Enhancing global-scale urban land cover representation using local climate zones in the Community Earth System Model

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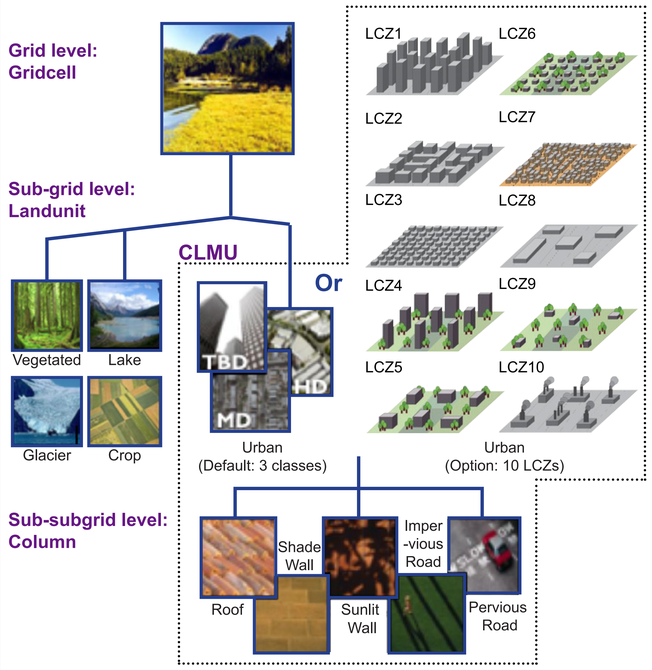
Highligths

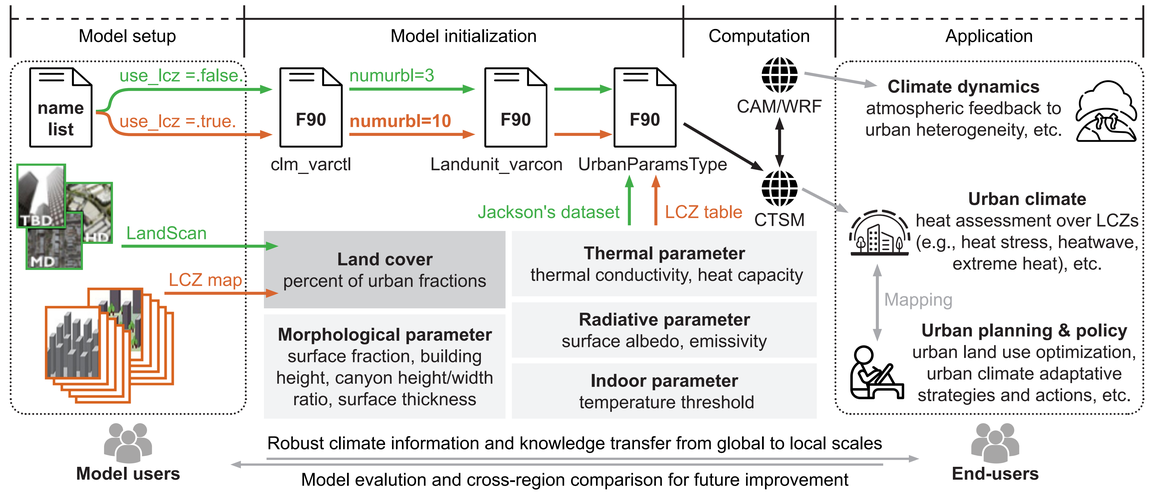
- We developed a modular approach to implementing an local climate zone (LCZ)-based urban land cover representation in the Community Earth System Model (CESM).
- Simulations at 20 flux tower sites showed the effectiveness of urban climate modeling using the LCZ scheme.
- Modeled sensible heat flux showed comparable sensitivity to LCZ morphological and thermal parameters.

Urban representation in CESM

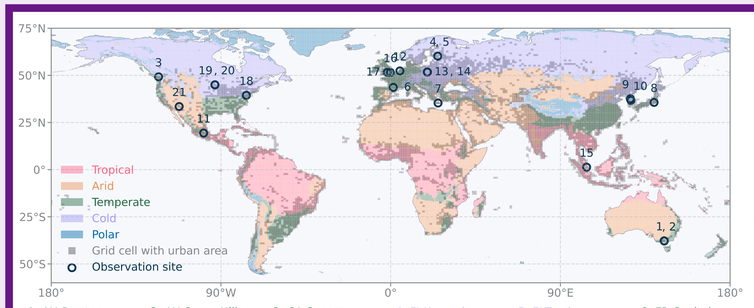
CESM is one of the global climate models explicitly representing and parameterizing urban biophysical processes. The default urban classes has 3 classes while the built LCZ scheme has 10.



A modularized way of model code modification



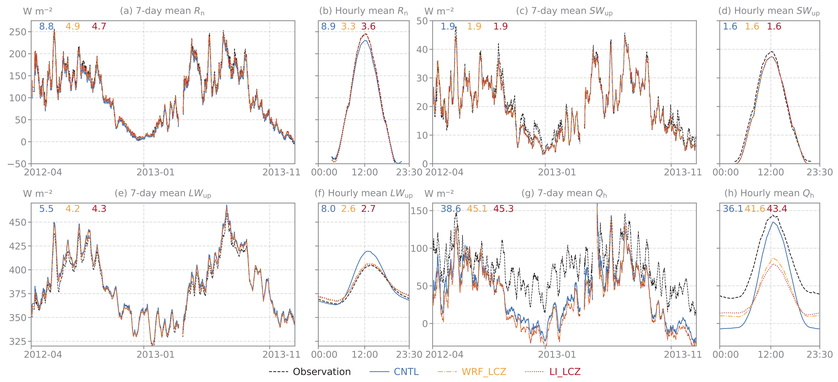
Model validation over 20 global flux tower sites



1- AU-Preston, 2- AU-SurreyHills, 3- CA-Sunset, 4- FI-Kumpula, 5- FI-Torni, 6- FR-Capitole, 7- GR-HECKOR, 8- JP-Yoyogi, 9- KR-Jungnang, 10- KR-Ochang, 11- MX-Escandon, 12- NL-Amsterdam, 13- PL-Lipowa, 14- PL-Narutowicza, 15- SG-TelokKurau06, 16- UK-KingsCollege, 17- UK-Swindon, 18- US-Baltimore, 19- US-Minneapolis1, 19- US-Minneapolis2, 20- US-WestPhoenix

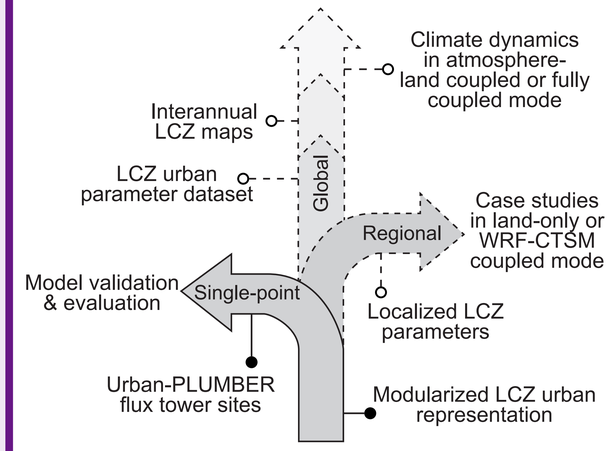
Single-point simulations were conducted to validate the LCZ scheme in CLMU by comparing model output with observations from the Urban-PLUMBER project (https://urban-plumber.github.io). This project assessed the performance of thirty urban models through simulations at twenty urban flux tower sites worldwide.

LCZ-based simulations have lower RMSEs in the modeled upward longwave radiation flux (LW_{up}) , but higher RMSEs in sensible heat flux (Q_h). Other variables including upward shortwave radiation flux (SW_{up}), show relatively good agreement between the model and the observations.



Implications for future work

This study primarily focuses on the module development and evaluation. Future applications of implementing LCZs for regional and global simulations will require refinement of LCZ-based urban parameters with city-level spatial variability.



Conclusions

- Incorporating LCZ-based urban land cover into Earth system models promotes consistency in urban classification and model configuration at the global scale.
- The LCZ approach produced more accurate results for simulating upward longwave radiation flux and anthropogenic heat flux compared to using the three-class urban representation, which used the CESM's default urban parameter data set.

Publication

Journal article in JAMES

Source code in GitHub Repo

Open data in figshare