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W2W: A Python package that injects WUDAPT's Local Climate Zone information in WRF

Matthias Demuzere[*1], **Daniel Argüeso**[2], **and Andrea Zonato**[3]

1 Urban Climatology Group, Department of Geography, Ruhr-University Bochum, Bochum, Germany **2** Physics Department, University of the Balearic Islands, Palma, Spain **3** Atmospheric Physics Group, Department of Civil, Environmental and Mechanical Engineering, University of Trento, Trento, Italy

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Software

- Review
- Repository
- Archive

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Summary

An important objective of WUDAPT, the World Urban Database and Acces Portals Tools community project, is to 1) to acquire and make accessible coherent and consistent information on form and function of urban morphology relevant to climate weather, and environment studies on a worldwide basis, and 2) to provide tools that extract relevant urban parameters and properties for models and for model applications at appropriate scales for various climate, weather, environment, and urban planning purposes Jason Ching et al. (2019).

The Python-based WUDAPT-to-WRF (W2W) package is developed in this context, and translates Local Climate Zone (LCZ) maps into urban canopy parameters readable by WRF, the community "Weather Research and Forecasting" model. It is the successor of the Fortran-based W2W package developed by Brousse et al. (2016) and Martilli et al. (2016), and provides a more simple, efficient and improved procedure to use LCZ information in WRF.

Statement of need

Since the pioneering work of Brousse et al. (2016) and Martilli et al. (2016), the level-0 WUDAPT information, the Local Climate Zone maps, have been used increasingly in WRF. We expect this trend to continue, because of two recent developments: 1) the creation of city-wide LCZ maps is now easier than ever with the online LCZ Generator (Demuzere et al., 2021), and 2) as of spring 2021, the new version 4.3 of WRF (Skamarock et al., 2021) is able to ingest 11 urban classses (corresponding to WUDAPT's LCZs) by default, whereas previous versions required manual WRF code changes by the user (see Martilli et al. (2016), Andrea Zonato et al. (Under Review) and Andrea Zonato & Chen (2021) for more information). Because of these developments, we decided to simultaneously built an improved, Python-based, WUDAPT-to-WRF (W2W) routine, to make the translation of LCZ-based parameters better and more simple.

Initial data requirements

In order to use the tool, two input files are required:

*corresponding author

1. A **geo_em.d0X.nc file** for the inner WRF model domain in which you would like to use the LCZ-based information. This file can be produced by WRF's geogrid.exe tool as part of the WRF Preprocessing System (WPS). ** (**ANDREA?**): does a user needs to use specific settings here to create this file?? Please extend this section if needed.**

2. A **Local Climate Zone map** that is slightly bigger than the domain of the geo_em.d0X.nc file. There are a number of ways to obtain an LCZ map for your region of interest:

- Extract your domain from the continental-scale LCZ maps for Europe (Demuzere et al., 2019) or the United States (Demuzere et al., 2020) (see here for more info).
- Check if your region of interest is already covered by the many LCZ maps available in the submission table of the LCZ Generator.
- Use the LCZ Generator to make an LCZ map for your region of interest.

General workflow

The goal of the Python-based W2W tool is to obtain a WRF domain file (*geo_em.d0X.nc*) that contains the urban LCZ classes and their corresponding urban canopy parameters relevant for all urban parameterizations embedded in WRF: the single layer urban canopy model Noah/SLUCM (Kusaka et al. (2001)), the Building Environment Parameterization (BEP, Martilli et al. (2002)), and BEP+BEM (Building Energy Model, Salamanca et al. (2010)). To get to that point, the following three general steps are followed, which are partly inspired by the work of Li et al. (2020):

- Step 1:
- Step 2:
- Step 3:

Urban canopy parameter assignment

MAKE A TABLE WITH ALL PARAMETERS, including abbrevation, long name, unit, type, source, etc ...

Two pathways are followed when assigning the various urban canopy parameters to the Local Climate Zone Map (Figure 1):

- Pathway 1: **Morphological** parameters are assigned directly to the high-resolution LCZ map, and are only afterwards aggregated to the lower-resolution WRF grid. In this way, the method produces a unique value of the different urban morphology parameters for each WRF grid cell. This was found to be more efficient in reproducing urban boundary layer features, especially in the outskirts of the city (A. Zonato et al., 2020), and is in line with the WUDAPT-to-COSMO routine (Varentsov et al., 2020).
- Pathway 2: In line with the former Fortran-based W2W procedure, **radiative and thermal parameters** are assigned to the modal LCZ class that is assigned to each WRF grid cell.

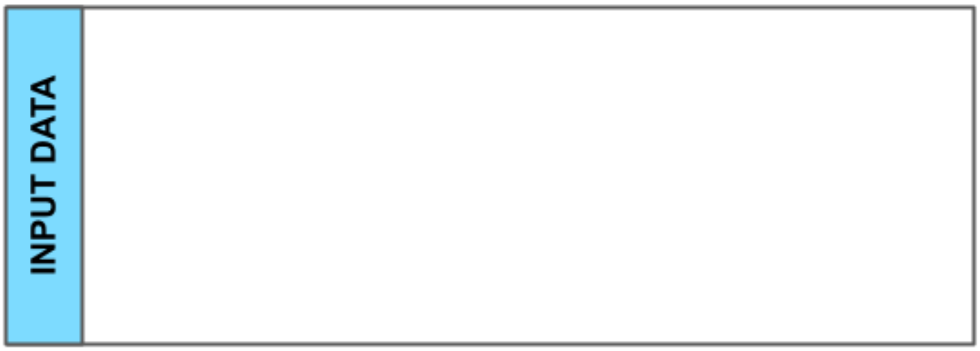


Figure 1: General workflow. The example maps are derived from the sample data for Zaragoza (Spain), available in the github repository.

As before, the LCZ-based urban canopy parameters generally follow the values provided by Stewart and Oke (2012) and Stewart et al. (2014).

Potential use case

Things to keep in mind (come up with better section title!!)

- best to use with BEP or BEP+BEM, because of the building heights / lowest model layer
- replace generic LCZ-based UCP values with site-specific ones when available
- Important to have good quality LCZ map, if not: garbage in, garbage out.

Mathematics

Single dollars ($) are required for inline mathematics e.g. $f(x) = e^{\pi/x}$

Double dollars make self-standing equations:

$$\Theta(x) = \begin{cases} 0 \text{ if } x < 0 \\ 1 \text{ else} \end{cases}$$

You can also use plain LaTeXfor equations

$$\hat{f}(\omega) = \int_{-\infty}^{\infty} f(x) e^{i\omega x} dx \tag{1}$$

and refer to Equation 1 from text.

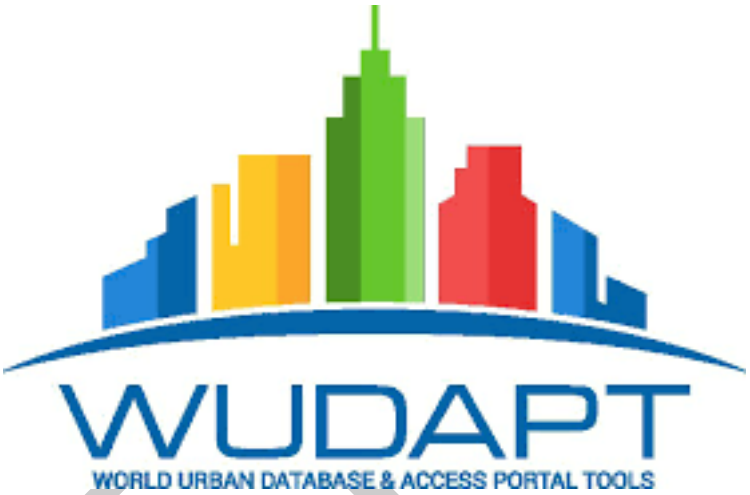
Citations

Citations to entries in paper.bib should be in rMarkdown format.

If you want to cite a software repository URL (e.g. something on GitHub without a preferred citation) then you can do it with the example BibTeX entry below for Smith et al. (2020).

For a quick reference, the following citation commands can be used: - `@author:2001` -> "Author et al. (2001)" - `[@author:2001]` -> "(Author et al., 2001)" - `[@author1:2001; @author2:2001]` -> "(Author1 et al., 2001; Author2 et al., 2002)"

Figures



Figures can be included like this:
and referenced from text using **??**.

Figure sizes can be customized by adding an optional second parameter:

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