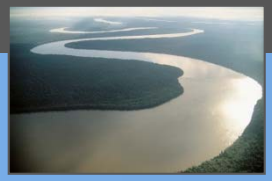
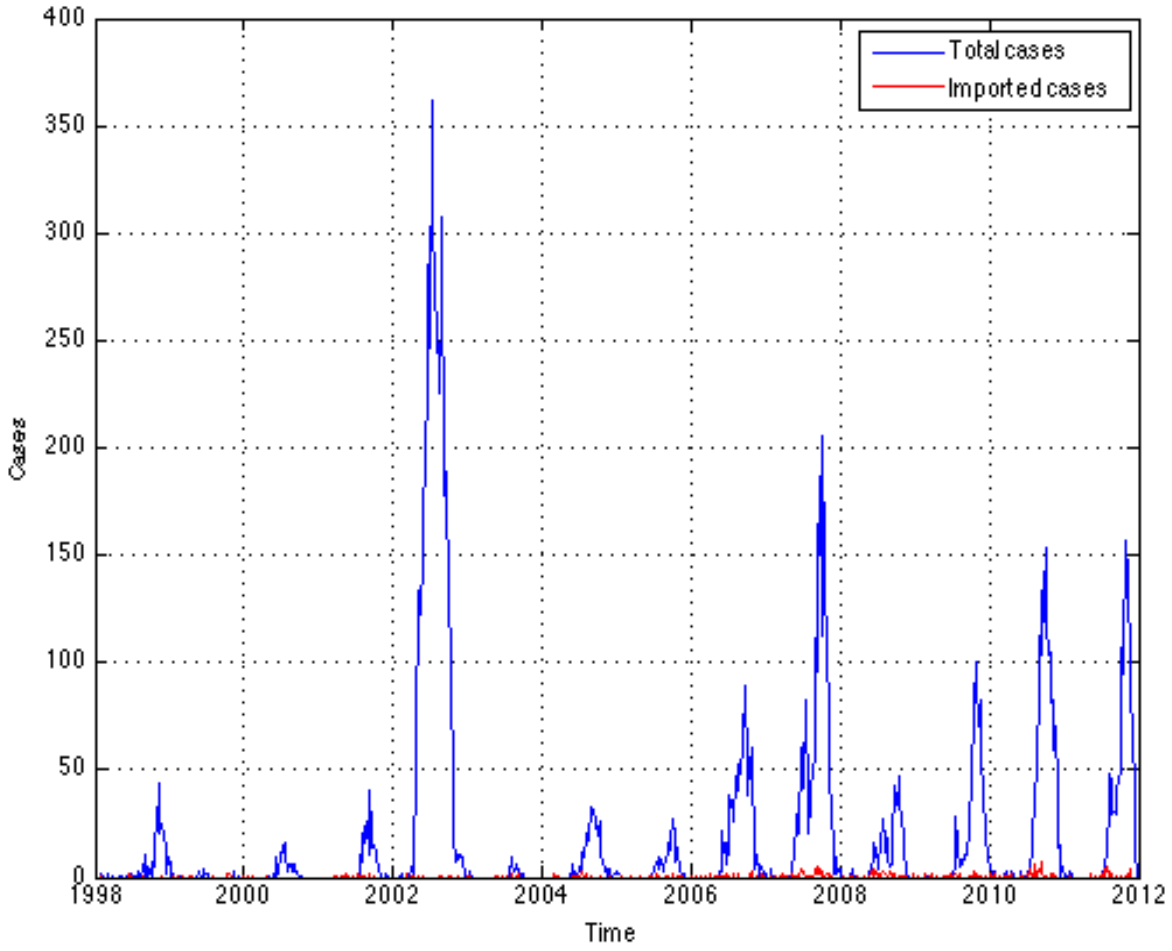



南部登革熱時空間傳播影響探討

台灣大學生物環境系統工程學系
余化龍 副教授

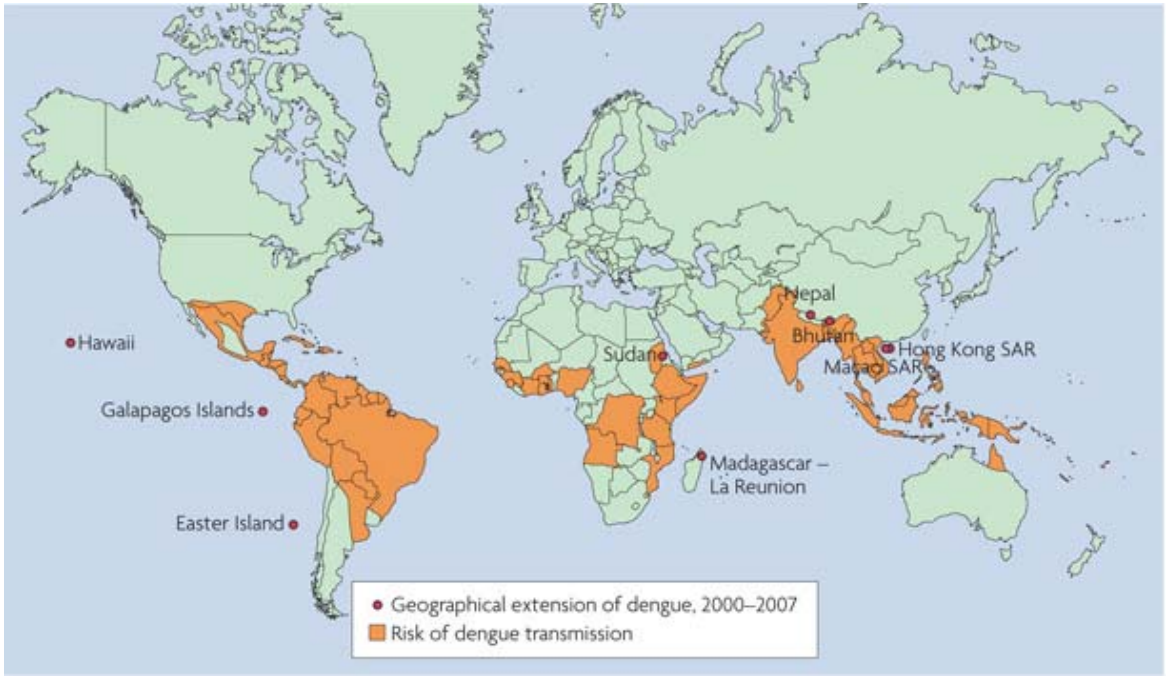
日期:2014/05/19

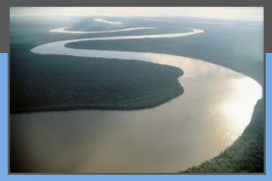
台灣地區登革熱疫情


Total cases
Imported cases
Cases
Time
0
50
100
150
200
250
300
350
400
1998
2000
2002
2004
2006
2008
2010
2012

Introduction - Dengue Fever (DF)

- Tropical & subtropical climate regions
- Over 40% of world's population at risk

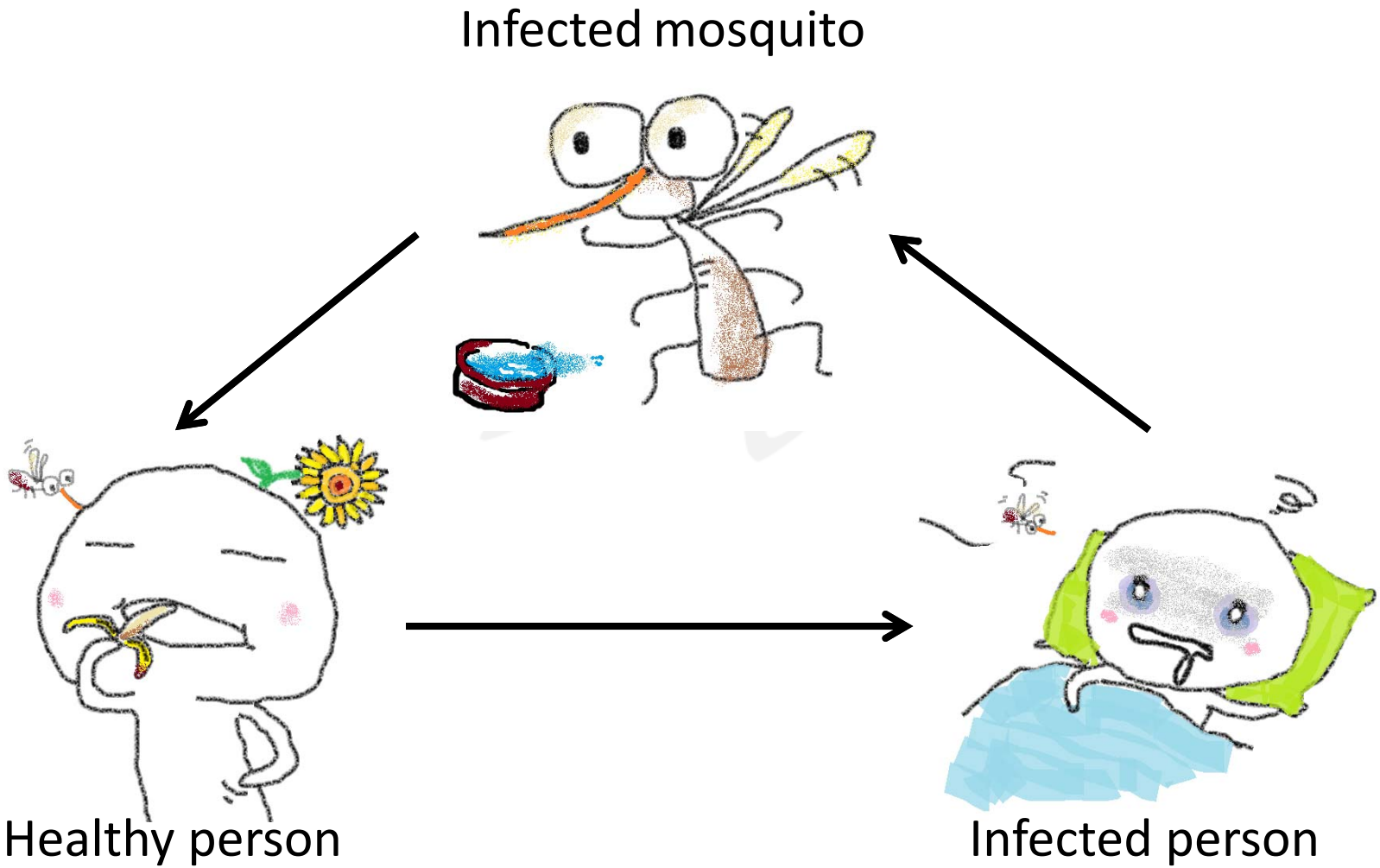




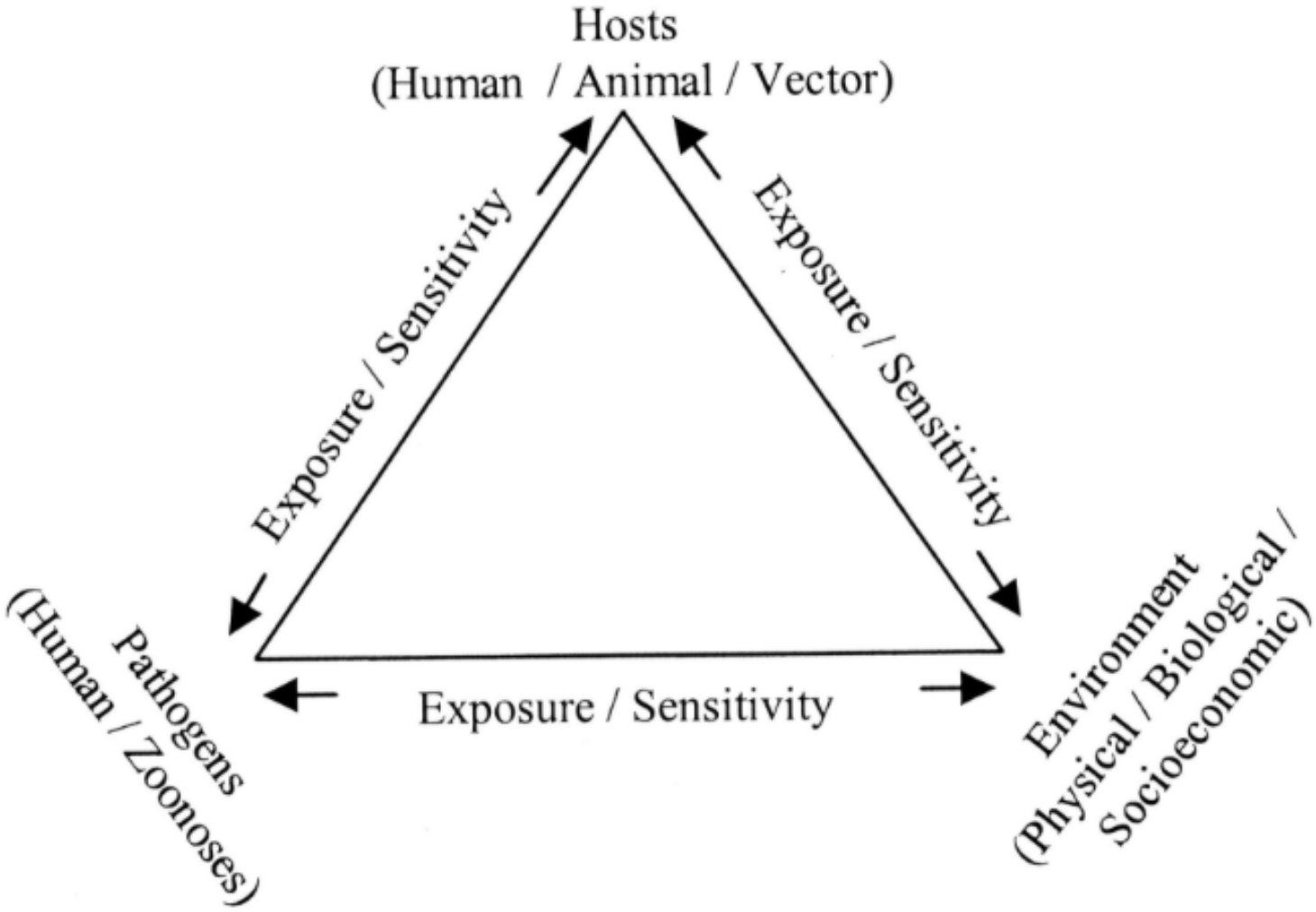

Introduction - Dengue Fever (DF)

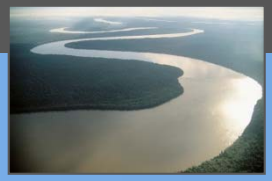
- Mosquito-borne disease
- The Virus
  - Four distinct serotypes
- The Mosquitos
  - *Aedes aegypti*
  - *Aedes albopictus*
- No specific treatment
- Effectively Anti-mosquito measures

Introduction - Transmission



Essentials of vector-borne disease transmission

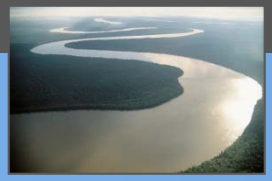





氣象變異的影響

- 氣象因子如何影響傳染病傳播機制? (WHO, 2005)
  - Disease pathogen
    - Increasing temperature can speed up the development of pathogen
  - Disease vector
    - Population increases at the suitable temperature, rainfall, humidity conditions
  - Human behavior
    - Activity pattern depends on weather conditions

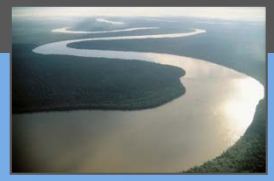
- 氣候與氣象變數可用來預測傳染病疫情 (WHO, 2005)
  - 虐疾、霍亂、登革熱、流感, …




氣候氣象對登革熱疫情影響分析 – (1)

» 氣象因子在蚊子的生態、發展以及存活扮演很重要的角色 (Patz, *et al.*, 1998; Reiter, 2001), Kuhn, *et al.* (2005b)提到登革熱的發生對氣象狀況(溫度、濕度、降雨量)有很高的敏感度

Authors	Published Year	Journal	Location	Sampling time	Correlated Variables	Method
Arcari et al.	2007	Singapore Journal of Tropical Geography	Indonesia	1992-2001	Rainfall, rainfall, temperature, humidity, SOI(south oscillation index)	Multiple regression
Halide and Ridd	2008	International Journal of Environmental Health Research	Indonesia	1998-2005	Humidity, temperature, SST(sea surface temperature)	Multiple regression with lags
Hurtado-Dı´az et al.	2007	Tropical Medicine and International Health	Mexico	1995-2003	Temperature, rainfall, SST, SOI	Autoregressive models
Katrin Kuhn et al.	--	WHO Report	--	--	Temperature, humidity, rainfall.	--
Luz et al.	2008	The American Society of Tropical Medicine and Hygiene	Brazil,	1997-2004	Temperature, rainy days	Box-Jenkins approach to ARIMA
Smith	2004	PLoS Biology	--	--	Rainfall, temperature, humidity.	--
Wu et al.	2007	Acta Tropica	Taiwan	1998-2003	Temperature; Relative humidity	ARIMA

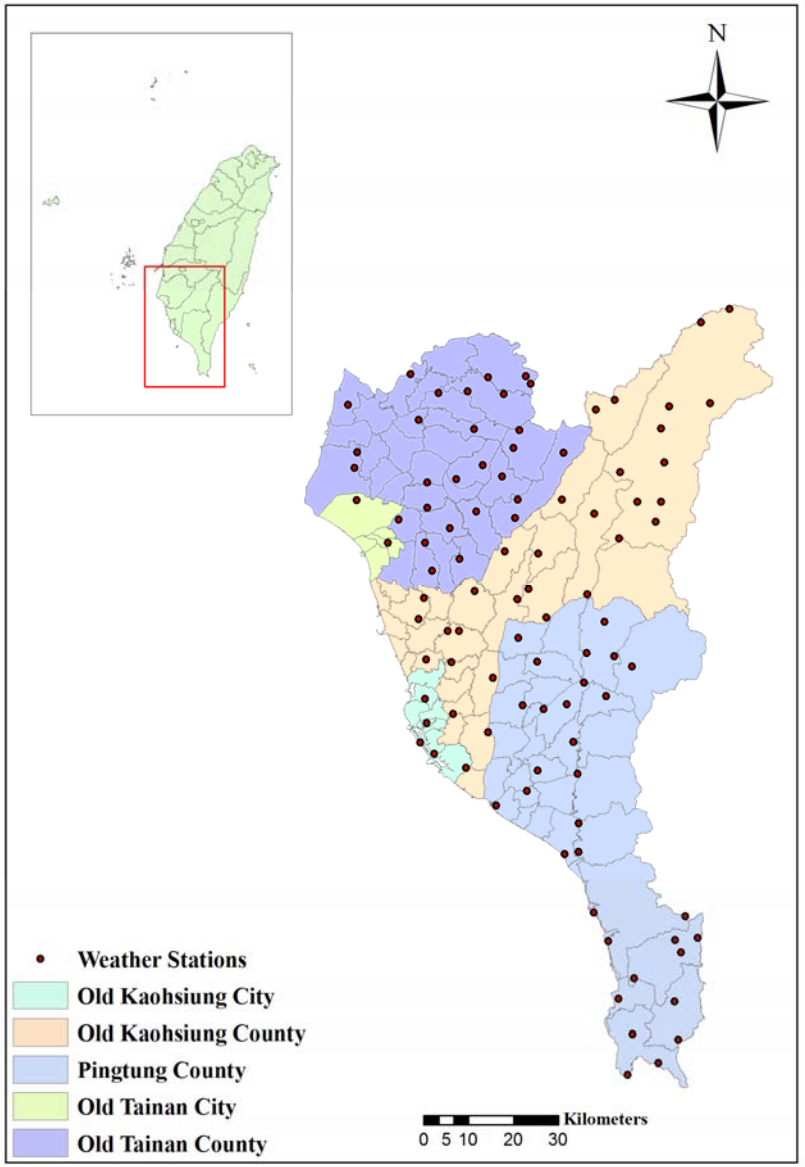



氣候氣象對登革熱疫情影響分析 – (2)

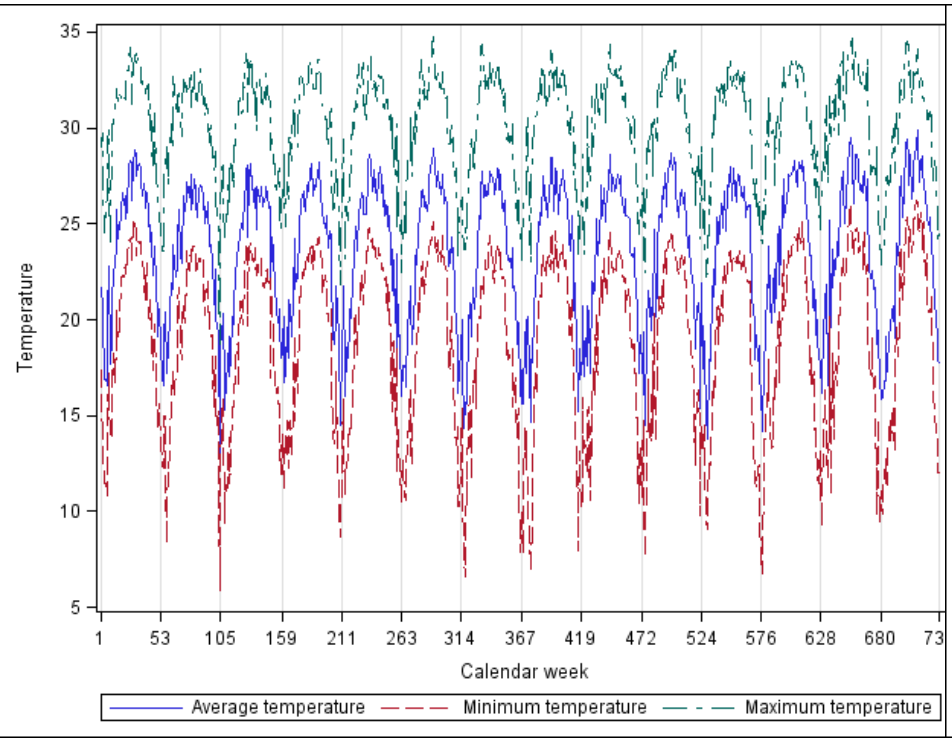
Authors	Published Year	Journal	Location	Sampling time	Correlated Variables	Method
Wang and Chen	1997	中華公共衛生雜誌	Southern Taiwan	1961-1994	Breteau index Average year temperature Average mouthly temperature Mean lowest mouthly temperature	Information value
Wu et al.	2007	Acta Tropica	Southern Taiwan ,Kaohsuing City	1998-2003	Monthly temperature deviation Relative humidity Vector density record Average temperature Socio-ecological cha	Autoregressive integrated moving average (ARIMA) models
Tseng et al.	2009	Climatic Change	Taiwan	Jan. 2000~ Feb. 2006	Breteau index Average monthly temperature Average monthly humidity Average monthly rainfall Average annual patient number	Panel data model Contingent Valuation Method
Wu et al.	2009	Science of the Total Evironment	Taiwan	1998-2006	Urbanization; Average temperature higher than 18 °C per year	Spatial Lag model
Yu et al.	2010	Stochastic Environmental Research and Risk Assessment	Southern Taiwan	2002–2006	Intercept Temperature Temperature Max temperature Log of rainfall SOI Breteau index	Bayesian Maximum Entropy analysis
Wu et.al	2010	Centers for Disease Control report	Southern Taiwan ,Kaohsuing City	2010	Precipitation Mean temperature Mean highest temperature Mean lowest temperature Breteau index	Information value

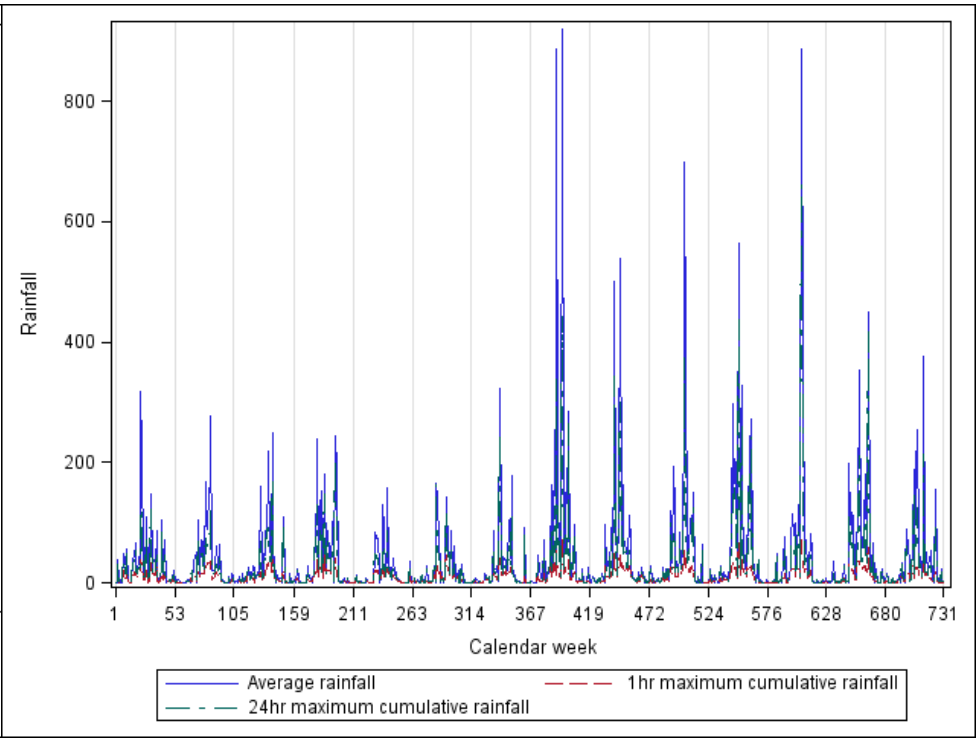
研究資料

- 每周各鄉鎮市登革熱病例數
- 氣象局人工與自動氣象觀測
- 1998-2011
- 氣象變數
  - 平均溫、最大溫、最低溫
  - 總雨量、連續24小時最大降雨、每小時最大降雨



研究變數

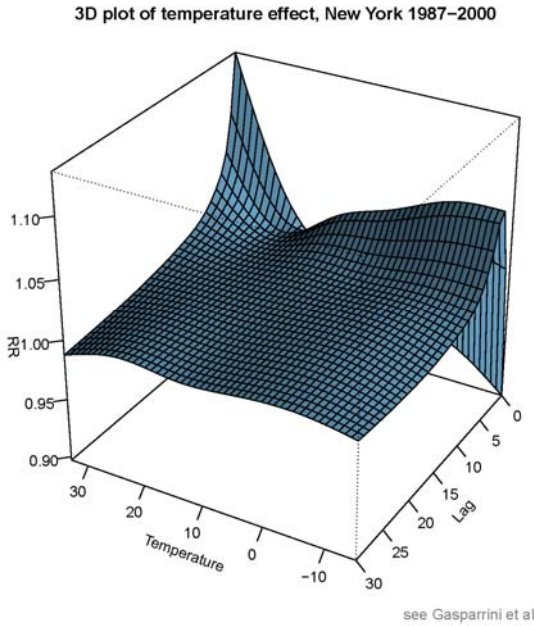

Temperature
35
30
25
20
15
10
5
1
53
105
159
211
263
314
367
419
472
524
576
628
680
73
Calendar week
Average temperature
Minimum temperature
Maximum temperature


Rainfall
800
600
400
200
0
1
53
105
159
211
263
314
367
419
472
524
576
628
680
731
Calendar week
Average rainfall
1hr maximum cumulative rainfall
24hr maximum cumulative rainfall

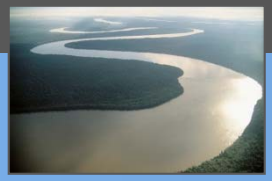
非線性分布延遲模型

- 探討不同時間氣象變數之變異對登革熱疫情之影響
- 非線性時間分佈架構 (Gasparrini, 2010)
- 以馬可夫隨機場探討空間自相關

$$\log(\mu_{ct}) = \alpha + \sum_{i=1}^{6}\sum_{j=0}^{15} s_j(x_{cij};\beta_j) + f(w) + f_{spat}(c) + \log(POP)$$



see Gasparrini et al. (2010)



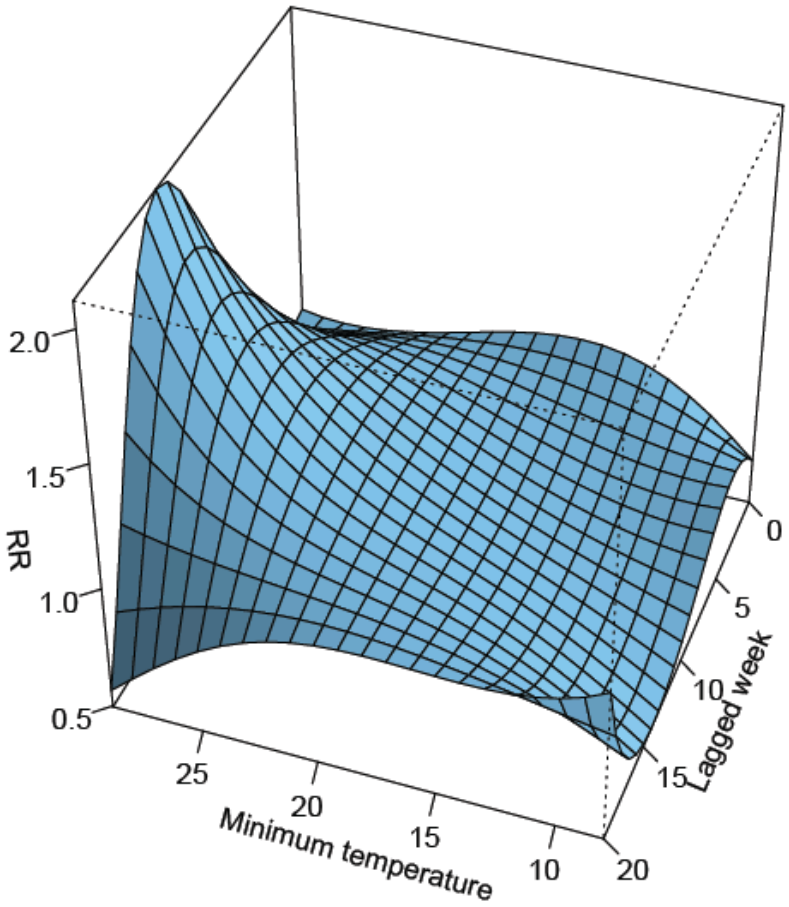

模式分析

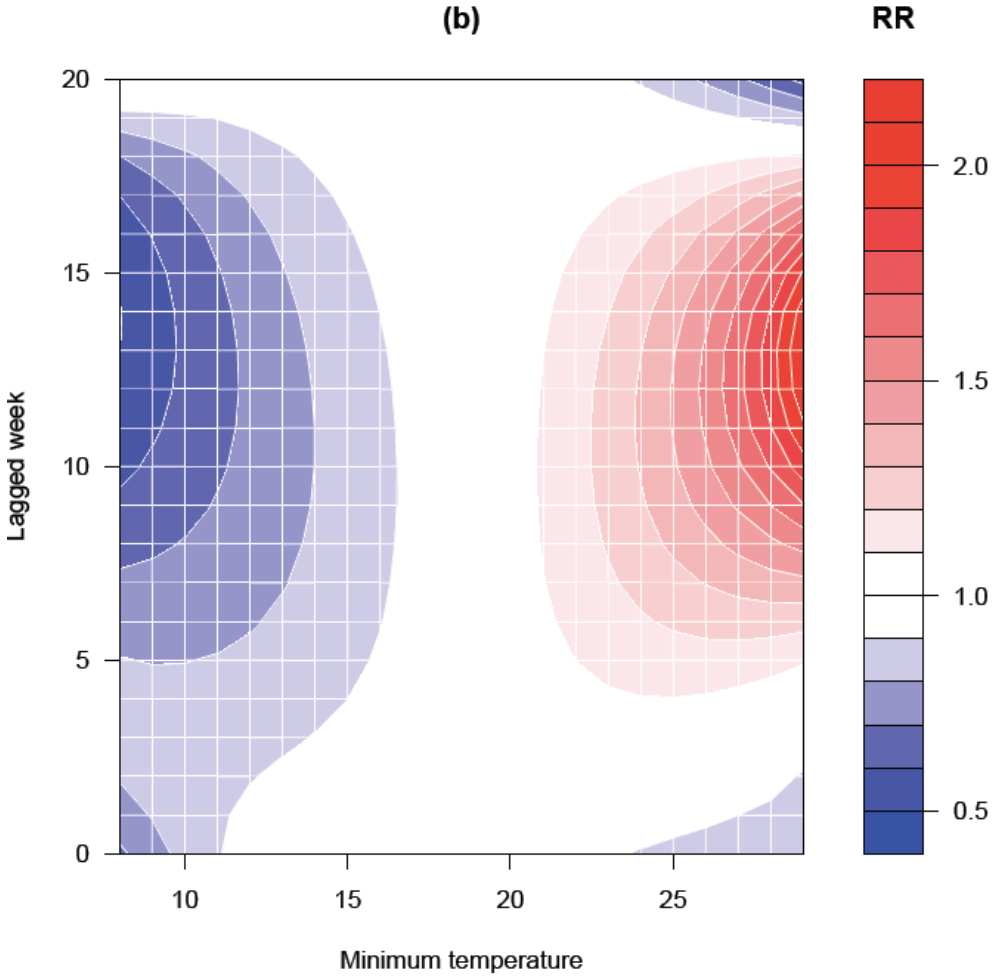
- 探討南部地區登革熱時空變異最適宜氣象變數
  - 每周最低溫
  - 每周最大24小時連續降雨

Model #	Temperature + Rainfall*	QAIC**	ΔQAIC
1	Mintemp + Maxcrain	1013.91	-
2	Mintemp + Maxrain	1021.33	7.42
7	Avgtemp + Maxcrain	1031.81	17.90
8	Avgtemp + Maxrain	1038.64	21.56
3	Mintemp + Avgrain	1035.47	24.73
9	Avgtemp + Avgrain	1054.29	40.38
4	Maxtemp + Maxcrain	1078.51	64.60
5	Maxtemp + Maxrain	1080.04	66.13
6	Maxtemp + Avgrain	1100.19	86.28

* Maxtemp = maximum temperature; Mintemp = minimum temperature; Avgtemp = average temperature; Maxcrain = 24hr maximum cumulative rainfall; Maxrain = 1 hr maximum cumulative rain fall; Avgrain = average rainfall

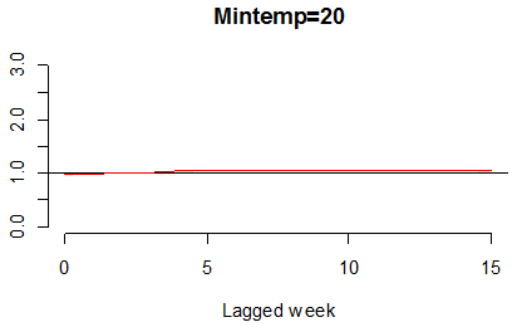
最低溫度與登革熱相對風險關係圖

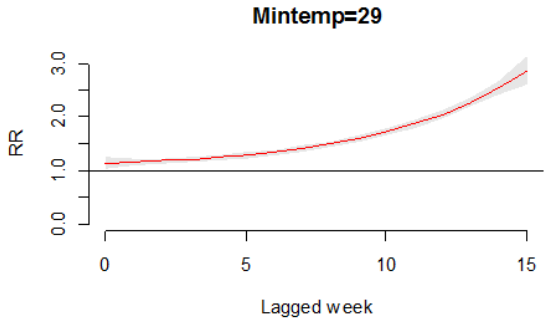




溫度變異對登革熱疫情的影響

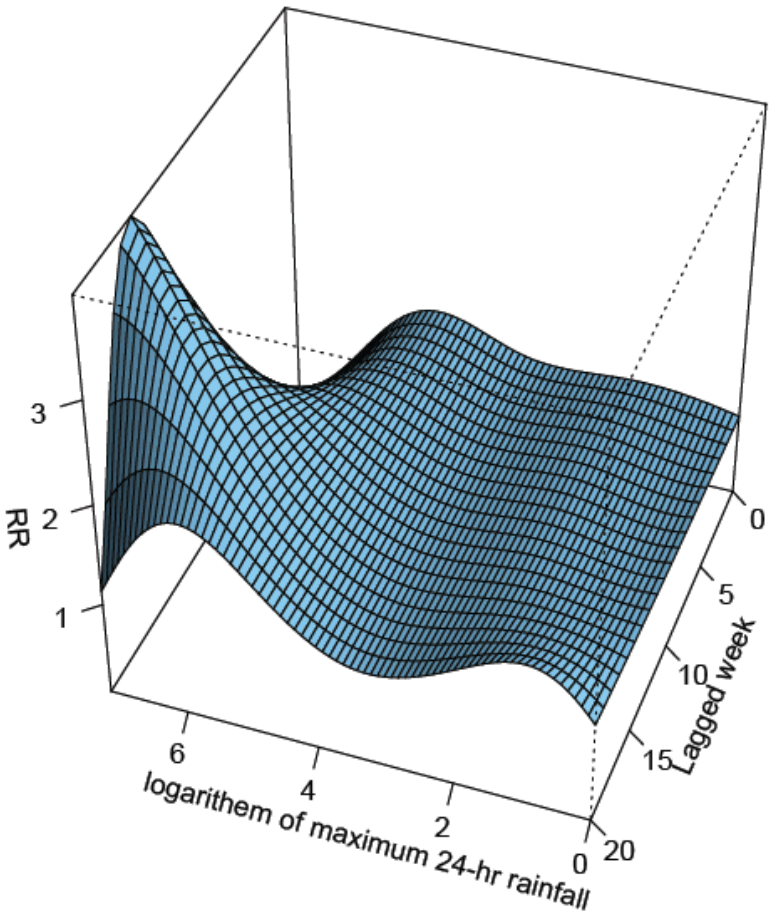
- 過去溫度對登革熱影響之研究
  - 登革熱適宜溫度 15度-35度 (Wu et al. 2007; Padmanabha et al. 2012)
  - 埃及斑蚊最佳溫度 27度-30度 (Yang et al. 2009a)
- 每周最低溫20度時，為登革熱相對風險增加之最低門檻

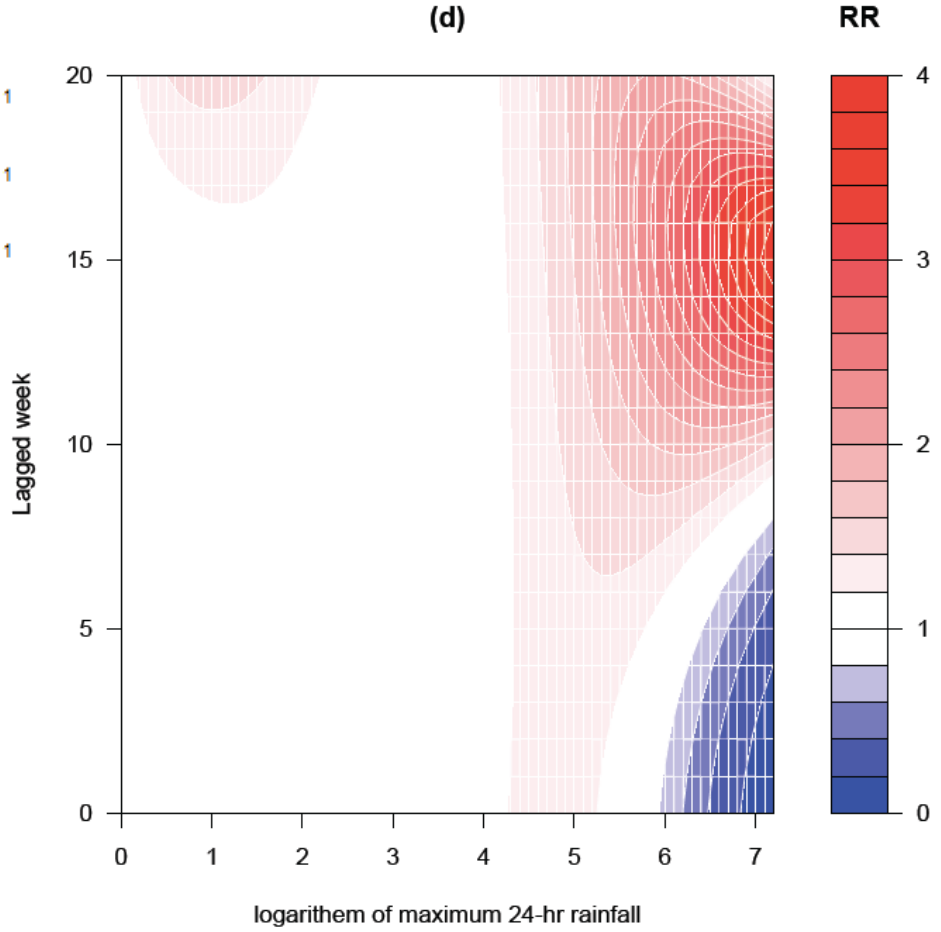


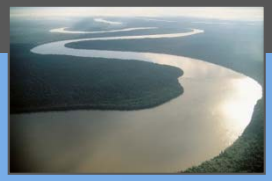


- 當每周最低溫超過20度，每周最低溫增加會
  - 增加登革熱發生之相對風險
  - 縮短溫度增加與登革熱疫情發生之時間間隔

每週24小時最大累積降雨量與登革熱相對風險關係圖



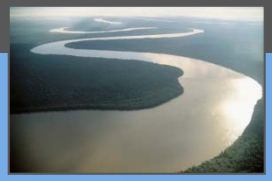





極端降雨對登革熱疫情的影響

- **降雨對登革熱的影響** (Reiter 2001; Lifson 1996; Smith et al. 2004; Wu et al. 2007; Yu et al. 2011)
  - 增加埃及斑蚊之棲息地
  - 極端降雨短期內會破壞埃及斑蚊棲息地

- **24小時最大降雨**
  - 超過50mm: 使登革熱相對風險開始增加
  - 超過350mm: 使短期登革熱風險降低約1-1.5個月，之後大增




雨量特報分級標準

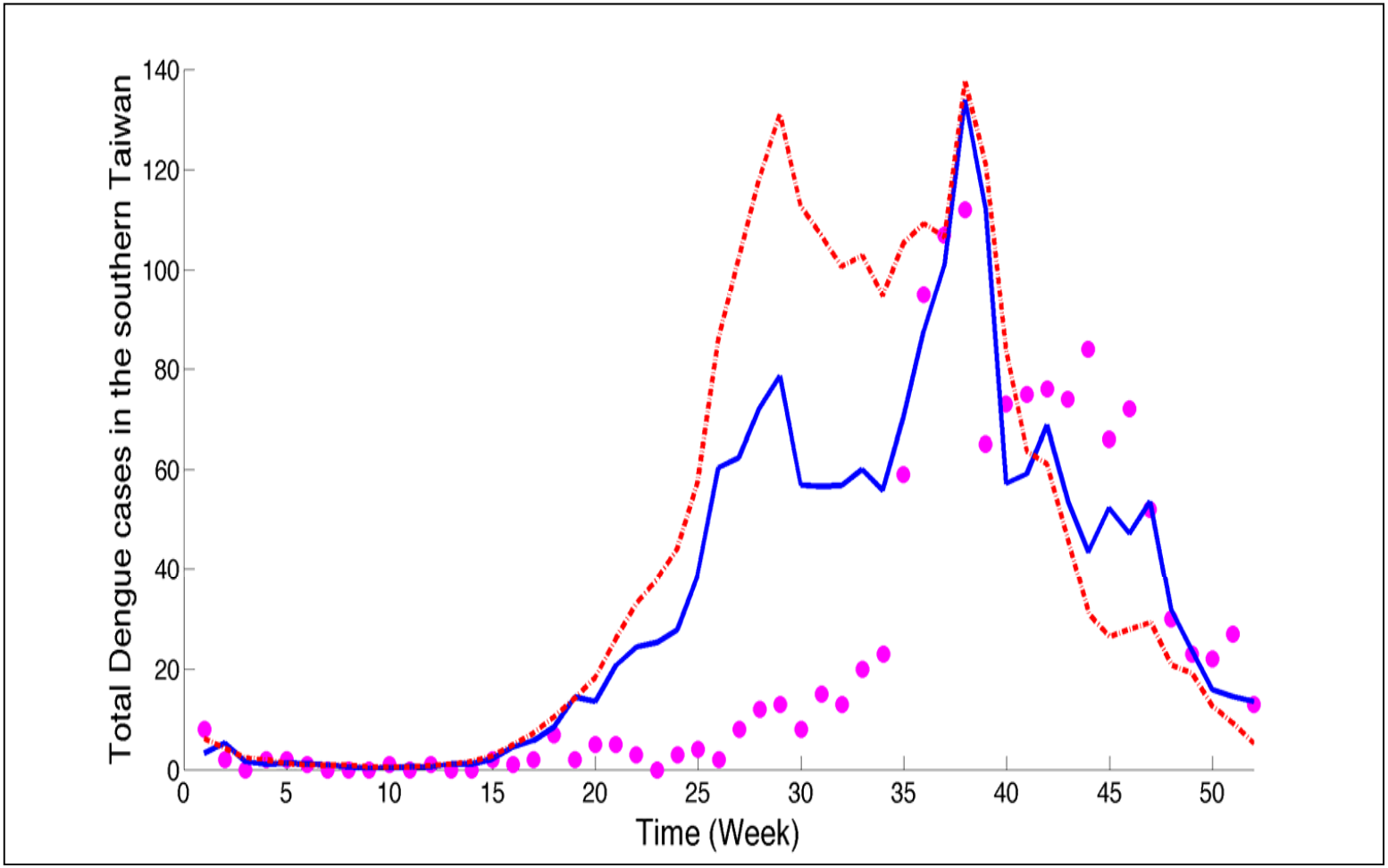
» 中央氣象局

中央氣象局雨量特報分級標準及24小時內累積雨量表	
大雨特報	50毫米以上
豪雨特報	130毫米以上
大豪雨特報	200毫米以上
超大豪雨特報	350毫米以上

» 全國各地區雨量警戒值 (天然災害停止上班與辦公辦法)

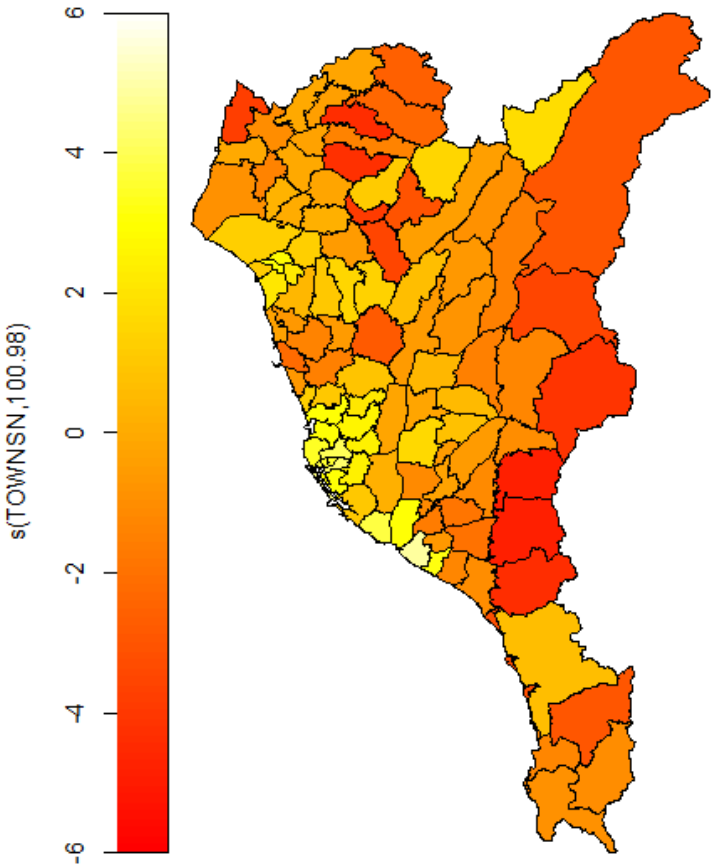
› 350mm (高雄縣市、台南縣市、屏東縣)

Real-time DF prediction

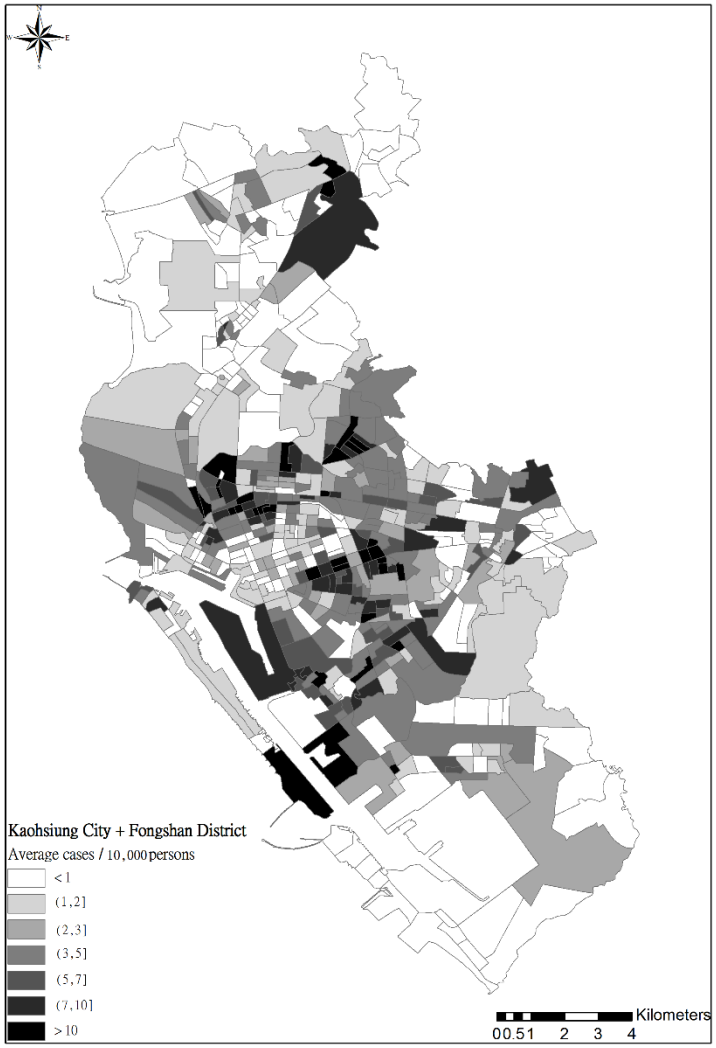


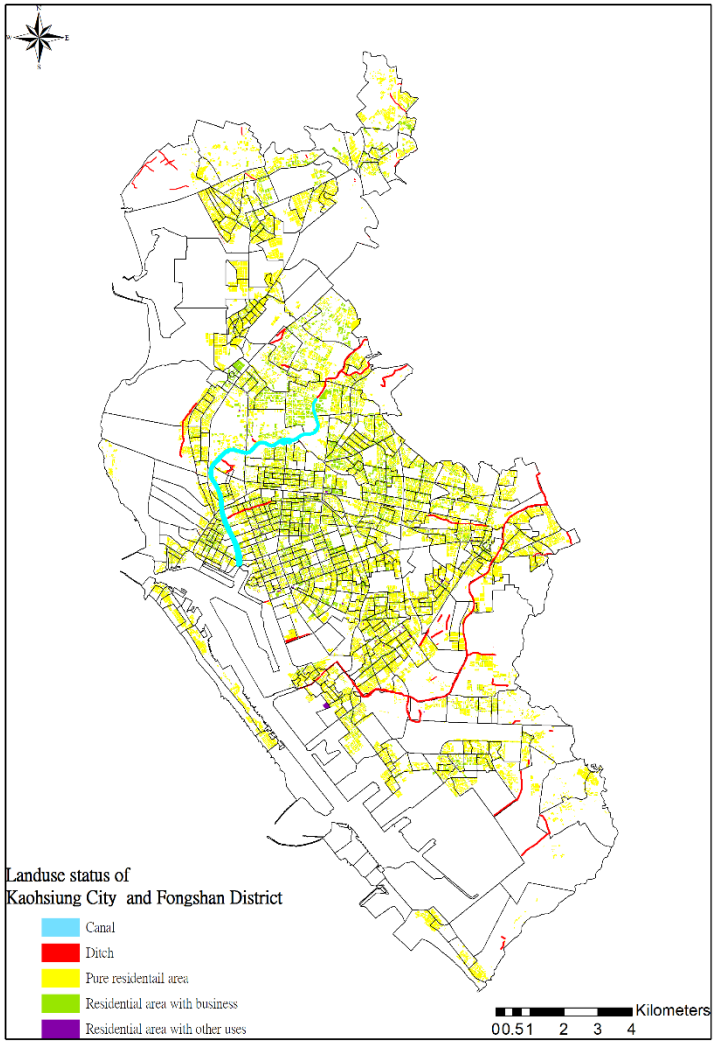
登革熱空間變異

- 風險較高之地區多為沿海岸之地區，尤以高雄市及台南市為主
- 由海岸向內慢慢遞減，最低值為靠近山脈地區

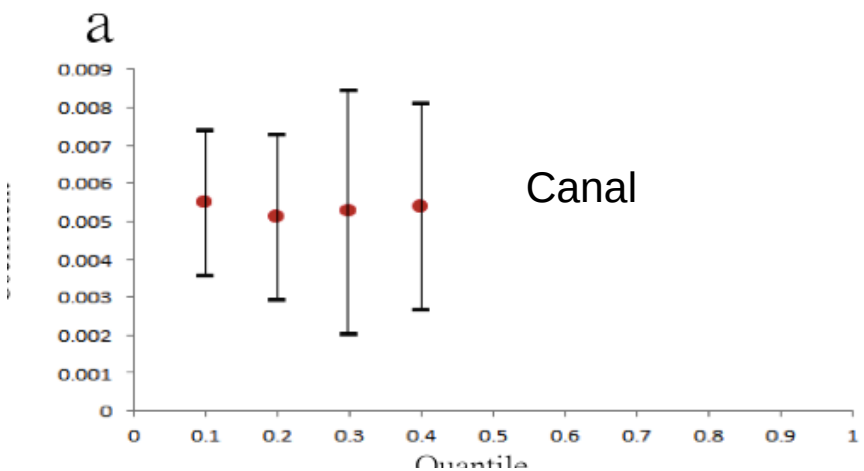


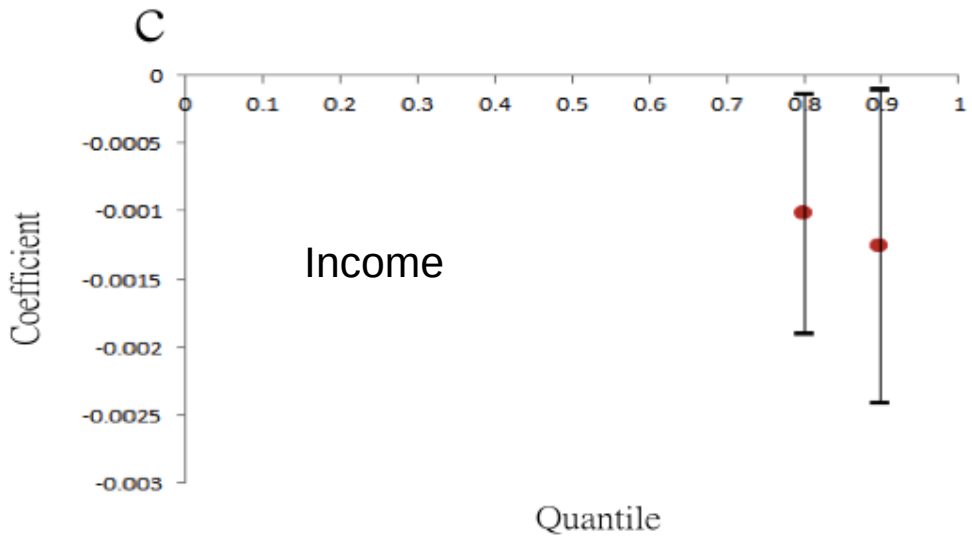
What affects the spatial DF distribution

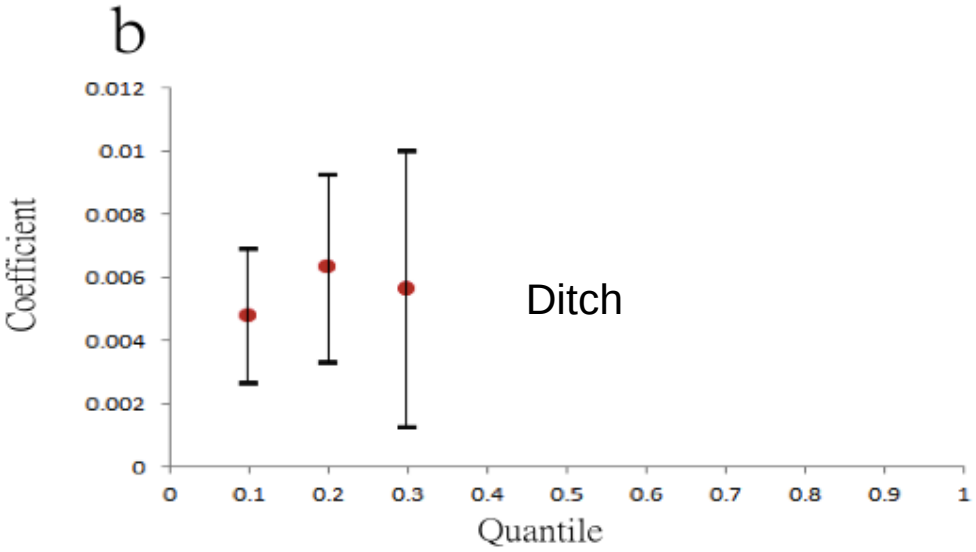




Major influential factors

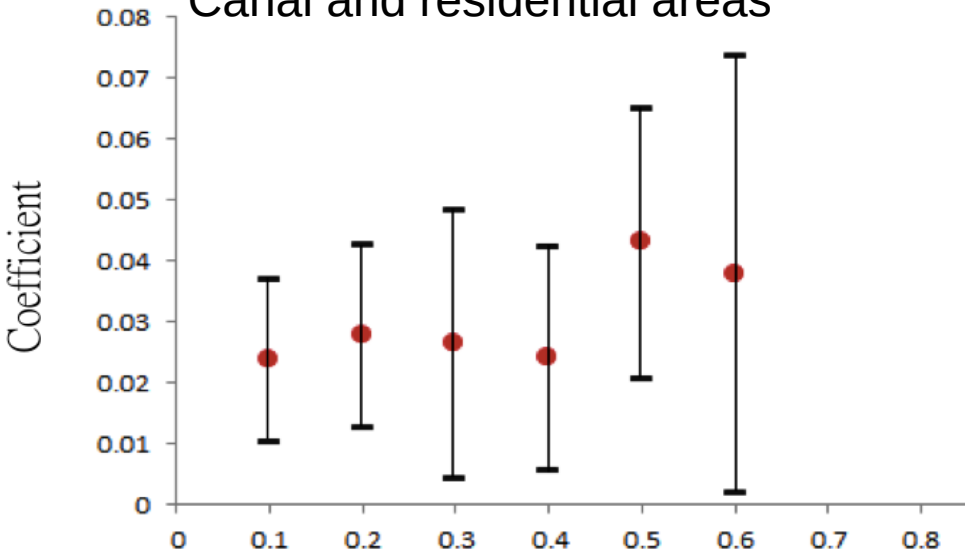




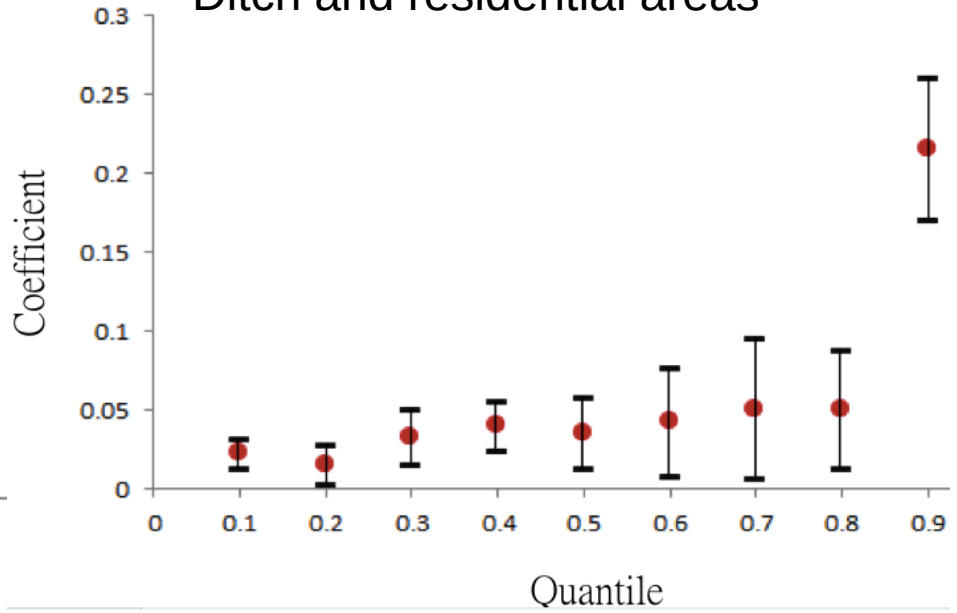


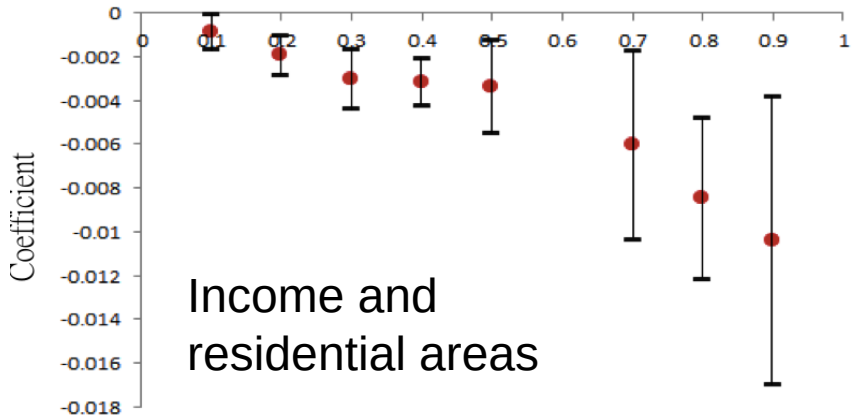
Major interactions between influential factors

Canal and residential areas



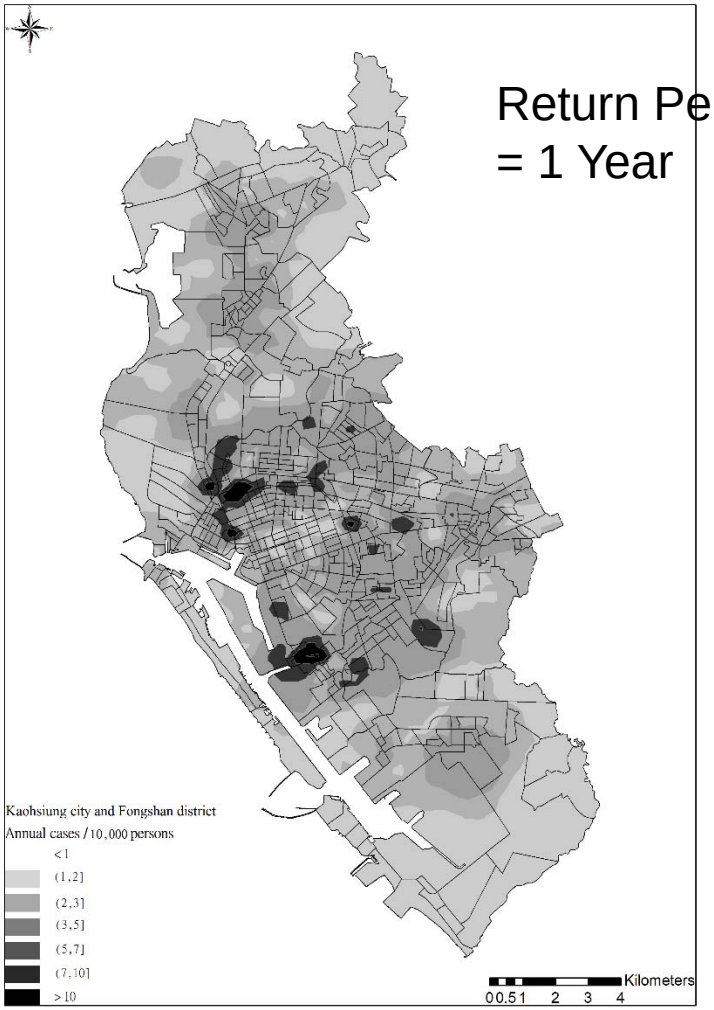
Ditch and residential areas

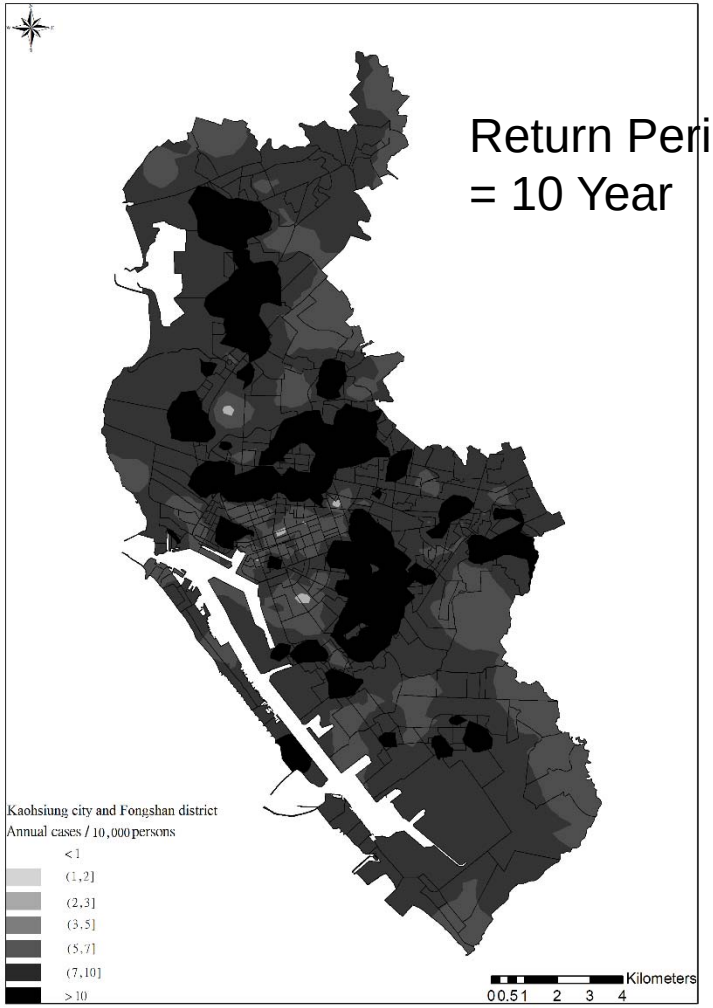




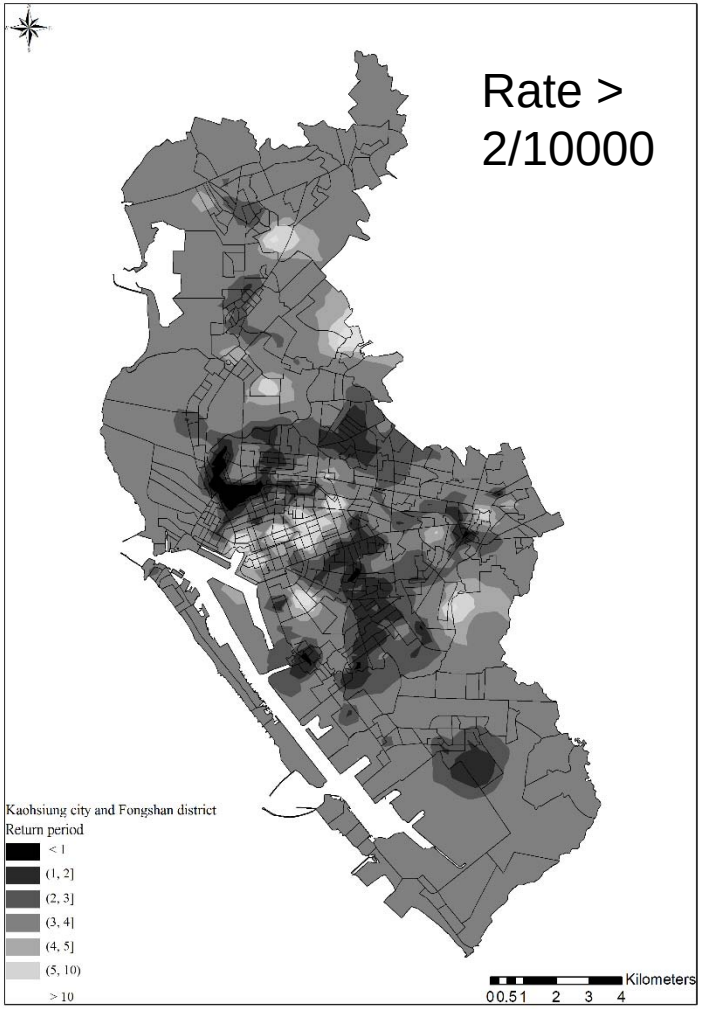
Income and residential areas

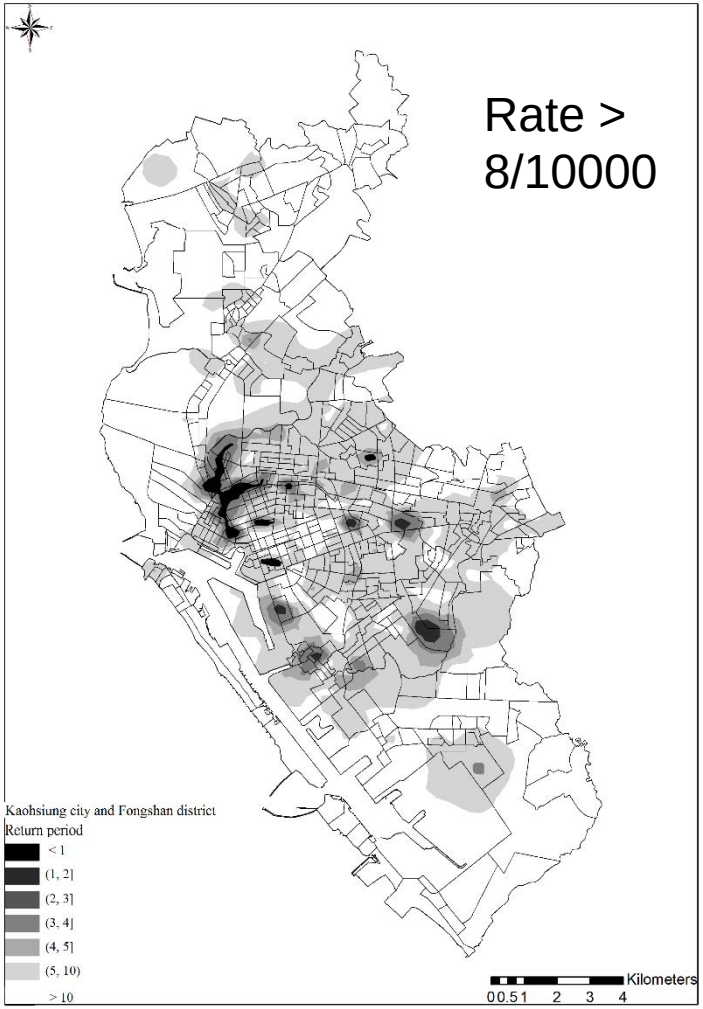
Spatial distribution of DF risks

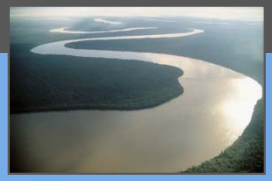




Spatial distribution of return periods








Summary

» 氣象因子對登革熱之影響

- 每周最低溫與24小時連續降雨為解釋登革熱最適變數
- 發現氣象因子對登革熱發生影響之量級與時間延遲關係
- 當地最低溫度超過於20˚C，其登革熱相對風險值會在約一個月後大於1(RR > 1)
- 中央氣象局發佈大雨特報，一兩周內會使登革熱風險增加並持續數周
- 若發生洪水，登革熱風險會降低1-1.5個月

» 土地利用與社經因子對登革熱空間分佈之解釋

- 愛河與溝渠對於登革熱空間分布有高度影響
- 在住商綜合住宅區區中，若有溝渠經過，會大幅增高登革熱風險
- 溝渠決定登革熱發生頻率、住宅區決定量級

Thank you for your attention!
Any questions or comments?