The impact of typhoons on a sandy beach – Insights from in-situ measurement in the Wan Tzu Liao barrier, south-westernmost Taiwan

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The presentation aims at offering an up-to-date and better understanding of the peculiar dynamics of sand barriers – these wave-driven narrow pieces of sand growing between the open sea and the lagoon – in settings where extreme events such as typhoons are preeminent. It is *a priori* suggested that extreme meteorological events drive abnormal morphodynamic response of the sand barrier. In other words, we discuss the fact that there may exist non-linear morphologic responses of the sand barrier to linear variations of the hydrodynamic forcings, and thus possible fundamental physical thresholds.

To address this question, we develop a strategy mainly based on the analysis of in-situ hydro-morphodynamic data of high quality acquired on the Wan Tzu Liao barrier and the adjacent Cigu lagoon, the largest barred beach system in Taiwan located in the vicinity of Tainan City (south-westernmost Taiwan). In Taiwan, more than 38 typhoons occurred in less than 10 years. Thus, from september 2011 to december 2012, we deployed a set of equipments (ADCP, wave gauge, HR profileur, pressiometer networks) fully adapted to catch and resist to typhoons in the nearshore from 7 m of water depth and up to the emerged beach, onto the sand dune itself and into the lagoon. The equipments were deployed along a cross-shore transect, with a wave buoy located in the shoaling zone, in ~ 20 m of water depth off the Wan Tzu Liao barrier. The full system provides a detailed characterization (measured burst at 4 Hz or more) of littoral hydrodynamics impacted by variable typhoon forcings. Concomitantly, high resolution DEMs (approx 300 m x 300 m, with 1 point per m^2) of the same domain, were acquired after each significant changes in the meteo-marine forcings, recording the morphological impact of typhoons or winter storms crossing Taiwan or moving off the taiwanese coastlines.

From the analysis of the hydrodynamic and morphodynamic data, and their comparison, we can give preliminary field evidences for several major processes occurring onto the beach while typhoons propagate around. We also tentatively quantify these processes and we

compare them to storms in other contexts, such those observed in the Gulf of Lions (South of France) when relevant.

The tide shows mixed semi-diurnal oscillations with mean tidal range around 1.5 m. Tidal currents are strongly bi-directional, flowing slightly across the isobaths to the North-East for the flood and south-westward for the ebb flow. The maximum flood flow is as strong and of same duration as the maximum ebb flow. During the winter period (Nov. 2011 to Jan. 2012), wave energy is quite constant with a time-averaged significant wave height at 0.9 m. The sand mainly moved from the beach front to the back-barrier. Therefore, a strong beach front erosion occured in spring and transported the sand offshore.

During summer 2012, from May to November, 12 typhons and tropical storms struke Taiwan's coasts. Amongst them, Talim (12/06/18-12/06/22) is the most representative. The signature of the Talim tropical storm is clearly identified in terms of free surface setup, watertable overheight, wave height, infragravity waves, current magnitude. The significant wave height, measured at Cigu buoy during the tropical storm Talim, is 10.3 m with a peak period of 13.5s. The offshore current profiler recorded a significant wave height of 2.3 m. It induces a rising of the watertable in the surf zone which remains quite high (25 cm) for two days after the storm decay. The oscillations of free surface and watertable in response to tides, waves and morphological evolutions generate pressure gradients inside the sand soil and related groundwater fluxes. The groundwater flows are systematically directed seaward with higher groundwater fluxes in the upper beach than the lower beach. Morphological changes, recorded during Talim, shows a 6 m retreat of the dune front, a 20 m large dune breaching and the deposit of a wash-over fan in the lagoon. Such coastal features result from combined effect of tide and over-topping of waves, leading to over-washes of the sand barrier and subsequent wash-over deposits in the lagoon. These are well-known morphodynamic responses to moderate storms. Besides, a significant nourishment of the supratidal zone and the shoal is also a good marker of typhoon occurrence.

At the time scale of the year, a 12 m landward migration of the sand barrier has been recorded. It is concomitant with a 12 m widening of the barrier without any significant abrasion of the dune. The impact of a full typhoon season is thus strikingly distinct from what occur in systems forced by more moderated wind/wave forcings.