

해양 재해재난 연구소개

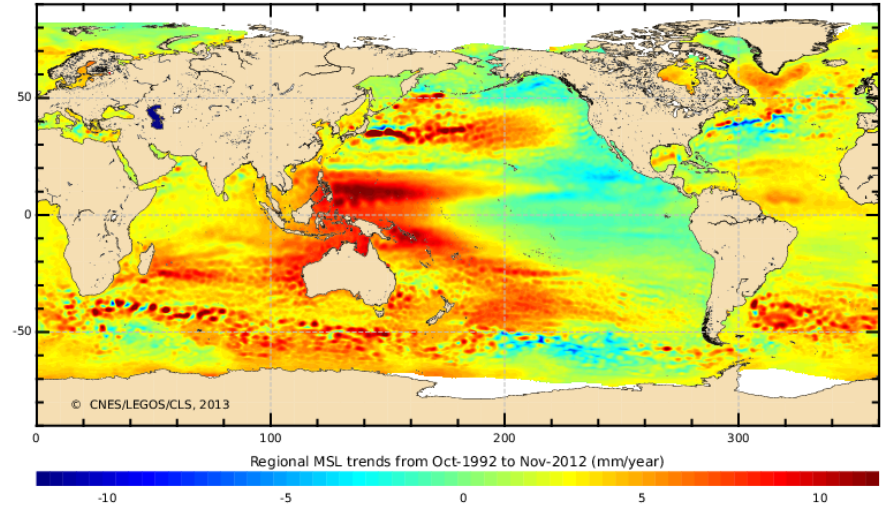
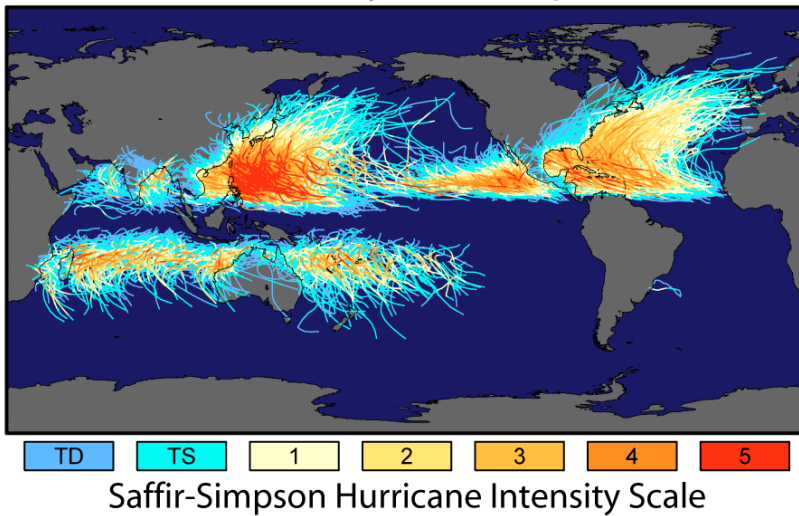
2017. 10



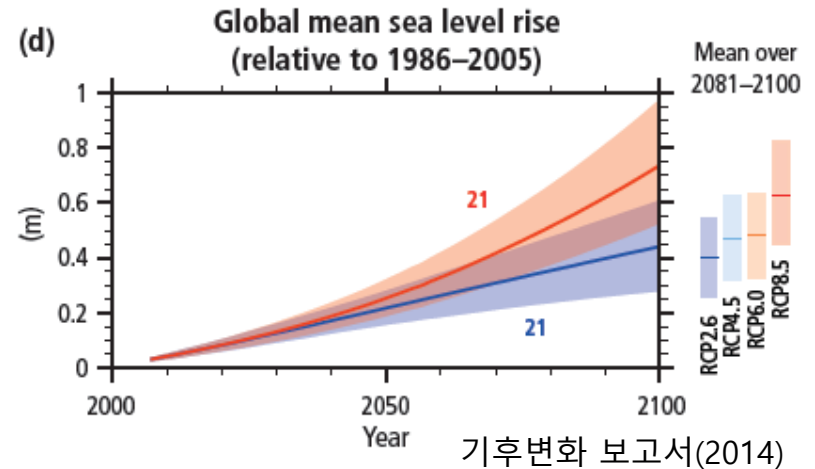
서승남

기후변화와 자연재해

Tracks and Intensity of All Tropical Storms



- 해수면 상승율 0.3cm/년
- 태풍의 강도 증가
- 기후변화 예측의 불확실성 존재
- 국내 자연재해 피해와 복구비
 - 최근 10년 피해 3580억원/년
 - 복구비는 피해액 2배 (태풍 2919억원/년)



기후변화 영향과 연안범람

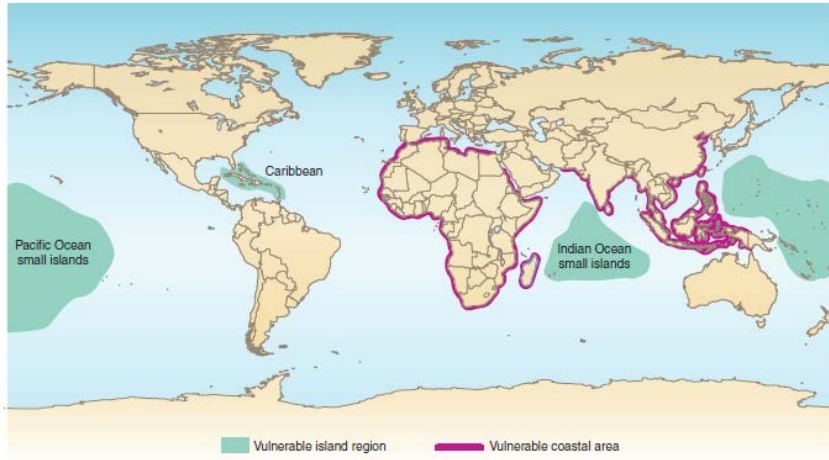
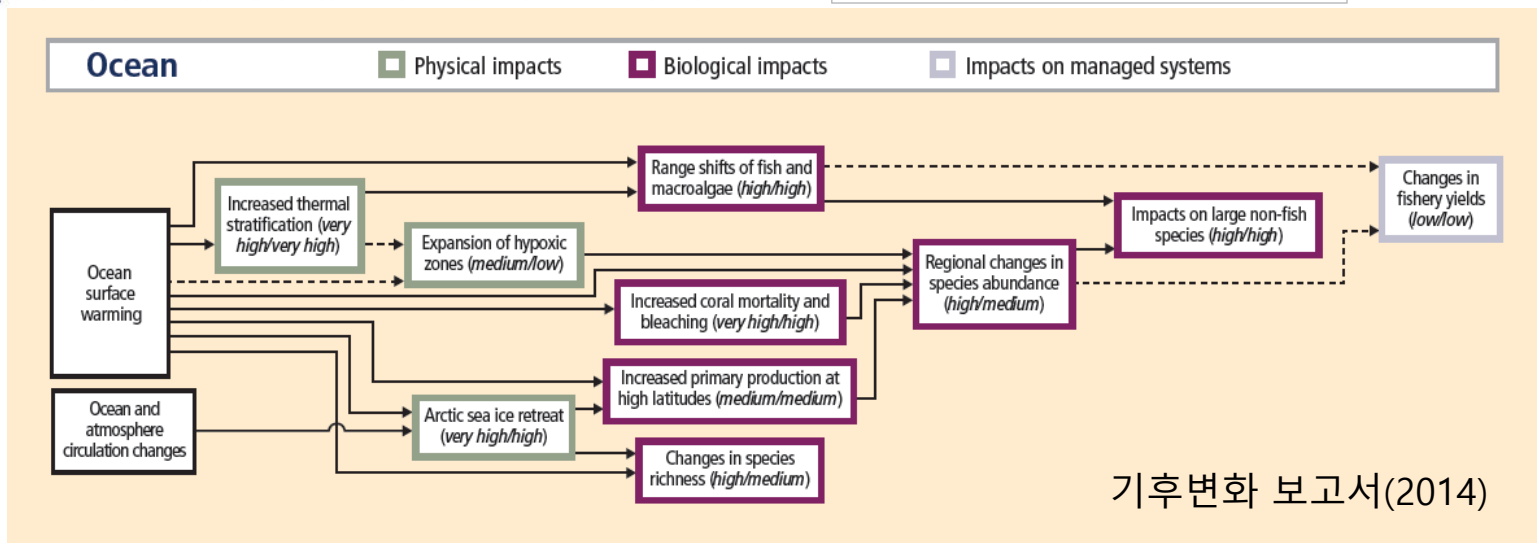
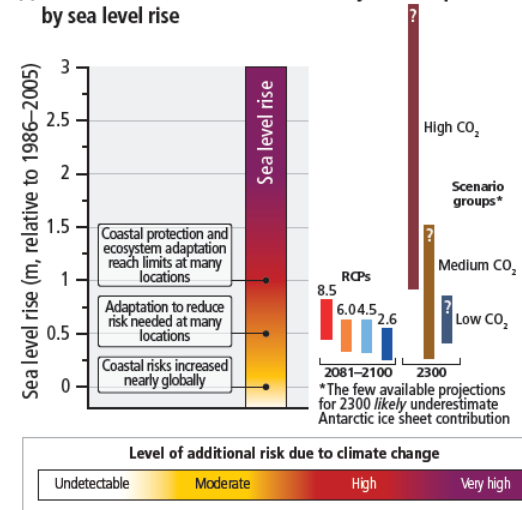


Fig. 3. Several regions are vulnerable to coastal flooding caused by future relative or climate-induced sea-level rise. At highest risk are coastal zones with dense populations, low elevations, appreciable rates of subsidence, and/or inadequate adaptive capacity.

(c) Risk for coastal human and natural systems impacted by sea level rise



우리나라 해양 재해와 재난

(2003.9) 태풍 매미 피해 - 부산, 마산



- 태풍 모의시 정밀격자 파랑 예측

월파, 이상고파



- 이상고파 및 이안류와 같은 연안이상현상의 원인 규명

허베이 스피리트호 유류유출 사고



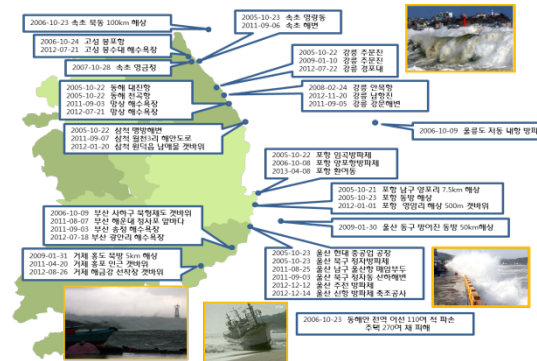
- 해로를 통한 원유 수입 시 발생할 수 있는 유류유출에 대한 확산예측 기술 개발

(2012.9) 태풍 산바 피해 - 여수, 마산



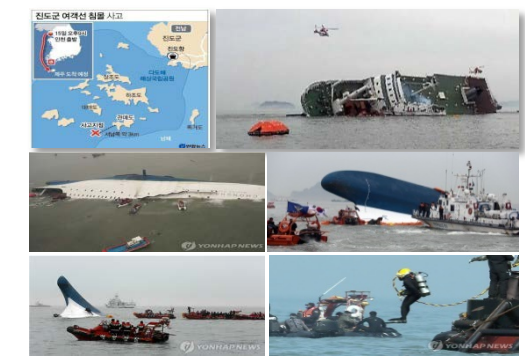
- 태풍 모의시 정밀격자 폭풍해일 예측

이상고파 발생현황



- 연안이상현상 재해저감을 위한 실용적인 예측 및 대응기술 개발

여객선 세월호 침몰사고

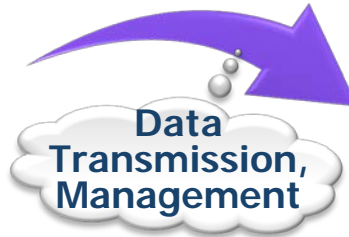


- 해난 사고 발생시 수색구조에 필요한 표류예측 정보 제공

운용해양예보시스템 구축

KOOS (Korea Operational Oceanographic System)

Real-time ocean observing System



Numerical Modeling

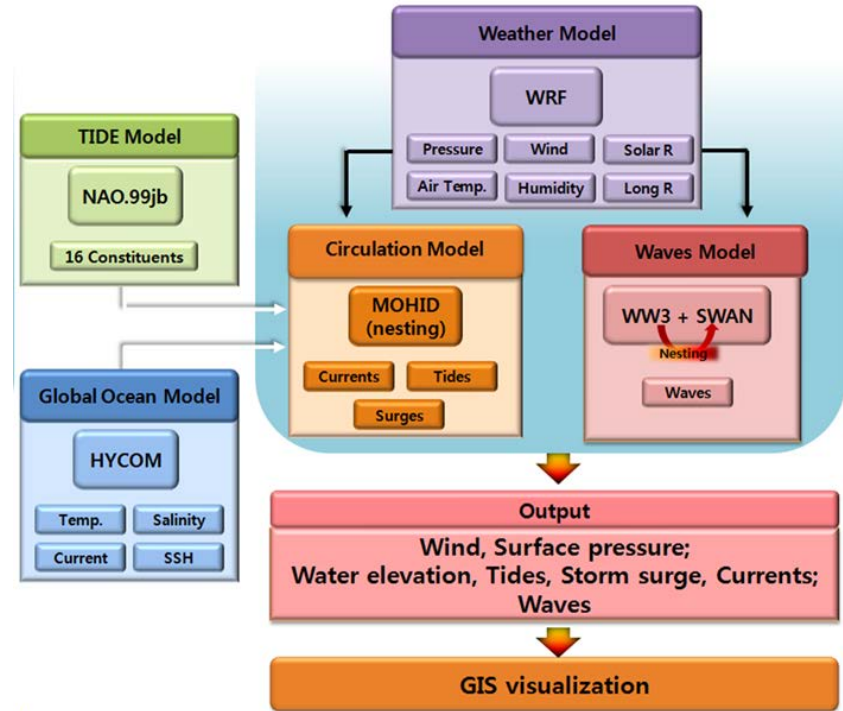
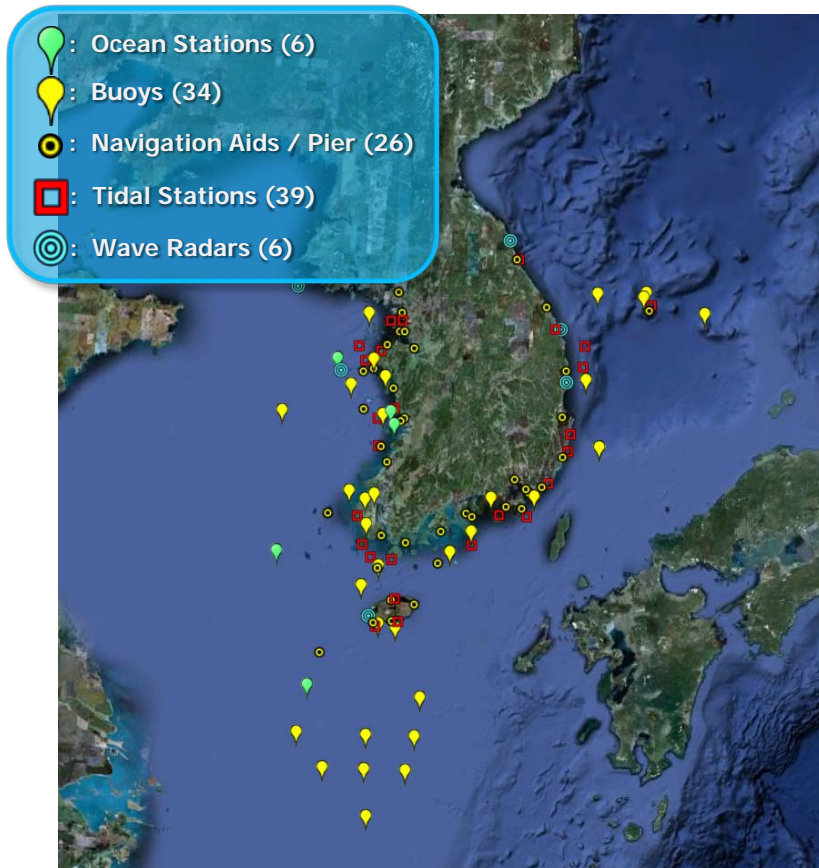


1단계 ('09.08 ~ '13.06)	2단계 ('13.10 ~ '19.04)
<ul style="list-style-type: none"> 기본요소예측시스템 개발, 구축 활용예보 시스템 개발, 구축 	<ul style="list-style-type: none"> KOOS 개선, 성능향상 시스템의 고도화(정확도 향상) 기술이전, 현업화

KOOS 연구개발 추진체계



Data & Numerical models in KOOS



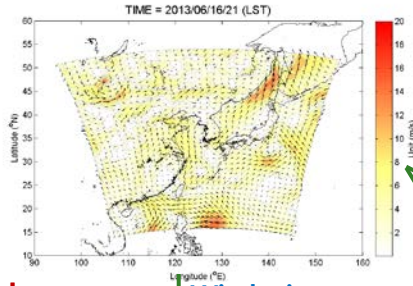
- Started from August 2009
- To provide both real-time and forecasting ocean information

KOOS (Korea Operational Oceanographic System)

Basic Forecast

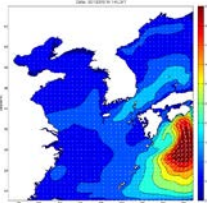
Wind, air Pressure, etc.

Atmospheric forecast

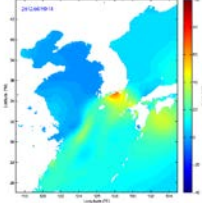


Sea surface state forecast

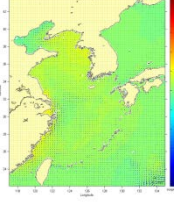
Wind, air pressure, etc.



Wave

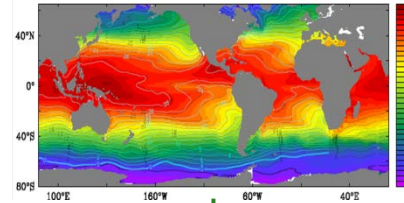


Storm surge



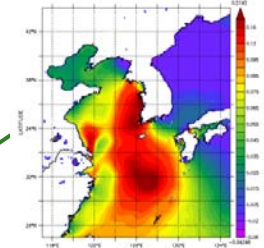
Wind-driven current

3D Ocean forecast (T, S, u, v, n)

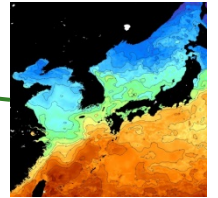


Global ocean circulation

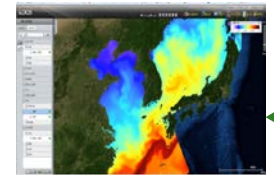
Data Information System



Satellite SST

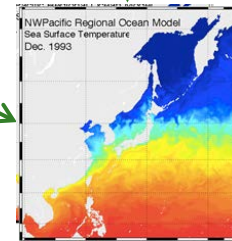


Web GIS

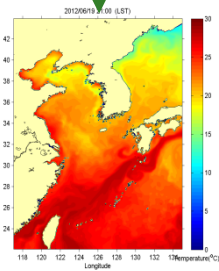


Observation & Forecast data

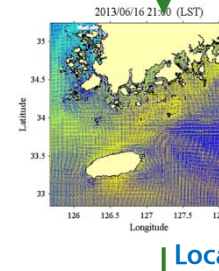
Wind, air pressure, etc.



Ocean circulation in Northwest Pacific



Regional ocean circulation



Local circulation

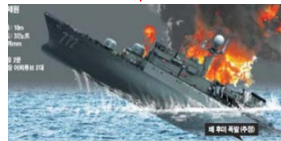
Applied Forecast



Oil Spills



Red tides



Search and Rescue



Coastal disaster prediction



Flooding/Inundation



Storm waves



Korean PORTS

Leisure Tourism etc.

국가 해양 재해재난 대응기술

연구목표 : 국가 해양 재해재난 방지를 위한 실시간 해양환경 관측과 예측정보 산출

연구기간 : 2015 - 2017 (3년)

연구비 : 2,870 백만원

세부연구목표

해양환경요소 통합지원 기술개발

- 실시간 통합해양환경 정보시스템 개발
- 고해상도 예측시스템 구축
- 유출유 및 표류체이동 예측시스템 개발
- 해난사고 지원 시스템 구축

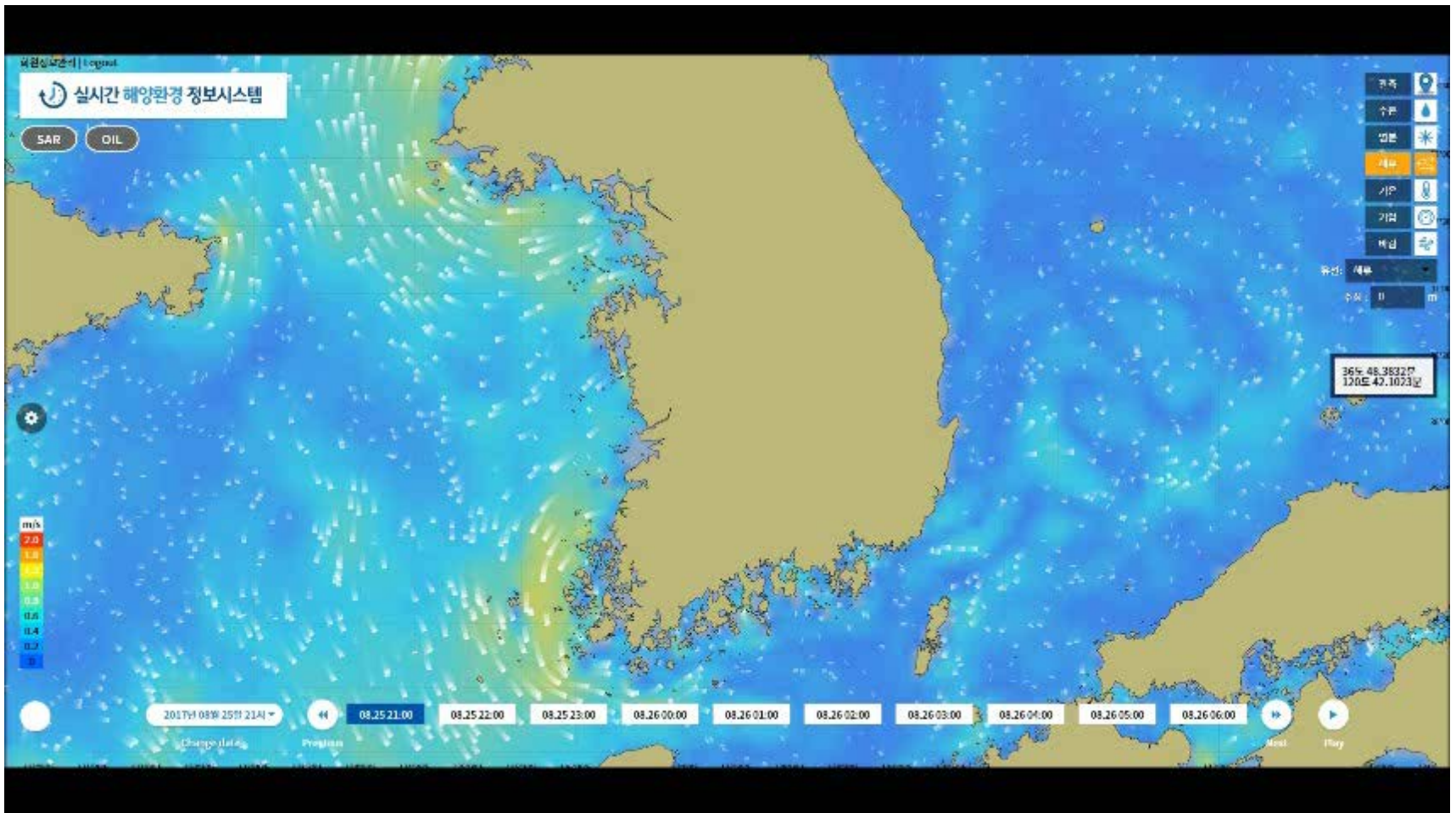
연안항만의 파랑 및 폭풍해일 재해위험도 분석평가 기술개발

- 연안 및 항만 재해요소 정밀예측 기술개발
- 재해요소 장기예측 및 극치분석
- 재해 위험도 분석시스템 개발

극한환경 극복 대응기술 개발

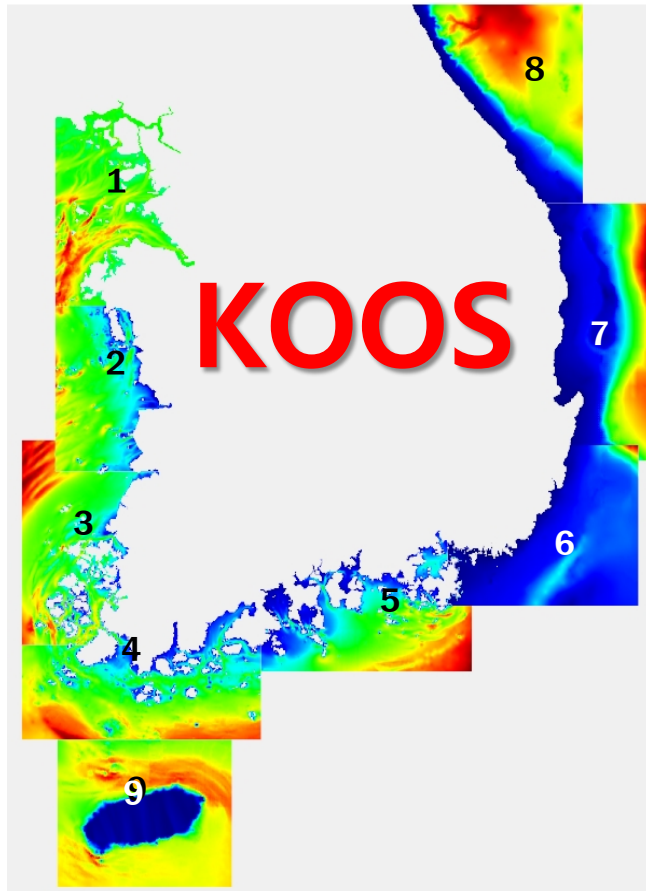
- 수중 생존자 탐지형 청음 시스템 개발
- 신속 설치형 부유식 파랑저감 구조물 설계기술 개발

실시간 통합해양환경 정보제공 시스템

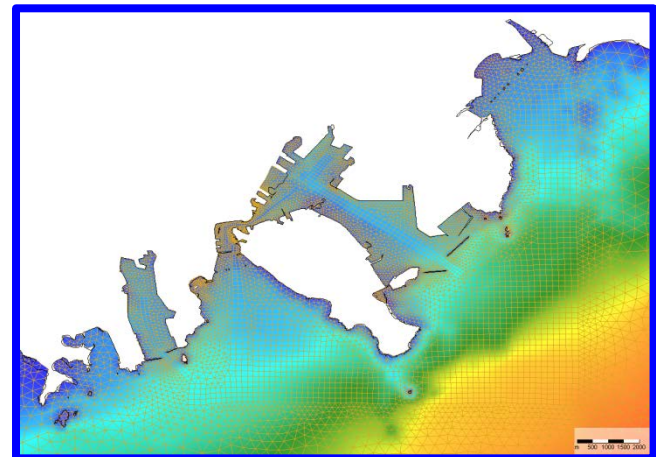
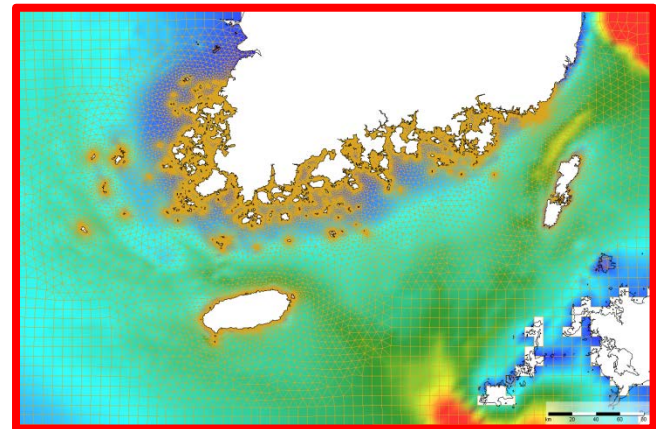


고해상도 예측시스템

- 최신 해수유동모델(Delft 3D)
- 가변 격자망 체계(Flexible Mesh)



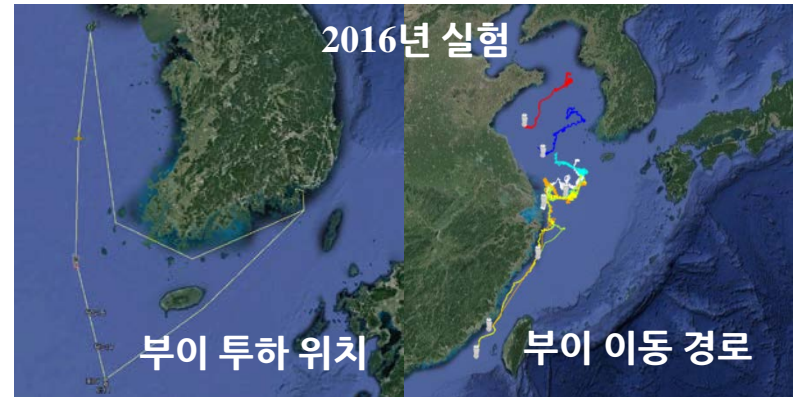
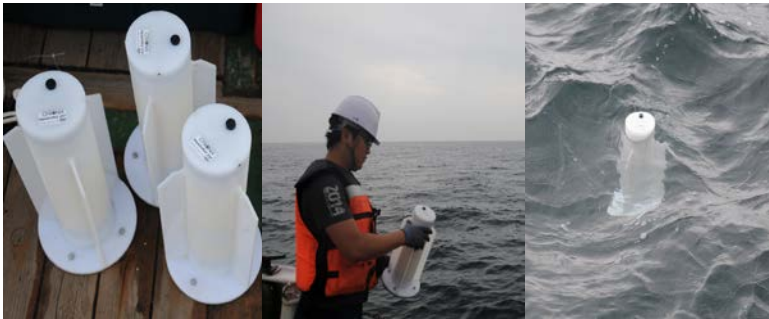
FM



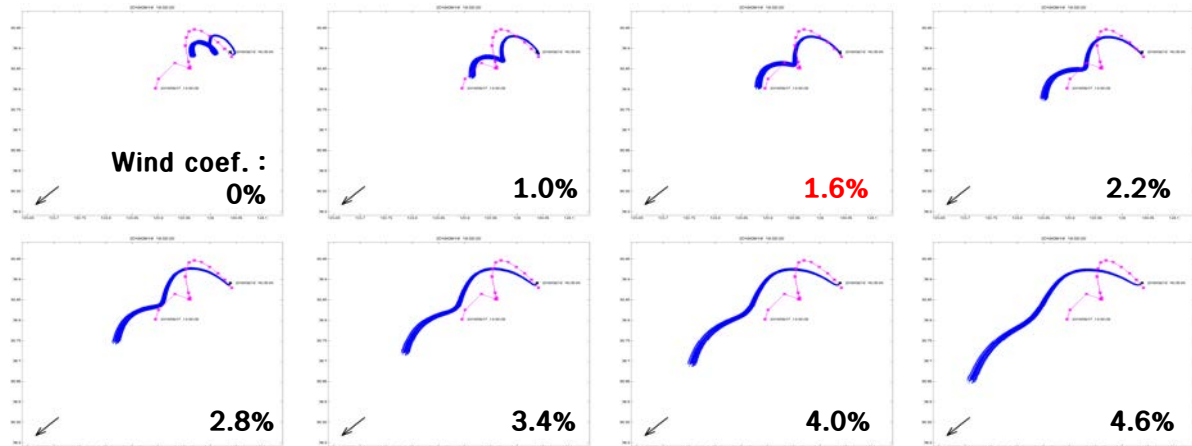
유류/표류체 이동예측 시스템

표류부이 사양

- 크기 : Ø214mm x 높이 400mm, 무게 : 4kg (웨이트 포함)
- 배터리 팩 용량 : 7.5VDC 12.5Ah (Alkaline D Size 5EA)
- 이리듬을 이용한 통신

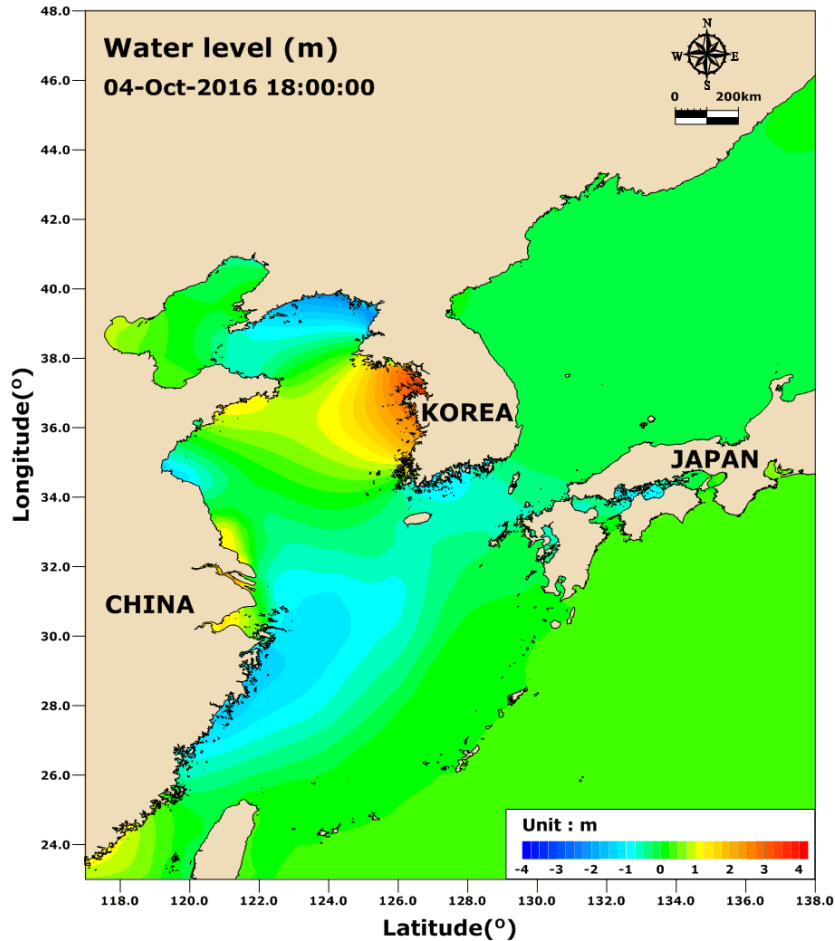


수치모형실험 계수조정



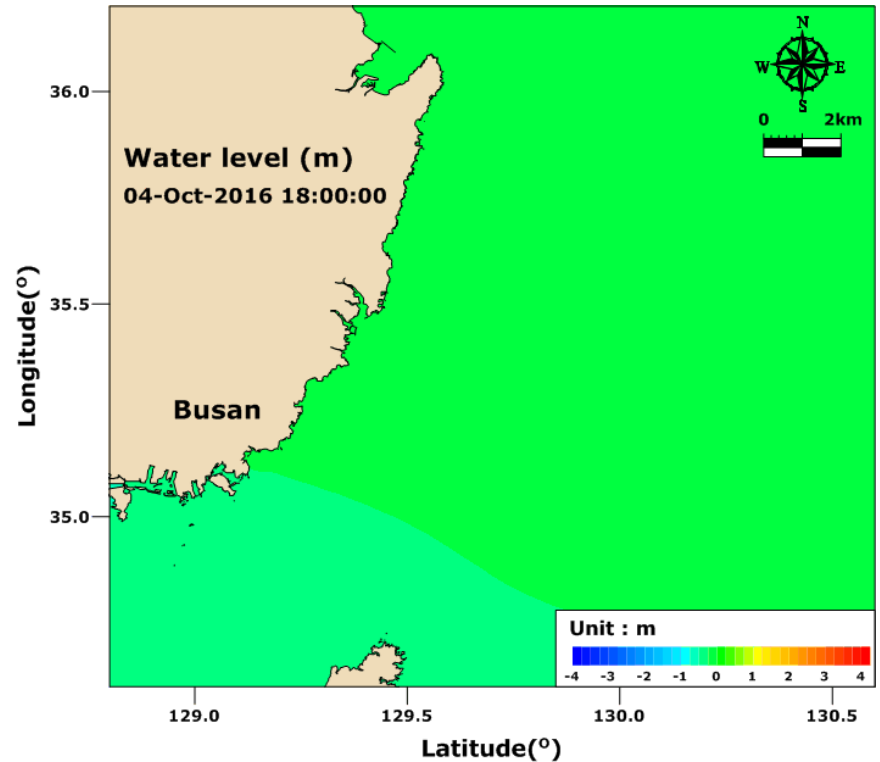
폭풍해일 정밀예측 기술 - 조석예측

모델 조석결과 - 태풍 차바



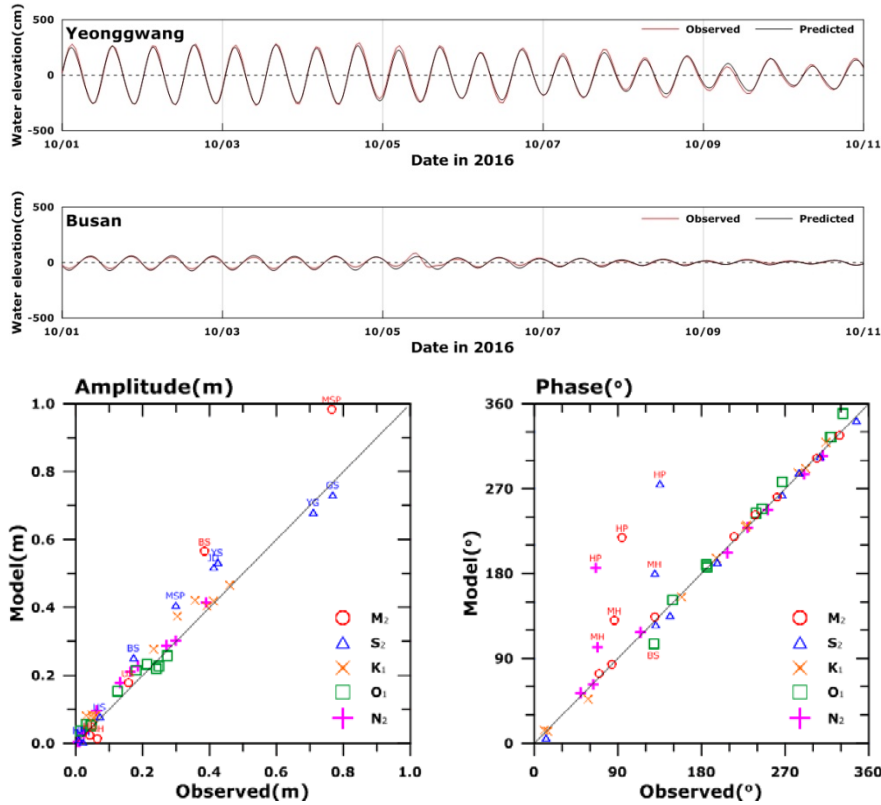
※ Tidal range

West coast > South coast > East coast

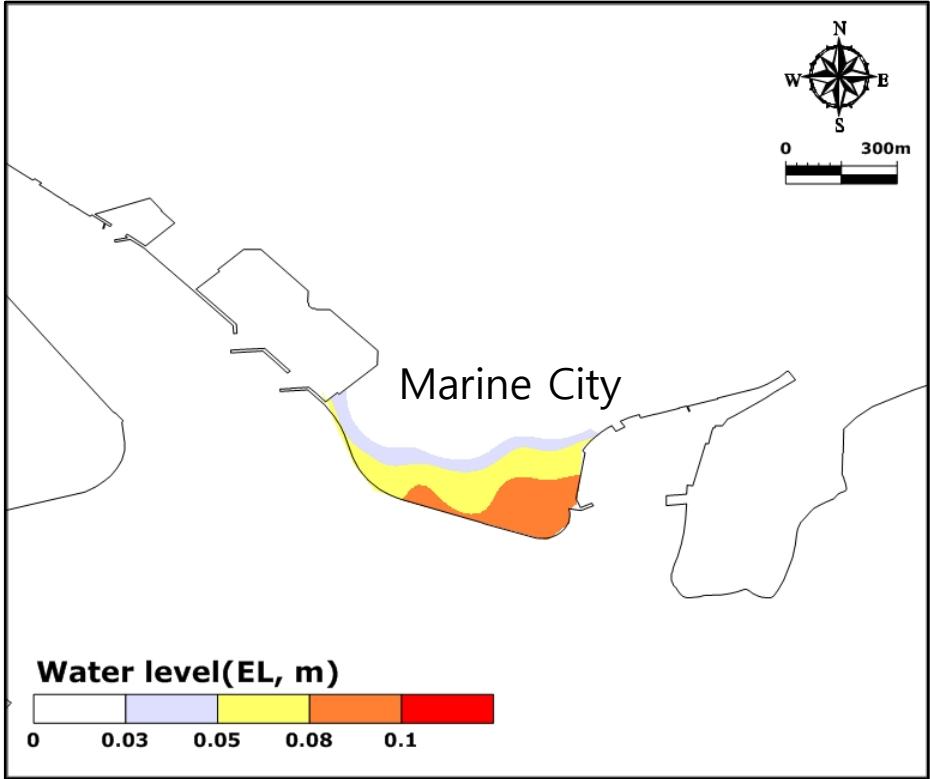


폭풍해일 정밀예측 기술 - 조석검증

조위 검증

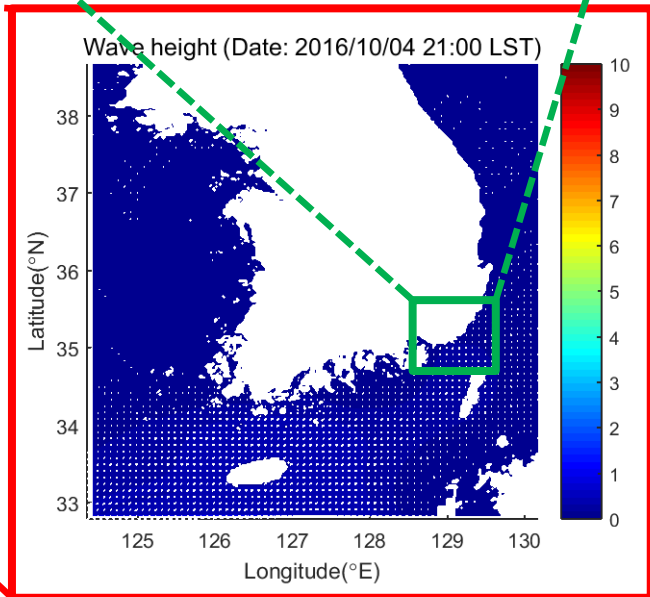
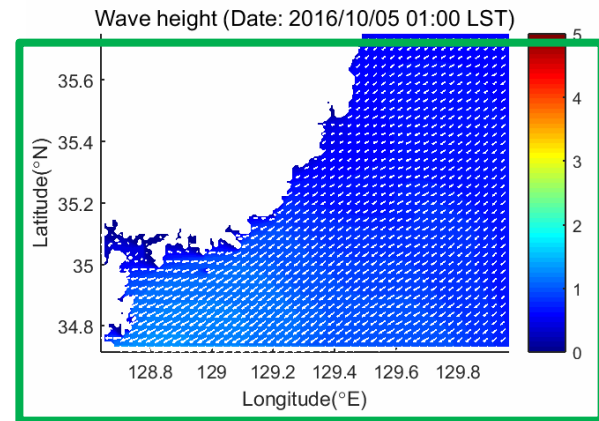
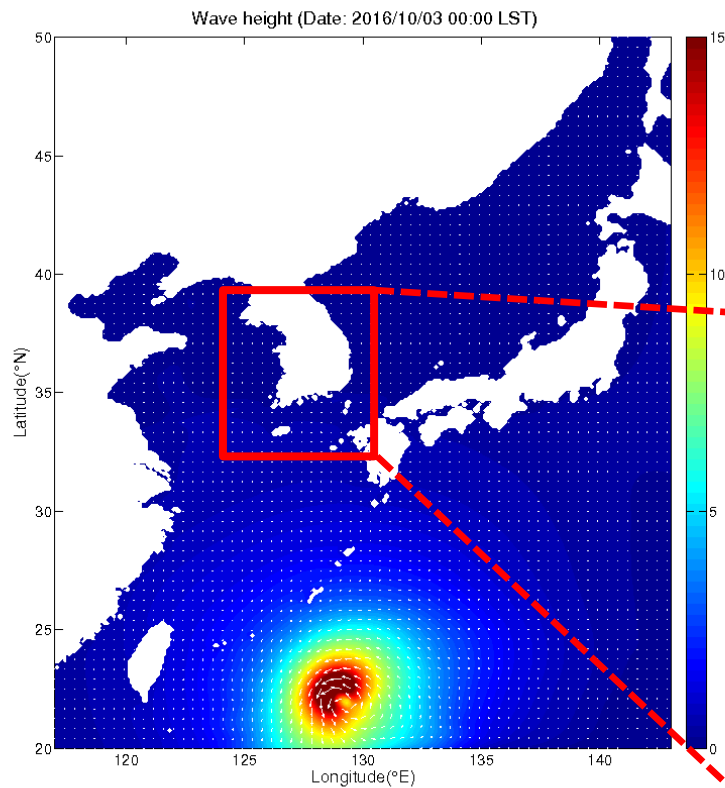


범람 결과

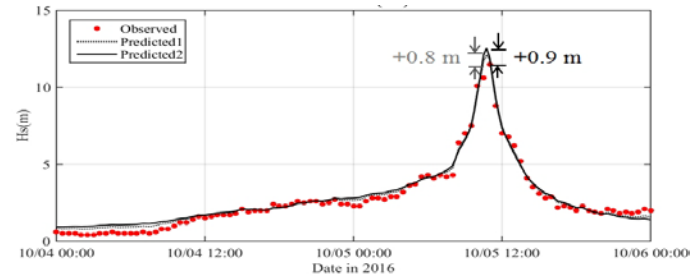
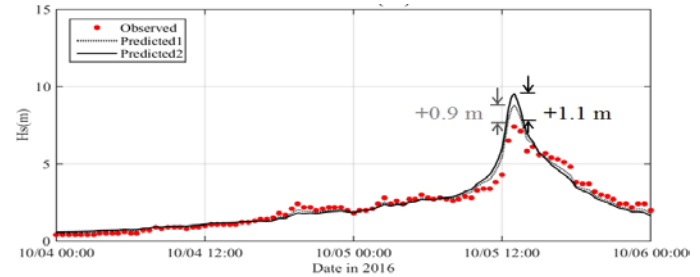


파랑 정밀예측 기술 – Open coast

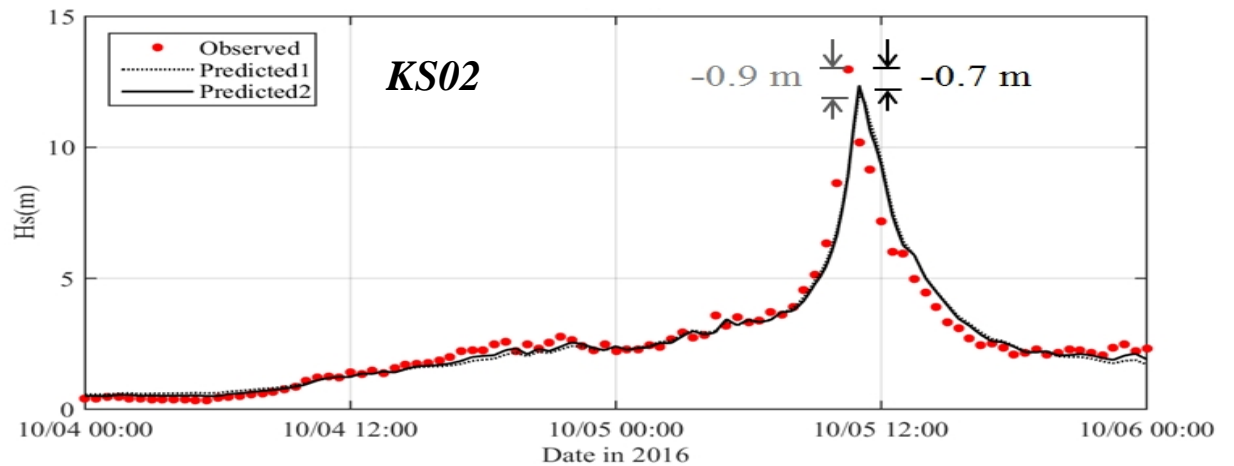
WRF, Typhoon Parameter model & SWAN model – *Typhoon Chaba*



파랑 정밀예측 기술 - 대수심 해역 검증



Solid line:
with current



파랑 정밀예측 기술 - 처오름 계산

※ Simple formula for wave run-up on structures

$$R_{u2\%} / H_s = a \xi_m \quad \text{for } 1.0 < \xi_m \leq 1.5$$

$$R_{u2\%} / H_s = b \xi_m^c \quad \text{for } \xi_m > 1.5$$

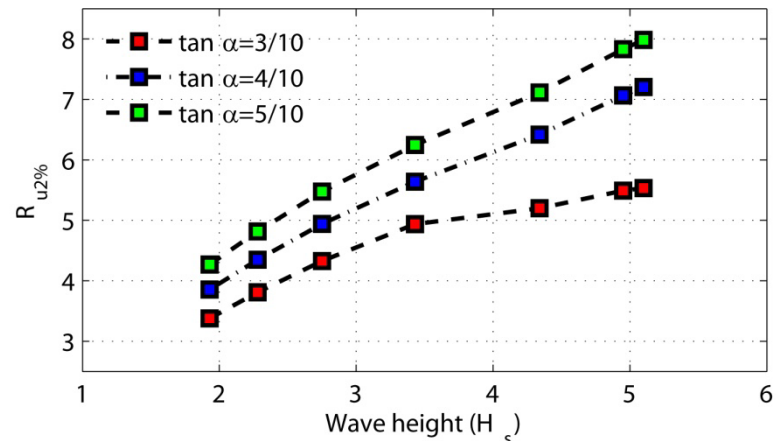
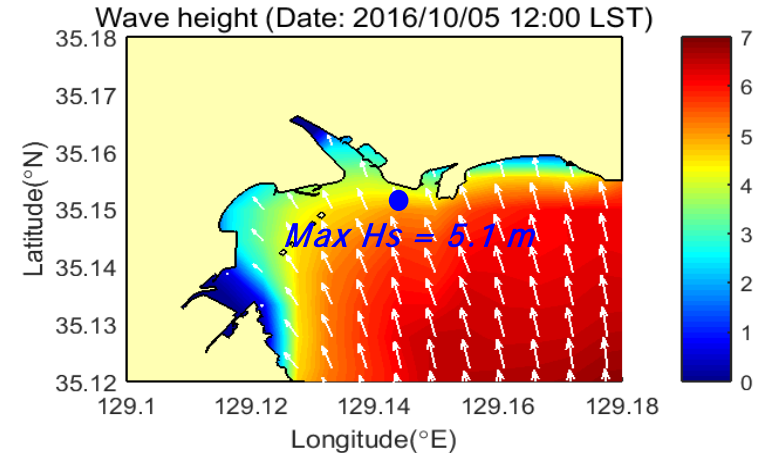
$$R_{u2\%} / H_s = d \quad : \text{Permeable}$$

$R_{u2\%}$: 2% run-up level above the still water line

$$\xi_m = \frac{\tan \alpha}{\sqrt{2\pi H_s / g T_m^2}}, \quad T_m : \text{mean wave period}$$

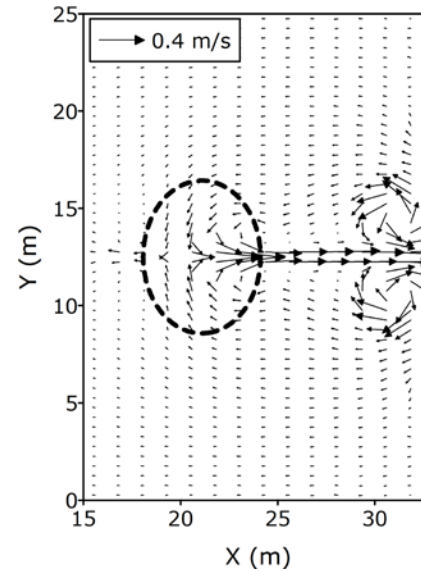
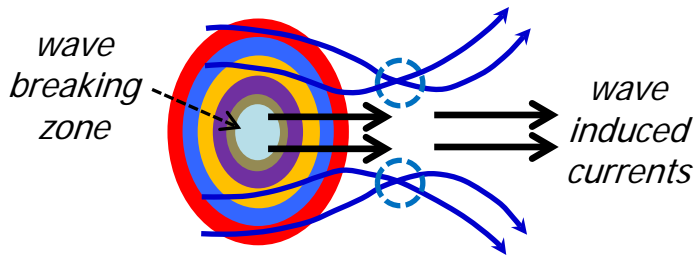
($a=0.96$, $b=1.17$, $c=0.46$, $d=1.97$)

- Delft Hydraulics (1989)



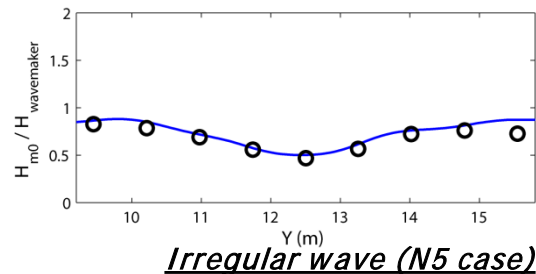
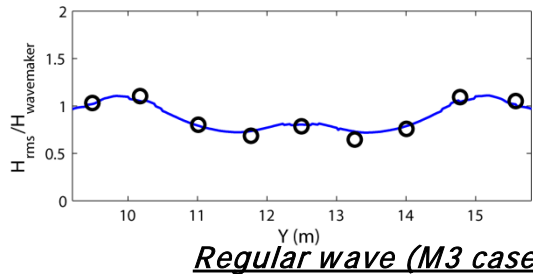
비선형 천해파랑 정밀예측 기술 - 검증

천퇴 수리모형실험
(Vincent and Briggs, 1989)



- 시간 평균한 (81.9s~118.3s) 계산 파랑류
- FUNWAVE-TVD 모델 오류수정

FUNWAVE-TVD 모델 결과비교(쇄파 경우)

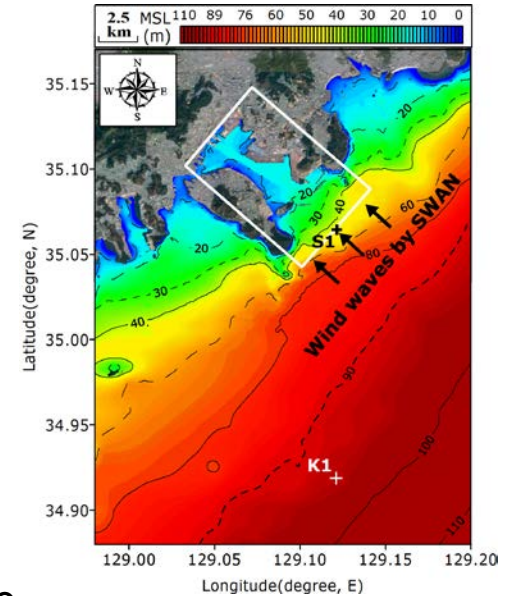
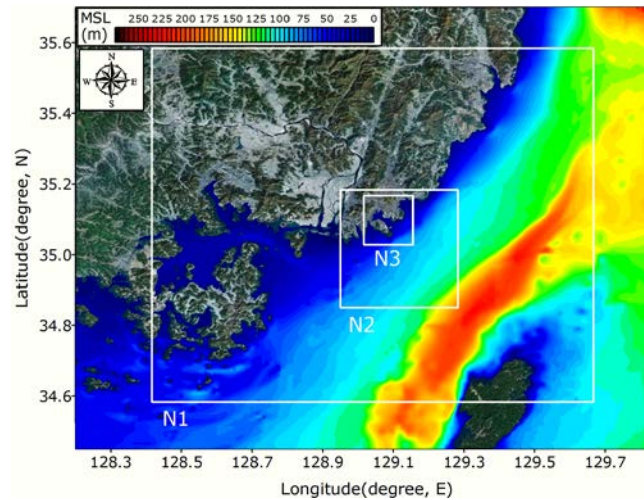
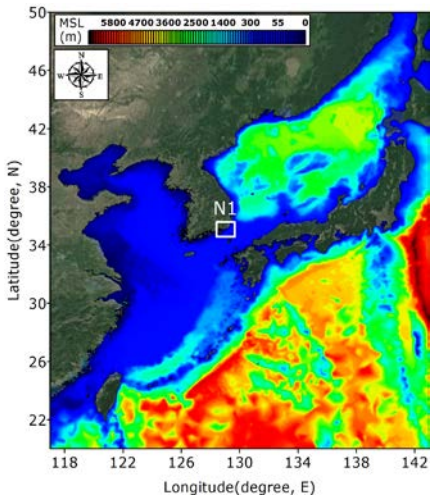


부산 북항내 파랑예측 - 계산영역

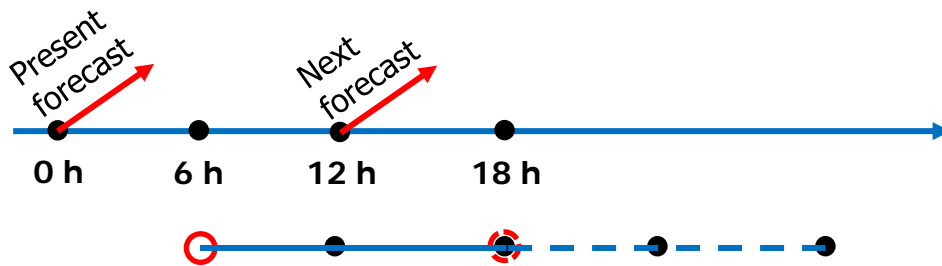
4 level nested grid system in SWAN

- Grid resolution :

L : $1/12^\circ$ (≈ 9 km), N1 : $1/60^\circ$ (≈ 2 km), N2 : $1/180^\circ$ (≈ 600 m), N3 : $1/540^\circ$ (≈ 200 m)



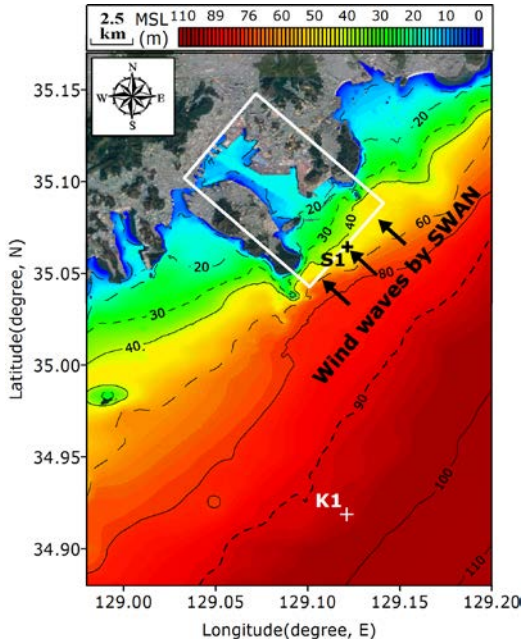
- 72-hour-long forecasts at every 0h and 12h in Greenwich Mean Time



72 h Forecasting time

SWAN input construction

부산 북항내 파랑예측 - 입사파 검증

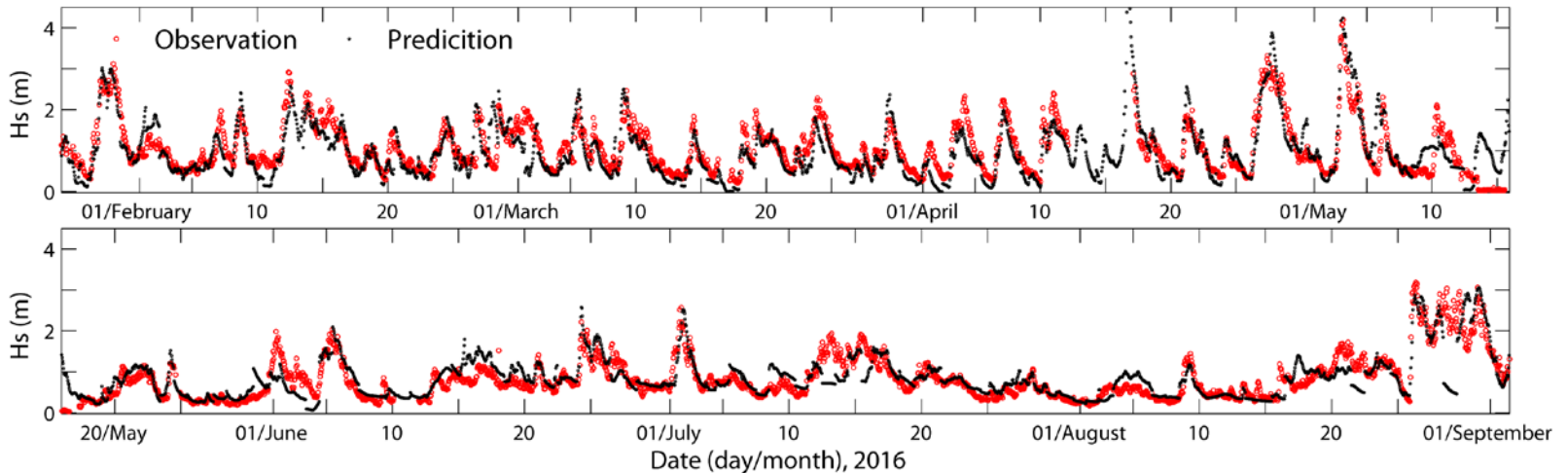


$$RMSE = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_{model,i} - x_{obs,i})^2} = 0.386$$

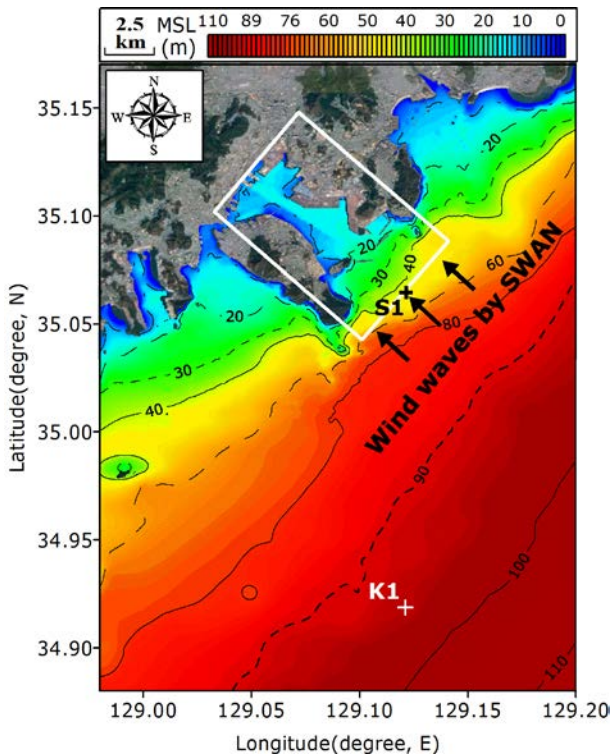
$$\chi = 1 - \frac{\sum_{i=1}^N (x_{model,i} - x_{obs,i})^2}{\sum_{i=1}^N (|x_{model,i} - \bar{x}_{obs}| + |x_{obs,i} - \bar{x}_{obs}|)^2} = 0.888$$

(Willmott, 1981)

Comparison between SWAN result (black) and observational data at K1 by KHOA



부산 북항내 파랑예측 - 실험조건



FUNWAVE model domain

Experimental cases for pre-calculation (total 45 cases)

Significant wave height (m)	0.1, 0.5, 1.0, 3.0, 5.0
Peak wave period (s)	8, 10, 12
Peak wave direction (deg)	117.5, 140.0, 162.5

Computational domain size

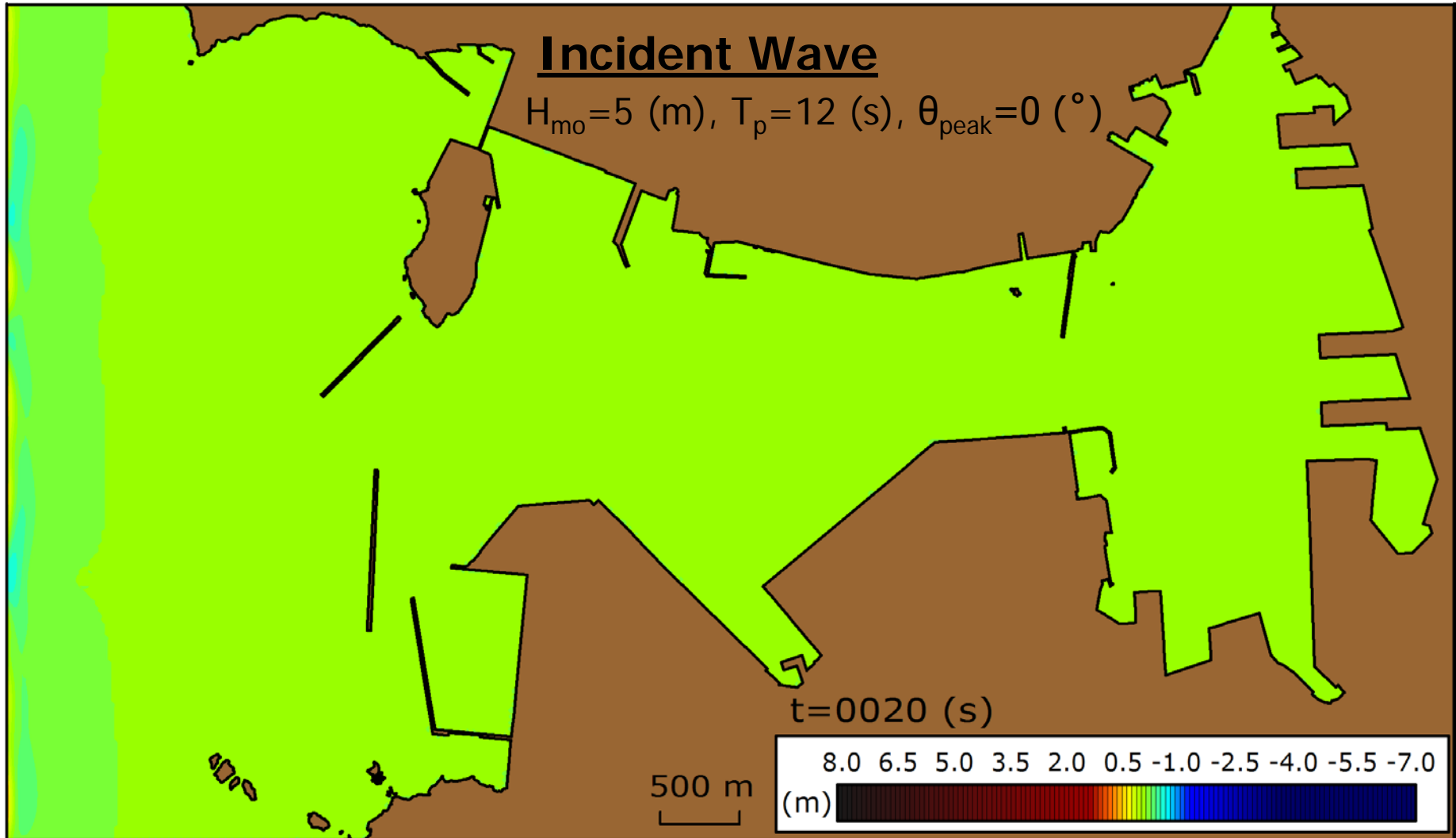
Peak wave direction	Computational domain size	Total number of grid
117.5	9,630 (m) × 6,532 (m)	4,816 × 3,267 = 15,733,872
140.0	9,630 (m) × 5,822 (m)	4,816 × 2,912 = 14,024,192
162.5	9,630 (m) × 7,004 (m)	4,816 × 3,503 = 16,870,448

grid resolution $\Delta x = \Delta y = 2$ (m) for irregular waves

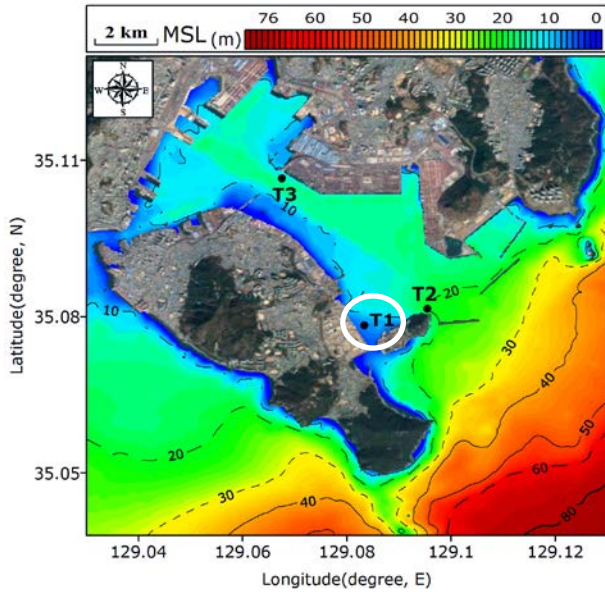
*※ (924 computational cores,
Total computing time : 71 days)*

부산 북항내 파랑예측 - 계산

$$H_s = 4.004\sqrt{m_0}, \quad m_0 = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \eta^2 dt, \quad t_1 = 2000(s), \quad t_2 = 7200(s)$$



부산 북항내 파랑예측 - 검증



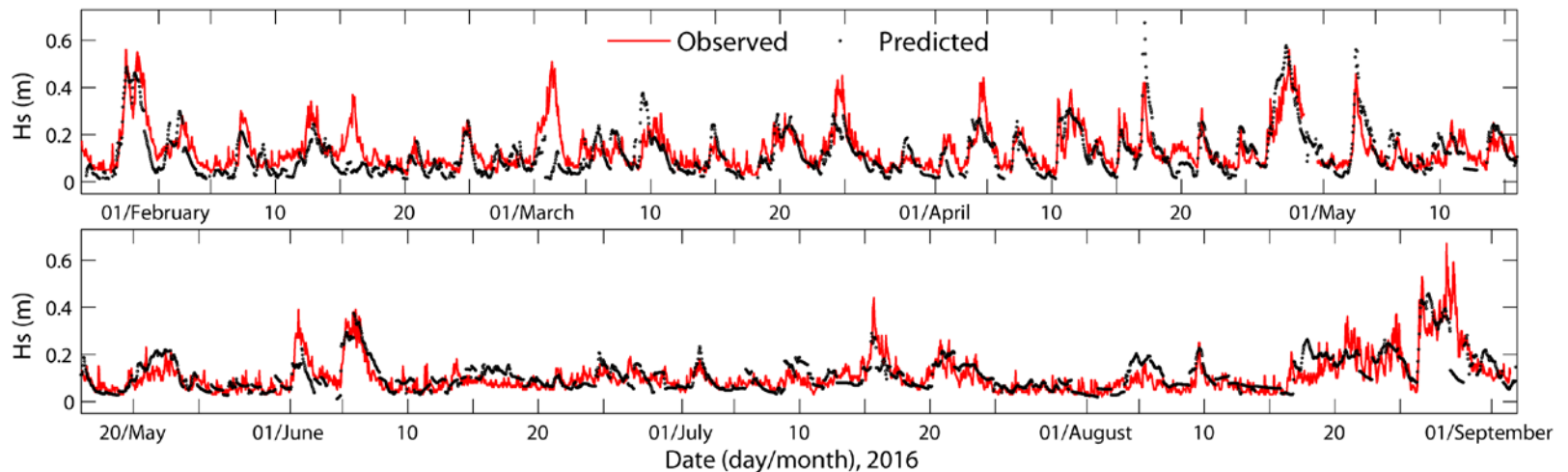
T1, T2, T3

- Locations of the observation for verification of the FUNWAVE-TVD model

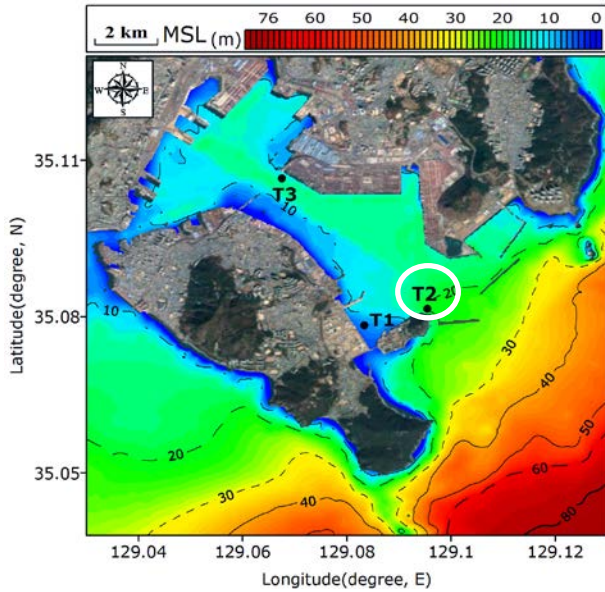
$$\chi = 1 - \frac{\sum_{i=1}^N (x_{model,i} - x_{obs,i})^2}{\sum_{i=1}^N (|x_{model,i} - \bar{x}_{obs}| + |x_{obs,i} - \bar{x}_{obs}|)^2} = 0.84$$

(Willmott, 1981)

St. T1 (depth=6.1m; 26 January ~ 2 September)



부산 북항내 파랑예측 - 검증



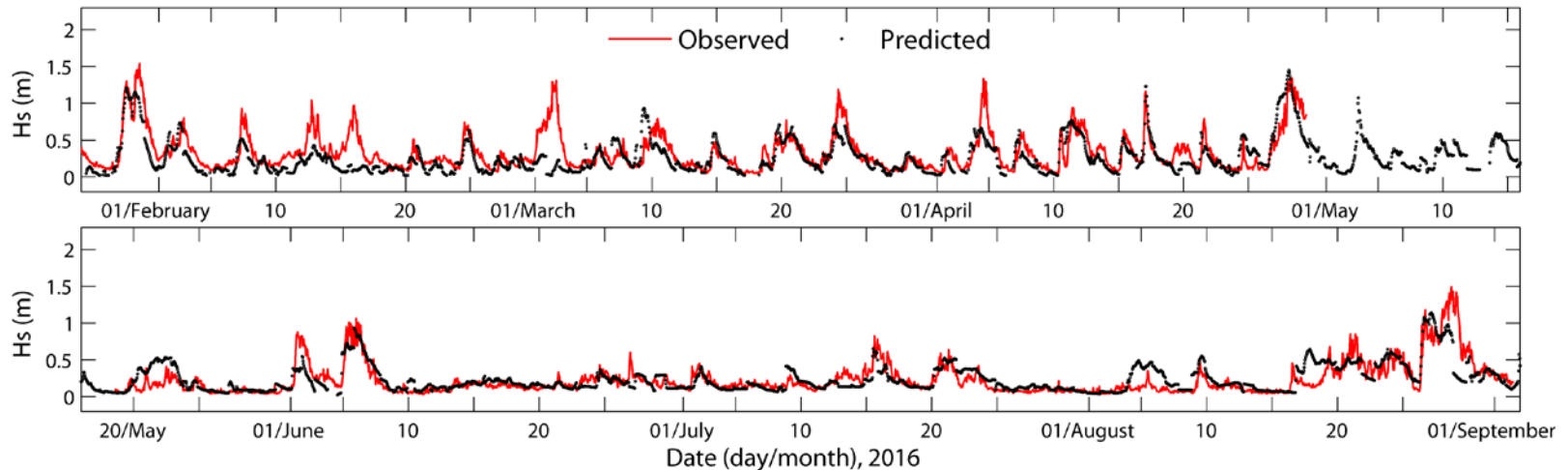
T1, T2, T3

- Locations of the observation for verification of the FUNWAVE-TVD model

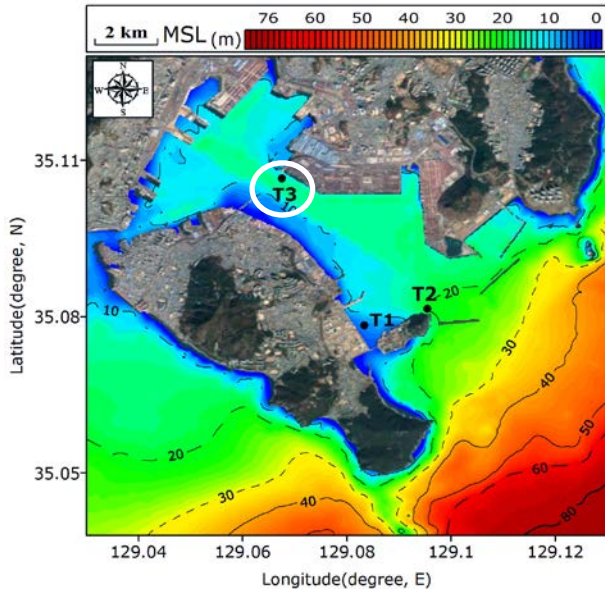
$$\chi = 1 - \frac{\sum_{i=1}^N (x_{model,i} - x_{obs,i})^2}{\sum_{i=1}^N (|x_{model,i} - \bar{x}_{obs}| + |x_{obs,i} - \bar{x}_{obs}|)^2} = 0.83$$

(Willmott, 1981)

St. T2 (depth=19.6m; 26 January ~ 2 September)



부산 북항내 파랑예측 - 검증



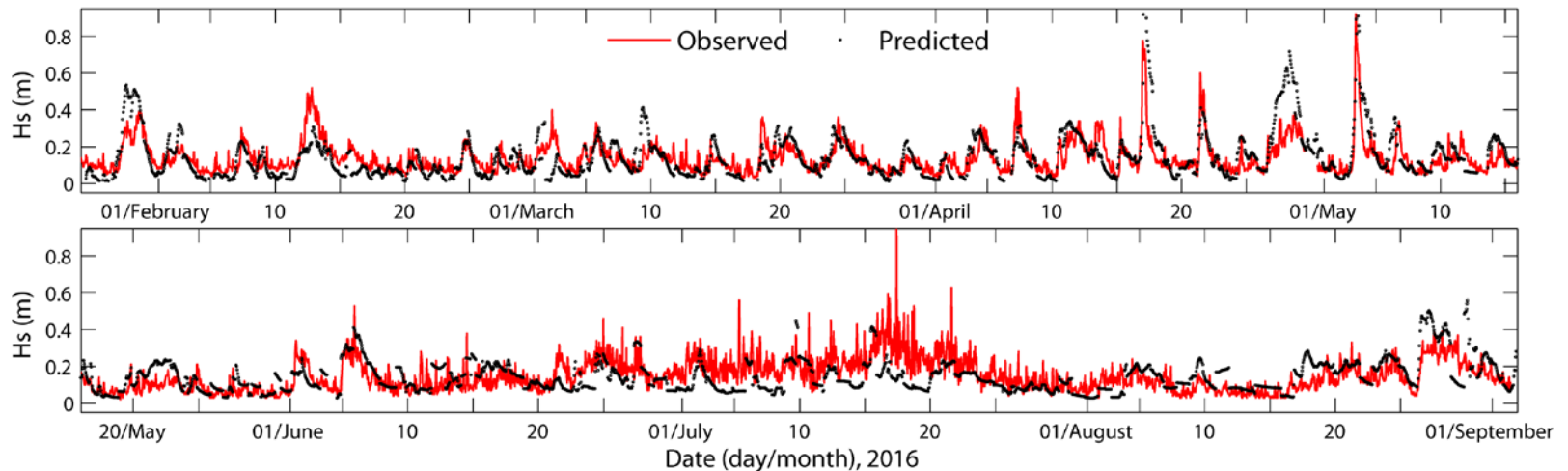
T1, T2, T3

- Locations of the observation for verification of the FUNWAVE-TVD model

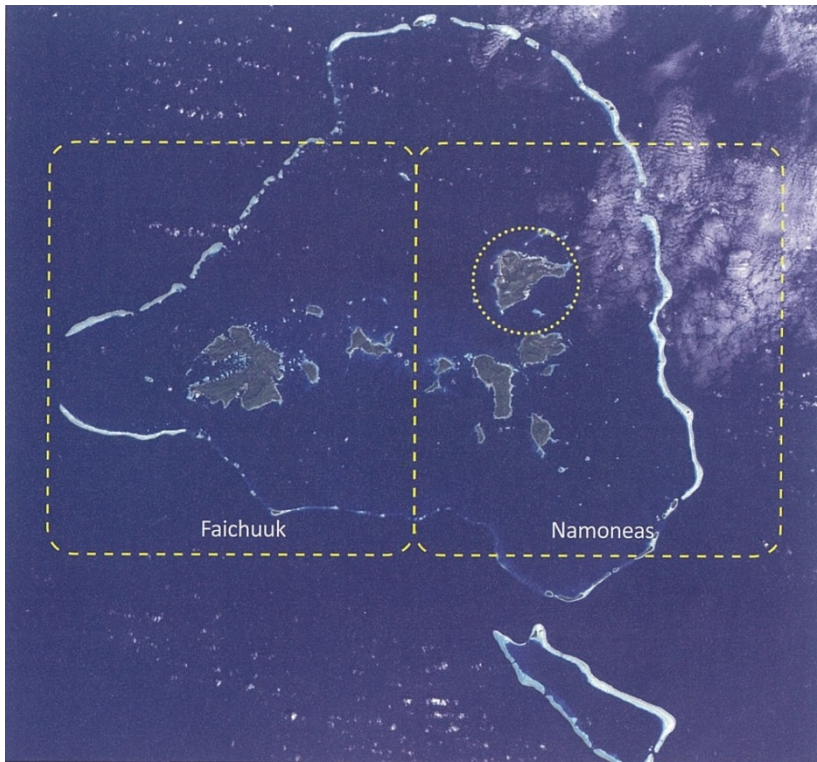
$$\chi = 1 - \frac{\sum_{i=1}^N (x_{model,i} - x_{obs,i})^2}{\sum_{i=1}^N (|x_{model,i} - \bar{x}_{obs}| + |x_{obs,i} - \bar{x}_{obs}|)^2} = 0.83$$

(Willmott, 1981)

St. T3 (depth=7.0m; 26 January ~ 2 September)



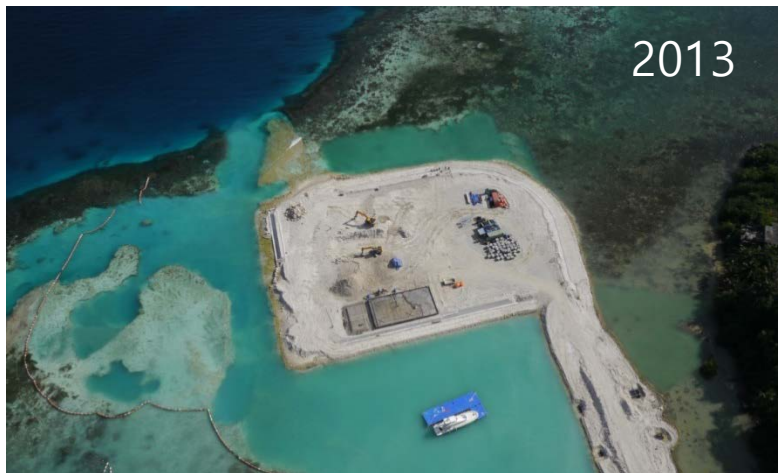
태평양해양과학기지(KSORC)



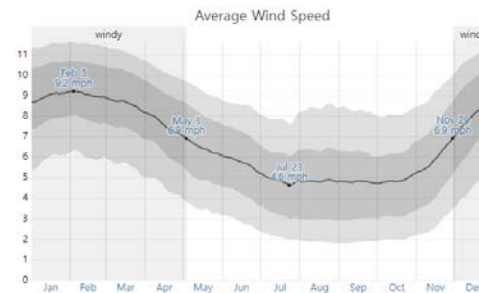
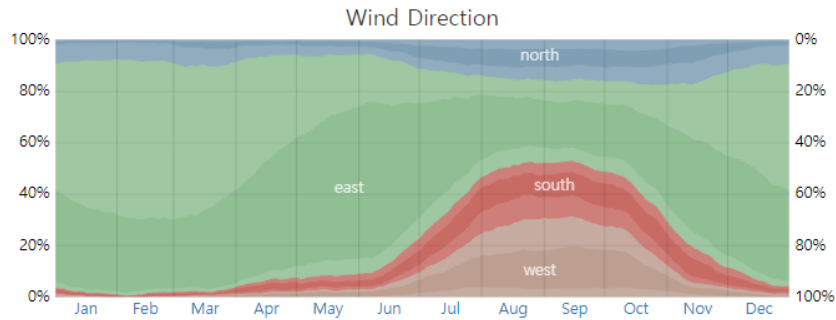
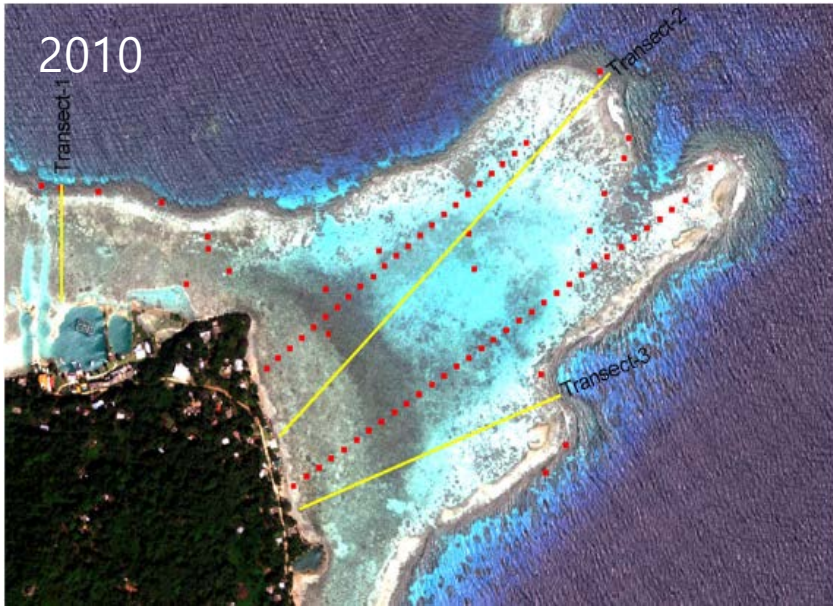
미크로네시아 Chuuk주에 2000년 설립
부지조성('13-'14) 및 시설관리동 건설
('15): 2,711백만원

태평양해양과학기지 기능

열대 태평양 해양과학연구 전진기지:
태평양 탐사 프로그램, 해양자원개발,
기후변화 연구, 환경보전연구,
태평양 도서국가 협력프로그램 등

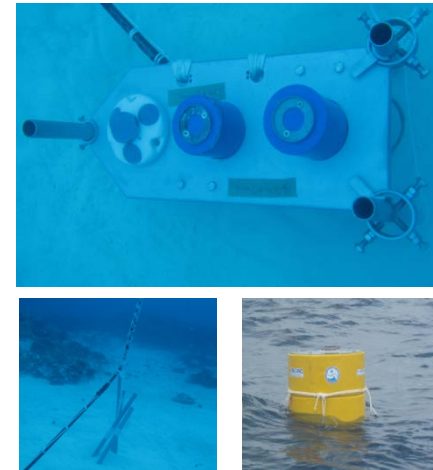
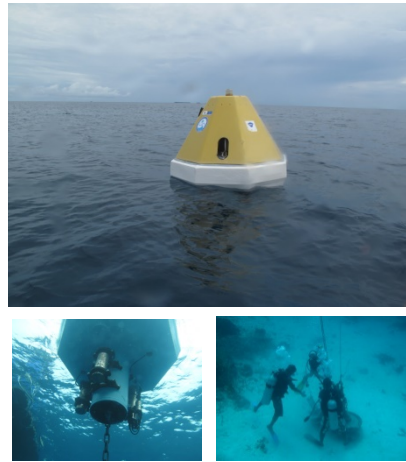
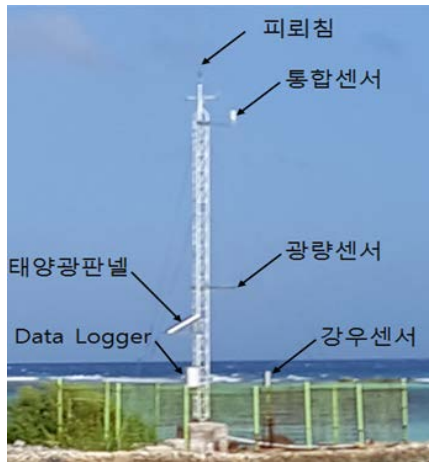


태평양해양과학기지 지형변화

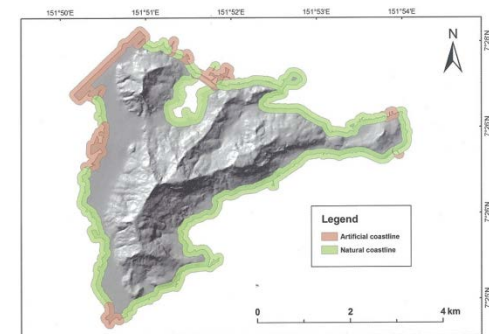


조차 0.9m
기온 78~86°F

KSORC 관측자료 시스템

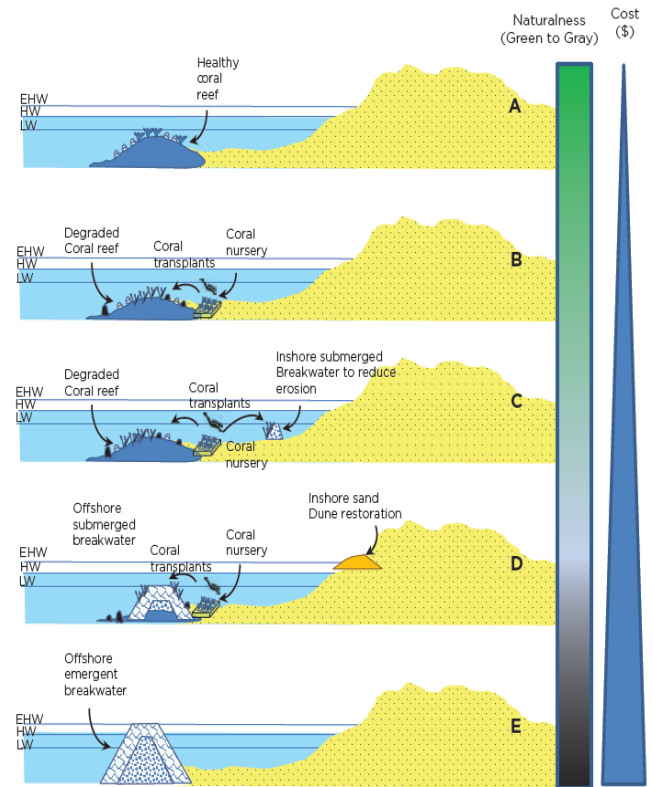
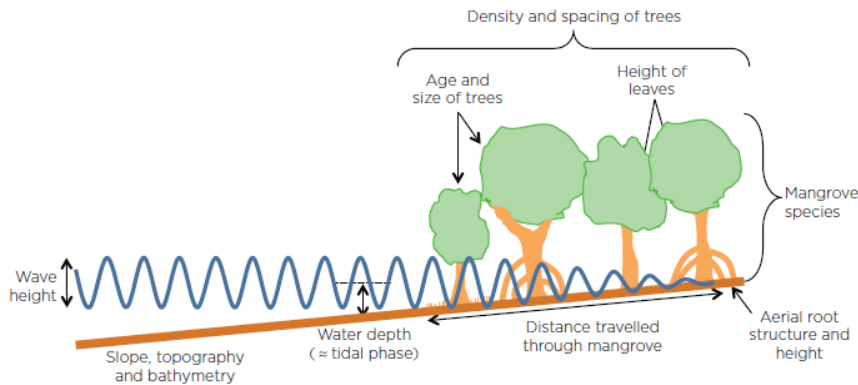


- 연속 관측자료: AWS 기상, NOAA 해양산성화, AWAC 파랑 · 다층유속, 조위
- 편집자료: 수심, (수치)지형, 연구성과물 등
- 현지의 인터넷 인프라와 운영관리의 효율성 감안,
- 자료관리의 자동화시스템을 본원에서 관리
- 웹사이트 자료표출 시스템 구축 · 운영



도서국 연안재해저감 대응기술

- 자연동화기법 (Building with Nature)을 이용한 재해저감기술
- 자연계 동적과정 순환사슬의 원활한 작동촉진
- 생태계의 역동적 발전과 성장을 도모
- 에너지와 물질 순환의 순기능 조장
- 생태계가 주는 다양한 편익을 이용
- 산호초와 맹그로브 숲의 재해저감효과
- 지속 가능한 개발추구

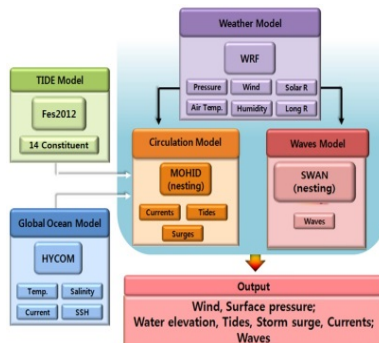


ODA 사업

- **목적** : 기후변화에 따른 연안재해 피해 저감, 해양예보능력 향상을 위해 해양예보시스템 구축에 필요한 해양과학기술 전수 및 전문가 양성, 관측장비 지원 등
- **수원국** : 인도네시아, 콜롬비아, 베트남

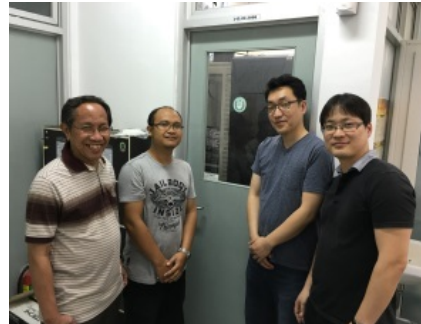
Cooperation

- Numerical Model Setup based on KOOS
- Development of counter measure for coastal disaster



Hardware Aid

- Computer Server

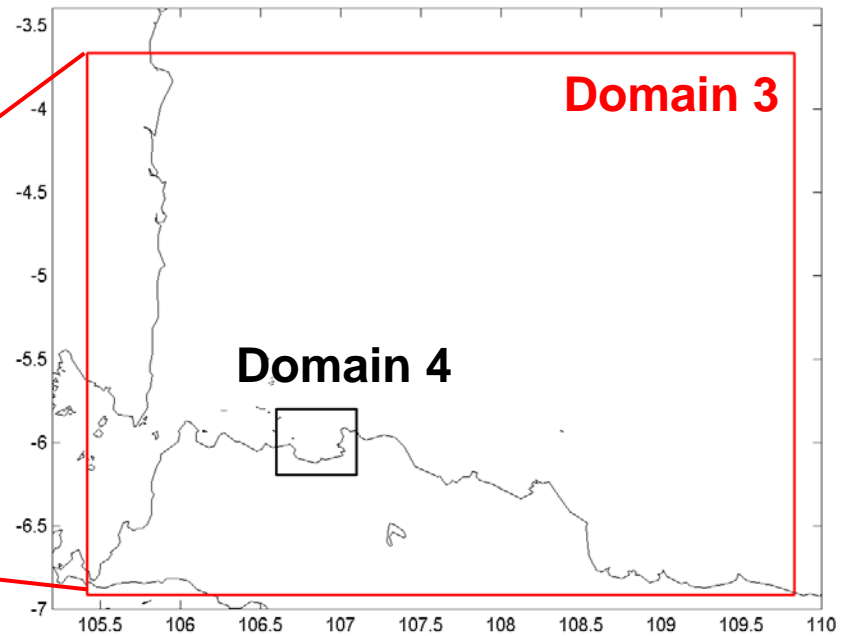
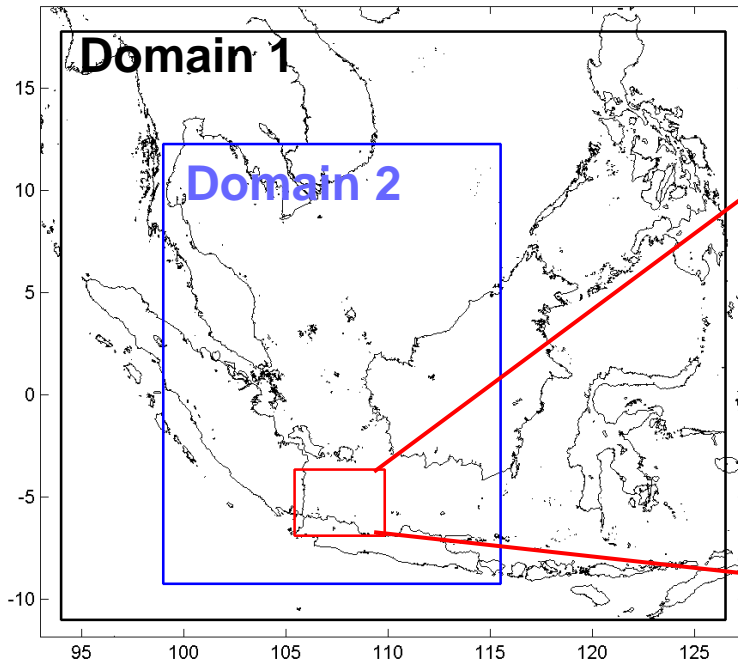


Training

- Workshop and Training



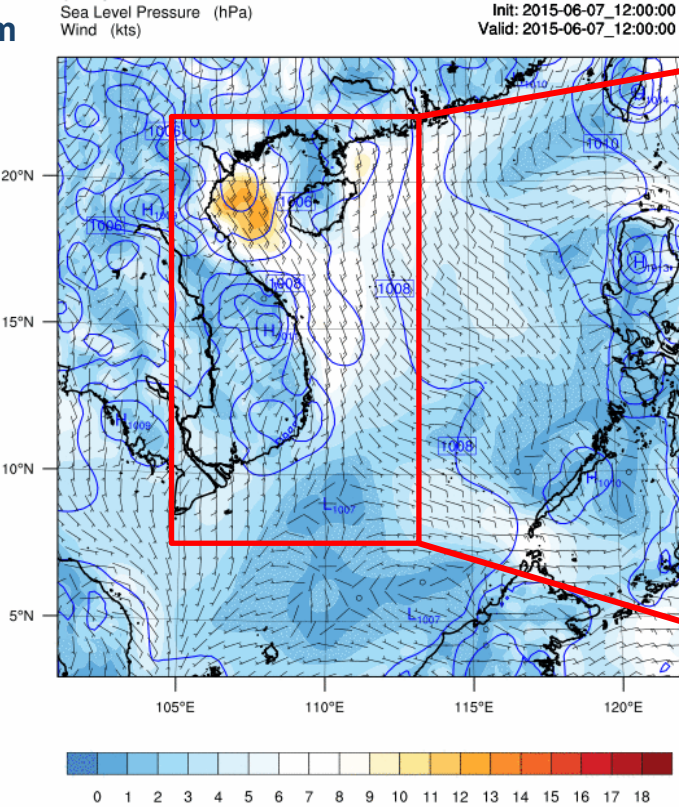
Indonesia



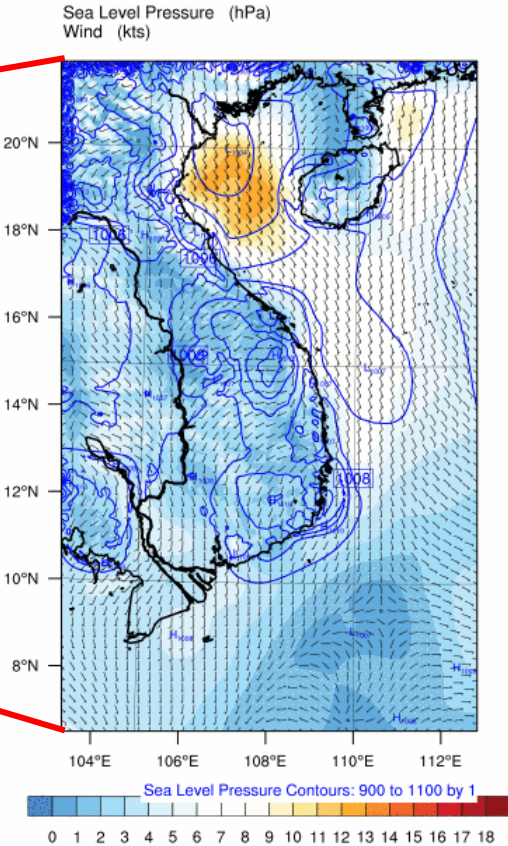
	Domain 1	Domain 2	Domain 3	Domain 4
Horizontal resolution	1°/6 (18 km)	1°/12 (9 km)	1°/36 (2 km)	1°/108 (1km)
Grid number	131 x 116	199 X 259	160 X 118	180 x 144
Vertical Levels (circulation)	1	1	8	8

Vietnam

D1: 20km



D2: 4km



Forecasting System	Lat	Long	Resolution	Model
Operational Weather	2° ~26°	98.8° ~120.5°	20km, 4km	WRF