104年天氣分析與預報研討會

臺灣近岸地區風暴潮溢淹速算系統之開發與研究

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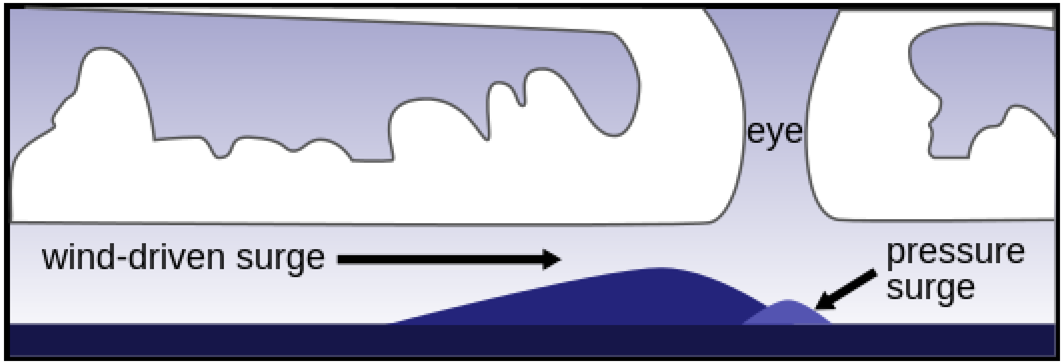
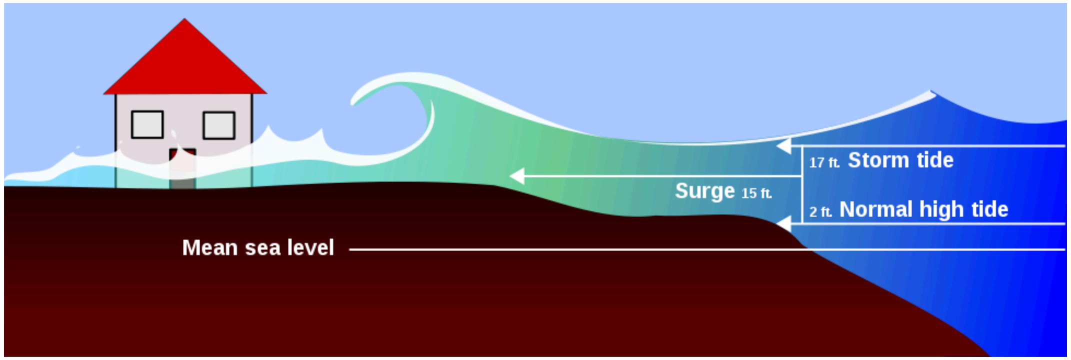
STORM SURGE

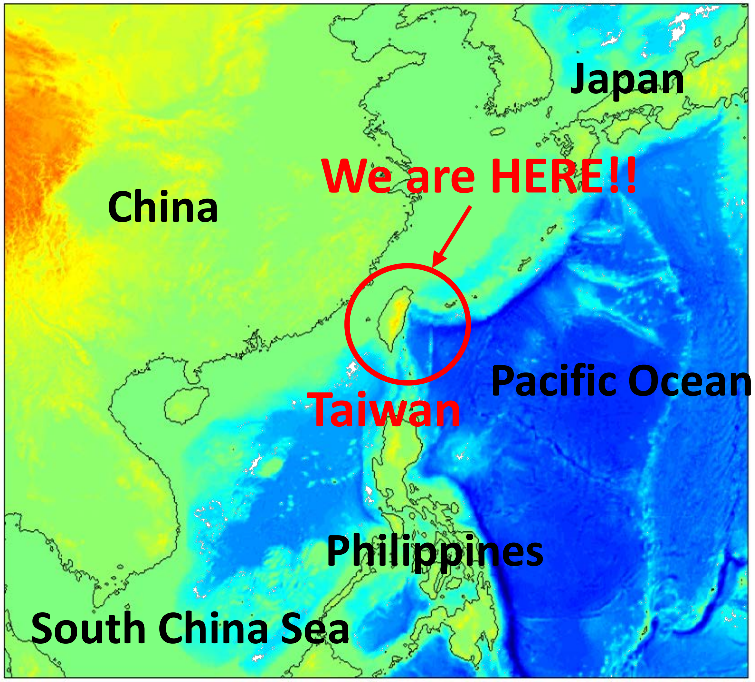
- Storm surge is a coastal flood of rising water commonly associated with low pressure weather systems (such as tropical cyclones and strong extratropical cyclones).
- The two main meteorological factors contributing to a storm surge are a long fetch of winds spiraling inward toward the storm, and a low-pressure-induced dome of water drawn up under and trailing the storm's center.

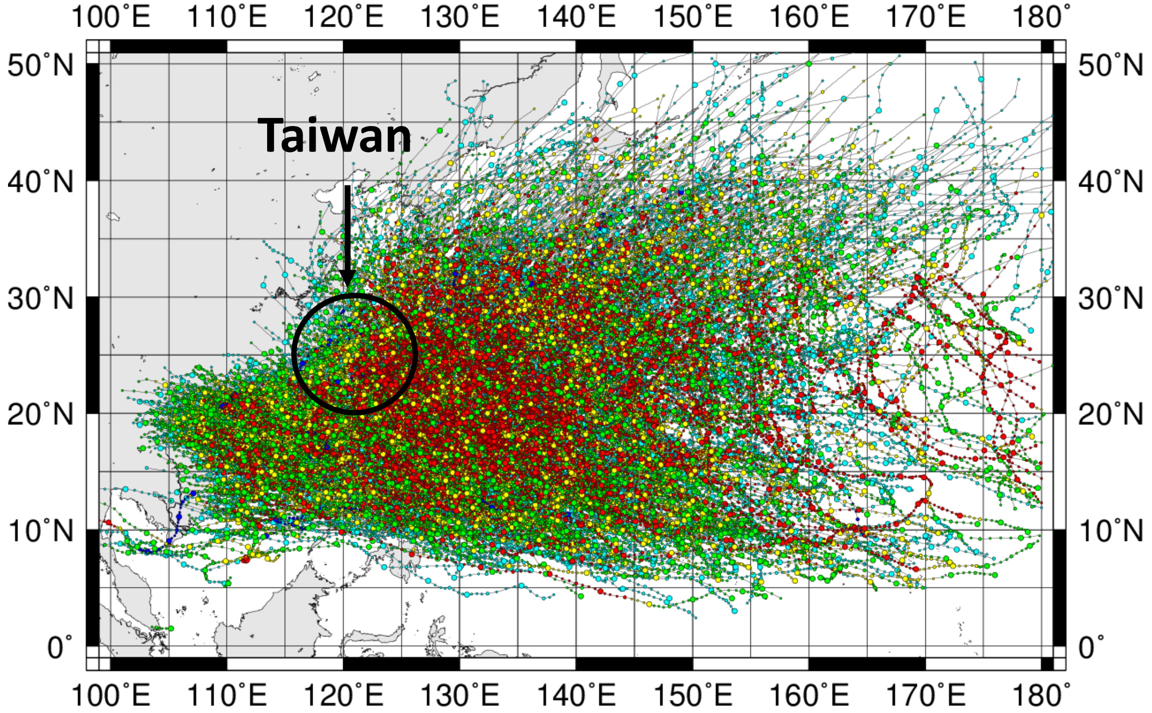




Flooded by storm surge of Hurricane Katrina (2005) in the area of northwest New Orleans.

Why We Need the Storm Surge Prediction?

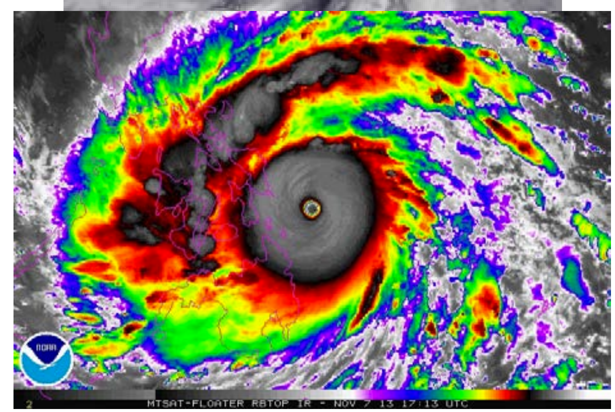




Tracks of all tropical cyclones in the northwestern Pacific Ocean between 1951 and 2014.

Potential STRONG Typhoons in the Eastern Asia

Typhoon Haiyan: 'It was like the end of the world'.



Typhoon Haiyan was one of the strongest tropical cyclones ever recorded, devastating portions of Southeast Asia, particularly the Philippines, in early-November 2013.

If we have a accurate storm surge prediction, we can have more time to prepare.

The Development of Numerical Models

- Wu (1984) established a model from the Taiwan Strait to southeast of China, but the domain was limited to the continental shelf of China.
- Jelesnianski et al. (1992) established a storm surge model named **SLOSH** (Sea, Lake, and Overland Surges from Hurricanes) for NOAA, which adopts the moving boundary scheme to evaluate surge inundation in Cartesian and polar coordinates.
- Flater (1994) developed a geographical storm surge prediction model, **CS3**, based on depth-averaged equations for the Northern Bay of Bengal and applied it to the 1991 event.
- Westerink et al. (2008) used a depth-integrated storm surge model with unstructured grid, **ADCIRC** (ADvanced CIRCulation), and applied in Southern Louisiana.
- Sheng et al. (2010) developed a three-dimensional model, **CH3D-SSMS**, coupled with the wave model to study effects of waves on storm surge, currents, and inundation in the Outer Banks and Chesapeake Bay during Hurricane Isabel in 2003.
- Weisberg and Zheng (2006) used three-dimensional model named **FVCOM** (Finite-volume coastal ocean model) to simulate the storm surge for Tampa Bay.

Our Goals for a Storm Surge Prediction

- Spherical coordinate system with a large computational domain was adopted to cover the complete life cycle of the typhoon .
- Nonlinear, bottom shear stress and shoaling effects should be all considered in nearshore and multi-scale wave propagation.
- Calculating inundation area with high-resolution topographic data.
- Coupled with atmospheric model and parametric typhoon model.
- Coupled with global tide model.
- High-speed efficiency for the warning system.
- Widely validated.

COMCOT風暴潮溢淹速算系統介紹

(COrnell Multi-grid Coupled of Tsunami Model-Storm Surge)

Nonlinear Shallow Water Equations on Spherical Coordinate

$$\frac{\partial \eta}{\partial t} + \frac{1}{R\cos\varphi}\left\{\frac{\partial P}{\partial \psi} + \frac{\partial}{\partial \varphi}(\cos\varphi \cdot Q)\right\} = 0$$

$$\frac{\partial P}{\partial t} + \frac{1}{R\cos\varphi}\frac{\partial}{\partial \psi}\left(\frac{P^2}{H}\right) + \frac{1}{R}\frac{\partial}{\partial \varphi}\left(\frac{PQ}{H}\right) + \frac{gH}{R\cos\varphi}\frac{\partial \eta}{\partial \psi} - fQ + F_\psi^b = -\frac{H}{\rho_w R\cos\varphi}\frac{\partial P_a}{\partial \psi} + \frac{F_\psi^s}{\rho_w}$$

$$\frac{\partial Q}{\partial t} + \frac{1}{R\cos\varphi}\frac{\partial}{\partial \psi}\left(\frac{PQ}{H}\right) + \frac{1}{R}\frac{\partial}{\partial \varphi}\left(\frac{Q^2}{H}\right) + \frac{gH}{R}\frac{\partial \eta}{\partial \varphi} + fP + F_\varphi^b = -\frac{H}{\rho_w R}\frac{\partial P_a}{\partial \psi} + \frac{F_\varphi^s}{\rho_w}$$

- **Moving Boundary Scheme**

Moving boundary scheme was also introduced in COMCOT to model the run-up and run-down. The instant "shoreline" is defined as the interface between a dry grid and wet grid and volume flux normal to the interface is assigned to zero.

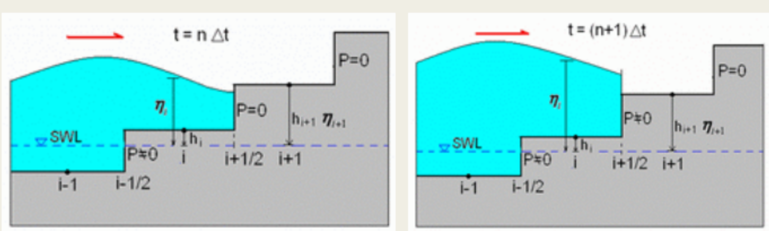


Fig.02 Moving Boundary Scheme

- Solve nonlinear shallow water equations on both spherical and Cartesian coordinate systems.
- Explicit leapfrog finite difference Method for stable calculation system.
- Nested-grid system for multiple storm surge propagation.
- Moving Boundary Scheme for inundation
- High-speed efficiency.

(2). COMCOT has been used on many scientific papers

At least 26 SCI papers were published during 2001~2011

(Including Science)

1. Title: Long waves through emergent coastal vegetation
Author(s): Mei Chiang C.; Chan I-Chi; Liu Philip L. -F.; et al.
Source: JOURNAL OF FLUID MECHANICS Volume: 687 Pages: 461-491 DOI: 10.1017/jfm.2011.373 Published: NOV 2011

2. Title: Insights on the 2009 South Pacific tsunami in Samoa and Tonga from field surveys and numerical simulations
Author(s): Fritz Hermann M.; Borrero Jose C.; Synolakis Costas E.; et al.
Source: EARTH-SCIENCE REVIEWS Volume: 107 Issue: 1-2 Special Issue: SI Pages: 66-75 DOI: 10.1016/j.earscirev.2011.03.004 Published: JUL 2011

3. Title: Solid landslide generated waves
Author(s): Wang Yang; Liu Philip L. -F.; Mei Chiang C.
Source: JOURNAL OF FLUID MECHANICS Volume: 675 Pages: 529-539 DOI: 10.1017/S0022112011000681 Published: MAY 2011

4. Title: An explicit finite difference model for simulating weakly nonlinear and weakly dispersive waves over slowly varying water depth
Author(s): Wang Xiaoming; Liu Philip L-F
Source: COASTAL ENGINEERING Volume: 58 Issue: 2 Pages: 173-183 DOI: 10.1016/j.coastaleng.2010.09.008 Published: FEB 2011

5. Title: Field Survey of the Samoa Tsunami of 29 September 2009
Author(s): Okal Emile A.; Fritz Hermann M.; Synolakis Costas E.; et al.
Source: SEISMOLOGICAL RESEARCH LETTERS Volume: 81 Issue: 4 Pages: 577-591 DOI: 10.1785/gssrl.81.4.577 Published: JUL-AUG 2010

6. Title: Impact of a 1755-like tsunami in Huelva, Spain
Author(s): Lima V. V.; Miranda J. M.; Baptista M. A.; et al.
Source: NATURAL HAZARDS AND EARTH SYSTEM SCIENCES Volume: 10 Issue: 1 Pages: 139-148 Published: 2010

7. Title: An insitu borescopic quantitative imaging profiler for the measurement of high concentration sediment velocity
Author(s): Cowen Edwin A.; Dudley Russell D.; Liao Qian; et al.
Source: EXPERIMENTS IN FLUIDS Volume: 49 Issue: 1 Special Issue: SI Pages: 77-88 DOI: 10.1007/s00348-009-0801-8 Published: JUL 2010

8. Title: Tsunami hazard from the subduction megathrust of the South China Sea: Part I. Source characterization and the resulting tsunami
Author(s): Megawati Kusnowidjaja; Shaw Felicia; Sieh Kerry; et al.
Source: JOURNAL OF ASIAN EARTH SCIENCES Volume: 36 Issue: 1 Pages: 13-20 DOI: 10.1016/j.jseaes.2008.11.012 Published: SEP 4 2009

9. Title: Simulation of Andaman 2004 tsunami for assessing impact on Malaysia
Author(s): Koh Hock Lye; Teh Su Yean; Liu Philip Li-Fan; et al.
Source: JOURNAL OF ASIAN EARTH SCIENCES Volume: 36 Issue: 1 Pages: 74-83 DOI: 10.1016/j.jseaes.2008.09.008 Published: SEP 4 2009
Times Cited: 0 (from Web of Science)

10. Title: Modeling tsunami hazards from Manila trench to Taiwan
Author(s): Wu Tso-Ren; Huang Hui-Chuan
Source: JOURNAL OF ASIAN EARTH SCIENCES Volume: 36 Issue: 1 Pages: 21-28 DOI: 10.1016/j.jseaes.2008.12.006 Published: SEP 4 2009
Times Cited: 0 (from Web of Science)

11. Title: Tsunami hazard and early warning system in South China Sea
Author(s): Liu Philip L. -F.; Wang Xiaoming; Salisbury Andrew J.
Source: JOURNAL OF ASIAN EARTH SCIENCES Volume: 36 Issue: 1 Pages: 2-12 DOI: 10.1016/j.jseaes.2008.12.010 Published: SEP 4 2009

12. Title: Analytical and numerical simulation of tsunami mitigation by mangroves in Penang, Malaysia
Author(s): Teh Su Yean; Koh Hock Lye; Liu Philip Li-Fan; et al.
Source: JOURNAL OF ASIAN EARTH SCIENCES Volume: 36 Issue: 1 Pages: 38-46 DOI: 10.1016/j.jseaes.2008.09.007 Published: SEP 4 2009

13. Title: Simulation of Andaman 2004 tsunami for assessing impact on Malaysia
Author(s): Koh Hock Lye; Teh Su Yean; Liu Philip Li-Fan; et al.
Source: JOURNAL OF ASIAN EARTH SCIENCES Volume: 36 Issue: 1 Pages: 74-83 DOI: 10.1016/j.jseaes.2008.09.008 Published: SEP 4 2009

14. Title: SPECIAL ISSUE Tsunamis in Asia Preface
Author(s): Liu Philip L. -F.; Huang Bor-Shouh
Source: JOURNAL OF ASIAN EARTH SCIENCES Volume: 36 Issue: 1 Pages: 1-1 DOI: 10.1016/j.jseaes.2009.05.001 Published: SEP 4 2009

15. Title: INDIAN OCEAN TSUNAMI ON 26 DECEMBER 2004: NUMERICAL MODELING OF INUNDATION IN THREE CITIES ON THE SOUTH COAST OF SRI LANKA
Author(s): Wijetunge J. J.; Wang Xiaoming; Liu Philip L. -F.
Source: JOURNAL OF EARTHQUAKE AND TSUNAMI Volume: 2 Issue: 2 Pages: 133-155 Published: JUN 2008

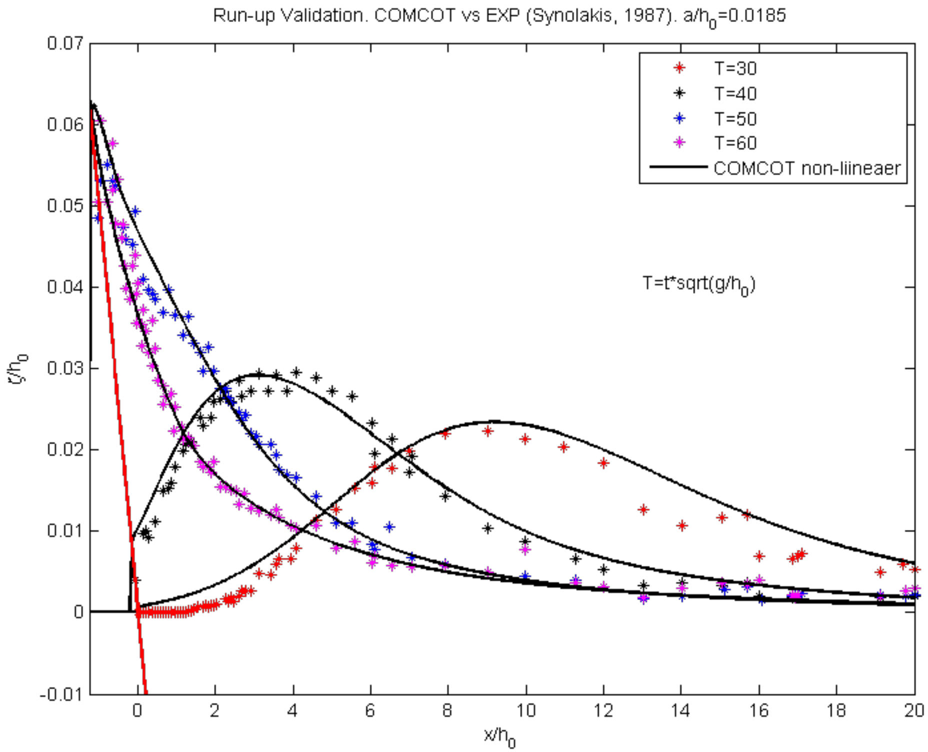
16. Title: TSUNAMI SOURCE REGION PARAMETER IDENTIFICATION AND TSUNAMI FORECASTING
Author(s): Liu Philip L. -F.; Wang Xiaoming
Source: JOURNAL OF EARTHQUAKE AND TSUNAMI Volume: 2 Issue: 2 Pages: 87-106 Published: JUN 2008

17. Title: Bottom friction and its effects on periodic long wave propagation
Author(s): Orfila A.; Simarro G.; Liu P. L. F.
Source: COASTAL ENGINEERING Volume: 54 Issue: 11 Pages: 856-864 DOI: 10.1016/j.coastalene.2007.05.013 Published: NOV 2007

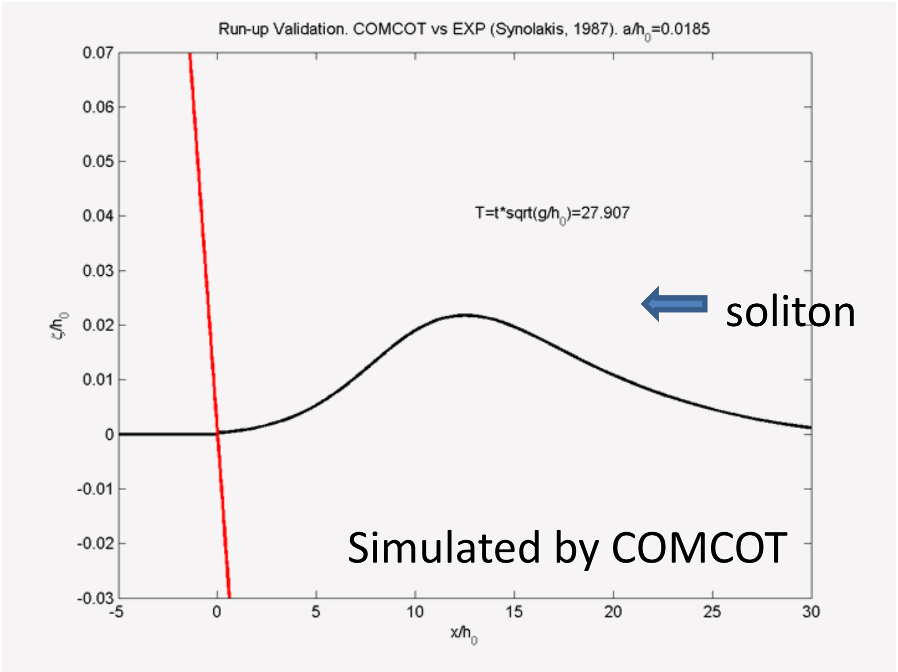
（To be continued）

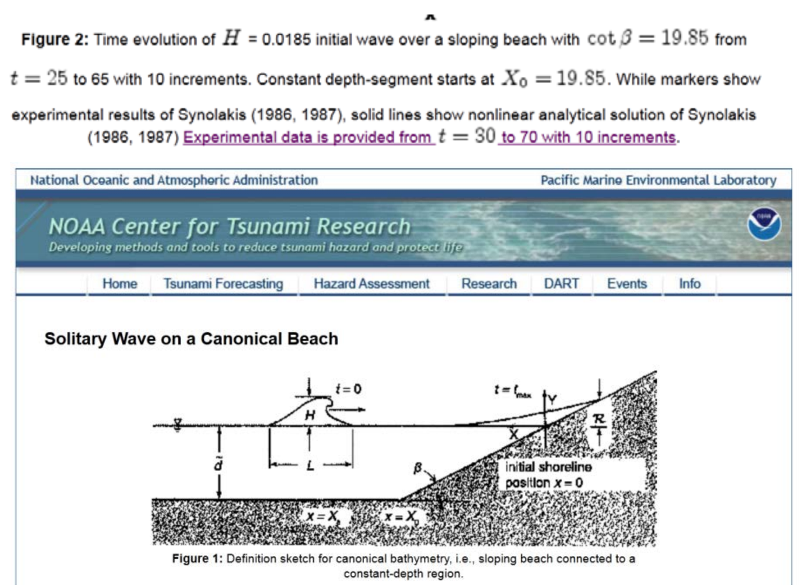
(3). COMCOT has been widely validated:

Synolakis solitary wave runup (1986, 1987).



(Wu, 2012)

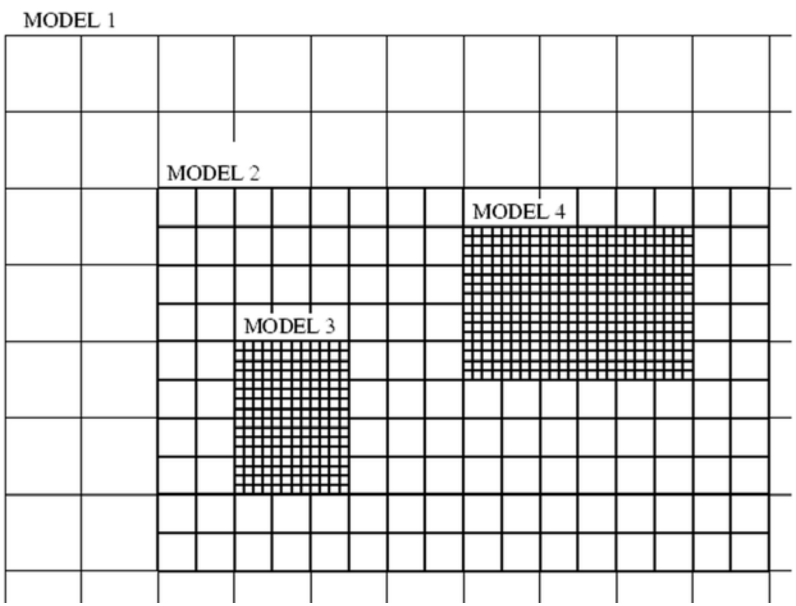


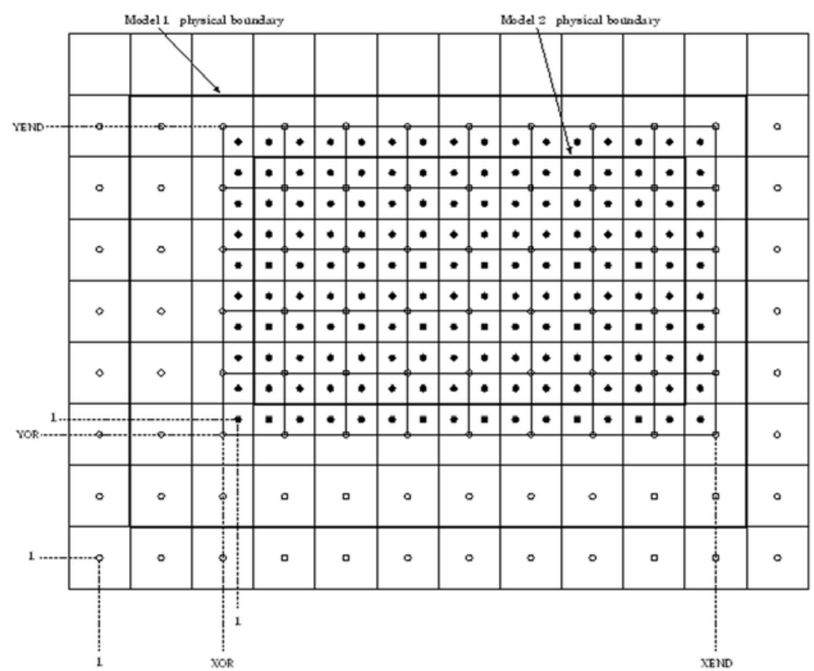


(NOAA)

(4).多重動態巢狀網格應用於暴潮速算系統

允許多尺度風暴潮傳遞：包含遠洋暴潮傳遞和近岸尺度暴潮溢淹





(T. L Clark, 1984; C. Chen, 1991; and Y. G. Kurihara, J. Tripoli and M. A. Bender, 1979)

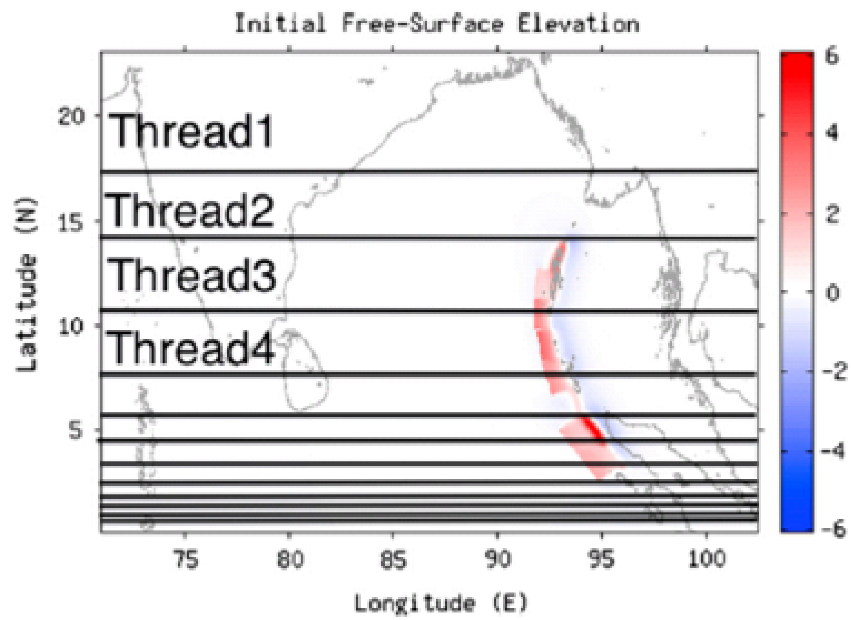
- Communication between coarse grid resolution and fine grid resolution.
- Make fast calculation of fine-grid storm surge inundation possible.
- High efficiency and more stable than unstructured grid system.

(5).平行化高速運算

計算效能與原版COMCOT相比提高10倍以上

使用OpenMP (Open Multi-Processing)方式命令執行緒進行獨立迴圈之計算。

```
!$OMP PARALLEL DO PRIVATE(J,I,ZZZ,DD)
DO J=JS, JE
  DO I=IS, IE
    IF (L%H(I,J) .GT. ELMAX) THEN
      ZZZ = L%Z(I,J,1) - RX*(L%M(I,J,1)-L%M(I-1,J,1)) &
              - RY*(L%N(I,J,1)-L%N(I,J-1,1))
      ZZZ = ZZZ - (L%HT(I,J,2)-L%HT(I,J,1))
      IF (ABS(ZZZ) .LT. EPS) ZZZ = 0.0
      DD = ZZZ + L%H(I,J)
      ...
    ELSE
      ...
    END IF
  END DO
END DO
!$OMP PARALLEL DO
```



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Review

Development of a tsunami early warning system for the South China Sea

Simon C. Lin[a], Tso-Ren Wu[c,*], Eric Yen[b], Hsin-Yen Chen[b], John Hsu[a], Yu-Lin Tsai[c], Chun-Juei Lee[c], Philip, L.-F. Liu[c,d]

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[c] Institute of Hydrological & Oceanic Sciences, National Central University, Jhongli 32001, Taiwan
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研究成果已發表於2015年Ocean Engineering

動態分配計算迴圈數量及範圍，增加計算機運算效能。

氣象力驗證－與壓力梯度解析解比較

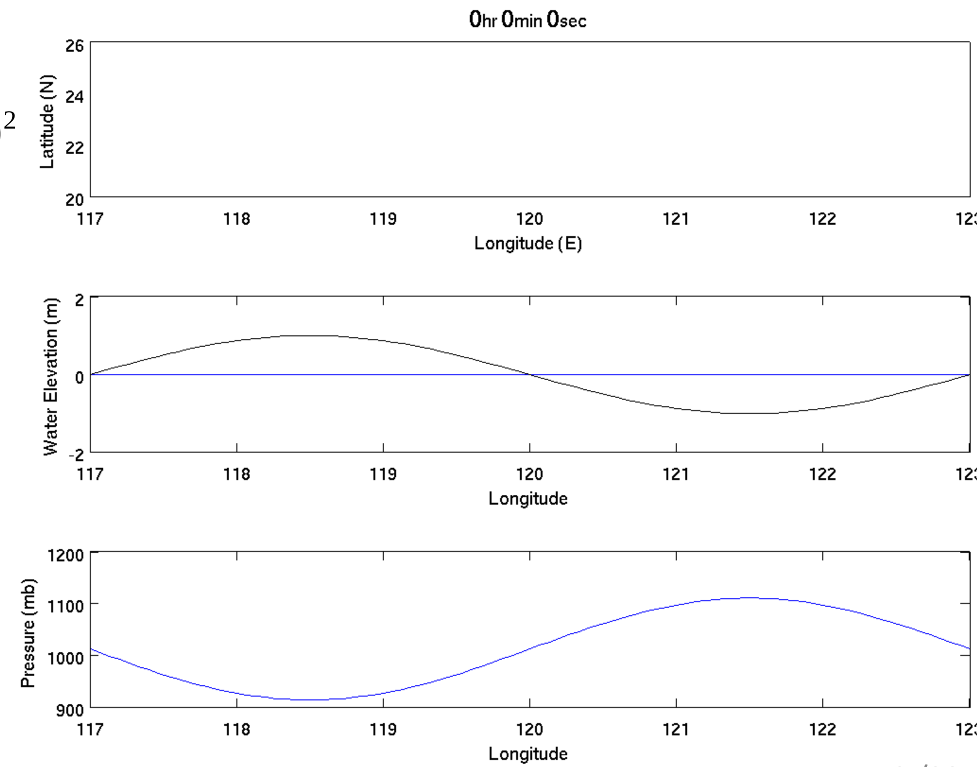
$$\frac{\partial P}{\partial t}+\frac{1}{R\cos\varphi}\frac{\partial}{\partial\psi}\left(\frac{P^2}{H}\right)+\frac{1}{R}\frac{\partial}{\partial\varphi}\left(\frac{PQ}{H}\right)+\frac{gH}{R\cos\varphi}\frac{\partial\eta}{\partial\psi}-fQ+F_\psi^b=-\frac{H}{\rho_w R\cos\varphi}\frac{\partial P_a}{\partial\psi}$$

$$\Rightarrow\quad \frac{\partial P}{\partial t}+\frac{gH}{R\cos\varphi}\frac{\partial\eta}{\partial\psi}=-\frac{H}{\rho_w R\cos\psi}\frac{\partial P_a}{\partial\psi}$$

$$P_a=-9800\cdot\sin\left[\frac{2\cdot\pi(\psi-\psi_1)}{\psi_2-\psi_1}\right]+1013.25\cdot10^2$$

$$\partial\eta=-\frac{\partial P_a}{g\rho_w}=\sin\left[\frac{2\cdot\pi(\psi-\psi_1)}{\psi_2-\psi_1}\right]$$

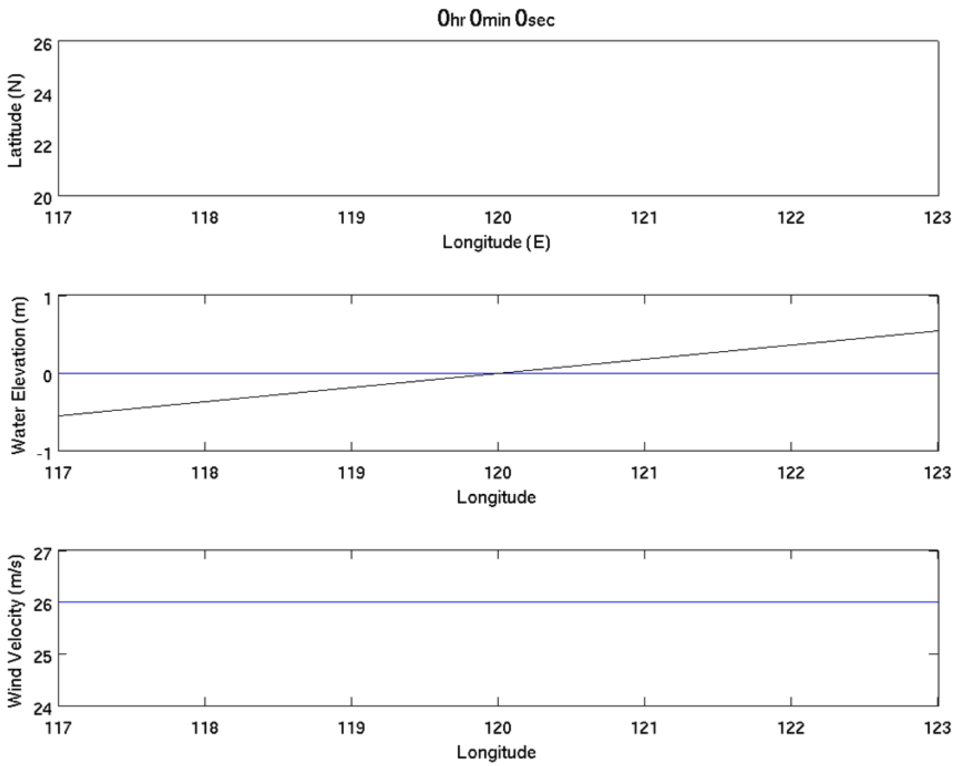
The simulated water elevation generated by the pressure gradient is in a good agreement with steady-state analytic solution.



氣象力驗證－與風剪力解析解比較

$$\frac{\partial P}{\partial t}+\frac{1}{R\cos\varphi}\frac{\partial}{\partial\psi}\left(\frac{P^2}{H}\right)+\frac{1}{R}\frac{\partial}{\partial\varphi}\left(\frac{PQ}{H}\right)+\frac{gH}{R\cos\varphi}\frac{\partial\eta}{\partial\psi}-fQ+F_\psi^b=\frac{F_\psi^s}{\rho_w}$$

$$\Rightarrow\quad \frac{\partial P}{\partial t}+\frac{gH}{R\cos\varphi}\frac{\partial\eta}{\partial\psi}=\frac{F_\psi^s}{\rho_w}$$



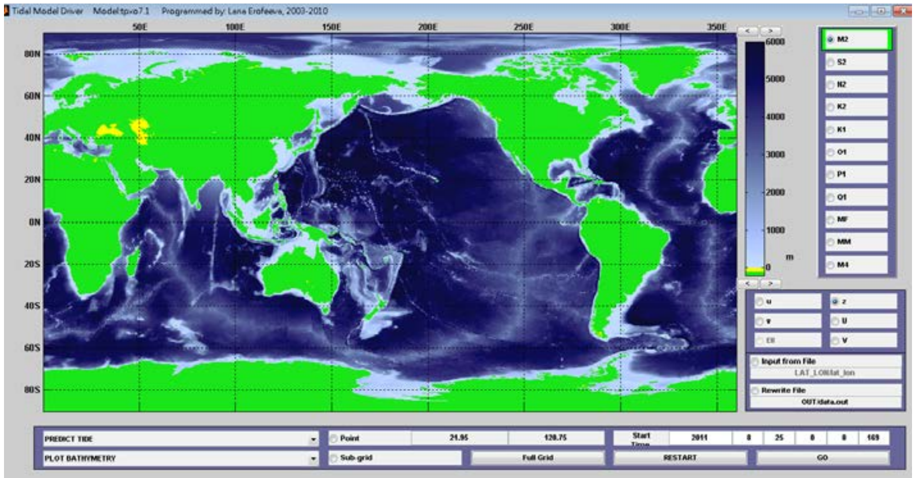
$$\overrightarrow{V}_w=26(m/s)\qquad F_\psi^s=\rho_a C_d\left|\overrightarrow{V}_w\right|\overrightarrow{V}_w$$

$$\partial\eta=\rho_a C_d\left|\overrightarrow{V}_w\right|\overrightarrow{V}_w\cdot\frac{R\cdot\cos\varphi\cdot\partial\psi}{\rho_w\cdot gH}$$

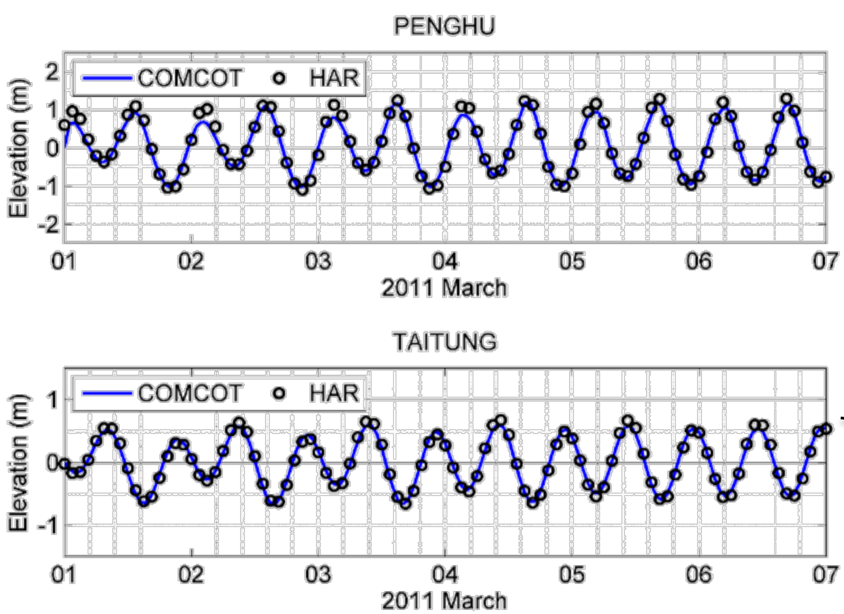
$$=1.0992(\mathrm{m})$$

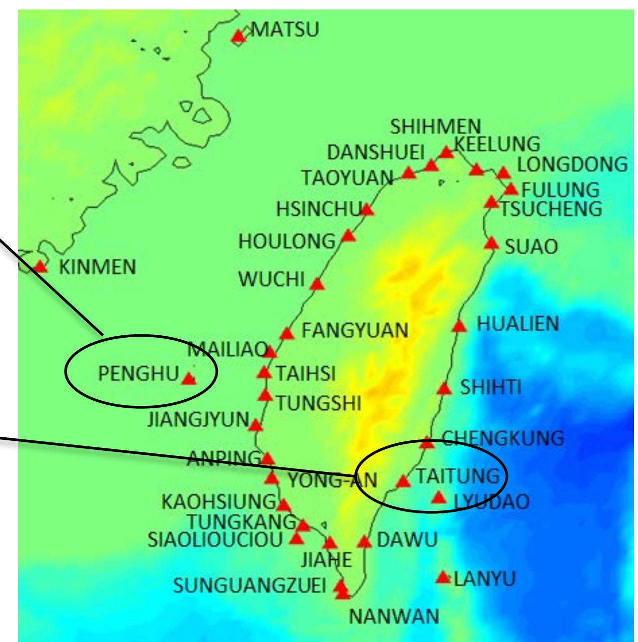
The simulated water elevation generated by wind shear stress is in a good agreement with steady-state analytic solution.

暴潮速算系統與全球天文潮TPXO模式即時耦合

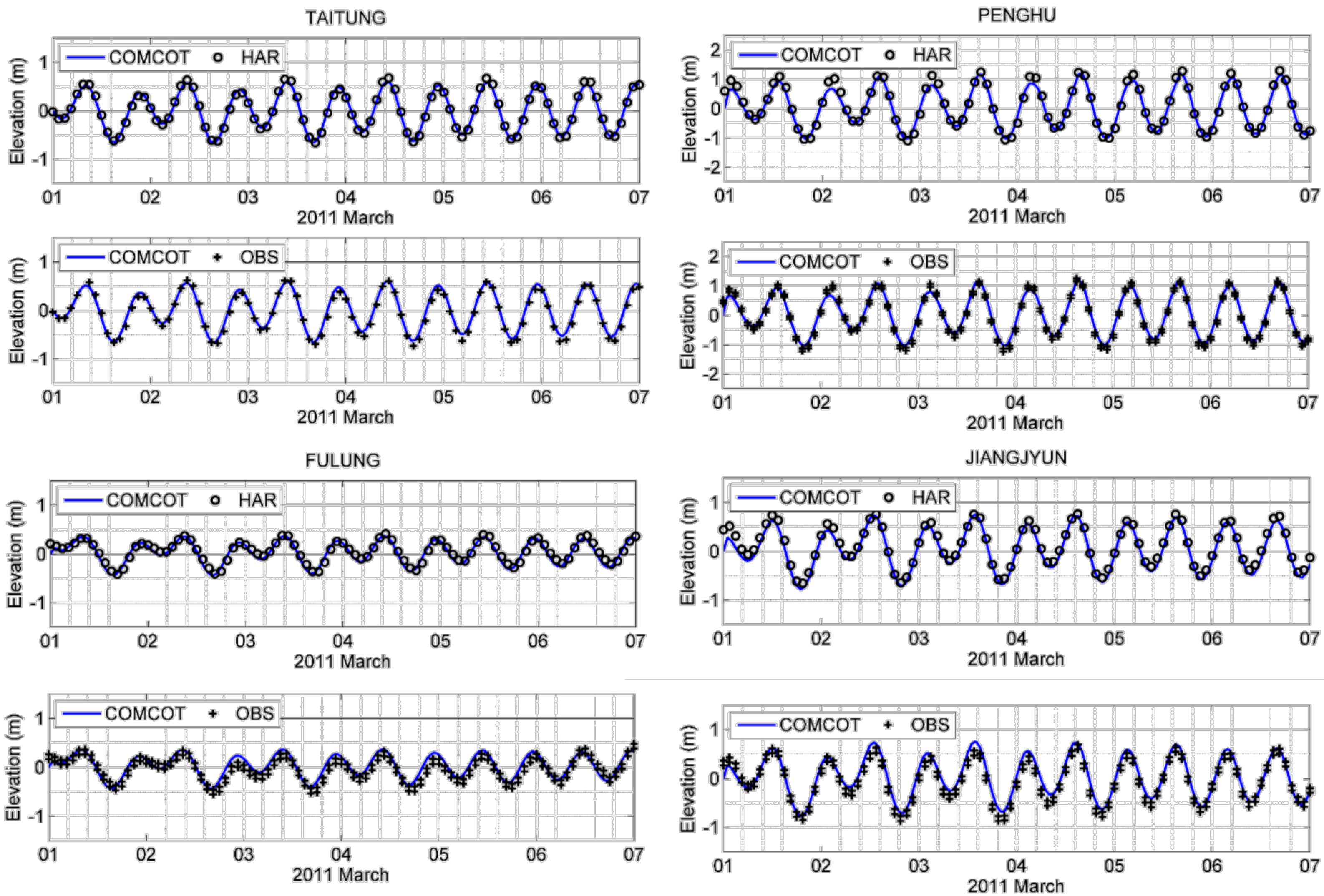


The tides are provided as complex amplitudes of earth-relative sea-surface elevation for eight primary (M2, S2, N2, K2, K1, O1, P1, Q1), two long period (Mf,Mm) and 3 non-linear (M4, MS4, MN4) harmonic constituents, on a 1440x721, 1/4 degree resolution full global grid (for versions 6.* and later).





高準確度的天文潮模擬

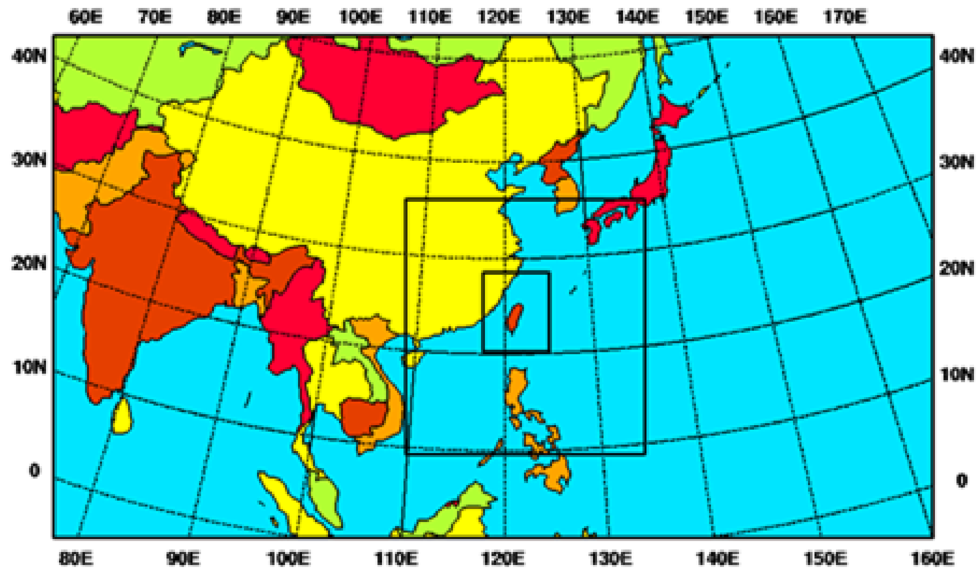


80%以上的潮位站比較，偏差量絕對值小於0.1 m，方均根誤差小於0.6m。

暴潮速算系統與大氣模式TWRF即時耦合

TWRF（Typhoon Weather Research and Forecasting Model）

- TWRF model is a atmospheric model used for operational progressing by Central Weather Bureau in Taiwan.
- The TWRF model would start its simulation per 6 hours in a day at 00, 06, 12 and 18 UTC time, respectively.
- Three nested grids were adopted in TWRF model.



Computational Domain (CWB)

Information of TWRF Model

	Domain 1	Domain 2	Domain 3
Projection System	Lambert		
Resolution	45 km	15 km	5 km
X Grid Number	221	181	151
Y Grid Number	127	193	181

Parametric Typhoon Model

CWB Model

$$P_a = P_c + (P_n - P_c)\exp[-(\frac{R_{max}}{r})^B]$$

$$V_w = 2 \cdot V_{max} \cdot \frac{R_{max} \cdot r}{{R_{max}}^2 + r^2}$$

$$B = \frac{1}{P_n - P_c}(\frac{V_{max}}{5.375})^2$$

$$R_{max} = \begin{cases} 42.6 - 0.86 \cdot (P_c - 990) & P_c \geq 990 \\ 51.0 - 0.84 \cdot (P_c - 980) & 980 \leq P_c < 990 \\ 58.4 - 0.74 \cdot (P_c - 970) & 970 \leq P_c < 980 \\ 63.0 - 0.46 \cdot (P_c - 960) & 960 \leq P_c < 970 \\ 70.0 - 0.234 \cdot (P_c - 930) & 930 \leq P_c < 960 \\ 80.0 - 0.167 \cdot (P_c - 870) & 870 \leq P_c < 930 \\ 80.0 & P_c < 870 \end{cases}$$

Holland Model (1980)

$$P_a = P_c + (P_n - P_c)\exp\left[-(\frac{R_{max}}{r})^B\right]$$

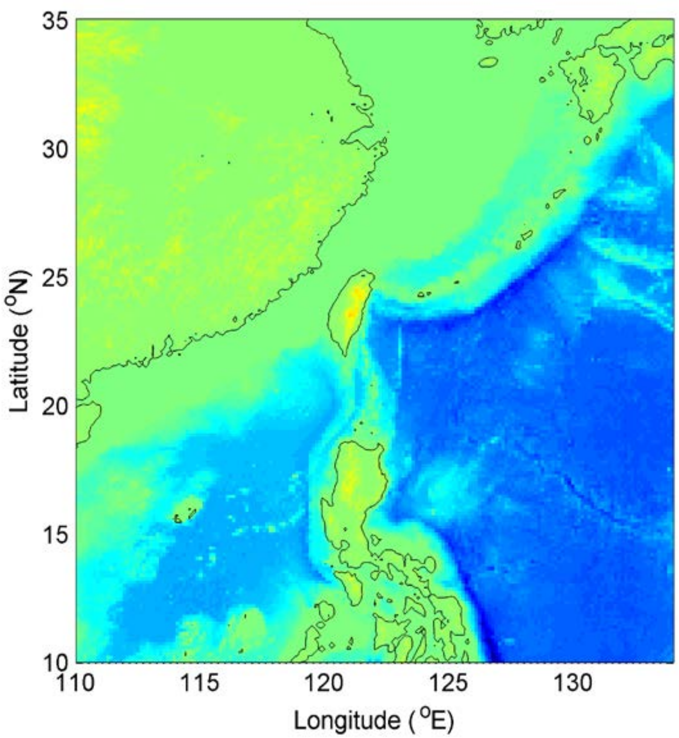
$$V_w = \sqrt{\frac{B(P_n - P_c)}{\rho_a}\left(\frac{R_{max}}{r}\right)^B \exp\left[-\left(\frac{R_{max}}{r}\right)^B\right] + \frac{r^2 f^2}{4}} - \frac{rf}{2} \qquad B = 2 - \frac{P_c - 900}{160}$$

耦合高解析度地形之暴潮預報系統

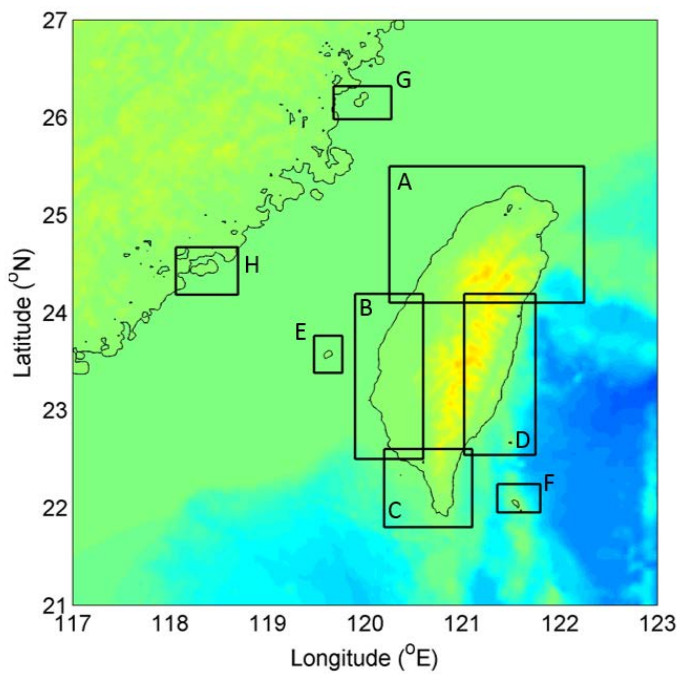
Layer 01 (8 arc-min) / Layer 02 (4 arc-min) / Layer 03 (0.5 arc-min)

	Longitude	Latitude	資料來源
Layer 01	110.0 – 135.0	10.0 – 35.0	ETOPO 2
Layer 02	118.475 - 123.125	21.142 - 26.192	ETOPO 1
Layer 03	119.768 - 122.249	21.518 - 25.499	科技部200m地形

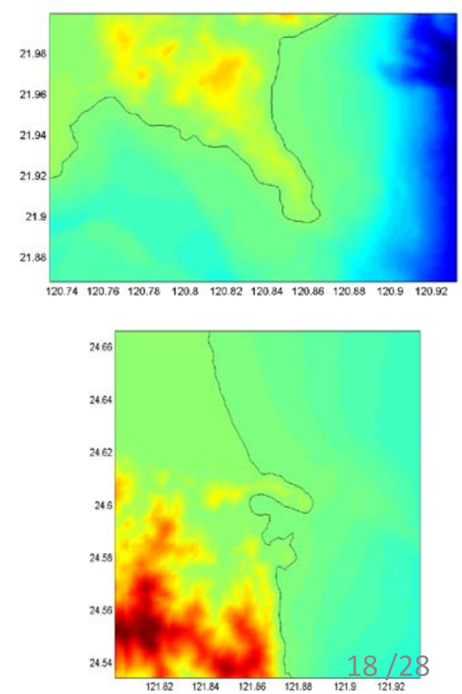
Layer 01



Layer 02

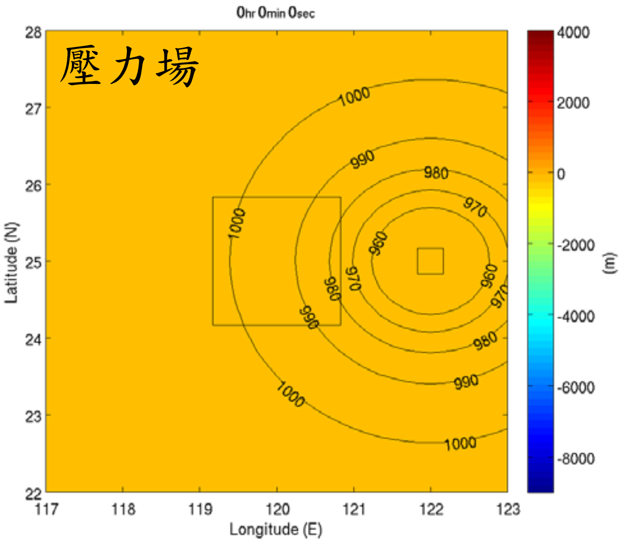


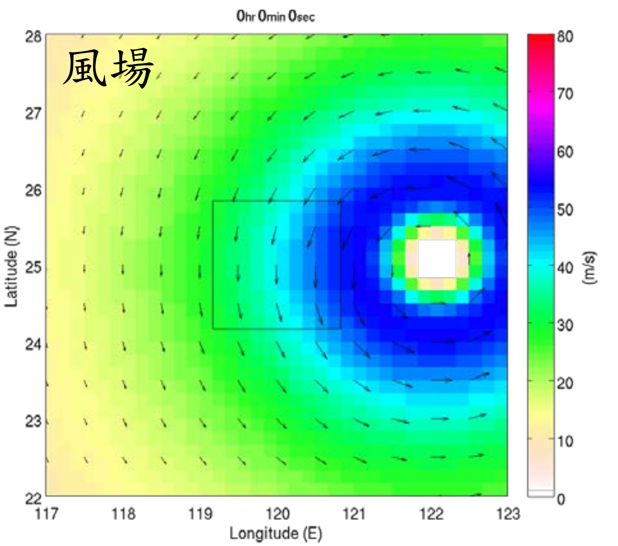
Layer 03



多重巢狀網格氣象力導入校驗

兼顧不同網格解析度且答案穩定

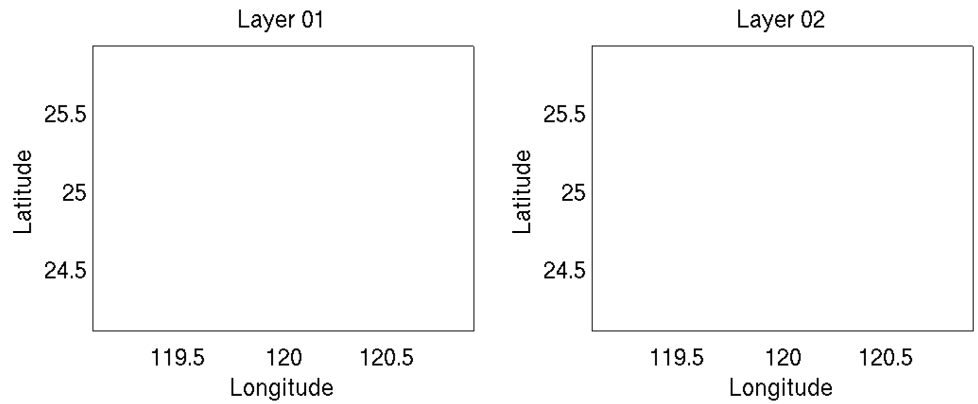


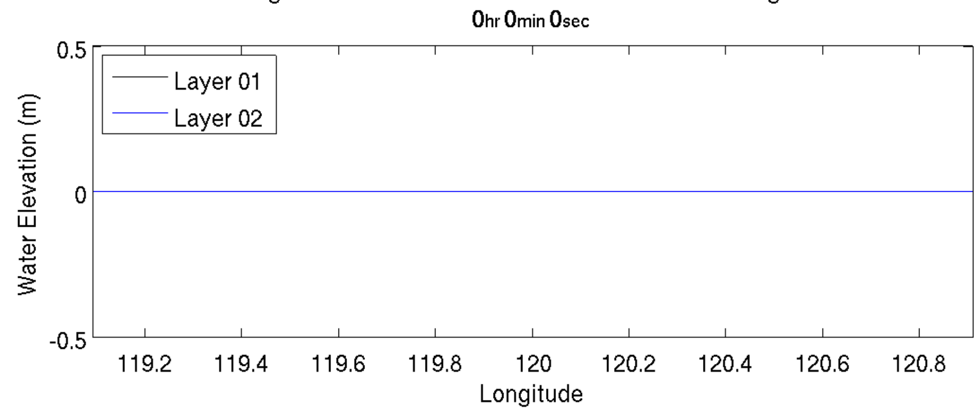


Resolution: 10.0/ 1.0 arc-min

Total Time: 14400 seconds

Time Step: 10 seconds



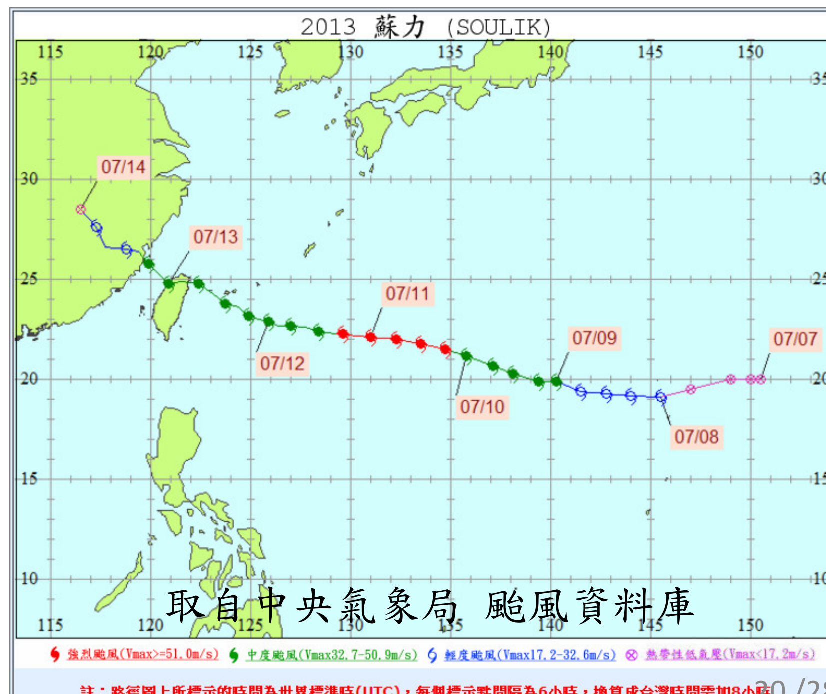


歷史案例校驗－2013年蘇力颱風

- 颱風蘇力（Typhoon Soulik）於2013年7月7日轉為熱帶性低氣壓，持續增強其威力，一直到7月9日變為中度颱風，於當天下午5時升格為強烈颱風；蘇力颱風7月13日上午於臺灣新北市三貂角登陸，颱風結構遭地形破壞，強度減弱，7月13日下午從新竹出海離開臺灣，為第2類侵臺路徑。

- 蘇力颱風造成臺灣7月13日全臺停班停課，出現12級之強風，同時造成新北市嚴重海水倒灌，野柳地質公園以及野柳海洋世界因設施遭海水破壞被迫關閉園區進行維修。

基隆－滿潮後海水倒灌（東森新聞）



取自中央氣象局 颱風資料庫

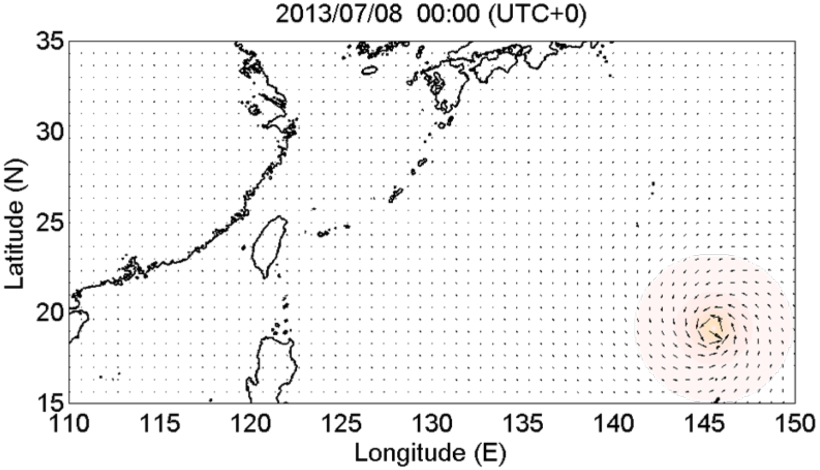
2013 Typhoon Soulik

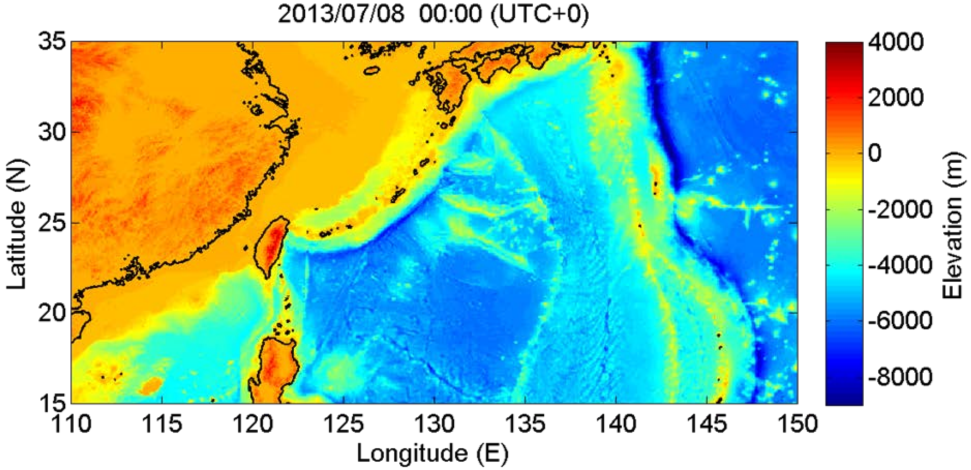
2013.07.08 00:00 – 2013.07.13 18:00 (UTC+0)

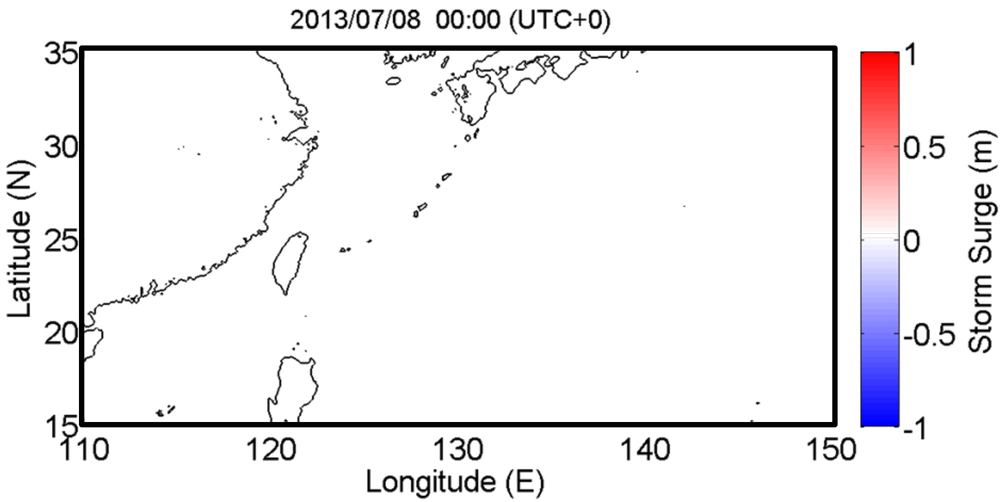
Total Time :496800 sec (~6 days)

Time Step : 8 sec

Resolution : 8/4/0.1 arc-min



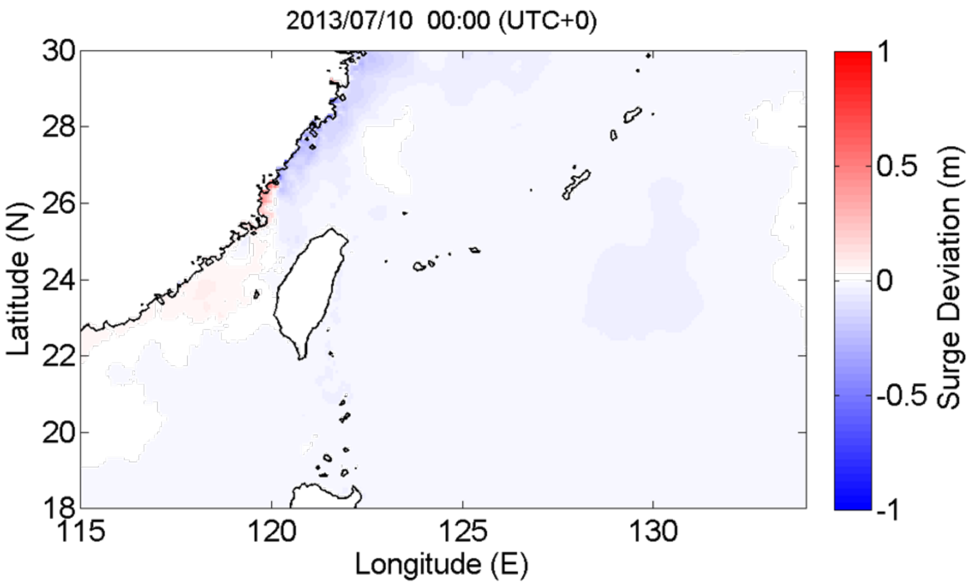


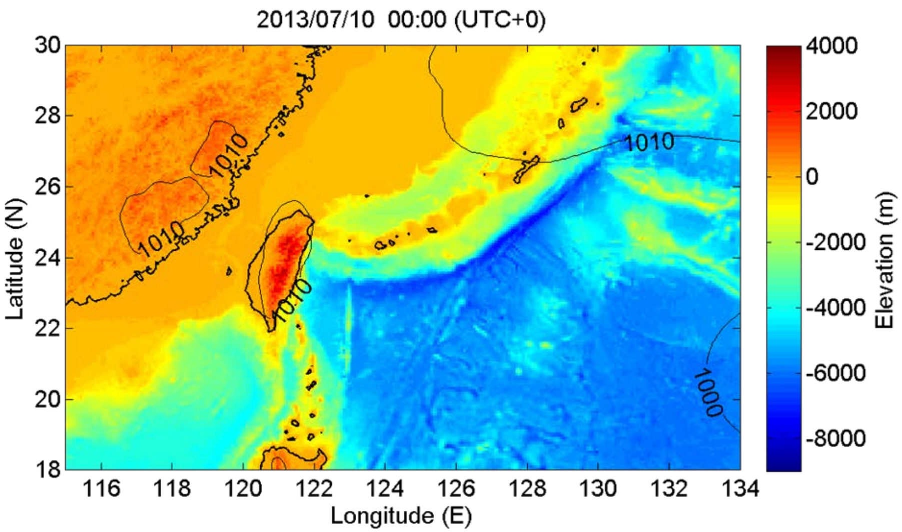


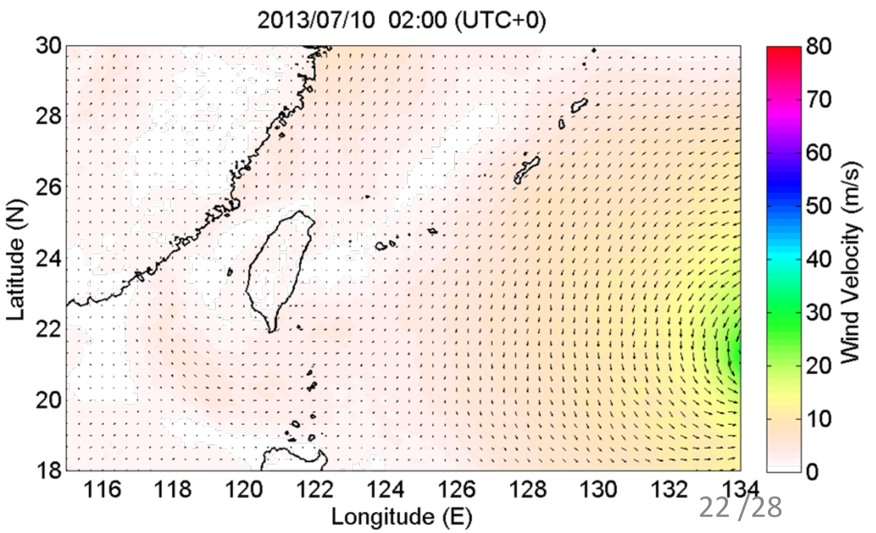
2013 Typhoon Soulik Coupled with TWRF

2013.07.05 00:00 – 2013.07.16 18:00 (UTC+0)

Total Time :1015200 sec(~12 days)
Time Step : 4 sec
Resolution : 4 arc-min

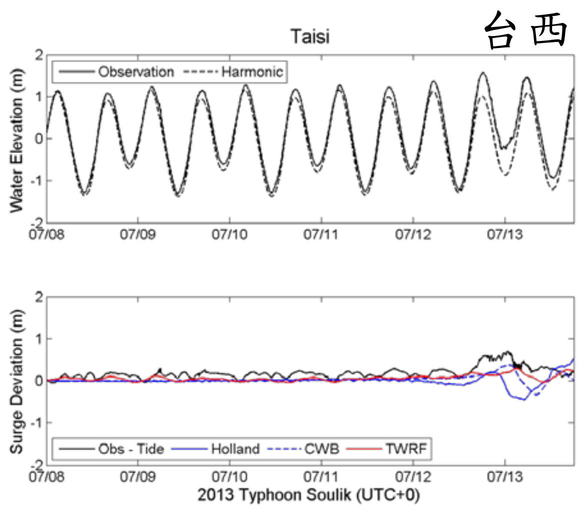


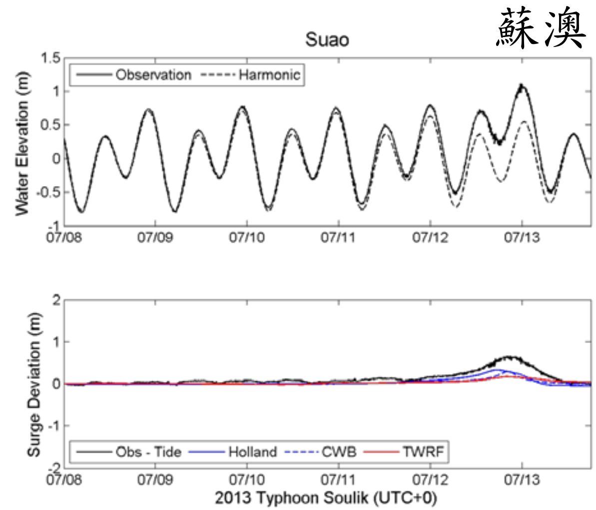


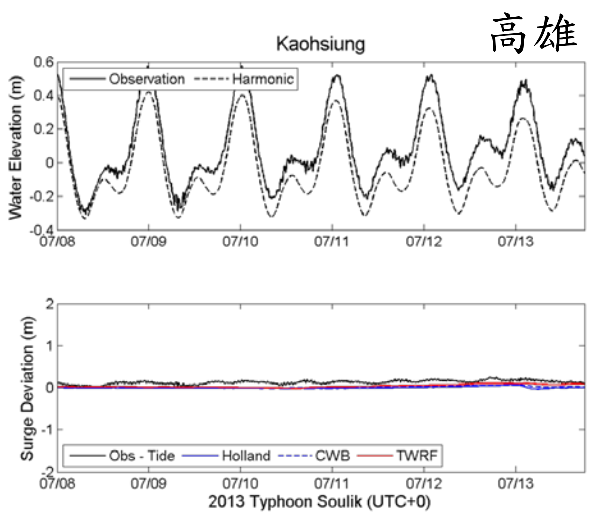


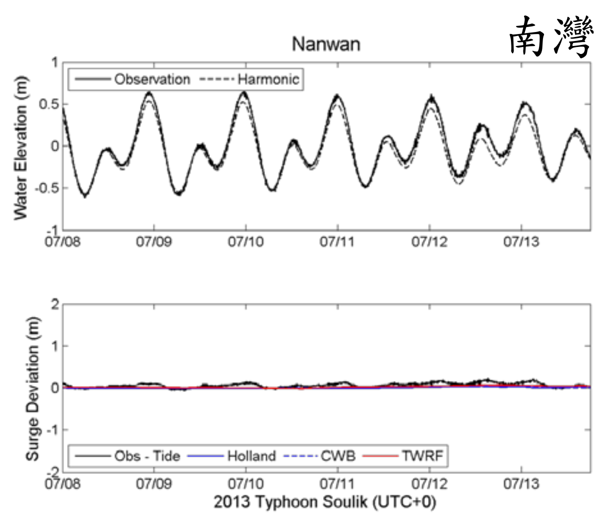
2013年蘇力颱風模擬結果與實測資料之比較

2013.07.08 – 2013.07.13 (UTC+0)

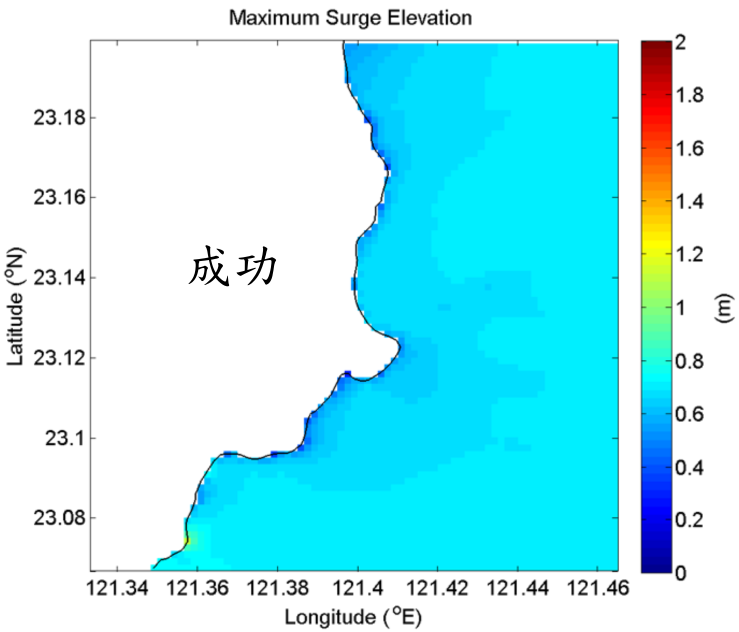


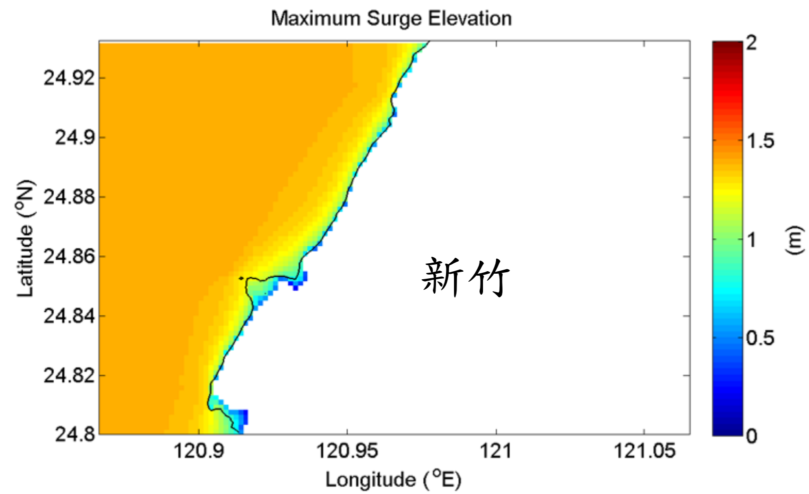


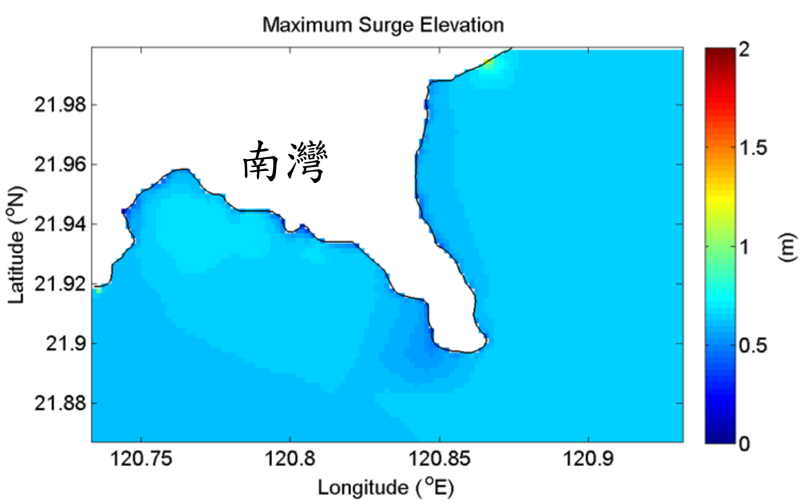


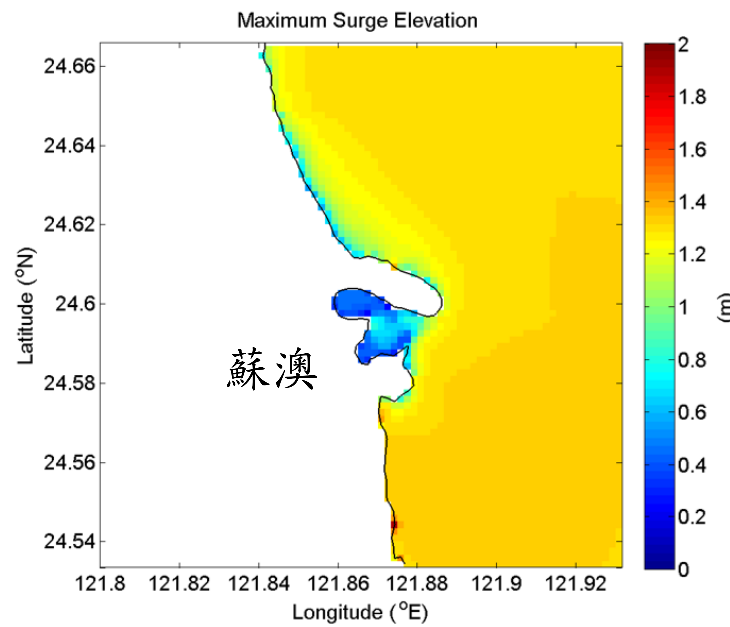


蘇力颱風溢淹模擬結果


Maximum Surge Elevation
成功
Latitude (°N)
23.18
23.16
23.14
23.12
23.1
23.08
121.34 121.36 121.38 121.4 121.42 121.44 121.46
Longitude (°E)
2 1.8 1.6 1.4 1.2 1 0.8 0.6 0.4 0.2 0
(m)

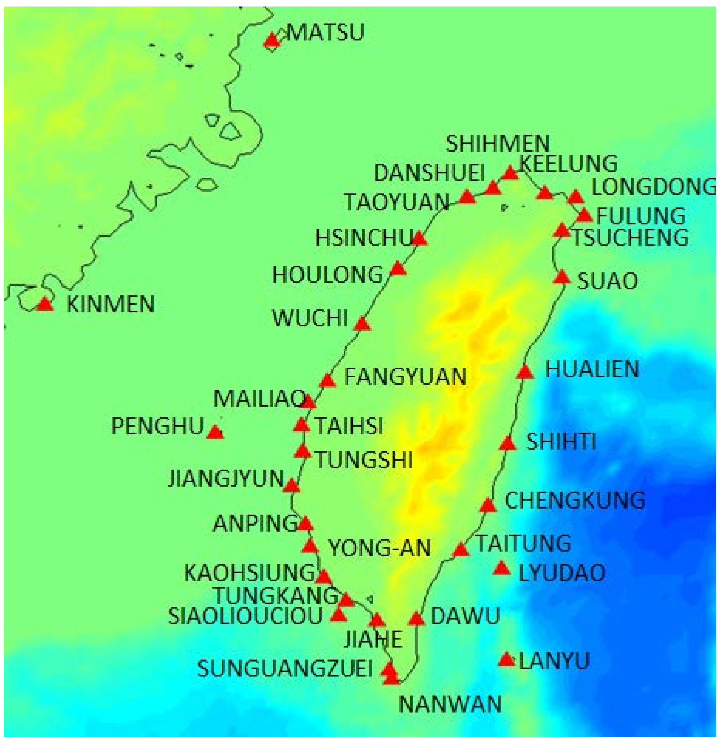

Maximum Surge Elevation
新竹
Latitude (°N)
24.92
24.9
24.88
24.86
24.84
24.82
24.8
120.9 120.95 121 121.05
Longitude (°E)
2 1.5 1 0.5 0
(m)


Maximum Surge Elevation
南灣
Latitude (°N)
21.98
21.96
21.94
21.92
21.9
21.88
120.75 120.8 120.85 120.9
Longitude (°E)
2 1.5 1 0.5 0
(m)


Maximum Surge Elevation
蘇澳
Latitude (°N)
24.66
24.64
24.62
24.6
24.58
24.56
24.54
121.8 121.82 121.84 121.86 121.88 121.9 121.92
Longitude (°E)
2 1.8 1.6 1.4 1.2 1 0.8 0.6 0.4 0.2 0
(m)

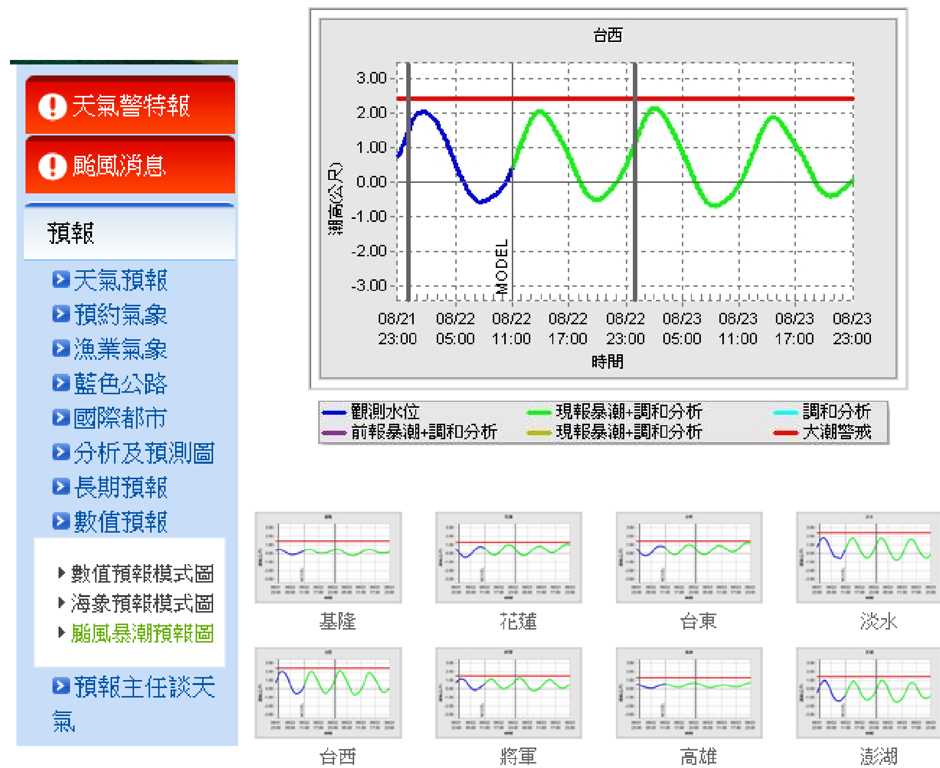
現階段暴潮溢淹模式產品規劃(1)-
時序潮位預報資料

- 針對臺灣本島及離島共34處地區進行未來48小時之模擬並預報未來36小時序潮位。
- 輸出格式配合中央氣象局展示系統，可即時上線提供民眾瀏覽。



預報全臺34處潮位站未來36小時之潮位

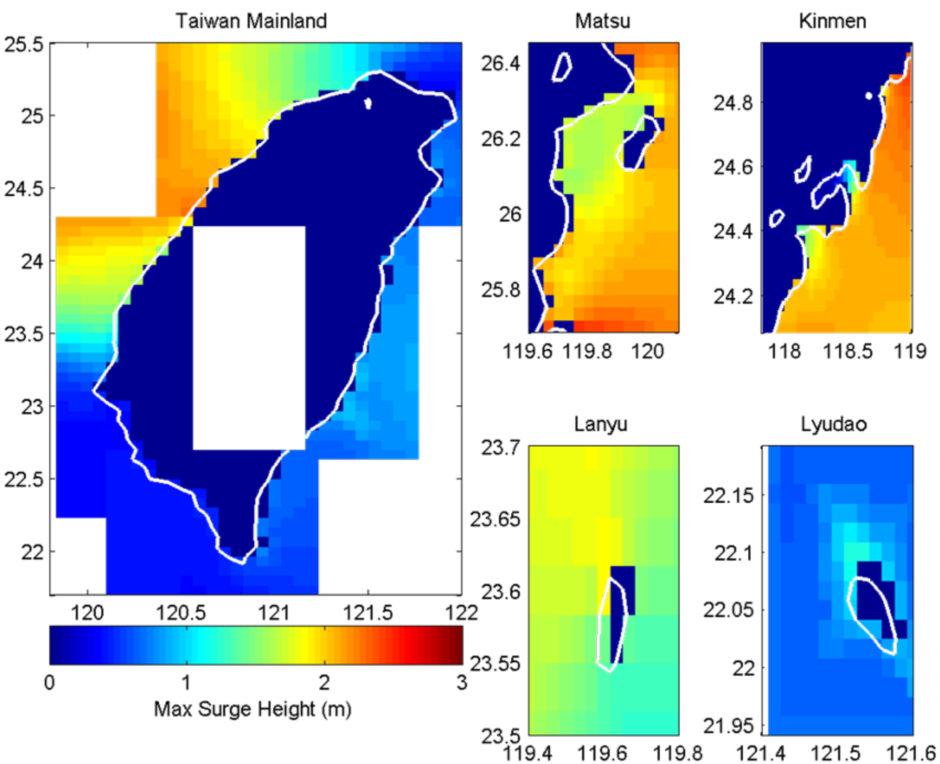
交通部中央氣象局
Central Weather Bureau



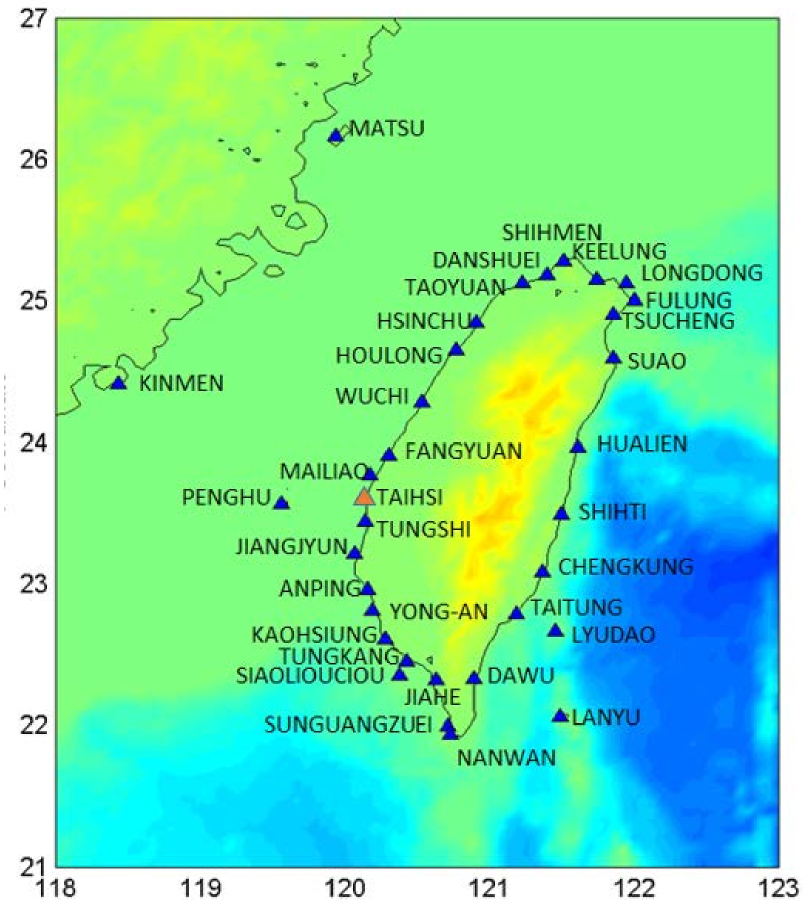
結合中央氣象局展示系統

現階段暴潮溢淹模式產品規劃(2)-
溢淹潛勢圖

- 提供臺灣沿海區域最大風暴潮高和未來48小時風暴潮淹水潛勢範圍。
- 提供48小時預報內海水溢堤之潛勢區域，並以不同燈號示警。



48小時預報內臺灣沿海區域最大風暴潮



Conclusion

1. 本研究以COMCOT海嘯模式為基礎，發展臺灣海域近岸風暴潮溢淹算系統；在球座標系統下以非線性淺水波方程式求解風暴潮傳遞和近岸溢淹過程，並以多重巢狀網格解析不同尺度之風暴潮傳遞行為。
2. 以大範圍計算域涵蓋颱風生命週期和風暴潮傳遞，同時耦合高解析度之近岸地形。
3. 利用OpenMP方法動態分配執行緒計算，效能與原版相比提升10倍以上，使得COMCOT模式得以進行高效能運算以符合風暴潮預報時效。
4. 於預報過程中即時耦合全球天文潮TPXO模式，並與調和分析資料和實測資料進行比對，85%以上之潮位站偏差量絕對值小於0.1公尺且方均誤誤差小於0.6公尺。
5. 於預報過程中即時耦合TWRF大氣模式。
6. 分別以壓力梯度和風剪力解析解進行校驗，模擬結果和解析解有良好比對成果，顯示模式準確度。
7. 以理想颱風進行巢狀網格校驗並比對答案，結果顯示本研究所開發之模式在兼顧效能之情況下，答案準確且數值方法穩定。
8. 以2013年蘇力颱風作為案例驗證，模擬結果與實測資料有良好比對結果，顯示模式準確性，該案例中同時進行高解析度之近岸地區溢淹計算，成功推算近岸地區淹水行為。
9. 目前暴潮速算系統規劃產品包含未來36小時臺灣34處潮位站之時序列資料預報以及48小時內最大風暴潮高和溢淹警示圖，同時結合中央氣象局目前所使用之展示系統，並上線測試。

謝謝各位聆聽

歡迎提供建議與討論

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