



Twelfth meeting of the ICG/PTWS Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region (ICG/PTWS WG-SCS), Jakarta, 7 - 8 November 2024

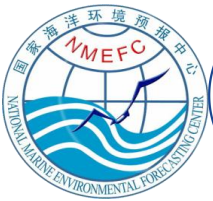
Progress of the Tsunami Decision Supporting System at SCSTAC

Reporter: WANG, ZONGCHEN

Main Technician: Dr. Li, HONGWEI

South China Sea Tsunami Advisory Center, UNESCO/IOC

National Marine Environmental Forecasting Center, MNR



Outline

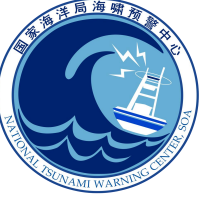
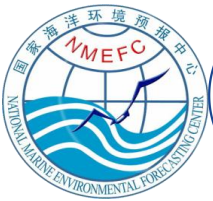


- **1. Background**
- **2. Modules of STIPS**
- **3. Customized STIPS**
- **4. Further Work**

1. Background

- ❑ In 2015, we initiated the development of a decision-making system through a technology company, and completed its 1.0 version in 2016, marking the beginning of its operational application.
- ❑ In the next few years, many operation actions were required to be continuously adjusted and optimised for more efficient warning performance. So we need to closely cooperate with the technicians.
- ❑ The challenge was the high mobility rate of the technicians in company, coupled with the fact that different engineers specialized in different programming languages, which led to difficulties in system maintenance and upgrade.





1. Background

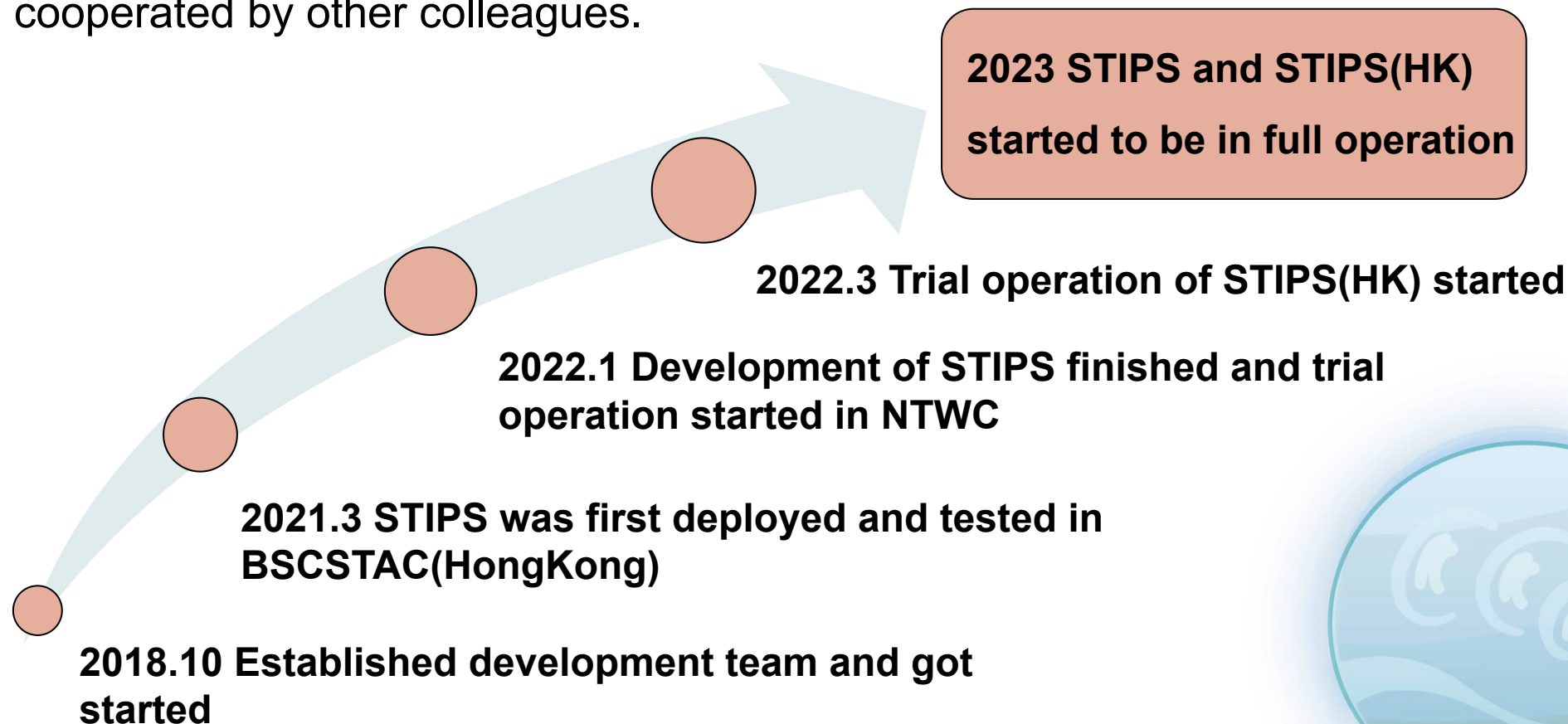


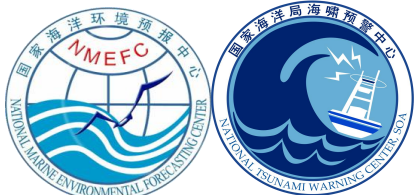
Requirement of Module Functions for DSS:

- **1. GIS interface for visual warning analysis;**
- **2. Acquire the earthquake information from multiple sources;**
- **3. Receive sea level data in real time from multiple sources;**
- **4. Compute the Estimated Time of Arrival (ETA);**
- **5. Compute wave amplitudes of tsunamis for designated forecast points;**
- **6. Make tsunami products according to potential threat;**
- **7. Disseminate tsunami bulletins via multiple channels;**

1. Background

- Smart Tsunami Processing System (**STIPS**) - a totally self-designed decision support system program - was established for the substitution. Dr Li, Hongwei was the main technician, cooperated by other colleagues.





1. Background



Smart Tsunami Processing System (**STIPS**)

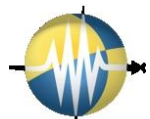
Interpreter:

Python 3.6.5

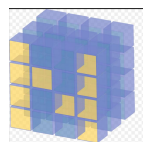
Package and dependency:



PyQt5 Create frame of UI



Obspy Library of seismology



Numpy Fast array operations

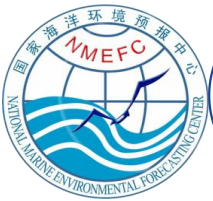


THE GENERIC MAPPING TOOLS

GMT4/5 Tsunami data visualization



MySQL Core database of the DSS

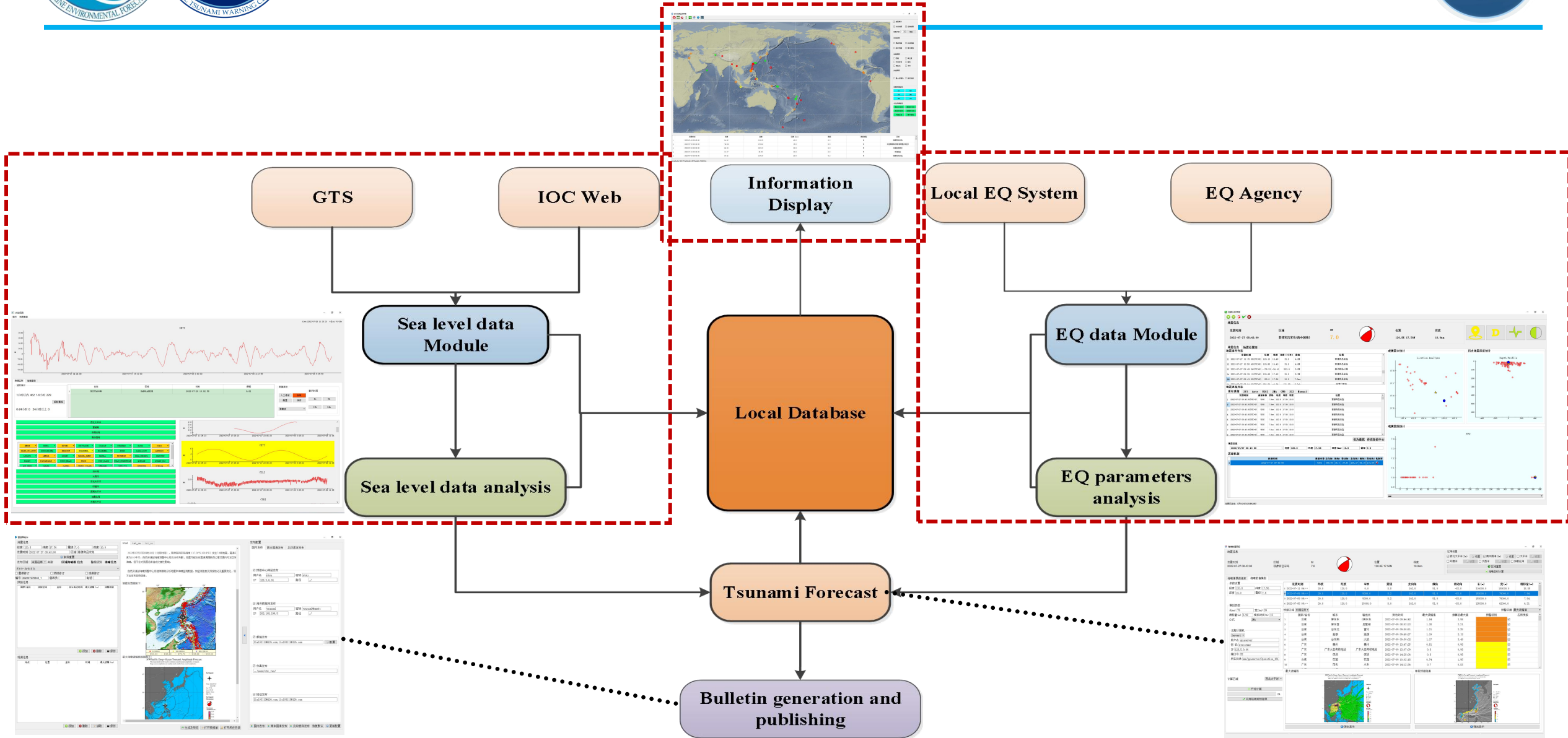


Outline



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- **2. Modules of STIPS**
- **3. Customized STIPS**
- **4. Further Work**

Data Processing framework





Earthquake Rapid Information



Mag	Type	Region
4.6	M	FLORES SEA
4.9	M	MINDANAO, PHILIPPINES
4.4	M	SOUTHERN SUMATRA, INDONESIA
4.6	M	OFF COAST OF EQUADOR
4.8	M	MYANMAR-CHINA BORDER REGION

Earthquake parameters crawling, displaying, archiving.

● **Source:**

Local system: Seiscomp, Antelope

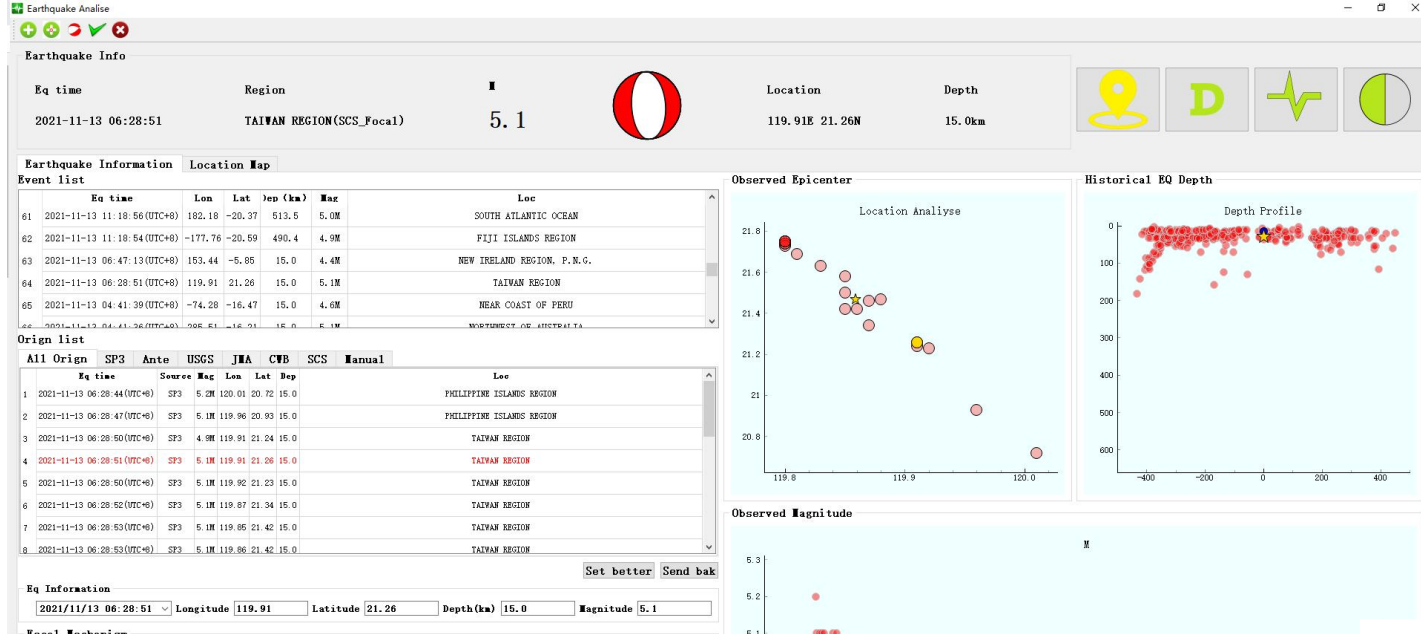
Others: USGS, JMA, CEA

● **CMT source:**

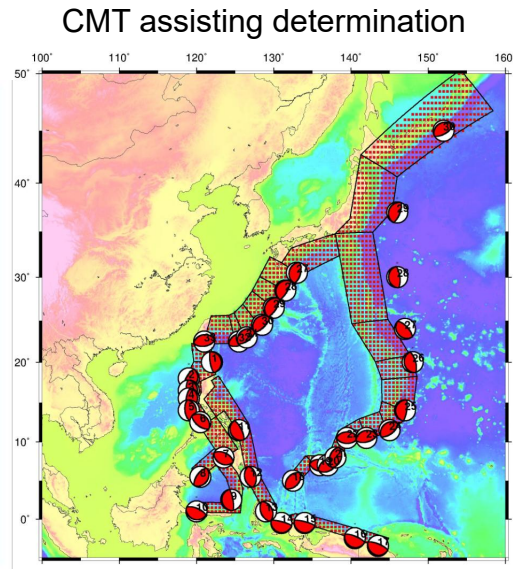
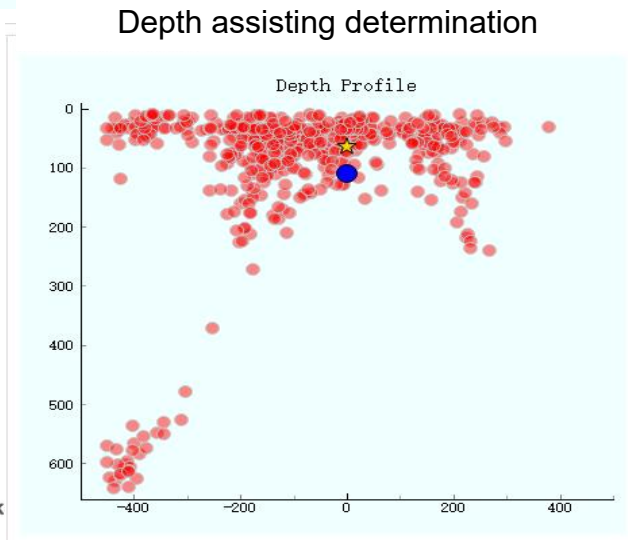
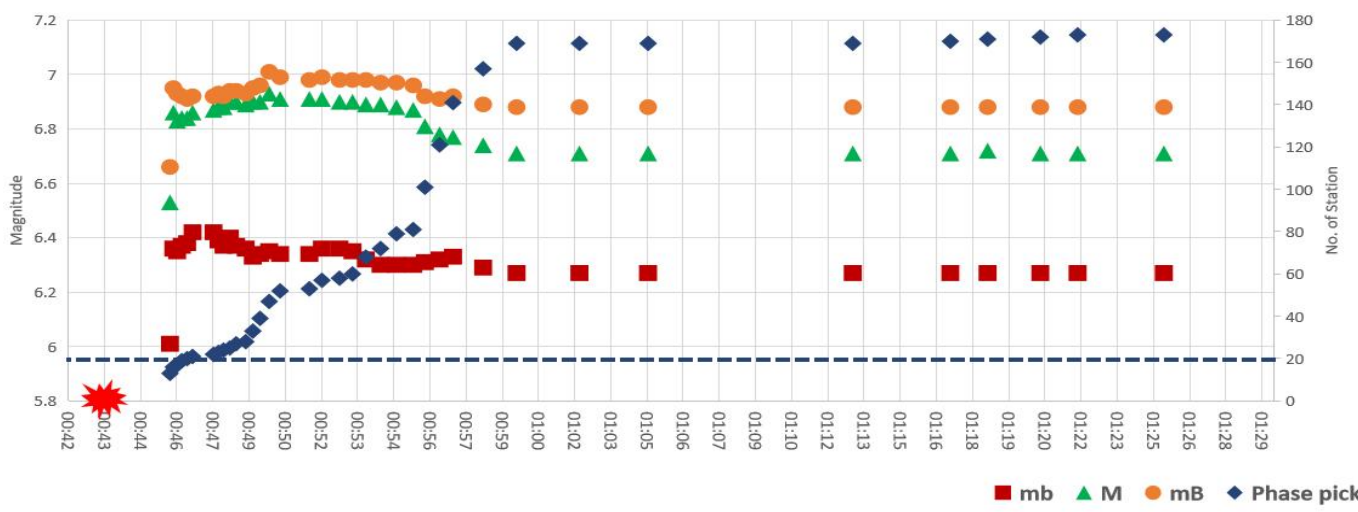
Local system: Wphase, MT of SP3

Others: USGS

Determination of EQ. Parameters



- Earthquake information table.
- Basic earthquake parameters assisting analysis based on historical events
- Estimation of CMT based on tectonic setting and W-phase inversion.



Tsunami Forecast

Tsunami Forecast

EQ info
 EQ time: 2021-11-22 10:01:12
 Region: TAIWAN
 M: 8.7
 Location: 120.0E 22.0N
 Depth: 15.0km

Setting Region
 Northwest Pacific(5m) South China Sea(5m) Pacific Ocean
 North Indian Atlantic Caribbean

Scenario Database Tsunami Modeling

Parameters setting:
 Lon: 120.0 Lat: 22.0
 Depth (km): 15.0 Mag: 8.7

Process: 100%

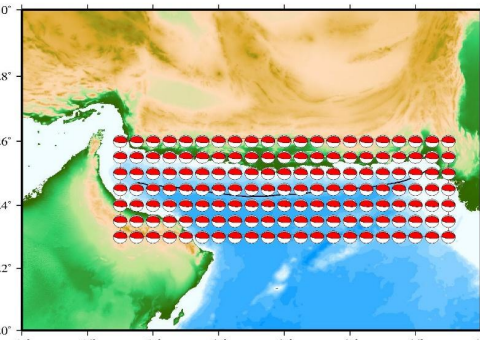
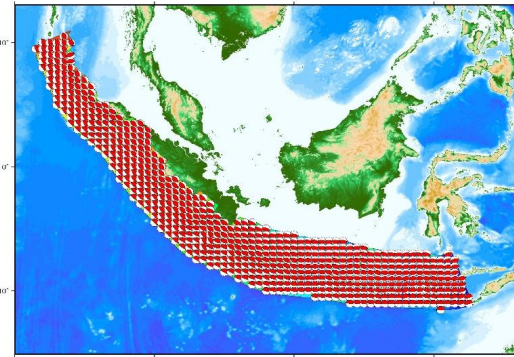
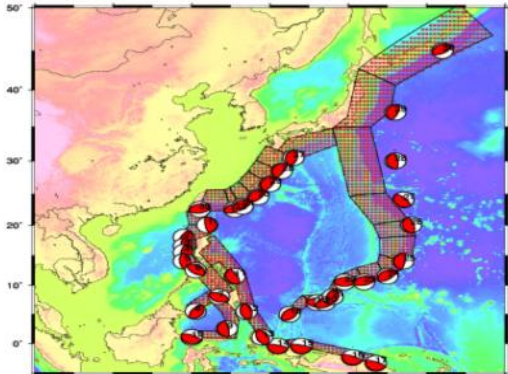
Green law transition:
 Default depth
 Fix depth [20] M
 Green Law

Forecast point	Arrival time	Max amp	Max amp green	Warn level	Apply result
1 后壁湖	2021-11-22 10:16:48	7.16	18.78	Red	<input checked="" type="checkbox"/>
2 高雄	2021-11-22 10:20:20	4.57	9.0	Red	<input checked="" type="checkbox"/>
3 0嘉义	2021-11-22 11:18:04	3.11	5.62	Red	<input checked="" type="checkbox"/>
4 0台南市	2021-11-22 10:38:10	3.08	5.81	Red	<input checked="" type="checkbox"/>
5 汕头	2021-11-22 12:55:54	2.6	3.42	Orange	<input checked="" type="checkbox"/>
6 0云林	2021-11-22 11:27:29	2.56	4.37	Orange	<input checked="" type="checkbox"/>
7 东山	2021-11-22 13:51:03	2.54	3.06	Orange	<input checked="" type="checkbox"/>
8 惠来	2021-11-22 12:36:27	2.21	3.05	Orange	<input checked="" type="checkbox"/>
9 0彰化	2021-11-22 12:09:27	2.12	2.58	Orange	<input checked="" type="checkbox"/>
10 广东大亚湾核电站	2021-11-22 13:51:31	2.06	2.81	Orange	<input checked="" type="checkbox"/>
11 惠州	2021-11-22 14:22:07	2.06	2.88	Orange	<input checked="" type="checkbox"/>

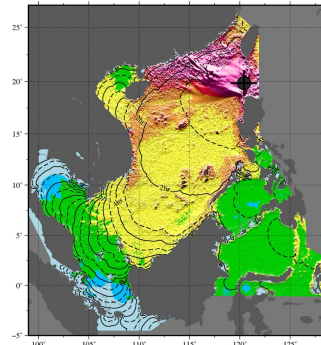
Maximum amp map: NW Pacific Deep Ocean Tsunami Amplitude Forecast (Sumatra-Java)

Coast map: CHINA Coastal Tsunami Maximum Amplitude (Makran_trench)

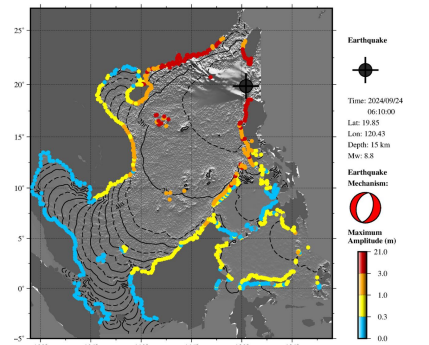
- Estimation of tsunami arrival time
- Scenario database
- On-the-fly tsunami model
- Automatic plotting and visualization.



SCS Deep-Ocean Tsunami Amplitude Forecast
 This map should not be used to estimate coastal tsunami amplitudes or impacts. Deep-ocean amplitudes are usually much smaller than coastal amplitudes.



SCS Coastal Tsunami Amplitude Forecast
 Actual amplitudes at the coast may vary from forecast amplitudes due to uncertainties in the forecast and local features.

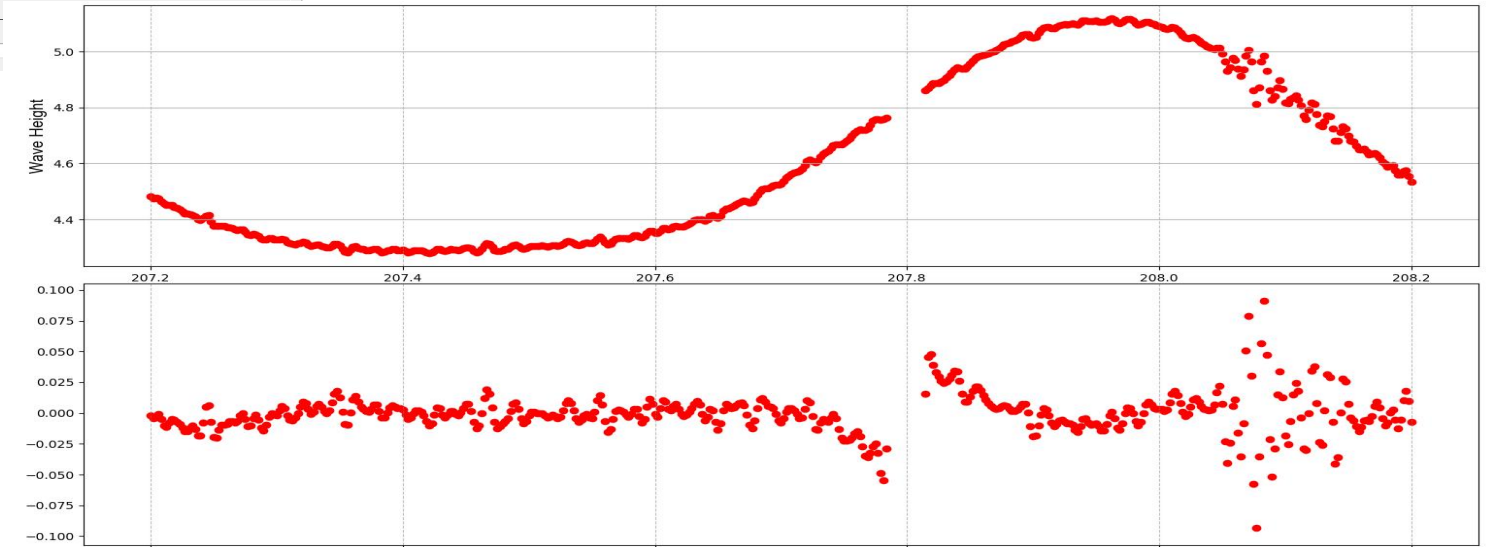
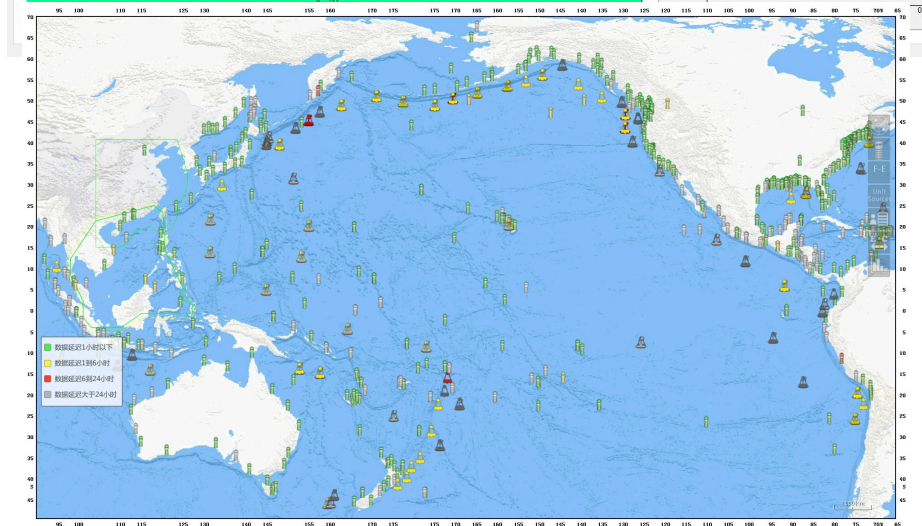




Tsunami Monitoring



- Real-time Data from Tidal gauges and Dart bouys
- Tsunami frequency band filtering
- Pickup of tsunami amplitude





Product Making and Dissemination



Production

Eq Info
 Lon 120.0 Lat 22.0 Mag 8.7 Dep 15.0
 Eq_time 2021-11-22 10:01:12 Region TAIWAN
 Sending region South China Sea Type Local source Alarm Level Red

[1st_bulletin=Tsunami Threat Message] Magnitude above 7.6
 Mag revised Forecast revised Observation revised
 ID 202111221001_1 Duty Tel

Forecast

Country/Province	Cor.	Arr time	Ampl (m)	Level
1 CHINA	(115.6, 2...	0447	1-3	Orange
2 CHINA	(113.9, 2...	0740	>3	Red
3 CHINA	(114.2, 2...	0700	>3	Red
4 CHINA	(113.6, 2...	0653	1-3	Orange
5 CHINA	(111.8, 2...	0635	1-3	Orange
6 VIETNAM	(105.7, 1...	1028	0.3-1	Yellow
7 VIETNAM	(108.3, 1...	0552	1-3	Orange
8 VIETNAM	(109.2, 1...	0458	1-3	Orange
9 VIETNAM	(109.2, 1...	0640	1-3	Orange
10 VIETNAM	(107.1, 1...	0854	0.3-1	Yellow
11 VIETNAM	(105.8, 9...	1223	0.3-1	Yellow

Obs. Info

Sta	Loc	Cor	Time	Ampl (m)
CHINA	SHANWEI	115.6, 22.6	0447	1-3M
CHINA	SHENZHEN	113.9, 22.5	0740	>3M
CHINA	HONG KONG	114.2, 22.3	0700	>3M
CHINA	MACAO	113.6, 22.2	0653	1-3M
CHINA	ZHAFU	111.8, 21.5	0635	1-3M
VIETNAM	SANTA	109.5, 18.2	0504	0.3-1M
VIETNAM	QINGLAN	110.9, 19.6	0500	1-3M
VIETNAM	KAHSIUNG	120.3, 22.5	0220	>3M
VIETNAM	VINH	105.7, 18.6	1028	0.3-1M
VIETNAM	DA_NANG	108.3, 16.0	0552	1-3M
VIETNAM	QUI_NHON	109.2, 13.7	0458	1-3M
VIETNAM	NHA_TRANG	109.2, 12.3	0640	1-3M
VIETNAM	VUNG_TAU	107.1, 10.3	0854	0.3-1M
VIETNAM	BAC_LIEU	105.8, 9.3	1223	0.3-1M
MALAYSIA	SANDAKAN	118.1, 5.9	0800	0.3-1M
MALAYSIA	KUDAT	116.9, 6.9	0606	1-3M
INDONESIA	MELONGUANE	126.6, 4.1	0457	0.3-1M
INDONESIA	TABUKAN_TENGAH	125.6, 3.6	0514	0.3-1M
INDONESIA	KEPULAUAN_RIAU	108.5, 4.0	0743	0.3-1M
PHILIPPINES				

Configuration

Chinese sending SCS Sending Indian Ocean

NMEFC Web
 User: _____ Passwd: _____
 IP: _____ Path: _____

Forecast Web
 User: _____ Passwd: _____
 IP: _____ Path: _____

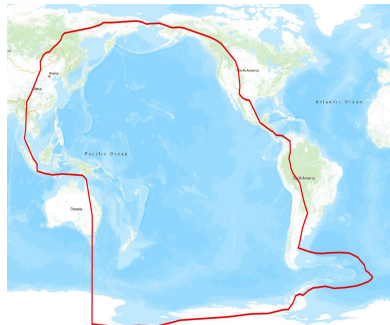
Email

Fax

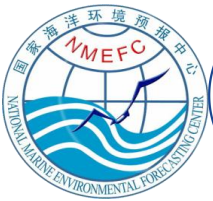
Message

Buttons: Produce, Open Path, Chinese sending, SCS sending, Indian sending, Set Default, Update

- **Templates based on SOP.**
- **Rapid generation of tsunami products (doc, txt, html)**
- **Multiple release channels**
- **One-Click Communication Test**



Region	Fax	SMS	E-mail	Website	GTS
China	✓	✓	✓	✓	
SCS	✓		✓	✓	✓



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- **4. Further Work**

A Lightweight Version of STIPS

Real-time tsunami hazard analysis for Macau triggered by earthquakes occurring in SCS Region

- Automatically modelling for earthquake with M_w 7.0+ in SCS
- Refined-scale numerical model
- 120s time consuming for 12-hour simulation (Based on NVIDIA RTX 2080Ti)
- Cost-effective and well-maintained

Modular deletion as follow

- GIS interface
- Acquire the earthquake information from multiple sources;
- Receive sea level data in real time;
- Compute the ETA;
- Compute wave tsunami amplitudes for designated forecast points;
- Make tsunami products;
- Disseminate tsunami bulletins via multiple channels;

The screenshot displays the STIPS software interface. On the left, a 3D topographic map shows the South China Sea region. Below the map is a table of earthquake data:

編號	發震時刻	經度	緯度	深度 (km)	震級	震級類型	區域	數據源	模擬	
1	TestManila_1721952649.0	2024-07-26 08:10:49	120.0	22.0	15.0	8.2	M	TAIWAN	UGS	W
2	TestManila_1721952434.0	2024-07-26 08:07:14	120.0	22.0	15.0	8.2	M	TAIWAN	UGS	
3	us6000nfyf	2024-07-26 05:35:00	46.37	34.32	10.0	4.9	mw	WESTERN IRAN	USGS	
4	us6000nfw2	2024-07-26 04:32:00	128.67	-7.37	147.3	5.5	mw	BANDA SEA	USGS	
5	us6000nfsb	2024-07-26 01:11:00	102.9	-6.09	10.0	5.3	mb	SOUTHWEST O...	USGS	
6	us6000nfr7	2024-07-26 00:11:00	-177.17	-22.9	141.49	4.8	mb	SOUTH OF FUJI ...	USGS	
7	TestBinhai_1721922334.0	2024-07-25 23:45:34	113.4	21.0	15.0	8.2	M	NEAR COAST OF...	UGS	W
8	us6000nfpd	2024-07-25 23:05:00	-25.37	-60.75	10.0	5.8	mw	SOUTH ...	USGS	
9	us6000nfnq	2024-07-25 22:11:00	-70.77	9.92	10.0	5.0	mb	VENEZUELA	USGS	
10	TestManila_1721909642.0	2024-07-25 20:14:02	120.0	22.0	15.0	8.2	M	TAIWAN	UGS	W

Below the table are controls for '地震抓取' (Earthquake Capture) and '添加演習' (Add Simulation). To the right, there are two forecast maps: '最大波幅圖' (Maximum Amplitude Forecast) showing deep ocean travel time and amplitude, and '岸段預報圖' (Coastal Forecast Map) showing Macao coastal tsunami amplitude. Below these maps is a '海嘯波曲線' (Tsunami Wave Curve) plot for '媽閣站' (Macao Station) showing wave height over time from 07-26 08:10 to 07-26 20:10. The plot shows a significant wave height peak around 07-26 11:00.

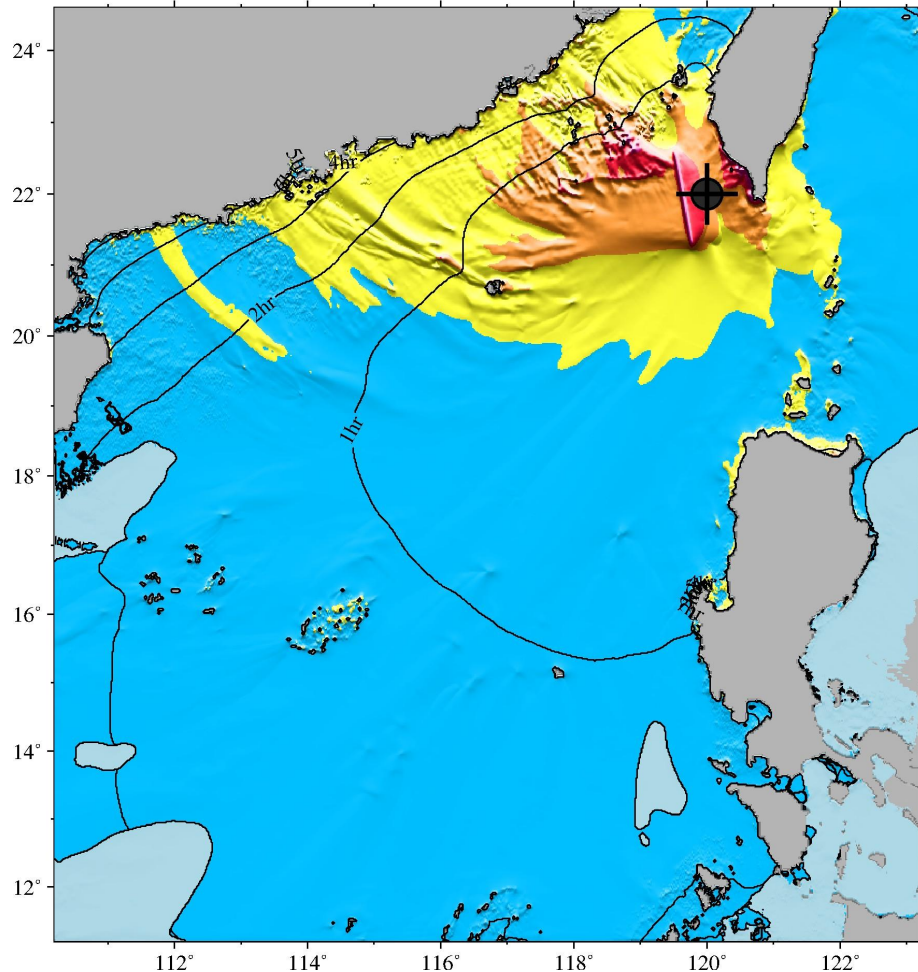


A Lightweight Version of STIPS

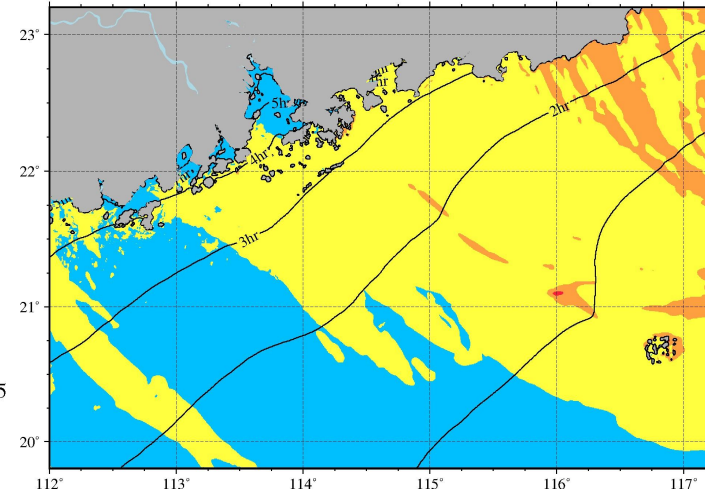


Map products:

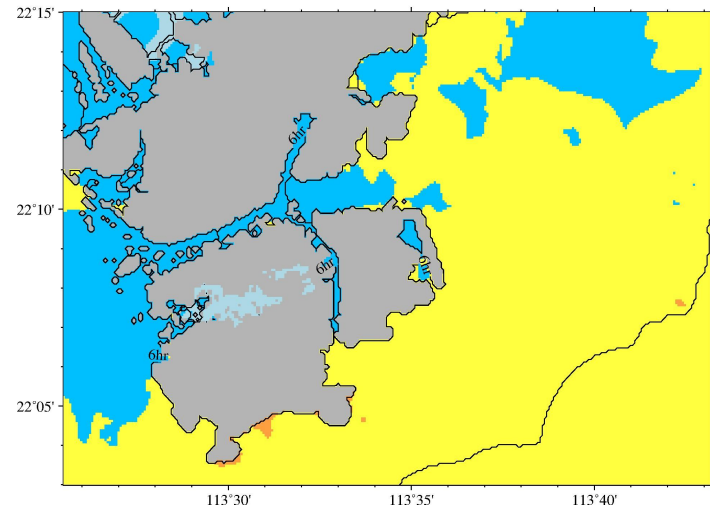
Deep-Ocean Tsunami Travel Time and Amplitude Forecast

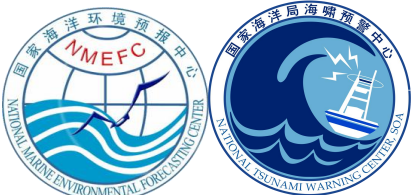


Macau offshore Tsunami Amplitude Forecast

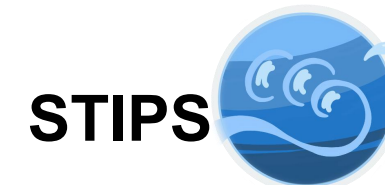


Macau Nearshore Tsunami Amplitude Forecast





A Lightweight Version of STIPS



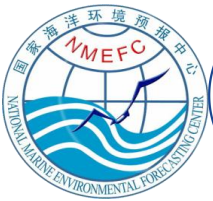
XML Products:

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Applications  Places  Text Editor
Open
<?xml version="1.0" encoding="utf-8"?>
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  <Earthquake>
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    <sim_tag>A</sim_tag>
    <real_evt>True</real_evt>
    <longitude>120.0</longitude>
    <latitude>22.0</latitude>
    <depth>15.0</depth>
    <mag>8.2</mag>
    <type>A1</type>
    <strike>350.0</strike>
    <dip>14.0</dip>
    <rake>90.0</rake>
  </Earthquake>
  <Tsunami>
    <sta>
      <name>妈阁站</name>
      <tsunami_time>2024-07-26 13:14:48</tsunami_time>
      <tsunami_height>0.228189</tsunami_height>
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    </sta>
    <sta>
      <name>青洲塘站</name>
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    <sta>
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      <tide_height>0.473394632339</tide_height>
    </sta>
    <sta>
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  </Tsunami>
</Information>
  
```

CSV Products:

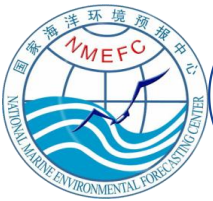
ts_record.nc	2024/7/26 11:09	NC 文件	44 KB
ts91_record.nc	2024/7/26 11:09	NC 文件	44 KB
ttt_layer01.nc	2024/7/26 11:09	NC 文件	2,457 KB
ttt_layer02.nc	2024/7/26 11:09	NC 文件	3,992 KB
ttt_layer03.nc	2024/7/26 11:09	NC 文件	320 KB
zmax_layer01.nc	2024/7/26 11:09	NC 文件	2,457 KB
zmax_layer02.nc	2024/7/26 11:09	NC 文件	3,992 KB
zmax_layer03.nc	2024/7/26 11:09	NC 文件	320 KB
loc_map.ps	2024/7/26 11:09	PostScript	1,316 KB
FP_INFO.TXT	2024/7/26 11:09	TXT 文件	2 KB
A.csv	2024/7/26 11:09	XLS 工作表	32 KB
B.csv	2024/7/26 11:09	XLS 工作表	32 KB
C.csv	2024/7/26 11:09	XLS 工作表	32 KB
D.csv	2024/7/26 11:09	XLS 工作表	32 KB
E.csv	2024/7/26 11:09	XLS 工作表	32 KB
F.csv	2024/7/26 11:09	XLS 工作表	32 KB
G.csv	2024/7/26 11:09	XLS 工作表	32 KB
H.csv	2024/7/26 11:09	XLS 工作表	32 KB
I.csv	2024/7/26 11:09	XLS 工作表	32 KB
J.csv	2024/7/26 11:09	XLS 工作表	32 KB
K.csv	2024/7/26 11:09	XLS 工作表	32 KB
MPE.csv	2024/7/26 11:09	XLS 工作表	32 KB
SBR.csv	2024/7/26 11:09	XLS 工作表	32 KB
SDV.csv	2024/7/26 11:09	XLS 工作表	32 KB



Outline



- **1. Background**
- **2. Modules of STIPS**
- **3. Customized STIPS**
- **4. Further Work**



Further Work



- Continuously Optimization**
- Upgrade according to SOP changes**
- Tsunami amplitude picking based on machine learning method**
- Bug fixed and stability enhancement.**



Thank you!

Main Technician: Dr. Li, Hongwei(lihw@nmefc.cn)
South China Sea Tsunami Advisory Center, UNESCO/IOC
National Marine Environmental Forecasting Center, MNR