Instituto Geológico y Minero de España

Modelling high precision lysimeter data to quantify vapor flux and the impact of dew on groundwater recharge

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CLIGRO

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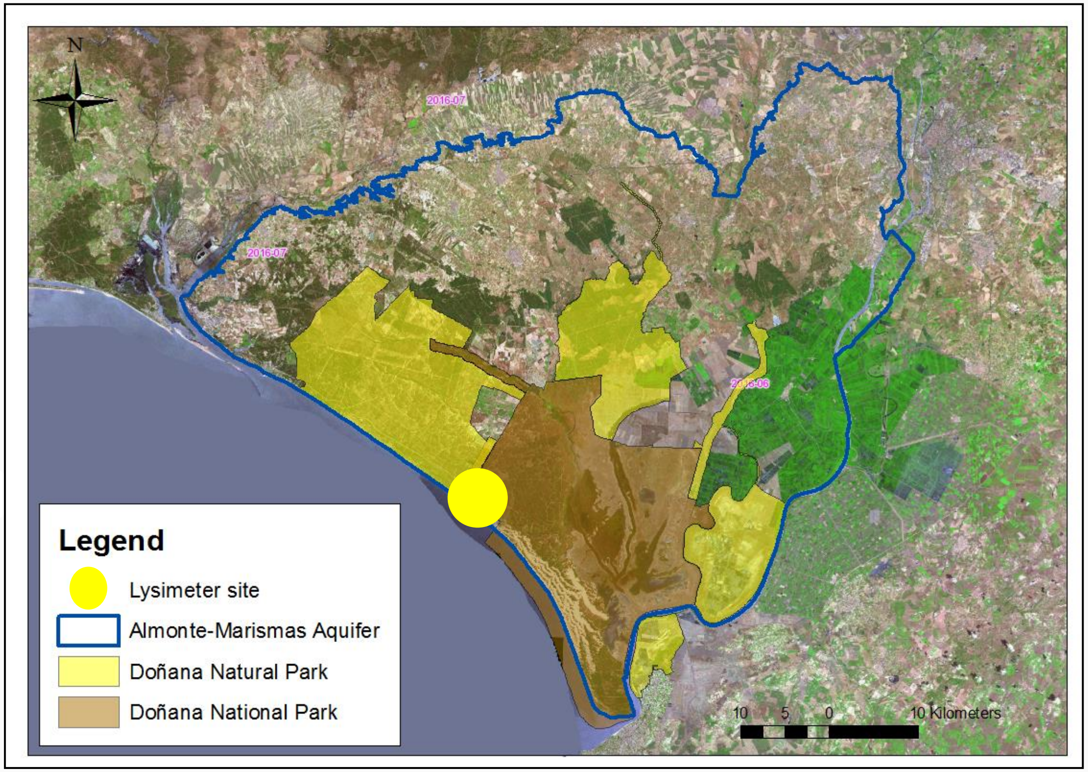
UNION EUROPEA
FONDO EUROPEO DE DESARROLLO REGIONAL
"Una manera de hacer Europa"

STUDY SITE

Southwest Spain: Doñana National Park => Almonte-Marismas aquifer

Geography

- surrounded by 46 villages and towns =>1.5 Mio people
- Agriculture and Tourism



Geology

- dunes
- beaches
- marshes

Climate

- Sub-humid Mediterranean with Atlantic influence
- Average rainfall: 500-600 mm
- Average Temperature: 17-18ºC

Ortophoto from Junta de Andalucia webpage: http://www.ign.es/wms-inspire/pnoa-ma

MOTIVATION

Threat of groundwater resources in **Doñana**:

Intensive agricultural irrigation

Water supply for Tourism

Dune belts

Fundamental for groundwater recharge

Key location for the quantitative and qualitative monitoring of water resources in ecological habitats.

INTRODUCTION

Climate Change may impact groundwater recharge due to:

- increasing temperatures
- changing seasonal patterns of precipitation
- change in vegetation

MAIN OBJECTIVES

To explore the impact of different meteorological conditions on groundwater recharge in dunes belts within semiarid climate.

To derive its dependence on regional climate trends predicted by climate models.

METEO LYSIMETER

- Most precise measures for recharge, precipitation and evapotranspiration.
- Mostly installed for agricultural purpose in crop areas.
- Limited knowledge exists about recharge dynamics and its dependence on meteorological parameters in dune belts.

Meteo Lysimeter Site Equipment

Weighting Lysimeter
(UMS AG, Munich, Germany)
- 1 m^2 area
- 1.5 m height
- 10 g weighting resolution

Six CS650 soil moisture sensors
(Campbell Scientific, Logan UT)

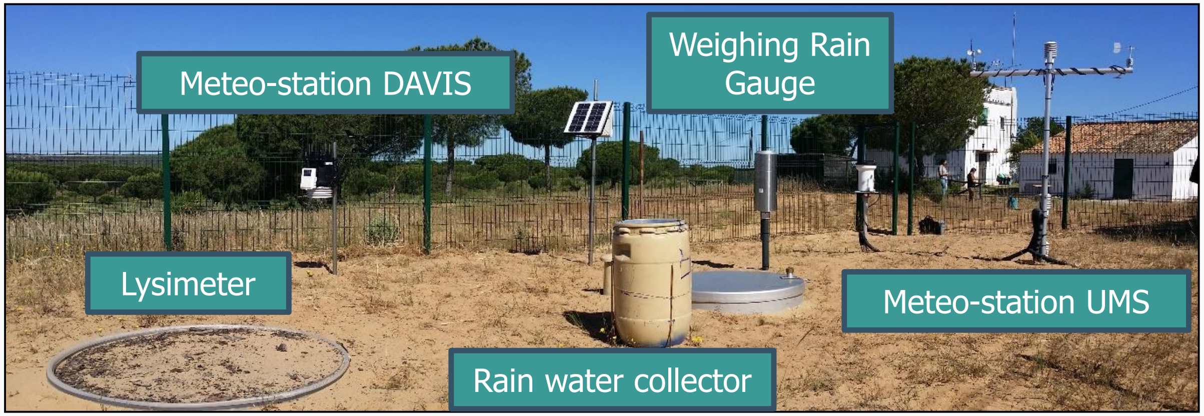
Depths (m)	
0.30	1.60
0.60	2.20
1.20	3

2 Automatic and Meteorological Stations
(Vantage PRO2 Davis, California, USA; UMS AG, Munich, Germany)

Weighing Rain Gauge (OTT pluvio1)

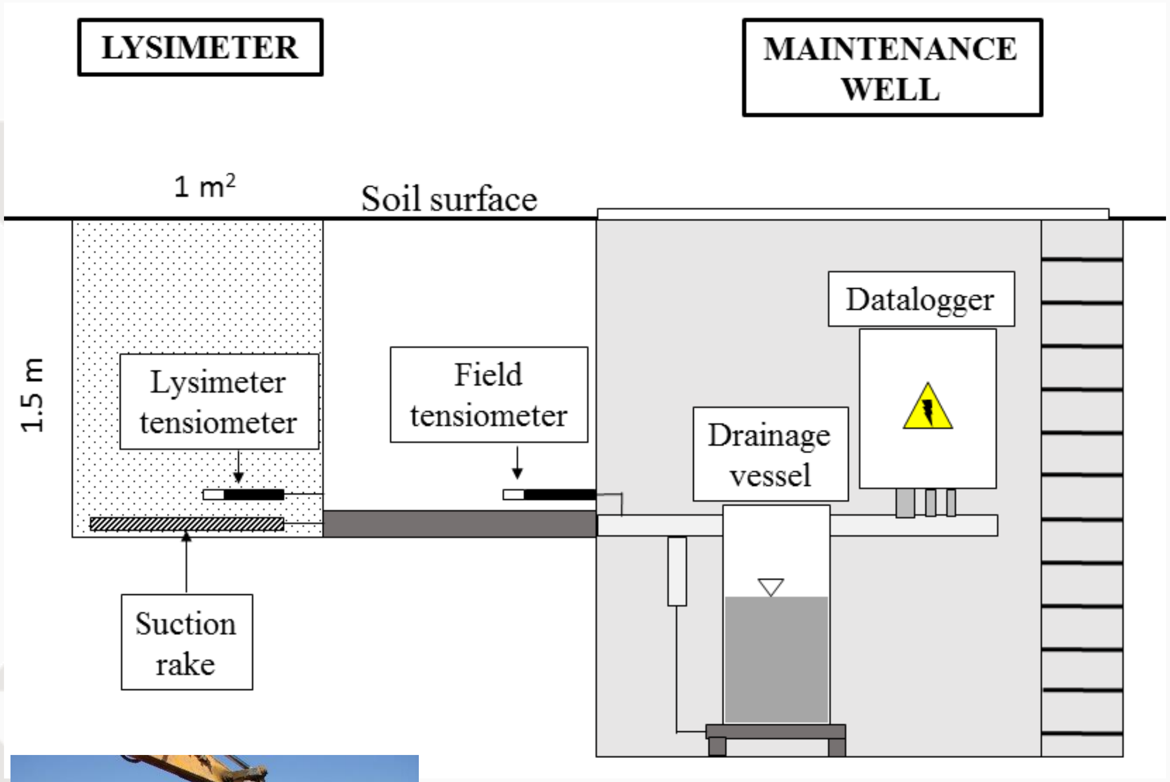
Rain water collector

Measured parameter	Time interval (minutes)
Soil mass lysimeter	1
Water mass drained from lysimeter	1
Soil water tension	10
Soil moisture	10
Wind direction	10
Wind velocity	10
Net radiation	10
Precipitation	10
Air humidity	10
Air and soil thermal profile	10
Soil bulk density	Once
Grain size distribution	Once
Mineralogy	Once
Metals content	Once



MATERIAL AND METHODS

METEO LYSIMETER



Data Noise Filtration: AWAT

(Peters et al. 2014; Schrader et al. 2013)

$$\mathbf{P = R + ET + \Delta Soil\ water\ volume}$$

$$\Delta W = \Delta w_{lys} + \Delta w_{drain}$$

Parameter measured by lysimeter:

- Precipitation
- Evapotranspiration
- Recharge
- ΔSoil water volume $= \Delta w_{lys}$

$$P = \begin{cases} \Delta W, & \Delta W > 0 \\ 0, & \Delta W \leq 0 \end{cases}$$

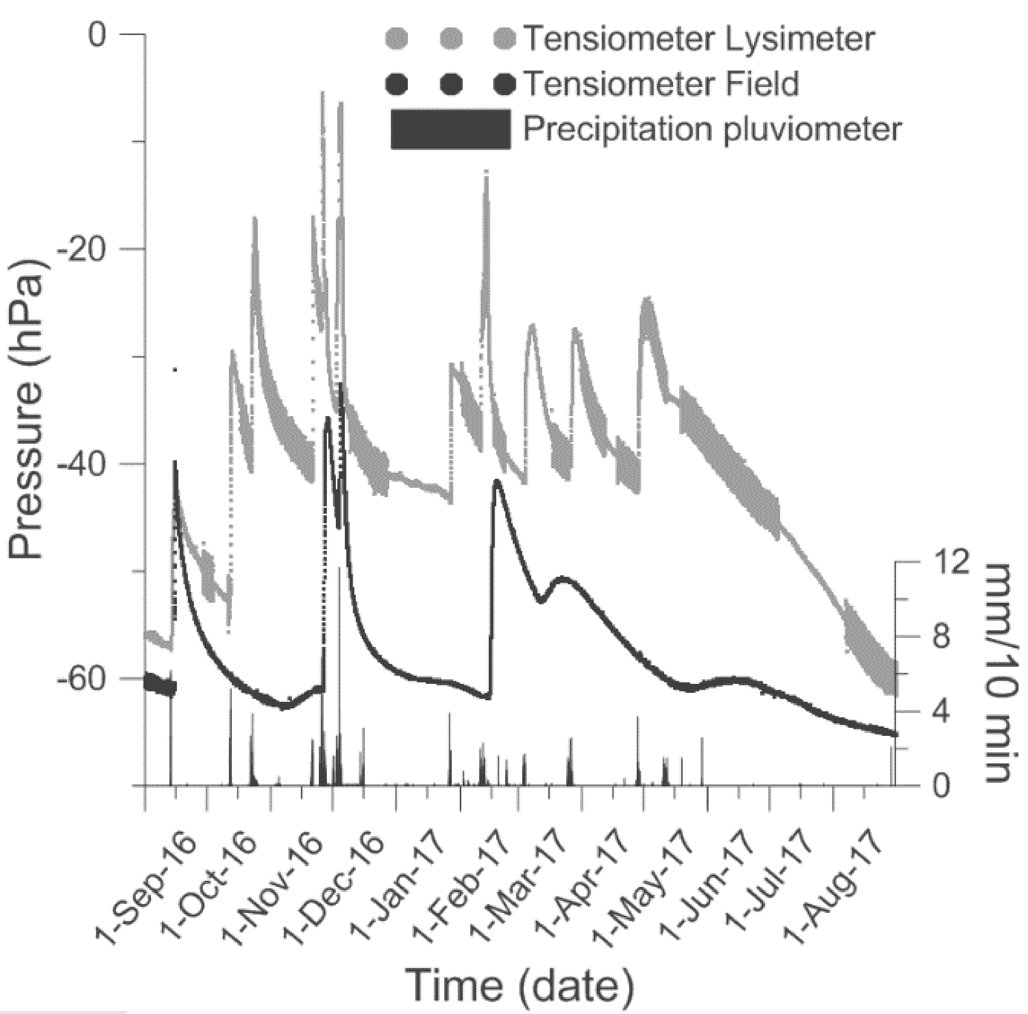
$$ET = \begin{cases} \Delta W, & \Delta W < 0 \\ 0, & \Delta W \geq 0 \end{cases}$$

Intrinsic noise reduced by smoothing → **AWAT filter**

Maximum window width: 31 min
Maximum threshold: 0.24 mm

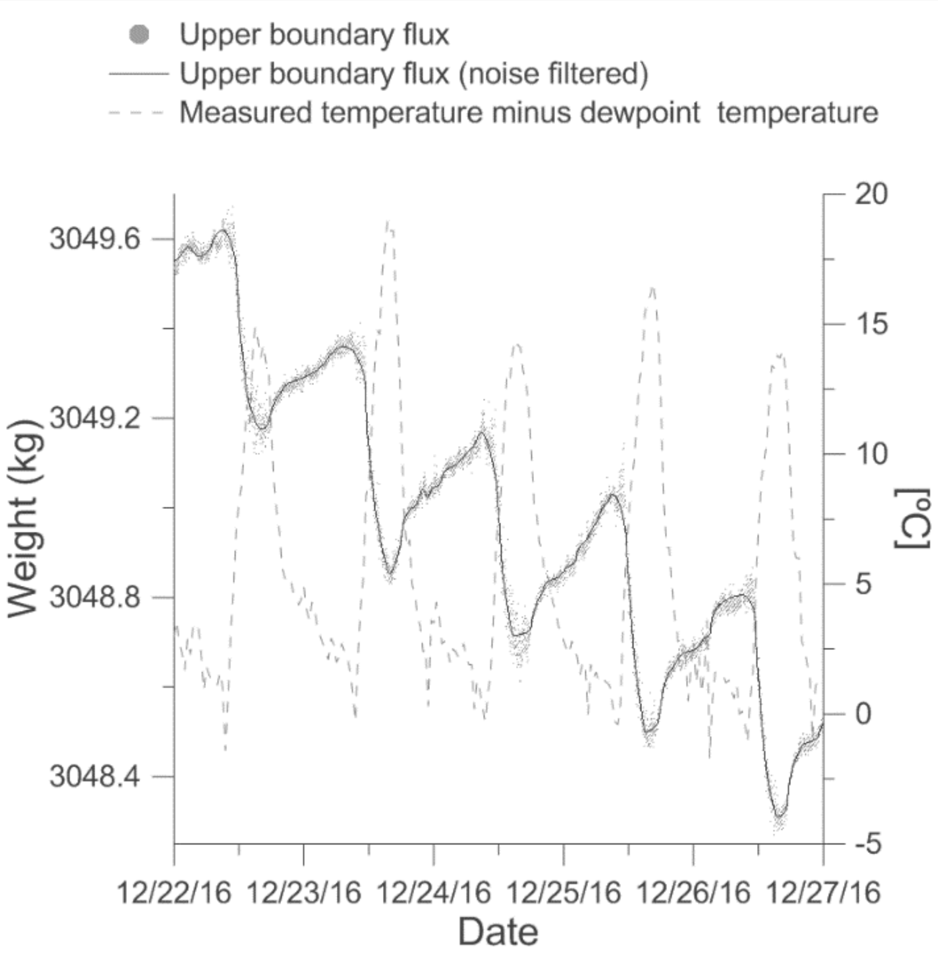
FIRST RESULTS AND DISCUSSION

Lower boundary control



FIRST RESULTS AND DISCUSSION

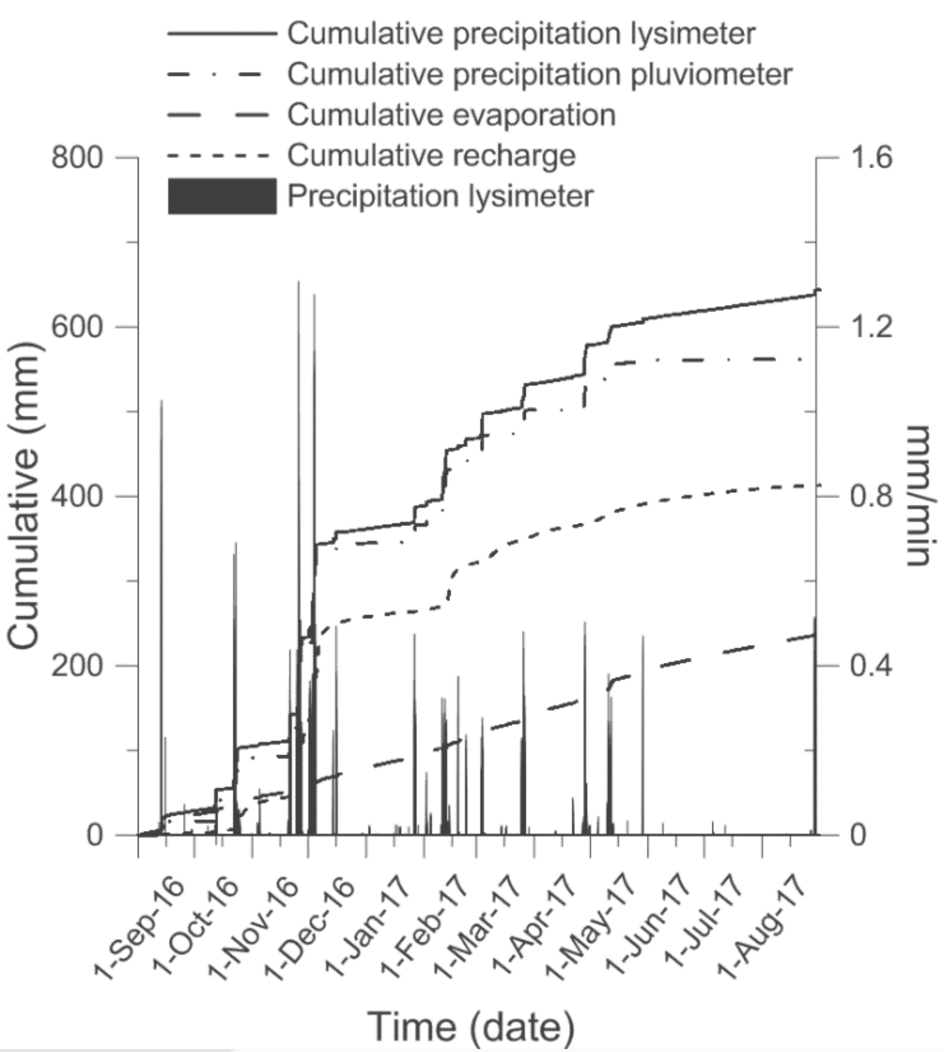
Dew and real evaporation



- ✓ Dew 0.3-0.5 mm/day
- ✓ Real evaporation 0.4-0.6 mm/day

FIRST RESULTS AND DISCUSSION

Soilwater budget in mm



Prec.$_{lysimeter}$	643.821
Prec. $_{pluviometer}$	566.5
Ev real	240.622
Recharge	412.8599
storage	-9.68 kg
Dew measured	146

✓ 64% recharge

Modelling results (Maarten Saaltink et al. in prep.)

- Software: **CODEBRIGHT** (Olivella et al., 1996) that
- Solves balance equations for **water, air and energy** in an unsaturated medium
- One-dimensional vertical homogeneous domain of 1.4 m length, divided into 140 elements of 0.01 m
- Starts at November 25, 2015 and ends at October 4, 2017, which is the period with available meteorological data

Modelling: boundary conditions

- **Flux of water:**

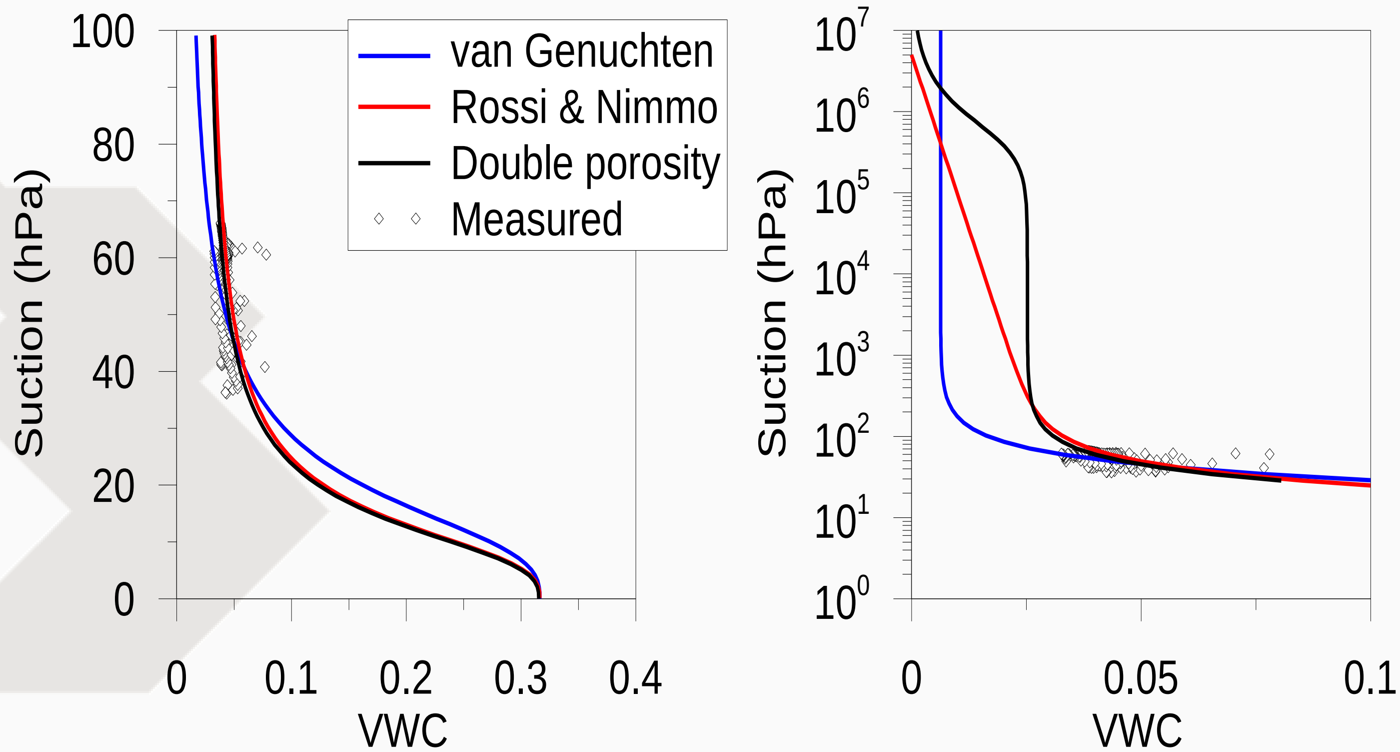
Precipitation is measured and the vapor diffusion is calculated by an aerodynamic diffusion relation

$$E = k^2 v_{z_a} \left(\ln \frac{z_a}{z_0} \right)^{-2} \left(\left(\rho_g \omega_g^w \right)_{z_a} - \left(\rho_g \omega_g^w \right)_{z_0} \right)$$

- **Flux of air:** gas pressure is fixed at 0.1 MPa. From this air flow (j_g^a) is calculated

- **Flux of energy:** net radiation (R_n) + sensible heat flux (H), + latent heat flux (or advective heat flux due to vapor flux)

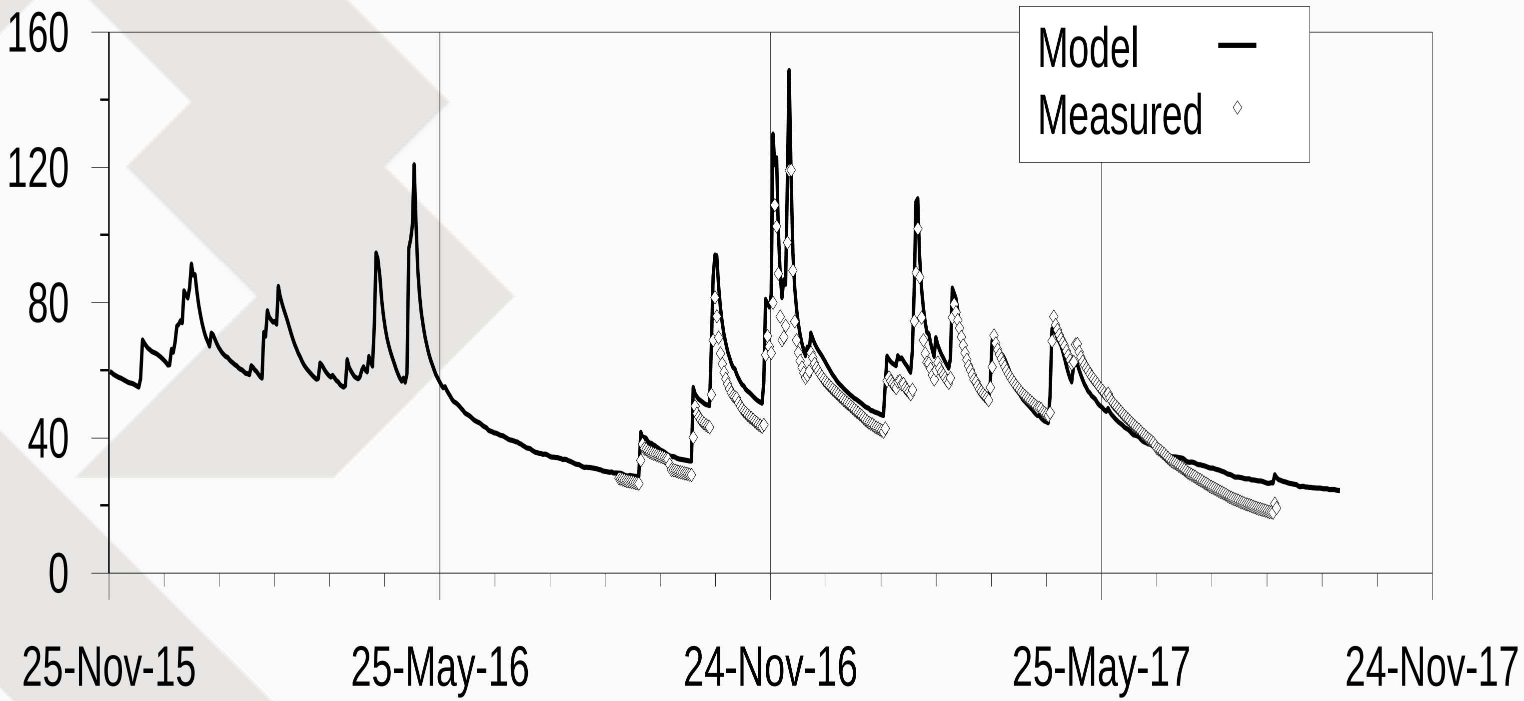
Modelling: retention curves



Retention curves used by the models together with suction and VWC (volumetric water content = ϕS_l), measured outside the lysimeter at a depth of 1.40 m. The three retention curves are plotted on an arithmetic (left) and logarithmic scale (right).

Modelling: retention curves

Mass of water in the lysimeter



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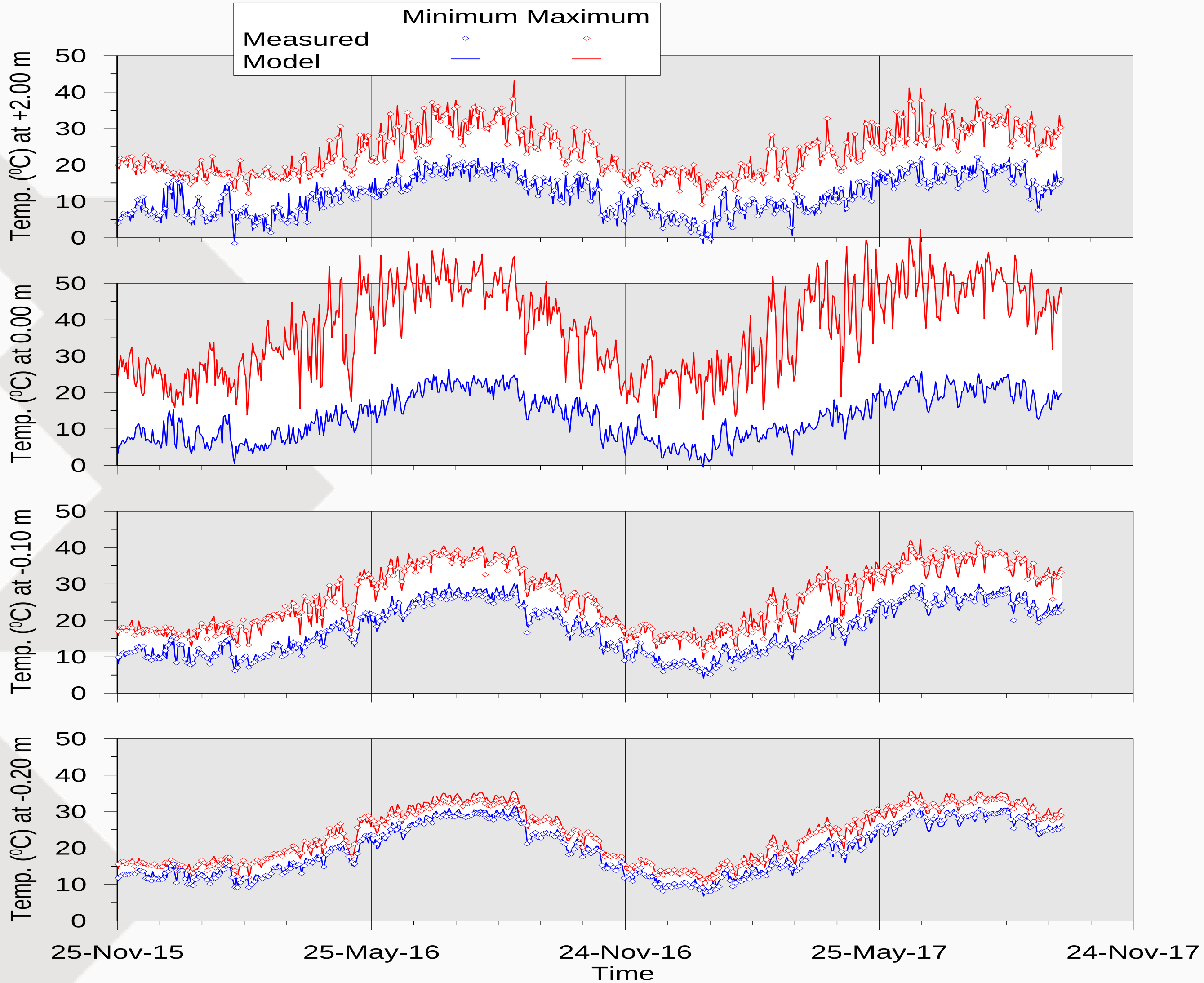
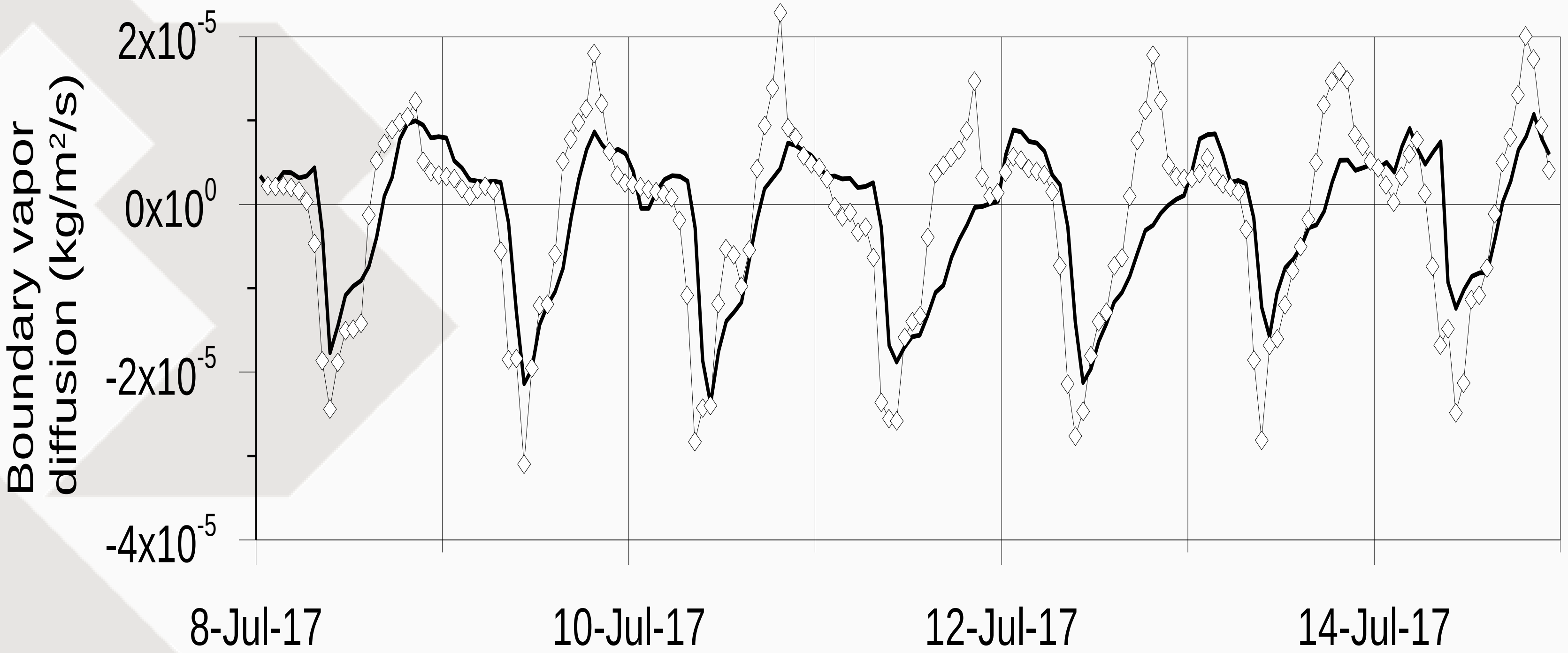
Modelling: retention curves

Temperature profiles



Modelling: retention curves

Evolution of vapor diffusion at the boundary



¡GRACIAS!

THANK YOU!

MERCI!

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Most Relevant Bibliography:

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