



Jet Propulsion Laboratory
California Institute of Technology

Autonomous Nested Search For Hydrothermal Venting

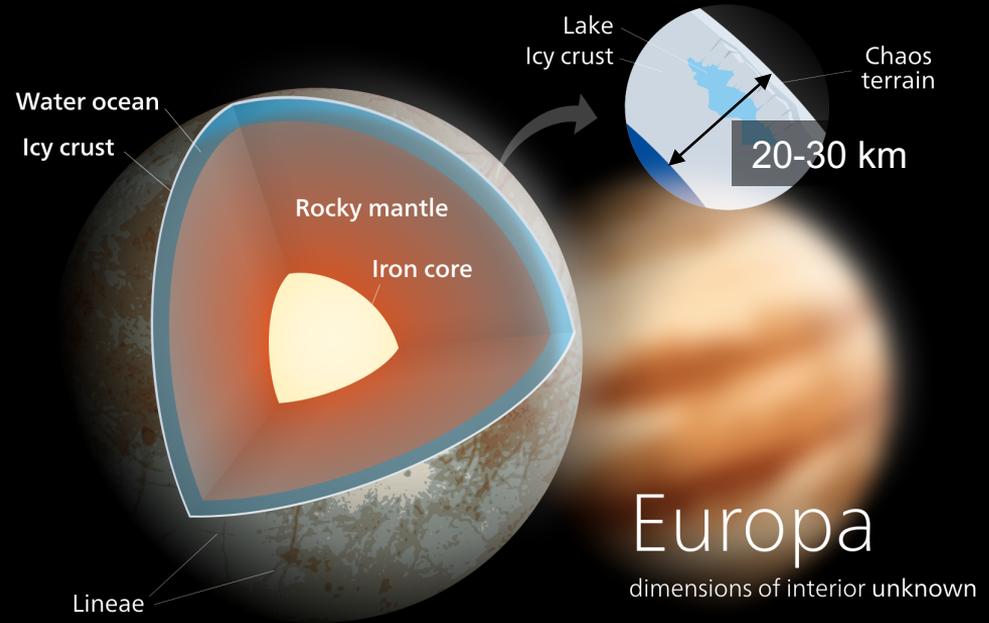
Andrew Branch

© Copyright 2018, California Institute of Technology, All Rights Reserved. This research was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Predecisional, for planning and discussion only.

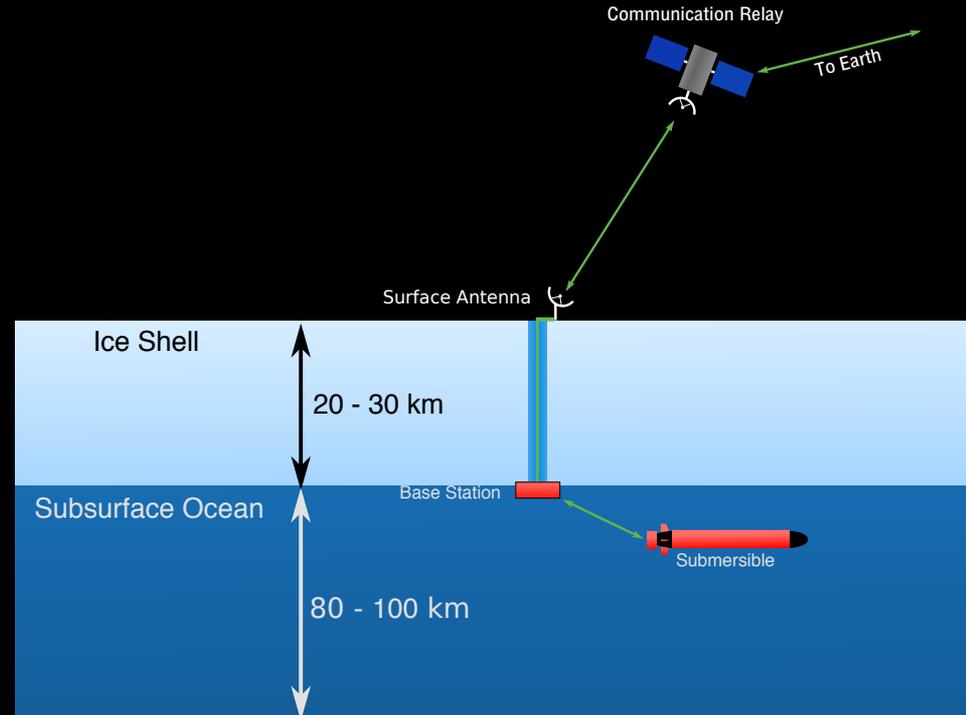
Ocean Worlds

- 8+ bodies in our Solar System thought to harbor liquid oceans (e.g. Europa, Enceladus)
- Often encased in icy shell (20 – 30 km for Europa)
- One of the best chances for extra-terrestrial life in our solar system



Europa Submersible Concept

- Long duration mission
 - 1+ years to penetrate ice plus 1 year mission
- 4 main components: Orbiting relay, surface antenna, under-ice base station, submersible
- Monthly communication windows with relay due to radiation environment
- No communication when distant from base station, sometimes 100s or 1000s of km
- Full autonomy needed for weeks or months at a time
- Goal: Autonomously detect, location, and study scientific targets of interest



Hydrothermal Venting

- Chemically altered seawater emanating from fissure in seafloor
- Harbors unique ecosystem based on chemosynthesis
- Potential for hydrothermal venting on Europa
- Evidence for venting on Enceladus

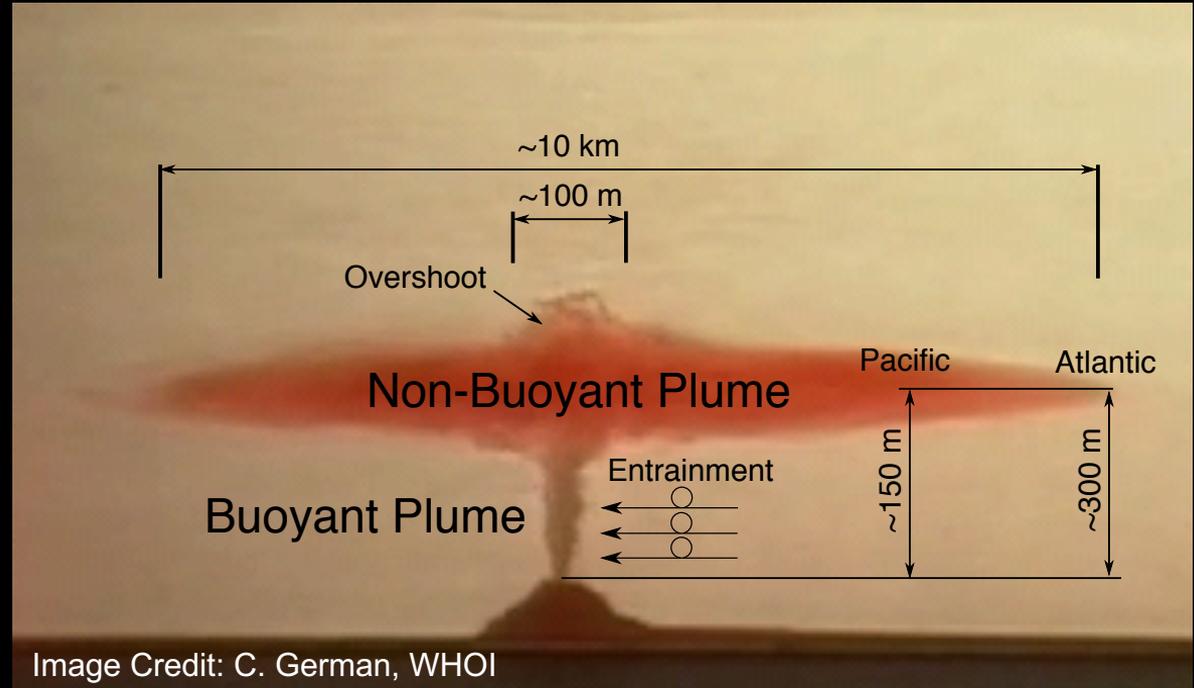


Washington, Juan de Fuca Ridge

Credit: IFE, URI-IAO, UW, Lost City Science Party; NOAA/OAR/OER; The Lost City 2005 Expedition

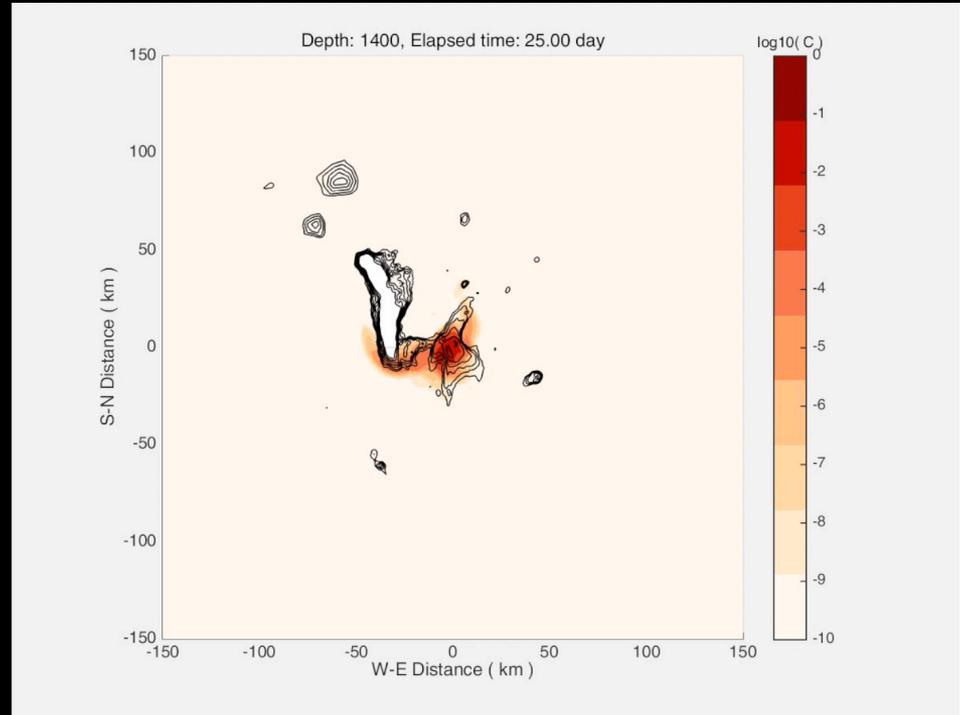
Hydrothermal Venting

- Hot, low density plume fluid exits vent forming buoyant plume
- Density equilibrium reached and non-buoyant plume formed
- Tracking Instruments
 - Temperature
 - Redox
 - Optical Backscatter



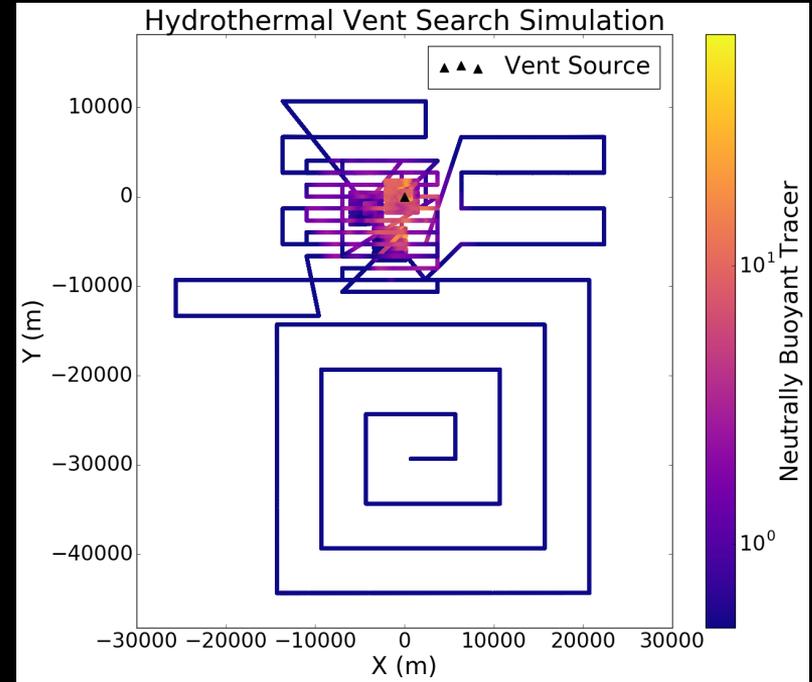
Plume Dispersion Model

- FVCOM based model of Axial Seamount
- 300km x 300km domain
- Unstructured grid
 - 200m at vent location
 - 10km at domain boundary
 - ~12m layer thickness at vent location
- 58 day simulation with outputs sampled at 1 hour
- 1 GW vent source at (0,0)
- Currents, Temperature, Salinity, Passive Tracer (dye).



Autonomous Nested Search

- Vehicle starts at a given location with no information about vent location
- Nested surveys of increasing resolution to pinpoint venting
- Goal: Survey the region surrounding the vent at a 200m resolution
- Results: 87% of simulation scenarios succeed in 30 days.



Future Work

- Development of more complex planning algorithms
 - Resource management (i.e. power, data, etc.)
 - Account for temporal variation in plume
- Further testing, including field deployments
- Incorporate into body-wide circulation model



Jet Propulsion Laboratory
California Institute of Technology