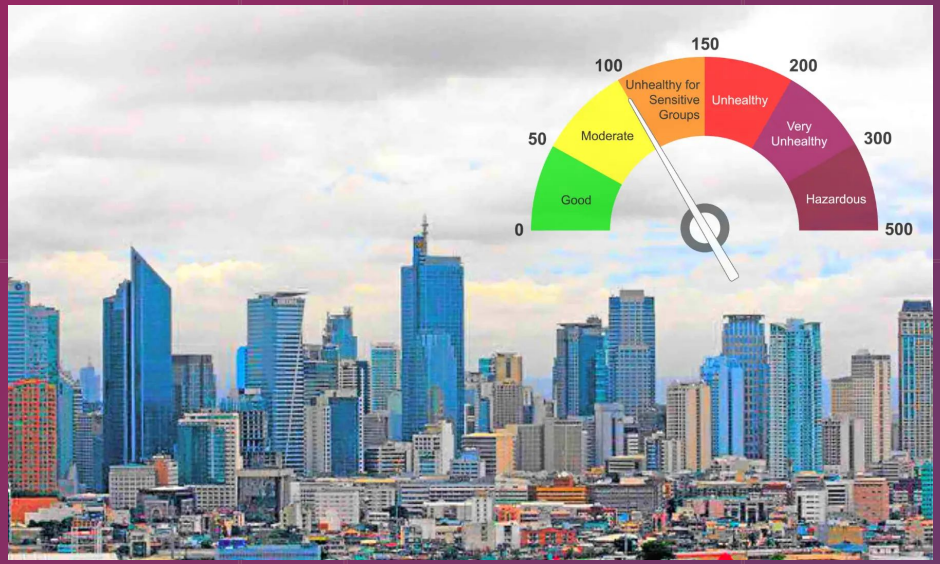
Lab 1
ID2223 / HT2025



Air Quality Prediction Service

Course Material: Prof Jim Dowling

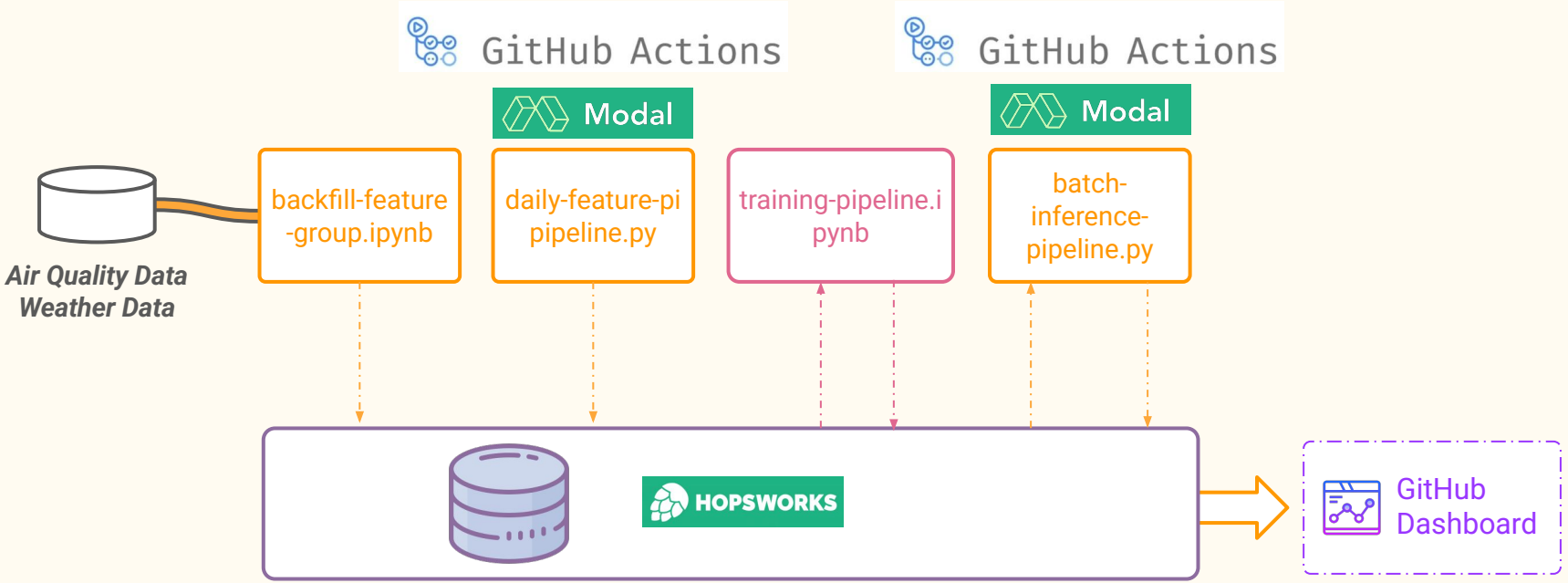
Source Code and References for Lab 1

- Source Code for this project Github https://github.com/featurestorebook/mlfs-book/

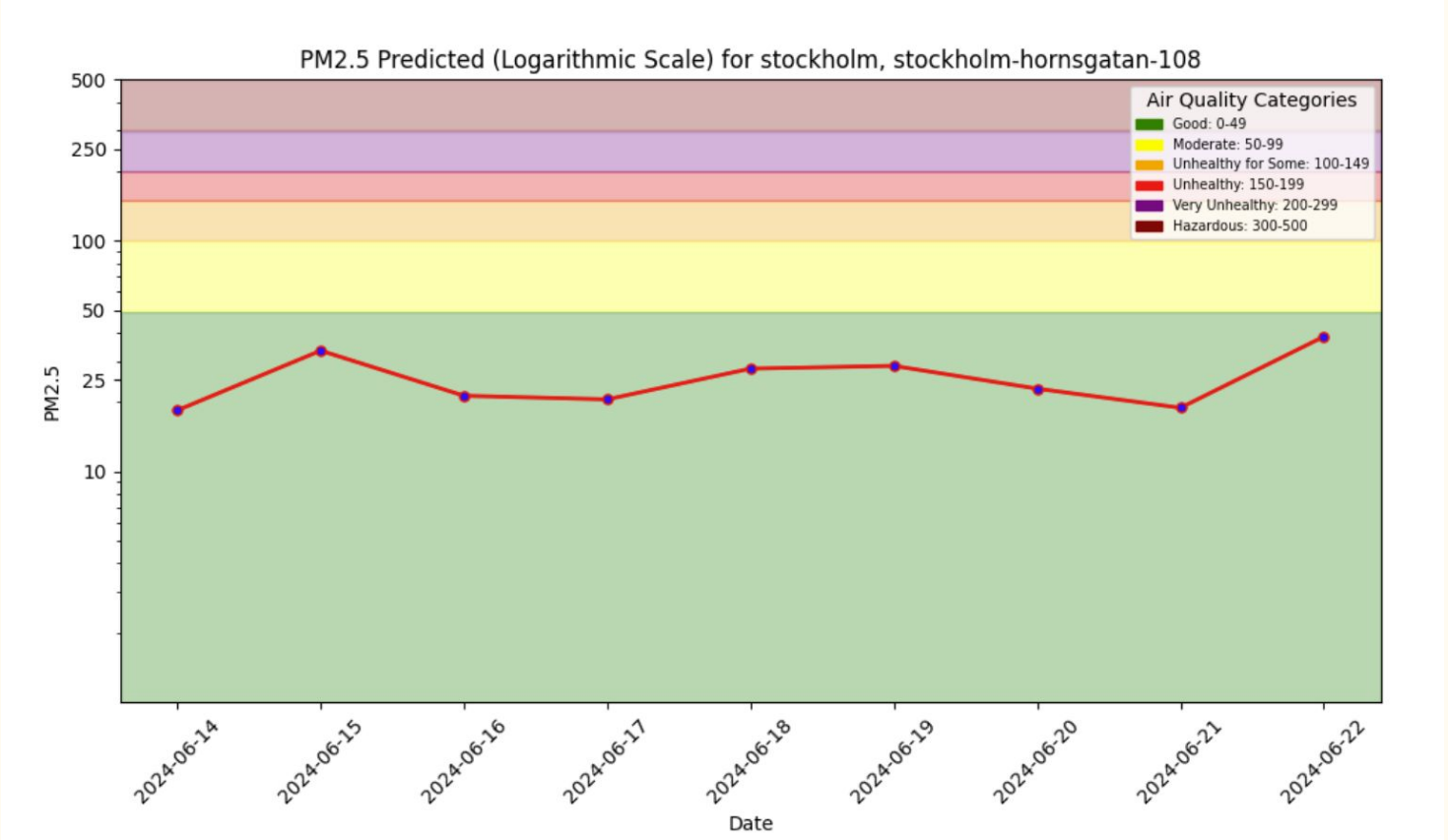
- See Chapter 3 in the "Building ML Systems with a Feature Store" book

- Use a virtual environment (e.g., Conda) to manage your python dependencies on your laptop. See more info on how to manage your Python environment here.

Serverless AI System that Predicts Air Quality for a Location



Dashboard for Serverless AI System that Predicts Air Quality for a Location

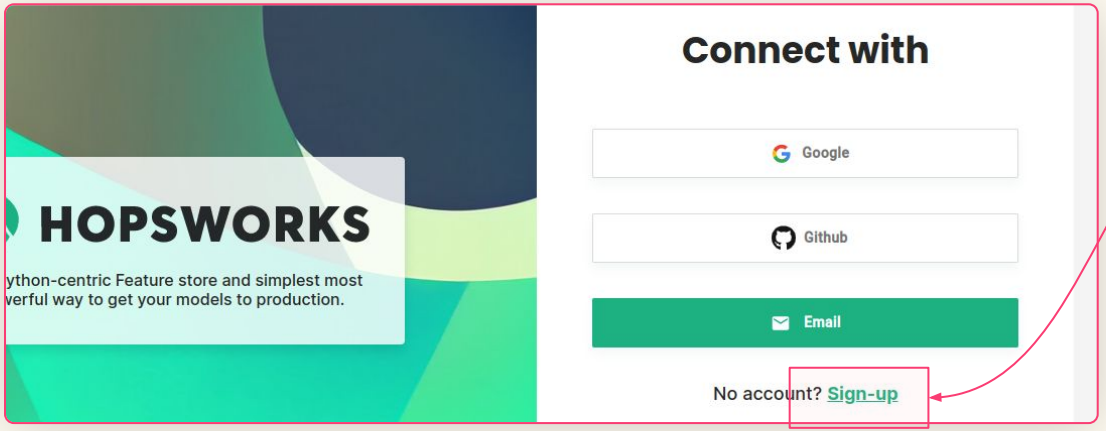


What will we cover in this part

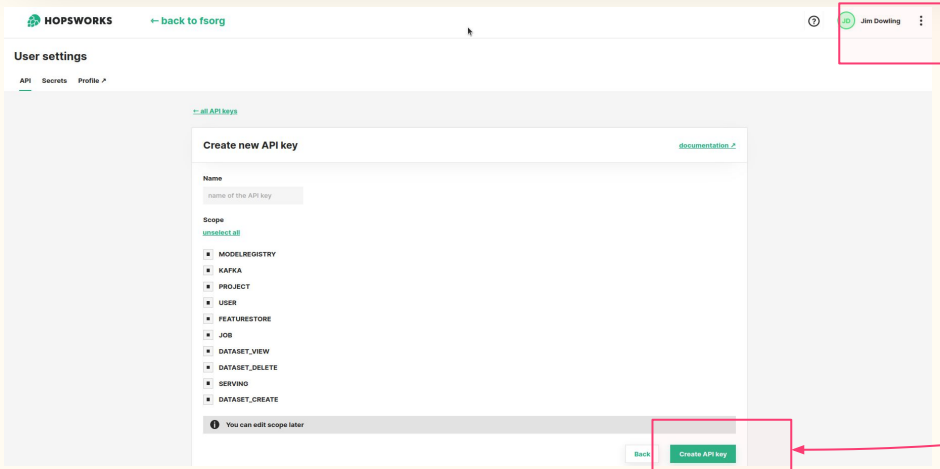
- **First Steps**
  a. Create a free account on hopsworks.ai
  b. Create a free account on github.com (and optionally modal.com)

- **Tasks**
  a. Build and run a feature pipeline on Github Actions or Modal
  b. Run a training pipeline
  c. Build and run a batch inference pipeline on Github Actions or Modal
  d. Visualize your air quality predictions with a dashboard

Register and Login to the Hopsworks Feature Store



1. First, create an account on https://app.hopsworks.ai



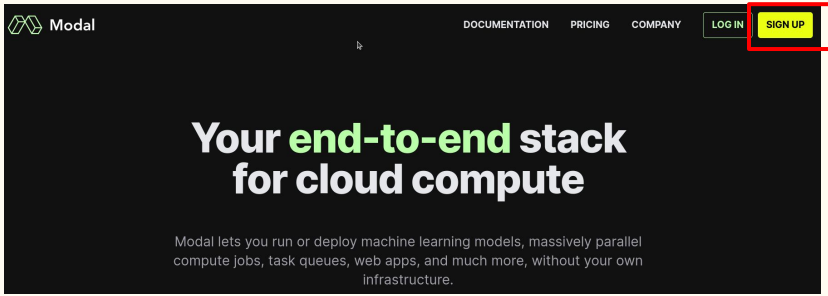
2. Click on “User Settings”

3. Create and Save an “API Key”

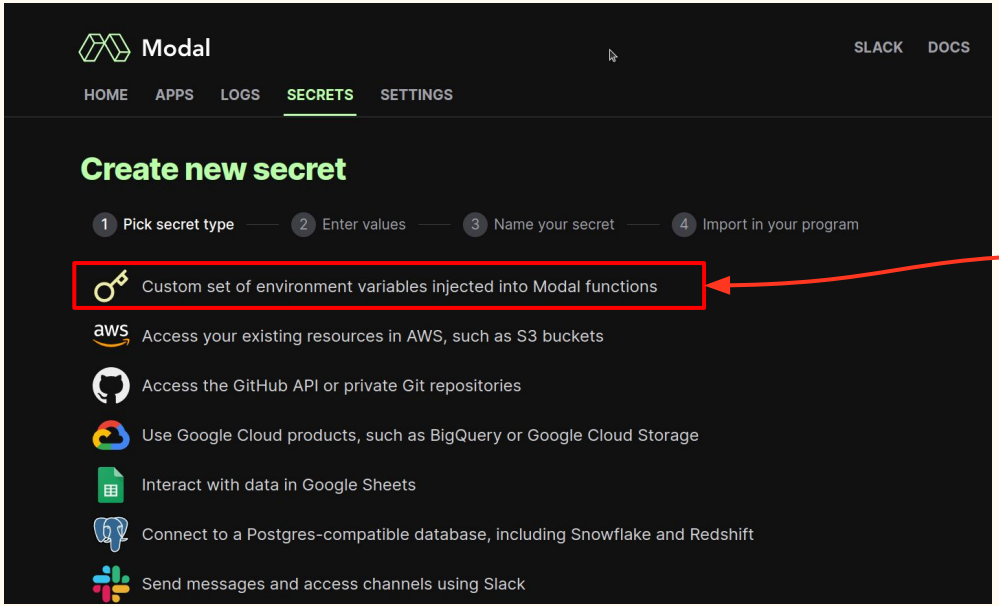
Choose how to run your serverless ML pipeline

Use either
(1) Modal - needs a credit card to register
(2) Github Actions - no credit card needed

Register to Modal and Set up HOPSWORKS_API_KEY environment variable

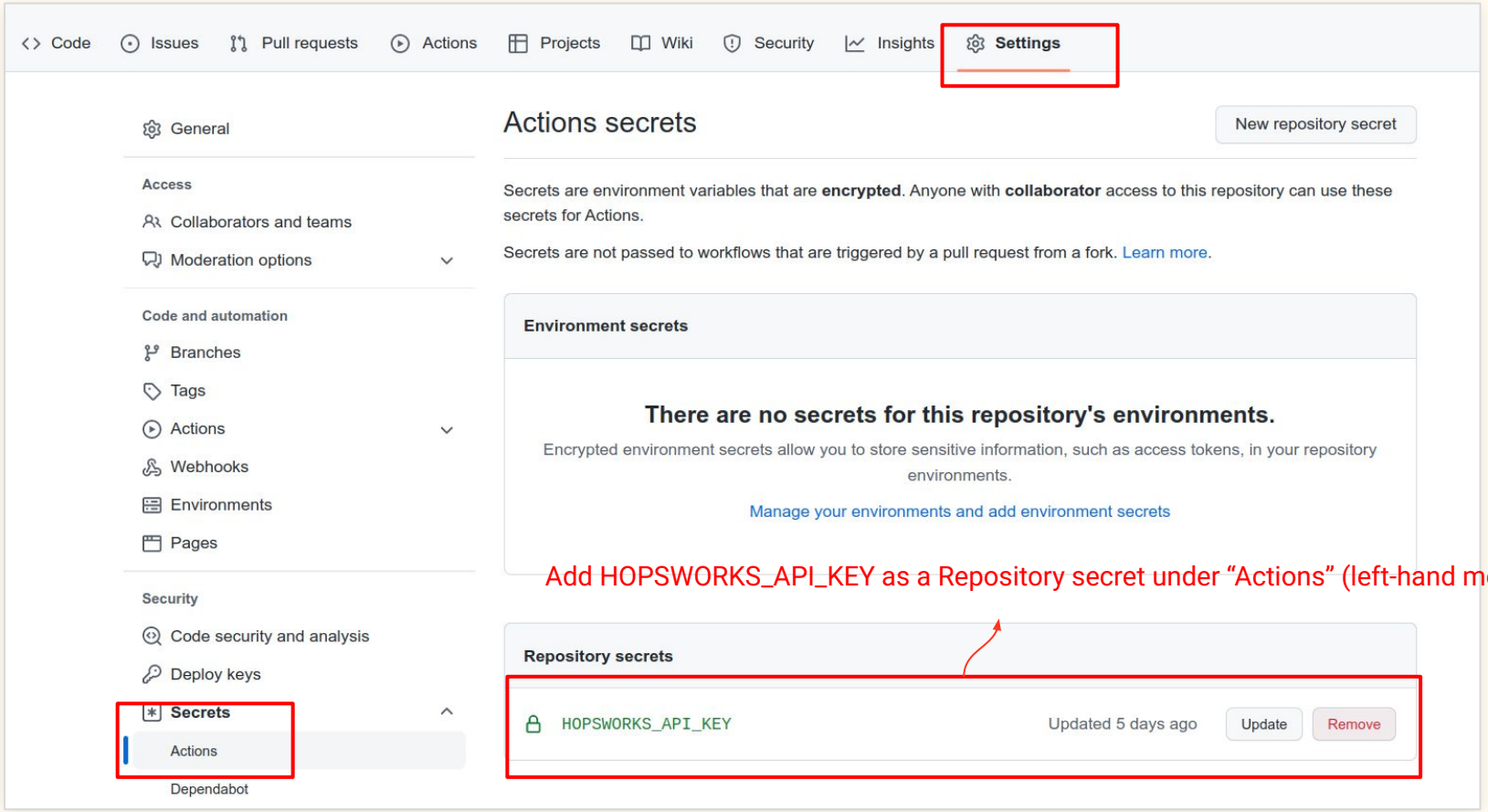


Create an account on Modal
(might need some time to be approved)

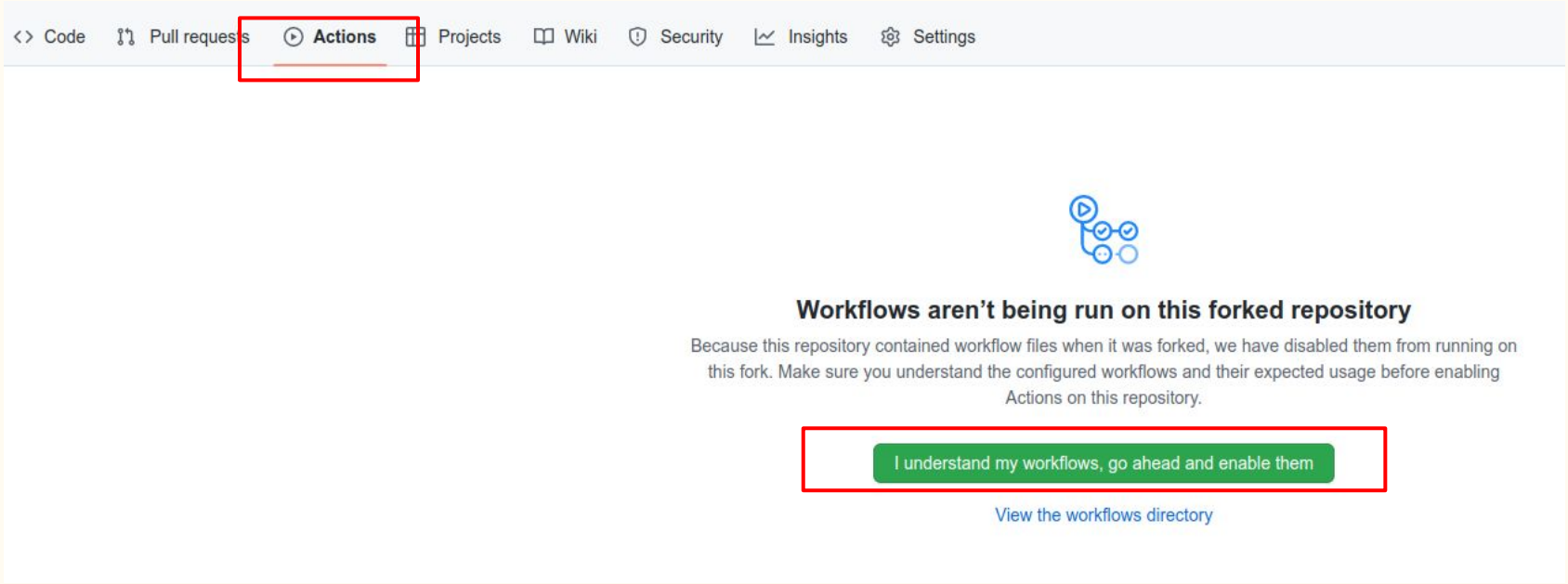


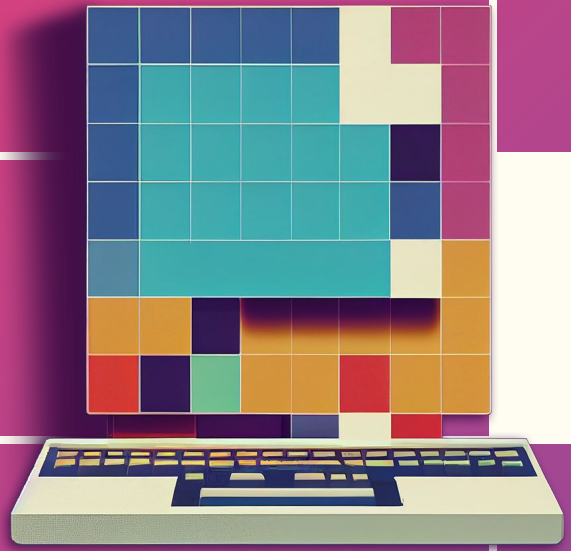
Add HOPSWORKS_API_KEY as a Environment variable secret

Add a HOPSWORKS_API_KEY as a secret for your Github Action



Enable the Github Actions for your Repository

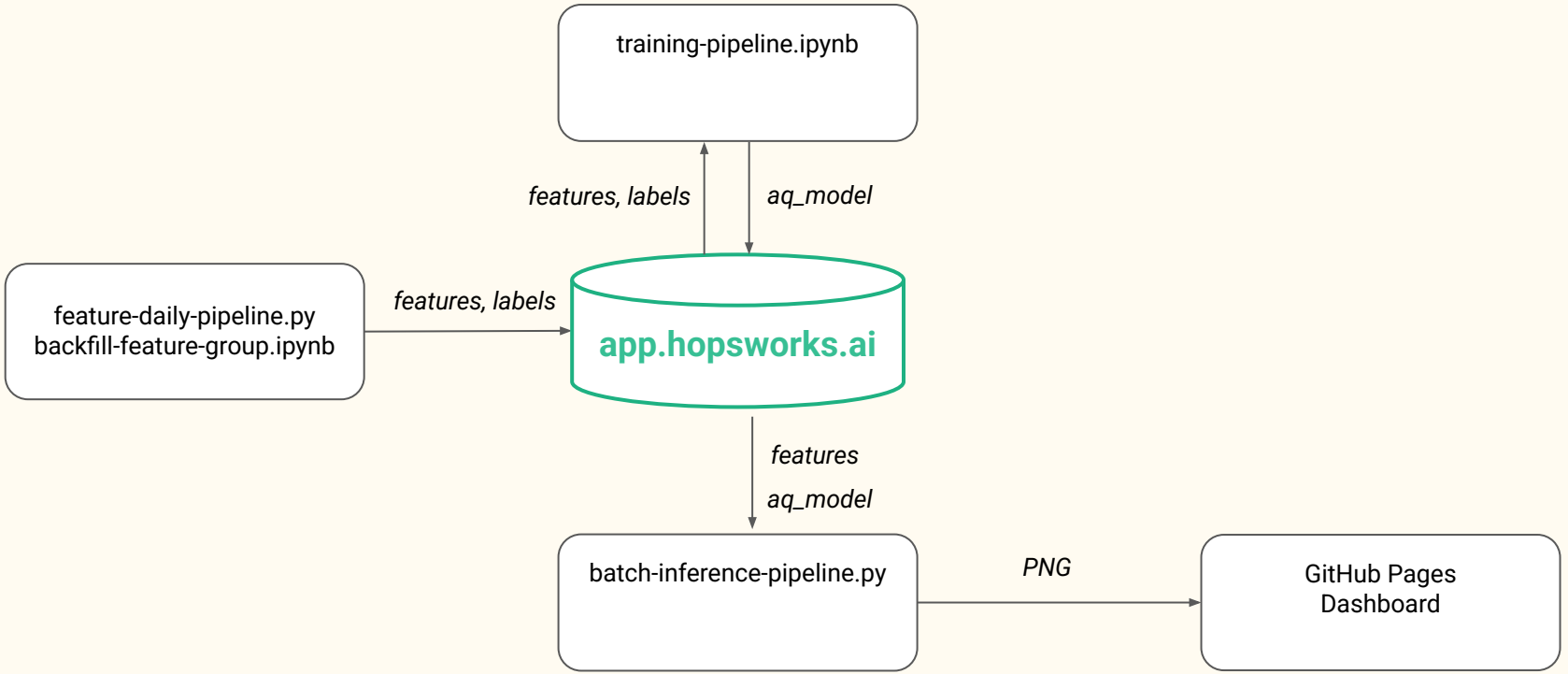




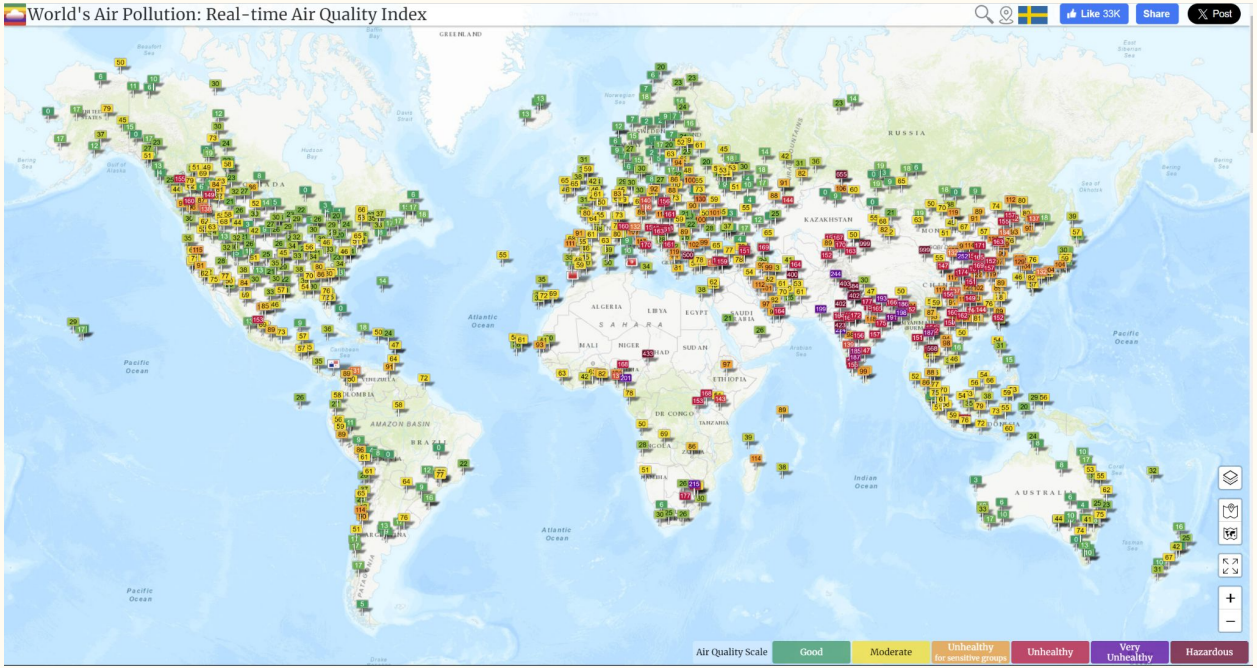
Weather and Air Quality

Data Sources

Air Quality Prediction: Feature, Training, Batch Inference Pipelines



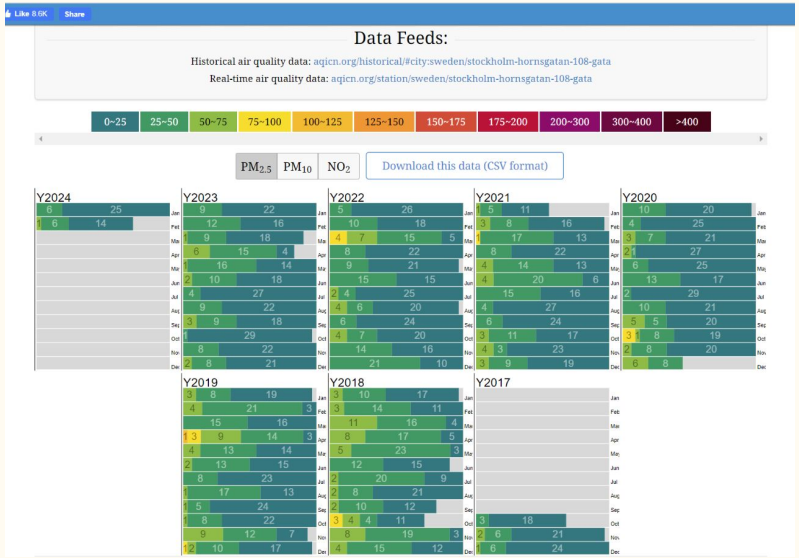
Air Quality Data Source: https://aqicn.org

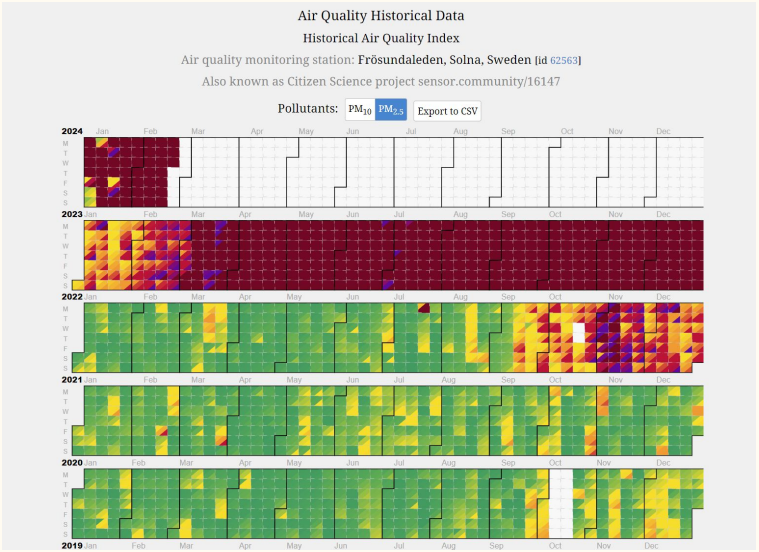


https://aqicn.org

You should pick a sensor on this page - not the one in the book. Near your childhood home, country house, favorite place, wherever. It should have enough good quality measurements.

Select 1 or more Air Quality Sensors with Good Quality Data





Data Source: Find the Closest City to your Sensor(s) on Open-Meteo

https://open-meteo.com/en/docs/air-quality-api

Overview of Lab

Dynamic Data Sources	Prediction Problem	UI or API	Monitoring
Air Quality Sensor Data: https://*aqicn*.info Weather Forecasts: https://open-meteo.com	Daily forecast of the level of $PM_{2.5}$ for the next 7 days at the position of an existing air quality sensor.	A web page with graphs and a LLM-powered UI in Python.	Hindcast graphs show prediction performance of our model.

'A' Grade	Provide predictions for all air quality sensors in a Swedish city. Select a city by entering your group number here. Your UI should show forecasts for all sensors in your chosen city.

Weather Data Ingestion into Hopsworks

```
weather_df = # 1. read today's data in as a Pandas DataFrame

# 2. create features for in Pandas DataFrame

weather_fg = fs.get_or_create_feature_group(name="weather",
                                    version=1,
                                    description="Weather Daily Updates",
                                    primary_key=['city'],
                                    event_time='date'
)
weather_fg.insert(weather_df) # 3. write Pandas DataFrame to Feature Group

# …
```

Weather Data in a Feature Group

Feature Group - **weather**

city_name	date	wind_speed_max	wind_direction_dominant	wind_gusts_max	temp_max	
<entity_id>	*<event_time>*	*<numerical feature>*	*<categorical feature>*	*<numerical feature>*	*<numerical feature>*	
string	*datetime*	*double*	*string*	*double*	*double*	
berlin	2022-01-01	14.3	ne	22.4	22.7	
dublin	2022-04-01	9.3	n	18.2	25.4	
seattle	2022-07-01	11.1	nw	15.2	20.8	
tacoma	2022-10-01	1.3	w	2.5	28.4	

Feature Types

Row

entity_id and event_time uniquely identify each row. They are not features.

Feature value. Store unencoded to maximize reuse over many models.

Feature vector. Set of feature values with the same primary key.

Air Quality Data Ingestion into Hopsworks

```
air_quality_df = # 1. read the most recent air quality observations

# 2. create features for in Pandas DataFrame

air_quality_fg = fs.get_or_create_feature_group(name="air_quality",
                                    version=1,
                                    description="City Air Quality Data",
                                    primary_key=['city'],
                                    expectation_suite=expectation_suite,
                                    event_time='date'
)
air_quality_fg.insert(air_quality_df) # 3. write DataFrame to Feature Group

# …
```

Air Quality Data in a Feature Group

Feature Group - **air_quality**

city_name	date	pm2_5
<entity_id>	*<event_time>*	*<numerical feature>*
string	*datetime*	*double*
berlin	2022-01-01	5.3
dublin	2022-04-01	2.3
seattle	2022-07-01	3.1
tacoma	2022-10-01	4.3

Label
Column is the target for the prediction problem

Scheduling a Feature Pipeline to run daily with Modal

```
stub = modal.Stub("air_quality_daily")
image = modal.Image.debian_slim().pip_install(["hopsworks"])

@stub.function(image=image, schedule=modal.Period(days=1),
secret=modal.Secret.from_name("jim-hopsworks-ai"))
def g():
    …

if __name__ == "__main__":
    stub.deploy("air_quality_daily")
    with stub.run():
            g()
```

Scheduling a Feature Pipeline to run daily with Github Actions

```
name: air-quality-daily
on:
  workflow_dispatch:
    schedule:
    - cron: '11 6 * * *'
jobs:
  schedule_pipelines:
    runs-on: ubuntu-latest
…
    steps:
…
      - name: install python packages
        run: |
          cd notebooks/ch03
          python -m pip install --upgrade pip
          pip install -r requirements.txt
      - name: execute python workflows from bash script
        env:
          HOPSWORKS_API_KEY: ${{ secrets.HOPSWORKS_API_KEY }}
        run: |
          cd notebooks/ch03
          jupyter nbconvert --to notebook --execute 2_air_quality_feature_pipeline.ipynb
```

https://github.com/featurestorebook/mlfs-book/blob/main/.github/workflows/air-quality-daily.yml

Training Pipeline

```
fg_air_quality = fs.get_feature_group(name="air_quality", version=1)
fg_weather = fs.get_feature_group(name="weather", version=1)

selected = fg_air_quality.select(['pm2_5').join(fg_weather.select_all())

fv = fs.create_feature_view(name="air_quality_fv",
            version=1,
            description="Weather and Air Quality",
            labels=['pm2_5'],
            query=selected
            )
```

Training Pipeline

```
X_train, X_test, y_train, y_test = fv.train_test_split(test_size=0.2)


categorical_transformer=Pipeline(steps=[("encoder",
OneHotEncoder(handle_unknown="ignore"))])


preprocessor = ColumnTransformer(transformers=[ \
        ("cat", categorical_transformer, categorical_feature_ids)])


clf = Pipeline(steps=[("preprocessor", preprocessor), ("regressor",
XGBRegressor())])
clf.fit(X_train, y_train)
```

Training Pipeline

```
joblib.dump(clf, 'air_quality_model/xgboost_pipeline.pkl')


input_schema = Schema(X_test)
output_schema = Schema(y_test)


aq_model = mr.sklearn.create_model("air_quality_model",
    metrics={'accuracy': accuracy},
    input_example=X_test.sample().to_numpy(),
    model_schema=ModelSchema(input_schema=input_schema,
output_schema=output_schema))


fraud_model.save('air_quality_model')
```

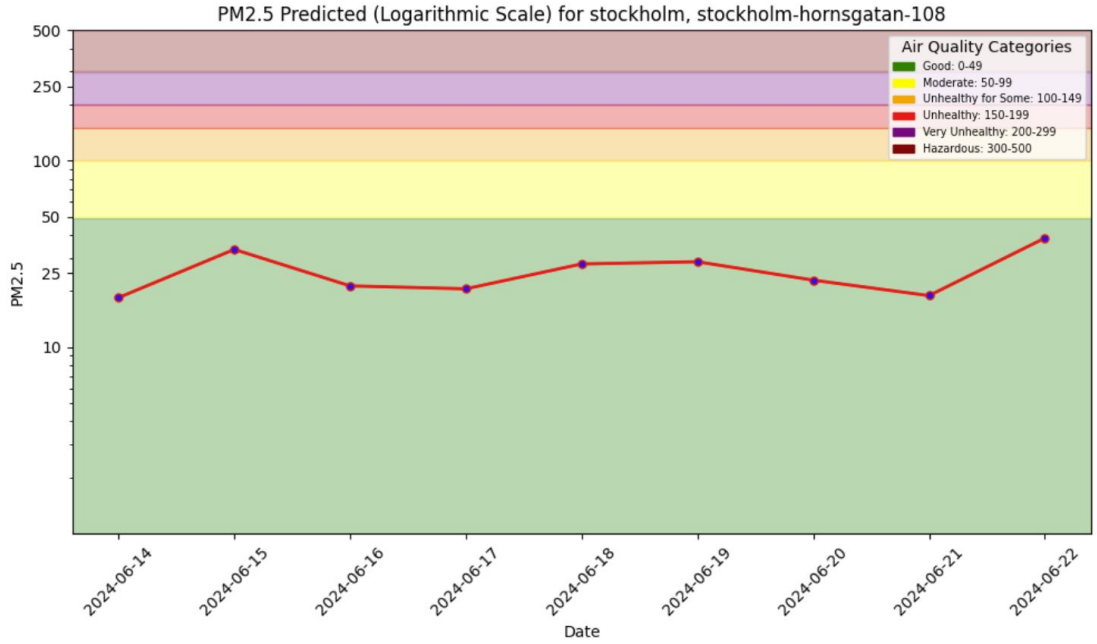
Batch Inference Pipeline

```
fv = fs.get_feature_view(name="air_quality_fv", version=1)
df = feature_view.get_batch_data(start_time=today)

mr = project.get_model_registry()
model = mr.get_model("lending_model", version=1)
model_dir = model.download()
model = joblib.load(model_dir + "/air_quality_model.pkl")

predictions_df = model.predict(df)
```

Communicate the value of your model with a UI (Gradio)

- Communicate the value of your model to stakeholders with an app/service that uses the ML model to make value-added decisions

- Here, we design a UI as a Github Page (a PNG file on a webpage - we use matplotlib to generate the PNG file)
  - Shows predictions of air quality for a place for the next few days



Task: Air Quality Prediction using Weather Features

Grade 'E' tasks

1. Write a backfill feature pipeline that downloads historical weather data (ideally >1 year of data), loads a csv file with historical air quality data (downloaded from https://aqicn.org) and registers them as 2 Feature Groups with Hopsworks.
2. Schedule a daily feature pipeline notebook that downloads yesterday's weather data and air quality data, and also the weather prediction for the next 7-10 days and update the Feature Groups in Hopsworks. Use GH Actions or Modal.
3. Write a training pipeline that (1) selects the features for use in a feature view, (2) reads training data with the Feature View, trains a **regression or classifier model** to predict air quality (*pm25*). Register the model with Hopsworks.
4. Write a batch inference pipeline that creates a dashboard. The program should download your model from Hopsworks and plot a dashboard that predicts the air quality for the next 7-10 days for your chosen air quality sensor.
5. Monitor the accuracy of your predictions by plotting a hindcast graph showing your predictions vs outcomes (measured air quality).

Grade 'C' tasks

6. Update your Model by adding a new feature, lagged air quality for the previous 1 day, 2 days, and 3 days. Measure and explain the performance improvement or regression for these features.

Grade 'A' tasks

7. Provide predictions for all air quality sensors in a Swedish city. Select a city by entering your group number here.

Deliverables

- Deliver your source code as a Github Repository.
- Deliver your lab description as a README.md file in the root of your project directory in your Github repository
- Deliver a public URL for the Dashboard.

Deadline midnight 18th November 2025.

The lab will be graded during a defence of your lab held over Zoom in the week of November 18th. Available Zoom slots for defence will be published in Canvas.

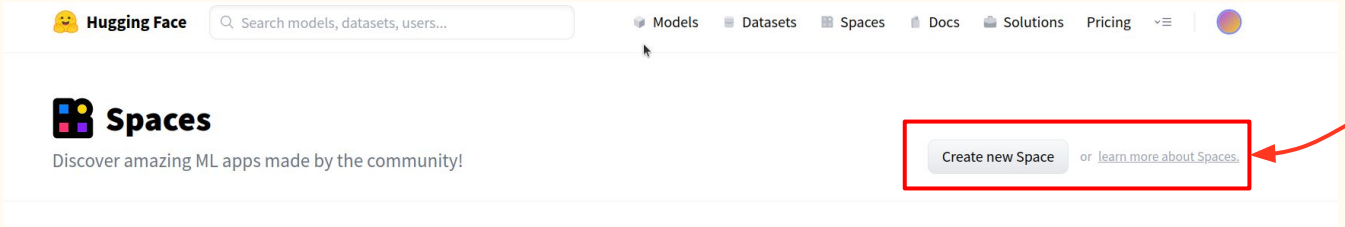
Grading

- The grade for this lab will be awarded if you (1) complete the tasks below, (2) and answer our questions during the grading defence.
- As a guide to your grade, assuming you answer questions successfully, you can expect:
  - Steps 1-5: Grade E
  - Steps 1-6: Grade C
  - Steps 1-7: Grade A

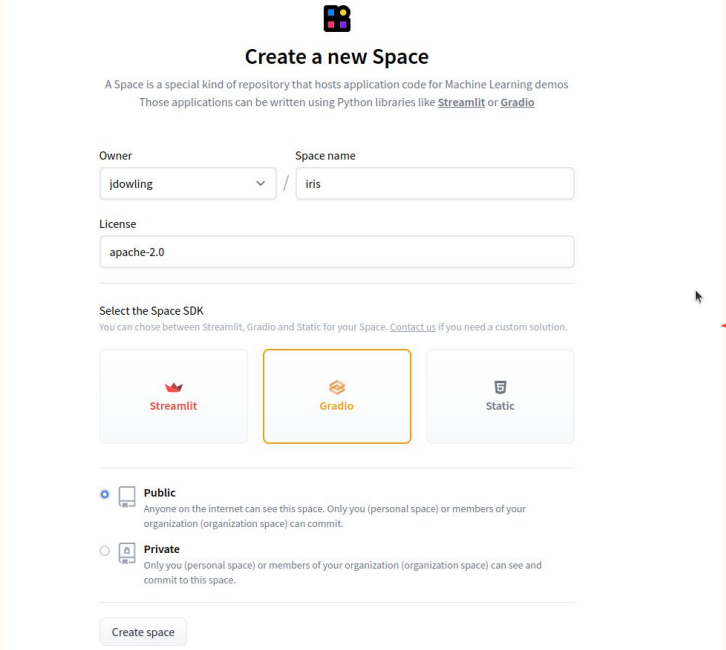
Alternative Dashboard developed in Python

- You can develop your own UI in Python if you prefer over GitHub Pages
  - Good frameworks are Gradio or Streamlit
  - You can deploy them for free on a serverless platform like HuggingFace or Streamlit Cloud
  - You can also vibe code your own UI - replit supports Python.

Optional: Register and Create a Hugging Face Space

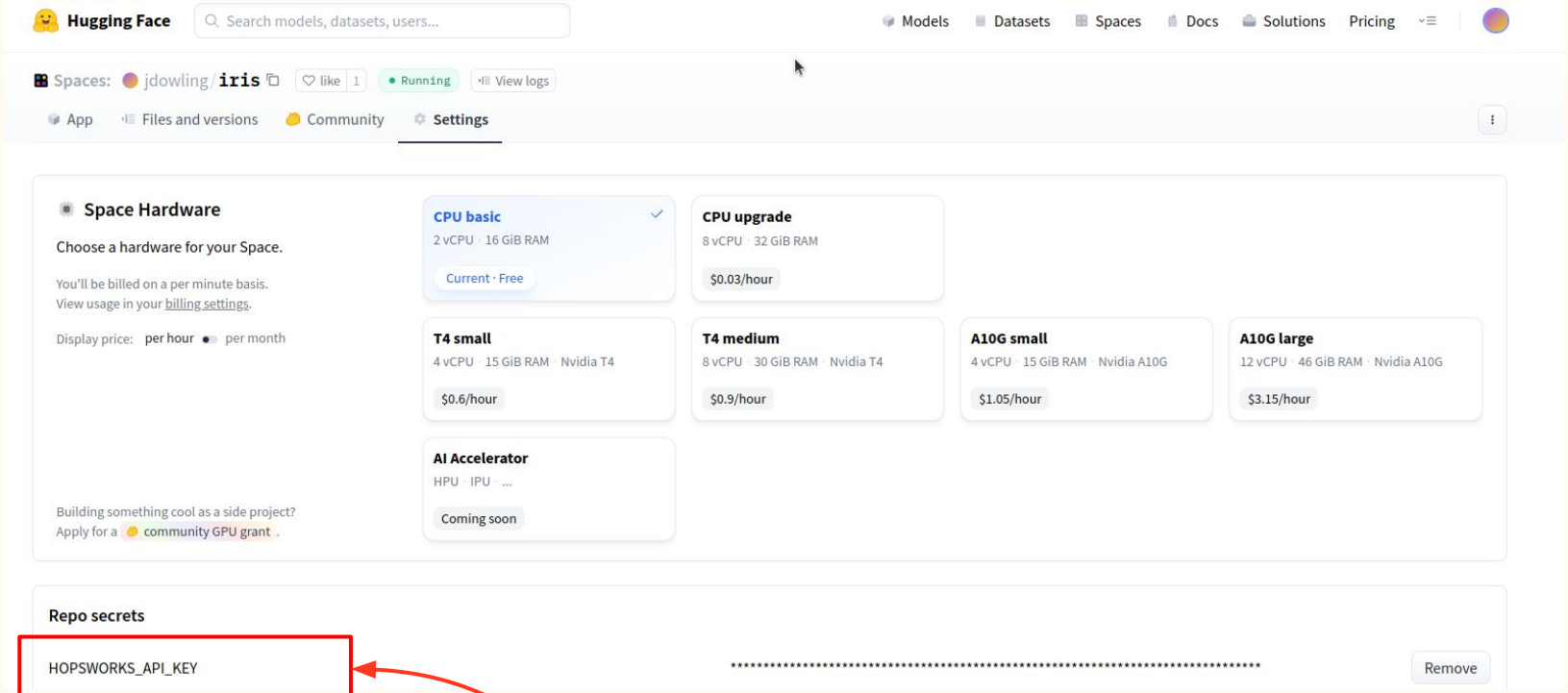


1. Create an account on Hugging Face
2. Create a “Space”



3. Create a Gradio App with the name Iris inside your account

Add a HOPSWORKS_API_KEY as a secret in your Space



1. Add your HOPSWORKS_API_KEY as a Repo Secret