



Workshop Azure MLOps

23 mars 2020



Vos interlocuteurs



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Version du document

- V 1.3
- 23 mars 2020

MLOps ?



The story of Machine Learning



ginablaber
@ginablaber

[Follow](#)



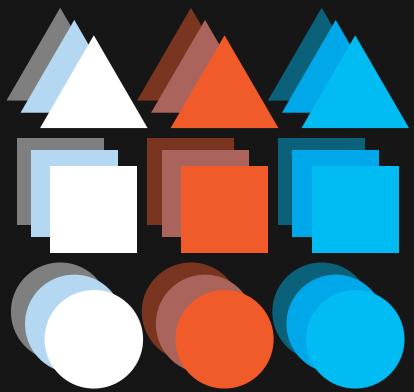
The story of enterprise Machine Learning: “It took me 3 weeks to develop the model. It’s been >11 months, and it’s still not deployed.”

@DineshNirmalIBM #StrataData #strataconf

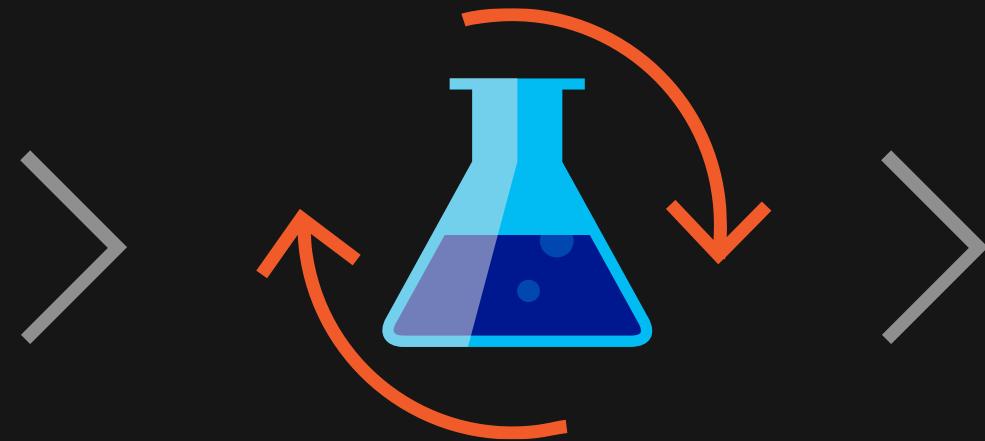
10:19 AM - 7 Mar 2018

Custom AI

Building your own AI models for Transforming Data into Intelligence



Prepare Data

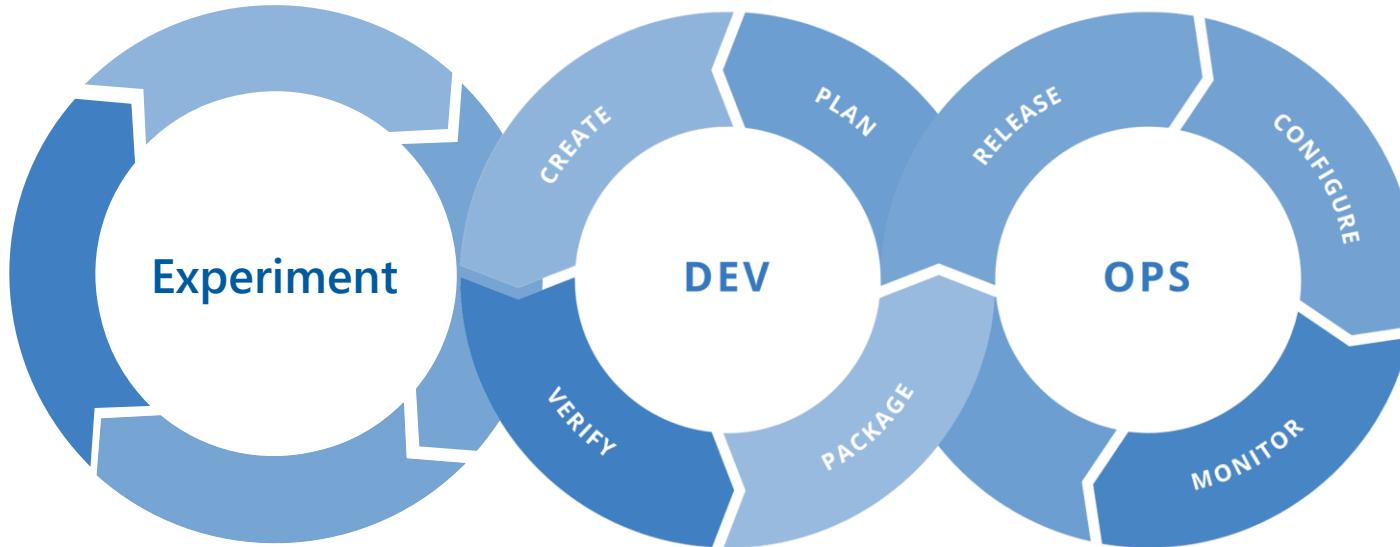


Build & Train



Deploy

AI DevOps lifecycle



Experiment

Data Acquisition
Business Understanding
Initial Modeling

Develop

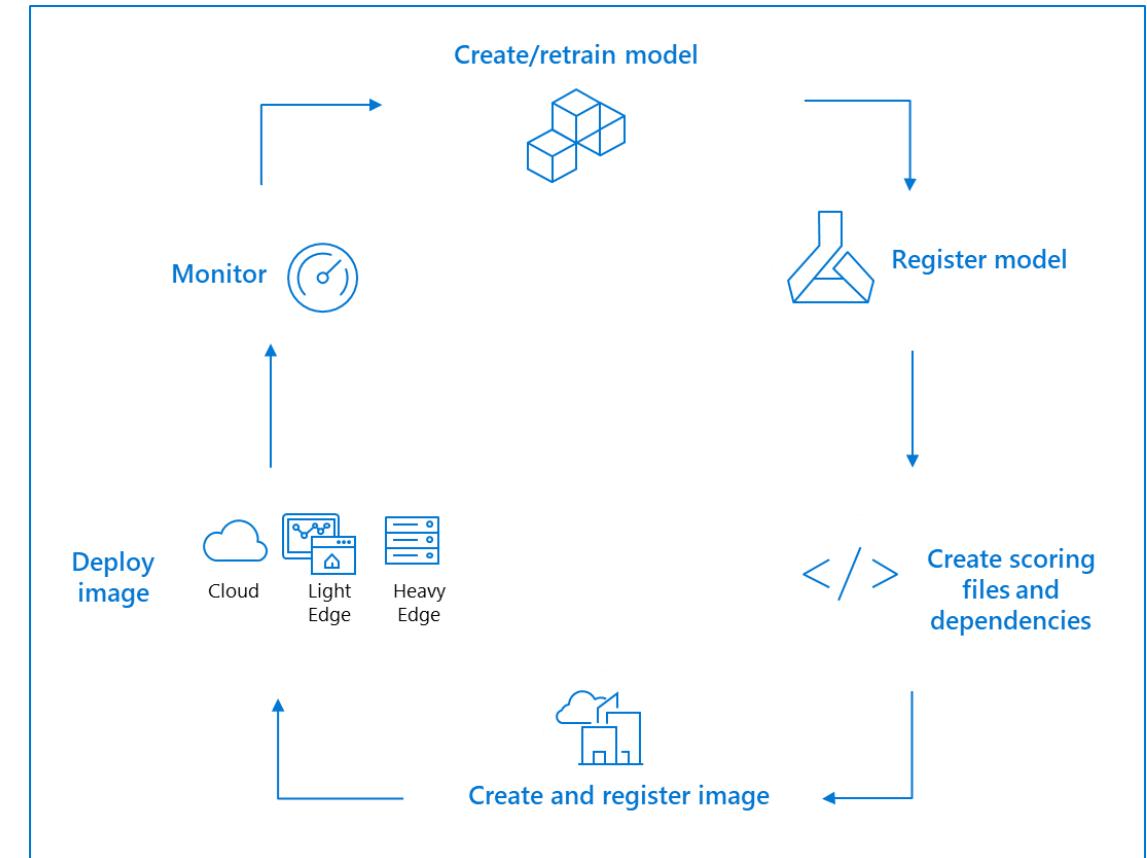
Modeling + Testing
Continuous Integration
Continuous Deployment

Operate

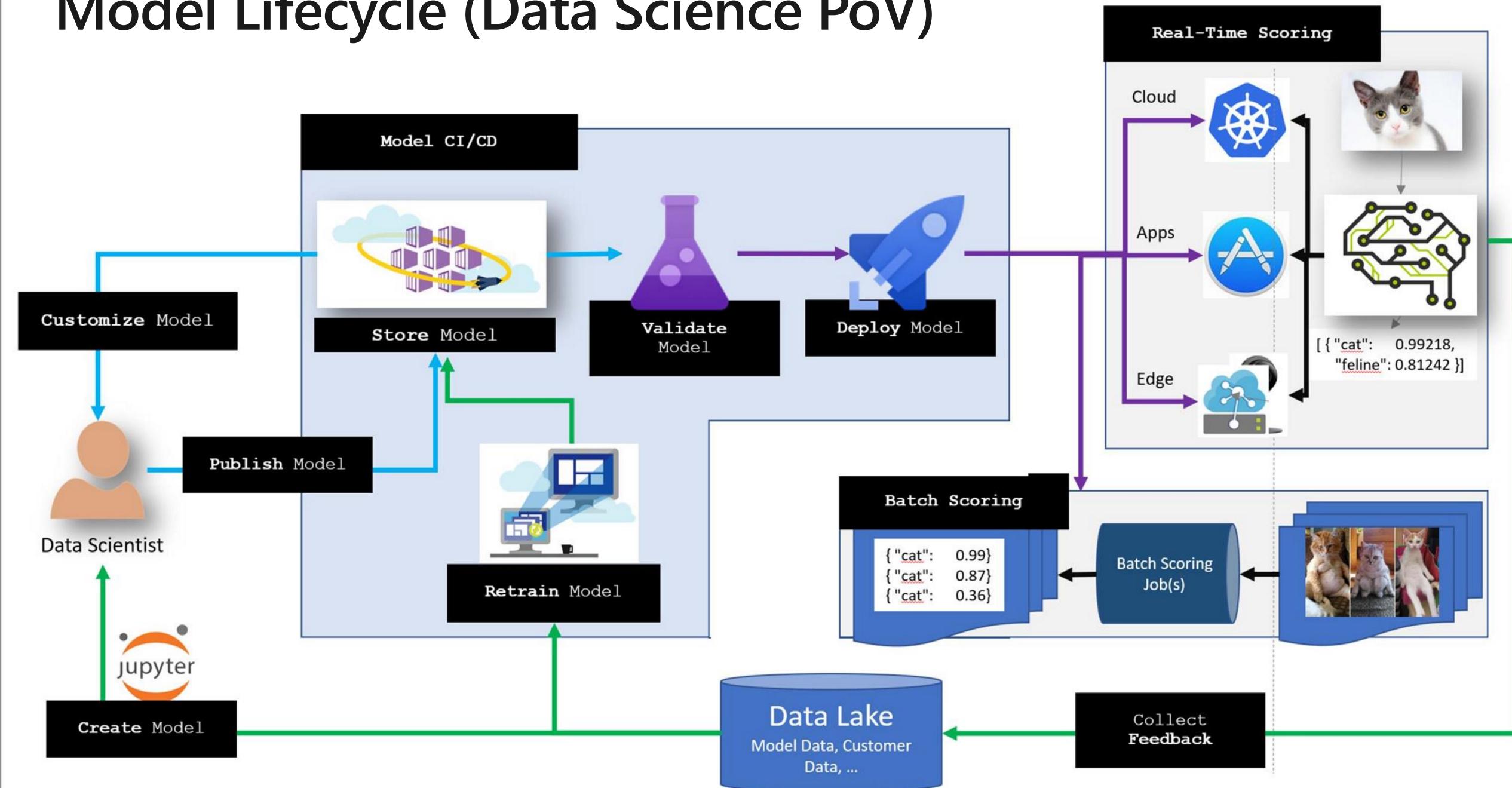
Continuous Delivery
Data Feedback Loop
System + Model Monitoring

Manage Model Lifecycle

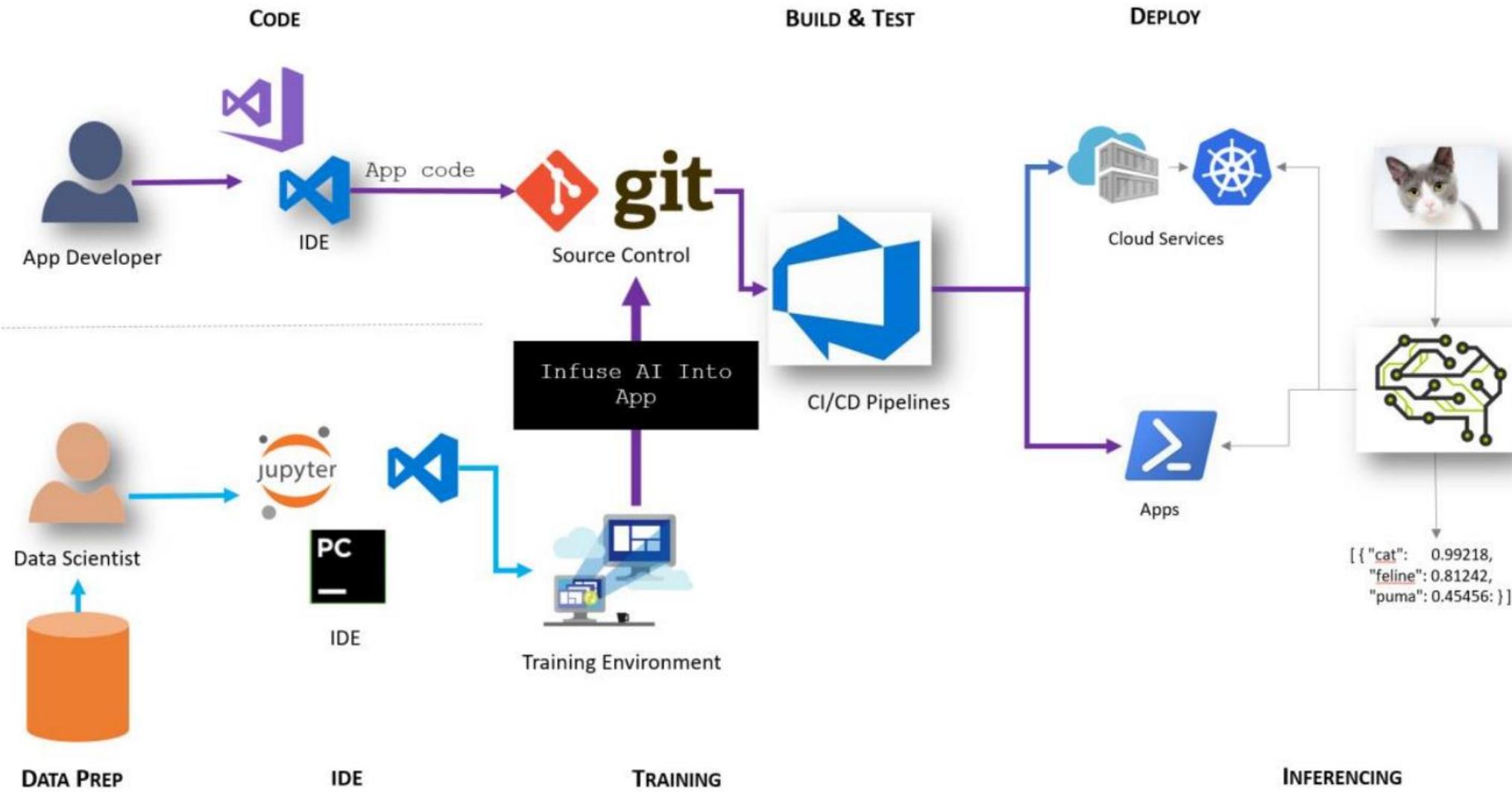
- **Track model versions & metadata** with a centralized **model registry**
- **Leverage containers** to capture runtime dependencies for inference
- Leverage an orchestrator like **Kubernetes** to provide **scalable inference**
- Capture **model telemetry** – health, performance, inputs / outputs
- **Encapsulate each step** in the lifecycle to **enable CI/CD and DevOps**
- Automatically **optimize models** to take advantage of hardware acceleration



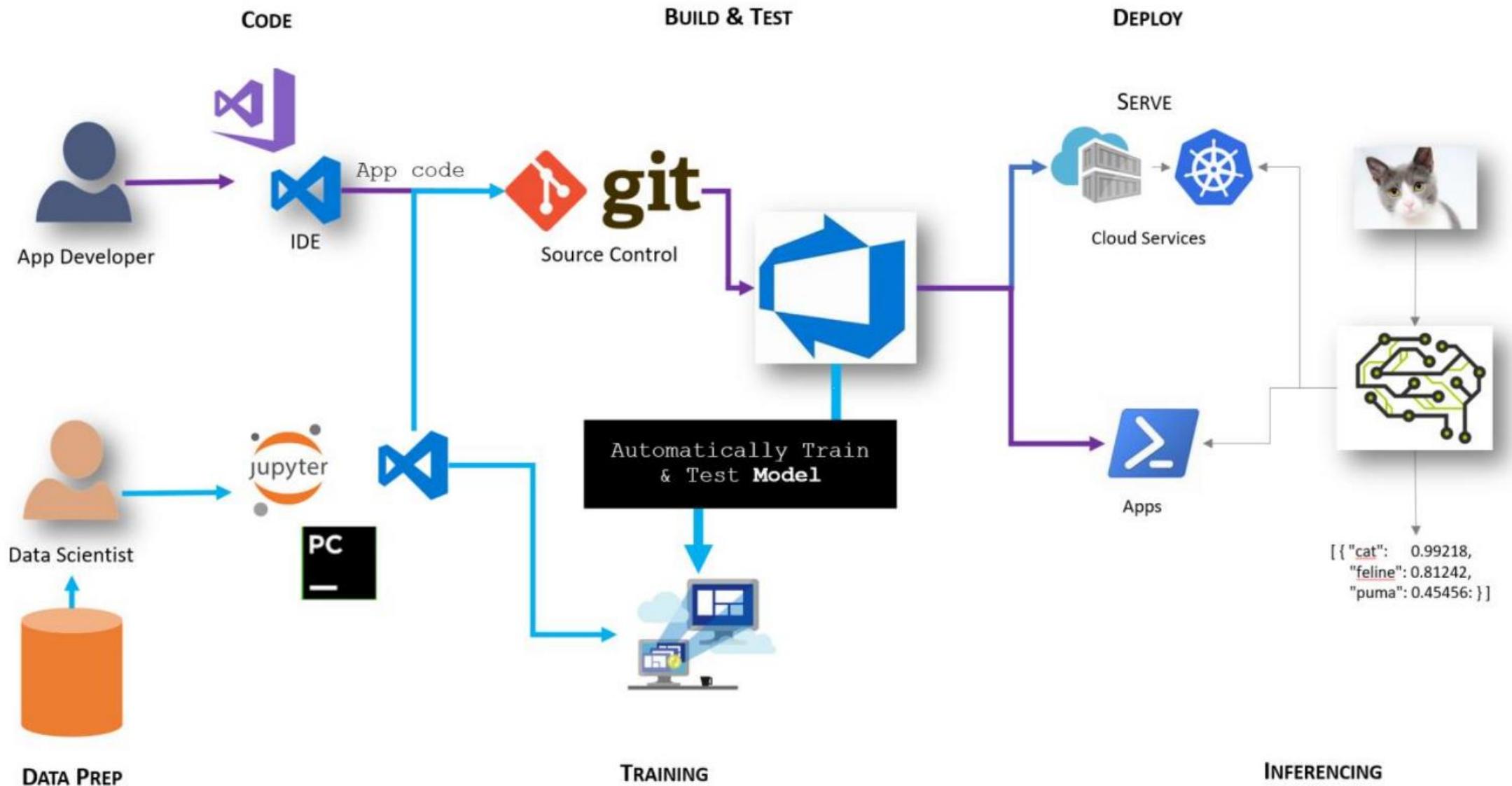
Model Lifecycle (Data Science PoV)



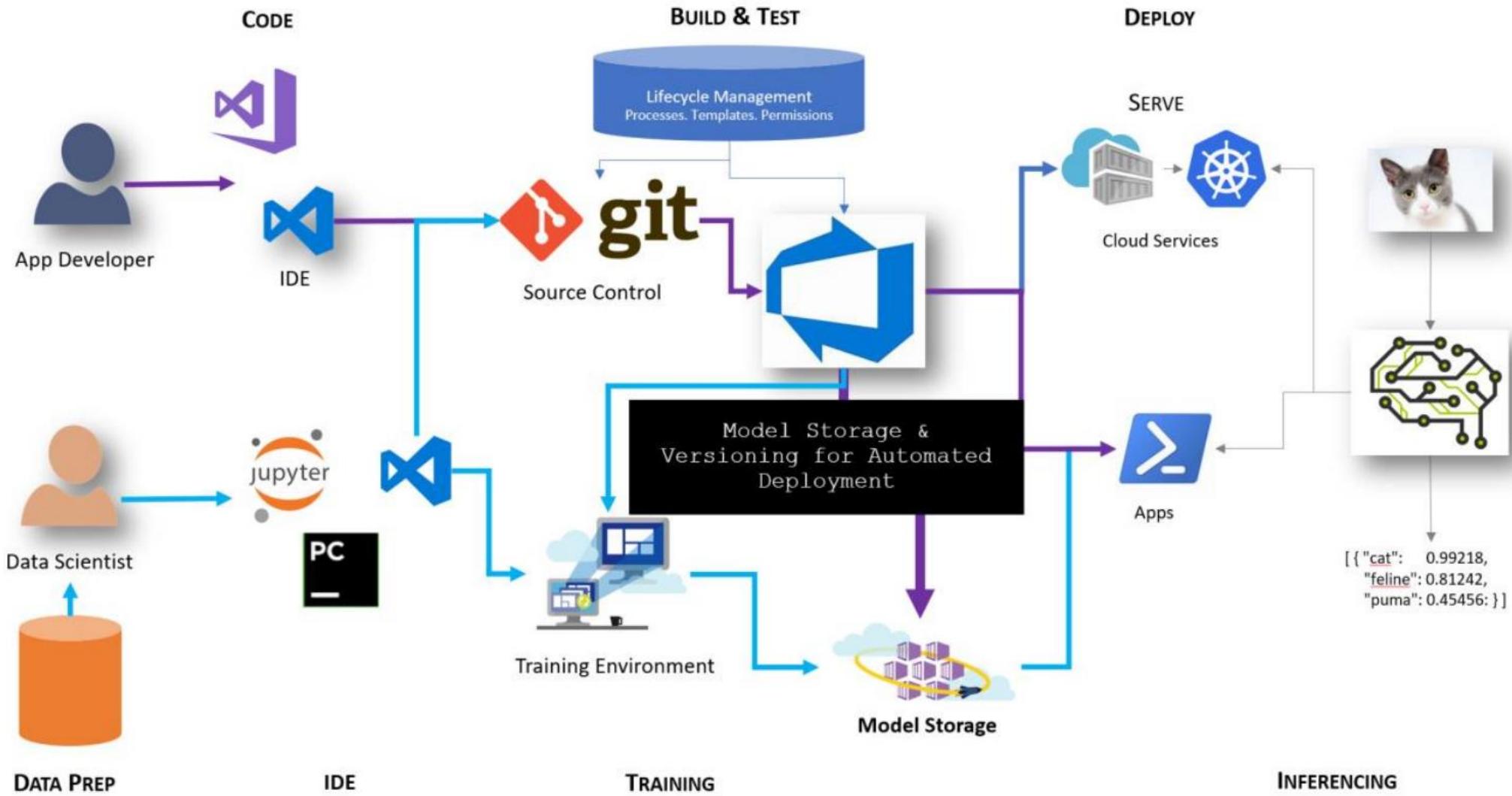
Step 1 – Infuse AI into App



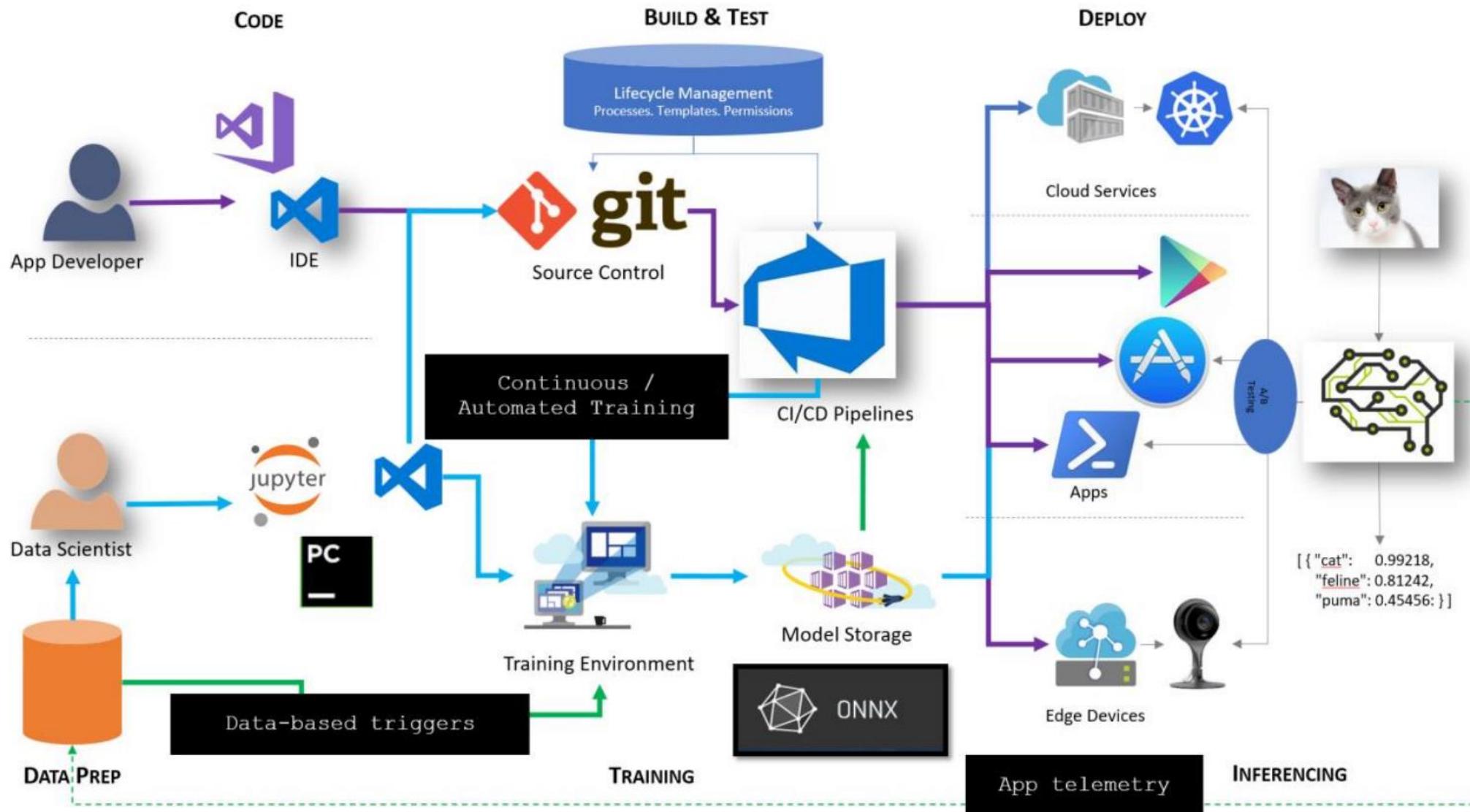
Step 2 – Automate Model Training



Step 3 – Store, Version and Validate Models



Step 4 – Automate Model Release



Model Reproducibility

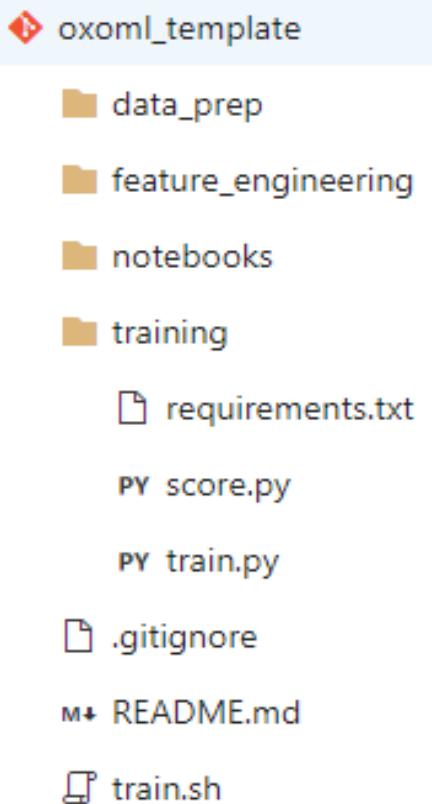
Processes and procedures to make **models reproducible**

- (code / data / config)

Capture

- Featurization code (w/ tests)
- Training pipeline
- Dependencies
- Training data persistence
- Evidence chain
- Model config
- Training job info
- Sample data
- Data profile

master oxoml_template / Type to find a file or folder...



Model Versioning & Storage

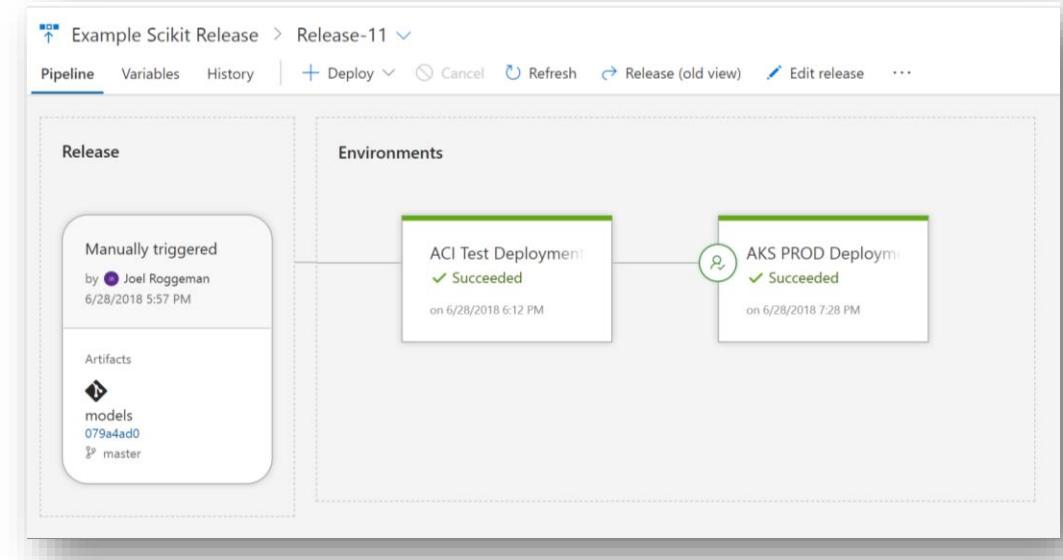
- Provide a consistent way to **discover, store, track & share models**
- Provide a consistent **model metadata format**
- Track where a model came from
 - which **data**,
 - which **experiment / previous model(s)**
 - where's the **code / notebook**
 - Was it **converted / quantized?**
- Track **where model is running**
- Control **who has access** to what models
 - Private / compliant data

ONNX – goal is to be interoperable format for models

Model Registry		
<input type="checkbox"/>	NAME	VERSION
<input type="checkbox"/>	best_model.pkl	13
<input type="checkbox"/>	best_model.pkl	12
<input type="checkbox"/>	best_model.pkl	11
<input type="checkbox"/>	best_model.pkl	10
<input type="checkbox"/>	best_model.pkl	9
<input type="checkbox"/>	best_model.pkl	8
<input type="checkbox"/>	best_model.pkl	7
<input type="checkbox"/>	best model.pkl	6

Model Deployment

- **Safe and efficient** deployment & feedback
- Simplify **consumption - code-generation, API specifications / interfaces**
- Support a **variety of inferencing targets**
 - Cloud Services
 - Mobile / Embedded Applications
 - Edge Devices
- **Convert / quantize / optimize** models for target platform
- **Control the rollout** of your models (with A/B)
- Feed telemetry back into your system on **service health** and **model behavior**



Models	Service "pairingexcel"
Manifests	pairingexcel.airestestcluster-2f813172.eastus2
Images	5/1/2018, 12:42:38 PM
Services	5/1/2018, 12:42:58 PM
	Succeeded
	airestestcluster
URL	http://13.68.75.180/api/v1/service/pairingel Copy
Primary key	eqsCYasTxddYwePMo5wHiuqVjoNAJbef Copy Regenerate
Secondary key	pN01Sr51r9SuLZ9alhft3vimmw4UYR17L Copy Regenerate
Event hub	false
Storage	true
CPU reserve capacity	0.1
Memory reserve capacity	500M
Scale settings	
Scale Type	Auto

What are ML pipelines?

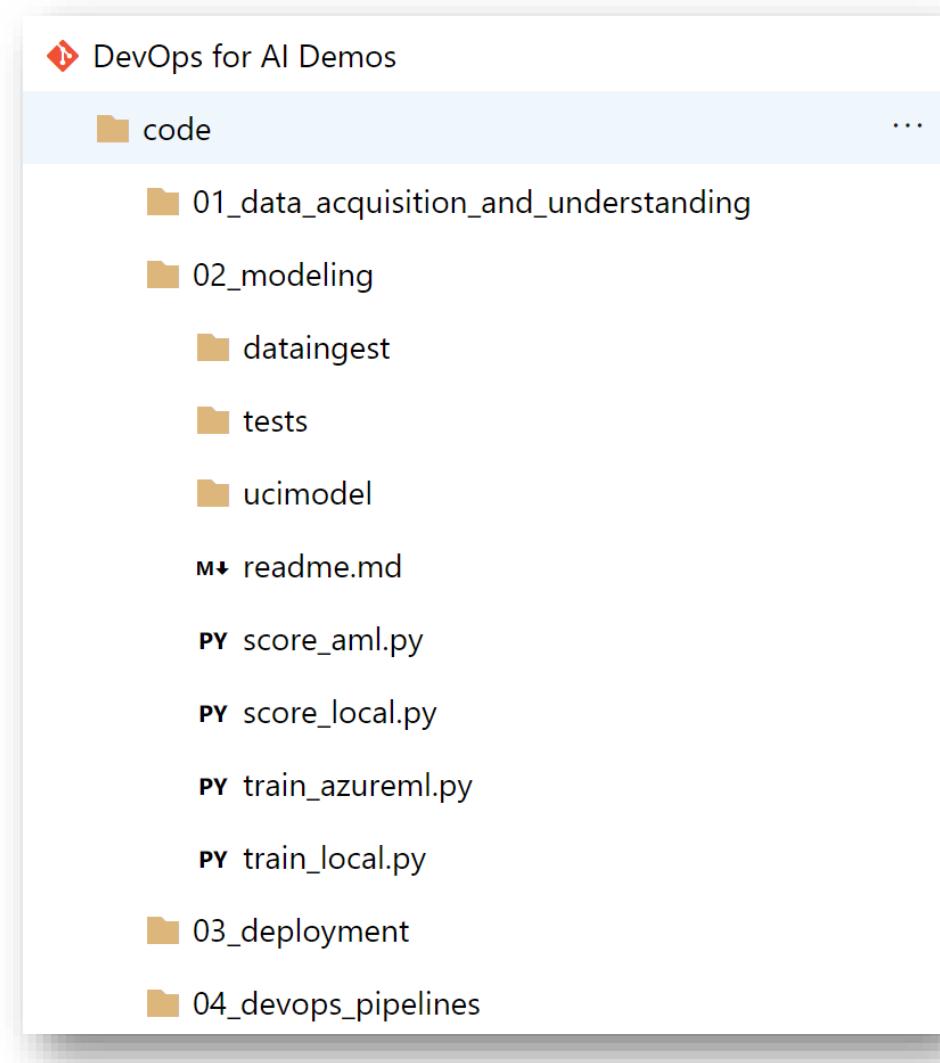
- Machine learning (ML) pipelines are used by data scientists to build, optimize, and manage their machine learning workflows.
- A typical pipeline involves a sequence of steps that cover the following areas:
 - Data preparation, such as normalizations and transformations
 - Model training, such as hyper parameter tuning and validation
 - Model deployment and evaluation
- They provide the job management infra we need for batch prediction pipelines

Why use ML pipelines?

Key advantage	Description
Unattended runs	Schedule a few steps to run in parallel or in sequence in a reliable and unattended manner. Since data prep and modeling can last days or weeks, you can now focus on other tasks while your pipeline is running.
Mixed and diverse compute	Use multiple pipelines that are reliably coordinated across heterogeneous and scalable computes and storages. Individual pipeline steps can be run on different compute targets, such as HDInsight, GPU Data Science VMs, and Databricks, to make efficient use of available compute options.
Reusability	Pipelines can be templated for specific scenarios such as retraining and batch scoring. They can be triggered from external systems via simple REST calls.
Tracking and versioning	Instead of manually tracking data and result paths as you iterate, use the pipelines SDK to explicitly name and version your data sources, inputs, and outputs as well as manage scripts and data separately for increased productivity.

Model Training

- **Training script** (`train.py`): The training script contains logic specific to the model that you are training.
- **Scoring file** (`score.py`): When the model is deployed as a web service, the scoring file receives data from clients and scores it against the model. The output is then returned to the client.
- **Experiment settings** (`project.json`): Links your project (`training.py` and other files required for training) with an experiment in your workspace.
- **RunConfig settings** (`myconfig.runconfig`): Defines how the training script is ran on the compute target that is used for training.
- **Conda environment** (`conda_dependencies.yml`): Defines the packages needed to run the training script.
- **Deployment environment** (`prod_dependencies.yml`): Defines the packages needed to run the model and scoring file in the deployment environment.



Model Training

CI pipeline captures:

1. Create sandbox
2. Run unit tests and code quality checks
3. Attach to compute
4. Train model
5. Evaluate model
6. Register model

The screenshot shows a pipeline titled "DevOps for AI - Build Model - AzureML". The pipeline consists of the following tasks:

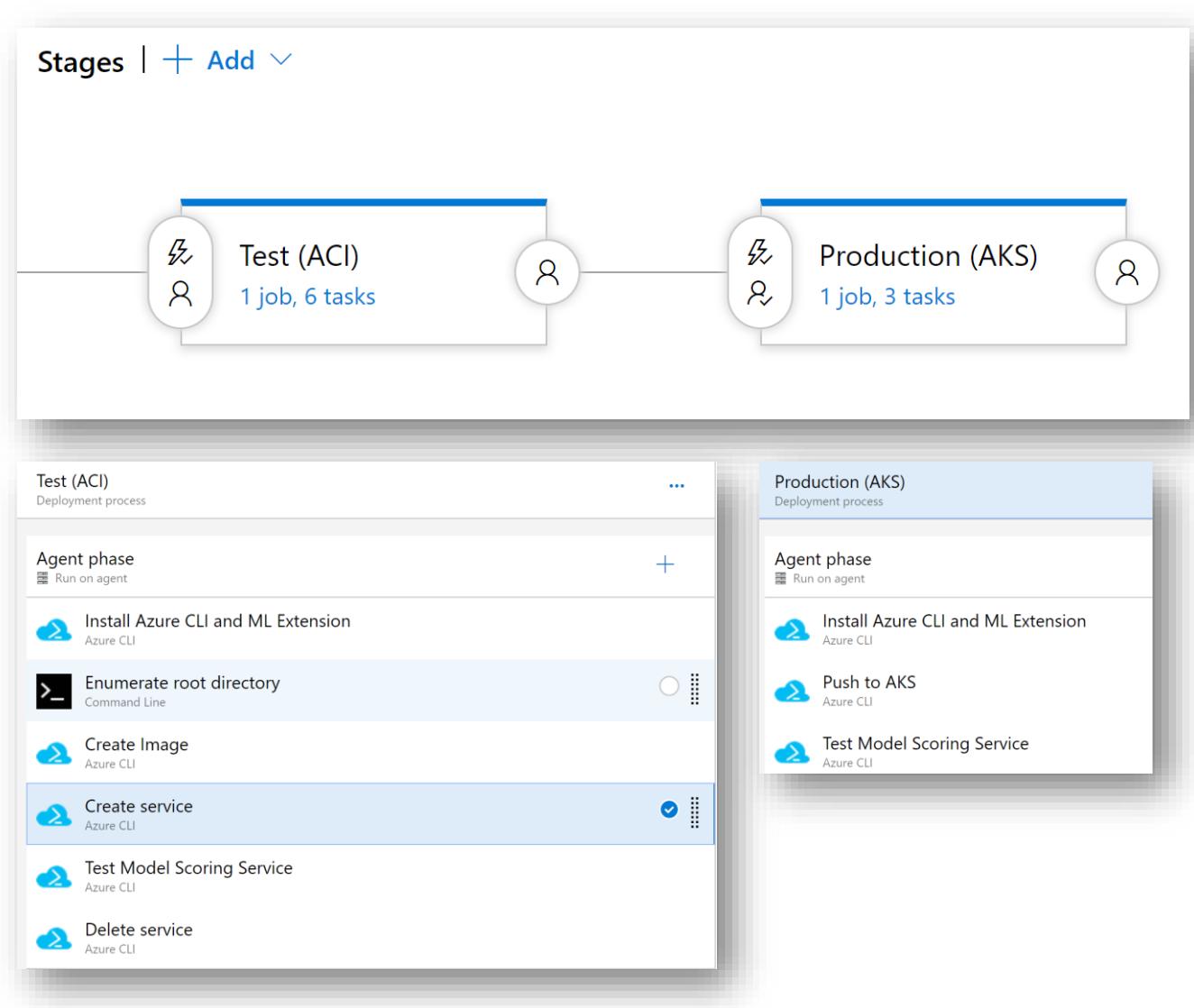
- Create Conda Environment (Conda Environment)
- Prepare Conda Environment (using yml) (Command Line)
- Install Azure CLI ML Extension (Preview) (Azure CLI)
- Unit tests (model code) (Command Line)
- Code Quality (flake8) (Command Line)
- Publish Unit Test Results (Publish Test Results)
- AzureML: Attach to an experiment (Azure CLI)
- AzureML: create dsvm run config (Azure CLI)
- AzureML: train model (Azure CLI)
- AzureML: download trained model (Azure CLI)
- Integration tests (Command Line)
- Publish Test Results (Publish Test Results)
- AzureML: register model (Azure CLI)
- Copy Model Requirements (Copy Files)

Model Deployment

CD pipeline captures:

1. Package model into container image
2. Validate and profile model
3. Deploy model to Dev/Test (ACI)
4. If all is well, proceed to rollout to AKS

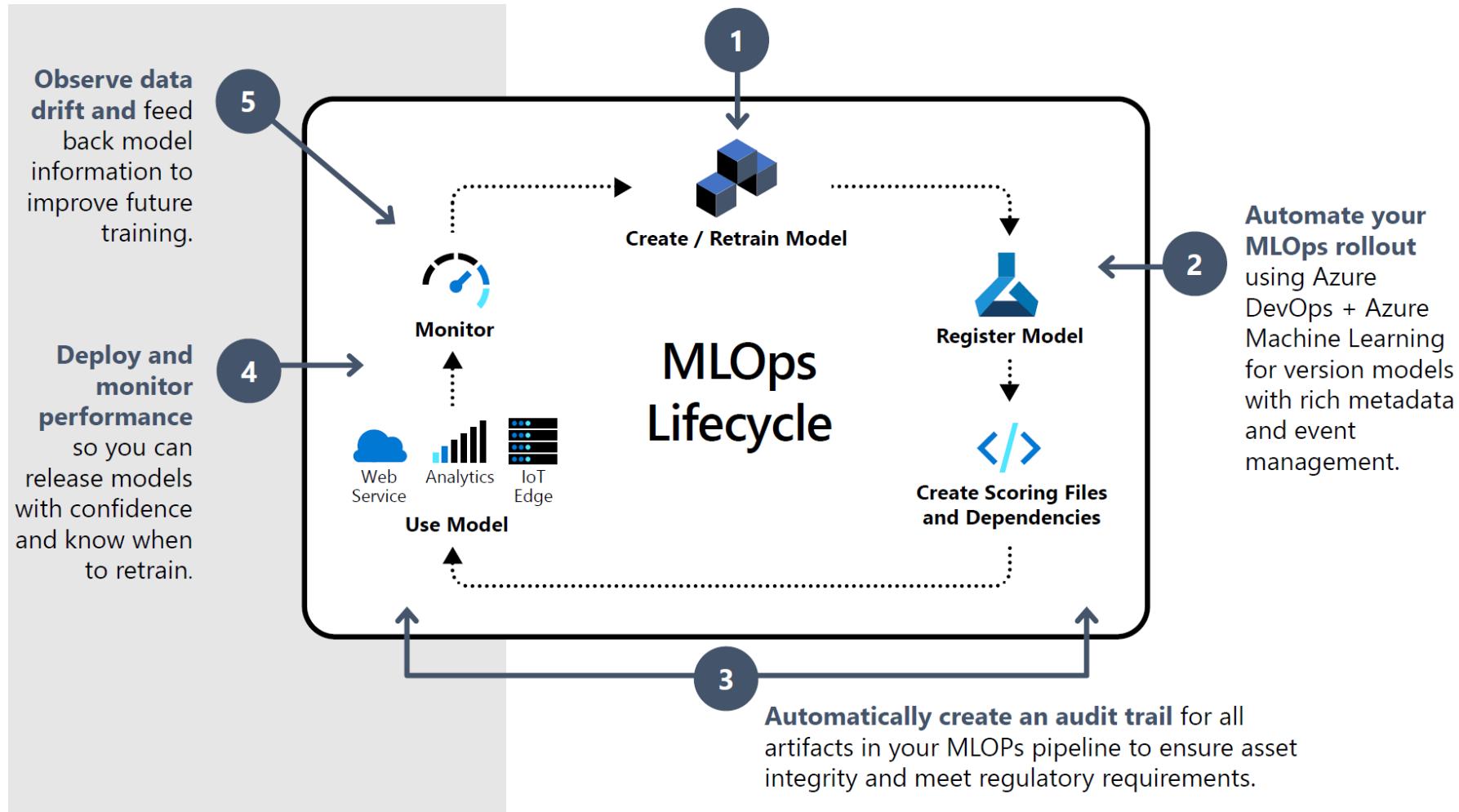
Everything is done via the CLI



MLOps workshop

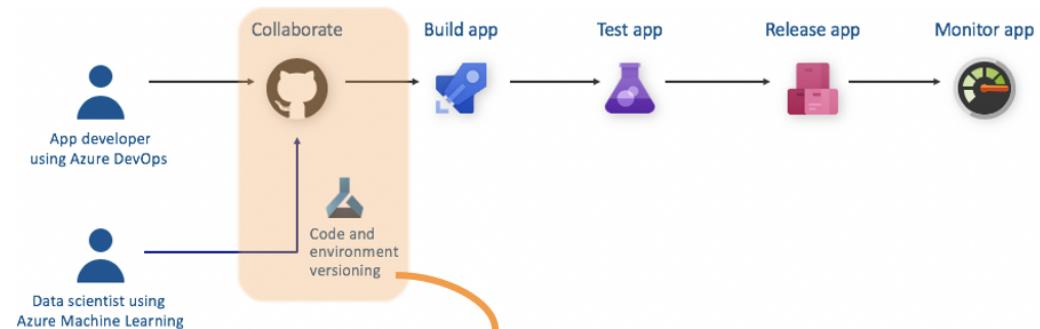


MLOps



MLOps

Overall - looks complicated..
As a data scientist I need to do what, now?



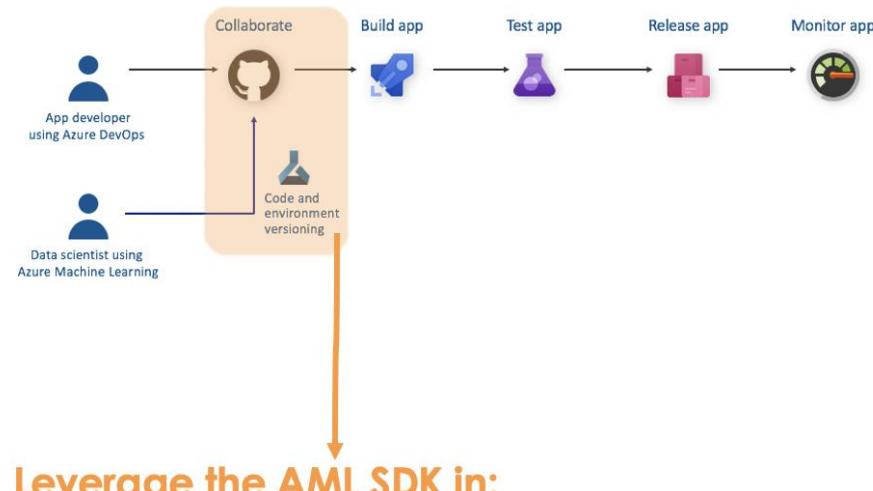
Develop and check this into git....

train.py
containerize.py
score.py

MLOps

As a data scientist...

What's additional in my regular code?



At a high-level...
In the lab, review the source code



Leverage the AML SDK in:

- train.py:** Provision transient compute, push training to it, and register the trained model to AML Model Registry
- containerize.py:** Create a docker container image and register into AML container registry
- score.py:** Input and output schema, scoring REST service, call log model metrics

MLOps

As a data scientist, I tend to be curious...
What else is needed for this MLOps?..

A whole bunch....lets review

More code

```
❖ ncr-chd-mlops
  :
  ✓ scripts-ml
    PY containerize.py
    PY score.py
    PY train.py
  ✓ scripts-operationalize
    agent-dependencies.sh
    aml-compute-dependen...
    PY aml-pipeline-for-build.py
    PY deploy-rest-service.py
    PY provision-aml-compute....
    build-master-pipeline.yml
    README.md
```

A "Build" pipeline

```
1 trigger:
2 - master
3
4 pool:
5   vmImage: 'Ubuntu-16.04'
6
7 variables:
8   resourceGroup: 'ncr-mlops-rg'
9   amlWorkspace: 'ncramlws'
10  experiment: 'chd-prediction'
11  amlComputeTargetName: 'chd-temp-compute'
12  modelName: 'chd-predictor'
13  containerImageName: 'chd-predictor-image'
14  serviceConnection: 'ncrMlopsServiceConexion'
15
16 steps:
17
18 - task: UsePythonVersion@0
19  displayName: 'Build step 1 – Python configuration for agent'
20  inputs:
21    versionSpec: '3.6'
22    architecture: 'x64'
23
24 - task: Bash@3
25  displayName: 'Build step 2 – Install dependencies on agent'
26  inputs:
27    targetType: filePath
28    filePath: 'scripts-operationalize/agent-dependencies.sh'
```

A "Release" pipeline

The screenshot shows a 'Release' pipeline interface. At the top, there's a navigation bar with 'Pipeline', 'Variables', 'History', and buttons for 'Deploy', 'Cancel', 'Refresh', and 'Ed'. Below the navigation, the pipeline is divided into two main sections: 'Release' and 'Stages'. The 'Release' section contains a card for a 'Continuous deployment...' run by user 'Anagha Khanolkar' on 1/28/2020 at 11:08 PM. It includes a 'Artifacts' section with a download icon and the file '_chd-build-pipeline...' from branch 'master'. The 'Stages' section shows a single stage named 'Deploy REST Service' which has succeeded with one warning on 1/28/2020 at 11:29 PM.

Contenu du workshop

<https://aka.ms/WorkshopMLOPS>

Workshop

Azure ML



Création d'un workspace Azure ML



Main * Tags Review *

Workspace Name *

 ✓

Subscription

 ▼

Resource group

 ▼

Create new

Location

 ▼

Workspace edition [View full pricing details](#) ⓘ

 ▼

ⓘ For your convenience, these resources are added automatically to the workspace, if regionally available: [Azure storage](#), [Azure Application Insights](#) and [Azure Key Vault](#).

Création en cours



Home > Microsoft.MachineLearningServices | Overview

Microsoft.MachineLearningServices | Overview

 Deployment

Search (Ctrl+/) <>

 Overview  Inputs  Outputs  Template

 Your deployment is underway

Deployment name: Microsoft.MachineLearningServices
Subscription: Microsoft Azure Internal Consumption
Resource group: MLOpsWorkshopRG

Start time: 12/03/2020 à 12:02:53
Correlation ID: 313c2f8b-3bc3-47b9-b548-0a2a60d51f8b

 Deployment details [\(Download\)](#)

Resource	Type	Status	Operation details
No results.			

Création terminée



Azure Machine Learning

Home > Microsoft.MachineLearningServices | Overview

Microsoft.MachineLearningServices | Overview

Deployment

Search (Ctrl+ /) << Delete Cancel Redeploy Refresh

Overview

Inputs

Outputs

Template

Your deployment is complete

Deployment name: Microsoft.MachineLearningServices
Subscription: Microsoft Azure Internal Consumption
Resource group: MLOpsWorkshopRG

Start time: 12/03/2020 à 12:02:53
Correlation ID: 313c2f8b-3bc3-47b9-b

Deployment details (Download)

Next steps

Go to resource

Accès au workspace Azure ML



Search (Ctrl +/)

Download config.json Delete

Overview

Activity log

Access control (IAM)

Tags

Diagnose and solve problems

Events

Assets

Experiments

Pipelines

Compute

Models

Images

Deployments

Activities

Settings

Properties

Locks

Export template

Monitoring

Workspace edition : Enterprise

Resource group : MLOpsWorkshopRG

Location : West Europe

Subscription : Microsoft Azure Internal Consumption

Subscription ID : [REDACTED]

Storage : mlopsworkshop6119741507

Registry : ...

Key Vault : mlopsworkshop7771179297

Application Insights : mlopsworkshop9122234384

Try the new Azure Machine Learning studio

Introducing a new immersive experience (preview) for managing the end-to-end machine learning lifecycle.

Launch now Learn more

Getting Started

View Documentation

Learn how to use Azure Machine Learning.

View more samples at GitHub

Get inspired by a large collection of machine learning examples.

View Forum

Learn about Enterprise Edition

A screenshot of the Azure Machine Learning workspace overview page. The left sidebar contains navigation links for Overview, Activity log, Access control (IAM), Tags, Diagnose and solve problems, Events, Assets (Experiments, Pipelines, Compute, Models, Images, Deployments, Activities), Settings (Properties, Locks, Export template), and Monitoring. The main content area shows workspace details: Edition (Enterprise), Resource group (MLOpsWorkshopRG), Location (West Europe), Subscription (Microsoft Azure Internal Consumption), and Subscription ID (redacted). It also lists associated resources: Storage (mlopsworkshop6119741507), Registry (...), Key Vault (mlopsworkshop7771179297), and Application Insights (mlopsworkshop9122234384). A prominent callout box promotes the "new Azure Machine Learning studio" as an immersive experience for managing the end-to-end machine learning lifecycle, with "Launch now" and "Learn more" buttons. Below this, sections for "Getting Started" include "View Documentation" (learn how to use Azure Machine Learning) and "View more samples at GitHub" (get inspired by a large collection of machine learning examples). At the bottom, there are links for "View Forum" and "Learn about Enterprise Edition".

Azure ML Studio



Azure Machine Learning

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Home

Welcome to the studio!

+ Create new ▾

Notebooks
Code with Python SDK and run sample experiments.
Start now

Automated ML
Automatically train and tune a model using a target metric.
Start now

Designer
Drag-and-drop interface from prepping data to deploying models.
Start now

Tutorials

What is Azure Machine Learning?

Train your first ML model with Notebook

Create, explore and deploy Automated ML experiments.

☰

+ New

Home

Author

Notebooks

Automated ML

Designer

Assets

Datasets

Experiments

Pipelines

Models

Endpoints

Manage

Compute

Création d'une compute instance



Azure Machine Learning

Compute

Training clusters Inference clusters Attached compute

Using the Notebook VM. You cannot create new Notebook VMs, but you can still use existing Notebook VMs. [Learn More](#).

Start Stop Restart Delete Show created by me only

Status	Application URI	Virtual Machine size
--------	-----------------	----------------------



New Compute Instance

Compute name * [i](#)

instancenotebook

Region * [i](#)

westeurope

Virtual Machine size * [i](#)

Standard_D4_v2

Enable SSH access [?](#)

[">>](#) Advanced settings



Azure Machine Learning

Création en cours de la compute instance

MLOpsWorkshop > Compute

Compute

Compute Instances Training clusters Inference clusters Attached compute

i Compute instance is replacing the Notebook VM. You cannot create new Notebook VMs, but you can still use existing Notebook VMs. [Learn More.](#)

+ New ⟳ Refresh ⟲ Start ⟳ Stop ⟳ Restart trash Delete Show created by me only

Name	Status	Application URI	Virtual Machine size	Created on
instancenotebook	C Creating	JupyterLab Jupyter RStudio SSH	STANDARD_D4_V2	Mar 12, 2020 12:06 PM

< Prev Next >



Azure Machine Learning

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Compute

Compute

Compute Instances Training clusters Inference clusters Attached compute

ⓘ Compute instance is replacing the Notebook VM. You cannot create new Notebook VMs, but you can still use existing Notebook VMs. [Learn More.](#)

+ New ⏪ Refresh ⏴ Start ⏴ Stop ⏴ Restart ⏹ Delete ⏵ Show created by me only

Name	Status	Application URI	Virtual Machine size	Created on
instancenotebook	Running	JupyterLab Jupyter RStudio SSH	STANDARD_D4_V2	Mar 12, 2020 12:06 PM

< Prev Next >

≡ New Home Author Notebooks Automated ML Designer Assets Datasets Experiments Pipelines Models Endpoints Manage Compute Databricks

Accès à Jupyter notebooks



Azure Machine Learning

jupyter

Files Running Clusters AzureML Samples

Select items to perform actions on them.

Upload New

	Name	Last Modified	File size
<input type="checkbox"/> 0	/		
<input type="checkbox"/> Users		4 minutes ago	



Téléchargement du repo pour le workshop

Screenshot of a GitHub repository page for "WorkshopMLOps" owned by "retkowsky".

The repository summary shows:

- Code tab selected
- Issues: 0
- Pull requests: 0
- Actions: 0
- Projects: 0
- Wiki: 0
- Security: 0
- Insights: 0
- Settings: 0

Key statistics:

- 26 commits
- 1 branch
- 0 packages
- 0 releases
- 1 contributor

Branch dropdown: master

File list:

- scripts-ml
- scripts-operationalize
- whitepaper
- 01 Analyse ML Python.ipynb
- 02 Modélisation avec Azure ML.ipynb
- 03 Test déploiement AKS.ipynb
- 04 Télémétrie AKS.ipynb
- README.md
- build-master-pipeline.yml
- framingham.csv

Latest commit: d59873c 29 minutes ago

Actions bar (highlighted with a red box):

- Create new file
- Upload files
- Find file
- Clone or download (button)

<https://github.com/retkowsky/WorkshopMLOps>

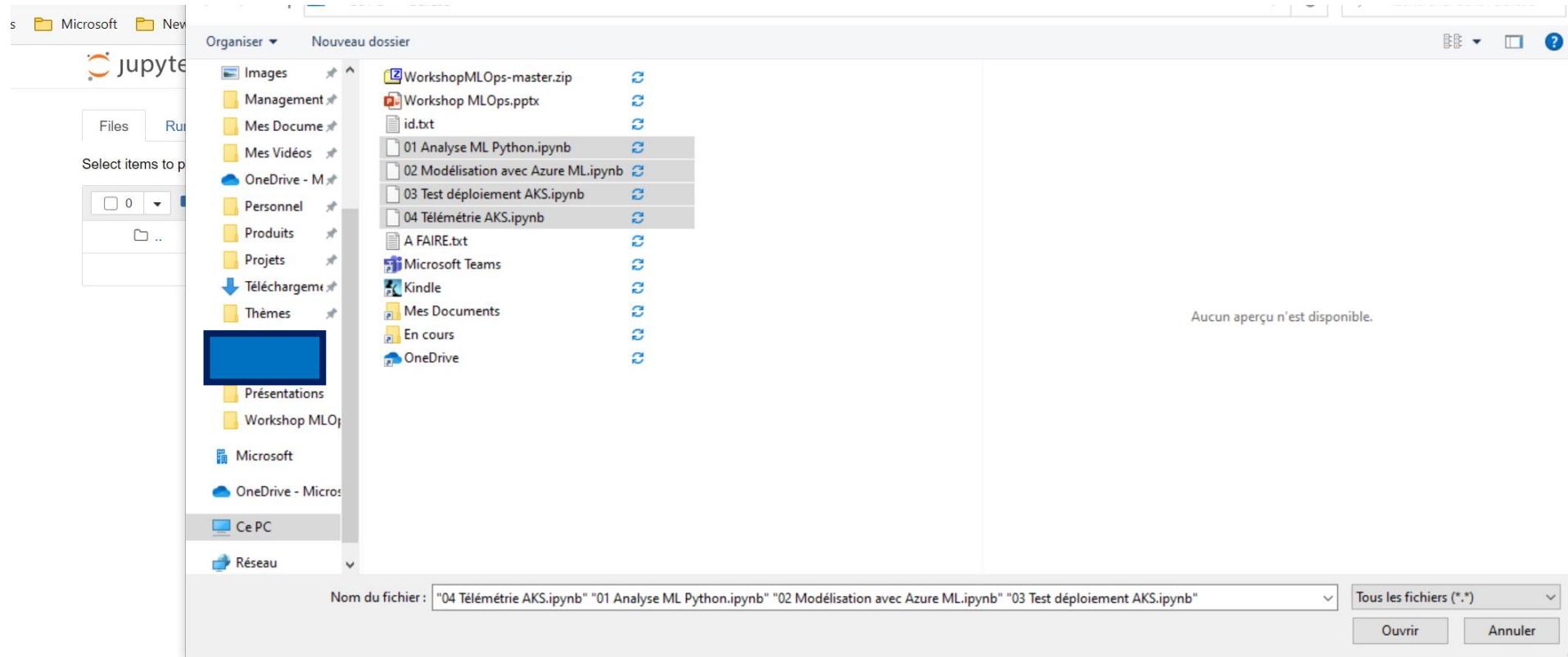


Azure Machine Learning

Fichiers du repo

Nom	Taille	Com
📁 ..		
📁 scripts-ml	15 319	
📁 scripts-operationalize	16 185	
📁 whitepaper	572 793	3
📄 01 Analyse ML Python.ipynb	50 825	
📄 02 Modélisation avec Azure ML.ipynb	171 970	
📄 03 Test déploiement AKS.ipynb	3 091	
📄 04 Télémétrie AKS.ipynb	8 601	
📝 build-master-pipeline.yml	2 771	
📄 framingham.csv	191 803	
📝 README.md	317	

Importation des notebooks dans Jupyter



Chargement des notebooks dans Jupyter



jupyter

Files Running Clusters AzureML Samples

Select items to perform actions on them.

Upload New ▾

0 / Users / seretkow

Name ↓ Last Modified File size

	04 Télémétrie AKS.ipynb	Upload Cancel
	03 Test déploiement AKS.ipynb	Upload Cancel
	02 Modélisation avec Azure ML.ipynb	Upload Cancel
	..	seconds ago
	01 Analyse ML Python.ipynb	Upload Cancel

Visualisation des notebooks importés



jupyter

Files Running Clusters AzureML Samples

Select items to perform actions on them.

Upload New ▾

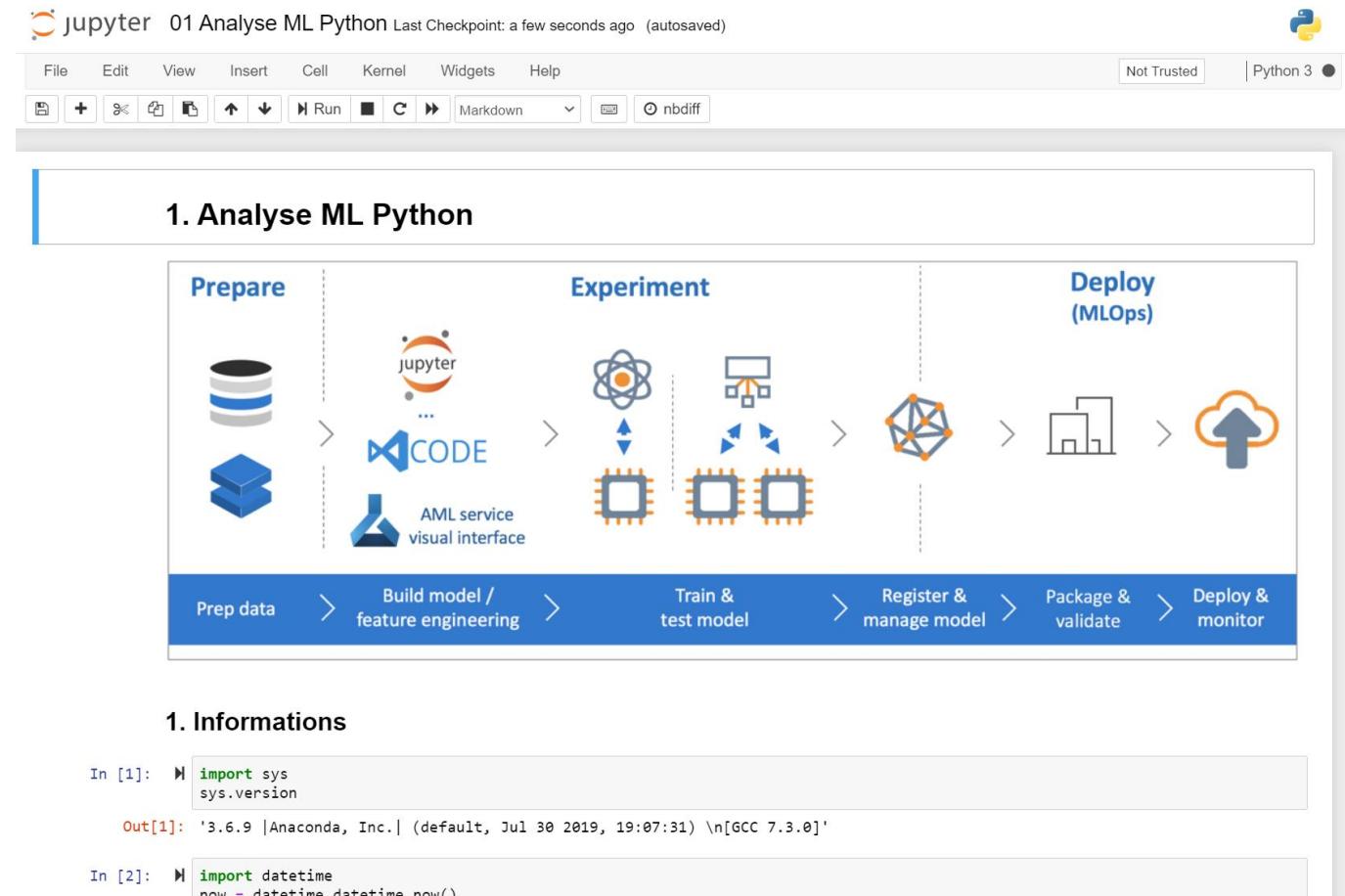
<input type="checkbox"/>	0	/ Users / seretkow	Name	Last Modified	File size
<input type="checkbox"/>	..			seconds ago	
<input type="checkbox"/>	01 Analyse ML Python.ipynb			seconds ago	50.8 kB
<input type="checkbox"/>	02 Modélisation avec Azure ML.ipynb			seconds ago	172 kB
<input type="checkbox"/>	03 Test déploiement AKS.ipynb			seconds ago	3.09 kB
<input type="checkbox"/>	04 Télémétrie AKS.ipynb			seconds ago	8.6 kB

Workshop Notebooks Azure ML



Notebook 1. Analyse ML Python

Ce notebook contient du code python pour construire un modèle de ML.



The screenshot shows a Jupyter Notebook interface with the title "01 Analyse ML Python". The notebook is set to "Python 3" and is marked as "Not Trusted". The main content area displays a diagram of the Machine Learning pipeline and some initial code cells.

1. Analyse ML Python

Prepare → **Experiment** → **Deploy (MLOps)**

Prep data > Build model / feature engineering > Train & test model > Register & manage model > Package & validate > Deploy & monitor

1. Informations

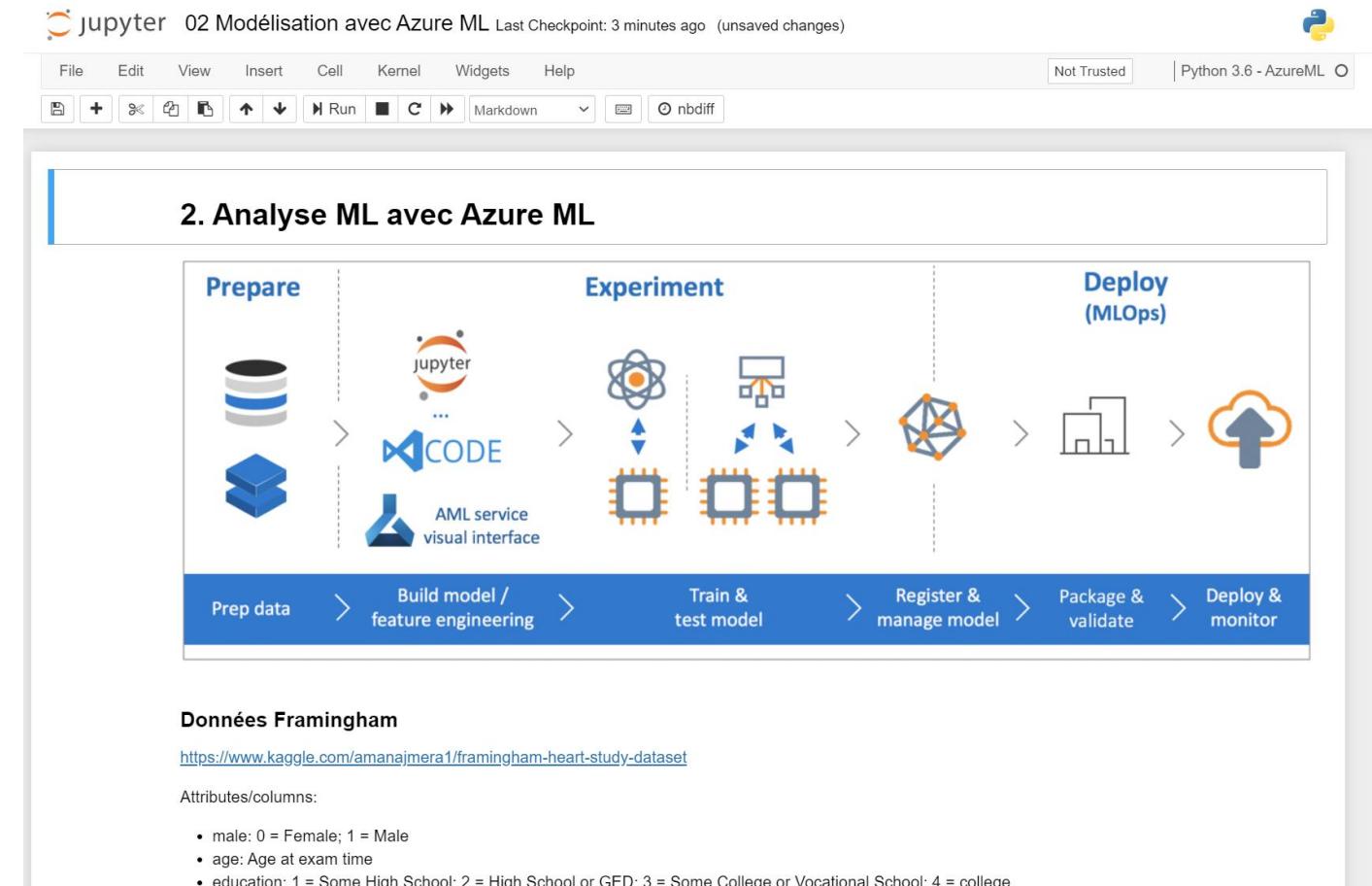
```
In [1]: import sys  
        sys.version  
  
Out[1]: '3.6.9 |Anaconda, Inc.| (default, Jul 30 2019, 19:07:31) \n[GCC 7.3.0]'
```

```
In [2]: import datetime  
now = datetime.datetime.now()
```

Notebook 2. Analyse ML avec Azure ML

Ce notebook réalise les mêmes instructions que le notebook précédent mais en exploitant cette fois Azure ML.

Une analyse autoML sera également réalisée.



The screenshot shows a Jupyter Notebook interface with the title "jupyter 02 Modélisation avec Azure ML Last Checkpoint: 3 minutes ago (unsaved changes)". The toolbar includes File, Edit, View, Insert, Cell, Kernel, Widgets, Help, Not Trusted, and Python 3.6 - AzureML. Below the toolbar is a toolbar with icons for file operations, run cell, and nbdiff. The main content area has a header "2. Analyse ML avec Azure ML". Below it is a diagram illustrating the Azure ML workflow:

```
graph LR; subgraph Prepare [Prepare]; A[Prep data]; end --> subgraph Experiment [Experiment]; B[Build model / feature engineering]; C[Train & test model]; end --> subgraph DeployMLOps [Deploy (MLOps)]; D[Register & manage model]; E[Package & validate]; F[Deploy & monitor]; end; A --> B --> C --> D --> E --> F;
```

The diagram also features icons for "jupyter", "CODE", and "AML service visual interface". Below the diagram, the steps are labeled: Prep data, Build model / feature engineering, Train & test model, Register & manage model, Package & validate, and Deploy & monitor.

Données Framingham
<https://www.kaggle.com/amanaJmera1/framingham-heart-study-dataset>

Attributes/columns:

- male: 0 = Female; 1 = Male
- age: Age at exam time
- education: 1 = Some High School; 2 = High School or GED; 3 = Some College or Vocational School; 4 = college

Modifier les champs suivants avec les infos de votre workspace Azure ML



```
import azureml.core
print("Version Azure ML service :", azureml.core.VERSION)

Version Azure ML service : 1.0.83

In [4]: # Azure subscription
subscription_id = "ARENSEIGNER"

# Resource Group
resource_group = "MLOpsworkshopRG"

# Workspace Name and Azure Region of the Azure Machine Learning Workspace
workspace_name = "MLOpsWorkshop"
workspace_region = "westeurope"

# Other variables
experiment_name = 'chd-prediction-manual'
project_dir = './chd'
deployment_dir = './deploy'
model_name = 'chd-predictor-manual'
model_description = 'Model to predict coronary heart disease'

# AML managed compute to be spun up for training
vm_name = "chd-manual"
```



Azure Machine Learning

Authentification

```
In [*]: ws = Workspace.create(  
    name = workspace_name,  
    subscription_id = subscription_id,  
    resource_group = resource_group,  
    location = workspace_region,  
    exist_ok = True) #Leverage existing  
  
ws.write_config()  
print('Workspace configuration succeeded')
```

Performing interactive authentication. Please follow the instructions on the terminal.

To sign in, use a web browser to open the page <https://microsoft.com/devicelogin> and enter the code CC7M2DDJZ to authenticate.

Exécution en cours du notebook

Widget pour suivre l'avancement du run

In [21]: RunDetails(run).show()

Run Properties		Output Logs
Status	Running	logs/azureml/155_azureml.log <input checked="" type="checkbox"/> Auto-switch
Compute Target		2020-03-12 11:22:48,704 azureml DEBUG Inputs:: kwargs: {'OutputCollection': True, 'snapshotProject': True, 'only_in_process_features': True, 'skip_track_logs_dir': True}, track_folders: None, deny_list: None, directories_to_watch: []
Nodes		2020-03-12 11:22:48,705 azureml.history._tracking.PythonWorkingDirectory DEBUG Execution target type: batchai
Start Time	12/03/2020 12:21:00	2020-03-12 11:22:48,710 azureml.history._tracking.PythonWorkingDirectory DEBUG Failed to import pyspark with error: No module named 'pyspark'
Duration	0:01:50	2020-03-12 11:22:48,710 azureml.history._tracking.PythonWorkingDirectory.workingdir DEBUG Pinning working directory for filesystems: ['pyfs']
Run Id	chd-prediction-manual_1584012057_28c60248	2020-03-12 11:22:48,949 azureml._base_sdk_common.user_agent DEBUG Fetching client info from /root/.azureml/clientinfo.json
Arguments	N/A	2020-03-12 11:22:48,949 azureml._base_sdk_common.user_agent DEBUG Error loading client info: [Errno 2] No such file or directory: '/root/.azureml/clientinfo.json'



Azure Machine Learning

Référencement du modèle

```
In [27]: if run.get_status() == 'Completed':
    print("Training completed successfully!")
    model_run = run.register_model(model_name=model_name,
                                    model_path='./outputs/model/chd-rf-model',
                                    tags={"type": "classification", "description": model_description, "run_id": run.id})
    print("Model registered with version number: ", model_run.version)
else:
    print("Training failed!")
    Exception("Training failed!")
```

```
Training completed successfully!
Model registered with version number: 1
```

Visualisation du modèle référencé dans Azure ML



Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Models

Model List

+ Register model Delete Deploy Refresh

Name	Version	Experiment	Run ID	Created on	Tags	Created by
chd-predictor-manual	1	chd-prediction-manual	chd-prediction-manual_158401...	Mar 12, 2020 12:25 PM	type: classification des... +1	Serge Retkowsky

Prev Next

New Home Author Notebooks Automated ML Designer Assets Datasets Experiments Pipelines Models Endpoints Manage

Après exécution du notebook on peut visualiser
le training cluster créé



Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Compute

Compute

Compute Instances Training clusters Inference clusters Attached compute

+ New Refresh Delete

Name	Type	Provisioning state	Created on
chd-manual	Machine Learning Com...	Succeeded (1 node)	2020-03-12T11:18:12.4152503+00:00

< Prev Next >

New Home Author Notebooks Automated ML Designer Assets Datasets Experiments Pipelines Models Endpoints Manage

The screenshot shows the Microsoft Azure Machine Learning interface. The left sidebar has sections for Preview, MLOpsWorkshop, Compute, Compute Instances, Training clusters (which is selected), Inference clusters, Attached compute, New, Refresh, and Delete. Below this is a table with columns: Name, Type, Provisioning state, and Created on. A row for 'chd-manual' is highlighted with a red box. The table also includes navigation arrows for previous and next pages. The bottom left sidebar lists various assets like Datasets, Experiments, Pipelines, etc.



Azure Machine Learning

AutoML avec Azure ML

```
In [38]: automl_settings = {  
    "enable_early_stopping": True,  
    "iterations" : 10,                      #20 itérations max  
    "iteration_timeout_minutes" : 2,          #Temps max par itération  
    "experiment_timeout_minutes" : 10,         #Temps max pour le process AutoML  
    "n_cross_validations": 5,                 #Validation croisée  
    "primary_metric": 'accuracy',            #Choix de La métrique  
    "verbosity": logging.INFO  
}  
  
automl_config = AutoMLConfig(task = 'classification',  
                             debug_log = 'automl.log',  
                             preprocess=True,  
                             training_data = df,  
                             label_column_name = targetvariable,  
                             **automl_settings  
)
```

```
In [*]: automl_run = experiment.submit(automl_config, show_output = True)
```

<https://docs.microsoft.com/en-us/azure/machine-learning/concept-automated-ml>

Résultats AutoML

In [41]: # Widget

```
# Widget
from azureml.widgets import RunDetails
RunDetails(automl_run).show()
```

AutoML_7d755811-d947-47a2-b8a4-f17e12df0a15:

Status: Completed

Status -



Iteration	Pipeline	Iteration metric	Best metric	Status	Duration	Started
8	VotingEnsemble	0.84929245	0.84929245	Completed	0:00:16	Mar 12, 2020 12:29 PM
1	MaxAbsScaler, SGD	0.84764151	0.84764151	Completed	0:00:14	Mar 12, 2020 12:27 PM
4	MaxAbsScaler, SGD	0.84716981	0.84764151	Completed	0:00:13	Mar 12, 2020 12:28 PM
6	MaxAbsScaler, SGD	0.84457547	0.84764151	Completed	0:00:14	Mar 12, 2020 12:29 PM
0	MaxAbsScaler, LightGBM	0.84221698	0.84221698	Completed	0:00:19	Mar 12, 2020 12:27 PM
9	StackEnsemble	0.83632075	0.84929245	Completed	0:00:27	Mar 12, 2020 12:30 PM
5	MaxAbsScaler, RandomForest	0.66462264	0.84764151	Completed	0:00:15	Mar 12, 2020 12:28 PM
3	MaxAbsScaler, ExtremeRandomTrees	0.65896226	0.84764151	Completed	0:00:14	Mar 12, 2020 12:28 PM
7	MaxAbsScaler, RandomForest	0.64740566	0.84764151	Completed	0:00:14	Mar 12, 2020 12:29 PM
2	MaxAbsScaler, SGD	0.64292453	0.84764151	Completed	0:00:14	Mar 12, 2020 12:28 PM

10 ▾ per page

accuracy ▾

Accès à l'expérimentation AutoML depuis Azure ML Studio



Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Experiments

Experiments

Refresh Archive experiment View archived experiments

Add filter

Experiment	Latest run	Last submitted	Created	Created by	Run types
chd-prediction-manual	2	Mar 12, 2020 12:27 PM	Mar 12, 2020 12:18 PM	Serge Retkowsky	Script, Automated ML

< Prev Next >

The screenshot shows the Azure Machine Learning Studio interface. The left sidebar has a 'Preview' tab selected, followed by 'Microsoft Azure Machine Learning'. The main navigation bar shows 'MLOpsWorkshop > Experiments'. The 'Experiments' section lists one experiment named 'chd-prediction-manual'. A red box highlights the experiment name. The table columns are 'Experiment', 'Latest run', 'Last submitted', 'Created', 'Created by', and 'Run types'. The experiment details are: Latest run (2), Last submitted (Mar 12, 2020 12:27 PM), Created (Mar 12, 2020 12:18 PM), Created by (Serge Retkowsky), and Run types (Script, Automated ML). The sidebar also includes links for New, Home, Author, Notebooks, Automated ML, Designer, Assets, Datasets, Experiments (which is selected and highlighted in grey), Pipelines, Models, Endpoints, Manage, and Compute.



Résultats AutoML

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Experiments > chd-prediction-manual > Run 2

Run 2 ✓ Completed [Switch to old experience](#) (?)

↻ Refresh ✖ Cancel

[Details](#) [Data guardrails](#) [Models](#) [Logs](#) [Outputs](#)

Data guardrails are run by Automated ML when automatic featurization is enabled. This is a sequence of checks over the input data to ensure high quality data is being used to train model.

Type	Status	Description	
Class balancing detection	passed	Classes are balanced in the training data.	✓
Missing values imputation	fixed	The training data had the following missing values which were resolved. Please review your data source for data quality issues and possibly filter out the rows with these missing values. If the missing values are expected, you can either accept the above imputation, or implement your own custom imputation that may be more appropriate based on the data type and business process.	✓
Additional details			
High cardinality feature detection	passed	Your inputs were analyzed, and no high cardinality features were detected.	✓

Résultats AutoML



Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Experiments > chd-prediction-manual > Run 2

Run 2 Completed Switch ↗

↻ Refresh ✖ Cancel

Details Data guardrails **Models** Logs Outputs ✖ Search to filter items...

Algorithm name	Accuracy ↓	Created	Duration	Status	Model
VotingEnsemble	0.8492924528301888	Mar 12, 2020 12:29 PM	17s	Completed	⬇️ Download
MaxAbsScaler, SGD	0.8476415094339622	Mar 12, 2020 12:27 PM	14s	Completed	⬇️ Download
MaxAbsScaler, SGD	0.8471698113207546	Mar 12, 2020 12:28 PM	14s	Completed	⬇️ Download
MaxAbsScaler, SGD	0.8445754716981131	Mar 12, 2020 12:29 PM	14s	Completed	⬇️ Download
MaxAbsScaler, LightGBM	0.8422169811320754	Mar 12, 2020 12:27 PM	19s	Completed	⬇️ Download
StackEnsemble	0.8363207547169811	Mar 12, 2020 12:30 PM	27s	Completed	⬇️ Download
MaxAbsScaler, RandomForest	0.664622641509434	Mar 12, 2020 12:28 PM	15s	Completed	⬇️ Download
MaxAbsScaler, ExtremeRandomTrees	0.6589622641509434	Mar 12, 2020 12:28 PM	14s	Completed	⬇️ Download
MaxAbsScaler, RandomForest	0.6474056603773585	Mar 12, 2020 12:29 PM	14s	Completed	⬇️ Download
MaxAbsScaler, SGD	0.6429245283018868	Mar 12, 2020 12:28 PM	14s	Completed	⬇️ Download



Résultats AutoML

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Experiments > chd-prediction-manual > Run 2 > Run 11

Run 11 Completed

Refresh Explain model Cancel

Model details Visualizations Explanations (preview) Logs Outputs

Model summary

Algorithm name VotingEnsemble

Accuracy 0.8492924528301888

Registered models AutoMLmodel:1

Deploy status No deployment yet

Run details

Status Completed

Run ID AutoML_7d755811-d947-47a2-b8a4-f17e12df0a15_8

Input datasets --

Created time Mar 12, 2020 12:29 PM

Duration 17s

Run Metrics

Accuracy 0.84929

AUC macro 0.69607

AUC micro

Deploy model Download model

Résultats AutoML

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Experiments > chd-prediction-manual > Run 2 > Run 11

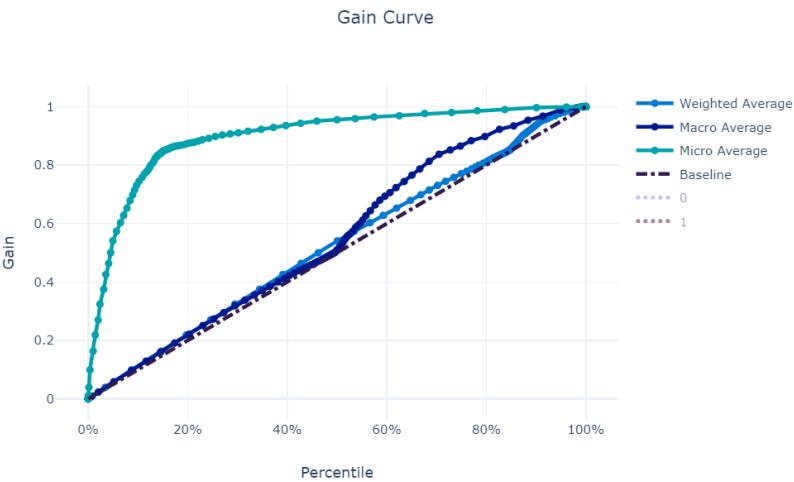
Run 11 Completed [Switch to old experience](#)

⟳ Refresh 🔍 Explain model ✖ Cancel

Model details Visualizations Explanations (preview) Logs Outputs

Predicted Probability Percentile

Gain Curve



Percentile

Confusion Matrix

		Predicted Label	
		0	1
True Label	0	3586	10
	1	629	15

Raw

3500
3000
2500
2000
1500
1000
500

Workshop Interfaces graphiques



Interfaces graphiques



Azure Machine Learning



AutoML user interface

Pour la réalisation des analyses AutoML
sans programmation Python



Designer

Pour la réalisation de vos analyses ML sans
programmation Python

AutoML User Interface

AutoML user interface



Azure Machine Learning

Utilisation de l'interface graphique pour la réalisation du processus AutoML:

- 1. Chargement du dataset
<https://raw.githubusercontent.com/retkowsky/WorkshopMLOps/master/framingham.csv>
- 2. Création AutoML depuis l'interface graphique (wizard)

AutoML user interface

Ajout source de données



Azure Machine Learning

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Datasets

Datasets

Registered datasets Dataset monitors (Preview)

+ Create dataset Refresh Unregister

Name	Version	Created on	Modified on	Properties	Created by	Tags
framingham	1	Mar 16, 2020 2:19 PM	Mar 16, 2020 2:19 PM	Tabular	Serge Retkowsky	

< Prev Next >

The screenshot shows the Microsoft Azure Machine Learning Studio interface. The left sidebar has sections for Preview, Microsoft Azure Machine Learning, MLOpsWorkshop, Datasets, Author (Notebooks, Automated ML, Designer), Assets (Datasets, Experiments, Pipelines, Models, Endpoints), and a selected item, Datasets. The main area displays 'Registered datasets' with a table showing one entry: 'framingham' (Version 1, created on Mar 16, 2020 2:19 PM, modified on Mar 16, 2020 2:19 PM, Tabular properties, created by Serge Retkowsky). A red box highlights the first row of the table. Navigation arrows at the bottom indicate previous and next datasets.

AutoML user interface

Utilisation de l'interface graphique



Azure Machine Learning

MLOpsWorkshop > Automated ML > Start run

Create a new Automated ML run

Select dataset

Select dataset

Select a dataset from the list below, or create a new dataset. Automated ML currently only supports tabular data for authoring runs.

+ Create dataset



Show supported datasets only



Search to filter items...

Dataset name

Dataset type

Created on

Modified

framingham

Tabular

Mar 16, 2020 2:19 PM

Mar 16, 2020 2:19 PM

< Prev Next >

AutoML user interface

Paramétrage



Azure Machine Learning

MLOpsWorkshop > Automated ML > Start run

Create a new Automated ML run

Select dataset

Configure run

Task type and settings

Configure run

Configure the experiment. Select from existing experiments or define a new name, select the target column and the training c
[experiment](#)

Dataset

framingham ([View dataset](#))

Experiment name *

AutoML-visualinterface

Target column * ⓘ

TenYearCHD

Select training cluster * ⓘ

chd-manual

[Create a new compute](#) [Refresh compute](#)



Azure Machine Learning

AutoML user interface

MLOpsWorkshop > Automated ML > Run Detail

Run 1 Running

↻ Refresh ✖ Cancel

[Details](#) [Data guardrails](#) [Models](#) [Logs](#) [Outputs](#)

Run summary

Task type

Classification ☰ View all run settings

Primary metric

Accuracy

Run status

Running

Experiment name

AutoML-visualinterface

Run ID

AutoML_9ef5e1e7-95d1-4329-a733-976d2075afb2

Input datasets

Input name: input_data, ID: [22785128-8a5c-431a-8889-4d57fdb37d91](#)

AutoML user interface

Meilleur modèle



Azure Machine Learning

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Automated ML > Run Detail

Run 1 ✓ Completed

Refresh Cancel

Details Data guardrails Models Logs Outputs

Model summary

Algorithm name
VotingEnsemble

Accuracy
0.8492947717580371 [View all other metrics](#)

Registered models
No registration yet

Deploy status
No deployment yet

Run summary

Task type
Classification [View all run settings](#)

Primary metric
Accuracy

Run status
Completed

Experiment name
AutoML-visualinterface

Run ID
AutoML_9ef5e1e7-95d1-4329-a733-976d2075afb2

Input datasets
Input name: input_data, ID: [22785128-8a5c-431a-8889-4d57fdb37d91](#)

Actions

Deploy best model View model details Download best model

AutoML user interface

Résultats



Azure Machine Learning

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Automated ML > Run Detail

Run 1 Completed

Refresh Cancel

Details Data guardrails Models Logs Outputs

Data guardrails are run by Automated ML when automatic featurization is enabled. This is a sequence of checks over the input data to ensure high quality data is being used to train model.

Type	Status	Description	Action
Cross validation	done	Each iteration of the trained model was validated through cross-validation.	✓
> Additional details			
Class balancing detection	passed	Classes are balanced in the training data.	✓
> Additional details			
Missing values imputation	fixed	The training data had the following missing values which were resolved. Please review your data source for data quality issues and possibly filter out the rows with these missing values. If the missing values are expected, you can either accept the above imputation, or implement your own custom imputation that may be more appropriate based on the data type and business process.	✓
> Additional details			
High cardinality feature detection	done	High cardinality inputs were detected in dataset and were featurized as {}.	✓
> Additional details			

AutoML user interface

Liste des itérations



Azure Machine Learning

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Automated ML > Run Detail

Run 1 Completed

Refresh Cancel

Details Data guardrails **Models** Logs Outputs

Search to filter items

Algorithm name	Accuracy ↓	Created	Duration	Status	Model
VotingEnsemble	0.8492947717580371	Mar 16, 2020 3:23 PM	1m 58s	Completed	Download
MaxAbsScaler, SGD	0.8483511529800234	Mar 16, 2020 2:34 PM	1m 37s	Completed	Download
MaxAbsScaler, SGD	0.8481152482855201	Mar 16, 2020 2:39 PM	1m 37s	Completed	Download
MaxAbsScaler, ExtremeRandomTrees	0.8481152482855201	Mar 16, 2020 2:47 PM	1m 37s	Completed	Download
MaxAbsScaler, ExtremeRandomTrees	0.8481152482855201	Mar 16, 2020 3:11 PM	1m 39s	Completed	Download
MaxAbsScaler, SGD	0.8481152482855201	Mar 16, 2020 3:21 PM	1m 37s	Completed	Download
MaxAbsScaler, SGD	0.8478795104260198	Mar 16, 2020 3:09 PM	1m 33s	Completed	Download
MaxAbsScaler, XGBoostClassifier	0.8455199629759761	Mar 16, 2020 2:26 PM	1m 40s	Completed	Download
StackEnsemble	0.8448125825624722	Mar 16, 2020 3:26 PM	1m 57s	Completed	Download
MaxAbsScaler, LightGBM	0.8443407731734652	Mar 16, 2020 3:17 PM	1m 36s	Completed	Download

< Prev Next >

The screenshot shows the Microsoft Azure Machine Learning studio interface. On the left is a navigation sidebar with sections like New, Home, Notebooks, Automated ML (which is selected), Designer, Datasets, Experiments, Pipelines, Models, Endpoints, Compute, Datastores, and Data Labeling. The main area displays a 'Run Detail' page for 'Run 1' which is completed. It shows a table of generated models with columns for Algorithm name, Accuracy, Created date, Duration, Status, and a Download link. The table lists various ensemble and single-model configurations. At the bottom, there are navigation links for 'Prev' and 'Next' runs.

AutoML user interface

Graphiques



Azure Machine Learning



AutoML user interface Explanations



Azure Machine Learning

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Automated ML > Run Detail > VotingEnsemble

Run 29 Completed

Refresh Explain model Cancel

Model details Visualizations Explanations (preview) Logs Outputs

Model explanations are used to understand what features are directly impacting the model and why. [Learn more](#)

Select Explanation

tabular | mimic | engineered | classification | 2dd87d62-4d1e-4825-8b2d-9f0db2e3d284 | 3/16/2020, 3:40:54 PM

Explainer: mimic

Global Importance

Summary Importance

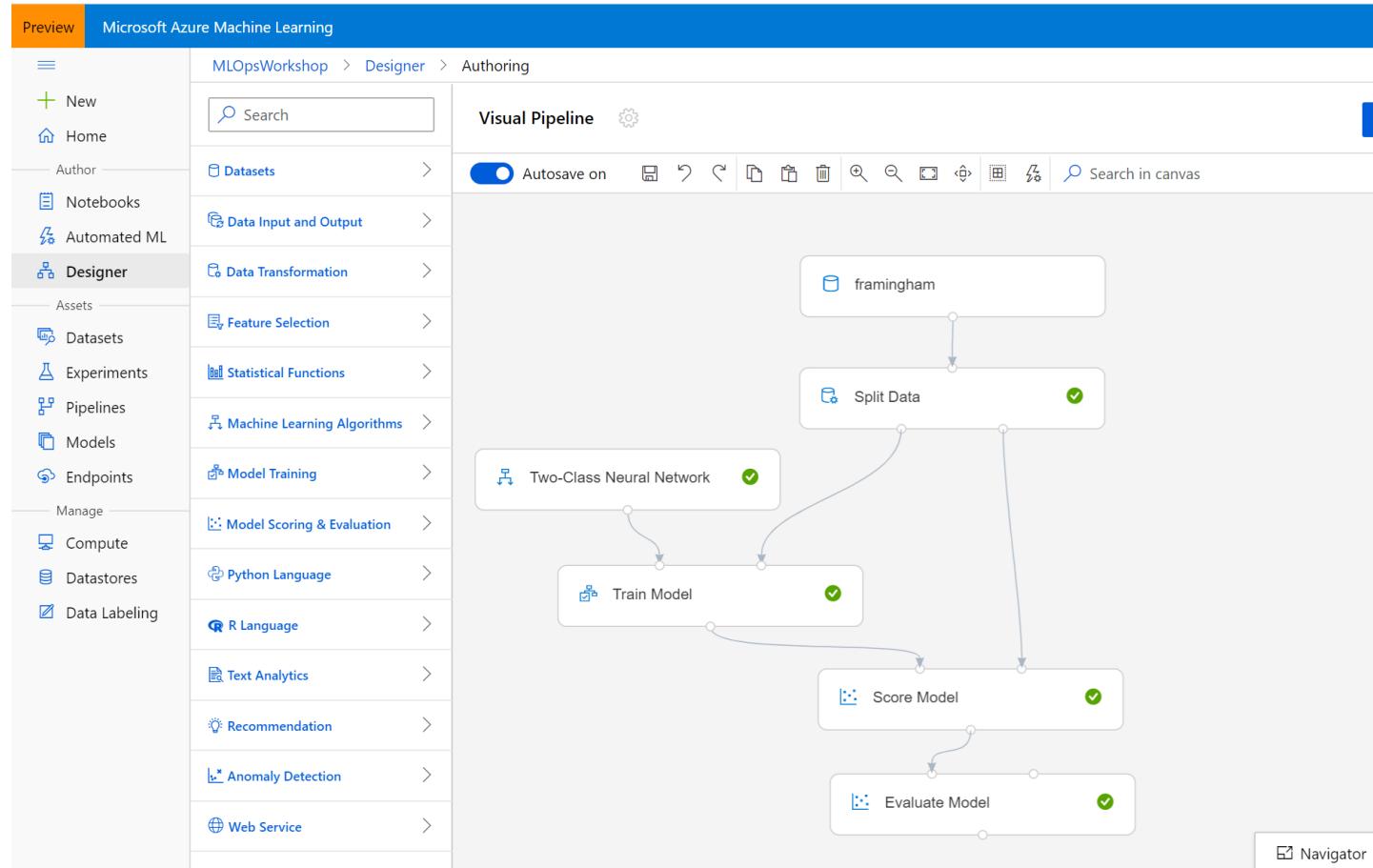
Chart type: Box Group by Predicted Y Top K Features: 8

Feature Importance

prevalentHyp_ModeCatImputer male_ModeCatImputer_LabelEncoder education_CharGramCountVectorizer currentSmoker_ModeCatImputer sysBP_MeanImputer age_CharGramCountVectorizer education_CharGramCountVectorizer age_CharGramCountVectorizer

Designer

Designer



Déploiement du modèle visual Interface

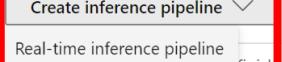
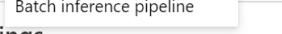
Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Designer > Authoring

Visual Pipeline 

Autosave on           

Search in canvas 

Submit     

Create inference pipeline 

Real-time inference pipeline 

Batch inference pipeline 

Settings

Default compute target 

chd-manual 

Pipeline parameters 

No parameters selected

Draft details

Draft name 

Draft description (optional) 

Created on March 16, 2020 2:42 PM

Created by Serge Retkowsky

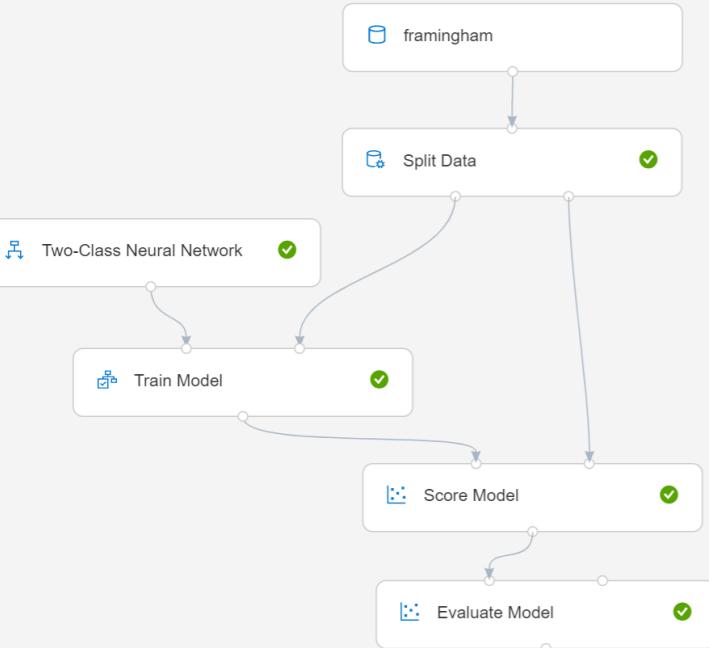
Last edit time March 16, 2020 2:45 PM

Last edited by Serge Retkowsky

Visual Pipeline

Pipeline created on 20200316

Navigator



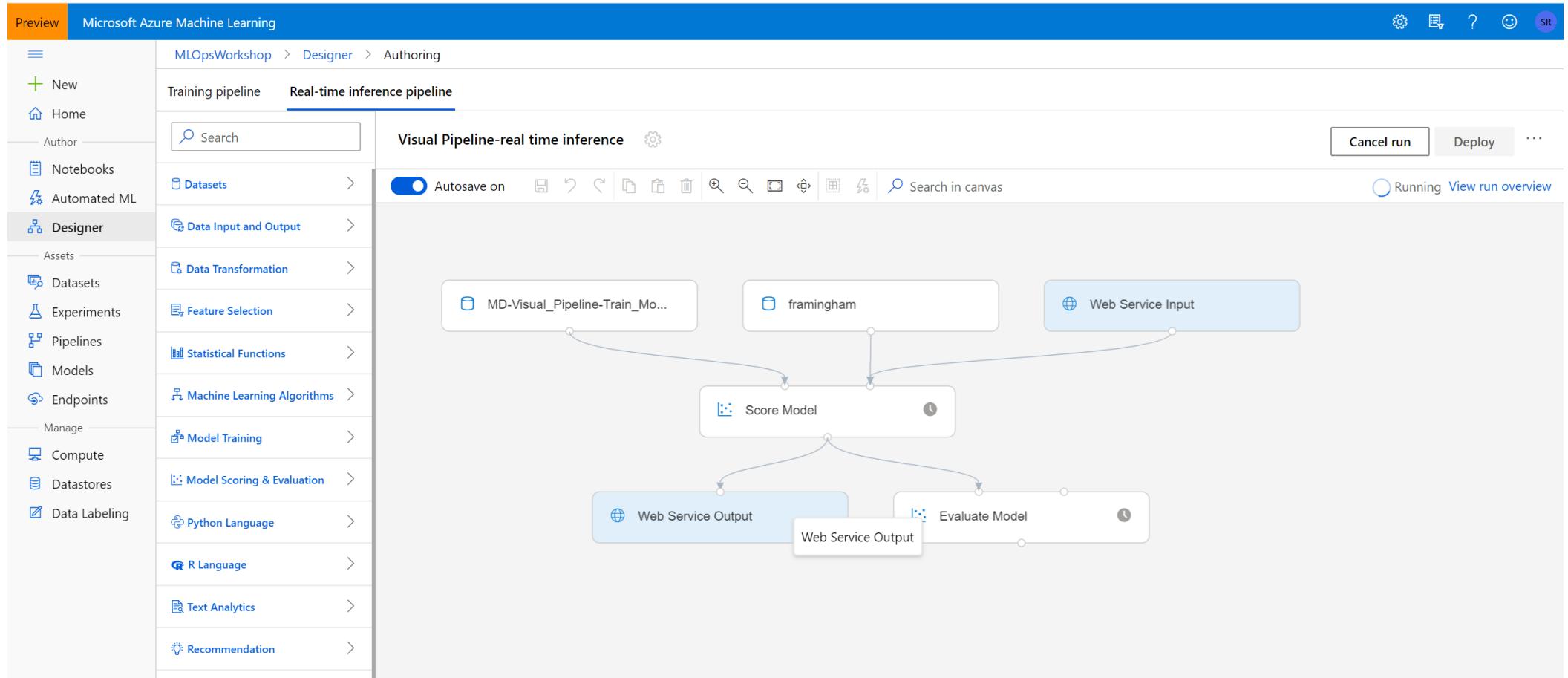
```

graph TD
    framingham[framingham] --> SplitData[Split Data]
    SplitData --> TwoClassNN[Two-Class Neural Network]
    TwoClassNN --> TrainModel[Train Model]
    TrainModel --> ScoreModel[Score Model]
    ScoreModel --> EvaluateModel[Evaluate Model]
  
```

Création pipeline Real Time



Azure Machine Learning



Création d'un nouveau AKS Inference cluster



Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Compute

Compute

Compute Instances Training clusters **Inference clusters** Attached compute

+ New ⏪ Refresh ⏷ Delete ⏷ Detach

Name	Type	Created/Attached	Provisioning state	Created on
aksvisual	Kubernetes Service	Created	Creating	Mar 16, 2020 2:50 PM

A screenshot of the Microsoft Azure Machine Learning interface. The top navigation bar shows 'Preview' and 'Microsoft Azure Machine Learning'. Below it, the 'Compute' section is selected. The 'Inference clusters' tab is active, indicated by a blue underline. A table lists an inference cluster named 'aksvisual', which is currently being provisioned ('Creating'). The entire row for this cluster is highlighted with a red box.

Déploiement du pipeline

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Designer > Authoring

Training pipeline Real-time inference pipeline

Visual Pipeline-real time inference

Search in canvas

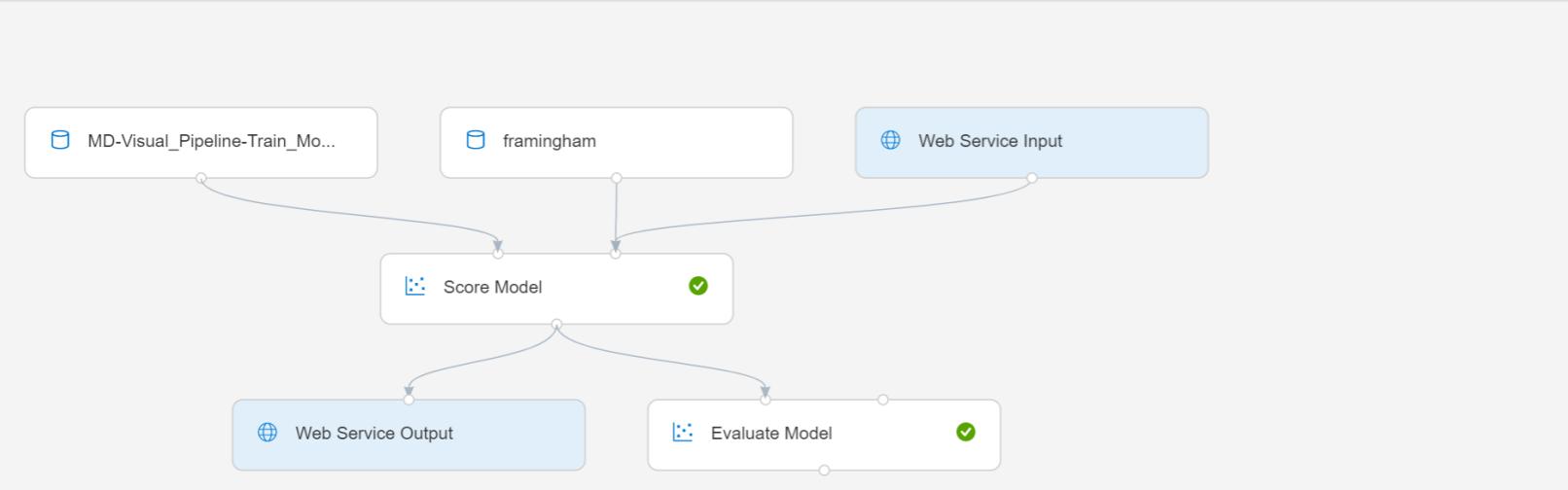
Submit Deploy ...

Run finished View run overview

MD-Visual_Pipeline-Train_Mo... framingham Web Service Input

Score Model

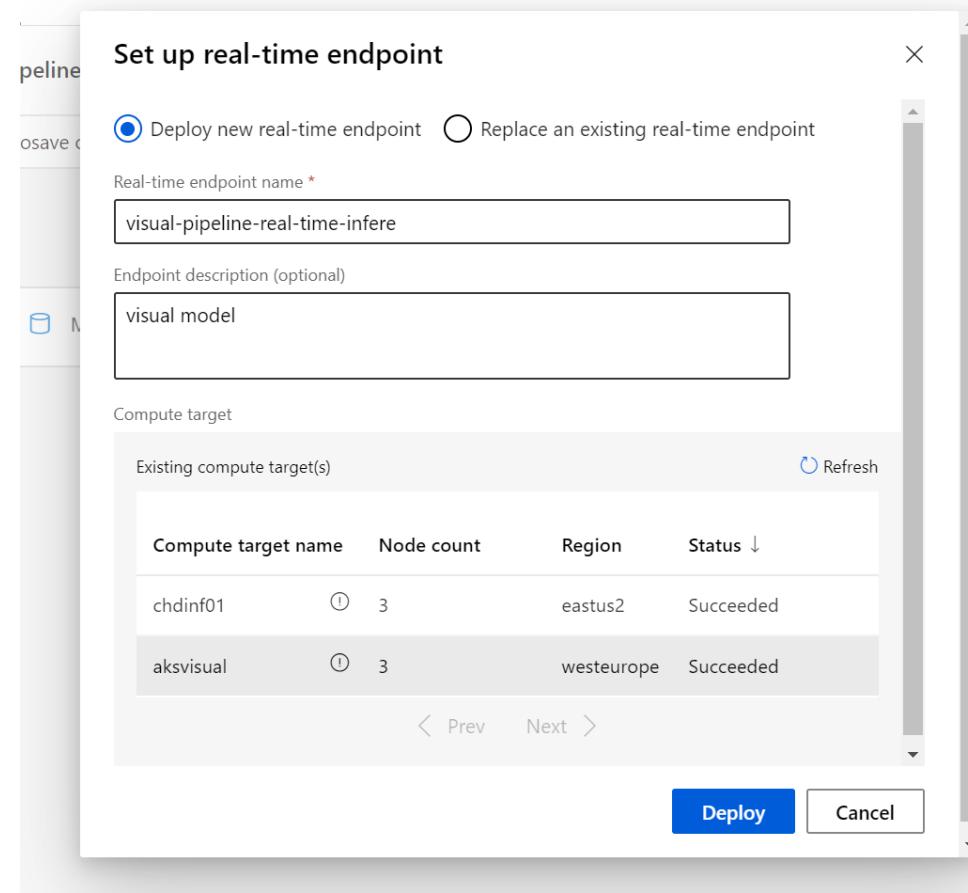
Web Service Output Evaluate Model



```

graph LR
    A[MD-Visual_Pipeline-Train_Mo...] --> C[Score Model]
    B[framingham] --> C
    D[Web Service Input] --> C
    C --> E[Web Service Output]
    C --> F[Evaluate Model]
  
```

Déploiement du pipeline



Déploiement du pipeline



Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Endpoints

Endpoints

Real-time endpoints Pipeline endpoints

Refresh Delete Search to filter items...

Name	Description	Created On	Created By	Updated On ↓	Compute Type	Compute Target
visual-pipeline-re...	visual model	March 16, 2020 3:16 PM	Serge Retkowsky	March 16, 2020 3:16 PM	AKS	aksvisual

Visualisation du modèle déployé

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Endpoints > visual-pipeline-real-time-infere

visual-pipeline-real-time-infere

Details	Test	Consume
Description visual model		Scoring timeout 60000 ms
Deployment state Healthy		CPU 0.1
Compute type AKS		Memory 0.5 GB
Service ID visual-pipeline-real-time-infere		Autoscale enabled true
Tags CreatedByAMLStudio: true		Min replicas 1
Created on 3/16/2020 3:16:42 PM		Max replicas 10
Last updated on 3/16/2020 3:16:46 PM		Target utilization 70%
Compute target aksvisual		Refresh period 1 s
REST endpoint http://52.233.226.122:80/api/v1/service/visual-pipeline-real-time-infere/		App Insights enabled true
score		Event Hubs enabled false
Key-based authentication enabled true		Storage enabled false
Token-based authentication enabled false		Region westeurope
Swagger URI http://52.233.226.122/api/v1/service/visual-pipeline-real-time-infere/swagger.json		Last edited by N/A
Related inference draft Related inference draft		Created by N/A

Visualisation du modèle déployé



Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Endpoints > visual-pipeline-real-time-infere

visual-pipeline-real-time-infere

Details Test Consume

Basic consumption info

REST endpoint
http://52.233.226.122:80/api/v1/service/visual-pipeline-real-time-infere/score

Using key Using token

Primary key
gJlx3sS8fJbmqghwdU5vT3b0OFBI1p7 [Regenerate](#)
Secondary key
lbwAbYXG5u1WyzqNzN9zcn5PBpxTh7WRc [Regenerate](#)

Consumption option

C# Python R

```
1 import urllib.request
2 import json
3 import os
4 import ssl
5
6 def allowSelfSignedHttps(allowed):
7     # bypass the server certificate verification on client side
8     if allowed and not os.environ.get('PYTHONHTTPSVERIFY', '') and getattr(ssl, '_create_unverified_context', None):
9         ssl._create_default_https_context = ssl._create_unverified_context
10
11 allowSelfSignedHttps(True) # this line is needed if you use self-signed certificate in your scoring service.
12
13 data = {
14     "Inputs": {
```

Workshop

Azure DevOps





Azure DevOps

Azure DevOps

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Azure Repos

Get unlimited, cloud-hosted private Git repos and collaborate to build better code with pull requests and advanced file management.

<https://azure.microsoft.com/en-us/services/devops/>



Azure DevOps

Azure DevOps



Azure Boards

Offrez de la valeur à vos utilisateurs plus rapidement en utilisant des outils agiles éprouvés pour planifier, suivre et commenter le travail entre équipes.

[En savoir plus >](#)



Azure Pipelines

Générez, testez et déployez avec une approche CI/CD qui fonctionne avec n'importe quel langage, plateforme et cloud. Connectez-vous à GitHub ou à tout autre fournisseur Git et déployez en continu.

[En savoir plus >](#)



Azure Repos

Bénéficiez de dépôts Git privés et illimités hébergés dans le cloud et collaborez pour créer un code de meilleure qualité avec les demandes de tirage et la gestion avancée des fichiers.

[En savoir plus >](#)



Azure Test Plans

Testez et livrez en toute confiance à l'aide d'outils de tests manuels et exploratoires.

[En savoir plus >](#)



Azure Artifacts

Créez, hébergez et partagez des packages avec votre équipe et ajoutez des artefacts à vos pipelines CI/CD en un seul clic.

[En savoir plus >](#)

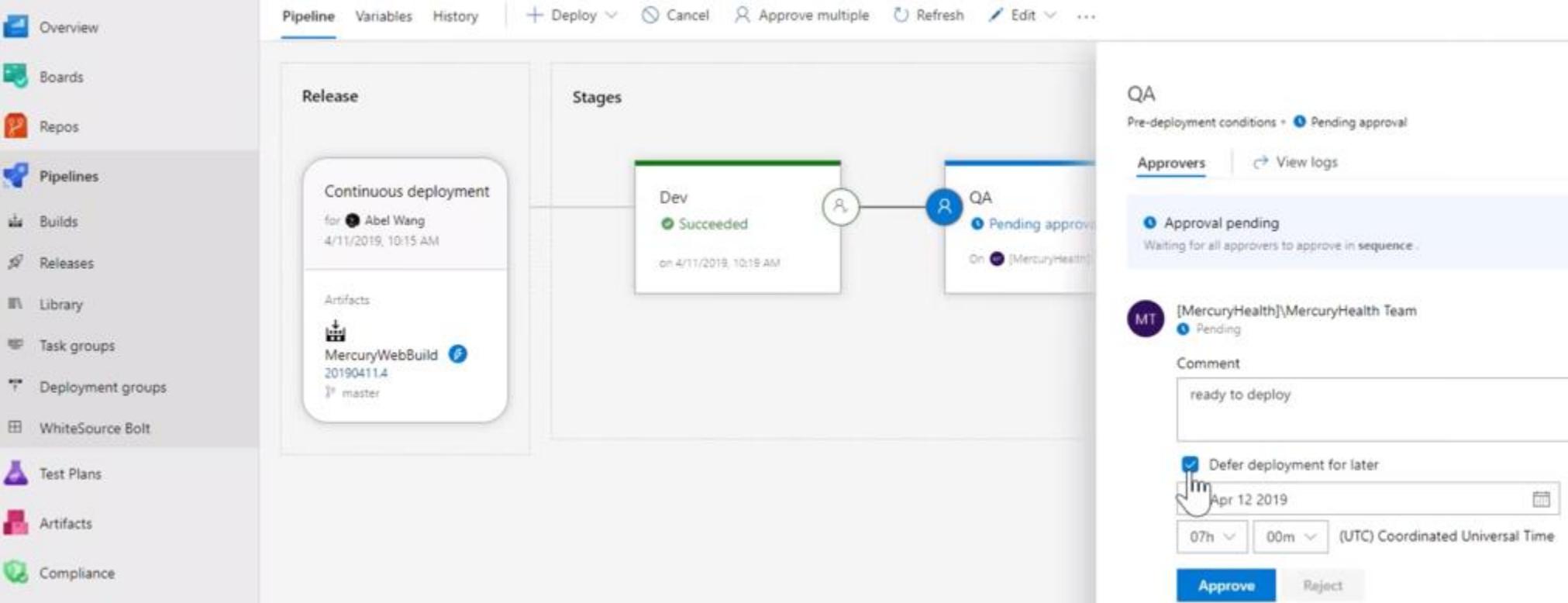
Place de marché des extensions

Accédez aux extensions proposées par Slack, SonarCloud et 1 000 autres applications et services, créés par la communauté.

[En savoir plus >](#)

<https://azure.microsoft.com/fr-fr/services/devops/#DevOps>

Exemple de Pipeline Azure DevOps



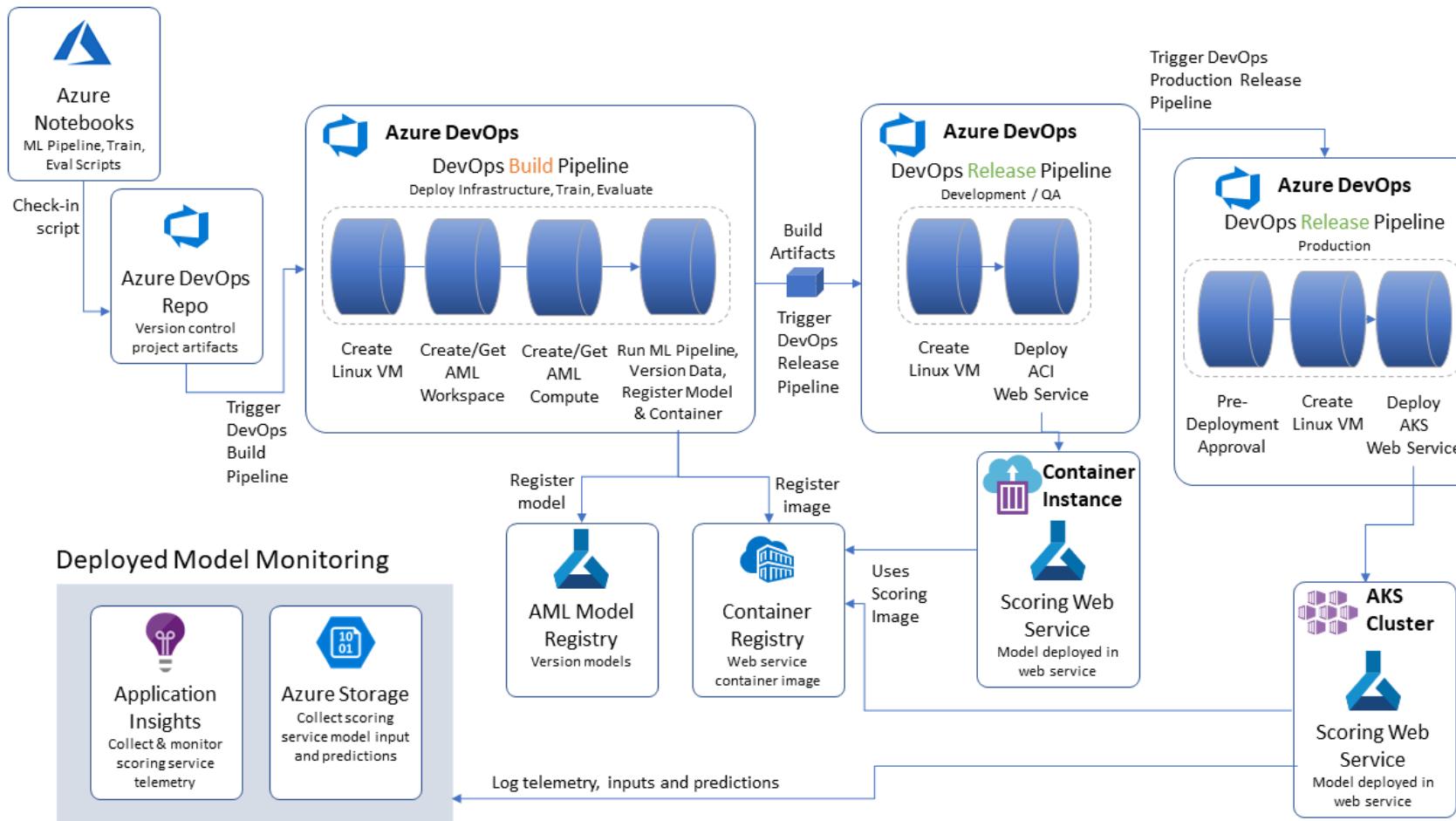
The screenshot shows the Azure DevOps Pipeline interface. On the left, the sidebar includes options like Overview, Boards, Repos, Pipelines (selected), Builds, Releases, Library, Task groups, Deployment groups, WhiteSource Bolt, Test Plans, Artifacts, and Compliance.

The main area displays a Release pipeline titled "Continuous deployment" for user "Abel Wang" on 4/11/2019, 10:15 AM. The pipeline consists of two stages: "Dev" and "QA".

- Dev Stage:** Status is "Succeeded". It was triggered on 4/11/2019, 10:18 AM. Artifacts listed are "MercuryWebBuild 20190411.4" from the "master" branch.
- QA Stage:** Status is "Pending approval". It is assigned to "[MercuryHealth]\MercuryHealth Team" (user MT). A comment "ready to deploy" is present.

On the right, the "Approver" section shows "Approval pending" with the message "Waiting for all approvers to approve in sequence". Buttons for "Approve" and "Reject" are available at the bottom.

Architecture MLOps avec Azure DevOps





Azure DevOps

Forrester has Microsoft among leaders (behind Electric Cloud, IBM, Xebia, and CA) in its 2018 Continuous Delivery And Release Automation market assessment



MLOps

Azure DevOps seretkov / Projet MLOps / Overview / Summary

Search

Proj MLOps +

Overview

Summary

Dashboards

Analytics views*

Wiki

Boards

Repos

Pipelines

Test Plans

Artifacts

Compliance

Proj MLOps

About this project

MLOps Workshop

Languages

Jupyter Notebook Python

Proj MLOps / README.md

WorkshopMLOps

Workshop MLOps Azure

Azure ML Service: <https://azure.microsoft.com/en-us/services/machine-learning-service/>

MLOps: <https://docs.microsoft.com/fr-fr/azure/machine-learning/concept-model-management-and-deployment>

Serge Retkowsky | serge.retkowsky@microsoft.com | <https://www.linkedin.com/in/serger/>

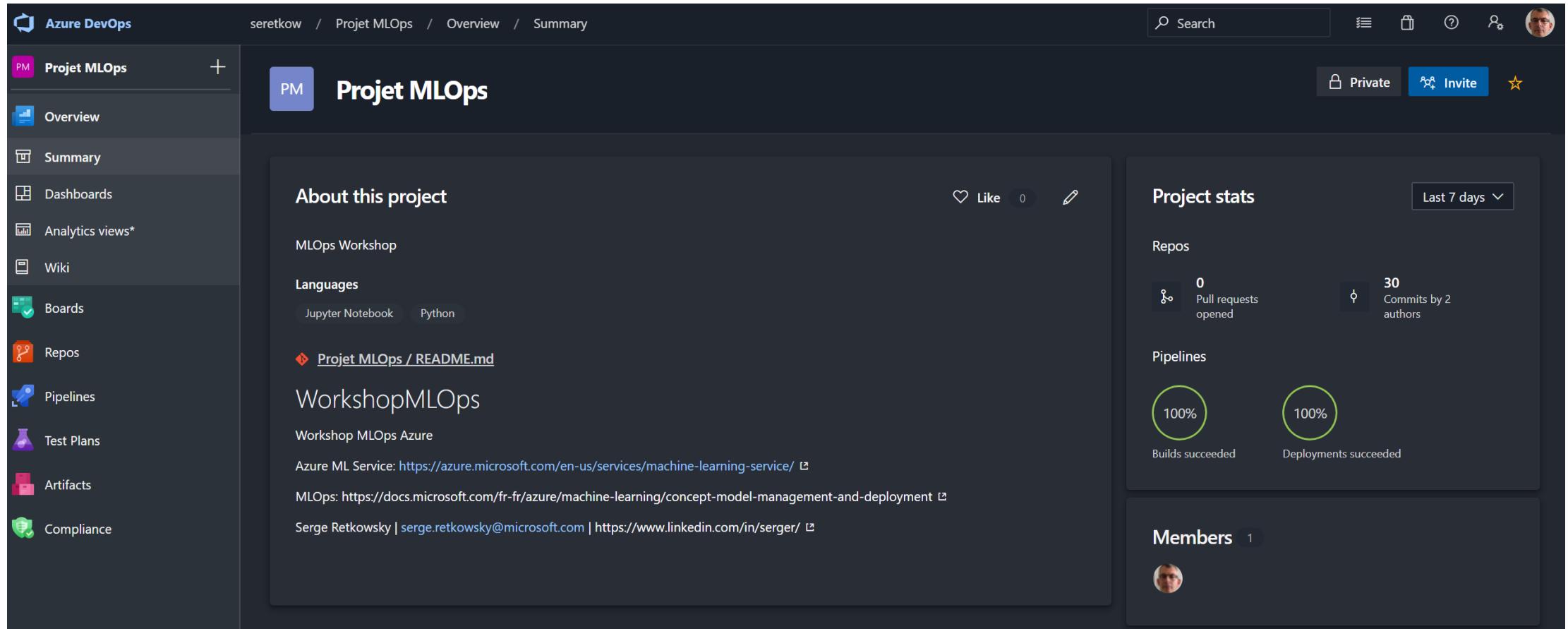
Like 0

Project stats Last 7 days

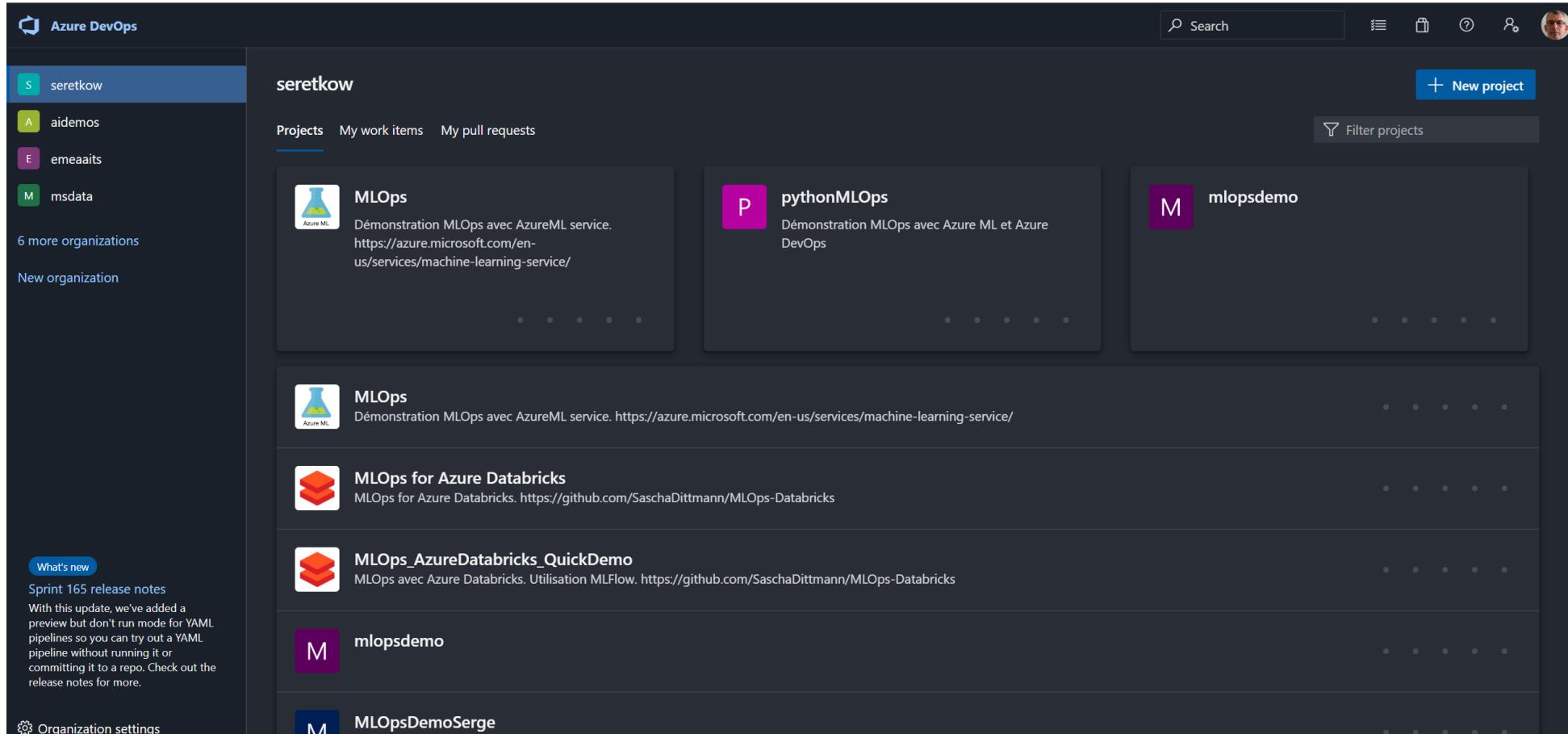
Repos 0 Pull requests opened 30 Commits by 2 authors

Pipelines 100% Builds succeeded 100% Deployments succeeded

Members 1



Azure DevOps

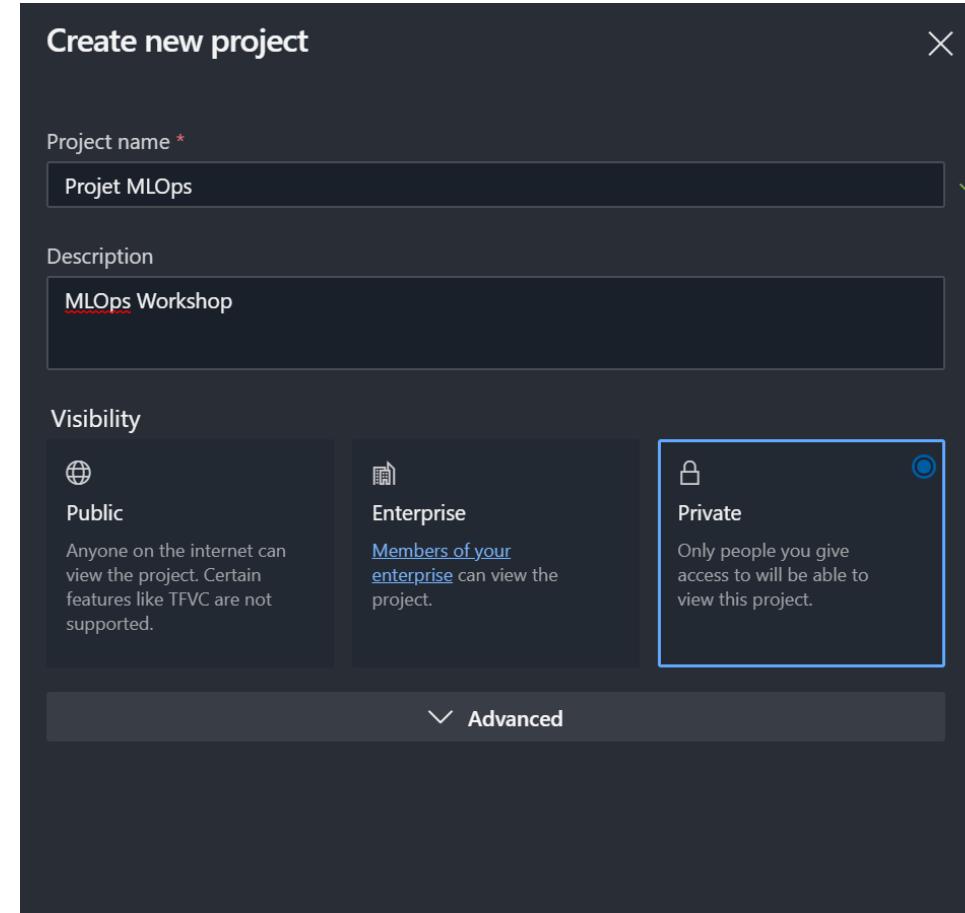


The screenshot shows the Azure DevOps organization dashboard for 'seretkow'. On the left sidebar, there are links for 'seretkow', 'aidemos', 'emeaait', 'msdata', '6 more organizations', and 'New organization'. A 'What's new' section highlights 'Sprint 165 release notes' with a preview for YAML pipelines. At the top right, there are buttons for 'Search', 'New project', and 'Filter projects'. The main area displays several projects:

- MLOps**: Démonstration MLOps avec AzureML service. <https://azure.microsoft.com/en-us/services/machine-learning-service/>
- pythonMLOps**: Démonstration MLOps avec Azure ML et Azure DevOps
- mlopsdemo**
- MLOps**: Démonstration MLOps avec AzureML service. <https://azure.microsoft.com/en-us/services/machine-learning-service/>
- MLOps for Azure Databricks**: MLOps for Azure Databricks. <https://github.com/SaschaDittmann/MLOps-Databricks>
- MLOps_AzureDatabricks_QuickDemo**: MLOps avec Azure Databricks. Utilisation MLFlow. <https://github.com/SaschaDittmann/MLOps-Databricks>
- mlopsdemo**
- MLOpsDemoSerge**

<https://dev.azure.com>

Création d'un projet Azure DevOps





Azure DevOps

Projet

Azure DevOps seretkov / Projet MLOps / Overview / Summary

Search ⋮ ≡ 🔗 ? ✖ Profile

🔒 Private 🔗 Invite ⭐

Projet MLOps

Project stats

No stats are available at this moment
Setup a service to see project activity.

Welcome to the project!

What service would you like to start with?

Boards Repos Pipelines Test Plans Artifacts

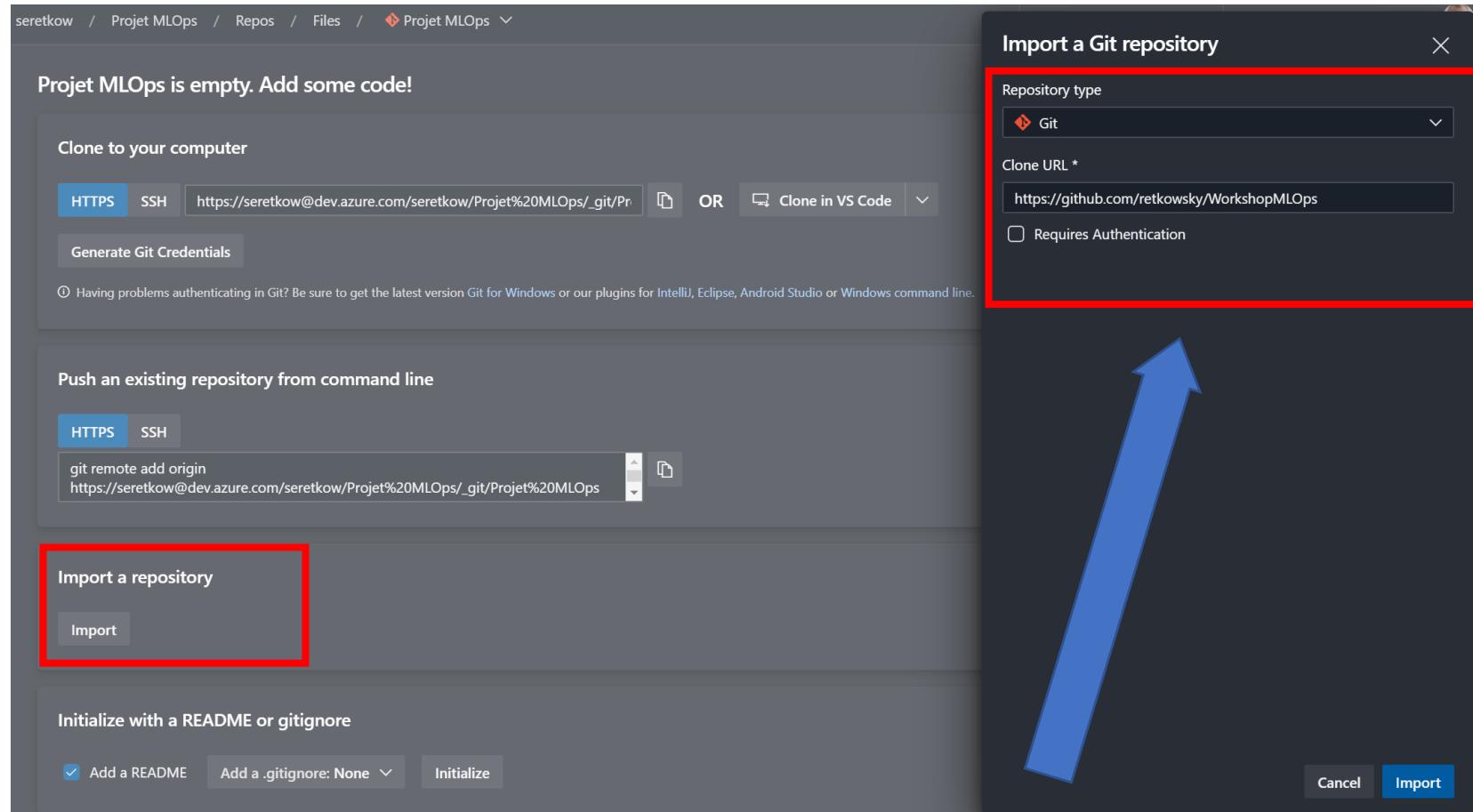
or manage your services

Members 1

Profile

Project settings ⟨⟨

Importation repo Git



The screenshot shows the Azure DevOps interface for importing a Git repository. A red box highlights the 'Import a Git repository' dialog, which contains fields for 'Repository type' (set to 'Git'), 'Clone URL' (set to <https://github.com/retkowsky/WorkshopMLOps>), and 'Requires Authentication' (unchecked). A large blue arrow points from the 'Clone URL' field in the dialog to the corresponding URL field in the 'Clone to your computer' section of the main page. Another red box highlights the 'Import a repository' button in the 'Clone to your computer' section.

seretkow / Projet MLOps / Repos / Files / Projet MLOps

Projet MLOps is empty. Add some code!

Clone to your computer

HTTPS SSH https://seretkow@dev.azure.com/seretkow/Projet%20MLOps/_git/Projet%20MLOps OR Clone in VS Code

Generate Git Credentials

Having problems authenticating in Git? Be sure to get the latest version Git for Windows or our plugins for IntelliJ, Eclipse, Android Studio or Windows command line.

Push an existing repository from command line

HTTPS SSH

```
git remote add origin https://seretkow@dev.azure.com/seretkow/Projet%20MLOps/_git/Projet%20MLOps
```

Import a repository

Import

Initialize with a README or .gitignore

Add a README Add a .gitignore: None Initialize

Import a Git repository

Repository type: Git

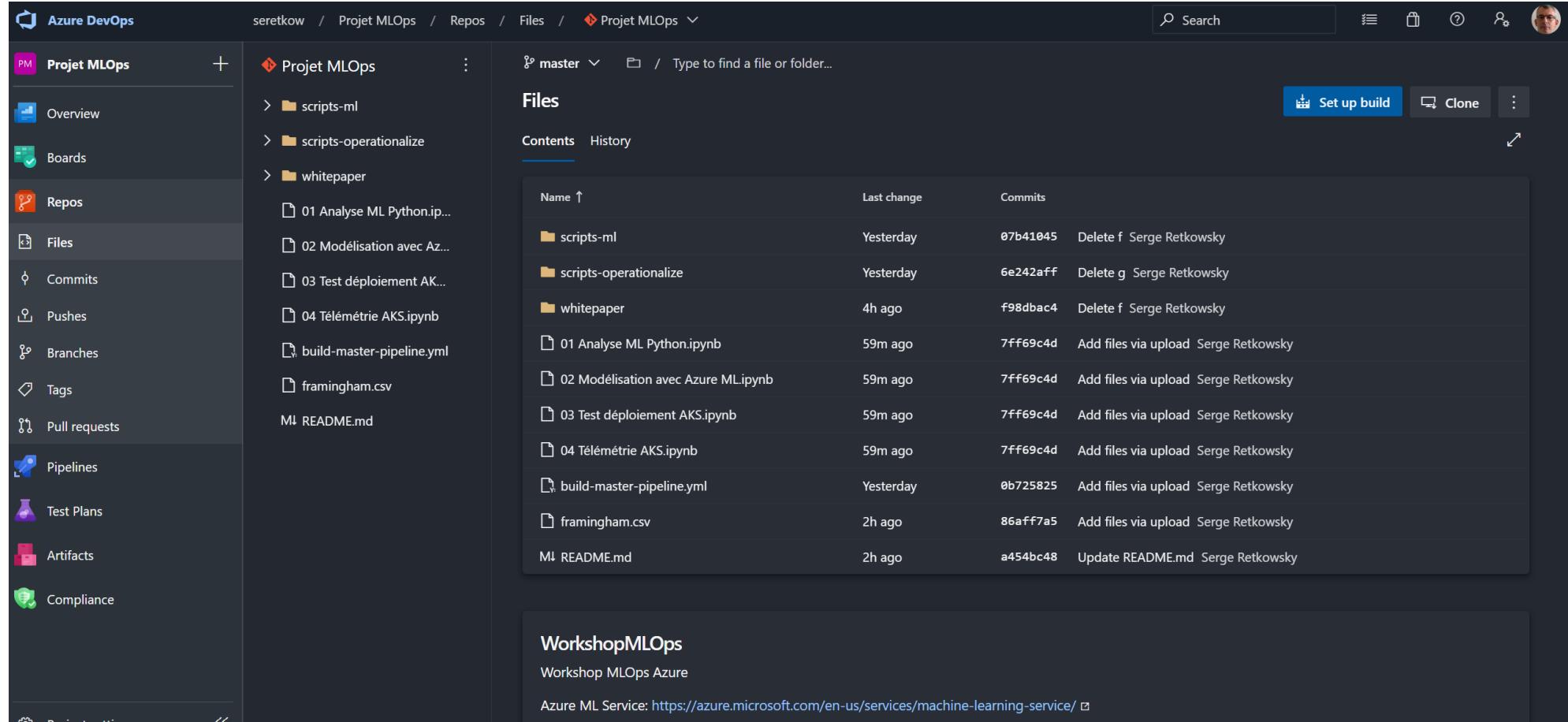
Clone URL: <https://github.com/retkowsky/WorkshopMLOps>

Requires Authentication

Cancel Import

<https://github.com/retkowsky/WorkshopMLOps>

Résultats de l'importation



The screenshot shows the Azure DevOps interface for a repository named "Projet MLOps". The left sidebar is visible with various project management and CI/CD options. The main area displays the repository structure under the "master" branch. The "Files" section lists the following contents:

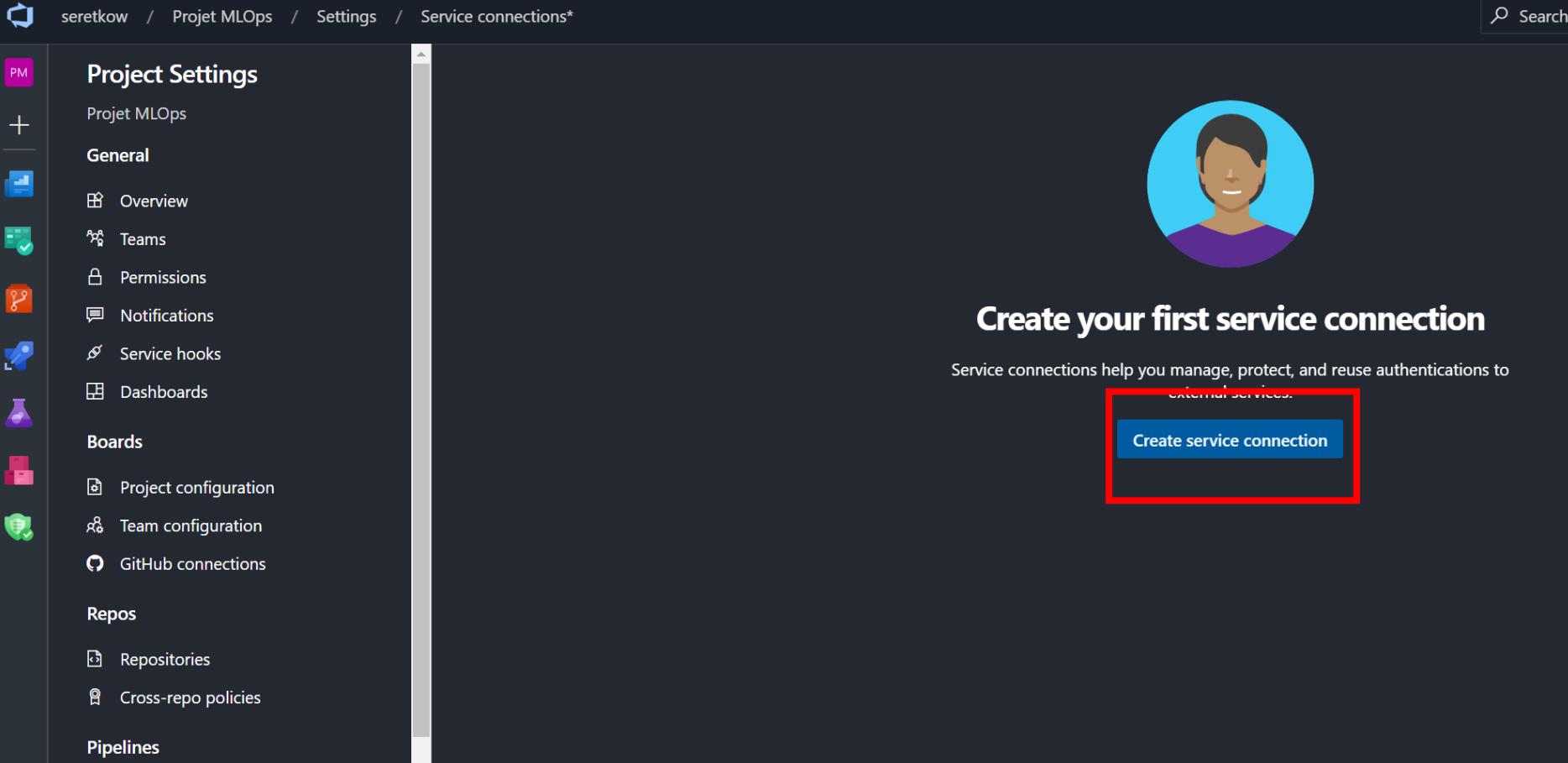
- scripts-ml
- scripts-operationalize
- whitepaper
 - 01 Analyse ML Python.ipynb
 - 02 Modélisation avec Az...
 - 03 Test déploiement AKS.ipynb
 - 04 Télémétrie AKS.ipynb
 - build-master-pipeline.yml
 - framingham.csv
- M README.md

Below the file list, a table shows the commit history for each file:

Name	Last change	Commits
scripts-ml	Yesterday	07b41045 Delete f Serge Retkowsky
scripts-operationalize	Yesterday	6e242aff Delete g Serge Retkowsky
whitepaper	4h ago	f98dbac4 Delete f Serge Retkowsky
01 Analyse ML Python.ipynb	59m ago	7ff69c4d Add files via upload Serge Retkowsky
02 Modélisation avec Azure ML.ipynb	59m ago	7ff69c4d Add files via upload Serge Retkowsky
03 Test déploiement AKS.ipynb	59m ago	7ff69c4d Add files via upload Serge Retkowsky
04 Télémétrie AKS.ipynb	59m ago	7ff69c4d Add files via upload Serge Retkowsky
build-master-pipeline.yml	Yesterday	0b725825 Add files via upload Serge Retkowsky
framingham.csv	2h ago	86aff7a5 Add files via upload Serge Retkowsky
M README.md	2h ago	a454bc48 Update README.md Serge Retkowsky

At the bottom of the interface, there is a footer with the text "WorkshopMLOps" and "Workshop MLOps Azure". It also includes a link to "Azure ML Service: <https://azure.microsoft.com/en-us/services/machine-learning-service/>".

Création d'un service connection



The screenshot shows the 'Service connections*' page in the Azure DevOps settings for the 'Projet MLOps' project. The left sidebar lists various project settings like General, Boards, and Repos. The main area features a user icon and the heading 'Create your first service connection'. A call-to-action button labeled 'Create service connection' is highlighted with a red box.

seretkov / Projet MLOps / Settings / Service connections*

Project Settings

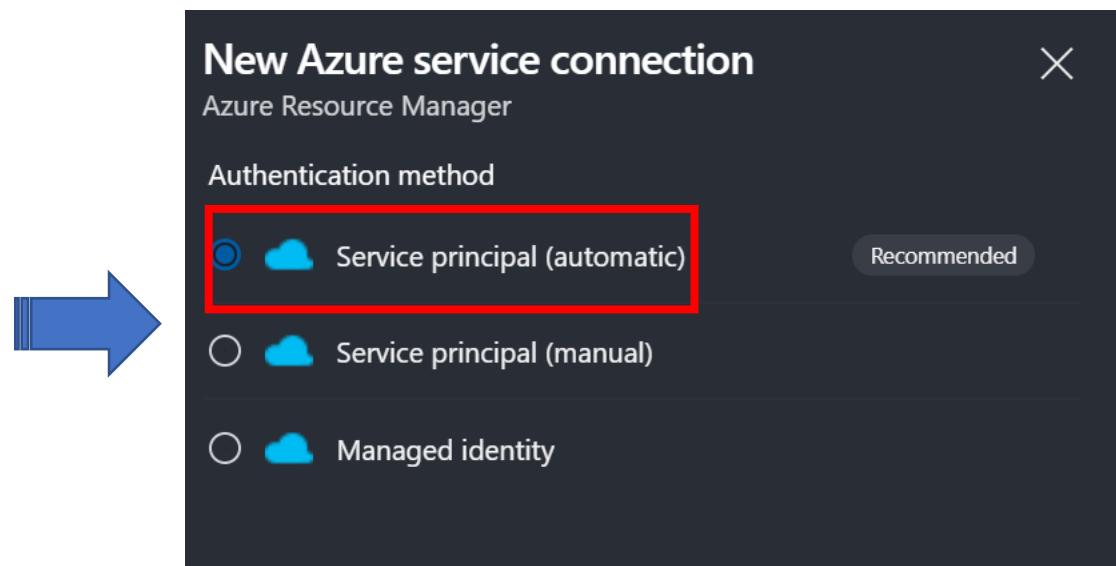
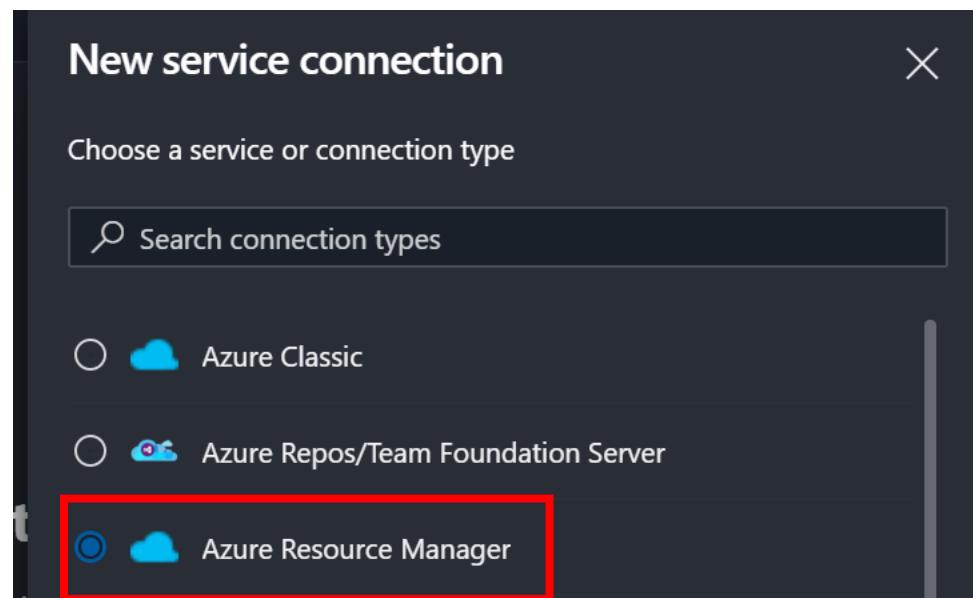
- General
 - Overview
 - Teams
 - Permissions
 - Notifications
 - Service hooks
 - Dashboards
- Boards
 - Project configuration
 - Team configuration
 - GitHub connections
- Repos
 - Repositories
 - Cross-repo policies
- Pipelines

Create your first service connection

Service connections help you manage, protect, and reuse authentications to external services.

Create service connection

Création d'un service connection





Azure DevOps

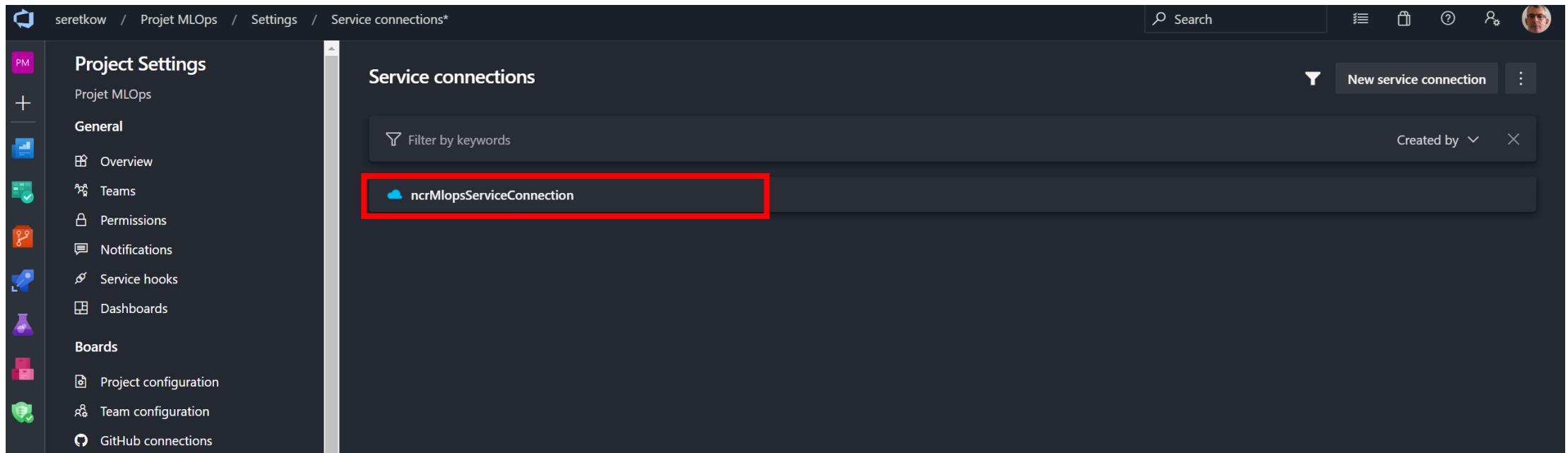
Création d'un service connection

The screenshot shows the Azure DevOps interface for creating a service connection. On the left, there's a dark sidebar with a user icon and a 'Create your first service connect' section. A blue button labeled 'Create service connection' is visible. On the right, a modal window titled 'New Azure service connection' is open, with a red border around its content area. The modal has the following fields:

- Scope level:** Machine Learning Workspace (radio button selected)
- Subscription:** Microsoft Azure Internal Consumption (70b8f39e-8863-49f7-b...)
- Resource group:** MLOpsWorkshopRG
- Machine Learning Workspace:** MLOpsWorkshop
- Details:**
 - Service connection name:** ncrMlopsServiceConnection
 - Description (optional):** Connexion
- Security:** Grant access permission to all pipelines (checkbox checked)

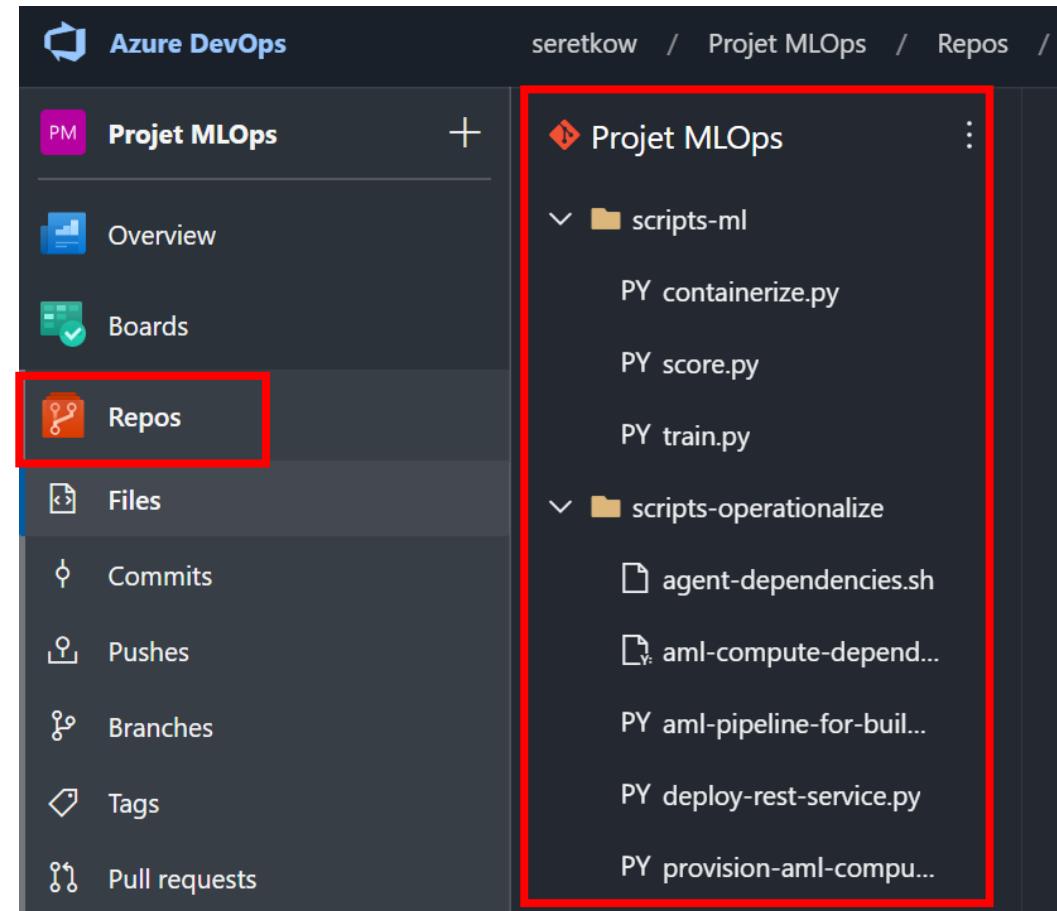
At the bottom of the modal, there are 'Learn more', 'Back', and 'Save' buttons.

Service connection créé



The screenshot shows the 'Service connections' page in the Azure DevOps interface. The left sidebar displays 'Project Settings' for 'Projet MLOps', including sections for General, Boards, and GitHub connections. The main area is titled 'Service connections' and contains a single item: 'ncrMlopsServiceConnection'. This item is highlighted with a red rectangular box. The page includes a search bar at the top right and a 'New service connection' button.

Visualisation des fichiers et scripts



Détails des fichiers et scripts

build-master-pipeline.yml (Build pipeline YAML)

- This is a script authored by the DevOps engineer typically
- It describes trigger for the pipeline, variables and pipeline steps in the order to be executed - it calls additional scripts to be executed.

2. train.py (Model training script)

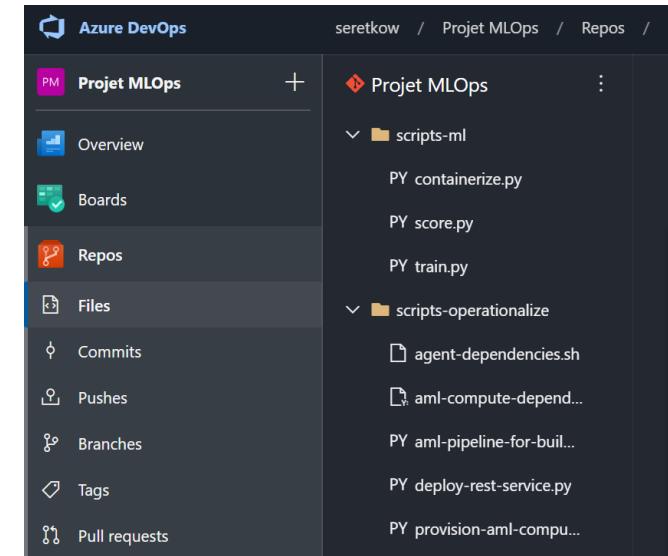
- This script is authored by the data scientist
- It trains the model and checks it into the AML model registry.
- It is called in the build pipeline

3. containerize.py (Container image creation script)

- This script is authored by the data scientist
- It creates a docker container with dependencies and model packed in and checks it into the AML container registry
- It is called in the build pipeline

4. score.py (REST API based scoring script)

- This script is authored by the data scientist
- It processes a scoring request by calling the REST service and returns a prediction
- It is deployed in the release pipeline



Détails des fichiers et scripts

5. agent-dependencies.sh

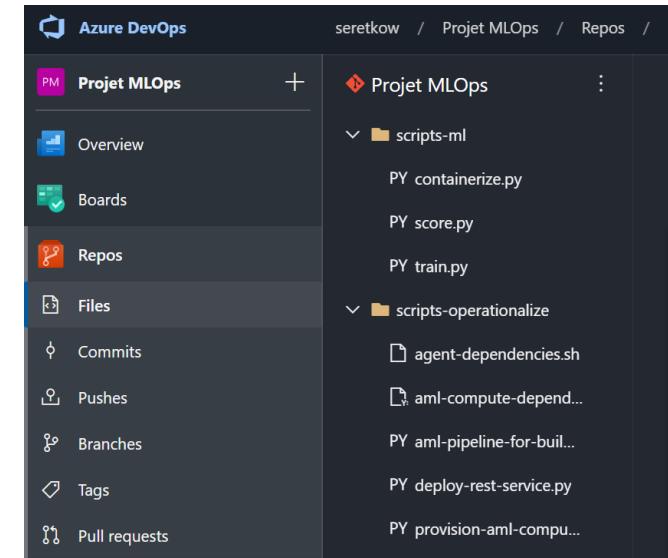
- This script is authored by the devops engineer in consultation with the data scientist
- It installs software dependencies for MLOps on the agents
- It is leveraged in the build and release pipelines

6. aml-compute-dependencies.yml

- This script is authored by the devops engineer in consultation with the data scientist
- It installs software dependencies for MLOps on training compute instances
- It is leveraged in the build pipeline

7. aml-pipeline-for-build.py

- This script is authored by the devops engineer in consultation with the data scientist
- It creates an AML pipeline with stages in it and executes it
- It is leveraged in the build pipeline



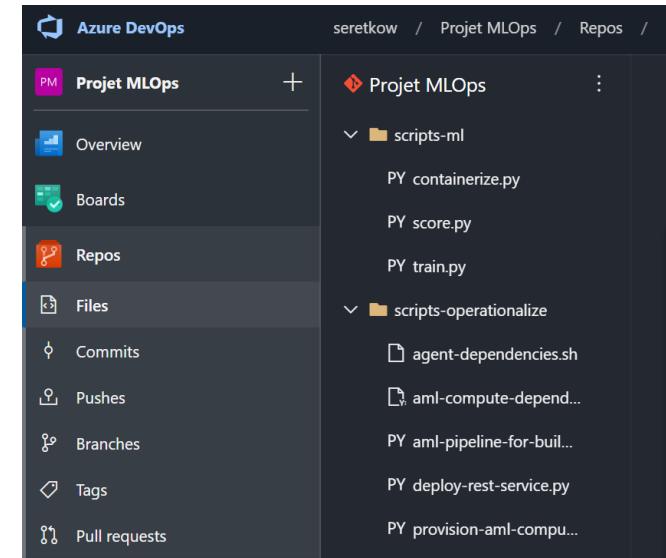
Détails des fichiers et scripts

8. provision-aml-compute.py

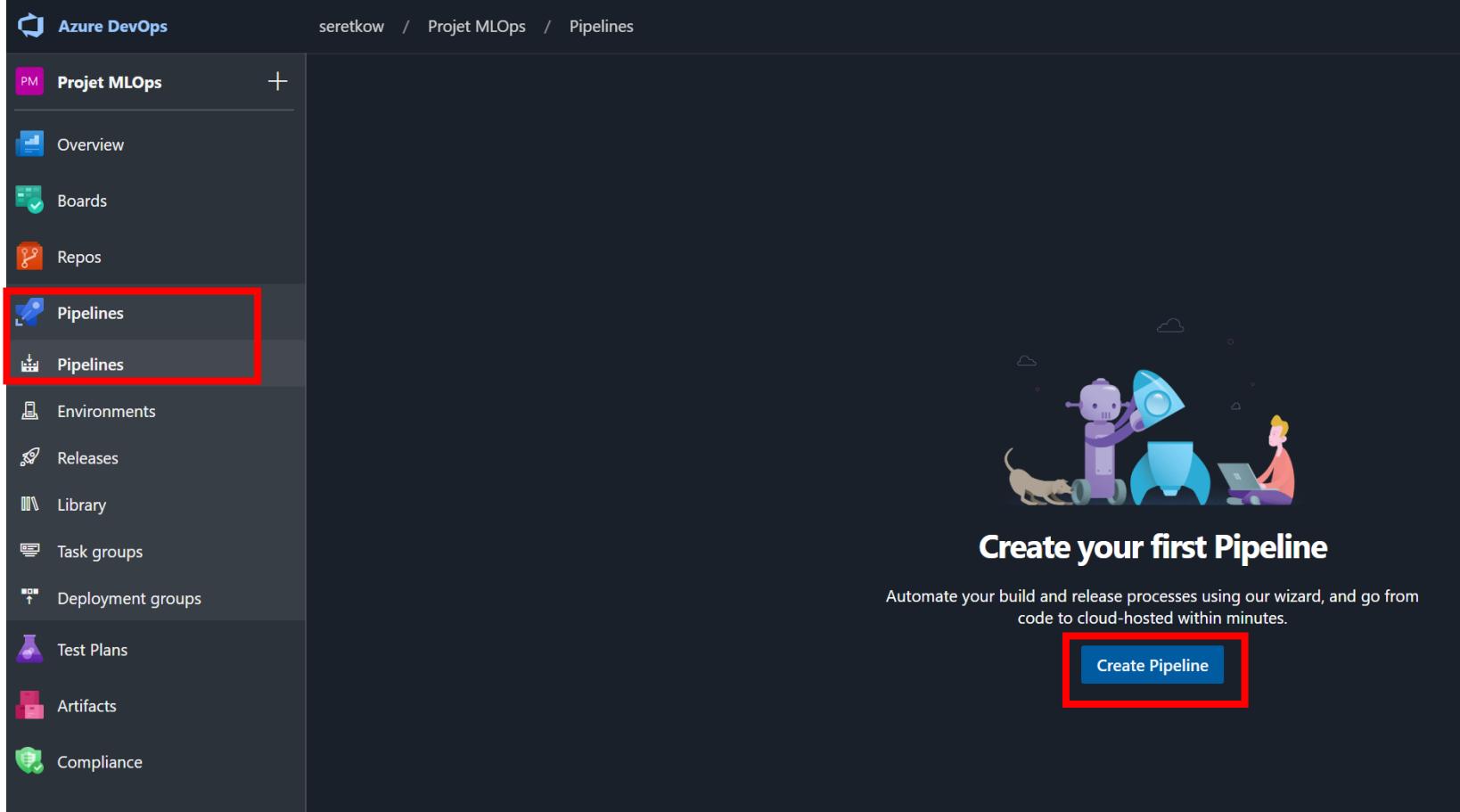
- This script is authored by the devops engineer in consultation with the data scientist
- It provisions transient AML compute for model training
- It is leveraged in the build pipeline

9. deploy-rest-service.py

- This script is authored by the devops engineer in consultation with the data scientist
- It provisions an AKS cluster and a REST service on the same leveraging the container image and scoring file
- It is leveraged in the release pipeline

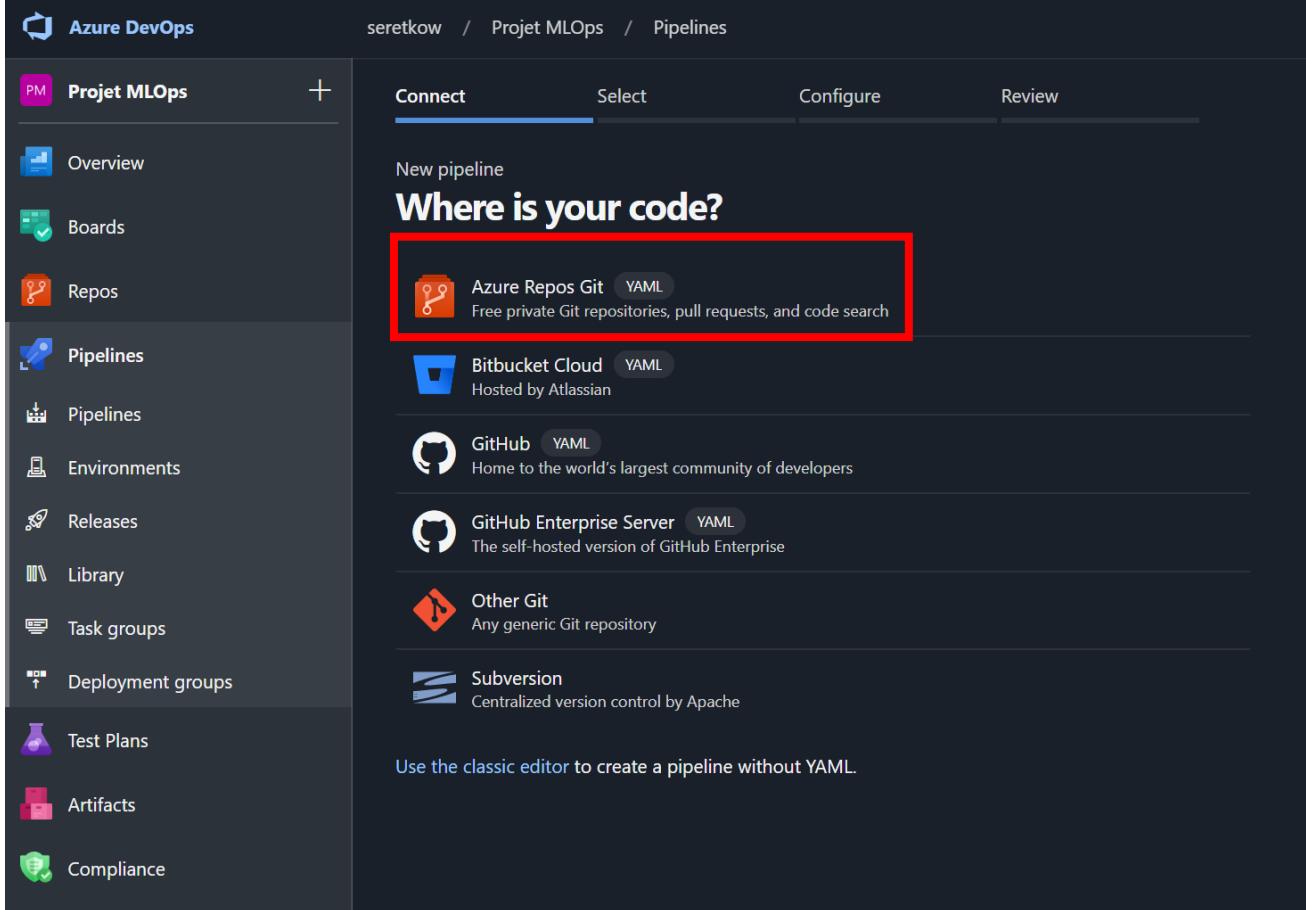


Création d'un Pipeline



The screenshot shows the Azure DevOps interface for creating a pipeline. The left sidebar lists project navigation items: Overview, Boards, Repos, Pipelines (highlighted with a red box), Environments, Releases, Library, Task groups, Deployment groups, Test Plans, Artifacts, and Compliance. The main content area displays a "Create your first Pipeline" wizard with a central illustration of a person interacting with a robot and a laptop. Below the illustration, the text reads: "Create your first Pipeline" and "Automate your build and release processes using our wizard, and go from code to cloud-hosted within minutes." A prominent blue "Create Pipeline" button is at the bottom right of the wizard area, also highlighted with a red box.

Sélectionner Azure Repos Git

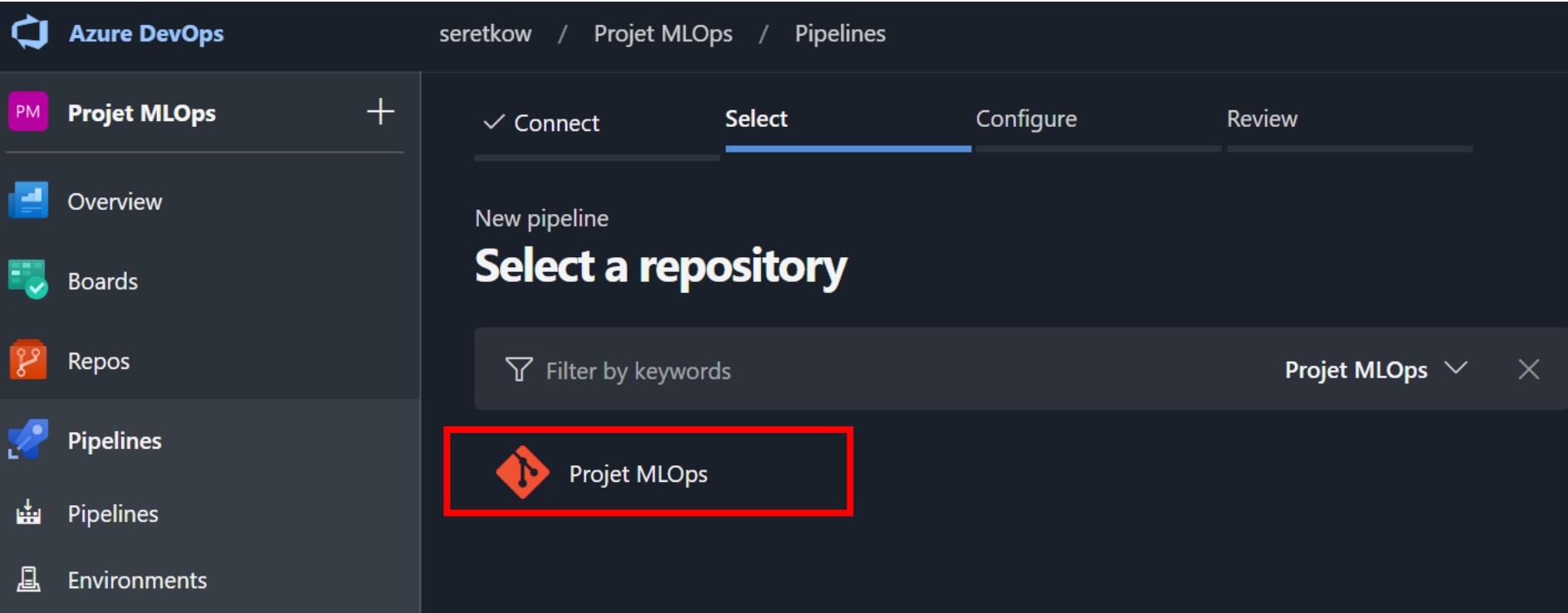


The screenshot shows the Azure DevOps interface for creating a new pipeline. The left sidebar lists various project management and development tools. The main area is titled 'New pipeline' and features a prominent heading 'Where is your code?'. Below this, a list of integration options is displayed:

- Azure Repos Git** (YAML) - Free private Git repositories, pull requests, and code search. This item is highlighted with a red box.
- Bitbucket Cloud (YAML) - Hosted by Atlassian
- GitHub (YAML) - Home to the world's largest community of developers
- GitHub Enterprise Server (YAML) - The self-hosted version of GitHub Enterprise
- Other Git - Any generic Git repository
- Subversion - Centralized version control by Apache

At the bottom of the list, there is a note: 'Use the classic editor to create a pipeline without YAML.'

Sélectionner le repo



The screenshot shows the Azure DevOps interface for creating a new pipeline. The top navigation bar includes the Azure DevOps logo, the organization name 'seretkov', the project 'Projet MLOps', and the current page 'Pipelines'. Below this, a progress bar indicates the steps: 'Connect' (with a checkmark), 'Select' (which is highlighted in blue), 'Configure', and 'Review'. The main area is titled 'New pipeline' and features the heading 'Select a repository'. A search bar at the bottom has the text 'Projet MLOps' and a clear button 'X'. A red rectangular box highlights the repository 'Projet MLOps' in the list below.

- Overview
- Boards
- Repos
- Pipelines
- Pipelines
- Environments

New pipeline

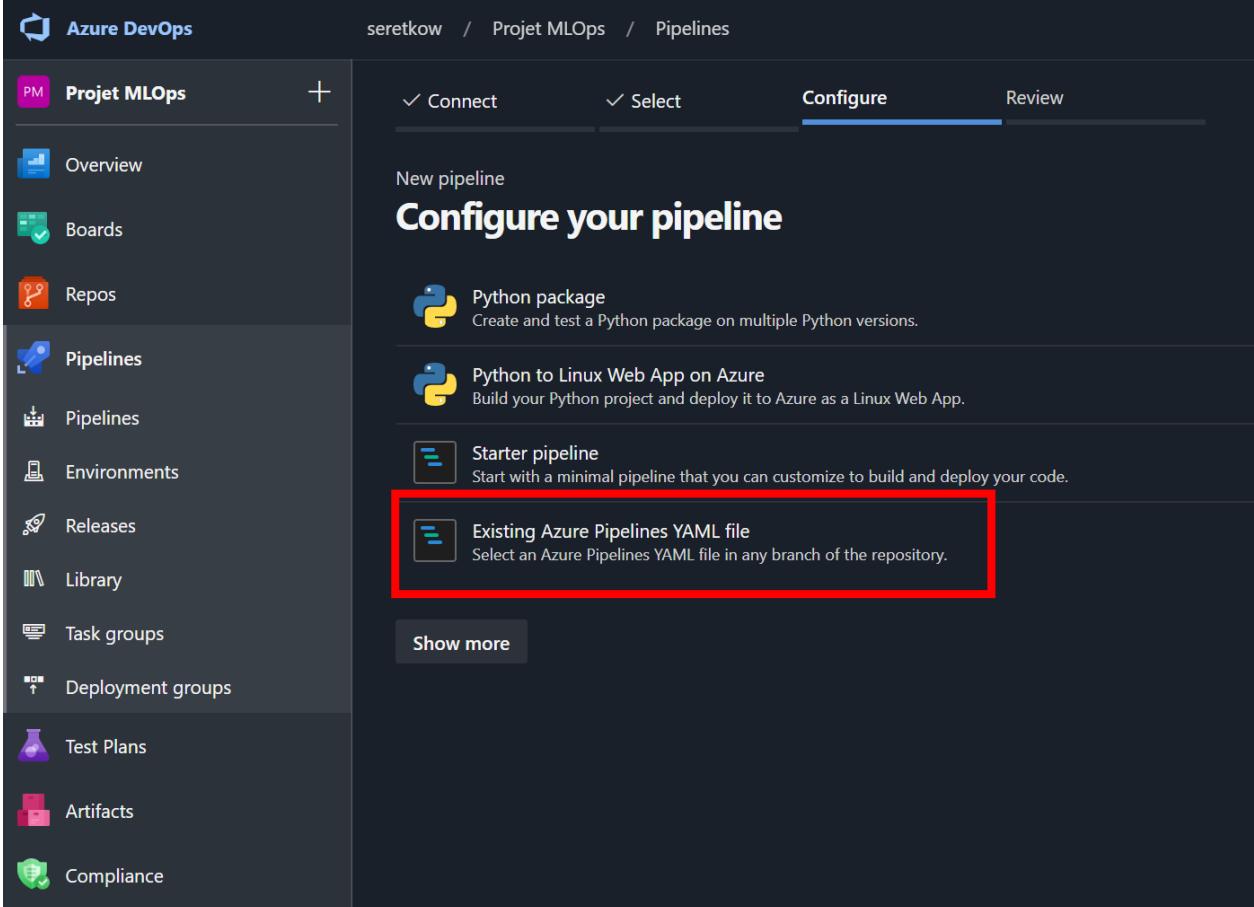
Select a repository

Filter by keywords

Projet MLOps

Projet MLOps

Configuration du Pipeline



The screenshot shows the Azure DevOps interface for configuring a new pipeline. The left sidebar lists various project management and CI/CD options. The main area is titled "Configure your pipeline" and displays several pipeline creation options. One option, "Existing Azure Pipelines YAML file", is highlighted with a red box, indicating it's the selected or recommended path for configuration.

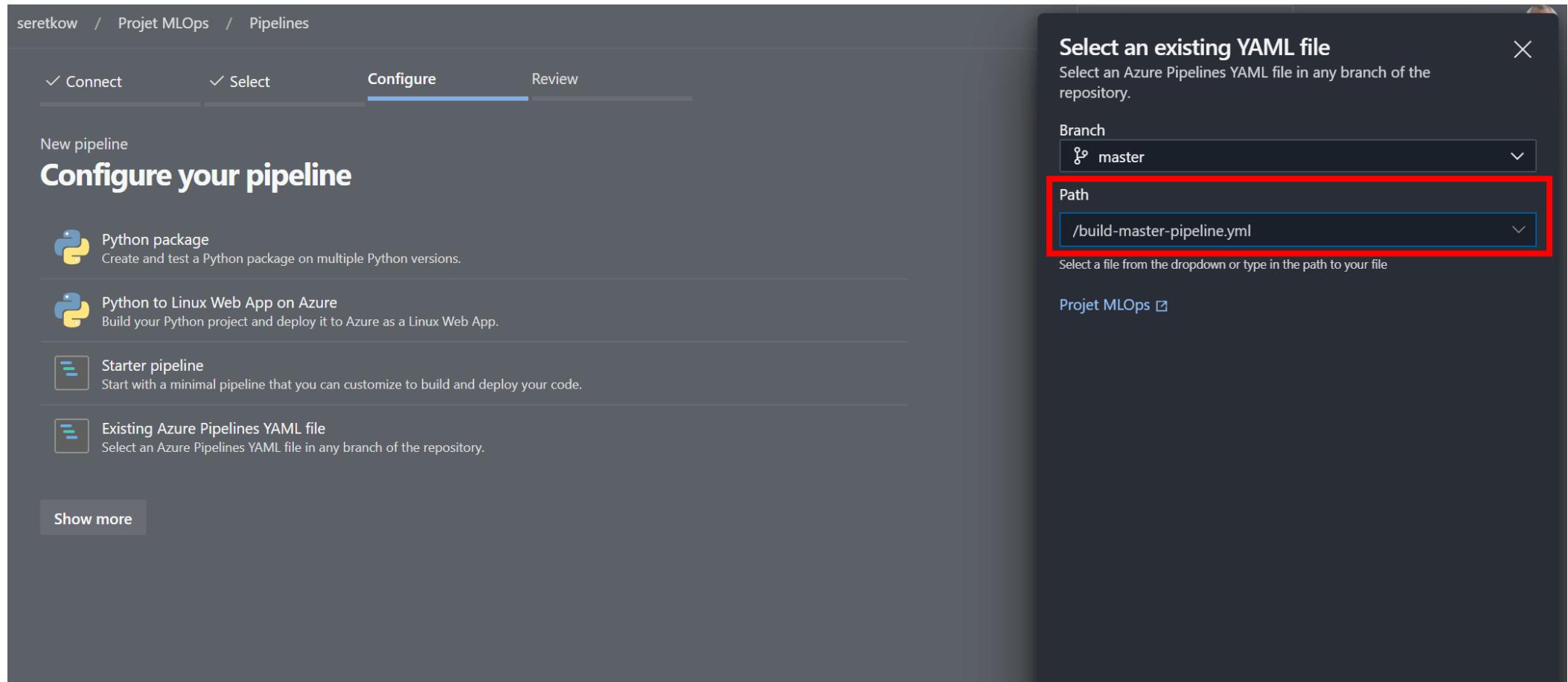
New pipeline

Configure your pipeline

- Python package
- Python to Linux Web App on Azure
- Starter pipeline
- Existing Azure Pipelines YAML file**

Select an Azure Pipelines YAML file in any branch of the repository.

Chemin du fichier YAML



The screenshot shows the Azure DevOps Pipeline configuration interface. The main screen displays the pipeline configuration steps: Connect, Select, Configure, and Review. The 'Configure' step is currently active. Below the steps, there are several pipeline template options:

- Python package
- Python to Linux Web App on Azure
- Starter pipeline
- Existing Azure Pipelines YAML file

A 'Show more' button is located at the bottom left of the main screen.

A modal window titled "Select an existing YAML file" is overlaid on the main screen. It includes fields for "Branch" (set to "master") and "Path" (set to "/build-master-pipeline.yml"). A red box highlights the "Path" input field. The modal also contains a note: "Select a file from the dropdown or type in the path to your file".



Azure DevOps

Visualisation du fichier YAML

The screenshot shows the Azure DevOps interface for reviewing a YAML pipeline. The left sidebar lists various project management and pipeline-related features like Overview, Boards, Repos, Pipelines, Releases, Library, Task groups, Deployment groups, Test Plans, Artifacts, and Compliance. The main area is titled "Review your pipeline YAML" and displays the contents of the file "build-master-pipeline.yml". The code is as follows:

```
1 trigger:
2 - master
3
4 pool:
5   vmImage: 'Ubuntu-16.04'
6
7 variables:
8   resourceGroup: '<yourResourceGroup>'
9   amlWorkspace: '<yourAMLWorkspace>'
10  experiment: 'chd-prediction'
11  amlComputeTargetName: 'chd-temp-compute'
12  modelName: 'chd-predictor'
13  containerImageName: 'chd-predictor-image'
14  serviceConnection: '<yourServiceConnectionName>'
15
16 steps:
17
18 - task: UsePythonVersion@0
19   displayName: 'Build step 1 -- Python configuration for agent'
20   inputs:
21     versionSpec: '3.6'
22     architecture: 'x64'...
```

Modifier les variables du fichier YAML avec vos informations

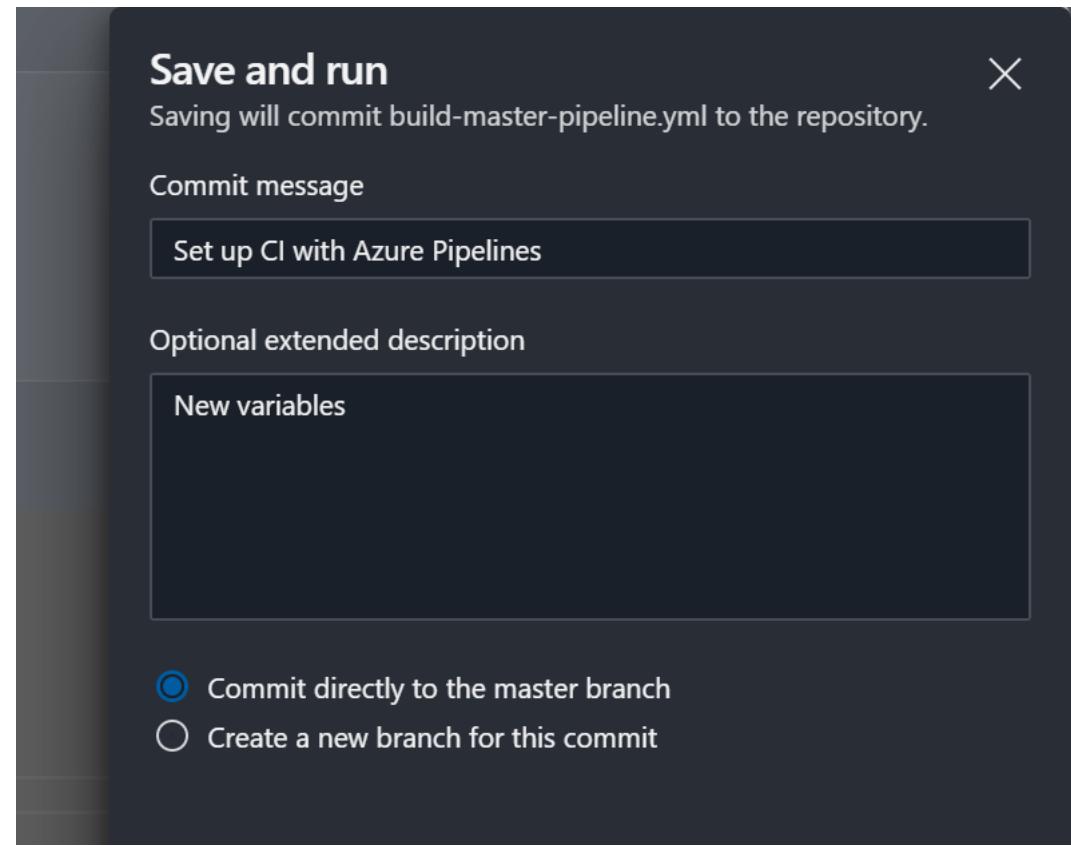
New pipeline

Review your pipeline YAML

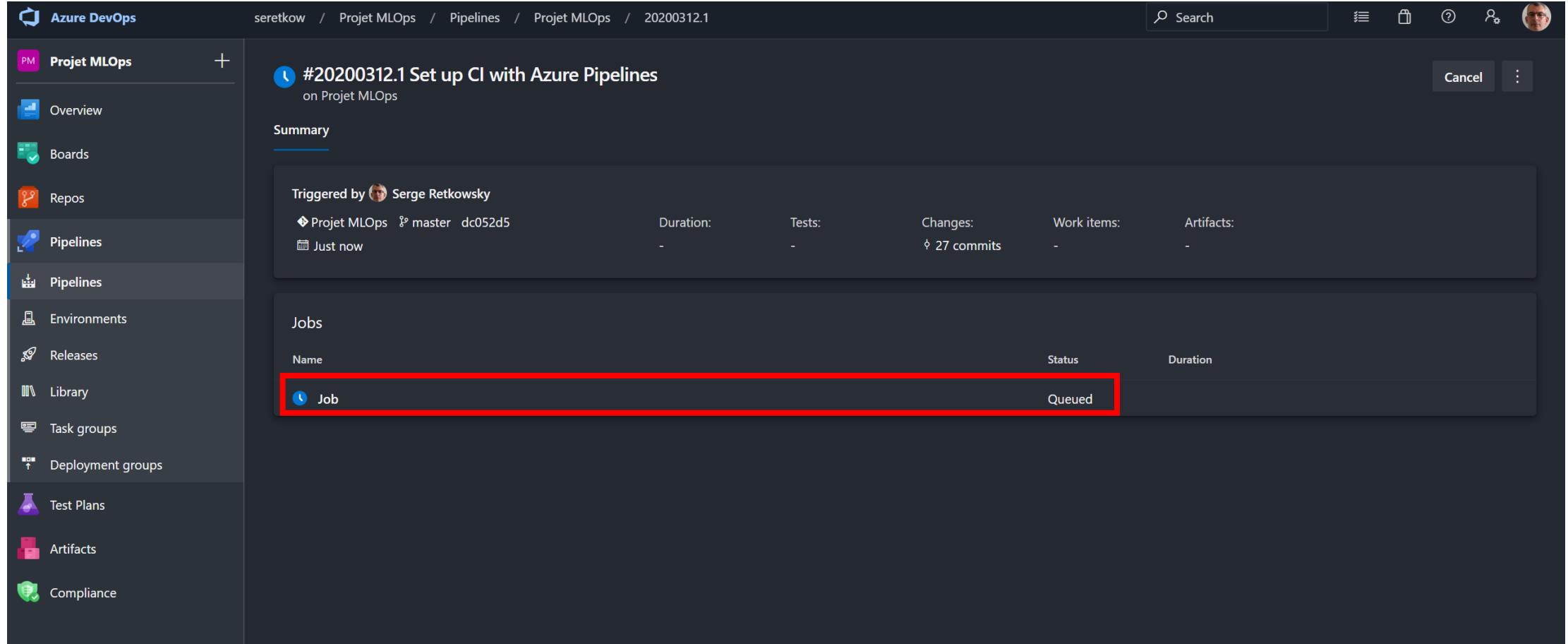
Projet MLOps / build-master-pipeline.yml *

```
1 trigger:
2 - master
3
4 pool:
5   vmImage: 'Ubuntu-16.04'
6
7 variables:
8   resourceGroup: 'MLOpsworkshopRG'
9   amlWorkspace: 'MLOpsWorkshop'
10  experiment: 'chd-prediction'
11  amlComputeTargetName: 'chd-temp-compute'
12  modelName: 'chd-predictor'
13  containerImageName: 'chd-predictor-image'
14  serviceConnection: 'ncrMlopsServiceConnection'
15
16 steps:
17
18  Settings
19    - task: UsePythonVersion@0
20      displayName: 'Build step 1 - Python configuration for agent'
21      inputs:
22        versionSpec: '3.6'
23        architecture: 'x64' ...
```

Sauvegarde du YAML



Mise à jour automatique du Pipeline



The screenshot shows the Azure DevOps Pipelines interface for the project "Projet MLOps". The pipeline is titled "#20200312.1 Set up CI with Azure Pipelines" and was triggered by "Serge Retkowsky" on the "master" branch. The pipeline summary indicates "Just now" and shows 27 commits. The "Jobs" section lists a single job named "Job" which is currently in the "Queued" status. A red box highlights this job entry.

Triggered by  Serge Retkowsky

Projet MLOps master dc052d5 Just now

Duration: - Tests: - Changes: 27 commits Work items: - Artifacts: -

Name	Status	Duration
Job	Queued	-



Pipeline en cours d'exécution

The screenshot shows the Azure DevOps interface for a pipeline named 'Projet MLOps'. The left sidebar is visible with various navigation options like Overview, Boards, Repos, Pipelines, and Test Plans. The main area displays the 'Jobs in run #20200312.1' for the 'Projet MLOps' pipeline. A red box highlights the 'Jobs' section, which lists the following steps:

- Job (8s)
 - Initialize job (3s) - Status: Succeeded
 - Checkout Projet MLOps... (1s) - Status: Succeeded
 - Build step 1 - Python ... (<1s) - Status: Succeeded
 - Build step 2 - Install de... (3s) - Status: In Progress
 - Build step 3 - Install the A... - Status: In Progress
 - Build step 4 - Attach direc... - Status: In Progress
 - Build step 5 - Provision A... - Status: In Progress
 - Build step 6 - Define and I... - Status: In Progress
 - Build step 7 - Copy build ... - Status: In Progress
 - Build step 8 - Publish buil... - Status: In Progress
 - Component Detection (au... - Status: In Progress
 - Post-job: Checkout Projet... - Status: In Progress

The 'Build step 2 - Install dependencies on agent' step is currently selected, showing its details and command output:

```
1 Starting: Build step 2 - Install dependencies on agent
2 =====
3 Task      : Bash
4 Description: Run a Bash script on macOS, Linux, or Windows
5 Version   : 3.163.1
6 Author    : Microsoft Corporation
7 Help      : https://docs.microsoft.com/azure/devops/pipelines/tasks/utility/bash
8 =====
9 Generating script.
10 ##[warning]Executable bit is not set on target script, sourcing instead of executing. More info at https://github.com/Microsoft/azure-pipelines-tasks/blob/master/Tasks/Bash@3/README.md#script-execution
11 Formatted command: . '/home/vsts/work/1/s/scripts-operationalize/agent-dependencies.sh'
12 =====
13 /bin/bash --noprofile --norc /home/vsts/work/_temp/4b041792-3e86-4927-a36b-ccb6924ea0af.sh
14 Python 3.6.10
15 Collecting azure-cli==2.0.72
16     Downloading azure_cli-2.0.72-py2.py3-none-any.whl (1.3 MB)
17 Collecting azure-mgmt-datamigration==0.1.0
18     Downloading azure_mgmt_datamigration-0.1.0-py2.py3-none-any.whl (219 kB)
```



Azure DevOps

Fin du traitement

Azure DevOps seretkow / Projet MLOps / Pipelines / Projet MLOps / 20200312.1

Projet MLOps +

Overview Boards Repos Pipelines Pipelines Environments Releases Library Task groups Deployment groups Test Plans Artifacts Compliance Project settings <<

← Jobs in run #20200312.1

Projet MLOps

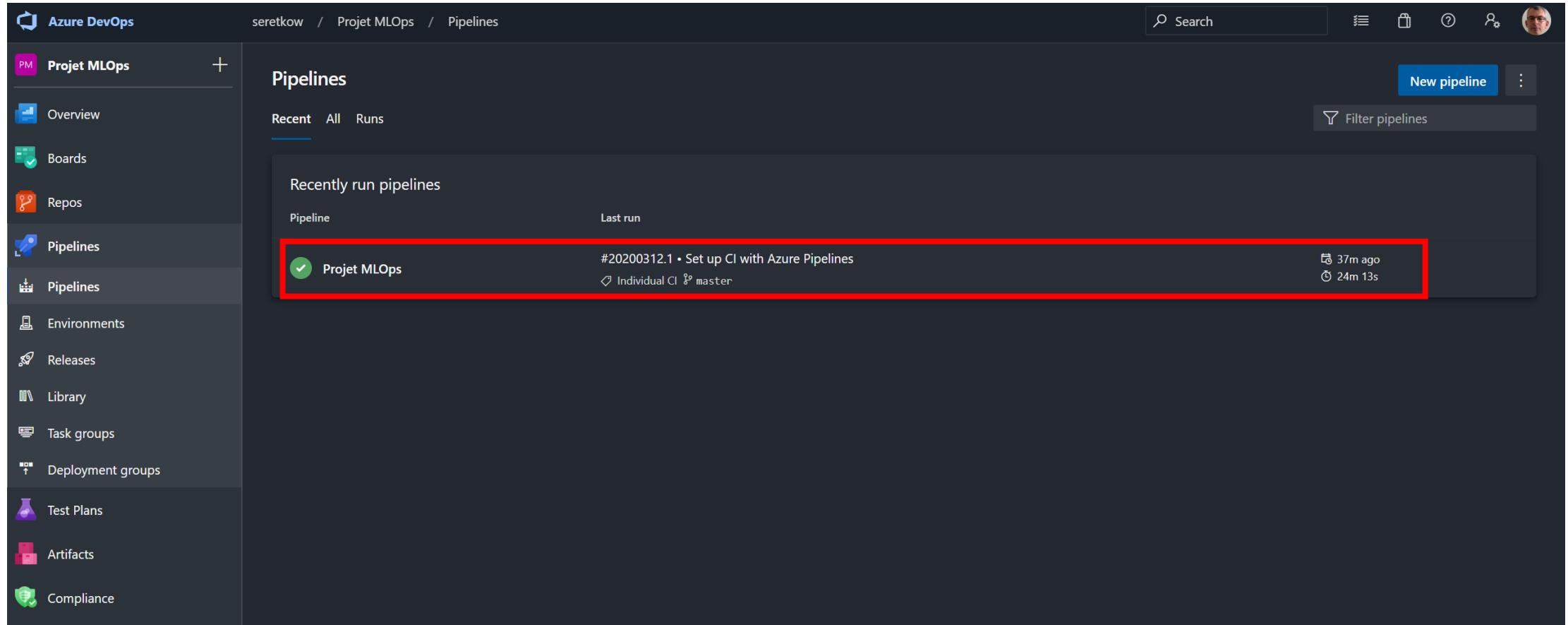
Jobs

Job	Duration
Initialize job	3s
Checkout Projet MLOps...	1s
Build step 1 - Python ...	<1s
Build step 2 - Install...	1m 2s
Build step 3 - Install th...	23s
Build step 4 - Attach d...	12s
Build step 5 - Provis...	2m 2s
Build step 6 - Def...	19m 42s
Build step 7 - Copy b...	<1s
Build step 8 - Publish b...	4s
Component Detection...	34s
Post-job: Checkout Pr...	<1s
Finalize Job	<1s
Report build status	<1s

Build step 6 - Define and launch build pipeline

```
1 Starting: Build step 6 - Define and launch build pipeline
2 -----
3 Task      : Azure CLI
4 Description: Run Azure CLI commands against an Azure subscription in a Shell
5 Version   : 1.163.0
6 Author    : Microsoft Corporation
7 Help      : https://docs.microsoft.com/azure/devops/pipelines/tasks/deploy/azur
8 -----
9 /opt/hostedtoolcache/Python/3.6.10/x64/bin/az --version
10 azure-cli           2.0.72 *
11 WARNING: You have 2 updates available. Consider updating your CLI installation.
12 -----
13 command-modules-nspkg      2.0.3
14 core                  2.0.72 *
15 nspkg                 3.0.4
16 telemetry              1.0.4
17 -----
18 Extensions:
19 azure-cli-ml            1.1.5
20 azure-devops             0.17.0
21 -----
22 Python location '/opt/hostedtoolcache/Python/3.6.10/x64/bin/python'
23 Extensions directory '/opt/az/azclixextensions'
24 -----
25 Python (Linux) 3.6.10 (default, Feb 14 2020, 11:07:53)
26 [GCC 5.4.0 20160609]
27 -----
28 Legal docs and information: aka.ms/AzureCliLegal
29 -----
30 Setting AZURE_CONFIG_DIR env variable to: /home/vsts/work/_temp/.azclitask
31 Setting active cloud to: AzureCloud
32 /opt/hostedtoolcache/Python/3.6.10/x64/bin/az cloud set -n AzureCloud
```

Visualisation des pipelines exécutés



The screenshot shows the Azure DevOps Pipelines interface for the project "Projet MLOps". The left sidebar has "Pipelines" selected. The main area displays "Recently run pipelines" with one entry:

Pipeline	Last run	
Projet MLOps	#20200312.1 • Set up CI with Azure Pipelines ⌚ Individual CI ➔ master	🕒 37m ago ⌚ 24m 13s

Modification du fichier train.py

Screenshot of the Azure DevOps repository interface showing the modification of the `train.py` file.

The left sidebar shows the project structure under "Projet MLOps":

- Overview
- Boards
- Repos** (selected)
- Files
- Commits
- Pushes
- Branches
- Tags
- Pull requests
- Pipelines
- Test Plans
- Artifacts
- Compliance

The right pane shows the contents of the `train.py` file in the `scripts-ml` directory. The file contains Python code for data preprocessing, model training, and feature selection. A red box highlights the line of code where the `n_estimators` parameter is set to 100:

```

54 df['glucose'].fillna(df['glucose'].mean(), inplace = True)
55 df['totChol'].fillna(df['totChol'].mean(), inplace = True)
56 df['education'].fillna(1, inplace = True)
57 df['BMI'].fillna(df['BMI'].mean(), inplace = True)
58 df['heartRate'].fillna(df['heartRate'].mean(), inplace = True)
59 print('..3. completed')
60 print('')
61 print('')
62
63 print("4. Train model")
64 print('.....')
65 # Features and label
66 features = df.iloc[:, :-1]
67 result = df.iloc[:, -1] # the last column is what we are about to forecast
68
69 # Train & Test split
70 X_train, X_test, y_train, y_test = train_test_split(features, result, test_size=0.2, random_state=42)
71
72 # RandomForest classifier
73 clf = RandomForestClassifier(n_estimators=100, max_depth=3, random_state=42)
74 clf.fit(X_train, y_train)
75
76 # Create a selector object that will use the random forest classifier to identify
77 # features that have an importance of more than 0.12
78 sfm = SelectFromModel(clf, threshold=0.12)
79
80 # Train the selector
81 sfm.fit(X_train, y_train)
82
83 # Features selected
84 featureNames = list(features.columns.values) # creating a list with features
85 print("Feature names:")
86 for featureNameListIndex in sfm.get_support(indices=True):
87     print(featureNames[featureNameListIndex])
88
89 # Feature importance
90 importances = clf.feature_importances_
91 std = np.std([tree.feature_importances_ for tree in clf.estimators_],
92             axis=0)
93
94 # Create a selector object that will use the random forest classifier to identify
95 # features that have an importance of more than 0.12
96 sfm = SelectFromModel(clf, threshold=0.12)
97
98 # Train the selector
99 sfm.fit(X_train, y_train)
100
101 # Features selected
102 featureNames = list(features.columns.values) # creating a list with features
103 print("Feature names:")
104 for featureNameListIndex in sfm.get_support(indices=True):
105     print(featureNames[featureNameListIndex])
106
107 # Feature importance
108 importances = clf.feature_importances_
109 std = np.std([tree.feature_importances_ for tree in clf.estimators_],
110             axis=0)

```



Sauvegarde du fichier train.py

seretkow / Projet MLOps / Repos / Files / Projet MLOps

Projet MLOps : master / scripts-ml / train.py

train.py

Contents Highlight changes

```
54 df['glucose'].fillna(df['glucose'].mean(), inplace = True)
55 df['totChol'].fillna(df['totChol'].mean(), inplace = True)
56 df['education'].fillna(1, inplace = True)
57 df['BMI'].fillna(df['BMI'].mean(), inplace = True)
58 df['heartRate'].fillna(df['heartRate'].mean(), inplace = True)
59 print('..3. completed')
60 print('')
61 print('')
62
63 print("4. Train model")
64 print('.....')
65 # Features and label
66 features = df.iloc[:, :-1]
67 result = df.iloc[:, -1] # the last column is what we are about to forecast
68
69 # Train & Test split
70 X_train, X_test, y_train, y_test = train_test_split(features, result, test_size=0.2)
71
72 # RandomForest classifier
73 clf = RandomForestClassifier(n_estimators=100, max_depth=2, random_state=0)
74 clf.fit(X_train, y_train)
75
76 # Create a selector object that will use the random forest classifier to identify
77 # features that have an importance of more than 0.12
78 sfm = SelectFromModel(clf, threshold=0.12)
79
80 # Train the selector
81 sfm.fit(X_train, y_train)
```

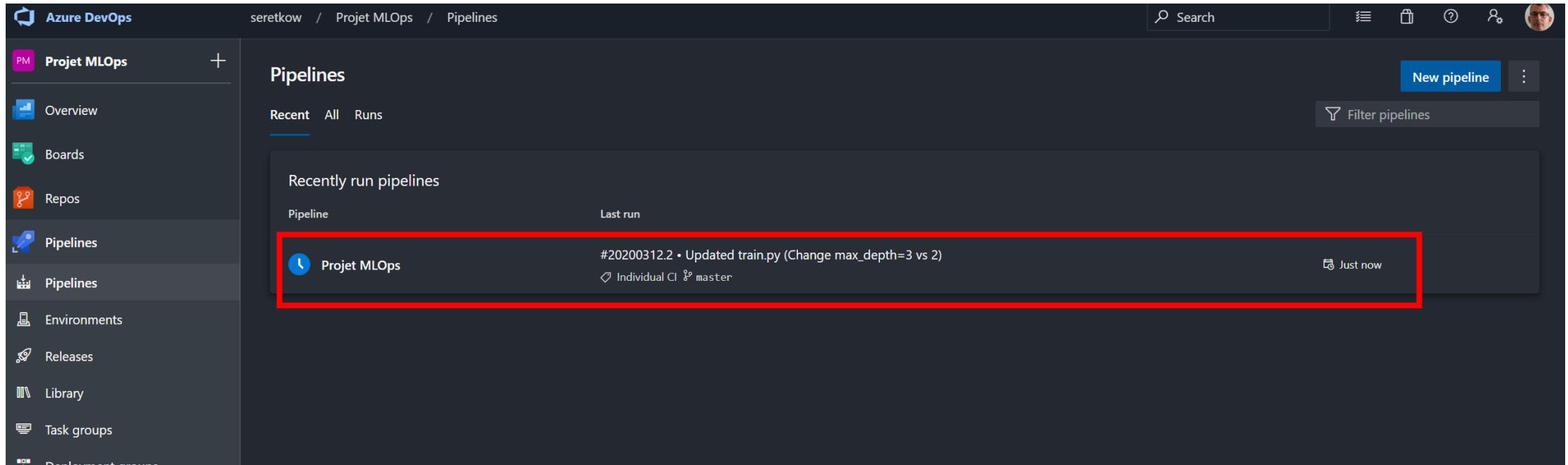
Commit

Comment: Updated train.py (Change max_depth=3 vs 2)

Branch name: master

Work items to link: Search work items by ID or title

Le Pipeline s'exécute automatiquement



The screenshot shows the Azure DevOps Pipelines interface for the project "Projet MLOps". The left sidebar has "Pipelines" selected. The main area displays "Recently run pipelines". A single pipeline entry is shown, highlighted with a red rectangle:

Pipeline	Last run
Projet MLOps	#20200312.2 • Updated train.py (Change max_depth=3 vs 2) ⌚ Individual CI ⚡ master Just now

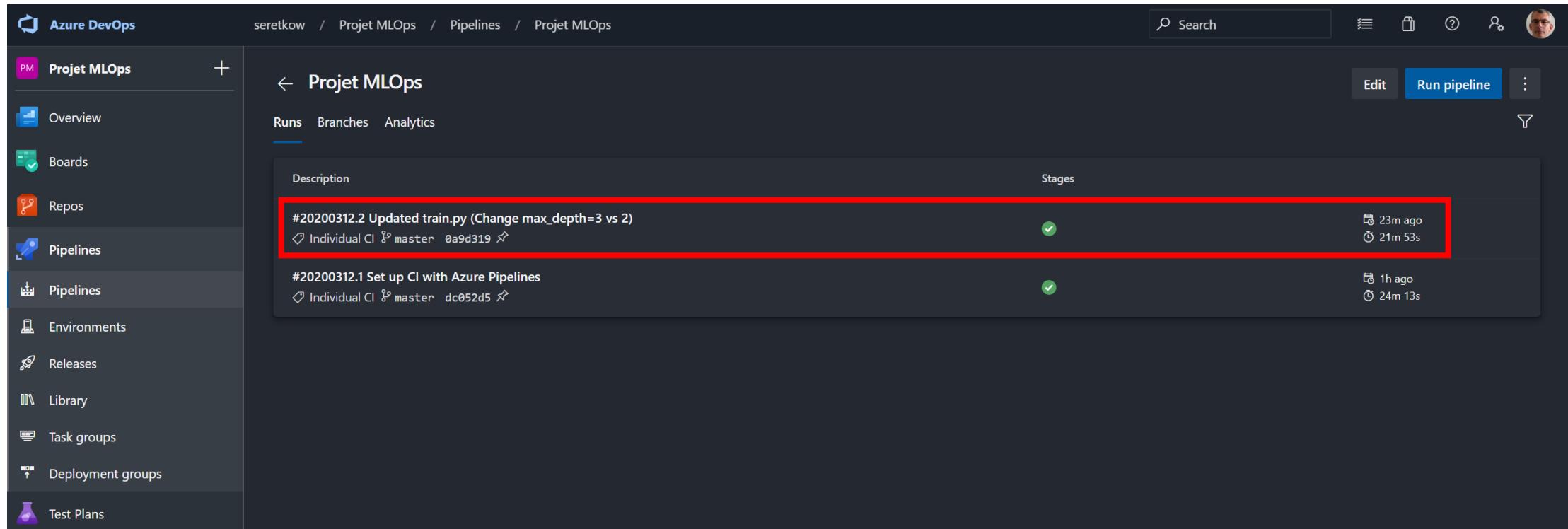
Exécution en cours



The screenshot shows the Azure DevOps Pipelines interface for the project "Projet MLOps". The left sidebar lists various project management and pipeline-related tabs. The main area displays two recent pipeline runs:

Description	Stages	Timestamp
#20200312.2 Updated train.py (Change max_depth=3 vs 2) ↳ Individual CI ↳ master 0a9d319	C	Just now 13s
#20200312.1 Set up CI with Azure Pipelines ↳ Individual CI ↳ master dc052d5 ✘	✓	39m ago 24m 13s

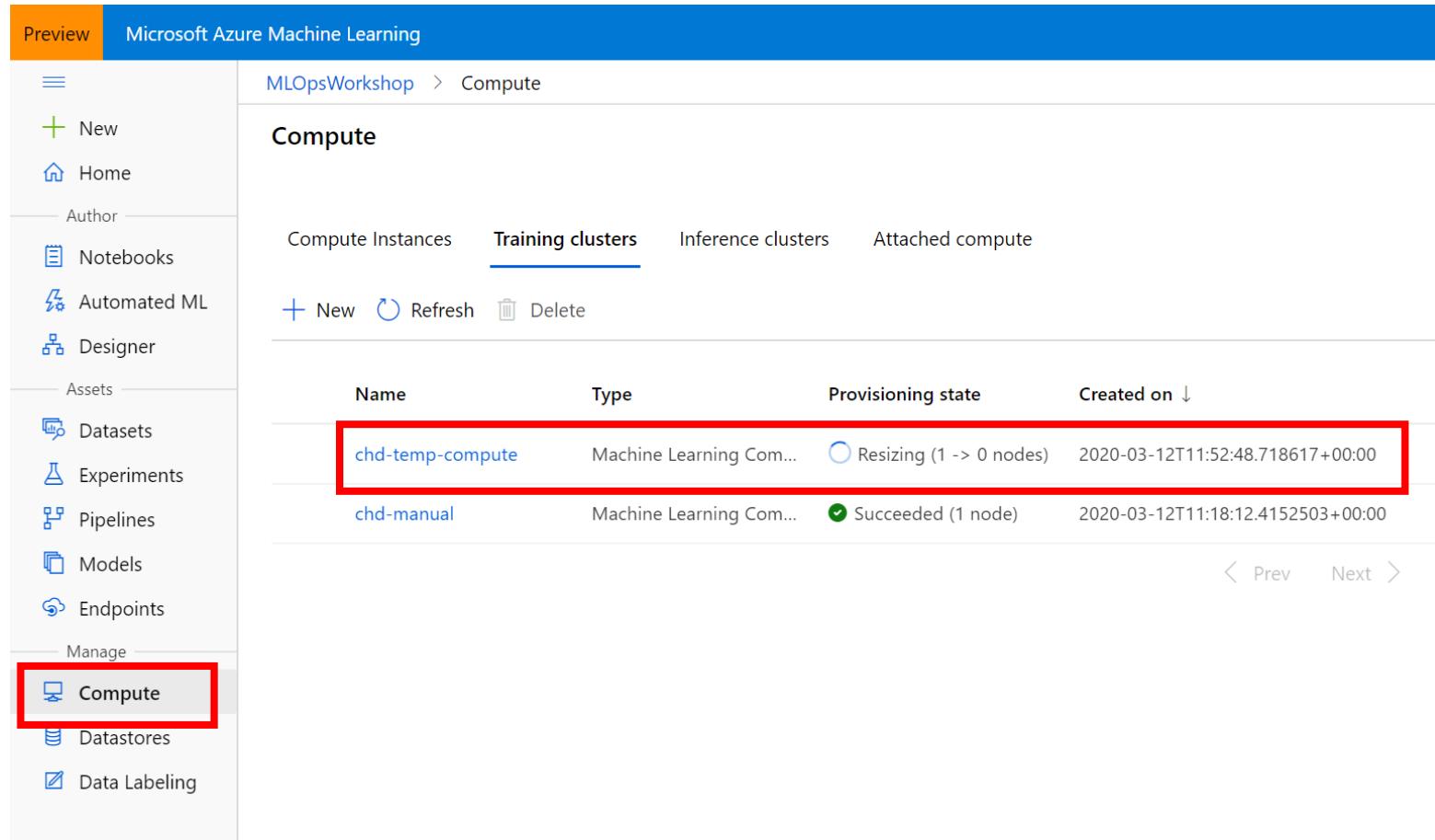
Fin de l'exécution du pipeline



The screenshot shows the Azure DevOps Pipelines interface for the 'Projet MLOps' project. The left sidebar lists various project management and development tools: Overview, Boards, Repos, Pipelines (selected), Pipelines, Environments, Releases, Library, Task groups, Deployment groups, and Test Plans. The main area displays two completed pipeline runs under the 'Runs' tab:

- #20200312.2 Updated train.py (Change max_depth=3 vs 2)**
 - Individual CI (master 0a9d319)
 - Stages: A green checkmark indicates success.
 - Run time: 23m ago.
 - Completion time: 21m 53s.
- #20200312.1 Set up CI with Azure Pipelines**
 - Individual CI (master dc052d5)
 - Stages: A green checkmark indicates success.
 - Run time: 1h ago.
 - Completion time: 24m 13s.

Visualisation depuis Azure ML Studio du training cluster créé par le pipeline



The screenshot shows the Microsoft Azure Machine Learning Studio interface. The top navigation bar has a blue header with the text "Microsoft Azure Machine Learning". On the far left, there is a vertical sidebar with several sections: "Author" (New, Home), "Assets" (Datasets, Experiments, Pipelines, Models, Endpoints), and "Manage" (Compute, Datastores, Data Labeling). The "Compute" item in the "Manage" section is highlighted with a red box. The main content area is titled "Compute" and shows four tabs: "Compute Instances", "Training clusters" (which is underlined, indicating it is selected), "Inference clusters", and "Attached compute". Below the tabs are buttons for "+ New", "Refresh", and "Delete". The main table lists two entries:

Name	Type	Provisioning state	Created on
chd-temp-compute	Machine Learning Com...	<input type="radio"/> Resizing (1 -> 0 nodes)	2020-03-12T11:52:48.718617+00:00
chd-manual	Machine Learning Com...	<input checked="" type="radio"/> Succeeded (1 node)	2020-03-12T11:18:12.4152503+00:00

At the bottom right of the table, there are navigation arrows for "Prev" and "Next".

Visualisation de l'expérimentation créée par le pipeline

Screenshot of the Microsoft Azure Machine Learning Studio interface showing the 'Experiments' page.

The left sidebar shows navigation links: Preview, New, Home, Author, Notebooks, Automated ML, Designer, Assets, Datasets, Experiments (highlighted with a red box), Pipelines, Models, Endpoints, Manage, Compute, Datastores, and Data Labeling.

The main content area displays the 'Experiments' list under the 'MLOpsWorkshop > Experiments' path. The list includes:

Experiment	Latest run	Last submitted	Created	Created by	Run types
chd-prediction	8	Mar 12, 2020 1:32 PM	Mar 12, 2020 12:51 PM	Service principal	Script, Pipeline
chd-prediction-manual	2	Mar 12, 2020 12:27 PM	Mar 12, 2020 12:18 PM	Serge Retkowsky	Script, Automated ML

Pagination controls at the bottom indicate 'Prev' and 'Next'.

Visualisation de l'expérimentation créée par le pipeline

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Experiments > chd-prediction

chd-prediction

[Switch to old experience](#)

Edit table Refresh Reset to default view Include child runs

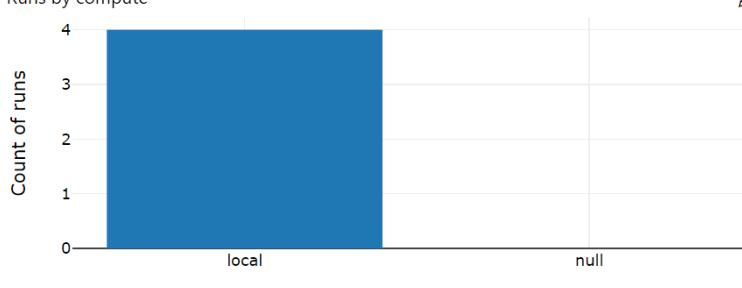
Add filter

Run status

Running	Completed
0	6

Failed	Other
0	0

Runs by compute

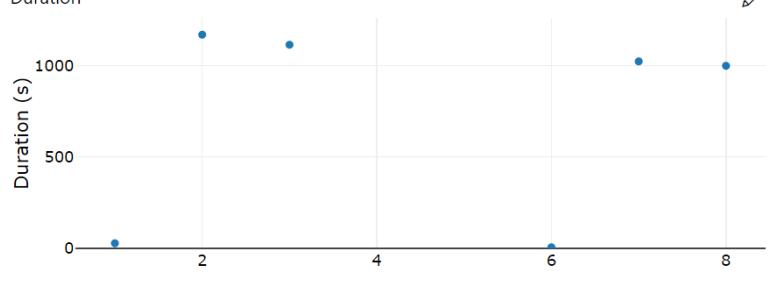


Count of runs

local null

Compute target

Duration



Duration (s)

Run number

0 500 1000

0 2 4 6 8

Run

Run ID

Status

Submitted time

Duration

Submitted by

Compute target

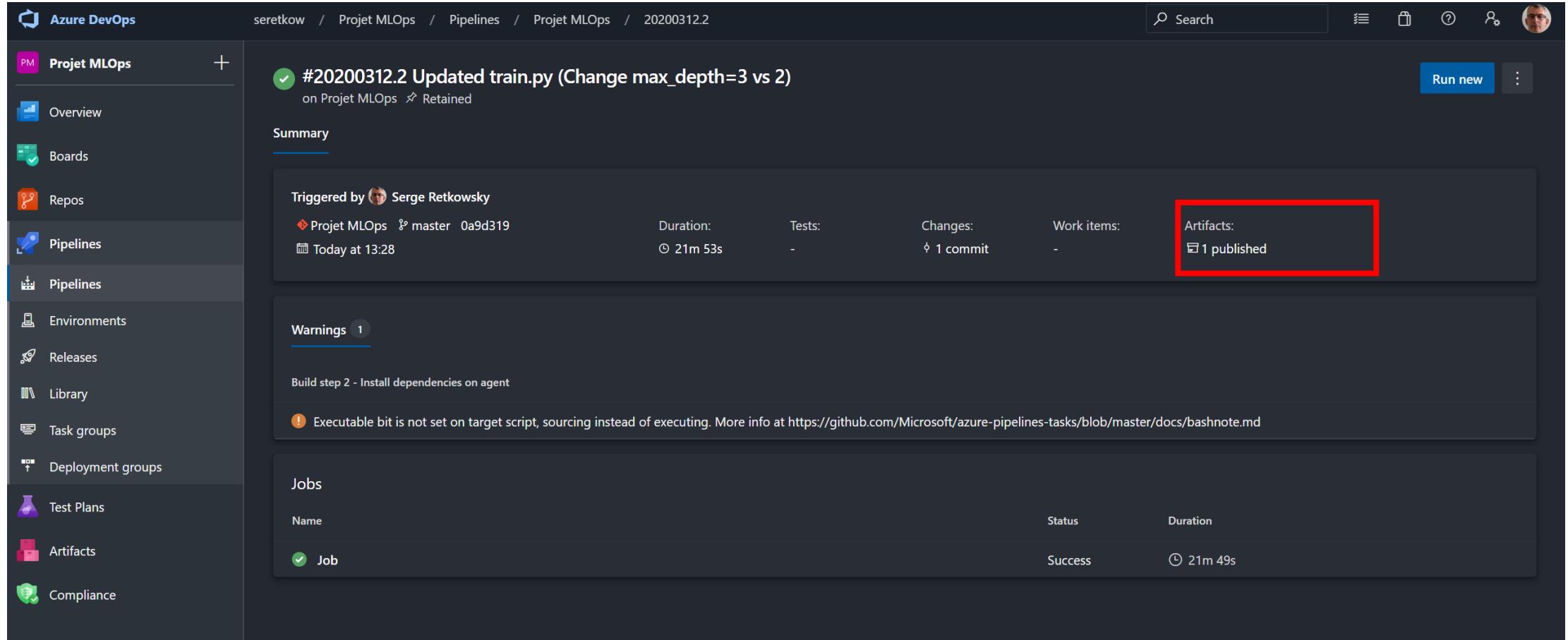
Run type

Tags

Run	Run ID	Status	Submitted time	Duration	Submitted by	Compute target	Run type	Tags
Run 8	89b09638-0be0-4cbc-9fdc-6e06462776...	Completed	Mar 12, 2020 1:32 PM	16m 38s	Service principal	Pipeline	azurerm.pipelineComponent: pipelinerun	

New Home Author Notebooks Automated ML Designer Datasets Experiments Pipelines Models Endpoints Compute Datastores Data Labeling

Accès aux artifacts



Project MLOps / Pipelines / Projet MLOps / 20200312.2

#20200312.2 Updated train.py (Change max_depth=3 vs 2)
on Projet MLOps Retained

Run new

Triggered by Serge Retkowsky
Projet MLOps master 0a9d319
Today at 13:28

Duration: 21m 53s Tests: - Changes: 1 commit Work items: - Artifacts: 1 published

Warnings 1

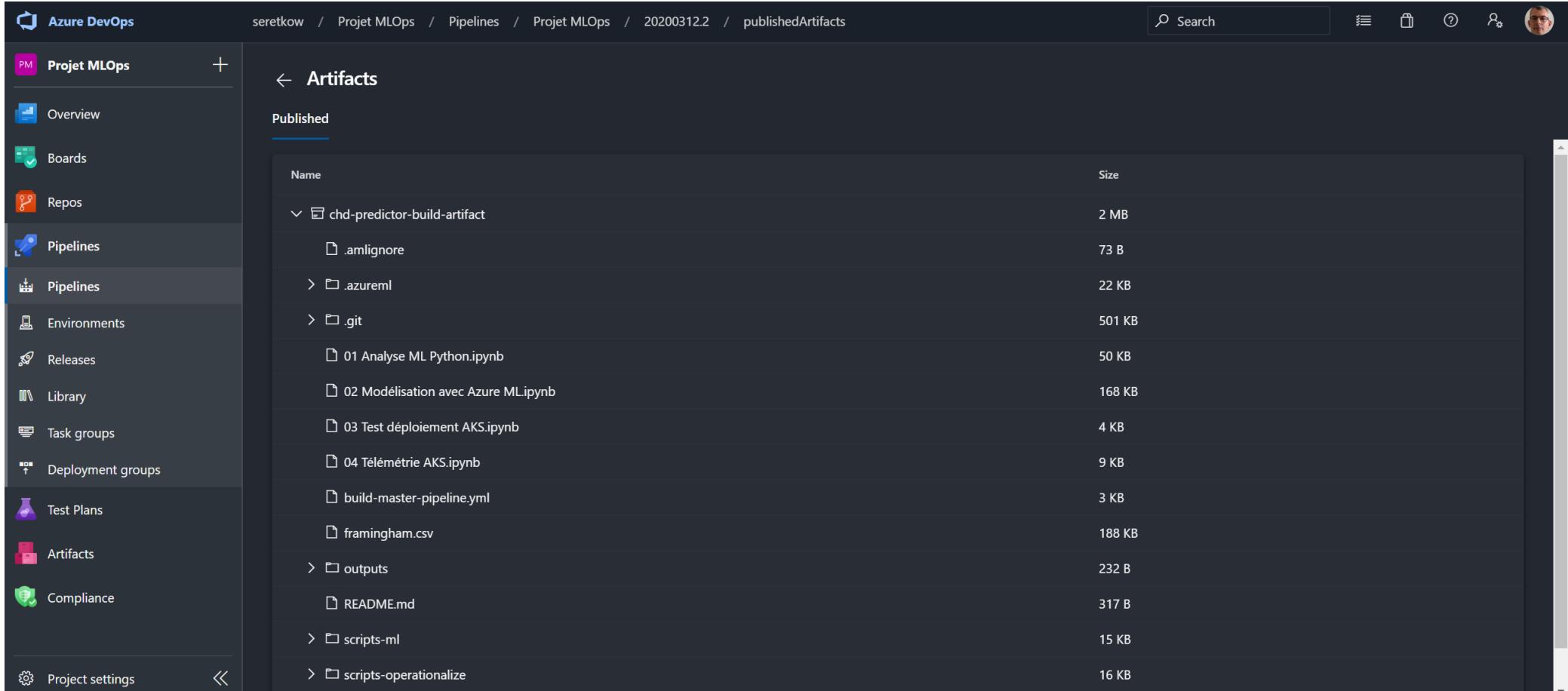
Build step 2 - Install dependencies on agent

Executable bit is not set on target script, sourcing instead of executing. More info at <https://github.com/Microsoft/azure-pipelines-tasks/blob/master/docs/bashnote.md>

Jobs

Name	Status	Duration
Job	Success	21m 49s

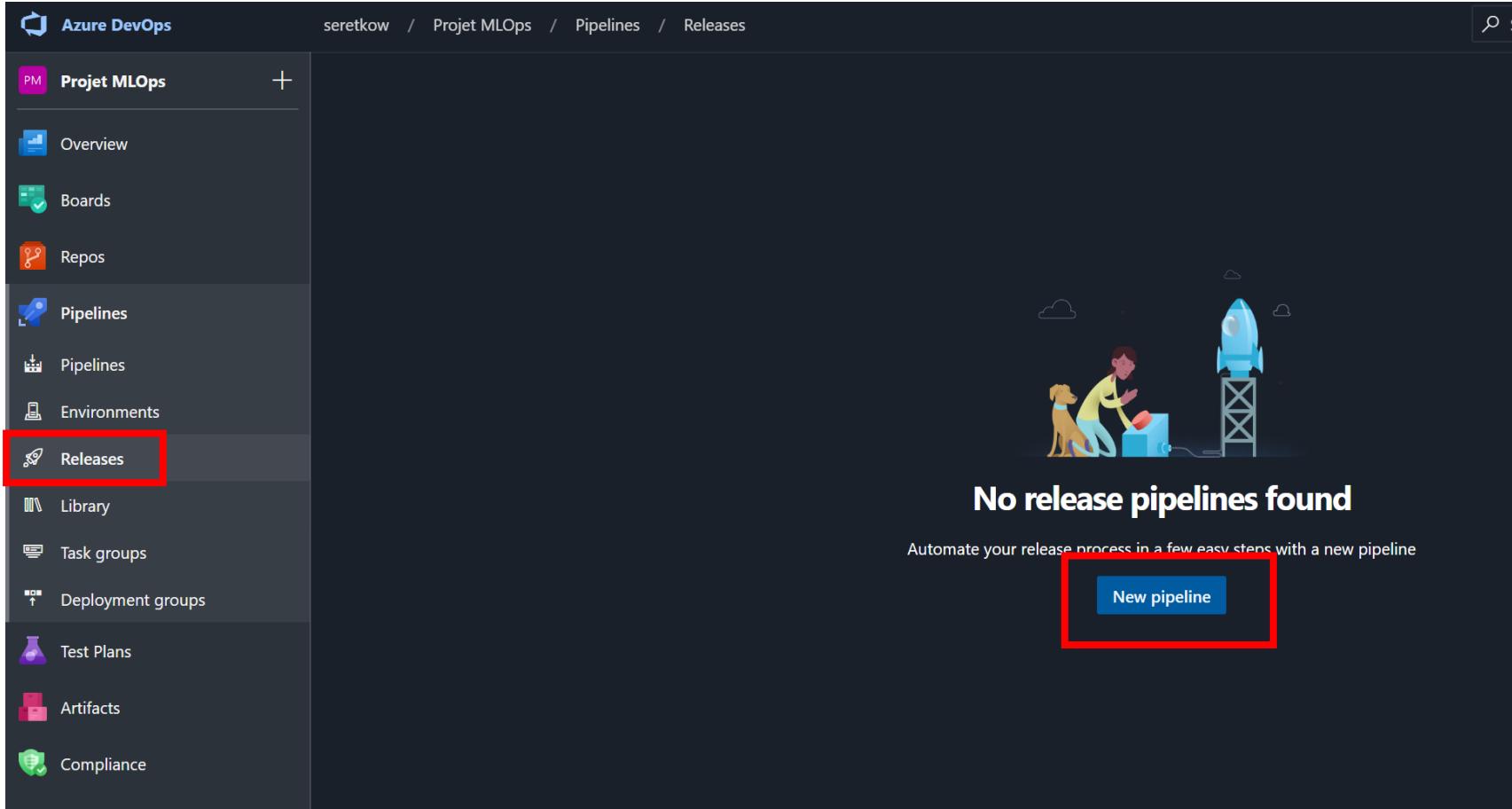
Visualisation des artifacts du pipeline



The screenshot shows the Azure DevOps interface for viewing pipeline artifacts. The left sidebar has a 'Pipelines' section selected. The main area shows a table of artifacts for a specific pipeline run.

Name	Size
chd-predictor-build-artifact	2 MB
amlignore	73 B
azureml	22 KB
git	501 KB
01 Analyse ML Python.ipynb	50 KB
02 Modélisation avec Azure ML.ipynb	168 KB
03 Test déploiement AKS.ipynb	4 KB
04 Télémétrie AKS.ipynb	9 KB
build-master-pipeline.yml	3 KB
framingham.csv	188 KB
outputs	232 B
README.md	317 B
scripts-ml	15 KB
scripts-operationalize	16 KB

Création d'un Pipeline Release



The screenshot shows the Azure DevOps interface for the 'Projet MLOps' project. The left sidebar navigation bar is visible, with the 'Releases' item highlighted by a red box. The main content area displays a message: 'No release pipelines found'. Below this message is a call-to-action button labeled 'New pipeline', which is also highlighted by a red box. The overall theme is dark, and there is a decorative illustration of a person and a dog launching a rocket.



Azure DevOps

Création Empty Job

The screenshot shows the Azure DevOps Pipelines interface for creating a new release pipeline. On the left, the navigation bar includes 'Projet MLOps' and 'Pipelines'. The main area displays 'All pipelines > New release pipeline'. The pipeline canvas shows 'Artifacts' and 'Stages'. A tooltip 'Stage 1 Select a template' is visible over the stages section. A modal window titled 'Select a template' is open, with the 'Empty job' option highlighted and surrounded by a red box. The 'Featured' section lists several deployment templates.

Select a template
Or start with an [Empty job](#)

Search

Featured

- Azure App Service deployment**
Deploy your application to Azure App Service. Choose from Web App on Windows, Linux, containers, Function Apps, or WebJobs.
- Deploy a Java app to Azure App Service**
Deploy a Java application to an Azure Web App.
- Deploy a Node.js app to Azure App Service**
Deploy a Node.js application to an Azure Web App.
- Deploy a PHP app to Azure App Service and Azure Database for MySQL**
Deploy a PHP application to an Azure Web App and database to Azure Database for MySQL.
- Deploy a Python app to Azure App Service and Azure database for MySQL**
Deploy a Python Django, Bottle, or Flask application to an Azure Web App and database to Azure Database for MySQL.
- Deploy to a Kubernetes cluster**
Deploy, configure, update your containerized applications to a Kubernetes cluster.
- IIS website and SQL database deployment**
Deployment Group: Deploy ASP.NET or ASP.NET Core web application to IIS Website and SQL database deployment.

Pipeline

Azure DevOps seretkov / Projet MLOps / Pipelines / Releases

All pipelines > New release pipeline

Save Create release View releases ...

Artifacts | + Add

+ Add an artifact

Schedule not set

Stages | + Add

Stage 1 1 job, 0 task

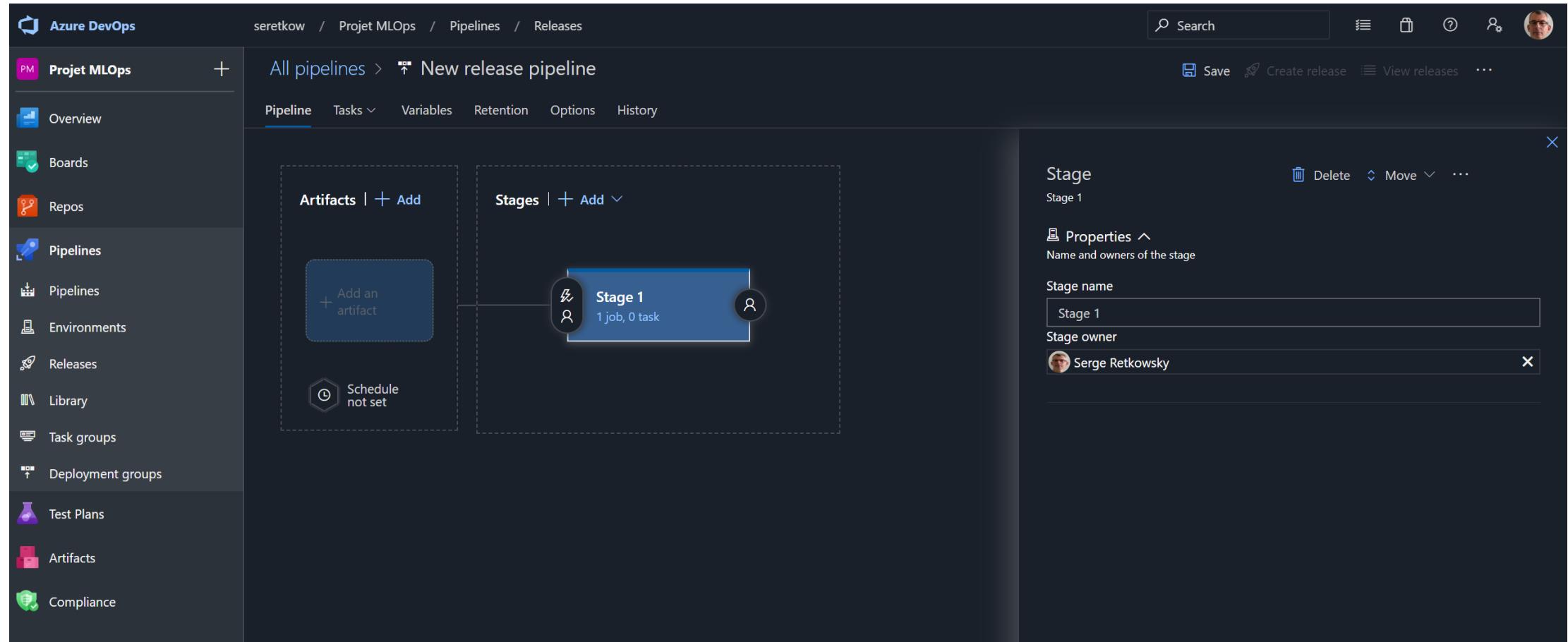
Stage Stage 1

Delete Move ...

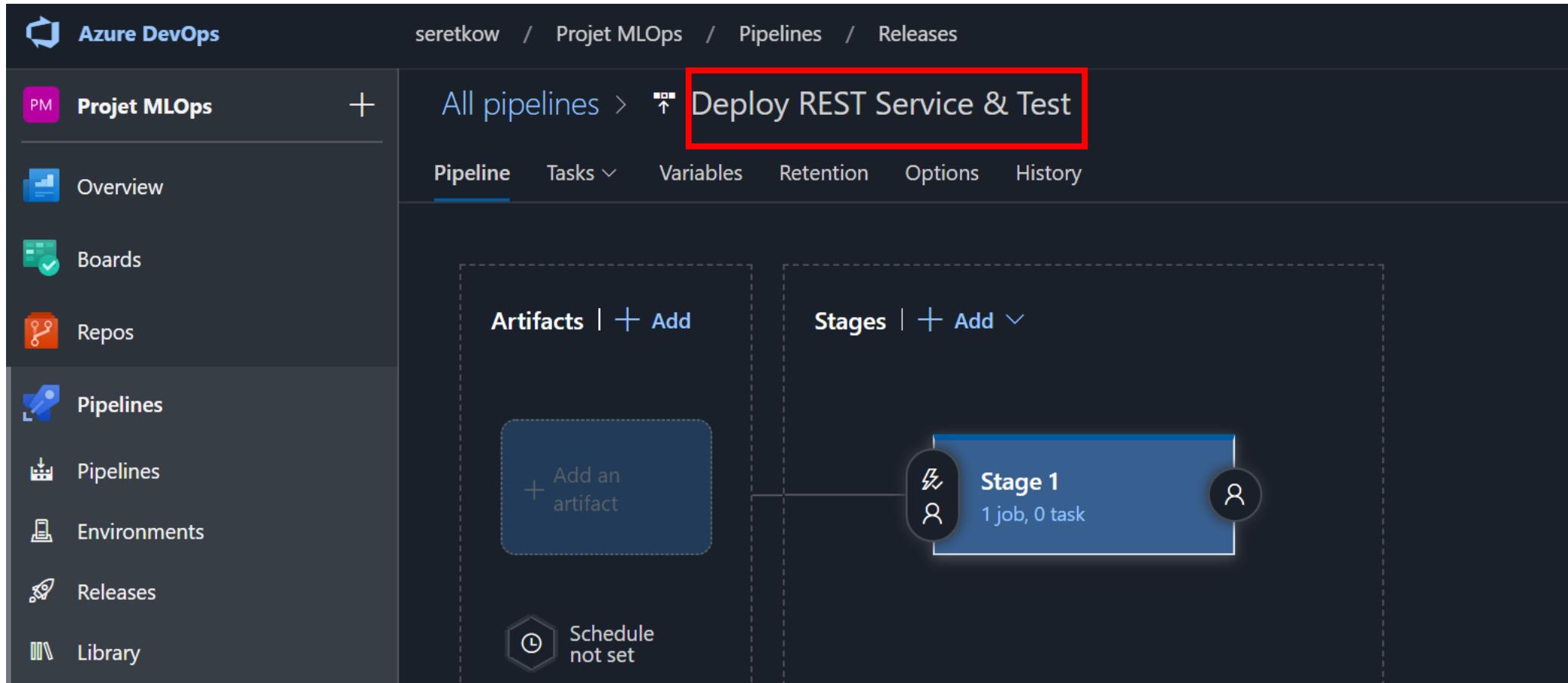
Properties Name and owners of the stage

Stage name Stage 1

Stage owner Serge Retkowsky



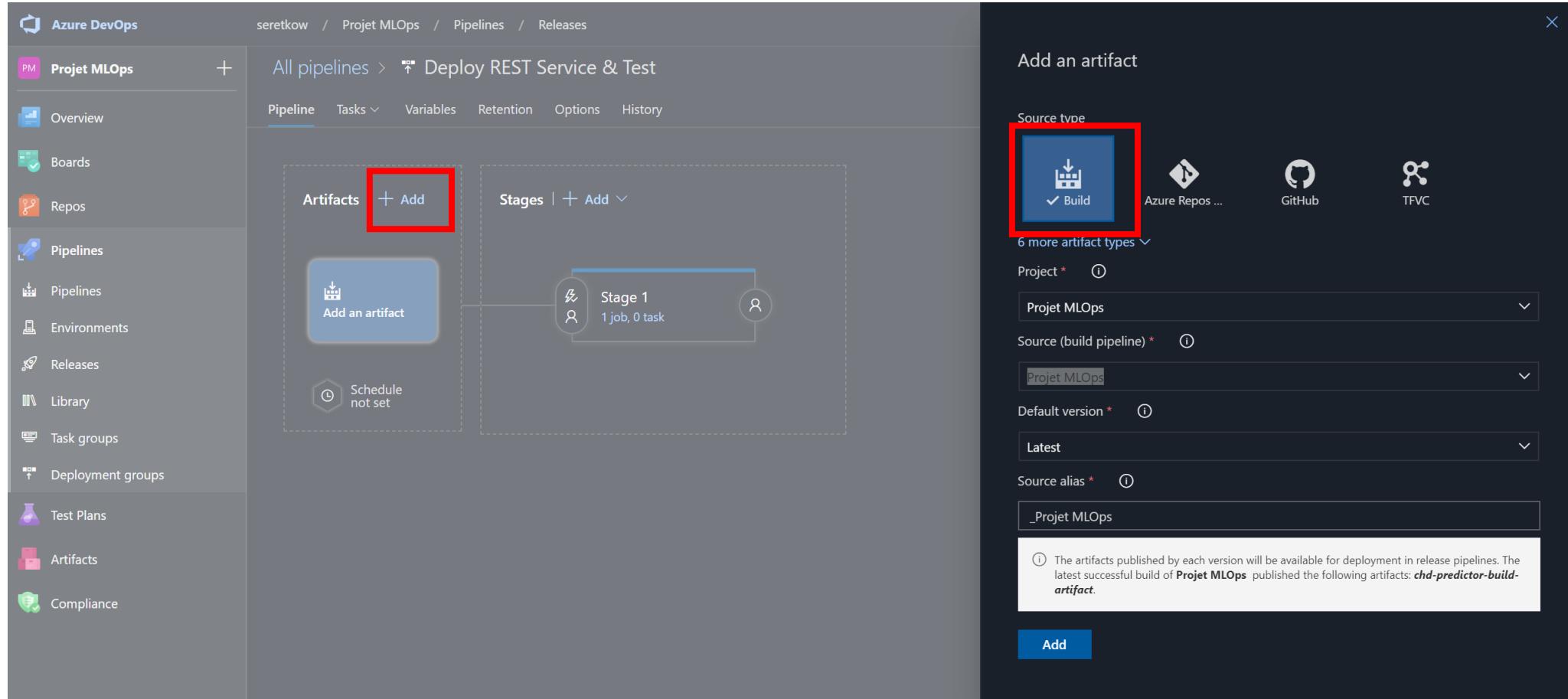
Nouveau nom du pipeline



The screenshot shows the Azure DevOps Pipelines interface for the 'Projet MLOps' project. The pipeline is named 'Deploy REST Service & Test'. The interface includes sections for Artifacts, Stages, and Pipeline settings.

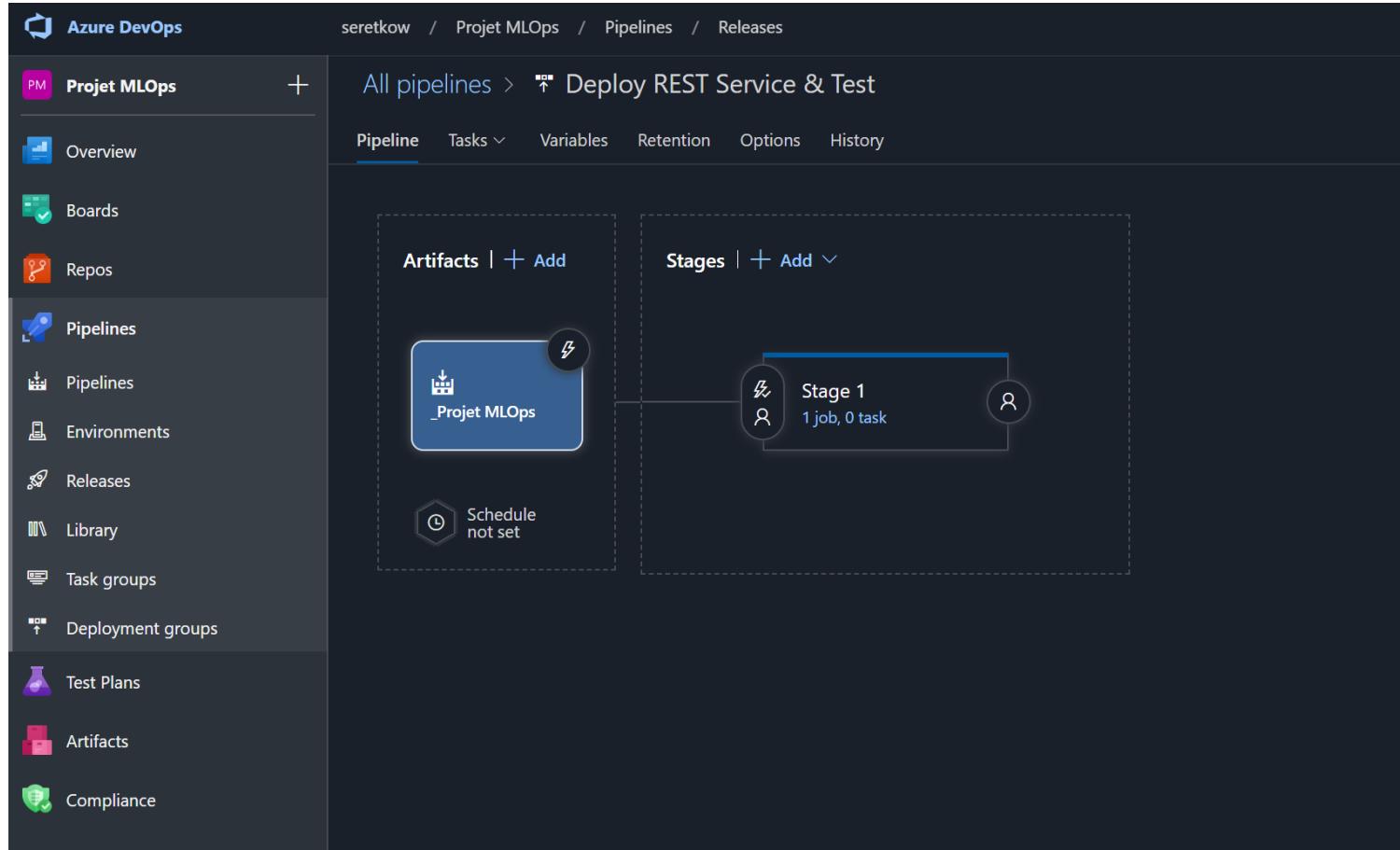
- Artifacts:** A button to 'Add an artifact'.
- Stages:** A stage named 'Stage 1' which contains '1 job, 0 task'.
- Pipeline Settings:** Options for Tasks, Variables, Retention, Options, and History.

Ajout Artifact



The screenshot shows the Azure DevOps interface for managing pipelines. On the left, the sidebar lists various project management and development tools. The main area displays a pipeline named "Deploy REST Service & Test" under the "Projet MLOps" project. The pipeline structure includes an "Artifacts" section and a "Stages" section. In the "Artifacts" section, there is a button labeled "+ Add". A red box highlights this button. To the right, a modal window titled "Add an artifact" is open, also featuring a red box around the "+ Add" button. The modal allows users to select a "Source type" (with "Build" highlighted), choose a "Project" (set to "Projet MLOps"), specify a "Source (build pipeline)" (set to "Projet MLOps"), and define a "Source alias" (set to "_Projet MLOPs"). A note at the bottom indicates that artifacts published by each version will be available for deployment in release pipelines.

Ajout Artifact

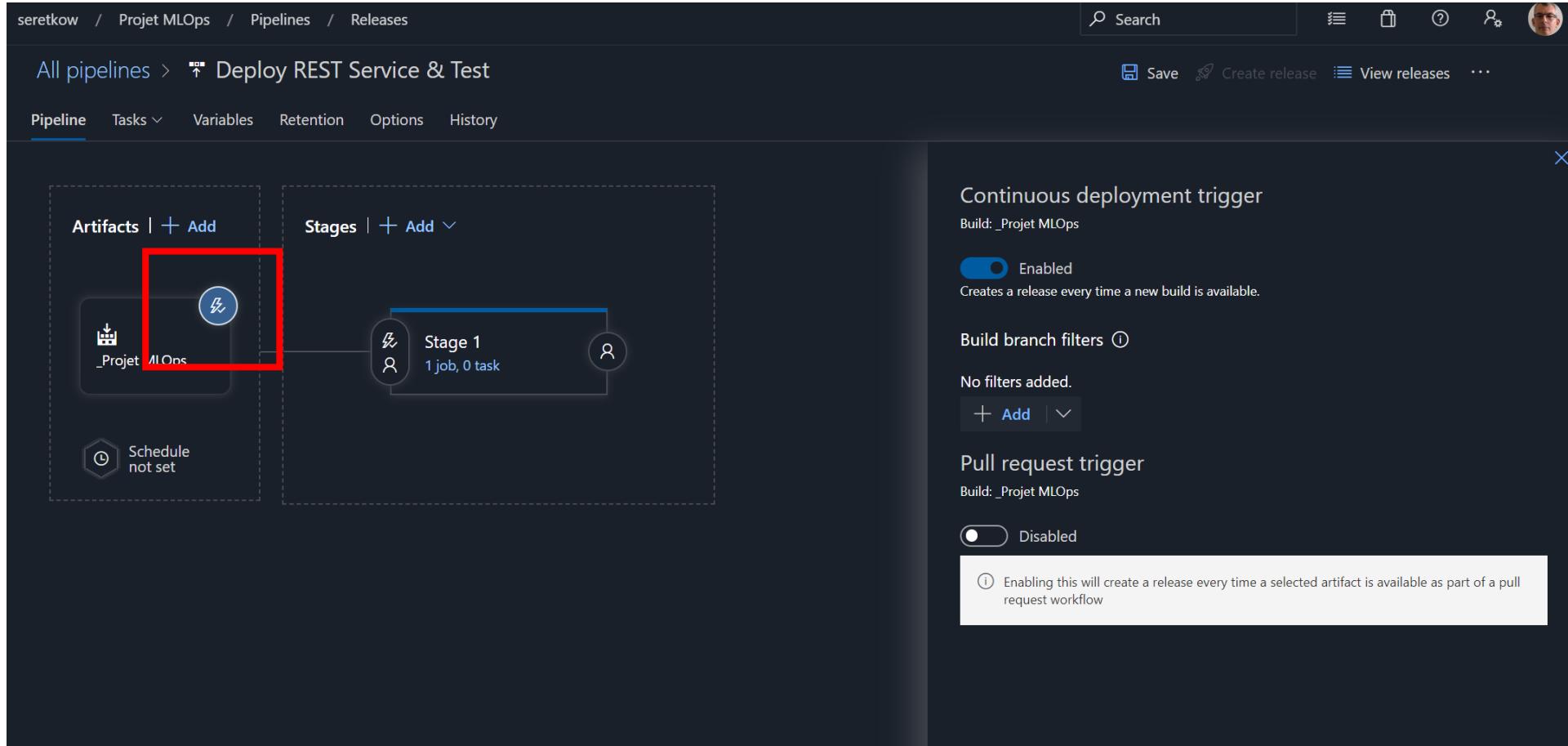


The screenshot shows the Azure DevOps Pipelines interface for the project "Projet MLOps". The pipeline is named "Deploy REST Service & Test". The left sidebar shows the navigation menu with "Artifacts" selected. The main area displays the pipeline structure:

- Artifacts:** A section containing a card for "_Projet MLOps" with a "Schedule not set" note.
- Stages:** A section containing a card for "Stage 1" which includes "1 job, 0 task".

The "Pipeline" tab is selected in the top navigation bar.

Paramétrage



The screenshot shows the Azure DevOps Pipelines interface for the 'Deploy REST Service & Test' pipeline. The pipeline structure is displayed on the left, featuring an 'Artifacts' section with a red box highlighting the '_Projet MLOps' artifact, and a 'Stages' section containing 'Stage 1' which includes one job and zero tasks. On the right, the 'Continuous deployment trigger' settings are shown, with the 'Enabled' toggle switch turned on and the note: 'Creates a release every time a new build is available.' Below it, 'Build branch filters' are listed as 'No filters added.' A 'Pull request trigger' section is also present, showing the 'Disabled' state with the note: 'Enabling this will create a release every time a selected artifact is available as part of a pull request workflow.'

seretkov / Projet MLOps / Pipelines / Releases

All pipelines > Deploy REST Service & Test

Pipeline Tasks Variables Retention Options History

Continuous deployment trigger

Build: _Projet MLOps

Enabled
Creates a release every time a new build is available.

Build branch filters ⓘ
No filters added.
+ Add | ↴

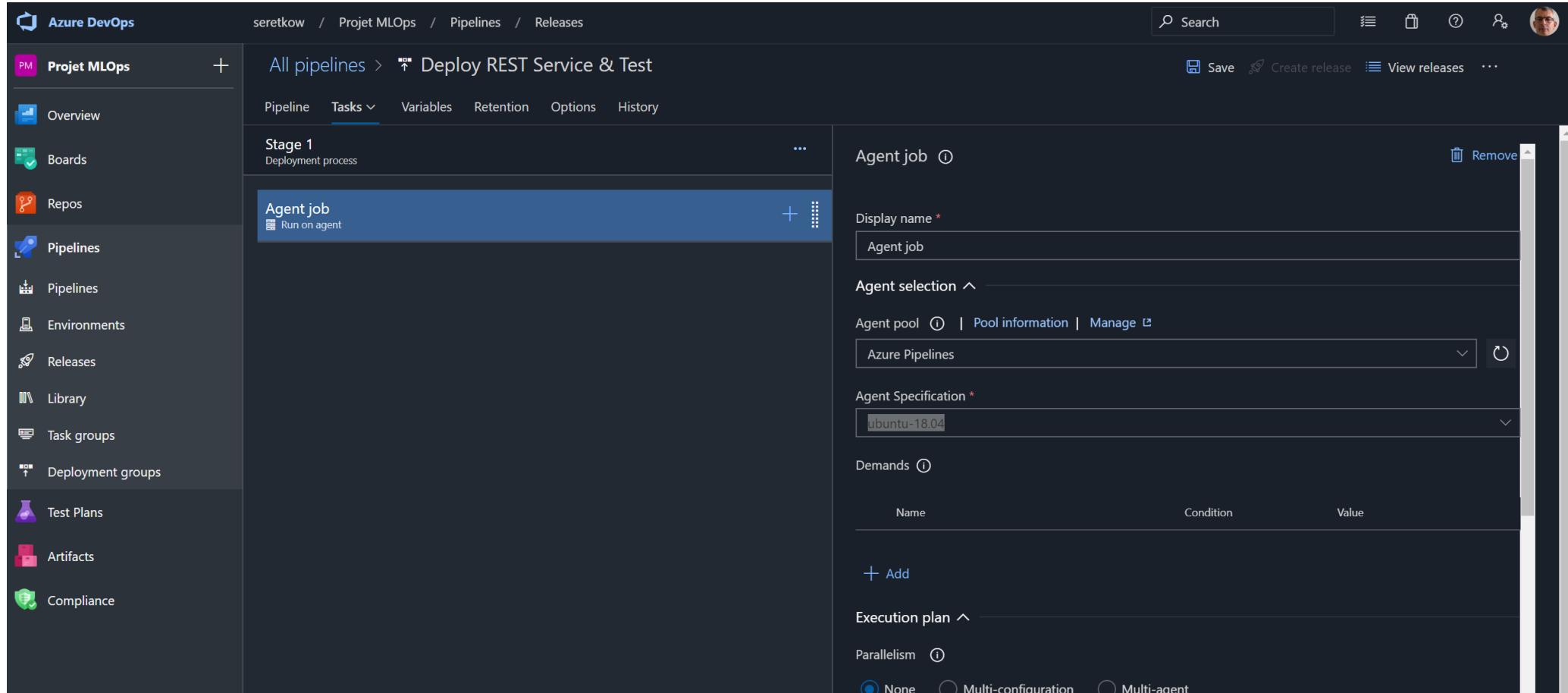
Pull request trigger

Build: _Projet MLOps

Disabled

ⓘ Enabling this will create a release every time a selected artifact is available as part of a pull request workflow

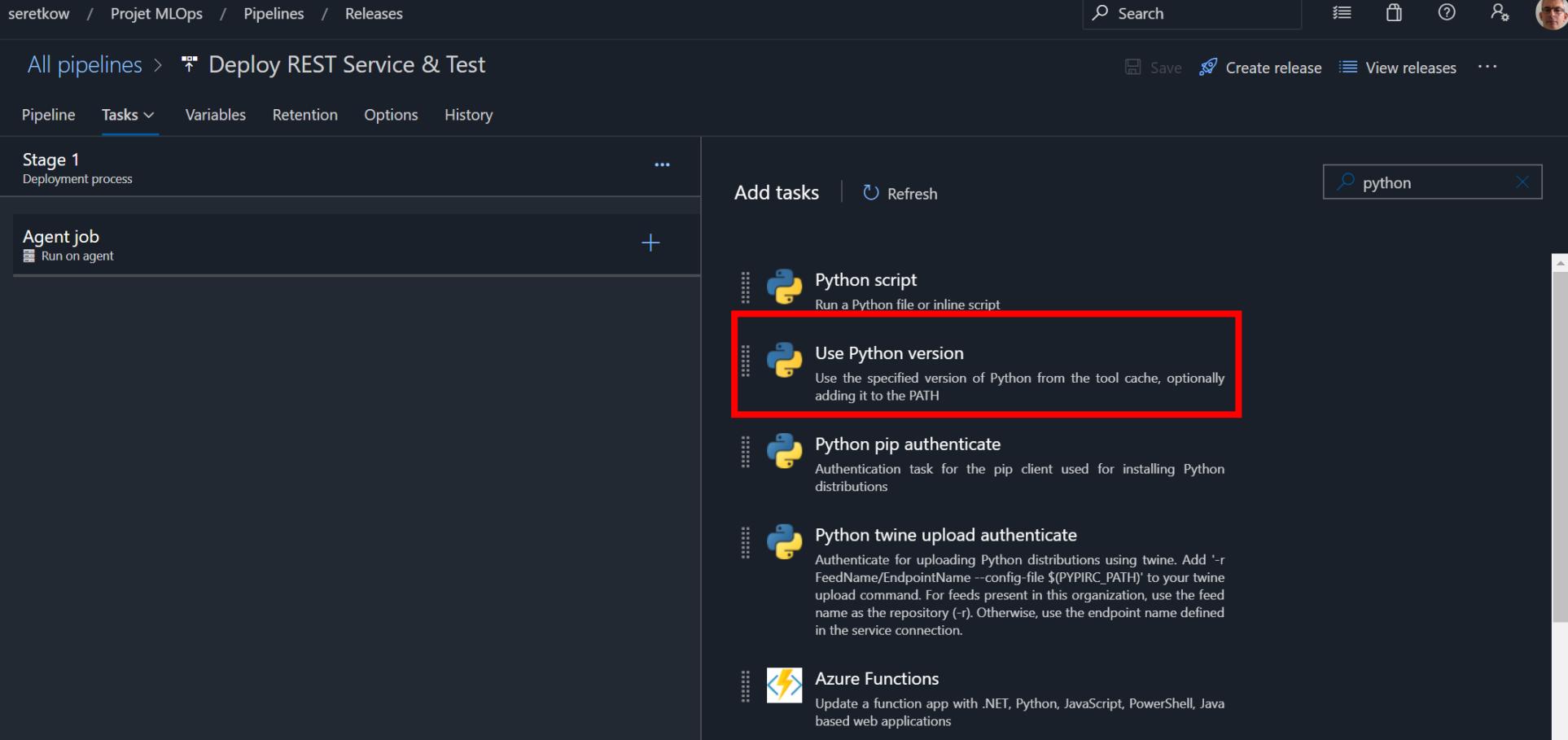
Ajout Agent Job



The screenshot shows the Azure DevOps Pipelines interface. On the left, the sidebar includes Project MLOps, Overview, Boards, Repos, Pipelines (selected), Environments, Releases, Library, Task groups, Deployment groups (selected), Test Plans, Artifacts, and Compliance. The main area displays the 'All pipelines > Deploy REST Service & Test' pipeline. The 'Stage 1 Deployment process' contains an 'Agent job' task, which is currently selected. The right-hand panel shows the configuration for this Agent job:

- Display name ***: Agent job
- Agent selection ^**
- Agent pool**: Azure Pipelines
- Agent Specification ***: ubuntu-18.04
- Demands**: (empty)
- Execution plan ^**
- Parallelism**: None

Ajout Python version

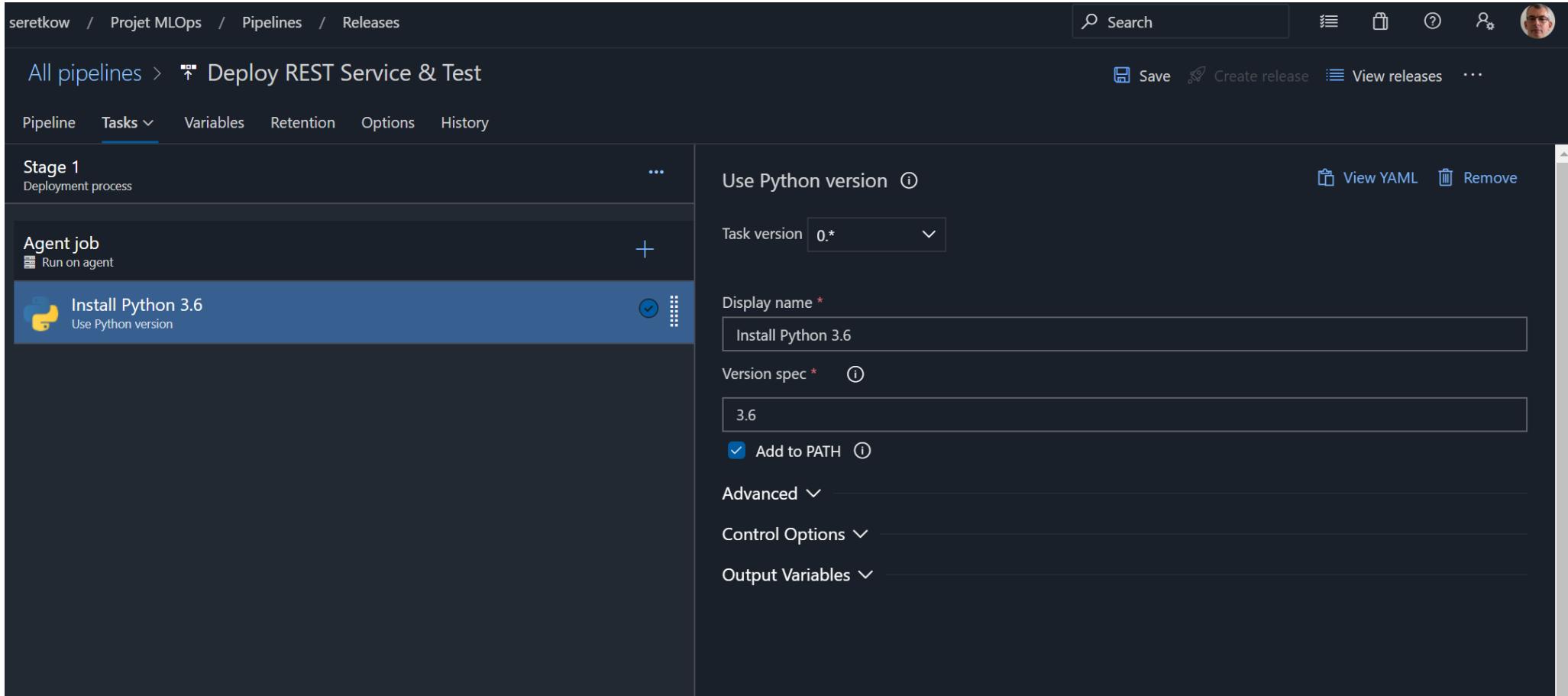


The screenshot shows the Azure DevOps Pipeline interface. The pipeline is named "Deploy REST Service & Test". The "Tasks" tab is selected. A search bar at the top right contains the text "python". The results list includes:

- Python script
- Use Python version** (highlighted with a red box)
- Python pip authenticate
- Python twine upload authenticate
- Azure Functions

The "Use Python version" task is described as "Use the specified version of Python from the tool cache, optionally adding it to the PATH".

Paramétrage Python version



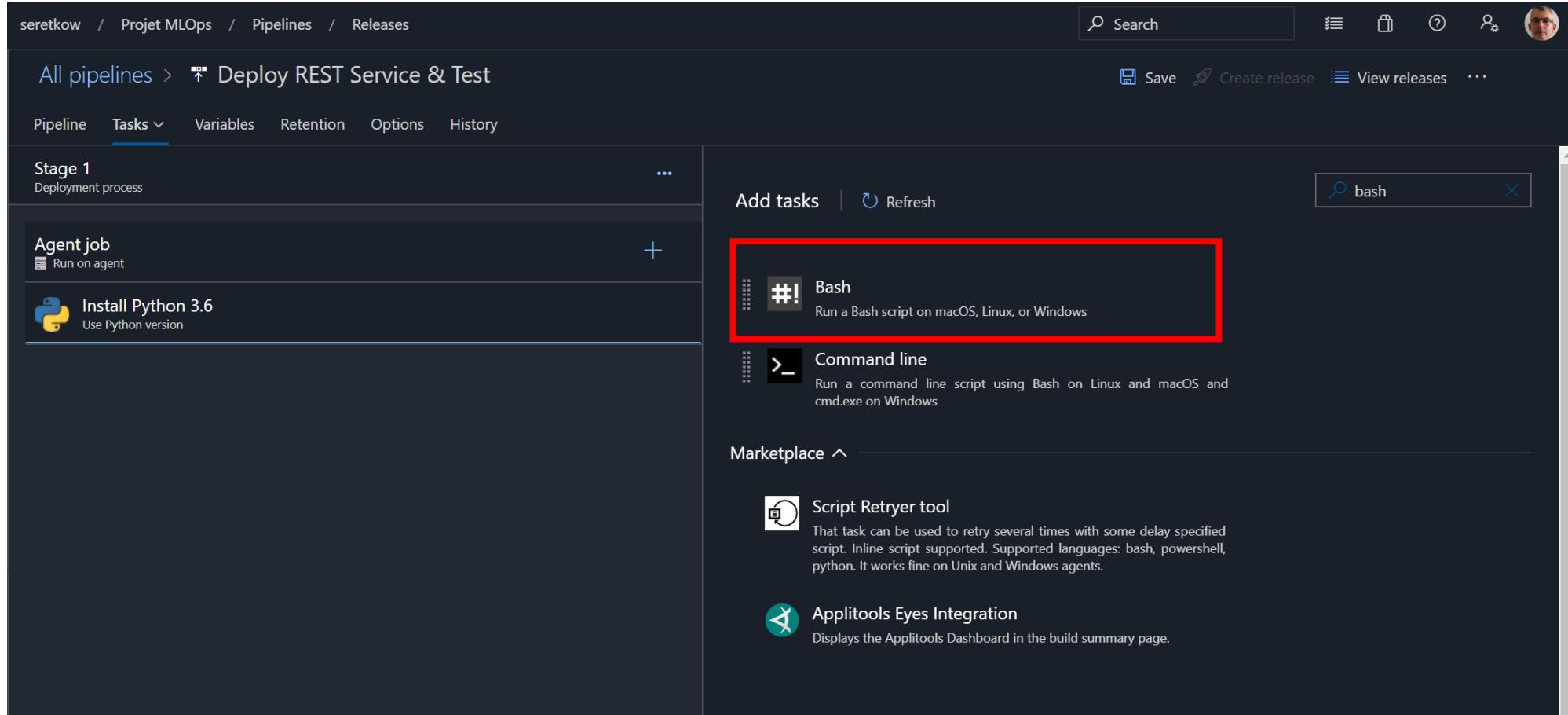
The screenshot shows the Azure DevOps Pipelines interface for a project named "Projet MLOps". The pipeline is titled "Deploy REST Service & Test". The "Tasks" tab is selected, showing a single stage named "Stage 1: Deployment process". Inside this stage, there is an "Agent job" with a task named "Install Python 3.6". This task is currently selected, highlighted in blue.

Task Configuration:

- Use Python version**: Task version is set to 0.*.
- Display name**: Set to "Install Python 3.6".
- Version spec**: Set to 3.6.
- Add to PATH**: Checked.
- Advanced**, **Control Options**, and **Output Variables** sections are collapsed.

At the top right of the pipeline view, there are buttons for "Save", "Create release", "View releases", and more.

Ajout Bash



The screenshot shows the Azure DevOps Pipeline interface. On the left, there's a navigation bar with 'seretkov / Projet MLOps / Pipelines / Releases'. Below it, the pipeline name 'All pipelines > Deploy REST Service & Test' is displayed. The 'Tasks' tab is selected. A search bar at the top right contains the text 'bash'. A red box highlights the first task in the list: '#! Bash'.

Add tasks | Refresh

bash

#! Bash
Run a Bash script on macOS, Linux, or Windows

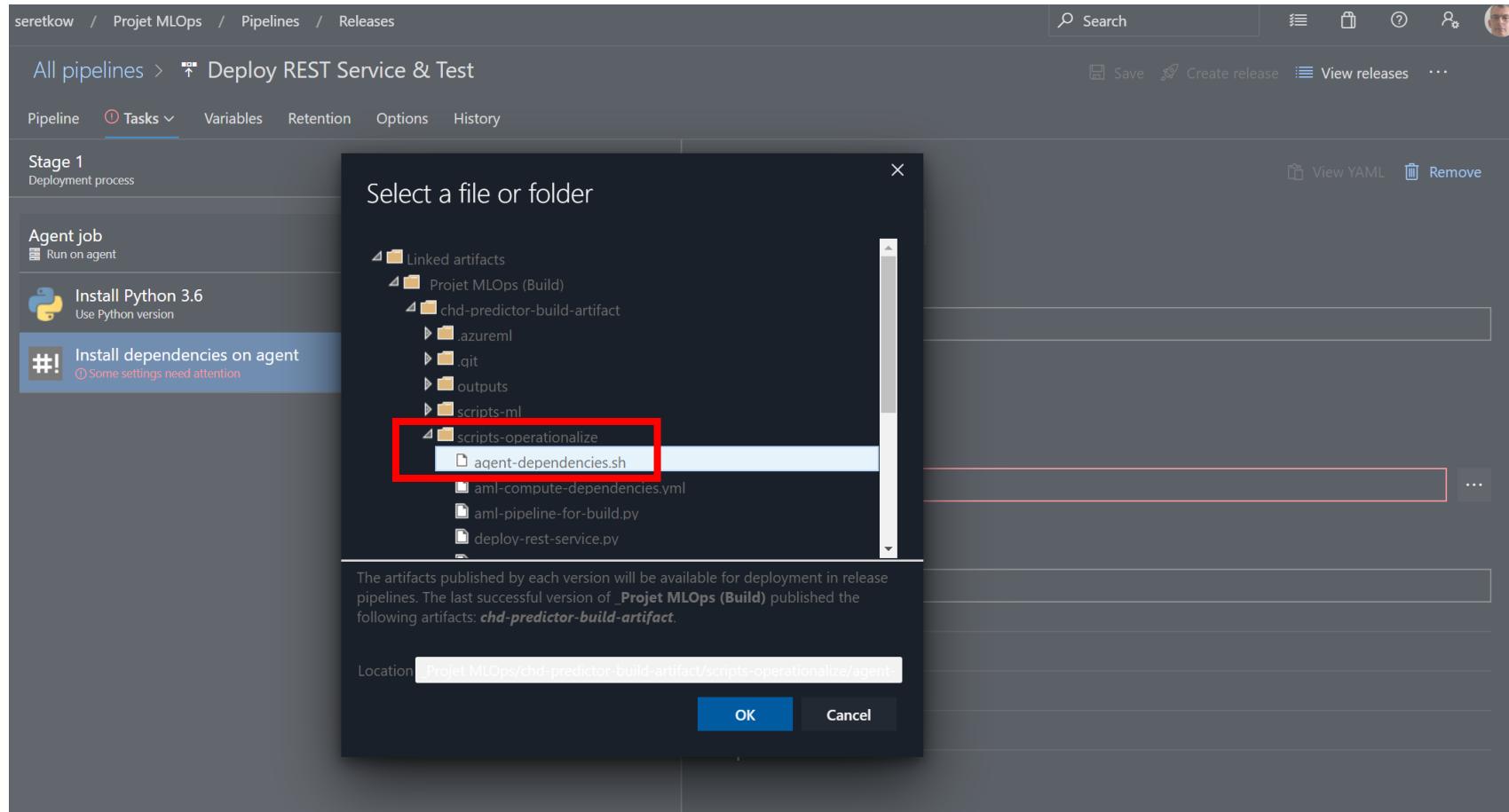
Command line
Run a command line script using Bash on Linux and macOS and cmd.exe on Windows

Marketplace

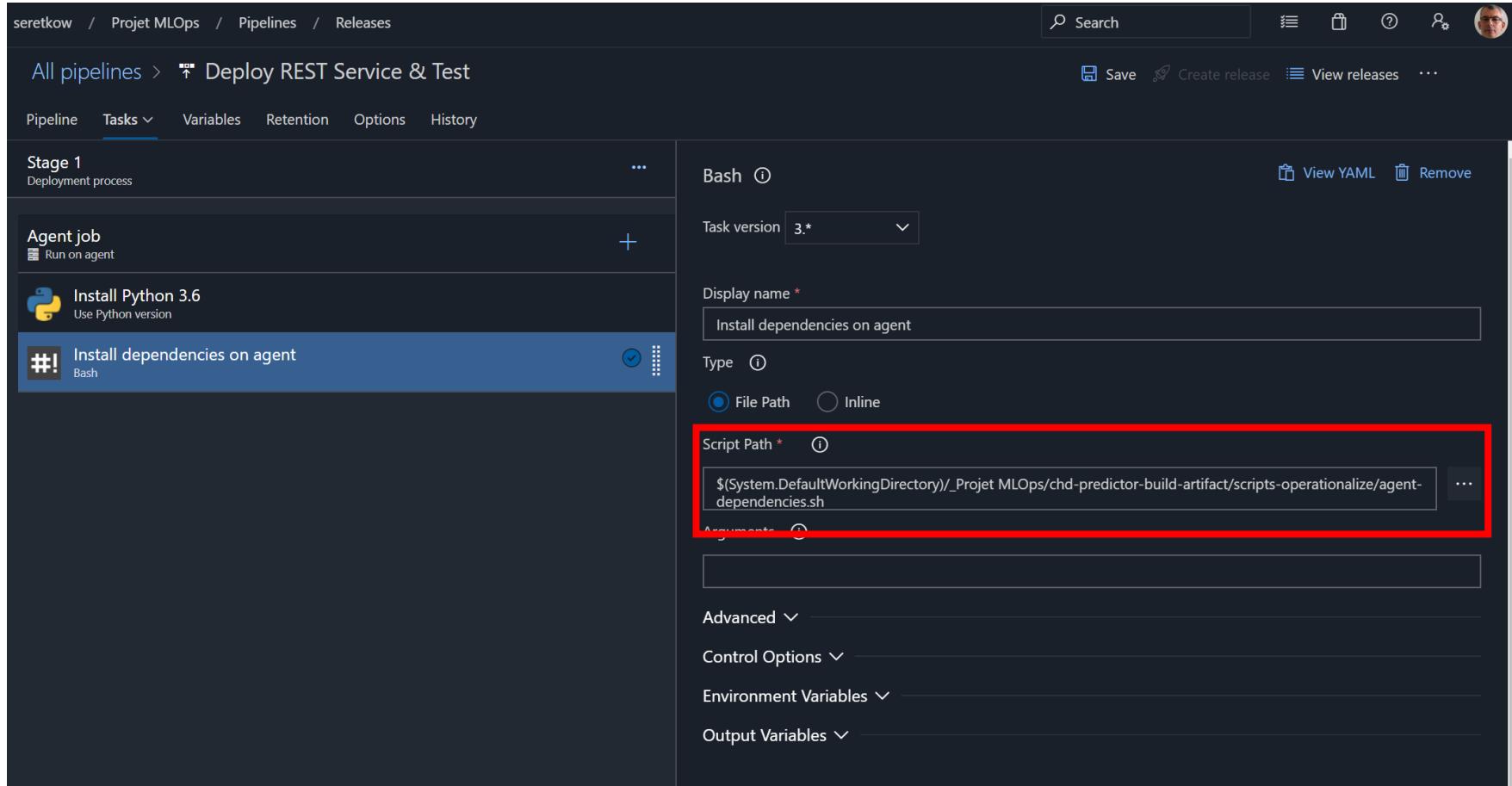
Script Retryer tool
That task can be used to retry several times with some delay specified script. Inline script supported. Supported languages: bash, powershell, python. It works fine on Unix and Windows agents.

Applitools Eyes Integration
Displays the Applitools Dashboard in the build summary page.

Paramétrage Bash



Paramétrage Bash



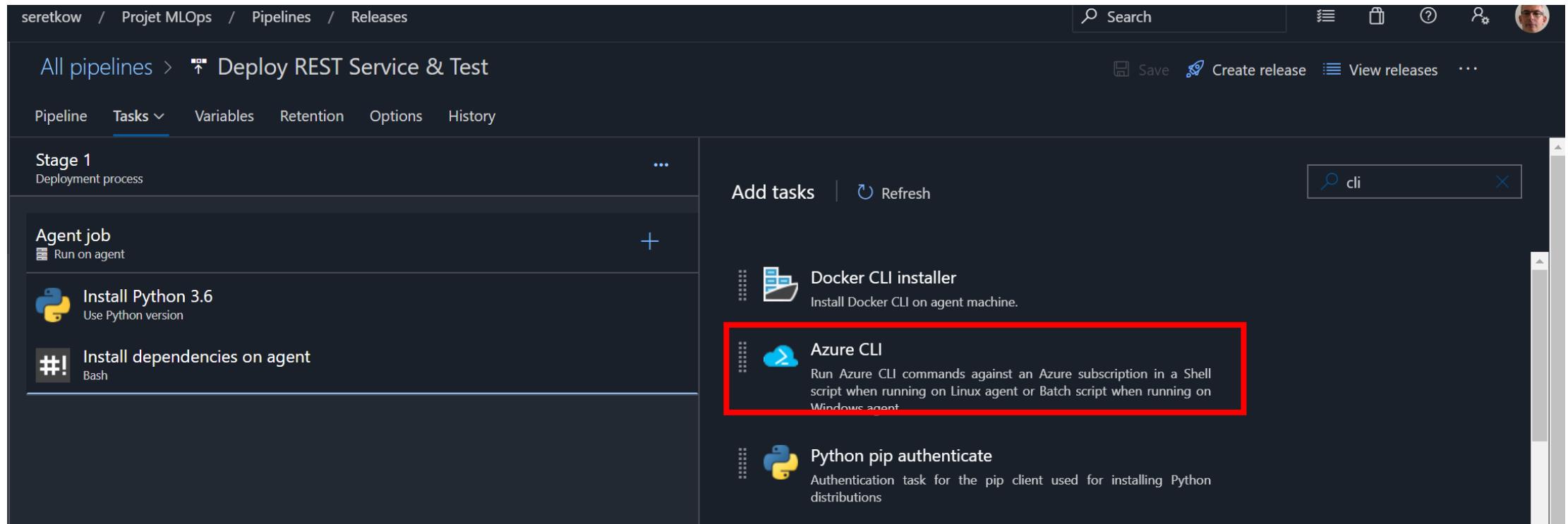
The screenshot shows the Azure DevOps interface for pipeline configuration. On the left, the pipeline structure is visible with a Stage 1 containing an Agent job and a Bash task named "Install dependencies on agent". The right side shows the detailed configuration for this Bash task.

Bash Task Configuration:

- Task version:** 3.*
- Display name:** Install dependencies on agent
- Type:** File Path (selected)
- Script Path:** \$(System.DefaultWorkingDirectory)/_Projet MLOps/chd-predictor-build-artifact/scripts-operationalize/agent-dependencies.sh

A red box highlights the "Script Path" input field, indicating it is the focus of the configuration being discussed.

Ajout Azure CLI



The screenshot shows the Azure DevOps Pipelines interface for a pipeline named "Deploy REST Service & Test". The pipeline has one stage, "Stage 1: Deployment process", which contains two tasks: "Install Python 3.6" and "Install dependencies on agent". A search bar at the top right is set to "cli". In the "Add tasks" pane, the "Azure CLI" task is highlighted with a red box. The task description states: "Run Azure CLI commands against an Azure subscription in a Shell script when running on Linux agent or Batch script when running on Windows agent".

seretkow / Projet MLOps / Pipelines / Releases

All pipelines > Deploy REST Service & Test

Save Create release View releases ...

Pipeline Tasks Variables Retention Options History

Stage 1 Deployment process

Agent job Run on agent

+
Install Python 3.6 Use Python version
Install dependencies on agent Bash

Add tasks Refresh

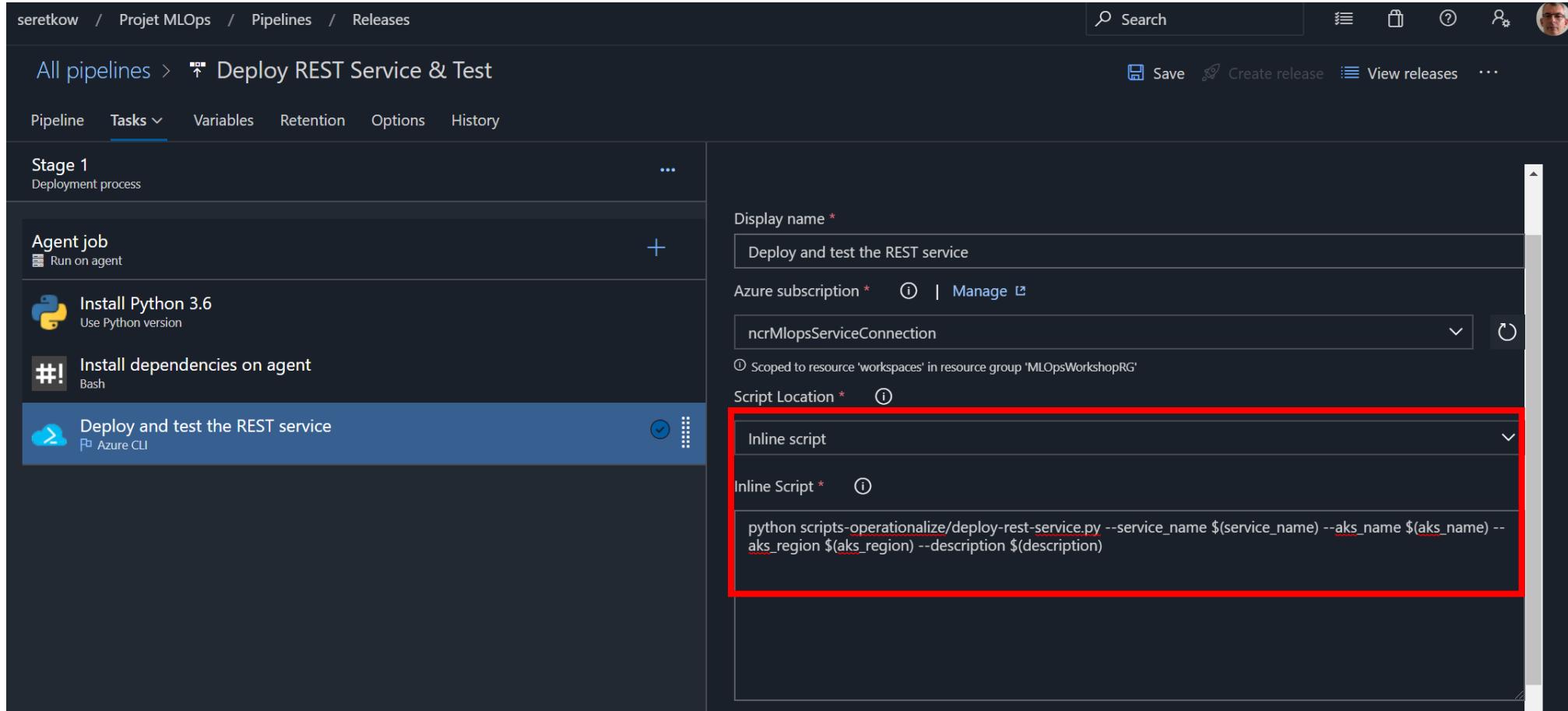
cli

Docker CLI installer
Install Docker CLI on agent machine.

Azure CLI
Run Azure CLI commands against an Azure subscription in a Shell script when running on Linux agent or Batch script when running on Windows agent

Python pip authenticate
Authentication task for the pip client used for installing Python distributions

Paramétrage Azure CLI



The screenshot shows the Azure DevOps Pipeline Editor interface. On the left, the pipeline structure is visible with a Stage 1 containing an Agent job with three tasks: Install Python 3.6, Install dependencies on agent, and Deploy and test the REST service. The Deploy and test the REST service task is currently selected, highlighted with a blue background. On the right, the task configuration pane is open, showing the following details:

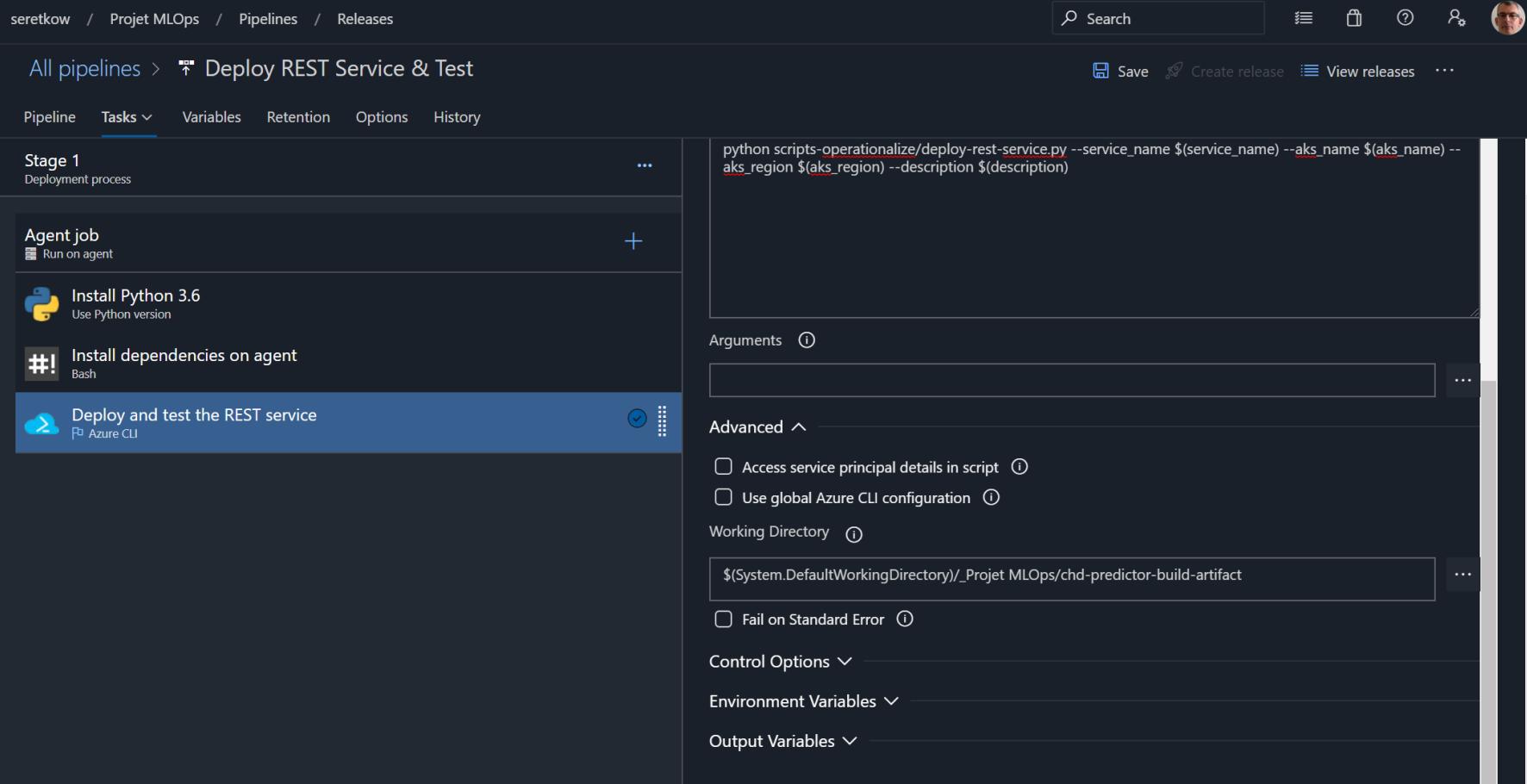
- Display name ***: Deploy and test the REST service
- Azure subscription ***: ncrMlopsServiceConnection
- Script Location ***: Inline script
- Inline Script ***:

```
python scripts-operationalize/deploy-rest-service.py --service_name $(service_name) --aks_name $(aks_name) --aks_region $(aks_region) --description $(description)
```

A red box highlights the inline script field.

python scripts-operationalize/deploy-rest-service.py --service_name \$(service_name) --aks_name \$(aks_name) --aks_region \$(aks_region) --description \$(description)

Paramétrage Azure CLI

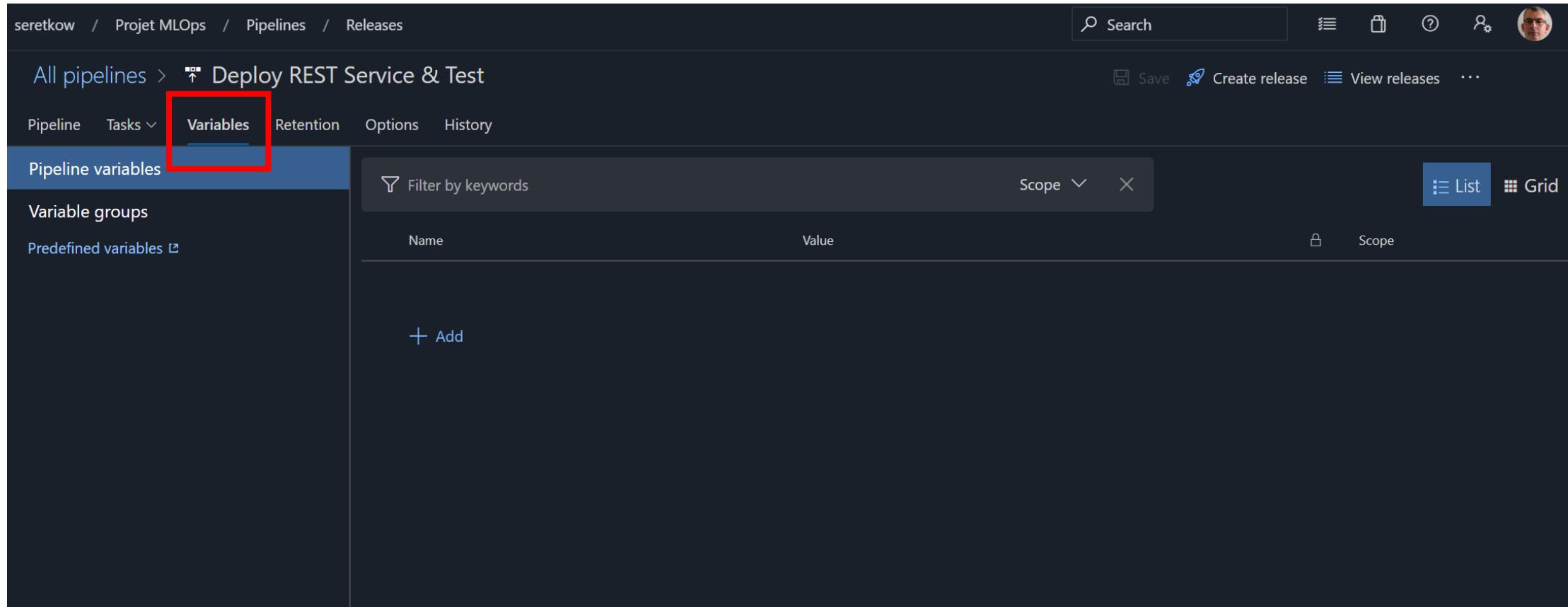


The screenshot shows the Azure DevOps Pipeline editor interface. The pipeline is named "Deploy REST Service & Test". The "Tasks" tab is selected. A single task, "Deploy and test the REST service" (using Azure CLI), is visible in the list. The task details pane on the right shows the command:

```
python scripts-operationalize/deploy-rest-service.py --service_name $(service_name) --aks_name $(aks_name) --aks_region $(aks_region) --description $(description)
```

The "Arguments" section contains an empty input field. The "Advanced" section includes options for "Access service principal details in script" and "Use global Azure CLI configuration", both of which are unchecked. The "Working Directory" is set to `$(System.DefaultWorkingDirectory)/_Projet MLOps/chd-predictor-build-artifact`. Other sections like "Control Options", "Environment Variables", and "Output Variables" are also present.

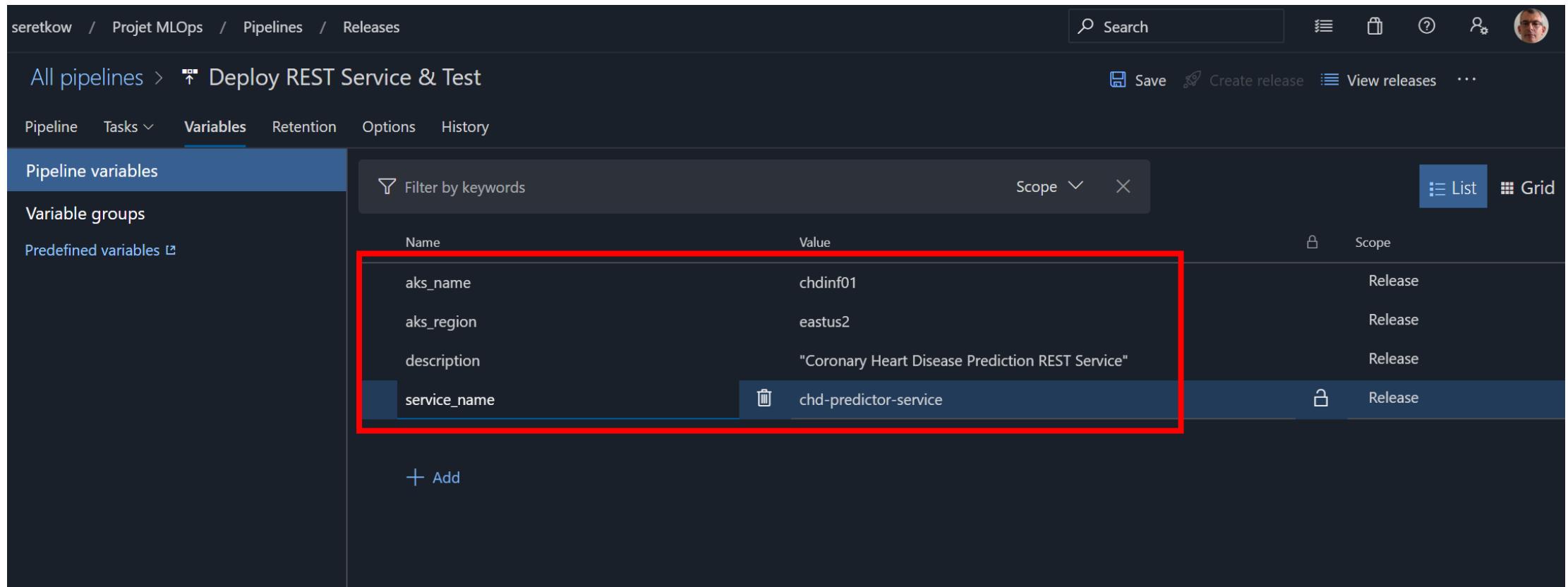
Accès définition des variables



The screenshot shows the Azure DevOps interface for managing pipeline variables. The top navigation bar includes 'seretkow / Projet MLOps / Pipelines / Releases'. On the right, there are 'Search', 'Save', 'Create release', 'View releases', and a user profile icon. The main title is 'All pipelines > Deploy REST Service & Test'. Below it, the 'Variables' tab is selected, highlighted by a red box. Other tabs include 'Pipeline', 'Tasks', 'Retention', 'Options', and 'History'. The left sidebar lists 'Pipeline variables', 'Variable groups', and 'Predefined variables'. The main content area displays a table with columns 'Name' and 'Value'. A 'Scope' dropdown and a 'Filter by keywords' input field are at the top of the table area. A 'List' button is also visible. At the bottom left, there is a '+ Add' button.

Name	Value	Scope	Scope
+ Add			

Ajout des variables

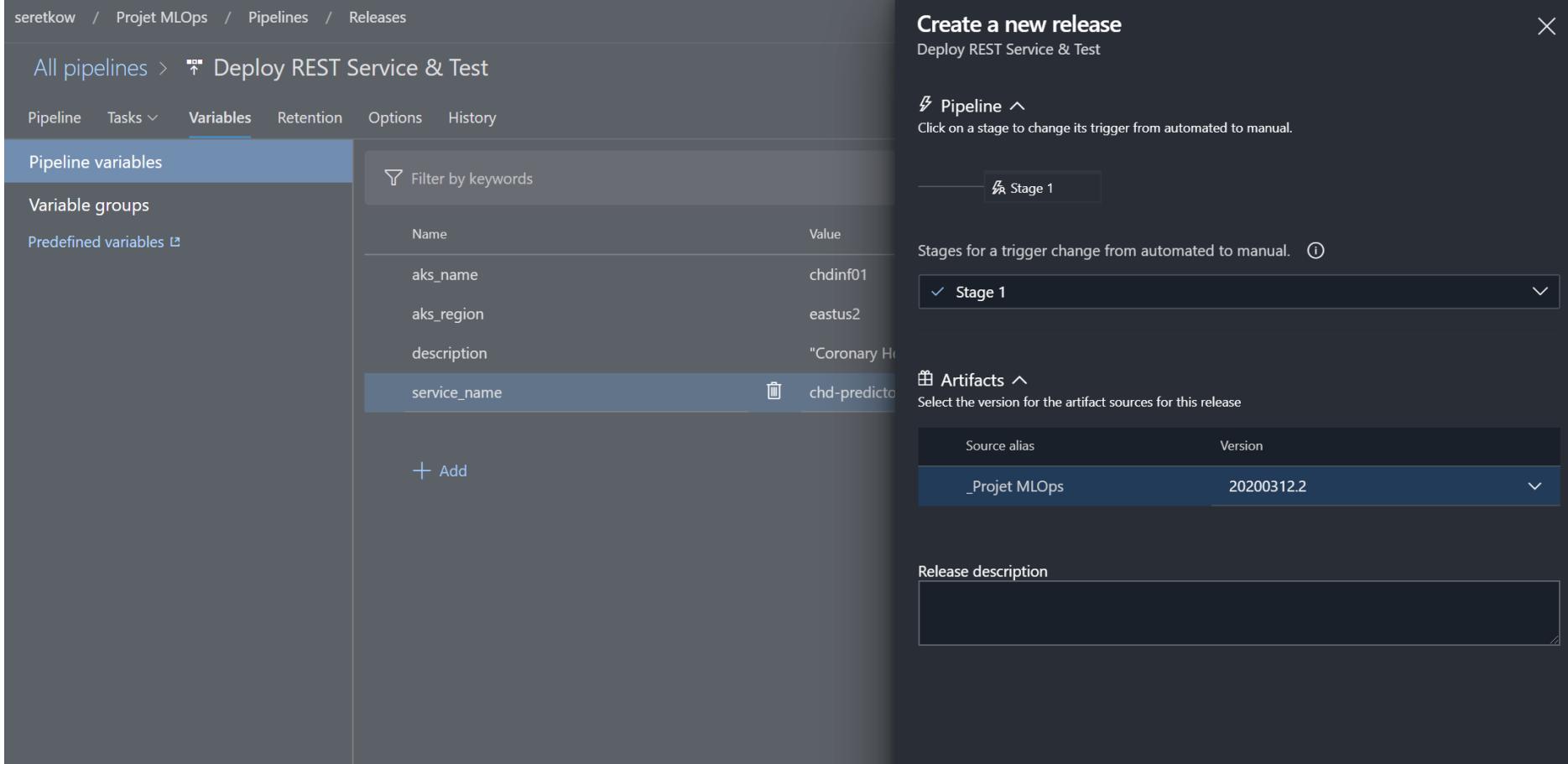


The screenshot shows the 'Variables' tab of a pipeline configuration in Azure DevOps. The pipeline is named 'Deploy REST Service & Test'. The 'Pipeline variables' section displays four variables:

Name	Value	Scope
aks_name	chdinf01	Release
aks_region	eastus2	Release
description	"Coronary Heart Disease Prediction REST Service"	Release
service_name	chd-predictor-service	Release

A red box highlights the last two rows of the table.

Sauvegarde



The screenshot shows the Azure DevOps interface for managing pipeline variables and creating a new release.

Pipeline Variables Page:

- Path: seretkow / Projet MLOps / Pipelines / Releases
- Pipeline: Deploy REST Service & Test
- Variables tab selected.
- Table of variables:

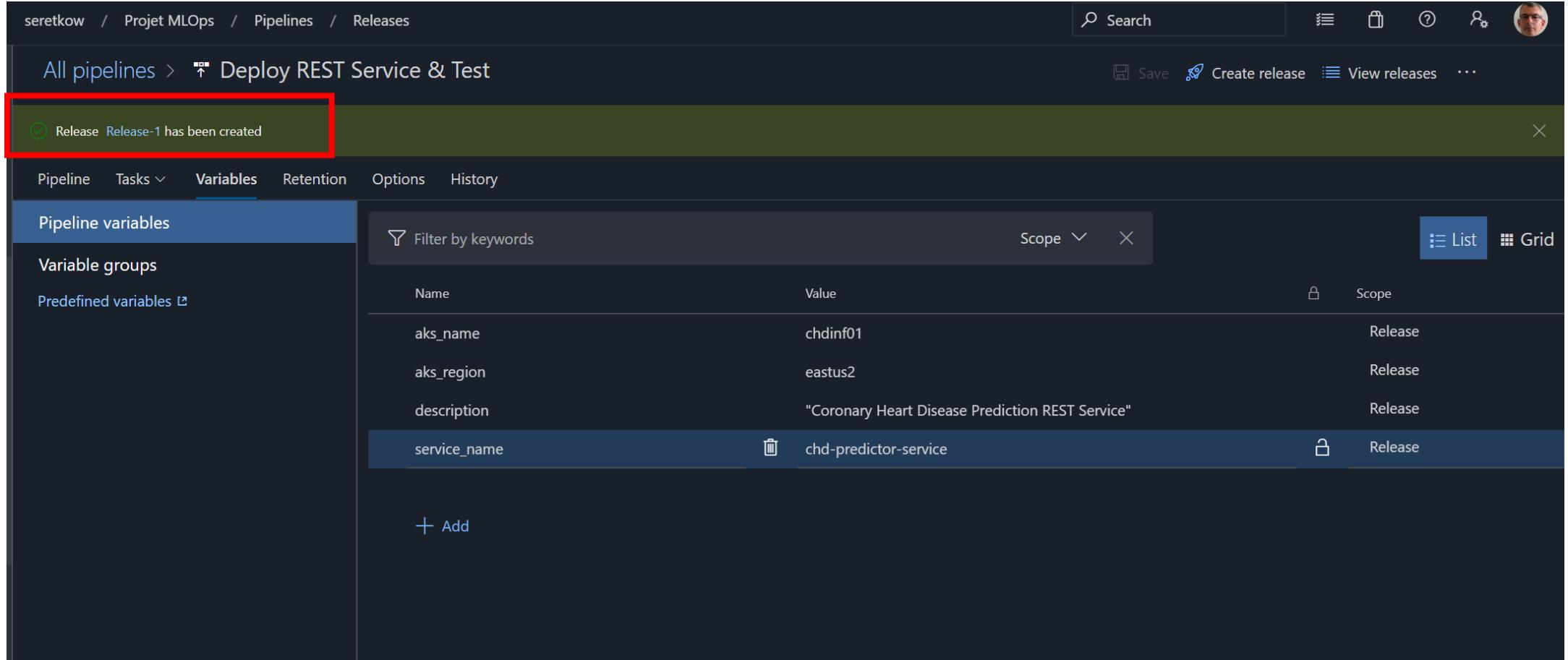
Name	Value
aks_name	chdinf01
aks_region	eastus2
description	"Coronary Heart Disease Prediction Model"
service_name	chd-predictor
- Add button (+) at the bottom left.

Create a new release Dialog:

- Title: Create a new release
Deploy REST Service & Test
- Pipeline section:
 - Stage 1 (selected)
 - Stages for a trigger change from automated to manual: Stage 1
- Artifacts section:
 - Select the version for the artifact sources for this release:

Source alias	Version
_Projet MLOps	20200312.2
- Release description field (empty).

Accès Release-1



The screenshot shows the Azure DevOps interface for managing pipeline variables. A red box highlights a green notification bar at the top stating "Release Release-1 has been created". The main area displays a table of pipeline variables:

Name	Value	Scope
aks_name	chdinf01	Release
aks_region	eastus2	Release
description	"Coronary Heart Disease Prediction REST Service"	Release
service_name	chd-predictor-service	Release

At the bottom left, there is a "+ Add" button.



Azure DevOps

Release-1

seretkow / Projet MLOps / Pipelines / Releases / Deploy REST Service & Test / Release-1

↑ Deploy REST Service & Test > Release-1

Pipeline Variables History + Deploy Cancel Refresh Edit ...

Release

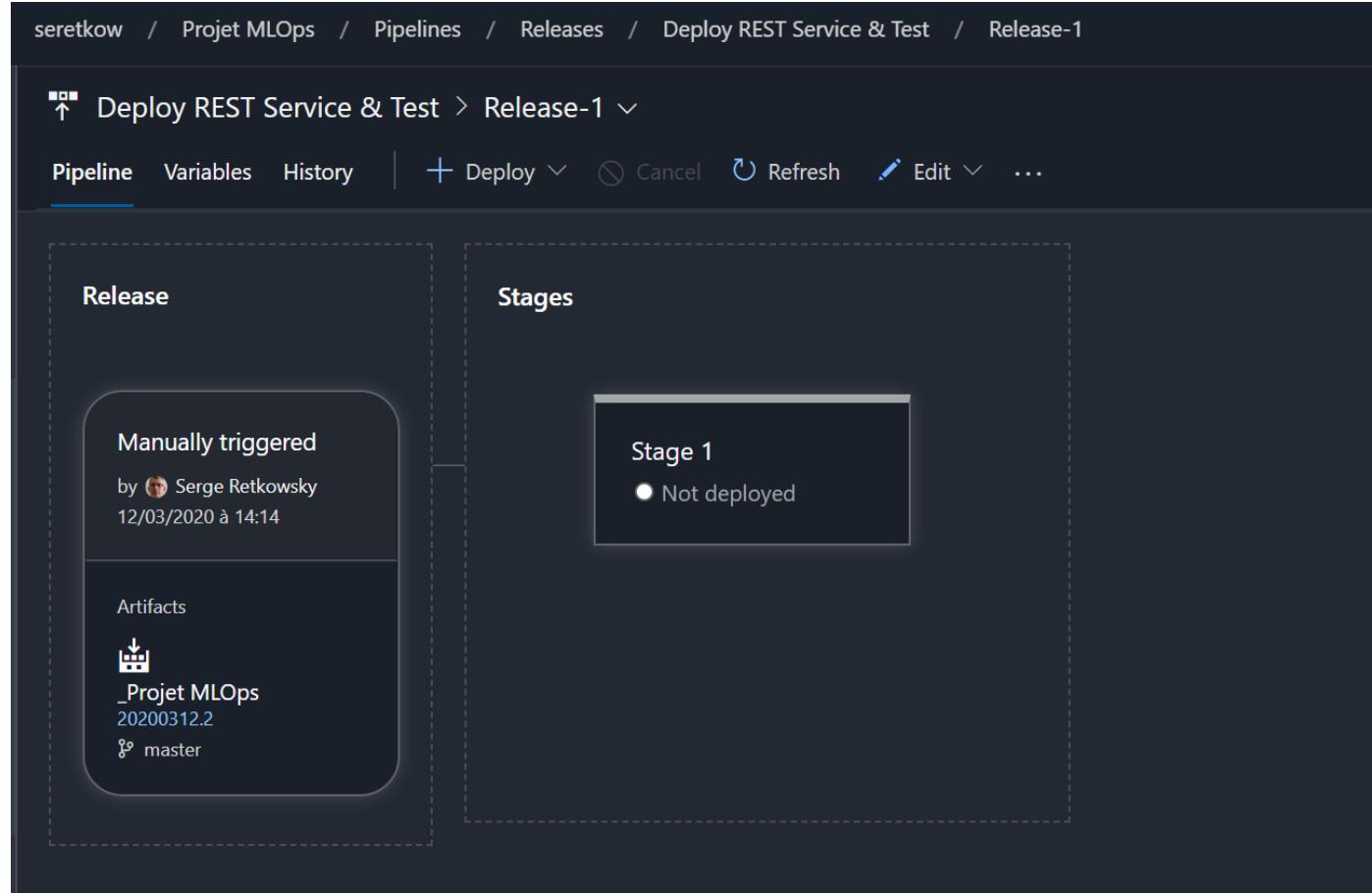
Manually triggered
by Serge Retkowsky
12/03/2020 à 14:14

Artifacts

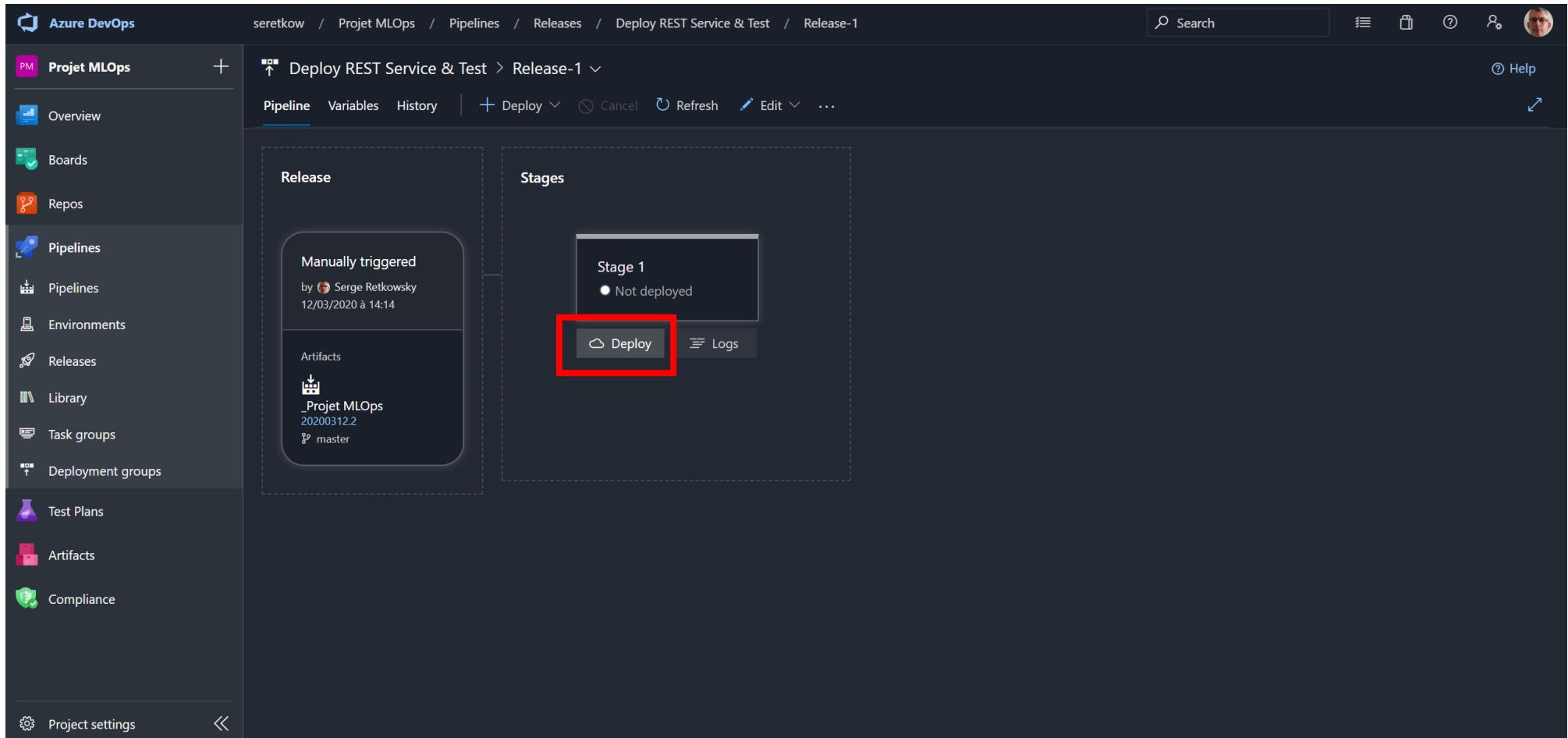
_Projet MLOps
20200312.2
master

Stages

Stage 1
● Not deployed



Deploy



The screenshot shows the Azure DevOps Pipeline interface for a project named "Projet MLOps". The pipeline is currently at the "Release-1" stage. On the left, the navigation menu is visible with options like Overview, Boards, Repos, Pipelines, Environments, Releases, Library, Task groups, Deployment groups, Test Plans, Artifacts, and Compliance. The "Releases" option is selected. The main area displays a "Release" card for "Manually triggered" by "Serge Retkowsky" on "12/03/2020 à 14:14". This release contains an artifact named "Projet MLOps 20200312.2" from the "master" branch. To the right, the "Stages" section shows a single stage named "Stage 1" which is currently "Not deployed". A prominent red box highlights the "Deploy" button associated with this stage.



Azure DevOps

Deploy

seretkow / Projet MLOps / Pipelines / Releases / Deploy REST Service & Test / Release-1 Search

[↑ Deploy REST Service & Test](#) > Release-1

Pipeline Variables History | + Deploy ▾ Cancel Refresh Edit ▾ ...

Release

Manually triggered by Serge Retkowsky 12/03/2020 à 14:14

Artifacts _Projet MLOps 20200312.2 master

Stages

Stage 1 Not deployed

Stage 1
Deploy release

Overview Commits Work Items

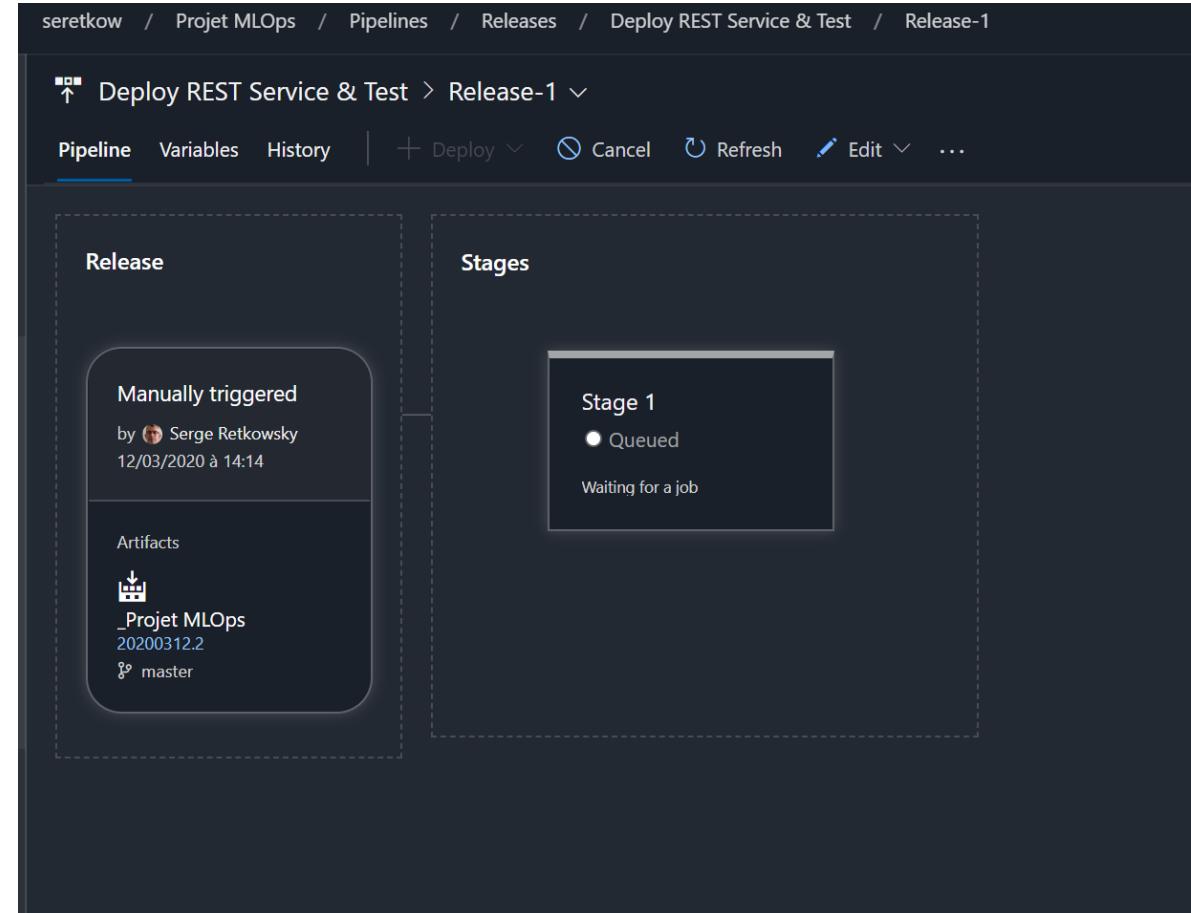
To be deployed (Deploying for the first time)
Release-1

Artifacts _Projet MLOps / 20200312.2 master

Comment
test

Deploy Cancel

Exécution du Release pipeline en cours





Azure DevOps

Exécution du Release pipeline en cours

seretkow / Projet MLOps / Pipelines / Releases / Deploy REST Service & Test / Release-1

↑ Deploy REST Service & Test > Release-1

Pipeline Variables History + Deploy Cancel Refresh Edit ...

Release

Manually triggered by Serge Retkowsky 12/03/2020 à 14:14

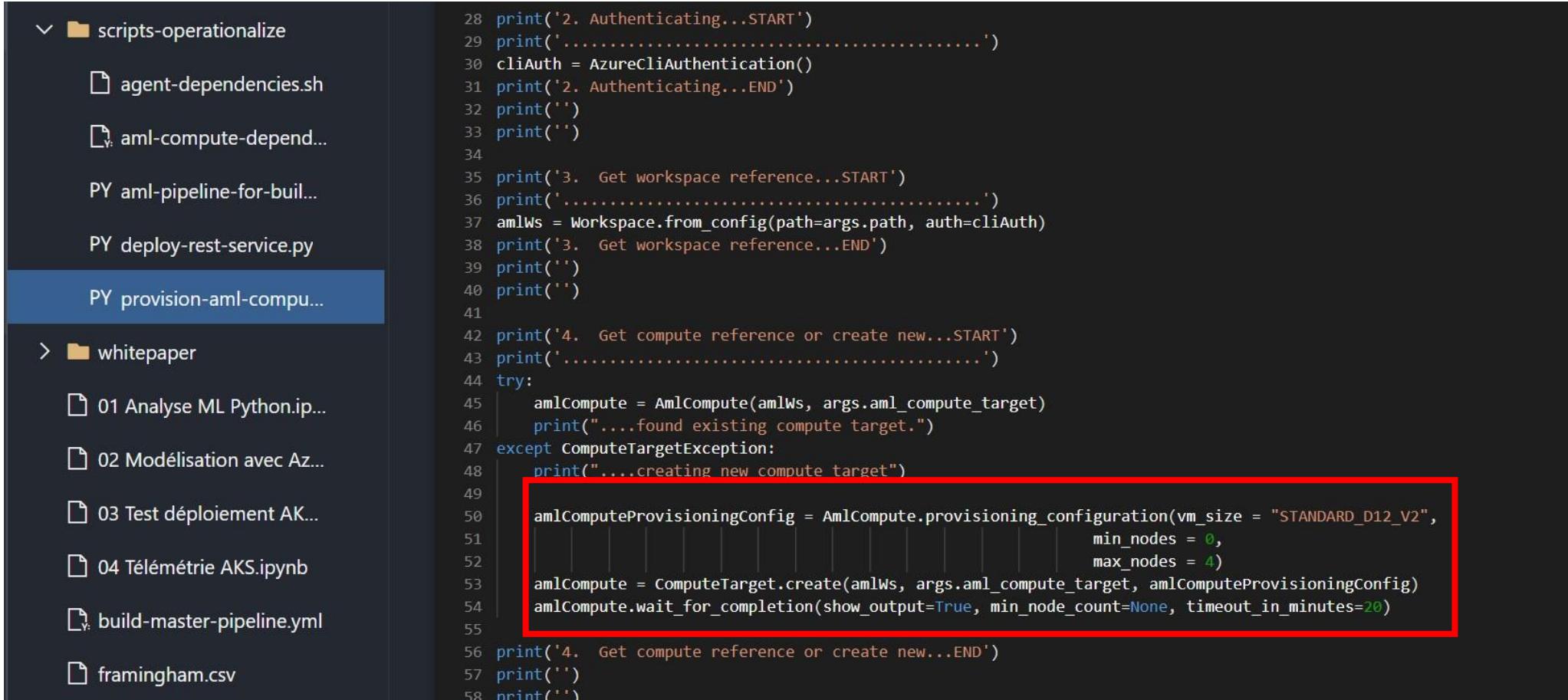
Artifacts _Projet MLOps 20200312.2 master

Stages

Stage 1 In progress 4/5 tasks Install dependencies 00:00

The screenshot shows the Azure DevOps interface for a release pipeline. The top navigation bar includes the organization name 'seretkow', project 'Projet MLOps', pipeline section, releases section, pipeline name 'Deploy REST Service & Test', and release name 'Release-1'. Below the navigation is a breadcrumb trail: Deploy REST Service & Test > Release-1. The main content area has tabs for Pipeline, Variables, History, and a primary tab for Deploy. It includes standard controls like Cancel, Refresh, Edit, and more options. On the left, under 'Release', it shows a summary of a manual trigger by 'Serge Retkowsky' on March 12, 2020, at 14:14, and lists artifacts from the '_Projet MLOps' build. On the right, under 'Stages', the first stage is displayed with a red border around its card. The stage is labeled 'Stage 1' and is currently 'In progress'. It shows a progress circle indicating '4/5 tasks' completed and the task 'Install dependencies' with a duration of '00:00'.

Informations AKS dans le fichier Python



The screenshot shows a code editor with a dark theme. On the left, there's a file tree:

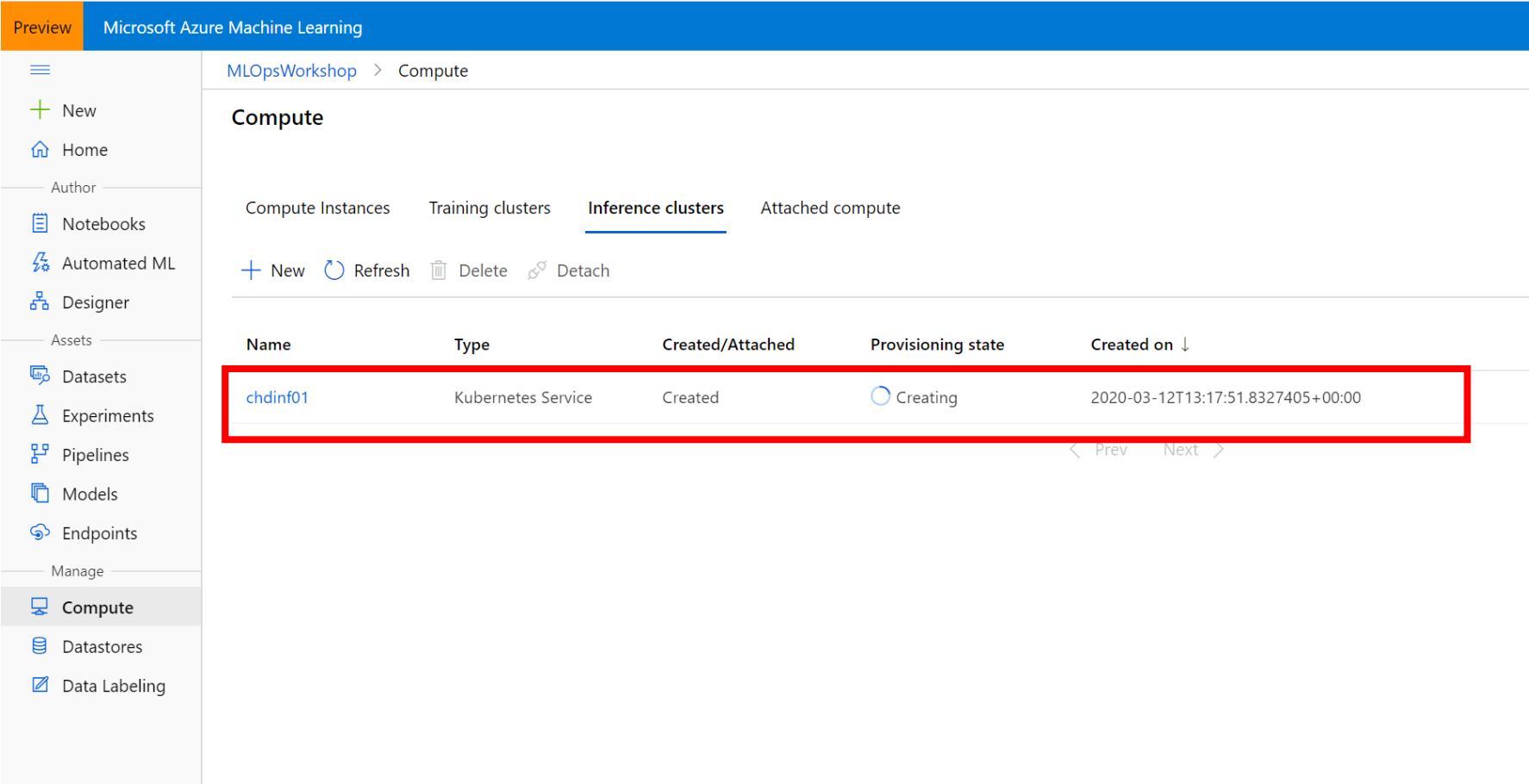
- scripts-operationalize
 - agent-dependencies.sh
 - aml-compute-depend...
 - aml-pipeline-for-buil...
 - deploy-rest-service.py
 - provision-aml-compu...** (highlighted in blue)
- whitepaper
 - 01 Analyse ML Python.ip...
 - 02 Modélisation avec Az...
 - 03 Test déploiement AK...
 - 04 Télémétrie AKS.ipynb
 - build-master-pipeline.yml
 - framingham.csv

The right pane contains the content of the `provision-aml-compu...` script:

```
28 print('2. Authenticating...START')
29 print('.....')
30 cliAuth = AzureCliAuthentication()
31 print('2. Authenticating...END')
32 print('')
33 print('')
34
35 print('3. Get workspace reference...START')
36 print('.....')
37 amlWs = Workspace.from_config(path=args.path, auth=cliAuth)
38 print('3. Get workspace reference...END')
39 print('')
40 print('')
41
42 print('4. Get compute reference or create new...START')
43 print('.....')
44 try:
45     amlCompute = AmlCompute(amlWs, argsaml_compute_target)
46     print("....found existing compute target.")
47 except ComputeTargetException:
48     print("....creating new compute target")
49
50 amlComputeProvisioningConfig = AmlCompute.provisioning_configuration(vm_size = "STANDARD_D12_V2",
51                                         min_nodes = 0,
52                                         max_nodes = 4)
53 amlCompute = ComputeTarget.create(amlWs, argsaml_compute_target, amlComputeProvisioningConfig)
54 amlCompute.wait_for_completion(show_output=True, min_node_count=None, timeout_in_minutes=20)
55
56 print('4. Get compute reference or create new...END')
57 print('')
58 print('')
```

A red box highlights the provisioning configuration code from line 50 to line 54.

Nous pouvons visualiser la création du cluster AKS par le Release Pipeline



The screenshot shows the Microsoft Azure Machine Learning interface. The left sidebar has a 'Preview' button highlighted in orange at the top, followed by a navigation menu with options like 'New', 'Home', 'Author', 'Notebooks', 'Automated ML', 'Designer', 'Assets', 'Datasets', 'Experiments', 'Pipelines', 'Models', 'Endpoints', and 'Manage'. Under 'Manage', the 'Compute' option is selected and highlighted in blue. The main content area is titled 'Compute' and shows tabs for 'Compute Instances', 'Training clusters', 'Inference clusters' (which is underlined in blue), and 'Attached compute'. Below these tabs are buttons for '+ New', 'Refresh', 'Delete', and 'Detach'. A table lists the details of an inference cluster:

Name	Type	Created/Attached	Provisioning state	Created on
chdinf01	Kubernetes Service	Created	Creating	2020-03-12T13:17:51.8327405+00:00

At the bottom of the table, there are navigation links for '< Prev', 'Next >'.

Exécution du Release Pipeline en cours

seretkow / Projet MLOps / Pipelines / Releases / Deploy REST Service & Test / Release-1

Search

Deploy REST Service & Test > Release-1 > Stage 1 In progress

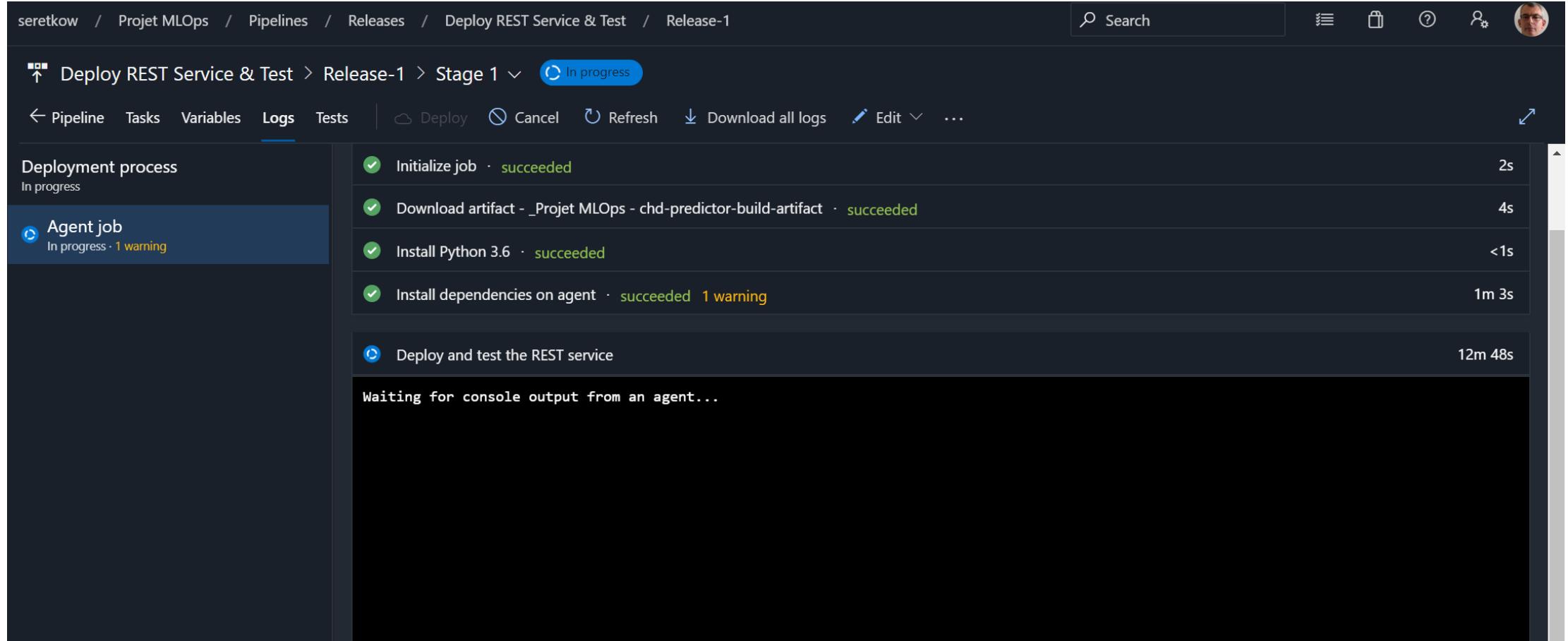
Pipeline Tasks Variables Logs Tests Deploy Cancel Refresh Download all logs Edit ...

Deployment process In progress

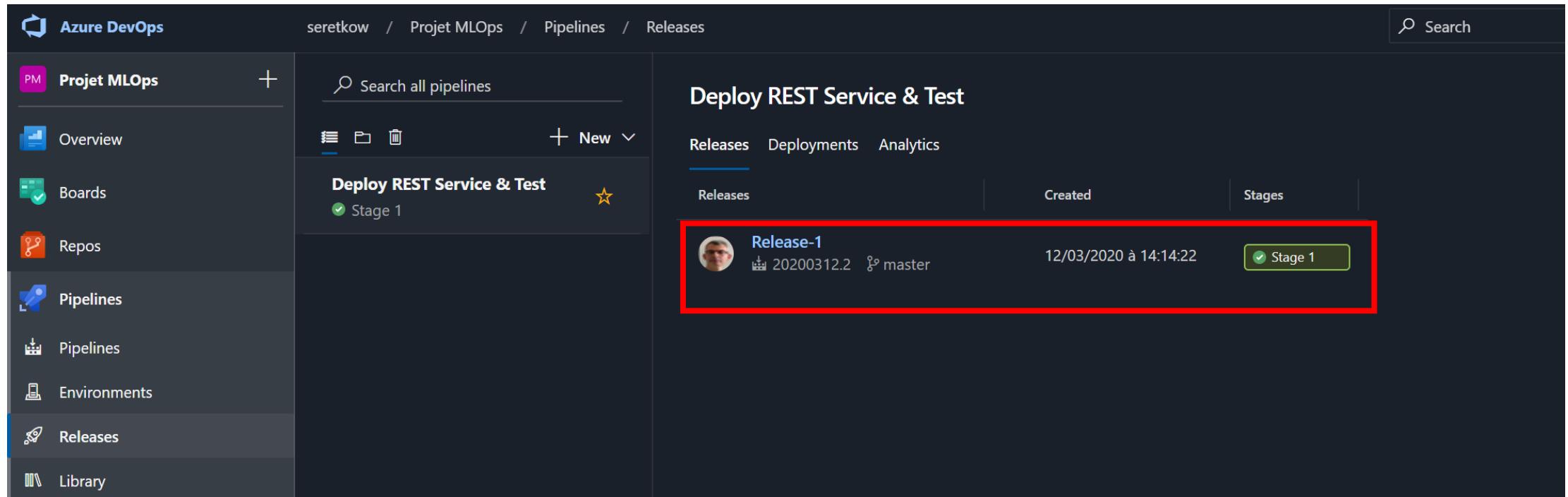
Agent job In progress - 1 warning

Task	Status	Duration
Initialize job	succeeded	2s
Download artifact - _Projet MLOps - chd-predictor-build-artifact	succeeded	4s
Install Python 3.6	succeeded	<1s
Install dependencies on agent	succeeded 1 warning	1m 3s
Deploy and test the REST service	In progress	12m 48s

Waiting for console output from an agent...



Fin de l'exécution du Release Pipeline



The screenshot shows the Azure DevOps interface for the 'Projet MLOps' project. The left sidebar highlights the 'Releases' section. The main area displays the 'Deploy REST Service & Test' pipeline. A specific release, 'Release-1', is shown in a card with a red border. The card details the release: it was created on 12/03/2020 at 14:14:22, triggered from the 'master' branch, and successfully completed 'Stage 1'.

Release	Created	Stages
Release-1 20200312.2 master	12/03/2020 à 14:14:22	Stage 1



Azure DevOps

Fin du traitement

The screenshot shows the Azure DevOps interface for a release pipeline. On the left, the sidebar lists various project management and development tools: PM, Overview, Boards, Repos, Pipelines, Pipelines, Environments, Releases, Library, Task groups, Deployment groups, Test Plans, Artifacts, and Compliance. The 'Releases' item is selected.

The main area displays a release pipeline named 'Deploy REST Service & Test' for 'Release-1'. The 'Release' section shows it was 'Manually triggered' by 'Serge Retkowsky' on '12/03/2020 à 14:14'. The 'Artifacts' section shows an artifact named '_Projet MLOps 20200312.2' from the 'master' branch.

The 'Stages' section shows a single stage named 'Stage 1' with a green checkmark indicating it has 'Succeeded'. A red box highlights this stage. Below it, a message states '1 warning' occurred on the same date and time as the trigger.

Notification automatique par email

[Build succeeded] Projet MLOps - Projet MLOps:master - Projet MLOps - 7ea1195a

Azure DevOps Notifications
À  Serge Retkowsky

Répondre Répondre à tous Transférer ...
ven. 13/03/2020 16:32
Autres compléments

AD Microsoft Azure DevOps

Build #20200313.2 SUCCEEDED

Projet MLOps

Ran for 22 minutes

[View results](#)

Summary

Build pipeline Projet MLOps

Finished Fri, Mar 13 2020 15:31:28 GMT+00:00

Requested for Serge Retkowsky

Reason Continuous integration

Visualisation AKS depuis le portail Azure



Home > Kubernetes services

Kubernetes services

Microsoft

+ Add Manage view Refresh Export to CSV Assign tags Feedback

Filter by name... Subscription == Microsoft Azure Internal Consumption Type == all Resource group == all Location == all Add filter

Showing 1 to 3 of 3 records.

<input type="checkbox"/> Name ↑↓	Type ↑↓	Resource group ↑↓	Location ↑↓	Subscription ↑↓	Location ID ↑↓	Tags	Kuberne... ↑↓
<input type="checkbox"/> aks-exemple42c702968f	Kubernetes service	AzureMLWorkshopRG	West Europe	Microsoft Azure Interna...	westeurope		1.14.8
<input type="checkbox"/> akstitanic75344941095	Kubernetes service	titanicworkspaceRG	West Europe	Microsoft Azure Interna...	westeurope		1.14.8
<input type="checkbox"/> chdinf0130d64001a0fc	Kubernetes service	MIOpsWorkshopRG	East US 2	Microsoft Azure Interna...	eastus2		1.14.8

Visualisation du real-time endpoint déployé dans AKS



Azure Machine Learning

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Endpoints

Endpoints

Real-time endpoints Pipeline endpoints

Refresh Delete Search to filter items...

Name	Description	Created On	Created By	Updated On ↓	Compute Type	Compute Target
chd-predictor-service	Coronary Heart Di...	March 12, 2020 2:32 PM	84611bf7-80f8-41c9-ad30-3c43d...	March 12, 2020 2:34 PM	AKS	chdinf01

< Prev Next >

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Endpoints

Endpoints

Real-time endpoints Pipeline endpoints

Refresh Delete Search to filter items...

Name	Description	Created On	Created By	Updated On ↓	Compute Type	Compute Target
chd-predictor-service	Coronary Heart Di...	March 12, 2020 2:32 PM	84611bf7-80f8-41c9-ad30-3c43d...	March 12, 2020 2:34 PM	AKS	chdinf01

< Prev Next >

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Endpoints

Endpoints

Real-time endpoints Pipeline endpoints

Refresh Delete Search to filter items...

Name	Description	Created On	Created By	Updated On ↓	Compute Type	Compute Target
chd-predictor-service	Coronary Heart Di...	March 12, 2020 2:32 PM	84611bf7-80f8-41c9-ad30-3c43d...	March 12, 2020 2:34 PM	AKS	chdinf01

< Prev Next >



Détails du endpoint

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Endpoints > chd-predictor-service

chd-predictor-service

[Details](#) [Consume](#)

Description	Coronary Heart Disease Prediction REST Service	CPU	0.1
Deployment state	Healthy	Memory	0.5 GB
Compute type	AKS	Autoscale enabled	true
Service ID	chd-predictor-service	Min replicas	1
Tags	name: chdinf01 image_id: chd-predictor-image:2	Max replicas	10
Created on	3/12/2020 2:32:48 PM	Target utilization	70%
Last updated on	3/12/2020 2:34:40 PM	Refresh period	1 s
Compute target	chdinf01	App Insights enabled	true
Image ID	chd-predictor-image:2	Event Hubs enabled	false
REST endpoint	[REDACTED]	Storage enabled	true
Key-based authentication enabled	true	Region	eastus2
Token-based authentication enabled	false	Last edited by	N/A
Swagger URI	[REDACTED]	Created by	N/A

Détails

Preview Microsoft Azure Machine Learning

MLOpsWorkshop > Endpoints > chd-predictor-service

chd-predictor-service

Details [Consume](#)

Basic consumption info

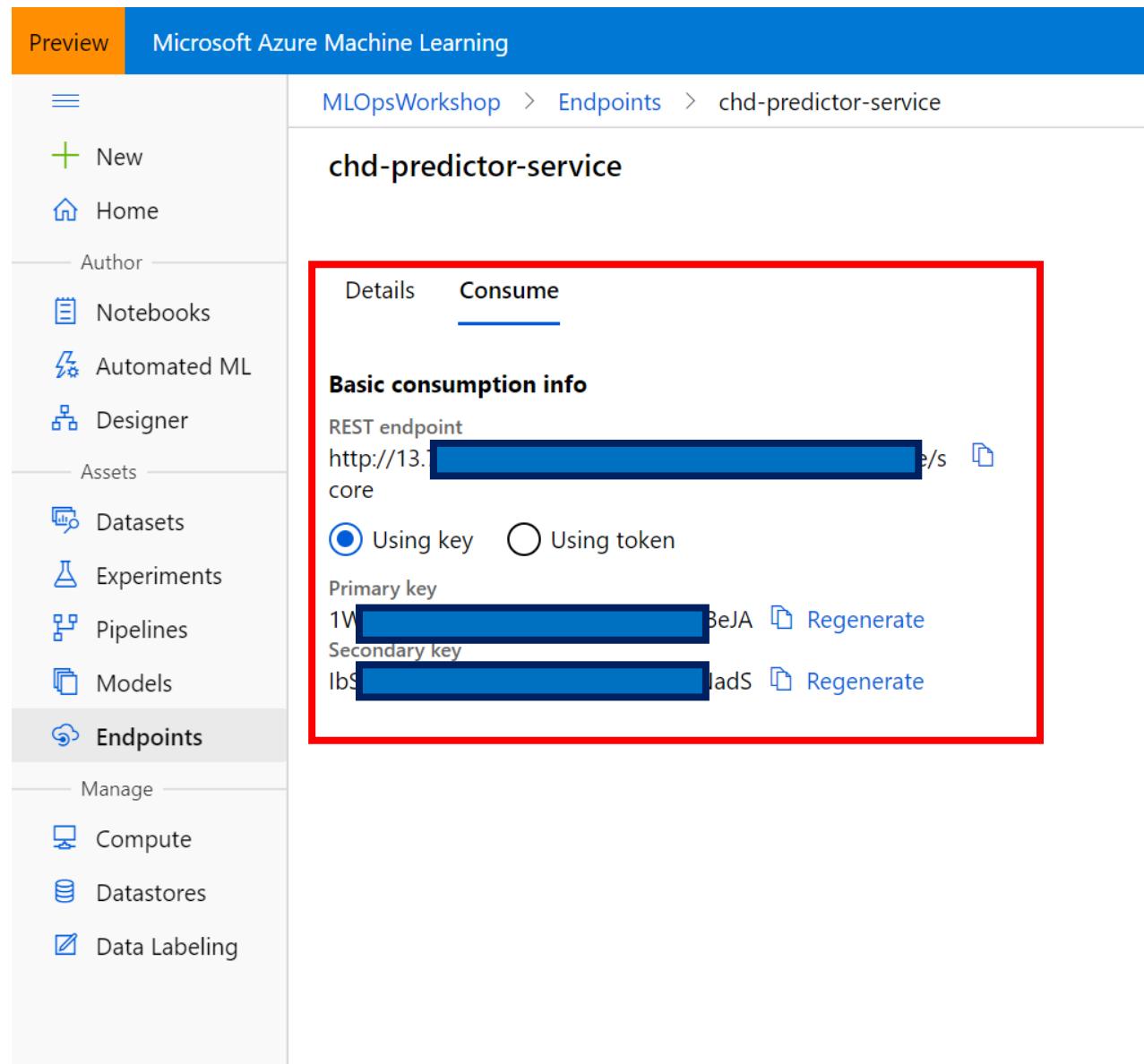
REST endpoint
http://13.1.1.1:8080/predictions [Copy](#)

core

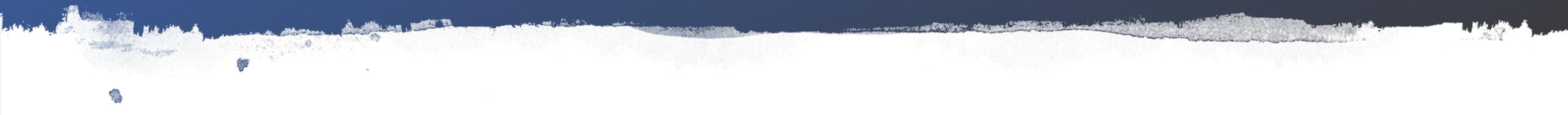
Using key Using token

Primary key
1WBeJA [Regenerate](#)

Secondary key
IbSdadS [Regenerate](#)



Workshop Tests et télémétrie



Test du modèle déployé avec notebook 03 Test déploiement AKS



Ce notebook Python permet de tester le modèle de ML déployé par MLOps.

jupyter 03 Test déploiement AKS Last Checkpoint: 3 hours ago (autosaved)

File Edit View Insert Cell Kernel Widgets Help

2020-03-12 09:57:00.588788

In [6]: `import requests
import json`

2. Tests call API

In [7]: `scoring_REST_uri = "ARENSEIGNER"`

In [8]: `REST_api_key = "ARENSEIGNER"`

In [9]: `# Set the content type
headers = {'Content-Type': 'application/json'}`
`# If authentication is enabled, set the authorization header
headers['Authorization'] = f'Bearer {REST_api_key}'`

In [10]: `toBeScored = {"data": [[61, 1, 150, 103], [43, 1, 180, 99]]}
resp = requests.post(scoring_REST_uri, json.dumps(toBeScored), headers=headers)
print("Résultats : ", resp.text)`

Résultats : "[1, 0]"

Fin

In []:

Test du modèle déployé avec notebook 03 Test déploiement AKS



Il est nécessaire de renseigner les informations relatives au endpoint et à la clef.

Jupyter 03 Test déploiement AKS Last Checkpoint: a few seconds ago (autosaved)

File Edit View Insert Cell Kernel Widgets Help

In [1]: `import sys
sys.version`
Out[1]: '3.6.9 |Anaconda, Inc.| (default, Jul 30 2019, 19:07:31) \n[GCC 7.3.0]'

In [2]: `import datetime
now = datetime.datetime.now()
print(now)`
2020-03-12 13:55:44.865632

In [3]: `import requests
import json`

2. Tests call API

In [4]: `scoring_REST_uri = "http://[REDACTED]:5000/predict"`

In [5]: `REST_api_key = "[REDACTED]"`

In [6]: `# Set the content type
headers = {'Content-Type': 'application/json'}`
`# If authentication is enabled, set the authorization header
headers['Authorization'] = f'Bearer {REST_api_key}'`

In [11]: `toBeScored = {"data":[[11, 1, 150],[67, 1, 138]]}
resp = requests.post(scoring_REST_uri,json.dumps(toBeScored), headers=headers)
print("Résultats : ", resp.text)`
Résultats : "[0, 1]"

Test du modèle déployé avec PostMan



The screenshot shows the Postman application interface. On the left, the sidebar lists collections: 'Azure ML service' (3 requests), 'Cognitive Services' (18 requests), 'Custom Vision' (7 requests), 'ACC' (4 requests), 'Maps' (4 requests), 'OpenHack Azure Cognitive Search' (63 requests), 'Workshop AML' (1 request), and 'Workshop MLOps' (1 request). The main workspace shows a POST request to 'http://13.77.72.52:80/api/v1/service/chd-predictor-service/score'. The 'Body' tab is selected, showing a JSON payload:

```
{"data":[[11, 1, 150],[67, 1, 138]]}
```

. The response at the bottom shows a status of 200 OK, time 1813ms, size 310 B, and the raw response:

```
1 "[0, 1]"
```

.

Test du modèle déployé avec PostMan



Azure Machine Learning

Params Authorization Headers (10) Body (1) Pre-request Script Tests Settings

▼ Headers (2)

KEY	VALUE
<input checked="" type="checkbox"/> Authorization	Bearer 1Wj4hE[REDACTED]eJA
<input checked="" type="checkbox"/> Content-Type	application/json

▶ Temporary Headers (8) i

Notebook 04 Télémétrie AKS

Ce notebook Python permet de générer différents appels au service afin de créer de la télémétrie.

jupyter 04 Télémétrie AKS Last Checkpoint: 3 hours ago (autosaved)

File Edit View Insert Cell Kernel Widgets Help Trusted

ws.write_config()
print('Workspace configuration succeeded')

Workspace configuration succeeded

2. Call du modèle

```
In [9]: # This is dummy data, just to test the call  
test_data = {"data": [[61, 1, 150], [43, 1, 180]]}
```

```
In [10]: headers = {'Content-Type': 'application/json', 'Authorization': ('Bearer ' + rest_service_key)}  
response = requests.post(rest_service_url, json.dumps(test_data), headers=headers)  
print('Predictions :')  
print(response.text)
```

Predictions :
"[0, 0]"

3. Activation télémétrie

```
In [11]: rest_service = Webservice(ws, rest_service_name)
```

```
In [12]: rest_service.update(enable_app_insights=True, collect_model_data=True)
```

4. Génération d'appels pour simuler des données de télémétries

```
In [28]: test_data = {"data": [[44, 1, 138], [43, 1, 150], [67, 1, 138]]}  
  
headers = {'Content-Type': 'application/json', 'Authorization': ('Bearer ' + rest_service_key)}  
response = requests.post(rest_service_url, json.dumps(test_data), headers=headers)  
print('Predictions :')  
print(response.text)
```

Predictions
"[0, 0, 1]"

Accès à AppInsights



Accès au service
AppInsights du
ressource group
Azure ML.

The screenshot shows the Azure Application Insights dashboard for the resource group `mlopsworkshop9122234384`. The dashboard includes the following details:

- Resource group (change) :** MLOpsWorkshopRG
- Location :** West Europe
- Subscription (change) :** Microsoft Azure Internal Consumption
- Subscription ID :** [REDACTED]
- Tags (change) :** Click here to add tags

The main area displays four charts under the heading "Show data for last: 1 hour":

- Failed requests:** A line chart showing 1 failed request at approximately 14:45 UTC+01:00.
- Server response time:** A line chart showing an average response time of 1,27 sec.
- Server requests:** A line chart showing 35 server requests at approximately 14:45 UTC+01:00.
- Availability:** A chart showing 80% availability.

Détails ApplInsights



The screenshot shows the Azure Application Insights Logs blade for the resource group 'mlopsworkshop9122234384'. The left sidebar has a red box around the 'Logs' item under the 'Monitoring' section. The main area displays a query editor with the following code:

```
traces  
| limit 50
```

The results table shows log entries from the last 24 hours:

timestamp [UTC]	message	severityLevel	itemType	customDimensions
12/03/2020 à 13:58:51.454	STDOUT	trace	trace	{"Workspace Name": "MLOpsWorkshop", "Timestamp": "Mar 12 13:58:51.454"}
12/03/2020 à 13:59:08.784	STDOUT	trace	trace	{"Workspace Name": "MLOpsWorkshop", "Timestamp": "Mar 12 13:59:08.784"}
12/03/2020 à 13:59:27.973	STDOUT	trace	trace	{"Workspace Name": "MLOpsWorkshop", "Timestamp": "Mar 12 13:59:27.973"}
12/03/2020 à 13:59:38.909	STDOUT	trace	trace	{"Workspace Name": "MLOpsWorkshop", "Timestamp": "Mar 12 13:59:38.909"}
12/03/2020 à 13:59:42.419	STDOUT	trace	trace	{"Workspace Name": "MLOpsWorkshop", "Timestamp": "Mar 12 13:59:42.419"}
12/03/2020 à 13:59:51.799	STDOUT	trace	trace	{"Workspace Name": "MLOpsWorkshop", "Timestamp": "Mar 12 13:59:51.799"}
12/03/2020 à 13:59:51.799	STDOUT	trace	trace	{"Workspace Name": "MLOpsWorkshop", "Timestamp": "Mar 12 13:59:51.799"}
12/03/2020 à 13:59:53.509	model_data_collection	trace	trace	{"Workspace Name": "MLOpsWorkshop", "Container Id": "chd-predictor", "Timestamp": "Mar 12 13:59:53.509"}
12/03/2020 à 13:59:53.510	STDOUT	trace	trace	{"Workspace Name": "MLOpsWorkshop", "Timestamp": "Mar 12 13:59:53.510"}

Page navigation and item count controls are at the bottom of the results table.

Métriques Azure ML



Searc resources, services, and docs (G+/)

Metrics

MLOpsWorkshop | Metrics

Machine Learning

Search (Ctrl+ /)

New chart Refresh Share Feedback Documentation Local Time : Last 24 hours (Automatic)

Assets

- Experiments
- Pipelines
- Compute
- Models
- Images
- Deployments
- Activities

Settings

- Properties
- Locks
- Export template

Monitoring

- Alerts
- Metrics
- Diagnostic settings

Support + troubleshooting

- Usage + quotas
- New support request OneNote 2016

Chart Title

Add metric Add filter Apply splitting Line chart Drill into Logs New alert rule Pin to dashboard ...

SCOPE: MLOpsWorkshop METRIC NAMESPACE: Machine Learning S... METER: Select metric AGGREGATION: Select aggregation

MODEL

- Model Deploy Failed
- Model Deploy Started
- Model Deploy Succeeded
- Model Register Failed
- Model Register Succeeded

QUOTA

- Active Cores

Select a metric above to see data appear on this chart or learn more below:

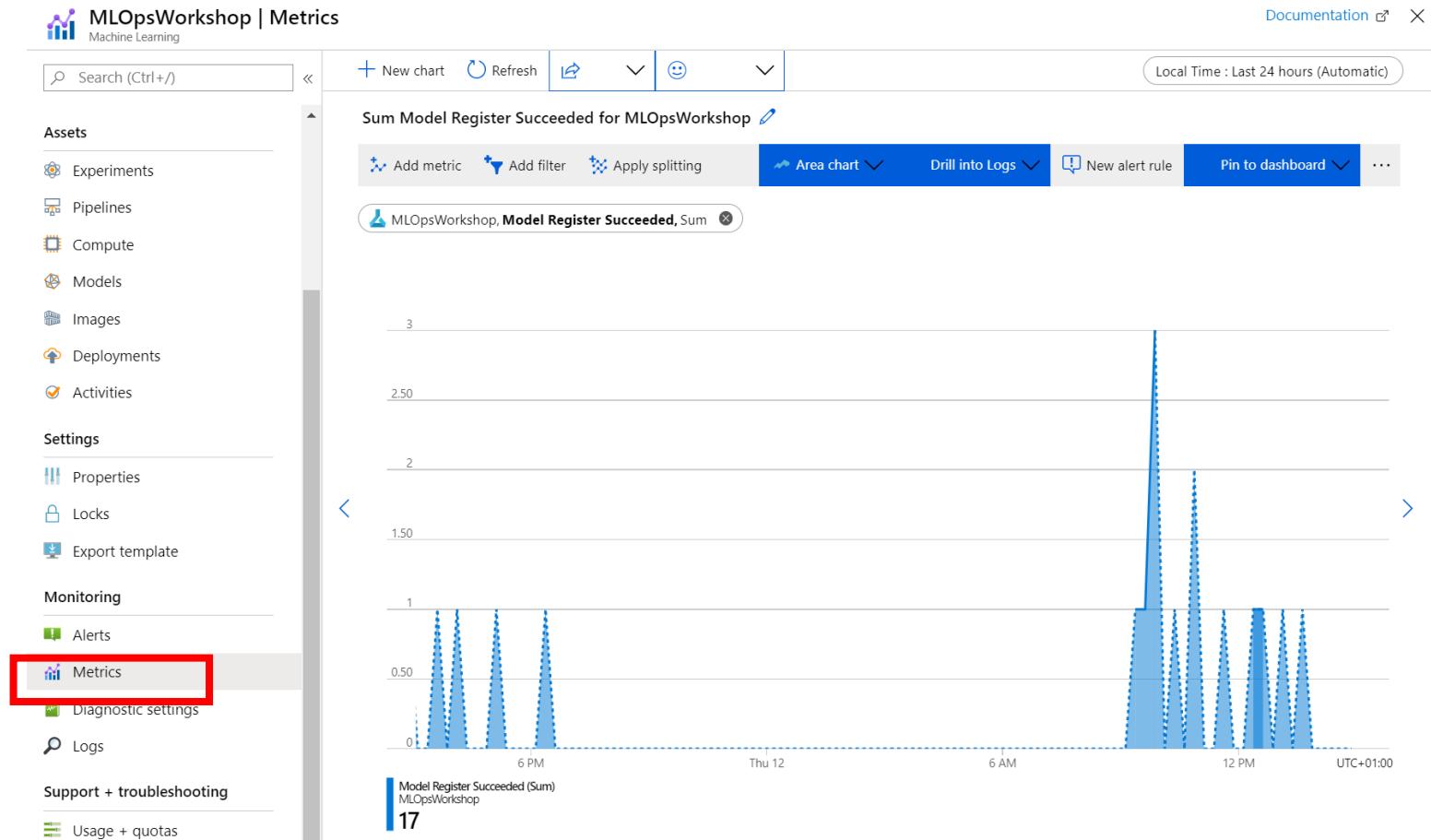
- Filter + Split Apply filters and splits to identify outlying segments
- Plot multiple metrics Create charts with multiple metrics and resources
- Build custom dashboards Pin charts to your dashboards

100
90
80
70
60
50
40
30
20
10
0

6 PM Thu 12 6 AM 12 PM UTC+01:00

The screenshot shows the Azure Machine Learning Metrics interface. The left sidebar is highlighted with a red box around the 'Metrics' option under the 'Monitoring' section. The main area displays a chart configuration screen with various filtering and aggregation options. A dropdown menu for selecting a metric is open, showing options like 'Model Deploy Failed', 'Model Deploy Started', etc. The interface includes a sidebar with sections for Assets, Settings, Monitoring, and Support + troubleshooting.

Métriques Azure ML





Azure Machine Learning

Stockage des données de télémétrie

Stockage des données dans un Blob storage.

Ajouter un blob storage dans l'option « **Continuous export** ».

The screenshot shows the 'mlopsworkshop9122234384 | Continuous export' page in the Azure Application Insights interface. The left sidebar lists various monitoring categories like Workbooks, Usage, and Configure. Under 'Configure', the 'Continuous export' option is highlighted with a red box. The main content area displays a table with one row of data:

STATUS	STORAGE ACCOUNT	LAST EXPORT
✓	continuousexpaml	16/03/2020 à 17:21:39



Visualisation des données de télémétrie

Home > Storage accounts > continuousexpaml | Containers > continuousexports

continuousexports Container

Search (Ctrl+ /) Upload Change access level Refresh Delete Change tier Acquire lease Break lease

Authentication method: Access key (Switch to Azure AD User Account)
Location: continuousexports / mlopsworkshop9122234384_a89c30e5d0434b8484b7b339ca68cee6 / Messages / 2020-03-16 / 16

Search blobs by prefix (case-sensitive)

Show deleted blobs

Name	Modified	Access tier	Blob type	Size	Lease state
[..]					
bc318085-b3d1-41ce-be05-0a4b2f8ada59_20200316_162209.blob	16/03/2020 à 17:22:08		Block blob	2.97 KiB	Available
cf2774bb-dae3-42e3-b788-6a40bd6c7dc7_20200316_162139.blob	16/03/2020 à 17:21:39		Block blob	1.01 KiB	Available

Export des données de télémétrie



Documentation



Documentation MLOps



MLOps

<https://azure.microsoft.com/fr-fr/services/machine-learning/mlops/>



Azure DevOps

<https://docs.microsoft.com/en-us/azure/devops/?view=azure-devops>



Blog

<https://devblogs.microsoft.com/devops/>



Pricing

<https://azure.microsoft.com/fr-fr/pricing/details/devops/azure-devops-services/>



Git MLOps

<https://github.com/microsoft/MLOps>

