Multi-lingual Jupyter notebooks for learning the Open Global Glacier Model

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Abstract

Glaciers are major contributors to global sea level change and regional freshwater resources. In light of the worldwide societal importance of glacier change, we see a need for accessible glacier-education materials in many languages. We have developed a set of Jupyter notebooks, available in both Spanish and English, that coaches users through basic simulations with the Open Global Glacier Model (edu.oggm.org). The notebooks are freely available via GitHub (github.com/ehultee/CdeC-glaciologia), with no special software installation requirements for users. Participants in a week-long glaciology workshop at Clubes de Ciencia Peru 2019 used our notebooks to study glacier physics and make future projections for mountain glaciers of their choice. Only one participant had previously used Python, and none had experience with numerical modelling of Earth systems in any language. All were able to run the notebooks and explain their findings. Most participants were also able to modify the notebooks to conduct experiments of interest to them. We consider this a particularly successful case of science outreach, in that workshop participants are now equipped to explore their own important questions independently. The notebooks we have developed can support multilingual glaciology outreach; we hope that sharing our experience can support public geoscience more broadly.

1

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Key Points

- Jupyter notebooks help students with limited programming experience learn to use a numerical glacier model.

- Educational notebooks for glacier modelling are publicly available in both English & Spanish from OGGM-Edu.

- In July 2019 workshop: 20 participants used OGGM to simulate changing water storage on a glacier of their choice.

Scan QR code with a mobile device to access example notebooks in Binder

Motivation

Glacier change affects human society.
As the world's glaciers retreat, they raise global sea level—and can both increase and decrease local water supply. There is ongoing public interest in and need for glaciological information.

Models help us understand nonlinear glacier change.
Mountain glacier response to climate change is modulated by locally-variable factors. To make realistic projections of future glacier change, we must be able to simulate ice dynamics accounting for these factors.

Basins worldwide depend on glacial water resources.
The demand for glaciological information, and for trained glaciological professionals, extends beyond the English language.

Learning objectives

- Learners are able to use a numerical model of glacier evolution to answer a research question

- Learners can explain the major factors influencing nonlinear response of mountain glaciers to climate change

- Learners can explore the impact of glacier change on societally-relevant quantities, e.g. water availability

Example workshop: Glaciología y recursos hídricos

At Clubes de Ciencia Perú 2019, we conducted a weeklong workshop on Glaciology and Glacial Water Resources. Topics covered included:

- Mechanics of glacier flow (qualitative)
- Observational methods of glaciology
- Role of glaciers in the hydro-social system
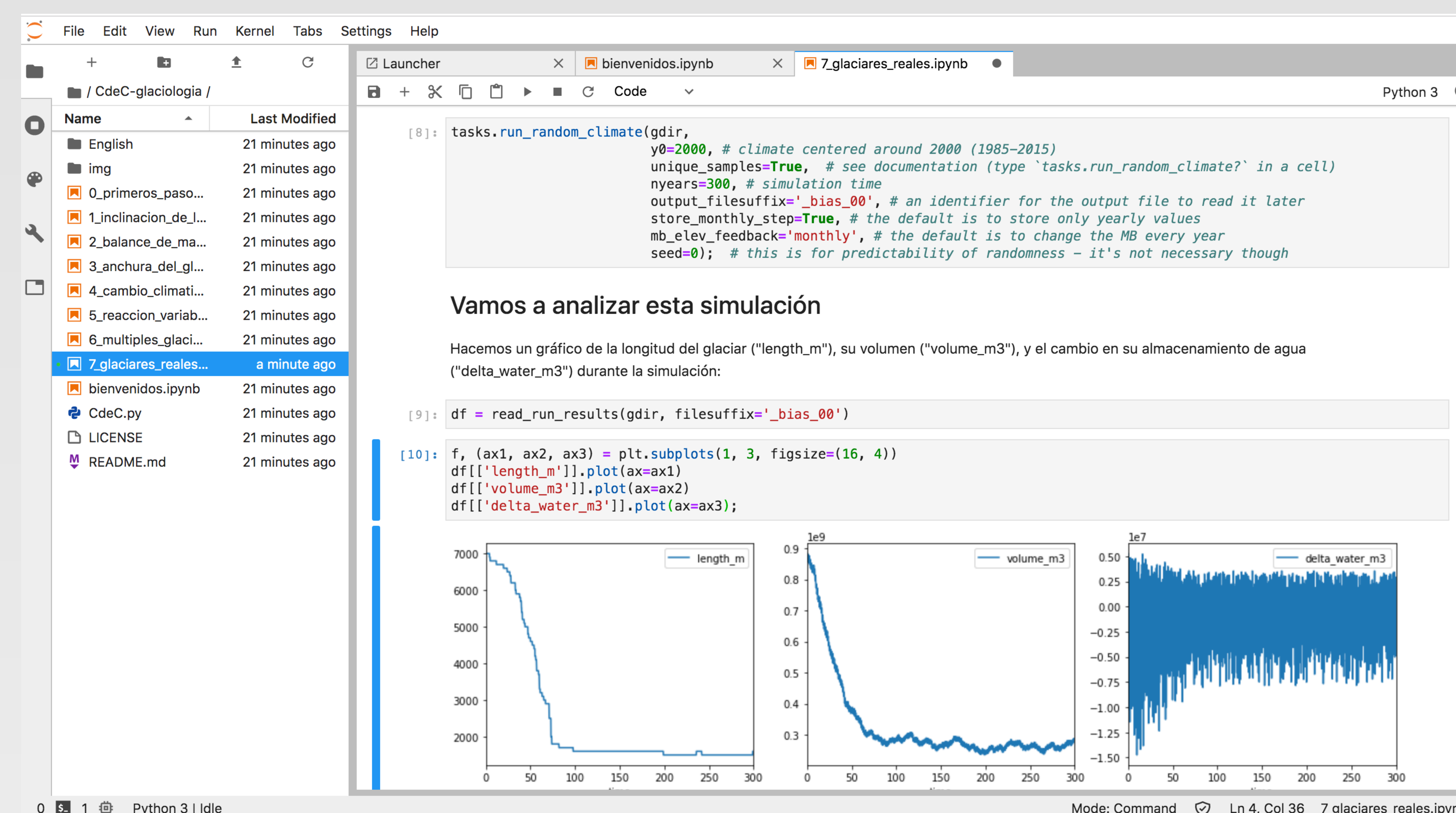- Basics of Jupyter & Python
- Best practices in code problem-solving

Figure 1. An example view of an OGGM-Edu Jupyter notebook displayed in Binder. Markdown headers and text structure the notebook around cells of executable Python code. Activities for students appear in bold. Tabs (near the top) separate active notebooks. Additional files, such as the raw Python code for commonly used functions (CdeC.py), appear in the left sidebar file directory.

Workshop participants ranged in age (17-22), career level (secondary school, B.Sc., applying for M.Sc.), and professional interests (geosciences, conservation, civil engineering). None had prior experience in ice dynamics or in Earth system modelling.

Participants developed intuition through
    laboratory experiments (Day 1),
    reading & discussing academic literature (Day 2),
    planning a hypothetical field campaign (Day 2), and
    presenting to peers (throughout).

We designed Jupyter notebook activities (Days 3-4) to connect with each topic of the previous days.

All participants executed the notebooks and explained their results. Most were also able to modify the code to conduct a new experiment. A final group presentation connected model results with both physical and societal context.

Figure 2. A participant leans over to confer with his neighbour about an exercise in their notebooks. (Photo: T. León Rojas)

Features

Jupyter notebooks help learners manipulate code
The format allows code to be interspersed with explanatory text, diagrams, and questions to spark further investigation. Users can modify parameters and re-run a few lines of code multiple times, facilitating experimentation.

No special installation required
Users run notebooks in a browser. The URL they access opens an interface (Fig 1) with a pre-set environment, where the model is already installed. Processing is virtual.

OGGM-Edu materials are modular
Instructors can combine material from our existing notebooks with new material to create notebooks tailored to their objectives. They can also write new modules to streamline learners' experience.

Modifiable on the fly
With notebooks and custom modules stored in a GitHub repository, instructors can update before each class session to reflect emerging priorities and resolve issues.

Spanish, English…and more
Markdown text can be presented in any language. Jupyter extension *nbtranslate* can translate explanatory text cells while keeping code untouched.

Con los cuadernos Júpyter los estudiantes entendieron los diversos fenómenos que ocurren en los glaciares…se preguntaran que obtendrían al ingresar datos de los nevado de Perú… y empezaron a plantear nuevos temas de investigación. - T. León Rojas, instructor

Additional resources

Workshop **GitHub repository:**
https://github.com/ehultee/CdeC-glaciologia

OGGM-Edu
- Website: https://edu.oggm.org
- World Glaciers Explorer app:
  https://edu.oggm.org/en/latest/explorer.html

We package our notebooks with a software environment using **Binder**: https://mybinder.org/

Our workshop was supported by **Clubes de Ciencia Perú**: https://www.clubesdecienciaperu.org/