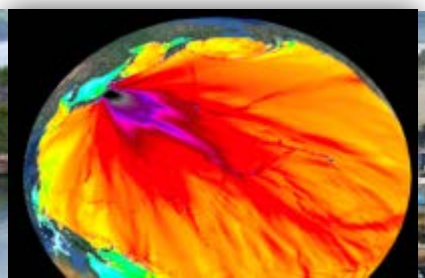
Tsunami Warning System and Service in China

Jianyu Shi

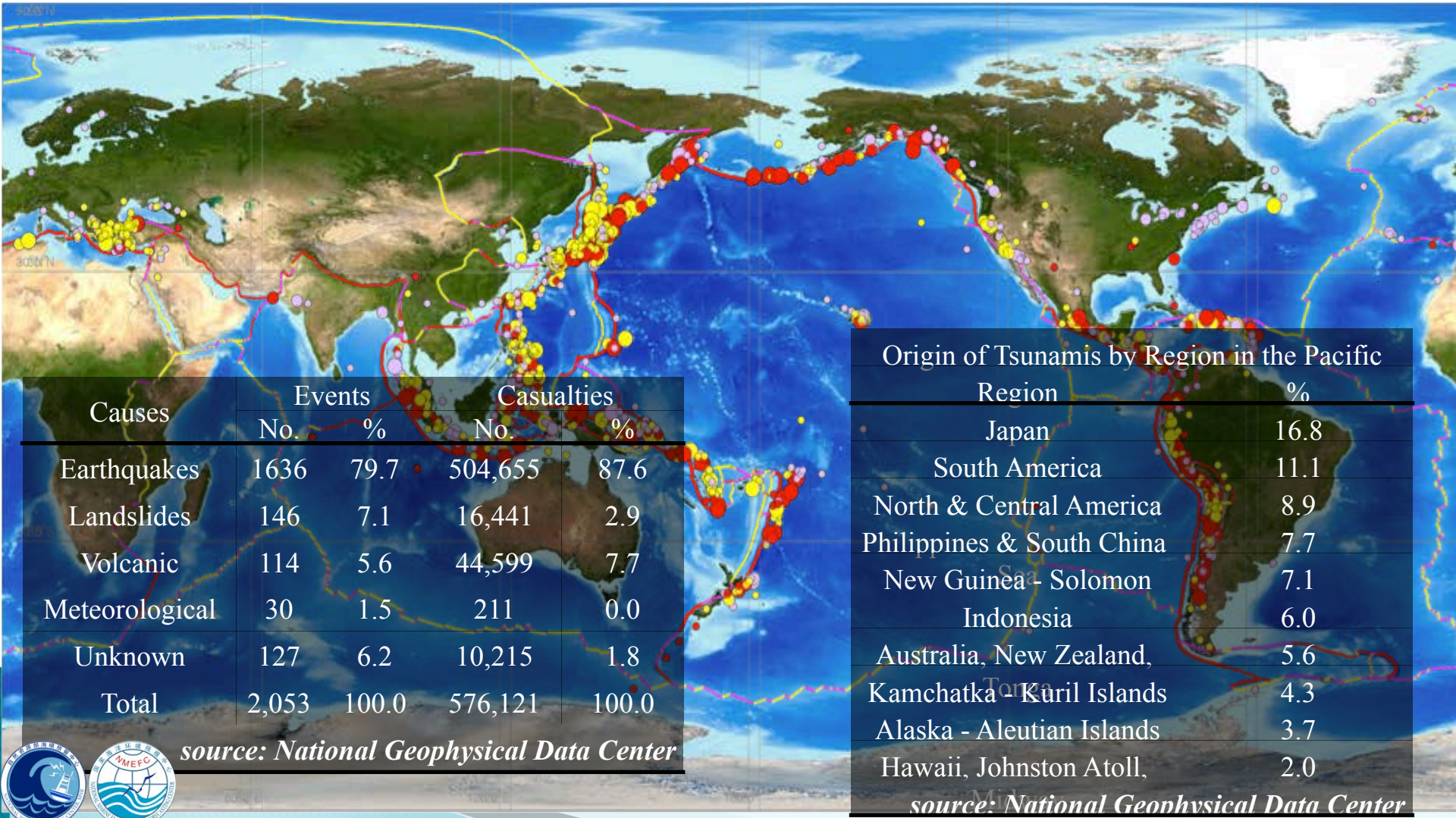
National Tsunami Warning Center,
Ministry of Natural Resources **P. R. China**
South China Sea Tsunami Advisory Center(SCSTAC)





Basic Information

Tsunamis in the Past 4,000 years



Causes	Events		Casualties	
	No.	%	No.	%
Earthquakes	1636	79.7	504,655	87.6
Landslides	146	7.1	16,441	2.9
Volcanic	114	5.6	44,599	7.7
Meteorological	30	1.5	211	0.0
Unknown	127	6.2	10,215	1.8
Total	2,053	100.0	576,121	100.0

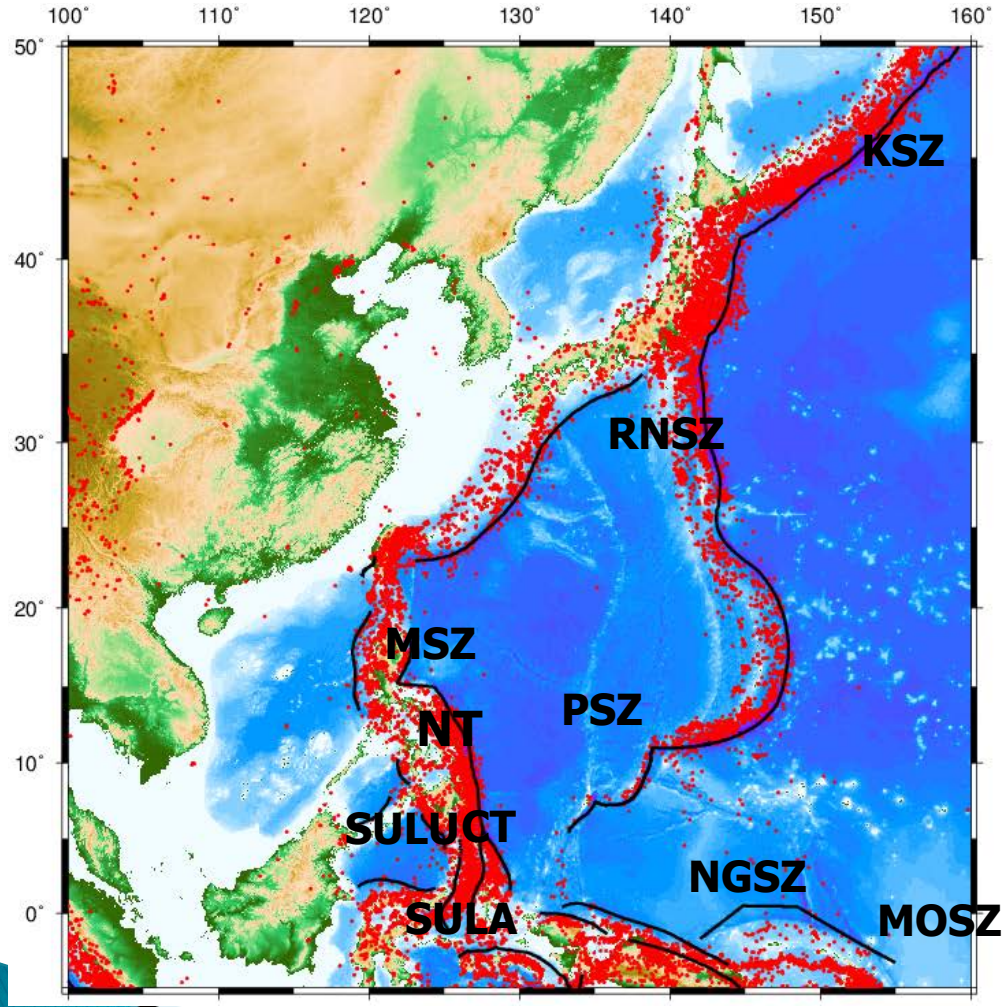
source: National Geophysical Data Center

Origin of Tsunamis by Region in the Pacific

Region	%
Japan	16.8
South America	11.1
North & Central America	8.9
Philippines & South China	7.7
New Guinea - Solomon	7.1
Indonesia	6.0
Australia, New Zealand,	5.6
Kamchatka - Kuril Islands	4.3
Alaska - Aleutian Islands	3.7
Hawaii, Johnston Atoll,	2.0

source: National Geophysical Data Center

Tsunami risk in China and Surrounding areas



- **basin–wide tsunami risk**

KSZ: Kamchatka-Kurile-Japan Sea

Izu-Bonin-Mariana Trench

NGSZ: New Guinea SZ

- **Regional and local tsunami risk**

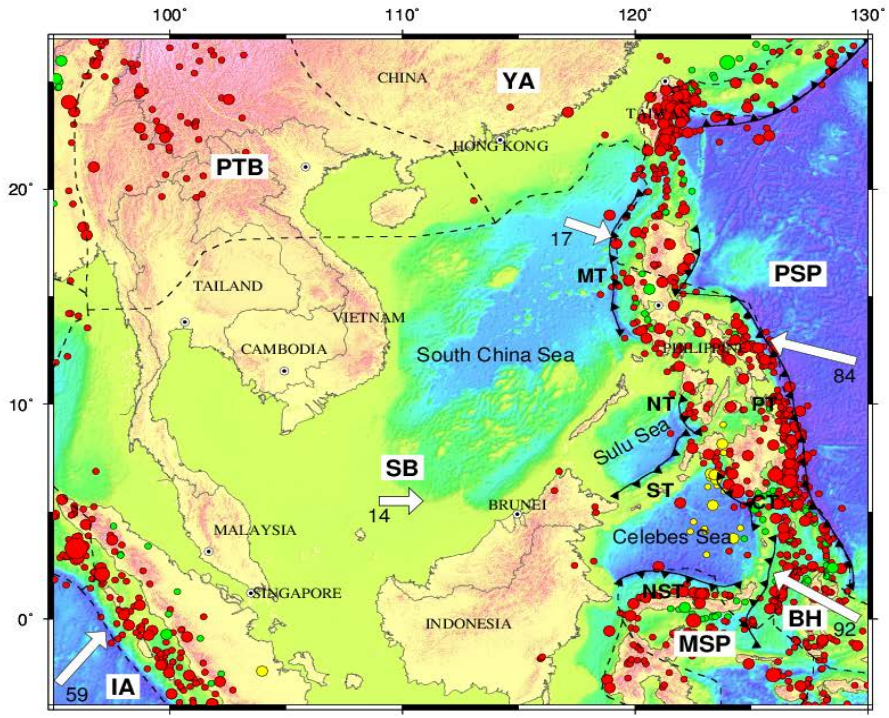
RNSZ: Ryukyu Trench SZ

TWSZ: Taiwan SZ

MSZ: Manila SZ

Negros / Cotobato / Sulawesi Trench

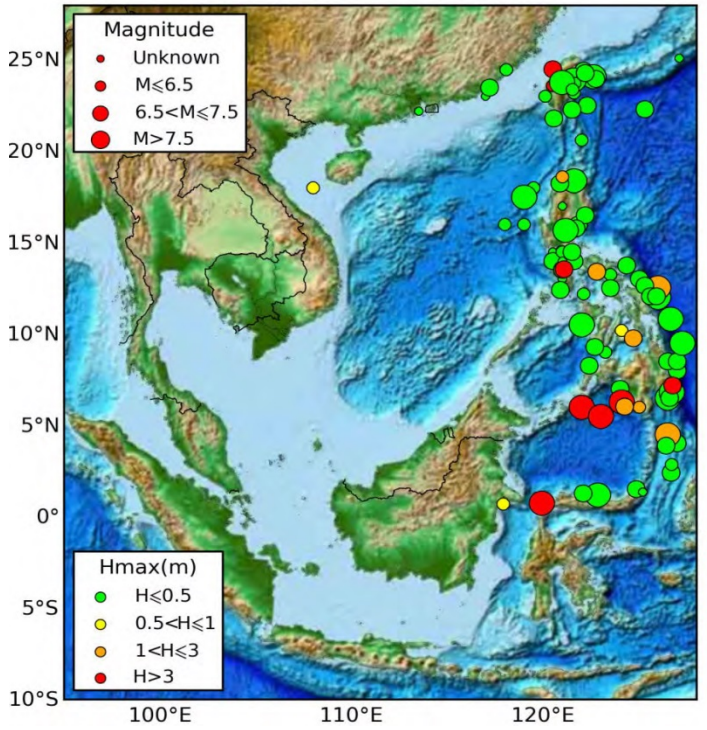
Earthquake Seismicity and Historical Tsunami in SCS Region



Tectonic Setting and Seismicity in SCS Region

MT, Manila Trench;
ST,Sulu Trench;
CT, Cotobato Trench;
NT, Negros Trench;
NST, North Sulawesi trench;
PFZ, Philippine Fault zone;
AU, Eurasia plate;
IA, Indo-Australia Plate;
PS,Philippine Sea Plate;
SB, Sunda

Since the 2004 Indian Ocean tsunami occurred, there has been a pronounced increase in the number of tsunami hazard in the South China Sea region and its adjoining basins.



Historical Tsunami in SCS Region

Development of Tsunami Warning in China

1983-2004

研究阶段

- 1983年：加入太平洋海啸预警与减灾系统政府间协调组（ITSU）
- 自主研制海啸数值模式（CTSU）和海啸传播时间模式（CTTT）

2004年印度洋海啸

2005-2010

初步能力

- 2006年：24小时业务化值班
- 2006年：开发南海定量海啸预警系统
- 2010年：南海布放海啸浮标

2011年日本海啸

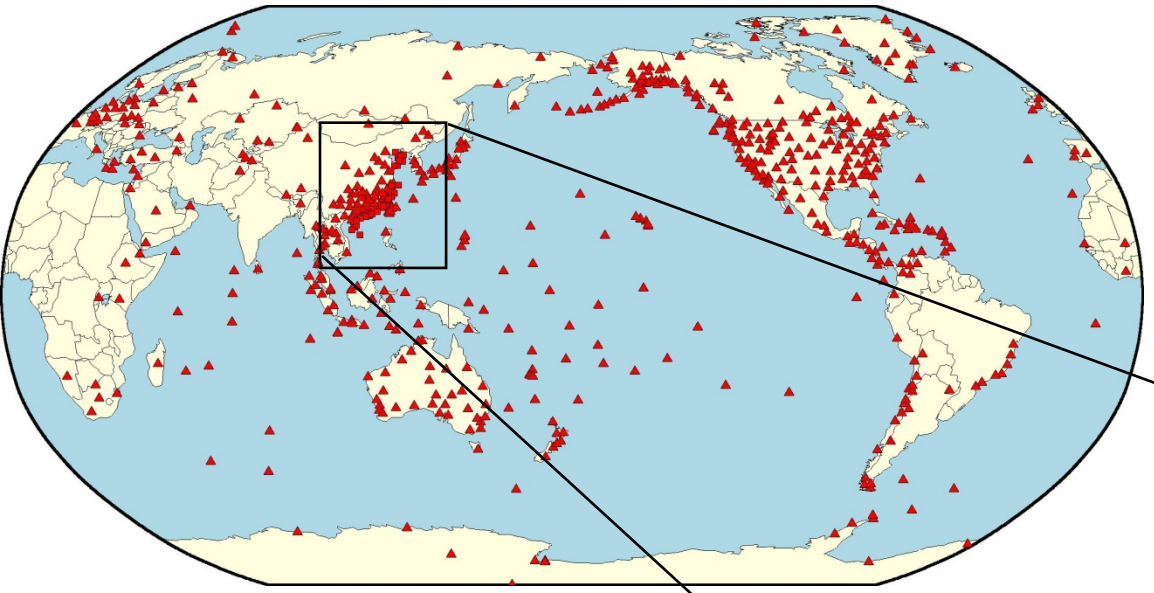
2011-2016

快速发展

- 2011年：发布我国首份海啸蓝色预警
- 2012年：财政部批复经费；开展我国沿海宽频地震台建设
- 2013年：中编办批准建立国家海洋局海啸预警中心
- 2013年：联合国教科文组织政府间海洋学委员会批准我国牵头建立南中国海区域海啸预警中心（SCSTAC）
- 2017年：联合国教科文组织政府间海洋学委员会批准南中国海区域海啸预警中心正式开展业务化试运行
- 2019年：联合国教科文组织政府间海洋学委员会批准南中国海区域海啸预警中心开始业务化正式运行

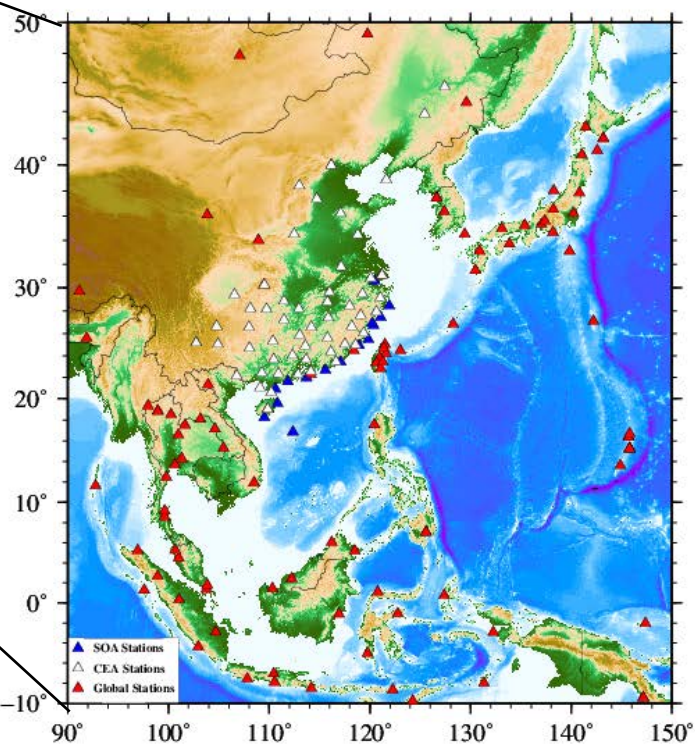
全球地震实时监测网(Global Seismic Monitoring Network)

Global Seismic Station



- Antelope
- SeisComp3
- CEA EQIM
- PTWC, USGS earthquake info.: via GTS, FAX and Email

Regional Seismic Networks



Real-time, broadband seismic waveform data from:

- **MNR(25)**
- **CEA(54)**
- **IRIS + GEOFON+GEOSCOPE (~580)**

Earthquake Analysis and detecting

SeisComp3 .&. Antelope

70 km N of Palu earthquake detecting performance

Source	Origin Time (UTC)	Lon. /°	Lat. /°	Mag.	Delay Time	Num. of Phase
SP3	2018-09-28 18:02:44	119.79	-0.20	7.5(Mwp)	3 min 22 s	9
SP3	2018-09-28 18:02:44	119.86	-0.26	7.5(Mwp)	7 min 43 s	102
Antelope	2018-09-28 18:02:44	119.83	-0.36	7.6(Mwp)	7 min 3 s	83
USGS	2018-09-28 18:02:44	119.84	-0.18	7.5(Mww)	-	100
CENC	2018-09-28 18:02:44	119.90	-0.25	7.4(M)	-	-

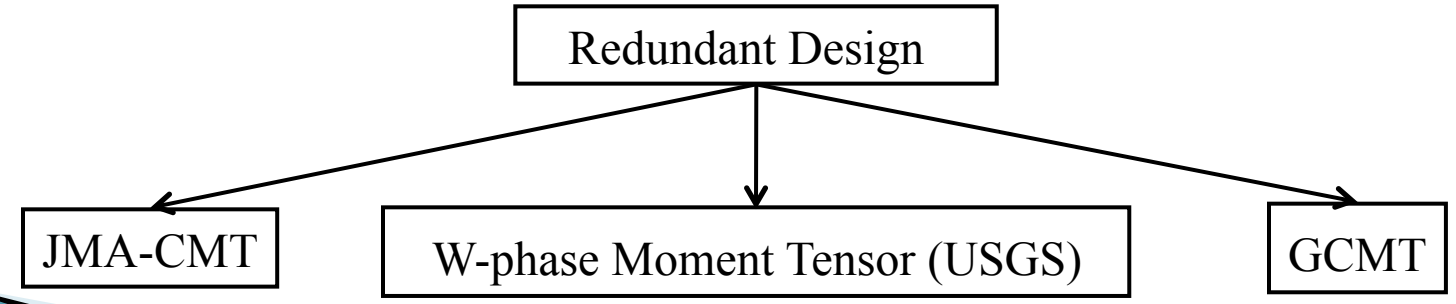
Compare with USGS's result, epicenter detecting variation scales 0.1 degrees for this event

Operational Focal Mechanism Inversion

- *Automatic focal mechanism inversion system is operationally running in NTWC*

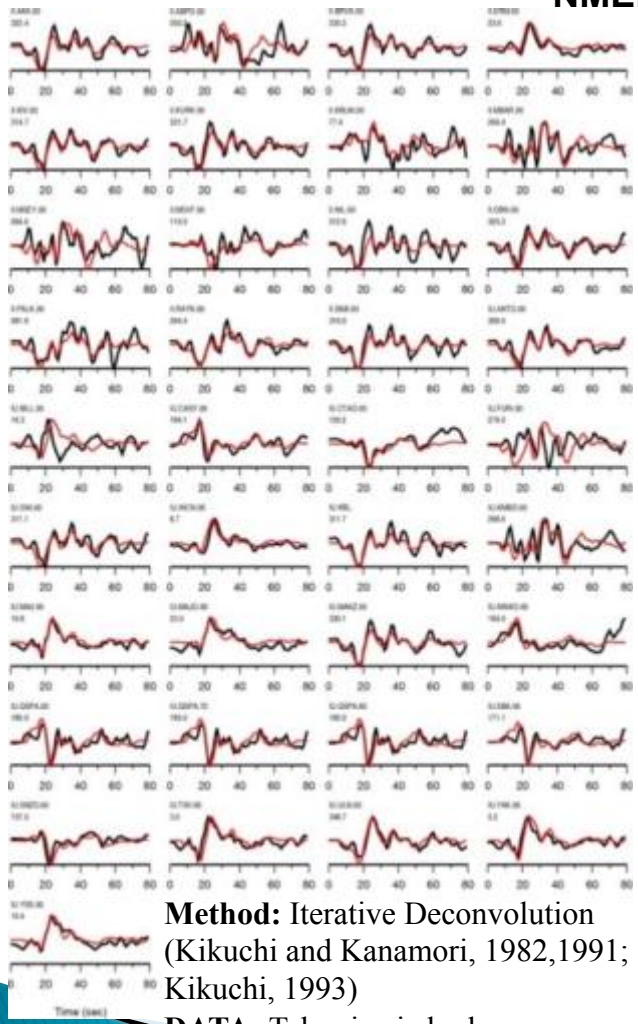
Focal mechanism of Palu earthquake with *M*w 7.5 on 28 Sep. 2018

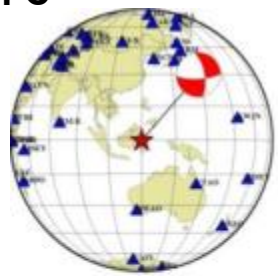
No.	Mw	Centroid location			Num of Stations	Time after earthquake (mins)	Beach ball
		Lat/°	Lon/°	Depth /km			
1	7.9	-0.8	119.0	13.5	1	6	
2	7.5	-0.5	120.1	9.5	6	11	
3	7.6	-1.3	120.1	30.5	26	15	
4	7.5	-0.6	119.9	15.5	35	19	
5	7.5	-0.6	119.9	15.5	54	22	
6	7.5	-0.6	119.9	15.5	63	26	

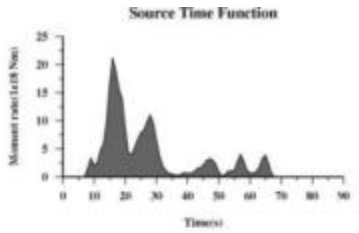


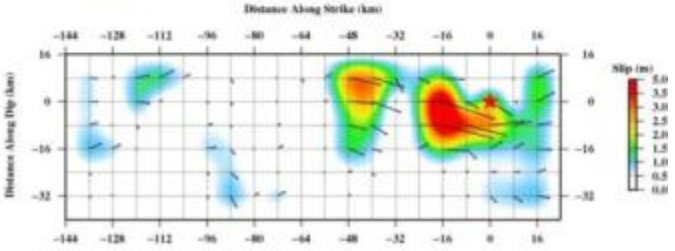
Rupture Process Research – Palu EQ. Case

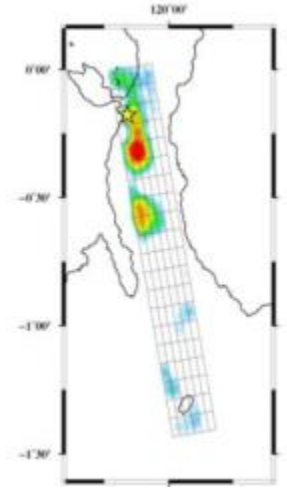
NMEFC







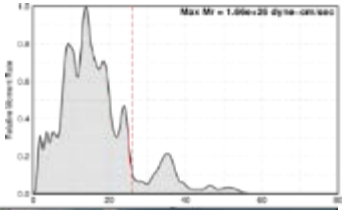


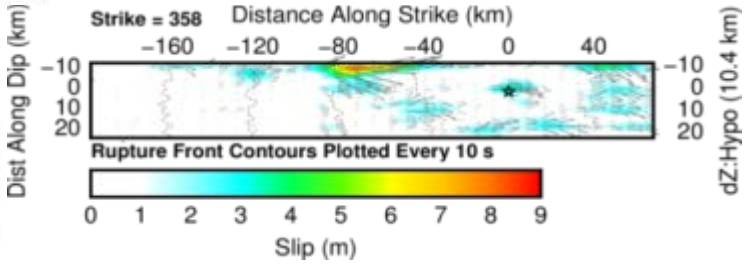


Teleseismic Inversion for Rupture Process

Event: Sep. 28, 2018 Sulawesi, Indonesia earthquake
Magnitude: Mw 7.5
Longitude: 119.84
Latitude: −0.178
Number of Stations: 38

USGS



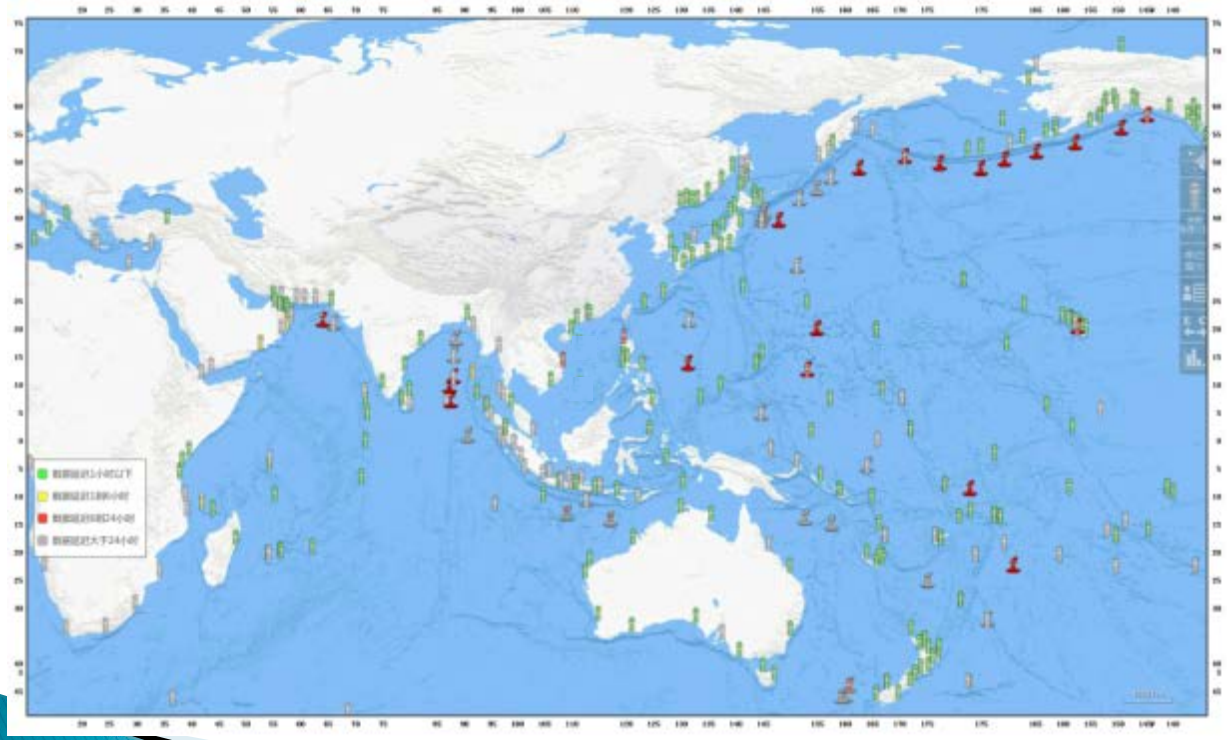


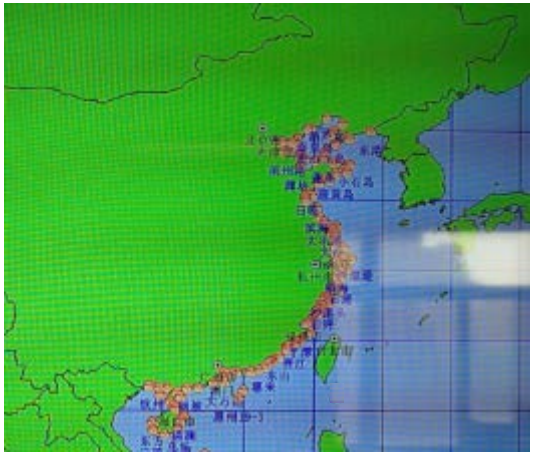
Method: Iterative Deconvolution (Kikuchi and Kanamori, 1982,1991; Kikuchi, 1993)

DATA: Teleseismic body waves

Real-time Sea Level Monitoring

- GTS and IOC sea level data
- 120 tidal gauges along the Chinese coasts via dedicated cable and VSAT
- The SCS tsunami buoy(*Offline because of vandalism*)

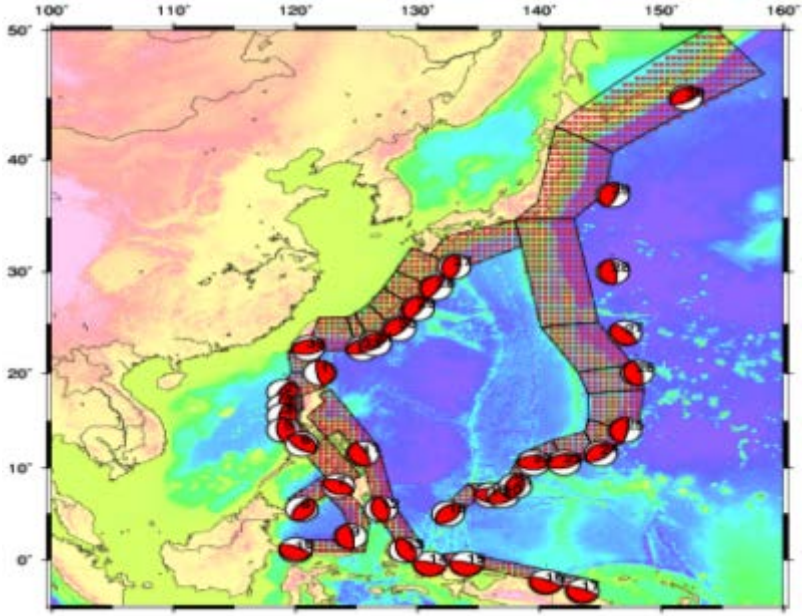




Tsunami Warning Technologies

Two Sets of Tsunami Database

NW Pacific Scenario Database



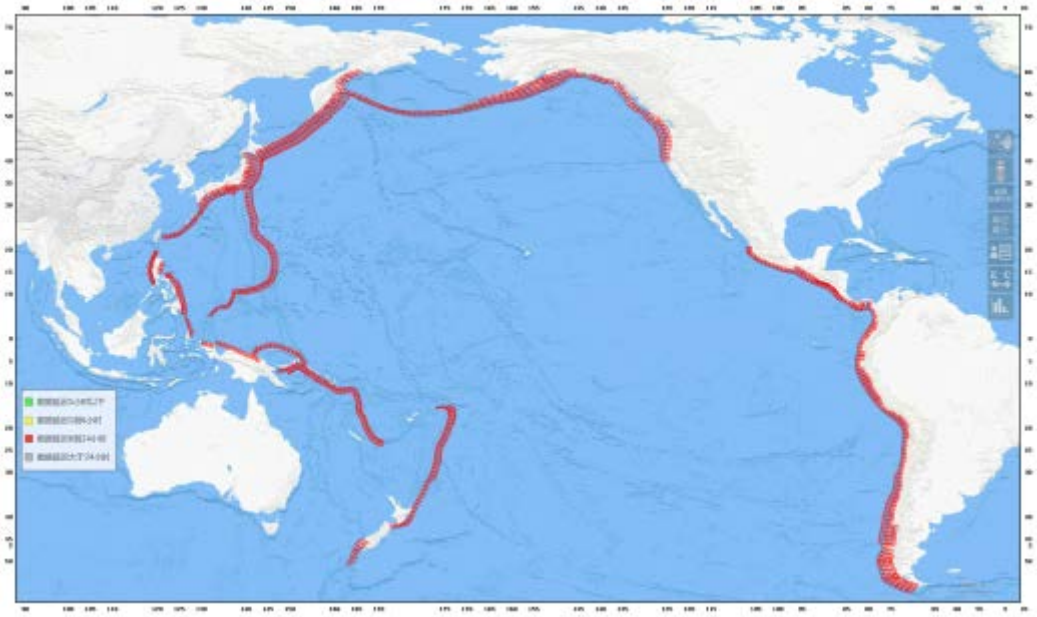
Source Coverage:

37 partitions, 1671 sources

Resolution: 0.5°×0.5°

Totally: 60,156 tsunami scenarios

Whole Pacific Unit Source Database



Source Coverage:

Length: 100 km

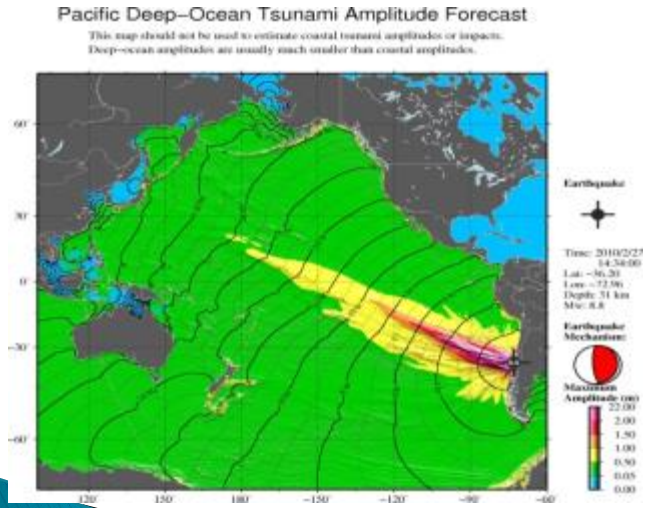
Width: 50 km

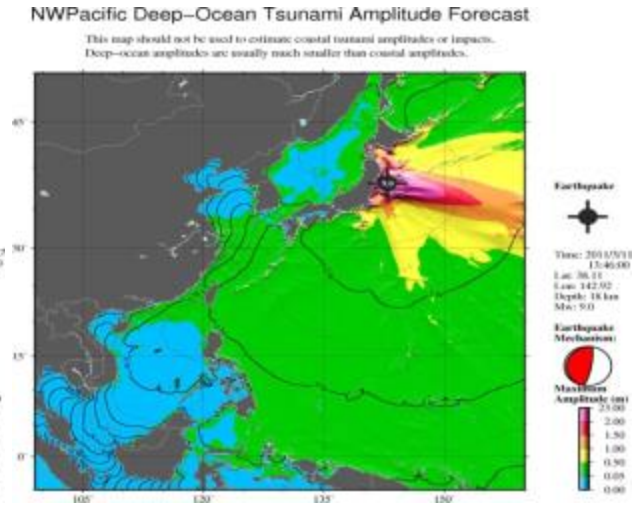
Totally: 1391 unit sources

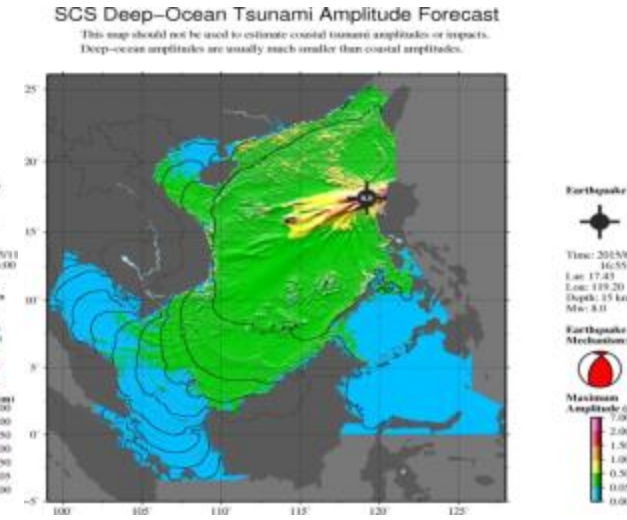
On-the-Fly Tsunami Forecast Model

Linear shallow water equation running performance on NVIDIA Tesla V100(GPU)

Forecast region	Space resolution	Forecast period (hours)	Consuming time (seconds)			Efficiency promotion	
			Series	OpenMP	**GPU**	OpenMP	**GPU**
Pacific Ocean	5 arc-min	32	6070	410	**45**	15	**135**
NW Pacific Ocean	4 arc-min	15	450	32	**4**	14	**113**
South China Sea	2 arc-min	15	467	31	**4**	15	**117**

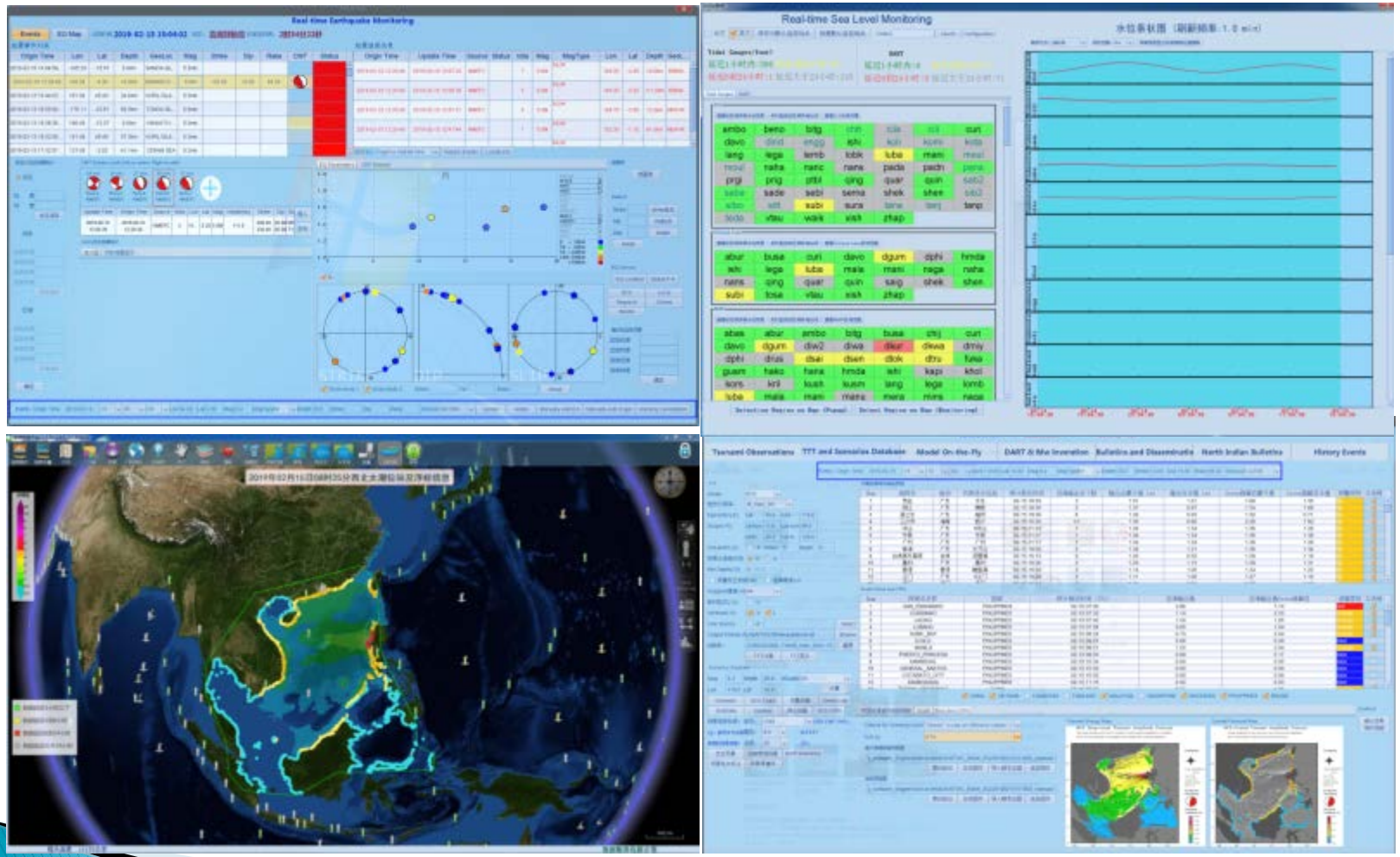






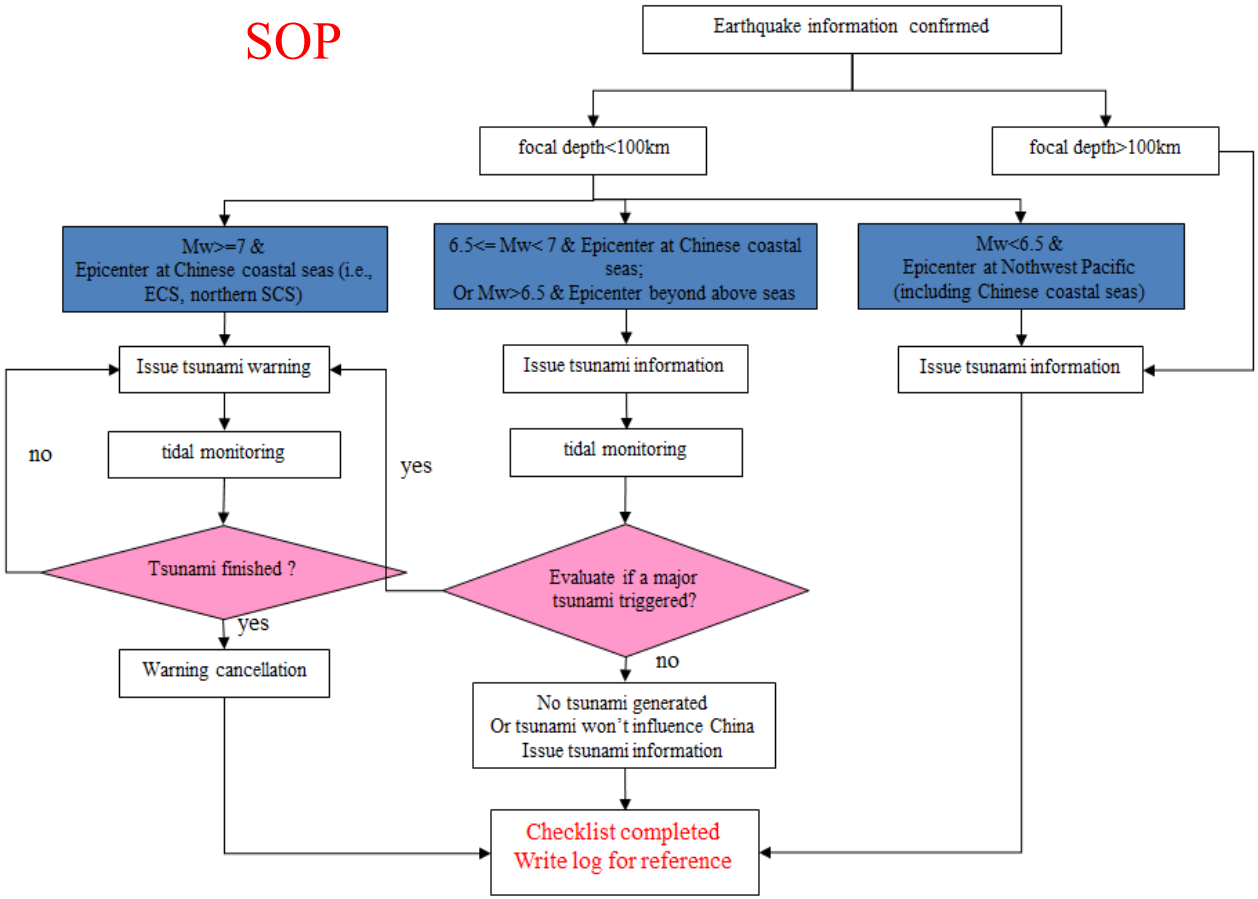
Decision Support System

An English version is being developed for international colleagues



Tsunami Warning Procedure and Criteria

SOP

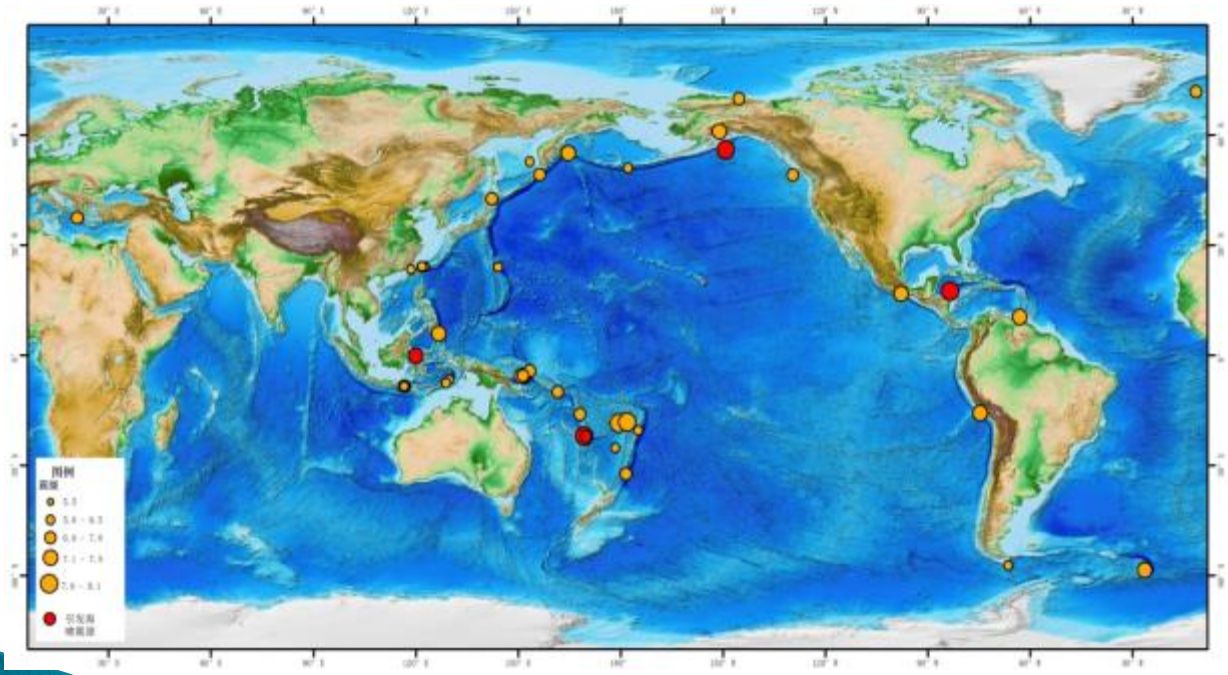


Tsunami warnings are classified as three levels:

- Red (Max. tsunami wave amplitude >= 300cm), corresponding to 'especially severe disaster possibly causing a number of casualties and huge economical losses'
- Orange (Amp. max>= 100cm), 'possibility of severe damage'
- Yellow (Amp. max>= 30cm) , 'watch out for potential danger near the coastline'

Major Earthquake and Tsunami in 2018

- Responded to 47 major Earthquakes with magnitude greater than 6.5
- 83 tsunami information bulletins issued to relevant agencies and stakeholders
- with average latency of 9 mins for the first message
  .VS. 11 mins in 2017

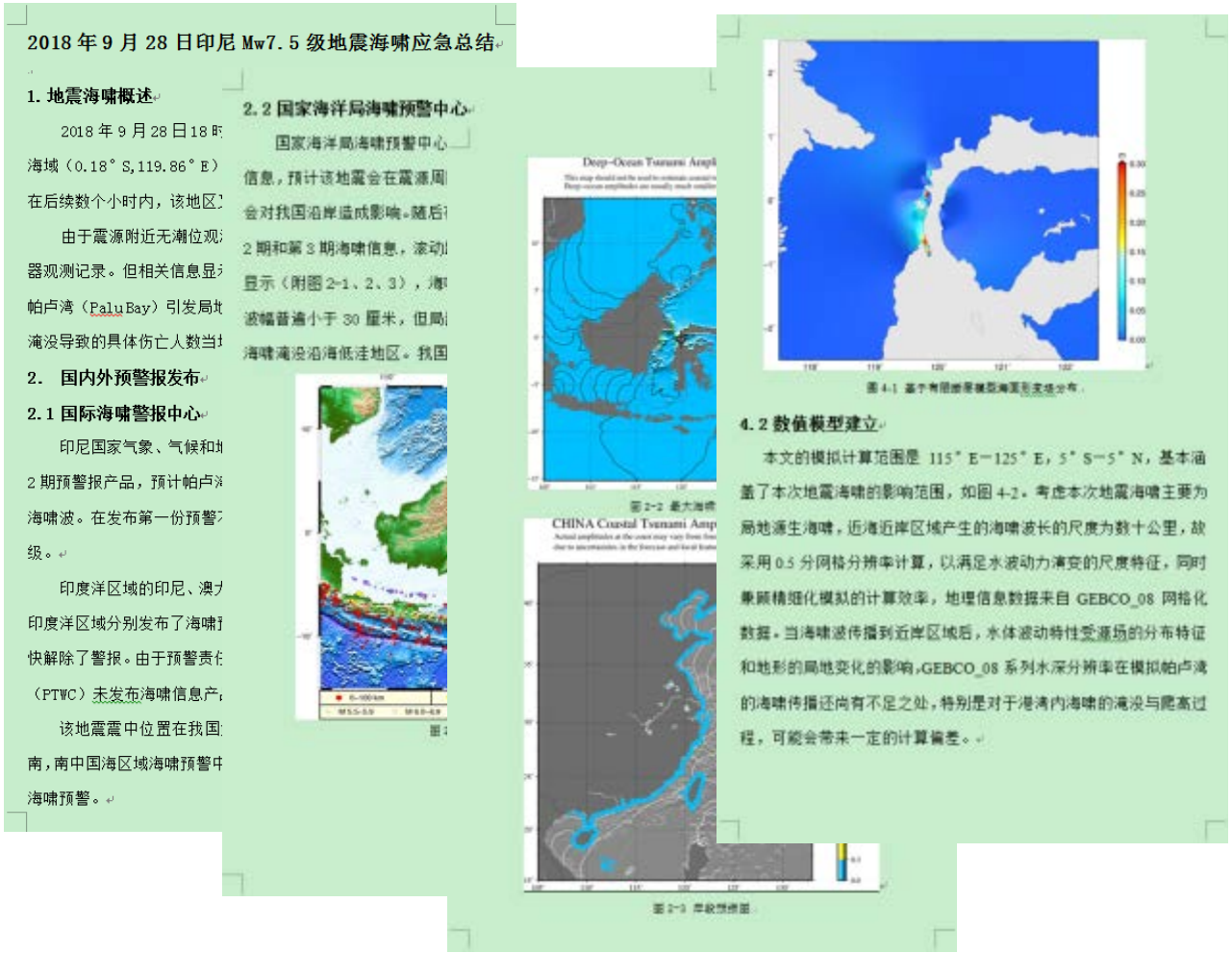


Time （BJT	Location	Mag.	Max. Observed Amp.
10:51 10 Jun.	North of Honduras	7.6	19 cm
17:31 23 Jun.	Alaska Bay	7.9	21 cm
11:5 29 Aug.	Southeast of Loyalty Is.	6.9	22 cm
18:02 28 Sep.	Minaharsha peninsula	7.5	~600 cm
12:18 5 Dec.	Southeast of Loyalty Is.	7.6	72 cm
22 Dec.	Sunda Straits	--	120 cm

Summary Report for major tsunami events

- Earthquake info.
- Tsunami observations
- Casualties and loss
- Focal mechanism
- Rupture process
- Tsunami modeling
- History tsunami
- Lessons learned

Report on Palu Tsunami on 28 Sept. 2018



2018 年 9 月 28 日印尼 Mw7.5 级地震海啸应急总结

1. 地震海啸概述

2018 年 9 月 28 日 18 时

海域（0.18° S,119.86° E）

在后续数个小时内，该地区

由于震源附近无潮位观

器观测记录。但相关信息显

帕卢湾（Palu Bay）引发局地

淹没导致的具体伤亡人数当

2. 国内外预警报发布

2.1 国际海啸警报中心

印尼国家气象、气候和地

2 期预警报产品，预计帕卢湾

海啸波。在发布第一份预警

级。

印度洋区域的印尼、澳大

印度洋区域分别发布了海啸

快解除了警报。由于预警责任

（PTWC）未发布海啸信息产

该地震震中位置在我国

南，南中国海区域海啸预警中

海啸预警。

2.2 国家海洋局海啸预警中心

国家海洋局海啸预警中心

信息，预计该地震会在震源周

会对我国沿岸造成影响。随后

2 期和第 3 期海啸信息，滚动

显示（附图 2-1、2、3），海

波幅普遍小于 30 厘米，但局

海啸淹没沿海低洼地区。我国

Deep-Ocean Tsunami Ampl

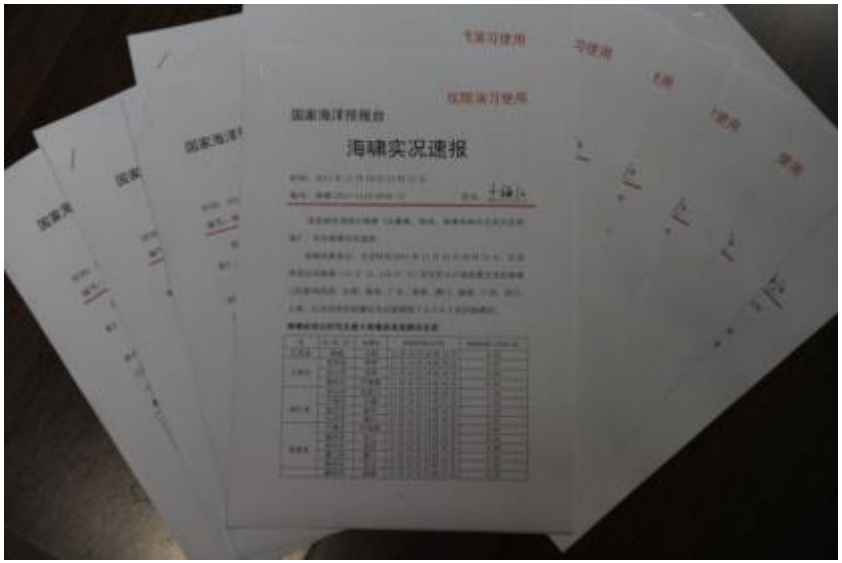
CHINA Coastal Tsunami Amp

4.2 数值模型建立

本文的模拟计算范围是 115° E－125° E，5° S－5° N，基本涵盖了本次地震海啸的影响范围，如图 4-2。考虑本次地震海啸主要为局地源生海啸，近海近岸区域产生的海啸波长的尺度为数十公里，故采用 0.5 分网格分辨率计算，以满足水波动力演变的尺度特征，同时兼顾精细化模拟的计算效率，地理信息数据来自 GEBCO_08 网格化数据。当海啸波传播到近岸区域后，水体波动特性受源场的分布特征和地形的局地变化的影响，GEBCO_08 系列水深分辨率在模拟帕卢湾的海啸传播还尚有不足之处，特别是对于港湾内海啸的淹没与爬高过程，可能会带来一定的计算偏差。

Wide Coverage of Dissemination

Dissemination is automated as much as possible to facilitate the widely-covering issuance of tsunami messages effectively and efficiently.



Dissemination channel includes:

FAX: 

Email: 

Broadcast and TV: 

Website: 

SMS/APP : 

Social media:

weibo

快报

一点资讯

腾讯新闻 事实派

头条 今日头条

網易新闻 有态度的新闻门户

Website of NTWC

Limited access:

- **Public User**
  - Bulletins
  - Historical messages
  - Education materials

Full access:

- **TER**
- **Related stakeholders**
  - + Focal mechanism
  - + Rupture process
  - + Sea level data

UNESCO/IOC SCSTAC Website

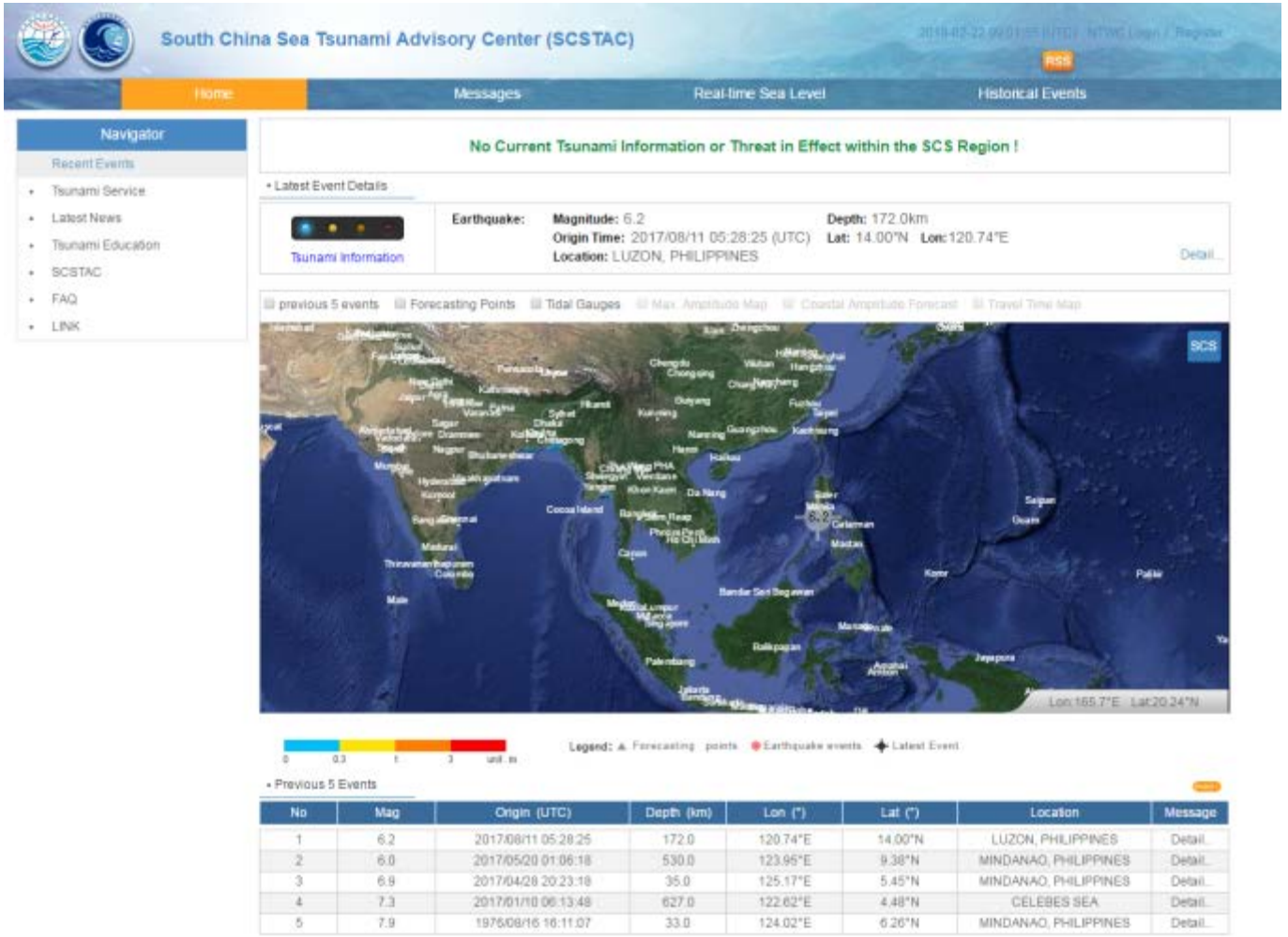
http://www.scstac.org

Limited Access:

- **Public User**
  - Text products
  - Historical bulletins

Full Access:

- **NTWC/**
- **FPs/**
- **Other TSPs**
  - + Graphic products
  - + Focal mechanism
  - + Sea level data



No	Mag	Origin (UTC)	Depth (km)	Lon (°)	Lat (°)	Location	Message
1	6.2	2017/08/11 05:28:25	172.0	120.74°E	14.00°N	LUZON, PHILIPPINES	Detail
2	6.0	2017/05/20 01:06:18	530.0	123.95°E	9.38°N	MINDANAO, PHILIPPINES	Detail
3	6.9	2017/04/28 20:23:18	35.0	125.17°E	5.45°N	MINDANAO, PHILIPPINES	Detail
4	7.3	2017/01/10 06:13:48	627.0	122.62°E	4.48°N	CELEBES SEA	Detail
5	7.9	1976/08/16 16:11:07	33.0	124.02°E	6.26°N	MINDANAO, PHILIPPINES	Detail

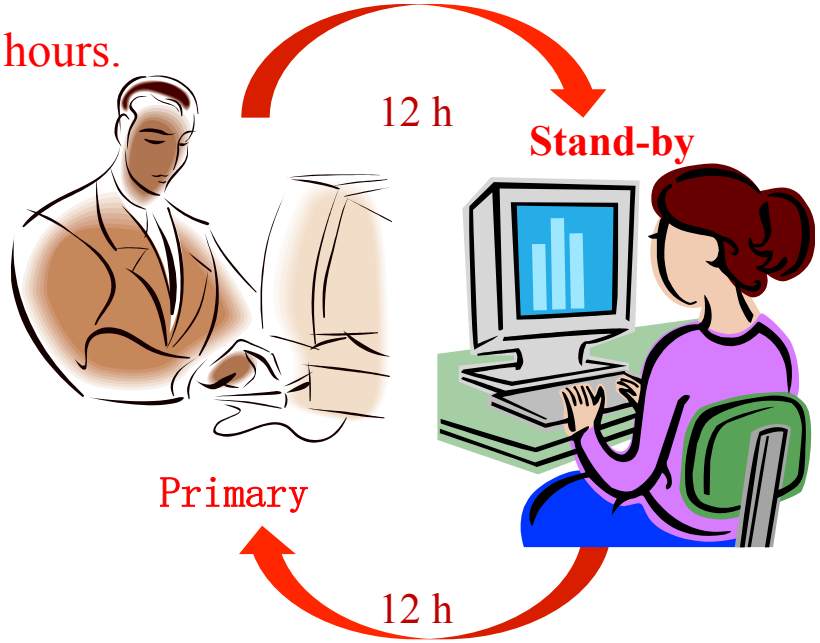
On-duty Shift

Before 26 Jan. 2018

One watch-stander was on duty in 24 hours, which was just responsible for national tsunami warning.

From 26 Jan. 2018 to now

Since the trial operation of SCSTAC, two watch-standers are on duty all the time in one day with shift time of 12 hours.



International Cooperation and Activities

The 7th Meeting of the ICG/PTWS Regional Working Group on Tsunami Warning and Mitigation System in the South China Sea Region, 6-8 March 2018, Hanoi, Veitnam

http://www.ioc-tsunami.org/index.php?option=com_oe&task=viewEventRecord&eventID=2208

Opening of South China Sea Tsunami Advisory Centre

8 May 2018, Beijing, China

https://en.unesco.org/news/ouverture-centre-consultatif-tsunamis-region-mer-chine-meridionale

Regional Training on “Strengthening Standard Operating Procedures for Tsunami Warning and the use of the ICG/PTWS SCSTAC Tsunami Advisory Products”, 8–11 May 2018, Beijing, China

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Thank you