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Marine robotics for sampling air-sea-ice interface in the Arctic region

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Although chemical-physical characterization of air and water columns in the proximity of fronts/tongues of tide-water glaciers is fundamental for understanding dynamics of atmospheric and water masses, only a few data are available due to the dangerousness in the access to these areas.
In recent years, field experimental activity carried out by Italian CNR researchers in Arctic regions supported the evaluation and demonstration of capabilities and effectiveness of Unmanned Marine Vehicles, aerial, surface and underwater, in sampling air-sea-ice interface in these dangerous and inaccessible areas. In particular three campaigns were carried out in Ny-Ålesund, Svalbard Islands, in 2015, 2017 and 2018 respectively to demonstrate: i) the capability of an Unmanned Semi-Submersible Vehicle (USSV) to approach a glacier tongue collecting water samples just below it; ii) the capability of a USSV to work in cooperation with Unmanned Aerial Vehicles for sea surface and air column characterization in the proximity of glaciers' fronts; iii) the capability of a USSV, equipped with suitable tools and instruments, to perform repetitive sampling of water surface as well as studying water and air column's parameters close to glaciers tongues. During the 2018 campaign in the Svalbard Islands, there was also a field training period for researchers in the framework of the H2020 project "EXCELLABUST - Excelling LABUST in marine robotics" focused on technological and operational innovations specifically introduced for the development of the data acquisition.
This paper will discuss the field activity, logistically supported by the Dirigibile Italia station in Ny-Ålesund, carried out in the proximity of the Blomstrandbreen, Kronebreen, Kongsbreen and Conwaybreen glaciers, in the Kongsfjorden, using the prototype USSV Shark (2015) and the modular vehicle PROTEUS (2017, 2018) together with the OTTO Unmanned Aerial Vehicle (2017).
Particular attention is paid to technological innovations introduced during the 2018 Excellabust campaign where PROTEUS, a portable, modular and reconfigurable USSV (45 kg weight, 1.5 m long, 0.35 m wide and 0.35 m high) was equipped with a new Mini Automatic Water Sampler (MAWS) for the collection of multiple water samples at different distances from the glacier front. Moreover, for carrying out a complete characterisation of the underwater-surface-air vertical column, two release systems based on automatic winches were installed on PROTEUS. One winch was used for launching and recovering an aerostat filled with helium and carrying a system for air quality monitoring (humidity, temperature, CO, CO_2, O_3, NO_2). The other winch was used for releasing and recovering a set of instruments for the chemical-physical characterization of the water column: a CTD (conductivity, temperature, depth,pH, Eh, oxygen), a multi-probe sensor (depth, temperature, chlorophyll a1, chlorophyll a2), a fluorimeter and a turbidimeter.
The paper will also highlight the advantages and issues given by single and multiple vehicle operations (surface and aerial) as well as logistic and operational lessons learned in the three campaigns carried out.