Estimating daily evaporation from poorly monitored lakes using limited meteorological data

Estimating water evaporation is vital in many problems that are related to agriculture, hydrology and lake operation planning. In fact, water loss by evaporation from rivers, lakes and open reservoirs is a crucial problem in regions that suffer from water scarcity or water salinity.

In general, open water evaporation is influenced by several meteorological parameters such as: irradiance, soil temperature, relative humidity, atmospheric pressure and wind speed. However, dealing with that matter, in a case of measurements scarcity, is a challenging task. In fact, most of the available procedures consist with estimating evaporation require many inputs and expensive data acquisition equipment in order to obtain accurate results.

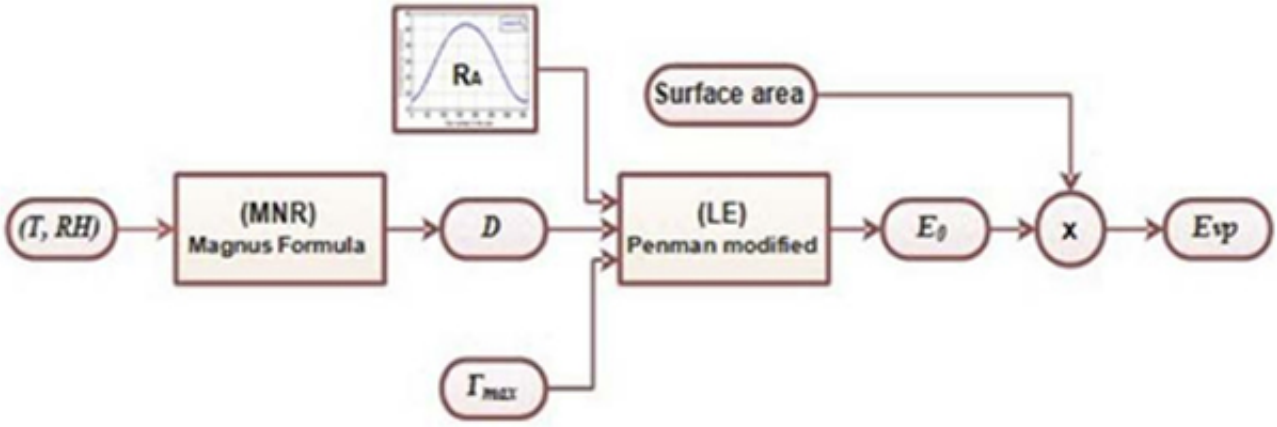

Fig. 1. Evaporation calculation scheme.

To overcome this problem, a less dimensional and non-expensive method to estimate lake evaporation (E_0) is presented. This technique requires only two commonly available weather data: temperature (T) and relative humidity (RH). In fact, the approach is composed of two steps: at step one the parameters of the Nonlinear Regression model (Magnus formula) are estimated using Levenberg Marquardt algorithm in order to meet the case study profile. Here, the trained model is responsible to estimate the dew point (D). At step two, the forecasted dew point is used to approximate irradiance which in turn is utilized in the simplified Penman formula to predict evaporation (Fig. 1).

To illustrate the effectiveness and capabilities of the suggested method, Qaraoun lake – Lebanon was selected as a case study. Upon testing, the regression model exhibited high accuracy with a goodness of fit value equal to 0.99. Afterwards, the evaporation rates were estimated using Penman formula. Unfortunately, evaporation measurements were not available on site to carry the

testing procedures. Instead, outcomes were investigated and compared with the monthly evaporation average retrieved from the nearest region to the lake. Considering the limited amount of data, estimated rates came reliable with correlation coefficient equal to 0.89 and a mean absolute percentage error equal to 9.8%. At the final stage of the study, sensitivity analysis was performed to quantify the impact of temperature and relative humidity change on evaporation. Fortunately, Lebanon and Greece share the same Mediterranean climate which led us to perform an evaporation differences comparison in order to validate our modelling approach. Upon comparing, the achieved outcomes came similar to the results presented in studies carried in Greece.

Overall, the achieved accuracy by the model motived us to carry out further assessment of the economic impact of evaporation losses from Qaraoun reservoir on hydropower generation and irrigation. In fact, following the same procedure, it is estimated that the water loss on the same site for the year 2013 is around 17.88 million of m^3. If this amount of water is considered for hydropower generation, the financial loss is about 850,000 USD. This number represents 5.1% of the total achieved profit. On the other hand, the impact of evaporation on the irrigation sector is drastic when compared to the hydropower sector. The approximated profit loss is around 43 million of USD.

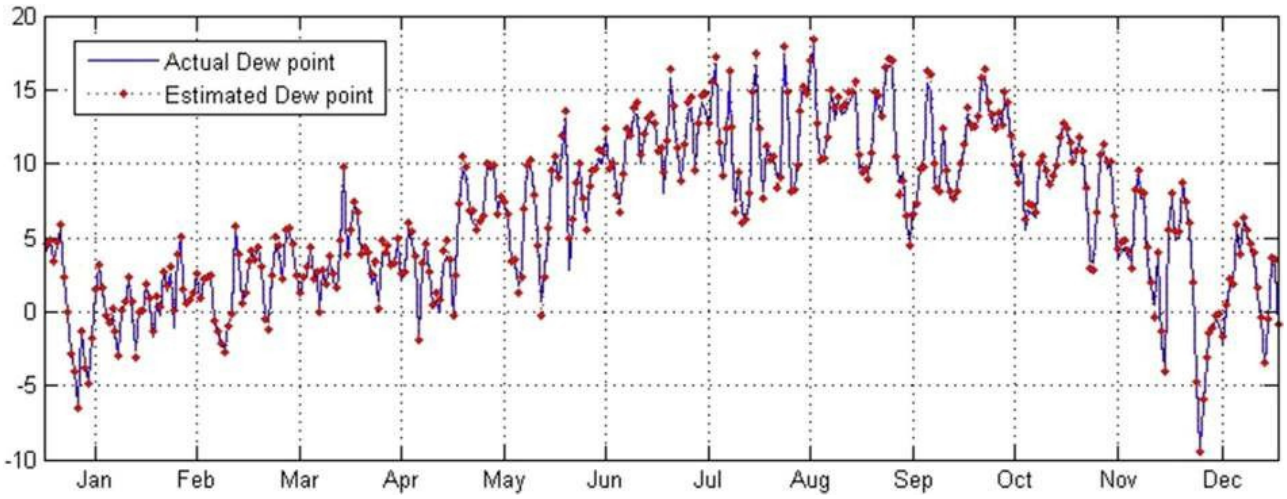

Fig. 2. Actual versus estimated dew point over the testing period (1st of January – 31st of December 2015).

In a word, the suggested approach offers a cheap method in order to estimate evaporation, rather than installing expensive, high-tech data acquisition systems for that purpose. Here, we provide a tool that may help engineers and researchers to carry first a preliminary investigation before going into a full-scale study. In fact, neglecting the critical impact of water losses due to evaporation may result in serious overestimation of water availability and thus underestimation of the required

storage capacity to support the proper water release for different sectors.

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