

台灣海域暴潮模式2維與3維 計算結果之探討

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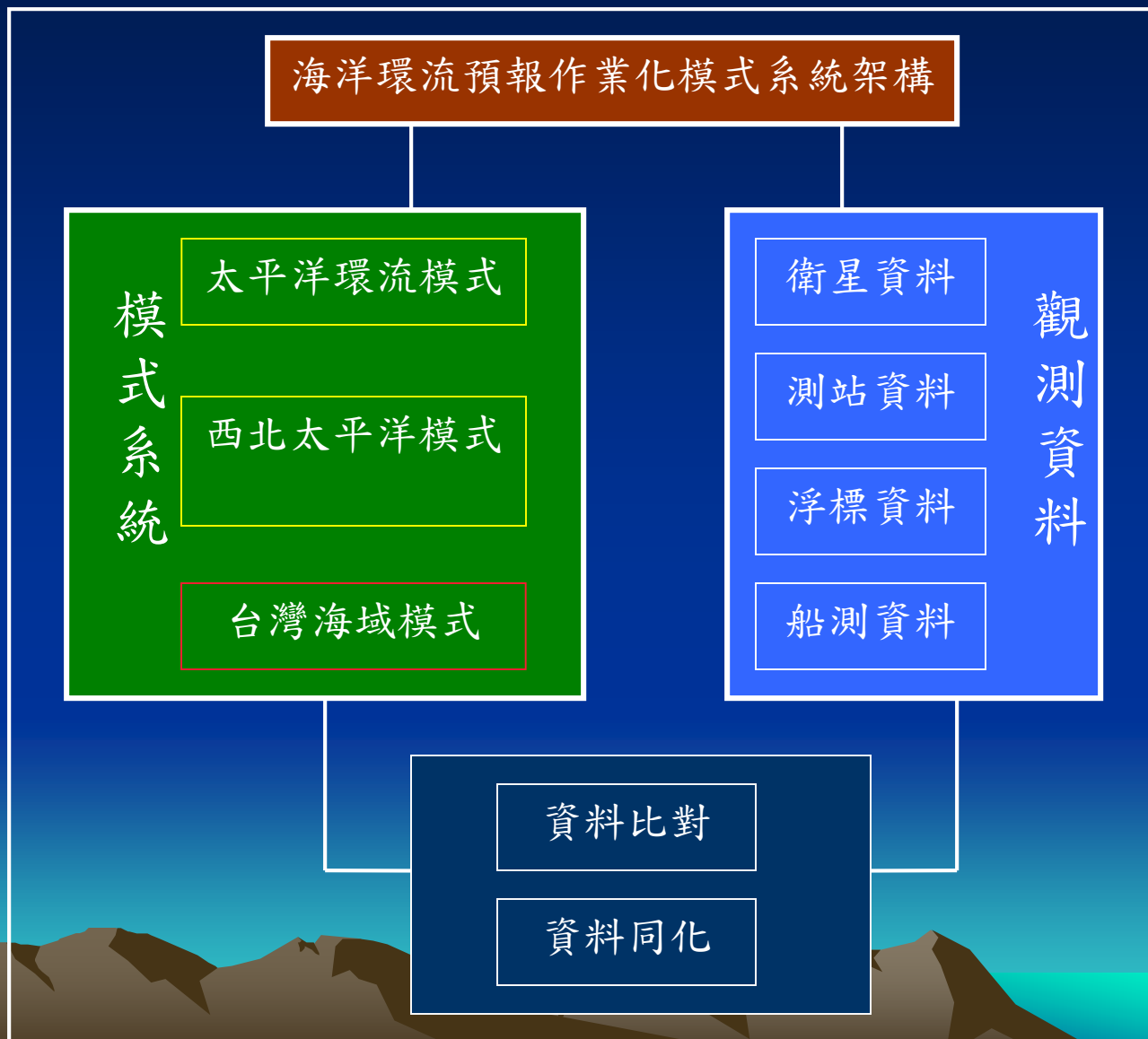
2013/5/14

Outline

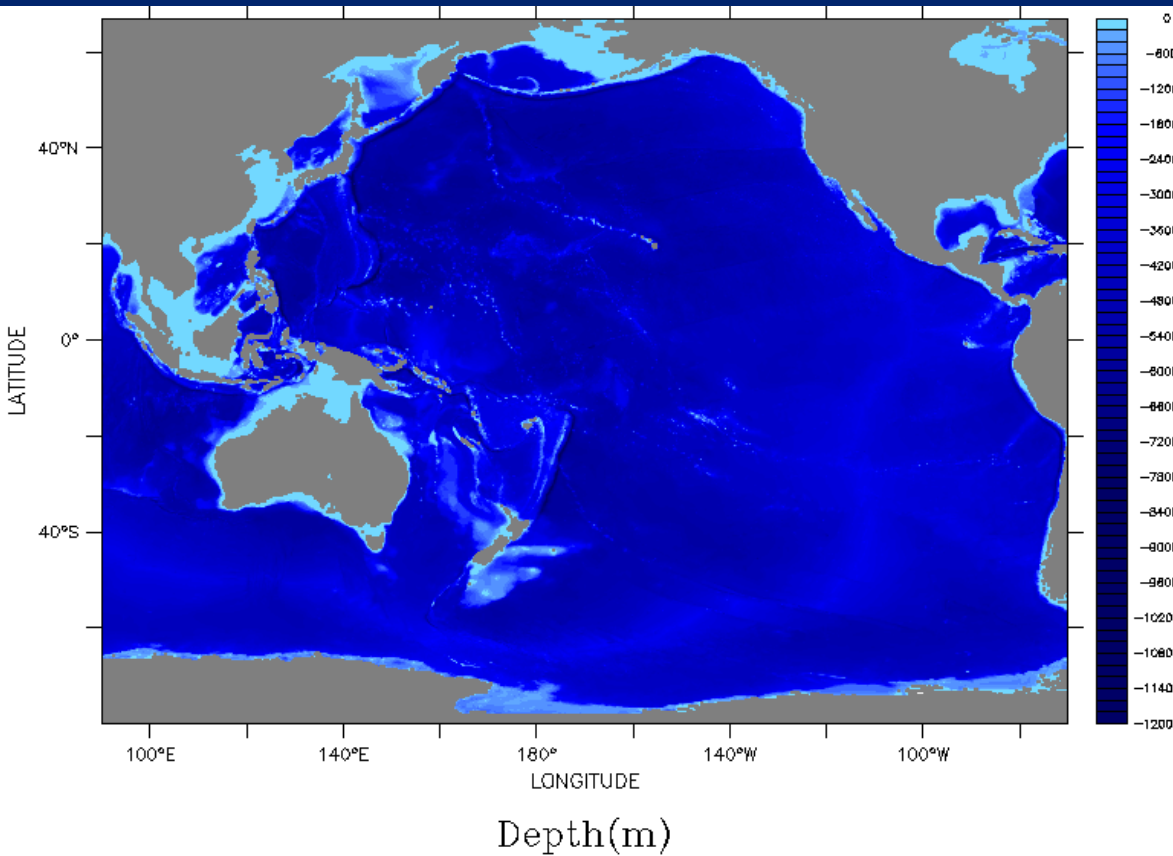
- Introductions
- Tide model setting & calibrations
- Verification
- 2D vs. 3D test
 - Tide
 - Storm surge: typhoon Morakot



台灣海域海流模式系統架構

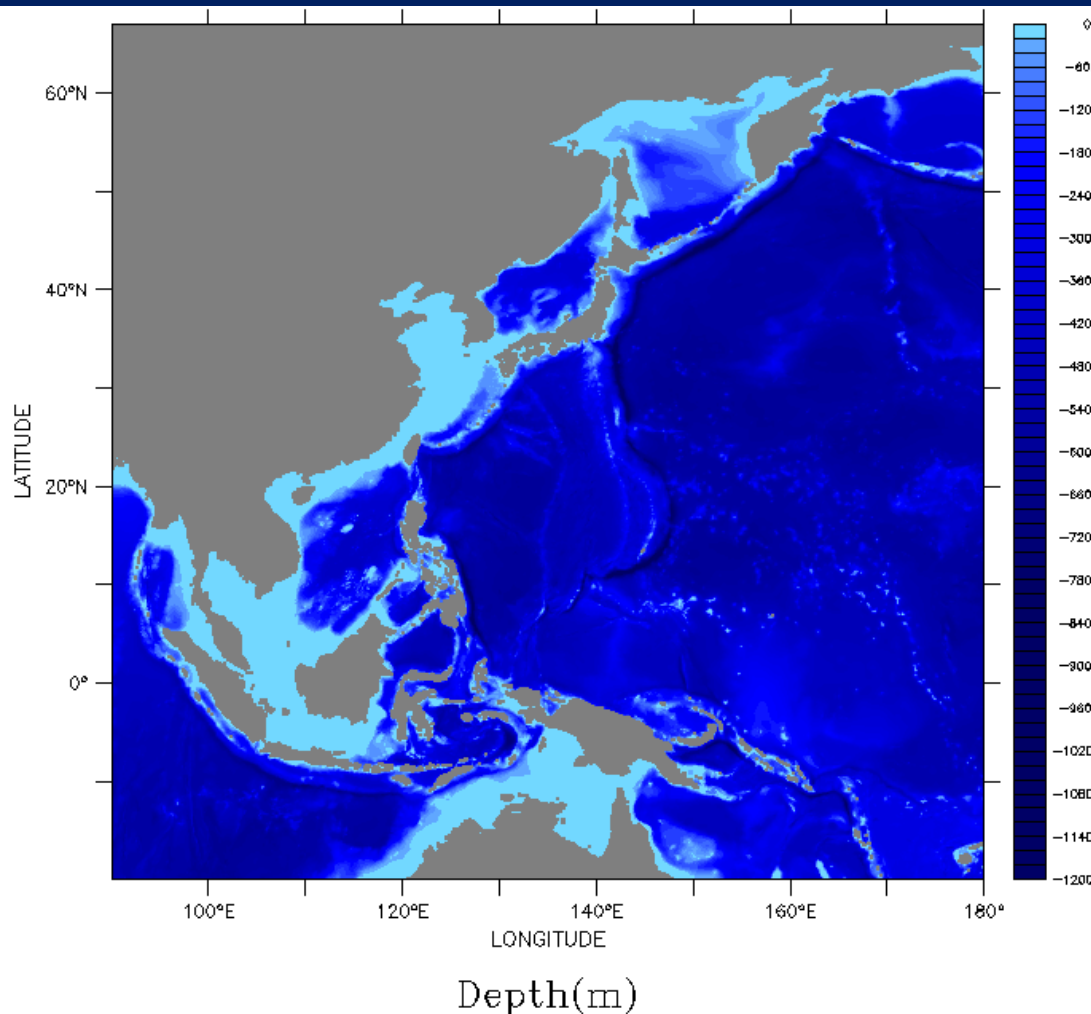


模式地形及範圍(1)



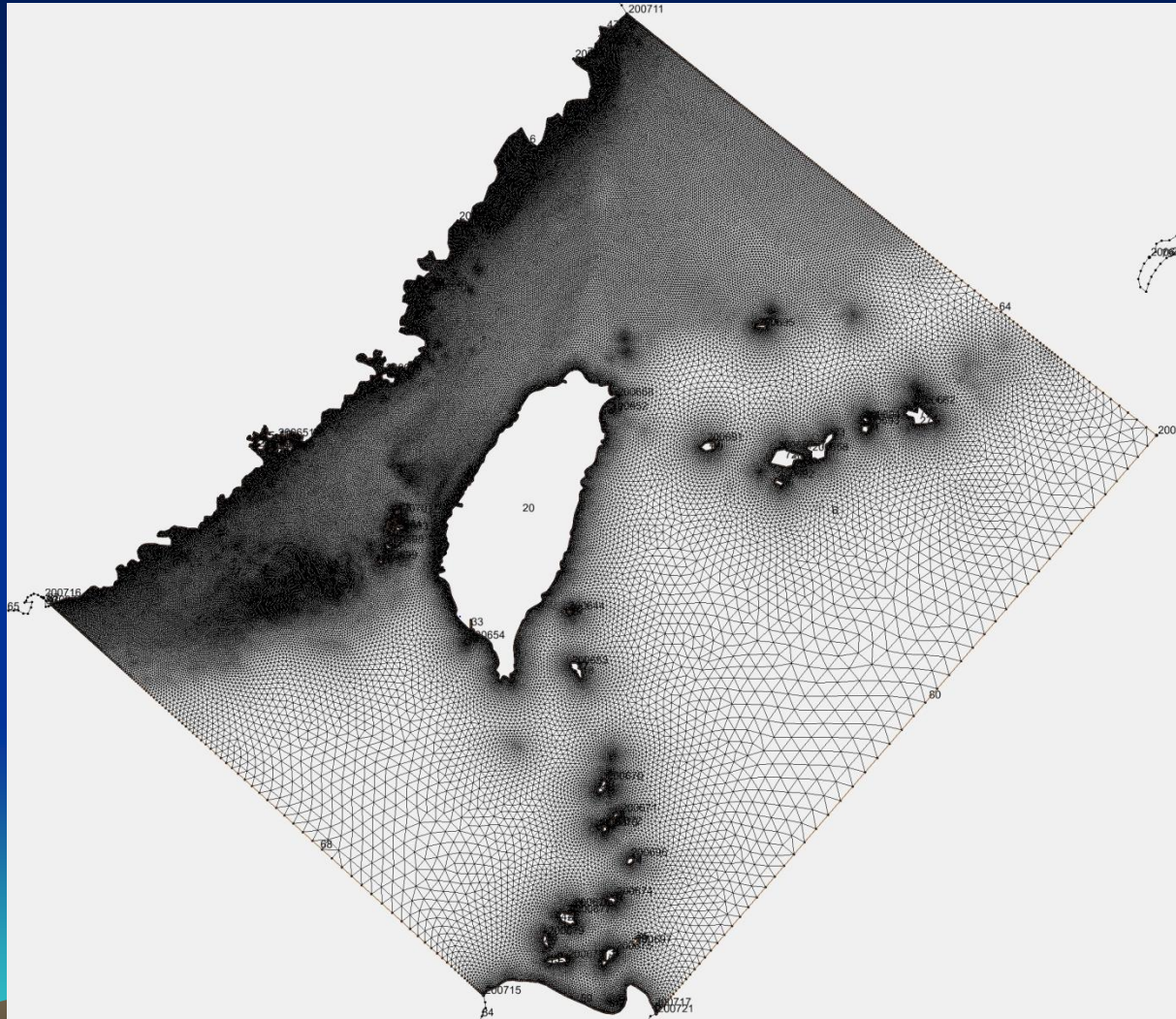
- 太平洋環流模式 (OCM1)
 - 整個太平洋
 - 經度
105° E~67° W
(626點)
 - 緯度
80° S~67° N
(450點)
 - 解析度 1/3度
 - s-coord. 垂直40層
 - ROMS

模式地形及範圍(2)



- 西北太平洋環流模式(OCM2)
 - 90°E到180°E (722點)
 - 20°S到50°N (706點)
 - 解析度1/8度
 - s-coord. 垂直40層
 - ROMS

模式地形及範圍(3)



- 台灣海域模式 (OCM3)
 - Nodes:94288
 - Elements:185105
 - 最大網格約13'
 - 大陸棚區域網格大小約為0.75'
 - 40 sigma layers
 - SELFE

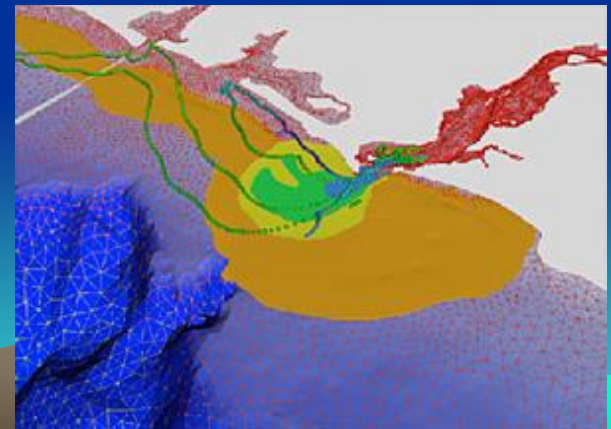
SELFE introduction

- Features

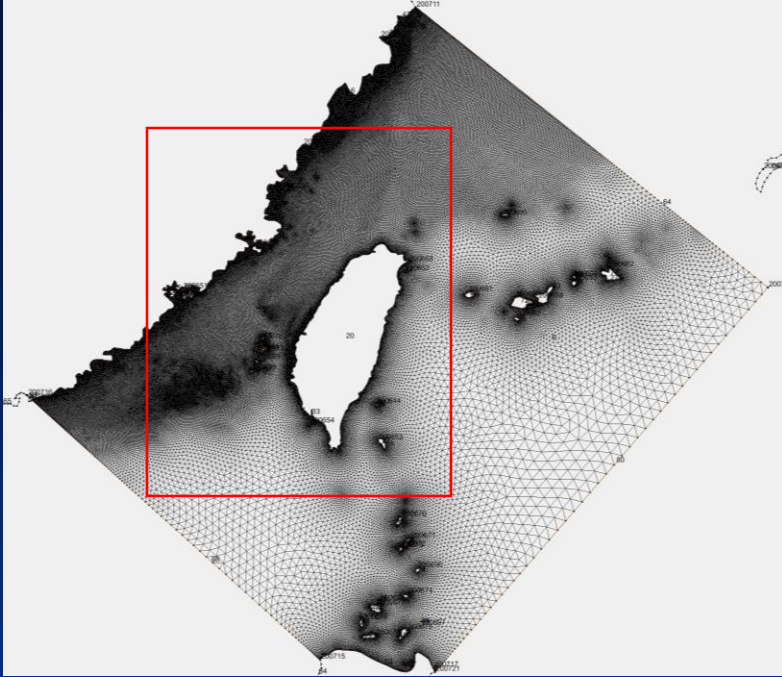
- Finite element/volume formulation
- Hydrostatic & **non-hydrostatic** options
- Unstructured grid in the horizontal dimension
- Hybrid SZ coordinates in the vertical dimension (with Z layers being optional)
- Semi-implicit time stepping (no mode splitting): **no CFL stability constraints** -> numerical efficiency
- All matrices are sparse, positive definite and symmetric -> robustness
- Higher-order Eulerian-Lagrangian treatment of advection
- Natural treatment of wetting and drying suitable for inundation studies
- **Three transport algorithms**: Eulerian-Lagrangian, upwind, or TVD
- Volume conservation generally good
- Mass conservation for transport
- **Realistic atmospheric forcings**

- Applications

- 3D baroclinic cross-scale river-estuary-plume-shelf circulations
- Global ocean circulation
- Tsunami hazards
- Storm surge
- Sediment transport
- Ecology
- Oil spill
- Short wave-current interaction (to be released soon)



模式網格構建



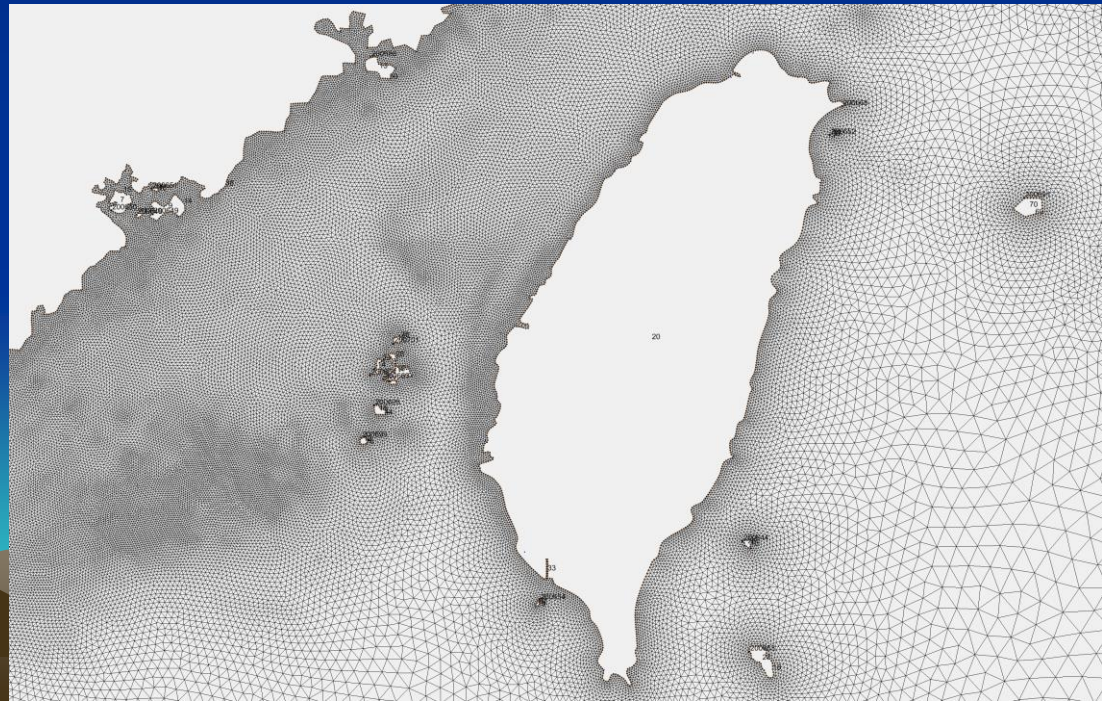
0.50' → 200000 nodes

0.60' → 140000 nodes

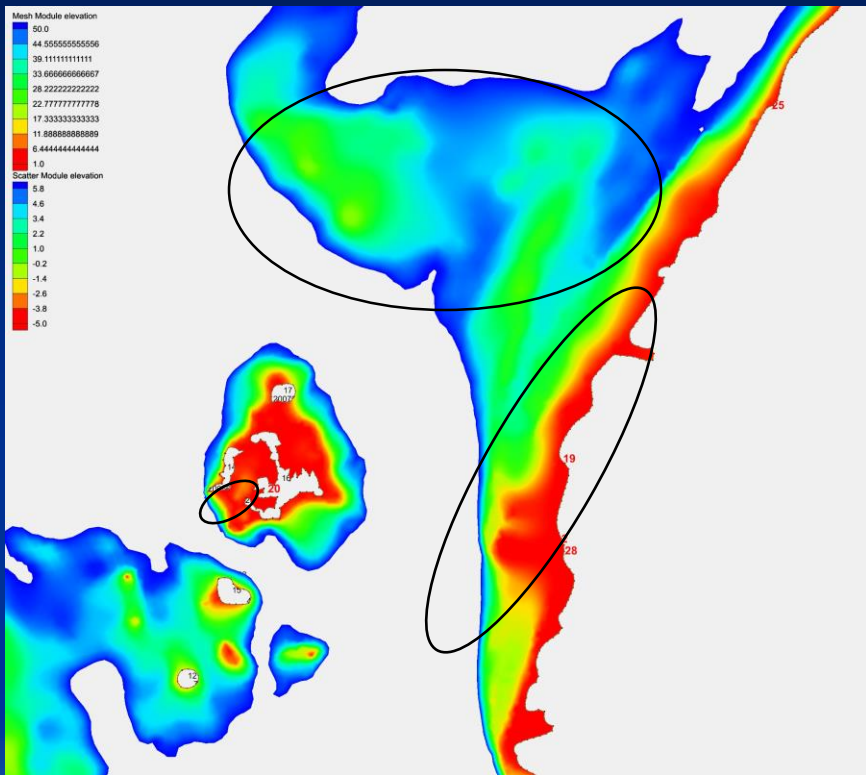
0.75' → 90000 nodes

1.00' → 50000 nodes

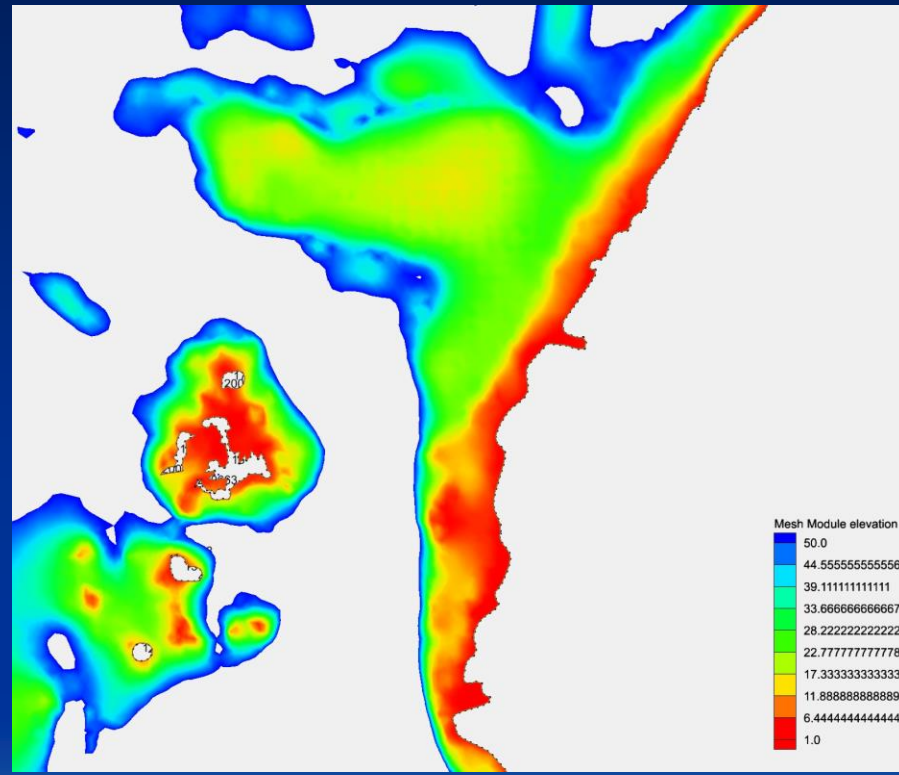
- 節點: 94286
- 網格: 185105
- 大陸棚區域網格大小約為 0.75'
- 最大網格約 13'
- 垂直網格: 28層z, 12層sigma (水深100 公尺內)
- 水深資料: **ETOPO1+TaiDBMv6**



地形差異

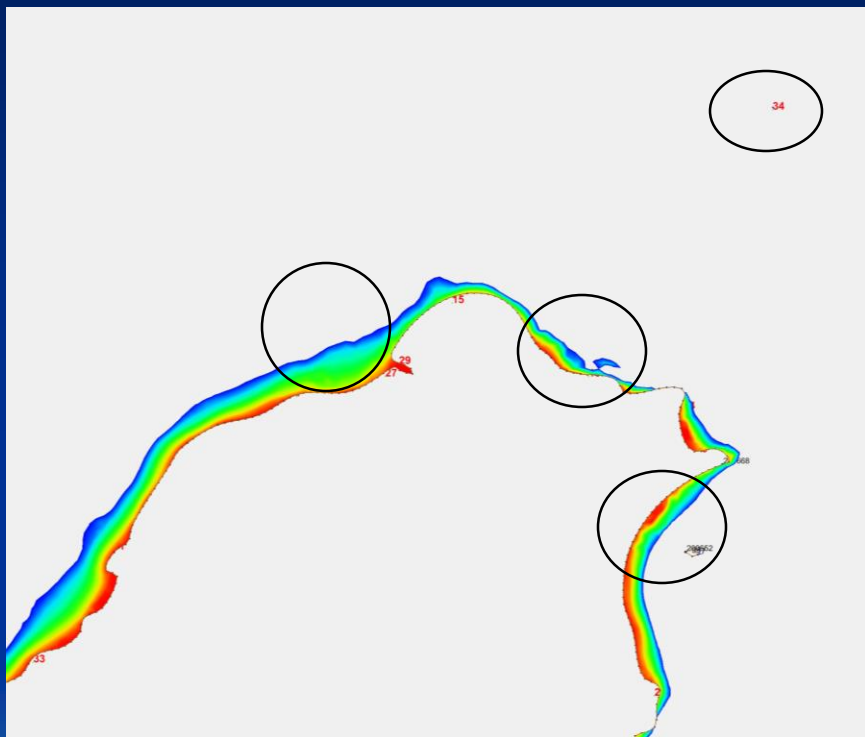


ODB (TaiDBMv6, 0.3')

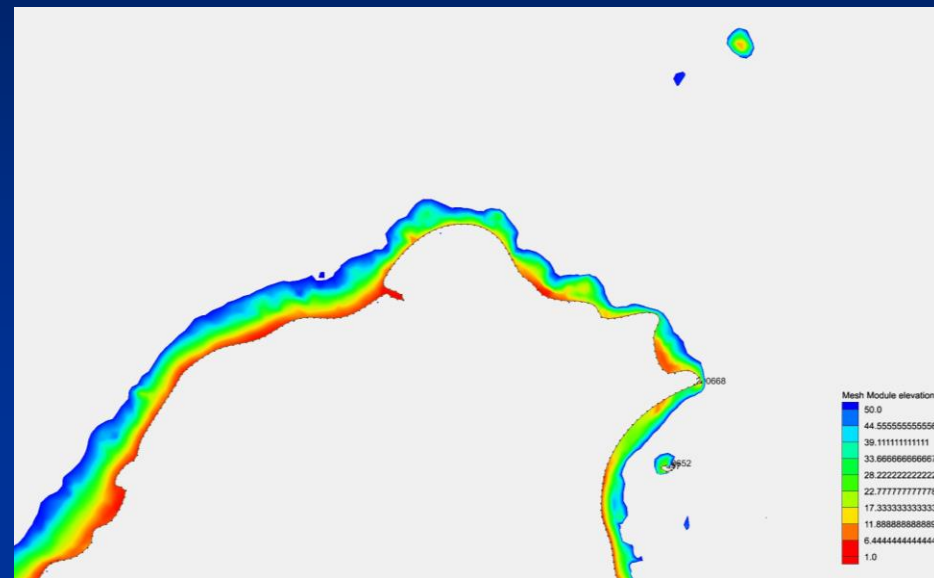


ETOPO1

地形差異



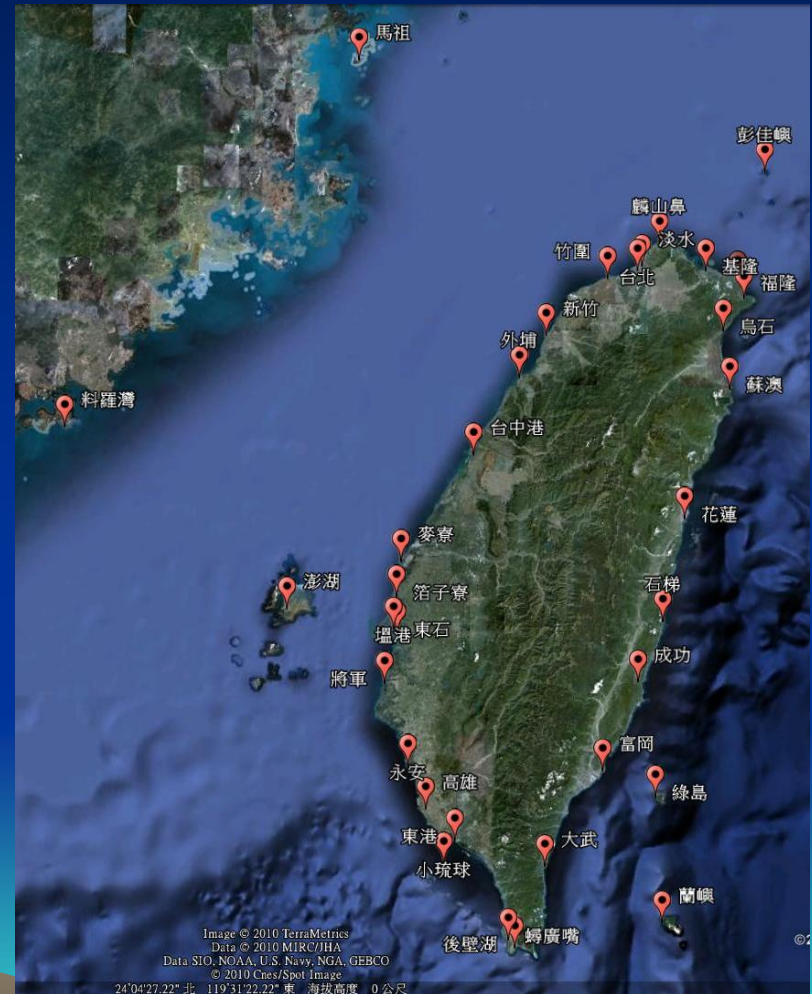
ODB (TaiDBMv6, 0.3')



ETOPO1

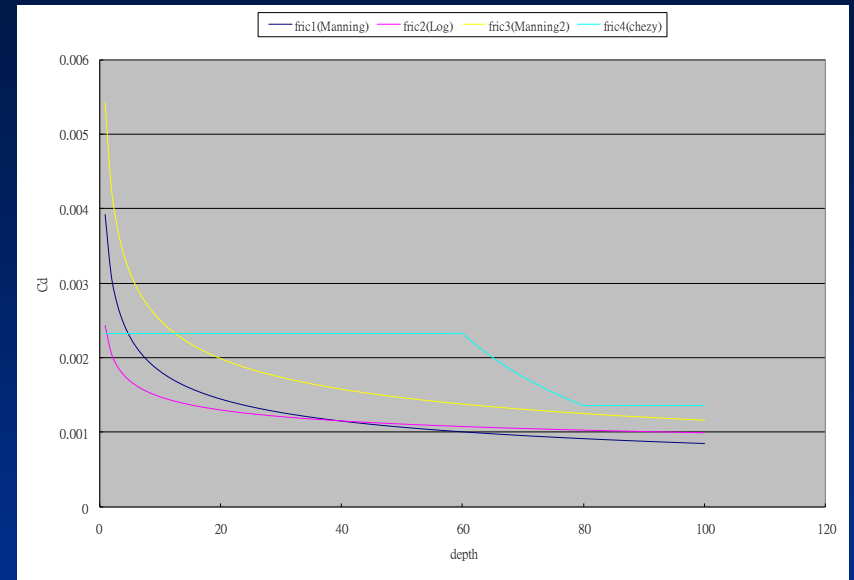
潮流模式設定

- 潮汐邊界採用 FES2004(Lyard et al., 2006)
- 以2009年台灣沿岸34個潮位站資料作為校驗
- 分別對摩擦係數與邊界條件調整



潮汐校驗

- 地形調整
- 底床摩擦係數
 - $C_d=0.0015$ (Hu et al., 2010)
 - Manning n (Kang et al., 1998; Zhang and Li, 1996)
 - Chezy (Verboom et al., 1992)
 - Classic: von Karmon (You, 2010)



$$C_d = \max\left(0.0027, g \left(\frac{H^{1/6}}{n}\right)^{-2}\right)$$

$$C_d = \frac{g}{chezy^2}$$

$$C_d = \frac{k^2}{\left(\log \frac{h}{d}\right)^2}$$

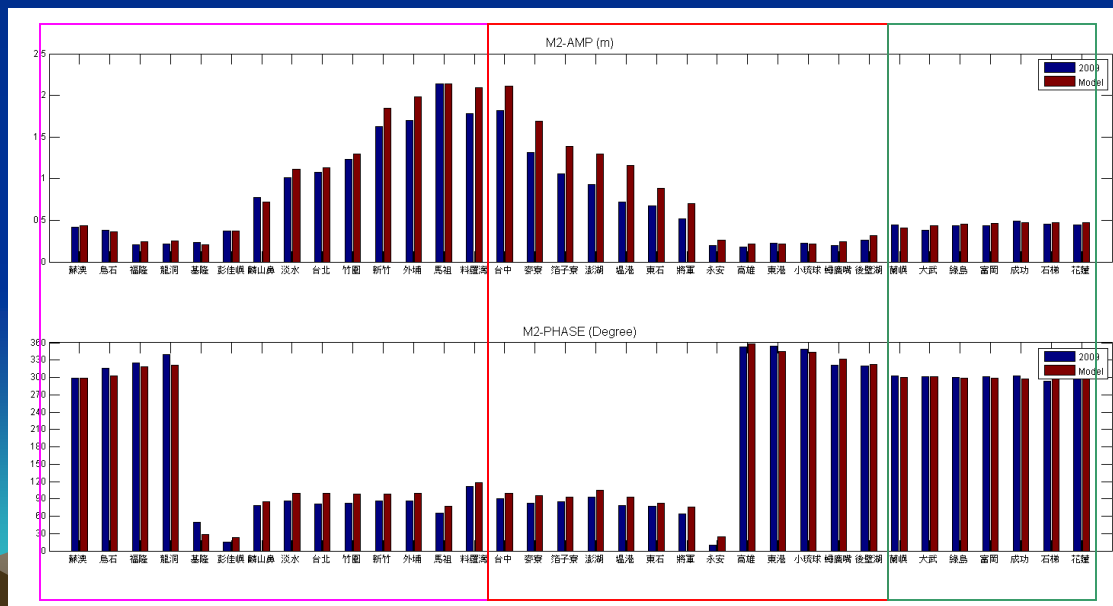
潮汐校驗 (底床摩擦係數)

- Harmonic vectorial difference (Foreman et al., 1993), RMSVD
- Manning n (Kang et al., 1998; Zhang and Li, 1996)

$$d = [(a_o \cos g_o - a_m \cos g_m)^2 + (a_o \sin g_o - a_m \sin g_m)^2]^{0.5}$$

$$C_d = g \left(\frac{H^{1/6}}{n} \right)^{-2}$$

- N, RMSVD-avg, M2-RMSVD
- 0.0295, 4.51, 19.21
- 0.0315, 4.60, 18.85
- 0.0350, 4.88, 17.46
- 0.0383, 5.29, 16.78



北部測站

台灣海峽測站

東部測站

潮汐校驗 (潮汐邊界)

- 單邊邊界調整M2振幅 (-5%,-15%,-25%)
- 以各區平均之振幅差異(模式與實測差異)作為校驗值

單位：公尺

	N	E	S
0	0.073	0.073	0.073
5	0.052	0.061	0.064
15	0.012	0.038	0.044
25	-0.027	0.018	0.025

	N	E	S
0	0.183	0.183	0.183
5	0.171	0.171	0.172
15	0.150	0.149	0.151
25	0.131	0.128	0.131

	N	E	S
0	0.012	0.012	0.012
5	0.011	-0.008	0.011
15	0.010	-0.050	0.009
25	0.009	-0.092	0.007

北部測站

台灣海峽測站

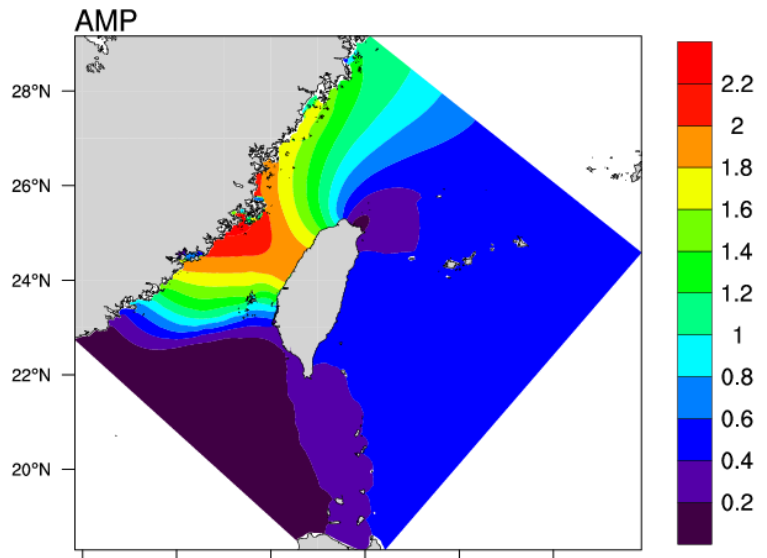
東部測站

潮汐校驗 (潮汐邊界)

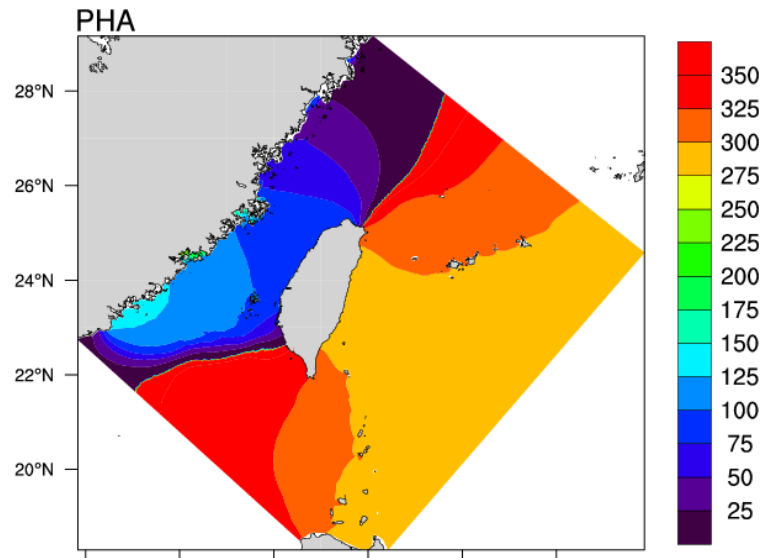
- 綜合調整M2振幅
 - 北邊25~5%, 40~5%, 20~5%
 - 東邊5%, 0%, 15%
 - 南邊25~0%, 35~0%, 40~0%
- RMSVD
 - M2: 13.32 cm (未調整前為18.85 cm)
 - Avg: 3.96 cm (未調整前為4.60 cm)

M2

CWB OCM3

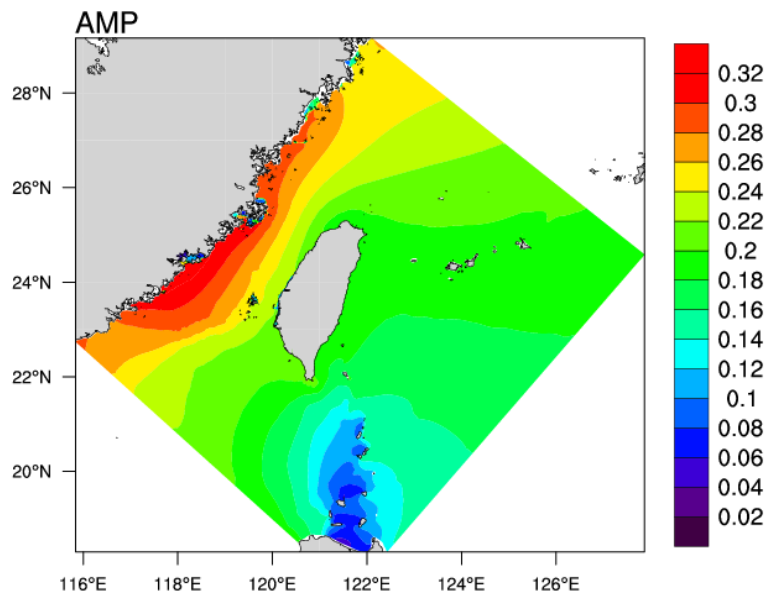


CWB OCM3

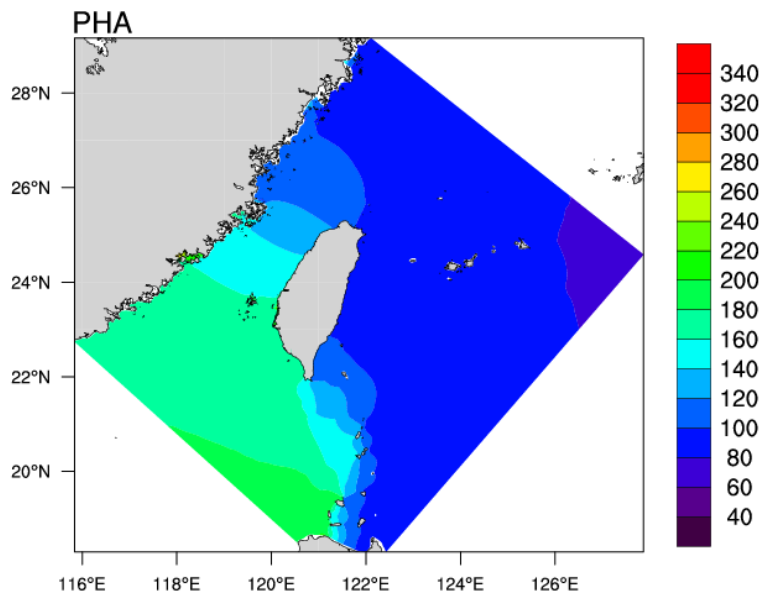


K1

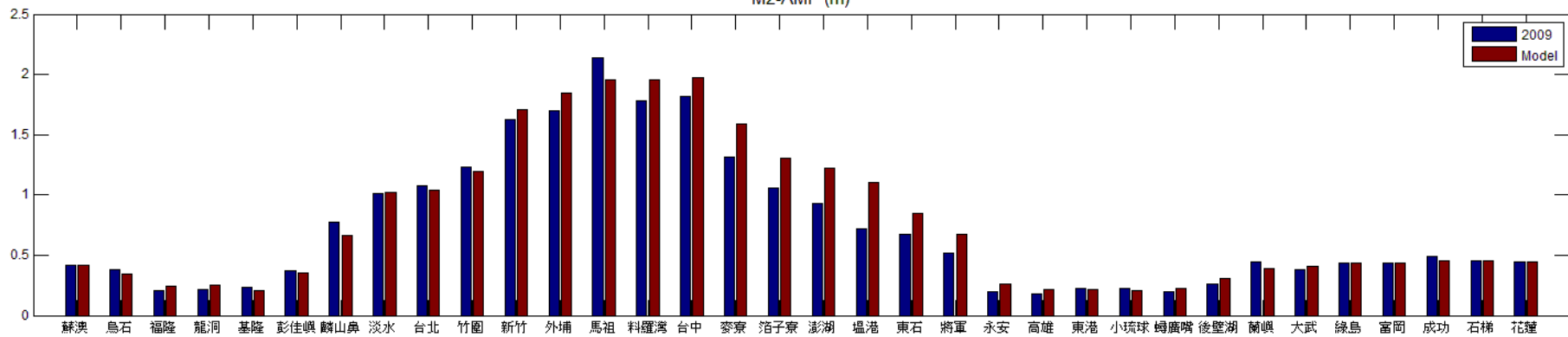
CWB OCM3



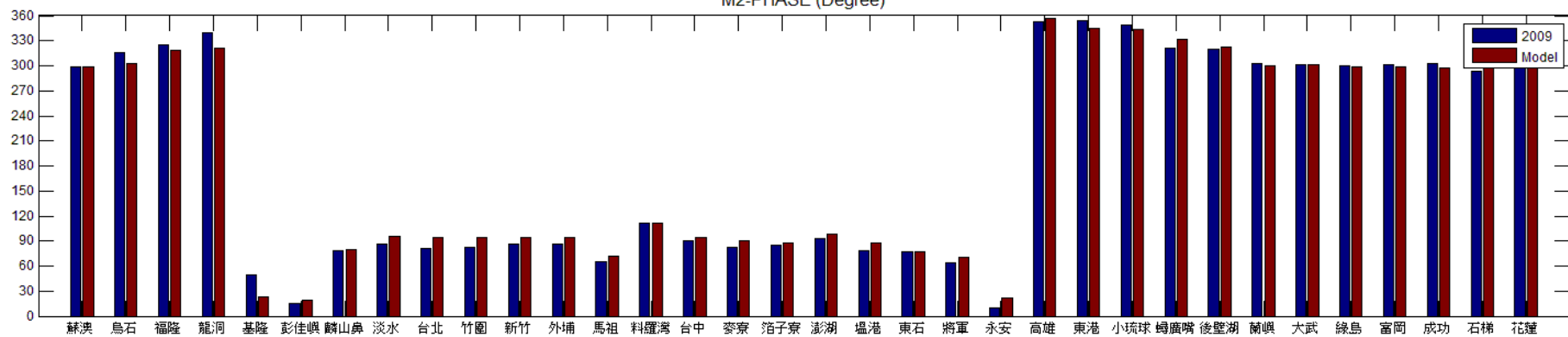
CWB OCM3

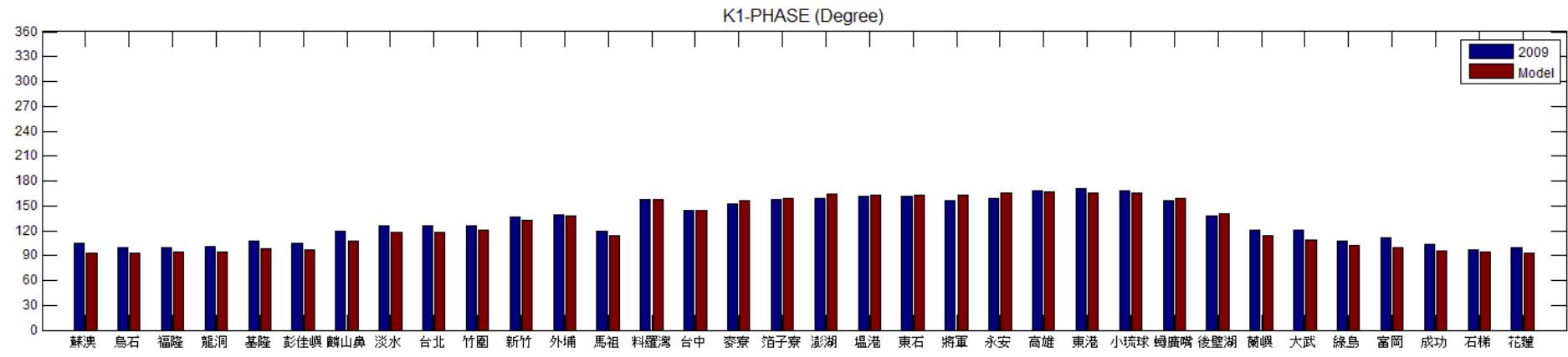
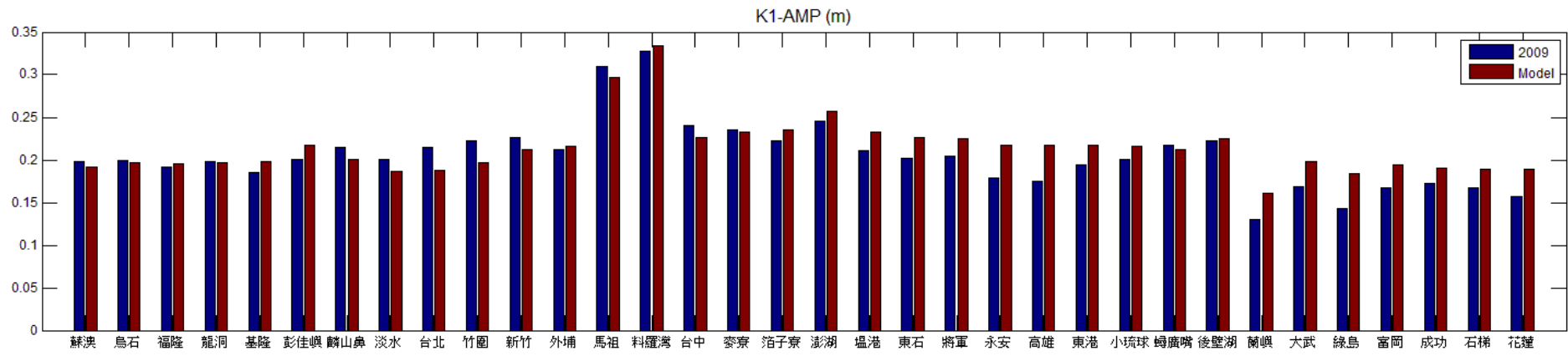


M2-AMP (m)

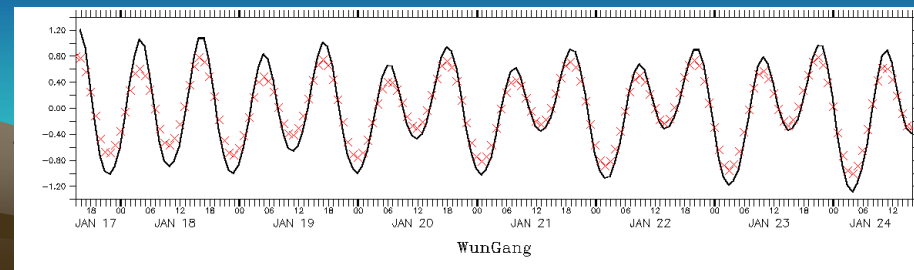
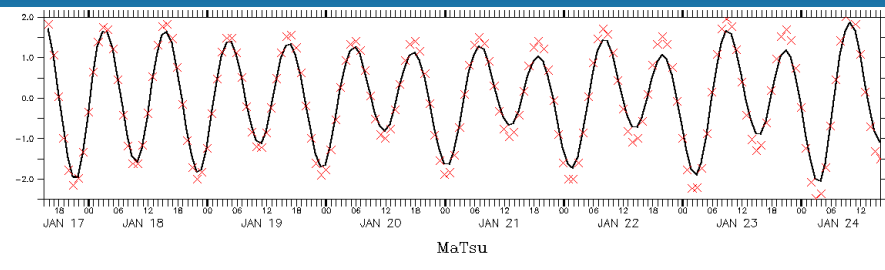
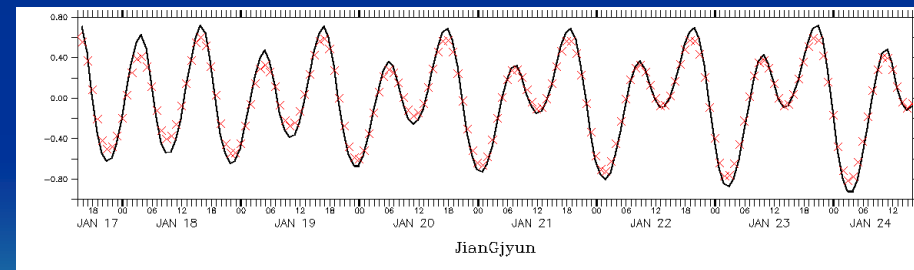
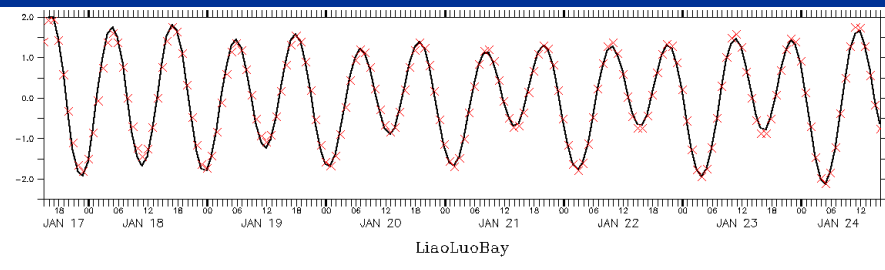
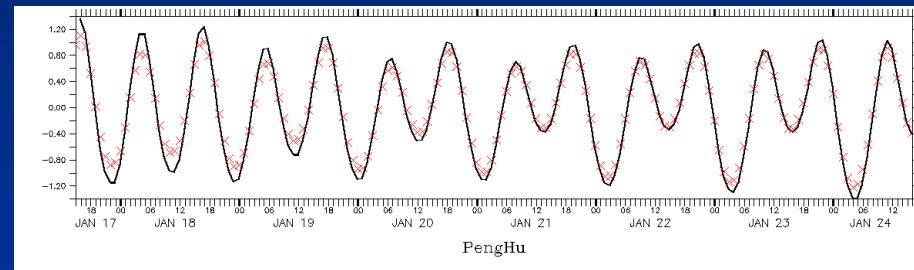
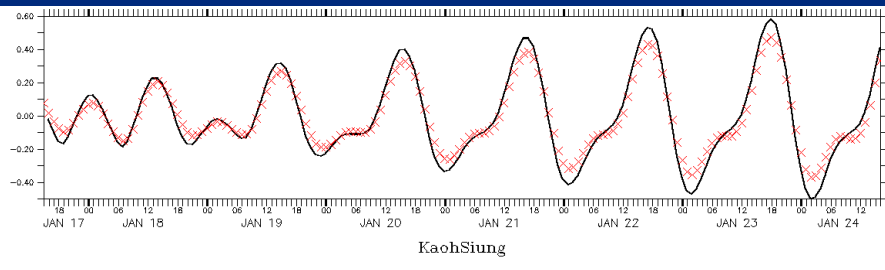
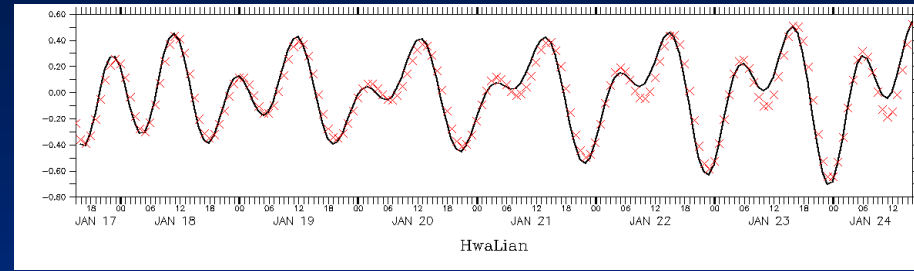
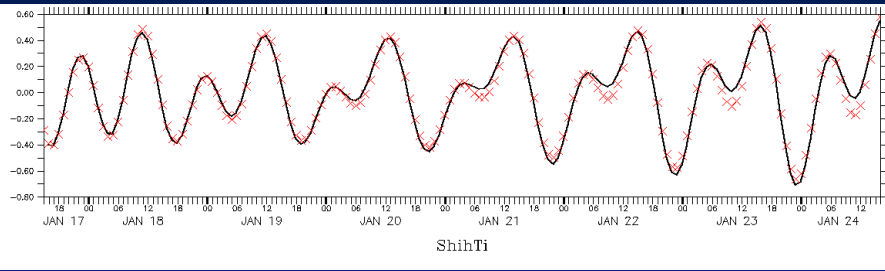


M2-PHASE (Degree)

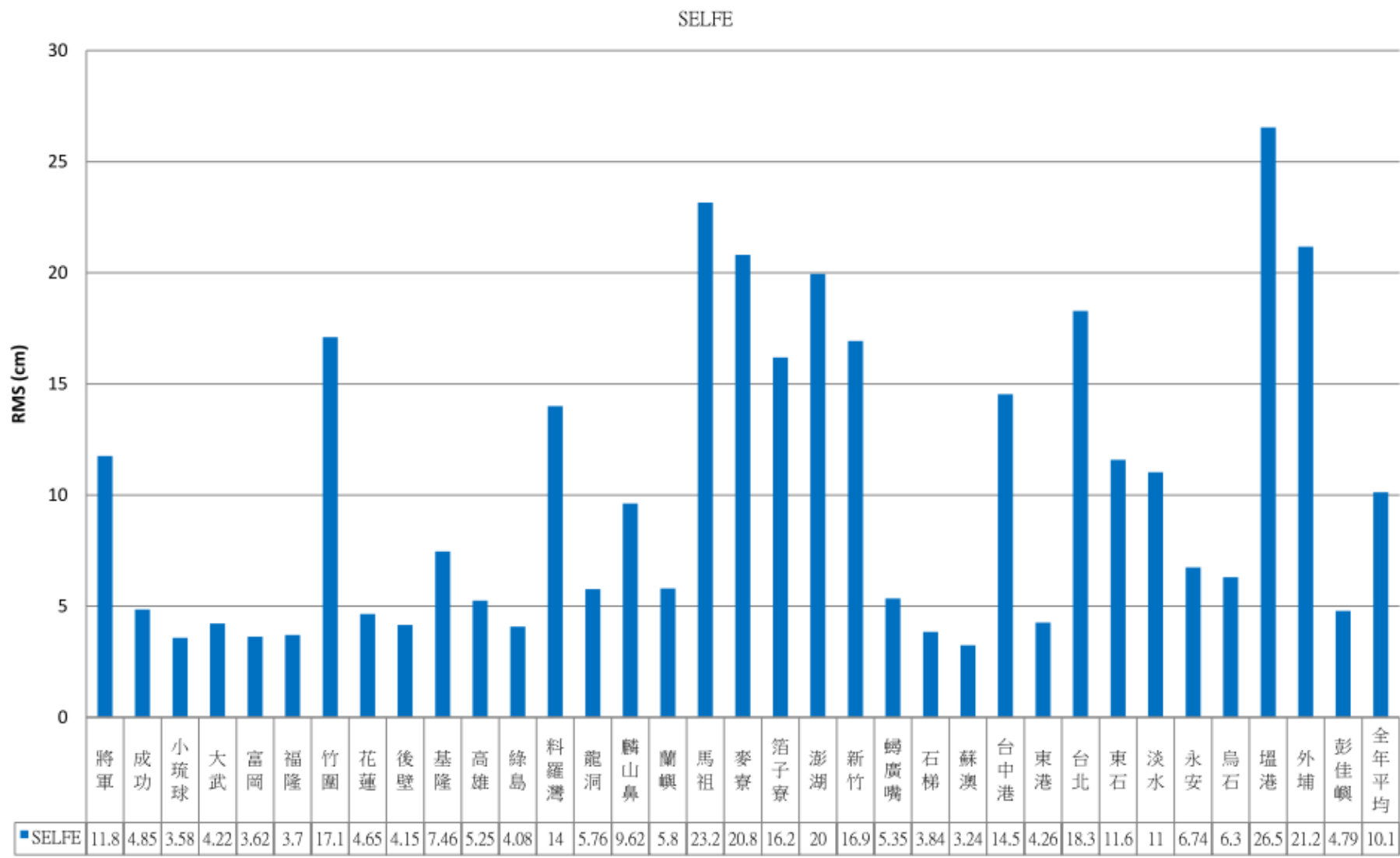




水位時序比對



2009 全年均方根誤差

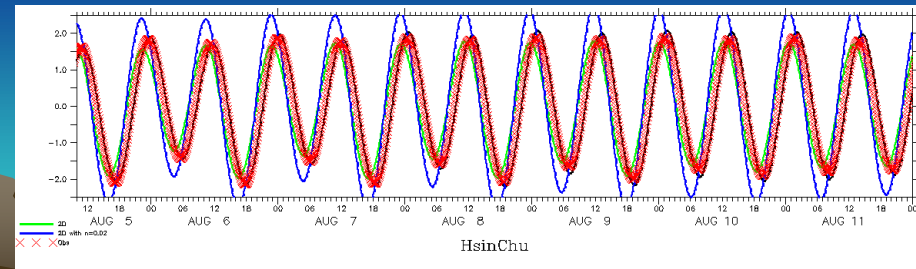
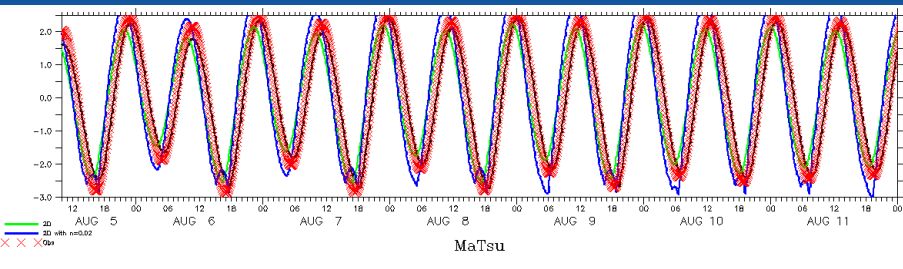
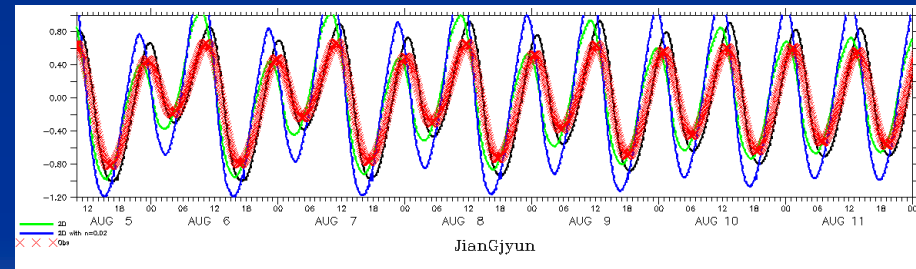
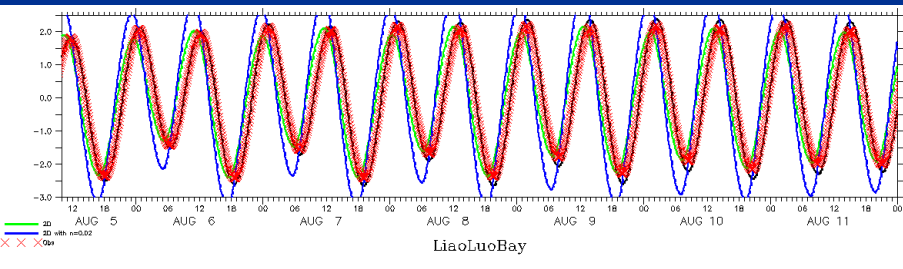
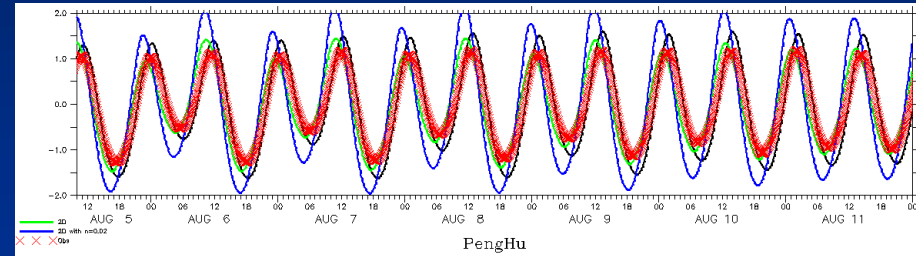
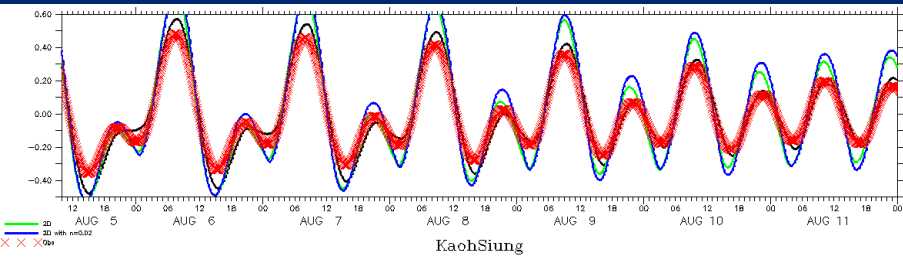
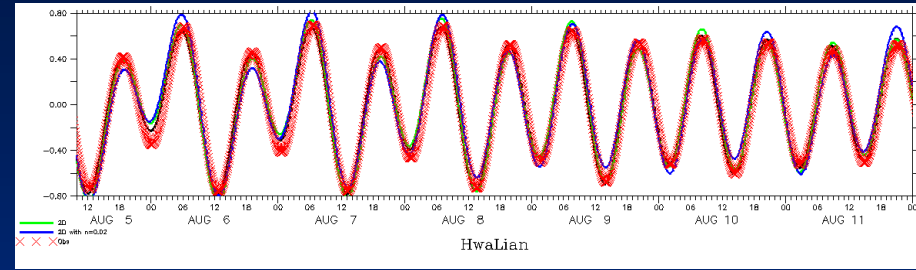
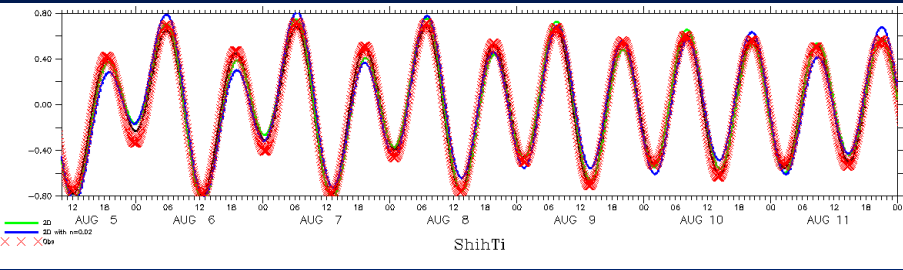


小結

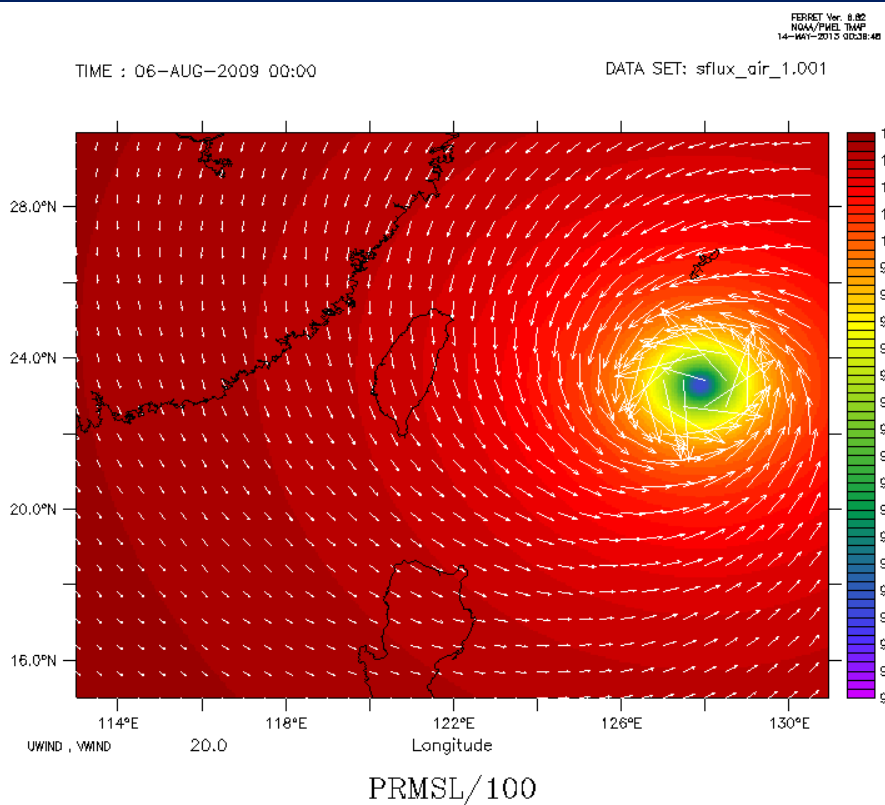
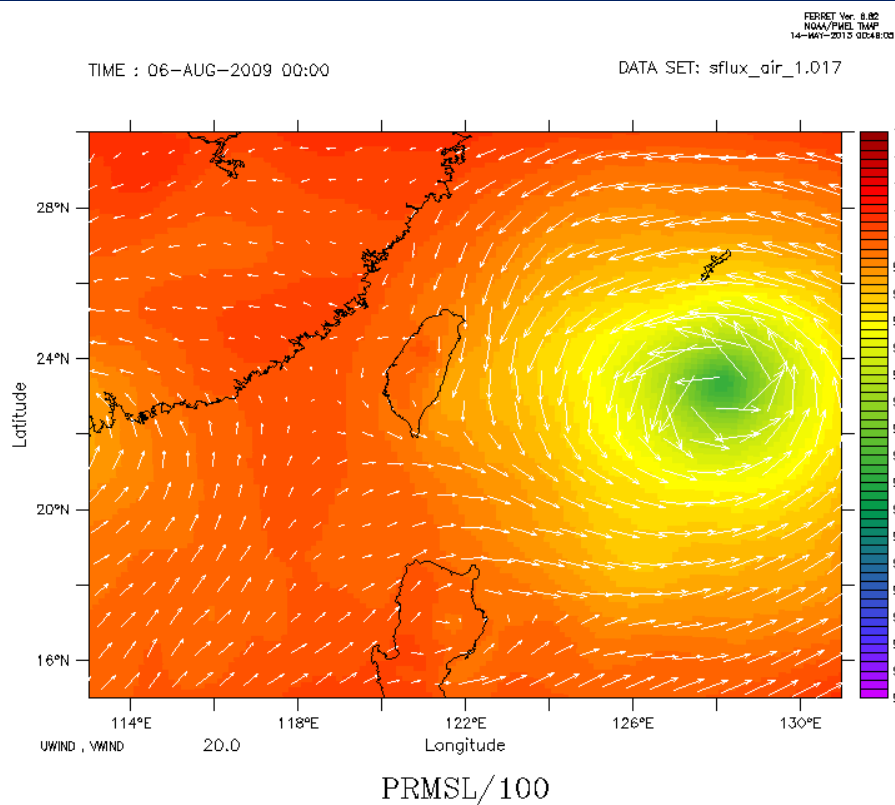
- 潮流模式經校驗後，模式計算結果與實測之全年平均誤差均方根為10.1 cm
- 校驗過程發現摩擦係數的提高，對於半日潮之振幅有明顯的降低效果，全日潮則無影響
- 調整潮汐邊界振幅時，需考慮其平面分布而調整，並維持其連續性，可得到較佳之結果



2維與3維計算結果差異 (Tide)



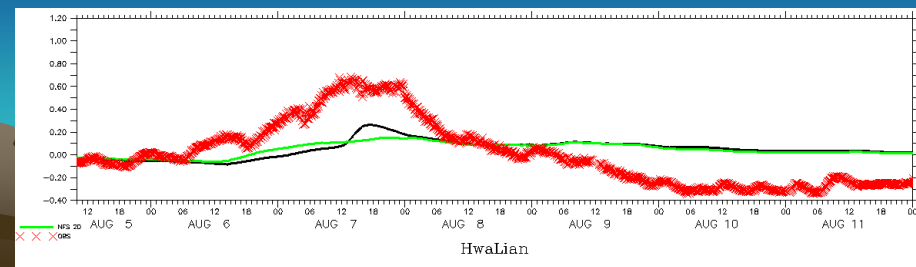
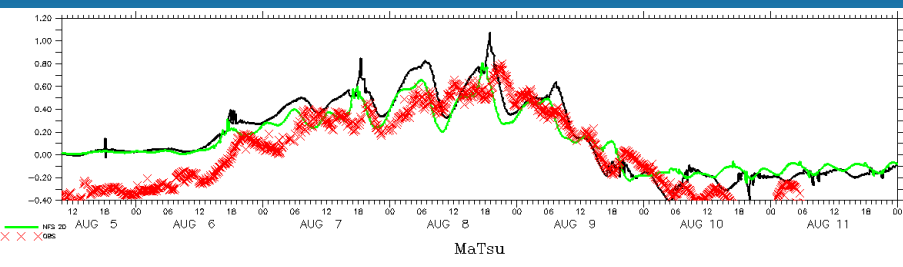
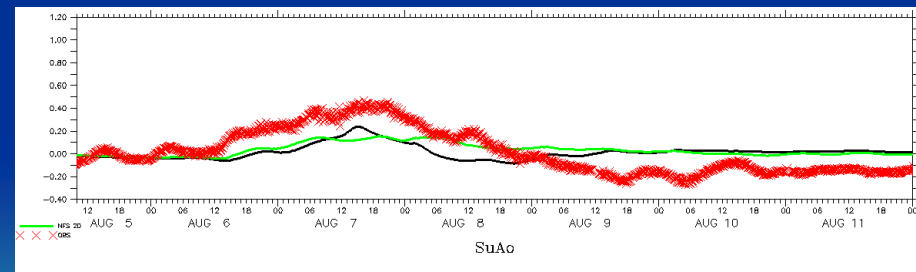
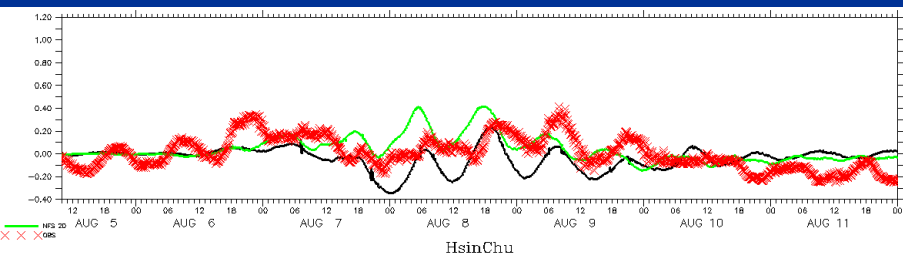
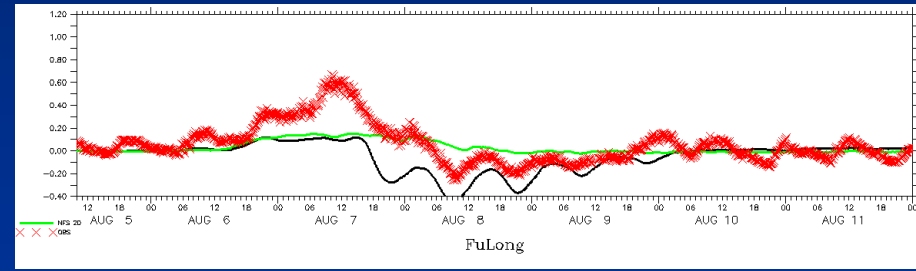
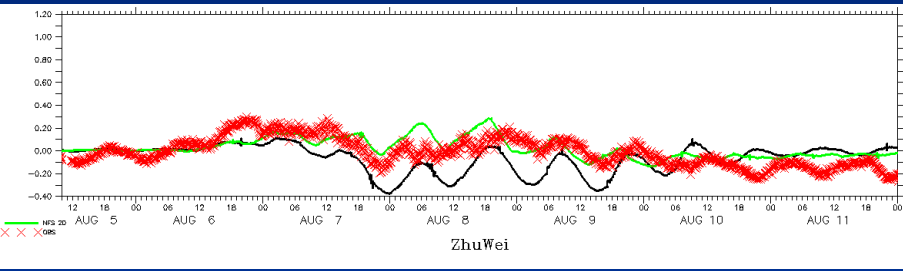
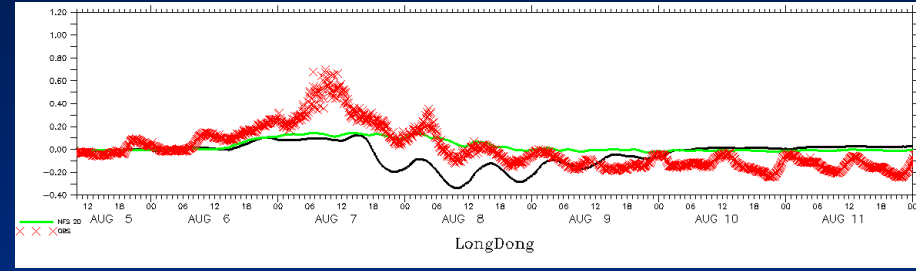
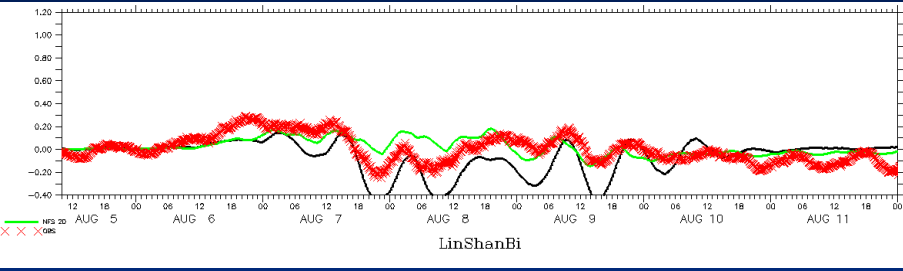
風場輸入



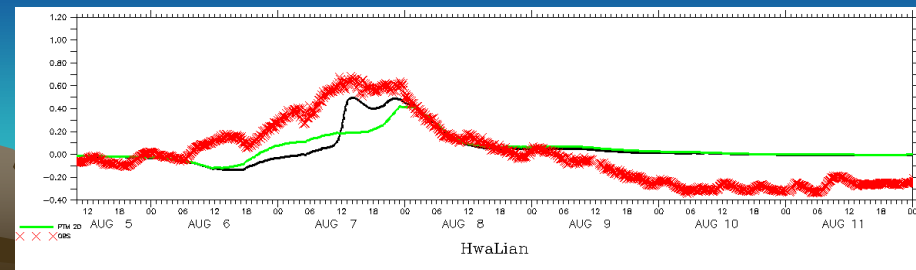
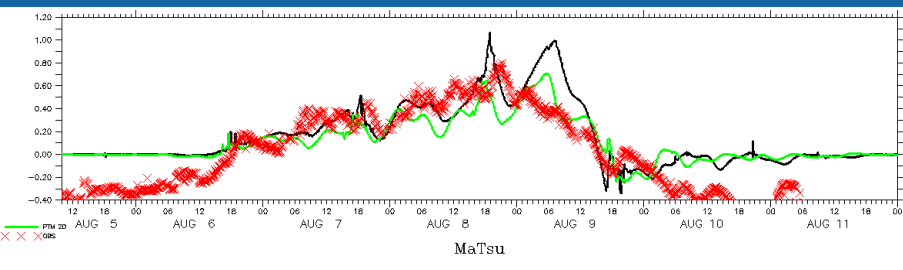
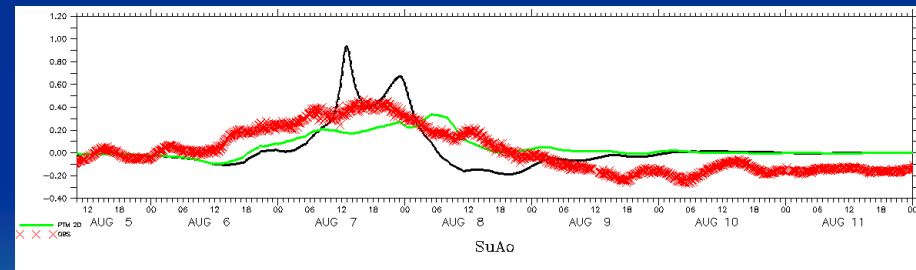
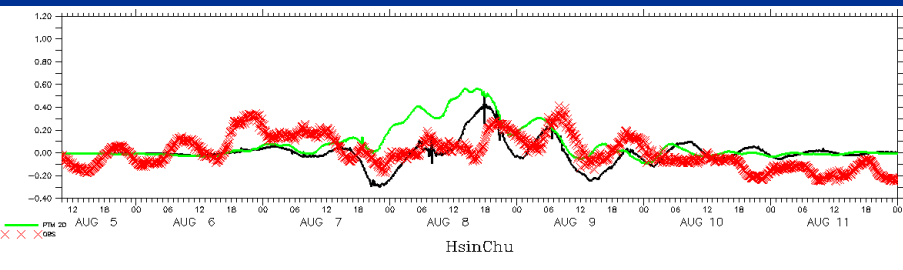
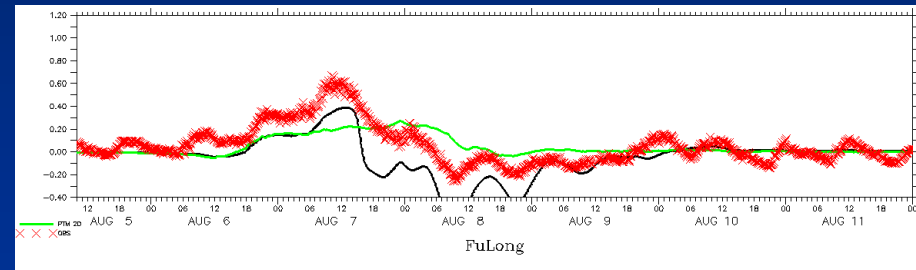
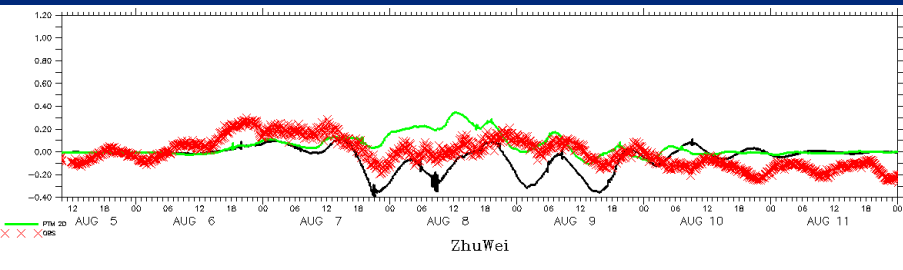
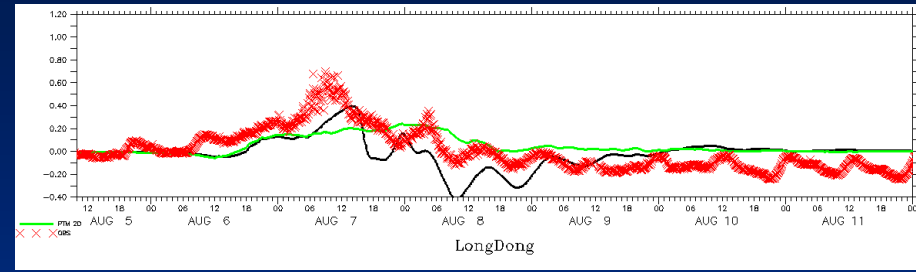
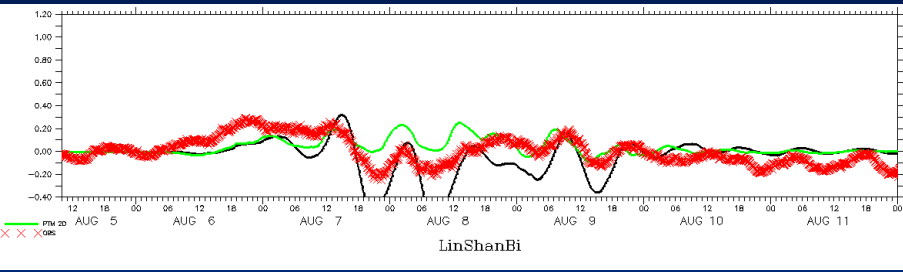
NFS-MC

PTM

2維與3維計算結果差異 (NFS)



2維與3維計算結果差異 (PTM)



結論

- 潮汐部分
 - 兩者計算時間約差3.6倍
 - 於台灣東部，2維與3維計算結果大致吻合實測
 - 海峽內部，2維結果與實測結果不符
 - 2維計算需利用平面分佈之不同n值進行調整
- 暴潮部分
 - NFS風場之計算結果之趨勢較為吻合實測
 - PTM風場之計算結果對於峰值有較佳之結果
 - 3維計算結果受到沿岸流場(downwelling)影響而有負值之產生，2維計算結果則無此現象。

敬請指正

