18th International Conference on
Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes

EVALUATION OF URBAN PARAMETERIZATIONS IN THE WRF MODEL USING ENERGY FLUXES MEASUREMENTS

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HARMO 18 GEMAC

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Overview
Scope

Environmental problems (e.g. air pollution)

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Climate change impacts (e.g. extreme weather events)

↓

Need to consider sustainable designs (e.g. green infrastructures) and planning, assessing the way of how these strategies impacts on the urban microclimate

Increase the accuracy of weather and air quality forecast at urban scale becomes crucial. This accuracy depends on the **integration of urban representations into mesoscale models**, mainly, on the level of accuracy of the urban processes modelling.

Overview

Research challenge

The link between energy fluxes and meteorological variables has promoted the evaluation of energy and water balance fluxes as a key issue in urban research.

Further investigation is needed to validate urban parameterization schemes, especially using measured energy fluxes for validation.

Contribution to the improvement of “modelling culture”, to make modelling processes transparent and ensure trust in modelling results (HARMO focus).

Overview

Goal

Assess the performance of different urban surface parameterizations in the WRF model to simulate urban energy fluxes and the meteorological variables

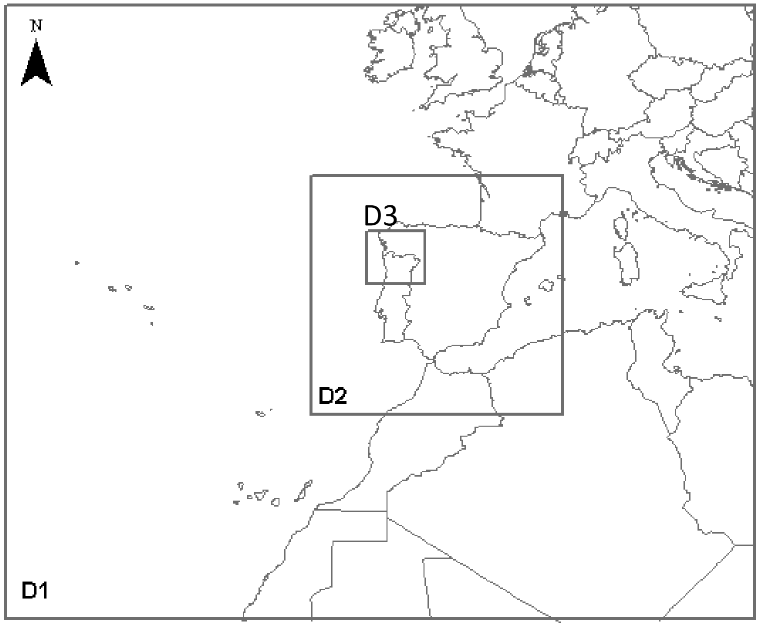
Case Study: High and Low intensity residential areas in Portugal

Period of Study: August-December 2014

Urban Parameterizations:
- Noah land surface model (LSM).
- Single-layer urban canopy model (UCM).
- Modelling setup composed by WRF-SUEWS (Surface Urban Energy and Water Balance Scheme model forced by Weather Research and Forecasting Model).

LSM and UCM are implemented as a WRF model module, whereas SUEWS is an individual model, initialized by WRF.

Methodology
Simulation Domains



D1 - 173x142 (grid cells) (27 km - resolution)

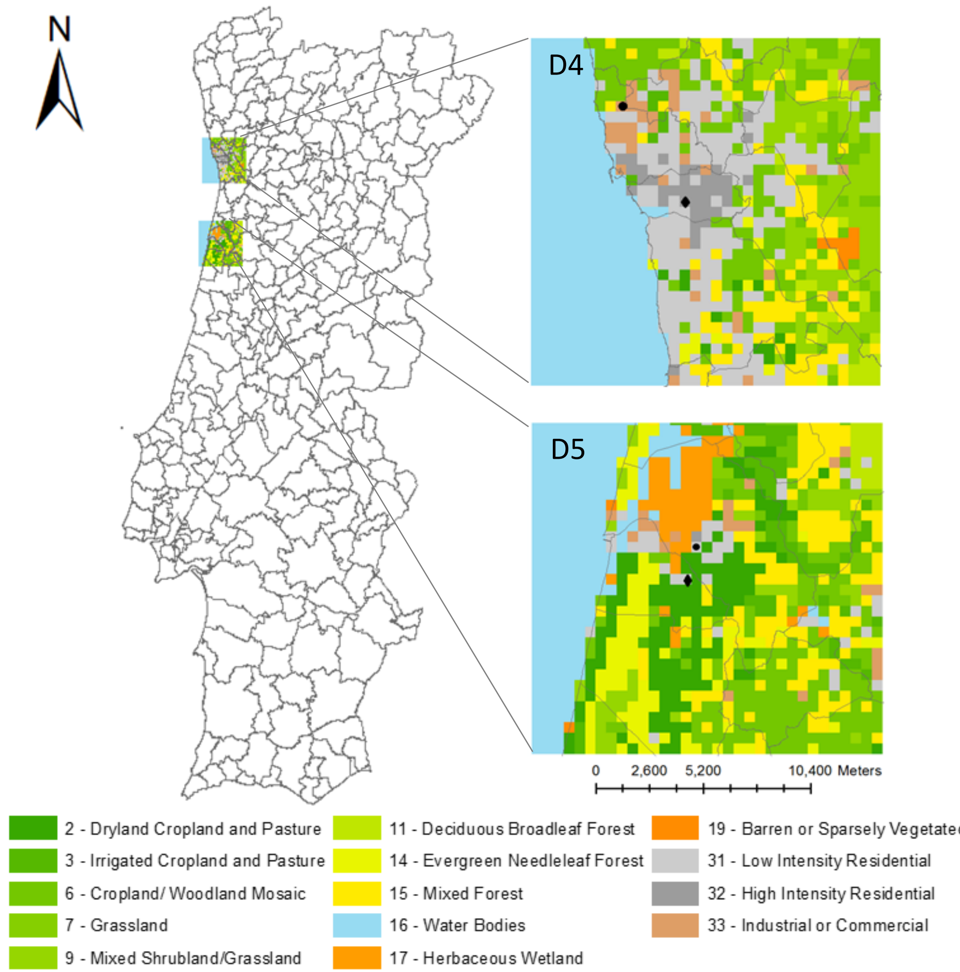
D2 - 175x166 (9 km)

D3 - 121x109 (3 km)

D4/D5 - 34x34 (1 km)

Spatial distribution of dominant land-use types

● meteorological sites ♦ surface energy sites



Methodology
Modelling Setup – WRF configuration

Category	Setup
Micro Physics Options	WSM 5-class scheme
Shortwave radiation	Dudhia scheme
Longwave radiation	RRTM scheme
Turbulence	YSU Planetary Boundary Layer scheme (YSU PBL)
Land surface process	Noah Land Surface Model
Cumulus Parameterization Options	New Grell scheme (only for the D1, D2 and D3)
Vertical spacing	30 vertical levels
	Lowest level: 2-m and 10-m, model top level: 50hPa

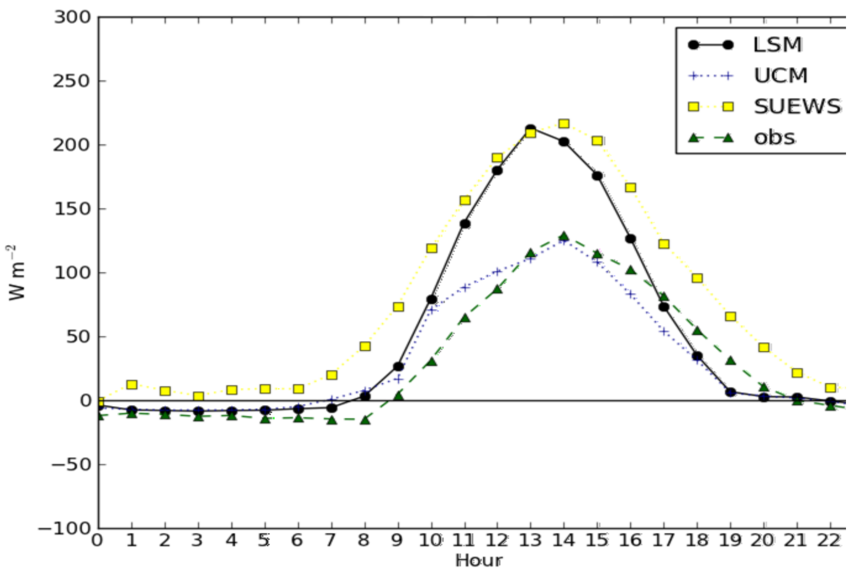
Field campaigns were carried out for both study areas, for the analysed period

Modelled results and the measured data were compared through two approaches: estimation of a set of statistic metrics; and representation of diurnal profiles.

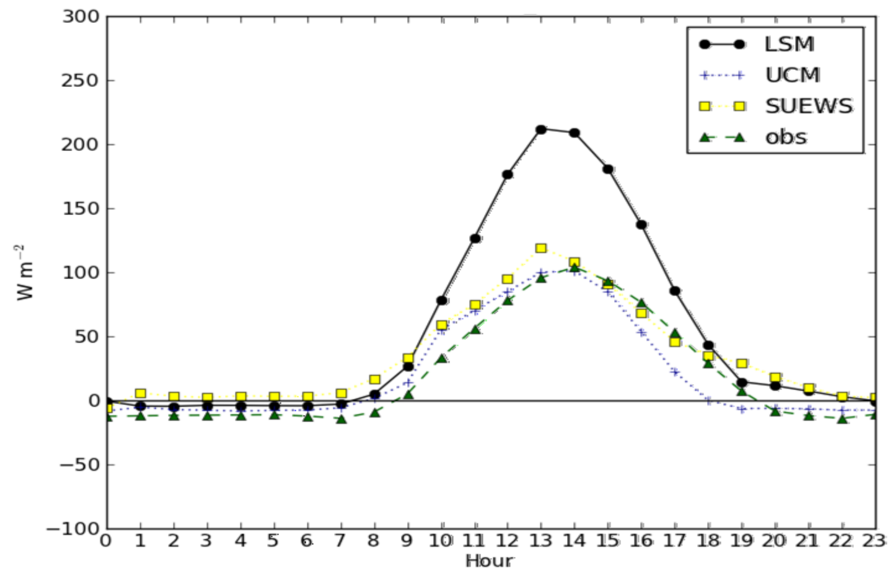
Results

Heat Fluxes – Sensible Heat Flux (Q_H 5-month averaged energy balance)

High intensity residential area



Low intensity residential area

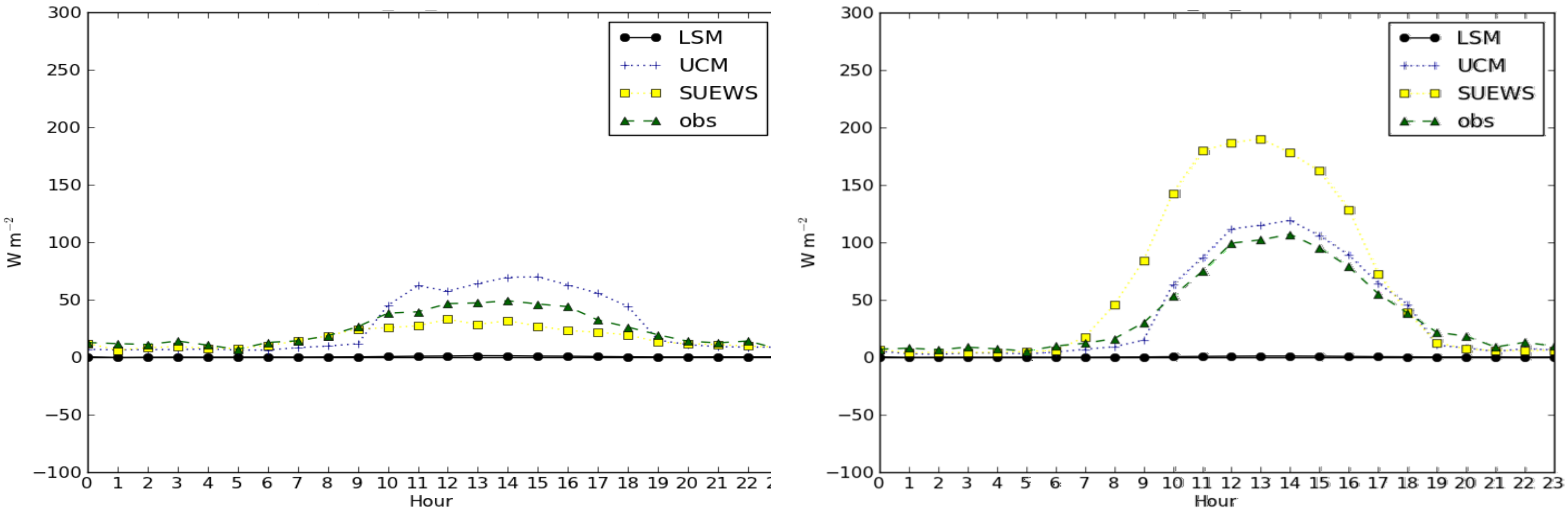


- LSM overestimates the sensible heat flux, for both areas (22 W·m^{-2} [high intensity residential area] and 34 W·m^{-2} [low intensity residential area]), however the modelled data follows quite well the measured data.
- UCM shows the lowest **RMSE**, a **NMSE** value closer to the ideal (4) and a **r** above 0.7, for both areas.

Results

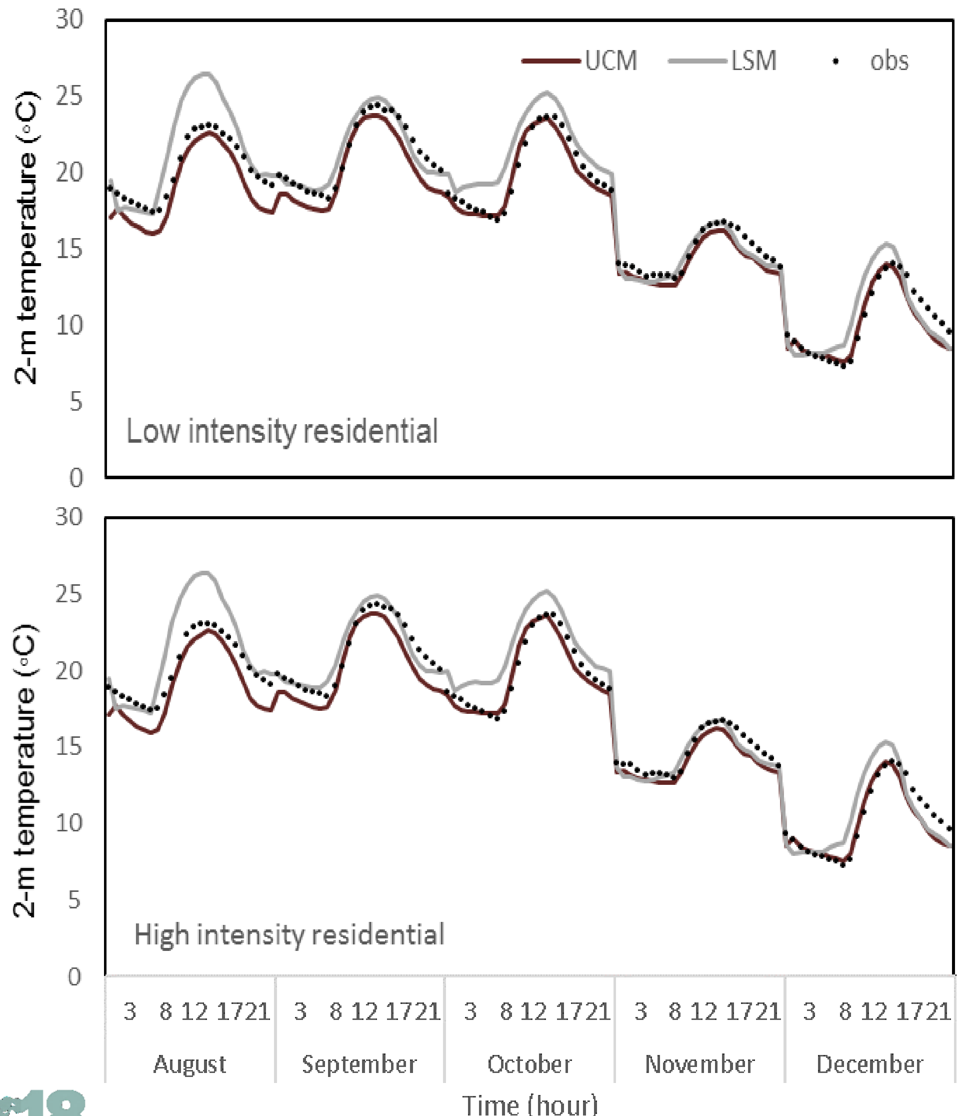
Heat Fluxes – Latent Heat Flux (Q_E 5-month averaged energy balance)

High intensity residential area | Low intensity residential area



- The urban vegetation effects of suppressing latent heat flux are neglectable with LSM. This underestimation is quantified by a high bias of around -23.6 and -37.2 W·m^{-2}
- SUEWS overestimate the latent heat flux, representing however the expected profile for both areas, according to the land cover characteristics.
- UCM shows the lowest **RMSE**, a **NMSE** value closer to the ideal (2) and a **r** of 0.6, for both areas.

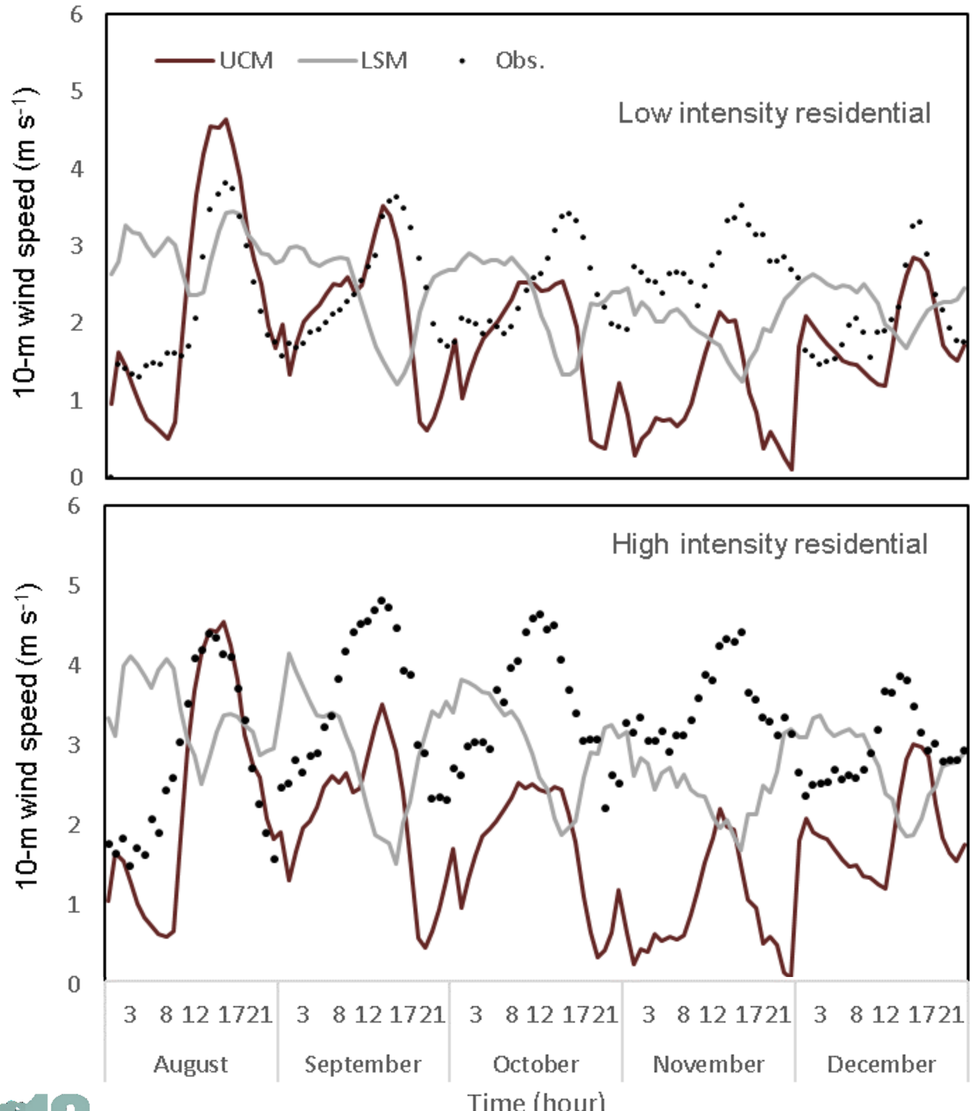
Results
Meteorological variables – temperature



- The UCM simulation compares better with the measurements than the LSM for both the residential areas, reproducing well the diurnal temperature profile.
- LSM overestimates the air temperature on both residential areas with a MBE of around 2°C in high intensity residential areas and 1°C in low intensity residential areas.
- A correlation factor of 0.9 is found for UCM in both areas.
- UCM reproduces the urban heat island intensity better then LSM.

Results

Meteorological variables – wind velocity and direction



- Discrepancies between modelled results and observed data, for both UCM and LSM and for both study areas are found, mainly overestimation of 0.95 **m.s^{-1}** (LSM) and 0.19 m.s^{-1} (UCM) at high-density residential area.
- Overall, the UCM simulation compares better with the observations than the LSM for both the residential areas, with an improvement of the statistical parameters.
- A correlation factor of 0.7 is found for UCM in both areas.

Conclusions

- SUEWS and UCM models reproduce well the changes related to the different land cover characteristics in the individual fluxes of the energy balance.

- UCM model reproduces better the relation between the sensible and latent heat fluxes. For both areas, and since LSM minimize the effects of urban vegetation, the latent heat flux is suppressed.

- Comparison between modelled and measured data showed that UCM model allow a more realistic representation of the **differences** in air temperatures related to different land covers (different levels of urbanization).

Conclusions

- For both UCM and LSM local wind speeds were similar in terms of statistic metrics. However, UCM has the potential to more accurately simulate the observed wind speeds in terms of the daytime profile related to the surface land use.

- The use of different urban surface parameterizations can explain the model performance in near-surface meteorological variables. In turn, near surface temperature and wind speeds influence evaporation rates, thereby influencing the energy balance and the hydrological cycle.

- The overall results demonstrate the relevance of the use of the most appropriated model physics for an accurate simulation of the urban microclimate. *If models are not capable to model current conditions and respond to parameters change, then simulations for the future scenarios could be very misleading!*

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Thank you!

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