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Adsorption of water vapor by soil in semi arid ecosystems: reconciling estimates from Lysimeters and Eddy Covariance

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Current climate change scenarios project altered rainfall frequencies which boosts scientific interest in ecosystems' responses to prolonged dry conditions. Under less rainfall, NRWI may play an increasingly important role, Yet, only sparse data are available to assess the role of non-rainfall water input (NRWI) during times of low water availability across ecoregions. Particularly, soil water vapor adsorption has received little attention at field scale. This term is used for the phase change of water from gas to liquid at highly negative matric potential. Under such conditions, water condensates already at relative humidity < 100%. The process has been broadly studied in laboratories but little is known from field experiments, which rarely cover periods longer than one month. Yet, several studies report soil water uptake from the atmosphere during soil surface cooling and in the early mornings. Lysimeters have played a strong role in quantifying these NRWI. Eddy Covariance (EC) measurements, in contrast, are known for their limited data quality under nighttime conditions when a stable boundary layer hinders the turbulent exchange of mass and energy. Therefore, EC has not been tested yet to trace soil adsorption.

In this contribution we adapt a methodology to derive NRWI from lysimeters data and compare them to EC measurements. We focus mainly on adsorption and evaluate the consistency between adsorption estimated with the lysimeters and negative (downward) latent heat (LE) fluxes from EC. We apply the method to a data set that comprises three years of observations from a semi-arid Spanish tree grass ecosystem.

Our results show that during the dry season the gradient in water vapour established between the atmosphere (more humid) and the soil pores (more dry) leads to adsorption by the soil. The observations from both instruments suggest that during the dry season, nightly transport of humidity from the atmosphere towards the ground is driven by soil vapor adsorption. This process occurs each night typically in the second half, but begins increasingly earlier in the evening the dryer the conditions are. The amount of water adsorbed is not directly comparable between EC

and the lysimeter readings. With the latter, we quantified a yearly mean uptake between 8.8 mm and 25 mm per year. With the lysimeters we measure additionally 23.1 mm of water that condenses as dew and fog in winter, when EC is impeded by stable conditions. We further analyze EC LE measurements from different sites to evaluate if adsorption can be detected from EC data collected at different locations.

We conclude that the temporal patterns of adsorption estimates from lysimeters match the nighttime negative LE data from the EC technique, although the absolute numbers are uncertain. This might open interesting perspective to fill the knowledge gap of the role of soil water vapor adsorption from the atmosphere at field scale and open the opportunity to broaden the topic across ecosystem research communities. Our results also highlight a potential shortcoming in the interpretation of EC measurements in the case that negative nighttime values, representing physically plausible adsorption, are neglected.