



## Ship-based MAX-DOAS measurements of nitrogen dioxide in the South China Sea

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In November 2011, the SHIVA-Sonne campaign took place in the South China Sea in order to investigate the transport of very short-lived substances to the stratosphere for a better understanding of their role in ozone depletion. Among other instruments, a Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) instrument was placed on board the RV Sonne to measure scattered sunlight at different elevation angles. These measurements can be used for the retrieval of vertical columns of several trace gases (e.g. nitrogen dioxide ( $\text{NO}_2$ ), formaldehyde (HCHO), and iodine monoxide (IO)) by applying the DOAS method.

In this study, we present tropospheric  $\text{NO}_2$  vertical columns (TVC  $\text{NO}_2$ ) retrieved from the MAX-DOAS measurements between 17 and 28 November 2011. During this period, the tropospheric  $\text{NO}_2$  levels were rather low ( $< 1 \times 10^{15}$  molec  $\text{cm}^{-2}$ ) in the open sea most of the time. However, elevated  $\text{NO}_2$  levels ( $> 5 \times 10^{15}$  molec  $\text{cm}^{-2}$ ) were observed when other large vessels navigated in the proximity of RV Sonne. Moreover, elevated levels of TVC  $\text{NO}_2$  ( $> 3 \times 10^{15}$  molec  $\text{cm}^{-2}$ ) were also observed close to the coast of the island Borneo. The web-based version of the Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) was used for the calculation of 24 h backward trajectories to better identify the sources of these elevated levels of TVC  $\text{NO}_2$ . The analysis of the backward trajectories indicated that some cases with elevated tropospheric  $\text{NO}_2$  levels could be the result of  $\text{NO}_2$  transport from biomass burning and urban/industrial sources.

In summary, the highest levels of TVC  $\text{NO}_2$  were found to be the result of the combustion process of large vessel engines. The contribution of biomass burning and urban/industrial sources to the tropospheric  $\text{NO}_2$  level in the South China Sea is rather low, at least during this part of the season.