4.401/4.464 Environmental Technologies in Buildings

Christoph Reinhart

L01 Course Introduction | Energy Use in Society

Massachusetts Institute of Technology
Department of Architecture
Building Technology Program

SUSTAINABLE DESIGN LAB

"Our goal is to change current architectural design and urban planning practice by developing, validating and testing workflows and metrics that lead to improved building and neighborhoods regarding resident comfort and resource efficiency."

Course Description

The primary focus of this course is the study of the thermal, luminous, and acoustic behavior of buildings.

The course examines the basic scientific principles underlying these phenomena and introduces students to a range of technologies and analysis techniques for designing comfortable indoor environments.

Students will be challenged to apply these techniques and explore the role light, energy, and sound can play in shaping architecture.

At the end of the course you will be able to ...

- ❑ understand and apply the scientific principles underlying the thermal and luminous behavior of buildings,
- ❑ learn to evaluate the pros and cons of a range of technologies for creating comfortable indoor environments,
- ❑ conduct a series of design analysis workflows regarding climate, building energy use, and daylighting,
- ❑ acquire the knowledge required to critically discuss/present the environmental concept of a building.

Educational Approach

- Balance between physical principles and design analysis techniques for a more evidence-based design approach.

- We will be covering an enormous field. Are there any specific topics of interest? Just ask!

My goal is to give you the skills that you need to design resource-efficient buildings with high occupant satisfaction.

Mechanics

- Weekly lectures on Mondays and Wednesdays from 11.00 to 12.30.
- Friday lab from 10.00 to 11.00 for 4.464 and 11 to noon for 4.401.
- My availability: After class and by appointment.

Course Requirements

- ❑ Attendance at all lectures and workshops is mandatory.
- ❑ All assignments have to be submitted in time. Late assignments will not be accepted.
- ❑ Preparation of 20-minute in-class group presentation on one of this year's AIA Cote Top Ten Projects.
- ❑ Present a group course project in class on (4.401) or during exam week (4.464).
- ❑ Active participation in class discussions.
- ❑ Participation in Simulation Game.

Course Evaluation

- Quality and timely submission of completed assignments (45%).
- Course project presentation (30%)
- Case study presentation (15%).
- Participation in class discussions (10%).

Course Project

The course project will be to develop and present an environmental concept for a medium-sized office building/innovation space in Seattle, Chicago, or Houston. Project presentations should include:

- ❑ Overall design approach and environmental features
- ❑ Daylighting, glare, and electric lighting analysis
- ❑ Thermal analysis and predicted energy use

AIA/COTE Top Ten Green Projects

2018 COTE TOP TEN

Albion District Library

One of the busiest libraries in Toronto, the Albion District Library serves a broad range of services to

2018 COTE TOP TEN

Georgia Tech Engineered Biosystems Building

This LEED Platinum Building is an innovative new model for research

2018 COTE TOP TEN

Mundo Verde at Cook Campus

Mundo Verde is a bilingual, sustainability-focused public

2018 COTE TOP TEN

The Renwick Gallery of the Smithsonian American Art Museum

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2018 COTE TOP TEN

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2018 COTE TOP TEN

Nancy and Stephen Grand Family House

Founded in 1981, Family House is a not-for-profit organization

2018 COTE TOP TEN

New United States Courthouse – Los Angeles

The New United States Courthouse in downtown Los

2018 COTE TOP TEN

Ortlieb's Bottling House

2018 COTE Top Ten Plus honoree. Faced with a growing firm and an increasing need for building and

2018 COTE TOP TEN

Sonoma Academy's Janet Durgin Guild & Commons

Embedded with maker/digital classrooms, productive gardens,

2018 COTE TOP TEN

Sawmill

Set in California's harsh Mojave Desert, Sawmill offers a new model for the sustainable single-

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Next week, we will form groups for the course project and AIA project presentations. Group sizes will depend on final enrollment numbers.

Simulation Game

Paper:

- C F Reinhart, T Dogan, D Ibarra and H W Samuelson, "Learning by doing - Teaching energy simulation as a game," *Journal of Building Performance Simulation,* October 2011.
- C F Reinhart, J Geisinger, M Saratsis and T Dogan, Building Simulation 2015 in Hyderabad, December 2015.

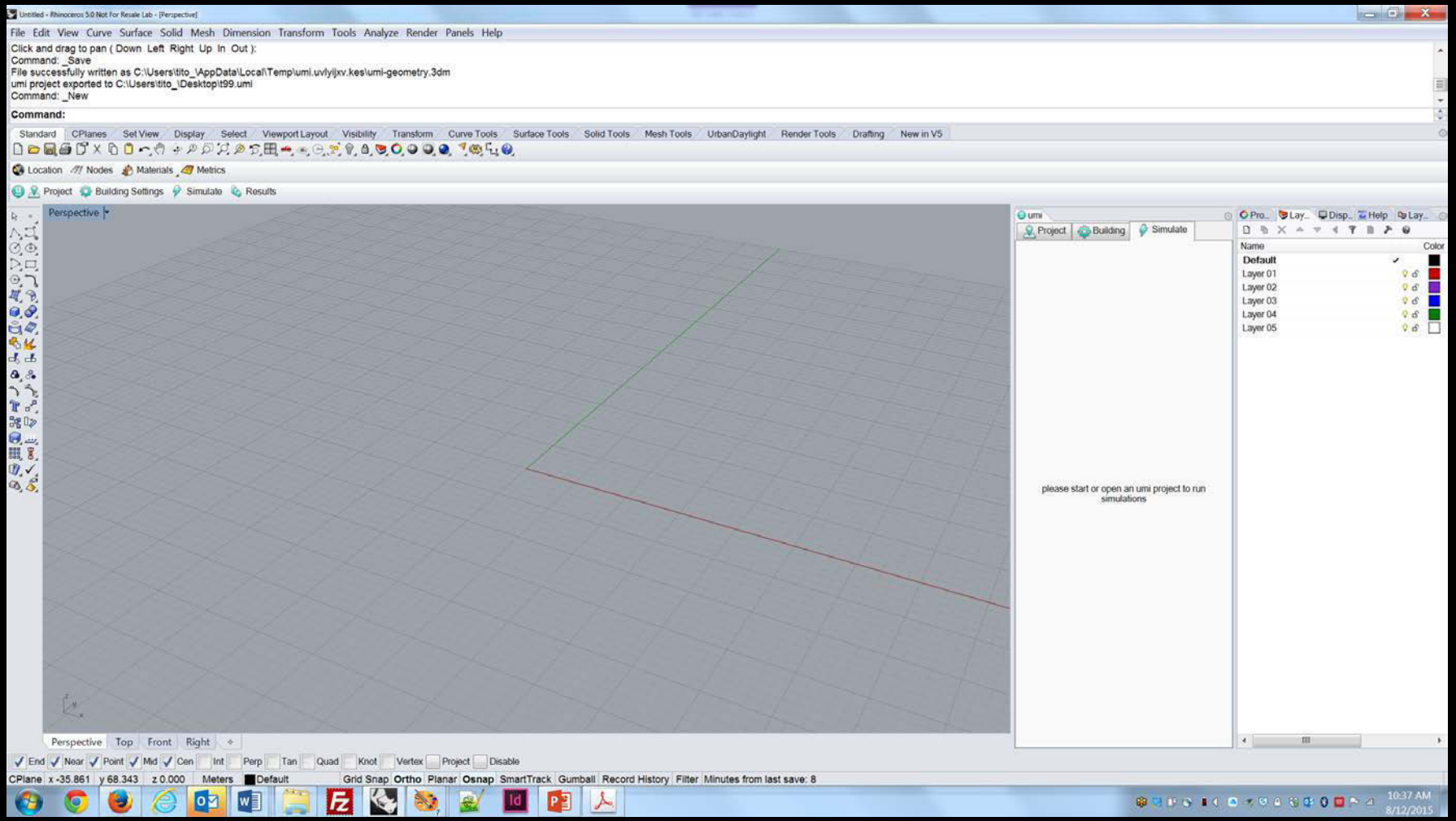
Resources

Course Software

You will be needing the following programs (latest version always):

- Rhinoceros3d
- DIVA4
- Climate Consultant

Workflows - Rhino



❑ Rhino and Grasshopper form the CAD backbone of all environmental analysis tools that we will be using in this class. You should ideally have a working version of Rhinoceros 5 or 6 installed on your laptop or workstations.

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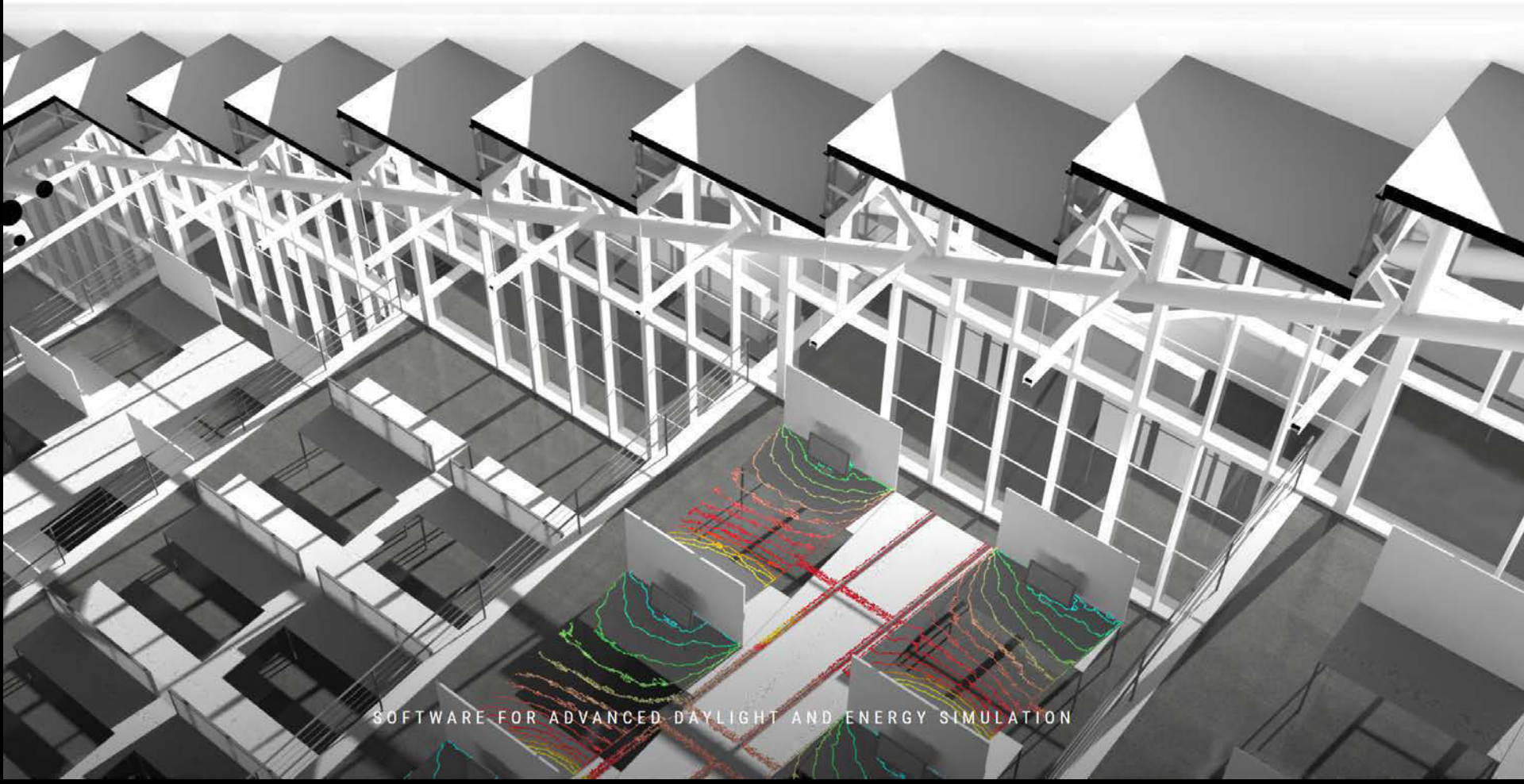
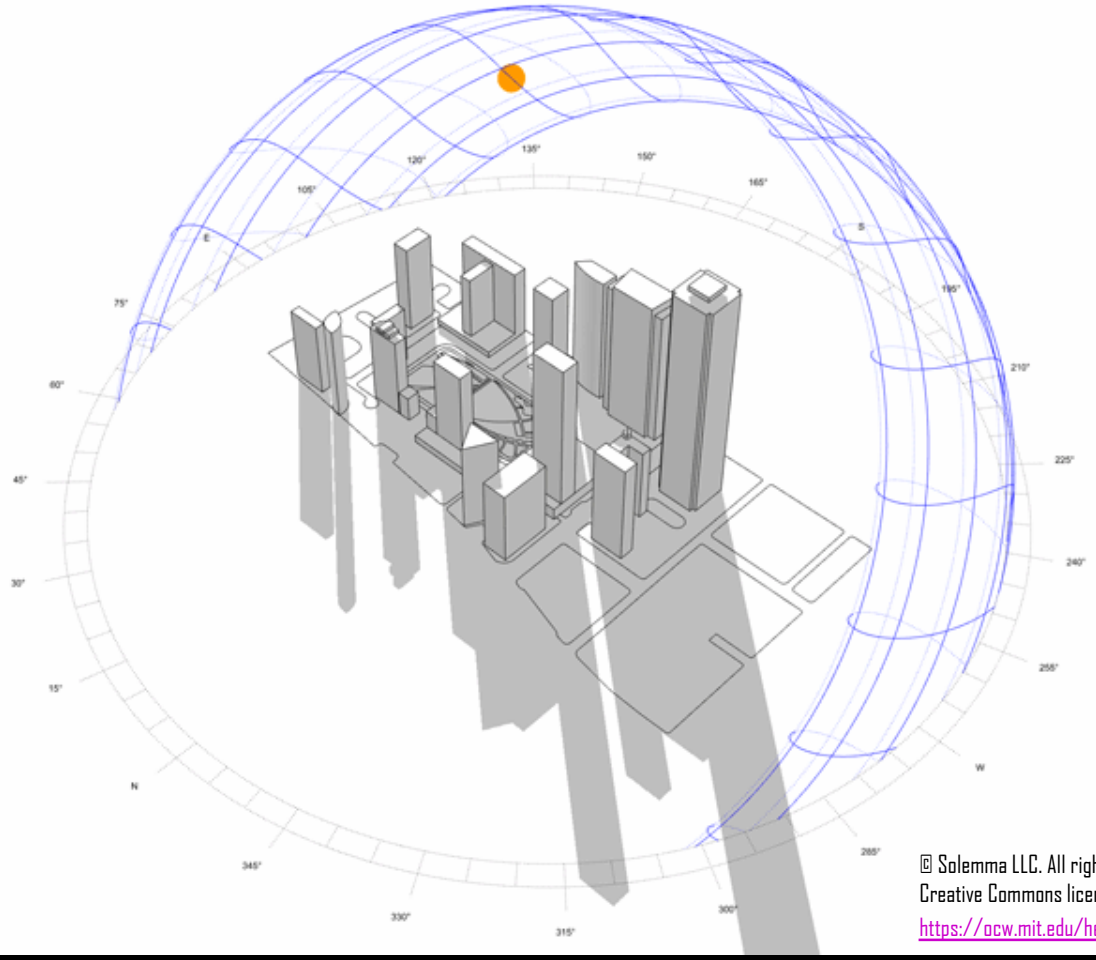


DIVA-for-Rhino is a daylighting and energy modeling plug-in for Rhinoceros 3D (www.Solemma.com). We will be using DIVA for assignments on solar radiation, daylighting and energy analysis. Students may request free licenses for their laptops from the Solemma web site or use DIVA on the MIT lab computers. Please note that you need a Windows Version of Rhino 6.0 or higher to run DIVA.

Diva Shading Analysis



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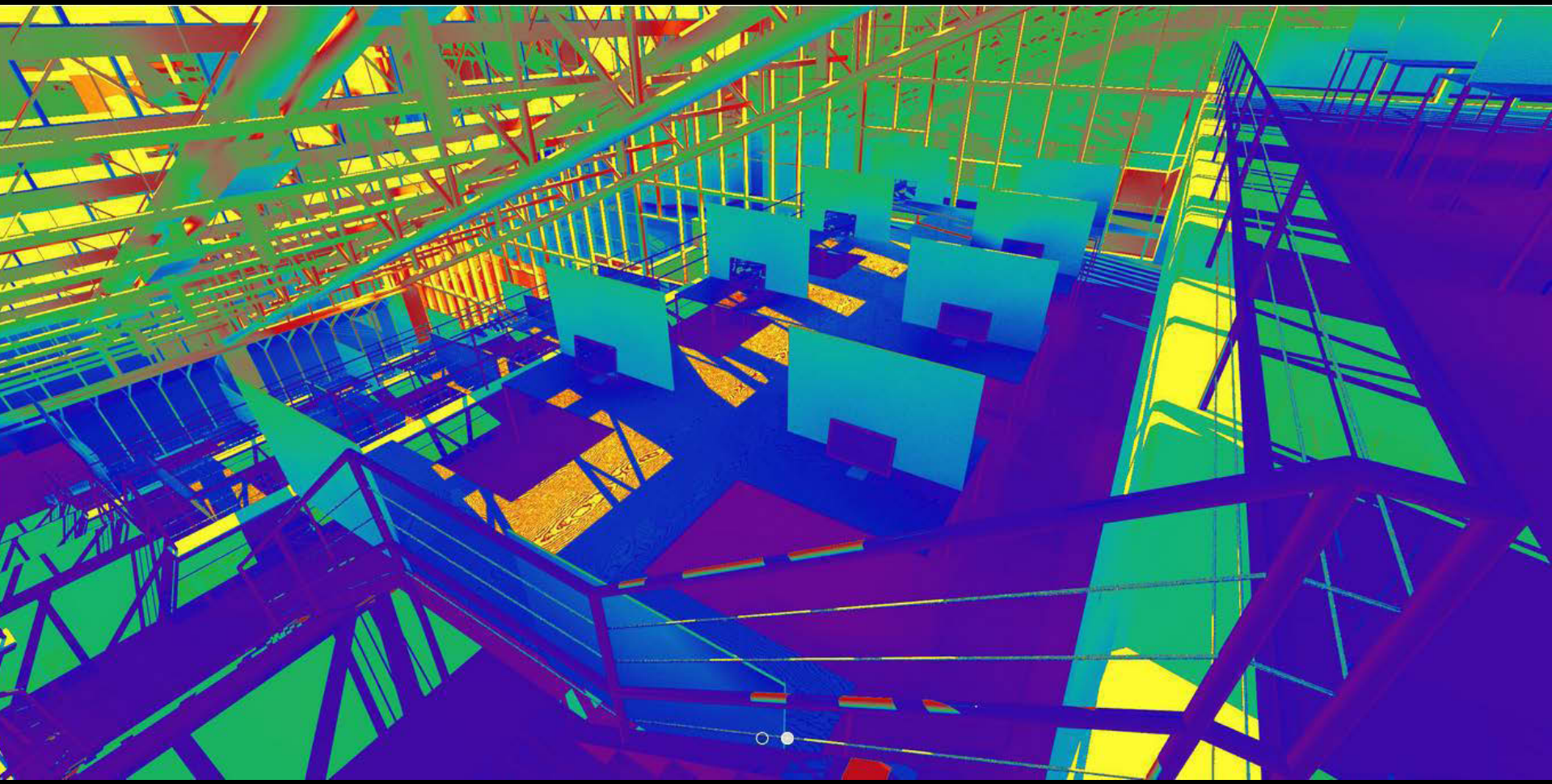
Diva Daylighting Analysis



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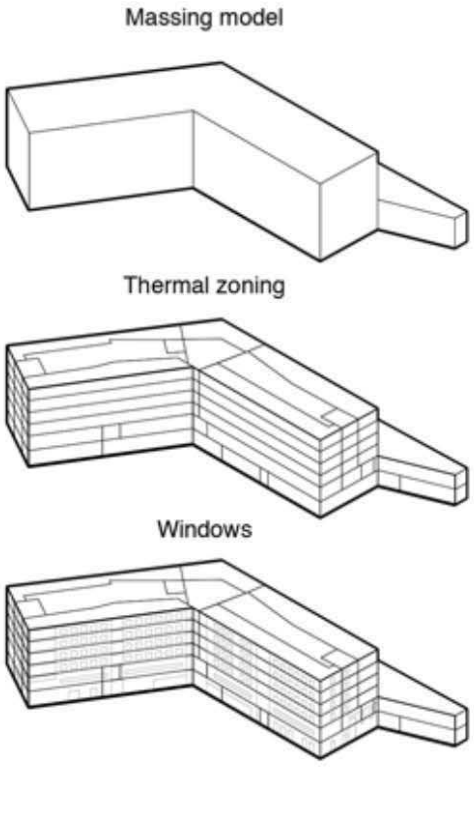
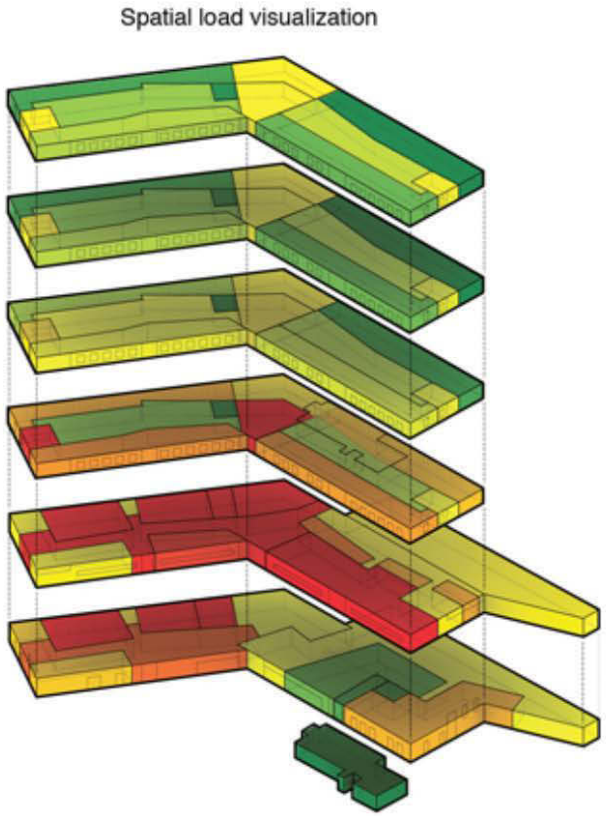
Thermal Analysis





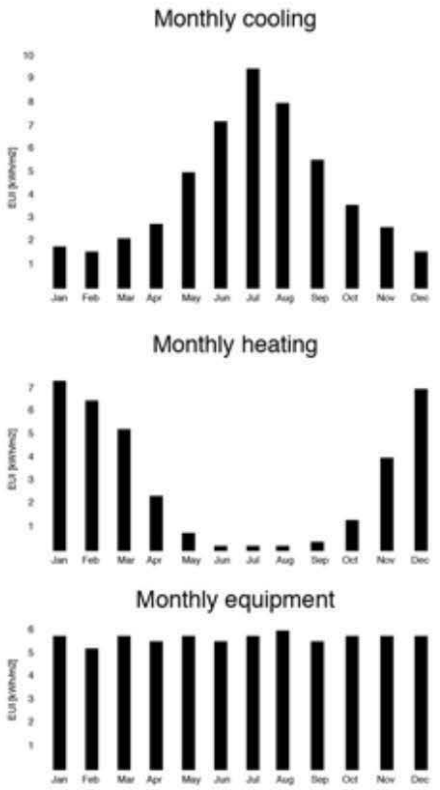


Image credits: Aiko Nakano, Denise Rivas, Manos Saratsis, Julia Sokol

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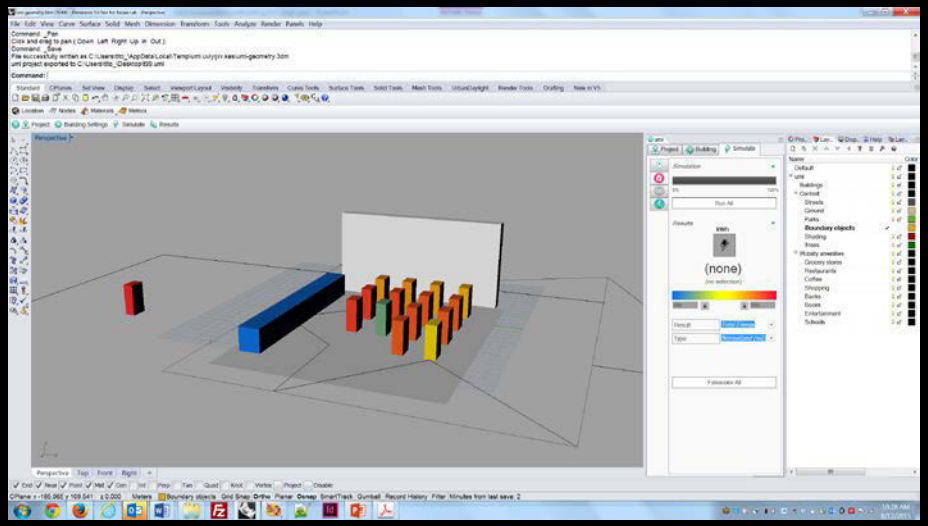
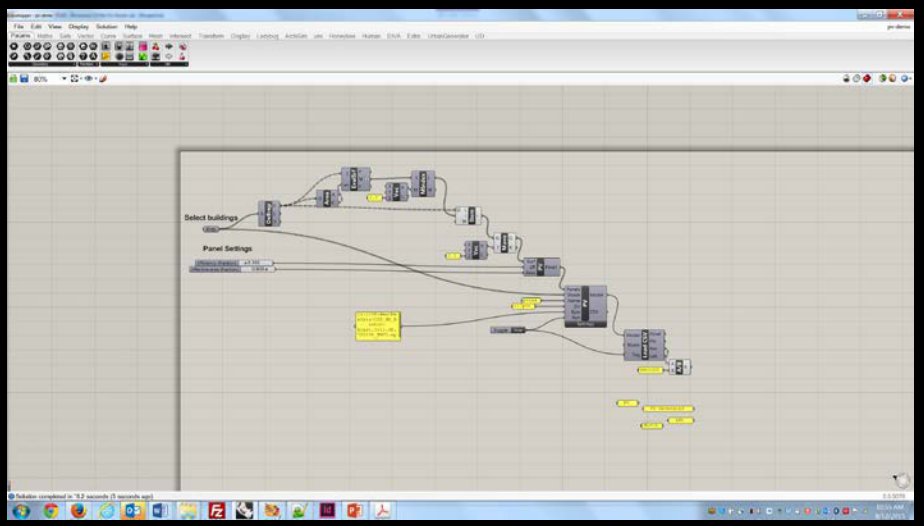
ArchSim is another Grasshopper plug-in that is part of DIVA 4 that supports detailed, dynamic, multi-zone thermal simulations using the US department of Energy's EnergyPlus whole building simulation engine.

Workflows - Grasshopper



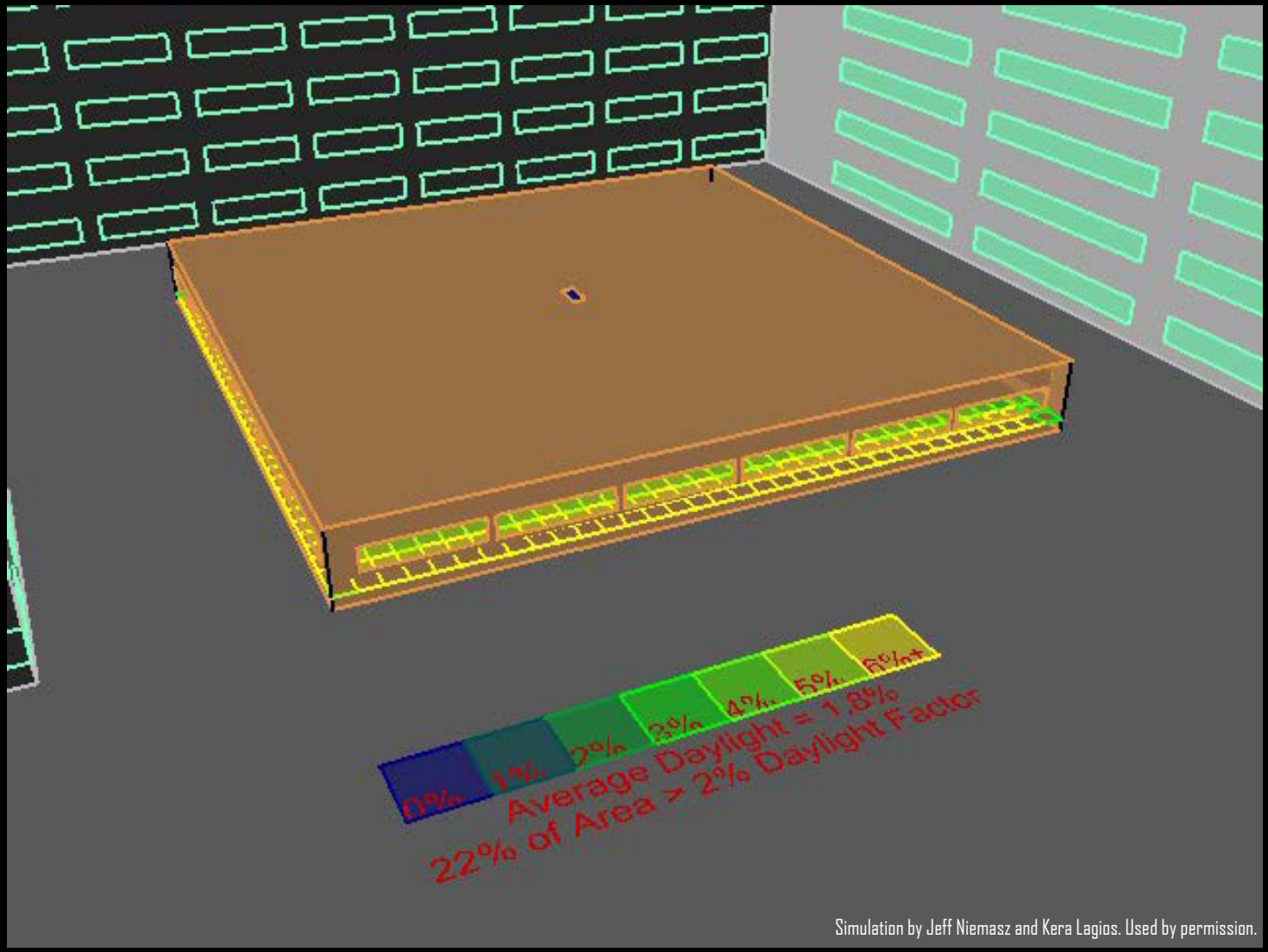
Rhino 3D



Grasshopper 3D

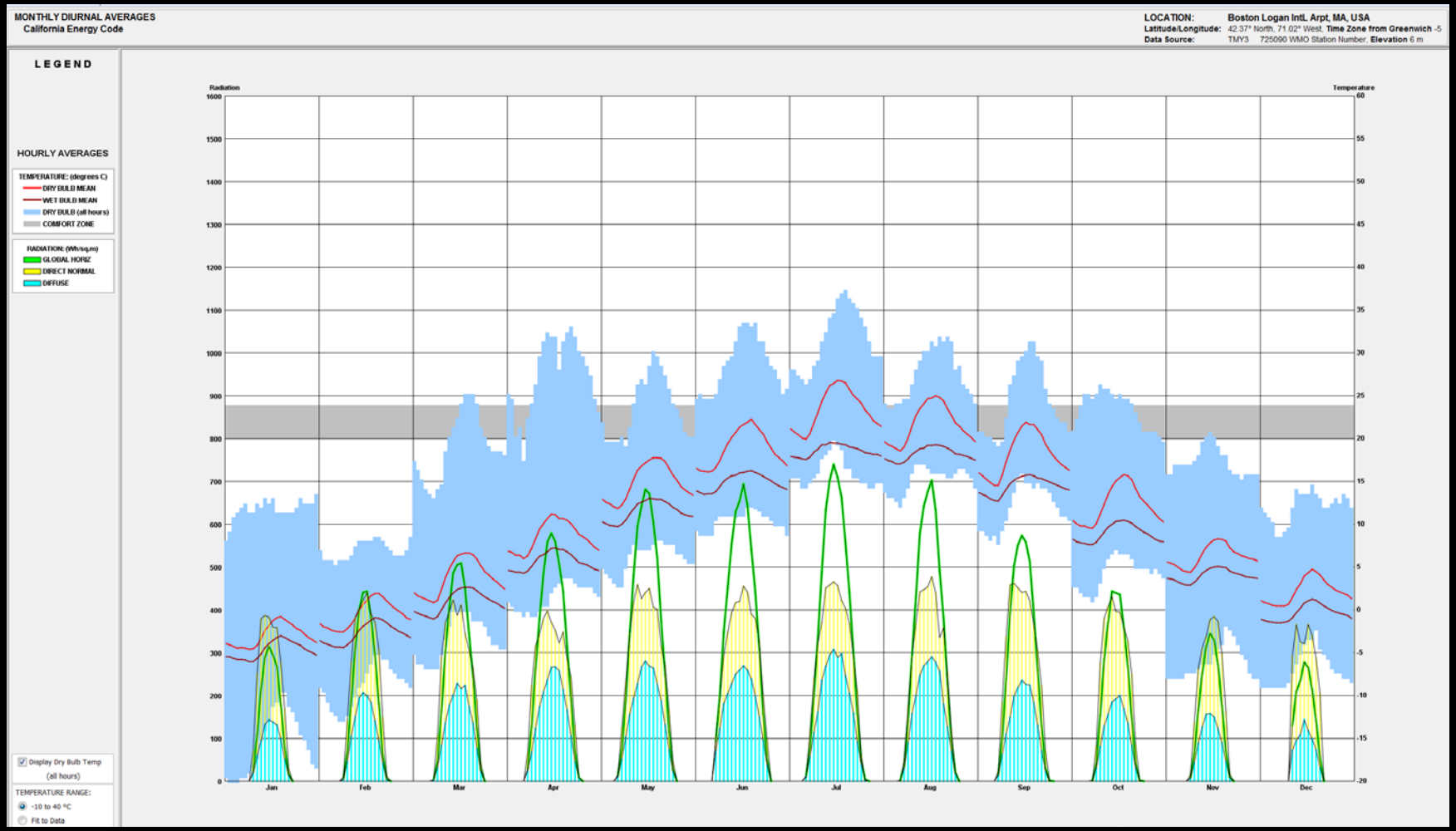
- Grasshopper3d is Rhino's visual scripting environment.

Animated Building Performance Simulation



Simulation by Jeff Niemasz and Kera Lagios. Used by permission.

Climate Consultant

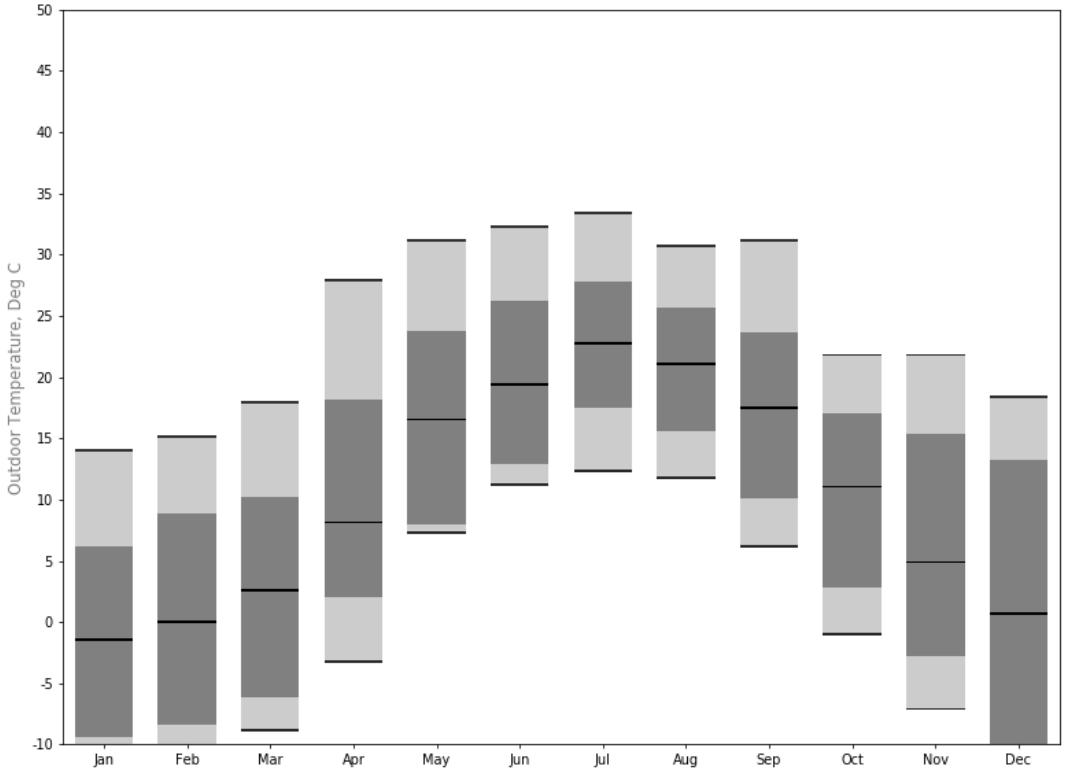


Clima+

CLIMA+

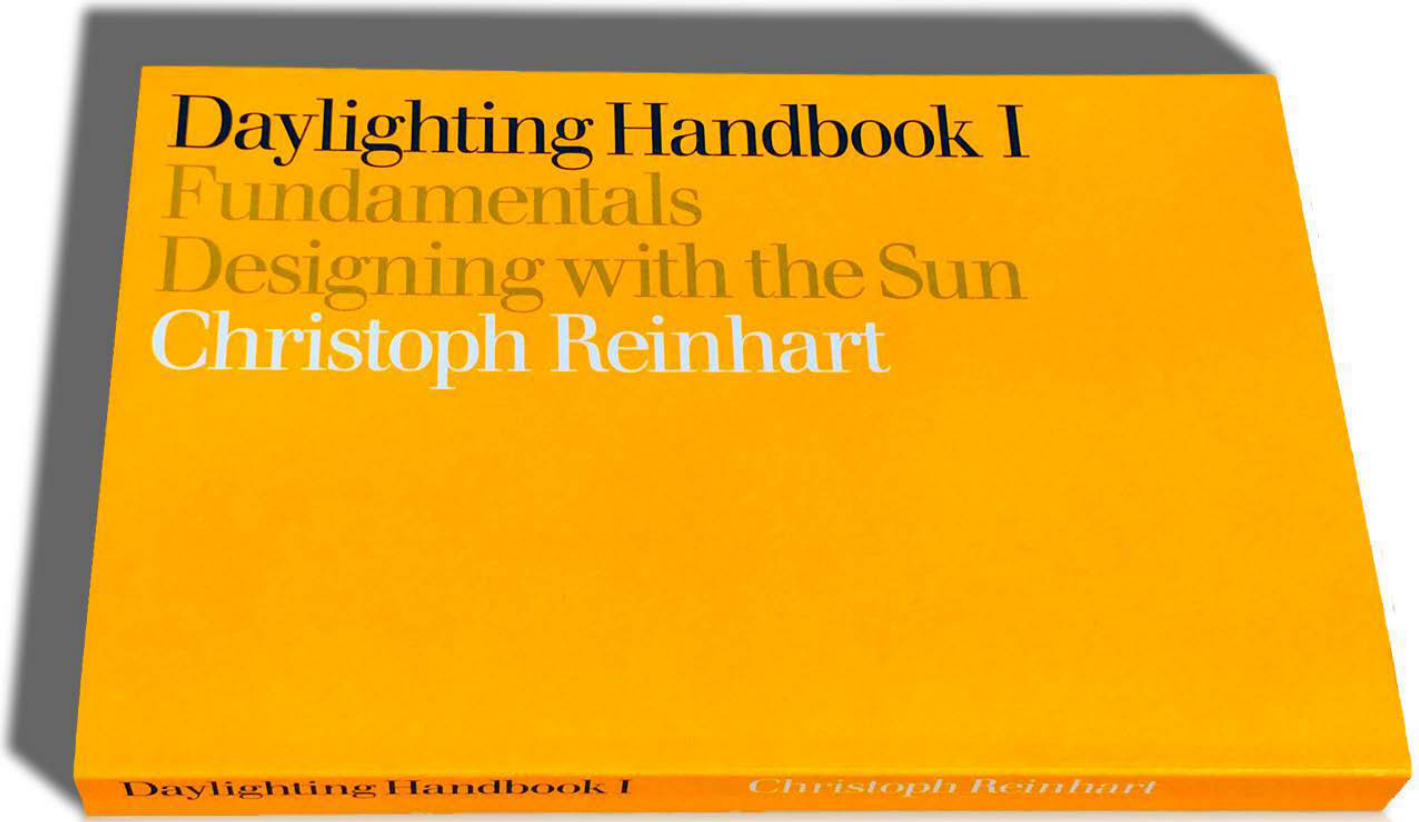
USA_MA_Boston-Logan

CZ4



SDLAB

Course Book



- Purchase on Amazon for $38 or directly from instructor for $20.

DIVA Tutorials

http://solemma.net/TrainingRhino.html

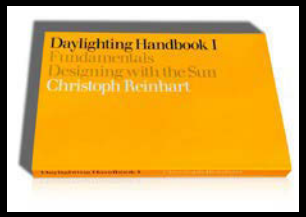
https://www.solemma.com/TrainingGH.html

Link to Studio

- Ultimately, it is up to you and your studio critic to implement sustainable design features in your projects.

- If you need help with your design projects there is a group of students in Building Technology who are prepared to help you. Some of the leading research on environmental building performance analysis is done at MIT. Make use of that knowledge.

This Week's Reading and Tutorials



Chapter 1: Introduction

DIVA RH 01: Visualizations

DIVA GH 01: Visualizations

Questions?

MIT OpenCourseWare
https://ocw.mit.edu/

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