Ali Al Farid

Knowledge and Data Driven Approaches for Hydrocarbon Microseepage Characterizations: An Application of Satellite Remote Sensing

Methane is a potent greenhouse gas that plays a major role in climate change. Significant uncertainty exists in the estimates of emissions from natural methane sources. This uncertainty in data is one of the primary scientific challenges in climate model. Geological seepage considered as the second largest natural source of methane after wetlands and today is recognized as a major contributor to atmospheric methane. This work focuses on positive methane fluxes to the atmosphere from sedimentary basins hosting natural gas and oil reservoirs termed as microseepage.

Microseepage contributes to the global atmospheric methane budget and creates large uncertainties in the global methane atmospheric budget estimates (sources and sinks). The global coverage of methane microseepage is unknown, and data available today is based on estimates. With respect to global and regional estimates, the level of microseepage emission was established by assuming, a priori, that the full area of petroleum basins in dry climate produces positive fluxes of methane into the atmosphere. This assumption is subject to considerable uncertainties because microseepage does not occur throughout the entire petroleum field area. In this context, satellite remote sensing imagery was used to investigation areas affected by natural hydrocarbon microseepage using knowledge and data-driven based approaches.

Knowledge-based approaches constructed based on the theoretical model established from literature targeting specific minerals and surface manifestations. The specific mineral groups or features were determined based on their reflectance and absorption characteristics. Methods in knowledge-driven approach include Band Ratio (BR), Principle Component Analyses (PCA) with Crosta technique and Mixture Tuned Matching Filtering (MTMF) classification. The data-driven approach used Support Vector Machine (SVM) algorithm. The SVM model was purely estimated from the multispectral image data based on occurrence and abundance of oil and dry hole wells and without any prior assumption of area mineralogical assemblage. The mapped microseepage extent exhibit some level of consistency between all models.

Results were satisfactory enough judged by the level of consistency realized between all models for the mapped microseepage extent, which indicates statistical significance. The data-driven model yields best results, the gain in performance from using data-driven approach as compared to knowledge-based was relatively small. However, the long processing steps and time in the knowledge-based approaches gives merits to the data driven approach. The work demonstrated the potential of satellite remote sensing and its analysis in mapping hydrocarbons microseepage extent on regional or even global scale.

Keywords: Geography, Geographical Information Systems, Hydrocarbon Microseepage, PCA, Crosta, Band Ratio, MTMF, Weight of Evidence, SVM, Methane Fluxes, Remote Sensing, Satellite Image Classification, Earth Observation, Mineral Classifications, Machine Learning.

Advisor: **Jonas Ardö**
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