

Dr Ting Sun

Urban Climate Modelling Using SuPy: Developing and Supporting New Research Software

Meteorologists Dr Ting Sun and Professor Sue Grimmond developed an Open Source urban climate model with the aim of delivering reproducible research and exciting urban climate teaching. By making strategic decisions about how to package, distribute and support the software they have built an active community of research and education users. Dr Sun and Professor Grimmond were **finalists in the University of Reading Open Research Award 2021**.

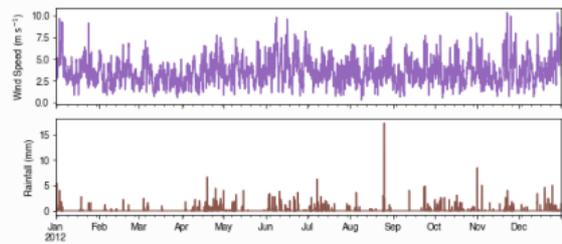
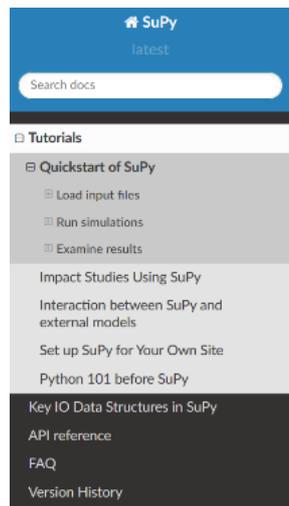
Cities occupy less than 0.5% of the surface of the globe, while more than **55% of the world's population live in urban environments**. It is imperative to better understand urban climates and their environmental impacts at various scales to build cities that are more resilient to changing climates.

To address this need we developed an urban climate model called SuPy: Surface Urban Energy and Water balance Scheme (SUEWS) in Python.^{1,2} **SUEWS** is a well-evaluated urban climate model that has been **widely used** to investigate urban climate questions across the world. Our objectives in developing SuPy were to create a tool for reproducible research which can also be used to teach students about urban climate. We used the Open Source scientific programming language **Python** to enhance the existing SUEWS model and make it more accessible to a wider range of users. The first publications using SuPy highlighted improvements in building energy simulations³ and modelling of anthropogenic heat fluxes.⁴

In the development of SuPy, we adopted several open practices:

- The source code (which is licensed under the **GNU General Public License**) is made **publicly available on GitHub** and deployed as **a standard Python package in PyPI** (the official Python package repository). This makes it easy for users to install and update the software.
- We have a dedicated **public SuPy documentation website** with step-by-step interactive tutorials in **Jupyter Notebooks** to help users apply SuPy in their study and research. The guide includes demonstration cases which users can reproduce.
- The philosophy and techniques for developing SuPy are published in an Open Access article in *Geoscientific Model Development*.²
- SuPy is integrated into the widely-used **Urban Multi-scale Environmental Predictor** (UMEP) climate service tool.⁵ UMEP is a plugin for the Open Source Geographic Information System software **QGIS**. This has helped to increase uptake of SuPy in the wider Open Source GIS community.

SuPy is being actively used in **teaching** and student projects, at the University of Reading and other institutions, including Ruhr University Bochum and the University of Freiburg in Germany, and the Foundation for Research and Technology (FORTH) in Greece. The **SuPy tutorials** help students learn quickly how to use the software. As the user community grows, we are developing more tutorials: for example, those used in the **urbisphere 2020 UMEP modelling workshop**.



Modification of SuPy input

Given `pandas.DataFrame` is the core data structure of SuPy, all operations, including modification, output, demonstration, etc., on SuPy inputs (`df_state_init` and `df_forcing`) can be done using `pandas`-based functions/methods.

Specifically, for modification, the following operations are essential:

locating data

Lessons learned from the SuPy project include:

- **Well-curated manuals and tutorials** are essential to attracting users and maintaining a vibrant community. These not only resolve problems (both scientific and technical), but also stimulate interaction with a wider community and foster new applications of the software.
- **Adopting common toolchains is critical.** Previously, our code was hosted on BitBucket. We made the decision to migrate to **GitHub** because it has more tools (such as **GitHub Actions**) and guidance. It has also facilitated greater interaction with our user community.

By adopting open software methods we have been able to increase the functionality of SuPy, develop the user community, and translate our research into open and reproducible outputs. SuPy has made a valuable addition to the urban climate modelling community by providing an easily accessible and **data processing-friendly tool** for reproducible research.

Open at a glance

- Urban climate modelling software source code distributed under Open Source licence
- Providing user manuals, tutorials and support, and choosing the right distribution methods, can greatly increase uptake and support ongoing development
- A peer-reviewed software paper can be used to promote the software and provide technical detail about its development

For more information, please contact:

Dr Ting Sun
Department of Meteorology

University of Reading
 Earley Gate
 Reading, RG6 6ET

ting.sun@reading.ac.uk

@DrTingSun

/theuniversityofreading

@UniRdg_Research

www.reading.ac.uk

References and further information

1. SuPy: SUEWS that speaks Python. Website. <https://supy.readthedocs.io/>
2. Sun, T. and Grimmond, S. (2019). A Python-enhanced urban land surface model SuPy (SUEWS in Python, v2019.2): development, deployment and demonstration. *Geoscientific Model Development* 12(7): 2781–2795. <https://doi.org/10.5194/gmd-12-2781-2019>
3. Tang, Y. et al. (2021). Urban meteorological forcing data for building energy simulations. *Building and Environment* 204: 108088. <https://doi.org/10.1016/j.buildenv.2021.108088>
4. Capel-Timms, I. et al. Fast estimates of anthropogenic heat flux informed by the agent-based model DASH (in preparation)
5. Lindberg, F. et al. (2018). Urban Multi-scale Environmental Predictor (UMEP): an integrated tool for city-based climate services. *Environmental Modelling & Software* 99: 70–87. <https://doi.org/10.1016/j.envsoft.2017.09.020>

