Current and Future Activities Relevant to FUTURE in China

Fangli Qiao
First Institute of Oceanography, SOA, China
PICES – OSM, April 18, 2014, Hawaii, USA

qiaofl@fio.org.cn
Outline

1. National police support
2. Typical case for marine ecosystem
3. Typical case for model development
4. Summary
1. National police support

(1) To extend ocean/climate in-situ observation and monitoring ability for improving scientific knowledge on ocean S&T;
(2) To extend the research ability in polar oceans;
(3) To extend the research and monitoring ability in open ocean;
(4) To develop new oceanic technology for nursing ocean strategy industries;
(5) To improve ability on ocean comprehensive management through the innovation of ocean services;
(6) To deeply combine ocean research and blue economy;
(7) To enhance capacity buildings for ocean S&T;
(8) To enhance the popularization of ocean S&T.
Chinese new government led by Chair Jinping Xi and Premier Keqiangli:

The 18th Chinese Communist Party congress pledged: (1) To improve the marine power is national strategy for China; (2) To enhance the civilization of marine ecosystem.

The above two points are so closely related with FUTURE, and will serve as the engine for Chinese scholars to take part in the activities of PICES.
2. Typical case for marine ecosystem

Since marine ecosystem research and protection is a key part of FUTURE, here we would show updated progress of marine ecosystem in China.
Background

Firstly noticed on May 31, 2008. And a scientific committee was formed.
Research foci

1. Drifting channel
2. Why burst (Trigger): weaken monsoon and low surface wave
3. Nutrient supply
4. Banded structure
5. Why accumulated in Qingdao in 2008
6. Sunken algea
7. Time window for 1800 ships
(1) Drifting Channel
Model results of June 23, 2008
Source identification from model
Operational application of drifting channel: This is an example of monitoring, prediction and management on July 6, 2008
Model validation

The operational forecast system at FIO

<table>
<thead>
<tr>
<th>Depth</th>
<th>Mean E</th>
<th>AME</th>
</tr>
</thead>
<tbody>
<tr>
<td>6m</td>
<td>0.5</td>
<td>7.8</td>
</tr>
<tr>
<td>10m</td>
<td>-0.2</td>
<td>7.2</td>
</tr>
<tr>
<td>20m</td>
<td>0.4</td>
<td>7.0</td>
</tr>
<tr>
<td>40m</td>
<td>-0.5</td>
<td>6.7</td>
</tr>
</tbody>
</table>
(2) Why existed in 2008

• Sediment numerical model
• The control effects on of surface wave
<table>
<thead>
<tr>
<th>Year</th>
<th>Period</th>
<th>MODIS (mg l(^{-1}))</th>
<th>Exp 1 (mg l(^{-1}))</th>
<th>Exp 2 (mg l(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>March</td>
<td>50.1</td>
<td>36.2</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>50.9</td>
<td>36.4</td>
<td>9.3</td>
</tr>
<tr>
<td>2007</td>
<td>March</td>
<td>42.9</td>
<td>48.1</td>
<td>10.2</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>32.7</td>
<td>35.8</td>
<td>9.4</td>
</tr>
<tr>
<td>2008</td>
<td>March</td>
<td>42.0</td>
<td>31.5</td>
<td>9.6</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>22.9</td>
<td>34.6</td>
<td>9.4</td>
</tr>
<tr>
<td>Average</td>
<td>March</td>
<td>45.0</td>
<td>38.6</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>35.5</td>
<td>35.6</td>
<td>9.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Wind speed (m s&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>Wave amplitude (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>March</td>
<td>6.03</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>6.06</td>
<td>0.82</td>
</tr>
<tr>
<td>2007</td>
<td>March</td>
<td>6.68</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>5.88</td>
<td>0.66</td>
</tr>
<tr>
<td>2008</td>
<td>March</td>
<td>5.65</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>5.50</td>
<td>0.65</td>
</tr>
</tbody>
</table>
(3) Nutrients supply

- **MASNUM** wave-tide-circulation coupled model
- **Upwelling** should provide the main nutrient supply

Lv et al, 2010, CSR
Upwelling system

Upwelling at 10 m (10^{-5} \text{ m/s})

$SH = \log \left( \frac{H}{|u|^3} \right)$

上升流基本位于锋面的浅水侧
The relationship between upwelling and tide

(a). 100% BTF
(b). 80% BTF
(c). 60% BTF
(d). 40% BTF
(e). 20% BTF
(f). 只有引潮势
The relationship between upwelling and tide

(a). Area A

(b). Area B

不同潮强迫作用下苏北外海上升流的变化曲线
(4) Banded structure

- Satellite data

- What’s the image anomaly?

Qiao et al, 2009, MPB
What's the anomaly?

Qiao et al, 2009, MPB

浒苔间距1－2公里
图4. Apollo photo of the Georgia Coast at 1500 GMT (1000 local time) on 4 April 1969 from a height of 125 mi. The cloud streets are over the land, aligned approximately with the geostrophic wind which is due north. They begin about 16 km after landfall, and occupy an area about 200 mi. The rows are about 2.3 km apart at about 1 km height. (The original photograph was in color.)

图3. Cloud streets caused by narrow mixed-layer rolls over Oklahoma taken by the Endeavour crew during NASA Mission STS068. The photograph was taken at 1942 UTC on an unspecified day in early Oct 1994. (Courtesy of the Johnson Space Center JSC Digital Image Collection.)
(5) Why accumulated in Qingdao in 2008

Simulated surface current and SST in June (left) and July 1-10 (right) 2008
The comparison between June, 2008 (red) and June 2010 (black). Left is monthly averaged wind field, and right is the ocean surface current.
We are facing other marine ecosystem challenges, such as jellyfish bloom in the Yellow Sea. Chinese central government has paid lots of attentions on these challenges.
The variations of fishery products and environmental effects of marine agriculture
The biological effects of hypoxia zone extension
3. Typical case for model development

The importance of improving forecasting ability for FUTURE
\[
B_v = \alpha \int \int E(\vec{k}) \exp\{2kz\} d\vec{k} \frac{\partial}{\partial z} \left( \int \int \omega^2 E(\vec{k}) \exp\{2kz\} d\vec{k} \right)^{1/2}
\]

\(E(K)\) is the wave number spectrum which can be calculated from a wave numerical model. It will change with \((x, y, t)\), so \(B_v\) is the function of \((x, y, z, t)\).

**Yuan et al, 1999; Qiao et al, GRL, 2004; OD, 2010**

If we regard surface wave as a monochromatic wave,

\[
B_v = \alpha A^3 k \omega e^{-3kz} = \alpha A u_s e^{-3kz},
\]

\(B_v\) is wave motion related vertical mixing instead of wave breaking.

Although the horizontal scale of surface wave, 100m, is much smaller than that of circulation, however, the wave-induced vertical velocity in the upper ocean could be stronger than vertical current turbulence velocity.
Challenge 1

(1) OGCMs: Simulated SST is overheating in summertime, and mixed layer depth is too shallow while the thermocline is too weak (Martin 1985, Kantha 1994, Ezer 2000, Mellor 2003).
Observation in summer
Lin et al, 2006 JGR

POM
POM+Bv

3-D coastal models
Vertical Temperature Distributions

Along 35N transect in Aug.

World Ocean Atlas

Along 35S transect in Feb.
Along 35N transect in Aug.

Vertical Temperature Distributions

Pacific

Atlantic

Indian

Pacific

Atlantic

With wave-induce mixing

Without wave-induce mixing

World Ocean Atlas

Along 35S transect in Feb.
The two lines represent the whole upper ocean: Zonal (x-direction) and upper 100m (z-direction) averaged correlation coefficient (t).

FIO wave-circulation coupled model with 0.1 X 0.1 resolution is set up
Aoyama et al
Website of 2013

165E section
Observation during June and July, 2012

Simulation for the same period

Bq m\(^{-3}\)

Bq/m\(^{3}\)
Observation during 1973-74

Simulation of 137Cs 1950-2010
Challenge 2

(2) Climate Models: The ML is too shallow in high latitudes; Tropical bias for all CGCMs.
Multi-model ensemble summer MLD compared with observations (Jul-Sep and Jan-Mar for the Northern and Southern hemispheres, respectively). (a) Observations, (b) mean of the 43 models (excluding NorESM1-M and NorESM1-ME), (c) multi-model ensemble minus observations, and (d) uncertainties represented by multi-model standard deviation.
Area-averaged MLD (in m) in the central North Pacific Ocean (35°N-55°N, and 160°E-140°W) during the boreal summer from the 45 CMIP5 models and the observation.

Huang and Qiao, 2014, JGR
FIO-ESM climate model took part in CMIP5

Qiao, F., Z. Song, Y. Bao, Y. Song, Q. Shu, C. Huang and W. Zhao, *JGR*, 2013

Song, Z., F. Qiao, and Y. Song, *JGR*, 2012

Song Yajuan, Fangli Qiao and Zhenya Song, *JAS*, 2012

Song Zhenya, Qiao Fangli, and Wang Chunzai, *Science China Earth Sciences*, 2011
Regional climate model with surface wave is developing which can be used for downscaling in PICES area, north of 30N in the Pacific.

WRF
Atmospheric Model

Coupler

MASNUM-Wav
Wave model

POM
Circulation model

波致混合系数、底切应力、辐射应力、波高

海流

海面风场
STOKES漂、破碎

风场、气温、气压、湿度

海流
We would like to share the experience on improving forecasting ability of ocean climate within PICES scientific community.
4. Summary

(1) China will pay more and more attention on marine ecosystem and marine environment in the following 10 years. A series of key research projects closely related with FUTURE are ongoing or will be arranged.

(2) China will pay special attention on the improvement of ocean and climate forecasting ability. Two projects from NSF and SOA were approved recently, which can support directly FUTURE of PICES.
Thanks for your attention