Electromagnetic measurements at Axial Ridge

seafloor lander (HPIES): monitoring eruption responses
autonomous profiling float (EM-APEX): tracking eruption plumes

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Monitoring eruption response with HPIES: (Horizontal electric field, Pressure, and Inverted Echo Sounder)

2 instruments (Axial Base and Slope Base) measure:
- \( E \): electric field proportional to depth-averaged water velocity
- \( P_{\text{bottom}} \): time variations of sea surface height travel time (IES): baroclinic dynamic height profile

Both instruments are working well:
- 9 months of data
- \( E \) is highly accurate (within 0.1 microvolts).
- self-powered, data downloaded by cable
- sample local ocean currents

Axial Base velocity (Aug-Dec 2014)
**HPIES:** Horizontal electric field, Pressure, and Inverted Echo Sounder

What can HPIES study (A) now, (B) soon, or (C) in 5 years?

**E:** depth-averaged velocity, ocean circulation
- ocean circulation response to eruption (A/B)
- drift velocity of eruption plume (A/B)
- electromagnetic signals from marine earthquakes/eruptions (A/B) – never measured before? (many mechanisms for seismogenic electromagnetic signals on land: Johnston, 2002; Parrot, 1990; Gao et al, 2014)

**P:** - provide depth-uniform barotropic ocean

**IES:** - observe thermal anomalies of eruption plume (A/B)

**Instrumenting the 4 Caldera nodes with HPIES (C) would provide spatial sampling of eruption plumes from seafloor sensors, especially the plume formation and short-term evolution/drift.**
Magnetotelluric (MT) analysis:
– use onboard 3-axis magnetometer or high resolution magnetometer, resolve temporal changes in seafloor conductivity profiles.
- Deploy HPIES at Axial Caldera sites to track changes in magma chamber or seawater venting/plumbing.

Inversions from MT at Axial Caldera: (left) cross-ridge/coast transect, (right) 1D resistivity profile at caldera (Heinson, Constable, White, 1996).

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A modified ARGO float made by T. Sanford and available from Teledyne Webb:
- has CTD and Iridium
- measures velocity profile with electrodes, via motional induction (Sanford, 1971; Szuts, 2012)
- capability for other sensors (turbulent dissipation, optical backscatter, etc)
- highly flexible sampling programming
- samples to depth of 2000 m

At right is data underneath a hurricane (Sanford et al, 2007), showing from top: temperature, salinity, u, v, heat content, and turbulence ($S^2 - 4Ri^2$). Note profiles are subsurface after hurricane arrives.
Tracking eruption plumes with EM-APEX (ElectroMagnetic Autonomous Autonomous Profiling Explorer)

Sample the eruption plume with multiple floats and monitor its long-term (year+) drift and evolution, to constrain budgets of heat, tracers, energy.

- deploy EM-APEX in rapid response
- program floats profile from plume top to bottom (down to 2000 m)
- in addition to T,S, also measure $\mathbf{v}$, dissipation, backscatter
- track at depth with acoustic ranging?