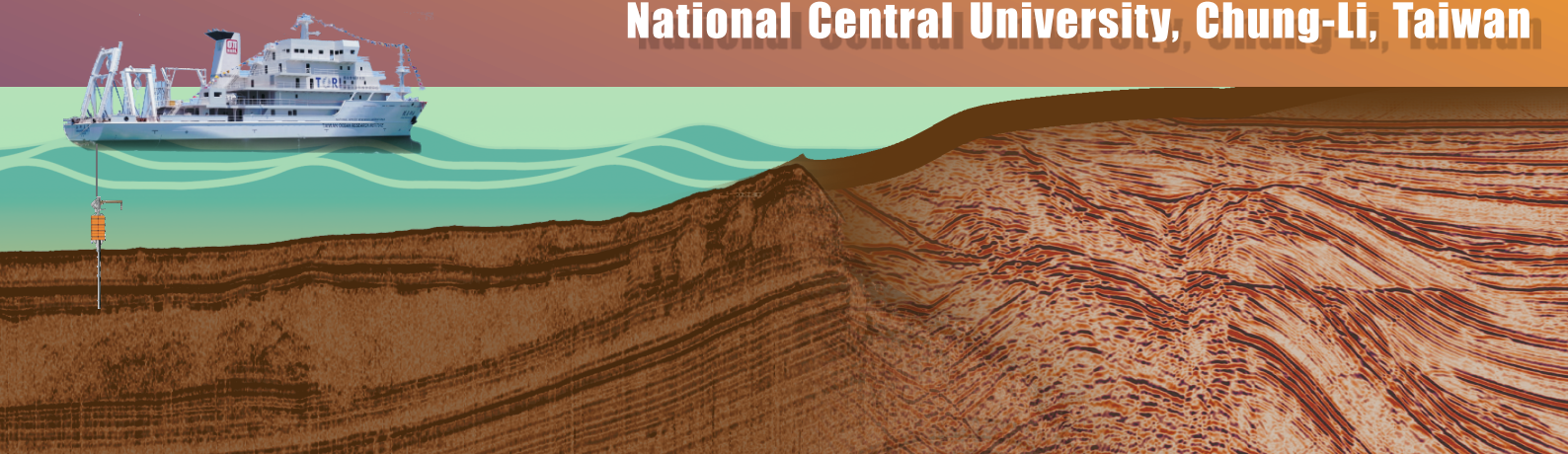
EAGER Workshop

Extreme events Archived in GEological Records

Nov. 7-8 2013 EAGER Workshop NCU Extreme events Archived in GEological Records

7th-8th November, 2013

National Central University, Chung-Li, Taiwan



EAGER Workshop

Extreme events Archived in GEological Records

Venue: Center for Space and Remote Sensing Research,
National Central University, Chung-Li, Taiwan

Dates: Meeting: November 7 and 8, 2013; Field trip: November 9-10, 2013

Workshop Organizers: Shu-Kun Hsu, Serge Lallemand, Andrew Lin, Lionel Siame

Sponsors: NSC (Taiwan), National Central University (Taiwan), CNRS-INSU (France), LIA ADEPT (France/Taiwan), BRT (Bureau de représentation de Taipei en France) and BFT (Bureau Français de Taipei)

Workshop website:

http://basin.earth.ncu.edu.tw/Meetings/2014%20EAGER%20Workshop/EAGER.html

Workshop Program

2013/11/07 Thursday

10:00 – 10:15	**Opening Remarks**		**Yen-Hsyang CHU, NCU, Taiwan**
10:15 – 10:25	**Introduction for EAGER Workshop**		**Shu-Kun HSU and Serge LALLEMAND**
Session 1: Extreme River Discharges on Source-to-Sink Fluxes **Chair: Char-Shine LIU, Co-chair: Christian FRANCE-LANORD**			
10:25 – 10:40	**Sandrine ANQUETIN**	LTHE, Grenoble, France	**Flash-Flood generating storms. State of the art in the Mediterranean climate context (P. 1)**
10:40 – 10:55	**James LIU**	NSYSU, Taiwan	**Experience from the FATES-HYPERS (FAte of Terrestrial / Nonterrestrial SEdiments of High Yield Particle-Export River-sea Systems) Research Program in Taiwan (P. 6)**
10:55 – 11:10	**Albert GALY**	CRPG Nancy, France	**Effect of cyclonal precipitations on the long-term dissolved and particulate fluxes of river in Taiwan (P. 8)**
11:10 – 11:25	**Ray T. HSU**	NSYSU, Taiwan	**Hyperpycnal events observed in the Gaoping Submarine Canyon (P. 10)**

11:25 – 11:40	**Laurent DEZILEAU**	Geosc. Montpellier, France	**Intense storm activity during the Little Ice Age on the French Mediterranean coast (P. 12)**
Session 2: Nearshore Dynamic Response to Extreme Events **Chair: Frédéric BOUCHETTE, Co-chair: Hwa CHIEN**			
11:40 - 11:55	**Hwa CHIEN**	NCU, Taiwan	**Monitoring of shoreline position and beach morphodynamical changes using microwave marine radar (P. 13)**
11:55 - 12:10	**Samuel MEULE**	CEREGE Aix, France	**The impact of typhoons on a sandy beach – Insights from in-situ measurement in the Wan Tzu Liao barrier, south-westernmost Taiwan (P. 15)**
12:10 - 12:25	**Tsung-Yi LIN**	NTNU, Taiwan	**Coastal hazard mitigation: Reconstruction of sand dunes and proper setback zoning (P. 17)**
12:25 – 14:00	**Lunch**		
14:00 – 14:15	**Nadia SENECHAL**	EPOC Bordeaux, France	**Runup dynamic and beach response under extreme energetic conditions: Video applications (P. 18)**
14:15 - 14:30	**Zhi-Cheng HUANG**	NCU, Taiwan	**Field measurements of turbulence properties over an algal reef (P. 20)**
14:30 - 14:45	**Frédéric BOUCHETTE**	Geosc. Montpellier, France	**Modelling storms and extreme events impacting sand beaches in Taiwan (P. 21)**
14:45 – 15:00	**Bruno CASTELLE**	EPOC Bordeaux, France	**Shoreline response to sequence of storms: Complex process-based or simple behaviour-oriented modelling? (P. 24)**
15:00 – 15:20	**Coffee Break**		
Session 3: Sedimentological Records of Seismic and Mass-movement Events **Chair: Serge LALLEMAND, Co-chair: Chih-Chieh SU**			
15:20 – 15:35	**Andrew T. LIN**	NCU, Taiwan	**Paleoclimates and geohazards recorded in sediments in the frontal Manila accretionary wedge near Taiwan (P. 26)**
15:35 – 15:50	**Serge LALLEMAND**	Geosc. Montpellier, France	**Sedimentary records of paleo-extreme events in marine cores offshore East Taiwan (P. 27)**
15:50 – 16:05	**Chih-Chieh SU**	NTU, Taiwan	**Is Morakot unique? An observation from deep sea (P. 29)**
16:05 – 16:20	**Nathalie BABONNEAU**	LDO Brest, France	**Turbidite deposits as long-term deep-marine record of extreme events (P. 30)**
16:20 – 16:35	**Shu-Kun HSU**	NCU, Taiwan	**Possible extreme geological events recorded in the lower reach of Kaoping submarine canyon (P. 32)**
16:35 – 16:50	**Yi-Ching YEH**	TORI, Taiwan	**Interbeded fluid activities induced slope failure in the Kaoping Slope area (P. 33)**
16:50 – 17:05	**Hong-Chun LI**	NTU, Taiwan	**The AMS 14C dating facility at NTU and its capability (P. 34)**
17:05 – 17:20	**Niels Hovius**	GFZ Postdam, Germany	**A global relation between surface uplift and erosion caused by large, compressional earthquakes (P. 35)**
18:00-20:00	**Welcome Banquet**		**Hotel Kuva Chateau**

2013/11/08 Friday

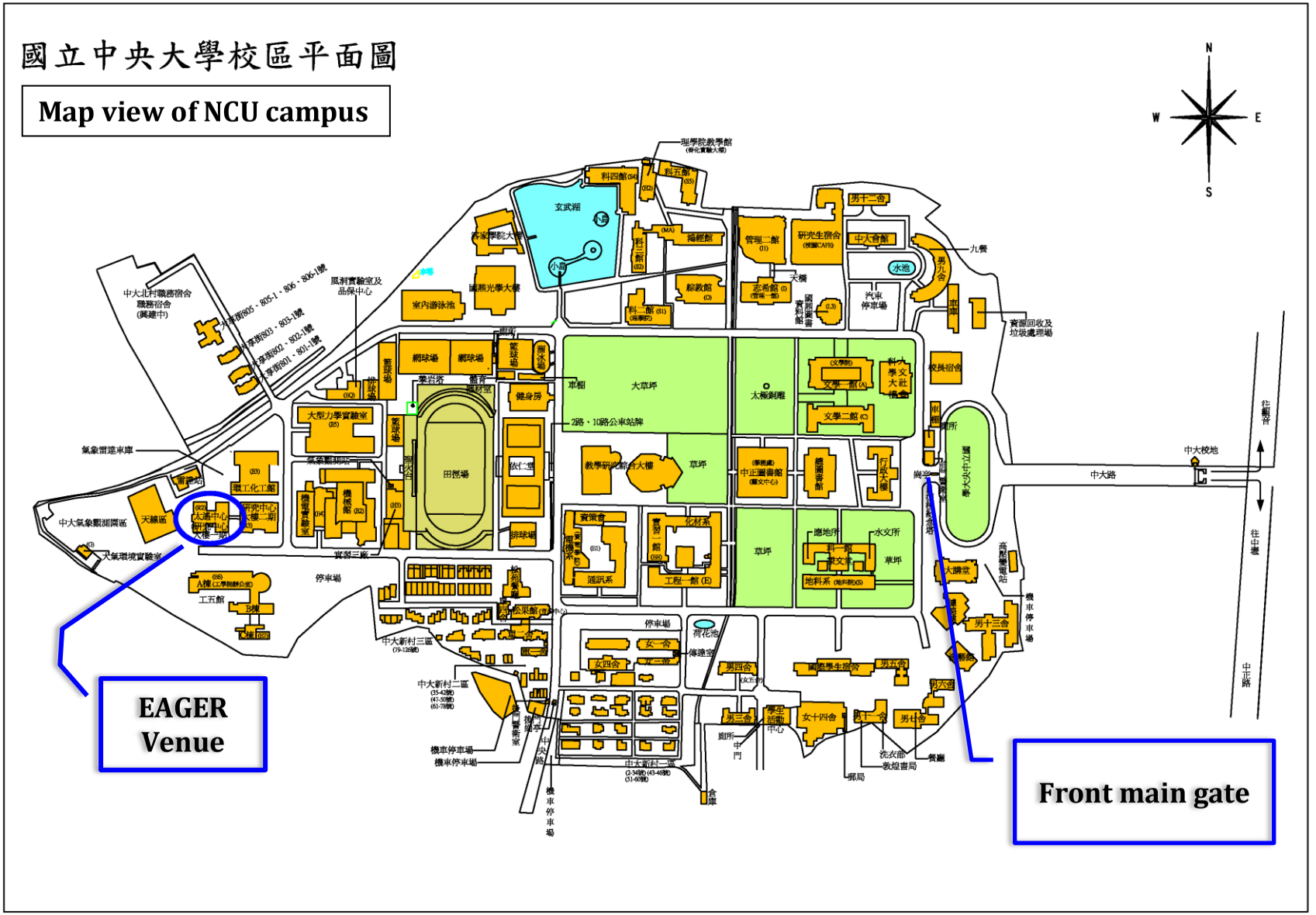
Session 4: Catastrophic Landscape and Seafloor Changes **Chair: Shu-Kun HSU, Co-chair: Vincent GODARD**			
09:00 – 09:15	**Jian-Cheng LEE**	IES, Taiwan	**Fluvial incision and knickpoint retreat across a co-seismic popup zone of the 1999 Chi-Chi earthquake, Da-An River gorge, Taiwan (P. 36)**
09:15 – 09:30	**Frédéric BOUDIN**	Geosc. Montpellier, France	**Analysis and modelling of tsunami-induced tilt for the 2007,M= 7.6, Tocopilla and the 2010,M= 8.8 Maule earthquakes, Chile, from long-base tiltmeter and broadband seismometer records (P. 38)**
09:30 – 09:45	**Meng-Long HSIEH**	NCCU, Taiwan	**Late Quaternary mass-wasting records in the actively uplifting Pa-chang catchment, southwestern Taiwan (P. 39)**
09:45 – 10:00	**Lionel SIAME**	CEREGE Aix, France	**Cosmogenic nuclides and surface processes in Taiwan (P. 40)**
10:00 – 10:15	**Hajime NARUSE**	U. Kyoto, Japan	**Reconstruction of flow condition of large-scale mass transport deposits from internal stress fields (P. 41)**
10:15 – 10:30	**Vincent GODARD**	CEREGE Aix, France	**Landscape relaxation after the 2008 Sichuan earthquake : insights from cosmogenic nuclides (P. 42)**
10:30 – 10:45	**Coffee Break**		
Session 5: Sedimentological Records of Paleoclimatic Extreme Events **Chair: Shou-Yeh GONG, Co-chair: Albert GALY**			
10:45 – 11:25	**Yoko OTA**	NTU, Taiwan	**Invited lecture :** **Problems on the paleoearthquake reconstruction based on geological evidences : View from active fault and paleotsunami studies (P. 44)**
11:25 – 11:40	**Christophe COLIN**	IDES Orsay, France	**Impact of the East Asian monsoon rainfall changes on the erosion of Asian river and sediment transfer to the South China Sea (P. 45)**
11:40 – 11:55	**Po-Sen YU**	TORI, Taiwan	**Preliminary results of marine core analyses off Southwestern Taiwan: R/V Ocean Researcher 5 Cruises (P. 47)**
11:55 – 12:10	**Franck BASSINOT**	LSCE Gif/Yvette, France	**Reconstructing paleo-monsoon changes and variability from marine sediment records: State-of-the-Art and perspectives (P. 48)**
12:25 – 12:25	**Shou-Yeh GONG**	NMNS, Taiwan	**An extreme wave event in Holocene coral reef, western Luzon, Philippines (P. 49)**
12:25 – 12:40	**Christian FRANCE-LANORD**	CRPG Nancy, France	**Erosion processes and sediment transfer to the ocean: A perspective from the Himalayan basin (P. 50)**
12:40 – 14:00	**Lunch**		
14:00 – 15:00	**Wrap-up Discussion**		**Workshop Organizers and Session Chairs and Co-Chairs**
15:00 – 15:40	**Report and Discussion for LIA and NSC Project Proposal**		**Shu-Kun HSU and Serge LALLEMAND**
15:40 – 15:50	**Field Trip Briefing**		**Andrew T. LIN and Rong-Kuan YANG**

Poster session

Rick YANG	**Absence of delta facies in the Holocene sedimentological record at the mouth of the Zhuoshui River on the west coast of Taiwan (P. 52)**

國立中央大學校區平面圖

Map view of NCU campus



Flash-Flood generating storms
State of the art in the Mediterranean climate context

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General Context

Global warming is expected to favor larger rainfall accumulations due to the increase of water vapor content ensuing from warmer air temperature. If the increase of temperature is now fully established at both global and regional scales (IPCC, 2007), the intensification of moisture-related phenomena still presents large uncertainties in particular at regional scales. Christensen et al. (2007), for instance, reported that intense precipitation events are likely to increase over Central Europe in the winter, but that the trends over the Mediterranean basin remain uncertain due to the **complex interactions at several scales** (presence of topography; interactions and feedbacks between atmosphere – ocean – land processes) **driving Mediterranean ecosystems**.

This region has been identified as one of the two main "hot-spots" of climate change (Giorgi, 2006). Addressing the issue of rainfall evolution in a context of climate change requires **improving the regional climate understanding and, in particular, the role of the topography in the Mediterranean rainfall regime,** both in terms of ordinary and extraordinary rainfall.

Frei and Schär (1998) analyzed high-resolution rain-gauge observations of daily rainfall to produce a precipitation climatology extending from the Western Alps (i.e. Massif Central, in France) to the Eastern Alps. They demonstrated that the southeastern part of the Massif Central (i.e. **Cévennes - Vivarais**) **was one of the five rainiest areas of the region**.

As far as the extreme rainfall is concerned, Molinié et al. (2012) pointed out, on an annual average basis, that at equivalent altitudes, extreme rainfall are higher above the Cévennes-Vivarais region than above the Alps foothills. Nuissier et al. (2008) showed that there is a prevailing location (i.e. over the southeastern flanks of the mountain ranges) for intense events with daily rainfalls exceeding 200 mm.

These intense precipitating events lead to **hydrological risk**, such as flash floods that rank among the most severe natural disasters in terms of number of people affected, number of fatalities and economic losses (Ruin et al., 2008). Flash floods result from interactions between heavy precipitation generating storms, induced and/or enhanced by orography, and the catchments able to rapidly concentrate the storms water in relation with the topography. **Because global warming** will likely result in an increase of flash-flood frequency (Huntington,

2006), **there is a need to improve the understanding of flash flood generating storms and their interaction with the topography.**

Mediterranean Precipitation Structure over Orography

The presentation will focus on coastal **orographically-driven and orographically-enhanced** precipitation events in the Mediterranean region that lead to flash floods. It aims at presenting new insights concerning **the physical processes** that govern their **specific scales of variability** and their location **with respect to the mountain range**.

The amount of precipitation is related to the characteristics of the precipitating system (**intensity, duration, extension**) and **its motion**. Stationary systems likely lead to larger amounts of precipitation. Over the Cévennes – Vivarais, **two main types of stationary precipitating systems, leading to intense precipitation,** have been identified: quasi-stationary mesoscale convective systems (**MCS;** e.g. Ducrocq et al, 2008) and stationary shallow orographic convection, often organized in bands parallel to the impinging flow (called hereafter Banded Orographic Convection (**BOC**); e.g Miniscloux et al., 2001). They differ not only from their spatial scales (vertical and horizontal extents), but also by their time scale and their rainfall intensity. The duration of the MCSs is several hours while BOC systems may last one or two days. Rainfall intensities may reach several tens of $mm.h^{-1}$ in the first case while they do not exceed 10 to 15 $mm.h^{-1}$ in the second case.

For climatological issues, Molinié et al. (2012) showed that **the statistical distribution of local intense rainfall strongly depends on the accumulation time.** At daily time step, the signature of the relief is clearly visible on the maps as the maxima are concentrated along the mountain range, whereas at smaller time steps (e.g. hourly) no specific trace of the relief is observed. The authors justified this result by **the atmospheric conditions and the nature of the precipitating systems**. Intense hourly rainfall may be attributed to deep convection (MCS) whereas heavy precipitation events at the daily time step may result from long-lasting and mixed stratiform / convective precipitation (BOC). Godart et al. (2011) showed that despite the small hourly rainfall intensity during BOC events, these systems may contribute to 40% of the rainfall regime in the Cévennes-Vivarais area. Several studies characterized the atmospheric conditions prevailing during precipitation events over the Cévennes-Vivarais region (Godart et al., 2010; Ricard et al., 2011). They showed that intense precipitating events, resulting from MCS and/or BOC, are associated with complex interactions of synoptic circulation and local topography.

Since these precipitating systems directly affect **flash-flood genesis** in mountainous area, our scientific approach addresses this **continuum of precipitation systems** ranging from banded shallow convection (BOC) to stationary fully developed mesoscale convective systems (MCS). It relies on:

i) A specific **hydrometeorological observation device** (Fig.1) implementing during the HyMeX enhanced observation period (EOP, 2010-2014; Ducrocq et al. (2013)) and the 2012 and 2013 special observation period in the French Mediterranean mountainous regions (i.e. Cévennes-Vivarais);

ii) Innovative **scaling analysis of the surface precipitation** based on statistical analysis constrained by the atmospheric physics;

iii) **Hydrometeorological numerical simulations** of precipitation events and the associated flash flood (Fig.2).

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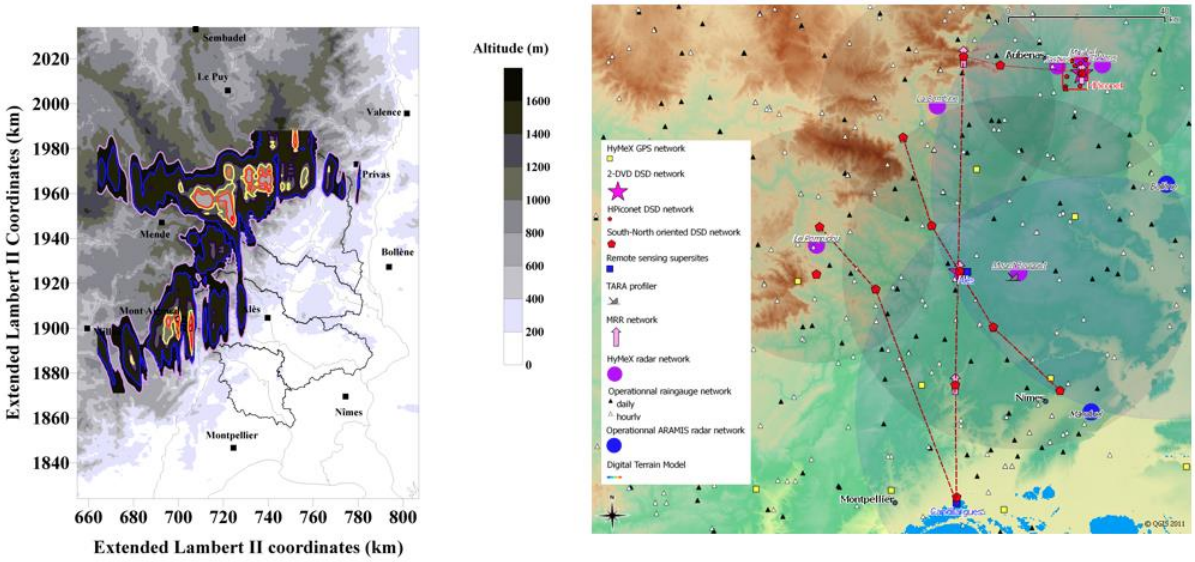

Figure 1: (left) Climatology of the orographic precipitation (Godard et al., 2011); (right) Hydrometorological observation device implemented during HyMeX.

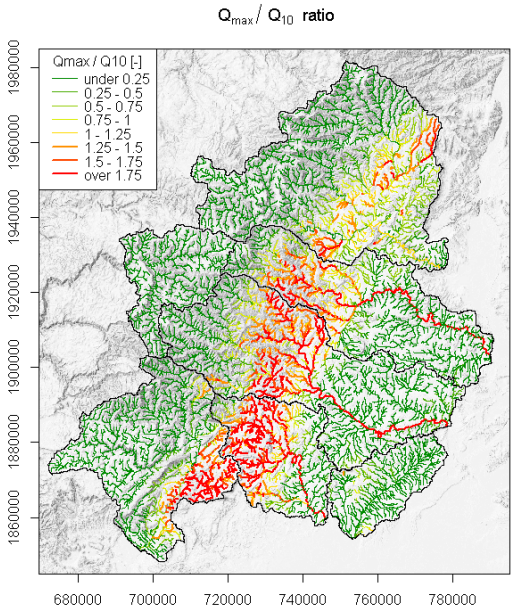

Figure 2: Ratio between the simulated maximum discharge and the 10-year return period discharge. Case of the November 2008 flash-flood event in the Cévennes-Vivarais region (Vannier, 2013)

Experience from the FATES-HYPERS (FAte of Terrestrial/Nonterrestrial SEdiments of High Yield Particle-Export River-sea Systems) Research Program in Taiwan

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Located in the tropic to subtropic climatic zone, straddling between two colliding tectonic plates, having a rugged terrain and prone to earthquakes, and also situated on the paths of typhoons, all these factors contribute to the disproportionally high sediment load delivered to the sea by small mountainous rivers on the island of Taiwan. These rivers also deposited sediment along the river courses and formed alluvial plains on the west coast of Taiwan, whose source areas could extend high above sea level in the Central Range.

The multidisciplinary research program FATES-HYPERS is the Source-to-Sink research program in Taiwan that focuses on the sediment dispersal in two river-sea systems in Taiwan. The Gaoping River (GPR) and Submarine Canyon (GPSC) in southern Taiwan connects the catchment of a small mountainous river and the deep South China Sea basin. The Zhuoshui River system in central Taiwan connects the high mountain source area to the shallow Taiwan Strait. We have made significant progress on the understanding of basic characteristics of how the modern GPR-GPSC functions dispersal system from the source to sink perspective. The GPR is an efficient system to deliver terrestrial sediment and carbon to the GPSC, which is an effective conduit for the trapping, transport, and sink of not only the terrestrial sediment, but also biogenic particles of marine origin. In rare opportunities we captured the passing of hyperpycnal turbidity currents in GPSC triggered by typhoon related floods GPR. We have documented the presence of turbidites and hyperpycnites in the GPSC.

FATES-HYPERS also drilled two bore-holes on the upper modern Zhuoshui River delta and the upper tidal flat immediately north of the delta and obtained two 100-m long cores to study the past history of the Land-Sea Interactions. This multi-disciplinary research is on-going and through AMS C-14 dating of over 140 samples, we have established a reliable time model. The preliminary results indicate that there was a major shift from terrestrial sedimentary phase (mainly flood plains and paleosol-like facies) to shallow marine phase at the time around ~10,000-12,000 BP at the coring sites about 47 m below the present sea-level.

The absence of deltaic facies is unexpected in the shallow marine phase. A preliminary explanation is that when the sea-level rose to inundate the paleo-delta of the Zhuoshui River, the strong currents not only eroded the delta but also created a hiatus in the core record.

Another independent study of the sediment dispersal of the modern Zhuoshui River shows that the sediment discharged by the river actually bypasses the delta and the tidal flat system immediate to the north. This might also be a factor why the deltaic signals are missing in our cores.

The FATES program published a special issue in Journal of Marine Systems, volume 76, issue 4, entitled 'The Fate of Terrestrial Substances on the Gaoping (Kaoping) Shelf/Slope and in the Gaoping Submarine Canyon off SW Taiwan Shelf/Slope and in the Gaoping Submarine Canyon off SW Taiwan. The articles of this special issue can be download at: http://www.mgac.nsysu.edu.tw/liu/.

Effect of Cyclonal Precipitations on the Long-term dissolved and particulate fluxes of river in Taiwan

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The burial of particulate organic carbon (POC) in marine sediments and carbonate deposition induced by excess alkalinity in the ocean due to continental silicate weathering represent the geological sinks of atmospheric carbon dioxide (CO_2) while its sources have to be the degassing of solid Earth. Superimposed on this carbon cycle at million year timescale, the exchange of carbon between the deep ocean and the surface ocean and/or between the biosphere and the geosphere are responsible for glacial interglacial variations in the atmospheric CO_2 level.

Understanding the long-term feedback mechanisms requires the quantification of the fluxes of alkalinity and POC. Here, we use example from Taiwan to demonstrate that these fluxes are strongly impacted by the landfall of typhoons. However the response of enhanced precipitation is rather different when POC or products of the silicate weathering are concerned. For instance, a consequence of Typhoon Morakot in August 2009 was the production of vast volumes of driftwood. Combining remote sensing, analysis of forest biomass, and field observations, returned a flux of 3.8-8.4 Tg of coarse woody debris to the oceans, carrying 50-111 tC km^{-2}. Previous estimate of POC flux during typhoon-triggered floods yielded 13 tC km^{-2} and detailed investigation showed that the concentration of POC from vegetation and soils is positively correlated with water discharge. On decadal timescales, 77–92% of eroded non-fossil particulate organic carbon is transported during large, cyclone-induced, floods with a corresponding yield of 16 to 202 tC km-$2yr^{-1}$. Flood associated to Typhoon Morakot have a recurrence time of more than 200 years but fits within this estimate.

On the other hand, the cyclonic precipitations have less of an impact on the decadal dissolved fluxes. In the steep and well-drained catchment of the Liwu river, the river chemistry at low- to medium-flow reveals a mixing between a deep groundwater

component and a rapid surface runoff characterized by the chemistry of first-order tributaries. Samples collected at high-flow, associated to the landfall of typhoons, show the contribution of a third water source not immediately mobile and therefore called slow surface runoff. The 37-yr average estimates that 21±5% of the river discharge originates from this slow surface runoff. The slow surface runoff is the least characterized of the end-members but the modeled evolution of water chemistry along its flow paths suggests that the atmospheric CO_2 consumption rate associated to this end-member could be around a quarter of the decadal rate for this catchment. This suggests that tropical cyclones, which affect many forested mountains within the Inter-tropical Convergence Zone (ITCZ) have a significant impact on the decadal to millennial average fluxes of alkalinity and POC. This strongly advocates for the need to sustain data collection at benchmark sites on long timescales, especially in locations at the fringe of the ITCZ, where recurrence time of these extreme events is greater than in Taiwan.

Hyperpycnal events observed in the Gaoping Submarine Canyon

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As the result of the interplay between frequent earthquake occurrence, typhoon invasion, and heavy rainfall, many rivers in Taiwan have the potential to generate hyperpycnal plume especially when the typhoon passes through the Taiwan Island and brings a large amount of rainfall. In order to capture the hyperpcnal turbidity current signal, two moorings each configured with an SCTD and ADCP, one with an additional non-sequential sediment trap, were deployed in the head region of the Gaoping Submarine Canyon three days after the typhoon-induced peak of the river discharge and suspended sediment concentration (SSC) of the Gaoping River in southern Taiwan (Figure 1). Our data show a demarcation between a tidal and hyperpycnal regimes. The latter lasted for the first 5 days for the 18-day deployment, as defined by higher water density due to high suspended sediment concentration. Several lines of evidence indicate the presence of the tail end of a hyperpycnal turbidity current (HTC), including the retention of warm water near the canyon floor, high SSC, down-canyon directed flow and its vertical structure, and high terrestrial fraction (larger than 70%) of the organic particles carried in the flow. The decreasing mass flux during the passing of the HTC is also an indication of a waning HTC. Our findings also show that the vertical flow structure and the direction of the gravity-driven down-canyon HTC were little affected by the instantaneous tidal oscillations in the canyon.

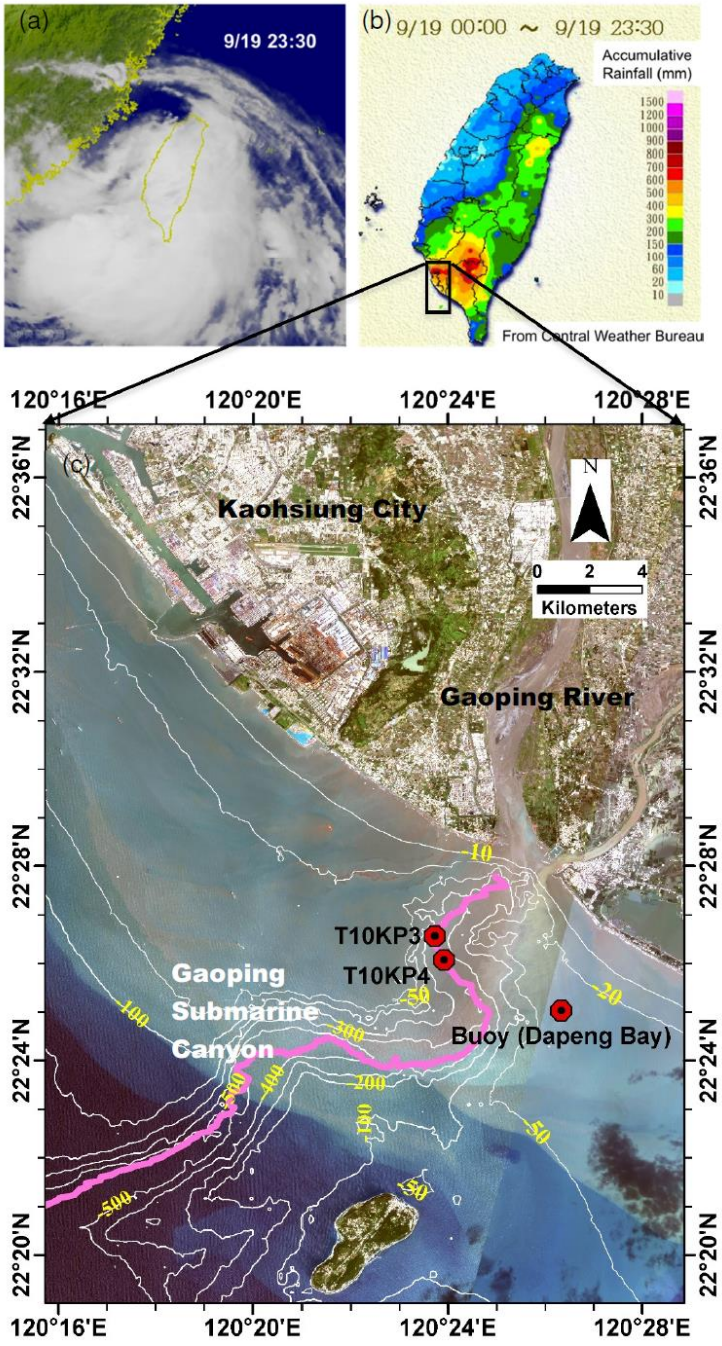

Figure 1. Typhoon Fanapi hit Taiwan on Sep. 19th. (a) The satellite image indicated the cyclonic clouds covered all over the island. (b) The heavy rainfall accumulated over 1000 mm in one day in the southwestern Taiwan. Especially, the high precipitation was concentrated mostly in the drainage basin of the Gaoping River in the southern central range. (Graphs in a and b are by courtesy of Central Weather Bureau-CWB in Taiwan) (c) This graph was taken by FORMOSAT-2 on Sep. 21st and superimposed by the Gaoping Submarine Canyon bathy contour (From Center for Space and Remote Sensing Research-CSRSR, National Central University, Taiwan). The pink line illustrated the thalweg of the submarine canyon. Two mooring's locations were pointed out by red circle in the thalweg. Another red circle was the weather buoy site maintained by CWB.

Intense storm activity during the Little Ice Age on the French Mediterranean coast

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Understanding long-term variability in the frequency of intense storm activity is important for assessing whether changes are controlled by climate evolution. Understanding this variability is also important for predicting present and future community vulnerability and economic loss. Our ability to make these assessments has been limited by the short (less than 50 years) instrument record of storm activity. Storm induced deposits preserved in the sediments of coastal lagoons offer the opportunity to study the links between climatic conditions and storm activity on longer timescales. We present a record of these extreme climatic events that have occurred in the French Mediterrannean coast over the past 1500 years. The identification of these extreme events is based on the analysis of sediment cores from Gulf of Aigues-Mortes lagoons that contain a specific sedimentary and geochemical signature associated with intense storms.

Overwash deposits do not show any evidence of intense storm landfalls in the region for several hundred years prior to the late 17th century A.D. The apparent increase in intense storms around 250 years ago occurs during the latter half of the Little Ice Age, a time of lower continental surface temperatures. Comparison of the sediment record with palaeoclimate records indicates that this variability was probably modulated by atmospheric dynamics. The apparent increase of the superstorm activity during the latter half of the Little Ice Age was probably due to the thermal gradient increase leading to enhanced lower tropospheric baroclinicity over a large Central Atlantic/European domain and leading to a modification of the occurrence of extreme wind events along the French Mediterranean coast.

Monitoring of shoreline position and beach morphodynamical changes using microwave marine radar

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Coastal zone is the intersection among atmosphere, sea and land, where the processes involved are complex and intense owing to the interactions of human activities and nature. Due to the global climate change and sea level rise, and the occurrence frequency of extreme weather events exhibits an increasing trend, and therefore enhance the coastal hazard such as coastline erosion, coastal inundation and coastal ecosystem degradation. These hazards bring direct impacts to the coastal residents. The coastal situation can be represented by the coast state indicators (CSIs) which are a reduced set of parameters that can simply, adequately and quantitatively describe the dynamic-state and evolutionary trends of a coastal system. For example, the beach volume, which is one of the CSIs, can be described by the variables of beach width, beach height, beach slope etc., and these variables can be obtained by estimating the waterline position. The detecting of the waterline position is of an important task regarding to the coastal management.

In this study, we proposed a new method to detect the waterline position using microwave radar. According to the principle of the radar backscattering mechanisms, we distinguished the area of beaches and seas according to the corresponding temporal variation of the radar backscatter strength. After the processes of radar signals through radar intensity correction, spatial geometric correction, coordinate transformation and the standard deviation of radar backscatter intensity, we can obtain the waterline position by image processing methods, i.e. the high-contrast-edge method and the filter noise process.

In order to assess the feasibility of present method, we compare the results of waterline position with CCD image method and the actual DGPS-RTK survey. After the process of lens distortion correction and orthographic projection, the waterline estimation results of the CCD orthoimages agree with the results of radar method. The comparison of waterline estimation using DGPS-RTK survey shows good consistency with our method.

Furthermore, the topographic vertical profiles of the intertidal flat are obtained by combining the waterline position and the water level information. Using the chronological record by high-contrast-edge treatment, filtering noise process, we can obtain the change of waterline position with time, and obtain the time averaged topographic vertical profile of the intertidal flat by combining with water level information. Finally we use DGPS RTK to measure the topography of intertidal flat to confirm the accuracy that the radar estimated.

In this study during the strong winter northeast monsoon and summer southwest monsoon events, we estimate the change of topography at the south intertidal flat of Yong-An fishery port, and discuss the coastal erosion under the groin effect.

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.

Coastal Hazard Mitigation: Reconstruction of Sand Dunes and Proper Setback Zoning

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In response to coastal erosion, engineering structures, such as seawalls, groins, and detached breakwaters, are usually used in Taiwan to protect the shoreline and prevent the life and property losses that result from hazardous typhoon events. However, the inadequacies of protective measures in combating strong waves and storm surges have become apparent. Even worse, the concrete structures are continuously inflicting negative effects on beach preservation. Beaches in front of the seawall, on the downdrift side of a groin or a series of detached breakwater, are disappearing soon after the completion of the structure construction, which leads to the loss of the sandy beaches' functions as natural buffers.

Other than the beach, sand dunes are also acting as natural barriers between the sea and the land. Shore-parallel foredunes can be a solution to avoid the engineering structures' negative effects on ecological and aesthetic values of the coast. Unfortunately, most of the coastal dunes in Taiwan are under degradation caused by either natural or anthropogenic pressures. A study in I-lan shows that coastal sand dunes have been eroded to form scarps or have been overwashed to reduce the height in extreme wave events. Dunes have also been removed artificially for the construction of new roads or industrial parks, or they have been reclaimed as fish or duck breeding ponds. Providing reinforcements to or reconstructing those sand dunes by artificial planting or seeding might help sand accumulation and, thus, enhance their natural functions of coastal defense. Along with proper buffer or setback zoning, which limits the developments or investments in the hazard-prone area, dune reinforcement or reconstruction will be a huge step toward environmental sustainability and will also greatly reduce the loss of people's lives and properties in the future.

Keywords: coast, hazard mitigation, dune degradation, dune reconstruction, setback zone.

Runup Dynamic and Beach Response under Extreme Energetic Conditions: Video Applications

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Runup is the time-varying vertical position of the water's edge on the foreshore of the beach. It is usually decomposed into a (quasi) steady component above the still water level (the wave set-up) and a time-varying, fluctuating, component termed as "swash". Runup is the main driver of beachface hydro- and morphodynamics (Elfrink and Baldock, 2002) and so is of great relevance when studying the sediment exchanges between the subaerial and subaqueous zones of the beach (Puleo et al., 2000; Masselink and Hughes, 1998). Runup also plays a critical role in dune erosion during storm conditions (Ruggiero et al., 2001) and structure overtopping (Van der Meer and Stam, 1992). Thus runup is key to successful coastal planning and management and a critical parameter in assessing the effect of sea-level rise on coastal inundation. As one might expect, interest is primarily focused on the estimation of extreme run-up during storm conditions, essential for accurate predictions of the impact on and damage to the coast.

Long-term recession of shorelines has been measured at worldwide locations, but the causes for such recession remain a topic of debate. Anthropogenic effects are sometimes the cause of short-term erosion (e.g. Frihy and Komar, 1993), while climate change or variations in sediment supply are potentially the main driver of long-term erosion (Zhang et al., 2004; Stive, 2004). Studies have shown that shorelines can partially recover from storm-induced erosion and that the initial recovery can be extremely fast (e.g. Birkemeier, 1979; Wang et al. 2006). On the other hand, a full recovery from major storms can extend up to years especially if erosion of the dunes backing the beach has occurred (e.g. Thom and Hall, 1991). In fact, the *'vulnerability'* of a beach, intended as the potential of a beach to be affected by a major storm, depends on the balance between storm frequency and recovery rates. The difficulty of collecting adequate datasets make the role of storms on long-term beach change challenging to study (e.g. Zhang et al., 2002; Anderson et al., 2010) and especially the effect of "clusters" of storms on beach response.

Here we will present results on runup dynamic and beach response derived from video images. Data were collected at two field sites situated on the Southern French Atlantic coast: Biscarrosse Beach and Truc Vert Beach. Biscarrosse Beach has been equipped with a video system in 2007. The main focus of this system is to collect a long term data set with a high temporal resolution to allow further insight into beach responses to storm events and evaluating the impact on seasonal and long term (several years). Truc Vert Beach has been equipped during the ECORS field experiment (winter 2008) and allowed continuous daylight

2Hz image sampling. The data set offers a great opportunity to look at runup dynamic under energetic conditions (Hs up to 8.0m in 20m water depth).

Field measurements of turbulence properties over an algal reef

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Field observations of turbulence in a tidal current bottom boundary layer (BBL) over an algal reef under the influence of onshore spectral waves are presented. Waves and flow velocities were measured by pressure sensors and by an array of acoustic Doppler velocimetries. The observed alongshore shear stress is consistent with the quadratic drag law; the estimated drag coefficient, however, is a factor of 2 to 5 larger than the previous observations over sandy bottom sites. The observed turbulent dissipation rate (TDR) is larger than the recently reported values over sandy bottoms and is comparable to that over coral reefs. The observed TDR does not follow the BBL scaling, and exhibits an absence of local equilibrium with the shear production rate. The observed shear production, however, approximates the BBL scaling, indicating an excess of TDR. In particular, the results reveal that the onshore spectral waves enhance the momentum flux and affect the turbulence properties of the BBL. The differences between the turbulence spectra, cospectra, and ogive curves in the present shallow marine BBL and the atmosphere boundary layer are discussed.

Modelling storms and extreme events impacting sand beaches in Taiwan

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Since a decade, by a fortunate reconciliation of physical oceanography and coastal engineering, sandy littoral dynamics forced by fair weather or storm conditions have been extensively studied. The same is applicable to the generation and the propagation of typhoons, and to their consequences in terms of continental rain falls and oceanic storm surges. But in contrast, it exists a very little number of studies discussing the combination of both topics that is the **peculiar nature** of the impact of typhoons – or extreme storms – on a sandy littoral system. Nevertheless, fundamental questions arise: "*are typhoons so strong that their littoral hydro-morphodynamics differs totally from that of classical storms? Do the impact of extreme storms to the shore is controled by thresholds in meteo-marine forcings or in nearshore hydro-morphodynamics?*". In particular, we identify striking open questionings: 1) what is the instantaneous water level at the shoreline during typhoons?, 2) how extreme waves attenuate towards the beach during typhoons?, 3) what are the peculiar beach morphologic changes during typhoons?, 4) What is the upgrowth of the liquefaction in the sand beach during typhoons and what are the features of water table dynamics?

The objective of this presentation is to provide an overview of what is actually possible to tackle these questionings with numerical modelling. Obviously, simulations must be performed together with and compared to in-situ field measurements and flume/basin experimentations. Here, we definitely focus on simulations, simply suggesting experimental/ in-situ results from the on-going project KUNSHEN, a Taiwan/ France collaborative funded program focussing on littoral dynamics and extreme coastal events in Taiwan. Indeed, in the Pacific Ocean, typhoons and extreme storms strike Taiwan from late April to late November, July–September being an apex. There are 3–4 typhoons crossing Taiwan each year, and more than ten class +IV storms evolve off the numerous taiwanese sandy beaches, either within the Taiwan Strait or along the eastern coast. The occurrence of typhoons usually combines

strong winds, torrential rains and huge waves which always evoke terrible disasters to people. To the coast, typhoons have major consequences such as destructions of the sand barrier by total over-washing or massive sand/ boulder transports in the nearshore and onto the beach. Taiwan is thus a very good place to analyze the specific impact of extreme storms onto littoral systems.

The strategy to simulate extreme hydro-morphodynamics is to develop a full numerical workflow with a systematic downscaling from the region (westernmost central Pacific), through the coastal domain (a 10–50 km wide domain in less than 100 m of water depth) to the nearshore (a km wide domain in less than 10 m of water depth). At the regional and coastal scales, simulations necessarily rely on models such as Wave Watch III and Symphonie. WW3 creates and transform full wave spectra forced by academic of realistic winds. Symphonie solves primitive equations, forced by rivers, tides, air/sea fluxes, global ocean circulation at the boundaries, and provides with 3D currents and temperature/salinity gradients. Besides, the forcing of currents by waves has been implemented in Symphonie (Michaud et al., 2012) following the glm2z RANS formalism of Ardhuin et al. (2008), so that wave-induced pressure gradient, vortex force and other air/wind/wave interactions are taken into account in the computation of 3D currents. This is particularly pivotal as typhoon-driven waves (e.g H_s up to 10 m in less than 20 m of water depth, or up to 3.2 m in 4.5 m of water depth) result in huge radiation stresses which dominate the other forcings by far. At the regional and coastal scales, realistic simulations can be performed using global forcings such as ECMWF (meteo-marines) and MERCATOR (hydrodynamics) worldwide data sets, leading to the most accurate simulation of hydro-morphodynamics possible at now.

Things are somewhat much more complicated at the nearshore scale. A first strategy is to extend the wave/ circulation coupling to the surf zone with the introduction of non-adiabatic terms dedicated to nearshore such as the effect of roller and others, but keeping the same numerical models. It was done recently for a realistic case in France in the Gulf of Lion (Michaud et al., 2012; Chailan et al., 2012) and will be performed in the framework of KUNSHEN in Taiwan. However, a strong bias arises when models are used in the vicinity of the shoreline. There, the seabottom vertical changes in the nearshore (especially the sand bars) are so strong that their effect on waves and circulation is preeminent. As a consequence, the use of classical 3D hydrodynamic coupled models may be irrelevant under some conditions, especially when seabottom change quickly. Another strategy is to couple the simulation of nearshore hydrodynamics with that of the particle transport, thanks to well established transport laws. With a simple flux balance, the seabottom elevation can be recomputed at each point of the simulation grid so that morphologic changes drive hydrodynamics at each time step. This approach could be planed along Taiwan beaches in a near future.

At the same time, we prone two innovative approaches. The first one aims at modelling nearshore hydro-morphodynamics thanks to the optimization theory (Bouharguane et al,

2010; Bouharguane and Mohammadi, 2012). Basically, minimization principles are used in fluid-structure coupling to model sandy seabottom evolutions. The sandy bed is seen as a structure with low stiffness. The water motion in shallow domains is described by the Saint Venant equations. This coupling is based on the assumption that the bed adapts to the flow in order to minimize some energy quantity together with minimal sand transport. The approach is equivalent to the use of an Exner equation for the bed with a nonlocal flux expression. It offers really interesting perspective in the modelling of hydro-morphodynamics under extreme conditions.

The second approach is based on SPH (Smooth Particle Hydrodynamics). It aims at modelling both water and sediment by a single formalism based on the idea that all materials can be considered to be particles submitted to extreme forcing (Oudart et al., 2013). In Taiwan, SPH models are deployed to model the ultimate propagation of waves and extreme waves on the beach and beyond.

During the presentation, we illustrate the various on-going simulations of extreme storms in Taiwan with the strategies mentioned above. We mention some striking results and on-going discussions.

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Shoreline response to sequence of storms: complex process-based or simple behaviour-oriented modelling?

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Shoreline position along wave-dominated sandy coasts varies over a wide range of temporal and spatial scales in response to a variety of processes (Stive et al., 2002). On timescales of years down to days and even hours for single storms, changes in wave energy arriving at the coast is the dominant process impacting shoreline change with cross-shore surf and swash sediment transport processes dictating changes in shoreline position.

Over the last decades, a number of complex process-based models have been developed to simulate and further predict beach changes (e.g. De Vriend et al., 1993; Nicholson et al., 1997; Roelvink et al., 2009). Among these models, the open source process-based Xbeach model is designed to assess the natural coastal response during time-varying storm and hurricane conditions, including dune erosion, overwash and breaching. A series of full-scale laboratory test cases (Deltaflume, The Netherlands) are presented showing that the model can simulate the rapid erosion of beaches pending calibration for each test case (Castelle et al., 2013), therefore limiting the applicability of this approach to predict storm impacts. In addition, computation costs and misspecifications of the physics and boundary conditions prevent them from properly predicting shoreline evolution on large timescales (months to years). These misspecifications of the physics typically cascade up through the scales resulting in an inescapable build-up of errors and unreliable simulations.

Instead, simple empirically-based behaviour-oriented models can lead to more reliable long-term evolution than do parameterizations of much smaller-scale processes in process-based models, as evidenced in many geomorphological systems (Murray, 2007). Behaviour-oriented shoreline evolution models typically relate the rate of cross-shore shoreline displacement to the wave energy and the wave energy disequilibrium between the wave energy and the equilibrium wave energy that would cause no change to the present shoreline location (e.g. Yates et al., 2011; Splinter et al., 2013). The application of such a model to a high-energy beach (Truc Vert, SW France) is presented (Castelle et al., in revision). The model shows that Truc Vert beach responds predominantly at seasonal timescales rather than at individual storm frequency. The first winter storms drive the most pronounced erosion events because both the wave energy disequilibrium and erosion change potential are large. Results reveal that erosion rate driven by a given storm is determined, non-surprisingly, by the storm characteristics, but more importantly by the recent (days to months) history of both the wave field and the beach morphology. This type

of simple behaviour-oriented models also appears suitable to predict shoreline evolution on beaches responding predominantly at individual storm frequency rather than at seasonal timescales, such as the East Coast of Taiwan exposed to Typhoons. Yet, these models have not been applied to such an environment so far.

Paleoclimates and geohazards recorded in sediments in the frontal Manila accretionary wedge near Taiwan

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The incipient arc-continent collision zone offshore SW Taiwan is prone for earthquakes and submarine landslides. The seismic activity of this accretionary wedge is commonly recorded by mass transport deposits (MTDs) and seismo-turbidites. The river-connected Kaoping canyon in the accretionary wedge is the major sediment conduit that delivers Taiwan-derived sediments during floods into the Manila Trench through hyperpycnal turbidity currents. The Kaoping-canyon head lies directly off the Kaoping-river mouth during fluctuating eustatic cycles. Sediments along the Kaoping canyon are therefore likely to record how onshore sediments are delivered to the deep sea through hyperpycnal flows during a full eustatic sea-level change, therefore, revealing paleoclimates through the recurrence intervals and strength of hyperpycnal-flow events. An episode of exceptional hyperpycnal turbidity currents was vividly evidenced by a series of submarine cable breaks along the Kaoping Canyon and the Manila Trench during the 2009 Morakot Typhoon.

This study documents the preliminary findings for MTDs that may associate with the earthquake slip along the splay faults, the paleoclimates revealed from a sediment core of ~20,000 yrs old recovered from the bank of the Kaoping Canyon, and the origins and sediment characteristics for hyperpycnal flows occurred during the 2009 Morakot Typhoon.

Keywords: Paleoclimates, geohazards, seismo-turbidites, hyperycnal flows, mass-transport deposits, accretionary wedge.

Sedimentary records of paleo-extreme events in marine cores offshore East Taiwan

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Taiwan gathers many conditions favoring extreme events. Uplift rates close or over a cm/yr together with tropical and sub-tropical climate favor strong erosion of the young mountain belt. Landslides are common and their occurrence is amplified by the high level of seismicity. East of Taiwan, the collision between the northern tip of the Luzon volcanic arc and the crustal wedge of the chinese continental platform is paroxysmal. There, changes in both onshore and offshore morphologies are extremely rapid. Huge amount of sediment supplied by rivers feed the submarine slopes and marine basins, active faults offset structural domains, submarine landslides and turbidity currents occur, and canyons incise within the steep slopes. Time series of climatic and seismic events are known for the last century but what about the last thousand years? Can we extrapolate our recent observations to the period older than 1900 and can we seriously estimate seismic, tsunami and climatic hazards?

To tackle this fundamental questioning, we have decided to investigate the sedimentological record of extreme events trapped in perched basins offshore East Taiwan. In this study, we aim to better constrain the occurrence of paleo-extreme events over the last ~4000 years. Eleven cores 0.4 to 4 meters long were collected during two cruises onboard R/V Ocean Researcher 1 in 2012 and 2013. Coring sites were selected for their various sediment sources: river-supplied turbidites (associated to major climatic events such as typhoons and floods), earthquake-triggered marine slope unstabilities and background hemipelagic sedimentation (reference core). Some complexity may appear since earthquakes may sometimes be triggered by typhoons, earthquakes can trigger landslides or tsunamis, submarine landslides can also trigger tsunamis or heavy rains on slumped material may produce floods.

Preliminary results from cores analyses are discussed. We primarily focused on the sites, which minimize the terrigenous component from rivers mouths. We studied the reference core collected on a bathymetric high of the submarine slope, 25 km off the coast, separated from the coastal slope by a trough so that we "theoretically" exclude any possibility of turbidite deposit on that site and expect to record mainly the hemipelagic sedimentation. Average sedimentation rates over the first 4 meters is estimated around 1±0.5 mm/yr and increases to about 2±0.5 mm/yr near the seafloor. We count about 30 turbiditic events that

could likely be triggered by paleo-earthquakes. The most recent one being dated around 1999 ± 1 yrs AD using $^{210}Pb_{ex}$ (Chi-Chi earthquake ?) and the oldest one around 3460 ± 30 yrs BP estimated from ^{14}C dating on planktonic forams which should correspond to 1100 ± 150 yrs BC taking into account reservoir age corrections. Detailed analyses on cores including granulometry, mineralogy, magnetic suceptibility, and major elements (XRF) are still under process.

This study done at the scale of the whole East coast of Taiwan leads us to test the capacity of investigating sedimentary records of paleo-extreme events in a marine environment characterized by recurrent earthquakes and landslides, huge erosional products from the nearshore washed after typhoons and strong oceanic surface currents such as the Kuroshio current. Our first results show that the modern ^{14}C reservoir age (R(t)) is larger, by up to 241 yrs, than the global mean surface reservoir age. This high value is probably due to local upwellings. We intend to model sea circulation offshore the east coast of Taiwan accounting for the rough bathymetry, the Kuroshio current and forcings from the wind in order to better constrain sedimentological processes offshore Taiwan.

Is Morakot Unique? An Observation from the deep sea

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Since 2006, SW Taiwan was experienced a series of natural hazards including earthquakes and typhoon that induced severe land slides and flooding. Not only on land, these natural hazards also touched off submarine cable-break incidents off southwestern Taiwan from Gaoping Slope to the northern terminus of the Manila Trench and these high destructive submarine gravity flows aroused our curiosity on how frequently such severe and devasting natural hazards will visit Taiwan? The deep sea records give us a clue. In the cruise of OR5-1302-2, two piston cores which were taken from the Maiden Ridge (MT7) and Penghu Canyon (MT6) provide a good opportunity to study the transport of submarine hazard related sediments, their frequency and whether these extreme events may enhance the potential for organic carbon burial. TOC and $\delta^{13}C$ data in conjunction with ^{210}Pb profiles indicate the thickness of Pingtung Earthquake and Morakot Typhoon related deposits exceed the total amount of sediments over the past 100 years. Our results reveal such kind of extreme events not only fast transported sediments to the deep sea but also delivered large amounts of organic carbon into abyss and it may plays an important role on the global carbon cycling system.

Turbidite deposits as long-term deep-marine record of extreme events

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Most of sediment transfer from land to deep-sea basins generally occurs during extreme climatic or geological events (floods, storms, earthquakes...) as brief and recurrent episodes. Onland and along the coast, apart in limited confined environments (lagoons, lakes, closed bays), the sedimentary processes are dominated by erosion and transport, preventing long-term sedimentary record of extreme events (thousands of years).

In marine environments, turbidity currents are one of the major processes of sediment transfer, that are in most cases directly triggered by extreme events affecting coastal areas. Three major origins are distinguished: 1) the continuity at sea of hyper-concentrated stream flows generating hyperpycnal flows into canyons (flood-induced turbidity currents), 2) mass wasting at various water depths (earthquake, sediment overload...) and 3) re-suspension of sediment deposits under the influence of oceanographic factors (storm waves, currents). Turbidites deposits represent a record of the gravity events, but to date, discriminating the trigger (earthquake, torrential floods...) based on sedimentological characters is hotly debated.

The location of depositional areas is highly controlled by the slope morphology (turbidite systems, channelization…), but also by the source areas of turbidites and the type of extreme event. Indeed, earthquakes can promote multiple and synchronous slope failures (coastal and submarine) over large segments of submarine slope (up to several hundreds of kms), whereas typhoons or torrential floods induce hyperpycnal flows (continental source) focused into submarine canyon networks. The understanding of the morpho-sedimentary setting, combined with turbidite characteristics (thickness, grain-size, composition…), give insights into the processes, the source and the potential triggering factors. This preliminary approach is necessary to target locations of sediment cores, which could collect separately the events generated by different trigger.

By collecting sediment cores where turbidite deposits are thin and fine-grained, it is possible (1) to identify elementary gravity events, (2) to establish a stratigraphic framework from continuous background hemipelagic deposits and thus (3) to obtain chronologies of events recorded in the cores. This approach requires an accurate sedimentological analysis (facies description, X-Ray data analysis, grainsize measurements, XRF data analysis), and the establishment of age models along the hemipelagic sedimentation using radiocarbon dates.

This strategy revealed fruitful in contexts where tectonic forcing prevails. Based on turbidite stratigraphy and correlation with land evidences when possible, the emerging

submarine paleoseismology discipline reconstructed ~10kyr time-series of large earthquakes in convergent zones (Cascadia, New-Zealand, Algeria…), thus allowing to better assess the seismic hazard. In contexts driven by climatic forcing, where hyperpycnal flows are generated, although individual historical events are retrieved, the establisment of time-series is more tricky, because of the higher frequency of the climatic events (floods, cyclones, typhoons), exceeding the time resolution of the sedimentary record.

The Eastern Taiwan margin which is under the influence of both climatic and tectonic events, exhibits among the greatest sedimentary rates worldwide, thus enhancing the temporal resolution, and has a strong historical record of seismicity and major typhoons allowing robust correlations. It therefore represents a great natural laboratory to investigate between the different triggers in the turbidite record, and subsequently assess kyr-long time series of climatic and seismic events.

Possible extreme geological events recorded in the lower reach of the Kaoping submarine canyon

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Submarine landslides or slumps may generate turbidity currents consisting of mixture of sediment and water. In terms of turbidities, those transported sediments can memorize the historical events. The sedimentary events can be triggered by earthquakes, typhoons or other artificial activities. In 2006, the Pingtung earthquakes had triggered at least 5 submarine landslides. Those submarine landslides had induced turbidity currents and broke telecommunication cables along the channel of the Kaoping (Gaoping) canyon. After the transportation of several hundred kilometers, the sediments finally deposited in the lower reach of the channel. Similar event was happened during the 2009 Typhoon Morako. Several telecommunication cables were also broken along the channel of the Kaoping canyon. These sedimentary records due to the extreme events can be used to decrypt the historical events due to the natural hazards. In the cases of the 2006 Pingtung earthquake and the 2009 Morako typhoon, the lower reach of the Kaoping Canyon could be an ideal location to decipher the frequency and type of the natural hazards. Similar scientific work can be also considered in the middle to lower reach of the Taitung canyon.

Interbeded fluid activities induced slope failure in the Kaoping Slope area

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In the past decade, numerous multi-channel seismic surveys as well as near seafloor high resolution geophysical investigations were conducted in order to explore and estimate the reserves of the gas hydrate southwestern offshore Taiwan. The previous survey object is focused on searching substitute energy rather than geo-hazards. However, it is suggested that most of the gas hydrate is generally distributed at slope area southwestern offshore Taiwan, which indicates the slope may be failed when steady state was changed such as sea level change or climate change. The slope failure may be furthered induced trunami which often damage the constructions and economics. Thus, it is of great urgency to investigate potential landslide area in particular abundant gas hydrate continental slope in adjacent to populous city like Kaohsiung. In this study, we collected several high resolution multi-channel seismic data with ten second shooting rate and 3.125 meters group interval streamer by using *R/V* ORI and *R/V* ORV. The seismic data was processed by conventional data processing strategy: geometry settings, band-pass filter, de-convolution, surface-related multiple rejection, water velocity stacking and migration. Two major results could be raised as followed: (1) Most of the surface stratigraphy creeping and landslide was occurred lower than 800 meters water depth, which corresponds to gas hydrate dissociation; (2) Some landslides were triggered by mud diaper uplifted, which is evidenced by pockmarks on the seafloor.

The AMS ^{14}C dating facility at NTU and its capability

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The NTUAMS Lab has been established since September 2012, equipped with a HVE 1.0MV Tandetron Model 4110 BO-Accelerator Mass Spectrometer (AMS) and two graphitization systems. In January of 2013, the AMS was passed its final acceptance tests for ^{14}C, ^{10}Be and ^{26}Al. The AMS background values for $^{14}C/^{12}C$, $^{10}Be/^{9}Be$ and $^{26}Al/^{27}Al$ are 2.75×10^{-15}, 1.70×10^{-14} and 3.92×10^{-14}, respectively. We have processed the principal modern radiocarbon standards including Oxalic Acid I (HOx1), Oxalic Acid II (HOx2) and ANU (Australian National University) sucrose, yielding averages of 8.854E-13±6.889E-14(n=17), 1.138E-12±1.675E-13(n=10) and 1.393E-12±1.493E-13(n=6), respectively, under $^{14}C^{3+}$ mode measurement. The HOx2/HOx1 and ANU/HOx1 ratios are all close to the reported values, indicating the AMS facility sets up correctly for ^{14}C dating. A carbonate background (NTUB) which is from the upper Devonian Limestone in Guilin of China and a fossil wood (CWOC) that is from the middle Pleistocene fluvial deposit in central coast of Taiwan were measured, showing that both backgrounds have the $^{14}C/^{12}C$ ratios of ~3.5E-15 which is close to the AMS machine background. The results demonstrate that the NTUAMS Lab is ready to serve ^{14}C dating. Currently, the lab is able to date organic matters and carbonates with ages within 50,000 years old. The minimum sample size is about 0.3mg of C, but general size is 1mg of C. Up-to-date, we have carried out ^{14}C dating on charcoals from an archeological site in Taiwan; on marine sediments vs. organic components from Baltic Sea; on plant remains, shells and bulk TOC in sediment cores from several lakes; on a stalagmite from South Taiwan; on peat samples from a wetland in Guilin, China; and on bulk TOC from sediment cores in Guan-Du near Taipei. We also plan to build up ^{10}Be and ^{26}Al analytical system in the future.

A global relation between surface uplift and erosion caused by large, compressional earthquakes

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Large earthquakes deform Earth's surface and drive topographic growth in the frontal zones of mountain belts. They also induce widespread mass wasting, reducing relief. Previous work has found strong contrasts in the relative importance of erosion by landsliding in the mass balance of two well-studied earthquakes. To determine the main controls on the trade-off between surface uplift and erosion caused by seismicity, we have estimated the net topographic effect of 12 earthquakes with a compressional component, ranging from Mw 5.9 to Mw 8.6. This was done by comparing the volume of seismically induced landslides, determined by comprehensive landslide mapping, with the volume change due to co-seismic surface uplift computed with Okada's deformation theory. Combining our new data with older, updated information, we have determined a global, empirical relationship between triggered landslide volume and earthquake moment, accounting for seismic wave attenuation and landscape sensitivity. Comparing this relationship with theoretical coseismic uplift, we show that there is a critical magnitude above which thrust earthquakes have a negative mass balance, with net destruction of topography. This critical magnitude is controlled primarilly by seismic wave attenuation and landscape sensitivity, rather than by earthquake mechanism, and can be as low as Mw~6.

Fluvial incision and knickpoint retreat across a co-seismic popup zone of the 1999 Chi-Chi earthquake, Da-An River gorge, Taiwan

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The lower Da-An River in western Taiwan was uplifted ~10 m during the 1999 Mw 7.6 Chi-Chi earthquake, that was subsequently resulting in a 20- to 30-m-deep bedrock gorge during less than 10 years. However, the amount of coseismic displacement along the channel bed does not fully explain the resulting bedrock channel incision. Using a series of aerial photographs, high-resolution digital elevation models (DEM), and real-time kinematic global positioning system (RTK GPS) surveys, we characterized knickpoint retreat and fluvial incision in the Da-An River gorge. We also analyzed discharge and precipitation data and collected measurements of rock strength and joint plane orientations to better understand the climatic, lithological, and structural influence on the evolution of the actively incising gorge. Two stages of fluvial incision and knickpoint migration are identified in the gorge following the surface uplift during the Chi-Chi earthquake. From 1999 to 2004, 3 to 5 m of alluvium was removed from the channel bed, followed by 3 to 4 m of bedrock channel incision. The knickpoint generated immediately after the earthquake remained where the uplift occurred at this time. Since 2005, the channel bed has lowered rapidly with local incision rates as high as 15 m/yr. The average upstream knickpoint migration rate over the period 2005 to 2009 was 238 m/yr; total upstream migration from the location of knickpoint formation was 1190 m. While tectonic uplift formed the knickpoint and set the stage for channel incision, climate played a critical role in accelerating the fluvial response to coseismic displacement. More than 20 m of vertical bedrock channel incision and 1180 m of upstream knickpoint migration occurred primarily during the post-2005 typhoon seasons (May-October). Based on repeat surveys of the Da-An River longitudinal profile and analysis of precipitation and discharge data, we suggest that a discharge threshold of 1200 to 2600 m^3/s is required to initiate upstream knickpoint migration. However, once the threshold is exceeded, bedding dip becomes the primary control on rates and patterns of knickpoint propagation. In a hinge zone where the bedding dips change from horizontal to upstream-dipping, replacement was observed in the strata dipping upstream. The highest knickpoint migration rates (> 300 m/yr) were recorded in flat-lying, horizontal strata (dip < 10º) where parallel retreat was the dominant process. Overall, the knickpoint propagation followed the process of replacement behavior, in which the height of knickpoint decreases

while migrating upstream. Thus, while tectonic processes set the initial conditions for knickpoint propagation in the Da-An River, the response time of the fluvial system to this forcing is strongly dependent on climate and local geology, including lithology and structure.

Keywords: Bedrock incision, Da-An River, Knickpoint migration, Chi-Chi earthquake

Analysis and modelling of tsunami-induced tilt for the 2007, *M*= 7.6, Tocopilla and the 2010, *M*= 8.8 Maule earthquakes, Chile, from long-base tiltmeter and broadband seismometer records

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We present a detailed study of tsunami-induced tilt at in-land sites, to test the interest and feasibility of such analysis for tsunami detection and modelling. We studied tiltmeter and broadband seismometer records of northern Chile, detecting a clear signature of the tsunamis generated by the 2007 Tocopilla (*M* = 7.6) and the 2010 Maule (*M* = 8.8) earthquakes. We find that these records are dominated by the tilt due to the elastic loading of the oceanic floor, with a small effect of the horizontal gravitational attraction. We modelled the Maule tsunami using the seismic source model proposed by Delouis *et al.* and a bathymetric map, correctly fitting three tide gauge records of the area (Antofagasta, Iquique and Arica). At all the closest stations (7 STS2, 2 long-base tiltmeters), we correctly modelled the first few hours of the tilt signal for the Maule tsunami. The only phase mismatch is for the site that is closer to the ocean.We find a tilt response of 0.005–0.01 µm at 7 km away from the coastline in response to a sea level amplitude change of 10 cm. For theMaule earthquake, we observe a clear tilt signal starting 20min before the arrival time of the tsunami at the nearest point on the coastline. This capability of tilt or seismic sensors to detect distant tsunamis before they arrive has been successfully tested with a scenario megathrust in the southern Peru-northern Chile seismic gap. However, for large events near the stations, this analysis may no longer be feasible, due to the large amplitude of the long-period seismic signals expected to obscure the loading signal. Inland tilt measurements of tsunamis smooth out short, often unmodelled wavelengths of the sea level perturbation, thus providing robust, large-scale images of the tsunami. Furthermore, tilt measurements are not expected to saturate even for the largest run-ups, nor to suffer from near-coast tsunami damages. Tiltmeters and broadband seismometers are thus valuable instruments for monitoring tsunamis in complement with tide gauge arrays.

Late Quaternary mass-wasting records in the actively uplifting Pa-chang catchment, southwestern Taiwan

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Although dominated by erosion over long term, the active mountains of Taiwan commonly contain thick landslide/debris-flow gravels capping hillslopes or forming alluvial terraces. These deposits, and their associated landforms, serve to study ancient mass-wasting histories and their controls on fluvial processes. This study focuses on the Pa-chang River draining the <2000 m high Ali-shan area in southwestern Taiwan (current tectonic uplift: 5–8 mm/yr by leveling surveys). Although small (catchment area: 83 km2), the Pa-chang exhibits one of the largest alluvial terraces in Taiwan (labeled CK), which stretches from the outlet of the catchment for 9 km along the river and comprises fluvial/debris-flow gravels up to 150 m thick. Totally 55 radiocarbon dates have been obtained, tracing the mass-wasting records back to 14.8 ka. The largest events, which created the CK and other alluvial terraces in the catchment, occurred in 10.0–11.3 ka and 8.7–9.4 ka. These events are synchronous with the formation of some regionally largest alluvial terraces in Taiwan, and may have been triggered by the frequent heavy rains associated with the maximum of the early Holocene East Asian summer monsoon. More mass-wasting events are dated at ~5.4 ka, ~1.9 ka, 1.2–1.7 ka, 0.7–0.9 ka, 0.5–0.6 ka, and ~0.2 ka. The vast supply of sediment from the recorded mass-wasting events not only caused aggradation of the river but also regulated the subsequent incision by forming boulder armors. This is shown by the negligible bedrock incision in the upper part of the catchment since the extensive early Holocene debris-flow deposition. The obtained incision rate increases to the downstream direction as the size/concentration of boulders reduce. Still, the 15 ka-averaged bedrock incision rate (<4.5 mm/yr) at the catchment outlet is lower than the uplift rate. In the same area, the bedrock incision rate in the past 0.5 ka is averaged ~25 mm/yr. Even higher rates of incision (>100 mm/yr) were detected further downstream after the recent gravel mining. The fact that the obtained bedrock incision rates/patterns are decoupled with the tectonic uplift advises caution in using short-term erosion data to interpret the long-term tectonics of the Taiwan's mountains.

Cosmogenic nuclides and surface processes in Taiwan

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Orogenic settings are particularly well suited to study and quantify the coupling relations between tectonics, topography, climate and erosion since they record tectonic evolution along convergent margins and the connection between deep and surface processes. However, the interaction of deep and shallow processes is still poorly understood and the role they play in the exhumation of rocks, the structural and kinematic evolution of orogenic wedges, and the relation between tectonics and climate-dependent surface processes are still debated. Therefore, quantification of denudation rates in a wide range of climatic and tectonic settings, as well as at various time and space scales, is a critical step in calibrating and validating landscape evolution models. Since 25 years, cosmogenic nuclides, which are produced within the Earth's environment through nuclear reactions involving secondary cosmic ray particles and nuclei of target minerals in rocks and soils, have literally revolutionized the way geologists can now quantify rates of surface processes. These last ten years, French and Taiwan teams collaborated to address an important aspect of the Taiwanese orogenic wedge dynamics: the topographic evolution of the wedge and the relationship between the development of the relief by internal processes and the rates of surface lowering due to erosion. In this presentation, I will briefly expose the basic aspects of cosmogenic nuclides applied to quantification of denudation rates. Then, I will focus on our investigation of the pattern and magnitude of denudation rates at the scale of the orogenic system, deriving denudation rates from in situ-produced cosmogenic nuclide ^{10}Be concentrations measured in (1) river-borne quartz minerals sampled at major watersheds outlets, and (2) bedrock outcrops along ridge crests and at summits located along the major drainage divide of the belt. Altogether, the cosmogenic-derived denudation pattern at the orogen-scale reflects fundamental mountain building processes from frontal accretion in the Western Foothills to basal accretion and fast exhumation in the Central Range. Applied to the whole orogen, such field-based approach thus provides important input data to validate and calibrate the parameters to be supplied to landscape evolution models.

Reconstruction of flow condition of large-scale mass transport deposits from internal stress fields

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Flow condition of large-scale mass transport deposits was reconstructed from both stress field analysis of the outcrop and numerical experiments of debris-flows. Deposits of gravelly mudstone containing large deformed sedimentary blocks occur in the Upper Cretaceous to Paleocene Akkeshi Formation distributed in the Hokkaido Island, northern Japan. Application of the multiple inverse method to meso-scale faults observed in the blocks reveals possible internal paleostress fields that existed prior to deposition. This analysis suggested two different stress fields: (1) a uni-axial compressional stress field, where the maximum principal compression axis is normal to the bedding surface, and (2) a tri-axial compressional stress field, where the orientation of maximum principal compression axis is parallel to the paleocurrent direction. In addition, the analysis suggested existence of the excess pore-pressure inside the debris flow that could explain the remarkable deformation of internal blocks of the debris-flow deposit.

Numerical experiments on subaqueous mass transport processes were conducted to understand the internal stress field associate with a natural example of a submarine debris flow, which was revealed by detailed analysis of a deposit exposed as a nearly1.6 km continuous outcrop. The results of numerical experiments imply that the first of these stress fields is generated by radial spreading of the flow during its downcurrent movement, while the second stress field results from compression during deposition on the basin plain. A horizontal compression paleo-stress field can be an indicator of the paleocurrent direction of the debris-flow. In addition, it is also suggested that existence of a horizontal compression paleo-stress field can provide a clue for the initial conditions of the submarine landslide.

Landscape relaxation after the 2008 Sichuan earthquake: insights from cosmogenic nuclides

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The discovery of the existence of complex interactions between surface denudation and tectonics in active mountain ranges has been a major paradigm shift for orogenic processes research, with major implications at different space- and time-scales. Quantifying denudation rates acting on mountainous topography has become an important research objective, and recent studies show that the denudation budget can be dominated by intense and rare events rather than by a progressive and steady evolution. Interactions between tectonic and denudation processes over short time-scales have also been under close scrutiny recently due to the detailed documentation of co-seismic landsliding after major earthquakes such as Chi-Chi (1999) or Wenchuan (2008). The latter is a very good example of such intense co-seismic shaking with a pronounced geomorphic imprint.

This M_w 7.9 earthquake ruptured a nearly 300 km long fault zone along the Eastern edge of the Tibetan plateau, resulting in more than 70 000 deaths. Massive and widespread deep-seated landsliding were a salient characteristic of this event, causing numerous fatalities, destruction of infrastructure and hazardous transient damming of rivers. Based on high resolution maps of co-seismic uplift from InSAR and estimates of total landslide volume from remote sensing, some studies suggest that the erosive impact of the earthquake might have been greater than the topographic buildup. These observations raised fundamental questions about the actual role of such large shaking as constructive or destructive mountain building processes.

In order to assess the geomorphic importance of this earthquake we have started to monitor the evolution of ^{10}Be concentration in rivers draining the Longmen Shan range, which is the area that was affected by the most intense co-seismic shaking. Our aim is to obtain quantitative information about the response of denudation processes following a major co-seismic event and associated landsliding, and we take advantage of the existence of pre-earthquake ^{10}Be concentration measurements for a limited number of basins along the Longmen Shan range, which provide a base level for the signal before the disturbance.

A comparison of the concentrations before and after the earthquake shows a significant dilution associated with sediments provided by the landslides. From the limited number of basins available we do not observe any significant correlation between the magnitude of this dilution and the geomorphic properties of the basins or the experienced intensity of the co-seismic shaking. The available time-series show that the ^{10}Be concentrations are

increasing quickly over the years following the earthquake and the extrapolation of the trends suggest that a pre-2008 level could be reached in the next 5 to 10 years. Such short relaxation time-scale is comparable to what was observed for other events such as the sediment flux response following Chi-Chi earthquake. Our on-going sampling will allow to refine the understanding of this post-seimic response and in particular the influence of the Summer 2013 exceptional monsoon event.

Problems on the paleoearthquake reconstruction based on geological evidences
--View from active fault and paleotsunami studies--

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It is essential to evaluate geomorphological and geological data for the reconstruction of paleoearthquake, and for the estimation of the future seismicities. In this presentation, I will talk about the problems on 1) active fault study and 2) paleotsunami study, based on my recent works. Firstly, I wish to discuss the problems of recognition of active fault, evaluation of fault length, comparison of fault activities between the short term and long term, taking the Chaochou fault and Kaouping River fault, Touhuanping fault as examples. 2) Then, some review on the study of paleotsunami deposits. This is a new field in Taiwan, just has started several years ago. Two ways for the identification of paleotsunami is introduced; One is an abrupt facies changes of deposits, identified from the excavation of Holocene deposits and the other is the presence of huge boulders on the coastal zone. I wish to introduce the works on Chengong marine terrace excavation and observation of coral boulders from Lanyu Island and others, with special reference to the distinction of tsunami deposits and storm deposits or other environmental changes.

Impact of the East Asian monsoon rainfall changes on the erosion of Asian river and sediments transfer to the South China Sea

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I will present an overview of results obtained in the deep-sea sediments of the South China Sea (SCS) in order to show: what is the main sedimentary sources of the clay minerals to the SCS? ; What is the main factors that control the clay distributions in the SCS? 3/ What information can give to us variation trough time of the clay minerals in deep-sea cores collected close to Asian river mouths?

Clay mineralogy in surface sediments collected from both the SCS and its surrounding major fluvial drainage basins have been conducted to reveal sources of fine-grained detrital sediments (clay fraction) and their transportation in the SCS. The mineralogical composition of the clay fraction combined with illite crystallinity and chemistry index in the surrounding fluvial drainage basins permits to determine the main sources of clay minerals in the SCS. In the northern part of the SCS, clay minerals are highly mixed by both surface and bottom currents.

A coupled approach based on clay mineral assemblages and isotopic data (Rb, Sr, Nd) of the Ocean Drilling Program (ODP) Site 1145 and sites 1146 has been utilized in order to trace the sources of the sediment feeding the northern part of the South China Sea (SCS), and to investigate the evolution of the East Asian monsoon intensity over the last 450 kyr. $^{87}Sr/^{86}Sr$ and Nd isotopic data, combined with the smectite/(illite+chlorite) ratio, indicate that the Pearl River is the main contributor for detrital material to the northwestern margin of the SCS, with variable continental input of volcanic material derived from the erosion of the Luzon Arc. These inputs follow the low-latitude solar insolation with a 23 kyr periodicity, as recorded by a periodic change of the clay mineralogy. This imply a narrow control of the smectite/(illite+chlorite) by the South-East Asian summer monsoon intensity.

At shorter time scale, paleohydrological changes in the southern South China Sea (SCS) combined with clay mineralogy have been also investigated along core MD01-2393 recovered off the Mekong River mouth in order to assess the impact of sea level and East Asian monsoon rainfall intensity on erosion and weathering during the last 25 000 yr. SSTs and ^{18}O values determined on *Globigerinoides ruber* were used to estimate past changes of local seawater oxygen isotope ($^{18}O_w$). The close position of the studied core to the Mekong River mouth at sea level lowstand likely played a role in the $^{18}O_w$ fluctuations resulting from changes of the monsoon rainfall and runoff into the Mekong River basin. The smectite/(illite+chlorite) and kaolinite/(illite+chlorite) ratios combined with the illite chemistry index during the Holocene show higher chemical weathering of detrital material

originating mainly from the lower reach of the Mekong River. At shorter time scales, periods of strong monsoon rainfall are associated with an intensification of erosion of the Mekong River lowland favoured by the development of incised-valley systems inducing higher inputs of detrital material from the lower relative to the upper reach of the Mekong River. Our findings suggest a rapid response of erosion processes of the Mekong River basin to the monsoon rainfall intensity changes.

Preliminary results of marine core analyses off Southwestern Taiwan: R/V Ocean Researcher 5 Cruises

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The establishment of Taiwan Ocean Research Institute (TORI) had been officially approved by the National Science Council since 2008. For better facility and service on marine sedimentary cores for Taiwanese oceanographic community, TORI began the development of a national Marine Core Repository and Laboratory. Long coring (>10 m) has been technically difficult since about mid-1980s on Taiwanese R/Vs. Yet the need for high quality long cores did not diminish. By participating IMAGES (International Marine Past Global Change Study) program, Taiwanese scientists have used successfully the great capabilities of long coring system such as that on French R/V Marion Dufresne in the last decade by collecting very long cores (>40 m) in many important locations. Today archives several thousand meters of high quality marine sedimentary cores are retrieved from the seas around Taiwan and the western Pacific. In 2013 a new 2700 ton R/V OR 5 of TORI, designed to accommodate new core handling system with significant strengthening of the deck, begins operation. The capacity to recover giant sediment cores is essential to reconstructions of climate/ocean change. Therefore, we are designing a long coring system (~20m) that expects to be installed on the OR 5 and served to science community by June 2013. Here we introduce coring system at R/V OR 5 and report a newly preliminary result of marine sedimentary cores around the southwest Taiwan.

Reconstructing paleo-monsoon changes and variability from marine sediment records: State-of-the-art and perspectives

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Many marine records deal with past changes of monsoon wind intensity based on the study of eolian material and/or changes in the development of seasonal upwelling systems. Far less marine records are available for the study of past changes in the intensity of monsoonal precipitations and changes in river runoffs. Over the last 10 years, we have seen the rapid development of Mg/Ca-thermometry on planktonic foraminiferal shells as a tool to reconstruct past surface water temperatures. This technique makes it possible to derive d18Osw of seawater from the coupled analysis of d18O and Mg/Ca performed on the same foraminifer species. This potentially eliminates several biases (depth, seasonality) associated to coupling planktonic d18O measurements with temperature reconstructions obtained from statistical analyses of foramininer assemblages or based on the chemical analyses of bio-material produced by other organisms (*i.e.*, Uk-37 from coccoliths). However, recent developments in Mg/Ca-thermometry have suggested several potential biases (eg dissolution effects, salinity dependency), which may significantly alter our capacity to derive accurate d18Osw of seawater. In this presentation, I will make a rapid review of past changes in monsoon intensity that can be derived from marine sedimentary records and will address the interest of Mg/Ca-d18O coupled analyses performed on foraminifer shells, the potential drawbacks and prospective of this approach.

An Extreme Wave Event in Holocene Coral Reef, Western Luzon, Philippines

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Here we report an Extreme Wave event (EWE) that caused rapid backreef infilling about three hundred years ago or later at the west coast of Luzon, Philippines. Five cores, 17-29.1 m in length, were drilled from a Holocene coral reef at Paraoir. Results of 30 ^{230}Th-dated fossil corals collected in the cores and on the ground surface showed that the reef flat developed in two stages. The reef margin was dated to start from 10,256 ± 50 yr BP (before 1950 AD) at 23.9 m below mean sea level (MSL) and ended about 6,654 ± 29 yr BP at 3.7 m below MSL with a stratigraphic order of fossil coral ^{230}Th dates. The back-reef zone was deposited by sediments of 818-324 yr BP old without an age-depth correlation. The evidences suggest that a back-reef moat remained empty throughout the development of the reef for about 6 kyr and was filled abruptly with a 26 m-thick sequence of rubble and bioclastics sometimes after 1626 AD. Field evidence, tsunami simulations and historical records indicate such a catastrophic sedimentation was probably caused by a single severe typhoon. Our study suggested that a reef flat can be built up abruptly by an EWE.

Erosion processes and sediment transfer to the Ocean: a perspective from the Himalayan basin

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A consequence of the Himalayan orogenesis is the development of the Ganga-Brahmaputra drainage basin. At the global scale, this basin is relatively modest in term of ocean discharge or continental area representing 2.9 and 1% respectively. On the contrary, its sediment discharge is above 1 billion tons/yr, which is about 10% of the global sediment flux to the oceans. The Himalayan erosion system presents a highly contrasted erosion and transport system with (1) a very steep and relatively short mountainous part, (2) a long and very flat floodplain and deltaic zone, and (3) a major turbiditic reservoir in the Bay of Bengal. Active processes that trigger erosion and transport in these different environments are very different from glaciers in the high Himalaya to turbidity current in the oceanic basin. Central in this system is the monsoon climate, which generates a four-month long flooding season that is the key to trigger landsliding in the mountain, and to allow massive sediment transport in the river system.

The Himalayan erosion products are stored in different continental and oceanic sedimentary reservoirs that record erosion processes at different time and space scales. These archives allow to unravel the geological history of Himalayan erosion as well as for scaling the magnitude of bio-geochemical fluxes associated with this basin or understanding relations between erosion and climate. Geochemical tracers can be used in addition to traditional sedimentological observations to trace the sources of sediments, the weathering intensity, the vegetation environment, and even in some cases, extreme events frequency. Most interpretations are based on the observation of the modern system of erosion, although we still do not fully understand the response of erosion regime to climate changes such as glacial-interglacial cycles for instance. Chemical and isotopic compositions of detrital sediments are however controlled at the first order by mineralogical sorting occurring during transport. In order to take into account these effects of mineralogical/chemical differentiation, depth profile in the rivers from the Himalayan front down to the Bangladesh delta allow characterizing these effects. Mineral segregation tends to enrich surface suspended load in fine grained / clay rich particles whereas bed-sediments tend to concentrate in coarser and quartz rich particles. Sorting process exerts a first order control on chemical and isotopic compositions and is well correlated to simple granulometric parameters or to Al/Si ratio. Provenance of sediment and weathering processes from soils to floodplain exert more discrete chemical variations. It is therefore necessary to decipher both

effects in order to quantify one or the other.

Modern river sedimentological and geochemical characteristics will be compared to the different detrital records in the Siwaliks at the front of the range, in the floodplain and the delta and in the Bengal Fan.

Absence of delta facies in the Holocene sedimentological record at the mouth of the Zhuoshui River on the west coast of Taiwan

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Taiwan is located between the two colliding tectonic plates, and receives the impact from the monsoon and the typhoons. All the factors contribute to the high sediment load delivered to the sea by small mountainous rivers on this island. The disproportionally large sediment load and the rising sea level constitute an important condition for the formation of river deltas. The sediment records of a fluvial system are expected to bear records of the changing sedimentary environment. This study hopes to resolve the deltaic developmental history during the post-glacial sea level rise. Furthermore, we hope to understand the patterns of past extreme events in the archived record.

The high sediment flux at the river mouth is expected to provide suitable conditions to preserve the information of the delta formation process. The FATES-HYPERS team drilled a bore hole (JRD core) on the upper part of the modern Zhuoshui River delta. The 100-m long core was obtained and then through AMS C-14 dating from over 70 samples the age model was established, which shows that C-14 dating limit (50000 BP) is reached at about -75 m. We estimates that the core deposit time across the late Quaternary (100000 BP) to the present. The preliminary results based on foraminifera assemblages and facies analysis indicate that there was a major shift from land to sea before 7500 BP. According to the conditions of delta formation, Zhuoshui River mouth should have developed a delta from the last deglaciation with sea-level rise. However, in our preliminary study we cannot identify the typical deltaic facies in the core. Why the delta sedimentological record was missing in the Holocene? We have to answer this question through the core and the adjacent seafloor topography.

The global sea level rose after the last glacial maximum. In 12000-10000 years BP, the sea level was 60 - 40 meters lower than present. The reconstructed sedimentary environments were river channels and floodplains in the JRD core during this time. The Zhuoshui River generated delta extended westward into the paleao-Taiwan Strait. In 10000-8000 years BP, the sea-level was 40 - 20 meters lower than present. The Zhuoshui River delta gradually retreated eastward/landward due to the rise of the sea level. At 8000 years BP, the sea-level was 20 meters lower than present. The sea level inundated the delta, seawater intruded landward quickly. The tidal and wave enargy affected the location where the JRD core was taken. Subsequently the JRD core recorded a major shift from fluvial facies to shoreface facies in this period. There was unconformity below the shoreface facies, suggesting an erosional gap within the shoreface facies. Between 7500-6000 years BP, the

sea-level was the highest. The JRD core records turned to offshore transitional facies. After 6000 year BP, the core shows facies of gradually shallowing sedimentary environments until the present day.

The modern-day Zhuoshui River mouth is classified as a mixed energy with tidal dominatance, so we speculate that the past river mouth was in the same morphodynamic condition. We speculate that the paleao-Zhuoshui River Delta was affected by tides and waves when it was formed. This effect is enhanced when sea level inundated the delta around 8000 years BP, and causes the absence of deltaic facies in the sedimentological record.

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