Dew contribution to the water balance in a semiarid coastal steppe ecosystem (Cabo de Gata, SE Spain)

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ABSTRACT

Dewfall deposition can be a significant source of moisture in arid and semiarid ecosystems, thus contributing to improve daily and annual water balances.. Occurrence, frequency and amount of dewfall were measured in the Balsa Blanca site (Cabo de Gata, Almería, Spain) from January 2007 to May 2008. This area has a sparse vegetation cover dominated by *Stipa tenaccisima* combined with bare soil and biological soil crusts.

Wetness sensors were used to detect occurrence and frequency of dew events. The single-source Penman—Monteith equation simplified for water condensation was used to calculate dew amount. Micro-meteorological conditions during dew formation were also measured. Dew condensation was recorded over 98% of nights during the study period. Dewfall length varied from 1 to 16 hours per day with an average of 6.3 ±0.5.hours per day. Average dew amount was 15.6±.0.34 g H2O $m^{-2}.h^{-1}$ showing a relatively small variability throughout the year. Therefore dew amount was mostly dependent on dew duration. Dew episodes were longer in late autumn and winter and decreases along spring. Annual dewfall was 30.5 mm in 2007, which represents 15% of total rainfall. 2007 was a relatively wet year with 280 mm rainfall. Comparing contribution of dew to the local water balance during a wet (January-May 2007, 120 mm rainfall) and dry period (January-May 2008, 15 mm rainfall), we have found a dew contribution of 15% in 2007 and 128% in 2008.

These results highlight the relevance of dew as a relatively small but constant source of water in arid ecosystems, as well as its significant contribution to the local water balance mainly during dry periods.

Key words: dewfall, potential dew, arid environments, wetness sensors, Cabo de Gata, SE Spain

INTRODUCTION

Information regarding dew precipitation is scarce, both because it is considered a minor component of the water balance and because of the difficulty in measuring it. Nevertheless, although yielding relatively low amounts of water, dew can contribute significantly to the local water balance in semiarid and arid environments especially during dry years. In particular, dewfall constitutes occasionally a constant and stable water source and thus, may be of great interest to incorporate it into energy and water balance models.

A previous study (Moro *et al*. 2007) found that the single-source Penman-Monteith evaporation model simplified for water vapour condensation (potential dew), adequately predicted actual dew in a semi arid, sparse shrubland in Rambla Honda experimental (Almería, SE Spain). The relative agreement between potential and actual dew amounts at daily and monthly scales found in that study suggested that dew condensation in these semiarid areas with sparse vegetation cover could be driven mainly by the radiative balance and thus, the advective term of the Penman-Monteith equation had a negligible relevance.

In this study, we estimate dewfall amount in a coastal semiarid steppe in Cabo de Gata (Almeria, SE Spain).This area has a sparse vegetation cover dominated by *Stipa tenaccisima*. We applied the potential dew model (Moro et al., 2007) to estimate dewfall amount and analysed its importance for the local water balance.

METHODS

The study area is the field station of Balsa Blanca (Parque Natural de Cabo de Gata-Níjar, Almería, Spain). This site is representative of the coastal-steppe ecosystems largely distributed along the region of the of the Cabo de Gata, one of the most dry of Spain with a long term average rainfall of 200 mm. Landscape is formed by alluvial fans deposited upon a calcrete bedrock. Vegetation cover is sparse and dominated by *Stipa tenaccisima* combined with bare soil and biological soil crusts. The experimental area is equipped with a micrometeorological station and a Eddy Covariance system (EC) to measure water vapour fluxes. Wind speed, net radiation, vapour pressure and air temperature were measured automatically at the reference height. The occurrence, frequency and length of dew episodes were measured by wetness sensors (WS) placed in open areas. Thermocouples and heat flux plates were placed in the soil to calculate the soil heat flux (G). All measurements were taken every 30 minutes

Following Moro *et al*. (2007), we use filtered databases from WS and EC data, together with its corresponding micrometeorological information, to evaluate the adequacy of the single-source Penman-Monteith evaporation model (Monteith, 1965), simplified for water vapour condensation (eq.1) to predict the amount of dewfall. For this purpose we selected those periods with negative latent heat flux (λE) by EC (measured dew) and simultaneous presence of wet conditions detected by WS. Rainfall events were excluded. Further filtering was applied selecting surface energy closure values higher than 75%.

$$\lambda E = \frac{\left[s(R_n - G)\right]}{\gamma + s} \qquad \text{(eq 1)}$$

where R_n is the net radiation, *G* is the soil heat flux, λE is the latent heat flux, *s* is the slope of the vapour pressure versus temperature curve and γ is the psychometric constant.

RESULTS AND DISCUSSION

The filtered 30' data of measured (EC) and calculated dew (potential dew, eq.1) were cumulated at monthly basis. The monthly potential dew amount provides an acceptable estimate for the actual dew amount (Fig. 1) with data approaching to the 1:1 line (r^2 = 0.97; p < 0.001). Hence, a simple equation for potential dew predicted reasonably well actual dew in this study. Other studies conducted in desert and semi arid areas (Jacobs *et al.* 2002, Moro et *al.*.2007) have also found the concordance between potential and actual dew amounts. Moro et *al.* (2007) suggested that dew condensation in these areas could be driven mainly by the radiative balance and thus, the advective term of the Penman-Monteith equation had a negligible relevance. We further applied this equation to quantify dew in the study area.

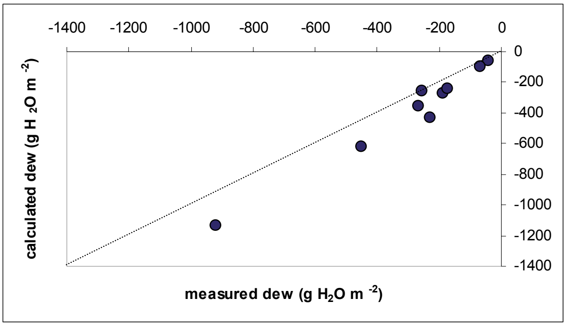

Fig. 1. Relationship between measured dew (EC) and estimated dew by equation (1) at monthly scale

Dew condensation occurred over 98% of the nights throughout the study period. Dewfall length varied from 1 to 16 hours per day (Fig 2) with an average of 6.3 ±0.5.hours per night. Episodes longer than 10 hours can be attributed to fog events. Dew events were longer in late autumn and winter and decreases along spring (Fig. 2).

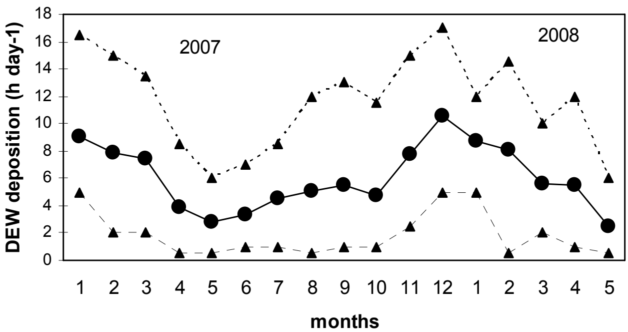

Fig. 2 . Average, minimum and maximum number of hours per day with dew condensation

In general dewfall starts at sunset and often continues sometime during the early morning. Mean dew condensation rates per night ranged from 8.6 to 16.3 g H_2O m^{-2} h^{-1} in 2007 and from 13.5 to 19 g H_2O m^{-2} h^{-1} in 2008.The average daily dew rate was 0.092 ± 0.003 mm d^{-1}. Dewfall showed a seasonal pattern with a maximum in winter and a minimum in spring (Fig.3). Cumulative dewfall was 30.5 mm in 2007 and 15.4 mm. from January to May 2008 (Table 1). Dew deposition in summer 2007 was slightly higher than rainfall. Dewfall inputs were similar during January-May of 2007 and 2008 (Table1). Nevertheless the contribution to the water balance (dewfall/ rainfall) was 11% in 2007 and 128% 2008. These results highlight the relevance of dew condensation during stress or dry periods.

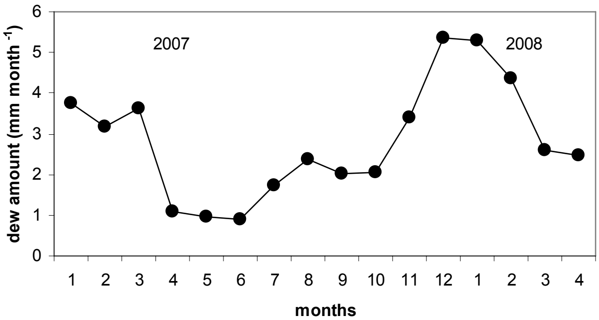

Fig. 3. Dewfall (mm month $^{-1}$) during the study period in Balsa Blanca coastal steppe

Table 1**.** Dewfall and rainfall (mm) from different study periods in Balsa Blanca (Cabo de Gata).

Period	Dew (mm)	Rainfall (mm)	Dew / Rainfall (%)
Jan-Dec 2007	30.5	280	11
Jan-May 2007	13.2	120	11
Jan-May 2008	15.4	13	128

CONCLUSIONS

A simple equation for potential dew predicted reasonably well actual dew in this study. Dewfall constituted a constant and stable water input in the study area. The amount of water incorporated by means of dew in the study area was a significant proportion (12%) of the rainfall in 2007, which was a relatively wet year. During dry periods it was even higher than rainfall and therefore, it can play a significant role in the local water balance.

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