Methane Dynamics in the Belgian Coastal Zone

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Introduction

Methane (CH_4) is the second most important greenhouse gas (GHG) after CO2, accounting for 32% of the anthropogenic global radiative forcing by well-mixed GHGs in 2011 relative to 1750. Yet, there remains an important uncertainty on estimates of the sources and sinks of CH_4. The open ocean is a very modest source of CH_4 to the atmosphere compared to other natural and anthropogenic CH_4 emissions. Coastal regions are more intense sources of CH_4 to the atmosphere than open oceanic waters. The high CH_4 concentrations in surface waters of continental shelves are due to direct CH_4 inputs from estuaries and from sediments where methanogenesis is sustained by high organic matter sedimentation. Natural gas seeps from continental shelves contribute additionally.

Study Area

The **Belgian coastal zone** (**BCZ**) is a coastal area with multiple possible sources of CH_4 such as from rivers and gassy sediments. The BCZ is also a site of important organic matter sedimentation and accumulation unlike the rest of the North Sea.

Datasets

We report a dataset of CH_4 concentrations in surface waters of the Belgian coastal zone (BCZ) in spring, summer and fall 2010 and 2011. Measurements were carried out by gas chromatography in the frame of the BELSPO BELCOULOUR-II project. Data were recovered, quality checked and formatted uniformly in the frame of the BELSPO project "4 decades of Belgian marine monitoring" (4Demon).

Hot-spot of dissolved CH_4

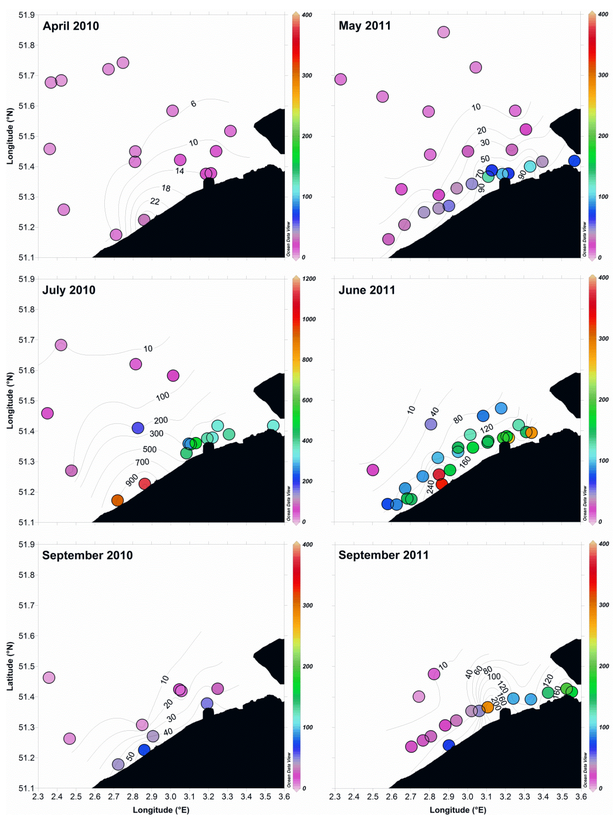

Figure 1: Hot-spot of dissolved CH4 concentration in the near-shore North Sea (up to ~300 times higher than in the open ocean).

Concentration of dissolved CH_4 (nmol L^{-1}) in surface waters of the Belgian coastal zone (BCZ) in spring, summer and fall 2010 and 2011. Note the different color scale in July 2010 compared to the other cruises.

Depth controls stratification

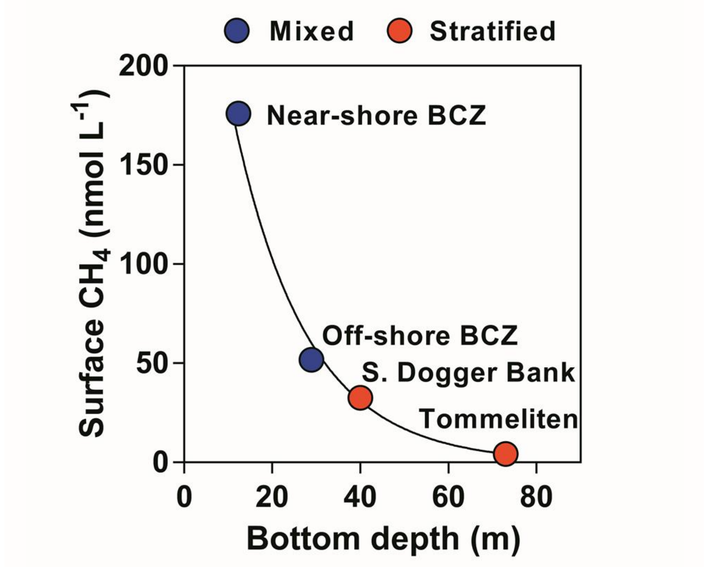

Figure 2: Depth controls stratification and dissolved CH4 levels across the North Sea.

Median CH_4 in surface waters in summer at the near-shore and off-shore Belgian coastal zone (BCZ) (<15 km and >15 km from coastline, respectively), south of the Dogger Bank and Tommeliten as a function of bottom depth. The water column is vertically homogeneous (mixed) in the BCZ and seasonally thermally stratified in the other two North Sea sites

Increasing T enhances dissolved CH_4 levels

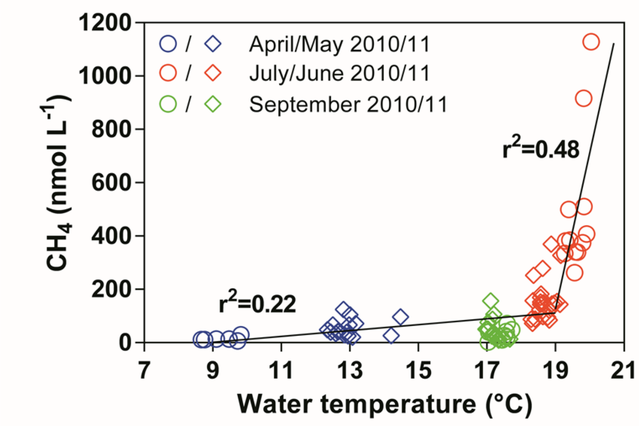

Figure 3: Increasing temperature enhances dissolved CH4 levels in the near-shore North Sea.

Concentration of dissolved CH_4 in surface waters of the near-shore Belgian coastal zone (BCZ) as a function of temperature in spring, summer and fall 2010 and 2011.

Solid lines indicate the linear regressions for data < and > 19°C.

Conclusions

Very high CH_4 concentrations (up to 1,100 nmol L^{-1}) were observed in surface waters of the BCZ compared to open oceanic conditions (<5 nmol L^{-1}) due to release of CH_4 from sediments (in-situ production and leakage from gassy sediments) and the well-mixed water column that allows an efficient transfer of CH_4 from bottom waters to surface waters.

Our data suggest that further warming of surface waters could increase CH_4 emissions and provide a positive feedback on warming climate. This feedback will be expected to be acute in shallow gassy areas such as the BCZ since they are natural hotspots of CH4 emission, and the well-mixed water column will allow an efficient propagation of additional heat to the sediment that will be buffered by seasonal thermal stratification in deeper seep areas. The increase of temperature will stimulate the biogenic CH_4 production, as well as, decrease Henry's constant promoting bubbling from sediments.

Further reading
Borges AV, W Champenois, N Gypens, B Delille, J Harlay (2016) Massive marine methane emissions from near-shore shallow coastal areas, Scientific Reports, 6:27908, doi:10.1038/srep27908
http://www.nature.com/articles/srep27908

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