Acoustic and In-situ Observations of Hydrothermal Discharge at ASHES Vent Field: an OOI Cabled Array Case Study

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Abstract

The Cabled Observatory Vent Imaging Sonar (COVIS) was initially installed on the Ocean Observatories Initiative's Cabled Array (OOI-CA) observatory at ASHES hydrothermal vent field on Axial Seamount in July 2018. COVIS recorded the acoustic backscatter from the water-column plumes formed above hydrothermal sources and the seafloor within the sonar's field-of-view until Oct 2018, when an instrument malfunction suspended regular data-collection procedures. In July 2019, COVIS was redeployed after repairs and has since been collecting data at full capacity. Here, we present a comprehensive analysis of the acoustic backscatter data recorded by COVIS along with the in-situ temperature measurements in 2018 and 2019. The results demonstrate significant influences of ocean tides and bottom currents on diffuse hydrothermal discharge within ASHES. In addition, comparison with local seismicity shows a positive correlation between diffuse hydrothermal venting and the seismic activity in the vicinity of the vent field, which provides evidence for an intimate connection between hydrothermal activity and geological processes during the dynamic period leading up to the next eruption of Axial Seamount. Overall, our results showcase the capabilities of underwater acoustic techniques as remote-sensing tools for long-term, quantitative monitoring of seafloor hydrothermal discharge.

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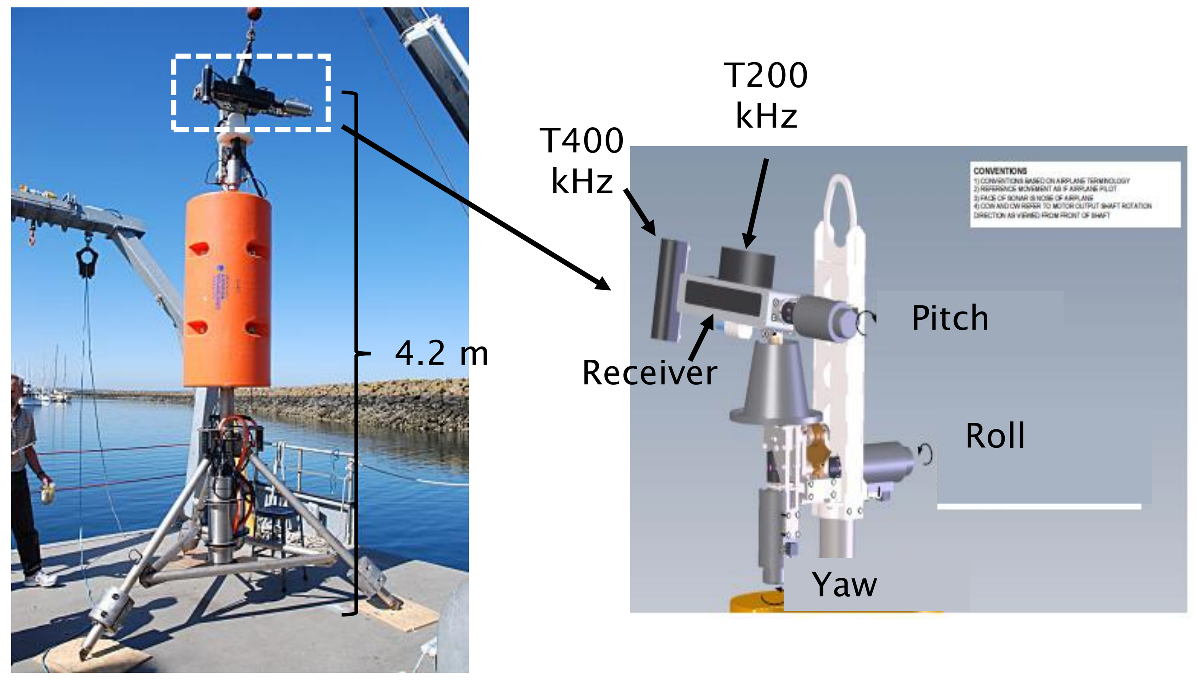
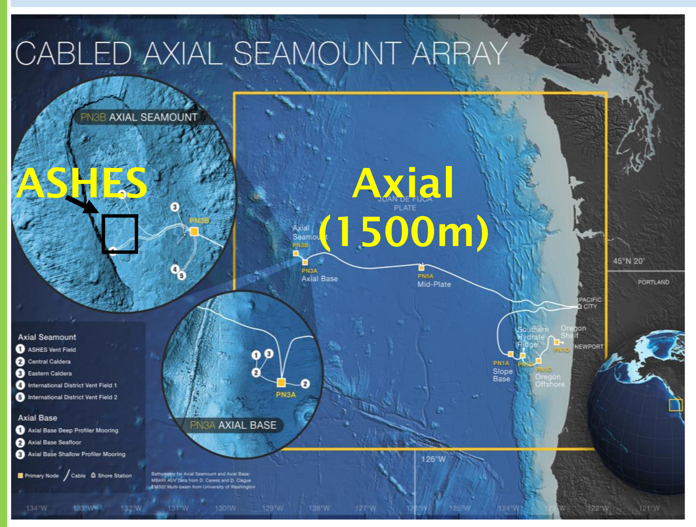
Cabled Observatory Vent Imaging Sonar (COVIS)

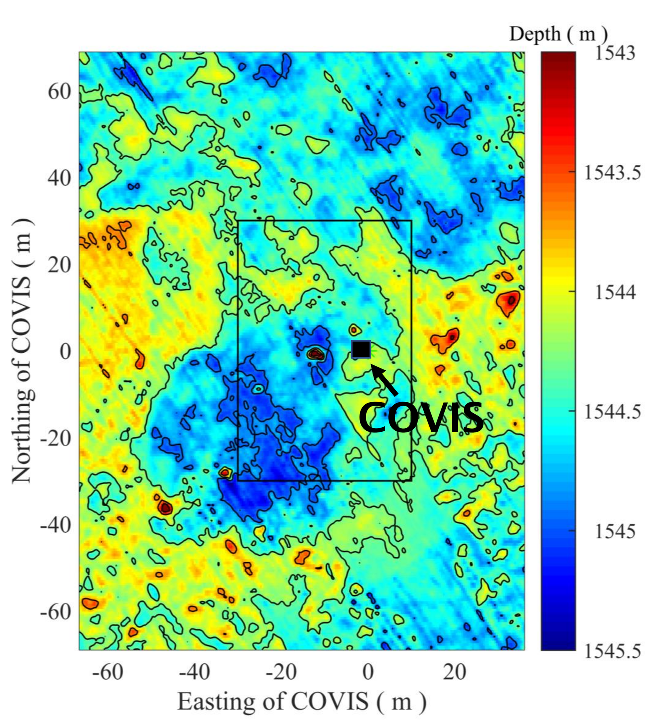


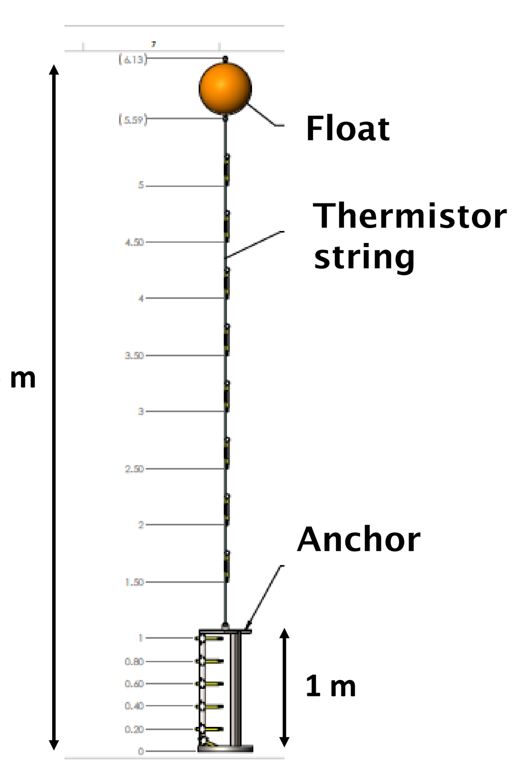
Dual frequencies: 200 kHz and 400 kHz.
Sonar orientation adjustable in three dimensions

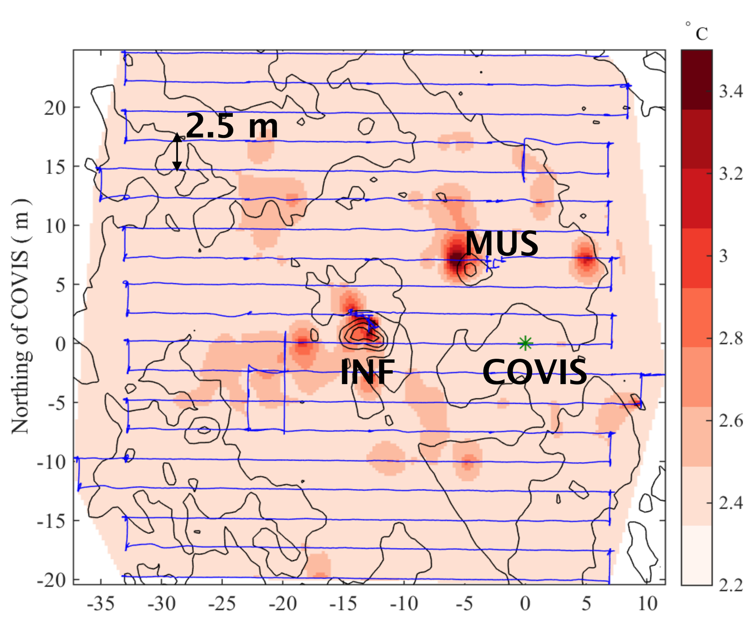
COVIS Field Operations Summer 2018 at ASHES, Axial Seamount



COVIS was connected to the Ocean Observatories Initiative's Regional Cabled Observatory (OOI-RCA) at ASHES hydrothermal vent field on Axial Seamount in July 2018.

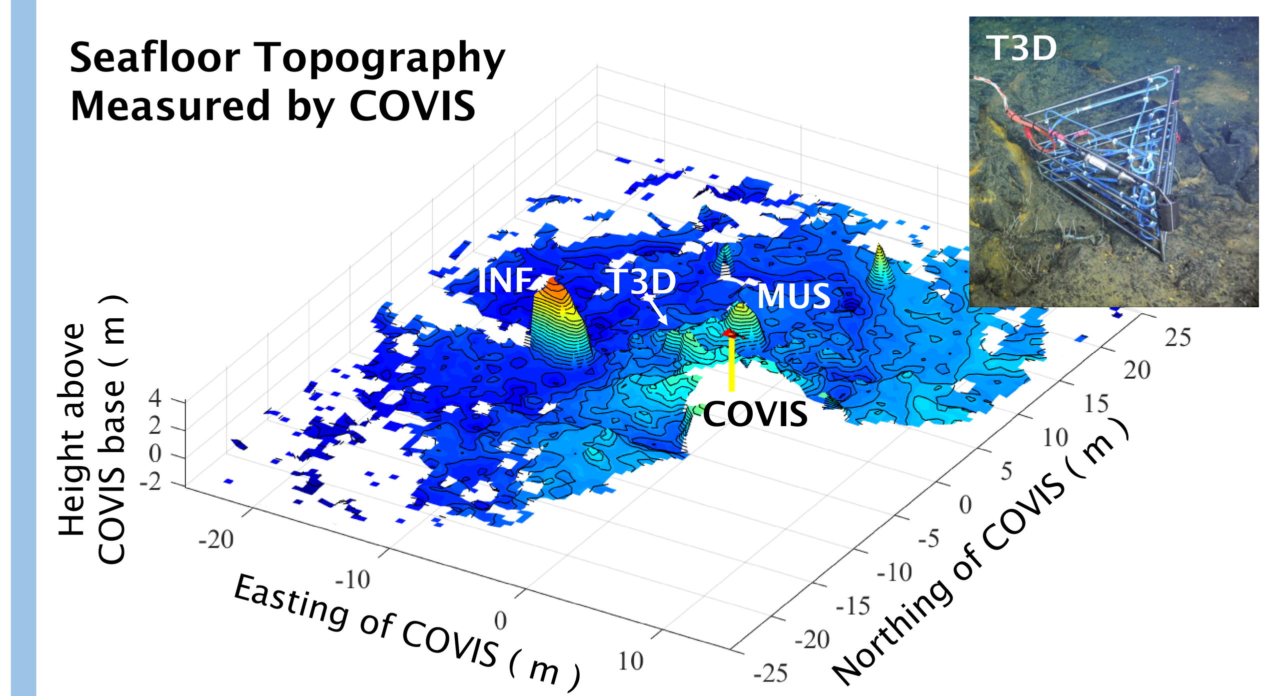




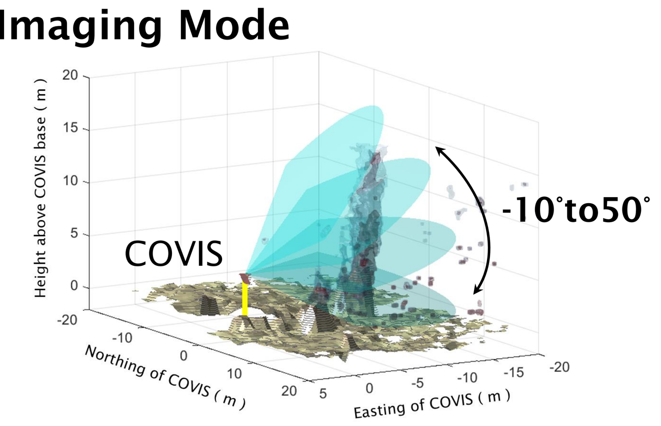


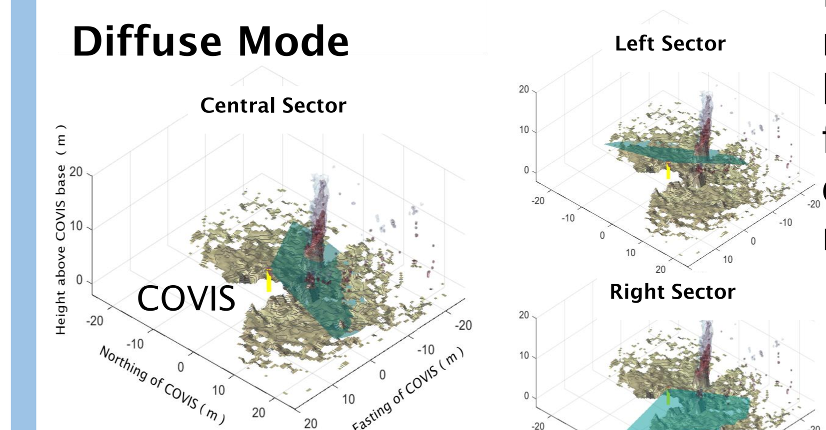
Near-bottom temperature within ASHES was surveyed using a 5-m thermistor array hanging beneath an ROV in Jun 2018.
INF: Inferno vent
MUS: Mushroom vent

COVIS Data Collection and Analysis

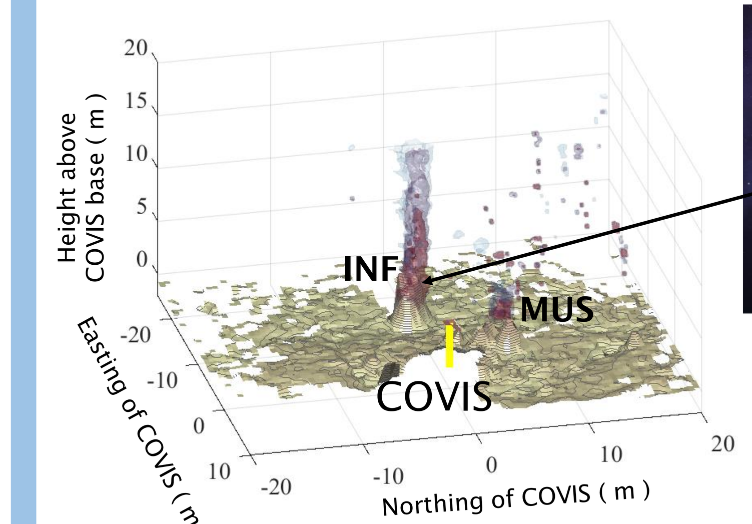


INF: Inferno vent
MUS: Mushroom vent
T3D: 3D Thermistor Array

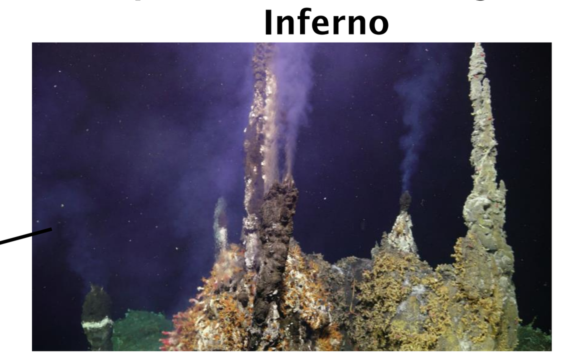


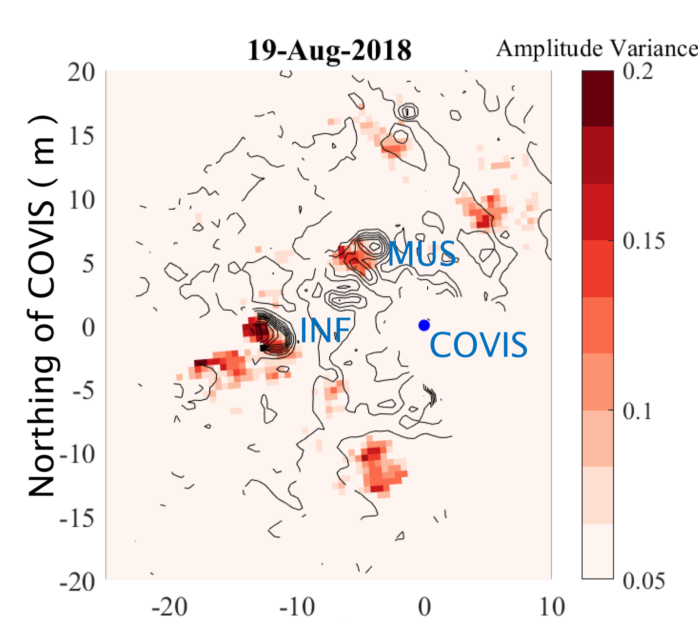


COVIS operates alternately in Imaging and Diffuse-flow modes for imaging and mapping of hydrothermal discharge from focused and diffuse sources, respectively



Hydrothermal Venting on Inferno

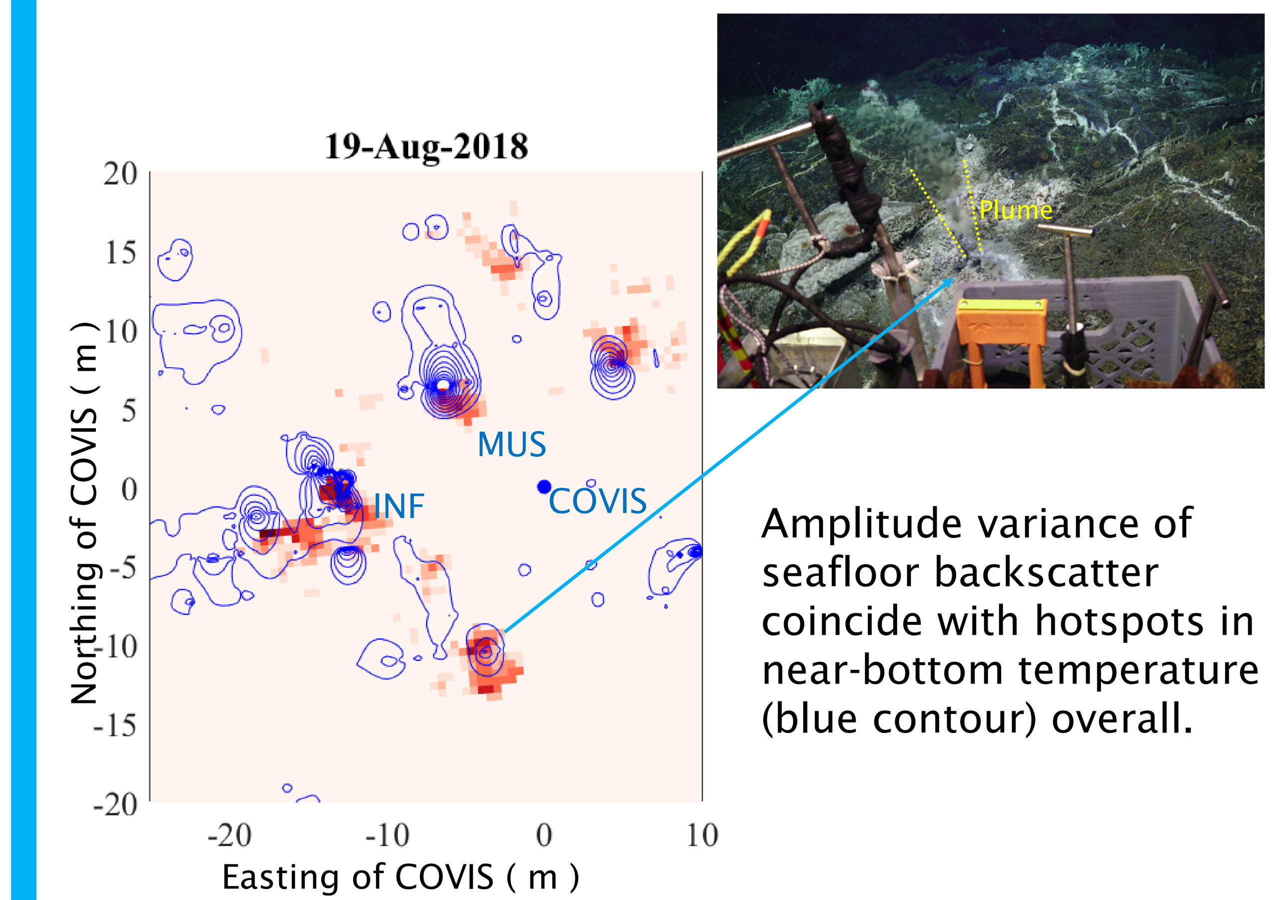




Amplitude variance of seafloor backscatter due to propagation through near-bottom hydrothermal discharge from diffuse sources.

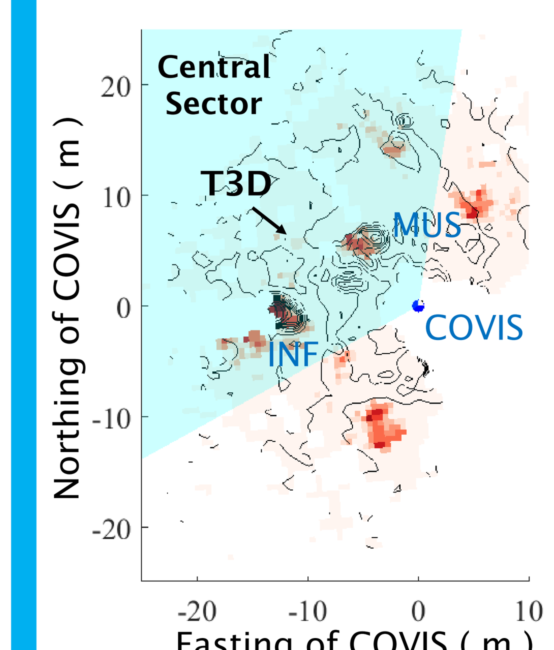
INF: Inferno vent
MUS: Mushroom vent

Comparison with Ground Truth

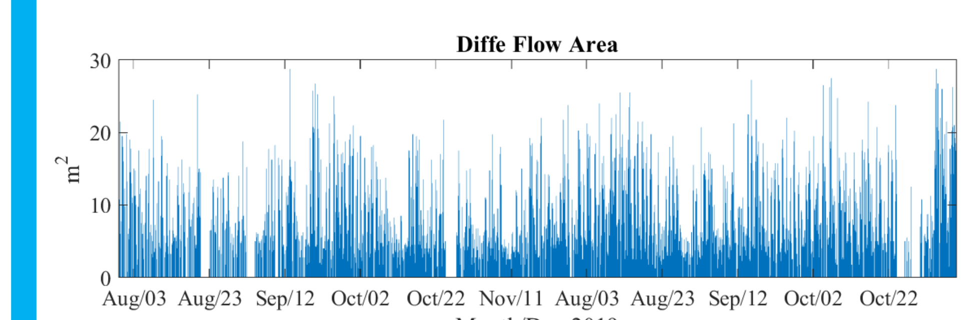


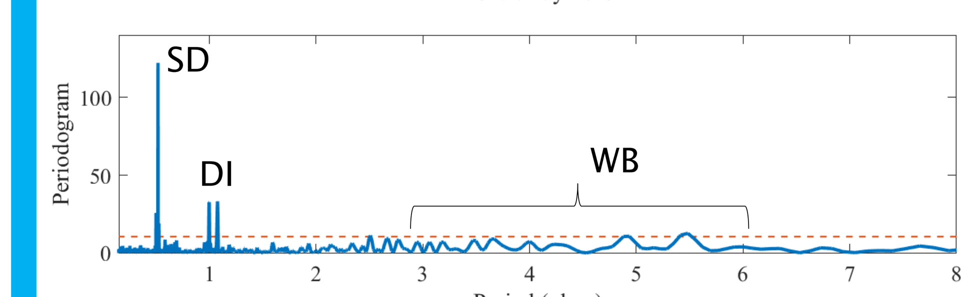
Amplitude variance of seafloor backscatter coincide with hotspots in near-bottom temperature (blue contour) overall.

Temporal Variation of Diffuse Hydrothermal Venting at ASHES

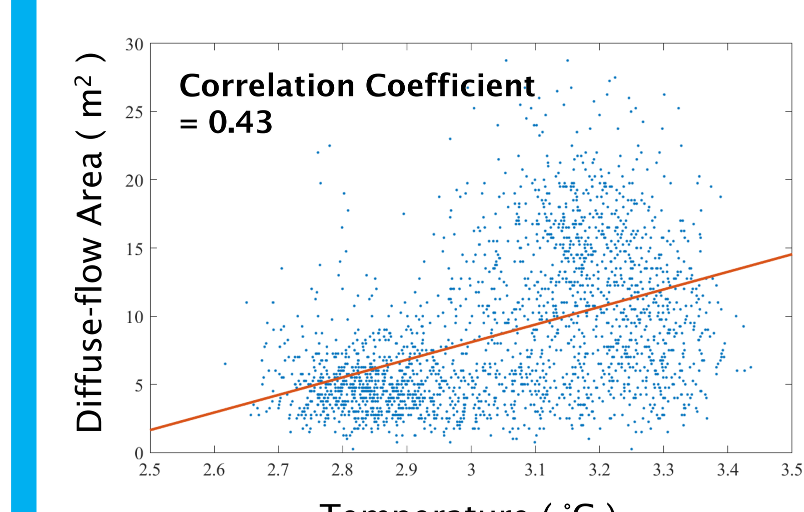


The areal extent of discharge from diffuse sources in the central sector, determined as where amplitude variance >0.2, shows substantial temporal variations. The periodogram show significant peaks at tidal (SD, DI), and the 3-6-day weather-band (WB) periods. Seafloor pressure and bottom currents are potential sources of tidal and WB signals.





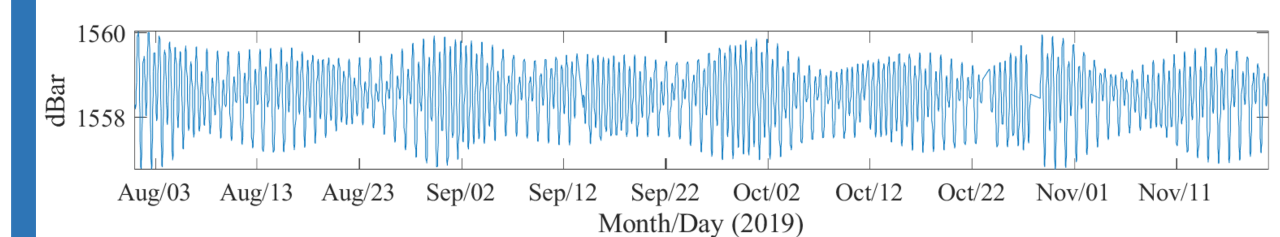
SD: Semi-diurnal
DI: Diurnal
WB: weather-band

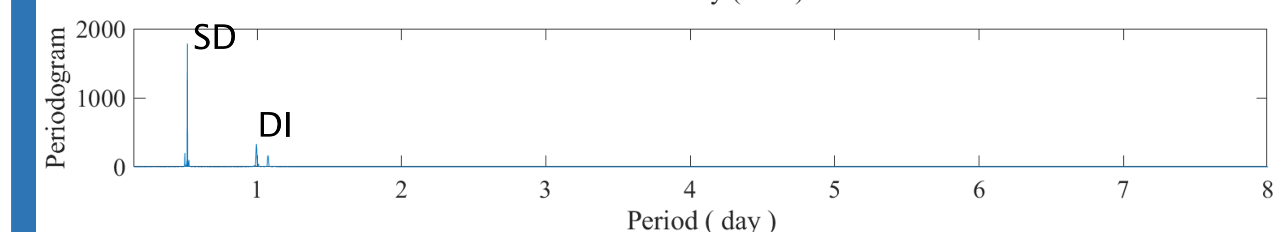


The areal extent of discharge from diffuse sources in the central sector has significant correlation with the temperature measured by the 3D thermistor array.

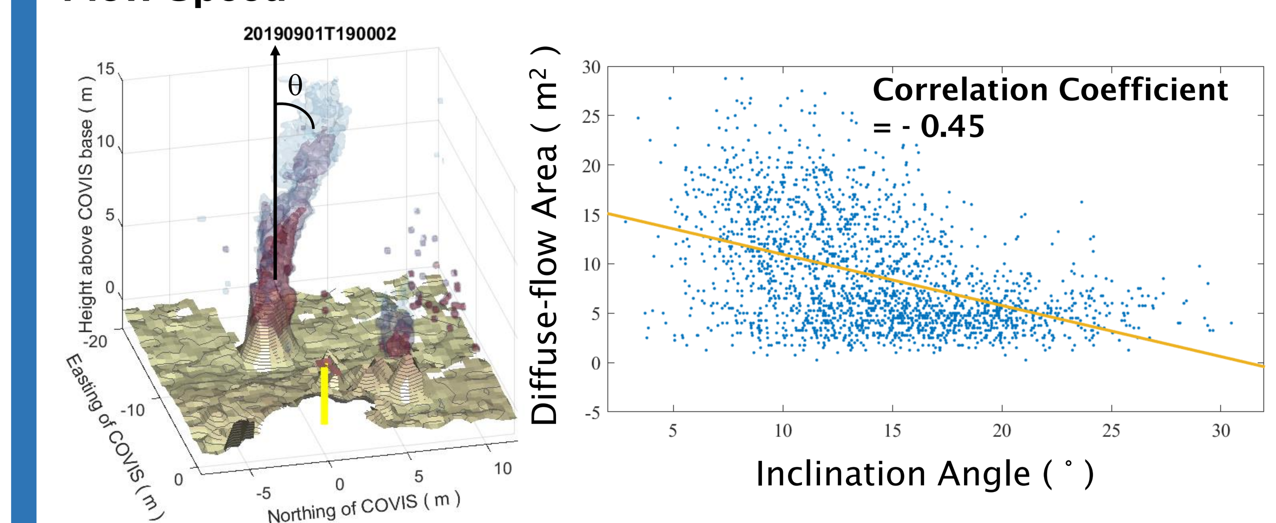
Source of Periodic Oscillations in Diffuse-flow Venting: Seafloor Pressure vs Bottom Currents

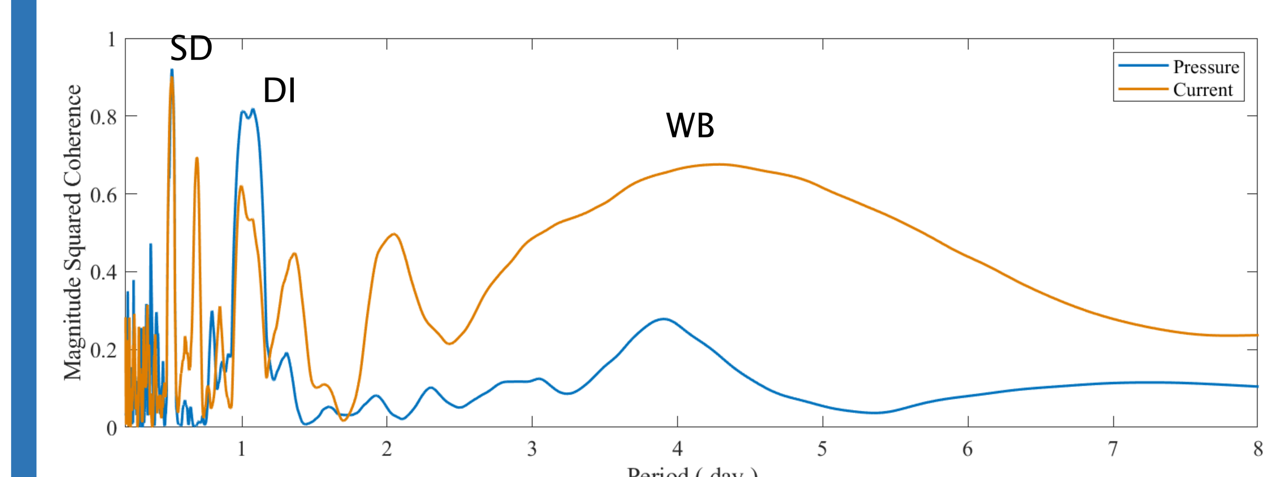
Seafloor Pressure Measured by CTD in ASHES





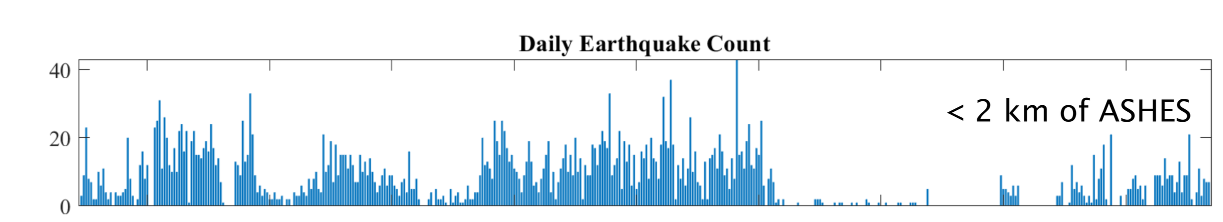
Plume Inclination Angle (θ) as a Measure of Background Flow Speed

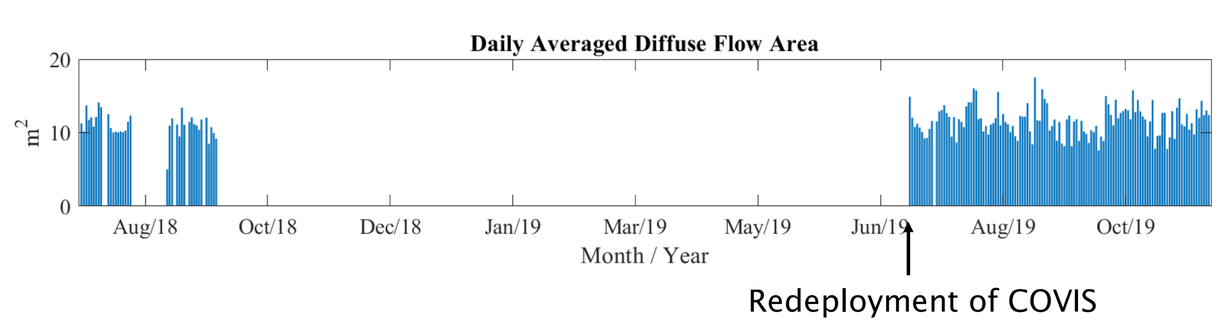




Coherences of diffuse-flow area with measured seafloor pressure and inferred background flow speed potentially suggests both pressure and currents contribute to tidal oscillations in diffuse-flow area. Currents are the dominant source of the WB signals.

Seismicity vs Diffuse-flow Venting





Redeployment of COVIS

Diffuse-flow venting in ASHES appears to be relatively stationary between 2018 and 2019, not responding to variation of local seismicity.

NSF Ocean Observatories Initiative Data Portal, http://ooinet.oceanobservatories.org