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Hydrodynamics and sediment transport pathways on a barred intertidal beach during high wave-energy conditions, Wissant bay, Nothern France

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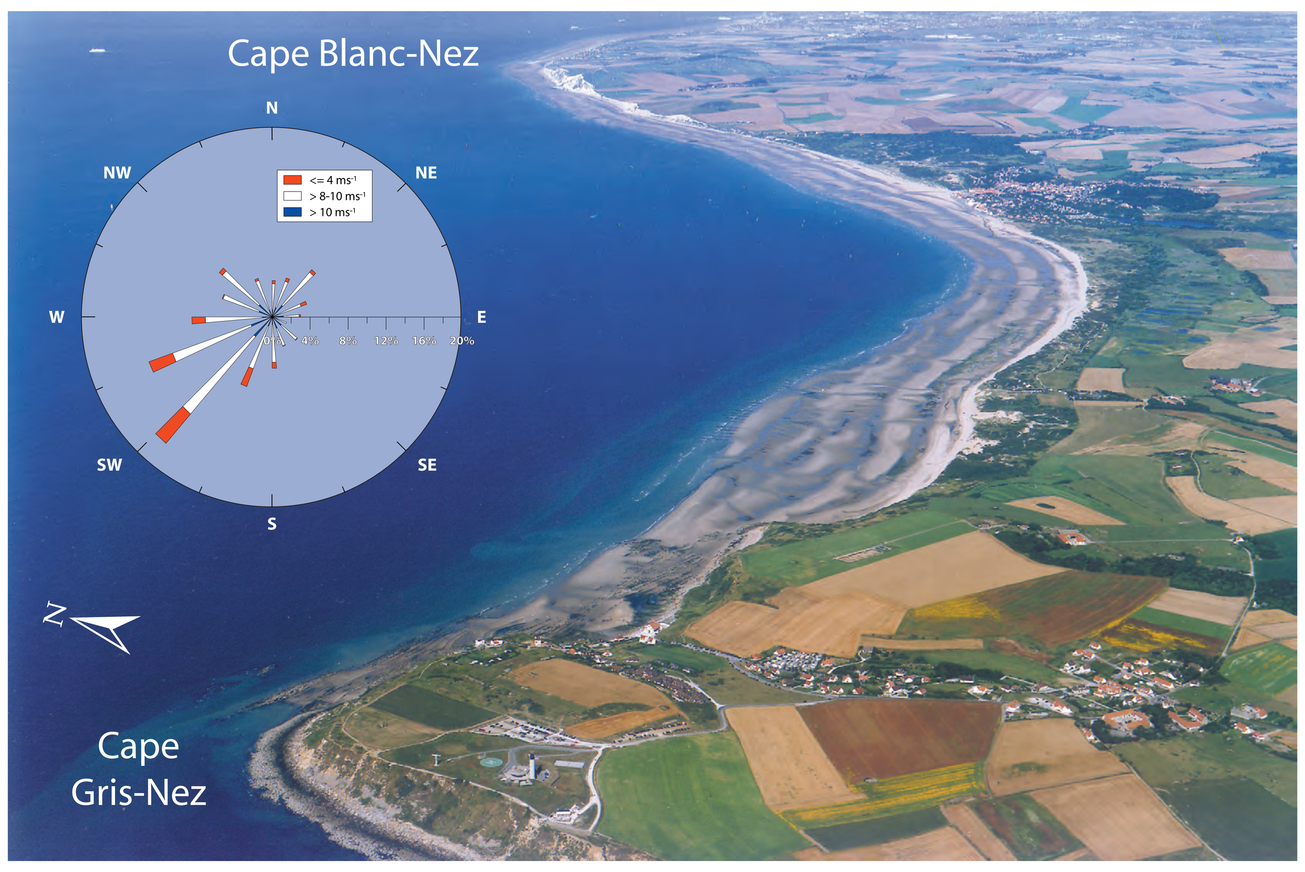

Fig 1. Oblique aerial photograph of Wissant Bay and wind rose of 2004.

Wissant Bay comprises a 6 km-long sandy beach open to the northwest, and limited by two capes (Fig. 1). The bay is located in the most rapidly eroding sector of coast in France (Fig. 2) with retreat of sectors of the dune front of over 100 m in the last decade in the central part of the bay. This eroded part of the bay shows outcrops of peat. The eastern part of the bay is now a zone of accretion (Fig. 2), after being a sand-starved zone in the past when the central part of this bay was either stable or accreting. The morphology of the beaches in Wissant Bay is characterised by three to four pronounced bar-trough systems, intersected by tidal drainage channels (Fig. 1).

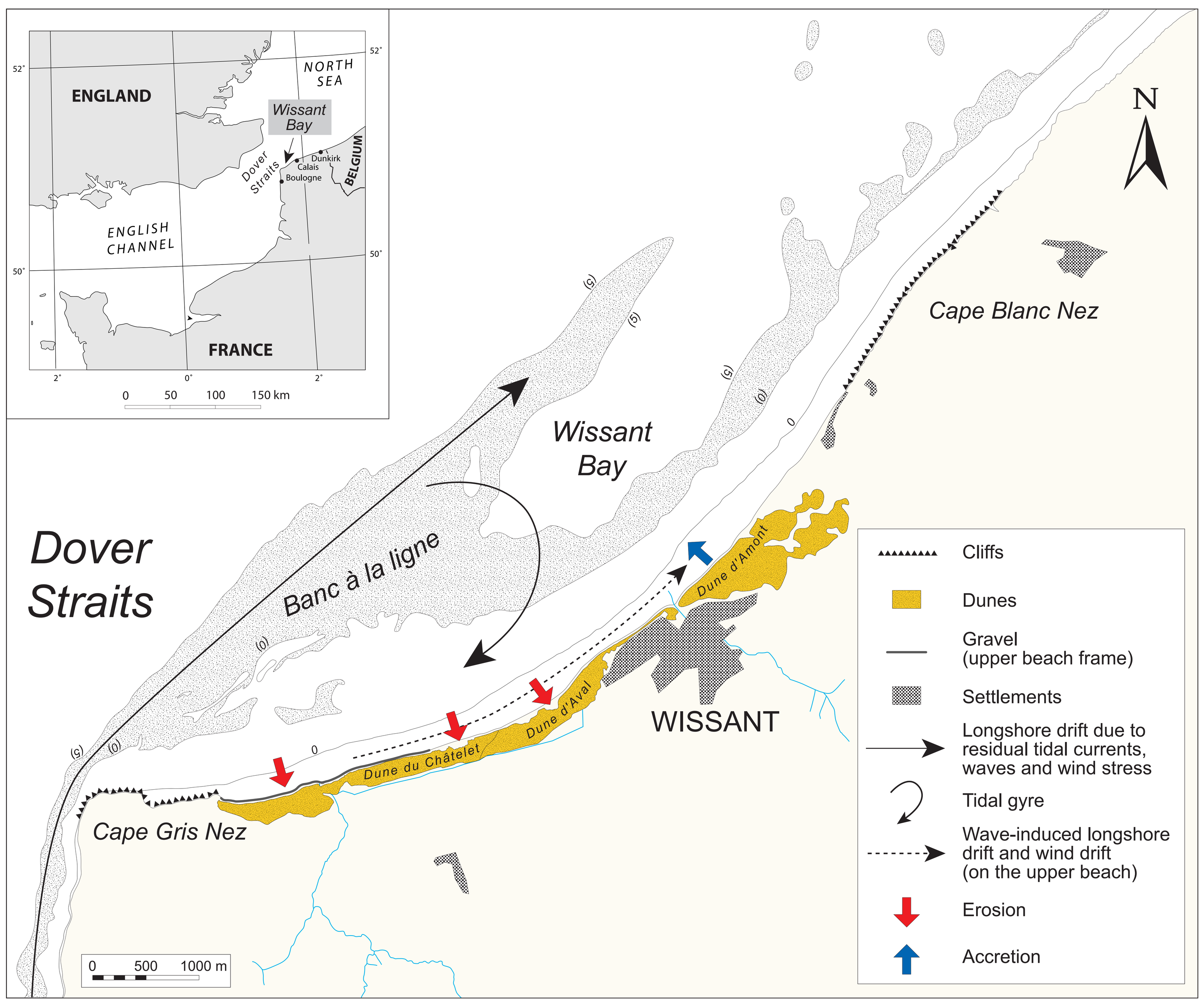

Fig 2. The morphology and sediment dynamics of Wissant Bay.

Facing the Dover Strait, this bay is affected by the lunar semi-diurnal M2 tide (12.4 hours), and by storm (wind and wave) activity. The mean spring tidal range in Wissant Bay is 7.2 m. Southwesterly winds are largely dominant on this coast (see wind rose in Fig. 1). Offshore wave periods range from 4 to 7 s and the dominant approach directions are from west to west-southwest, with fetch and coastal orientation conditions restricting the incidence of southwesterly waves.

During calm wave conditions, the hydrodynamic circulation in Wissant bay shows a divergent current structure between the western and eastern parts. This current structure involves a large-scale tidal gyre probably related to the projecting headland of Cape Gris-Nez in the western part of the bay (Fig. 2). Tidal currents generally flow northeastward during the flood (mean current velocity = 50 cm.s^{-1} at high water springs), following the coastline, and in a southwestward direction during the ebb (mean current velocity = 24 cm.s^{-1} at high water springs) (Sedrati 2002). Wind forcing significantly enhances the mean velocities (Sedrati *et al.* 2003).

Hydrodynamic measurements (deployement of three currentmeters: cf Fig. 5) were carried out during high-energy conditions (from 05 to 19 january 2005: cf Fig. 3) in order to highlight the effects of significant wind stress conditions on the Wissant bay hydrodynamic circulation. Moreover, a grain-size trend analysis using the Gao and Collins (1992) procedure was applied (50 sand samples collected on 13/01/2005: cf Fig. 5) in order to identify the residual transport direction.

Hydrodynamic results (Fig. 4) highlight a dynamic and homogeneous regime related to significant wind forcing. During conditions of significant wind stress (sustained wind speeds > 8 m.s^{-1}), the peak longshore current velocities attained up to 2 m.s^{-1} and were unidirectional along the bay. The peak cross-shore current velocities were four to five times lower than the longshore current velocities.

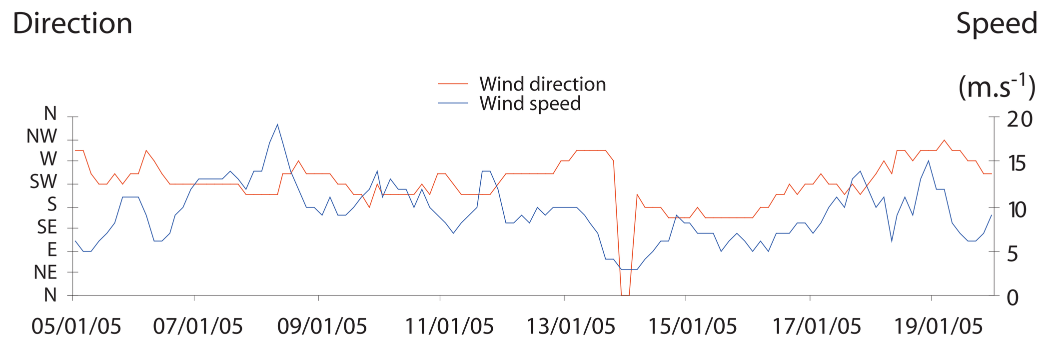

Fig 3. Characteristics of winds recorded at Wissant Bay from 05 to 19 January 2005.

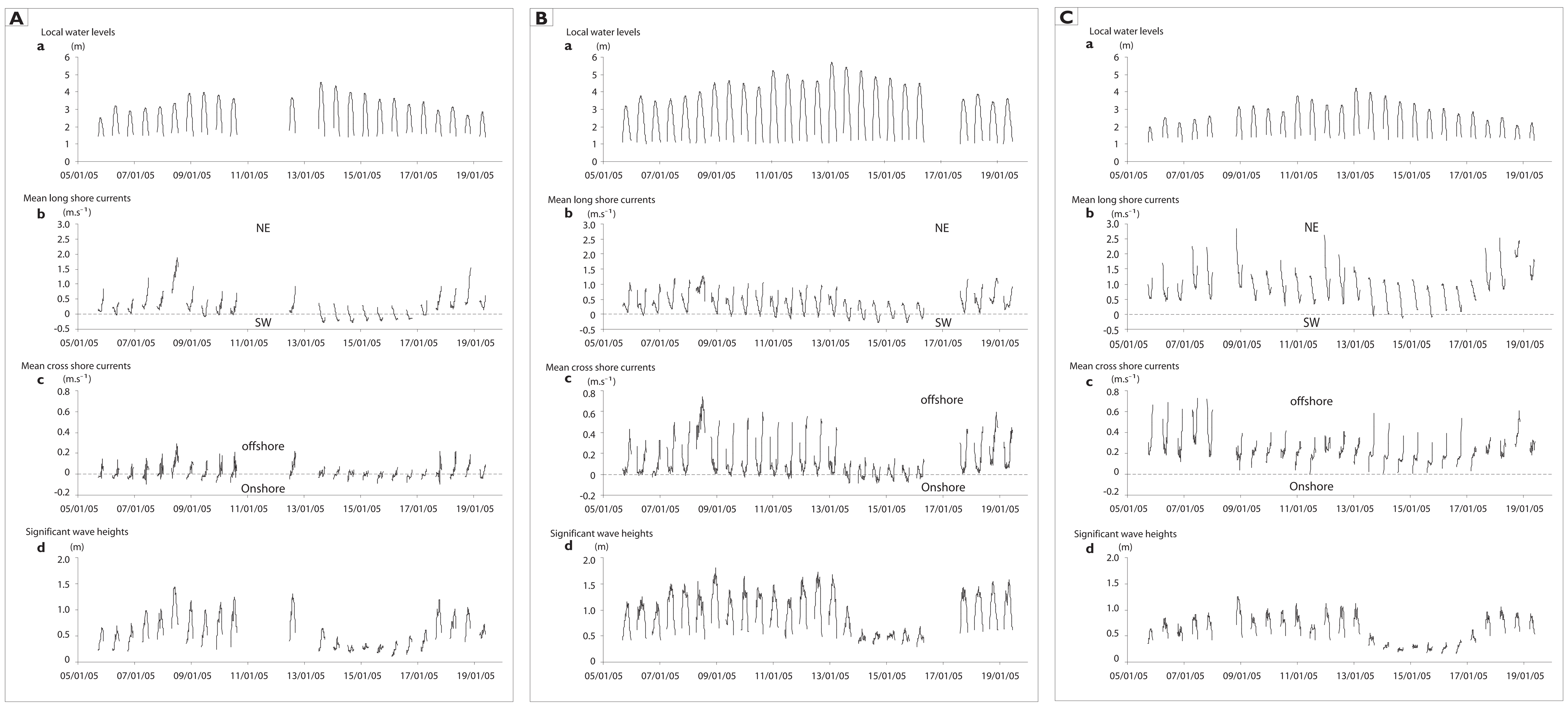

Fig 4. Water levels, mean currents and significant wave heights at currentmeter locations A, B and C. (a)water levels, (b) long-shore currents, (c) cross-shore currents and (d) the significant wave heights.

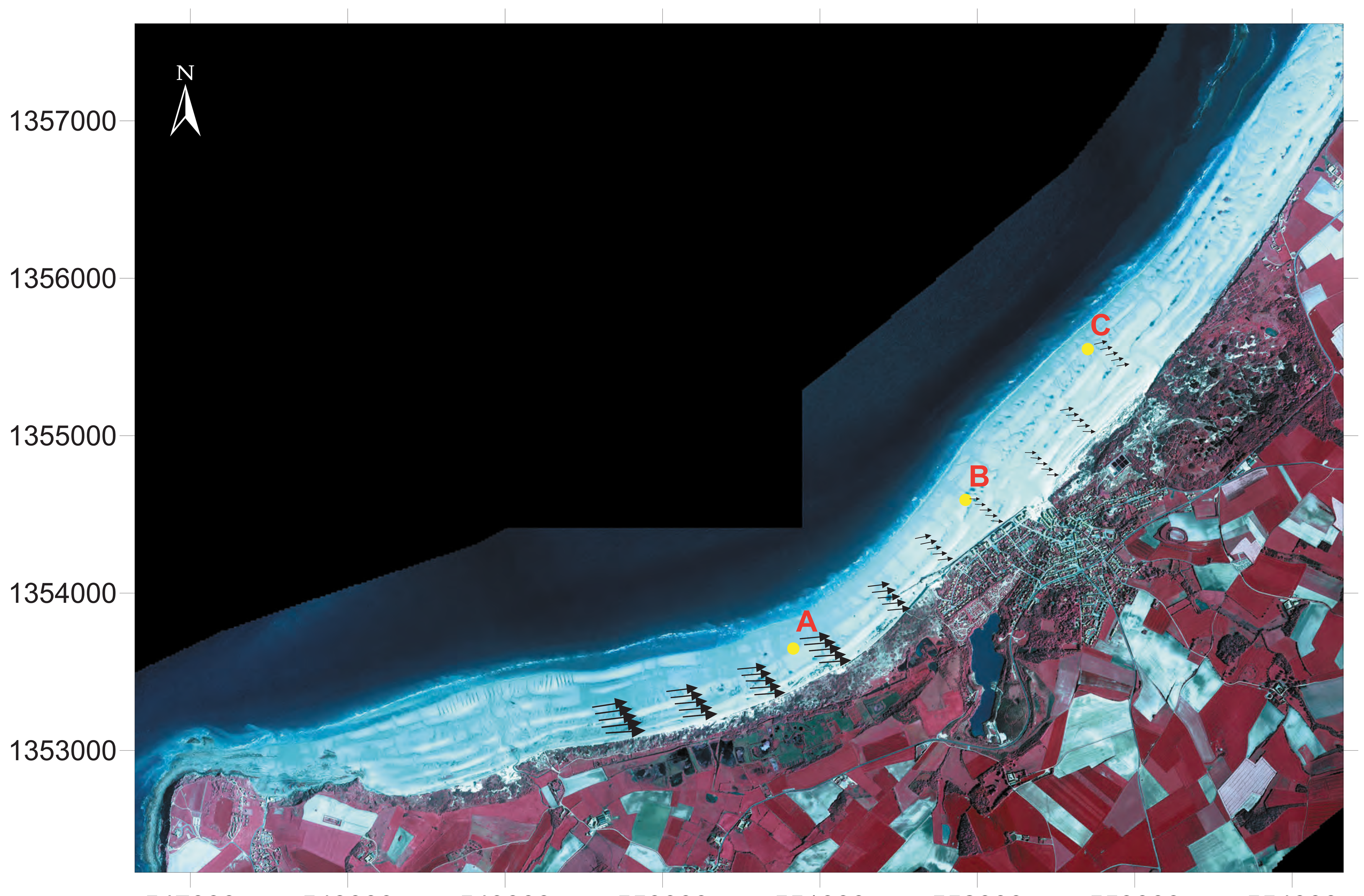

Fig 5. Aerial photograph of Wissant bay showing positions of currentmeters and sediment trend analysis using the Gao and Collins (1992) approach. The tchikness of arrows represents the significance of the result at each location.

From combined hydrodynamic measurements and sediment transport trend analysis, residual sediment transport directions were identified during the high wave energy conditions (Fig. 5). The sand transport pathways strongly conform to the high-energy hydrodynamic regime. The intertidal bar-trough beach system of this bay can be dominated for long periods of time by strong longshore wave and wind-forced unidirectional currents, thus suggesting that the long-term evolution of the bay, involving significant beach erosion, is largely controlled by these high-energy events.

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FEDER

BEACHES AT RISK

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