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Meteorological Variables And Visibility Range Estimates At the Greek Airports of Tatoi, Elefsina and Mikra – A Time Series from 2008 to 2018

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Abstract

This work assesses visibility variation measurements performed locally at the Greek airports of Tatoi, Elefsina and Mikra. The pattern of low-visibility conditions is then not only examined for seasonal trends, but most importantly against local variables in order to identify correlation patterns. Lastly, correlations between meteorological variables and visibility are examined to determine a local profile typical for each site.

2. Objectives

The goals of this analysis should be interpreted within the context of field trials of a novel lidar system to estimate visibility range in the near future.

The first and goal is to assess if existing visibility reporting practices will allow successful validation and subsequent calibration of the proposed SAFETRANS system.

Secondly, we aim to identify the distribution of low visibility over the course of the calendar year, in order to select time periods conductive to a wide possible range of visibilities.

Thirdly, we investigate the possible correlation of reported visibility range with measured meteorological variables, in order to identify the existence of local trends associated with low visibility. Identification of such trends would allow an indirect verification of visibility estimates.

1. Background

Atmospheric visibility under different conditions constitutes a field of intense study, with applications ranging from its correlation to air pollution levels (Du et al., 2013) to aviation safety (ICAO, 2013). Calculation of the atmospheric transmissibility in the visible part of the spectrum (~550 nm) from first principles requires a number of simplifying assumptions in order to apply absorption and scattering models for each atmospheric component. Such atmospheric models also tend to assume the scenario of a homogeneous atmosphere, resulting in decreased predictive power under intense weather phenomena.

Consequently, especially in facilities related to aviation, such as airports, on-site measurements (based on conventional techniques) are routinely used in order to derive approximations of atmospheric transmissibility in a limited volume of air, which is then used as a proxy for the actual conditions surrounding the facility.

The SAFETRANS project is based on a UV 3D-scanning lidar system to measure the aerosol extinction distribution along the laser beam directions, and thus, retrieve the relevant visibility based on the Koschmieder's law (ICAO, 2013). In preparation for the field trials of our proposed lidar-based meteorological visibility estimation lidar system (SAFETRANS), we present historic meteorological data covering the decade 2008-2018, as well as the time series of estimated visibility ranges reported by the Hellenic National Meteorological Service (HNMS) for the Greek airports of Tatoi, Elefsina and Mikra.

Figure 1. The SAFETRANS LiDAR manufactured by RAYMETRICS S.A.

3. Methods

Following data preparation, we measured the frequency of each visibility range value reported by each of the three airports participating in the study. Within the context of aviation, a location with consistently clear atmosphere is ideal, whereas an ideal location to test, verify and calibrate our system would have to exhibit a wide range of visibility values and weather conditions.

Secondly, we investigate whether one or more atmospheric variables exhibit different distributions under conditions of "low" (≤ 4km) or "high" (≥ 9 km) visibility throughout the decade 2008-2018. Moreover, the instances of low visibility throughout the calendar year were used to identify local seasonal trends of increased incidence of low-visibility measurements.

Thirdly, the distributions of reported visibility by varying wind direction were visualized, in order to account for local sources of pollutants, such as industrial areas and local cities.

Fourthly, the correlation coefficients between the atmospheric variables identified in the second step of our analysis and reported visibility were calculated. In this manner, the predictability of visibility from local atmospheric conditions would be tested, contributing both to the argument for or against the introduction of the SAFETRANS system.

4. Results

Over 85%-90% of the reported visibility measurements (depending on the airport) overpassed 9 km range, with the only categories in this range being "9000 m", "9999 m" and "CAVOK", signifying the importance of performing field tests during time periods with an increased probability of low visibility. Low visibility occurrences showed definite trends favouring winter months (especially during December and February months), which differ noticeably between airports due to local conditions.

Similarly, the set of meteorological variables that showed a shift of their mean and median values between "low" and "high" visibility conditions differed between airports, as shown in Table 1. The discretized distributions of values also show clear changes differentiating "low" and "high" visibility conditions, supporting the suggestions provided by mean and median changes (cf. Figure 1, for Mikra airport).

Lastly, correlation estimates between reported visibility and meteorological variables confirm all observations made so far by being noticeably higher in the variables shown in Table 1 for each airport, but have absolute values in the (0.195-0.410) range. Consequently, they may be used as weak indicators of the probability of low visibility reports but cannot provide predictions, even accounting for knowledge of local conditions.

Airport	Temperature	MSLP	Relative Humidity	Wind Speed	Calendar month
Tatoi (Athens)	YES	-	YES	-	Feb., Jan., Dec., Mar.
Elefsina (Athens)	YES	YES	YES	-	Feb., Dec., Oct.
Mikra (Thessaloniki)	YES	-	YES	YES	Jan., Dec., Feb., Nov.

Table 1. Variables exhibiting significant change between high* and low** visibility. Months ordered by descending rate of low visibility instances.

* Reported visibility ≥ 9 km
** Reported visibility ≤ 4 km

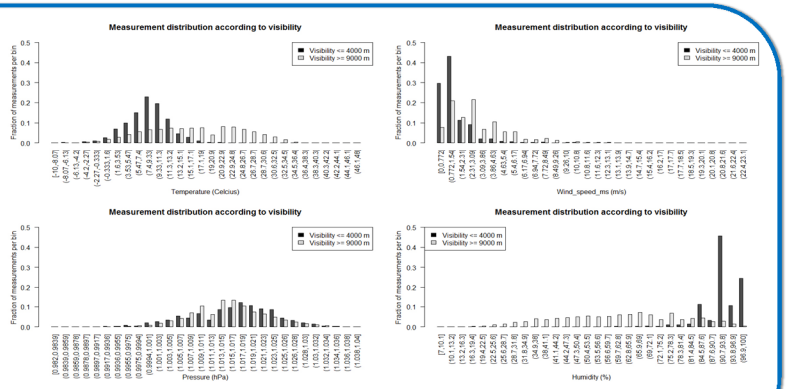

Figure 1. Mikra airport meteorological variable distributions (temperature, wind speed, mean sea level pressure (MSLP) and relative humidity) for two different visibility measurements.

5. Conclusions

In this work we presented our preparatory work for scheduling field trials of the SAFETRANS 3-dimensional (3D) scanning visibility range estimation lidar system. Based on extensive time series of meteorological data of the period 2008-2018 for the airports of Tatoi, Elefsina and Mikra, we attempted to assess the probability of encountering conditions of impaired visibility with respect to the time of the year and available atmospheric variables. The results show that most associated with low visibility instances in these airports are the month of the year, temperature, mean sea level pressure (MSLP), humidity and wind speed. The specific pattern of correlations is markedly different for each airport, and loosely correlated enough to necessitate a system dedicated to the estimation of meteorological visibility range. At the same time, the results appear to be conclusive enough to allow an estimation of windows of opportunity for each airport that are conductive to rigorous testing of the SAFETRANS 3D-scanning lidar system, both in terms of time of the year, as well as in terms of specific conditions that have historically been conductive to drops in visibility.

References

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