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A novel Multi-Fiber Optode sensor system (MuFO) for monitoring oxygen

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In the marine environment, dissolved oxygen concentrations often vary significantly spatially as well as temporally. Monitoring these variations is essential for our understanding of the biological and chemical processes controlling the oxygen dynamics in water columns and sediments. Such investigations require a high number of measuring points and a high temporal resolution. A Multi-Fiber Optode sensor system (MuFO) was designed to assess these requirements. The MuFO system simultaneously controls 100 fiber optodes enabling continuous monitoring of oxygen in 100 positions within a 5-10m radius.
The measurements are based on quenching of an oxygen sensitive luminophore, which is immobilised at the end of each fiber optode. The optical oxygen measurements are based on lifetime-imaging, which are converted into oxygen concentrations using a multipoint calibration. At a constant temperature of 21C, the system overall had a mean accuracy of 1.3%, a precision of 0.2% air saturation, the average 90% response time was 16 seconds and the detection limit was 0.1% air saturation.
The MuFO set-up was build into a waterproof titanium casing for marine field applications. The system is battery-powered and has a maximum operational capacity of 15 hours for continuous measurements. The MuFO system was recently used for various research tasks in the marine environment: Mounted on a lander, the in situ MuFO system was used for investigations of oxygen dynamics in marine water columns placing the fiber optodes in a vertical line on a 7m high pole. For studies of oxygen dynamics in marine wetland rhizospheres, the sensing ends of the fiber optodes were covered with a 50cm protective sleeve made from stainless steel tubing, and the sensors were manually pushed into the rhizosphere. For laboratory measurements of sediment oxygen demand, the MuFO system was used to simultaneously monitor the oxygen consumption in multiple sediment slurry incubations. The MuFO system proved to be a useful tool for field studies as well as in the laboratory and the system has multiple applications in marine research. This work was supported by the 7th framework EU-projects SENSEnet and HYPOX.