RC6

The comment "Most importantly, the authors should decide what their main focus of the study is. Is it the effect of macrophytes on evaporation or is it the different estimation methods? At the moment, this is not clear. I would suggest the former to be the more interesting subject." gives relevant advice to the authors.

In revising the manuscript, authors may challenge the concept that there is a single 'potential evaporation' metric that applies to all vegetation or open-water surfaces: the presence of water plants in Class A pans will influence surface temperature (hopefully you have some data on this) and hence evaporation. Clarifying the physical basis of this effect will be more relevant for future authors than a comparison of 'interpolation techniques' within the existing data set (with little confidence in using results elsewhere.

According to the RC-6 reviewer's advice (this is his second term), the clarified physical basis of the pan with submerged macrophyte was added to the manuscript. See below. At the same time, we omit the Fig. provided in the answer of RC1. Instead, the analysis below completes the manuscript.

The aim of the study will be clarified as previous answers present it.

To M & M

In the last vegetation period, to detect vertical T_w profiles, four fastened thermistors of Delta Ohm HD-226-1 (accuracy: 0.3ºC) collected the temperature data at 0.05, 0.10, 0.15 m depth from the pan bottom and on the water surface, at 10-min intervals. Hourly averaged T_w values were used in the analysis. To present diurnal variation in T_w and stratification, sample days were selected for clear-sky, calm, and cloudy weather conditions.

To Results

On the basis of daily variation of T_w in different depth, two time-periods were distinguished (Fig. 1); daytime (7:00 – 18:00 h, LMT) and nighttime cooling (19:00 – 6:00 h, LMT).

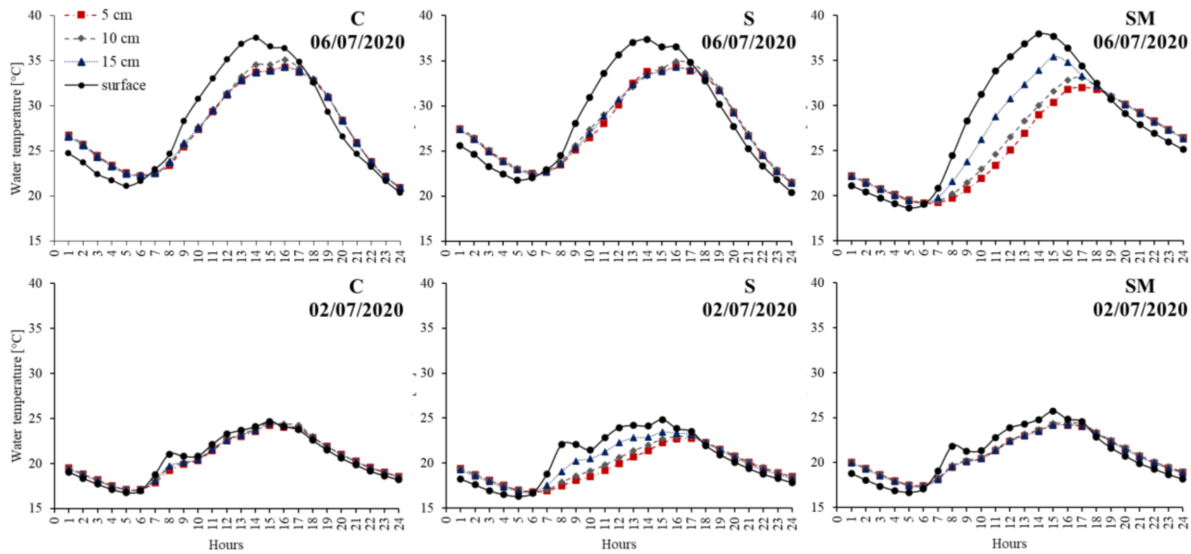

Fig. 1 Water temperature of different pan treatments (C – Class A pan/control; S – Class A pan with sediment covered bottom; SM – Class A pan with submerged macrophyte) in clearsky and cloudy sample days

On clear sky conditions, the surface T_w peaked at 14:00 h, irrespective to treatment. The magnitudes of surface T_w in daytime (between 07:00 and 14:00 hours) increased from 21.6 to 37.5ºC in C, from 23.0 to 37.4ºC in S, and from 19.8 to 38.0ºC in SM. Then, with declining solar radiation, the T_w slightly decreased during the nighttime cooling to 21.2, 21.8 and 18.7ºC in C, S and SM, respectively, until sunrise. In deeper water depth, a similar pattern of T_w with slightly smaller magnitudes was measured with time lag of 1-to-2-hours from the surface T_w. In classic A pan, the T_w in deeper depth from the surface did not reduce as rapidly as T_w in seeded pans. On cloudy days, insignificant T_w differences less than 1ºC (p=0.059 - 0.969) between the neighbouring layers were observed in every treatment.

To Discussion

Daily mean T_w increases were 5.4 and 4.5ºC in S and SM, respectively, compared to C during clear-sky conditions. Despite the less intense stratification on overcast days, T_w of seeded pans was 5.4ºC higher than that of daily mean T_w of C.

Increased stratification was evident in daytime, but the number of layers strongly depended on macrophyte presence. More moderate T_w layer differences were also present at night. The stratification was the most intense with 3 significantly different layers ($p<0.001$) in seeded pans, during clear-sky daytime. At the same time, the number of layers with varied T_w was only 2 ($p<0.001$ – $p=0.012$) in classic A and sediment covered pans. Results in the study were confirmed by Andersen et al. (2017) concluding that shallow lakes colonized by submerged macrophytes strongly stratify the water body, mainly during the daytime. The reason of this stratification is the dissipating turbulent kinetic energy and absorbing heat (Vilas et al., 2018). The plants may act as a barrier to seeded pans water mixing, attenuating underwater light, thereby enhancing the thermal stratification inside the pan's water column.

The strength of stratification, the daily mean T_w differences between the surface and bottom water were 2.5 ($p=0.005$), 3.0 ($p<0.001$) and 6.5ºC ($p<0.001$) in C, S and SM, respectively, on cloudless days. At night-time cooling, variation in T_w between different layers was less pronounced, remaining below 1ºC ($p<0.001$ – $p= 0.005$).

In addition to stratification, the macrophytes have strengthened the daily variation of T_w in different depth. A 0.3ºC increase in daily mean surface T_w of seeded pans related to C was obtained during daytime, with variation (T_{max} – T_{min}) of 18.4 and 19.3ºC in C and SM, respectively. On the bottom, an opposite trend in daytime mean T_w was detected; the seeded pans T_w in 0.05 m depth was 3.1ºC ($p=0.040$) cooler than that of the T_w of C. Probably the macrophyte presence resulted in insufficient downward heat transport, maintaining the more stratified water body of seeded pans. Herb and Stefan (2004) also found reduced turbulent mixing in shallow Otter Lake, Minnesota, with rooted macrophytes. The authors observed that T_w fluctuations at 20 cm depth were 3ºC in open water and 4.5ºC in lake water with macrophyte cover. Evapotranspiration functions of SM fitted to surface T_w evolution; the higher the surface T_w, the more intense the E_p rate was measured in SM related to E_p of classic A pan.

To Conclusion

Macrophyte induced thermal stratification in water bodies (lakes/evaporation pans) emerge only in the vegetation period, during macrophytes development. One less layer in Classic A pan compared to macrophyte seeded pans was probably due to modified T_w stratification causing changed water column stability. Wider T_w values induced dynamics presented in the macrophyte seeded pans demonstrated the possibility of developing a more heterogenous environment for aquatic ecosystems. Macrophyte induced modified thermal stratification with higher surface T_w could explain the increased E_p in seeded pans. Modified E_p of seeded pan made those values closer to the E_p of natural lakes with submerged macrophytes. While T_w stratification trend in SM was similar to that of natural shallow lake's one, it may also provide a new consideration for routine hydrometeorological management. T_w distribution in macrophyte covered lakes impacts other physical properties such as nutrient cycling, dissolved oxygen etc. When treating E_p from a pan to that from a vegetated surface including lakes or other aquatic habitats, to improve evaporation estimation, multidimensional approximation is necessary offering simple methods for end-users including hydrologists, meteorologists, or any other specialists.

To References

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