Git, GitHub, Python & Datalake Tooling

A Beginner's Guide

Texas A&M Transportation Institute

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Before We Start: Installation Checklist

Required Tools

1. **Git** - Version control
   - Download: https://git-scm.com
2. **GitHub Account**
   - Sign up: https://github.com
3. **UV** - Package manager
   - Install: UV installation guide
5. **VS Code** (Recommended)
   - Download: https://code.visualstudio.com
6. **cookie cutter** - Code template
   - user guide: https://github.com/cookiecutter/cookiecutter

Verify Installation

Open terminal and run:

```
git --version
python --version
uv --version
```

Python Packages (install during workshop):

```
uv add duckdb
uv add ruff --dev
uv add vulture --dev
```

TTI Tools:

- datalake-sync (will be provided)

Why Version Control?

The Problem

- "Which version is the latest?"
- "Who changed this and why?"
- "I broke something, how do I go back?"
- "How do we work on the same file?"
- `report_final_v2_FINAL_revised.docx`

The Solution: Git

- Complete history of every change
- Know who changed what and when
- Revert to any previous version
- Work in parallel without conflicts
- One source of truth

Without Git:

- Manual backups everywhere
- Emailing files back and forth
- Overwriting each other's work
- No history of changes

Benefits:

- Reproducible research
- Safe experimentation (branches)
- Seamless collaboration
- Backup in the cloud (GitHub)

What is Git?

Git is a distributed version control system that tracks changes in your code.

Why use it?

- Track every change you make
- Collaborate with others without conflicts
- Revert to previous versions anytime
- Work on features in isolation (branches)

```
git init          # Start a new repository
git clone <url>   # Clone a repository
git status        # Check what's changed
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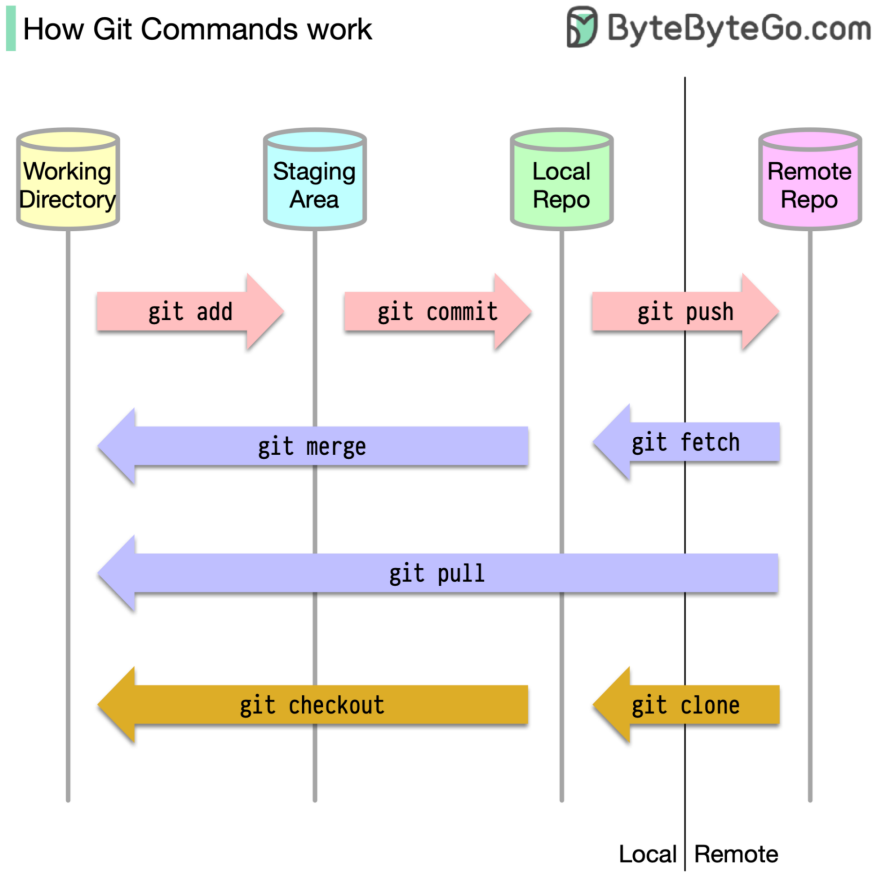


Git Workflow & Branching

Basic Workflow

```
# Stage your changes
git add .

# Commit with a message
git commit -m "Add new feature"

# Push to remote
git push

# Pull latest changes
git pull
```

Branching

```
# Create a new branch
git branch feature-name

# Switch to a branch
git checkout feature-name

# Create & switch (shortcut)
git checkout -b feature-name

# Merge branch into main
git checkout main
git merge feature-name
```

Branching Flow: main → feature-branch → *work on feature* → merge back to main

Handling Merge Conflicts

What Are Conflicts?

Occur when Git can't auto-merge changes:

- Two people edit the same line
- File deleted in one branch, modified in another

Conflict Markers:

```
<<<<<<< HEAD
Your changes here
=======
Their changes here
>>>>>>> branch-name
```

How to Resolve

1. Open the conflicted file
2. Choose which code to keep
3. Delete conflict markers
4. Stage the resolved file
5. Complete the commit

```
git add resolved-file.py
git commit -m "Resolve conflicts"
```

Pro tip: VS Code has a built-in merge editor!

Setting Up

1. Create a repository on GitHub
2. Connect your local repo:

```
# Add remote origin
git remote add origin <url>

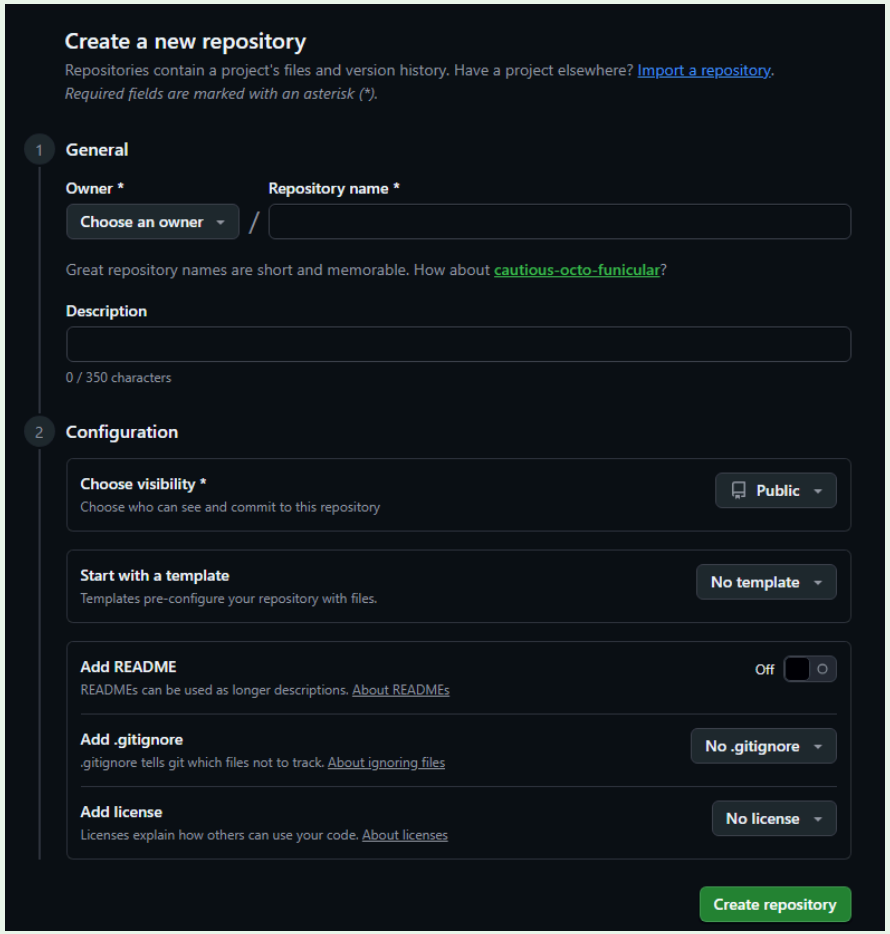
# Push for the first time
git push -u origin main
```

The `-u` flag sets upstream tracking, so future pushes just need `git push`.

Typical Workflow

1. Clone the repo
2. Create a branch
3. Make changes
4. Commit your work
5. Push to GitHub
6. Open a Pull Request
7. Review & Merge

GitHub: Creating a New Repository



Python Tooling: UV, Ruff & Vulture

UV

Fast Python package manager

```
# Create new project
uv init .

# Add a package
uv add pandas

# Run a script
uv run main.py

# Sync dependencies
uv sync
```

Ruff

Lightning-fast linter & formatter

```
# Lint your code
ruff check .

# Auto-fix issues
ruff check --fix .

# Format code
ruff format .
```

Replaces flake8, black, isort!

Vulture

Find dead/unused code

```
# Scan for dead code
vulture .

# Set confidence level
vulture --min-
confidence 80 .

# Check specific files
vulture src/
```

Clean up your codebase!

Why DuckDB?

Traditional Data Analysis Pain Points

- Loading large CSVs crashes Python
- Pandas is slow on big datasets
- Need a database server for SQL
- Converting between formats is tedious
- Memory limitations

Common Workarounds:

- Chunk processing (complex code)
- Spin up PostgreSQL/MySQL (overkill)
- Use Spark (heavy setup)

DuckDB Solves This

- Query files directly (no loading)
- Blazing fast on large data
- Zero setup, just `import duckdb`
- SQL on DataFrames instantly
- Handles larger-than-memory data

Perfect For:

- Data exploration and analysis
- ETL pipelines
- Quick aggregations on big files
- Replacing slow Pandas operations

DuckDB: In-Process SQL Database

What is DuckDB?

- Fast, in-process SQL database
- No server setup required
- Reads files directly (CSV, Parquet, JSON)
- Perfect for data analysis

Basic Usage

```
import duckdb

# In-memory database
con = duckdb.connect()

# Persistent database
con = duckdb.connect("my.db")
```

Read Files Directly

```
# CSV
duckdb.sql("SELECT * FROM 'data.csv'")

# Parquet
duckdb.sql("SELECT * FROM
'data.parquet'")

# JSON
duckdb.sql("SELECT * FROM
'data.json'")

# Multiple files with glob
duckdb.sql("SELECT * FROM 'data/
*.csv'")
```

DuckDB: Pandas Integration

Query DataFrames with SQL

```
import pandas as pd
import duckdb

df = pd.read_csv("sales.csv")

# Query DataFrame directly
result = duckdb.sql("""
    SELECT region, SUM(amount)
    FROM df
    GROUP BY region
""")
```

DuckDB auto-detects DataFrames by name!

Convert Results

```
# To DataFrame
result.df()

# To Polars
result.pl()

# To Arrow
result.arrow()

# To Python list
result.fetchall()
```

Useful Operations

```
# Describe table
duckdb.sql("DESCRIBE df")
```

Why datalake-sync?

Data Lake Challenges

- Manual file transfers to Azure
- Duplicate shared datasets across projects
- Complex format conversions
- Missing metadata and documentation

Common Workarounds:

- Manually copy files to/from Azure
- Store same dataset in multiple places
- Manual format conversions (error-prone)
- Share data between team members

datalake-sync Solution

- Git-like workflow for data
- Automatic sync with Azure ADLS Gen2
- Copy-by-reference (no duplication)
- Built-in format conversion (DuckDB)

Perfect For:

- Data tracking and reproducibility
- Team collaboration on datasets
- Shared data management
- Quick data format conversions
- Backup in the cloud (Azure)

datalake-sync: Core Features

Key Features

- Bidirectional Azure sync
- Shared data references (manifest-based)
- Format conversion (DuckDB-powered)
- Metadata validation
- Project initialization and management

Basic Commands

```
# Initialize project
datalake init . -c CLIENT \
  -y YEAR -p PROJECT_ID

datalake sync    # Sync with Azure

datalake status  # Check status
```

Shared Data Workflow

Typical Workflow

1. Initialize project
2. Add shared data references
3. Fetch shared data to local
4. Work with local files
5. Sync project data changes to Azure
6. Convert formats as needed

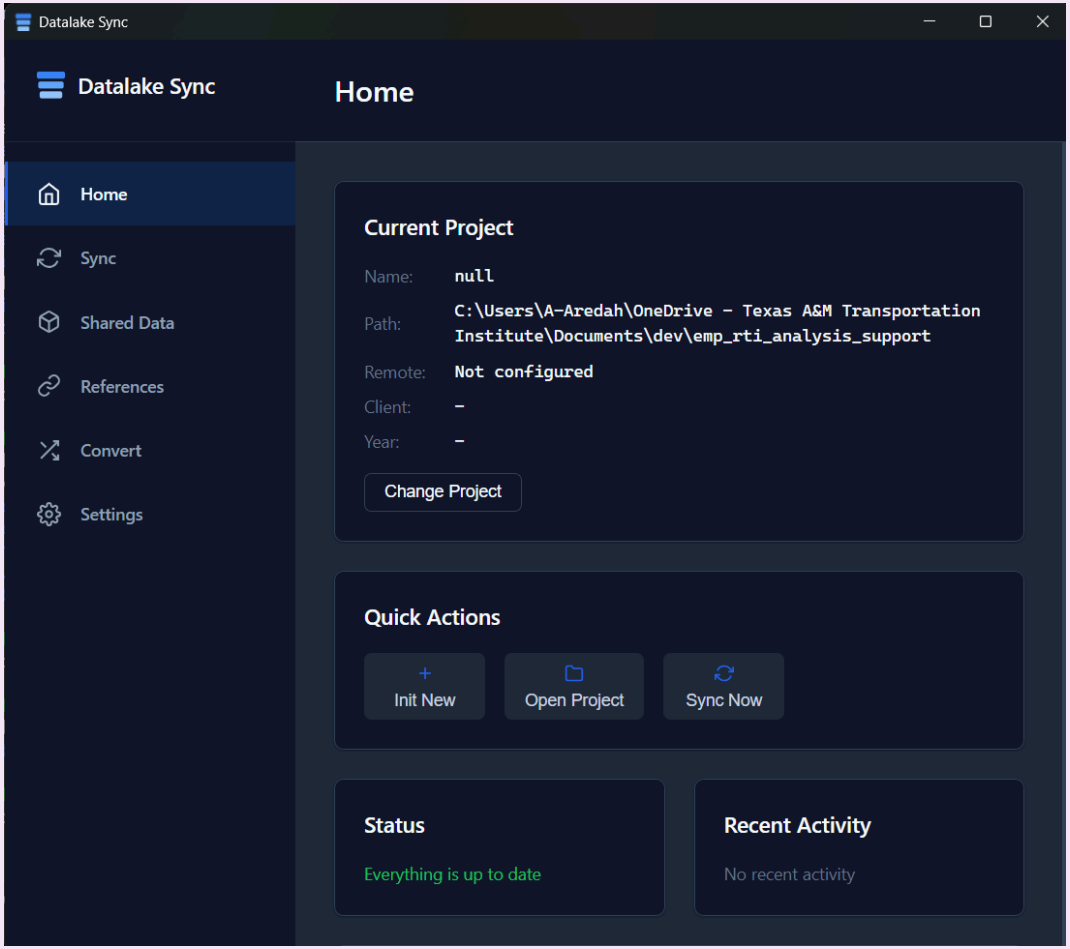
Example Commands

```
# Add shared reference
datalake refs add shared/inputs/census

# Fetch all shared data
datalake shared fetch --all

# Convert to Parquet
datalake convert file data.csv \
  --format parquet
```

datalake-gui: Visual Interface



Quick Reference

Git Commands

`git init`	Start repo
`git clone <url>`	Copy repo
`git status`	Check changes
`git add .`	Stage all
`git commit -m ""`	Commit
`git push`	Upload
`git pull`	Download
`git branch`	Create branch
`git checkout`	Switch branch
`git merge`	Merge branch

Python Tools

`uv init .`	Create project
`uv add <pkg>`	Add package
`uv run <file>`	Run script
`uv sync`	Sync deps
`ruff check .`	Lint code
`ruff format .`	Format code
`vulture .`	Dead code

DuckDB

`duckdb.connect()`	Connect
`duckdb.sql()`	Run query
`FROM 'file.csv'`	Read CSV
`FROM 'file.parquet'`	Read Parquet
`FROM df`	Query DataFrame
`.df()`	To Pandas
`COPY ... TO`	Export file

datalake-sync

`datalake init`	Create project
`datalake sync`	Sync data
`datalake status`	Check status
`datalake refs add`	Add reference
`datalake shared fetch`	Fetch data
`datalake convert`	Convert format
`datalake config`	Configure

Hands-On Exercises Overview

What We'll Practice Today

1.	**Git Basics**: Create repo, commit, push to GitHub	20 min
2.	**Python Environment**: Set up UV project, add packages	15 min
3.	**Code Quality**: Run Ruff and Vulture on code	10 min
	Break	5 min
4.	**DuckDB**: Query CSV files, convert to Parquet	25 min
5.	**datalake-sync**: Initialize project, sync with Azure	25 min

Reference guides available in `notes/` folder for detailed commands!

Common Issues & Quick Fixes

Git Issues

Error: `fatal: not a git repository`

Fix: Run `git init` in your project folder

Error: `Authentication failed`

Fix: Set up GitHub personal access token or SSH key

Error: `UV: command not found`

Fix: Restart terminal or check PATH

Python/Package Issues

Error: `ModuleNotFoundError: No module named 'duckdb'`

Fix: `uv add duckdb`

Error: `ruff: command not found`

Fix: `uv add ruff --dev` or use `uv run ruff`

Resources & Next Steps

Reference Guides

- `notes/git.md` - Git commands
- `notes/uv.md` - UV commands
- `notes/ruff.md` - Ruff usage
- `notes/vulture.md` - Vulture usage
- `notes/duckdb.md` - DuckDB CLI
- `notes/duckdb_python.md` - DuckDB Python
- `notes/datalake-sync.md` - TTI data tool

Practice & Learning

Next Steps:

1. Practice Git daily with your projects
2. Use UV for all new Python projects
3. Run Ruff before every commit
4. Try DuckDB for data analysis tasks
5. Use datalake-sync for TTI data

Questions? Let's discuss!