

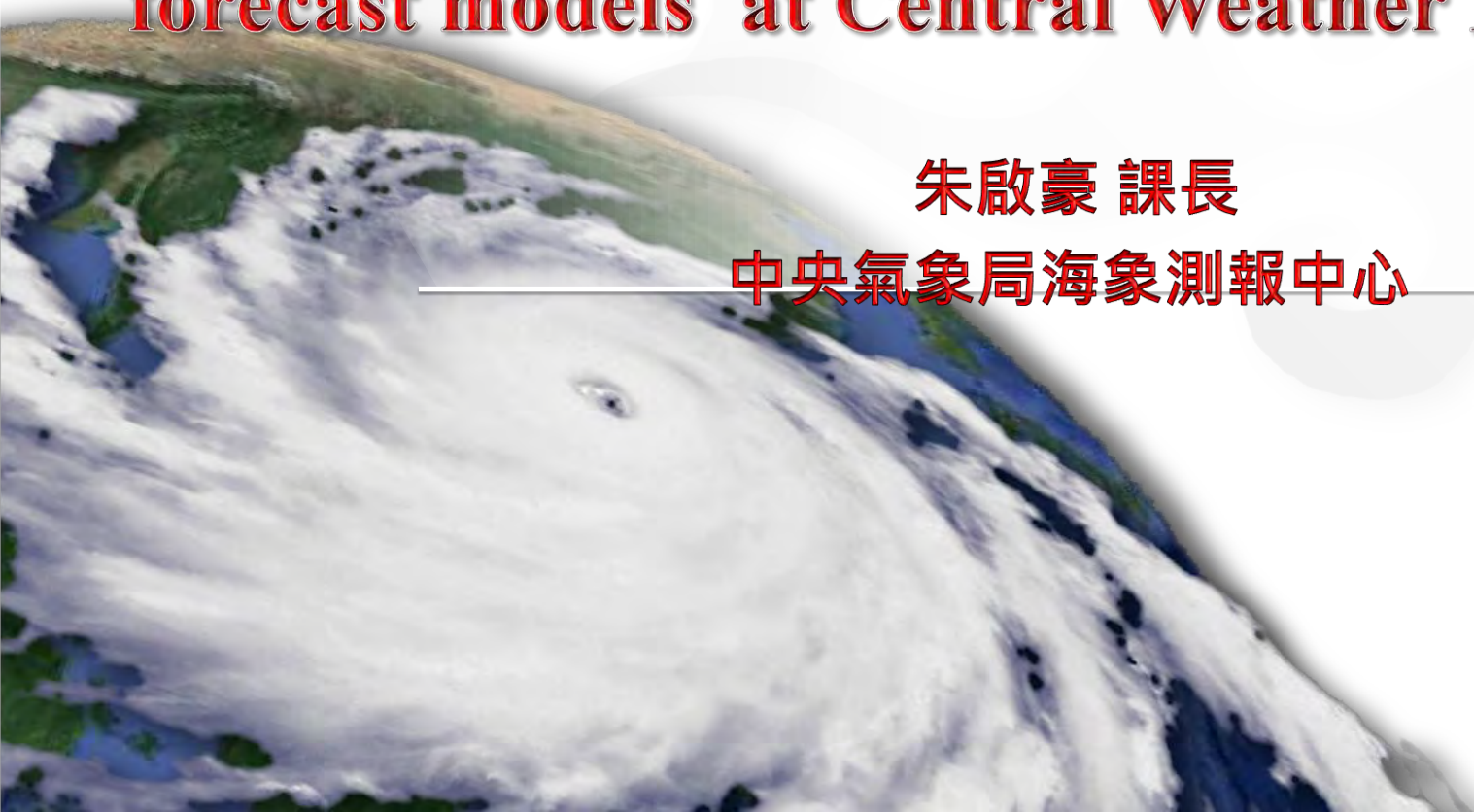


**Central Weather Bureau** cwb.gov.tw

# **An introduction to marine meteorology forecast models at Central Weather Bureau**

**朱啟豪 課長**

**中央氣象局海象測報中心**



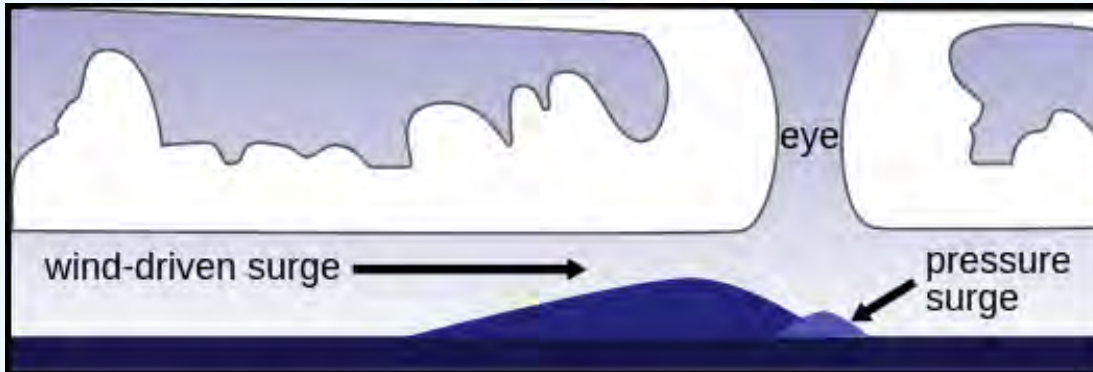


# outline

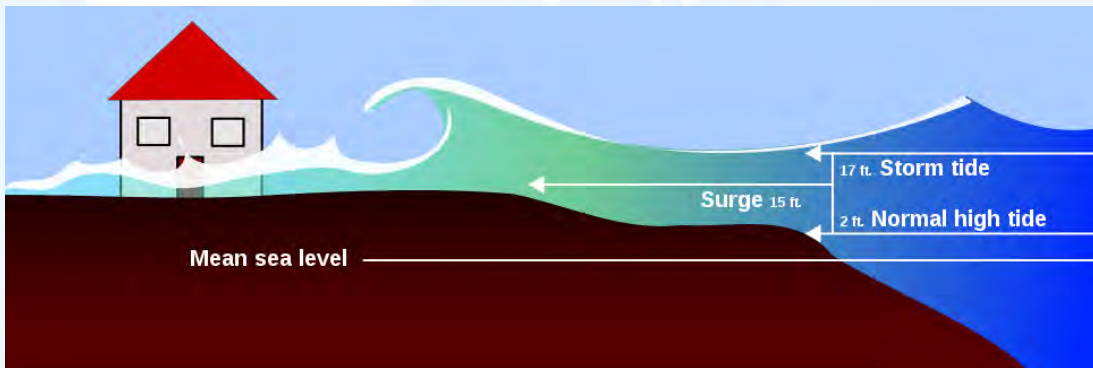
- 海象中心介紹
- 暴潮模式
- 波浪模式
- 海流模式



## STORM SURGE



*Sea Surface induced by typhoons (Wiki)*



*Tidal Effect with Storm Surges (Wiki)*

- Storm surge is a coastal flood of rising water commonly associated with low pressure weather systems :
  - ✓ **Tropical cyclones**
  - ✓ **Storms**
  - ✓ **Typhoons**
  - ✓ **Hurricanes**
  
- The two main meteorological factors contributing to a storm surge are:
  - ✓ **Pressure gradient**
  - ✓ **Wind shear stress**



# The Introduction of CWB COMCOT-Surge Model (**C**ornell **M**ulti-grid **C**oupled **T**sunami Model – Storm Surge)

## Nonlinear Shallow Water Equations on the Spherical Coordinate

$$\frac{\partial \eta}{\partial t} + \frac{1}{R \cos \varphi} \left\{ \frac{\partial P}{\partial \psi} + \frac{\partial}{\partial \varphi} (\cos \varphi \cdot Q) \right\} = 0$$
$$\frac{\partial P}{\partial t} + \frac{1}{R \cos \varphi} \frac{\partial}{\partial \psi} \left( \frac{P^2}{H} \right) + \frac{1}{R} \frac{\partial}{\partial \varphi} \left( \frac{PQ}{H} \right) + \frac{gH}{R \cos \varphi} \frac{\partial \eta}{\partial \psi} - fQ + F_{\psi}^b = -\frac{H}{\rho_w R \cos \varphi} \frac{\partial P_a}{\partial \psi} + \frac{F_{\psi}^s}{\rho_w}$$
$$\frac{\partial Q}{\partial t} + \frac{1}{R \cos \varphi} \frac{\partial}{\partial \psi} \left( \frac{PQ}{H} \right) + \frac{1}{R} \frac{\partial}{\partial \varphi} \left( \frac{Q^2}{H} \right) + \frac{gH}{R} \frac{\partial \eta}{\partial \varphi} + fP + F_{\varphi}^b = -\frac{H}{\rho_w R} \frac{\partial P_a}{\partial \psi} + \frac{F_{\varphi}^s}{\rho_w}$$

- Solve nonlinear shallow water equations on **both spherical and Cartesian coordinates**.
- **Explicit leapfrog Finite Difference Method** for stable and high speed calculation.
- **Multi/Nested-grid system** for multiple shallow water wave scales.
- **Moving Boundary Scheme** for inundation.
- **High-speed efficiency**.

### • 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.

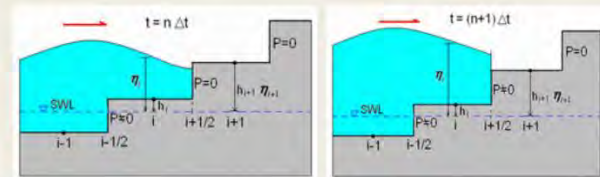
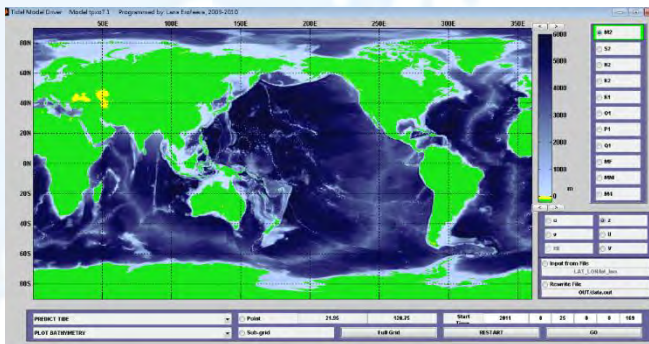


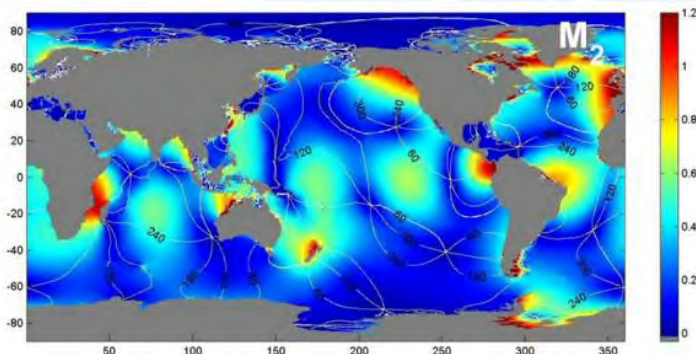
Fig.02 Moving Boundary Scheme



## (4). Combine with Global Tide TPXO Model (USA OSU TOPEX/POSEIDON Global Tidal Model)



User Interface of TPXO



TPXO can provide tidal information, like M2.



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.

### A TOPEX/POSEIDON global tidal model (TPXO.2) and barotropic tidal currents determined from long-range acoustic transmissions

BRIAN D. DUSHAW<sup>1</sup>, GARY D. EGBERT<sup>2</sup>, PETER F. WORCESTER<sup>3</sup>, BRUCE D. CORNUELLE<sup>3</sup>,  
BRUCE M. HOWE<sup>1</sup> and KURT METZGER<sup>4</sup>

<sup>1</sup>Applied Physics Laboratory, College of Ocean and Fishery Sciences,  
University of Washington, Seattle, WA, U.S.A.

<sup>2</sup>College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR, U.S.A.

<sup>3</sup>Scripps Institution of Oceanography, La Jolla, CA, U.S.A.

<sup>4</sup>Department of Electrical Engineering and Computer Science, University of Michigan,  
Ann Arbor, MI, U.S.A.

**Abstract** – Tidal currents derived from the TPXO.2 global tidal model of Egbert, Bennett, and Foreman are compared with those determined from long-range reciprocal acoustic transmissions. Amplitudes and phases of tidal constituents in the western North Atlantic are derived from acoustic data obtained in 1991–1992 using a pentagonal array of transceivers. Small, spatially coherent differences between the measured and modeled tidal harmonic constants mostly result from smoothing assumptions made in the model and errors caused in the model currents by complicated topography to the southwest of the acoustical array. Acoustically measured harmonic constants (amplitude, phase) of M<sub>2</sub> tidal vorticity ( $3-8 \times 10^{-9} \text{ s}^{-1}$ , 210–310°) agree with those derived from the TPXO.2 model ( $2-5 \times 10^{-9} \text{ s}^{-1}$ , 250–300°), whereas harmonic constants of about ( $1-2 \times 10^{-9} \text{ s}^{-1}$ , 350–360°) are theoretically expected from the equations of motion. Harmonic constants in the North Pacific Ocean are determined using acoustic data from a triangular transceiver array deployed in 1987. These constants are consistent with those given by the TPXO.2 tidal model within the uncertainties. Tidal current harmonic constants determined from current meters do not generally provide a critical test of tidal models. The tidal currents have been estimated to high accuracy using long-range reciprocal acoustic transmissions; these estimates will be useful constraints on future global tidal models. © 1998 Elsevier Science Ltd. All rights reserved

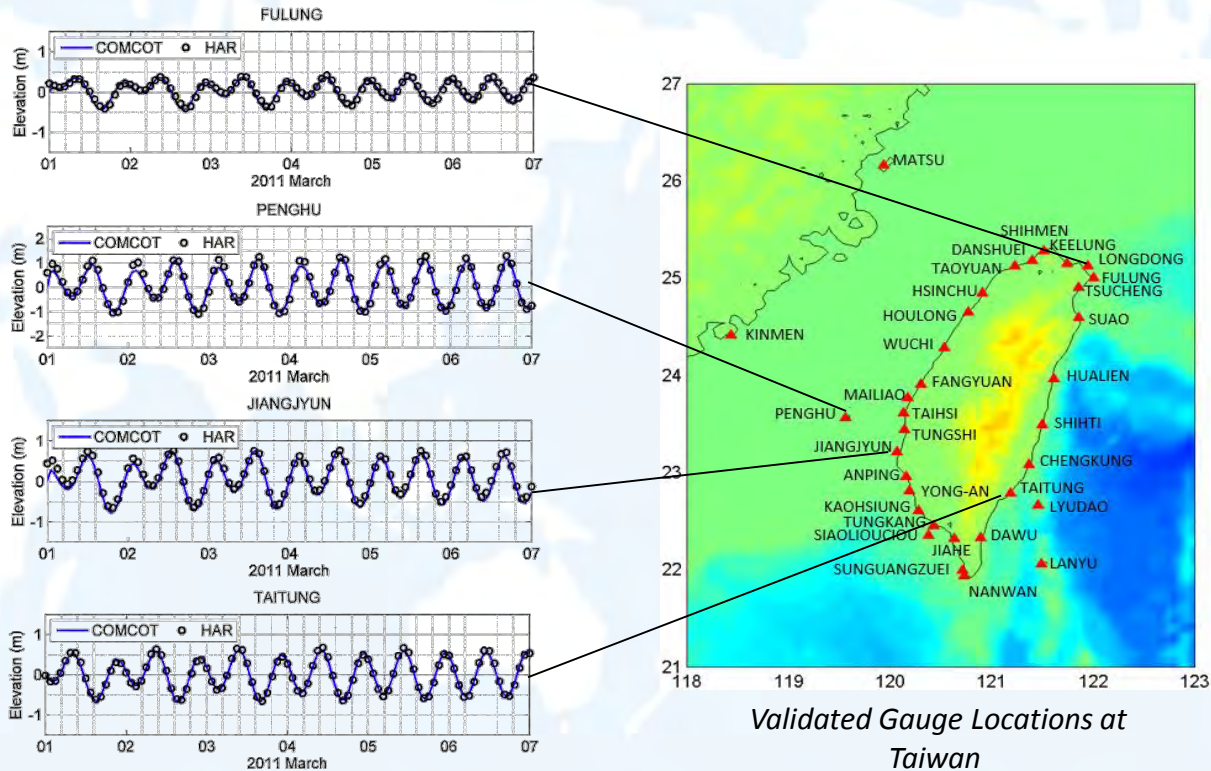
(Dushaw et al., 1997)





## (5). High-Accuracy Tide Simulation

The bias is smaller than 0.1 m and RMSE is smaller than 0.4 m.



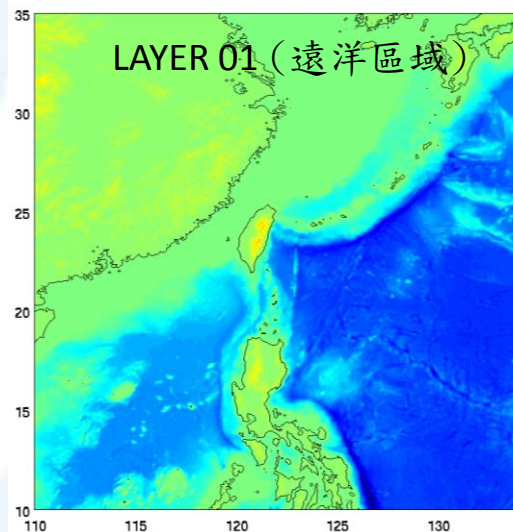
*The observed data and harmonic data are provided by CWB (Taiwan).*



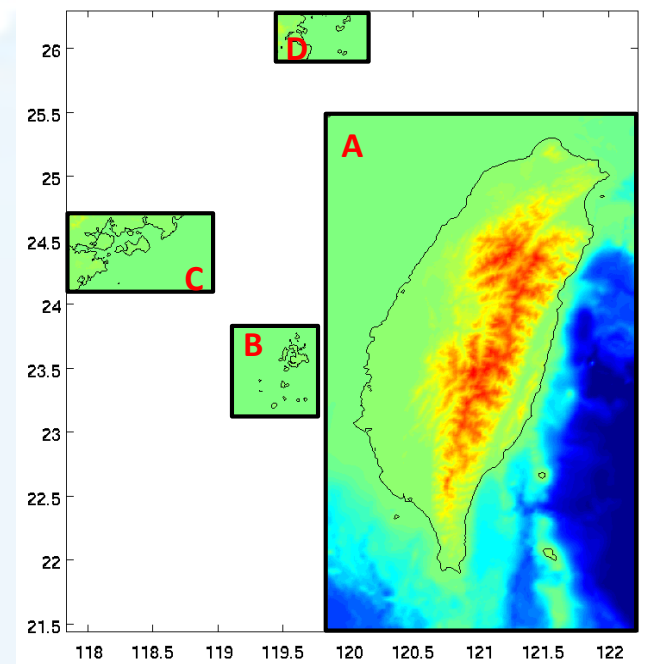


## 現採用之COMCOT暴潮溢淹預報模式 計算網格設定

預報模式計算域分為遠洋區域和近岸區域，近岸區域則利用巢狀網格，分割為台、澎、金、馬等4個區域。



### LAYER 02 (近岸區域)



Layer ID	Domain	Array Size	Grid Number	Bathymetry Database
LAYER-01	(110.00-134.00, 10.00-35.00)	361 * 376	135,736	ETOPO
LAYER-02-A	(119.80-122.25, 21.40-25.50)	144 * 244	35,136	GEBCO
LAYER-02-B	(119.09-119.80, 23.05-23.89)	80 * 88	7,040	GEBCO
LAYER-02-C	(117.80-118.99, 24.09-24.70)	136 * 72	9,792	GEBCO
LAYER-02-D	(119.39-120.19, 25.84-26.35)	88 * 48	4,224	GEBCO

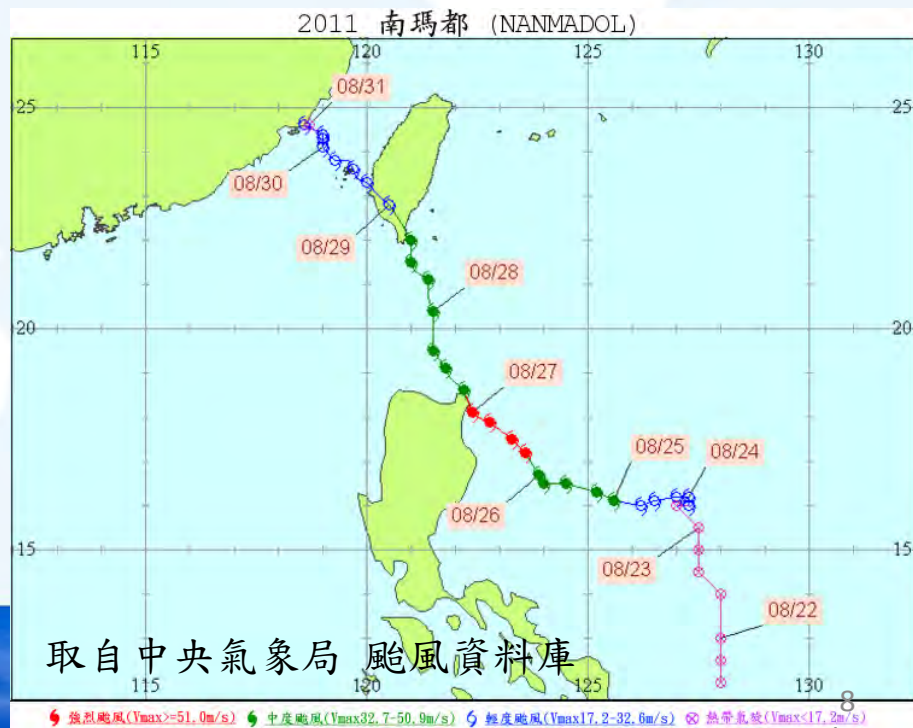
# 2011 Typhoon Nanmadol (第四類路徑)



- 南瑪都 (Nanmadol) 颱風，國際颱風編號：1111，生命週期由2011年8月21日至2011年8月35日，為一強烈颱風，第4類侵臺路徑，颱風中心於35日4時20分左右由臺東縣大武附近登陸，13時左右在臺南附近出海，進入臺灣海峽，緩慢向西北移動，35日8時於臺灣海峽減弱為熱帶性低氣壓。
- 南瑪都颱風影響臺灣期間，造成彰化縣西塭仔漁港海水倒灌，海水溢堤進入附近商店街，水深及膝，沿海居民財產受到損害。

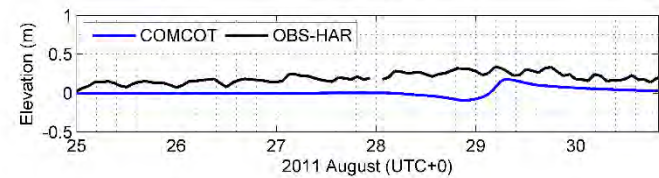
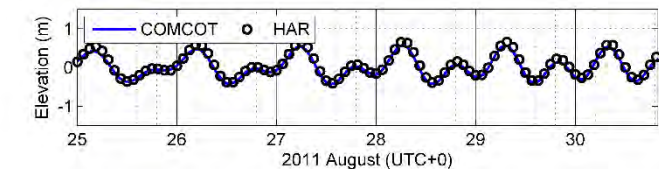
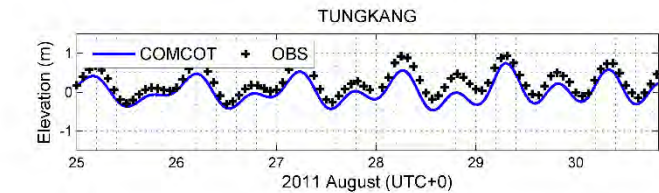
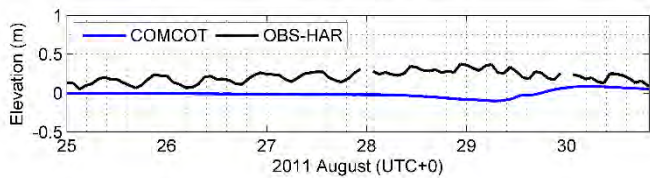
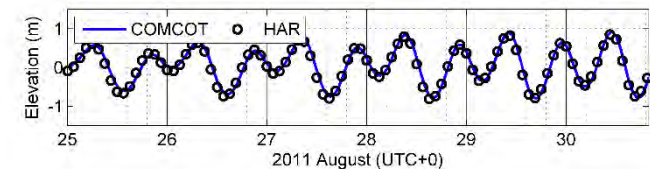
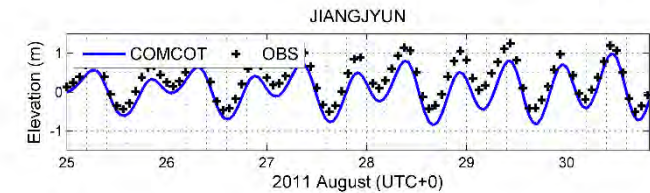
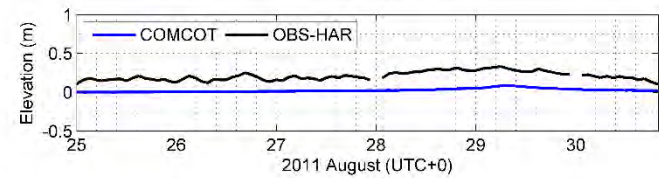
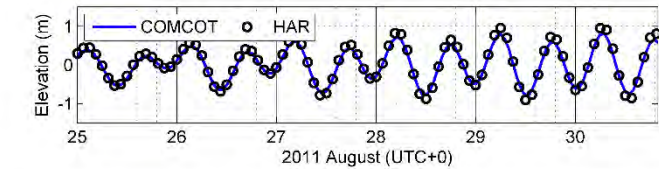
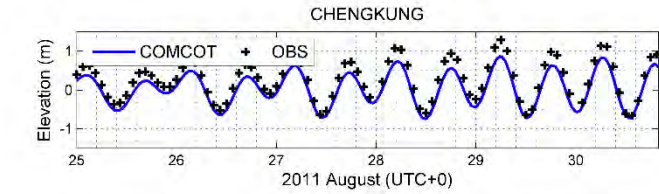
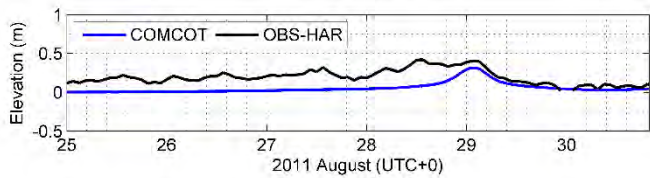
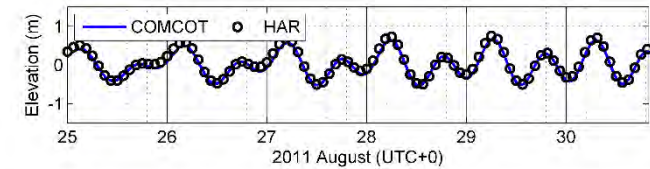
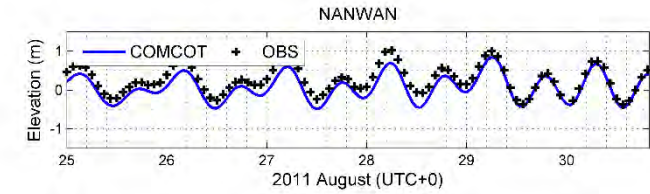


海水倒灌 - 台灣彰化





# 潮位計資料比對 (南瑪都颱風)



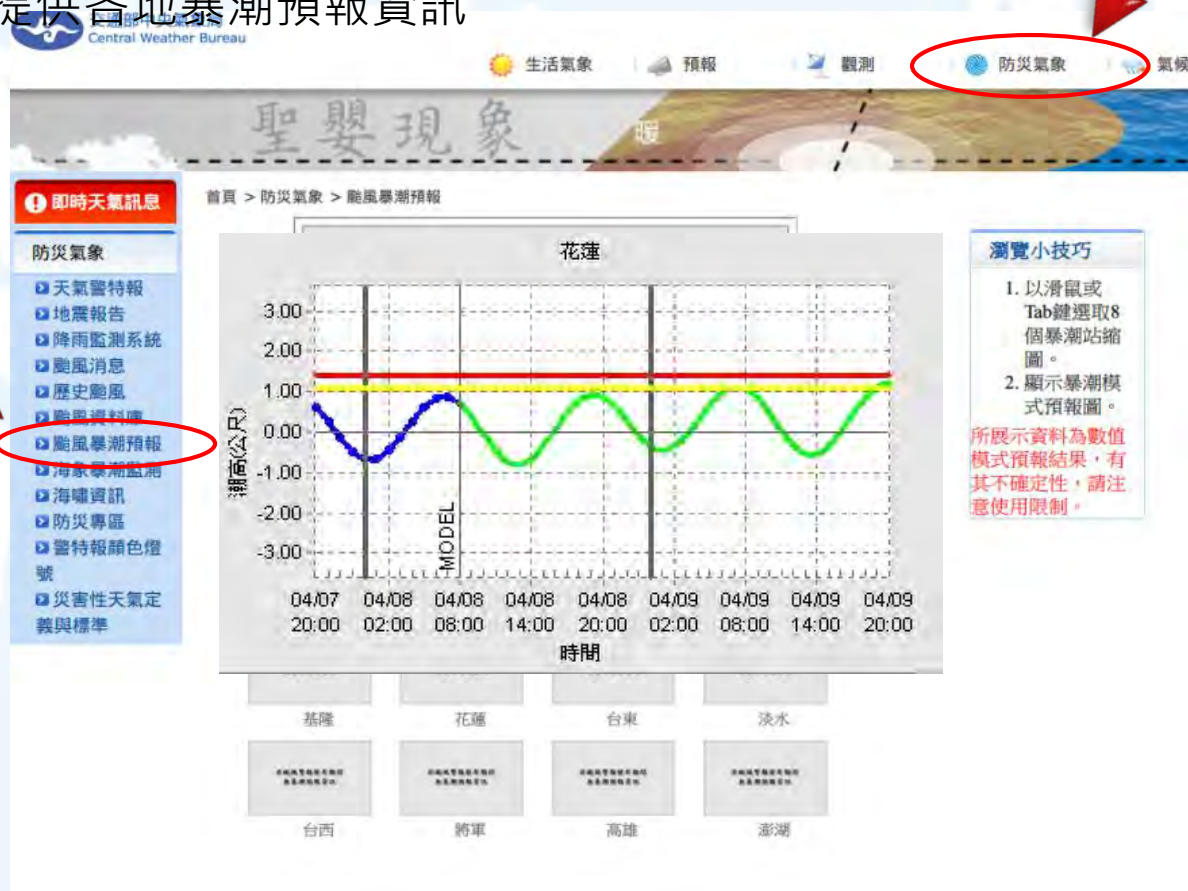
# 暴潮預報圖



## 颱風暴潮預報

### ☀ 官網 / 防災氣象 / 颱風暴潮預報

颱風期間提供各地暴潮預報資訊





## 碎波半經驗公式耦合

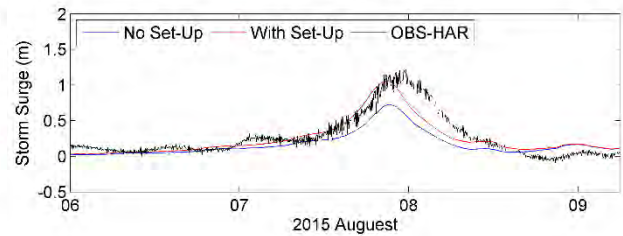
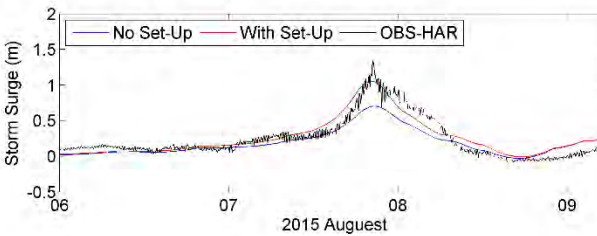
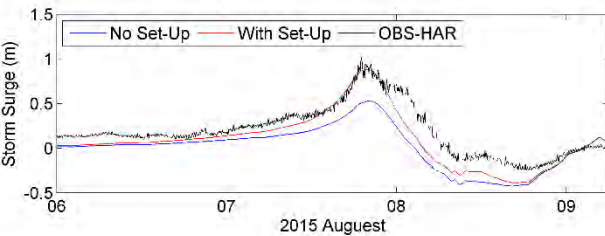
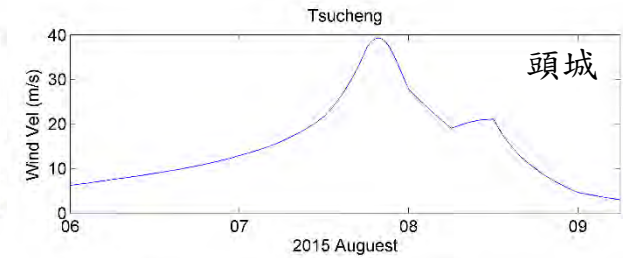
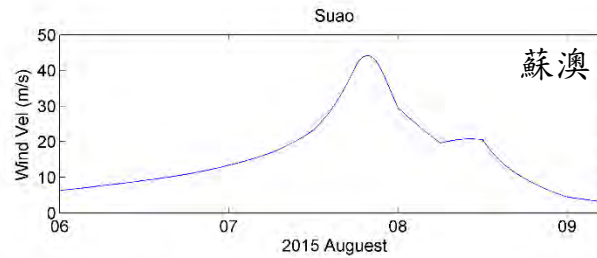
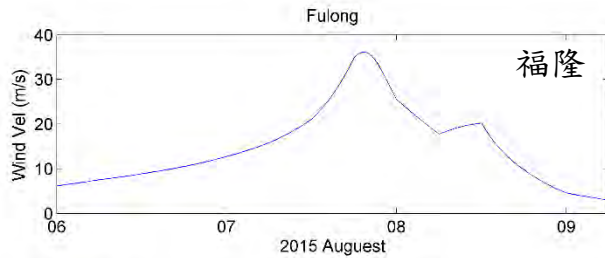
$$h = K^* (d_B - d) + h_B$$

$$K^* = \left( 1 + \frac{8}{3 \cdot r_*^2} \right)^{-1}$$

$h$ : 波浪碎波後的水位變化（波揚或波降）。

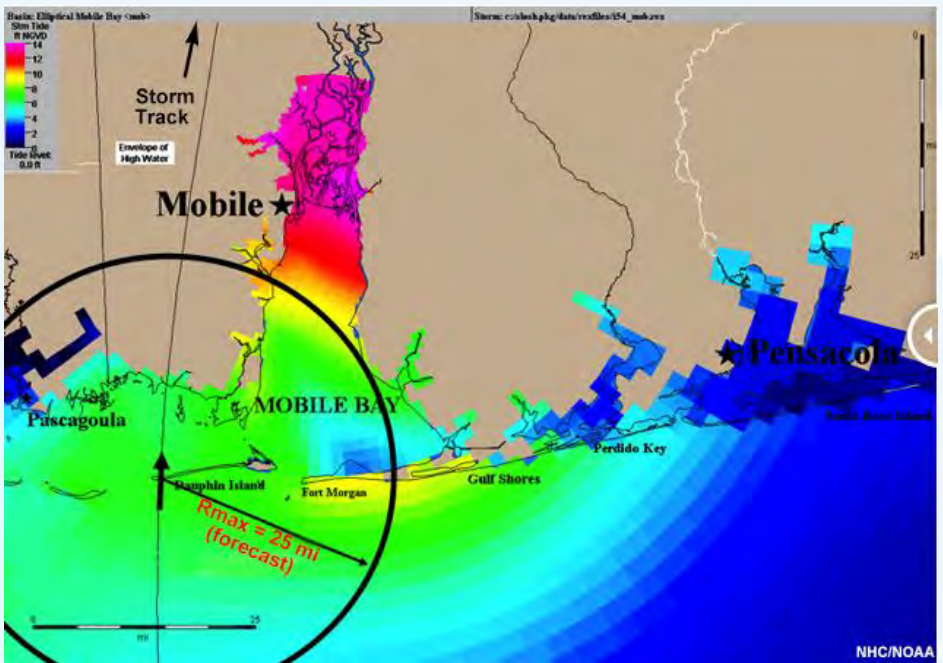
$d_B$ : 波浪碎波時水深。

$r_*$ : 波高水深比。

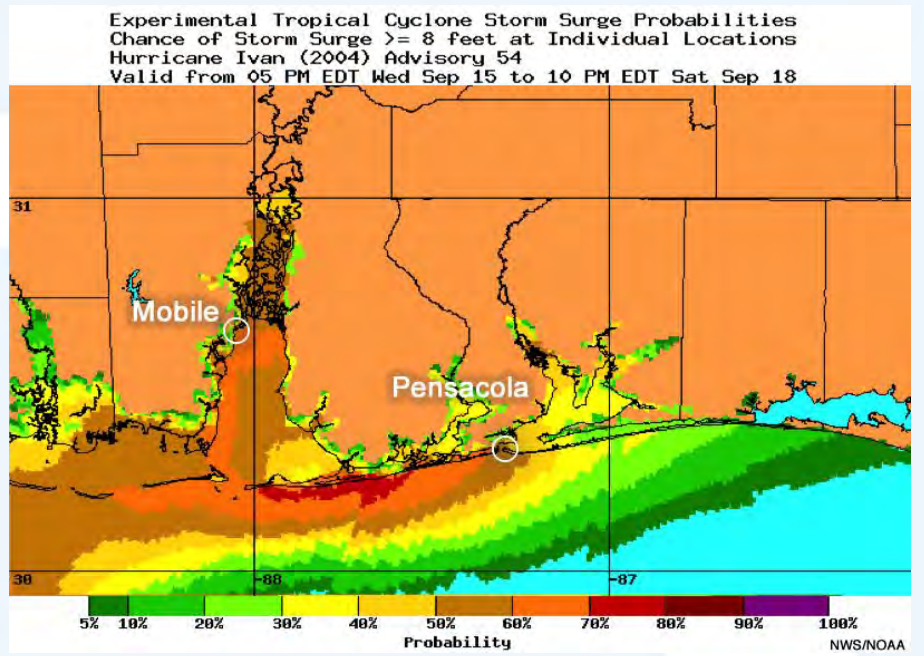




## Deterministic Forecast



## Probabilistic Forecast



### Ensemble Guidance

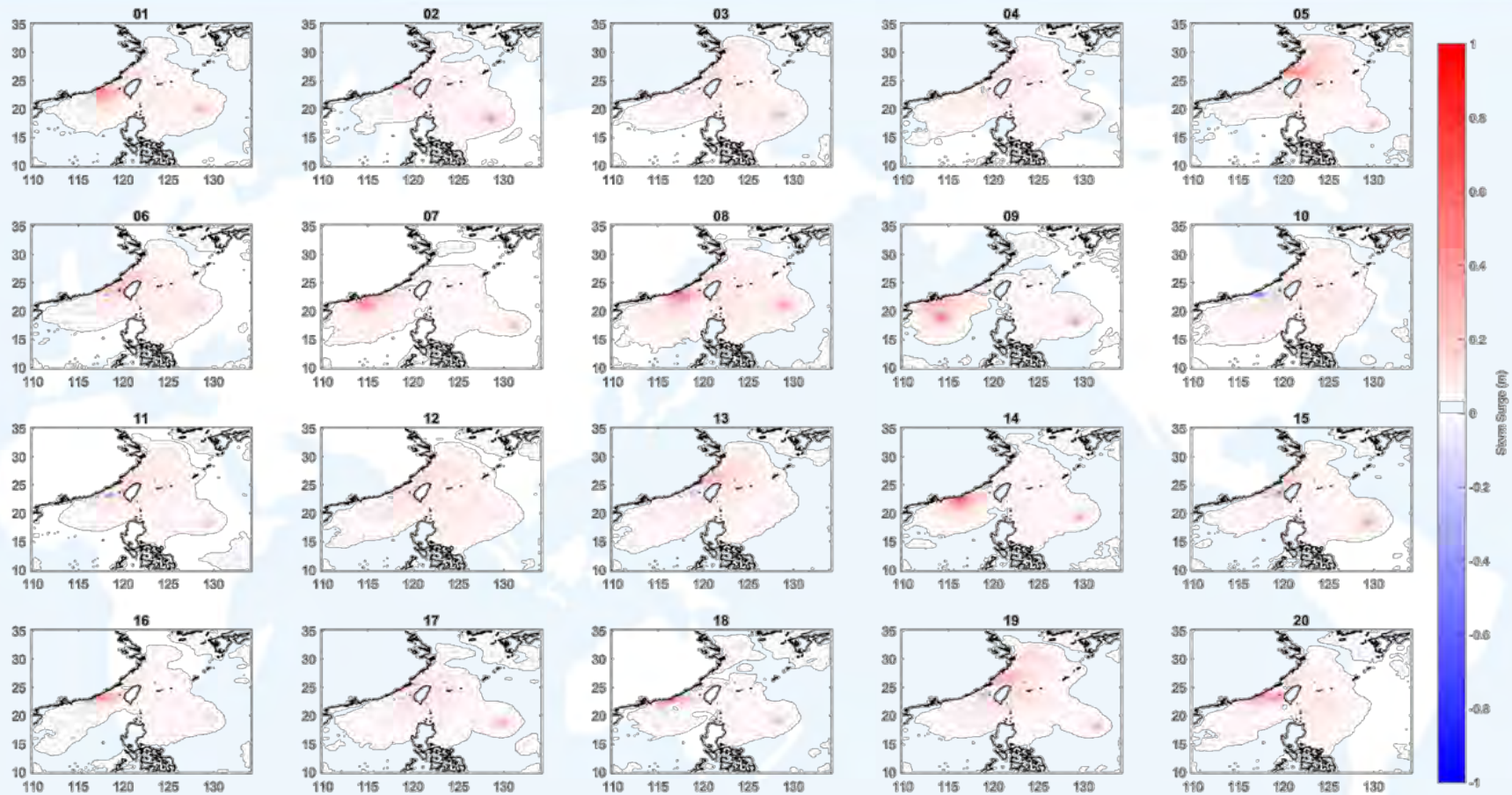
Type	Product
Pre-Computed	<ul style="list-style-type: none"><li>• Maximum Envelopes of Water (MEOWs)</li><li>• Maximum of the MEOWs (MOMs)</li></ul>
Real-Time	<ul style="list-style-type: none"><li>• Probabilistic Storm Surge (P-Surge)</li></ul>

NHC





2016.09.15 00:00 (UTC)



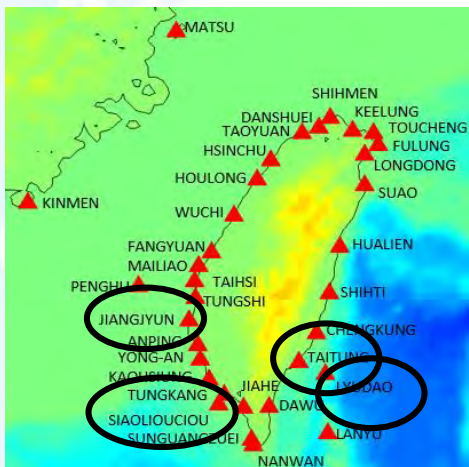
2016.09.15 00:00 (UTC) 暴潮系集預報結果，初始預報時間**2016.09.13 00:00 (UTC)**。



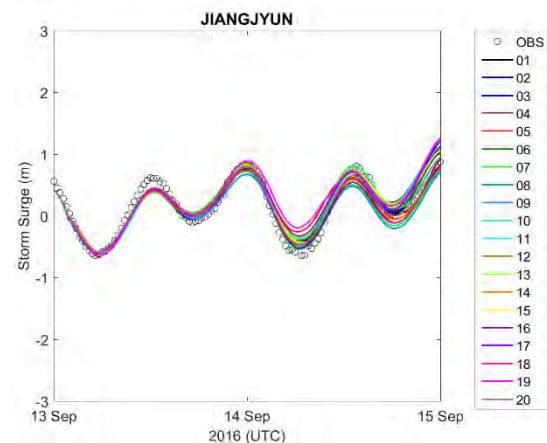
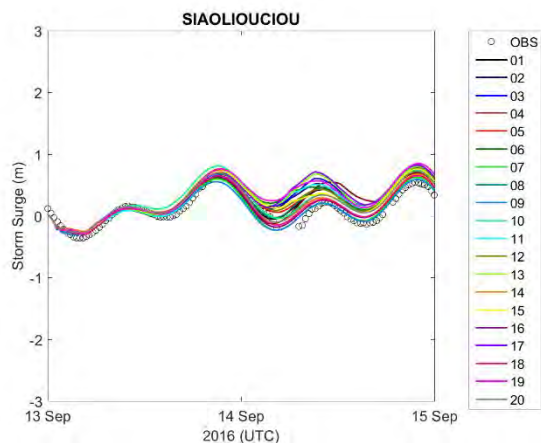
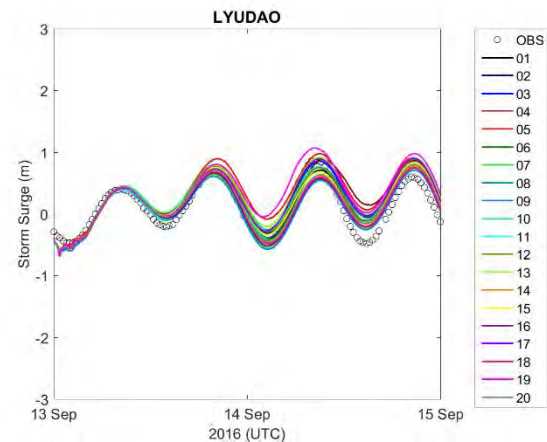
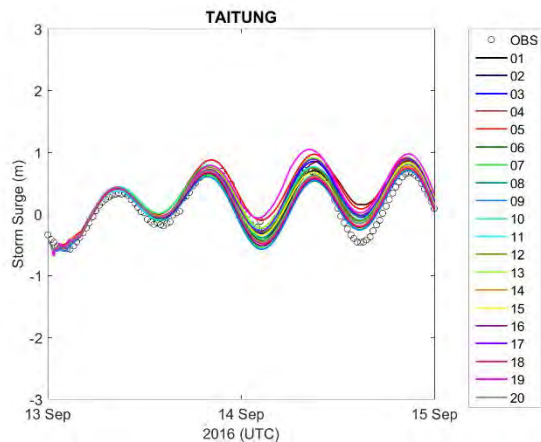


# 暴潮系集預報結果 總水位與觀測資料比對

2016.09.13 00:00 – 2016.09.15 00:00



觀測資料由中央氣象局提供。



# 基本方程式



此外，WAVEWATCH III 湧浪及風浪預報模式考量流場存在時的波浪變化，發現波浪作用力在此狀況依然保持守恆的性質(Whitham, 1965; Bretherton and Garrett, 1968)，即波浪作用力密度波譜( $N(k, \theta) \equiv F(k, \theta) / \sigma$ )亦保持守恆，故 WAVEWATCH III 湧浪及風浪預報模式在描述波浪傳遞現象時使用下式為控制方程式，

$$\frac{DN}{Dt} = \frac{S}{\sigma} \quad (3-4)$$

上式中，右側表示波浪作用力密度波譜的全微分，左側描述波浪傳遞過程中物理機制造成的波能成長及消散的淨效應。

# 基本方程式



其中群波速度向量  $\bar{c}_g$  由  $c_g$  及波向  $\theta$  定義， $s$  為  $\theta$  方向的座標， $m$  為垂直  $s$  方向的座標。上式是適用於卡氏座標之作用力密度波譜平衡方程式，若於大尺度範圍應用則需將上式轉換成球面座標的平衡方程式，

$$\frac{\partial N}{\partial t} + \frac{1}{\cos \phi} \frac{\partial}{\partial \phi} \dot{\phi} N \cos \theta + \frac{\partial}{\partial \lambda} \dot{\lambda} N + \frac{\partial}{\partial k} \dot{k} N + \frac{\partial}{\partial \theta} \dot{\theta}_g N = \frac{S}{\sigma} \quad (3-9)$$

$$\dot{\phi} = \frac{c_g \cos \theta + U_\phi}{R} \quad (3-10)$$

$$\dot{\lambda} = \frac{c_g \sin \theta + U_\lambda}{R \cos \phi} \quad (3-11)$$

$$\dot{\theta}_g = \dot{\theta} - \frac{c_g \tan \phi \cos \theta}{R} \quad (3-12)$$

其中  $\lambda$  為經度、 $\phi$  為緯度， $R$  為地球半徑， $U_\phi$  和  $U_\lambda$  為流速分量，(3-12) 式中包含大曲率下傳遞的修正項。藉有上述兩種座標的平衡方程式，WAVEWATCH III 湧浪及風浪預報模式可執行不同座標架構下的波浪運算。





## 3-2 源函數

波浪傳遞過程中造成波浪能量成長及消散的物理機制以源函數  $S$  表示。計算深海區域波浪能量時，WAVEWATCH III 湧浪及風浪預報模式僅考量三種物理機制源函數，分別是風浪成長項  $S_{in}$ 、波能消散(白沫效應)項  $S_{ds}$  以及非線性波波交互作用項  $S_{nl}$ 。其中風浪成長項  $S_{in}$  描述指數成長項所主導的波能輸入過程，然而為了模式初始化計算並提供更實際的波浪成長初始條件，WAVEWATCH III 湧浪及風浪預報模式亦考量線性成長過程的波能輸入項  $S_{ln}$ 。計算近岸海域波浪能量時需要考量額外的物理機制，因此 WAVEWATCH III 湧浪及風浪預報模式提供作用顯著的波浪-底床交互作用項  $S_{bot}$  (Shemdin 等人, 1978)。計算極淺海域波浪能量時，三個波波交互作用  $S_{tr}$  與水深導致碎波現象  $S_{db}$  等物理機制的作用即變得相當重要。此外，WAVEWATCH III 湧浪及風浪預報模式尚提供底床特性造成的波浪散射現象  $S_{sc}$  及使用者自行定義的源函數項  $S_{xx}$ 。因此，在 WAVEWATCH III 湧浪及風浪預報模式所使用之源函數定義為：

$$S = S_{ln} + S_{in} + S_{nl} + S_{ds} + S_{bot} + S_{db} + S_{tr} + S_{sc} + S_{xx} \quad (3-13)$$

# Wave forecast system-1



## Wave model

1、NOAA-- WAVEWATCHⅢ (NWW3) Version3.14

2、Simulating WAVes Nearshore (SWAN)

interval : 4 times a day (00、06、12、18Z) 72 hours forecast

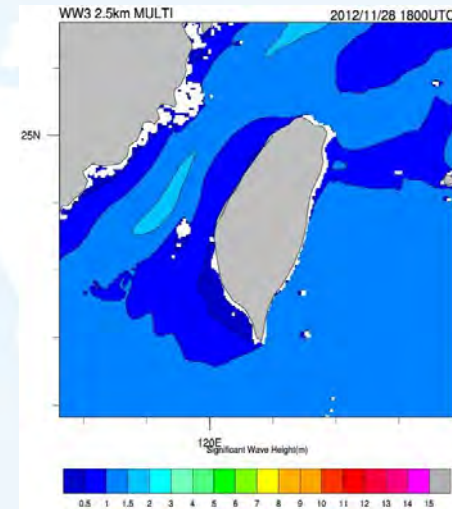
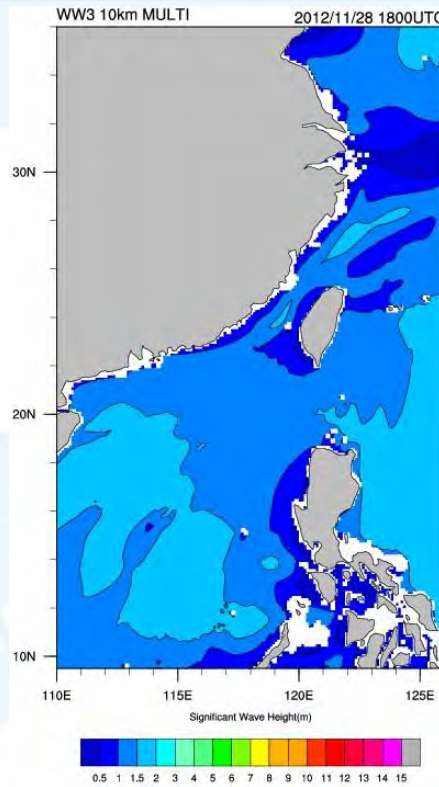
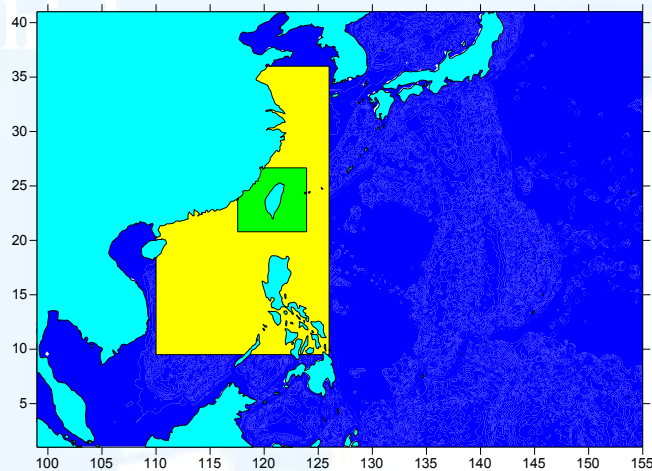
product : Hs,windsea,swell, period,direction

	Resolution	domain		X	Y	wind
NWW3	0.25	99E 1N	155E 41N	225	161	WRF NCEP JMA
SWAN	0.05	118.75E 21N	123E 26.25N	86	106	WRF



# Wave forecast system-2

## High-resolution wave forecasting system for Blue



interval : 4 times a day ( 00 、 06 、 12 、 18Z ) 60-72 hours forecast

Resolution:0.25degree 、 10km 、 2.5km

product : Hs,windsea,swell,  
period,direction

109.9E 9.4N  
126.1E 36.1N

117.6E 20.8N  
123.9E 26.7N



# 海象預報資訊

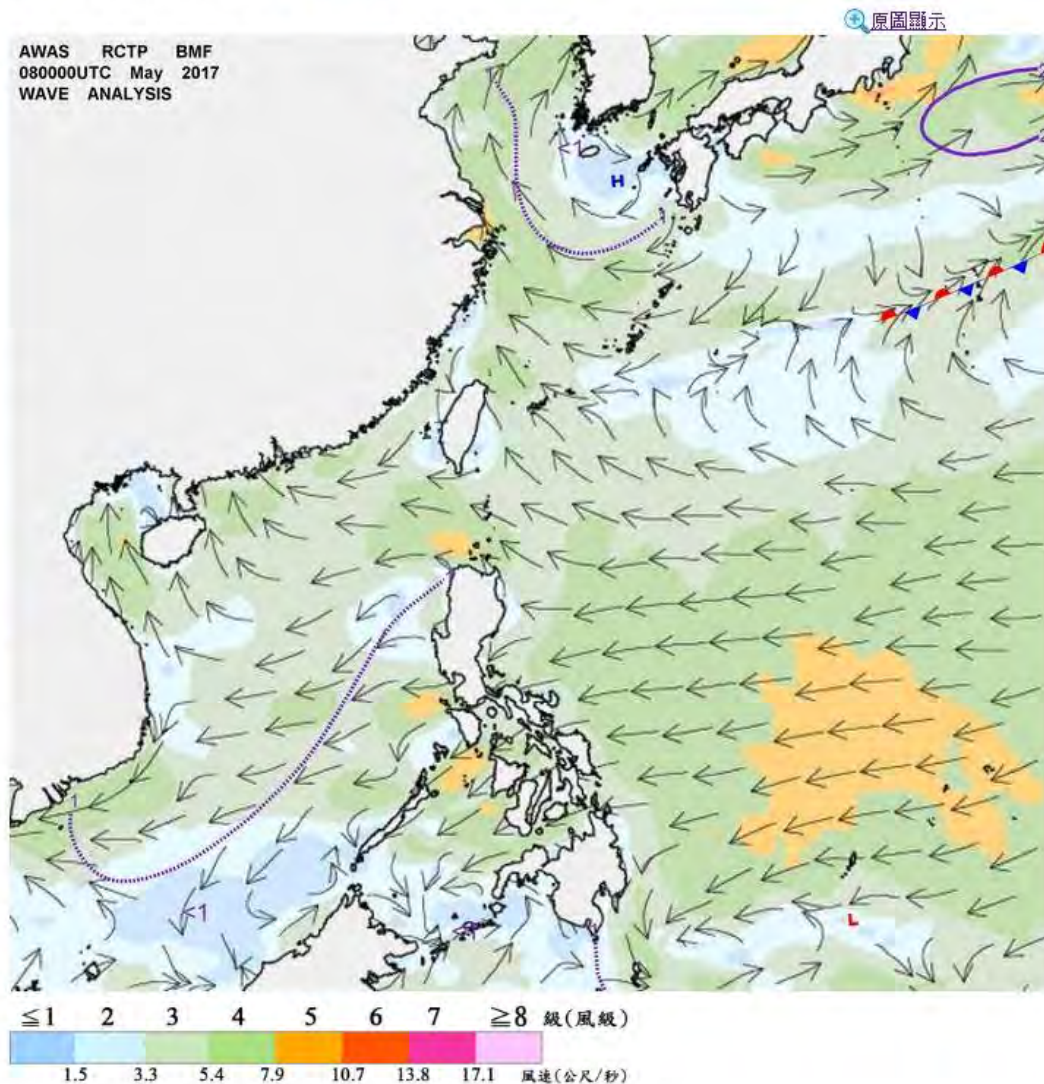
## 波浪分析與預報圖



### 預報

- ▶ 天氣預報
- ▶ 預約氣象
- ▶ 漁業氣象
- ▶ 藍色公路
- ▶ 國際都市
- ▶ 分析及預測圖
  - ▶ 最新天氣圖
  - ▶ 地面天氣圖
  - ▶ 1週預測圖
  - ▶ 定量降水預報
  - ▶ 波浪分析圖
  - ▶ 24小時波浪預報圖
  - ▶ 36小時波浪預報圖
  - ▶ 48小時波浪預報圖
- ▶ 長期預報
- ▶ 數值模式
- ▶ 風場預報顯示圖

首頁 > 預報 > 分析及預測圖 > 波浪分析圖



- 波浪圖之等值線代表海上所有波的前三分之一較大波之平均波高。
- 最大波有可能到達上述波高的兩倍，使用此圖需加以注意。



## 數值預報 / 海象預報模式圖

☀ 官網 / 預報 / 數值預報 / 海象預報模式圖 / 波浪模式  
NWW3模式。分析及72小時(間隔3hr)預報，單張及動畫圖。  
一天執行4次(00Z、06Z、12Z、18Z)。

交通部中央氣象局  
Central Weather Bureau

生活氣象 預報 觀測 防災氣象 氣候 地震

雲和雨

天氣警特報 地震報告

預報

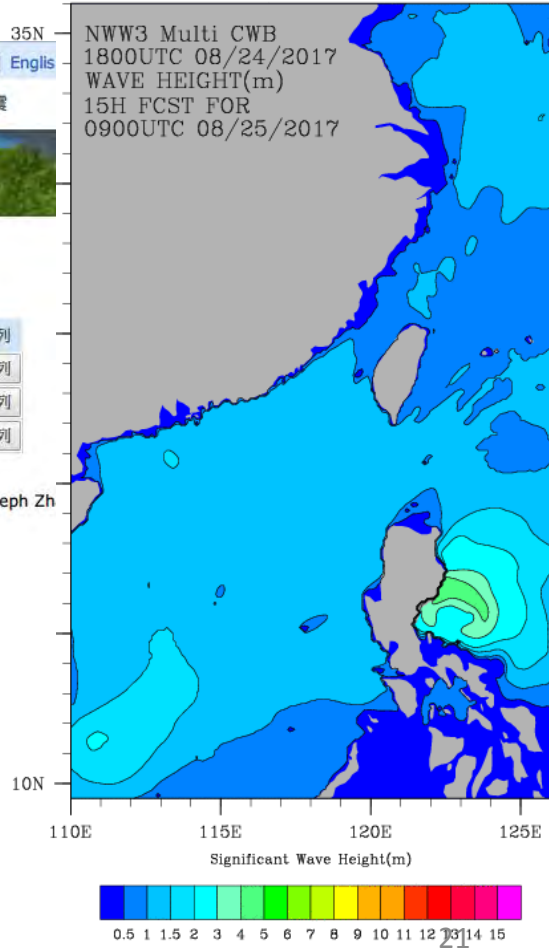
- 天氣預報
- 預約氣象
- 漁業氣象
- 藍色公路
- 國際都市
- 分析及預測圖
- 長期預報
- 數值預報
  - 數值預報模式圖
  - 海象預報模式圖
  - 颱風暴潮預報圖
- 預報主任談天氣

首頁 > 預報 > 數值預報 > 海象預報模式圖

2016/04/28 00 ▾

預報時	000	003	006	009	012	015	018	021	024	027	030	033	036	039	042	045	048	051	054	057	060	063	066	069	072	全選	取消	動畫	排列
波浪模式	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	全選	取消	動畫	排列
表層海流流速	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	全選	取消	動畫	排列
表層海溫	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	全選	取消	動畫	排列

中央氣象局海流預報系統使用美國威廉瑪莉學院維吉尼亞海洋研究所(VIMS, Virginia Institute of Marine Science, College of William and Mary) Dr. Joseph Zh  
中央氣象局波浪預報系統使用美國海洋暨大氣總署(NOAA, National Oceanic and Atmospheric Administration) 發展之NWW3波浪模式所建構。  
所展示資料為數值模式預報結果，有其不確定性，請注意使用限制。

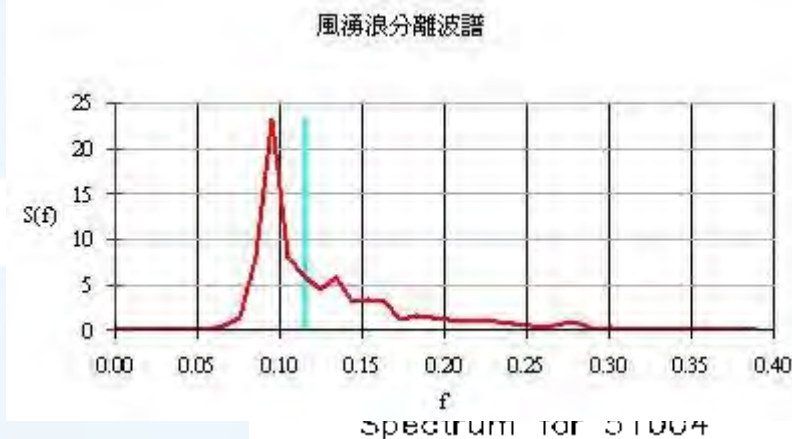


# 建置湧浪及風浪模式



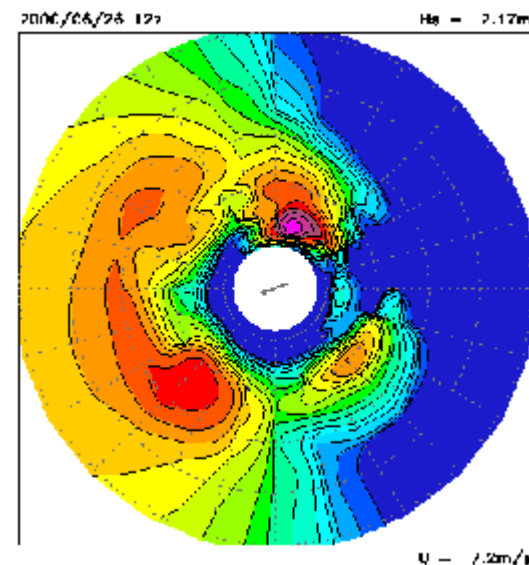
## ➤ 方法1

- 利用觀測站一維能譜決定示性波高之湧浪成分，粗略算出湧浪的能量百分比，尚無預報
- 截斷頻率之計算方式還需調校
- 實作上以週期研判



## ➤ 方法2

- 新版波浪模式可利用二維方向能譜，可產出風浪、2個以上的湧浪及個別的波高、週期、波向
- 較能反應真實的海面狀況



- sw Winds 5 to 10 kt.
- Wind Waves less than 2 ft.
- w Swell 6 to 8 ft and s 3 to 4 ft



# Wave spectra <sup>5</sup>

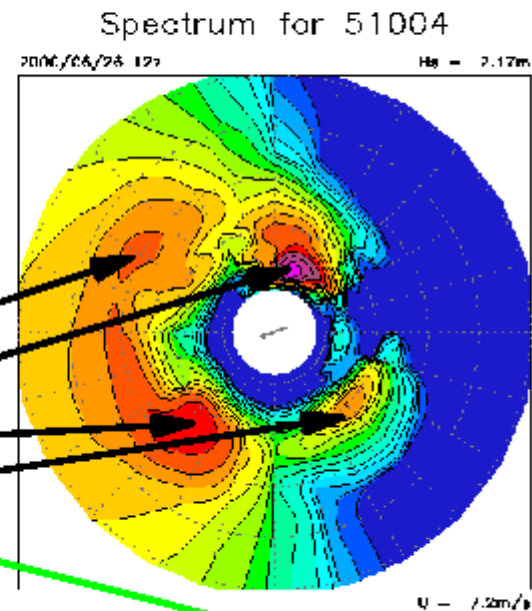
The info in the spectral plots and the bulletins can be combined as follows ( $H_s$  is significant wave height,  $T_p$  is peak or dominant period)

$H_s = 0.7\text{m}$ ,  $T_p = 6.6\text{s}$

$H_s = 1.4\text{m}$ ,  $T_p = 15.9\text{s}$

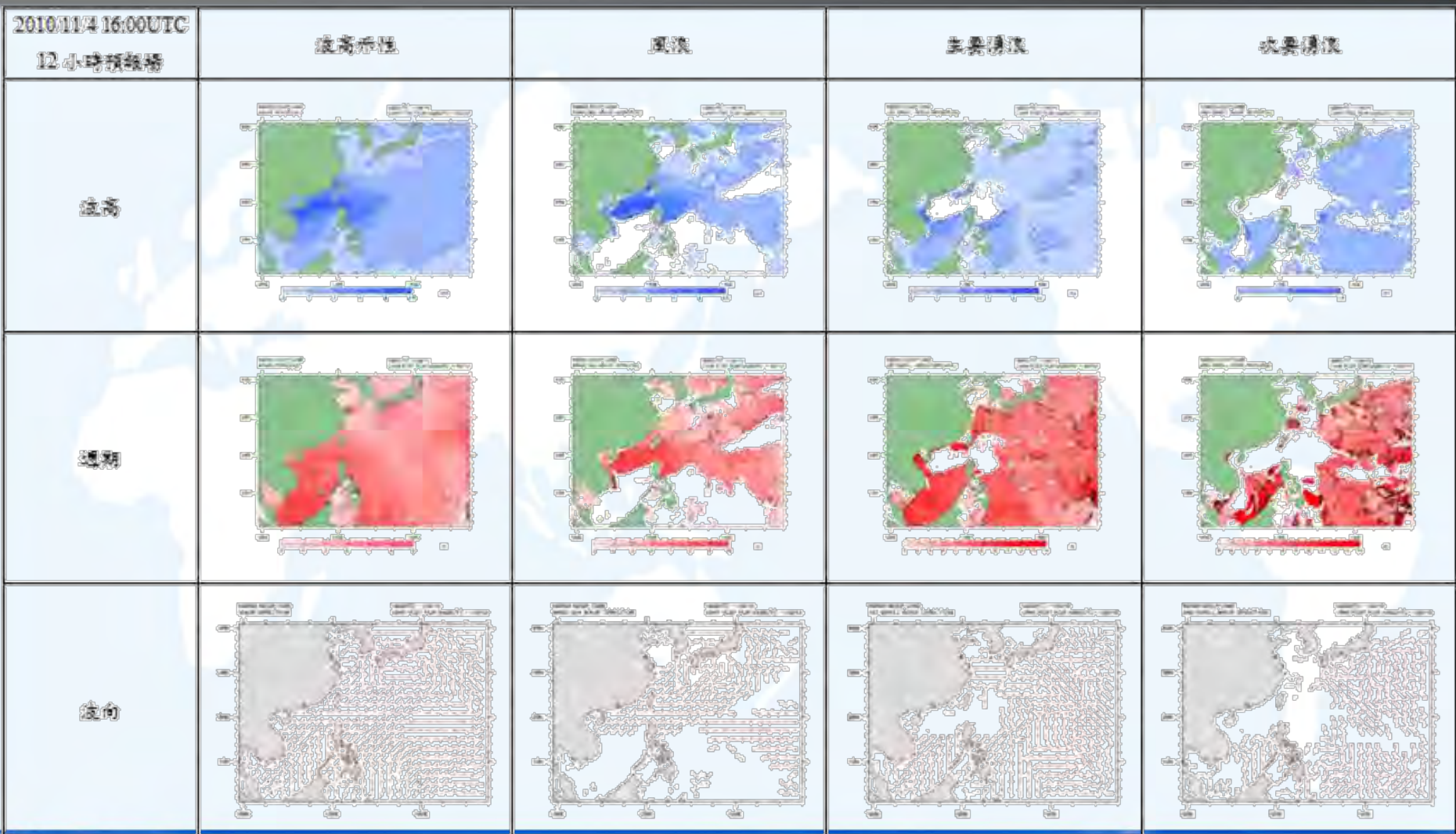
$H_s = 1.4\text{m}$ ,  $T_p = 7.0\text{s}$

$H_s = 0.3\text{m}$ ,  $T_p = 9.9\text{s}$



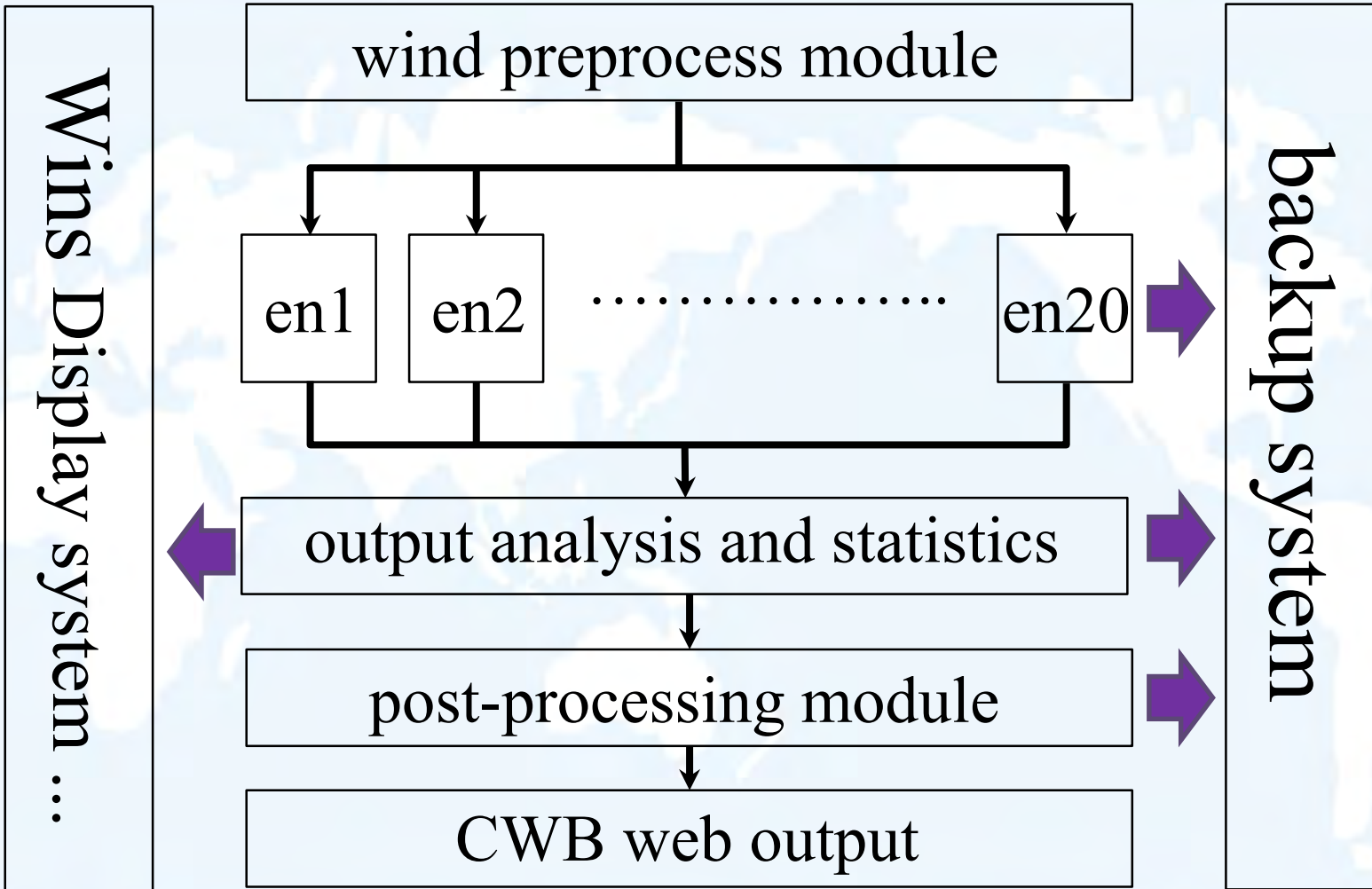
| 26 12 | 2.2 4 | 1.4 15.9 16 | 0.7 6.6 306 | 1.4 7.0 239 | **0.3 9.9 136** |

# 湧浪與風浪模式預報產品



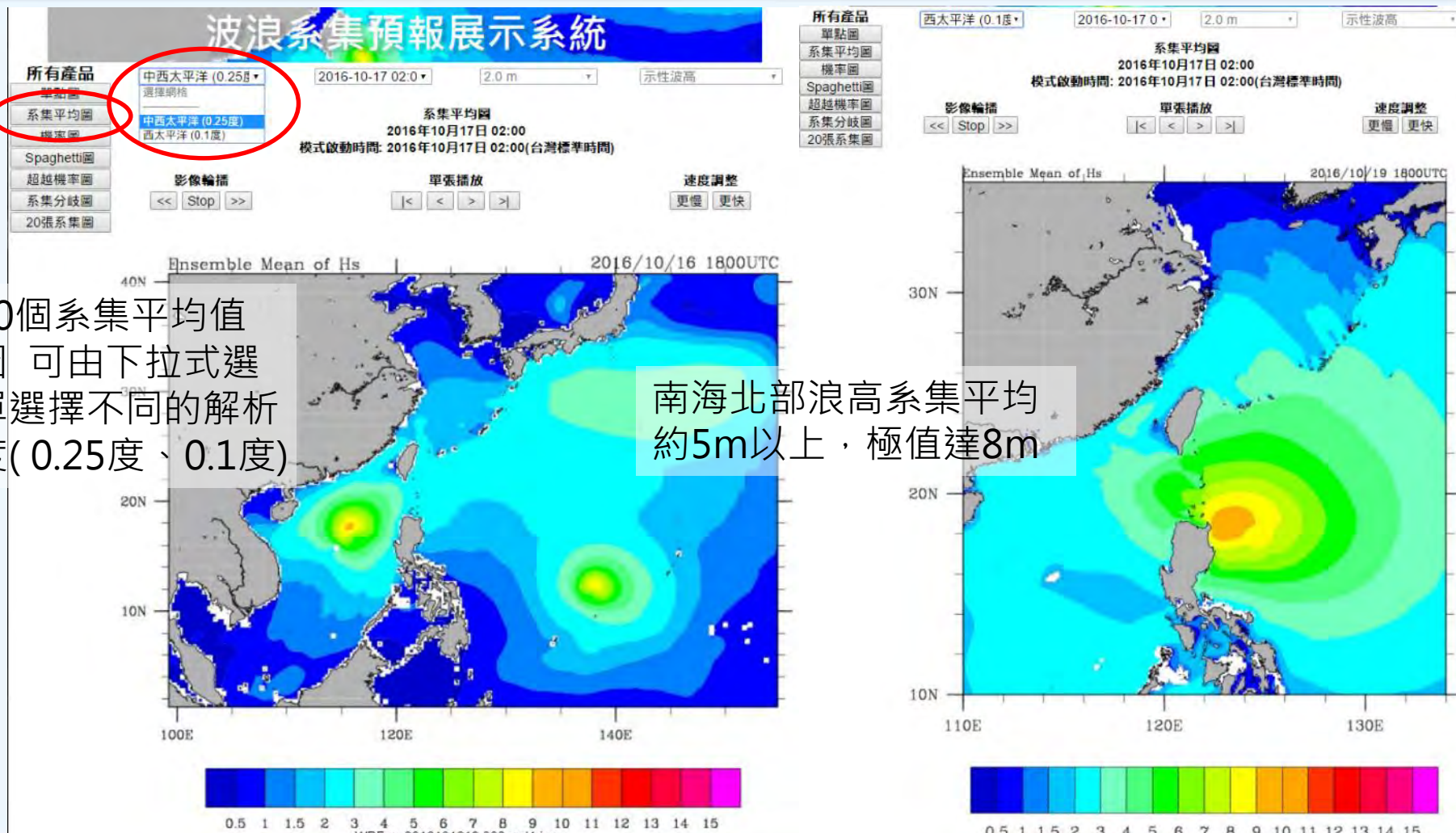


# Wave ensemble operation system scheme



# 波浪系集產品介紹

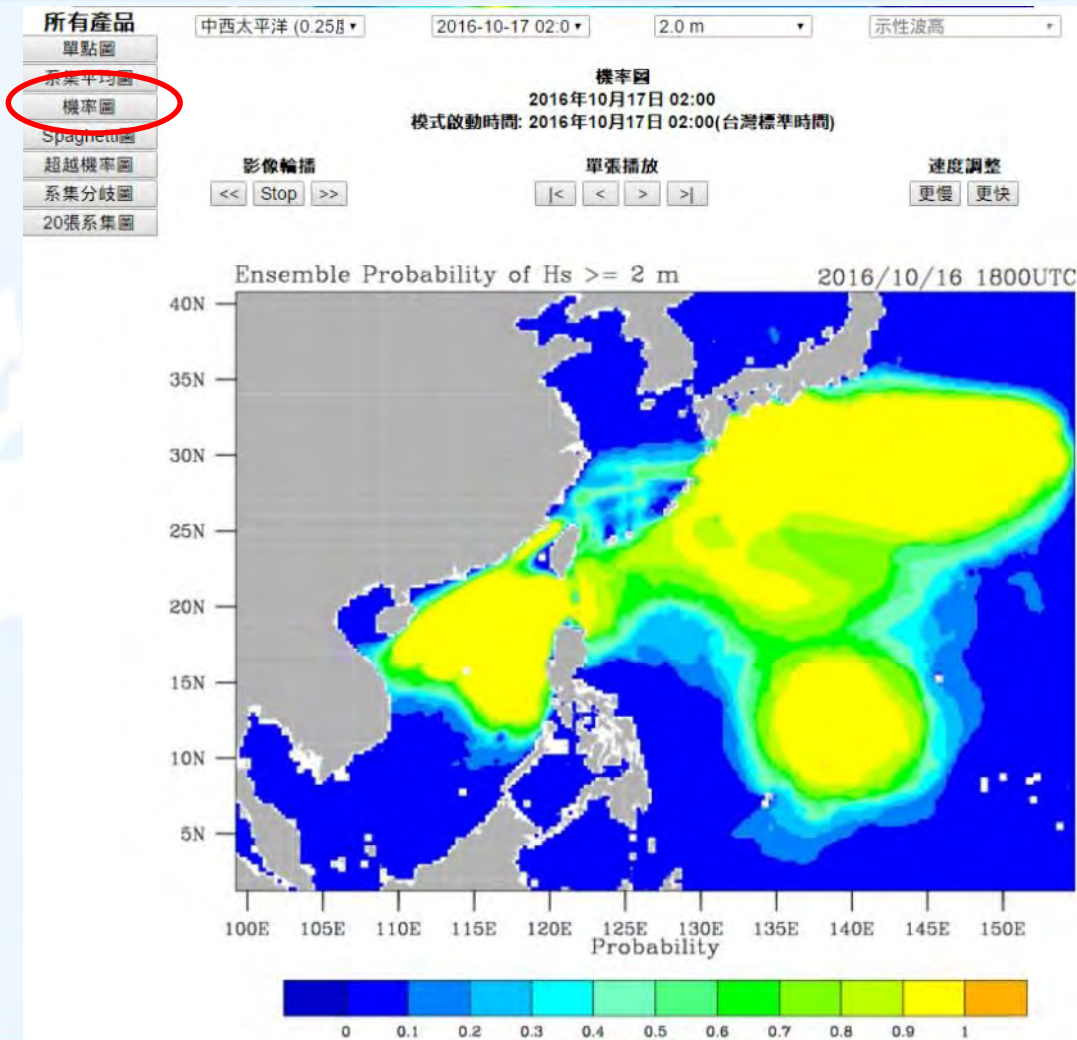
## 系集平均圖



20個系集平均值圖 可由下拉式選單選擇不同的解析度(0.25度、0.1度)



## 機率圖

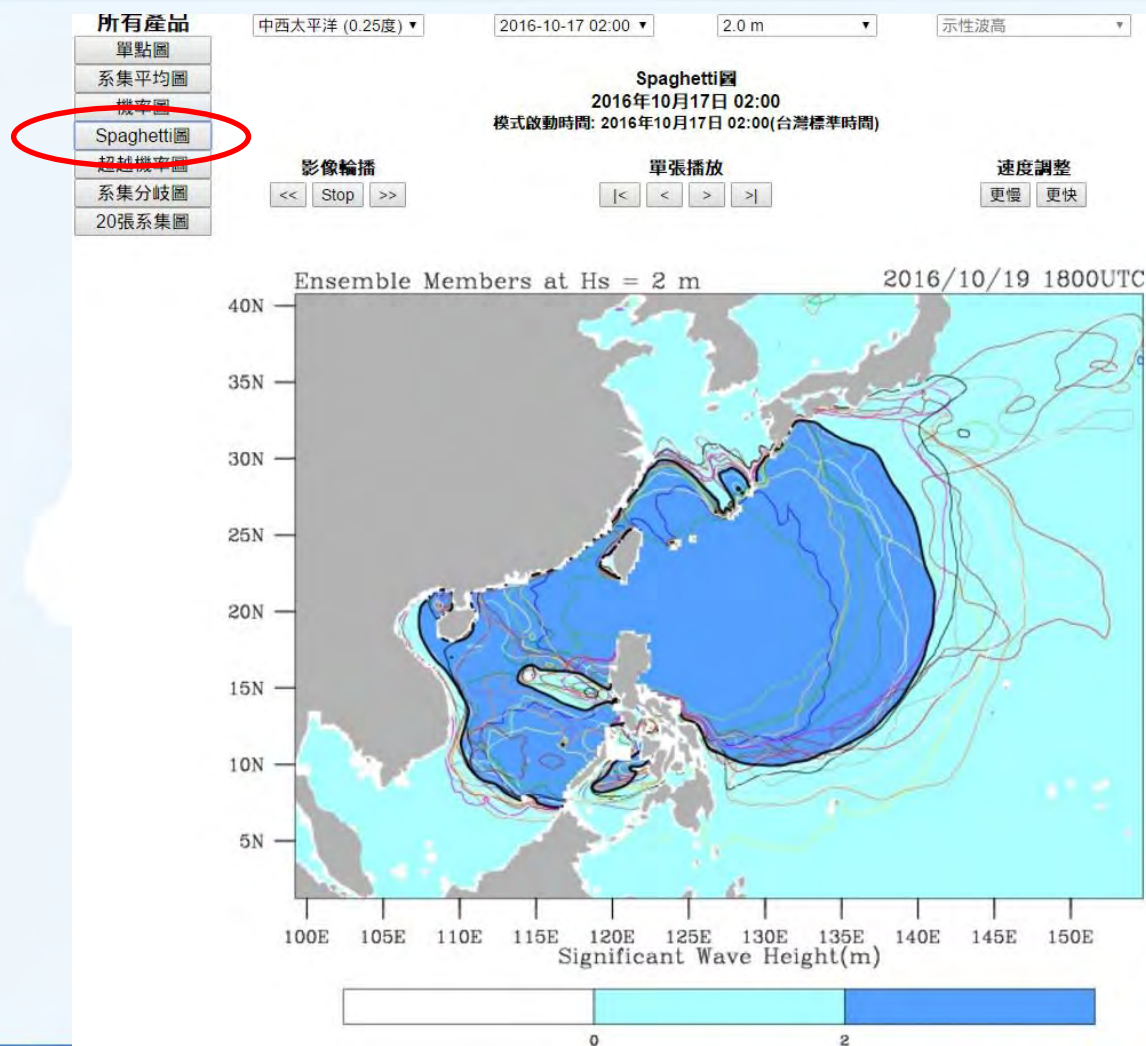


機率圖：  
大於浪高2公尺的機率。  
下拉式選單可選擇 1m、  
2m、3m、4m、5.5m  
7m、9m

大於波高2m的機率分布高於9成的區域包含南海及臺灣海峽、巴士海峽與臺灣東南部海域一帶。

# 波浪系集產品介紹

## Spaghetti圖

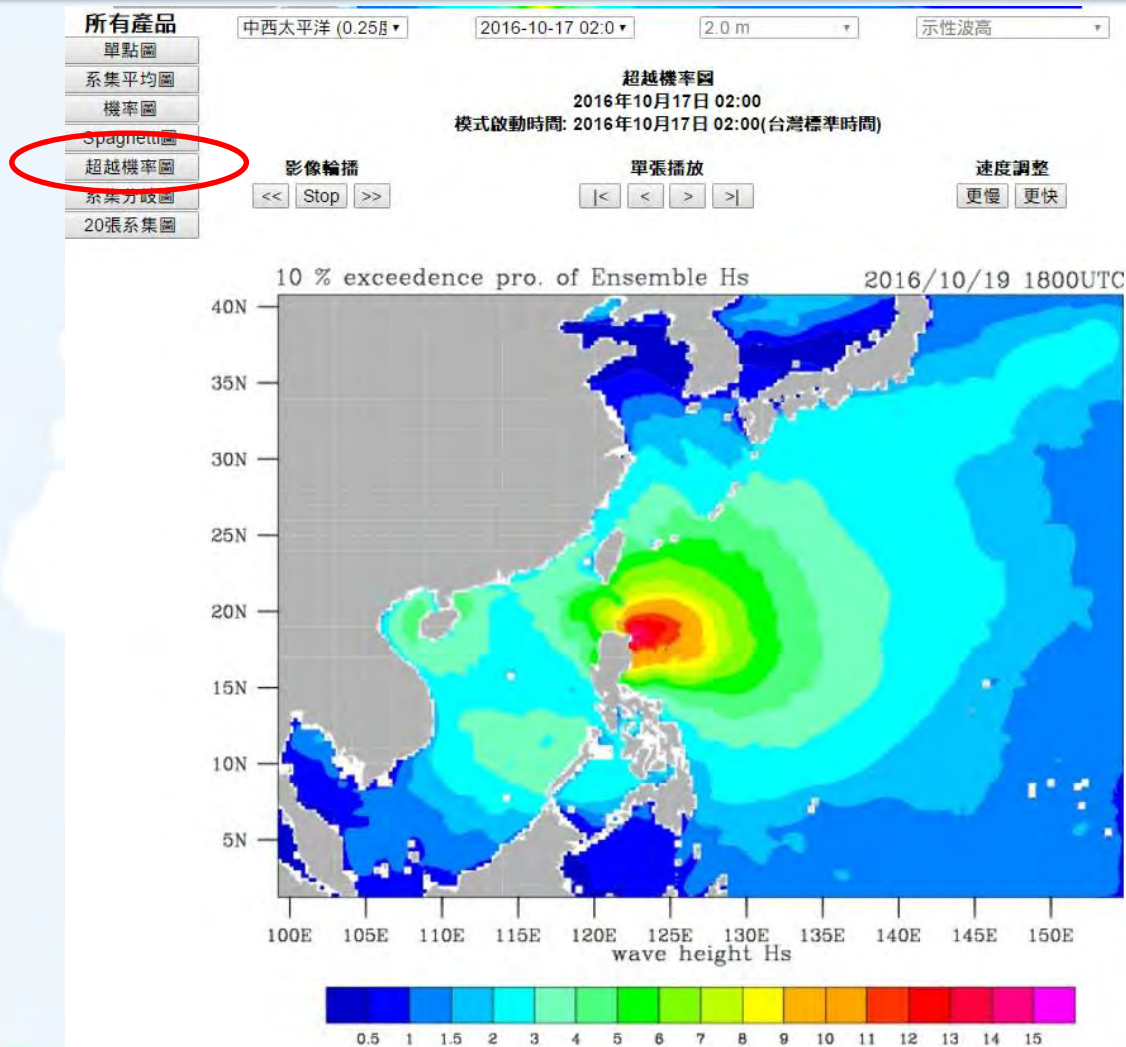


Spaghetti圖：  
波高於不同指定值的分部圖。  
黑線(系集平均)，各色線代表  
不同成員。

每個成員的浪高2m線的分  
布線，臺灣地區幾乎被每個  
成員2米浪高線所包圍，黑  
線系集平均(黑線)也涵蓋  
於此。

# 波浪系集產品介紹

## 超越機率圖



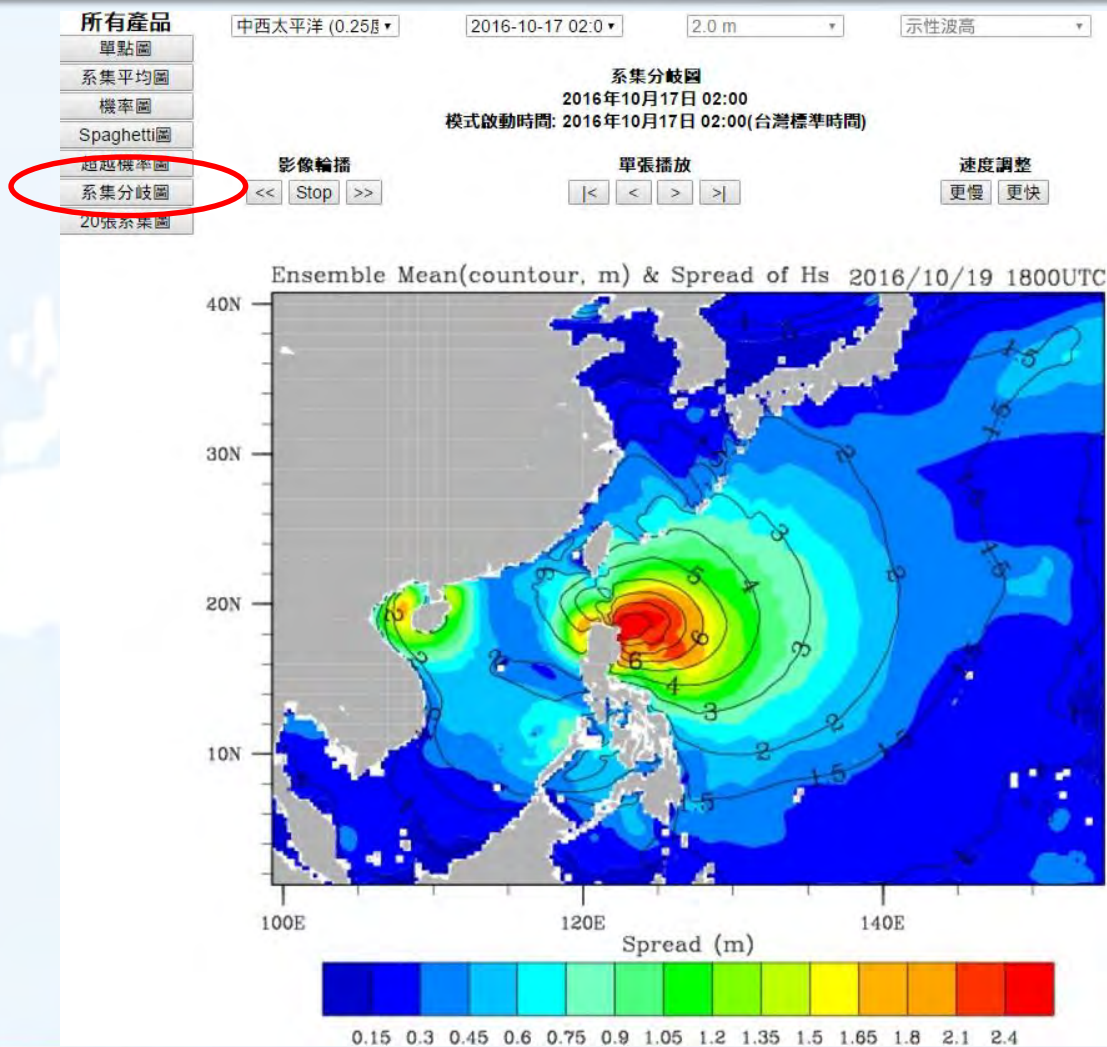
超越機率圖：  
前10%區域大於某個臨界波  
高值之機率分布

菲律賓東北角有10%  
機率波高達到12公尺  
以上浪高；臺灣南部  
及東部及海峽內有  
10%機率波高達到3公  
尺以上浪高

# 波浪系集產品介紹



## 系集分歧圖



系集分歧圖：  
系集平均波高(等高線)及系集分歧(1個標準差 shaded)

菲律賓東北角浪高系集平均達10m以上。  
SHADED表示上下1個標準差即代表在此區域有可能達 $10+2.4=12.4$ 米以上或 $10-2.4=7.6$ 米的浪高

# 工作方法-建構波浪系集預報系統

## 1.系集波浪預報之成員建置方法及分歧度分析

### Ensemble Spread

系集預報和系集平均的差異。Rank Histogram 對於離散程度的評估較為定性判斷，因此透過ensemble spread可提供一個定量的數值協助判斷。

- RMSE為ensemble mean的預報值和分析值(觀測)的差異。
- SPRD為ensemble預報和ensemble mean的差異。

$$S_{SPRD} = \sqrt{\frac{1}{N-1} \sum_{n=1}^N (\bar{f} - f(n))^2}$$

**perfect : RMSE=SPRD**

**Spread too small : RMSE > SPRD**

**Spread too large : RMSE < SPRD**

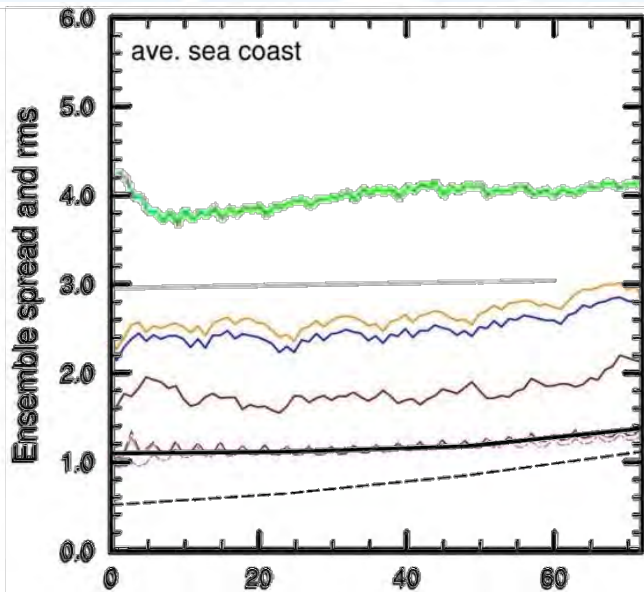


# SPREAD

## Root Mean Square Error

2012/1~2

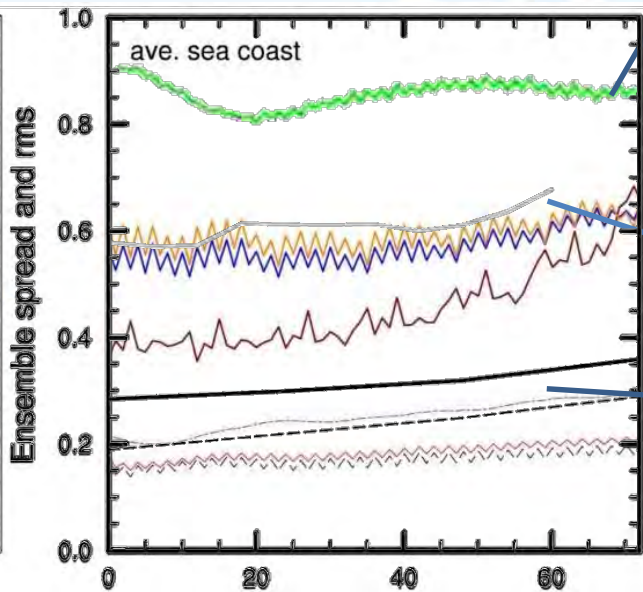
### Wind (m/s)



Forecast hour

- rms(ave.)
- spread(ave.)
- rms(sea)
- spread(sea)
- rms(coast)
- spread(coast)

### wave(m)



Forecast hour

- rms(ave.)
- spread(ave.)
- rms(sea)
- spread(sea)
- rms(coast)
- spread(coast)

M00

10km/sat.

NOAA

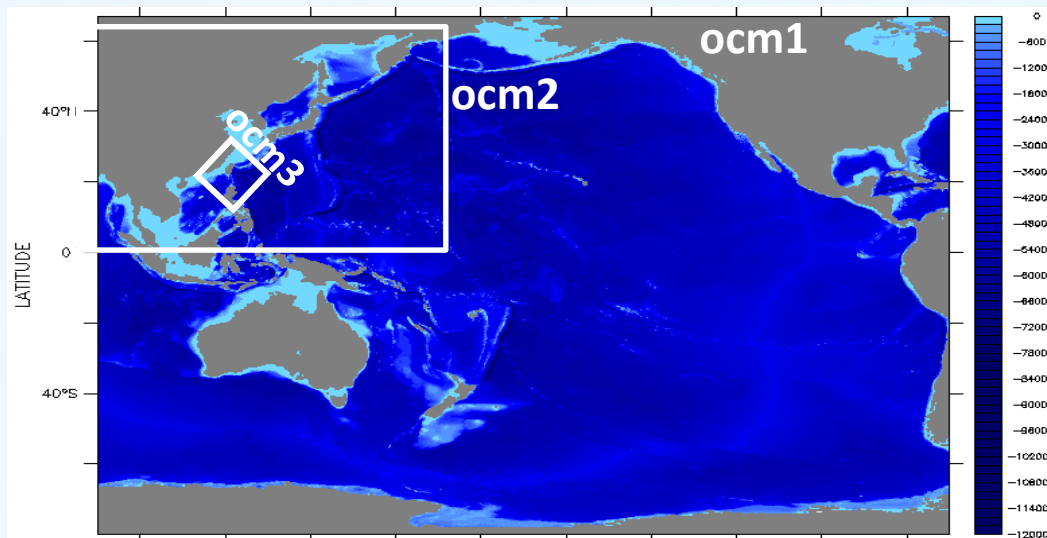




# CWB ocean current model (OCM)

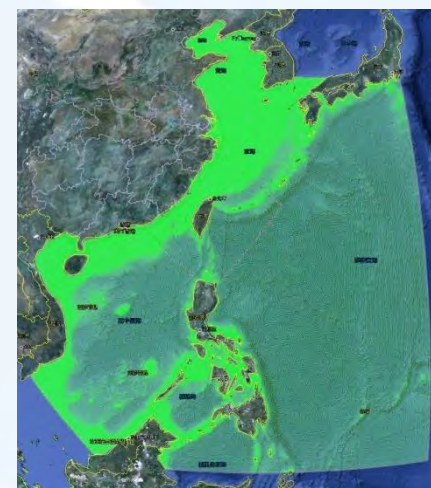


## Domain and Resolution

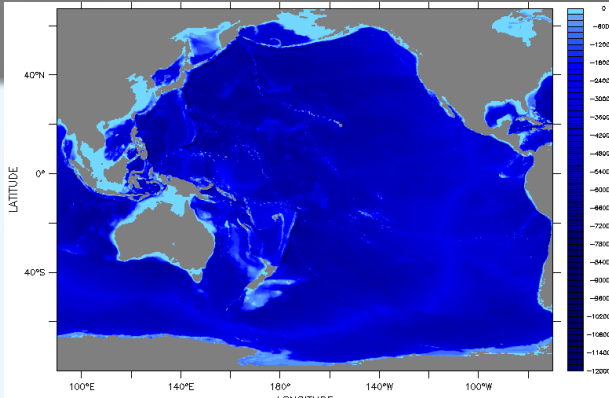


**SCHISM (Semi-implicit Cross-scale Hydroscience Integrated System Model)**

CURRENT MODEL	ocm1/ocm2	S-ocm2	S-ocm3
Resolution	1/3° / 1/8°	7.5' ~ 3'	13' ~ 0.75'
S-coord.	40	33	33
model	ROMS	<b>SCHISM</b>	<b>SCHISM</b>
run time	30/120 min	60min	120min

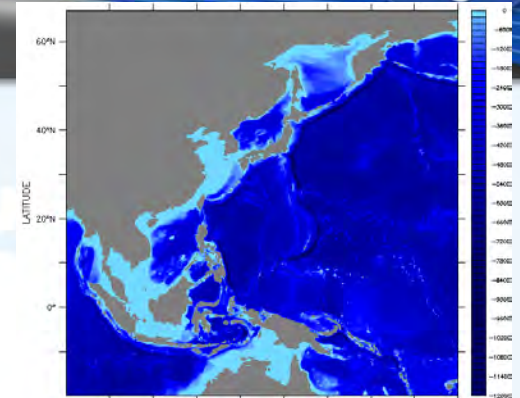


# 海流模式系統(ROCFORS)



OCM1

- 太平洋環流模式(OCM1)
- 西北太平洋環流模式(OCM2)
- 使用模式與解析
  - ROMS
  - 垂直s-coord. 40層
  - 水平解析度
    - OCM1: 1/3度
    - OCM2: 1/8度
  - GFS 驅動



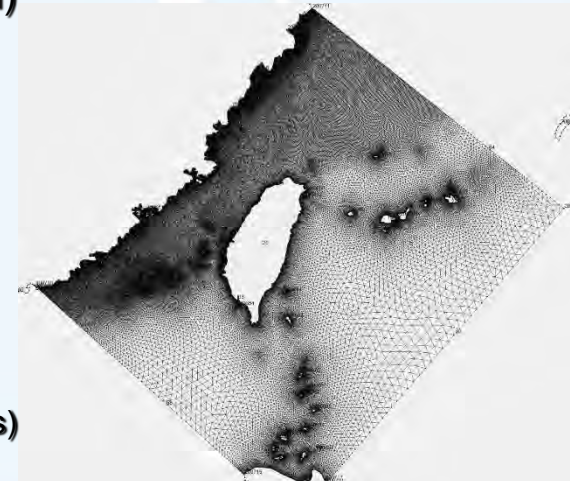
OCM2

產品皆為1天現報，3天預報



OCM2-SCHISM

- 西北太平洋環流模式(OCM2-SCHISM)
- 台灣海域模式(OCM3)
- 使用模式與解析
  - SCHISM
  - 垂直33 sz-layers
    - 表層1000公尺: 25層s-coord. 解析
    - 1000公尺以下: 8層z, 與HYCOM資料分佈相同
  - 水平解析度
    - OCM2-SCHISM (167020 nodes)
      - 3'~7.5'
    - OCM3 (94288 nodes)
      - 0.75'~13'
  - CWB-WRF 驅動



OCM3



兩個假設的條件，一為 Boussinesq approximation，及水體內部的密度差異可忽略，另一為 hydrostatic approximation，及垂直壓力梯度力與浮力平衡，以卡氏座標表現方程式如下所述，

$$\nabla u + \frac{\partial w}{\partial z} = 0$$

$$\frac{\partial \eta}{\partial t} + \nabla \int_{-h}^{\eta} u \, dz = 0$$

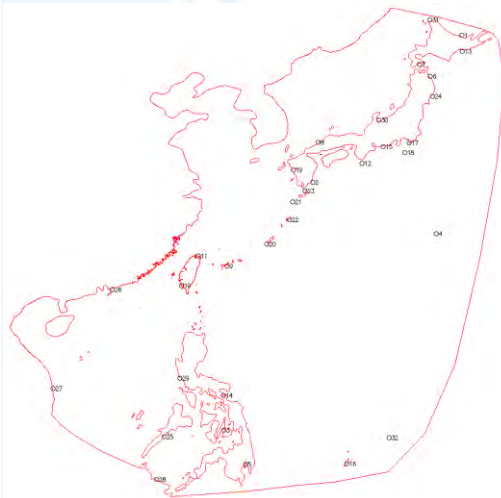
$$\frac{Du}{Dt} = F - g \nabla \eta + \frac{\partial}{\partial z} \left( \nu \frac{\partial u}{\partial z} \right);$$

$$F = -fk \times u + \alpha g \nabla \hat{\psi} - \frac{1}{\rho_0} \nabla P_A - \frac{g}{\rho_0} \int_z^{\eta} \rho \, d\zeta + \nabla \cdot (\mu \nabla u)$$

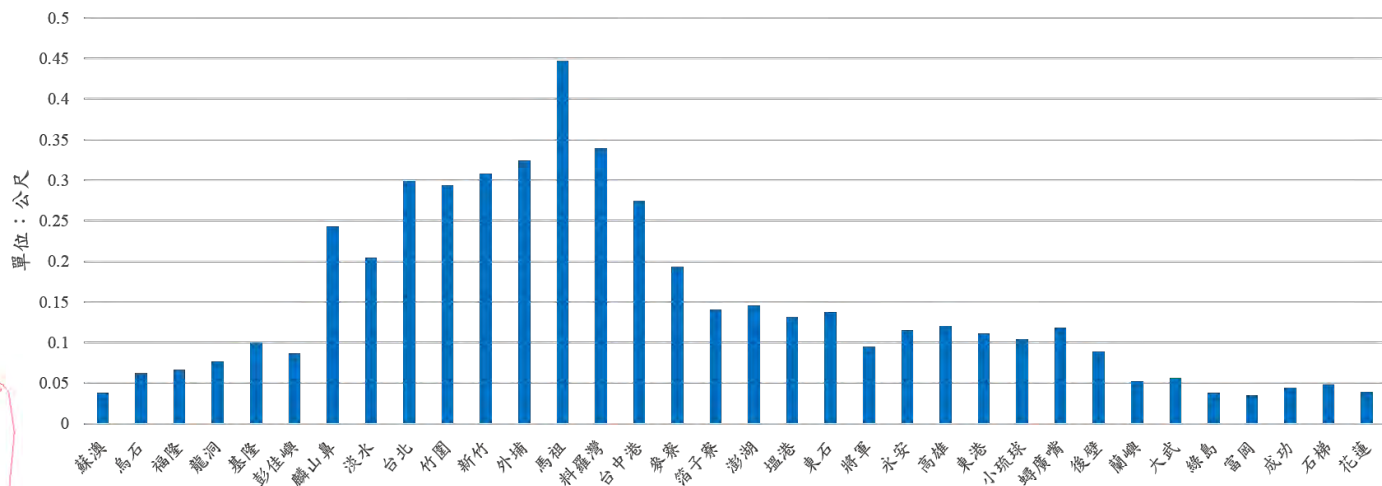
$$\frac{DS}{Dt} = \frac{\partial}{\partial z} \left( k \frac{\partial S}{\partial z} \right) + F_s$$

$$\frac{DT}{Dt} = \frac{\partial}{\partial z} \left( k \frac{\partial T}{\partial z} \right) + \frac{\dot{Q}}{\rho_0 C_p} + F_h$$

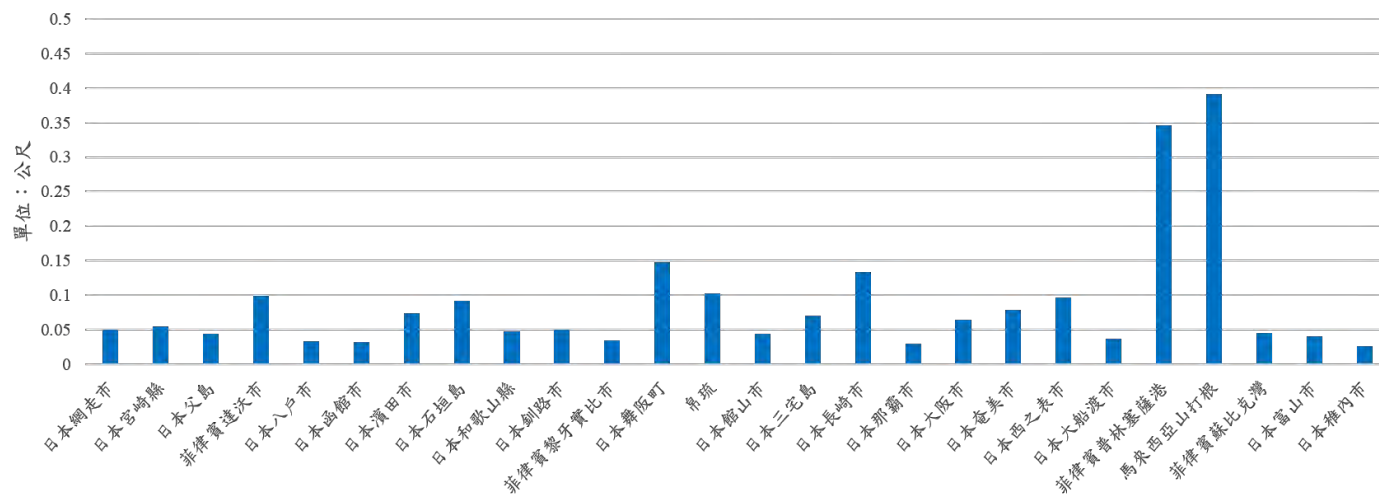
# 潮汐模組率定結果



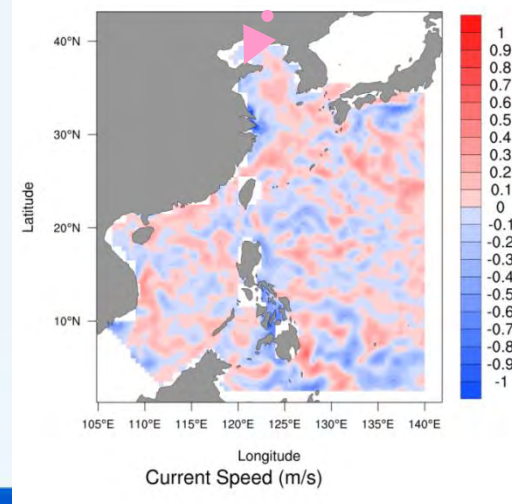
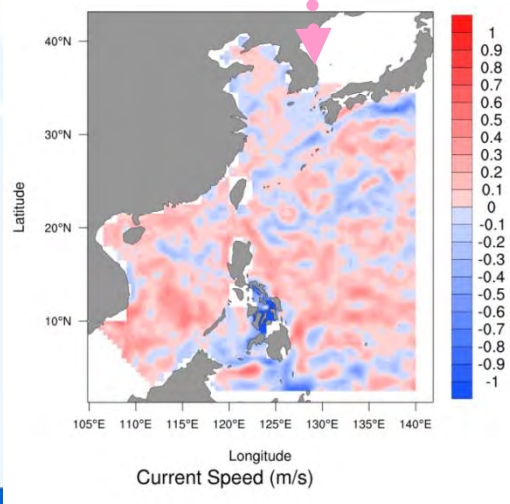
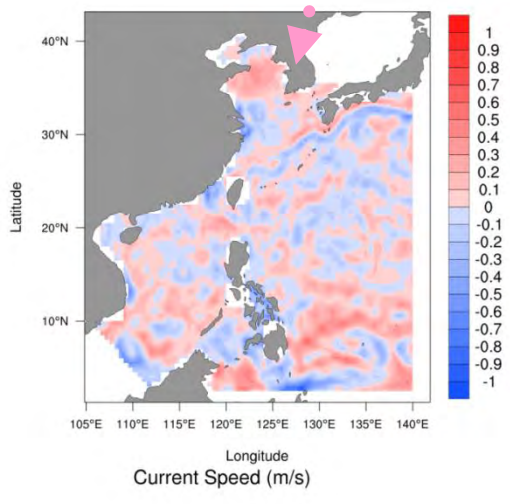
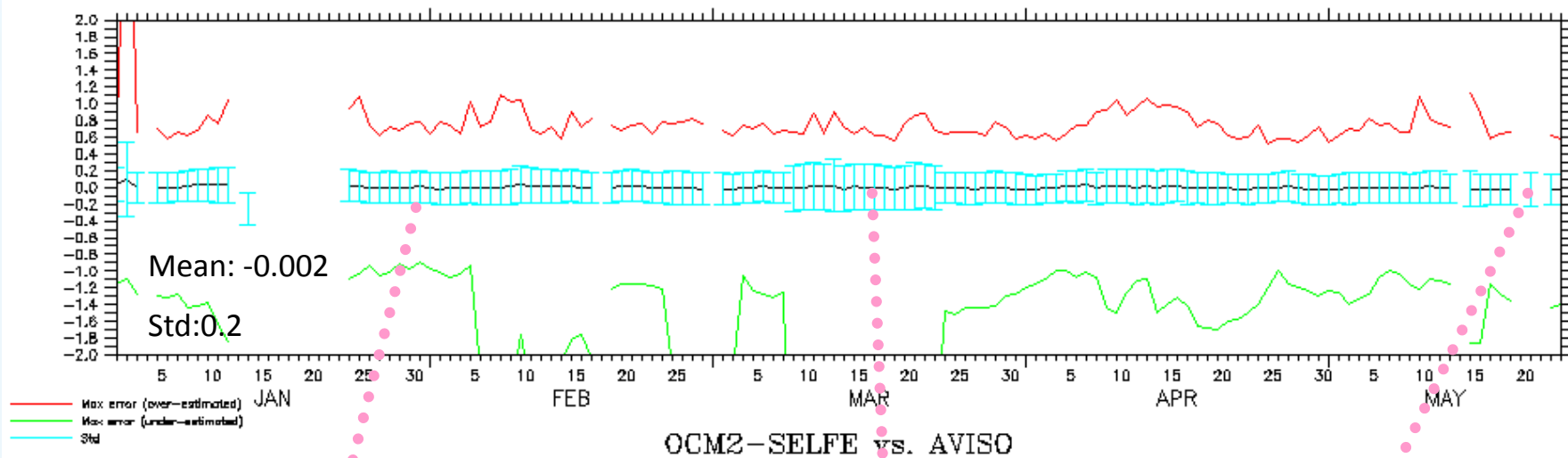
誤差分析(臺灣)



誤差分析(太平洋)

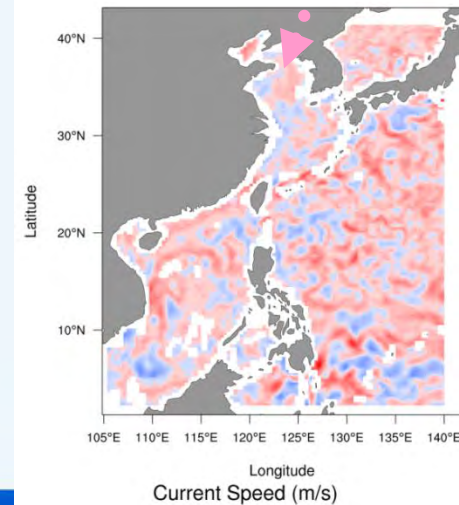
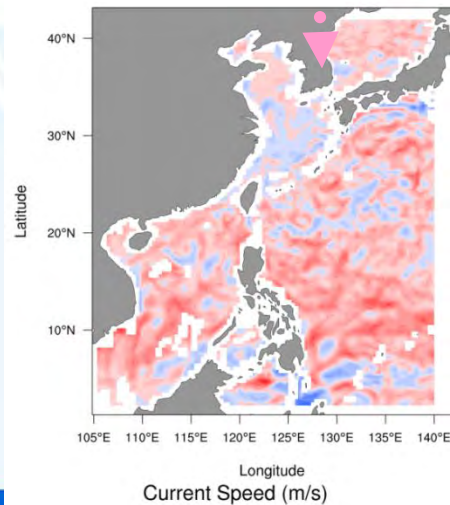
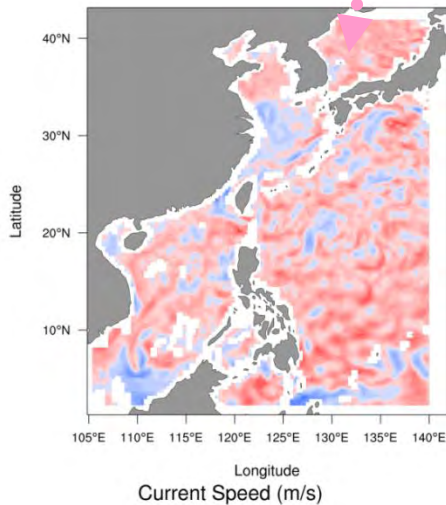
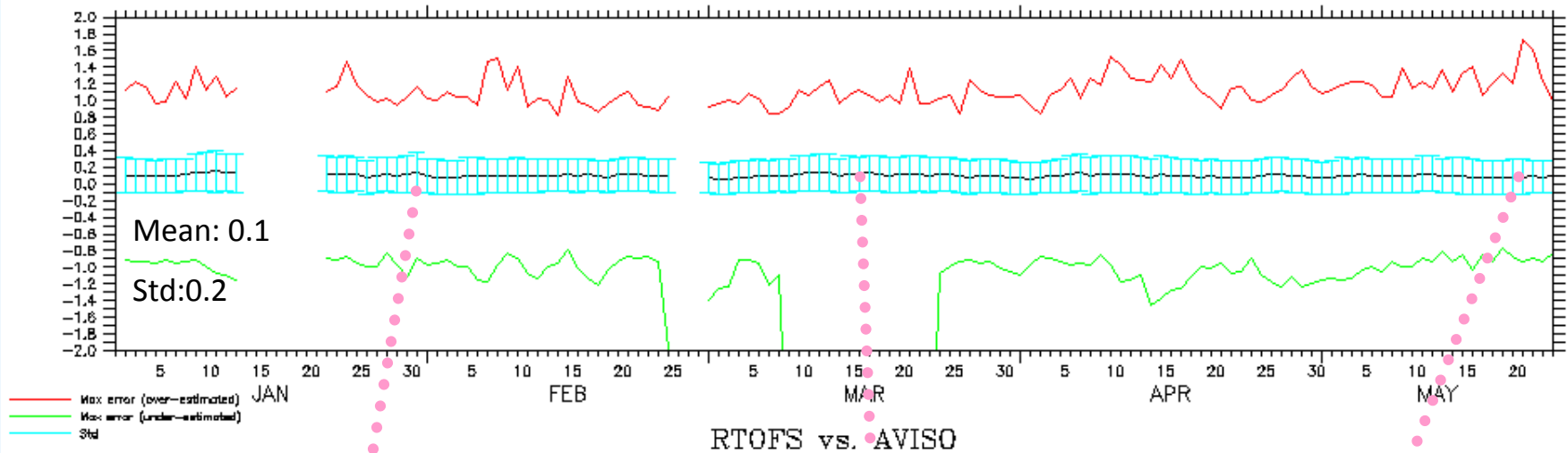


# Verification – surface current



# Verification

## surface current (OCM2-S)



# 海象預報資訊



## 數值預報 / 海象預報模式圖

☀ 官網 / 預報 / 數值預報 / 海象預報模式圖 / 表層海流流速

☀ 官網 / 預報 / 數值預報 / 海象預報模式圖 / 表層海溫

SCHISM模式。一天執行1次(00Z)，預報72小時(間隔3hr)。

交通部中央氣象局  
Central Weather Bureau

生活氣象 | **預報** | 觀測 | 防災氣象

聖嬰現象 暖

預報時 000 003 006 009 012 0

波浪模式

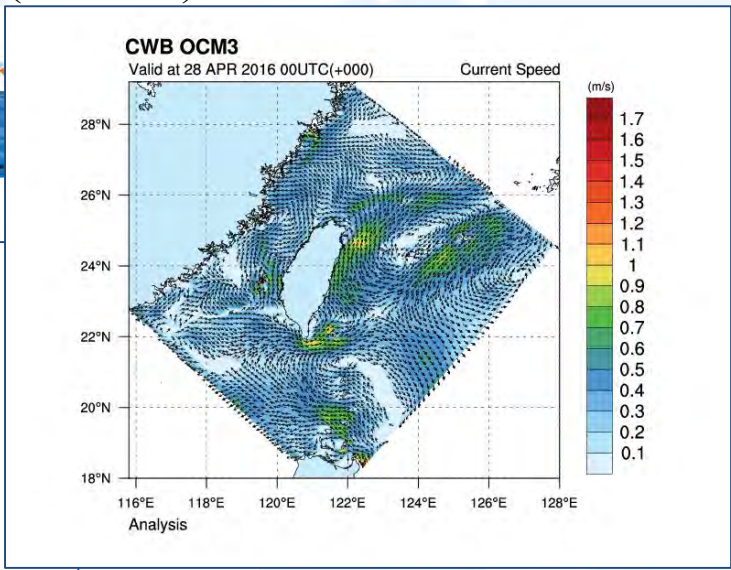
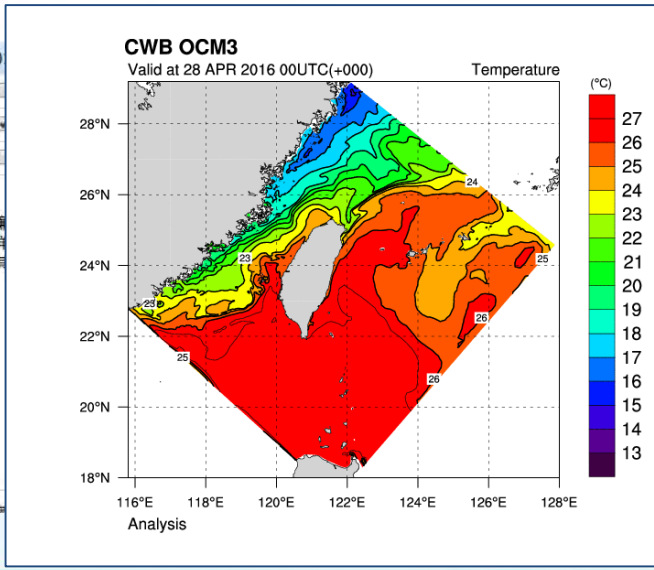
表層海流流速

表層海溫

- 中央氣象局海流預報系統使用美國威爾遜
- 中央氣象局波浪預報系統使用美國海洋
- 所展示資料為數值模式預報結果，有其

預報

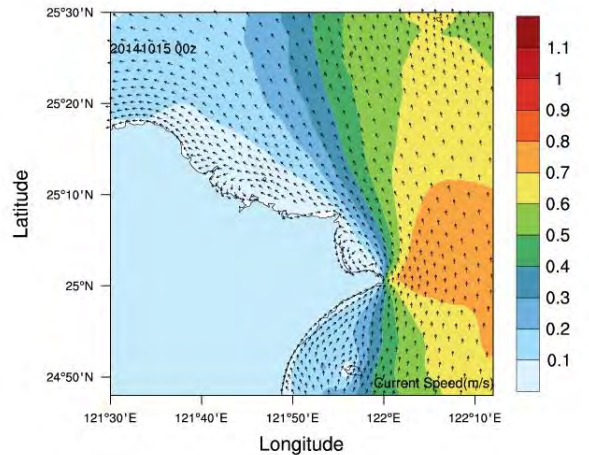
- 天氣預報
- 預約氣象
- 漁業氣象
- 藍色公路
- 國際都市
- 分析及預測
- 長期預報
- 數值預報
- 數值預報模式圖
- 海象預報模式圖
- 颱風暴雨預報圖
- 預報主任談天氣



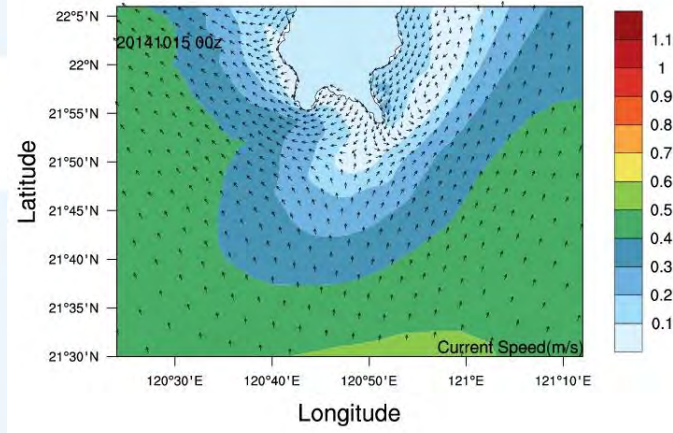
# OCM customized products



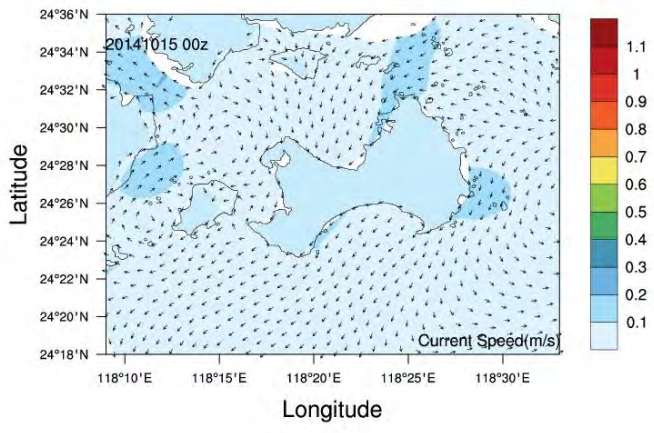
Northeast and Yilan coast national science area



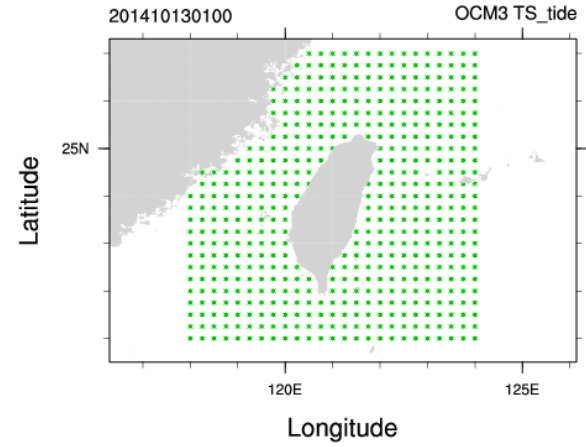
Kenting national park



kinmen



Trajectory plot





# Thank you

