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Non Methane Hydrocarbons (C2-C8) around the Arabian Peninsula: sources, sinks and model evaluation

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Atmospheric Non Methane Hydrocarbons (NMHC) have been extensively studied around the globe due to their importance to atmospheric chemistry and their utility in emission source and chemical sink identification. This study reports on shipborne NMHC measurements made around the Arabian Peninsula during the AQABA (Air Quality and climate change in the Arabian BAsin) ship campaign. The ship traversed the Mediterranean Sea, the Suez Canal, the Red Sea, the Northern Indian Ocean and the Arabian Gulf, before returning by the same route. This region is one of the largest producers of oil and gas (O&G); yet among the least studied. Atmospheric mixing ratios of C2-C8 hydrocarbons ranged from a few ppt in unpolluted regions (Arabian Sea) to several ppb over the Suez Canal and Arabian Gulf where a maximum of 166.5 ppb of alkanes was detected. The ratio between i-pentane and n-pentane was found to be 0.93 $\pm$ 0.03 ppb ppb-1 over the Arabian Gulf which is indicative of widespread O&G activities, while it was 1.71 $\pm$ 0.06 ppb ppb-1 in the Suez Canal which is a characteristic signature for ship emissions. We provide evidence that international shipping contributes to ambient C3-C8 hydrocarbon concentrations but not to ethane which was not detected in marine traffic exhausts. NMHC relationships with propane differentiated between alkane-rich associated gas and methane-rich non-associated gas through a characteristic enrichment of ethane over propane atmospheric mixing ratios. Utilizing the variability-lifetime relationship, we show that atmospheric chemistry governs the variability of the alkanes only weakly in the source dominated areas of the Arabian Gulf (bAG = 0.16) and along the northern part of Red Sea (bRSN = 0.2), but stronger dependencies are found in unpolluted regions such as the Gulf of Aden (bGA = 0.53) and Mediterranean Sea (bMS = 0.46). NMHC oxidative pair analysis indicated that OH chemistry dominates the oxidation of hydrocarbons in the region but along the Red Sea and the Arabian Gulf the NMHC ratios showed evidence for chlorine radical chemistry. A comparison between the measured and simulated (ECHAM/MESSy Atmospheric Chemistry (EMAC) model) alkane mixing ratios reveals considerable underprediction over the northern part of Red Sea and over the Suez Canal. We investigate the indications for an important missing source in this region and suggest re-evaluation of emission inventories that would match the observations.