Evidence for lognormal spatial distribution of gaseous hydrocarbon seepage off Coal Oil Point, California

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In some oceans and lakes bubbles originating at the sea floor contribute significantly to the total flux of methane and other gasses to the local atmosphere. Methane generated by thermogenic and bacterial processes beneath the sea floor forms plumes of rising bubbles extending to the sea surface. This occurs strongly offshore of Coal Oil Pt. near Santa Barbara, California where natural hydrocarbon seepage produces extensive, dense bubble plumes. Volumetric concentrations of methane in the bubble plumes at Coal Oil Point is ~60%. Natural hydrocarbon seeps occur elsewhere on continental shelves including the Gulf of Mexico, the Gulf of California, and the North Sea. Gaseous marine hydrocarbon seepage is potentially an important source of atmospheric methane.

Quantifying the bubbling flux of methane and other gasses to the atmosphere from oceans and lakes is important for estimating global budgets. At present sources such as natural marine seepage are poorly constrained due to a lack of measurements. To estimate the hydrocarbon seepage contribution to the global methane budget, it has been sometimes assumed that the spatial distribution of seeps is lognormal, but this has not been verified by observation. Few systems for direct measurement of bubbling gas flux in oceans and lakes have been reported.

We report observations from a newly developed instrument for measuring bubbling gas flux near the surface in oceans and lakes. Gas flux is quantified using a gas capture technique. The instrument captures gas through an inverted cone beneath the sea surface and directs it into a collecting chamber while continuously measuring the position of the gas-water interface that forms as gas accumulates. Interface position is determined from the differential pressure between the chamber and ambient seawater. A spar buoy provides flotation and stability to reduce vertical motions due to surface waves. The gas collection assembly and spar, referred to as a flux buoy, is suitable for deployment from small boats under conditions of light wind and small waves. Because our study area is a region of very strong fluxes, the instrument is configured to measure high rates. The basic design, however, may be readily adapted for use in environments with much weaker gas flux. The gas capture assembly can be operated independently of the buoy for applications such as deployment over gas vents on the seafloor or lakebeds. A smaller version of the buoy could also be made for deployments in small bodies of water where surface wave effects are minimal.

We are using the flux buoy to determine the spatial distribution of natural hydrocarbon seepage off the south-central California coast. Hydrocarbon seepage from continental shelves may be an important source of atmospheric methane. Our observations indicate that the spatial distribution of the bubbling gas flux measured at the sea surface is lognormal in the region of strong seepage off Coal Oil Point. Based on preliminary analysis, the mean and standard deviation of the (natural) logarithm of flux rate are –3.9 and 2.1, respectively. These parameters were obtained by fitting a lognormal form to the measured probability distribution function over a range of fluxes well above the instrumental noise level. Our current research efforts focus on better constraining the spatial distribution of seepage along with the total methane flux from the region.