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REMOTE SENSING QUANTITATIVE RESEARCH OF ELEVATION, DEPOSITION AND EROSION OF TIDAL FLAT

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Abstract: Tidal flat morphodynamics is usually related with tidal flat reclamation, aquiculture, jetty construction, and navigation channel dredging up and so on. The change of deposition and erosion is a complicated physical process. It depends on many natural factors and human being factors. The research of tidal flat is difficult because of shortage of routine topography data. In this paper the Dachan bay of inner Lingding estuary and Wenzhou bay are taken as research area, and the satellite data resources such as MSS, TM, ETM and SPOT in more twenty years were applied for the study. This paper introduces the remote sensing inversion technique of elevation, deposition and erosion of silt-mud flat. At first, the waterside line in satellite images of research area is determined. Then it successfully inverses the elevation and the deposition (erosion) rate of the target tidal flats in horizontal and vertical at different locations of the Dachan bay of inner Lingding estuary and Wenzhou bay area, by applying waterline elevation inverse technology based on multi temporal satellite remote sensing images. The result of research has provided scientific basis for the development of those areas.

Key words: Tidal flat; Inversion; Elevation; Deposition and erosion

1. TECHNIQUE WAY OF ELEVATION, DEPOSITION AND EROSION REMOTE SENSING INVERSION OF TIDAL FLAT

Tidal flat is marsh which is often flooded by sea water under tidal action. It is dynamical and unstable natural resources, and has obviously variety of deposition and erosion. Tidal flat is the important foundation of human being existing and continuable development with others concomitant resources and the important protective object of coastal resource and environment. Realizing the characteristics and distribution of that benefit to develop tidal flat resources with reason. The traditional topography survey of tidal flat is difficult because they spread widely and vary frequently, so the development isn't well.

The change of deposition and erosion is a complicated physical processing. It includes many natural factors and human being factors. Natural factor include geological processing and sea level elevation of researching area, dynamical condition, sand origin, sedimentary variety and so on. Human being factor include tidal flat reclamation, aquiculture and inlet dredging up et al.

The key technology of remote sensing application is the extraction and inversion of information, that is extracting object characteristics from the electromagnetic wave signal bring the information. Donoghue D N M et al. mapped and monitored the intertidal zone of the east coast of England using remote-sensing techniques and a coastal monitoring GIS; Alberotanza L et al. recognized submerged vegetation in the Orbetello Lagoons Ital by hyperspectral aerial images. But no paper that inversed deposition and erosion of tidal flat was

found nowadays. This paper has tried to do that taking Dachan bay of inner Lingding estuary and Wenzhou estuary as research area. The Fig. 1 is the technique flow.

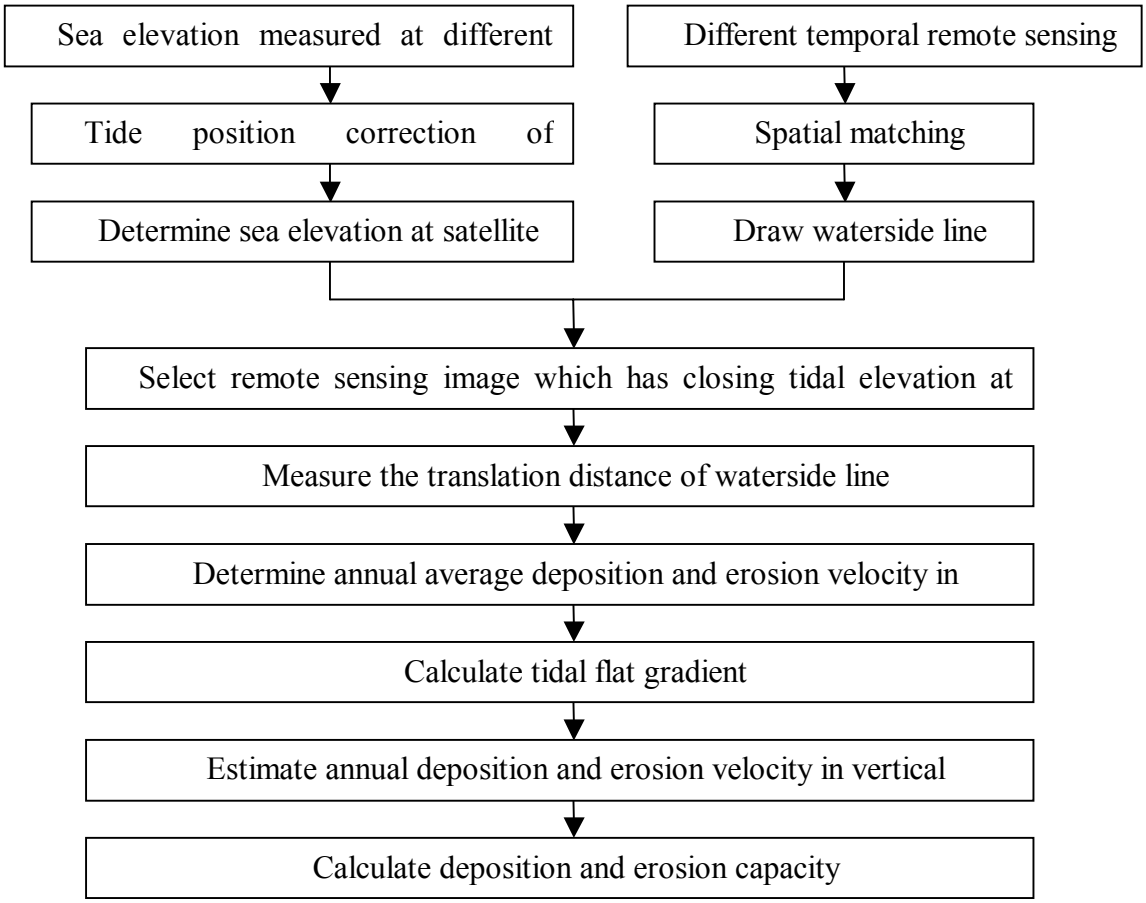

Fig. 1 Technology flow

2. ELEVATION, DEPOSITION AND EROSION REMOTE SENSING INVERSION OF TIDAL FLAT IN DACHAN BAY OF LINGDING ESTUARY

2.1 INTRODUCTION OF RESEARCH AREA

Lingding is an estuary which has many inlets. Drainage area is wide, and its sand comes from Hu gate, Jiao gate, Hongqili and Heng gate. Lingding estuary can be divided into “three channels and two slots”, which is west shoal, west channel, middle shoal, east channel and east shoal from west to east. According to the research task and tidal position of satellite imaging, authors choose 17 images including MSS, TM and ETM. Span from 1978 to 2001. Their spacial resolution is 80m, 30m and 15m. It can be to meet requirement of inversion analysis of the Dachan bay of Lingding estuary tidal flat.

2.2 DATA ANALYSIS

According to the measured sea elevation of different satellite images of Shanbanzhou tide station, aerodrome tide station, inner lingding island tide station and Chi bay tide station, authors obtained the instantaneous sea elevation of Dachan bay by tide position correction of difference zones for determining the elevation of waterside line at different area. In order to ensuring inversing precision, elevation error was limited in 10cm when remote sensing

information specimens were chosen. The error caused by wave can not be considered owing to research area located in the inside bay of inner Lingding estuary.

Combining the satellite imaging tide of inner Lingding estuary, authors chosen four group waterside lines which tide elevation of satellite image is similar, and obtained tidal flat average deposition and erosion velocity in horizontal at different years (Table 1).

Deposition velocity in vertical can be calculated by the movement distance of same elevation at different years (Table 2). The formula shows :

$$Y=AX \tag{1}$$

Y is annual deposition velocity in vertical; A is the gradient of tidal flat; X is annual deposition velocity of waterside line in horizontal

Annual deposition velocity in vertical of intertidal flat is about 5cm/a or so in last decade year because of aquiculture in Dachan bay from the result of Table 2. The data meet with the engineering layout design of production department, and was adopted by the Planning Institute of Communication Ministry.

Table 1 Siltation variety table of tidal flat at different years

	1987-2001	1988-2000	1992-1999	1987-1998
Elevation of waterside line (theory datum plane) /cm	103 -105	103 -111	142 -146	154 -156
Translation distance of waterside line /m	434	370.8	345.1	604.34
Average silt velocity in horizontal /ma^{-1}	31	30.9	49.3	54.94
Annual average silt velocity in horizontal /ma^{-1}	30.95		52.12	

Table 2 Deposition velocity and siltation capacity estimation table of intertidal flat zone

	Lower of intertidal flat zone	Upper of intertidal flat zone
Elevation of waterside line (theory datum plane) /cm	67–111	111-161
Annual average silt velocity in horizontal /ma^{-1}	30.95	52.12
gradient	0.00131	0.00131
Annual deposition velocity in vertical /cma^{-1}	4.1	6.8
Annual silt capacity /ten thousand m^3	37.3325	

3. ELEVATION, DEPOSITION AND EROSION REMOTE SENSING INVERSION OF TIDAL FLAT IN WENZHOU BAY AREA

3.1 INTRODUCTION OF RESEARCH AREA

The tidal flat of Wenzhou bay area mainly distributed in the Wenzhou bay and Yueqing bay. Tidal flat of Wenzhou bay is made up of coarse sediment and fine sediment. The coarse sediment is consisted of medium-grained sandstone and fine-grained sandstone, and the fine sediment is consisted of fine-grained sandstone and clay stone. According to the research task and tidal position of satellite imaging, authors choose 24 images including MSS, TM, ETM and SPOT. Span from 1976 to 2002. Their spacial resolution is 80m, 30m, 15m and 10m. Specimens can be to meet requirement of reversion analysis of the silt tidal flat in Wenzhou area.

3.2 DATA ANALYSIS

At first, authors drew the boundary of tidal flat and sea water. Then corrected the tidal flat elevation in zoning for different tidal station (Wenzhou tidal station, Huangdaao tidal station, Dongmen village tidal station, Ruian tidal station, Nanji mountain tidal station). And divided the tidal flat of Wenzhou area into the top of Yueqing bay tidal flat, Ximen Mountain tidal flat, the west of Yueqing bay tidal flat, Wenrui shoal tidal flat, Wenzhou shoal tidal flat five areas according to the distribution of tidal flat in Wenzhou area.

Table 3 Estimation table of different position deposition velocity of tidal flat at different years

	Top of Yueqing bay (93-01)	West of Yueqing bay (93-01)	Wenzhou shoal		Wenrui shoal	
			(93-01)	(93-02)	(93-00)	(94-01)
Elevation of waterside line (theory datum plane) /cm	529 -528	503 -513	317 -310	466 -471	445 -441	256 -262
Translation distance between waterside line /m	11	171	360	306	372	83
Annual average silt velocity of horizontal /ma^{-1}	1.38	21.38	45	34	53.14	11.86
Average silt velocity of horizontal in many years /ma^{-1}			39.5		32.5	
Gradient	0.0023	0.0013	0.00026		0.00094	
Annual deposition velocity in vertical /cma^{-1}	0.3174	2.7794	0.1027		0.03055	

Table 4 Estimation table of the erosion velocity of Ximen mountain tidal flat at different years

	1993-2001
Elevation of waterside line (theory datum plane) /cm	523 -520
Translation distance between waterside line /m	21
Annual average erosion velocity of horizontal /ma^{-1}	2.63
gradient	0.0019
Annual erosion velocity in vertical /cma^{-1}	0.4997

Authors calculated the translation distance between waterside line, and got annual siltation (erosion) velocity in horizontal and annual deposition (erosion) velocity in vertical (Table 3, Table 4). In Table 3, the annual average siltation vertical velocity is 45ma^{-1} from 1993 to 2001 and the annual average silt vertical velocity is 34ma^{-1} from 1993 to 2002 in Wenzhou shoal. Owing to adopting different waterside line elevation, the siltation velocity near the sea water is bigger than that of near land. From 317cm to 310cm close to sea water for 466cm to 471cm. The annual average silt velocity of Wenzhou shoal proved it too. The result (Table 3, Table 4) shows that, the top of Yueqing bay tidal flat, the west of Yueqing bay tidal flat, Wenrui shoal tidal flat, Wenzhou shoal tidal flat silt. The silt velocity in horizontal is fastest in Wenzhou shoal tidal flat, which annual average silt is 39.5ma^{-1}; and the slowest is the west of Yueqing bay tidal flat, which annual average silt is 1.38ma^{-1}. The annual deposition velocity in vertical is biggest in the west of Yueqing bay tidal flat, which is 2.7794cma^{-1}; and the smallest is

Wenrui shoal tidal flat, which is 0.03055cma^{-1}. The reason is that the west of Yueqing bay tidal flat locates in the inside of inner bay and Wenrui shoal tidal flat locates in the outer of inner bay. Therefore, wave reaction less affected the former than the latter. The error caused by wave can not be considered owing to research area located in the inner bay. Ximen mountain tidal flat is erosive, which is related with its position. It locates in the position of sand trap. The erosive velocity is 2.63 ma^{-1} in horizontal and erosive velocity is 0.4997cma^{-1} in vertical.

4. CONCLUSIONS

It more affected the layout and renovation of estuary and coastal zone that lacking of routine topographic data in tidal flat. Applying waterline elevation reverse technology based on multi temporal satellite remote sensing images, the paper inversed the silt velocity in horizontal and deposition velocity in vertical of silt tidal flat in Dachan bay of inner Lingding estuary, top of Yueqing bay, west tidal flat of Yueqing bay, Wenzhou shoal and Wenrui shoal. The result shows: the annual average silt velocity in horizontal and annual average deposition velocity in vertical of intertidal flat upper is 50.12m and 6.8cm in Dachan bay, and the lower of intertidal flat is 30.95m and 4.1cm. The annual average silt velocity in horizontal is 1.38ma^{-1}, 21.38ma^{-1}, 39.5ma^{-1}and 32.5ma^{-1} in different Wezhou area. Their annual average deposition velocity in vertical is 0.3174cma^{-1}, 2.7794cma^{-1}, 0.1027cma^{-1}and 0.03055cma^{-1}. And the annual average erosive velocity in horizontal and vertical is 2.63ma^{-1}and 0.4997cma^{-1}. It made up the deficiency of routine topographic data, and the conclusion built the theory foundation for the development of research areas.

REFERENCES

Alberotanza L, Brando V E, Ravgnan G, et al. Hyperspectral aerial images: a valuable tool for submerged vegetation recognition in the Orbetello Lagoons, Italy. Int. J. remote sensing, 1999, 20(3):523-533.

Allen J R L, M J Duffy. Temporal and spatial depositional patterns in the Severn estuary, southwestern Britain: intertidal studies at spring-neap and seasonal scales, 1991-1193. Marine Geology, 1998, 146(1):147-171.

Donoghue D N M, Thomas D C R, ZONG Y, Mapping and Monitoring the intertidal zone of the east coast of England using remote-sensing techniques and a coastal monitoring GIS. Marine Technology Society Journal, 1994. 28(2):19-29.

Le Hir P, W Roberts, O Cazaillet. et al. Characterization of intertidal flat hydrodynamics. Continental Shelf Research, 2000, 20(12):1433-1459.

Luo zhang-ren, Zhen Tian-xiang. Port group of Zhujiang delta. Nanjing: Hehai university press. 2002. 20-22.

Ryu Joo-Hyung, Joong-Sun Won, Kyung Duck Min. Waterline extraction from Landsat TM data in a tidal flat: a case study in Gomso Bay, Korea. Remote Sensing of Environment, 2002, 83(3):442-456.

Shi zhong, Chen ji-yu, Yu zhi-ying. Development of silt tidal flat deposition in China, Development of Geo-science, 1996，11（6）：555-562.

Sohma Akio, Tatsuaki Sato and Kisaburo Nakata. New numerical model study on a tidal flat system – seasonal, daily and tidal variations. Spill Science and Technology Bulletin, 2000, 6(2):173-185.

Solomon S, P J Mudie, R Cranston, et al. Characterisation of marine and lacustrine sediments in a drowned thermokarst embayment, Richards Island, Beaufort Sea, Canada. International Journal of Earth Sciences, 2000, 89(12):503-521.

Stanimirova I, S Tsakovski, V Simenonov. Multivariate statistical analysis of coastal sediment data. Analytical & Bioanalytical Chemistry. 1999, 365(6):489-493.

Van Deventer, A P, et al. Using thematic mapper data to identify contrasting soil plains and tillage practices. Photogrammetric Engineering and remote sensing. 1997. 63(11): 87-93.

Youdeowei P O, T K S Abam. Local engineering practices of erosion control in the coastal areas of the Niger delta. Environmental Geology, 1991,31(3):231-235.