

WP2 DELIVERABLE NO.3: GIS-MAP OF HOT-SPOTS OF PRESENT AND FUTURE CH₄-EMMISSION

Authors:

Schlüter, M.; Gentz, T.; Martinez, R.

Objective

Potential hot-spots for present and future CH₄-emmission are regions characterized by the intense formation of biogenic methane or the transport of thermogenic methane from depths via fracture zones or other conduits. In such regions features like (1) pockmarks (morphological depression at the seafloor), (2) gas flares, where gaseous methane is released from the seabed, (3) shallow gas regions, where gas bubbles are detected in close vicinity to the sediment-water interface as well as (4) chemo-autotrophic communities nourished by upward fluxes of e.g. methane were observed.

An objective of WP2-3 was the data mining and mapping of free gas layers in the sediment, pockmarks, gas flares etc. known for the Baltic Sea. This allows to characterize regions in terms of drivers for the formation of methane. By application of GIS techniques to such data sets the occurrence of free gas regions can be predicted for the entire Baltic Sea.

Methods and Results

In close cooperation with the partners of the BalticGas project, we compiled data related to the spatial distribution of Pockmarks, free gas regions etc. (Fig. 1). These data were integrated into GIS and combined with data sets of the sedimentology, the bottom morphology, the mass accumulation of particulate organic matter and the bottom water concentration of oxygen or sulfate, for example. These parameters are considered as potential drivers for the formation of methane. All data sets were projected to the same cartographic reference system and the same raster size. This supports GIS techniques designed for spatial analysis and modeling.

Applying techniques like clipping, overlay, buffer etc., former mentioned parameters were selected from the free gas regions as well as for the adjacent sediments where free gas was not observed. By comparison of both data sets, parameters were identified which could be applied to generate predictive maps about the spatial distribution of free gas.

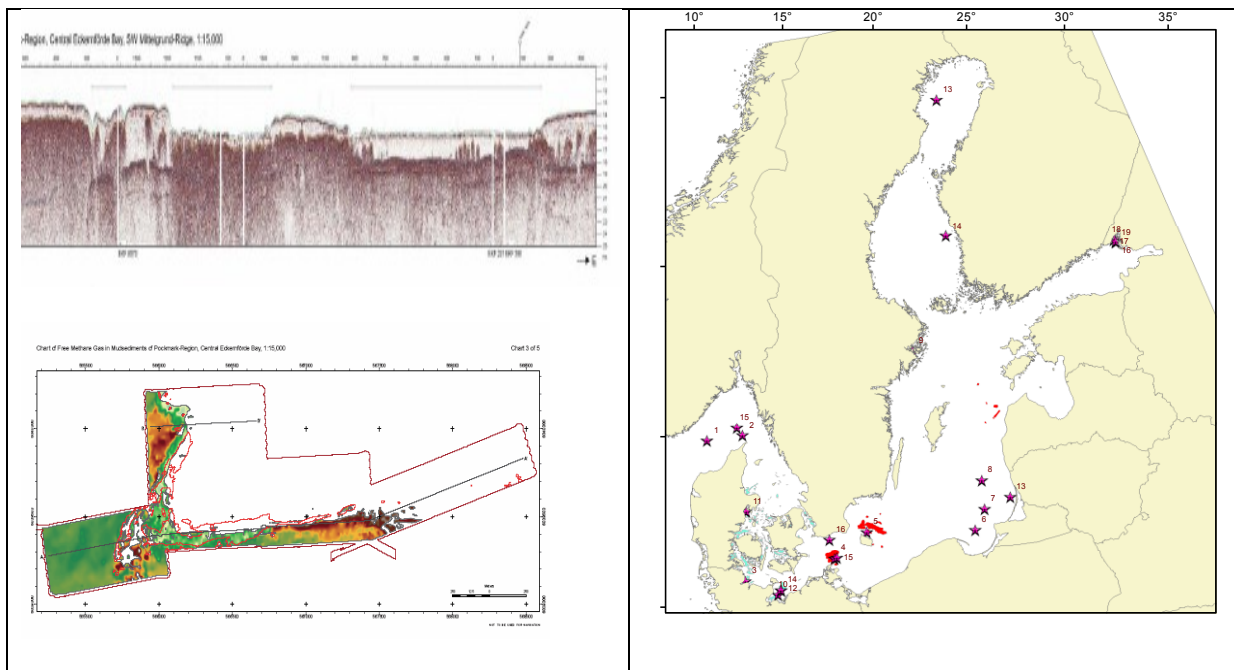


Figure 1: Left: Seismic line crossing a pockmark area in the Eckernförde Bay. Morphological depressions as well as the occurrence of free gas in the subsurface is shown. The depth of the free gas layer was mapped during AUV dives (lower left). Right: Example for the spatial distribution of pockmarks and free gas region in the Baltic Sea.

For consideration of regional differences within the Baltic Sea, we applied the spatial analysis for the different sub-basins (Kattegat, Belt Sea, The Sound and Baltic Proper). To support this rather laborious objective, we implemented the work and analysis flow by the ModelBuilder of the ArcGIS 10.0 software (Fig. 2).

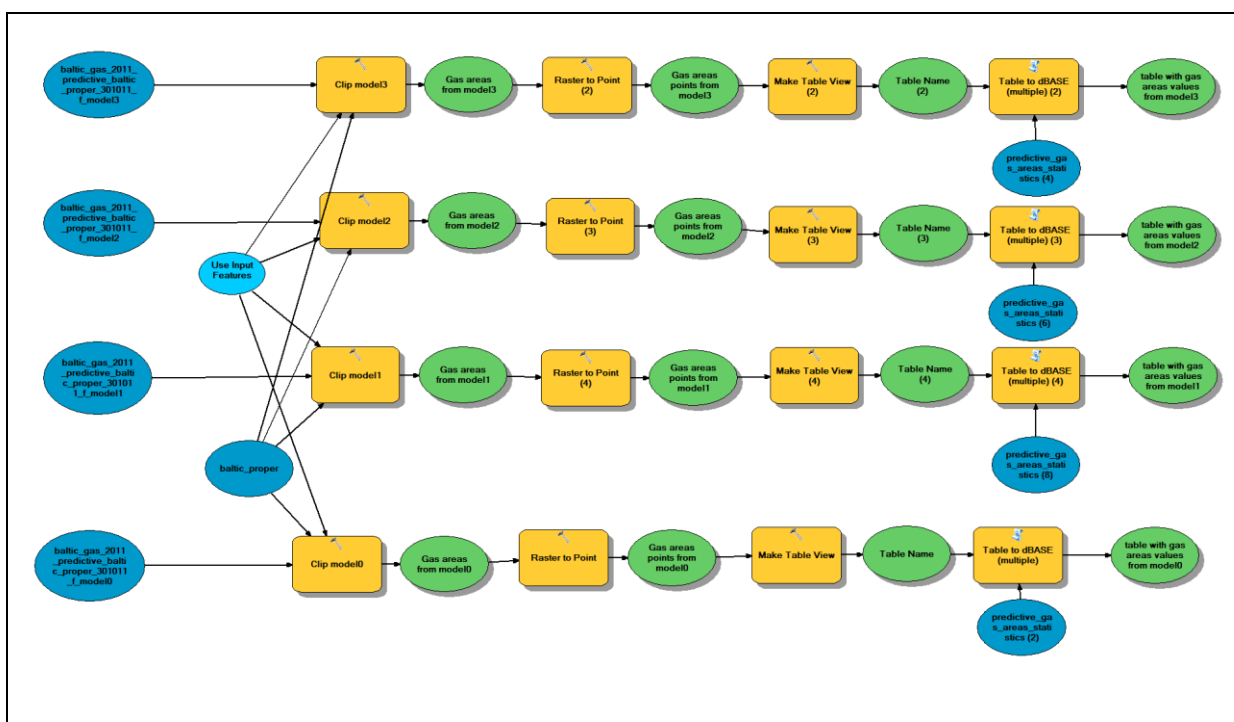


Figure 2: ModelBuilder scheme representing the work and analysis flow by GIS.

Pockmarks and free gas areas were observed especially in the western part of the Baltic Sea. In the eastern part of the Baltic Sea pockmarks were detected in Gdansk Bay or the Gulf of Finland. For some of these sites, there seems to be indications for thermogenic sources of methane.

Comparing the differences between data derived from free gas regions within non-free gas regions provides information about parameters they might have a high or low significance (from a descriptive perspective) for the formation of free gas (Fig. 3).

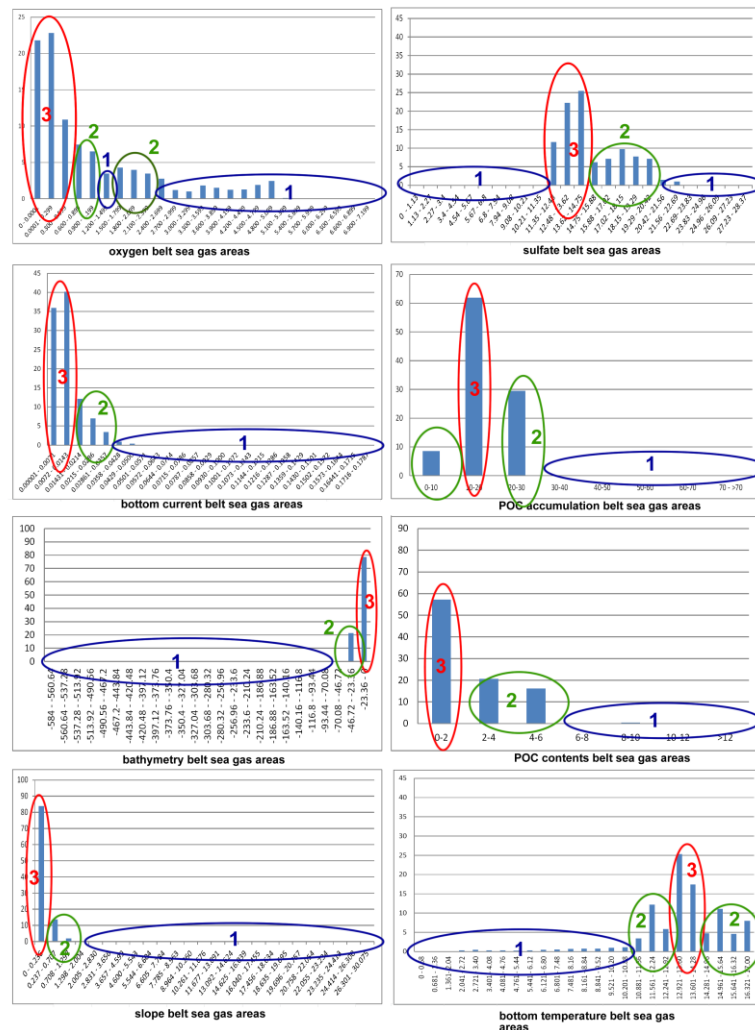


Figure 3: Comparison of parameter like the particulate organic carbon accumulation rate etc between region where free gas and non-free gas, respectively was observed.

As a first step towards a predictive mapping, weighting factors were assigned for each parameter which is considered as indicative for the occurrence of free gas (a simplified example is given by Fig. 3). By the Map Algebra of GIS different weighting factors were applied to each layer of the parameter to calculate a new layer containing at each raster cell a kind of probability value for the occurrence of free gas. The derived predictive map was compared with the known areas where free gas occurs. By an iterative procedure the weighting factors were adjust to produce an

optimize accordance between observed and predicted free gas regions. Figure 4 provides an example for the predictive map of biogenic free gas in surface sediments of the Baltic Sea.

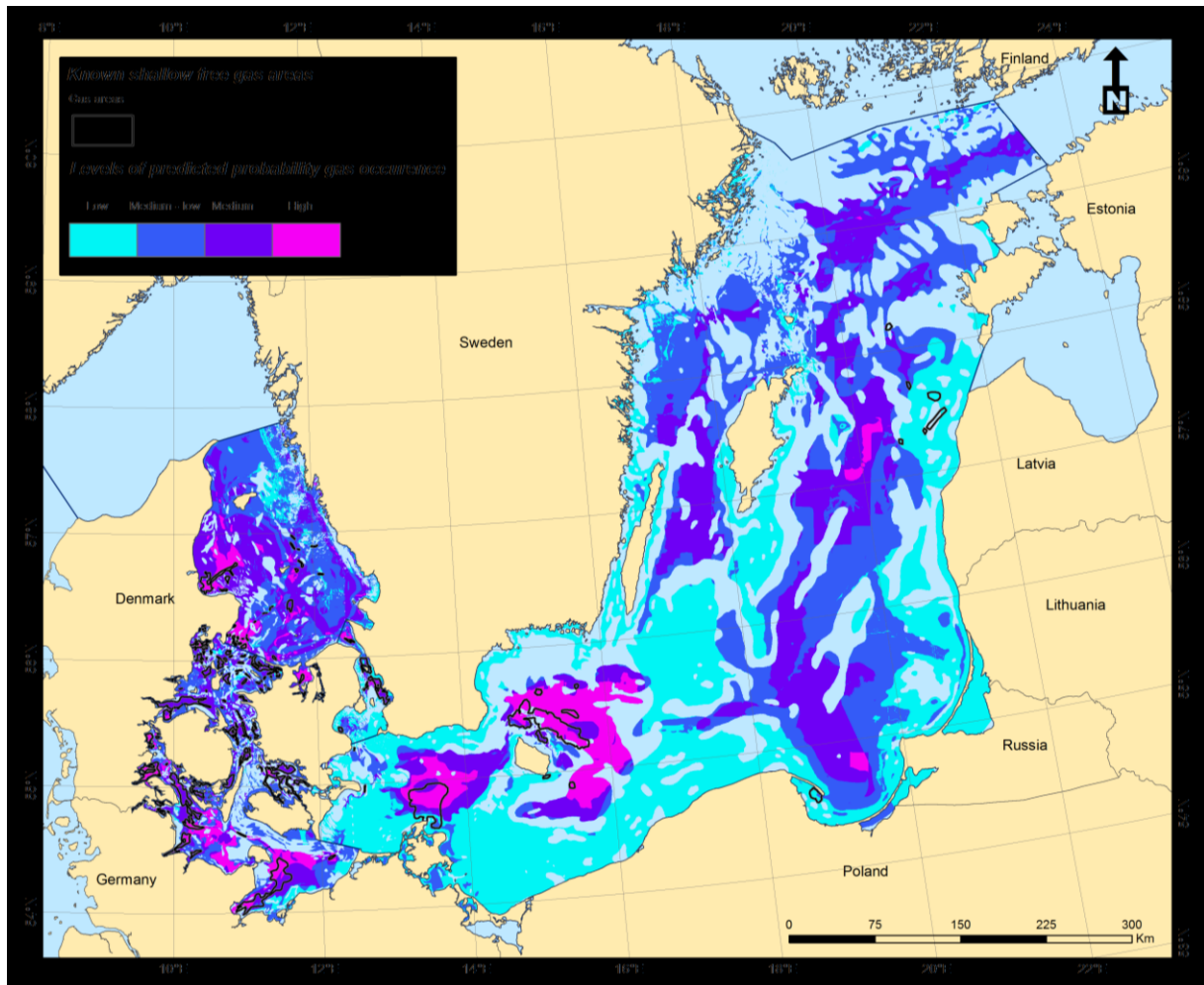


Figure 4: Example for a predictive map about the spatial distribution of free gas in surface sediments of the Baltic Sea derived by spatial modeling. The prediction is based on the analysis of parameters like POC-accumulation, O₂ and SO₄ concentration in bottom water as well sediment type, observed within known free gas areas. The data set was factorized to obtain a prediction for the occurrence of free gas areas within the entire Baltic Sea. This procedure was optimized by comparison of the similarity of the spatial distribution of **known free gas** and predicted free gas areas. Based on this on this comparison **predicted probability levels of gas occurrence (low, medium-low, medium, high)** were assigned.

Conclusion

The match between known and predicted free gas areas was considerably improved during the course of the project. This is mainly due to the increased amount of geodata which were compiled and combined within GIS and new publications about e.g. mass accumulation rates (e.g. Leipe et al., 2011).

We consider the GIS-mapping of hot-spots as well as the computation of predictive maps as a step towards a hypothesis based approach. Such an approach could be used for identification of new survey areas as well as retrospective analysis. By this means regions where highest benefit, in terms of falsification as well as improvement, might be achieved.

References

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