ATOP - an Advanced Taiwan Ocean Prediction System for the Western N-Pacific Ocean: Modeling & Climate Research at NCU

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(http://mpipom.ihs.ncu.edu.tw/index.php)
Motivation

• NW-Pacific is home to over 1/4 of the world’s population
• Ocean is indispensable
• Many scientific (& practical) questions remain
Outline

• ATOP
• Taiwan Strait currents
• Air-Wave-Sea Coupling
• Ice-Ocean Coupling
• STCC Eddies
• PTO: Climate Index
• Summary
ATOP Goals

- Prediction
- Research
- Cultivate young scientists
ATOP sea-surface temperature (SST) on Jun/06/1988 during the developing stage of the strong 88-89 La Niña when waters as cold as 19°C is simulated in the eastern equatorial Pacific in excellent agreement with observation ([http://www.pmel.noaa.gov/tao/elnino/la-nina-story.html#](http://www.pmel.noaa.gov/tao/elnino/la-nina-story.html#)). ATOP also simulates a beautiful meandering Kuroshio that separates off the eastern coast of Japan, as well as the intrusion of very warm waters (SST≈31°C) into the South China Sea through the Luzon Strait. (Plot courtesy of H.-F. Lu).
MPIPOM

Data: Altimetry, SST, ADCP, drifters, floats, CODAR, Hydrography.

Other Data: rivers, tides, topography.

Wind & Other Surf-Flux Forecasts

Outputs
http://mpipom.ihs.ncu.edu.tw/index.php

t = t + \Delta t
$$C_T = \frac{\langle \delta T \delta \eta \rangle}{\sqrt{\langle \delta T^2 \rangle \langle \delta \eta^2 \rangle}}$$
Wind & Eddy-induced currents Forecasts

GFS Wind, MCSST, SSHA → Assimilation

GFS Wind Forecast

-7 days \hspace{1cm} \text{Today} \hspace{1cm} +7 days
Result from NW-Pacific forecast model

Date: 05/07 ~ 05/20

Date: 05/07 ~ 05/13
Taiwan Ocean Prediction (TOP) Research Highlights

We are developing an ocean current and wave prediction model: the Taiwan Ocean Prediction (TOP) system that eventually will include also air-sea (with typhoons) and air-sea-ice coupling, as well as biogeochemical processes. An example of the simulated SST over the entire North Pacific Ocean is given below.

TOP sea-surface temperature (SST) on Jun/06/1988 during the developing stage of the strong 88-89 La Niña when waters as cold as 19°C is simulated in the eastern equatorial Pacific in excellent agreement with observation [http://www.gpdd.noaa.gov/laoslalina](http://www.gpdd.noaa.gov/laoslalina). TOP also simulates a beautiful meandering Kuroshio that separates off the eastern coast of Japan, as well as the intrusion of very warm waters (SST~25deg.) into the South China Sea through the Luzon Strait. (Animation courtesy of H.F. Li)

Three recent publications:
Analysis Methods:
7th day (5/13) RMS (>0.1) & correlation of Model SSH & AVISO SSH
ATOP Currents in Taiwan Strait: Mar/11 – Apr/11/2012
EOF Model SSH
mode1
77.7%

EOF Model UV
mode1
58.6%

Mean Tr = 1.3

5/18/2012
Oey-etal-ATOP
Air-Wave-Sea Coupling: Wind, Stokes Transport & Oceanic Front

(a) Cold
- Wind anomaly
- Ocean anomaly
- Waves

(b) Cold
- Wind anomaly
- Ocean anomaly
- Waves

Wind, Stokes Transport & Oceanic Front
Rampal et al. JGR, 2011: “… IPCC climate models underestimate the decrease of the Arctic sea ice extent… by a factor of almost 4…”

One cause may be that ‘turbulence’ in the upper ocean in climate models are poorly parameterized, and the relevant physics poorly understood…
 lee-wave induced  
vertical motions

Vertical motions →  
Ice Melt →  
Thinning ice →  
Decreased strength →  
Fracturing →  
Increased drift & deformation →  
More lead Opening & export →  
Decreased albedo & ice age →  
Thinner ice …

No ice melting…
Shading: negative values; contours: (-30,-20,-10,-8,-6,-4,-2,0,1,2,10,20,30,40,50 cm/s)

Courtesy of H.-F. Lu
0-relax

Mar

3 year animations

Sep

elevation

Mar

3 year animations

Sep

elevation (days since spin-up: 0000)

5/18/2012

u & temp

section@137E

5/18/2012

u_temp (days since spin-up: 0000)

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24
Philippines-Taiwan Oscillation (PTO) = \nabla \times \tau_o|_{\text{Philippines}} - \nabla \times \tau_o|_{\text{Taiwan}}

Chang & Oey, J.Clim 2012
Summary

• NCU has developed an ocean prediction system – first(?) in Taiwan

• ATOP produces daily forecasts of currents, SST etc in the N-Pacific – in particular: the marginal seas around Taiwan

• Further enhancements are planned

• Rigorous research with focus on the western N-Pacific – some were outlined herein - and in cooperation with other researchers is also planned

• Hope is that our activities at NCU will foster the next generation of world-class ocean modelers and physical oceanographers in Taiwan – and hope also is that these younger generation of researchers will collaborate towards a common goal to advance our knowledge of ocean & climate science
The 4th International Workshop on Modeling the Ocean (IWMO2012) will be held at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) Yokohama Institute for the period from 21 to 24 May 2012, hosted by JAMSTEC. Yokohama is a beautiful seaport city of Japan near the capital city of Japan, Tokyo.

The IWMO evolves from the POM users group meetings, but it is open to the ocean modeling community at large. The IWMO2012 solicits abstracts for presentations at the workshop on all aspects of ocean and coupled air-wave-sea, ice, current-sediment, and climate modeling: processes, analysis and prediction. The earth system is inter-connected on a broad range of temporal and spatial scales, and we welcome coastal, regional, basin-scale and global studies, as well as interdisciplinary topics. As in the past workshops, we particularly encourage participations from young scientists - graduate students and postdocs, and will again host the Outstanding Young Scientist Awards (OYSA) competition. Papers presented at the workshop will be eligible for submissions to the IWMO-4 Special Issue to be published by Ocean Dynamics (2010 Impact Factor: 1.677).

**NCU Representatives**

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

**Air-Sea coupling and the quickening pace of Loop Current shedding in a warming climate (Y.-L. Eda Chang)**

Session Title: Biogeochemical Oceanographic Modeling, Session Chair: Huijie Xue

**Simulation of diatom and non-diatom distributions in the northern South China Sea using Photo-CoSINE model (Hsieh Fu-yang)**

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

**The Simulation of the Intense Cooling Caused by Ling-Ling Typhoon off the Vietnam Coast in 2001 (Huang Shih-Ming)**

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

**ATOP (Yo-Yo Lin)**

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

**On the augmentation of sea surface roughness on inner shelf (Hwa Chien)**