ML and Data Engineering with Snowpark and Python

In this experiment, we will learn how to use Snowpark and Python for Machine Learning and Data Engineering.

Overview

By completing this guide, you will be able to go from raw data to an interactive application that can help organization optimize their advertising budget allocation.

Here is a summary of what you will be able to learn in each step by following this quickstart:

- Setup Environment: Use stages and tables to ingest and organize raw data from S3 into Snowflake
- Data Engineering: Leverage Snowpark for Python DataFrames to perform data transformations such as group by, aggregate, pivot, and join to prep the data for downstream applications.
- Data Pipelines: Use Snowflake Tasks to turn your data pipeline code into operational pipelines with integrated monitoring.
- Machine Learning: Prepare data and run ML Training in Snowflake using Snowpark ML and deploy the model as a Snowpark User-Defined-Function (UDF).
- Streamlit: Build an interactive Streamlit application using Python (no web development experience required) to help visualize the ROI of different advertising spend budgets.

In case you are new to some of the technologies mentioned above, here's a quick summary with links to documentation.

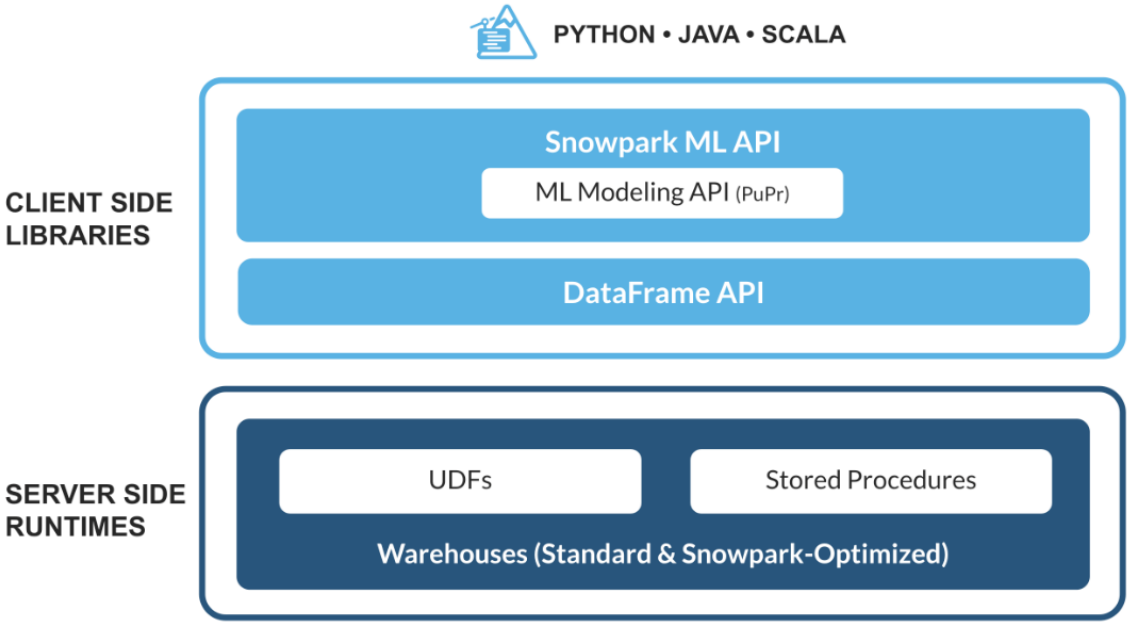
What is Snowpark?

The set of libraries and runtimes in Snowflake that securely deploy and process non-SQL code, including Python, Java and Scala.

Familiar Client Side Libraries - Snowpark brings deeply integrated, DataFrame-style programming and OSS compatible APIs to the languages data practitioners like to use. It also includes the Snowpark ML API for more efficient ML modeling (public preview) and ML operations (private preview).

Flexible Runtime Constructs - Snowpark provides flexible runtime constructs that allow users to bring in and run custom logic. Developers can seamlessly build data pipelines, ML models, and data applications with User-Defined Functions and Stored Procedures.

Learn more about Snowpark.



What is Snowpark ML?

Snowpark ML is a new library for faster and more intuitive end-to-end ML development in Snowflake. Snowpark ML has 2 APIs: Snowpark ML Modeling (in Public Preview) for model development and Snowpark ML Operations (in Private Preview) for model deployment.

This quickstart will focus on the Snowpark ML Modeling API, which scales out feature engineering and simplifies ML training execution in Snowflake.

What is Streamlit?

Streamlit enables data scientists and Python developers to combine Streamlit's component-rich, open-source Python library with the scale, performance, and security of the Snowflake platform.

Learn more about Streamlit.

What You Will Learn

- How to analyze data and perform data engineering tasks using Snowpark DataFrames and APIs
- How to use open-source Python libraries from curated Snowflake Anaconda channel
- How to train ML model using Snowpark ML in Snowflake
- How to create Scalar and Vectorized Snowpark Python User-Defined Functions (UDFs) for online and offline inference respectively
- How to create Snowflake Tasks to automate data pipelines
- How to create Streamlit application that uses the Scalar UDF for inference based on user input

Prerequisites

- Git installed
- Python 3.9 installed
    - Note that you will be creating a Python environment with 3.9 in the Get Started step
- A Snowflake account with Anaconda Packages enabled by ORGADMIN. If you do not have a Snowflake account, you can register for a free trial account.
- A Snowflake account login with ACCOUNTADMIN role. If you have this role in your environment, you may choose to use it. If not, you will need to 1) Register for a free trial, 2) Use a different role that has the ability to create database, schema, tables, stages, tasks, user-defined functions, and stored procedures OR 3) Use an existing database and schema in which you are able to create the mentioned objects.

IMPORTANT: Before proceeding, make sure you have a Snowflake account with Anaconda packages enabled by ORGADMIN as described here.

Using Third-Party Packages from Anaconda

For convenience, a number of popular open source third-party Python packages that are built and provided by Anaconda are made available to use out of the box inside Snowflake. There is no additional cost for the use of the Anaconda packages apart from Snowflake's standard consumption-based pricing.

To view the list of third-party packages from Anaconda, see the Anaconda Snowflake channel.

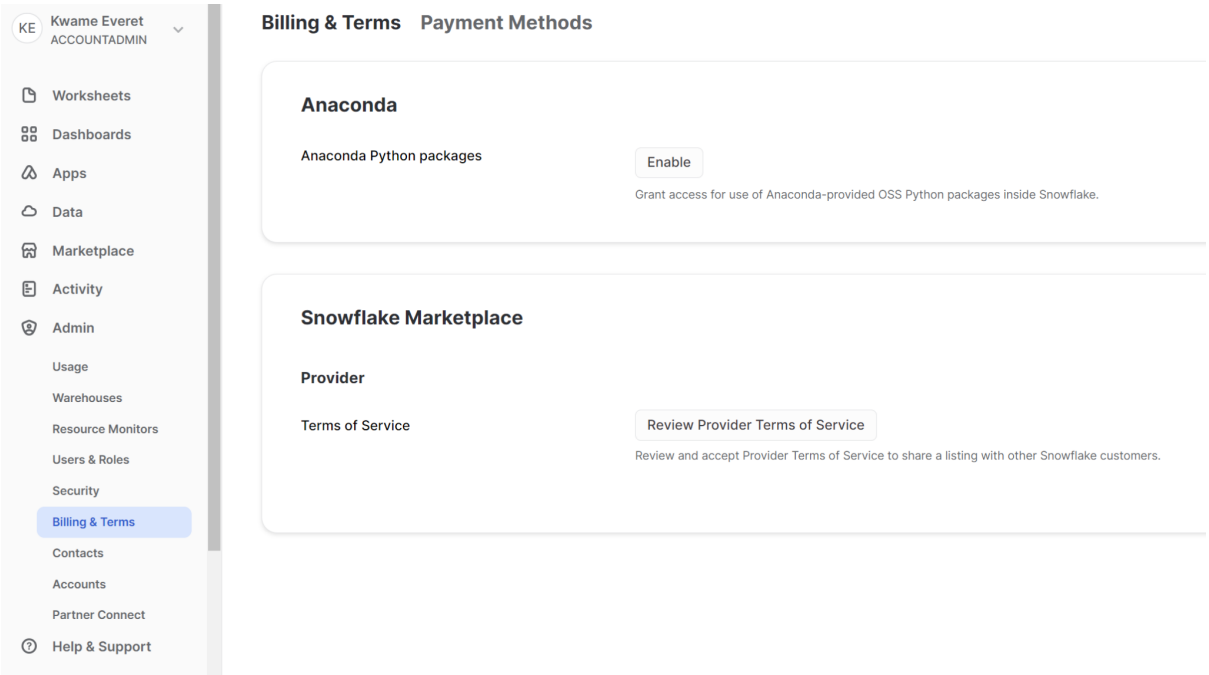
To request the addition of new packages, go to the Snowflake Ideas page in the Snowflake Community. Select the **Python Packages & Libraries** category and check if someone has already submitted a request. If so, vote on it. Otherwise, click **New Idea** and submit your suggestion.

Getting Started

Before you start using the packages provided by Anaconda inside Snowflake, you must acknowledge the Snowflake Third Party Terms.

Note
You must be the organization administrator (use the ORGADMIN role) to accept the terms. You only need to accept the terms once for your Snowflake account. Refer to Enabling the ORGADMIN Role in an Account.

1. Sign in to Snowflake.
2. Select **Admin** » **Billing & Terms**.
3. In the **Anaconda** section, select **Enable**.
4. In the **Anaconda Packages** dialog, click the link to review the Snowflake Third Party Terms page.
5. If you agree to the terms, select **Acknowledge & Continue**.



If you see an error when attempting to accept the terms of service, your user profile might be missing a first name, last name, or email address. If you have an administrator role, refer to Setting User Details and Preferences to update your profile using Snowsight. Otherwise, contact an administrator to update your account.

Create Tables, Load Data and Setup Stages

Log into Snowsight using your credentials to create tables, load data from Amazon S3, and setup Snowflake internal stages.

IMPORTANT:

- If you use different names for objects created in this section, be sure to update scripts and code in the following sections accordingly.
- For each SQL script block below, select all the statements in the block and execute them top to bottom.

Run the following SQL commands to create the warehouse, database and schema.

```
--Create warehouse, database and schema

USE ROLE ACCOUNTADMIN;

CREATE OR REPLACE WAREHOUSE DASH_L;
CREATE OR REPLACE DATABASE DASH_DB;
CREATE OR REPLACE SCHEMA DASH_SCHEMA;

USE DASH_DB.DASH_SCHEMA;
```

Run the following SQL commands to create table CAMPAIGN_SPEND from data hosted on publicly accessible S3 bucket.

```
-- Get the campaign spend data
CREATE or REPLACE file format csvformat
  skip_header = 1
  type = 'CSV';

CREATE or REPLACE stage campaign_data_stage
  file_format = csvformat
  url = 's3://sfquickstarts/ad-spend-roi-snowpark-python-scikit-learn-streamlit/campaign_spend/';

CREATE or REPLACE TABLE CAMPAIGN_SPEND (
  CAMPAIGN VARCHAR(60),
  CHANNEL VARCHAR(60),
  DATE DATE,
  TOTAL_CLICKS NUMBER(38,0),
  TOTAL_COST NUMBER(38,0),
  ADS_SERVED NUMBER(38,0)
```

```
);

COPY into CAMPAIGN_SPEND
  from @campaign_data_stage;
```

Run the following SQL commands to create table MONTHLY_REVENUE from data hosted on publicly accessible S3 bucket.

```
--Get the monthly revenue data
CREATE or REPLACE stage monthly_revenue_data_stage
  file_format = csvformat
  url = 's3://sfquickstarts/ad-spend-roi-snowpark-python-scikit-learn-streamlit/monthly_revenue/';

CREATE or REPLACE TABLE MONTHLY_REVENUE (
  YEAR NUMBER(38,0),
  MONTH NUMBER(38,0),
  REVENUE FLOAT
);

COPY into MONTHLY_REVENUE
  from @monthly_revenue_data_stage;
```

Run the following SQL commands to create table BUDGET_ALLOCATIONS_AND_ROI that holds the last six months of budget allocations and ROI.

```
-- Create budget allocations table
CREATE or REPLACE TABLE BUDGET_ALLOCATIONS_AND_ROI (
  MONTH varchar(30),
  SEARCHENGINE integer,
  SOCIALMEDIA integer,
  VIDEO integer,
  EMAIL integer,
  ROI float
);

INSERT INTO BUDGET_ALLOCATIONS_AND_ROI (MONTH, SEARCHENGINE, SOCIALMEDIA,
VIDEO, EMAIL, ROI)
VALUES
('January',35,50,35,85,8.22),
('February',75,50,35,85,13.90),
('March',15,50,35,15,7.34),
('April',25,80,40,90,13.23),
('May',95,95,10,95,6.246),
('June',35,50,35,85,8.22);
```

Run the following commands to create Snowflake internal stages for storing Stored Procedures, UDFs, and ML model files.

```
--Create internal stages
CREATE OR REPLACE STAGE dash_sprocs;
CREATE OR REPLACE STAGE dash_models;
CREATE OR REPLACE STAGE dash_udfs;
```

Get Started

This section covers cloning of the GitHub repository and setting up your Snowpark for Python environment.

Clone GitHub Repository

The very first step is to clone the GitHub repository. This repository contains all the code you will need to successfully complete this QuickStart Guide.

Using HTTPS:

git clone https://github.com/Snowflake-Labs/sfguide-getting-started-dataengineering-ml-snowpark-python.git

Snowpark for Python

To complete the Data Engineering and Machine Learning steps, you have the option to either install everything locally (option 1) or use Hex (option 2) as described below.

Option 1 – Local Installation

Step 1: Download and install the miniconda installer from https://conda.io/miniconda.html. *(OR, you may use any other Python environment with Python 3.9, for example, virtualenv).*

Step 2: Open a new terminal window and execute the following commands in the same terminal window.

Step 3: Create Python 3.9 conda environment called snowpark-de-ml by running the following command in the same terminal window

conda create --name snowpark-de-ml -c https://repo.anaconda.com/pkgs/snowflake python=3.9

Step 4: Activate conda environment snowpark-de-ml by running the following command in the same terminal window

conda activate snowpark-de-ml

Step 5: Install Snowpark Python, Snowpark ML, and other libraries in conda environment snowpark-de-ml from Snowflake Anaconda channel by running the following command in the same terminal window

conda install -c https://repo.anaconda.com/pkgs/snowflake snowflake-snowpark-python snowflake-ml-python pandas notebook cachetools

Step 6: Update the connection.json in the GitHub repo with your Snowflake account details and credentials.

Here's a sample *connection.json* based on the object names mentioned in Setup Environment step.

Unset

```
{
 "account"  : "<your_account_identifier_goes_here>",
 "user"     : "<your_username_goes_here>",
 "password" : "<your_password_goes_here>",
 "role"     : "ACCOUNTADMIN",
 "warehouse" : "DASH_L",
 "database"  : "DASH_DB",
 "schema"   : "DASH_SCHEMA"
}
```

Data Engineering

The Notebook linked below covers the following data engineering tasks.

1. Establish secure connection from Snowpark Python to Snowflake
2. Load data from Snowflake tables into Snowpark DataFrames
3. Perform Exploratory Data Analysis on Snowpark DataFrames
4. Pivot and Join data from multiple tables using Snowpark DataFrames
5. Automate data pipeline tasks using Snowflake Tasks

Data Engineering Notebook in Jupyter or Visual Studio Code

To get started, follow these steps:

1. In a terminal window, browse to this folder and run `jupyter notebook` at the command line. (You may also use other tools and IDEs such Visual Studio Code.)
2. Open and run through the cells in Snowpark_For_Python_DE.ipynb

Data Pipelines

You can also operationalize the data transformations in the form of automated data pipelines running in Snowflake.

In particular, in the Data Engineering Notebook, there's a section that demonstrates how to optionally build and run the data transformations as Snowflake Tasks.

For reference purposes, here are the code snippets.

Root/parent Task

This task automates loading campain spend data and performing various transformations.

```
def campaign_spend_data_pipeline(session: Session) -> str:
  # DATA TRANSFORMATIONS
  # Perform the following actions to transform the data

  # Load the campaign spend data
  snow_df_spend_t = session.table('campaign_spend')

  # Transform the data so we can see total cost per year/month per channel using group_b
  snow_df_spend_per_channel_t = snow_df_spend_t.group_by(year('DATE'), month('DATE'),'CH
      with_column_renamed('"YEAR(DATE)"',"YEAR").with_column_renamed('"MONTH(DATE)"',"MO

  # Transform the data so that each row will represent total cost across all channels pe
  snow_df_spend_per_month_t = snow_df_spend_per_channel_t.pivot('CHANNEL',['search_engin
  snow_df_spend_per_month_t = snow_df_spend_per_month_t.select(
      col("YEAR"),
      col("MONTH"),
      col("'search_engine'").as_("SEARCH_ENGINE"),
      col("'social_media'").as_("SOCIAL_MEDIA"),
      col("'video'").as_("VIDEO"),
      col("'email'").as_("EMAIL")
  )

  # Save transformed data
  snow_df_spend_per_month_t.write.mode('overwrite').save_as_table('SPEND_PER_MONTH')
```

```
# Register data pipelining function as a Stored Procedure so it can be run as a task
session.sproc.register(
  func=campaign_spend_data_pipeline,
  name="campaign_spend_data_pipeline",
  packages=['snowflake-snowpark-python'],
  is_permanent=True,
  stage_location="@dash_sprocs",
  replace=True)

campaign_spend_data_pipeline_task = """
CREATE OR REPLACE TASK campaign_spend_data_pipeline_task
    WAREHOUSE = 'DASH_L'
    SCHEDULE  = '3 MINUTE'
AS
    CALL campaign_spend_data_pipeline()
"""
session.sql(campaign_spend_data_pipeline_task).collect()
```

Child/dependant Task

This task automates loading monthly revenue data, performing various transformations, and joining it with transformed campaign spend data.

```
def monthly_revenue_data_pipeline(session: Session) -> str:
  # Load revenue table and transform the data into revenue per year/month using group_by
  snow_df_spend_per_month_t = session.table('spend_per_month')
  snow_df_revenue_t = session.table('monthly_revenue')
  snow_df_revenue_per_month_t = snow_df_revenue_t.group_by('YEAR','MONTH').agg(sum('REVE

  # Join revenue data with the transformed campaign spend data so that our input feature
  snow_df_spend_and_revenue_per_month_t = snow_df_spend_per_month_t.join(snow_df_revenue

  # SAVE in a new table for the next task
  snow_df_spend_and_revenue_per_month_t.write.mode('overwrite').save_as_table('SPEND_AND

# Register data pipelining function as a Stored Procedure so it can be run as a task
session.sproc.register(
  func=monthly_revenue_data_pipeline,
  name="monthly_revenue_data_pipeline",
  packages=['snowflake-snowpark-python'],
  is_permanent=True,
  stage_location="@dash_sprocs",
  replace=True)

monthly_revenue_data_pipeline_task = """
  CREATE OR REPLACE TASK monthly_revenue_data_pipeline_task
      WAREHOUSE = 'DASH_L'
      AFTER campaign_spend_data_pipeline_task
  AS
      CALL monthly_revenue_data_pipeline()
  """
session.sql(monthly_revenue_data_pipeline_task).collect()
```

Start Tasks

Snowflake Tasks are not started by default so you need to execute the following statements to start/resume them.

```
session.sql("alter task monthly_revenue_data_pipeline_task resume").collect()
session.sql("alter task campaign_spend_data_pipeline_task resume").collect()
```

Suspend Tasks

If you resume the above tasks, suspend them to avoid unecessary resource utilization by executing the following commands.

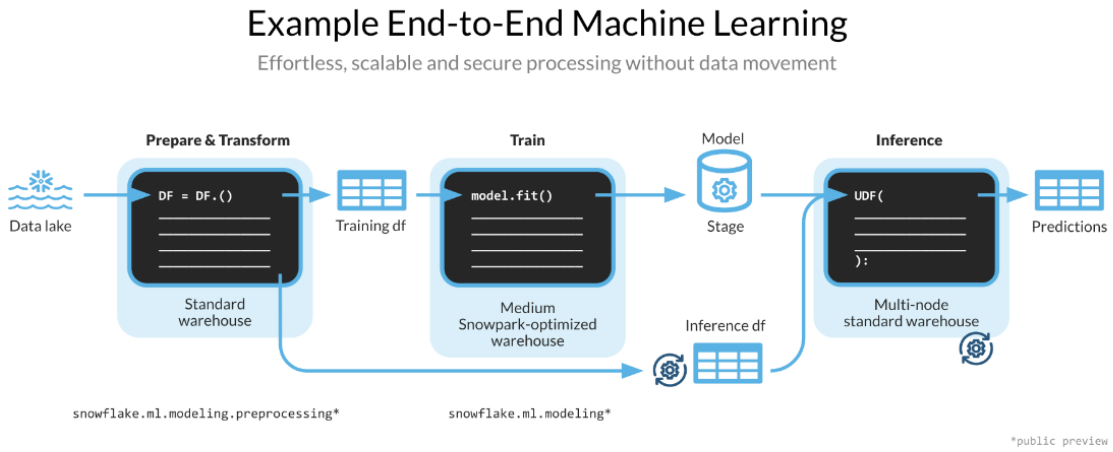
```
session.sql("alter task campaign_spend_data_pipeline_task suspend").collect()
session.sql("alter task monthly_revenue_data_pipeline_task suspend").collect()
```

Machine Learning

PREREQUISITE: Successful completion of Data Engineering steps outlined in Snowpark_For_Python_DE.ipynb.

The Notebook linked below covers the following machine learning tasks.

1. Establish secure connection from Snowpark Python to Snowflake
2. Load features and target from Snowflake table into Snowpark DataFrame
3. Prepare features for model training
4. Train ML model using Snowpark ML on Snowflake
5. Create Scalar and Vectorized (aka Batch) Python User-Defined Functions (UDFs) for inference on new data points for online and offline inference respectively.



Machine Learning Notebook in Jupyter or Visual Studio Code

To get started, follow these steps:

1. In a terminal window, browse to this folder and run jupyter notebook at the command line. (You may also use other tools and IDEs such Visual Studio Code.)
2. Open and run through the Snowpark_For_Python_ML.ipynb

IMPORTANT: Make sure in the Jupyter notebook the (Python) kernel is set to *snowpark-de-ml* – which is the name of the environment created in Clone GitHub Repository step.

Streamlit Application

Follow these steps to build Streamlit application in Snowsight.

Step 1. Click on Streamlit on the left navigation menu

Step 2. Click on + Streamlit App on the top right

Step 3. Enter App name

Step 4. Select Warehouse (X-Small) and App location (Database and Schema) where you'd like to create the Streamlit applicaton

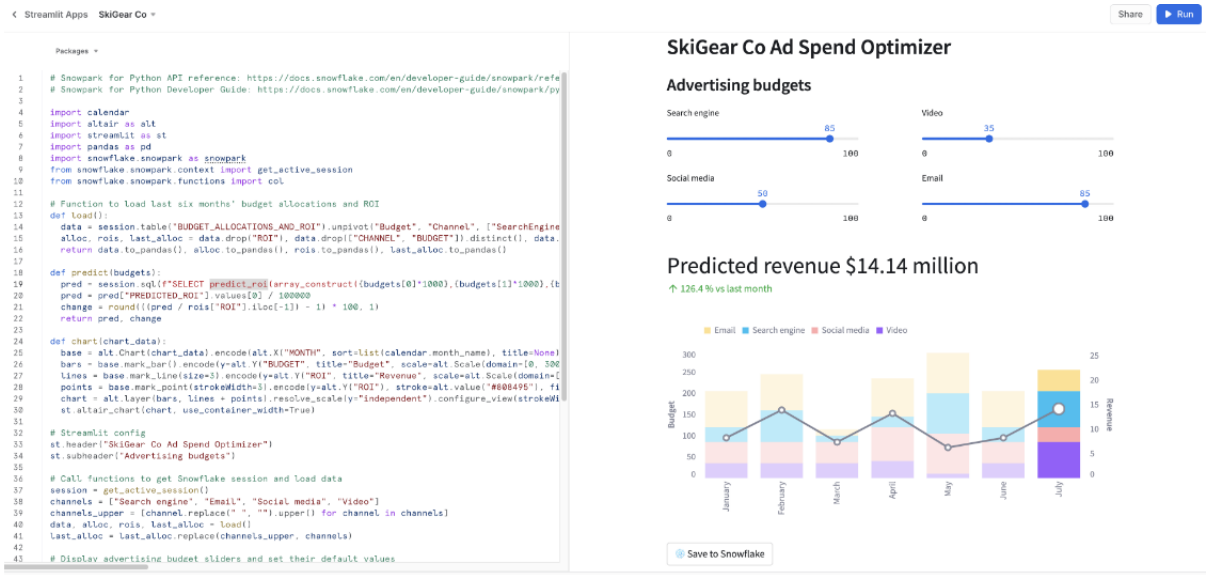
Step 5. Click on Create

- At this point, you will be provided code for an example Streamlit application

Step 6. Replace sample application code displayed in the code editor on the left with the code provided in [Snowpark_Streamlit_Revenue_Prediction_SiS.py]

Step 7. Click on Run on the top right

If all goes well, you should see the application in Snowsight as shown below



Step 8. Save data to Snowflake

In the application, adjust the advertising budget sliders to see the predicted ROI for those allocations. You can also click on Save to Snowflake button to save the current allocations and predicted ROI into BUDGET_ALLOCATIONS_AND_ROI Snowflake table.

Cleanup

If you started/resumed the two tasks `monthly_revenue_data_pipeline_task` and `campaign_spend_data_pipeline_task` as part of the Data Engineering or Data Pipelines sections, then it is important that you run the following commands to suspend those tasks in order to avoid unecessary resource utilization.

In Notebook using Snowpark Python API

```
session.sql("alter task campaign_spend_data_pipeline_task suspend").collect()
session.sql("alter task monthly_revenue_data_pipeline_task suspend").collect()
```

In Snowflake

--Clean up resources

alter task campaign_spend_data_pipeline_task suspend;

alter task monthly_revenue_data_pipeline_task suspend;