Evaluation of local weather observations as predictors of fog and low-level stratiform clouds at the airport of Odessa

Khomenko Inna, Hustenko Oleksii

Odessa State Environmental University, Odessa, Ukraine

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INTRODUCTION

Forecast of low-level stratiform clouds and fogs is one of the most complex problem of the aviation meteorology due to some causes, such as:

- **similarity of mechanisms of formation of the both events**, it makes their identification and separation difficult under forecasts;
- **complexity and indeterminacy of processes of the atmospheric boundary layer** where low-level stratiform clouds and fogs form;
- **srtrong dependence on local conditions:** characteristics of low-level stratiform clouds and fogs, including cloud base height, fog density, are extremely variable in both time and space, and strongly dependent on the geographic conditions, therefore revealing of dependence between simulated and observed characteristics of low-level stratiform clouds and fogs.

Therefore determination of local dependencies is necessary in order to forecast both events.

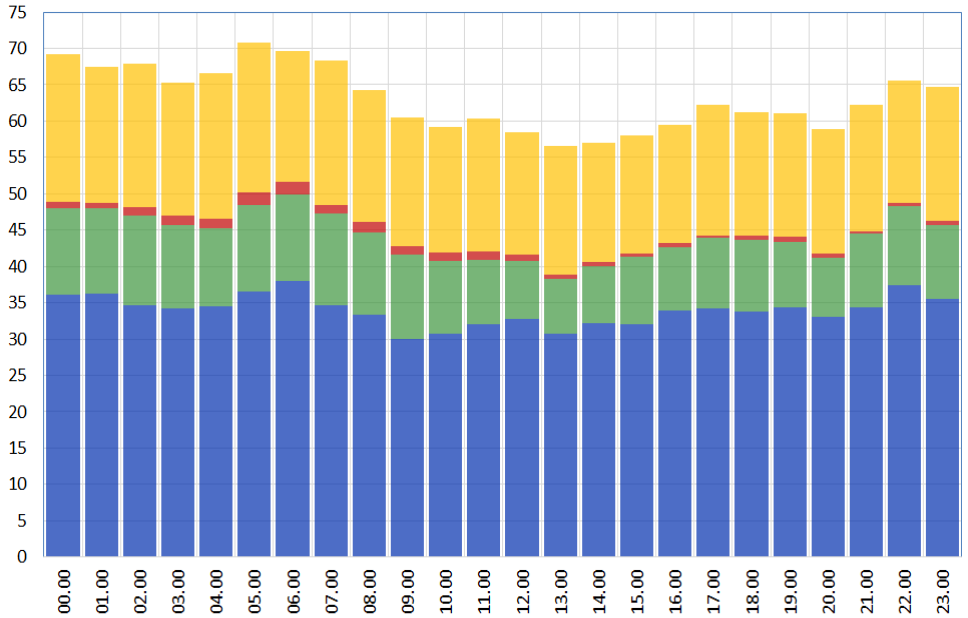
Database

The seasonal and diurnal characteristics of both events are investigated using observations of meteorological parameters such as: visibility, air temperature, dew point temperature, air relative humidity, wind vector, precipitation, and cloud base height and coverage, for the 2010-2017 period for fog and the 2010-2018 period for low-level stratiform cloud.

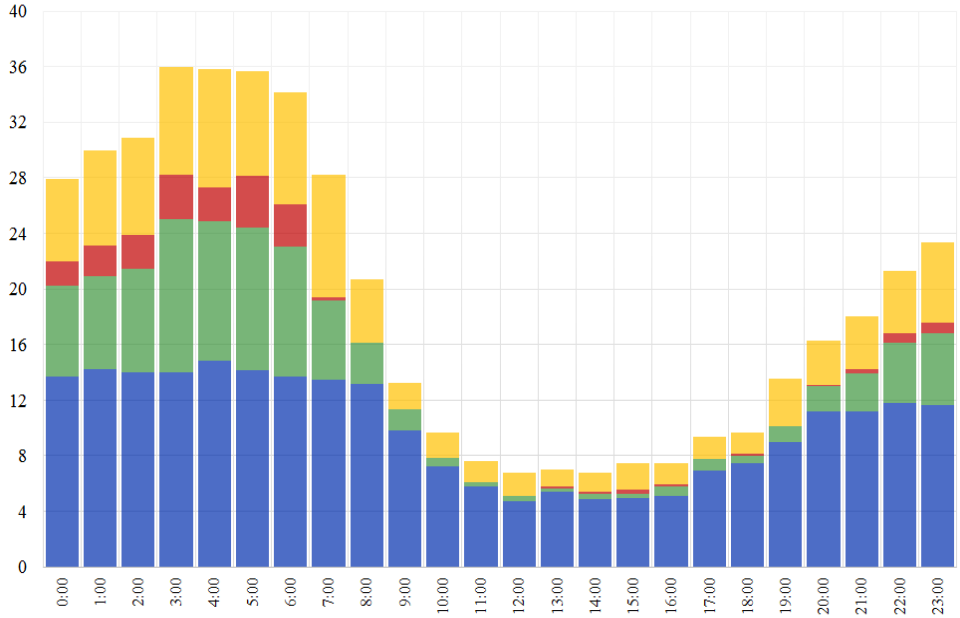
For investigated periods **22 383 cases of low-level stratiform cloud** and **9759 cases of fog were registered at the airport of Odessa**.

Occurrence (% of the totality of the cases) of low-level stratiform clouds for the 2010-2018 period (a) and fogs for the 2010-2017 period (b) as dependent on time of the day

(a)

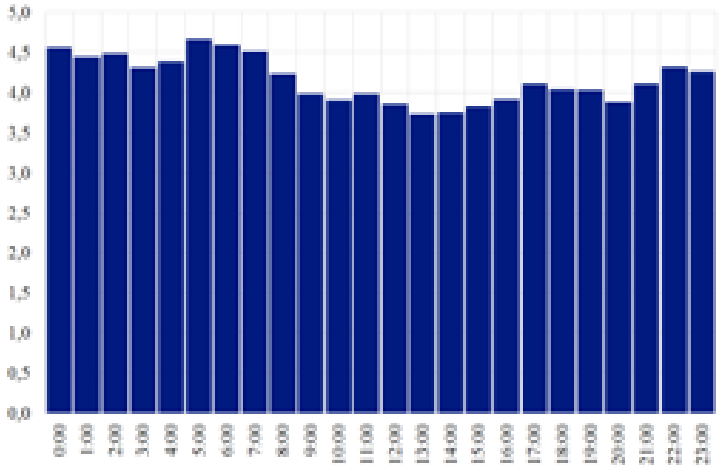


(b)

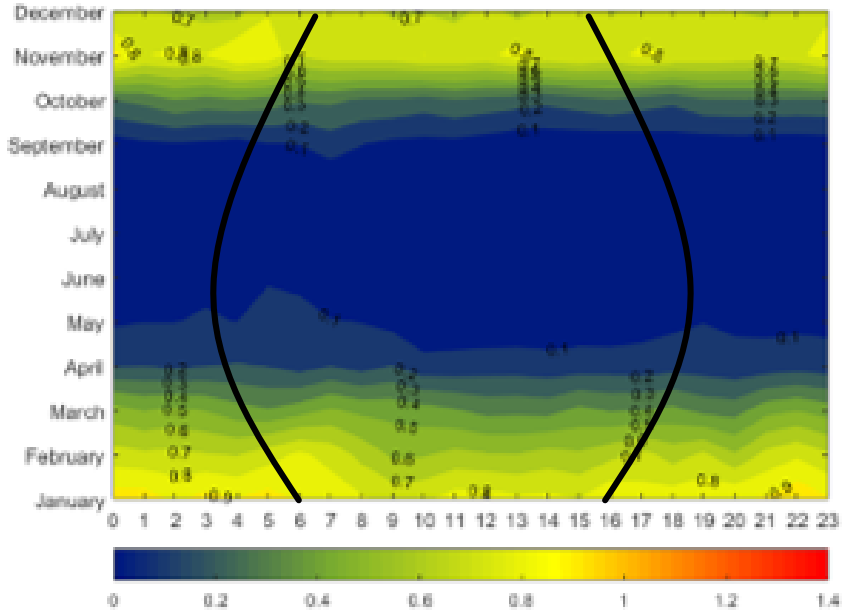


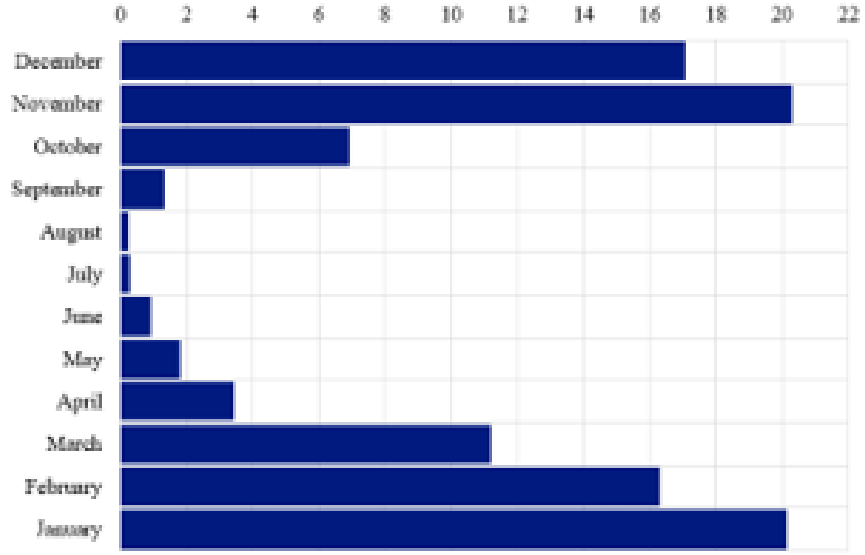
winter spring summer autumn

Frequency distribution of low-level stratiform clouds as a function of the time of the day and the month of the year

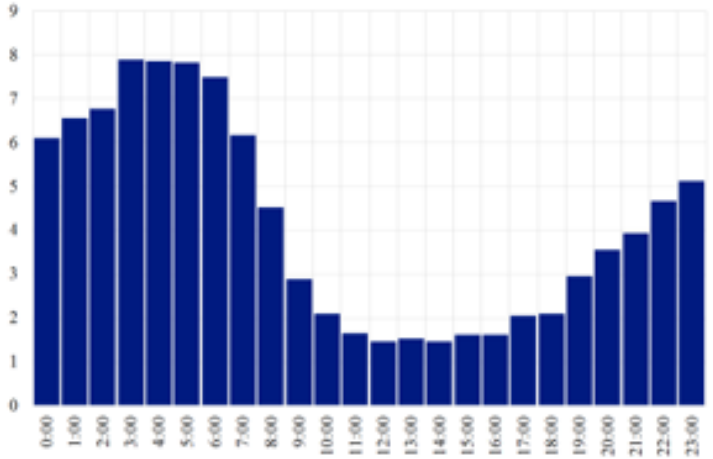


Frequency distributions of low-level stratiform cloud, as a function of the time of the day and the month of the year. Times of sunrise and sunset (solid lines) are indicated. The corresponding monthly distribution of low-level stratiform cloud case frequencies is shown on the right, and the frequency distribution with respect to the time of day is shown in the top panel of the figure. The data cover the 2010–2018 period.

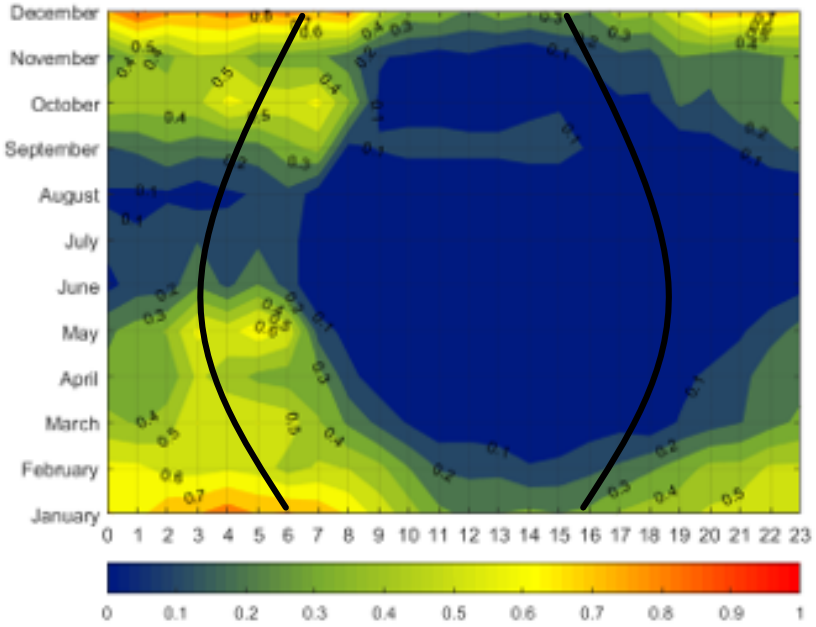


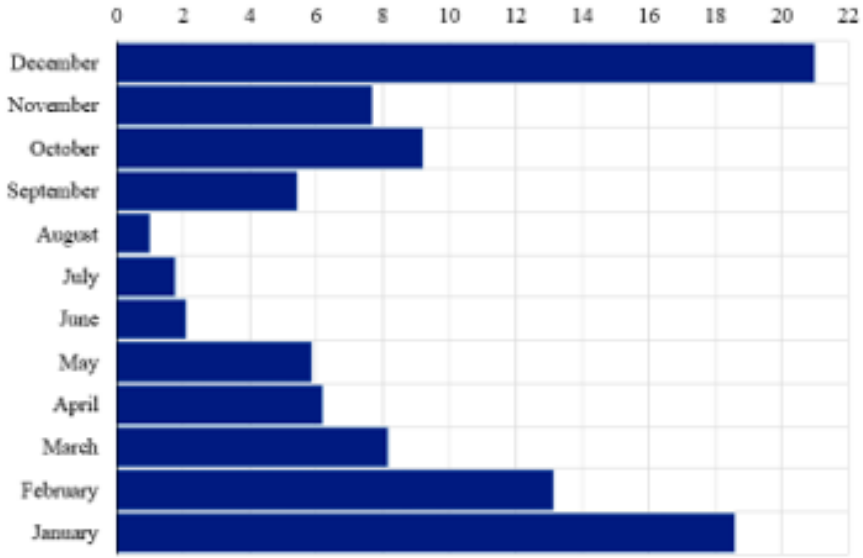


Frequency distributions of fog as a function of the time of the day and the month of the year

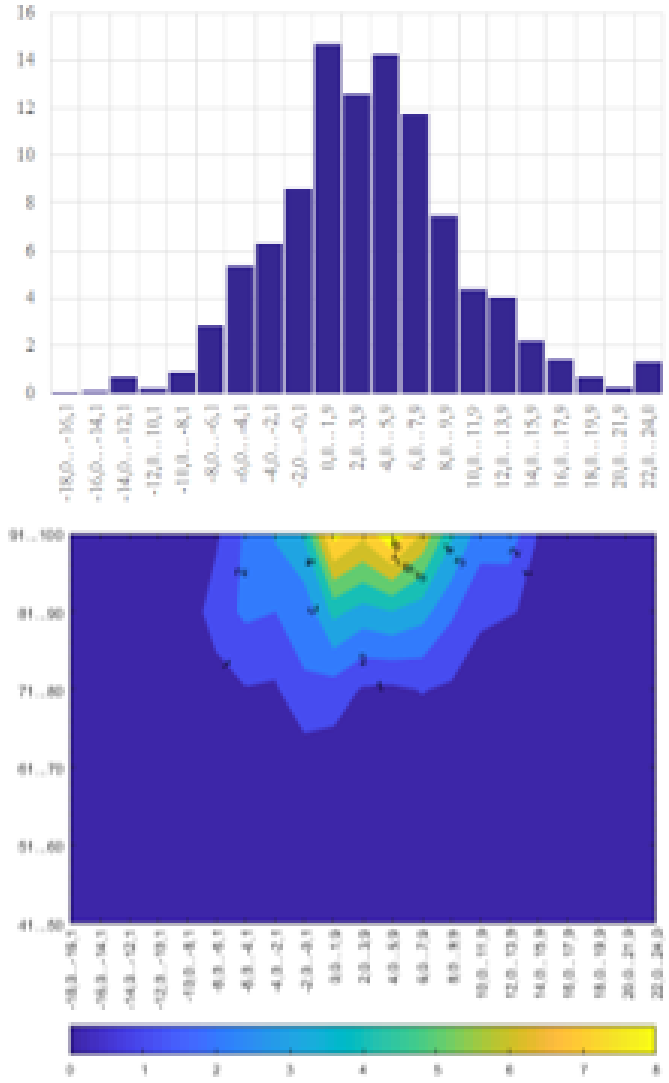


Frequency distributions of fog, as a function of the time of the day and the month of the year. Times of sunrise and sunset (solid lines) are indicated. The corresponding monthly distribution of fog event frequencies is shown on the right, and the frequency distribution with respect to the time of day is shown in the top panel of the figure. The data cover the 2010–2017 period.

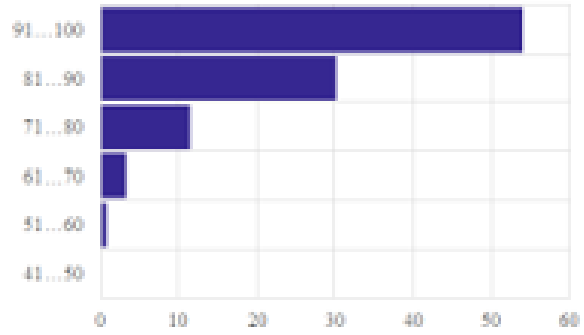




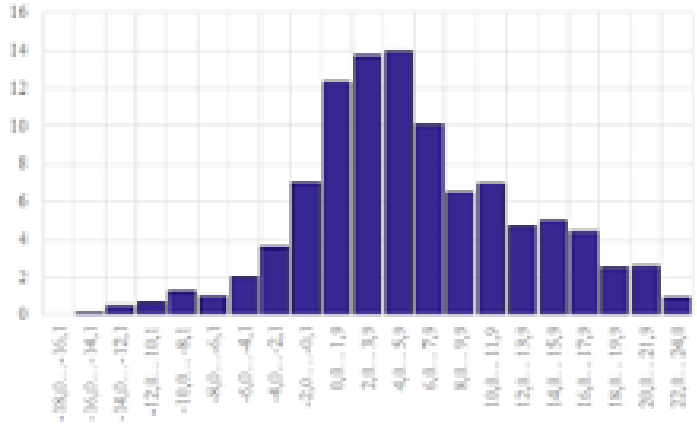
Frequency distribution of low-level stratiform clouds as a function of air temperature and relative humidity near the surface

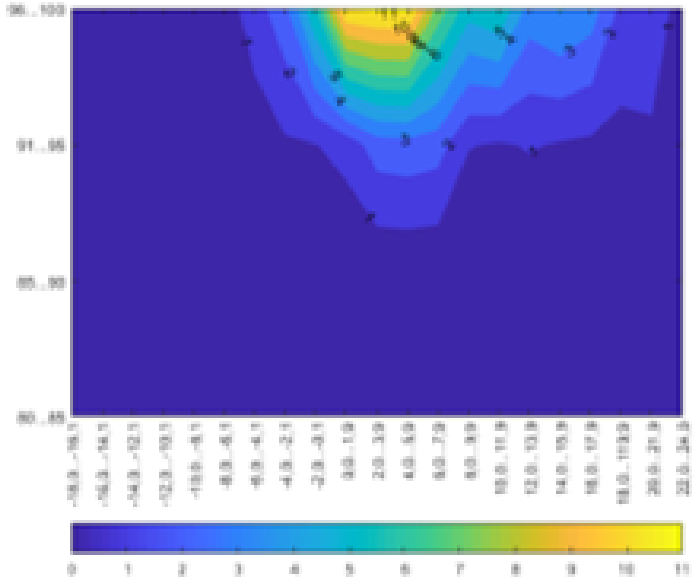


Frequency distributions of low-level stratiform cloud, as a function of the air temperature and relative humidity near the surface. The corresponding relative humidity distribution of low-level stratiform cloud event frequencies is shown on the right, and the frequency distribution with respect to temperature is shown in the top panel of the figure. The data cover the 2010–2018 period.

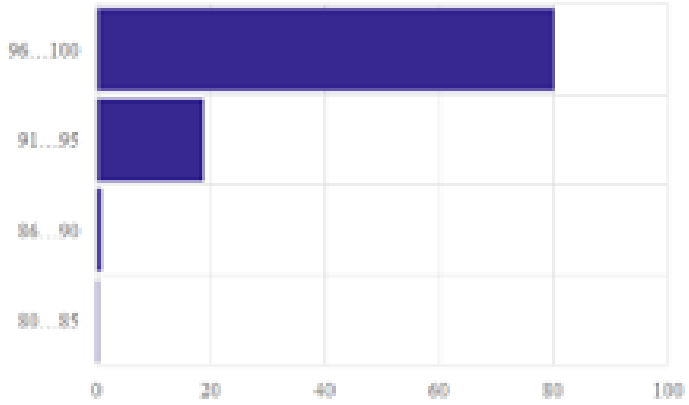


Frequency distribution of fogs as a function of air temperature and relative humidity near the surface

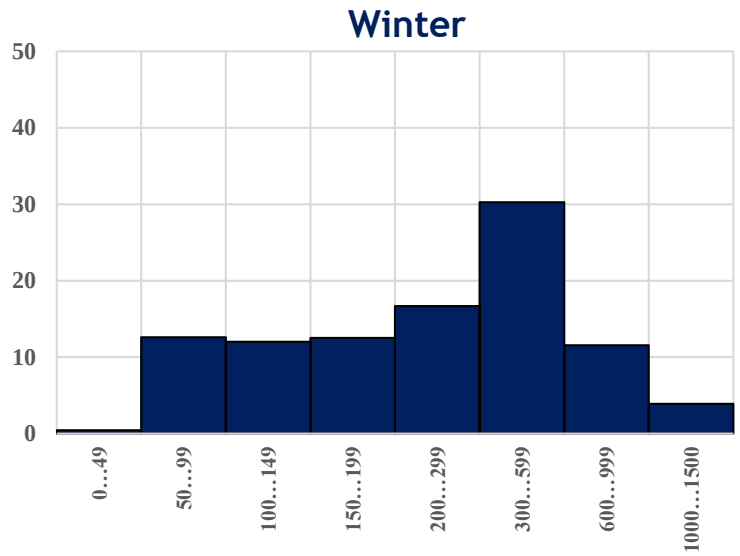


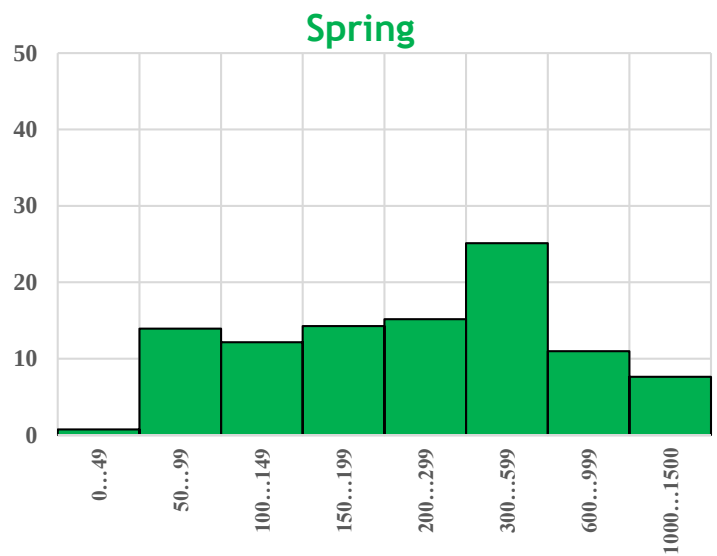


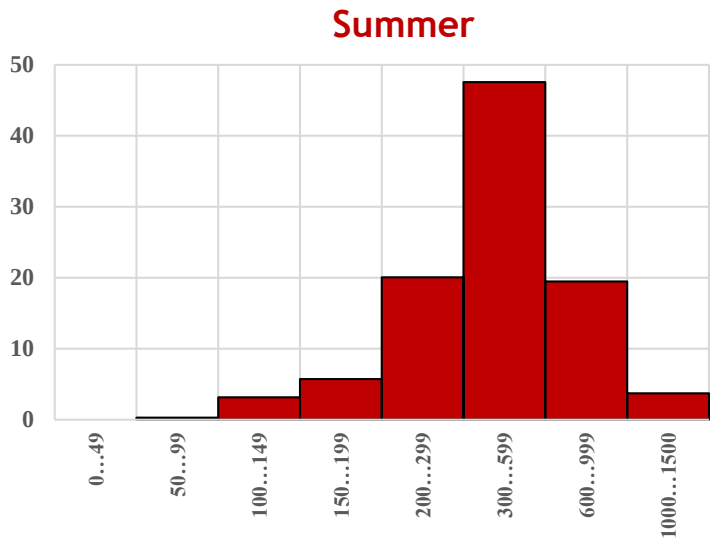
Frequency distributions of fog event, as a function of the air temperature and relative humidity near the surface. The corresponding relative humidity distribution of low-level stratiform cloud event frequencies is shown on the right, and the frequency distribution with respect to temperature is shown in the top panel of the figure. The data cover the 2010–2017 period.

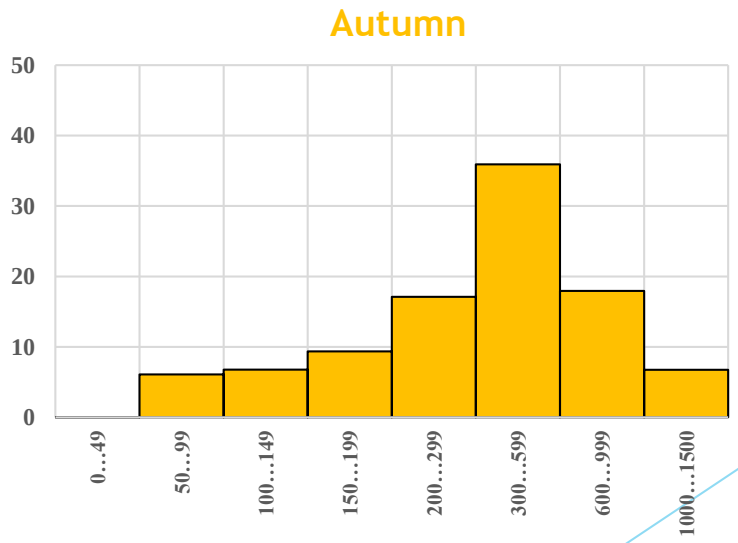


Frequency distribution (% of the totality of the cases) of cloud base height, m a.g.l., associated with low-level stratiform clouds for the 2010-2018 period

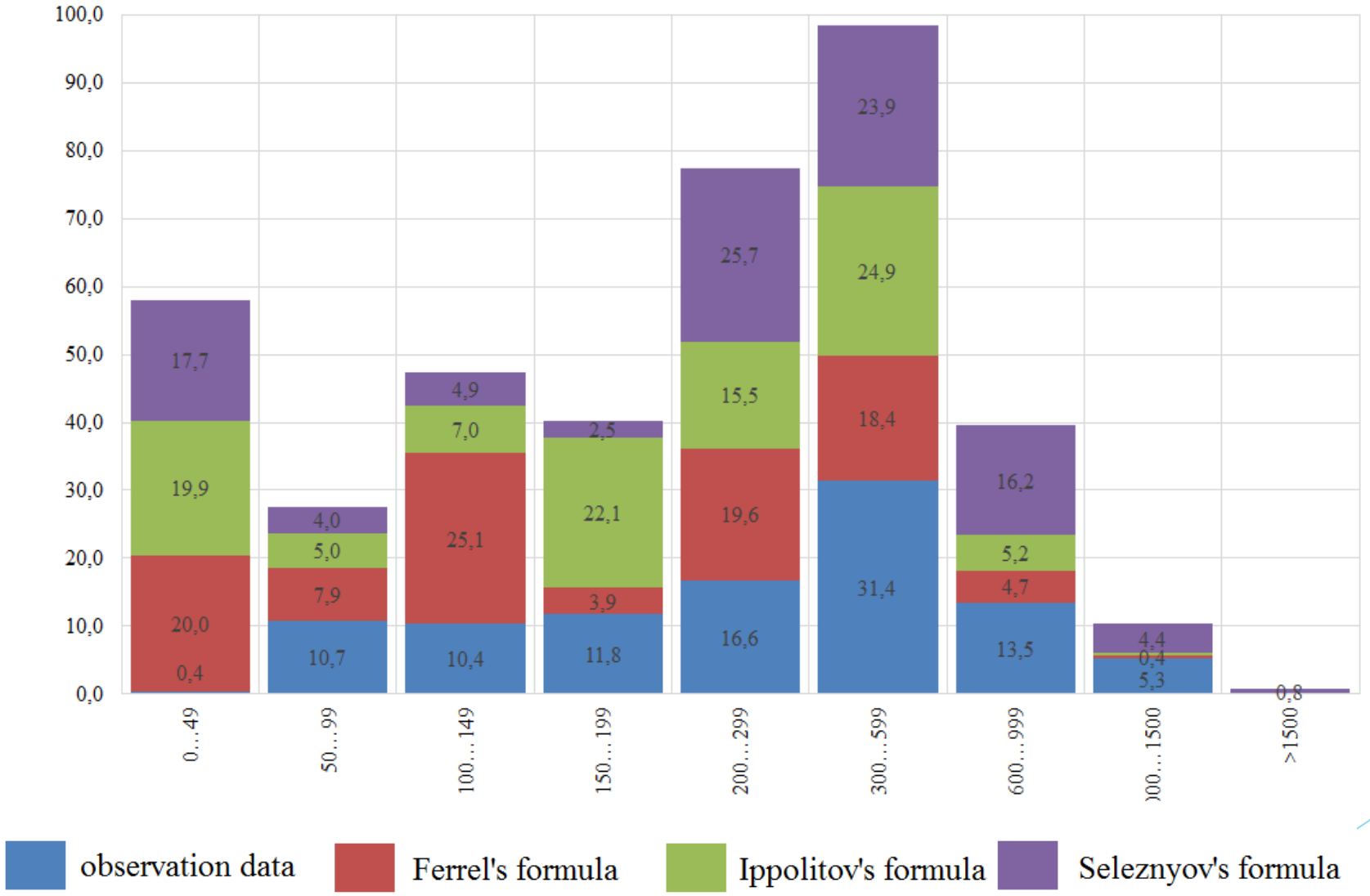








Frequency distribution (% of the totality of the cases) of cloud base height, m a.g.l., according to observation and simulated data



Ferrel's formula

$CBH = 123\ (T - \tau)$

Ippolitov's formula

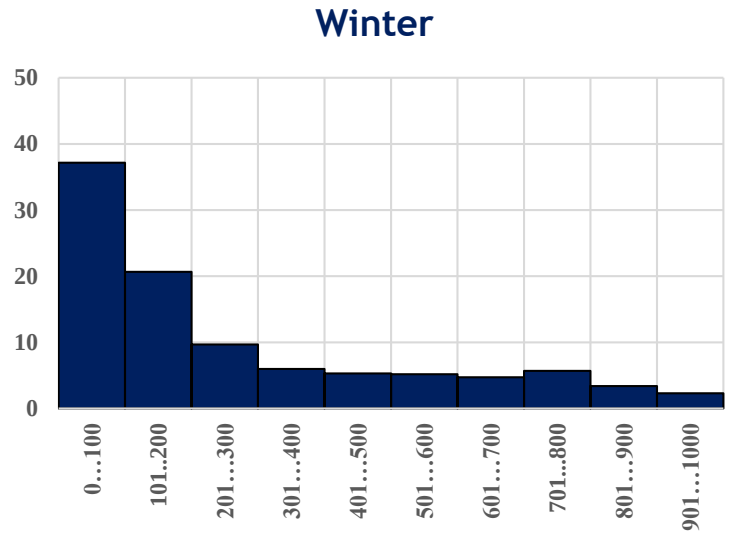
$CBH = 22\ (100 - RH)$

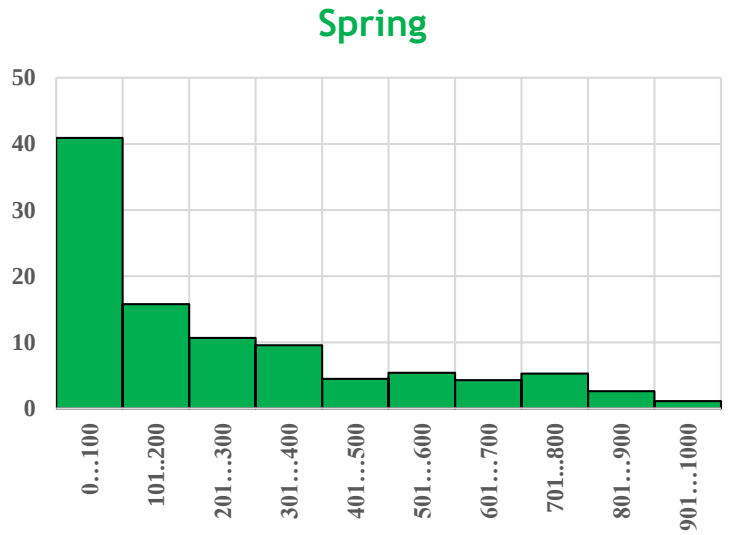
Seleznyov's formula

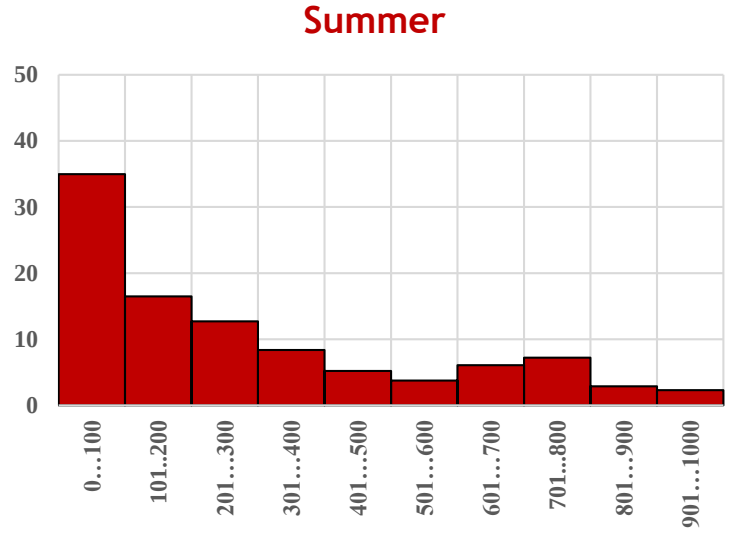
$CBH = 100\ (\gamma - \gamma\tau) - 1(T - \tau)$

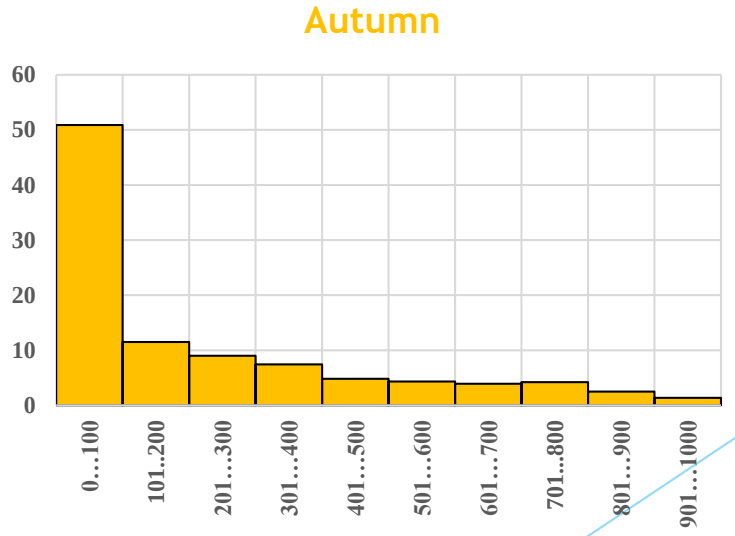
T – air temperature,
τ – dew point temperature,
RH – relative humidity
CBH – cloud base height

Visibility distribution frequencies compiled for the totality of fog observations for the 2010–2017 period

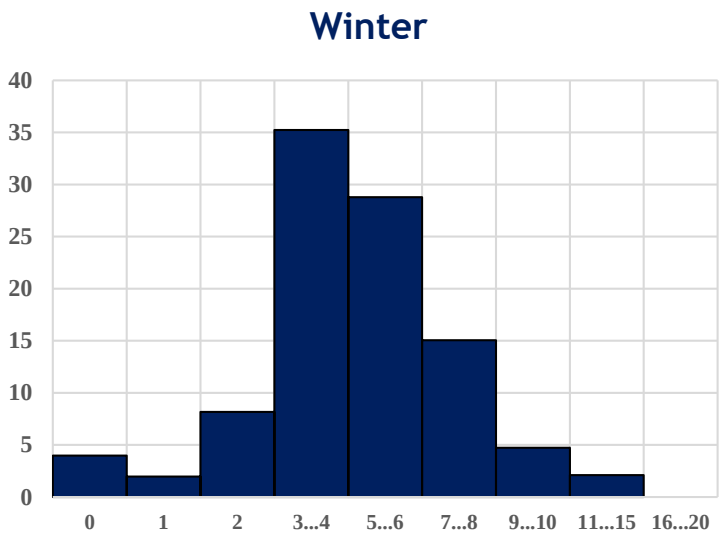


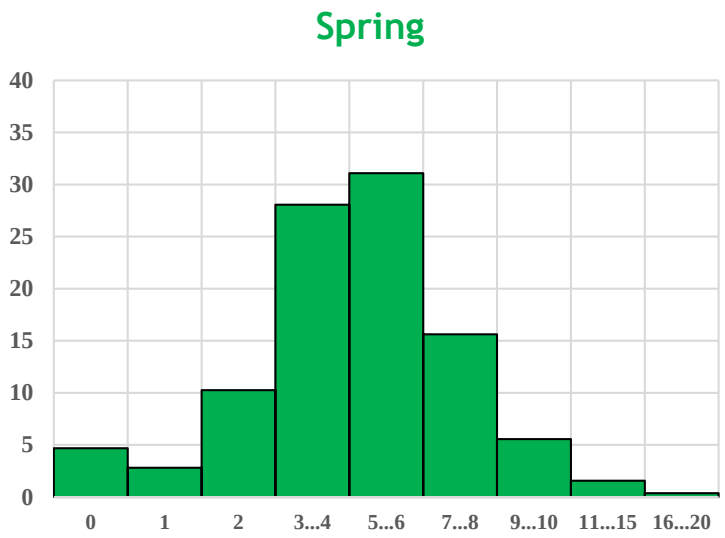


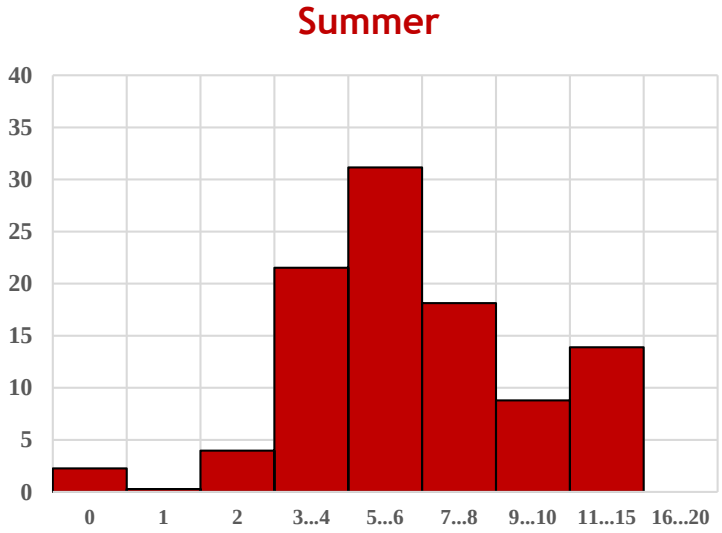


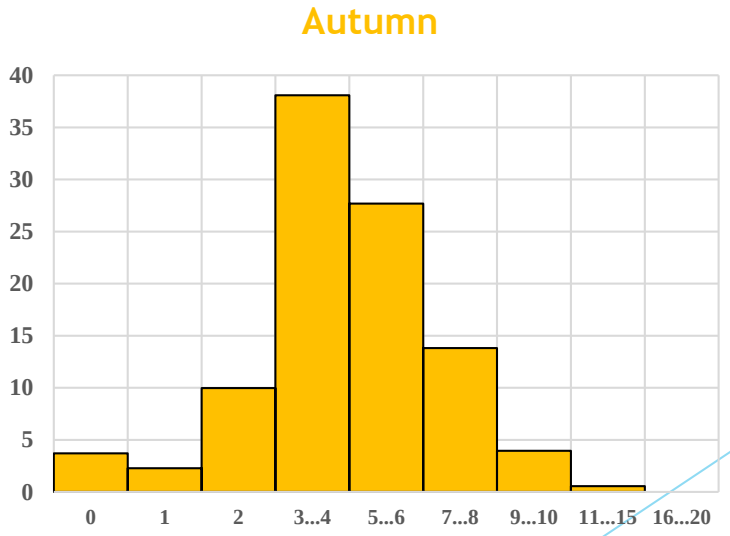


Frequency distribution (% of the totality of the cases) of wind speeds, m/s, associated with low-level stratiform clouds for the 2010-2018 period

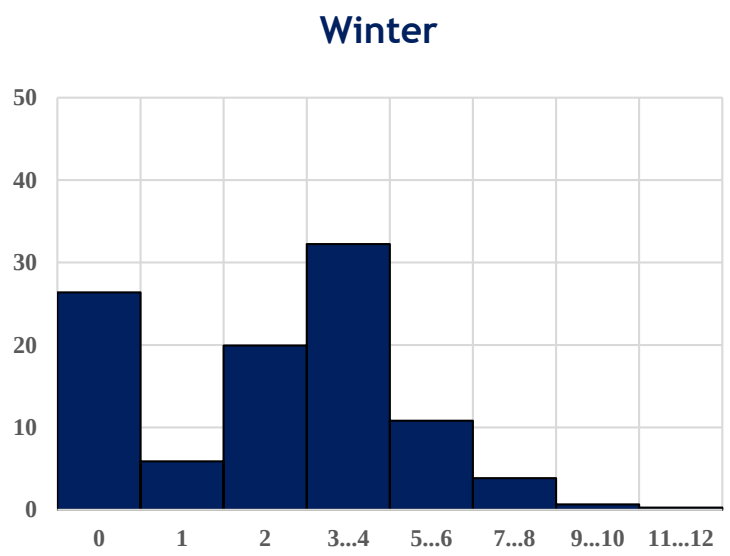


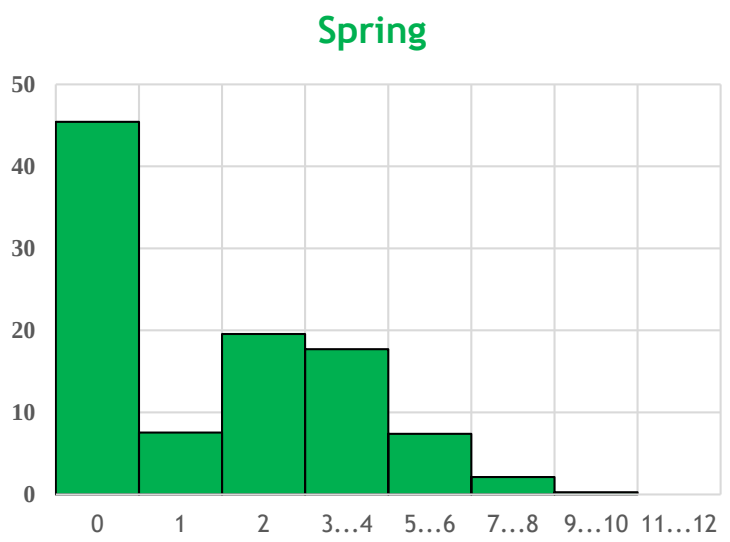


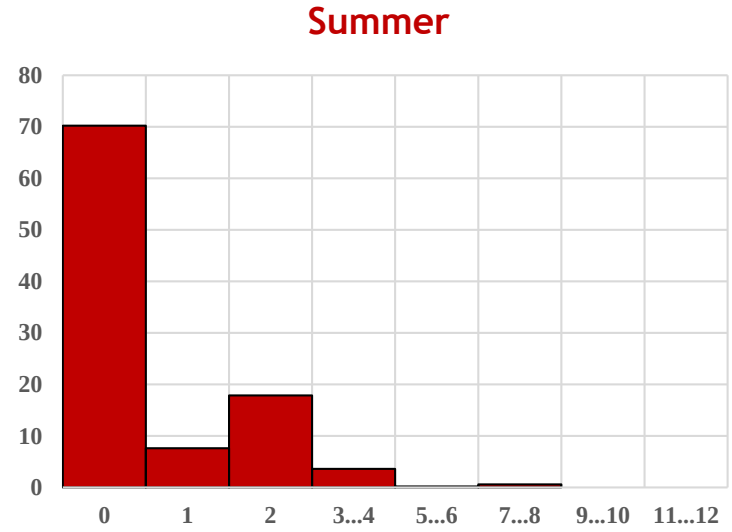


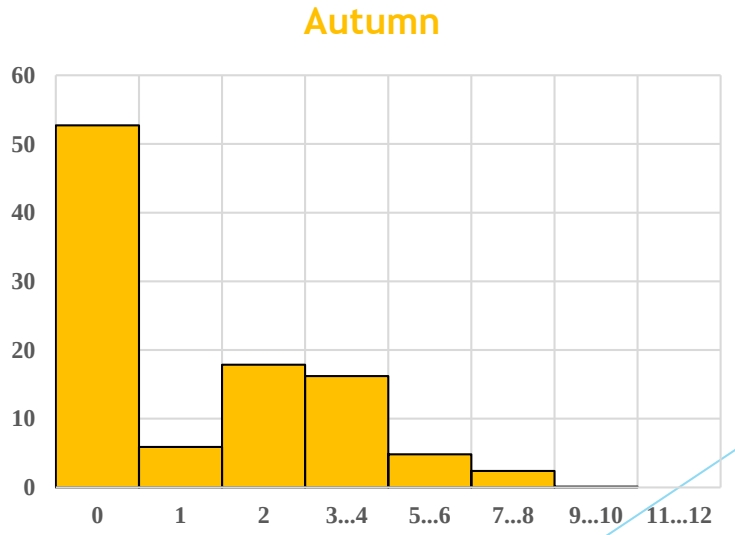


Frequency distribution (% of the totality of the cases) of wind speeds, m/s, associated with fogs for the 2010-2017 period

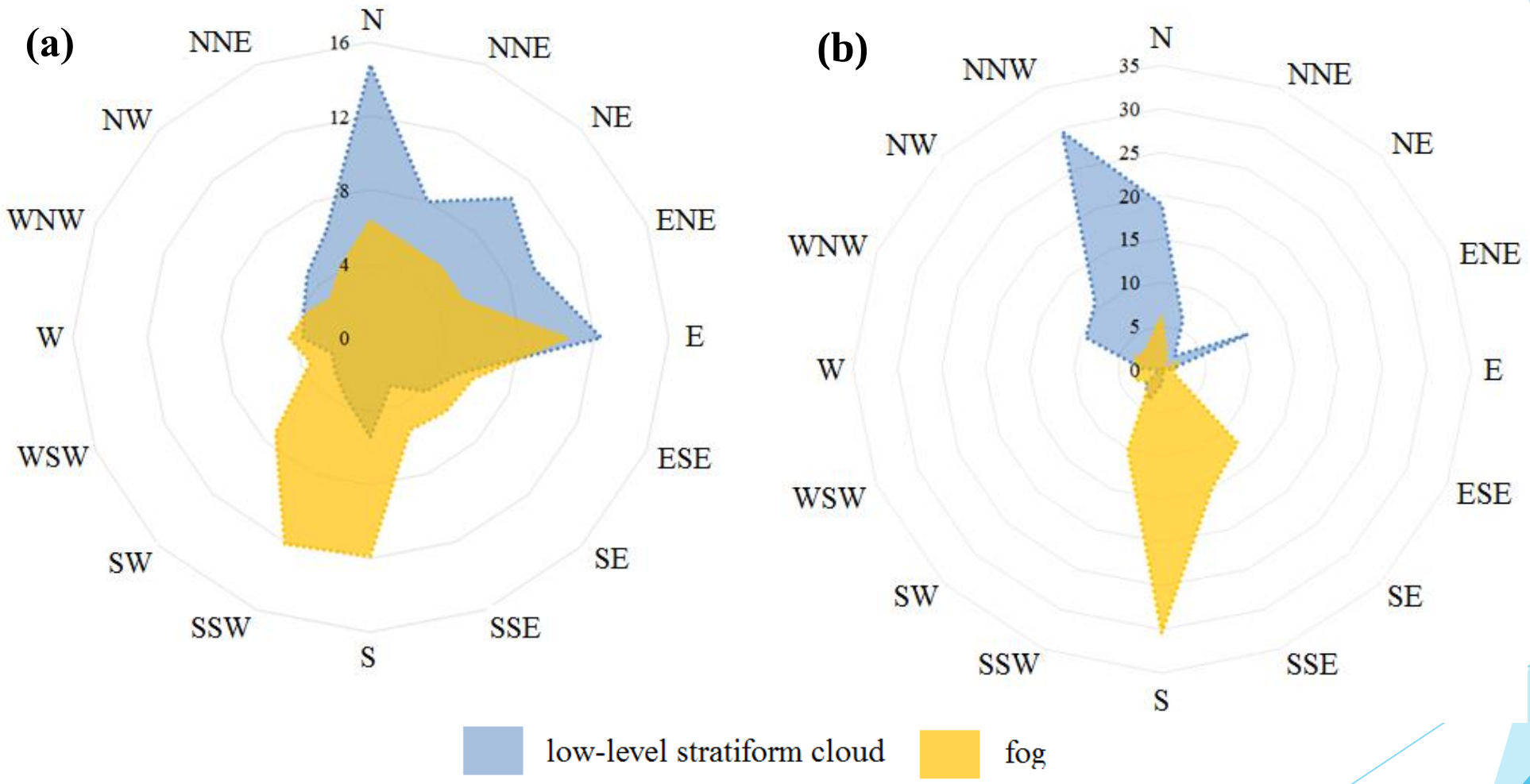




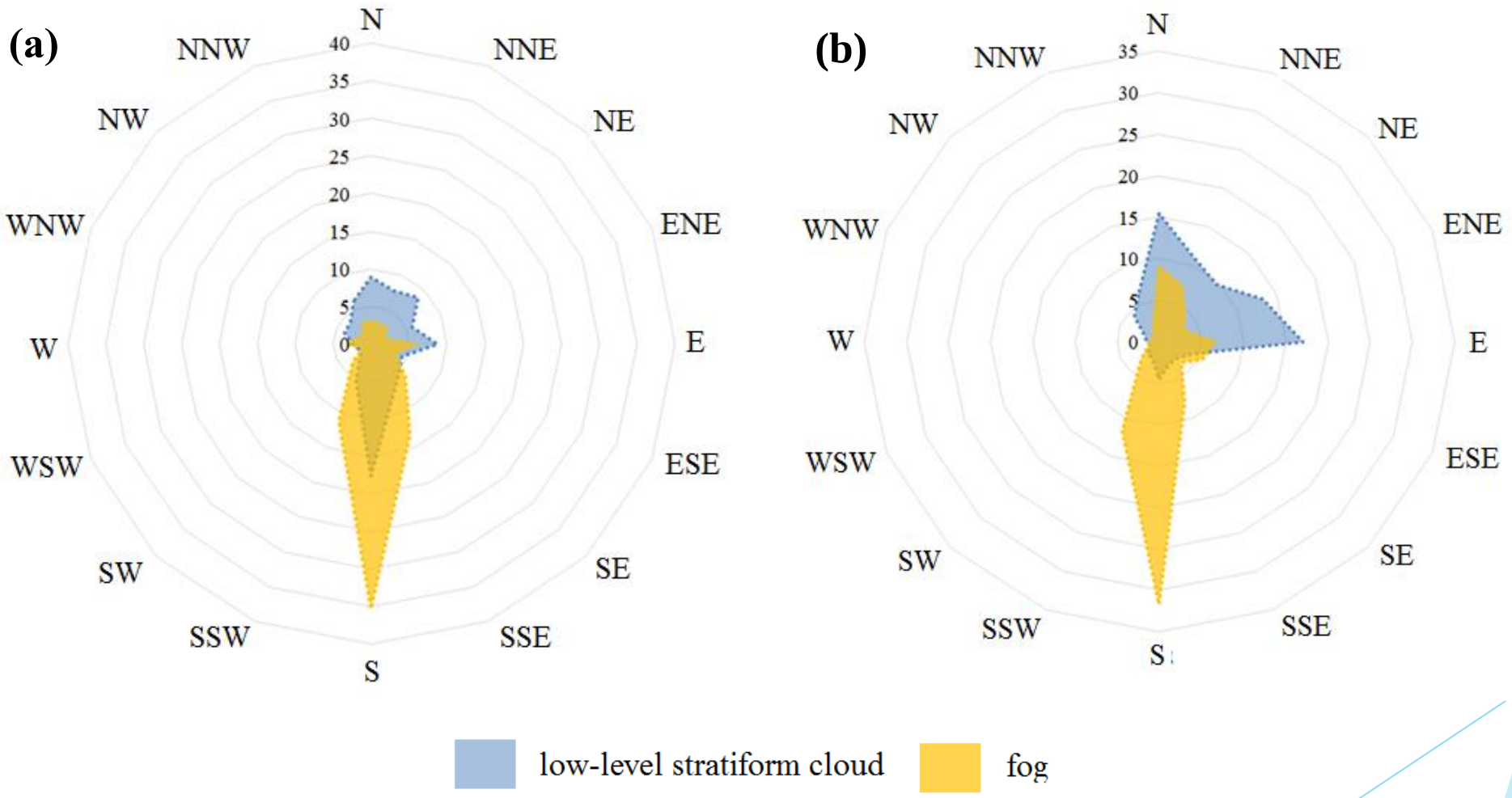




Frequency distribution (% of the totality of the cases) of wind directions associated with low-level stratiform clouds for the 2010-2018 period and fogs for the 2010-2017 period for winter (a) and summer (b)



Frequency distribution (% of the totality of the cases) of wind directions associated with low-level stratiform clouds for the 2010-2018 period and fogs for the 2010-2017 period for spring (a) and autumn (b)



SUMMARY

- Low-level stratiform clouds at the airport of Odessa more frequently occur in November, as well as in winter months with the highest frequency in all seasons except summer, in evening or night time, and minimum – in the afternoon. In summer, low-level stratiform clouds are extremely rare: the maximum frequency is 2% and they are observed more frequently in the morning. Fog is mainly formed in December and January. In all seasons, the highest frequency of the fog events occurs in the night and early morning hours.
- With the increase of relative humidity at temperatures of 0–10 ° C, high occurrence frequency of low-level stratiform clouds are observed, which indicates the close statistical relationship between the occurrence of cloud, relative humidity and air temperature near the surface. The closest relationship is between the relative humidity and the fog occurrence: more than 50% of fog cases are observed at 95% relative humidity and higher in the temperature range from -2 to + 12°C.
- In more than 75% of all fog cases, a minimum visibility of 400 m or below is registered, which indicates the severity of the problem, because, despite the season and type, fogs are usually quite intense and dense.
- In all seasons, the highest occurrence frequency of low-level stratiform clouds are associated with wind velocities of 3 ... 4 m/s, excluding summer, when the most cases are observed at higher speeds. In summer and winter, surface wind associated with low-level stratiform clouds is characterized by high occurrence frequency of north and east directions. Fogs, on the contrary, are most frequently formed at calm in all seasons, except winter. In winter, most typical wind directions for fogs are north-east and east.