4th International Workshop on Modeling the Ocean

21-24 May 2012 Yokohama Japan

Agenda and Abstracts

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JAMSTEC 独立行政法人 海洋研究開発機構
JAPAN AGENCY FOR MARINE-EARTH SCIENCE AND TECHNOLOGY

4th International Workshop on Modeling the Ocean (IWMO2012)

Keynote Speakers:
George L. Mellor (Princeton University)
Toshio Yamagata (JAMSTEC)

International Scientific Committee:
Chairman: Lie-Yauw Oey (Princeton University)
Jarle Berntsen (University of Bergen)
Tal Ezer (Old Dominion University)
Alejandro Orfila Forster (Mediterranean Institute for Advanced Studies)
Jianping Gan (Hong Kong University of Science & Technology)
Xinyu Guo (Ehime University)
Yukio Masumoto (JAMSTEC)
Yasumasa Miyazawa (JAMSTEC)
Fangli Qiao (The First Institute of Oceanography, SOA)
Bo Qiu (University of Hawaii)
Jinyu Sheng (Dalhousie University)
Huijie Xue (University of Maine)
Jin Yi Yu (University of California)
Xiao Hua Wang (University of New South Wales)
Takuji Waseda (The University of Tokyo)
Joerg-Olaf Wolff (University Oldenburg)
Chau-Ron Wu (National Taiwan Normal University)

Local Steering Committee:
Chairman: Yukio Masumoto (JAMSTEC)
Mari Tsuzuki (JAMSTEC)
Sergey M. Varlamov (JAMSTEC)
RuoChao Zhang (JAMSTEC)
Yasumasa Miyazawa (JAMSTEC)

Organizer:
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Venue: Miyoshi Memorial Hall, JAMSTEC Yokohama Institute

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10:30			Chien		3
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11:10			Tsai		5
11:30			Jörg-Olaf Wolff (invited) 30 min		6
12:00			Uchiyama		7

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16:40			Achiari		6
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11:30			Roscinski (2)		7
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11:50	**Session -4**	Bo Qiu + Jarle Berntsen	Humio Mitsudera (invited) 40 min		1
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14:10			Patrice Klein (invited) 30 min.		5
14:40			Yamaguchi		6
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15:20	Coffee Break				
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23 May 2012					
08:20	**Session -5**	Jinyu Sheng + Yasumasa Miyazawa	Alejandro Orfila (invited) 30 min		1
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09:10			Escobar (OYSA)		3
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09:50			Varlamov		5
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		End of Session			
10:30	Coffee Break				

10:50	**Session -6**	Jin Yi Yu + Yukio Masumoto	Gheiby		1
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11:50			Yu		4
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12:50	Lunch break 1 hour				
13:50	**Session -7**	Jianping Gan + Chau-Ron Wu	Duong (OYSA)		1
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15:00			Saramul (OYSA)		4
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09:30	Coffee break + OYSA discussion				
10:00	**Session -9**	Huijie Xue + Xinyu Guo	I-I Lin (invited) 30 min		1
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11:30 -	Discussion & Closing				

Schedule

21 May 2012

08:00-08:30 Registration

08:30- 08:35 Opening (Chairman of the Local Steering Committee: Yukio Masumoto)
08:35-08:45 Introduction of IWMO (Chairman of the International Scientific Committee: Lie-Yauw Oey)
08:45-08:50 Guidance (Yasumasa Miyazawa)

Session Title: Keynote Lecture, Session Chair: Yasumasa Miyazawa

08:50-09:30 **Keynote Lecture:** Predictability of the Subtropical Dipole Modes in the Atlantic and Indian Oceans (Toshio Yamagata)

Photo session & Coffee Break & Poster Session

Session Title: Waves, Currents, and Their Interactions in Coastal and Shelf Seas, Session Chair: Alejandro Orfila and Joerg-Olaf Wolff

09:50-10:10 **OYSA:** Numerical simulation of wave penetration into Bordekhoon- A natural spit (Ali Nasrollahi)
10:10-10:30 Turbulent mixing by non-breaking wind waves (Malek Ghantous)
10:30-10:50 On the augmentation of sea surface roughness on inner shelf (Hwa Chien)
10:50-11:10 Numerical study of wave and current dynamics in the Baltic Sea (Vitalij Roscinski)
11:10-11:30 Temporal growth of small-scale water waves sheared by a laminar air flow (Yuan-Shiang Tsai)
11:30-12:00 **Invited Talk**: Wave induced currents in and around a tropical coral reef: a comparison of observations with theoretical and numerical modelling results (Joerg-Olaf Wolff)
12:00-12:20 Three-dimensional unsteady wave-driven littoral currents (Yusuke Uchiyama)

12:20-12:40 **OYSA:** Numerical investigation of the effect of wind on four-wave interaction (Tomoyuki Hirobe)

Lunch Break & Poster Session

14:00-14:20 Initial generation of wind-waves a comparison of physical experiment and direct numerical simulation (Takuji Waseda)
14:20-14:40 Thickness-weighted-mean theory for the effect of surface gravity waves on mean flows in the upper ocean (Hidenori Aiki)

Session Title: Numerical techniques and approaches in ocean modeling, Session Chair: Tal Ezer

14:40-15:00 Tracing the trajectories of particles in case of a radiological leakage from a nuclear reactor using POM (Kaushik Sasmal)
15:00-15:20 Effect of Atmospheric Forcing on Plume dispersion utilizing Princeton Ocean Model (Subhendu Maity)
15:20-15:40 The role of secondary circulation in gravity currents (Jarle Berntsen)

Coffee Break & Poster Session

16:00-16:20 An estimate of Lorenz energy cycle for the world ocean based on the 1/10 deg. STORM simulation (Jin-Song von Storch)
16:20-16:40 Effects of wind stress topography and surface heat flux on the circulation in Tokyo Bay (Li-Feng Lu)
16:40-17:00 Application of 3D Non-orthogonal Boundary Fitted Hydrodynamics and Sediment Transport and Wave Model in Ciasem Estuary Indonesia (Hendra Achiari)

17:10-19:10 Welcome Reception at the JAMSTEC Yokohama Institute

22 May 2012

Session Title: Keynote Lecture, Session Chair: Takuji Waseda

08:20-09:00 **Keynote Lecture:** Waves Circulation and Vertical Dependence (George

Mellor)

Session Title: Air-Wave-Sea coupled processes and modeling, Session Chair: Takuji Waseda and Fangli Qiao

09:00-09:20 Coupled atmosphere-wave-ocean modeling under tropical cyclone conditions (Tetsu Hara)
09:20-09:40 **OYSA:** A regional air-sea coupled model adopted over the winter Yellow and East China Seas (Shinsuke Iwasaki)
09:40-10:00 Application of Anisotropy based Eddy Viscosity Model to cyclone Fung-Wong (Subhendu Maity)
10:00-10:30 **Invited Talk**: Investigation of the Response of the Ocean Mixed Layer under Surface Heating during Summer Using Large Eddy Simulation (Yign Noh)

Coffee Break & Poster Session

10:50-11:10 Coupling of A Regional Atmospheric Model (RegCM3) and A Regional Oceanic Model (POM) Over the Maritime Continent (Jun Wei)
11:10-11:30 Air-Sea-Wave Interactions in the Kuroshio and Okinawa Trough Region during the 2007 Typhoon Season (Philip Chu)
11:30-11:50 Cross-comparison of wind wave modelling by wave forecasting model WAM and the coupled circulation-wave POM model (Vitalij Roscinski)

Session Title: Multi-scale interactions in the ocean, Session Chair: Bo Qiu and Jarle Berntsen

11:50-12:30 **Invited Talk**: Ice band formation due to resonant interaction between sea ice and internal gravity waves & Impacts of the Amur River discharge on the circulation over the northwestern continental shelf of the Sea of Okhotsk (Humio Mitsudera and Ayumi Fujisaki)
12:30-12:50 On the Dynamics of Strait Flows and their Importance for Large-Scale Circulation and Climate: An example from a Bering Sea Model (Tal Ezer)

Lunch Break & Poster Session

13:50-14:10 SSH wavenumber spectra in the North Pacific from a high-resolution

realistic simulation (Hideharu Sasaki)
14:10-14:40 **Invited Talk:** Emergence of wind-driven near-inertial waves into the deep ocean triggered by a turbulent mesoscale eddy field: Impact on mixing at large-scale (Patrice Klein)
14:40-15:00 Modeling of river water dynamics over the tidal falt - tidal creek complex and its dependence on model resolution (Soichi Yamaguchi)
15:00-15:20 **OYSA:** Numerical analysis of internal shock wave generation around an island in strongly stratified oceanic jet. (Tsubasa Kodaira)

Coffee Break & Poster Session

15:40-16:00 Effect of Decadal Kuroshio Extension Jet and Eddy Variability on the Modification of North Pacific Intermediate Water (Bo Qiu)
16:00-16:20 **OYSA:** Interaction between basin scale topographic wave and estuarine circulation induced anti-cyclonic gyre in the gulf with sill type ROFI (Edith Soosaar)
16:20-16:40 Intensified down-slope transport over a widened shelf (Jianping Gan)
16:40-17:00 The Stokes drift and wave induced-mass flux in the North Pacific (Hitoshi Tamura)
17:00-17:30 **Invited Talk**: Comparison between vertical shear mixing and surface wave-induced mixing in global ocean (Fangli Qiao)

Dinner at Minato-Mirai Place 18:30-20:30
Foodiun Bar Issa, Colette Mare- Minato Mirai
http://www.d-issa.jp/shop/shop1347.html

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Session Title: Data Assimilation and Ocean Forecast Systems, Session Chair: Jinyu Sheng and Yasumasa Miyazawa

08:20-08:50 **Invited Talk**: An operational system for oil spill tracking in the probability domain. Application to the Western Mediterranean Sea (Alejandro Orfila)
08:50-09:10 **OYSA:** Forecasting the trajectories of drifters in the Sea of Okhotsk by using data on currents and wind (Igor Oleynikov)
09:10-09:30 **OYSA:** Validation of Numerical Model (ROMS) in equatorial region

between Ecuadorian coast and Galapagos Islands (Ma. Gabriela Escobar)
09:30-09:50 ATOP - Assimilated Taiwan Ocean Prediction System (Lie-Yauw Oey)
09:50-10:10 Operation of Tide-Resolving Regional Ocean Model for Japan Coastal Waters(JCOPE-T) (Sergey M. Varlamov)
10:10-10:30 Local Ensemble Kalman Filter Analysis of Loop Current & Eddy in the Gulf of Mexico (Fanghua Xu)

Coffee Break & Poster Session

Session Title: Climate Dynamics and Modeling, Session Chair: Jin Yi Yu and Yukio Masumoto

10:50-11:10 ENSO Events, Rainfall Variability, and the Potential of SOI for the Seasonal Precipitation Predictions over Iran (Abolhassan Gheiby)
11:10-11:30 **OYSA:** Air-Sea coupling and the quickening pace of Loop Current shedding in a warming climate (Y.-L. Eda Chang)
11:30-11:50 **OYSA:** Simulation of Princeton Ocean Model for Northern Indian Ocean: A study of Indian Monsoon events with simulated SST anomalies (Surendra Pratap Singh)
11:50-12:10 Modeling the Two Types of ENSO and Their Climate Impacts (Jin-Yi Yu)
12:10-12:30 The Atlantic ITCZ simulated in the new high-resolution coupled climate model GFDL-CM2.5 (Takeshi Doi)
12:30-12:50 A review of the Indian Ocean Dipole: An Australian perspective (Evan Weller)

Lunch Break & Poster Session

Session Title: Circulation and transport/exchange in coastal seas, Session Chair: Jianping Gan and Chau-Ron Wu

13:50-14:10 **OYSA:** Study on the circulation features in the Mekong river mouth area by ROMS model (Pham Xuan Duong)
14:10-14:40 **Invited Talk:** Numerical Study of the Far-field Effect of Tidal Energy Extraction in the Minas Passage on Circulation and Hydrography in the Bay of Fundy and Gulf of Maine (Jinyu Sheng)
14:40-15:00 The Weak Influence of the Tidal Residual Currents on Lagrangian

Trajectories ibn the Southwestern Yellow Sea (Bin Wang)
15:00-15:20 **OYSA:** Numerical Simulations of the upper Gulf of Thailand: Coastal Dynamics and Forcing Mechanisms (Suriyan Saramul)

Coffee Break & Poster Session

15:40-16:00 Topographic influence of the Kii peninsula on the strength of the Kuroshio and its variability (Toru Miyama)
16:00-16:20 Modeling the circulation in the Beibu Gulf South China Sea (Huijie Xue)
16:20-16:40 Numerical simulation and dynamical analysis for the low-salinity water lenses in the northeast out of the Changjiang river mouth (Wen Jingzhang)
16:40-17:00 **OYSA:** The importance of the wind-driven circulation in the tidally-driven Malacca Strait (Chen Haoliang)
17:00-17:20 Wind-driven surface Kuroshio intrusion into the South China Sea (Chau-Ron Wu)

24 May 2012

Session Title: Modeling of sediment transport dynamics in ports, harbors and coastal environments, Session Chair: Xiao Hua Wang

08:20-08:40 **OYSA:** Sediment dynamics in Darwin Harbour, Northern Territory, Australia (Li Li)
08:40-09:00 **OYSA:** Study of the Turbidity Maximum in the Deepwater Navigation Channel in the Yangtze River Estuary (Dehai Song)
09:00-09:30 **Invited Talk:** Sediment transport dynamics in ports estuaries and other coastal environments (Xiao Hua Wang)

Coffee Break & Poster Session & OYSA discussion

Session Title: Biogeochemical Oceanographic Modeling, Session Chair: Huijie Xue and Xinyu Guo

10:00-10:30 **Invited Talk**: Typhoon-induced Phytoplankton Blooms and Primary Productivity Increase in the Western North Pacific Subtropical Ocean (I-I Lin)

10:30-10:50 Modeling Carbon Cycle and Biological Productivity in the Pacific Ocean (Fei Chai)
10:50-11:10 The age of Yellow River water in the Bohai Sea (Xinyu Guo)
11:10-11:30 Turbulent mixing by tropical storm and phytoplankton bloom in the southeast continental shelf region of Hainan Island (Zhang Shuwen)

11:30-11:40 Introduction of Ocean Dynamics journal (Chief Editor: Joerg-Olaf Wolff)
11:40-11:50 Awards Ceremony (Chairman of the International Science Committee: Lie-Yauw Oey)
11:50-12:30 Discussion & Closing

Poster Session Titles (Poster: A0, Portrait)

1. Analysis of sediment transport in the central region of Santos (SP Brazil) through numerical modeling (Thiago Marques Coelho)
2. Numerical Study of Circulation in the Abandoned Yellow River Mouth And Adjacent Coastal Waters (Ji Xiaomei)
3. Numerical Simulations of the Hydrodynamics in the Coastal Waters of the Nan-Wan Bay in Southern Taiwan (Jian-Ming Liau)
4. Argo data assimilation in ocean general circulation model of Northwest Pacific Ocean (Xunqiang Yin)
5. Wave Transformations over a Submerged Crescent Shoal (Chao-Min Hsu)
6. On the variation of Air-Sea flux on Kuroshio waters using Taiwan Earth System Model (Hau-Yuan Cheng)
7. 3-D water and substance's long-term transport velocity and its application in the Changjiang Estuary (Shouxian Zhu)
8. Improvement of MOM4 by including surface wave-induced vertical mixing (Qi Shu)
9. Simulation of the tide and tidal current in the Qinzhou Bay (Changshui Xia)
10. Variability of the drag coefficient over the North and Baltic Sea (Joerg-Olaf Wolff)
11. A model study on phytoplankton dynamical processes in Laizhou Bay Bohai Sea (Bo Yang)
12. Impact of surface drifter data for "ocean weather forecast" - an example of mesoscale variability in the Kuroshio Extension Region (Kei Nishina)
13. Oceanic dispersion of cesium-137 off the north-eastern Pacific coast of Japan (Tomomi Ishii)

14. Oceanic responses to surface gravity waves in the Southern California Bight (Tatsuya Nishii)
15. Effects of wave-current interaction on development of rip currents (Hideki Kaida)
16. Pacific ocean swell case study and WavewatchIII model assessment (Fan Bi)
17. Simulation of diatom and non-diatom distributions in the northern South China Sea using Photo-CoSINE model (Hsieh Fu-yang)
18. The Simulation of the Intense Cooling Caused by Ling-Ling Typhoon off the Vietnam Coast in 2001 (Huang Shih-Ming)
19. Unstructured grid numerical wave model simulation of swells on the East Sea (Taerim Kim)
20. Mechanism of the clockwise circulation in the southern Sea of Okhotsk by localized tidal mixing (Humio Mitsudera)
21. Monsoon-driven upwelling effect on the phytoplankton blooms in the Southeast Asia Seas: An eddy-resolving physical-biological model study (Yoshikazu Sasai)

Keynote Lectures

Predictability of the Subtropical Dipole Modes in the Atlantic and Indian Oceans

Morning, 21 May 2012

Toshio Yamagata[1]* and collaborators

(Chaoxia Yuan[2], Tomoki Tozuka[2], and Jin-Jia Luo[3])

[1]Application Laboratory, JAMSTEC, Yokohama 236-0001, Japan

[2]School of Science, The University of Tokyo, Tokyo 113-0033, Japan

[3]Center for Australian Weather and Climate Research, Melbourne, Australia)

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Prediction of climate modes inducing abnormal weather and extreme events over the globe is useful for mitigating the societal impacts. Many studies have been devoted to predicting El Niño/Southern Oscillating (ENSO) over the past decades. Since the discovery of the Indian Ocean Dipole (IOD; Saji et al. 1999), predictability of the tropical Indian Ocean climate has also received much attention. In contrast to these climate modes in the tropical oceans, prediction of climate modes in the extratropics is considered to be a more difficult task owing to large internal variability of the atmosphere and weak ocean-atmosphere coupling. Hence, very few studies to date have examined predictability of climate modes in the extratropics. In this study, we focus on the Indian Ocean Subtropical Dipole (IOSD) and South Atlantic Subtropical Dipole (SASD), and evaluate their predictability for the first time using ensemble seasonal predictions of a CGCM.

A positive IOSD (SASD) is associated with positive SST anomalies over the southwestern pole and negative SST anomalies over the northeastern pole in the southern Indian Ocean (South Atlantic). Both the IOSD and SASD are known to influence precipitation over the southern African region in austral summer at their height of evolution. Anomalous southeasterlies between the two SST anomaly poles carry extra moisture from the subtropical Indian Ocean to the southern Africa and enhance the moisture convergence and precipitation there. On the other hand, the SST anomalies of SASD modulate the westerly jet in the mid-latitudes and influence the zonal moisture

exchange between the South Atlantic and southern Africa, and thus the southern African rainfall. Also, the positive IOSD and SASD are linked to an atmospheric circulation condition that favors the development of tropical temperate troughs in the continent-based South Indian Convergence Zone, giving rise to a high rainfall rate over the southeastern southern Africa and southwestern Indian Ocean. Therefore, successful predictions of the IOSD and the SASD with sufficient lead-time in a CGCM will contribute to better predictions of the southern African summer precipitation.

Here, predictability of the subtropical dipole modes is assessed using the SINTEX-F coupled model. Despite the known difficulty in predicting subtropical climate, it is shown for the first time that the model can successfully predict the Indian Ocean Subtropical Dipole (IOSD) and South Atlantic Subtropical Dipole (SASD) at lead time of up to 1 to 2 seasons with a prediction barrier in austral autumn due to the seasonal locking of the IOSD and the SASD to austral summer. The overall prediction skills of the IOSD are higher than those of the SASD. Also, the predictability of SST anomalies in the northeastern pole of the IOSD is higher than that of the southwestern pole, whereas no significant difference is found in the predictability for the two poles of the SASD.

Keynote Lectures

Waves, Circulation and Vertical Dependence

Morning, 22 May 2012

George L. Mellor

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When vertically distributed, a portion of the integrated wave radiation stress derived by Longuet-Higgins and Stewart (1962, 1964) and later by Phillips (1977) is singular and concentrated at the surface so that recourse to vertically dependent continuity and momentum equations is necessary. When applied to the classical problem of waves incident on a beach, the flow solution is significantly altered compared to the solution from vertically integrated continuity and momentum equations and vertically integrated wave radiation stress. A bottom slope criterion for the application of linear wave relations to the derivation of the wave radiation stress is obtained.

Session-1: Waves, Currents, and Their Interactions in Coastal and Shelf Seas

Session Chair: Alejandro Orfila and Joerg-Olaf Wolff

Morning, 21 May 2012

OYSA: Numerical simulation of wave penetration into Bordekhoon- A natural spit

Ali Nasrollahi

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Bordekhoon (Fig.1) is a natural spit located in northern coasts of Persian Gulf formed by sediments of Mond river discharging upstream of the region. Importance of the area as a natural fishery shelter caused some engineering activities started to provide appropriate fishery conditions. Morphological phenomena induced by river sediments together with hydrodynamics effects of waves and currents make a lot of complexities predicting natural behavior of the area and its interaction with any man-made structure. In this paper, numerical modeling of wave penetration into this natural shelter was performed using BW-MIKE21. Characteristics of deep water wave were extracted from deep water waves which were obtained using numerical simulation.

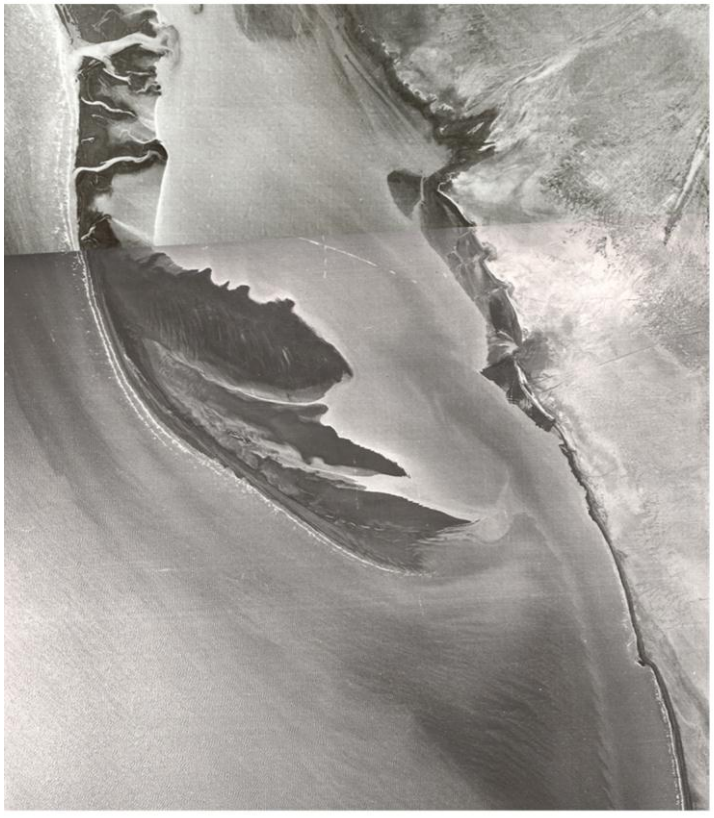

Fig.1. Bordekhoon spit

Turbulent mixing by non-breaking wind waves

Malek Ghantous*, Alexander V. Babanin, Dmitry Chalikov

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Operational forecasting models presently do not account for the effect of non-breaking wind-generated surface waves on the turbulent mixing of the upper ocean. Numerous studies have shown that the effect not only exists, but that its absence from the models can in many situations lead to an under-mixed upper ocean and sea surface temperatures which are too high.

Surface waves, particularly those on the ocean, are normally presumed to be irrotational and to have little or no interaction with near-surface turbulence, except through surface injection of turbulent kinetic energy and distortion of turbulence by the Stokes drift and Langmuir circulation. However real waves are non-irrotational, and it has been known for at least half a century that they can generate turbulence; furthermore, the turbulence is unstable to the irrotational orbital motion of the waves which leads to growth of the turbulence. By modelling the turbulence generation in a large eddy simulation we can develop a parameterization which can be introduced into an ocean mixing model. Preliminary results suggest that a decrease in surface temperature of around two degrees can occur quickly under large enough waves, a value well above that required to have an impact on weather systems such as tropical cyclones.

On the augmentation of sea surface roughness on inner shelf

Hwa Chien[1]*, Hau-Yuan Cheng[1], Jyn-Fong Yuan[1], and Chao-Min Hsu[2]

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The alongshore component of wind stress is the primary forcing for the circulation in coastal seas. During storms, the wind forcing is important even on tidally dominated inner shelves. The air-sea momentum flux estimation is crucial for the predictions of transportation and dispersion of pollutant and sediment as well as the storm surge. Two field observation campaigns were carried out at the coastal observatory on the north-western coast of Taiwan in 2011. Observations including dual-band microwave radars for sea surface roughness measurement, an array of bottom-mount ADCPs for current profile and directional wave and Eddy Covariance System for the air-sea heat, CO2, moisture and momentum fluxes.

First, it is found that the Drag Coefficient (Cd) of weak to moderate U10 is greater than those observed on open oceans (TOGA COARE). The Mean Square Slope (MSS), estimated from full-range wavenumber spectrum, is then adopted as a direct measure to represent the physical roughness of sea surface. The augment of Cd in coastal waters is then found to be correlated to the increasing MSS at high wavenumber, which is owing to the deviation of the spectral tail slope to k-3 in shallow water. The tidal elevation features profound effects on the spectral tail slope and the wave directional spreading. As water depth decreases, the wave directional spreading becomes narrower, and is consistent with the Snell's Law's prediction. It is also found that the broadening of the directional spreading can be identified in strong tidal current. It is hypothesized that the surface wave pattern on inner shelf would be altered by the turbulence due to the thickening of bottom boundary layer.

Numerical study of wave and current dynamics in the Baltic Sea

W. Cieslikiewicz, A. Dudkowska, V. Roscinski*, and Sz. Roziewski

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E-mail: ciesl@ug.edu.pl

An operational decision-making based on atmospheric and sea conditions system for the Baltic Sea was constructed and is operated routinely as a part of the PROZA project (UDA-POIG.01.03.01-00-140/08-00) financed from the Polish Innovative Economy Programme and the European Regional Development Fund. The main elements of the system are the input weather data from Coamps model from ICM (Interdisciplinary Centre for Mathematical and Computational Modelling), data interpolation package based on SCRIP (Spherical Coordinate Remapping and Interpolation Package) and ocean models such as wind wave forecasting WAM and hydrodynamics POM model. The system provides hourly forecasts of significant wave height, mean wave period, sea level, ocean currents, water temperature and salinity for surface as well as deep waters at a lead time of up to 84 hours and is operated daily.

This study presents a setup of the wind wave forecasting models: WAM and POM coupled with a wave module. A sensitivity of the modelled wind wave field to the coupling with currents and sea level is analyzed with a special attention. The models have been validated against observations recorded with a directional waverider buoy over the period from 2010 to present. Quite a good agreement between the modeled and observed significant wave height and mean wave period was obtained.

Temporal growth of small-scale water waves sheared by a laminar air flow

Yuan-Shiang Tsai*, Chou-Min Hsu, and Li-Wen Wang

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The initial growth of two-dimensional perturbation was studied by employing the coupled air-water interfacial linear instability theory. A numerical scheme of the filtered integration method was introduced to solve the coupled Orr-Sommerfeld equations, focusing on the temporal amplification. Different from previous studies using a turbulent boundary layer, an experimentally confirmed Blasius type velocity distribution, the Lock profile, was employed to drive the Orr-Sommerfeld equations. This is a crucial point because the physical meaning of the Orr-Sommerfeld equation is to explain the instability in the circumstance of a laminar flow.

The numerical model predicted that the temporal growth rate and phase velocity are fetch dependent. The growth rate falls with increasing downwind distance. The curves of the growth rate show significant differences between turbulent and laminar boundary layer as shown in figure 1. Previous studies with the turbulent log-linear profile, the most unstable waves are predicted in the range of the wavenumber between 400 and 600 m-1, which is corresponding to the wave frequency between 15 to 25 Hz. In contrast, in the present study using the laminar Lock profile, the most unstable wave occurs at the wavenumber decreasing as the fetch increases, generally between 90 and 200 m-1 with the corresponding frequency between 5 Hz and 8 Hz when the fetch is between 0.5 and 2.5 m. The comparison indicates that the turbulent shear flow will generate a wave pattern with a greater dominant frequency and with much larger growth rates further downstream.

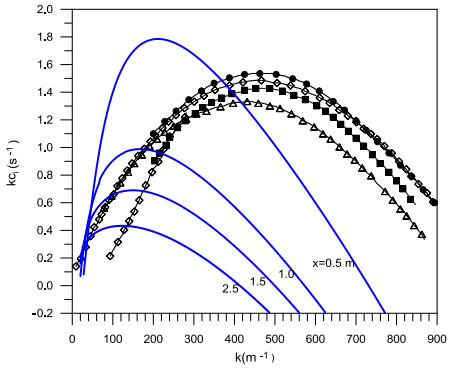

Figure 1 Comparison of temporal growth rates between calculations using the laminar Lock profile and turbulent Log-linear profile., —✕— , Miles (1962) u_*=0.23 m/s; —◇—, Valenzulea (1976) u_*=0.25 m/s; —●—, Kawai (1979) u_*=0.248 m/s; —■—,von Gastel et al. (1985) u_*=0.248 m/s; —△—, Saetra (1998) u_*=0.248 m/s; ——, present study $U_{a\infty}$ =7.2 m/s.

Wave induced currents in and around a tropical coral reef: a comparison of observations with theoretical and numerical modelling results

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Wave-driven circulation in coral reef systems is an important mechanism for water renewal behind the reefs and for maintaining a complex and fragile habitat. Coral reefs transform arriving waves and thus create special currents that are important for biodiversity and distribution of larvae, phyto- and zooplankta.

In 2009 an in-situ deployment took place in Paopao Bay, Moorea. The isolated location of the island and the unique ocean/atmosphere characteristics, like small tidal and wind influences, provide a simple test-bed for the comparison of theoretical studies of the influence of surface gravity waves on currents with observations in this special coastal environment.

In this study ADCP data are used to compare three slightly different theoretical assumptions in the analytical theory of shallow water hydrodynamics (linear, non-linear and mixed linear/non-linear approximations).

Results from a high resolution numerical model (FVCOM-SWAVE) are presented to extend the 2-D analytical solutions to a full picture of the 3-D interaction of waves, currents and topography. Especially the effects of radiation stress and Stokes drift will be discussed in detail.

Three-dimensional unsteady wave-driven littoral currents

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The multi-scale asymptotic theory by McWilliams et al. (2004) with a vortex-force formalism is extended appropriate for strong current regimes applicable to wave-driven nearshore currents around surf zones. The wave-averaged, three-dimensional primitive equations for current and tracers are derived and implemented in ROMS with appending non-conservative parameterizations that account for momentum transfer and mixing associated with depth-induced wave breaking and bottom friction (Uchiyama et al., 2010). A set of the narrow-banded WKB wave ray refraction equation and wave action balance equation is tightly coupled with the slowly evolving currents to provide wave-induced forcing. The coupled system is then applied to the Duck94/SandyDuck field datasets to reproduce three-dimensional unsteady longshore and rip currents. We demonstrate that realistic surfzone topography with shallow incident wave angles leads to unstable rip currents consisting of abrupt ejection of the inner-surfzone water to enhance cross-shore mixing, whereas shear instability of longshore currents, also known as shear waves, is induced by obliquely incident waves.

OYSA: Numerical investigation of the effect of wind on four-wave interaction

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Four-wave interaction plays an important role in the evolution of deep ocean waves. The so-called resonance condition of surface gravity waves was first discovered by Phillips (1960), and was validated by two historical experiments (Longuet-Higgins et al. 1965, McGoldrick et al. 1965). However, experimental and numerical investigations of the four-wave interactions are surprisingly scarce. It is needless to say that the influence of wind or surface current on the four-wave interaction has not been exploited and is not well understood yet. We have developed a numerical wave model which directly takes into consideration the air-layer effect (Kawamura 1998). The model was validated for 2D regular wave evolution with wind forcing (Mitomi 2006) and 3D initial wind-wave generation by wind (Hirobe 2009). In this study, we numerically investigate the wind effect on four-wave interaction, utilizing the fully coupled air-water RANS solver. Our results show that under influence of wind, the initially discrete wave spectrum becomes continuous. This spectral broadening can be accounted for by changes in the resonance condition through modification of the dispersion relation. First, the air pressure distribution along the wave profile will directly alter the dispersion relationship. Second, the wind-driven current will indirectly alter the dispersion relationship via Doppler shift. As a result of the combined effect, the resonance condition will alter in time, and likewise the waves in resonance with the initial three waves.

Initial generation of wind-waves, a comparison of physical experiment and direct numerical simulation

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A generation of wind-waves was studied experimentally revealing three stages governed by distinct physical processes: in stage 1, initial wavelets are generated due to shear instability; in stage 2, a rhombic wave pattern forms and spectral energy at around twice the period grows independent of the initial wavelets; this lower frequency peaks become dominant in energy, continuously downshift and finally in stage 3, nearly planar wind-waves accompanied by parasitic capillary waves evolve (Waseda 1997). Waseda speculated that in stage 2, wind-waves are generated in resonance with the atmospheric pressure disturbance, and therefore, denying the possibility of "period-doubling (Janssen 1986)" as the generation mechanism of the lower frequency spectral peak. Recently, Hirobe (2009) had successfully reproduced the wind-wave generation processes corresponding to stages 1 to 3 with direct numerical simulation of coupled air-sea-wave system. The initial wavelets and lower frequency spectral peaks were reproduced, resembling somewhat the original experiment by Kawai (1979). In this paper, we will analyze the coupled air-sea-wave model data from the DNS in an attempt to critically test the hypothesis posed by Waseda. Contrasting the two independent studies conducted by Waseda in 1997 and by Hirobe in 2009, it becomes apparent that numerical simulation is an extremely useful tool that can reveal key physical processes that are difficult to discover experimentally.

Thickness-weighted-mean theory for the effect of surface gravity waves on mean flows in the upper ocean

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The residual effect of surface gravity waves on mean flows in the upper ocean is investigated using thickness-weighted mean (TWM) theory applied in a vertically Lagrangian and horizontally Eulerian coordinate system. Depth-dependent equations for the conservation of volume, momentum, and energy are derived. These equations allow for (i) finite amplitude fluid motions, (ii) the horizontal divergence of currents, and (iii) a concise treatment of both kinematic and viscous boundary conditions at the sea surface. Under the assumptions of steady and monochromatic waves and a uniform turbulent viscosity, the TWM momentum equations are used to illustrate the pressure- and viscosity-induced momentum fluxes through the surface, which are implicit in previous studies of the wave-induced modification of the classical Ekman spiral problem. The TWM approach clarifies, in particular, the surface momentum flux associated with the so-called virtual wave stress of Longuet-Higgins. Overall, the TWM framework can be regarded as an alternative to the three-dimensional Lagrangian mean framework of Pierson. Moreover, the TWM framework can be used to include the residual effect of surface waves in large-scale circulation models. In specific models that carry the TWM velocity appropriate for advecting tracers as their velocity variable, the turbulent viscosity term should be modified so that the viscosity acts only on the Eulerian mean velocity.

http://www.jamstec.go.jp/frcgc/research/p1/aiki/jpo12-aiki-greatbatch.pdf

Session-2: Numerical techniques and approaches in ocean modeling

Session Chair: Tal Ezer

Afternoon, 21 May 2012

OYSA: Tracing the trajectories of particles in case of a radiological leakage from a nuclear reactor using POM

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The present work aims to find the trajectories of particles from the outfall of an upcoming Prototype Fast Breeder Reactor (PFBR) at Kalpakkam, south of the Chennai city, located on the east coast of India adjacent to Bay of Bengal. The reactor is safe in ordinary circumstances; however an attempt is made to simulate a case of radiological leakage in which some particles are released to the ocean. Such a hypothetical accidental scenario from PFBR is simulated using a three-dimensional hydrodynamic state-of-the-art ocean model (POM). Surface circulation pattern is observed as it is one of the key parameters that control the movement of the particles. The circulation patterns over this region reveal the occurrence of two prominent monsoons viz. the Southwest (SW) and the Northeast (NE) monsoons which are in the opposite directions. The simulated surface circulation depicts that the maximum magnitude of current occurs during the SW monsoon. A three-dimensional particle tracking (tracer) subroutine based on Euler forward step method is incorporated inside the main code of the model and modified as required to track the movement of a particle during different months in a year. The particle movements at the surface of the ocean depend on time and current magnitude and are presented in the form of trajectories. The resultant particle trajectories indicate that they follow the existing ocean current pattern. Thus these trajectories can be used to track the particle during any accidental radioactive leakage in the site in addition to their ability in building up a coastal forecasting system.

Effect of Atmospheric Forcing on Plume dispersion utilizing Princeton Ocean Model

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The air-sea interaction process and its implication to an outfall location emanating from a nuclear power plant are investigated in the present study. The state-of-art numerical model POM under varied forcing parameters was investigated to understand the effect of atmospheric forcing on the resultant dispersion trajectories. The numerical experiments were performed for a coastal station Kalpakkam located in the south-east coast of India with constant and variable momentum and heat fluxes. The variability of sea surface temperature (SST) arising due to these differential forcing mechanisms has been investigated. In the first set of experiment, constant momentum flux was used with reversing wind speeds of 2 ms-1 and 10 ms-1 respectively which resulted in higher plume spread for low wind magnitudes. As wind speed tends to increase, the directional spread of plume dispersion was narrow unlike the case with low winds. The addition of constant heat flux (300 Wm-2) along with constant momentum flux show marginal difference in computed SST at outfall location. The second set of numerical experiment was performed with variable momentum and heat fluxes which decipher significant variations of SST, salinity and circulation patterns. The inclusion of variable heat and momentum flux resulted in a net variation of about 2□ - 3□C in SST at the outfall location. The variation in salinity is however marginal (about 0.005 PSU) with insignificant variation in current magnitude. It could be concluded from the present study that to obtain realistic estimates of plume dispersion characteristics and associated SST at outfall location, variable heat and momentum flux is an essential pre-requisite for ocean modeling studies.

The role of secondary circulation in gravity currents

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The role of overflows and gravity currents as components of the global circulation will be addressed. In these flows, Ekman transport create transverse or secondary flows. The mixing associated with overflows may be affected by the secondary circulation. To address this, the flow of dense water in a V-shaped laboratory scale canyon is investigated by using laboratory experiments and simulations with a non-hydrostatic numerical ocean model.

An estimate of Lorenz energy cycle for the world ocean based on the 1/10° STORM simulation

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We present an estimate of the oceanic Lorenz energy cycle derived from a 1/10° OGCM-simulation forced by the NCAR/NCEP reanalysis. To the lowest order, the energy reservoirs of the ocean Lorenz energy cycle are isolated, meaning that the generation of a reservoir largely balances the respective dissipation, leaving the conversions between the reservoirs being less important. The total rate of generation amounts to 6.6 TW (tera Watts), of which 4 TW originates from the winds and the rest from the surface buoyancy flux. The dissipation of kinetic energy amounts to 4.4 TW, leaving enough room for supplying interior mixing via wind-induced mechanical power. The power exchanges between the reservoirs, which are a factor of two weaker than the major generation, are dominated by the baroclinic pathway that converts the mean available potential energy to the eddy available potential energy and finally to the eddy kinetic energy. This pathway amounts to 0.7 to 0.8 TW. Different from the atmosphere, in which the baroclinic pathway is driven solely by the differential heating, the baroclinic pathway in the ocean is facilitated not only by the surface buoyancy flux but also by the winds via the conversion of the mean kinetic energy to the mean available potential energy. This conversion is an essential constitute that distinguishes the Lorenz cycle in the ocean from that in the atmosphere. It is directed from the mean kinetic energy to the man available potential energy and amounts to about 0.5 TW, reaching about 60% of the baroclinic production in the ocean. For comparison, the same conversion is the weakest chain link, with a not well-defined direction, in the atmospheric Lorenz energy cycle. It is this conversion that makes the ocean to behave like a ”wind mill”, rather than a “heat engine”.

Effects of wind stress, topography and surface heat flux on the circulation in Tokyo Bay

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Tokyo Bay is a semi-enclosed bay which is located to the southeast of Tokyo city and connects to the Pacific Ocean through a very narrow strait. In the previous studies, many observational and modeling evidences have shown that the circulation in Tokyo Bay exhibits a strong seasonal variation characteristic. That is in summer, cyclonic circulation appears in head part of the bay; while in winter the circulation inside the bay is anticyclonic. In this study, a Multi-Scale Simulators for the Geoenvironment (MSSG model) is used to examine the effects of wind stress, topography and surface heat flux on the circulation in Tokyo Bay. Several sensitivity experiments have been conducted, through which we make an attempt to diagnose the relative importance of these factors.

Application of 3D Non-orthogonal Boundary Fitted Hydrodynamics and Sediment Transport and Wave Model in Ciasem Estuary Indonesia

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This paper presents an application of 3D Non-orthogonal Boundary Fitted Ocean Hydrodynamics and Sediment Transport Model (MuSed3D) and Wave Model (SWAN) to study sedimentary processes in Ciasem Estuary, Indonesia. MuSed3D developed by Muin (1998) on Windows System can simulate cohesive and non-cohesive sediment transport using a non-orthogonal boundary fitted grid system in spherical coordinates, which is very efficient approach to simulate the sedimentation processes in the estuary with very complex geometry. The model was applied to obtain spatial extents and time variation of suspended solid concentration, deposition, and erosion in the estuary. This study combines the sedimentation results from 3D hydrodynamics-sediment model and the result of bottom stress distribution due to wave action to observe whether the current or wave dominate in Ciasem estuary.

The calibration of model was conducted by comparing the simulation results of MuSed3D with measured data in 2010 and considering the correlation to wave distribution in the estuary. The wave input based on real wave data of a platform gauge in North of Java. The results of simulation show that the wave distribution profile has a corresponding to sediment deposition pattern which is dominated by cohesive sediment.

Session-3: Air-Wave-Sea coupled processes and modeling

Session Chair: Takuji Waseda and Fangli Qiao

Morning, 22 May 2012

Coupled atmosphere-wave-ocean modeling under tropical cyclone conditions

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A coupled atmosphere-wave-ocean modeling framework has been developed and has been used for a variety of process studies under high wind and tropical cyclone conditions. In this framework, the bottom boundary condition of the atmospheric model incorporates sea-state dependent air-sea fluxes of momentum, heat, and humidity, and may include the effect of sea-sprays. The wave model is forced by the sea-state dependent wind stress and includes the ocean surface current effect. The ocean model is forced by the sea-state dependent wind stress and includes the ocean surface wave effects (Coriolis-Stokes effect, wave growth/decay effect, Langmuir turbulence effect). In this presentation we focus on the surface wave effect on the ocean model forcing. It is shown that the effective wind forcing (momentum flux) on ocean currents may be significantly different from the wind stress under tropical cyclone conditions, where the surface wave field is typically less developed and complex. In addition, the upper ocean mixing may be significantly modified by the Stokes drift (Langmuir turbulence) depending on the surface wave conditions.

OYSA: A regional air–sea cpupled model adopted over the winter Yelollow and East China Seas

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In regions of strong sea surface temperature (SST) fronts such as Yellow and East China Sea (YES) shelves, surface winds are positively correlated with SST. In the winter YES shelves, SST is also determined by surface winds due to the surface heat flux and wind-driven ocean currents over the shallow shelves. It is therefore anticipated that SST over these areas is determined by an air-sea coupled process, and so we have established a regional air-sea coupled model to examine how SST in the YES is controlled by the coupled process. The coupled model consists of MM5 and POM. The MM5 provides POM with surface heat, freshwater and momentum fluxes, while POM gives SST as a lower boundary condition of MM5. It is interesting that the SST in the couple model is closer to the observed one than that computed in the uncoupled POM.

OYSA: Application of Anisotropy based Eddy Viscosity Model to cyclone Fung-Wong

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Eddy viscosity in turbulence is determined with the help of stability functions in three dimensional state-of-art hydrodynamic numerical ocean models like POM. These stability functions are functions of the shear number and the buoyancy number and are complex in nature. Moreover these models take into consideration the fact that the return to isotropy in turbulence is instantaneous. An alternative formulation is adopted here where the eddy viscosity depends on the second invariant to anisotropy (II). The alternative formulation takes into account an improved model for the slow pressure strain rate which incorporates within it the concept of return to isotropy. In addition this slow pressure strain rate model takes in to account the dissipation anisotropy unlike the two-equation turbulence closure models. The alternative formulation has been used to study the cyclone Fung-Wong that caused havoc in Taiwan and South China coast in July 2008. This is then compared with the existing stability function based turbulence closure model of Mellor-Yamada that is in use today in three-dimensional Princeton Ocean Model (POM). The comparisons depict that a better distribution or mixing is achieved by the present anisotropy based eddy viscosity formulation. In other words the alternative formulation with anisotropy and dissipation can speculate the features of turbulence more than the existing two equation models.

Investigation of the Response of the Ocean Mixed Layer under Surface Heating during Summer Using Large Eddy Simulation

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The response of the ocean mixed layer to the surface heating during summer is investigated using LES. The dynamical process leading to the formation of a seasonal thermocline and to the SST increase is investigated. LES results reveal that the Coriolis force plays a critical role in the formation of a seasonal thermocline, without which a seasonal thermocline cannot be formed. The MLD during summer h is found to be scaled in terms of both the Ekman length scale λ (= u_* / f) and the Monin-Obukhov length scale L (= u_*^3 / Q_0) as $h \cong 0.5(L\lambda)^{1/2} = 0.5u_*^2 /(Q_0 f)^{1/2}$, which is in contrast to the widely used scaling as $h \propto L$. Here u_* is the frictional velocity, Q_0 is the surface buoyancy flux, and f is the Coriolis parameter. The consequent increase of SST during summer is predicted as $\Delta \mathrm{SST} \propto Q_0^{2/3} f^{1/2} / u_*^2$, if the freshwater flux is neglected. The distributions of h and ΔSST during summer in the N. Pacific are also investigated by analyzing the reanalysis data in comparison with LES results.

Coupling of a Regional Atmospheric Model (RegCM3) and A Regional Oceanic Model (POM) Over the Maritime Continent

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This study describes a successful coupling of two regional models of the atmosphere and the ocean: Regional Climate Model version 3 (RegCM3) and Princeton Ocean Model (FVCOM). The coupled model is developed and tested over the Southeast Asian Maritime Continent, a region where a relatively shallow ocean occupies a significant fraction of the area and hence atmosphere-ocean interactions are of particular importance. The coupled model simulates a stable equilibrium climate without the need for any artificial adjustments of the fluxes between the ocean and the atmosphere. We compare the simulated fields of sea surface temperature, surface wind, ocean currents and circulations, rainfall distribution, and evaporation against observations. While differences between simulations, the coupled model succeeds in simulating the main features of the regional climate over the Maritime Continent including the seasonal north-south progression of the rainfall maxima and associated reversal of the direction of the ocean currents and circulation driven by the surface wind. Sensitivity experiments are then carried out to examine the difference between the coupled and non-coupled results, and the optimal coupling frequencies for different coupling fluxes.

Air-Sea-Wave Interactions in the Kuroshio and Okinawa Trough Region during the 2007 Typhoon Season

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The US Navy's Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS) was used to study the air-wave-current interactions in the Okinawa Trough and Kuroshio region during the 2007 Typhoon season. Numerical experiments with different coupling strategies were validated using satellite altimeter data (ENVISAT, JASON1 and GFO), drifter buoys, satellite images, and in-situ measurements. The domain covers a 16 x 16 degree region (118E-134E, 18N-34N). Atmospheric forcing has a spatial resolution of 27 km. The Navy Coastal Ocean Model (NCOM) has 4-km spatial resolution and the Simulating Wave Nearshore (SWAN) wave model was run at 9-km spatial resolution with 36 directions. Boundary conditions were derived from Global NCOM and Wavewatch III. The coupling between models was facilitated through the Earth System Modeling Framework (ESMF) and parameters were exchanged at 6 minute intervals. Validation results and statistics indicate coupling improved wind speed, wave height, and current predictions. Coupling also enhanced coastal upwelling with subsequent impact on SST, including the magnitude of the cold wake during strong wind or typhoon events. It is found that the most significant improvement due to air-wave–current coupling is sonic layer prediction and related acoustic properties.

Cross-comparison of wind wave modelling by wave forecasting model WAM and the coupled circulation-wave POM model

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In modelling and studying sea dynamics the interaction between sea wave and current is often overlooked. In recent years, however, more attention and efforts have been put to adequate taking into account the effect of a current on a wave motion and vice versa, the effect of surface sea waves on current generated by wind and the vertical distribution of its velocity. It is now believed the wave-current interaction should be included in modelling procedures when determining wave energy spectra. However, the significance of its effect on output wind wave field is still under discussion.

In this study the influence of wave-current interactions on the wind wave field modelled with coupled ocean circulation-wave model POM08 recently developed based on Mellor et al. (2008) is examined. This is done by cross-comparing the WAM model and the coupled circulation-wave POM08 model outputs obtained from models' runs over a number of simple artificial sea basins and for various predefined wind conditions. A series of numerical examples performed within this study provides a better idea, on one hand, about the accuracy of wind wave modelling with wave module of POM08 and, on the other hand, gives some more insight into the sensitivity of modelled wind wave fields to including wave-current interactions.

In order to make sure the wave models generate realistic results for the predefined artificial sea basins and wind forcing some empirical prediction models for wave height and period are applied. These are Shore Protection Manual (1984) prediction formulae and the Krylov method (Krylov 1966, Massel 1996). All those empirical formulae and methods have been developed based on a great number of observations taken in nature and thus provide a very reliable reference for the numerical experiments with WAM and POM08 performed and analysed in this study.

References

Krylov, Y.M., 1966. Spectral Methods of Studying and Predicting of Wind Waves. Gidrometeoizdat, Leningrad. 256 pp.

Massel, S.R., 1996. Ocean Surface Waves: their Physics and Prediction. World Scientific, Singapore. 491 pp.

Mellor, G. L., M. A. Donelan and L.-Y. Oey, 2008. A surface wave model for coupling with numerical ocean circulation models. J. Atmos. Ocean. Tech., 35, 1785-1807.

Shore Protection Manual, 1984. U.S. Army Coastal Engineering Research Center, Fort Belvoir, Vol. I–III.

Session-4: Multi-scale interactions in the ocean

Session Chair: Bo Qiu and
Jarle Berntsen

Afternoon, 22 May 2012

Ice band formation due to resonant interaction between sea ice and internal gravity waves

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Ice bands tend to be formed at marginal ice zones as wind blows off ice edge in polar seas. In this paper, a new theory for the ice band formation is proposed in which vertical velocity due to the banded structure of sea ice and that due to internal inertio-gravity waves are coupled resonantly. The across-band scale is determined by the wavelength where the phase speed of the internal waves and the ice-drift velocity coincide with each other. It was also found that growth of the ice band is preferred if the wind direction is oriented at some degree to the left (in the northern hemisphere) with respect to the ice band's travelling direction; this feature is consistent with observations. Ice-ocean coupled model was used to examine above properties of the ice band formation. It was noted that earth rotation is essential for this band formation mechanism.

Impacts of the Amur River discharge on the circulation over the northwestern continental shelf of the Sea of Okhotsk

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The Amur River, which is suspected to be a source of huge amounts of dissolved and particle iron found in the intermediate layer of the western subarctic Pacific and the Sea of Okhotsk, could significantly influence the material and thermohaline circulations. It is still unknown how the Amur River discharge controls the circulations jointly with the dense shelf water, which is formed as a result of brine rejection due to active ice formation along the coastal polynya. In this study, we will conduct a high-resolution ice-ocean coupled simulation for the northern Sea of Okhotsk from June 1998 to September 2000 to investigate the following questions: 1) Can the Amur River discharge supply materials to the dense shelf water? 2) Can the Amur River change TS property of the dense shelf water and its subduction to the intermediate layer? The simulated velocity field near the surface from spring to summer in 1999 is characterized by the northeastward flow on the shelf, the narrow westward jet along the isobath, an anticyclone in the Amur River estuary, and a cyclone over the offshore canyon that control the surface circulation to effectively transport the river discharge over the continental shelf region.

On the Dynamics of Strait Flows and their Importance for Large-Scale Circulation and Climate: An example from a Bering Sea Model.

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The dynamics of flows through narrow straits may play important roles in large-scale ocean circulation, for example, the overflow through the Denmark Strait and the Faroe Bank Channel impact the Atlantic water mass formation, and the flow through the Yucatan Channel is important for the dynamics of the Loop Current in the Gulf of Mexico. The strait transport in and out of the Bering Sea is quite complex, with many Aleutian passages connecting the Bering Sea to the Pacific Ocean in the south, but only the Bering Strait connecting the Bering Sea to the Arctic Ocean in the north. A numerical ocean circulation model of the Bering Sea, with realistic topography but idealized forcing, is used to study the dynamics of the various passages and straits and the possible interaction with the large-scale circulation. The flow dynamics in different passages depend strongly on the topography. For example, shallow passages such as the Bering Strait and the Unimak Passage have surface-intensified, near barotropic flow with maximum transport at a fixed location, while wide passages such as Near Straits have complex flow patterns with subsurface return flows that are modulated by meso-scale eddies. Comparisons of the Bering Sea passages with other straits, such as the Yucatan Channel and the Faroe Bank Channel, suggest that the dynamics of straits with a particular type of topography may be quite universal independent of geographical location.

SSH wavenumber spectra in the North Pacific from a high-resolution realistic simulation

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Following recent studies based on altimetric data, we analyse the spectral characteristics of the Sea Surface Height (SSH using a new realistic simulation of the North Pacific Ocean with high resolution at 1/30°. This simulation resolves smaller scales (down to ≈ 10 km) than altimetric data (limited to 70 km because of the noise level). In high eddy kinetic energy (EKE) regions (as in the western part), SSH spectral slope almost follows a $\mathbf{k}^{-4}$ (with $\mathbf{k}$ the wavenumber) or slightly steeper law in agreement with altimeter studies. The new result is that such a $\mathbf{k}^{-4}$ slope is also observed in low EKE regions (as in the eastern part), that mostly concerns a scale range including smaller scales than those resolved by altimetric data. Such $\mathbf{k}^{-4}$ SSH spectral slopes are weaker from what is expected from Quasi Geostrophic turbulence theory but closer to Surface Quasi Geostrophic (SQG) turbulence theory. Consequence is that the small scales concerned by these spectral slopes, in particular in low EKE regions, may affect the larger ones because of the inverse EKE cascade. These results emphasize the need for higher-resolution observations as well as modeling studies that take into account internal tides.

Emergence of wind-driven near-inertial waves into the deep ocean triggered by a turbulent mesoscale eddy field: Impact on mixing at large-scal

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Using high resolution numerical simulations in a large domain, the authors show that the interaction between the wind-driven mixed-layer and a mesoscale eddy field intensifies the frontogenesis at small-scale. The resulting submesoscale eddy field accelerates the vertical propagation of the wind-forced near-inertial waves (NIW) and produces the emergence of a maximum of super-inertial waves into the deep ocean (around 3000m) with a mean amplitude of 25m/day, a dominant 2f-frequency and, dominant scales as small as O(30km). The characteristics of the deep maximum are explained by a resonance mechanism triggered by submesoscale relative vorticity structures. Such 2f-frequency in the deep interior raises the question of the mechanisms, still unresolved, that may ultimately transfer this super-inertial energy into significant mixing at these depths.

Modeling of river water dynamics over the tidal falt – tidal creek complex and its dependence on model resolution

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Huge tidal flats with tidal creeks develop around rivers in Ariake Sea. River water that contains anthropogenic pollutants flows into the inner sea area over complicated geometry of the tidal flats. Numerical simulation for the Ariake Sea, up to date, has applied low-resolution numerical model incapable of representing the geometry in detail. The present study applied a finite volume coastal ocean model (FVCOM) with high resolution capable of representing such complex geometry. The model results have been validated against extensive observations and showed that the complex geometry of the tidal flats with tidal creeks had great effects on the dynamics of river water. Also shown is the dependence of the model accuracy on the model resolution around rivers by comparing with coarse resolution models, and its effects on the calculated dynamics of river waters.

OYSA: Numerical analysis of internal shock wave generation around an island in strongly stratified oceanic jet

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To reveal fine oceanic flow structures around the Miyake Island south Japan, we have conducted a four-day ADCP and CTD measurements from 30/Aug/2010. Vertical velocity and density profiles up to nearly 100 m were obtained. Fortunately, ALOS/PALSAR sea surface image was captured around the Miyake Island on 30/Aug/2010. Therefore, both in-situ observational data (ADCP and CTD) and satellite observational data were concurrently acquired.

The acquired SAR image shows a shock-wave-like pattern in the upstream of the island. From the CTD data, a strong seasonal thermocline was found in the upper 100 m, producing a two-layer configuration whose internal wave phase speed nearly equals the background flow speed. The nearly steady internal wave will produce horizontal current shear at the surface, stretching and contracting the surface gravity waves. The resulting sea surface roughness variation will appear in the SAR image as bright and dark pattern, revealing the internal shock wave upstream the island. From the SAR images we can estimate the oceanic situation around an island because of the internal wave/surface current – surface gravity wave interaction (Liu et al 1998).

To investigate the formation mechanism of the internal shock wave around an island of diameter about 6 km, we have conducted idealized numerical experiments of the oceanic jet flowing through an island modeled as a cylinder or a Gaussian bell shape using MITgcm. The most important parameter for the generation of shock wave is the Froude Number (Fr=U/Cint) where U is the mean fluid velocity and Cint is the phase speed of internal gravity wave. We have simulated both super-critical and sub-critical upstream flow conditions including cases without stratification. In addition, we have compared non-hydrostatic and hydrostatic simulations for each case to discover the role of internal waves in forming the shock wave. The results of numerical simulations indicate that SAR images may have captured a transient situation and not necessarily the steady shock wave pattern.

Effect of Decadal Kuroshio Extension Jet and Eddy Variability on the Modification of North Pacific Intermediate Water

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Salinity modifications in the North Pacific Intermediate Water (NPIW) core layer of 26.7-26.8 sigma_theta in the western North Pacific Ocean are investigated using temperature-salinity data from available profiling float and hydrographic measurements in 2002-09. During 2002-05 when the Kuroshio Extension (KE) jet was intense and zonally elongated, coherent positive salinity anomalies appeared along the inflow KE jet southeast of Japan and in the downstream Mixed Water region east of 152E. Broad-scale negative salinity anomalies were detected south of the KE jet and in the upstream Mixed Water region west of 152E. The signs of these observed salinity anomalies were reversed in 2006-09 when the KE jet transitioned to a weakened and zonally-contracted dynamic state. By adopting an isopycnal advection-diffusion model and conducting model runs with the time-dependent advective field inferred from the eddy-resolving, satellite altimeter sea surface height data, it is found that the observed salinity anomalies are oscillatory in nature and are determined not only by the decadally-varying KE jet itself, but also by mesoscale eddy signals that modulate temporally and longitudinally along the path of the KE jet.

OYSA: Interaction between basin scale topographic wave and estuarine circulation induced anti-cyclonic gyre in the gulf with sill type ROFI.

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We study the interaction of two circulation patterns in the gulf with sill type region of fresh water influence (ROFI). Wind driven basin scale topographic wave forms double gyre circulation with the flow in the wind direction near the coast and return flow in the central region. This circulation is independent of spatial salinity distribution. Anti-cyclonic circulation that is driven by the estuarine circulation forms at the head of gulf type ROFI when the width of the gulf is greater than the Rossby internal deformation radius.

The Gulf of Riga (GoR) a semi-enclosed sub-basin of the Baltic Sea was chosen as the study area. Estuarine type salinity distribution is maintained by inflow of saline water through the strait at the mouth of the gulf and freshwater discharge by Daugava River in the Gulf head. This is a suitable condition for the formation of anti-cyclonic circulation at the head of the gulf. Earlier studies have shown presence of wind driven basin scale topographic waves as well as anti-cyclonic circulation in the GoR.

In the present study we used three dimensional circulation model GETM (General Estuarine Transport Model, Burchard, H. et al. (2002)) that is coupled to GOTM (General Ocean Turbulence Model, Burchard, H. et al. (1999); Umlauf, L. et al. (2005)) for vertical turbulence parameterization. The numerical simulation domain covers the whole Baltic Sea but present study focuses on the circulation in the GoR area. Model simulation with realistic wind forcing, river inflows, temperature and salinity distribution were made for a ten-year period 1997-2006. The spring was chosen for analyses as then the river runoff is maximal and estuarine type salinity stratification is well established. The analyses of monthly mean circulation pattern showed well established anti-cyclonic circulation in the gulf head when wind driven circulation pattern supports it and vice versa. Multiple idealized simulations with initial estuarine type salinity distribution and different wind conditions were made to quantify the wind forcing necessery to break the esuarine circulation.

Intensified down-slope transport over a widened shelf

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This study reveals the dynamics behind intensified, down-slope, cross-isobath transport over a widened shelf during a downwelling event. We derived the unique dynamics from the analyses of linked potential vorticity (PV)-momentum balances using a three-dimensional numerical model over an idealized shelf. The intensified transport was contributed mostly by a strong along-isobath pressure gradient force (PGF), Py*. The formation of Py* was associated with the shear vorticity field induced by downwelling jet over the widened shelf, which, in turn, is determined by the strengthened cross-isobath PGF, Px*, or intensities of the shear jet. The down-slope transport over the widened shelf was strengthened in a stratified flow by the strengthened barotropic Px due to increase of volume flux upstream of the widened shelf.

The Stokes drift and wave induced-mass flux in the North Pacific

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Stokes drift and wave induced-mass flux in realistic wave fields and ocean currents in the North Pacific Ocean are studied using a third generation wave model with ambient geostrophic currents estimated from satellite altimetry data to directly estimate the Stokes drift for random directional waves. Comparison with in situ buoy data shows that the model performed well in representing the Stokes drift field and total wave momentum. In the North Pacific, the surface Stokes drift ranges from about 1 to 18cm/s and the Stokes e-folding depth is 0.5 to 3m. The Stokes drift fields estimated using bulk wave parameters compare poorly against buoy data, and are shown to overestimate (underestimate) the Stokes e-folding depth (the surface Stokes drift) computed directly from wave spectra by as much as 5-20 times larger (2-10 times smaller). The spatial distributions of mean wave height and mass transport approximately follow the synoptic scale associated with atmospheric forcing, and the divergence of wave induced-mass flux is significantly modified by local fetch, the coast and ocean currents. Due to strong wave refraction along the Kuroshio extension, surface vertical velocity induced by Stokes divergence is comparable to the Ekman velocity, and can fundamentally alter the meso-scale dynamics of the front.

Comparison between vertical shear mixing and surface wave-induced mixing in global ocean

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Most parameterizations of vertical mixing are associated with local shear instability, which does not have effects of surface waves. Here, we compare the performance of vertical mixing induced by vertical shear of the mean current and that by non-breaking surface waves in the upper ocean through three numerical experiments. The vertical mixing from vertical shear alone was too weak especially in the extra-tropical ocean, and failed to produce a reasonable seasonal thermocline, which resulted in a large cold bias and an unrealistic seasonal cycle in the subsurface. Surface waves can enhance the vertical mixing in the upper ocean, and induce vertical mixing to sustain a reasonable upper-ocean temperature structure in the extra-tropical ocean. Both the temperature structure and seasonal cycle were significantly improved by including the non-breaking surface wave-induced vertical mixing, no matter whether shear effect was included or not. These results indicate that the vertical mixing from surface waves is more important than that associated with velocity shear of the mean current for the upper ocean especially in the extra-tropics.

Session-5: Data Assimilation and Ocean Forecast Systems

Session Chair: Jinyu Sheng and Yasumasa Miyazawa

Morning, 23 May 2012

An operational system for oil spill tracking in the probability domain. Application to the Western Mediterranean Sea

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An operational model for oil spill and Search and Rescue Operations is presented. The model constructs a daily database of velocity predictions provided by an Operational Forecasting System and integrates the Eulerian velocities to obtain the trajectory forward in time adding a random walk term to simulate the diffusion. The model computes the probability density function from a set of particles giving the areas of accumulated probability.

Several tests are performed in order to determine the optimal numerical scheme as well as the internal computational time step. Diffusion is assessed by computing the distance between the trajectories of particles computed from model forecast and model reanalysis velocities. A total of 8 months of daily diffusion fields are averaged to get a constant in time and variable in space diffusion in the Western Mediterranean. The model is tested against the trajectory of three SVP-drifters deployed in the Balearic Sea. For these experiments, the position of the drifters laid within the curve of the 50% of accumulated probability for a 24 hours forecast. For a 72 hours forecast the drifters fall, in the worse cases, within the contour of 90% of accumulated probability. The areas corresponding to 70% and 90% of accumulated probability are similar in shape and magnitude.

Deep to shallow water wave-current interaction modeling with improved Boussinesq-type models

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A fully nonlinear phase resolving Boussinesq-type model with improved deep water dispersive properties is presented. The new set of equations is highly nonlinear and highly dispersive and therefore is able to model wave-current interactions both in shallow and deep waters (k*h up to 20, with k the wave number and h the local water depth). Special effort is paid in the wave and current generation within the domain using a simple source function. The numerical results are compared with analytical solutions as well as available experimental data.

OYSA: Forecasting the trajectories of drifters in the Sea of Okhotsk by using data on currents and wind

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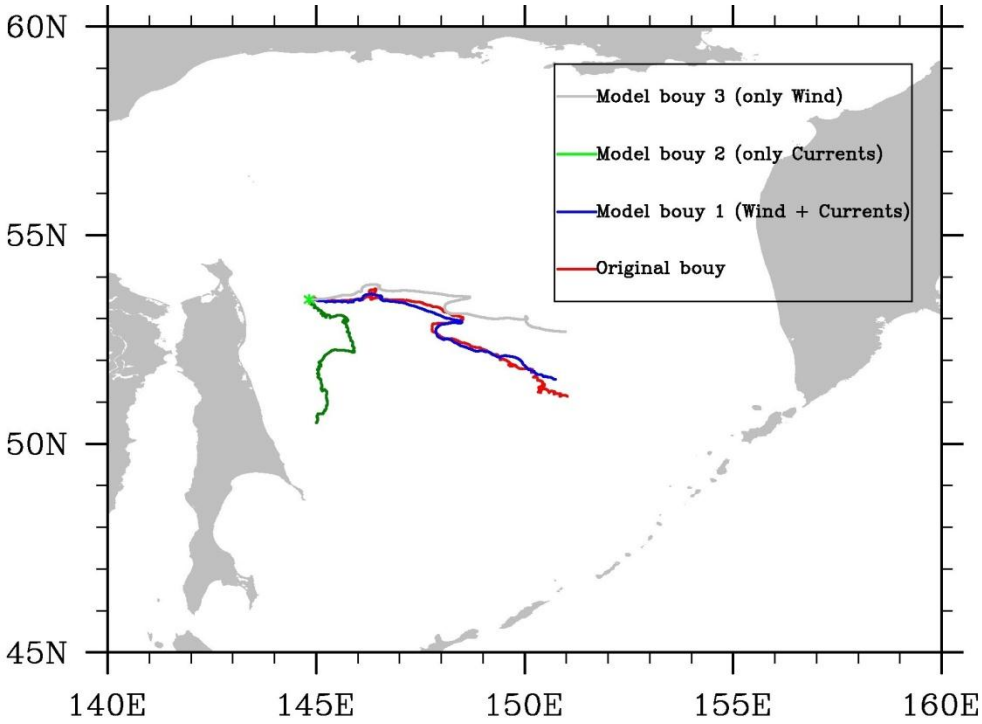
Our aim is to predict trajectories of drifting buoys using ocean data to ocean currents and wind in 10m high in corresponding time period. We have eight drifter's trajectories data packs in Okhotsk Sea from July 2008 to February 2010 inclusive. Ocean Currents were taken from Russian Hydrometeorological Center ocean model. Wind data were able to taken from NCEP NCAR Reanalysis Project 2 (NNRP2). To predict drifting of the buoy we used this equation: $\bar{X}_{new} = \bar{X}_{start} + A * U_{current} + B * U_{wind}\,(1)$, where $X_{start} -$ is point of previous buoy position, $X_{new} -$ is point of next model buoy position , $U_{current} -$ is current vector $U_{wind} -$ wind vector and A,B – coefficient vectors. Unfortunately, drifting of the buoys is strongly nonlinear moving because it depends from all previous points of trajectory and from time, where drifter came in it.

We tried to use several methods to found unknown coefficients A and B in equation 1. Initially we tried to found coefficients by a man based on assumption that the length of model and real trajectories as closer as possible. The result of applying this method to buoy "84892" You can see in Pic.1.



Picture 1. Trajectory of the buoy "84892" since September 08 2008 to November 10 2008 and modeling buoys trajectories to the same period using only wind forcing, only current forcing and A*current + B*wind forcing.

This method was shown us that it is possible to use coefficient obtained from one buoy to model another one trajectory, but it is better to use different coefficient to the different buoys.

The next method is to obtain coefficients using the least square method (LSM) to optimize difference between previous and next coordinate of real buoy $\sum_{i=1}^{n-1}((\bar{X}_{i+1} - \bar{X}_i) - (A * U_{current} + B * U_{wind}))^2$ (2), where $\bar{X}_{i+1}$ and $\bar{X}_i -$ is a point of real buoy trajectory. This method was shown us that buoys in open sea are more predictable than buoys at nearshore. The third method that we used was a genetic algorithm. For the chromosome we took concatenation of A and B vectors. Initial state of algorithm was the result of LSM. We experimented with different study and prediction periods: 7 days, two weeks and one month. Obvious the results on 7 days prediction period were better than 14 days, that better than one month period.

OYSA: Validation of Numerical Model (ROMS) in equatorial region between Ecuadorian coast and Galapagos Islands

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The Regional Ocean Modeling System (ROMS) model has been implemented in the Equatorial Oriental Pacific Ocean (EOPC) to produce a hindcast of its thermohaline structure, with the purpose of investigating the accuracy of its prediction on temperature and salinity variables in the EOPC region for three periods (Sept/2002, Oct/2005, Oct/2009) corresponding to oceanographic cruisers made by the Navy Oceanographic Institute of Ecuador, with the support of the South Pacific Permanent Commission. This region is very important because of its fisheries activity and to understand climate variability and change in the tropical Pacific, because of the interaction of the equatorial front, water masses, the Equatorial and Peru Currents; thus the validation of the forecast is necessary to determine the areas with the better and worse bias. This analysis was done from the continental coast of Ecuador to the Galapagos Islands, and from the surface to 75m in the water column. Data from In Situ measurements was revised with a quality control for the ranges and thermal inversions accepted in the Equatorial Pacific. Also, data was homogenized with objective analysis (Cressman-Poisson Technique). It was necessary to get the observed data at the same resolution and point of forecasts values from ROMS. The model has the capability to predict salinity with better accuracy than water temperature, and the bias increased as we leave the surface towards deeper waters, it's due to the time of spin up. And the least bias was for the cruise that made more oceanographic stations, It means that the number of measurements of temperature and salinity influence the hindcast analysis. The preliminary results show the potential of using the ROMS model in this area of the Tropical Pacific for a series of applications at the seasonal time scales.

ATOP – Assimilated Taiwan Ocean Prediction System

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A data-Assimilated Taiwan Ocean Prediction (ATOP) system is being developed since Jan/2012 at the National Central University (NCU) based on the mpi-version of the Princeton Ocean Model (mpiPOM; http://www.aos.princeton.edu/WWWPUBLIC/PROFS/NewPOMPage.html)

and the Princeton Regional Ocean Forecast System
(PROFS: http://www.aos.princeton.edu/WWWPUBLIC/PROFS/).

The model includes the North Pacific Ocean from 25S-75N and 100E-70W at $0.1^\circ \times 0.1^\circ$ resolution and 41 vertical sigma levels with a 4th-order pressure-gradient scheme. The model is spun up, driven by the CCMP wind from 1988-2009, and an additional experiment is also conducted using the ECMWF wind from 1979-2011; thereafter, NCEP-GFS wind is used for forecast. Since March of 2012, 7day test forecasts are issued once a day and analyses are carried out focusing on the wind and eddy-induced circulation of the western North Pacific: the Kuroshio east of Taiwan, eddies in the Subtropical Counter Current, Taiwan Straits transport and currents in South China Sea and East China Sea. For each forecast, satellite altimetry and SST data are assimilated into the model to derive the initial analysis field. Model skills are assessed by comparing hindcast and free-running model outputs against observations in the regions around Taiwan. We will report these and other progress, and outline plans for future efforts and collaborations with scientists in Taiwan and worldwide.

Operation of Tide-Resolving Regional Ocean Model for Japan Coastal Waters (JCOPE-T)

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A tide-resolving regional ocean modeling system was designed and operated for coastal waters around Japan. Model is a generalized sigma coordinates model nested to the non-tidal assimilation JCOPE model with tides introduced at the open boundaries and as a body force. Regional model has horizontal resolution of 1/36 degree and 46 vertical levels. It is forced by surface fluxes estimated by bulk formulas using analyses and forecasts of Japan Meteorological Agency and USA National Centers for Environmental Prediction. Hourly JCOPE-T model results are provided to customers and used for research purposes. One of model applications was drift estimation of radioactive substances following the Fukushima Dai-Ichi nuclear power station accident.

To deliver the statistically consistent product for ocean researchers, using JCOPE-T we have created annual re-analysis data set that would be extended up to the latest period. It was generated using hourly meteorological analyses and short term (1 to 3 hours) forecasts of JMA non-hydrostatic regional MSM model and latest ocean assimilation analyses of JCOPE system. Some features of re-analysis are discussed, including spectral characteristics of simulated and observed internal and inertial waves.

Local Ensemble Kalman Filter Analysis of Loop Current & Eddy in the Gulf of Mexico

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The Local Ensemble Transformation Kalman Filter (LETKF) algorithm with twenty-member ensemble using the mpi-version of the Princeton Ocean Model is used to estimate the states of Loop Current and eddies in the Gulf of Mexico during the BP Oil Spill period from April to August of 2010. Sensitivity tests are conducted to explore the sensitivity of the estimates to incremental additions of different observational datasets which include satellite sea surface height anomaly (SSHA), satellite sea surface temperature (MCSST), shipboard temperature and salinity profiles, and moored ADCP's. All of the tests successfully reproduced the Loop Current and eddy variability in the Gulf of Mexico, and the results were compared against independent data to assess the skills of the estimates.

Session-6: Climate Dynamics and Modeling

Session Chair: Jin-Yi Yu and
Yukio Masumoto

Morining, 23 May 2012

ENSO Events, Rainfall Variability and the Potential of SOI for the Seasonal Precipitation Predictions over Iran

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In fact, the day to day weather which we are experiencing locally may be the result of climatic events that occur in some other part of the world. The studies in recent decades show that many natural disasters such as tropical severe storms, hurricanes development, torrential rain, river flooding, and landslides in some regions of the world and severe droughts and wildfires in other areas are due to El Nino-Southern Oscillation (ENSO). The El Nino is defined by water pressure gradient along the west-east tropical region of southern Pacific Ocean known as Southern Oscillation Index (SOI), as well as by temperature anomaly of the surface water in some points in the Pacific Ocean.

In this paper the impact of SOI index on rainfall variability and the seasonal precipitation predictions for 40 synoptic meteorological stations, distributed over different parts of Iran, during 46 years period (1960-2005), was estimated. Due to the fact that about 80 percent of water resources in Iran are fed by autumn and winter rainfall, the precipitation variations in autumn and winter seasons have been analyzed only. The results show that during autumn, the positive phase of SOI is associated with decrease in the rainfall amount in most part of the country; negative phase of SOI is associated with a significant increase in the rainfall amount. It is also found that, during the winter time when positive phase of SOI is dominant, water resources and winter precipitation increases in most areas of the eastern part of the country while at the same time the decreases in the amount of rainfall in other parts is not significant. Moreover, with negative phase of SOI in winter season the amount of rainfall in most areas except costal band of Caspian Sea in the north decreases, so that the decrease of rainfall amount in the eastern part is statistically significant but the increase of precipitation in costal band of Caspian Sea is not significant.

OYSA: Air-Sea coupling and the quickening pace of Loop Current shedding in a warming climate

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The shedding of Loop Current eddies in the Gulf of Mexico has long been considered to be primarily driven by internal chaotic dynamics. Recent studies suggest that eddy-shedding is both internally-driven and wind-forced, has biannual (summer and winter) preferences, and therefore is not entirely chaotic. The process may then be subject to larger-scale and longer-term climate forcing. Here we show that the rate of eddy-shedding has accelerated to become more biannual in recent decades after 1995 concurrent with the warming of the tropical Atlantic sea-surface temperature (SST). The meridional SST-gradient across the Caribbean Sea and warming of the eastern Gulf by the Loop Current are coupled to the atmosphere to produce anomalously stronger fluctuations of the seasonal trade wind after 1995, making the Loop Current more susceptible to shed eddies. Our results establish for the first time the importance of coupling between wind, Caribbean Sea SST and Loop Current dynamics to the climate variability of tropical-subtropical Atlantic.

OYSA: Simulation of Princeton Ocean Model for Northern Indian Ocean: A study of Indian Monsoon events with simulated SST anomalies

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The Northern Indian Ocean (NIO) is unique in itself in more ways than one. NIO is divided into the Arabian Sea and the Bay of Bengal by the Indian subcontinent. Apart from the similarities between Arabian Sea and Bay of Bengal, like being in the same latitudinal region and receiving same amount of incident solar radiation, it is the dissimilarities that make up for most of the complexities in this region. The sea surface temperature, being one of the dissimilarities, is higher in the bay than in the Arabian Sea region, because of the difference in their heat budgets. The Indian Ocean Dipole is a very important phenomenon influencing the Indian summer monsoon. It is the difference in the SST's between the Arabian Sea and the Bay of Bengal. A positive IOD means a stronger monsoon but a negative IOD leads to a weaker monsoon.

The main aim of the present study is to analyze the simulated results from a numerical ocean model for positive and negative IOD events and consecutively relate these results to good monsoon years and bad monsoon years. Princeton Ocean Model (POM) is used for this study. After the spin up, the POM is simulated for a period from 1999 to 2009 with QSCAT real time winds as input. For the period from 1999 to 2009, 2002 and 2004 are considered as the bad monsoon years and 2006 and 2007 are the good monsoon years as notified by the India Meteorological Department.

The simulated SST anomalies for these study years were analyzed for positive and negative IOD events. It is observed that 2002 and 2004 (bad monsoon years) have negative IOD, -6o C and -16oC respectively and 2006 and 2007 (good monsoon years) have positive IOD, +11oC and +9oC respectively for the month of May (pre-monsoon month). POM is able to show the relationship between the IOD events and monsoon.

Modeling the Two Types of ENSO and Their Climate Impacts

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One major new development in El Niño research that needs to be adopted in the analysis and development of coupled climate models is the recognition of the existence of two distinct types of El Niño-Southern Oscillation (ENSO): an Eastern-Pacific (EP) type that has its sea surface temperature (SST) anomalies centered near the cold tongue and a Central-Pacific (CP) type that has its SST anomalies centered near the international dateline. One source of uncertainty in model projections of future ENSO activity and climate impacts will have to do with the type of ENSO produced in each of the models. In this talk, we discuss the underlying dynamics of these two types of ENSO, the keys to their realistic simulations, and the modeling of their different impacts. Analyses with observations, NCEP CFS models, and both the CMIP3 and CMIP5 models will be presented.

The Atlantic ITCZ simulated in the new high-resolution coupled climate model GFDL-CM2.5

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Using two fully coupled ocean-atmosphere models of CM2.1 (the Climate Model version 2.1 developed at the Geophysical Fluid Dynamics Laboratory) and CM2.5 (a new high-resolution climate model based on CM2.1), the characteristics and sources of SST and precipitation biases associated with the Atlantic ITCZ have been investigated.

CM2.5 has an improved simulation of the annual mean and the annual cycle of the rainfall over the Sahel and the northern South America, while CM2.1 shows excessive Sahel rainfall and lack of northern South America rainfall in boreal summer. This marked improvement in CM2.5 is due to not only high-resolved orography, but also a significant reduction of biases in the seasonal meridional migration of the ITCZ. In particular, the seasonal northward migration of the ITCZ in boreal summer is coupled to the seasonal variation of the SST and a subsurface doming of the thermocline in the northeastern tropical Atlantic, known as the Guinea Dome.

A review of the Indian Ocean Dipole: An Australian perspective

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The Indian Ocean Dipole (IOD) is a dominant mode of interannual variability in the tropical Indian Ocean, having significant impacts on the climate of surrounding countries, including Australia. A review of recent findings by our climate group with regards to the IOD is presented. Topics include the simulation of the IOD by CMIP3 and CMIP5 models and diagnosis of some key properties, such as amplitude, non-linear responses, and the IODs relationship with other climate modes such the El Niño-Southern Oscillation (ENSO) and Southern Annular Mode (SAM). In addition, we draw upon some observational data to test the validity of model results. Future simulations are also investigated to gain an understanding of whether there is any relevance of current climate IOD properties to future climate changes.

Session-7: Circulation and transport/ exchange in coastal seas

Session Chair: Jianping Gan and Chau-Ron Wu

Afternoon, 23 May 2012

OYSA: Study on the circulation features in the Mekong river mouth area by ROMS model

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This paper presents circulation features in the Mekong River mouth area by using ROMS model corresponding to monsoonal winds (SW monsoon from June to August, and NE monsoon from November to March of the next year). Modeled results were relatively suitable to measured data. Study results show that during NE monsoon period existence a current system flows paralelle to the coast from north to south and Mekong River water is constrained to the coast in southward direction up to Camau Headland. In contrast during the SW monsoon period existence a current system flows paralelle to the coast from south to north. In river mouth region the dominant current was flowing towards west direction. Whereas, in offshore region the dominant current was flowing towards south-west direction. The above mentioned features of current system have been occurred at all water layers in the study area.

Numerical Study of the Far-field Effect of Tidal Energy Extraction in the Minas Passage on Circulation and Hydrography in the Bay of Fundy and Gulf of Maine

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A nested-grid shelf circulation model based on the POM was developed for the Gulf of Maine and the Bay of Fundy (GoM-BoF). The nested-grid model consists of a coarse-resolution (~4.5 km) parent sub-model for the GoM and a high-resolution (~1.5 km) child sub-model for the BoF. A two-way nesting technique is used in exchanging information between the parent and child sub-models. The shelf circulation model was successfully in examining the far-field effect of tidal in-stream energy extraction in the Minas Passage of the BoF on the three-dimensional (3D) barotropic tidal circulation in the GoM-BoF (Hasegawa et al., 2011). In this study, the nested-grid model is used in examining the far-field effect of the tidal in-stream energy extraction on the 3D baroclinic circulation and temperature/salinity distributions in the GoM-BoF. The tidal in-stream energy extraction is parameterized in terms of nonlinear Rayleigh friction in the model momentum equation. Two special cases are considered in which harnessing tidal in-stream energy is taken from (a) the entire water column and (b) the lower water column within 20 m above the bottom in the Minas Passage. The model results in these two cases will be presented.

The Weak Influence of the Tidal Residual Currents on Lagrangian Trajectories in the Southwestern Yellow Sea

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The influence of the tidal residual currents on Lagrangian trajectories is investigated using a high-resolution circulation model of the southwestern Yellow Sea with and without wind forcing, which is based on the Princeton Ocean Model (POM). The simulated tidal harmonic constants agree with the observations and existing studies well. The numerical experiment reproduces the broad southeastward Eulerian tidal residual current over the sloping bottom around Yangtze Bank as shown in previous studies. However, the artificial drifters deployed at the northeast flank of Yangtze Bank in the simulation move northward against this strong southeastward Eulerian tidal residual current rather than follow it. The result suggests that the influence of tidal residual currents on Lagrangian trajectories is weaker than that of southerly wind. Thus, the Lagrangian trajectories (Lagrangian velocities) are dominated by wind driven currents in the southwestern Yellow Sea. The result is consistent with the northeastward movement of ARGOS surface drifters released in the southwestern Yellow Sea in the summer of 2009. Further analyses suggest that the quadratic bottom friction scheme is the crucial factor for the weaker influence of the tidal residual currents on Lagrangian trajectories in the southwestern Yellow Sea. This study demonstrates that Lagrangian trajectory and Eulerian velocity could have different directions of movement at shallow coastal regions due to nonlinearity of the bottom friction.

OYSA: Numerical Simulations of the upper Gulf of Thailand: Coastal Dynamics and Forcing Mechanisms

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A high-resolution (~1 km) sigma-coordinate ocean circulation model has been used to study the forcing mechanisms and coastal dynamics of the upper Gulf of Thailand (UGOT). The upper Gulf is a low latitude shallow basin (average depth ~15 m; size ~100x100 km) which is influenced by the seasonal monsoon winds and potentially circulation patterns in the lower Gulf. The model forcing includes tides, wind stress and surface heat fluxes. The latter includes a cloud cover component, which is strongly related to the seasonal monsoon. Sensitivity experiments are conducted to investigate the role of different forcing mechanisms, and to study the tidal, sub-tidal and seasonal dynamics. The influence of the wind stress on the shallow topography of the UGOT resulted in seasonal shifts between clockwise and counter-clockwise circulations during the southwest and northeast monsoons, respectively. Even with spatially constant surface forcing, narrow plumes of anomalous temperatures are generated along the coast and advected around the upper Gulf by the coastal currents. Interannual variability due to the impact of ENSO are simulated, whereas surface temperatures in the upper Gulf can be 2-4°C warmer during an El Nino year compared to a La Nina year.

Topographic influence of the Kii peninsula on the strength of the Kuroshio and its variability

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As the Kuroshio currents flow along the southern boundary of the Japan, the flow encounters irregular coastlines. Especially the Kii peninsula is one of the major bumps intersecting the Kuroshio. By analyzing JCOPE2 ocean reanalysis data, we investigated the topographic influence of the Kii peninsula on the strength of the Kuroshio and its variability. Sudden acceleration of Kuroshio jet appears off the Kii peninsula. The increase of velocity is accompanied by downstream flow separation from the coast and an outcrop of cold temperature inshore. The sudden acceleration of Kuroshio appears in Kuroshio non-Large-Meander. The Kuroshio acceleration collocates with the topographic ridge of the continental slope. Thus, we propose the dynamics of this Kuroshio acceleration as a type of hydraulic control. Short term variations (10-50 days) on the Kuroshio also change their amplitudes as they pass off the Kii peninsula. The eddy activities are much stronger on the downstream side than the upstream side. The Kii peninsula acts to trigger various types of eddy.

Modeling the circulation in the Beibu Gulf, South China Sea

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The circulation in the Beibu Gulf (the Gulf of Tonkin) is modeled using the Princeton Ocean Model. The simulation for 2006 and 2007 with the tide, daily wind and heat flux, as well as monthly discharge from several major rivers in the region compares favorably with in situ observations. The interior circulation shows an apparent seasonal variability. In summer the surface circulation consists of an unclosed anticyclonic gyre in the southern gulf (south of ~19° N) and mostly northeastward flows in the north, whereas in winter the pattern changes to an unclosed cyclonic gyre in the southern gulf and mostly southward flows in the north. The Guangxi coastal current is westward throughout the year. The current in the Qiongzhou Strait is mostly westward and its strength is sensitive to the wind and sea level gradient between the two ends of the Strait, through which the less saline water from the Guangdong coast enters the Beibu Gulf under the northeasterly wind. The salinity distribution in the northern Beibu Gulf and along the northern Vietnam coast is strongly affected by rivers. On the other hand, the high salinity water from the South China Sea penetrates into the gulf to ~20° N only in winter, but it can reach the western mouth of the Qiongzhou Strait along the western coast of Hainan Island in summer.

Numerical simulation and dynamical analysis for the low-salinity water lenses in the northeast out of the Changjiang river mouth

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The expansion of the Changjiang diluted water (CDW) is a dominant hydrographic phenomenon in the East China Sea. Observations clearly show that there are some isolated low-salinity water lenses (LSWLes) in the expansion area of the CDW, which change the traditional structure of the Changjiang River plume, and also the characteristic of salinity in the East China Sea. The numerical simulaiton and dynamical analysis for the real LSWLes is absent.

A new vertical hybrid σ-z coordinate, namely σ coordinate for current and hybrid σ-z coordinate for salinity, is introduced to POM to develop POM-σ-z. The real LSWLes in the northeastern area outside of the Changjiang Estuary in Aug 1977, Aug 1983 and Aug 1986 have been simulated with POM-σ-z. POM has also simulated the LSWLes in Aug 1977, Aug 1986, but it failed to simulate the LSWL in Aug 1983.

A series of numerical experiments using POM-σ-z are set up to analyze the dynalmical mechanisms of the LSWLes in Aug 1977, Aug 1983, Aug 1986. The results indicate that wind makes important influence on each LSWL. The influence of tide on LSWL is complex. In general, the effect of tidal mixing restrain the formation of LSWL.While the vertical tidal mixing from neap tide to spring tide vails to the formation of LSWL. And the tidal Lagrange residual current is useful to LSWL's formation in the northeast out of the Changjiang river mouth. The river discharge and the Taiwan Warm Current make little influence on the formation of LSWL.

OYSA: The importance of the wind-driven circulation in the tidally-driven Malacca Strait

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The Malacca Strait is traditionally treated as a typical tidally-driven channel with other components of the circulation, such as the wind-driven one, negligible. However, the strait is frequently affected by the variable winds with high intensity and large stress curl due to the intense land-sea breeze distorting the background along-strait monsoon. To answer the question of how significant the wind-driven circulation is on impacting the total circulation, numerical simulations are carried out by separating and superimposing the different driving mechanisms. The results show that "strong winds" having high intensity and large stress curl can produce a basin-scale eddy which significantly distorts the tidal circulation even during the spring tide. The eddy is purely wind-driven, but its center is shifted southeastward from the deeper to the surface layer by the realistic topography through the bottom pressure torque. The contracted geometry of the strait only has a secondary effect on the circulation. Our study highlights the importance of including the full wind forcing in the predictions of the current circulation in a tidal channel like the Malacca Strait, as accurate predictions are important for local fisheries and navigation.

Wind-driven surface Kuroshio intrusion into the South China Sea

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We use a high-resolution numerical model to examine the forcing mechanism responsible for the Kuroshio intrusion into the South China Sea. A series of experiments are carried out to identify the wind-related forcing regulating the intrusion. Model experiments demonstrate the importance of wind inside the South China Sea is superior to that outside the South China Sea. Especially, wind stress curl is chiefly responsible for the Kuroshio intrusion. Both wind stress curl and intrusion present not only seasonal variation, but also intra-seasonal fluctuation. The good consistency between wind stress curl variability and intrusion suggests that wind stress curl is the driving force for the variation of the Kuroshio intrusion.

Session-8: Modeling of sediment transport dynamics in ports, harbors and coastal environments

Session Chair: Xiao Hua Wang

Morning, 24 May 2012

OYSA: Sediment dynamics in Darwin Harbour, Northern Territory, Australia

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The sediment dynamics of Darwin Harbour is studied by a sediment model (Wang, 2002) and a hydrodynamic model based on FVCOM. The sediment model bathymetry includes the high resolution Darwin Harbour coastal line, sea surface area and mangroves distribution. The model is forced by tides at the ocean open boundary with constant salinity and temperature. 20 sigma layers with 3/4 logarithmic layers near the surface/bottom and 13 evenly distributed layers in the middle are used in the model. The observed tidal elevation, currents and the suspended sediment concentration (SSC) data were used to calibrate the model.

The simulation finds that the SSC in the Habour reaches the maximum at the bottom near Nightcliff Jetty and in the channel at spring and neap tide with a value of 10.0 and 0.1 gm^{-3}, respectively. During spring tides, vertical averaged residual flux of SSC is mainly landward with a value of 0.8 $gm^{-2}s^{-1}$. During neap tide, vertical averaged residual flux of SSC is seaward with peak value of 0.05 $gm^{-2}s^{-1}$. An eddy in the East Arm found by David (2009) is also well reproduced by the model.

OYSA: Study of the Turbidity Maximum in the Deepwater Navigation Channel in the Yangtze River Estuary

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A field work has been conducted in the Deep Navigation Channel (DNC) in the Yangtze River Estuary to study the suspended sediment transport and the turbidity maximum there. The in-situ data shows that the water is highly stratified on neap tides, but relatively well mixed on spring tides. The sediment resuspension is affected by strong stratification. Analysis of residual flux shows the suspended sediment transport is determined by residual flow during spring tidal cycles, but tidal pumping also plays an import role during neap tidal cycles.

The timeseries of suspended sediment concentration indicates that the highly turbid water is not locally generated but transported upstream like salt intrusion. The model results verify that it is related to the estuarine turbidity maximum (ETM) generated in the sand bar area. The model also confirms that the gravitational circulation plays the major role in the ETM formation in the North Channel, but tidal distortion effects dominate the ETM in the South Passage. By using of this model, we explained the intrusion of the turbid water to the DNC and the siltation occurred in the DNC. In addition, the DNC impacts on the suspended sediment transport and turbidity maximum are given through comparing the situation before and after its construction. We found the turbidity maximum in the North Passage has been dramatically reduced since its completion, but it is not able to solve the silting problem completely.

Sediment transport dynamics in ports, estuaries and other coastal environments

Xiao Hua Wang

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Given our ever expanding global trade, international economy is linked to the well-being of major coastal infrastructure such as waterways and ports. This talk concerns topics from both observation and modelling of sediment erosion, transport and siltation in the ports, estuaries and other coastal environments. I will present several case studies of the sediment dynamics in the high-energy environment such as Po River estuary in the Adriatic Sea (Italy), Mokpo Coastal Zone in the Yellow Sea (Korea), Shanghai Port in the East China Sea (China) and Darwin Harbour, Australia, where strong sediment resuspension/deposition and transport are driven by surface waves, tides, winds and buoyancy driven currents. Interdisciplinary studies of sediment effects on the ecosystems in these turbid environments will also be discussed.

Session-9: Biogeochemical Oceanographic Modeling

Session Chair: Huijie Xue and Xinyu Guo

Morning, 24 May 2012

Typhoon-induced Phytoplankton Blooms and Primary Productivity Increase in the Western North Pacific Subtropical Ocean

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Using multiple satellite observations and series of numerical experiments, this work systematically studied phytoplankton blooms induced by tropical cyclones in the western North Pacific subtropical Ocean (WNPSO), because WNPSO is among the world oceans where most number of intense tropical cyclones are found. All eleven typhoon cases passing the study domain in 2003 were examined in detail. It was observed that only two typhoons (18%) were able to induce phytoplankton blooms (chlorophyll-a concentration increased from $\leqq$0.1 mg m^{-3} to 0.4-0.8 mg m^{-3}) and strong sea surface temperature cooling of -2.5 to -6℃. The other nine typhoons, including the most intense tropical cyclone on earth in 2003 (i.e., supertyphoon Maemi), were not able to induce phytoplankton blooms and the associated sea surface temperature cooling was weak (0 to -1.5℃). Using series of numerical experiments, it was found that the presence of warm ocean eddy can effectively isolate the cold, nutrient-rich water to be entrained to the surface ocean. Under this situation, even category-5 typhoon Maemi at its peak intensity of 150kts could not induce phytoplankton bloom in the WNPSO. The weak responses of the other eight typhoons were due to insufficient wind intensity and transit time (caused by relatively small storm size and fast translation speed) in this deep nutricline/mixed layer ocean. As a result, the total annual primary production increase induced by typhoons in the WNPSO was estimated to be ~ 3.27×10^{12}g C (0.00327 Pg), equivalent to 0.15% of the global annual anthropogenic CO_2 uptake. This suggests that though WNPSO has the highest number and intensity of tropical cyclones among the world oceans, tropical cyclones in the WNPSO have little contribution to enhance biological carbon fixation in the context of global carbon-climate system.

Reference:

Eric D'Asaro, Peter Black, Luca Centurioni, Patrick Harr, Steven Jayne, I-I Lin, Craig Lee, Jan Morzel, Rosalinda Mrvaljevic, Peter Niiler, Luc Rainville, Thomas Sanford, and Tswen-Yung David Tang (2011), Typhoon-Ocean Interaction in the Western North Pacific, Part 1, *Oceanography*, Vol. 24, No. 4, p. 24-31, doi: 10.5670/oceanog.2011.91.

I-I Lin (2011), Typhoon-induced Phytoplankton Blooms and Primary Productivity Increase in the Western North Pacific Subtropical Ocean, *Journal of Geophysical Research - Oceans*, in press, doi:10.1029/2011JC007626.

I-I Lin, Iam-Fei Pun, and Chun-Chieh Wu (2009), Upper Ocean Thermal Structure and the Western North Pacific Category-5

Typhoons Part II: Dependence on Translation Speed, *Monthly Weather Review*, Vol. 137, Issue 11, p. 3744-3757, doi: 10.1175/2009MWR2713.1.

I-I Lin, W. Timothy Liu, Chuin-Chieh Wu, George T.F. Wong, Chuanmin Hu, Zhiqiang Chen, Wen-Der Liang, Yih Yang, and Kon-Kee Liu (2003), New evidence for enhanced ocean primary production triggered by tropical cyclone, *Geophysical Research Letters*, vol. 30, No. 13, 1718, doi: 10.1029/2003GL017141.

Iam-Fei Pun, Ya-Ting Chang, I-I Lin, Tswen-Yung Tang, and Ren-Chieh Lien (2011), Typhoon-Ocean Interaction in the Western North Pacific, Part 2, *Oceanography*, Vol. 24, No. 4, p. 32-41, doi: 10.5670/oceanog.2011.92.

Modeling Carbon Cycle and Biological Productivity in the Pacific Ocean

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The ocean plays an important role in regulating global carbon cycle by taking up and releasing carbon dioxide (CO2) from and to the atmosphere simultaneously. From 1800 to 1994, the ocean absorbed about 50% of CO2 emitted to the atmosphere by fossil fuel burning (Sabine et al., 2004), and this ability has been suggested to continue at a relatively stable rate of 1.4-1.8 PgC per year (Gloor et al., 2003; Takahashi et al., 2009). One challenge to understand and predict the mechanisms regulating ocean's ability, in terms of sources and sinks of CO2, is that the contemporary variability of CO2 flux consists of a natural component, i.e. the variability due to the atmospheric CO2 existed in preindustrial period and due to the physical and biological process changes in the ocean, and an anthropogenic component due to human activities. However, until recently, routine measurements or other inversion calculations usually can't fully separate each of these components due to very limited observations, and subsequently evaluate the contributions from each of them.

In this work, we use a coupled three-dimensional numerical modeling study to investigate the dynamics of carbon cycle in the Pacific Ocean (45°S to 65°N, 100°E to 70°W). The physical model is based on the Regional Ocean Modeling System (ROMS), which has a spatial resolution about 50 km and 20 vertical layers (Chai et al., 2009). The biogeochemical model is based on the CoSiNE model (Chai et al., 2002), along with the carbonate system from Fujii and Chai (2007). To elucidate the influence of anthropogenic CO2, two modeling studies were conducted. The first one is the control run forced with measured atmospheric CO2 at Mauna Loa Observatory from 1958 to 2010. The other one is a case run forced with the constant atmospheric CO2 from 1958 (with seasonal cycle fixed at 1958 values). Both of the runs are integrated from 1958 to 2010 with the same initial condition and wind, heat, and freshwater forcing at the air-sea interface. The results from the control run were compared with available in-situ measurements. For example, we compared modeled dissolved inorganic carbon (DIC) and nutrients with World Ocean Circulation Experiment (WOCE) transections (P2 and P16N). We also compared modeled sea pCO2 and pH time series with in-situ measurements from South East Asia Time-Series (SEATS), the Hawaii Ocean Time-Series (HOT), the Monterey Bay Time Series, and eastern Equatorial Pacific Ocean (EEP). All those comparisons show good agreements suggesting the coupled model is enough to be used to investigate different scenarios and cases. Further analysis of the model results indicate the carbon

cycle dynamics in the Pacific Ocean has strong spatial and temporal variations in terms of sea pCO2, pH, and the calculated aragonite saturation state. Long-term trends of these variables were also analyzed, which show conspicuous spatial variation that could be related to the local physical and biogeochemical processes. We separate the total carbon system (control run) into the internal (natural) one (case run) and the forced one (anthropogenic). Thus, we are able to investigate the pathway and penetration depth of the anthropogenic CO2 in the Pacific Ocean, as well as the individual contributions from the internal (natural) component and the anthropogenic component. This modeling study allows us to look into the detailed mechanisms in regulating carbon cycle with high spatial and temporal resolutions that field observations can't provide. Our modeling results also provide us means to investigate the rate and severity of ocean acidification in the different regions of the Pacific Ocean (Feely et al., 2008).

The age of Yellow River water in the Bohai Sea

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To quantitatively understand the transport timescale of dissolved material discharged from large rivers into a semi-enclosed sea, the age of Yellow River water in the Bohai Sea was calculated with a constituent-oriented age and residence-time theory and particle-tracking method. Yellow River water has a mean age of 3.0 years for the entire Bohai Sea. The spatial variation of the water age is significant: 1.2 years near the Yellow River estuary but 3.9 years in the Liaodong Bay. However, the temporal variation in water age is insignificant at a minimum of 2.8 years in fall and a maximum of 3.1 years in spring. To understand the strong spatial but weak temporal variations in the water age, water parcels were released at the Yellow River mouth. The water parcels released at the river mouth needed only several days to reach the estuary area. The great water age (1.2 years) near the Yellow River estuary is caused by the presence of aged water particles that initially left this area but returned to this area again after a long journey. Without the re-entry of Yellow River water from the Yellow Sea to the Bohai Sea, the mean age of Yellow River water in the Bohai Sea decreases from 3.0 years to 1.2 years. Calculations without tidal forcing give a reduction in mean water age of more than 50%, suggesting that tidal forcing plays the most dominant role in controlling the age of Yellow River water in the Bohai Sea. Calculations without winds give an increase in water age, which is consistent with the understanding that wind-driven currents are favorable for water exchange through the Bohai Strait. Changes in discharge of the Yellow River and in thermal stratification have limited influences on the age of Yellow River water.

Turbulent mixing by tropical storm and phytoplankton bloom in the southeast continental shelf region of Hainan Island

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The South China Sea (SCS) is a tropical oligotrophic continental shelf sea with low primary productivity. However, after the passage of tropical cyclone or hurricane, the bloom of chlorophyll a (chl-a) often observed by remote sensing in the SCS. Previous work focused on the contribution of strong and slow-moving typhoon on marine ecosystem in the SCS. The present study analyzes the bloom of chl-a after a weak and fast-moving tropical storm Washi in the southeast continental shelf of Hainan Island. Observations indicate that a strong vertical turbulent mixing is existed during the tropical storm Washi, and evident enhancement of Chl-a after the storm with a significant increase of 111.1%. The prominent increase of Chl-a may be attributed by the wind-forced near-inertial mixing which can be raised the uptake fluxes of nutrient-rich deep waters into the lower euphotic zone during the passage of tropical storm Washi.

Poster session

A side of Miyoshi Memorial Hall

21-24 May 2012

Analysis of sediment transport in the central region of Santos (SP, Brazil) through numerical modeling

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(Presenter: Hemínio Foloni Neto)

This study aimed to analyze the sediment transport in the central region of Baixada Santista (SP, Brazil) using the numerical model ROMS (Regional Ocean Modeling System) coupled to the numerical model SWAN (Simulating Waves Nearshore) in simulations representing the months of August 2009 and January 2010. The results suggested peaks in sediment transport, especially on the continental shelf and the Bay of Santos, during the passage of frontal systems, reaching values of 4,2 kg m^{-2} s^{-1} nearshore. The lowest rates of concentration of suspended sediment in the water column occurred during periods of neap tides, without the presence of strong winds and incidence of waves with high energy. In both simulated months, the bedload transport found in the coastal area was predominantly to the southwest, with the highest rates of transport observed in the month of August, with values of 1 x 10^6 kg m^{-2}. The rate of sedimentation in the upper estuary has been on the order of 1 cm $year^{-1}$, in agreement with the data available in the literature. The numerical model represented the transport patterns of sediments found in the region in a satisfactory way.

Numerical Study of Circulation in the Abandoned Yellow River Mouth And Adjacent Coastal Waters

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The abandoned Yellow River Mouth (AYRM) in Northern Jiangsu Province, China is a typical erodible silty and muddy coast which has been undergoing severe coastal erosion since 1855 when the Yellow River diverted directly into Bohai Sea. A coastal circulation model based on Princeton Ocean Model (POM) was used to investigate the circulation and variability in the abandoned Yellow River Mouth and adjacent coastal waters. The simulated surface elevations and tidal currents agreed well with the observations made in 2006. The circulation in the summer is stronger than that in the winter, with the average surface residual velocity being about 7.3 cm/s during the summer while only 3.8 cm/s during the winter. Using the same coastal circulation model, several well-designed numerical experiments were performed to investigate the effect of oceanic tide, wind stress, and thermal stratification on the circulation. The results shown that winds play an important role in the circulation in the AYRM during both winter and summer. Density circulation is important during summer; however, it is negligible during winter. Compared with the wind and thermohaline effect, the contribution of the tides is small during summer.

Numerical Simulations of the Hydrodynamics in the Coastal Waters of the Nan-Wan Bay in Southern Taiwan

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The Nan-Wan Bay is located in the southernmost Taiwan which is a semi-enclosed basin. The Bay is surrounded by the Pacific Ocean in the eastern side and Taiwan Strait in the western side and faces the Luzon Strait to the south direction. The sea surface temperature is typically 22~26°C in winter but rises to 24~29°C in summer. Jan et al. (2009) indicated that the temperature fluctuation is primarily caused by internal tide-induced upwelling. Observations showed that currents are dominated by tidal force, generating southwestern flows in the flood and northeastern flows in the ebb. The amplitudes of tidal currents range from 0.2 to 0.4 m/s. It was also observed that there is a sudden temperature drop approximately up to 9°C when the tide is approaching lower low water level. In the present study, a parallel computation and high-resolution three-dimensional tidal model, the Princeton Ocean Model (POM), was used to simulate ocean current in the coastal waters around southern Taiwan. Fig. 1 and 2, show that the results of numerical model represents typical characteristics of the hydrodynamics in the Nan-Wan Bay. The simulation reveal that there is a main stream outside the Bay with the direction from west to east. Inside the Bay, the current forms a counter clockwise vortex because of the topographic effect during neap tides. In contrast, during the spring tide, the main stream is significantly influenced by the tidal force, changing its flow direction into the Bay. This current then flows out the Bay to the Taiwan Strait with the direction from east to west. Different to the neap tide, there is no apparent vortex formation in the Bay.

Argo data assimilation in ocean general circulation model of Northwest Pacific Ocean

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The Argo temperature and salinity profiles in 2005-2009 are assimilated into a coastal ocean general circulation model of the Northwest Pacific Ocean using the ensemble adjustment Kalman filter (EAKF). Three numerical tests, including the control run (without data assimilation, which serves as the reference experiment; CTL), ensemble free run (without data assimilation; EnFR) and EAKF experiment (with Argo data assimilation using EAKF), are carried out to examine the performance of this system. Using the restarts of different years as the initial conditions of the ensemble integrations, the ensemble spreads from EnFR and EAKF are all kept at a finite value after a sharp decreasing in the first few months because of the sensitive of the model to the initial conditions, and the reducing of the ensemble spread due to Argo data assimilation is not much. The ensemble samples obtained in this way can well represent the probabilities of the real ocean states and no ensemble inflation is necessary for this EAKF experiment. Different experiment results are compared with satellite sea surface temperature (SST) data and the Global Temperature-Salinity Profile Program (GTSPP) data. The comparison of SST shows that modeled SST errors are reduced after data assimilation; the error reduction percentage after assimilating the Argo profiles is about 10% on average. The comparison against the GTSPP profiles, which are independent of the Argo profiles, shows improvements in both temperature and salinity. The comparison results indicated that a great error reduction in all vertical layers relative to CTL and the ensemble mean of EnFR; the maximum value for temperature and salinity reaches to 85% and 80% respectively. The standard deviations of sea surface height are employed to examine the simulation ability and it is shown that the mesoscale variability is improved after Argo data assimilation, especially in the Kuroshio extension area and along the section of 10ºN. All these results suggest that this system is potentially useful for improving the simulation ability of oceanic numerical models.

Wave Transformations over a Submerged Crescent Shoal

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The purpose of this research is to investigate wave transformations over a submerged crescent Shoal. The theoretical model is based on the Boussinesq equation demonstrated by The fully nonlinear Boussinesq equations, which include wave run-up, wave-breaking and bottom friction effects that were applied by Chen et al. [2003], were used to study waves traveling over a submerged crescent shoal. The governing equations are shown as below,

$$\beta\eta_t + \nabla\cdot\boldsymbol{M} = 0 \tag{1}$$

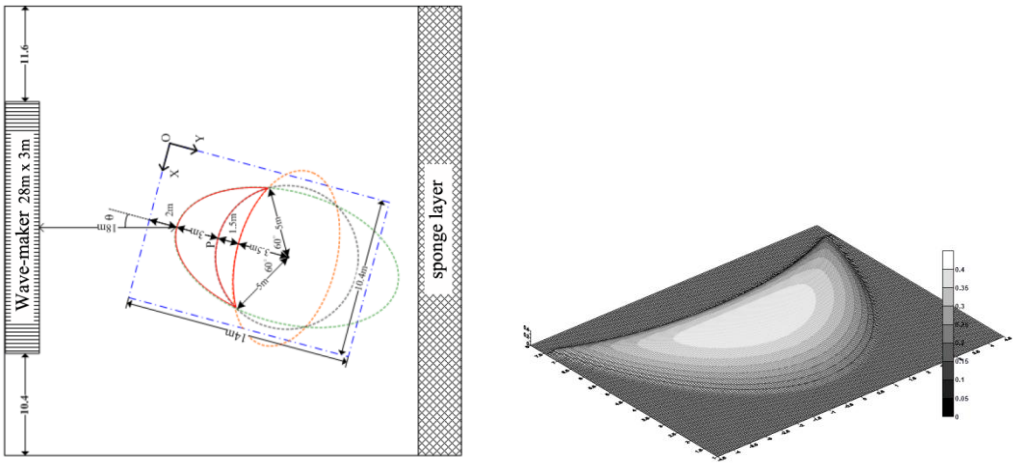
$$\frac{\partial \boldsymbol{u}_\alpha}{\partial t} + (\boldsymbol{u}_\alpha\cdot\nabla)\boldsymbol{u}_\alpha + g\nabla\eta + \boldsymbol{V}_1 + \boldsymbol{V}_2 + \boldsymbol{V}_3 + \boldsymbol{R}_f - \boldsymbol{R}_b - \boldsymbol{R}_s = 0 \tag{2}$$

The definitions of symbols please referred to Chen et al. [2003]. Equation (2) conserves the vertical vorticity with a leading-order error of $O(\mu^4)$. In Equation (2), $\boldsymbol{R}_f$, $\boldsymbol{R}_b$ and $\boldsymbol{R}_s$ represent the bottom friction, wave breaking and sub-grid lateral turbulent mixing, respectively. A Fourth–order Adams-Bashforth-Moulton predictor-corrector scheme used by Wei and Kirby (1995) was imposed to solve the problem.

To verify that the numerical model is feasible for simulating wave transformations over submerged obstacles, numerical simulations were performed for waves propagating over varying bathymetry with a submerged elliptic shoal. Figure 4 shows a schematic of the basin layout. The wave basin was 50 m long and 50 m wide, and the water depth in the basin was h_0=0.5 m. The bottom contours on the slope were oriented at an angle of 15^o relative to the wavemaker. The thickness of the sponge layer is 3.0 m in the left and right sides of the domain. The time step of calculation, Δt, is chosen to be 0.01 second. In each grid the spatial step size, Δx, is chosen to be 0.1 m, and Δy is also set to be 0.1m. 500×500 grids cells were generated in our computational domain. The incident wave period, T, is 1.0 seconds. The non-breaking (H_0=2.6 cm, h_0=50 cm) case are simulated to study the wave transformations. The computed time for the numerical experiments is run for 90 sec. The wave height is analyzed for the last 2 sec of numerical results. It is to note that the origin of the coordinate system, (x, y), in our computation domain is located at the lower left-hand corner as shown in Fig. 1. However, for the ease of showing our results, another (X, Y) coordinate system, located to the upper left of the elliptic shoal, will be used. The data were recorded at a sampling rate of 100 *Hz* for 9,000 sample points at all of the gauges in the simulation.

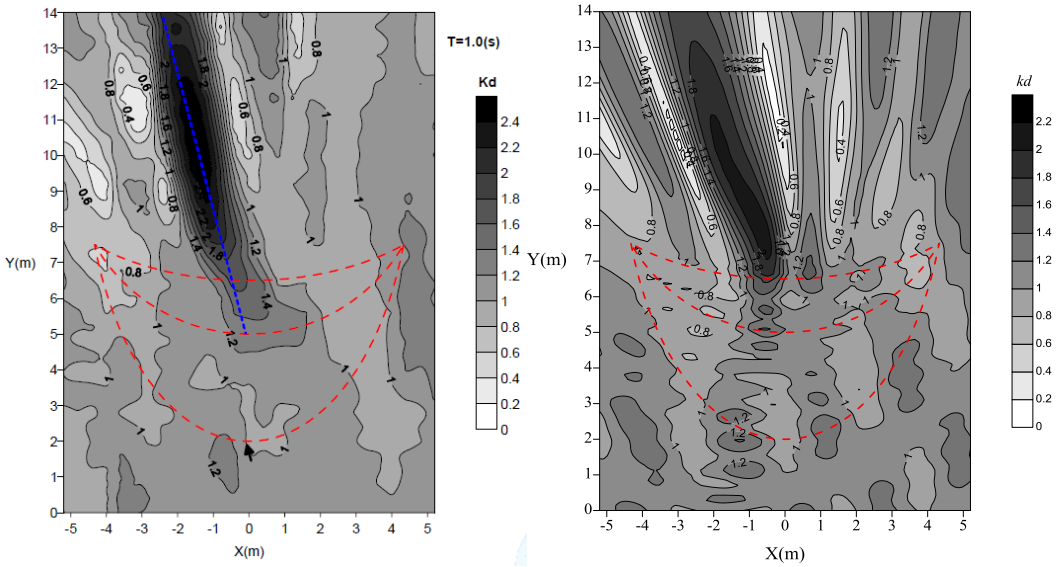
The computational results and experimental data for an incident angle of θ=15^o are shown in Fig. 2.

The wave height is not greatest on the shoal top. The wave focus on the lee side of the shoal is clearly observable, and the wave is highest in the rear region. The phenomena of the wave focus exist at the right rear of the shoal. It is due to wave refraction, the wave velocity diminishes on the shoal. The wave celerity beside the shoal is faster than that of a wave on the shoal. Thus, the lateral wave interacts with the refractive wave generating the wave focus.



(a) schematic layout (b) The topography of the crescent

Fig.1 Schematic of the geometric layout in the numerical simulations



(a) experimental results (b) numerical results

Fig.2 Non-dimensional wave height distributions and induced current field for a monochromatic wave over a submerged crescent shoal (red dashed line) for waves with θ=15°, T=1.0 s and H_0=2.6 cm.

On the variation of Air-Sea flux on Kuroshio waters using Taiwan Earth System Model

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Kuroshio waters is the major oceanic source that provides moisture and heat to the north-western Pacific rim during winter. The variation of the air-sea flux on Kuroshio waters may alter the precipitation, evaporation and fluvial runoff patterns in Japan, Korea, north China and Taiwan. In present study, the temporal-spatial variation of Air-Sea flux on the Kuroshio waters off the eastern coast of Taiwan is discussed. The 40-years Air-Sea flux is simulated using an Ocean-Atmosphere coupled model, i.e. the Taiwan Earth System Model. The present model is consisted of coupled AGCM, OGCM and a SIT module. ECHAM (European Center Hamburg Model v.5) is used as AGCM, running at various resolutions. A high-resolution global earth system model (ESM) (~ 63 km resolution) is used in present study. TIMCOM(DIECAST) is the OGCM. It is a 3-D global ocean model with 2 degree/T31-T213 in the equator, covering the latitude from 60 degree S to 60 degree N, with 31 levels. SIT is a one-column snow/ice/ocean model with 41-level ocean+ 2-level ice + 2-level snow. It reads surface energy fluxes and wind stress from AGCM, and reads below surface (> 10 m depth) water temperature, salinity, current from OGCM. Then, it computes SST to drive AGCM and OGCM. It has 12 layers in the upper 10 m of ocean.

The output of the model is first validated using observational time series from data buoys that deployed in and outside the main stream of Kuroshio. The temporal variations of the air-sea moisture and heat flux are then discussed with respect to ENSO and the climatological patterns of precipitation and drought in Taiwan.

3-D water and substance's long-term transport velocity and its application in the Changjiang Estuary

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Based on the opinion that the water and substance's long-term transport is separated in estuary, 3-D water and substance's long-term transport velocities are defined, which describe the water and substance's long-term transport direction and speed of every vertical layer, and their difference gives the vertical separation character of the water and substance's long-term transport. 3-D substance's long-term transport velocity is decomposed as 3-D water's long-term transport velocity and 3-D tide pumping transport velocity, which describe the substance's long-term transport from residual current transport and tide pumping transport of every vertical layer respectively. Tide pumping transport results in the difference of water and substance's long-term transport of every vertical layer. The observation data is analyzed on 1997 flood season in the Changjiang Estuary to give the vertical character of suspended sediment, salinity and water's long-term transport. It is show that the separation of suspended sediment, salinity and water's long-term transport isn't same in the vertical direction.

Improvement of MOM4 by including surface wave-induced vertical mixing

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A parameterized surface wave-induced vertical mixing (Bv) is incorporated into the Modular Ocean Model version 4 (MOM4). A comparison of the two numerical experiments with and without Bv shows that Bv can significantly improve the upper-ocean (20-100 m) simulation in summer. The simulated upper-ocean temperature errors are reduced in summer due to the surface wave-induced vertical diffusive heat flux. The non-breaking-wave-induced vertical mixing can increase the probability of the simulated SST biases between -1ºC and 1ºC from 64% to 76% in the Southern Hemisphere (60ºS-10ºS) in January, and from 66% to 75% in the Northern Hemisphere (10ºN-60ºN) in July. The averaged mixed layer depth (MLD) simulated by the MOM4 without Bv is 14.4 m shallower than the observations in 10ºS-60ºS in January, and 7.2 m shallower than the observations in 10ºN-60ºN in July. Bv can deepen the modeled MLD by 12.4 m in the Southern Hemisphere in January and by 6.3 m in the Northern Hemisphere in July. By including Bv, the corresponding MLD biases from the observations are only 2.0 and 0.9 m in the Southern and Northern hemispheres, respectively. These results clearly demonstrate that the incorporation of Bv can improve the performance of MOM4 significantly in summer.

Simulation of the tide and tidal current in the Qinzhou Bay

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Qinzhou Bay is located off the coast of Guangxi Autonomous regions, China. It include the Maowei bay and the outer Bay. The bottom of the Maowei bay is mainly mud. The local government decides dig mud and increase the water depth 2 meter. Princeton Ocean Model (POM) is used to study the tide and tidal current in the Qinzhou Bay and evaluate the impact of the project on the tide, tidal current and the tidal volume of the Maowei Bay and the Qingzhou Bay. The model simulated tide and tidal current agree with the observation well. The result shows that the project can increase the tidal volume of the Maowei bay 18.1%.

Variability of the drag coefficient over the North and Baltic Sea

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In this study, we analyze the drag coefficients, vertical wind speed and turbulence profiles observed at three different met-masts in the German North and Baltic Sea. We present an assessment of different models in unstable, neutral and stable thermal stratification of the atmosphere. Atmospheric turbulent flux measurements performed with sonic anemometers are compared to a bulk Richardson number formulation of the atmospheric stability. This is used to classify the cup wind speed profiles into atmospheric stability classes. The meso-scale models comprise WRF and COSMO-DE. Both COSMO-DE from the German Weather Service DWD and WRF include a turbulence closure of 2.5th order and lead to similar results. Apart from the effect of a low boundary layer height in very stable situations (which are seldom), standard Monin-Obukhov formulations in combination with the Charnock relation for the sea surface roughness show good agreement with the met-mast data.

Promising results were also achieved with two more detailed micro-scale approaches:
- the parameterisation proposed by Pena et al. (2008) that depends on the boundary layer height and
- our own ICWP-model, were the flux of momentum through the air-sea interface is described by a common wave boundary layer with enhanced Charnock dynamics (Bye et al. 2010).

The ICWP-model is based on the coupled pair of similarity relations for “aerodynamically” rough flow in both fluids (air and sea). A feature of the derived drag law is that it is of Charnock form, almost independent of the wave age, consistent with the transfer of momentum to the wave spectrum being due to the smaller rather than the dominant wavelengths.

References

Pena A, Gryning S-E, Hasager CB (2008) Measurements and Modelling of the Wind Speed Profile in the Marine Atmospheric Boundary Layer. Boundary Layer Meteorol 129:479-495

Bye JAT, Ghantous M, Wolff J-O (2010) On the variability of the Charnock constant and the functional dependence of the drag coefficient on wind speed. Ocean Dynamics 60(4) 851-860

Impact of surface drifter data for "ocean weather forecast" - an example of mesoscale variability in the Kuroshio Extension Region

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In order to better estimate meso-scale variabilities in the energetic Kuroshio Extension (KE) region, simultaneous assimilation of drifter-derived velocity data together with satellite and in-situ hydrographic data is attempted by using a high resolution 4-dimensional variational data assimilation (4D-VAR) system. Our experimental results, both with or without assimilation of drifter data (Exp. Drf and Exp. Ref, respectively) for the period during Aug-Oct 2005, show that the reproduced fields in Exp. Drf better reflect the observed meso-scale features such as the KE meandering jet and associated eddies. This result suggests the potential of surface drifter data for improving "ocean weather forecast". In addition, we investigate a possible mechanism of improvement by drifter data using our adjoint model. The adjoint sensitive analyses indicate that strong signals of the KE jet trapped in recirculation gyres have the potential to control basic components of the KE system in an efficient manner.

Oceanic dispersion of cesium-137 off the north-eastern Pacific coast of Japan

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The 2011 earthquake off the Pacific coast of Tohoku, Japan, and the associated tsunami caused a severe nuclear accident at the Fukushima Daiichi Nuclear Power Plant (1F), leading to radioactive materials leaking into the ocean. We conducted a retrospective, double-nested high-resolution numerical experiment to evaluate oceanic dispersion of the leaked radioactive 137Cs in the coastal marginal sea to successfully reproduce fluctuations of the measured 137Cs concentration. Following the method proposed by Tsumune et al. (2011), a total amount of the 137Cs from 1F is estimated quantitatively. Alongshore distribution of the concentration is found to be highly inhomogeneous with lower 137Cs concentration distributed widely at the south of 1F, while medium concentration in the nearshore area at the north of 1F. The probability density function (PDF) of 137Cs concentration suggests that hotspots exist along the Sanriku coast, a rias coastline located north of 1F. According to the previous work by Tsumune et al. (2011), 137Cs leaked from 1F is reported to be transported offshore rather quickly. Defining two control volumes centered at 1F, a budget of 137Cs flux is diagnosed. Time-integrated 137Cs fluxes at the northern and southern (alongshore) boundaries indicate apparent outgoing tendency, while the net cross-shore flux at the eastern boundary (100 km offshore) almost vanishes or even has an incoming flux, suggesting that 137Cs tend to remain in the coastal area with mostly being transported alongshore back and forth.

Oceanic responses to surface gravity waves in the Southern California Bight

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Influences of surface gravity waves on inner-shelf circulations in the Southern California Bight is investigated by using a quadruple nested high-resolution modeling framework based on ROMS (Regional Oceanic Modeling System) along with double nested SWAN (Simulating Waves Nearshore) and WRF (Weather Research and Forecasting). The wave effects on the circulation includes an interaction between waves' Stokes-drift and Coriolis force (Stokes-Coriolis effect), a correlation between Stokes-drift and background relative vorticity (vortex force), momentum transport to the currents by depth-induced wave breaking, Bernoulli pressure head, etc.

The primary momentum balance occurs between the pressure gradient and Coriolis forces, consistent with the geostrophic balance at a small Rossby number. However, Stokes-Coriolis effect comes in at the same order of magnitude if waves are considered. Advective momentum and vortex force are rather small, while increased to dominate over Stokes-Coriolis effect in the nearshore area outside of the surfzone. It is also found that turbulent kinetic energy associated with mesoscale and submesoscale momentum fluctuation is strongly affected by waves, in particular in the nearshore area for the latter. Therefore, waves are found to play a substantial role in changing the dynamic balance in the bight.

Effects of wave-current interaction on development of rip currents

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Haas et al. (1997) found that the offshore extent of rip currents can be significantly reduced if the current effects on waves (CEW) are considered. Subsequently, Yu and Slinn (2003, hereafter YS03) suggested that it could be led by change of the work done by radiation stress. Since radiation stress is also affected by CEW, it has been an open question that how CEW acts to suppress rip currents. Weir et al. (2011) analyzed rip currents with a vortex force formalism to answer this question. They showed that rip currents are modulated due to the wave ray bending associated with offshore-headed rip currents. However, they limited themselves in the asymptote where alongshore topography does not change that much, and didn't consider momentum balance modified by CEW.

In the present study, a two-dimensional shallow-water model based on Regional Oceanic Modeling System (ROMS) with wave effects through the vortex-force formalism, coupled with a set of wave ray equations (Uchiyama et al., 2009), is used to examine dynamic effects essential to development of rip currents. In prior to the analyses, the numerical experiment conducted by YS03 is revisited to confirm the validity of the present modeling framework. Then multiple terms attributed to CEW in the wave action and wavenumber conservation equations affecting the offshore evolution of rip currents are explored. The result reconfirms that the wave ray bending by currents is substantial to evolution of rip currents among others. If CEW is taken into consideration, wave ray bending occurs with a modified wavenumber field that changes the alongshore pressure gradient force and the cross-shore component of acceleration due to wave breaking through wave shoaling, leading to the reduction of the extent of rip current.

Pacific ocean swell case study and WavewatchIII model assessment

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A storm induced ocean swell process across the Pacific is studied using buoy full spectrum and satellite Envisat ASAR L2P wave mode observations. The spectrum energy partition (SEP) method is applied to extract swell partitions from the full or partial spectrum. It is found that ASAR spectrum is capable to capture swells travelling in a long way. The swell energy decay along quasi-great-circle tracks and its propagation characters in different directions are analyzed. The consensus of the shortness of wave model performance in swell simulation lead us to do experiments with Wavewatch III to find a more suitable model setup to reproduce this swell process. Considering the better performance of two experiments, the default model setup and the version 3.14 ACC350 setup, they are selected to hindcast Pacific waves and swells in 2007. Output of spectrums and parameters are further compared with satellite altimeter data, together with data mentioned above. The ACC350 setup show improvement in the most significant swell wave height but the underestimation still reside in most areas. More accurate analysis with ocean swell propagation and decay are required to modify the source terms and further reduce these defects.

Simulation of diatom and non-diatom distributions in the northern South China Sea using Photo-CoSINE model

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Because the South China Sea is a valuable repository of paleoceanographic records, it is desirable to better understand how biogeochemical conditions respond to atmospheric forcing. The biogeochemical conditions are in turn controlled by the community composition, especially the ratio between different size classes of phytoplankton. We modified CoSINE model by including photo-acclimation and other processes to simulate distributions of diatoms and non-diatoms at the SEATS station. The Photo-CoSINE model improves on the CoSINE model by including nitrate-dependency of diatom growth and predicts the diatom contribution of 14% in the Chl-a inventory in the top 100m, consistent with observations. The Photo-CoSINE model successfully reproduces the subsurface Chl-a maximum in both spatial distribution and magnitude.

The Simulation of the Intense Cooling Caused by Ling-Ling Typhoon off the Vietnam Coast in 2001

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In study a high resolution wind field of Typhoon Ling-ling is simulated with the WRF model (Weather Research and Forecasting Model) and used to drive the POM model (Princeton Ocean Model) for the simulation of the intense cooling off the Vietnam coast. The typhoon's track simulated by WRF is close the best track of JTWC (Joint Typhoon Warning Center). There is good reason to simulate the wind field because the wind speed of satellite observations is too low in this region during the growth phase of the typhoon. However, the maximal wind speed of the WRF simulation is still lower than that of JTWC. The result of POM shows that the sea surface current is much enhanced by Typhoon Ling-ling in the SCS, especially on Nov. 10. The modeled SST displays the typhoon induced intense cooling on Nov. 11, one day after the typhoon reached its maximum intensity. The maximum cooling predicted by the POM reached 7.5℃, but it is not as strong as that 11℃ observed by the TMI satellite. This is probably because the wind field of the WRF simulation is not as high the maximal wind speed observed by the JTWC.

Unstructured grid numerical wave model simulation of swells on the East Sea

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Large swells occurred on the coast of the East Sea of Korea in February, 2008 are simulated using SWAN model with unstructured grids. The swells caused a loss of three lives in Korea and also damaged several west coasts of Japan. Most of the East Sea is deep sea and semi-enclosed by Korea and Japan with very steep bathymetry near shores. In order to calculate the shallow water effects on the propagating waves to the shore, a shallow water wave model with unstructured grids, which can efficiently reflect the steep topography, need to be developed.

The SWAN model results are compared with significant wave heights and periods observed by Korea and Japan, Specially, two frequency spectrum and one directional wave spectrum measured on the east coast of Korea are intensively compared with model results. In general, the wave height comparison is relatively good but sharp peaks of observed wave energy spectrum at low frequencies in terms of frequency and direction are still difficult to predict.

Mechanism of the clockwise circulation in the southern Sea of Okhotsk by localized tidal mixing

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Formation processes of a broad clockwise circulation by localized mixing over a ridge is investigated. A layer model was used, where mixing is parameterized as a vertical velocity. A localized enhanced mixing is considered as a model of tidal mixing over submarine ridges along the Kuril Islands that are the southern boundary of the Sea of Okhotsk. When mixing commences, the interface deepens over the ridge locally, resulting in formation a localized clockwise circulation with low potential vorticity (PV) water there. It has been found that the deepening is further enhanced when Rossby waves associated with interface deformation are captured by barotropic circulation over the ridge; energy dispersion due to westward wave radiation is prevented in this case, so that baroclinic energy tends to accumulate over the ridge. If the local deepening becomes strong enough, however, eddies are formed consequently and the low PV water is carried westward, leading to formation of a broad clockwise circulation in the entire basin westward from the ridge. Bimodal states in the clockwise circulation were found. One state includes a tight recirculation adjacent to the ridge surrounded by a basin-wide broad circulation, while the other includes only a basin-wide circulation.

Monsoon-driven upwelling effect on the phytoplankton blooms in the Southeast Asia Seas: An eddy-resolving physical-biological model study

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An eddy-resolving coupled physical-biological ocean model has been employed to investigate physical influences on the phytoplankton blooms in the South East Asian region during 2000-2007. The model captures the seasonal and interannual variability of chlorophyll distribution associated with the mesoscale eddies, ocean circulation and upwelling generated by the monsoon. During boreal winter, the high chlorophyll concentration in the northwest of Luzon is related to monsoon-driven upwelling and Kuroshio inflow. Monsoon-driven upwelling and current also control the high chlorophyll concentration in the east coast of Vietnam in boreal summer. The high chlorophyll region is linked to the variability of offshore current system. During boreal summer-fall, the phytoplankton blooms along the south coast of Java-Sumatra extend westward and offshore in the southeastern tropical Indian. The spreading of phytoplankton blooms in 2006 summer is the maximum. The southeasterly winds are stronger in 2006, and the coastal upwelling widely uplifts nutricline and the high chlorophyll is generated. The high chlorophyll in the south of Java coincides with the Indian Ocean Dipole event in 2006.

Meeting Place

JAMSTEC Yokohama Institute for Earth Sciences (YES)

The nearest stations to YES are

1) Shin-Sugita station for JR (Japan Railways) Line.

2) Sugita station for Keikyu (Keihin Kyuko) Line.

It takes about 15 min on foot from both stations to YES.

Let’s enjoy a 15-minute walk! Thanks.