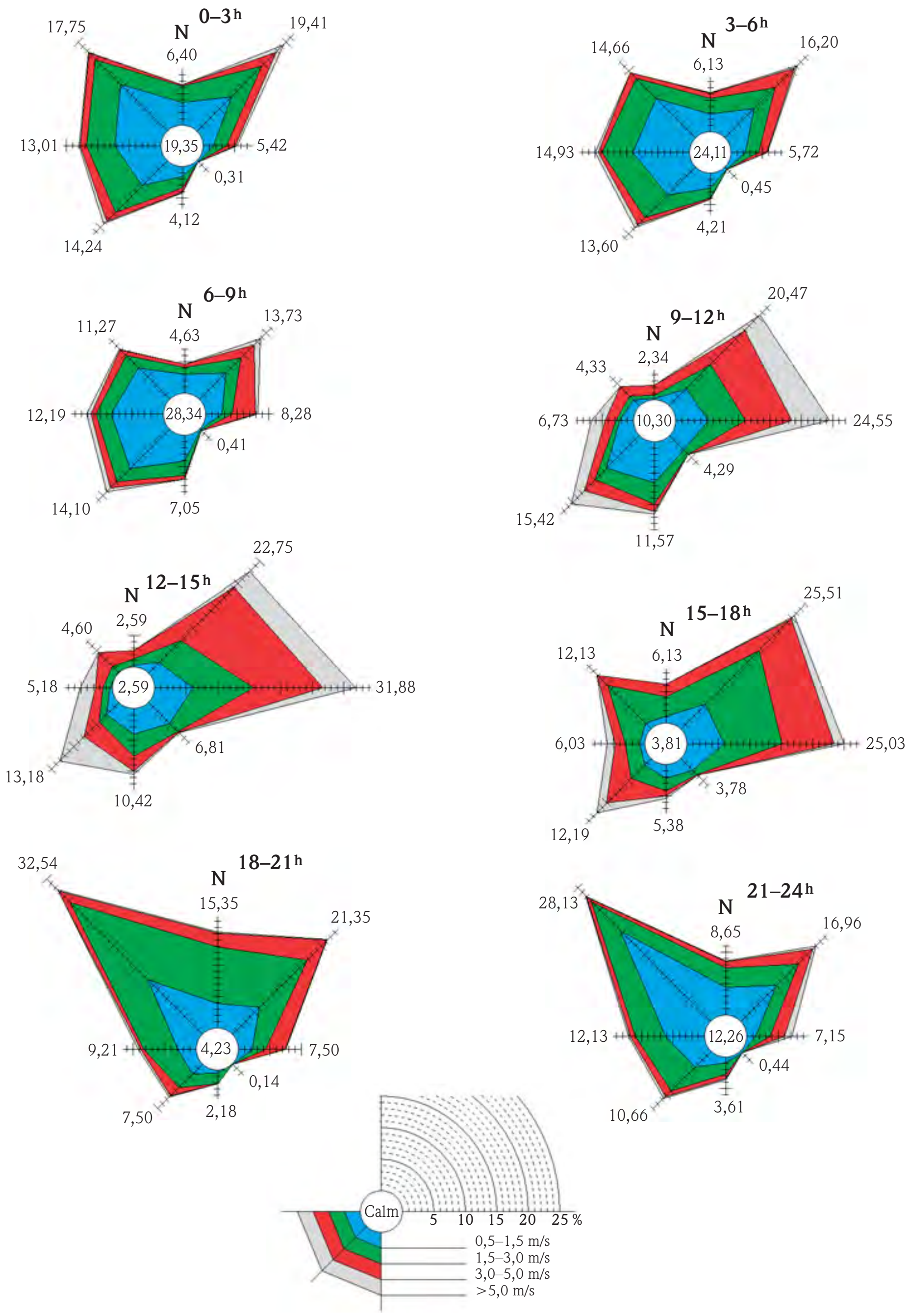

Fig. 8. Mean wind directions and speeds on clear days in Geisenheim 1961–1990, month October.