DEFINING AN ESTUARY USING THE HILBERT-HUANG TRANSFORM

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TAIPEI TECH

河口界定的研究

提出之研究學者	年份	河口之分類
Pritchard	1967	一個半封閉的海灣，其水體與海水相連接。
Gorsline	1967	地形就如同有一個缺口之海岸，並且受到潮汐及逕流的影響。
Visser,W.A.	1980	形狀像漏斗之河口，並且受潮汐影響。
Lyell,C	1983	地形為一個彎，如同一個入口，同時匯入河川及海洋潮汐。
Perillo	1989	為一個半封閉的海灣，其範圍延伸到水體受潮汐影響的最遠距離。
台灣河川管理辦法 第六條第四款	2007	指河川區域線與海岸高潮線銜接處向臨海面延伸至一百五十公尺之區域，但延伸推距超過海拔標高負五公尺等深線者，以海拔標高負五公尺等深線處為準。

提出之研究學者	年份	河口之分類
Odum, E.P.	1959	位於河川出海口不但受潮汐影響水體中包含氯化物及淡水。
Barnes,R.S.K.	1974	河口是一個水理混合鹹水與淡水之排水系。
Portmann, J.E.	1985	河口是一個過渡地帶，其水體質量變化的特點從內陸淡水河流的水至大海鹹水。
Davidson,N.C.、Laffoley,D.d'A、Doody,J.P.、WayL.S.、Gordon,J.、Key,R.、Pienkowski,M.W.、Mitchell,R.、Duff,K.L.	1991	以地貌類型區分河口地區。
Conley,D.J.、Kaas,H.、Mohlenberg,F.、Rasmussen,B.、Windolf,J.	2000	提出河口為一個半封閉的半開放水體，此區域受鹽水從海洋往河川上游傳遞和從河川上游往下游傳遞的的淡水河流，在加上陸地逕流或滲漏。

提出之研究學者	年份	河口之界定
Fairbridge,R.W	1980	(1)緊鄰海洋，其完全受海洋影響(2)河口中段，是鹹水與淡水混合處(3)河口較上游處，河水為淡水淡受潮汐影響。
錢寧等	1982	由河床演變學的角度出發，將水流泥沙因素與型態結合，提出逕流潮流比值值a(a=Q_{fb} / Q_f ；Q_{fb}為逕流流量，Q_f為漲潮平均流量)，因此用逕流潮流比值和含沙量作為河口分類的指標。
McLusky	1993	以含鹽(氯化鈉)濃度0.5ppm為分界
Dyer,K.R.	1996	利用潮汐物理學之觀點來區分河口地區
賴進松	1998	潮汐漲落影響的最遠點-潮區界；到漲潮時海潮潮流上朔得最遠點之間-潮流界；到海水鹽分入侵的最遠點之間-鹽水界

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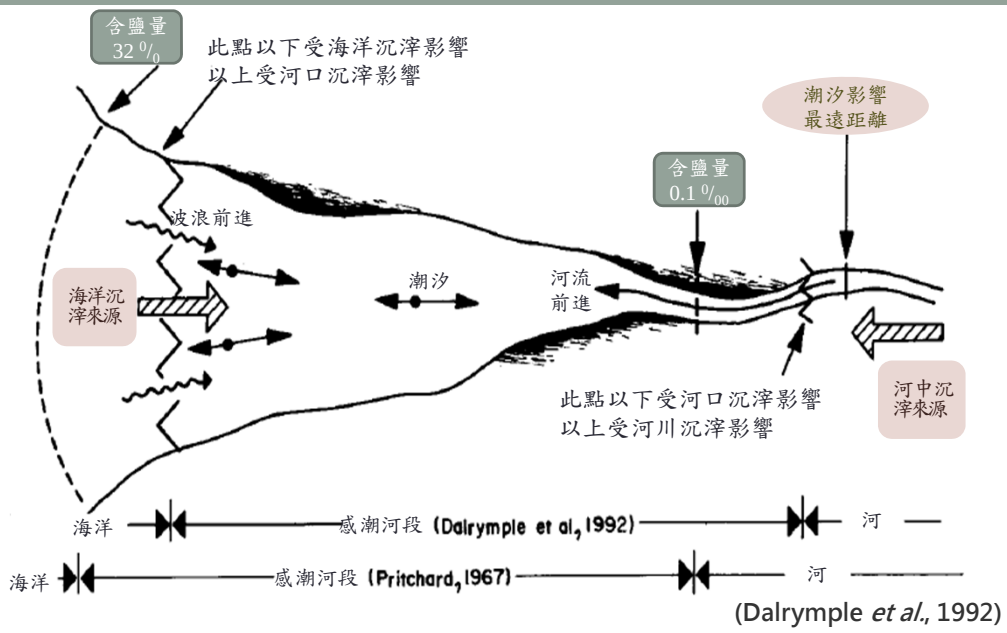

(Dalrymple *et al.*, 1992)

Definitions And Geomorphologic Classifications Of Estuaries

界定河口範圍或感潮河段對於水利工程的重要性

- 灌溉取水
- 防洪規劃
- 給水工程
- 汙廢水排放
- 流量量測

舉例來說:The Gambia, West Africa

潮汐灌溉計畫

- 水質
- 水位
- 感潮段長度

甘比亞河不同取樣點導電度

Conductivity值(ms/cm)
for irrigation water 0.75ms/cm

Year		2000									2001		
Month / Place		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Lamin Lodge		71.10	75.50	83.80	62.00	54.40	50.40	55.50	62.30	52.70	61.30	57.50	64.8
Tendaba		40.20	42.20	47.30	45.00	3.97	0.51	0.39	5.36	8.95	8.70	9.18	38.6
Jenoi	210km	25.60	17.05	40.90	37.00	0.80	0.40	0.28	0.67	1.22	3.54	5.79	13.52
Jappeni		15.88	14.59	18.46	32.00	0.32	0.29	0.21	0.37	0.44	1.08	4.32	6.17
Jareng		3.20	4.72	8.12	2.40	0.22	0.50	0.13	0.11	0.11	0.11	0.15	0.31
Kudang		0.38	1.37	4.82	0.10	0.06	0.06	0.05	0.07	0.07	0.05	0.07	0.31
Kuntaur	260km	0.07	0.36	0.61	0.08	0.05	0.06	0.05	0.06	0.06	0.05	0.05	0.05
Barajally	280km	0.05	0.07	0.12	0.09	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05
ROC Mission to the Rep. of Gambia													

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潮汐影響最高點到哪裡，季節不同時，影響點上溯到哪?

這個結果關係到潮汐灌溉稻米增產計畫的開發潛力與該國未來的糧食自主安全。

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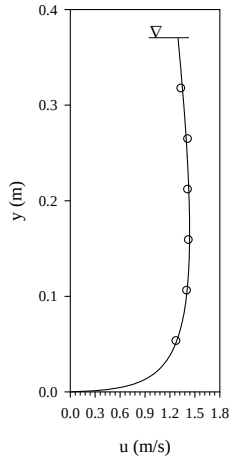
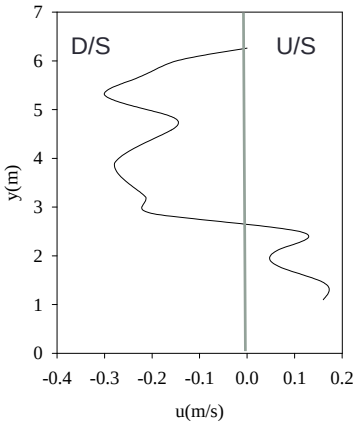
舉例來說，淡水河的流量觀測

- 非感潮河段

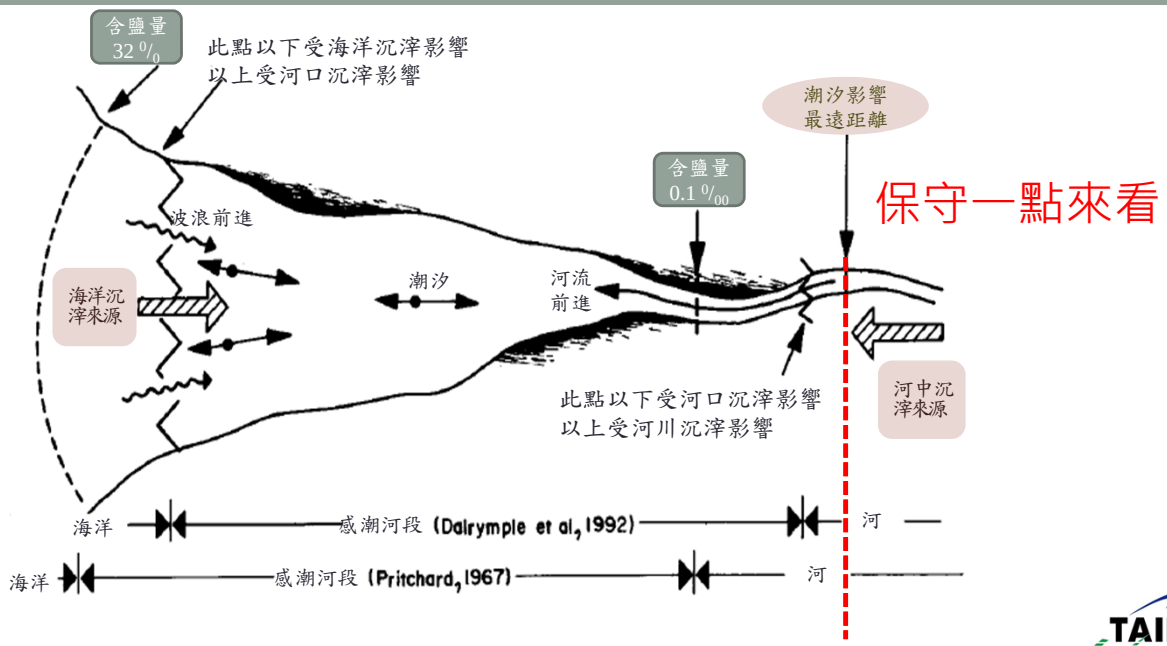


- 感潮河段



界定河口或是感潮河段

- 對水利工程師來說，請告訴我們”這裡”是不是在河口或是感潮河段，這樣就好了。
- 方法越簡單越好，另外有物理意義的數據證明更好。



Definitions And Geomorphologic Classifications Of Estuaries

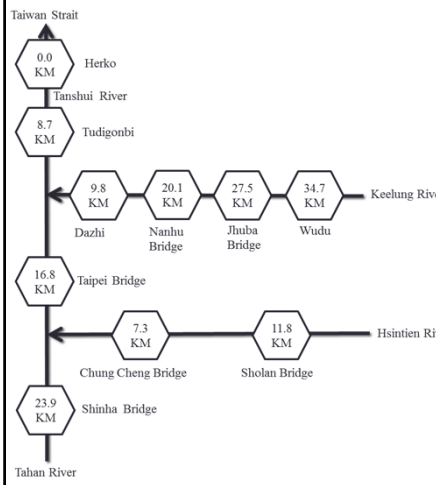
是否有替代方法

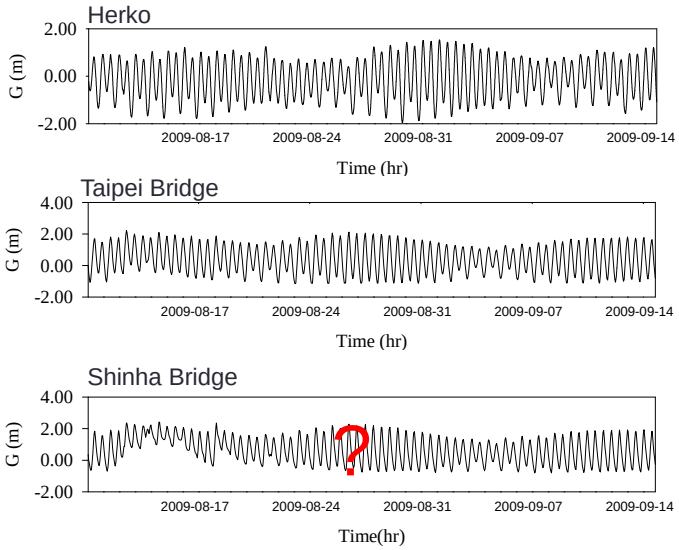
- 風險較低
- 數據具有代表性
- 方法比較簡便

水位紀錄

- 自記式
- 連續資料
- 量測便利

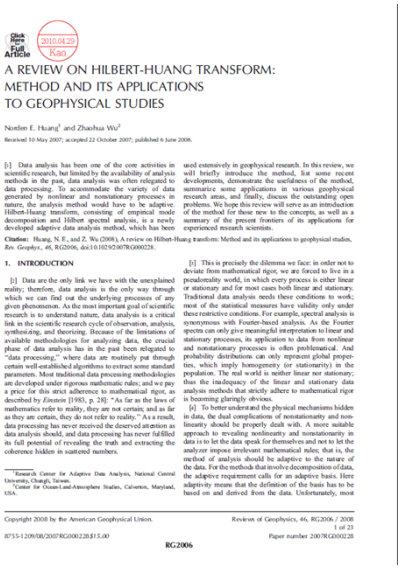
淡水河水位站水位紀錄





Huang, N.E., Wu, Z. (2008) A review on Hilbert-Huang Transform: method and its applications to geophysical studies. *Reviews of Geophysics* **46**, 1-23.

- IMF有物理意義。



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2010.04.29 Kao

A REVIEW ON HILBERT-HUANG TRANSFORM: METHOD AND ITS APPLICATIONS TO GEOPHYSICAL STUDIES

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[1] Data analysis has been one of the core activities in scientific research, but limited by the availability of analysis methods in the past, data analysis was often relegated to data processing. To accommodate the variety of data generated by nonlinear and nonstationary processes in nature, the analysis method would have to be adaptive. Hilbert-Huang transform, consisting of empirical mode decomposition and Hilbert spectral analysis, is a newly developed adaptive data analysis method, which has been used extensively in geophysical research. In this review, we will briefly introduce the method, list some recent developments, demonstrate the usefulness of the method, summarize some applications in various geophysical research areas, and finally, discuss the outstanding open problems. We hope this review will serve as an introduction of the method for those new to the concepts, as well as a summary of the present frontiers of its applications for experienced research scientists.

Citation: Huang, N. E., and Z. Wu (2008), A review on Hilbert-Huang transform: Method and its applications to geophysical studies, *Rev. Geophys.*, *46*, RG2006, doi:10.1029/2007RG000228.

1. INTRODUCTION

[1] Data are the only link we have with the unexplained reality; therefore, data analysis is the only way through which we can find out the underlying processes of any given phenomenon. As the most important goal of scientific research is to understand nature, data analysis is a critical link in the scientific research cycle of observation, analysis, synthesizing, and theorizing. Because of the limitations of available methodologies for analyzing data, the crucial phase of data analysis has in the past been relegated to "data processing," where data are routinely put through certain well-established algorithms to extract some standard parameters. Most traditional data processing methodologies are developed under rigorous mathematic rules; and we pay a price for this strict adherence to mathematical rigor, as described by *Einstein* [1983, p. 28]: "As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality." As a result, data processing has never received the deserved attention as data analysis should, and data processing has never fulfilled its full potential of revealing the truth and extracting the coherence hidden in scattered numbers.

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[2] This is precisely the dilemma we face: in order not to deviate from mathematical rigor, we are forced to live in a pseudoreality world, in which every process is either linear or stationary and for most cases both linear and stationary. Traditional data analysis needs these conditions to work; most of the statistical measures have validity only under these restrictive conditions. For example, spectral analysis is synonymous with Fourier-based analysis. As the Fourier spectra can only give meaningful interpretation to linear and stationary processes, its application to data from nonlinear and nonstationary processes is often problematical. And probability distributions can only represent global properties, which imply homogeneity (or stationarity) in the population. The real world is neither linear nor stationary; thus the inadequacy of the linear and stationary data analysis methods that strictly adhere to mathematical rigor is becoming glaringly obvious.

[3] To better understand the physical mechanisms hidden in data, the dual complications of nonstationarity and nonlinearity should be properly dealt with. A more suitable approach to revealing nonlinearity and nonstationarity in data is to let the data speak for themselves and not to let the analyzer impose irrelevant mathematical rules; that is, the method of analysis should be adaptive to the nature of the data. For the methods that involve decomposition of data, the adaptive requirement calls for an adaptive basis. Here adaptivity means that the definition of the basis has to be based on and derived from the data. Unfortunately, most

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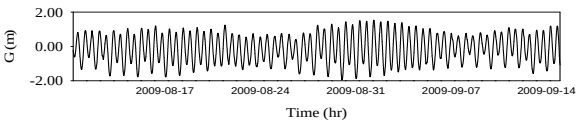
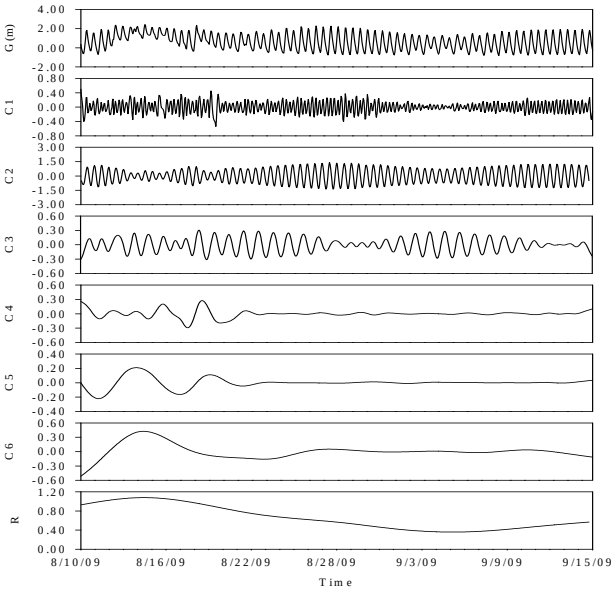
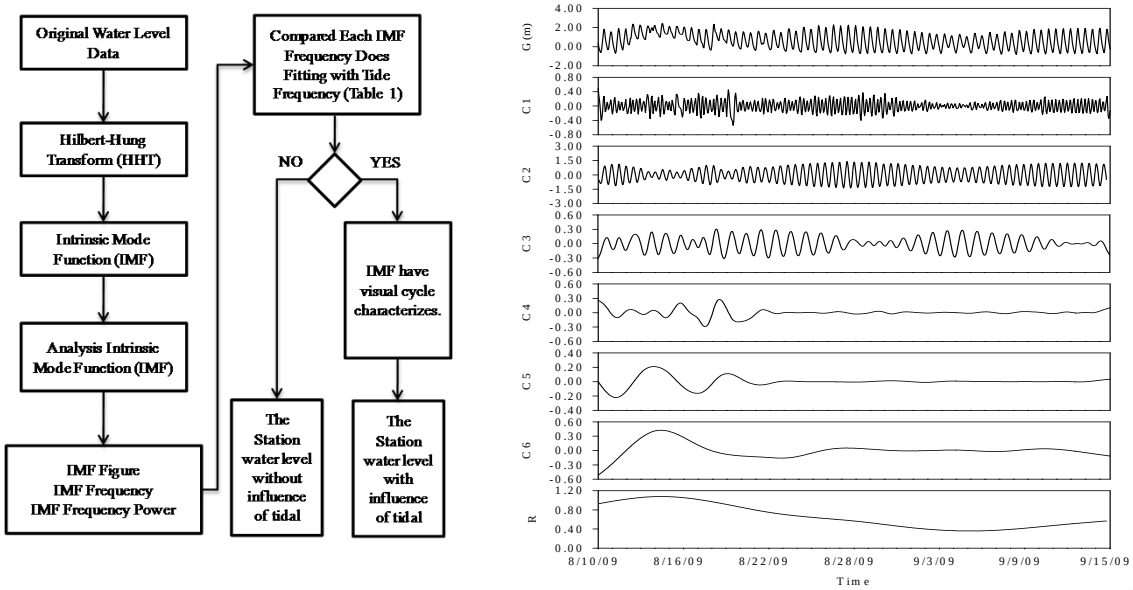
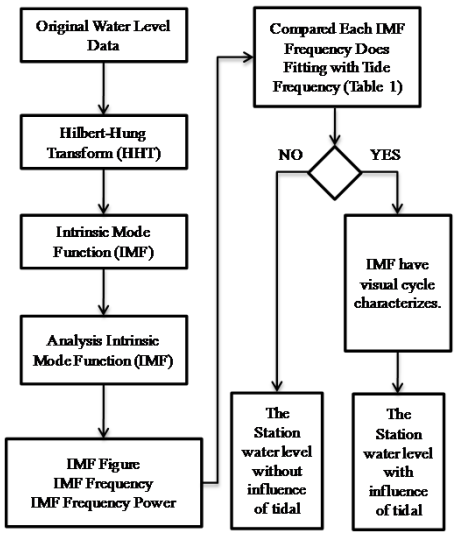


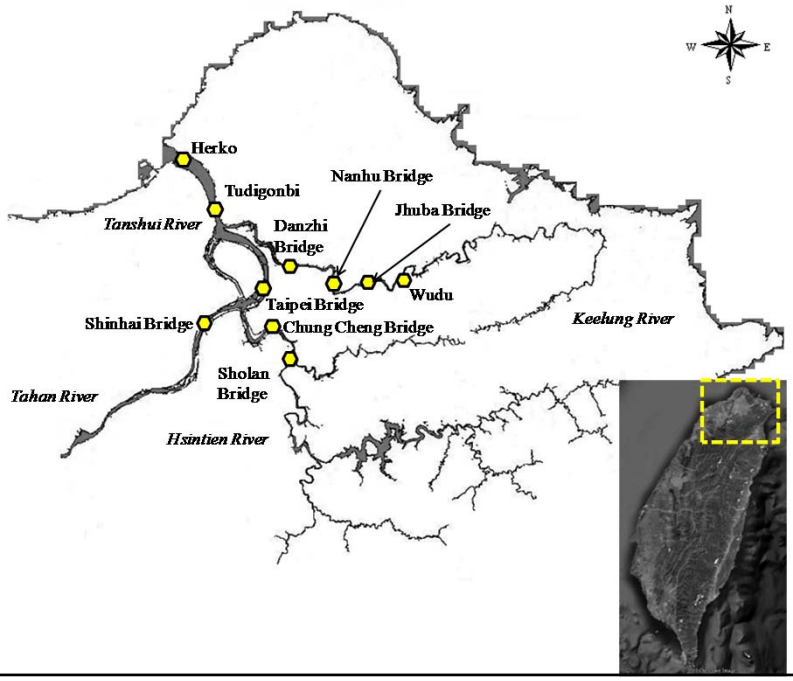




The classical tidal type

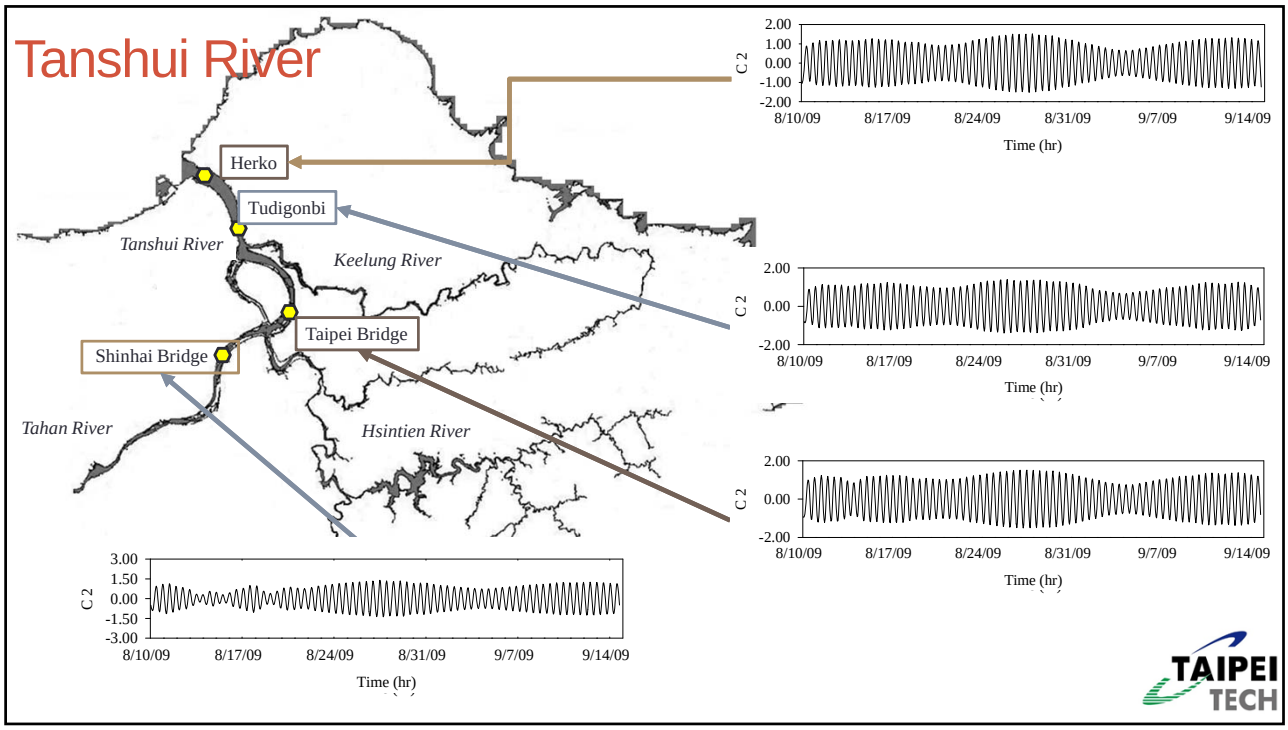


Type	Characterizes	Name	Cycle (hour/cycle)	Frequency
Semi-diurnal tides	K_2	Lunisolar diurnal constituent	11.9672	0.0836
	S_2	Principal solar semidiurnal constituent	12.0000	0.0833
	M_2	Principal lunar semidiurnal constituent	12.4206	0.0805
	N_2	Large lunar elliptic semidiurnal constituent	12.6583	0.0775
	$2N_2$	Second large lunar elliptic semidiurnal constituent	12.9054	0.0790
Diurnal tides	K_1	Lunisolar diurnal constituent	23.9345	0.0418
	P_1	Principal solar diurnal constituent	24.0659	0.0416
	O_1	Principal lunar diurnal constituent	25.8193	0.0387
	Q_1	Large lunar elliptic constituent	26.8684	0.0372
Overtides	S_4	Solar quarter constituent	6.0000	0.1667
	M_4	Large lunar quarter constituent	6.2103	0.1610



The Frequency and power distribution (%) of IMFs and Residual

	Tanshui River			Keelung River				Hsintien River		Tahan River
Station	Herko	Tudigonbi	Taipei Bridge	Danzhi Bridge	Nanhu Bridge	Jhuba Bridge	Wudu	Chung Cheng Bridge	Sholan Bridge	Shinhai Bridge
River Kilometers (km)	0	8.7	16.8	9.8	20.1	27.5	34.7	7.3	11.8	23.9
C1	0.2220 (0.517%)	0.2330 (1.87%)	0.2100 (0.973%)	0.1891 (1.09%)	0.1510 (12.5%)	0.1642 (12.6%)	0.2241 (1.7%)	0.1792 (2.46%)	0.2271 (1.19%)	0.1601 (3.77%)
C2	0.0806 (93.8%)	0.0805 (92.4%)	0.0806 (93.9%)	0.0806 (95.3%)	0.0804 (71.2%)	0.0804 (32%)	0.0874 (3.49%)	0.0805 (81.5%)	0.0979 (3.2%)	0.0806 (87.1%)
C3	0.0425 (5.11%)	0.0402 (4.77%)	0.0425 (3.93%)	0.0420 (2.73%)	0.0396 (2.16%)	0.0396 (5.12%)	0.0390 (3.84%)	0.0425 (3.67%)	0.0046 (10.4%)	0.0425 (3.45%)
C4	0.0221 (0.256%)	0.0210 (0.298%)	0.0204 (0.194%)	0.0211 (0.182%)	0.0181 (1.29%)	0.0204 (4.32%)	0.0157 (10.8%)	0.0204 (2.65%)	0.0239 (6.69%)	0.0192 (1%)
C5	0.0128 (0.0273%)	0.0117 (0.0488%)	0.0093 (0.155%)	0.0122 (0.128%)	0.0087 (3.1%)	0.0076 (22.1%)	0.0070 (16.8%)	0.0122 (0.512%)	0.0128 (36.2%)	0.0093 (0.879%)
C6	0.0058 (0.0875%)	0.0058 (0.136%)	0.0047 (0.624%)	0.0070 (0.0589%)	0.0058 (1.39%)	0.0041 (23.8%)	0.0035 (56.9%)	0.0047 (5.22%)	0.0070 (42.3%)	0.0052 (3.84%)
C7	0.0018 (0.215%)	0.0023 (0.516%)	0.0029 (0.223%)	0.0035 (0.548%)	0.0035 (8.41%)	--	0.0023 (6.46%)	0.0023 (4%)	--	--
Residual	0.00058	0.00058	0.00058	0.00058	0.00058	0.00058	0.00058	0.00058	0.00058	0.00058


Tanshui River
Herko
Tudigonbi
Tanshui River
Keelung River
Taipei Bridge
Shinhai Bridge
Tahan River
Hsintien River
C 2
Time (hr)
8/10/09
8/17/09
8/24/09
8/31/09
9/7/09
9/14/09
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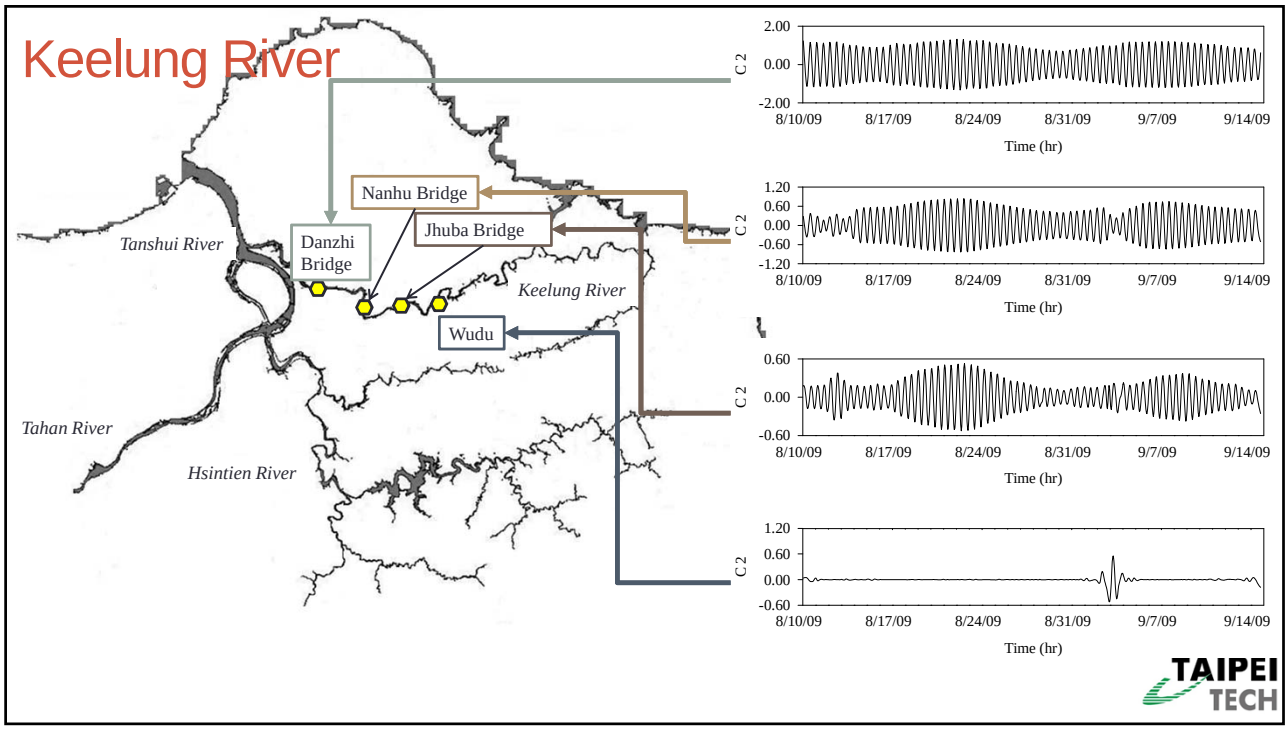
Keelung River
Nanhu Bridge
Jhuba Bridge
Danzhi Bridge
Tanshui River
Keelung River
Wudu
Tahan River
Hsintien River
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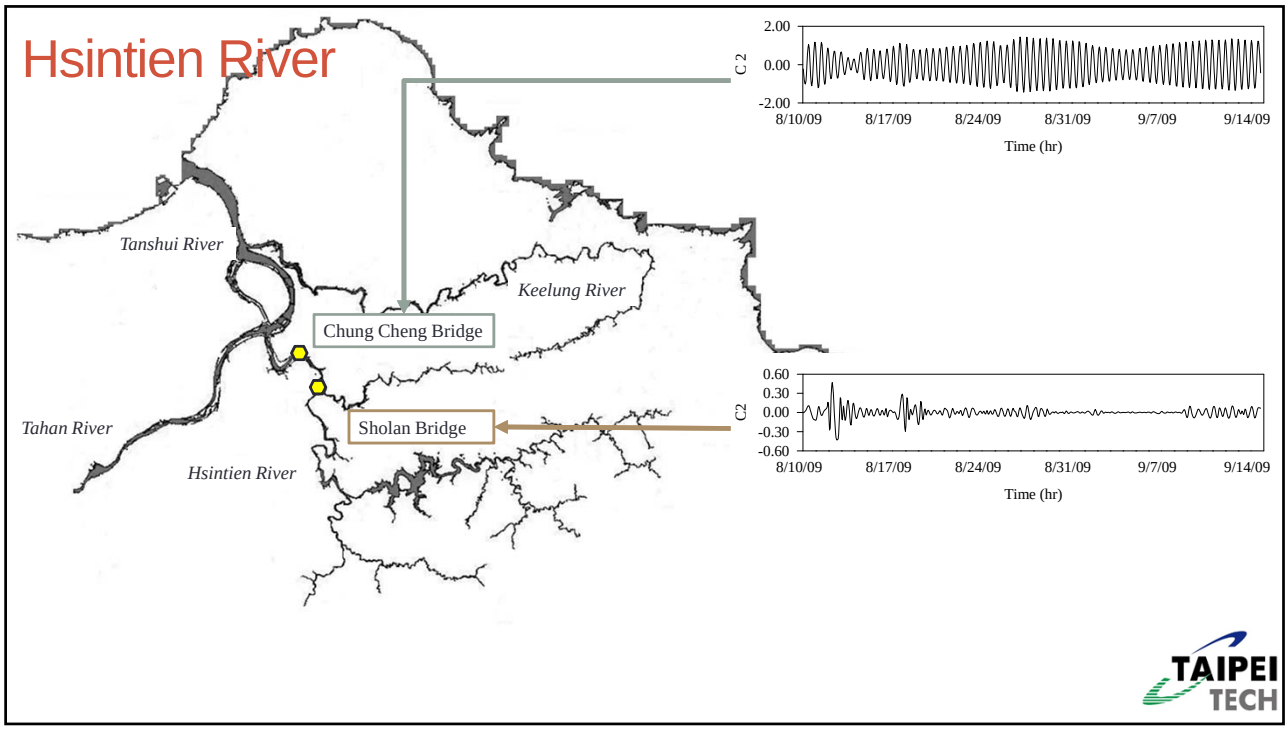
Hsintien River
Tanshui River
Keelung River
Chung Cheng Bridge
Tahan River
Sholan Bridge
Hsintien River
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2.00
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8/17/09
8/24/09
8/31/09
9/7/09
9/14/09
Time (hr)
C2
0.60
0.30
0.00
-0.30
-0.60
8/10/09
8/17/09
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9/14/09
Time (hr)
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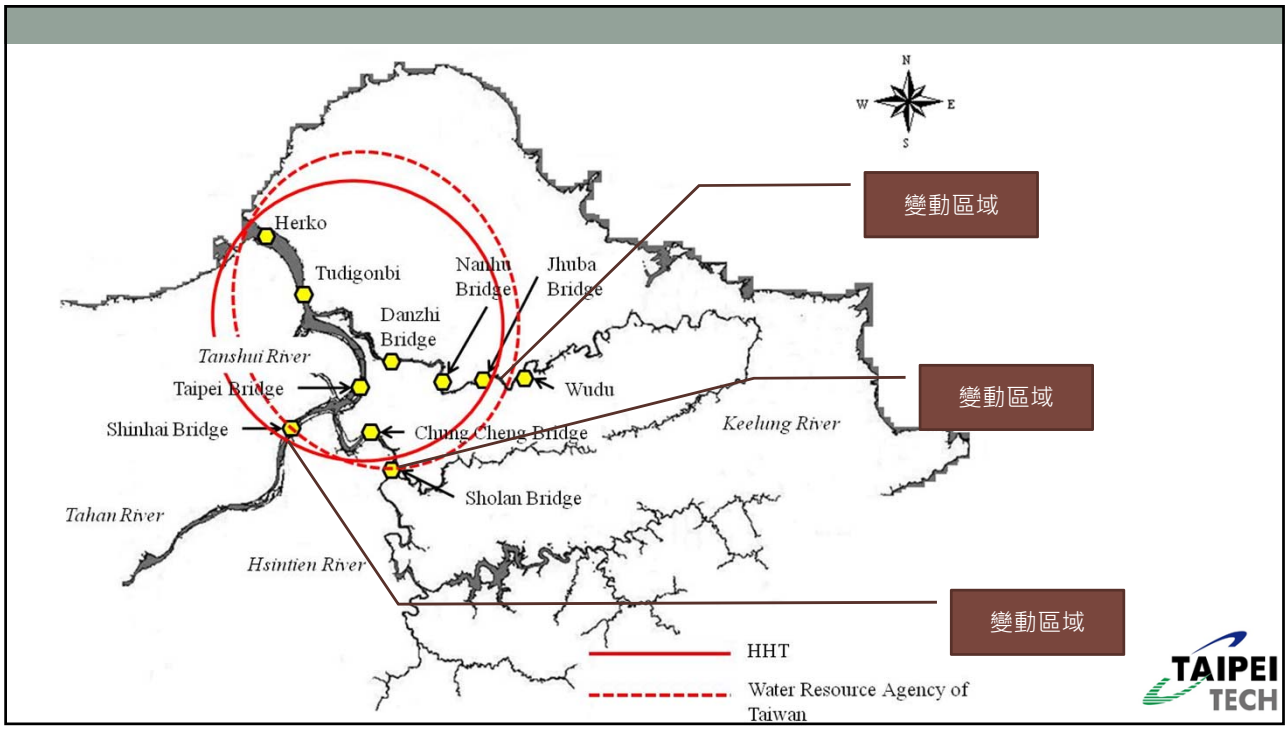
N
W
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S
變動區域
Herko
Tudigonbi
Nanhu Bridge
Jhuba Bridge
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變動區域
Shinhai Bridge
Chung Cheng Bridge
Keelung River
Sholan Bridge
Tahan River
Hsintien River
變動區域
HHT
Water Resource Agency of Taiwan
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