Drift of individual marine floating debris and clusters of debris, incl. waste materials incl. plastics: translational and rotational dynamics of rigid and deformable bodies at the sea surface

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The first version of the Litter-TEP (Thematic Exploitation Platform), which was developed by ARGANS Ltd on a grant of the Copernicus Marine Environment monitoring service (CMEMS), aimed at forecasting litter introduction by rivers and marine drift on the European North-Western Shelf (NWS) so as to help local coastal communities schedule beach cleansing and assess the potential origin of materials collected. It relies on the classic approximation that the pieces or patches of litter are passively transported like Lagrangian floats by currents, whether large-scale, meso-scale, sub-meso-scale, Eckman, tides, Stokes drift, the elusive Langmuir circulation...

Yet, windage, i.e. the effect of wind on items with a freeboard, is often more critical than transport by currents. To stay in the ‘Lagrangian Particle Tracking’ framework, but correct the discrepancy between ground-truth and drift speed's and direction's forecast, windage has been grossly modelled in the Litter TEP as if we had an enhanced ocean surface layer drift which affects similarly all floating litter. Yet, neither ocean transport nor this modelling allows to reproduce the formation of litter rows. Hence the current study: coming back to the basics of classical mechanics (Newton-Euler equations for translations & rotations of rigid bodies) we have performed simulation of marine debris' dynamics at the interface between i. the turbulent atmospheric surface layer (ASL) which is at the bottom of the atmospheric boundary layer (ABL), and ii. the wave breaking layer (WBL) which tops the wave-affected-surface-layer (WASL) within the turbulent ocean boundary layer (OBL), in maturing wave fields (wave age <1) in the open ocean, that are characterized by wind gusts, wave crest breaking and spray. The classic framework for the drift of flotsam, by which wind-induced drag force exerted on objects floating on the sea surface causes motion relative to ocean currents (i.e. leeway drift), and vice-versa, is obviously right; but that it reaches an equilibrium stationary state between the wind-induced drag force and current-induced one on the floating objects in a relatively short timescale proves wrong. In various situations a litter piece will constantly change its attitude and settings in the water, yet reaching a +/- time-invariant time state (but not time-independent) though chaotic. In short: if litter pieces "sail", it is without Control & Command. The litter drift, i.e. motion from source to sink, might therefore be drastically different from usual views, temporarily by orders of magnitude, and on the long run by factors 2 to 3.
For a proper assessment of the behavior of litter pieces, one needs precise modelling of wind profiles above the waves in a non-equilibrium boundary layer (wind gusts above the wave crests and counter wind in the troughs), of wave breaking that creates shock dynamics (surf, immersion and/or flight), of sea spray that batters the litter pieces, and.

Our modelling applies to rigid bodies lighters, cans, wood..., and shall be extended to deformable bodies for algae, plastic bags..., as well as entangled debris that are +/- linked together. We look for partners to perform scaled physical experiments in tanks.