Python Workflow for High-Fidelity Modeling of Overland Hydrocarbon Flows with GeoClaw and Cloud Computing

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Summary

Motivation

Hydrocarbon overland flow plays a vital role in the analysis of pipeline rupture events (e.g., high-consequence area analysis). Low-fidelity models currently dominate these simulations due to the massive computing power required by high-fidelity models. Given the advance of the modern cloud computing technology, high-fidelity models may now be feasible for pipeline rupture analysis.

Goal

- Full shallow-water equation solver
  - A fork from GeoClaw
  - New features specific to pipeline rupture simulations: *rupture point, inland water bodies, Darcy-Weisbach friction models, temperature-dependent viscosity, and evaporation models.*
- Integration with Microsoft Azure
- Integration with ArcGIS Pro
- Equivalent workflow and interface in Jupyter Notebook with open-source library dependencies only.

Supplemental information

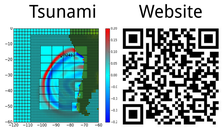
HCA (high-consequence area) analysis

HCA analysis identifies pipeline segments that could affect high-consequence areas defined by the US government.

GeoClaw

- Originally for tsunami simulations
- 2D full shallow-water equations
- OpenMP parallelization
- Adaptive mesh refinement

Tsunami Website



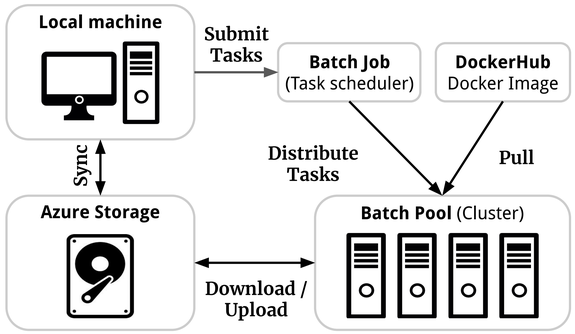
Microsoft Azure SDK for Python

Free and open-source Python API library for Azure.

ArcPy

Proprietary Python library provided by ArcGIS.

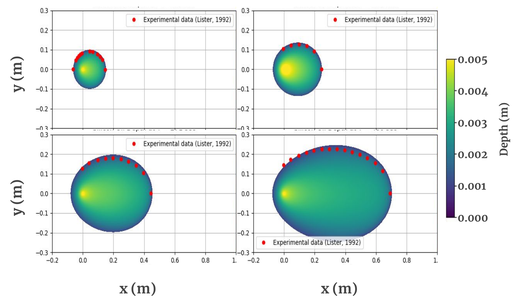
Cloud solution integration



Validation

Silicone oil on an inclined glass plate @ 2.5°

Rate: 1.48e^{-6} m^3/sec; Surface roughness: 0; No evaporation

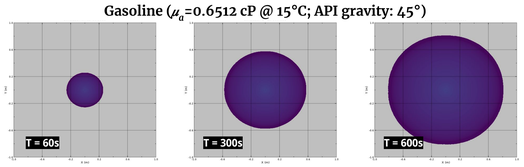


Showcase

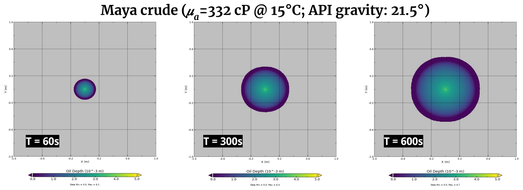
Verification: viscosity effect

Horizontal plate; rate: 1.48e^{-6} m^3/sec; roughness: 0 m; no evaporation

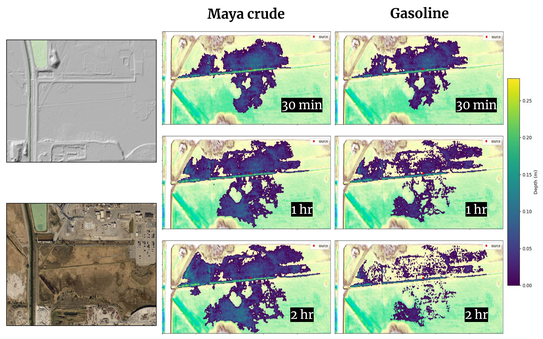
Gasoline (μ_a=0.6512 cP @ 15°C; API gravity: 45°)



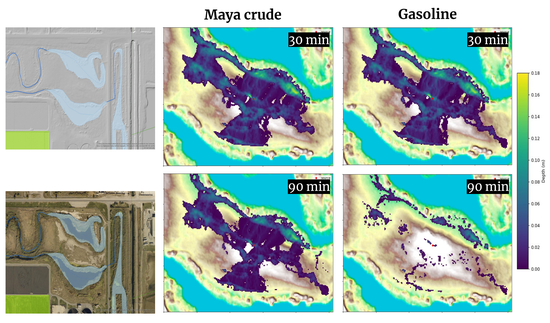
Maya crude (μ_a=332 cP @ 15°C; API gravity: 21.5°)



Salt Lake City: flat terrain

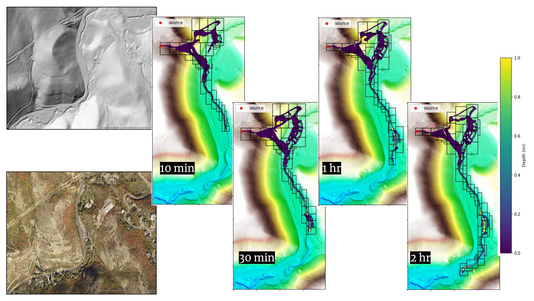


Salt Lake City: w/ inland water bodies



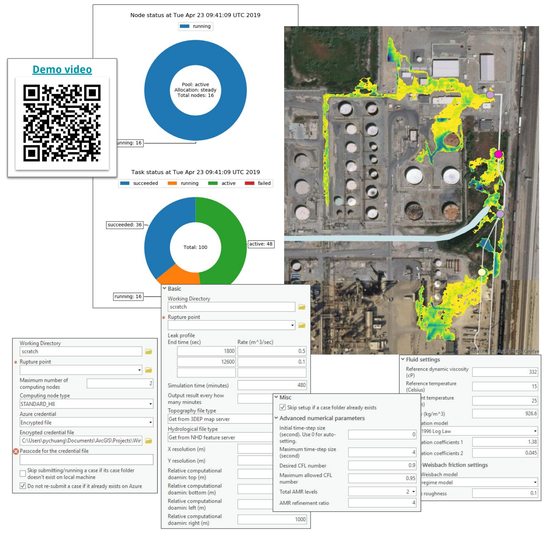
Salt Lake City: w/ drainage feature

Maya crude only

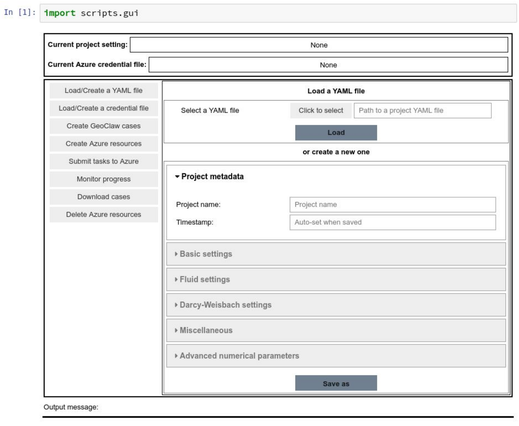


ArcGIS Pro Python Toolbox

Demo video



Jupyter Notebook interface



Repositories

Core flow solver | Interfaces | Showcase cases

Barba Group: https://lorenabarba.com/