Underworld in the Cloud — a research code for all to use

a.k.a. Research-driven education tools …

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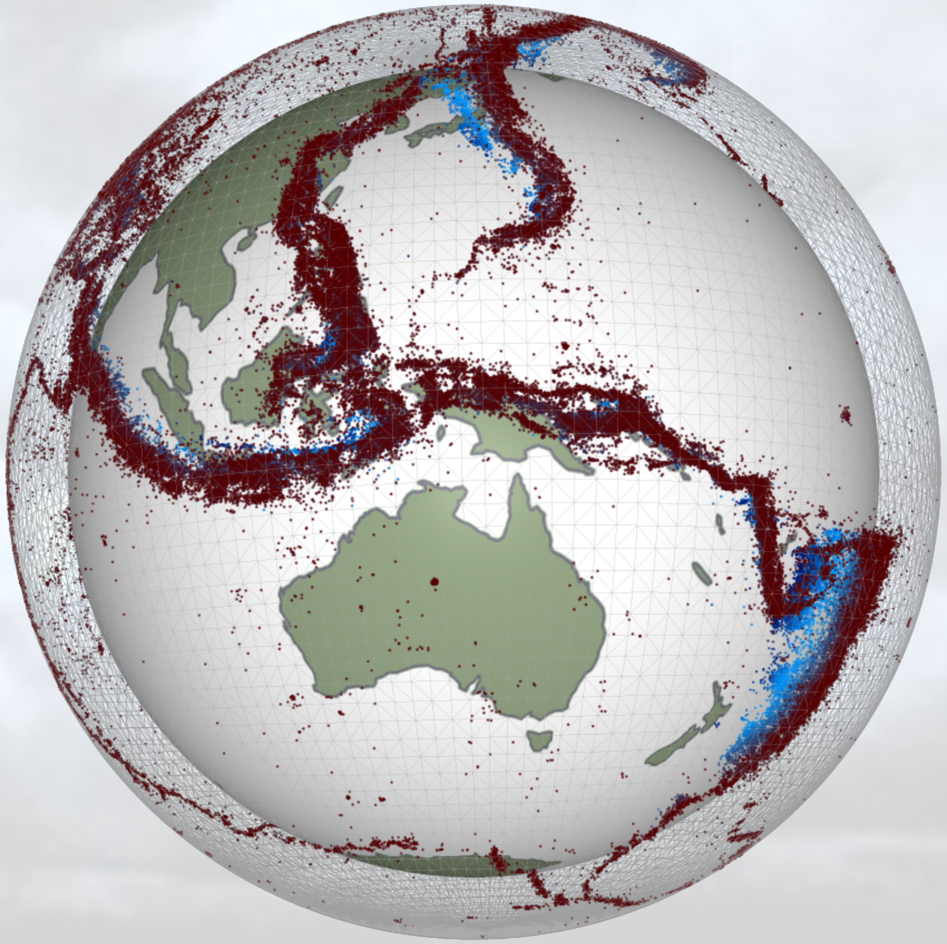
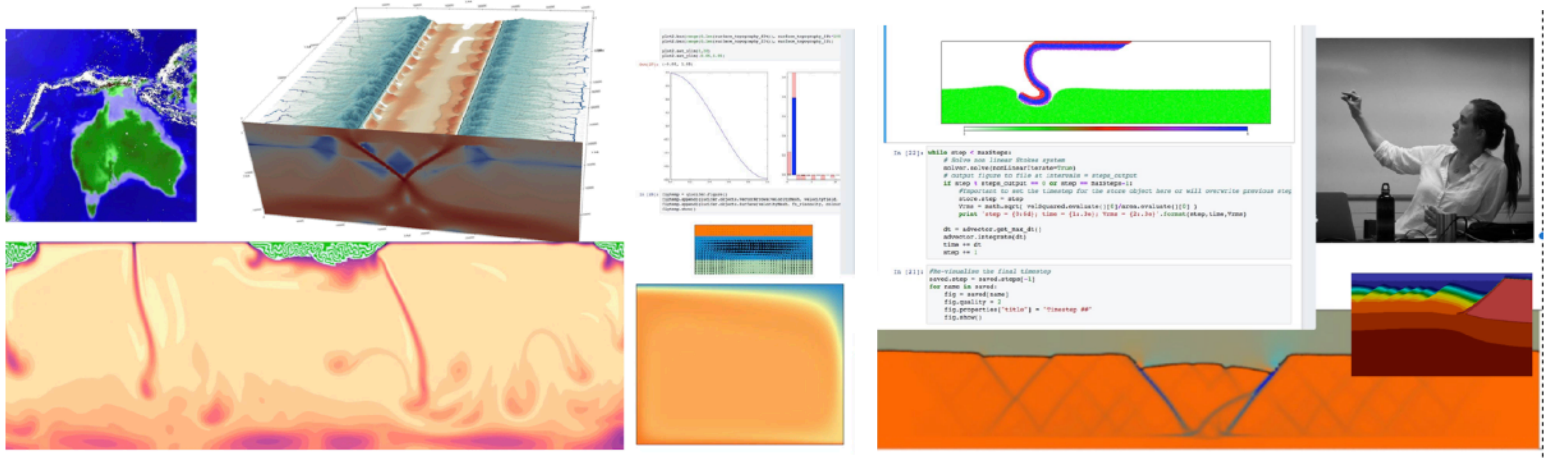
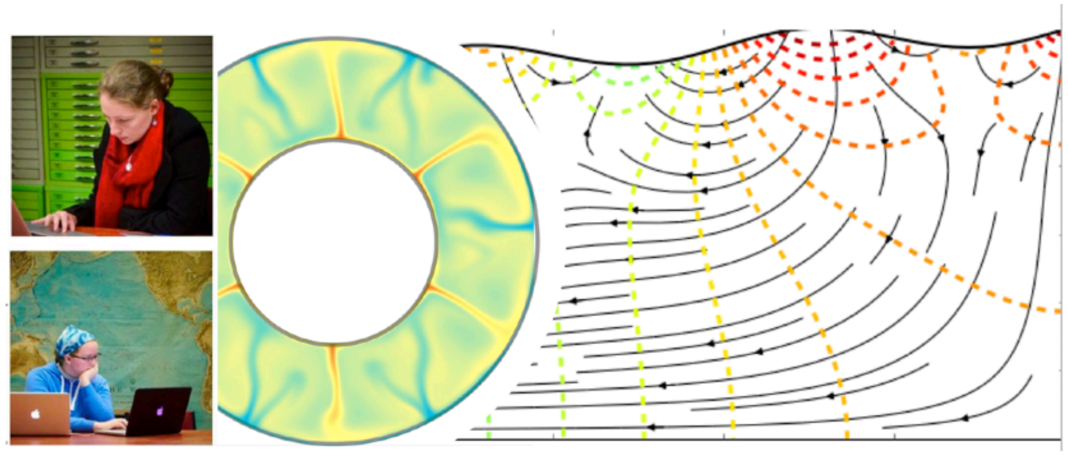
The UNDERWORLD team
The AuScope AVRE team

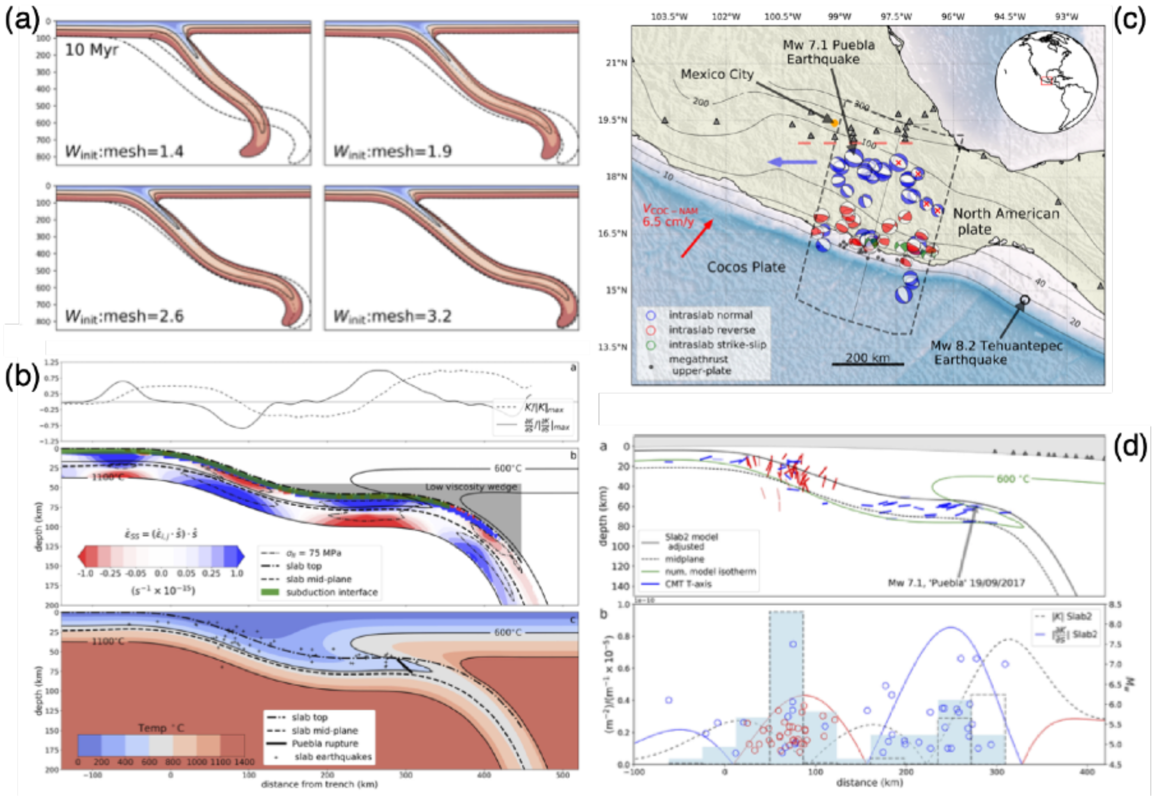


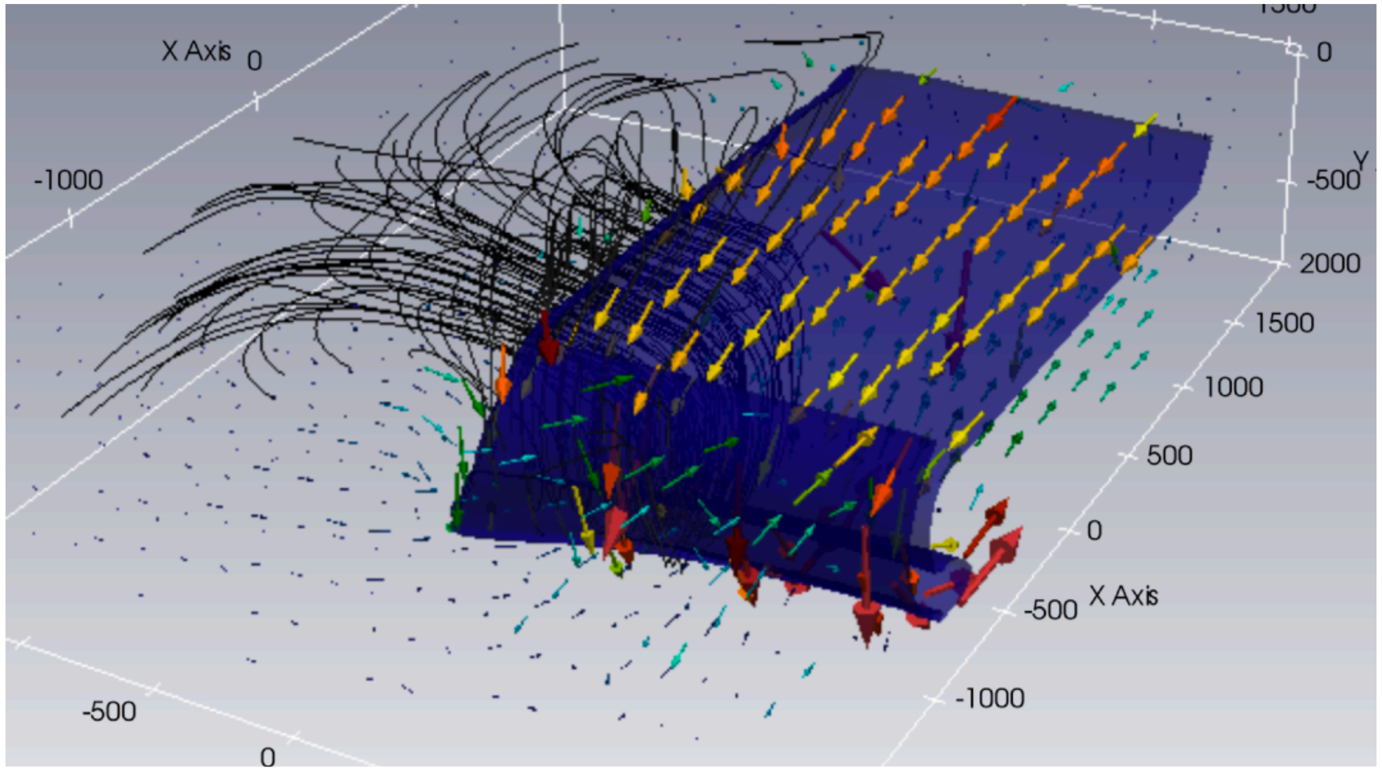
Recap — underworld is a flexible, research code



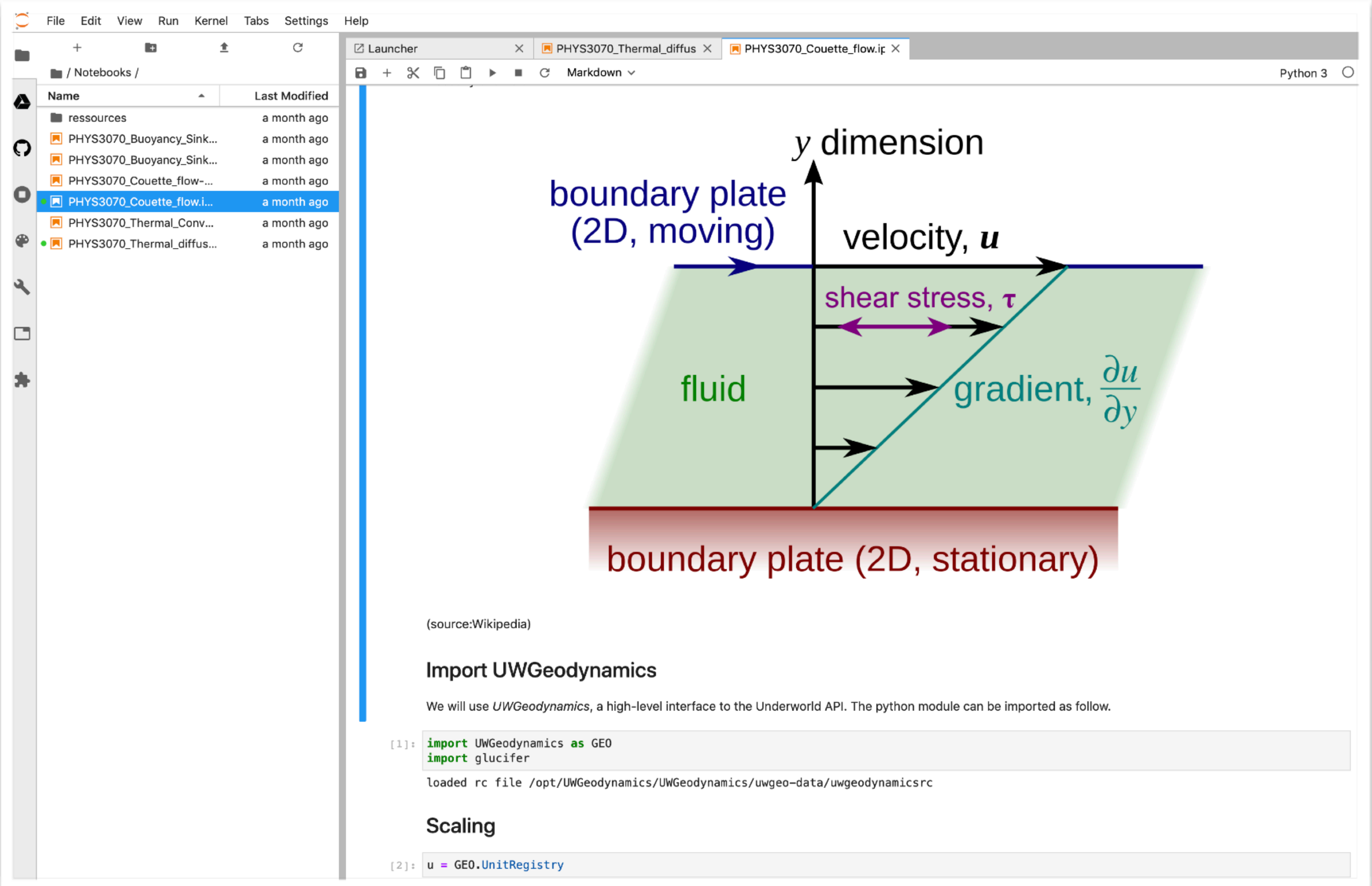
```
In [22]: while step < maxsteps:
             # Solve non linear Stokes system
             solver.solve(nonLinearIterate=True)
             # output figure to file at intervals = steps_output
             if step % steps_output == 0 or step == maxsteps-1:
                 #Important to set the timestep for the store object here or will overwrite previous step
                 store.step = step
                 Vrms = math.sqrt( velSquared.evaluate()[0]/area.evaluate()[0] )
                 print 'step = {0:6d}; time = {1:.3e}; Vrms = {2:.3e}'.format(step,time,Vrms)

             dt = advector.get_max_dt()
             advector.integrate(dt)
             time += dt
             step += 1

In [23]: #Re-visualise the final timestep
         saved.step = saved.steps[-1]
         for name in saved:
             fig = saved[name]
             fig.quality = 2
             fig.properties["title"] = "Timestep ##"
             fig.show()
```







Recap — underworld is easy to use



Name	Last Modified
ressources	a month ago
PHYS3070_Buoyancy_Sink...	a month ago
PHYS3070_Buoyancy_Sink...	a month ago
PHYS3070_Couette_flow-...	a month ago
PHYS3070_Couette_flow.i...	a month ago
PHYS3070_Thermal_Conv...	a month ago
PHYS3070_Thermal_diffus...	a month ago

(source:Wikipedia)

Import UWGeodynamics

We will use *UWGeodynamics*, a high-level interface to the Underworld API. The python module can be imported as follow.

```
[1]: import UWGeodynamics as GEO
     import glucifer
```

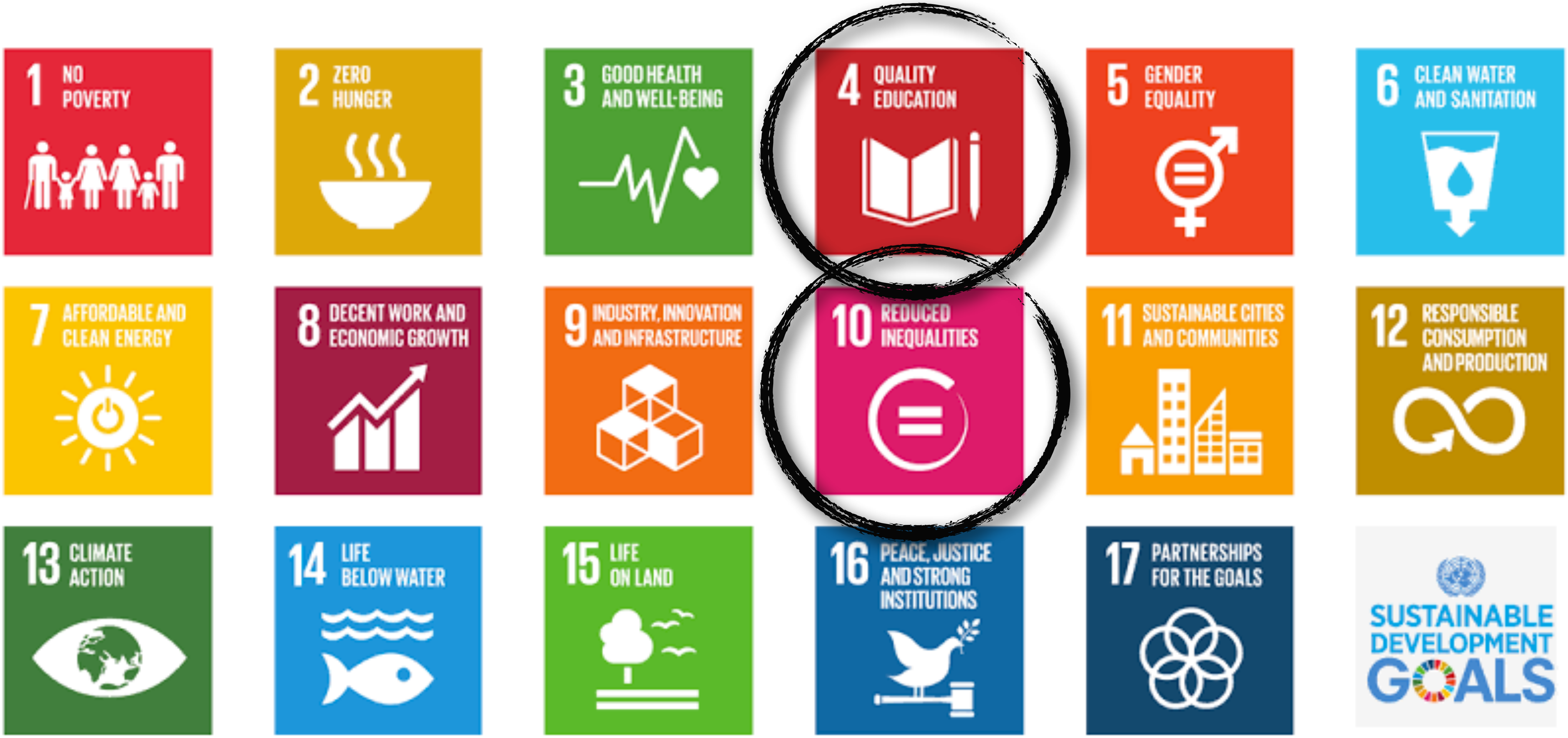
```
loaded rc file /opt/UWGeodynamics/UWGeodynamics/uwgeo-data/uwgeodynamicsrc
```

Scaling

```
[2]: u = GEO.UnitRegistry
```

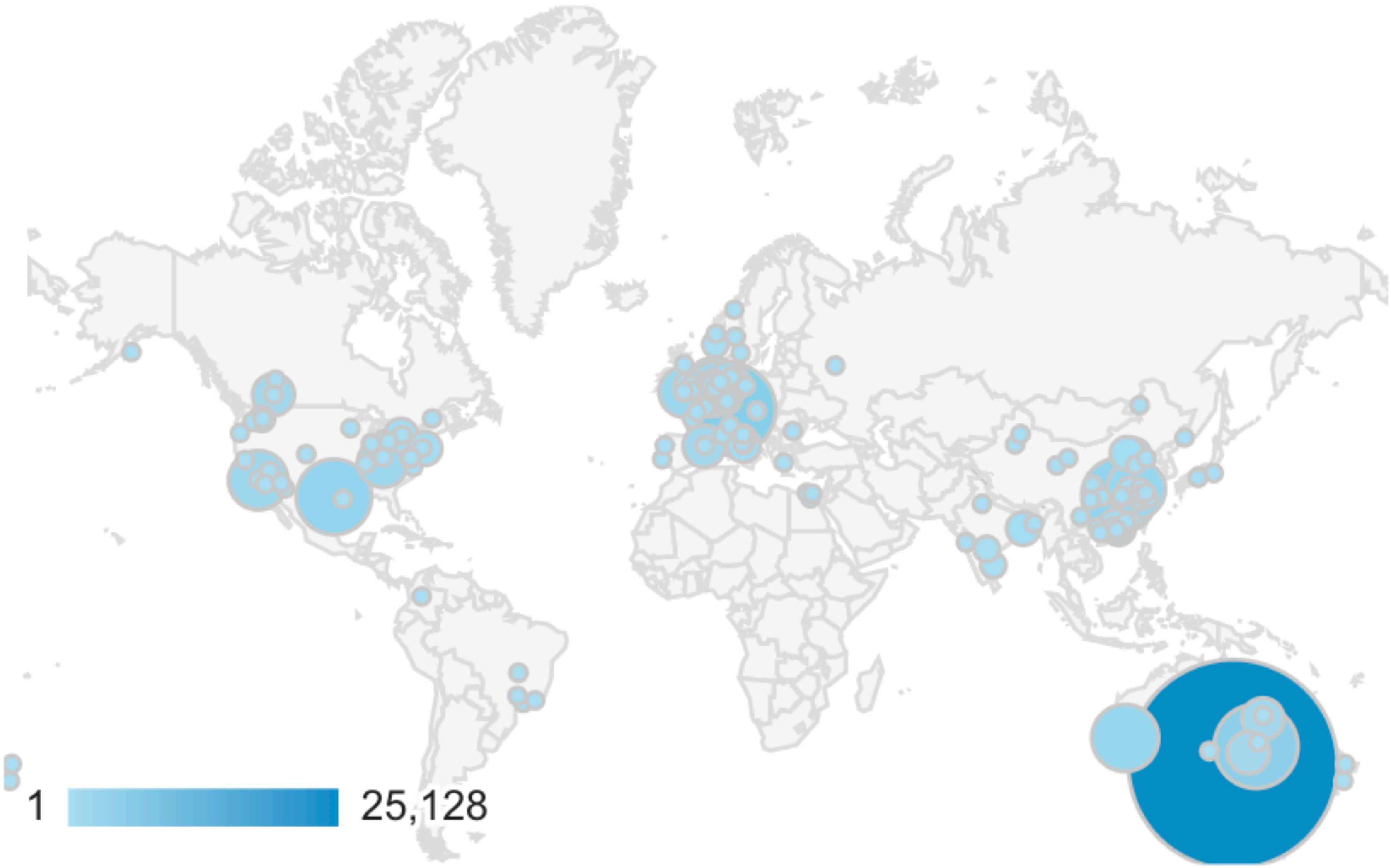
Python based, fully compatible with jupyter, …

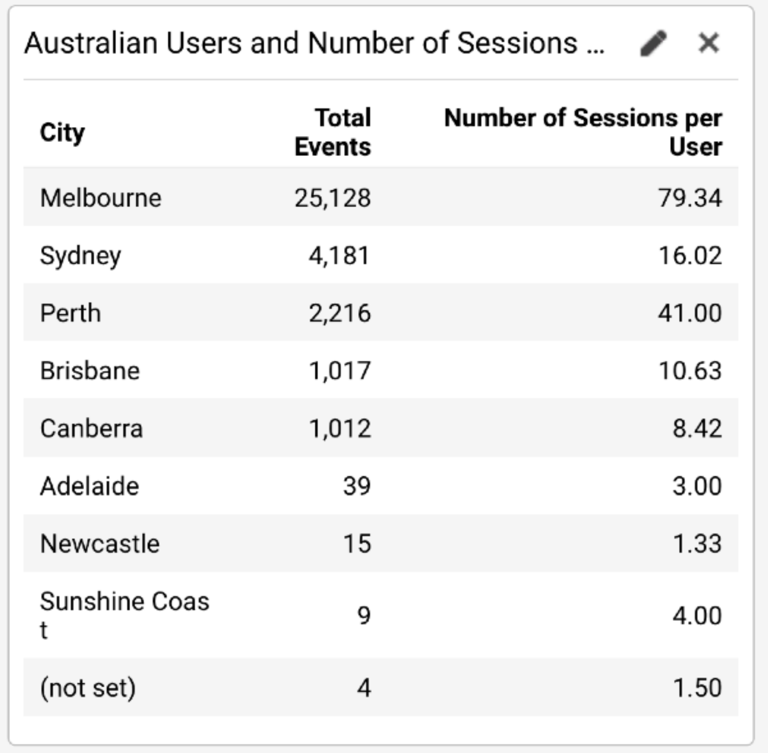
Sustainable development goals


1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

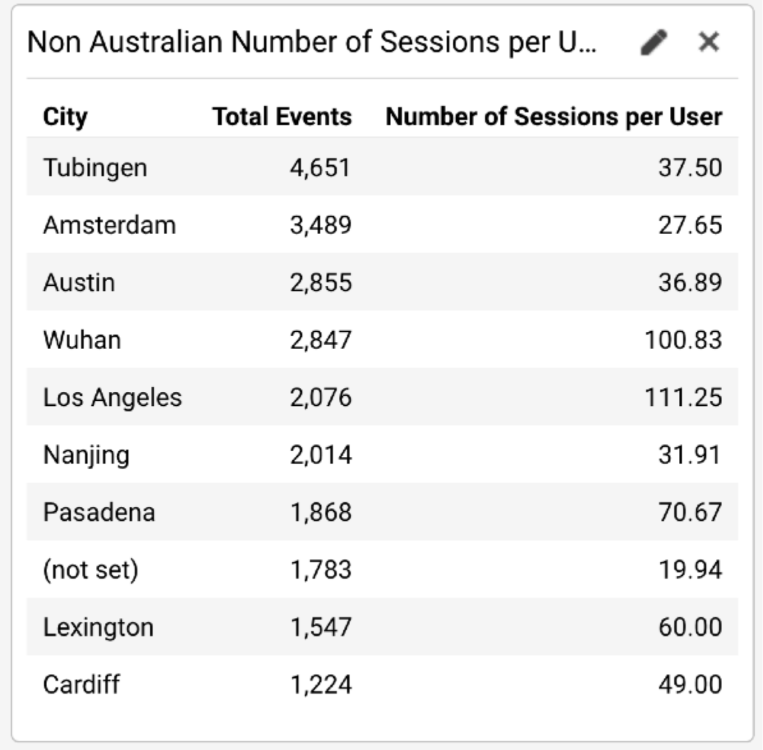
The cloud brings underworld into the classroom and is available worldwide

All the cloud users appear in Melbourne or Sydney (Google)




Australian Users and Number of Sessions ... ✎ ✕

City	Total Events	Number of Sessions per User
Melbourne	25,128	79.34
Sydney	4,181	16.02
Perth	2,216	41.00
Brisbane	1,017	10.63
Canberra	1,012	8.42
Adelaide	39	3.00
Newcastle	15	1.33
Sunshine Coas t	9	4.00
(not set)	4	1.50


Non Australian Number of Sessions per U... ✎ ✕

City	Total Events	Number of Sessions per User
Tubingen	4,651	37.50
Amsterdam	3,489	27.65
Austin	2,855	36.89
Wuhan	2,847	100.83
Los Angeles	2,076	111.25
Nanjing	2,014	31.91
Pasadena	1,868	70.67
(not set)	1,783	19.94
Lexington	1,547	60.00
Cardiff	1,224	49.00

Google Analytics, total events
‘import Underworld’
12 months to yesterday morning !

What do we mean by "cloud" ?

User is not providing computational resource

User does not need to install anything

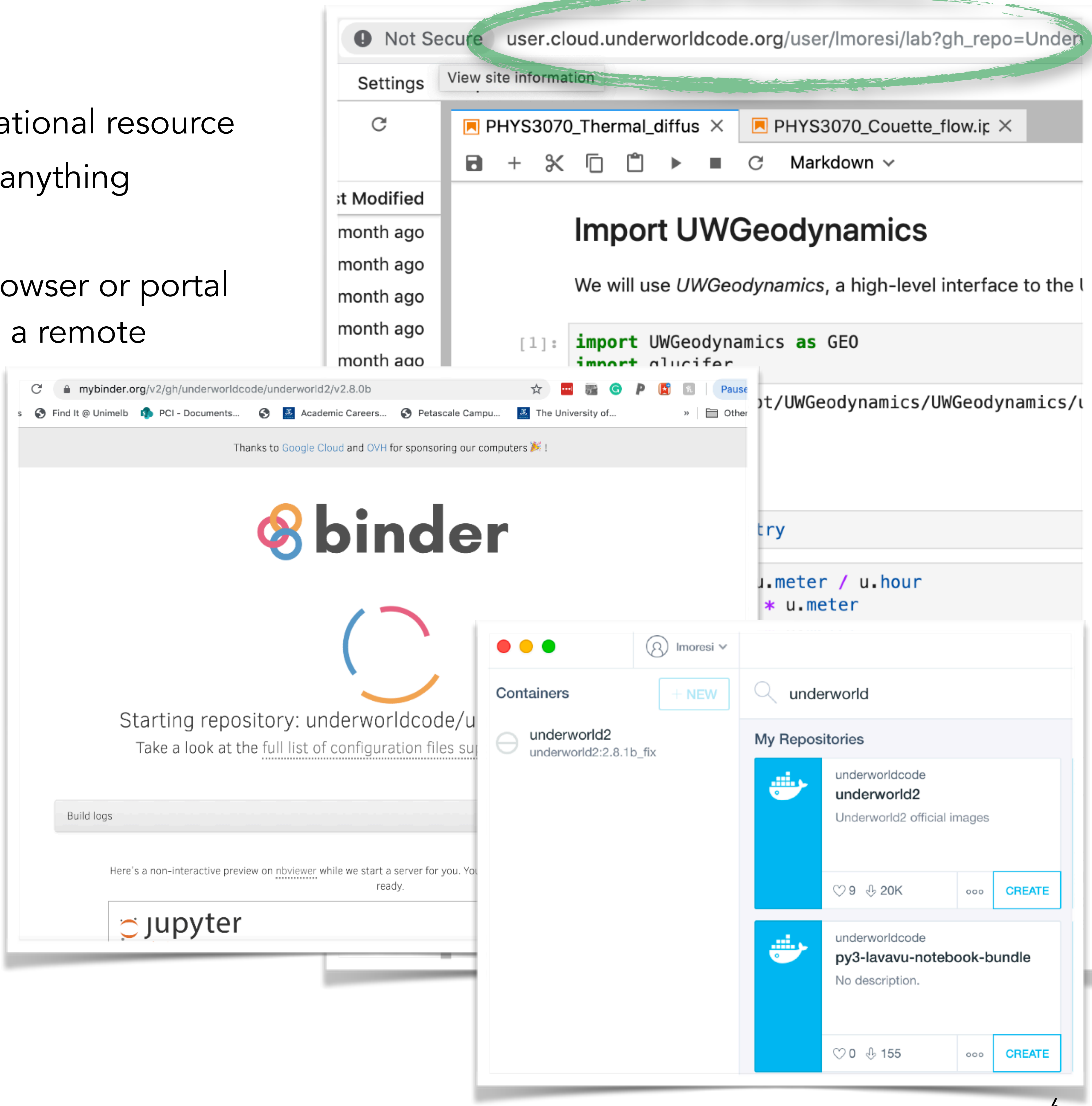
Access is usually through a browser or portal but actually could be through a remote kernel on a local app.

Examples:

- www.mybinder.org
- user.cloud.undeworldcode.org

Not dissimilar:
(except local computation)

- kitematic + container



Not Secure user.cloud.underworldcode.org/user/lmoresi/lab?gh_repo=Under

Settings View site information

Import UWGeodynamics

We will use *UWGeodynamics*, a high-level interface to the

```
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     import glucifer
```

```
ot/UWGeodynamics/UWGeodynamics/u
```

```
try
```

```
u.meter / u.hour
* u.meter
```

mybinder.org/v2/gh/underworldcode/underworld2/v2.8.0b

Thanks to Google Cloud and OVH for sponsoring our computers 🎉 !

Starting repository: underworldcode/u

Take a look at the full list of configuration files su

Build logs

Here's a non-interactive preview on nbviewer while we start a server for you. You ready.

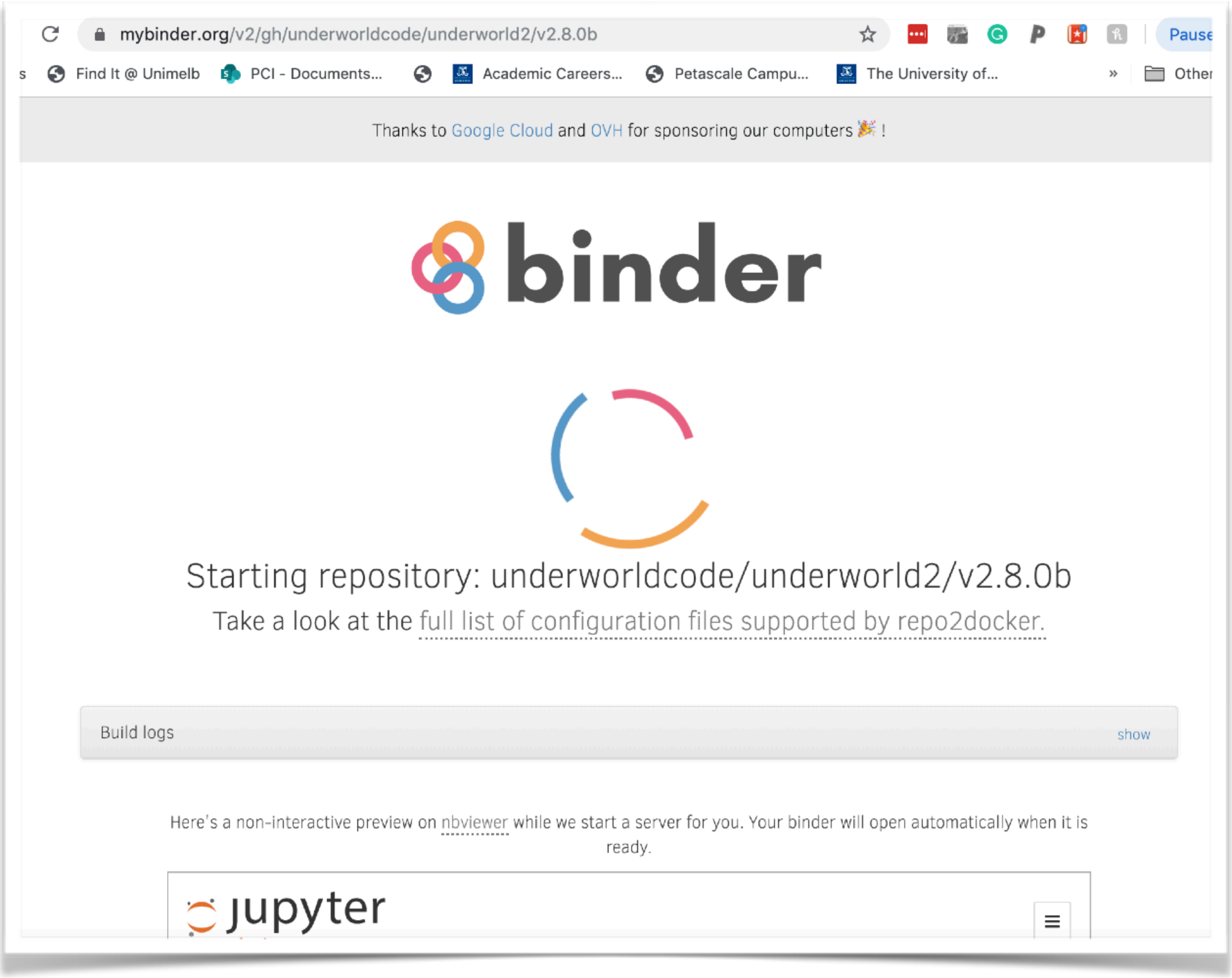
underworld2
underworld2:2.8.1b_fix

My Repositories

underworldcode
underworld2
Underworld2 official images
♡ 9 20K CREATE

underworldcode
py3-lavavu-notebook-bundle
No description.
♡ 0 155 CREATE

Binder v. uwcloud



mybinder.org/v2/gh/underworldcode/underworld2/v2.8.0b

Thanks to Google Cloud and OVH for sponsoring our computers 🎉 !

Starting repository: underworldcode/underworld2/v2.8.0b

Take a look at the full list of configuration files supported by repo2docker.

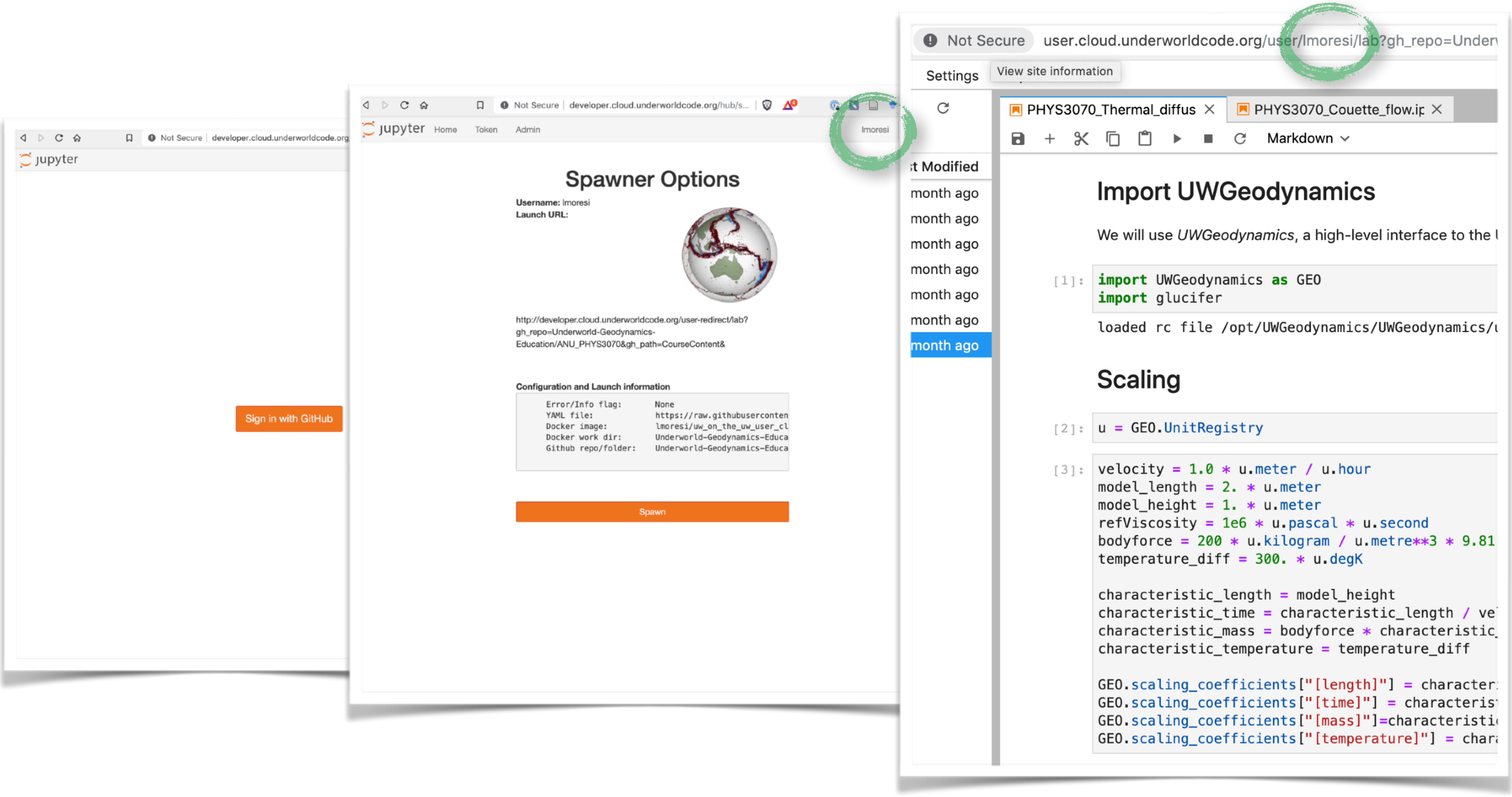
Here's a non-interactive preview on nbviewer while we start a server for you. Your binder will open automatically when it is ready.

Binder: prepare a repository with build information in a `binder` subdirectory.

Launch, run, lose everything, repeat

Note: usually **"lose everything"** is a feature not a bug (e.g. reset a worked example)

Binder v. uwcloud



Spawner Options

Username: lmoresi
Launch URL:

http://developer.cloud.underworldcode.org/user-redirect/lab?gh_repo=Underworld-Geodynamics-Education/ANU_PHYS3070&gh_path=CourseContent&

Configuration and Launch information

```
    Error/Info flag:       None
    YAML file:             https://raw.githubuserconten
    Docker image:          lmoresi/uw_on_the_uw_user_cl
    Docker work dir:       Underworld-Geodynamics-Educa
    Github repo/folder:    Underworld-Geodynamics-Educa
```

Spawn

Import UWGeodynamics

We will use *UWGeodynamics*, a high-level interface to the U

```
[1]: import UWGeodynamics as GEO
     import glucifer
```

```
loaded rc file /opt/UWGeodynamics/UWGeodynamics/u
```

Scaling

```
[2]: u = GEO.UnitRegistry
```

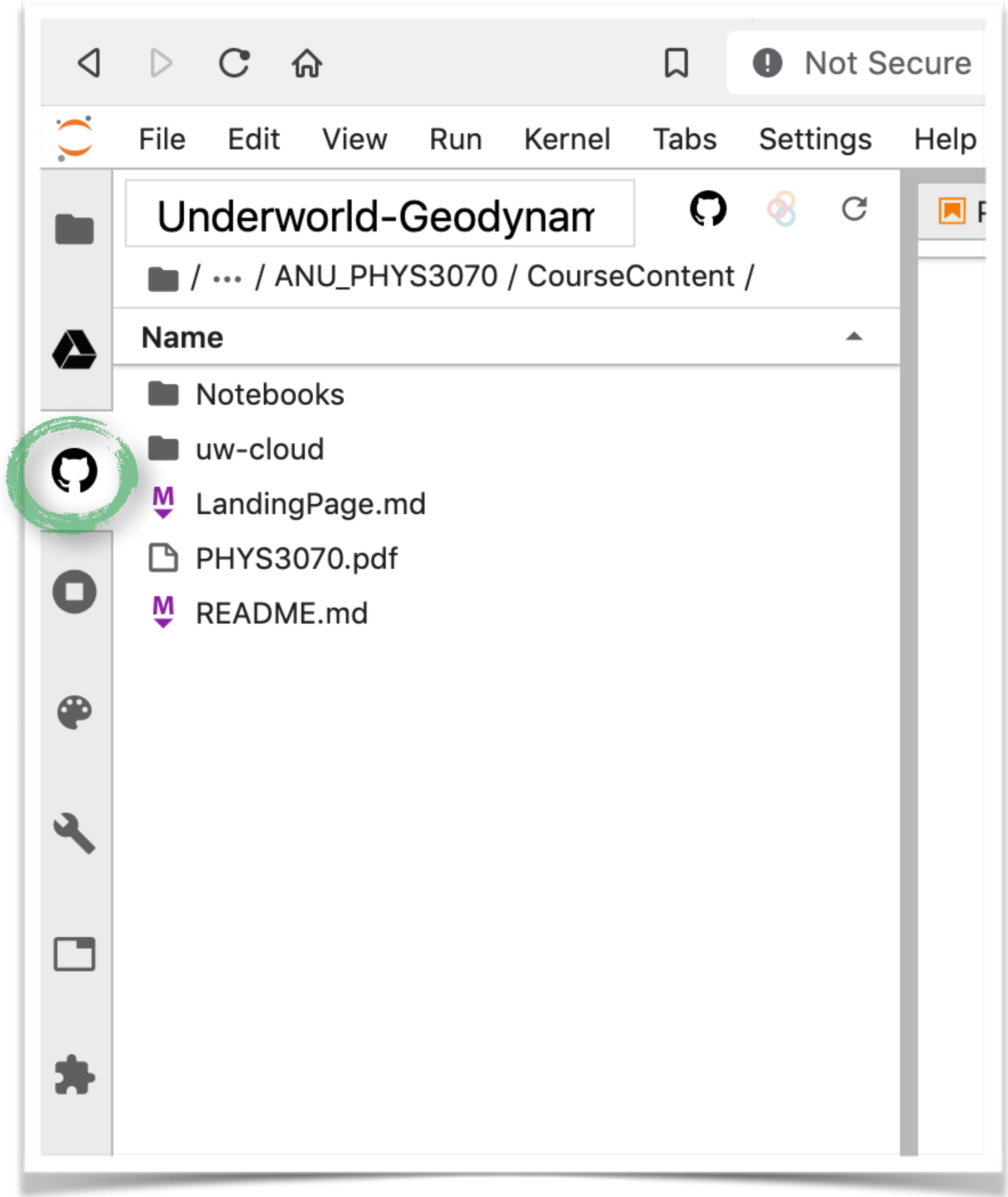
```
[3]: velocity = 1.0 * u.meter / u.hour
     model_length = 2. * u.meter
     model_height = 1. * u.meter
     refViscosity = 1e6 * u.pascal * u.second
     bodyforce = 200 * u.kilogram / u.metre**3 * 9.81
     temperature_diff = 300. * u.degK

     characteristic_length = model_height
     characteristic_time = characteristic_length / ve
     characteristic_mass = bodyforce * characteristic_
     characteristic_temperature = temperature_diff

     GEO.scaling_coefficients["[length]"] = character
     GEO.scaling_coefficients["[time]"] = characteris
     GEO.scaling_coefficients["[mass]"]=characteristi
     GEO.scaling_coefficients["[temperature]"] = chara
```

uwcloud: prepare a repository with build information in a `uwcloud` subdirectory.

Launch, authenticate, run, keep everything, repeat

Note: we have to authenticate you in some way in order to know how to keep your stuff !

Users own data ?



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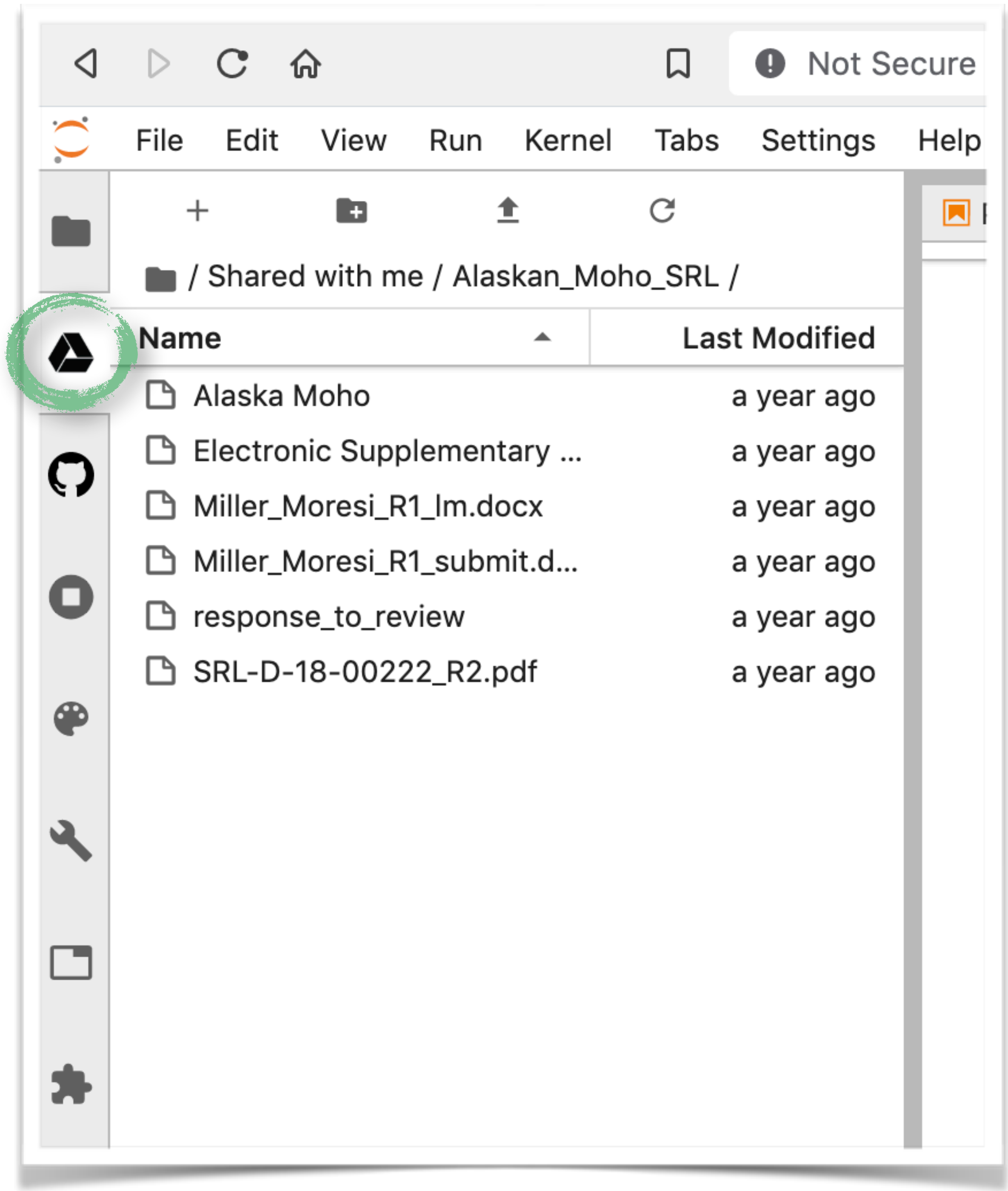
Name
Notebooks
uw-cloud
LandingPage.md
PHYS3070.pdf
README.md



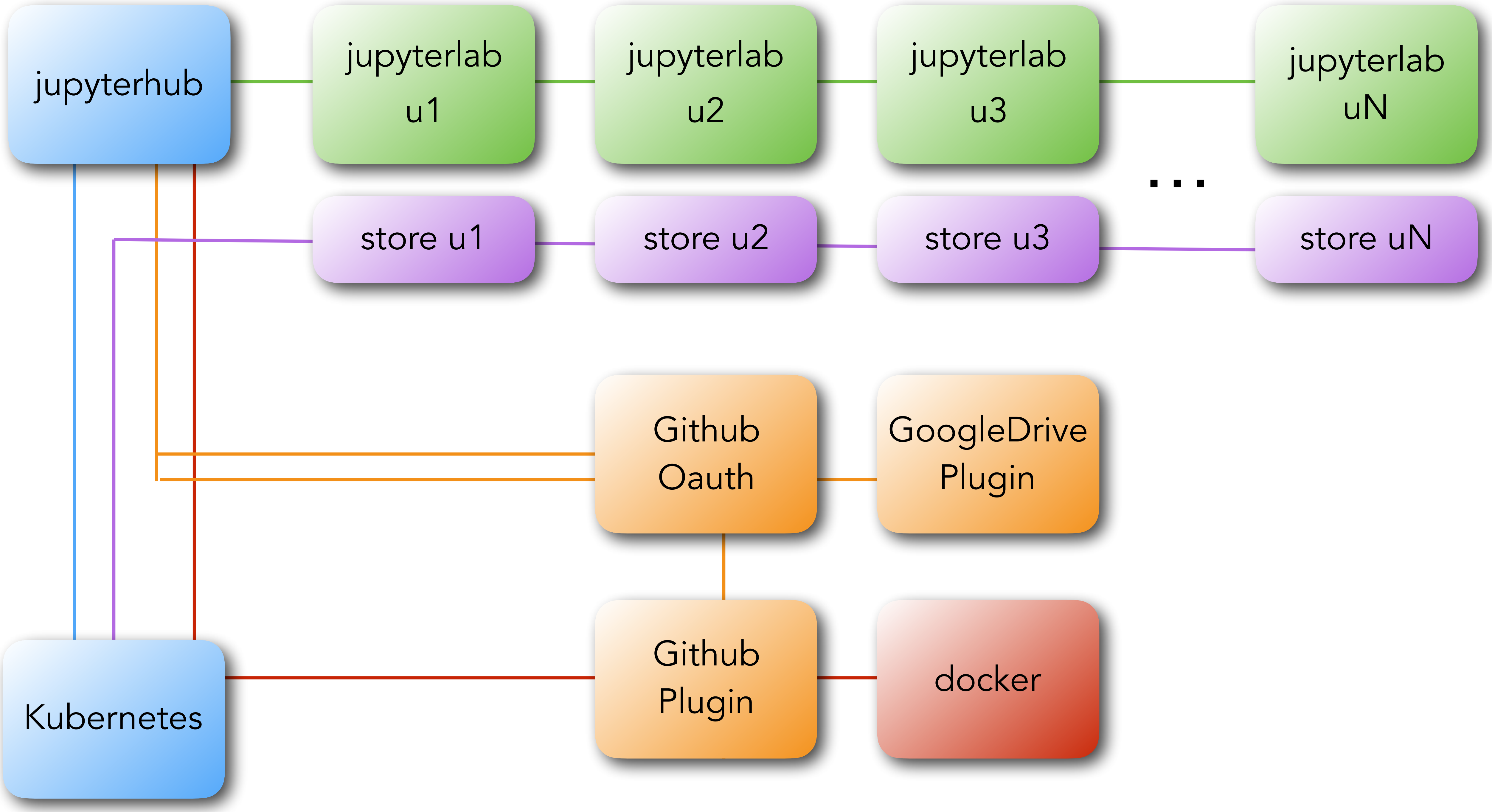
/ Shared with me / Alaskan_Moho_SRL /

Name	Last Modified
Alaska Moho	a year ago
Electronic Supplementary ...	a year ago
Miller_Moresi_R1_lm.docx	a year ago
Miller_Moresi_R1_submit.d...	a year ago
response_to_review	a year ago
SRL-D-18-00222_R2.pdf	a year ago

We can connect google drive and github (browse only) via jupyterlab plugins

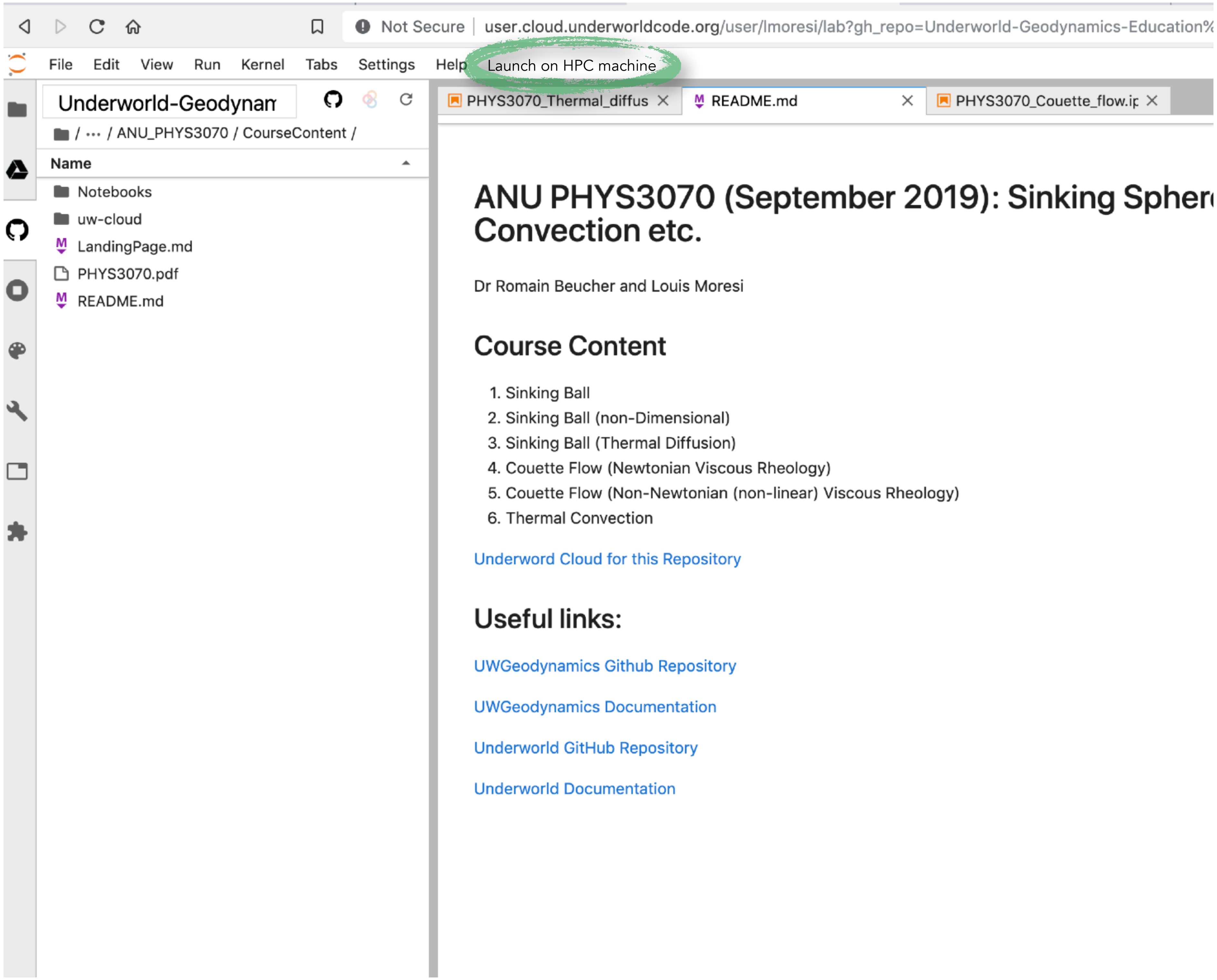
Might be helpful to have a local service such as cloudstor provided the same way

How is this implemented ?



Runs on any kubernetes installation — specify target github repository via URL. Repository must have docker container instructions.

What next ?


Not Secure | user.cloud.underworldcode.org/user/lmoresi/lab?gh_repo=Underworld-Geodynamics-Education%
File Edit View Run Kernel Tabs Settings Help
Launch on HPC machine
Underworld-Geodynam
/ ··· / ANU_PHYS3070 / CourseContent /
Name
Notebooks
uw-cloud
LandingPage.md
PHYS3070.pdf
README.md
PHYS3070_Thermal_diffus
README.md
PHYS3070_Couette_flow.ip

ANU PHYS3070 (September 2019): Sinking Spher Convection etc.

Dr Romain Beucher and Louis Moresi

Course Content

1. Sinking Ball
2. Sinking Ball (non-Dimensional)
3. Sinking Ball (Thermal Diffusion)
4. Couette Flow (Newtonian Viscous Rheology)
5. Couette Flow (Non-Newtonian (non-linear) Viscous Rheology)
6. Thermal Convection

Underword Cloud for this Repository

Useful links:

UWGeodynamics Github Repository

UWGeodynamics Documentation

Underworld GitHub Repository

Underworld Documentation

Also … roll out your own cloud easily, anywhere with appropriate scalability

Try some UWGeodynamics examples

http://user.cloud.underworldcode.org/user-redirect/lab?gh_repo=Underworld-Geodynamics-Education/ANU_PHYS3070&gh_path=CourseContent

This is from our recent class to the Physics of the Earth students at ANU — you need to authenticate via github for access