Air-Sea Interaction in the Kuroshio Extension and its Climate Impact (AIKEC)

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Ocean University of China

Ping Chang
Texas A&M University
Key Region for the ocean and climate

Mass and Heat transport

Air-sea Heat Flux

Hot Spot under Global Warming

CO₂ Sink
We still do not fully understand the multi-scale oceanic process and air-sea interaction in the KE region, nor their climate impact.

But there will be only KEO buoy after 2014!
1. Project Objectives

- Develop sustainable observation networks in the Kuroshio extension region.
- Establish the theoretical framework of the multiscale ocean-atmosphere interaction in the midlatitudes, especially in the Kuroshio extension region, to provide a theoretical basis for understanding and predicting the global climate change.
- Reveal the key physical processes in determining climate change and improve the understanding of ocean and climate predictability in the Western Pacific.
Activities in the past 3 year
Second ‘International Symposium on Boundary Current dynamics’ at 2013
Co supported by the WESTPAC, CLIVAR, NSFC and OUC

1. A new observation plan in the Kuroshio Extension region lead by AIKEC.
2. The data from AIKEC should be shared to public like KESS project was accepted by all the participants.
3. The scientific goal is to combine observation and dynamics to predict the Northwest Pacific Ocean Climate.
Steering Group Meeting, Texas A&M:
Lixin Wu, Ocean University of China, China
Xiaopei Lin, Ocean University of China, China
Ping Chang, Texas A&M University, USA
Shang-Ping Xie, Scripps Institution of Oceanography, USA
Bo Qiu, University of Hawaii, USA
Meghan F Cronin, NOAA Pacific Marine Environmental Laboratory, USA
Hisashi Nakamura, University of Tokyo, Japan
Yoshimi Kawai, Japan Agency for Marine-Earth Science and Technology, Japan
Peter Brandt, GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany
Black Cross: The Key Region
Focus Meso to Sub-meso Scale
Possible Joint Cruise
2014 Cruise

Reseaching cruise in the Northwestern Pacific Ocean was accomplished from 18 March to 28 April 2014, carried out by the research vessel “Dong Fang Hong 2”. In the 40-day voyage, researchers placed 25 sets of Argo floats and, for the first time in China, a deep-sea (6000m) mooring buoy system in the Kuroshio extension region.
2015 Cruise

Researching cruise in 2015. Enhance the international cooperation in observation in the Kuroshio extension region (with US, Japan and Korea).

2015: 2 moorings, 2 Gliders, 40 stations
Next 3 Years: 5-10 moorings, 4 Gliders, 20-40 CPIES
Developing Global-Regional Model System

An International Work Shop on June 13, 2015

Ocean Only

Air-Sea Coupling
An New Session On Next Year Ocean Science Meeting

Interactions between the open ocean and marginal/coastal seas in a changing climate

Session Title: Interactions between the open ocean and marginal/coastal seas in a changing climate
Session Description: Climate changes affect physical and biogeochemical processes in both the open ocean and marginal/coastal seas. Observations have shown that coastal waters in some areas have experienced significant changes in the last several decades, such as rises in water temperature, changes in coastal circulations and marine ecological systems. Processes in the open ocean, such as gyres and overturning circulations, have also been affected by changes in surface wind stress and buoyancy fluxes. Oceanic processes in marginal/coastal seas and the open ocean are intimately linked through processes that govern cross-shelf exchanges. Flows on shelves, for instance, are influenced by oceanic gyres through boundary currents and eddy fluxes. Marginal/coastal seas also exert their influences on open-ocean processes. Thermohaline circulations in the deep open ocean, for example, are driven in part by water-mass transformations in marginal/coastal seas. To assess and to predict oceanic responses to climate changes, it is imperative to understand how the open ocean interacts with marginal/coastal seas, and how such interactions are affected by climate changes. This session provides a venue for sharing interdisciplinary studies that address key linkages of physical and biogeochemical processes between the open ocean and marginal/coastal seas under a changing climate.

Primary Topic: Physical Oceanography/Ocean Circulation
Cross-Topic(s):

- A - Air-sea Interactions and Upper Ocean Processes
- EC - Estuarine and Coastal
- PC - Past, Present and Future Climate
- O - Other

Society Membership(s):

- American Geophysical Union
3 Results Generated
National research project “Response to global warming and regulation of climate change by the Pacific and Indian Oceans” by the Ministry of Science and Technology 30 million RMB ($4.9 million). 2012, Shang-Ping Xie, Scripps.
National research project “Multiscale variations, mechanisms and predictability of the Northwest Pacific Ocean” by the Ministry of Science and Technology 30 million RMB ($4.9 million). 2013, Lixin Wu, OUC.
National research project of the “Mechanisms and climatic impacts of ocean-atmosphere interaction in the Kuroshio and its extension region” was recently granted by the National Natural Science Foundation of China 20 million RMB ($3.2 million). 2014, Lixin Wu, OUC.
Institutional coordination of global ocean observations

Wenju Cai, Susan K. Avery, Margaret Leinen, Kenneth Lee, Xiaopei Lin and Martin Visbeck

A sustainable global ocean observation system requires timely implementation of the framework for ocean observing. The recent Qingdao Global Ocean Summit highlighted the need for a more coherent institutional response to maintain an integrated ocean-observing system.

Pacific western boundary currents and their roles in climate

Dunxin Hu¹, Lixin Wu²*, Wenju Cai³;²*, Alex Sen Gupta⁴, Alexandre Ganachaud⁵, Bo Qiu⁶, Arnold L. Gordon⁷, Xiaopei Lin², Zhaohui Chen², Shijian Hu¹, Guojian Wang³, Qingye Wang¹, Janet Sprintall⁸, Tangdong Qu⁹, Yuji Kashino¹⁰, Fan Wang¹, & William S. Kessler¹¹
Meso Scale-Enhanced eddy transport and energy towards the KE region

Eddy Transport Equal to Wind Driven Circulation

[Graph showing eddy transport]

Zhang, Wang and Qiu., 2014, Science

Wave/Eddy Energy Ratio

[Map showing energy ratio]

Lin et al., 2014, JGR
Meso Scale-Eddy affect mode water and circulation

Mode Water Path Way

Subduction Rate

Liu and Hu 2007, GRL

Xu, Xie et al., 2014, JGR
Meso Scale-Eddy affect regional sea level

Observation

Eddy Forcing

Qiu et al., 2014, JC

Wind Forcing
Meso Scale-Eddy is key for air-sea interaction

Lead by Ping and Xiaohui at TAMU
Small Scale Enhanced mixing in south of KE due to near-inertial variance

Correlation of near-inertial shear variance to dissipation rate at Mooring 7

Mean dissipation rate in Winter (red) and Summer (blue)

Jing and Wu 2010 GRL

## 4 workplan for the next intersessional period

<table>
<thead>
<tr>
<th>Project/Programme</th>
<th>Activities</th>
<th>Objectives</th>
<th>Date and place</th>
<th>IOC</th>
<th>Other sources (i.e. from national or international)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The third 'International Symposium on Boundary Current dynamics'</td>
<td>Discuss the studies in the Western Boundary Regions</td>
<td>Improve understanding of the boundary current dynamics and raise level of climate prediction</td>
<td>July 2016, Qingdao, China</td>
<td>10,000 USD</td>
<td>50,000 USD</td>
</tr>
<tr>
<td>Ocean Science Meeting Session</td>
<td>Summarize Progress and Perspective</td>
<td>Set the new scientific goals for the next 5 year. Involve more international collaborations.</td>
<td>Feb 2016, New Orleans, US</td>
<td>10,000USD</td>
<td></td>
</tr>
<tr>
<td>Cruise in 2016</td>
<td>As above</td>
<td>As above</td>
<td>April 2016, Kuroshio extension region</td>
<td>2,000,000USD</td>
<td></td>
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<tr>
<td>Cruise in 2017</td>
<td>As above</td>
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<td>April 2017, Kuroshio extension region</td>
<td>2,000,000USD</td>
<td></td>
</tr>
<tr>
<td>Cruise in 2018</td>
<td>As above</td>
<td>As above</td>
<td>April 2018, Kuroshio extension region</td>
<td>2,000,000USD</td>
<td></td>
</tr>
</tbody>
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Roughly Budget for Field Work in the Next 5 Years

• Shipping Cost:
  5 Cruises with 5M/cruise=25M RMB (10M)

• Instrument Cost:
  10 Moorings (25M), 4 Gliders (10M), 40 CPIES (20M), 1 Buoy (5M)
  =60M RMB (15M)

• Other Cost:
  Data transfer, labor and materials 10M RMB (5M)

*65M RMB more Funding is needed in the future*

• Potential New Funding:
  Key Research Project of NSFC 500M
  Smart Float Project of NSFC 100M
  MOST, MOE, SOA…

International Collaboration
Future Ocean Observation Net Work 2020
5 Challenges and Suggestions

1. More international cooperation among the Pacific Rim countries.
2. Integrate the existing observation systems to develop a systematic observation network.
3. Strengthen communication and education to improve the observation capability and academic levels of the member states of WESTPEC.
Thank You!