MAX-DOAS measurements of reactive trace gases during two ship cruises in the Western Pacific

F. Wittrock, Institute of Environmental Physics, University of Bremen, Germany (September 2013)

Application Note

Reactive halogen species (RHS) like BrO and IO are known to play an important role in the troposphere as well as in the stratosphere by e.g. catalytically taking part in ozone destruction, NO_x and HO_x cycles and thus actually influencing the oxidation capacity of the atmosphere. These species can be created by oxidizing directly emitted halogen compounds, by photolysis of very short-lived species emitted from the ocean or in chemical reactions upon surfaces. Iodine compounds can significantly increase ozone destruction compared to bromine compounds.

Remote sensing measurements using Differential Optical Absorption Spectroscopy (DOAS) are one method that can be used to observe key trace species in the atmosphere, including RHS but also O_3, NO_2, HCHO, CHOCHO and water vapor. With the development of flexible multi-axis (MAX-DOAS) instruments information on the vertical distribution of the trace species can be retrieved. By pointing the instrument into different azimuths, the horizontal variability around a measurement location can be assessed.

MAX-DOAS instruments are basically UV/visible spectrometers observing scattered light in different viewing directions towards the sky. The standard Bremen MAX-DOAS instrument consists of two grating spectrometers, one for the UV (~300 to 380 nm) and one for the visible light (~400 to 550 nm), each equipped with a cooled CCD detector. The light is collected with a separate telescope unit connected to the spectrometers via a splitted quartz fibre bundle. Spectrometers are temperature stabilized to avoid wavelength drifts. Although the CCD used is a 2-dimensional detector, it is operated in full vertical binning for optimal signal to noise. The quartz fibre bundle efficiently depolarizes the incoming light and also provides flexibility for instrument set-up. The telescope unit is mounted on a commercial pan-tilt head which enables us to point the telescope to almost every direction (see Figure 1).

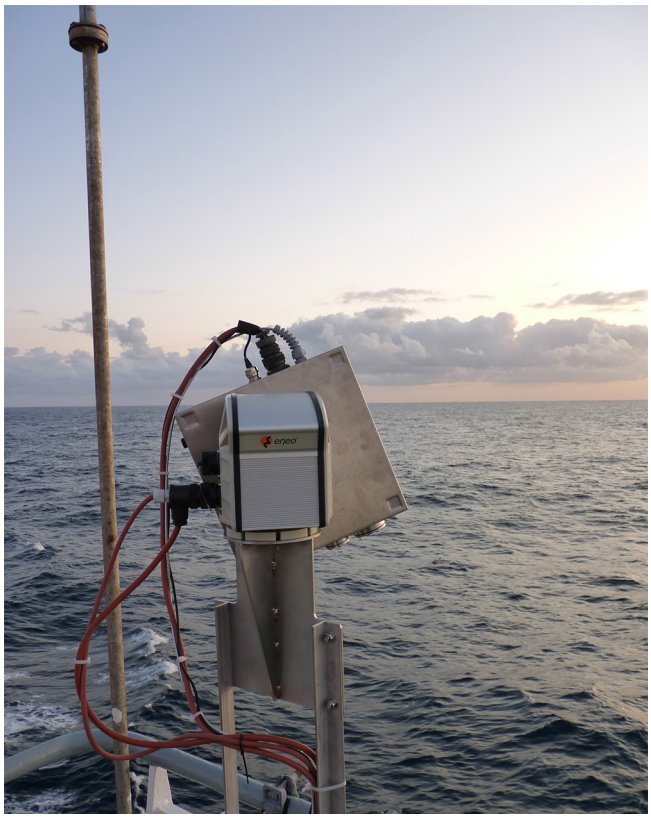

Figure 1: Telescope unit of the MAX-DOAS (located on the Peildeck of the RV "Sonne", here measuring the surface reflectance of the ocean).

In order to get a very good signal to noise ratio and a good spectral resolution, a combination of the Shamrock SR-303i-A spectrograph and the back-illuminated Newton DU940P-BU CCD detector was chosen for each channel (see Figure 2). This setup was also used prior to the ship campaigns in an international intercomparison study for MAX-DOAS systems in the Netherlands and finally the Bremen instrument was chosen as a reference.

Figure 2: The Bremen MAX-DOAS instrument on the scientific bridge of the RV "Sonne". Spectrometers are temperature-stabilized and located inside the pink boxes.

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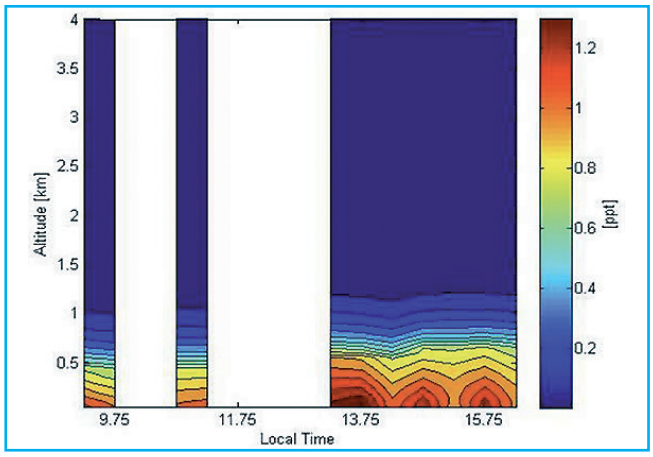

Figure 3: Exemplarily IO profiles for 16 October 2009. Most of the IO observed is located close to the surface.

In October 2009 and 2011 the instrument was installed onboard the German research vessel "Sonne" as part of the TransBrom (very short lived bromine compounds in the ocean and their transport pathways into the stratosphere) and SHIVA (Stratospheric Ozone: Halogen Impacts in a Varying Atmosphere) projects. In 2011 a second very similar setup was also used for ground based measurements on Boheydulang Island close to the eastern coast of Borneo. The data sets we got from these campaigns are also very valuable to validate satellite observations (Figures 3 and 4). Since measurements of this type were carried out for the first time in this part of the world, they provide new insights into the chemistry of the tropical marine troposphere.

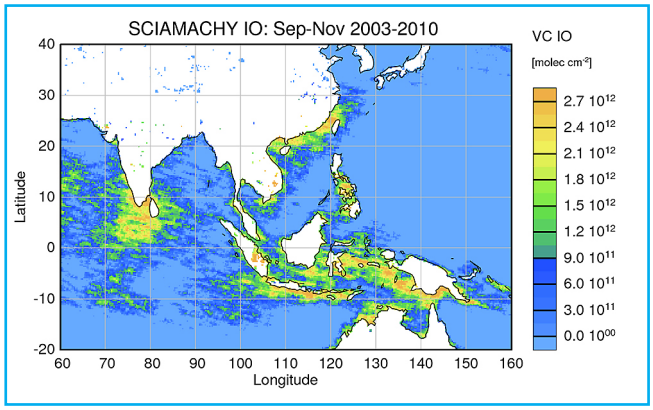

Figure 4: IO columns above South East Asia as seen by the ENVISAT instrument SCIAMACHY. Elevated levels of IO are mainly found close to the coast lines but also some hot spots in the open ocean are visible.

References

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