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**1.6 – Observation, nowcast and forecast of future needs**

**1.6.2 – Seamless nowcast and numerical weather prediction, probabilistic forecast and statistical methods**

# Applying Statistical Tool CLIPER in Forecasting Visibility at Airports

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One of the biggest challenges in meteorology is predicting fog. The theoretical background of processes in fog formation, maintenance and dissipation is well understood and the availability of measured data at airports is very extensive. Aviation meteorology has a special interest in visibility forecasts at airports since low visibility and low ceiling can cause significant problems to air traffic. Locally on airport, the operations can be severely limited or even completely prevented due to fog lasting from one hour to even several days. It can also be an excluding factor to all planned flights in visual flight conditions when visual contact to ground is required. Although advanced technology used in aviation can bypass the majority of problems caused by fog, conditions in which air traffic is limited are still not rare. Additionally, when compared to other significant weather phenomena, such as thunderstorms or windstorms, fog occurs more frequently and usually lasts longer. Standard airport forecast products that are used for air traffic planning are: Terminal aerodrome forecast (TAF) for 9, 24 or 36 hours in advance and TREND forecast for conditions in the following two hours.

The forecasting of low visibility and ceiling is easier for larger mesoscale area in products like the significant weather chart for low levels. On the other hand, forecasting fog at airports is very demanding due to several reasons. First, forecasting fog for a single point is very hard because of its meso- and micro- scale nature. Conditions leading to low visibility and ceiling are also changing in time, especially in nonhomogeneous surface, terrain, or turbulent mixing conditions. Second, TAF forecast time range is usually 24 hours, with hourly time steps. Related to this is significant interest of users for the punctual forecast of fog onset and dissipation, which is very challenging. Third, the criteria used for the inclusion of change groups forecasted in TAF and TREND forecasts are very demanding. The visibility thresholds of 150, 350, 600, 800, 1500, 3000, 5000 m and the ceiling thresholds 100, 200, 500, 1000 and 1500 ft are very hard to meet, especially in the TREND forecast. At the end, operationally desirable accuracy of forecasts stated in ICAO Annex 3 Attachment B are also rather strict with, e.g. allowed forecast visibility deviation less than 200 m in 90 % of cases for visibility up to 800 m. All of mentioned properties reveal significant challenges regarding forecasting fog conditions for the aviation.

Several approaches are used to operationally forecast reduced horizontal visibility due to fog. Usage of models, post processing and statistical tools (or combination of them) are the most common ones. In Croatia Control we implemented CLIPER - a simple statistical model for probabilistic short-range forecasting (nowcasting), which was proposed by Juras and Pasarić in 2006. In the process of visibility forecast evaluation, climatology, persistence or some random forecast are usually used as a reference forecast. Following Gringorten (1972) and Murphy

(1992), Juras and Pasarić suggest that this method, as a combination of climatology (CLI) and persistence (PER), could be applied as a reference forecast for visibility forecast evaluation. Present visibility is related to climatological visibility distribution for the present hour and month. The corresponding percentile of visibility, in its equivalent normal distribution, is slightly moved from starting percentile to the median during the following hours, depending on strength of the correlation coefficient between the hours. CLIPER forecast of visibility is given for the following 9 hours. Additionally, the probabilistic CLIPER forecast values are made by interpreting percentile ranges.

Together with the information of persistence (PER) forecast of visibility (which is basically forecasting the same percentile in equivalent normal distribution), this method should be a helpful tool to operational forecasters, especially in conditions of low visibility. The method is rather easy to apply to all airports with METAR (routine meteorological reports) databases.
In Croatia Control, operational forecasters use the so called 'Fog Panel', which is an extended graphical representation of the basic method. It consists of several graphs which show present and recent observed visibility and climatological distribution. In addition to the median forecast of visibility, 50 % and 80 % confidence intervals are shown as well to provide a measure of the forecast uncertainty. An example of a 'Fog Panel' is shown in Figure 1.

The results of subjective verification of forecast for the last fog season at Zagreb Airport show very good results, considering the known limitations. The best results are obtained in all situations which show rather usual behaviour of weather, such as fog in anticyclonic situation. The dissipation of fog is well forecasted, especially in situations when clear radiation from the sun is expected after sunrise (in period from February to October). On the other hand, the onset of fog is very challenging due to the method's limitations - the forecasted visibility always tends to regress to the median value. However, forecasting the fog onset with persistence (PER) shows better results, especially when starting visibility is in range from 1000 - 5000 m, meaning that the process of fog formation has already started. This method has limitations in recognizing changes of visibility for fog that was formed from stratus (lowering base), and fog that was advected.

Together with observations and NWP models, this statistical method complements the visibility nowcasting methods. Using the critical judgement of each weather situation and knowing the (dis)advantages of each forecasting material, the forecaster provides added value in forecasting low visibility at airports.

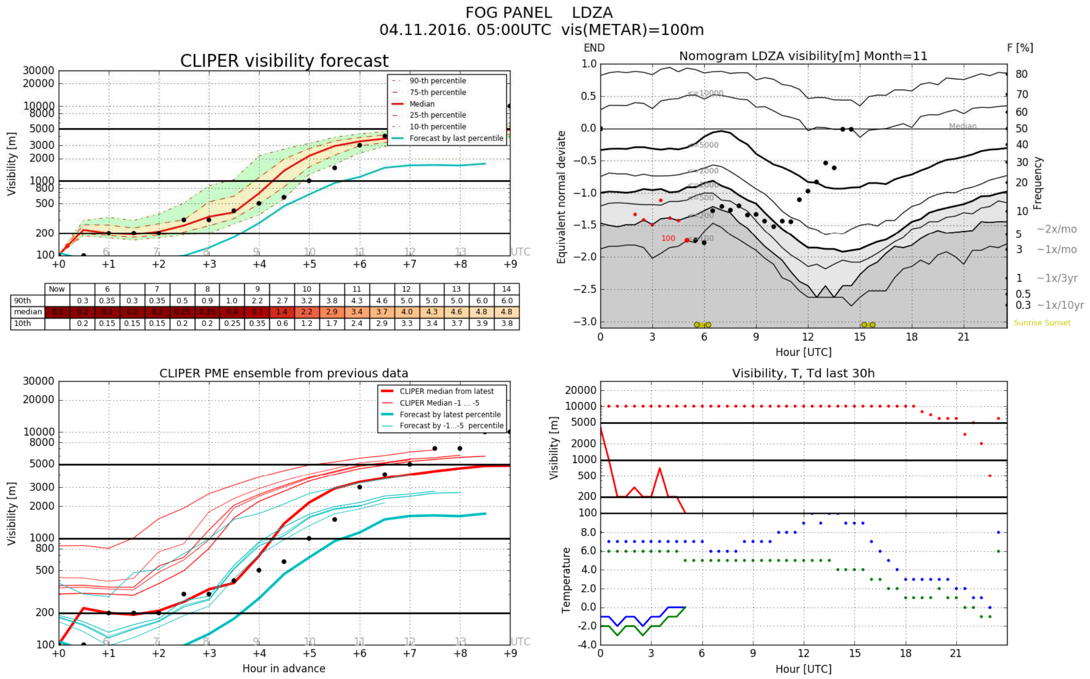


*Figure 1 : Fog panel for Zagreb airport for 4th of November 2016, at 5 UTC.*

Upper left figure shows the CLIPER forecast in the following nine hours, starting from the actual visibility of 100 m. Bold red line is CLIPER forecast together with confidence intervals (yellow and green area bounds 50 % and 80 % confidence intervals, respectively). Cyan line shows forecast following persistence (PER), visibility values which follows same percentile in equivalent normal distribution.
Upper right figure is the visibility nomogram, which clearly relates observed values to the climatological distribution. X-axis depicts time during day (00:00-23:30) and Y-axis is equivalent normal deviate from visibility. On the right axis, derived frequency are shown. Lines represent cumulative frequency of visibility. Red dots represent measured visibility from previous three hours. The extremes of the sunrise and sunset in present month are depicted with yellow dots.
Lower left figure shows the variability of CLIPER and PER forecast from last five visibility values. Spread in the results is a measure of confidence of methods due to variations in equivalent normal deviate.
In previous three figures, black dots shows verified measured values during time of CLIPER forecast.
Lower right figure shows the comparison of some basic meteorological variables during recent 30 hours. Thick lines show the values of visibility (red), temperature (blue) and dew point (green) during the last six hours. Dotted lines show the same, but for previous 24 hours.

**References:**

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