Improving urban climate adaptation modelling in the Community Earth System Model (CESM) through transient urban surface albedo representation

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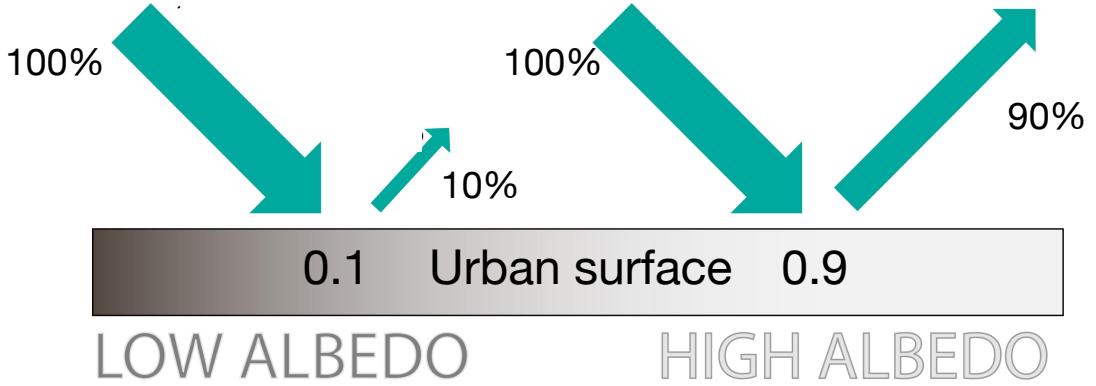
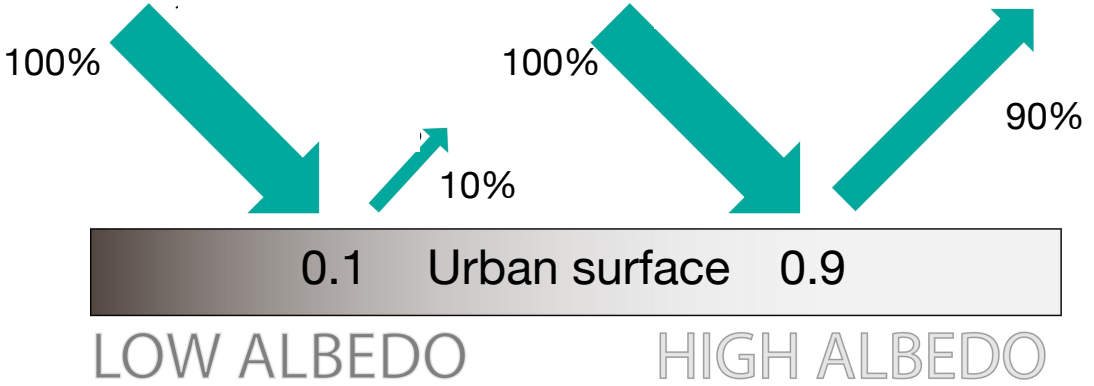
Introduction

- **Why urban albedo**
  - urban climate-sensitive design——white roof, cooling pavement;
  - international networks such as C40 cities for urban climate adaptation;



White roof in New York City.
https://www.c40.org/

Introduction



- **Why urban albedo**
  - urban climate-sensitive design——white roof, cooling pavement;
  - international networks such as C40 cities for urban climate adaptation;
- **Why CESM**
  - a state-of-art global climate model with explicit urban modelling capacities;
  - large-scale urban climate simulation;

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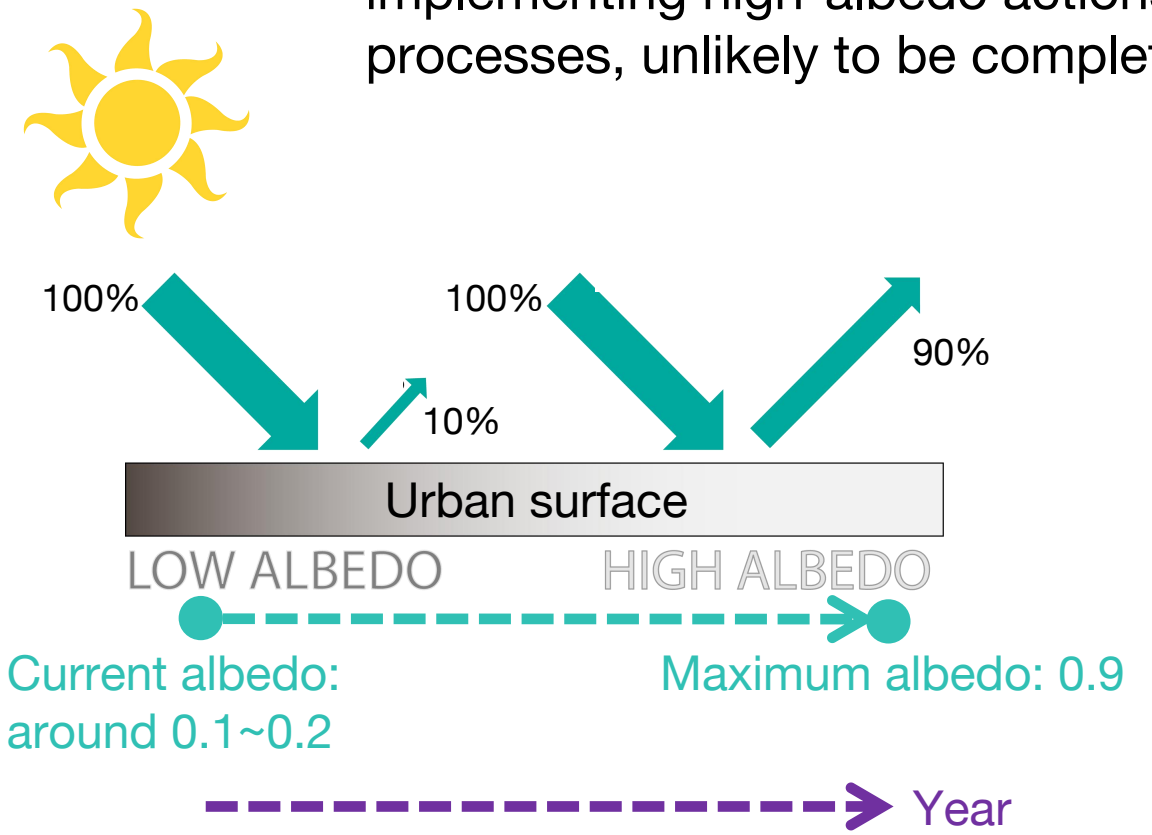
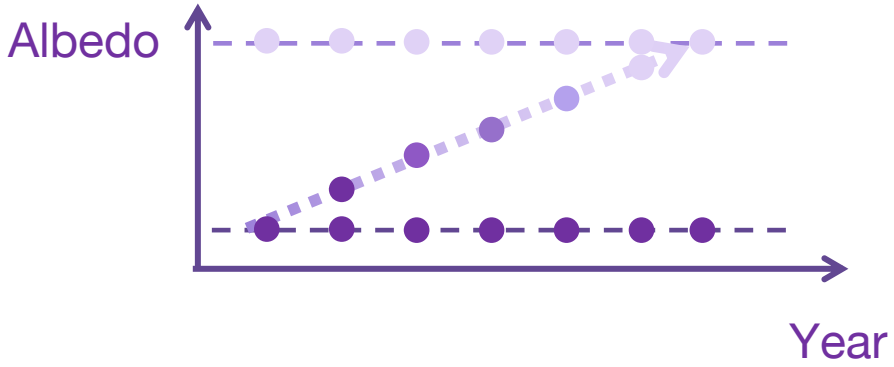
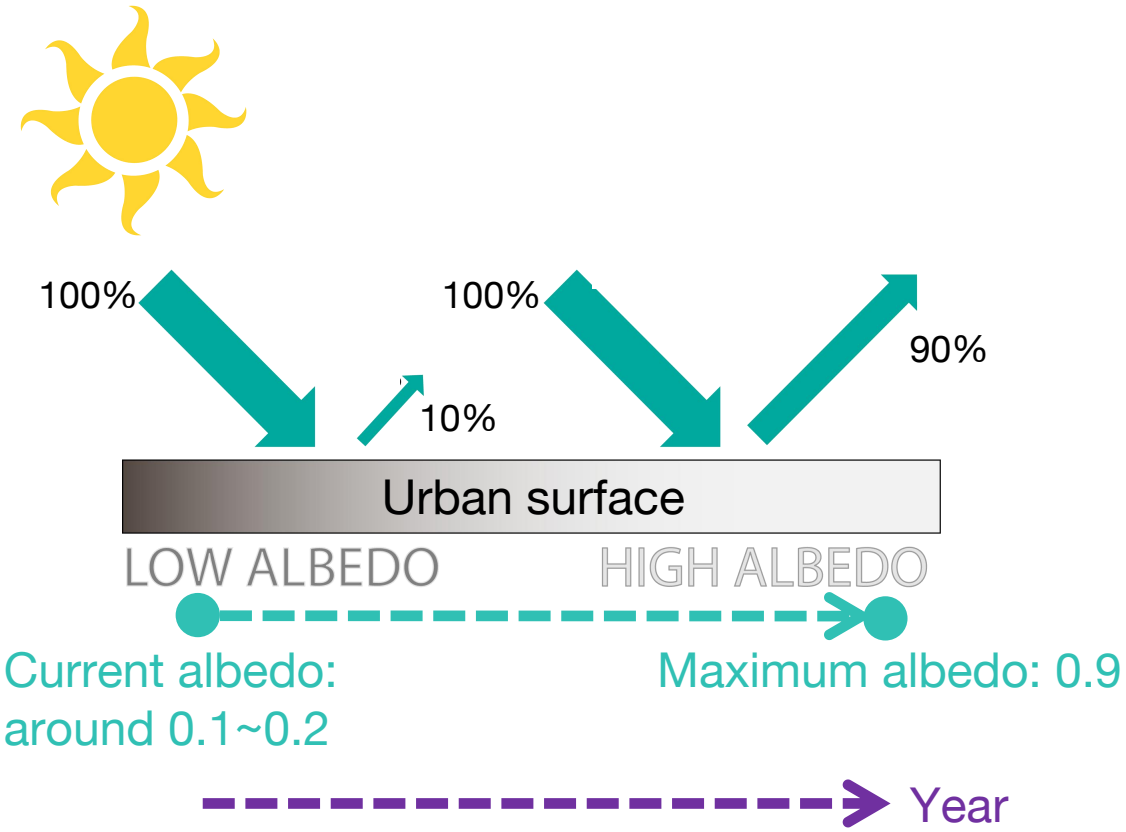
Why transient albedo

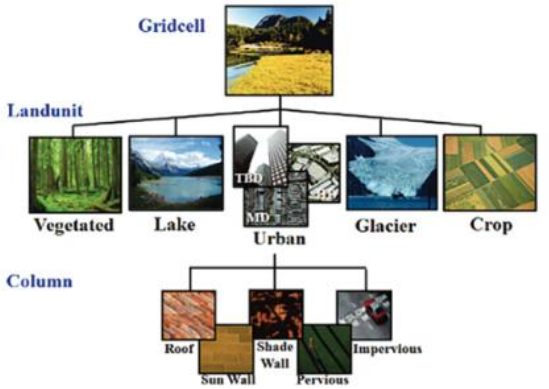
- implementing high-albedo actions such as white-roof installations are gradual processes, unlikely to be completed within a single day;

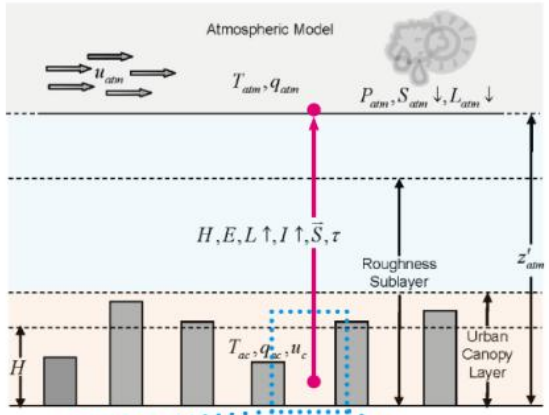


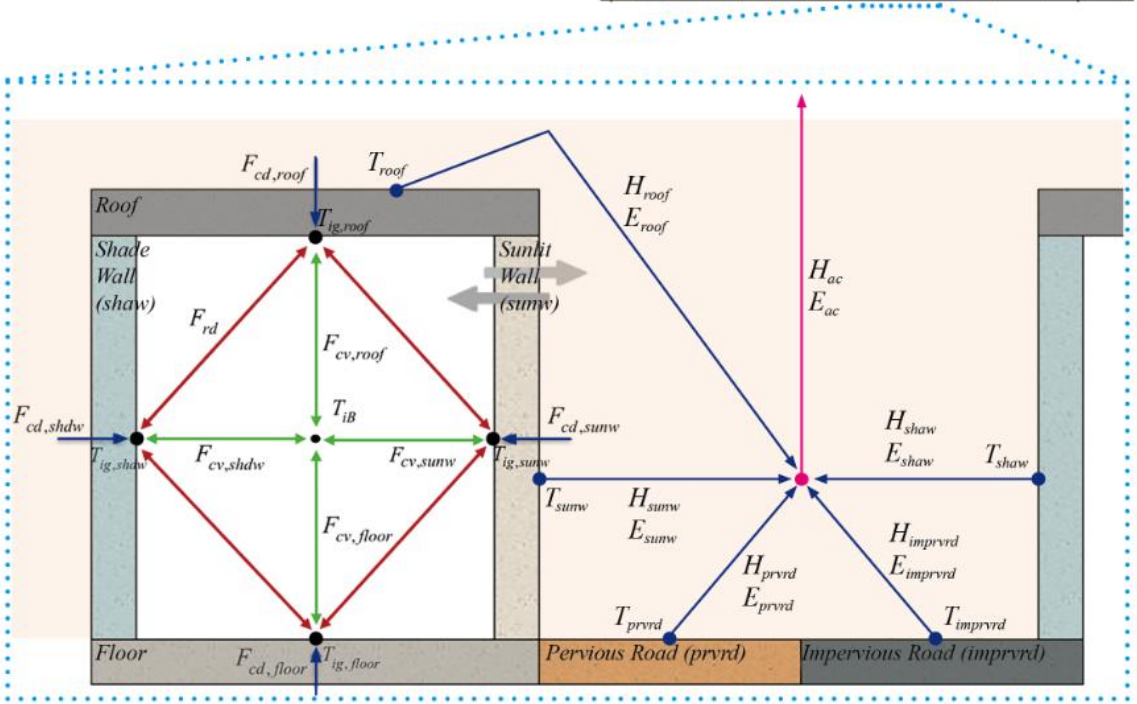


Urban climate adaptation modelling

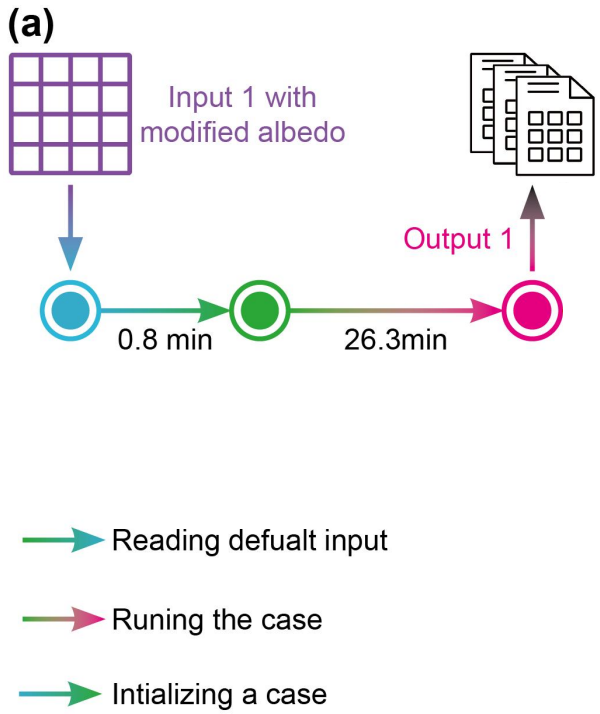








(a) Traditional way of changing urban albedo over time



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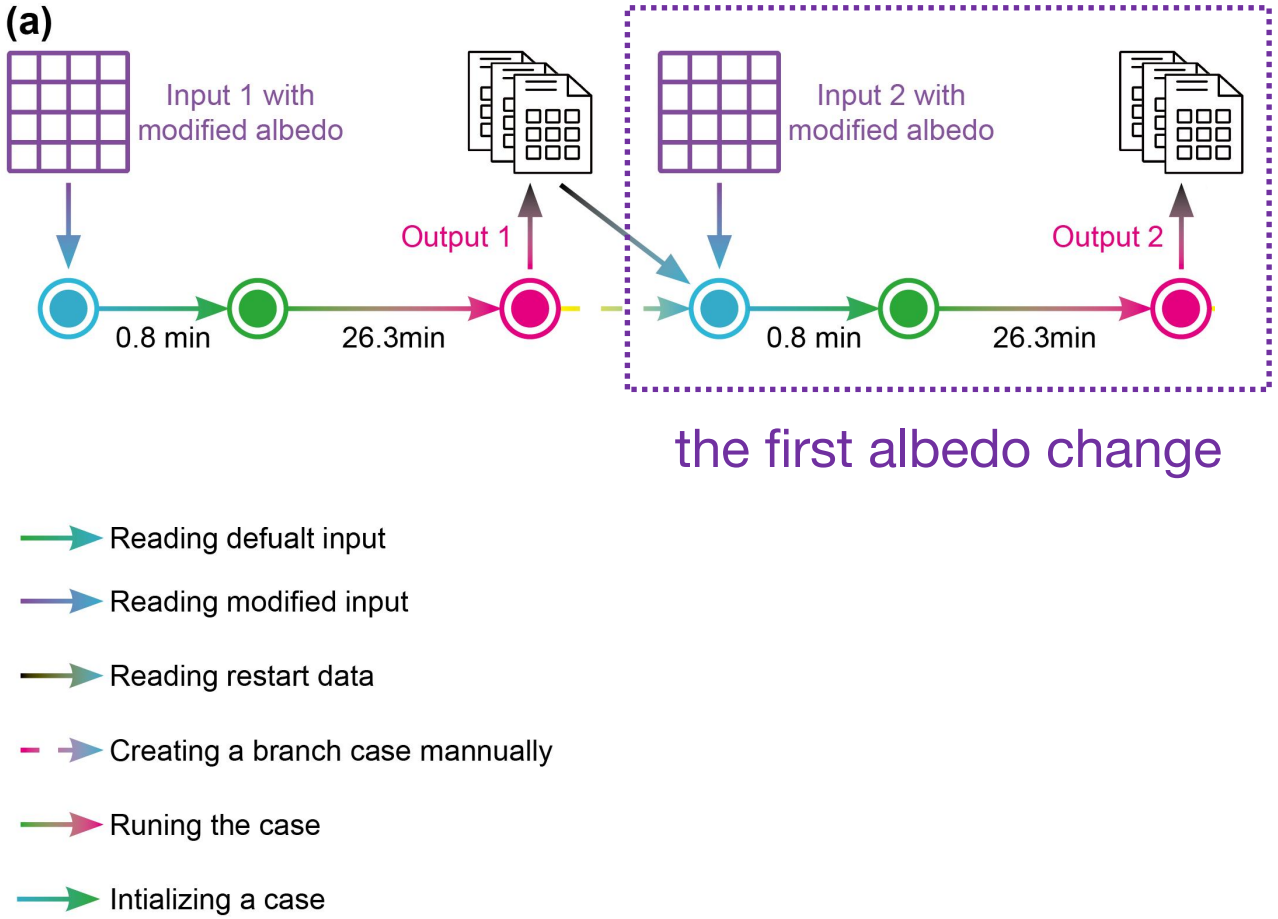

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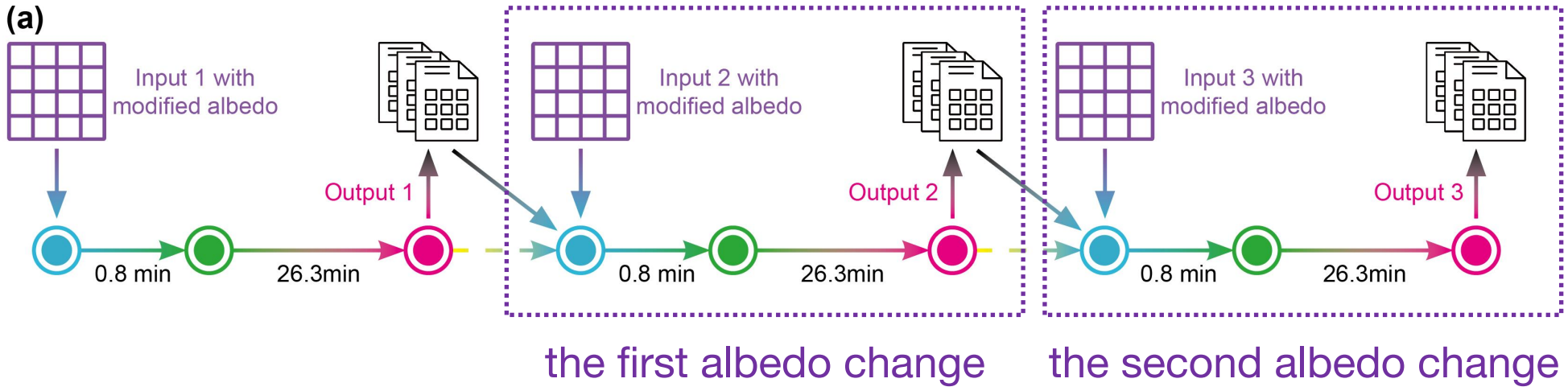
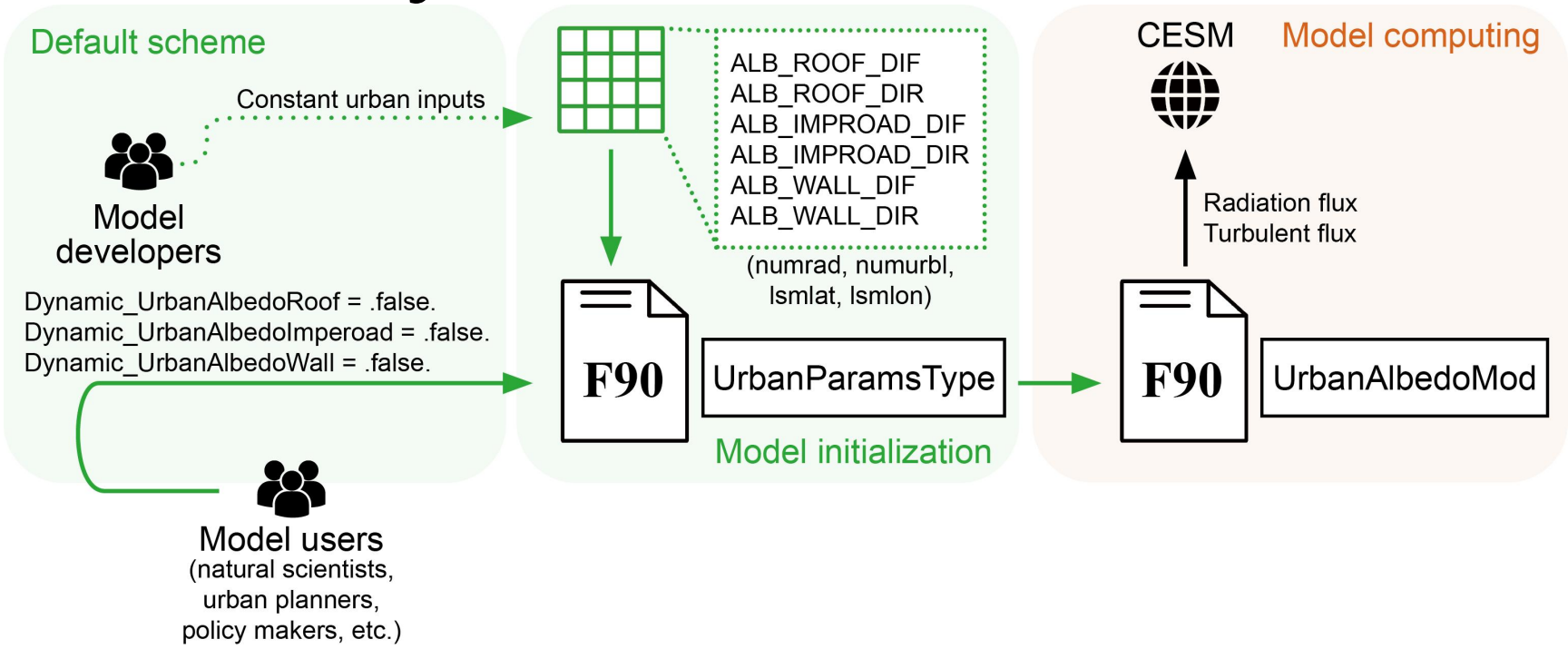


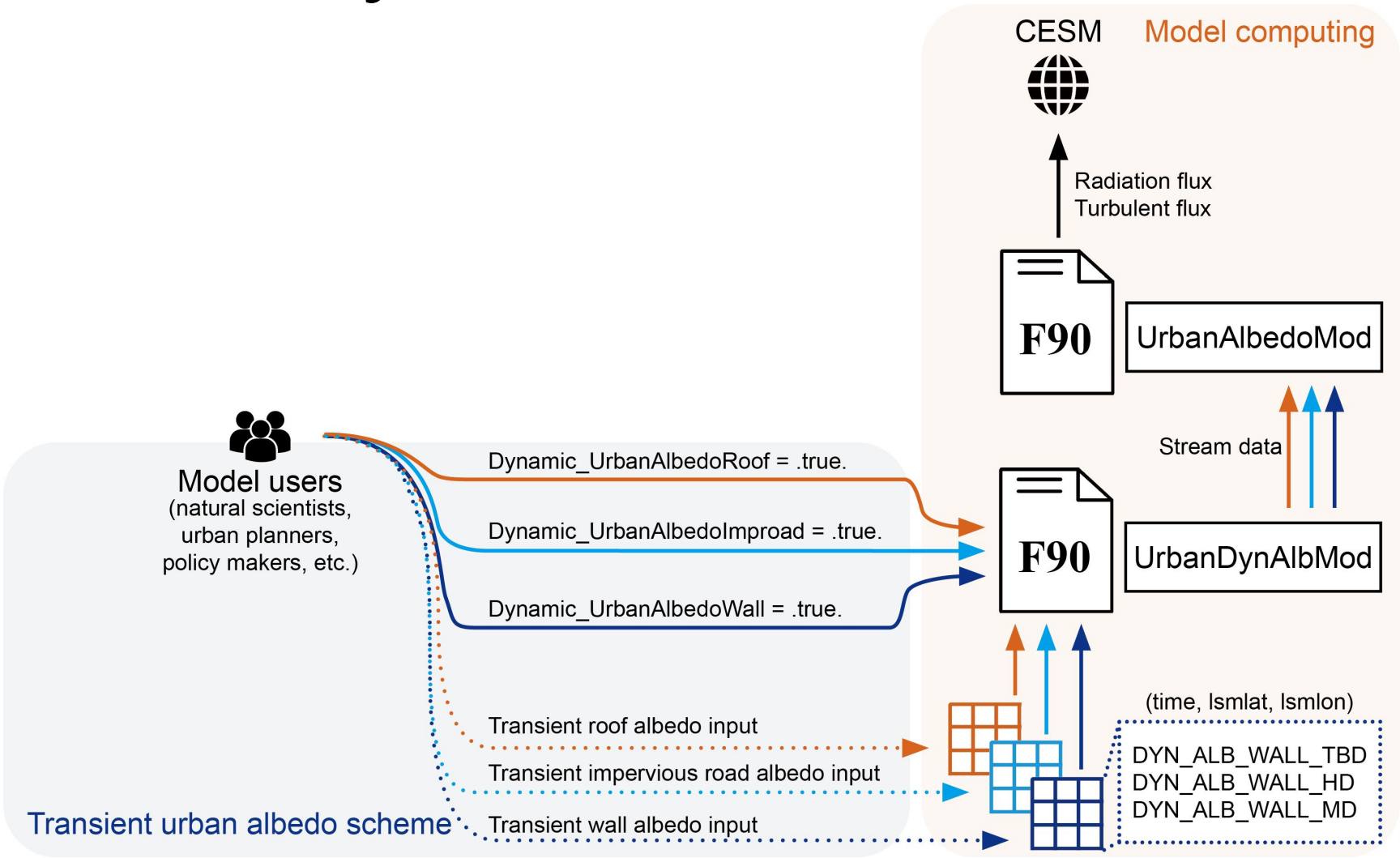
New module: UrbanDynAlbMod

Constant urban albedo



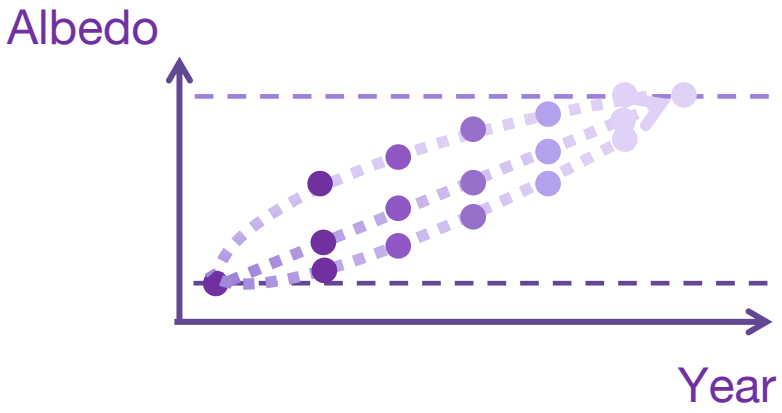
New module: UrbanDynAlbMod

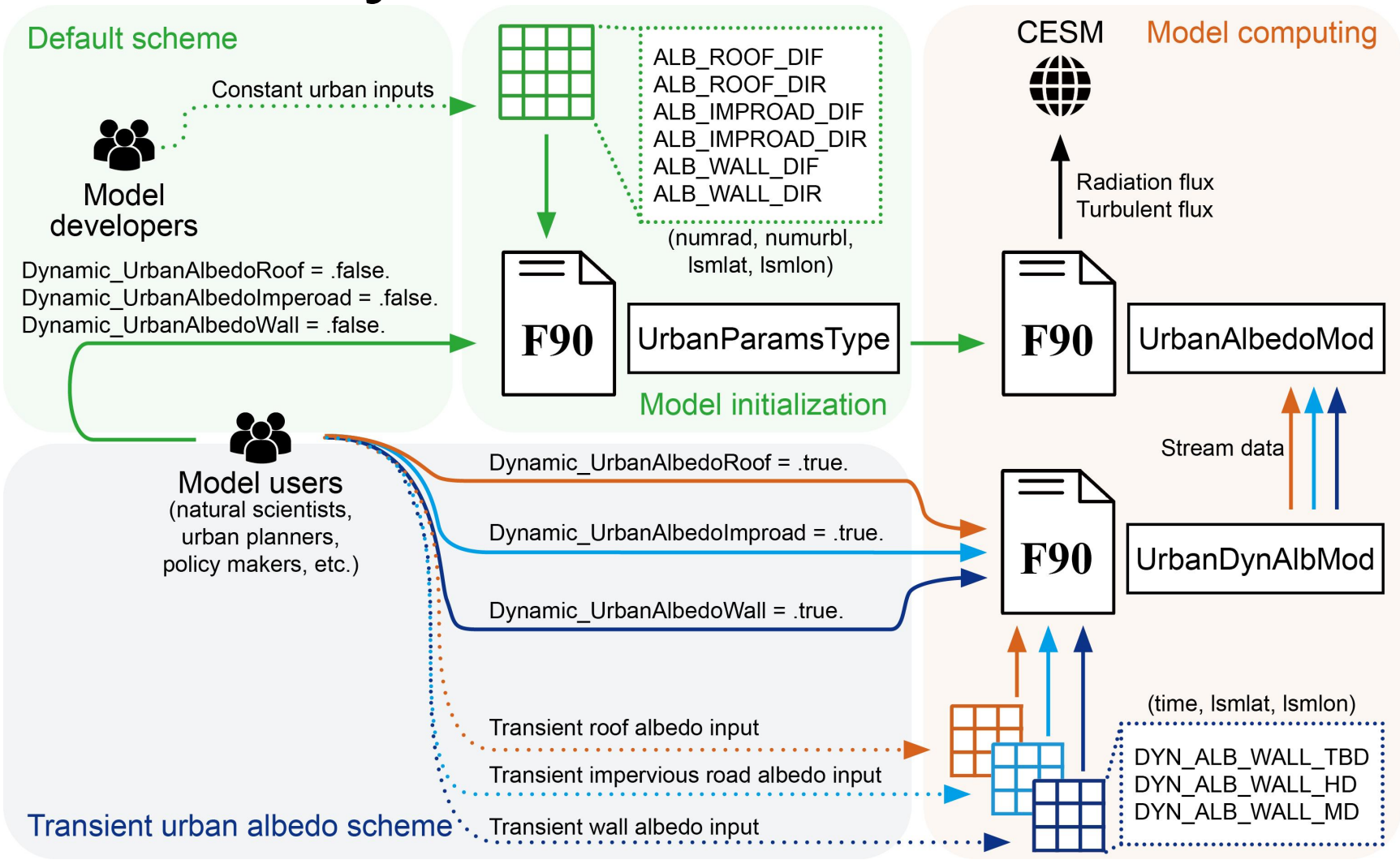
Transient urban albedo



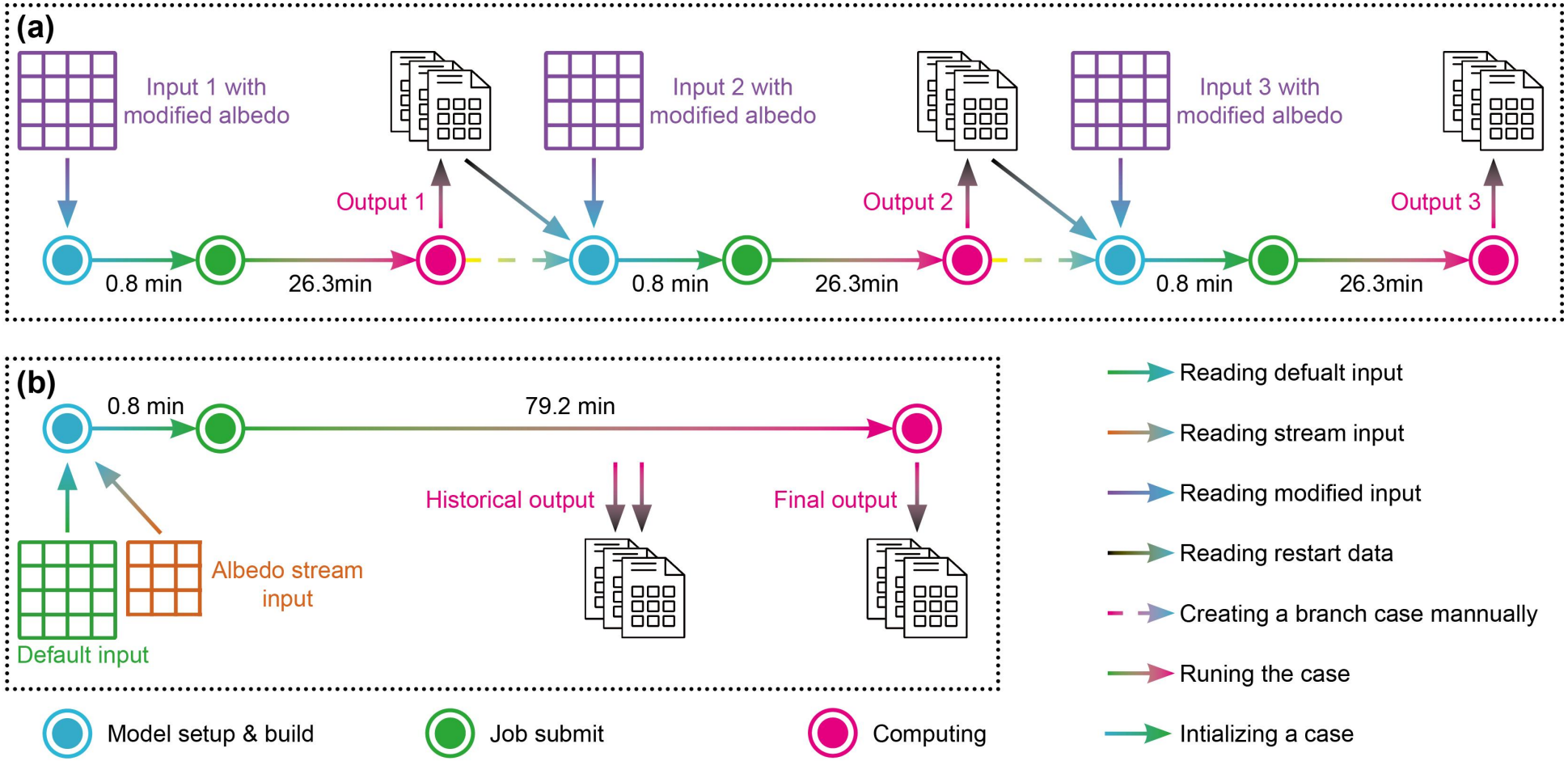
New module: UrbanDynAlbMod

User-targeted inputs:
- maginitude of varying
- timestep of varying





(b) Using the new module



Experiment design

Table 2. Urban climate adaptation strategies under varying urban albedo configurations.

Simulation name	Input data description	Roof albedo	Wall albedo	Impervious road albedo	Pervious surface albedo
CNTL	Static urban albedo	□	□	□	□
ROOF_0.9	Static high albedo of roof	0.9	□	□	□
ROOF_DA	Transient albedo of roof	■	□	□	□
WALL_DA	Transient albedo of wall	□	■	□	□
IMPROAD_DA	Transient albedo of impervious road	□	□	■	□
ROOF_IMPROAD_DA	Transient albedo of horizontal built surfaces	■	□	■	□
ROOF_IMPROAD_WALL_DA	Transient albedo of vertical and horizontal built surfaces	■	■	■	□

Note: The symbol □ represents static urban albedo parameters in CLM5, while ■ is transient urban surface albedo inputs. Albedo values in each grid cell were modified to increase annually by 0.01 starting from 2015, capping at a maximum of 0.9. The albedo of pervious roads was not altered, in recognition of their natural characteristics.

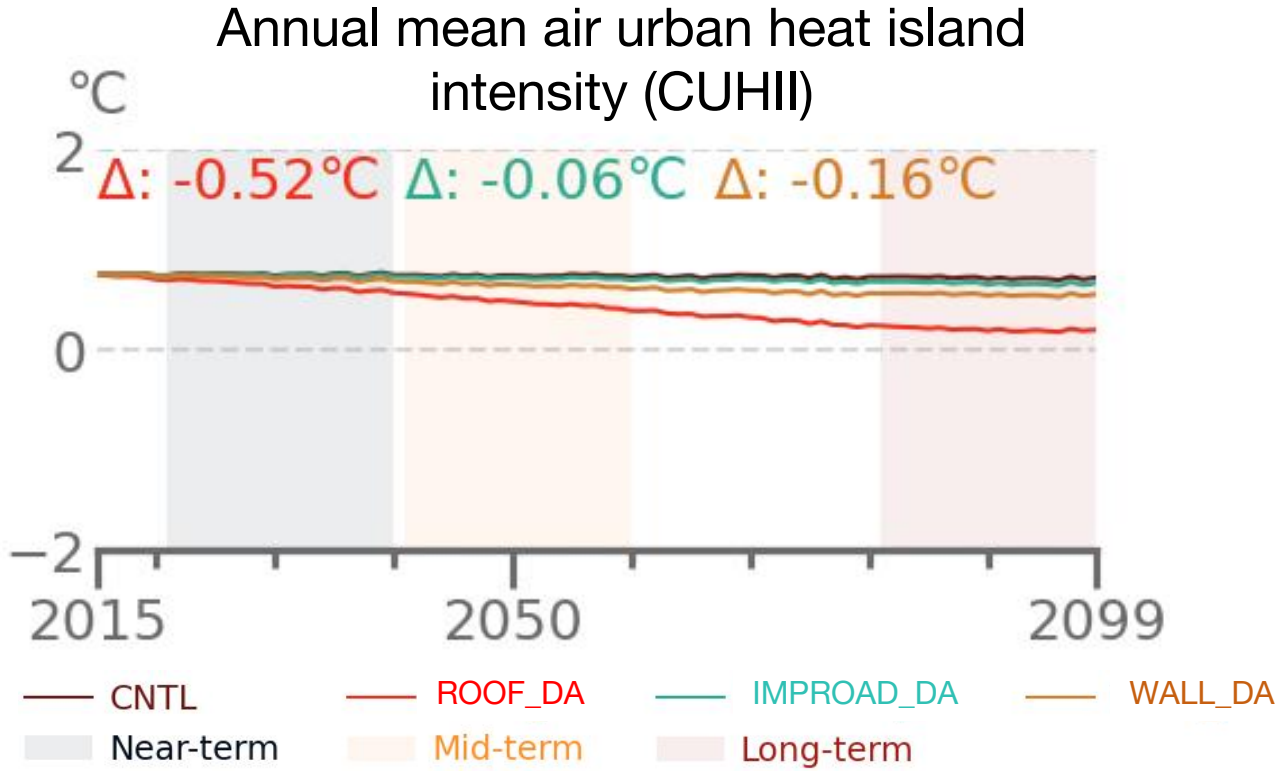
Model version: CESM 2.1.4
Grid spacing: 0.9 ˚ latitude by 1.25 ˚ lontitude
Component set: SSP370_DATM%CPLHIST_CLM50%SP_SICE_SOCN_MOSART_CISM2%NOEVOLVE_SWAV
Period: 2015-2099, SSP-3.70 scenario

Increasing the roof albedo is more effective at cooling than increasing wall and road albedo.

CUHII reduction:

- 0.01 Roof albedo -> ↓ 0.009 ˚ C
- 0.01 Wall albedo -> ↓ 0.004 ˚ C
- 0.01 Imprevious road albedo -> ↓ 0.001 ˚ C

Heat is trapped in the urban canyon.



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Implications for urban design and planning

- Give priority to increase roof albedo than other urban surface;
- Give priority to increase albedo in tall building districts;
- White roof is not an universal strategy for mitigating urban heat;
  - Be cautious about wintertime heating in high latitude regions;

Looking forward

- Transient albedo under different SSP scenario to mitigate urban heat;
- Combined effects of transient urban and transient albedo to balancing urban land changes and surface energy;

Thank you! Comments & questions?

Contact us!: yuan.sun@manchester.ac.uk, zhonghua.zheng@manchetser.ac.uk, oleson@ucar.edu