
Hydrodynamics of Giant Comet Marks in the Deep Ocean: Modeling and Observational Analysis of Sediment Dynamics Under Present Hydrodynamical Conditions

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Résumé

The Demerara Plateau, located in the equatorial Atlantic, is a bathymetric salient that provides favourable conditions for recording the Deep Western Boundary Current (DWBC), which transports North Atlantic Deep Water (NADW) southward into the Atlantic Ocean. These current form the deep part of the global thermohaline circulation, playing a key role in climate regulation. The Demerara plateau is notable for the widespread presence of comet marks, sedimentary structures formed by hydrodynamics covering large areas of the seafloor, with kilometer-scale dimensions. These features are currently used as proxies for deep current velocity, with formation thresholds estimated in the literature between 0.6 and 0.75 m/s. The DIADEM oceanographic campaign (<https://doi.org/10.17600/18000672>) deployed a wide range of tools (AUV, Nautilie submersible, moorings, CTD, MBES, ADCP, sediment cores) to study one of these structures in detail, aiming to better understand its hydrodynamics. The oceanographic results suggest that the studied feature is relict, with very low current velocities measured in the eroded areas that correspond to the comet tails. They show also that present-day current behavior is modulated by barotropic tides, with current alignment along the comet axis during strong flow phases. However, technical limitations of the ADCP prevent observations of current dynamics close to the seafloor (24m) thereby excluding the sediment-water interface. To overcome these limitations, Computational Fluid Dynamics (CFD) modeling was performed. The results of CFD confirm that stronger currents become aligned with the axis of the comet-like structure. Additionally, the critical shear stress (τ_{taucrit}) required to resuspend fine sediments, dependent on sediment grain size, is not exceeded in the comet tails. This supports the interpretation of these features as inactive or fossil structures. Overall, these findings demonstrate that such comet marks may not be necessarily active under present-day hydrodynamics conditions and highlight the importance of caution when using these features as direct proxies for current velocity in oceanographic reconstructions.

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Mots-Clés: Computational fluids dynamics, Deep Western Boundary Current, Deep sedimentation, Demerara plateau, Comet mark