Microlysimeter station for long term non-rainfall water input and evaporation studies

O. Uclés a,*, L. Villagarcía b, Y. Cantón c, F. Domingo a

a Estación Experimental de Zonas Áridas (EEZA-CSIC), Carretera de Sacramento s/n, 04120 La Cañada de San Urbano, Almería, Spain
b Departamento de Sistemas Físicos, Químicos y Naturales, Universidad Pablo de Olavide, Carretera de Utrera Km.1, 41013 Sevilla, Spain
c Departamento de Agronomía, Universidad de Almería, La Cañada de San Urbano s/n, Almería, Spain

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A B S T R A C T
Non-rainfall atmospheric water input (NRWI), which is comprised of fog, dew and soil water vapour adsorption (WVA), has been proven to be an important water source in arid and semi-arid environments. Its minor contribution to the water balance and the difficulty in measuring it have resulted in a wide variety of measurement methods (duration and quantification), especially for dew. Microlysimeters seem to be the most realistic method for dew measurement on natural surfaces and they can also detect WVA. This paper presents an automated microlysimeter that enables accurate studies of NRWI and evaporation on soil and small plants. Furthermore, we have developed a field strategy for their long term placement and installation which prevents damage from rainfall, soil movement or other field conditions, keeping the microlysimeters balanced and dry. This design allows the measurement of evaporation and NRWI on different cover types, including small plants. By monitoring the surface temperatures, dewfall and water vapour adsorption can be distinguished and the relative contribution of dew and WVA on the NRWI can also be found. Our automated microlysimeter design, construction and field installation have proven to be an useful and effective tool in an NRWI study.

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1. Introduction

Non-rainfall atmospheric water input into an ecosystem can originate from fog, dew or water vapour adsorption (WVA). Fog occurs when the atmospheric water vapour concentration reaches saturation, a mass of condensed water droplets remains suspended in the air and is deposited on the surface by interception. Dew forms when the temperature of the surface where water will condense equals or falls below the dew point temperature of the surrounding air. WVA takes place when the relative humidity of the air is higher than the relative humidity in the pore space in the soil while the surface temperature is higher than the dew point temperature of the surrounding air (Agam and Berliner, 2006).

Non-rainfall atmospheric water has been proven to be an important water source in arid and semi-arid environments (Jacobs et al., 1999; Kalthoff et al., 2006; Uclés et al., 2013; Veste et al., 2008). Some studies have confirmed that summer soil WVA plays an important role in the stomatal conductance and vital transpiration in Stipa tenacissima in SE Spain (Ramirez et al., 2007), dew plays an important role in biomass production of plants at low water cost (Ben-Asher et al., 2010) and dew evaporation in the morning alleviates moisture stress in plants by cooling the leaves and reducing transpiration losses (Sudmeyer et al., 1994). Furthermore, several studies have stated that dewfall can play an important role in the development of biological soil crusts (del Prado and Sancho, 2007; Kidron et al., 2002; Pintado et al., 2005) and microorganisms (Lange et al., 1970). Dew and fog may also have a negative effect on plants promoting bacterial and fungal infections (Duddevani, 1964), which may have an important impact on agriculture (Kidron, 1999). Some attempts have been made to study the duration and quantification of non-rainfall water input (NRWI), but there is no international agreement on how this should be done. Its minor contribution to the water balance and the difficulty in measuring it, have resulted in a wide variety of measurement methods, especially for dew.

Dew duration has been long studied, mainly because of its importance in plant diseases, as leaf wetness duration can determine pathogen and fungus development. But leaf wetness duration is a difficult variable to measure or estimate, since wetness varies considerably with weather conditions, surface cover type or crop, as well as position, angle, geometry and location of the leaves (Hughes and Brimblecombe, 1994; Madeira et al., 2002; Magarey et al., 2006). Some micrometeorological data and mathematical models have been used to predict leaf surface wetness duration...
(Madeira et al., 2002; Magarey et al., 2006; Monteith and Butler, 1979; Pedro Jr and Gillespie, 1981a,b; Weiss et al., 1989). However, the use of leaf wetness sensors is necessary when estimations by empirical or physical models are too complex. For this purpose, Gillespie and Kidd (1978) developed an electrical impedance grid that has evolved on actual commercial leaf wetness sensors. These sensors consist of a grid that a current can flow through when free water bridges the gap between two trace wires. The wires are energized by a potential difference from a datalogger’s excitation circuitry. When dew or rain is deposited on the sensor surface, the datalogger senses the current due to the presence of water on the grid.

As dew may have an important role in the water budget in arid and semiarid ecosystems (Jacobs et al., 1999; Kalthoff et al., 2006; Uclés et al., 2013; Veste et al., 2008), its quantification becomes an important issue. Some theoretical and modelling methods, such as the Bowen ratio technique (Kalthoff et al., 2006; Malek et al., 1999), the Penman Monteith equation (Jacobs et al., 2002; Moro et al., 2007) and, more recently, the Combined Dewfall Estimation Method (CDEM) (Uclés et al., 2013) may be found in the literature. These techniques can quantify the amount and duration of dew, but require an enormous amount of atmospheric variable data. Furthermore, they can be difficult to implement and do not measure fog or WVA, or do not differentiate between these two phenomena and dew.

Other efforts at estimating dew have resulted in the development of direct measurement methods using artificial surfaces, such as the Duvdevani dew gauge (Duvdevani, 1947; Evenari et al., 1971; Subramaniam and Kesava Rao, 1983), the cloth plate method (Kidron, 2000; Kidron et al., 2000) and the Hiltner dew balance (Zangvil, 1996). The Duvdevani dew gauge consists of a rectangular wooden block (32 cm × 5 cm × 2.5 cm) coated with a special paint where dew condenses. Using reference dew photographs, the dew amount can be stated visually in the early morning. The cloth plate method consists of an absorbent cloth (6 cm × 6 cm) attached to a glass plate (10 cm × 10 cm × 0.2 cm) and placed on a wooden plate (10 cm × 10 cm × 0.5 cm). The cloth is collected in the early morning and it is weighed and dried to calculate its water content. Baysens et al. (2005) used plexiglas surfaces as dew collectors and some attempts have also been made to measure dew on plants using artificial collecting surfaces such as poplar wood stick, sunflower stick and filter paper (Yan and Xu, 2010). These methods are unable to record the dew duration but the Hiltner dew balance does. This method consists of a continuous registration of the weight of an artificial condensation plate hanging 2 cm above the ground. All these direct measurement methods are easy to implement but under or overestimate dew, since their surface properties are different from natural surfaces. Hence, these dew measurement methods are useful for intersite comparisons but do not provide real values and are unable to measure WVA.

Microlysimeters are an effective method for measuring NRWI on natural surfaces, as they can detect dew and WVA with accuracy (Uclés et al., 2013). Several NRWI studies have been done with manual microlysimeters (Jacobs et al., 2000, 2002; Ninami and Berliner, 2002; Rosenberg, 1969; Sudmeyer et al., 1994; Waggoner et al., 1969). However, manual methods usually underestimate NRWI, because the beginning and end of the measurement period are predetermined by the researcher and the entire water input period may be reduced. Recently, automated weighing microlysimeters are being more used (Graf et al., 2004; Heusinkveld et al., 2006; Kaseke et al., 2012; Uclés et al., 2013), because this method avoids daily manipulation of the sample and records continuously anywhere. Sample dimensions in automated microlysimeters are determined by the load cell characteristics, since the larger the sample or the load cell are, the lower the resolution. Heusinkveld et al. (2006) and Kaseke et al. (2012) used a 1.5 kg rated capacity single-point aluminium load cell for measuring dewfall on bare soil and on biological soil crusts (BSCs). Indeed, microlysimeter studies have focused on bare soil and BSCs monitoring, as sampling cup dimensions are insufficient for plants. However, Uclés et al. (2013) successfully used a larger load cell (3 kg rated capacity) to measure NRWI on small plants.

The accuracy of the automated microlysimeter measurements depends on their field installation as they must be buried with the surface of the soil samples flush with the surrounding soil. Furthermore, they have to be mounted with the balance of the load cells perpendicular to avoid eccentricity. After burial, the soil tends to move and the microlysimeter may tip, twist, be thrown out of the balance and break. Another common problem is damage from soil movements caused by rain and water entering the load cell case. Therefore, only short automated microlysimeter studies have been done with a small number of replicates. The study of Kaseke et al. (2012), for example, had to be stopped because of an imminent rainstorm which could have flooded and damaged the load cell. Microlysimers must be improved and a suitable field installation method must be developed to be able to deal with all these drawbacks and carry out long-term studies with all the replicates needed.

This paper presents an automated microlysimeter (MLs) which may be used for the accurate study of NRWI and evaporation on soils and small plants. We have also developed a long-term MLs field installation and placement strategy which avoids damage from rain, soil movement or other field conditions, keeping the MLs balanced and dry. In this study, 12 MLs were installed in a Mediterranean semiarid steppe ecosystem (Balsa Blanca, Almería, SE Spain) with different cover types in the sampling cups (plants, BSCs, stones and bare soil). The MLs and the field installation were tested for: (1) input signal; (2) sample dimensions with two different soil types; (3) load cell temperature dependence; and (4) effectiveness of the field installation strategy. MLs data for 49 days (May–June 2012) were analyzed and their daily signal and the possibility of differentiating between WVA and dew were verified. Furthermore, the sensitivity of the MLs in differentiating NRWI and evaporation on different cover types was also studied.

2. Materials and methods

2.1. Study site

Most of the measurements were conducted at Balsa Blanca, but El Cautivo field site was also used for Test_2.

Balsa Blanca is a Mediterranean coastal steppe ecosystem in Almería, SE Spain (36°56'30" N, 2°1’58" W, 208 m a.s.l.). This site, which is one of the driest ecosystems in Europe, is located in the Cabo de Gata–Nijar Natural Park. Balsa Blanca is in the Nijar Valley catchment, 6.3 km away from the Mediterranean Sea. Vegetation is sparse and dominated by S. tenocissima. The mean annual air temperature is 18 °C and the long-term average rainfall is 220 mm (historical data recorded by the Spanish Meteorological Agency (1971–2000); www.aemet.es). The predominant soils are thin, with varying depths (about 30 cm at most, average 10 cm), alkaline, saturated in carbonates, with moderate stone content, frequent rock outcrops (Rey et al., 2011) and with a sandy loam texture. For further information of the study site, see Uclés et al. (2013).

The study site at El Cautivo was used for testing our second hypothesis (Test_2). El Cautivo field site is a badlands ecosystem located in the Sorbas–Tabernas basin in Almería, SE Spain (N 37°00'37", W 2°26'30"). Soils are silty loam, affected by surface crusting processes (Cantón et al., 2003), and in general soil is less developed and organic matter content is lower than in Balsa Blanca soils.
2.2. Automated microlysimeter design and field installation

We have designed an automated microlysimeter (MLs) using a single-point aluminium load cell based on Heusinkveld et al. (2006). A load cell is a transducer that converts a force into a measurable electrical signal by the deformation of strain gauges. When weight is applied, the strain changes the electrical resistance of the gauges in proportion to the load. The load cell gives a mV signal that is a function of the electricity applied. Hence, the voltage input must be supplied by a stable energy source. The final data is given by the ratio of the load cell mV signal to the input voltage (mV V⁻¹). In our case, the load cells were connected to a datalogger (CR1000, Campbell Scientific, Logan, UT, USA) and were excited with 12 V directly from the input plug. The system energy was supplied by a solar photovoltaic installation composed by a solar panel (Suntech, STP050D-12/MFA), a battery (12 V, 90 Ah) to store energy for nocturnal measurements and a solar charge controller (Solarix PRS 1010, Steca).

One of the purposes of this study is not only to measure dew on bare soil, but also on small plants. Hence, the sampling cup must allow the development of roots inside it, or allow the plant to survive long enough for the experiment. Therefore, a 3 kg rated capacity single-point aluminium load cell (model 1022, 0.013 m × 0.0026 m × 0.0022 m, Vishay Tedea-Huntleigh, Switzerland) was selected. We used a 0.152 m diameter and 0.09 m deep PVC sampling cup with this load cell. This size is large enough for small dwarfs bushes, grasses and annuals to survive long enough to carry out an experiment. We hypothesized that this sample depth would provide a good temperature gradient within the soil profile without significantly affecting the soil heat balance. Soil cores were extracted by excavating plastic tubes that had been hammered into the soil. A cap was fitted to the bottom of the tube to retain the soil and prevent drainage.

Once the sample dimensions were established, the MLs (Fig. 1a) were designed in two parts; a mobile weighing part (Fig. 1b) and a fixed protection part (Fig. 1c). The mobile part is made up of the load cell, which is connected to a PVC plate (0.10 m diameter) by a rod (0.022 m long and 0.006 m diameter). The sample is located over the PVC plate. The load cell has four mounting holes, two in the loading end and two in the attached end. An aluminium connecting piece (0.025 m × 0.025 m × 0.001 m) with three screw holes in it is used for mounting. Two holes are for screwing the aluminium piece to the loading end of the load cell and the third is for screwing it to the rod. The load cell is held by an aluminium plug (0.074 m × 0.026 m × 0.017 m) attached to an aluminium base plate (0.18 m × 0.10 m × 0.01 m) inside a protective PVC housing (0.18 m × 0.23 m × 0.09 m). The rod is inside a protective PVC tube (0.15 m long, 0.043 m diameter and 0.004 m thick). A circular aluminium case (0.017 m diameter, 0.011 m deep and 0.001 m thick) at the top of the tube protects the PVC plate and the sample. The bottom of the circular aluminium case is riddled with holes, so rainwater can drain out (Fig. 2d), and to maximize drainage, the PVC plate also has a protruding ridge around the bottom, and an inverted PVC funnel is inserted in the top of the tube. Finally, a piece of aluminium is placed under the loading end of the load cell for overload protection.

According to the manufacturer, the total error found was 0.02% of the rated output with internal temperature range compensation. To minimize the remaining temperature dependence and water exposure, the MLs were made of aluminium, and the PVC box was placed inside a 0.015-m-thick polyspan box with a waterproof cover.

Finally, two calibration tests were performed in the laboratory: one for general calibration to check the whole measurement range of the load cell and another for specific calibration by adding small loads to 2 kg fixed weight to simulate the soil sample weight. This set-up methodology was based on experience from an unsuccessful earlier attempt where the load cells were buried directly in the soil. This first attempt ended with a flooding of the system and failure of the load cells during a strong rain event. A new set-up was performed where the MLs were placed inside wooden boxes in groups of three (Fig. 2). They were buried in the field with the surface of the sampling cup flush with the surrounding surface (Fig. 2a and b). These boxes were anchored and levelled in the soil with steel rods. A total of four boxes were buried, each with its own drainage tube connected to a pit (Fig. 2a and c). A pipe connected
the pit to the surface so that pit conditions could be checked after each rainfall event (Fig. 2d). The boxes were filled with polystyrene to stabilize the temperature. The surface of the boxes can be covered with material from the surroundings to avoid changing the albedo near the samples.

The MLs design and the field installation were checked with several tests.

Test 1: This test checked the input signal. The system energy was supplied by a solar photovoltaic installation and even if we used a solar charge controller the input voltage varied from 12 to 14 V, depending on the input from the solar panel. We checked whether this variation in the input voltage would affect the load cell function or not, and if so, look for a solution.

Test 2: Sample dimensions were studied in this test. Surface temperatures were monitored in the sample and in the surroundings to check whether they could be affected by the sampling cup dimensions. Thermocouples buried 2–3 mm deep (Type T, Thermocouples, Omega Engineering, Broughton Astley, UK) were used to monitor the temperature recorded at 15-s intervals and averaged every 15 min by a datalogger (CR1000, Campbell Scientific, Logan, UT, USA). This study was done in Balsa Blanca and in El Cauíto sites to check the sample dimensions in two different soil types.

Test 3: This test checked the influence of the temperature on the load cell signal. Once the MLs were placed in the field, and before the placement of the soil samples, they were covered for one month (April 2012) to avoid water exchange with the environment and their signals were recorded. Thermocouples (TCRT 10, Campbell Scientific, Logan, UT, USA) were installed inside the PVC load cell boxes to monitor their temperatures.

Test 4: Specific calibrations were done once a month in the field to adjust the calibration range over time. These calibrations were done by adding small weights to the MLs samples. Furthermore, the field installation strategy was tested by checking the MLs conditions over time (dryness and balance).

2.3. Non-rainfall water input (NRWI) measurements

Twelve MLs in four boxes were installed in the field. Six of the sampling cups contained S. tenacissima and the others contained undisturbed bare soil, stones and biological soil crust samples (BSCs) (Fig. 2d). Plants had an LAI of around 0.4 m² m⁻², and were 0.3 m wide and 0.2 m high. Stones were embedded in the soil and covered 70% of the sample surface. BSCs consisted of cyanobacteria and lichens and covered almost 100% of the sample surface. For the MLs data analysis and interpretation, some meteorological variables were measured on site. Ground-level air temperature and humidity were monitored by a thermo-hygrometer (HMP45C, Campbell Scientific, Logan, UT, USA). Rainfall was measured by a
tipping bucket rain gauge (ARG 100, Campbell Scientific, Logan, UT, USA) and wind speed was measured at a height of 3.5 m (CSAT-3, Campbell Scientific, Logan, UT, USA). Data were sampled at 15-second intervals and averaged every 15 min by dataloggers (Campbell Scientific, Logan, UT, USA).

Daily changes in the water content of the uppermost soil layer were analyzed: evaporation during the day and NRWI during the night. Negative changes in mass in the MLs corresponded to evaporation and positive changes to NRWI. Hence, evaporation was calculated as the difference between the daytime maximum and minimum, and NRWI was calculated as the difference in weight between the night-time maximum and the minimum of the day before. We studied the daily MLs signal and its relationship with the meteorological variables involved in an NRWI event, specially the surface temperature. The dew point temperature can be used to differentiate between dew and water vapor adsorption (WVA). The bare soil surface temperature was monitored by thermocouples (Type TT-T-24S, Thermocouples, Omega Engineering, Broughton Astley, UK) buried 0.002–0.003 m deep and this temperature was compared to the dew point temperature to differentiate between dew and WVA. The real soil surface temperature is difficult to measure with in situ sensors, but we assume our thermocouples provide a good estimation. Dew was considered when positive changes in mass in the MLs matched with the surface temperature below the dew point temperature and the rest of water input was assumed to be WVA. Furthermore, the sensitivity of the MLs in recording differences in evaporation and NRWI among the different cover types was also checked.

3. Results and discussion

3.1. MLs and field installation tests

Calibration tests in the laboratory were successful and had a satisfactory resolution of 0.01 g (0.00055 mm) (Fig. 3).

The system was powered by a solar photovoltaic installation with a solar charge controller, but the input voltage was unstable. Since the load cells need a constant excitation voltage, this volts variation caused strong noise in the load cell signal that made the data analysis impossible, especially in determining the beginning and end of evaporation and NRWI. We solved this problem during Test_1 by installing a voltage stabilizer that maintained the input at 12 V (LB-10, Cebeč) (Fig. 4).

Regarding the sampling cup dimensions, Ninari and Berliner (2002) stated that for measuring dew, the minimum depth of a sample should exceed the depth at which the diurnal temperature is constant (0.5 m in the Negev). However, Jacobs et al. (1999) carried out several tests in the Negev with sampling cups having a 0.06 m diameter and three different heights (0.01, 0.035 and 0.075 m), and found consistent results with the 0.035 and 0.07 m – high sampling cups, reporting that the daily moisture cycle is confined to the upper 0.02–0.03 m of the soil profile. In fact, several studies have been carried out successfully using small sampling cups (Table 1).

We assessed the representativeness of our sampling cup and its dimensions by finding the effect of changes in soil surface temperature in the sample at two sites with markedly different soil characteristics: Balsa Blanca and El Cauto (Test_2). Results confirmed that there were no significant differences between night-time soil surface temperatures measured in the sample and in the surroundings (Fig. 5). But this representativeness is temporary and MLs samples must be replaced with time, since the soil characteristics inside the sampling cup change differently from the surroundings (Roast and Robertson, 1982). The longer the sample is isolated from the soil matrix, the greater the differences will be. However, under extremely dry conditions, water movement in the liquid phase becomes negligible, and the change of water content at any given depth will thus be the result of water vapour movement and physical adsorption or desorption (Scanlon and Milly, 1994). Since these processes are mostly confined to the uppermost soil layer, samples operation time will be longer during dry periods and must be replaced more often during the wetting season, especially after a strong rainfall event.

When the surface temperatures of the sample and the surroundings are similar, it can be assumed that they both have similar temperature profiles, and therefore the latent heat flux in the sample is representative of the surrounding soil (Ninari and Berliner, 2002). Hence, it can be stated that these sample dimensions are adequate for the study of NRWI. But the duration of this representativeness depends on the weather conditions, so continuous surface monitoring is necessary to confirm sample validity over time.

In the load cell temperature dependence analysis, the temperature test (Test_3) did not show any direct or significant temperature effect on the load cell signal (R² = 0.03; N = 3200; 15-min data). Neither was any temperature effect found when these data were analyzed daily, and the daily temperature differences were compared to the load cell signal (R² = 0.20; N = 30 days).

The monthly MLs field calibrations were successful (Test_4) and only small variations were found after rainfall events and during the following evaporation. These variations were higher after strong rainfall events, so samples were replaced and the MLs were recalibrated after the evaporation period. These periodic specific calibrations allowed us to use the calibration line with the best fit each time. Furthermore, the MLs were checked after the rainfall events, and one year after their placement at the site. The field installation did not allow water to get inside the PVC boxes, the load cells remained dry and the MLs remained balanced.

Fig. 3. Calibration tests in the laboratory.
3.2. Non-rainfall water input (NRWI) measurements

One of the advantages of the proposed method is the capability to non-manually measure non-rainfall input. This is emphasized in light of former measurements that were carried out manually, such as in different regions of Israel aiming to study the effect of dew on plants (Ashbel, 1949; Duvedevani, 1964; Kidron, 1999) or aiming to quantify dew amounts (Jacobs et al., 2000, 2002; Ninari and Berliner, 2002).

When the MLs and their field installation were assessed and found to be adequate, the daily MLs signal was analyzed. Daily evaporation and NRWI on three nights in a bare soil sample may be clearly observed in Fig. 6. During the first and second nights, the surface temperature (Ts) dropped below the dew point temperature (Td), the wind speed was low and the relative humidity (RH) was over 90%. Until Td was reached, the positive change in the MLs mass was due to WVA, and when Td was reached, dew condensation took place in the sample. On the third night, RH was under 70% and Td was not reached, so, only WVA was responsible for the water uptake by the sample.

The MLs signal was not a smooth line, but jagged, since the output was not perfectly stable, and a 0.01 mm background noise was found. This error agrees with the error found by Heusinkveld et al. (2006) in their MLs. Furthermore, it has been shown that there can be small evaporation episodes during a dewfall event (Uclés et al., 2013) as shown in Fig. 6. The MLs signal rose during the night because of NRWI and small descents also occurred as consequence of evaporation events. The same trend can be found during the day, as the MLs signal went down because of evaporation and small WVA events occurred. But these small increases can also be produced by the wind moving the sampling cups or transporting small soil particles. It is worth mentioning that during an NRWI event the wind is very low and there is less possibility of noise from wind in the signal.

Kaseke et al. (2012) calculated the NRWI as the sum of all inputs excluding any evaporation that may take place. We think this calculation overestimates the input because it includes all the MLs background noise. They used the same procedure for calculating evaporation and the noise generated by wind during the day may also have been added in. However, we used the differences between daytime minimums and night-time maximums to calculate NRWI and evaporation, so the daily error, i.e., background and wind noise, should be negligible.

Our MLs were able to find differences in NRWI and evaporation in the uppermost soil layer between different cover types. These differences were analyzed during a study period of 49 days with no fog or rainfall events (Doy 121–169, year: 2012) (Table 2).

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Table 1
Microlysimeters sampling cup sizes in bibliography.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Place</th>
<th>Samples size</th>
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<td></td>
<td></td>
<td>Diameter (m)</td>
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<td>Pan et al. (2010)</td>
<td>Shapotou Desert, China</td>
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<tr>
<td>Kaseke et al. (2012)</td>
<td>Stellenbosch, South Africa</td>
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</tr>
<tr>
<td>Uclés et al. (2013)</td>
<td>Almeria, Spain</td>
<td>0.150</td>
</tr>
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</table>
Maximum NRWI was recorded for plants followed by BSCs, bare soil, and finally, stones. The same pattern was found for evaporation. Our daily NRWI for BSCs and bare soil is in agreement with the bibliography (Agam and Berliner, 2004; Heusinkveld et al., 2006; Jacobs et al., 1999; Pan et al., 2010).

A more accurate study on bare soil was made to distinguish dewfall from WVA based on the bare soil surface temperature and the dew point temperature (Fig. 6). During the study period, WVA represented 66% of the NRWI on bare soil, while dew contributed only 34%. Several studies have shown that WVA is the predominant NRWI input vector on bare soil in arid and semiarid environments (Agam and Berliner, 2004; Kaseke et al., 2012; Pan et al., 2010). But the role of WVA and dew on the other surface cover types has not been studied. These MLs and the field installation strategy seem to be a good tool for further studies assessing the contribution of WVA and dew to the NRWI, and, consequently, to the water budget of a given site.

4. Conclusions

Our automated microlysimeter design, construction and field installation have proven to be a useful and effective tool in a non-rainfall water input study. The automated microlysimeter design enables the measurement of evaporation and water input on different cover types and the sample size makes the study of small plants possible. The different heat capacities of each cover affects the surface temperatures, and therefore, the beginning of the dew deposition. Hence, if the surface temperatures are monitored, dewfall and water vapour adsorption can be distinguished, and the relative contributions of dew and water vapour adsorption to the non-rainfall water input and, thereby, to the water budget, can be found. This system is an economical and easy method for a non-rainfall water input study.

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