OFFSHORE HYDROCARBON SEEPAGE CHARACTERIZATION THROUGH SPECTROSCOPY, QUIMIOMETRY AND OPTICAL REMOTE SENSING

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Remote sensing has been a key tool for oil monitoring and new discoveries based on offshore seepages detection. Spectroscopic measurements identify hydrocarbon (HC) diagnostic spectral features which are linked to its chemical composition and allow for the characterization of oil, oil standing over water, and emulsified oil.

The approach provided in this work is twofold. The first part includes the results of lab spectral measurements of petroleum samples yielded from key, oil-rich sedimentary basins in Brazil. Measurements comprised reflectance data (visible, near and short-wave infrared – VNIR-SWIR), Attenuated Total Reflectance, Directional Hemisferical Reflectance, and emissivity data (thermal - TIR). These spectra were analyzed by quimiometric tools, such as Principal Components Analysis (PCA) and Partial Least Square Regression (PLS). The experimental results indicate that in the visible interval HCs show flat, non-diagnostic spectral features, but can be distinguished from water due to a difference in the baseline reflectance, which is related to the measurement geometry. In the NIR-SWIR range the measurement geometry has a minor effect on the spectral features of HCs, which can be recognized whether oil is emulsified or over ocean water. Moreover, different oil types (i.e. light or heavy), can be qualitatively distinguished based on these features even considering oil over water. These reflectance spectra were resampled to the spectral resolution of hyperspectral (220-bands/Hyperion) and multispectral (50-band/HSS, 9-bands/ASTER) sensors nowadays in operation. These spectra wew also analyzed by quimiometric tools. The results revealed that, as well as for the full resolution spectra, it is possible to distinguish oil types. Within TIR wavelengths (3-14 µm), typical HC spectral features can also be resolved and oil types qualitatively segregated using PCA, including both full-resolution spectra and spectra resampled to thermal multispectral sensors (e.g. HSS). However, despite the fact that oil emissivity is always lower than water, such separation seems unworkable using 8-12 µm TIR features only; emissivity spectra are essentially flat for all samples in this interval.

In November/2004 a seepage event at the Campos Basin (RJ – Brazil) was recorded by the Spaceborne Thermal Emission and Reflection Radiometer (ASTER) sensor. The second part of this work comprises its remote characterization based on a theoretical detection model that includes: (i) oil and ocean water spectral responses in the VIS to TIR interval differ; (ii) there are differences on oil appearances depending on their thickness, exposition time, oil emulsification, environmental conditions and imaging geometry; and (iii) the detection of chlorophyll spectral signatures within darker patches over the sea excludes the possibility of petrogenetic origin for the oil. Oil films appearance on ASTER bands 3N and 3B could be explained based on trigonometric calculations. For the thermal interval it was possible to notice that emissivity, brightness and kinetic temperature values over sea sectors with thicker oil films are smaller than the surroundings areas lacking in oil. Quimiometric models built using Principal Component Analysis and Partial Least Square Regression made it possible, for the first time, to remote characterize oils qualitatively by satellite. The

ASTER data was processed through Spectral Angle Mapper, Mixture Tuned Matched Filtering and Linear Spectral Unmixing (techniques commonly used for the classification of hyperspectral data; here adapted for multispectral data), as well as for an unsupervisioned neural-network system. The last two techniques allowed not only oil detection, but also separation of thicker/thinner oil films.

This work demonstrated the potential of ASTER data, quimiometric models, and spectral-spatial methodologies for low-cost offshore exploration and qualitative characterization of hydrocarbons.