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The Development of a Nitrogen Dioxide Sonde

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Nitrogen dioxide is an important pollutant in the atmosphere, it is toxic for living species, it forms photochemical tropospheric ozone, and acid rain.

There is a growing number of space-borne instruments to measure nitrogen dioxide concentrations in the atmosphere, but validation of these instruments is hampered by lack of ground–based and in-situ profile measurements.

The Royal Netherlands Meteorological Institute (KNMI) has developed a working NO_2 sonde. The sonde is attached to a small meteorological balloon and measures a tropospheric NO_2 profile. The NO_2 sonde has a vertical resolution of 5 meter, and a measurement range between 1 and 100 ppbv. The instrument is light in weight ($\pm$300 gram), cheap (disposable), energy efficient and not harmful to the environment or the person who finds the package after use. Therefore the popular molybdenum catalytic converter or a photomultiplier tube can not be used. Instead the sonde uses the chemiluminescent reaction of NO_2 in an aqueous luminol solution. The NO_2– luminol reaction produces a faint blue/purple light ($\pm$ 425 nm), which is detected by an array of silicon photodiodes.

The instrument is equipped with a reservoir filled with luminol solution. A small piezoelectric diaphragm pump, pumps the luminol solution into a reaction vessel. A Teflon air pump forces the ambient air into the reaction vessel. The NO_2 in the ambient air reacts with the luminol solution, and the emitted light is detected by an array of silicon photodiodes which are mounted on the reaction vessel. The generated current in the photodiodes is amplified and relayed to the ground by a Vaisala (RS92) radiosonde.

The reaction vessel and the amplifiers are mounted in a tin can, to shield against electrostatic and radio interference, and stray light. All the air tubes used for the instrument are made of Teflon.

The luminol solution is optimised to be specific to NO_2. Sodium sulphate, sodium EDTA and Triton X-100 are added to the luminol solution to exclude ozone (O_3) and PAN (peroxy acetyl nitrate) interference. The efficiency of the NO_2 luminol reaction depends on the pH of the solution. To avoid acidification of the system by carbon dioxide, the chemicals are refreshed constantly. Furthermore, treating the luminol solution with clean air for an extended period before the measurement, makes the luminol / NO_2 reaction more efficient.

The NO_2 sonde is compared to a NO_2 in-situ monitor with bluelight converter (M200E, BLC) of RIVM. Both instruments measure the same NO_2 variations during a certain period of time during the day.

During the Cabauw Intercomparison campaign of Nitrogen Dioxide measuring Instruments (CINDI) in June/July 2009 we measured six vertical profiles of NO_2 from the ground to 5 km altitude. The NO_2 sonde measurements will be compared with the Ozone Monitoring Instrument (OMI) on the EOS-Aura satellite, and other in-situ measurements like LIDAR and MAX Doas.