Quakeworx Kick-off workshop
Tandem demonstration

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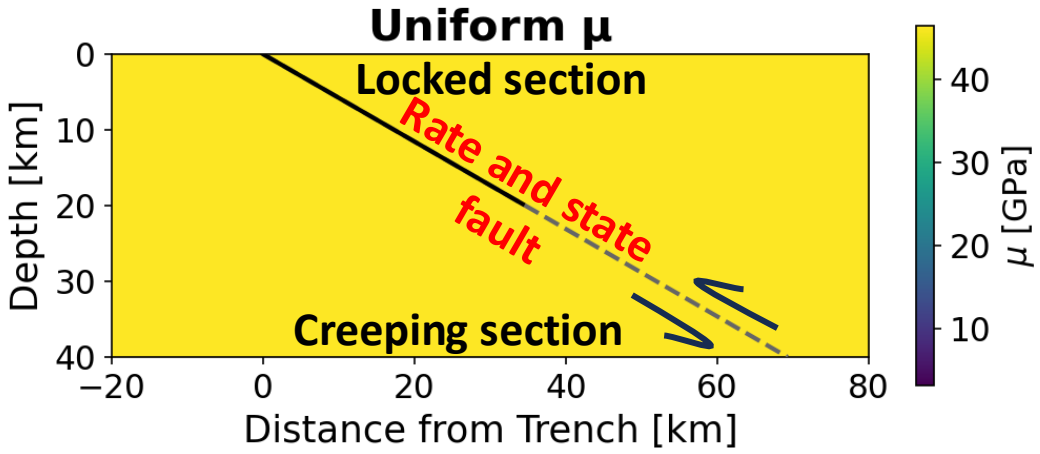
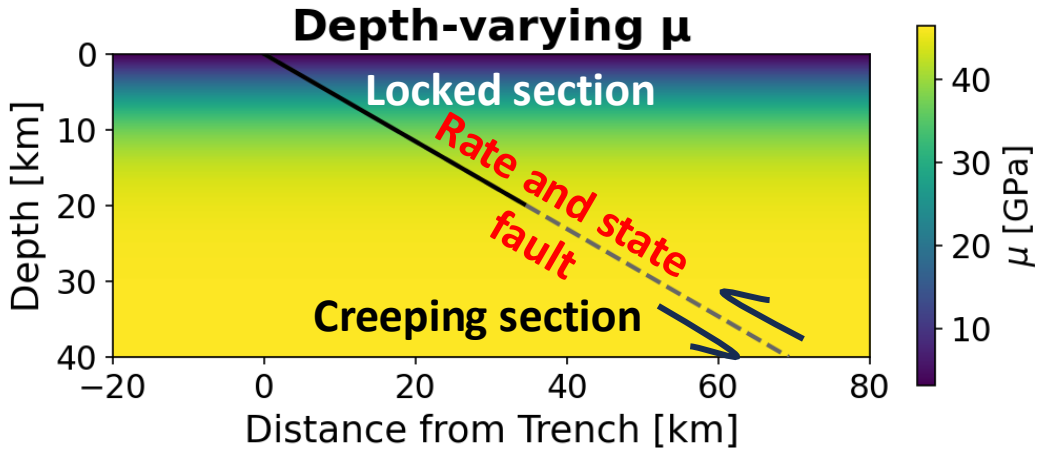
Day 3 (Jan 23) 2025

SCRIPPS INSTITUTION OF OCEANOGRAPHY

UC San Diego

Plan for the tandem training session





Learn how to utilize **Quakeworx** for running Tandem simulations of Sequences of Earthquake and Aseismic Slip (SEAS)

Run two simulations for **550 years** along a **30-degree thrust fault**
Simulations setup:

1. **First simulation**: Domain characterized by **uniform rigidity**
2. **Second simulation**: Domain characterized by **depth-varying rigidity**

Post-simulation:

- Learn how to **plot the results** using **Jupyter Notebook** on **Quakeworx**

If time permits:

- "Auto Tandem" app

Plan for the tandem training session

Learn how to utilize **Q** ke and Aseismic Slip (SEAS)

Run two simulations fo

Simulations setup:

1. **First simulation**: Domain characterized by **uniform rigidity**
2. **Second simulation**: Domain characterized by **depth-varying rigidity**

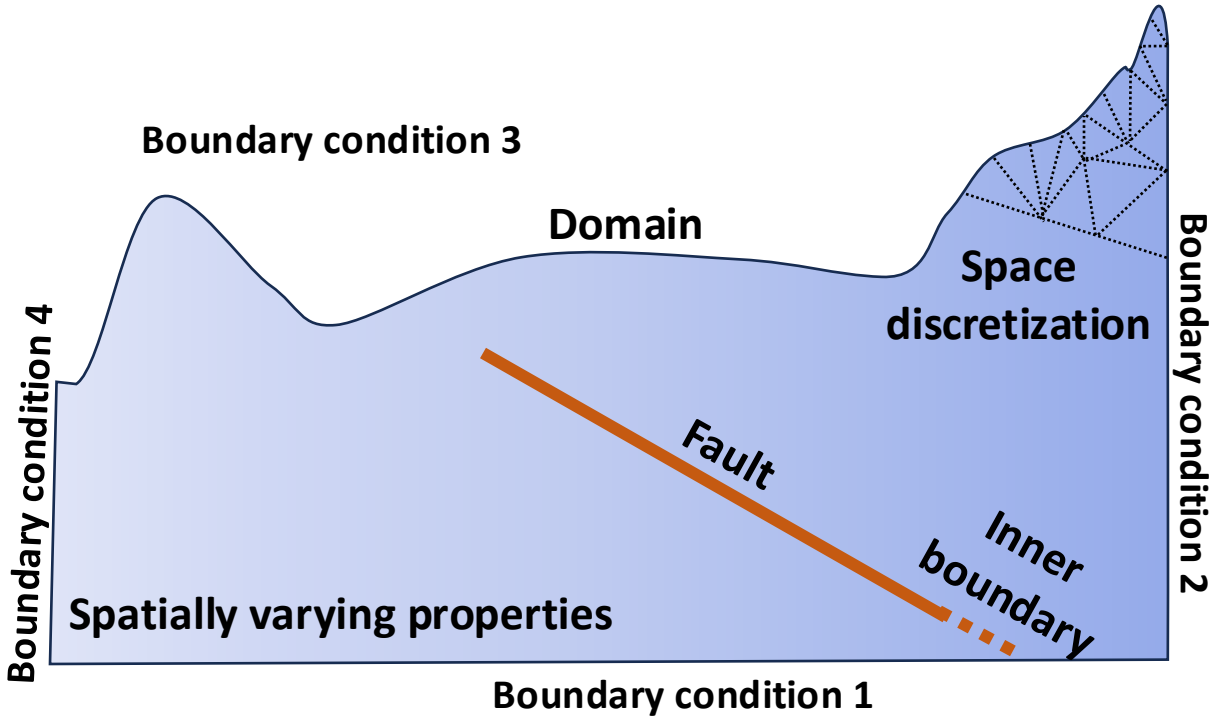
Post-simulation:

•Learn how to **plot the results** using **Jupyter Notebook** on **Quakeworx**

Benefits of using Tandem

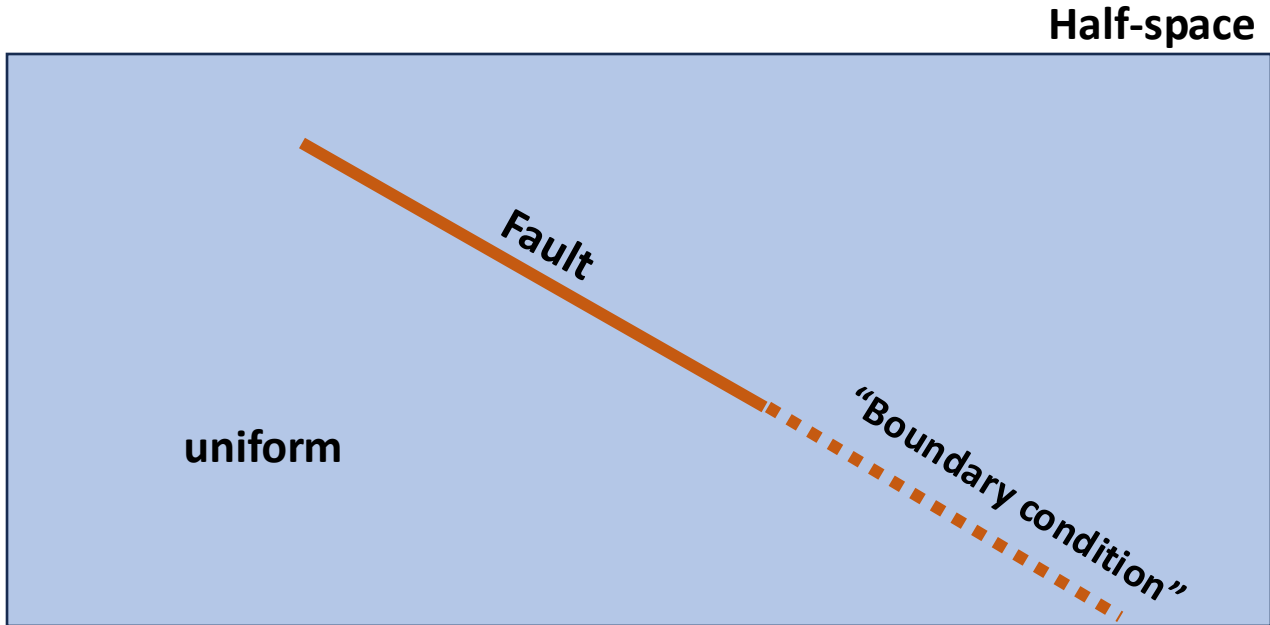
Tandem (Discontinuous Galerkin)

model domain with spatially varying properties and boundary conditions

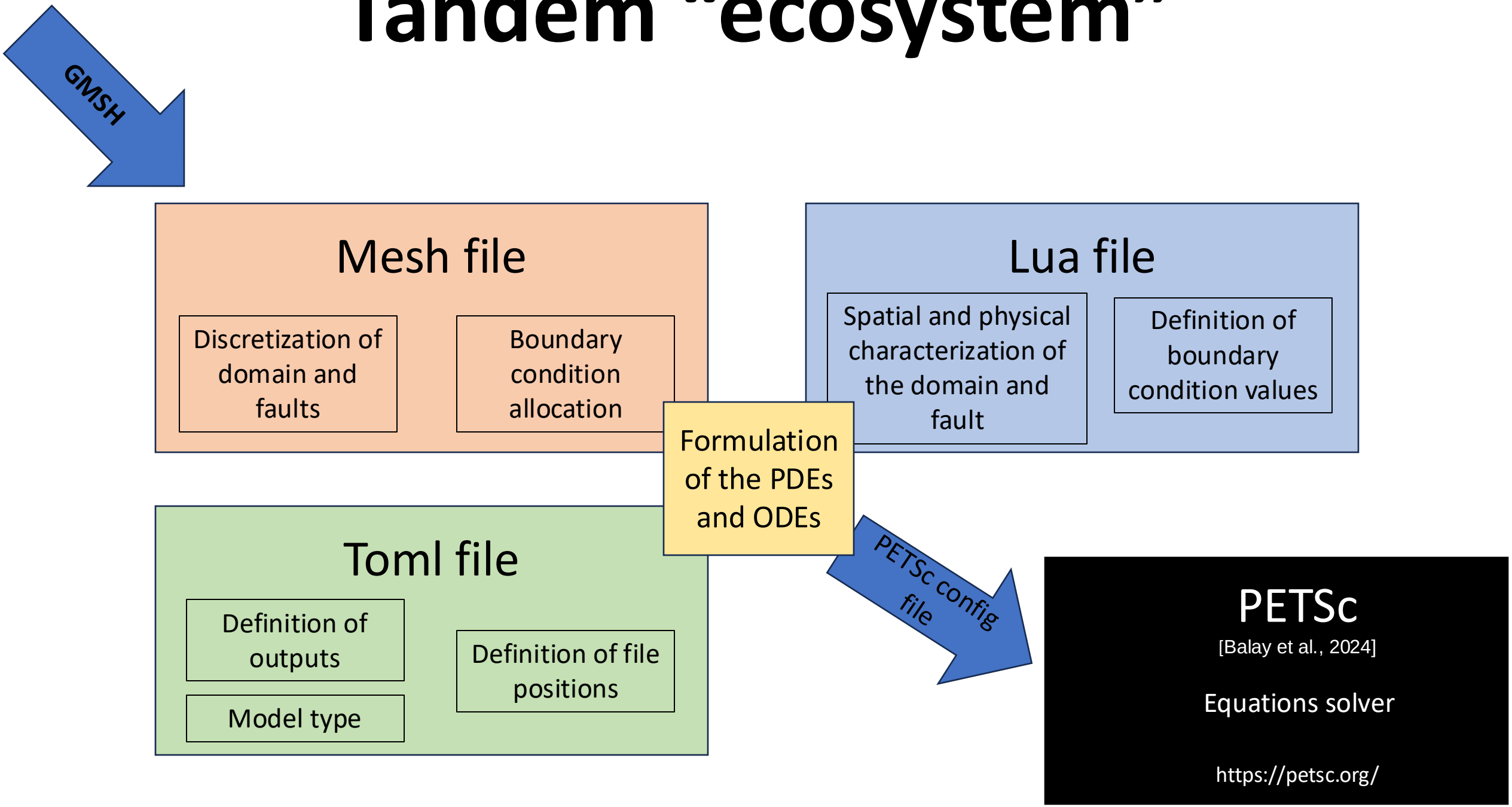


Boundary element codes

model half space with limited control over domain properties and boundary conditions



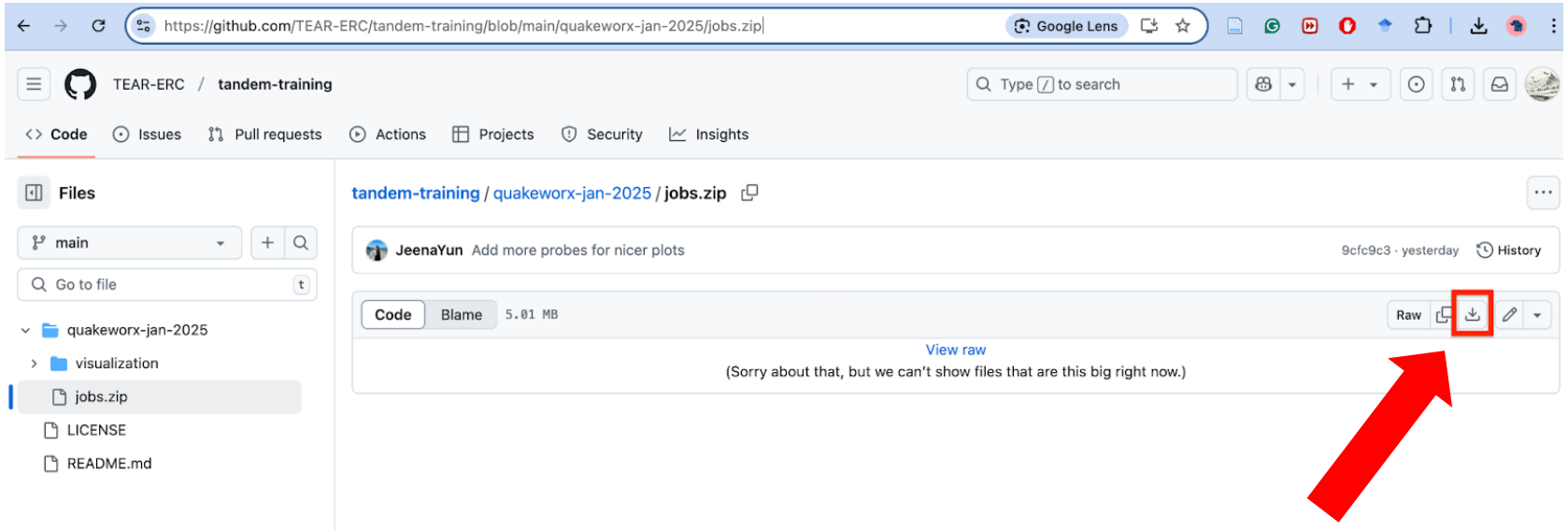
Tandem “ecosystem”



Download the input files for Tandem to your local machine

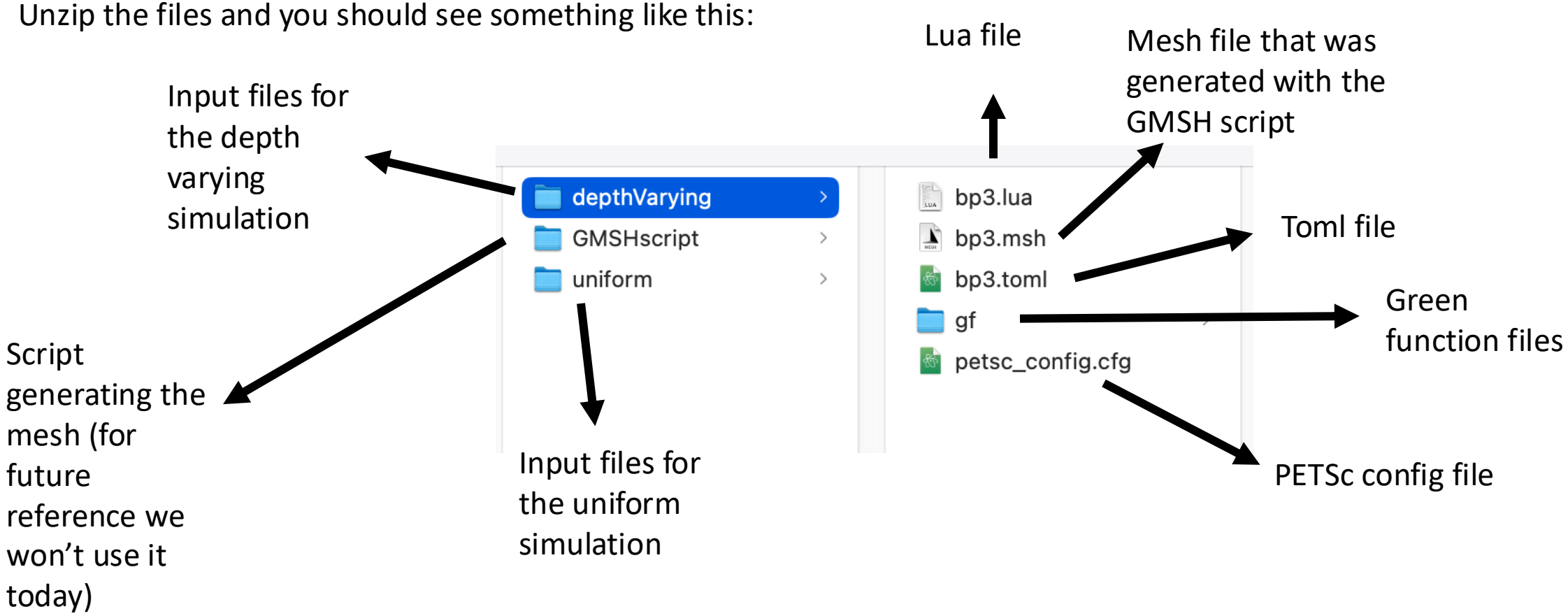
If you haven't done so, please download the input files to your local machine from the following link:

https://github.com/TEAR-ERC/tandem-training/blob/main/quakeworx-jan-2025/jobs.zip

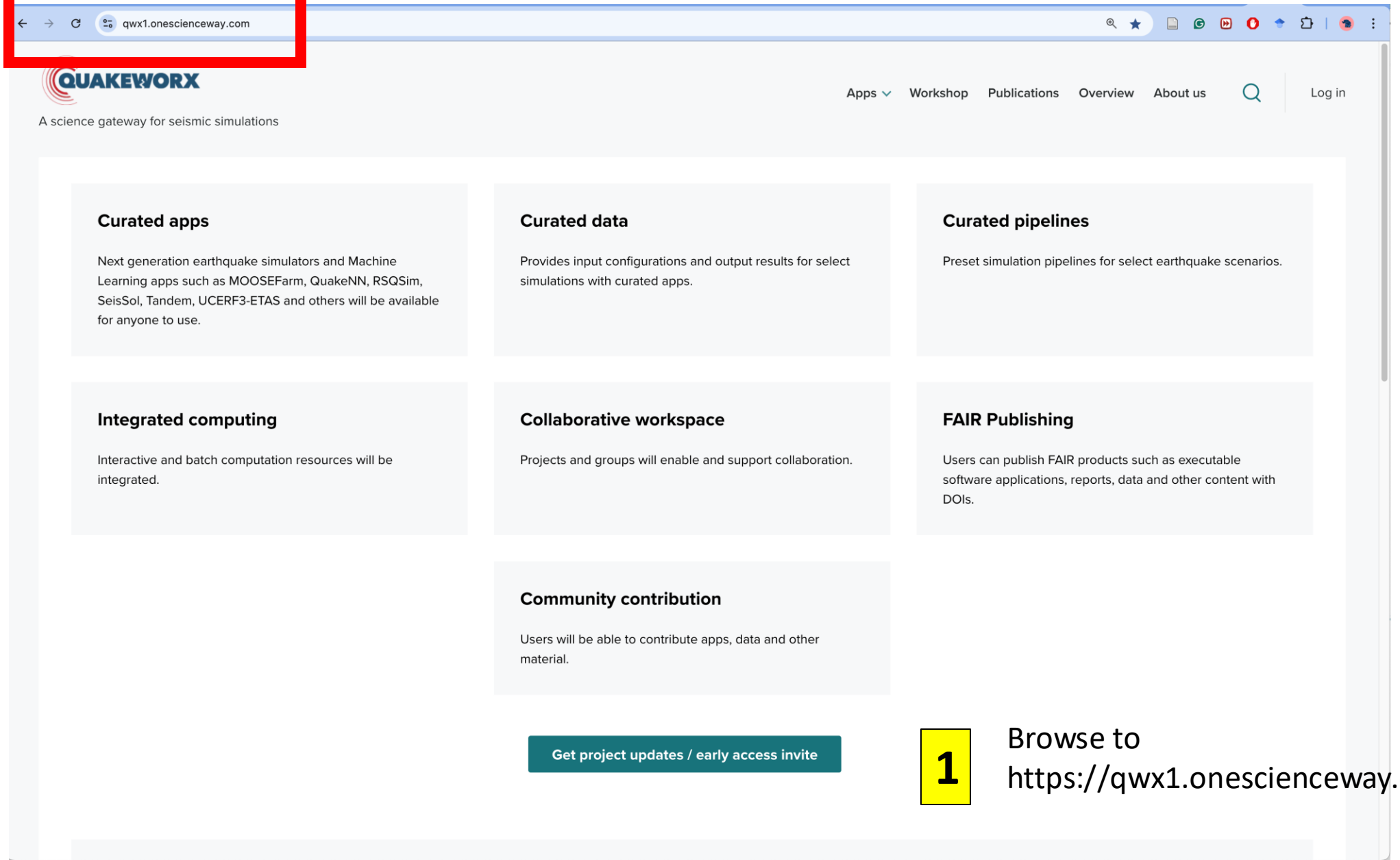


Download the input files for Tandem to your local machine

Unzip the files and you should see something like this:

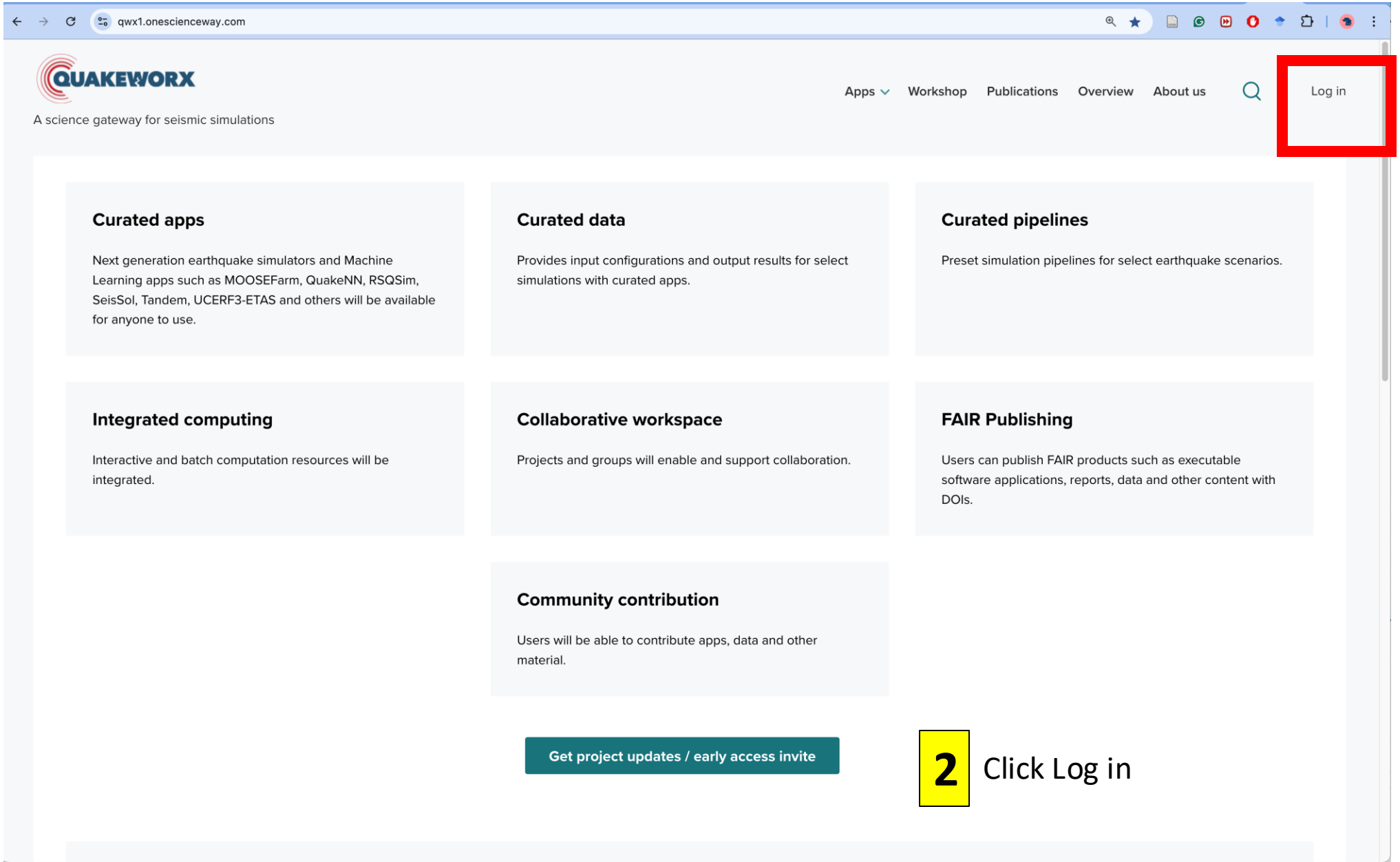


Accessing Quakeworx

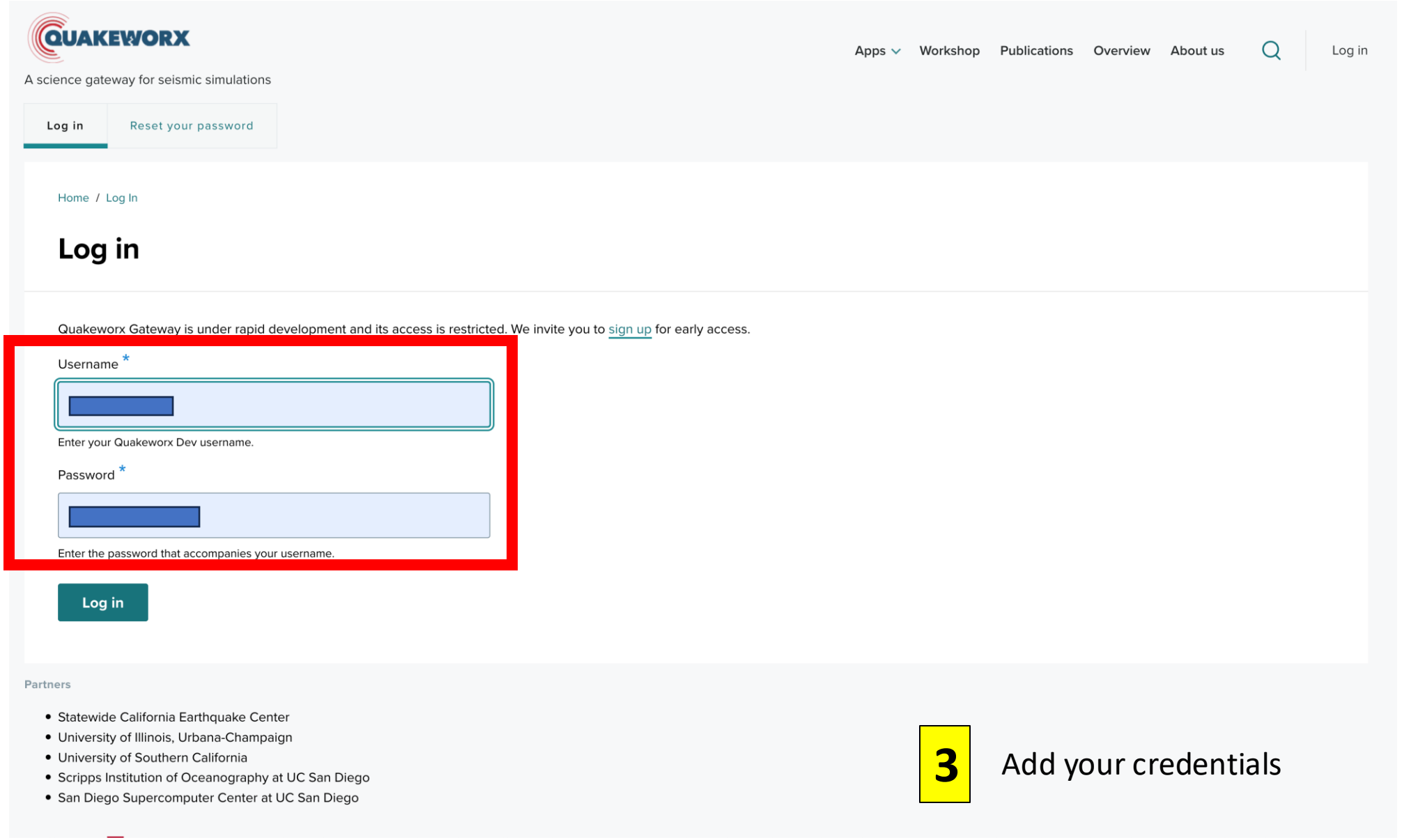


1 Browse to https://qwx1.onescienceway.com/

Accessing Quakeworx

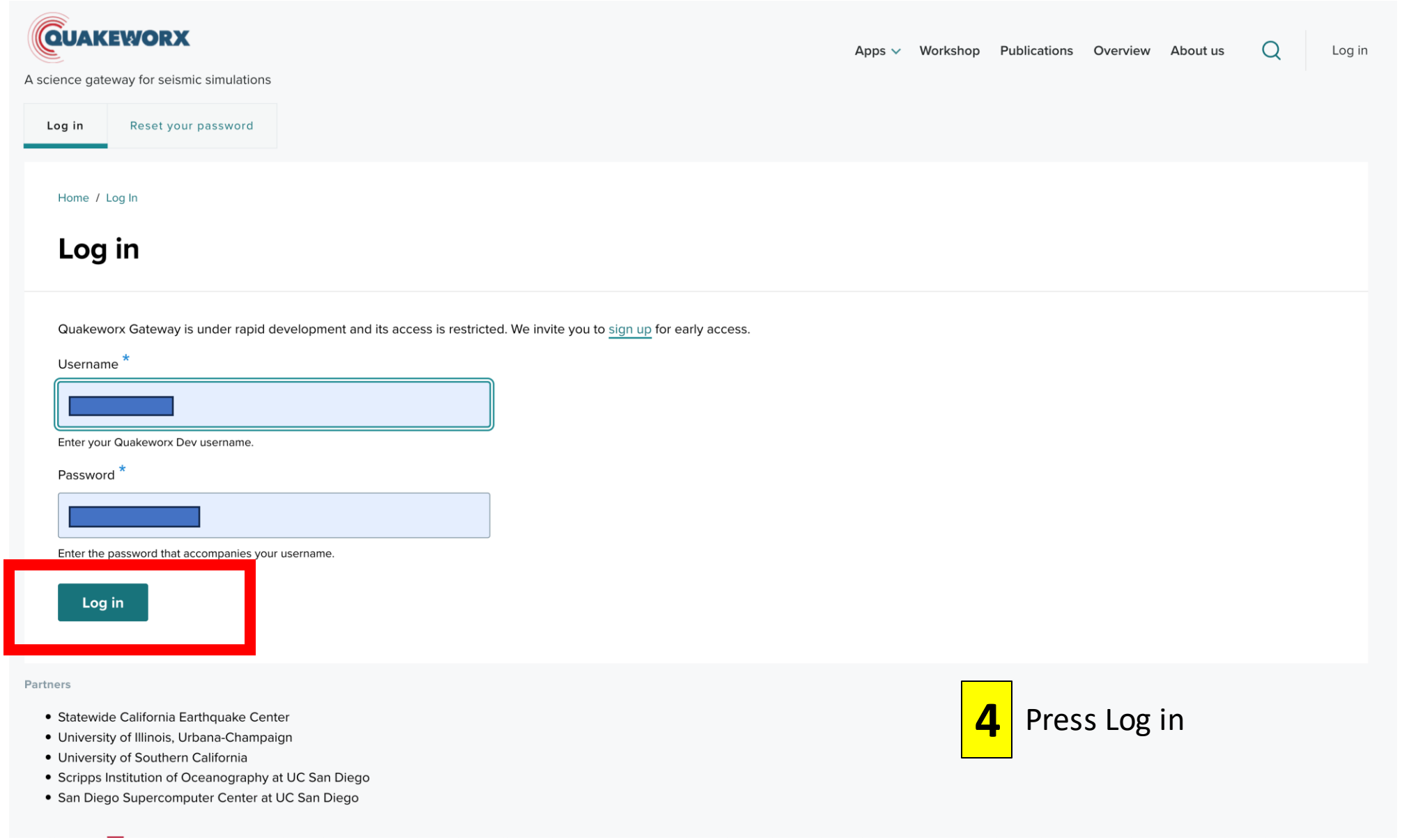


Accessing Quakeworx



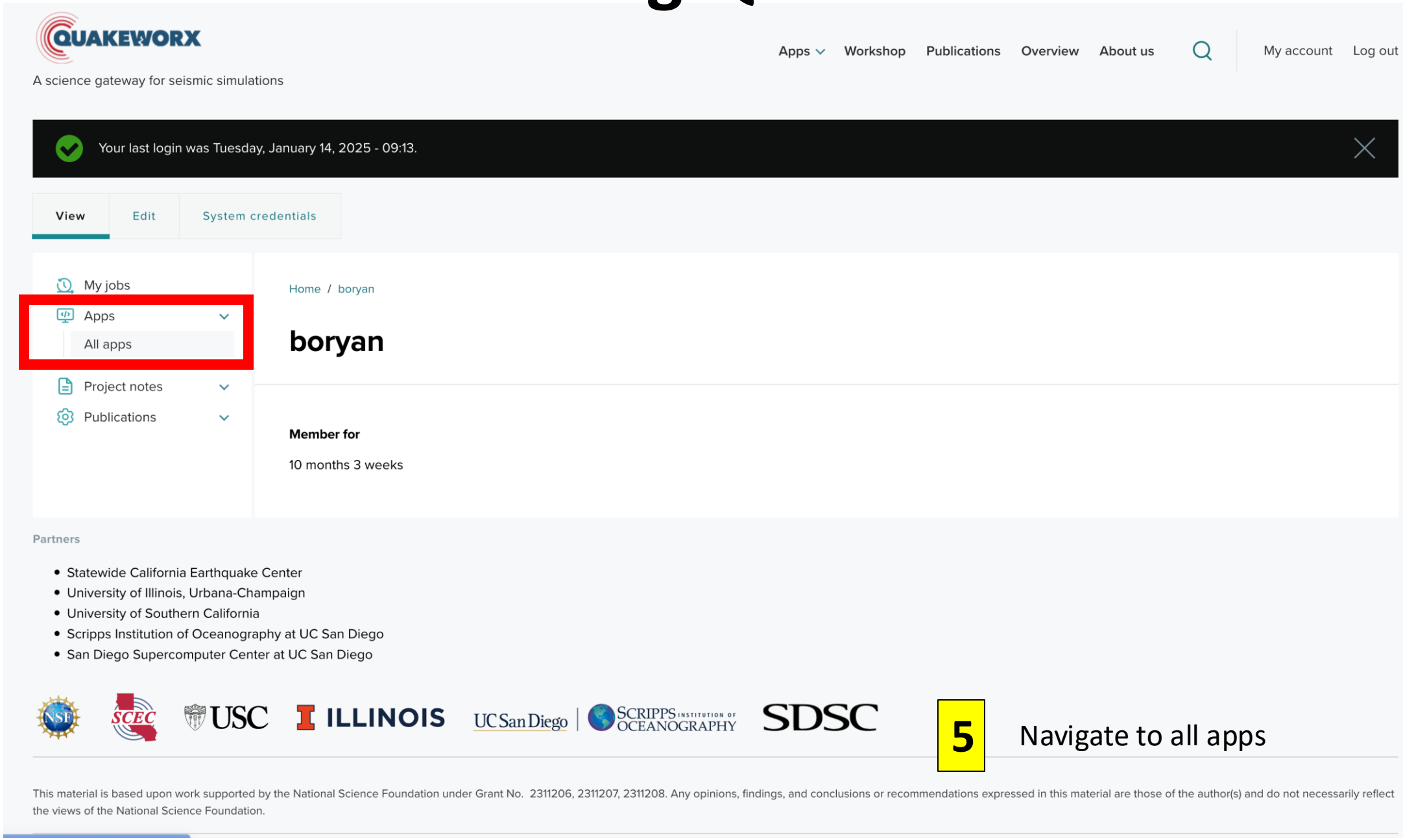
3 Add your credentials

Accessing Quakeworx

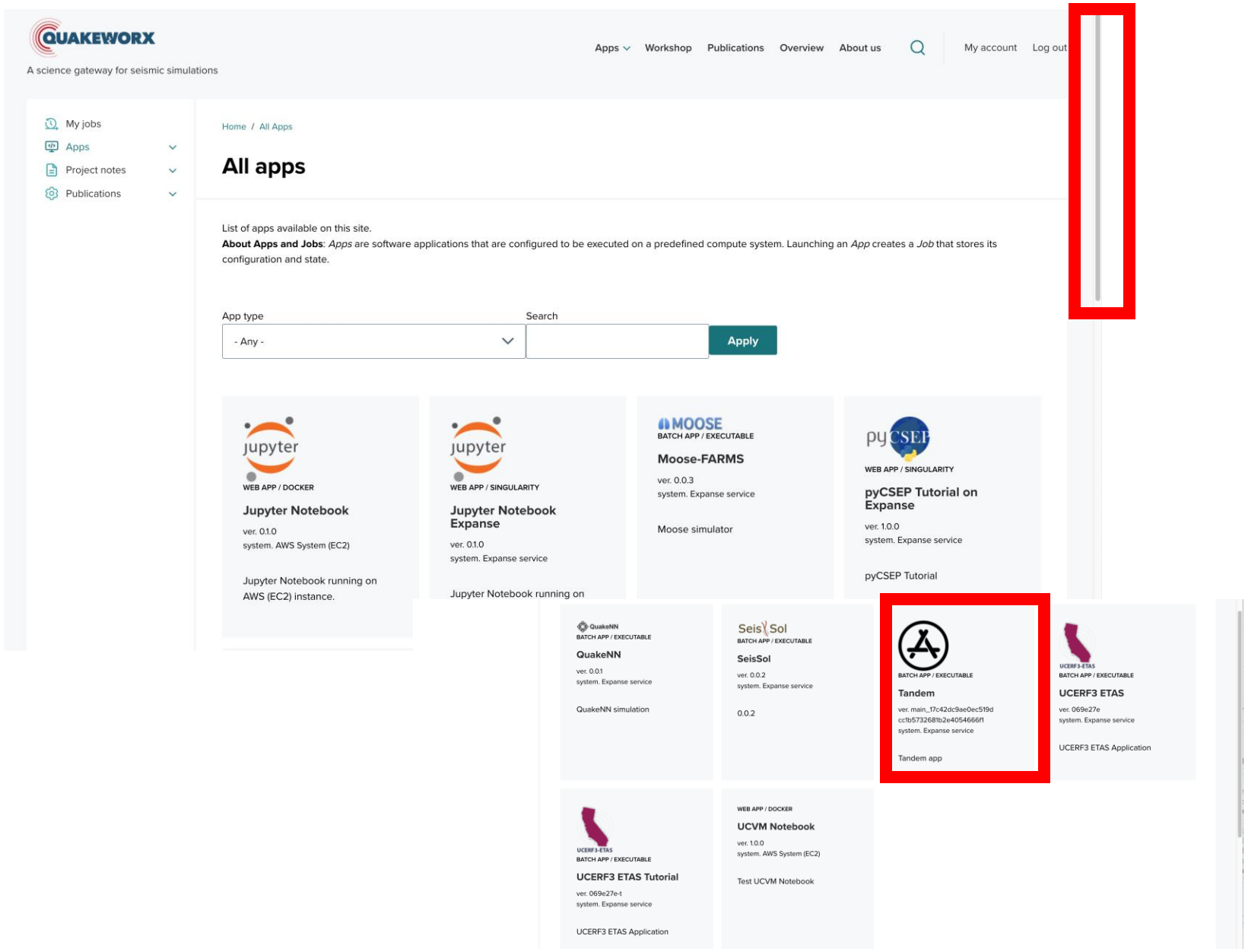


4 Press Log in

Accessing Quakeworx

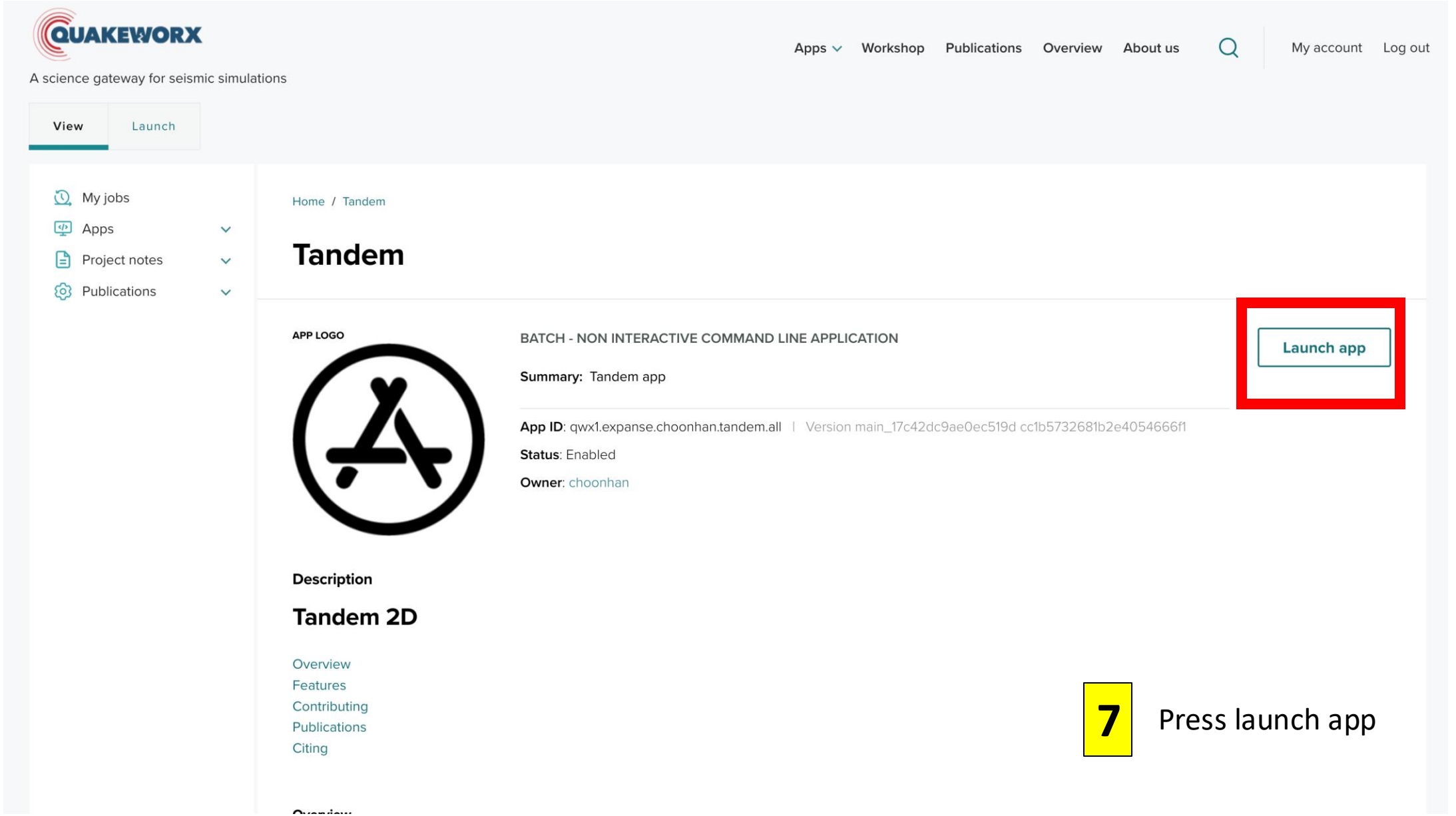


Running my first Tandem job (uniform)



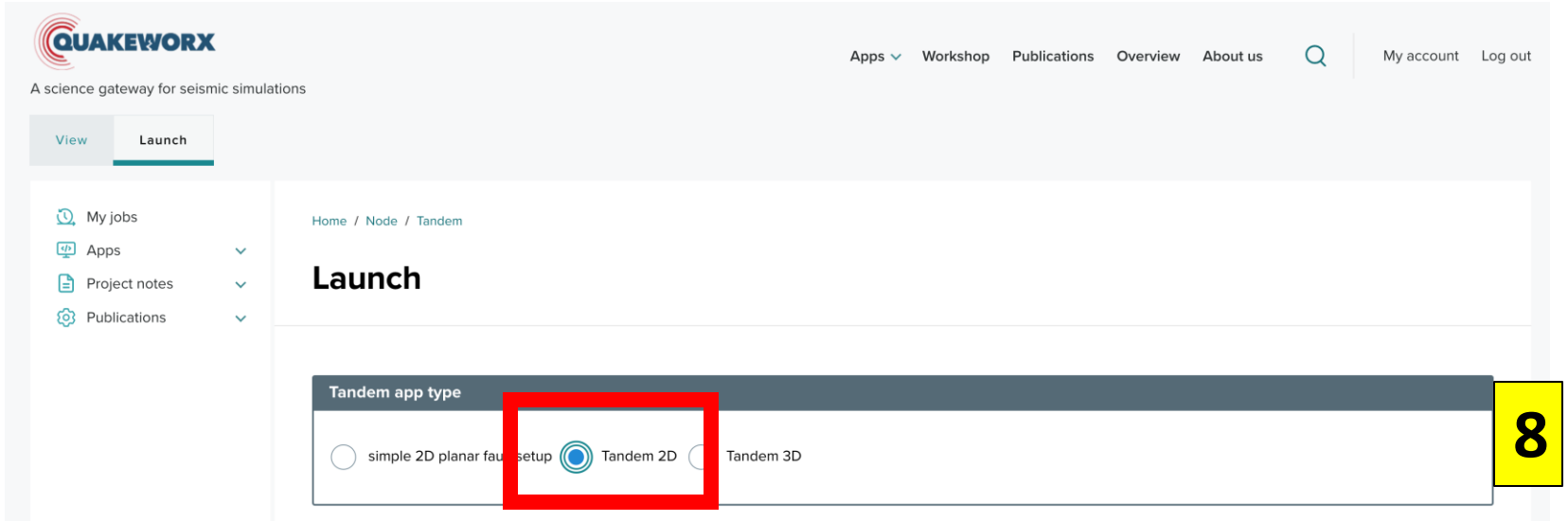
6 Scroll down and choose Tandem

Running my first Tandem job (uniform)

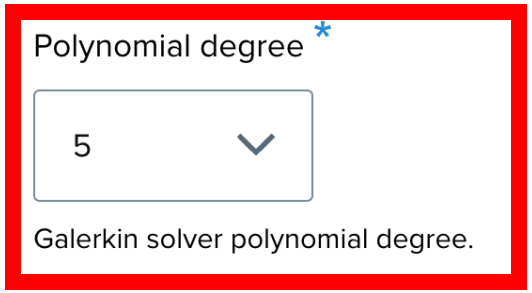


7 Press launch app

Running my first Tandem job (uniform)



8 Choose Tandem 2D



9 Choose polynomial degree 5

10 Change job name to Tandem_uniform_dense

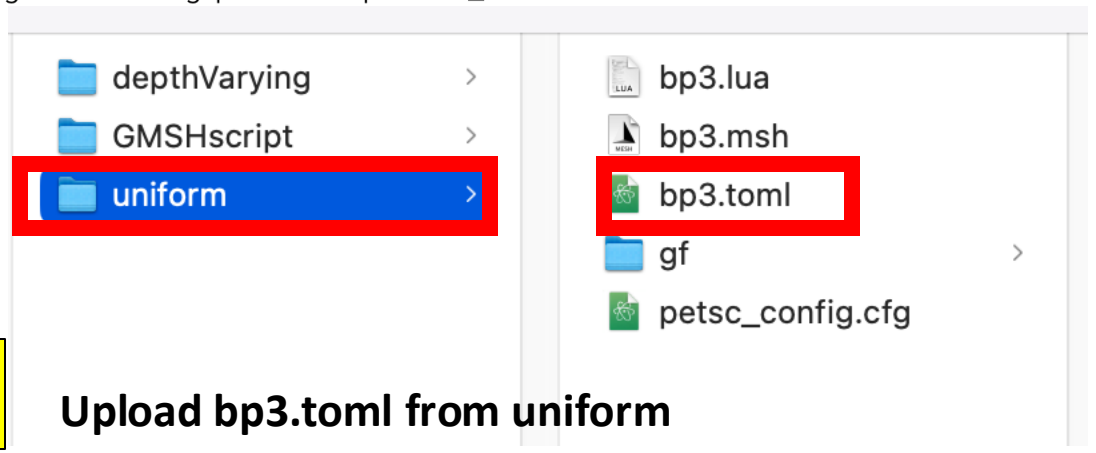
Running my first Tandem job (uniform)

Configuration file (.toml)

The results must be directed to a directory named *outputs* in the configuration file. e.g. prefix = "outputs/fltst_"

Choose File No file chosen

One file only.
512 MB limit.
Allowed types: toml.



11 **Upload bp3.toml from uniform**

No file chosen

Green's function

Create files

Upload files

Green's function files

Choose Files No file chosen

Maximum 10 files.
512 MB limit.
Allowed types: bin, gz, info.

12 **Upload all files from uniform/gf**

Web browser

Local computer

Running my first Tandem job (uniform)

Mesh file (.msh)

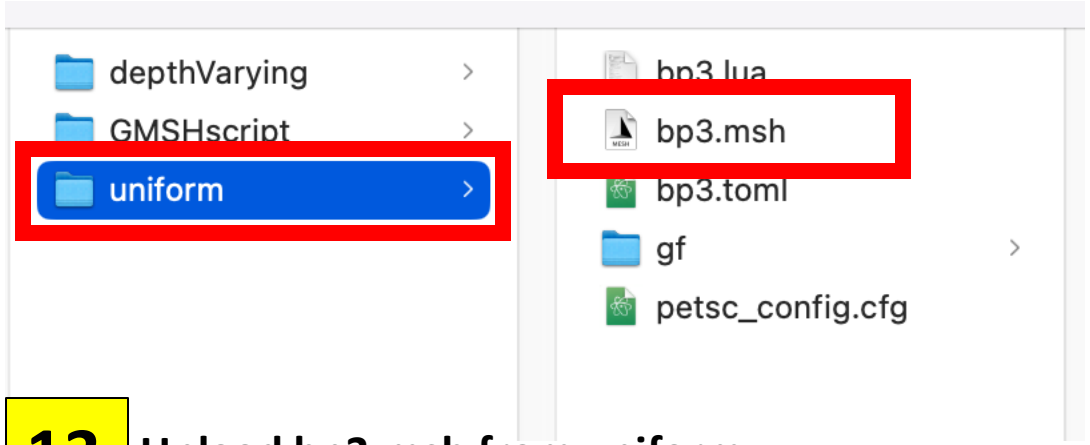
Choose File No file chosen

One file only.
512 MB limit.
Allowed types: msh.

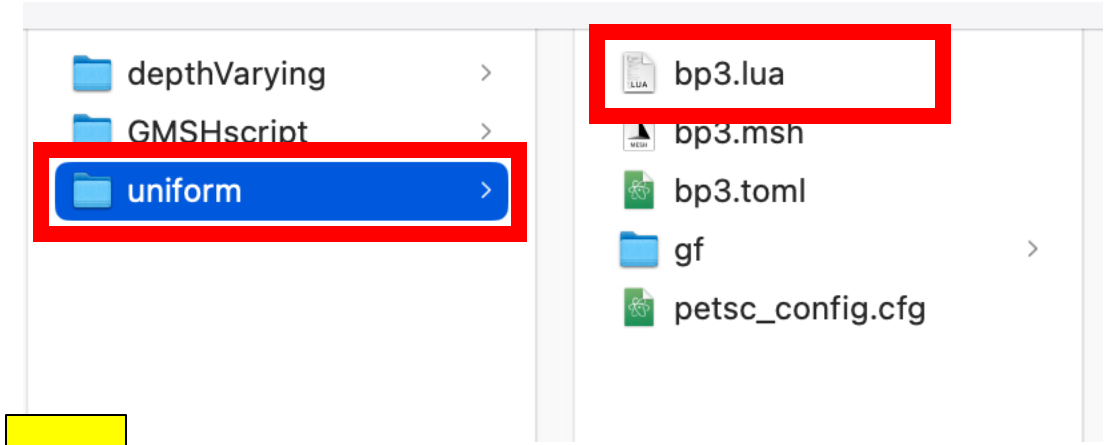
Lua file (.lua)

Choose File No file chosen

One file only.
512 MB limit.
Allowed types: lua.



13 **Upload bp3.msh from uniform**



14 **Upload bp3.lua from uniform**

Web browser

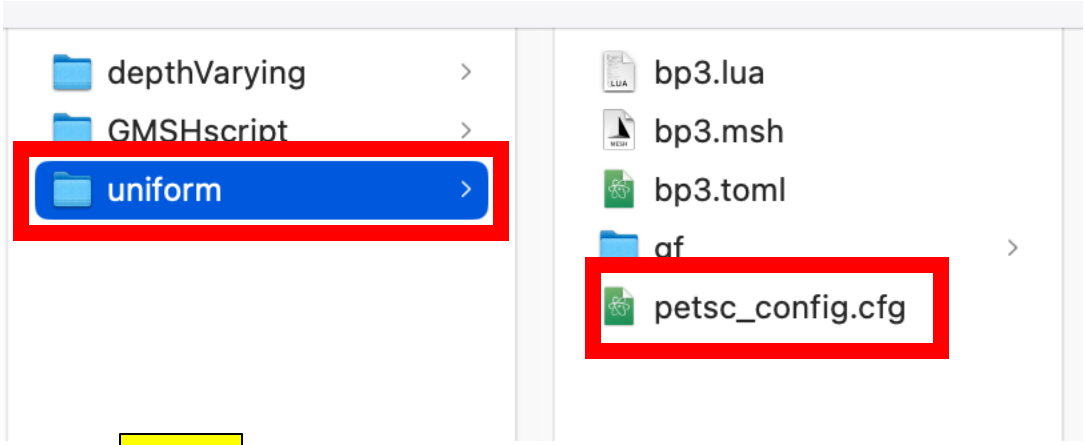
Local computer

Running my first Tandem job (uniform)

Options file 1 (.cfg)

Choose File No file chosen

One file only.
512 MB limit.
Allowed types: cfg.



15 **Upload petsc_config.cfg from uniform**

Local computer

Simulation time [seconds] *

17356680000

The default simulation time is set to 550 years so no need to change

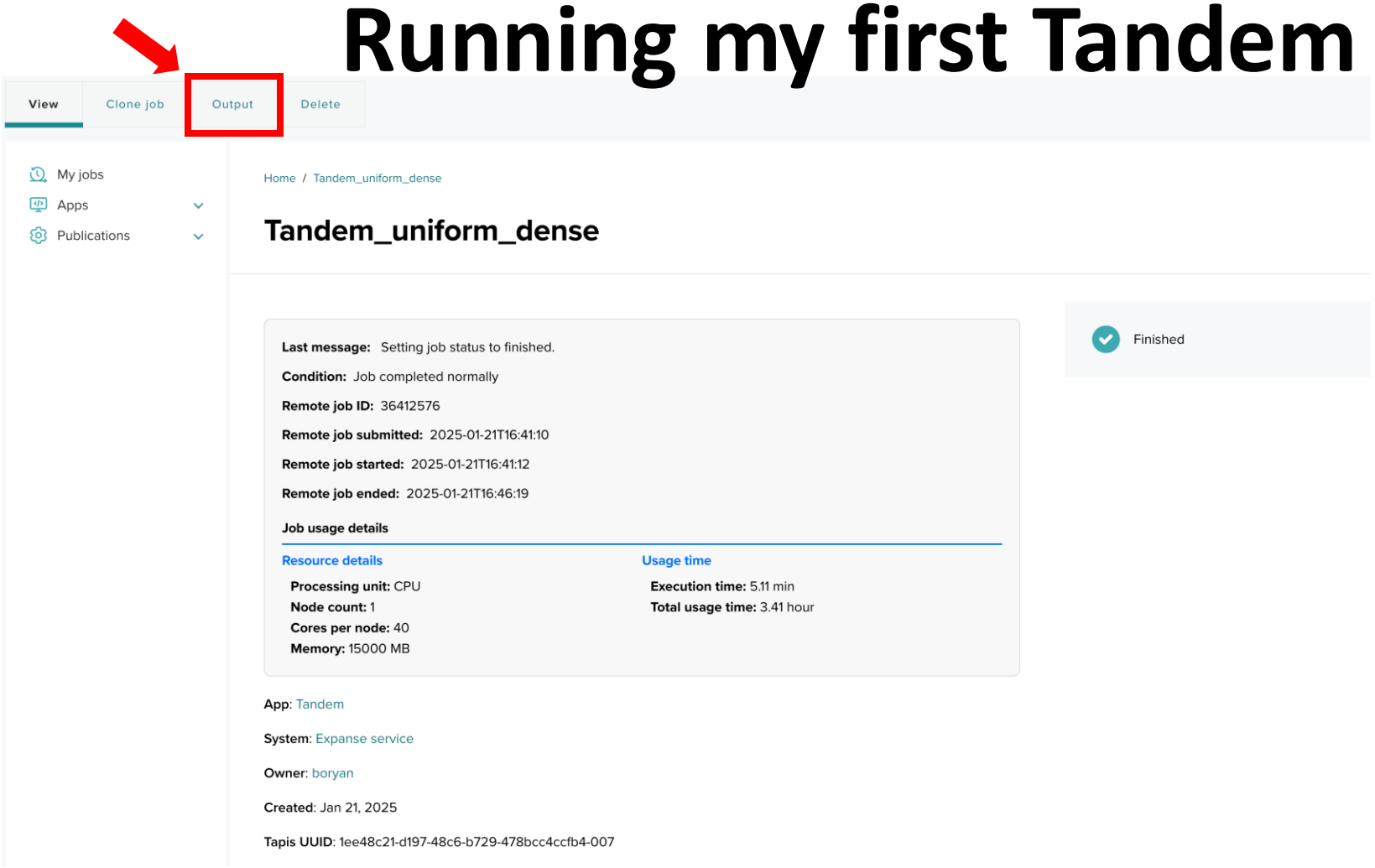
Save Draft

Submit

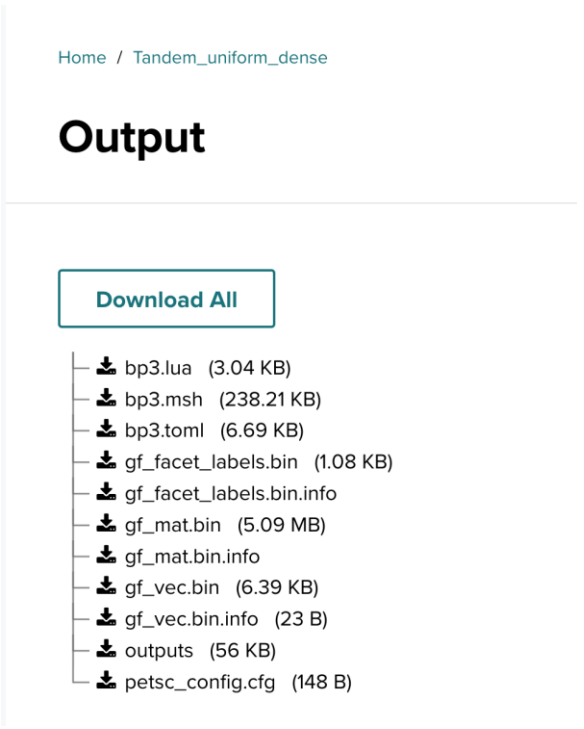
16 **Click submit**

Web browser

Running my first Tandem job (uniform)



If everything went smoothly it should look like this



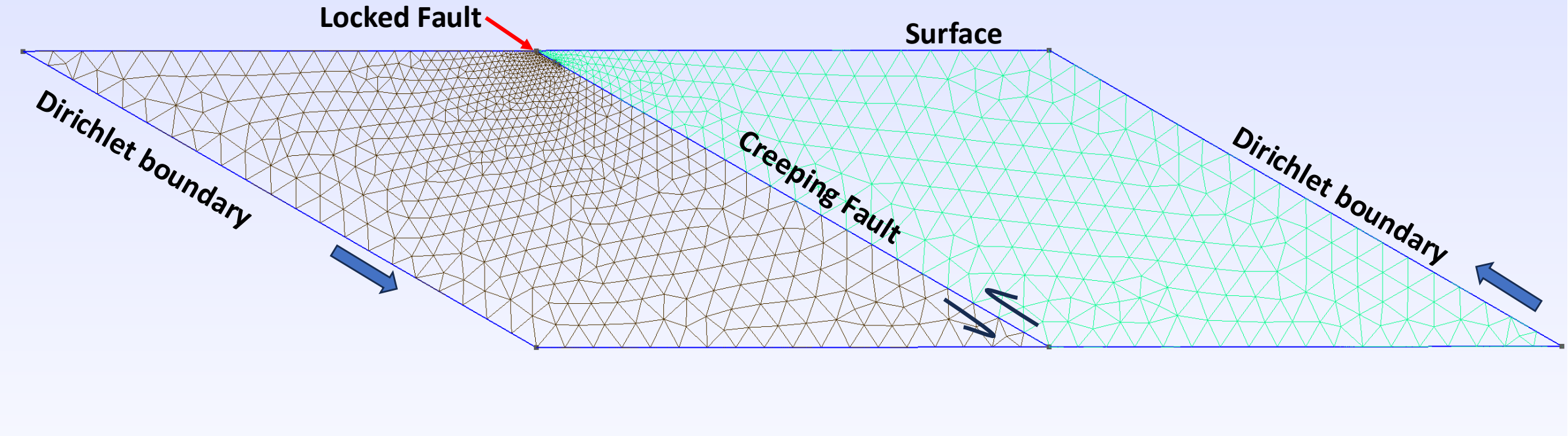
17

If you click output you can can see the Tandem output files

TOML FILE

```toml
final_time = 17356680000        # Final simulation time in seconds. (550 yrs)
mesh_file = "bp3.msh"           # Mesh file.
lib = "bp3.lua"                 # Lua file containing material&frictional paramters.
scenario = "bp3_d30_reverse"    # Specific scenario defined in the lua library.
mode = "QDGreen"                # Mode of SEAS simulation: [QuasiDynamic/QD | QuasiDy
type = "elasticity"             # Type of problem: [poisson | elastic/elasticity].
ref_normal = [1, 0]             # Reference normal vector.
boundary_linear = true          # Assert that boundary is a linear function of time

gf_checkpoint_prefix = "gf/"    # Path to pre-computed Green's function

# On-fault probe outputs
[fault_probe_output]
prefix = "outputs/fltst_"
t_max = 9460800
probes = [
    { name = "dp000", x = [0.0, -0.0] },
    { name = "dp001", x = [0.40527648287912316, -0.233986486486486 48] },
    { name = "dp002", x = [0.8105529657582463, -0.46797297297297297] },
    { name = "dp003", x = [1.2158294486373697, -0.7019594594594595] },
    { name = "dp004", x = [1.6211059315164926, -0.9359459459459459] },
    { name = "dp005", x = [2.026382414395616, -1.1699324324324323] },
```

MESH FILE



Open with GMSH

Defining domain parameters using the Lua file

Tandem looks for Lua object defined in the toml file

Function generating the object

```
function BP3.new(params)
        ....
        return self
end

function BP3:boundary(x, y, t)
        ..........
        return Vx,Vy
end


function BP3:mu(x,y)
        ..........
        return mu
End
```

the object definition

```
bp3_d30_reverse = BP3.new{.....}
```

Defining domain parameters using the Lua file

Each object is associated with functions

Boundary sets the boundary conditions for x,y,t

```
function BP3.new(params)
        ....
        return self
end

function BP3:boundary(x, y, t)
        ..........
        return Vx,Vy
end


function BP3:mu(x,y)
        ..........
        return mu
End

bp3_d30_reverse= BP3.new{.....}
```

Defining domain parameters using the Lua file

Each object is associated with functions

```
function BP3.new(params)
        ....
        return self
end

function BP3:boundary(x, y, t)
        ..........
        return Vx,Vy
end


function BP3:mu(x,y)
        ..........
        return mu
End

bp3_d30_reverse = BP3.new{.....}
```

mu sets the rigidity for the domain

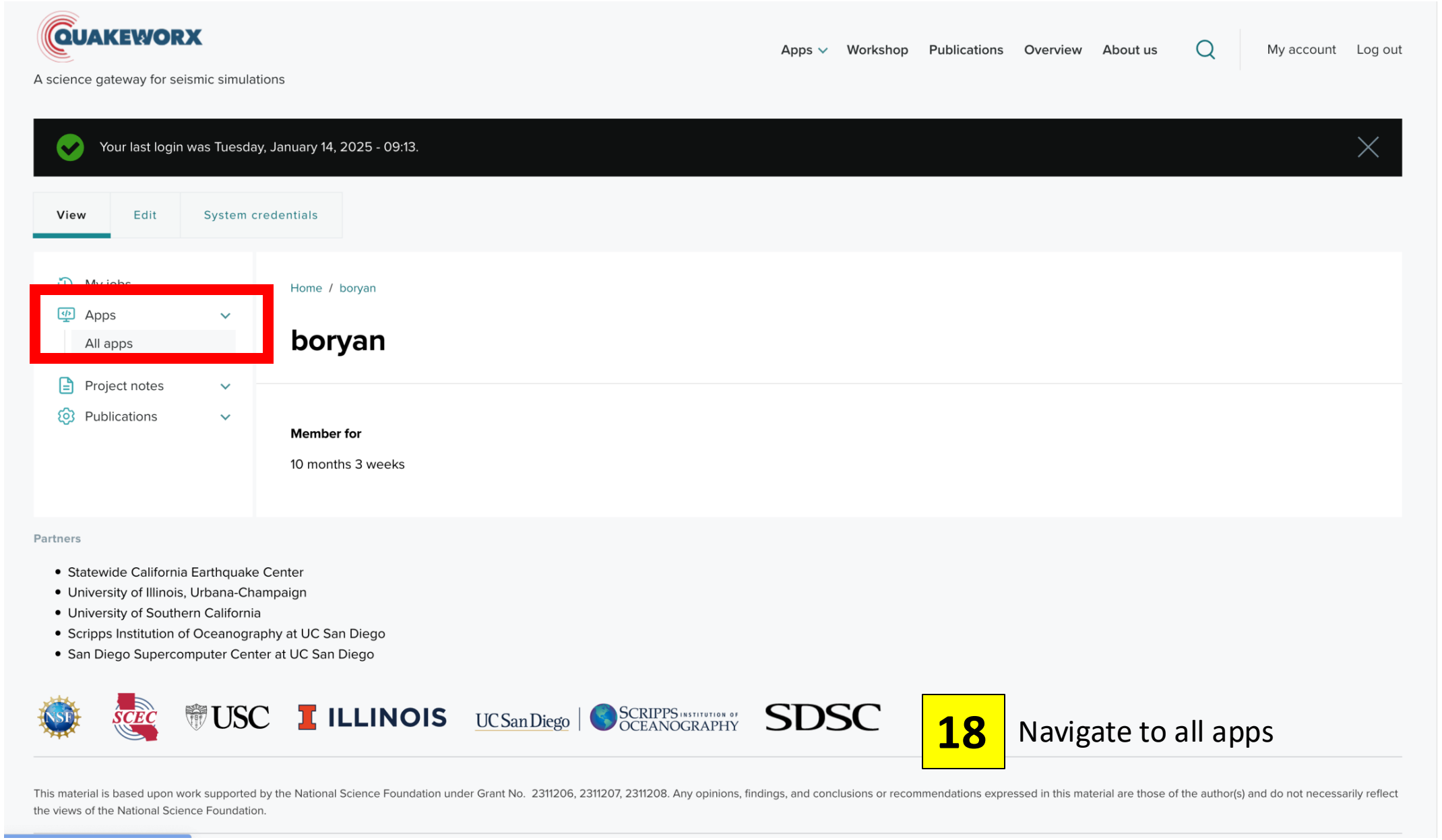
Defining domain parameters using the Lua file

Each object is associated with functions

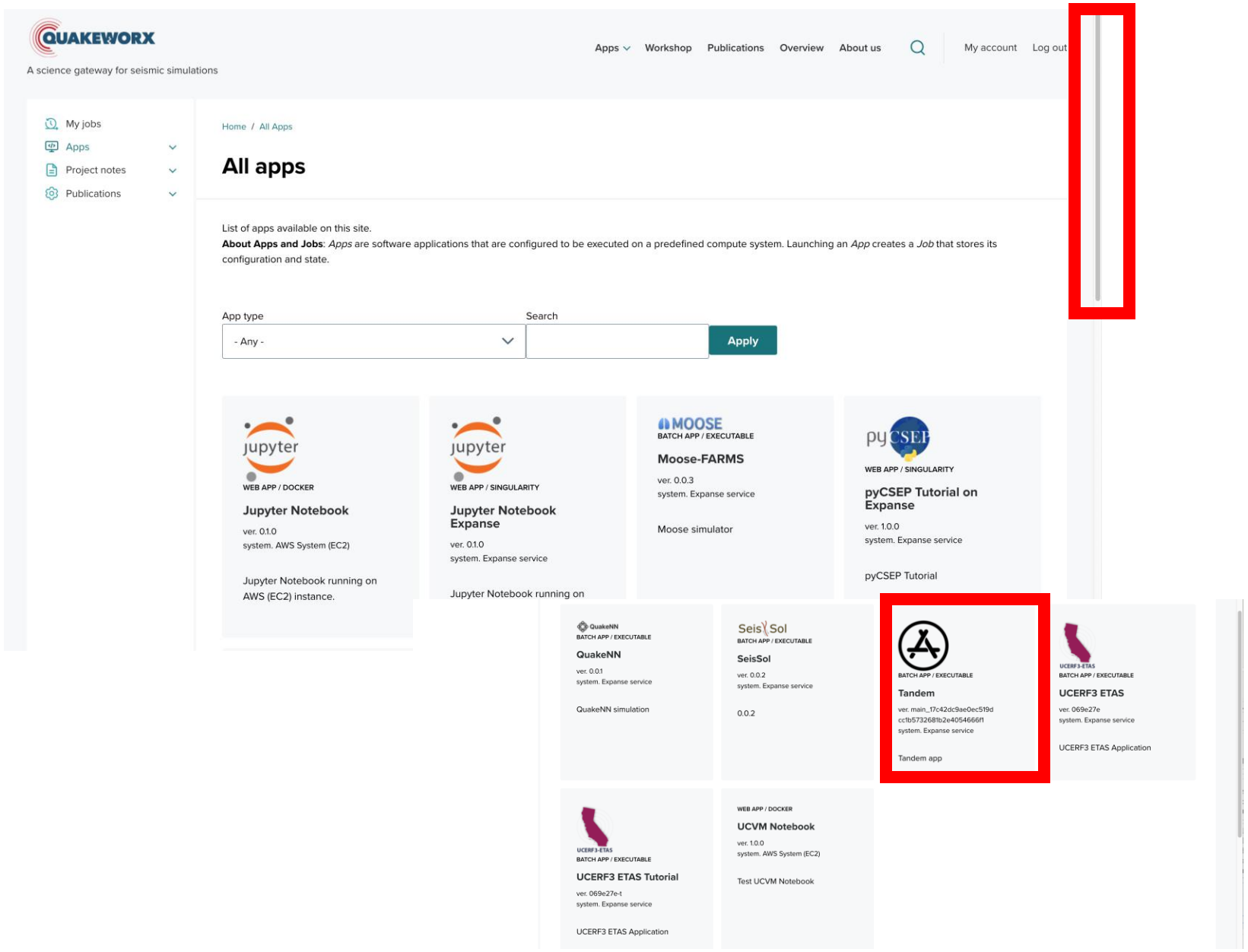
There are many more functions in the lua file setting the normal stress, Dc, initial velocity and others

```
function BP3.new(params)
        ....
        return self
end

function BP3:boundary(x, y, t)
        ..........
        return Vx,Vy
end


function BP3:mu(x,y)
        ..........
        return mu
End

bp3_d30_reverse = BP3.new{.....}
```

Running my second Tandem job (depth varying)

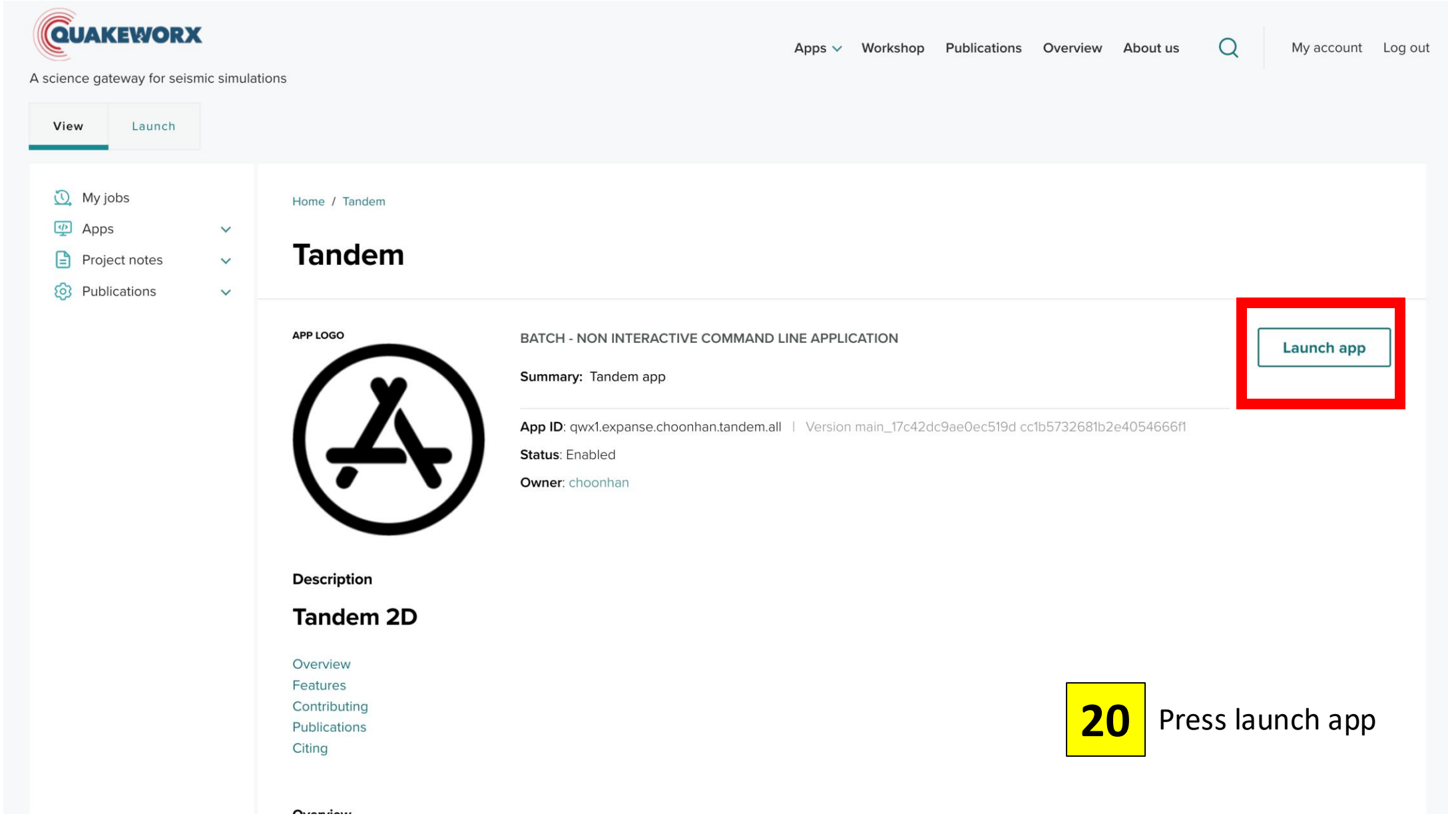


Running my second Tandem job (depth varying)

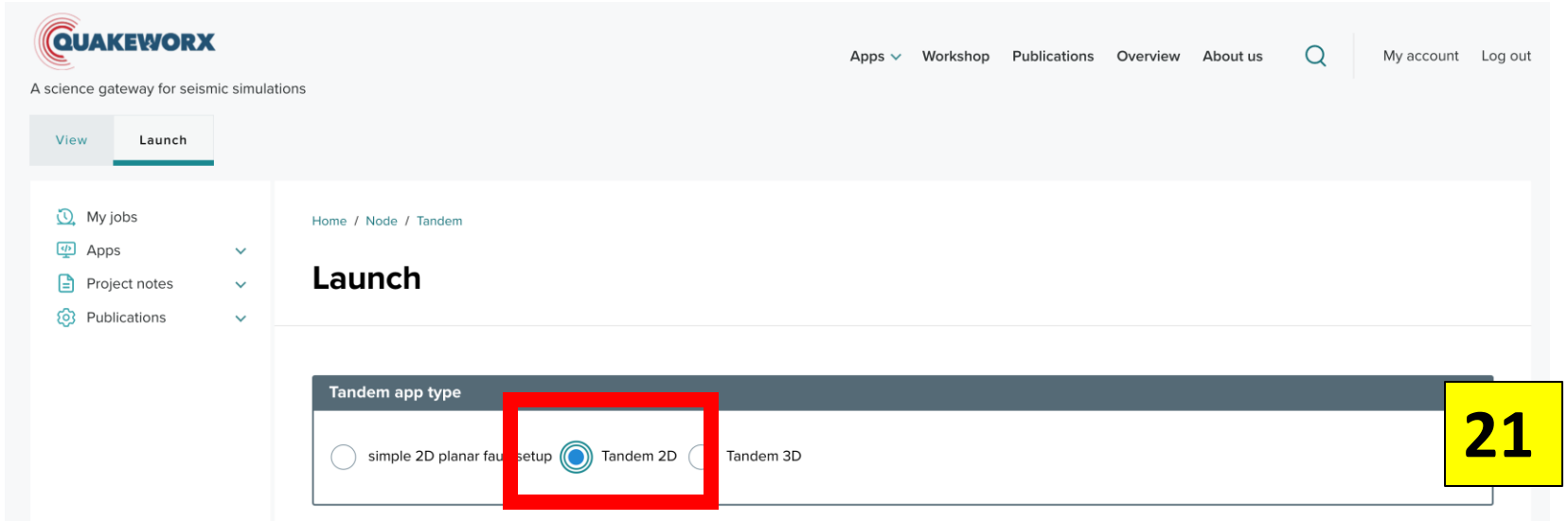


19 Scroll down and choose Tandem

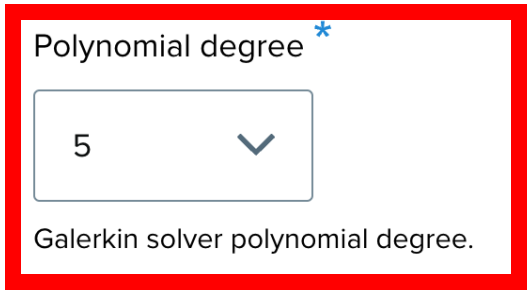
Running my second Tandem job (depth varying)



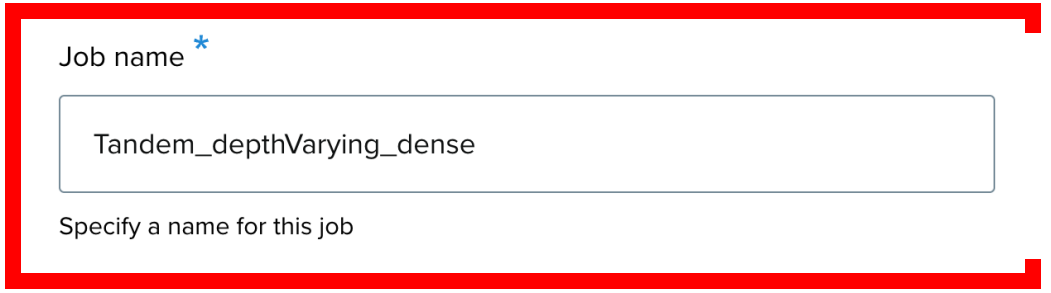
Running my second Tandem job (depth varying)



21 Choose Tandem 2D



22 Choose polynomial degree 5



23 Change job name to Tandem_depthVarying_dense

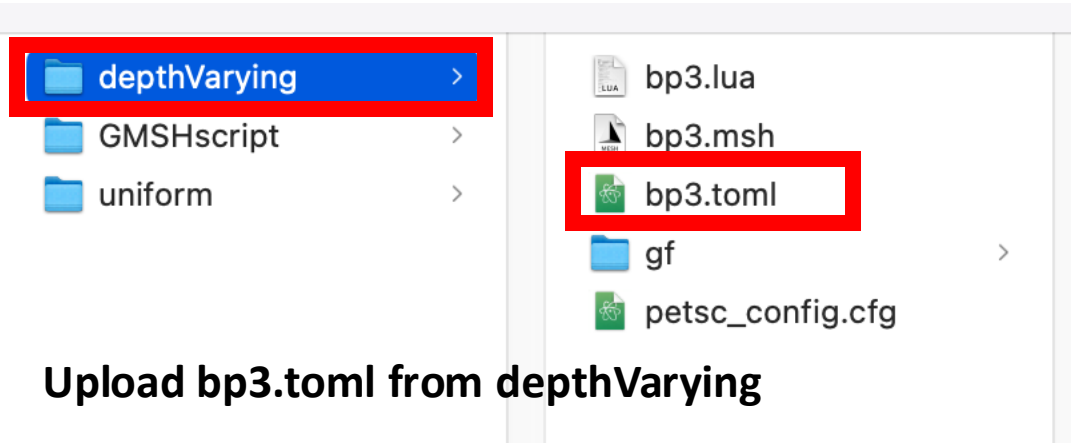
Running my second Tandem job (depth varying)

Configuration file (.toml)

The results must be directed to a directory named *outputs* in the configuration file. e.g. prefix = "outputs/fltst_"

Choose File No file chosen

One file only.
512 MB limit.
Allowed types: toml.



24 **Upload bp3.toml from depthVarying**

No file chosen

Green's function

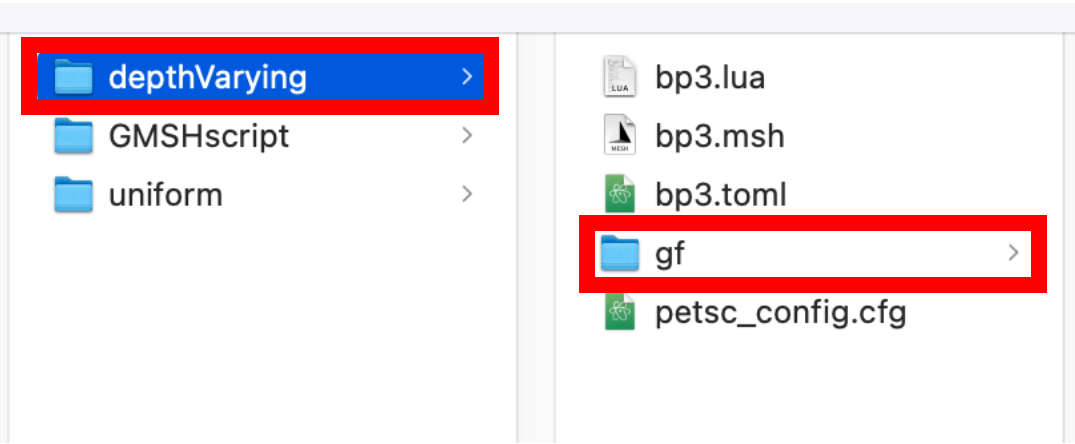
Create files

Upload files

Green's function files

Choose Files No file chosen

Maximum 10 files.
512 MB limit.
Allowed types: bin, gz, info.



25 **Upload all files from depthVarying/gf**

Web browser

Local computer

Running my second Tandem job (depth varying)

Mesh file (.msh)

Choose File No file chosen

One file only.
512 MB limit.
Allowed types: msh.

Lua file (.lua)

Choose File No file chosen

One file only.
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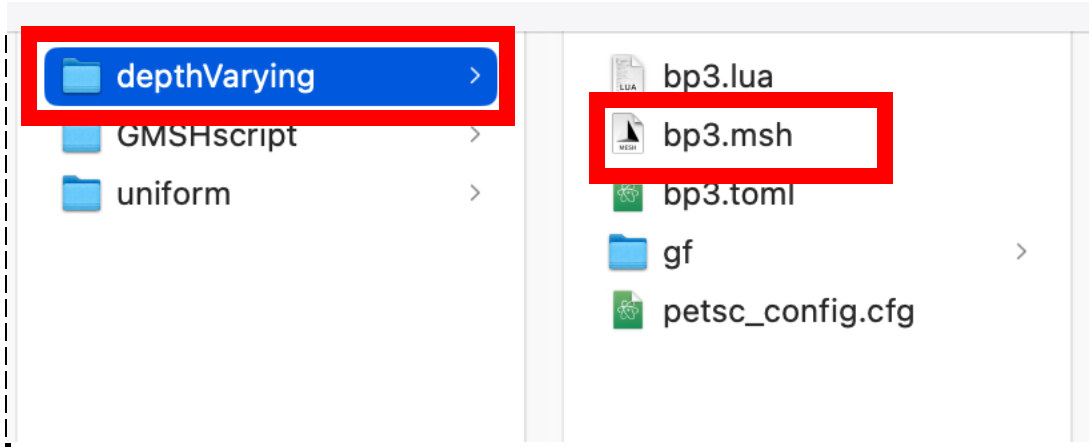
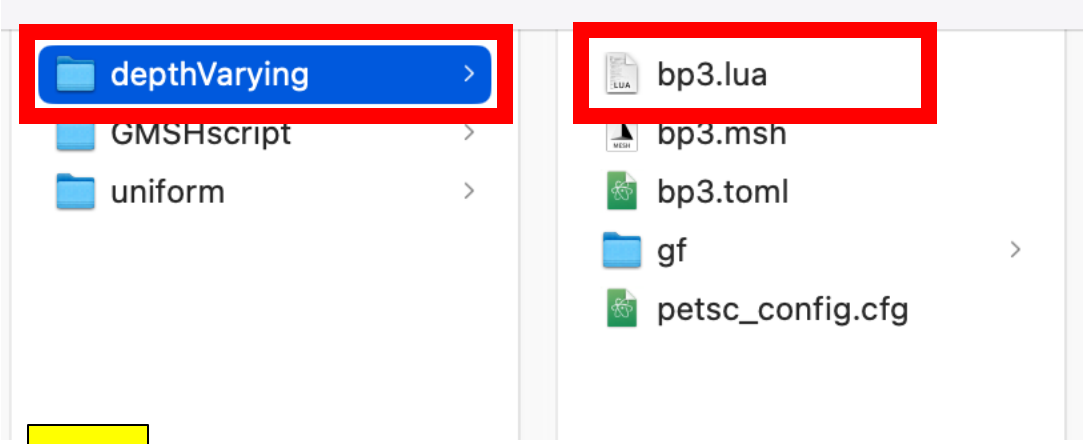
Allowed types: lua.



26 **Upload bp3.msh from depthVarying**



27 **Upload bp3.lua from depthVarying**

Web browser

Local computer

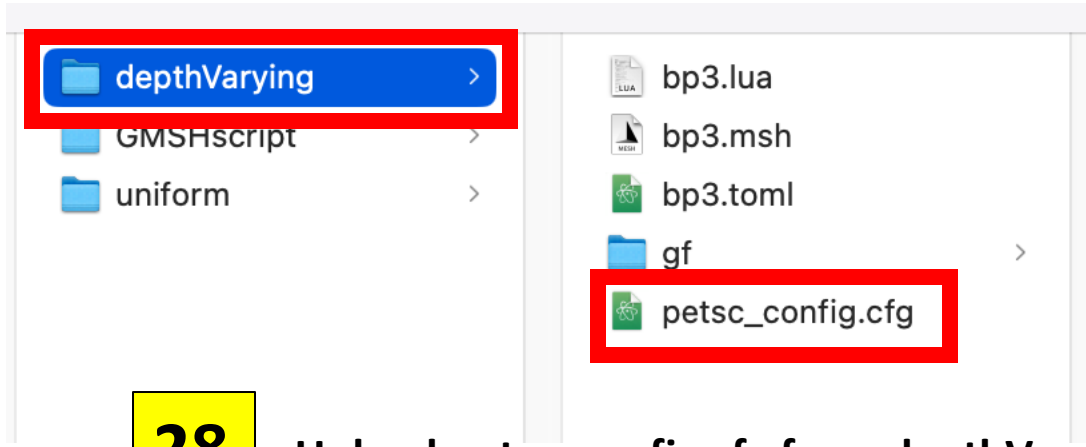
Running my second Tandem job (depth varying)

Options file 1 (.cfg)

Choose File No file chosen

One file only.
512 MB limit.
Allowed types: cfg.

Web browser



28 **Upload petsc_config.cfg from depthVarying**

Local computer

Simulation time [seconds] *

17356680000

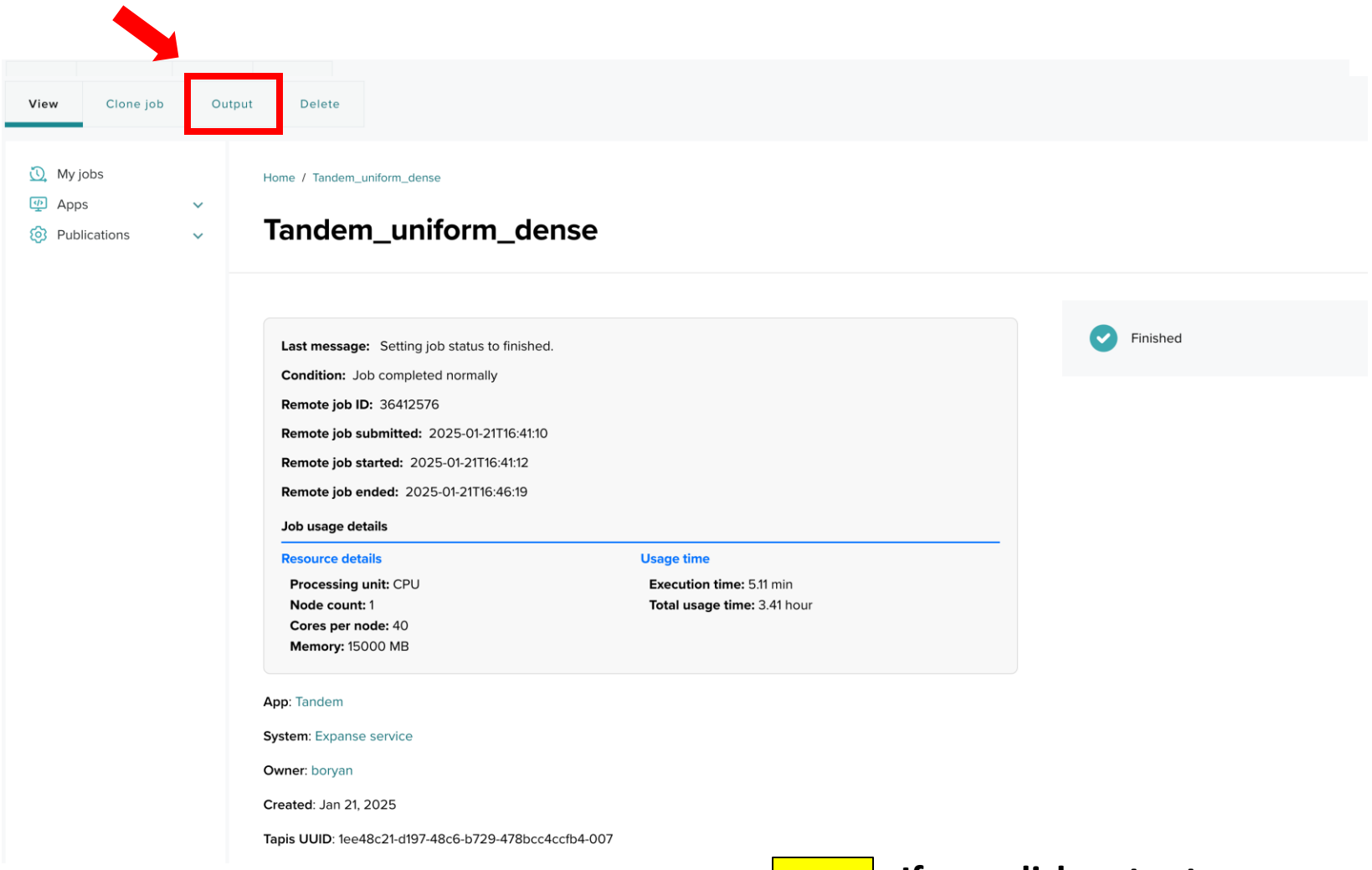
The default simulation time is set to 550 years so no need to change

Save Draft

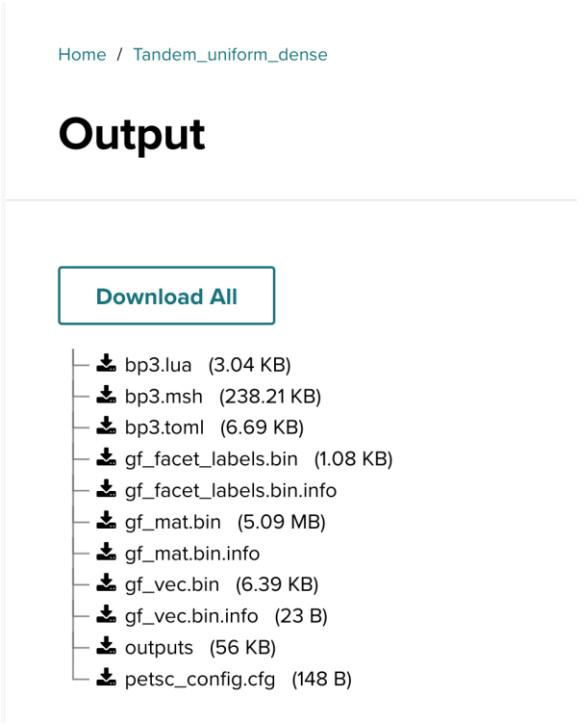
Submit

29 **Click submit**

Running my second Tandem job (depth varying)



If everything went smoothly
it should look like this



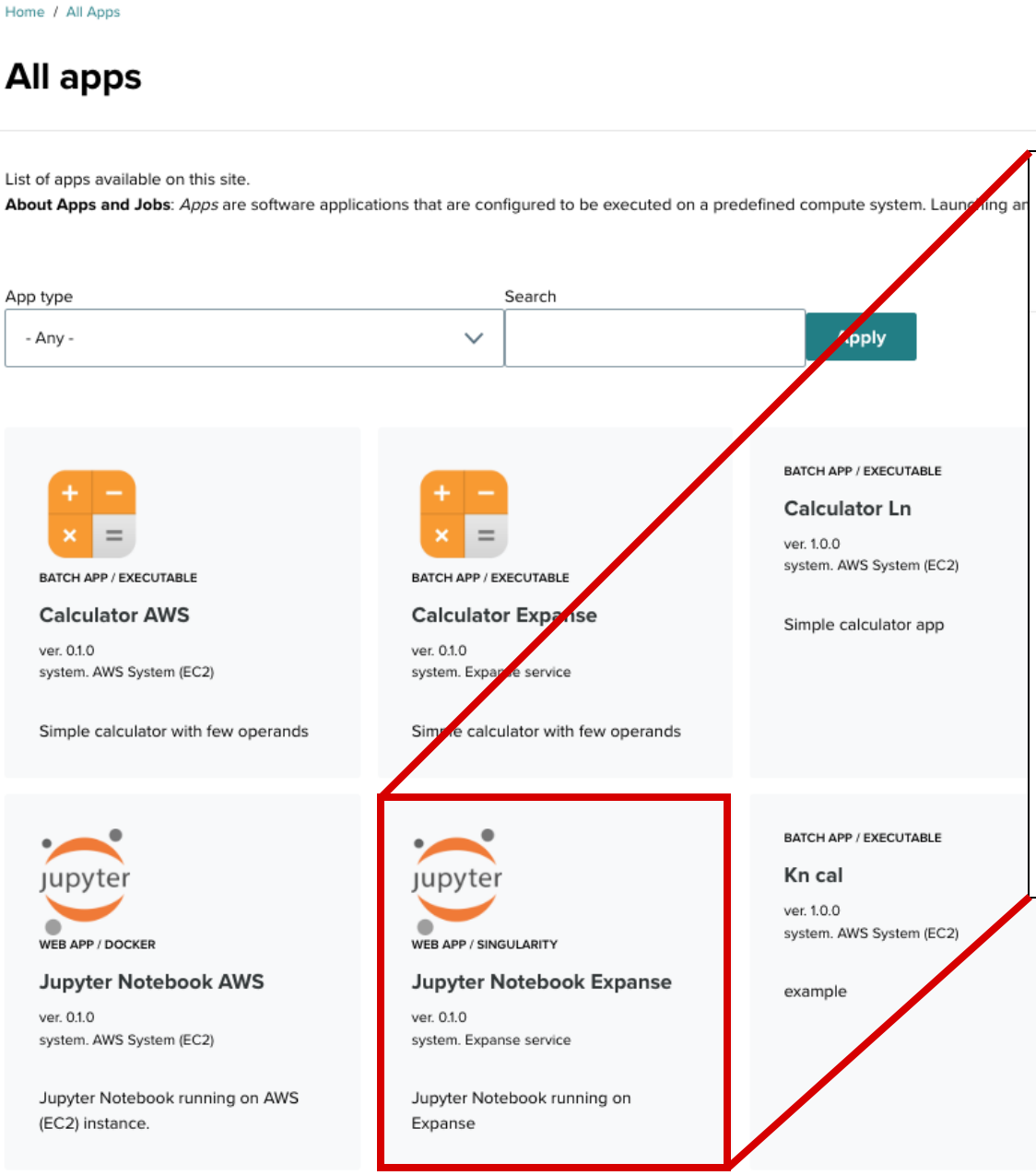
30

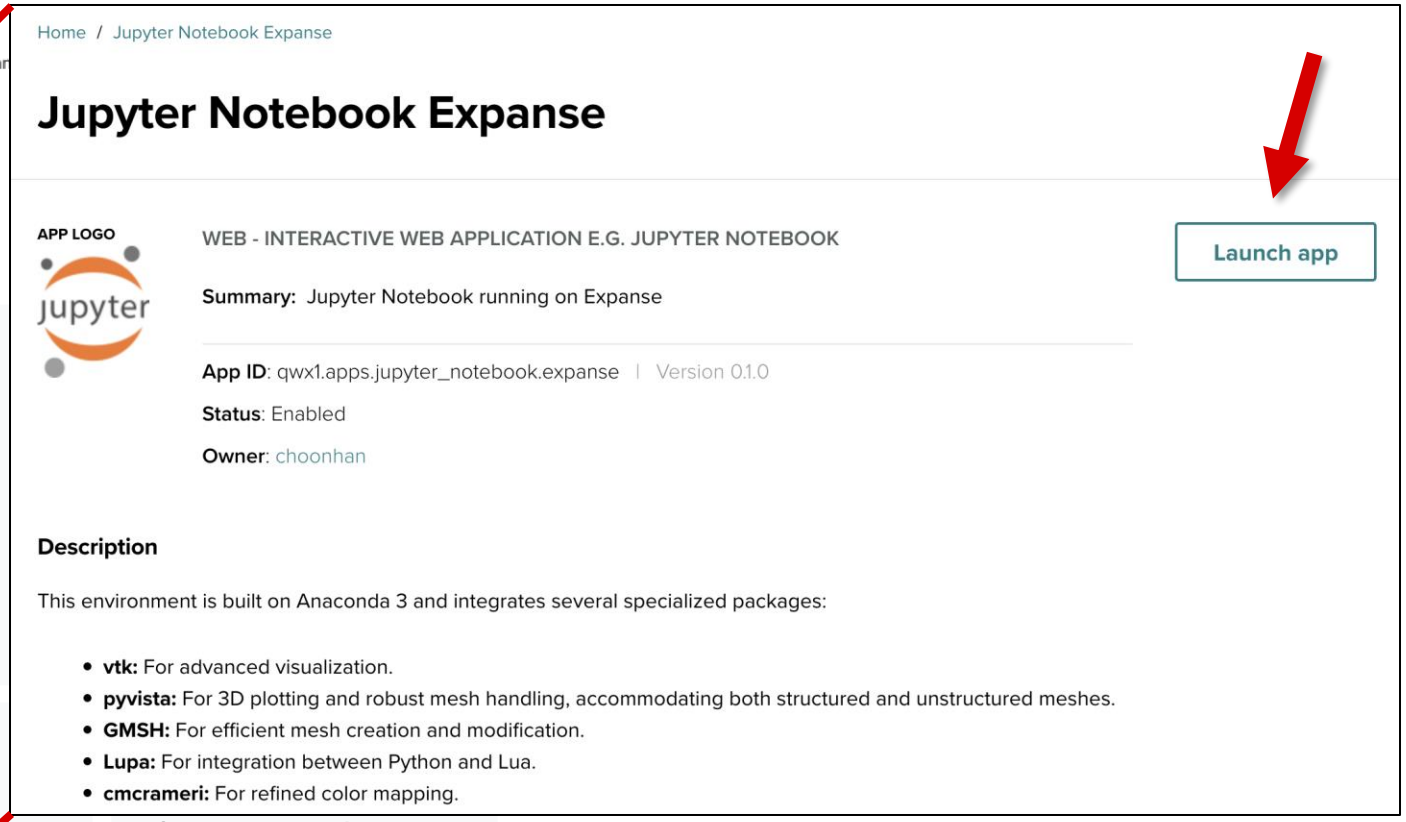
If you click output you can can see
the Tandem output files

Next we will learn how to open a Jupyter Notebook and use it to plot the simulations !

1. Launch Jupyter Notebook Expanse App

Apps → All apps → Jupyter Notebook Expanse → Launch app





1. Launch Jupyter Notebook Expanse App

Launch

Job name *

visualization

Specify a name for this job

Password *

Whatever password you want (remember it!)

▼ Job resources

Specify the job resources for this app

Max runtime (minutes) *

30

The maximum amount of time to run this app.

Change for the reminder of the session. Do not forget to kill your session in case you are done

System *

Expanse service

The system to run this app on.

Batch Logical Queue *

shared

The batch logical queue on which to run this application.

Save Draft | Submit

Wait until the job status becomes 'Running' and the 'Open app session' button activates

Home / visualization

visualization

Last message: Setting job status to running.

Remote job ID: 36370362

Remote job submitted: 2025-01-19T22:19:42

Remote job started: 2025-01-19T22:19:44

Job usage details

Resource details

Processing unit: CPU
Node count: 1
Cores per node: 1
Memory: 4000 MB

App: Jupyter Notebook Expanse

System: Expanse service

Owner: jeena

Created: Jan 19, 2025

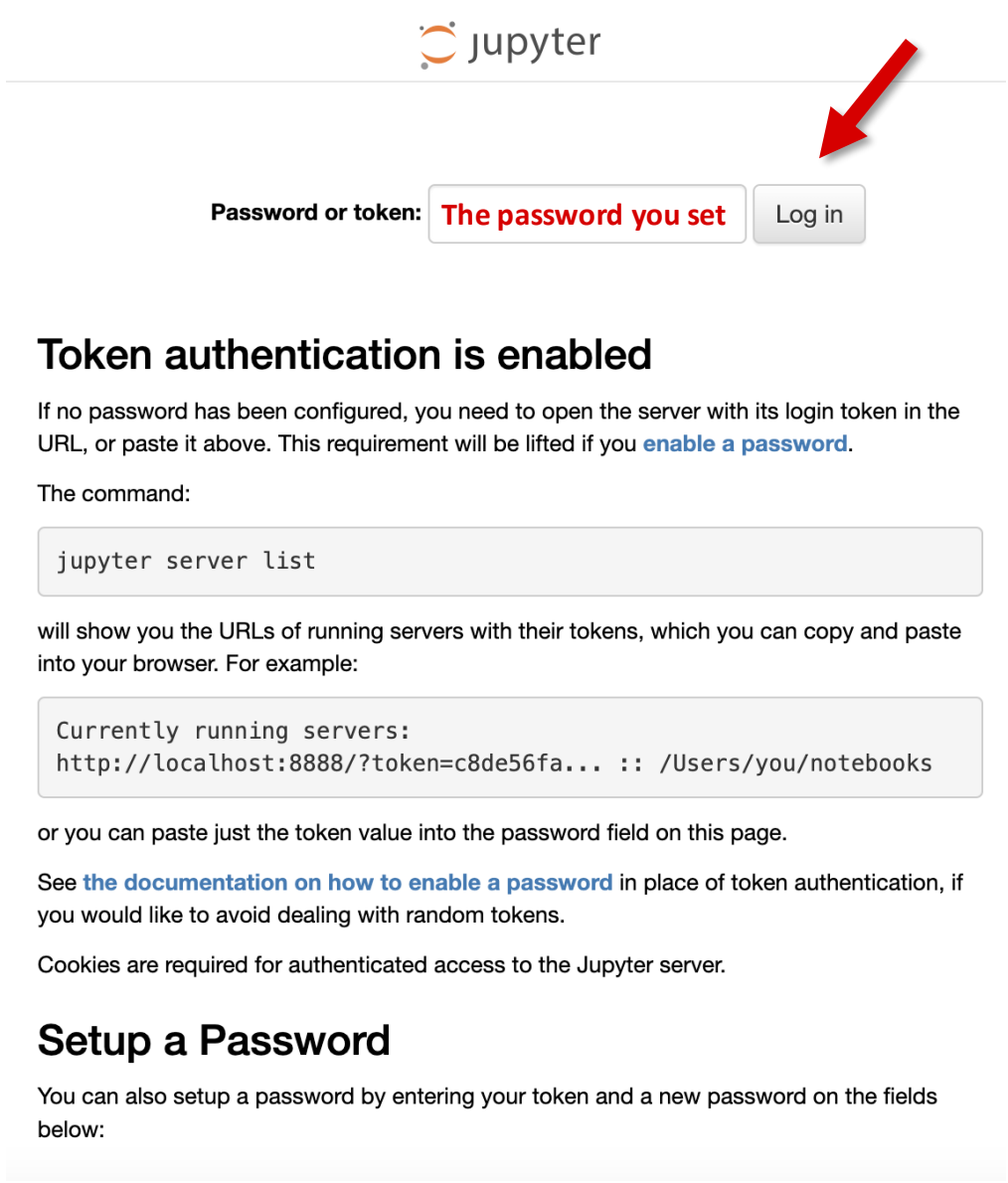
Tapis UUID: 247066da-ed7e-4bcf-8b3c-def5ffa90dd6-007

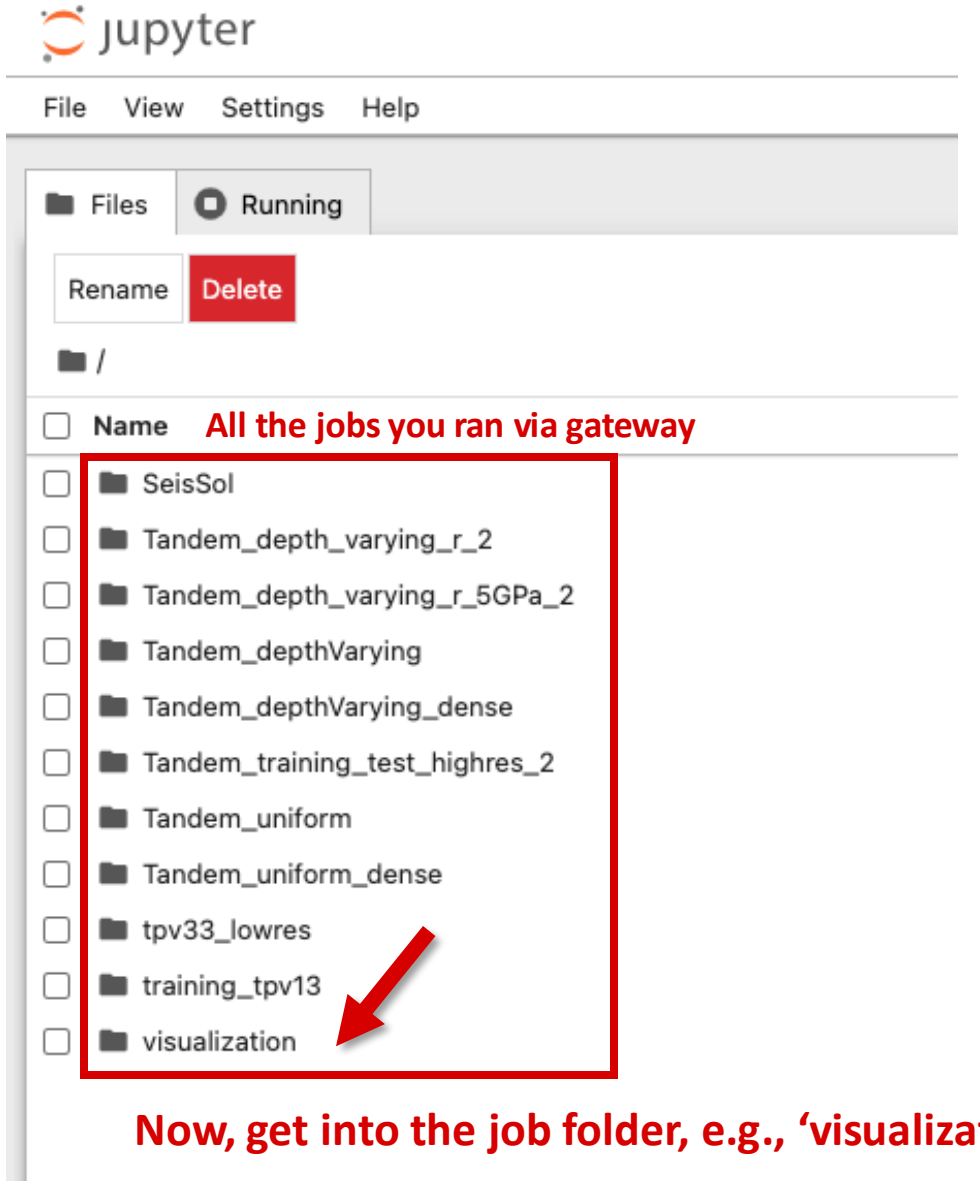
Open app session

Terminate Job

Running
Queued
Staging job
Processing inputs

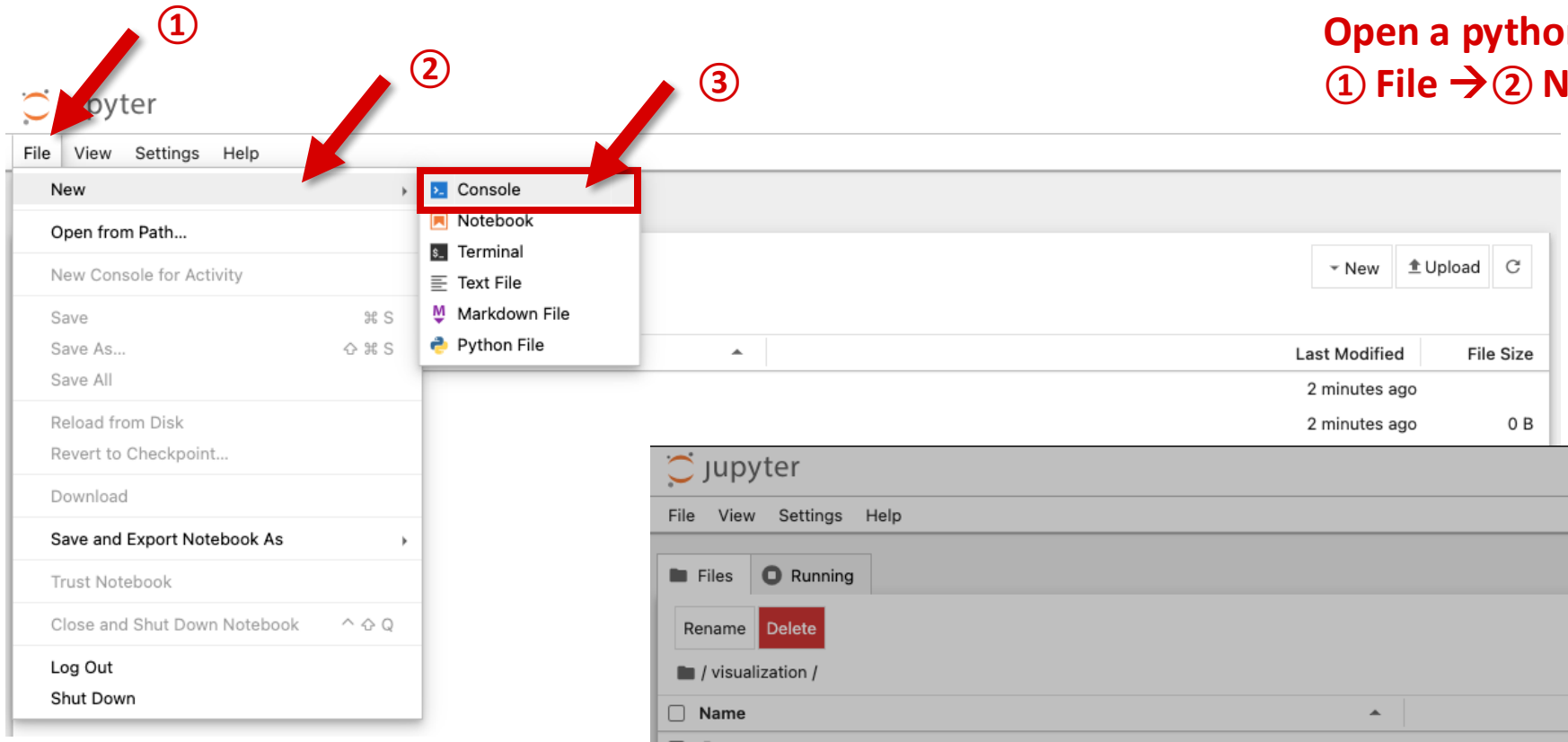
2. Open Jupyter Notebook App Session

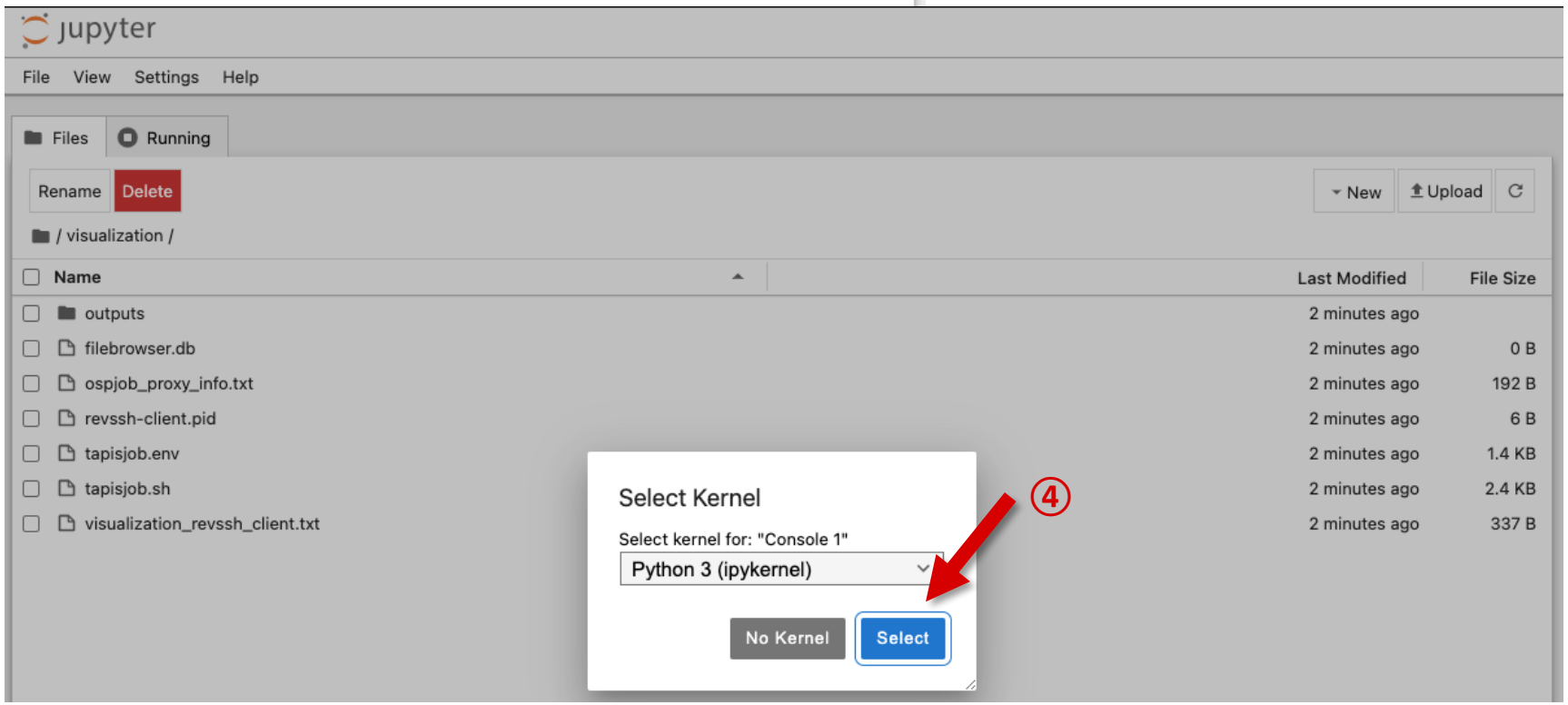




3. Clone the git repository containing plotting scripts

Open a python console by:
① File → ② New → ③ Console → ④ Select





3. Clone the git repository containing plotting scripts

jupyter

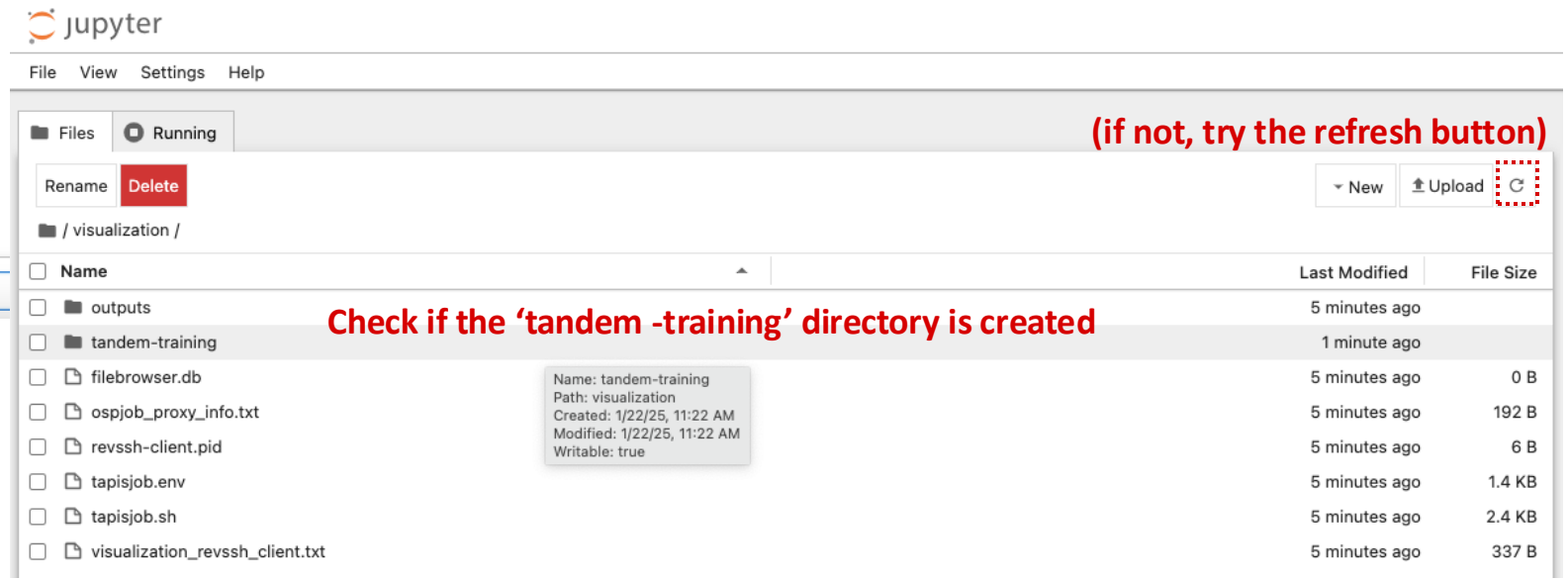
File View Settings Help

```
Python 3.12.2 | packaged by conda-forge | (main, Feb 16 2024, 20:50:58) [GCC 12.3.0]
Type 'copyright', 'credits' or 'license' for more information
IPython 8.27.0 -- An enhanced Interactive Python. Type '?' for help.

[1]: !ls

     filebrowser.db         revssh-client.pid  visualization_revssh_client.txt
     ospjob_proxy_info.txt  tapisjob.env
     outputs                tapisjob.sh

[2]: !git clone https://github.com/TEAR-ERC/tandem-training.git

     Cloning into 'tandem-training'...
     remote: Enumerating objects: 61, done.
     remote: Counting objects: 100% (61/61), done.
     remote: Compressing objects: 100% (47/47), done.
     remote: Total 61 (delta 26), reused 42 (delta 10), pack-reused 0 (from 0)
     Receiving objects: 100% (61/61), 7.29 MiB | 23.33 MiB/s, done.
     Resolving deltas: 100% (26/26), done.

[3]: !ls

     filebrowser.db         revssh-client.pid  tapisjob.sh
     ospjob_proxy_info.txt  tandem-training    visualization_revssh_client.txt
     outputs                tapisjob.env

[ ]:
```

In the console, type (with the exclamation mark):

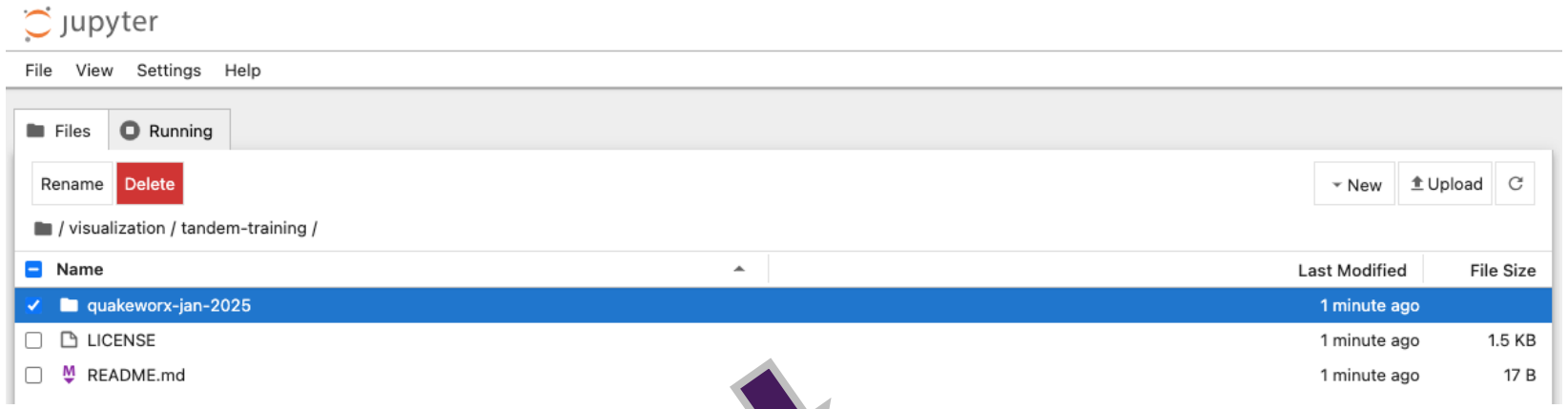
```
!git clone https://github.com/TEAR-ERC/tandem-training.git
```

** **To run a command, use shift + enter**

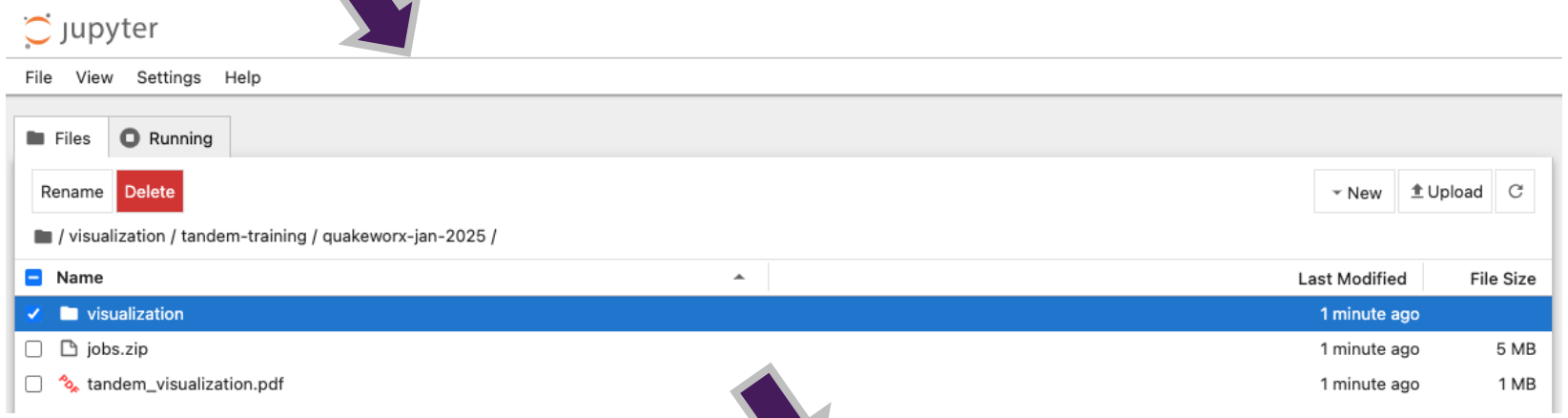


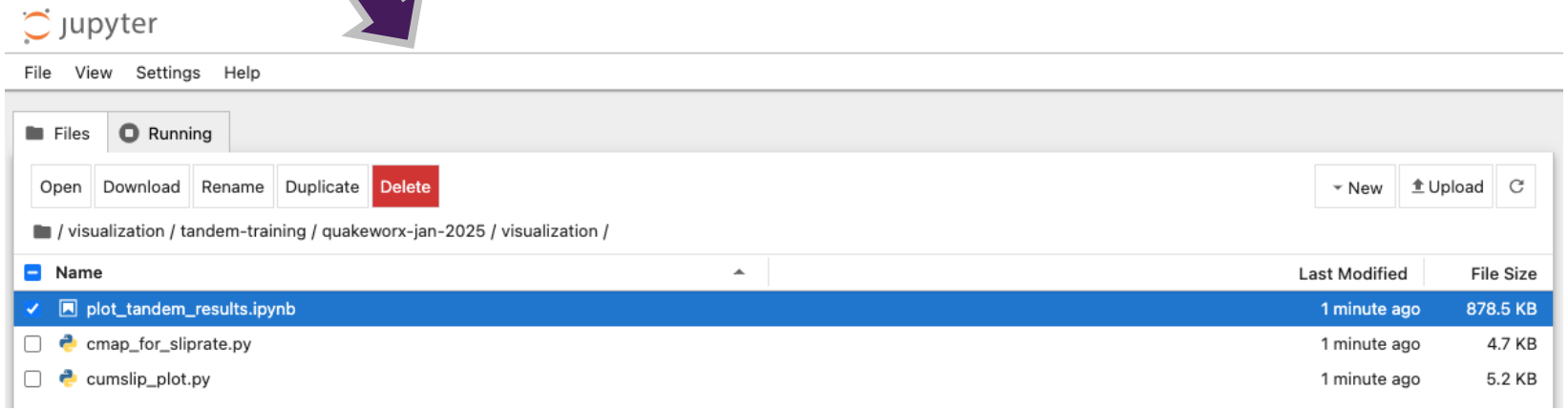
Check if the 'tandem -training' directory is created

4. Open the Jupyter Notebook for plotting scripts



Under the 'tandem-training' get into…
quakeworx-jan-2025/visualization





… and open
plot_tandem_results.ipynb