Progress in Urban Model Development

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What is the purpose of an urban model in CCSM?

- Provide climate and climate-change information (e.g., air temperature, humidity, surface hydrology, diurnal temperature range, extremes, etc.) for cities (where the majority of people live and work).

Urbanizing CLM (CLMU)

Gridcell

Landunits



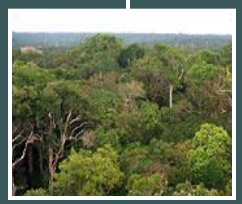


Glacier **Wetland** **Vegetated** **Lake** **Urban**

Columns

Soil Type 1

PFTs

Urbanizing CLM (CLMU)

Gridcell

Landunits

Glacier

Wetland

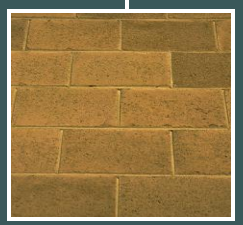
Urban

Lake

Vegetated

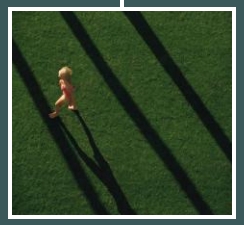
Columns/PFTs

Roof



Sunlit Wall

Shaded Wall



Pervious

Impervious

Canyon Floor

Density Classes

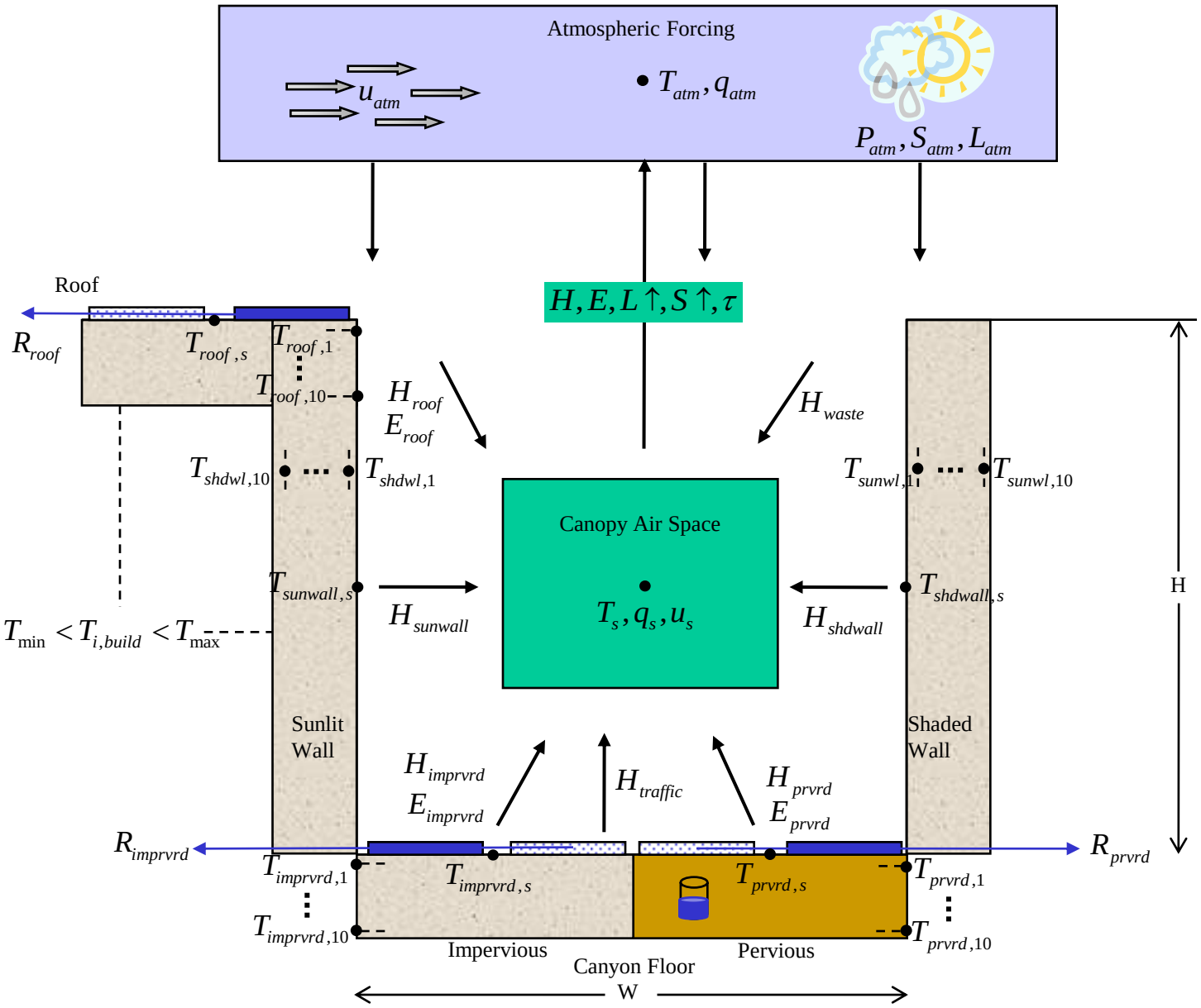
TBD

HD

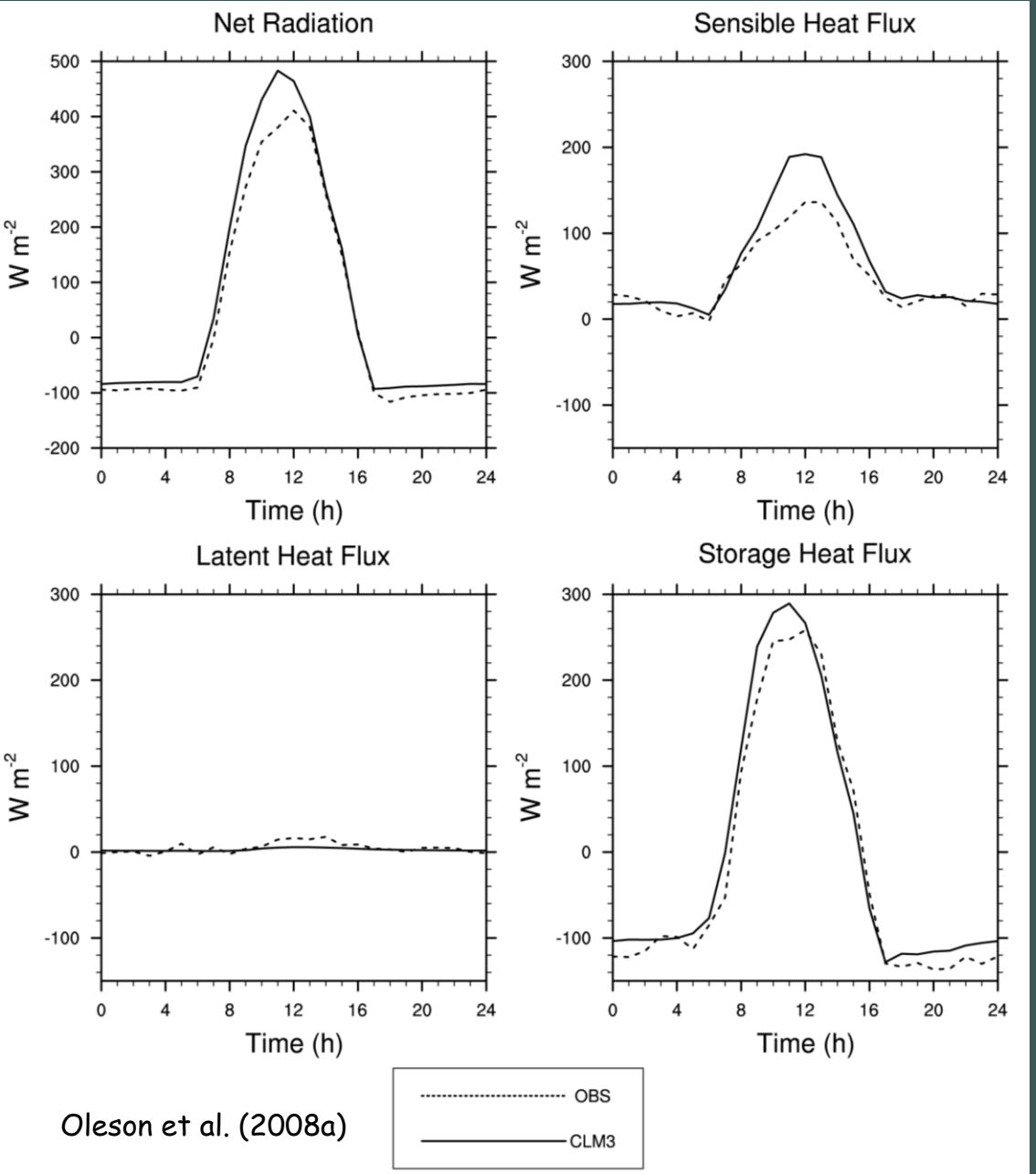
MD

LD

Urban Canyon Approach



Simulated energy balance – Mexico City



Oleson et al. (2008a)

Average diurnal cycle of simulated and observed heat fluxes for the Mexico City site (Me93) for Dec 2-7, 1993

Key features

- Diurnal cycle is well represented
- Simulated net radiation is too high (model ignores pollution), which drives high sensible heat
- Negligible latent heat flux
- Large storage heat flux

Observations from Oke et al. (1999)

More Information on CLMU

- Model description and performance for two cities:

Oleson, K.W., G.B. Bonan, J. Feddema, M. Vertenstein, and C.S.B. Grimmond, 2008a: An urban parameterization for a global climate model. 1. Formulation and evaluation for two cities, *J. Appl. Meteorol. Clim.*, 47, 1038-1060.

- Sensitivity to parameters and characteristics of the simulated heat island:

Oleson, K.W., G.B. Bonan, J. Feddema, and M. Vertenstein, 2008b: An urban parameterization for a global climate model. 2. Sensitivity to input parameters and the simulated urban heat island in offline simulations, *J. Appl. Meteorol. Clim.*, 47, 1061-1076.

CLMU – Current Status

- Runs globally within CLM (pre-CLM4 science branch tag), thanks to Eric Kluzek.

- Global urban datasets from KU (J. Feddema, T. Jackson) now being evaluated.

Model input requirements

- Fractional area of city

- Urban Morphology
  - Building height
  - Height to width ratio of canyon
  - Roof fraction
  - Vegetated (pervious) fraction

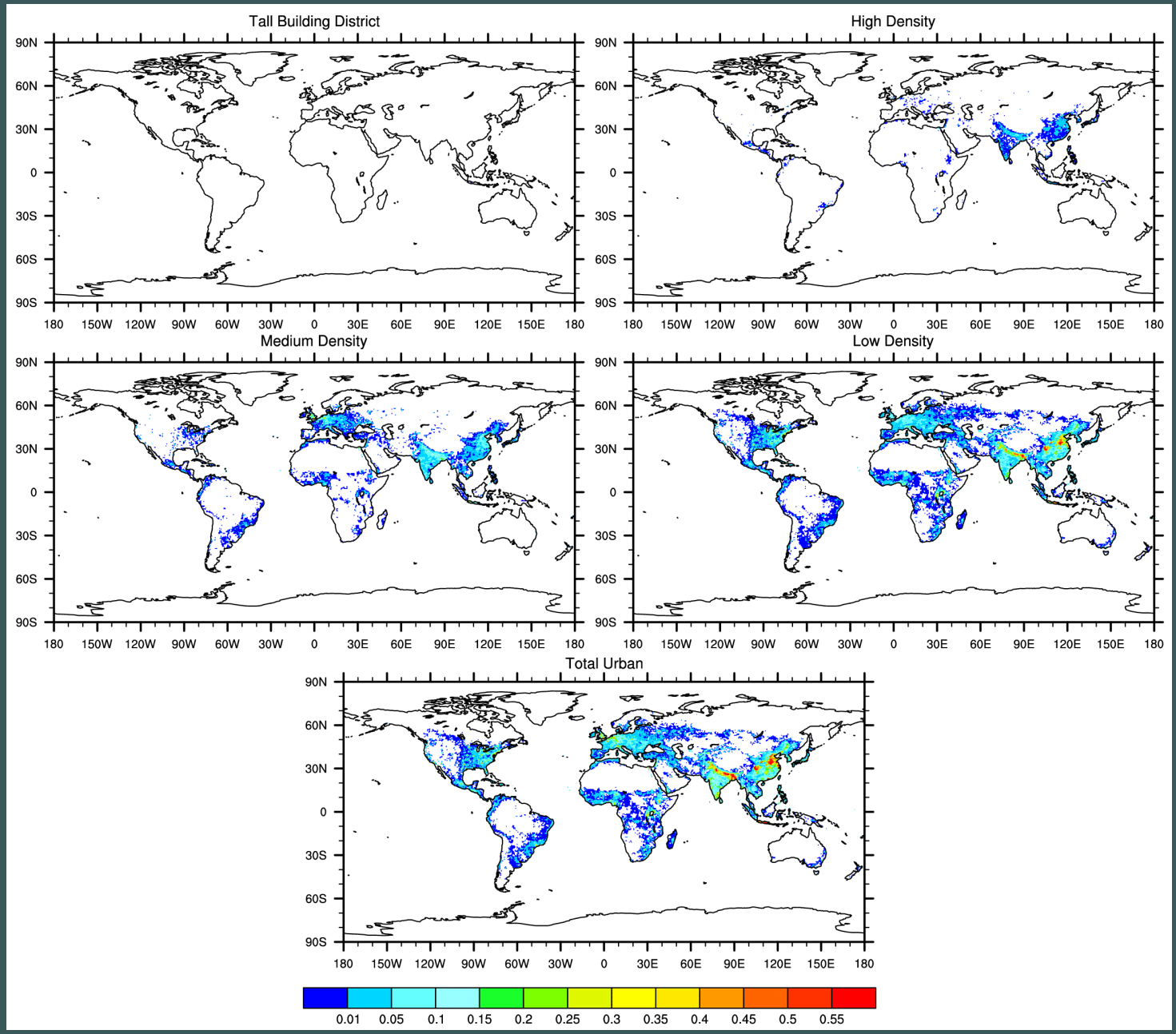
- Thermal/radiative properties of building materials
  - Emissivity
  - Albedo
  - Thermal conductivity and heat capacity

Global Urban Datasets

Urban Class	H/W	Building Heights (m)	Vegetative Fraction (%)	Population Density (km2)	Typical Building Types
Tall Building District (TBD)	4.6	40-200+	5-15	14,000 – 134,000+	Skyscrapers
High Density (HD) Residential/ Commerical/ Industrial	1.6	17-45	15-30	5,000 – 80,000+	Tall apartments, office bldgs, industry
Medium Density (MD) Residential	0.7	8-17	20-60	1,000 – 7,000	3-5 story apartment bldgs, row houses
Low Density (LD) Residential	0.5	3-8	50-85	250 – 2,000	Wood frame or corrugated metal homes

T. Jackson 2007

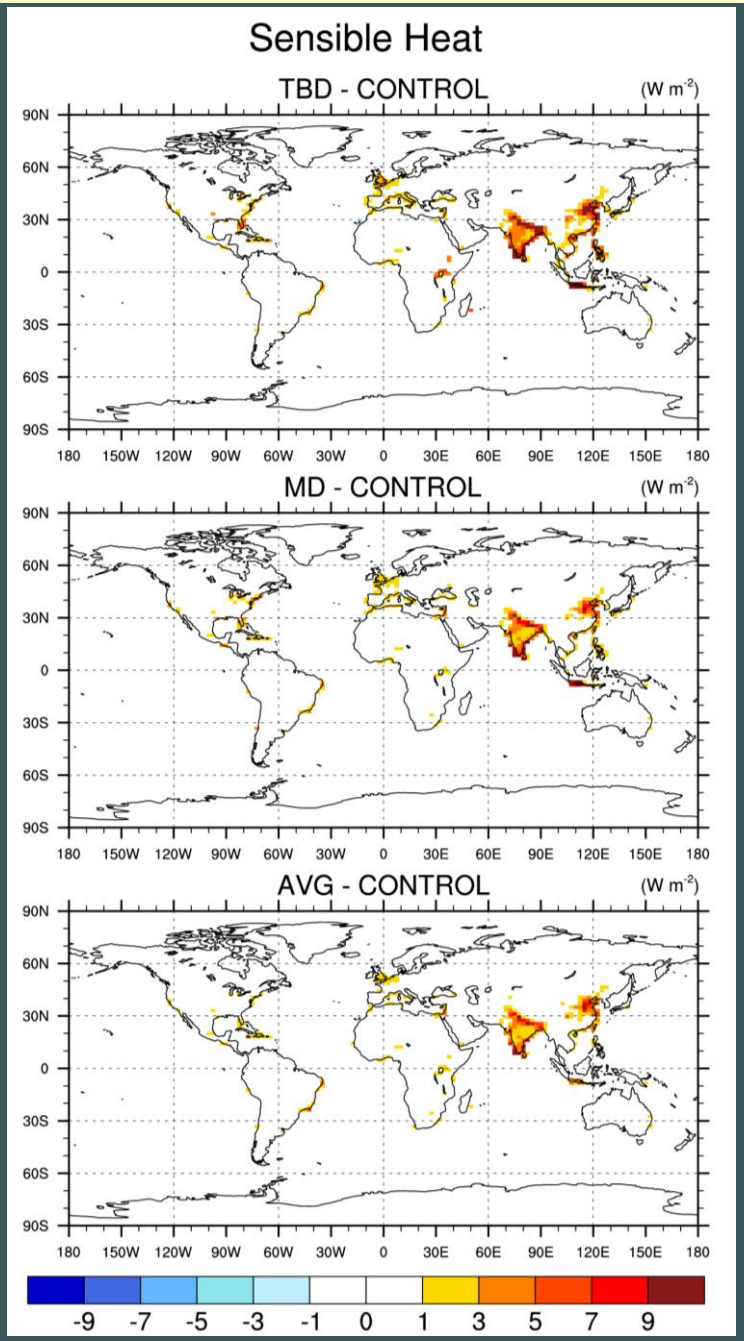
Urban Fraction at 0.5°



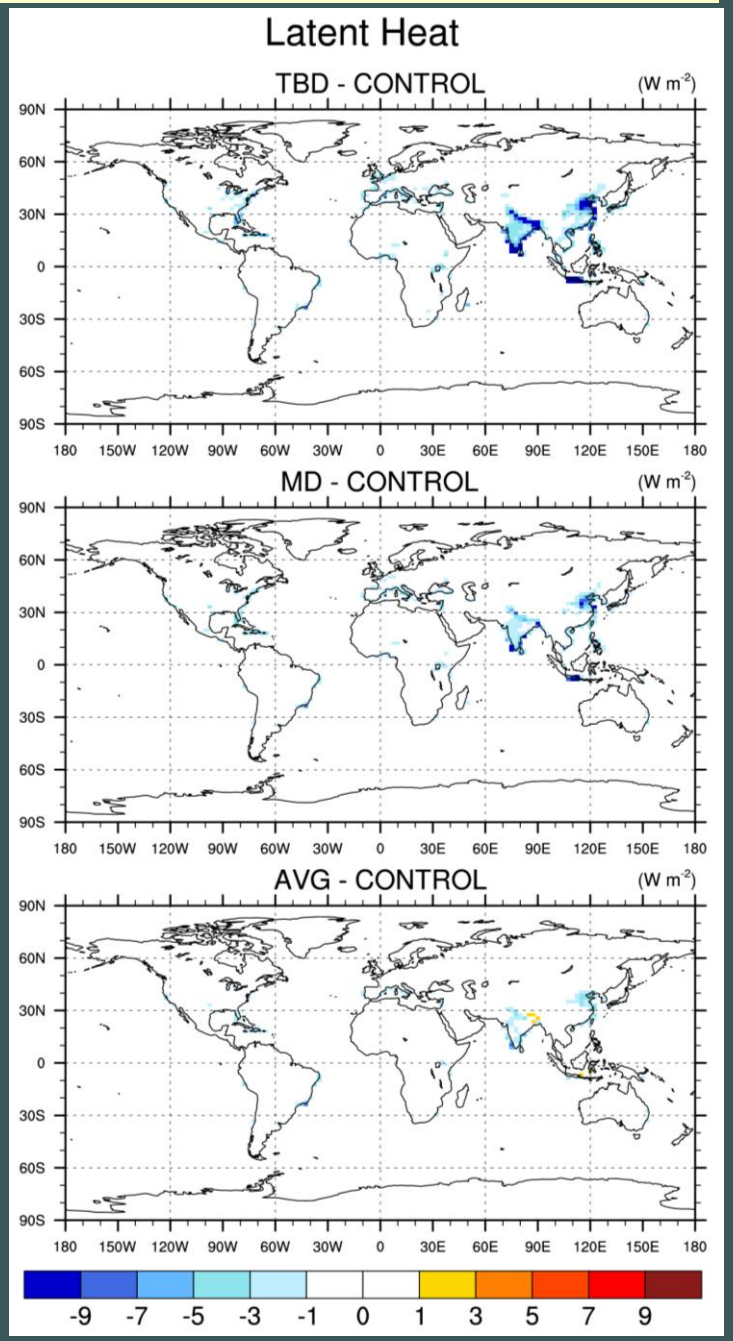
Exploratory Global Simulations

- Objectives
  - Verify CLMU can operate with spatially explicit urban fraction and TBD, HD, MD, and LD parameter sets
  - Explore differences between parameter sets.
  - Explore effects of averaging (i.e., a single urban landunit with parameters averaged over density classes).
- Methods
  - Combine TBD, HD, MD, and LD urban fractions into total urban fraction
  - Simulation with same city everywhere (Vancouver parameters)
  - Simulation with each parameter set, including average (AVG)
  - Prescribed atmosphere (Qian et al. 2006), FV1.9x2.5, no anthropogenic heat fluxes

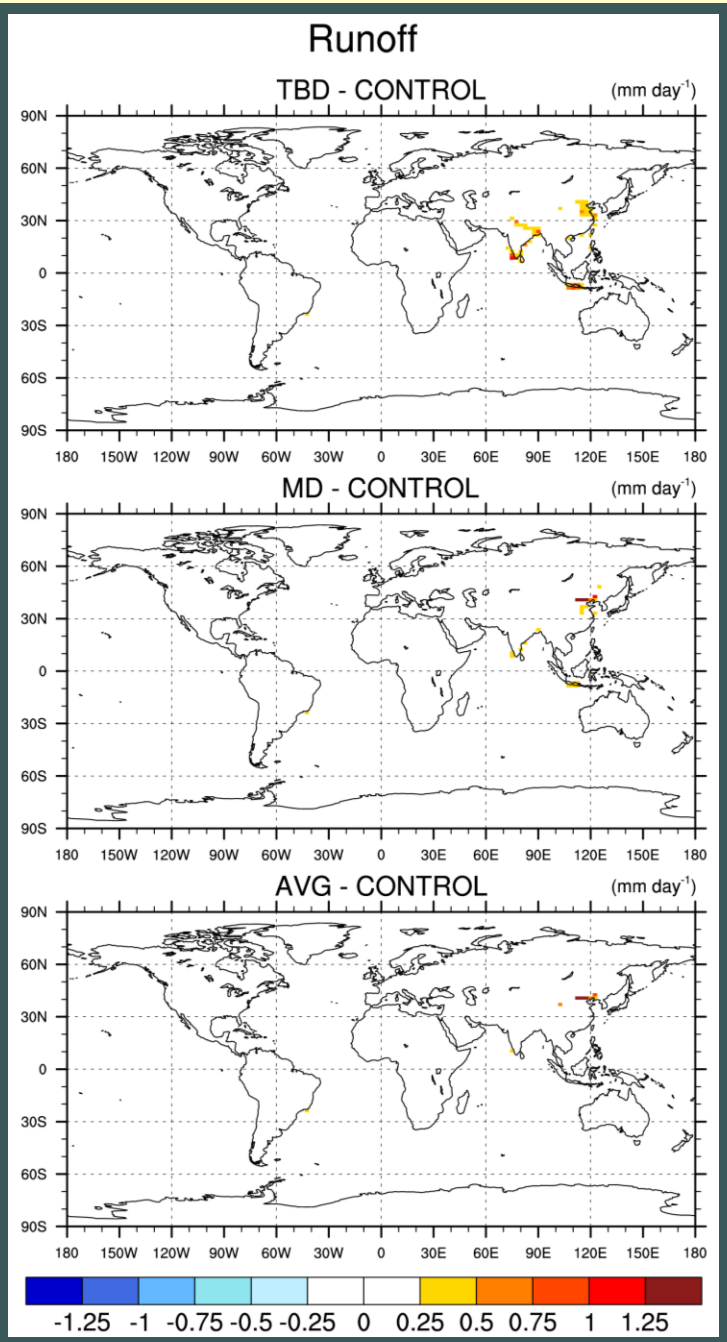
Urban Effects on Grid-Averaged Variables



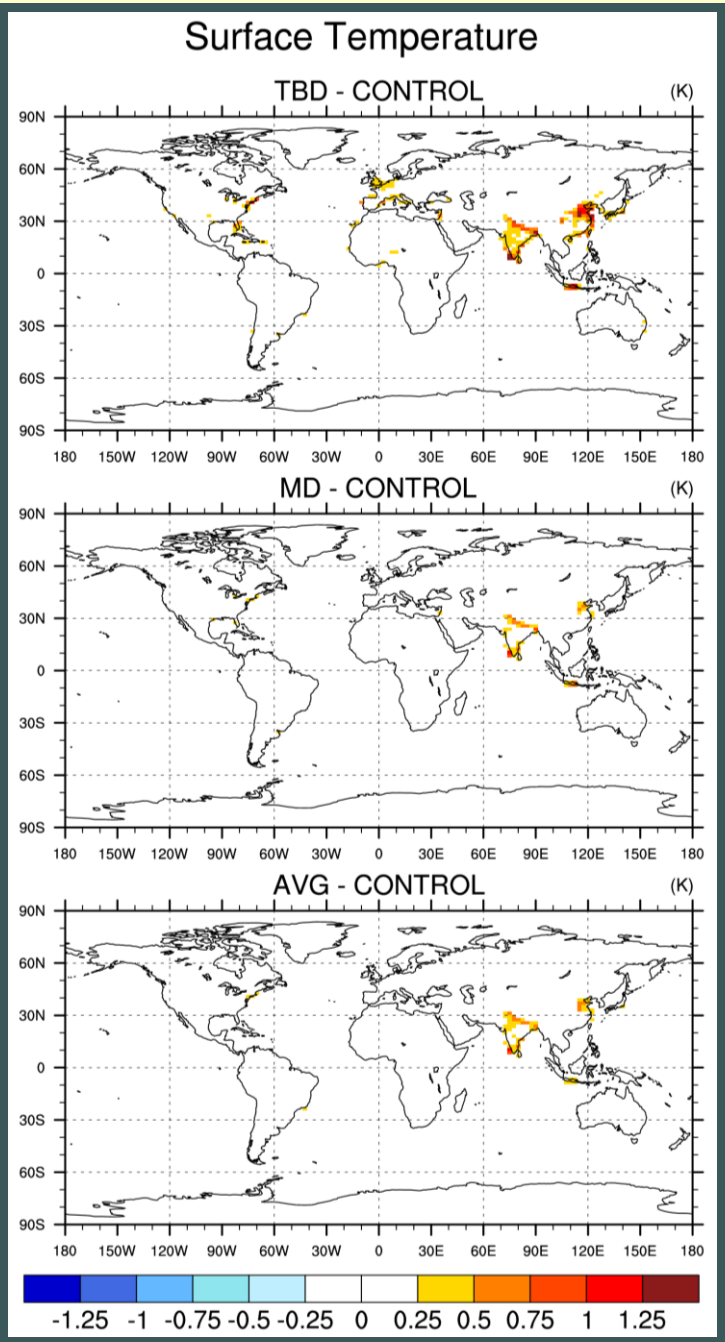
Annual Average



Urban Effects on Grid-Averaged Variables

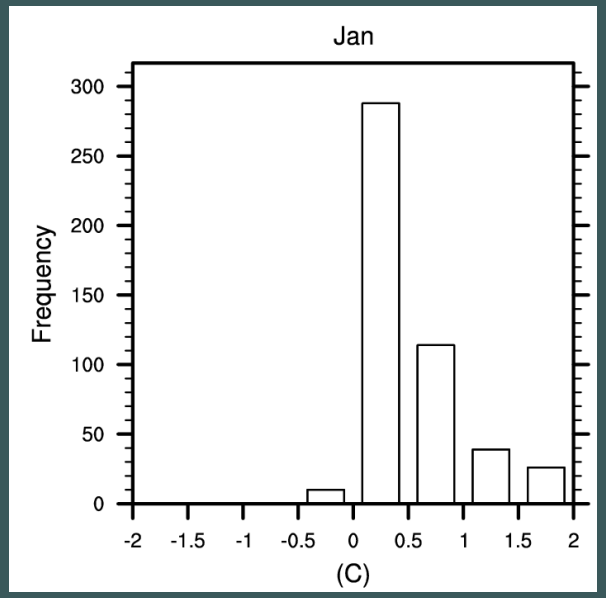


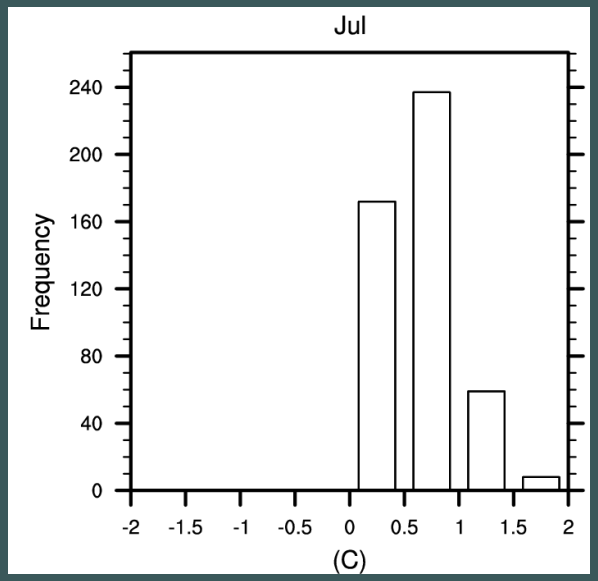
Annual Average



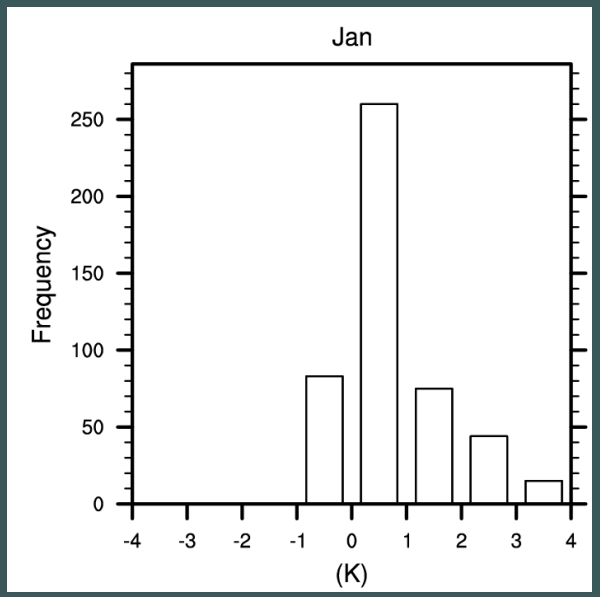
Urban Minus Rural (AVG Parameters)

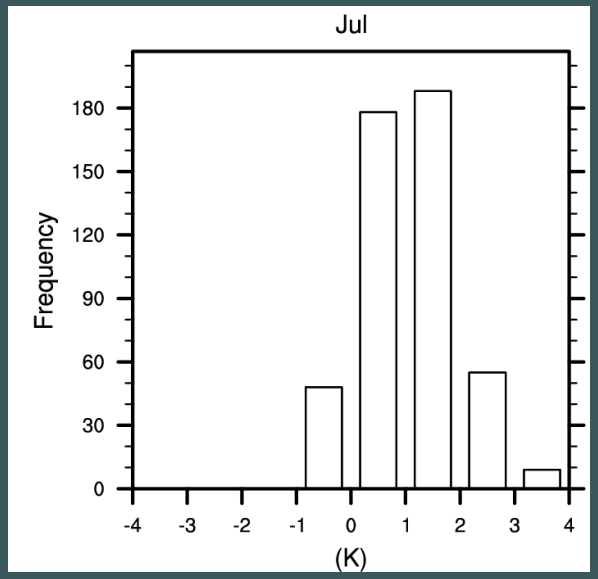
2m Air Temperature





Surface Temperature

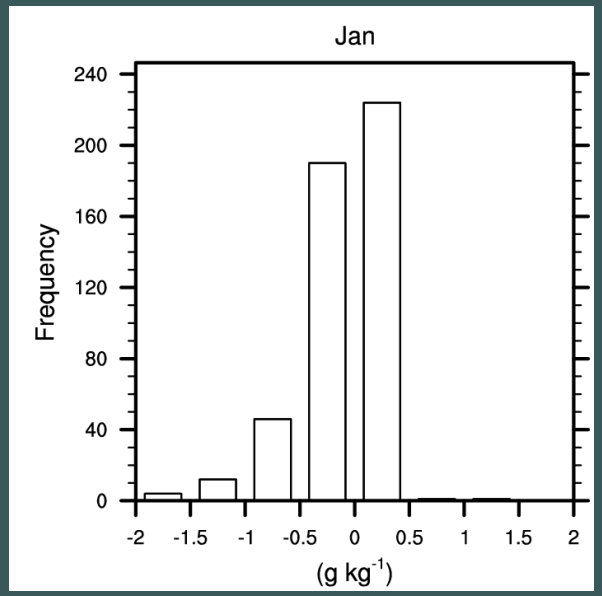


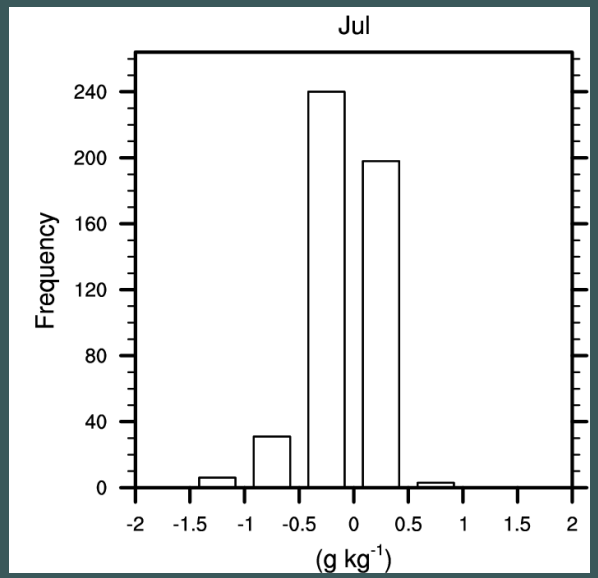


"Rural" is average over non-urban pfts within gridcell, excluding lake, wetland, glacier

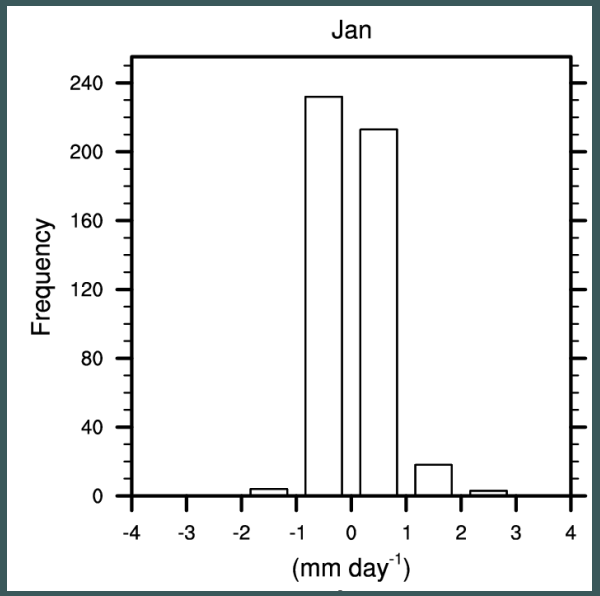
Urban Minus Rural (AVG Parameters)

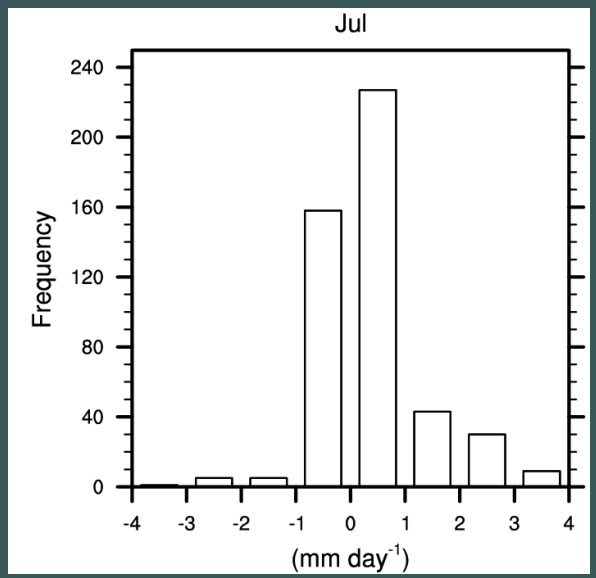
2m Specific Humidity





Runoff





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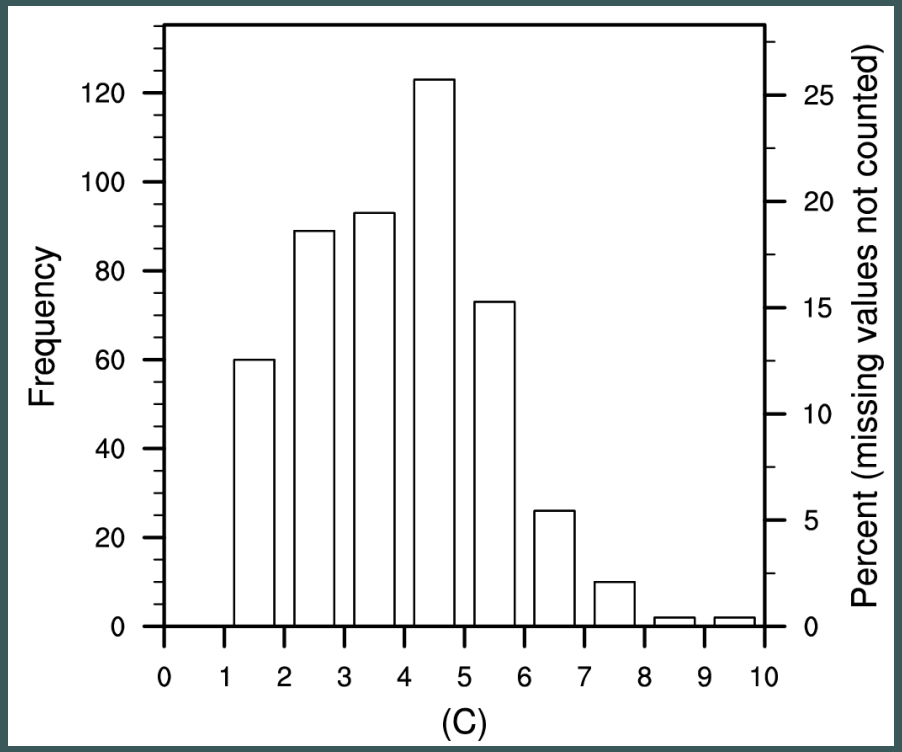
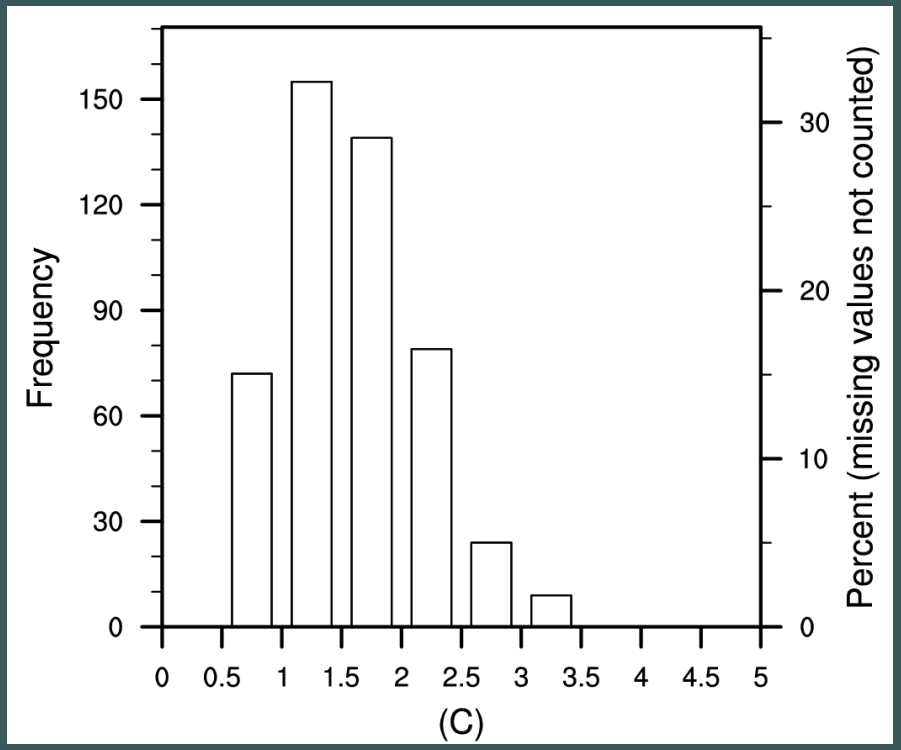
Heat Island (AVG Parameters)

Maximum Annual Heat Island



Daily Average of Maximum Heat Island



Tasks

- Continue to investigate CLMU behavior with global datasets
- How many urban landunits? Recommend one for now using averaged parameters.
- Conversion of urban input datasets into standard CLM dataset format with ability to be aggregated to any resolution
- Modify surface data creation so that urban replaces bare soil preferentially
- Coupled simulations
- Further evaluation with observed data