

ASHRAE and IBPSA-USA SimBuild 2016: Building Performance
Modeling Conference

A Framework for Daylighting Optimization in Whole Buildings with OpenStudio

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Required Slides

[Where we tell you what's about to happen (and other administrivia).]

Learning Objectives

Attendees/survivors of this presentation will be able to:

- Understand the challenges of performing daylight simulations in a whole building energy context
- Locate OpenStudio measures and other tools that allow for large-scale daylighting analysis

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Acknowledgements

This work would not be possible without the support of the US Department of Energy's Buildings Technology Office (BTO).

In addition, several features of the Radiance Measure were developed for work under the Wells Fargo Innovation Incubator (IN²) project.

Agenda

- Existing Work (to be leveraged)
 - The OpenStudio Measure Framework
 - OpenStudio Analysis Framework (OSAF)
- Case Study, Part I
 - Problem
- OpenStudio Radiance Measure
- Case Study, Part II
 - Application
- Conclusions/Next Steps
- Snacks

Existing Work

OpenStudio & Measures

- Integrated application suite, SDK, and API for parametric building energy modeling
- Model/API for building energy modeling
- Application, SketchUp plugin, Parametric Analysis Tool (PAT)
- Ruby-based API for model generation, manipulation, and reporting
- [<http://openstudio.net>, <https://unmethours.com/questions/>]

OpenStudio Analysis Framework

- Containerized OpenStudio instance (and many helper programs) for *large scale analysis* using OpenStudio and measures
- Spreadsheet-based problem generation, supporting advanced analysis problem generation and sampling (Morris method, LHS, et al.)
- [<https://github.com/NREL/OpenStudio-server>, <https://github.com/NREL/OpenStudio-analysis-spreadsheet>]

Case Study, Part I

[Da' Problem]

Technology Evaluation

- Investigate energy savings and glare control potential via "climate sweep"
- Large scale analysis of the product prototype on multiple, exemplar, commercial building types and climate zones
- Use Radiance to calculate Dynamic Daylight Metrics and account for spatial, climate-based daylight distributions (DA/cDA/UDI)
- Compare energy savings and daylight metrics of study building models with and without product installed



Meanwhile, in OpenStudio...

Meanwhile...

Tedious Model Articulation

- No automated way to add daylighting objects to models
- No ability to model shading controls (i.e., no dynamic windows)

Limited output

- No daylight metrics

Limited batch processing

- Radiance Implementation "glued on" to OS GUI:



- Batch processing only via command line
- **No Access** to Measures, PAT, Spreadsheet, OS-Server [this is lame]

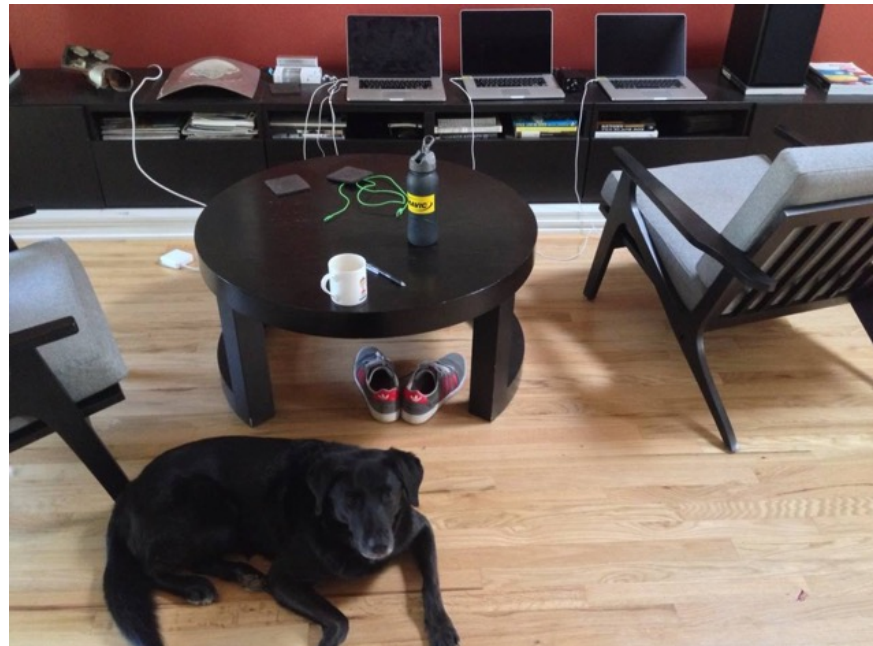
Previously...

IDEAKit
Climate
Sweep

Suboptimal Cluster Computing Resource

- Three (3) Macbook Pros
- Coffee(^n)
- Comfy Chair
- Dog (moral support)

Job creation, queuing, results collation and processing all performed by one (1) human (not shown).



Previously...

IDEAKit Climate Sweep

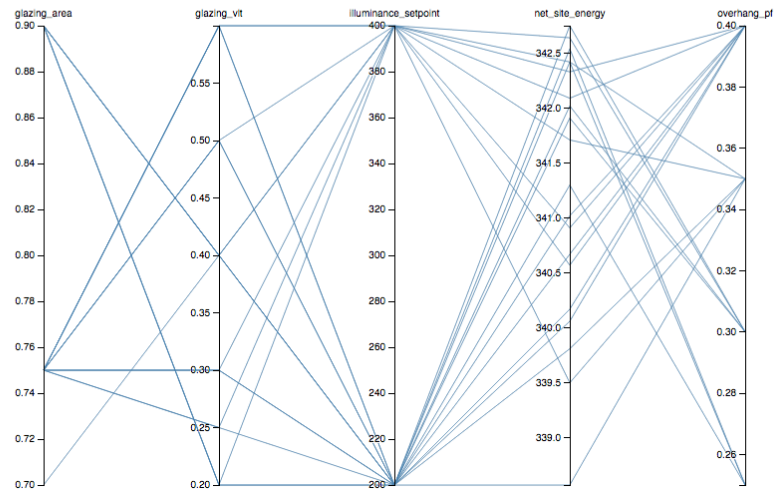
Manual model generation + Manual process
distribution and management = Lean dataset

- 2 building types
- 2 climate zones
- 4 Daylighting ECMs, but very coarse sampling

IDEAKit

Daylighting Options

Small Office | 4C Mixed - Marine | pre1980



#TODO

- Support Shading Controls
 - Switchable Glazing
 - Daylight Redirection Devices
 - Traditional (e.g. blinds, shade cloth)
- "Measureize" the existing Radiance workflow
 - Radiance can leverage whole OpenStudio ecosystem
- New measures to add daylighting elements to model automatically

Measurification of the Radiance Workflow

Oh man, it was super hard! Look:

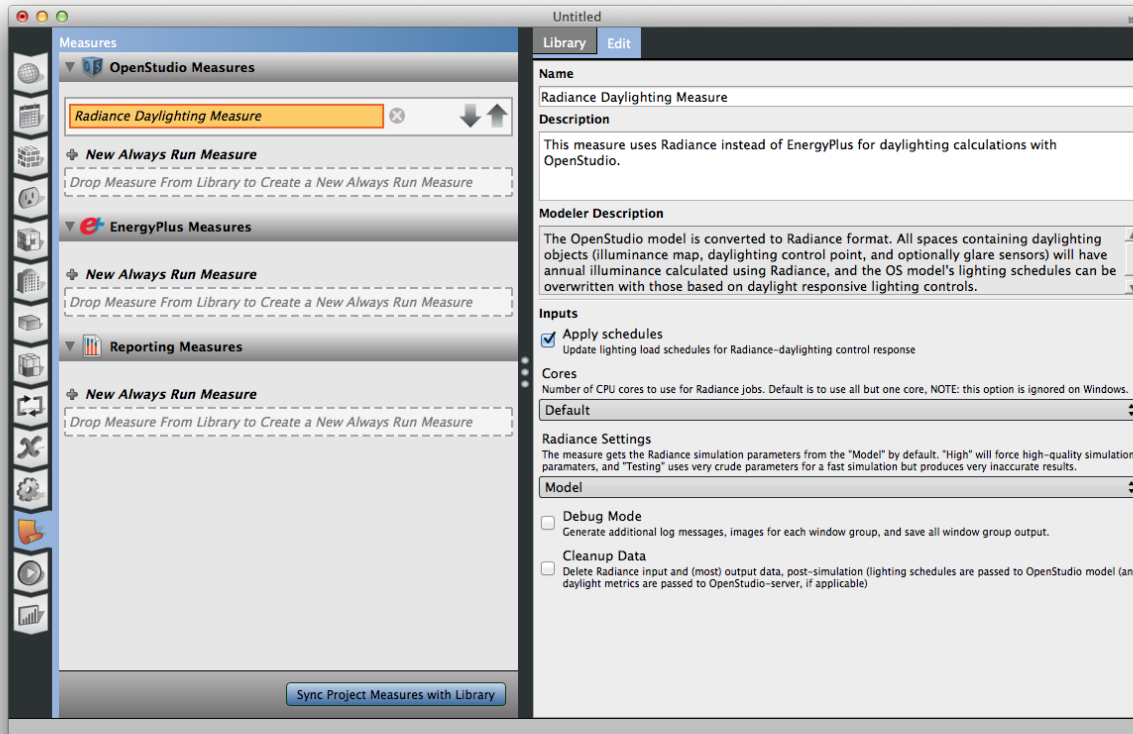
```
class RadianceMeasure < OpenStudio::Ruleset::ModelUserScript
```

- The OpenStudio API offers a macro* class for easy script generation within the OpenStudio application ecosystem

*Some folks call 'em macros, or scripts; we call 'em measures (mmm-hmmm).

Radiance Measure

- Incorporated new functionality
- Accessed via App/PAT GUI:



New Radiance Functionality

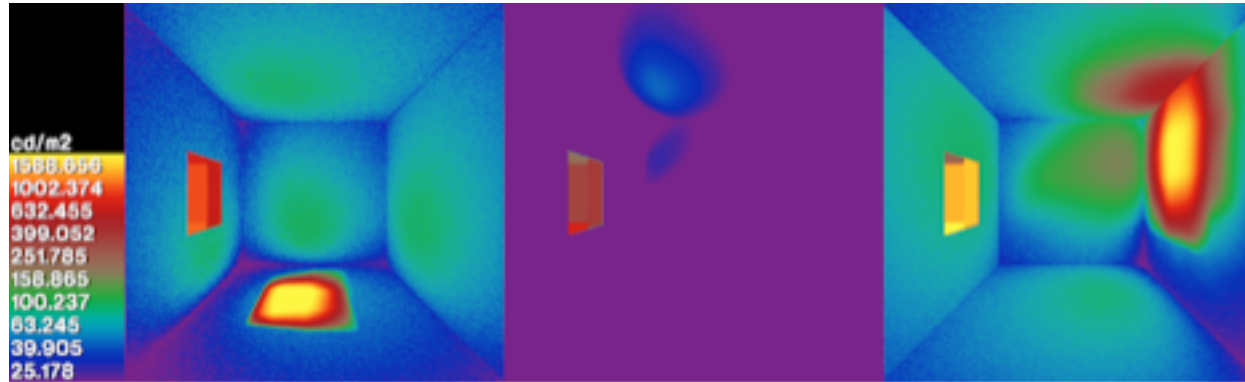
Support for dynamic windows in OpenStudio

Complex fenestration with bidirectional scatter distribution functions (BSDFs)

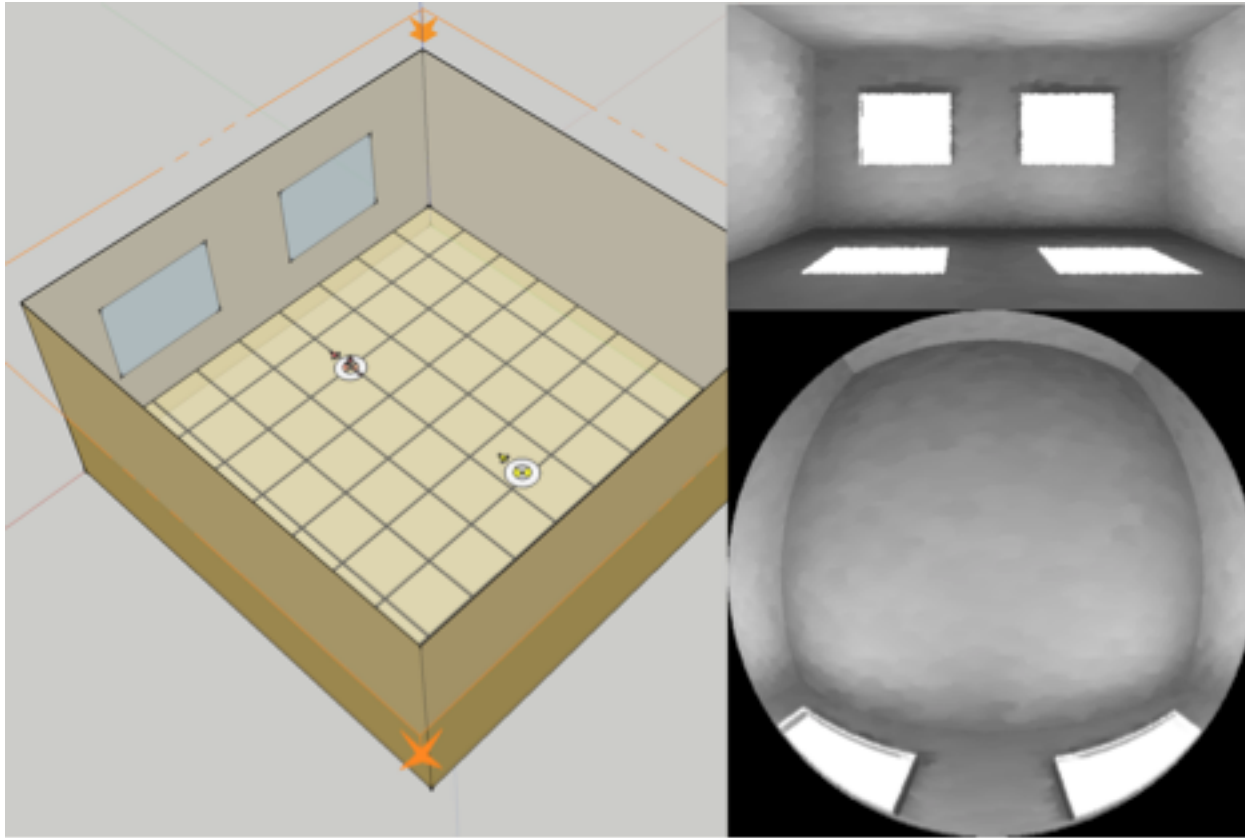
- Blinds
- Shadecloth
- Daylight Redirecting Devices

Dynamic glazings via multi-pass Radiance runs

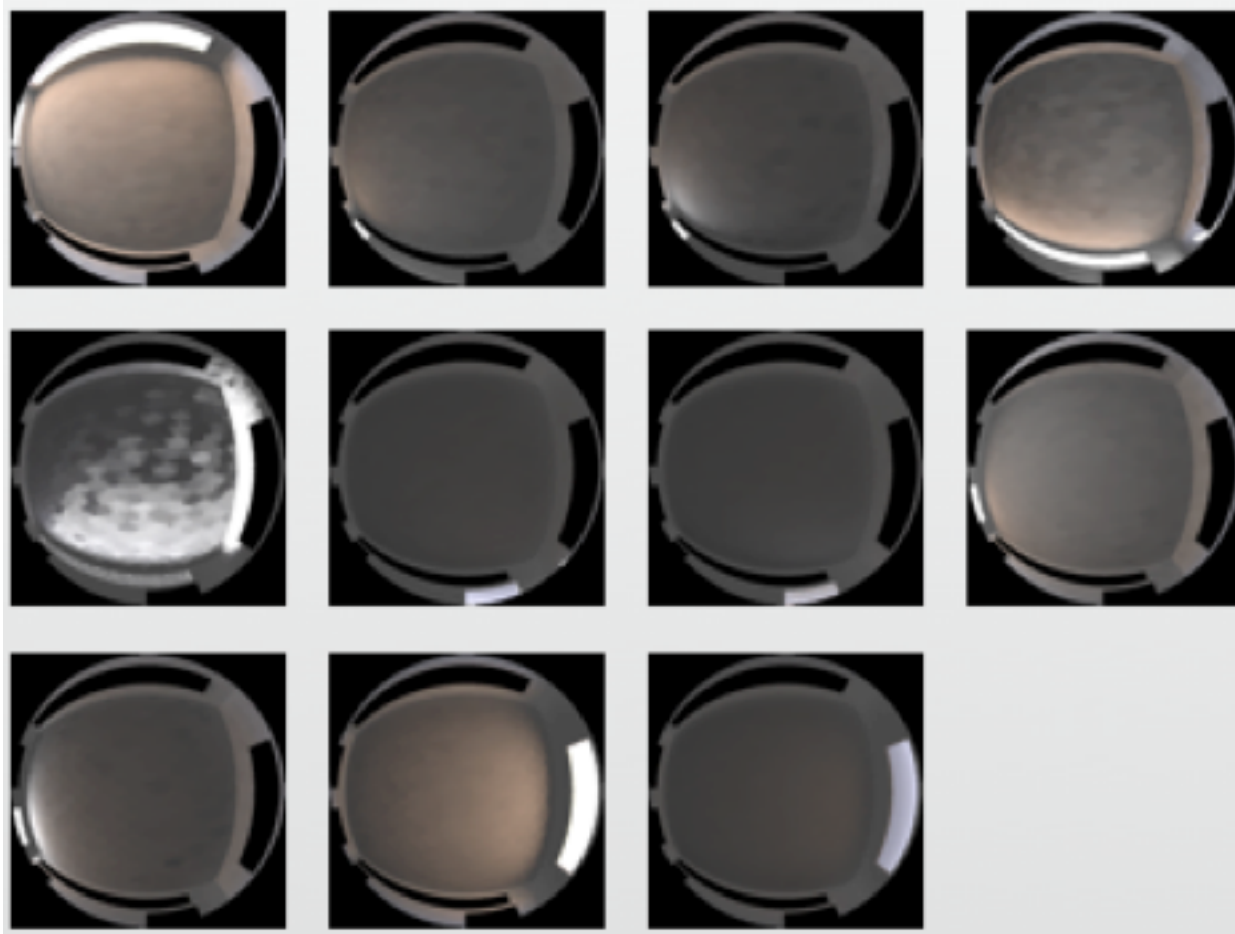
- Traditional Radiance materials **glass** and **trans** materials



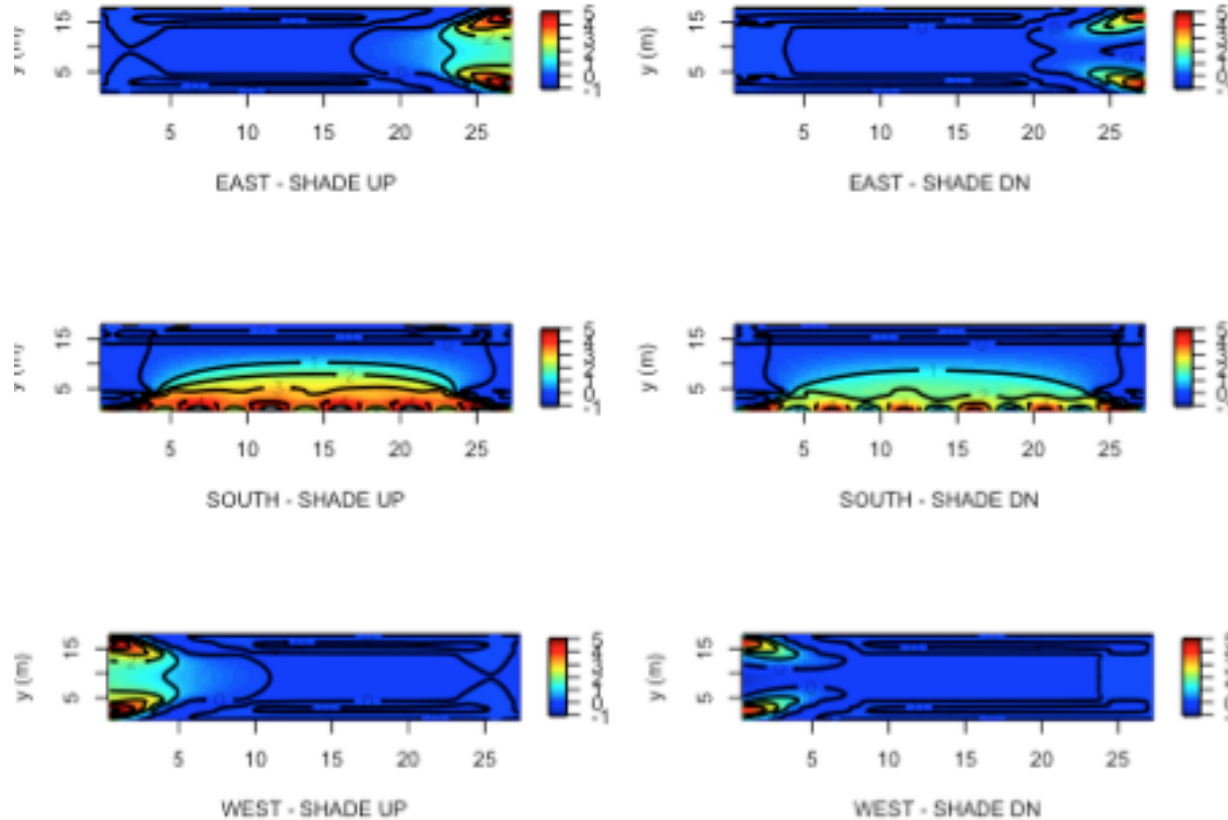
Generate sensor views of models, with Radiance



Generate "debug images" of each window group



Calculate daylight illuminance per window group



Case Study Part II

IN2 Climate Sweep

Proving ground for Radiance Measure

- Broke OpenStudio Server
 - Data merges overran available memory
- added silly hacks to git'er done, e.g.:

```
# check for number of rmtxop processes
def merge_count()
  return `pgrep rmtxop`.split.size
end
...
while merge_count() > 2
  puts "waiting in rmtxop queue..."
  sleep(5)
end
rad_command = "dctimestep output/dc/#{wg}.vmx \
annual-sky.mtx | rmtxop -fa -c 47.4 120 11.6 - \
> output/ts/#{wg}.ill"
exec_statement(rad_command, runner)
```

- Still broke server
 - Output overran available storage
- Ultimately had to reduce the parameter space
 - 1 building type (Small Office)
 - 16 climate zones
 - base case/lighting controls/shading controls (SmarterShade)

Conclusions, Benefits, WhatHaveYou

Benefits

Wells Fargo IN2 Project

- Determined ideal use cases for product
- Verified pre-existing concerns WRT ultimate energy efficiency potential ヽ(ツ)/

NREL

- Vastly improved the Radiance integration within OpenStudio
- Added functionality
 - Works with other measures (e.g. in a parametric matrix)
 - PAT
 - OpenStudio Spreadsheet
- Simbuild Paper

Conclusions

"Just because you can, doesn't mean you should."

Running Radiance on an entire building, at a resolution to support complex fenestration devices AND dynamic daylight metrics, is intractable:

- Not enough time
- Not enough memory (RAM)
- Not enough storage

The "cloud" is of little help; it just masks the mountain.



Next Steps

Give users ability to:

- Tag spaces (or groups of spaces) for Radiance analysis
- Apply shade & lighting schedules from exemplar spaces to similar spaces

Add new measures for:

- Simple reporting of static data
- Interactive data browsing and manipulation (e.g. sensor setpoint optimisation)

Questions?

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[thank you.]

