



VICTOR

A new cyber-
infrastructure
for volcanology



VICTOR

Volcanology
Infrastructure for
Computational
Tools and
Resources

What is

VICTOR

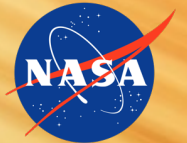


“A cloud-based platform
for volcanologists to
find, use, and integrate
numerical models and
other computational
tools”

Funded by:



EARTH CUBE

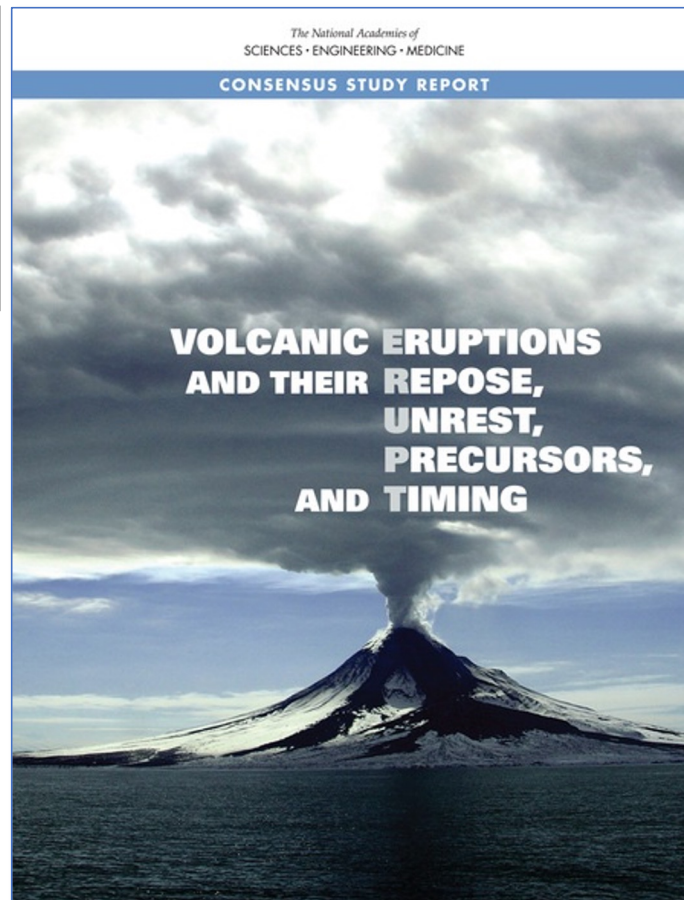


Learn more at victorproject.org

Motivation – 2018 ERUPT report

“Access to high-performance computing ... are essential for state-of-the-art models”

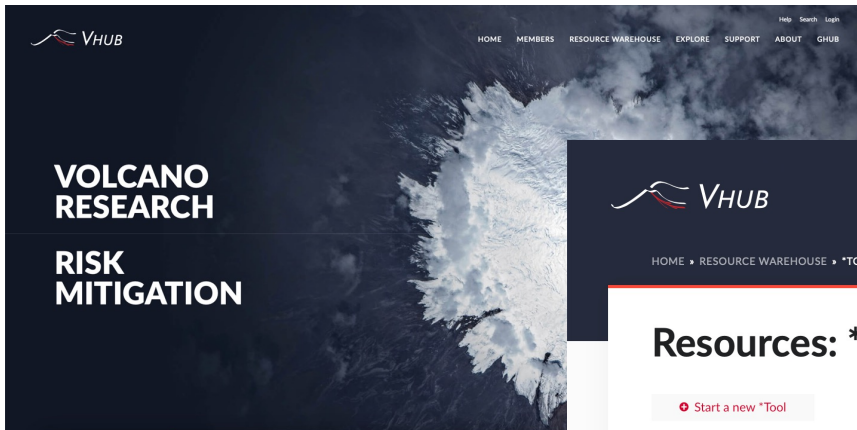
“Communal cyber-infrastructure supports comprehensive databases, model development, benchmarking, and implementation”



“Community facilities... could help improve the accessibility and user-friendliness of computational approaches

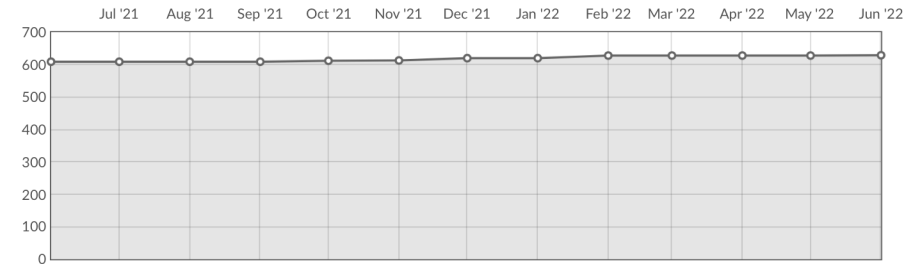
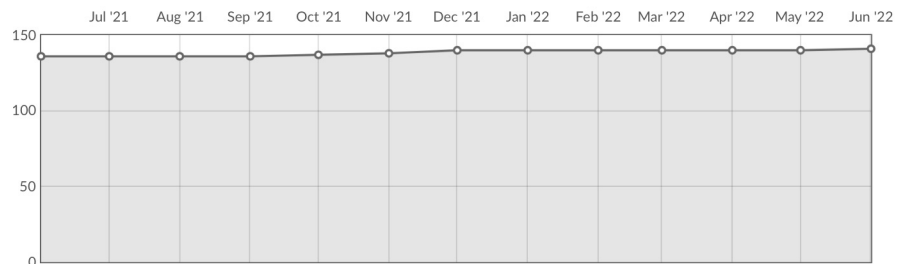
...enhancing code efficiency and offering resources not available to individuals.”

2010–2020 The Vhub Era

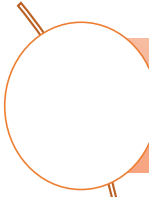


A screenshot of the VHUB website's "Resources: *Tools" page. The page has a dark blue header with the VHUB logo and navigation links. Below the header, the title "Resources: *Tools" is displayed in a large, bold, black font. A button labeled "Start a new *Tool" is visible. A search bar with the text "*Tools" and a "Go" button is present. Below the search bar, there are two main sections: "Tag" and "Resources". The "Tag" section lists various tags with their respective counts, such as "ash (2)", "ash clouds (1)", etc. The "Resources" section is titled "Sort by Title" and lists several resources, each with a right-pointing arrow. The "Info" section on the right contains the text "Select a resource to see details." The footer of the page includes "Slide 5 of 12", "English (United States)", "Accessibility: Investigate", "Notes", "Comments", "The following are top-rated resources", and a zoom level of "119%".

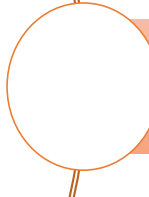
2010–2020 The Vhub Era



Goals for VICTOR



Make it easier to run computational models and tools

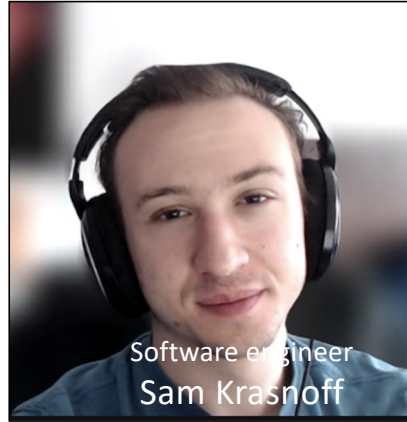
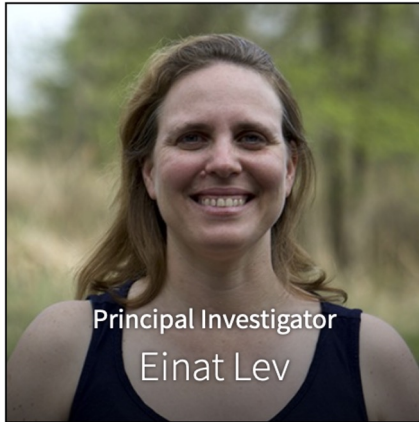


Broaden model literacy



Reduce volcanic hazards by making models more accessible

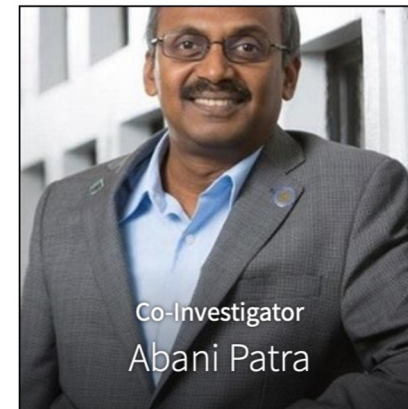
The VICTOR team



Columbia University

[Learn more at victorproject.org](https://victorproject.org)

University of South Florida

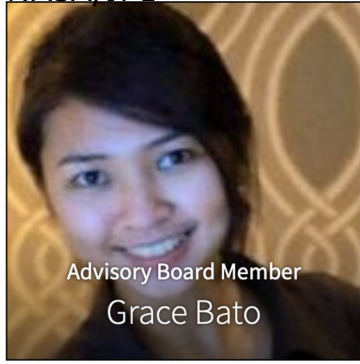


Tufts University

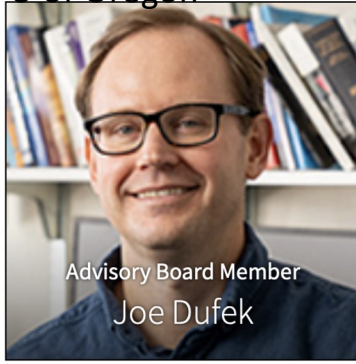
VICTOR Advisory committee



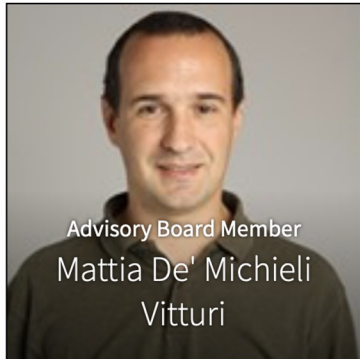
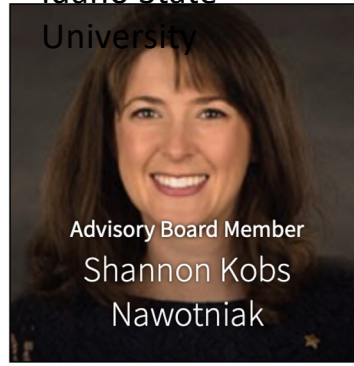
NASA/JPL



U of Oregon



Idaho State
University



INGV



U of Hong Kong

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VICTOR Advisory committee



Marina Rosas Carbajal



Sophie Leiter



Learn more at victorproject.org

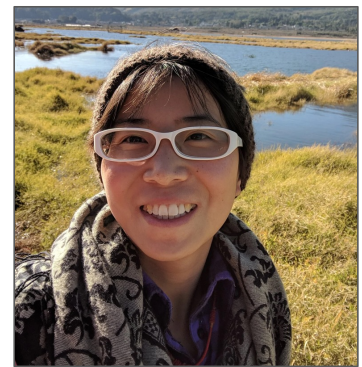
Andrea Bevilacqua



Matthew Blackett



Shuo Ding



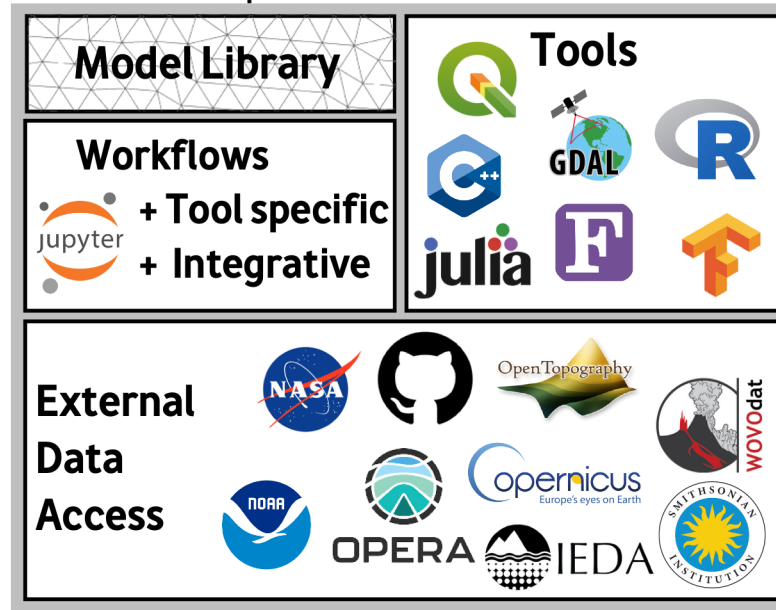
Paul Jarvis



victorproject.org



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Workshops &
Demo Sessions

Development and
Management Team

Advisory Committee

Partner Instructors



jupyterhub

Model Library

Workflows

+ Tool specific
+ Integrative

Tools



External
Data
Access



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Workshops &
Demo Sessions



Development and
Management Team

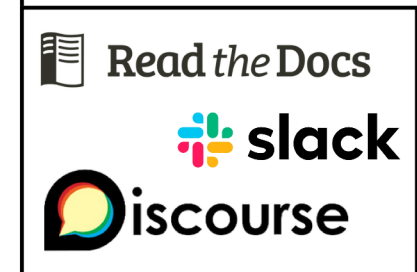
Advisory Committee

Partner Instructors

Model Library

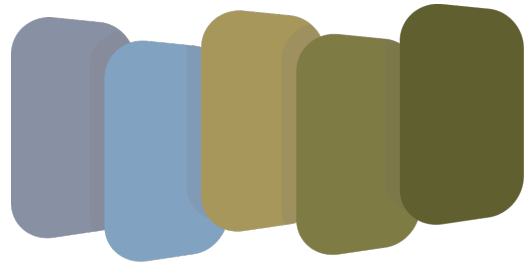
Workflows
+ Tool specific
+ Integrative

External
Data
Access



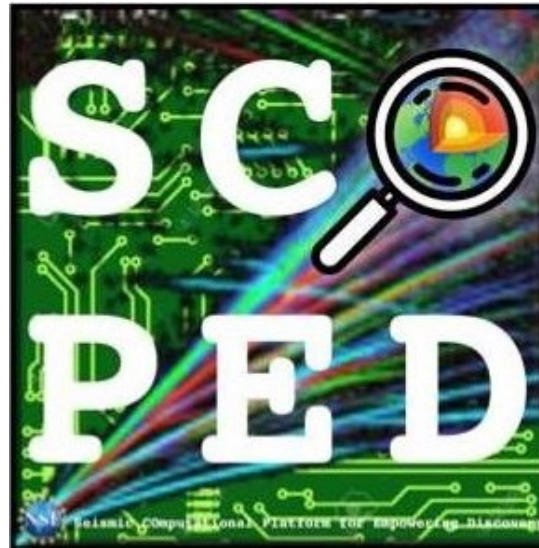
Learn more at victorproject.org

Parallel efforts



CSDMS

community surface
dynamics modeling system



PANGEO



Learn more at victorproject.org

A Technical View of the Hub



- Running Ubuntu 22.04
- Fully featured C/C++, Fortran compilers, as well as Javascript, Python, R interpreters
- A variety of python packages for machine learning, image recognition, and remote storage access (S3, Google Cloud, Azure)
 - The majority of packages are installed through a conda environment, allowing for great flexibility
- Hosted through AWS EC2 instances managed by Kubernetes control panel

Connect to the VICTOR JupyterHub



- 1) From main site, or via hub.victorproject.org

The 2i2c JupyterHub for **VICTOR**



Operated by: **2i2c** | Funded by: **National Science Foundation** | Designed by: **2i2c**

[Log in to continue](#)

Welcome to the **VICTOR 2i2c JupyterHub**.

VICTOR, or Volcanology Infrastructure for Computational Tools and Resources (VICTOR), is a pilot service running on open source infrastructure. It is designed for use by the volcano science community, providing a standard environment and set of tools for all users.

Learn more at victorproject.org

Connect to the VICTOR JupyterHub



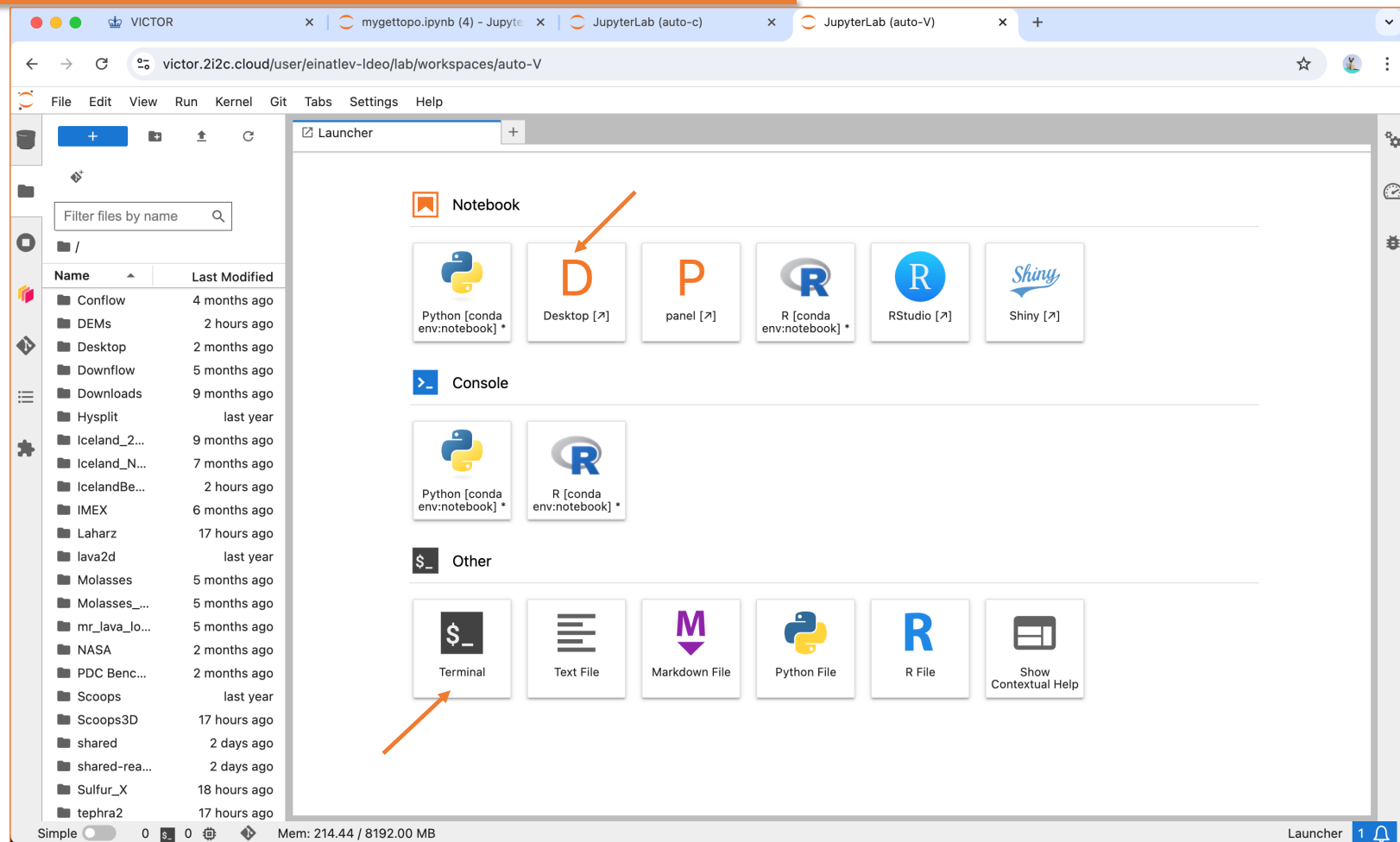
1) From main site, or via
hub.victorproject.org

2) Choose a server type

The screenshot shows a web browser window with the URL `hub.victorproject.org`. The page has a header with the JupyterHub logo and navigation links: Home, Token, Admin. On the right, it shows the user 'einatlev-ideo' and a 'Logout' button. The main content area is titled 'Server Options' and contains two radio button selections. The first option, 'CPU Only', is selected and includes a dropdown for 'Image' (set to 'Victor Notebook') and a dropdown for 'Resource Allocation' (set to '3.7 GB RAM, upto 3.7 CPUs'). The second option is 'NVIDIA Tesla T4, ~16 GB, ~4 CPUs', with a subtext 'Start a container on a dedicated node with a GPU' and an 'Image' dropdown (set to 'Victor Notebook'). At the bottom, there is a large orange 'Start' button.

Learn more at victorproject.org

The Launch Pad



Pre-installed workflows



File Edit View Run Kernel Git Tabs Settings Help

Filter files by name

/ IMEX /

Name	Last Modified
dem_esri_nodata.asc	2 months ago
dem_esri.asc	2 months ago
IMEX_LavaFlow	2 months ago
IMEX_LavaFlow.inp	2 months ago
IMEX_temp.nc	2 months ago
IMEX-EL.ipynb	2 months ago
IMEX.ipynb	an hour ago
IMEX.nc	2 months ago
MaunaLoa_0000.asc	2 months ago
MaunaLoa_0000.p_...	2 months ago
MaunaLoa_0001.asc	2 months ago
MaunaLoa_0001.p_...	2 months ago
MaunaLoa_0002.asc	2 months ago
MaunaLoa_0002.p_...	2 months ago
MaunaLoa_0003.asc	2 months ago
MaunaLoa_0003.p_...	2 months ago
MaunaLoa_max.asc	2 months ago
MaunaLoa_T_0000....	2 months ago
MaunaLoa_T_0001....	2 months ago
MaunaLoa_T_0002....	2 months ago
MaunaLoa_T_0003....	2 months ago
MaunaLoa.bak	2 months ago
test20m.asc	2 months ago
topography_dem.asc	2 months ago

Terminal 1 IMEX.ipynb

Python [conda env:notebook] 9/35

A model workflow for IMEX

IMEX is a highly versatile liquid simulation model, with some specialized parameters for lava flow.

```
[1]: import rioarray as rxr
import xarray as xr
import subprocess
import numpy as np
import matplotlib.pyplot as plt
import subprocess
from netCDF4 import Dataset
import cartopy.crs as ccrs
import pyproj
import netCDF4
import sys
import shutil
```

```
[2]: sys.path.insert(0, "/home/jovyan/shared/Scripts")
import victor
```

In the following sections, we will provide a variety of input information, including topographical, rheological and thermal parameters.

First, the user must enter the run name, along with some time constraints and flags to determine the kind of output they would like to produce.

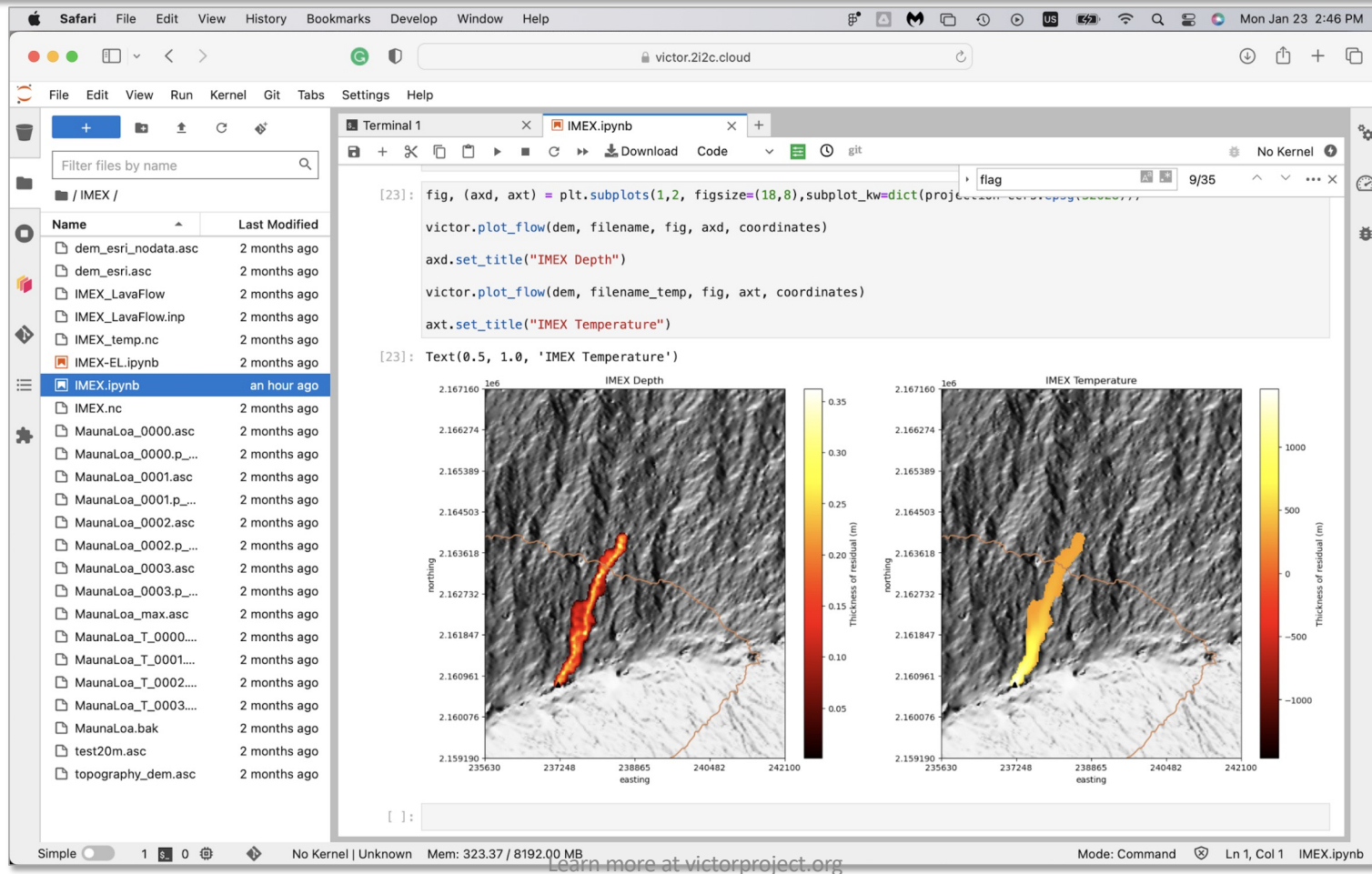
```
[3]: #prefix for output files
run_name = "MaunaLoa"

#starting a run from a previous output (T/F)
restart = 'F'

#Starting simulation time, recommended is 0
t_start = 0
```

Learn more at victorproject.org

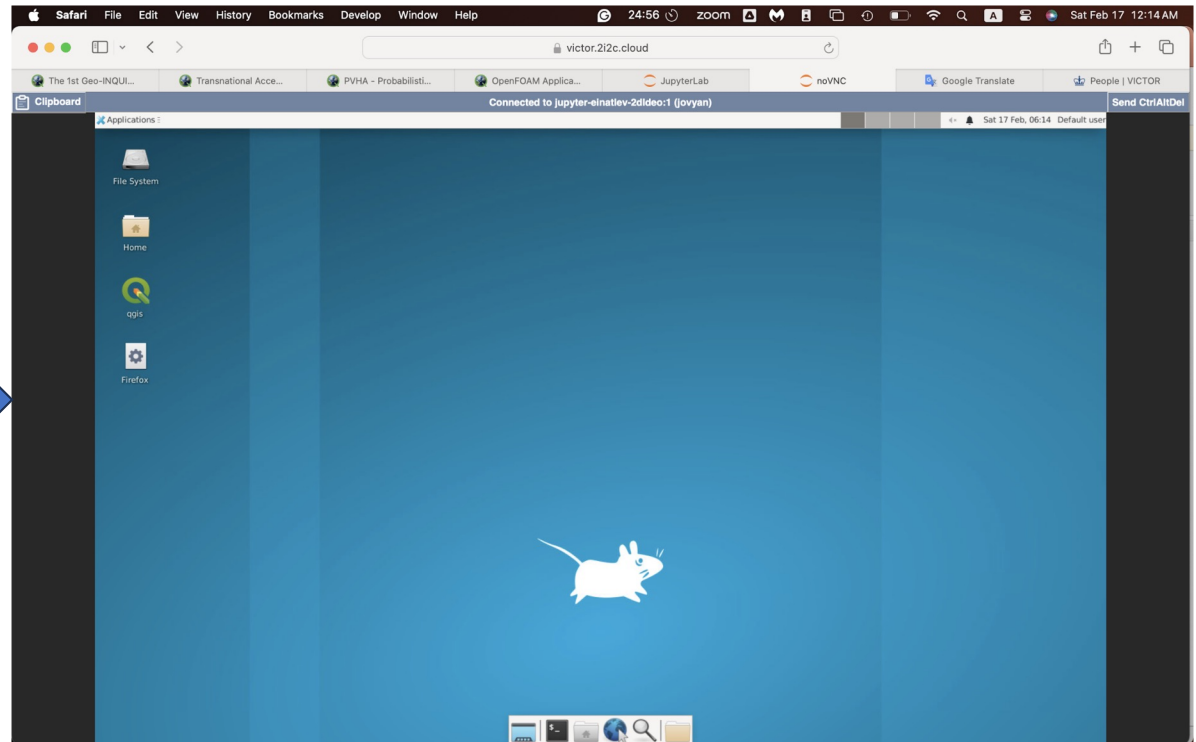
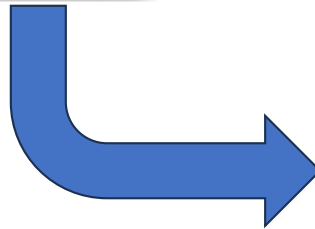
Pre-installed workflows



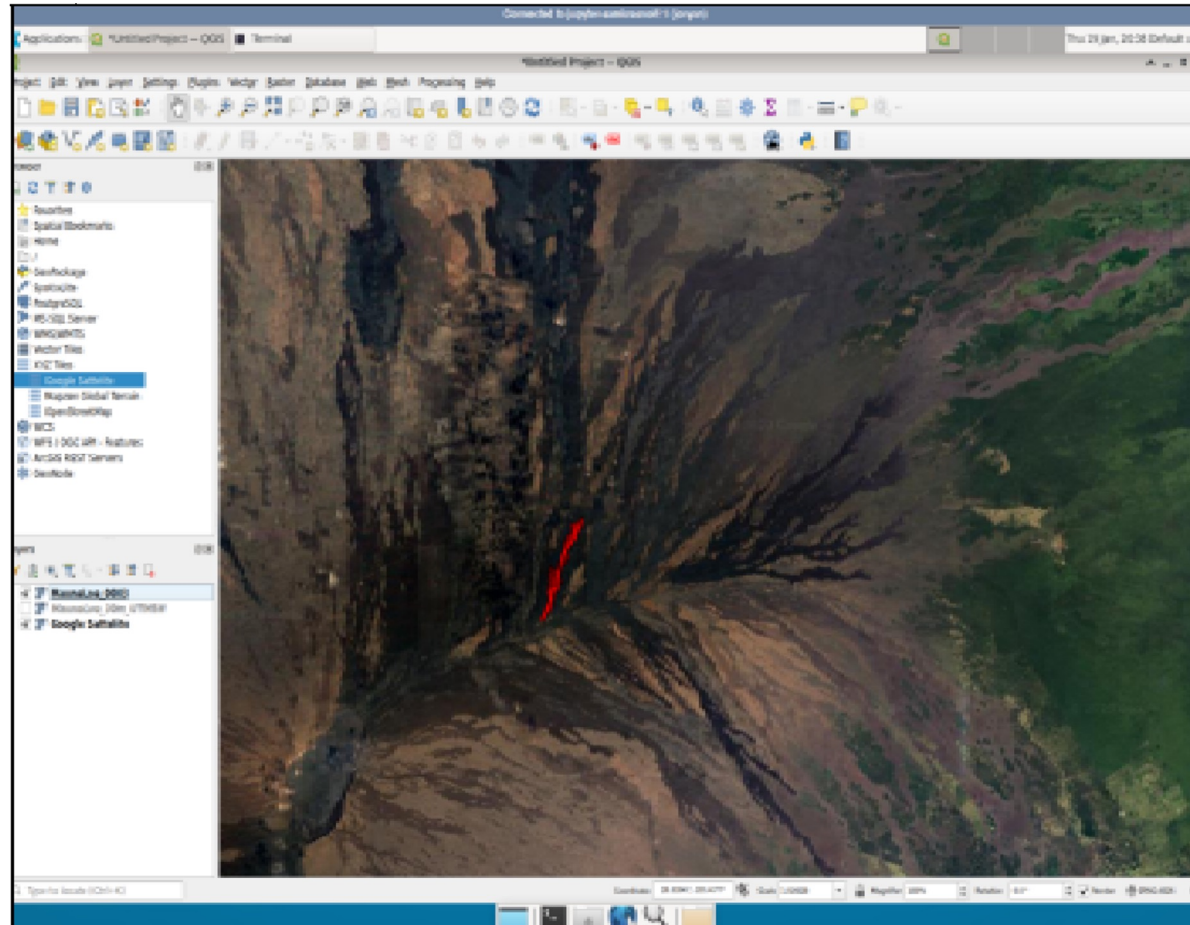
Virtual Desktop



To run applications with GUI, e.g. QGIS



Virtual Desktop



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Currently Available Models and Tools

Volcanic Process	Models or Tools currently available
Lava Flows	DOWNFLOW, IMEX-Lava, Lava2d, MOLASSES, MrLavaLoba, pyFLOWGO, Q-LavHA, VENUSS, VolcFlow
PDCs	TITAN2D, IMEX_SfloW2D_V2
Ash Dispersal	HAZMAP, HySPLIT, Fall3D, PLUME-MoM, Plumeria
Tephra dispersal	Tephra2, Fall3D
Gas dispersal	DISGAS, HySPLIT, TWODEE
Lahars	LaharZ
Slope Stability	Scoops3D
Conduit ascent	CONFORT, MAMMA
Sulfur and Volatile Degassing	Sulfur_X
Magmatic / geochemical tools	alphaMELTS, Perple_X, Thermobar



Currently Available Models and Tools

Volcanic Process	Models or Tools currently available
Lava Flows	DOWNFLOW, IMEX-Lava, Lava2d, MOLASSES, MrLavaLoba, pyFLOWGO, Q-LavHA, VENUSS, VolcFlow,
PDCs	TITAN2D, IMEX_Sflow2D_V2
Ash Dispersal	HAZMAP, HySPLIT, Fall3D, PLUME-MoM, Plumeria
Tephra dispersal	Tephra2, Fall3D
Gas dispersal	DISGAS, HySPLIT, TWODEE
Lahars	LaharZ
Slope Stability	Scoops3D
Conduit ascent	CONFORT, MAMMA
Sulfur and Volatile Degassing	Sulfur_X
Magmatic / geochemical tools	alphaMELTS, Perple_X, Thermobar

New tools and
models added all
the time!

Documentation

docs.victorproject.org

A screenshot of the VICTOR documentation page. The page has a dark blue sidebar on the left with the VICTOR logo and a search bar. The main content area is white and contains a welcome message, a note about active development, and a table of contents. The browser tabs at the top show "Home Page - Select or create a notebook", "PyFlowGo_wrapper - Jupyter Notebook", and "JupyterLab".

Home Page - Select or create a notebook | PyFlowGo_wrapper - Jupyter Notebook | JupyterLab

VICTOR
latest

Search docs

Usage
Models

Read the Docs v: latest

Welcome to the VICTOR documentation! [Edit on GitHub](#)

Welcome to the VICTOR documentation!

VICTOR is a JupyterHub based platform for volcano science modeling and data analysis. All of our infrastructure and modeling code is open-source and/or publicly available. We hope for VICTOR to function as a continuously evolving service, fostering novel mathematical models and encouraging further data sharing among the volcanology community and beyond.

For more detailed information on the project overall, check out the [Usage](#) section.

For details on running each individual model, please go to the [Models](#) section.

Note

This project is under active development and is subject to changes.

Contents

- Usage
 - Registration
 - Run Models
 - Citations and References
 - Contributing Models and Hub Additions
- Models
 - Models Overview
 - Utilizing Workflows
 - Conflow/Confort
 - Harmon

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Education



Training and Tutorials

Getting Started With VICTOR

VICTOR background

(images and links will open presentations in a new tab):

Welcome to the VICTOR Workshop! While you're settling in, please navigate to https://tinyurl.com/victorreg and fill out the form so we can get you set up on VICTOR!	An Introduction to Cloud Computing	Intro to Python and Jupyterhub
Introduction to VICTOR	Introduction to Cloud Computing	Introduction to Python and JupyterHub

⬅ Back to Top

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Education

VICTOR-based teaching modules

Educators' webinars:
June 29,
July 30

victorproject.org



VICTOR
Volcanology Infrastructure
for Computational Tools and
Resources, or VICTOR.
• A cloud-based cyberinfrastructure

Lecture Slides

 The VICTOR Team
Overview of VICTOR
[Google Slides File](#)
This lecture slide deck introduces students to VICTOR. These slides can be used on their own or added to any related lecture where VICTOR will be demoed or used.



LAVA FLOW MODELING
AND INSIGHTS FROM THE 2022
MAUNA LOA ERUPTION

Lecture Slides

 The VICTOR Team
Lava Flow Modeling
[Google Drive Download](#)
These lecture slides were developed for upper-undergraduate level science majors. The lecture was designed to prepare students to complete the accompanying Lava Flow Lab.



LAVA FLOWS
SIGNIFICANCE,
CHARACTERISTICS, AND
HAZARDS

Lecture Slides

 The VICTOR Team
Lava Flows
[Google Slides File](#)
This lecture presentation introduces students to the study of lava flows, developed to supplement the Lava Flow Modeling lecture. It is best suited for undergraduate- graduate students. .



[Course Code] Lava Flow Modeling Lab
November 8, 2024

Learning Objectives

1. Identify and navigate key aspects of the VICTOR interface.
2. Analyze real-world data from the 2022 eruptions of Mauna Loa and conduct a parameter sweep using VICTOR.
3. Compare and contrast outputs from three VICTOR models.

Note: Text that requires input from you is indicated in blue.

Background: In this assignment, you will use three numerical flow models - MOLA2, MOLA2-2D, and MOLA2-3D - to simulate the 2022 eruption of Mauna Loa volcano (in Hawaii).

Lab Assignment

 The VICTOR Team
Lava Flows Lab
[PDF Download](#)
This lab assignment required student access to the internet. Designed for upper-undergraduate level science majors, this lab was developed to follow the Lava Flow Modeling lecture.



HAZARD ASSESSMENT

INPUTS

OUTPUTS

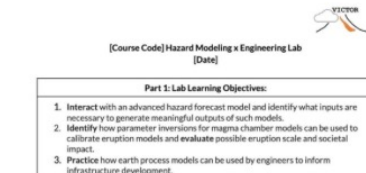
Tephra sedimentation models are used to forecast the accumulation of ground volcanic material across a region. We need tephra hazard models that we can trust in order to make reliable forecasts critical to hazard assessment.

Inputs to the model include eruption parameters, particle parameters, atmospheric parameters, and grid parameters.

The model outputs the mass per unit area of tephra on the ground and the air percent of each grain size at each of the specified locations.

Lecture Slides

 The VICTOR Team
Tephra2 Manual Guide
[Google Drive Download](#)
This lecture deck summarizes the Tephra2 manual and works well to prepare graduate level students for a lab assignment using the Tephra2 workflow. (See: [Engineering x Hazard Monitoring Lab](#))



[Course Code] Hazard Modeling x Engineering Lab
[Date]

Part 1: Lab Learning Objectives:

1. Interact with an advanced hazard forecast model and identify what inputs are necessary to generate meaningful outputs of such models.
2. Identify how parameter inversions for magma chamber models can be used to calibrate eruption models and evaluate possible eruption scale and societal impact.
3. Practice how earth process models can be used by engineers to inform infrastructure development.

Lab Assingment

 The VICTOR Team
Tephra2 for Civil Engineering
[Google Document](#)
This lab assignment combines the topics of hazard modeling and civil engineering, making it best suited for graduate level students. Supplement this lab with the Tephra2 slides. (See: [Tephra2 Manual Guide](#))

Civil Engineering x Hazard Modeling

Tephra2 on VICTOR



Objectives:

1. **Interact** with an advanced hazard forecast model & **identify** which inputs are necessary to generate meaningful outputs of such models.
2. **Identify** how parameter inversions for magma chamber models can be used to calibrate eruption models and evaluate possible eruption Scale and societal impact.
3. **Practice** and **apply** how engineers can use earth process models to inform infrastructure development.

Introduction and Background:

In this lab, you will use a numerical model called "Tephra2", which simulates the dispersion of volcanic ash from an eruption, to assess how eruption conditions impact the built infrastructure in surrounding communities. The lab uses a hypothetical eruption at South Sister volcano as the test case.



```
[9]: locations = [[44.05812334099115, -121.3180703622792], [44.27043708913616, -121.17467125646367], [43.86843088378271, -121.17467125646367]]
      elevation = 1000
      locations = np.array(locations)
      loded = utm.from_lation(locations[:,0], locations[:,1])
```

calculations from page 6.

Site Name	Erupted Volume	Erupted Mass	Deposit Mass/area (kg/m2)	Deposit load (kPa)	Total mass on the roof (kg)
Site 1	1km ³				
	3km ³				
	5km ³				
Site 2	1km ³				
	3km ³				
	5km ³				
Site 3	1km ³				
	3km ³				
	5km ³				

Mass per unit area of deposit at each site:
eruption mass (kg) / roof area (m2)

Gravitational Acceleration:

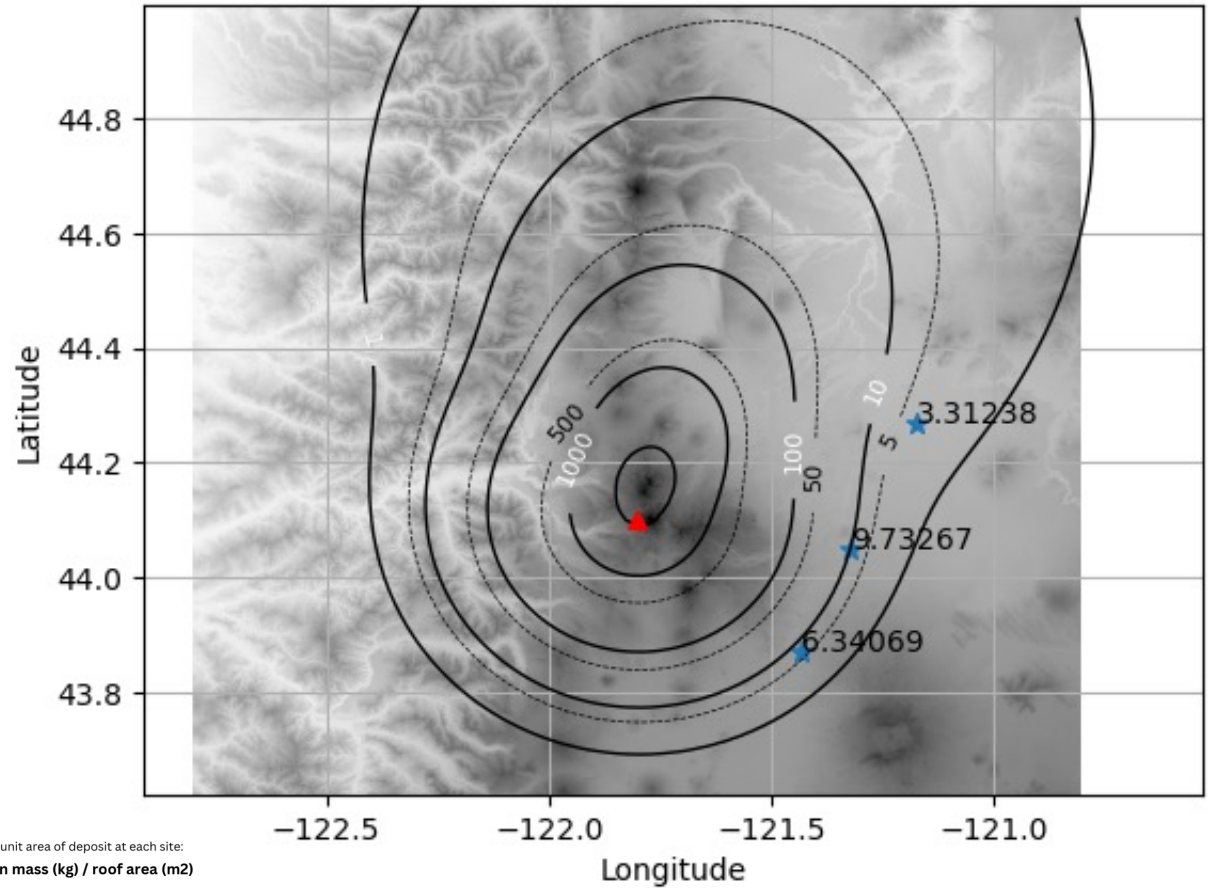
9.8 m/s²

Density of Tephra:
1200 kg/m³

Page 5 / 7



Tephra Dispersion

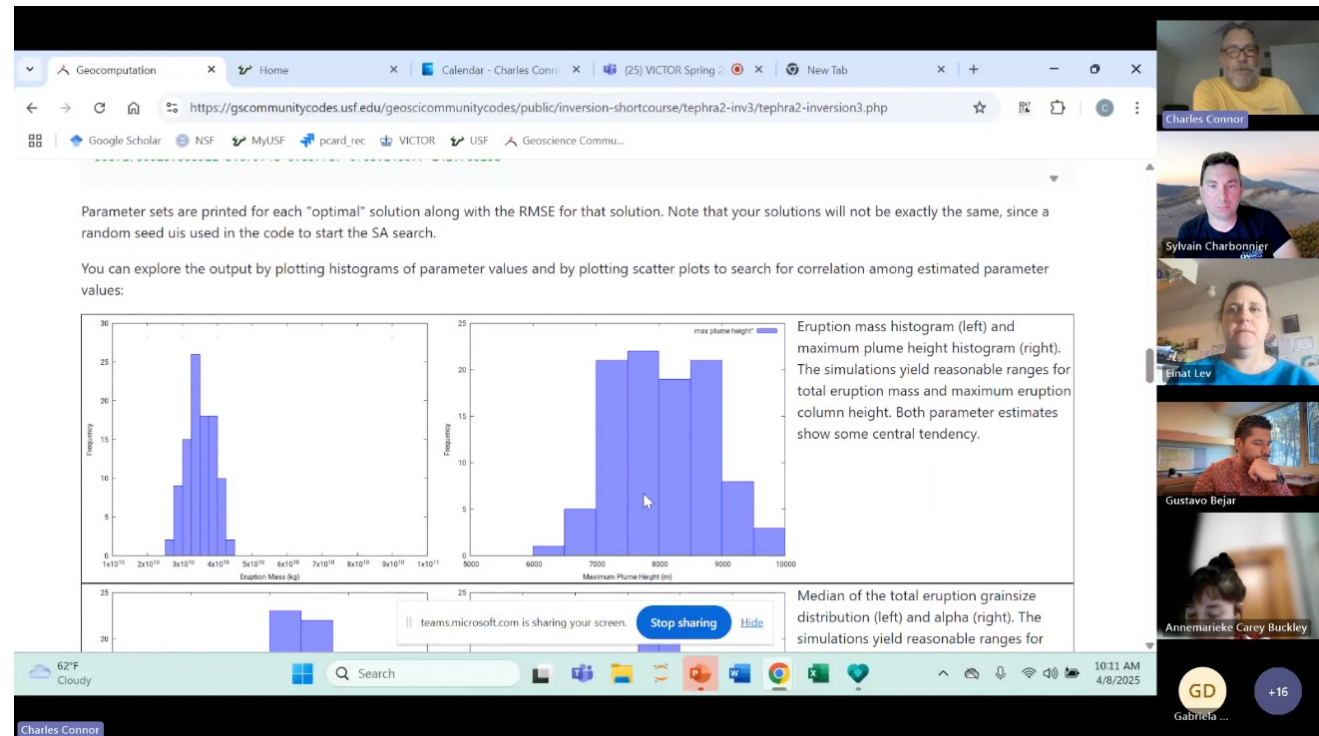


Learn more at victorproject.org

Computational Volcanology Course



	Topic
week 1	Introduction to VICTOR
week 2	DEMs/raster tools
week 3	Tephra fallout
week 4	Lava Flows
week 5	PDCs
week 6	Lahars
week 7	Differential equations
week 8	SPRING BREAK
week 9	Magma storage
week 10	Magma ascent
week 11	Magma degassing
week 12	Inversion
week 13	Remote sensing



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Workshops at Conferences



Cascades24,
Oregon



Cities on Volcanoes 12,
Guatemala



Learn more at victorproject.org

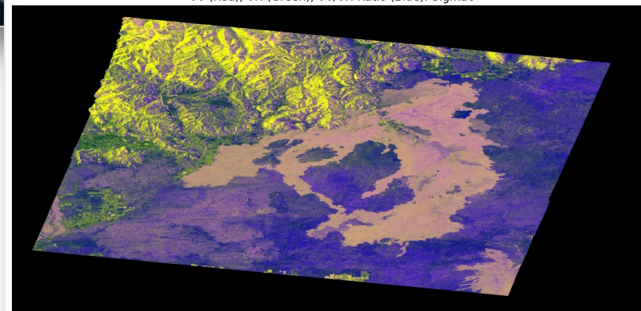
Developers Summit



Field + Compute hybrid workshop

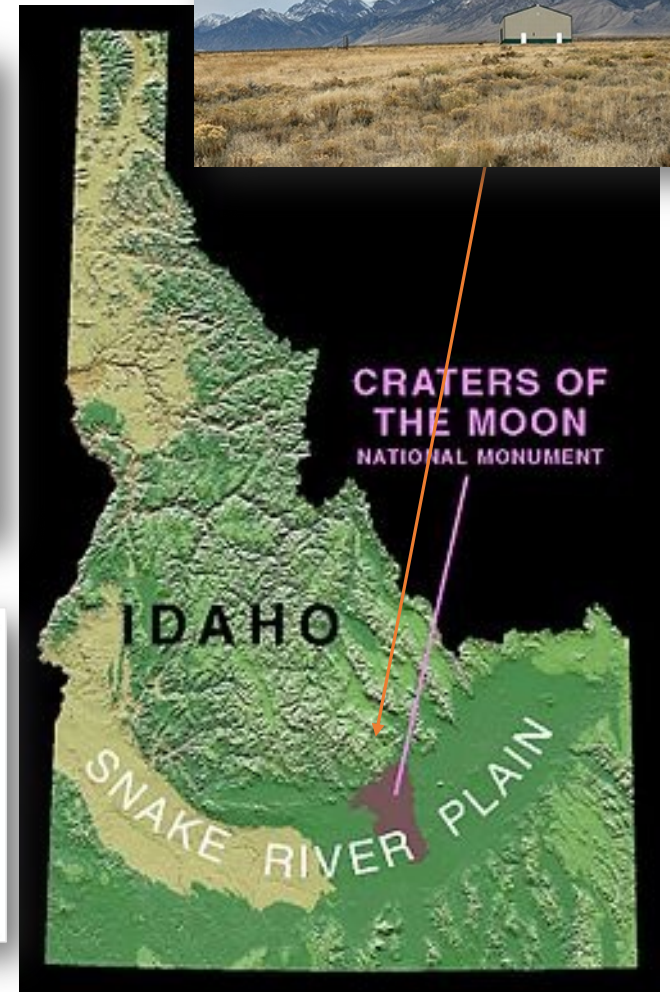


VV (Red), VH (Green), VV/VH Ratio (Blue): Sigma0



Learn more at victorproject.org

USF Field Station
McKay, ID



Added-value Capability: Model Benchmarking



Set up common inputs, e.g.:

- Vent location
- DEM file
- Effusion duration / flux / volume

Set up model-specific inputs for Model 1

Run Model 1

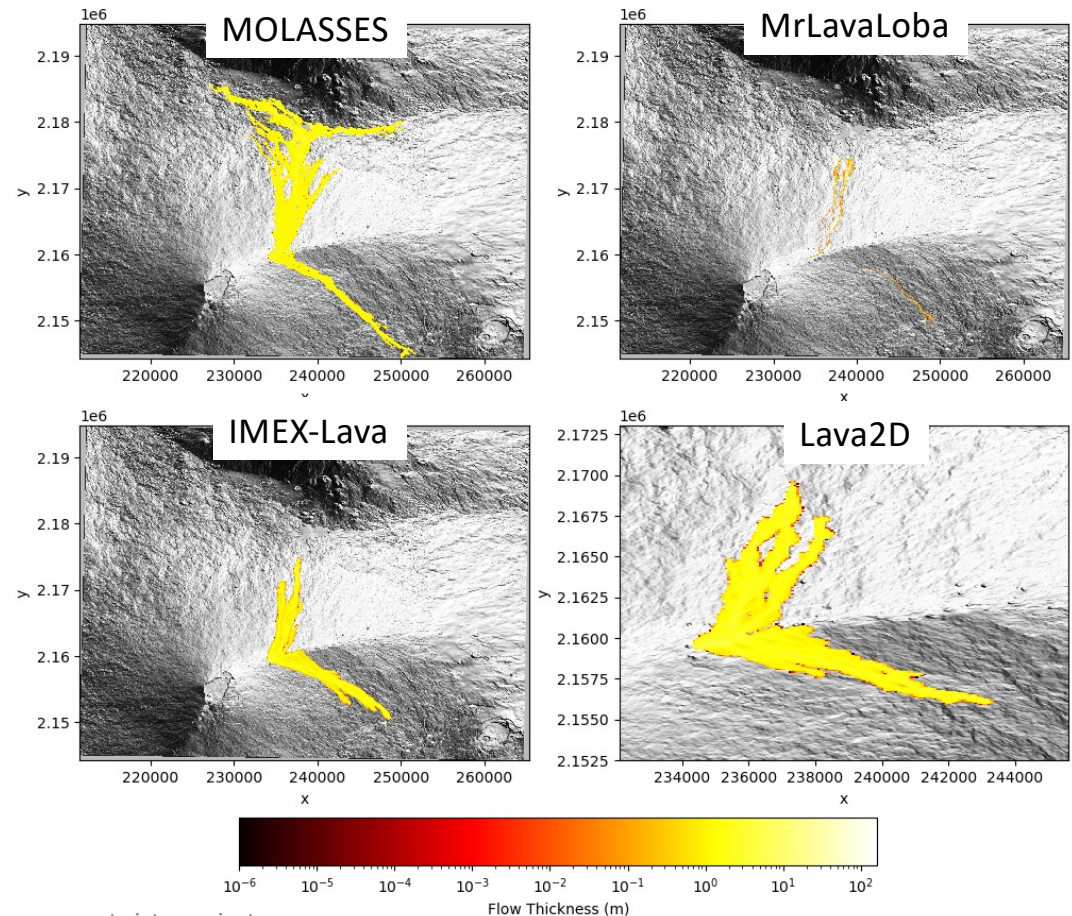
Set up model-specific inputs for Model 2

Run Model 2

Set up model-specific inputs for Model 3

Run Model 3

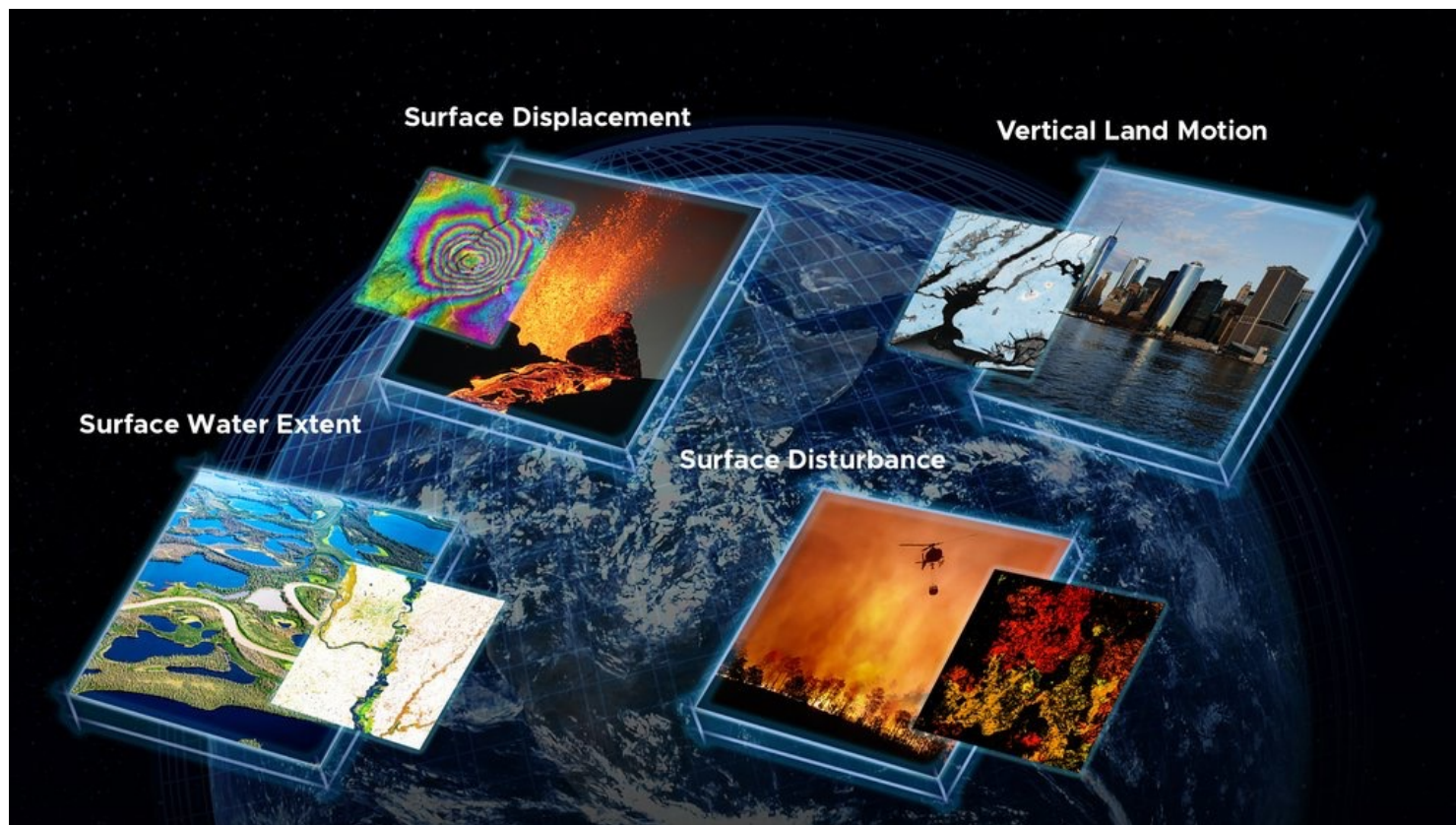
Visualize results



New Capability: remote-sensing workflows



Jet Propulsion Laboratory
California Institute of Technology

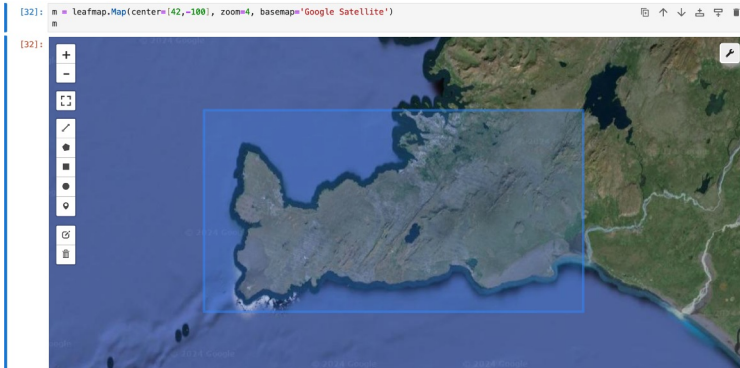


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New Capability: remote-sensing workflows



1. Interactively define AOI



2. Granule Search using OPERA's DIST set

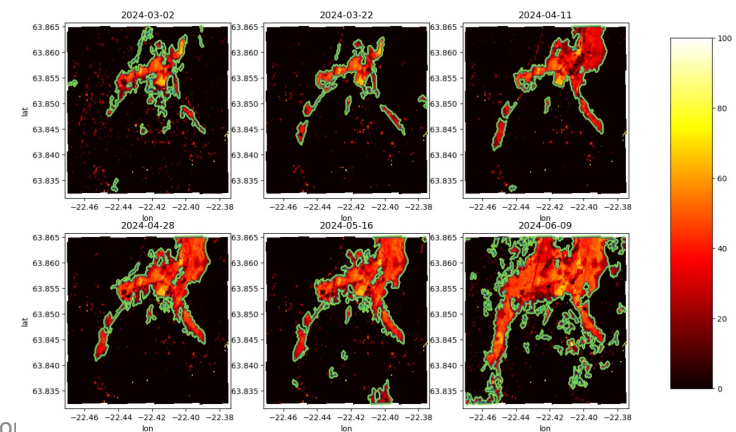
```
[35]: dist_results, dist_gdf = leafmap.nasa_data_search(
    short_name='OPERA_L3_DIST-ALERT-HLS_V1',
    cloud_hosted=True,
    bounding_box=AOI,
    temporal=(start_date, end_date),
    count=-1, # use -1 to return all datasets
    return_gdf=True,
)
```

Granules found: 262

3. Interactive Time Series of Eruption Data

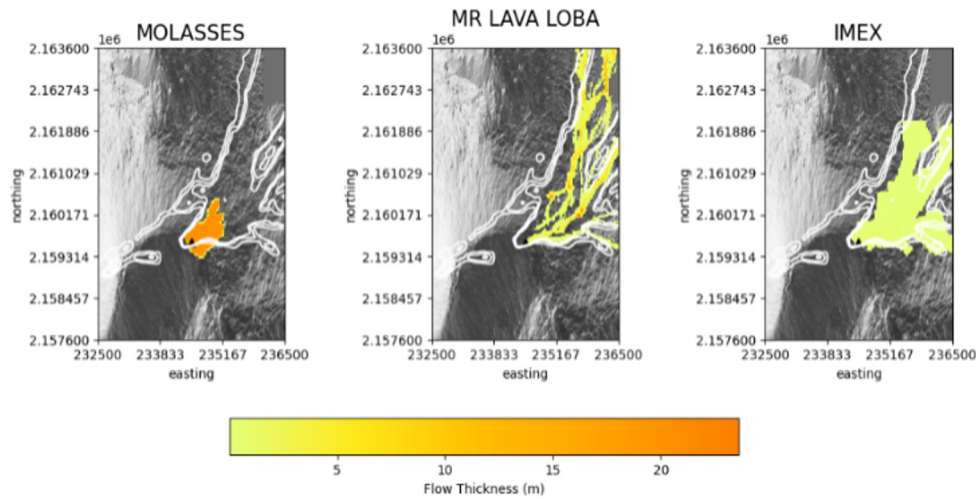


4. Automated flow footprint detection



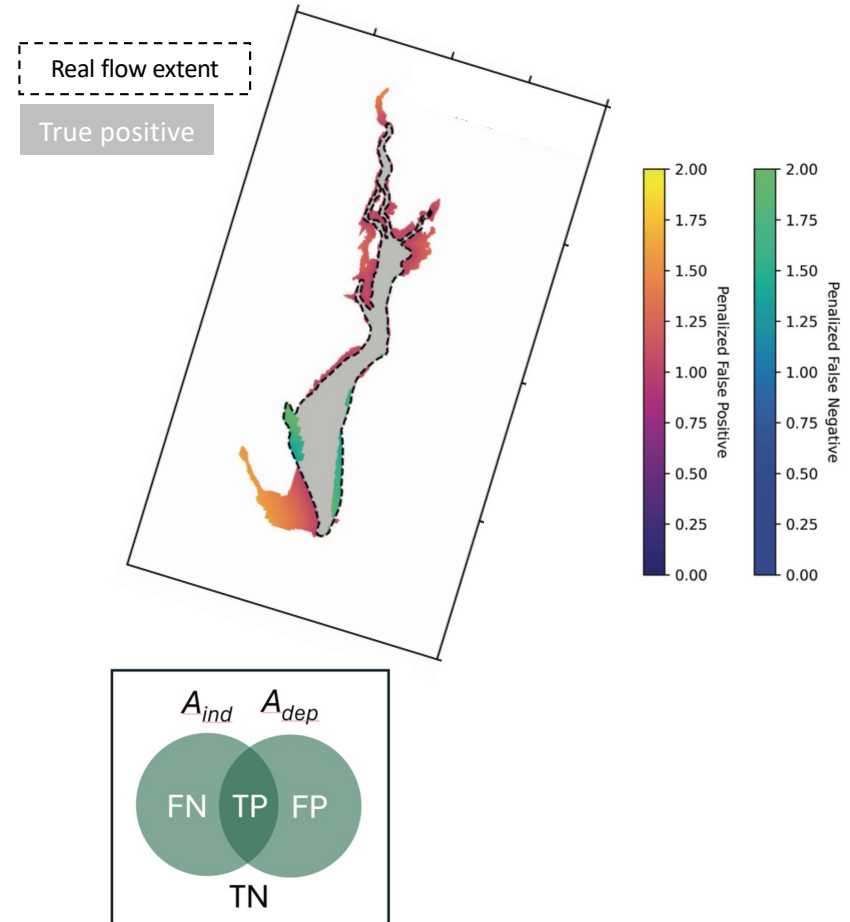
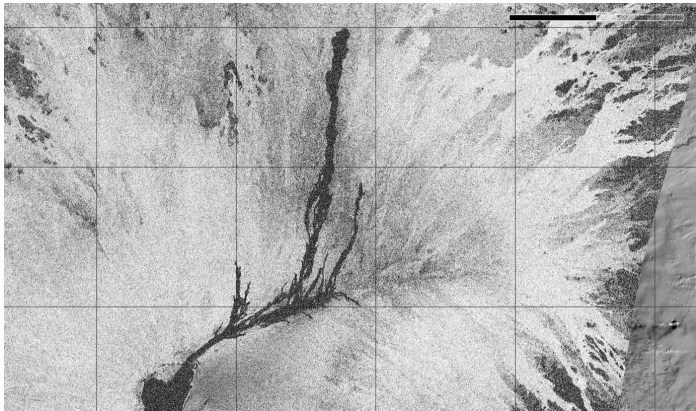
Learn more at victorproject.org

New Capability: Combine Remote Sensing and Models



Mauna
Loa 2022

SAR coherence



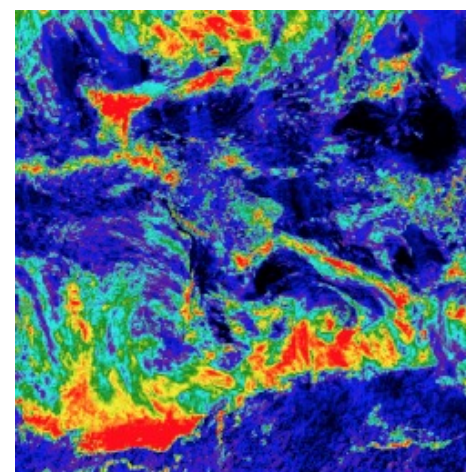
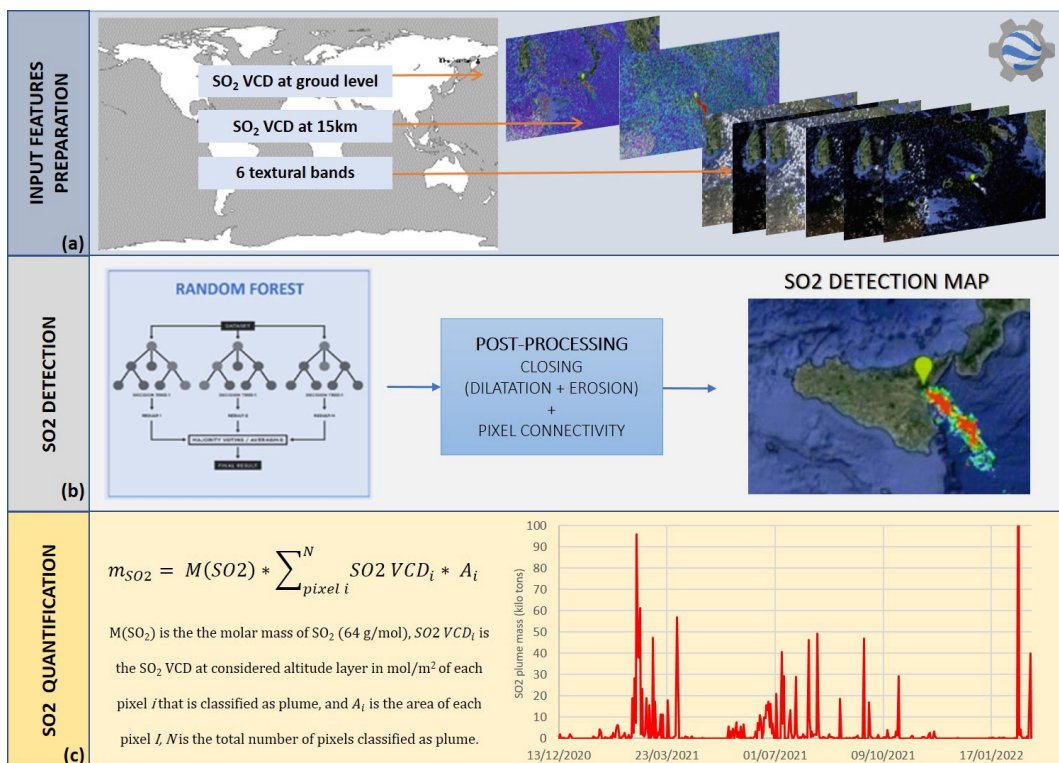
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Upcoming Capability: remote-sensing workflows



Monitoring Earth's atmosphere with Sentinel-5 TROPOMI and Artificial Intelligence

Claudia Corradino, Istituto Nazionale di Geofisica e Vulcanologia Osservatorio Etneo



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Developing capabilities – Inversion workflows



METHODOLOGY

Tephra deposit inversion by coupling *Tephra2* with the Metropolis-Hastings algorithm: algorithm introduction and demonstration with synthetic datasets

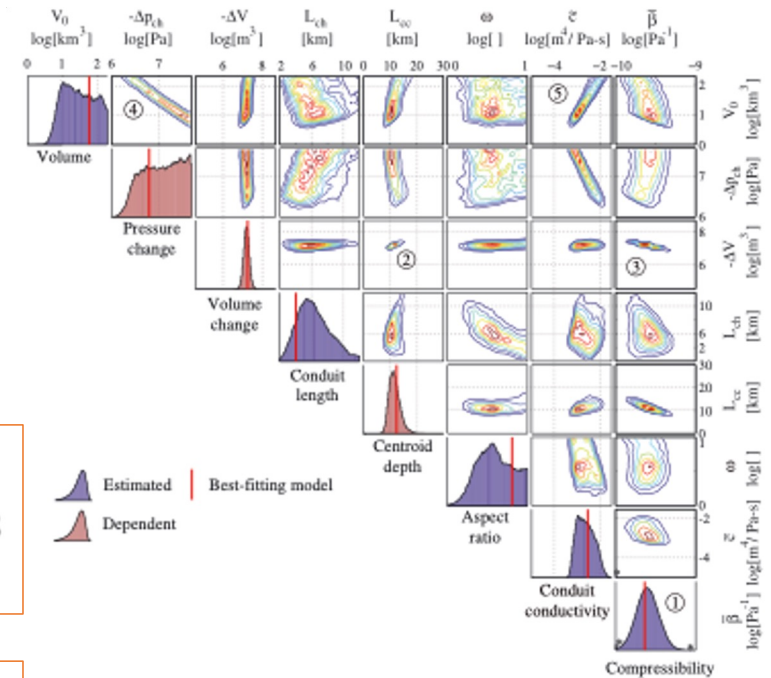
Qingyuan Yang^{1,2*}, E. Bruce Pitman³, Marcus Bursik⁴ and Susanna F. Jenkins^{1,2}

Bayesian inversion of data from effusive volcanic eruptions using physics-based models: Application to Mount St. Helens 2004–2008

Kyle Anderson^{1,2} and Paul Segall¹

Volcanic ash forecast using ensemble-based data assimilation: an ensemble transform Kalman filter coupled with the FALL3D-7.2 model (ETKF-FALL3D version 1.0)

Soledad Osorio^{1,2,3}, Juan Ruiz⁴, Arnau Folch⁵, and Estela Collini⁶



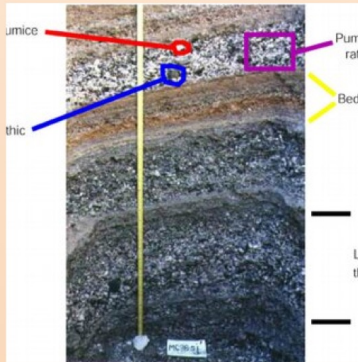
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Inversion example – Tephra deposits

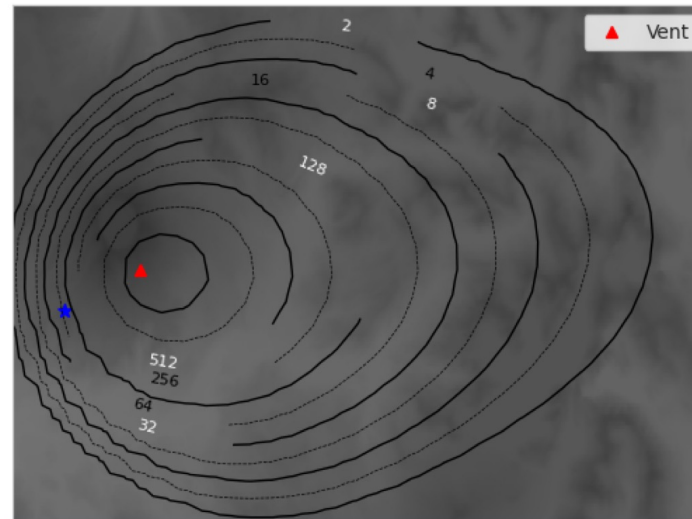


Field observations of tephra deposits

Deposits observations



Eruption parameters:
Plume height
Eruption mass
Wind direction
Grain size distribution

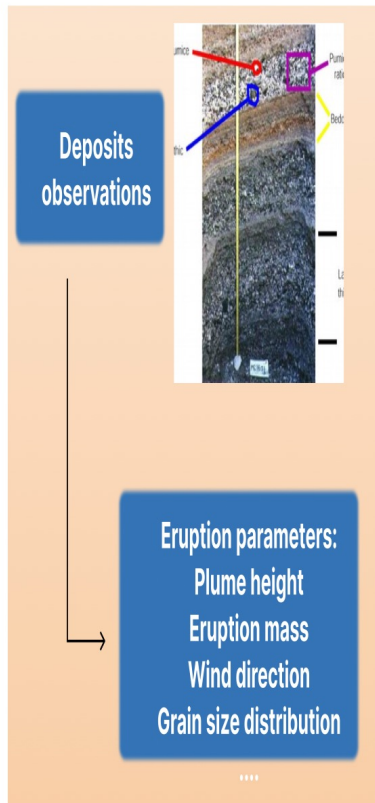


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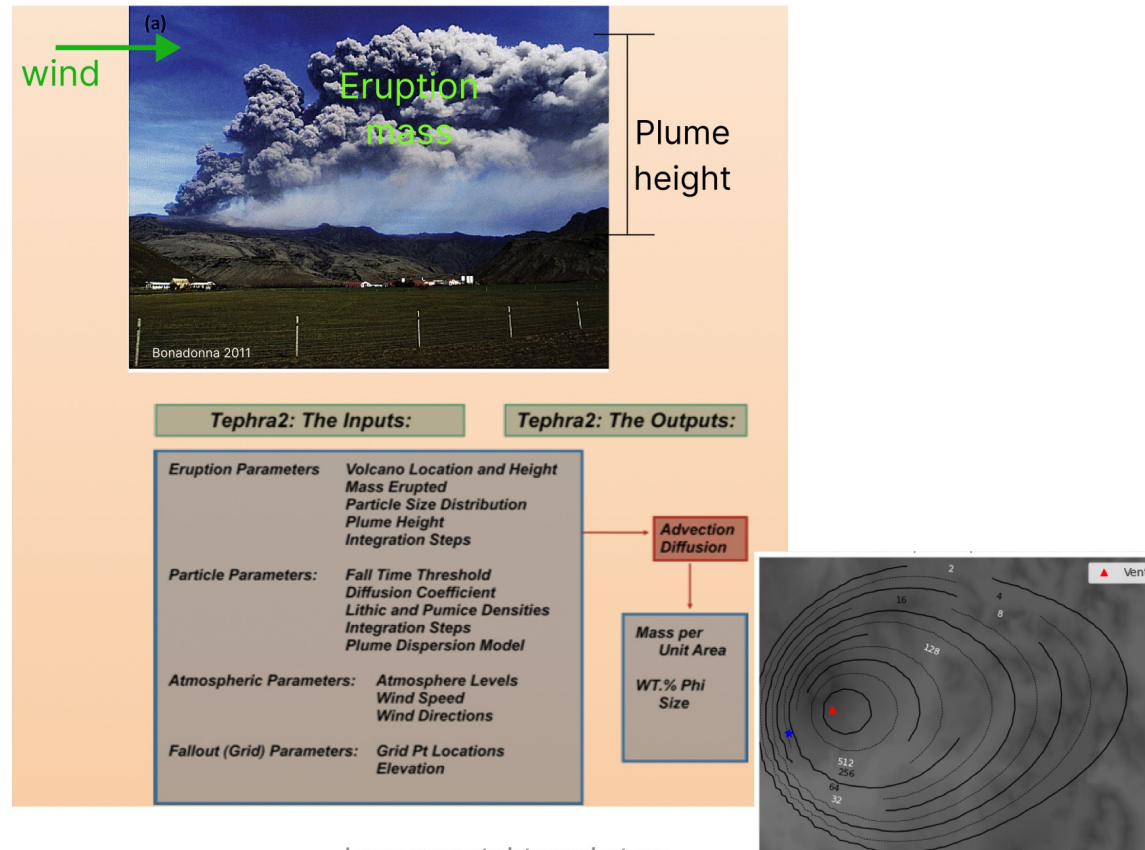
Inversion example – Tephra deposits



Observations



Tephra2 Forward Model



Learn more at victorproject.org

Inversion example – Tephra deposits

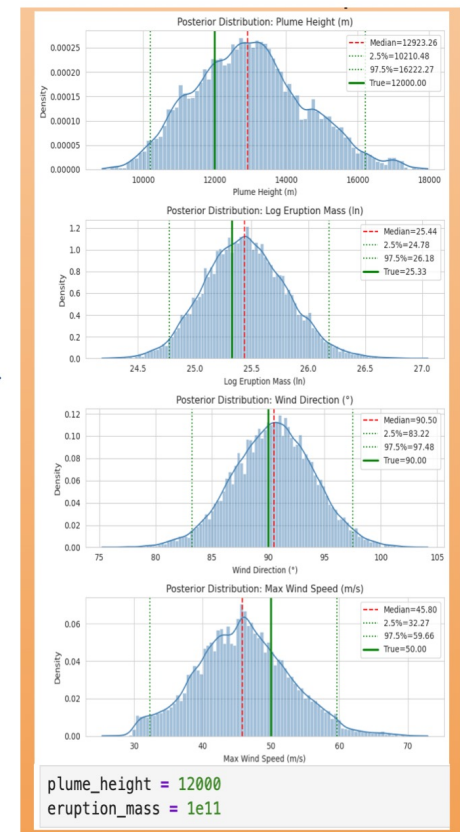
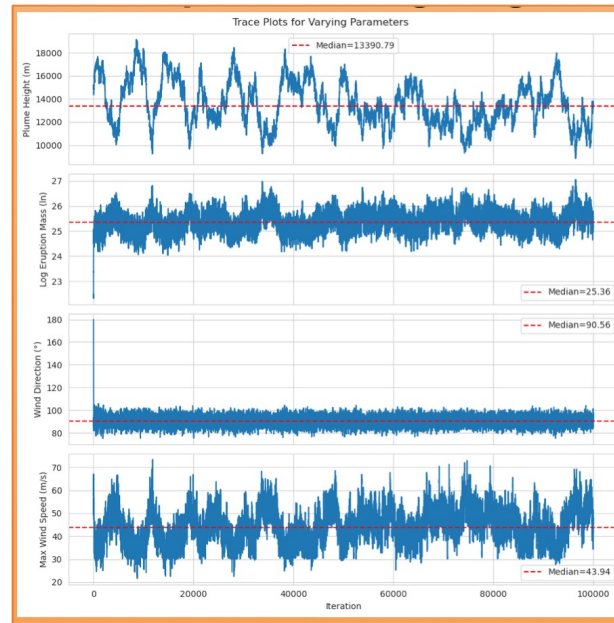
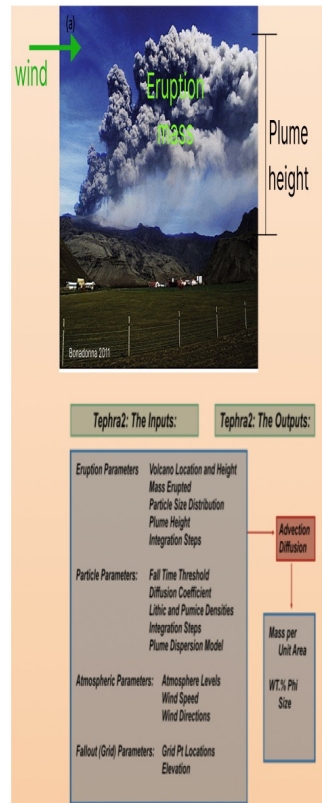
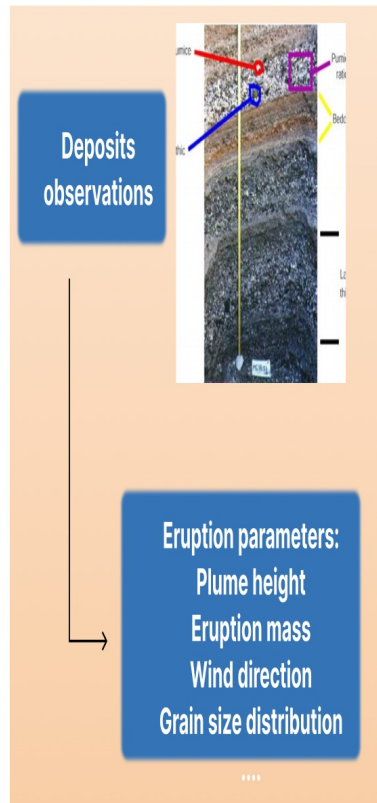


Observations

Model

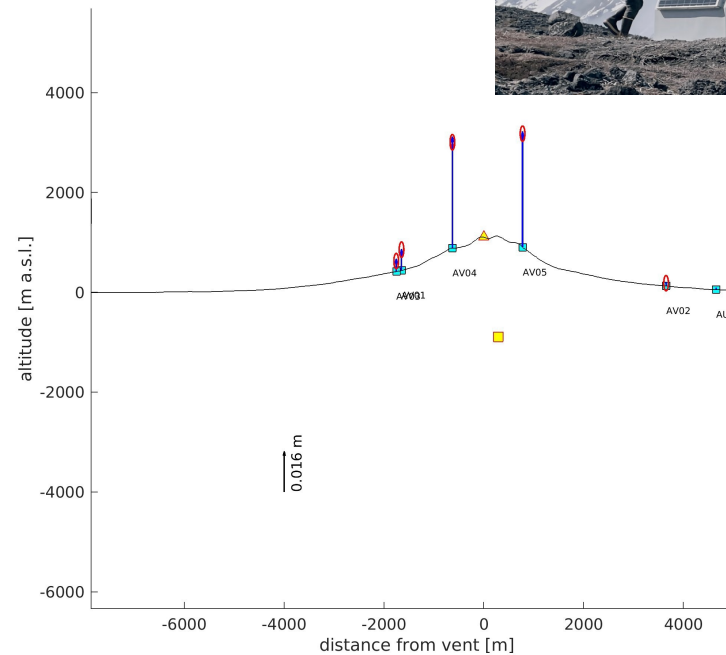
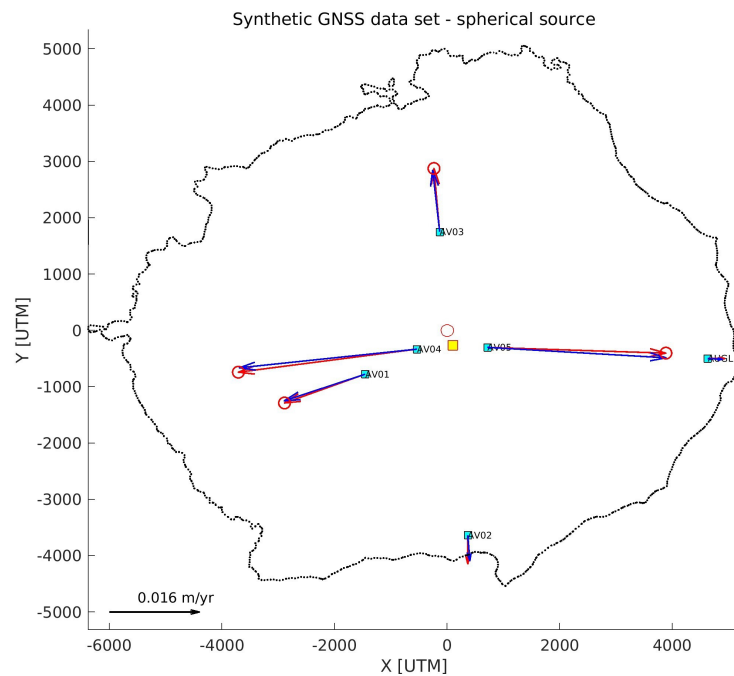
Metropolis-Hastings Algorithm

Distribution of Eruption Parameters

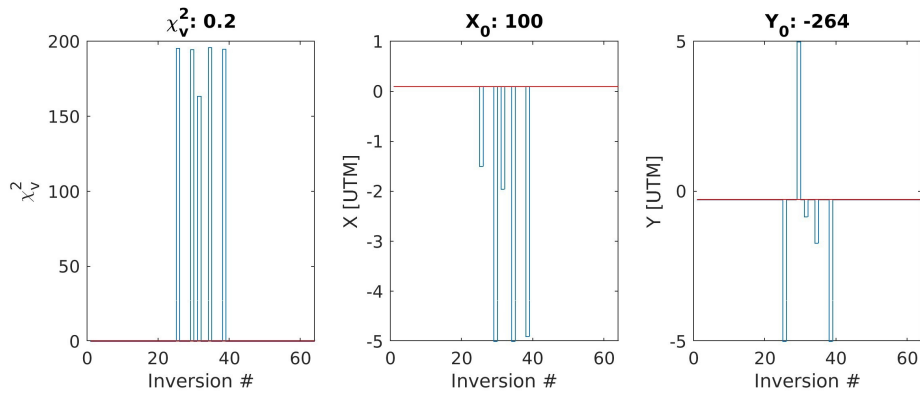


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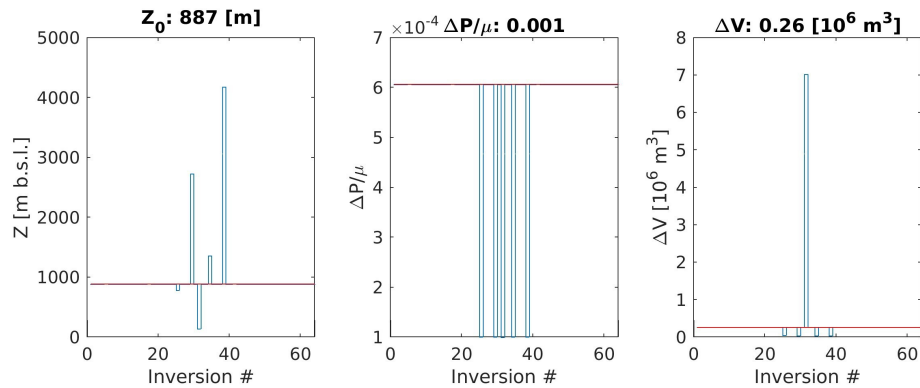
Inversion example – GNSS data



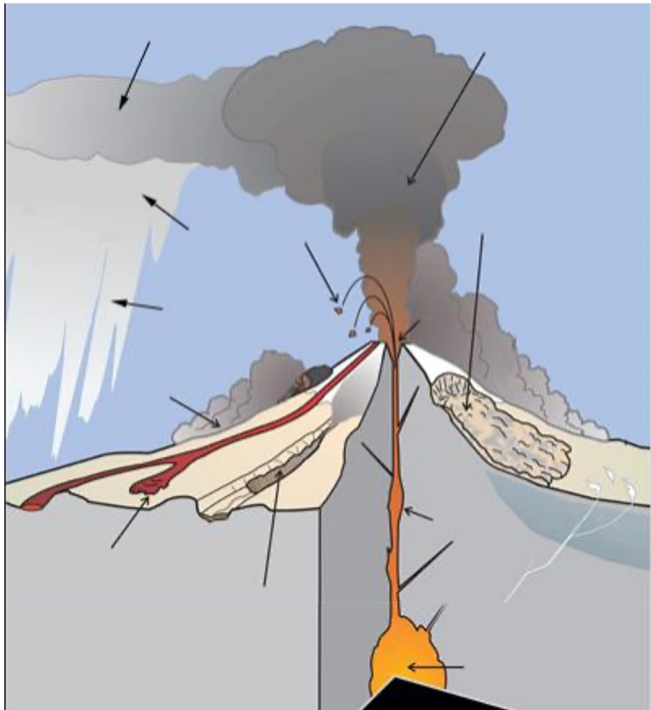
Inversion example – GNSS data



Parameter	Symbol	Units	Original value	Best-fit	Error
X-location	X0	m	111	100	26
Y-location	Y0	m	-255	-264	15
Depth	Z0	m	-850	-887	30
Volume change	dV	10^6 m^3	0.244531	0.2621	0.0130



Future capabilities – Model Coupling + UQ



Currently:

Separate models of individual components of the magmatic system

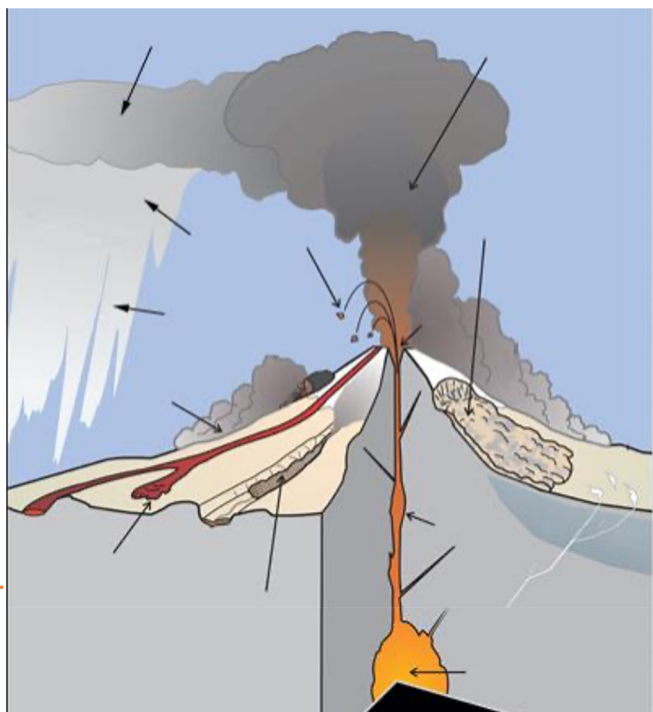
Goal:

System-scale models of connected processes, enabling digital twins and source-to-sink uncertainty quantification

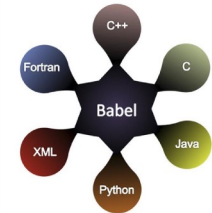
Future capabilities – Model Coupling + UQ



A proposed collaboration (Lev, Hutton, Karlstrom)



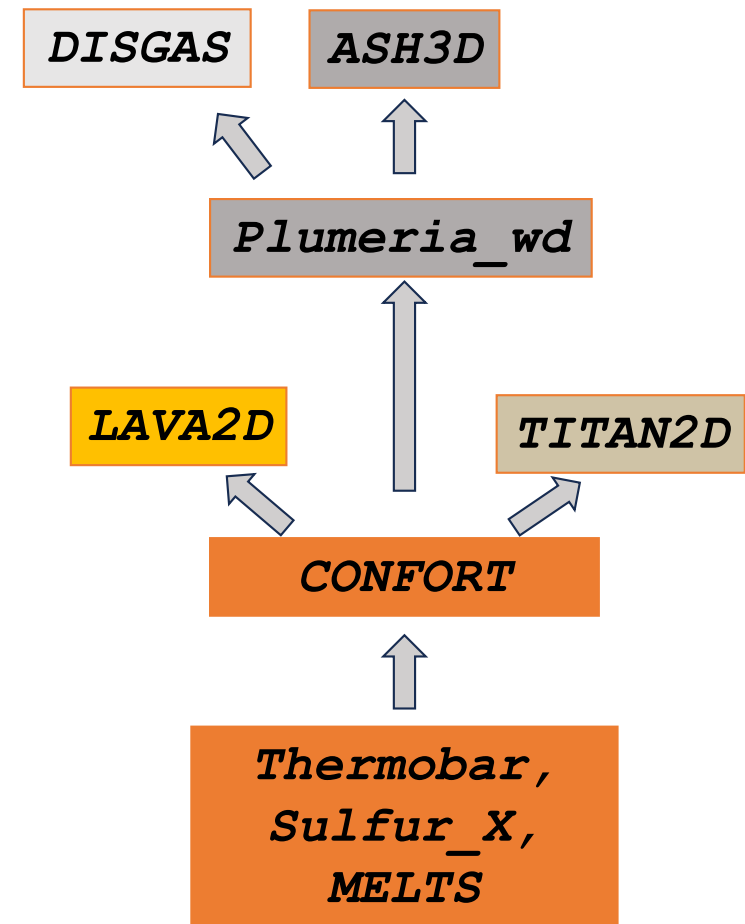
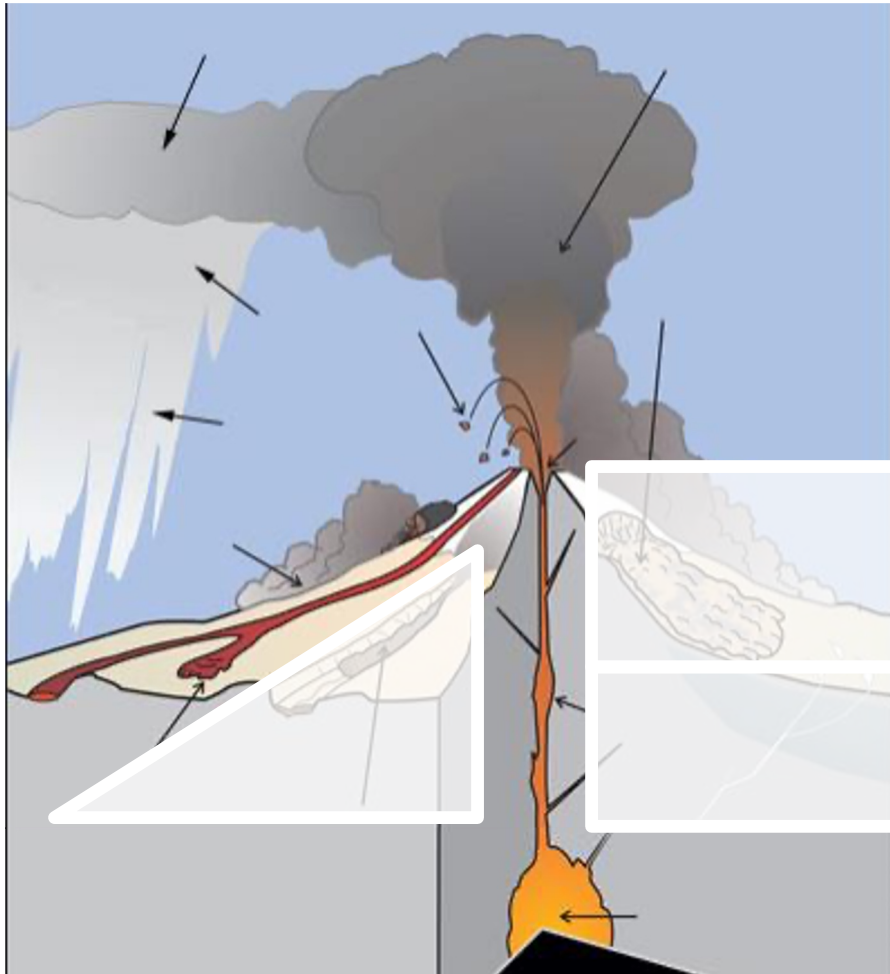
**Volcanology Infrastructure for
Computational Tools and
Resources**



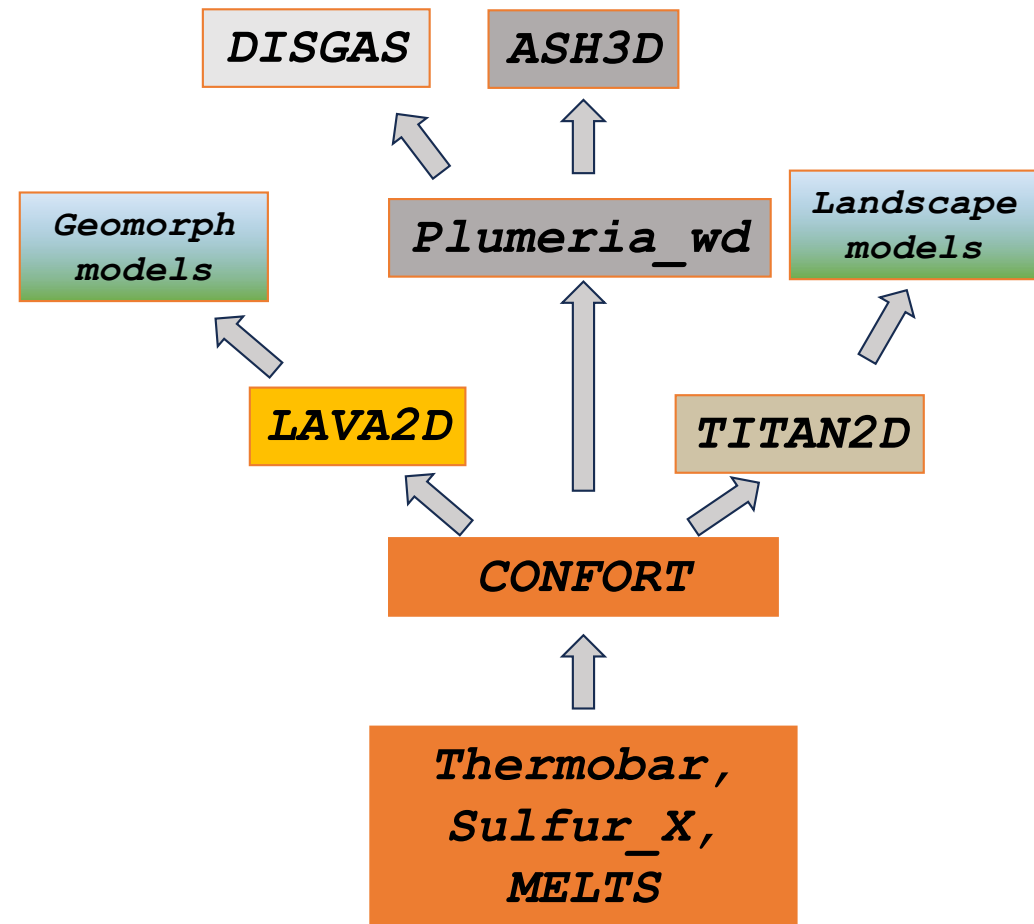
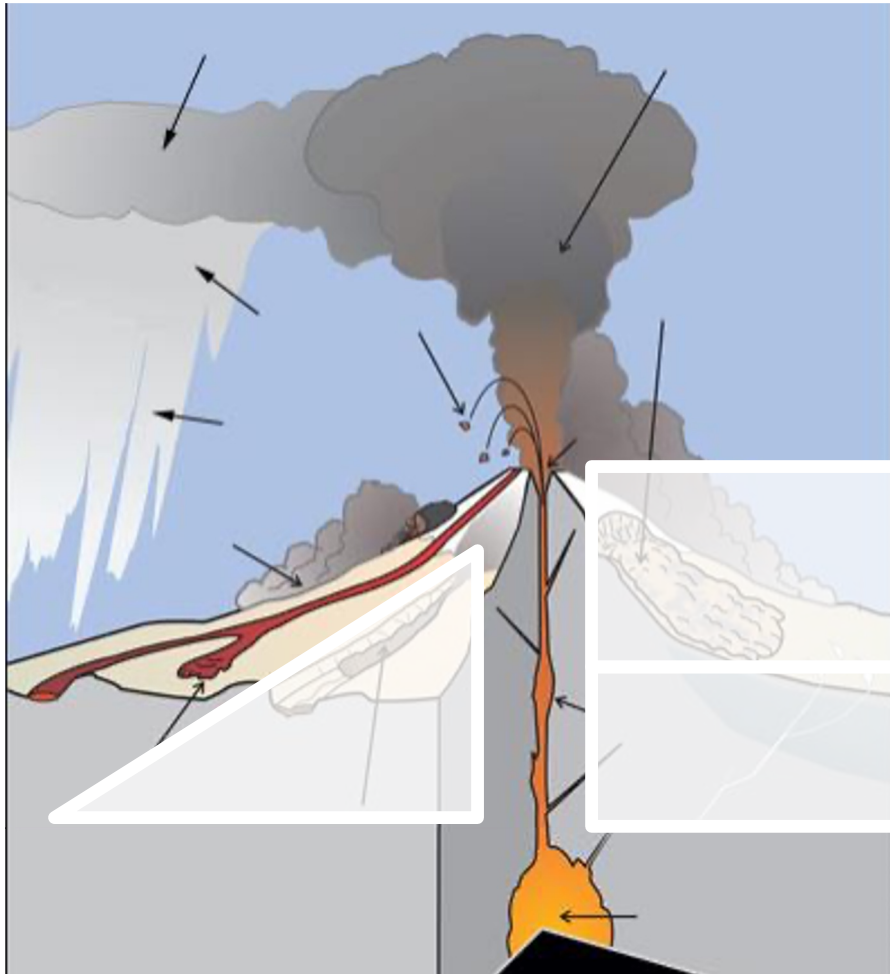
CSDMS
community surface
dynamics modeling system

1. CSDMS Basic Model Interface (BMI)
2. Babelizer
3. Pynt coupling library
4. Landlab

Future capabilities – Model Coupling + UQ



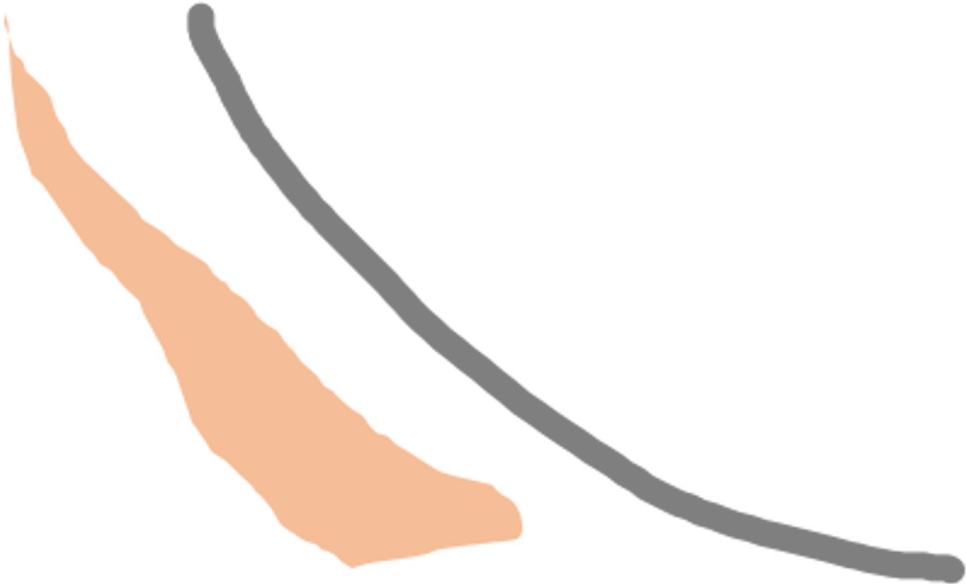
Future capabilities – Model Coupling + UQ



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Questions?



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