Variations of bulk floc density and porosity of different sizes in suspended particles in related to organic carbon in the Gaoping river plume in southern Taiwan

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FATE's HYPERS — FAte of TErrestrial/Nonterrestrial Sediments in High Yield Particle-Export River-Sea Systems

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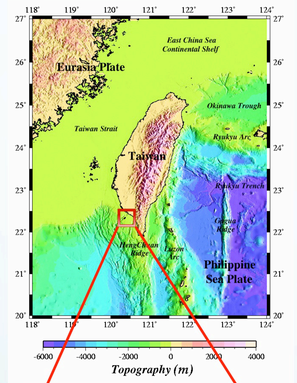
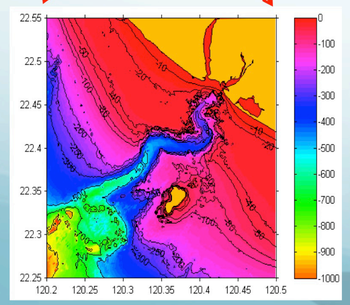
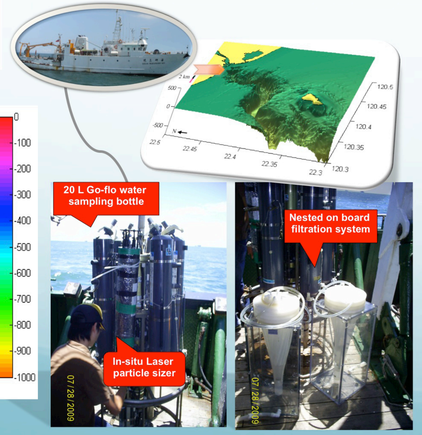
Introduction: Suspended particles are carriers of terrestrial sediment and biogeochemical matter transported from the land to the sea. Suspended particles also play an important role in the chemical and biological processes in coastal and estuarine environments (Turner and Millward, 2002). The organic matter in suspended particles influences the physical property of the particulate matter and thus affects the particle dynamics and the transport process in the estuarine and coastal environments.

Study area and method



The field experiment was conducted on May 23rd and 24th, 2008 in the head region of Gaoping Submarine Canyon (GPSC). In this investigation, hourly CTD and LISST-100 profiling and water sampling were carried out every 3-hours on board R/V Ocean Research III. This study used an an on-board filtration system of nested filters (CatNet) to filter water samples *in situ* in three mesh-sizes of 10, 63, and 153 mm. The residual which contained particles smaller than 10 μm were then collected and further filtered by 3 μm filter in the lab (Hsu and Liu, 2010). The filtered were subsequently further analyzed for mass, POC, PIC, PON, PIN, and chlorophyll-a concentrations. We use POC and PIC to illustrate their co-relations to the bulk floc density and porosity of different grain-size classes in this poster.





Hydrographic profiles

Figure 1 shows time-series structures of temperature, salinity, density, transmission, fluorescence in the head of the GPSC off the Gaoping River mouth during the measurement period. These panels showed a thin surface layer with higher temperature, lower salinity, and smaller light transmission that indicated the plume signal of the Gaoping River. Beneath the plume layer, there was cooler and saltier water swelling up from deeper layer at a semi-diurnal tidal frequency.

Figure 1

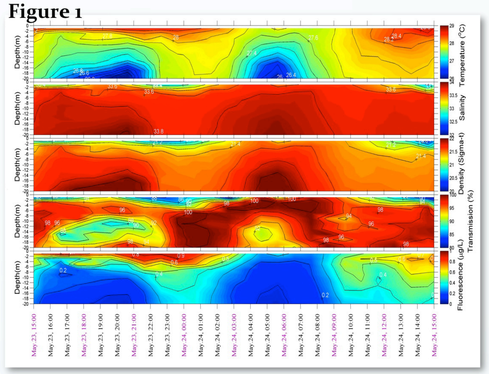
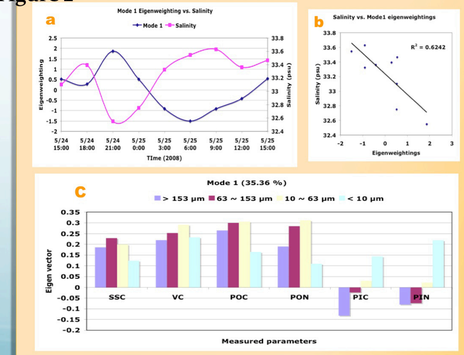
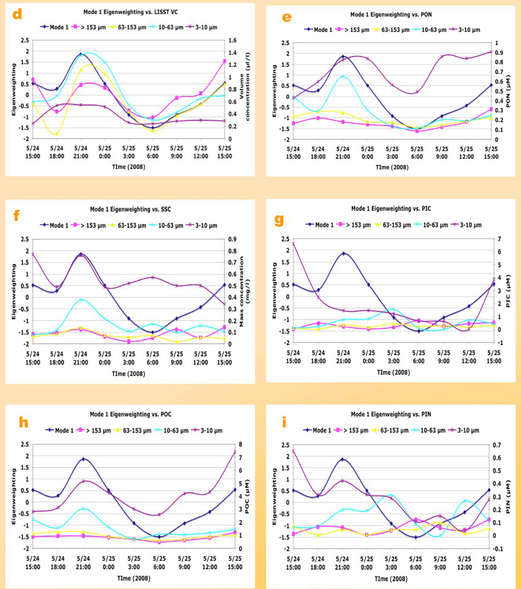


Figure 2



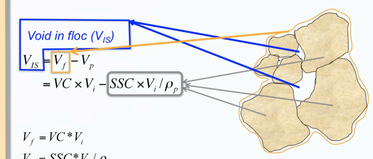


Source of the suspended particles

The total carbon (TC) fraction of suspended particles is higher in size-classes greater than 63 μm. The averaged percentage in the size-class of 63-153 μm is 30.23% which is the largest portion in four size-classes.

The further EOF (empirical orthogonal function) analysis of the time series of mass concentration, volume concentration, POC, PON, PIC, PIN in 4 different size-classes, and salinity (Figure 2, a-i) indicated that most carbon and nitrogen content in particles are of terrestrial origin, except PIC and PIN in the size-class of 63-153 and > 153 μm that are of marine origin.

Floc model



$$V_{IS} = V_f - V_p = VC \times V_i - SSC \times V_i / \rho_p$$

$$V_f = VC * V_i$$

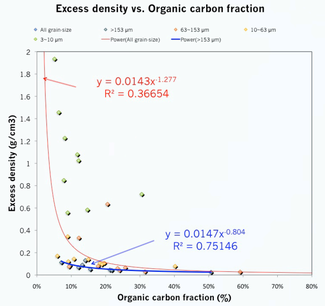
$$V_p = SSC * V_i / \rho_p$$

VC : volume concentration measured by LISST

SSC : suspended sediment concentration determined by filltering-dry-weight process

V_i : unit volume

ρ_p : asume primary paritcle density = 2.65 g/cm^3 (as quartz)



Formula for floc density (ρ_f) estimation

$$\rho_f = \frac{M_p + M_{IW}}{V_f} = \frac{M_p}{V_f} + \frac{V_{IW}\rho_{IW}}{V_f}$$

$$= \frac{SSC \cdot V_i}{VC \cdot V_i} + \frac{(VC - SSC/\rho_p)V_i\rho_{IW}}{VC \cdot V_i} = \frac{SSC}{VC} + \frac{(VC - SSC/\rho_p)\rho_{IW}}{VC}$$

$$= \frac{SSC}{VC} + \left(\rho_{IW} - \frac{\rho_{IW}}{\rho_p}\frac{SSC}{VC}\right) = \rho_{IW} + \left(1 - \frac{\rho_{IW}}{\rho_p}\right)\frac{SSC}{VC}$$

M_p, M_{IW} : Mass of primary particles and interstitial water

V_f, V_i : Volume of flocs and unit volume of water

SSC : Suspended sediment concentration

VC : Volume concentration measured by LISST-100

ρ_p, ρ_{IW} : Density of primary particles and interstitial water

- Assumptions:
  - 1. Density of primary particle (ρ_p) --- 2.65 g/cm^3
  - 2. Density of interstitial water (ρ_{IW})1.025 ---1 g/cm^3

Formula for floc porosity (ϕ) estimation

$$\phi = V_{IS}/V_f = (V_f - V_p)/V_f = \frac{VC \times V_i - SSC \times V_i/\rho_p}{VC \times V_i} = 1 - \frac{1}{\rho_p}\frac{SSC}{VC}$$

$V_f = VC * V_i$ $V_p = SSC * V_i / \rho_p$

VC : volume concentration measured by LISST

SSC : suspended sediment concentration determined by filltering-dry-weight process

V_i : unit volume

ρ_p : asume primary paritcle density = 2.65 g/cm^3 (as quartz)

The finest particles (< 10 μm) contributed over 50 % to the total mass of suspended particles but only 16 % to the volume. Floc densities (and porosities) also revealed decreasing (and increasing) trend with increasing grain-size. Organic matter in suspended particles affects the floc size structure during flocculation/ aggregation process. Higher organic contents form looser and lighter flocs. Our data indicated that floc densities showed exponential decay with increasing POC fraction in the suspended particulate matter. This tendency was more significant in the grain size greater than 153 μm.

References

Hsu, R.T., Liu, J.T., 2010. In-situ estimation of the density and porosity of flocs of varying sizes in a submarine canyon. Marine Geology, 276, 105-109.

Turner, A., Millward, G. E., 2002. Suspended particles: their role in estuarine biogeochemical cycles. Estuarine, Coastal and Shelf Science: 55, 857-883.

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