A YOLO model for coccolithophore identification using images from ocean water samples

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Coccolithophores represent one of the major phytoplankton groups and have been extensively studied by scientists. Despite their small size (2–20 µm diameter), the use of polarized light facilitates their microscopic observation, thanks to the birefringent properties of their calcite composition. In 2002, the neural network SYRACO (SYstème de Reconnaissance Automatique de COccolithophores), developed since 1994 by Luc Beaufort and Denis Dollfus, was used to count and identify coccolithophores from different types of samples from deep-sea sediments to ocean water samples. Recent developments in artificial intelligence allow fast segmentation and classification that are fully adapted to oceanic samples. YOLO (« You Only Live Once »), a deep learning algorithm developed since 2016, is a rapid method (several minutes or hours) to train models for the detection of specific objects on images. Besides its precision and versatility, one of YOLO's most prominent features is its ability to instantly detect and identify objects after scanning an image once. It can also be used for image segmentation, and it is frequently updated with version 8 released in January 2023.

In order to train a model, a dataset comprised of artificially generated images was assembled by gathering a large number of segmented images of coccolithophores of various species and shapes. These images were then randomly pasted onto background images. Two training courses were tested: first, a single class model trained with 1950 instances of various species of coccolithophores that were distributed on approximately 150 images, and second, a multi-species model trained to identify 10 classes of coccolithophores, each containing 200 instances. We also created a third dataset by combining 320 images from water samples collected in the Caribbean Sea and eastern Pacific. Several models were generated with varying training parameters (image size, base model size, etc.). Each model was then tested by running a detection on the third dataset to measure and compare their efficiency (precision, recall, and F1-Score), thus allowing an assessment of the best training parameters. The best neural network was then applied to coccolithophores from samples collected in the southern tropical Pacific in a transect going from the Marquesas Islands to Chile during the cruise BIOSOPE in 2005. The results were compared with published SYRACO coccosphere counts and unpublished human counts. The quality of the YOLOv8 model will be evaluated through this comparison.