

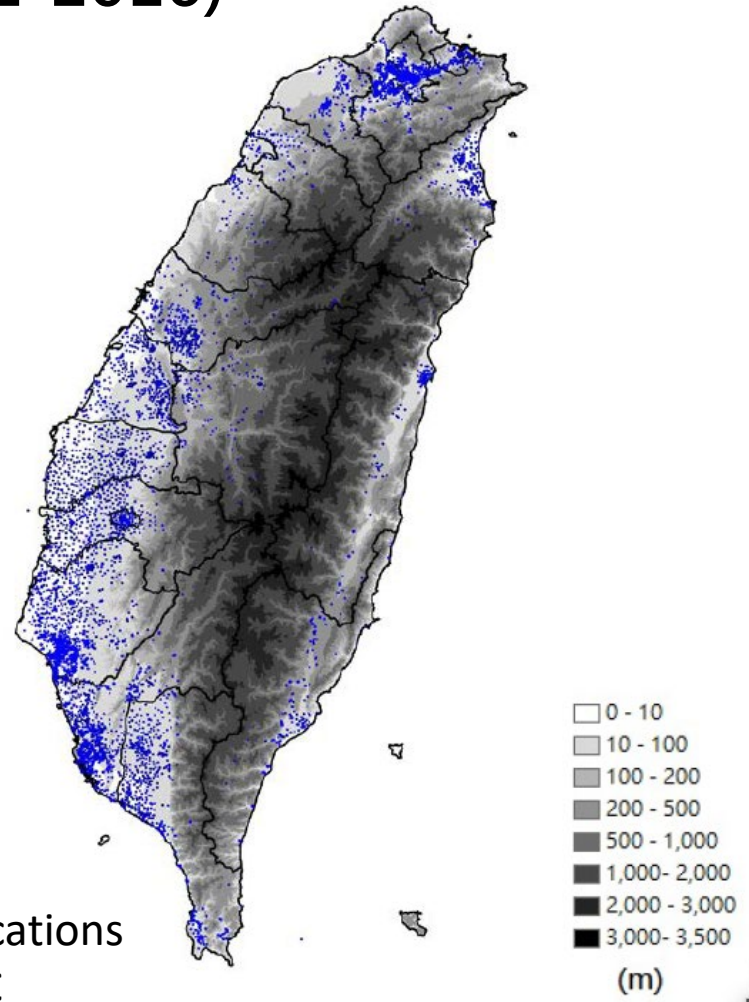
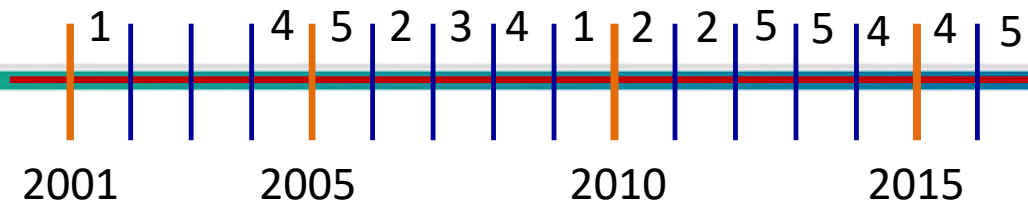
# 聯合風險分析方法於淹水災害之應用

林媿瑛、吳宜昭

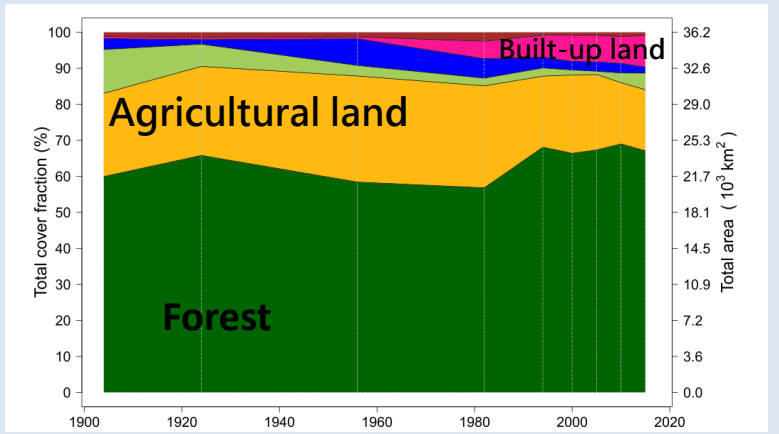
CWB天氣分析與預報研討會  
2020.10.14

# 淹水事件

47 flood events  
(2001-2016)

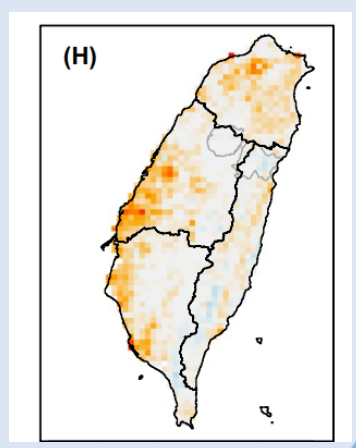
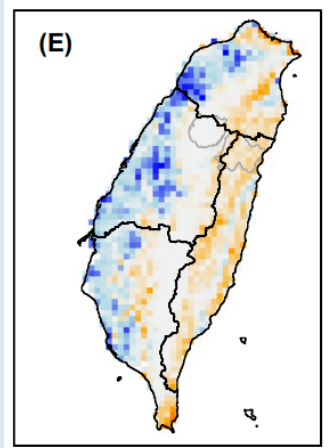


Chen et al. (2019) Scientific Reports



Agricultural land

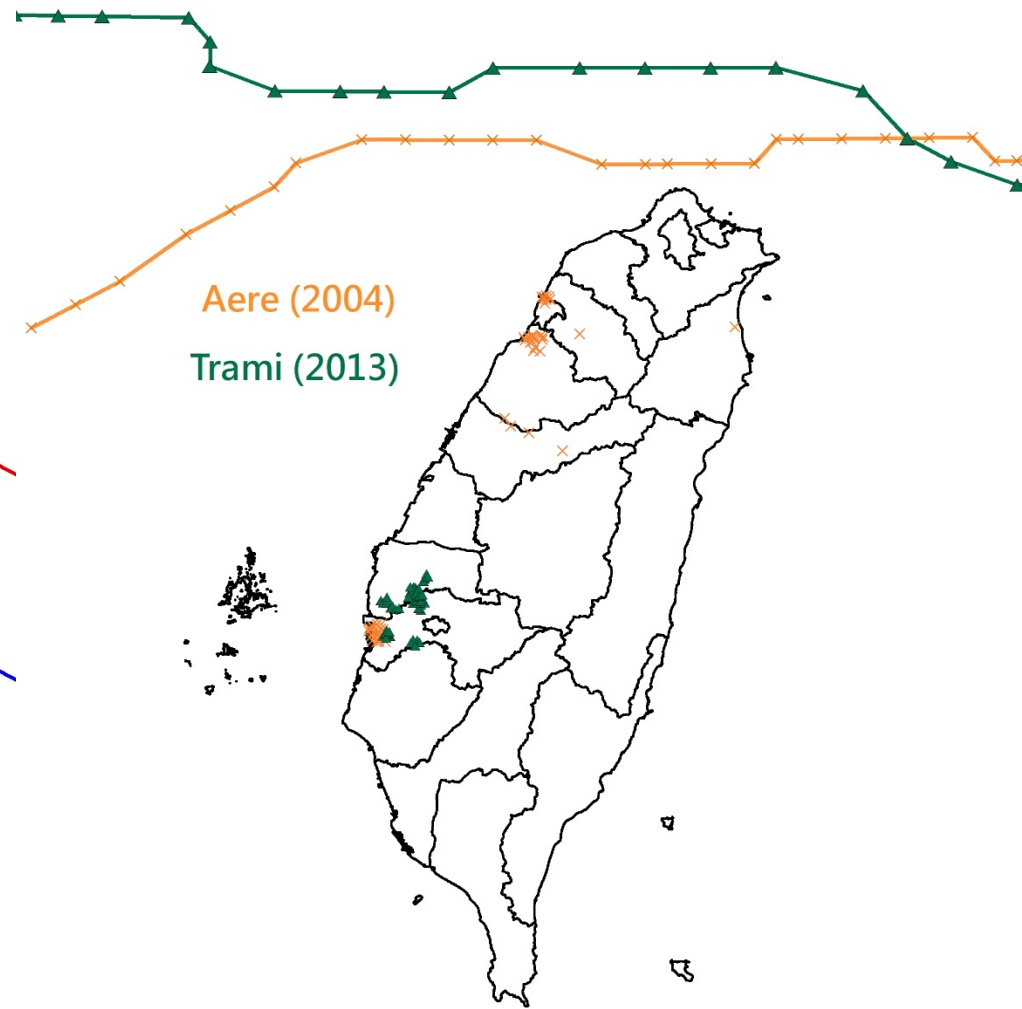
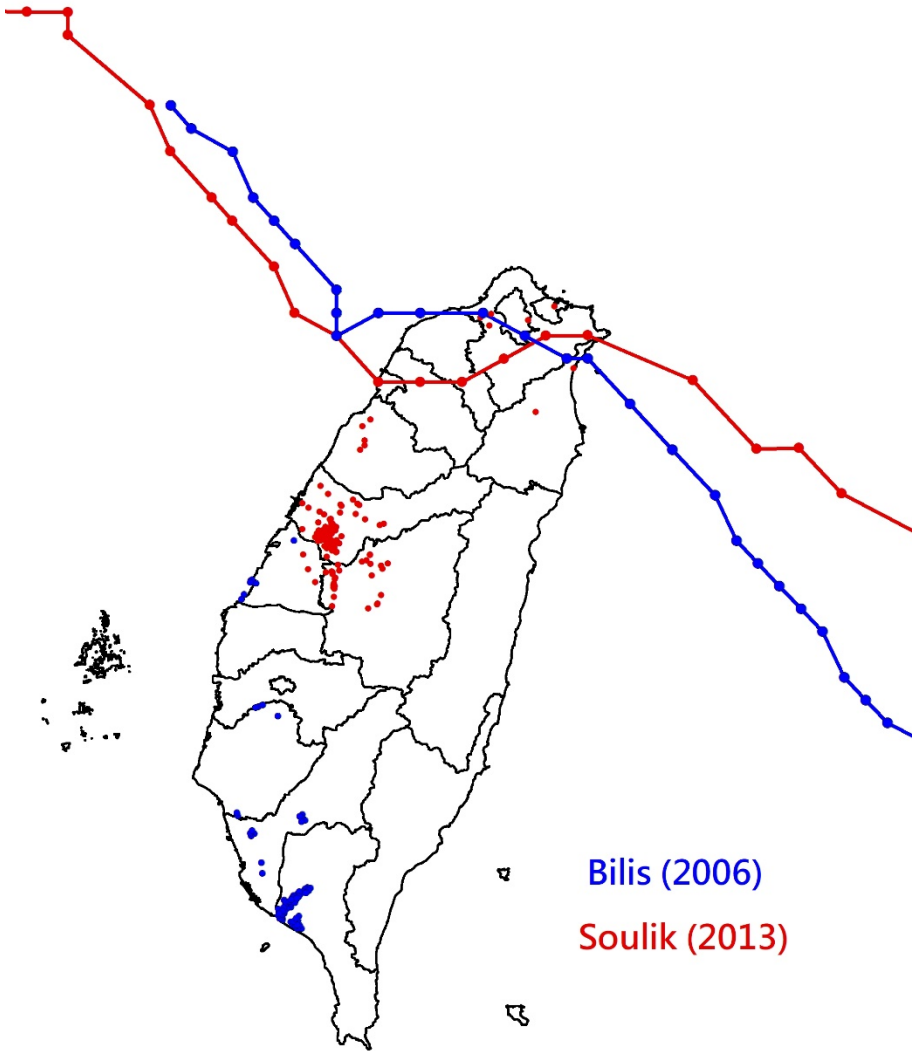
Built-up land



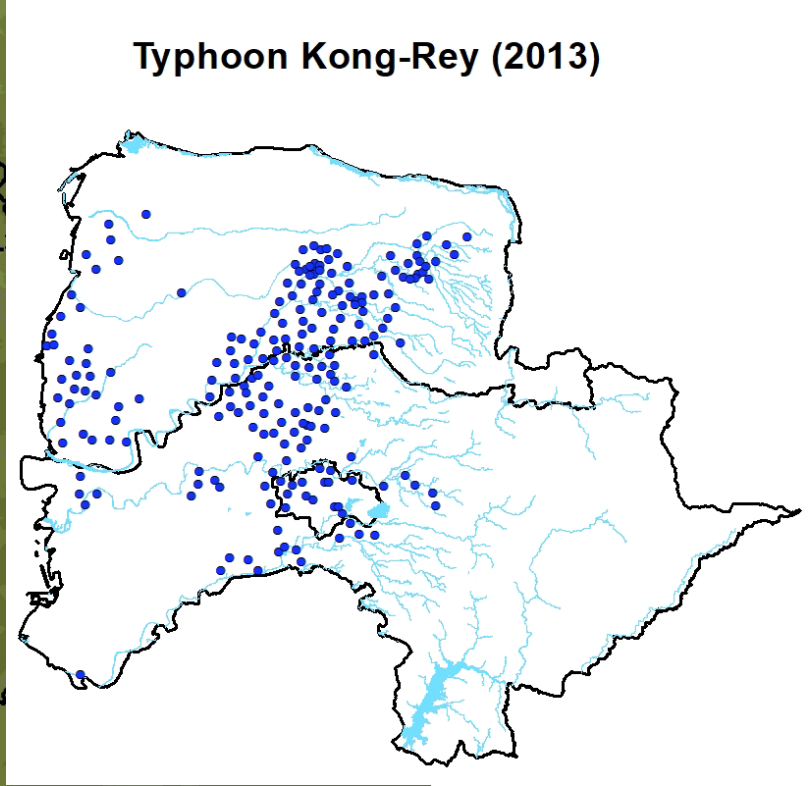
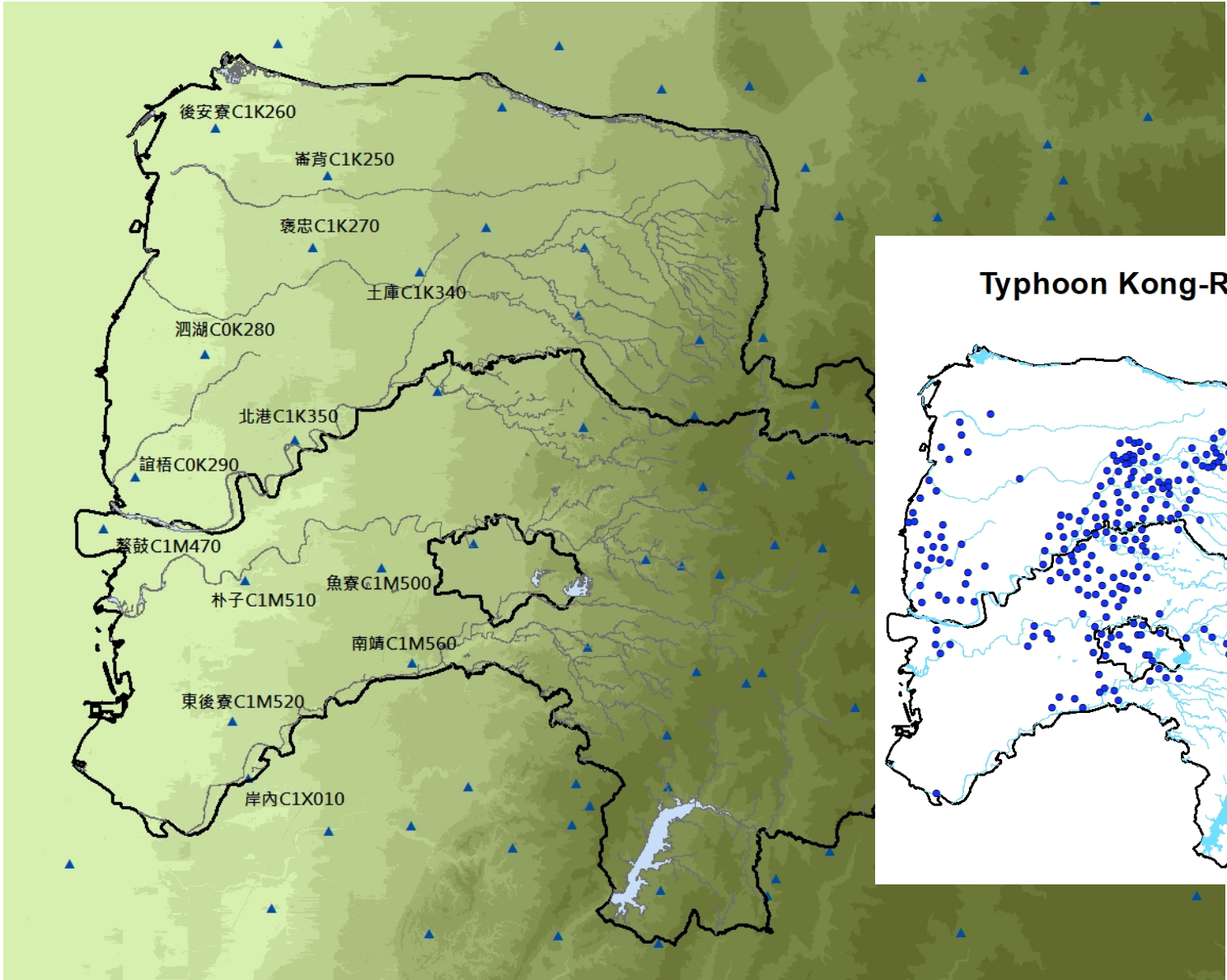
Blue color: loss

Orange color: gain

# 淹水位置 與 颱風路徑



# 淹水位置 與 地形



# 淹水事件 和 雨量 (單影響因子)

## 淹水事件數目/2001-2015強降雨事件

累積雨量 (mm)\雨量站	1h	3h	6h	9h	12h	24h
鰲鼓	$\frac{11}{31}$	$\frac{9}{32}$	$\frac{11}{32}$	$\frac{12}{32}$	$\frac{13}{31}$	$\frac{13}{35}$
泗湖	$\frac{13}{36}$	$\frac{13}{37}$	$\frac{15}{36}$	$\frac{12}{38}$	$\frac{14}{39}$	$\frac{13}{39}$
誼梧	$\frac{8}{33}$	$\frac{10}{33}$	$\frac{11}{35}$	$\frac{13}{33}$	$\frac{14}{35}$	$\frac{13}{33}$
朴子	$\frac{11}{29}$	$\frac{13}{28}$	$\frac{13}{31}$	$\frac{15}{31}$	$\frac{16}{34}$	$\frac{15}{35}$

## 鰲鼓雨量站 (C1M470)

累積雨量/降雨事件代號

100	4549	166	4549	204	4549	291	4549	380	4549	529	4202
82	6065	152	6065	178	6065	230	6065	334	4202	464	4549
68	7442	97	5270	141	4202	212	4202	284	4201	412	6065
68	5270	97	1243	127	1243	132	4908	269	6065	408	4550
64	5759	96	4202	115	4201	178	5344	246	4908	338	4909
63	1961	95	5337	112	4908	175	1243	240	5344	322	4908
62	2796	90	4201	108	6727	164	4201	218	1985	317	4201
60	1243	88	4908	108	2042	148	6727	214	4627	296	4627
56	4899	86	1876	108	5270	148	1984	208	6417	288	4628
55	5337	82	5724	100	5337	142	4627	203	1984	282	6066
54	890	80	7546	96	5344	138	5688	194	1243	279	5337
54	4908	76	4584	90	4256	133	6417	172	5336	274	5344
52	4202	76	2042	90	5688	130	2042	168	6727	244	1985
52	5633	75	1984	90	211	125	4256	164	2043	244	6417
51	5724	74	6727	90	7111	124	211	162	6064	243	5345
50	2042	73	7538	88	1984	114	1985	162	1643	239	1644
50	5759	72	5759	88	5759	113	7538	159	6816	238	1643
50	4584	71	890	88	890	113	113	158	5688	214	1984
50	1876	70	70	87	87	113	113	158	5688	211	7547
49	5336	70	70	87	87	113	113	158	5688	209	891
48	7546	70	70	87	87	113	113	158	5688	208	1309
48	4202	70	70	87	87	113	113	158	5688	208	1309
48	4202	70	70	87	87	113	113	158	5688	204	6817
47	4256	69	69	87	87	113	113	158	5688	203	6418
46	7538	68	7538	87	87	113	113	158	5688	203	6418
46	1644	68	1644	87	87	113	113	158	5688	200	5689
45	4550	68	5344	87	87	113	113	158	5688	200	1244
44	5290	68	5688	87	87	113	113	158	5688	199	1243
44	3790	67	7111	75	75	100	100	138	5270	198	7106
44	1984	66	5290	74	74	100	3183	136	2042	196	4256
43	211	66	1965	74	211	98	5336	132	162	184	6064
42	6727	65	5644	73	3183	96	4550	131	5633	182	6816
41	2376	64	2075	72	5759	94	1309	130	1309	180	4203
40	1965	64	5001	72	1961	90	3183	128	6418	180	7539
40	4158	62	3087	71	8179	90	6385	127	5337	179	5336
40	4851	62	3872	71	5290	90	2377	126	7538	179	890
40	1840	62	3868	70	7442	89	7824	126	6817	178	7548
40	75	62	5633	70	6385	89	3505	125	2415	172	2043
39	5344	60	4899	70	5644	88	5724	124	211	171	5751
38	7806	59	3133	68	5633	88	3868	120	4584	168	6727
38	7111	58	3790	68	3183	88	1876	120	3133	166	5688
37	5688	57	7106	68	2766	87	3872	119	7539	166	4584
36	4546	55	8179	67	2075	87	3504	119	3183	159	4955
36	1928	55	7806	66	5001	86	5644	116	2377	157	7546
36	4627	55	6417	66	1965	86	1644	113	589	156	7111

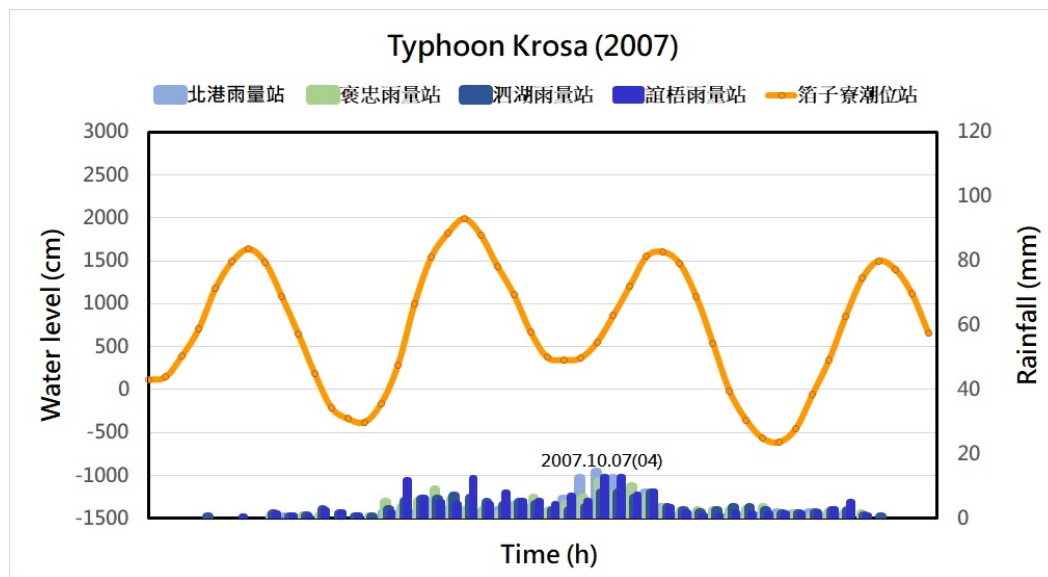
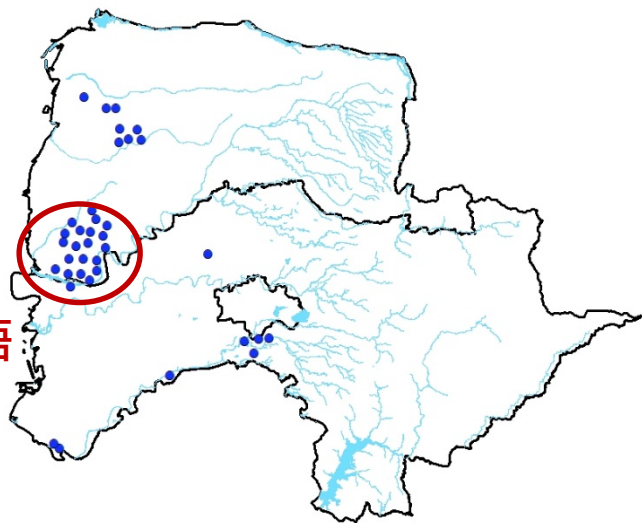


右表為1993-2015之50大強降雨事件

不同延時: 1 h 3 h 6 h 9 h 12 h 24 h

# 淹水事件 (未達降雨警戒但有淹水)

Typhoon Krosa (2007)



誼梧 (口湖鄉)

時間	雨量	警戒	
		二級	一級
1H	0	40	50
3H	0	80	90
6H	0	110	130

## 二級警戒：

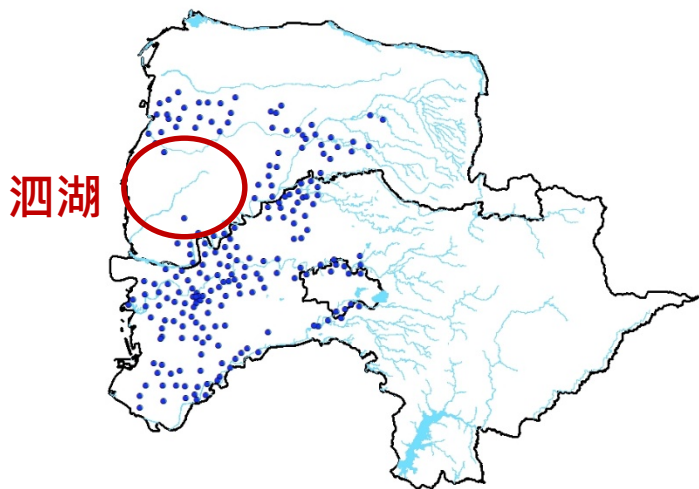
轄內易淹水村里及道路可能三小時內開始積淹水。

## 一級警戒：

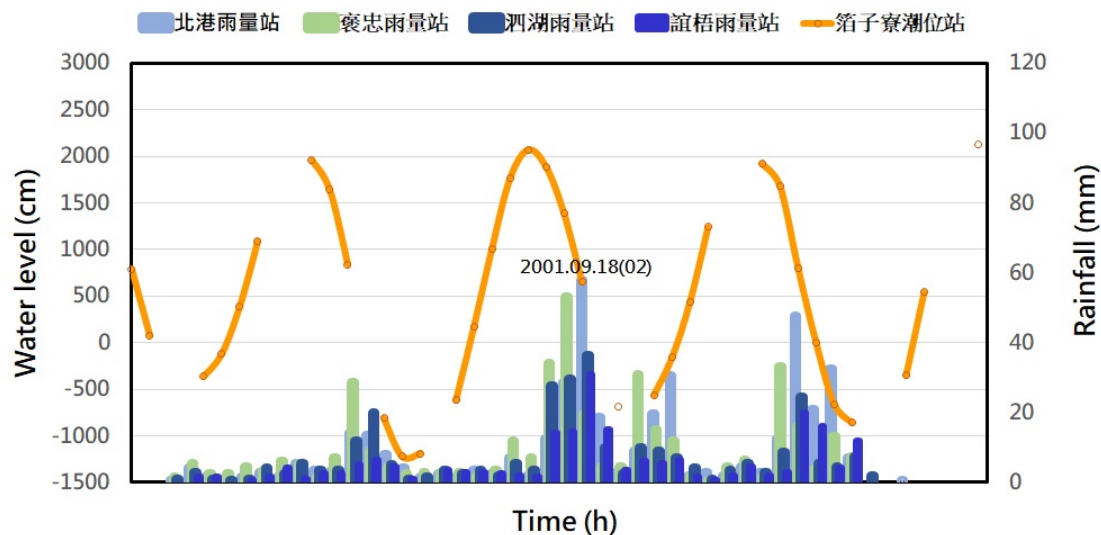
轄內易淹水村里及道路可能已經開始積淹水。

# 淹水事件 (達降雨警戒但未淹水)

Typhoon Nari (2001)



Typhoon Nari (2001)



## 四湖 (四湖鄉)

時間	雨量	警戒	
		二級	一級
1H	0	40	50
3H	0	80	90
6H	0	110	130

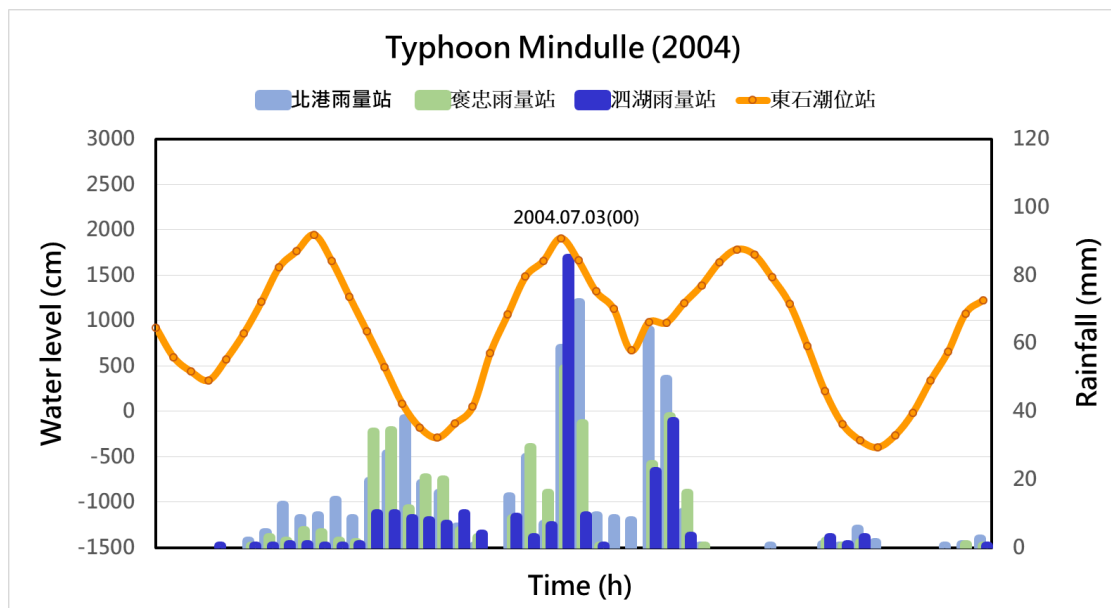
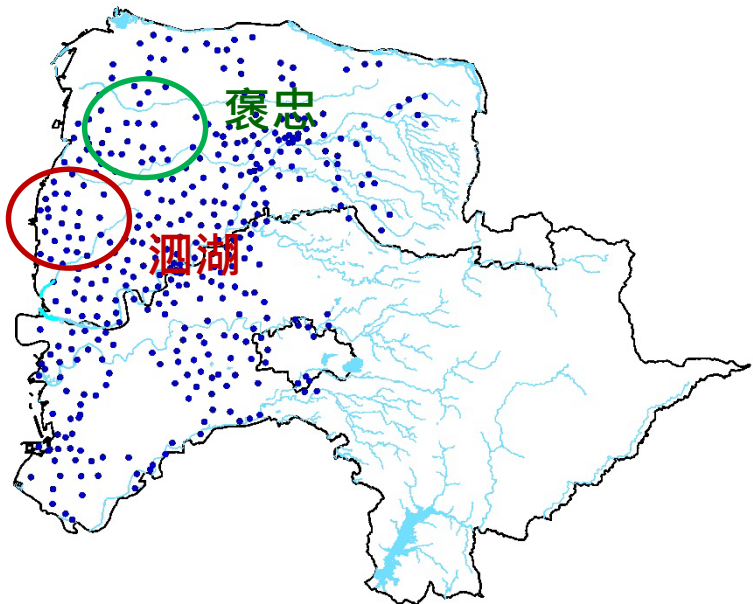
### 二級警戒：

轄內易淹水村里及道路可能三小時內開始積淹水。

### 一級警戒：

轄內易淹水村里及道路可能已經開始積淹水。

# 淹水事件



## 四湖 (四湖鄉)

時間	雨量	警戒	
		二級	一級
1H	0	40	50
3H	0	80	90
6H	0	110	130

## 北港 (北港鎮)

時間	雨量	警戒	
		二級	一級
1H	0	50	60
3H	0	90	100
6H	0	120	140

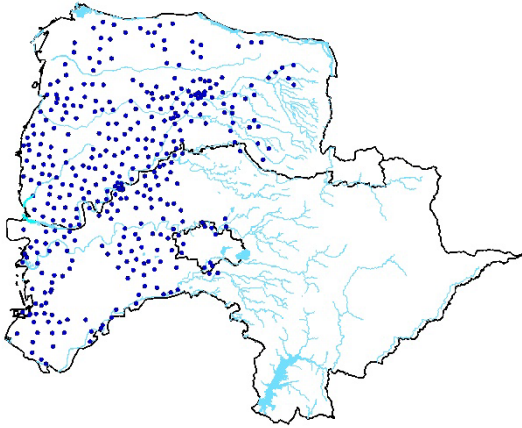
## 褒忠 (褒忠鄉)

時間	雨量	警戒	
		二級	一級
1H	0	50	60
3H	0	110	120
6H	0	150	170

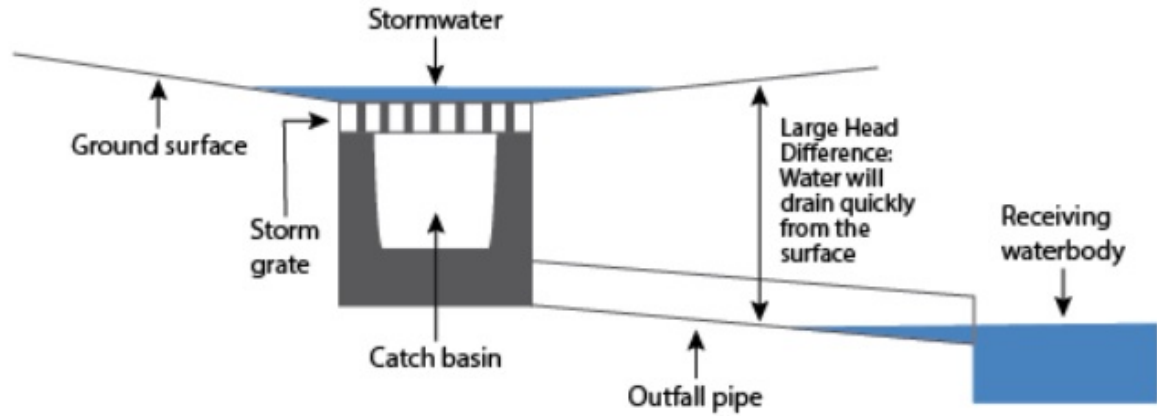


# 淹水成因 (雙影響因子)

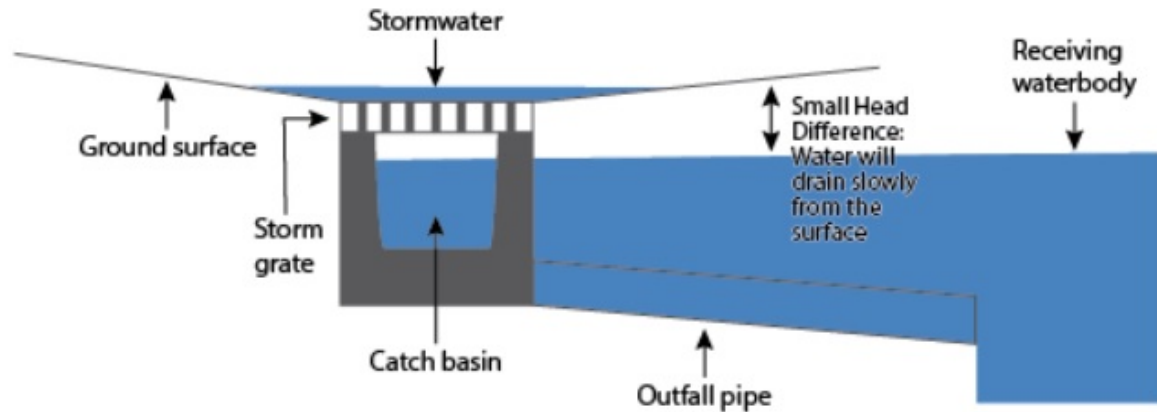
**Flooding** is caused by heavy rainfall overwhelming drainage capacity



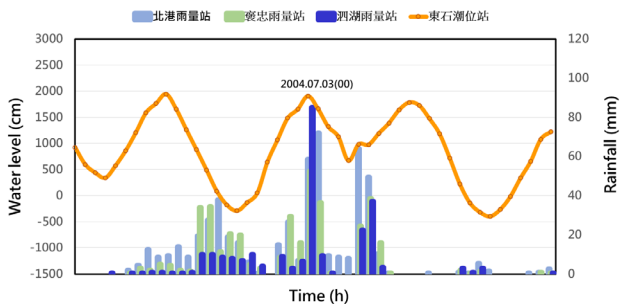
## Low Tide Scenario



## High Tide Scenario



Typhoon Mindulle (2004)



## Copula describes the dependence structure between the variables

- Random variables: X and Y
- Marginal cumulative distribution functions of X and Y:  $F_X(x)$  and  $F_Y(y)$
- The continuous joint probability distribution function (**Joint CDF**):

$$F_{XY}(x, y) = C(F_X(x), F_Y(y))$$

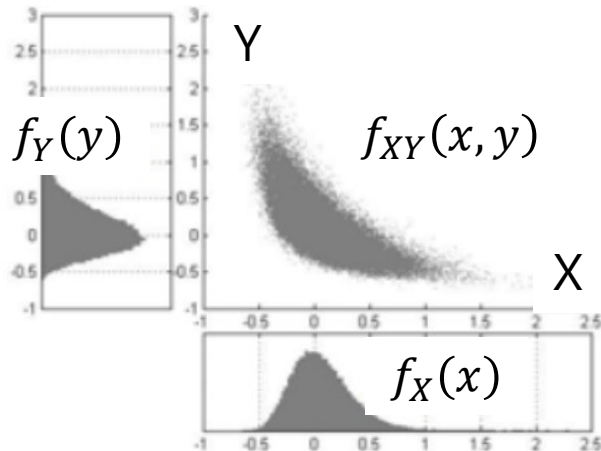
- Joint probability density function (**Joint PDF**)

$$f_{XY}(x, y) = \frac{\partial^2 F_{XY}(x, y)}{\partial x \partial y}$$

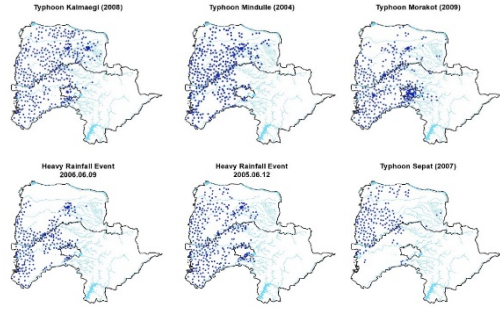
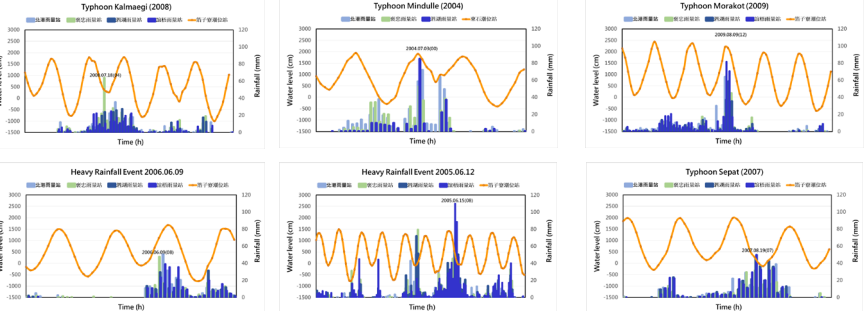
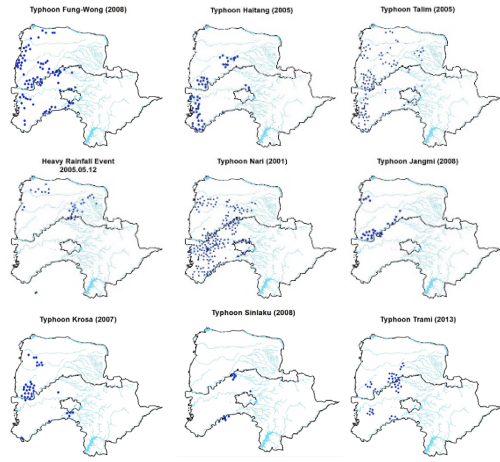
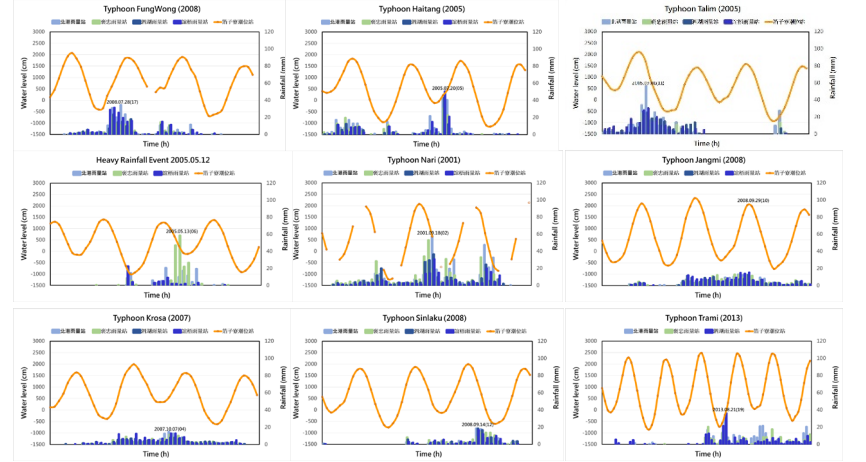
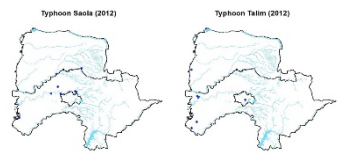
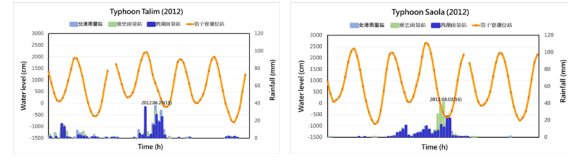
...

$$f_{XY}(x, y) = c(u, v) f_X(x) f_Y(y)$$

where  $c(u, v)$  is the copula density function



# 淹水事件 和 雨量、潮位

<h2>淹水情境</h2>	<h2>淹水位置</h2>	<h2>雨量&amp;潮位時序圖</h2>
<p><b>強降雨</b> + <b>大潮</b></p>		
<p><b>強降雨</b> + <b>中水位</b></p> <p>-----</p> <p><b>降雨</b> + <b>高水位</b></p>		
<p><b>強降雨</b> + <b>低水位</b></p>		

## 資料採樣方式

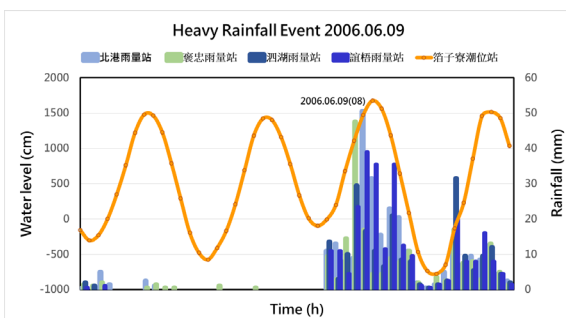
資料位置：雲嘉示範區

採樣資料：時雨量、時潮位

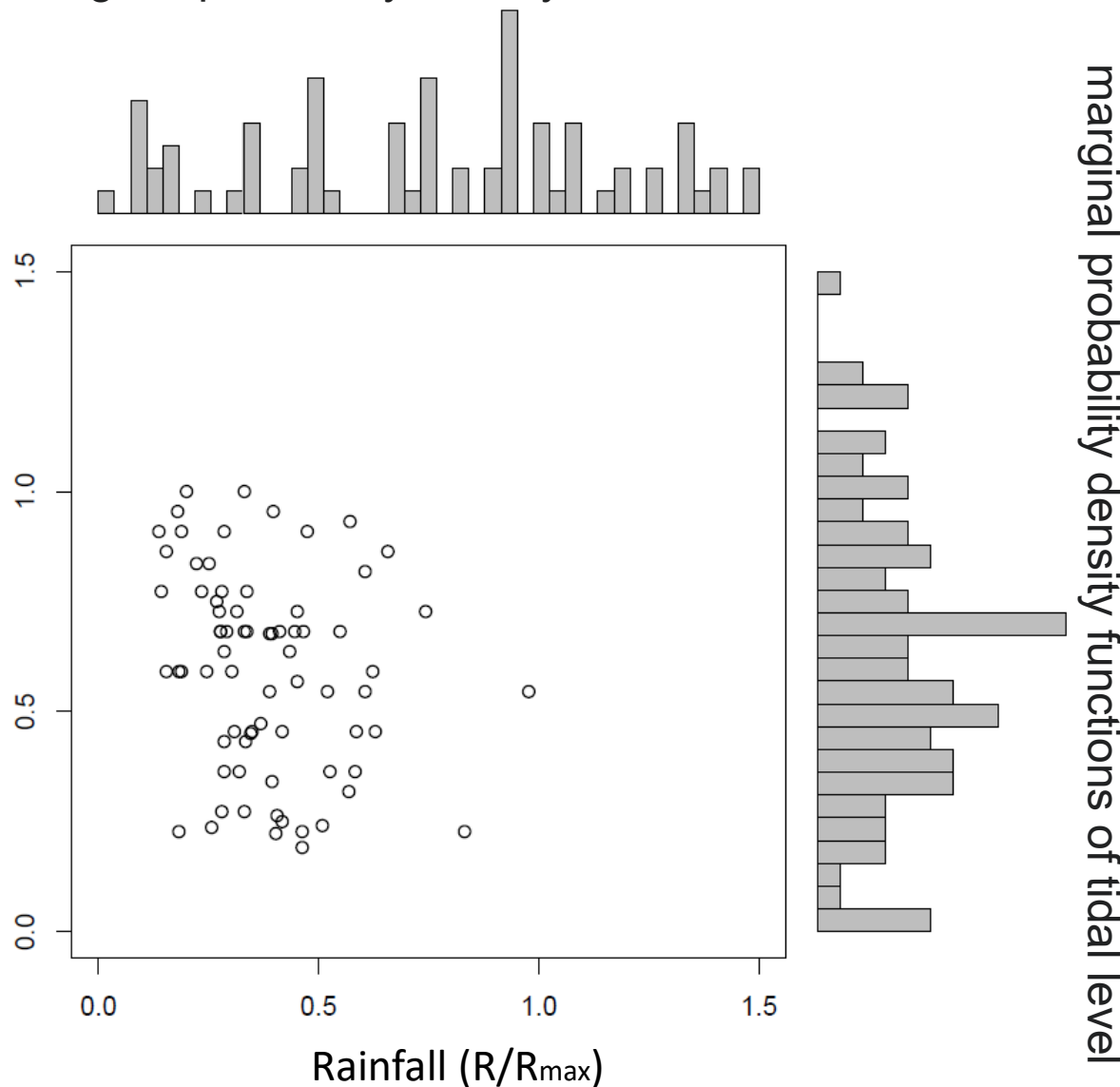
採樣區間：6小時

採樣依據：6小時區間中  
有強降雨或大潮

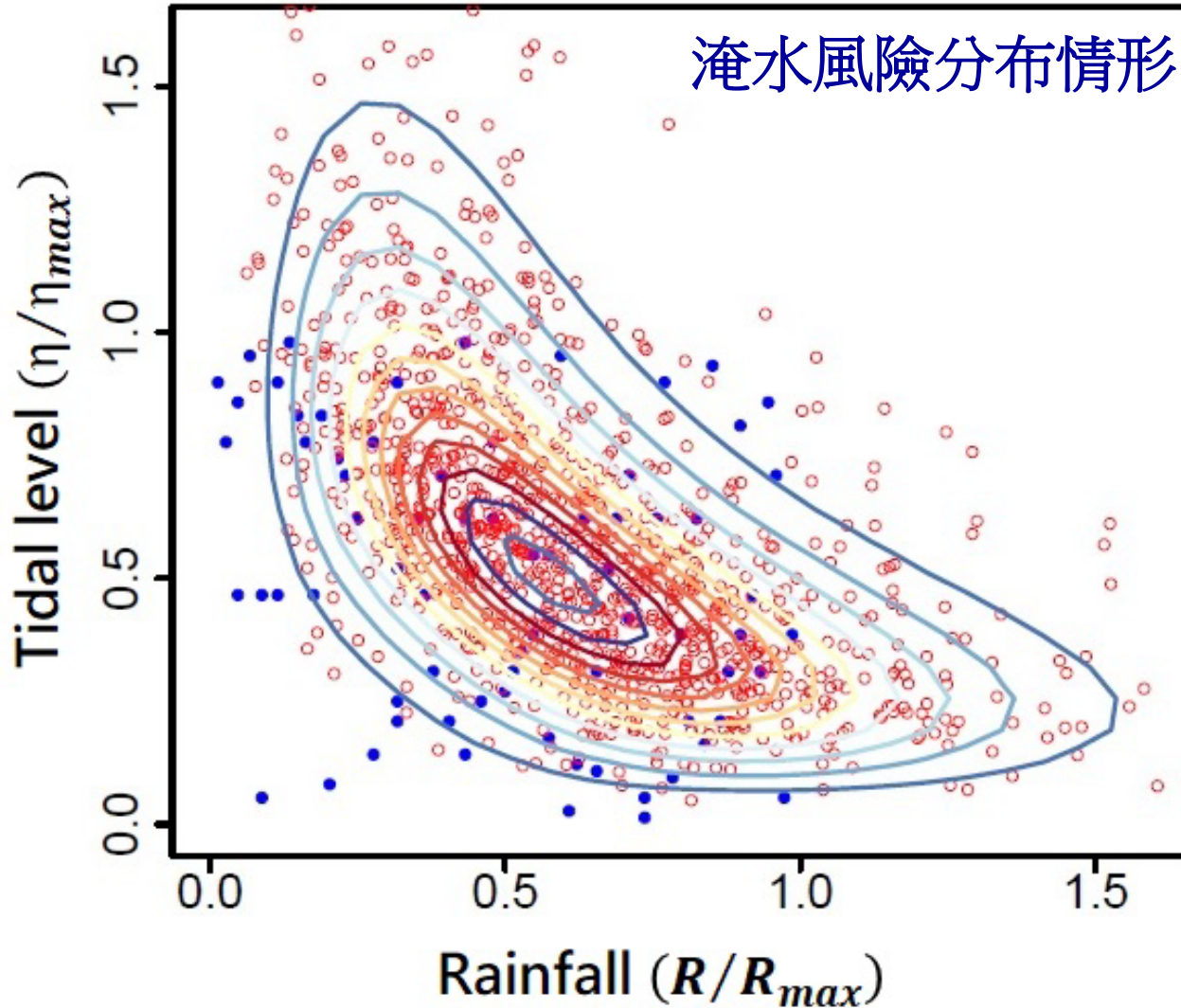
Tidal level  
( $L/L_{max}$ )



marginal probability density functions of rainfall



Observation/Simulation:Blue/Red



最適聯合函數：  
Frank Copula

聯合函數參數：  
parameter=-4.83

資料相依性：  
Kendall's  $\tau = -0.44$



敬請指正

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Thank you for your time and attention