The impacts of thermal anomalies in the East China Sea and its adjacent seas on East Asian atmospheric circulation and climate change in East China

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1. Background
★ East Asian marginal seas have been warming in the past decades.

**East China Sea**

**Yellow Sea**

**EOF1 (51.9%) for SSTA in Winter**

**EOF1 (43.6%) for SSTA in Summer**
\[
y(t) = c_0 + c_1 t + c_2 t^2 + c_3 t^3 + c_4 t^4 + c_5 t^{1/2} + c_6 t^{-1} + c_7 t^{-1/2} + c_8 t^{-2} + c_9 e^t + c_{10} \ln t
\]

\[
y = 15.46525 + 7.2749966 \times 10^{-4} t^2
\]

\[
y = 23.50874 + 1.5130692 \times 10^{-7} t^4
\]

(a) The SST increased by 1.96°C in winter in East China Sea

(b) The SST increased by 1.10°C in summer in Yellow Sea

The SST increased by 1.96°C in winter for the period of 1955-2005 and 1.10°C in summer for the period of 1971-2006
For example,
1) **HABs (Harmful Algal Blooms)** frequently happens in East China Sea;
2) Marine bio-geographic distributions have been greatly changing, including warm water species increasing, temperate water species decreasing, tropical fish expanding their range northward into the subtropical area etc., in the past decades.
• Inter-decadal weakening trend of East Asian Monsoon in winter might greatly contribute to the rise in SST of the offshore area of China, particularly in ECS.

• Variations of SST in ECS are closely related with the increasing heat transport of the source area of Kuroshio on inter-annual and inter-decadal timescales.

• Weakening East Asian Monsoon and increasing heat transport of Kuroshio may cause East Asian Marginal Seas rapidly warming.

• Q: We are still wondering if the thermal (SST) anomalies in ECS play an important role in regional climate change?
What impacts?

What extent?

What mechanism?

Thermal Anomalies

Atmospheric circulation

Regional climate, e.g., Atmospheric circulation, summer precipitation?
Standard deviation of Pacific SST in winter

Local impact factors?

Dominant impact factors
2. Numerical Experiments: Simulation of Sensibitity of Summer Precipitation to Thermal (SST) Anomalies of ESC

1) Model: RegCM3

2) Domain: center position (29.5°N, 119°E), resolution 20km x 20km, Grids points 104x112, Vertical levels 18, Pressure of model top 5hPa

3) Initial and boundary conditions: NNRP1 (NCEP/NCAR), SST: OISST (NOAA)

4) Convective Precipitation Schemes: Fritsch-Chappell

5) Simulation Time: 1989.1-2010.1

1 Control Test: climatological SST (annual mean 1982~2009)

3 Sensitive Test: change SST in ESC and other areas remain unchanged
### Experimental scheme

<table>
<thead>
<tr>
<th>Control Test (CTL)</th>
<th>Sensitization Test</th>
<th>Domain</th>
<th>SST</th>
<th>Simulation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ECS-1</td>
<td>(13°N, west of 138°E)</td>
<td>Climatological SST</td>
<td>1989.1-2010.1</td>
</tr>
<tr>
<td></td>
<td>ECS+0.5</td>
<td>(22°-45°N, west of 135°E)</td>
<td>Climatic SST -1°C</td>
<td>Same as CTL</td>
</tr>
<tr>
<td></td>
<td>ECS+1</td>
<td>Same as ECS-1</td>
<td>Climatic SST +0.5°C</td>
<td>Same as CTL</td>
</tr>
</tbody>
</table>

**Model experimental Area**

- Domain: (13°N, west of 138°E) for ECS-1, (22°-45°N, west of 135°E) for ECS+0.5, Same as ECS-1 for ECS+1.
- SST: Climatological SST, Climatic SST -1°C, Climatic SST +0.5°C, Climatic SST +1°C.
Simulated summer rainfall anomalies in eastern China responding to different SST conditions in ESC. (a) climatological mean SST; (b) -1, (c)+0.5 and (d)+1°C SST anomalies to climatological mean SST, respectively.

The warm (cold) anomalies in ECS can contribute to the less (more) rainfall in the middle and lower reaches of the Yangtze River, JiangHuai valley and most of North China and more (less) precipitation in South China, southeast part of Northeast China and Korean Peninsula.
When SST in ECS is above normal in summer, an anomalous downward motion can appear over the middle and lower reaches of the Yangtze River and the Yangtze River/Huaihe River valley (105-120E) in East China, which contributes to the decrease in summer rainfall in these areas, in addition to an upward motion over the region to the east of these seas, and vice versa.
When SST in ECS is above normal in summer, an anomalous upward motion occurs in South China (22-25N), the southern part of Northeast China (35-40N) and the Korean Peninsula (35-40N). Thus, there is an obvious increase in summer precipitation in these regions, and vice versa.
3. Observations

DATA

1) SST Data: HadISST, resolution 1°×1°

2) Atmosphere Data: Reanalysis data from NCEP/NCAR

3) Rainfall Data:
   752 observational stations from China Meteorological Administration
   GPCP2.1(Global Precipitation Climatology Project) monthly Reanalysis data

Time Range: Summer (June~August) in 1979~2008
(a) East China Sea SST index (ECSI) and (b) detrended and standardized ECSI index (b). The warm (above) and cold (below) years are shaded.
When SST in ECS is in warm (cold) anomalies, there are less (more) rainfall in middle and lower reaches of the Yangtze River and Jianghuai valley and the more (less) rainfall in the southern part of Northeast China.
Distributions of correlation coefficients between the summer precipitation in eastern China and the SST index of ECS

The solid (dotted) line denote positive (negative) value; shading indicates 90% significant level.
Altitude-longitude cross sections of the simulated zonal for 25-35° N and meridional circulation anomalies averaged corresponding to (a) warm and (b) cold anomalies in ECS.
4. Conclusion

1) The experimental result and observations show that warm (cold) state in the ECS has remarkable effects on zonal and meridional atmospheric circulations over East Asia.

2) The East Asian zonal and meridional atmospheric circulations which could be modified by thermal variations in ECS affect regional climate, e.g., summer precipitation in East China and some other places in East Asia.
It is suggested that the thermal state of ECS has obvious impacts on East Asian atmospheric circulation and regional climate change in East China.

3) The regional climate in East Asia is actually comprehensively affected by various impact factors, thermal variations of ECS plays a non-neglected role in the regional climate.

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Thanks!