Auto-generated Building Energy Models (AutoBEM) of Urban Morphologies and Analysis of Microclimate Interaction

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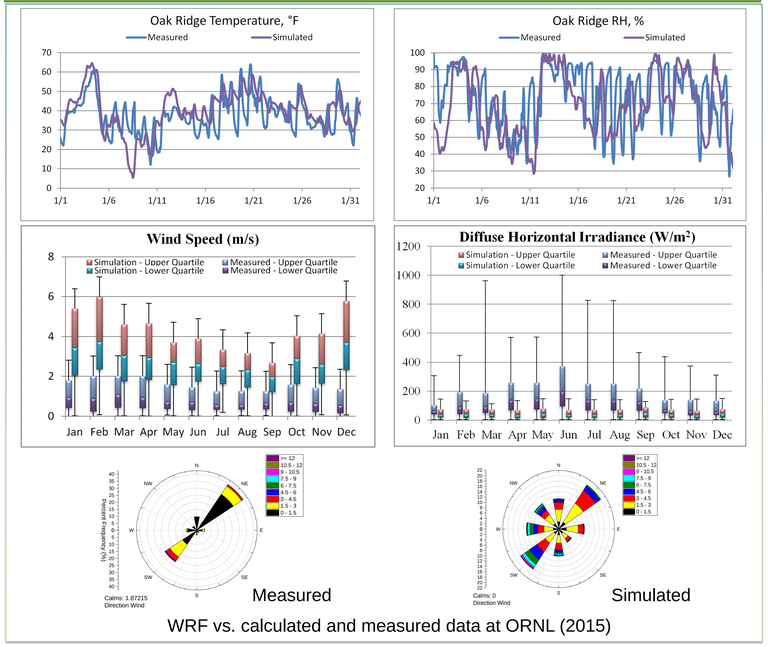
Objectives

- Understand and quantify microclimate effects on building energy consumption using different urban morphologies.
- Validation of Weather Research and Forecasting (WRF) simulation model data compared to first principles, measured data and impact on building energy use.

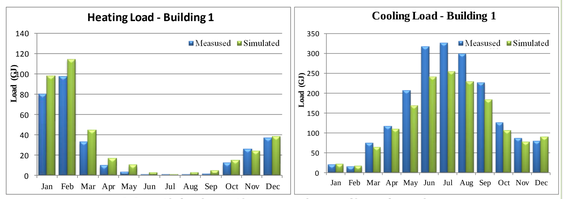
Background

Weather data comparison



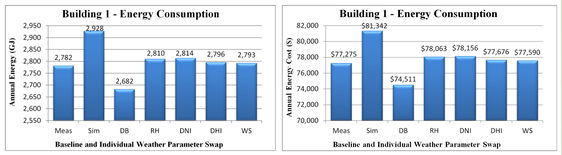
WRF vs. calculated and measured data at ORNL (2015)

Energy simulation results



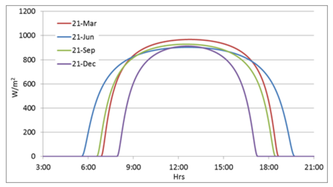
Monthly heating and cooling loads

Hourly heating and cooling loads



Weather + Modeling Resources

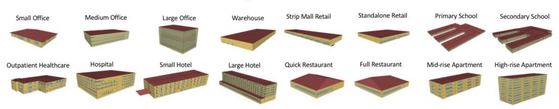
Weather station at ORNL



ASHRAE Clear Sky Model's predicted beam normal irradiance for ORNL Campus

- Automatically generate OpenStudio and EnergyPlus energy models from GIS data.
- Use custom geometry along with prototypical building model from OpenStudio-Standards measure to construct a fully articulated building energy model.
- 2,717-page I/O reference manual for EnergyPlus allows detailed analysis from these models

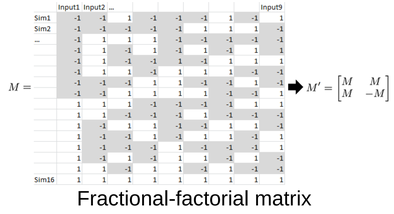
Sensitivity Analysis All Buildings and Locations



	Restaurant	Hospital	LargeHotel	LargeOffice	MediumOffice	MidriseApartment	OutPatient	PrimarySchool
#Inputs	49	227	110	85	81	155	470	166
#Groups	41	117	64	37	30	73	255	93

	QuickService	SecondarySchool	SmallHotel	SmallOffice	Stand-aloneRetail	StripMall	SuperMarket	Warehouse	TOTAL
#Inputs	53	231	281	71	59	113	78	47	2,276
#Groups	44	108	132	52	46	79	69	37	1,064

- World's fastest building creator: Using the fractional-factorial design and efficient OpenMP code, we generated 155,793 unique building files in only 2.6 minutes with an uncompressed size of 35.4GB.
- World's fastest buildings simulator: Simulated all 16x DOE reference buildings, 16x climate zones, and 3x vintages using the Wrangler supercomputer at the Texas Advanced Computing Center and the Titan supercomputer at Oak Ridge National Laboratory.



Fractional-factorial matrix

Summary

- Multiple data sources were fused to create building energy models and WRF building models for buildings on the Oak Ridge National Laboratory campus.
- Titan was used to simulate ORNL buildings and results of real data, simulation, and geometry are made available for interaction on the web.
- The current high-resolution WRF model output shows significant differences with hourly, monthly, and annual measured data and the ASHRAE Clear Sky model (first principles for maximum possible irradiance).
- DOE's flagship whole-building simulation tool, EnergyPlus, were used to assess impact of these differences on 3 typical building types.
- Individual simulated weather variables were injected into measured data to assess the variable-by-variable impact on whole-building annual energy consumption.
- Developed and extended framework to semi-automatically generate prototypical buildings, apply fractional factorial design of experiments to perform sensitivity analysis, and parallelize runs of EnergyPlus simulations on leadership class supercomputing.

Urban Dynamics Institute, Oak Ridge National Laboratory · Climate Change Science Institute, Oak Ridge National Laboratory · Oak Ridge National Laboratory, Building Technologies Research and Integration Center

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