Impact of longer Drought Periods on Climate in Greater Vienna: appropriate Mitigation measures (Imp_DroP)

Weihs, P. [1], Trimmel, H. [7,1], Gützer, C. [1], Sadriu, M. [1], Eitzinger, S. [1], Thaler, S. [1], Mursch-Radlgruber, E. [1], Formayer, H. [1], Perny, K. [1], Pröll, T. [2], Wöss, D. [2], Hofer, A. [2], Rauch, HP., [3] Hörbinger, S., [3] Szocska, D. [3], Preiss, J. [4], Wittkowski, M. [4], Masson, V., [5] Schoetter , R. [5], Schmidt, T. [6]

[1] University of Natural Resources and Life Sciences (BOKU), Institute of Meteorology and Climatology, Vienna, Austria
[2] University of Natural Resources and Life Sciences (BOKU), Institute of Chemical and Energy Engineering , Vienna, Austria
[3] University of Natural Resources and Life Sciences (BOKU), Institute of Soil Bioengineering and Landscape Construction
[4] City of Vienna / Environmental Agency (MA22), Dresdner Str. 45, 1200 Vienna, Austria
[5] Meteo-France, CNRM, Universite de Toulouse, Météo-France, CNRS, GMGEC/COMETS, 42, Av. G. Coriolis, 31057 , Toulouse Cedex, France
[6] Gartenbau Schönbrunn (HBLFA), Grünbergstraße 24. 1130 Vienna
[7] Institute for Applied System Analysis (IIASA), Schloßpl. 1, 2361 Laxenburg

*philipp.weihs@boku.ac.at

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Introduction

Thermal stress during heat waves in urban areas is recognized for its strong devastating effect on human health. This project aims to quantify the cooling potential of green areas within and around Vienna via evapotranspiration, future irrigation needs and the quantification of potential anthropogenic heat reductions.

Fig. 1: Final setup of the experimental units covered up with white foil at the non-irrigated setups at the sites (a) KAN, (b) AKH, (c) REW, (d) JAE.

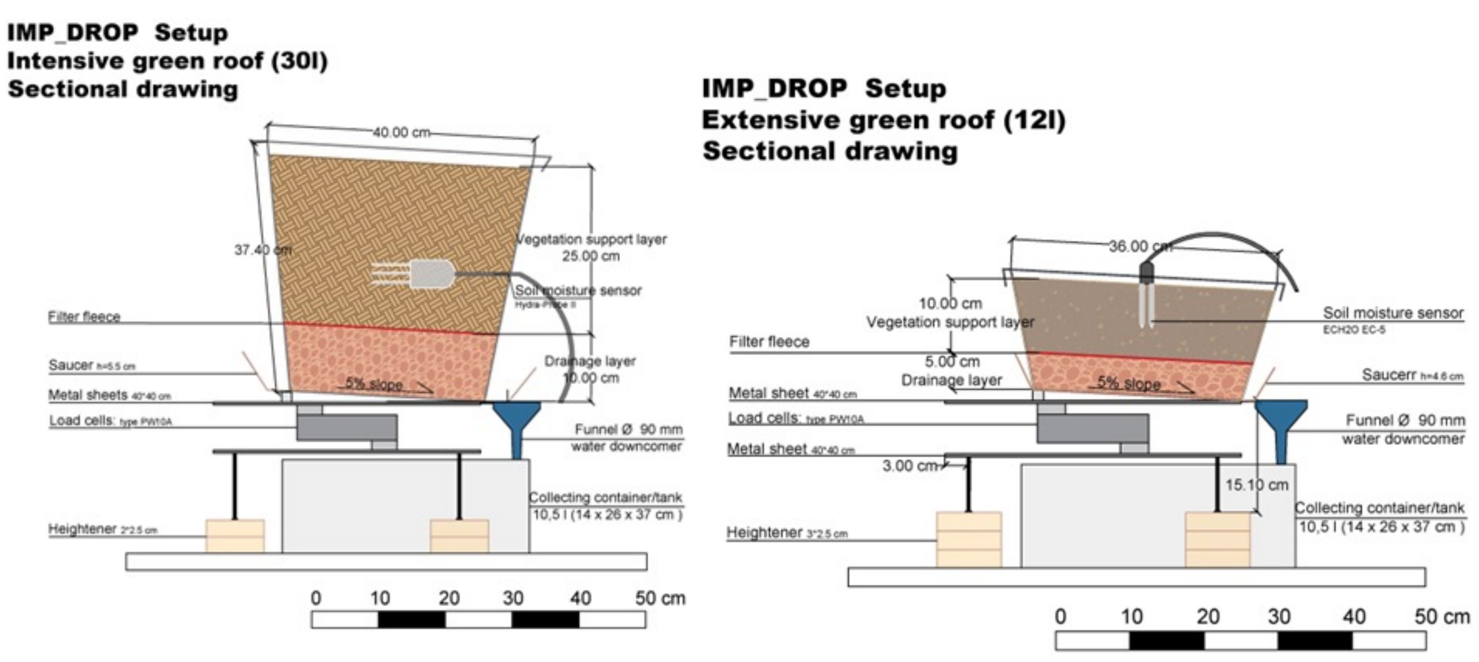


Figure 2: Sectional drawing of the experimental setup of the ysimeter for the investigation of an intensive (left) and extensive (right) green roof

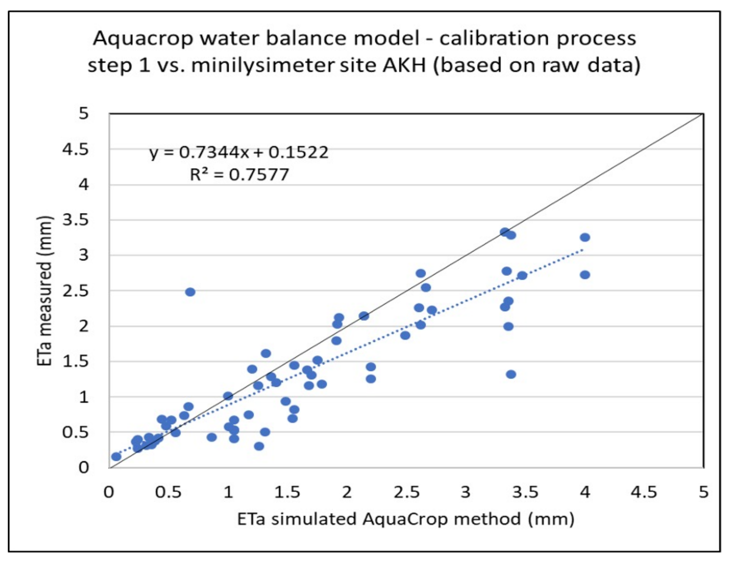
Green roof lysimeters

Four measurement sites (Fig 1) are set up on green roofs in different local climate zones of Vienna (compact-midrise rooftop, compact-midrise below rooftop, open mid-rise and large low-rise). A pair of extensive and intensive green roof lysimeters next to a standard meteorological station has been installed in each of the four sites. In one site an additional set of lysimeters is irrigated and the surface temperature is monitored with infrared radiometers.

A green roof lysimeter setup was developed for use in this project (Fig 2). Three soil moisture sensors were included in the top layer of the lysimeters and the surrounding green roof. The onset of rain can be seen clearly in the data. Further one soil moisture sensor was installed in the deeper layer of the intensive green roof lysimeter. The first results show that the driest green roofs are found at the large-low-rise site and the above-roof-level site is dryer than the below-roof-level site. Despite the long dry period in the summer of 2022, nearly all plants survived without irrigation.

This data is used to calibrate the AQUACROP vegetation model (Fig 3). AQUACROP will be used to simulate the soil moisture for selected drought periods on green roofs. ARIS will be used to simulate the soil moisture of the surrounding agricultural areas of Vienna.

Fig. 3: Comparison of 3-day average actual evapotranspiration measured by mini lysimeter vs. simulated by Aquacrop method (uncalibrated)



Energy flow and anthropogenic heat flux

To estimate the anthropogenic heat flux of Vienna energy use data (oil, gas, electricity, and others) are compiled for different spatial and temporal scales to derive the fluxes stemming from Viennese traffic, services, private households, and industry. Further, the properties and climate effects caused by using photovoltaics on roofs are investigated. Literature research and communication with stakeholders are used to update and refine the prospective changes of Viennese building parameters used in the different urban categories of the models.

The analysis of the energy flow of Vienna shows, that most primary energy sources are imported (Fig 4). 47 PJ of oil (which is more than a third of total Viennese final energy consumption) is combusted in the traffic sector annually, which produces the highest heat losses due to inefficient energy conversion. The absolute magnitude affecting thermal comfort in urban canyons needs to be localized using NOx emission maps.

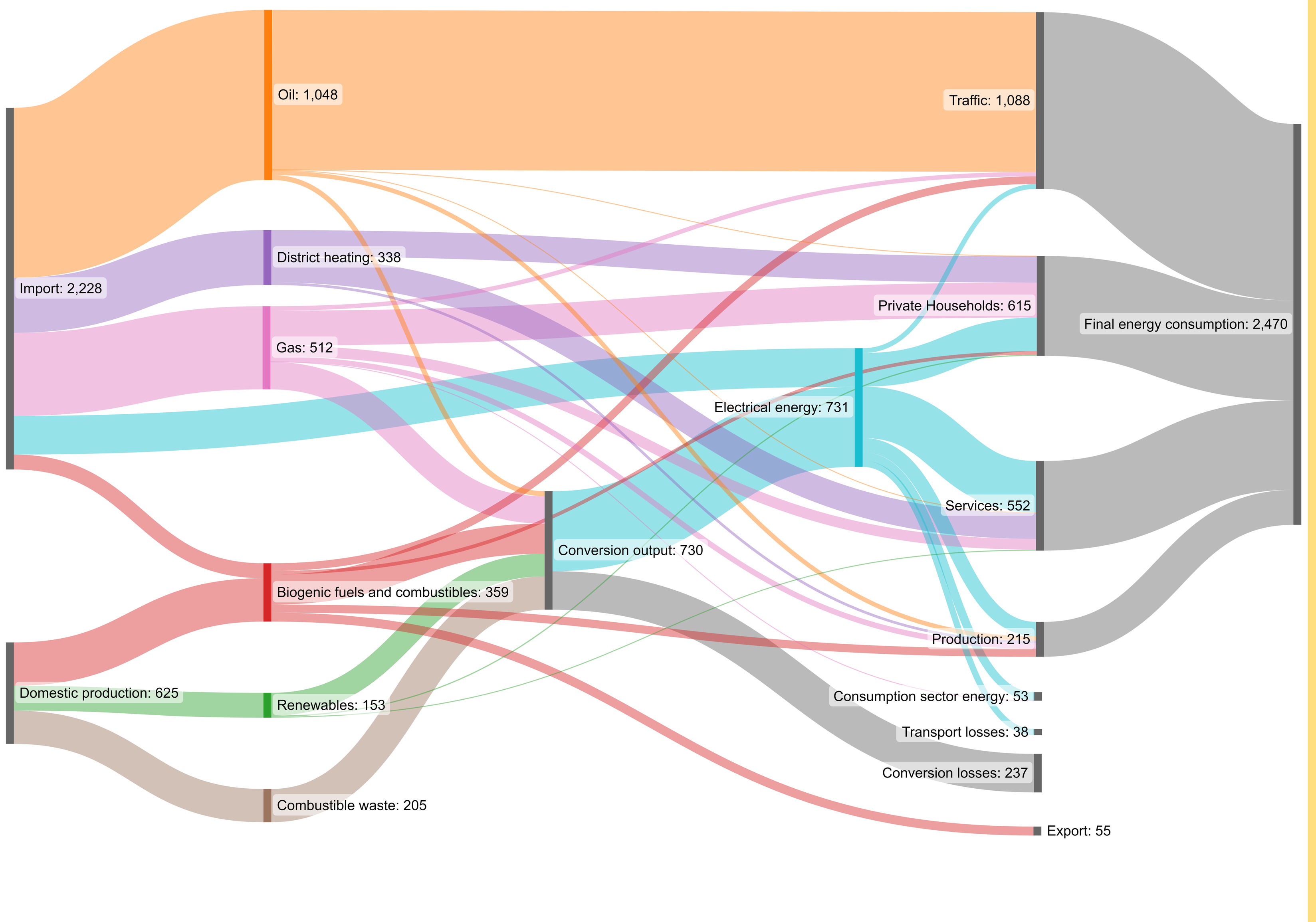


Figure 4: : Sankey flow chart for Vienna for August 2015 in GWh

Scenario preparation and Modelling

The consecutive dry day climate change signal was analysed (Fig 5,6). The selection criteria of drought episodes were defined as a 2 yearly event of cumulated negative NPET (Precipitation - Potential Evapotranspiration (PET) not exceeding 5 mm precipitation and the 80% quantile of daily maximum air temperature. The timeframe 2050 is set, where the zero-carbon aim of Vienna ought to be achieved. Despite all optimism also an anthropogenic heat worst-case scenario including air conditioning and fossil fuel use is being developed for comparison. Regarding the climate scenarios next to droughts episodes, a status quo scenario with no irrigation need is being defined. Next to a maximum irrigation scenario also an adapted crop irrigation scenario is considered. All collected data will be used to initialize, run, and validate the coupled WRF-TEB model (Fig 7) and simulate the atmospheric condition as well as urban canyon microclimate for present and future summer drought episodes to estimate the expected thermal strain on inhabitants in Vienna. Best- and worst-case scenarios will be run and compared.

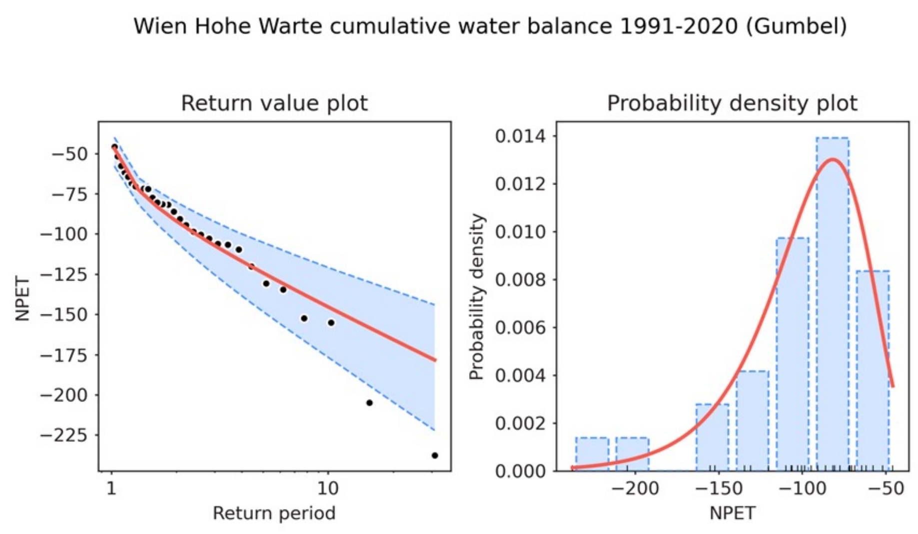


Figure 5: Climate change signal of consecutive dry days from ÖKS15 models for near-time (2030), mid-century (2050) and end od century (2080) projections

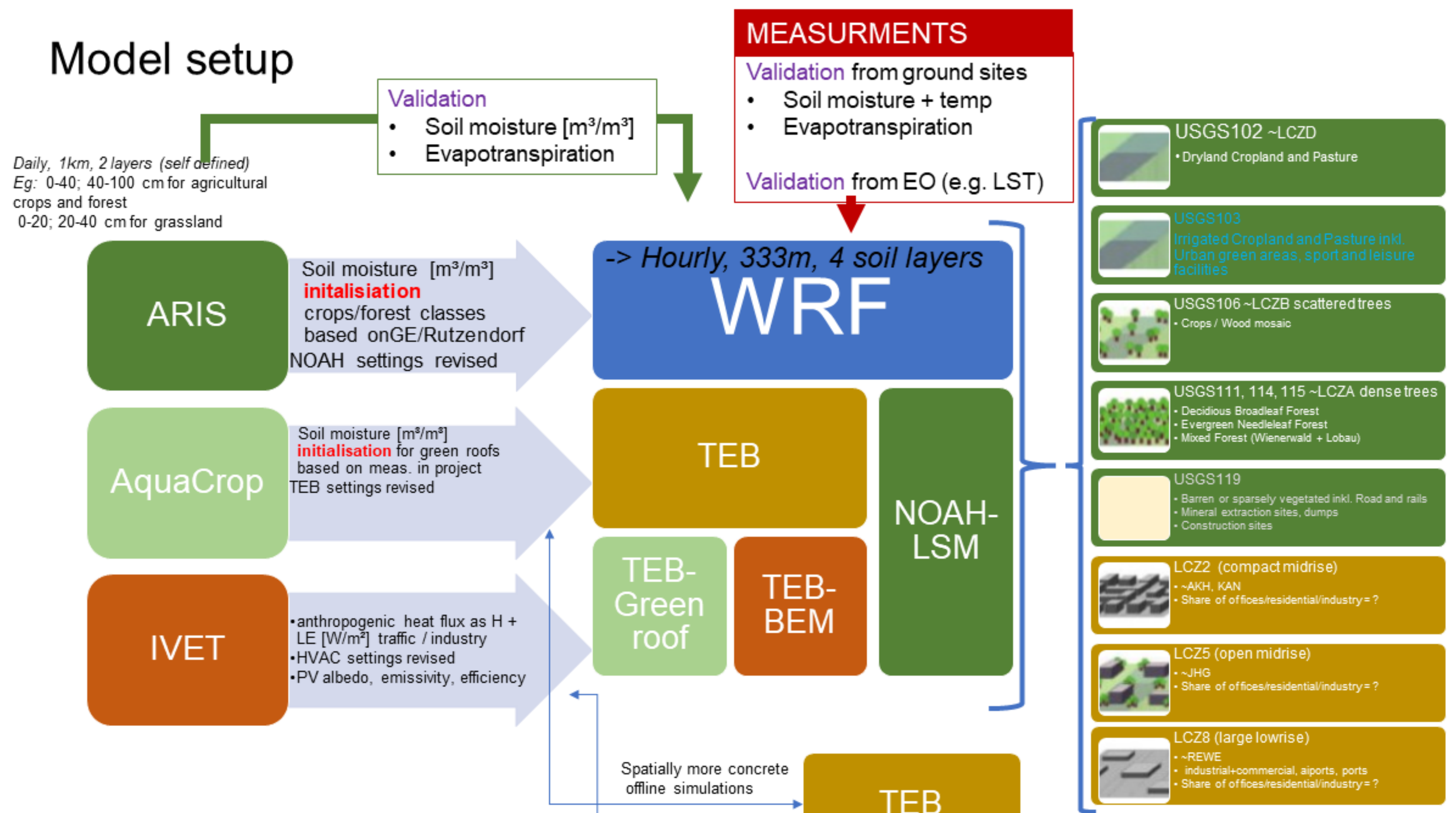


Fig. 7: Overview of multi-scale model