

MEAGAN LANG

CROPS IN SILICO
HACKATHON 2021

BUT FIRST...

NOTEBOOK PREP

PREP CHECKLIST

1. SIGN-UP FOR GITHUB

We will be using GitHub Issues to debug

2. OPEN THE PROJECT MATERIALS

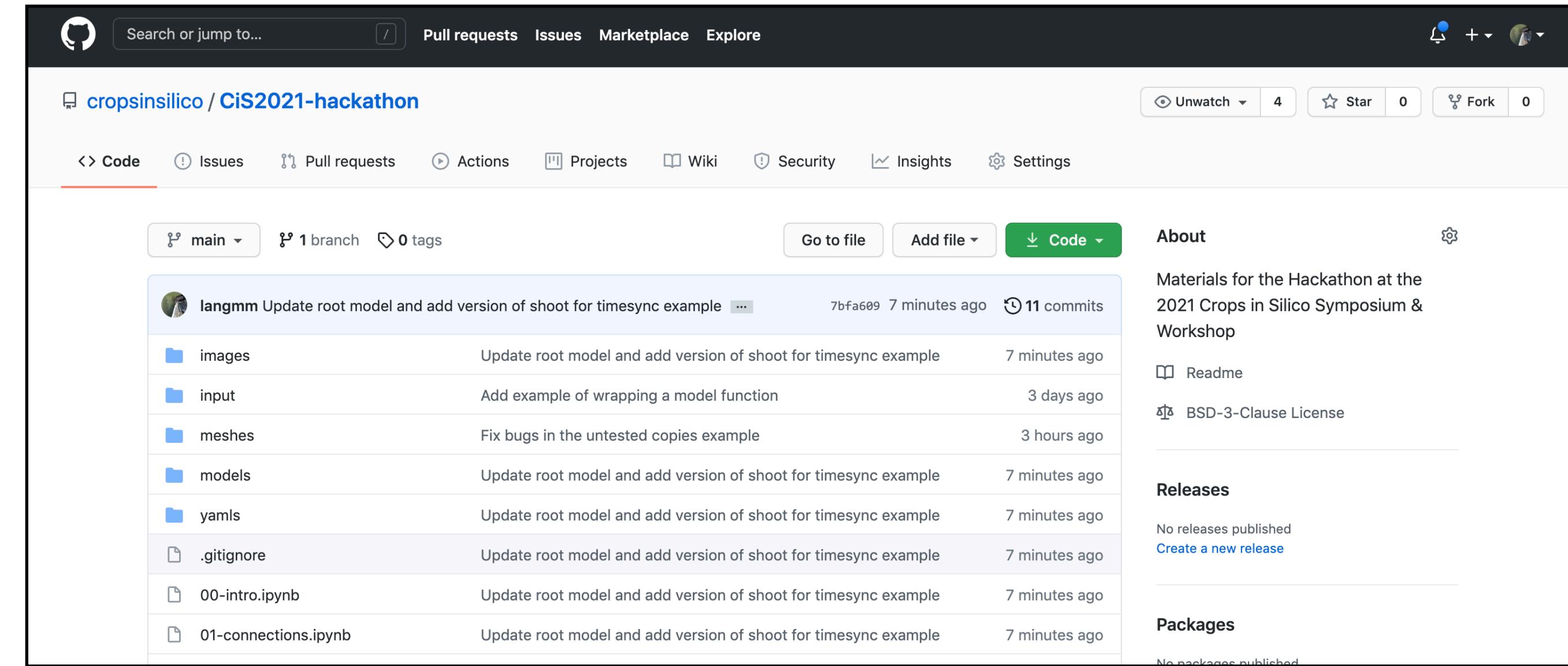
3. START A MYBINDER INSTANCE

We will be using Jupyter notebooks via MyBinder to avoid local installations (instructions for installing locally are found in the README)

Materials: <https://github.com/cropsinsilico/CiS2021-hackathon>

Launch binder
in a new
window/tab

Keep the
materials repo
open, we will
need it later



Materials: <https://github.com/cropsinsilico/CiS2021-hackathon>

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cropsinsilico / CiS2021-hackathon

Code Issues Pull requests Actions Projects Wiki Security Insights Settings

main 1 branch 0 tags

langmm Update root model and add version of shoot for timesync example ... 7bfa609 7 minutes ago 11 commits

images Update root model and add version of shoot for timesync example 7 minutes ago

input Add example of wrapping a model function 3 days ago

meshes Fix bugs in the untested copies example 3 hours ago

models Update root model and add version of shoot for timesync example 7 minutes ago

yaml Update root model and add version of shoot for timesync example 7 minutes ago

.gitignore Update root model and add version of shoot for timesync example 7 minutes ago

00-intro.ipynb Update root model and add version of shoot for timesync example 7 minutes ago

01-connections.ipynb Update root model and add version of shoot for timesync example 7 minutes ago

About

Materials for the Hackathon at the 2021 Crops in Silico Symposium & Workshop

Readme

BSD-3-Clause License

Releases

No releases published

Create a new release

Packages

No packages published

SCROLL

README.md

CiS2021-hackathon

Materials for the Hackathon at the 2021 Crops in Silico Symposium & Workshop

[launch binder](#)

Requirements

- Browser (tested on Google Chrome)
- Github Account

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DOCUMENTATION

Requirements

- Browser (tested on Google Chrome, Safari, Firefox)
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Preparing for the hackathon

- Check that you can sign-in to Github, creating an account as necessary. We will be using Github Issues to track problems encountered during the hackathon.
- Try launching a mybinder instance by clicking on this  launch binder icon (or the link below).

It may take a few moments to initialize. If you encounter an error, open an issue and try with another browser. If you still cannot launch the binder, you can install the materials on your machine by following the instructions at one of the links below

- Local install (via conda)
- Docker container

<https://mybinder.org/v2/gh/cropsinsilico/CiS2021-hackathon/HEAD>

Useful links

- [Hackathon Repository](#)
- [Hackathon Documentation](#)
- [yggdrasil Repository](#)
- [yggdrasil Documentation](#)
- [Additional Examples](#)
- [Debugging Tips & Documented Errors](#)

DOCUMENTATION

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- [yggdrasil Documentation](#)
- [Additional Examples](#)
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Notes on Autowrapping C/C++ Model Functions
 Conditional I/O
 Transformed I/O
 Timestep Synchronization
 YAML Files
 Configuration Files
 Units
 C-Style Format Strings
 Debugging
 OpenMP Threading in Models
 Examples
 Advanced
 Development
 Publications
 Welcome to the 2018 Crops in Silico Hackathon!
 Welcome to the 2019 Crops in Silico Hackathon!

>Welcome to the 2021 Crops in Silico Hackathon!

Setup
 Debugging
 Introduction to Yggdrasil
 Introduction to Jupyter Notebooks
 Command Line Interfaces (CLIs)
 Command Line Interfaces (CLIs)

» Welcome to the 2021 Crops in Silico Hackathon!

[View page source](#)

Welcome to the 2021 Crops in Silico Hackathon!

These materials walk through some of the basics to using yggdrasil to connect models using Jupyter notebooks. These exercises were created for the 2021 Crops in Silico hackathon, but can be used by anyone who would like to learn how to use yggdrasil.

Contents:

- Setup
 - [MyBinder](#)
 - [Local Install](#)
 - [Docker Container](#)
- Debugging
- Introduction to Yggdrasil
 - [What](#)
 - [Why](#)
 - [How](#)
 - [Who](#)
- Introduction to Jupyter Notebooks
 - [Some notes about notebooks](#)
- Command Line Interfaces (CLIs)
 - [Running Integrations](#)
 - [Validating Integration YAML\(s\)](#)

LIVE FEEDBACK



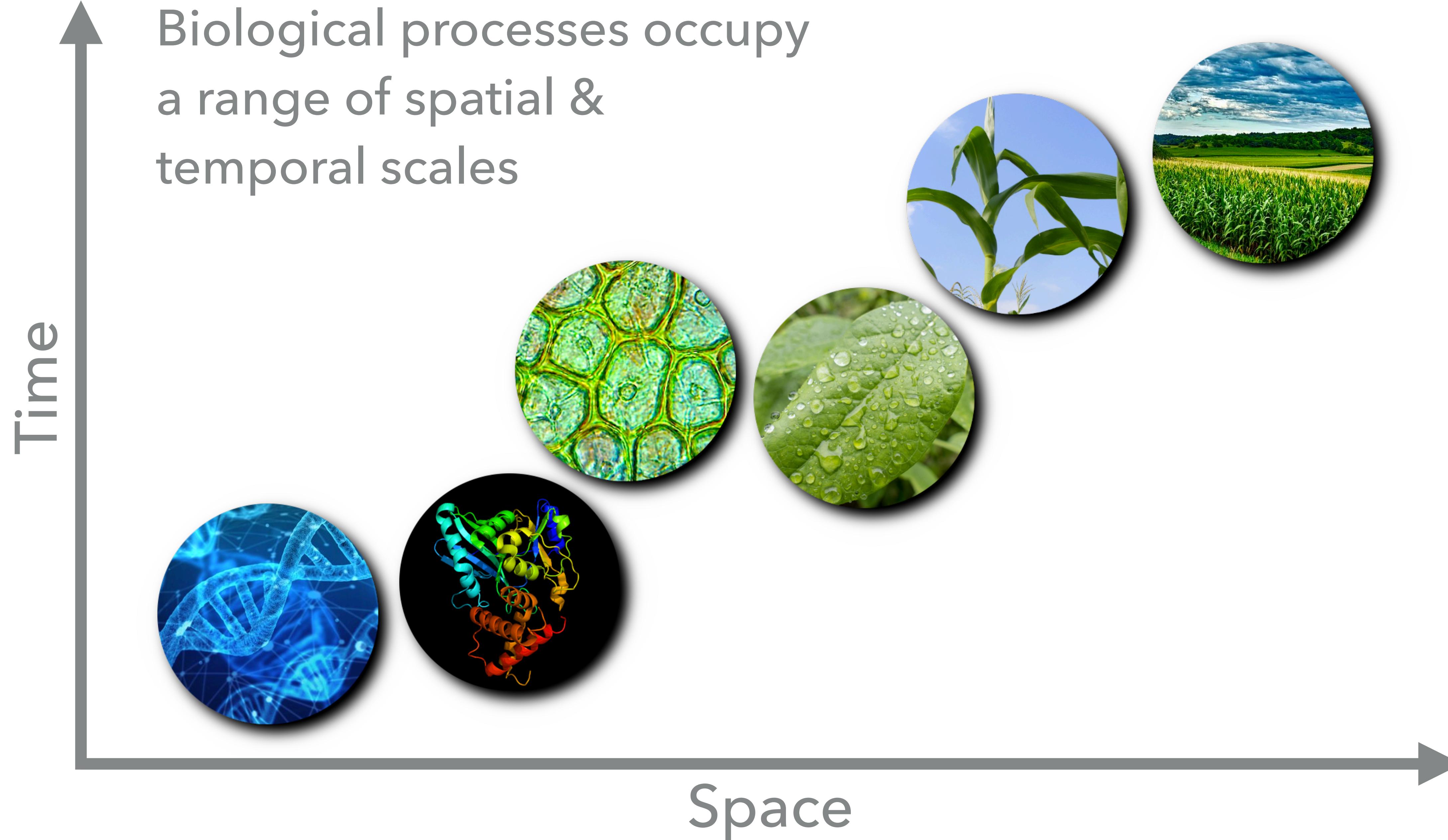
"Slow down I'm still waiting for a previous step to finish!"

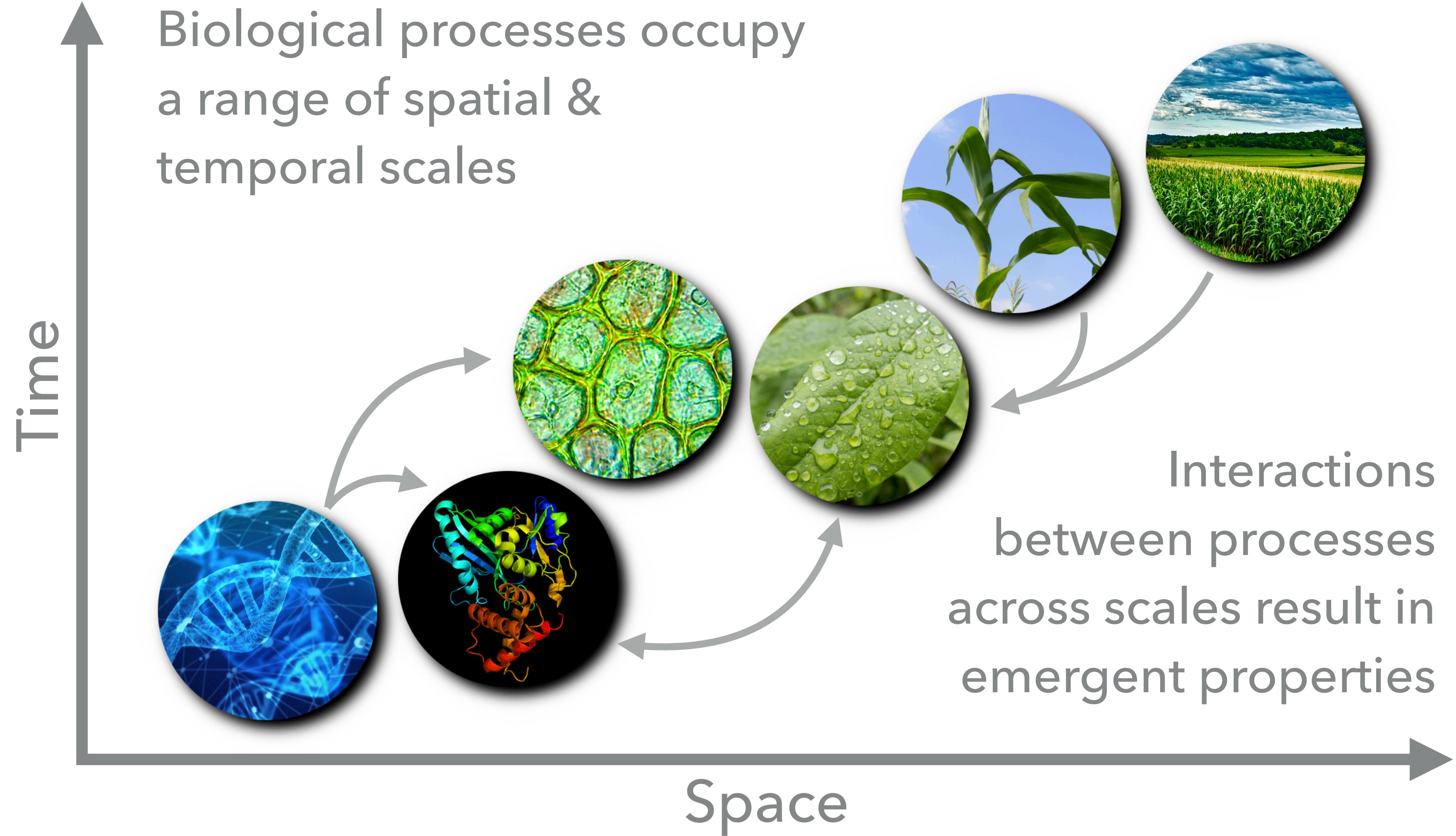


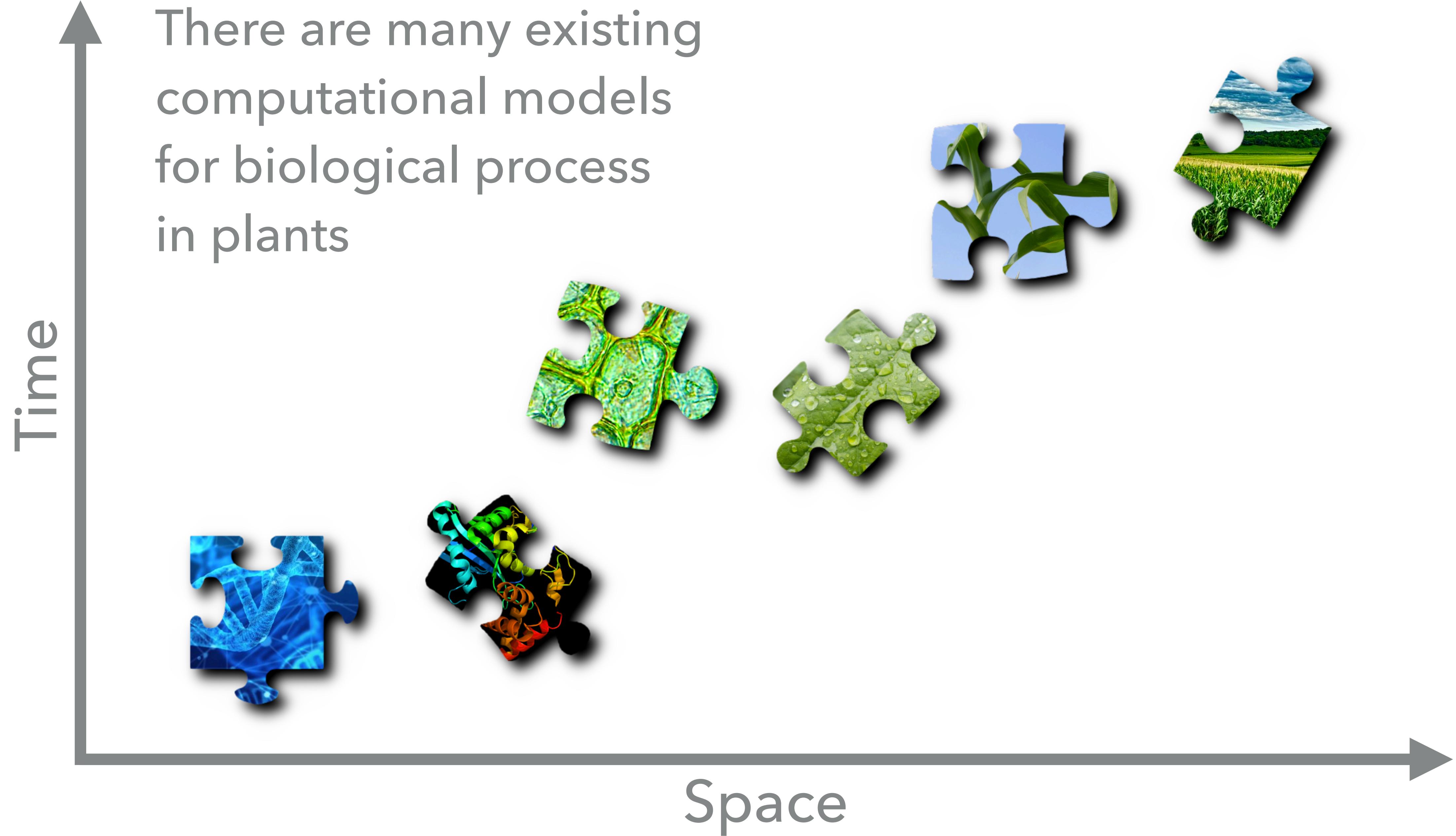
"I've caught up" or " I have finished the task you are asking about"

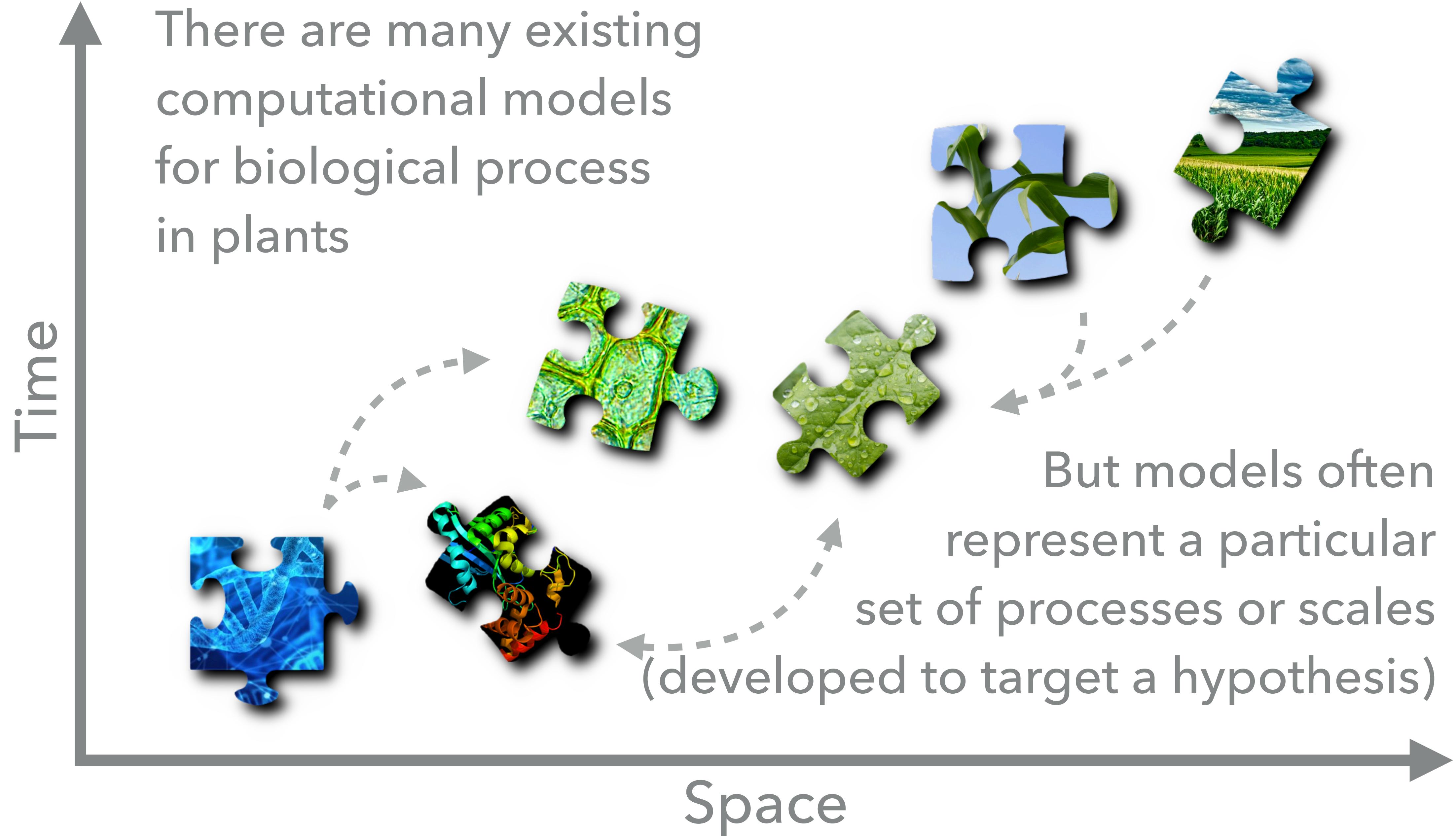
OK BACK TO THE...

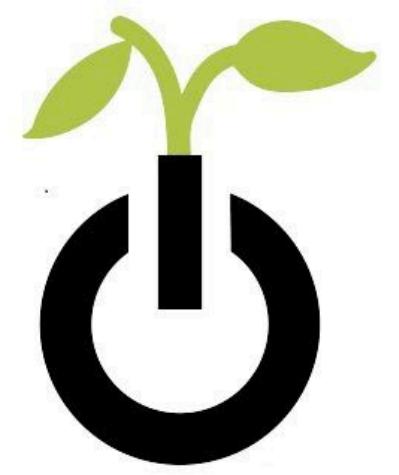
INTRODUCTION











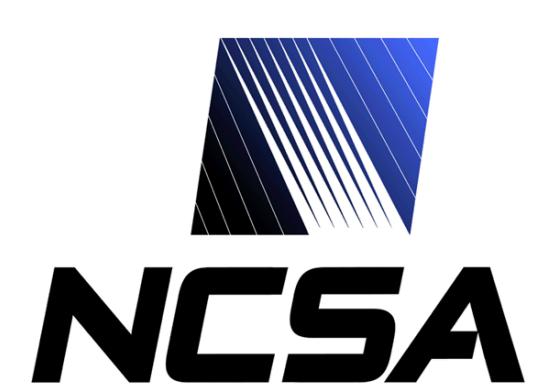
Crops *in silico*

I ILLINOIS

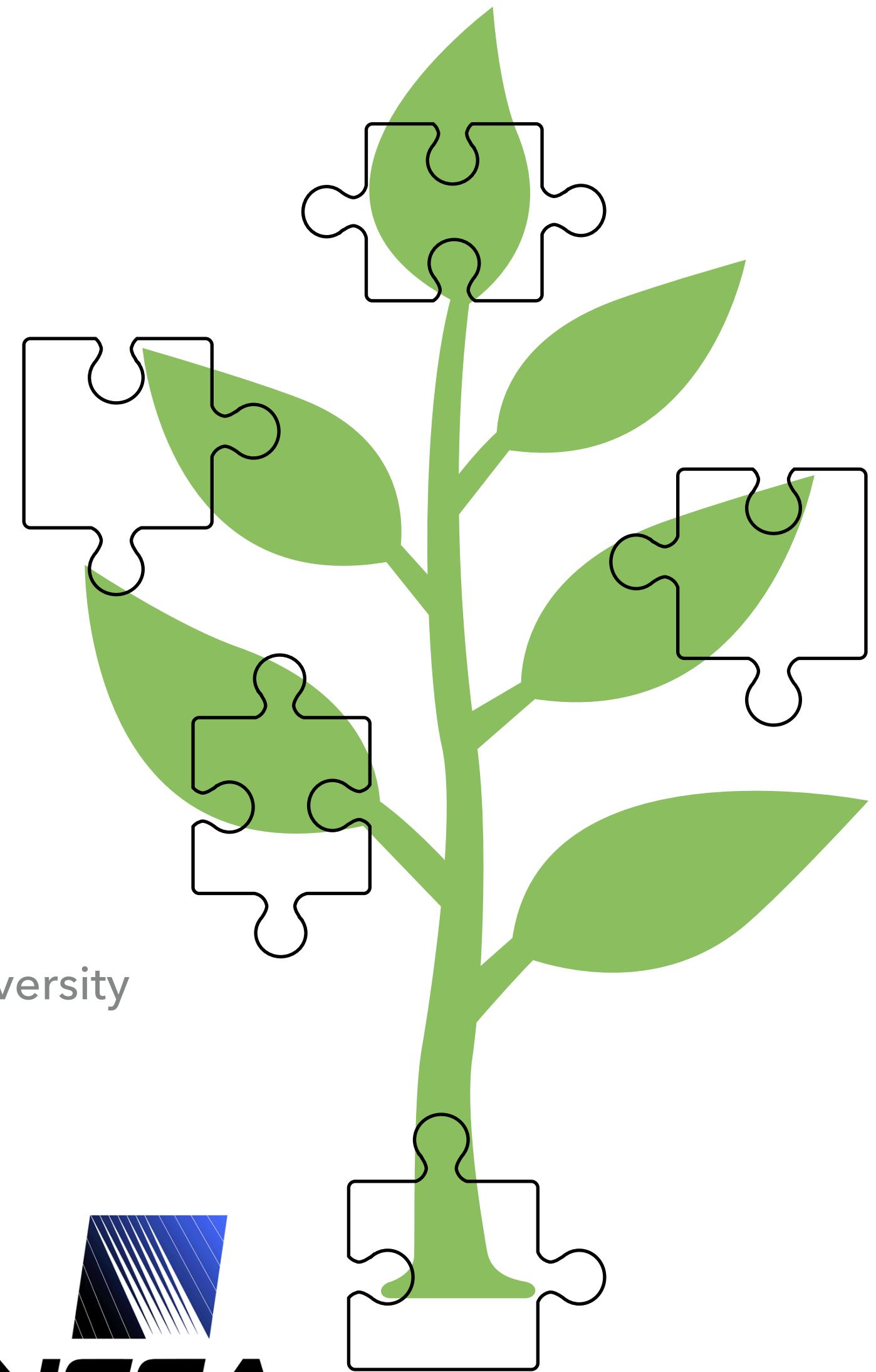
Funded by



FFAR



In partnership with
Oxford University
Pennsylvania State University
Purdue University
University of Nebraska





Models are pieces from
different puzzles

We need an adapter



Crops *in silico*¹



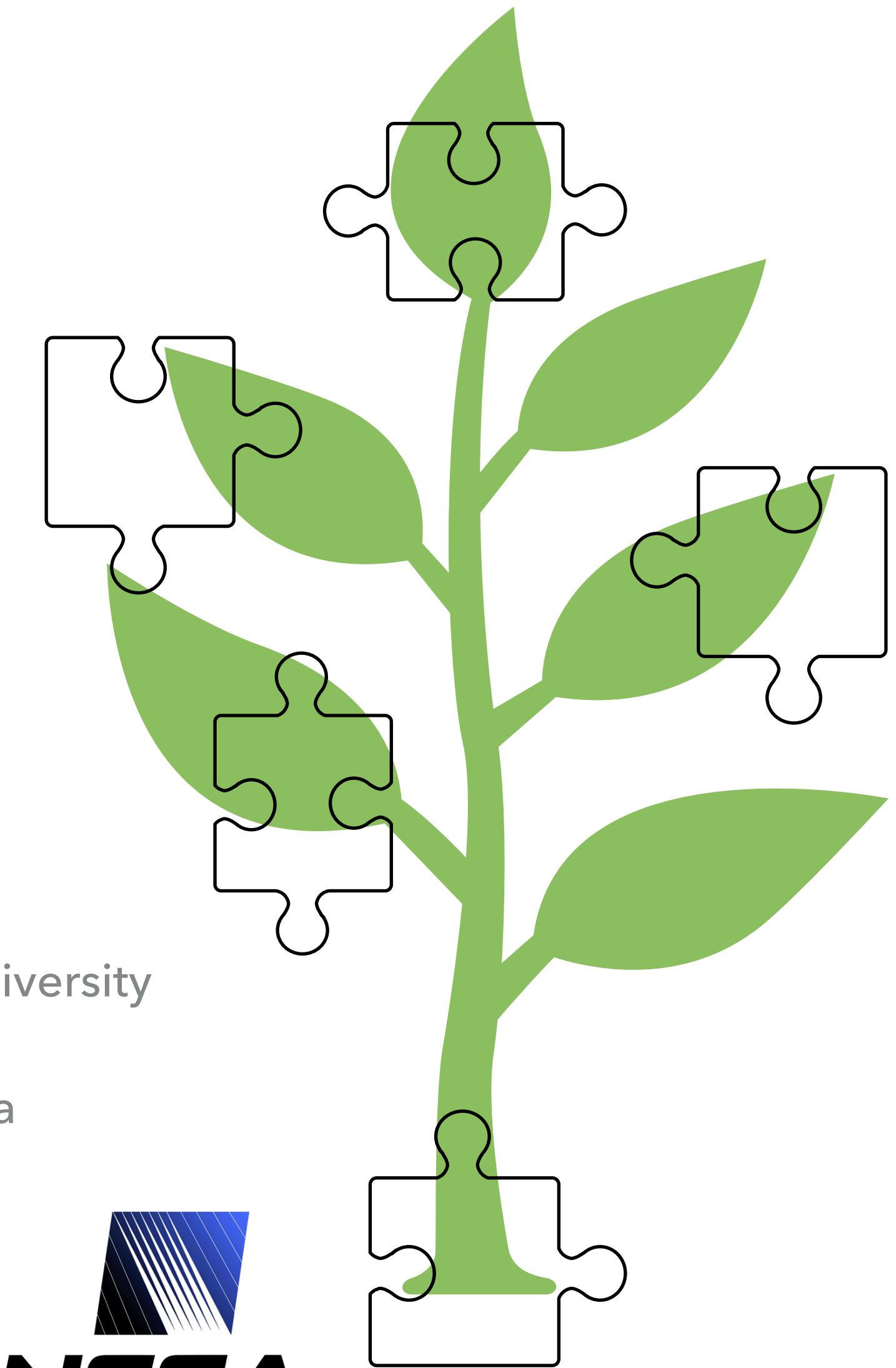
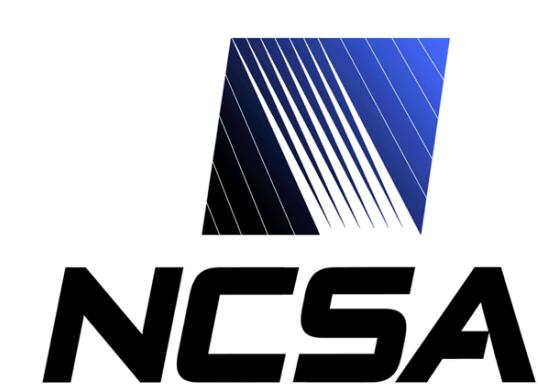
ILLINOIS

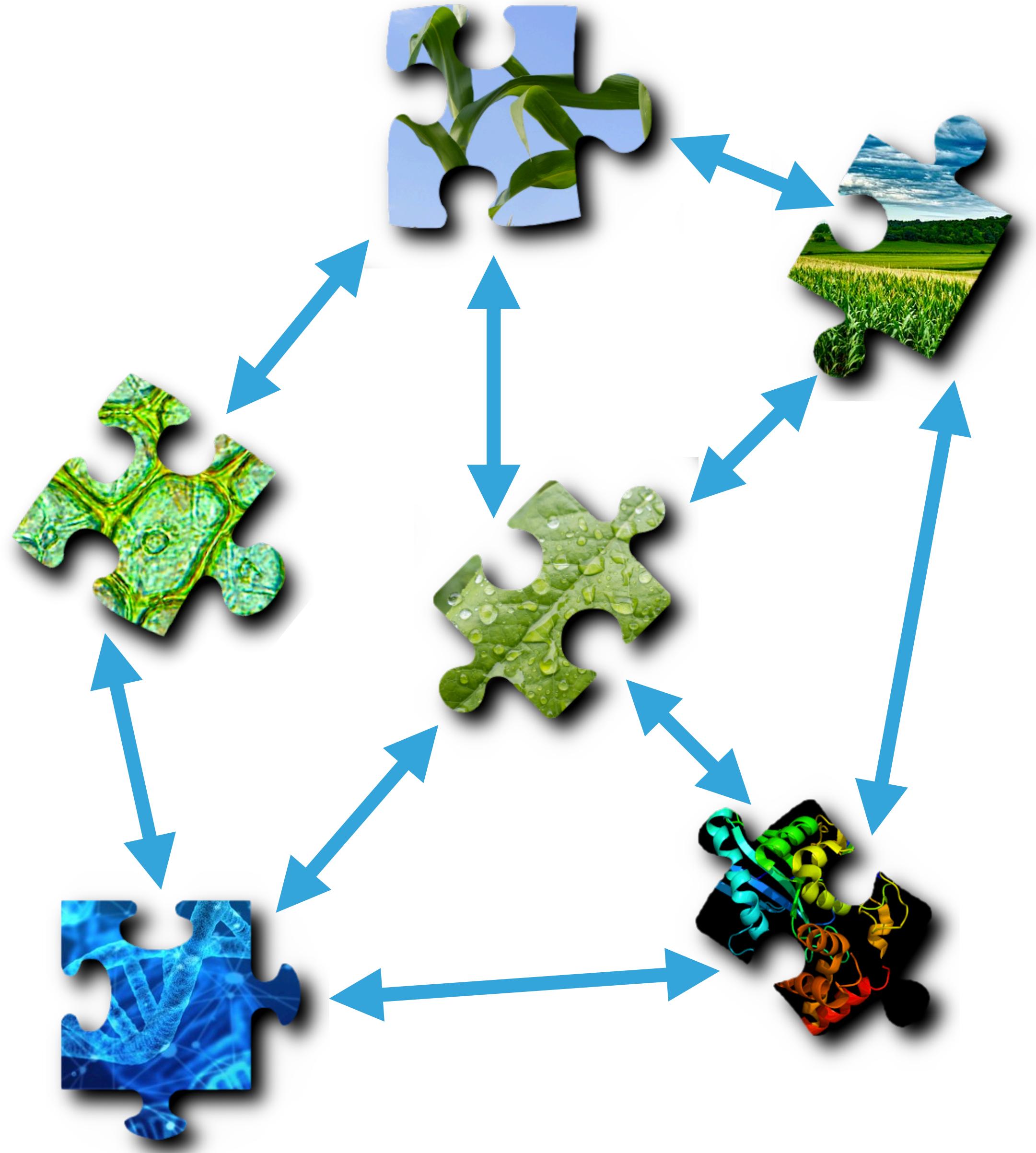
In partnership with
Oxford University
Pennsylvania State University
Purdue University
University of Nebraska

Funded by



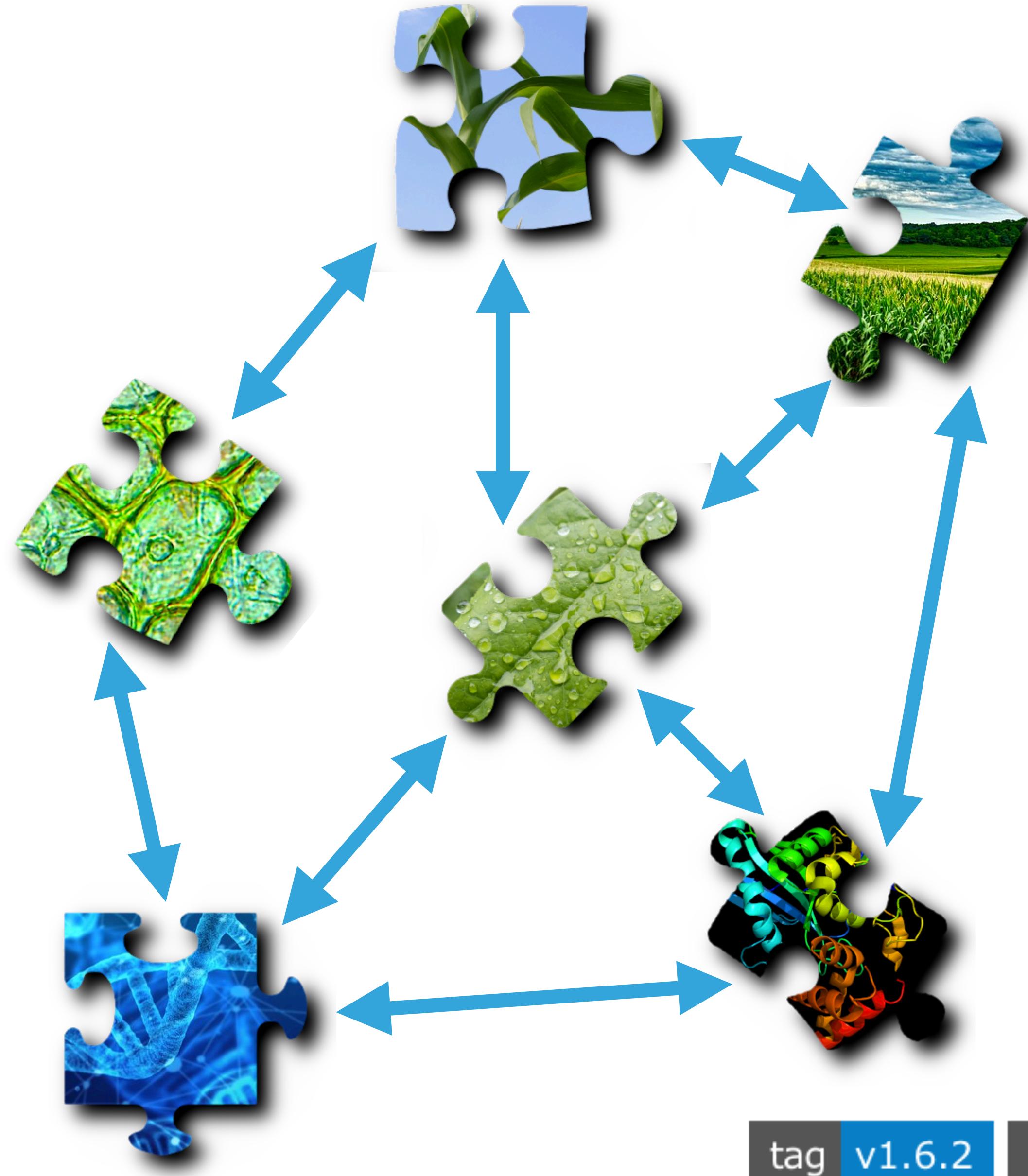
FFAR





YGGDRASIL:

OPEN SOURCE PYTHON
PACKAGE FOR
CONNECTING MODELS
ACROSS SCALES AND
LANGUAGES



YGGDRASIL:

OPEN SOURCE PYTHON
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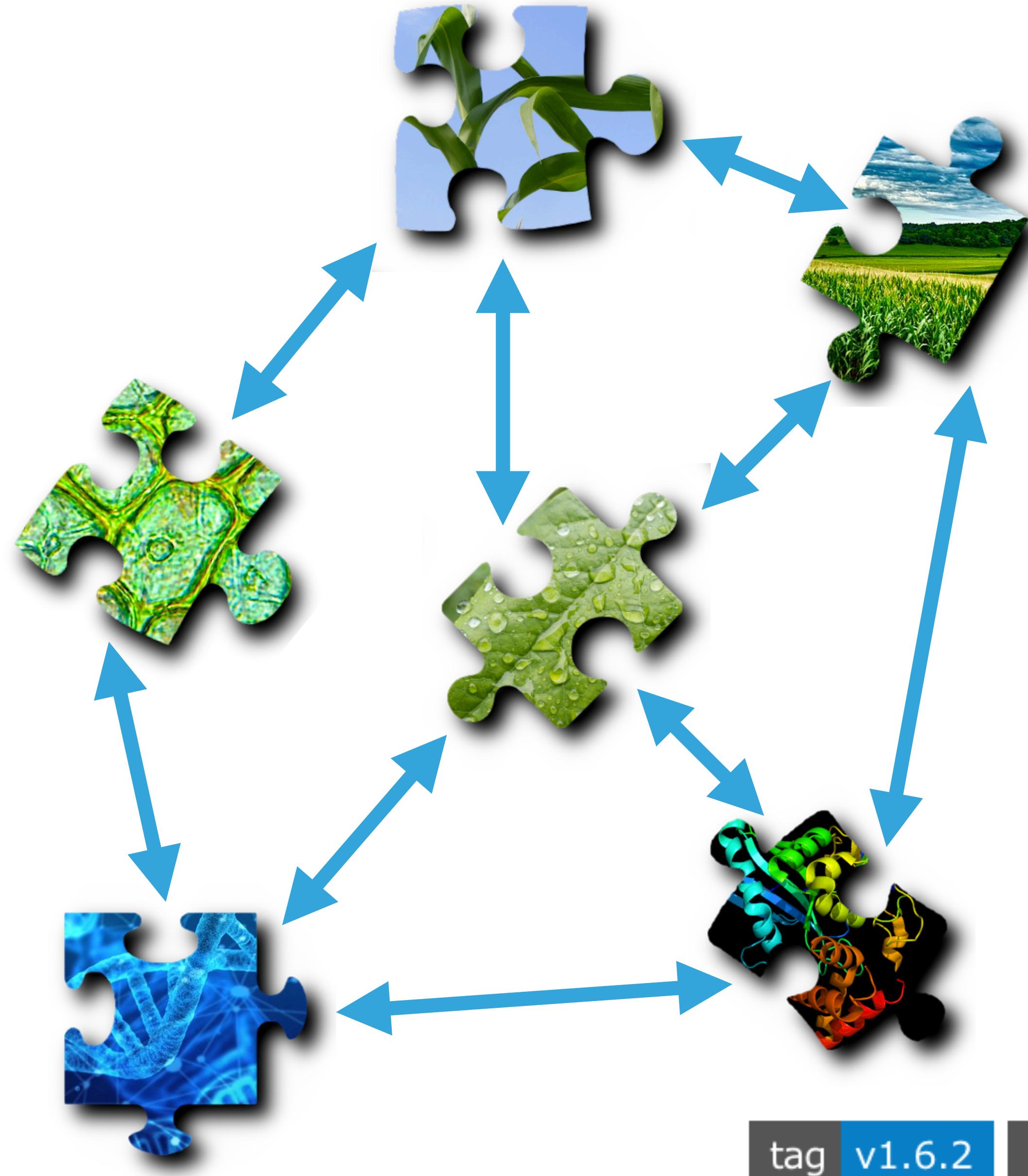
tag v1.6.2

pypi v1.6.2

build passing

coverage 100%

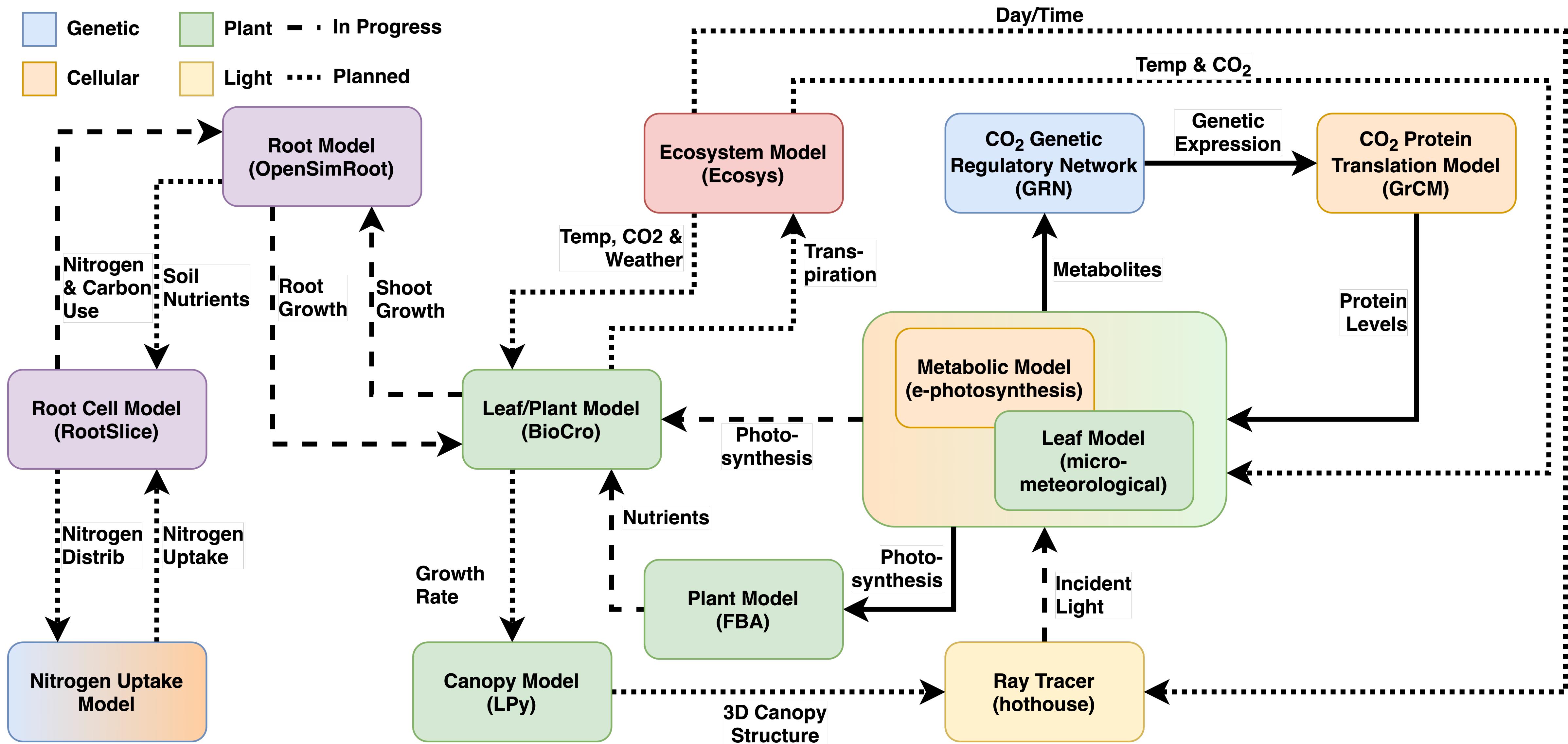
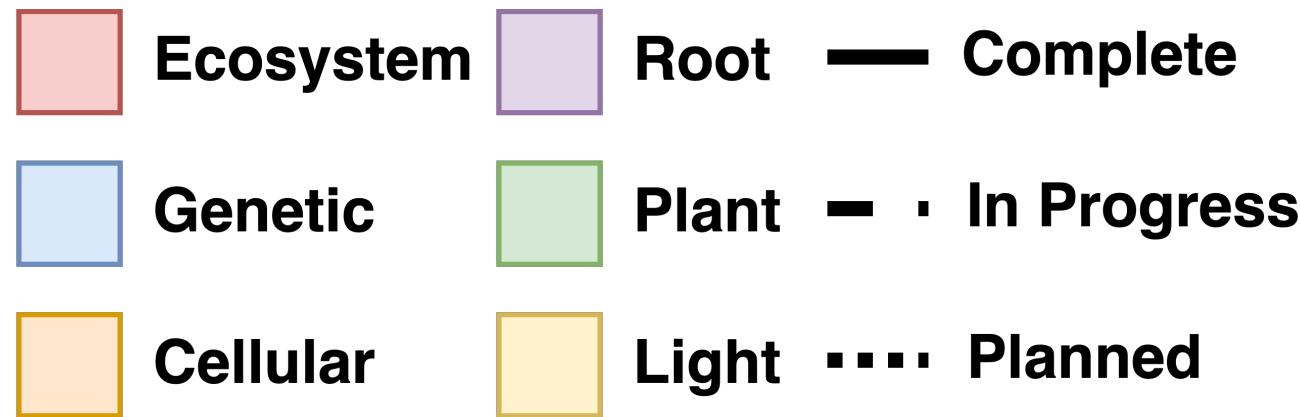
code style pep8

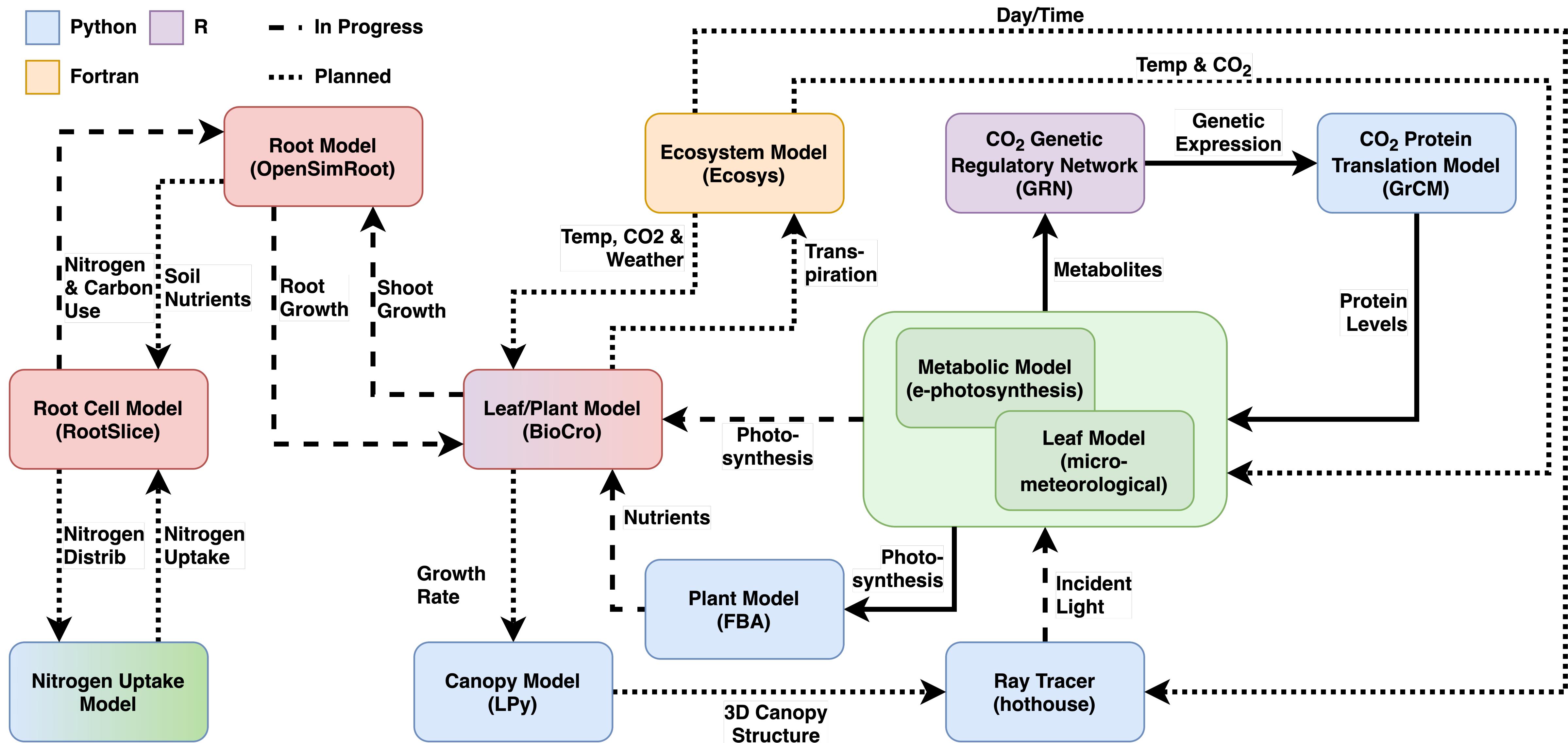
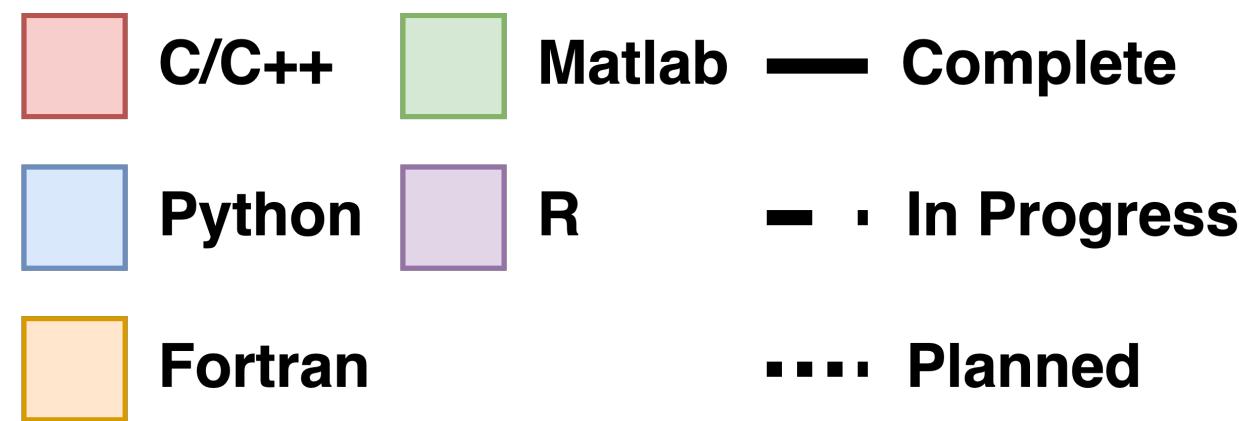


YGGDRASIL:

OPEN SOURCE PYTHON PACKAGE FOR CONNECTING MODELS ACROSS SCALES AND LANGUAGES

tag v1.6.2 pypi v1.6.2 build passing coverage 100% code style pep8
license BSD conda platforms linux-64 | win-64 | osx-64





LANGUAGES

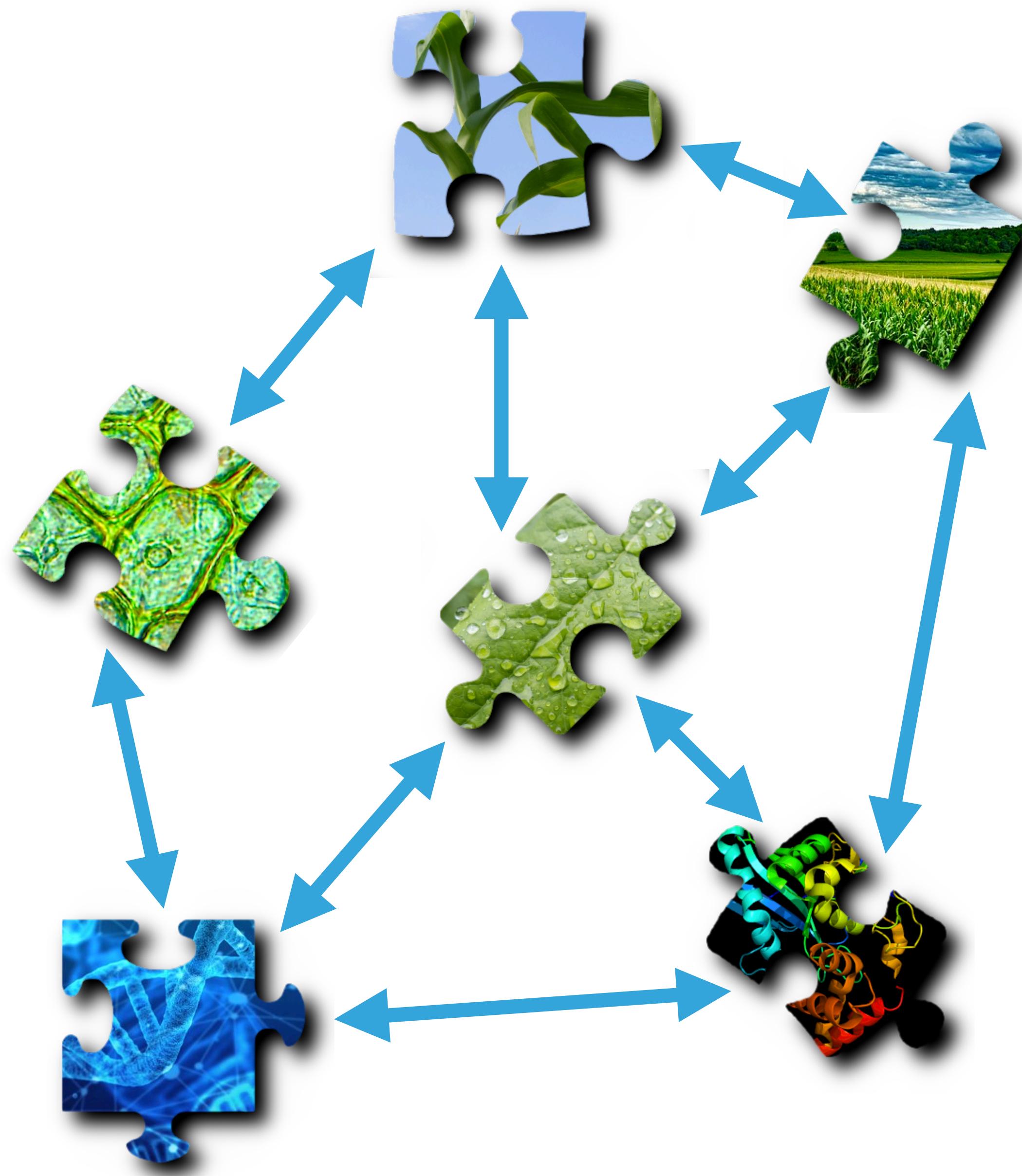
PYTHON

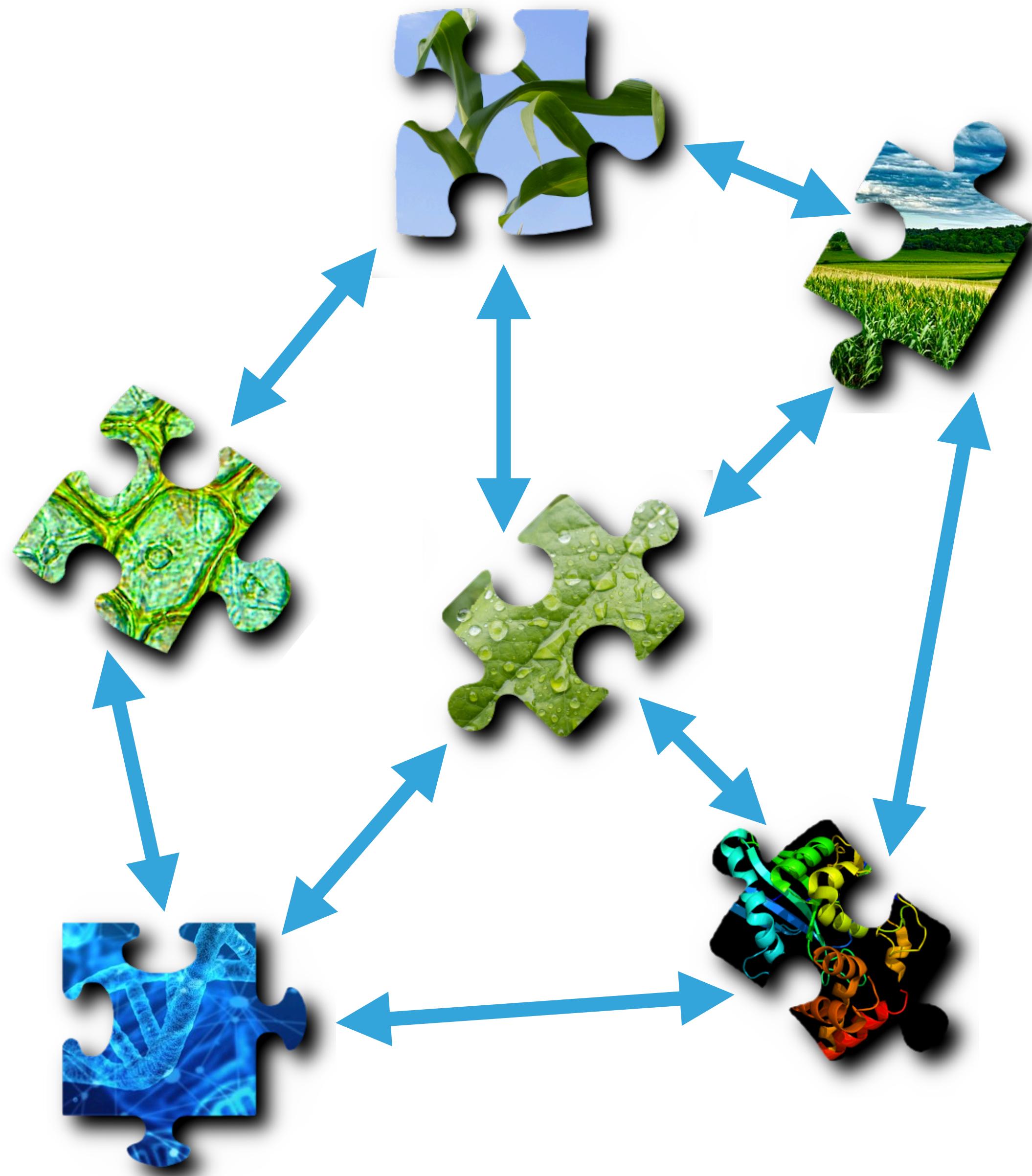
MATLAB

R

C/C++

FORTRAN ('03)





LANGUAGES

PYTHON

MATLAB

R

C/C++

FORTRAN ('03)

DOMAIN SPECIFIC LANGUAGES

SBML

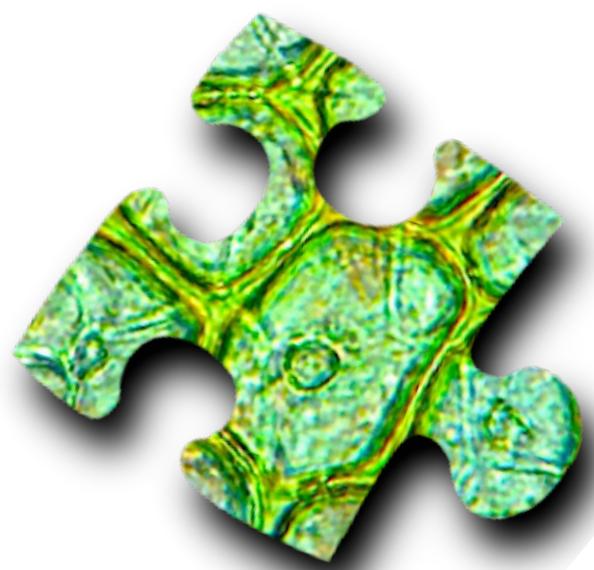
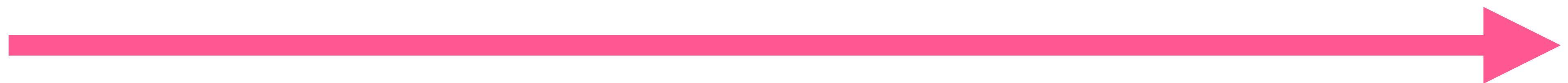
OPENSIMROOT XML

COMMUNICATION

PARALLEL EXECUTION



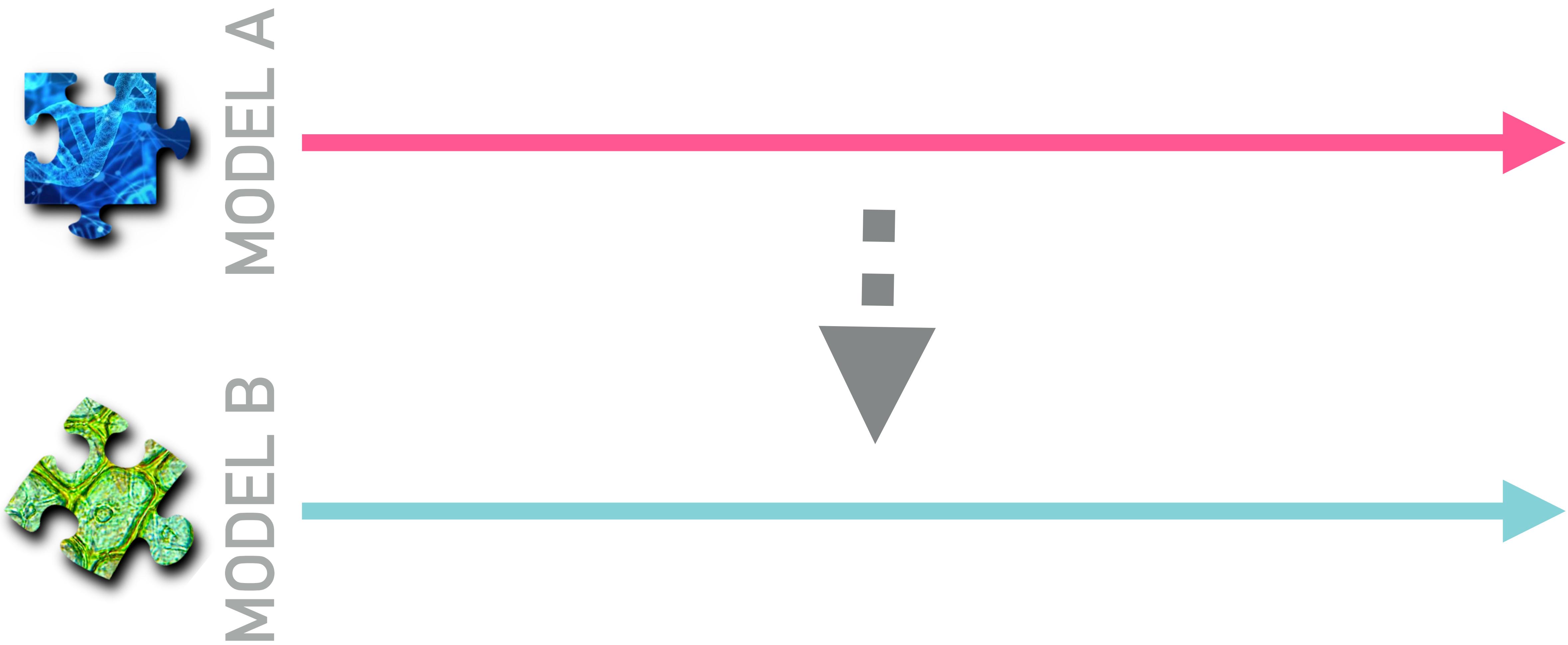
MODEL A



MODEL B



PARALLEL EXECUTION

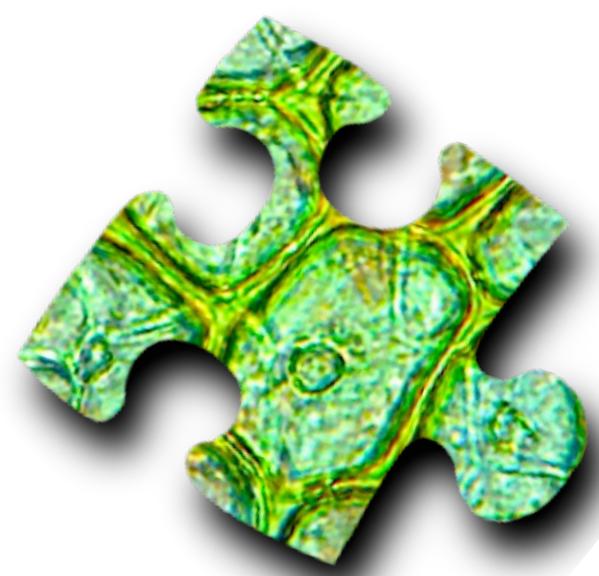


ASYNCHRONOUS COMMUNICATION

(SEND FIRST)



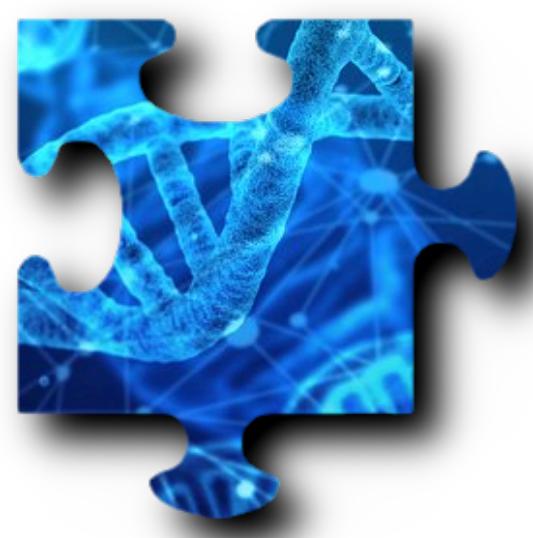
MODEL A



MODEL B

ASYNCHRONOUS COMMUNICATION

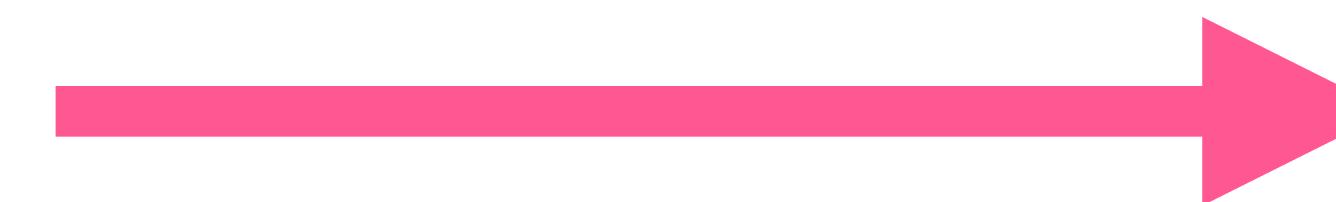
(SEND FIRST)



MODEL A



MODEL B



SEND

ASYNCHRONOUS COMMUNICATION

(SEND FIRST)



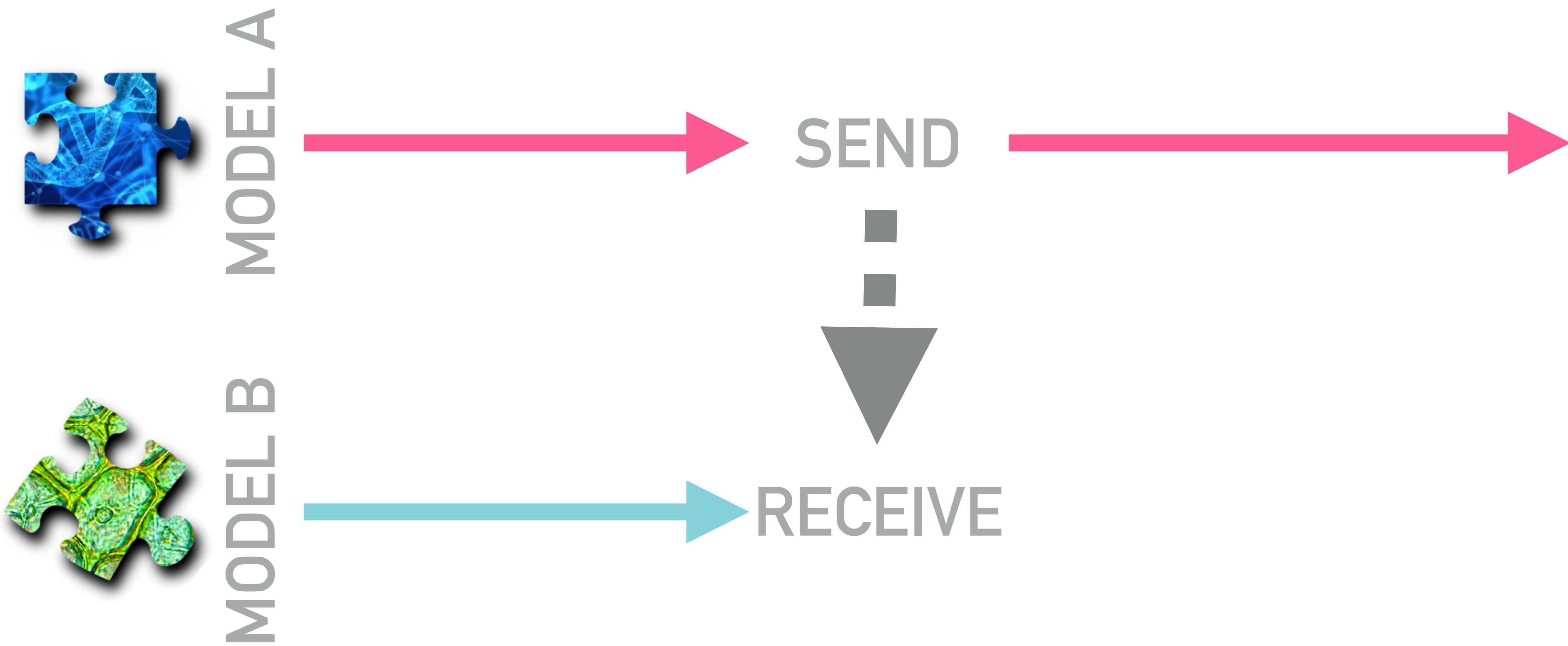
ASYNCHRONOUS COMMUNICATION

(SEND FIRST)



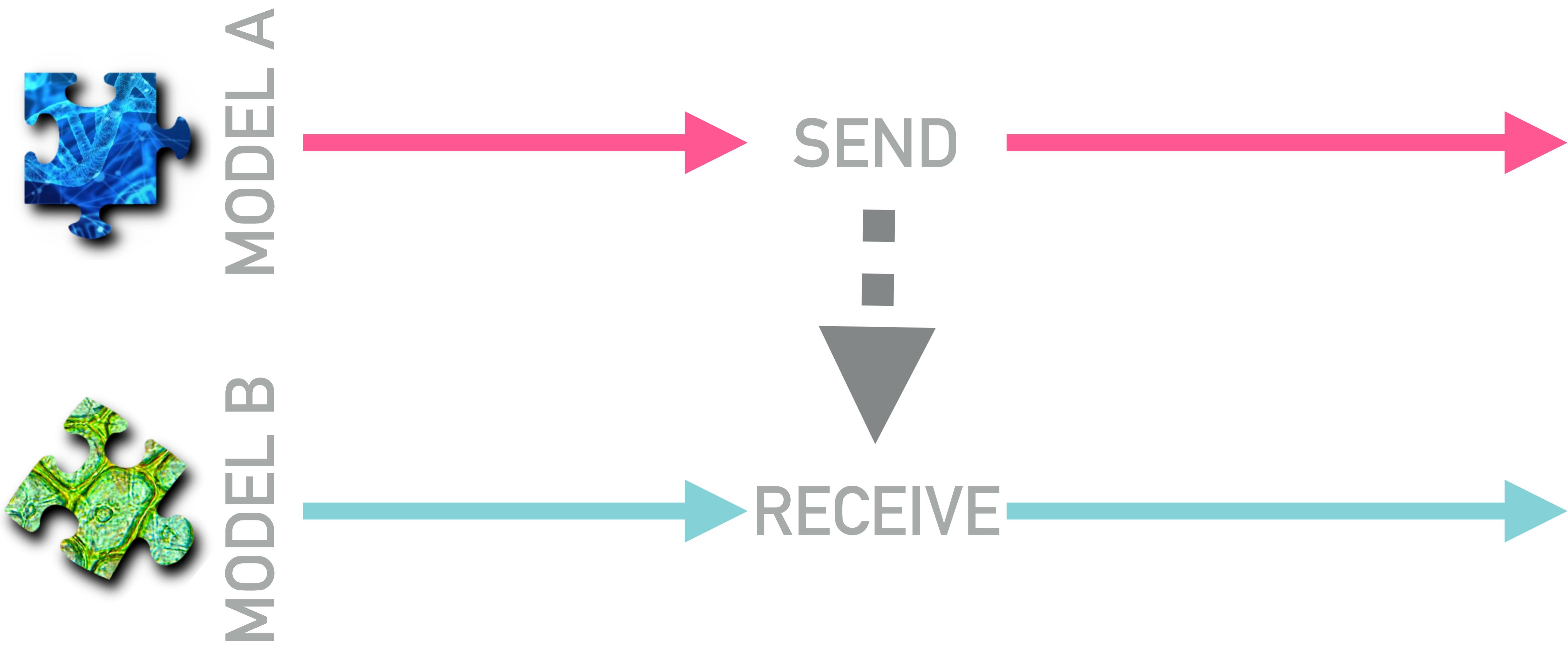
ASYNCHRONOUS COMMUNICATION

(SEND FIRST)



ASYNCHRONOUS COMMUNICATION

(SEND FIRST)



ASYNCHRONOUS COMMUNICATION

(RECEIVE FIRST)



MODEL A



MODEL B

ASYNCHRONOUS COMMUNICATION

(RECEIVE FIRST)



MODEL A



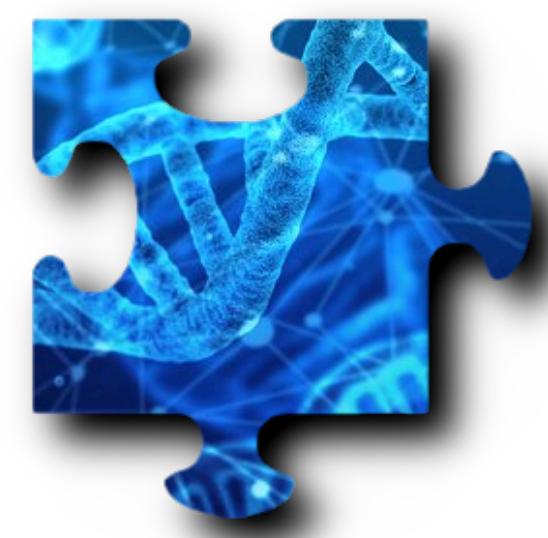
MODEL B



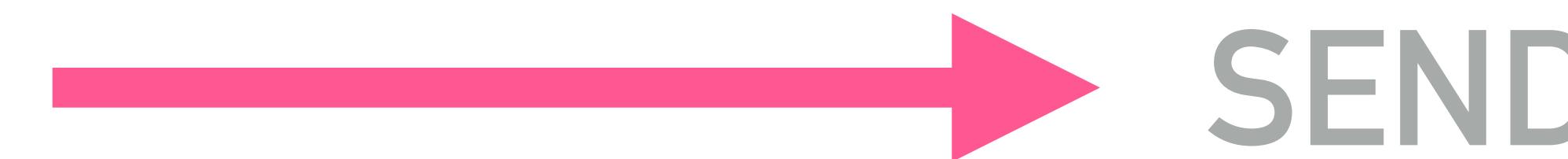
RECEIVE

ASYNCHRONOUS COMMUNICATION

(RECEIVE FIRST)



MODEL A

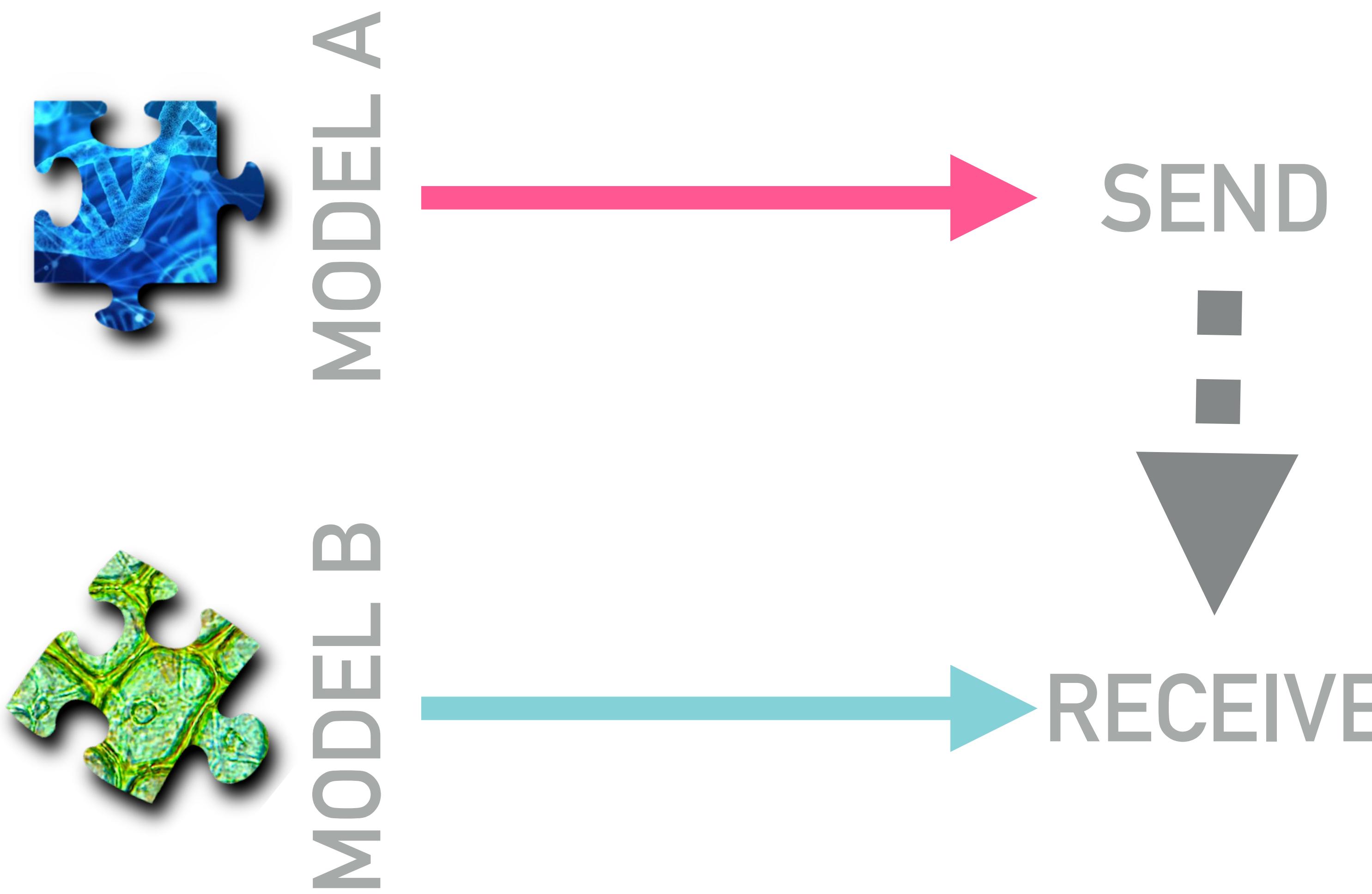


MODEL B



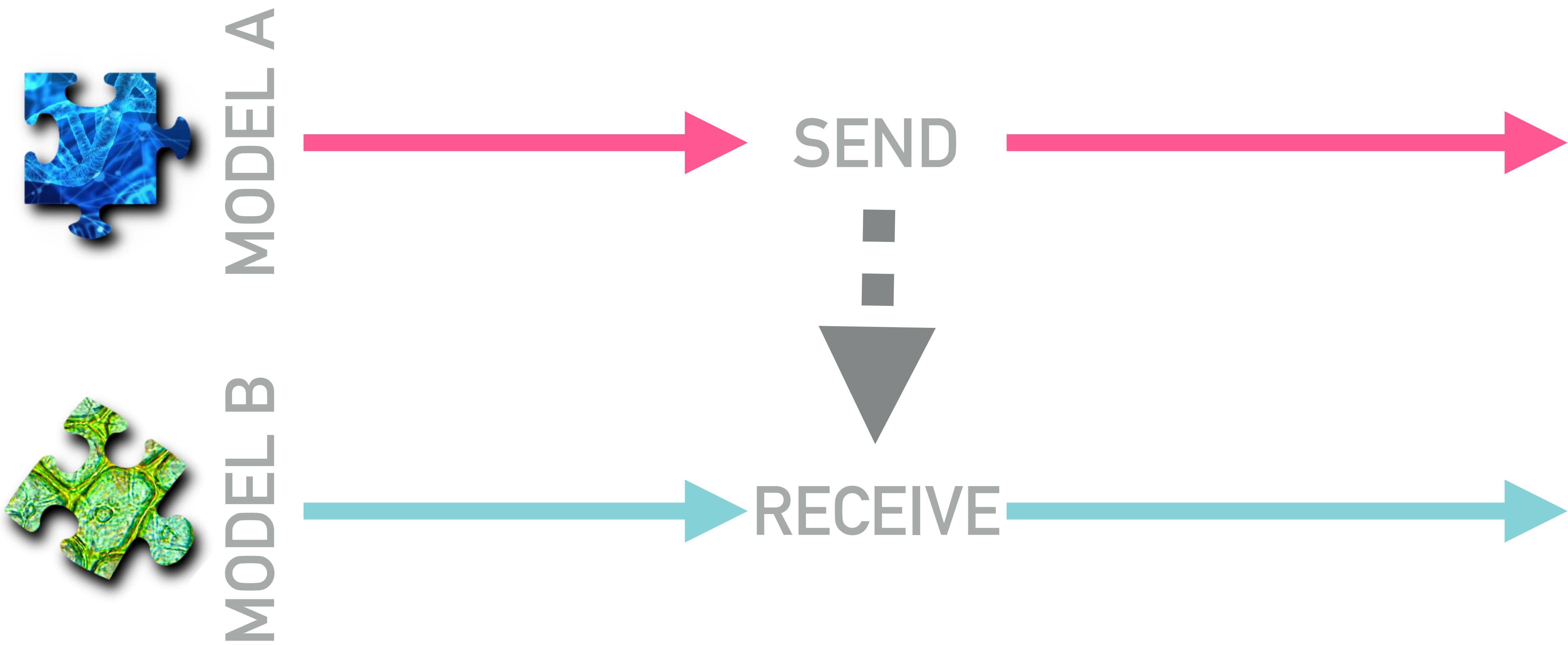
ASYNCHRONOUS COMMUNICATION

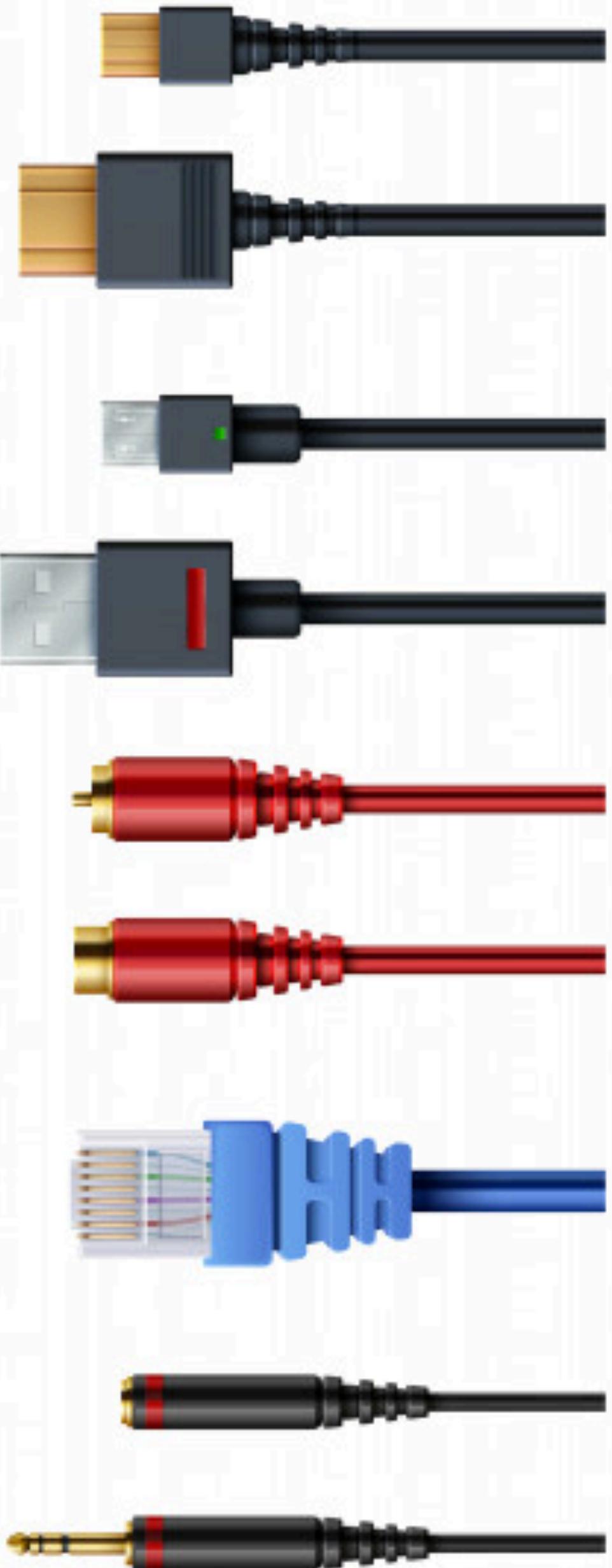
(RECEIVE FIRST)



ASYNCHRONOUS COMMUNICATION

(RECEIVE FIRST)





COMM:

COMMUNICATION OBJECT
ALLOWING MODELS TO
SEND/RECEIVE MESSAGES
TO/FROM OTHER MODELS

COMM CLASSES

INPUT

Receive messages from another model



OUTPUT

Send messages to another model



COMM CLASSES

INPUT

Receive messages from another model

OUTPUT

Send messages to another model



OUTPUT

INPUT



COMM CLASSES

INPUT

Receive messages from another model



OUTPUT

Send messages to another model

SERVER

Receive requests from client models and send responses



CLIENT

Send requests to a server model and receive messages ("call" a server model)

COMM CLASSES

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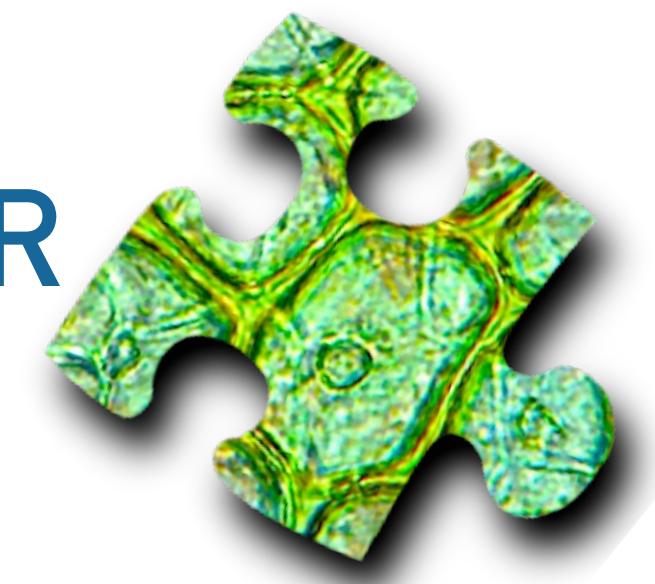
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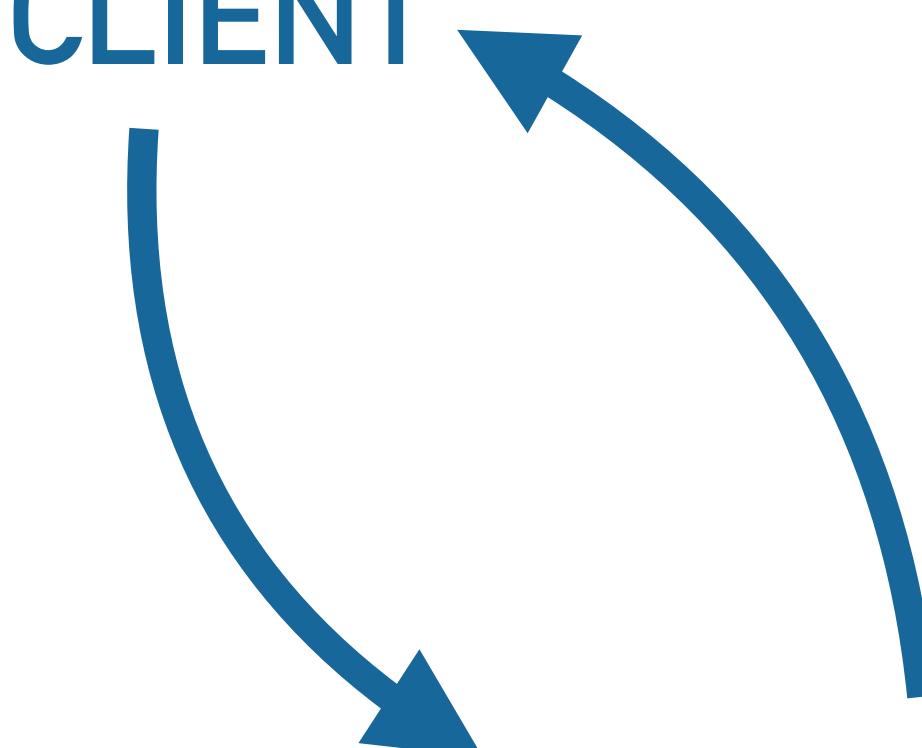
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CLIENT

Send requests to a server model and receive messages ("call" a server model)

TIMESYNC

Send requests to a set of time-dependent models and receive time-dependent variables ("call" a time step synchronization)

COMM CLASSES

INPUT

Receive messages from another model

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Send messages to another model

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Receive requests from client models and send responses

CLIENT

Send requests to a server model and receive messages (“call” a server model)

TIMESYNC

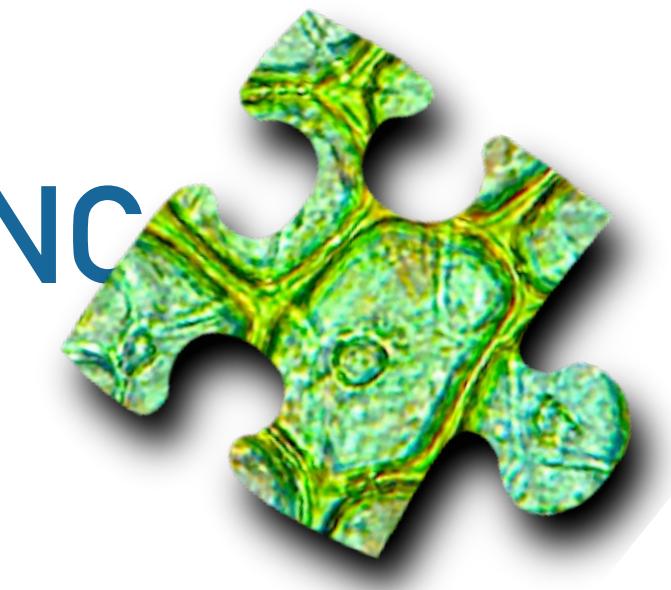
Send requests to a set of time-dependent models and receive time-dependent variables (“call” a time step synchronization)



TIMESYNC

SYNC

TIMESYNC



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TIMESYNC

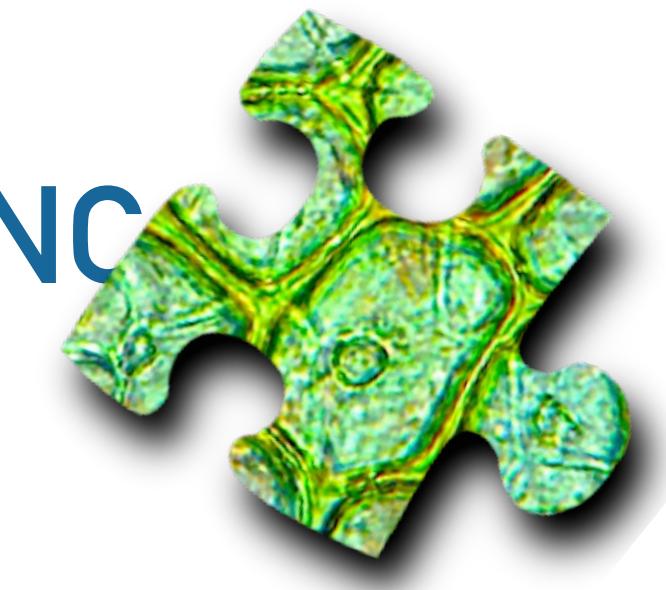
Send requests to a set of time-dependent models and receive time-dependent variables ("call" a time step synchronization)



TIMESYNC



SYNC



TIMESYNC

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Send messages to another model

SERVER

Receive requests from client models and send responses

CLIENT

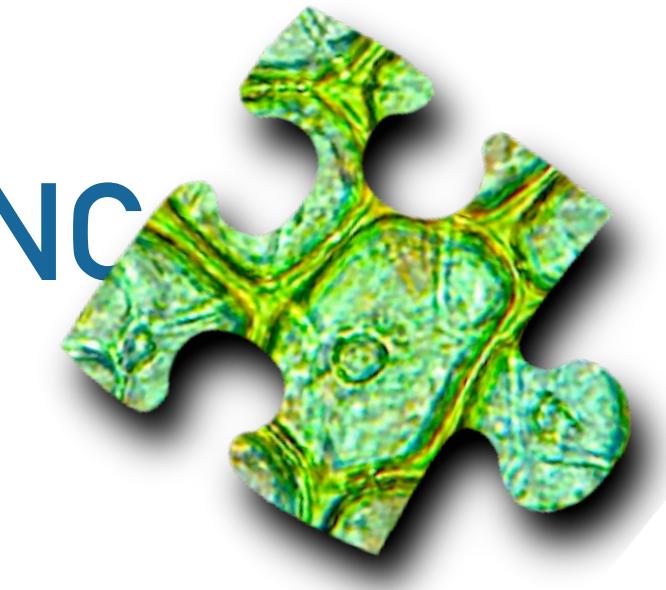
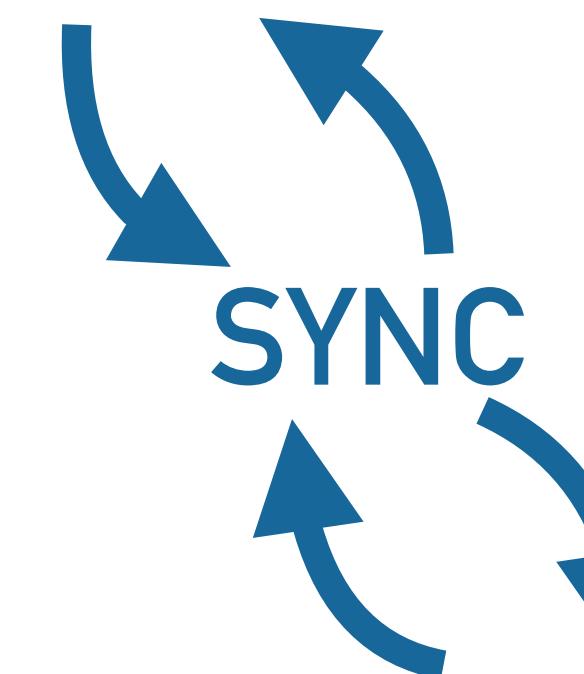
Send requests to a server model and receive messages ("call" a server model)

TIMESYNC

Send requests to a set of time-dependent models and receive time-dependent variables ("call" a time step synchronization)



TIMESYNC



TIMESYNC

COMM METHODS

IPC

Interprocess communication, only available on Unix (Linux & Mac)

ZEROMQ

Broker-less communication sockets via TCP, IPC, UDP, inproc, etc.; available on all OSs

RABBITMQ

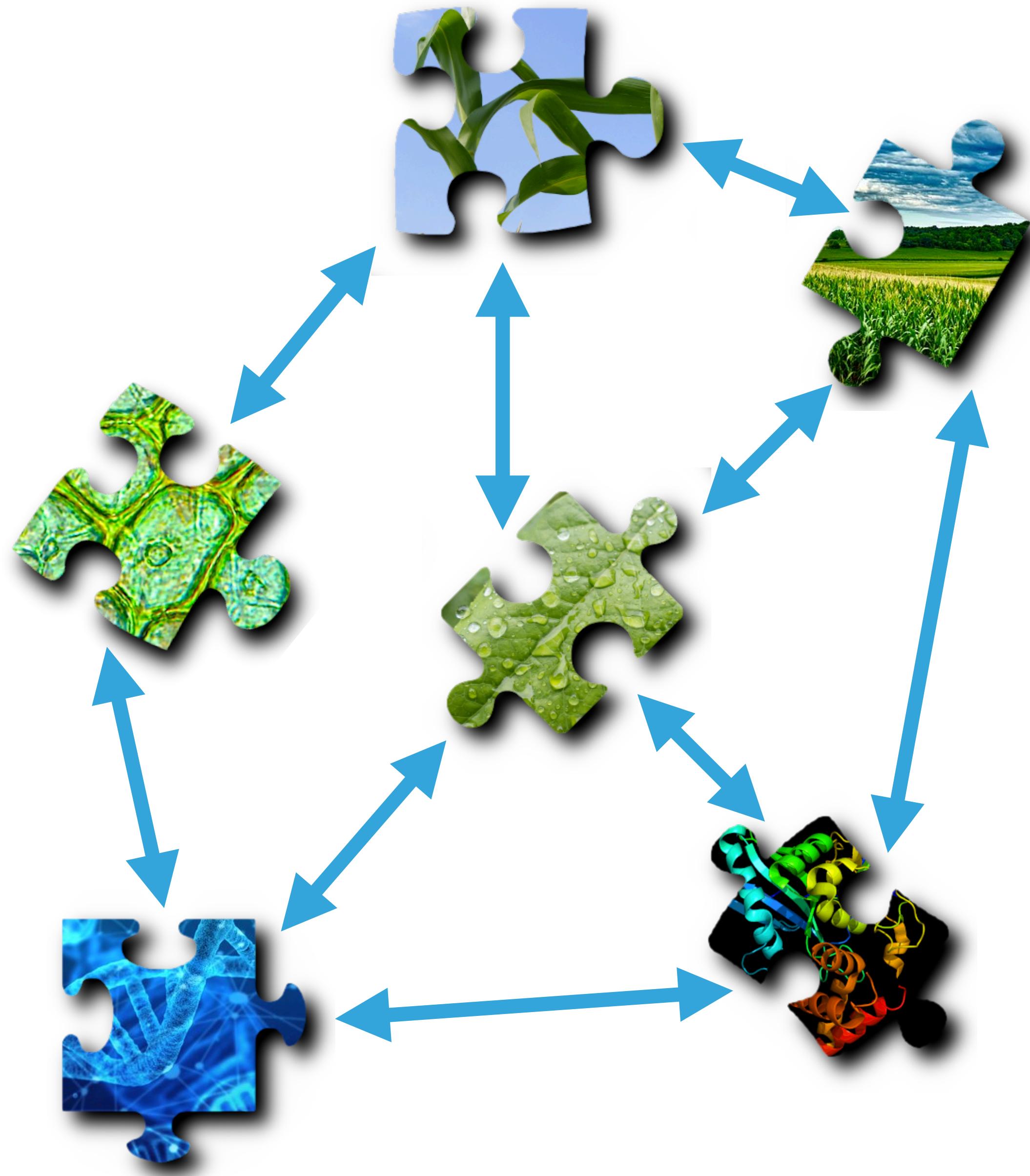
Brokered communication; requires a RabbitMQ server, but allows for more reliable communication with remote machines

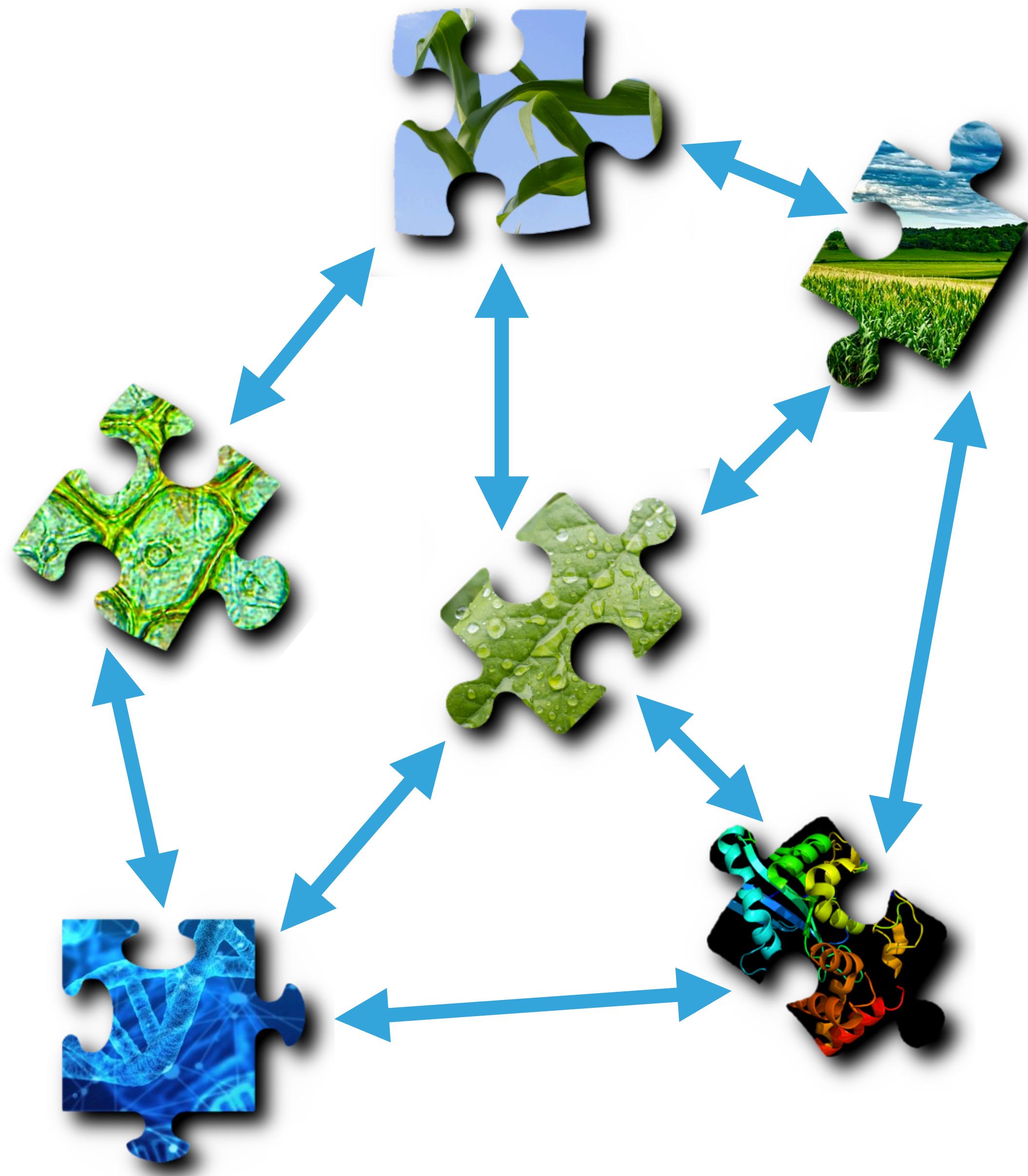
FILES

Slow due to interaction with the disk, but useful for input/output of parameters in a generic way that allows the same model to be used w/ files or other models

UNITS (AUTOMATED CONVERSION)

UNYT (PYTHON)
MATLAB SYMBOLIC UNITS
R UNITS





UNITS (AUTOMATED CONVERSION)

UNYT (PYTHON)

MATLAB SYMBOLIC UNITS

R UNITS

DATA FORMATS

SCALARS/ARRAYS

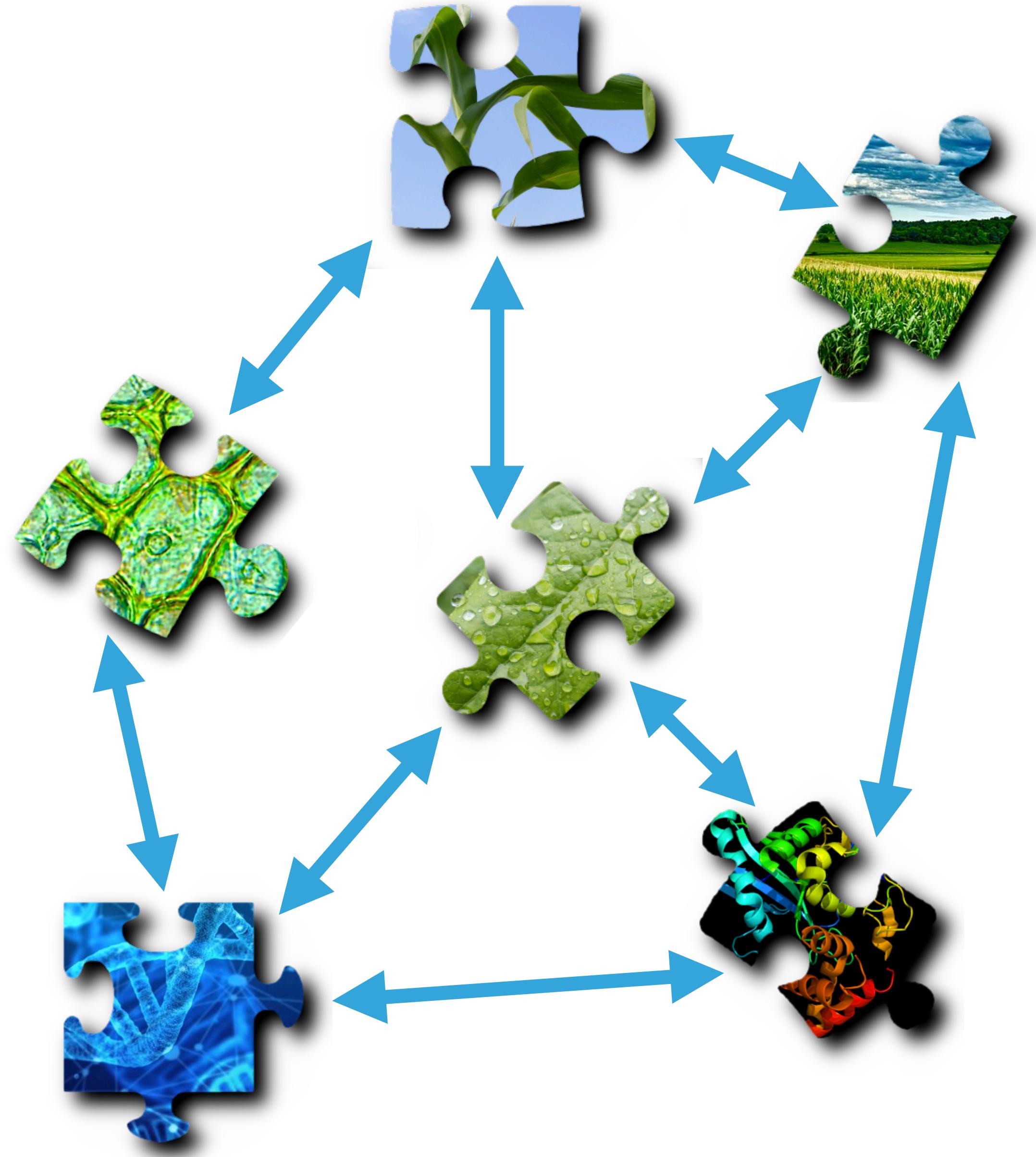
DELIMITED TABLES

PANDAS/R DATA FRAMES

PLY/OBJ

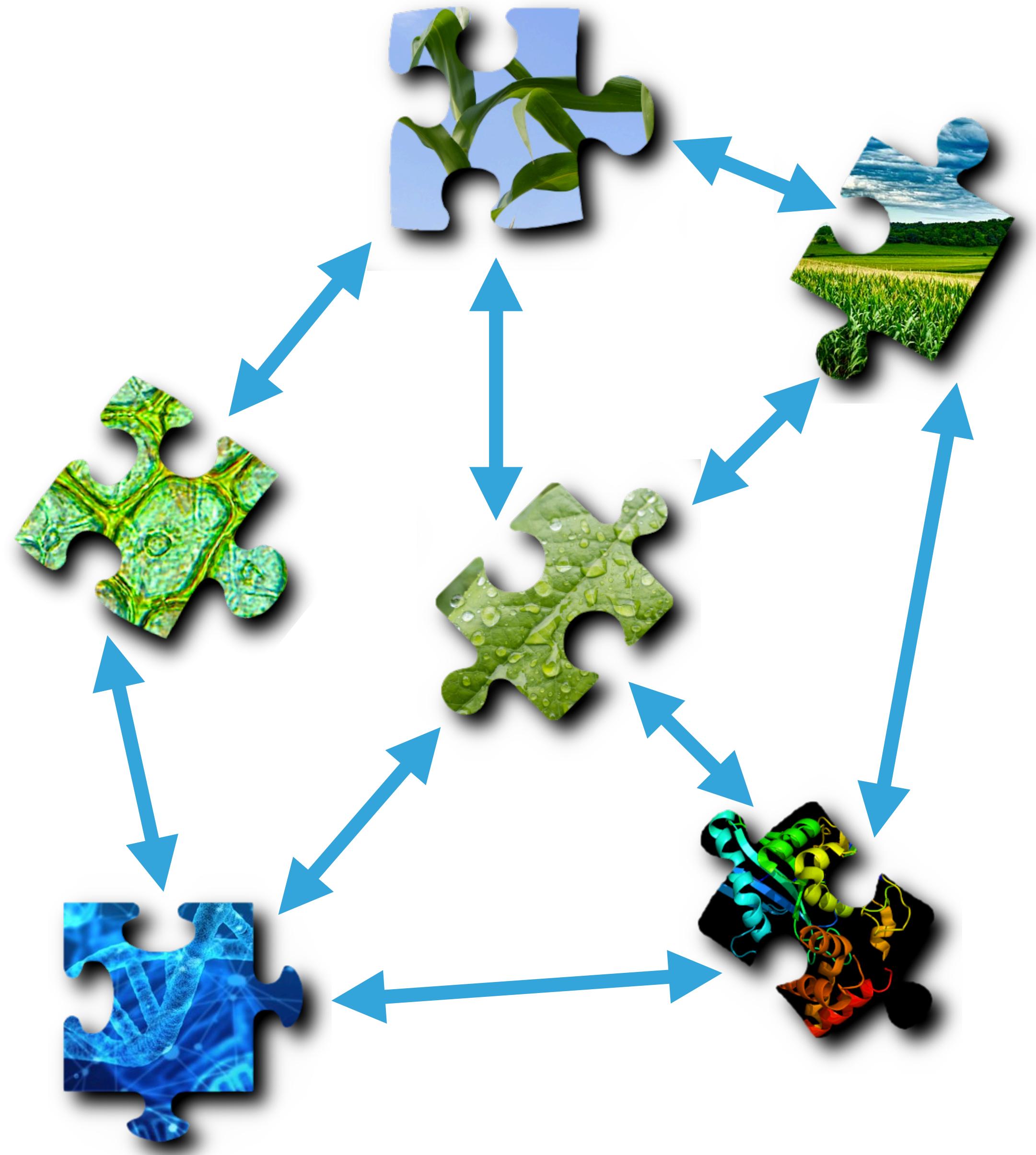
PYTHON PICKLES/
R .RDATA/MATLAB .MAT

EXECUTION



INTEGRATION:

NETWORK OF MODELS RUN USING YGGDRASIL



YAML SPECIFICATION:

INPUT FILE(S) TO
YGGDRASIL CONTAINING
INFO ON MODELS &
CONNECTIONS

YAML SPECIFICATION:

INPUT FILE(S) TO
YGGDRASIL CONTAINING
INFO ON MODELS &
CONNECTIONS

```
model:
  name: GrowthModel
  language: python
  args: ./src/growth.py
  inputs:
    - light
  outputs:
    - growth_rate
```

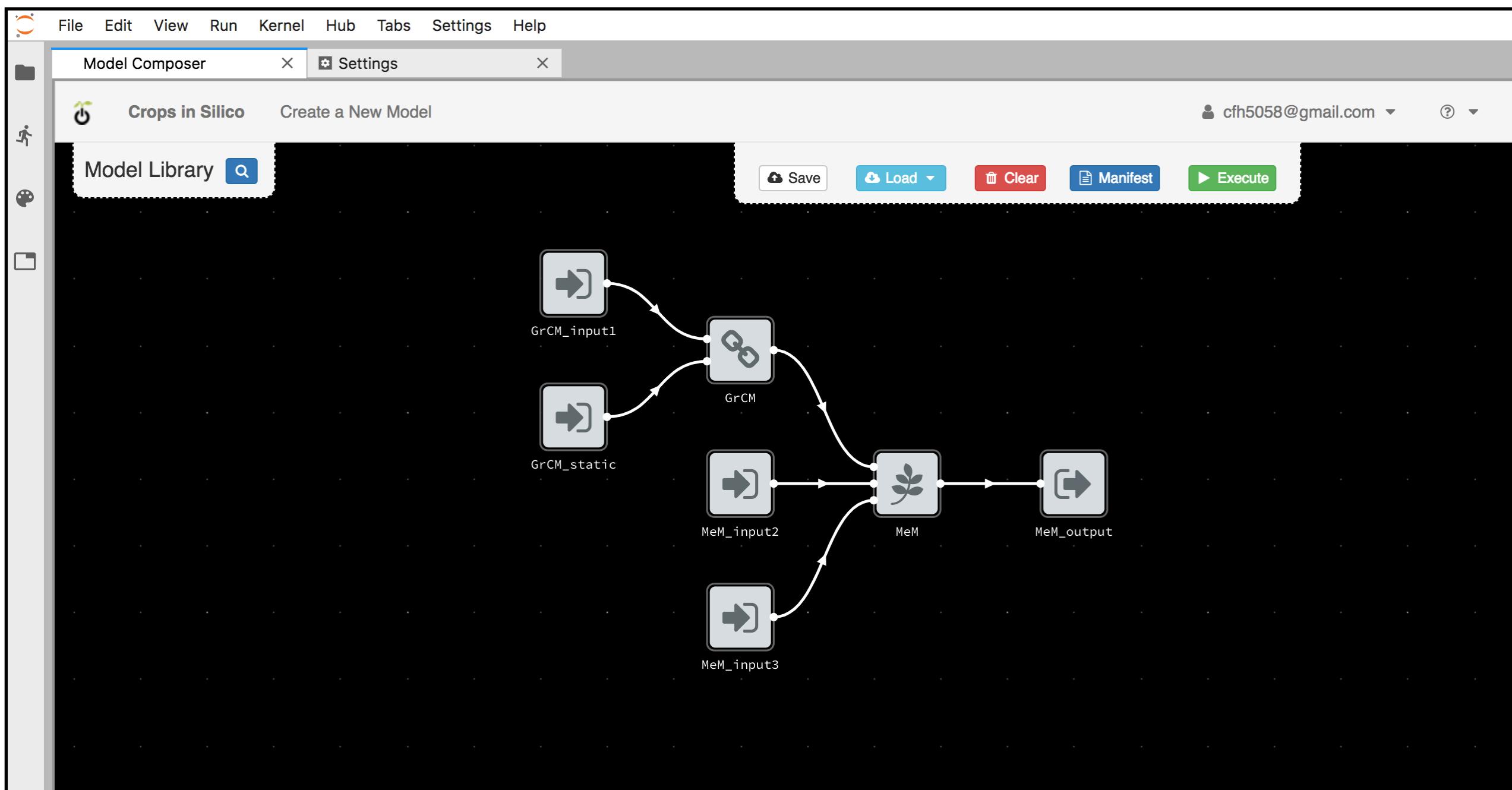
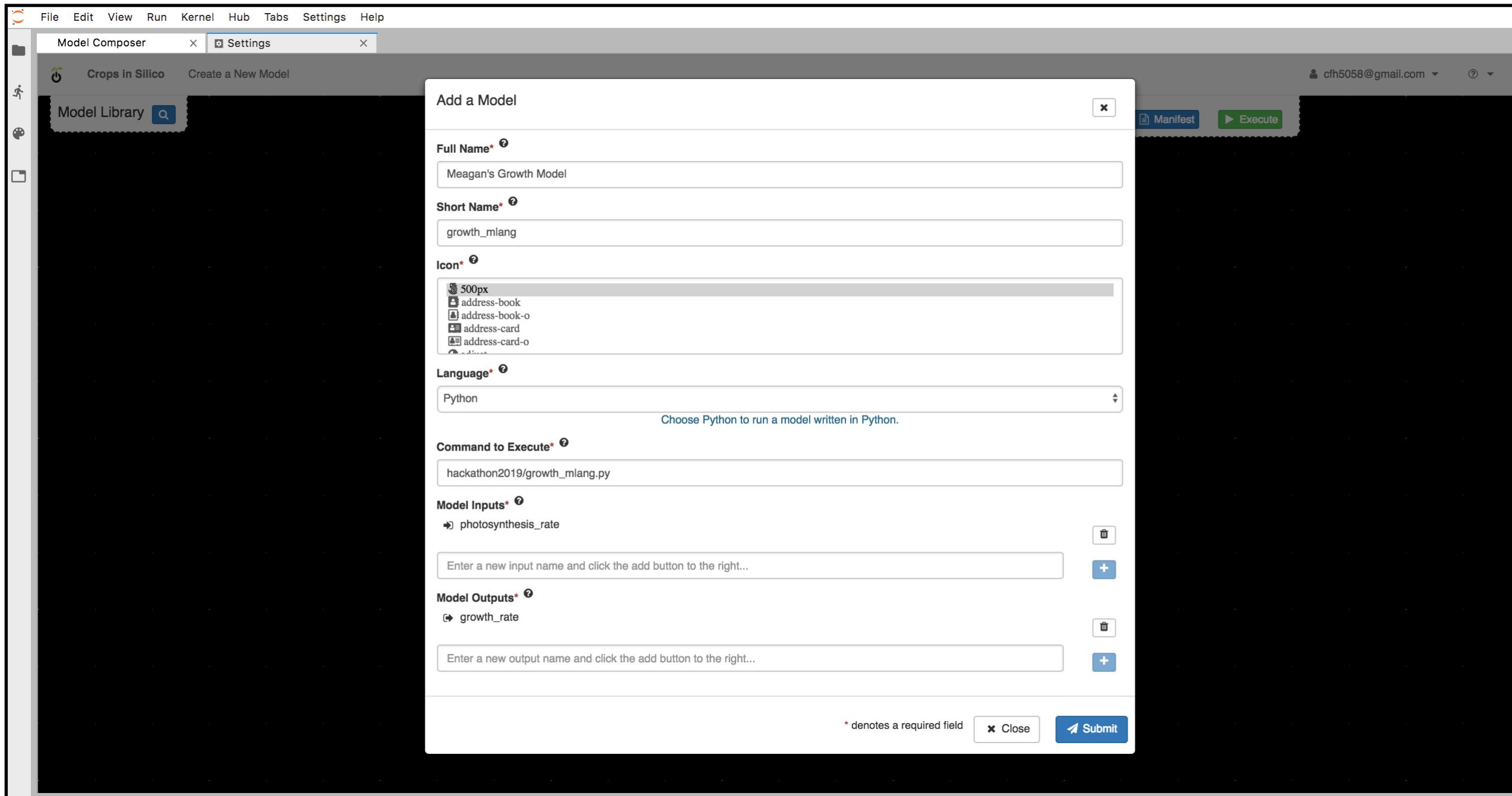
YAML SPECIFICATION:

INPUT FILE(S) TO
YGGDRASIL CONTAINING
INFO ON MODELS &
CONNECTIONS

```
model:  
  name: GrowthModel  
  language: python  
  args: ./src/growth.py  
  inputs:  
    - light  
  outputs:  
    - growth_rate  
  
connections:  
  - input: LightModel:light  
    output: GrowthModel:light  
  - input: growth_rate  
    output: ./Output/growth.txt  
    filetype: table  
    field_names: growth_rate
```

YAML SPECIFICATION:

INPUT FILE(S) TO
YGGDRASIL CONTAINING
INFO ON MODELS &
CONNECTIONS



GUI:

UPDATE TO GRAPHICAL
USER INTERFACE (GUI) IN
DEVELOPMENT FOR
YGGDRASIL CAN
GENERATE THE YAML

Work by Doug Friedel

Yggdrasil Model Submission Form

[Submit](#) [Reset](#) [not valid](#)

I'm not a robot

reCAPTCHA

Privacy - Terms

The following errors must be corrected

- Model.name: Value required

Model YAML Schema [Properties](#) [Upload](#)

Schema for yggdrasil model YAML input files.

name

Name used for component in log messages.
Value required.

language

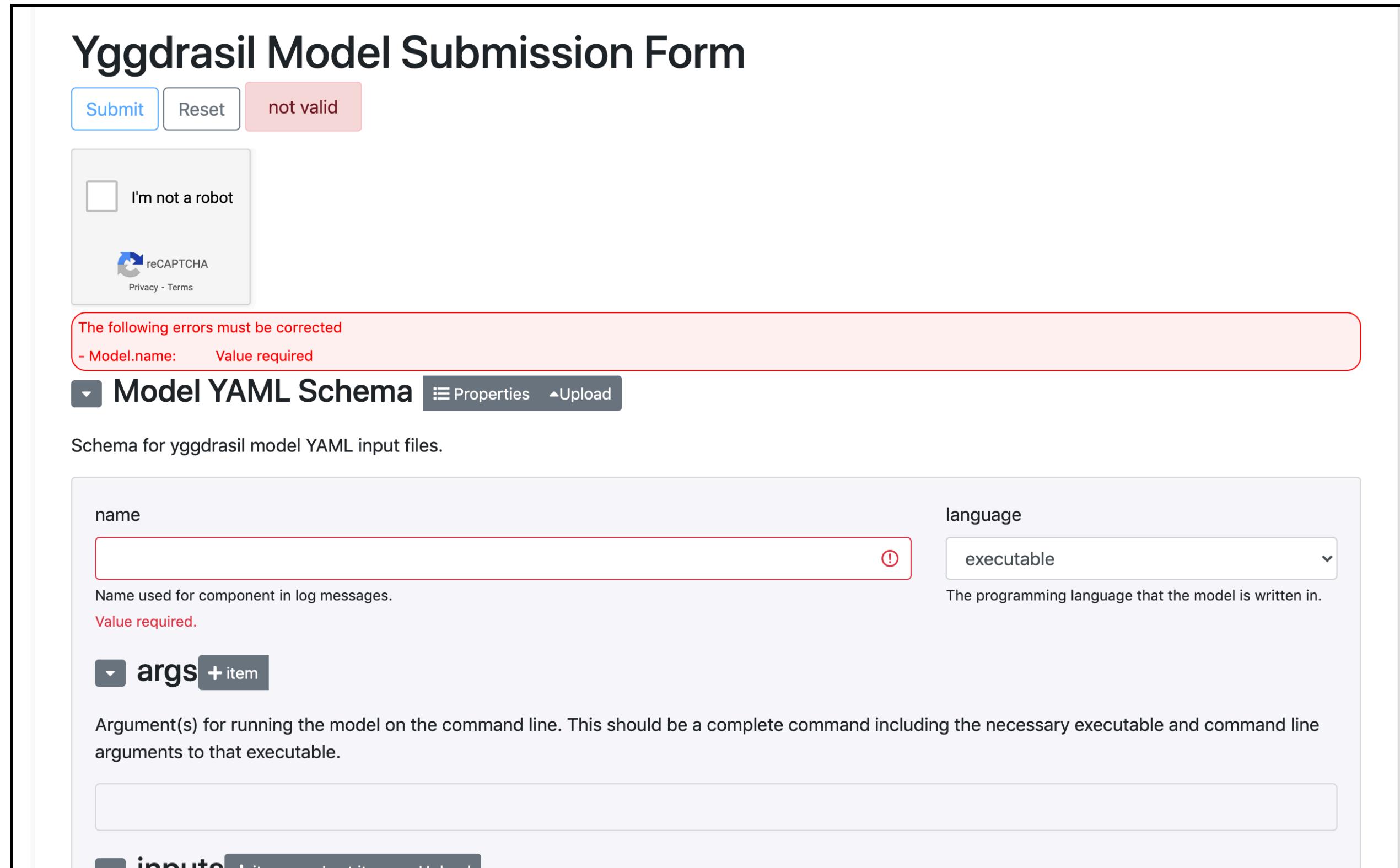
executable

The programming language that the model is written in.

args [+ item](#)

Argument(s) for running the model on the command line. This should be a complete command including the necessary executable and command line arguments to that executable.

inputs [+ item](#) [Last item](#) [Upload](#)



MODEL REPOSITORY:

FORM FOR ENTERING
MODEL INFORMATION TO
VALIDATE, GENERATE &
SHARE MODEL YAMLS
WITH OTHERS

<https://yggdrasil-models.herokuapp.com/>

DEBUGGING

DEBUGGING

1. TRY ANOTHER BROWSER (IF USING MYBINDER)
2. IF IN A NOTEBOOK CELL, TRY RE-RUNNING PREVIOUS CELLS
3. CHECK FOR SIMILAR ISSUES ON GITHUB

Materials: <https://github.com/cropsinsilico/CiS2021-hackathon>

GITHUB ISSUES

Screenshot of a GitHub repository page for `cropsinsilico / CiS2021-hackathon`.

The repository has 4 issues, 1 star, and 1 fork.

Code navigation buttons: Go to file, Add file, Code (selected).

Code section:

- main branch (2 branches, 0 tags)
- Recent commits by langmm:
 - Fixed temp cmake that was added (16 hours ago)
 - Update issue template and fix typo in README (7 days ago)
 - Fixed temp cmake that was added (16 hours ago)
 - Add example of wrapping a model function (16 days ago)
 - Fix bugs in the untested copies example (13 days ago)
 - Fixed temp cmake that was added (16 hours ago)
 - Fixed temp cmake that was added (16 hours ago)
 - Update root model and add version of shoot for timesync example (13 days ago)
 - Fixed temp cmake that was added (16 hours ago)

About section:

Materials for the Hackathon at the 2021 Crops in Silico Symposium & Workshop

- Readme
- BSD-3-Clause License

Releases section:

No releases published

Packages section:

No packages published

GITHUB ISSUES

Screenshot of a GitHub repository page for `cropsinsilico / CiS2021-hackathon`.

The repository has 2 branches and 0 tags.

The Issues tab is selected (circled in red).

The repository contains 56 commits from user `langmm`:

Commit	Message	Time Ago
<code>a38cd3f</code>	Fixed temp cmake that was added	16 hours ago
<code>.github</code>	Update issue template and fix typo in README	7 days ago
<code>images</code>	Fixed temp cmake that was added	16 hours ago
<code>input</code>	Add example of wrapping a model function	16 days ago
<code>meshes</code>	Fix bugs in the untested copies example	13 days ago
<code>models</code>	Fixed temp cmake that was added	16 hours ago
<code>yamls</code>	Fixed temp cmake that was added	16 hours ago
<code>.gitignore</code>	Update root model and add version of shoot for timesync example	13 days ago
<code>00-intro.ipynb</code>	Fixed temp cmake that was added	16 hours ago

About

Materials for the Hackathon at the 2021 Crops in Silico Symposium & Workshop

[Readme](#) [BSD-3-Clause License](#)

Releases

No releases published [Create a new release](#)

Packages

No packages published

GITHUB ISSUES

The screenshot shows a GitHub repository page for 'cropsinsilico/CiS2021-hackathon'. The 'Issues' tab is selected. A prominent message box at the top right encourages labeling issues and pull requests for new contributors, mentioning 'good first issue'. Below the message, there are filters for 'Filters', a search bar containing 'is:issue is:open', and buttons for 'Labels' (10), 'Milestones' (0), and 'New issue'. At the bottom left, there are filter options for '0 Open' and '1 Closed'. The main content area displays a single exclamation mark icon with the text 'There aren't any open issues.'

Search or jump to... / Pull requests Issues Marketplace Explore

cropsinsilico / CiS2021-hackathon

Unwatch 4 Star 1 Fork 1

Code Issues Pull requests Actions Projects Wiki Security Insights Settings

Label issues and pull requests for new contributors

Now, GitHub will help potential first-time contributors [discover issues](#) labeled with [good first issue](#)

Dismiss

Filters is:issue is:open Labels 10 Milestones 0 New issue

0 Open 1 Closed Author ▾ Label ▾ Projects ▾ Milestones ▾ Assignee ▾ Sort ▾

!

There aren't any open issues.

GITHUB ISSUES

Search or jump to... /

Pull requests Issues Marketplace Explore

cropsinsilico / CiS2021-hackathon

Unwatch 4 Star 1 Fork 1

Code Issues Pull requests Actions Projects Wiki Security Insights Settings

Label issues and pull requests for new contributors

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0 Open ✓ 1 Closed

Author ▾ Label ▾ Projects ▾ Milestones ▾ Assignee ▾ Sort ▾

!

There aren't any open issues.

GITHUB ISSUES

The screenshot shows the GitHub Issues page for the repository `cropsinsilico/CiS2021-hackathon`. The page has a dark theme. At the top, there is a navigation bar with links for **Pull requests**, **Issues**, **Marketplace**, and **Explore**. On the far right of the header are icons for notifications, a plus sign, and a user profile.

The main content area shows a modal dialog titled **Label issues and pull requests for new contributors**. It informs users that GitHub will help potential first-time contributors discover issues labeled with **good first issue**. A **Dismiss** button is located in the top right corner of the modal.

Below the modal, there are search and filter options. The search bar contains the query `is:issue is:closed`. To the right of the search bar are buttons for **Labels 10** and **Milestones 0**, and a green **New issue** button. There is also a link to **Clear current search query, filters, and sorts**.

The issue list table has columns for status (**Open** or **Closed**), title, author, labels, milestones, assignee, and sort order. The first issue listed is **"Binder not found"** by `mybinder`, which was closed 21 hours ago. A comment icon next to the issue indicates 1 comment.

At the bottom of the page, a **ProTip!** message suggests searching for `author:langmm` to find everything created by the user `langmm`.

Filter	Value
is:issue	is:closed

Action	Count
Labels	10
Milestones	0

New issue

Clear current search query, filters, and sorts

Status	Count
Open	0
Closed	1

Author	Label	Projects	Milestones	Assignee	Sort
--------	-------	----------	------------	----------	------

"Binder not found" mybinder

#2 by langmm was closed 21 hours ago 2 of 7

ProTip! Find everything you created by searching `author:langmm`.

DEBUGGING

1. TRY ANOTHER BROWSER (IF USING MYBINDER)
2. IF IN A NOTEBOOK CELL, TRY RE-RUNNING PREVIOUS CELLS
3. CHECK FOR SIMILAR ISSUES ON GITHUB
4. IF USING A LOCAL INSTALL, CHECK THE DEBUGGING DOCS FOR YGGDRASIL

Materials: <https://github.com/cropsinsilico/CiS2021-hackathon>

OTHER RESOURCES

Requirements

- Browser (tested on Google Chrome, Safari, Firefox)
- Github Account

Preparing for the hackathon

- Check that you can sign-in to Github, creating an account as necessary. We will be using Github Issues to track problems encountered during the hackathon.
- Try launching a mybinder instance by clicking on this  launch binder icon (or the link below).

It may take a few moments to initialize. If you encounter an error, open an issue and try with another browser. If you still cannot launch the binder, you can install the materials on your machine by following the instructions at one of the links below

- Local install (via conda)
- Docker container

<https://mybinder.org/v2/gh/cropsinsilico/CiS2021-hackathon/HEAD>

Useful links

- [Hackathon Repository](#)
- [Hackathon Documentation](#)
- [yggdrasil Repository](#)
- [yggdrasil Documentation](#)
- [Additional Examples](#)
- [Debugging Tips & Documented Errors](#)

OTHER RESOURCES

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- [Hackathon Documentation](#)
- [yggdrasil Repository](#)
- [yggdrasil Documentation](#)
- [Additional Examples](#)
- [Debugging Tips & Documented Errors](#)

Requirements

- Browser (tested on Google Chrome, Safari, Firefox)
- Github Account

Preparing for the hackathon

- Check that you can sign-in to Github, creating an account as necessary if you do not have one. This will help you report any problems encountered during the hackathon.
- Try launching a mybinder instance by clicking on this  [launch binder](#)

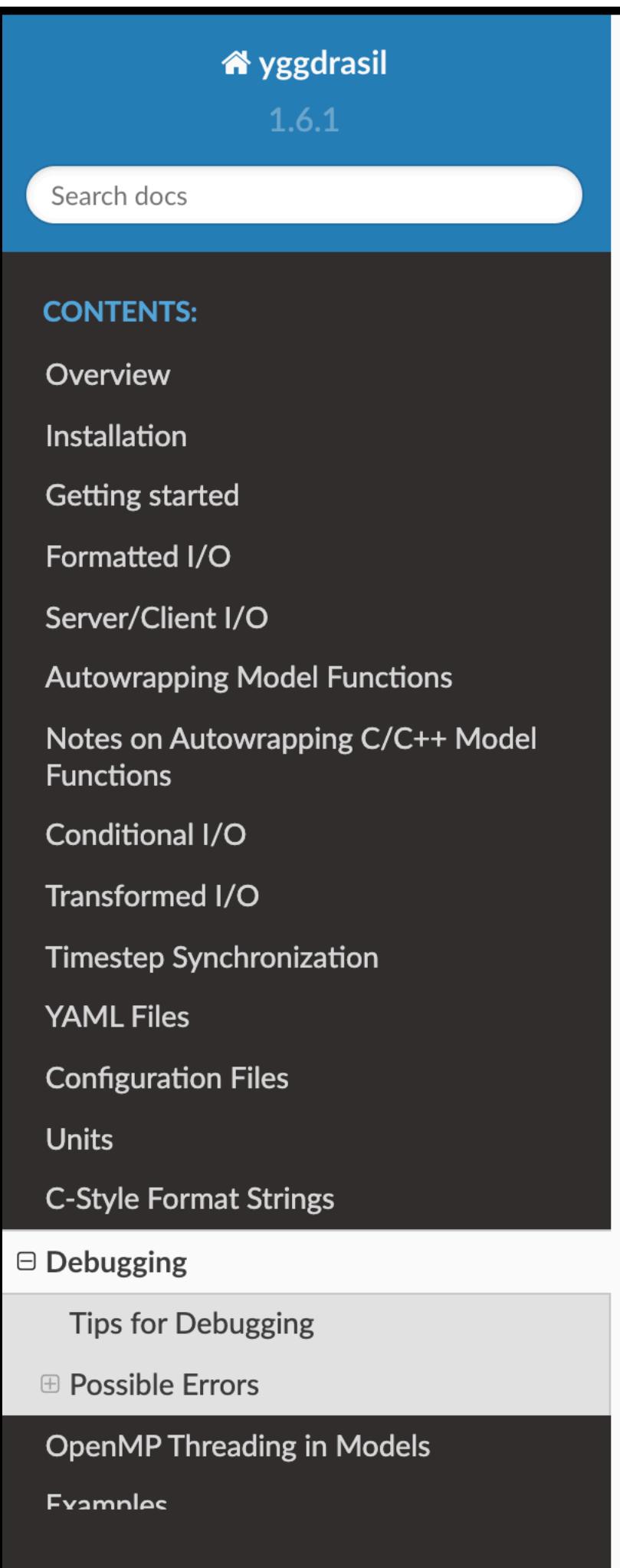
It may take a few moments to initialize. If you encounter an error, open the browser's developer tools to inspect the page source. If you still cannot launch the binder, you can install the materials on your local machine by following one of the links below

- [Local install \(via conda\)](#)
- [Docker container](#)

<https://mybinder.org/v2/gh/cropsinsilico/CiS2021-hackathon/HEAD>

Useful links

- [Hackathon Repository](#)
- [Hackathon Documentation](#)
- [yggdrasil Repository](#)
- [yggdrasil Documentation](#)
- [Additional Examples](#)
- [Debugging Tips & Documented Errors](#)



The screenshot shows the yggdrasil documentation website. At the top, it says "yggdrasil 1.6.1". Below that is a search bar labeled "Search docs". The main content area has a sidebar titled "CONTENTS:" with a list of topics: Overview, Installation, Getting started, Formatted I/O, Server/Client I/O, Autowrapping Model Functions, Notes on Autowrapping C/C++ Model Functions, Conditional I/O, Transformed I/O, Timestep Synchronization, YAML Files, Configuration Files, Units, C-Style Format Strings. Below the sidebar, there is a section titled "Debugging" which contains "Tips for Debugging" and "Possible Errors". At the bottom of the sidebar, there are links for "OpenMP Threading in Models" and "Examples".

OTHER RESOURCES

[View page source](#)

Debugging

Tips for Debugging

1. *Look at the full output.* The final error raised by yggdrasil may not contain all of the information provided by errors that were raised within a model due to limitations of error forwarding between the different languages. It is important to look at the full output from a failed run. Usually the first error encountered or the error raised within the model's language will be the most relevant and be the most useful for debugging.
2. *Check for known errors.* The list below includes several errors that have already been encountered by yggdrasil users and the method used to solve the issue.
3. *Turn on debugging log messages.* This will increase the number of log messages greatly and help you track down any issues. Debug messages can be enabled by setting the `ygg` and `client` debug options in your config file to `DEBUG` (see [Configuration Options](#) for details on the location of the user config file and additional logging options).
4. *Trace the flow of data.* Use the debug messages to trace the flow of data from one model to the next and determine where the failure is occurring.
5. *Check `|yggdrasil| summary`.* yggdrasil includes a command line utility, `ygginfo` that will print out relevant information about yggdrasil, the languages it supports, and the operating system. This information can be useful for running down conflicting dependencies or determining why yggdrasil thinks a language is or isn't installed. Additional information about the system can be displayed by adding the `--verbose` flag, including the current conda environment information (if you are using a conda environment) and information about the current R installation (if R is installed). This information should be included in any Github issues opened related to bugs in order to help us assist you.

DEBUGGING

1. TRY ANOTHER BROWSER (IF USING MYBINDER)
2. IF IN A NOTEBOOK CELL, TRY RE-RUNNING PREVIOUS CELLS
3. CHECK FOR SIMILAR ISSUES ON GITHUB
4. IF USING A LOCAL INSTALL, CHECK THE DEBUGGING DOCS FOR YGGDRASIL
5. OPEN A NEW GITHUB ISSUE

Materials: <https://github.com/cropsinsilico/CiS2021-hackathon>

GITHUB ISSUES

The screenshot shows the GitHub Issues page for the repository `cropsinsilico/CiS2021-hackathon`. The page has a dark theme. At the top, there is a navigation bar with links for Pull requests, Issues, Marketplace, and Explore. On the far right of the header are a bell icon, a plus sign, and a user profile picture.

The main content area shows the repository name `cropsinsilico / CiS2021-hackathon` and a summary bar with Unwatch (4), Star (1), and Fork (1) buttons. Below this is a navigation bar with links for Code, Issues (which is underlined in red), Pull requests, Actions, Projects, Wiki, Security, Insights, and Settings.

A prominent callout box in the center of the page says "Label issues and pull requests for new contributors". It explains that GitHub will help potential first-time contributors discover issues labeled with "good first issue". A "Dismiss" button is located in the top right corner of the callout.

Below the callout are filtering options: "Filters" dropdown, search bar with query "is:issue is:open", "Labels" (10), "Milestones" (0), and a green "New issue" button. There are also checkboxes for "0 Open" and "1 Closed". To the right are dropdown menus for Author, Label, Projects, Milestones, Assignee, and Sort.

The main content area displays a single exclamation mark icon (!) centered on the page, with the text "There aren't any open issues." below it.

GITHUB ISSUES

The screenshot shows the GitHub Issues page for the repository `cropsinsilico / CiS2021-hackathon`. The page includes a navigation bar with links for Pull requests, Issues, Marketplace, and Explore. On the right side of the header are icons for notifications, a plus sign, and user profile.

The main content area features a navigation bar with links for Code, Issues (which is underlined), Pull requests, Actions, Projects, Wiki, Security, Insights, and Settings. A modal window titled "Label issues and pull requests for new contributors" is displayed, stating that GitHub will help potential first-time contributors discover issues labeled with "good first issue". There is a "Dismiss" button in the top right corner of the modal.

Below the navigation bar are filters: "Filters ▾" and a search bar containing "is:issue is:open". To the right of the search bar are buttons for "Labels 10", "Milestones 0", and a prominent green "New issue" button, which is circled in red.

At the bottom left, there are filter options: "0 Open" (unchecked) and "1 Closed" (checked). At the bottom right are dropdown menus for Author, Label, Projects, Milestones, Assignee, and Sort. In the center of the page, a large exclamation mark icon is followed by the text "There aren't any open issues."

GITHUB ISSUES

The screenshot shows a GitHub repository page for 'cropsinsilico/CiS2021-hackathon'. The 'Issues' tab is active. A new issue is being created, with the 'Title' field highlighted. The issue body contains the following placeholder text:

```
<!-- Provide some information about how you are accessing the hackathon materials. -->
<!-- To mark a check box, replace the space inside the brackets with an X, e.g. [X] -->
## Context (Environment)
* [ ] MyBinder instance
* [ ] Local install
* [ ] Docker container

<!-- What operating system are you on? (e.g. Windows, Mac, Linux) -->
#### OS:

<!-- What web browser are you using to access the notebooks? -->
#### Browser:

<!-- Tell us what type of issue you are having -->
```

On the right side, there are settings for the new issue:

- Assignees:** No one—assign yourself
- Labels:** None yet
- Projects:** None yet
- Milestone:** No milestone
- Linked pull requests:** Successfully merging a pull request may close this issue.

GITHUB ISSUES

Screenshot of a GitHub Issues page for the repository `cropsinsilico / CiS2021-hackathon`.

The page shows the following navigation bar:

- Search or jump to... (with a search icon)
- Pull requests
- Issues
- Marketplace
- Explore

On the right side of the header are icons for Unwatch (with a bell), Star (with a star), Fork (with a fork), and a user profile.

The main content area has tabs for Code, Issues (selected), Pull requests, Actions, Projects, Wiki, Security, Insights, and Settings.

The Issues tab displays a form for creating a new issue:

- Title:** (Input field)
- Write** and **Preview** buttons (the **Preview** button is circled in red).
- Rich text editor toolbar with buttons for H, B, I, etc.
- Text input area containing placeholder code snippets for accessing materials, specifying environment, operating system, browser, and issue type.

On the right side of the issue creation form are several configuration sections:

- Assignees:** No one—assign yourself
- Labels:** None yet
- Projects:** None yet
- Milestone:** No milestone
- Linked pull requests:** Successfully merging a pull request may close this issue.

GITHUB ISSUES

Screenshot of a GitHub repository page for `cropsinsilico / CiS2021-hackathon`.

The page shows the following navigation bar:

- Search or jump to... (with a search icon)
- Pull requests
- Issues
- Marketplace
- Explore

On the right side of the header are icons for Unwatch (with a bell), Star (with a star), Fork (with a fork), and a user profile.

The repository name `cropsinsilico / CiS2021-hackathon` is displayed, along with metrics: 4 issues, 1 star, and 1 fork.

The main navigation tabs are:

- Code
- Issues** (selected)
- Pull requests
- Actions
- Projects
- Wiki
- Security
- Insights
- Settings

The Issues tab is selected, showing a form to create a new issue:

- Title**: A text input field.
- Write** and **Preview** buttons for the title input.
- Context (Environment)**: A section with checkboxes for:
 - MyBinder instance
 - Local install
 - Docker container
- OS:** (empty field)
- Browser:** (empty field)
- Type of Issue**: A section with a checkbox for:
 - Jupyter notebook failed to open

On the right side of the page, there are settings sections for:

- Assignees**: No one—assign yourself.
- Labels**: None yet.
- Projects**: None yet.
- Milestone**: No milestone.
- Linked pull requests**: Successfully merging a pull request may close this issue.

DEMO TIME!



Starting repository: cropsinsilico/CiS2021-hackathon/HEAD

You can connect with the Binder community in the [Jupyter community forum](#).

Build logs

[hide](#)

libgfortran-ng-9.3.0	22 KB	#####	100%
gitdb-4.0.7	46 KB	#####	100%
r-jsonlite-1.7.2	462 KB	#####	100%
smmap-3.0.5	22 KB	#####	100%
czmq-4.2.1	540 KB	#####	100%
networkx-2.5.1	1.2 MB	#####	100%
gcc_linux-64-9.3.0	23 KB	#####	100%
openjpeg-2.4.0	444 KB	#####	100%
r-rappdirs-0.3.3	50 KB	#####	100%

[Files](#) [Running](#) [Clusters](#) [Nbextensions](#)

Select items to perform actions on them.

[Upload](#) [New ▾](#) [⟳](#)

<input type="checkbox"/>	0	▼	 /	Name 	Last Modified	File size
<input type="checkbox"/>	 images				33 minutes ago	
<input type="checkbox"/>	 input				33 minutes ago	
<input type="checkbox"/>	 meshes				33 minutes ago	
<input type="checkbox"/>	 models				33 minutes ago	
<input type="checkbox"/>	 yaml				33 minutes ago	
<input type="checkbox"/>	 00-intro.ipynb				33 minutes ago	457 kB
<input type="checkbox"/>	 01-connections.ipynb				33 minutes ago	470 kB
<input type="checkbox"/>	 02-timesync.ipynb				33 minutes ago	298 kB
<input type="checkbox"/>	 03-misc.ipynb				33 minutes ago	3.56 kB

[Files](#) [Running](#) [Clusters](#) [Nbextensions](#)

Select items to perform actions on them.

[Upload](#) [New ▾](#) 

<input type="checkbox"/> 0	<input type="button" value="▼"/>	 /	Name 	Last Modified	File size
<input type="checkbox"/>		 images		33 minutes ago	
<input type="checkbox"/>		 input		33 minutes ago	
<input type="checkbox"/>		 meshes		33 minutes ago	
<input type="checkbox"/>		 models		33 minutes ago	
<input type="checkbox"/>		 yaml		33 minutes ago	
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<input type="checkbox"/>		 02-timesync.ipynb		33 minutes ago	298 kB
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NOTEBOOK INTRO



Introduction

(NOTE: This notebook is intended for use with the slides found [here](#)).

This is a Jupyter notebook. It allows us to run code (in this case Python) alongside text in different "cells". This cell is a markdown cell that can display text and html, the next cell is a code cell.

In the code cells (prefixed by `In []:`), you can assign variables, perform calculations or call external functions/classes. You can run code cells by selecting the cell (so that a blue or green box appears around it) and then clicking the run button (located at the top of the page) or pressing `Shift+Enter` together. Then a number will appear inside the brackets indicating the order of when the cell was executed.

Output from the cell will be displayed below it with the `Out [#]:` prefix where the number in the brackets indicates the input cell that generated it.

```
In [ ]: x = 1
y = 3
z = (x + y)**3
z
```

Any Python code can be used, and we can import external packages as well just like in Python scripts. Cells can also use any variables created in any previously executed cell. The cell below imports some tools that will be used in the rest of this notebook.



TEXT
CELL

Introduction

(NOTE: This notebook is intended for use with the slides found [here](#)).

This is a Jupyter notebook. It allows us to run code (in this case Python) alongside text in different "cells". This cell is a markdown cell that can display text and html, the next cell is a code cell.

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Output from the cell will be displayed below it with the `Out [#]:` prefix where the number in the brackets indicates the input cell that generated it.

In []:

```
x = 1
y = 3
z = (x + y)**3
z
```

CODE
CELL

Any Python code can be used, and we can import external packages as well just like in Python scripts. Cells can also use any variables created in any previously executed cell. The cell below imports some tools that will be used in the rest of this notebook.

Code cells can contain any valid Python code

Run cells by holding shift and pressing enter
(shift + enter)

In []:

```
x = 1
y = 3
z = (x + y)**3
z
```

Code cells can contain any valid Python code

Run cells by holding shift and pressing enter
(shift + enter)

In [1]:

```
x = 1
y = 3
z = (x + y)**3
z
```

Out[1]: 64

Code cells can contain any valid Python code
Run cells by holding shift and pressing enter
(shift + enter)

In [1]:

```
x = 1
y = 3
z = (x + y)**3
z
```

Out[1]: 64

Output appears below
Number in bracket is the order of execution
("∗" indicates the cell is still running)

We need some tools!

trimesh - package for loading/displaying meshes in the notebook

yggdrasil - the method for running yggdrasil integration

In [2]:

```
from yggdrasil import tools # Displaying syntax
from yggdrasil.runner import run # Running integ.
import trimesh # Load & display 3D meshes
```

We need some tools!

trimesh - package for loading/displaying meshes in the notebook

yggdrasil - the method for running yggdrasil integration

In [2]: `from yggdrasil import tools # Displaying syntax
from yggdrasil.runner import run # Running integ.
import trimesh # Load & display 3D meshes`

No output, so nothing appears below

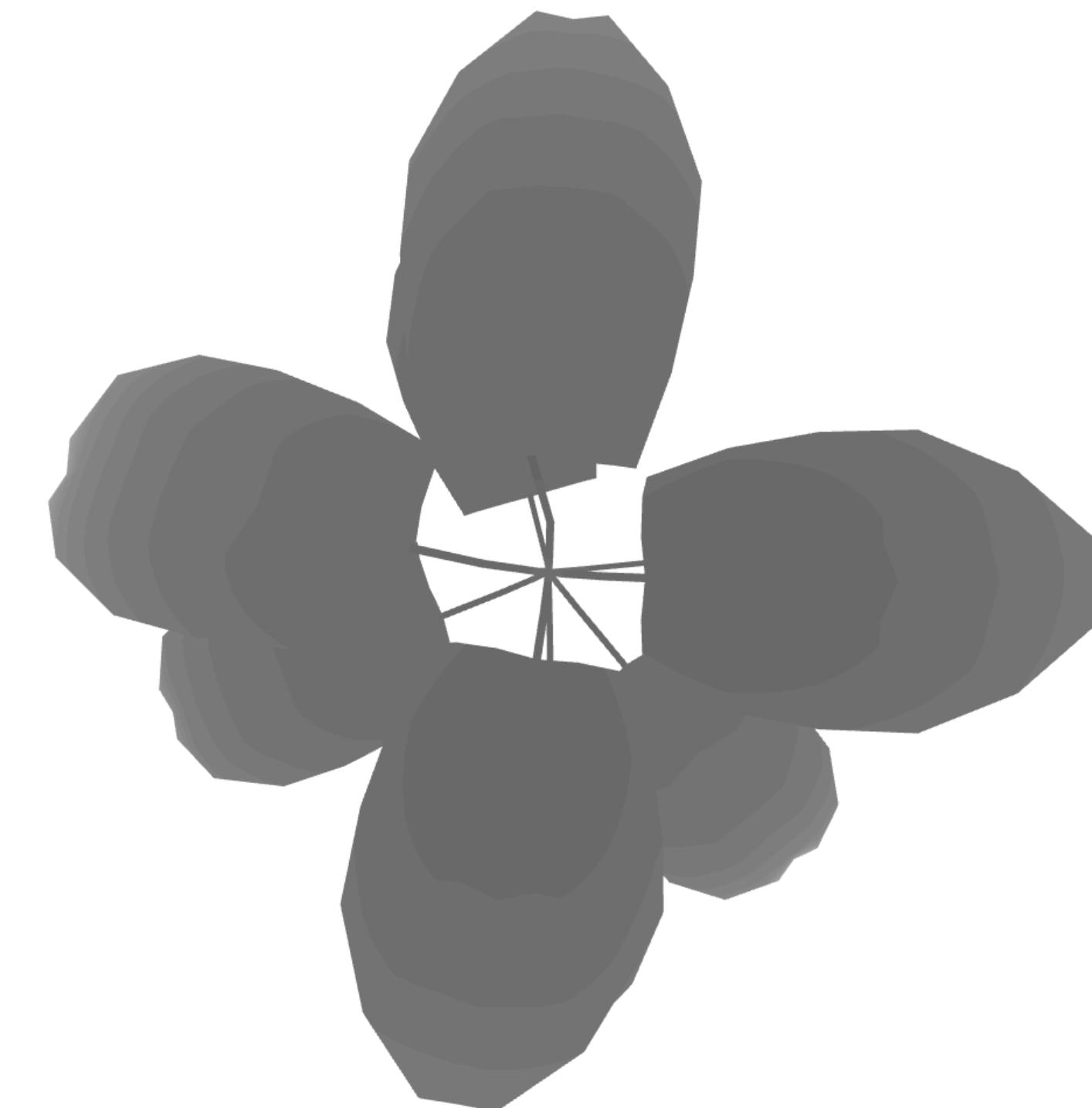
Lets load & display some 3D mesh data

```
In [ ]: fname = 'meshes/plants-2.obj'  
mesh = trimesh.load_mesh(fname)  
mesh.show()
```

Lets load & display some 3D mesh data

```
In [3]: fname = 'meshes/plants-2.obj'  
mesh = trimesh.load_mesh(fname)  
mesh.show()
```

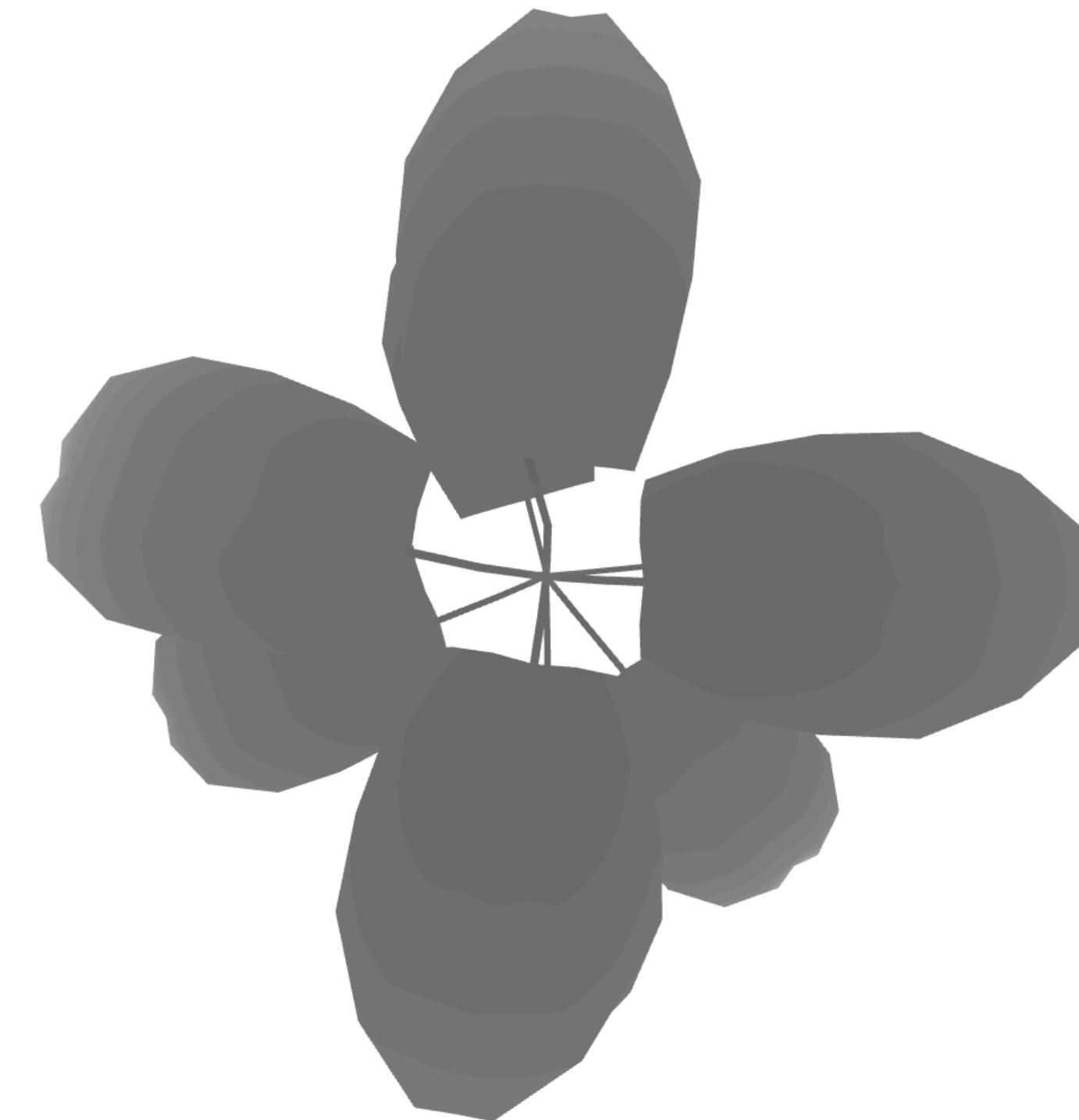
Out[3]:



Lets load & display some 3D mesh data

```
In [3]: fname = 'meshes/plants-2.obj'  
mesh = trimesh.load_mesh(fname)  
mesh.show()
```

Out[3]:



Click and drag
to move mesh

BREAK! (10 MIN)

INTEGRATING MODELS AS FUNCTIONS

```
In [4]: tools.display_source('models/light_v0.py', number_lines=True)
```

```
In [4]: tools.display_source('models/light_v0.py', number_lines=True)
```

```
file: models/light_v0.py
=====
1: import numpy as np
2: from yggdrasil import units
3:
4:
5: def light(doy, height):
6:     """Compute the intensity of light.
7:
8:     Args:
9:         doy (float): Day of year.
10:        height (float): Distance from ground in cm.
11:
12:    Returns:
13:        float: Intensity of light in ergs cm^-2 s^-1.
14:
15:    """
16:    # Define parameters that are static across a run
17:    amplitude = units.add_units(80.0, 'ergs cm^-3 s^-1')
18:    doy_offset = units.add_units(0.0, 'days')
19:
20:    # Calculate intensity
21:    intensity = (
22:        amplitude * height *
23:        (1.0 + np.sin(2.0 * np.pi * (doy - doy_offset) /
24:                      units.add_units(365.0, 'days'))))
25:
26:    return intensity
```

```
In [5]: tools.display_source('yamls/light_v0_python.yml', number_lines=True)
```

```
In [5]: tools.display_source('yamls/light_v0_python.yml', number_lines=True)
```

YAMLS provide info needed to run model

function - name of the function that yggdrasil should wrap

```
In [5]: tools.display_source('yamls/light_v0_python.yml', number_lines=True)
```

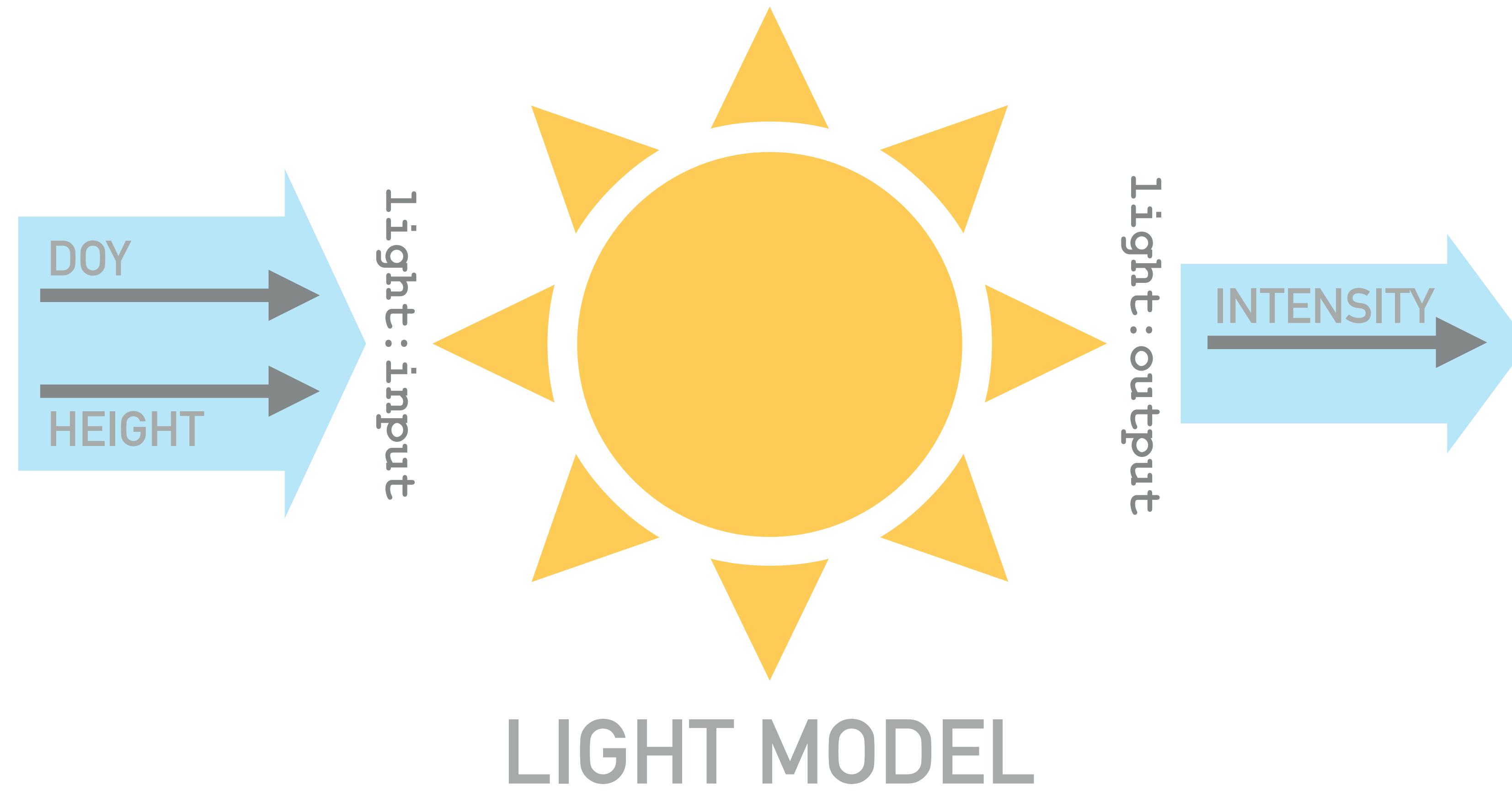
```
file: yamls/light_v0_python.yml
=====
1: model:
2:   name: light
3:   language: python
4:   args: ../models/light_v0.py
5:   function: light
```

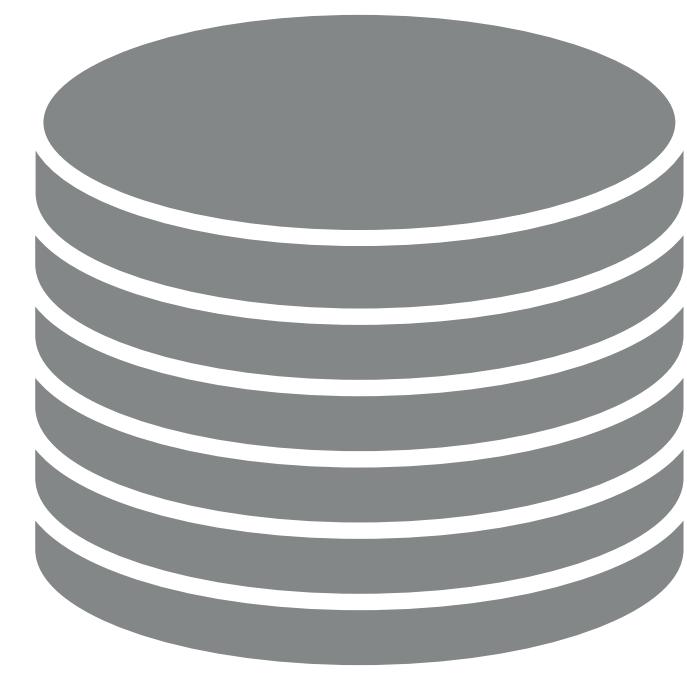
YAMLs provide info needed to run model

function - name of the function that yggdrasil should wrap

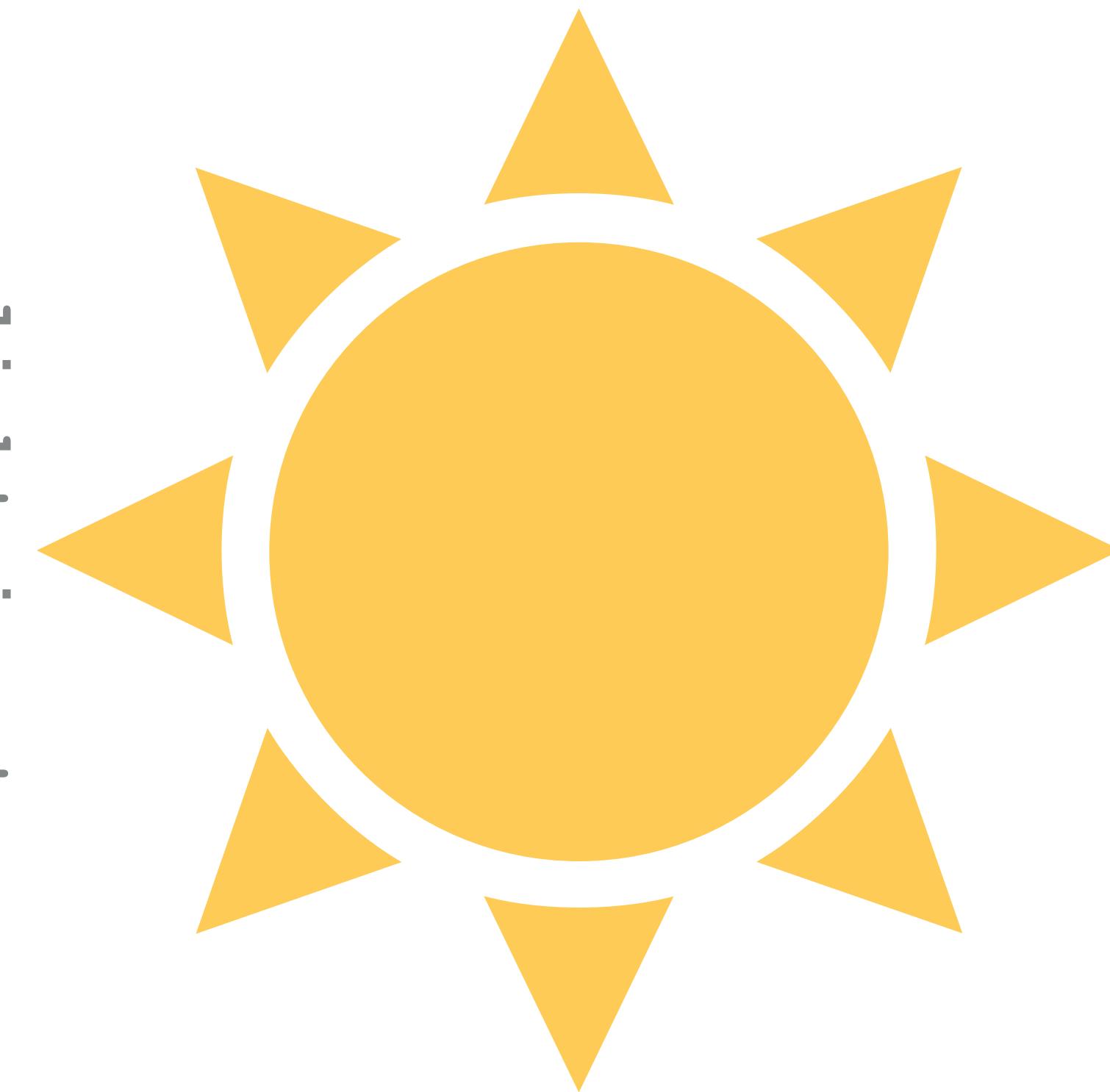
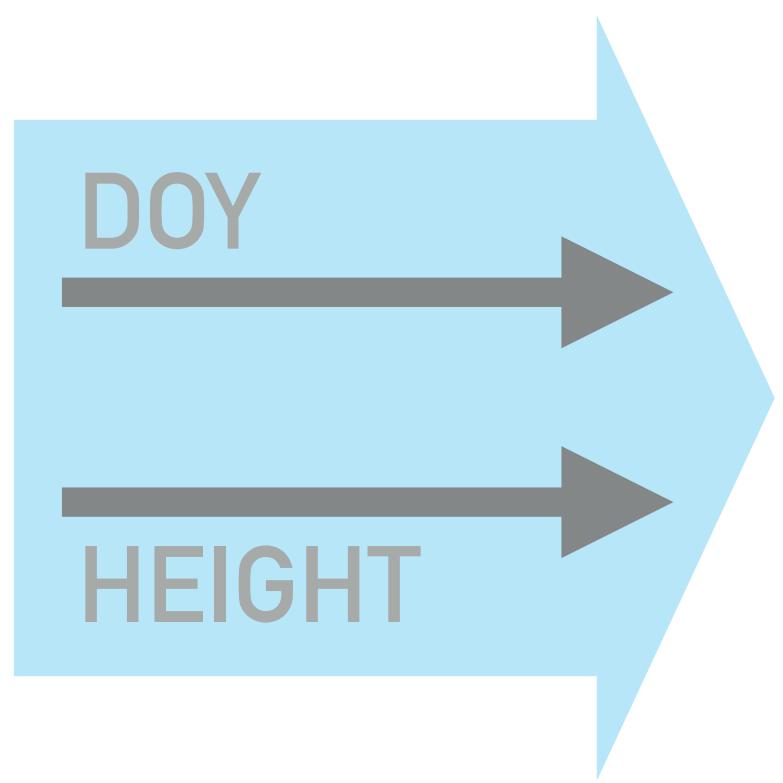


LIGHT MODEL





`input/light_v0.txt`

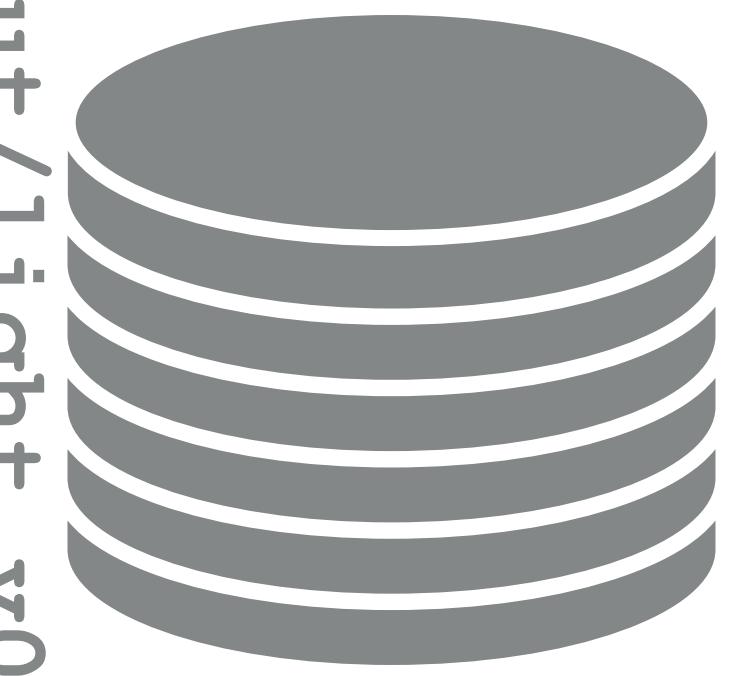


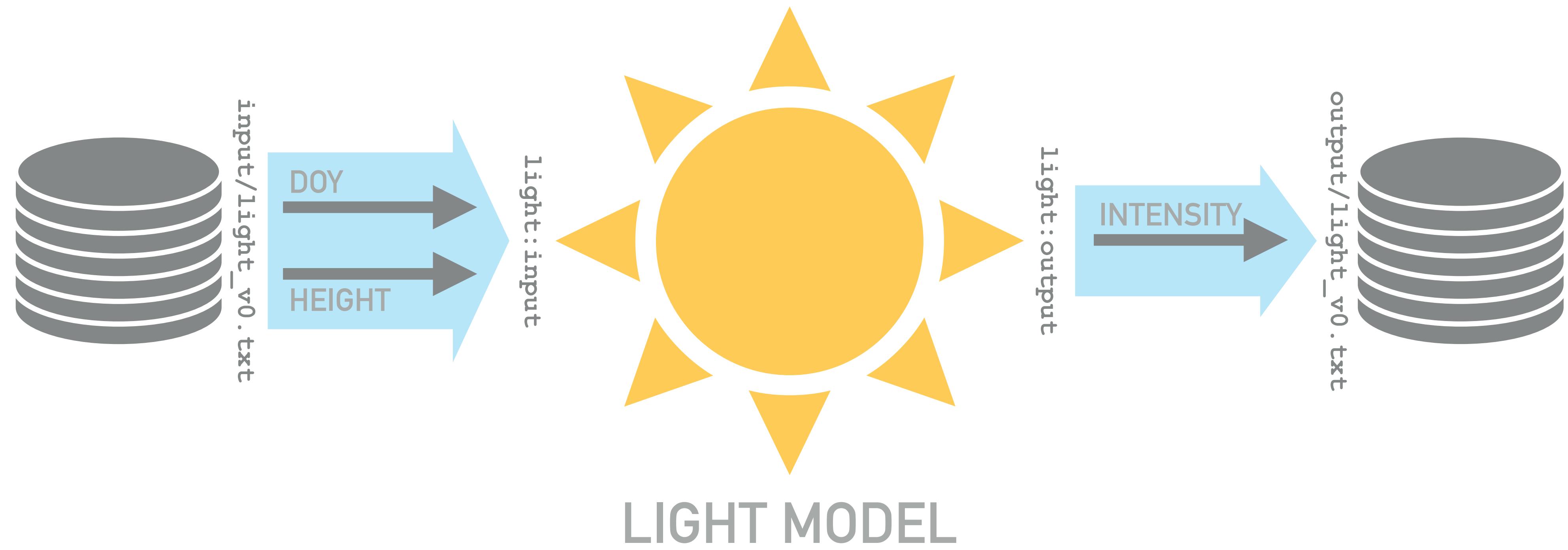
LIGHT MODEL

`light:output`



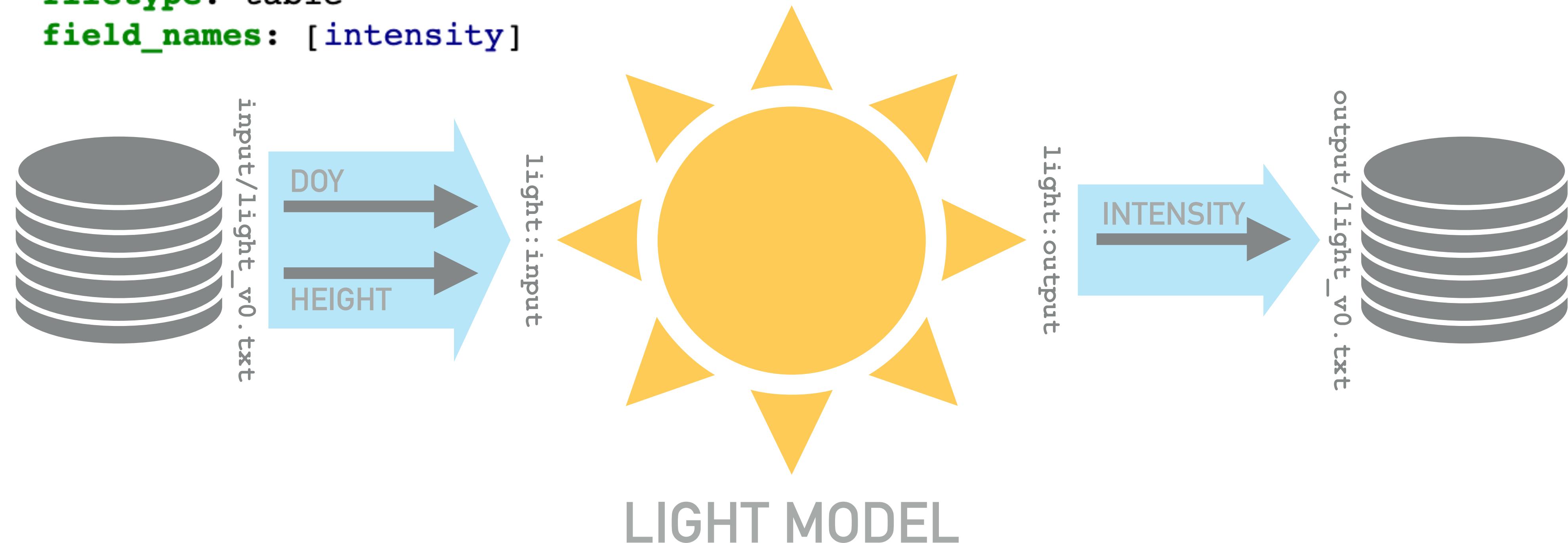
`output/light_v0.txt`





```
In [6]: tools.display_source('yamls/connections_v0.yml', number_lines=True)
```

```
file: yamls/connections_v0.yml
=====
1: connections:
2:   - input:
3:     name: ../input/light_v0.txt
4:     filetype: table
5:   output: light:input
6:   - input: light:output
7:     output:
8:       name: ../output/light_v0.txt
9:       filetype: table
10:      field_names: [intensity]
```



```
In [7]: run(['yamls/light_v0_python.yml', 'yamls/connections_v0.yml'], production_run=True)
```

```
In [7]: run(['yamls/light_v0_python.yml', 'yamls/connections_v0.yml'], production_run=True)
```

```
INFO:88383:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg  
_light_v0.py  
End of input from temp_doy.  
INFO:88383:runner.waitModels[553]:YggRunner(runner): light finished running.  
INFO:88383:runner.waitModels[559]:YggRunner(runner): light finished exiting.  
INFO:88383:runner.waitModels[573]:YggRunner(runner): All models completed  
INFO:88383:runner.run[374]:YggRunner(runner):           init      0.000001  
INFO:88383:runner.run[374]:YggRunner(runner):           load drivers    0.309536  
INFO:88383:runner.run[374]:YggRunner(runner):           start drivers   0.091199  
INFO:88383:runner.run[374]:YggRunner(runner):           run models     5.400952  
INFO:88383:runner.run[374]:YggRunner(runner):           at exit        0.023104  
INFO:88383:runner.run[376]:YggRunner(runner): =====  
INFO:88383:runner.run[377]:YggRunner(runner):           Total      5.824792
```

```
In [7]: run(['yamls/light_v0_python.yml', 'yamls/connections_v0.yml'], production_run=True)
```

```
INFO:88383:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg  
_light_v0.py  
End of input from temp_doy.  
INFO:88383:runner.waitModels[553]:YggRunner(runner): light finished running.  
INFO:88383:runner.waitModels[559]:YggRunner(runner): light finished exiting.  
INFO:88383:runner.waitModels[573]:YggRunner(runner): All models completed  
INFO:88383:runner.run[374]:YggRunner(runner):           init      0.000001  
INFO:88383:runner.run[374]:YggRunner(runner):           load drivers    0.309536  
INFO:88383:runner.run[374]:YggRunner(runner):           start drivers   0.091199  
INFO:88383:runner.run[374]:YggRunner(runner):           run models     5.400952  
INFO:88383:runner.run[374]:YggRunner(runner):           at exit        0.023104  
INFO:88383:runner.run[376]:YggRunner(runner): =====  
INFO:88383:runner.run[377]:YggRunner(runner):           Total      5.824792
```

```
In [8]: tools.display_source('output/light_v0.txt', number_lines=True)
```

```
In [7]: run(['yamls/light_v0_python.yml', 'yamls/connections_v0.yml'], production_run=True)
```

```
INFO:88383:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg  
_light_v0.py  
End of input from temp_doy.  
INFO:88383:runner.waitModels[553]:YggRunner(runner): light finished running.  
INFO:88383:runner.waitModels[559]:YggRunner(runner): light finished exiting.  
INFO:88383:runner.waitModels[573]:YggRunner(runner): All models completed  
INFO:88383:runner.run[374]:YggRunner(runner):           init      0.000001  
INFO:88383:runner.run[374]:YggRunner(runner):           load drivers   0.309536  
INFO:88383:runner.run[374]:YggRunner(runner):           start drivers  0.091199  
INFO:88383:runner.run[374]:YggRunner(runner):           run models    5.400952  
INFO:88383:runner.run[374]:YggRunner(runner):           at exit       0.023104  
INFO:88383:runner.run[376]:YggRunner(runner): =====  
INFO:88383:runner.run[377]:YggRunner(runner):           Total      5.824792
```

```
In [8]: tools.display_source('output/light_v0.txt', number_lines=True)
```

```
file: output/light_v0.txt  
=====  
1: # intensity  
2: # erg/(cm**2*s)  
3: # %g  
4: 0  
5: 40.6885  
6: 82.7537  
7: 168.259  
8: 342.017  
9: 434.386  
10: 617.737  
11: 896.166
```

SOME NOTES



Usually run via the command line

[Visit repo](#)

[Copy Binder link](#)

```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2d9y79y126:~$ yggrun -h
usage: Run an integration. [-h] [--loglevel LOGLEVEL] [--rmq-loglevel RMQ_LOGLEVEL] [--client-loglevel CLIENT_LOGLEVEL]
                           [--validate-components] [--validate-messages {False,True,First}] [--namespace NAMESPACE]
                           [--host HOST] [--vhost VHOST] [--user USER] [--password PASSWORD] [--cluster CLUSTER]
                           [--default-comm DEFAULT_COMM] [--production-run] [--debug]
                           yamlfile [yamlfile ...]

positional arguments:
  yamlfile            One or more yaml specification files.

optional arguments:
  -h, --help          show this help message and exit
  --loglevel LOGLEVEL    Logging level for yggdrasil operations.
  --rmq-loglevel RMQ_LOGLEVEL, --rmqloglevel RMQ_LOGLEVEL
                        Logging level for RabbitMQ operations.
  --client-loglevel CLIENT_LOGLEVEL, --clientloglevel CLIENT_LOGLEVEL
                        Logging level for yggdrasil operations on model processes.
  --validate-components, --validatecomponents
                        Validate components on creation using their JSON schema (Decreases performance).
  --validate-messages {False,True,First}, --validatemessages {False,True,First}
                        Which messages should be validated during communication. 'True': all messages (decreases
                        performance), 'False': no messages, or 'First': only the first message a comm sends/receives.
  --namespace NAMESPACE
                        RabbitMQ namespace.
  --host HOST
  --vhost VHOST
  --user USER
  --password PASSWORD
  --cluster CLUSTER
  --default-comm DEFAULT_COMM, --defaultcomm DEFAULT_COMM
                        Comm type that should be used by default.
```

SOME NOTES

```
In [7]: run(['yamls/light_v0_python.yml', 'yamls/connections_v0.yml', . production_run=True])
```

INFO:88383:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg_light_v0.py
End of input from temp_doy.
INFO:88383:runner.waitModels[553]:YggRunner(runner): light finished running.
INFO:88383:runner.waitModels[559]:YggRunner(runner): light finished exiting.
INFO:88383:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:88383:runner.run[374]:YggRunner(runner): init 0.000001
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INFO:88383:runner.run[374]:YggRunner(runner): run models 5.400952
INFO:88383:runner.run[374]:YggRunner(runner): at exit 0.023104
INFO:88383:runner.run[376]:YggRunner(runner): =====
INFO:88383:runner.run[377]:YggRunner(runner): Total 5.824792

“production_run” flag turns off checks to improve performance
and should only be used after testing

```
In [9]: tools.display_source('models/light_v0.cpp', number_lines=True)
tools.display_source('yamls/light_v0_cpp.yml', number_lines=True)
run(['yamls/light_v0_cpp.yml', 'yamls/connections_v0.yml'], production_run=True)
tools.display_source('output/light_v0.txt', number_lines=True)
```

OTHER LANGUAGES

OTHER LANGUAGES

```
In [9]: tools.display_source('models/light_v0.cpp', number_lines=True)
tools.display_source('yamls/light_v0_cpp.yml', number_lines=True)
run(['yamls/light_v0_cpp.yml', 'yamls/connections_v0.yml'], production_run=True)
tools.display_source('output/light_v0.txt', number_lines=True)

file: models/light_v0.cpp
=====
1: #define _USE_MATH_DEFINES // Required to use M_PI with MSVC
2: #include <math.h>
3:
4: /**
5:  @brief Compute the intensity of light.
6:
7:  @param[in] doy Day of year.
8:  @param[in] height Distance from ground in cm.
9:
10: @returns intensity Intensity of light in ergs cm^-2 s^-1.
11: */
12: double light(double doy, double height) {
13:     // Define parameters that are static across a run
14:     double amplitude = 80.0;
15:     double doy_offset = 0.0;
16:
17:     // Calculate intensity
18:     double intensity = amplitude * height * (1.0 + sin(2.0 * M_PI * (doy - doy_offset) / 365));
19:
20:     return intensity;
21: }
```

```
In [9]: tools.display_source('models/light_v0.cpp', number_lines=True)
tools.display_source('yamls/light_v0_cpp.yml', number_lines=True)
run(['yamls/light_v0_cpp.yml', 'yamls/connections_v0.yml'], production_run=True)
tools.display_source('output/light_v0.txt', number_lines=True)
```

```
file: yamls/light_v0_cpp.yml
=====
1: model:
2:   name: light
3:   language: c++
4:   args: ../models/light_v0.cpp
5:   function: light
6:   inputs:
7:     - name: input
8:       vars: [doy, height]
9:       datatype:
10:         type: array
11:         items:
12:           - type: float
13:             units: day
14:           - type: float
15:             units: cm
16:   output:
17:     - name: output
18:       datatype:
19:         type: float
20:         units: ergs/(cm**2*s)
```

OTHER LANGUAGES

```
In [9]: tools.display_source('models/light_v0.cpp', number_lines=True)
tools.display_source('yamls/light_v0_cpp.yml', number_lines=True)
run(['yamls/light_v0_cpp.yml', 'yamls/connections_v0.yml'], production_run=True)
tools.display_source('output/light_v0.txt', number_lines=True)
```

```
file: yamls/light_v0_cpp.yml
=====
1: model:
2:   name: light
3:   language: c++
4:   args: ../models/light_v0.cpp
5:   function: light
6:   inputs:
7:     - name: input
8:       vars: [doy, height]
9:       datatype:
10:         type: array
11:         items:
12:           - type: float
13:             units: day
14:           - type: float
15:             units: cm
16:   output:
17:     - name: output
18:       datatype:
19:         type: float
20:         units: ergs/(cm**2*s)
```

OTHER LANGUAGES

Inputs & outputs are explicit in the compiled languages so that units can be specified

```
In [9]: tools.display_source('models/light_v0.cpp', number_lines=True)
tools.display_source('yaml/light_v0_cpp.yml', number_lines=True)
run(['yaml/light_v0_cpp.yml', 'yaml/connections_v0.yml'], production_run=True)
tools.display_source('output/light_v0.txt', number_lines=True)
```

```
INFO:91854:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg_light_v0_cpp_clang++x_clang++x.out
End of input from &doy, &height.
INFO:91854:runner.waitModels[553]:YggRunner(runner): light finished running.
INFO:91854:runner.waitModels[559]:YggRunner(runner): light finished exiting.
INFO:91854:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:91854:runner.run[374]:YggRunner(runner):           init      0.000001
INFO:91854:runner.run[374]:YggRunner(runner):           load drivers   3.856998
INFO:91854:runner.run[374]:YggRunner(runner):           start drivers  0.148603
INFO:91854:runner.run[374]:YggRunner(runner):           run models    0.533877
INFO:91854:runner.run[374]:YggRunner(runner):           at exit       0.075296
INFO:91854:runner.run[376]:YggRunner(runner): =====
INFO:91854:runner.run[377]:YggRunner(runner):           Total      4.614775
```

OTHER LANGUAGES

```
In [9]: tools.display_source('models/light_v0.cpp', number_lines=True)
tools.display_source('yamls/light_v0_cpp.yml', number_lines=True)
run(['yamls/light_v0_cpp.yml', 'yamls/connections_v0.yml'], production_run=True)
tools.display_source('output/light_v0.txt', number_lines=True)
```

```
INFO:91854:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg_light_v0_cpp_clang++x_clang++x.out
End of input from &doy, &height.
INFO:91854:runner.waitModels[553]:YggRunner(runner): light finished running.
INFO:91854:runner.waitModels[559]:YggRunner(runner): light finished exiting.
INFO:91854:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:91854:runner.run[374]:YggRunner(runner):           init      0.000001
INFO:91854:runner.run[374]:YggRunner(runner):           load drivers   3.856998
INFO:91854:runner.run[374]:YggRunner(runner):           start drivers  0.148603
INFO:91854:runner.run[374]:YggRunner(runner):           run models    0.533877
INFO:91854:runner.run[374]:YggRunner(runner):           at exit       0.075296
INFO:91854:runner.run[376]:YggRunner(runner): =====
INFO:91854:runner.run[377]:YggRunner(runner):           Total      4.614775
```

file: output/light_v0.txt

=====

```
1: # intensity
2: # ergs/(cm**2*s)
3: # %g
4: 0
5: 40.6885
6: 82.7537
7: 168.259
8: 342.017
9: 434.386
10: 617.737
11: 896.166
```

OTHER LANGUAGES

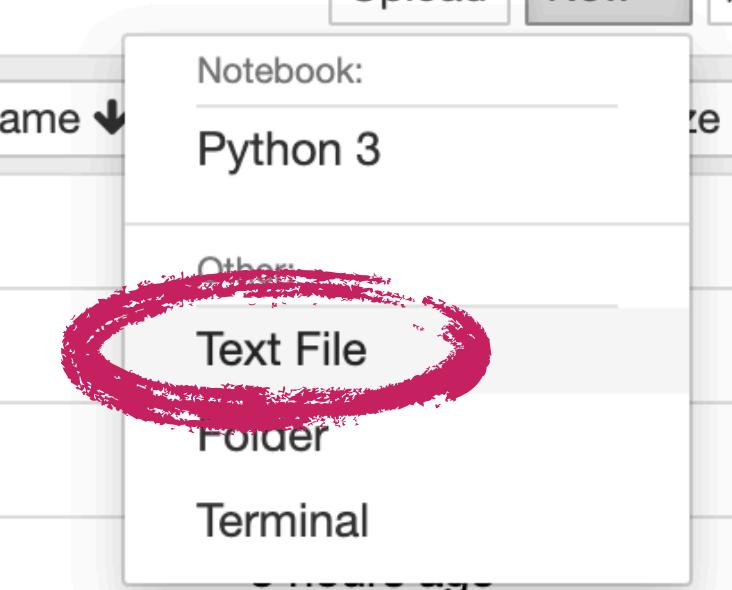
**TEST YOUR
KNOWLEDGE**

Need to be in desired directory

[Quit](#)[Logout](#)[Files](#) [Running](#) [Clusters](#) [Nbextensions](#)

Select items to perform actions on them.

<input type="checkbox"/>	0	/	Name	Upload	New ▾	↻
<input type="checkbox"/>		images				
<input type="checkbox"/>		input				
<input type="checkbox"/>		meshes				
<input type="checkbox"/>		models				
<input type="checkbox"/>		output				a day ago
<input type="checkbox"/>		save				34 minutes ago
<input type="checkbox"/>		yamls				20 hours ago
<input type="checkbox"/>		00-intro.ipynb				21 hours ago 470 kB
<input type="checkbox"/>		01-connections.ipynb				8 days ago 455 kB
<input type="checkbox"/>		02-timesync.ipynb				7 days ago 454 kB
<input type="checkbox"/>		03-misc.ipynb				an hour ago 6.79 kB
<input type="checkbox"/>		environment.yml				a day ago 176 B
<input type="checkbox"/>		launch_local.sh				a day ago 210 B
<input type="checkbox"/>		LICENSE				17 days ago 1.52 kB
<input type="checkbox"/>		local.Docker				a day ago 1.02 kB
<input type="checkbox"/>		postBuild				8 days ago 223 B
<input type="checkbox"/>		postBuild.bat				8 days ago 71 B
<input type="checkbox"/>		README.md				44 minutes ago 3.14 kB



File Edit View Language

Plain Text

1

Select the language you want to write in

jupyter untitled.txt a few seconds ago

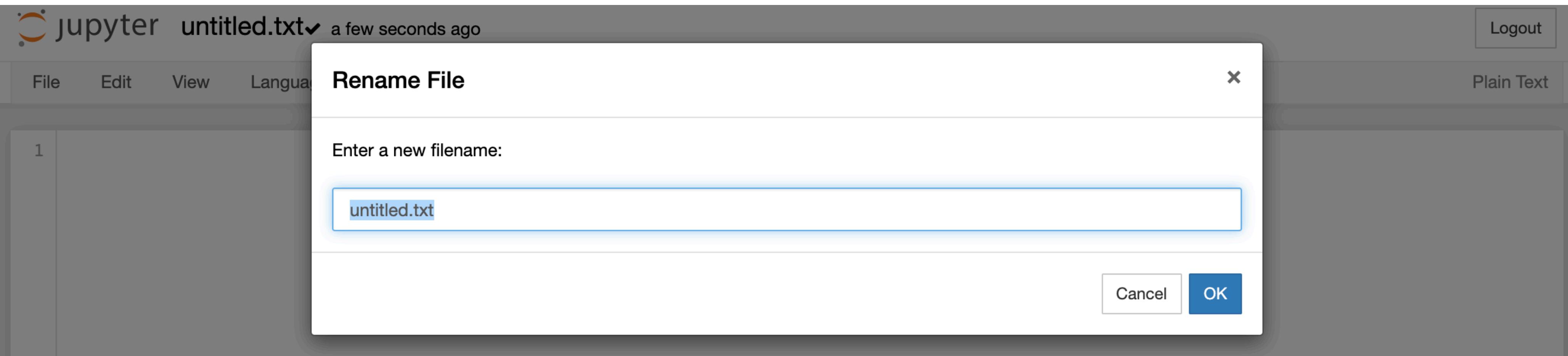
Logout

The screenshot shows a Jupyter Notebook interface. At the top, there is a header bar with the Jupyter logo, the file name "untitled.txt", and a timestamp "a few seconds ago". On the far right of the header is a "Logout" button. Below the header is a menu bar with "File", "Edit", "View", and "Language". The "Language" menu is currently open, displaying a list of available languages: APL, PGP, ASN.1, Asterisk, Brainfuck, C, C++, Cobol, C#, Clojure, and ClojureScript. To the left of the menu, there is a small preview area showing the first line of the notebook, which is just the number "1". On the right side of the interface, there is a large, empty text area where code can be written.

- File
- Edit
- View
- Language
 - APL
 - PGP
 - ASN.1
 - Asterisk
 - Brainfuck
 - C
 - C++
 - Cobol
 - C#
 - Clojure
 - ClojureScript

Plain Text

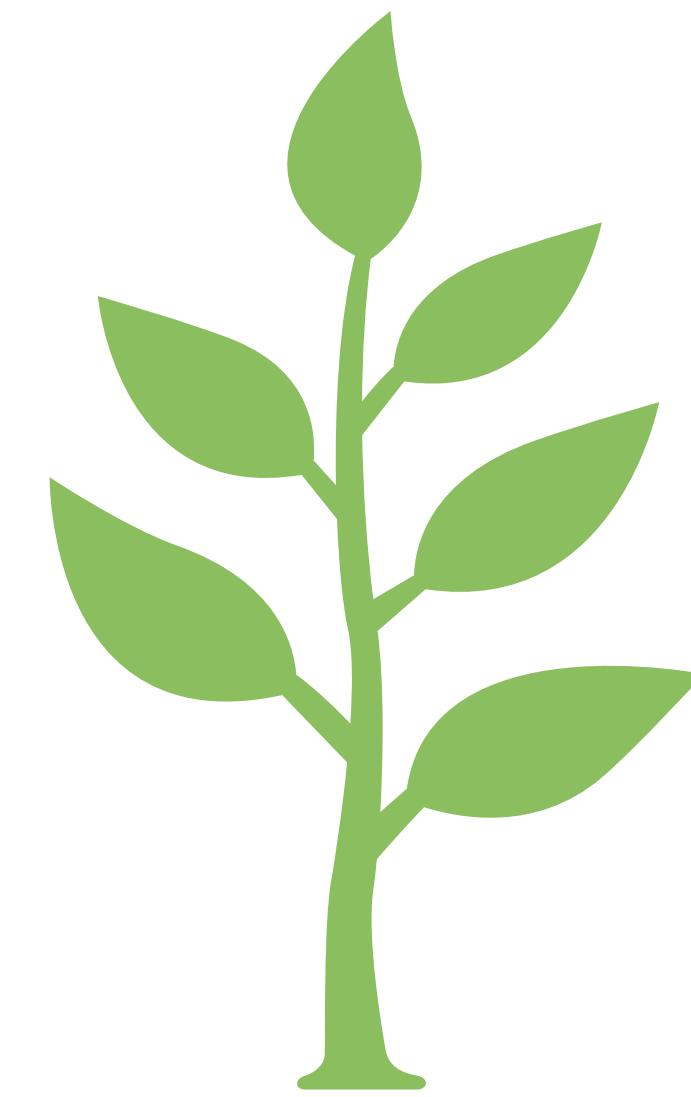
Rename the file



**TEST YOUR
KNOWLEDGE (10 MIN)**

**INTEGRATING MODELS
VIA INTERFACE**

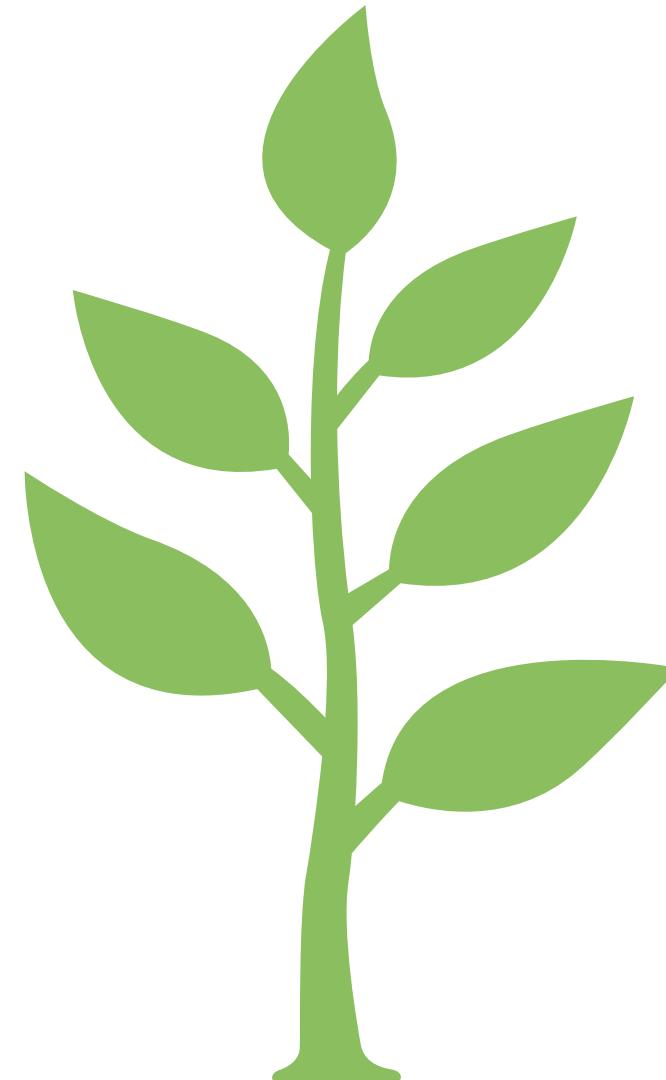
```
In [12]: tools.display_source('models/shoot_v0.py', number_lines=True)
```



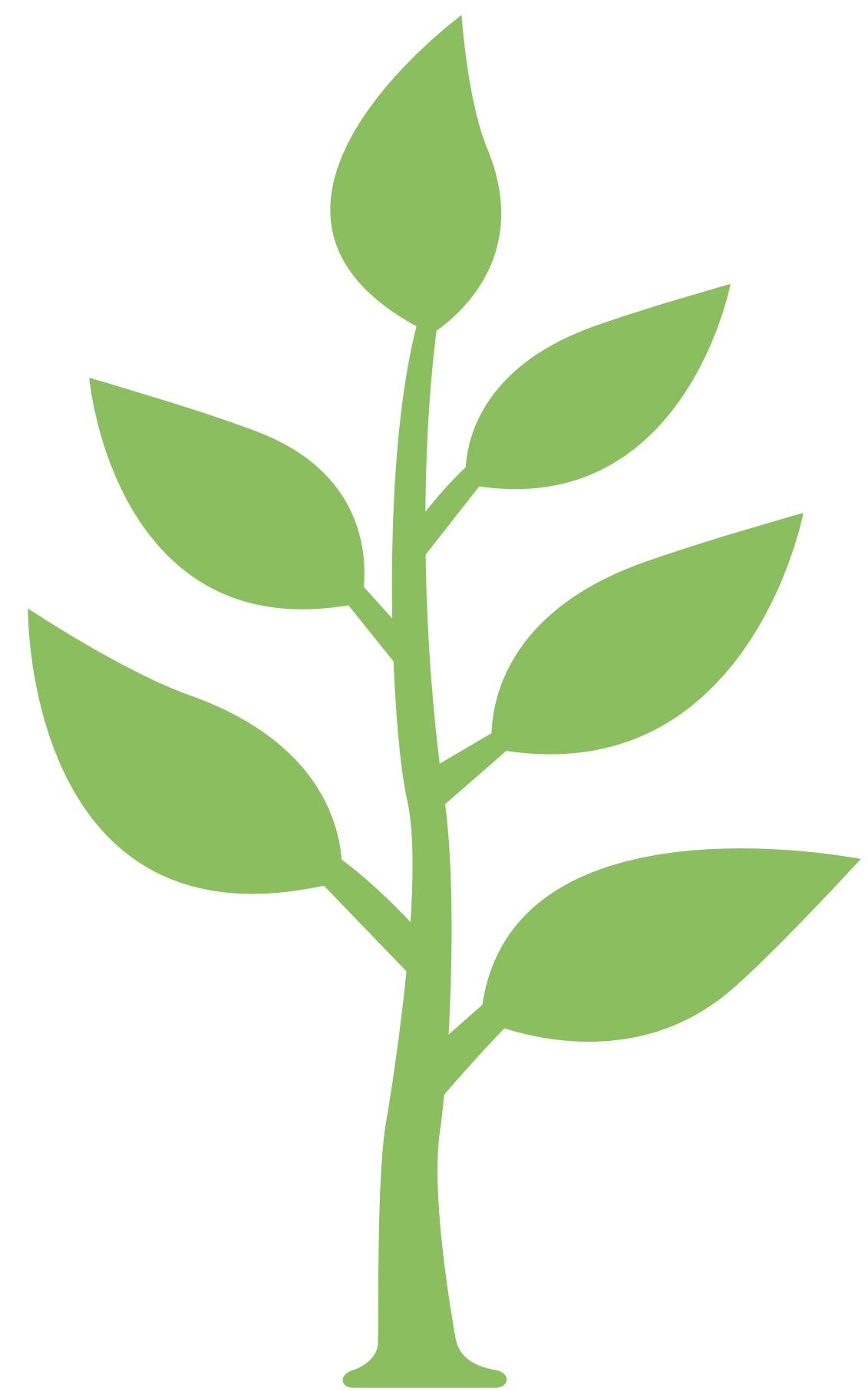
SHOOT
MODEL

```
In [12]: tools.display_source('models/shoot_v0.py', number_lines=True)
```

```
file: models/shoot_v0.py
=====
1: import os
2: import trimesh
3: import argparse
4:
5: _dir = os.path.dirname(os.path.realpath(__file__))
6:
7: # Parse command-line arguments
8: parser = argparse.ArgumentParser("Simulate a shoot's growth over time.")
9: parser.add_argument('tmin', help='Starting time (in hours)', type=float)
10: parser.add_argument('tmax', help='Ending time (in hours)', type=float)
11: parser.add_argument('tstep', help='Time step (in hours)', type=float)
12: parser.add_argument('--meshfile', help='Path to file where mesh is stored.',
13:                     default='../meshes/plants-2.obj')
14: args = parser.parse_args()
15: tmin = args.tmin
16: tmax = args.tmax
17: tstep = args.tstep
18: mesh = trimesh.load_mesh(args.meshfile)
19:
20: # Set initial conditions
21: mass = 2000.0
22: t = tmin
23: i = 0
24:
25: # Continue simulation until time limit is reached
26: while t <= tmax:
27:
28:     # Compute the scale factor
29:     # (pretend this is a biologically complex calculation)
30:     scale = mass / 4.5e4
31:
32:     # Grow the shoot
33:     # (pretend this is a biologically complex calculation)
34:     mesh.vertices[:, 2] += mesh.vertices[:, 2] * scale
35:     mass += mass * scale
36:
37:     # Save mesh for this timestep
38:     filename_mesh = os.path.join(_dir, f'../output/mesh_{i:03d}.obj')
39:     with open(filename_mesh, 'w') as fd:
40:         mesh.export(fd, 'obj')
41:
42:     # Advance time step
43:     t += tstep
44:     i += 1
```



SHOOT
MODEL



SHOOT
MODEL

```
In [13]: tools.display_source('yamls/shoot_v0.yml', number_lines=True)
run('yamls/shoot_v0.yml', production_run=True)
```

```
In [13]: tools.display_source('yamls/shoot_v0.yml', number_lines=True)
run('yamls/shoot_v0.yml', production_run=True)
```

```
file: yamls/shoot_v0.yml
=====
1: model:
2:   name: shoot
3:   language: python
4:   args: [./models/shoot_v0.py, 0.0, 48.0, 6.0]
```

```
In [13]: tools.display_source('yamls/shoot_v0.yml', number_lines=True)
run('yamls/shoot_v0.yml', production_run=True)
```

```
file: yamls/shoot_v0.yml
=====
1: model:
2:   name: shoot
3:   language: python
4:   args: [./models/shoot_v0.py, 0.0, 48.0, 6.0]
```

```
INFO:91854:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/shoot_v0.py 0.0 48.0 6.0
INFO:91854:runner.waitModels[553]:YggRunner(runner): shoot finished running.
INFO:91854:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.
INFO:91854:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:91854:runner.run[374]:YggRunner(runner):           init      0.000001
INFO:91854:runner.run[374]:YggRunner(runner):           load drivers  0.000918
INFO:91854:runner.run[374]:YggRunner(runner):           start drivers 0.042213
INFO:91854:runner.run[374]:YggRunner(runner):           run models    0.856992
INFO:91854:runner.run[374]:YggRunner(runner):           at exit       0.000524
INFO:91854:runner.run[376]:YggRunner(runner): =====
INFO:91854:runner.run[377]:YggRunner(runner):           Total      0.900648
```

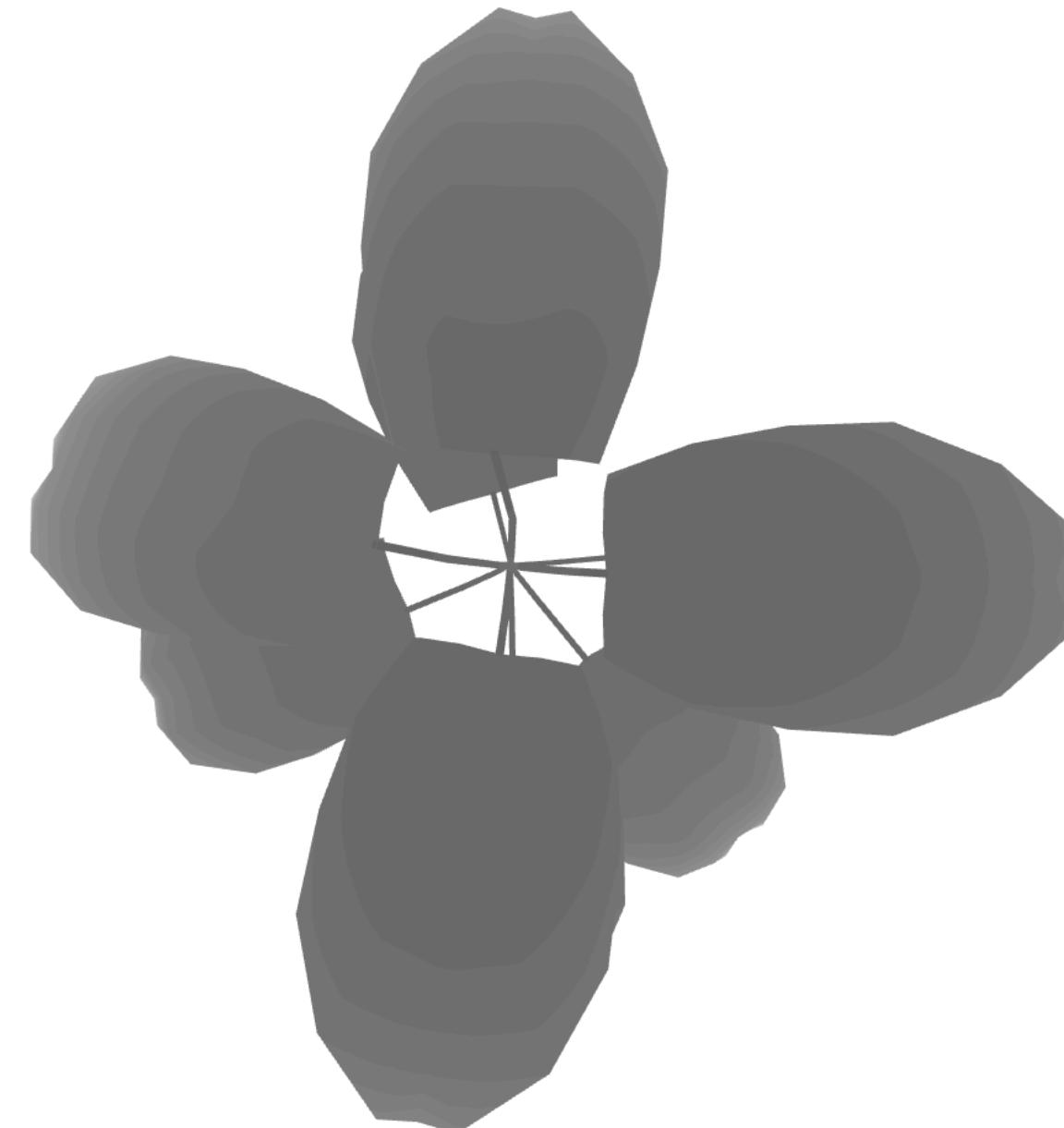
```
In [13]: tools.display_source('yaml/shoot_v0.yml', number_lines=True)
run('yaml/shoot_v0.yml', production_run=True)
```

```
file: yaml/shoot_v0.yml
=====
1: model:
2:   name: shoot
3:   language: python
4:   args: [./models/shoot_v0.py, 0.0, 48.0, 6.0]
```

```
INFO:91854:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/shoot_v0.py 0.0 48.0 6.0
INFO:91854:runner.waitModels[553]:YggRunner(runner): waiting for 1 models
INFO:91854:runner.waitModels[559]:YggRunner(runner): waiting for 1 models
INFO:91854:runner.waitModels[573]:YggRunner(runner): waiting for 1 models
INFO:91854:runner.run[374]:YggRunner(runner): running 1 models
INFO:91854:runner.run[376]:YggRunner(runner): running 1 models
INFO:91854:runner.run[377]:YggRunner(runner): running 1 models
```

```
In [14]: mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.show()
```

Out[14]:



```
In [15]: tools.display_source_diff('models/shoot_v0.py', 'models/shoot_v1.py', number_lines=True)
```

```
In [15]: tools.display_source_diff('models/shoot_v0.py', 'models/shoot_v1.py', number_lines=True)
```

```
file1: models/shoot_v0.py
file2: models/shoot_v1.py
=====
1: import os
2: import trimesh
3: import argparse
4:
5: _dir = os.path.dirname(os.path.realpath(__file__))
6:
7: # Parse command-line arguments
8: parser = argparse.ArgumentParser("Simulate a shoot's growth over time.")
9: parser.add_argument('tmin', help='Starting time (in hours)', type=float)
10: parser.add_argument('tmax', help='Ending time (in hours)', type=float)
11: parser.add_argument('tstep', help='Time step (in hours)', type=float)
12: parser.add_argument('--meshfile', help='Path to file where mesh is stored.',
13:                     default='../meshes/plants-2.obj')
14: args = parser.parse_args()
15: tmin = args.tmin
16: tmax = args.tmax
17: tstep = args.tstep
18: mesh = trimesh.load_mesh(args.meshfile)
19:
20: # Set initial conditions
21: mass = 2000.0
22: t = tmin
23: i = 0
24:
25: + # Check if model is running as a part of an yggdrasil integration
26: + with_yggdrasil = os.environ.get('YGG_SUBPROCESS', False)
27: +
28: + # If the model is running as part of an yggdrasil integration, import
29: + # the relevant yggdrasil routines and use the interface routine to
30: + # complete the connection defined in the YAML
31: + if with_yggdrasil:
32: +     from yggdrasil import units
33: +     from yggdrasil.languages.Python.YggInterface import YggOutput
34: +     height_out = YggOutput('height')
35: +
36:     # Continue simulation until time limit is reached
37:     while t <= tmax:
38:
39: +         # If running as part an yggdrasil integration, send the time and
40: +         # maximum height of the mesh to the height channel with units
41: +         if with_yggdrasil:
42:             flag = height_out.send(
43:                 [units.add_units(t, 'hrs'),
44:                  units.add_units(max(mesh.vertices[:, 2]), 'm')])
45:             if not flag:
46:                 raise Exception("Error sending height to output")
47:
48:         # Compute the scale factor
49:         # (pretend this is a biologically complex calculation)
50:         scale = mass / 4.5e4
51:
52:         # Grow the shoot
53:         # (pretend this is a biologically complex calculation)
54:         mesh.vertices[:, 2] += mesh.vertices[:, 2] * scale
55:         mass += mass * scale
56:
57:         # Save mesh for this timestep
58:         filename_mesh = os.path.join(_dir, f'../output/mesh_{i:03d}.obj')
59:         with open(filename_mesh, 'w') as fd:
60:             mesh.export(fd, 'obj')
61:
62:         # Advance time step
63:         t += tstep
64:         i += 1
```

Code to call yggdrasil inside "if blocks" so that model runs exactly the same without yggdrasil

```
In [15]: tools.display_source_diff('models/shoot_v0.py', 'models/shoot_v1.py', number_lines=True)
```

```
file1: models/shoot_v0.py
file2: models/shoot_v1.py
=====
1: import os
2: import trimesh
3: import argparse
4:
5: _dir = os.path.dirname(os.path.realpath(__file__))
6:
7: # Parse command-line arguments
8: parser = argparse.ArgumentParser("Simulate a shoot's growth over time.")
9: parser.add_argument('tmin', help='Starting time (in hours)', type=float)
10: parser.add_argument('tmax', help='Ending time (in hours)', type=float)
11: parser.add_argument('tstep', help='Time step (in hours)', type=float)
12: parser.add_argument('--meshfile', help='Path to file where mesh is stored.',
13:                     default='../meshes/plants-2.obj')
14: args = parser.parse_args()
15: tmin = args.tmin
16: tmax = args.tmax
17: tstep = args.tstep
18: mesh = trimesh.load_mesh(args.meshfile)
19:
20: # Set initial conditions
21: mass = 2000.0
22: t = tmin
23: i = 0
24:
25: + # Check if model is running as a part of an yggdrasil integration
26: + with_yggdrasil = os.environ.get('YGG_SUBPROCESS', False)
27: +
28: + # If the model is running as part of an yggdrasil integration, import
29: + # the relevant yggdrasil routines and use the interface routine to
30: + # complete the connection defined in the YAML
31: + if with_yggdrasil:
32: +     from yggdrasil import units
33: +     from yggdrasil.languages.Python.YggInterface import YggOutput
34: +     height_out = YggOutput('height')
35: +
36:     # Continue simulation until time limit is reached
37:     while t <= tmax:
38:
39: +         # If running as part an yggdrasil integration, send the time and
40: +         # maximum height of the mesh to the height channel with units
41: +         if with_yggdrasil:
42:             flag = height_out.send(
43:                 [units.add_units(t, 'hrs'),
44:                  units.add_units(max(mesh.vertices[:, 2]), 'm')])
45:             if not flag:
46:                 raise Exception("Error sending height to output")
47:
48:         # Compute the scale factor
49:         # (pretend this is a biologically complex calculation)
50:         scale = mass / 4.5e4
51:
52:         # Grow the shoot
53:         # (pretend this is a biologically complex calculation)
54:         mesh.vertices[:, 2] += mesh.vertices[:, 2] * scale
55:         mass += mass * scale
56:
57:         # Save mesh for this timestep
58:         filename_mesh = os.path.join(_dir, f'../output/mesh_{i:03d}.obj')
59:         with open(filename_mesh, 'w') as fd:
60:             mesh.export(fd, 'obj')
61:
62:         # Advance time step
63:         t += tstep
64:         i += 1
```

Import yggdrasil functions and connect to the channel that will be listed in the YAML.

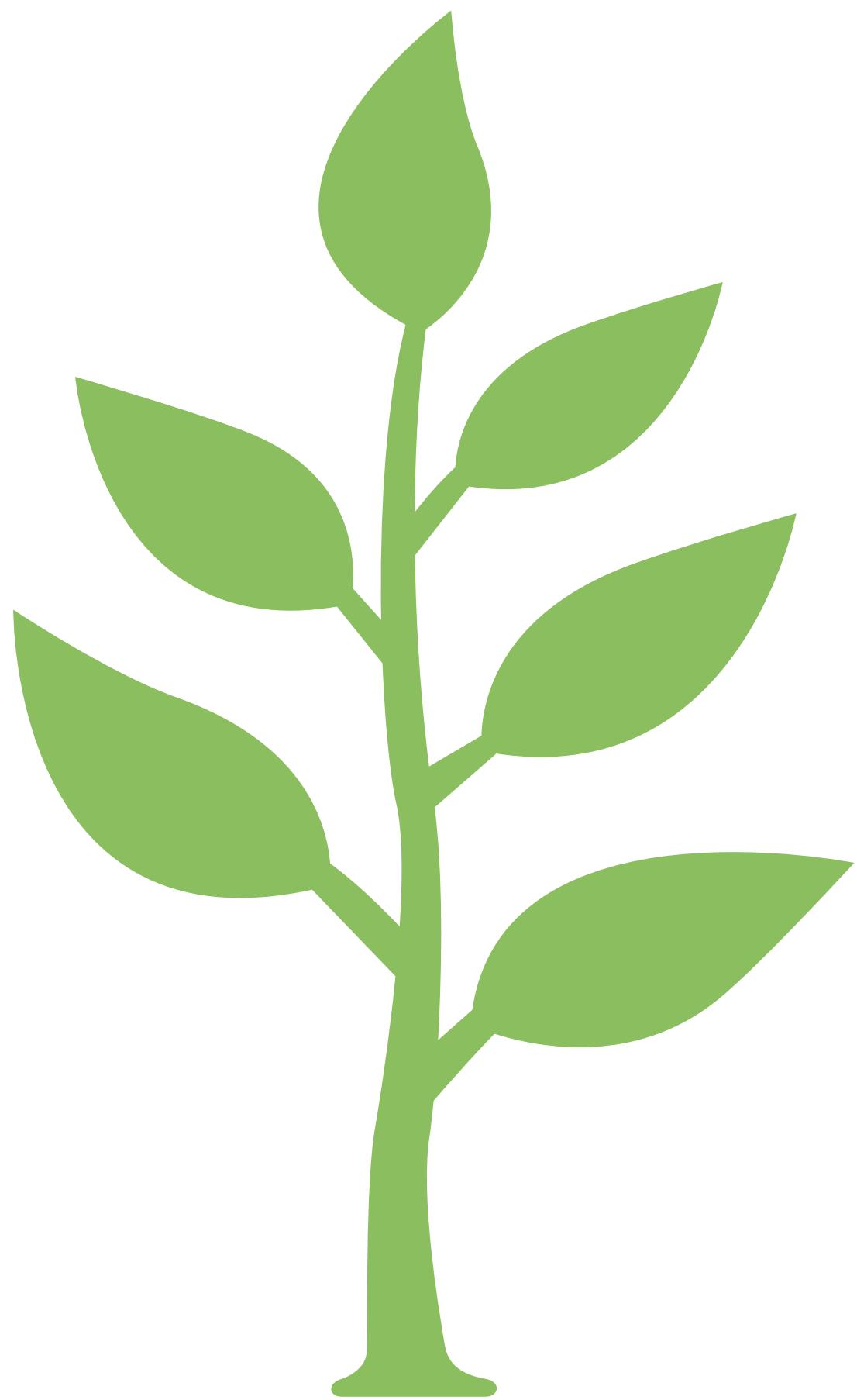
Code to call yggdrasil inside “if blocks” so that model runs exactly the same without yggdrasil

```
In [15]: tools.display_source_diff('models/shoot_v0.py', 'models/shoot_v1.py', number_lines=True)
```

```
file1: models/shoot_v0.py
file2: models/shoot_v1.py
=====
1: import os
2: import trimesh
3: import argparse
4:
5: _dir = os.path.dirname(os.path.realpath(__file__))
6:
7: # Parse command-line arguments
8: parser = argparse.ArgumentParser("Simulate a shoot's growth over time.")
9: parser.add_argument('tmin', help='Starting time (in hours)', type=float)
10: parser.add_argument('tmax', help='Ending time (in hours)', type=float)
11: parser.add_argument('tstep', help='Time step (in hours)', type=float)
12: parser.add_argument('--meshfile', help='Path to file where mesh is stored.',
13:                     default='../meshes/plants-2.obj')
14: args = parser.parse_args()
15: tmin = args.tmin
16: tmax = args.tmax
17: tstep = args.tstep
18: mesh = trimesh.load_mesh(args.meshfile)
19:
20: # Set initial conditions
21: mass = 2000.0
22: t = tmin
23: i = 0
24:
25: + # Check if model is running as a part of an yggdrasil integration
26: + with_yggdrasil = os.environ.get('YGG_SUBPROCESS', False)
27: +
28: + # If the model is running as part of an yggdrasil integration, import
29: + # the relevant yggdrasil routines and use the interface routine to
30: + # complete the connection defined in the YAML
31: + if with_yggdrasil:
32: +     from yggdrasil import units
33: +     from yggdrasil.languages.Python.YggInterface import YggOutput
34: +     height_out = YggOutput('height')
35: +
36:     # Continue simulation until time limit is reached
37:     while t <= tmax:
38:
39: +         # If running as part an yggdrasil integration, send the time and
40: +         # maximum height of the mesh to the height channel with units
41: +         if with_yggdrasil:
42: +             flag = height_out.send(
43: +                 [units.add_units(t, 'hrs'),
44: +                  units.add_units(max(mesh.vertices[:, 2]), 'm')])
45: +             if not flag:
46: +                 raise Exception("Error sending height to output")
47: +
48:         # Compute the scale factor
49:         # (pretend this is a biologically complex calculation)
50:         scale = mass / 4.5e4
51:
52:         # Grow the shoot
53:         # (pretend this is a biologically complex calculation)
54:         mesh.vertices[:, 2] += mesh.vertices[:, 2] * scale
55:         mass += mass * scale
56:
57:         # Save mesh for this timestep
58:         filename_mesh = os.path.join(_dir, f'../output/mesh_{i:03d}.obj')
59:         with open(filename_mesh, 'w') as fd:
60:             mesh.export(fd, 'obj')
61:
62:         # Advance time step
63:         t += tstep
64:         i += 1
```

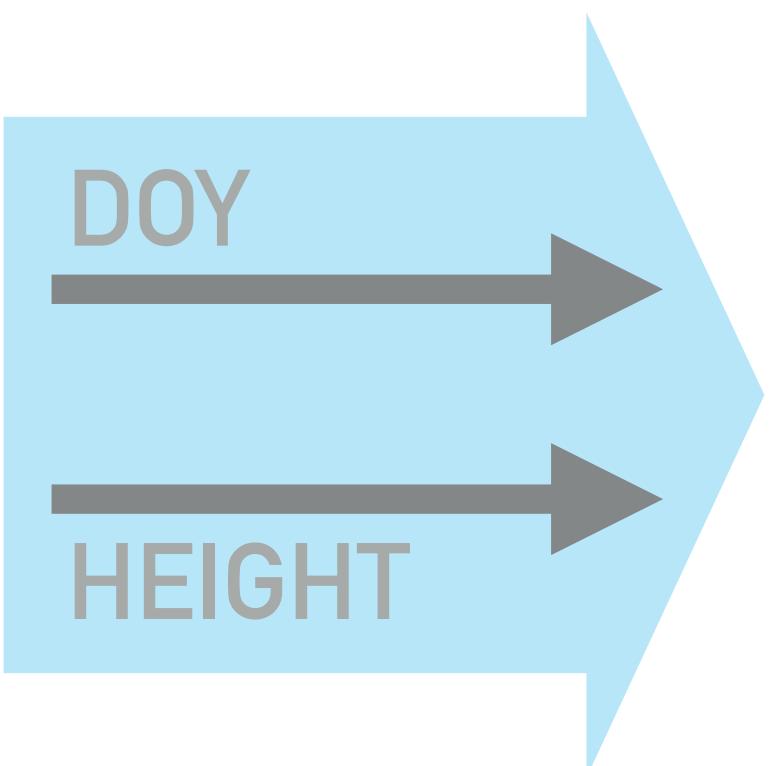
Send height to output channel

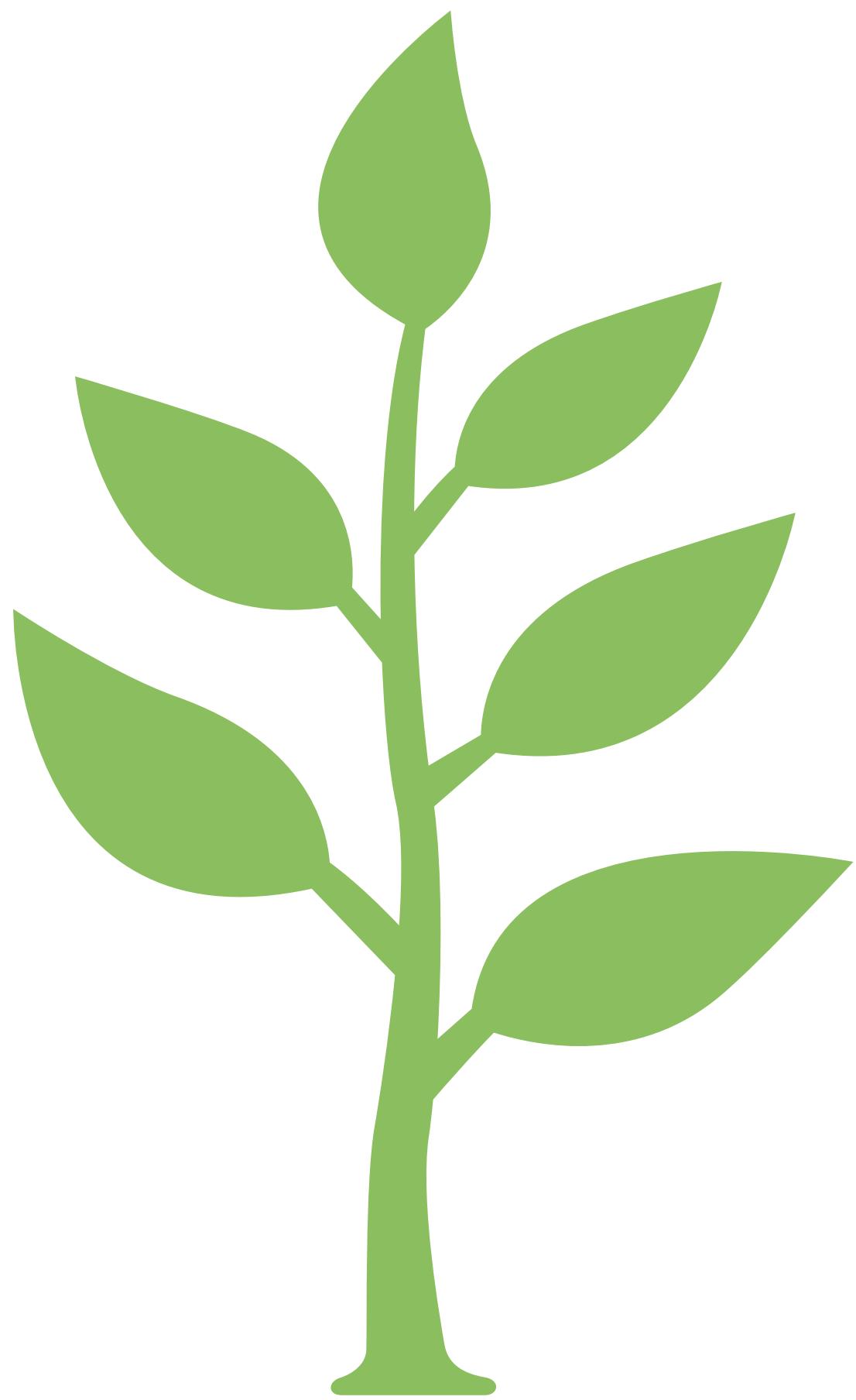
Code to call yggdrasil inside "if blocks" so that model runs exactly the same without yggdrasil



SHOOT
MODEL

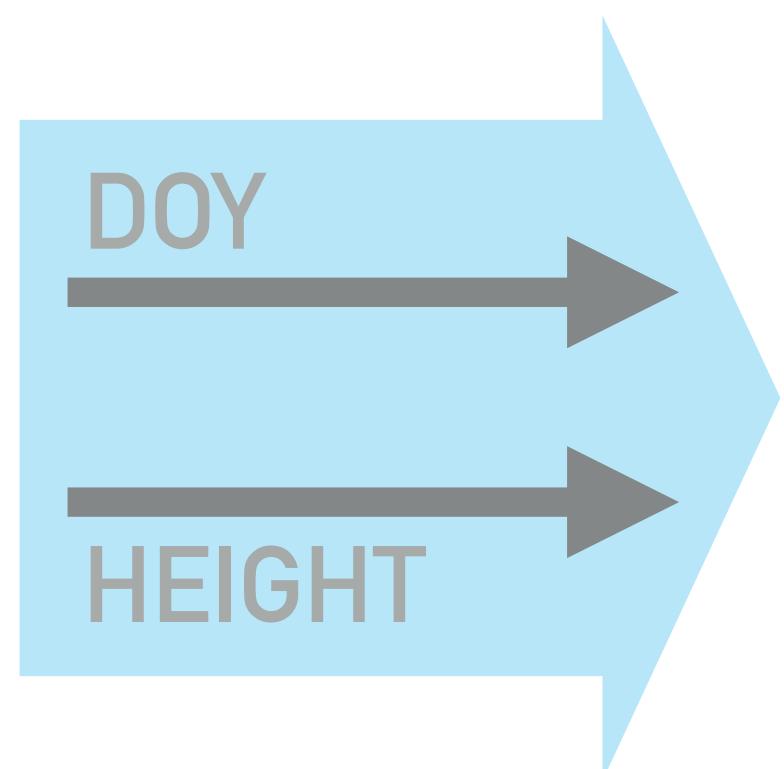
height



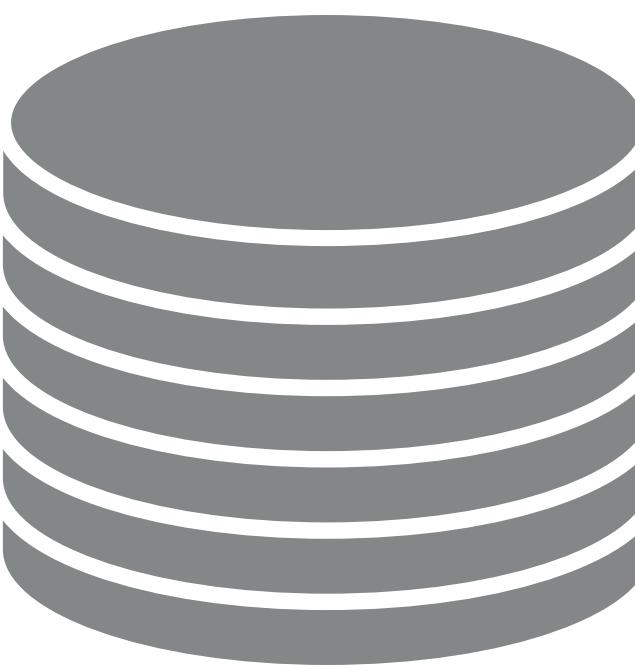


SHOOT
MODEL

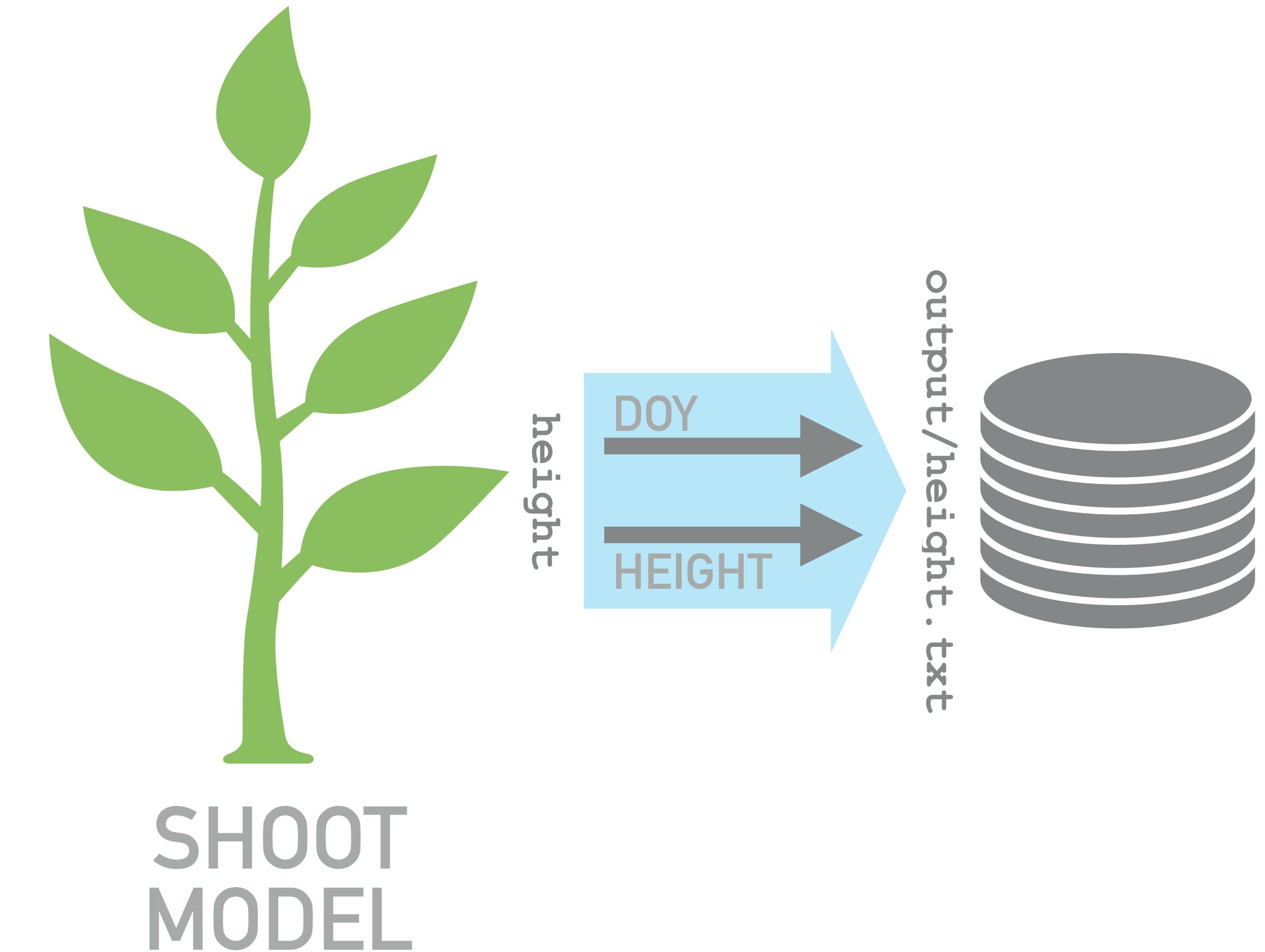
height



output/height.txt

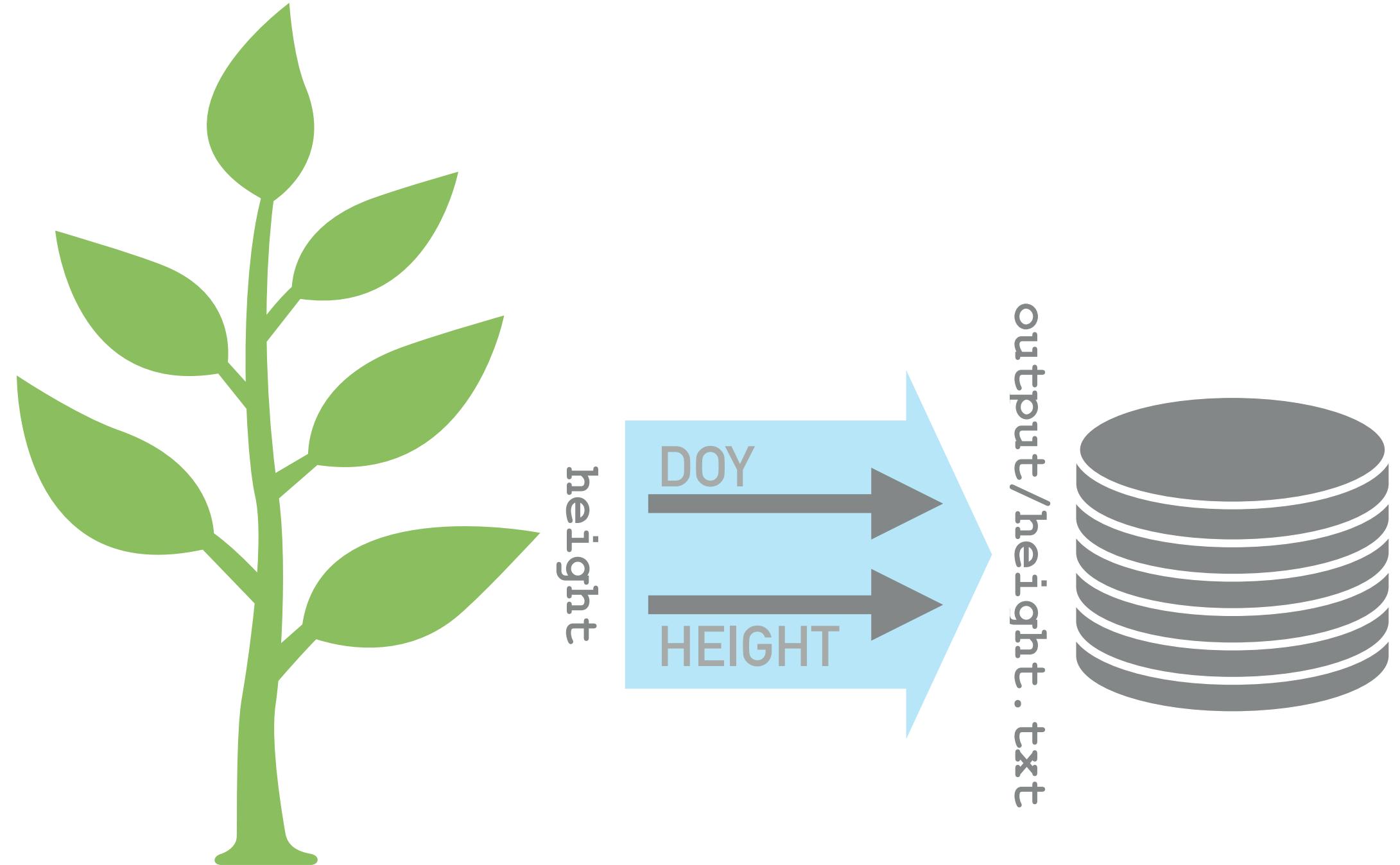


```
In [16]: tools.display_source_diff('yamls/shoot_v0.yml', 'yamls/shoot_v1.yml', number_lines=True)
```



```
In [16]: tools.display_source_diff('yamls/shoot_v0.yml', 'yamls/shoot_v1.yml', number_lines=True)
```

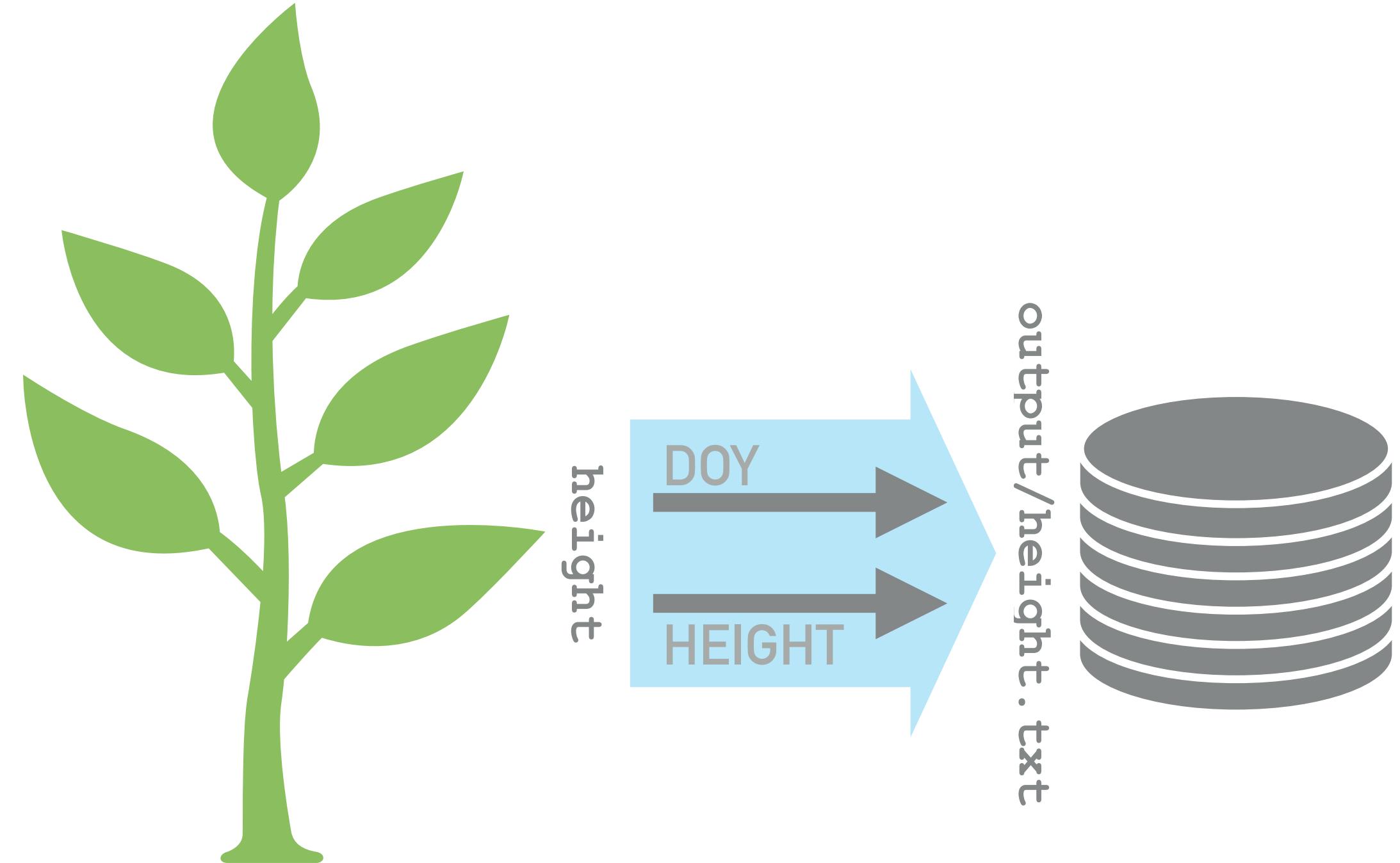
```
file1: yamls/shoot_v0.yml
file2: yamls/shoot_v1.yml
=====
1:   model:
2:     name: shoot
3:     language: python
4:     - args: [../models/shoot_v0.py, 0.0, 48.0, 6.0]
5:     ?
6:
7: +   args: [../models/shoot_v1.py, 0.0, 48.0, 6.0]
8: +
9: +   ?
10: +
11: +   outputs:
12: +     - name: height
13: +       default_file:
14: +         name: ../output/height.txt
15: +       filetype: table
```



SHOOT
MODEL

```
In [16]: tools.display_source_diff('yamls/shoot_v0.yml', 'yamls/shoot_v1.yml', number_lines=True)
```

```
file1: yamls/shoot_v0.yml
file2: yamls/shoot_v1.yml
=====
1:   model:
2:     name: shoot
3:     language: python
4:     - args: [../models/shoot_v0.py, 0.0, 48.0, 6.0]
5:     ?
6:
7: +   args: [../models/shoot_v1.py, 0.0, 48.0, 6.0]
8: +
9: +
10: +   outputs:
11: +     - name: height
12: +       default_file:
13: +         name: ../output/height.txt
14: +       filetype: table
```



Declare one output with a default file
that is only used if no other connection
connects to it.

SHOOT
MODEL

```
In [17]: run(['yamls/shoot_v1.yml'], production_run=True)
```

```
In [17]: run(['yamls/shoot_v1.yml'], production_run=True)
```

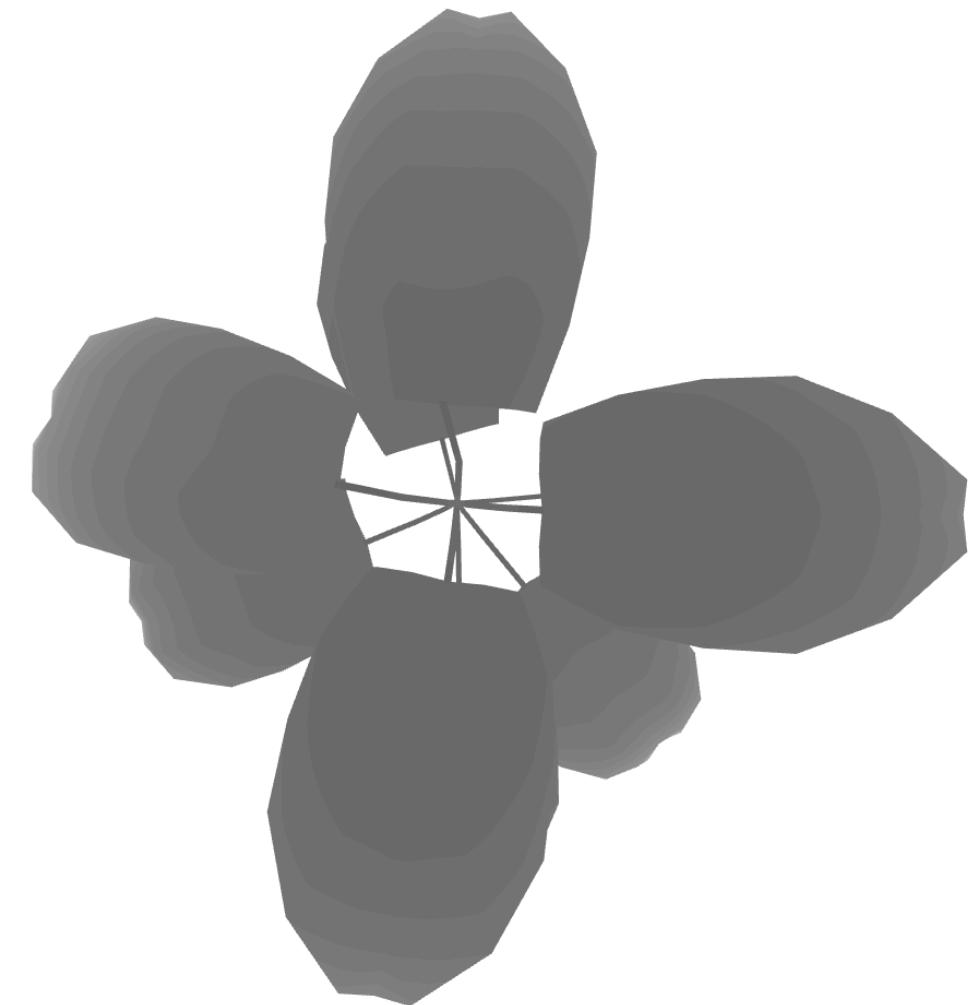
```
INFO:91854:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/sho  
ot_v1.py 0.0 48.0 6.0  
INFO:91854:runner.waitModels[553]:YggRunner(runner): shoot finished running.  
INFO:91854:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.  
INFO:91854:runner.waitModels[573]:YggRunner(runner): All models completed  
INFO:91854:runner.run[374]:YggRunner(runner):           init      0.000001  
INFO:91854:runner.run[374]:YggRunner(runner):           load drivers  0.006655  
INFO:91854:runner.run[374]:YggRunner(runner):           start drivers 0.060119  
INFO:91854:runner.run[374]:YggRunner(runner):           run models    5.849015  
INFO:91854:runner.run[374]:YggRunner(runner):           at exit       0.003885  
INFO:91854:runner.run[376]:YggRunner(runner): =====  
INFO:91854:runner.run[377]:YggRunner(runner):           Total      5.919675
```

```
In [17]: run(['yamls/shoot_v1.yml'], production_run=True)
```

```
INFO:91854:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/sho  
ot_v1.py 0.0 48.0 6.0  
INFO:91854:runner.waitModels[553]:YggRunner(runner): shoot finished running.  
INFO:91854:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.  
INFO:91854:runner.waitModels[573]:YggRunner(runner): All models completed  
INFO:91854:runner.run[374]:YggRunner(runner):           init      0.000001  
INFO:91854:runner.run[374]:YggRunner(runner):           load drivers  0.006655  
INFO:91854:runner.run[374]:YggRunner(runner):           start drivers 0.060119  
INFO:91854:runner.run[374]:YggRunner(runner):           run models    5.849015  
INFO:91854:runner.run[374]:YggRunner(runner):           at exit       0.003885  
INFO:91854:runner.run[376]:YggRunner(runner): =====  
INFO:91854:runner.run[377]:YggRunner(runner):           Total      5.919675
```

```
In [18]: mesh = trimesh.load_mesh('output/mesh_008.obj')  
mesh.show()
```

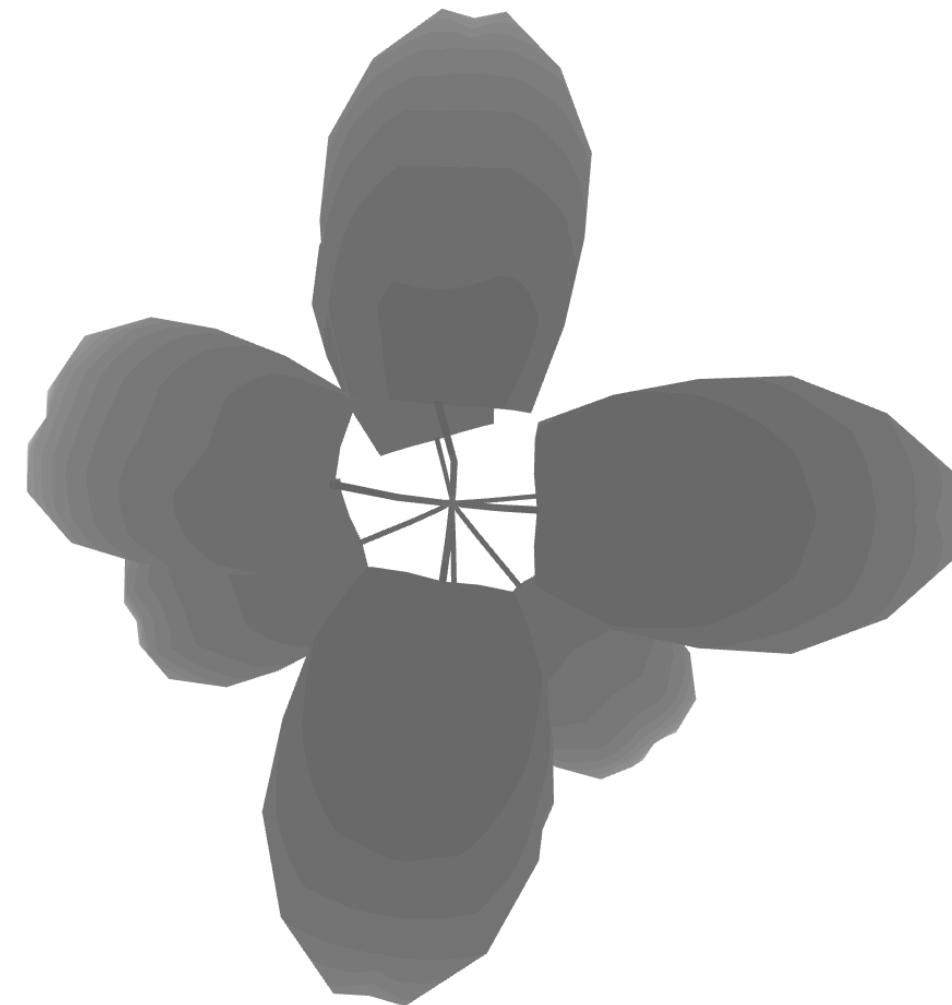
```
Out[18]:
```



```
In [17]: run(['yamls/shoot_v1.yml'], production_run=True)
```

```
INFO:91854:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/sho  
ot_v1.py 0.0 48.0 6.0  
INFO:91854:runner.waitModels[553]:YggRunner(runner): shoot finished running.  
INFO:91854:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.  
INFO:91854:runner.waitModels[573]:YggRunner(runner): All models completed  
INFO:91854:runner.run[374]:YggRunner(runner): init 0.000001  
INFO:91854:runner.run[374]:YggRunner(runner): load drivers 0.006655  
INFO:91854:runner.run[374]:YggRunner(runner): start drivers 0.060119  
INFO:91854:runner.run[374]:YggRunner(runner): run models 5.849015  
INFO:91854:runner.run[374]:YggRunner(runner): at exit 0.003885  
INFO:91854:runner.run[376]:YggRunner(runner): =====  
INFO:91854:runner.run[377]:YggRunner(runner): Total 5.919675
```

```
In [18]: mesh = trimesh.load_mesh('output/mesh_008.obj')  
mesh.show()  
out[18]:
```



```
In [19]: tools.display_source('output/height.txt')
```

```
file: output/height.txt  
=====
```

#	hr	m
0	77.2603	
6	80.6941	
12	84.4399	
18	88.5415	
24	93.0513	
30	98.0321	
36	103.561	
42	109.73	
48	116.656	

**TEST YOUR
KNOWLEDGE (10 MIN)**

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<input type="checkbox"/>	 input				33 minutes ago	
<input type="checkbox"/>	 meshes				33 minutes ago	
<input type="checkbox"/>	 models				33 minutes ago	
<input type="checkbox"/>	 yaml				33 minutes ago	
<input type="checkbox"/>	 00-intro.ipynb				33 minutes ago	457 kB
<input type="checkbox"/>	 01-connections.ipynb				33 minutes ago	470 kB
<input type="checkbox"/>	 02-timesync.ipynb				33 minutes ago	298 kB
<input type="checkbox"/>	 03-misc.ipynb				33 minutes ago	3.56 kB

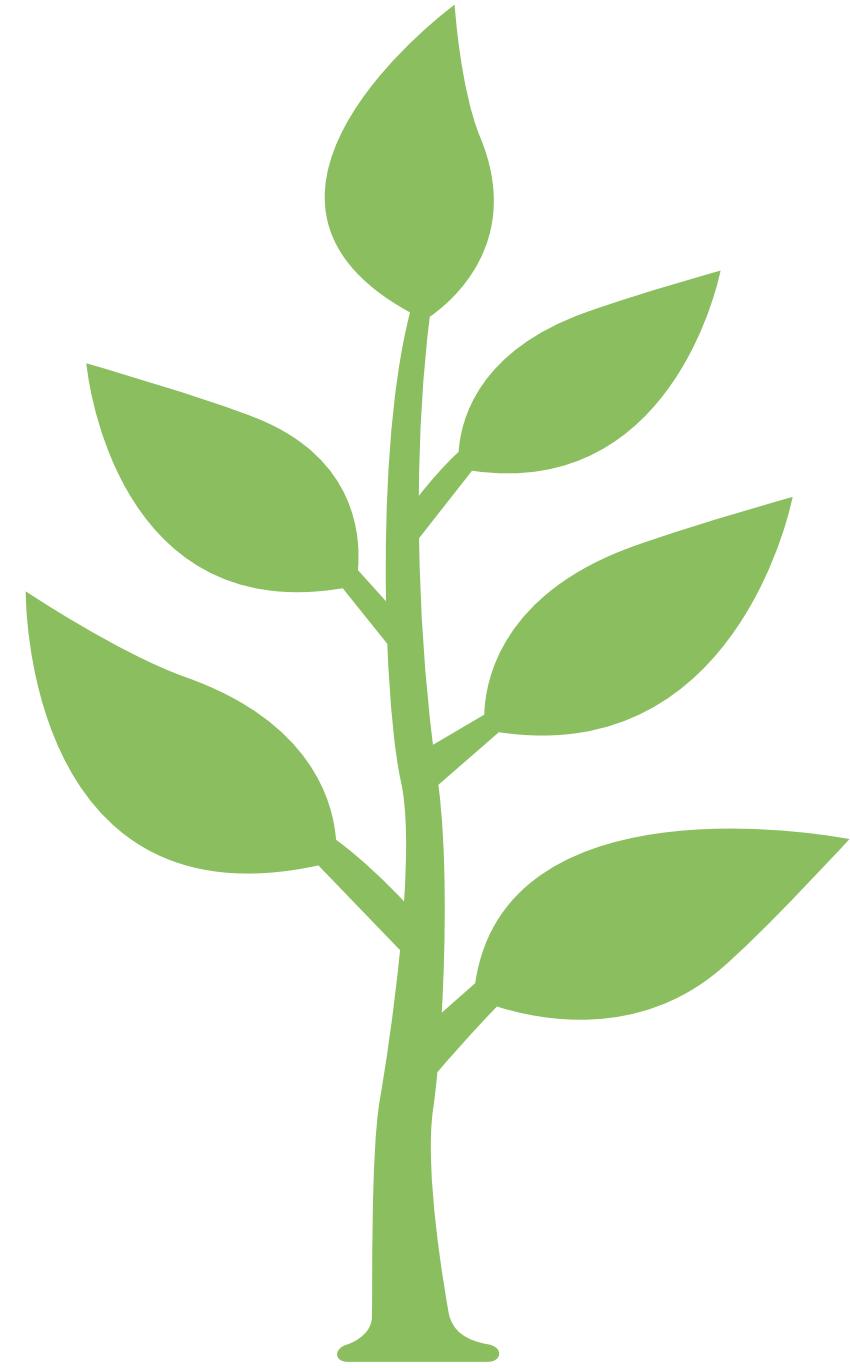
[Files](#) [Running](#) [Clusters](#) [Nbextensions](#)

Select items to perform actions on them.

[Upload](#) [New ▾](#) 

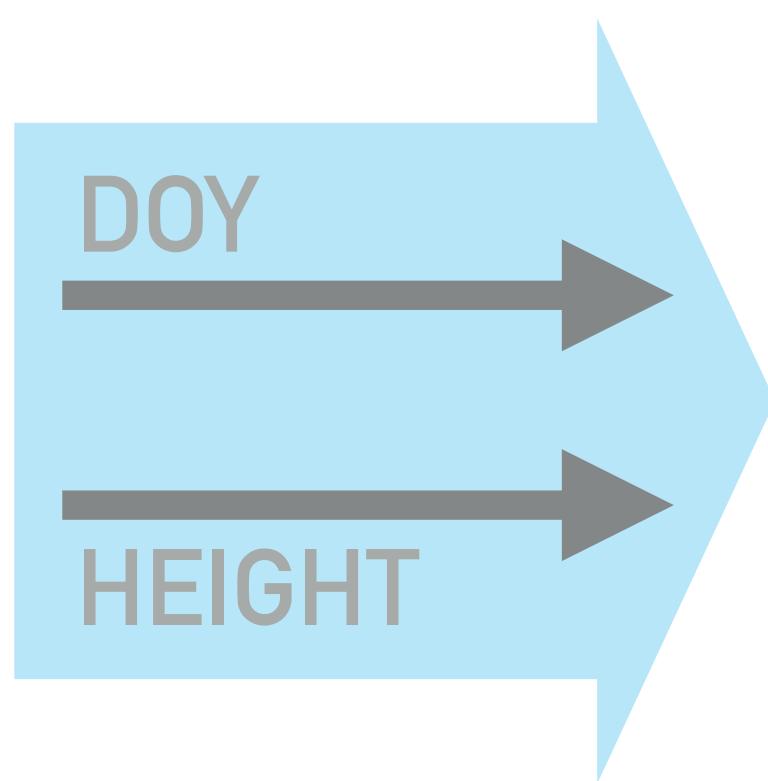
<input type="checkbox"/> 0	 /	Name 	Last Modified	File size
<input type="checkbox"/>	 images		33 minutes ago	
<input type="checkbox"/>	 input		33 minutes ago	
<input type="checkbox"/>	 meshes		33 minutes ago	
<input type="checkbox"/>	 models		33 minutes ago	
<input type="checkbox"/>	 yaml s		33 minutes ago	
<input type="checkbox"/>	 00-intro.ipynb		33 minutes ago	457 kB
<input checked="" type="checkbox"/>	 01-connections.ipynb		33 minutes ago	470 kB
<input type="checkbox"/>	 02-timesync.ipynb		33 minutes ago	298 kB
<input type="checkbox"/>	 03-misc.ipynb		33 minutes ago	3.56 kB

**ONE WAY
MODEL-TO-MODEL
CONNECTION**

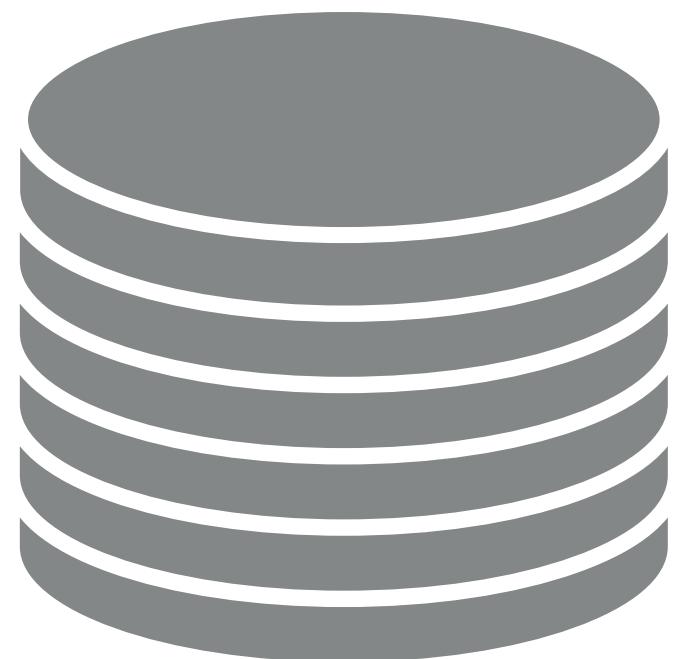


SHOOT
MODEL

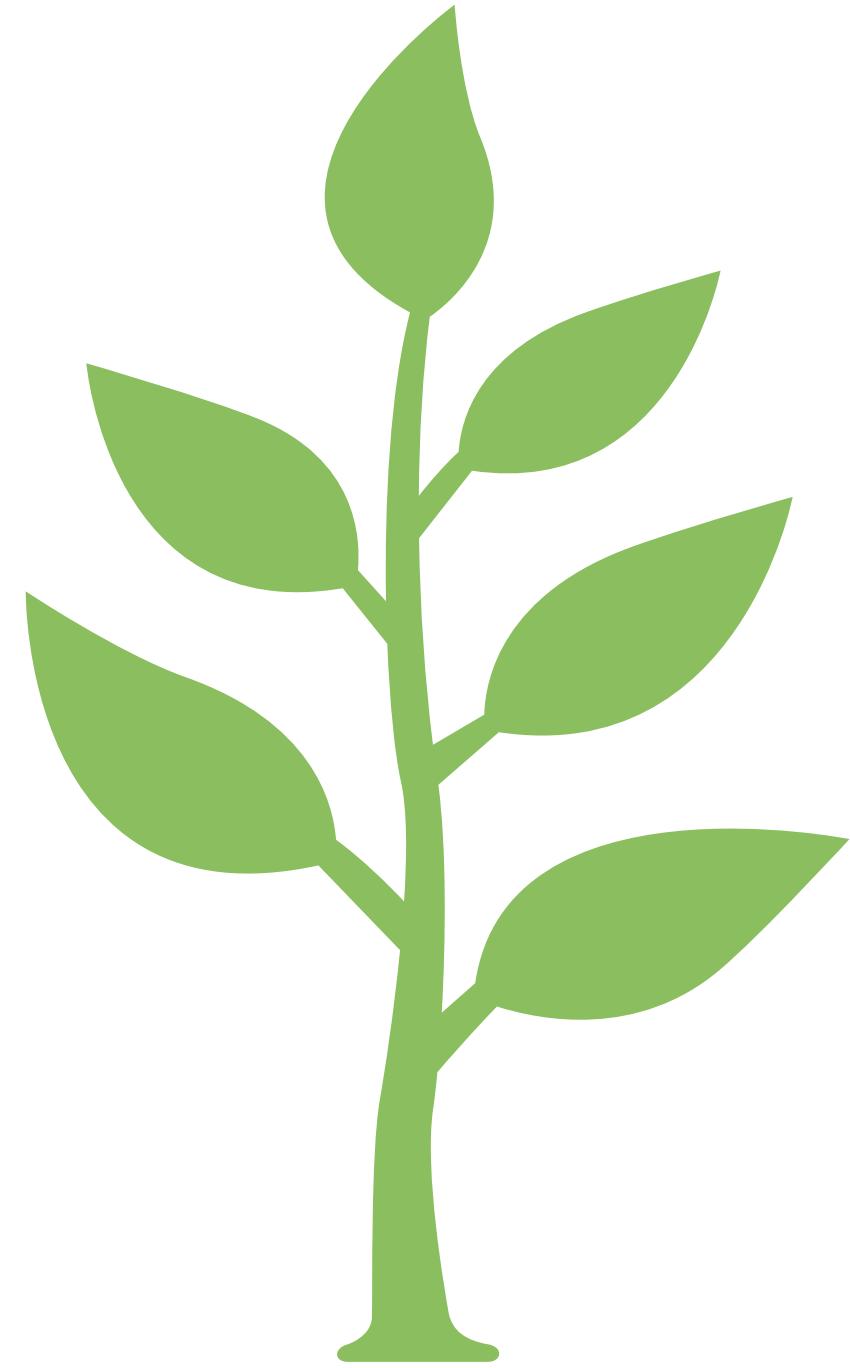
shoot:height



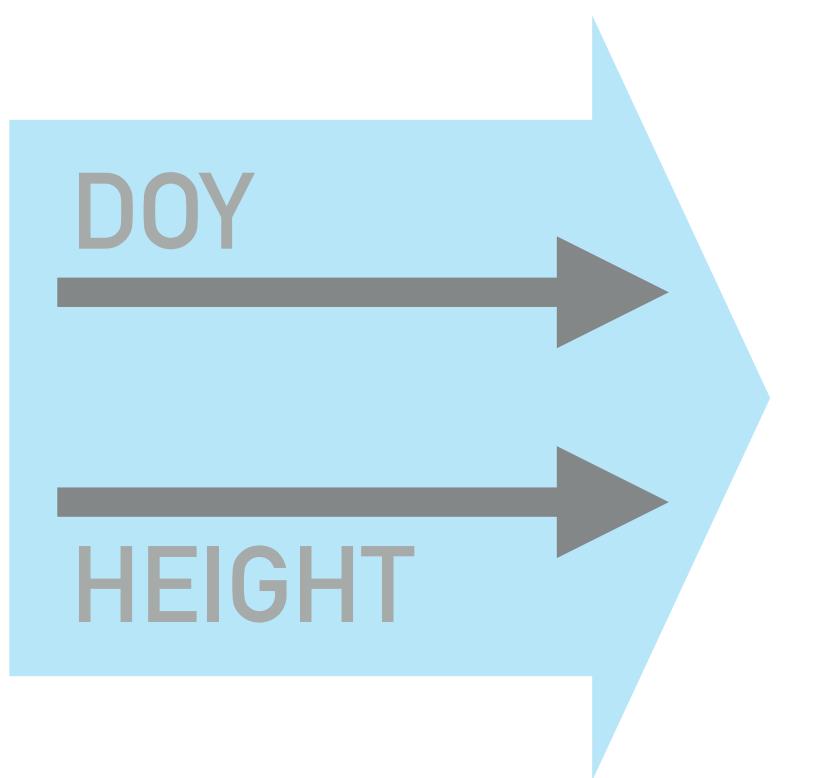
DOY
HEIGHT



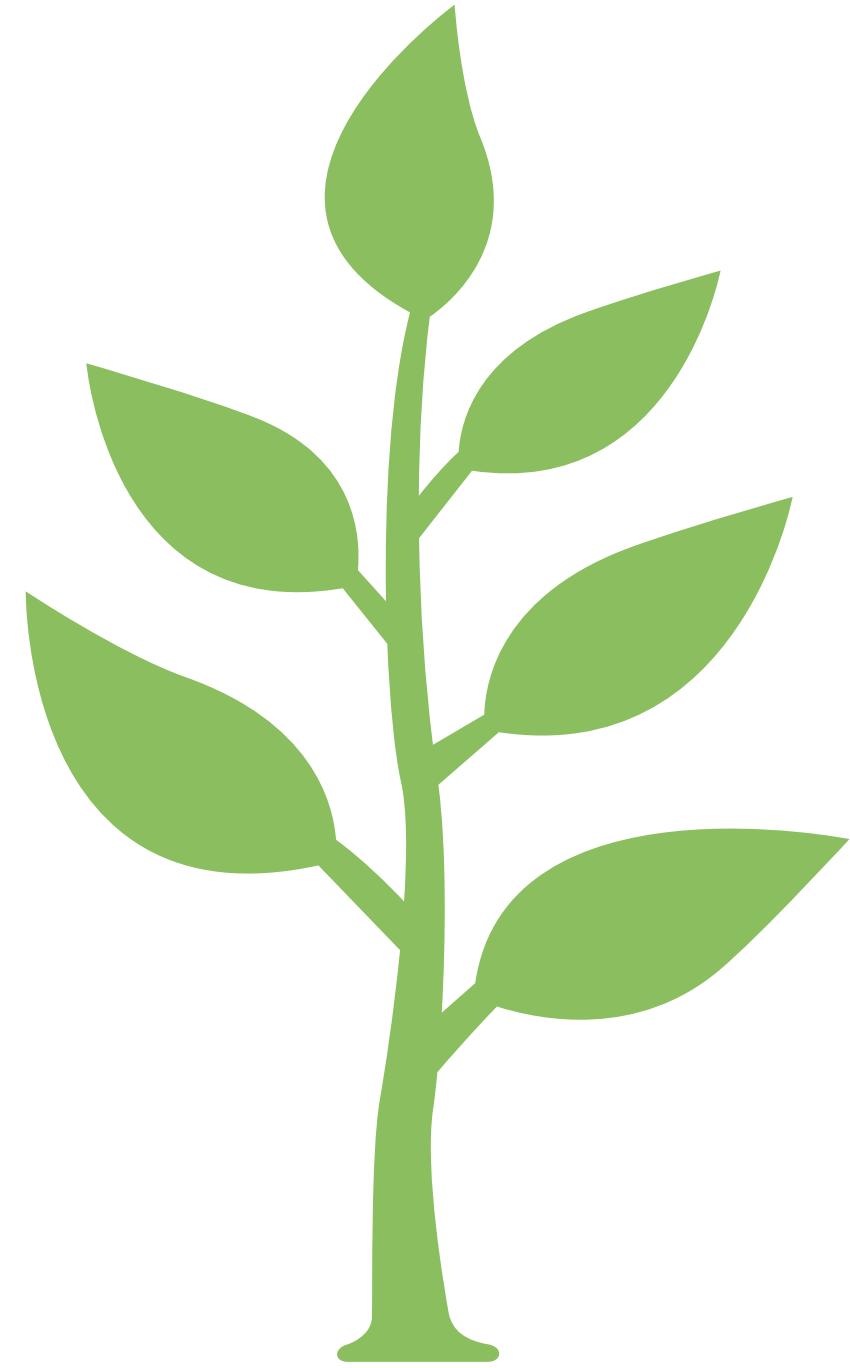
output/height.txt



shoot:height

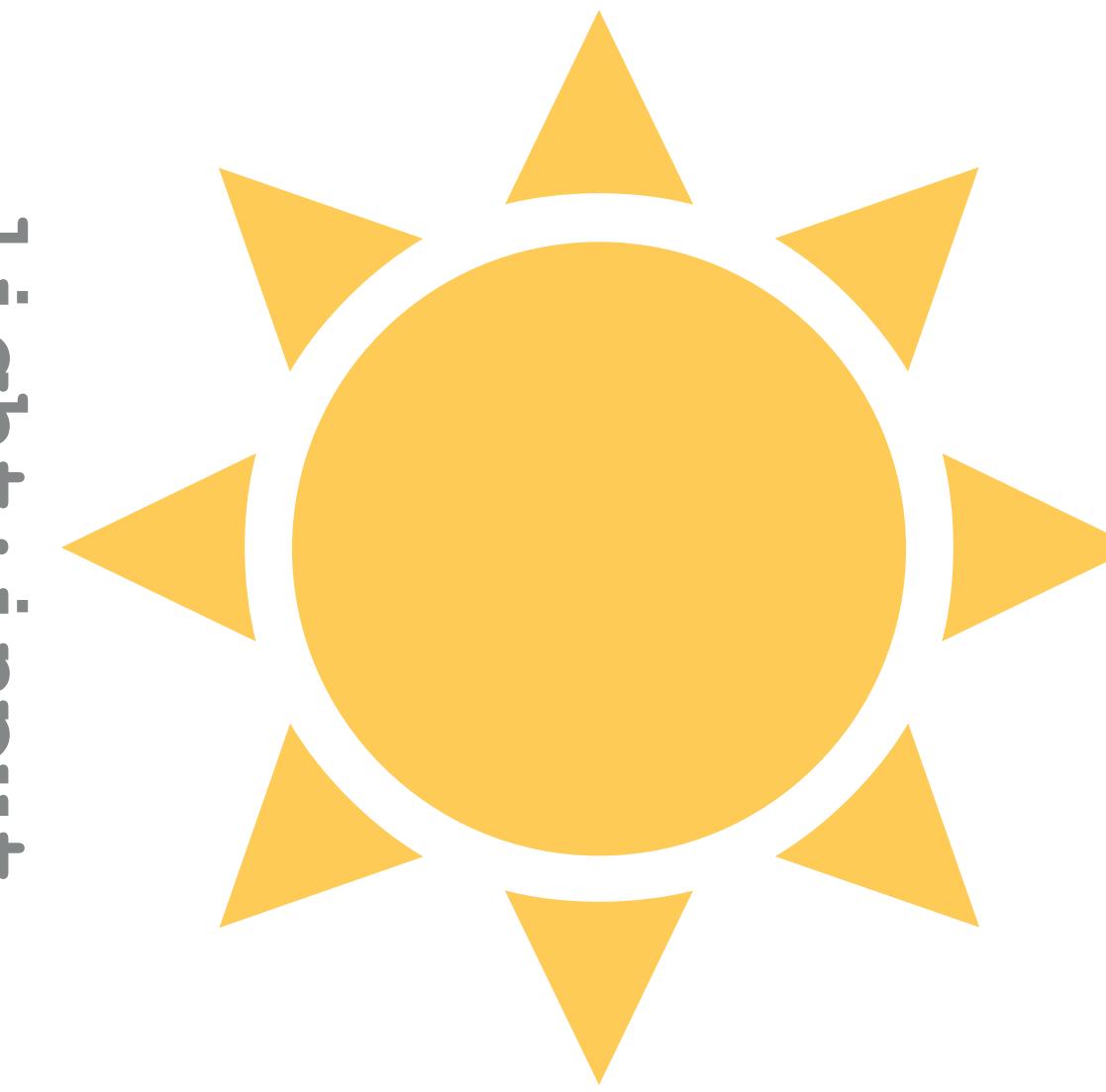
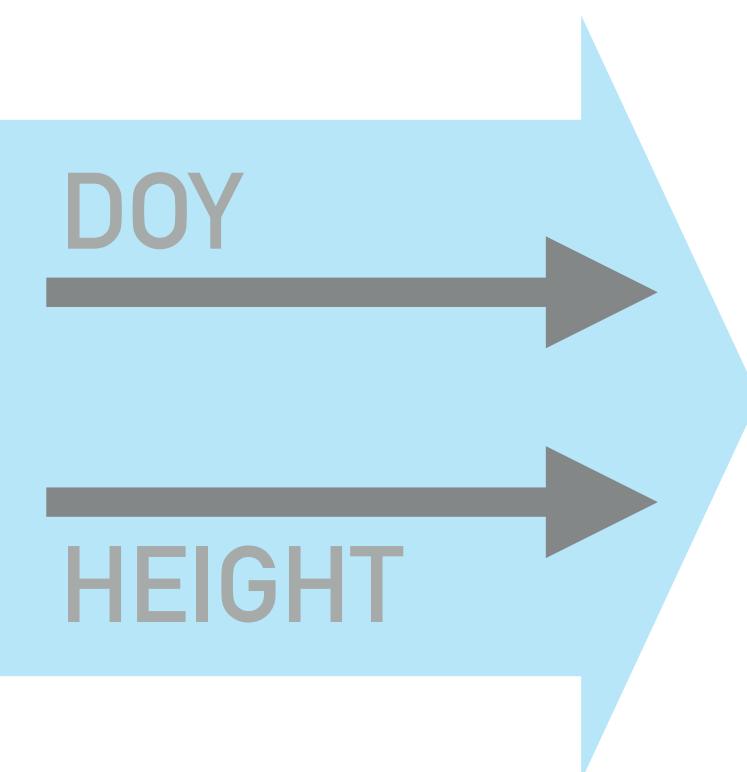


SHOOT
MODEL



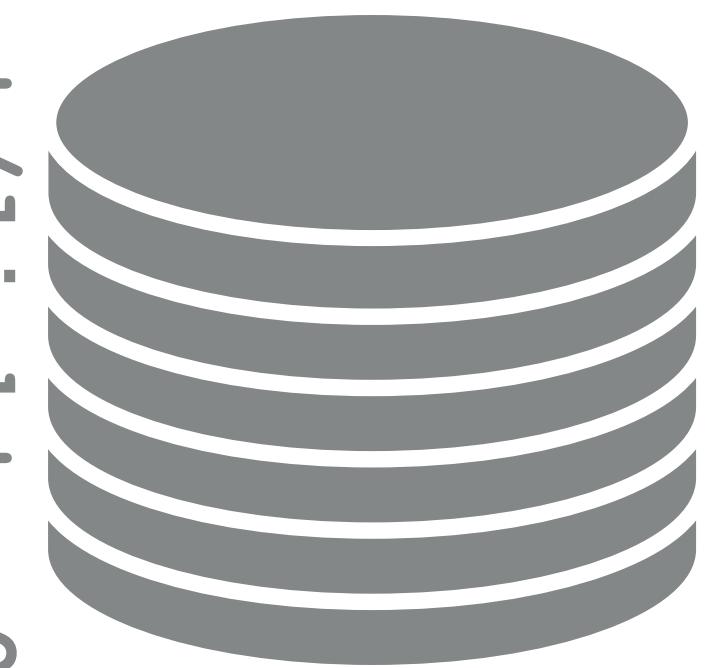
SHOOT
MODEL

shoot:height



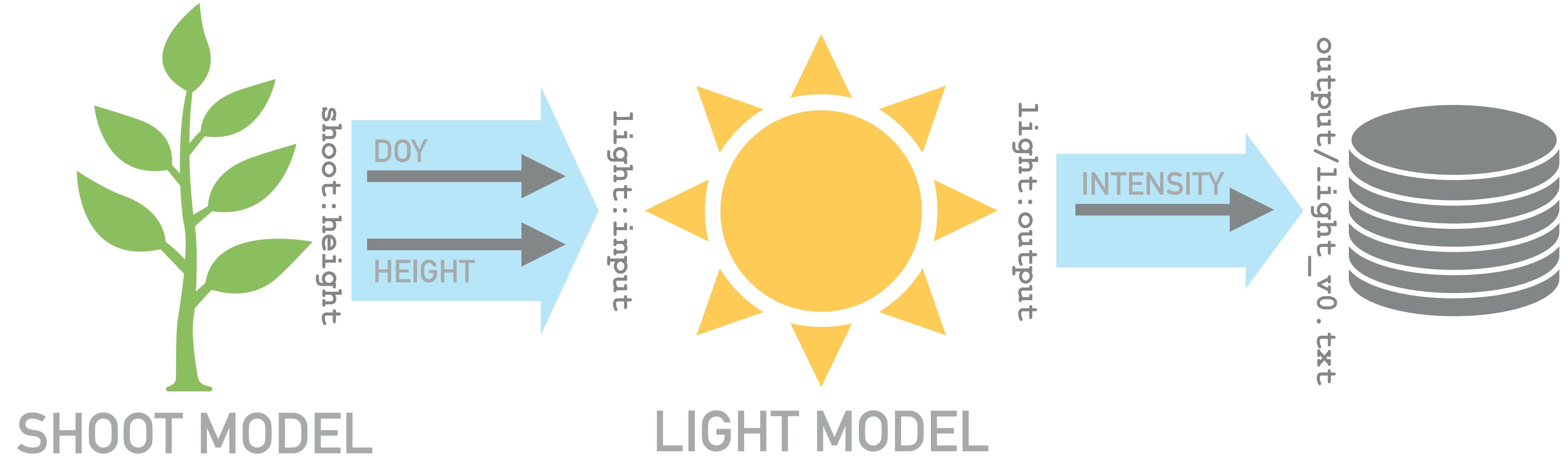
LIGHT MODEL

light:output



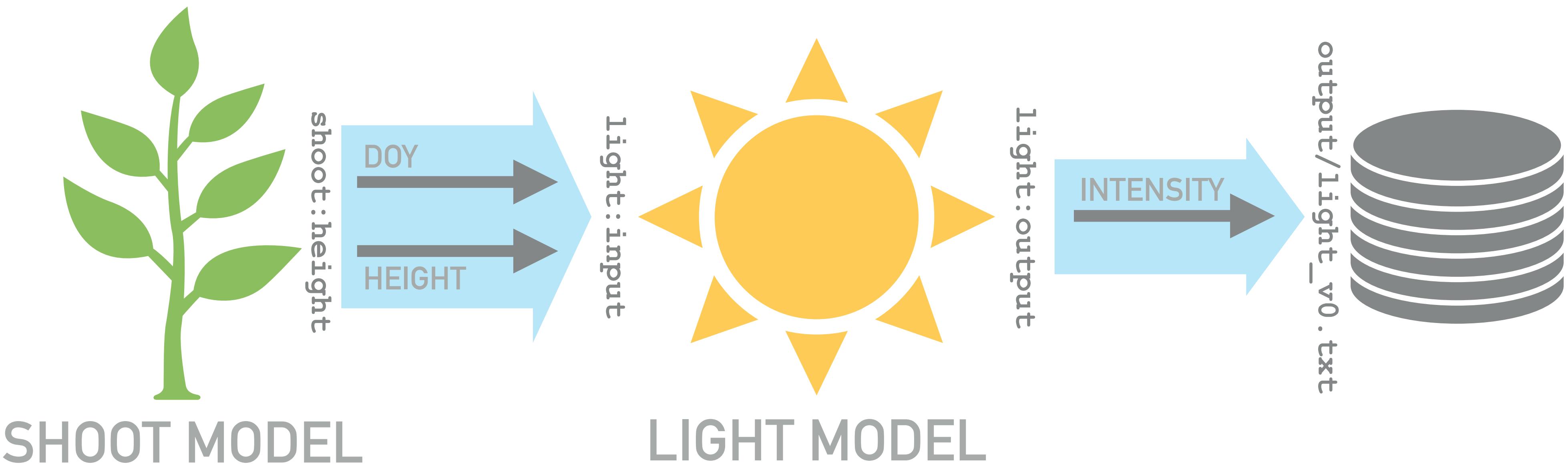
output/light_v0.txt

```
In [2]: tools.display_source_diff('yamls/connections_v0.yml', 'yamls/connections_v1.yml', number_lines=True)
```



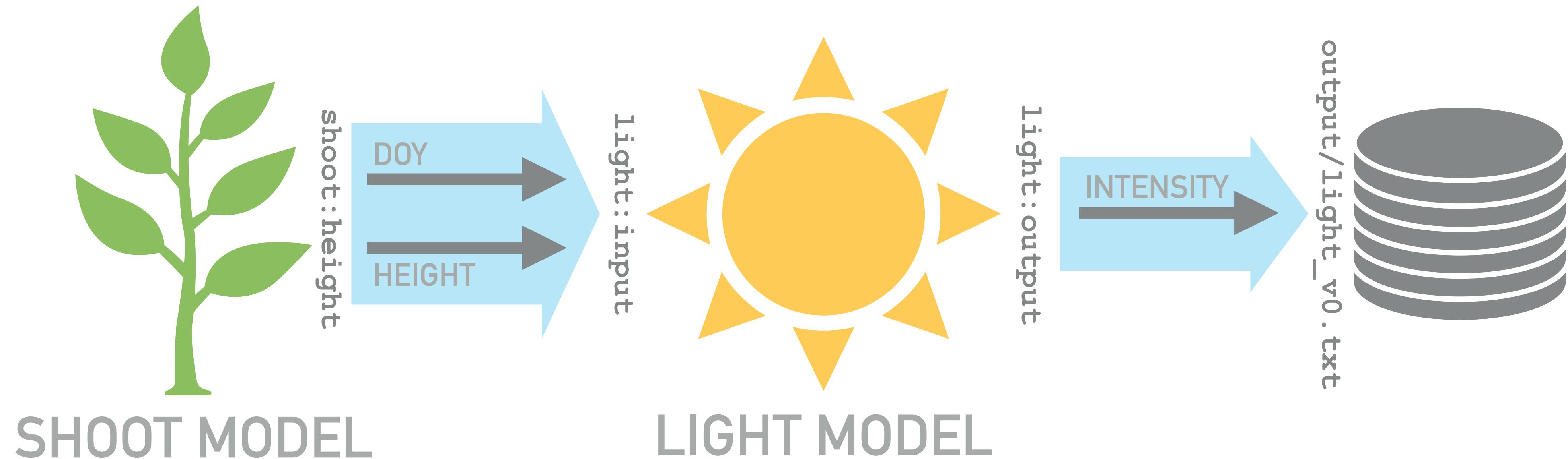
```
In [2]: tools.display_source_diff('yamls/connections_v0.yml', 'yamls/connections_v1.yml', number_lines=True)
```

```
file1: yamls/connections_v0.yml
file2: yamls/connections_v1.yml
=====
1:   connections:
2:     - input:
3:     - input: shoot:height
4:     ?
5:       ++++++
6:
7:     - name: ../input/light_v0.txt
8:     - filetype: table
9:     - output: light:input
10:    - input: light:output
11:    output:
12:      name: ../output/light_v0.txt
13:      filetype: table
14:      field_names: [intensity]
```



```
In [2]: tools.display_source_diff('yamls/connections_v0.yml', 'yamls/connections_v1.yml', number_lines=True)
```

```
file1: yamls/connections_v0.yml
file2: yamls/connections_v1.yml
=====
1:   connections:
2:     - input:
3:       - input: shoot:height
4:     ?
5:       ++++++
6:
7:       - name: ../input/light_v0.txt
8:       - filetype: table
9:       output: light:input
10:      - input: light:output
11:      output:
12:        name: ../output/light_v0.txt
13:        filetype: table
14:        field_names: [intensity]
```



```
In [3]: run(['yamls/light_v0_python.yml', 'yamls/shoot_v1.yml', 'yamls/connections_v1.yml'], production_run=True)
```

```
In [3]: run(['yamls/light_v0_python.yml', 'yamls/shoot_v1.yml', 'yamls/connections_v1.yml'], production_run=True)
```

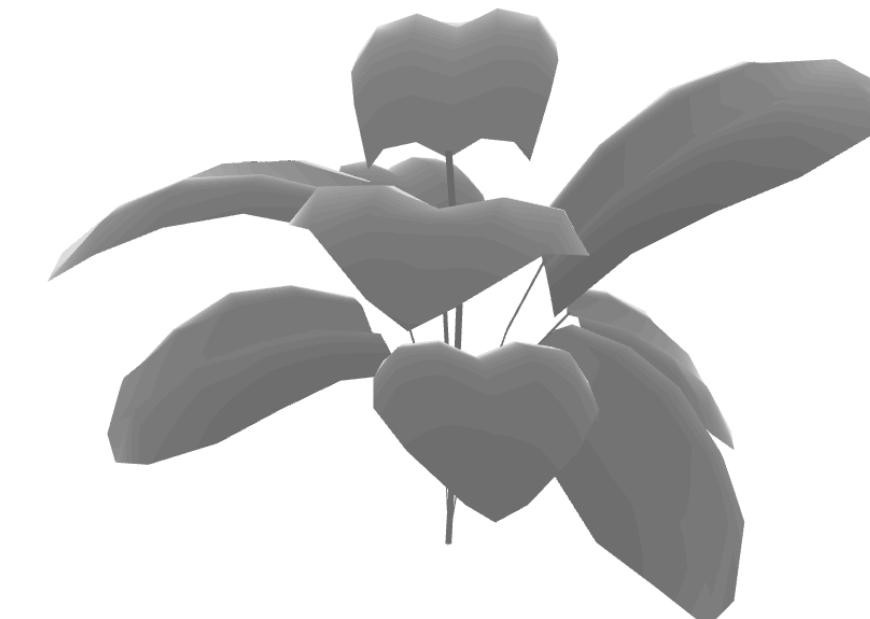
```
INFO:93696:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg  
_light_v0.py  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/sho  
ot_v1.py 0.0 48.0 6.0  
End of input from temp_doy.  
INFO:93696:runner.waitModels[553]:YggRunner(runner): shoot finished running.  
INFO:93696:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.  
INFO:93696:runner.waitModels[553]:YggRunner(runner): light finished running.  
INFO:93696:runner.waitModels[559]:YggRunner(runner): light finished exiting.  
INFO:93696:runner.waitModels[573]:YggRunner(runner): All models completed  
INFO:93696:runner.run[374]:YggRunner(runner):           init      0.000000  
INFO:93696:runner.run[374]:YggRunner(runner):       load drivers    0.282206  
INFO:93696:runner.run[374]:YggRunner(runner):     start drivers    0.090545  
INFO:93696:runner.run[374]:YggRunner(runner):       run models    6.751301  
INFO:93696:runner.run[374]:YggRunner(runner):        at exit     0.021096  
INFO:93696:runner.run[376]:YggRunner(runner): =====  
INFO:93696:runner.run[377]:YggRunner(runner):           Total     7.145148
```

```
In [3]: run(['yamls/light_v0_python.yml', 'yamls/shoot_v1.yml', 'yamls/connections_v1.yml'], production_run=True)
```

```
INFO:93696:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg  
_light_v0.py  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/sho  
ot_v1.py 0.0 48.0 6.0  
End of input from temp_doy.  
INFO:93696:runner.waitModels[553]:YggRunner(runner): shoot finished running.  
INFO:93696:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.  
INFO:93696:runner.waitModels[553]:YggRunner(runner): light finished running.  
INFO:93696:runner.waitModels[559]:YggRunner(runner): light finished exiting.  
INFO:93696:runner.waitModels[573]:YggRunner(runner): All models completed  
INFO:93696:runner.run[374]:YggRunner(runner): init 0.000000  
INFO:93696:runner.run[374]:YggRunner(runner): load drivers 0.282206  
INFO:93696:runner.run[374]:YggRunner(runner): start drivers 0.090545  
INFO:93696:runner.run[374]:YggRunner(runner): run models 6.751301  
INFO:93696:runner.run[374]:YggRunner(runner): at exit 0.021096  
INFO:93696:runner.run[376]:YggRunner(runner): =====  
INFO:93696:runner.run[377]:YggRunner(runner): Total 7.145148
```

```
In [4]: mesh = trimesh.load_mesh('output/mesh_008.obj')  
mesh.show()
```

```
Out[4]:
```

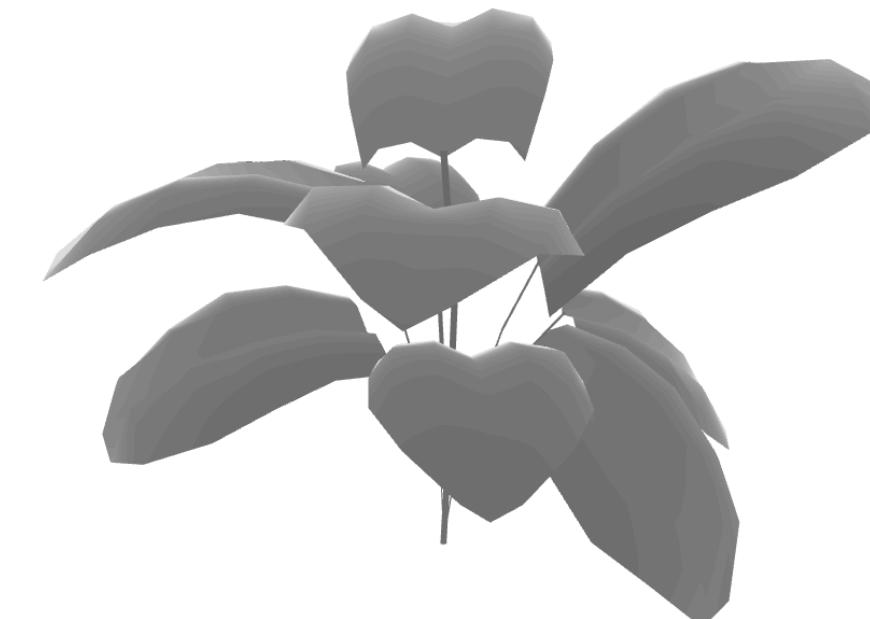


```
In [3]: run(['yamls/light_v0_python.yml', 'yamls/shoot_v1.yml', 'yamls/connections_v1.yml'], production_run=True)
```

```
INFO:93696:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg  
_light_v0.py  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/sho  
ot_v1.py 0.0 48.0 6.0  
End of input from temp_doy.  
INFO:93696:runner.waitModels[553]:YggRunner(runner): shoot finished running.  
INFO:93696:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.  
INFO:93696:runner.waitModels[553]:YggRunner(runner): light finished running.  
INFO:93696:runner.waitModels[559]:YggRunner(runner): light finished exiting.  
INFO:93696:runner.waitModels[573]:YggRunner(runner): All models completed  
INFO:93696:runner.run[374]:YggRunner(runner): init 0.000000  
INFO:93696:runner.run[374]:YggRunner(runner): load drivers 0.282206  
INFO:93696:runner.run[374]:YggRunner(runner): start drivers 0.090545  
INFO:93696:runner.run[374]:YggRunner(runner): run models 6.751301  
INFO:93696:runner.run[374]:YggRunner(runner): at exit 0.021096  
INFO:93696:runner.run[376]:YggRunner(runner): =====  
INFO:93696:runner.run[377]:YggRunner(runner): Total 7.145148
```

```
In [4]: mesh = trimesh.load_mesh('output/mesh_008.obj')  
mesh.show()
```

```
Out[4]:
```



```
In [5]: tools.display_source('output/light_v0.txt')
```

```
file: output/light_v0.txt  
=====  
# intensity  
# erg/(cm**2*s)  
# %g  
618082  
648331  
681333  
717477  
757224  
801131  
849874  
904281  
965376
```

**TEST YOUR
KNOWLEDGE (10 MIN)**

REMOTE PROCEDURE CALL (RPC)



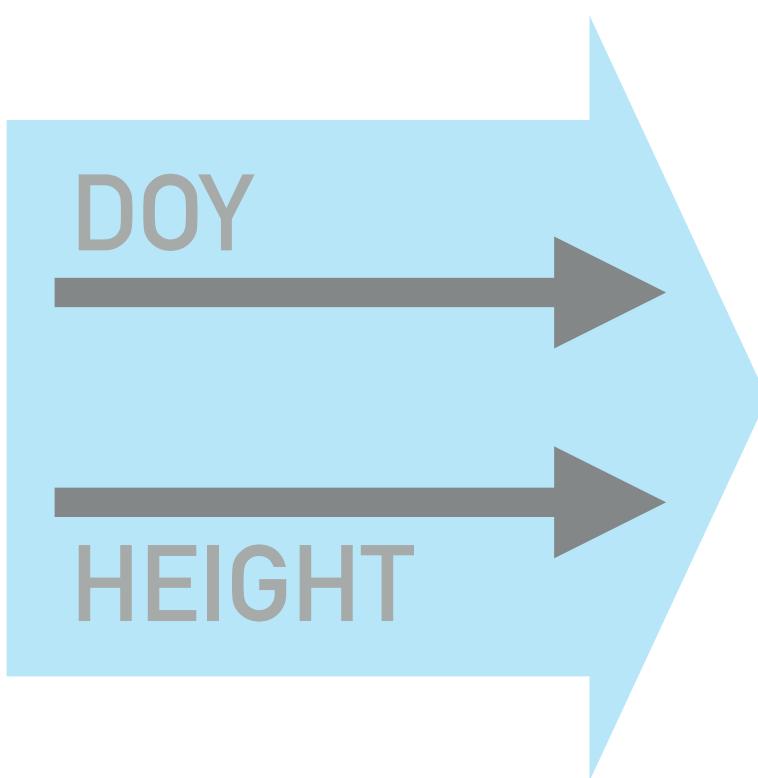
light_shoot

SHOOT
MODEL

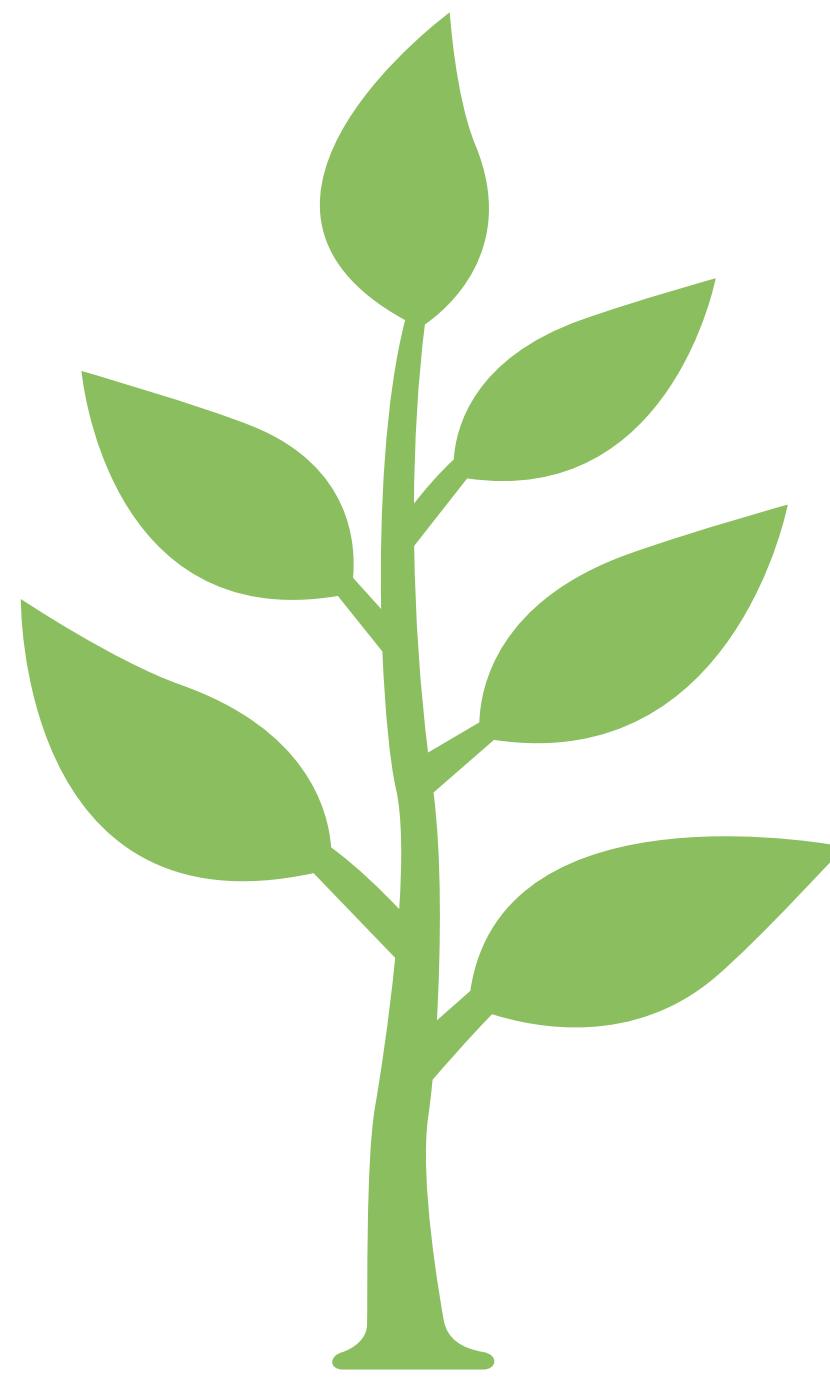


SHOOT
MODEL

light_shoot

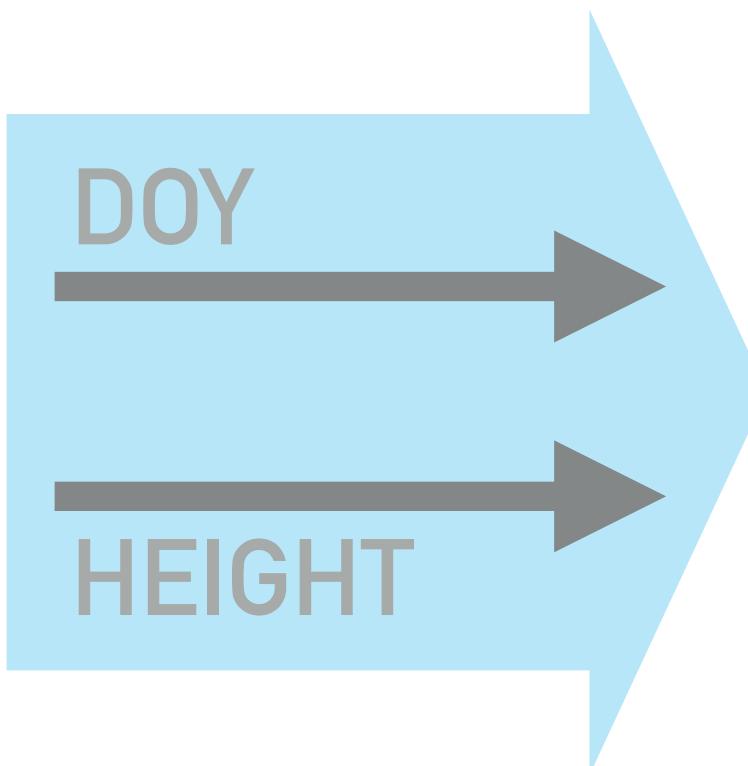


light:input



SHOOT
MODEL

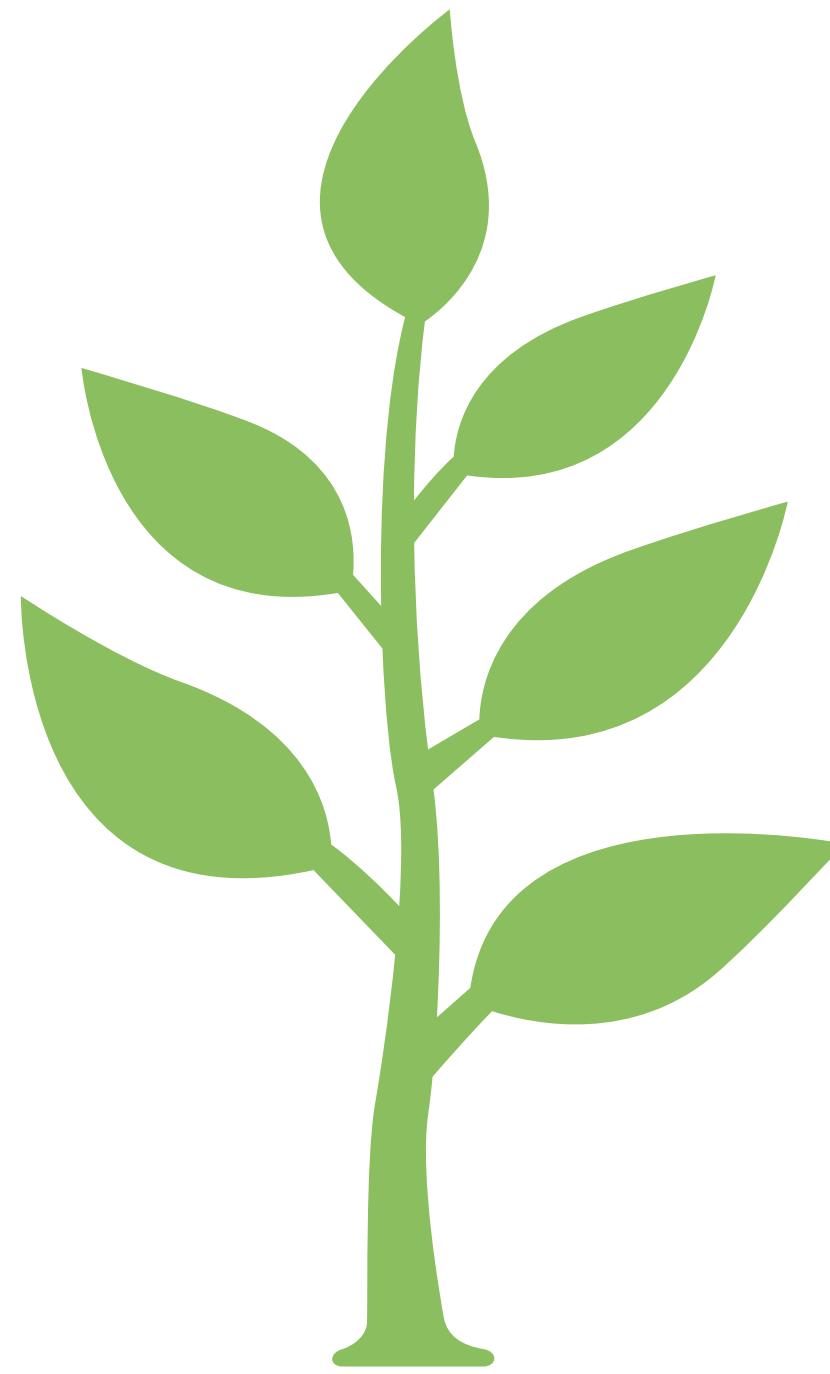
light_shoot



light:input

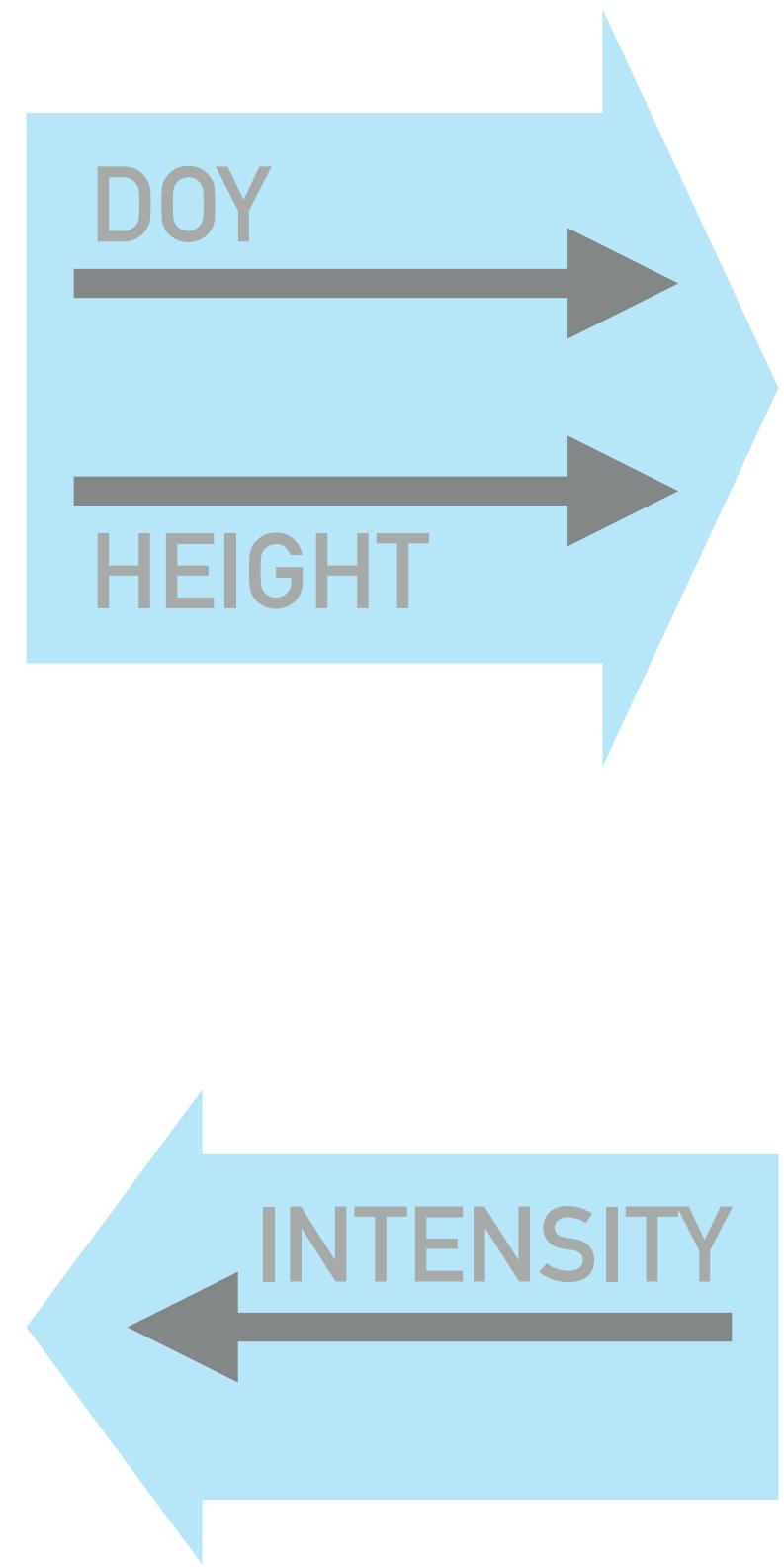


LIGHT
MODEL



SHOOT
MODEL

light_shoot



light:input light:output



LIGHT
MODEL

```
In [6]: tools.display_source_diff('models/shoot_v1.py', 'models/shoot_v2.py', number_lines=True)
```

```
In [6]: tools.display_source_diff('models/shoot_v1.py', 'models/shoot_v2.py', number_lines=True)
```

```
file1: models/shoot_v1.py
file2: models/shoot_v2.py
=====
1: import os
2: import trimesh
3: import argparse
...
28: # If the model is running as part of an yggdrasil integration, import
29: # the relevant yggdrasil routines and use the interface routine to
30: # complete the connection defined in the YAML
31: if with_yggdrasil:
32:     from yggdrasil import units
-     from yggdrasil.languages.Python.YggInterface import YggOutput
?
^__ __
33: +     from yggdrasil.languages.Python.YggInterface import YggRpcClient
?
^_____
-     height_out = YggOutput('height')
?
^__ __
34: +     light_rpc = YggRpcClient('light_shoot')
?
^__ __
35:
36: # Continue simulation until time limit is reached
37: while t <= tmax:
38:
39: # If running as part an yggdrasil integration, send the time and
40: # maximum height of the mesh to the height channel with units
41: if with_yggdrasil:
-     flag = height_out.send(
?
        ^__ __
42: +     flag, intensity = light_rpc.call(
?
            ++++++
        ^
        ^__ __
43:             [units.add_units(t, 'hrs'),
44:              units.add_units(max(mesh.vertices[:, 2]), 'm')])
```

```
In [6]: tools.display_source_diff('models/shoot_v1.py', 'models/shoot_v2.py', number_lines=True)
```

```
file1: models/shoot_v1.py
file2: models/shoot_v2.py
=====
1: import os
2: import trimesh
3: import argparse
...
28: # If the model is running as part of an yggdrasil integration, import
29: # the relevant yggdrasil routines and use the interface routine to
30: # complete the connection defined in the YAML
31: if with_yggdrasil:
32:     from yggdrasil import units
-     from yggdrasil.languages.Python.YggInterface import YggOutput
?
^---^
33: +     from yggdrasil.languages.Python.YggInterface import YggRpcClient
?
^-----^

-     height_out = YggOutput('height')
?
^-----^
34: +     light_rpc = YggRpcClient('light_shoot')
?
^-----^
^-----^

35:
36: # Continue simulation until time limit is reached
37: while t <= tmax:
38:
39:     # If running as part an yggdrasil integration, send the time and
40:     # maximum height of the mesh to the height channel with units
41:     if with_yggdrasil:
-         flag = height_out.send(
?
        ^-----^
42: +         flag, intensity = light_rpc.call(
?
        +-----+
        ^-----^
        ^-----^
43:             [units.add_units(t, 'hrs'),
44:              units.add_units(max(mesh.vertices[:, 2]), 'm')])

...

```

Replace the interface function

```
In [6]: tools.display_source_diff('models/shoot_v1.py', 'models/shoot_v2.py', number_lines=True)
```

```
file1: models/shoot_v1.py
file2: models/shoot_v2.py
=====
1: import os
2: import trimesh
3: import argparse
...
28: # If the model is running as part of an yggdrasil integration, import
29: # the relevant yggdrasil routines and use the interface routine to
30: # complete the connection defined in the YAML
31: if with_yggdrasil:
32:     from yggdrasil import units
33:     from yggdrasil.languages.Python.YggInterface import YggOutput
34: +     from yggdrasil.languages.Python.YggInterface import YggRpcClient
35:
36: # Continue simulation until time limit is reached
37: while t <= tmax:
38:
39:     # If running as part an yggdrasil integration, send the time and
40:     # maximum height of the mesh to the height channel with units
41:     if with_yggdrasil:
42:         flag = height_out.send(
43:             [units.add_units(t, 'hrs'),
44:              units.add_units(max(mesh.vertices[:, 2]), 'm')])
45:
46:     # Compute the scale factor
47: +     scale = units.get_data(
48:         units.add_units(mass, 'g') * intensity /
49:         units.add_units(4.0e10, 'g*erg/(cm**2*s)'))
50: +     else:
51:         # Compute the scale factor
52:         scale = mass / 4.5e4
53:     # (pretend this is a biologically complex calculation)
54: +     scale = mass / 4.5e4
55: ? +++++
```

Replace the send with a call

```
In [6]: tools.display_source_diff('models/shoot_v1.py', 'models/shoot_v2.py', number_lines=True)
```

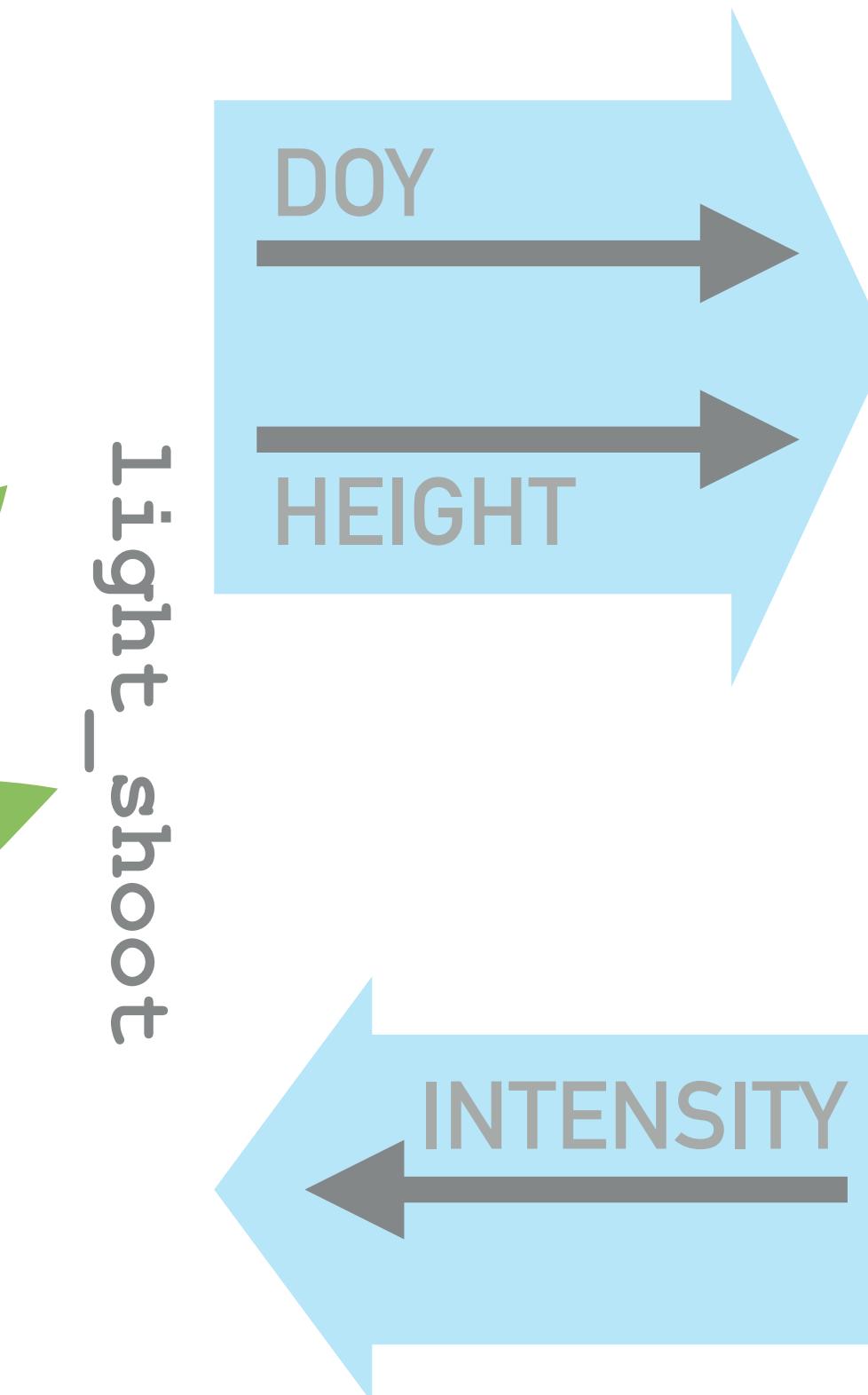
```
file1: models/shoot_v1.py
file2: models/shoot_v2.py
=====
1: import os
2: import trimesh
3: import argparse
...
28: # If the model is running as part of an yggdrasil integration, import
29: # the relevant yggdrasil routines and use the interface routine to
30: # complete the connection defined in the YAML
31: if with_yggdrasil:
32:     from yggdrasil import units
33:     from yggdrasil.languages.Python.YggInterface import YggOutput
34:     from yggdrasil.languages.Python.YggInterface import YggRpcClient
35:
36:     # Continue simulation until time limit is reached
37:     while t <= tmax:
38:
39:         # If running as part an yggdrasil integration, send the time and
40:         # maximum height of the mesh to the height channel with units
41:         if with_yggdrasil:
42:             flag = height_out.send(
43:                 flag, intensity = light_rpc.call(
44:                     [units.add_units(t, 'hrs'),
45:                      units.add_units(max(mesh.vertices[:, 2]), 'm')]))
46:
47:             # Compute the scale factor
48:             # Compute the scale factor using intensity, stripping units
49:             # of the result to allow use with trimesh
50:             # (pretend this is a biologically complex calculation)
51:             # (pretend this is a biologically complex calculation)
52:             scale = units.get_data(
53:                 units.add_units(mass, 'g') * intensity /
54:                 units.add_units(4.0e10, 'g*erg/(cm**2*s)'))
55:         else:
56:             # Compute the scale factor
57:             # (pretend this is a biologically complex calculation)
58:             scale = mass / 4.5e4
59:             scale = mass / 4.5e4
? +++++
```

Change how scale is computed when
yggdrasil used

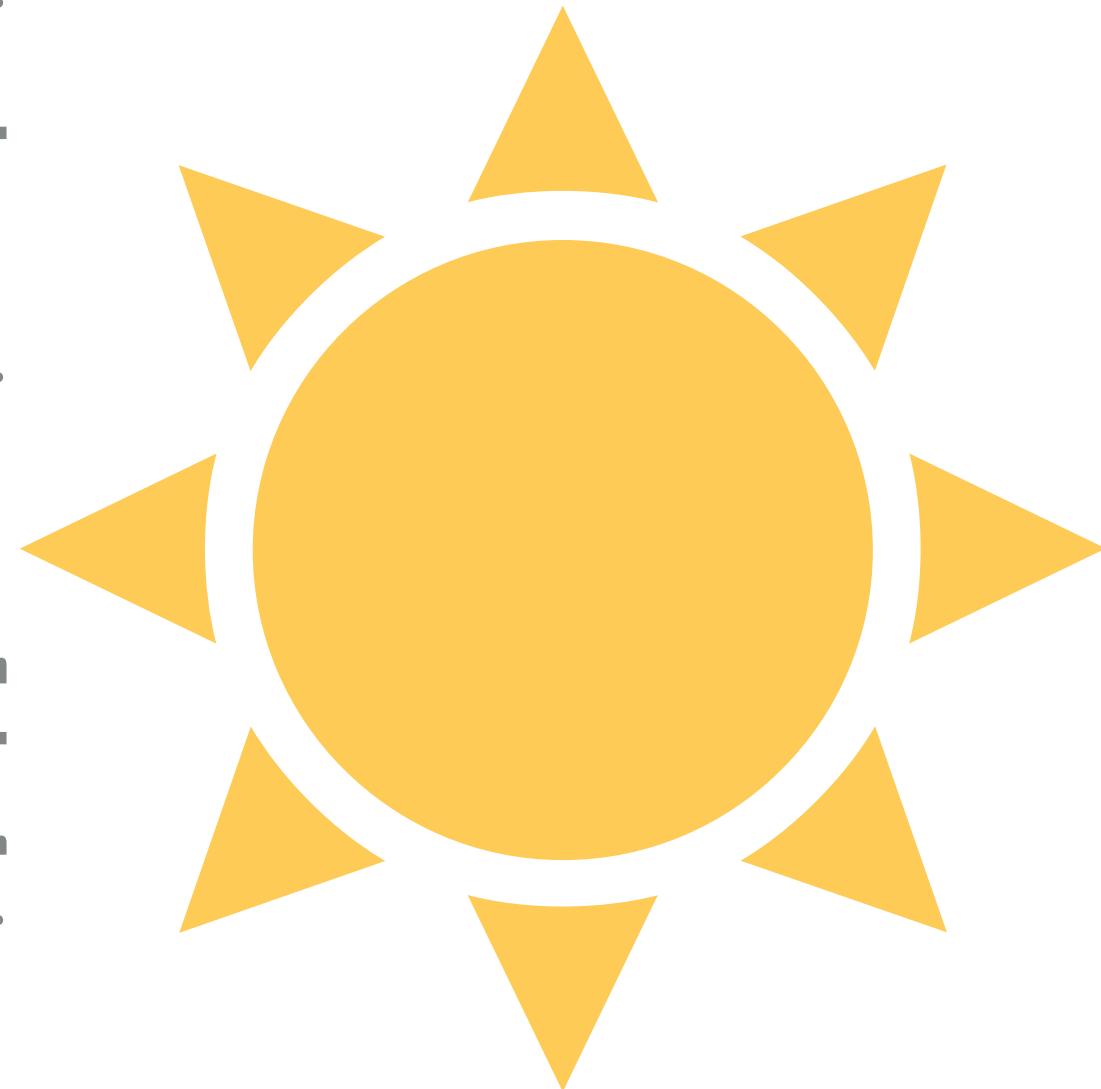
```
In [7]: tools.display_source_diff('yamls/shoot_v1.yml', 'yamls/shoot_v2.yml', number_lines=True)
tools.display_source_diff('yamls/light_v0_python.yml', 'yamls/light_v1_python.yml', number_lines=True)
```



SHOOT
MODEL



light:input
light:output

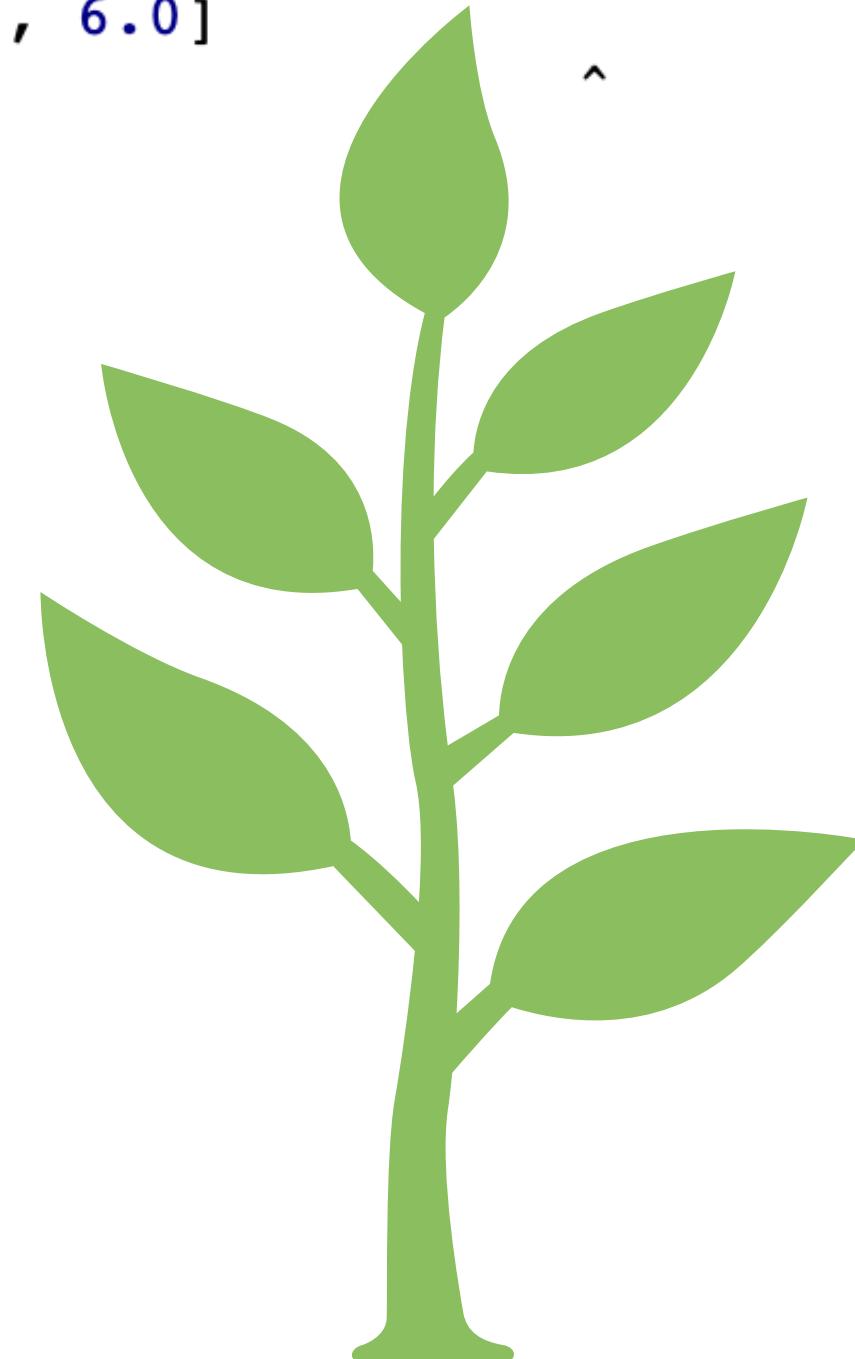


LIGHT
MODEL

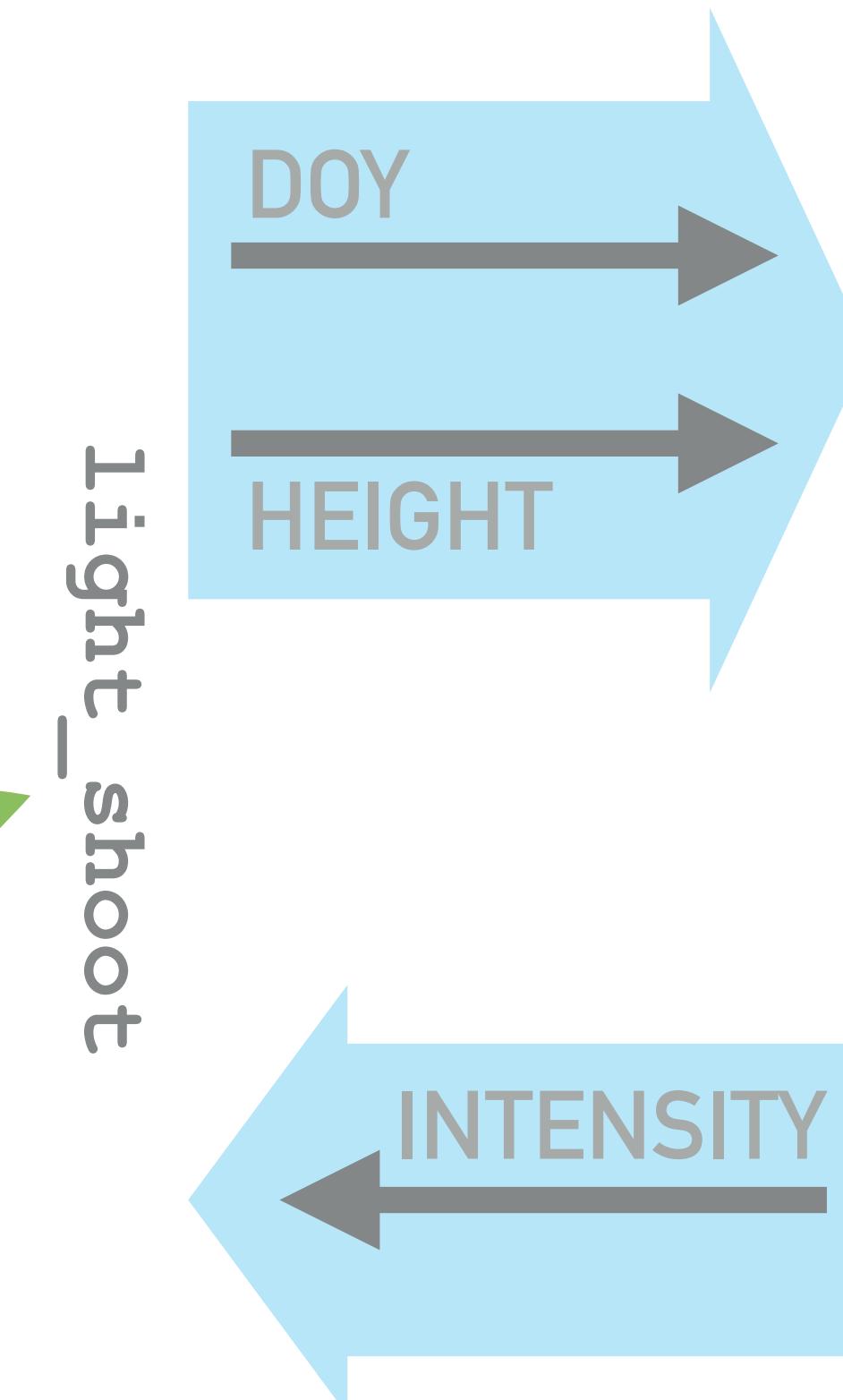
```
In [7]: tools.display_source_diff('yamls/shoot_v1.yml', 'yamls/shoot_v2.yml', number_lines=True)
tools.display_source_diff('yamls/light_v0_python.yml', 'yamls/light_v1_python.yml', number_lines=True)
```

```
file1: yamls/shoot_v1.yml
file2: yamls/shoot_v2.yml
=====
1:   model:
2:     name: shoot
3:     language: python
4:     - args: [../models/shoot_v1.py, 0.0, 48.0, 6.0]
5:     ?
6:
7: 4: +   args: [../models/shoot_v2.py, 0.0, 48.0, 6.0]
8:  ?
9:
10: -   outputs:
11: -     - name: height
12: ?   ----
13: 5: +   client_of: light
14: ?     +--+ ^^^
15:
16: -     default_file:
17: -       name: ../output/height.txt
18: -       filetype: table
19:
20: file1: yamls/light_v0_python.yml
21: file2: yamls/light_v1_python.yml
=====
```

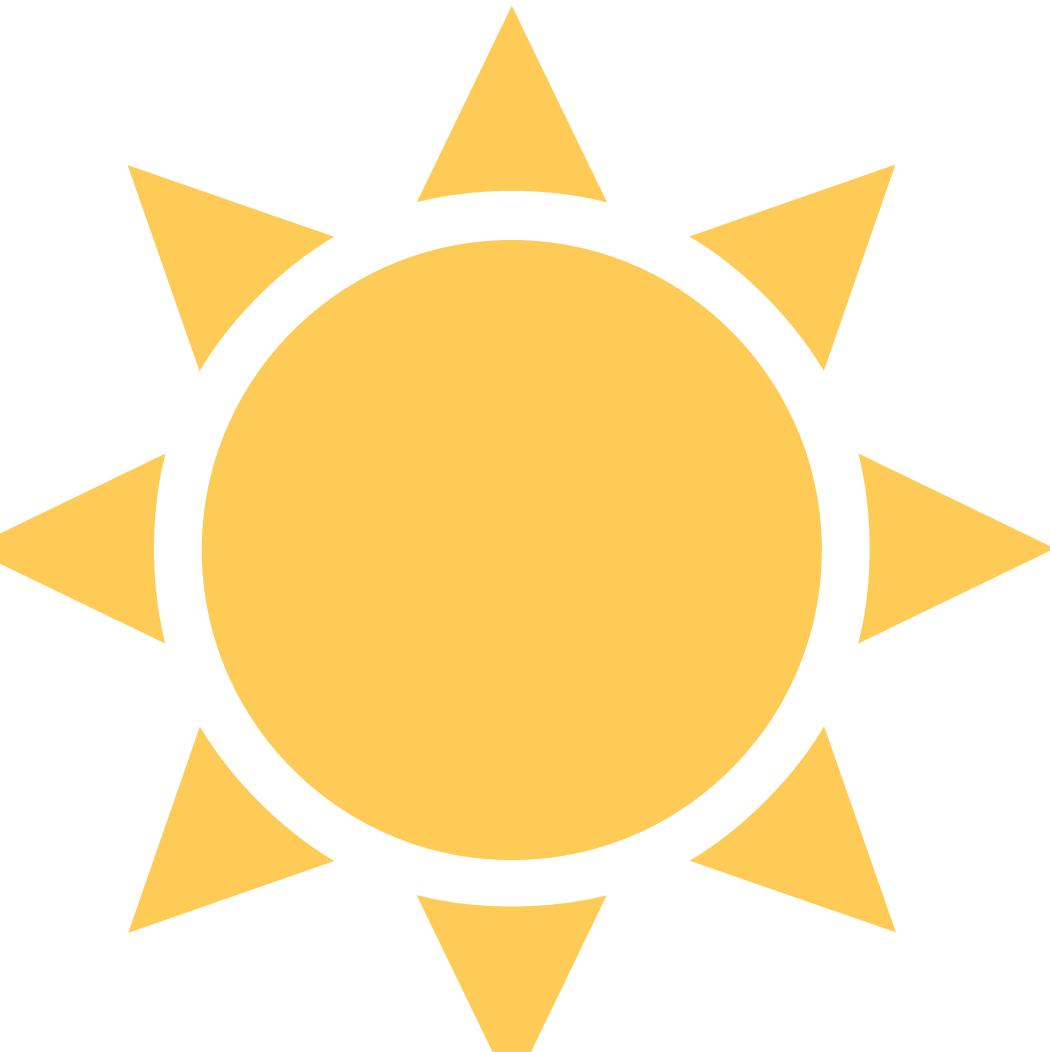
1: model:
2: name: shoot
3: language: python
4: - args: [../models/shoot_v1.py, 0.0, 48.0, 6.0]
5: ?
6:
7: 4: + args: [../models/shoot_v2.py, 0.0, 48.0, 6.0]
8: ?
9:
10: - outputs:
11: - - name: height
12: ? ----
13: 5: + client_of: light
14: ? +--+ ^^^
15:
16: - default_file:
17: - name: ../output/height.txt
18: - filetype: table
19:
20: file1: yamls/light_v0_python.yml
21: file2: yamls/light_v1_python.yml
=====



SHOOT
MODEL



light:input light:output

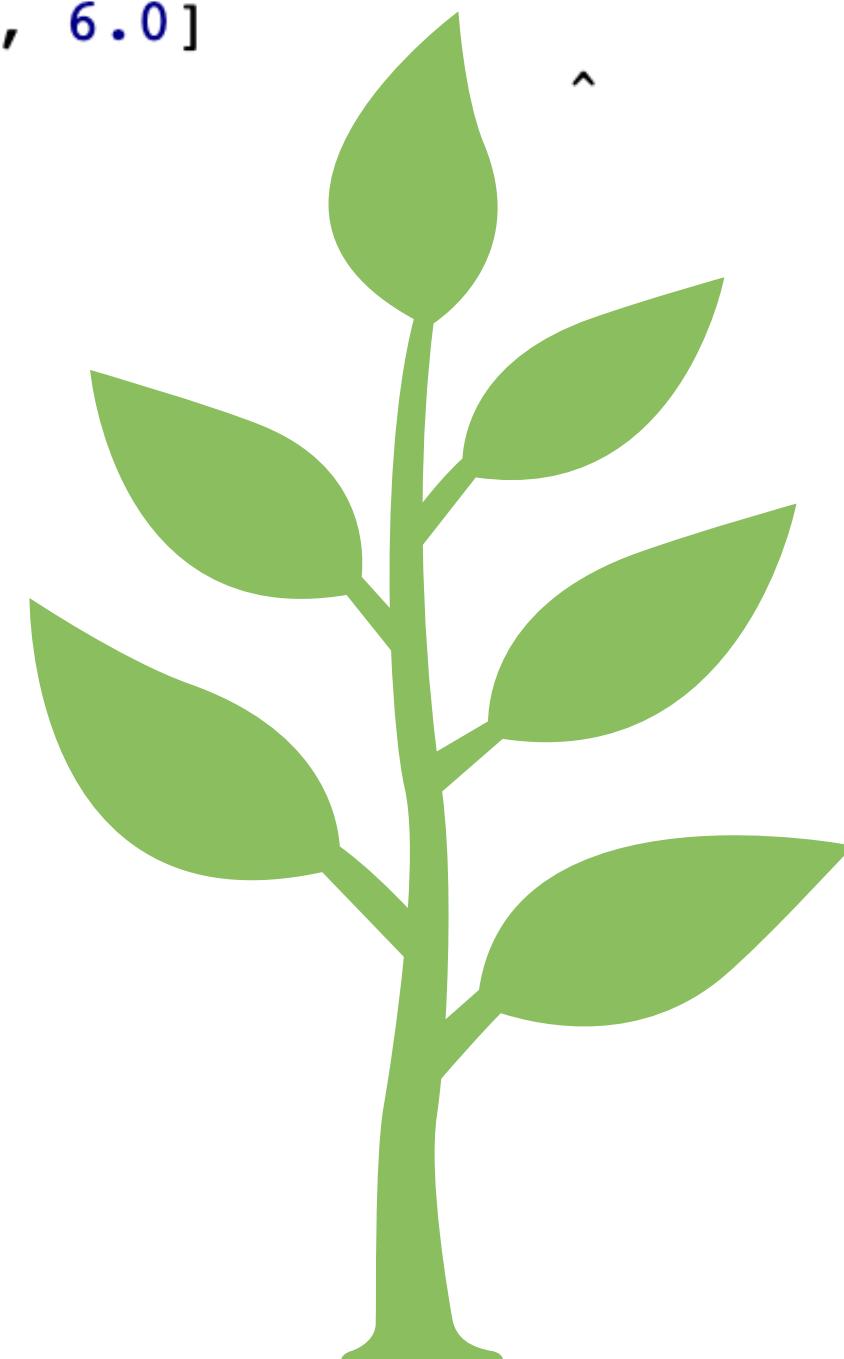


LIGHT
MODEL

```
In [7]: tools.display_source_diff('yamls/shoot_v1.yml', 'yamls/shoot_v2.yml', number_lines=True)
tools.display_source_diff('yamls/light_v0_python.yml', 'yamls/light_v1_python.yml', number_lines=True)
```

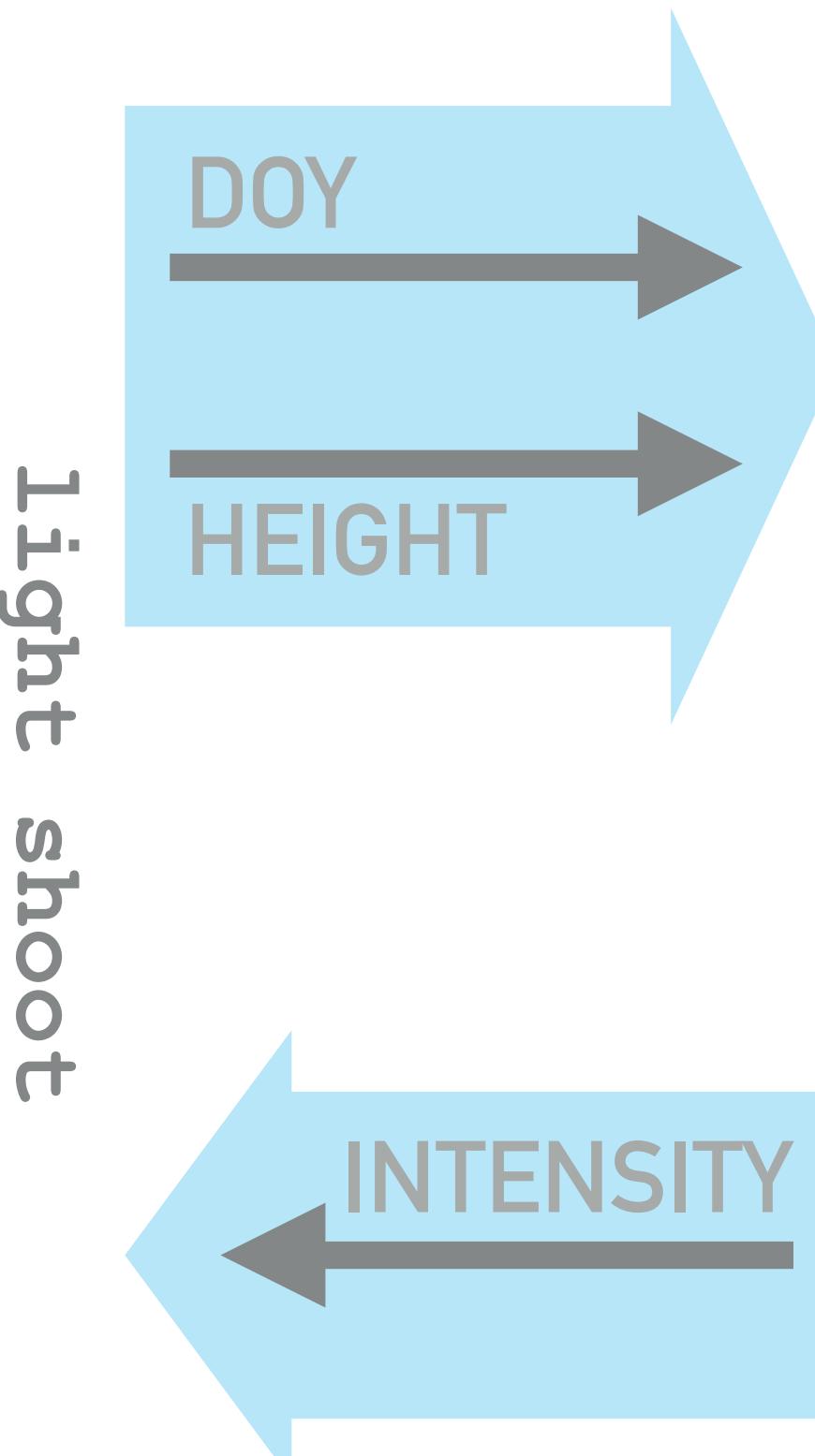
```
file1: yamls/shoot_v1.yml
file2: yamls/shoot_v2.yml
=====
1:   model:
2:     name: shoot
3:     language: python
4:     args: [../models/shoot_v1.py, 0.0, 48.0, 6.0]
5:     ?
6:
7: 4: +   args: [../models/shoot_v2.py, 0.0, 48.0, 6.0]
8:    ?
9:
10: -   outputs:
11: -     - name: height
12:    ?   ----
13: 5: +   client_of: light
14:    ?   +--+ ^^^
15:    -
16:    -   default_file:
17:    -     name: ../output/height.txt
18:    -     filetype: table
```

```
file1: yamls/light_v0_python.yml
file2: yamls/light_v1_python.yml
=====
1:   model:
2:     name: light
3:     language: python
4:     args: ../models/light_v0.py
5:     function: light
6: +   is_server: true
```



SHOOT
MODEL

Remove output & add "client_of" to
shoot model



light_shoot

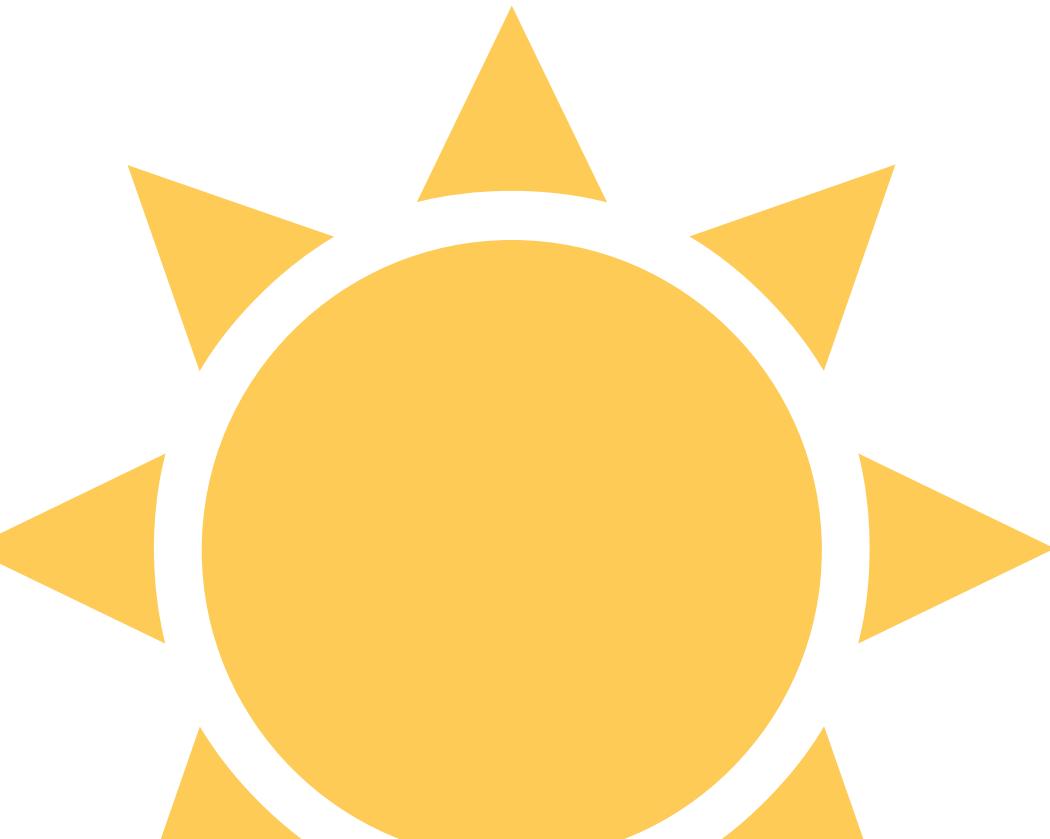
DOY

HEIGHT

INTENSITY

light:input

light:output

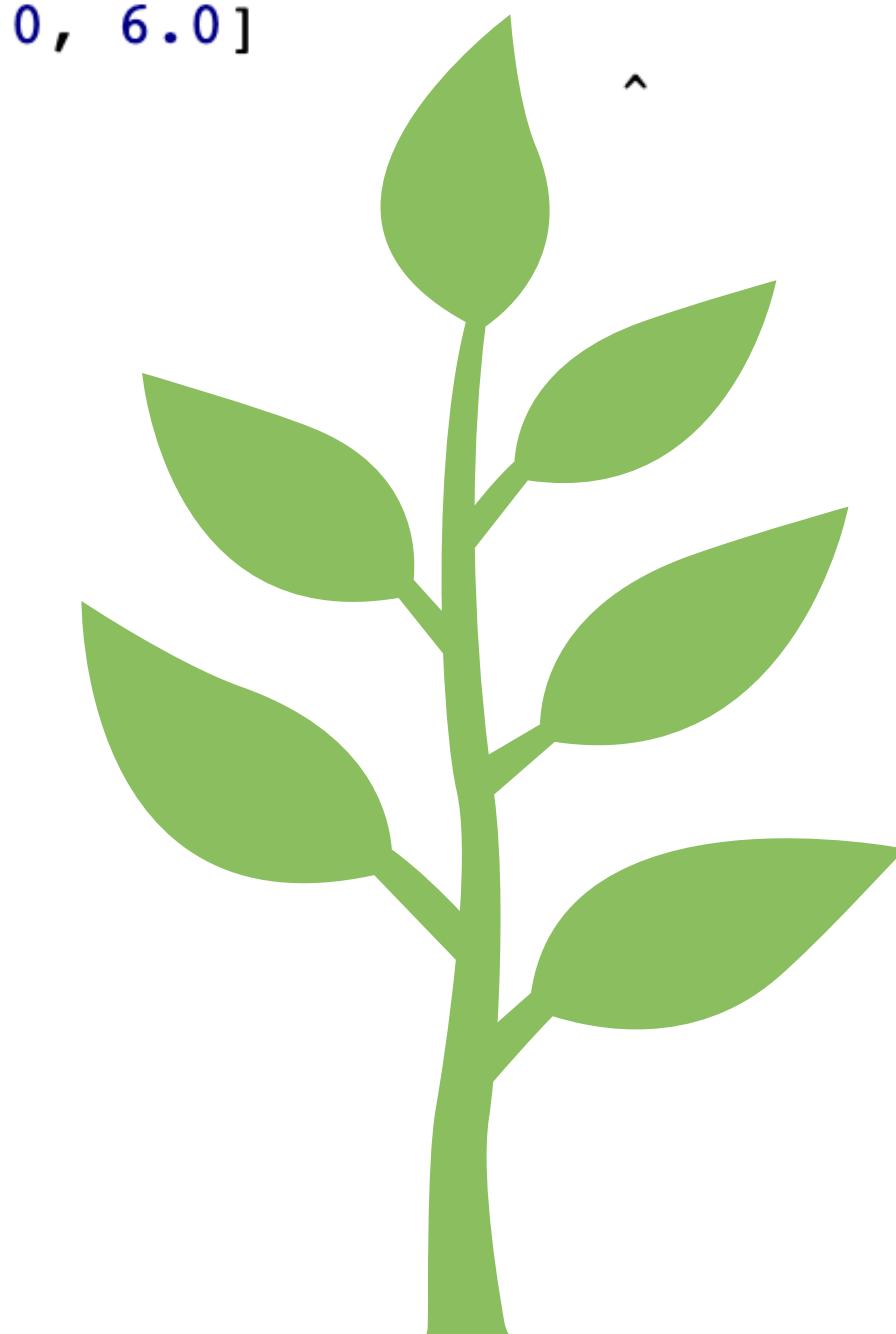


LIGHT
MODEL

```
In [7]: tools.display_source_diff('yamls/shoot_v1.yml', 'yamls/shoot_v2.yml', number_lines=True)
tools.display_source_diff('yamls/light_v0_python.yml', 'yamls/light_v1_python.yml', number_lines=True)
```

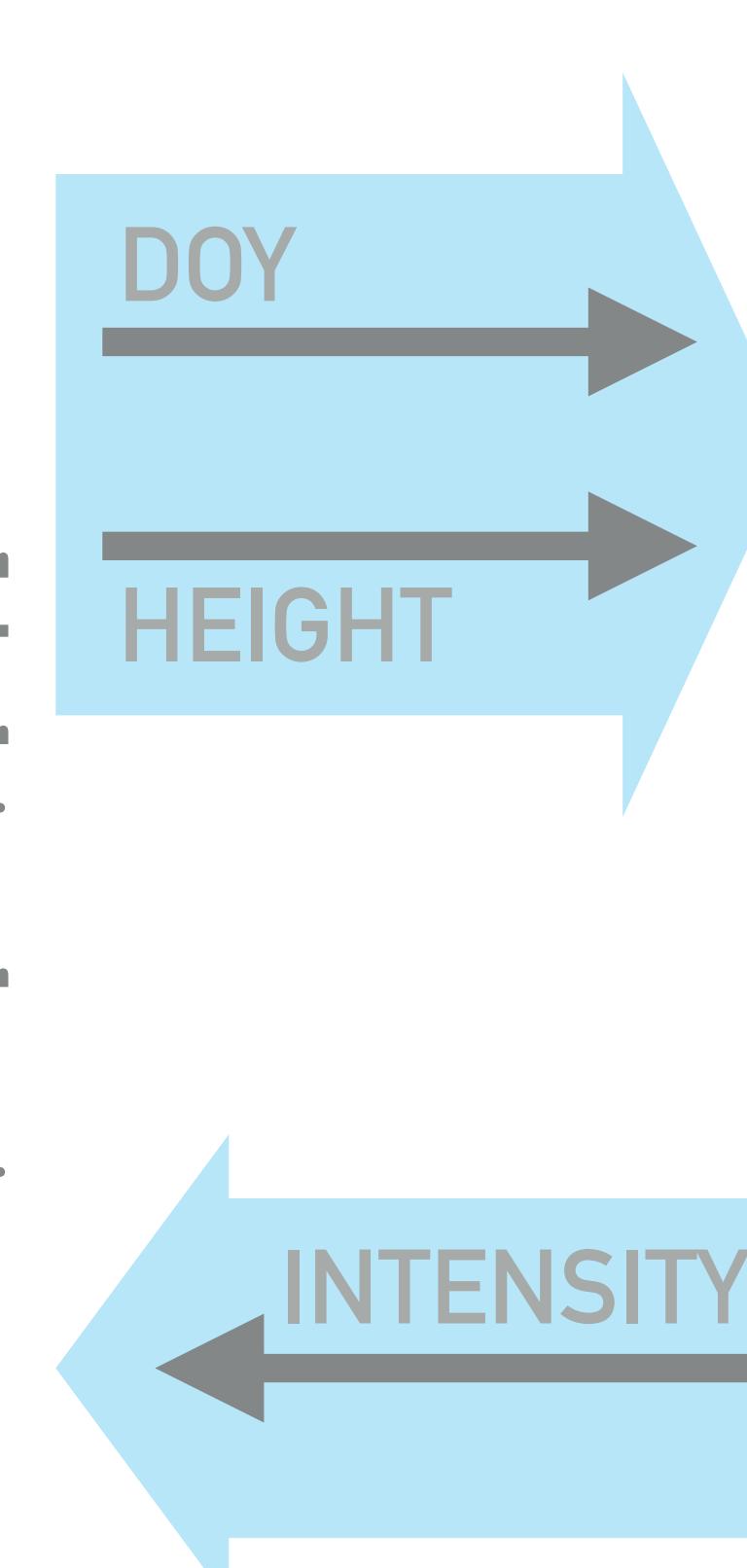
```
file1: yamls/shoot_v1.yml
file2: yamls/shoot_v2.yml
=====
1:   model:
2:     name: shoot
3:     language: python
4:     args: [../models/shoot_v1.py, 0.0, 48.0, 6.0]
5:     ?
6:
7:     +
8:       args: [../models/shoot_v2.py, 0.0, 48.0, 6.0]
9:       ?
10:
11:      -
12:        outputs:
13:          - name: height
14:          ?
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```

Add "is_server" to light model



SHOOT
MODEL

light_shoot



light:input light:output



LIGHT
MODEL

```
In [8]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2.yml'], production_run=True)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.show()
```

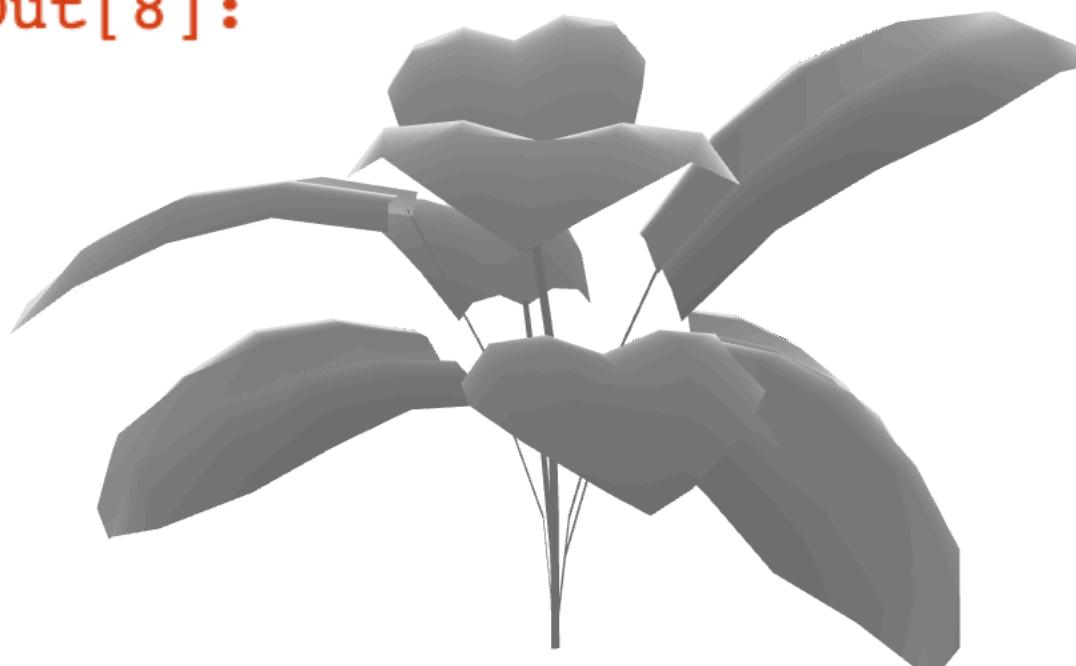
```
In [8]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2.yml'], production_run=True)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.show()
```

```
INFO:93696:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/ygg
_light_v0.py
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/sho
ot_v2.py 0.0 48.0 6.0
End of input from temp_doy.
INFO:93696:runner.waitModels[553]:YggRunner(runner): light finished running.
INFO:93696:runner.waitModels[559]:YggRunner(runner): light finished exiting.
INFO:93696:runner.waitModels[553]:YggRunner(runner): shoot finished running.
INFO:93696:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.
INFO:93696:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:93696:runner.run[374]:YggRunner(runner):
                           init      0.000001
INFO:93696:runner.run[374]:YggRunner(runner):
                           load drivers   0.010089
INFO:93696:runner.run[374]:YggRunner(runner):
                           start drivers  0.090419
INFO:93696:runner.run[374]:YggRunner(runner):
                           run models    7.769536
INFO:93696:runner.run[374]:YggRunner(runner):
                           at exit       0.044337
INFO:93696:runner.run[376]:YggRunner(runner): =====
INFO:93696:runner.run[377]:YggRunner(runner):
                           Total      7.914382
```

```
In [8]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2.yml'], production_run=True)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.show()
```

```
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/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/sho
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INFO:93696:runner.run[374]:YggRunner(runner):
                           init      0.000001
INFO:93696:runner.run[374]:YggRunner(runner):
                           load drivers   0.010089
INFO:93696:runner.run[374]:YggRunner(runner):
                           start drivers  0.090419
INFO:93696:runner.run[374]:YggRunner(runner):
                           run models    7.769536
INFO:93696:runner.run[374]:YggRunner(runner):
                           at exit       0.044337
INFO:93696:runner.run[376]:YggRunner(runner): =====
INFO:93696:runner.run[377]:YggRunner(runner):           Total      7.914382
```

Out[8]:



SPLITTING RPC CALLS

```
In [9]: tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v2_split.py', number_lines=True)
```

```
In [9]: tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v2_split.py', number_lines=True)
```

```
file1: models/shoot_v2.py
file2: models/shoot_v2_split.py
=====
...
39:     # If running as part an yggdrasil integration, send the time and
40:     # maximum height of the mesh to the height channel with units
41:     if with_yggdrasil:
42:         # Send request to the light model
43:         flag, intensity = light_rpc.call(
44:             [units.add_units(t, 'hrs'),
45:              units.add_units(max(mesh.vertices[:, 2]), 'm')])
46:     if not flag:
47:         raise Exception("Error calling the light model.")
48:     raise Exception("Error sending request to the light model.")
+
49:     # Calculations that don't rely on the output from the light model
50:     # can be run here in parallel with the light model calculations
51:
52:     # Receive response from the light model
53:     flag, intensity = light_rpc.recv()
54:     if not flag:
55:         raise Exception("Error receiving response from the light model.")

...
```

```
In [9]: tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v2_split.py', number_lines=True)
```

```
file1: models/shoot_v2.py
file2: models/shoot_v2_split.py
=====
...
39:     # If running as part an yggdrasil integration, send the time and
40:     # maximum height of the mesh to the height channel with units
41:     if with_yggdrasil:
42:         # Send request to the light model
43:         flag, intensity = light_rpc.call(
44:             [units.add_units(t, 'hrs'),
45:              units.add_units(max(mesh.vertices[:, 2]), 'm')])
46:         if not flag:
47:             raise Exception("Error calling the light model.")
48:         ...
49:     # Calculations that don't rely on the output from the light model
50:     # can be run here in parallel with the light model calculations
51:     ...
52:     # Receive response from the light model
53:     flag, intensity = light_rpc.recv()
54:     if not flag:
55:         raise Exception("Error receiving response from the light model.")

...

```

Calls can be split into
send & recv to enhance
parallelism

```
In [10]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2_split.yml'], production_run=True)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.show()
```

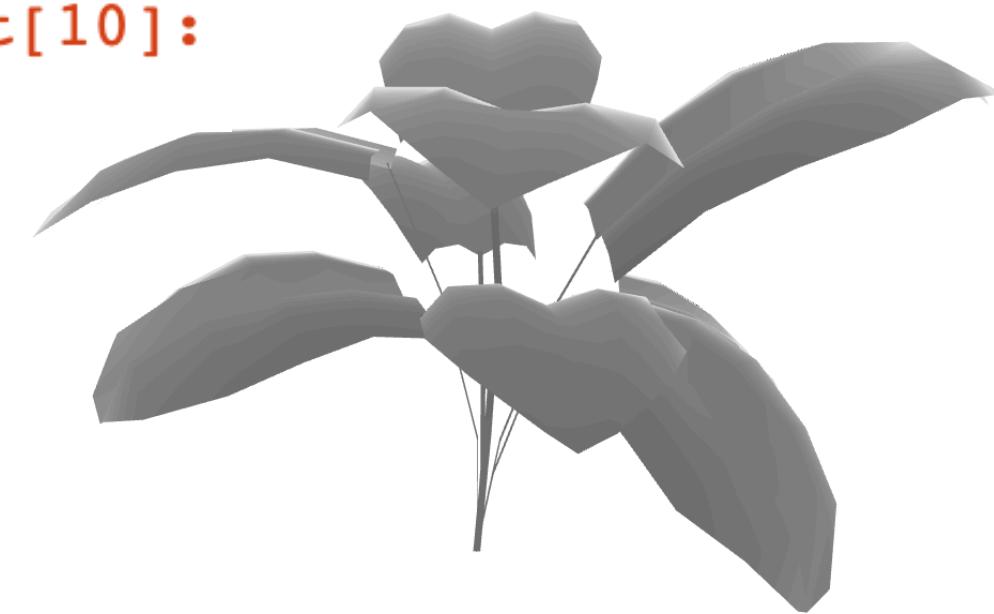
```
In [10]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2_split.yml'], production_run=True)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.show()
```

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INFO:93696:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg
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/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/sho
ot_v2_split.py 0.0 48.0 6.0
End of input from temp_doy.
INFO:93696:runner.waitModels[553]:YggRunner(runner): light finished running.
INFO:93696:runner.waitModels[559]:YggRunner(runner): light finished exiting.
INFO:93696:runner.waitModels[553]:YggRunner(runner): shoot finished running.
INFO:93696:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.
INFO:93696:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:93696:runner.run[374]:YggRunner(runner):
                           init      0.000001
INFO:93696:runner.run[374]:YggRunner(runner):
                           load drivers   0.009048
INFO:93696:runner.run[374]:YggRunner(runner):
                           start drivers  0.087974
INFO:93696:runner.run[374]:YggRunner(runner):
                           run models    7.865753
INFO:93696:runner.run[374]:YggRunner(runner):
                           at exit       0.044422
INFO:93696:runner.run[376]:YggRunner(runner): =====
INFO:93696:runner.run[377]:YggRunner(runner):
                           Total      8.007198
```

```
In [10]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2_split.yml'], production_run=True)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.show()
```

```
INFO:93696:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg
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/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/sho
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End of input from temp_doy.
INFO:93696:runner.waitModels[553]:YggRunner(runner): light finished running.
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INFO:93696:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.
INFO:93696:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:93696:runner.run[374]:YggRunner(runner):
                           init      0.000001
INFO:93696:runner.run[374]:YggRunner(runner):
                           load drivers   0.009048
INFO:93696:runner.run[374]:YggRunner(runner):
                           start drivers  0.087974
INFO:93696:runner.run[374]:YggRunner(runner):
                           run models    7.865753
INFO:93696:runner.run[374]:YggRunner(runner):
                           at exit       0.044422
INFO:93696:runner.run[376]:YggRunner(runner): =====
INFO:93696:runner.run[377]:YggRunner(runner):
                           Total      8.007198
```

Out[10]:



**TEST YOUR
KNOWLEDGE (10 MIN)**

DUPPLICATING MODELS

```
In [11]: tools.display_source_diff('models/shoot_v2_split.py', 'models/shoot_v2_copies.py', number_lines=True)
```

...

```
In [11]: tools.display_source_diff('models/shoot_v2_split.py', 'models/shoot_v2_copies.py', number_lines=True)
```

```
file1: models/shoot_v2_split.py
file2: models/shoot_v2_copies.py
=====
...
41:     # If running as part an yggdrasil integration, send the time and
42:     # maximum height of the mesh to the height channel with units
43:     if with_yggdrasil:
44:         -           # Send request to the light model
44:         +           # Send requests to the light model for each mesh vertex
44:         ?
45:         +           +
45:         for v in mesh.vertices[:, 2]:
46:             -           flag = light_rpc.send(
46:             +           flag = light_rpc.send(
46:             ? ++++
47:             -           [units.add_units(t, 'hrs'),
47:             +           [units.add_units(t, 'hrs'),
47:             ? ++++
48:             -           units.add_units(max(mesh.vertices[:, 2]), 'm'))
48:             +           units.add_units(v, 'm'))
48:             -           if not flag:
49:             +           if not flag:
49:             ? ++++
...

```

```
In [11]: tools.display_source_diff('models/shoot_v2_split.py', 'models/shoot_v2_copies.py', number_lines=True)
```

```
file1: models/shoot_v2_split.py
file2: models/shoot_v2_copies.py
=====
...
41:     # If running as part an yggdrasil integration, send the time and
42:     # maximum height of the mesh to the height channel with units
43:     if with_yggdrasil:
44:         -           # Send request to the light model
44: +           # Send requests to the light model for each mesh vertex
44: ?
45: +           for v in mesh.vertices[:, 2]:
45: -
46: +               flag = light_rpc.send(
46: ?       +++)
46: -
47: +                   [units.add_units(t, 'hrs'),
47: ?       +++)
47: -
48: +                   units.add_units(max(mesh.vertices[:, 2]), 'm'))
48: +                   units.add_units(v, 'm'))
48: -
49: +               if not flag:
49: +                   if not flag:
49: ?       +++
49: ...

```

Send heights for each vertex to the light model


```
In [11]: tools.display_source_diff('models/shoot_v2_split.py', 'models/shoot_v2_copies.py', number_lines=True)
```

```
file1: models/shoot_v2_split.py
file2: models/shoot_v2_copies.py
=====
...
56: +         nvert = mesh.vertices.shape[0]
57: +         intensity = np.zeros(nvert, 'f8')
58: +         for iv in range(nvert):
59: -             flag, intensity = light_rpc.recv()
59: +             flag, v_intensity = light_rpc.recv()
      ? ++++
      ? ++++
      -         if not flag:
60: +             if not flag:
      ? ++++
      -             raise Exception("Error receiving response from the light model.")
61: +             raise Exception("Error receiving response from the light model.")
      ? ++++
      ? ++++
      -         if not units.has_units(intensity):
62: +             intensity = units.add_units(intensity,
63: +                                         units.get_units(v_intensity))
64: +             intensity[iv] = v_intensity
65: +             filename_light = os.path.join(_dir, f'../output/light_{i:03d}.pkl')
66: +             with open(filename_light, 'wb') as fd:
67: +                 pickle.dump(intensity, fd)
68: +
...

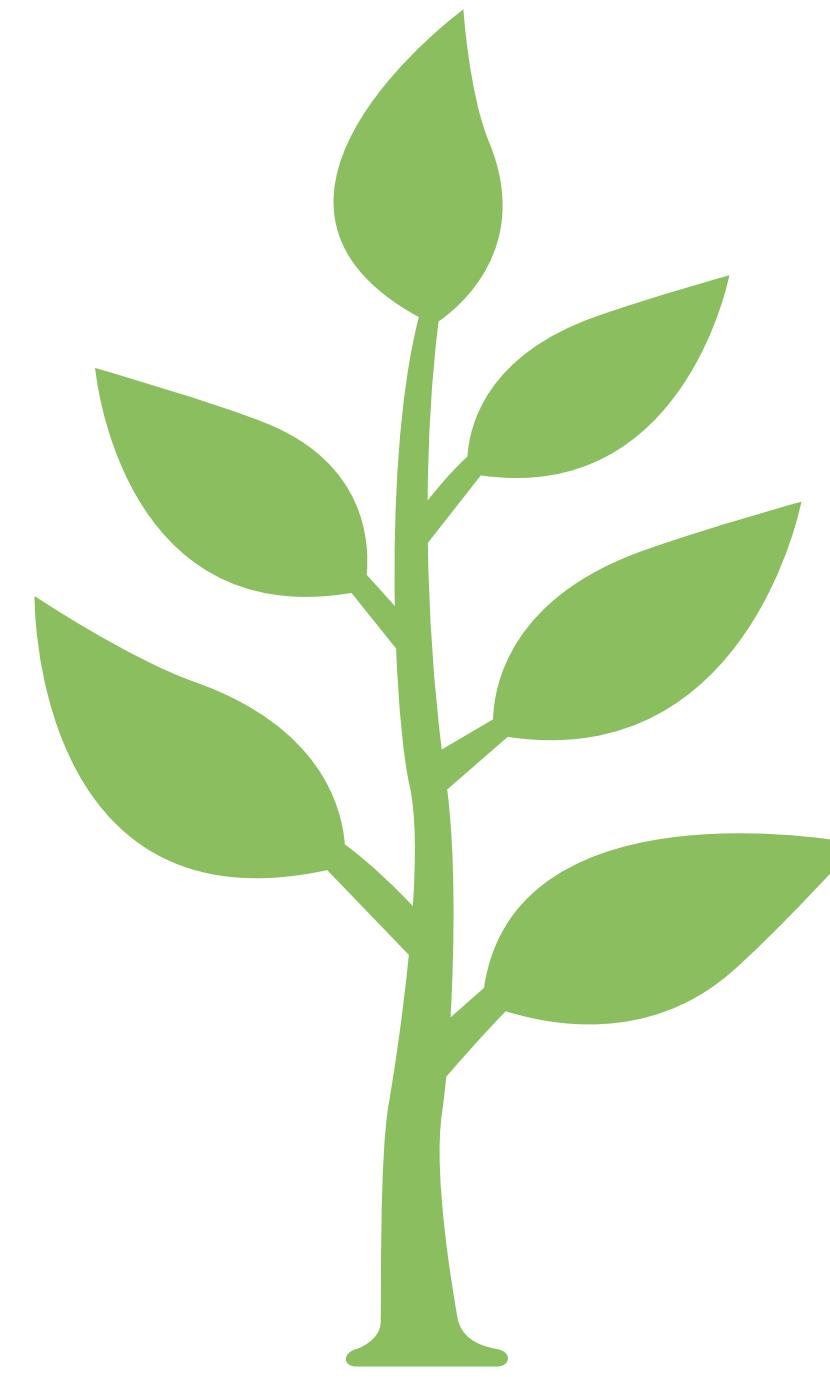
```

Receive intensities for each vertex

```
In [11]: tools.display_source_diff('models/shoot_v2_split.py', 'models/shoot_v2_copies.py', number_lines=True)
```

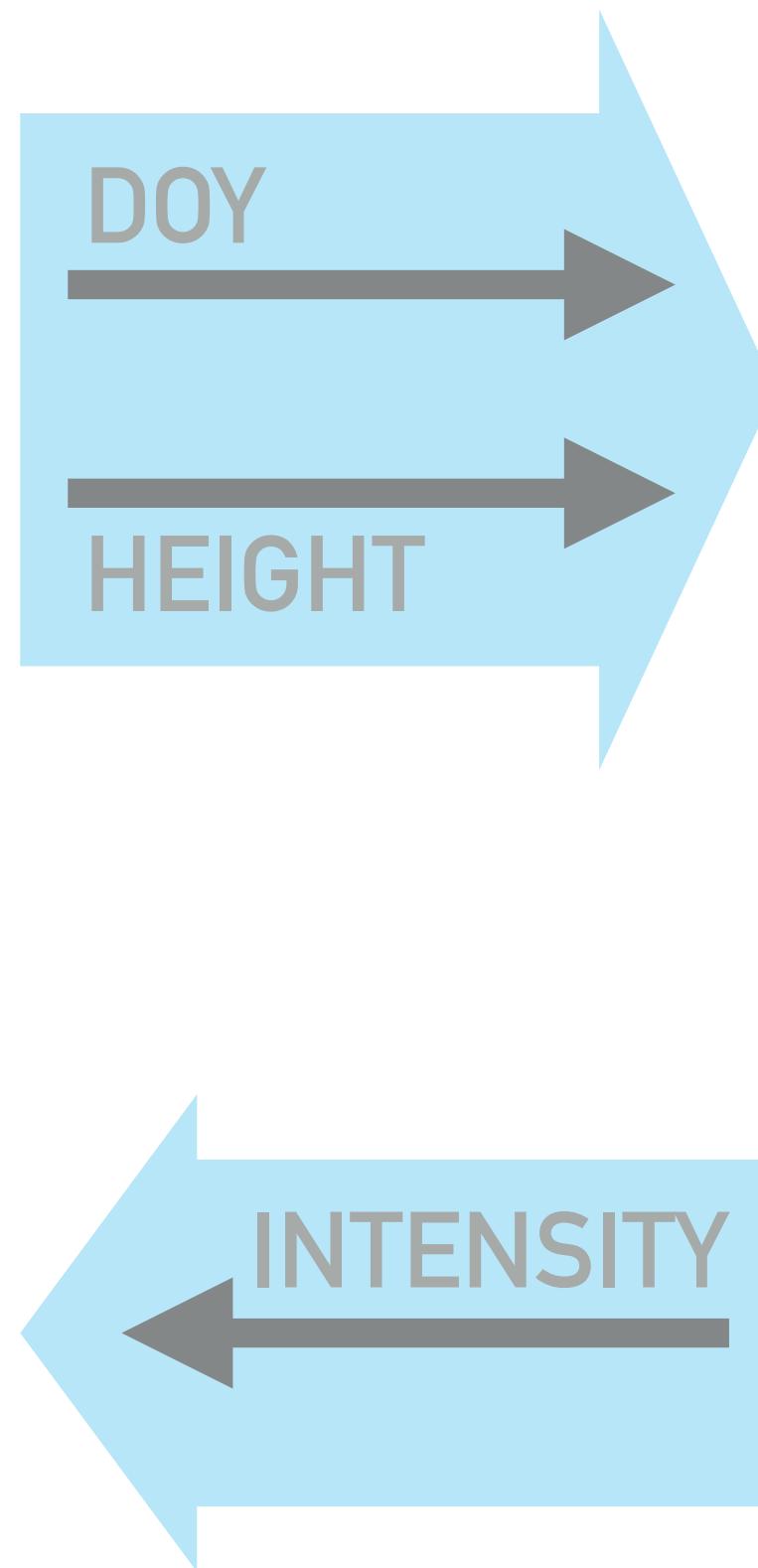
```
file1: models/shoot_v2_split.py
file2: models/shoot_v2_copies.py
=====
...
56: +         nvert = mesh.vertices.shape[0]
57: +         intensity = np.zeros(nvert, 'f8')
58: +         for iv in range(nvert):
59: -             flag, intensity = light_rpc.recv()
60: +             flag, v_intensity = light_rpc.recv()
61: ? ++++
62: -             if not flag:
63: +                 if not flag:
64: ? ++++
65: -                     raise Exception("Error receiving response from the light model.")
66: +                     raise Exception("Error receiving response from the light model.")
67: ? ++++
68: +         if not units.has_units(intensity):
69: +             intensity = units.add_units(intensity,
70: +                                         units.get_units(v_intensity))
71: +             intensity[iv] = v_intensity
72: +             filename_light = os.path.join(_dir, f'../output/light_{i:03d}.pkl')
73: +             with open(filename_light, 'wb') as fd:
74: +                 pickle.dump(intensity, fd)
```

Save intensities for each vertex to a file

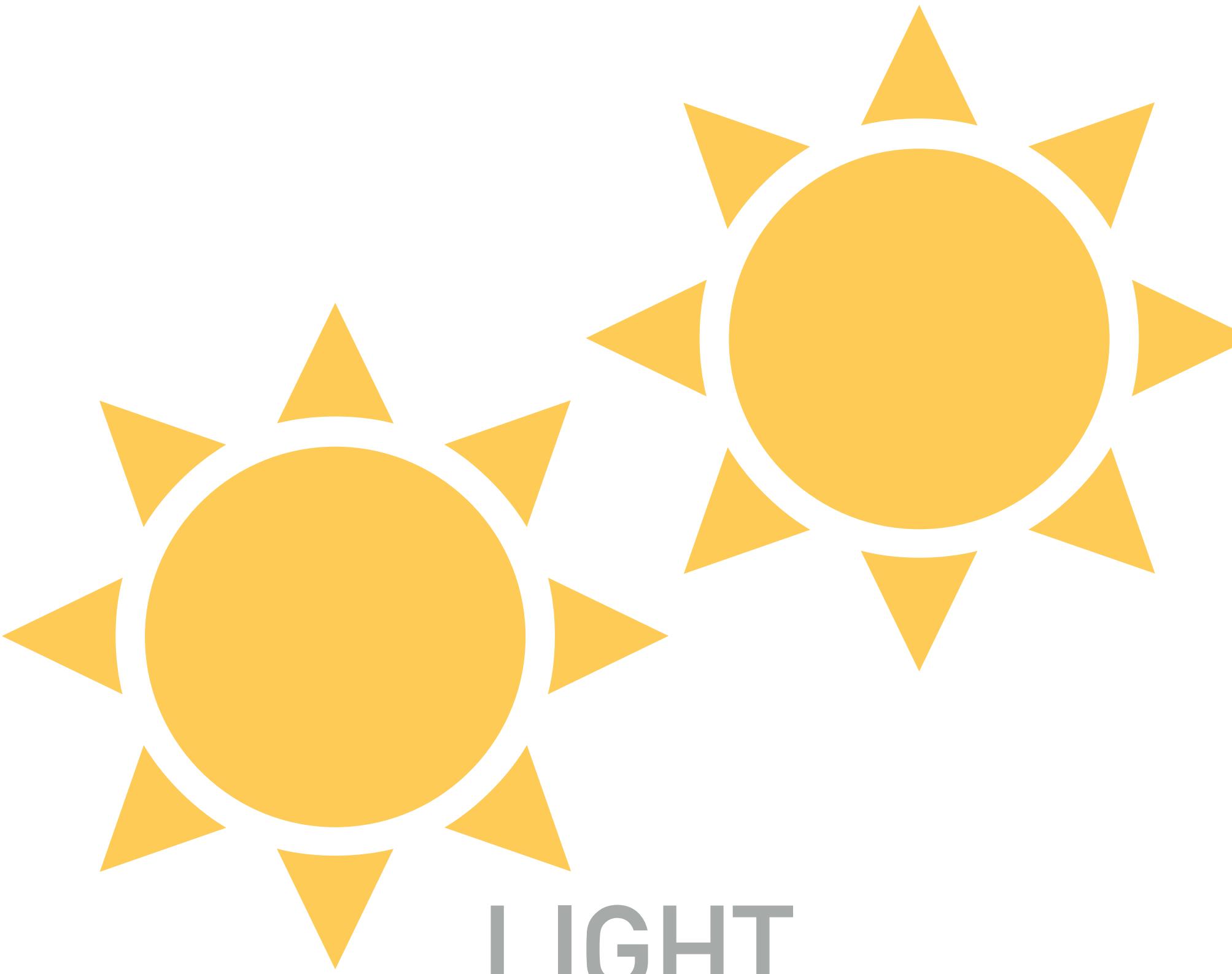


SHOOT
MODEL

light_shoot



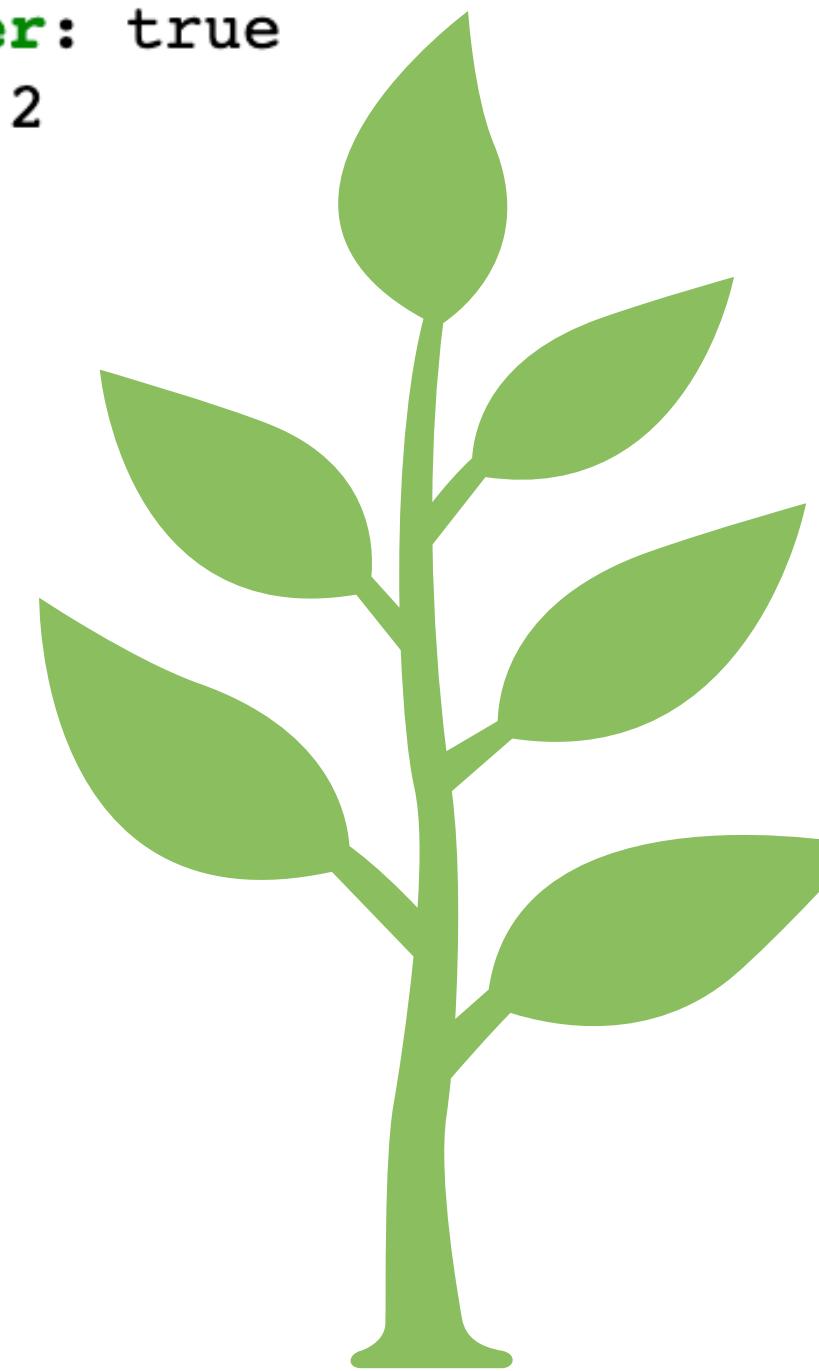
light:input



light:output

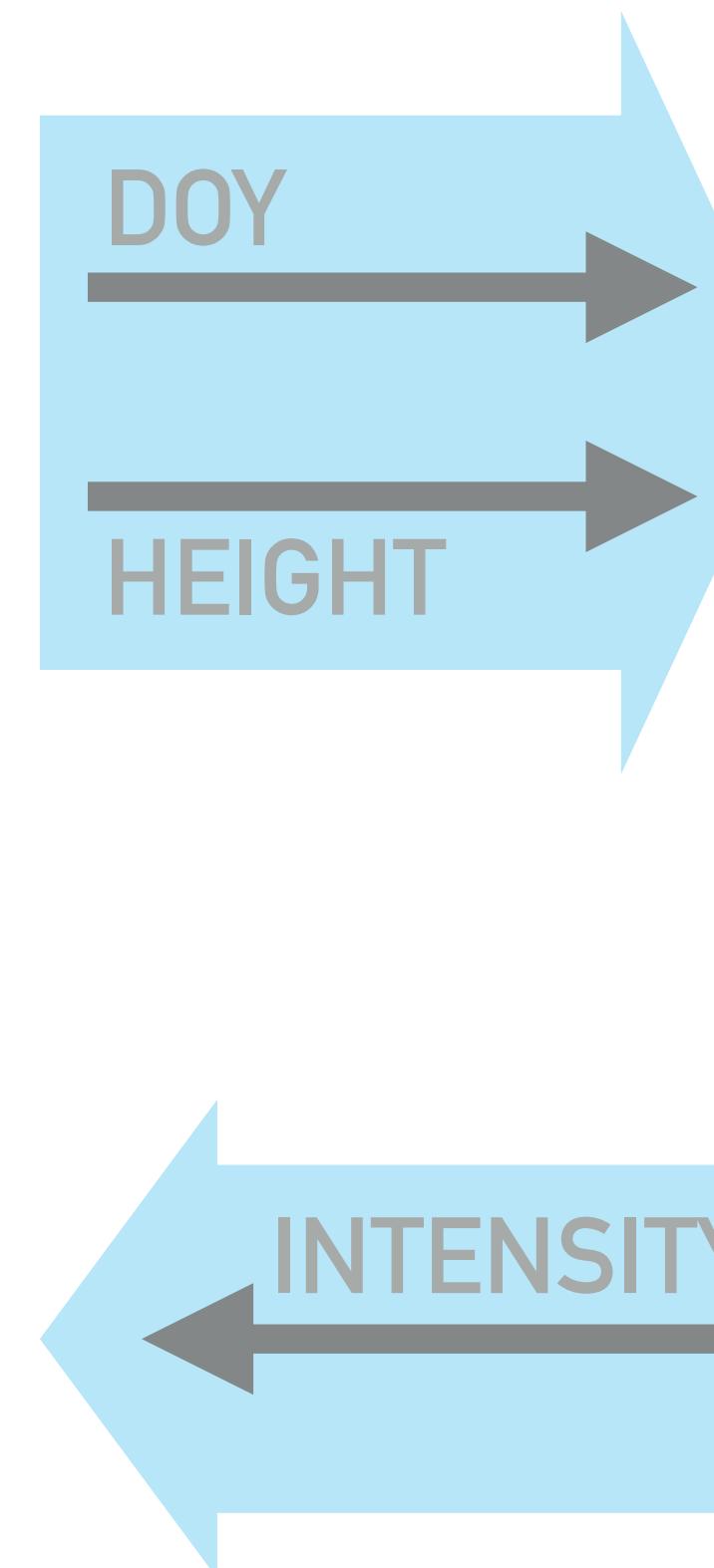
```
In [12]: tools.display_source_diff('yamls/light_v1_python.yml', 'yamls/light_v2_python.yml', number_lines=True)
```

```
file1: yamls/light_v1_python.yml
file2: yamls/light_v2_python.yml
=====
1:   model:
2:     name: light
3:     language: python
4:     args: ../models/light_v0.py
5:     function: light
6:     is_server: true
7: +   copies: 2
```

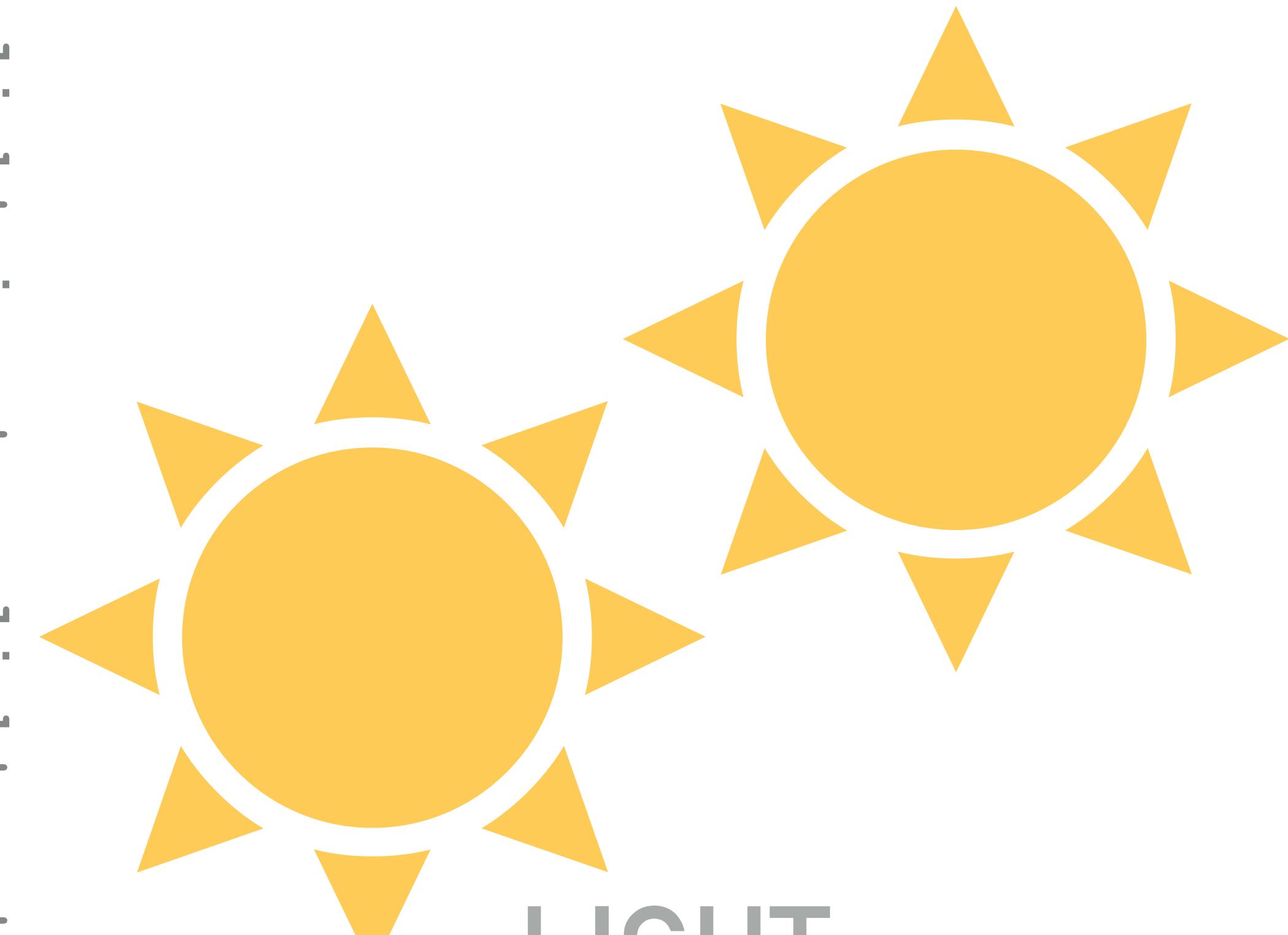


SHOOT
MODEL

light_shoot



light:input
light:output



LIGHT
MODELS

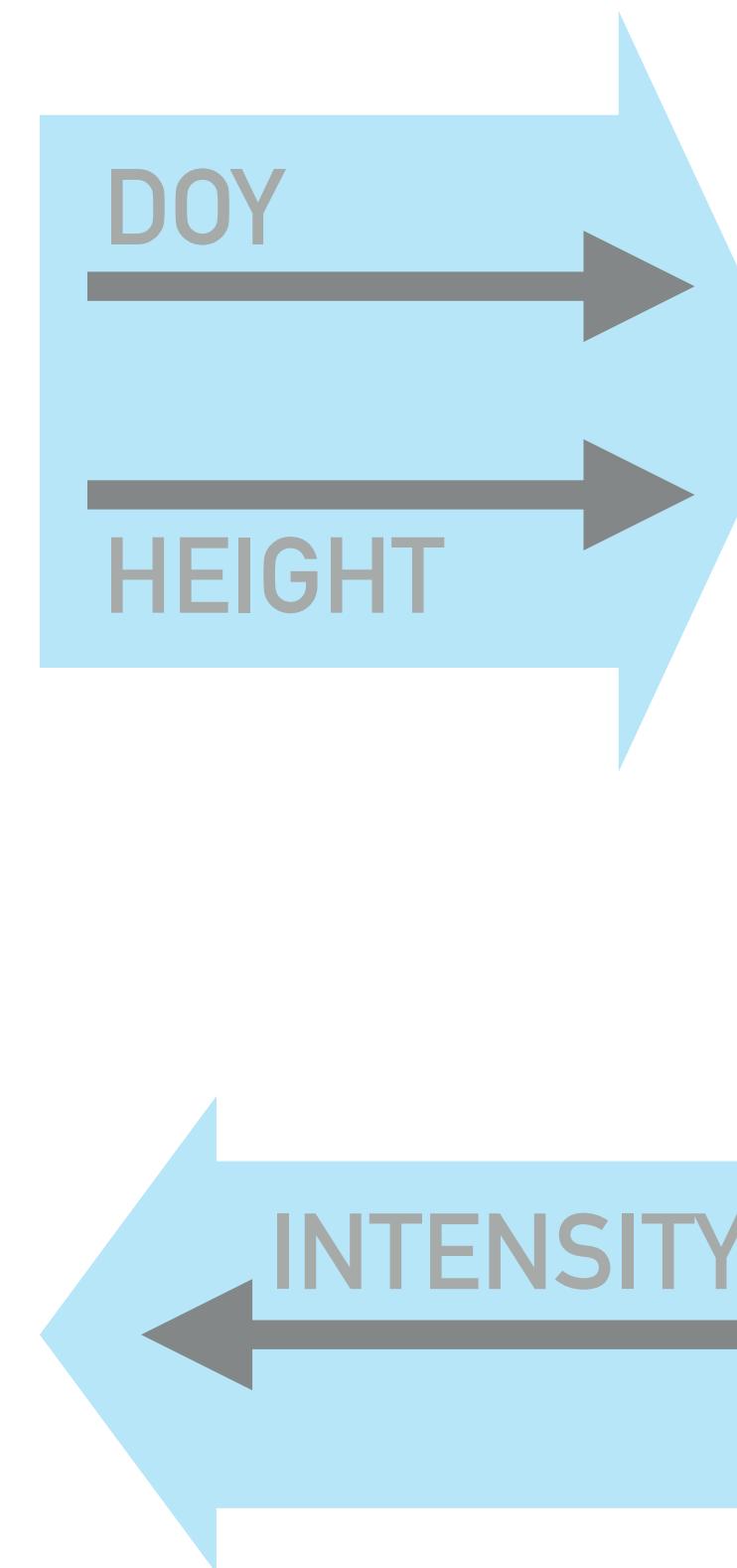
```
In [12]: tools.display_source_diff('yamls/light_v1_python.yml', 'yamls/light_v2_python.yml', number_lines=True)
```

```
file1: yamls/light_v1_python.yml
file2: yamls/light_v2_python.yml
=====
1:   model:
2:     name: light
3:     language: python
4:     args: ../models/light_v0.py
5:     function: light
6:     is_server: true
7: +   copies: 2
```

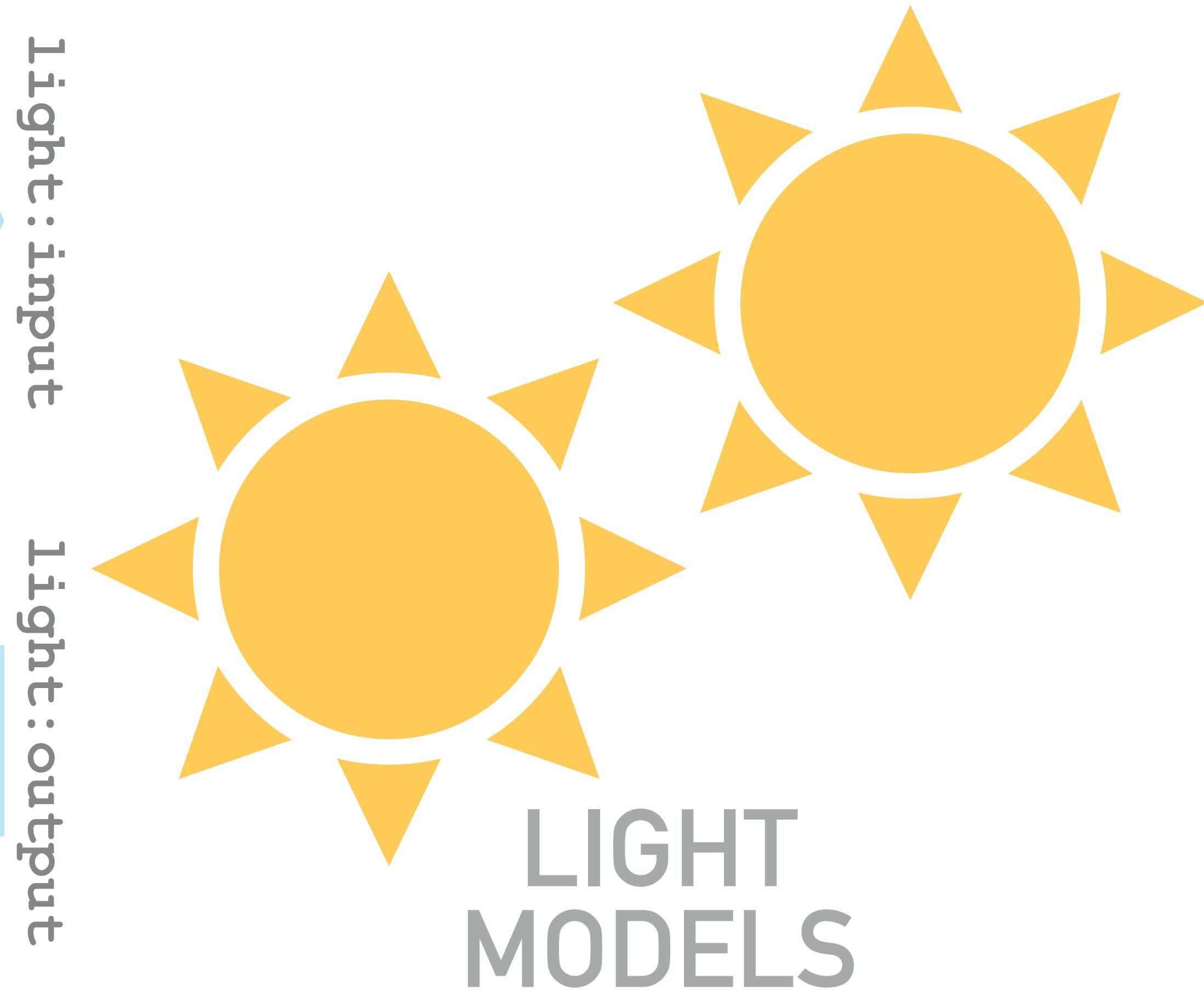


SHOOT
MODEL

light_shoot



Add “copies” to indicate multiple instances of a model should be run



LIGHT
MODELS

```
In [13]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2_copies.yml'], production_run=True)

# Plot results w/ light intensity mapped to color
import pickle
with open('output/light_008.pkl', 'rb') as fd:
    light = pickle.load(fd)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.visual.vertex_colors = trimesh.visual.interpolate(light/max(light))
mesh.show()
```

Out[13]:

```
In [13]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2_copies.yml'], production_run=True)
```

```
# Plot results w/ light intensity mapped to color
import pickle
with open('output/light_008.pkl', 'rb') as fd:
    light = pickle.load(fd)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.visual.vertex_colors = trimesh.visual.interpolate(light/max(light))
mesh.show()
```

```
INFO:93696:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg
_light_v0.py
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/sho
ot_v2_copies.py 0.0 48.0 6.0
End of input from temp_doy.
INFO:93696:runner.waitModels[553]:YggRunner(runner): light finished running.
INFO:93696:runner.waitModels[559]:YggRunner(runner): light finished exiting.
INFO:93696:runner.waitModels[553]:YggRunner(runner): shoot finished running.
INFO:93696:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.
INFO:93696:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:93696:runner.run[374]:YggRunner(runner):           init      0.000000
INFO:93696:runner.run[374]:YggRunner(runner):           load drivers  0.009468
INFO:93696:runner.run[374]:YggRunner(runner):           start drivers 0.086156
INFO:93696:runner.run[374]:YggRunner(runner):           run models   107.365030
INFO:93696:runner.run[374]:YggRunner(runner):           at exit      0.028054
INFO:93696:runner.run[376]:YggRunner(runner): =====
INFO:93696:runner.run[377]:YggRunner(runner):           Total      107.488708
```

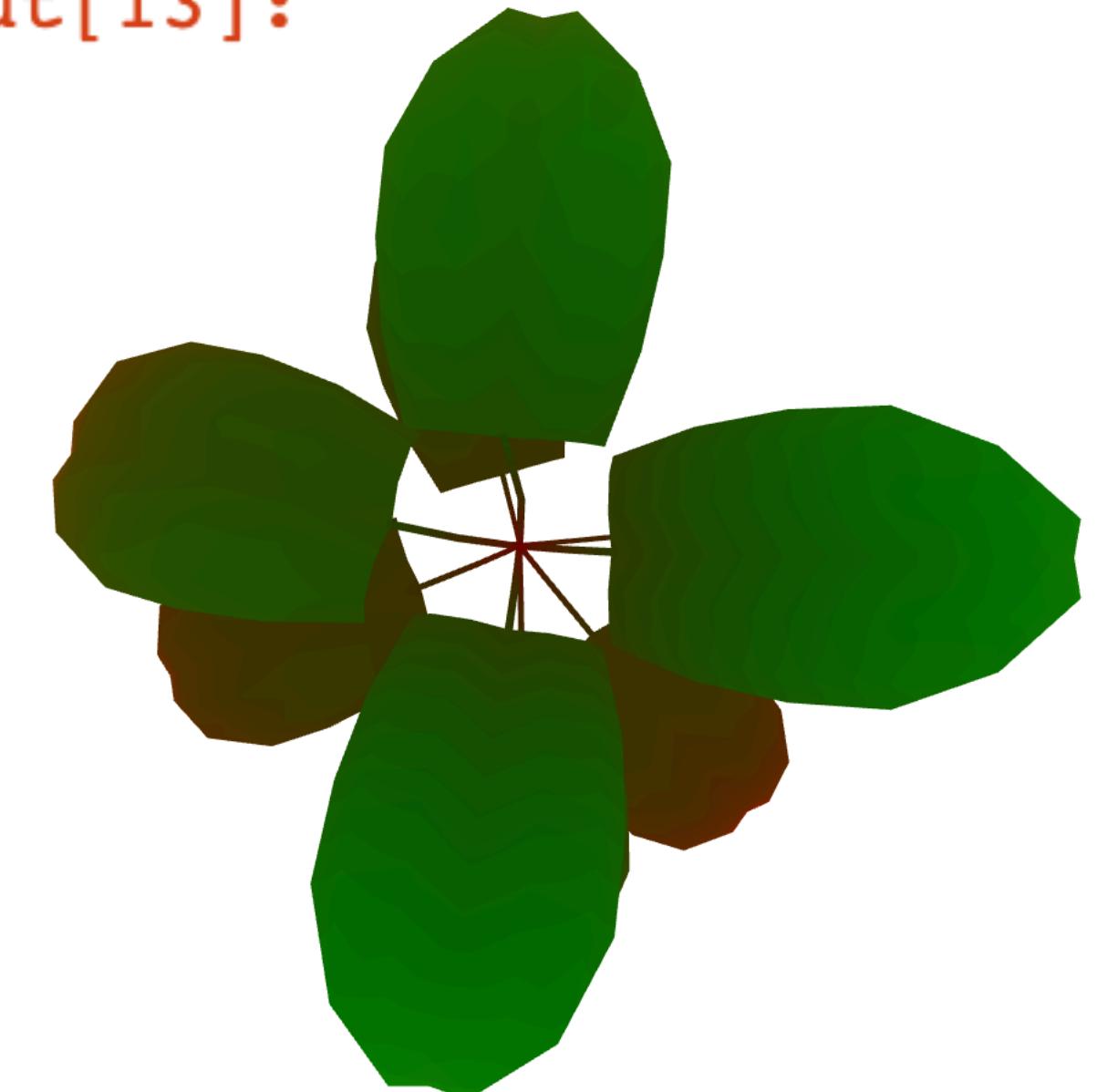
Out[13]:

```
In [13]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2_copies.yml'], production_run=True)
```

```
# Plot results w/ light intensity mapped to color
import pickle
with open('output/light_008.pkl', 'rb') as fd:
    light = pickle.load(fd)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.visual.vertex_colors = trimesh.visual.interpolate(light/max(light))
mesh.show()
```

```
INFO:93696:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg
_light_v0.py
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/sho
ot_v2_copies.py 0.0 48.0 6.0
End of input from temp_doy.
INFO:93696:runner.waitModels[553]:YggRunner(runner): light finished running.
INFO:93696:runner.waitModels[559]:YggRunner(runner): light finished exiting.
INFO:93696:runner.waitModels[553]:YggRunner(runner): shoot finished running.
INFO:93696:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.
INFO:93696:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:93696:runner.run[374]:YggRunner(runner):           init      0.000000
INFO:93696:runner.run[374]:YggRunner(runner):       load drivers   0.009468
INFO:93696:runner.run[374]:YggRunner(runner):     start drivers   0.086156
INFO:93696:runner.run[374]:YggRunner(runner):       run models  107.365030
INFO:93696:runner.run[374]:YggRunner(runner):       at exit     0.028054
INFO:93696:runner.run[376]:YggRunner(runner): =====
INFO:93696:runner.run[377]:YggRunner(runner):           Total    107.488708
```

Out[13]:

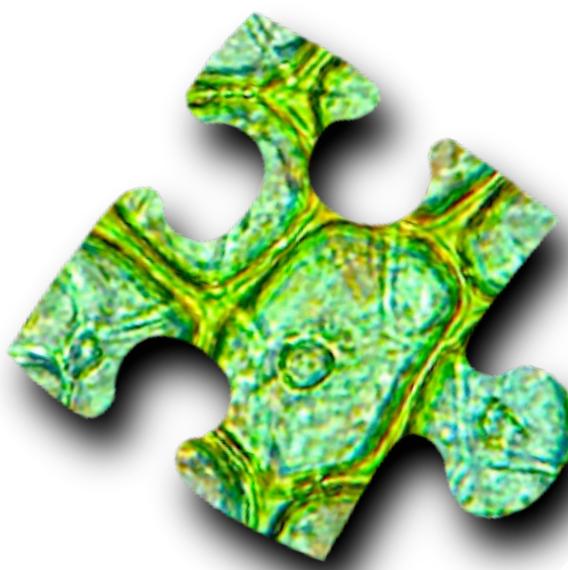
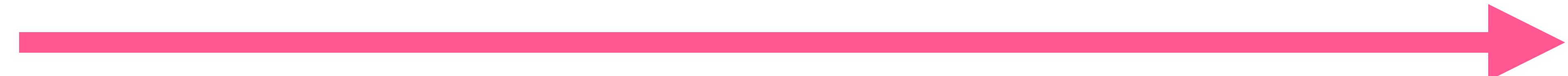


PARALLELISM ON MYBINDER

MyBinder instances only have access to 1 core (models run in serial)



MODEL A



MODEL B



PARALLELISM ON MYBINDER

MyBinder instances only have access to 1 core (models run in serial)



MODEL A



MODEL B



**TEST YOUR
KNOWLEDGE (10 MIN)**

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<input type="checkbox"/>	yaml		33 minutes ago	
<input type="checkbox"/>	00-intro.ipynb		33 minutes ago	457 kB
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<input type="checkbox"/>	02-timesync.ipynb		33 minutes ago	298 kB
<input type="checkbox"/>	03-misc.ipynb		33 minutes ago	3.56 kB

TIME STEP SYNCHRONIZATION

```
In [2]: tools.display_source('models/roots_v0.py', number_lines=True)
```

...

...

```
In [2]: tools.display_source('models/roots_v0.py', number_lines=True)
```

```
file: models/roots_v0.py
=====
1: import os
2: import argparse
3: import pickle
4:
5: _dir = os.path.dirname(os.path.realpath(__file__))
6:
7: # Parse command-line arguments
8: parser = argparse.ArgumentParser("Simulate root growth over time.")
9: parser.add_argument('tmin', help='Starting time (in days)', type=float)
10: parser.add_argument('tmax', help='Ending time (in days)', type=float)
11: parser.add_argument('tstep', help='Time step (in days)', type=float)
12: args = parser.parse_args()
13: tmin = args.tmin
14: tmax = args.tmax
15: tstep = args.tstep
16:
17: # Set initial conditions
18: mass = 0.0
19: t = tmin
20: times = []
21: masses = []
22:
23: # Continue simulation until time limit is reached
24: while t <= tmax:
25:
26:     # Compute the scale factor
27:     # (pretend this is a biologically complex calculation)
28:     scale = 0.2
29:
30:     # Calculate mass for the time step
31:     # (pretend this is a biologically complex calculation)
32:     mass += t * scale
33:
34:     # Add mass & time to array
35:     times.append(t)
36:     masses.append(mass)
37:
38:     # Advance time step
39:     t += tstep
40:
41:     # Write the total mass array to output
42:     filename_masses = os.path.join(_dir, '../output/masses.pkl')
43:     with open(filename_masses, 'wb') as fd:
44:         pickle.dump({'times': times, 'masses': masses}, fd)
...

```

```
In [3]: tools.display_source('yamls/roots_v0.yml', number_lines=True)
run(['yamls/roots_v0.yml'], production_run=True)
```

```
In [3]: tools.display_source('yamls/roots_v0.yml', number_lines=True)
run(['yamls/roots_v0.yml'], production_run=True)
```

```
file: yamls/roots_v0.yml
=====
1: model:
2:   name: roots
3:   language: python
4:   args: [./models/roots_v0.py, 0.0, 2.0, 0.5]
```

```
In [3]: tools.display_source('yamls/roots_v0.yml', number_lines=True)
run(['yamls/roots_v0.yml'], production_run=True)
```

```
file: yamls/roots_v0.yml
=====

```

```
1: model:
2:   name: roots
3:   language: python
4:   args: [./models/roots_v0.py, 0.0, 2.0, 0.5]
```

```
INFO:96257:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/roots_v0.py 0.0 2.0 0.5
INFO:96257:runner.waitModels[553]:YggRunner(runner): roots finished running.
INFO:96257:runner.waitModels[559]:YggRunner(runner): roots finished exiting.
INFO:96257:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:96257:runner.run[374]:YggRunner(runner):
                           init      0.000000
INFO:96257:runner.run[374]:YggRunner(runner):
                           load drivers    0.279398
INFO:96257:runner.run[374]:YggRunner(runner):
                           start drivers   0.039544
INFO:96257:runner.run[374]:YggRunner(runner):
                           run models     0.103028
INFO:96257:runner.run[374]:YggRunner(runner):
                           at exit        0.000614
INFO:96257:runner.run[376]:YggRunner(runner): =====
INFO:96257:runner.run[377]:YggRunner(runner):
                           Total      0.422584
```

```
In [3]: tools.display_source('yamls/roots_v0.yml', number_lines=True)
run(['yamls/roots_v0.yml'], production_run=True)
```

```
file: yamls/roots_v0.yml
=====
1: model:
2:   name: roots
3:   language: python
4:   args: [./models/roots_v0.py, 0.0, 2.0, 0.5]
```

```
INFO:96257:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/roots_v0.py 0.0 2.0 0.5
INFO:96257:runner.waitModels[553]:YggRunner(runner): roots finished running.
INFO:96257:runner.waitModels[559]:YggRunner(runner): roots finished exiting.
INFO:96257:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:96257:runner.run[374]:YggRunner(runner):           init      0.000000
INFO:96257:runner.run[374]:YggRunner(runner):       load drivers    0.279398
INFO:96257:runner.run[374]:YggRunner(runner):     start drivers    0.039544
INFO:96257:runner.run[374]:YggRunner(runner):      run models     0.103028
INFO:96257:runner.run[374]:YggRunner(runner):        at exit      0.000614
INFO:96257:runner.run[376]:YggRunner(runner): =====
INFO:96257:runner.run[377]:YggRunner(runner):           Total      0.422584
```

```
In [4]: import matplotlib.pyplot as plt
filename_masses = 'output/masses.pkl'
with open(filename_masses, 'rb') as fd:
    masses = pickle.load(fd)
plt.plot(masses['times'], masses['masses'])
```

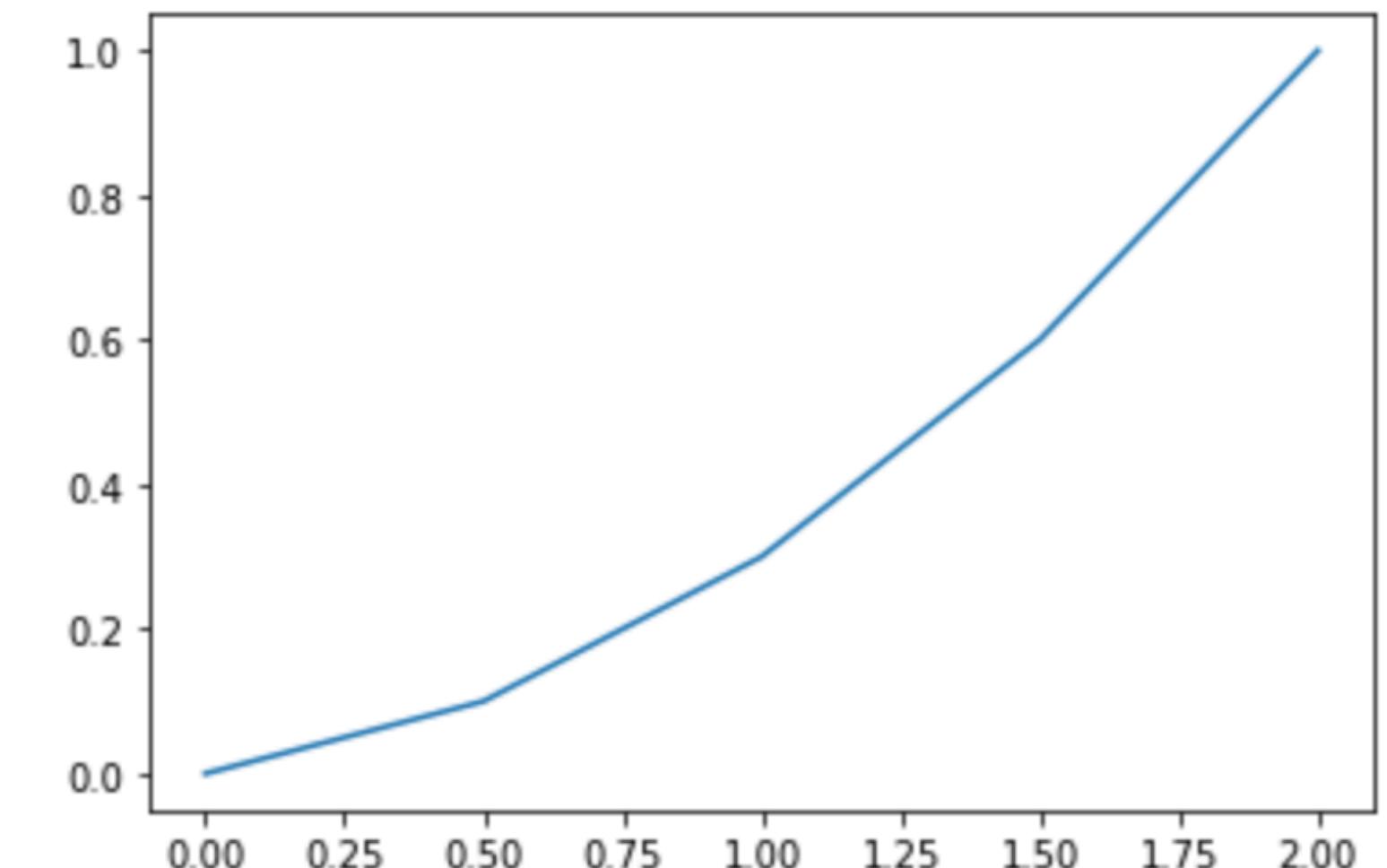
```
In [3]: tools.display_source('yamls/roots_v0.yml', number_lines=True)
run(['yamls/roots_v0.yml'], production_run=True)
```

```
file: yamls/roots_v0.yml
=====
1: model:
2:   name: roots
3:   language: python
4:   args: [./models/roots_v0.py, 0.0, 2.0, 0.5]
```

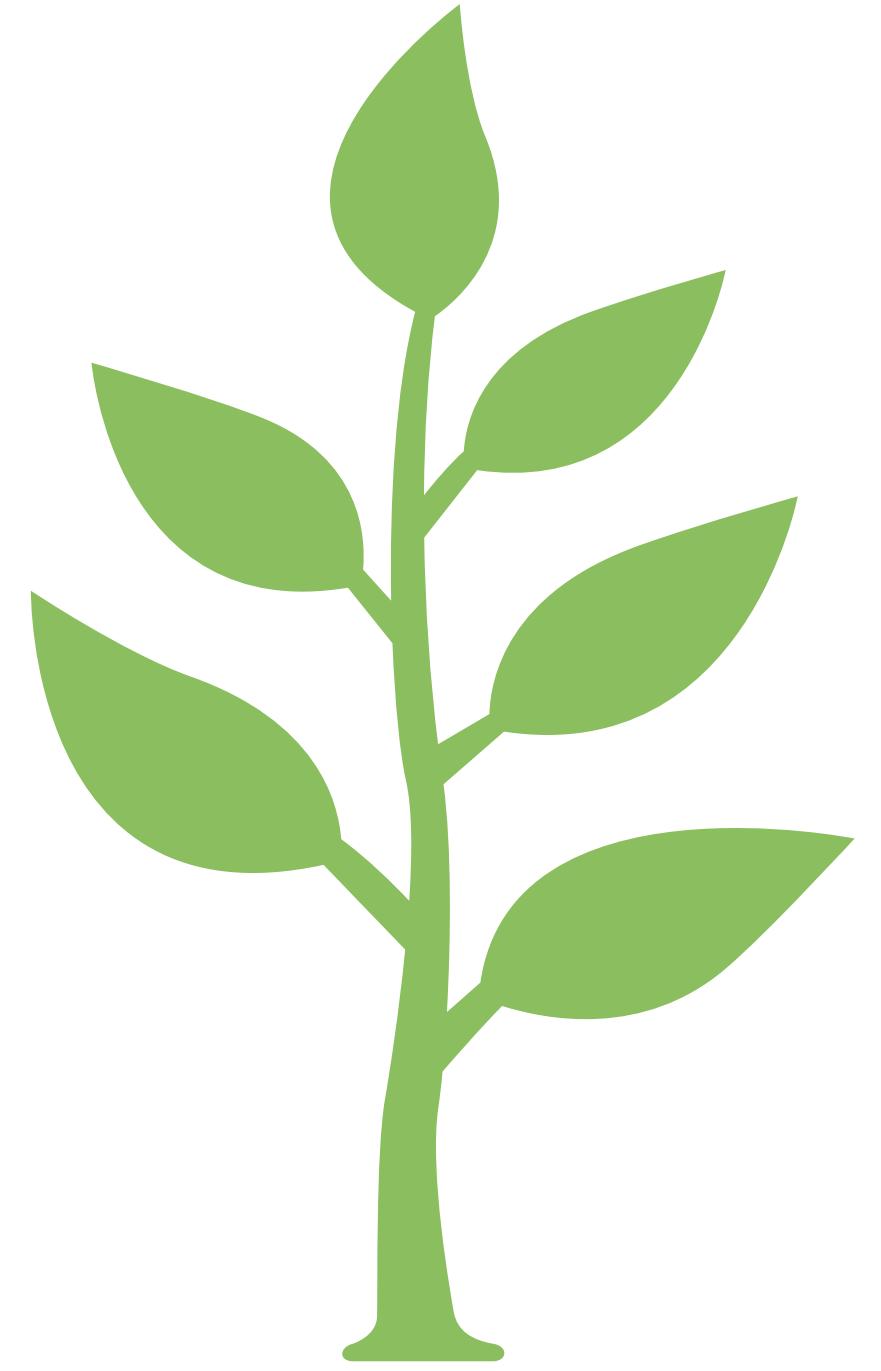
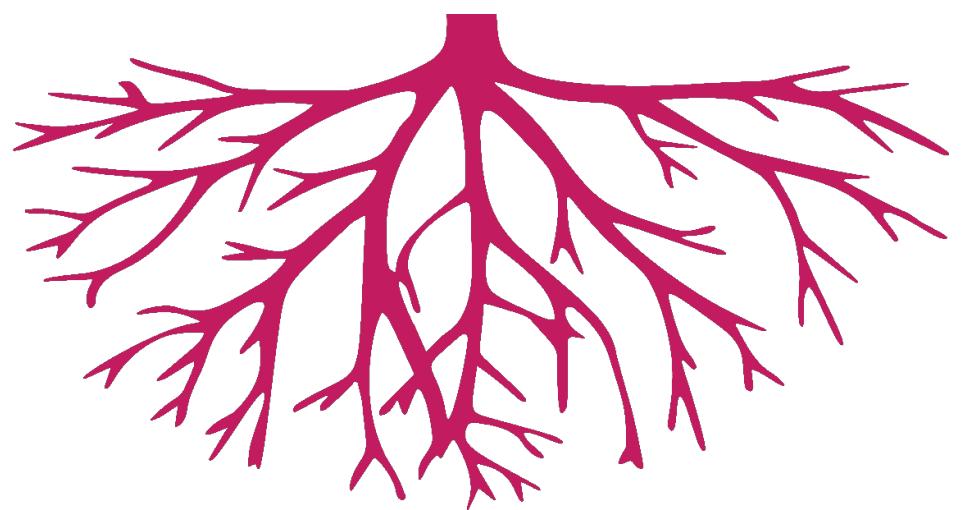
```
INFO:96257:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.
local in namespace yggdrasil with rank 0
/Users/langmnm/miniconda3/envs/conda36/bin/python /Users/langmnm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/roots_v0.py 0.0 2.0 0.5
INFO:96257:runner.waitModels[553]:YggRunner(runner): roots finished running.
INFO:96257:runner.waitModels[559]:YggRunner(runner): roots finished exiting.
INFO:96257:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:96257:runner.run[374]:YggRunner(runner):           init      0.000000
INFO:96257:runner.run[374]:YggRunner(runner):       load drivers    0.279398
INFO:96257:runner.run[374]:YggRunner(runner):     start drivers    0.039544
INFO:96257:runner.run[374]:YggRunner(runner):      run models     0.103028
INFO:96257:runner.run[374]:YggRunner(runner):        at exit      0.000614
INFO:96257:runner.run[376]:YggRunner(runner): =====
INFO:96257:runner.run[377]:YggRunner(runner):           Total      0.422584
```

```
In [4]: import matplotlib.pyplot as plt
filename_masses = 'output/masses.pkl'
with open(filename_masses, 'rb') as fd:
    masses = pickle.load(fd)
plt.plot(masses['times'], masses['masses'])
```

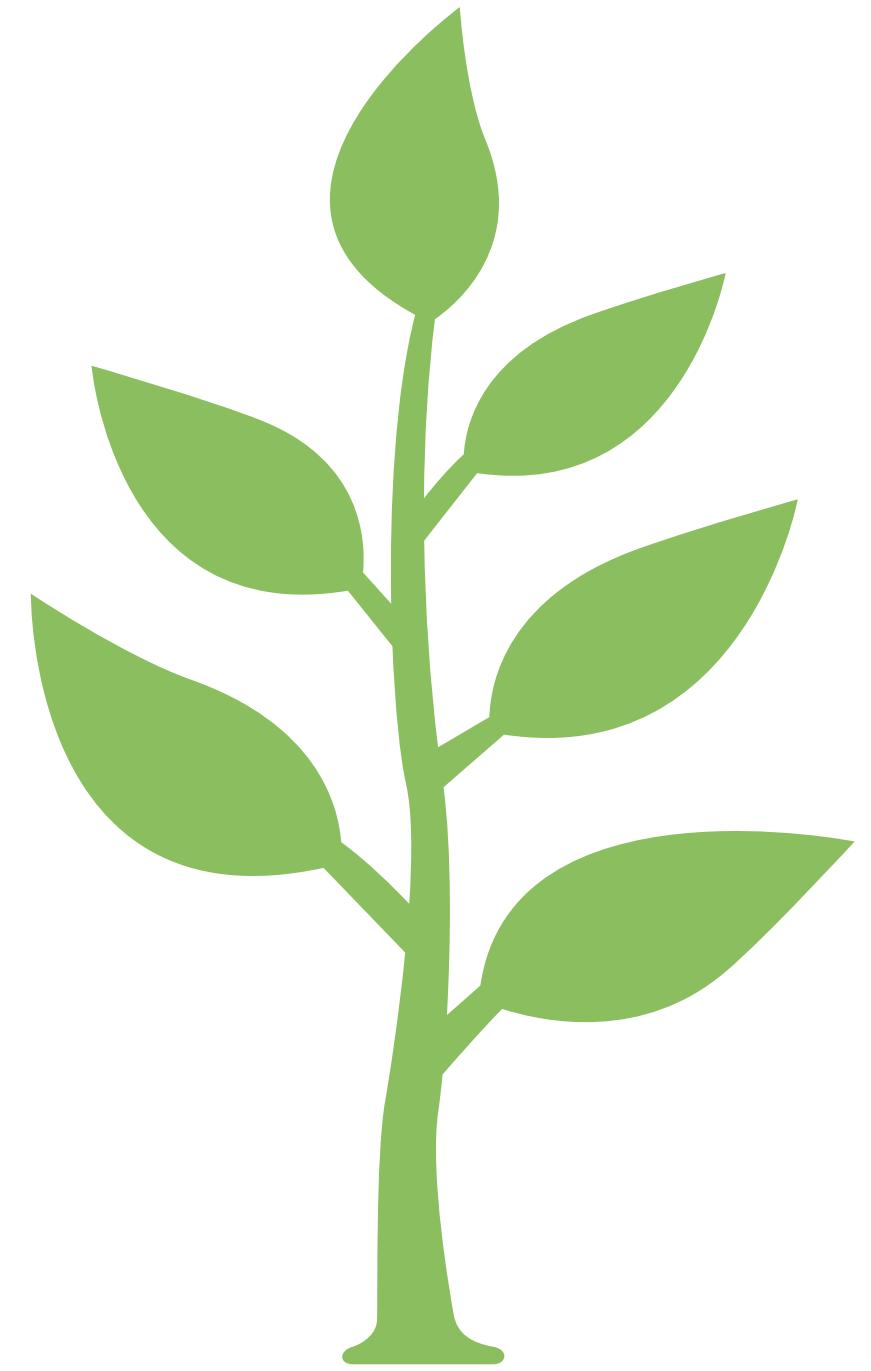
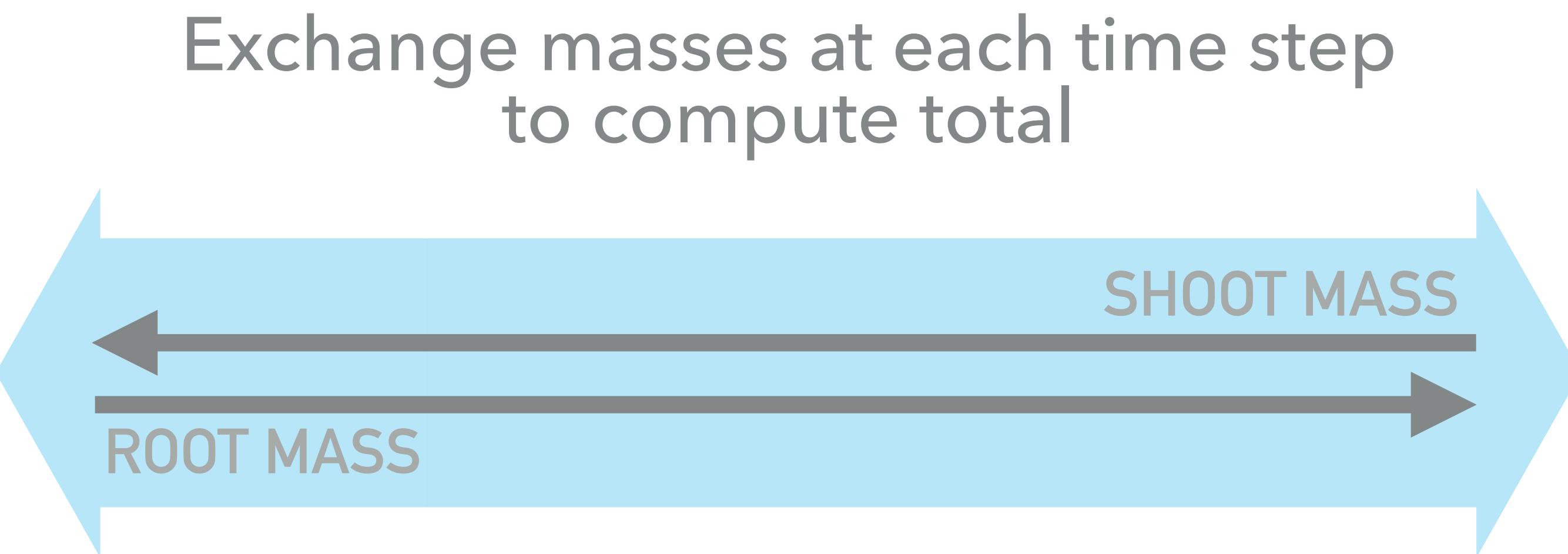
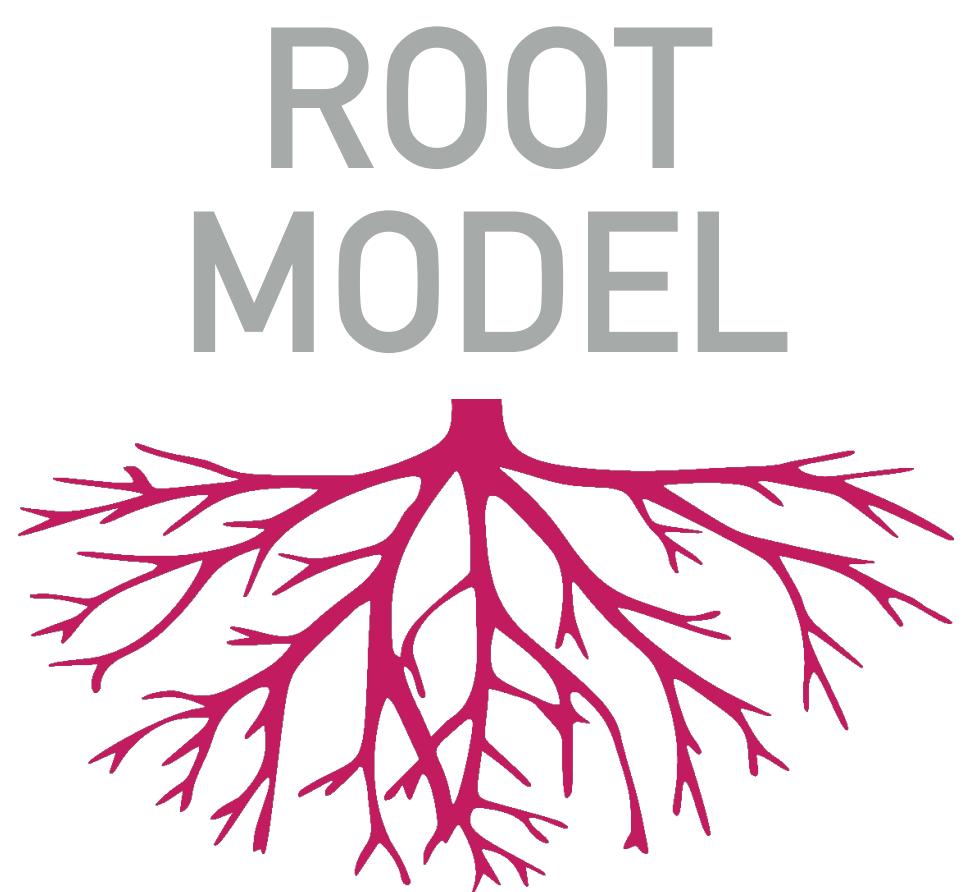
```
Out[4]: [
```

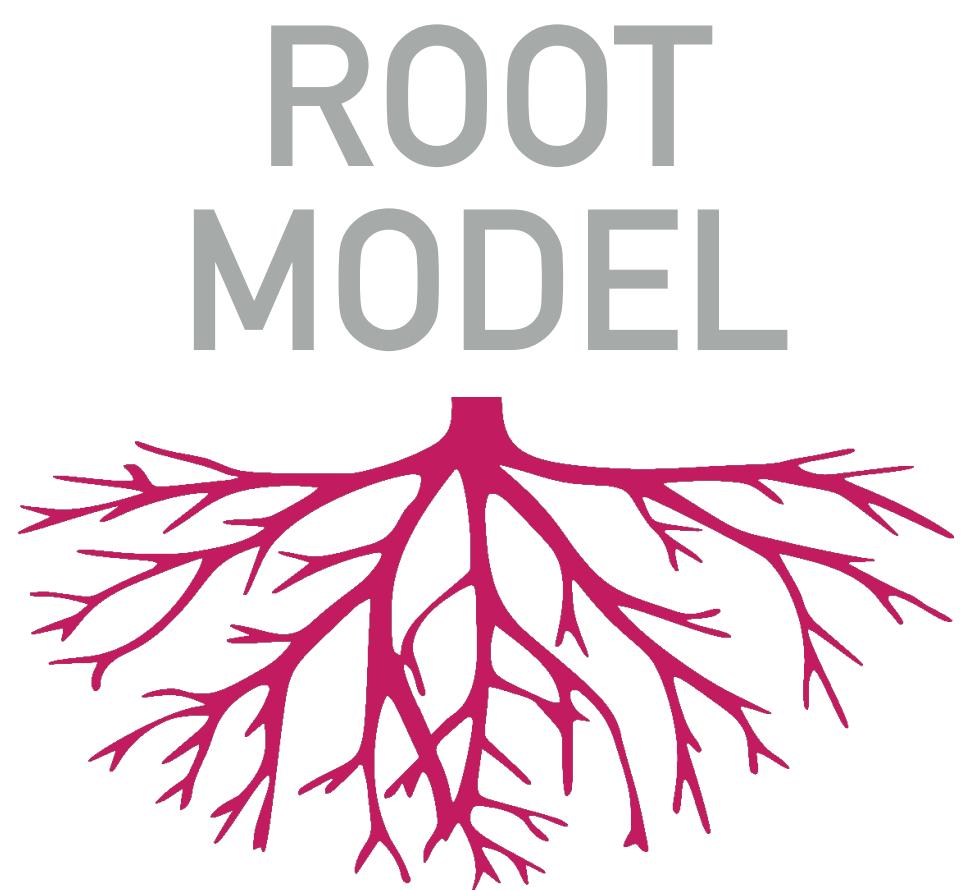


ROOT
MODEL

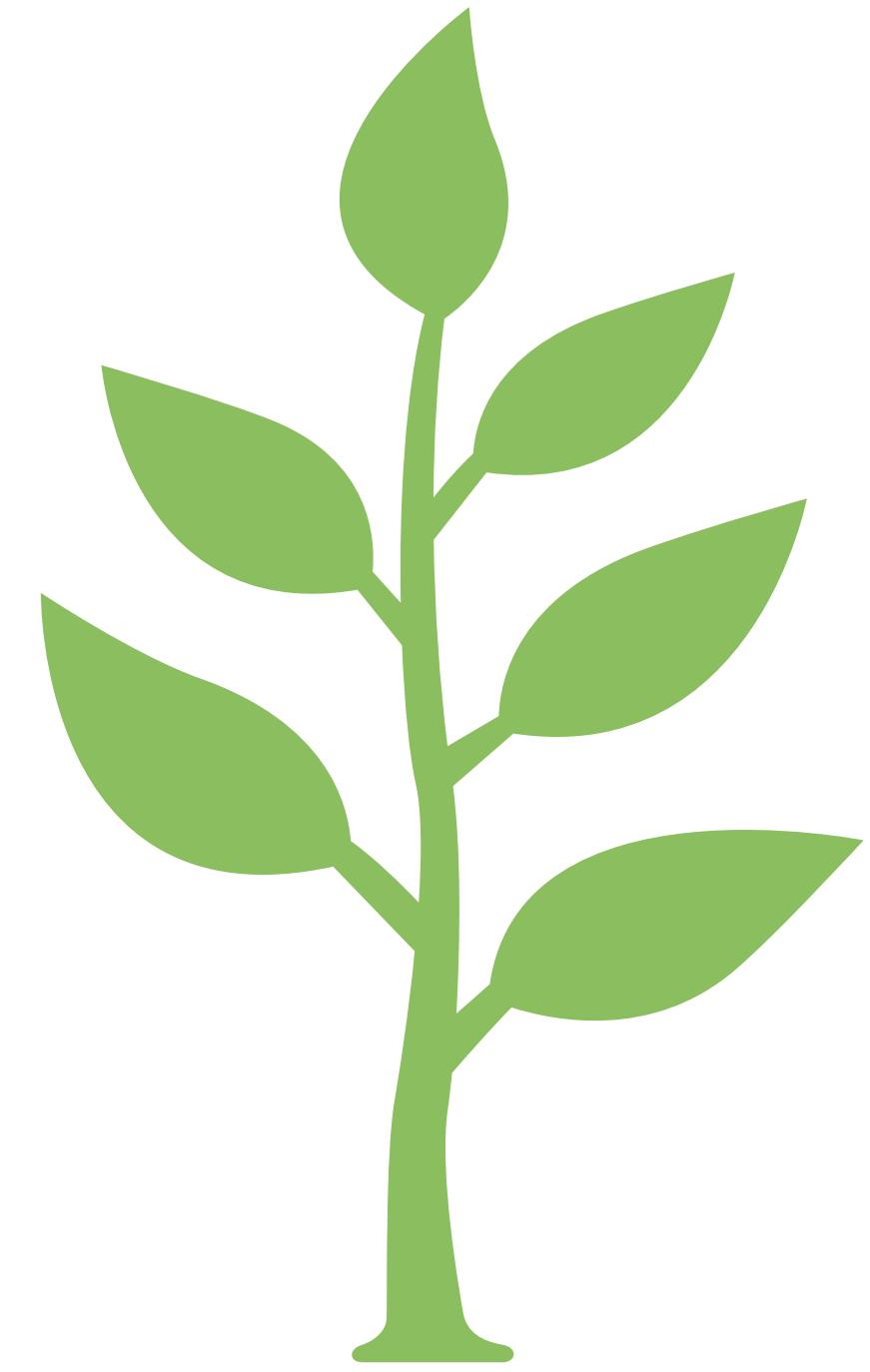
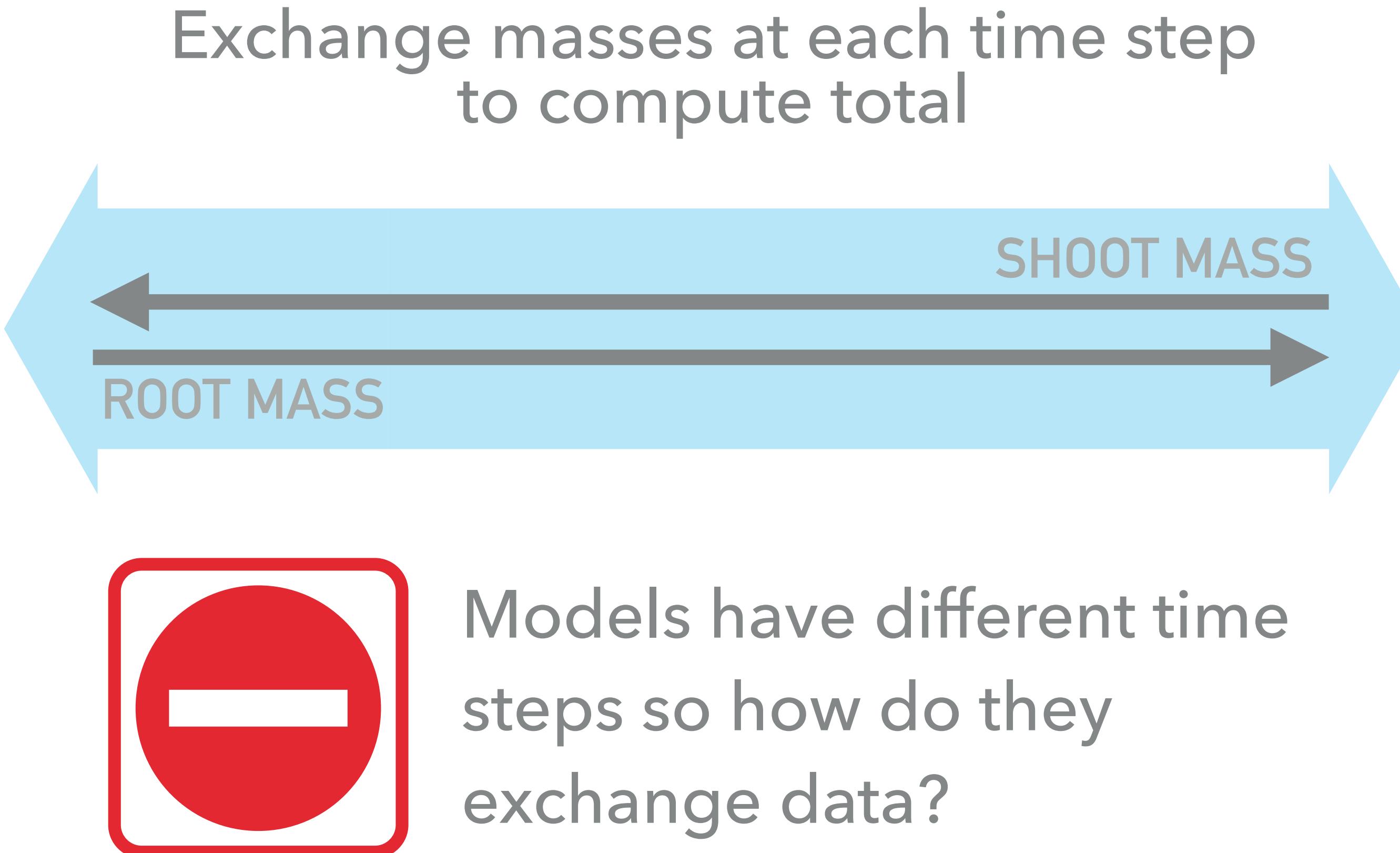


SHOOT
MODEL



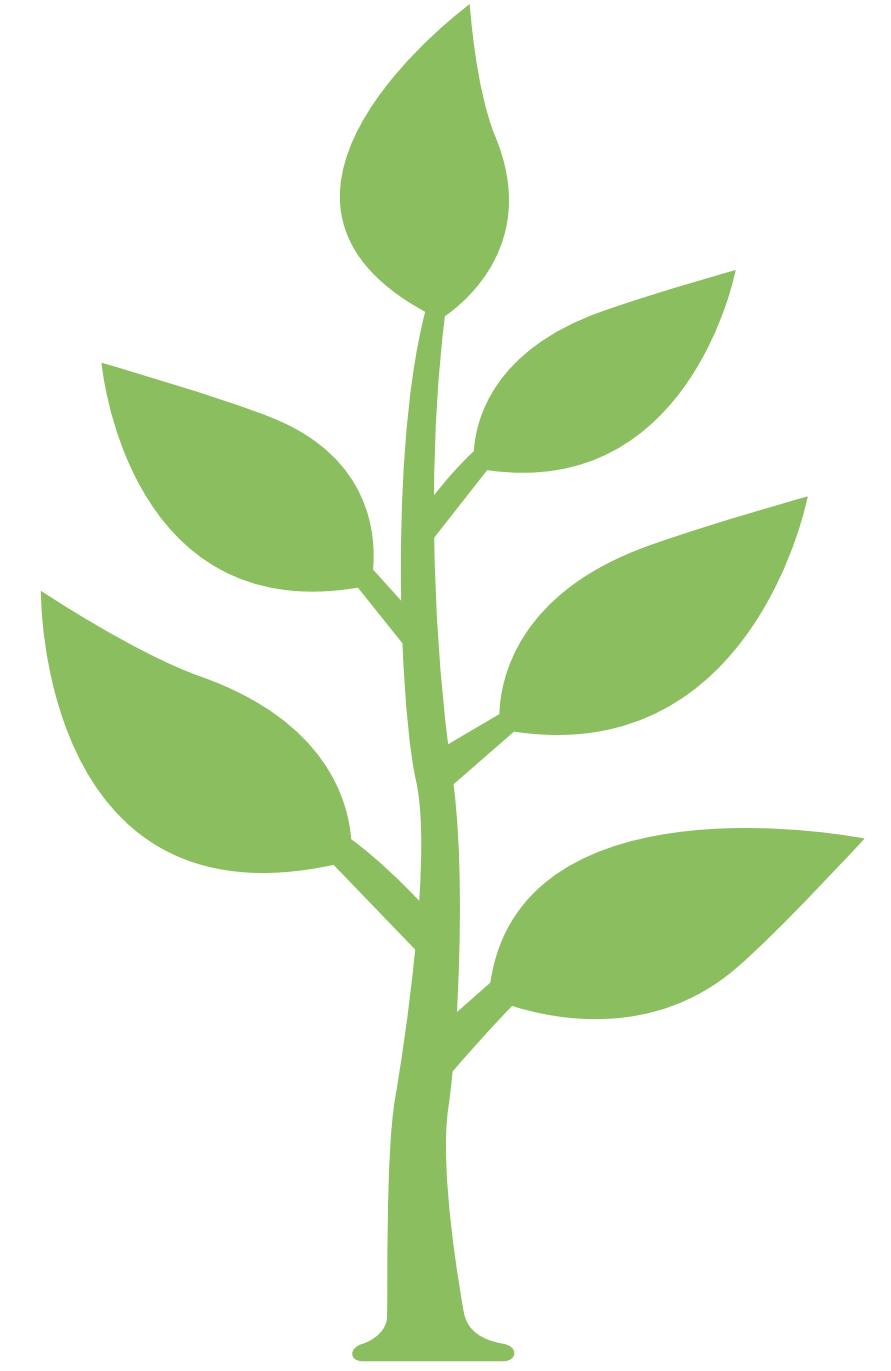
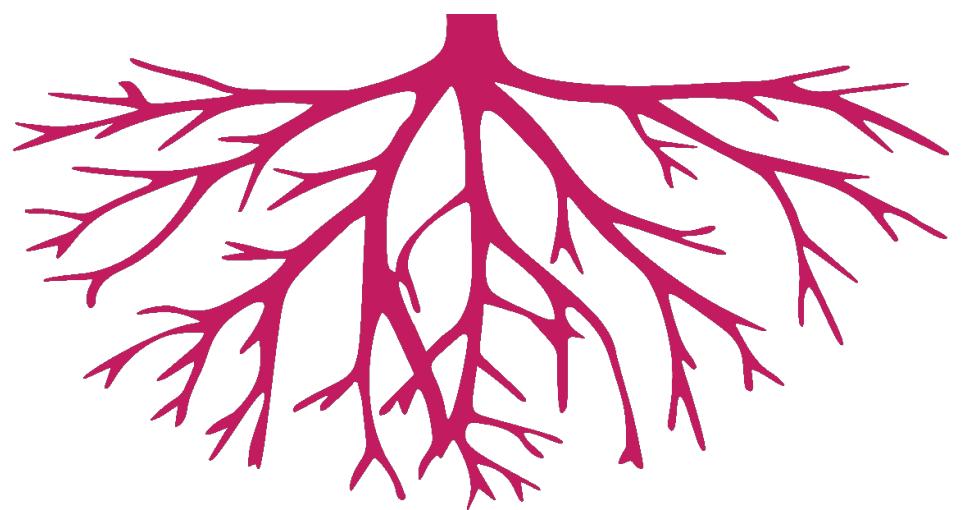


0.5 DAYS

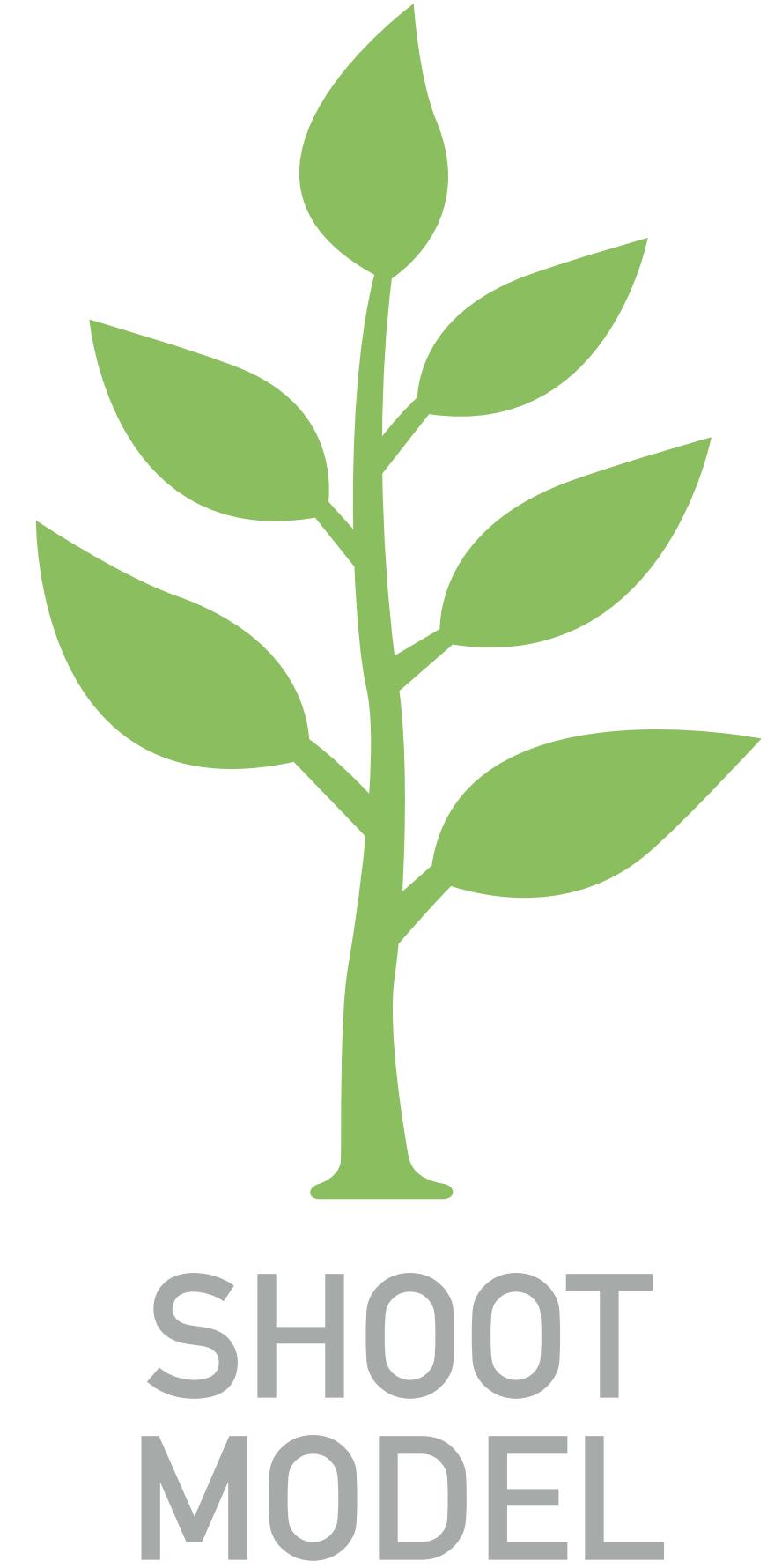
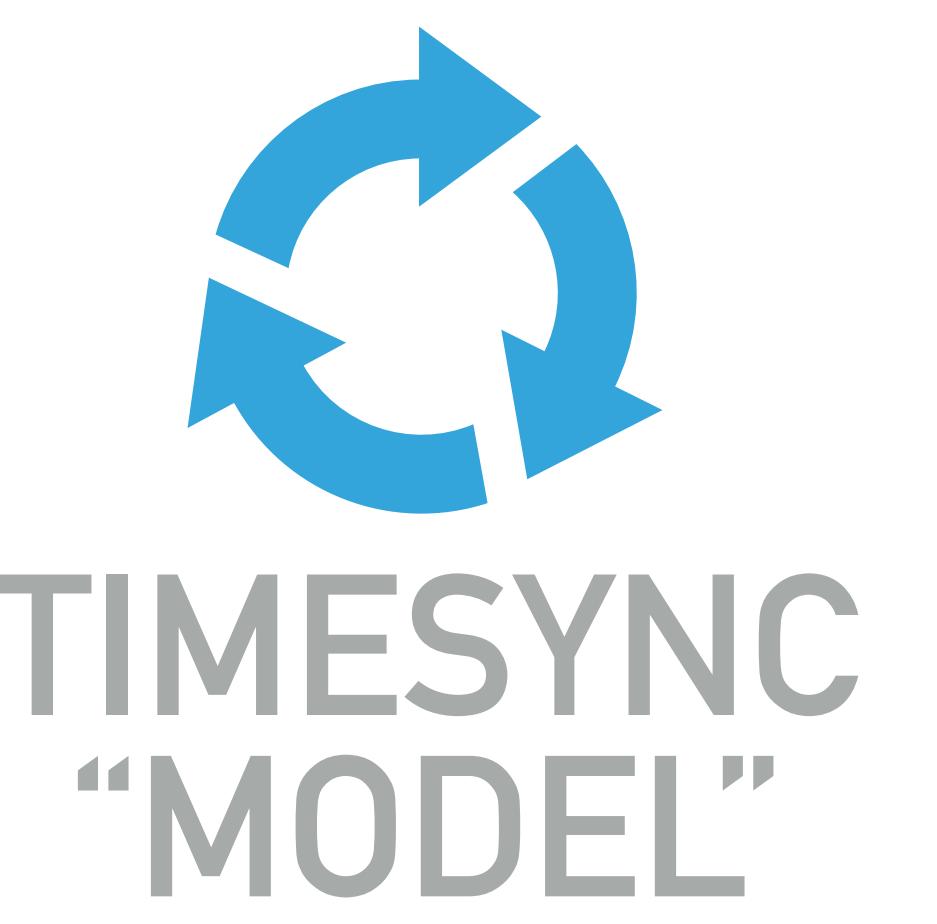
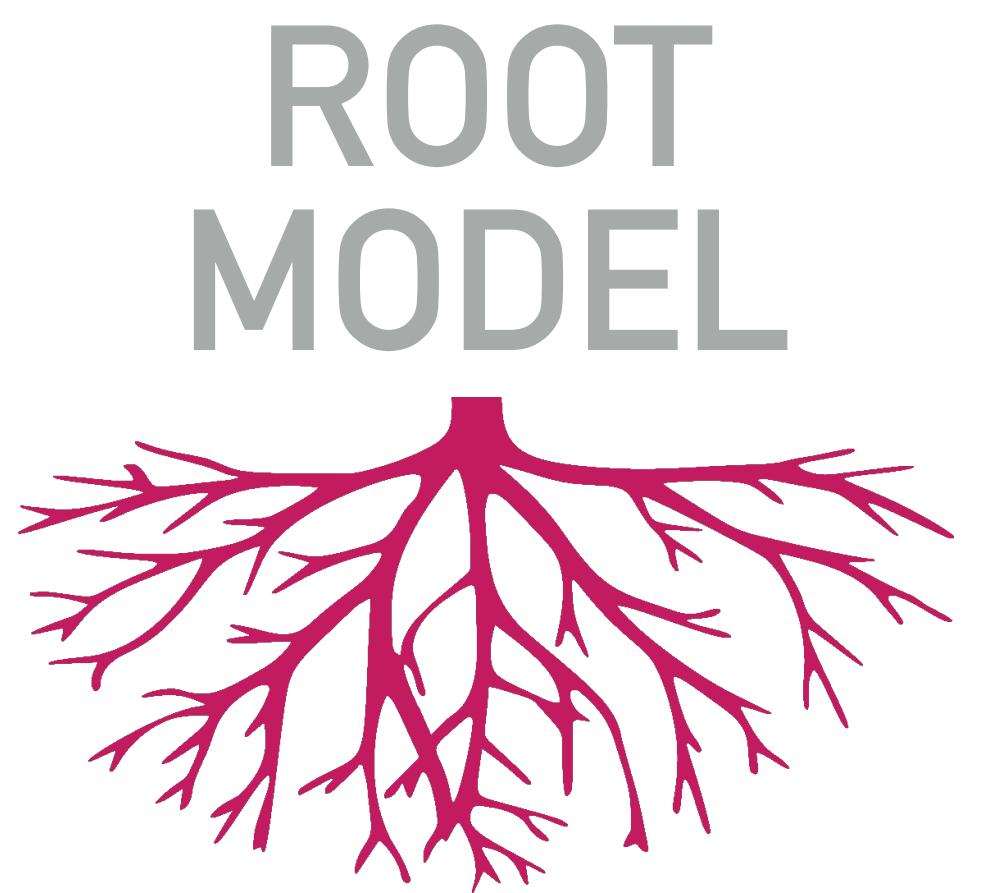


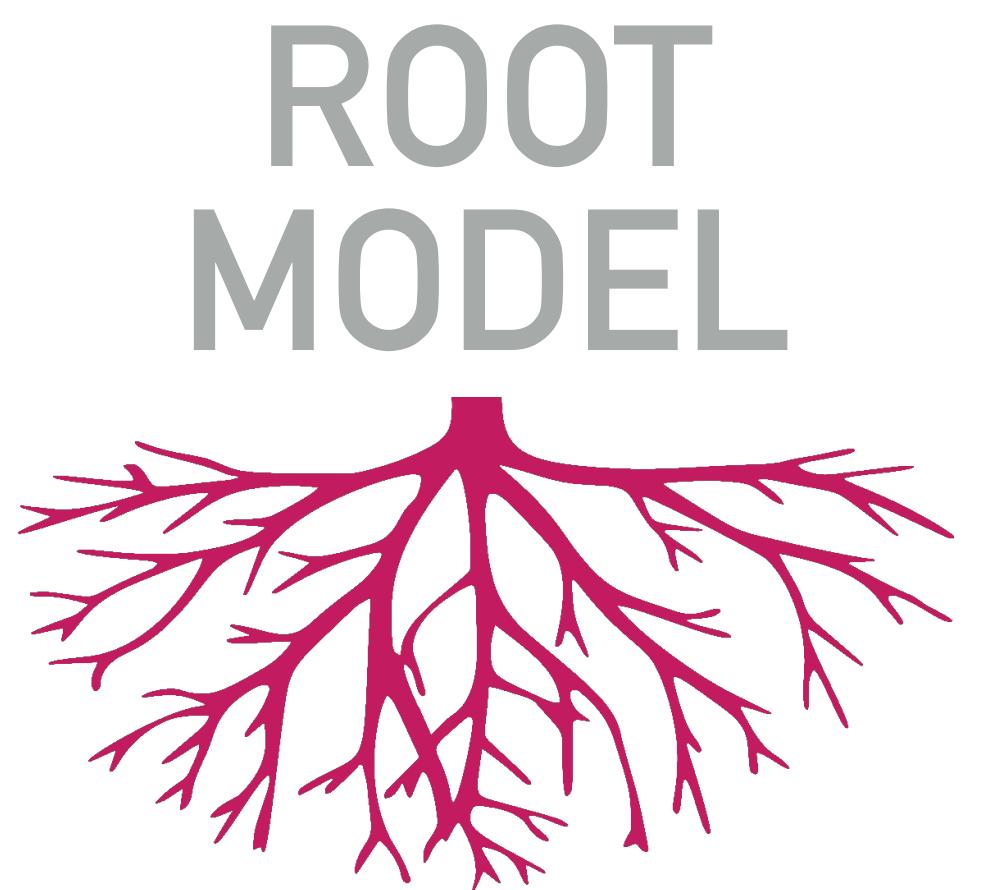
6 HRS

ROOT
MODEL

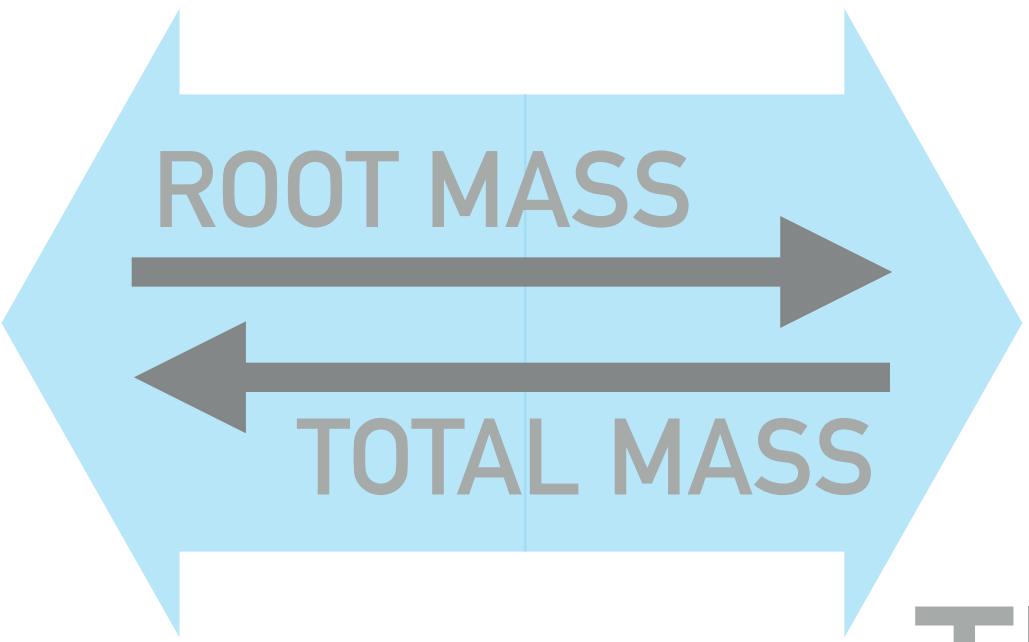


SHOOT
MODEL



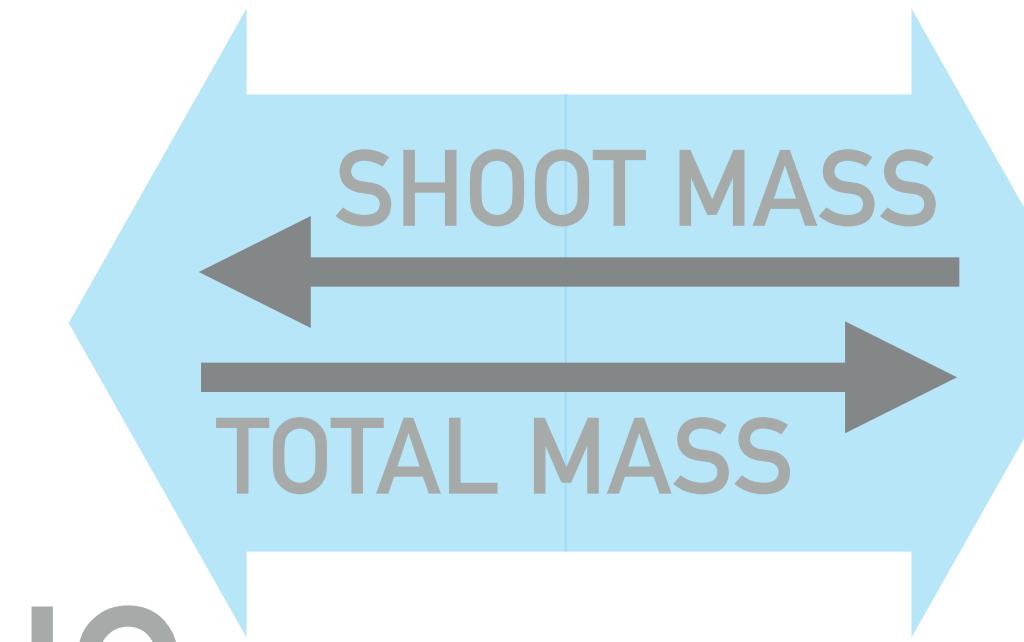
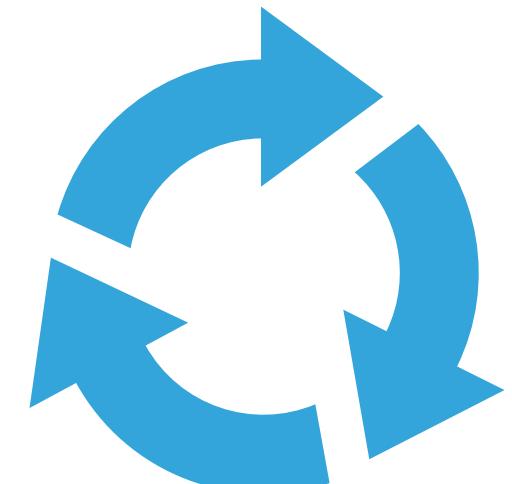


shoot2root

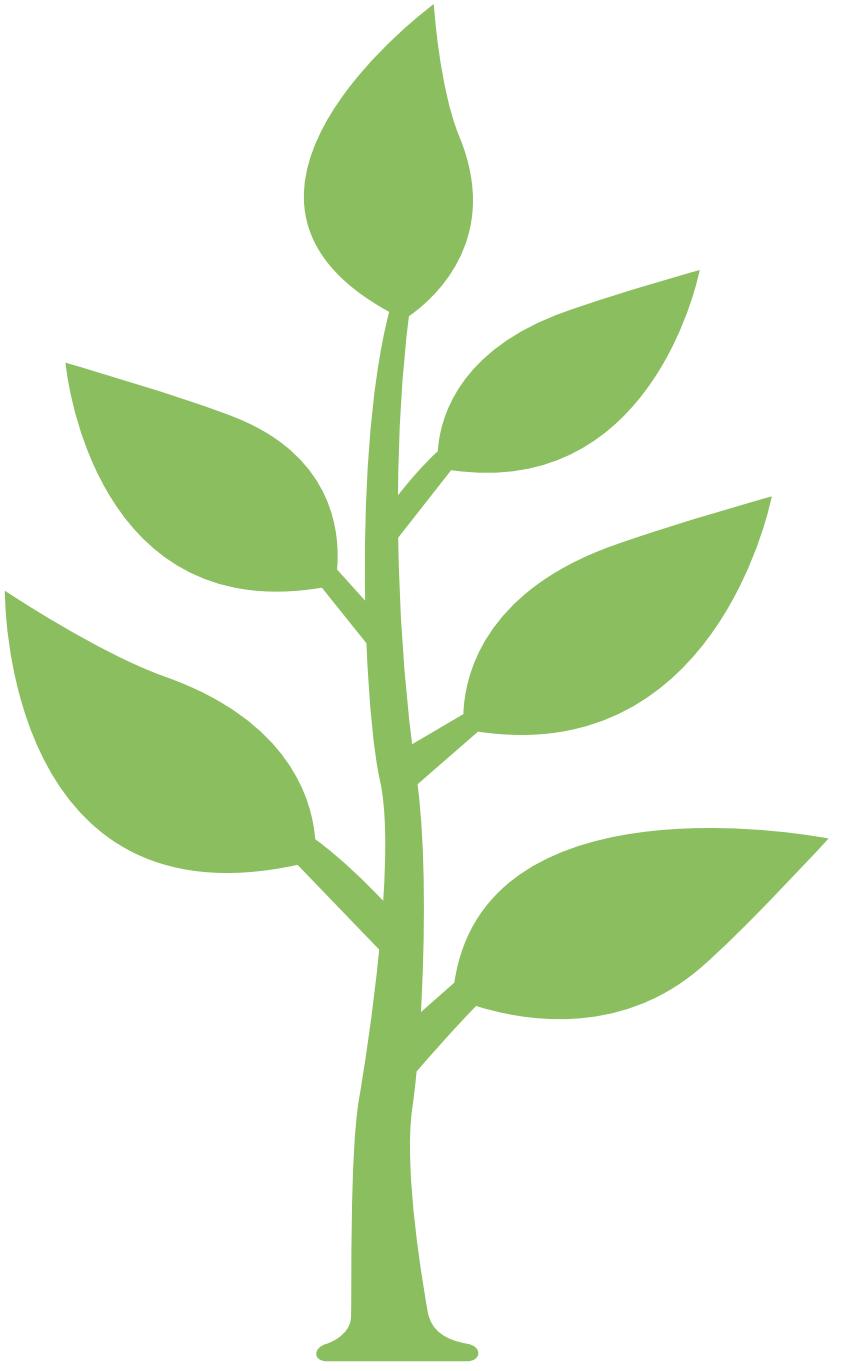


Aggregate masses at each time step

**TIMESYNC
“MODEL”**

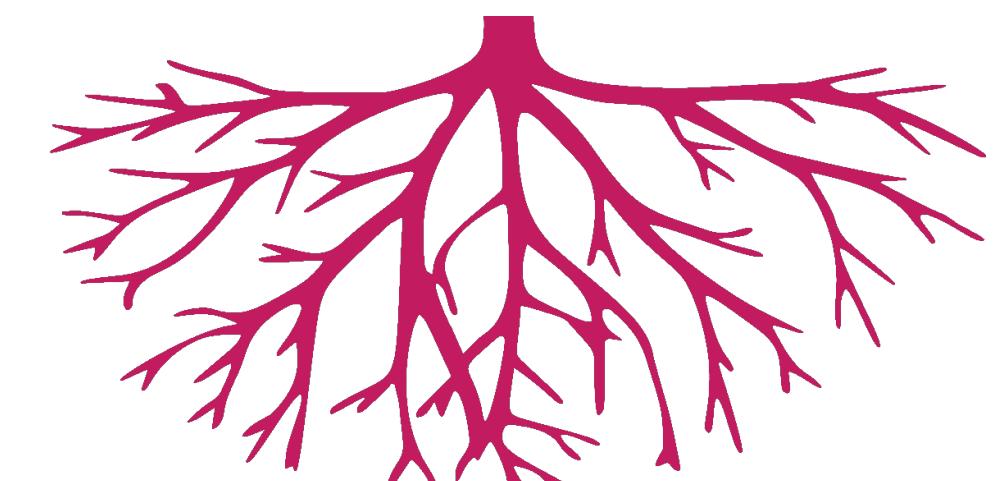


shoot2root

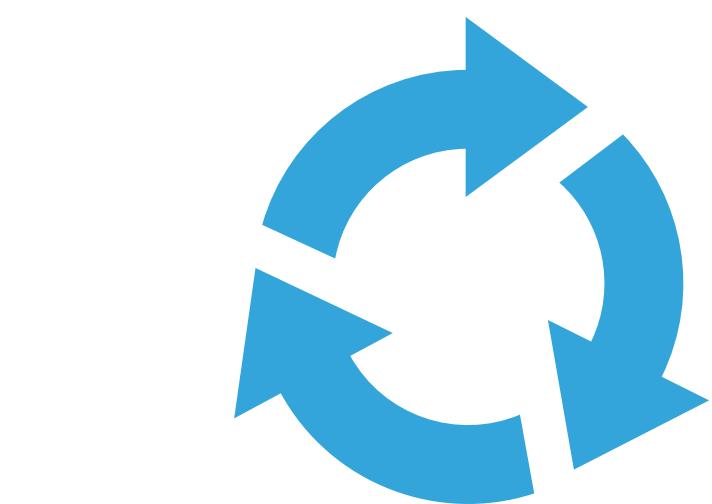
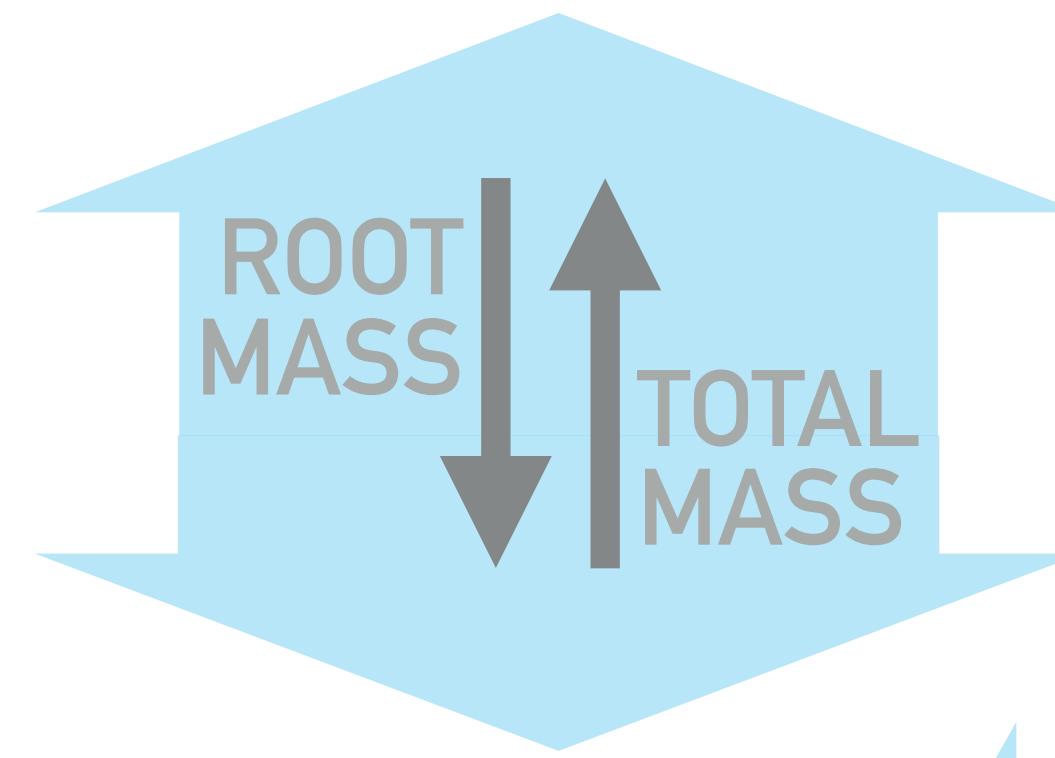


**SHOOT
MODEL**

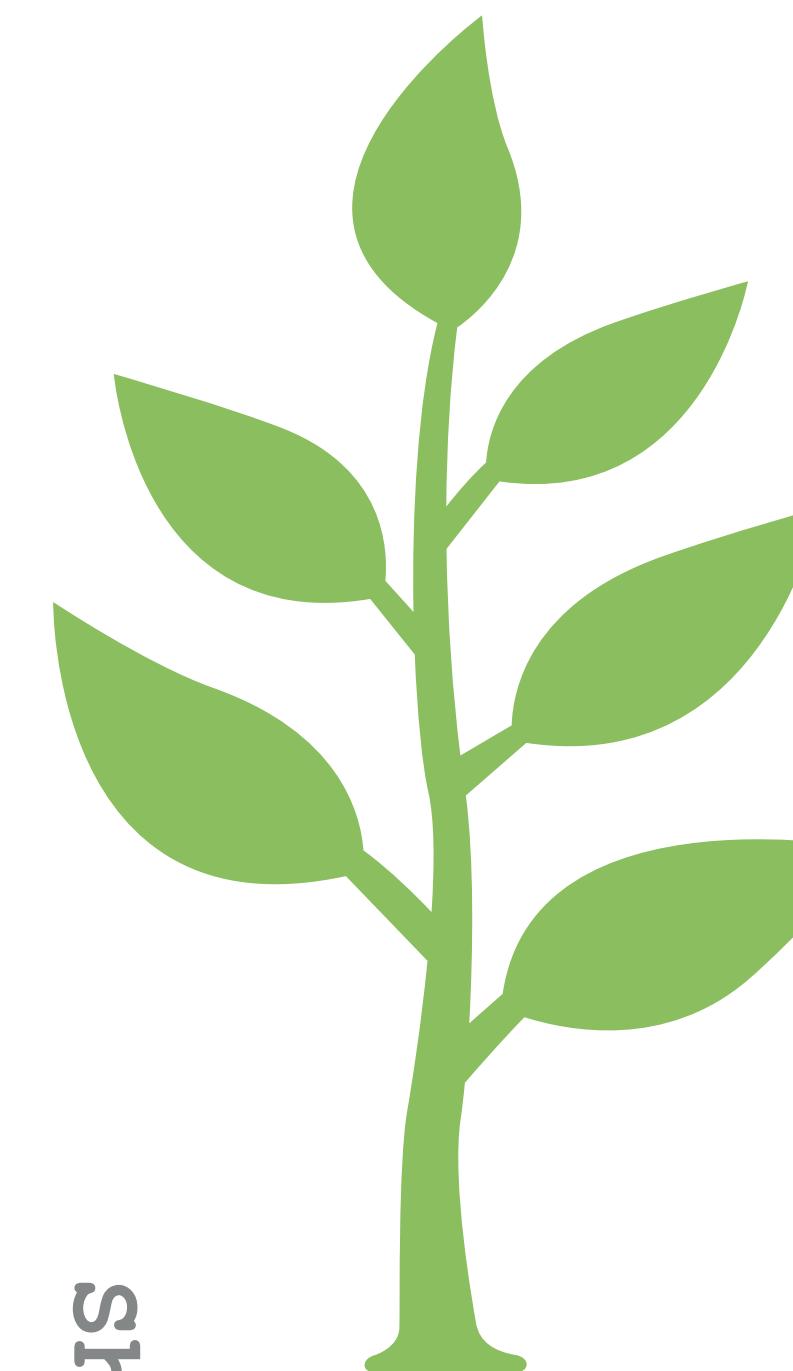
ROOT MODEL



Shoot2root

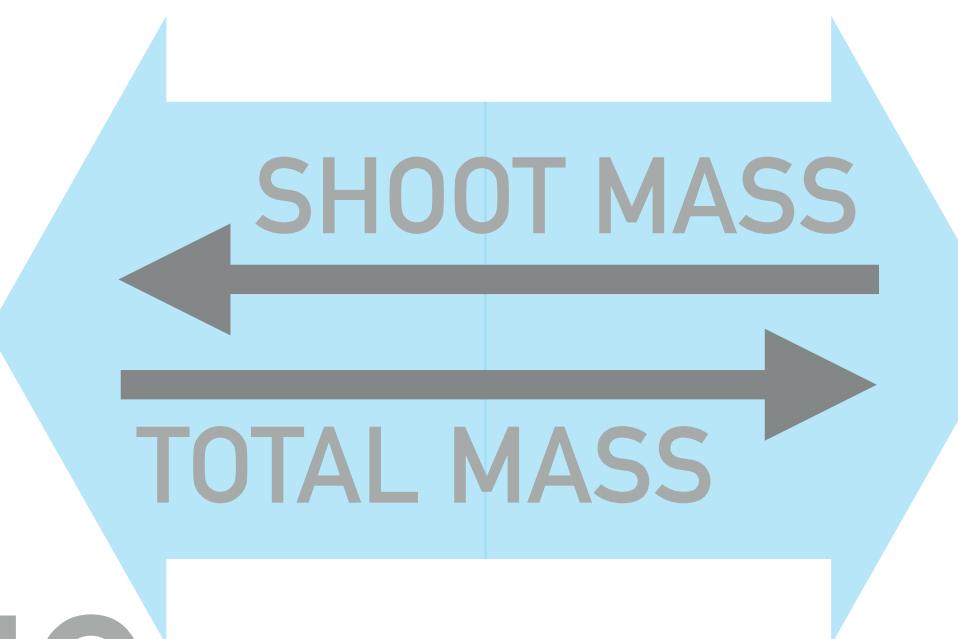


TIMESYNC
“MODEL”

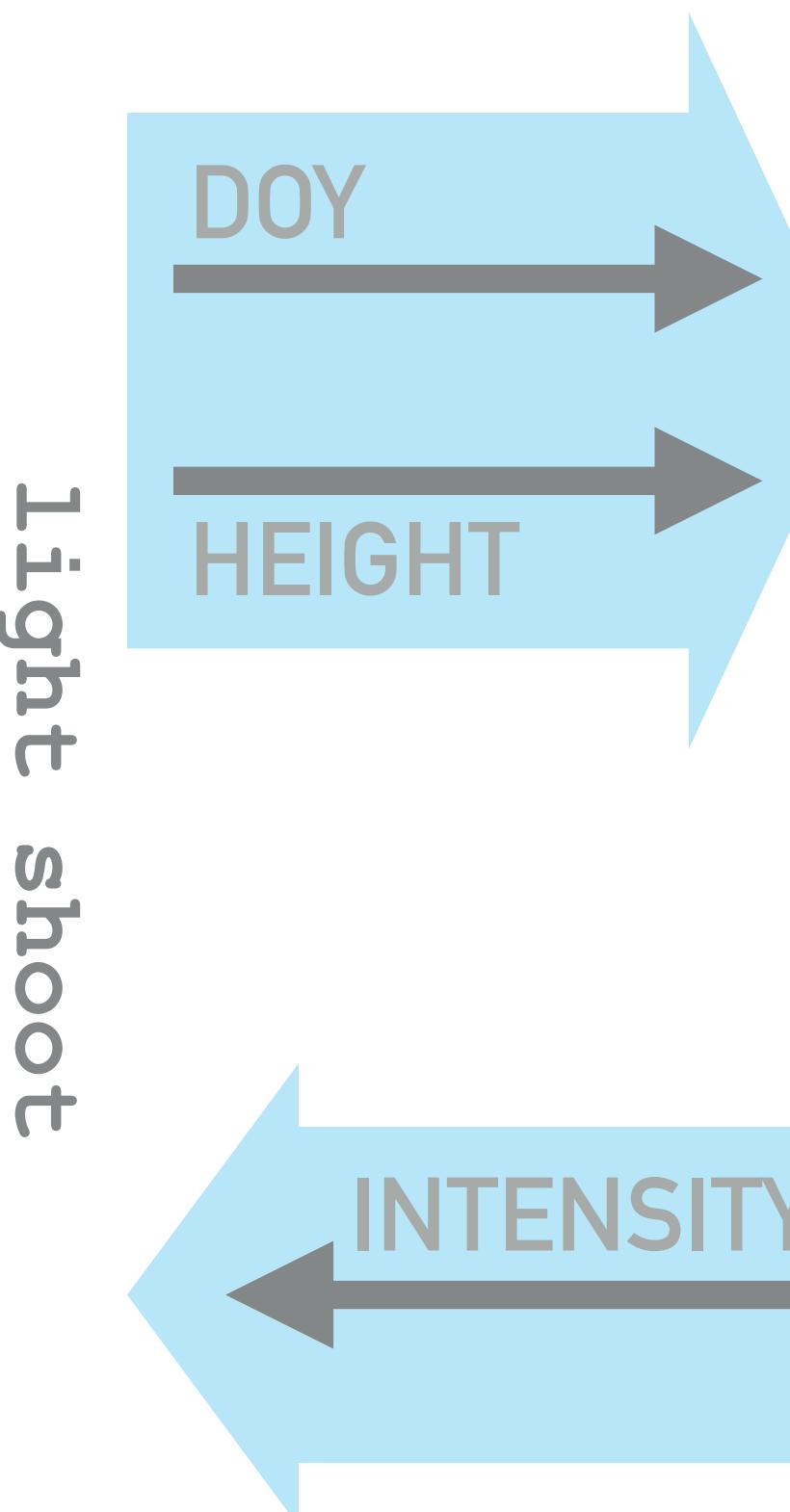


SHOOT
MODEL

Shoot2root



light_shoot



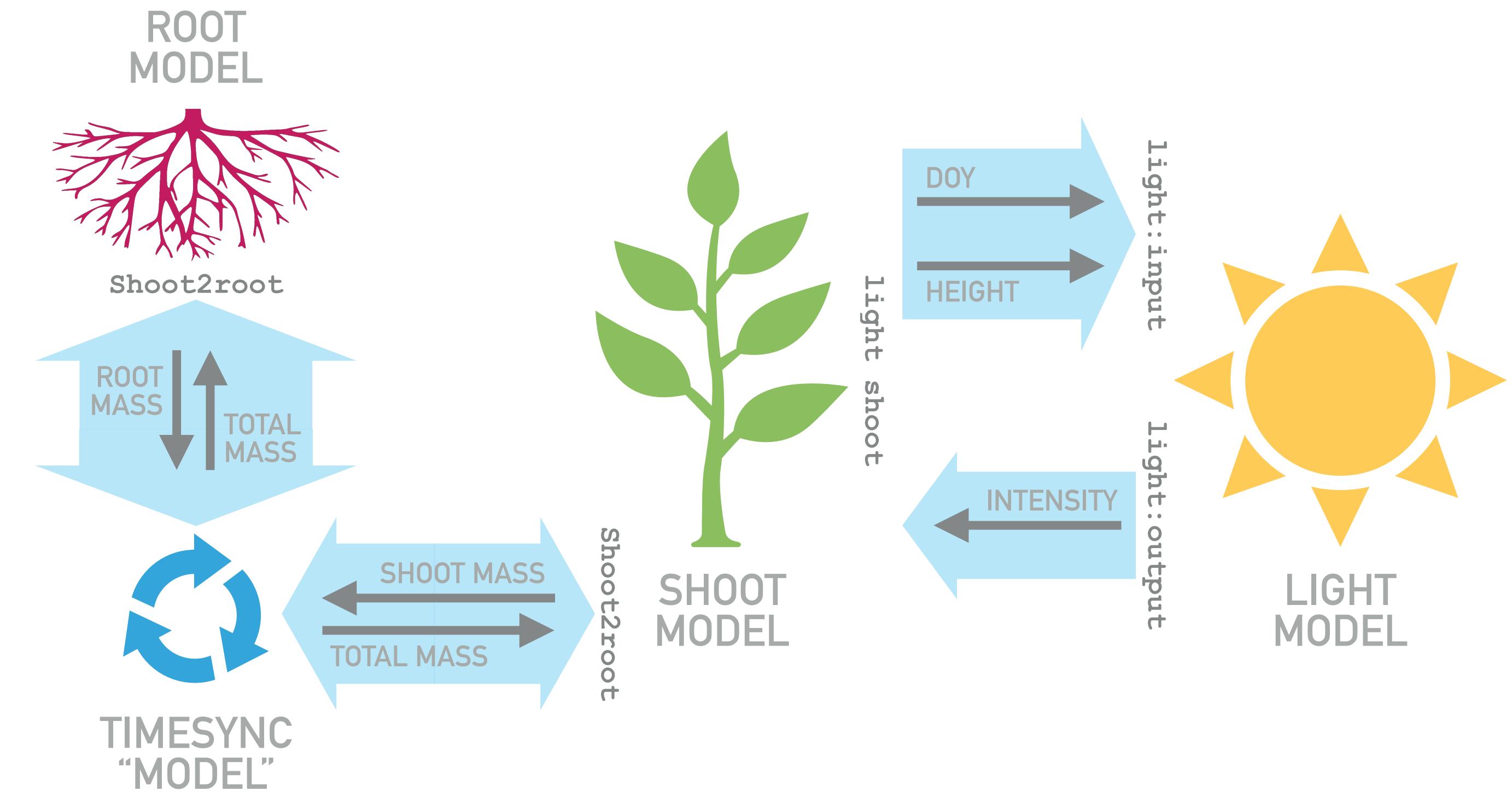
light:input

light:output



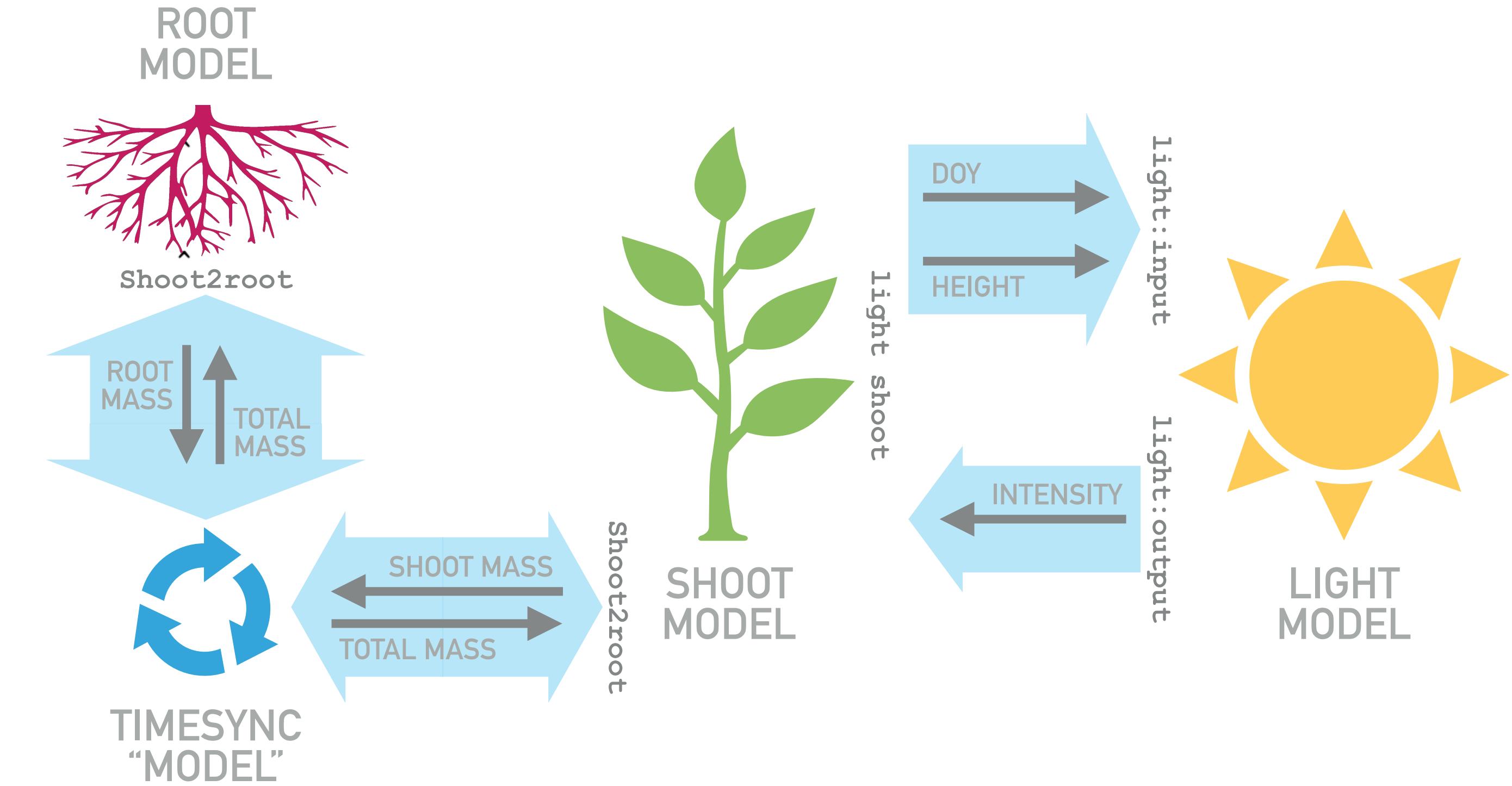
LIGHT
MODEL

```
In [5]: tools.display_source_diff('yamls/roots_v0.yml', 'yamls/roots_v1.yml', number_lines=True)
tools.display_source_diff('yamls/shoot_v2.yml', 'yamls/shoot_v3.yml', number_lines=True)
```



```
In [5]: tools.display_source_diff('yamls/roots_v0.yml', 'yamls/roots_v1.yml', number_lines=True)
tools.display_source_diff('yamls/shoot_v2.yml', 'yamls/shoot_v3.yml', number_lines=True)
```

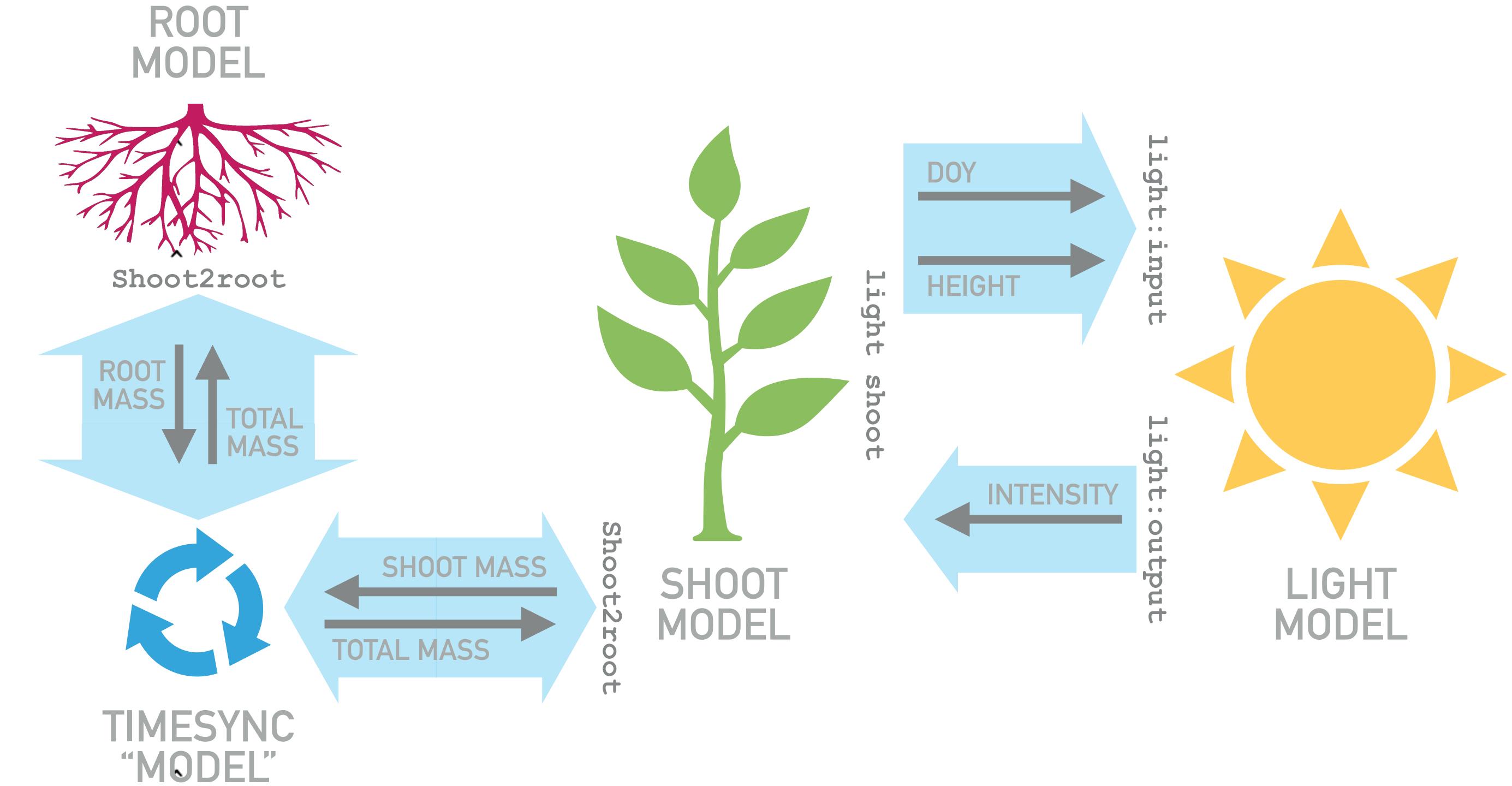
```
file1: yamls/roots_v0.yml
file2: yamls/roots_v1.yml
=====
1:   model:
2:     name: roots
3:     language: python
4:     - args: [..../models/roots_v0.py, 0.0, 2.0, 0.5]
5:     ?
6:
7: +   args: [..../models/roots_v1.py, 0.0, 2.0, 0.5]
8:     ?
9:
10: +   timesync: shoot2root
```



```
In [5]: tools.display_source_diff('yamls/roots_v0.yml', 'yamls/roots_v1.yml', number_lines=True)
tools.display_source_diff('yamls/shoot_v2.yml', 'yamls/shoot_v3.yml', number_lines=True)
```

```
file1: yamls/roots_v0.yml
file2: yamls/roots_v1.yml
=====
1:   model:
2:     name: roots
3:     language: python
-   args: [../models/roots_v0.py, 0.0, 2.0, 0.5]
?
4: +   args: [../models/roots_v1.py, 0.0, 2.0, 0.5]
?
5: +   timesync: shoot2root

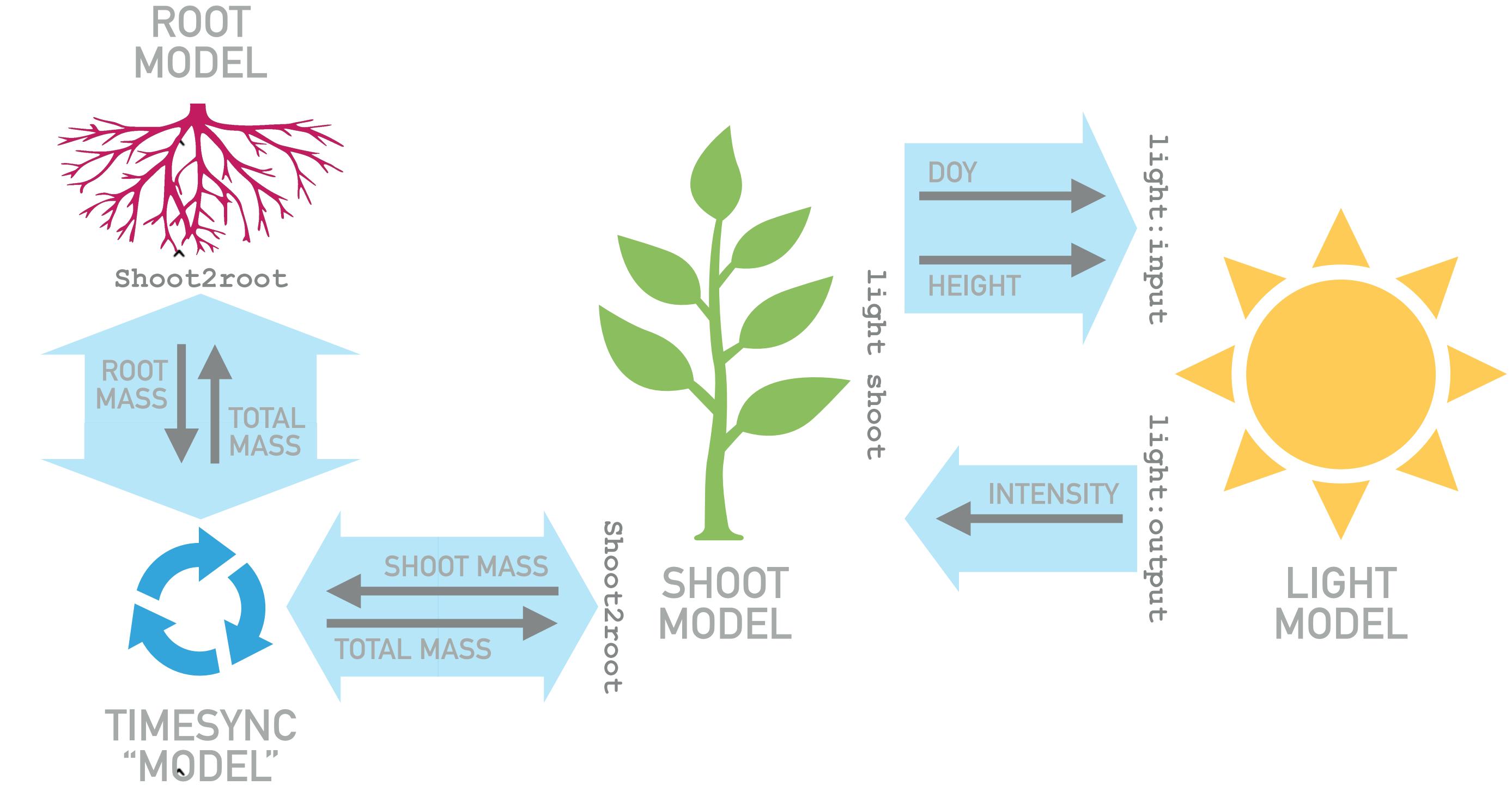
file1: yamls/shoot_v2.yml
file2: yamls/shoot_v3.yml
=====
1:   model:
2:     name: shoot
3:     language: python
-   args: [../models/shoot_v2.py, 0.0, 48.0, 6.0]
?
4: +   args: [../models/shoot_v3.py, 0.0, 48.0, 6.0]
?
5:   client_of: light
6: +   timesync: shoot2root
```



```
In [5]: tools.display_source_diff('yamls/roots_v0.yml', 'yamls/roots_v1.yml', number_lines=True)
tools.display_source_diff('yamls/shoot_v2.yml', 'yamls/shoot_v3.yml', number_lines=True)
```

```
file1: yamls/roots_v0.yml
file2: yamls/roots_v1.yml
=====
1: model:
2:   name: roots
3:   language: python
-   args: [../models/roots_v0.py, 0.0, 2.0, 0.5]
?
4: + args: [../models/roots_v1.py, 0.0, 2.0, 0.5]
?
5: + timesync: shoot2root

file1: yamls/shoot_v2.yml
file2: yamls/shoot_v3.yml
=====
1: model:
2:   name: shoot
3:   language: python
-   args: [../models/shoot_v2.py, 0.0, 48.0, 6.0]
?
4: + args: [../models/shoot_v3.py, 0.0, 48.0, 6.0]
?
5:   client_of: light
6: + timesync: shoot2root
```



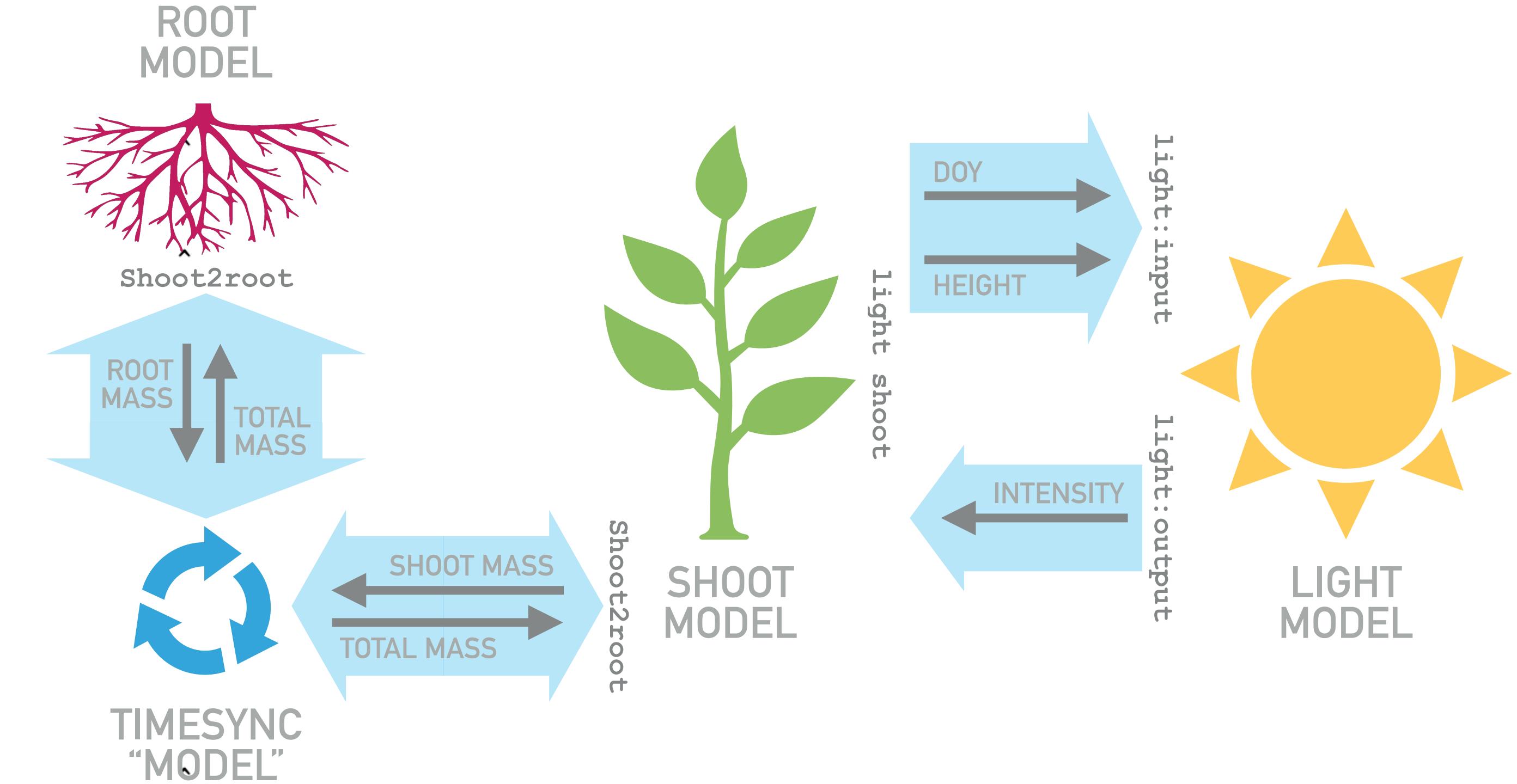
```
In [6]: tools.display_source('yamls/timesync.yml', number_lines=True)
```

```
file: yamls/timesync.yml
=====
1: model:
2:   name: shoot2root
3:   language: timesync
4:   aggregation: sum
```

```
In [5]: tools.display_source_diff('yamls/roots_v0.yml', 'yamls/roots_v1.yml', number_lines=True)
tools.display_source_diff('yamls/shoot_v2.yml', 'yamls/shoot_v3.yml', number_lines=True)
```

```
file1: yamls/roots_v0.yml
file2: yamls/roots_v1.yml
=====
1: model:
2:   name: roots
3:   language: python
-   args: [../models/roots_v0.py, 0.0, 2.0, 0.5]
?
4: + args: [../models/roots_v1.py, 0.0, 2.0, 0.5]
?
5: + timesync: shoot2root

file1: yamls/shoot_v2.yml
file2: yamls/shoot_v3.yml
=====
1: model:
2:   name: shoot
3:   language: python
-   args: [../models/shoot_v2.py, 0.0, 48.0, 6.0]
?
4: + args: [../models/shoot_v3.py, 0.0, 48.0, 6.0]
?
5:   client_of: light
6: + timesync: shoot2root
```



```
In [6]: tools.display_source('yamls/timesync.yml', number_lines=True)
```

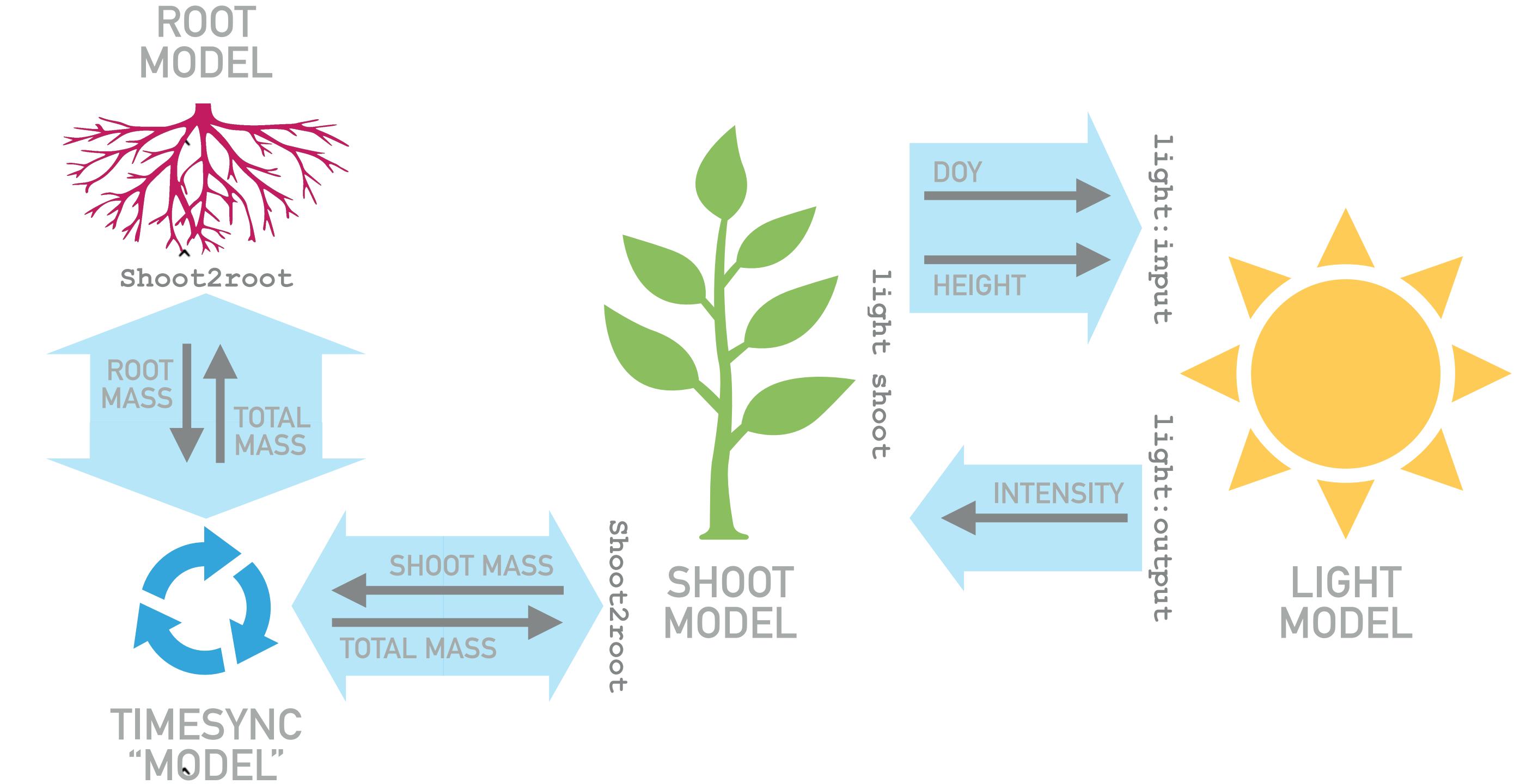
```
file: yamls/timesync.yml
=====
1: model:
2:   name: shoot2root
3:   language: timesync
4:   aggregation: sum
```

Match name of time sync
model "shoot2root"

```
In [5]: tools.display_source_diff('yamls/roots_v0.yml', 'yamls/roots_v1.yml', number_lines=True)
tools.display_source_diff('yamls/shoot_v2.yml', 'yamls/shoot_v3.yml', number_lines=True)
```

```
file1: yamls/roots_v0.yml
file2: yamls/roots_v1.yml
=====
1: model:
2:   name: roots
3:   language: python
-   args: [../models/roots_v0.py, 0.0, 2.0, 0.5]
?
4: + args: [../models/roots_v1.py, 0.0, 2.0, 0.5]
?
5: + timesync: shoot2root

file1: yamls/shoot_v2.yml
file2: yamls/shoot_v3.yml
=====
1: model:
2:   name: shoot
3:   language: python
-   args: [../models/shoot_v2.py, 0.0, 48.0, 6.0]
?
4: + args: [../models/shoot_v3.py, 0.0, 48.0, 6.0]
?
5:   client_of: light
6: + timesync: shoot2root
```



```
In [6]: tools.display_source('yamls/timesync.yml', number_lines=True)
```

```
file: yamls/timesync.yml
=====
1: model:
2:   name: shoot2root
3:   language: timesync
4:   aggregation: sum
```

“aggregation”
determines how values
should be combined

```
In [7]: tools.display_source_diff('models/roots_v0.py', 'models/roots_v1.py', number_lines=True)
tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v3.py', number_lines=True)
```

```
In [7]: tools.display_source_diff('models/roots_v0.py', 'models/roots_v1.py', number_lines=True)
tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v3.py', number_lines=True)
```

```
file1: models/roots_v0.py
file2: models/roots_v1.py
=====
23: + # Check if model is running as a part of an yggdrasil integration
24: + with_yggdrasil = os.environ.get('YGG_SUBPROCESS', False)
25: +
26: + # If the model is running as part of an yggdrasil integration, import
27: + # the relevant yggdrasil routines and use the interface routine to
28: + # complete the connection defined in the YAML
29: + if with_yggdrasil:
30: +     from yggdrasil import units
31: +     from yggdrasil.languages.Python.YggInterface import YggTimesync
32: +     shoot2root = YggTimesync('shoot2root')
33: +
34:     # Continue simulation until time limit is reached
35:     while t <= tmax:
36:
37:         - # Compute the scale factor
38:         + # If running as part an yggdrasil integration, send the time and
39:         + # mass to the timesync channel and then updated the mass based on
40:         + # the returned state
41:         + if with_yggdrasil:
42:             root_state = {'mass': units.add_units(mass, 'kg')}
43:             flag, total_state = shoot2root.call(units.add_units(t, 'days'),
44:                                                 root_state)
45:             if not flag:
46:                 raise Exception("Error performing time-step synchronization "
47:                                 "with shoot model.")
48:         +     # Compute the scale factor using total mass, stripping units
49:         +     # of the result to allow use with original code
50:         -     # (pretend this is a biologically complex calculation)
51:         +     # (pretend this is a biologically complex calculation)
52:         ? +++
53:         +     scale = units.get_data(
54:             units.convert_to(
55:                 units.add_units(0.05, 'days-1') * total_state['mass'],
56:                 'kg/day'))
57:         +     else:
58:             # Compute the scale factor
59:             # (pretend this is a biologically complex calculation)
60:             -     scale = 0.2
61:             +     scale = 0.2
62:         ? +++
```

```
In [7]: tools.display_source_diff('models/roots_v0.py', 'models/roots_v1.py', number_lines=True)
tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v3.py', number_lines=True)
```

```
file1: models/roots_v0.py
file2: models/roots_v1.py
=====
23: + # Check if model is running as a part of an yggdrasil integration
24: + with_yggdrasil = os.environ.get('YGG_SUBPROCESS', False)
25: +
26: + # If the model is running as part of an yggdrasil integration, import
27: + # the relevant yggdrasil routines and use the interface routine to
28: + # complete the connection defined in the YAML
29: + if with_yggdrasil:
30: +     from yggdrasil import units
31: +     from yggdrasil.languages.Python.YggInterface import YggTimesync
32: +     shoot2root = YggTimesync('shoot2root')
33: +
34:     # Continue simulation until time limit is reached
35:     while t <= tmax:
36:
37:         - # Compute the scale factor
38:         + # If running as part an yggdrasil integration, send the time and
39:         + # mass to the timesync channel and then updated the mass based on
40:         + # the returned state
41:         + if with_yggdrasil:
42:             root_state = {'mass': units.add_units(mass, 'kg')}
43:             flag, total_state = shoot2root.call(units.add_units(t, 'days'),
44:                                                 root_state)
45:             if not flag:
46:                 raise Exception("Error performing time-step synchronization "
47:                                 "with shoot model.")
48:         +     # Compute the scale factor using total mass, stripping units
49:         +     # of the result to allow use with original code
50:         -     # (pretend this is a biologically complex calculation)
51:         +     # (pretend this is a biologically complex calculation)
52:         ? +++
53:         scale = units.get_data(
54:             units.convert_to(
55:                 units.add_units(0.05, 'days-1') * total_state['mass'],
56:                 'kg/day'))
57:         else:
58:             # Compute the scale factor
59:             # (pretend this is a biologically complex calculation)
60:             - scale = 0.2
61:             scale = 0.2
62:         ? +++
```

Import yggdrasil functions and connect to the time sync channel listed in the YAML.

```
In [7]: tools.display_source_diff('models/roots_v0.py', 'models/roots_v1.py', number_lines=True)
tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v3.py', number_lines=True)
```

```
file1: models/roots_v0.py
file2: models/roots_v1.py
=====
23: + # Check if model is running as a part of an yggdrasil integration
24: + with_yggdrasil = os.environ.get('YGG_SUBPROCESS', False)
25: +
26: + # If the model is running as part of an yggdrasil integration, import
27: + # the relevant yggdrasil routines and use the interface routine to
28: + # complete the connection defined in the YAML
29: + if with_yggdrasil:
30: +     from yggdrasil import units
31: +     from yggdrasil.languages.Python.YggInterface import YggTimesync
32: +     shoot2root = YggTimesync('shoot2root')
33: +
34:     # Continue simulation until time limit is reached
35:     while t <= tmax:
36:
37:         - # Compute the scale factor
38:         + # If running as part an yggdrasil integration, send the time and
39:         + # mass to the timesync channel and then updated the mass based on
40:         + # the returned state
41:         + if with_yggdrasil:
42:             root_state = {'mass': units.add_units(mass, 'kg')}
43:             flag, total_state = shoot2root.call(units.add_units(t, 'days'),
44:                                                 root_state)
45:             if not flag:
46:                 raise Exception("Error performing time-step synchronization "
47:                                 "with shoot model.")
48:         + # Compute the scale factor using total mass, stripping units
49:         + # of the result to allow use with original code
50:         - # (pretend this is a biologically complex calculation)
51:         + # (pretend this is a biologically complex calculation)
52:         ? +++
53:         scale = units.get_data(
54:             units.convert_to(
55:                 units.add_units(0.05, 'days-1') * total_state['mass'],
56:                 'kg/day'))
57:         else:
58:             # Compute the scale factor
59:             - # (pretend this is a biologically complex calculation)
60:             scale = 0.2
61:             scale = 0.2
62:         ? +++
```

Send root state to the time sync model
and receive the total state back

```
In [7]: tools.display_source_diff('models/roots_v0.py', 'models/roots_v1.py', number_lines=True)
tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v3.py', number_lines=True)
```

```
file1: models/roots_v0.py
file2: models/roots_v1.py
=====
23: + # Check if model is running as a part of an yggdrasil integration
24: + with_yggdrasil = os.environ.get('YGG_SUBPROCESS', False)
25: +
26: + # If the model is running as part of an yggdrasil integration, import
27: + # the relevant yggdrasil routines and use the interface routine to
28: + # complete the connection defined in the YAML
29: + if with_yggdrasil:
30: +     from yggdrasil import units
31: +     from yggdrasil.languages.Python.YggInterface import YggTimesync
32: +     shoot2root = YggTimesync('shoot2root')
33: +
34:     # Continue simulation until time limit is reached
35:     while t <= tmax:
36:
37:         - # Compute the scale factor
38:         - # If running as part an yggdrasil integration, send the time and
39:         - # mass to the timesync channel and then updated the mass based on
40:         - # the returned state
41:         + if with_yggdrasil:
42:             root_state = {'mass': units.add_units(mass, 'kg')}
43:             flag, total_state = shoot2root.call(units.add_units(t, 'days'),
44:                                                 root_state)
45:             if not flag:
46:                 raise Exception("Error performing time-step synchronization "
47:                                 "with shoot model.")
48:         +
49:             # Compute the scale factor using total mass, stripping units
50:             # of the result to allow use with original code
51:             - # (pretend this is a biologically complex calculation)
52:             + # (pretend this is a biologically complex calculation)
53:             ? +++
54:             scale = units.get_data(
55:                 units.convert_to(
56:                     units.add_units(0.05, 'days-1') * total_state['mass'],
57:                     'kg/day'))
58:             else:
59:                 # Compute the scale factor
60:                 # (pretend this is a biologically complex calculation)
61:                 - scale = 0.2
62:                 scale = 0.2
63:             ? +++
```

Compute the scale using the total state
when run with yggdrasil

```
In [7]: tools.display_source_diff('models/roots_v0.py', 'models/roots_v1.py', number_lines=True)
      tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v3.py', number_lines=True)
```

```
file1: models/shoot_v2.py
file2: models/shoot_v3.py
=====
...
31: if with_yggdrasil:
32:     from yggdrasil import units
33: -     from yggdrasil.languages.Python.YggInterface import YggRpcClient
33: +     from yggdrasil.languages.Python.YggInterface import YggRpcClient, YggTimesync
34:     ?
+++++
34:         light_rpc = YggRpcClient('light_shoot')
35: +     shoot2root = YggTimesync('shoot2root')
36:
37: # Continue simulation until time limit is reached
38: while t <= tmax:
39:
40: # If running as part an yggdrasil integration, send the time and
41: - # maximum height of the mesh to the height channel with units
41: + # maximum height of the mesh to the height channel with units and
42:     ?
42: +     ++++
42: +     # send the current mass and tiem to the timesync channel
43: if with_yggdrasil:
44: +     shoot_state = {'mass': units.add_units(mass, 'g')}
45: +     flag, total_state = shoot2root.call(units.add_units(t, 'hrs'),
46:                                         shoot_state)
47: +     if not flag:
48: +         raise Exception("Error performing time-step synchronization "
49:                         "with root model.")
50: +
51:
52: ...
53:
54: scale = units.get_data(
55:     units.add_units(mass, 'g') * intensity /
56:     ^
57:     -----
58:
59:     total_state['mass'] * intensity /
60:     ^^^^ ++++++ ^^^^
61:     ^
62:     -----
63:     units.add_units(4.0e10, 'g*erg/(cm**2*s)'))
64:     units.add_units(4.0e10, 'g*erg/(cm**2*s)'))
65:     ? ++++
66:
```

```
In [7]: tools.display_source_diff('models/roots_v0.py', 'models/roots_v1.py', number_lines=True)
      tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v3.py', number_lines=True)
```

```
file1: models/shoot_v2.py
file2: models/shoot_v3.py
=====
...
31: if with_yggdrasil:
32:     from yggdrasil import units
33: -     from yggdrasil.languages.Python.YggInterface import YggRpcClient
34: +     from yggdrasil.languages.Python.YggInterface import YggRpcClient, YggTimesync
35: ?
+++++
36:
37:     light_rpc = YggRpcClient('light_shoot')
38: +     shoot2root = YggTimesync('shoot2root')
39:
40:     # Continue simulation until time limit is reached
41:     while t <= tmax:
42:         # If running as part an yggdrasil integration, send the time and
43:         # maximum height of the mesh to the height channel with units
44: -         # maximum height of the mesh to the height channel with units and
45: +         # send the current mass and tiem to the timesync channel
46: ?
47: +         if with_yggdrasil:
48:             shoot_state = {'mass': units.add_units(mass, 'g')}
49: +             flag, total_state = shoot2root.call(units.add_units(t, 'hrs'),
50:                                         shoot_state)
51: +
52:         if not flag:
53:             raise Exception("Error performing time-step synchronization "
54:                             "with root model.")
55:
56:
57:         scale = units.get_data(
58:             units.add_units(mass, 'g') * intensity /
59:             ^^^ ^ -----
60:             total_state['mass'] * intensity /
61:             ^^^^ +++++ ^^^^
62:             units.add_units(4.0e10, 'g*erg/(cm**2*s)'))
63:             units.add_units(4.0e10, 'g*erg/(cm**2*s)'))
64: ?
+++++
```

Import the time sync interface & connect to the “shoot2root” channel

```
In [7]: tools.display_source_diff('models/roots_v0.py', 'models/roots_v1.py', number_lines=True)
      tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v3.py', number_lines=True)
```

```
file1: models/shoot_v2.py
file2: models/shoot_v3.py
=====
...
31: if with_yggdrasil:
32:     from yggdrasil import units
-     from yggdrasil.languages.Python.YggInterface import YggRpcClient
33: +     from yggdrasil.languages.Python.YggInterface import YggRpcClient, YggTimesync
?
+++++
34:         light_rpc = YggRpcClient('light_shoot')
35: +     shoot2root = YggTimesync('shoot2root')
36:
37: # Continue simulation until time limit is reached
38: while t <= tmax:
39:
40:     # If running as part an yggdrasil integration, send the time and
-     # maximum height of the mesh to the height channel with units
41: +     # maximum height of the mesh to the height channel with units and
?
+
42: +     # send the current mass and tiem to the timesync channel
43:     if with_yggdrasil:
44: +         shoot_state = {'mass': units.add_units(mass, 'g')}
45: +         flag, total_state = shoot2root.call(units.add_units(t, 'hrs'),
46: +                                             shoot_state)
47: +         if not flag:
48:             raise Exception("Error performing time-step synchronization "
49:                             "with root model.")
50: +
...
60:         scale = units.get_data(
-             units.add_units(mass, 'g') * intensity /
?
+             ^_____
+
61: +             total_state['mass'] * intensity /
?
+             ^____^ +____^ ^_____
-
-             units.add_units(4.0e10, 'g*erg/(cm**2*s)'))
?
+             units.add_units(4.0e10, 'g*erg/(cm**2*s)'))
?
```

Send the shoot state to the time sync model & receive back the total state

```
In [7]: tools.display_source_diff('models/roots_v0.py', 'models/roots_v1.py', number_lines=True)
tools.display_source_diff('models/shoot_v2.py', 'models/shoot_v3.py', number_lines=True)
```

```
file1: models/shoot_v2.py
file2: models/shoot_v3.py
=====
...
31:     if with_yggdrasil:
32:         from yggdrasil import units
33:         - from yggdrasil.languages.Python.YggInterface import YggRpcClient
34:         + from yggdrasil.languages.Python.YggInterface import YggRpcClient, YggTimesync
35:         ?
36: =====+
37:         light_rpc = YggRpcClient('light_shoot')
38:         + shoot2root = YggTimesync('shoot2root')
39: 
40:         # Continue simulation until time limit is reached
41:         while t <= tmax:
42:             # If running as part an yggdrasil integration, send the time and
43:             # maximum height of the mesh to the height channel with units
44:             # maximum height of the mesh to the height channel with units and
45:             ?                               +++
46:             # send the current mass and tiem to the timesync channel
47:             if with_yggdrasil:
48:                 shoot_state = {'mass': units.add_units(mass, 'g')}
49:                 flag, total_state = shoot2root.call(units.add_units(t, 'hrs'),
50:                                                       shoot_state)
51: 
52:             if not flag:
53:                 raise Exception("Error performing time-step synchronization "
54:                                 "with root model.")
55: 
56:             ...
57:             scale = units.get_data(
58:                 - units.add_units(mass, 'g') * intensity /
59:                 ?                               ^-----^
60: 
61:                 + total_state['mass'] * intensity /
62:                 ?                               ++++++ ^^^^
63: 
64:                 - units.add_units(4.0e10, 'g*erg/(cm**2*s)'))
65:                 + units.add_units(4.0e10, 'g*erg/(cm**2*s)'))
66:                 ? ++++
```

Change the scale calculation to use
the total state

```
In [8]: run(['yamls/shoot_v3.yml', 'yamls/roots_v1.yml', 'yamls/light_v1_python.yml', 'yamls/timesync.yml'], production_run=True)
```

```
In [8]: run(['yamls/shoot_v3.yml', 'yamls/roots_v1.yml', 'yamls/light_v1_python.yml', 'yamls/timesync.yml'], production_run=True)
```

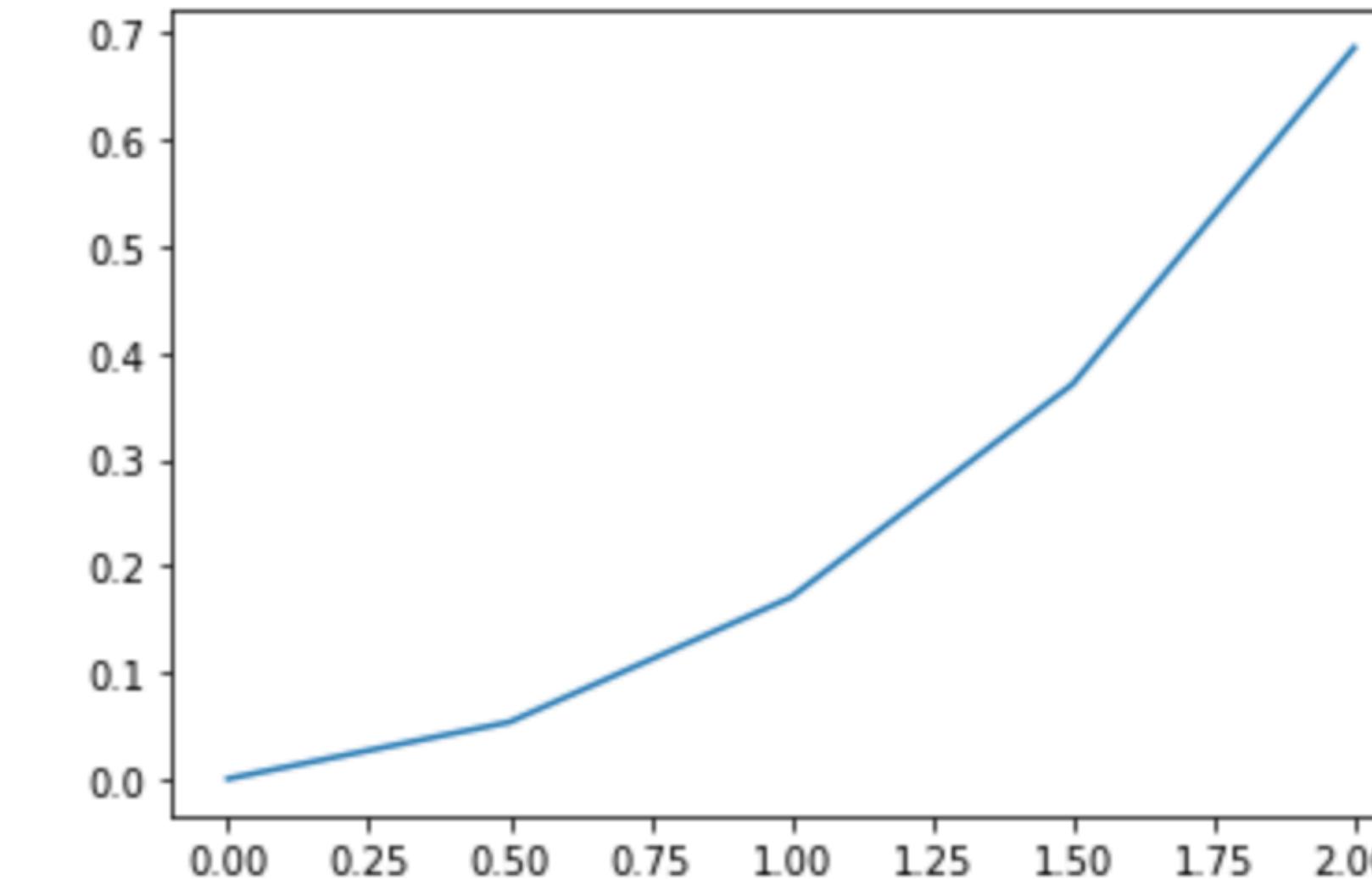
```
INFO:96257:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/ygg  
_light_v0.py  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/sho  
ot_v3.py 0.0 48.0 6.0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/roo  
ts_v1.py 0.0 2.0 0.5  
End of input from temp_doy.  
INFO:96257:runner.waitModels[553]:YggRunner(runner): shoot finished running.  
No more messages from model process.  
INFO:96257:DSLModelDriver.after_loop[131]:TimeSyncModelDriver(shoot2root): returncode = 0  
INFO:96257:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.  
INFO:96257:runner.waitModels[553]:YggRunner(runner): light finished running.  
INFO:96257:runner.waitModels[559]:YggRunner(runner): light finished exiting.  
INFO:96257:runner.waitModels[553]:YggRunner(runner): roots finished running.  
INFO:96257:runner.waitModels[559]:YggRunner(runner): roots finished exiting.  
INFO:96257:runner.waitModels[553]:YggRunner(runner): shoot2root finished running.  
INFO:96257:runner.waitModels[559]:YggRunner(runner): shoot2root finished exiting.  
INFO:96257:runner.waitModels[573]:YggRunner(runner): All models completed  
INFO:96257:runner.run[374]:YggRunner(runner): init 0.000001  
INFO:96257:runner.run[374]:YggRunner(runner): load drivers 0.051068  
INFO:96257:runner.run[374]:YggRunner(runner): start drivers 0.303378  
INFO:96257:runner.run[374]:YggRunner(runner): run models 19.234870  
INFO:96257:runner.run[374]:YggRunner(runner): at exit 0.117888  
INFO:96257:runner.run[376]:YggRunner(runner): =====  
INFO:96257:runner.run[377]:YggRunner(runner): Total 19.707205
```

```
In [8]: run(['yamls/shoot_v3.yml', 'yamls/roots_v1.yml', 'yamls/light_v1_python.yml', 'yamls/timesync.yml'], production_run=True)
```

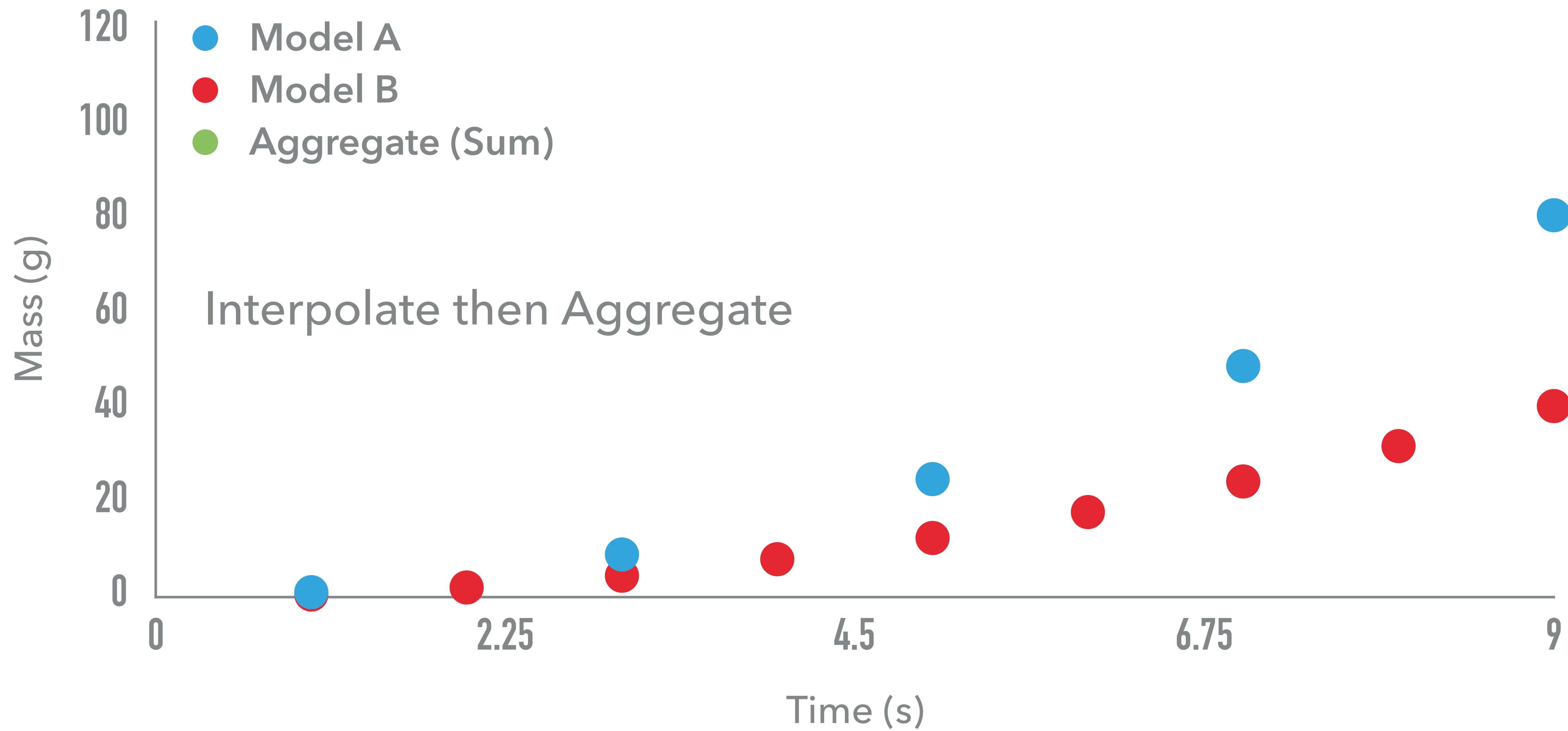
```
INFO:96257:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system Meagans-MacBook-Air.  
local in namespace yggdrasil with rank 0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/ygg  
_light_v0.py  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/sho  
ot_v3.py 0.0 48.0 6.0  
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/Cis2021-hackathon/models/roo  
ts_v1.py 0.0 2.0 0.5  
End of input from temp_doy.  
INFO:96257:runner.waitModels[553]:YggRunner(runner): sho  
No more messages from model process.  
INFO:96257:DSLModelDriver.after_loop[131]:TimeSyncModelD  
INFO:96257:runner.waitModels[559]:YggRunner(runner): sho  
INFO:96257:runner.waitModels[553]:YggRunner(runner): lig  
INFO:96257:runner.waitModels[559]:YggRunner(runner): lig  
INFO:96257:runner.waitModels[553]:YggRunner(runner): roo  
INFO:96257:runner.waitModels[559]:YggRunner(runner): roo  
INFO:96257:runner.waitModels[553]:YggRunner(runner): sho  
INFO:96257:runner.waitModels[559]:YggRunner(runner): sho  
INFO:96257:runner.waitModels[573]:YggRunner(runner): All  
INFO:96257:runner.run[374]:YggRunner(runner):  
INFO:96257:runner.run[374]:YggRunner(runner):          lo  
INFO:96257:runner.run[374]:YggRunner(runner):          sta  
INFO:96257:runner.run[374]:YggRunner(runner):  
INFO:96257:runner.run[374]:YggRunner(runner):  
INFO:96257:runner.run[376]:YggRunner(runner): ======  
INFO:96257:runner.run[377]:YggRunner(runner):
```

```
In [9]: import matplotlib.pyplot as plt  
filename_masses = 'output/masses.pkl'  
with open(filename_masses, 'rb') as fd:  
    masses = pickle.load(fd)  
plt.plot(masses['times'], masses['masses'])
```

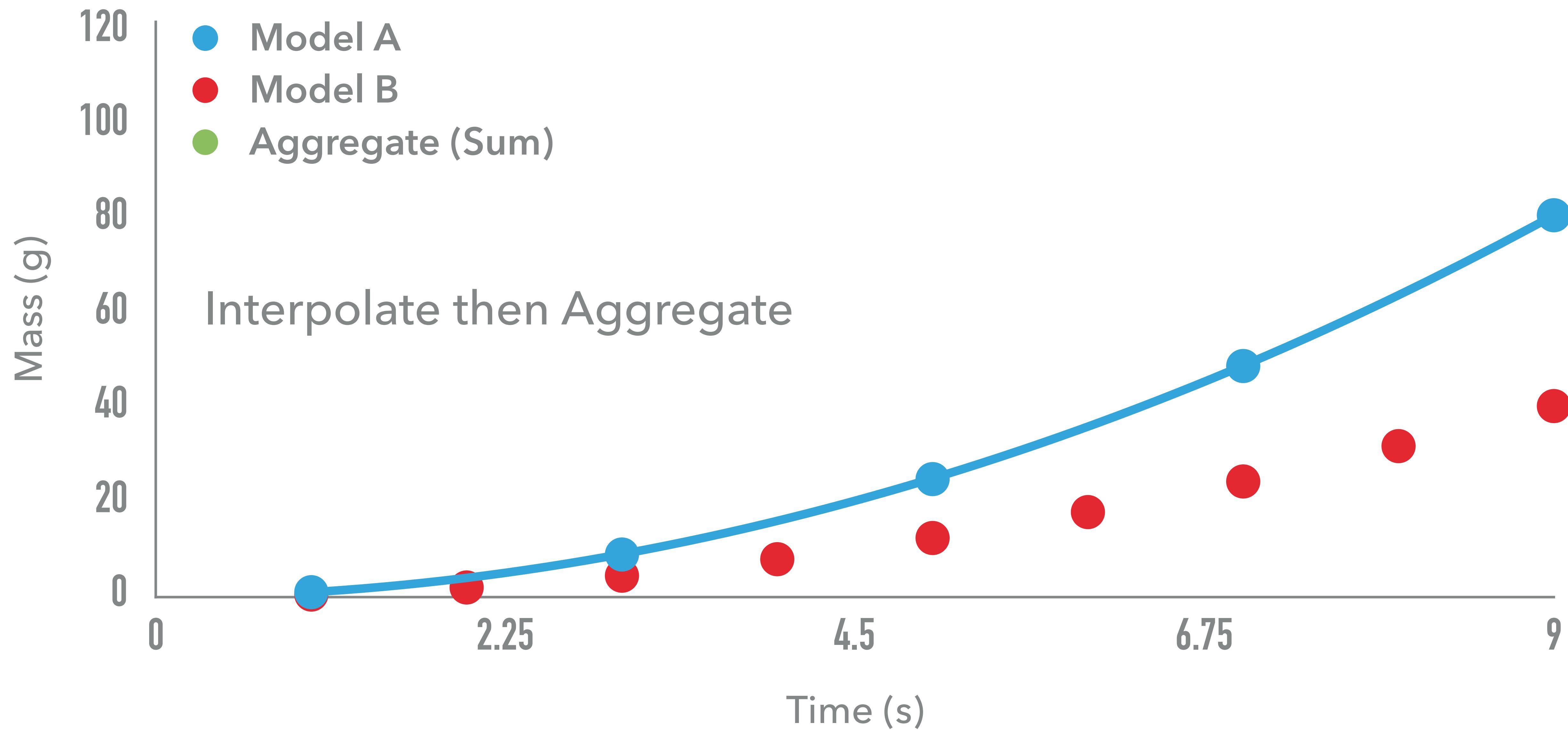
```
Out[9]: <matplotlib.lines.Line2D at 0x147d40048>
```



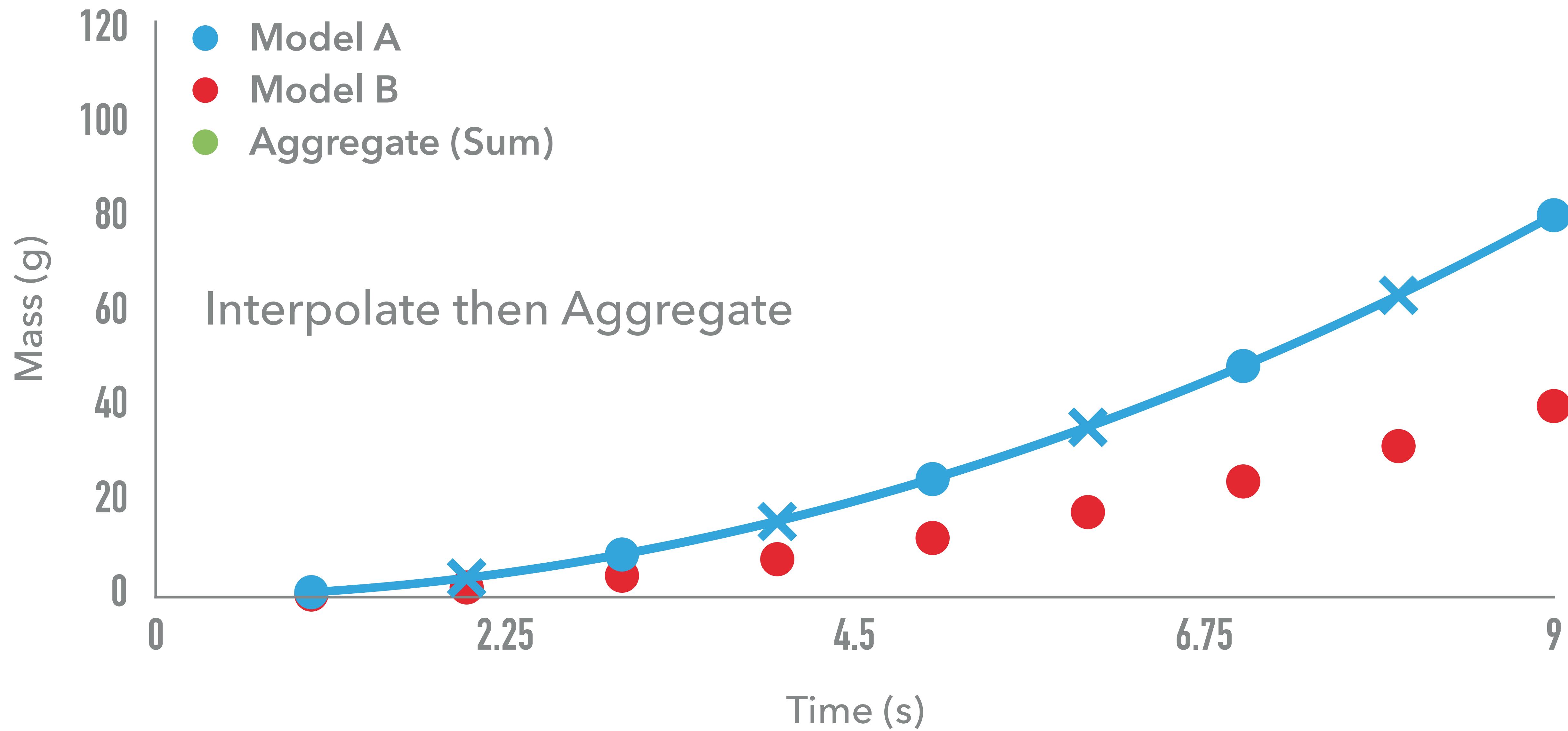
AGGREGATION OF TIME STEPS



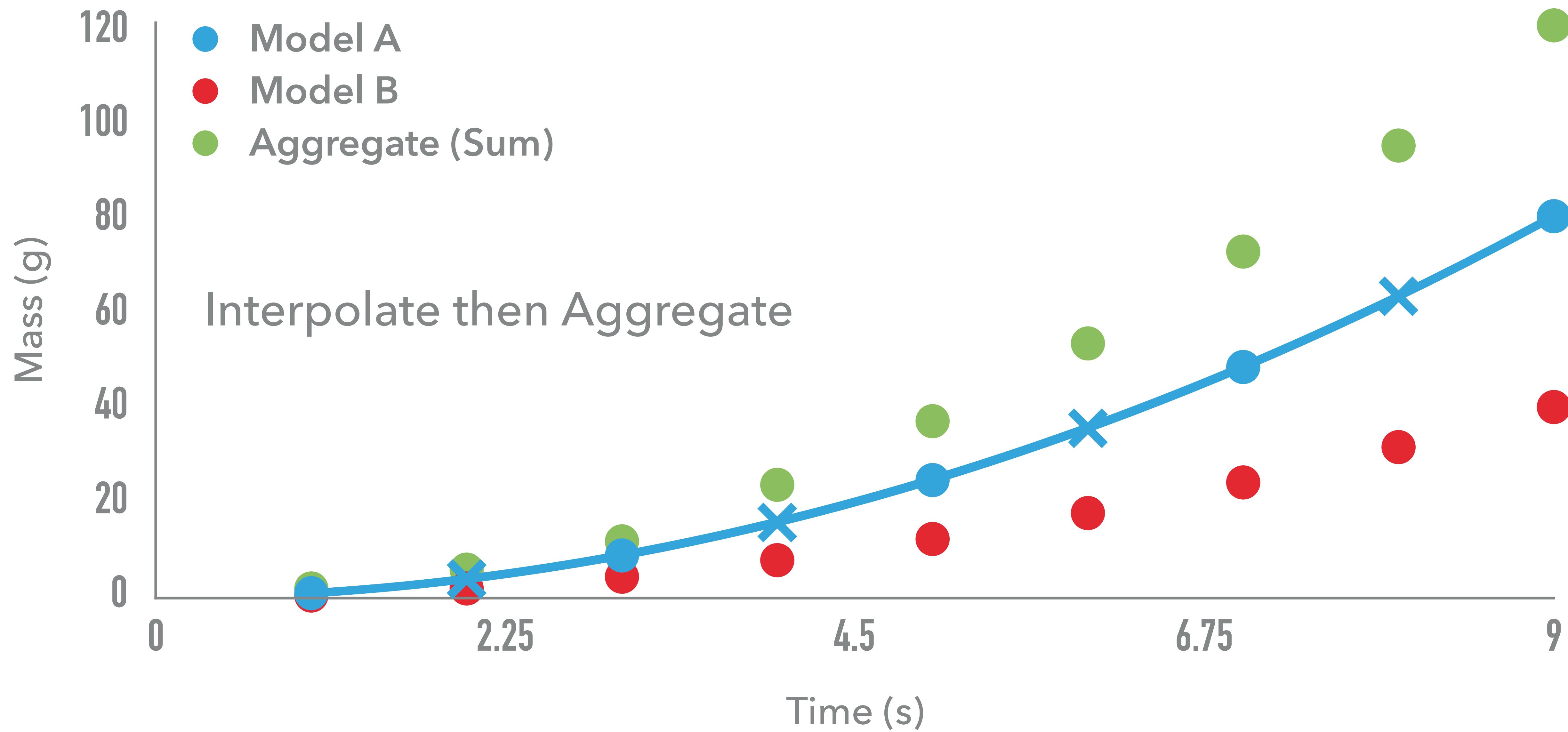
AGGREGATION OF TIME STEPS



AGGREGATION OF TIME STEPS



AGGREGATION OF TIME STEPS



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IMPORTING MODELS AS PYTHON FUNCTIONS

```
In [1]: from yggdrasil import tools
tools.display_source('models/light_v0.f90', number_lines=True)
tools.display_source('yamls/light_v0_fortran.yml', number_lines=True)
```

```
In [1]: from yggdrasil import tools
```

```
tools.display_source('models/light_v0.f90', number_lines=True)
tools.display_source('yamls/light_v0_fortran.yml', number_lines=True)
```

```
file: models/light_v0.f90
=====
1: !-----
2: !> @brief Compute the intensity of light.
3: !
4: !> @param[in] doy: Day of year.
5: !> @param[in] height: Distance from ground in cm.
6: !
7: !> @return intensity: Intensity of light in ergs cm^-2 s^-1.
8: !-----
9: function light(doy, height) result(intensity)
10:    real(kind=8) :: doy
11:    real(kind=8) :: height
12:    real(kind=8) :: intensity
13:    real, parameter :: Pi = 3.1415927
14:
15:    ! Define parameters that are static across a run
16:    real, parameter :: amplitude = 80.0
17:    real, parameter :: doy_offset = 0.0
18:
19:    ! Calculate intensity
20:    intensity = amplitude * height * (1.0 + SIN(2.0 * Pi * (doy - doy_offset) / 365))
21: end function light
```

```
In [1]: from yggdrasil import tools
tools.display_source('models/light_v0.f90', number_lines=True)
tools.display_source('yamls/light_v0_fortran.yml', number_lines=True)

file: models/light_v0.f90
=====
1: !-----
2: !> @brief Compute the intensity of light.
3: !
4: !> @param[in] doy: Day of year.
5: !> @param[in] height: Distance from ground in cm.
6: !
7: !> @return intensity: Intensity of light in ergs cm^-2 s^-1.
8: !-----
9: function light(doy, height) result(intensity)
10:    real(kind=8) :: doy
11:    real(kind=8) :: height
12:    real(kind=8) :: intensity
13:    real, parameter :: Pi = 3.1415927
14:
15:    ! Define parameters that are static across a run
16:    real, parameter :: amplitude = 80.0
17:    real, parameter :: doy_offset = 0.0
18:
19:    ! Calculate intensity
20:    intensity = amplitude * height * (1.0 + SIN(2.0 * Pi * (doy - doy_offset) / 365))
21: end function light

file: yamls/light_v0_fortran.yml
=====
1: model:
2:   name: light
3:   language: fortran
4:   args: ../models/light_v0.f90
5:   function: light
6:   inputs:
7:     - name: input
8:       vars: [doy, height]
9:       datatype:
10:         type: array
11:         items:
12:           - type: float
13:             units: day
14:           - type: float
15:             units: cm
16:   output:
17:     - name: output
18:       datatype:
19:         type: float
20:         units: ergs/(cm**2*s)
```

```
In [2]: from yggdrasil import import_as_function  
light = import_as_function('yamls/light_v0_fortran.yml')
```

Model can be called from Python regardless of the language

```
In [2]: from yggdrasil import import_as_function
```

```
light = import_as_function('yamls/light_v0_fortran.yml')
```

```
INFO:97475:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system None in namespace yg  
gdrasil with rank 0  
/Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg_light_v0_f90_gfortranx_gfortranx.out  
INFO:97475:runner.run[374]:YggRunner(runner):           init      0.000001  
INFO:97475:runner.run[374]:YggRunner(runner):           load drivers    0.828631  
INFO:97475:runner.run[374]:YggRunner(runner):           start drivers   0.061332  
INFO:97475:runner.run[376]:YggRunner(runner): =====  
INFO:97475:runner.run[377]:YggRunner(runner):           Total      0.889964
```

Model can be called from Python regardless of the language

```
In [2]: from yggdrasil import import_as_function
```

```
light = import_as_function('yamls/light_v0_fortran.yml')
```

```
INFO:97475:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system None in namespace yg  
gdrasil with rank 0
```

```
/Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg_light_v0_f90_gfortranx_gfortranx.out
```

```
INFO:97475:runner.run[374]:YggRunner(runner):           init      0.000001
```

```
INFO:97475:runner.run[374]:YggRunner(runner):       load drivers    0.828631
```

```
INFO:97475:runner.run[374]:YggRunner(runner):      start drivers   0.061332
```

```
INFO:97475:runner.run[376]:YggRunner(runner): =====
```

```
INFO:97475:runner.run[377]:YggRunner(runner):           Total      0.889964
```

```
In [3]: light.model_info()
```

Model can be called from Python regardless of the language

```
In [2]: from yggdrasil import import_as_function
```

```
light = import_as_function('yamls/light_v0_fortran.yml')
```

```
INFO:97475:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system None in namespace yg  
gdrasil with rank 0
```

```
/Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg_light_v0_f90_gfortranx_gfortranx.out
```

```
INFO:97475:runner.run[374]:YggRunner(runner):           init      0.000001
```

```
INFO:97475:runner.run[374]:YggRunner(runner):       load drivers    0.828631
```

```
INFO:97475:runner.run[374]:YggRunner(runner):      start drivers   0.061332
```

```
INFO:97475:runner.run[376]:YggRunner(runner): =====
```

```
INFO:97475:runner.run[377]:YggRunner(runner):           Total      0.889964
```

```
In [3]: light.model_info()
```

```
Models: light
```

```
Inputs:
```

```
    light:input_to_light:input (vars=['doy', 'height'])
```

```
Outputs:
```

```
    light:output (vars=['intensity'])
```

Model can be called from Python regardless of the language

```
In [4]: print(light(100.0, 100.0))
print(light(1.0, 2.9))
print(light(2.0, 3.0))
```

```
In [4]: print(light(100.0, 100.0))
print(light(1.0, 2.9))
print(light(2.0, 3.0))
```

```
{'intensity': unyt_quantity(15909.42066435, 'erg/(cm**2*s)' )}
{'intensity': unyt_quantity(235.99349874, 'erg/(cm**2*s)' )}
{'intensity': unyt_quantity(248.26118702, 'erg/(cm**2*s)' )}
```

Model units are assumed if not provided

```
In [4]: print(light(100.0, 100.0))
print(light(1.0, 2.9))
print(light(2.0, 3.0))
```

```
{'intensity': unyt_quantity(15909.42066435, 'erg/(cm**2*s)' )}
{'intensity': unyt_quantity(235.99349874, 'erg/(cm**2*s)' )}
{'intensity': unyt_quantity(248.26118702, 'erg/(cm**2*s)' )}
```

Model units are assumed if not provided

```
In [5]: from yggdrasil import units
print(light(units.add_units(24.0, 'hrs'), units.add_units(2.9, 'cm')))
print(light(units.add_units(1.0, 'days'), units.add_units(0.029, 'm')))
```

```
In [4]: print(light(100.0, 100.0))
print(light(1.0, 2.9))
print(light(2.0, 3.0))
```

```
{'intensity': unyt_quantity(15909.42066435, 'erg/(cm**2*s)')}
{'intensity': unyt_quantity(235.99349874, 'erg/(cm**2*s)')}
{'intensity': unyt_quantity(248.26118702, 'erg/(cm**2*s)')}
```

Model units are assumed if not provided

```
In [5]: from yggdrasil import units
print(light(units.add_units(24.0, 'hrs'), units.add_units(2.9, 'cm')))
print(light(units.add_units(1.0, 'days'), units.add_units(0.029, 'm')))
```

```
{'intensity': unyt_quantity(235.99349874, 'erg/(cm**2*s)'})
{'intensity': unyt_quantity(235.99349874, 'erg/(cm**2*s)'})
```

If units are provided, yggdrasil can handle transformations to/from the model's units

OVERHEAD

```
In [7]: # Calculation using numpy in Python
```

```
import numpy as np  
%timeit np.sin(0.0)
```

Yggdrasil wrapped models can't outperform the direct call

```
In [7]: # Calculation using numpy in Python
```

```
import numpy as np  
%timeit np.sin(0.0)
```

```
2.76 µs ± 274 ns per loop (mean ± std. dev. of 7 runs, 100000 loops each)
```

Yggdrasil wrapped models can't outperform the direct call

```
In [7]: # Calculation using numpy in Python
import numpy as np
%timeit np.sin(0.0)
```

```
2.76 µs ± 274 ns per loop (mean ± std. dev. of 7 runs, 100000 loops each)
```

```
In [8]: # Calculation calling numpy in Python via yggdrasil
sine_python = import_as_function('yamls/sine_model_python.yml')
%timeit sine_python(0.0)
sine_python.stop()
```

Yggdrasil wrapped models can't outperform the direct call

```
In [7]: # Calculation using numpy in Python
```

```
import numpy as np  
%timeit np.sin(0.0)
```

```
2.76 µs ± 274 ns per loop (mean ± std. dev. of 7 runs, 100000 loops each)
```

```
In [8]: # Calculation calling numpy in Python via yggdrasil
```

```
sine_python = import_as_function('yamls/sine_model_python.yml')  
%timeit sine_python(0.0)  
sine_python.stop()
```

```
INFO:63595:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system None in namespace yg  
gdrasil with rank 0
```

```
/Users/langmm/miniconda3/envs/conda36/bin/python /Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg  
_sine_model.py
```

```
INFO:63595:runner.run[374]:YggRunner(runner):           init      0.000002
```

```
INFO:63595:runner.run[374]:YggRunner(runner):       load drivers    0.035941
```

```
INFO:63595:runner.run[374]:YggRunner(runner):      start drivers    0.092159
```

```
INFO:63595:runner.run[376]:YggRunner(runner): =====
```

```
INFO:63595:runner.run[377]:YggRunner(runner):           Total      0.128102
```

```
186 ms ± 43.1 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
```

```
End of input from x.
```

```
INFO:63595:runner.waitModels[553]:YggRunner(runner): sine_model finished running.
```

```
INFO:63595:runner.waitModels[559]:YggRunner(runner): sine_model finished exiting.
```

```
INFO:63595:runner.waitModels[553]:YggRunner(runner): function_model finished running.
```

```
INFO:63595:runner.waitModels[559]:YggRunner(runner): function_model finished exiting.
```

```
INFO:63595:runner.waitModels[573]:YggRunner(runner): All models completed
```

Yggdrasil wrapped models can't outperform the direct call

```
In [9]: # Calculation calling the fortran SIN function via yggdrasil
sine_fortran = import_as_function('yamls/sine_model_fortran.yml')
%timeit sine_fortran(0.0)
sine_fortran.stop()
```

Method	Time (ms)
Direct Python	0.00276
Python via Yggdrasil	186
Fortran via Yggdrasil	337

Yggdrasil wrapped models can't outperform the direct call

```
In [9]: # Calculation calling the fortran SIN function via yggdrasil
sine_fortran = import_as_function('yamls/sine_model_fortran.yml')
%timeit sine_fortran(0.0)
sine_fortran.stop()
```

Method	Time (ms)
Direct Python	0.00276
Python via Yggdrasil	186
Fortran via Yggdrasil	337

Extreme example (highly optimized function, no parallelism, etc.), but useful demonstration.

Yggdrasil wrapped models can't outperform the direct call

```
In [9]: # Calculation calling the fortran SIN function via yggdrasil
sine_fortran = import_as_function('yamls/sine_model_fortran.yml')
%timeit sine_fortran(0.0)
sine_fortran.stop()
```

```
INFO:63595:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system None in namespace yg
gdrasil with rank 0
/Users/langmm/yggdrasil/yggdrasil/demos/CiS2021-hackathon/models/ygg_sine_model_f90_gfortranx_gfortranx.out
INFO:63595:runner.run[374]:YggRunner(runner):           init      0.000015
INFO:63595:runner.run[374]:YggRunner(runner):           load drivers    1.385137
INFO:63595:runner.run[374]:YggRunner(runner):           start drivers   0.118329
INFO:63595:runner.run[376]:YggRunner(runner): =====
INFO:63595:runner.run[377]:YggRunner(runner):           Total      1.503481
337 ms ± 32.7 ms per loop (mean ± std. dev. of 7 runs, 1 loop each)
End of input from yggarg(x).
INFO:63595:runner.waitModels[553]:YggRunner(runner): sine_model finished running.
INFO:63595:runner.waitModels[559]:YggRunner(runner): sine_model finished exiting.
INFO:63595:runner.waitModels[553]:YggRunner(runner): function_model finished running.
INFO:63595:runner.waitModels[559]:YggRunner(runner): function_model finished exiting.
INFO:63595:runner.waitModels[573]:YggRunner(runner): All models completed
```

Method	Time (ms)
Direct Python	0.00276
Python via Yggdrasil	186
Fortran via Yggdrasil	337

Extreme example (highly optimized function, no parallelism, etc.), but useful demonstration.

Yggdrasil wrapped models can't outperform the direct call

COMPIRATION VIA BUILD TOOLS

Yggdrasil can inject compilation flags to existing builds that use build tools like make & cmake

```
In [10]: tools.display_source('yamls/roots_v1_c.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_make.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_cmake.yml', number_lines=True)

file: yamls/roots_v1_c.yml
=====
1: model:
2:   name: roots
3:   language: c
4:   args: [../models/roots_v1.c, 0.0, 2.0, 0.5]
5:   timesync: shoot2root
```

Yggdrasil can inject compilation flags to existing builds that use build tools like make & cmake

```
In [10]: tools.display_source('yamls/roots_v1_c.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_make.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_cmake.yml', number_lines=True)

file: yamls/roots_v1_c.yml
=====
1: model:
2:   name: roots
3:   language: c
4:   args: [../models/roots_v1.c, 0.0, 2.0, 0.5]
5:   timesync: shoot2root
```

Yggdrasil can inject compilation flags to existing builds that use build tools like make & cmake

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In [10]: tools.display_source('yamls/roots_v1_c.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_make.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_cmake.yml', number_lines=True)
```

```
file: yamls/roots_v1_c.yml
=====
1: model:
2:   name: roots
3:   language: c
4:   args: [../models/roots_v1.c, 0.0, 2.0, 0.5]
5:   timesync: shoot2root
```

```
file1: yamls/roots_v1_c.yml
file2: yamls/roots_v1_make.yml
=====
1: model:
2:   name: roots
-   language: c
?
^

3: + language: make
?
^^^

4: + target: roots_v1
5:   args: [../models/roots_v1.c, 0.0, 2.0, 0.5]
6:   timesync: shoot2root
```

Yggdrasil can inject compilation flags to existing builds that use build tools like make & cmake

```
In [10]: tools.display_source('yamls/roots_v1_c.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_make.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_cmake.yml', number_lines=True)
```

```
file: yamls/roots_v1_c.yml
=====
1: model:
2:   name: roots
3:   language: c
4:   args: [../models/roots_v1.c, 0.0, 2.0, 0.5]
5:   timesync: shoot2root
```

```
file1: yamls/roots_v1_c.yml
file2: yamls/roots_v1_make.yml
=====
1: model:
2:   name: roots
3:   - language: c
4:   ?
5:   +
6:   + language: make
7:   ?
8:   +
9:   + target: roots_v1
10:  args: [../models/roots_v1.c, 0.0, 2.0, 0.5]
11:  timesync: shoot2root
```

Yggdrasil can inject compilation flags to existing builds that use build tools like make & cmake

```
In [10]: tools.display_source('yamls/roots_v1_c.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_make.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_cmake.yml', number_lines=True)
```

```
file: yamls/roots_v1_c.yml
=====
1: model:
2:   name: roots
3:   language: c
4:   args: [../../models/roots_v1.c, 0.0, 2.0, 0.5]
5:   timesync: shoot2root
```

```
file1: yamls/roots_v1_c.yml
file2: yamls/roots_v1_make.yml
=====
1: model:
2:   name: roots
3:   - language: c
4:   ?
5: + language: make
6: ?
7: + target: roots_v1
8: args: [../../models/roots_v1.c, 0.0, 2.0, 0.5]
9: timesync: shoot2root
```

```
file1: yamls/roots_v1_c.yml
file2: yamls/roots_v1_cmake.yml
=====
1: model:
2:   name: roots
3:   - language: c
4: + language: cmake
5: ?
6: + target: roots_v1
7: args: [../../models/roots_v1.c, 0.0, 2.0, 0.5]
8: timesync: shoot2root
```

Yggdrasil can inject compilation flags to existing builds that use build tools like make & cmake

```
In [10]: tools.display_source('yamls/roots_v1_c.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_make.yml', number_lines=True)
tools.display_source_diff('yamls/roots_v1_c.yml', 'yamls/roots_v1_cmake.yml', number_lines=True)
```

```
file: yamls/roots_v1_c.yml
=====
1: model:
2:   name: roots
3:   language: c
4:   args: [../../models/roots_v1.c, 0.0, 2.0, 0.5]
5:   timesync: shoot2root
```

```
file1: yamls/roots_v1_c.yml
file2: yamls/roots_v1_make.yml
=====
1: model:
2:   name: roots
3:   - language: c
4:   ?
5:   + language: make
6:   ?
7:   + target: roots_v1
8:   args: [../../models/roots_v1.c, 0.0, 2.0, 0.5]
9:   timesync: shoot2root
```

```
file1: yamls/roots_v1_c.yml
file2: yamls/roots_v1_cmake.yml
=====
1: model:
2:   name: roots
3:   - language: c
4:   +
5:     language: cmake
6:   ?
7:   + target: roots_v1
8:   args: [../../models/roots_v1.c, 0.0, 2.0, 0.5]
9:   timesync: shoot2root
```

**TEST YOUR
KNOWLEDGE (10 MIN)**

COMMAND LINE INTERFACE (CLI)

COMMAND LINE INTERFACE (CLI)

Run yggdrasil integration from the command line w/o opening Python

COMMAND LINE INTERFACE (CLI)

Run yggdrasil integration from the command line w/o opening Python

The screenshot shows a Jupyter Notebook interface with the following elements:

- Header:** "jupyter" logo, "Visit repo", "Copy Binder link", and "Quit" buttons.
- Navigation:** "Files", "Running", "Clusters", and "Nbextensions" tabs. The "Running" tab is selected.
- File Browser:** A table listing files and folders in the current directory. The table includes columns for selection, name, last modified, and file size.
- Table Data:**

	Name	Last Modified	File size
<input type="checkbox"/>	0		
<input type="checkbox"/>	meshes	6 hours ago	
<input type="checkbox"/>	models	6 hours ago	
<input type="checkbox"/>	output	6 hours ago	
<input type="checkbox"/>	yamls	6 hours ago	
<input type="checkbox"/>	yggdrasil	6 hours ago	
<input type="checkbox"/>	plant.ipynb	6 hours ago	17.4 kB
<input type="checkbox"/>	environment.yml	6 hours ago	168 B
<input type="checkbox"/>	LICENSE	6 hours ago	1.52 kB
<input type="checkbox"/>	postBuild	6 hours ago	202 B
<input type="checkbox"/>	README.md	6 hours ago	486 B
<input type="checkbox"/>	utils.py	6 hours ago	4.3 kB

COMMAND LINE INTERFACE (CLI)

Run yggdrasil integration from the command line w/o opening Python

The screenshot shows the Jupyter Notebook interface. At the top, there is a navigation bar with tabs for "Files", "Running", "Clusters", and "Nbextensions". On the right side of the header, there are "Quit" and "Logout" buttons. Below the header, a message says "Select items to perform actions on them." To the right of this message is a file browser sidebar with a tree view of files and folders: "0", "images", "input", "meshes", "models", "output", and "yamls". A tooltip for the "New" button in the sidebar lists options: "Notebook: Python 3", "Other: Text File", "Folder", and "Terminal". The main area displays a list of files and their details:

File	Last Modified	Size
00-intro.ipynb	3 hours ago	457 kB
01-connections.ipynb	2 hours ago	470 kB
02-timesync.ipynb	5 days ago	298 kB
03-misc.ipynb	5 days ago	3.56 kB
environment.yml	9 days ago	169 B
LICENSE	9 days ago	1.52 kB
postBuild	2 hours ago	290 B

COMMAND LINE INTERFACE (CLI)

Run yggdrasil integration from the command line w/o opening Python

The screenshot shows the Jupyter Notebook interface. At the top, there is a navigation bar with tabs: 'Files' (selected), 'Running', 'Clusters', and 'Nbextensions'. On the right side of the header, there are 'Quit' and 'Logout' buttons. Below the header, a sidebar displays a file tree with directories like 'images', 'input', 'meshes', 'models', 'output', and 'yamls', along with several Jupyter notebooks and configuration files. To the right of the file tree, a 'New' button is open, showing a dropdown menu with options: 'Notebook:' (set to 'Python 3'), 'Other:' (set to 'Text File'), 'Folder', and 'Terminal'. The 'Terminal' option is circled in red.

File Type	Name	Status	Modified	Size
Folder	/			
Folder	images			
Folder	input			
Folder	meshes			
Folder	models			
Folder	output		5 days ago	
Folder	yamls		5 days ago	
Notebook	00-intro.ipynb	Running	3 hours ago	457 kB
Notebook	01-connections.ipynb	Running	2 hours ago	470 kB
Notebook	02-timesync.ipynb		5 days ago	298 kB
Notebook	03-misc.ipynb		5 days ago	3.56 kB
Environment	environment.yml		9 days ago	169 B
File	LICENSE		9 days ago	1.52 kB
File	postBuild		2 hours ago	290 B

COMMAND LINE INTERFACE (CLI)

Run yggdrasil integration from the command line w/o opening Python



jupyter

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```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2d9y79y126:~$
```

COMMAND LINE INTERFACE (CLI)

Run yggdrasil integration from the command line w/o opening Python



jupyter

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```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2d9y79y126:~$ yggrun -h
```

COMMAND LINE INTERFACE (CLI)

Run yggdrasil integration from the command line w/o opening Python

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```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2d9y79y126:~$ yggrun -h
usage: Run an integration. [-h] [--loglevel LOGLEVEL] [--rmq-loglevel RMQ_LOGLEVEL] [--client-loglevel CLIENT_LOGLEVEL]
                           [--validate-components] [--validate-messages {False,True,First}] [--namespace NAMESPACE]
                           [--host HOST] [--vhost VHOST] [--user USER] [--password PASSWORD] [--cluster CLUSTER]
                           [--default-comm DEFAULT_COMM] [--production-run] [--debug]
                           yamlfile [yamlfile ...]

positional arguments:
  yamlfile            One or more yaml specification files.

optional arguments:
  -h, --help          show this help message and exit
  --loglevel LOGLEVEL    Logging level for yggdrasil operations.
  --rmq-loglevel RMQ_LOGLEVEL, --rmqloglevel RMQ_LOGLEVEL
                        Logging level for RabbitMQ operations.
  --client-loglevel CLIENT_LOGLEVEL, --clientloglevel CLIENT_LOGLEVEL
                        Logging level for yggdrasil operations on model processes.
  --validate-components, --validatecomponents
                        Validate components on creation using their JSON schema (Decreases performance).
  --validate-messages {False,True,First}, --validatemessages {False,True,First}
                        Which messages should be validated during communication. 'True': all messages (decreases
                        performance), 'False': no messages, or 'First': only the first message a comm sends/receives.
  --namespace NAMESPACE
                        RabbitMQ namespace.
  --host HOST
                        RabbitMQ host address.
  --vhost VHOST
                        RabbitMQ virtual host address.
  --user USER
                        RabbitMQ username.
  --password PASSWORD
                        RabbitMQ password.
  --cluster CLUSTER
                        Cluster that should be used.
  --default-comm DEFAULT_COMM, --defaultcomm DEFAULT_COMM
                        Comm type that should be used by default.
```

COMMAND LINE INTERFACE (CLI)

Run yggdrasil integration from the command line w/o opening Python

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```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2d9y79y126:~$ yggrun yaml/shoot_v3.yml yaml/roots_v1.yml yaml/light_v1_python.yml yaml/timesync.yml --production-run
```

COMMAND LINE INTERFACE (CLI)

Run yggdrasil integration from the command line w/o opening Python

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```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2d9y79yl26:~$ yggrun yaml/shoot_v3.yml yaml/roots_v1.yml yaml/light_v1_python.yml yaml/timesync.yml --production-run
INFO:1423:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system jupyter-cropsinsilico-2dcis
2021-2dhackathon-2d9y79yl26 in namespace yggdrasil with rank 0
/srv/conda/envs/notebook/bin/python /home/jovyan/models/ygg_light_v0.py
/srv/conda/envs/notebook/bin/python /home/jovyan/models/shoot_v3.py 0.0 48.0 6.0
/srv/conda/envs/notebook/bin/python /home/jovyan/models/roots_v1.py 0.0 2.0 0.5
End of input from temp_doy.
timesync server: End of input.
INFO:1423:runner.waitModels[553]:YggRunner(runner): shoot finished running.
No more messages from model process.
INFO:1423:DSLModelDriver.after_loop[131]:TimeSyncModelDriver(shoot2root): returncode = 0
INFO:1423:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.
INFO:1423:runner.waitModels[553]:YggRunner(runner): light finished running.
INFO:1423:runner.waitModels[559]:YggRunner(runner): light finished exiting.
INFO:1423:runner.waitModels[553]:YggRunner(runner): roots finished running.
INFO:1423:runner.waitModels[559]:YggRunner(runner): roots finished exiting.
INFO:1423:runner.waitModels[553]:YggRunner(runner): shoot2root finished running.
INFO:1423:runner.waitModels[559]:YggRunner(runner): shoot2root finished exiting.
INFO:1423:runner.waitModels[573]:YggRunner(runner): All models completed
INFO:1423:runner.run[374]:YggRunner(runner):           init      0.000001
INFO:1423:runner.run[374]:YggRunner(runner):       load drivers    0.164377
INFO:1423:runner.run[374]:YggRunner(runner):     start drivers    0.372987
INFO:1423:runner.run[374]:YggRunner(runner):       run models    23.552745
INFO:1423:runner.run[374]:YggRunner(runner):         at exit     0.054842
INFO:1423:runner.run[376]:YggRunner(runner): =====
INFO:1423:runner.run[377]:YggRunner(runner):           Total     24.144952
```

```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2d9y79yl26:~$ █
```

“PRODUCTION RUN” FLAG

Speeds up execution by skipping type checking and input validation
(only used once integration has been debugged)

```
In [10]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2_split.yml'], production_run=True)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.show()
```

[Visit repo](#)[Copy Binder link](#)

```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2d9y79y126:~$ yggrun yamls/
yamls/roots_v1.yml yamls/light_v
1_python.yml yamls/timesync.yml --production-run
INFO:1423:runner.startDrivers[499]:YggRunner(runner): Starting I/O drivers and models on system jupyter-cropsinsilico-2dcis
2021-2dhackathon-2d9y79y126 in namespace yggdrasil with rank 0
/srv/conda/envs/notebook/bin/python /home/jovyan/models/ygg_light_v0.py
/srv/conda/envs/notebook/bin/python /home/jovyan/models/shoot_v3.py 0.0 48.0 6.0
/srv/conda/envs/notebook/bin/python /home/jovyan/models/roots_v1.py 0.0 2.0 0.5
End of input from temp_doy.
timesync server: End of input.
INFO:1423:runner.waitModels[553]:YggRunner(runner): shoot finished running.
No more messages from model process.
INFO:1423:DSLModelDriver.after_loop[131]:TimeSyncModelDriver(shoot2root): returncode = 0
INFO:1423:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.
INFO:1423:runner.waitModels[553]:YggRunner(runner): light finished running.
```

“PRODUCTION RUN” FLAG

Speeds up execution by skipping type checking and input validation
(only used once integration has been debugged)

```
In [10]: run(['yamls/light_v1_python.yml', 'yamls/shoot_v2_split.yml'], production_run=True)
mesh = trimesh.load_mesh('output/mesh_008.obj')
mesh.show()
```

[Visit repo](#)[Copy Binder link](#)

```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2d9y79y126:~$ yggrun yamls/
yamls/roots_v1.yml yamls/light_v
1_python.yml yamls/timesync.yml --production-run
INFO:1423:runner.startDrivers[1]: YggRunner(runner): Starting I/O drivers and models on system jupyter-cropsinsilico-2dcis
2021-2dhackathon-2d9y79y126 in namespace yggdrasil with rank 0
/srv/conda/envs/notebook/bin/python /home/jovyan/models/ygg_light_v0.py
/srv/conda/envs/notebook/bin/python /home/jovyan/models/shoot_v3.py 0.0 48.0 6.0
/srv/conda/envs/notebook/bin/python /home/jovyan/models/roots_v1.py 0.0 2.0 0.5
End of input from temp_doy.
timesync server: End of input.
INFO:1423:runner.waitModels[553]:YggRunner(runner): shoot finished running.
No more messages from model process.
INFO:1423:DSLModelDriver.after_loop[131]:TimeSyncModelDriver(shoot2root): returncode = 0
INFO:1423:runner.waitModels[559]:YggRunner(runner): shoot finished exiting.
INFO:1423:runner.waitModels[553]:YggRunner(runner): light finished running.
INFO:1423:runner.waitModels[553]:YggRunner(runner): shoot finished exiting.
```

COMMAND LINE INTERFACE (CLI)

Validate sets of YAML files for integration



```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2dt1docu2r:~$ yggvalidate -h
```

[Visit repo](#)[Copy Binder link](#)

COMMAND LINE INTERFACE (CLI)

Validate sets of YAML files for integration



jupyter

[Visit repo](#)

[Copy Binder link](#)

```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2dt1docu2r:~$ yggvalidate -h
usage: Validate a set of YAML specification files for an integration. [-h] yamlfile [yamlfile ...]

positional arguments:
  yamlfile    One or more YAML specification files.

optional arguments:
  -h, --help    show this help message and exit
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2dt1docu2r:~$ █
```

COMMAND LINE INTERFACE (CLI)

Get information about the yggdrasil installation



```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2dt1docu2r:~$ ygginfo -h
```

[Visit repo](#)[Copy Binder link](#)

COMMAND LINE INTERFACE (CLI)

Get information about the yggdrasil installation

[Visit repo](#)[Copy Binder link](#)

```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2dt1docu2r:~$ ygginfo -h
usage: Display information about the current yggdrasil installation. [-h] [--no-languages]
                                                [--no-comms] [--verbose]
                                                {compiler,linker,archiver} ...

optional arguments:
  -h, --help            show this help message and exit
  --no-languages        Don't print information about individual languages.
  --no-comms           Don't print information about individual comms.
  --verbose, -v         Increase the verbosity of the printed information.

tool:
  Compilation tool types to get info about.

  {compiler,linker,archiver}
    compiler            Get information about a compiler.
    linker              Get information about a linker.
    archiver            Get information about a archiver.
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2dt1docu2r:~$ █
```

```
INFO:14976:command_line.func[667]:yggdrasil info:  
Location /Users/langmm/yggdrasil/yggdrasil  
Version v1.6.3+3.gc31f41f5b.dirty  
Languages matlab, c, cmake, cpp, make, osr, python, function, fortran, timesync, executable  
, R  
Communication Mechanisms zmq, ipc  
Default Comm Mechanism zmq  
Config File /Users/langmm/miniconda3/envs/conda36/.yggdrasil.cfg  
Installed Languages:  
R:  
  Location /Users/langmm/miniconda3/envs/conda36/bin/Rscript  
  Version R scripting front-end version 3.6.3 (2020-02-29)  
C:  
  Location /Users/langmm/miniconda3/envs/conda36/bin/clang  
  Version clang version 11.1.0  
CMAKE:  
  Location /Users/langmm/miniconda3/envs/conda36/bin/cmake  
  Version cmake version 3.20.1  
CPP:  
  Location /Users/langmm/miniconda3/envs/conda36/bin/x86_64-apple-darwin13.4.0-clang++  
  Version clang version 11.1.0  
EXECUTABLE:  
  Version Darwin-18.6.0-x86_64-i386-64bit  
FORTRAN:  
  Location /Users/langmm/miniconda3/envs/conda36/bin/x86_64-apple-darwin13.4.0-gfortran  
  Version GNU Fortran (GCC) 9.3.0  
FUNCTION:  
  Location None  
  Version 0  
MAKE:  
  Location /Users/langmm/miniconda3/envs/conda36/bin/make  
  Version GNU Make 4.3  
MATLAB:  
  Location /Applications/MATLAB_R2019a.app/bin/matlab  
  Version R2019a  
OSR:  
  Location /Users/langmm/OpenSimRoot/OpenSimRoot/StaticBuild/OpenSimRootYgg  
  Version Darwin-18.6.0-x86_64-i386-64bit  
PYTHON:  
  Location /Users/langmm/miniconda3/envs/conda36/bin/python  
  Version Python 3.6.13  
TIMESYNC:  
  Location None  
  Version None
```

Languages Not Installed:

SBML:

Language Installed	True
Base Languages Installed	True
Dependencies Installed	False
Dependencies Not Installed	['roadrunner']
Interface Installed	True
Comm Installed	True
Configured	True
Disabled	False

LPY:

Language Installed	True
Base Languages Installed	True
Dependencies Installed	False
Dependencies Not Installed	['openalea.lpy']
Interface Installed	True
Comm Installed	True
Configured	True
Disabled	False

Comms Available for All Languages:

IPC

ZMQ

Comms Available for Some/No Languages:

VALUE:

Available for	['PYTHON']
Not Available for	['C', 'CMAKE', 'CPP', 'FORTRAN', 'MAKE', 'MATLAB', 'R', 'TIMESYNC']

RMQ_ASYNC:

Available for	[]
Not Available for	['C', 'CMAKE', 'CPP', 'FORTRAN', 'MAKE', 'MATLAB', 'PYTHON', 'R', 'TIMESYNC']

BUFFER:

Available for	['PYTHON']
Not Available for	['C', 'CMAKE', 'CPP', 'FORTRAN', 'MAKE', 'MATLAB', 'R', 'TIMESYNC']

RMQ:

Available for	[]
Not Available for	['C', 'CMAKE', 'CPP', 'FORTRAN', 'MAKE', 'MATLAB', 'PYTHON', 'R', 'TIMESYNC']

COMMAND LINE INTERFACE (CLI)

Other utilities



```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2dt1docu2r:~$ yggdrasil -h
```

[Visit repo](#)[Copy Binder link](#)

COMMAND LINE INTERFACE (CLI)

Other utilities

[Visit repo](#)[Copy Binder link](#)

```
jovyan@jupyter-cropsinsilico-2dcis2021-2dhackathon-2dt1docu2r:~$ yggdrasil -h
usage: Command line interface for the yggdrasil package. [-h] [--version]
                                                {run,info,validate,compile,compile-deps,clean,
install,config,metaschema,schema,model-form-schema,dev-update,test,timing,gha}
                                                ...
optional arguments:
  -h, --help            show this help message and exit
  --version             show program's version number and exit

subcommands:
  {run,info,validate,compile,compile-deps,clean,install,config,metaschema,schema,model-form-schema,dev-
update,test,timing,gha}
    run                  Run an integration.
    info                Display information about the current yggdrasil installation.
    validate            Validate a set of YAML specification files for an integration.
    compile              Compile a program from source files for use in an yggdrasil integration.
    compile-deps        Compile yggdrasil dependency libraries. Existing libraries are first deleted.
    clean                Remove dependency libraries compiled by yggdrasil.
    install              Update the user config file.
    config               Regenerate the yggdrasil metaschema.
    schema               Regenerate the yggdrasil schema.
    model-form-schema   Save/print the JSON schema for generating the model specification form.
```

ADDITIONAL EXAMPLES

40+ EXAMPLES IN SUPPORTED LANGUAGES

Requirements

- Browser (tested on Google Chrome, Safari, Firefox)
- Github Account

Preparing for the hackathon

- Check that you can sign-in to Github, creating an account as necessary. We will be using Github Issues to track problems encountered during the hackathon.
- Try launching a mybinder instance by clicking on this  icon (or the link below).

It may take a few moments to initialize. If you encounter an error, open an issue and try with another browser. If you still cannot launch the binder, you can install the materials on your machine by following the instructions at one of the links below

- Local install (via conda)
- Docker container

<https://mybinder.org/v2/gh/cropsinsilico/CiS2021-hackathon/HEAD>

Useful links

- [Hackathon Repository](#)
- [Hackathon Documentation](#)
- [yggdrasil Repository](#)
- [yggdrasil Documentation](#)
- [Additional Examples](#)
- [Debugging Tips & Documented Errors](#)

40+ EXAMPLES IN SUPPORTED LANGUAGES

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- Github Account

Preparing for the hackathon

- Check that you can sign-in to Github, creating an account as necessary if you don't have one. This will help you track your progress and share your work with others.
- Try launching a mybinder instance by clicking on this [launch binder](#) button.

It may take a few moments to initialize. If you encounter an error, open the terminal and run the command `curl -L https://mybinder.org/v2/gh/cropsinsilico/CiS2021-hackathon/HEAD`. If you still cannot launch the binder, you can install the materials on your local machine by following the instructions in the README file.

- [Local install \(via conda\)](#)
- [Docker container](#)

<https://mybinder.org/v2/gh/cropsinsilico/CiS2021-hackathon/HEAD>

Useful links

- [Hackathon Repository](#)
- [Hackathon Documentation](#)
- [yggdrasil Repository](#)
- [yggdrasil Documentation](#)
- [Additional Examples](#)
- [Debugging Tips & Documented Errors](#)

The screenshot shows the yggdrasil documentation site at version v1.6.3. The top navigation bar includes a search bar labeled "Search docs". Below it is a "CONTENTS:" section with a list of topics: Overview, Installation, Getting started, Formatted I/O, Server/Client I/O, Autowrapping Model Functions, Notes on Autowrapping C/C++ Model Functions, Conditional I/O, Transformed I/O, Timestep Synchronization, YAML Files, Configuration Files, Units, C-Style Format Strings, Debugging, OpenMP Threading in Models, Examples, Advanced, and Development.

40+ EXAMPLES IN SUPPORTED LANGUAGES

[View page source](#)

Examples

Name	Description
SaM	One model that receives input from two files and sends output to one file in the temporary directory. The YAML uses the deprecated driver-based method to represent connections.
ascii_io	A single model that receives data from three input files and sends received messages to three output files. The first file is an unstructured ASCII text file, the second file is a table delimited ASCII table that is read row by row, and the third file is a table identical to the second that is read all at once.
backwards	A single model using the deprecated "Cis" versions of the interface.
conditional_io	Three models, A, B1, & B2, that conditionally pass messages. Model A receives input from a tab delimited table and sends output to both models B1 & B2. The outputs to models B1 & B2 only succeed if the data satisfies conditions described in the YAML. Output from both models B1 & B2 are sent to a tab delimited table.
fakeplant	Four models that can be run in isolation or as an integration. Each model approximates a simplified model of a process governing plant growth. When run in isolation each model receives input from a file and sends output to a file. In the larger integration, the canopy model receives input from three files (initial structure, time steps, and some growth parameters). For each time step received, the canopy model also receives a growth rate from the growth model, computes the new structure, and send the structure to the light model. The light model receives the ambient light level from a file, calculates the intensity for each element of the structure, and sends the output to the photosynthesis model. The photosynthesis model receives temperature and CO ₂ from files, calculates the photosynthesis rate, and sends the result to the growth model. The growth model calculates the growth rate and sends the output to the canopy model.
formatted_io1	Two models, A & B, that send/receive ASCII data (strings). Model A receives input from a file and then sends its output to model B. Model B receives input from model A and sends its output to a file.
formatted_io2	Two models, A & B, that send/receive rows of table data. Model A receives input from a file and then sends its output to model B. Model B receives input from model A and sends its output to a file.

INTEGRATION TIPS

1. DETERMINE THE COMMUNICATION PATTERN YOU WANT
2. WRITE THE MODEL YAML WITHOUT CONNECTIONS
3. WRITE A YAML WITH CONNECTIONS TO FILES (OR DUMMY MODELS) FOR TESTING
4. WRITE A YAML WITH CONNECTIONS BETWEEN MODELS

Materials: <https://github.com/cropsinsilico/CiS2021-hackathon>

QUESTIONS? MODELS?

Github: <https://github.com/cropsinsilico/yggdrasil>

Docs: <https://cropsinsilico.github.io/yggdrasil/>

Paper: <https://doi.org/10.1093/insilicoplants/diz001>

Project Website: <http://cropsinsilico.org/>